NEWSLETTER

of the

28th EWGLAM and 13th SRNWP meetings

9th to 12th October 2006, Zurich, Switzerland

MeteoSwiss

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Newsletter of the 28th EWGLAM and 13th SRNWP meetings, 9-12 October 2006, Zurich, Switzerland

Editor Philippe A.J. Steiner, Federal Office of Meteorology and Climatology MeteoSwiss

European Working Group on Limited Area Modelling, Meeting 28, Zurich, Switzerland

Short-Range Numerical Weather Prediction, Meeting 13, Zurich, Switzerland

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1 Introduction

1.1 Foreword

In 2006, MeteoSwiss had the pleasure to organise and host the 28th meeting of the European Working Group on Limited Area Modelling (EWGLAM) and the 13^{th} meeting of the EUMETNET Programme Short-Range Numerical Weather Prediction (SRNWP). They took place from the 9^{th} to the 12^{th} of October, 2006, in Zurich. I want to warmly thank all the colleagues of MeteoSwiss involved in the organisation and all the participants; they have so well contributed to the success of the meetings.

The meetings were for the first time held in the new format, defined in the 2005 meetings in Ljubljana, with the target to better allow the decision making for enhanced collaboration. A more formalised and extended presentation of the recent developments of the consortia has been introduced in the EWGLAM part enabling a discussion between leaders of the four areas: data assimilation, numerics & coupling numerics/physics, physics, predictability & EPS. In the SRNWP part, the reports of the lead centres have been replaced by a discussion of the new EUMETNET programme to replace SRNWP after 2007. The new format has very well passed its first trial and all agreed to keep it for the next meetings planed in Dubrovnik in October 2007.

In this Newsletter, you will find after the program and the list of participants, the reports of ECMWF and of the consortia, the national status reports and the scientific contributions grouped by area and at the end the minutes of the EWGLAM final discussion as well as the report of the SRNWP session.

Zurich, February 2007

Philippe Steiner

1.2 List of Partipicants

Marco Arpagaus	MeteoSwiss	Switzerland
Jean-Marie Bettems	MeteoSwiss	Switzerland
Gergely Bölöni	Hungarian Meteorological Service	Hungary
Massimo Bonavita	CNMCA	Italy
Mike Bush	Met Office	United Kingdom
Gerard Cats	KNMI	Netherlands
Jean-Pierre Chalon	EUMETNET	France
Guy de Morsier	MeteoSwiss	Switzerland
Terry Davies	Met Office	United Kingdom
Maria Derkova	Slovak Hydrometeorogical Institute	Slovakia
Pierre Eckert	MeteoSwiss	Switzerland
Claude Fischer	Météo-France	France
Richard Forbes	Met Office	United Kingdom
Carl Fortelius	Finnish Meteorological Institute	Finland
Jean-François Geleyn	Czech Hydrometeorological Institute	Czech Republic
Stefan Gollvik	SMHI	Sweden
Nils Gustafsson	SMHI	Sweden
James Hamilton	Met Éireann	Ireland
Andras Horanyi	Hungarian Meteorological Service	Hungary
Mariano Hortal	ECMWF	England
Tamara Ivanova	LVGMA	Latvia
Stjepan Ivatek-Sahdan	Meteorological & Hydrological Service	Croatia
Trond Iversen	Norwegian Meteorological Institute	Norway
Dijana Klaric	Meteorological & Hydrological Service	Croatia
Daniel Leuenberger	MeteoSwiss	Switzerland
Bruce Macpherson	Met Office	United Kingdom
Aarne Männik	University of Tartu	Estonia
Chiara Marsigli	ARPA-SIM	Italy
Jan Masek	Slovak HydroMeteorological Institute	Slovakia
Jean-Antoine Maziejewski	Météo-France	France
Lars Meuller	SMHI	Sweden
Dmitrii Mironov	Deutscher Wetterdienst	Germany
Maria José Monteiro	Instituto de Meteorologia	Portugal
Mark Naylor	Met Office	United Kingdom
Jeanette Onvlee	KNMI	Netherlands
Bartolome Orfila	Instituto Nacional de Meteorología	Spain
Tiziana Paccagnella	ARPA-SIM Emilia-Romagna	Italy
Ioannis Papageorgiou	Hellenic National Meteorological Service	Greece
Jean-Marcel Piriou	Meteo-France	France
Patricia Pottier	Météo-France	France
Neva Pristov	Environmental Agency of the Republic of Slovenia	Slovenia
Jean Quiby	EUMETNET	Switzerland
Bent Sass	Danish Meteorological Institute	Denmark
Francis Schubiger	MeteoSwiss	Switzerland
Jan-Peter Schulz	Deutscher Wetterdienst	Germany
Harald Seidl	Central Institute for Meteorology and Geodynamics	Austria

Cornel Soci	National Meteorological Administration	Romania
Philippe Steiner	MeteoSwiss	Switzerland
Jürgen Steppeler	Deutscher Wetterdienst	Germany
Sander Tijm	KNMI	Netherlands
Martina Tudor	Meteorological & Hydrological Service	Croatia
Per Unden	SMHI	Sweden
Filip Vana	Czech Hydrometeorological Institute	Czech Republic
Josette Vanderborght	Institut Royal Météorologique	Belgique
André Walser	MeteoSwiss	Switzerland
Xiaohua Yang	Danish Meteorological Institute	Denmark

1.3 Programme

Monday, 9th October 2006		
8:15 – 8:45	Registration	
9:00	Opening by the Director of MeteoSwiss, D. Keuerleber and organisational matters	
09:15 – 11:30	**Presentation of the Consortia and ECMWF**	chair: Marco Arpagaus
09:15 – 09:30	Tiziana Paccagnella	COSMO
09:30 – 09:45	Mike Bush	UK Met Office
09:45 – 10:00	Jeanette Onvlee	HIRLAM
10:00 – 10:15	Jean-François Geleyn	ALADIN
10:15 – 10:30	Dijana Klaric	LACE
10:30 – 11:00	Coffee break	
11:00 – 11:30	Mariano Hortal	ECMWF
11:30 – 14:45	**Presentations of national posters**	chair: Per Unden
	Harald Seidl	Austria
	Josette Vanderborght	Belgium
	Stjepan Ivatek-Sahdan	Croatia
	Filip Vana	Czech Republic
	Bent Sass	Denmark
	Aarne Männik	Estonia
	Carl Fortelius	Finland
	Claude Fischer	France
	Jan-Peter Schulz	Germany
	Andras Horanyi	Hungary
12:30 – 13:45	Lunch break	
	James Hamilton	Ireland
	Massimo Bonavita	Italy
	Gerard Cats	Netherlands
	Maria José Monteiro	Portugal
	Cornel Soci	Romania
	Maria Derkova	Slovakia
	Neva Pristov	Slovenia
	Bartolome Orfila	Spain
	Lars Meuller	Sweden
	Philippe Steiner	Switzerland
	Mike Bush	United Kingdom
14:45 – 15.15	Poster session	
15:15 – 15:45	Coffee break	
15:45 – 17:45	**Scientific presentations on numerics and coupling numerics/physics**	Chair: Claude Fischer
15:45 – 16:15	Terry Davies	Lateral boundary conditions, variable resolution or both?

16:15 – 16:45 16:45 – 17:00 17:00 – 17:30 17:30 – 17:45	Filip Vana Jürgen Steppeler Jan Masek All	general Dynamics status in ALADIN and LACE Overview and strategy on numerics. The LMZ_ including coupling Numerics & Physics Idealised test of ALADIN NH dynamical core at very high resolution (and comparison of hydrostatic and NH versions) Discussion
18:30	City tour (start at hotel Basilea) with optional dinner	

	Tuesday, 10th October	
08:30 – 11:50	**Scientific presentations on data assimilation**	Chair: Terry Davies
08:30 – 09:00 09:00 – 09:15 09:15 – 09:45 09:45 – 10:00	Nils Gustafsson Jürgen Steppeler Bruce Macpherson Mark Naylor	Recent results and plans for HIRLAM 4D-VAR Overview and strategy on data assimilation for LM Assimilation developments in North Atlantic and UK models Aspects of 4DVAR in North Atlantic model
10:00 – 10:30	Coffee break	
10:30 – 10:45 10:45 – 11:15 11:15 – 11:35 11:35 – 11:50	Daniel Leuenberger Claude Fischer & Andras Horanyi Gergely Bölöni All	The LHN scheme of COSMO Data assimilation - ALADIN Data assimilation – LACE specific Discussion
11:50 – 13:30	Lunch break with optional visit of the forecast service	
13:30 – 17:30	**Scientific presentations on Physics**	Chair: Tiziana Paccagnella
13:30 – 14:00 14:00 – 14:15 14:15 – 14:30 14:30 – 15:00	Jean-Marcel Piriou Marco Arpagaus Dmitrii Mironov Mike Bush	Parametrisation in ALADIN Overview and strategy on LM Physics The UTCS Project Physics improvements in the North Atlantic Model
15:00 – 15:30	Coffee break	
15:30 – 16:00 16:00 – 16:30 16:30 – 16:55 16:55 – 17:15 17:15 – 17:30	Richard Forbes Sander Tijm Stefan Gollvik Neva Pristov All	Recent results from parametrization developments in the convective-scale (~1 km) Unified Model Physics developments in HIRLAM-A Snow, forest and lake aspects in the HIRLAM surface scheme ALARO part developed at LACE Discussion
18:00	Apero offered by MeteoSwiss on the occasion of its 125th anniversary	

	Wednesday, 11th October		
08:30 – 11:00	**Scientific presentations on predictability and EPS**		Chair: Andras Horanyi
08:30 – 09:00	Harald Seidl	LAMEPS Development and Plan of ALADINLACE	
09:00 – 09:20	Trond Iversen	A proposal for Grand Limited Area Model Ensemble Prediction System (GLAMEPS)	
09:20 – 09:45	Bartolome Orfila	Recent experiences with the INM multi-model EPS scheme	
09:45 – 10:00	Chiara Marsigli	The COSMO SREPS project	
10:00 – 10:30	Coffee break		
10:30 – 10:45	Pierre Eckert	COSMO ensemble systems	
10:45 – 11:00	All	Discussion	
11:00 – 11:30	EWGLAM Final Discussion -Preparation of the newsletters -Date and place of the next meeting (2007) -Place of the meeting 2008 (tentative)		Chair: Stjepan Ivatek-Sahdan
11:30 – 12:00	SRNWP business meeting		Chair: Jean Quiby
12:30	Excursion and offered dinner		

	Thursday, 12th October	
09:00 – 13:00	Discussion of the 3rd phase (from 1st January 2008) of the SRNWP Programme	Chair: Jean Quiby
	-Introduction to the NWP vision -draft “Programme Proposal” and “Programme Decision” -Procedure for the elaboration of a larger SRNWP scientific project	
10:30 – 11:00	Coffee break	
	-Other proposals identified ad the Vision Workshop: -Common format for the product exchange -NWP requirements for next phase of EUMETNET obs pgm -Procedure for the prioritization of the proposals from the Vision Workshop -Work plan/timeline for programme proposal until spring Council	
13:00	End of the meetings	

2 Consortia and ECMWF reports

2.1 ECMWF

Research Progress at ECMWF 2005-2006

Mariano Hortal

The highlights of the activity at ECMWF during the last year have been:

- Cycle 30r1 of the IFS went into operations on February the 1st, after extensive pre-operational testing (more than 300 days). It included resolution upgrades to T799 in the horizontal and 91 levels in the vertical (with the top of the model raised to 0.01 hPa) for both the deterministic forecast and the outer loops of 4D-Var, T255 horizontal resolution in the second minimization of 4D-Var (the first minimization stayed at T95), and T399 with 62 levels for the Ensemble prediction system (EPS).
- Cycle 31r1 of the IFS, including significant upgrades of the model physics, a variational bias correction scheme and the variable-resolution EPS (VAREPS) was made operational on September the 12th. The physics upgrades produce a significant improvement of the model's climate and planed upgrades of the radiation parameterization will improve that further.
- The ERA-interim production has started.
- The cycle 31r1 of the IFS is now used for the deterministic model, the 4D-Var, the EPS, the seasonal forecast, the ERA-interim and the OSSE (observation systems simulation experiments) nature runs, in line with the strategy objective of increase efforts towards a fully unified ensemble system.

Unfortunately, due to budget cuts, two research positions (one in Numerical Aspects and the other in Seasonal Forecasts) are now frozen.

Ensemble Prediction System (EPS)

On February 1st the resolution of the EPS forecast model was increased to T399L62, as a first step towards the variable-resolution EPS (VAREPS) whose second phase was implemented on September 12th. The singular vectors for the initial perturbations are computed with a T42L62 resolution.

In the second phase towards the full VAREPS, the first 10 days of the ensemble are run at a resolution of T399. Then the day-9 forecast is interpolated to T255 resolution and run to day 15 at that resolution. The 1-day overlap allows the model to settle down at the new resolution.

The third phase of the implementation, planned to become operational in 2007, will be to extend, once per week, the forecasts to one month, including coupling with the ocean.

The VAREPS system aims to provide a better prediction of small-scale, severe-weather events in the early forecast range, and skilful large-scale guidance in the medium forecast range.

The performance of the EPS since the resolution increase has been very good.

For verification purposes, a new climatology of each day of the year has been compiled using ERA-40 analyses. The use of the new climatology for the operational 2005 forecasts tends to reduce the ACC of Z500, in particular for months with ACC lower than 70%.

The impact of a stochastic representation of unresolved processes on systematic model error was assessed using a) a cellular automaton stochastic backscatter scheme (CASBS) and b) a stochastic-super-cluster (SSC) scheme run at T_L95L60 for 40 winters. The CASBS improves blocking (see Fig 1), reduces the systematic error over the North Pacific and greatly improves the precipitation in the tropics. The SSC scheme aims at representing the dynamical signature of organised convection in a stochastic manner and is only active in the tropical band. First results indicate that the introduction of the signature of cloud-super-clusters not only improves tropical precipitation but more importantly increases the activity of the model in the MJO-band of 30-60 days.

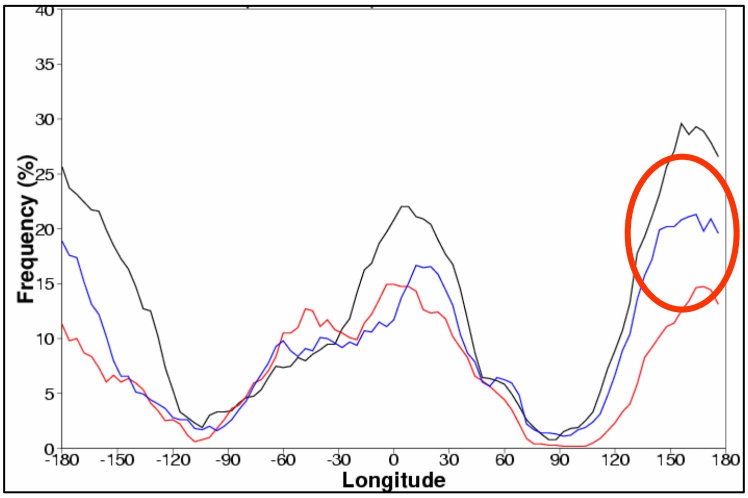


Fig 1. Mean blocking frequency (Tibaldi and Molteni index) over the Northern Hemisphere in winter (DJFM, 1-month lead time) for control (red), CASBS (blue) and ERA40 (black)

Montly and seasonal forecasts

During the past year, several model changes have taken place. In June 2005, Cycle CY29R2 was implemented and a new sea-ice treatment was introduced. Now the sea-ice is persisted until day 10, and then relaxed to climatology until day 30. After day 30, climatological sea-ice from ERA40 is used. In February 2006, cycle CY30R1 was introduced, with a new vertical resolution for the atmospheric part: $T_L159L62$ instead of $T_L159L40$. Hindcast experiments suggest that those changes had no significant impact on the probabilistic scores of the monthly forecasting system over the Northern Hemisphere.

During the development of System 3 for monthly forecasts various versions of the atmospheric model were tested, both in the medium-range system and in the seasonal system, culminating in the creation of cycle 31r1. Tests of this model version suggest that it is the best cycle to date in terms of SST anomaly forecasts, and that the model climate has also improved. It was therefore adopted for System 3.

Re-forecasts using this new system 3 are now in production and the first operational forecast using this system should be in January 2007.

Following the users' request, System 3 forecasts will be 7 months long rather than 6 months. Additionally, once per quarter a modest ensemble will be run to 13 months, in order to give an "ENSO outlook".

A new ocean analysis system has been developed to provide initial conditions for S3 and for monthly forecasts. It consists of an ocean re-analysis and a real time ocean analysis. The ocean data assimilation system for S3 is based on HOPE-OI, as in the previous system (S2), but major upgrades have been introduced.

Initial results of the ENSEMBLES project show that the multi-model approach to monthly and seasonal forecasts is still the most skilful one but a better stochastic physics treatment can improve significantly several aspects.

Numerical Aspects

1) **The high resolution system T799L91** & T399L62 EPS (IFS Cycle 30R1) which had undergone extensive pre-operational testing during 2005 became operational on February 1st 2006. A total of ten months of assimilation-forecast experimentation were run with Cycle 30R1, four months (1 October 2005 to 31 January 2006) in e-suite mode by the Operations Department and six months by the Research Department. Better representation of the orography and increased vertical resolution lead to more observations being accepted in the analysis. The mean scores are in general better than the control scores with T511L60 and Cycle 29R2, with the largest gain and highest statistical significance in the southern hemisphere.

Table 1 summarizes the statistical significance obtained with the t-test for Z500 scores for the northern hemisphere, southern hemisphere and for Europe. Numbers in green mean the high resolution system T799L91 (Cycle 30R1) is better than T511L60 (Cycle 29R1) with a statistical significance given by the value. Smaller values mean higher statistical significance. The sample size is 311 forecasts.

Area	**Score**	**Day 2**	**Day 3**	**Day 5**	**Day 7**
N Hem.	***AC***	0.1%	2%	-	-
	RMSE	0.1%	0.1%	10%	-
S Hem.	***AC***	0.1%	0.1%	0.1%	0.1%
	RMSE	0.1%	0.1%	0.1%	0.1%
Europe	***AC***	-	-	2%	-
	RMSE	0.5%	2%	10%	5%

2) **Development of a non-interpolating version of the semi-Lagrangian advection**.

The quality of the semi-Lagrangian advection scheme depends on the quality of the interpolations to the departure points of the trajectories. In the operational configuration, cubic Lagrange interpolations with quasi-monotone limiters are used for the advected quantities and linear interpolations are used for the right-hand side of the equations.

An alternative to more accurate interpolation to improve the quality of the semi-Lagrangian advection may be a "non-interpolating version" that does not require interpolations at the departure point. A non-interpolating algorithm in three dimensions has been coded. The nearest grid point to the semi-Lagrangian departure point is found and the semi-Lagrangian method is applied with this point as departure point, while the remaining or "residual" advection is performed in an Eulerian way. As part of the research process, a "non-interpolating in the vertical only" version has also been coded. Finite-elements in the vertical are used for computing accurate vertical derivatives for the residual advection. Several options for treating the residual advection of the scheme have been coded and will be compared. This non-interpolating semi-Lagrangian scheme is expected to have less damping of the smallest scales than the operational scheme, and hence produce a more realistic kinetic energy spectrum.

3) **Fast Legendre transform algorithm**

The Legendre transforms of our spectral model is the part of the model which runs most efficiently. It is therefore not clear yet at which horizontal resolution the advantage of a smaller number of computations in a fast Legendre transform algorithm will overcome the loss of efficiency stemming from not being a pure matrix-multiply operation. This together with the fact that a position of the Numerical Aspects Section has been frozen due to cuts in the budget has made this work a low-priority work.

4) **Dynamics and physics run at different horizontal resolutions**.

The possibility of running the dynamics and the physics at different resolutions has been introduced in the forecast model. Preliminary results indicate that the verification scores, for a given dynamics resolution, degrade progressively as the physics resolution coarsens and become better when the resolution of the physics increases. More work is needed in order to check other aspects of the runs such as the influence on the model climate.

5) The improvement in the efficiency of the forecast model when using the **Symmetric Multi Threading** (SMT) capability of the processors of the new IBM computer has been realized, the efficiency becoming 13% of the peak speed instead the 7% achieved with the previous machine.

6) **Non-hydrostatic dynamics in the IFS**

In collaboration with Météo-France, the non-hydrostatic version developed by the ALADIN group has been implemented in the global IFS/ARPEGE model and interfaced with the ECMWF physics.

Work in collaboration with ALADIN and HIRLAM will be carried out to implement a finite-element discretization in the vertical.

Some experiments have been run using idealized conditions which expose the non-hydrostatic effects and compared with a reference non-hydrostatic model supplied by NCAR. Fig 2 shows cross-sections of the horizontal divergence in model runs with only a bell-shaped mountain and the stability parameter NL/U (where N is the Brünt-Väisalä frequency, L the length-scale of the mountain and U the constant background zonal wind) set to a value of 5 to expose non-hydrostatic effects.

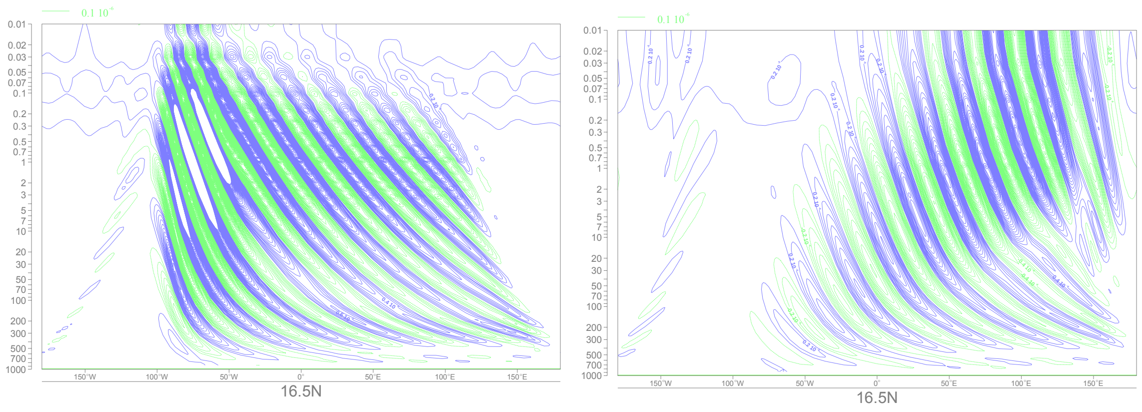


Fig 2. Cross-section of the horizontal divergence near a bell-shaped mountain using the hydrostatic (left) and the non-hydrostatic (right) versions of the IFS model.

Physical Aspects

1) **The introduction of cycle 31r1** involves a substantial number of changes in the parametrized physics:

- Changes in the cloud scheme related to ice sedimentation, treatment of ice super-saturation and the conversion to snow.
- Implicit computation of all convective transports.
- Introduction of the turbulent orographic form drag scheme (TOFD) to replace the effective roughness length concept, exclusion of the blocked layer in the forcing of gravity waves (cut-off mountain), and a combined implicit computation of turbulence, TOFD and subgrid orographic drag.
- The wind gust parametrization (for post processing only) has a revised numerical treatment which behaves better over orography and solves to a large extent the adverse interaction with stochastic physics of the previous implementation.
- Air/sea interaction assumes 98% relative humidity at the ocean surface instead of 100% to account for ocean salinity. Apart from cool skin and warm layer effects (which are included in the code but not activated), this change brings the ECMWF scheme close to the TOGA/COARE algorithm (Fairall et al. 1996) and results in a minor reduction of latent heat flux over the ocean.
- The linear convection model, as used in the assimilation of rain-affected radiances, has been improved.

The model changes improve physical realism (e.g. ice super saturation, salinity effects on evaporation) and most of these changes are necessary for further development (e.g. TOFD to allow work on atmosphere/vegetation exchange, implicit convection for numerical stability). The impact is very positive on the tropical climate of the model which is clearly reflected in radiation at the top of the atmosphere and in upper tropospheric winds. The impact on medium range forecasts is mainly neutral except for some seasonal dependent positive signals related to the surface drag over land and orographic effects.

2) **New radiation scheme**

A new version of the short-wave part of the radiation scheme RRTM is being developed. This version uses the "Monte-Carlo independent column approximation" for the cloud overlap and new cloud radiative properties. More work is needed to reduce the cost of the scheme which uses 112 spectral intervals and increases the cost of the forecast model by 30%.

The scheme improves dramatically the radiative forcing in the model leading to an improved climate.

3) **New version of the linearized moist physics**

The use of the new moist physics in the high-resolution minimization part of 4D-Var leads to a larger decrease in the cost function. The influence on the verification scores over the Northern Hemisphere is slightly positive but it improves substantially the scores over North America in winter.

Work has started on the tangent-linear and adjoint of the surface parameterization.

4) **New soil hydrology H-TESSEL**

The new scheme uses a recent digital soil map of the world and shows an improved match to soil temperature observations with respect to the previous scheme TESSEL.

Ocean waves

The resolution of the European wave model will increase shortly.

An algorithm for retrieving wind from altimeter data has been developed at ECMWF and adopted operationally by ESA.

Data assimilation

Experimentation with three outer loops at T799 is in progress using inner loop resolutions of T95/T159/T255 and the new linear physics. The forecast skill is improved with this setup but the cost is incompatible with operational delivery times and needs further optimization.

A weak constraint 4D-Var is being developed in order to account for model error in the assimilation which will allow the use of longer assimilation windows. At the present moment, the skill of a 12h weak constraint 4D-Var (using two 6-h windows) is lower that the operational 12-h window 4D-Var.

The ensemble data assimilation system is being further developed. The system will allow an easier J_b recalibration. Future work in the system includes the generation of flow-dependent background error variances and defining optimal perturbations to observations, with due representation of observation error correlations.

Including observation error correlations in the assimilation: an approximation is to use block-diagonal matrices with groups of intercorrelated data (observations of the same category). Another possibility which will be explored is to use an approximation based on a truncated eigenvector representation of the correlation matrices.

Surface data assimilation system (SDAS): An Extended Kalman Filter method, based on the experience gained during ELDAS is being developed.

The principle of the method is to adjust the initial soil moisture content to minimize the differences between observations and model-equivalent for soil-moisture related quantities during a 24-hour window.

In addition to soil moisture and temperature, the SDAS development version also treats the snow cover, the SST and the sea-ice.

Other work in data assimilation includes a better coupling between temperature and humidity during the assimilation process and better interpolation of the high-resolution trajectory to the lower resolution of the inner loops of 4D-Var.

Satellite Data

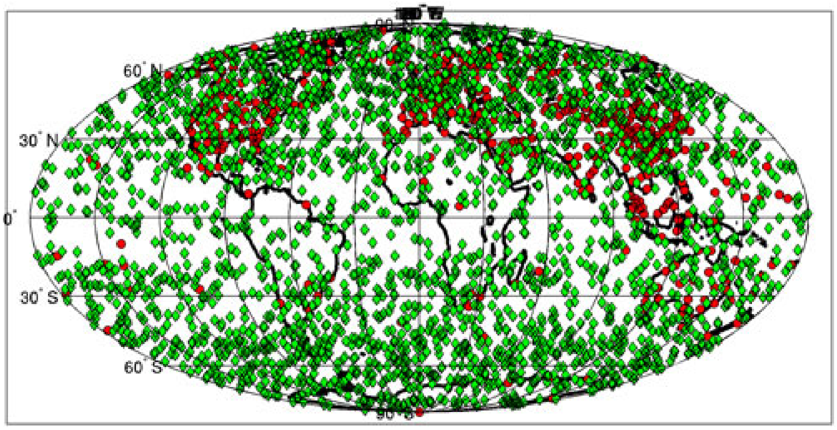
Several modifications to the first operational version of the 1D+4D-Var assimilation of rain-affected passive microwave radiometer data from SSMI have been introduced in cycle 31r1 of the IFS.

Development of the variational bias correction system (VARBC) for satellite radiances has reached maturity. The scheme has demonstrated an ability to distinguish between systematic errors in the observations (or observation operators) and the assimilating model. Corrections generated by the adaptive scheme have been implemented *statically* in operations in February 2006, significantly improving the fit of the assimilation system to radiosonde temperature data in the lower stratosphere. Implementation of the fully evolving VARBC system is undergoing final pre-operational testing as part of IFS cycle 31r1 and is performing well.

Developments for the assimilation of emitted infrared limb radiances from MIPAS have been completed as part of the EU-funded ASSET project. MIPAS radiances can now be assimilated either with a 1-dimensional observation operator which assumes local horizontal homogeneity for the radiative transfer calculations, or with a 2-dimensional observation operator which takes into account horizontal gradients along the limb-viewing plane.

The first set of experiments assimilating CHAMP GPS radio occultation (GPSRO) measurements with 2-dimensional bending angle observation operators has been completed. The 2-dimensional operators improved the bending angle departure statistics in the lower troposphere by around ~5% compared with a 1-dimensional bending angle operator, although this did not translate into a clear, statistically significant improvement in the forecast scores.

COSMIC data (which has been seen to be of high quality) have been received from August and should be used in operations soon.



Green dots – COSMIC GPSRO locations over a 24 hour period. Red dots: radiosondes

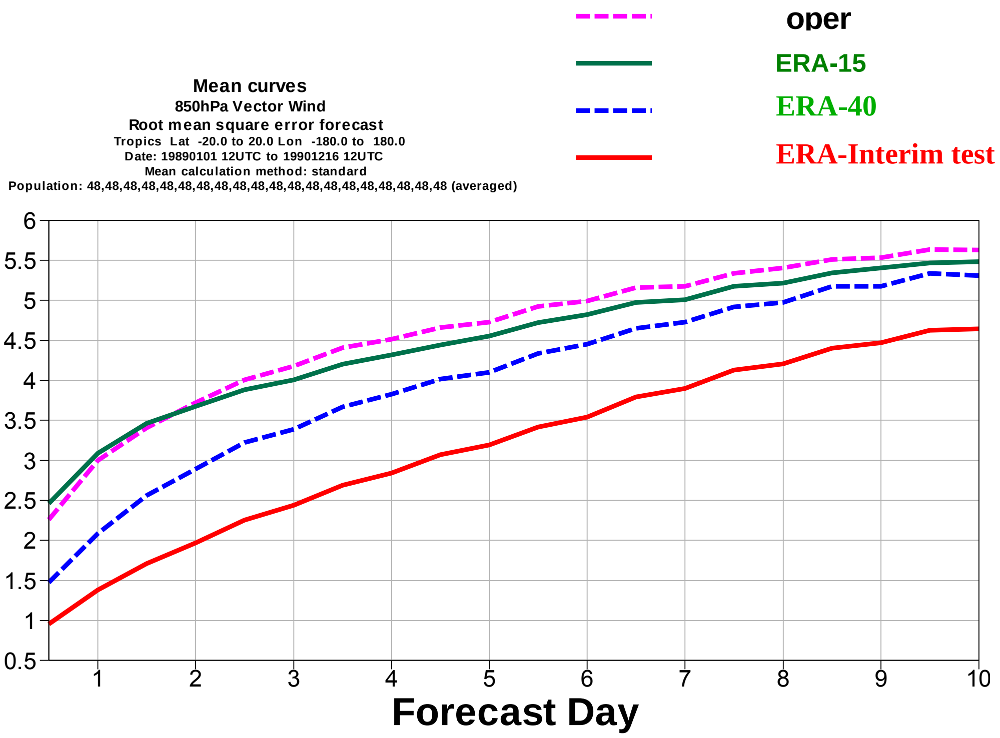
Observing System Experiments (OSEs) coordinated by EUCOS have been performed to examine the various components of the terrestrial Observing System, in the presence of the current satellite-based Observing System. Results from a summer period (46 days) are currently being assessed. The winter studies indicate a large impact of the radiosondes (wind and temperature) and aircraft (wind and temperature), a marginal impact of radiosonde humidity information, and a contrasted impact (with negative spells) from the wind profilers.

REANALYSIS

The ERA-interim reanalysis has started. It covers the period from 1989 and will be continued in near-real time when it reaches the present ("climate data assimilation mode").

- It uses Cycle 31r1 of the IFS 12-hour window 4D-Var and T255 resolution in the outer loops. Currently two versions exist: 60 and 91 levels. Only the best version will be continued in near-real time.
- The set of observations and SST/ice information used is the same as in ERA-40 until 2002, then operational datasets will be used.
- It also uses Meteosat AMV´s reprocessed by Eumetsat and ERS-1 and ERS-2 altimeter and scatterometer data reprocessed by ESA.
- It uses 1dVar+4dvar assimilation of rain-affected SSMI radiances.
- It uses variational bias correction of all clear sky satellite radiances and automated bias correction for surface pressure observations.

- Special attention currently paid to the behaviour of the VarBC scheme.
- It uses radiosonde homogenization and improved bias correction tables.
- Most problems identified in ERA-40 have been solved.



2.2 ALADIN

ALADIN: now a Programme; with a new governance; with new emphases; and with “HARMONIE” as background

J.-F. Geleyn

CHMI & Météo-France

ALADIN Programme Manager

Introduction

Since the last EWGLAM/SRNWP meeting of 2005, many changes happened within the scope of the ALADIN Consortium. What was still implicitly considered as a Project, fourteen years after its effective launching, became a Programme at the occasion of the signature by 15 Partners (Algeria, Austria, Belgium, Bulgaria, Croatia, Czech Republic, France, Hungary, Morocco, Poland, Portugal, Romania, Slovakia, Slovenia, Tunisia) of the third ALADIN Memorandum of Understanding (MoU3) on 21/10/05 in Bratislava. This MoU3 differs significantly from the two previous ones:

- The ‘Programme’ aspects are (i) a clearer definition of Membership and of the conditions of accession to the status of full Membership, (ii) the establishment of a basic budgetary procedure (with the previously existing efforts of Météo-France and RC LACE continuing independently) and (iii) a completely new governance, the details of which shall be listed now.
- The ALADIN General Assembly (GA) keeps its composition and decision role, but it gets a stable Chairmanship.
- There is now a Policy Advisory Committee (PAC), that meets once or twice a year.
- Each Partner must identify a Local Team Manager (LTM) with a reinforced amount of rights and duties for the day to day progress of the Programme.
- There is a Programme Manager (PM) for the overall coordination of planned actions as well as for the contacts with the Chair of the GA, the PAC, RC LACE, the specific features happening in Toulouse and HIRLAM.
- The PM gets assistance from both a Committee for Scientific and System Issues (CSSI, structured by topics) and a Support Team (structured by type of tasks).

In a nutshell, the three issues that the new structure/governance gave priority to within the past twelve months were:

- Establishing a better ‘transversal support to operations’ in order to save manpower and to streamline some previously non-codified aspects.
- Finding a clearer definition for the links between the AROME and ALARO sub-projects (see Part II).
- Kicking off the collection and use of the central budget.

Another important event happened, in parallel to these reorganisation steps. The annual 'HIRLAM All Staff Meeting' and 'ALADIN Workshop' were held jointly in Sofia in May, thanks to the kind dedication of our Bulgarian colleagues. There was even a SRNWP workshop happening in parallel in order to take advantage of the wide attendance. The twinning of the two major events was so successful that it was decided to continue in an alternating way for the ensuing years (Oslo in 2007, Brussels in 2008).

The scientific and technical content of the ALADIN Programme

- The scientific and technical content of ALADIN Programme can best be defined by the three main contributing sub-projects:
    i. The 'classical' ALADIN project, with its 15-countries operational applications, still running in a manner hardly different from the one under the old governance, but for the above-mentioned attention paid to transversal support to operations.
    ii. The AROME project, aiming at the 2.5 km mesh-size applications and thus at an explicit description of moist physics (relying for this on the Meso-NH physical package), with parallel emphasis on the fine scale transcription and extension of the lager scale data assimilation algorithms. The use of the ALADIN-NH dynamical core with its high stability properties allows to rely on long time-steps (≥60s at 2.5 km of mesh) in order to make the above-mentioned ambitions affordable.
    iii. The ALARO intermediate endeavour, aiming at scales where deep convection is half resolved and half parameterised. This is currently embodied by the SLHD development at the frontier between dynamics and physics (see below) and by the ALARO-0 physical package which, besides the above-mentioned horizontal scale target, aims at algorithmic efficiency and tries to build a bridge with the AROME determining parameterisation specificities.
- All the above components are more or less tightly connected to the IFS/ARPEGE global common code, especially for the maintenance that remains a heavily centralised activity, under the leadership of the French LTM, Claude Fischer.
- This diversity within the Programme under a single code effort offers a unique opportunity to go for interdisciplinary thrusts on the modelling side and hence to be in a better situation to accommodate the new links with HIRLAM while respecting the diversity of ideas and methods that can help to better build future applications.
- For some other parts (data assimilation for instance) the transversal character is implicit, given the very complex nature of the environment for R&D and the even tighter links with the global applications IFS and ARPEGE. In such cases all new developments are automatically leading to general purpose tools.

An example of interdisciplinarity

This example is not important from the scientific point of view (it requires very specific ingredients to be meaningful) but it is quite telling from the point of view of cross-team work and of surprises happening when merging various research streams within a NWP application. As such it can best be described by separating the 'contributing items' and the 'problems'.

Contributing items:

- The ALADIN-NH dynamical core, conceived as a switch on top of the Hydrostatic Primitive Equations ALADIN basic code.

- SLHD (for Semi-Lagrangian Horizontal Diffusion, a typical ALARO development made by Filip Vana), i.e. a way to incorporate a stable and flow-dependent lateral mixing in a spectral model, via the degree of smoothing of the semi-Lagrangian interpolation operators, this degree being linked to the diagnosed field of deformation.
- The Meso-NH complex physical package, previously validated (at the AROME scale) in academic mode.
- The AROME prototype applied here over south-east France, as an integrator of the three above pieces.

Problems:

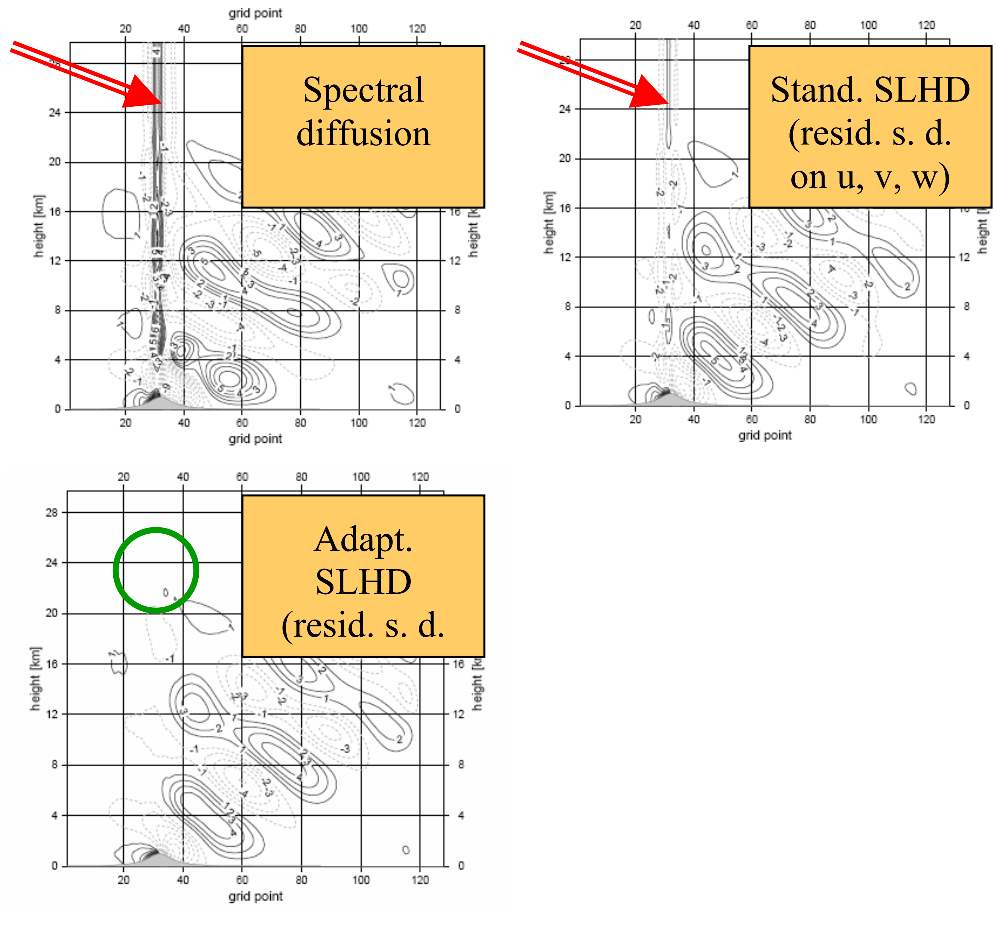
- For reasons too long to explain here, SLHD cannot treat all the impact of orographic slopes, so it must in principle be twinned with some residual spectral diffusion on the three components of motion, u, v and w. The latter component is of course subject to SLHD only in the NH mode, but alike for full spectral diffusion, this creates a so-called 'chimney syndrome' within the flow pattern over mountains. The solution to this problem seemed to be the acceptance of the small inconsistency of no SLHD action on w, see Figure 1.
- 

***Figure 1**: Classical Non-Linear Non-Hydrostatic (NLNH) bell-shape mountain test. Top left, full spectral diffusion (the arrow points to the 'full chimney' that also distorts the flow solution => one important argument for using SLHD); top right, standard SLHD with residual spectral diffusion on all wind components (the arrow indicates a weakened but still structured 'chimney'); bottom left, adapted SLHD with residual spectral diffusion only on the horizontal wind components (the circle shows the quasi disappearance of the 'chimney'). Courtesy of Miklos Voros.*

- However inspection of T2m forecasts in deep valleys, like around Grenoble (see Figure 2), revealed that an interaction between the above-described best ‘dynamical’ choice for SLHD and the AROME physical package created spurious spots of too hot temperatures, these spots disappearing when almost all horizontal diffusion is removed (a testing solution without any operational application, of course).

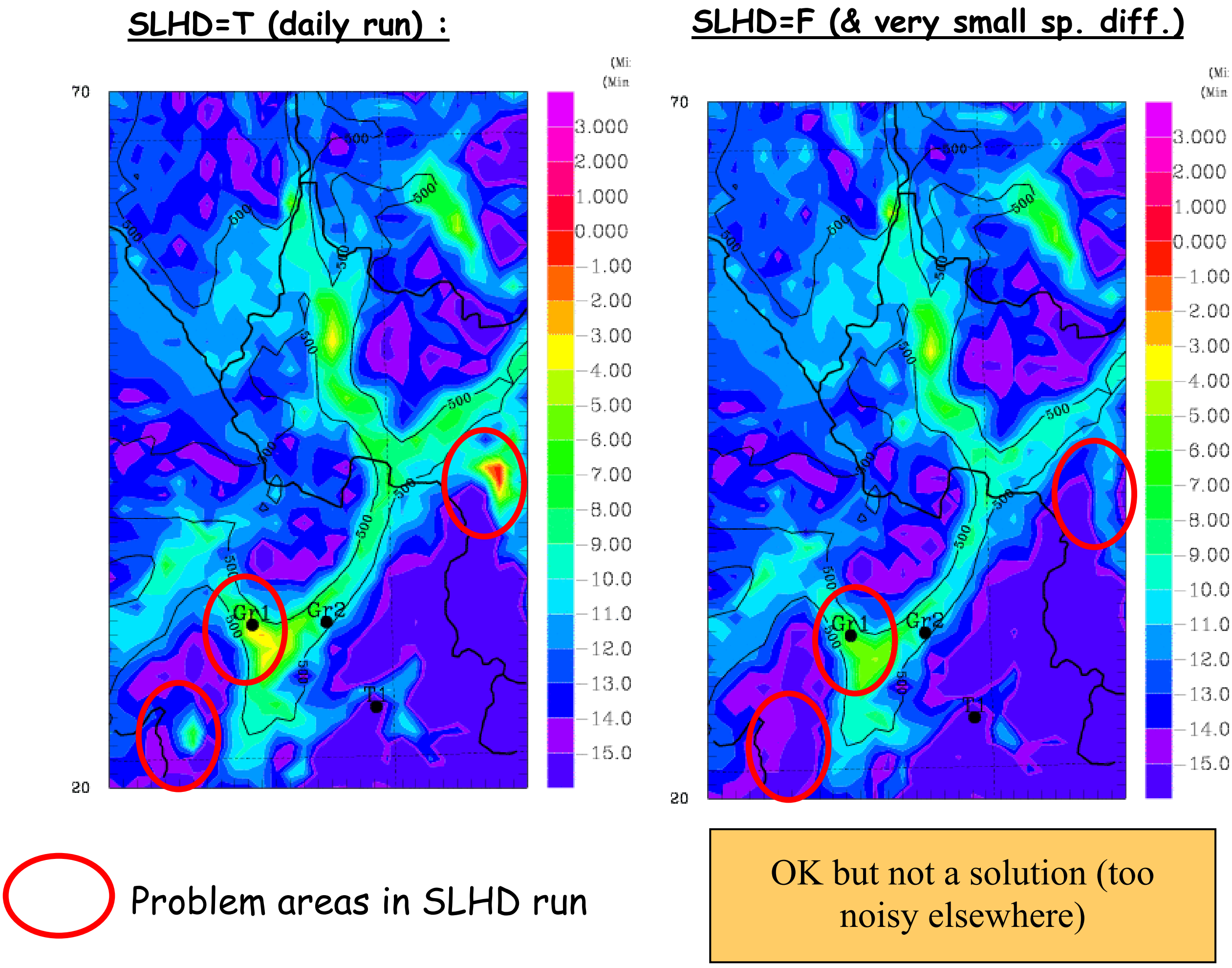


Figure 2*: Illustration of the valley ‘hot-spots’ problem (on the left). It can be cured (on the right) by removing nearly all kind of lateral diffusion, spectral and/or SLHD, but this is not a viable solution for a full purpose NWP model. The solution (not shown but quasi identical to that of the picture on the right) will surprisingly come from a study about the intrinsic SLHD behaviour. Courtesy of Yann Seity.*

- Inspection of the spectral behaviour of SLHD, visualised through the vertical divergence (closely linked to the vertical velocity w) created a big surprise (see Figure 3). The studied syndrome was a ‘bifurcation-type’ one. Indeed the spectra with vanishing residual diffusion on w were radically differing from the whole effect, with the zero solution in between! Of course, this immediately lead to a solution without hardly any sign of either the ‘chimney syndrome’ or the presence of ‘hot-spots’, solution obtained with a division by 15 of the intensity of the SLHD action on w.

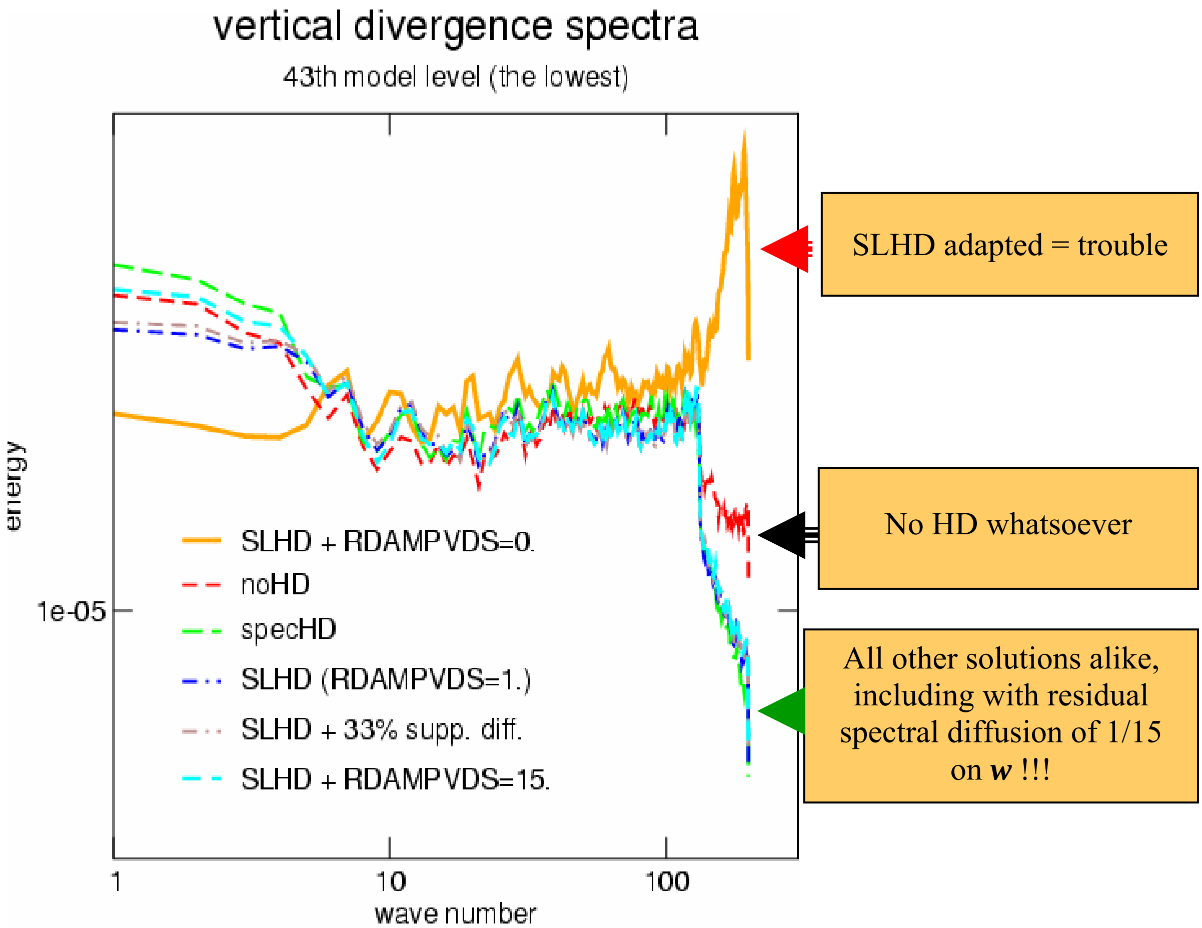


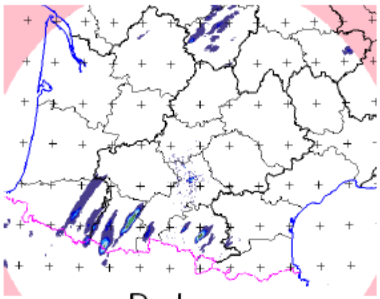
Figure 3: *The vertical divergence spectra of ALADIN-NH with various configurations for the lateral mixing. One clearly sees the 'bifurcation' between all 'reasonable' solutions and the one with the homogeneous application of SLHD on u, v and w, the zero effect being far less problematic than the latter. Courtesy of Filip Vana.*

An example of general purpose tool

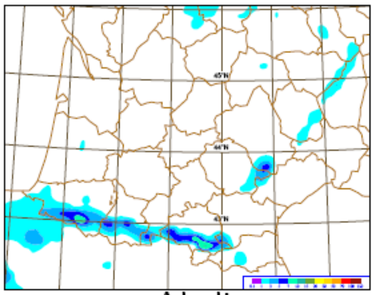
Within AROME, one of the main accents (if not the main one) is put on the capacity to improve the initial state of forecasts via the inclusion of high-resolution measurements in the data assimilation procedures. Full use of such a facility requires however the capacity to cycle, and at a high time frequency, the merging between model- and data born pieces of information. This leads to the Rapid Update Cycle target, with tests made at 3h (as shown below) and even 1h time frequency. The additional high density data are mainly provided by the SEVIRI sensors and by an increased density of use of conventional data (surface and aircrafts).

The test case shown below (courtesy of Pierre Brousseau) provides a good example of the important potential of the system (there are also less clear-cut cases). It compares the observed radar images (top-left) with precipitation maps provided by the coupling model ALADIN with its 6h own cycling at 10km mesh (top-right), by AROME in dynamical adaptation (AD) mode (bottom-left) and by AROME in RUC mode (bottom-right). Even if the full structure of the convective moving development is not captured, the solution provided by AROME-RUC is clearly superior in this situation to both other ones, at all studied ranges (Fig. 4a-b-c).

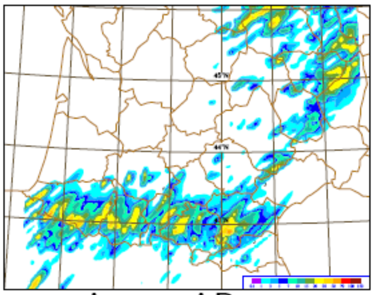
Run de 12h : Cumul 12h-15h (ech 00-03)



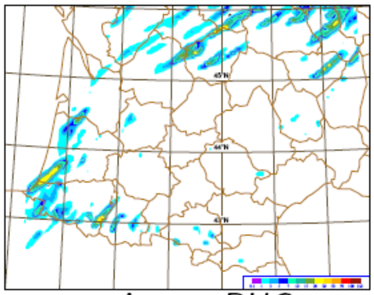
Radar



Aladin

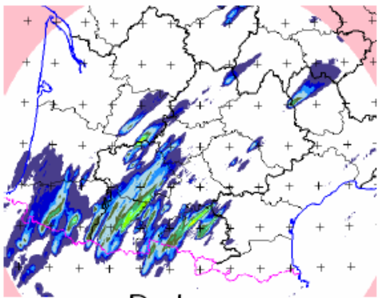


Arome AD

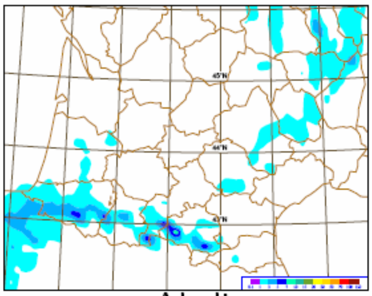


Arome RUC

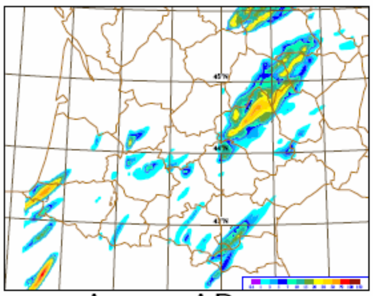
Run de 12h : Cumul 15h-18h (ech 03-06)



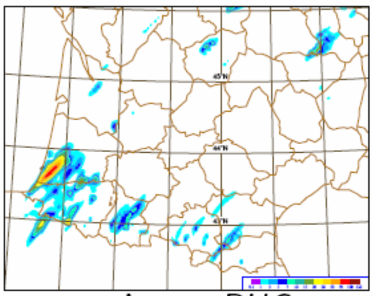
Radar



Aladin



Arome AD



Arome RUC

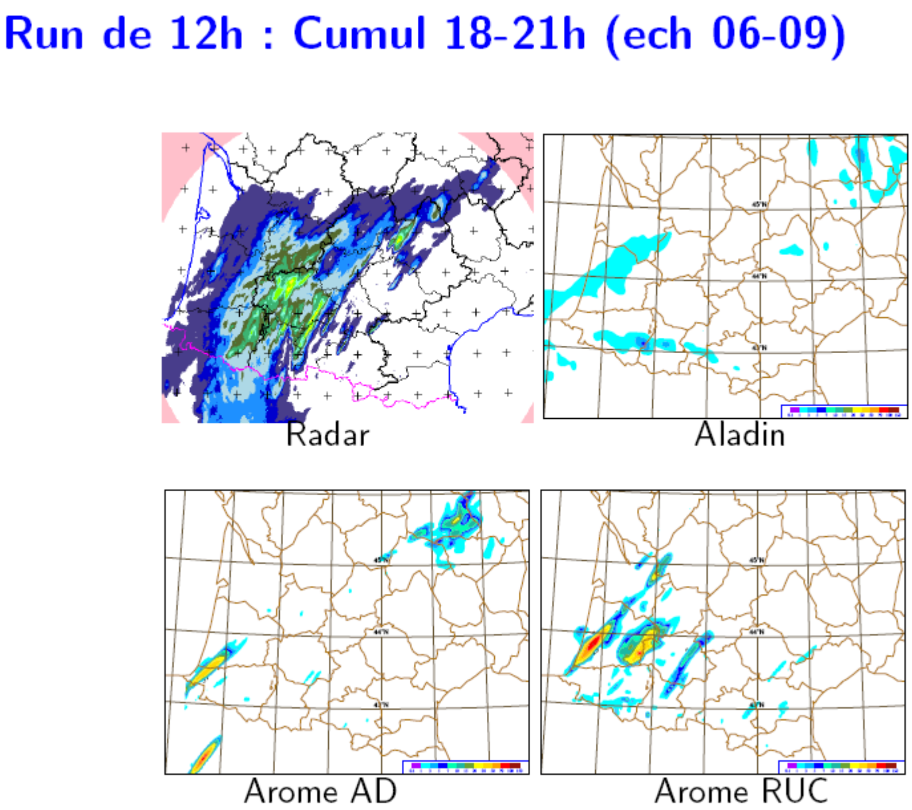


Figure 4*: One case of intercomparison of various data assimilation procedures. (a) 00-03h range; (b) 03-06h range; (c) 06-09h range.*

Towards "HARMONIE"

The progressive merging of HIRLAM and ALADIN activities is for the ALADIN consortium both the main challenge and the most promising long-term perspective. Things are progressing at a reasonable speed (neither too quickly, nor too slowly), even if not always as homogeneously as one would ideally wish. But such an endeavour was lacking identity without a name, be it only to be used selectively and progressively. Peter Lynch removed this lack via the following proposal:

HIRLAM
ALADIN
Research (towards)
Meso-scale
Operational
NWP
In
Euromed

There cannot be any more fitting conclusion for this brief introduction to the other ALADIN contributions to this Newsletter.

2.3 COSMO

The COSMO Consortium in 2005-2006

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Most of the information included in this report are taken from the last COSMO Newsletter, edited by U. Schaettler and A. Montani, available on the COSMO web site (www.cosmo-model.org mirrored at http://cosmo-model.cscs.ch).

Please see the other COSMO Scientific Reports and National Reports, included in this NEWSLETTER, as complementary to this overview.

1. Organization and structure of COSMO

The Consortium for Small-Scale Modelling (COSMO) aims at the improvement, maintenance and further development of a non-hydrostatic limited-area modelling system to be used both for operational and for research applications by the members of COSMO. The emphasis is on high-resolution numerical weather prediction by small-scale modelling based on the "Lokal-Modell" (LM), initially developed at DWD, with its corresponding data assimilation system. At present, the members of COSMO are the following national meteorological services:

DWD	Deutscher Wetterdienst, Offenbach, Germany
HNMS	Hellenic National Meteorological Service, Athens, Greece
IMGW	Institute for Meteorology and Water Management, Warsaw, Poland
MeteoSwiss	Meteo-Schweiz, Zurich, Switzerland
USAM (ex UGM)	Ufficio Spazio Aereo e Meteorologia, Roma, Italy

Additionally, these regional and military services within the member states are also participating:

ARPA-SIM	Servizio IdroMeteorologico di ARPA Emilia-Romagna, Bologna, Italy
ARPA-Piemonte	Agenzia Regionale per la Protezione Ambientale-Piemonte, Italy
AWGeophys	Amt für Wehrgeophysik, Traben-Trarbach, Germany

NMA, the Romanian Meteorological Service, has applied for membership in COSMO and at present is cooperating with the Consortium as associated member.

All internal and external relationships of COSMO are defined in an Agreement among the national weather services. There is no direct financial funding from or to either member. However, the partners have the responsibility to contribute to the model development by providing staff resources and by making use of national research cooperations. A minimum of two Full Time Equivalent (hereafter referred as FTE) scientists, working in COSMO research and development areas is required from each member. In general, the group is open for collaboration with other NWP groups, research institutes and universities as well as for new members.

The COSMO's organization consists of a STeering Committee (STC, composed of representatives from each national weather service), a Scientific Project Manager (SPM), Work-Package Coordinators (WPCs) and scientists from the member institutes performing research and development activities. At present, six working groups covering the following areas are active: Data Assimilation, Numerical Aspects, Physical Aspects, Interpretation and Applications, Verification and Case Studies, Reference Version and Implementation. The organisation of COSMO is reported in the following:

Steering Committee Members:

Mathias Rotach **(the Chairman)**	MeteoSwiss	(Switzerland)
Hans-Joachim Koppert	DWD	(Germany)
Massimo Ferri	UGM	(Italy)
Ioannis Papageorgiou	HNMS	(Greece)
Ryszard Klejnowski	IMGW	(Poland)

Scientific Project Manager:

Tiziana Paccagnella	ARPA-SIM	(Italy)

Working Groups/Work Packages Coordinators:

Data assimilation /	Christoph Schraff	DWD
Numerical aspects /	Jürgen Steppeler	DWD
Physical aspects/	Marco Arpagaus	MeteoSwiss
Interpretation and Applications/	Pierre Eckert	MeteoSwiss
Verification and case studies/	Adriano Raspanti	UGM
Reference Version and Implementation/	Ulrich Schättler	DWD

COSMO activities are developed through extensive and continuous contacts among scientists, work-package coordinators, scientific project manager and steering committee members via electronic mail, special meetings and internal mini-workshops. Twice a year the Scientific Advisory Committee (SAC), composed by the WPCs, the SPM and the chairman of the STC, meets together to discuss about ongoing and future activities. The STC also meets two times a year and once a year there is the General COSMO meeting where results are presented and future plans are finalized. Several mini-workshops (at working groups and/or Projects level) are also frequently organized.

As already reported last year, the procedure to define the annual work-plan has been revised to improve the efficiency of COSMO cooperation through a more *project oriented* management approach. The “vertical” organization of the activities grouped in the six working groups is now complemented by a “transversal” organization in Priority Projects (PPs). In these PPs the most relevant scientific issues to be investigated are clearly defined and all the scientific activities contributing to tackle those issues are grouped together and framed in a real project layout. PPs are proposed by the SAC, finalized during the general meeting after collecting contributions and proposals from all the COSMO scientists. The final step is the final approval by the STC which is also responsible of allocating the required human resources for a minimum of 2 FTEs per Country per year. The other COSMO activities, not included in the Priority Projects, are carried on with extra resources if available.

Every year the LM-User Seminar is organized to illustrate the activities carried on by groups and people using LM. The next LM-user seminar will be held in March 2007 in Langen, Germany.

2. Model system overview

The key features of LM are reported below:

Dynamics

Basic equations: Non-hydrostatic, fully compressible primitive equations; no scale approximations; advection form; subtraction of a stratified dry base state at rest.

Prognostic variables: Horizontal and vertical Cartesian wind components, temperature, pressure perturbation, specific humidity, cloud water content. Options for additional prognostic variables: cloud ice, turbulent kinetic energy, rain, snow and graupel content.

Diagnostic variables: Total air density, precipitation fluxes of rain and snow.

Coordinates: Rotated geographical coordinates (λ,φ) and a generalized terrain-following coordinate ς. Vertical coordinate system options:

- Hybrid reference pressure based σ-type coordinate (default)
- Hybrid version of the Gal-Chen coordinate
- Hybrid version of the SLEVE coordinate (Schaer et al. 2002)
- Z coordinate system almost available for testing (see the report by Juergen Steppeler)

Numerics

Grid structure: Arakawa C grid in the horizontal; Lorenz vertical staggering

Time integration: Second order horizontal and vertical differencing Leapfrog (horizontally explicit, vertically implicit) time-split integration including extension proposed by Skamarock and Klemp 1992. Additional options for:

- a two time-level Runge-Kutta split-explicit scheme (Wicker and Skamarock, 1998)
- a three time level 3-D semi-implicit scheme (Thomas et al., 2000)
- a two time level 3rd-order Runge-Kutta scheme (regular or TVD) with various options for high-order spatial discretization (Förstner and Doms, 2004)

Numerical smoothing: 4th order linear horizontal diffusion with option for a monotonic version including an orographic limiter (Doms, 2001); Rayleigh-damping in upper layers; 3-d divergence damping and off-centering in split steps.

Lateral Boundaries: 1-way nesting using the lateral boundary formulation according to Davies and Turner (1977). Options for:

- boundary data defined on lateral frames only;
- periodic boundary conditions

Driving Models: The GME from DWD, the IFS from ECMWF and LM itself.

Thanks to the cooperation with INM, in the framework of the INM-SREPS and COSMO SREPS projects, ICs and BCs can now be extracted also from the NCEP and UK Met Office global models (see the report from Chiara Marsigli about the COSMO SREPS Project).

Physics

Grid-scale Clouds and Precipitation: Cloud water condensation /evaporation by saturation adjustment. Cloud Ice scheme HYDCI (Doms,2002). Further options:

- prognostic treatment of rain and snow (Gassman,2002; Baldauf and Schulz, 2004, for the leapfrog integration scheme)

- a scheme including graupel content as prognostic variable
- the previous HYDOR scheme: precipitation formation by a bulk parameterization including water vapour, cloud water, rain and snow (rain and snow treated diagnostically by assuming column equilibrium)
- a warm rain scheme following Kessler

Subgrid-scale Clouds: Subgrib-scale cloudiness based on relative humidity and height. A corresponding cloud water content is also interpreted.

Moist Convection: Mass-flux convection scheme (Tiedtke) with closure based on moisture convergence. Further options:

- a modified closure based on CAPE within the Tiedtke scheme
- the Kain-Fritsch convection scheme

Vertical Diffusion: Diagnostic K-closure at hierarchy level 2 by default. Optional:

- a new level 2.5 scheme with prognostic treatment of turbulent kinetic energy; effects of subgrid-scale condensation and evaporation are included and the impact from subgrid-scale thermal circulations is taken into account.

Surface Layer: Constant flux layer parameterization based on the Louis (1979) scheme (default). Further options:

- A new surface scheme including a laminar-turbulent roughness sub-layer

Soil Processes:

Two-layer soil model including snow and interception storage; climate values are prescribed as lower boundary conditions; Penman-Monteith plant transpitration. Further options:

- a new multi-layer soil model including melting and freezing (Schrodin and Heise, 2002)

Radiation: δ-two stream radiation scheme after Ritter and Geleyn (1992) for short and longwave fluxes; full cloud-radiation feedback

Initial Conditions:

- Interpolated from the driving model.
- Nudging analysis scheme (see below).

Diabatic or adiabatic digital filtering initialization (DFI) scheme (Lynch et al., 1997).

Physiographical data Sets:

Mean orography derived from the GTOPO30 data set (30"x30") from USGS.
Prevailing soil type from the DSM data set (5'x5') of FAO.
Land fraction, vegetation cover, root depth and leaf area index from the CORINE data set.
Roughness length derived from the GTOPO30 and CORINE data sets.

Code:

Standard Fortran-90 constructs.
Parallelization by horizontal domain decomposition.
Use of the MPI library for message passing on distributed memory machines.

Data Assimilation for LM

Method: Nudging towards observations

Implementation: Continuous cycle
Analyzed variables: horizontal wind vector, potential temperature, relative humidity, 'near-surface' pressure (i.e. at the lowest model level)
Observations:
SYNOP, SHIP,DRIBU: station pressure, wind (stations below 100m above msl) and humidity
TEMP,PILOT: wind,temperature: all standard levels up to 300 hPa; humidity:all levels up to 300 hPa; geopotential used for one "near-surface" pressure increment.
AIRCRAFT: all wind and temperature data
WIND PROFILER: all wind data (not included in blacklisted stations)
Quality Control: Comparison with the model fields from the assimilation run itself.
A Latent Heat Nudging scheme is also implemented for testing.

3. Recent developments.

During this last year, five new version of LM have been released. The present one is the version 3.21 which is going to became the future LM reference version 4.1. The most relevant changes with respect to last year are:

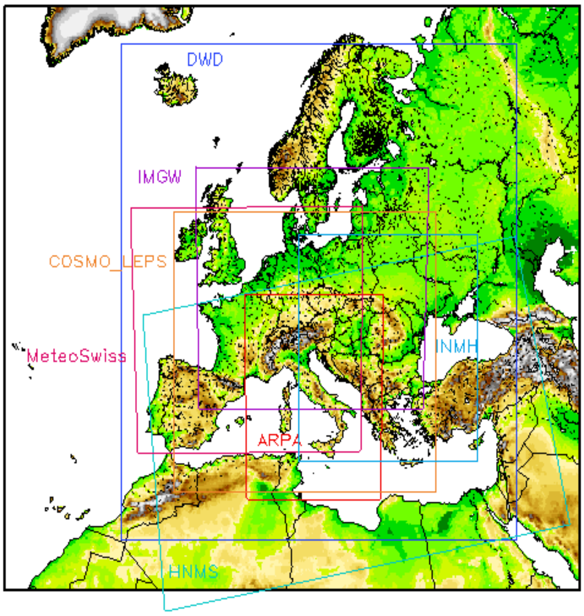
- The implementation of snow density to the multilayer soil model
- Some changes and tuning in the assimilation scheme. Much work has been done to allow the assimilation of temperature and humidity profiles retrieved from satellite data by means of a 1-DVAR technique (1-DVAR Special Project). This scheme is now under tuning and extensive testing.
- The implementation of the FLake Model
- Some changes to Runge-Kutta Scheme (RK Priority Project)
- The complete harmonization with the LMK code
- The adaptation of the code and of the input files to support the run of LM in Ensemble Mode by parameters perturbations (SREPS Special Project)

Another important and relevant upgrading of LM was the Climate Mode extension of the code to allow and support the use of the model in climate applications. Major changes were related to the restart of the model and to the output now available also in NetCDF format. This cooperation with the CLM group already gave some useful feedbacks to the COSMO community highlighting some technical inconsistencies and bugs of the model and testing the long-term behaviour of LM. For more information see the presentation by Andrea Will available at the 2006 COSMO general Meeting WEB site.

4. LM operational applications.

The LM runs operationally at the different COSMO Countries. The operational integration domains, the correspondent horizontal resolution and the driving models are reported in figure 1.

For more details please see the national reports in this Newsletter issue.



DWD Germany:

LM-E 7 km

BCs from GME

MeteoSwiss

LM-aLMo 7 km

BCs from IFS

Italy (UGM/ARPA-SIM/ARPA Piemonte)

LM-LAMI 7 km

BCs from GME

LM-EUROLM 7 km

BCs from IFS

HNMS

LM-HNMS 7 km

BCs from GME

Figure 1. Operational settings of LM in the different COSMO Countries.

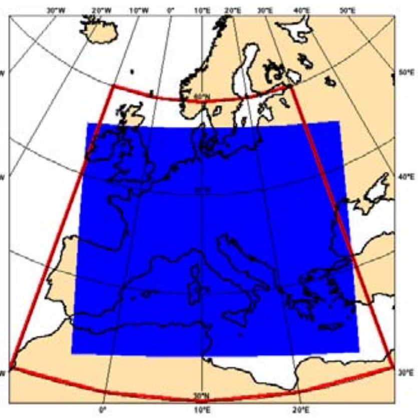


Figura 2 COSMO-LEPS integration domain

The **COSMO-LEPS** system is running every day regularly at ECMWF as a Time-Critical Application.

In figure 2 the integration domain is represented. Since January 2006, COSMO-LEPS is composed by 16 members (previously it was 10) with the same 10 km horizontal resolution. The vertical discretization is on 40 levels again since January 2006. The forecast length is 132 hours starting from the 12 UTC analysis time. For more details on COSMO LEPS status see the presentation by Pierre Eckert on this issue.

5. COSMO Long-Term Perspectives and Priority Projects

The Long Term Perspectives defined last year were:

1. Develop and improve ensemble prediction systems based on LM (including cloud resolving scale)

2. Assimilation of ‘all’ available observations, including radars and satellites, at high resolution including also slowly-changing information (soil moisture, vegetation state, etc)

2. LM performance known, critically discussed and improved

It was also stressed the importance and the need for more collaboration with the other Consortia

Another issue discussed this year was the *name* of the Model of the COSMO Consortium
It is well known that COSMO is cooperating on the Lokal Modell (LM) but the applications of LM in the different Countries have been named without any precise rule and adapting the name to the particular configuration (LME for LM Europe, aLMo for alpine LM, LAMI etc.. etc..for).
To increase the visibility of the model, to avoid confusion and to follow the tradition of other European Consortia, it has been decided that from here on the unique name of the COSMO model will be "COSMO".

Following the above guidelines, 10 Priority Projects were defined and started:

1. **Support Activities** -Project Leader: Ulrich Schaettler (DWD)

   This is not really a project, but an ongoing activity, which takes care about the Source Code Administration, the Documentation and related things (editing of newsletters, tech. Reports, WEB site). It includes many of the activities of WG6 Implementation and Reference Version). Due to the importance of these basic and "vital" activities, it has been decided to keep this as a permanent Priority Project.

2. **SIR: Sequential Importance Resampling filter -** Project Leader: Christoph Scraff (DWD):

   The aim of the project is the development of a prototype for a new data assimilation system for the convective scale by means of a sequential Bayesian weighting and importance re-sampling (SIR) filter (van Leeuwen, 2003). The SIR filter is a Monte-Carlo approach. It uses an ensemble of very-short range forecasts and selects the most likely members by comparing them to observations. From the selected members, a new ensemble is created for the next analysis time. In its pure form, no direct modification of model fields by observations is required by this method. The start of this project was delayed due to lack of human resources. At the moment only preliminary investigation have been carried on. The real start-up of the project is planned during the last months of 2006.

3. **Assimilation of Satellite Radiances into LM with 1D-Var and Nudging** - Project Leader: Reinhold Hess (DWD)**:**

   Data of polar orbiting as well as geostationary satellites (ATOVS, AIRS/IASI, and SEVIRI) will be assimilated into LM in two steps: First, profiles of temperature and humidity will be retrieved from the satellite radiances using a 1D-Var analysis scheme. Second, these profiles will be assimilated like conventional data with the nudging scheme of the LM.

   This project is well on schedule. The 1-DVAR scheme has been developed and the LM code has been modified in accordance to the new requirements. Some sensitivity tests have been performed on case studies and now the system is under tuning and regular testing.

4. **Further development of the Runge Kutta time-integration scheme -** Project leader: Michael Baldauf (DWD):

   The Runge-Kutta method is implemented in the LM as another time integration scheme besides the Leapfrog method. It will be used for high resolution applications with LM-K and possibly replace the Klemp-Wilhelmson scheme later on. It offers a substantial gain in accuracy at no additional costs. The method is quite new and differs from the Runge-Kutta scheme used in WRF, for example by having less conservation properties and a smaller approximation order in the vertical. Further work is required to investigate the advantages (and possible problems to be solved) thoroughly and to investigate further developments, such as third (or higher) order in the vertical and conservation properties. Within the WRF group possibilities of increasing the efficiency of RK are seen. Such developments should be followed. With an increased order a better interface to physics as well as the observation of other approximation conditions should become more essential. Interactions with fine scale orography should be investigated more thoroughly. For more details please see the report by J. Steppeler on this Newsletter.

5. **Further development of LM_Z -** Project leader: Juergen Steppeler (DWD)

   LM_Z is a research version of the LM, where the Leapfrog dynamics is not formulated on the vertical terrain-following grid, but on so-called Z-levels. These levels are plain for the whole domain and have a fixed height above sea-level everywhere. Near the surface, these levels really cut into the orography. For the numerical treatment the cut-cells approach is used. With the z-level coordinate, LM_Z avoids the violation of an approximation condition, which (in the case of a terrain-following grid) could lead to artificial circulations near mountains, with potentially unrealistic results in respect of mountain valley circulations, low stratus and precipitation.

   The project will deliver a version of the model ready for testing at the end of 2006. This version will include also the option of running LM_Z by employing a new semi-lagrangian/semi-implicit scheme developed during the last years. Testing will be performed both on selected cases and on a regular basis at DWD. For more details please see the report by J. Steppeler on this Newsletter

6. **Towards a Unified Turbulence-Shallow Convection Scheme (UTCS) -** Project leader: Dmiitri Mironov (DWD).

   Representation of shallow convection and boundary-layer turbulence in numerical models of atmospheric circulation is one of the key unresolved issues that slows down progress in numerical weather prediction. Even in high-resolution limited-area NWP models, whose horizontal grid size is of order 1 km, these phenomena remain at sub-grid scales and should be adequately parameterised. The goal of the proposed project is to make a step forward along this line. The project is aimed at

   (i) parameterising boundary-layer turbulence and shallow non-precipitating convection in a unified framework

   (ii) achieving a better coupling between turbulence, convection and radiation. Boundary-layer turbulence and shallow convection will be treated in a unified second-order closure framework. Apart from the transport equation for the sub-grid scale turbulence kinetic energy (TKE), the new scheme will carry at least one transport equation for the sub-grid scale variance of scalar quantities (potential temperature, total water). The second-order equations will be closed through the use of a number of advanced formulations, where the key point is the non-local parameterisation of the third-order turbulence moments. The proposed effort is expected to result in an improved representation of a number of processes and phenomena, including non-local transport of heat, moisture and momentum due to boundary-layer turbulence and shallow convection, triggering of deep cumulus convection, and stratiform cloud cover. This in turn is expected to lead to an improved forecast of several key quantities, such as the rate and timing of precipitation and the 2m temperature.

For more details please see the report by D.Mironov on this Newsletter

7. **Tackle deficiencies in precipitation forecasts -** Project leader: Marco Arpagaus (MeteoSwiss)

Quantitative precipitation forecasting (QPF) is one of the most important reasons to utilize and pay for a numerical weather prediction model, both for forecasters and customers. Unfortunately, it is also among the most difficult parameters to quantitatively forecast for an NWP model, and the LM is not doing a particularly good job at it (other models may not be much better, though). This project aims at looking into the LM deficiencies concerning QPF by running sensitivity experiments on a series of well chosen cases which have verified very poorly. If successful, the outcome of these sensitivity experiments will suggest what parts of the model need to be reformulated and improved most urgently to obtain better quantitative precipitation forecasts. At the present stage, the list of cases is ready and the sensitivity runs are ongoing.

8. **Development of Short Range ensemble based on LM -** Project Leader: Chiara Marsigli (ARPA-SIM)

Thanks to COSMO-LEPS, COSMO already has experience in ensemble forecasting but mainly as a downscaling of the ECMWF ensemble with the main focus on the (early) medium range. This COSMO SREPS (Short-Range Ensemble Prediction System) project deals with the development and implementation of a short-range ensemble based on LM to fulfil some needs arisen in the COSMO community:

(i) To have a short-range mesoscale ensemble to improve the support especially in situations of high-impact weather.

(ii) To have a very short-range ensemble for data assimilation purposes (e.g. the SIR filter project and the possibility to evaluate the flow dependent model error statistics for the 1D-VAR system).

The strategy to generate the mesoscale ensemble members proposed by this project tries to take into account all the possible sources of uncertainty and then to model many of the possible causes of forecast error. The proposed system would benefit of perturbations in the boundary conditions, perturbations of the model and, in the future, perturbations of the initial conditions. This project is carried on in close cooperation with the INM SREPS project. For more details please see the report by C. Marsigli on this Newsletter.

9. **Advanced Interpretation of LM output -** Project leader: Pierre Eckert (MeteoSwiss, Genève)

This project investigates several methods that can be used to exploit high resolution model output in an optimal way. Issues considered are the diagnosis of high impact weather, how to extract the most valuable information out of high-density fields, how to produce the best input for a forecast matrix or the driving of other models like hydrological models. During the last period the scope of this project has been enlarged to cover also verification methodologies for higher resolution models (1-3 km) which is strongly related to interpretation and adaptation issues. The new name of this project is now **Advanced interpretation and verification of very high resolution models.** You can find some more in the report by P. Eckert in this Newsletter.

10. Implementation of a Common Conditional Verification (CV) library - Project Leader: Adriano Raspanti (CNMCA (USAM)- AM)

Aim of this project is the development of a common and unified verification library including a Conditional Verification Tool. The main purpose of conditional verification is the systematic evaluation of model performances in order to reveal typical shortcomings and the reasons behind them, in a way different from the usual classical verification tools. Once delivered and applied routinely, it should provide information straight to the scientists in the Working Groups 1-3, to give them hints of the causes for model deficiencies. The first release of this library will be distributed to the COSMO partners at the end of 2006.

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2.4 HIRLAM

HIRLAM-A activities in 2006

Jeanette Onvlee

A new programme: organizational aspects

In January 2006, the HIRLAM cooperation entered a new phase of its existence, with the official start of the HIRLAM-A programme and the entering in force of the cooperation agreement with ALADIN.

The main targets of the HIRLAM-A programme, as they have been formulated in the scientific strategy for 2006-2015, are as follows. The most important deliverable of HIRLAM-A is an operational mesoscale analysis and forecast system, at a target horizontal resolution of 2km, by 2008/2009. A second goal is the continued development and maintenance of the synoptic HIRLAM (~10km resolution) system, for as long as necessary. The huge past efforts to develop a 4D-VAR system are to bear fruit in HIRLAM-A, through the operational implementation of 4D-VAR as the default analysis scheme on synoptic scales in early 2007. The third major deliverable is the development of a reliable short-range ensemble forecasting system.

A more general goal is to enhance the quality assurance, reliability and user-friendliness of the Reference system. It is aimed to intensify contacts with (end) users, in order to ensure a proper feedback of user experiences and needs into the programme. And finally, the HIRLAM programme has been tasked to explore the potential of operational cooperation between the member institutes. This is new, because until now HIRLAM has always been quite explicitly regarded as a research cooperation only.

The institutes participating in HIRLAM-A from the start are the national meteorological services of Denmark, Finland, Iceland, Ireland, the Netherlands, Norway, Spain and Sweden. Météo-France is an associated member, participating in HIRLAM research but not running the model in an operational context. In the summer of 2006, the meteorological service of Estonia, EMHI, has requested and been granted accession to the HIRLAM consortium, from January 2007 onwards. The Latvian met service, LEGMA, has recently also applied for membership, and this is under consideration. Close cooperation further exists between HIRLAM countries, most notably Finland, and researchers from Lithuania and St. Petersburg university (RSHU).

The HIRLAM programme is led by a programme manager (Jeanette Onvlee), and has been organized into 5 projects: Data assimilation and use of observations (project leader: Nils Gustafsson, SMHI); Model dynamics (Mariano Hortal; INM); Model physics parametrizations (Sander Tijm, KNMI); Probabilistic forecasting (Trond Iversen, met.no); and System and applications (Xiaohua Yang, DMI). The programme manager, project leaders and a scientific secretary (Rene Noordhoek, KNMI) together form the management group of HIRLAM.

Member institutes contribute to the program by research staff and a yearly financial contribution. Man power contributions to be delivered by each institute depend on the institute's size, and range from 0.5 to 5.5 fte/year. Of this staff contribution, a part has been put explicitly under the full control of the HIRLAM programme management: all but the smallest institutes contribute a so-called core group member to the programme, a researcher who is full-time available for high-priority tasks and under the direct supervision of the management group. This core group concept has proven to be essential for the achievement of critical tasks at the desired time.

The cooperation with ALADIN, which had already been taking shape in earlier years, has continued to intensify. In May, the HIRLAM All Staff Meeting was held in Sofia jointly with the ALADIN workshop, and coincidentally also with the SRNWP Mesoscale Verification workshop. This proved to be a very good opportunity for HIRLAM and ALADIN staff to discuss progress and make plans in direct contact. The meeting in Sofia also was an opportunity for the ALADIN Committee for Scientific and Strategic Issues and the HIRLAM management group to re-align, update and refine their common plans. Several other planning meetings have been held in 2006 on specific issues such as probabilistic forecasting and mesoscale data assimilation. The challenge now will be to manage a transition from the presently largely parallel activities to more truly jointly operating mixed HIRLAM-ALADIN research and development teams.

Mesoscale modelling activities:

In the field of mesoscale modelling, a growing number of HIRLAM institutes is now gaining experience in running 2-4 km-scale models on a (semi-)operational basis. Denmark is using the non-hydrostatic ALADIN model with partly HIRLAM physics, while AROME has been installed at SMHI and FMI, and will presumably be installed in 2007 at INM and KNMI. Met.no has been running the UM at 4km for years now, and is now also implementing (hydrostatic) HIRLAM at this resolution.

This spring, HIRLAM staff have had their first experience with phasing code into the IFS system. It is expected that at the end of June, a recoded sub-package of the HIRLAM physics will be phased into IFS. This HIRLAM physics will serve as a baseline, against which to test mesoscale physics developments. The ALADIN non-hydrostatic dynamics and 3D-VAR/FGAT assimilation system, together with the AROME physics and SURFEX surface scheme will form the base for future mesoscale developments within the IFS framework. Useful concepts from the present HIRLAM system, from e.g. 4D-VAR, the physics and surface modelling, will be ported to this code.

A mesoscale code repository, including a standard system setup and common visualization and verification tools, will be installed in the HIRLAM repository at ECMWF later this year. Henceforth, this mesoscale system, containing HIRLAM, ALADIN and AROME components, will be designated the HARMONIE model.

The main initial contribution from HIRLAM to the mesoscale physics package will be the development of a coupled eddy diffusivity – mass flux convection scheme. In addition, several parametrizations have been developed on synoptic scales which presumably will also be useful in the mesoscale model, such as the mean and sub-grid scale orography (MSO/SSO) scheme and the surface slope additions to the radiation scheme. The present AROME system contains some highly sophisticated but also computationally expensive physics parametrizations, most notably the microphysics and the radiation scheme. The impact of replacing these complex schemes by simpler and cheaper variations will be investigated.

In the field of dynamics, HIRLAM will contribute to the ALADIN dynamics in a number of ways: the implementation of a Mercator map factor, the development of a vertical finite element (VFE) method, and an improved treatment of pmsl near steep orography. In addition, research on the construction of transparent lateral boundary conditions will be continued.

Surface modelling and data assimilation both are believed to become of increasing importance at higher resolutions. Mesoscale surface developments will be based on the externalized SURFEX scheme. For the time being, new developments in both the surface modelling and data assimilation will first take place and be evaluated on synoptic scales, and then ported to SURFEX. Areas in which HIRLAM is likely to contribute to the mesoscale surface assimilation and modelling system, are: the improved snow and forest descriptions by Stefan Gollvik, the assimilation of OSI-SAF sea surface temperature and sea ice, and the introduction of a lake model component, the development of which has recently started in close cooperation with RSHU.

For mesoscale data assimilation, 2006 has been a year of learning and preparation. HIRLAM researchers have received training in the use of the ALADIN 3D-VAR and ODB systems; they have begun implementing the ALADIN 3D-VAR system locally for further study of the relevant differences between the ALADIN and HIRLAM 3D-VAR. It is intended to begin developing a joint 3D-VAR system within the IFS framework in 2007.

Joint research with Météo-France on the assimilation of radar reflectivities has started. For other relevant types of observation, such as satellite radiances and profiles, in-situ screen level observations, GPS and radar winds, the impact of assimilation will first be tested on synoptic scales, and after that on mesoscales. A plan has been proposed to achieve convergence between the ALADIN and HIRLAM formulation of observation operators; both sides are preparing a description of the treatment of observation operators in their own systems, after which a common formulation will be chosen. A planning meeting to determine the strategy on how to develop a mesoscale data assimilation capability during the coming years, will be held in October.

A mesoscale verification working group has been set up as an outcome of the Oslo workshop (December 2005). This group has selected a set of relevant cases of typical mesoscale weather situations of importance, which is to be used to validate the performance of (new versions of) the mesoscale models against. Extended case studies are expected to begin in early 2007.

Synoptic scale developments:

For the synoptic model, the testing and preparation for the introduction of 4D-VAR has been a major area of attention in 2006. A breakthrough has been achieved with the introduction of a statistical balance formulation and the detection of a nasty bug; 4D-VAR now is performing consistently and significantly better than 3D-VAR. Extensive testing and tuning of the 4D-VAR system has been carried out through the summer, in preparation of its implementation in the HIRLAM Reference System. After that, the impact of using more sophisticated (moist) physics in the TL/AD model will be investigated.

The number of remote sensing data to be assimilated in the model will increase significantly this year. The assimilation of AMSU-A over sea has been introduced in Reference version 7.0. This will be followed by the inclusion of AMV and MODIS winds, screen level parameters, OSI SAF sea ice and SST, and scatterometer data in early 2007. Research on the assimilation of AMSU-B, AMSU-A over land, (slant) GPS, and radar winds is ongoing. Studies on the impact of high-resolution (clear and cloudy) radiances, winds (MODIS) and profiles (IASI) are ongoing. A slight positive impact has been found from the assimilation of near-surface SYNOP observations, provided that a rigorous quality control of the observations is performed.

As to physics parametrizations on the synoptic scale, the aim is to finish far advanced developments, and then concentrate on solving existing problems, and shift resources to the mesoscale. A moist version of the CBR turbulence has been developed and tuned together with the STRACO convection scheme. It is attempted to adapt the scheme to improve the description of the stable boundary layer. A new spectral turbulence formulation (the QNSE scheme of Sukoriansky et al. 2006) is being evaluated to see how well it is able to correct for the deficiencies of the HIRLAM boundary layer description under stable circumstances. A new mean surface and sub-grid surface orography (MSO/SSO) scheme has been developed and tested, as well as sloping surface adjustments to the radiation scheme. An improved description of snow and forest has been introduced in the surface scheme; this will be implemented on synoptic scales first. The same will be done for a new lake model component, which is being developed in close cooperation with St. Petersburg University (RSHU).

Probabilistic forecasting:

In the area of probabilistic forecasting, several HIRLAM institutes have been active in the past, but these efforts were largely steered at a national level, and not under the control of the programme. Short-range EPS systems are now operational at met.no and INM. SMHI and DMI have been experimenting with the downscaling of precipitation and wind. At KNMI, a method for producing HIRLAM singular vectors is under development. Experiments in calibrating and evaluating the performance of short-range ensembles with conventional tools but also newer methods such as Bayesian Model Averaging (BMA) have been carried out at INM and KNMI.

The intention is now to integrate these existing and new efforts into a HIRLAM short-range EPS system. In a planning workshop in March, in which scientists from ALADIN and ECMWF participated, it was decided to build a HIRLAM-ALADIN grand ensemble of limited area EPS systems. This grand ensemble (GLAMEPS) is intended to be produced in a distributed manner, all members being run on the same area and grid, and using a variety of ensemble generation techniques. These techniques should include methods to generate perturbations in initial, lateral boundary, and lower boundary conditions, and in model parameters or parametrizations. In a strategic context, the GLAMEPS system can be viewed as a European contribution to the THORPEX/TIGGE program.

Special project resources have been requested from ECMWF to allow the construction of a laboratory environment for GLAMEPS there. In this laboratory, a variety of new short-range EPS generation techniques will be tested. Much attention will be paid to calibration of the ensemble, and optimization of the output products by means of e.g. BMA techniques. The HIRLAM ensemble system contributions to GLAMEPS will be implemented in the ECMWF environment during the first half of 2007, together with a set of calibration, visualization and assessment tools.

HIRLAM Reference System developments and changes:

The new project leader for System and Applications, Xiaohua Yang, has formed a system expert group around him. This group has been very active not only in preparing new Reference System releases, but also in the upgrading of revision procedures and tools, the initiation of code and script overhaul activities and the creation of improved internal communication tools, such as new mailing lists and wiki pages on the HIRLAM internal web site Hexnet. The system group has also provided support to developers and local system managers in the case of (operational) problems.

During 2006, the following changes have been introduced, or prepared for introduction, in the HIRLAM Reference System:

- HIRLAM version 7.0 (released in May 2006):
  - Assimilation of AMSU-A observations
  - The blending in of ECMWF large scale analyses in the HIRLAM analysis

- HIRLAM version 7.1 (expected release February 2007):
  - An increase in horizontal and vertical resolution
  - Introduction of a statistical balance and increased resolution structure functions in the data assimilation system
  - Introduction of 4D-VAR
  - Assimilation of screen level parameters, AMV and MODIS winds
  - Upgrade to RTTOV-8
  - A moist turbulence TKE scheme
  - A more advanced snow and forest surface parametrization
  - A new mean and subgrid scale orography parametrization
  - Sloping surface adaptations to the radiation scheme
  - Introduction of an extensive package of postprocessing tools.

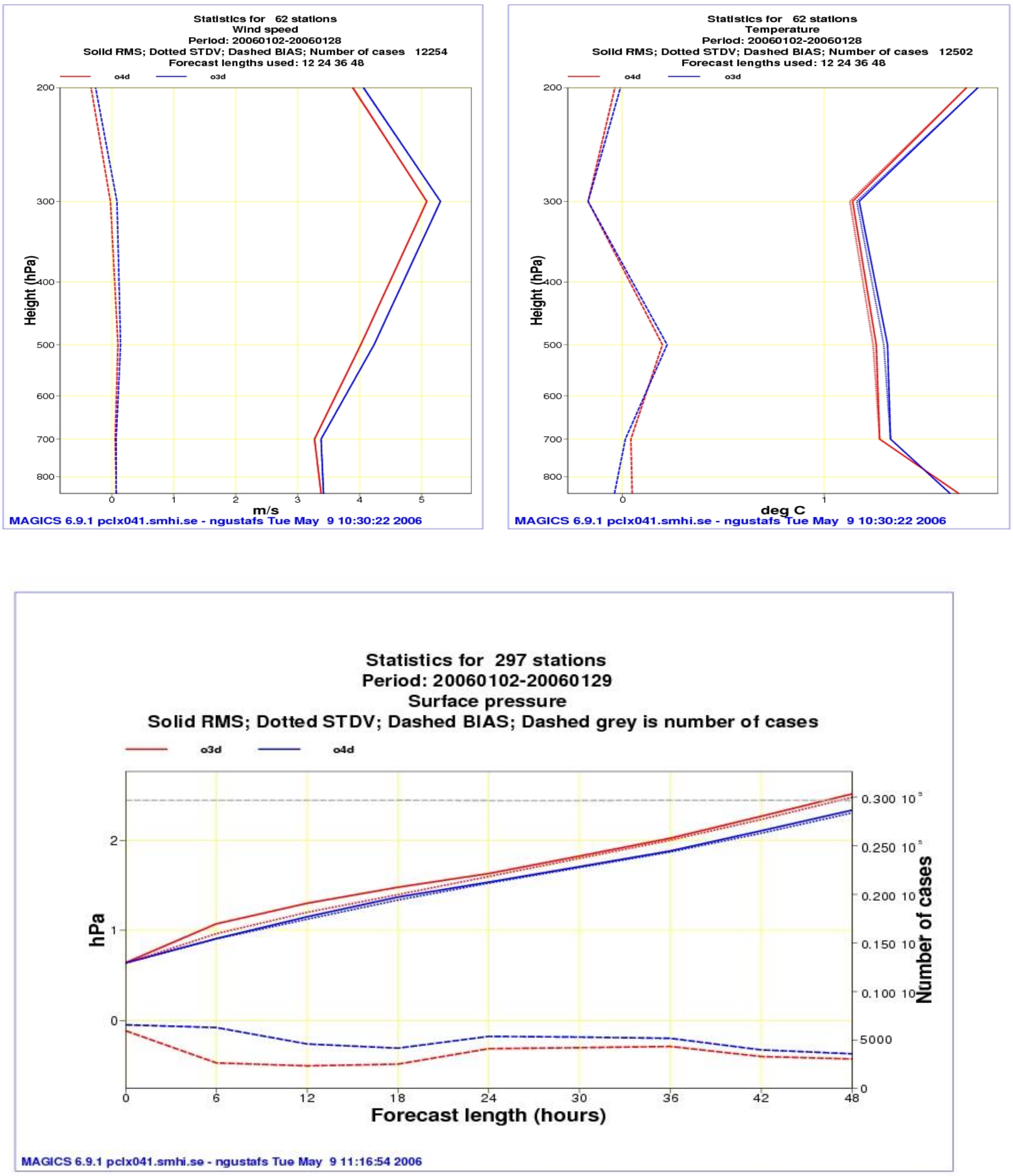

Fig. 1: Examples of verification scores showing the improved performance of 4D-VAR with respect to 3D-VAR. Fig. 1a shows an upper air score verification for wind and temperature for the month January 2006. Red lines indicate version 7.0 with 4D-VAR, the blue ones version 7.0 with 3D-VAR. Fig. 1b shows rms and bias for mean sea level pressure, verified against EWGLAM stations. In this case, blue lines indicate 4D-VAR, and red ones 3D-VAR. In both cases a clear beneficial impact of 4D-VAR is observed. This has also been shown to be the case for months in other seasons.

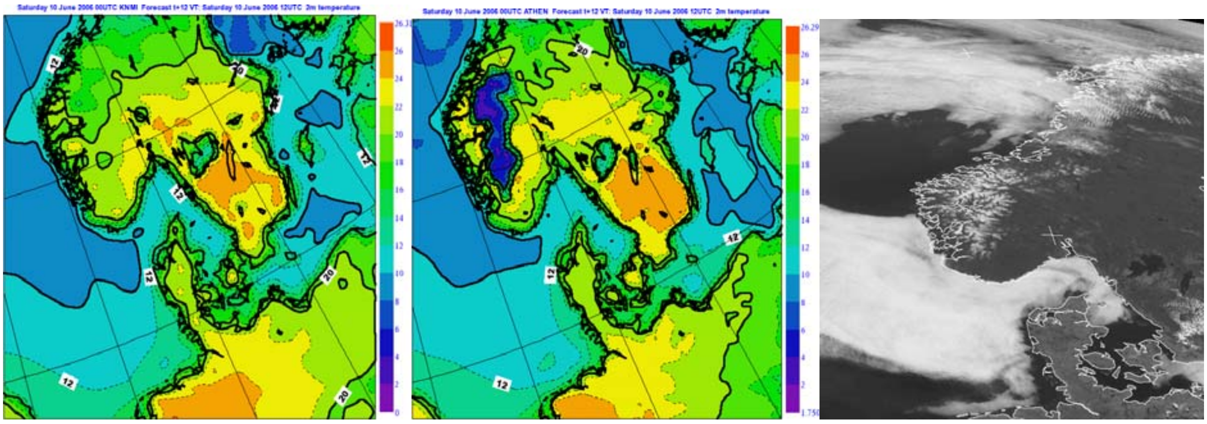

Fig. 2: Case study for 10 June 2006 for Norway. This is a typical example of a type of situation during the snow melt season which has presented long-standing problems for Nordic forecasters, which can be relieved by the introduction of the new snow and forest scheme. On the left is shown a T2m map for HIRLAM version 7.0, in the middle the corresponding T2m field for version 7.0 with the new snow scheme. To the right a satellite image for the same time. In the version without the new scheme, near-surface temperatures are too high and snow is erroneously melted over large areas in the day time, while with the new scheme the snow is correctly maintained in the model.

Table 1: Contributions to GLAMEPS development from HIRLAM and ALADIN participants.

Method	INM	HMS	KNMI	DMI	ZAMG	Met.no	SMHI	LTM
Downscaling of global EPS		X			X			
Initial and lateral boundary perturbations according to SLAF (Scaled Lagged Averaging Forecasting)	X							
Initial perturbations based on global singular vectors (and targeted singular vectors)			X			X		
Initial perturbations based on HIRLAM singular vectors		X	X			X		
Initial perturbations based on ETKF					X		X	
Lateral boundary perturbations from global model EPS						X		
Lateral boundary perturbations based on stationary forecast error statistics							X	
Lower boundary condition Perturbations				X		X		
Model tendency perturbations base don forcing singular vectors			X			X		
Multi-physics parametrizations					X			
Stochastic physics	X			X				

2.5 UKMO

Unified Model Developments 2006

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Configurations

The current NWP model configurations are shown in figure 1

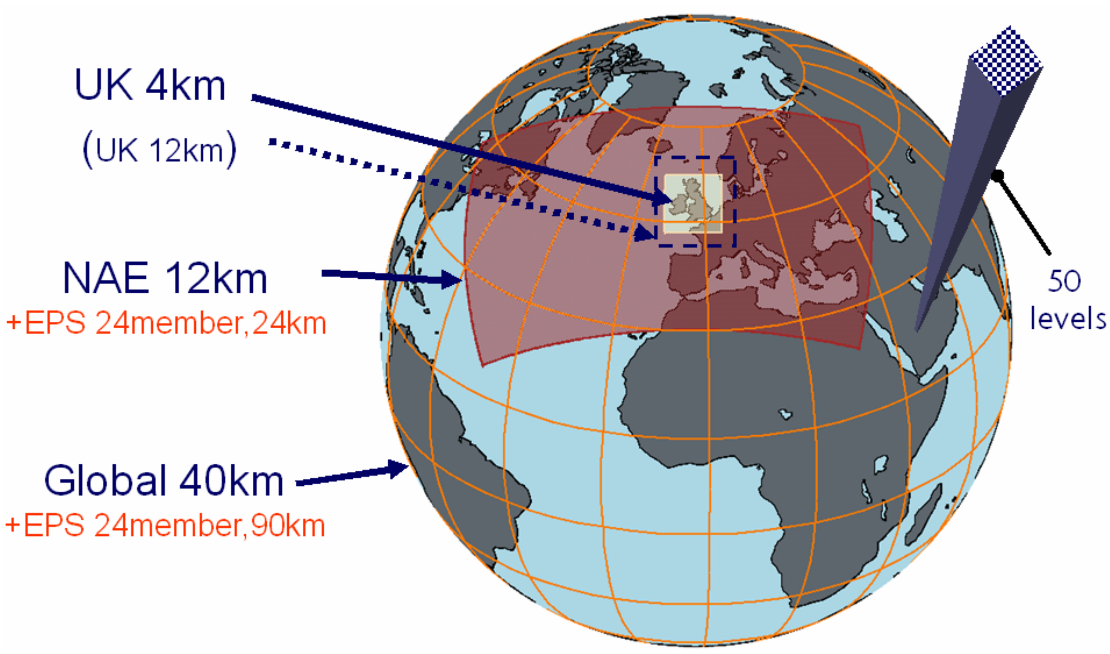
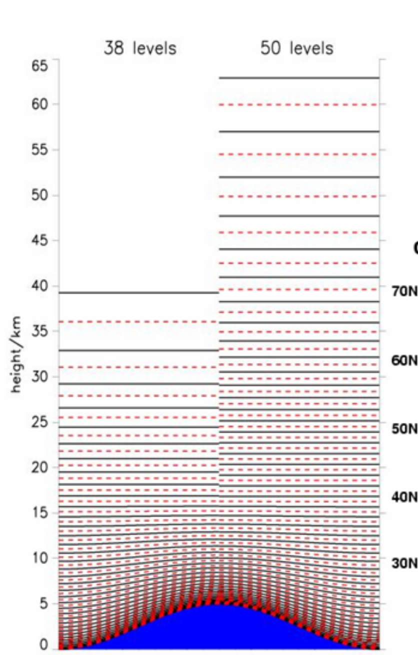


Figure 1: Current NWP model configurations.

Global Model developments

Cycle	Date	Model change and impact
G38	**13 Dec 2005**	Resolution change: N320L50 replaces N216L38 Most extra levels in stratosphere 'Lid' raised from 39km to 63km Replace stratospheric model Extra levels make better use of satellite obs Better capture of extremes Improve orographic interactions Increased EKE and deeper tropical cyclones
G39	**14 Mar 2006**	Physics package: Boundary layer and convection changes to improve known model errors in the tropics
G40	**14 Jun 2006**	Data assimilation upgrade Improved soil moisture nudging
G41	**26 Sep 2006**	Satellite changes: SSMIS and GPS RO



	N216 38L	N320 50L
Grid points	432 (EW) x 325 (NS)	640 (EW) x 481 (NS)
Resolution: Mid-lat Equator	~60 km 93 km	~ 40 km 63 km
Time-step	20 min	15 min

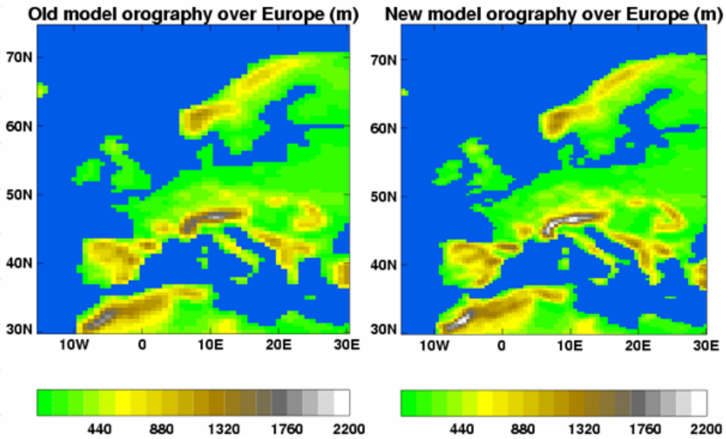


Figure 2: Global model Cycle G38 – resolution upgrade

Planned Increase of Vertical Resolution to 70 levels (Summer 2007)

There are plans for the Global (50 levels) and the NAE and UK4 models (38 levels) to move to 70 levels. The increased resolution will be throughout the depth of the model atmosphere with a new model top at 80km as shown in Figure3. The number of boundary layer levels will increase from 13 to 18.

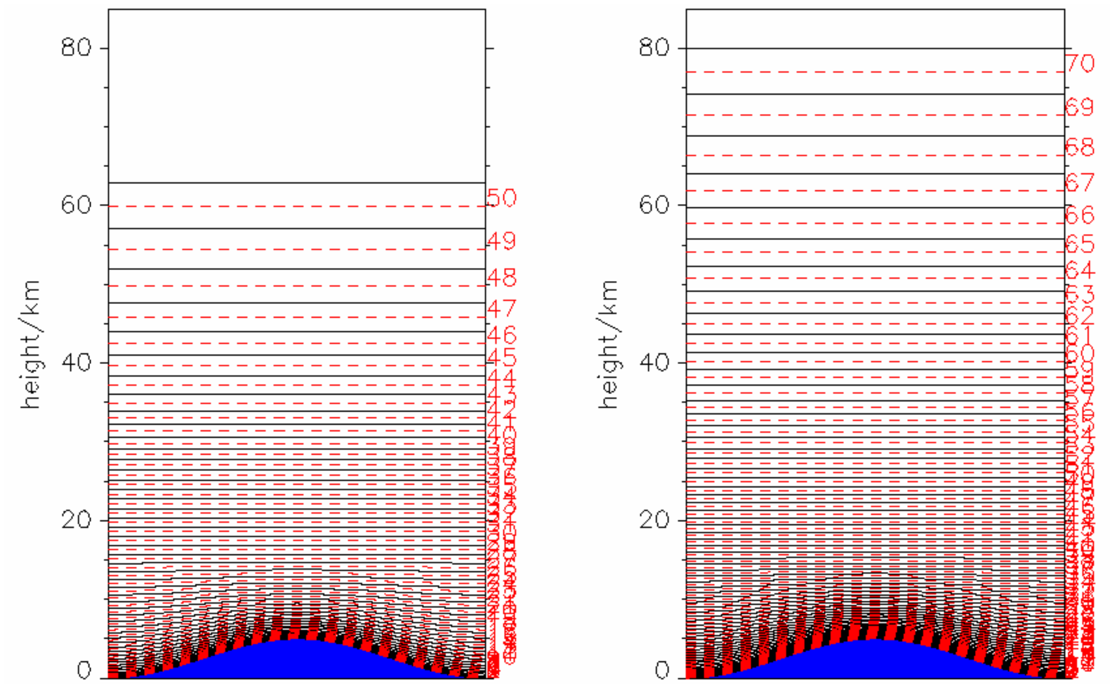


Figure 3: Planned increase in vertical resolution.

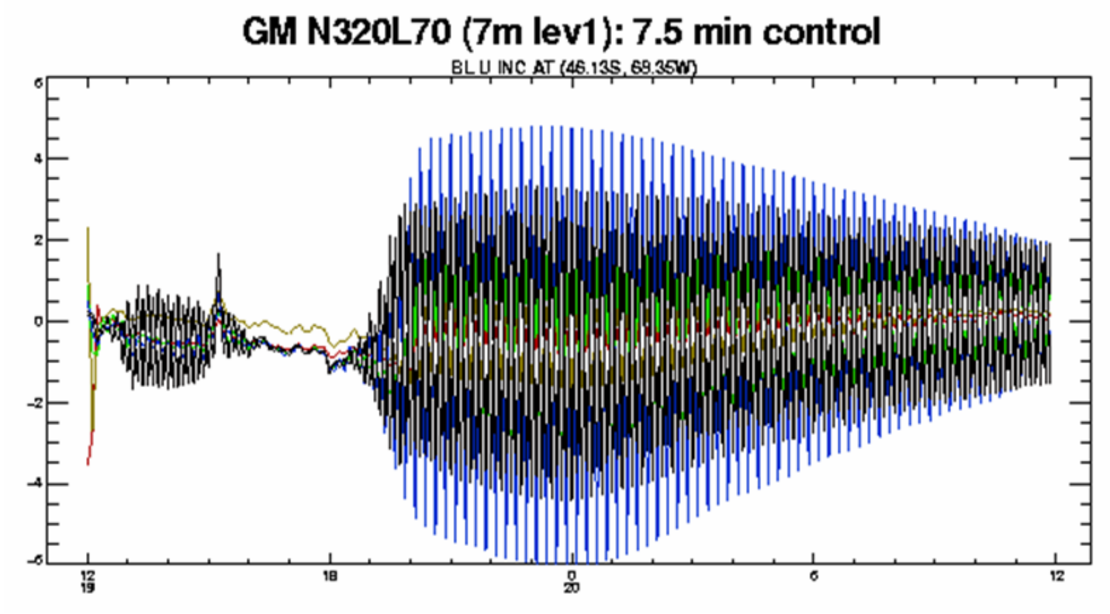


Figure 4: Noise in increments from the Boundary Layer scheme at 70 levels.

Figure 4 shows noise in increments from the Boundary Layer scheme at 70 levels. This noise may be reduced by sub-stepping the boundary layer (BL) scheme however this is costly and there are issues with using partially updated values in calculating K

Therefore an unconditionally and non-oscillatory BL vertical diffusion numerical scheme has been developed. This is currently under test and results show that the oscillations are eliminated. Work is ongoing to optimize accuracy.

Dynamics developments

The dynamics uses a two-time-level semi-implicit semi-Lagrangian discretization. This is stable when long timesteps are used, however stability and accuracy can be further enhanced by iterating the time-stepping scheme. This increases the computational cost by ~60% but some initial results have been very positive.

SL schemes lack conservation properties (important for tracers etc.) and so work is in progress on an inherently conservative scheme called SLICE (Semi-Lagrangian Inherently Conservative and Efficient algorithm).

Ensemble Forecasting developments

The emphasis is on short range (0-3 days) and high resolution regional ensembles (global ensemble run to provide LBCs for regional ensembles) to complement ECMWF 3-10 day ensembles. 15 day forecasts are run at ECMWF contributing to the TIGGE (THORPEX Interactive Grand Global Ensemble) multi-model ensemble project.

A Local ETKF scheme in Global Ensemble was introduced on 14th June 2006. Observations local to a limited set of points (approximately evenly distributed around globe) are used to calculate the transform matrix. The transform matrix is then interpolated to intermediate grid points. This has a large impact and reduces spread in the extra-tropics – improving performance.

NAE Model developments

Cycle	Date	Model change and impact
E10	**13 Dec 2005**	ATOVS & Satwind changes
E11	**14 Mar 2006**	Introduction of 4DVAR
E12	**14 Jun 2006**	Data assimilation upgrade
E13	**26 Sep 2006**	Schedule change (replace U.K Mesoscale model) Introduction of AIRS, SST improvements and physics upgrade

NAE Cycle E10 included an ATOVS change to commence assimilation of NOAA-18 data (successfully assimilated in the Global Model since mid-August 2005).

Figure 5 below shows the increased data coverage in a typical NAE assimilation cycle when NOAA-18 is added.

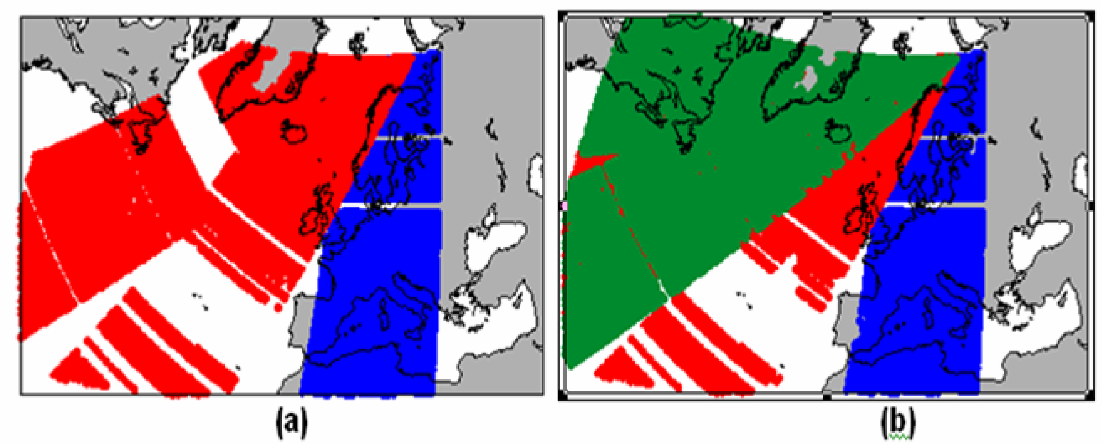


Figure 5: ATOVS data used to form a typical NAE analysis. (a) is as operations and (b) includes NOAA-18. Key: NOAA-15 blue, NOAA-16 red, NOAA-18 green.

UK4 Model developments

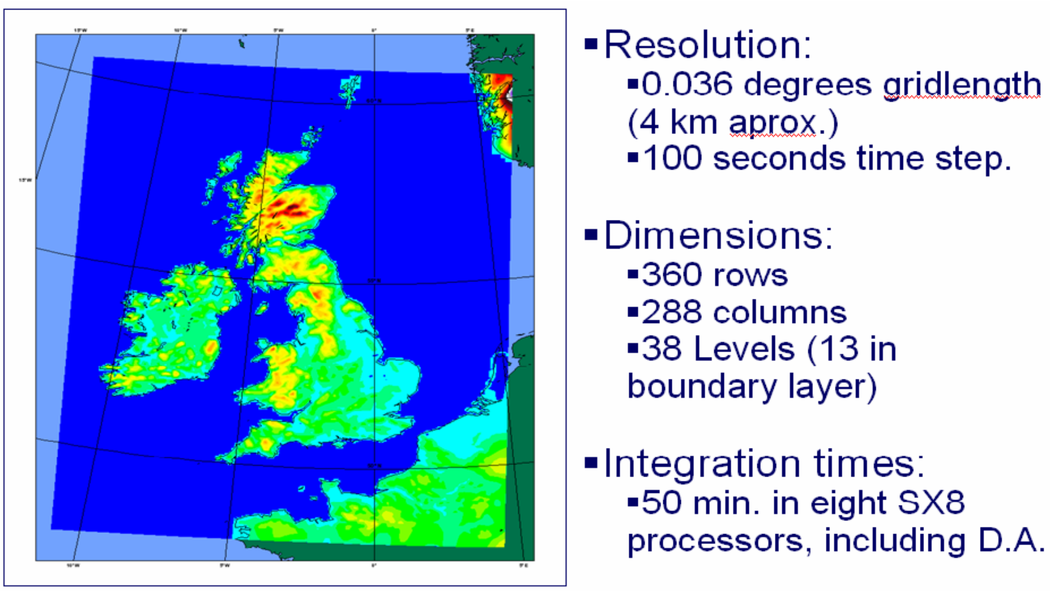


Figure 6: UK4 domain and technical details

Cycle	Date	Model change and impact
U4.03	**11 Oct 2005**	UM version upgraded to UM6.1 Targeted moisture diffusion instead of horizontal moisture diffusion. (change reversed in cycle U4.04) Empirically adjusted cloud fraction introduced - removes negative cloud bias. Convection upgrade to 4A - improves precipitation Microphysics upgrade to 3D & revised autoconversion coefficients: reduces excessive light precipitation. Change in orography blending weights: Improve consistency of orography in LBC rim area.
U4.04	**13 Dec 2005**	Introduce 3D-Var and an Analysis Correction scheme for cloud and precipitation 4 main runs at 03, 09, 15 and 21 UTC Introduce gravity wave drag Replace targeted diffusion with horizontal diffusion Add water loading term as the specific humidity based dynamics does not consider the weight of precipitation products in the density.
U4.05	**14 Mar 2006**	Mixing ratio replaces specific humidity in dynamics Include anthropogenic urban heat source
U4.06	**14 Jun 2006**	Extension of domain to cover Shetlands Correction of MOPS cloud height
U4.07	**26 Sep 2006**	Two small changes to the assimilation of radar data by Latent Heat Nudging (LHN): 1) The scale for horizontal filtering of temperature increments reduced from 21km to 6km. 2) The derivation of increments from sections of the model profile below cloud base, where evaporation is taking place is removed.

The northward extension of the model domain allows a better representation of showers around Scotland in a northerly airstream as shown in Figure 7.

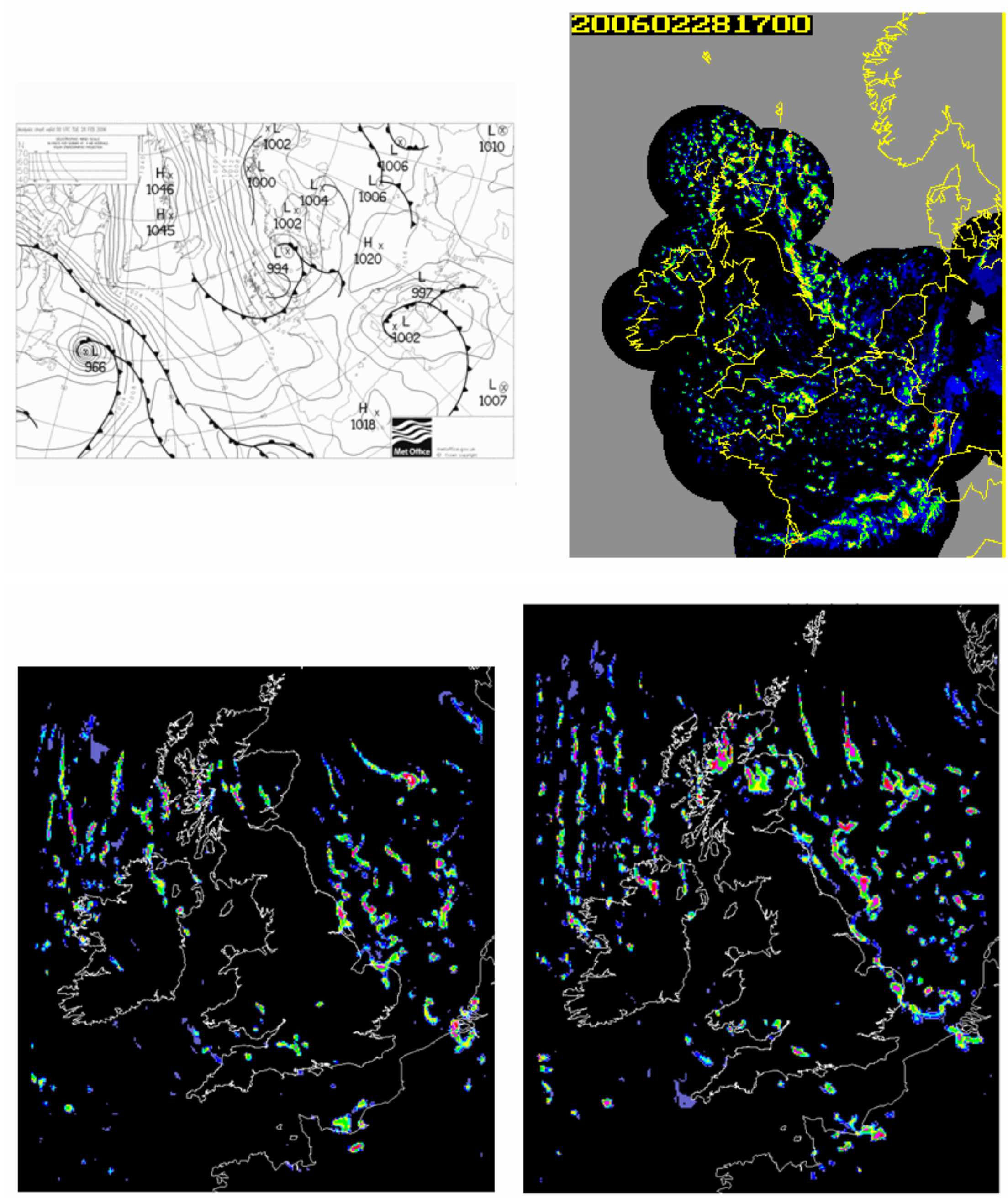


Figure 7: Impact of domain extension: 28th Feb 2006 case study

1.5km On-demand model

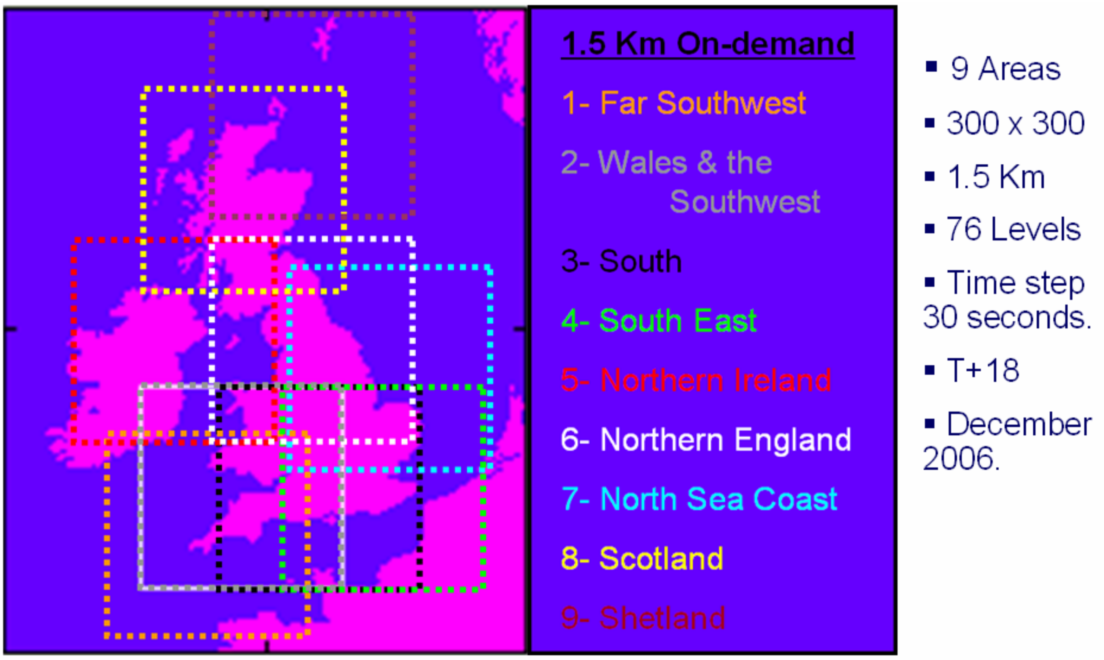


Figure 8: 1.5km On-demand model domains

3 National status reports

3.1 Belgium

LIMITED AREA MODELLING ACTIVITIES AT THE ROYAL METEOROLOGICAL INSTITUTE OF BELGIUM

Josette VANDERBORGHT (josette.vanderborght@oma.be)

Operational Aladin Belgium

The computer system

- SGI Altix 3700 BX2 , 56 Itanium2 1,5Ghz 6Mbyte CPU's
- Peak performance: 4.1 Gflop/processor
- 104 Gbyte internal memory

Aladin-Belgium

- Model version : AL29t2
- 60 hour production forecasts 4 times a day (0,6,12 and 18 UTC)
- Lateral boundary conditions from ALADIN-France and ARPEGE global model

Model geometry

- 7 km horizontal resolution (240*240 points)
- 46 vertical levels
- Linear spectral truncation, Lambert projection

Forecast settings

- Digital filter initialisation (DFI)
- 2-time level semi-implicit semi-Lagrangian- advection scheme, 300 s time step
- Lateral boundary coupling every 3 hours
- Hourly post-processing (latitude-longitude and Lambert)

Technical aspects of the operational suite:

- Transfer of coupling files from Météo-France via Internet and via he Regional Meteorological Data Communication Network RMDCN
- Model integration on 16 processors
- Continuous monitoring by home-made kornshell/web interface
- In the next future: monitoring by the SMS system

RESEARCH ACTIVITIES

MOIST PARAMETERIZATIONS

A coherent package integrating the main "moist" parameterizations: ***deep convection, resolved condensation, microphysics*** has been developed by Luc **Gerard**.

It produces realistic behaviors at all resolutions, from grid meshes larger than 20km (where deep convection is sub-grid) to 2km (where deep convection is mostly resolved), including the intermediate resolutions (typically 4km).

The package, developed in the frame of the Arpège-Aladin model, includes:

- *A large-scale condensation scheme* based on Smith (1990).

- A prognostic mass-flux scheme for the *convective up-draught*,
- *Microphysical routines* widely derived from the scheme of Lopez (2002)
- A prognostic mass-flux parameterization of a moist *downdraught*

The acute verification of the functioning and the behaviour of such a large package required to make tri-dimensional experiments, because the closure of the convective updraught, based on the moisture convergence towards a grid box, and the use of prognostic variables, induce 3-D feedbacks that are absent from single-column model tests. The evolution of up- and downdraught profiles as well as the evolution of the internal variables passing through the microphysical routines had to be assessed thoroughly.

The key was the development of specific software to be able to follow internal variables within the physics package without being submerged under data.

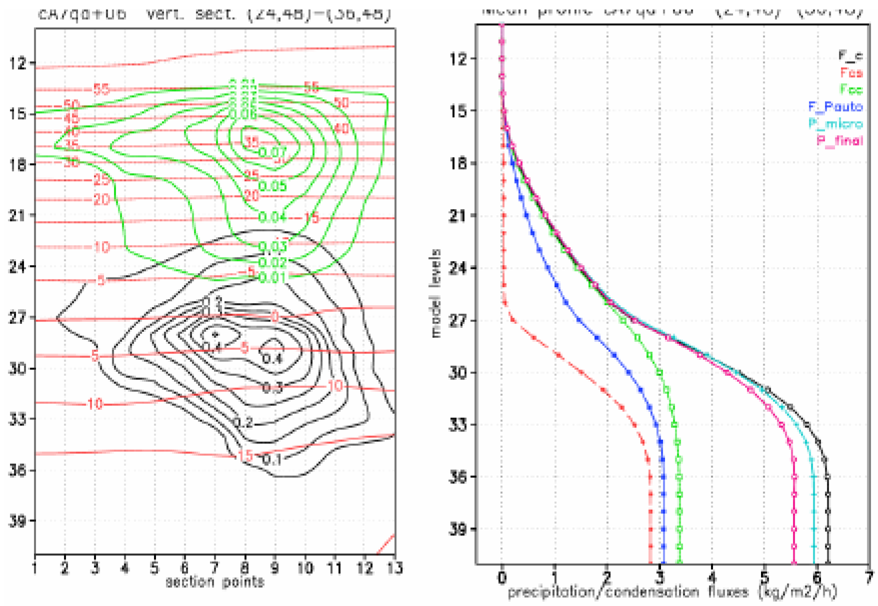


Fig. 1: Vertical cross section in a 3-D run. **Left**: temperature (°C, red), cloud ice (g/kg, green), cloud droplets (g/kg, black). **Right**: mean profile over the same section of the resolved condensation flux (red dashes), the convective condensation flux (green dots), their sum (black), the auto-conversion flux (blue), the total precipitation from auto-conversion, collection and evaporation in microphysics (cyan), and the final precipitation flux after the downdraught

Varying the model resolution

This new scheme has been tested for a situation of active thunderstorms that caused very intense showers over Belgium on 10 September 2005. The operational model (no microphysics, diagnostic convection) missed most of the episode.

The integrated scheme has been applied at different resolutions (6.97 km, 4.95 km and 2.18km) and the results are consistent, i.e. the location of the maxima is the same and the amounts increase regularly with increasing resolution. The smaller precipitation amounts at coarser resolution come first from a wider averaging area. The smoother model orography and the bigger uncertainty on the correlation between vertical velocity and water vapour contents are additional sources of differences.

This case also illustrates the importance of using a parametrization of deep convection (and one which is fit for high resolution): when we switch it off, the convective updraughts are forced to a coarser-than realistic scale, producing a too strong atmospheric response (Deng and Staufer, 2006): the areas of intense precipitation are much wider than observed. In the 2.18-km run, the convection scheme still produces significant condensation, while without it the resolved scheme alone takes over the totality. The prognostic convection scheme is by construction nonhydrostatic: in the frame of the hydrostatic model dynamics, it appears that it continues to enhance the forecast down to the 2-km resolution.

Benefits at 7-km resolution

This is a first demonstration that this new scheme may be beneficial at coarser resolutions. The prediction of our operational Aladin model for 17 August 2006 (using diagnostic schemes and no cloud water variables) was particularly unrealistic, showing intense precipitation over all Belgium, and the birth around 18:00utc of a local depression in the South of Belgium, which deepened and moved slowly to the North-East (to be on the North of Netherlands 12h later).

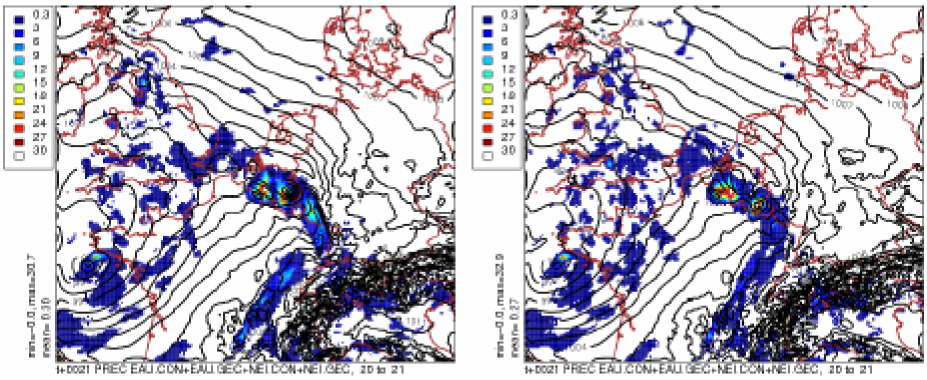


Fig. 2: 2006-08-17, 21:00 UTC. 1-h accumulated precipitation (mm), mean sea-level pressure (hPa).

Left: operational Aladin-Belgium model (7-km grid mesh, 46 vertical levels). **Right**: same with SLHD.

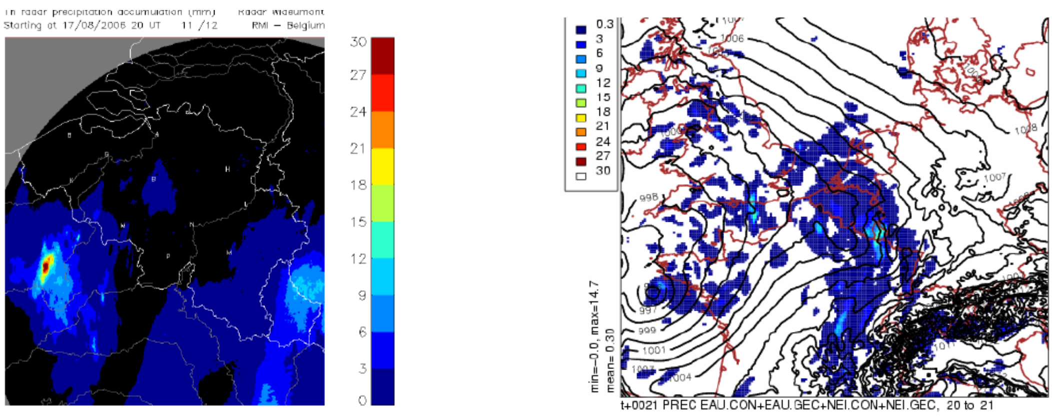


Fig. 3: 2006-08-17, 21:00 UTC. **Left**: Radar picture: 1-h accumulated precipitation. **Right**: new integrated package, same geometry as operational.

On figure 2, the operational forecast for 21:00 UTC presents intense precipitation over South of Belgium and the bogus surface low around 997 hPa. Using the Semi-Lagrangian Horizontal Diffusion scheme smoothes the low to around 1000 hPa, but the maximum precipitation is even bigger (32.9 mm/h instead of 30.7) On the contrary, with the new integrated package (Fig. 3, right), the bogus depression has completely disappeared, while the accumulated precipitation (5 to 9 mm/h on Belgium) is much more acceptable compared with the location and amounts given by the radar picture (left).

Perspectives

The integrated package of Luc Gerard is presently included in the new ALARO-0 version of the ALADIN model, where it will also be able to use different resolved clouds or precipitation schemes. Thorough validation tests in this frame are programmed as well as more refinements, like the use of a prognostic mixing in the updraught parametrization.

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J. Appl. Meteorol. and Clim. 45, 361-381.

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Physics-dynamics interfaces

The aim of this research is to perform a general approach to the following problem: *Given a candidate physics-dynamics interface, quantify the stability and the accuracy of the numerical scheme and provide guidelines and rules to set up new interfaces for new physics parameterizations.*

Results of this research will give us answers to the following questions:

- Can the coupling of meso-NH physics to ALADIN-NH dynamics benefit from a reorganization of the time step in the ARPEGE/ALADIN/AROME framework?
- Should the physics computations be done before or after the dynamics in the model?
- Should the physics computations be done in a parallel of fractional manner?
- Should we compute physics at the origin point, at the arrival point or at the middle point in the semi-Lagrangian scheme?

A comparative study between the time-step organization of ARPEGE/ALADIN/AROME (physics before dynamics, parallels physics) and the ECMWF model (physics after dynamics, sequential physics) has been performed and the results will be published in a paper "*Stability and the accuracy of the physics-dynamics coupling in spectral models*"

Model-Inspired predictors for MOS

To improve the performance of Model Output Statistics, it is proposed that the choice of predictors might be inspired by the equations of the NWP model. Physics parameterizations give estimates of sub-grid processes and can thus be viewed as projections of sub-grid physical degrees of freedom onto the resolved scales.

They may thus be used to provide some independent sub-grid predictors, supposing that physically independent variables also behave highly uncorrelated.

Concentrating on the 2m temperature predictions, it is shown that the addition of *latent* and *sensible heat fluxes* and of *radiation fluxes* as predictors, gives a statistically significant improvement in the performance of the MOS.

This can be illustrated by comparing the RMSE of the original prediction with that of the MOS systems with and without model-inspired fluxes.

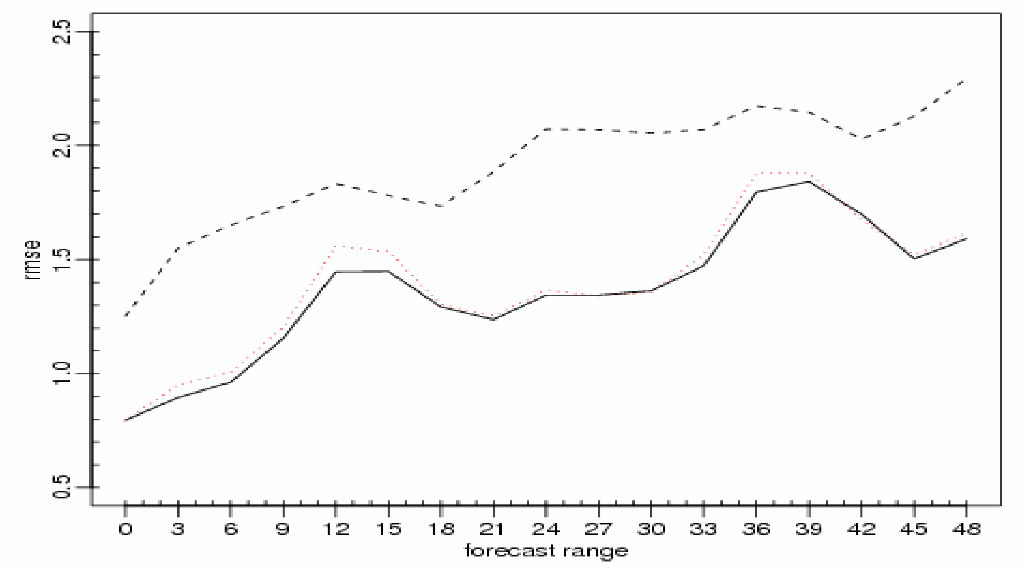


Fig. 4: RMSE of the original model (dashed), of MOS with conventional predictors (red, dotted) and with the addition of model-inspired predictors (**full)**.

3.2 Croatia

National status report for Croatian Meteorological and Hydrological Service

Dunja Drvar, Stjepan Ivatek-Šahdan, Blaženka Matjačić & Martina Tudor

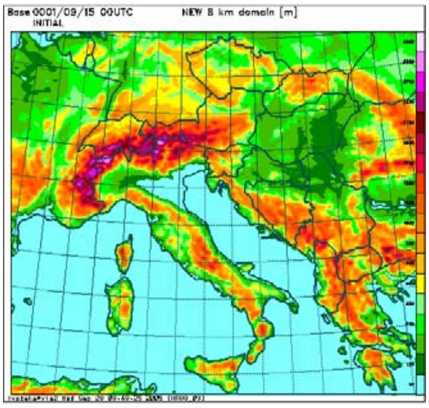
Current status of the operational suite

- **Computer**: SGI Altix LSB-3700 BX2 Server with 24 Intel Itanium2 1.6GHz/6MB; 48 GB standard system memory, 2x146 GB/10Krpm SCSI disk drive; OS SUSE Linux Enterprise Server 9 for IPF with SGI Package; Intel Fortran & C++ compilers version 9.0.031; PBS Pro for LINUX as queuing system.

- **LBC files and lines**: global model ARPEGE, coupling frequency 3 hrs; Internet and RMDCN through ecgate as backup from July 2006.

- **Free products on Internet** (72 hrs fcst) http://prognoza.hr/aladin_prognoz a_e.html .

- **Domains and forecast range**
  resolution: **8 km**, 37 levels from 1st Dec 2005;
  229x205 (240x216) grid points;
  Corners: SW (36.18,3.90) NE (50.68,26.90);
  2 km wind dinamical adapt. - 15 levels;
  6x 72x72 (80x80) 1x 97x72 (108x80) grid points;
  prolongated forecast range 54 to 72 hours in May.

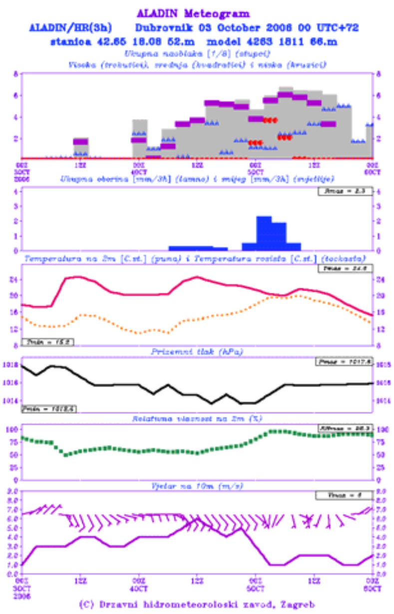


- **Model set-up**
  AL29T2mxl with SLHD;
  Xu-Randall cloudines scheme with random overlap;
  mean orograhy with changed gravity wave drag;
  Digital Filter Initialisation.

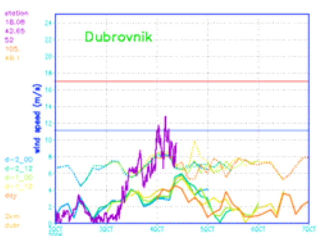
- **Visualisation**
  numerous surface field;
  and fields on pressure levels;
  meteograms, vertical time cross section HRID's and vertical cross sections;
  hourly verification against automatic meteorological stations;
  50 points for wind, 26 for 2m temperature and 9 for pressure;
  comparison of forecasts with data measured on SYNOP and automatic stations;
  is done hourly for the last 5 runs giving an EPS-like picture through 5 days (see bellow).

New developed products

New **meteograms** of "surface parameters" up to 72 hours were developed that should be more user-friendly for forecasters, showing: total, low, medium and high cloudiness, total precipitation and snow, 2 m temperature and dew point, msl pressure, 2 m relative humidity, 10 m wind direction and wind speed. Some special fields are still missing (surface temperature, wind gusts, convective precipitation, ...). (figure right)



Hourly comparison of forecasts with data measured on automatic stations for 10 m wind (fig. right), pressure and 2 m temperature.



New computer

Core of the new computer were bought with help of the Norwegian Meteorological Institute through WMO Voluntary Co-operation Programme. Therefore computer got a name - Viking. First upgrades were done with help of the Croatian Ministry of science education and sport and Croatian Meteorological and Hydrological Service. At the moment computer is used for operational NWP forecast. In the framework of the joint project with met.no EMEP4HR ("High resolution environmental modelling and evaluation programme for Croatia") computer will be used to develop air chemistry models on meso and urban scales as well as regional downscaling of global climate models.

Status of compilation and porting

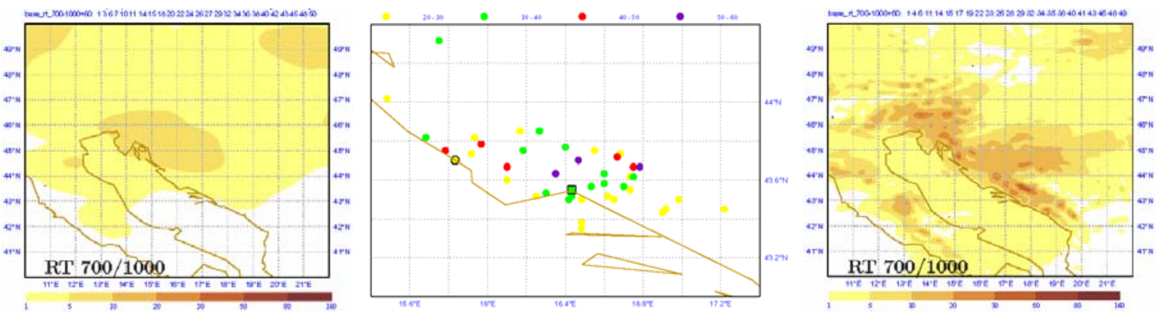
Compilation of ALADIN code (including a version of ALARO0) is ported with gmkpack tool. Better optimisation of code is still missing. Some problems were solved during compilations as accvimp and accvimpd should not be optimized with Intel compiler version 9.0.031. PALADIN, emoslib, gribeuse are installed too. Thanks a lot to Jure Jerman, Hungarian and Czech coleagues for help with porting and to Ryad El Khatib for the new version of gmkpack.

Research activities in 2006

EPS downscaling with ALADIN

Four cases with Severe weather (precipitation and wind) in 2003 and 2004 were studied. 5 day forecasts of the full set of 50+1 ECMWF EPS members were downscaled with ALADIN on old LACE domain (12.2 km horizontal resolution 37 levels). The same clustering method was applied on ECMWF EPS and downscaled ECMWF EPS with ALADIN NWP model. Results from both systems were manipulated in the same way (interpolated to 0.5°x0.5° grid) to determine the impact of dynamical downscaling. Comparison with ECMWF analysis was done on same resolution. Clustering was done using the Metview, unfortunately clustering on the Lambert projection was not possible with Metview 3.6.

First results for the chosen severe weather events in Croatia show that downscaling is a useful tool, especially if orography is the triggering effect and it is promising that good ECMWF EPS forecast were not spoiled with downscaling. The two measures of modelling error with respect to ECMWF operational analysis, defined over the downscaling domain indicate that the errors in ECMWF and ALADIN EPS upper-air fields are comparable.



24-hour accumulated precipitation from the Dalmatian rain gauges between 06UTC 4 July 2003 and 06UTC 5 July 2003 (middle figure). Only rain gauges with more than 20 mm/24 hr are shown, most of the precipitation in first 12 hour. The 12-hour accumulated precipitation between T+54 and T+66 hr in the summer Adriatic convective case: left- for ECEPS cluster no. 3 for the RT 500/1000 clustering base, and right-for ALEPS cluster no. 2 for the ω500 clustering base. Contouring for precipitation 1, 5, 10, 20, … mm/12 hr

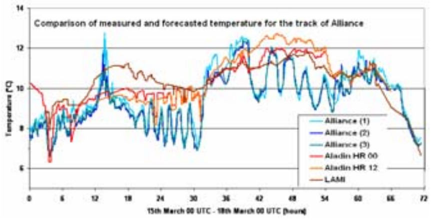
Clustering on different base parameters were done for Z500, Z700, T850, wind 850, RT500/1000, RT700/1000, ω500, ω700. In principle a lot of common cluster members were found in most populated clusters members for ECMWF and ALADIN EPS. It seems therefore that in the case of dynamical downscaling many common members do not necessarily guarantee similarity between clusters from the two different populations.

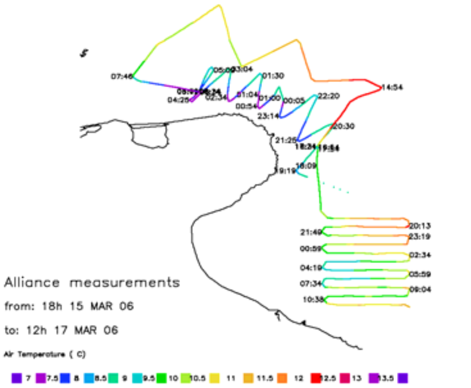
DART cruise (Dynamics of the Adriatic in the Real Time)

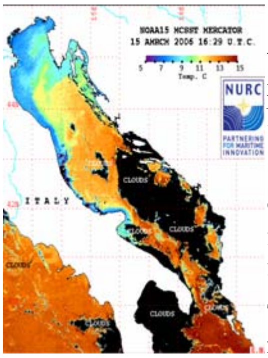
From 28th February till 28th March and from 13th till 31st August 2006 the central Adriatic was a subject of an interdisciplinary research under DART acronym using NRV Alliance as a platform. Aladin/HR forecast were used for driving ocean and wave model forecast operationally. It was also used for planning the schedule of sensitive operations. Already the first results show potential for improving atmospheric forecast using better ocean data. The cold current along the Italian coast of 7 °C is 6 °C colder than the nearby waters of open Adriatic cooling the air above and supporting for formation that was not recognized in the model forecasts.

Naval research vessel Alliance

Retrieval of meteo buoy







Sea surface temperature measured from NOAA satellite (left)

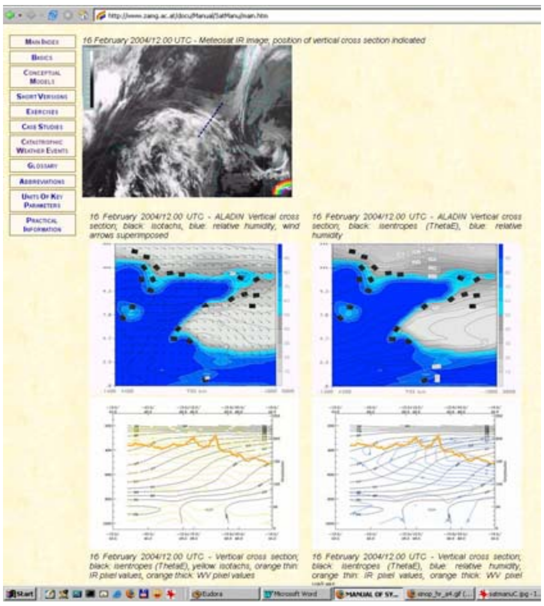
Comparison of Aladin/HR (00 and 12 UTC) and LAMI forecasts for the track of Alliance with measured values from the 3 sensors on the ship (top left).

Trajectory of Alliance colored in the shades showing measured temperature (top right).

SatManu

Weather analysis and forecasting department of Croatian Met Service participates in EUMETSAT's satellite and synoptic meteorology projects. For SatManu (2003-2005), a new conceptual model of Jet Fibres was investigated and some Computer Aided Learning materials were produced. Together with ECMWF, Aladin fields and cross-sections were used for research of this interesting small-scale phenomenon. Some of Aladin products were included in the Manual, in chapters Typical Appearance in Vertical Cross Sections and some related Exercises.

In addition, in the chapter of Catastrophic Weather Events a case study of the Adriatic Hail Storm is included, together with relevant model forecast fields. Satellite Manual can be found on the web: www.zamg.ac.at/docu/Manual/SatManu/main.htm



Further work in this field is continuing within the framework of EUMeTrain (2005-2009), an international project dedicated to the development of training materials and methods for satellite meteorology in the form of case studies, interactive exercises and manuals. Aladin horizontal fields and vertical cross-sections will be included in the same manner as in SatManu.

Figure on the left: Manual of Synoptic Satellite Meteorology, section Conceptual Models - MESOSCALE PHENOMENA - Jet Fibres, chapter Typical Appearance in vertical cross-sections. ALADIN model fields and vertical cross-sections are used for research of this interesting phenomenon. Example of the products included in the Manual.

3.3 Czech Republic

Status report of the Czech Hydrometeorological Institute (CHMI)

October 2005 - September 2006

Filip Váňa

The core NWP application at CHMI is the ALADIN/CE model. Its main characteristics are to this date (October 2006) as follows:

- LACE domain (309x277 grid points, linear truncation E159x143, Δx=9km),
- 43 vertical levels,
- time step 360 s,
- mean orography,
- OI surface analysis based on SYNOP data,
- digital filter spectral blending of the upper air fields, long cut-off cycle (6h cycle, filtering at truncation E47x42, no DFI in the next +6h guess integration),
- digital filter blending + incremental DFI initialization of short cut-off production analysis of the upper air fields,
- 3h coupling interval,
- ARPEGE/ALADIN cycle 29T2 with modifications,
- OpenMP parallel execution,
- daily 4x per day execution: 00 and 12 UTC forecast to +54h, 06 and 18 UTC forecast to +24h,
- hourly off-line fullpos,
- post-processing of near-surface parameters into selected localities using obs-operators of OI.

The major operational changes during the period October 2005 - September 2006 were:

10th of January 2006 New model cycle CY29T2 with modifications in physics: Geleyn-Cedilnik mixing length computation, re-tuning of roughness term over sea in Charnock's formula and small change in GWD. Since this change the quasi-monotonous interpolators in the SL advection were completely abandoned. The settings of the SLHD scheme has been changed to new defaults (preserving the same performance of the scheme at resolution of the ALADIN/CE). Finally the parallelization was switched from the MPI to exclusive use of the OpenMP.

23th of January 2006 Switch to new climate files based on the GTOPO30 database (collective change for all the ALADIN world).

21st of February 2006 Migration of the ALADIN/CE to the new upgraded NEC SX-6/8A computer.

8th of August 2006 Blending of surface fields replaced by the OI assimilation based on SYNOP data. Here the impact was really significant to the model scores, especially for the MSL pressure, T2m and q2m. The figure (1) bellow illustrates the impact of this change to the field of the ice deep reservoir for the April 1st 2006. The left frame corresponds with the information coming with the ARPEGE analysis (what would be used in case of dynamic adaptation). The right frame shows the same field obtained from the OI assimilation cycle of the ALADIN/CE. The corresponding forecast was differing for around 2 K in T2m, 8% of relative humidity and 4 Pa of surface pressure in the direction that the forecast without assimilation was worse.

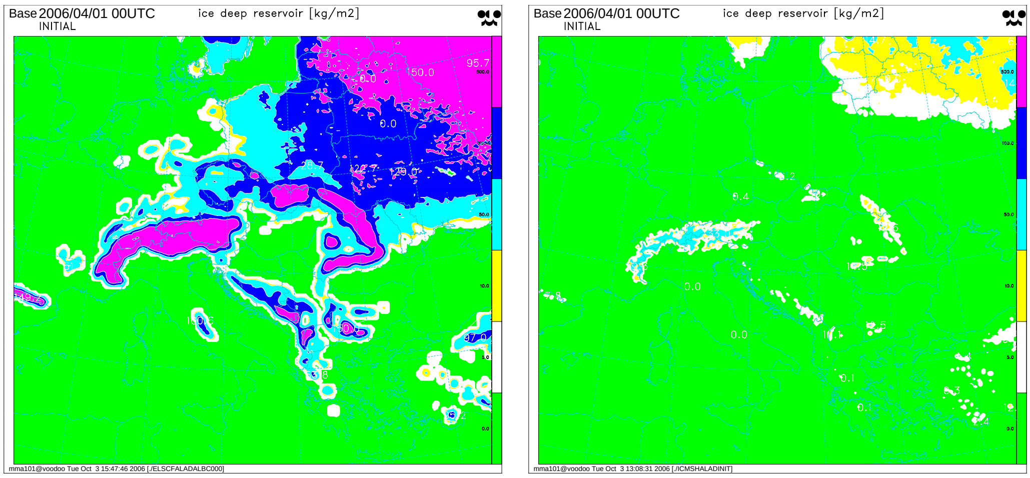


Figure 1: Ice deep reservoir for 1st of April 2006 from the ARPEGE assimilation (left) and the ALADIN/CE surface assimilation (right).

In the close future the main operational point of interest at CHMI is to complete and validate the ALARO-0 package being the extension of the ALADIN model toward the AROME mesoscale model. Besides this priority topic pre-operational validations of the 3DVAR assimilation of the upper air fields are planned for the year 2007.

3.4 Denmark

EWGLAM Report 2006 from the Danish Meteorological Institute

Bent H. Sass

Danmarks Meteorologiske Institut

1. Operational HIRLAM at DMI

The operational HIRLAM system (DMI-HIRLAM) run at the Danish Meteorological Institute (DMI) is essentially unchanged since autumn 2005. However, a substantial research activity is ongoing in various areas, and parallel test suites are run on a daily basis. 4D-Var as developed in the HIRLAM-A project is run in a daily test setup with similar or slightly better scores compared to the operational 3D-VAR system. Increased resolution from 40 to 60 levels is also tested in daily runs. This impact of vertical resolution increase is so far modest. Most operational upgrades for the future is planned to follow the changes of the new HIRLAM reference system scheduled for 2007. However, data from NOAA-18 will be used operationally before the end of 2006.

The performance of the operational DMI-HIRLAM-T (big DMI-HIRLAM domain) for near surface parameters such as 10m wind is remarkably good when verified against EWGLAM stations. Fig.1 shows day by day comparisons of operational T15 with corresponding ECMWF output received in 1.0 deg. The results of M1U 4DV applies to the experimental 4D-VAR run. The results (standard deviation and bias) apply to a 24 h forecast range.

In order to monitor an 'overall quality' of the operational system an NWP index has been constructed (fig. 2) in order to communicate forecast quality with Danish authorities. This index measures the fit of 10m wind and 2m temperature to observed values on selected synoptic stations in Denmark, Greenland and the Faeroe Islands. In addition, precipitation over Denmark is verified based on a contingency table. The index has been constructed to achieve a value of 100 by year 2002. The 12 month running mean indicates that forecast quality measured in this way is so far steadily increasing. It is estimated however, that new supplementary verification methods suitable for high resolution models need to be developed and introduced operationally in the future.

2. ALADIN setup

An ALADIN setup is run on a daily basis during the past year. Lateral boundaries are provided by the operational DMI-HIRLAM. The setup is double nested with ALADIN model resolutions corresponding to 0.10 deg and 0.025 respectively.

Until November 2006 the setup has been based on Cycle 29t2. Two physics packages were run independently with this type of setup. The first run was using 'standard' ALADIN physics. The second setup was using HIRLAM physics as implemented in Cycle 31t1. An example of a forecast based on HIRLAM physics with 2.5 km grid size is shown in fig. 3. The land-sea aspects of the temperature prediction are clear as expected.

The quality of the performance of the two packages is currently very simililar in most respects. An implementation error of the turbulence scheme was corrected on September

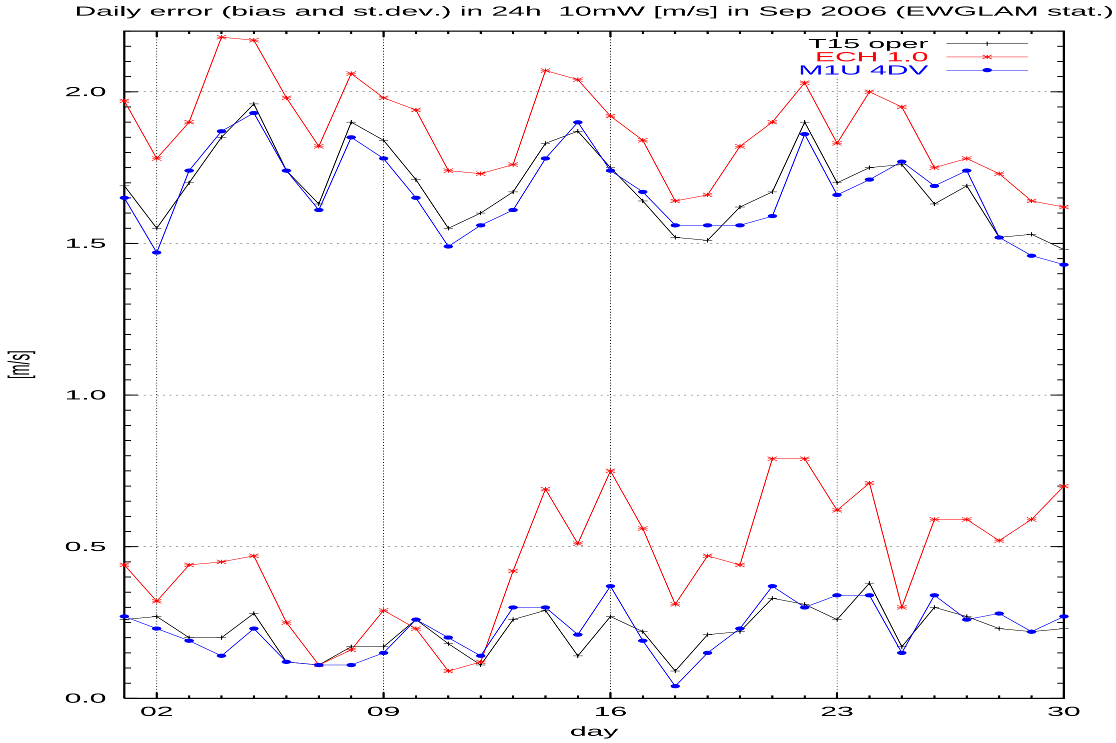


Figure 1: 10m wind bias and std. deviation in Sept. 2006 for operational T15, a daily run based on 4D-VAR (M1U) and the ECMWF global model verified on EWGLAM station list

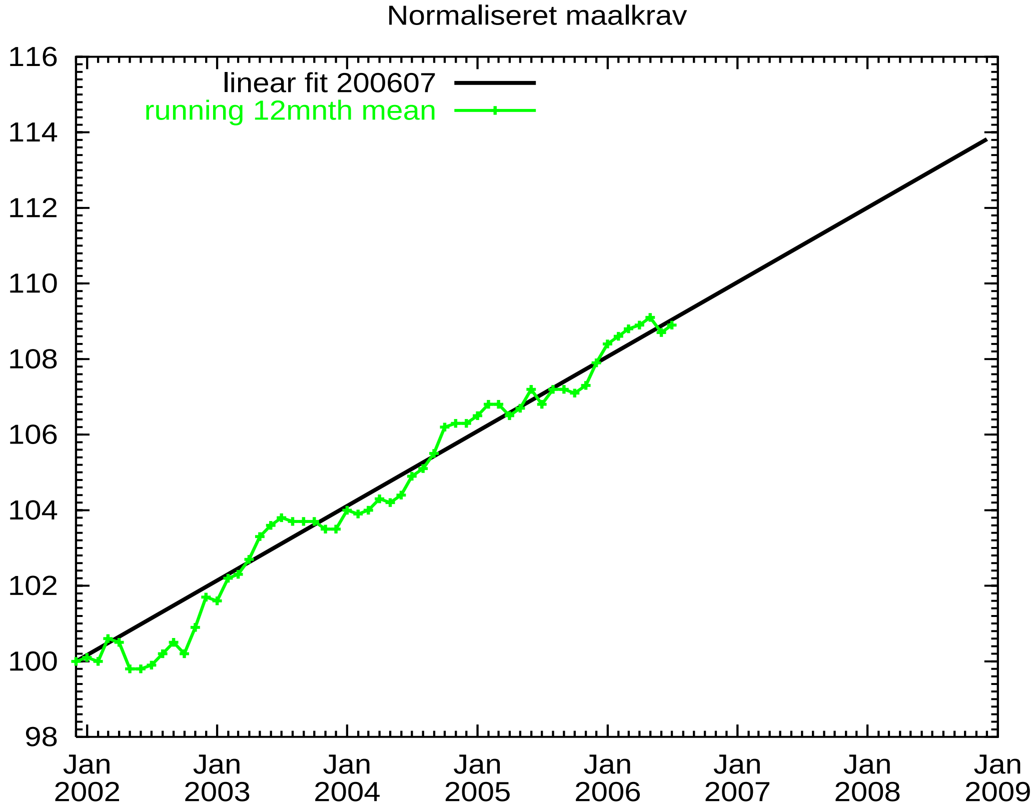


Figure 2: Normalised forecast index since 2002 as used operationally at DMI.

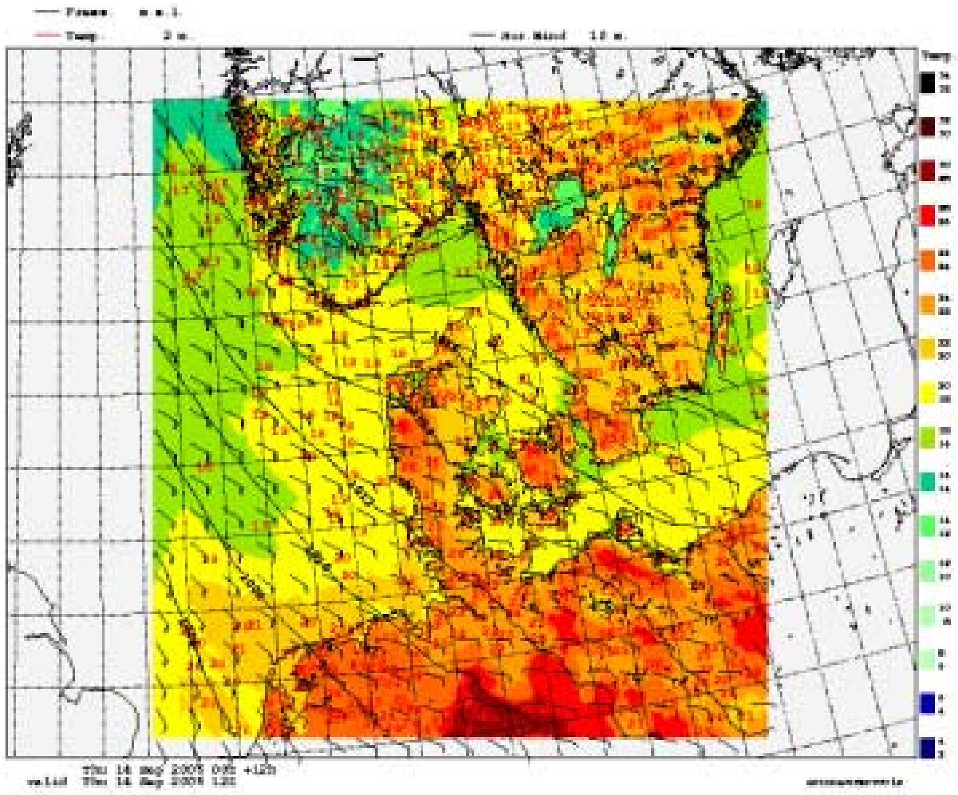


Figure 3: Surface parameters from a 2.5 km grid size non-hydrostatic run using HIRLAM physics (12h forecast 14 Sept 2006)

7th. It is considered that there is room for considerable improvements with regard to the HIRLAM physics implementation. For example the externalised surface scheme is not yet called. Currently the 2.5 km non-hydrostatic model is run without convection. This setup appears to be able to produce high precipitation rates in localized areas. Experimentation has emphasized the role of an unbiased humidity prediction in the planetary boundary layer.

By the end of November 2006 the daily runs are based on cycle 31t1 and the non-hydroatatic run using ALADIN physics is replaced by a run using AROME physics.

3. Nowcasting

A special version of DMI-HIRLAM is run every hour. This version is devoted to road-weather forecasting. A special road-weather module with detailed computations of road weather conditions is called as one big subroutine inside DMI-HIRLAM.

A special feature of this system is that a 3D cloud analysis is made by combining first guess, MSG Nowcasting SAF (Meteosat-9) data and cloud cover observations from synoptic data. An assimilation run is carried out between -3h and current time 0h. Nudging terms of humidity and condensate tendency fields are proportional to differences between analysed and forecasted cloud cover field. This enables an adjustment of model state towards an analysed state. There is positive impact coming from the introduced procedures and the system is developed further for special very short range applications.

3.5 Estonia

LAM efforts at Estonian Meteorological Hydrological Institute

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Introduction

Starting from the end of the year 2003, a very high resolution nonhydrostatic NWP system is running in a near-operational regime at Estonian Meteorological Hydrological Institute (EMHI). This is a collaboration effort between University of Tartu (UT), EMHI and Finnish Meteorological Institute (FMI). EMHI hosts the environment, provides communication and computing facilities. EMHI helps also to define the requirements and societal demand to the project. FMI provides boundary and observational data to the forecast model. FMI delivers also its long-lasting limited area modelling and operational forecasting know-how. The role of UT is to maintain the environment, to develop nonhydrostatic core model together with high resolution physics package and ensure its scientific and operational quality.

The project aims for high-precision presentation of local effects and improvement in short range forecasting. The advances are expected mostly in precipitation event or local wind modelling and in increase of severe weather forecasting precision. In addition, it is hoped that the high resolution NWP data is beneficial to wide range of practical and scientific applications like air pollution modelling or coastal research. Thus, the project should benefit and facilitate the scientific research by providing numerical output and research problems to scientific community. The project helps hopefully to improve the quality of short range forecasts and to develop a new range of services of local high precision forecasts.

Model description

The NWP system is based on the NWP model of HIRLAM Consortium and also on its nonhydrostatic (NH) extension, developed at UT. In February 2005, the semi-implicit semi-Lagrangian (SISL) nonhydrostatic dynamic core was introduced into the NWP environment. The basis for dynamics are the semi-anelastic pressure-coordinate equations of motion and thermodynamics in Lagrangian form (Rõõm, Männik and Luhamaa 2006). The pressure-coordinate model is essentially the White model (White 1989) which has been successfully employed in HIRLAM framework before, using Eulerian representation (Männik, Rõõm and Luhamaa 2003, Rõõm and Männik 2002, Männik and Rõõm 2001)

The main properties of the NH SISL HIRLAM scheme are:

- It uses height dependent reference temperature profile which results in enhanced stability rates as the nonlinear residuals are minimized in vertical development equations
- The model is semi-anelastic which means that internal acoustic waves are filtered out with the assumption of incompressibility in pressure space.

NH SISL tries to be as close as possible to the parent hydrostatic HIRLAM SISL scheme (McDonald 1995, McDonald and Haugen 1992). The existing routines of trajectory calculations and interpolations as well as the interface to physical packages are maintained.

To evaluate baric (includes nonhydrostatic component) geopotential, an elliptic equation is solved using FFT algorithms. The Earth curvature is assumed to be small perturbation to flat geometry.

It must be noted that the NH SISL scheme is only an adiabatic core. A substantial problem to the application of the NH SISL HIRLAM grows out from the lack in parent model of suitable physical package for very high resolution modelling. NH SISL uses physics routines as they are in HIRLAM without modification, as developed for lower resolution synoptic scale modelling purposes. It is possible to adapt current routines of physics to very high resolution and some modifications of that kind are available from newer official versions of HIRLAM. However, the fine tuning and possible critical revision of the schemes might require considerable effort in the future.

The biggest advantage of NH SISL is that it allows to use remarkably longer time-step and to increase modelling domain at NH resolutions compared to Eulerian implementations. The switch from previous NH SI Eulerian system to NH SISL allowed to increase the modelling area three times (ca 1.7 times in respective horizontal direction) and decreased computational time by factor of two.

NWP environment

The NWP model, which is employed in the environment, is HIRLAM version 6.4.0 with minor modifications. HIRLAM provides a wide range of options for modelling applications, but the following set has been chosen for current environment:

- 3DVAR data analysis
- Implicit normal mode initialization as initialization scheme
- Semi-implicit semi-Lagrangian scheme
- ISBA scheme for surface parameterization
- The STRACO scheme for large scale and convective condensation
- Savijärvi radiation scheme
- CBR-turbulence scheme

The integration areas are presented in Figure 1. Lower resolution area named ETA has horizontal resolution 11 km and hydrostatic SISL scheme with 400 s time-step is applied in the forecast model. The grid is 114x100 points in horizontal directions and 40 levels. The ETB area has 3.3 km horizontal resolution and applies NH SISL with 150 s time-step. The

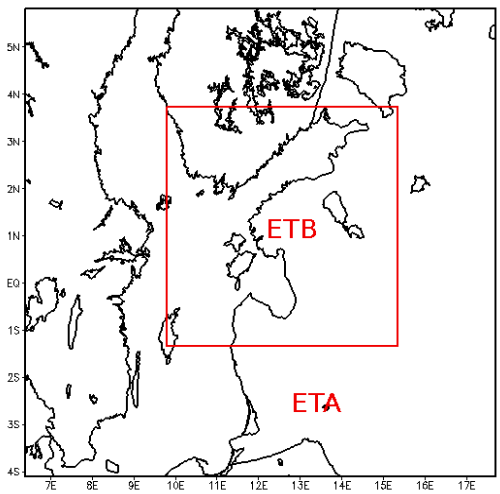

Figure 1. Modelling areas.

grid is 186x170 points in horizontal and 40 levels.

Boundary fields to ETA are provided by FMI. They are cut out from forecasts of FMI operational model which has horizontal resolution 22 km. The fields are provided four times a day with forecasting start-point at 00, 06, 12 and 18 GMT. As FMI requires the time to prepare the analysis and calculate the forecast, the fields arrive 4.5 h hours later. The time frequency of boundary fields for ETA is 3h. The time frequency of boundary fields for ETB area is 3h as well. However, the frequency can be increased up to 1h. The environment utilizes the boundary relaxation scheme which is similar to MC2 model.

Twice a day 36h forecasts are produced in ETA area. Start-points for forecast are 00 and 06 GMT. Due to the time spent on obtaining boundaries and computing, plus time zone difference, forecast products are delivered to users at 8.15 and 14.15 local time. Computation of analysis and forecast takes approximately 15 minutes. To maintain analysis cycle, additional two 6h forecasts are produced by ETA with start at 12 and 18 GMT

The ETB area uses forecasts of ETA area as lateral boundaries. 36h forecasts are produced twice per day with start at 00 and 06 GMT. ETB has its own analysis cycle similar to ETA. The time spent on computing of forecast is about two and a half hours.

Experience

The very high resolution NWP system has been in work since autumn 2003. The system has been in continuous development improving gradually. Starting from February NH SISL model was introduced to the environment which resulted in increased domain and smaller time consumption rates which means shorter delay from observations to forecast. The current cut-off time is 7.5 hours. This is still too high for a system which should produce frequent short forecasts. Thus, the methods to shorten the delay must be considered in future.

To evaluate the model performance, simple comparison with standard observations have been used so far. The set of stations common to both modelling domains is used to compute bias and root mean square error statistics.

As Estonia joined ECMWF in November 2005 it has become possible to compare the quality

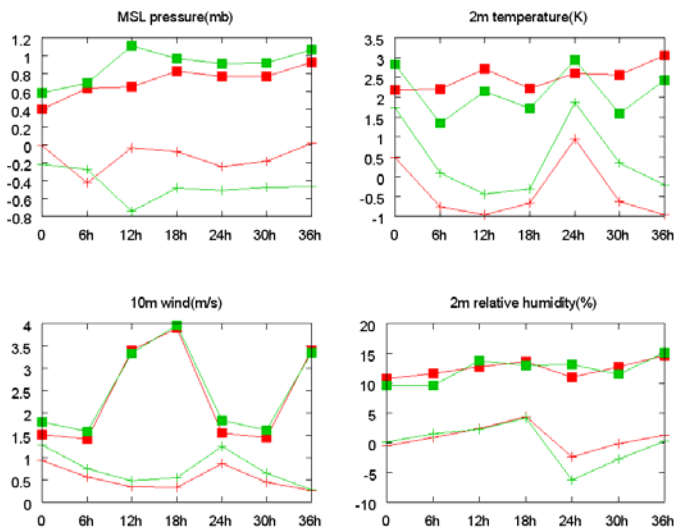

Figure 2. Biases (crosses) and RMS errors (rectangles) of surface parameters of HIRLAM ETA area (red) and ECMWF (green) in July 2006. 00 GMT forecasts are used to compute the statistics.

of NWP environment at EMHI to ECMWF forecasts. Sample results from July and August are presented in Figure 2. It is evident from the error statistics that the NWP environment at EMHI offers competitive quality to ECMWF forecasts over short range. In combination with earlier availability and more frequent updating of the forecasts the LAM approach proves to be viable solution to short range NWP at EMHI.

To compare the performance of ETB and ETA a skill score is used. Positive values of score indicate better performance of high resolution ETB area. Sample scores are presented for February 2006 (Figure 3). It can be seen that ETB may offer skill in wind prediction while temperature forecasts are poor. The reason for poor temperature forecasts is not clear yet.

It is of course hard to evaluate the high resolution model on the basis of standard verification scores as features can be easily missed and phase errors can produce double penalties.

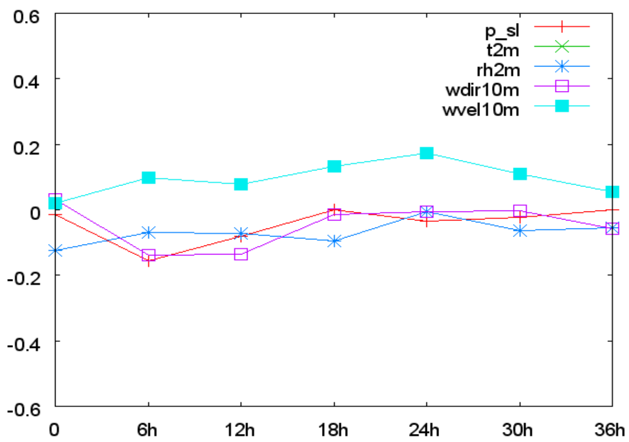

Figure 3. Skill of ETB over ETA (MSESS=1-MSE_{ETB}/MSE_{ETA}) surface variables in February 2006.

Future developments

In near future the NH SISL HIRLAM and very high resolution NWP environment at EMHI will focus on the following goals:

- Estonia will join HIRLAM Consortium in 01.01.2007
- The computing system will be upgraded this autumn.
- Increase of vertical resolution, area increase of ETA to include the whole Baltic Sea.
- Forecasts will be provided 4 times a day.
- Usage of boundary conditions from ECMWF is being considered.
- Physical package of HIRLAM needs critical revision at 3.3 km resolution. The interaction with nonhydrostatic adiabatic core should be investigated as well. It is planned to use explicit representation for deep convection and the parameterization of shallow convection. The explicit representation is in development.

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3.6 Finland

Operational NWP Activities at the Finnish Meteorological Institute

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Finnish Meteorological Institute

Domestic NWP at FMI is based on the HIRLAM weather prediction system. Since the year 2003 FMI has the special task of operationally employing the common HIRLAM reference system, and maintaining a data archive and a monitoring and verification facility for the whole consortium. The duties, known as RCR for Regular Cycling of the Reference system, also include extensive testing of new releases.

The HIRLAM RCR suite is operated in full data assimilation mode and is nested into the global forecasts from the optional BC suite of the ECMWF. In addition to the RCR-suite with a grid spacing of 0.2° we operate a nested high-resolution suite (MBE) with a grid-spacing of 0.08° and its own data assimilation.

In addition to the operational LAM-suites, an experimental suite of the AROME meso-scale model is nested into the RCR-suite, and has been running regularly since May 2006.

The operational LAMs are executed in-house on a Silicon Graphis Altix 3700 BX2 high performance consisting of 304 Intel Itanum 2 1.5 GHz processors with 4 MB of cache, and a total of 304 GB of shared memory. The system is operated by Novell Suse Linux and we use the Platform LSF work load management software.

The operational forecast and 3DVAR analysis both use 30 processors in parallel executions, and a 54 hour forecast including 3DVAR analysis takes 50 minutes of wall-clock time to complete.

Meteorological implementation

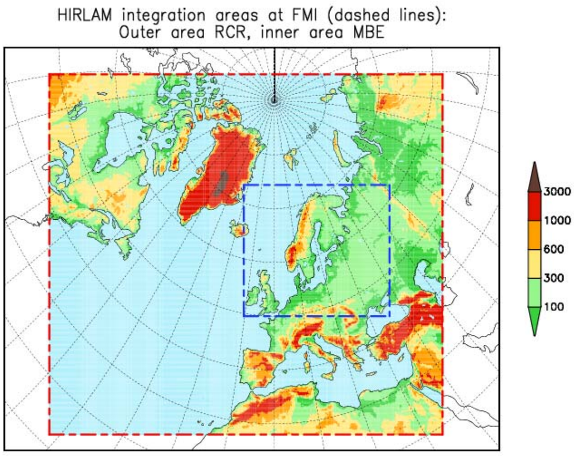

Figure 1. Integration areas of the operational suites at FMI.

The RCR-suite is currently based on HIRLAM reference system version 7.0 with default settings, featuring the HIRLAM 3DVAR analysis scheme, and ISBA surface scheme. The main features of the RCR suite are listed in Table 1, and the integration area is shown in Figure 1.

The observations used include conventional data and ATOVS AMSU-A radiances over oceans. The cut-off time of observations is 2 hours for the main synoptic hours (00, 06, 12, and 18 UTC) and 4 hours 20 minutes for the intermediate hours (03, 09, 15, and 21 UTC). Incremental digital filter is used for initialization.

The forecast length is 54 hours for 00, 06, 12, and 18 UTC runs. Between them, additional 6 hour forecasts are run to provide an improved back-ground for the main runs. The schedule also includes a re-assimilation step every 6 hours, where large-scale features from the ECMWF analysis are allowed to influence the fields through the digital filtering.

A second suite, MBE, using a slightly older version of HIRLAM and a shorter grid length of 0.08° is nested into the RCR-suite. The integration area of the MBE suite is shown in Figure 3. Besides in grid spacing and version, MBE differs from RCR in that AMSU-A data are not assimilated, and a six-hourly cycling is used without blending of ECMWF analyses.

The observations, including Baltic ice data from the Finnish Institute of Marine Research as well as the boundary data obtained from the ECMWF are collected inside the FMI firewall, processed, and used in HIRLAM. During the forecast runs, the results are loaded into a real time data base as soon as they appear, for further use by duty forecasters, automated downstream applications and researchers. Input and output data are made available to all HIRLAM members by archiving the data to the ECMWF's ECFS using the ecaccess gateway. A graphical interface for monitoring is provided to the whole HIRLAM community through the HeXnet facility.

Table 1. Characteristics of the RCR-suite.

Analysis	
Upper air analysis	3-dimensional variational data assimilation
Version	HIRVDA 6.3.8, FGAT option
Parameters	surface pressure, wind components, temperature, specific humidity
Surface analysis	Separate analysis, consistent with the mosaic approach of the surface/soil treatment * sea surface temperature, fraction of ice * snow depth * screen level temperature and humidity * soil temperature and moisture in two layers
Horizontal grid length	0.2 degrees on rotated lat-lon grid
Integration domain	438 x 336 grid points
Levels	40 hybrid levels
Observation types	TEMP, PILOT, SYNOP, SHIP, BUOY, AIREP, ATOVS AMSU-A brightness temperatures
Background	3 hour forecast, 3 hour cycle
Initialization	Incremental digital filter (IDFI)
Data cut-off time	2 h for main cycles, 4 h 20 min for intermediate cycles
Assimilation cycle	3 h cycle, reanalysis step every 6 h to blend with large-scale features of the ECMWF analysis.

Model	
Forecast model	Limited area grid point model
Version	HIRLAM 7.0
Basic equations	Primitive equations
Independent variables	longitude, latitude, hybrid level, time
Dependent variables	log. of surface pressure, temperature, wind components
	sp. humidity, sp. cloud condensate, turbulent kinetic energy
Discretization	Arakawa-C
Horizontal grid length	0.2 degrees on rotated lat-lon grid
Integration domain	438 x 336 grid points
Levels	40 hybrid levels
Integration scheme	Semi-Lagrangean semi-implicit, time step 360 s.
Orography	Hirlam physiographic data base, filtered
Physics	* Savijärvi radiation scheme
	* Turbulence based on turbulent kinetic energy
	* STRACO condensation/convection scheme
	* Surface fluxes according to drag formulation
	* Surface and soil processes using mosaic approach
Horizontal diffusion	Implicit fourth order
Forecast length	54 hours
Output frequency	Hourly
Boundaries	* “Frame” boundaries from the ECMWF optional BC runs
	* Projected onto the HIRLAM grid at ECMWF
	* Boundary file frequency 3 hours
	* Updated four times daily

Experimental meso-scale forecasting

FMI takes an active part in the HIRLAM-ALADIN cooperation for development of the AROME meso-scale forecasting system. As a part of this effort we are maintaining an experimental real-time AROME-suite since May 2006, based on the IFS cycle cy30t1. Characteristics of the system are as follows:

- Horizontal grid length 2.5 km
- 40 hybrid levels (same as in the HIRLAM-suites)
- Time step 60 s
- 24 hour forecasts at 00 and 12 UTC
- Output every 15 minutes
- Nested into HIRLAM RCR via 11km ALADIN
- No data assimilation

AROME is run of 64 CPUs of the SGI Altix, and one 24-hour forecast takes 3 hours to complete.

Figure 2 shows the integration area and the instantaneous precipitation intensity predicted by the AROME test-suite for 12.15 UTC, 10th of July 2006. Figure 3 shows a close up of the MCS seen over south eastern Finland with wind vectors of the lowest model level relative to the storm motion added. A realistic gust-front at the leading edge of the storm is clearly visible

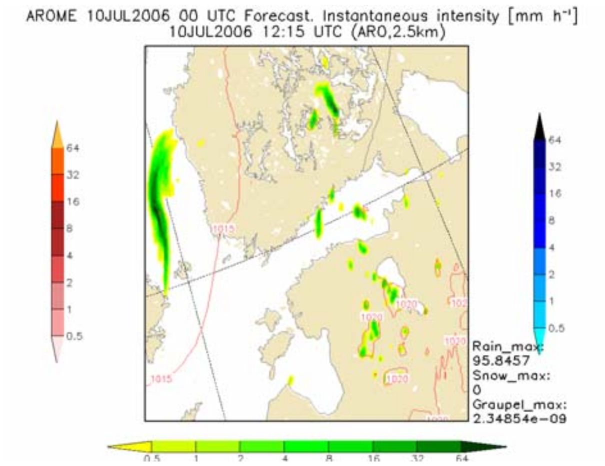

Figure 2. Integration domain and instantaneous precipitation intensity predicted by the AROME test-suite for 12.15 UTC, 10th of July 2006.

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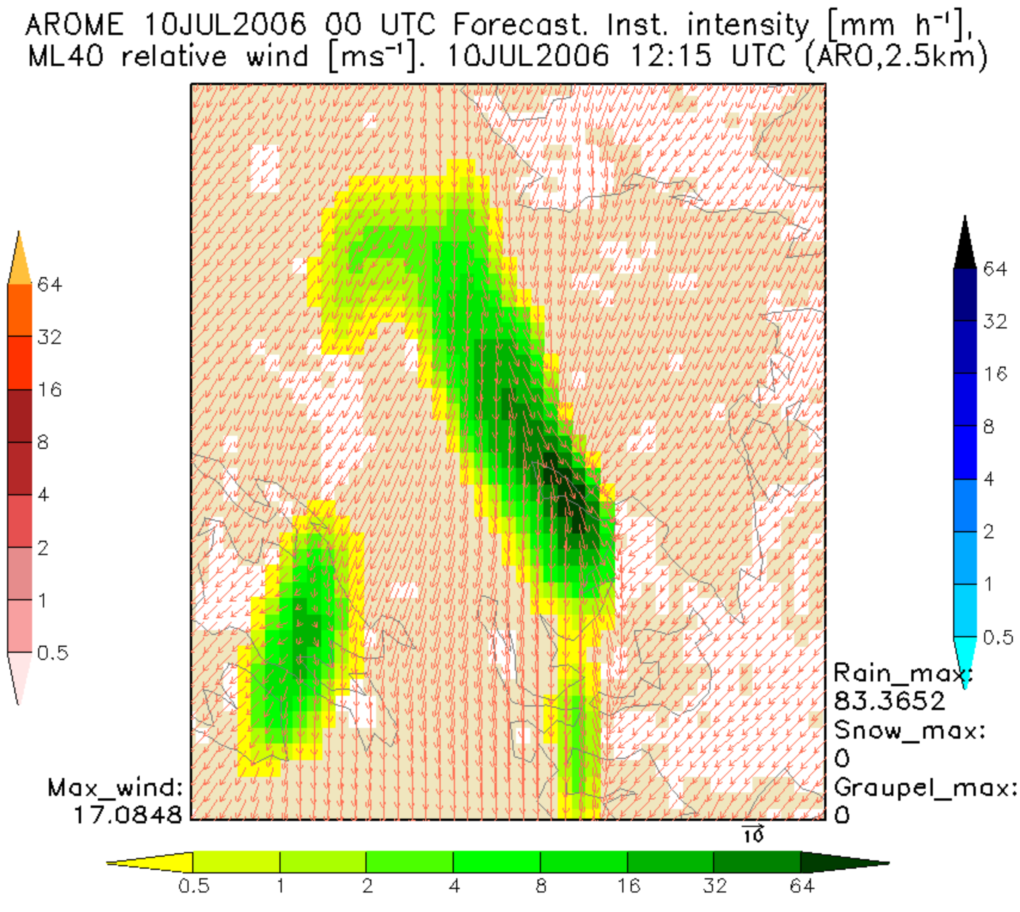

Figure 3. Instantaneous precipitation intensity and wind vectors of the lowest model level relative to storm motion, predicted by the AROME test-suite for 12.15 UTC, 10th of July 2006.

3.7 France

Status of operational and research activities in France:

Aladin-France and Arome

C. Fischer

About ALADIN-FRANCE

The French domain can be seen in Figure 1. The centre of the domain is located at 46.47°N; 2.58°E. Computations are performed in spectral bi-Fourier space with elliptic truncation at wave number 149. The equivalent grid has 9.51 Km gridmesh. The vertical dimension is discretized in 46 levels (+ a surface)

During a forecast, ALADIN-FRANCE is coupled to its coupling model (ARPEGE) every 3 hours. The timestep is 415.385 s

Operationally, 4 runs are performed each day at 00, 06 12 ant 18 UTC. Forecasts terms are 54H for the 00H forecast, 48H at 06H, at 42H at 12 and 36H at 18H.

The operational Data assimilation

The assimilation scheme is 3D-Var with a 6H window. A continuous "long cut-off" cycle provides the guess for a "Short cut-off" production which provides the operationally used analysis.

Assimilated observations are
–Surface pressure and SHIP winds
–2m temperature and RH
–Aircraft data
–SATOB motion winds
–Drifting buoys
–Soundings (TEMP, PILOT)
–Satellite radiances: AMSU-A, AMSU-B, HIRS, Meteosat-8 SEVIRI
–QuikSCAT winds
–Ground-based GPS zenithal delays

A refinement of the analysis scheme: The Jk term

The variational scheme used by ALADIN 3D-Var allows for the introduction of supplementary penalisation terms in the cost function.

In order to keep advantage from the ARPEGE analysis of large atmospheric scales, a new term is introduced: the Jk term. It penalises departures of the ALADIN analysis from ARPEGE for wave numbers ranging from 1 to 12.

The idea is close to the « blending » procedure, which has been shown to improve the structure of precipitation fields.

So far, slightly positive improvements in term of forecast error for temperature, brought by this new term, have been demonstrated. The effect is located in the upper stratosphere, showing that this analysis takes profit of ARPEGE's better representation of this region of the atmosphere. The extra term has however not been included in our operations for the time being.

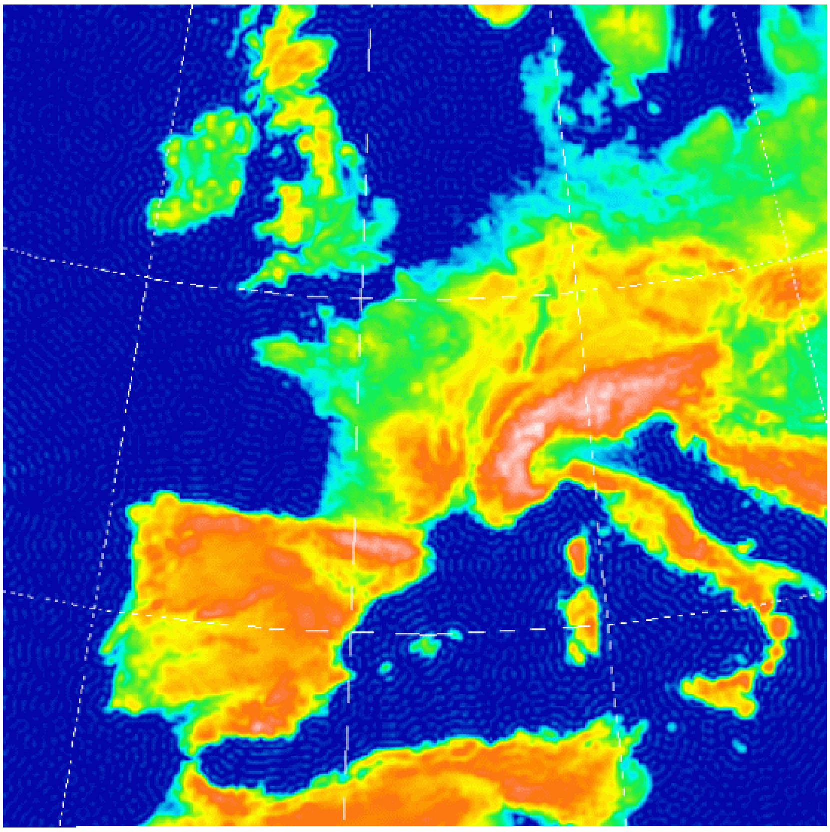

Fig.1. The ALADIN-France domain, with the orography.

An ALADIN based nowcasting tool : VARPACK

Varpack diagnostic analysis is a diagnostic tool that provides to forecasters every hour an analysis of atmospheric fields as precise as possible for immediate forecasting purposes. Most currently used output fields are 2m humidity and temperature, 10m winds, CAPE and MOCON (Moisture Convergence). Two more levels are used close to the ground: 10m and 2m levels in order to have an analysis independent of surface fields.

A new B matrix was designed to fit the new geometry, statistics for the two new levels are deduced from statistics of the last level from the usual B matrices.

All the observations available for ALADIN-3dvar plus 10m wind observations are currently used.

When tested on some heavy precipitation events over France, the Varpack outputs have allowed to foresee by about two hours in advance the areas for major rain outbreaks. Most noticeably, fields of predicted CAPE can be compared with radar echoes.

The September/October/December E-suite

What is in the E-suite ?

The most remarkable items:

- Observations: independent extractions for Aladin; de-biasing of MSLP;
- Assimilation methods: Sigma_b maps of the day; W and NL balance in Aladin Jb
- Physics: envelope orography halved, 6 bands in the SW Morcrette radiation; and in the APCS:
    - pseudo-statistical sedimentation

- autoconversion in the microphysical adjustment
- abandon the second microphysical adjustment after turbulence

- -Semi-Lagrangian Horizontal Diffusion and associated reformulated spectral diffusion
- -CY31T1

Impact from the onset of a prognostic microphysics scheme ("APCS") : the likelihood of precipitations

Figure 2 compares 6H accumulated precipitations for ALADIN with the former Kessler scheme (right panel) and with the new Advanced Prognostic Cloud Scheme (left) on the 1st of April 2006 at 00UTC. It can easily be seen how the jagged intense precipitation spots, to a large amount determined by orography, have been replaced by smoother larger scale structures. This is a consequence of the new water variables which have been introduced in the treatment of resolved precipitations (rain, snow, cloud liquid and ice contents).

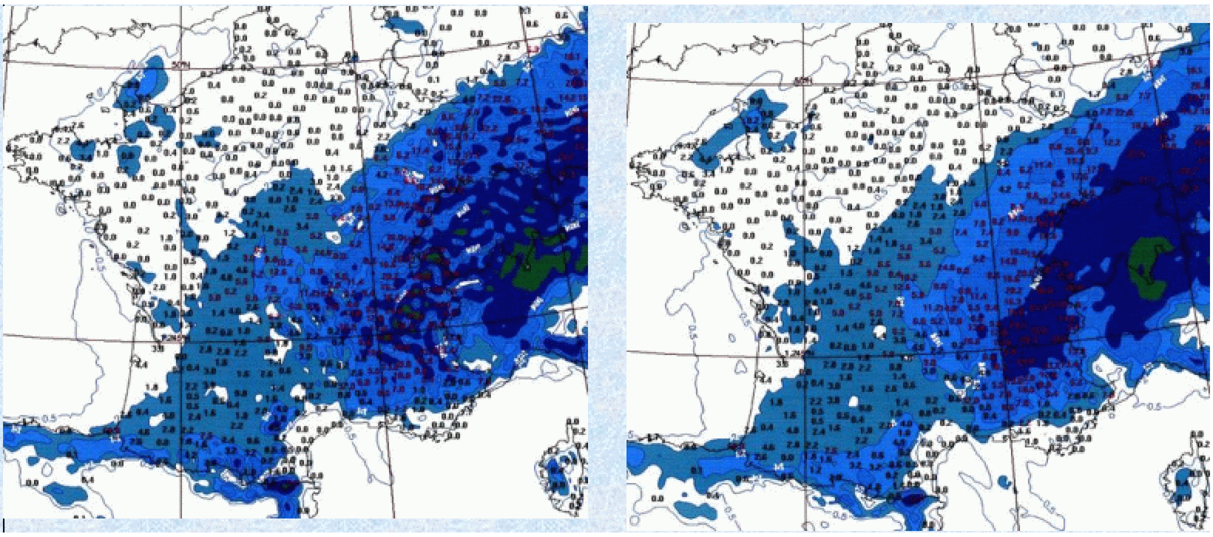

Fig. 2 compares the six hour accumulated precipitation forecast seen by the former Kessler-scheme model (left) and the APCS version (right) on April the 1st at 00H

Further developments in Data Assimilation

3D-Fgat

The 3D Fgat (First Guess at Appropriate Time) scheme allowing for a low-cost taking into account of the temporal distribution of observations is currently being developed in collaboration with the Hungarian service.

Ensemble Jb

The current B already uses the information from an ensemble of ALADIN forecasts issued from an ARPEGE analyses ensemble. Future statistics will be produced from an ensemble of cycled ALADIN analyses. Longer term works will aim to include more flow dependency into it.

Future observations

A noticeable effort is being made to include among analysed observations the METEOSAT 9 imager instruments and METOP in 2007. Future developments will, in a longer term, also include AMSU-B and HIRS land observations, as well as radial winds from Doppler radars.

Towards AROME, A first try of a Rapid Update Cycle (RUC)

The future AROME system will become operational for the meso-gamma scale in 2008. Its data assimilation part will greatly be inspired by the ALADIN data assimilation. The system will need to exploit all the numerous, high density, time distributed observations to provide a useful mesoscale analysis A possible way to achieve this is the RUC scheme, which performs successive analyses with a short time window. Figure 3 below compares Radar reflectivities with an ALADIN analysis of precipitations on a six hour window and a RUC with two three hour windows. While the conventional analysis of precipitations is not even correctly localized, it can be seen that the RUC analysis is more accurate and that its structures are closer to those seen by the reflectivities.

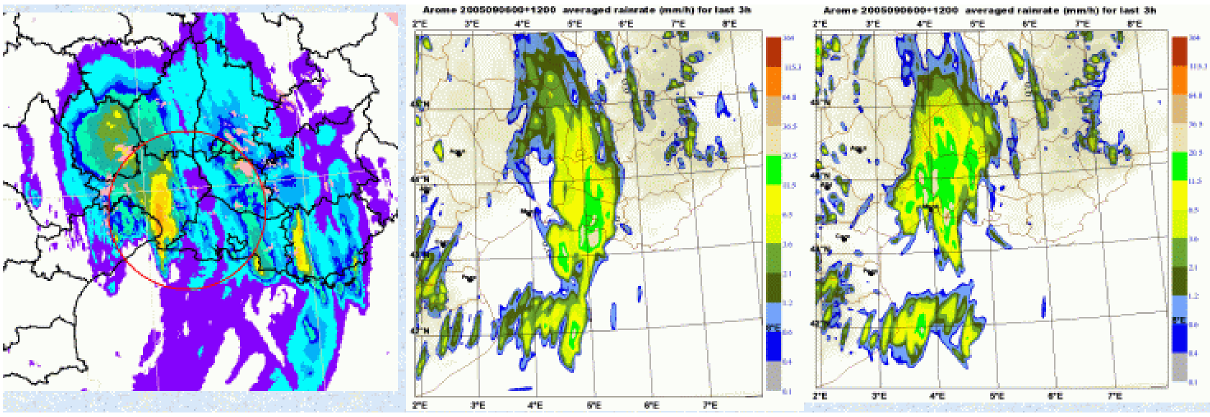

Fig. 3 compare observed precipitation (reflectivities) in the left panel, precipitations analysed by the current 3D-Var, in the middle panel and precipitations analysed by the RUC in the right panel.

3.8 Germany

Status Report of the Deutscher Wetterdienst DWD

2005 - 2006

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Operational Numerical Weather Prediction System GME and LM

Tab. 1 gives an overview of the operational numerical weather prediction system at the Deutscher Wetterdienst.

Table 1:The numerical weather prediction system at DWD.

Model	Domain	Δ (km)	Layers	GP/layer	Flop/24 h (10^{12})	Initial date (UTC)	Forecast range (h)
GME	global	~ 40	40	~ 368642	47.3	00 06 12 18	174 48 174 48
LM-E	almost entire Europe	~ 7	40	~ 436905	110.0	00 06 12 18	78 48 78 48

The **Global Model (GME)** uses an icosahedral-hexagonal grid which allows a nearly uniform resolution with less than 20% variation of mesh size over the globe.

The key features of the GME include:

- icosahedral-hexagonal grid (Sadourny et al., 1968), mesh size between 36.7 and 43.4 km, average mesh size ~ 40 km,
- Arakawa A grid, all variables are placed at triangle vertices,
- tangential plane with local spherical coordinate system at each node,
- hybrid vertical coordinate (Simmons and Burridge, 1981), 40 layers,
- second order accurate gradient and Laplace operators based on local coordinates and using the 6 (5) surrounding nodes,
- bilinear interpolation using the 3 surrounding nodes,
- biquadratic interpolation using the 12 surrounding nodes,
- prognostic variables: surface pressure, temperature, horizontal wind components, specific water vapour, cloud water and cloud ice contents,
- Eulerian, split semi-implicit (first 5 modes) treatment of surface pressure, temperature, horizontal wind components,
- semi-Lagrangian, positive-definite, monotone advection of water substances,
- three time level, Asselin filtering,
- physical package: adapted from the former operational regional model EM/DM plus the parameterization of sub-grid scale orographic drag by Lott and Miller (1997). Latest developments: multi-layer soil model with refined snow treatment, sea-ice model,
- incremental Digital-Filtering-Initialization by Lynch (1997),
- intermittent 4-d data assimilation based on OI scheme, 3-h cycle.

Detailed descriptions of GME are available in Majewski (1998) and Majewski et al. (2002).

The limited area **Lokal-Modell (LM)** (Doms and Schättler, 2002; Steppeler et al., 2003; Schulz, 2006) is designed as a flexible tool for forecasts on the meso-ß and on the meso-γ scale as well as for various scientific applications down to grid spacings of about 100 m. For operational NWP, LM is nested within GME on a 665 x 657 grid with 40 layers. The mesh size is 7 km. The model domain comprises almost entire Europe, this application is called LM-E. The LM is based on the primitive hydro-thermodynamical equations describing compressible nonhydrostatic flow in a moist atmosphere without any scale approximations. The continuity equation is replaced by an equation for the perturbation pressure (respective a height dependent base state) which becomes a prognostic variable besides the three velocity components, temperature, water vapour, cloud water and ice, prognostic precipitation and TKE. The set of model equations is formulated in rotated geographical coordinates and a generalized terrain-following vertical coordinate. Spatial discretization is by second order finite differences on a staggered Arakawa-C/Lorenz-grid. For the time integration, three different methods have been implemented:

- a leapfrog scheme using the Klemp and Wilhelmson time splitting method including extensions proposed by Skamarock and Klemp (1992) to solve for the fast modes,
- a two-time level split-explicit scheme proposed by Wicker and Skamarock (1998), and
- a fully 3D implicit scheme treating all pressure and divergence terms implicitly (Thomas et al., 2000).

Currently, the leapfrog scheme is used operationally.

The structure of the GME grid and the model domain of LM-E are shown in Fig. 1. For more information about LM and its data assimilation system, see separate report on the COSMO group in this volume.

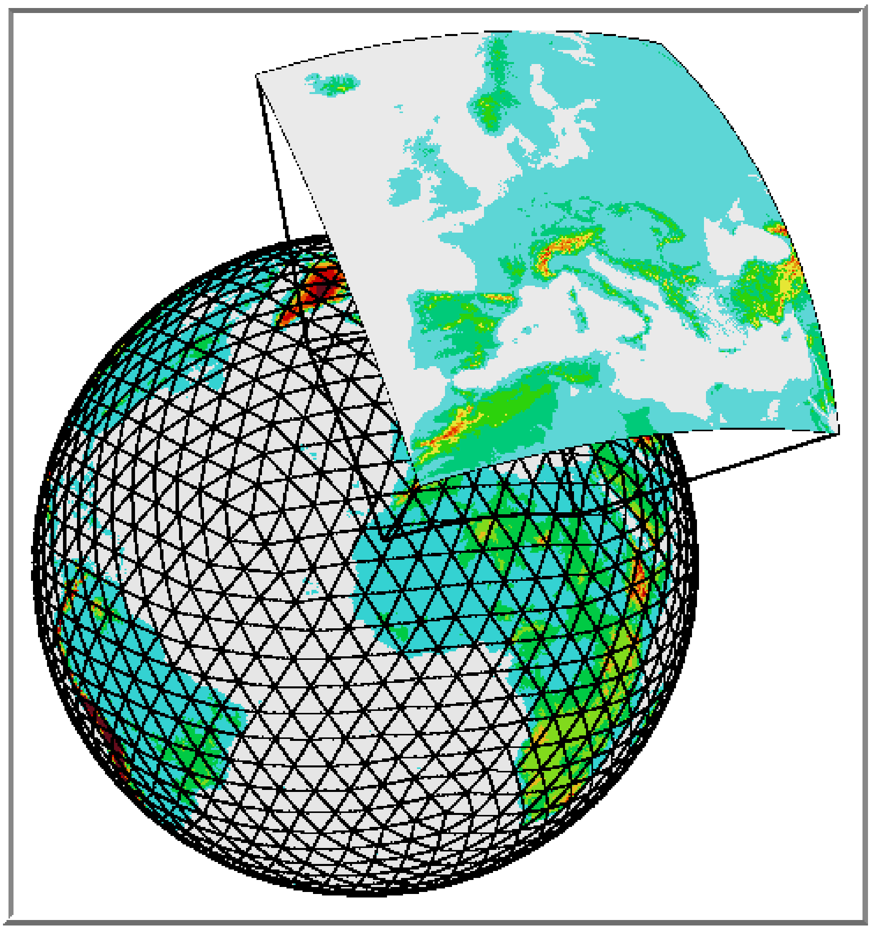

Figure 1: Structure of the GME grid and model domain of LM-E.

In August 2006 production with the meso-γ scale version of LM, **LM-K (LM-Kürzestfrist)**, was started in pre-operational mode. The aims of LM-K are a direct simulation of the coarser parts of deep convection and a representation of the interactions with fine scale topography. The mesh size is 2.8 km. The model domain comprises Germany and some parts of the surrounding countries. The model uses 421 x 461 grid points per layer and 50 vertical layers. LM-K produces 21-h forecasts eight times per day (00, 03, …, 18, 21 UTC) with a very short data cut-off.

LM-K uses a parameterization of shallow convection, but none for deep convection since the model is supposed to explicitly simulate this process. The cloud microphysics scheme has been extended by an additional class of hydrometeors representing graupel. In contrast to LM-E, a two-time level time integration scheme is used in LM-K. As an additional data source, compared to LM-E, data from the German radar network are used. This network consists of 16 radar facilities covering almost the entire German domain. This extra information is provided to the model using the methodology of latent heat nudging, generally leading to considerably improved precipitation forecasts, in particular in the first 4-5 hours.

High Performance Computing at DWD

The high performance computing system at DWD are two IBM P5-575 (52 nodes with 8 processors each). The processors (PE: processing elements) are equipped with a 1.9 GHz CPU (Power3). The nodes have 32 GByte of shared memory. The peak performance of one processor is 7.6 GFlops.

The operational NWP system, i.e. the

- global icosahedral-hexagonal grid point model GME and its data assimilation suite,
- nonhydrostatic local model LM-E and its data assimilation suite,
- global sea state model GSM,
- local sea state model LSM,
- Mediterranean sea state model MSM,
- trajectory model TM,
- Lagrangian particle dispersion model LPDM, and
- objective weather interpretation scheme for GME and LM-E,

is running on 44 nodes, for development another 44 nodes are available.

International Usage of the HRM and Distributed Regional NWP

A portable version of the former hydrostatic regional model EM/DM of the DWD, called HRM (**H**igh resolution **R**egional **M**odel), is being used by a number of National Meteorological Services (NMS), namely Botswana, Brazil (NMS in Brasilia and Military Naval Service in Rio de Janeiro), Bulgaria, China (Regional Service of Guangzhou), India, Israel, Italy, Kenia, Malawi, Mosambique, Oman, Pakistan, Philippines, Romania, Saudi-Arabia, Senegal, Spain, UAE and Vietnam, for regional NWP. HRM is designed for shared memory computers, is written in Fortran90 and uses OpenMP for parallelization. Via the Internet, GME initial and lateral boundary data are sent to the users of the HRM. This enables distributed computation of regional NWP. The DWD starts sending the GME data 2h 30min past 00 and 12 UTC; only the sub-domain covering the region of interest is sent to the NMS in question. Depending on the speed of the Internet, the transmission of the 48-h (78-h) forecast data at 3-hourly intervals (i.e. 17 (27) GRIB1 code files each with a size between 0.3 to 3 MByte depending on the area of the regional domain) takes between 30 minutes to 2 (3) hours. Thus, at the receiving NMS the HRM can run in parallel to the GME at DWD using the interpolated GME analysis as initial state and GME forecasts from the same initial analysis as lateral boundary conditions. This is a considerable step forward because up to now most regional NMS have to use 12h “old” lateral boundary data which degrade the regional forecast quality by more than 10%.

Future development

The main task for the numerical weather prediction system at DWD for 2007 will be the transition from the pre-operational mode of LM-K to a full operational service. Since the pre-operational runs started already in August 2006, this should be feasible in summer, the main target season for LM-K in terms of convective activity.

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3.9 Hungary

LIMITED AREA MODELLING ACTIVITIES AT THE HUNGARIAN METEOROLOGICAL SERVICE (2006)

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INTRODUCTION

The numerical weather prediction (NWP) group (now its division is called as Division for Numerical Modelling and Climate Dynamics) of the Hungarian Meteorological Service (HMS) belongs to the Department of Forecasting and Climate (the Department of Research and Development was dissolved at the end of 2005). The team consists of around 15 people, however the main activities are not only strictly related to NWP (also visualisation and interpretation, post-processing, verification, regional climate modelling are part of our work). The main NWP activities are concentrating on the work around the ALADIN limited area model. The backbone of the research and development is the operational version and exploitation of the ALADIN/HU limited area model. The most important news for the last year was the purchase of a new SGI Altix computer and the migration of the operational suite to the new platform. At the same time the ALADIN/HU model started to be executed four times a day. The two most important research and development areas of interest are data assimilation and short range ensemble prediction (detailed in the thematic consortia summaries), hereafter additional fields of activities will be briefly summarised.

ALADIN OPERATIONAL EXPLOITATION: ALADIN/HU

The main change in the operations was related to the migration of the operational suite from the IBM (AIX) to the new SGI Altix (linux) platform. Beside that the four model integrations per day was introduced at the beginning of October.

Main features of the operational ALADIN/HU model

- Model version: AL30T1
- Initial conditions: 3d-var data assimilation (see also below)
- 48 hour production forecasts four times a day
- Lateral boundary conditions (LBC) from the ARPEGE French global model**Model geometry**

- 8 km horizontal resolution (349*309 points)
- 49 vertical model levels
- Linear spectral truncation
- Lambert projection

Assimilation settings

- 6 hour assimilation cycle
- Short cut-off analyses for the production runs
- NMC background error co-variances
- Digital filter initialisation (DFI)

- LBC coupling at every 3 hours

Observation usage

- SYNOP (surface pressure)
- TEMP (T, u, v, q on standard pressure levels)
- ATOVS/AMSU-A (radiances from NOAA 15 and 16 satellites) with 80 km thinning distance
- ATOVS/AMSU-B (radiances from NOAA 16 and 17) with 80 km thinning distance
- AMDAR (T, u, v) with 25 km thinning distance and 1 hour time-window together with a special filter (that allows only one profile in one thinning-box)
- Web-based observation monitoring system (see also below)**Forecast settings**
- Digital filter initialisation (DFI)
- 300 s time-step (two-time level semi-implicit semi-Lagrangian – SISL – advection scheme)
- LBC coupling at every 3 hours
- Hourly post-processing in the first 36 hours and 3 hourly afterwards**Operational suite/technical aspects/main steps**
- Transfer ARPEGE LBC files from Météo France, Toulouse via Internet (primary channel) and ECMWF re-routing as backup3d-var on 32 processorsModel integration on 32 processors
- Post-processing
- Continuous monitoring supported by a web based system

The computer system

- IBM p690 server (regatta) + IBM (p655) cluster server + SGI Altix 3700
- CPU: 32 + 32 + 144 processors (1,3 Ghz POWER4 + 1,7 Ghz POWER 4+ + 1,5GHz Itanium II)
- 64 + 128 + 288 Gbyte internal memory
- IBM TotalStorage 3584 Tape Library (capacity ~ 30 Tbyte)
- Loadleveler job scheduler on both IBM and PBSpro on Altix platform
- Totalview debugger (on regatta)

VERIFICATION (OBJECTIVE AND SUBJECTIVE) AND POST-PROCESSING

Objective verification

The interactive web-based verification system is in operational use. It provides the verification of NWP forecasts used at HMS against SYNOP observations, including: scatterplots, contingency tables, maps and temporal evolution diagrams (MAE, BIAS, RMSE), probability distributions and wind-direction pie charts. The system is going to be extended in the near future with the use of upper-air observations as well. There is also a version of the verification system, which visualises pre-defined products for the forecasters.

Subjective verification

The subjective verification is carried out in order to complement the objective verification scores, especially for variables that are hard to evaluate in an objective way (e.g. cloudiness, precipitation). The present system includes the comparison of the 0-48h forecasts of 3 different ALADIN model versions (operational and test versions) and ECMWF. The 5-degree qualification indices together with some additional data (e.g. synoptic situation) are fed into a database that can be accessed through a web interface. The verification of the most important NWP models used at the Hungarian Meteorological Service is carried out in a quarterly (seasonal) basis.**Post-processing**

The first results of a Model Output Statistics (MOS) based post-processing system are delivered. MOS is applied to ALADIN and ECMWF near surface temperature, humidity and wind forecasts. The MOS coefficients were computed via multiple linear regression for each variable, time-step, location and month.**FIRST investigations with the prototype of the AROME non-hydrostatic modelAROME model and its installation in Budapest**

The AROME model is a non-hydrostatic model, which is built from the data assimilation (3d-var) system and non-hydrostatic kernel of the ALADIN model and the physical parameterization package of the meso-NH French research model. The prototype version of the model was installed (see more details about technical aspects at http://www.cnrm.meteo.fr/aladin/newsletters/news29/PLANEWS.html) in Budapest. The first, preliminary tests of the model were aimed for demonstrating the capabilities of the AROME model in extreme meteorological situations with respect to the operationally used ALADIN model version. For that end, first, a new AROME domain was created taking into account the (heavy) computer resources needed for the model integration (24h integration takes around 4,5 hours on the 16 processors of the IBM p655 cluster server). Note that at that stage all the experiments were performed without data assimilation!

Preliminary conclusions of the case studies

The selected cases were heavy precipitation events, where the sensitivity of the model was examined with respect to the coupling model, coupling frequency and domain size.

Sensitivity to the coupling model:

ALADIN model versions were used for initial and lateral boundary conditions for the AROME model: ALADIN with and without 3d-var data assimilation. The event investigated was a heavy precipitation case over the Western part of Hungary. The ALADIN forecasts were although giving precipitation, but its amount was strongly underestimated (the dynamical adaptation version was the slightly better one). The AROME forecasts could equally improve the precipitation forecasts independently from the differences in the lateral boundary conditions.

Sensitivity to the coupling frequency:

Different coupling frequencies were tried: 6h, 3h and 1h respectively. On the investigated cases no direct relation was found between the coupling frequency and the quality of the forecasts.

Sensitivity to domain size:

Based on the results on the coupling frequency it was decided to extend the originally defined domain slightly to the West and South. There is a clear improvement in terms of precipitation with the bigger domain.

ECMWF/IFS model as initial and boundary conditions for the ALADIN model

There is a technical possibility in ALADIN to use ECMWF/IFS data for initial and lateral boundary conditions for the ALADIN model integration. From 2006 onwards there is a Special Project at ECMWF, which (beside others) plans to investigate the possibility of using

IFS as driving model for ALADIN. The study detailed below was performed in the framework of this Special Project at the Hungarian Meteorological Service.

Methodology: technicalities

The ALADIN model cannot use the frames provided by the optional BC project of ECMWF, therefore the IFS GRIB information stored in the MARS database can be applied for research purposes. The GRIB files are converted to ARPEGE/ALADIN FA file format with the help of special ARPEGE/ALADIN model configurations. The difficulty of the exercise is coming from the fact that the surface parameterisation in the IFS system is different than that of the ALADIN one, i.e. additional surface variables should be initialised for the ALADIN model. This problem can be circumvented with the help of ARPEGE surface characteristics and some climatic information. Nevertheless this treatment might be some source of possible problems in the model integration (see later).

Experiments

The inter-comparison experiments were carried out for the period of 10 days (1-10 January, 2005). No data assimilation was involved, therefore always dynamical adaptation integrations were performed with different (ARPEGE and IFS) initial and lateral boundary conditions. The following experiments were realised (IFS initial and ARPEGE lateral boundary conditions were not tried):

- the “traditional” setting: ARPEGE initial and lateral boundary conditions
- application of IFS lateral boundary conditions, but keeping ARPEGE initial conditions
- both initial and lateral boundary conditions from the IFS model

These experiments could give a hint about the relative importance and impact of initial and lateral boundary conditions in the course of ALADIN integrations.

Results

It can be clearly seen that significant improvements can be identified with the use of ECMWF/IFS lateral boundary conditions in during the ALADIN model integration. At the same time the IFS initial conditions also provide important improvements. However there are also some problems (weaknesses) mostly coming from the surface treatment, more particularly in the 2m relative humidity fields (when the IFS model is used for initial conditions). Therefore future attention should be paid to the careful investigation of the surface initialisation of the ALADIN model. It is also noted that the reason for the erroneous behaviour of the relative humidity at 250 hPa is not yet known for the time being.

Observation monitoring system

A prototype of an observation monitoring system has been developed to support the maintenance and evaluation of the ALADIN 3d-var data assimilation systems, concerning both the operational suites and the experimental runs. The work has been carried out within the RC-LACE Data Manager activity. The system is dealing with all kinds of observations that are available in the recent 3d-var system in Budapest. It can handle analysis dates and periods of analyses, as well. The system can monitor the number and status flag of observations and compute statistics for the observation and background, and the observation and analysis departures. Advanced visualization on maps, vertical profiles, time-series and time-height diagrams is provided. The system can be used both in batch mode and interactive mode, the latter is based on a web interface with on-the fly graphics generation.

Technical background

The recent version of the system is using an ASCII dump of the ODB observational database. The system was written in C++ and the graphics is based on the GMT package.

Recent developments

The ongoing work is the modification of the system to use ODB directly. It will make possible the advanced usage of the wide range of information stored in ODB. New statistics (Jo-table, residuals), graphical types (histograms, time distribution graphs) and automatic report generation is also under development. The new system will be capable of performing local blacklisting of SYNOP and TEMP observations.

SUMMARY

The main limited are modelling (and related) activities were briefly summarised in this overview: only those work were emphasised, which are on the one hand operational ones and on the other hand doesn't falling into the usual NWP themes, which are reported elsewhere in the same newsletter. Due to the requirement of brevity, figures are not enclosed to this report, therefore the interested readers are kindly asked to contact the author, if further details explanations are needed.

ACKNOWLEDGEMENTS

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3.10 Ireland

NWP at Met Éireann – Ireland – 2006

Introduction

The Hirlam system is used at Met Éireann – the Irish Meteorological Service – to produce operational forecasts out to 48-hours. The model [version 5.0.1 with 3DVAR] is run four times per day using an IBM RS/6000 SP with 9 nodes each with 4 processores sharing 2 Gbytes of memory [i.e. a total of 36 CPUs and 18 Gbytes of memory].

Data Assimilation

Observations: SYNOP, SHIP, BUOY, AIREP, AMDAR, ACARS TEMP, TEMPSHIP, PILOT, SATOB and SATEM observations are used. The data are packed into BUFR format both for storage and for input to Hirlam.

Analysis: Hirlam 3D-Var [3-dimensional variational assimilation]. The analysis runs on 31 hybrid [eta] levels. Upper-air observational data is accepted on all standard and significant levels (10 hPa to 1000 hPa) and interpolated to eta levels.

Assimilation Cycle: Three-hour cycle using the forecast from the previous cycle as a first-guess. [It is also possible to use an ECMWF forecast as a first-guess].

Analysed Variables: Wind components (u,v), geopotential and specific humidity.

Forecast Model

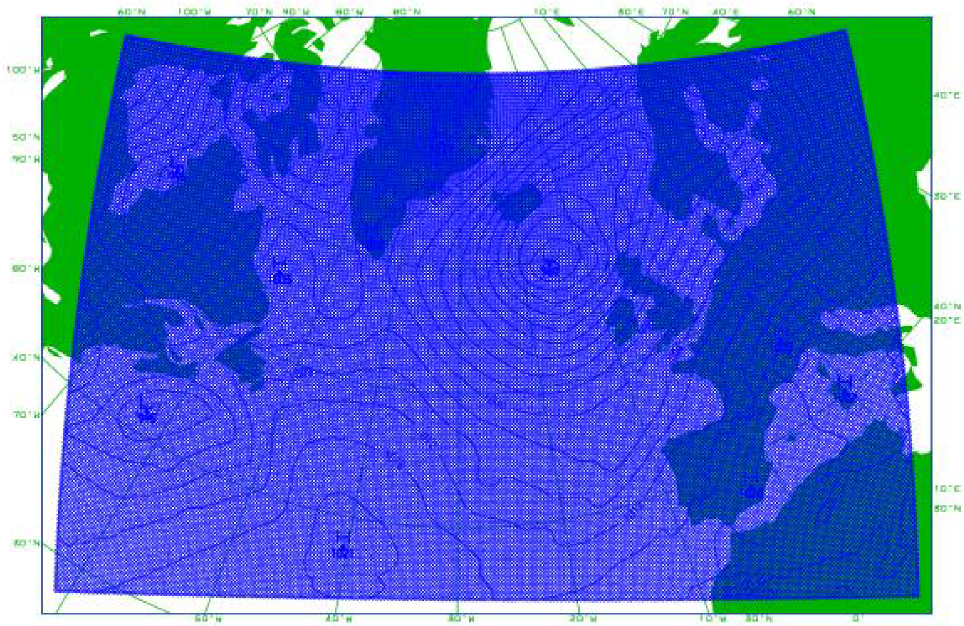
Forecast Model: Hirlam 5.0.1 reference system grid point model.

Horizontal grid: A rotated latitude-longitude grid is used with the South-Pole at -30˚ longitude, -30˚ latitude). Fields are based on a 438x284 grid corresponding to 0.15˚ x $0.15˚ horizontal Arakara C-grid [see diagram below].

Vertical Grid: Hybrid [eta] coordinate system with 31 levels.

Initialisation: Digital Filter.

Integration Scheme: We use a two time-level three-dimensional semi-Lagrangian semi-implicit scheme with a time-step of 300 seconds.



Filtering: Fourth order implicit horizontal diffusion.

Physics: CBR vertical diffusion scheme; Sundqvist condensation scheme with the 'STRACO' (Soft TRAnsition COndensation scheme) cloud scheme; Savijarvi radiation scheme.

Lateral Boundary Treatment: Davies-Kallberg relaxation scheme using a cosine dependent relaxation function over a boundary zone of 8-lines. The latest available ECMWF 'frame' files are used [based on 4 ECMWF runs per day at 00Z, 06Z, 12Z and 18Z, respectively]. ECMWF data is received on a 0.3˚ x 0.3˚ rotated latitude-longitude grid on a selection of the 60 ECMWF eta levels. The data is interpolated both horizontally and vertically to the Hirlam 0.15˚ x 0.15˚ rotated latitude-longitude grid at [Hirlam] 31 eta levels. [The selected 0.3˚ x $0.3˚ grid corresponds to half the resolution of the 0.15˚ x 0.15˚ grid, the line speed is not sufficient to receive the data at full resolution].

In general the ECMWF boundary files are just provided as 'frame' boundaries where the data is not defined in the central section of the grid. However, the ECMWF analysis fields are received on a 'full' grid and so can be used as a 'first-guess' in the case of a 'cold-start'.

Data Monitoring

The analysis departures/flags are fed back to the original BUFR reports to create 'feedback' files which are used to monitor the quality of the data on an ongoing basis and to identify problems [e.g. station elevation errors].

Operational Usage

General Forecasting: Hirlam forecasts are used for general forecasting in Met Éireann out to 48-hours. [ECMWF forecasts are used beyond that period]. Hirlam output can be displayed using an interactive graphics system called *xcharts* (developed at Met Éireann).

WAM model: Forecast 10-metre winds from Hirlam are use to drive a WAM wave model.

Roadice Prediction System: Forecast surface parameters [temperature, wind, cloud-cover, humidity and rainfall] are used [after forecaster modification] as input to a roadice model.

SATREP: Hirlam output can be overlaid on satellite plots as part of the ZAMG SATREP analysis scheme.

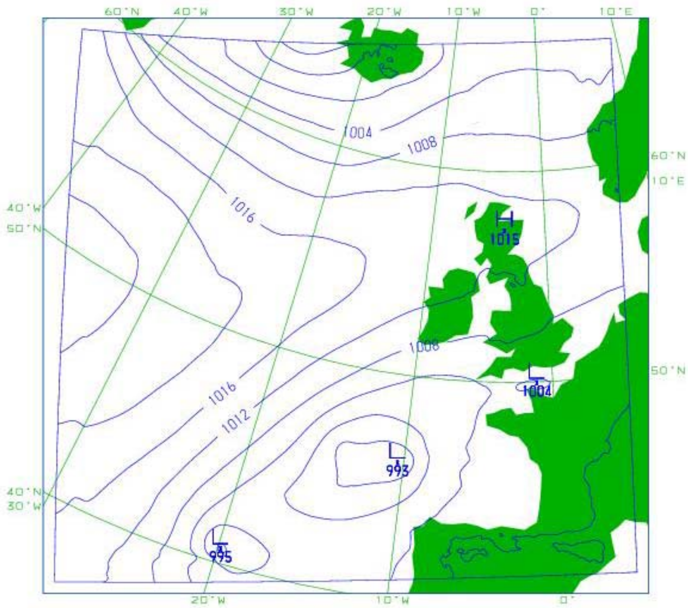
Verification

Verification against Fields: A small number of Hirlam parameters are verified against the corresponding Hirlam analysis fields. [This is to provide continuity with an earlier model which was used before Hirlam became operational].

Verification against Observations: The Hirlam verification system is used to verify forecasts against observations from EGWLAM stations within the area.

Nested Hirlam

A nested version of Hirlam is also run on the IBM RS/6000 SP. It works on a three hour cycle producing 27-hour forecasts at the intermediate hours [viz. 03Z, 09Z, 15Z and 21Z]. It runs on a 222 x 210 grid, with 40 levels in the vertical. [The grid spacing is 0.12˚ x 0.12˚ which is slightly finer than the main Hirlam grid of 0.15˚ x 0.15˚]. It uses a more advanced version of the physics than the main Hirlam i.e. it uses the Kain-Fritsch/Rasch-Kristjansson convection/condensation scheme and the ISBA surface scheme. Many of the outputs of the model are post-processed using MOS. The following diagram shows the area:



Nested Hourly Analysis

A separate nested version of Hirlam is run every hour on a dual-processor 500Mhz PC running Linux. The run provides an hourly analysis and also a short range [3-hour] local forecast.

Forecast Model: Hirlam 4.3 forecast model in conjunction with the Hirlam 4.8 OI analysis scheme.

Vertical grid: A set of 24 hybrid [eta] levels.

Horizontal grid: A rotated latitude-longitude grid is used with the South-Pole at -9˚ longitude, -38˚ latitude). There are 97x98 grid points with a resolution of 0.15˚ x 0.15˚.

Experiments with Linux Cluster

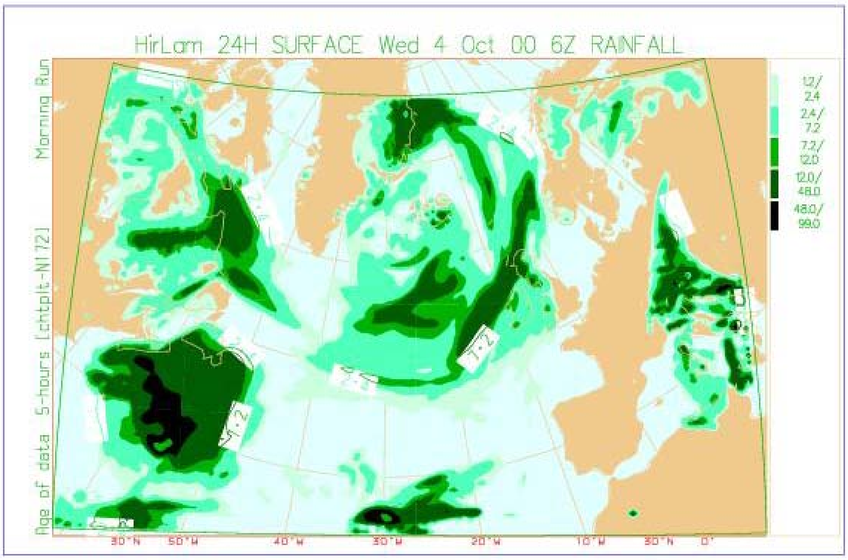
Met Éireann started to experiment with running Hirlam on a Linux cluster in early 2004. The experiences have been generally good. The cluster performance is similar to the IBM mainframe with the current operational system [Hirlam 5.0.1 and 3DVAR]. We are experimenting with Hirlam 7.0.1.

Cluster Hardware: The cluster consists of 10 rack mounted Dell Poweredge 1750 nodes (i.e. 1 master node and 9 compute nodes). The master node has dual 2.8GHz Xeon processors with 4 Gigabytes of ECC DDR RAM; each compute node has dual 3.2GHz Xeon processors with 2 Gigabytes of memory. The compute nodes are connected as a two-dimensional torus via 4 Port Dolphin SCI HBA cards.

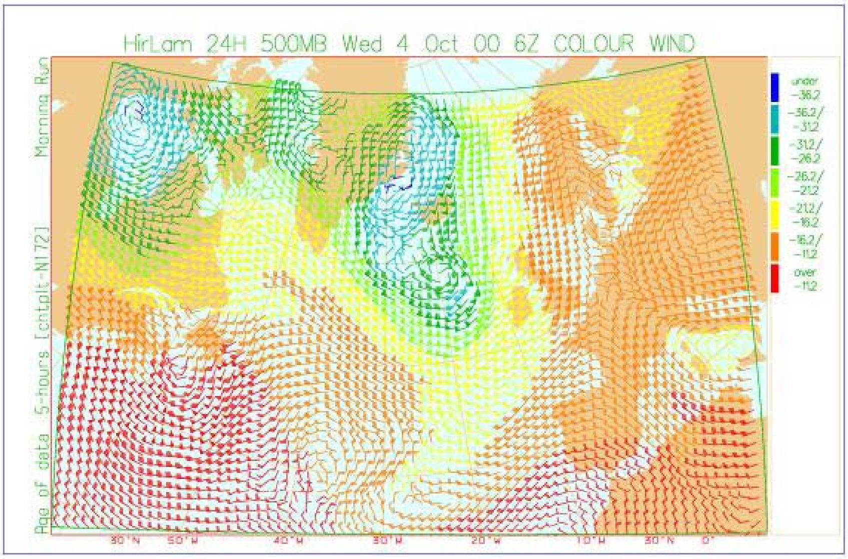
Cluster Software: (a) Operating system: Redhat ES 3.0 / WS 3.0 (b) Networking software: Scali MPI connect, Scali TCP connect, Scali Manage; (c) Compilers: PGI cluster development kit and Intel Fortran compiler.

Sample Products

The following are some examples of typical Hirlam output as displayed on the forecaster's workstation [using the *xcharts* graphics program]. The first chart shows accumulated rainfall:



The next chart shows wind arrows at 500hPa. The colour of each arrow has been chosen to indicate the temperature at that level:



Replacement of Mainframe

Our IBM mainframe is coming to the end of its life [maintenance is getting too expensive] and we hope to find a replacement system within the next 1twelve months. One option would be to purchase a large linux cluster [or equivalent] but we are also looking at other possibilities including outsourcing. However, no final decision is likely for at least a few more months.

We plane to run a nested system using Hirlam 7.0.1 [or a later version, if available]. The outer area will be the same as our current area but with 60 levels; the inner area is still being considered.

3.11 Italy

Italian Meteorological Service Status Report

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Regional Modelling and Data Assimilation

The regional model EURO_HRM, whose main features are summarised in Table 1, is operationally run by the Italian Meteorological Service (IMS) over the domain shown in Fig. 1. An intermittent 6-hour data assimilation cycle is run to provide initial conditions for the model (Bonavita and Torrisi, 2005).

The main changes to the operational setup implemented over the past year have been:
- use of synchronous boundary conditions;
- use of AMSU-A radiances from NOAA-18;
- upgrade of radiative transfer model from RTTOV7.1 to RTTOV8.7;
- Use of METEOSAT8 Atmospheric Motion Vectors (Bonavita and Torrisi, 2006).

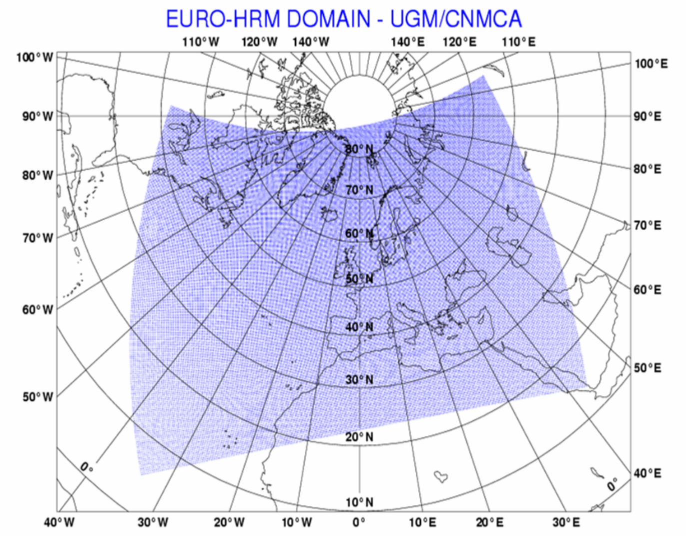

Fig. 1 Integration domain of EURO_HRM model

Domain size	385 x 257
Grid spacing	0.25 Deg (~28 km)
Number of layers	40
Time step	150 sec
Forecast range	72 hrs
Initial time of model run	00/12 UTC
L.B.C.	IFS
L.B.C. update frequency	3 hrs
Initial state	CNMCA 3DVAR
Initialization	N.M.I.
External analysis	None
Status	Operational
Hardware	IBM P960
N° of processors used	14 (Model), 90 Analysis)

Tab. 1 Characteristics of EURO-HRM

Current development activities in the regional modelling and data assimilation sector involve:

- NMC evaluation of background error matrix (Fig.2) and its operational implementation;
- Introduction of new multi-level soil model;
- new treatment of leaf area index;
- experimental run of a 3-hourly data assimilation cycle in order to make use of the large amount of a-synoptic data which is currently discarded;

- experimental run of a parallel data assimilation cycle with an objective analysis based on a hybrid EnKF-3Dvar approach.
- horizontal resolution doubling (0.125 Deg., ~14 Km).

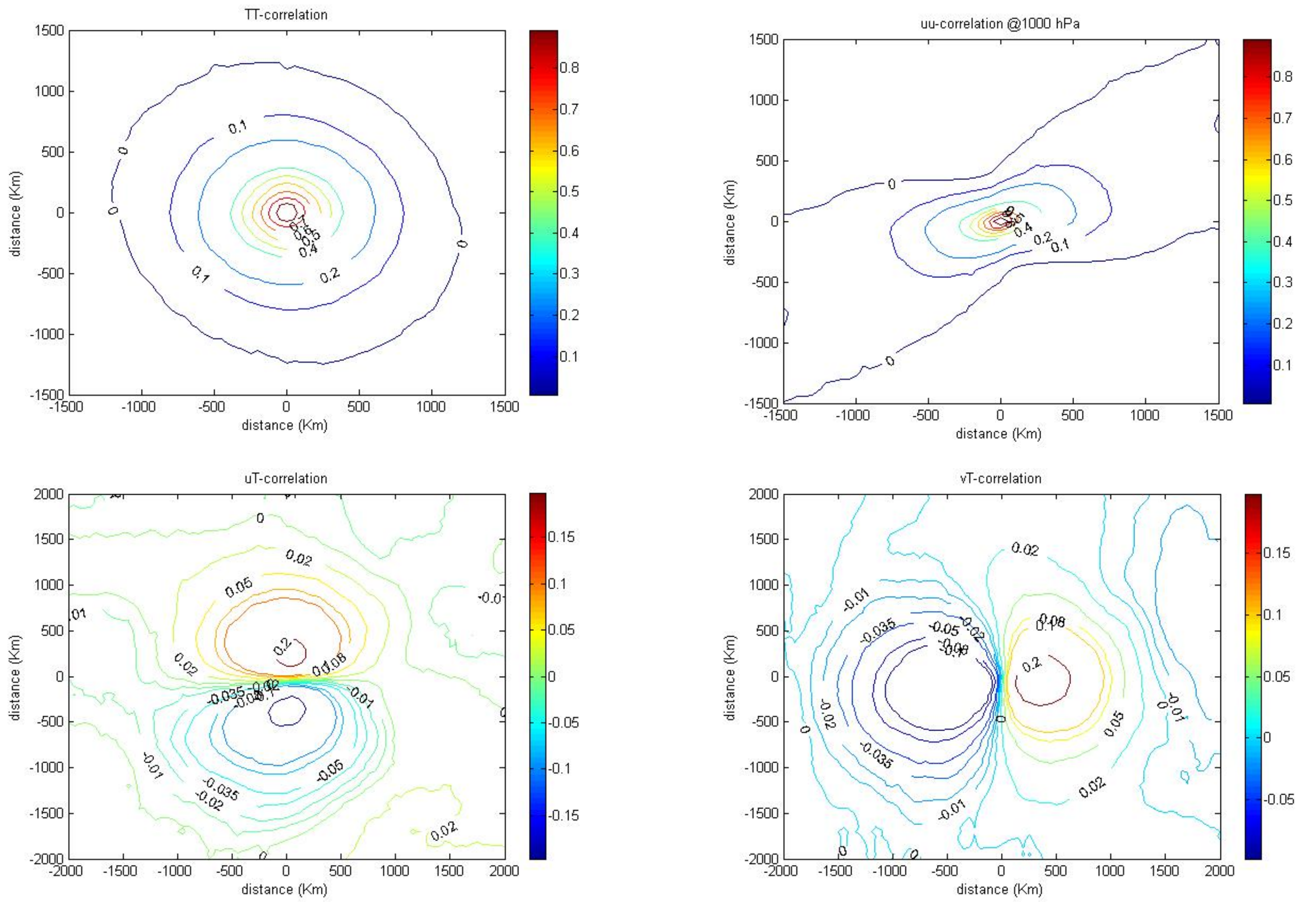

Fig.2 Examples of NMC-derived background error correlations.

Local Area Modelling

The current operational implementation of the Lokal Modell (**LM-EURO**) has been enlarged to cover the whole mediterranean basin, as shown in Fig.3 and summarized in Table 2, while the number of vertical layers has been increased to 40.

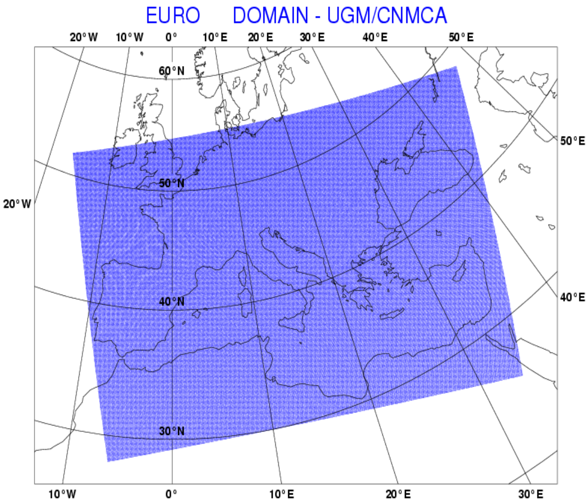

Fig.3 Integration domain for LM-EURO model**.**

Domain size	**641 x 401**
Grid spacing	0.0625 (7 km)
Number of layers	**40**
Time step and scheme	40 s. 2 time-lev split-expl
Forecast range	60 hrs
Initial time of model run	00 UTC
Lateral bound. condit.	IFS
L.B.C. update frequency	3 hr
Initial state	ICNMCA 3DVAR (Interp.)
Initialization	Digital Filter
External analysis	T,u,v, PseudoRH, SP
Special features	Filtered topography
Status	Operational
Hardware	IBM P690 (ECMWF)
N° of processors	120

Table 2 Characteristics of LM-EURO model.

In parallel with the operational configuration of the Lokal Modell described above, an experimental one has been set up over the Italian domain (**LM-ITA**, Fig.4 and Table 3).

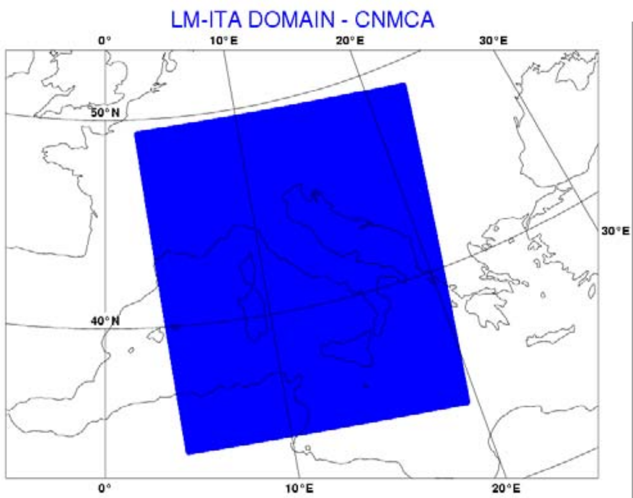

Fig.4 Integration domain for LM-ITA model

Domain size	542 x 604
Grid spacing	0.025 (2.8 km)
Number of layers	50
Time step and scheme	**30 s** 3 time-lev split-expl
Forecast range	48 hrs
Initial time of model run	00 UTC
Lateral bound. condit.	LM-EURO
L.B.C. update frequency	1 hr
Initial state	LM-EURO
Initialization	Digital Filter
External analysis	None
Special features	Filtered topography
Status	Experimental
Hardware	IBM P690 (ECMWF)
N° of processors	160

Table 3 Characteristics of LM-ITA model.

The LM-ITA implementation differs from the LM-EURO implementation in terms of both horizontal (2.8 vs 7 Km) and vertical resolution (50 vs 40 layers). Taking into account the complex orographic structure of Italy (Fig.5), this increase in resolution should be beneficial towards a more realistic treatment of near surface parameters and accurate forecast of sensible weather.

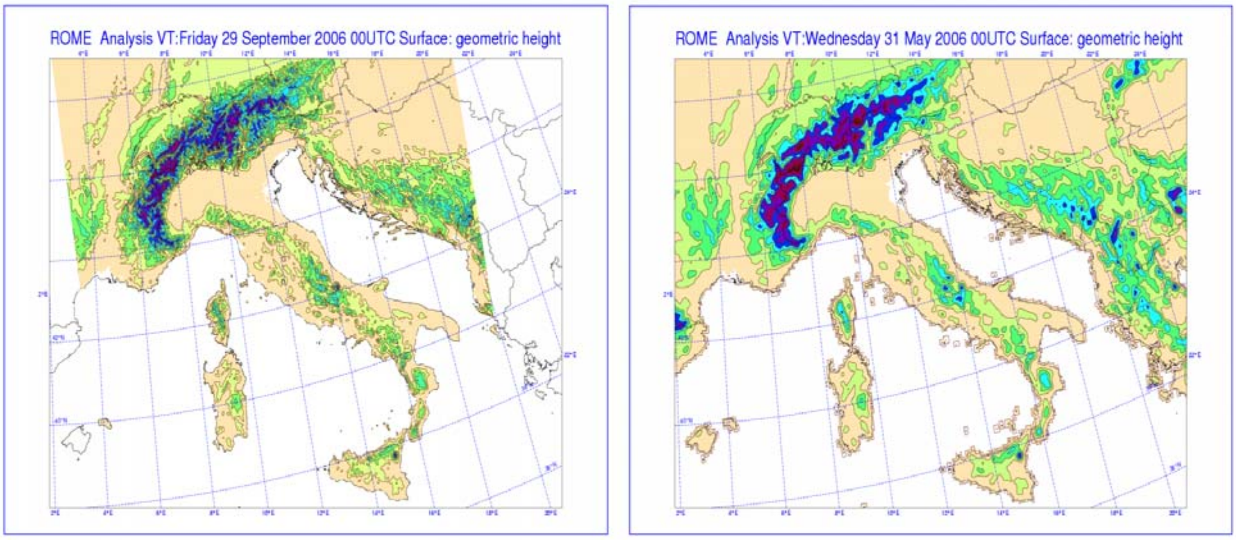

Fig. 5 Model orography over Italy for LM-ITA (left) and LM-EURO (right)

References

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Bonavita M., and L. Torrisi, 2006: Characterization and use of MSG AMVs in the Italian Weather Service regional NWP system. Proceedings of the Eighth International Winds Workshop, Beijing, China, 24 - 28 April 2006.

www.meteoam.it presents a selection of updated NWP products over Italy.

3.12 Netherlands

A simple parameterization for detrainment in shallow cumulus.

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Recently there has been a regained interest in the parameterization for entrainment in cumulus convection. Unfortunately little attention has been paid to the parameterization of the detrainment process although this counterpart of the cloud mixing process is, as this study shows, even more important for obtaining realistic mass flux profiles in cumulus convection.

A new simple but flexible parameterization for the detrainment process in shallow convection is presented. From ensemble considerations and confirmed by LES results it is shown that the magnitude of the fractional detrainment for shallow convection is decreasing with increasing depth of the cloud layer. A simple detrainment formulation is presented that takes this dependency into account by considering the mass flux profile in a non-dimensionalized way. The only free parameter in this detrainment formulation is the percentage of the mass flux at cloud base that is still present half-way the cloud layer (called m^*). This free parameter turns out to depend on the environmental conditions as well as updraft properties and can be expressed with a parameter coming from the buoyancy sorting concept, $\overline{\chi}_c$, the fraction of environmental air necessary to make the updraft air just neutrally buoyant and averaged over the lowest half of the cloud layer. LES results show a distinct relation between m^* and $\overline{\chi}_c$ which can be used to close our parameterization.

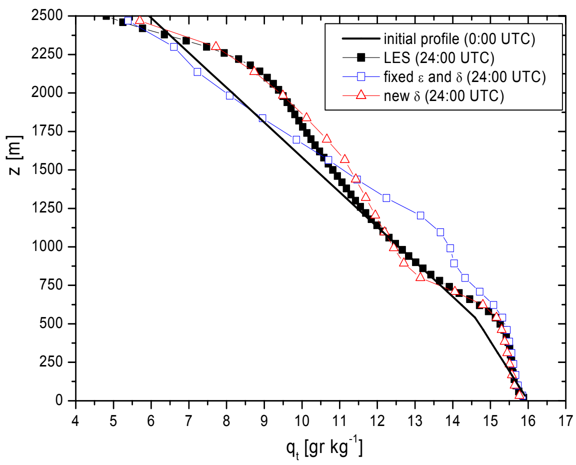

Fig. 2. Total specific humidity profiles after 24 hrs of simulation during the RICO case for the LES model (black squares) and the SCM using fixed ε and δ (blue squares) or the new detrainment parameterization (red triangles). The black solid line represents the initial profile.

Results of the new parameterization in a Hirlam single column model (SCM) for a wide range of shallow cumulus convection cases (BOMEX, ARM and RICO) illustrate the strength of this new detrainment parameterization. As an example, we show in Fig. 2 the total specific humidity profile of the independent RICO case after 24 hours of simulation. Presented are the results for an LES model, a SCM with fixed fractional entrainment (ε) and detrainment (δ) coefficients as known from literature, and finally a SCM with the new detrainment parameterization. The new parameterization gives an almost perfect match with the LES humidity profile. There is also a large improvement on the

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results with fixed entrainment and detrainment coefficients which can be explained by the relatively deep and moist cloud layer in RICO which leads to relatively small fractional detrainment values and thus strong convection.

The new parameterization can be seen as an alternative for more complex buoyancy sorting based convection schemes without some of the disadvantages. Moreover, the new parameterization can be easily included in existing mass flux schemes.

Reference

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Single-column modeling versus mesoscale modeling for an episode with three diurnal cycles in cases99

E.I.F. de Bruijn[1], A.B.C. Tijm[1], G.J. Steeneveld[2]

1: Royal Netherlands Meteorological Institute, The Netherlands
2: Wageningen University, The Netherlands

INTRODUCTION

From previous studies it is obvious that single-column models are useful to study specific parts of the physics. A 1-D experiment can be conducted for various reasons: 1) intercomparison of different models or model versions 2) dedicated study of the performance of a particular part of the 3D model. 3) develop and quickly test model updates. During the GABLS experiments (Holtslag 2006) the first point is addressed extensively. Here we focus on the question: “How can we run a 1D-model with constraints from the 3D-model and what can we conclude from the results of the 1D and 3D model runs”. In the GABLS2 experiment the performance of the wind profile with respect to the observations was rather poor. Contrarily a mesoscale 3D experiment revealed better results, especially for the nocturnal wind maximum. Is it possible to achieve a similar result for a single column model using output from the 3D model?

3D/1D HIRLAM

In our experiment we use the HIRLAM model (Undén et al, 2002). The HIRLAM physics consists of: the ISBA surface scheme, CBR turbulence, Sarvijarvi radiation and STRACO convection. The CBR scheme (Cuxart, Bougeault and Redelsberger al., 2000) is a prognostic TKE scheme with a diagnostic length scale. This length scale has been adjusted for stable conditions according to the findings in the first GABLS intercomparison.

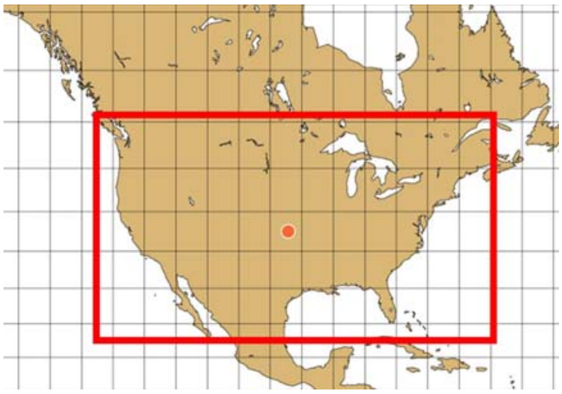

Figure 1: Integration area of HIRLAM and the location of Leon (Kansas)

The 3D experiment domain is 406 by 306 points (see Fig. 1) with a resolution of 0.1 degree. The time step is 180 seconds. ECMWF analyses are used as boundaries with a time resolution of 6 hours. There are two experimental periods: The first one is the GABLS2 case-study and starts at 22 October 1999 1900 UTC and ends at 25 October 1999 0700 UTC. The second period is from 23 October 1999 1800 UTC to 27 October 1999 1800 UTC and has been carefully studied by Steeneveld et al., 2006. It comprises three typical archetypes of stable nocturnal boundary layer. For validation of the model we have used data from the CASES99 field experiment (Poulos et al., 2002).

The GABLS2 case-study starts from prescribed conditions which are kept as simple as possible. The surface temperature is prescribed and the surface water content and geowind are kept constant during the

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simulation. In order to allow a good comparison between the participating models the physics have been reduced, i.e. the surface and the radiation scheme have been switched off. Because no cloud formation occurs during the simulation the only remaining active component of the physics is the turbulence scheme.

For the second period we try to get the best possible results in the lowest 1000 meters with the 1D model. We use the full physical package and we also provide extra information from the 3D model. For example the initial profiles of temperature and moisture are now taken from the 3D model fields by bi-linear interpolation. In the 1D model we prescribe the actual wind just above the ABL from the 3D model. As we want to let the night time low level jet evolve freely, we do not prescribe the 3D winds just above the night time ABL, but above the level of the day time ABL with a correction for subsidence. The geostrophic wind (constant with height) is derived from the geopotential height of the 925 hPa height and prescribed through the entire column.

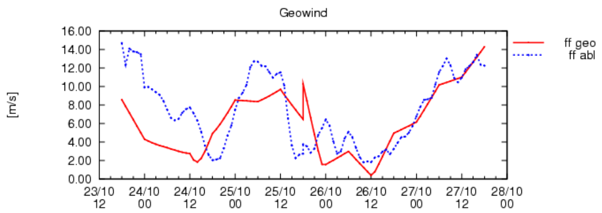

Figure 2: Time series (UTC) of the geowind derived from the 3D-model compared with diagnosed wind just above the ABL

In Fig. 2 the geowind as derived from the geopotential is depicted. In that picture also the diagnosed wind above the boundary layer is depicted. During the presented period the two wind speeds do not reveal a complete overlap, because the wind above the ABL is prone to inertial oscillations. Note the discontinuity in the geowind which is caused by a transition between two successive runs. The analysis of the next run does not guarantee a smooth transition of model variables.

Results

A. Idealized case (GABLS2)

At first we present the results of the 1D model according to the GABLS2 recipe. The geowind is kept constant with u=3 and v=-9 m/s.

In Fig. 3 the wind profiles are presented. Close to the surface the 1D model is resembling the observed radiosonde, but above 960 hPa there is hardly any correspondence with the observations. Increasing the number of vertical levels to 100 instead of 40 does not improve the results. Subsequently we diverted slightly from the GABLS2 recipe and switched the surface and radiation scheme on, but none of these changes had a positive effect. Then a mesoscale 3D run was made and the results revealed a much better match. It is obvious that the dynamic forcing and large-scale changes are important for this case. Also, the very local wind maximum just 100m above the surface is not found in both the 3D and the 1D runs.

B. Realistic case (Mesoscale Intercomparison)

In this case we try to improve the results from the 1D model by prescribing the dynamic constraints from the 3D model. We follow a mesoscale intercomparison experiment which was set up by Steeneveld (see session 8.8).

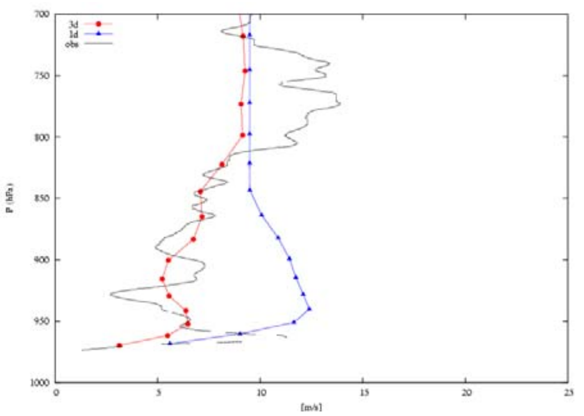

Figure 3: GABLS2 case 22 October 1999 19 UTC +36h wind speed valid at 24 October 1999 0200 LT with the 3D model (red circles), the 1D model (blue, triangles) and observations (black) from the radiosonde.

Results are presented which are valid at 25 October 1999 0200 LT and the nocturnal boundary layer is classified as turbulent (Steeneveld et al., 2006).

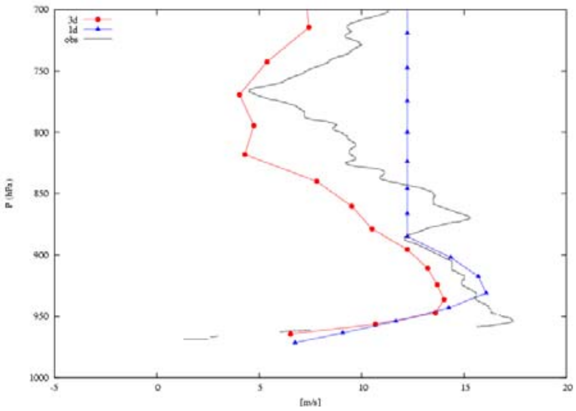

Figure 4: Mesoscale intercomparison case 23 October 1999 1800 UTC +37h wind speed valid at 25 October 0200 LT.

This means that mechanical turbulence is the dominant factor of the nocturnal boundary layer due to a stronger average wind than in the first case. From the observations a clear wind maximum can be seen in Fig. 4. The 3D run and the improved 1D run also show a wind maximum, but in the models the maximum is found at a higher level and the maximum wind speed is weaker. Note that 1D and 3D results are similar.

Both 1D and 3D model have a similar CBR scheme. Recently this scheme has been modified by turning the stress vector, causing a larger Ekman pumping at the same stability (Tijm, 2004). This enables a decrease in turbulent mixing under stable conditions which results in a much better representation of the nocturnal jet. From Fig. 4 it is clear that both models (1D/3D) have their wind maximum on a too high level. Apparently there is still too much mixing. A promising technique to tackle this problem would be the application of a turbulence scheme with stability functions based upon QNSE (Sukoriansky, 2006).

CONCLUSIONS

Single column modeling is a useful tool to study the physics in more detail and for comparing models or model versions.

The 3D model gives the best results and this implies that the dynamic forcing is important in the GABLS2 experiment

Comparing with observations is a delicate matter and makes only sense if the dynamic constraints (geowind), are well described. For the selection of a case study the geowind should not vary too much.

The nocturnal wind maximum is still too far from the surface in the 1D model as well as the 3D model. Even in this model version, with already reduced mixing, there is too much mixing in stable conditions.

OUTLOOK

Exchange processes in the nocturnal boundary layer have to be better described in the model. A new turbulence scheme with stability functions based upon QNSE shows potential (Sukoriansky 2006). The new K-ϵ model is able to simulate the complicated process of the formation and disappearance of low-level jets. First tests demonstrate promising results of predicted windprofiles. However more testing in a broader context is necessary. It is recommended to collect data of more case-studies to allow more experimentation.

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Probabilistic 0-12 h forecasts of (severe) thunderstorms in the Netherlands

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In this project the technique of Model Output Statistics (MOS)[1)] has been used to derive logistic regression[1)] equations for the (conditional) probability of (severe) thunderstorms in the warm half-year (from mid-April to mid-October) in the Netherlands. For 12 regions of about 90×80 km^2 each and for projections out to 12 hours in advance (with 6-hour periods), we have developed these equations using four different potential predictor sources. They consist of combined (postprocessed) output from the HIRLAM and ECMWF models, as well as an ensemble of 18 members of advected radar and lightning data. The predictands are derived from reprocessed SAFIR[2)] lightning data, being either the probability of a thunderstorm (≥ 2 discharges) or the conditional probability of a *severe* thunderstorm (≥ 50 discharges/ 5 min. and possibly ≥ 100 discharges/ 5 min. and ≥ 200 discharges/ 5 min.) under the condition that ≥ 2 discharges will be detected. The dataset used for the development consists of ⅔ part of the July 2002 to July 2005 data (warm half-years only) and the independent verification set consists of the remaining ⅓ part.

Figure 1a shows an example of a probabilistic forecast of severe thunderstorms and Figure 1b shows the observed maximum 5-min. lightning intensity.

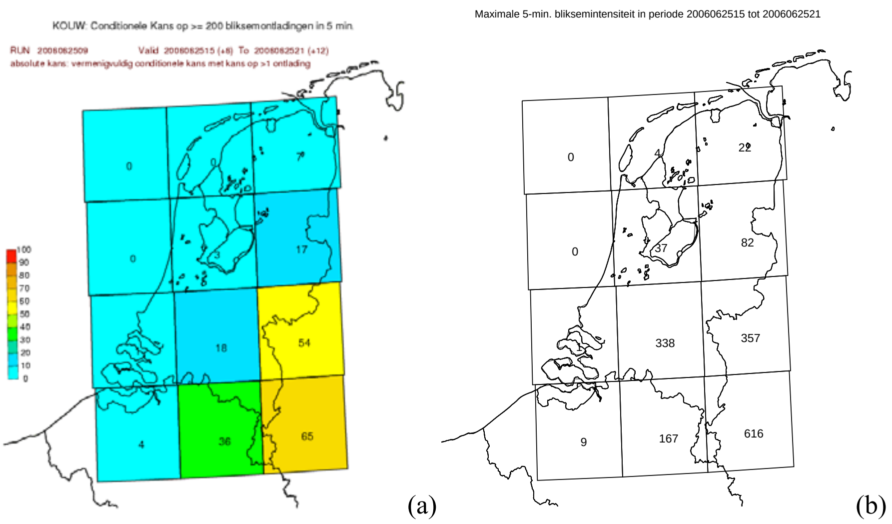

Figure 1. (a) +6 to +12 h (conditional) probability forecast (%) of maximum 5-min. lightning intensity ≥ 200 discharges/ 5 min. for 15-21 UTC on June 25 2006. This forecast is based on the 09 UTC run of the MOS system. (b) Maximum 5-min. lightning intensity, as detected by the SAFIR network, during the same period.

We can conclude from the objective verification results for the independent dataset (not shown) that the overall skill of the MOS (severe) thunderstorm forecast system is good. Therefore, the system was made quasi-operational at KNMI in April 2006. The thunderstorm forecast system shows the best skill for the afternoon (12 and 15 UTC) and evening (18 and

21 UTC). The *severe* thunderstorm forecast system shows the best skill for these central verification times as well.

Finally, future developments in our MOS system may be even more extreme criteria for severe thunderstorms together with the inclusion of advected Meteosat Second Generation (MSG) data as a potential predictor source.

References

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3.13 Portugal

Limited Area Modelling Activities at Portuguese Meteorological Service (2005-2006)

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1. Summary of main activity

Since the last year main effort was (still) devoted to the progress of our operational system and training of the NWP team. GDPFS and GTS data processing is now being fully mounted under UNIX/Linux environment and a new computer platform is being used to run an updated version of ALADIN/Portugal in operational mode. A new computer platform is being tested for our local model now under parallel processing on a PC's cluster, using the scientific live Linux distribution PaiPix/cluster. The restricted version of PaiPix plus ECMWF tools is used both for development work and for operational graphical production. Finally, we started our historical archive of operational production under the home-made TIDB2 relational data base. Verification tools for inter-comparison of NWP models present at IM are still being reviewed and prepared to became fully operational. CANARI is now being validated to our domain and the wind dynamical adaptation is being tested against MM5 (Portuguese University) as possible forcing fields to the management models of wind power supply stations. Finally, training was a priority inside the team and inside our meteorological service where an internal workshop has just taken place.

2. Workstation version of ALADIN/Portugal

2.1 History of the main events

Since 24 of April 2000, IM has a Limited Area Model (LAM) running in operational mode. This NWP model is a local installation of the ALADIN model, hereafter called ALADIN/Portugal.

As a brief history, we refer the following operational changes:

- Apr 2000 → cycle AL09
- Jun 2000 → cycle AL11T2 (CYCORA included)
- Jul 2001 → cycle AL12_bf02 (CYCORA_bis included)
- Apr 2002 → change os the time step (540s to 600s)
- Jun 2006 → cycle AL28T3 with new geographical configurations

Under test:

- Midle 2006 → cycle Al29T2 installed on a PC's cluster
- Midle 2006 → CANARI (AL12)
- Midle 2006 → wind dynamical adaptation (AL12, new climatologies)

2.2 Foreseen activities

- ⇒ **Upgrade of ALADIN/Portugal WS actual operational version (+ levels)**
- ⇒ Validation of RISCON

⇒ Improvement of verification tools
⇒ Start of dynamical adaptation for the wind as support of forest fire prevention and wind power supply management
⇒ Dissemination of coupling fields as forcing of navy oceanographic models (cont.)
⇒ Dissemination of ALADIN/Portugal fields to INM (Spain) (cont.)
⇒ Operationality of CANARI

2.3 Operational version

The operational environment and main characteristics of ALADIN/Portugal are:

Computer characteristics

Oper: DecApha cluster ES40 2/667, 3Gb mem., True 64 UNIX V5,1A; In both systems: DIGITAL F90 and 77 Compilers, native C Compiler

Model characteristics

Spectral hydrostatic model; Hybrid vertical co-ordinates; DF initialisation; Semi-Implicit Semi-Lagrangian two-time-level advection scheme; ISBA surface parametrisation scheme; Initial and lateral boundary conditions from the latest ARPEGE forecast; 6 hour coupling frequency from ARPEGE; Integration domain: 108x108 points; Number of vertical levels: 31; Horizontal resolution: 12,7 km; Time step: 600 s; Integration frequency: twice a day; Forecast range: 48 hours; Output frequency: 1 hour

Available configurations

001, e927, e923 and 701

Graphical software

The METVIEW/MAGICS graphical software (ECMWF) is used to display ALADIN/Portugal products under operational and development environments. Besides, a user-friendly visualisation tool for PC's was designed to display up to a maximum of three overlapped meteorological fields coming from the last two operational runs of the model.

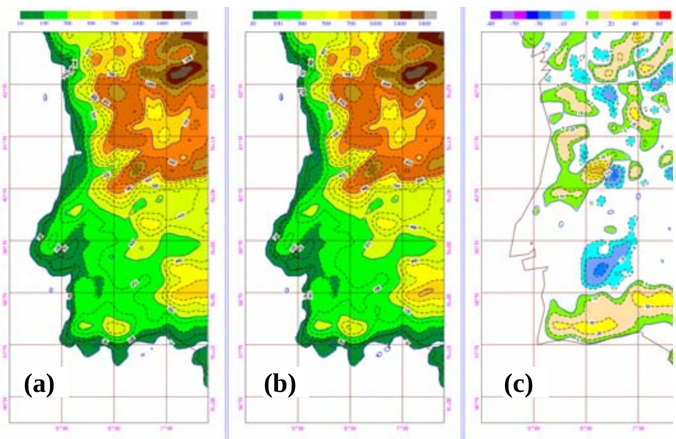


Figure 1 ALADIN/Portugal orography: (a) AL12; (b) AL28; (c) AL28-AL12

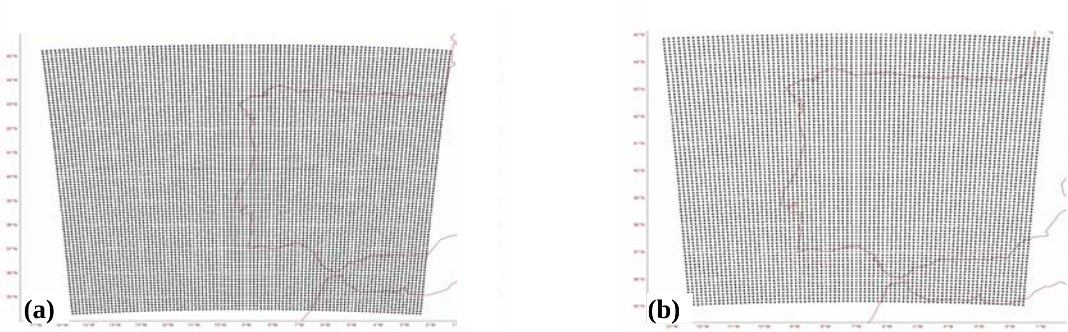


Figure 2 ALADIN/Portugal geographical domain: (a) old operational version; (b) number of points in lat, lon: 85,96; central coordinates: 30,9ºN,350,9ºE; Lat/lon of most SW: 34,76ºN, 345,2ºE; Lat/lon of most NE: 44,84ºN, 356,6ºE; resolution: 0,12º

3. Diagnostic tools

(info: manuel.lopes@meteo.pt)

Since last report, the verification of diagnostic tools has been successfully done. By now, diagnostic tools post-processed from direct model outputs are fully in use on the weather forecasting room for the identification of severe weather situations. The composite of some diagnostic fields was recently created as a risk assessment – RISCON – for heavy precipitation situations. This tool is under validation.

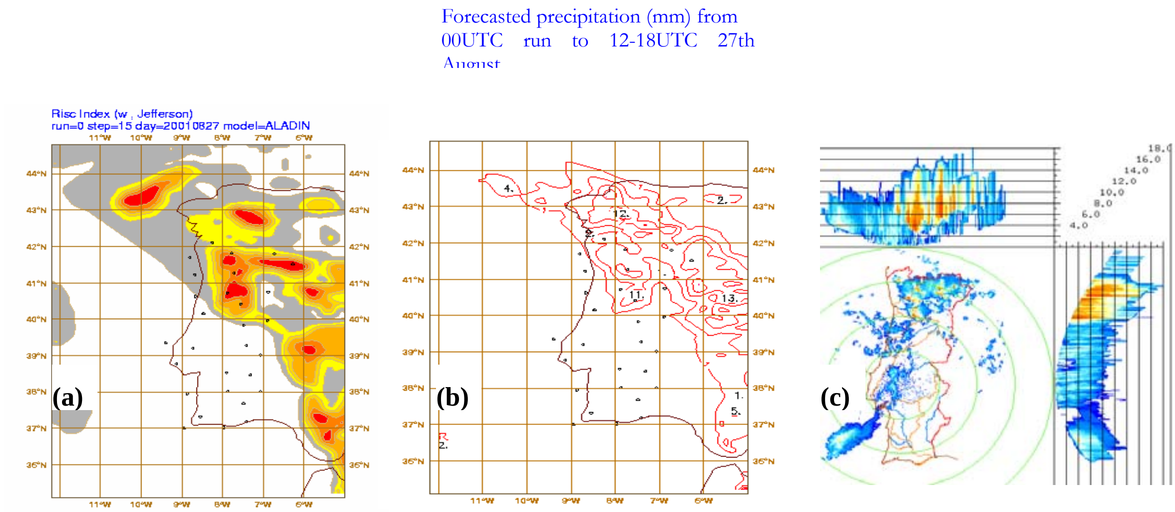
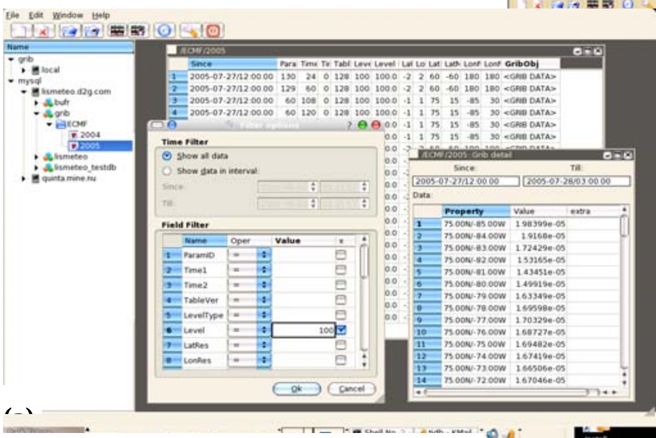


Figure 3 (a) RISCOM a composite of derived fields from ALADIN/Portugal, verified against a (b) reflectivity radar image (14:30UTC) and (c) the accumulated value of forecasted precipitation

4. NWP data archive

(info: joao.simoes@meteo.pt)

Since last report, our TIDB2, an open source Reports Data Base Management System is under test as the heart of operational and development work, being used to store our GRIB production, the coupling files to ALADIN/Portugal and BUFR near-real time observations. An historical archive of ALADIN/Portugal is finally being created. Besides, GRIB data from a local version of MM5 and GRIB data from HIRLAM/Spain is also available and will be verified against ALADIN/Portugal.



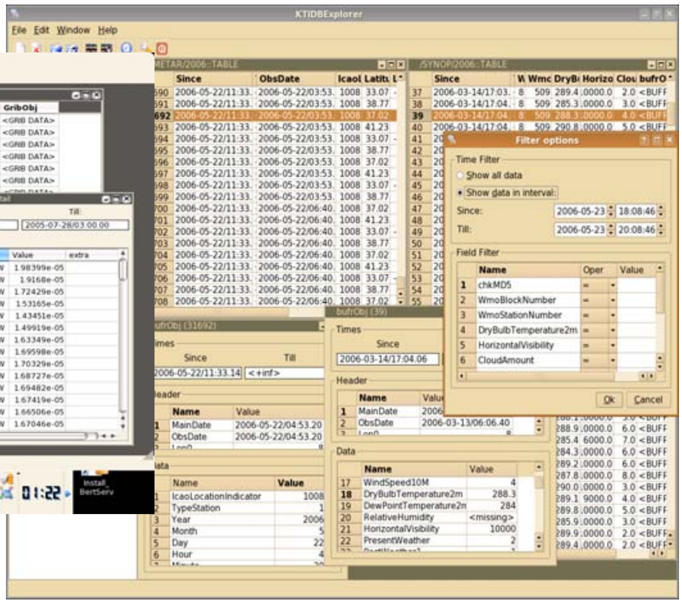


Figure 4 Portuguese NWP archive details: (a) GRIB data; (b) BUFR data

5. Wind dynamical adaptation

(info: margarida.belo@meteo.pt & pedro.sousa@meteo.pt)

Wind dynamical adaptation is being validated for 3 different domains of Portugal. Tests have been performed as case studies under different synoptical situations. The temperature dynamical adaptation has been tried as well. Preliminary conclusions are: results are good for the wind field (in opposition to direct fields); however, incresed value over the direct wind output fields depend on the synoptic situation; we will need an objective verification to understand if results are better with 15 or 26 vertical levels; time step and adaptation step seem to be irrelevant for this tool on the studied cases.

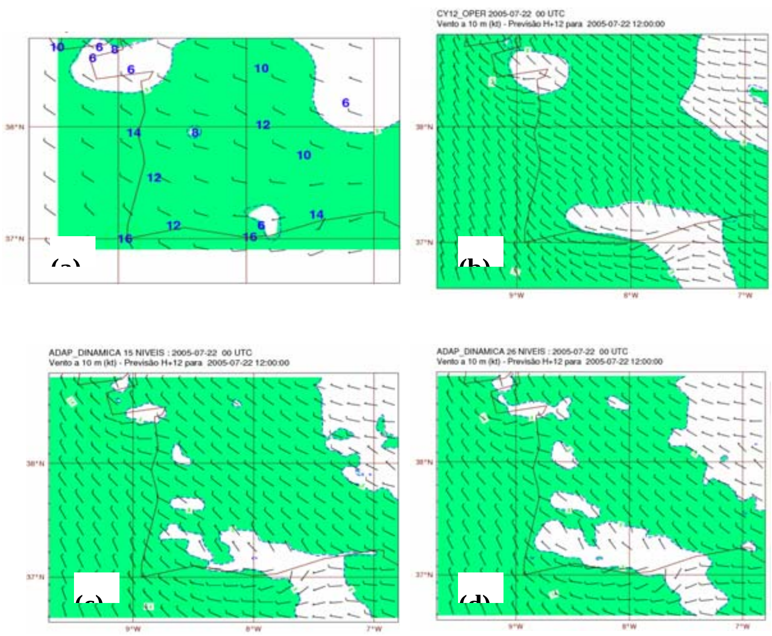


Figure 5 Wind dynamical adaptation in the South of Portugal: (a) obs; (b) oper; (c) 15 levels; (d) 26 levels

6. ALADIN/Portugal on AMD 64 dual core processors

(info: joao.ferreira@meteo.pt)

With the new models generation of the ALADIN community NWP challenges are grown for countries with few resources. The new computer requirements of the community trigger local strategies based on low price solutions[1]. Recently, the PaiPix[2]/IM Linux distribution has been locally implemented as an optimised development environment for NWP activities. This work consisted in creating the appropriate Debian packages and patches for the ECMWF applications using the Debian Sarge distribution and the Linux kernel 2,6. The PaiPix work also integrated the database tools currently being developed at IM, or TIDB2[3]. Although this platform could be directly booted from a DVD (live) it has been locally installed on the hard disk of each AMD64 PC available for each working position. Basic tests with ALADIN source code have now allowed the installation of the local version of ALADIN/Portugal on a private 6 AMD dual core PC cluster under the PaiPix operating system: *gmkpack* has been used on the installation of CY29T2. Foreseen tests will increase power of this cluster with the compatible AMD64 PC's of each NWP working position. At the end conclusions will be taken about the suitable design of the best quality/price computer platform solution for operational and development NWP activities.

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3.14 Romania

LAM ACTIVITIES IN ROMANIA

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1. ALADIN model *(D.Banciu, M.Caian, S.Stefanescu, S. Tascu)*

1.1 <u>Operational Suite</u>

- Computing platform:
  - SUN E4500 server (8-CPU 400GHz, 8*1 GB RAM) for direct integrations and in line post-processing
  - ALPHA DEC 500 workstation (1CPU, 704 MB RAM) for different processing of model output
- Domains (quadratic grid, Lambert projection)
  - ALADIN-Romania: 41 vertical levels, 144x144 grid points (Δx=10 km)
  - ALADIN-Selam: 46 vertical levels, 120x90 grid points (Δx=24 km)
- Characteristics :
  - Model version: Cy28t3
  - Dynamical adaptation mode
  - DFI initialization
  - 2TL Semilagrangian scheme; Δt= 450s for 10km and 900s for 24 km
  - Physics –changes in respect to previous version of the model:
    - radiation scheme (Ritter and Geleyn,1992): more exact computation of the exchange with the surface; maximum overlap for adjacent radiative clouds and climatological profile for ozone
    - ISBA soil and vegetation scheme: prognostic albedo for snow
    - Gravity wave drag: a more consistent definition of wave and form drag components, a lift acting (orthogonal) on the geostrophic wind, usage of mean orography instead of envelope orography
    - Xu-Randall cloudiness formulation
- 4 runs per day :
  - new climatic files and new variables in the coupling files;
  - Arpege LBC; 6hours coupling frequency forecast range: 78h for 00 UTC run, 66h for 12 UTC run, 48h for 06 and 18 UTC run
- Post-processing:
  - in line FPOS on geographical regular grid, every 3 hours (pressure & near surface standard levels output in grib format, routed towards the visualization systems in Bucharest and to the Regional Meteorological Centers)
  - of line FPOS on model grid, every 3 hours

- additional post processing: stability indexes, pseudo-temp, different isotherms height

- Graphical products: meteograms, pseudo – satellite images, cloudiness, 1.5 PV surface height, minimum and maximum temperature, equivalent potential temperature, MSL pressure, accumulated precipitation over 12h and 24 h, height of specific isotherms, stability indexes, etc, available on the intranet ALADIN web page.Statistical adaptation

- Operational verification (common verification project)

- Input for downstream applications: wave models (WAM and VAGROM), sea circulation models, hydrological models

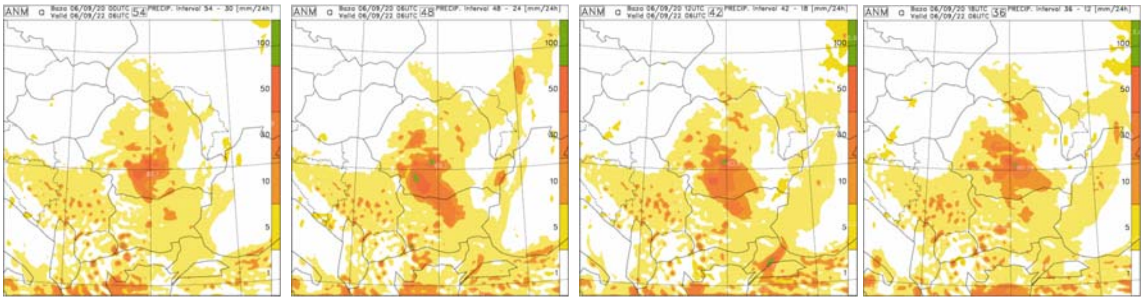


Fig1. *Updated information is available due to the 4 runs: the 24h accumulated precipitations forecasted by 00, 06, 12 and 18 UTC runs.*

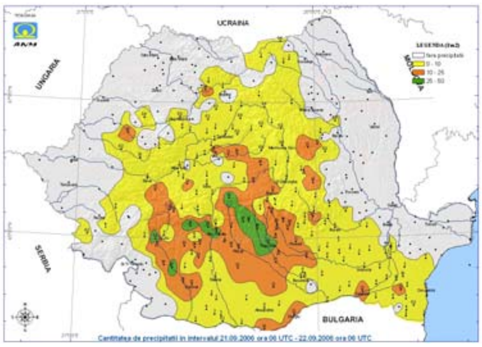


Fig 2. observation-24 h cumulated precipitation valid at 22.092006, 06 UTC

1.2 Research and development *(mainly in the frame of the ALADIN and LIFE projects)*

- Data assimilation: J_b formulation Physical parameterization (3MT approach)
- Scale analysis and tunning of spectral coupling for fine scale process representation
- Case studies (severe weather events)
- Study of the urban boundary layer using an extended database; application for Bucharest region

2. High resolution Regional Model (*I.V.Pescaru, R.Dumitrache, L.Velea, C.Barbu*)

- Workstation version (updated accordingly with DWD version)
- Full operational implementation
- Initial and boundary conditions from GME-DWD
- Rotated geographical grid with 0.25 deg. resolution., 20 vertical levels
- 78 hours forecast range, twice per day

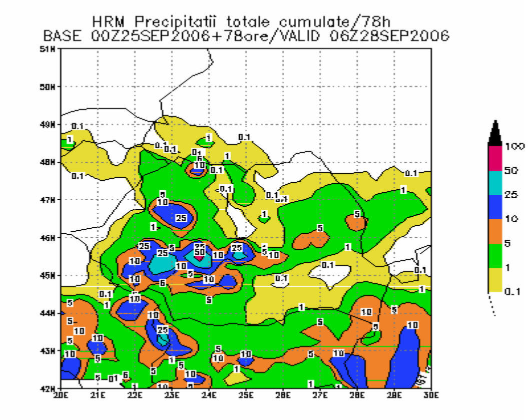
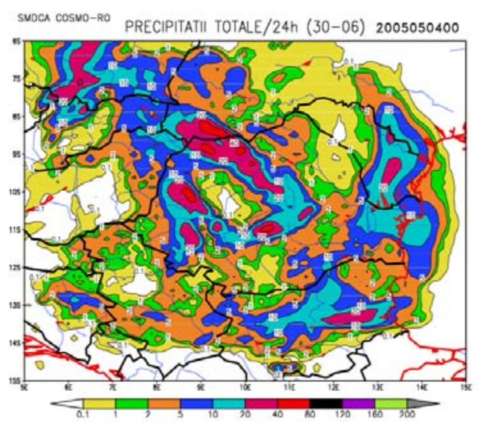


Fig.3 HRM domain, 78 cumulated precipitation forecast

3. Lokal Model (*I.V.Pescaru, R.Dumitrache, L.Velea, C.Barbu*)

<u>3.1 Operational set-up</u>

- 14km horizontal resolution, 35 vertical levels
- Time step: 80s, up to 54 hours
- Initial and boundary layer from GME 00, every 3h
- No data asimilation
- Physical parameterizations: prognostic grid-scale precipitation (2-ice category scheme), convection scheme (Tiedtke), grid-scale clouds, radiation, turbulent fluxes, soil processes
- Operational products: 2m temperature, sea level pressure, 10 m wind speed, wind direction, total precipitation, geopotential at 850, 700, 500 hPa, cloudiness, convective precipitation, grid scale precipitation



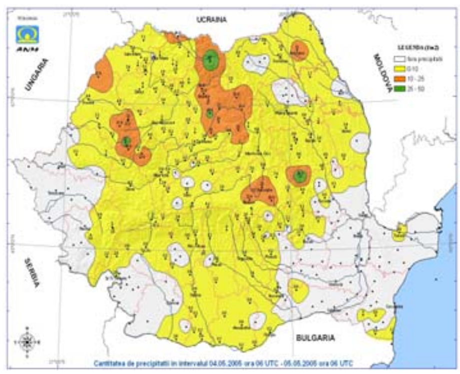


Fig.4 LM domain, 24h cumulated precipitation forecast (left), observed precipitation (right)

<u>3.2 Local developments</u>

- New domain: 301x301 grid points (Δx=7km) and 40 vertical levels
- Design of an operational suite for 4 runs/day (00, 06,12 and 18 UTC)
- Installing of LM code on the new HPC machine
- First tests with LMK for a domain covering Romanian territory
- Data assimilation for SYNOP and AMDAR data
- Improvement of the data visualisation

- Operational verification versus observational data3.3 Develeopments in the frame of COSMO consortium
- Further participations on SIR *(Sequential Importance Resampling filter)* - priority project
- Further participations on QPF *(Tackle deficiencies in precipitation forecasts)*- priority project
- Participations on CV *(Conditional Verification, Extended Common Verification Suite)* - priority project
- Participations on SPRT *(Support Activities)* - priority project **MM5** (I.Ibanescu)

4.1 Operational suite

- Characteristics:
  - non-hydrostatic mm5v3.4 versionhorizontal grid: Arakawa-Lamb B-staggering of the velocity variables with respect to the scalar ssemi-implicit scheme
  - coupling: relaxation technique (Davies, 1976)
  - physics
    - Grell cumulus parameterization
    - simple ice (Dudhia) microphysics
    - no radiation effects on atmosphere; surface radiation active
    - horizontal diffusion of perturbation from the base-state temperature
    - Burk Thompson PBL; Surface force/restore (Blackadar) scheme
- initial and boundary conditions from global model GFS (Global Forecast System, 1.25° resolution) and the sea-surface temperature from NCEP)
- model domain: 80 x 167 points (Δx=15 km, stereographic projection), 25 vertical σ levels, 4 runs per day, up to 24 hours
- Output: pressure & near surface standard levels output in grib format routed towards the visualization systems in Bucharest and to the Regional Meteorological Centers)

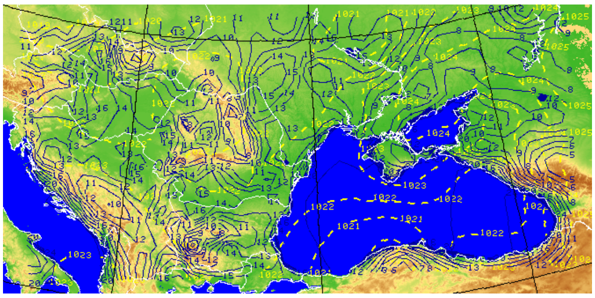


Fig. 5 MM5: MSL pressure and 2m temperature forecast

4.2 Reasearch and developments

Data assimilation of SYNOP and TEMP data using FDDA scheme based on nudging:

- Main objective: asses the the assimilation schme impact on the quality of the regional forecast.

- <u>Experiments</u> : variation of the free parameters of the scheme

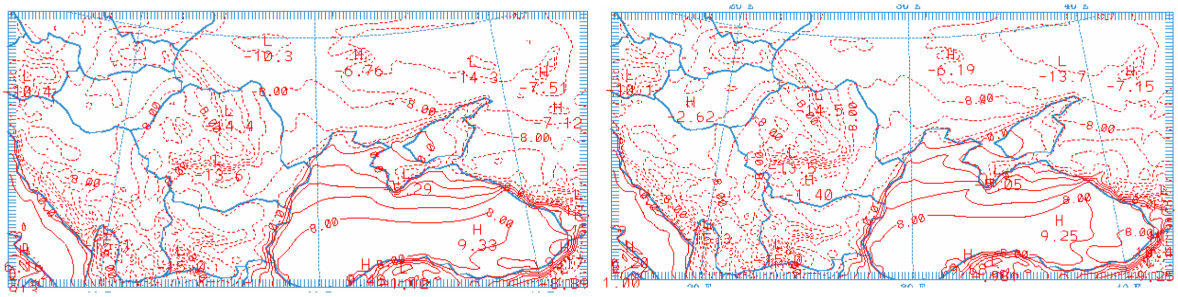


Fig. 6 Temperature, σ level=0,988, without FDDA scheme (left) and with FDDA (right)

5. Regional Climate Modelling (*M.Caian*)

Since September 2005, ensemble regional simulations are operationally carried out for 10 days (daily) and 1 month (weekly) forecast, using REGCM3 (Giorgi, 1993), coupled with the ECMWF, with 10 members ensemble perturbations in initial and lateral boundary conditions.

- For10 days: Dx=10km, 23 σ - levels.
- For 1 month: Dx=50 km, 15 σ levels
- Integration Platform: Altix 350 - 2 ITANIUM processors
- Physical parameterizations: Kiehl (1996) scheme, BATS (Dickinson, 1993) surface exchange parameterization with a complex soil hydrology, Holtslag (1990) non-local boundary layer treatment, Grell convection scheme with Arakawa-Schubert closure, Pall (2001) large-scale precipitation, an interactive Hostetler 1D lake model and Zhong ocean scheme**.**

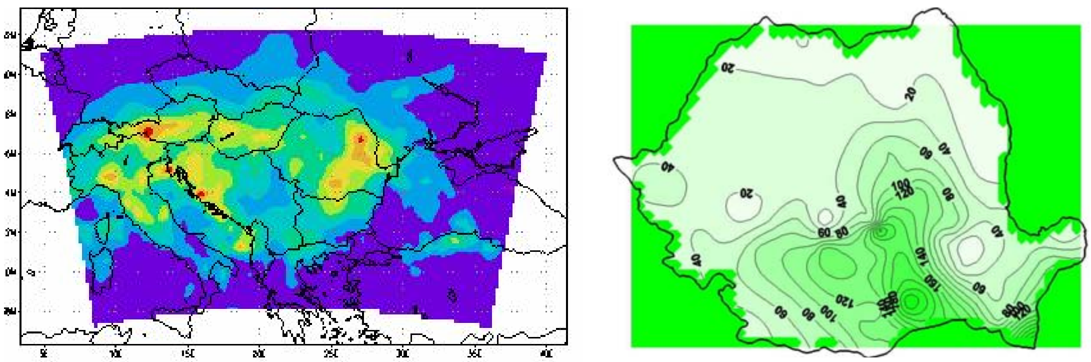


Fig. 7 10 days ensamble simulation (left) versus observations for cumulated precipitations (right).

3.15 Slovakia

NWP activities at Slovak Hydrometeorological Institute (2006)

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Introduction

This report gives a summary of the NWP activities at Slovak Hydrometeorological Institute (SHMU) during the year 2006.

SHMU is a member of ALADIN and LACE Consortia, and its main operational NWP tool is ALADIN model. The 2006 highlights are the coordinated update of the climatological and lateral boundary files (LBC); the prolongation of the integration up to +72h and the change of the backup system for LBC download.

Operational setup

The NWP operational system at SHMU is based on ALADIN model with 9km resolution (domain covering whole RC LACE area), running on the IBM p690 server. The main characteristics of the supercomputer and the ALADIN/SHMU system features are summarized in Tables 1 and 2; the model domain is shown on Figure 1.

ALADIN/SHMU is running four times per day (00, 06, 12 and 18UTC) up to +72h (at 18UTC only up to +60h), with hourly output frequency. The lateral boundary data are provided by the global model ARPEGE, and model runs in the dynamical adaptation mode (no assimilation cycle). The LBC data are downloaded via Internet. Till 31/07/2006 the backup system was the RETIM2000, which was replaced during July 2006 by LBC data transfer via Meteo-France – ECMWF – ZAMG dedicated lines. From ZAMG the Internet connection is used.

ALADIN/SHMU outputs are the main source of information for the forecasters (short-range forecast), and serve as the basic input for other numerous applications and products (automatic point forecast, dispersion model, hydrological model etc.). The data for the PEPS project are operationally provided as well.

The operational suite is based on the in-house developed system of perl scripts and programs that enables on-line monitoring and documentation via the web interface. The suite is non-stop human monitored with the possibility of remote access and intervention in case of emergency. The ALADIN/SHMU outputs are regularly verified: surface parameters at SHMU (point verification plots available on intranet), both surface and upper air parameters via the common ALADIN verification project.

HPC	ARCHIVE
IBM @server pSeries 690	HW:
Type 7040 Model 681	IBM Total Storage 3584
32 CPUs POWER 4+ 1.7GHz	Tape Library (24TB)
32GB RAM Memory	SW:
IBM FAST T600 Storage Server, 1.5TB	IBM Tivoli Storage Manager
AIX 5.2	

Table 1: HPC and archive device characteristics

domain size	2882x2594km; 320 x 288 points in quadratic grid
domain corners	[2.19 W ; 33.99 S] [39.06 E ; 55.63 N]
horizontal resolution	9.0 km
vertical resolution	37 layers
time step	400s
forecast length	72h (60h at 18UTC), hourly output frequency
runs	four times per day (00, 06, 12 and 18UTC)
mode	dynamical adaptation
coupling model	ARPEGE global model
coupling frequency	3hours
code version	AL28T3_czphys

Table 2: ALADIN/SHMU system characteristics

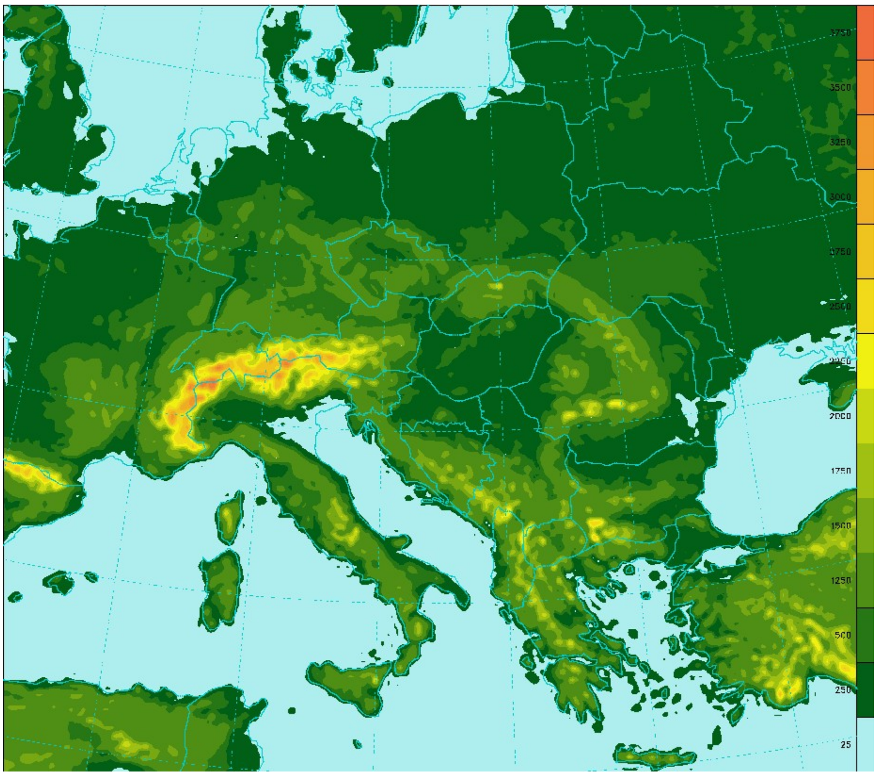


Figure 3: The domain of ALADIN/SHMU with model orography

Operational suite upgrades

- 23/01/2006 (ARPEGE) coordinated upgrade of LBC/CLIM files
- 27/03/2006 forecast up to +72h
- June 2006 reorganisation of operational tasks due to ARPEGE rescheduling and upgrade
- 24/07/2006 new LBC backup via ECMWF/ZAMG
- 01/08/2006 end of RETIM2000 LBC backup

Research and developments

<u>Activities in frame of the FLOODMED project</u>

The FLOODMED project (floodmed.chi.civil.ntua.gr) aims at the Monitoring, forecasting and best practices for FLOOD Mitigation and Prevention in the CADSES region. Within FLOODMED SHMU plans to consolidate its flood forecasting and warning technological link in order to complete the hydro-meteorological forecasting cascade and to implement the methodology of rainfall and discharges real-time prediction. Concerning the meteorological part, some modules of the INCA nowcasting system (Integrated Nowcasting through Comprehensive Analysis, developed at ZAMG) were installed, the tests with new gravity wave drag and lift parameterizations using mean orography, and with the (pseudo)assimilation using blending by digital filter were performed.

Figure 2: 24h cumulated precipitation. From left to right operational run, experimental run with mean orography and new GWD, observations

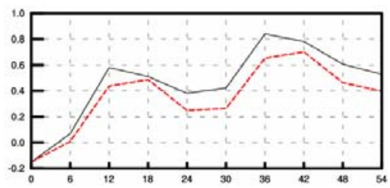


Figure 3: The temperature BIAS at 850hPa. Operational forecast in black solid , experimental run with red dashed line.

- **Mean orography with new gravity wave drag and lift parameterizations** brought improvements of the precipitation distribution – smaller unrealistic orographicaly enhanced maxima (Figure 2), significantly better scores for higher precipitation amounts (above 30mm/24h), improvement of temperature scores at 2m and 850 hPa (Figure 3).

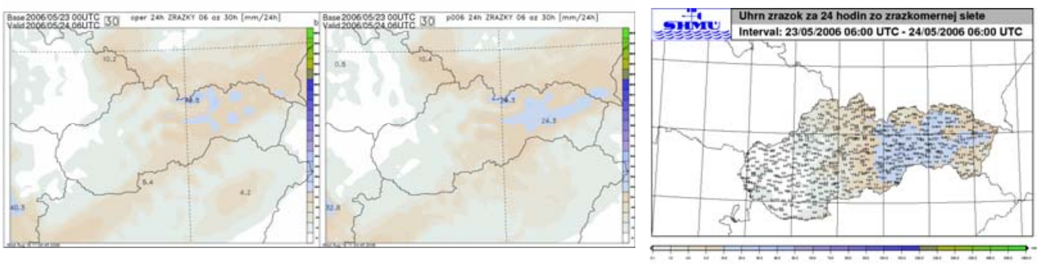


Figure 2: 24h cumulated precipitation. From left to right operational run, experimental run with mean orography and new GWD, observations.

- **Blending by digital filter** pseudoassimilation technique gave very encouraging results after preliminary tests. The operational forecast with the initial conditions obtained in dynamical adaptation mode did not capture light precipitation in western part of Slovakia. With initial conditions prepared by blending the precipitation patterns were correct, as illustrated on Figure 4.

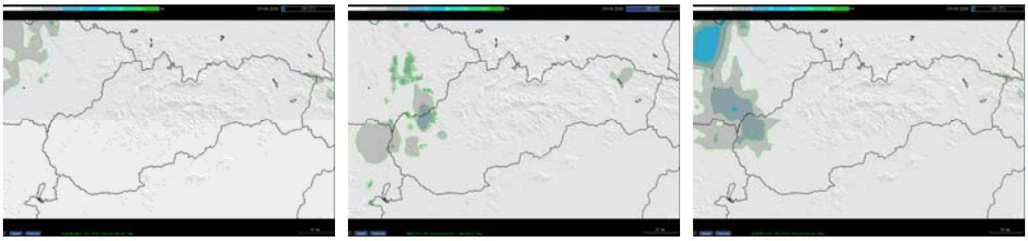


Figure 4: 6h forecast of 1h cumulated precipitation. From left to right operational forecast, analysis, forecast started from blended initial conditions. Note that the precipitation predicted by blended initial conditions in Bohemia occurred in reality, just they could not be visualized due to software limitations.

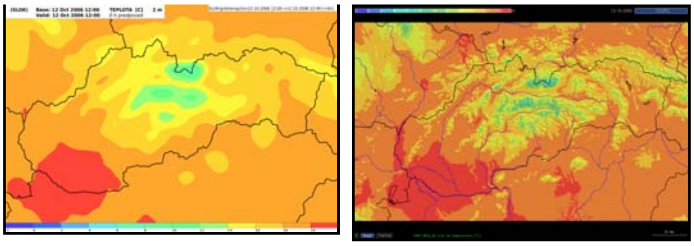


Figure 5: The analysis of 2m temperature. Left ALADIN, right INCA

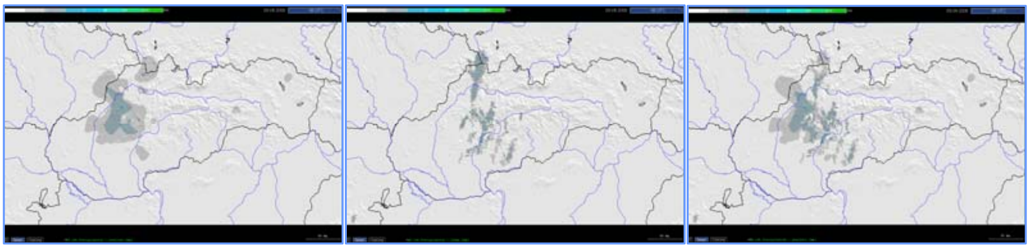


Figure 6: The precipitation analysis. Automatic stations network (left), radar (middle), composite (right)

- INCA enables to combine local observations with the forecast of NWP model to provide analysis and nowcasting of meteorological parameters over 1km grid (2m temperature on Fig. 5, precipitation on Fig. 6).

<u>R&D issues tackled – mainly during the research stays - within the ALADIN & LACE projects</u>

- Vertical Finite Elements in NH ALADIN
- Combination of large scale initial conditions uncertainty with small scale initial perturbations obtained by breeding method using blending procedure
- Study of semi-Lagrangian interpolators in idelized framework
- Diagnostic tool for lateral coupling
- Assimilation of SEVIRI data
- Quality control for radar reflectivity observations
- Study of the new mixing length formulation in the ALARO-3MT physical parameterization
- Technical work on ALARO-0 code
- Technical work on phasing and optimisation of the model source code

<u>Other local research and development work</u>

- New cloud optical properties for ALARO-0 scheme (continuation)

3.16 Slovenia

Limited Area Modelling Activities in Slovenia

Neva Pristov, Mark Žagar, Jure Cedilnik, Rahela Žabkar

Environmental Agency of Slovenia is a partner in the international projects ALADIN and RC LACE. Our group's operational task is to prepare three times a day a limited area numerical forecast using ALADIN model. We take the leading role in the common ALADIN verification project for the objective verification on the synoptic scale. A web service (http://www.arso.gov.si/verification) is available to the NWP community.

Our group has contributed to some parts of physics parameterizations (in ALARO-0) and performed some tests and validation. Some additional options for improvement of model-forecaster relationship in case of a very high resolution model have been investigated. In particular, the temporal and spatial distributions of upscaled precipitation fields were treated as a new forecast parameter. The colleague at the University in Ljubljana is dealing with air pollution and has performed a trajectory analysis on the basis of ALADIN wind fields.

Operational ALADIN application (neva.pristov@rzs-hm.si)

Our current ALADIN model configuration (started in June 2003 on a Linux cluster system) mainly stayed unchanged in 2006. For details about configuration and computer system please see the 2005 report. Main novelty is the prolongation of the length of the integration to 72 hours for both 00 and 12 runs in April 2006. Another 48-hours integration starting at 18 UTC with reduced number of post-processed products was added in June.

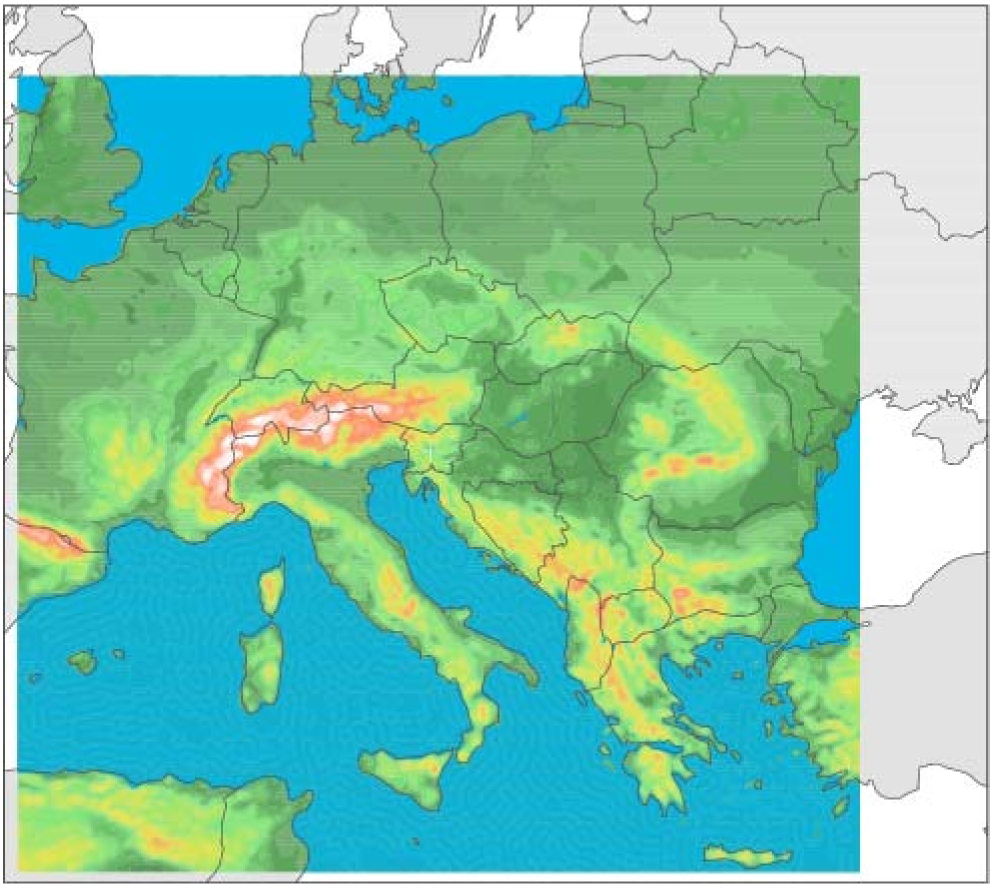


Figure 1: The domain of ALADIN/SI (colored) is smaller than the domain with initial and coupling fields prepared from ARPEGE model.

First experiments with new physical parameterization (jure.cedilnik@rzs-hm.si)

The following additions to the physical parameterization in ALADIN have been introduced (also known as ALARO-0) and tested:

- microphysical scheme with 5 water species (water vapour, cloud water, cloud ice, rain and snow) and statistical treatment of rain and snow
- modified radiation scheme including an optical cloud model, a more complex statistical method for the weighting function between max and min inter-layer gaseous exchange terms .
- simplified prognostic TKE scheme (simplified TKE equation with only advection and Newtonian relaxation towards the diagnosed state compensating for the 4 remaining terms of full TKE equation)

First results indicate improvement in precipitation distribution. The advection of hydrometeors is reducing the peak values of precipitation, thus smoothing the fields. There is less correlation of precipitation pattern with orography that was a traditional problem so far (with a much too strong emphasis on precipitation on the windward side and too dry conditions on leeward side of mountain ridges).

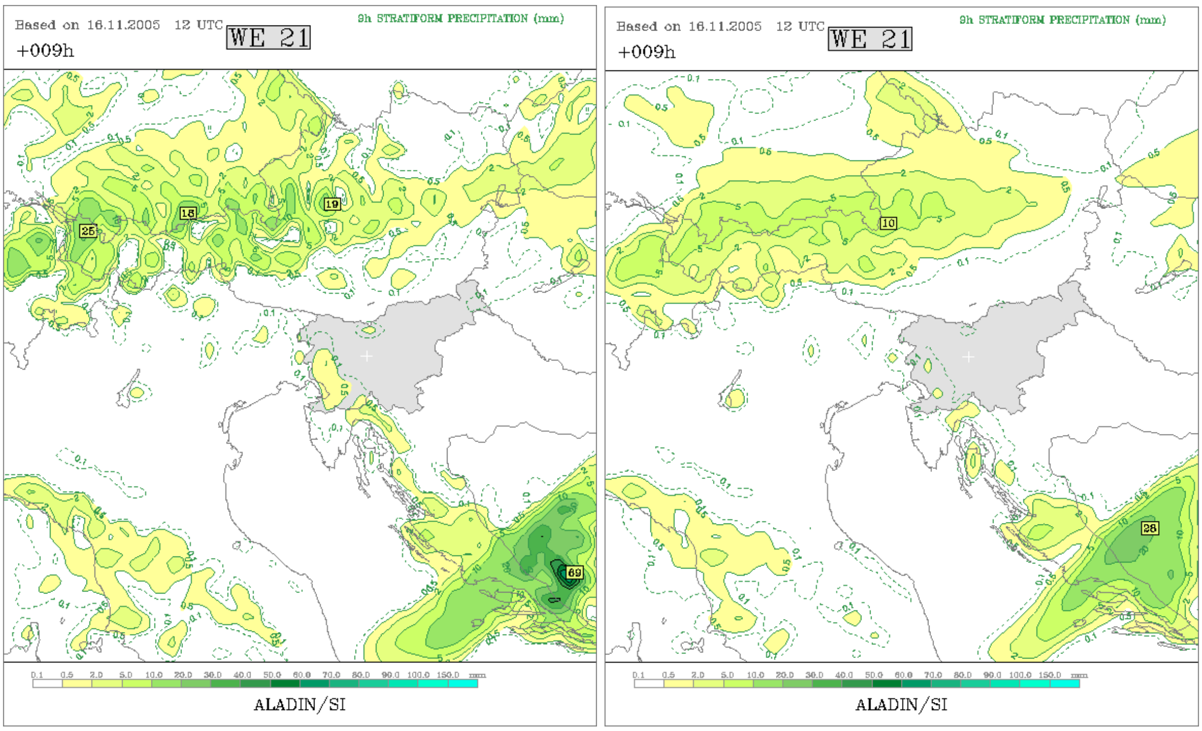


Figure 2: 9-hours accumulated stratiform precipitation from the reference model (operational ALADIN/SI, left) and ALARO-0 (right) are shown.

Some considerations on very high resolution (VHR) modelling of precipitation (mark.zagar@gov.si)

Everybody has great expectations from future operational NWP models, running at resolutions of 2km and above. It is, however, not trivial to show how accurate those predictions, performed with such tools as for example AROME model, really are. Dealing with spatial and temporal variability is important.

Two possible approaches for use and verification of VHR precipitation are: i) new measures of temporal variability for application and verification against frequent measurements (1 minute), for example standard deviation, standard deviation normalized by maximal intensity, duration of intensity above threshold, etc. and ii) upscaling, where sub-grid information is analyzed and presented.

In *Figure 3* the observed precipitation intensity with 5 minute frequency and the same parameter modelled with AROME at 2.5km and ALADIN at 9.5km resolution, is presented for one geographic location. To estimate similarity between the two is the challenge. Some measures enabling objective comparison between the model and observations have been tried:

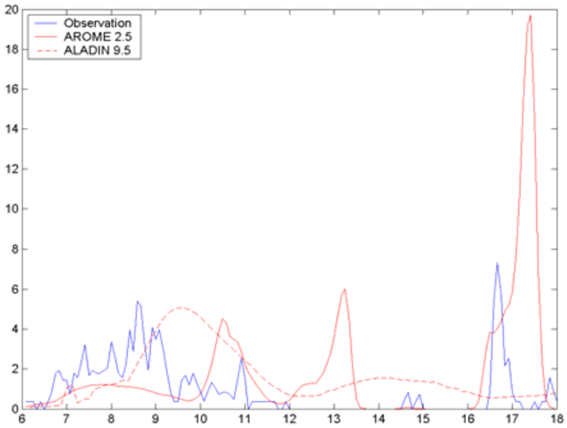


Figure 3: Observed and modeled precipitation intensity for one geographic location between 6 and 18 UTC on 27 April 2006.

- duration above 90% of maximum intensity between 15-18 (Obs. 0.08h, AROME 0.17h); usually indicates a non-steady rainfall,
- idem, except for 25% (Obs. 0.4h, AROME 0.75h); an estimation of the event character - large values meaning steady rainfall,
- standard deviation normalized by mean intensity (Obs. 2.18, AROME 1.50),
- std. deviation normalized by maximum intensity (Obs. 0.24, AROME 0.28).

An example of upscaling is presented in *Figure 4*, where we choose to plot the standard deviation of AROME rainfall within a 9.5km square (from around 16 values) normalized by the mean AROME rainfall within a 9.5km square. Large values indicate that rainfall occurred as localized showers, while small values indicate large-scale rain.

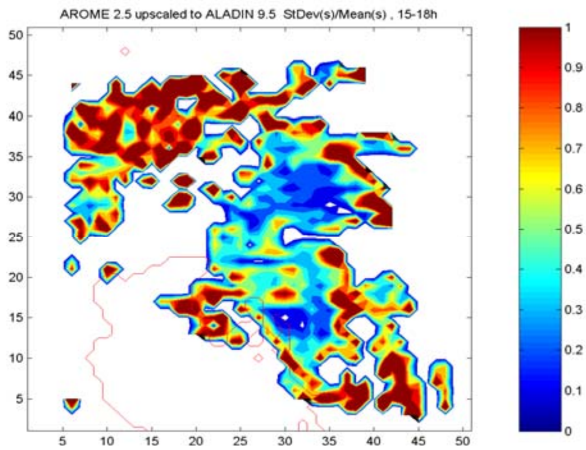


Figure 4: Standard deviation (in mm) of the precipitation accumulation between 15 and 18 UTC on 27 April 2006, simulated by AROME model at 2.5km resolution, upscaled to 9.5km.

High-resolution trajectory analysis of pollution cases (rahela.zabkar@fmf.uni-lj.si)

In Slovenia, tropospheric ozone concentrations occasionally exceed thresholds of 180 μg/m^3 per 1 h. Maxima occur most often in urban and coastal regions. To determine the origins of ozone and its precursors, high resolution backward trajectories for selected days with ozone concentrations above 165 μg/m^3 were calculated for four measuring sites in Slovenia. Beside the number density also the residential time, average time, average height and average velocity fields were calculated for trajectories reaching measuring sites at different heights above the ground.

Description of the method:

- computation of 96-hour 3D backward trajectories with Flextra (http://www.forst.uni-muenchen.de/EXT/LST/METEO/stohl/flextra.html),
- input ALADIN/SI fields,

- resolution of meteorological fields: 9.5 km spatial, every 1 hour,
- time period: days with measured maximum hourly ozone concentration above 165μg/m^3 at least at one measuring site in Slovenia in months from April to September 2004 and 2005,
- hours of arrival: 10, 12, 14, 16, 18, 20 UTC,
- arrival level: 50 and 200 m above ground, 1000, 1500, 3000 and 5500 m above mean sea level.

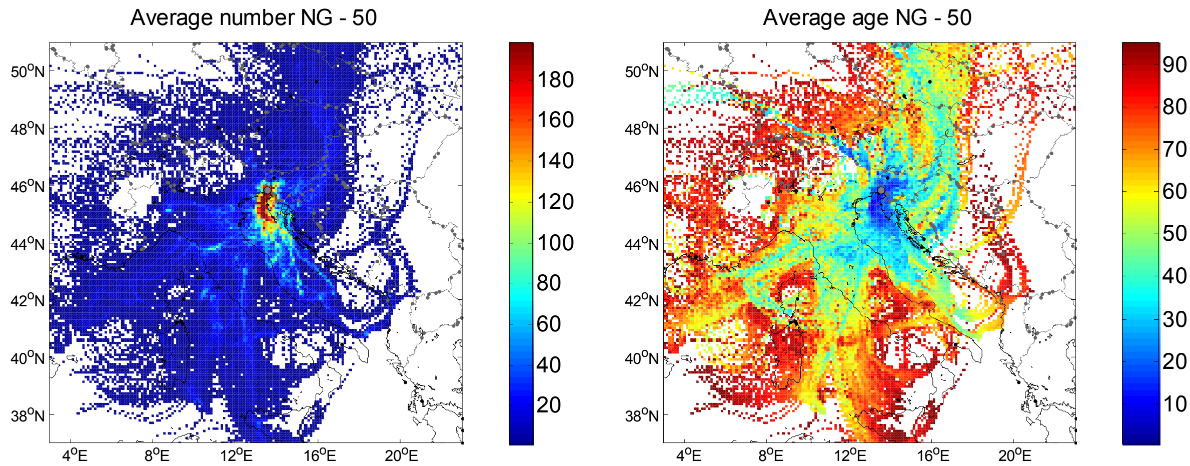


Figure 5: The average number density (left) and the average age of a trajectory in grid box (hours) of polluted trajectories arriving at Nova Gorica 50 m above the ground.

Results of analysis made for polluted backward trajectories arriving at Nova Gorica 50 m above ground are presented on Figure 5. Areas of high trajectory average number density indicate possible source regions of ozone precursors. Other analysis, among them average trajectory age, confirm that in Nova Gorica case with ozone and it's precursors polluted air masses most probably originate from the Gulf of Trieste and the west Coast of Istria. Similarly, main source regions of photochemical pollution were determined also for some other measuring sites in Slovenia.

3.17 Spain

NWP activities in INM

Bartolomé Orfila
Modelling area, INM

1. INTRODUCCIÓN

The NWP operational and research activities undertaken during 2005 and 2006 in INM are summarized below. Operational activities are mainly related to the implementation of HIRLAM 6.1.4 to the CRAY X1E, upgraded to the final configuration in 2005. Recent verification results are included as well as one example of verification against the precipitation measured by the INM pluviometric network. The wave model WAM has also been ported to the new platform. One ocean current model uses as input the HIRLAM HNR. Research activities cover those in Dynamics, Data Assimilation, Physical parametrizations and Predictability. A detailed description of the Short Range Ensemble Prediction System under development in INM is given in the contribution 'Recent experiences with the INM-multimodel EPS scheme' in this volume.

2. OPERATIONAL ACTIVITIES

2.1 Computer resources.

The characteristics of the CRAY X1E, whose final acceptance took place in December 2005 are:

- 15 nodes, 8 MSP's each node
- 4 SSP's each MSP
- 320 Gb memory
- 2.3 TF peak performance

The machine is quite compact as it can be seen in fig. 1, which also includes the scheme of the multistream processors (MSP).

2.2 HIRLAM operational in INM.

The current HIRLAM version installed in the CRAY X1E is the 6.1.4 one working in three configurations at the areas shown in fig 2 and fig 3. Non rotated areas are also included corresponding to versions still running in the CRAY SV1. The configuration and resolutions are:

- ONR
  - 0.16 deg latxlon, 40 levels
  - 72 hours forecast, 4 times a day
  - 3DVAR
  - BC's from ECMWF
- HNR and CNN
  - 0.05 deg latxlon, 40 levels
  - 36 hours forecast, 4 times a day
  - 3DVAR
  - BC's from ONR

The integration areas of the WAM wave operational model are displayed in fig 4 to 7. ESEOO is an Spanish interdepartamental project for operational oceanography. Its ain is to run operationally an ocean limited area model to prepare current forecast. Table I presents the block diagramme of the project. It uses as input the HIRLAM HNR outputs and It is planned it eventually uses the HIRALD outputs.

2.3 Verification.

From the INM WEB page http://www.inm.es, -> Meteorological information

->numerical models-> HIRLAM -> verification, it is possible to visualize seasonal and monthly verifications against observations. Examples of it are also shown in fig 8. The monthly comparison of ONR and HNR model for mean sea level pressure during the June August 2006 period is given in fig.9. Hit rate vs false alarm rate for precipitation forecasts verified after a set of thresholds against the observations at the full INM pluviometric network for the period 1996-2004 are presented in fig. 10.

3. RESEARCH RELATED ACTIVITIES.

A list of INM research related activities in Data Assimilation, Dynamics and Physical parametrization follow:

3.1 Data assimilation

Assimilation of GPS data. It has been found that increasing the number of GPS sites improves model precipitation.

Soil moisture analysis comparison between reference system and 1DVar version (ELDAS project.

Assimilation of VADS winds from INM radar network. Non conclusive results have been obtained.

3.2 Contribution to building HIRALD

3.2.1. Dynamics

Improvement of the treatment of the map factor in the ALADIN semimplicit scheme. Testing of the rotated Mercator coordinate options, with a view to efficiency for large domains

Nesting of grids after the fig.11 scheme. The outer model (11 km) is hydrostatic. The high resolution domain model (2.5 km grid size runs in non-hydrostatic mode)

Validation of mesoscale models on test cases.

3.2.2 Physics

Testing together in HIRALD the three major parts of the physical parametrization from the HIRLAM model: turbulence, condensation/convection and radiation.

The new moist scheme based on Kain-Fritsch convection and Rasch-Kristjannsson large scale condensation has been implemented into the HIRLAM reference system. It improves precipitation over Iberia. Vector optimization is in progress in the CRAY X1E.

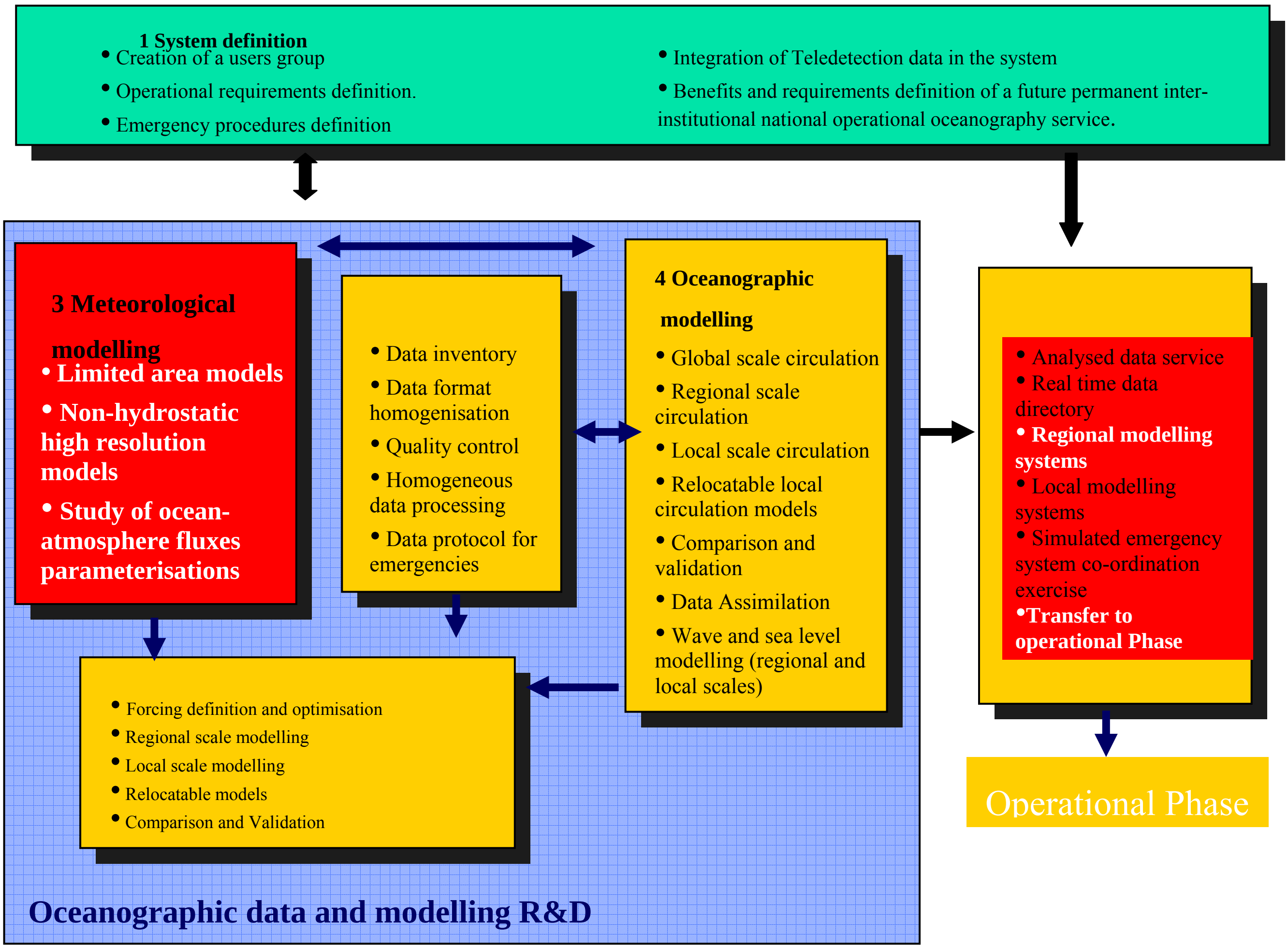
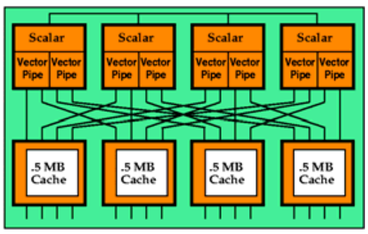


Table I

NWP Activities at INM



Cray X1e MSP

Figure 1

ONR integration area

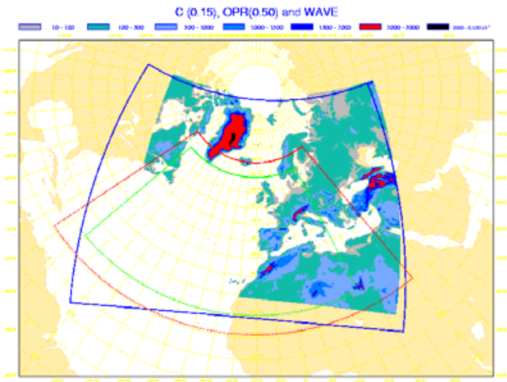


Figure 2

HNR – CNN integration areas

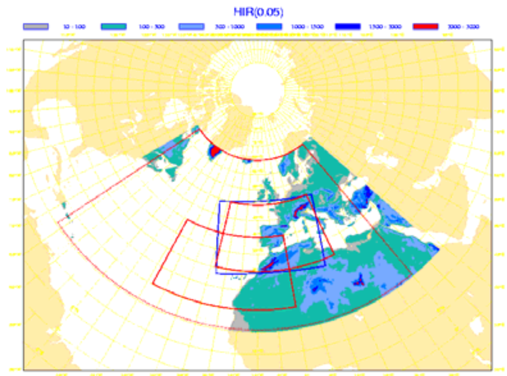


Figure 3

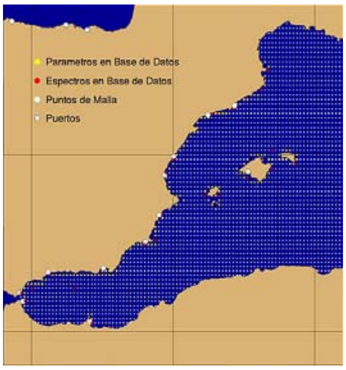


Figure 4

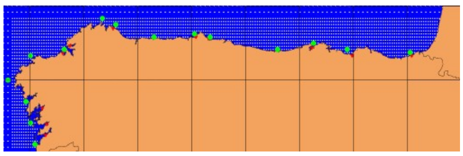


Figure 5

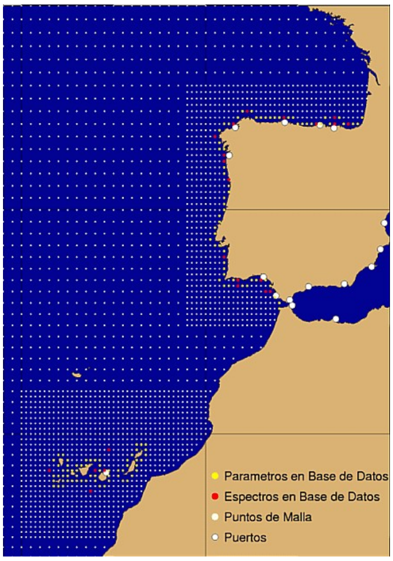


Figure 6

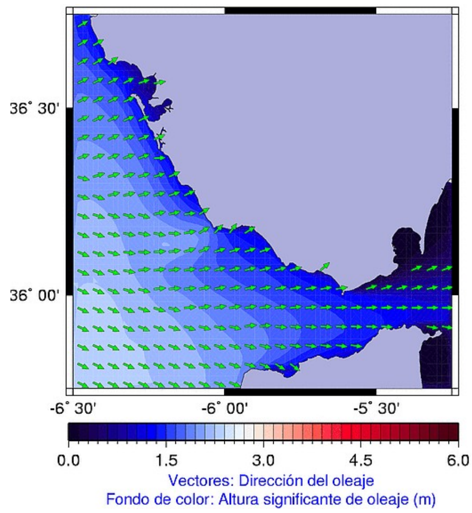


Figure 7

MSLP June-August 2006

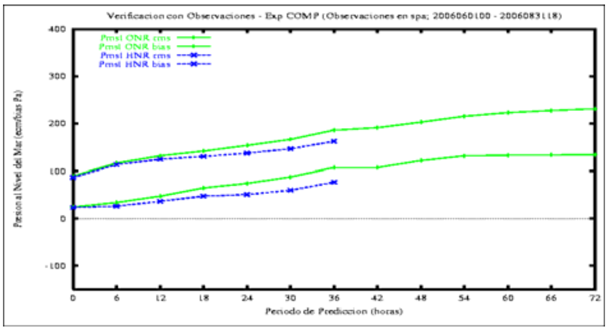


Figure 8

Geopotential June-August 2006

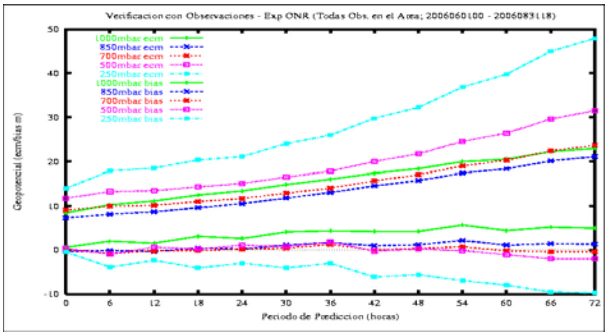


Figure 9

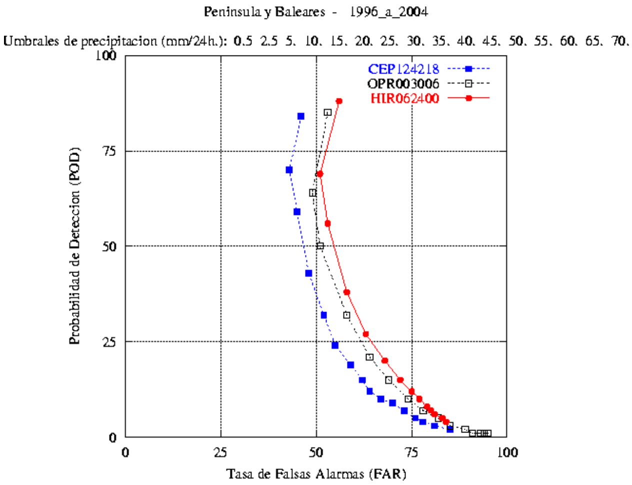


Figure 10

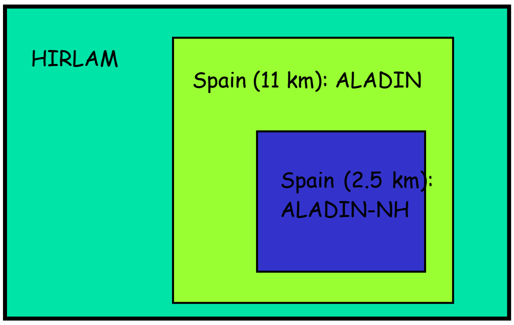


Figure 11

3.18 Sweden

NATIONAL STATUS REPORT on Operational NWP at the Swedish Meteorological and Hydrological Institute

Lars Meuller, SMHI

Introduction

The Swedish Meteorological and Hydrological Institute (SMHI) is a member of the HIRLAM project. All research and development in the area of numerical weather prediction are done within the HIRLAM project. This report will only describe the operational HIRLAM at SMHI.

Computer system

HIRLAM at SMHI is run on the computer resources at the National Supercomputer Center (NSC) at Linköping University.

SMHI operational models, HIRLAM and an oceanographic model, HIROMB, are run on a dedicated cluster, BLIXT, that consists of:

- Linux operating system.
- 83 nodes.
- dual Intel Xeon processors, 3.2 GHz, 2 GB memory.
- Infiniband Interconnect.
- PCI Express bus.
- Scali MPI connect.
- Intel compilers.
- 5.6 TB disc.

SMHI has for a long time also, for backup reasons, been running a complete model setup also at another computer. If BLIXT is down the production can easily be switched to BRIS by just issuing one operator command.

BRIS is also a Linux cluster:

- home made by NSC.
- 16 nodes.
- dual Intel Xeon processors, 2.2 GHz, 1GB memory.
- Scali interconnect.
- ScaMPI.
- Intel compilers.
- 1 TB disc.

HIRLAM system

SMHI runs a HIRLAM model with version number 6.3.5 which in our case means a system with:

- 3D-VAR analysis
- DFI initialization
- ISBA surface scheme
- CBR turbulence

- Kain-Fritsch convection
- Rasch-Kristjansson large scale

SMHI at present runs 3 operational suites of the HIRLAM analysis and forecast model with different horizontal resolutions, C22, E11 and G05. They all have their own separate 6 hour data assimilation cycle.

Domain:	**C22**:	**E11**	**G05**
Horizontal resolution:	0.2×0.2° (22 km)	0.1×0.1° (11 km)	0.05×0.05° (5.5 km)
Nr of gridpoints:	306x306	256x288	294x441
Vertical levels:	40	60	60
Boundaries:	ECMWF 3 hourly	ECMWF 3 hourly	HIRLAM E11 every hour
S.L time step:	10 min	5 min	2.5 min
Forecast length:	+48 hour	+72 hour	+24 hour

E11 is run to +72 hour to give input to a LEPS (Lagged EPS) system

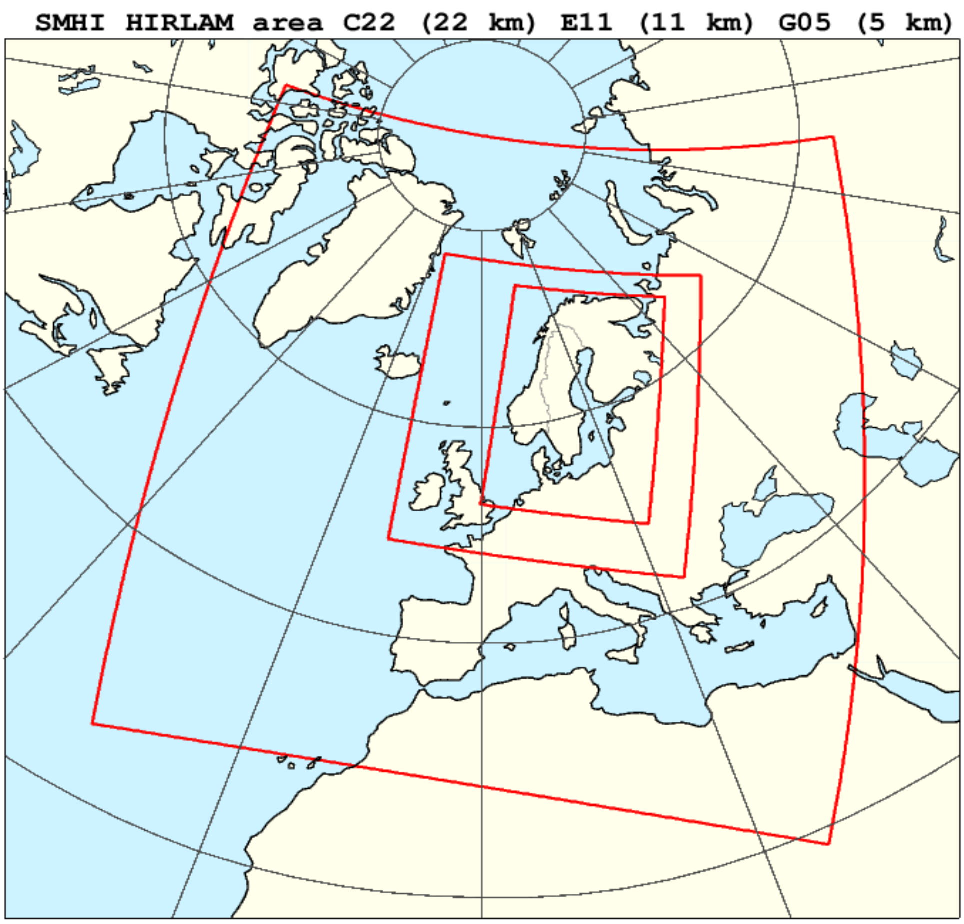


Fig 1. SMHI HIRLAM horizontal domain's

Model input

The observations used for the analysis are SYNOP, SYNOP SHIP, TEMP, PILOT, BUOY, AIREP and AMDAR.

Additional AMDAR in BUFR form from GTS are also used.

ATOVS AMSU-A radiances (EARS) over sea used in HIRLAM C22

A version of ECMWF observational pre processing system is used to convert from WMO alphanumeric code forms to BUFR.

In SMHI version of HIRLAM, the ice-cover and the sea surface temperatures in the Baltic Sea comes from the oceanographic HIROMB model.

Operational schedule

Every 3 hour a preliminary HIRLAM analysis is run with a cut-off time of +0h25m using mainly SYNOPs. The output is mainly used for the automated analysis of weather charts.

Every 6 hour E11 is started with a cut-off time for observations of +1 h 15 min. After E11 have ended G05 is started.

Every 6 hour C22 is started with a cut-off time for observations of +2 hours.

The clock time for all the runs to complete is about 40 – 50 minutes.

Model output files are written every hour and sent to SMHI.

Events

- Dec 2005 - Ice + SST from the oceanographic model HIROMB (instead of BOBA ice model and pseudo-SST from manually analysed SST maps)
- Jan 2006 - 27 additional nodes on BLIXT
- Feb 2006

  - new, extended, domain, G05, for the 5.5 km resolution setup

  - boundaries from the new BC suite at ECMWF

  - incremental DFI instead of full DFI

Plans

- Starting of preoperational HIRLAM 4D-VAR analysis (200612)
- 4D-VAR is planned to be operational 200604
- The 5.5 km G05 suite will be extended to +48 hours
- The C22 and E11 suites are planned to be replaced by a new suite with 0.1 degree (11 km) horizontal resolution, 60 levels, on roughly the C22 area. 200611
- Replacement of the old BRIS cluster with a new 200611. The new cluster will be designed to be able to run 4D-VAR on the new domain
- HIRLAM has now started a cooperation with the ALADIN group to develop a non-hydrostatic model and a version of that has been tested at SMHI and very soon near-real time runs will be started

3.19 Switzerland

Numerical Weather Prediction at MeteoSwiss

Philippe A.J. Steiner[1], Pirmin Kaufmann[1], Oliver Marchand[1] and Donat Perler[2]

[1] Federal Office of Meteorology and Climatology (MeteoSwiss), Zurich, Switzerland
[2] Swiss Federal Institute of Technology, Department of Computer Science, Zurich, Switzerland

Current operational configuration

System run schedule and forecast ranges

The actual short-range forecasting system of MeteoSwiss is the alpine Model aLMo, the Swiss implementation of the non-hydrostatic Local Model developed by COSMO (the Consortium for Small-Scale Modelling currently composed of the national weather services of Germany, Switzerland, Italy, Greece and Poland – see www.cosmo-model.org). It is operational at MeteoSwiss since April 2001, with IFS frames as lateral boundary conditions provided by the ECMWF BC special project.

A continuous assimilation cycle has been implemented, currently ingesting mainly conventional observations. A main assimilation suite has been defined with a cut-off time larger than 4 hours, implemented with 3-hour assimilation runs; an additional short cut-off suite is also calculated to provide initial conditions for the operational forecasts and for other near-real time requirements. Two daily 72 hours forecasts are calculated, based on the 00 and the 12 UTC analyses, with a 90 minutes cut-off time. The time critical forecast products are available in about 105 minutes.

A sophisticated set of scripts controls the whole operational suite, and allows for a very high reliability of the system, with less than 1% of the forecasts requiring manual intervention. This same environment is also used to run parallel suites, to validate proposed modifications to the system, and to facilitate experimentation by the modelling group.

The computing resources and expertise are provided by the Swiss National Supercomputing Centre (CSCS, see www.cscs.ch). aLMo is calculated on a single node 16 processors NEC SX-5, and achieves a sustained performance of 29 GFlops, or more than 25% of the peak performance of the machine. Pre- and post-processing needs are covered by a 8 processors SGI O3200 front-end platform; a large multi-terabytes long term storage is used for archiving purposes, and a 100 Mbit/s link connects the MeteoSwiss main building with the CSCS (on the other side of the Alps!). A migration on a new platform Cray XT3 using some nodes of an IBM-SP5 for pre- and post-processing is in preparation.

Data assimilation, objective analysis and initialization

Data assimilation with aLMo is based on the nudging or Newtonian relaxation method, where the atmospheric fields are forced towards direct observations at the observation time. Balance terms are also included: (1) hydrostatic temperature increments balancing near-surface pressure analysis increments, (2) geostrophic wind increments balancing near-surface pressure analysis increments, (3) upper-air pressure increments balancing total analysis increments hydrostatically. A simple quality control using observation increments thresholds is in action.

Currently, conventional observations are assimilated: synop/ship/buoys (surface pressure, 2m humidity for the lowest model level, 10m wind for stations below 100 m above msl), temp/pilot (wind, temperature and humidity profiles) and airep/amdar (wind, temperature) as well as wind profiler data. Typical 24 h assimilation at MeteoSwiss ingests about 120 vertical soundings, about 8000 upper-air observations, about 28000 surface observations and about

1000 wind profiles. Assimilation of GPS derived integrated water vapour and of wind profiles from VAD and SODAR are being developed.

A new snow analysis derived from MSG satellites combined with dense observations will be used the first time for the winter 2006/2007. All other surface and soil model fields are obtained by interpolating IFS analysis. These fields are updated twice daily by direct insertion in the assimilation cycle. Finally, the ozone and vegetation fields are based on climatic values.

In addition to the MARS retrieving system, the full ECMWF decoding, quality control and database software are used on the front end machine. New observation types are stored in a new file system offering database-like functions.

Model

A thorough description of the Local Model itself can be found on the COSMO web site. aLMo is a primitive equation model, non-hydrostatic, fully compressible, with no scale approximations. The prognostic variables are the pressure perturbation, the cartesian wind components, the temperature, the specific humidity, the liquid water content, cloud ice, rain, snow and turbulent kinetic energy.

The model equations are formulated on a rotated latitude/longitude Arakawa C-grid, with generalized terrain-following height coordinate and Lorenz vertical staggering. Finite difference second order spatial discretization is applied, and time integration is based on a 3 time levels split explicit method. Fourth order linear horizontal diffusion with an orographic limiter is in action. Rayleigh-damping is applied in the upper layers.

aLMo is calculated on a 385x325 mesh, with a 1/16° mesh size (about 7 km), on a domain covering most of Western Europe. In the vertical a 45 layers configuration is used; the vertical resolution in the lowest 2 km of the atmosphere is about 100 m. The main time step is 40 seconds.

Development of the future high resolution model of MeteoSwiss

The development of the high resolution model aLMo2 is progressing according to plans. It will be pre-operational in 2007 and operational in 2008. This new model will get its boundary conditions from the actual aLMo, have a mesh size about 1/50°~2.2km and its domain of 520 x 350 grid points with 60 levels will be centred on the Alps. In addition to the current operational forecasts, it will produce 8 times a day a 18 hours forecast.

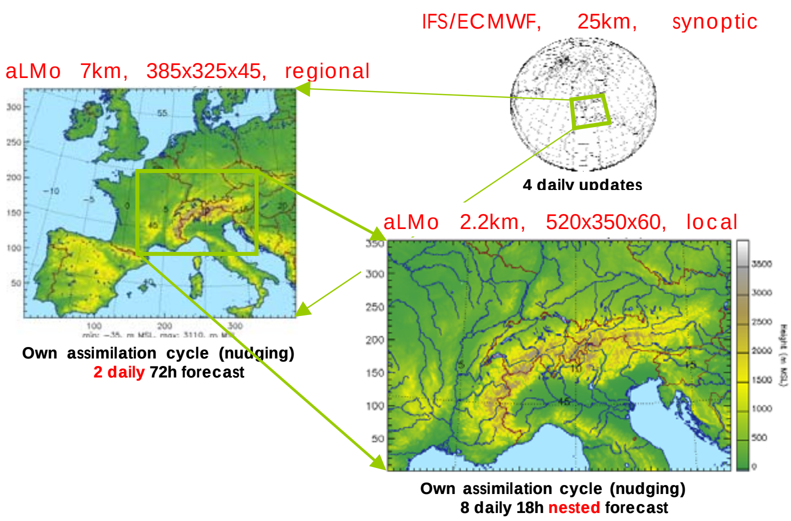


Figure 1 future NWP system of MeteoSwiss

The setup is based on a new numerical kernel, 2-timelevel 3rd order Runge-Kutta, with a main time step of about 15 seconds. It uses improved physics with e.g. new schemes for graupel, improved turbulence and shallow convection (the deep convection being resolved), as well as with implementation of the topographic effects on radiation. A new multi-layer soil model with 8 layers for energy and 6 for moisture is used; moisture is updated every 24h form IFS in the lowest levels. A measurement driven soil moisture analysis is being implemented, as well as a mosaic approach will enable to use the same soil for aLMo and aLMo2. A snow analysis at 2.2 km refined with the HRV channel of MSG will be used.

It will have its own assimilation cycle with a rapid update cycle having a short cut-off of 60 min. Additional measurements will be assimilated like radar data using the 2-dimension latent heat nudging scheme and the analysis of the boundary layer will be improved through a better usage of surface measurements and of the lower part of wind profiles.

Validation of aLMo2 winds (P. Kaufmann and O. Marchand)

The local dispersion modeling for the Swiss emergency response system for nuclear hazards is currently based on a set of pre-determined wind fields (WINDBANK). The project “Centrale Nucléaire et Météorologie” (CN-MET) has the purpose to replace the current system with a system based directly on aLMo2. The comparison between aLMo2 and a temporal, dense wind measurement network during the WINDBANK campaigns conducted by the Paul Scherrer Institute is a first step to establish the validity of this concept. The main advantage of aLMo2 over the current system, to deliver fully three-dimensional wind information over the whole volume of interest, does however not come into play in this comparison.

The mean error and standard deviation of the error were calculated for hourly values of 72 days. In addition, histograms and scatter-plots for direction and speed serve to compare model and measurements. Directions at speeds smaller than 3 ms^{-1} were filtered out. When looking at the results, one should keep in mind that the WINDBANK observations were point-observations, whereas the aLMo2 forecasts represent a spatial mean over a whole grid cell, and thus a perfect match cannot be expected.

The wind direction bias (ME) is well below 10° and the wind speed bias far below 1 ms^{-1} for all model versions. The direction bias is significantly larger for the coarser-resolution aLMo analysis than for the others (below 5°, see Table 1). In regards of standard deviation of the error (STDE), the wind direction of the high-resolution aLMo2 analysis is clearly better. The wind speed standard deviation however does not show a significant difference (Table 1).

	wind direction (°)			wind speed (ms^{-1})		
	ME	STDE	N	ME	STDE	N
aLMo analysis	8.26	53.	15326	0.36	1.743	44155
aLMo2 analysis	3.23	47.	23032	0.17	1.749	64280
aLMo2 19-24h	3.53	57.	5424	0.09	1.789	16347

Table 1: Bias and standard deviation of the difference model minus measurement, for wind direction and wind speed.

The wind direction histograms for the WINDBANK measurement show a channeling of the flow over the Swiss plateau (e.g. Fig. 2a). This channeling is underestimated by aLMo2 at many stations (Fig. 2b). In the single-station scatter plots, this results in vertical bands (Fig. 2c), caused by channeled flow that shows widely varying wind directions in the model.

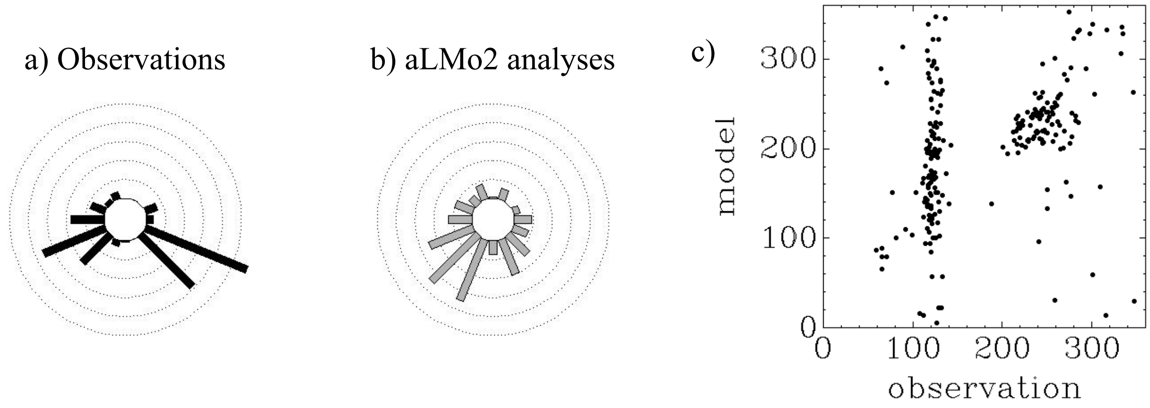


Figure 2: Wind-direction: Histograms of a) observations and b) aLMo analyses; c) scatter-plot model versus observation (Site: Plaffeien)

aLMo2 tends to over-predict the wind speed in general, and specifically at locally influenced, sheltered stations. Only few mountain-top stations are underestimated, because the grid-average in the model does not represent the local acceleration effect of a mountain top. Overall, the dynamic range of the wind speed in aLMo2 seems too narrow.

This study is a first screening of the quality of aLMo2 near-surface winds. It shows that the fine-grid aLMo2 is at least as good as or systematically better than the coarser-resolution aLMo. One can conclude that aLMo2 has the potential to replace the current statistic tool for simulating local wind.

Thunderstorm–prediction from aLMo output using boosting (D. Perler and O. Marchand)

Introduction

We present a new approach to weather model output interpretation. We use Adaptive Boosting [FS97] to train a set of simple base classifiers with historical data from weather model output, SYNOP messages and lightning data. The resulting overall method then interprets weather model forecast output and generates for each timestep and gridpoint a certainty measure between zero and one for how likely a thunderstorm is to occur. We compare resulting cross–validation scores to existing systems and approaches and find that we can significantly improve the POD to 72% and FAR to 34%. The method has several advantages over existing approaches, namely expert systems and other statistical methods:

- the superior cross–validation results,
- the short learning time (less than 10 minutes sequential runtime for our experiments on a standard PC),
- the possibility to interpret the results of the underlying statistical analysis, and,
- the simplicity to add any predictors to a running system.

Boosting

Boosting is a new approach to machine learning that employs the power of many simple classification schemes called base classifiers. These base classifiers then take a vote for the final classification[2]. Depending on the training performance the base classifiers receive a

[2] Much like the Ask-the-audience option (joker of the game) in the popular TV “Who wants to be a millionaire?”

weight of importance in the voting procedure. The method is simple and the output contains parameters in the original physical space (temperature, pressure, …), rather than “artificial” values common in neural networks or principal component analysis. The resulting classification does not only indicate the class, but also a measure for the certainty of the machine’s decision.

Experiments

We carried out some experiments for training boosting to identify thunderstorms in aLMo output. For this purpose we trained 600 base classifiers with approximately 150.000 training instances covering each full hour in the year 2005. Data was retrieved from SYNOP stations and the Météorage automatic lightning detection system for 80 stations in Switzerland. Altogether 55 predictants, both from direct model output and derived quantities, such as many convective potential stability indices like CAPE were used. In 5–fold cross validation we obtained the above mentioned scores with variances of the order of 10^{-3}. Details about this work can be found in [PM07].

References

[FS97] Y. Freund and R. Shapire. A decision-theoretic generalization of online learning and an application to boosting. Journal of Computer and System Science, 55:119–139, 1997.

[PM07] D. Perler and O. Marchand. Thunderstrom-prediction from model output using boosting. Weather and Forecasting, 2007, submitted.

4 Scientific presentations on numerics and coupling numerics/physics

4.1 F. Vana: Dynamics & Coupling, ALADIN and LACE progress report for 2005-2006

Dynamics & Coupling

ALADIN and LACE progress report for 2005-2006

Filip Váňa

The research on the field of modelling in the ALADIN consortia and its sub-part RC LACE is specially focussed to the effects playing important role at high resolution. Among the others the NH dynamic, non-linear horizontal diffusion, better physics/dynamics coupling and LBC treatment were of a primary interest during period between October 2005 and September 2006.

In the following a brief summary of activities and progress on the area of dynamics and LBC coupling is given.

Diffusive chimney in NH dynamics

(Work of M. Vörös, R. Brožková and F. Váňa (all LACE))

It is known advantage of spectral models that an implicit linear horizontal diffusion of any order can be computed at low cost in spectral space. A typical time step is organized in the way that the spectral space computation is applied at the end of a given time step. This imply that contributions from the spectral horizontal diffusion are not available by the end of the grid-point computation within a given times-step. This fact plays important role for the evaluation of the bottom boundary condition of the NH dynamics at the end of the grid-point computation. The absence of the spectral diffusion contribution create vertically constant inconsistency above orographic features being known as diffusive chimneys.

To get rid of this unfavorable feature one has basically following three options:

- To switch off horizontal diffusion,
- to introduce extra spectral computation or
- to compute horizontal diffusion at the grid-point space.

It is evident that none of the solutions seems to be ideal. Horizontal diffusion is generally considered as profitable feature with respect to the model score. Logically the first option is not really the expected direction to avoid the problem. Second solution would imply significant difficulty to the code efficiency and maintenance. Finally the third option then reduces the benefit of having spectral model. There is no reason to compute horizontal diffusion at the grid-point space for higher model cost when and just limited order when it is almost trivial to have it from spectral space. The only justification to accept a grid-point horizontal diffusion in a spectral model seems to happen in a case that such diffusion brings additional extra skills with respect to the spectral one, for example being non-linear. This is already the case in ALADIN/ARPEGE model where relatively cheap, stable and non-linear diffusion is available. This diffusion acting through the semi-Lagrangian interpolation is known as the SLHD. Having it already available in the model the default spectral horizontal diffusion is replaced by the SLHD for the NH dynamics.

Unfortunately due to the given discretization of the ALADIN/ARPEGE/IFS model, the grid-point part of the SLHD needs some residual support of a spectral diffusion applied to the 3D flow components being represented by vorticity, divergence and d variable (function of the vertical divergence) in spectral space. As shown by figure (1) this supporting spectral diffusion diffusion is still responsible for some residual chimney. This chimney is significantly reduced with respect to the original chimney from the spectral diffusion but it is still too strong to be accepted as the problem solution. By further study it has been found that the major contributor to the chimney is the spectral diffusion to the d variable. Although a spectral diffusion of d must be present in the model, it was found sufficient to significantly reduce it. As it is demonstrated by the last bottom right frame of figure (1) when the spectral diffusion of d is reduced by factor 15 (with respect to the default SLHD tuning), the chimney effect almost disappears. Surprisingly the real atmospheric performance seems to show almost no difference in performance from the original SLHD settings.

Non-isothermal SI background

(Work of J. Vivoda (LACE))

In order to further stabilize the dynamic core of the model, the possibility to replace the constant profile of the linear model by a more general one with temperatures ($T^*(\eta)$, $T_a^*(\eta)$ being function of the model levels was studied.

As found this is generally possible. However it complicates the setup part (as the $T^*(\eta)$, $T_a^*(\eta)$ has to fulfil some criteria). It also makes the Helmholtz solver to become the two equations system. As the analyze for optimal profile of $T^*(\eta)$ and $T_a^*(\eta)$ becomes complicated it is missing for the moment. With the estimate empirically found the new scheme is fully comparable in terms of stability and results quality with the original isothermal case. It seems unless precise analyze is available to derive the best SI background we are not able to profit from this study in terms of better stability. However this work out-came to a more general model code for the Helmholtz solver. This is considered as a very important base for the implementation of the vertical finite element discretization to the NH dynamics.

Vertical Finite Element scheme in ALADIN-NH dynamics

(Work of J. Vivoda (LACE))

In order to have comparable NH dynamics to the hydrostatic one it has been decided to adapt the existing VFE scheme of hydrostatic of IFS to the ALADIN/ARPEGE NH dynamics. The initial idea was to preserve the existing reached NH status and to extend it by the VFE option. This decision implies to add to the existing non-local vertical integrals also derivative operators. The first version following the mentioned design of the NH VFE has been coded (thanks to outcomes from the previous topic). It causes 2-3% extra CPU requirements and fits the stability analysis. It is however subjected by a noise.

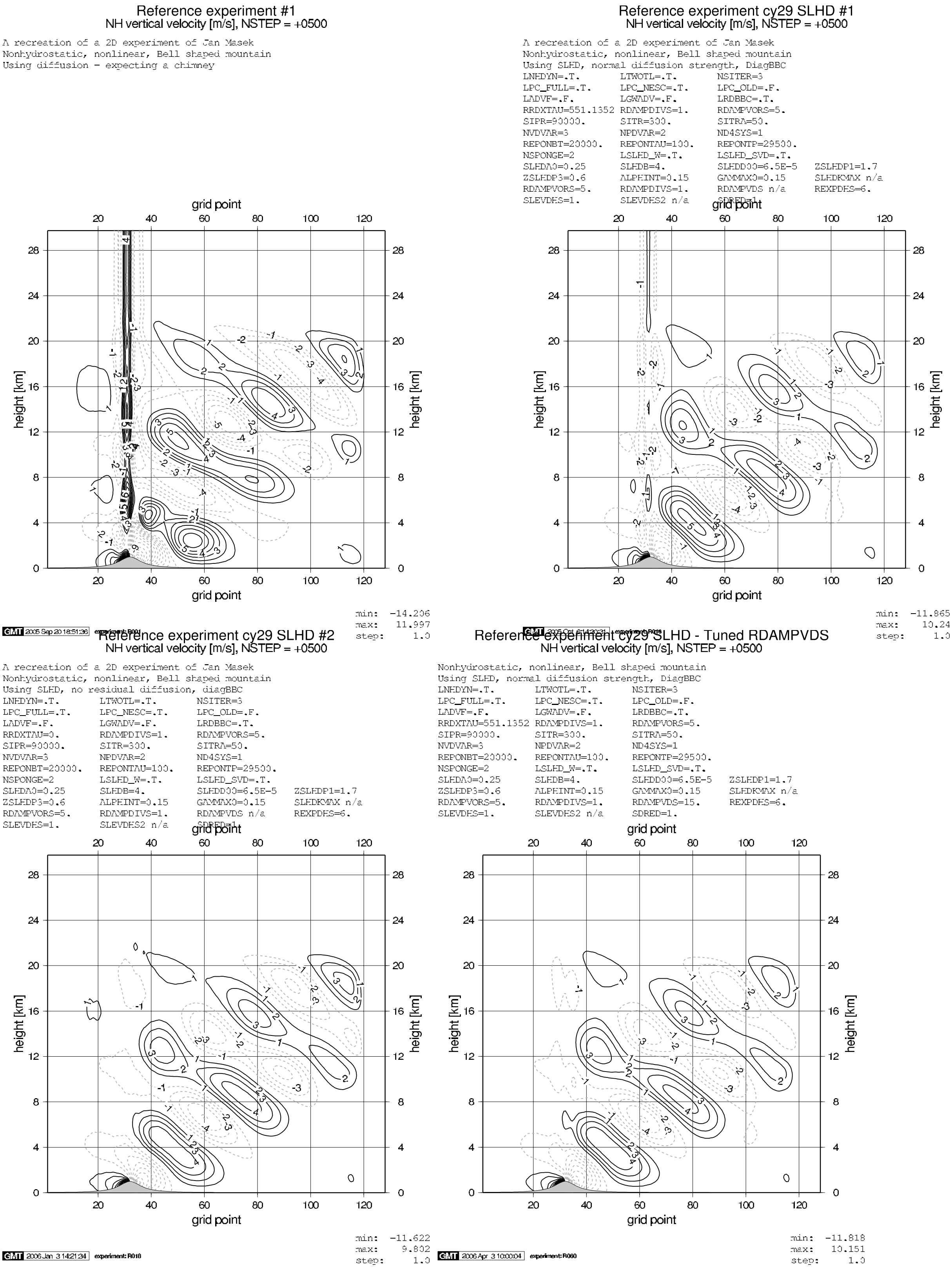


Figure 1: 2D non-linear flow experiment with default spectral diffusion (upper left), default SLHD settings (upper right), the grid-point part of SLHD only (bottom left) and the new SLHD tuning (bottom right).

Further investigation proved that it comes from the discretization of the d prognostic variable. At the moment the source of the noise has to be detected as it is still believed that the originally planned design of the VFE is possible.

New interpolators for SL advection

(Work of J. Mašek and F. Váňa (both LACE))

The known weakness of the SLHD diffusion are worse conservative properties of the model. It is caused by the controlled degradation by the accurate semi-Lagrangian interpolation by more damping interpolation. It has been found out that simple replacement of the Lagrangian cubic interpolator used as the basic SL interpolator by a interpolator of higher accuracy is not really improving the existing situation. The reduced background diffusivity has to be compensated in such a case by more active SLHD. Like that the interpolator is more degraded which at the end leads to the original conservation property of the whole interpolation.

To improve this situation, a new generic interpolator is proposed for the SL scheme. In case of uniform mesh, such interpolator can be defined as:

$$\begin{aligned} F(x,y) &= w_0(x)y_0 + w_1(x)y_1 \\ &\quad + w_1(1-x)y_2 + w_0(1-x)y_3 \quad , \end{aligned}$$

where

$$\begin{aligned} w_0(x) &= a_1 x + a_2 x^2 - (a_1 + a_2)x^3 \\ w_1(x) &= 1 + (a_2 - 1)x - (3a_1 + 4a_2)x^2 + 3(a_1 + a_2)x^3 \quad . \end{aligned}$$

Here a_1 and a_2 are the parameters controlling the properties of the interpolation. The modified SLHD then can act directly through the two parameters maintaining the 2^{nd} order accuracy for the interpolation while playing with its damping properties with respect to the small scales (short waves represented by the model).

TL/AD code of the ALADIN semi-Lagrangian scheme

(Work of F. Váňa (LACE))

In order to have 4DVAR with a sufficient performance, an efficient advection scheme has to be designed for the TL/AD model. As the SL advection offers fairly longer time-step than the other schemes, it is logical and desirable to derive its TL/AD code for ALADIN. The design of the TL/AD ALADIN SL code should ideally follow the already existing code available for the IFS/ARPEGE global model. This rather technical work has just two specific areas to be solved: First it is the design of the lateral boundary condition treatment as this is something not existing in the global model version. Second it is desirable to preserve the reached high sophistication of code (in terms of its computer efficiency) also in case of the LAM geometry.

At the moment the TL code is fully available in ALADIN (entering the common cycle at the level of CY31T2). The AD code is to be finished before the end of year 2006 entering the common source code in CY32T0.

Revisited interface for physics-dynamics coupling

(Work of R. Hamdi and P. Termonia (both Belgium))

The way the physics is coupled to the dynamics has significant influence on the stability and the accuracy of the model results. In order to diagnose the existing situation (and alternatively propose a better way of coupling) a simple 1D model simulations were performed based on the framework proposed by Staniforth, Wood and Côté (2002) extended in a way to take into account the spectral nature of the model and the difference between the real atmosphere and the background of the linearisation. To organize time step with respect to the physics-dynamics coupling there are four degrees of freedom:

- coupling of the physics parameterization before or after the explicit part of the dynamics;
- coupling of the physics to the dynamics at different positions (in space and time with respect to dynamics) on the SL trajectory;
- computing the physics parameterization in a parallel or a fractional manner;
- coupling the physics to the dynamics by updating the model state and using this for the dynamics, or computing the physics tendency and the dynamics tendencies separately and adding them to get the update, in other words to treat the physics/dynamics in a fractional or a sequential manner.

The special attention has been focused to the current physics coupling of the ALADIN/ARPEGE comparing it with the way it is used at ECMWF (SLAVEPP).

The results of this yet theoretical study are as follows:

- The physics should be always coupled to the air parcel along the SL trajectory. Otherwise the properties (stability and accuracy) depend on the advection.
- The structure of ALADIN/ARPEGE is more stable but less accurate in case of a single diffuse process compared to the SLAVEPP way.
- In parallel physics coupling one should couple the diffusive processes last. (Note that the study was restricted to the explicit to implicit treatments of physics, no over-implicitness was considered.)
- The ALADIN/ARPEGE way corrupts the steady state solution, so it may create some climatic drift. The presence of a strong vertical diffusion may correct this. However, SLAVEPP as studied in the 1D model does not corrupt the steady state.
- In the ALADIN/ARPEGE framework, coupling the physics after the dynamics gives a more accurate treatment of the steady state. This might be beneficial for climate simulations.
- If the physics were treated in a semi-implicit way (in the ALADIN/ARPEGE) the same stability and also second-order accuracy as in the SLAVEPP approach can be achieved. This is maybe not practical but nevertheless a nice surprise because it means that (in the 1D model) one could get the same benefits of the time step reorganization, by an internal reorganization of the physics.

The specific conclusions for the ALADIN/ARPEGE physics-dynamics coupling are: In case of stability, there is no better alternative to the existing way of coupling. Hence the only way to further stabilize the time step (from the physics point of view) is to stabilize the physics itself. The ALADIN/ARPEGE way offers just first order accuracy interface with drifted steady state. Reorganization of the time step is expected to yield benefits.

Transparent LBCs in spectral models

(Work of F. Voitus (France) and P. Termonia (Belgium))

The way a general transparent LBCs are treated requires their imposing in grid-point space. This forces the need to do it in an explicit way even in spectral SI models. Logically a deeper question can be studied: " Can one impose LBCs independently from the details of the dynamics integration scheme?"

This has been studied in the framework of SISL 2TL shallow water model. As the boundary scheme can be only explicit the sub-stepping method was used to achieve sufficient stability. However the results were surprisingly good. By this treatment the transparent LBCs were implemented up to wave Courant number 5.6. (Extra research is going on to get higher Courant numbers.) This treatment replaces the LBC problem to the data-flow: extra large stencil is needed near to the boundary.

4.2 J. Masek: Idealized tests of ALADIN-NH dynamical kernel at very high resolution

Idealized tests of ALADIN-NH dynamical kernel at very high resolution
(comparison of hydrostatic and non-hydrostatic versions)

Ján Mašek, Slovak HydroMeteorological Institute

1 Introduction

This talk is divided in two main parts. First part summarizes current shape of ALADIN-NH dynamical kernel, provides brief historical overview of its development and lists some remaining problems and challenges. Second part demonstrates stability and accuracy of the kernel using 2D adiabatic tests – non-linear potential flow and cold bubble test. It also estimates applicability limit of hydrostatic approximation by comparing hydrostatic and non-hydrostatic bubble simulations performed at various horizontal resolutions.

Horizontal and vertical mesh sizes used in 2D tests were typically 10–20 m, much finer than those of present or near future operational NWP models. In case of potential flow, high horizontal resolution was imposed by necessity to resolve short orographic scales responsible for trapped wave response (for lower horizontal resolution, explicitly resolved potential flow regime would be possible only with unrealistically strong wind). In case of cold bubble test, main reason for using such high resolution was to reduce importance of unresolved scales. At the same time it made non-hydrostatic effects more pronounced.

2 Overview of ALADIN-NH dynamical kernel

2.1 Current configuration

ALADIN-NH uses fully compressible set of governing equations, formulated in mass based hybrid eta coordinate of Laprise [1]. Thanks to this choice it could have been designed as an extension of ALADIN hydrostatic version. It employs two additional prognostic variables $\hat{q}, d_4$ based on true pressure p and vertical velocity w:

$$\begin{aligned}\hat{q} &= \ln \frac{p}{\pi} \\ d_4 &= d_3 + X = \frac{\partial w}{\partial z} + X\end{aligned}$$

In previous definition π denotes mass coordinate or "hydrostatic pressure", d_3 is true vertical divergence and X is cross term appearing in 3D divergence D_3 ($\mathbf{v}$ denotes horizontal wind velocity):

$$D_3 = \nabla_\eta \cdot \mathbf{v} + X + d_3 \qquad X = -\frac{\partial \mathbf{v}}{\partial z} \cdot \nabla_\eta z$$

Spatial discretization combines spectral transform technique on horizontal with finite difference method on vertical. Because of spectral technique, horizontal grid is unstaggered (Arakawa A-grid). Vertical grid uses Lorenz type of staggering.

Temporal discretization is two time level centered implicit with semi-Lagrangian advection. Centered implicit treatment of non-linear model M is achieved iteratively with semi-implicit operator L used as preconditioner. Operator L is constructed by linearization of M around resting and isothermal background state X^*, then it is modified by introduction of acoustic background temperature. This choice leads to time independent solver for each pair of horizontal wavenumbers and stabilizes semi-implicit step despite large non-linear residuals present in the formulation of the scheme (see below).

Iterative centered implicit treatment enables to use non-extrapolating semi-Lagrangian scheme while preserving second order accuracy in time. First step is standard semi-implicit scheme with uncentered in time treatment of non-linear residual $M - L$. It provides guess $X^{+(0)}$ of model state at time $t + \Delta t$ (subscripts O and F denote origin and final points of semi-Lagrangian trajectory):

$$\frac{X_F^{+(0)} - X_O^0}{\Delta t} = \frac{1}{2} \quad (M - L)X_F^0 + (M - L)X_O^0 \quad + L\frac{X_F^{+(0)} + X_O^0}{2}$$

Subsequent iterations $i = 1, 2, 3, \ldots$ recover second order accuracy in time:

$$\frac{X_F^{+(i)} - X_O^0}{\Delta t} = \frac{1}{2} \quad (M - L)X_F^{+(i-1)} + (M - L)X_O^0 \quad + L\frac{X_F^{+(i)} + X_O^0}{2}$$

In order to keep consistency with model state $X^{+(i)}$, origin points O are recomputed in each iteration.

Choice of semi-implicit operator L is crucial for convergence of iterative scheme. On the other hand, converged solution X^+ does not depend on L.

2.2 Historical background

Brief history of ALADIN-NH can be found in [7]. First non-hydrostatic version was ready in 1994 [2]. It used three time level semi-implicit scheme with Eulerian advection. For stability reasons, X-term had to be treated in centered implicit way. Because of its non-linearity, this treatment had to be achieved iteratively. In practice it was sufficient to use 1 iteration.

Following attempts to introduce semi-Lagrangian advection failed, because they faced instability which was particularly severe for two time level scheme. Problem was analyzed and solved in several steps during period 1999–2005:

- In original formulation, vertical discretization of pressure gradient term was imposed by requirement of angular momentum conservation. However, such approach lead to instability since it created inconsistency between non-linear model M and linear semi-implicit operator L. Solution was to relax angular momentum conservation and impose it only on "hydrostatic part" of pressure gradient term.

- Based on the results of linear stability analysis, original non-hydrostatic prognostic variables were replaced by pair $\hat{q}, d_3$. This choice removed some instabilities related to imperfect semi-implicit background. Following step was introduction of prognostic variable $d_4 = d_3 + X$, which reduced orographic instability by making 3D divergence linear in prognostic variables (and thus fully treated by semi-implicit scheme).

- Modifications listed in previous two points were sufficient to stabilize three time level semi-Lagrangian scheme. Stabilization of two time level semi-Lagrangian scheme was more difficult, requiring centered implicit time treatment of non-linear model M. This treatment was achieved iteratively. Sometimes it is referred as predictor/corrector scheme which is a bit imprecise, since the "predictor" semi-implicit step can be followed by several "corrector" steps.

- Finally the instability of two time level semi-implicit scheme was understood. It is due to the fact that stable treatment of gravity modes requires warmer semi-implicit backround than model atmosphere ($T^* > T$), while stable treatment of acoustic modes requires colder background ($T^* < T$). These contradicting requirements cannot be satisfied by choice of single background temperature T^*. However, since the terms responsible for gravity and acoustic modes are well separated, it is possible to introduce different background temperature T_a^* for acoustic terms such that $T_a^* < T < T^*$. In such case, semi-implicit operator L is no longer linearization of full model M around some background state X^*. In principle, linear operator L can be chosen totally arbitrarily, the only restricitions being stable temporal scheme and feasible solver.

- Idealized 2D tests with orographic flows revealed spurious response in w field when semi-Lagrangian scheme was used ("SL chimney" in ALADIN slang). It is related to bottom boundary condition when vertical divergence is used as prognostic variable. It was first treated by advection of w – hybrid scheme which uses vertical divergence in spectral computations (needed for stability) and vertical velocity w in gridpoint computations (simplifies right hand side and makes bottom boundary treatment trivial). At the end of gridpoint computations, explicit guess for w is transformed to explicit guess for vertical divergence. Except from eliminating SL chimney, this treatment also removed noise observed in bubble experiments when vertical divergence was used as prognostic variable. On the other hand, advection of w is not fully consistent with current code philosophy where all prognostic variables should be defined in the middle of layers. Since w is defined on layer interfaces, its semi-Lagrangian advection requires computation of extra origin points and corresponding interpolation weights.

  Second treatment of SL chimney retained vertical divergence also in gridpoint computations, but it removed inconsistency caused by mixing semi-Lagrangian discretization of prognostic equations with bottom boundary condition evaluated in Eulerian way.

- Another problem with spurious orographic response in w field appeared when horizontal diffusion was turned on ("HD chimney" in ALADIN slang). It was observed for both Eulerian and semi-Lagrangian advection. This time it was caused by ignoring diffusive tendencies in bottom boundary condition. Since for spectral diffusion getting diffusive tendencies in gridpoint space was not feasible, adopted solution reduces spectral diffusion applied on vertical divergence to necessary minimum and replaces it by semi-Lagrangian horizontal diffusion which is computed in gridpoint space.

Listed steps led to final goal – sufficiently robust and accurate semi-Lagrangian two time level scheme with centered implicit treatment of non-linear model M, requiring only one iteration. Key ideas were published in series of papers [3]–[6].

2.3 Remaining problems and future challenges

Even if current shape of ALADIN-NH dynamical kernel is sufficiently robust, there are still some details to be finalized, as well as challenges for further improvement. First three are related to boundary treatment.

Lateral boundary treatment uses classical Davies relaxation scheme. Going to kilometric horizontal mesh sizes will necessarily lead to the use of small domains, where lateral boundary conditions dominate the solution very early. Question is whether Davies relaxation will still be sufficient in such circumstances.

For the time being ALADIN-NH bottom boundary condition is formulated adiabatically, i.e. it ignores possible diabatic tendencies coming from model physics. With this simplification there is a risk that diabatic runs will be contaminated by some sort of Φ-sics chimney.

Current ALADIN-NH formulation uses elastic upper boundary condition $p_T = \text{const}$ (for the time being $p_T = 0$), which reflects acousto-gravity waves. Since reflective model top is unphysical, its non-reflective treatment would be desirable. In the past there was some work carried on this subject, resulting in generalization of radiative upper boundary condition to fully compressible system formulated in mass coordinate. Next steps should be code implementation in 2D ALADIN-NH and experimental testing.

Advection of w is currently the only configuration which gives clean results in bubble simulations. Because of its non-standard code implementation, it was always assumed as experimental option and it was coded only for two time level non-extrapolating scheme. For finalization of ALADIN-NH dynamical kernel it is necessary to know whether problem seen in bubble simulations can be prevented without advection of w or not. In first case advection of w would be removed from the code, in second case it would have to be coded for all relevant configurations and become compulsory.

Remaining two topics, performance of ALADIN-NH above steep orography and implementation of vertical finite element discretization, are solved jointly with HIRLAM. Last topic is of strategic importance, since successful implementation of vertical finite elements in ALADIN-NH dynamical kernel could lead to its usage by ECMWF.

Finally, optimal coupling and interfacing between model physics and dynamics should not be forgotten (including of diabatic tendencies into bottom boundary condition belongs to this category). Robust adiabatic kernel means nothing, when coupling it to physics makes the model unstable or fibrillating. This issue becomes especially important since different physical packages are to be plugged into ALADIN-NH dynamical kernel.

3 Idealized 2D experiments

3.1 Potential flow

Potential flow regime was selected to illustrate model orographic response for several reasons. It is purely non-hydrostatic regime, containing only trapped waves which are excluded from hydrostatic solution. Orographic forcing can be made sufficiently strong so that response is non-linear, still the semi-analytical solution can be constructed iteratively. Available analytical reference makes detection of model deficiencies easier. Very important aspect is weak sensitivity of model solution to upper boundary treatment. In regimes with propagating waves sensitivity to upper boundary treatment is very strong, it can eventually affect model stability and make the results incoclusive.

Experiments used isothermal background state $\bar{X}$ with temperature $\bar{T} = 239\,\mathrm{K}$ (corresponding Brunt-Väisälä frequency $\bar{N} = 0.02\,\mathrm{s^{-1}}$), surface pressure $\bar{\pi}_S = 101\,325\,\mathrm{Pa}$ and constant wind profile $\bar{u} = 15\,\mathrm{m\,s^{-1}}$. Orography was bell shaped mountain with halfwidth $a = 100\,\mathrm{m}$ and height $h = 100\,\mathrm{m}$:

$$z = \frac{h}{1 + \left(\frac{x}{a}\right)^2}$$

Horizontal mesh size was $\Delta x = 20\,\mathrm{m}$ with quadratic truncation, vertical spacing of undisturbed eta levels was $\Delta z = 20\,\mathrm{m}$. Stationary final state was obtained by short integration ($t = 200\,\mathrm{s}$) with time constant lateral boundary conditions.

Model was integrated in adiabatic mode, using two time level non-extrapolating semi-Lagrangian scheme. Time treatment was centered implicit with one iteration. Semi-implicit background was set to imperfect values $T^* = 300\,\mathrm{K}$, $T_a^* = 100\,\mathrm{K}$ and $\pi_S^* = 90\,000\,\mathrm{Pa}$, which are close to settings used in 3D real cases. Prognostic variable was d_4 with bottom boundary condition diagnosed in semi-Lagrangian way. Lateral boundaries were coupled with background state $\bar{X}$ and sponge layer was applied at model top. Except from lateral coupling and sponge, the only source of dissipation was diffusion introduced by suitably chosen semi-Lagrangian interpolators.

First tested aspect was stability and accuracy of the scheme and its behaviour for long timesteps. Results are shown on figure 1. It can be seen that numerical solution for CFL up to 3 (plots b, c) is in good agreement with analytical solution (plot a) and there is almost no dependency on timestep. Numerical solution gives slightly stronger response, with areas of maximum vertical velocity displaced towards mountain top. When CFL is pushed to value 5.6 (plot d), response is further amplified but the scheme remains stable. Still the correspondence with analytical solution is quite good.

Second test demonstrated stabilizing efect of prognostic variable d_4 in the presence of orographic forcing. When integration was repeated using prognostic variable d_3, three iterations were needed in order to get stable scheme. Otherwise, for CFL $= 3$ there was hardly any visible difference between the two solutions (not shown).

Third test demonstrated stability impact of acoustic background temperature T_a^*. Without T_a^* (i.e. by setting $T_a^* = T^* = 300\,\mathrm{K}$), two time level semi-Lagrangian semi-implicit scheme is strongly unstable, integration with CFL $= 3$ blows up just after 9 timesteps. Lowering T_a^* to $100\,\mathrm{K}$ stabilizes even semi-implicit scheme, so for potential flow there is no need to use iterated centered implicit treatment (in this case, however, extrapolating scheme have to be used in order to keep second order accuracy in time). Anyway, some other tests showed that two time level semi-Lagrangian semi-implicit scheme with T_a^* and prognostic variable d_4 is not sufficiently robust for operational use, which means that iterated centered implicit treatment cannot be avoided.

3.2 Cold bubble test

Explicitly resolved dry convection is very sensitive case, suitable for testing non-hydrostatic dynamical kernels. Being driven by local imbalance between buoyancy and gravity, convection is non-hydrostatic effect. Comparison of results obtained with hydrostatic and non-hydrostatic model versions at various horizontal resolutions gives direct estimate for validity limit of hydrostatic assumption.

Cold bubble test was preferred to warm bubble one because it enables to simulate interaction of sinking bubble with solid surface and it is not very sensitive to upper boundary treatment. Main complication connected to bubble tests is missing analytical reference. Moreover, realistic results cannot be obtained in inviscid case. Some viscosity is needed in order to simulate energy dissipation into unresolved scales. Since in ALADIN there is no fully consistent 3D viscous treatment, semi-Lagrangian interpolators with controlled diffusivity were used for this purpose.

Experiments used resting initial state ($u, w = 0$) with horizontally constant surface pressure $\pi_S = 101\,325\,\mathrm{Pa}$. Background stratification was neutral with potential temperature $\bar{\theta} = 300\,\mathrm{K}$ and there was cold bubble perturbation in initial θ field ($\theta = \bar{\theta} + \theta'$).

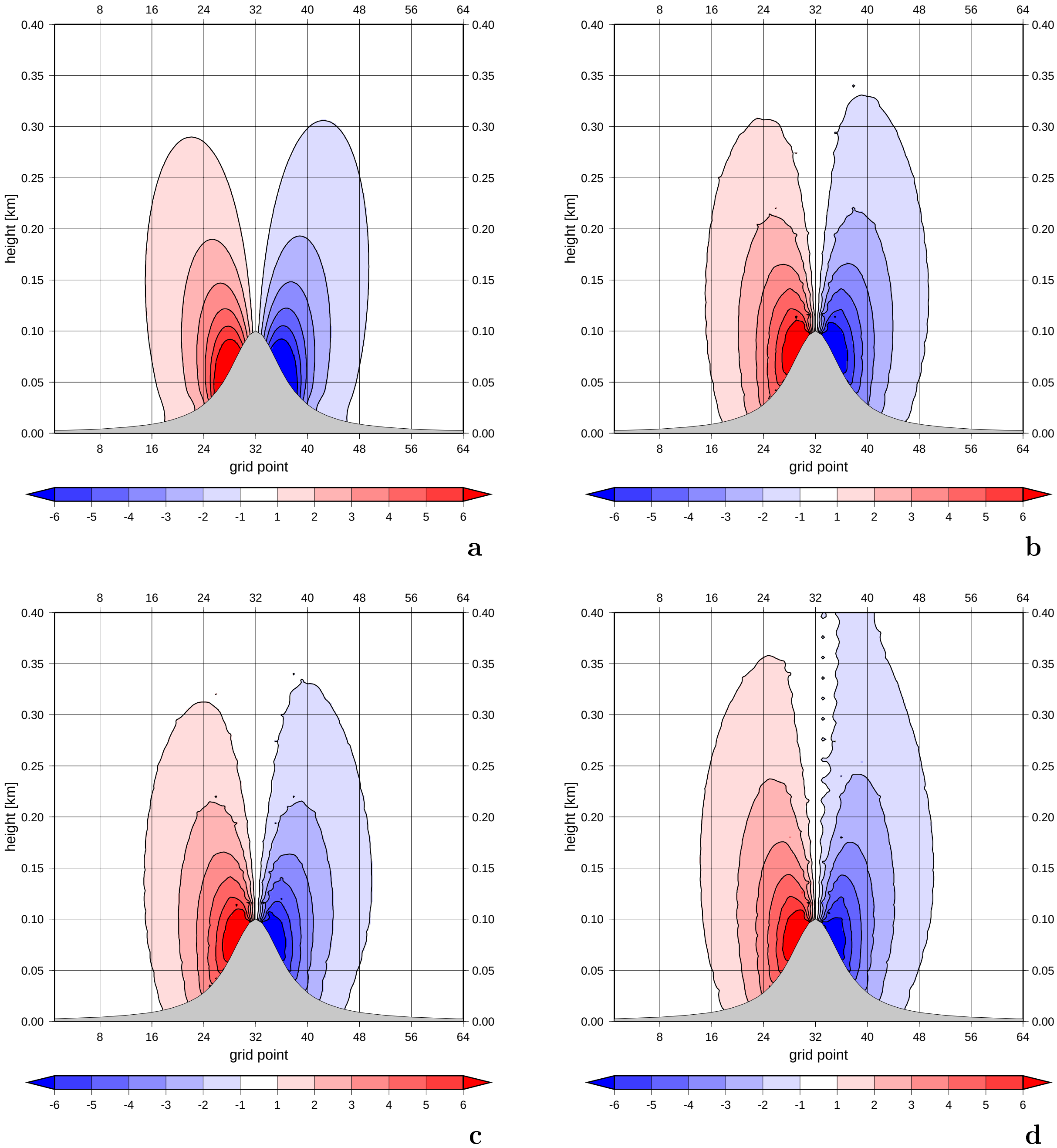


Figure 1: Potential flow, field of vertical velocity w [$\mathrm{m\,s^{-1}}$]: a – analytical solution, b – solution with typical Eulerian timestep $\Delta t = 0.2\,\mathrm{s}$ (CFL $= 0.6$), c – solution with typical semi-Lagrangian timestep $\Delta t = 1.0\,\mathrm{s}$ (CFL $= 3.0$), d – solution with timestep $\Delta t = 2.0\,\mathrm{s}$ (CFL $= 5.6$).

Orography was flat and the domain was horizontally periodic, so there was no need of lateral coupling.

Domain of interest had vertical extent 1.2 km with regular level spacing $\Delta z = 10\,\mathrm{m}$. At the top, there were 30 additional levels with isothermal stratification and gradually decreasing resolution. In horizontal direction domain had 120 points with quadratic truncation.

First set of experiments used horizontal mesh size $\Delta x = 10\,\mathrm{m}$. Initial circular bubble with radius $r = 150\,\mathrm{m}$ was placed 600 m above ground, perturbation of potential temperature in bubble centre was $\theta'_{\mathrm{max}} = -0.5\,\mathrm{K}$. Model configuration was the same as in potential flow case, just the timestep was reduced to $\Delta t = 0.4\,\mathrm{s}$ and advection of w had to be used in order to get clean solution. Hydrostatic simulations were performed with two time level extrapolating semi-lagrangian semi-implicit scheme.

Bubble evolution is shown on figure 2. It can be seen that after 50 s bubble hardly moved in non-hydrostatic simulation, while in hydrostatic one it decayed into smaller cells and some of them already reached the ground. After 600 s non-hydrostatic solution contains typical pair of downburst vortices. Hydrostatic solution is completely unrealistic and it is already affected by periodicity of computational domain.

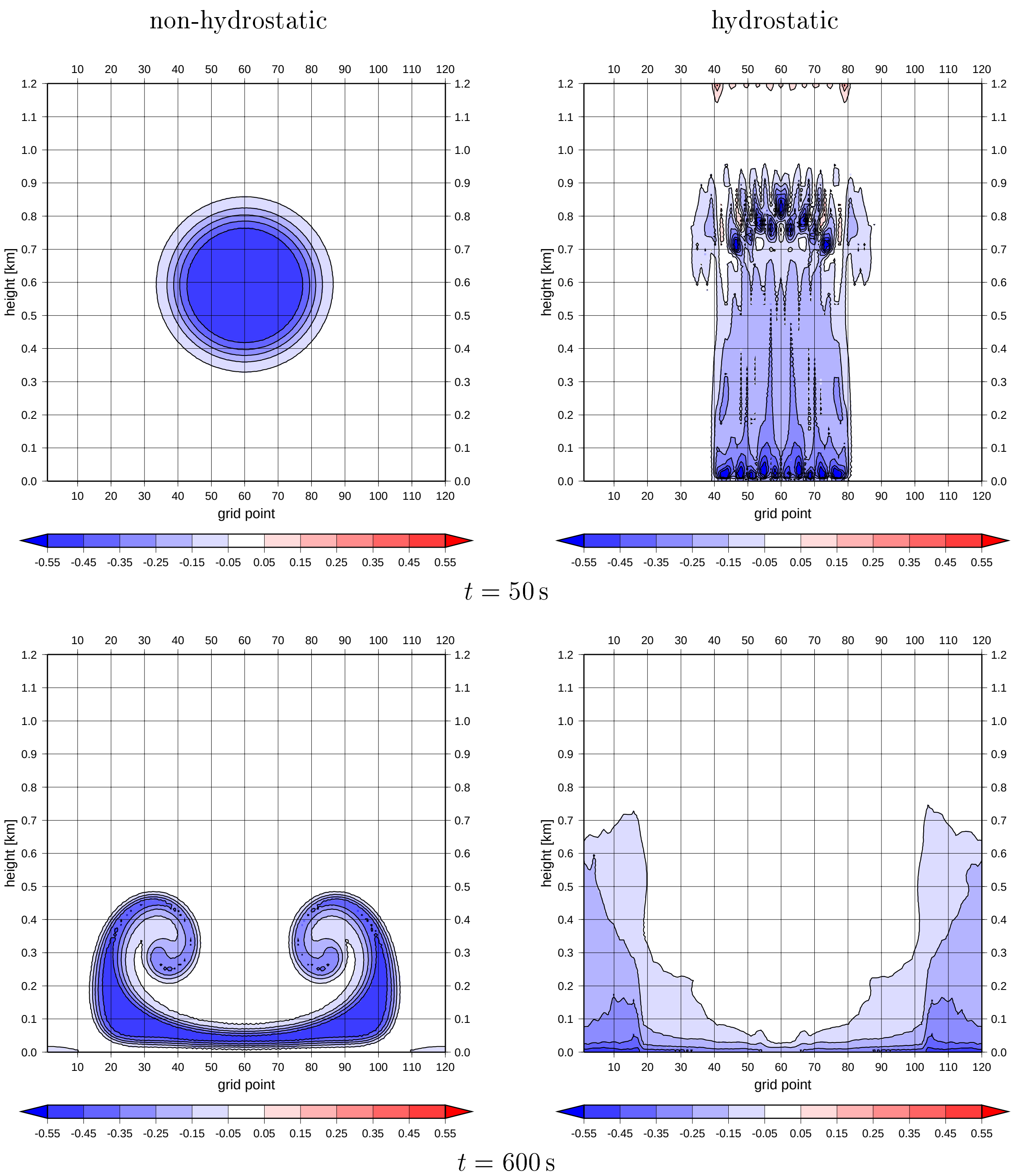


Figure 2: Cold bubble test with horizontal mesh size $\Delta x = 10\,\mathrm{m}$. Perturbation of potential temperature θ' [K].

Because of missing analytical solution, care must be taken when interpreting numerical results. Convection and turbulence are non-linear phenomena consisting of multiple interacting scales. In reality, subgrid scales can have significant influence one resolved ones, which leads to the necessity of their parameterization. Simple test to judge whether this is the case is to increase horizontal resolution and redo the simulation.

Figure 3 shows results of two non-hydrostatic simulations with horizontal mesh sizes 10 and 5 m. It can be seen that solution with $\Delta x = 5\,\mathrm{m}$ evolves sharper horizontal gradients, but otherwise the two solutions are in close agreement. It means that for mesh sizes around 10 m and finer, viscous dissipation satisfactorily represents unresolved convective and turbulent scales.

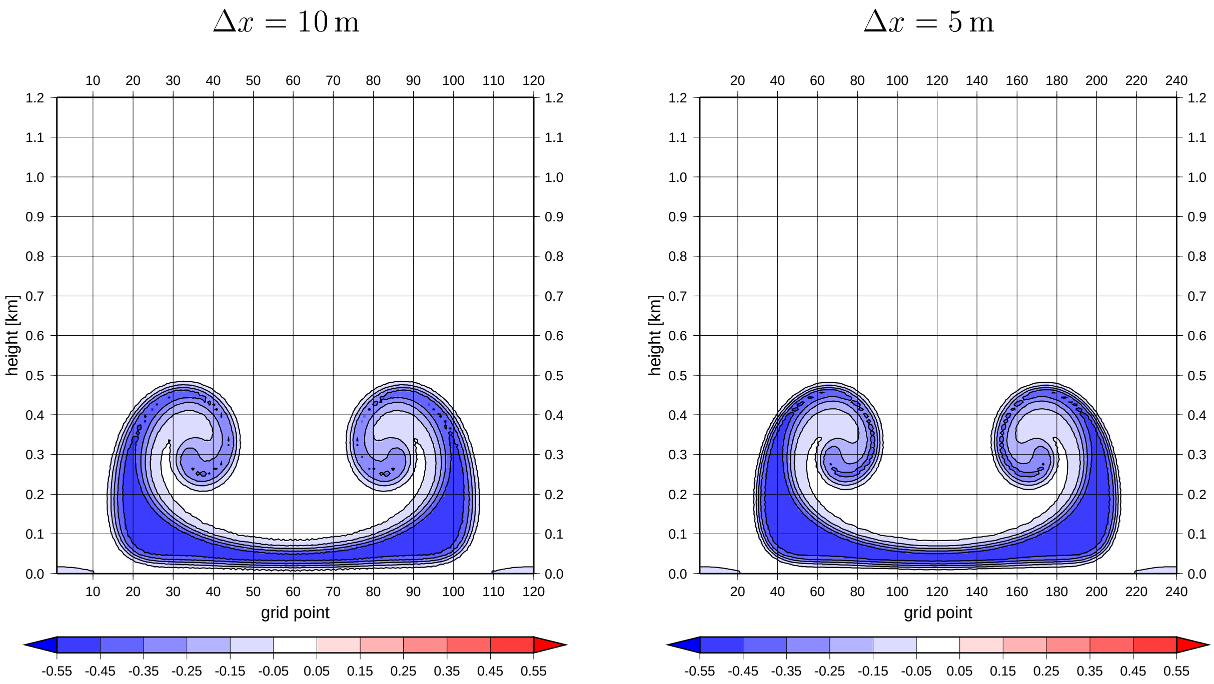


Figure 3: Sensitivity of non-hydrostatic cold bubble simulation to horizontal resolution. Perturbation of potential temperature θ' [K] after 600 s.

Second set of experiments increased horizontal mesh size to $\Delta x = 1\,\mathrm{km}$. Initial bubble was stretched accordingly to ellipse with half axes $a = 15\,\mathrm{km}$ and $b = 150\,\mathrm{m}$. In order to get stronger non-hydrostatic effects, perturbation of potential temperature in bubble centre was increased to $\theta'_{\mathrm{max}} = -5\,\mathrm{K}$. Model was integrated with timestep $\Delta t = 40\,\mathrm{s}$, other settings remained unchanged.

Non-hydrostatic and hydrostatic simulations are compared on figure 4, which shows bubble shape after 2 h. The two solutions are quite similar now. Differences can be seen in central part of bubble and in the position of bubble edges which are shifted 6 points outwards in non-hydrostatic case. More significant differences can be expected for diabatically forced deep convective systems. Anyway, importance of non-hydrostatic effects is much smaller than for 10 m horizontal mesh size.

With lower resolution, importance of subgrid scales might become stronger and their viscous representation insufficient. In order to verify this, non-hydrostatic simulations with horizontal mesh sizes 1 and 0.5 km were compared. Figure 5 shows the two solutions after 20 min. In both cases bubble decays into smaller cells and this process accelerates descent of cold air. However, solution with $\Delta x = 0.5\,\mathrm{km}$ gives smaller and faster descending cells. It means that for kilometric horizontal mesh sizes subgrid convective

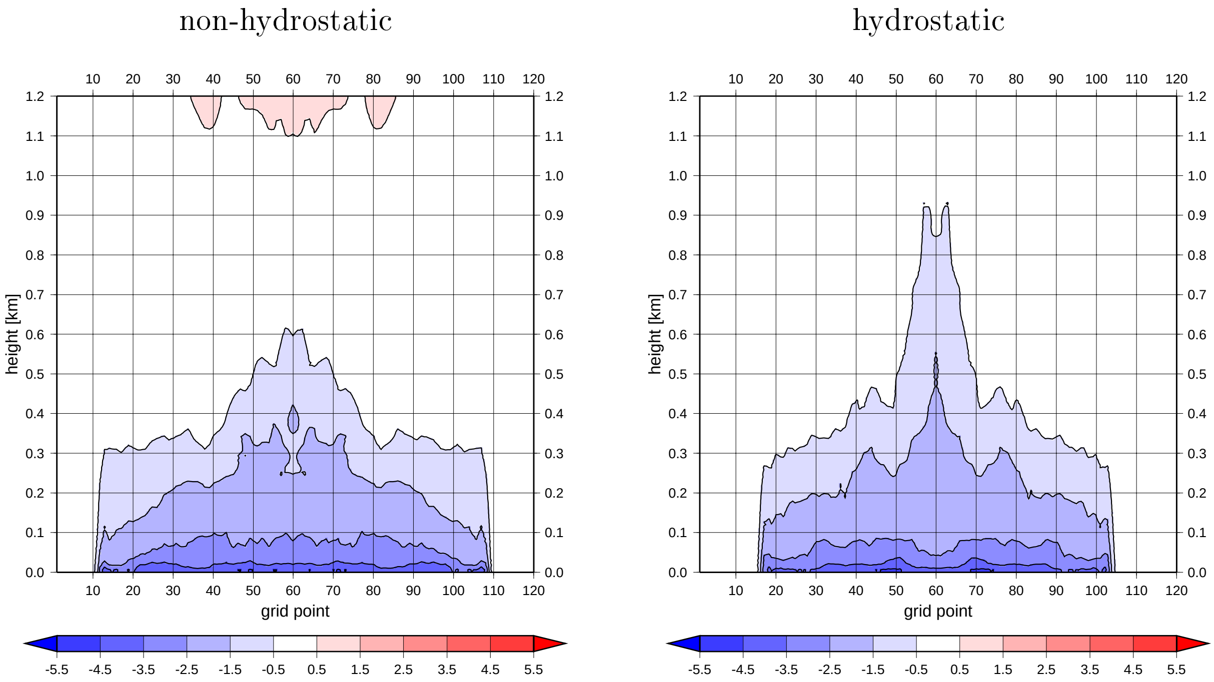


Figure 4: Cold bubble test with horizontal mesh size $\Delta x = 1\,\text{km}$. Perturbation of potential temperature θ' [K] after 2 h.

processes cannot be neglected and their parameterization is still needed.

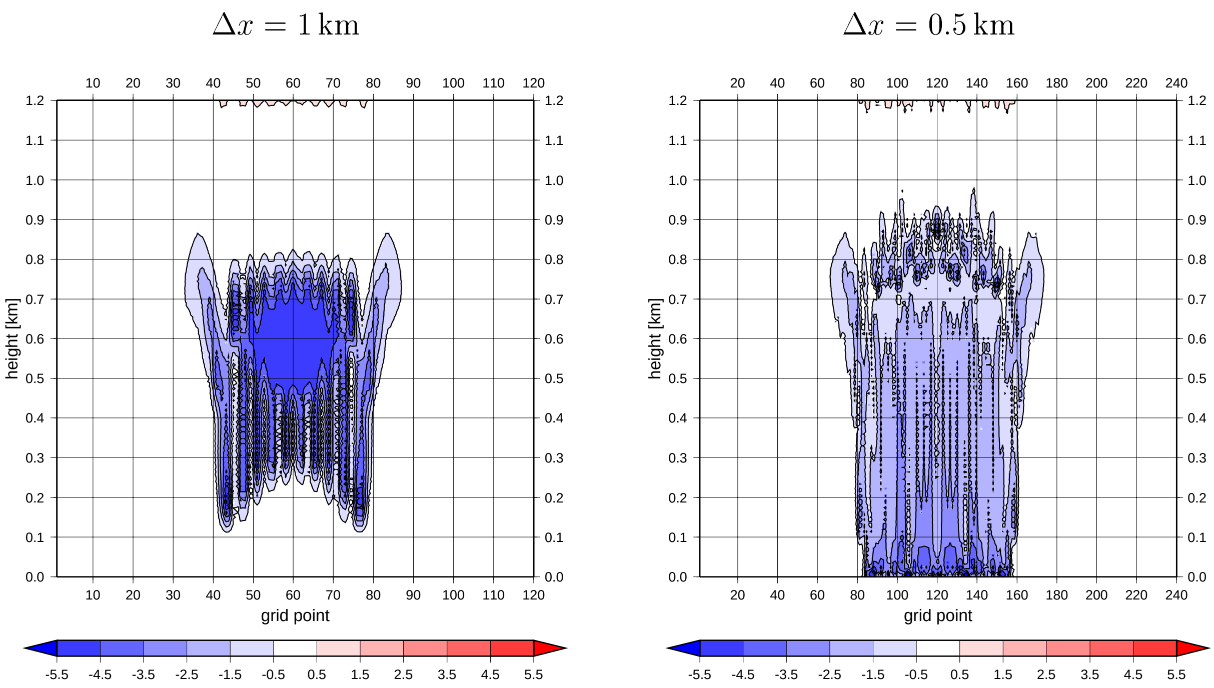


Figure 5: Sensitivity of non-hydrostatic cold bubble simulation to horizontal resolution. Perturbation of potential temperature θ' [K] after 20 min.

4 Conclusions

Presented idealized 2D tests showed that current shape of ALADIN-NH dynamical kernel is sufficiently stable and accurate. Potential flow case demonstrated its robustness up to CFL ≈ 5. Cold bubble test performed with various horizontal resolutions showed that non-hydrostatic effects start to be visible for $\Delta x = 1$ km and they completely take over for $\Delta x = 10$ m. At the same time, influence of subgrid scales diminishes and for $\Delta x = 10$ m they can be satisfactorily represented by viscous dissipation.

ALADIN-NH dynamical kernel is now ready for operational use, but there are still some details to be solved (noise in bubble experiments when vertical divergence is advected, missing diabatic tendencies in bottom boundary condition, non-reflective upper boundary treatment, ...). Big challenges are implementation of vertical finite element discretization and optimal coupling to model physics.

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5 Scientific presentations on data assimilation

5.1 C. Schraff: COSMO: Overview and Strategy on Data Assimilation for LM

COSMO: Overview and Strategy on Data Assimilation for LM

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1. Current Status

The data assimilation for LM is performed by a scheme based on **nudging** towards direct observations. It is currently the only scheme implemented in LM and used to compute initial conditions directly on the model grid. In this technique, a relaxation term is introduced into the model equations, and the tendency for the prognostic variable $\psi(\mathbf{x},t)$ is given by

$$\frac{\partial}{\partial t}\psi(\mathbf{x},t) \;=\; F(\psi,\mathbf{x},t) \;+\; G_{\psi}\cdot\sum_{k_{(obs)}} W_k \cdot \left[\psi_k - \psi(\mathbf{x}_k,t)\right]$$

(F denotes the model dynamics and physical parameterisations, ψ_k the value of the k^{th} observation influencing the grid point $\mathbf{x}$ at time t, $\mathbf{x}_k$ the observation location, G_{ψ} the constant nudging coefficient and W_k an observation-dependent weight.) Currently, such a relaxation term is added to the original model equation only for the horizontal wind components, temperature and specific water vapour content at all model levels and for pressure at the lowest model level. In the equations above, the observation increments are expressed in terms of model variables. This can be generalised (at least approximately) to variables that can be mapped to a single model variable. Thus, observation increments of relative humidity are used to adjust the model's specific humidity. The increments from all upper-air observations are spread laterally along purely horizontal surfaces since spreading along the terrain-following model levels as usually applied in nudging-type schemes has disadvantages near steep orography particularly in cases with low stratus (Schraff, 1997). In contrast, surface-level increments are spread along the model levels to limit the area of influence to close to the ground. The wind correlations are split into a longitudinal and transverse part, and this allows for specifying the degree of non-divergence of the wind analysis increment field (Lorenc et al., 1991). Both the correlation scales for all variables and the degree of non-divergence are time-dependent and increase with height and with distance to the observation time.

In a plain nudging scheme, balancing between the different model variables occurs implicitly due to the direct inclusion of the model dynamics and physics in the assimilation process. The balancing thus induced considers all scales and is flow-dependent, however it is (more or less) incomplete. To enhance the balancing in the LM scheme, the analysis increment fields from the plain nudging are partly balanced explicitly in three extra steps before being added to the model fields. First, a hydrostatic upper-air temperature correction balances the (near-)surface pressure analysis increments. Approximating statistical background errors for the mesoscale, it is nearly constant within the lowest 1500 m (therefore hardly modifies the stability within the boundary layer) and decreases rapidly further above such that the mass field above 400 hPa is not directly modified by the surface pressure nudging. This significantly reduces the vertical extent of the mass field disturbance, results in a better wind adjustment, and greatly improves the assimilation of pressure data. Secondly, a geostrophic wind correction partly balances the mass field increments from the surface pressure nudging. Finally, upper-air pressure increments balance the total analysis increments hydrostatically in the nonhydrostatic model. They prevent the uncontrolled introduction of direct sources of vertical velocity which is still small on the scales to be analysed using non-gridded conventional observations.

The **observations used operationally** are radiosonde (including all significant-level data in the troposphere), aircraft, and wind profiler data in the upper air and surface synoptic, ship and buoy data. 2-m temperature data are not used in the nudging to adjust the boundary layer directly, but they are used in a variational soil moisture analysis (Hess, 2001) to adjust the soil (currently applied at DWD only). Satellite-derived wind data can optionally be nudged.

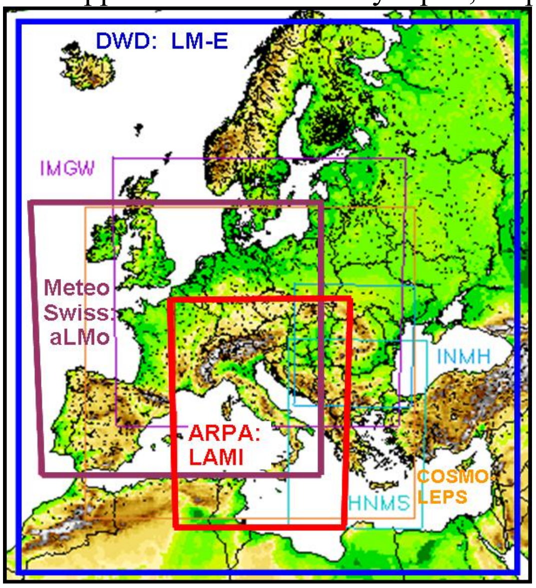

Fig 1: Operational model domains with (thick lines) and without (thin lines) continuous data assimilation cycles based on nudging.

Operational continuous data assimilation cycles using the nudging at a model resolution of 7 km are running at DWD, MeteoSwiss and at ARPA-SMR (Fig. 1). All other operational LM-based forecast applications at this or at a lower resolution use interpolated coarser-grid analyses (e.g. from DWD's global model GME) as initial conditions. In most cases of investigated operational forecast failures occurring when deploying the nudging, LM test runs starting from interpolated GME global analyses were even worse. The nudging runs very robustly, and it can easily be applied to other model configurations. Since August 2006, LM-K, a convective-scale application (Δx = 2.8 km) of LM at DWD, runs pre-operationally with a continuous data assimilation cycle based on the nudging, and a pre-operational suite with 2.2 km resolution is in preparation at MeteoSwiss. In addition to the conventional nudging, these convective-scale applications also assimilate radar-derived precipitation rates by latent heat nudging.

2. Long-term vision and strategy

In a COSMO workshop in autumn 2005, a **long-term vision** has been devised for NWP in 2015. Besides assuming that the use of indirect observations at high frequency will become ever more important, it is also envisioned that the task of NWP will not only be to deliver deterministic forecasts but mainly a representation of the probability density function (PDF), likely in the form of ensemble members with probabilities. This is expected to apply particularly for the convective scale since it does not appear realistic to forecast deterministically individual convective cells or small convective systems beyond their short lifetime.

Therefore, the first issue of the **long-term strategy** is to put an emphasis on ensemble techniques, both for the forecasting and the data assimilation components. Furthermore, due to the special conditions in the convective scale, such as non-Gaussian PDF, flow-dependent and unknown balance, and high non-linearity, the data assimilation should be split up into a generalised data assimilation for global and regional modelling, based on variational techniques, and a separate data assimilation for the convective scale.

ICON (ICOsahedral Non-hydrostatic general circulation model) is the name of a future generalised global and regional forecast system which will include a data assimilation component and is currently being developed jointly by DWD and the Max Planck Institute for

Meteorology in Hamburg (MPI-M). The model will be global and non-hydrostatic and accommodate the possibility of static local grid refinement for any user-defined areas on the globe (Fig 2). It is designed to be applied both for operational NWP and for climate modelling, and its numerics will guarantee the conservation of mass and of other conservation properties. The data assimilation will be based on 3DVAR and eventually include an Ensemble Transform Kalman Filter (ETKF). At DWD, ICON is planned to replace GME and LM-E around 2010, and it will provide the lateral boundary conditions for the convective-scale LM-K. With the ETKF, it will be an alternative to the SREPS (short-range ensemble prediction system currently being developed by COSMO) for providing perturbed lateral boundaries for a (data assimilation and) forecast ensemble system based on LM-K.

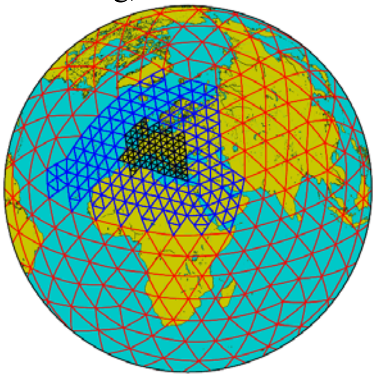

Fig 2: ICON model grid

As a consequence, COSMO should focus on the convective scale for its longer-term development activities, and ensemble data assimilation should play a major role. Since variational techniques and conventional ensemble Kalman Filter methods have basic shortcomings with regard to the convective scale, it has been decided that a **sequential importance resampling** (**SIR**) filter should be developed and investigated by COSMO. This technique combines a prior PDF, represented by an ensemble of short-range forecasts, with the distance of each ensemble member to new observations (using any kind of norm) in order to obtain a posterior PDF. Then, a new ensemble reflecting the posterior PDF is constructed and integrated to the next observation time. In other words, the ensemble members are weighted by observations and redistributed according to the posterior PDF without any modification of the forecast fields.

The SIR method can in principle handle the major challenges on the convective scale, i.e. non-Gaussian PDF, highly nonlinear processes, model errors, unknown and flow-dependent balance, and indirect observations with highly nonlinear observation operators. It has been applied to realistic ocean simulations with highly nonlinear flow (van Leeuwen, 2003), however it has not yet been investigated for real-size NWP. The main potential problem is ensemble size. The filter can potentially drift away from reality and not be brought back to the right track without fresh blood, and dense observations may not be used optimally. For application to an ensemble LM-K with its very limited model domain nevertheless, strong forcing from the lower and the lateral boundaries is expected to avoid drifting into unrealistic states. Furthermore, if the method is not found to work well the pure way, there are fallback solutions, albeit at the cost of weakening the ideal properties of the filter. It could be combined with nudging by weakly influencing some members, and there are approaches for localising the filter.

3. Mid-term strategy

The mid-term strategy consists of two main points:

- **start developing the SIR filter**
- **further develop the nudging**, in particular **retrieval techniques** for the use of indirect observations

The first issue is a direct consequence from the long-term strategy. For the second issue, there are two reasons. Firstly, the nudging is needed for one of the above mentioned drawback solutions for the SIR filter. Secondly, since the SIR filter will be a longer-term development, a scheme is also needed for the meantime. Since the nudging is available and runs robustly and efficiently and does not have severe drawbacks for the convective scale in the short and mid term provided that retrievals can be made available, accordant development should be done.

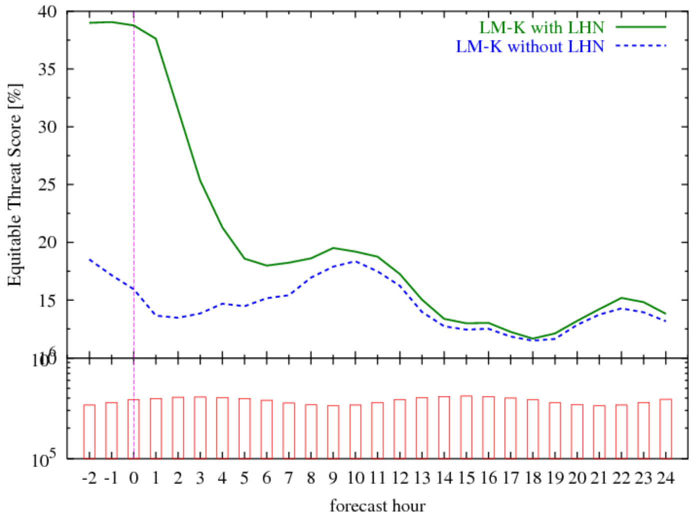

Fig 3: Equitable threat scores for hourly precipitation (threshold: 0.1 mm/h) of LM-K forecasts (00- and 12-UTC runs) from 16 June to 15 August 2006 against radar-derived precipitation as a function of forecast time (in hours; the vertical pink dashed line indicates the start of the forecasts, in which data are still assimilated during the first 30 min.). Green solid line: forecasts starting from the assimilation cycle with LHN; blue dashed line: forecasts starting from the assimilation cycle without LHN. The red bars indicate number of rainy radar pixels.

4. Some ongoing and planned activities

This section lists and details the main activities on the further developments of the nudging and in particular of the retrieval schemes.

- Assimilation of **radar-derived precipitation rates** by **latent heat nudging** (LHN):

  Surface precipitation rates are derived from radar reflectivity and assimilated by means of LHN (and an adjustment of humidity). The main task has been to adapt the original LHN scheme (similar to that of Jones and Macpherson, 1997) such that it works well (see Fig.3) with the prognostic treatment of precipitation in the high-resolution LM (Schraff et al., 2006). Since August 2006, it has been running as part of the pre-operational LM-K at DWD. The work continues on a better understanding of the convection in the model and of LHN itself and on further refining the scheme. A special contribution dedicated to LHN in LM is included in this volume.

- Simple adjoint retrieval (SAR) of **3-dimensional wind from radar Doppler velocity and reflectivity**:

  3-dimensional wind fields are retrieved from three consecutive scans of 3-d reflectivity and radial velocity from single radars by means of a simple adjoint method (Gao et al., 2001). A cost function is set up which consists of a background term, a mass continuity term, a smoothing term, an observation term in the usual form for radial velocity, and a second observation term for a tracer, typically reflectivity. For this term, the tracer observed in the first scan is advected with the retrieved velocity and compared to the tracer observations from the second and third scan. The simplified advection model includes eddy viscosity. First tests with data from Polish radars have revealed problems with the quality of the radial velocity input data. After implementing high-frequency noise removal and a revised interpolation to Cartesian coordinates, the method works now for single radar data. Assimilation tests with nudging of the wind retrievals are planned.

- Use of ground-based GPS data and **GPS tomography**:

  Past attempts to use ground-based GPS data in COSMO have been based on assimilating integrated water vapour derived from zenith total delay data by scaling the model's humidity profiles within the nudging scheme. Besides improving upper-air humidity and temperature forecasts, this had a significant positive impact on precipitation on occasions, however the positive cases outnumbered the negative ones only slightly. The main problem was identified to be related to the vertical distribution of the vertically integrated humidity information.

Information on the vertical distribution is required and can be provided by GPS tomography in the form of vertical humidity profiles. This has been developed at the ETH (Federal Institute of Technology, Zurich) by Troller et al. (2006), and sets of 18 hourly humidity profiles are produced quasi-operationally over Switzerland where there is a dense network of GPS ground receivers (Fig 4). Although the method is found to work well in some cases provided that surface synoptic data are included in the tomographic reconstruction, preliminary statistical comparisons of tomography profiles with Payerne radiosonde and model analysis and forecast data have revealed shortcomings in the overall quality. Further work focuses on improving the tomography technique and on monitoring and eventually assimilating the resulting profiles.

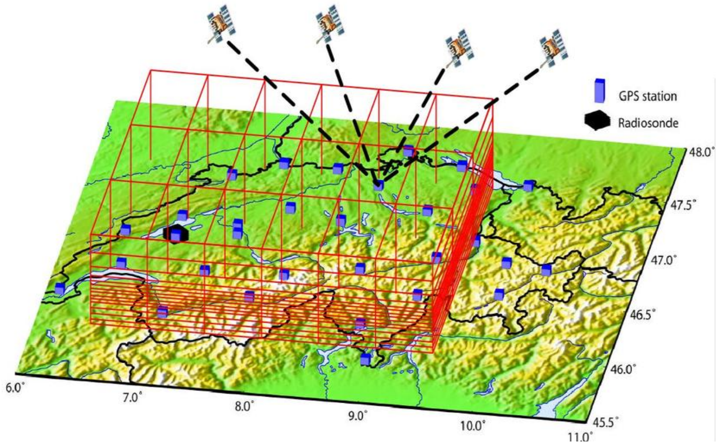

Fig 4: Location of the Swiss GPS gound receivers and of the voxels for which hourly humidity profiles are retrieved quasi-operationally.

- **Cloud analysis**

  It is planned to derive vertical profiles of cloudiness from radiosonde humidity, surface synoptic and ceilometer data, using Meteosat IR brightness temperature and model fields as background. These profiles will then be spread horizontally using the cloud type product of the MSG Nowcasting SAF as a cluster analysis. Each profile will be assigned a class and spread only to pixels with the same class. The cloud analysis will be used to adjust humidity and possibly condensate.

- Use of **satellite radiances by 1DVAR**

  A 1DVAR minimisation is being implemented in LM. This is to derive temperature and humidity profiles from radiances of polar orbiting as well as geostationary satellites (ATOVS, AIRS / IASI, SEVIRI). The resulting profiles will be assimilated like conventional data with the nudging scheme. Currently, the focus lies on clear-sky radiances, and the work is carried out as a COSMO priority project. In the mid-term, it is planned to extend the methodology to cloudy radiances by retrieving profiles of cloud cover, liquid water content and ice content, and converting them to temperature and humidity profiles by employing the diagnostic cloud scheme of LM and its adjoint.

- Use of **screen-level observations and PBL initialisation**

  Work is about to start on advancing the use of in-situ screen-level observations in order to improve the initialisation of the planetary boundary layer (PBL), in particular with regard to moisture convergence in convective situations. The selection and screening of representative land stations, the meteorological pre-processing to extrapolate the observational information to the lowest model level, and the vertical and horizontal structure functions will be re-considered.

Furthermore, work on assimilating scatterometer wind data has begun. Here, as well as for the in-situ wind data, balance and the relation with the pressure field will be addressed.

In addition to these issues related to initialising the atmosphere in the framework of the nudging scheme, there is also work in progress on improving the lower boundary.

- In the variational **soil moisture analysis**, the use of a parameterised regression between 2-m temperature and the soil moisture as a gradient in the minimisation of the cost function should make obsolete the additional model runs currently needed. As an alternative approach to the variational scheme, running offline a measurement-driven soil model is investigated.
- The **snow analysis** is enhanced by including a MSG-derived snow mask. An instantaneous snow mask is derived from spectral classification and change detection using five successive images and then used to update a running composite snow map and its quality index (De Ruyter de Wildt et al., 2007).

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5.2 D. Leuenberger et al.: The Latent Heat Nudging Scheme of COSMO

The Latent Heat Nudging Scheme of COSMO

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Abstract: Latent Heat Nudging (LHN) is an efficient data assimilation scheme for surface precipitation as measured by weather radar. In this paper we present the current state of the COSMO model LHN scheme with a focus on modifications due to the introduction of the prognostic treatment of precipitation constituents. In addition, results of a nested ensemble simulation of a severe convective event in southern Germany are presented which quantify the effect of the environment on the success of the assimilation with LHN and prediction of precipitation.

1. INTRODUCTION

The main focus of the meso-γ-scale version of the operational non-hydrostatic limited area COSMO model, is on the very short range prediction of severe weather, which often forms in context of deep moist convection. Thus, in addition to the assimilation of conventional data, as a first step, radar-derived surface precipitation has been introduced in the nudging-type analysis of the COSMO model. Using the Latent Heat Nudging (LHN) technique (Jones and Macpherson 1997, Leuenberger, 2005) the model latent heating is scaled by a fraction α of observed to modelled precipitation in order to nudge the simulated rain rates towards those observed.

Past experiments with a purely diagnostic precipitation scheme have shown that precipitation patterns can be assimilated in good agreement with those observed by radar, both in position and amplitude (Leuenberger, 2005; Leuenberger and Rossa, 2007). In order to simulate the horizontal distribution of precipitation in mountainous terrain more realistically, a prognostic treatment of precipitation (Baldauf and Schulz 2004) including advection has been introduced. It tends to decorrelate the surface precipitation rate from the vertically integrated latent heat release and thereby violate the basic assumption to the LHN approach. This, and resulting problems have been shown by Klink and Stephan (2005), and they also suggested possible adaptations to the LHN scheme.

It is well known that the simulation of convection is strongly dependent on the model representation of the convective environment in which the storm develops. In order to quantify the effect of the environment on the success of the assimilation with LHN and prediction of precipitation, a nested ensemble simulation of a severe convective event in southern Germany has been conducted.

2. MAJOR REVISIONS TO THE LHN SCHEME

At horizontal model resolutions of 3 km or less, the prognostic treatment of precipitation allows the model to distinguish between updrafts and downdrafts inside deep convective systems. Compared to using the diagnostic precipitation scheme, it modifies both the 3-D spatial structure and the timing of the latent heating with respect to surface precipitation. Therefore, three revisions have been introduced to the LHN scheme. Two of them address spatial aspects and a third one an important temporal issue:

- In updraft regions at the leading edge of convective cells, very high values of latent heat release occur often where modelled precipitation rates are low. Thus high values of the scaling factor α and of the latent heat nudging temperature increments often occur. To mitigate this, the upper limit for α is reduced to 2 and the lower limit increased accordingly to 0.5. Furthermore, the linear scaling is replaced by a logarithmic scaling, leading to effective limits of 1.7 and 0.3, respectively. This adaptation reduces the simulated precipitation amounts during the LHN.

- In downdraft regions further upstream in convective cells, high precipitation rates occur often where latent heating is weak or even negative in most vertical layers. In order to avoid negative LHN temperature increments and cooling where the precipitation rate should be increased (and vice versa), only the vertical model layers with positive simulated latent heating are used to compute and insert the LHN increments. This modification tends to render the increments more coherent and the scheme more efficient.

- Precipitation produced by the prognostic scheme will take some time to reach the ground where it is compared to the radar-derived surface precipitation rate. Thus, the conventional LHN scheme can notice only with some temporal delay when it has already initiated precipitation aloft. Therefore, a more immediate information on the precipitation rate already initialised is required, i.e. a sort of undelayed 'reference precipitation' which is used merely to replace the delayed prognostic model precipitation in the computation of the scaling factor α. One choice to work reasonably well is found to be the vertically averaged precipitation flux.

a) b)

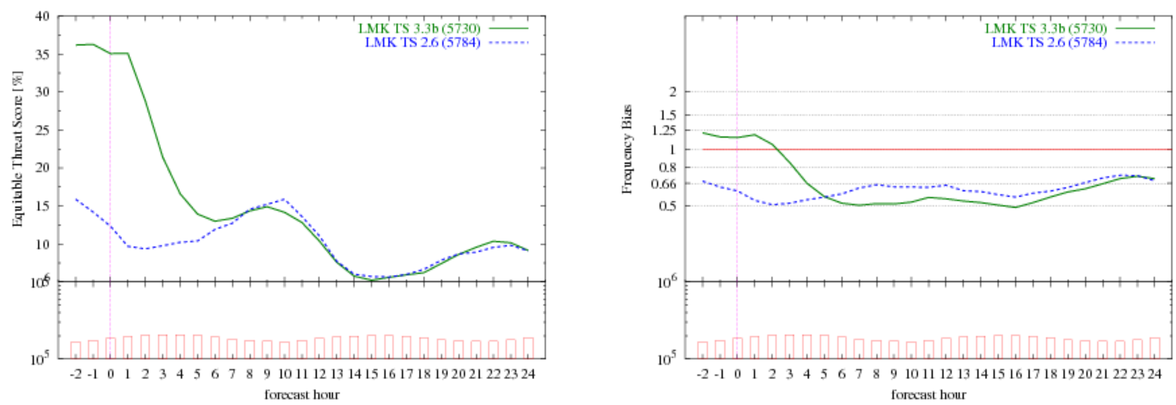

Figure 1. Mean equitable threat score (a) and mean frequency bias (b) for hourly precipitation (threshold 0.1 mm) for the overall (combined 0 and 12 UTC forecast) runs as a function of forecast time. The thin vertical purple lines indicate the starting time of the free forecasts. The "mean" scores were obtained by adding up the contingency table over a 45-day period. Assimilation cycles: nudging without LHN (blue dashed, label "LMK TS 2.6 (5784)") and nudging with LHN (green solid, label "LMK TS 3.3b (5730)"). The red bars at the bottom of the panels show the number of observed precipitation events above the considered threshold value.

3. VERIFICATION OF MODELLED AGAINST RADAR-OBSERVED PRECIPITATION

For an assessment of the overall performance of the revised LHN during assimilation and especially for an evaluation of LHN's forecast impact, two experiments using the COSMO model in the 2.8km version (LM-K) of the German weather service (DWD) have been carried out for a 45-day period in June and July 2006. A LHN experiment, comprising of an LM-K assimilation run with LHN and two daily 24-hour forecasts starting at 0 and 12 UTC, is compared to a control experiment, which has been set up in the same way but does not use LHN during assimilation. The particular comparison measures are "Equitable Threat Score" (ETS) and "Frequency Bias" (FBI) for hourly precipitation.

On average, the positive impact of radar data is visible in the combined 0 and 12 UTC forecasts' ETS for up to 5 hours for a threshold value of 0.1 mm (fig. 1a). This impact time decreases slightly for higher threshold values (not shown). Whether the rapid decrease of ETS is partly due to the double penalty problem inherent to the ETS still needs to be evaluated. The mean FBI curve presented in fig. 1b indicates that LM-K forecasts starting from an assimilation without LHN (blue dashed lines) generally underestimate the precipitation. On the contrary, forecasts starting from an assimilation with LHN (green solid lines) begin with almost ideal values (1.0) of FBI, rapidly drop off towards the graph of the control experiment after 3-4 hours, and afterwards still stay slightly below this one for several hours. It seems that there exists a general model deficiency in generating precipitation, and LHN, however, is only able to help this problem for a short time period directly after the assimilation. More precisely, LHN does not cure the problem but it just rearranges the occurrence of precipitation during the first several hours. A higher FBI during the first four forecast hours is compensated by lower FBI-values for several hours thereafter.

4. A CASE STUDY WITH A NESTED ENSEMBLE SYSTEM

a) The role of the convective environment

In order to quantify the role of the convective environment, a nested ensemble simulation of a severe convective event in southern Germany has been performed at MeteoSwiss. The setup of the experiment is depicted in Fig. 2. Each of the 10 members of a 7km COSMO-LEPS (Marsigli et al., 2005) simulation, driven by an ECMWF EPS run, provides the initial and boundary conditions for a 2.2km COSMO model ensemble and thus a different convective environment in which the storm develops. Each fine-scale ensemble member starts from the interpolated corresponding 7km member at 06UTC. In addition, a deterministic run interpolated from an operational MeteoSwiss 7km analysis at 06UTC is performed. Conventional and radar data are assimilated during the first 10 hours in all 2.2km simulations, followed by a free forecast of 8 hours.

Figure 3a) shows the mean precipitation over the QPF validation area shown in Fig. 2 (black) as simulated by the fine-scale 2.2km ensemble (member 1-10, color lines) and observed by the radar (bold black line). A large variation of the simulated precipitation amount is evident among the different ensemble members. This variation results only from the different convective environment each COSMO-LEPS member provides for its nested fine-scale member. The timing of the maximum convective activity is captured by all members due to the radar assimilation which ends at $t=0$ at the beginning of the convective event. But the amount of precipitation among the members differs by a factor of up to 3. The best member supports convection and reaches 78% of the observed peak, while the worst member does not support the storm and reaches only 21%.

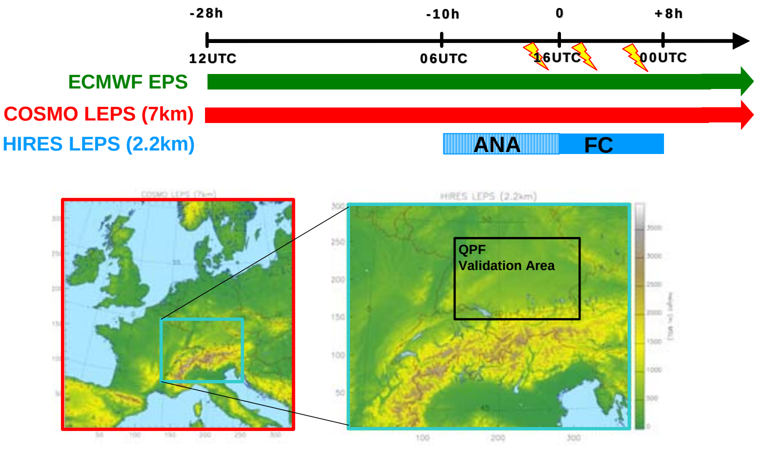

Figure 2. Setup of the nested ensemble experiment. An ECMWF EPS run (green) drives the COSMO-LEPS (7km) (red) which drives the 2.2km (HIRES) ensemble (blue). The yellow flashes mark the time of the convection. The domains of the COSMO-LEPS and the 2.2km ensemble are depicted in the respective colors and the QPF validation area is depicted in black.

a) b)

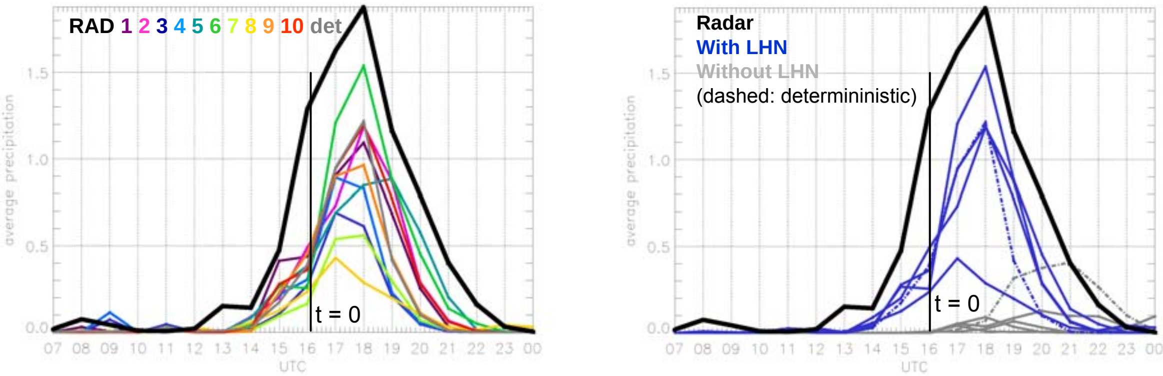

Figure 3. Time series of average surface precipitation over a 375x220km domain in southern Germany (shown in Fig. 2). The black bold line represents the radar observations and the colour lines model precipitation from the 2.2km ensemble. a): all ensemble members (1-10) plus a deterministic run (det) started at 06 UTC. All simulations are calculated with assimilation of conventional and radar data until t=0 (16 UTC) followed by a free forecast until 00UTC. b): as a) but for selected members calculated with (blue lines) and without (grey lines) radar assimilation. The deterministic runs are depicted with dashed lines.

b) The benefit of the radar data assimilation

The radar data assimilation with LHN turned out to be highly beneficial for the QPF in this case, as can be demonstrated with additional simulations without the assimilation of radar data. Figure 3b) shows the simulated precipitation of selected members with (blue) and without (grey) LHN. None of the members without LHN is able to simulate the storm, while all of the members with LHN show at least some signal of the convection.

5. CONCLUSION

Several modifications to the LHN scheme have been implemented which enable the model with prognostic precipitation to simulate the rain patterns in good agreement with radar observations during the assimilation. Thus, the problems related to prognostic precipitation appear to be mitigated to a satisfactory degree. However, the rapid decrease of benefit in the forecasts remains a shortcoming.

With a nested ensemble system experiment of a case of strong convection it has been demonstrated that an environment which supports the convective evolution of during the forecast can be as important for a skilful QPF as the forcing of convection with radar assimilation at the right time and location.

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5.3 C. Fischer and A. Horanyi: Aladin consortium activities in data assimilation

Aladin consortium activities in data assimilation

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The Aladin consortium pursues the development of its variational assimilation facility, in close software interaction with the IFS/Arpège global system, and some first applications at the convective scale in the frame of the Arome project. In the two previous years, significant efforts have been spent for preparing the progressive convergence of this tool with the Hirlam system and plans for mesoscale data assimilation. We show in our note some prominent activities of the last year and draw perspectives in terms of development and collaborations.

1. Mainframe 3D-VAR: example of Aladin-France

Below are listed the most important technical features of the Aladin assimilation system, as far as its variational component for upper air fields is concerned, based on the example of the French application (Fischer etal., 2005):

►Incremental 3D-VAR

►Continuous assimilation cycle, 6 hour frequency, long cut-off assimilation cycle and short cut-off production, coupled with Arpège, Analysis=Model gridmesh=*9.5km*

►Observations:

- Surface pressure, SHIP winds, *synop T2m and RH2m*
- Aircraft data
- SATOB motion winds
- Drifting buoys
- Soundings (TEMP, PILOT)
- Satellite radiances: AMSU-A, AMSU-B, HIRS, *Meteosat-8 SEVIRI*
- QuikSCAT winds
- Ground-based GPS zenital delays

►Digital filter initialisation (non incremental)

2. Background error covariance modelization

2.1. Non-linear and omega balances

Based on the work by Mike Fisher for the IFS, we have adapted the Aladin balance formulations in order to apply a quasi-geostrophic omega equation and a non-linear balance constraint. Figure 1 shows the effect on the analysis increment for a single observation of temperature.

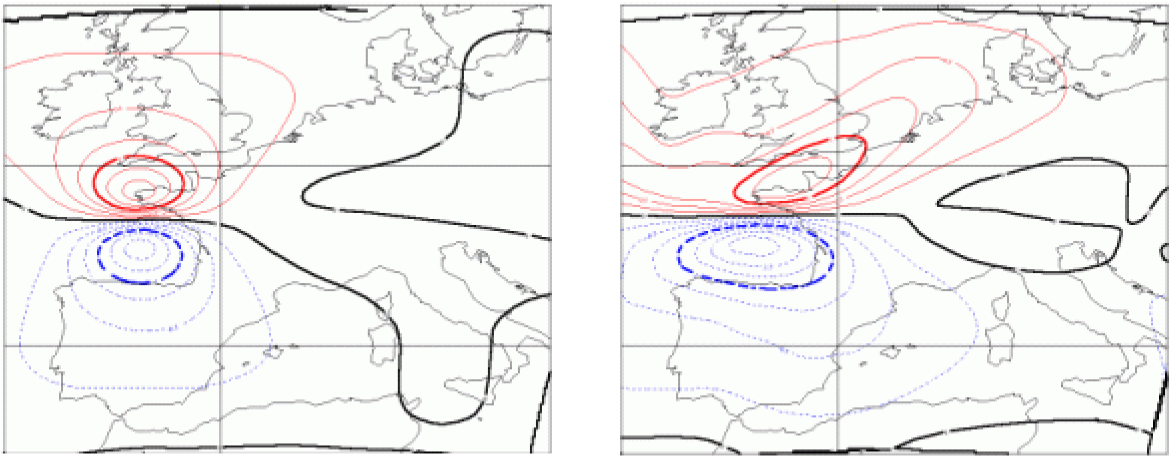


Figure 1: analysis increments of wind for a single observation of temperature. Left: usual geostrophic-type of balance; right: non-linear balance derived from Fisher (2003)

2.2. Wavelet structure function for a limited area

►Wavelets are (partially) localised in both grid point space and Fourier space.

►Diagonalization of B in wavelet space can reproduce local variations in the structure functions and standard deviations.

►Current work is focussing on reproducing 3D structure functions for different variables

Figure 2 shows maps of standard deviations, as derived using the NMC method for sampling of dispersions (36 minus 12 hour forecast data). We compare the fields obtained after casting the dispersions onto a complex wavelet basis with those obtained directly in gridpoint space.

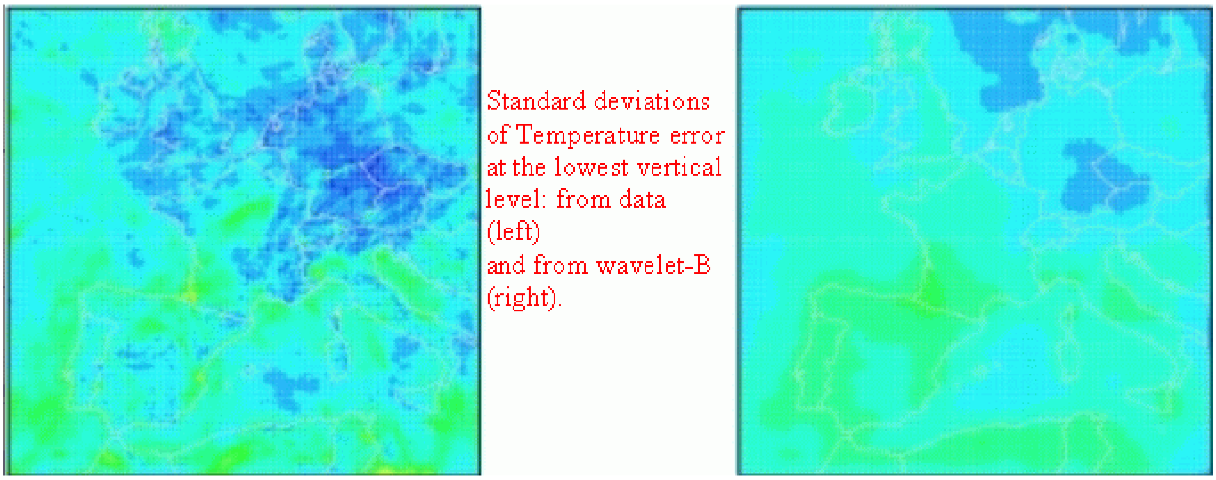


Figure 2: maps of standard deviations for temperature. Left: gridpoint data; right: wavelet basis.

2.3. Ensemble-derived sampling of dispersions

Work is ongoing on using small ensembles (about 6 members) in order to sample forecast dispersions, which then enter into the B matrix information. Tests have shown that a fairly small ensemble, which can be run at a reasonable computational cost, already can provide sensible, flow-dependent values and structures for error fields. The small size of the ensemble suggests however to filter the small scale structures in order to filter sampling noise, which is mostly present in the shortest wavelengths (Berre et al., 2006). Figure 3 shows the result for maps of standard deviations of two parallel, twin, ensemble of 3 member each. The filtering function is derived from the cross-correlation function between the two sub-ensembles.

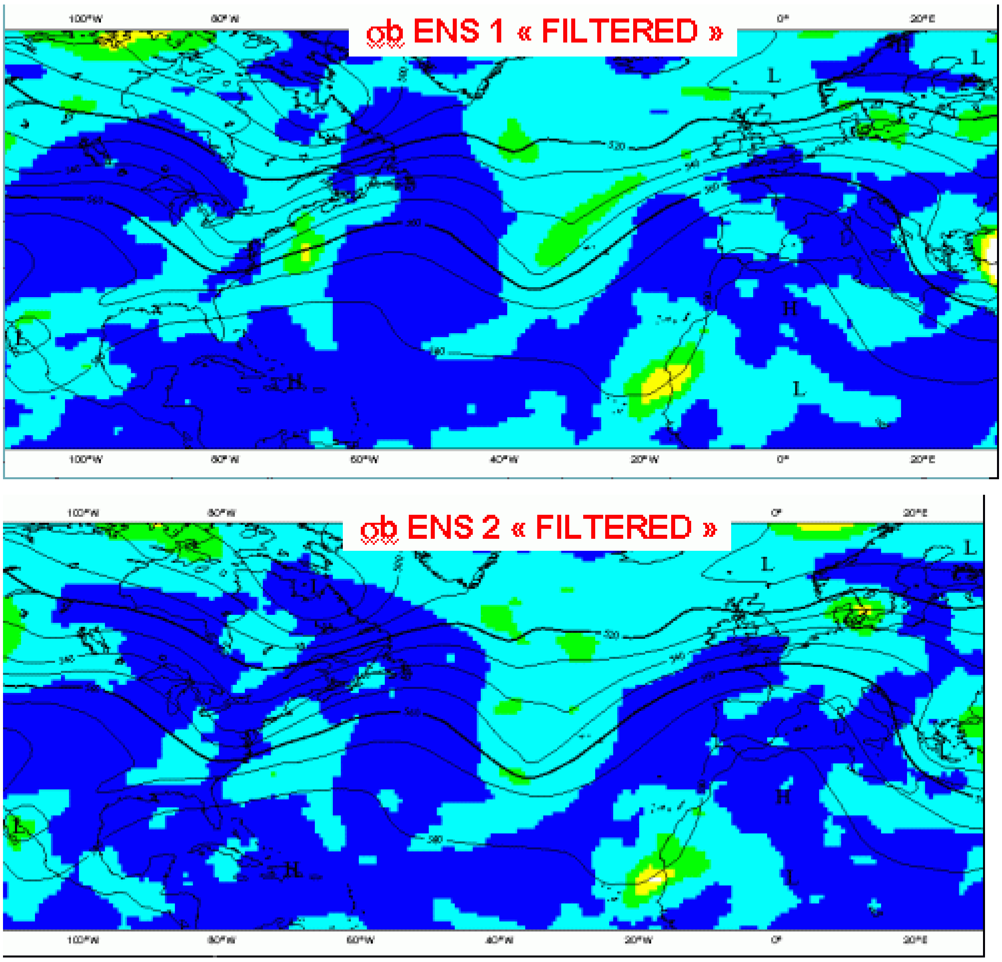


Figure 3: standard deviations of (Arpège) vorticity fields, obtained for two, twin ensembles of 3 member each (each ensemble is re-initialized using the background perturbations from the twin ensemble). The maps show that both ensembles provide similar dispersions, with usual flow-dependent information, once small scale sampling noise has been filtered out.

3. Observations and O.S.E. experiments

3.1. Towards the assimilation of microwave surface sensitive channels from AMSU-A, AMSU-B & SSM/I over land:

Over land:

- Only microwave channels that are the least sensitive to the surface are assimilated
- There exists a significant uncertainty about land emissivity and skin temperature
- Existing emissivity models : facilitate the assimilation of channels that receive a contribution from the surface
- The models need accurate input parameters which are hardly available at global scale

We search for alternatives to estimate the land emissivity, which has lead to new land surface emissivity parameterisations at Météo-France:
1) Dynamically varying emissivities derived from only one channel for each instrument
2) Averaged emissivities over 2 weeks prior to the assimilation period

3) Averaged emissivities + dynamically adjusted skin temperature from one channel for each instrument

We show below results from the dynamical approach (1). Figure 4 shows the comparison of innovation values for a number of AMSU-A microwave channels, using the standard or the new surface emissivity maps. It is clear that the innovations have been reduced drastically for assimilation experiments using the new maps, most notably for low-level sensitive channels. Very little impact is seen for the mid- and high level channels. Identical results have been obtained for AMSU-B and SSM/I channels over land. The reduced innovations (and biases) allow to start assimilating additional low-level channels for impact studies. This work is ongoing. First results indicate a significant impact on the distribution of humidity and precipitations, especially in the Tropical areas for Arpège tests. Further tests also in the LAM model are expected.

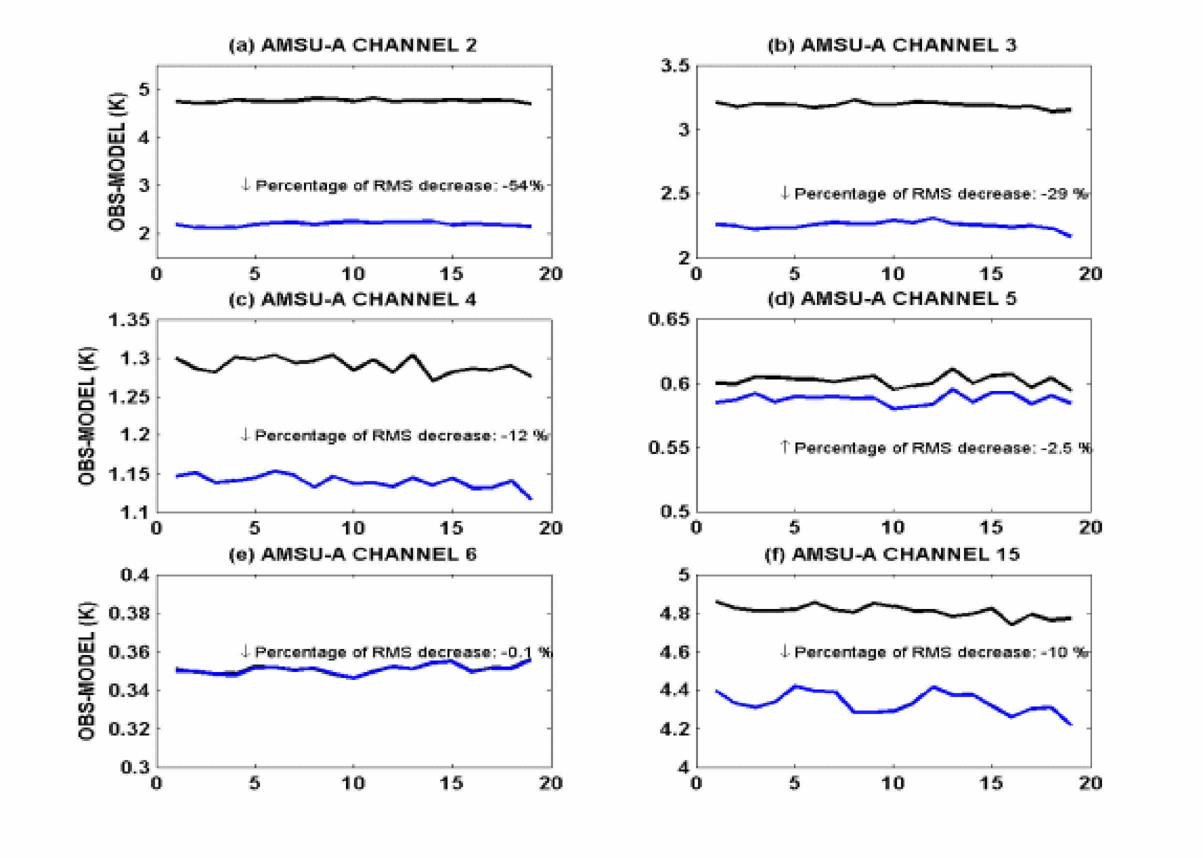


Figure 4: statistics of innovations for 6 AMSU-A channels, using the standard surface emissivity conditions (black) or the new maps (blue).

3.2. Tests of 3D-VAR assimilation over North Africa

The Moroccan Aladin team has undertaken an extensive testing of the 3D-VAR assimilation over a wide North-African domain. Yet, the absence of major components of the satellite radiance data for the time being prevents an operational usage of 3D-VAR. progressively, the installation of satellite data databases, conversions and monitoring will allow a testing of the complete observation assimilation system. Figure 5 shows biases of 2m temperatures for both the dynamical adaptation (Arpège-triggered spin-up model) and the 3D-VAR assimilation systems over North-Africa. Despite the fairly small amount of observational information (a number of surface stations, aircraft data and a few radiosondes), the assimilation system already competes reasonably well with the spin-up model.

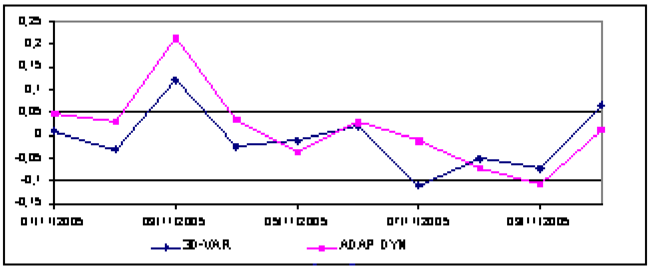


Figure 5: 2m temperature biases for Aladin-NORAF. Spin-up model from Arpège (magenta); 3D-VAR assimilation (blue).

3.3. Assimilation of reflectivities for the Arome version

The principle of the assimilation of radar reflectivities, which is felt as being a major component of the future Arome data assimilation system, is based on a 1D retrieval method, followed by a 3D-VAR analysis of the retrieved profiles of humidity and possibly temperature. The 1D retrieval method is a Bayesian inversion technique where the pseudo-observed column of temperature and humidity is obtained as a weighted average of a number of neighbouring model columns. The weights are determined by a cost function which measures the likelihood of any column to produce the observed reflectivity profile (Caumont et al., 2005). The overall dataflow for the 1D+3D-VAR analysis is sketched in Figure 6 below. Only the retrieved temperature and humidity profiles enter the analysis, in a way similar to radiosonde data.

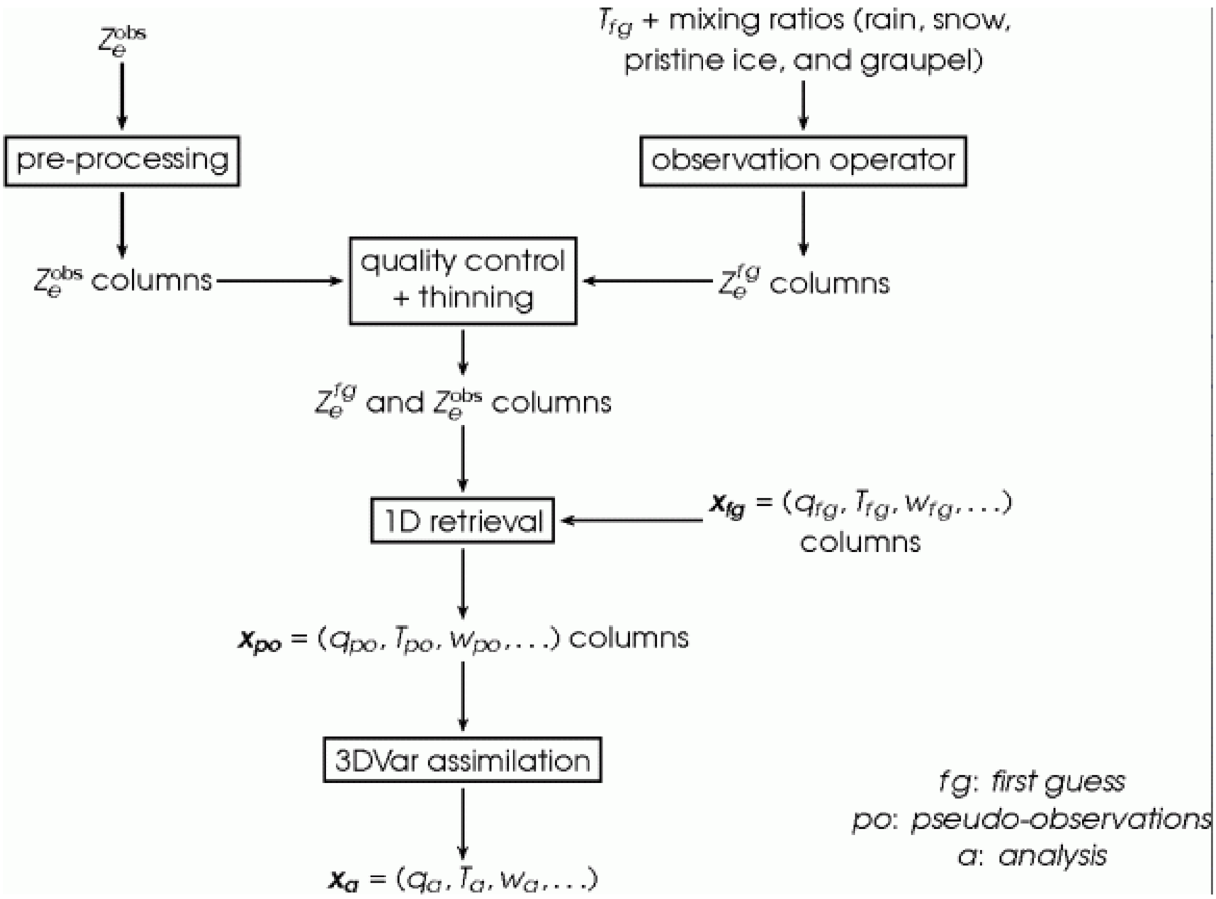


Figure 6: sketch of the technical dataflow of the 1D+3D-VAR retrieval and analysis method.

In parallel, a direct radar observation operator has been developed and is used in case studies for reflectivity monitoring and model-to-reflectivity applications. The radar observation operator also allows to study and improve carefully the quality control checks to be operated later on in a routine operational manner. So far, conclusions are the following:

► 1D retrieval seems able to correct for humidity,

► Quality control of data and observation operator evaluation (M. Jurašek, LACE)

► Implementation in Arome is well advanced

Future work:

► More 1D + 3D-VAR high resolution cases

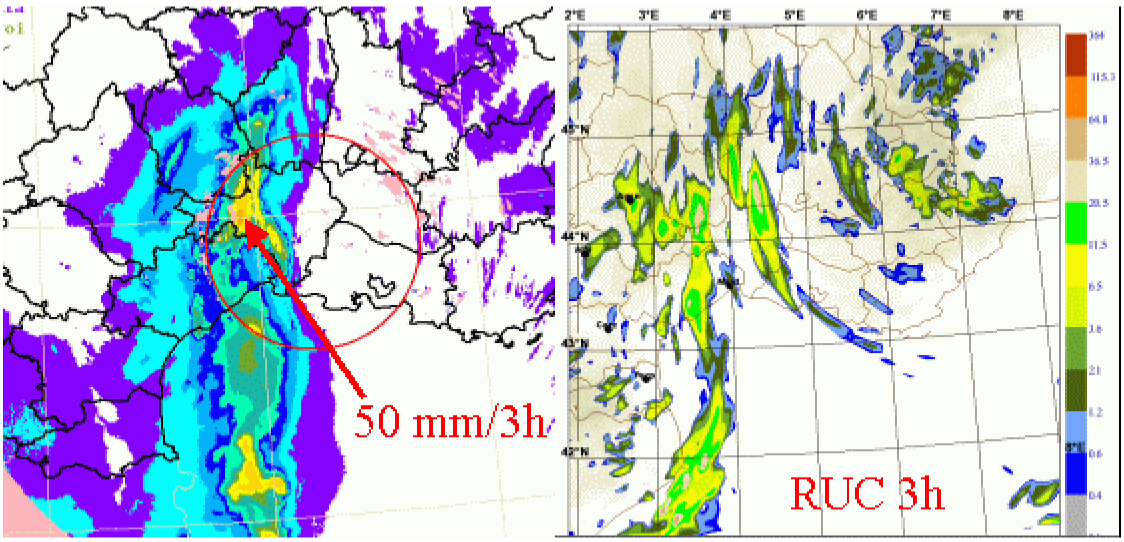
► Perform cycled assimilation experiments,

Collaborations:

► Introduce beam blockage in observation operator (G. Haase, Hirlam)

4. The Arome assimilation prototype: a R.U.C.

Decision has been taken to start the preparation and the early evaluation of an Arome model based assimilation system in the context of a Rapid Update Cycle. The RUC typically is started 12 or 24 hours before the target initial time of interest, allowing thus for 5 to 9 3D-VAR data analyses in a 3-hourly frequency (13 to 25 in a 1-hourly mode). While we still wish to carefully evaluate the spin-up properties (especially in the 1 hour cycle), work also needs to be performed in order to tune the system with respect to data density. Also, in 2007, further case studies are planned, still focussing on severe cases of heavy precipitating events. Figure 7 shows one such case, a typical strong event triggered by the advection of moist, warm air from the Mediterranean Sea over South-East of France. This air is orographically forced over the Cévennes mountain ridge, with some additional forcing from a synoptic upper-air trough. The result is a heavy convective mesoscale system, usually fairly stationary for several hours, which represents a major threat to the surrounding areas. Some critical aspects for a good forecast here are a good initial state for humidity, low level winds and the position and orientation of the upper air trough.



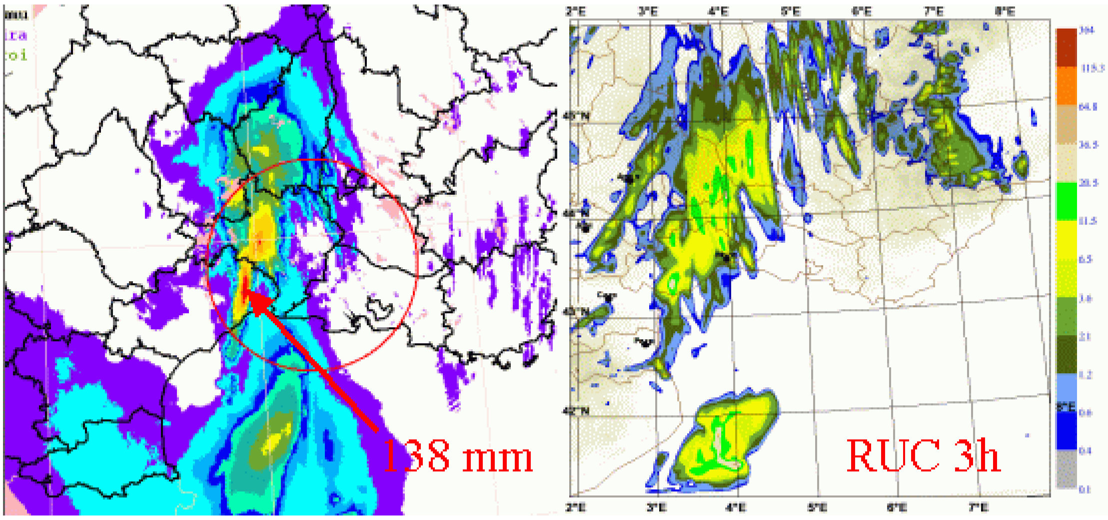


Figure 7: 3 hour aggregated precipitations (mm/3h) as deduced from radar data (left), and as modelled by the Arome 2.5 km model (right). In the latter case, the initial state was obtained by a preliminary 12 hour long RUC with a 3 hourly 3D-VAR data analysis of surface observations, aircraft, radiosonde and satellite radiances (ATOVS, HIRS, MSG/SEVIRI). Top: 0-3 hour lead time; bottom: 3-6 hour lead time.

5. Surface assimilation

There exist for the time being a variety of approaches for initializing surface fields. It is planned to derive Sea Surface Temperature and possibly ice cover sheet information from up-to-date satellite observations (NESDIS and Eumetsat products). Furthermore, in France for instance, land surface fields could be initialized straight away from the coupled soil/surface/hydrology system “SAFRAN”. For a more genuine data analysis inside the LAM NWP model, we still do have the CANARI Optimal Interpolation code, which actually now is used in Czech Republic (in link with upper-air blending of Arpège fields) and Morocco. Most likely, France and Hungary also are going to test its implementation in link with the 3D-VAR upper-air analysis.

For the future developments, provisional plans are to integrate a specific surface field analysis (first using an Optimal Interpolation approach, then using some Dynamically adaptive algorithm derived from a 2D-VAR approach). This system would be coded inside the externalized surface scheme SURFEX, which is to replace our present operational surface model ISBA in the coming years. Additionally, the development of a spatialization tool for 2D horizontal fields (having strong heterogeneities) is planned. This tool would allow the analysis of screen-level fields.

Further plans for surface assimilation will be discussed and decided within the frame of the Aladin/Hirlam collaboration.

6. Plans for 2007 and outlook

►Background error covariances:

- Errors of the day for screening
- Gridpoint maps of Sigma_b’s for minimization
- Filtering of the ensemble background errors (low-pass)
- Native Aladin ensemble of analyses
- Derive from those an Arome ensemble forecast
- Wavelets (A. Deckmyn, Belgium; T. Landelius, Hirlam)

►Algorithms:

- FGAT (with Hungary - LACE)
- Semi-Lagrangian TL/AD and 4D-VAR in a nutshell (F. Vaňa, LACE)
- Incremental digital filters
- Some kick-off on a simplified microphysics scheme for the mesoscale?
- Towards an integrated « Ensemble/Variational » data assimilation system; ETKF

►Observations:

- SEVIRI radiances in Hungary (LACE) and Morocco (non-LACE)?
- SEVIRI/Clear Sky Radiances monitoring and bias correction; surface emissivity for IR SEVIRI channels (M. Stengel, Hirlam)
- Metop sensors
- Work on radial radar wind observation operator (T. Montmerle and C. Facchani)
- Continuation on radar reflectivity observation operator & retrieval methods (M. Jurašek, LACE; G. Haase, Hirlam)
- Microphysics modules for HIRS/IASI (M. Stengel, Hirlam)

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5.4 G. Bölöni: Data assimilation activities in LACE 2006-2007

Data assimilation activities in LACE 2006-2007

Gergely Bölöni

with contributions from LACE colleagues

January 15, 2007

Introduction

Coordinated work on data assimilation started in 2003 within LACE. During the last three years, most of the cooperative members had an important contribution to this work (Croatia, Czech Republic, Hungary, Romania, Slovakia) and also an intensive correspondence took place with the French assimilation team. Local assimilation installations exist in Czech Republic (upper-air blending + surface OI scheme in the operational suite) and in Hungary (operational 3DVAR for the upper-air + interpolated ARPEGE surface analysis). It is important to mention that data assimilation planning within LACE should always fit the ALADIN or more recently the HIRLAM-ALADIN (HARMONIE) strategy. This paper summarizes the data assimilation activities during 2006.

Background errors

A posteriori tuning of background errors has been started following the method described in Desroziers et al. (2005). In this method one estimates the background and observation error variances based on the covariances of the analysis residuals (observation – guess, observation – analysis, analysis – guess). The advantage of this method is that the analysis residuals can easily be accumulated in case of a working assimilation cycle consequently the variance estimations are quite cheap and straightforward. After estimating the optimal variance one can tune the predefined (gotten from an earlier estimation like the NMC or the Ensemble method) variances of system. For the tuning one has to multiply the predefined variances with the v_e/v_p misfit ratio, where v_e stands for the estimated and v_p for the predefined variance. In the Hungarian assimilation system so far 2 different approaches were taken in order to estimate the background error variances: a) Global misfit ratio for all the control variables together b) Separate misfit ratios for the different control variables. Note that in both approaches vertically uniform estimations were used. The tuning was done for background error variances predefined by the Ensemble method and was tested through assimilation cycle experiments. The results show (Fig. 1) that the tuning can improve the forecast scores.

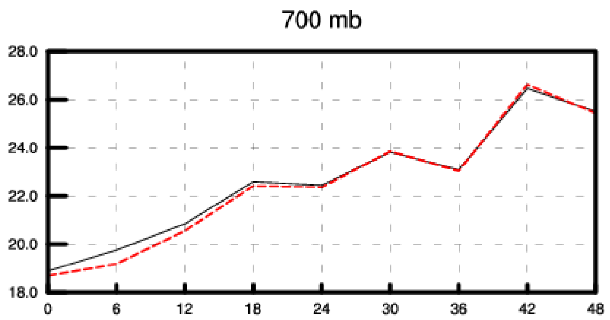

Fig. 1. Relative humidity RMSE on 700 hPa using the predefined variances (solid black line) and the tuned variances with approach a) (dashed red line)

3D-FGAT

Tests with the 3D-FGAT method were started at the Hungarian Meteorological Service. Originally the 3D-FGAT coded in ARPEGE/ALADIN adds the analysis increment to the background at the beginning of the assimilation window, as it is a simplification of 4DVAR. For better comparison with 3DVAR this feature was changed by adding the increment to the background at the middle of the assimilation window. For the comparison of 3D-FGAT with 3DVAR several assimilation experiments were run using as many observations as possible. Results show, that the FGAT method can improve the quality of the forecast at the beginning of the integration for geopotential, wind and slightly for temperature but degrades the scores for humidity in the PBL. On Fig 2. the impact of the FGAT is shown for geopotential as an example.

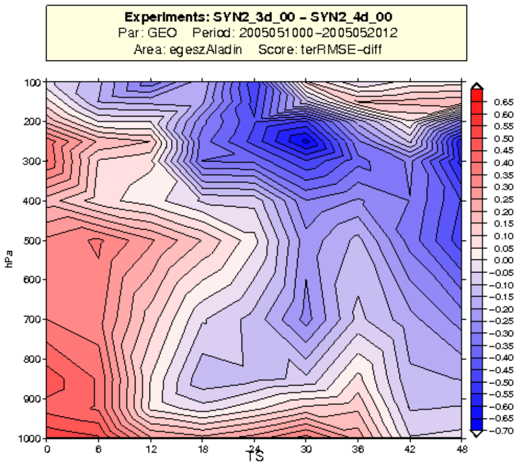

Fig 2. Impact of the 3D-FGAT compared to 3DVAR. Red colors correspond to improvement, blue colors to degradation due to FGAT

Further studies were dedicated to examine the impact of SYNOP observations in FGAT in different ways. Possible ways are to use the SYNOPs in every timeslot (there are 7 slots in the 6 hour assimilation window) or just the one observed at analysis time. The results reflect that a better analysis and forecast is provided if only that SYNOP report is assimilated which was observed at the analysis time.

Observation use

During the first half of the year the main emphasis was put to the use of AMV (Atmospheric Motion Vectors) data from MSG. The goal was to find the optimal use of these data with two degrees of freedom given by the quality index of the data and the usability over land and sea. The quality indexes (QI) are provided according to the actual quality of each observation. As the number of available observation is decreasing with an increasing QI, it is the user's choice to set the optimal QI to be used. Concerning the usage of the data over land and sea, we should mention that in the global ARPEGE model, AMV data are used uniquely over sea. However as the European domain used at the Hungarian Meteorological Service (HMS) includes mainly land surface, experiments were run using these high-resolution data over land as well. Altogether 3 experiments were run within the Hungarian 3DVAR system (WDEF: QI > 85%, data only over sea, W80P: QI>80%, data only over sea, WLAN: QI>85% data over sea + land). The reference was the operational 3DVAR suite (NAM2). Results show that the AMV data have a good impact on the analysis and the forecast especially for geopotential and wind but also for humidity through the multivariate Jb (Fig 3). It can also be concluded, that adding the AMV data over land can further improve the forecast (Fig. 4).

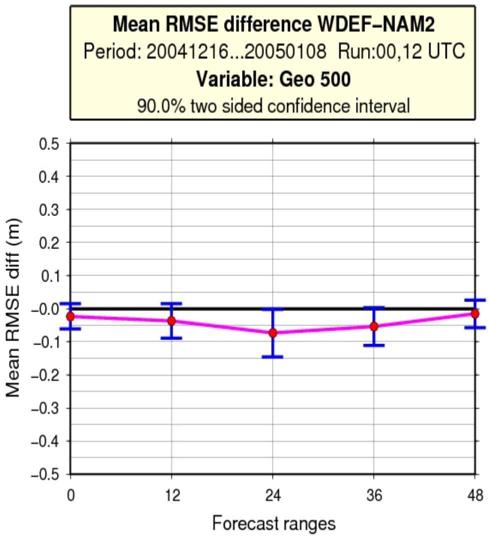

Fig.3 RMSE difference (WDEF-NAM2). Negative values correspond to improvements. The result is significant if the vertical bars does not cross the 0 line.

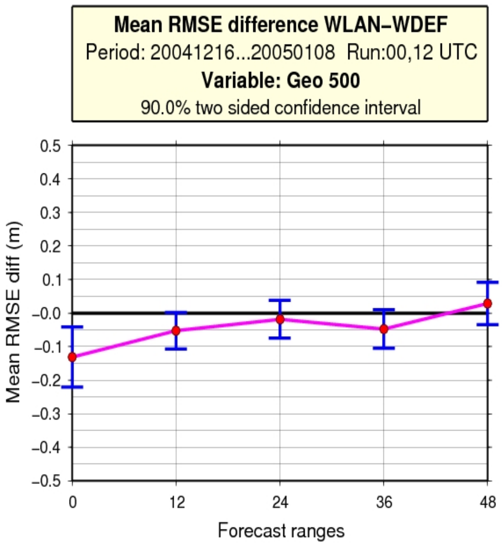

Fig.4 RMSE difference (WLAN -WDEF). Negative values correspond to improvements. The result is significant if the vertical bars does not cross the 0 line.

Another important contribution to the work on observation use was given by the participation of HMS in the EUCOS project. In this framework intensive assimilation experiments were run to examine the relative impact of ground based observations compared to the satellites available. The work consisted of running 8 OSEs (Observing System Experiments) for 2 one month long periods (one summer and one winter period). Conclusions were driven by score comparisons together with significance tests and through the analysis of case studies from both periods. As the project has not been fully closed yet, we do not show pictures here but our main conclusion is that the ground based observing system is a quite important component of our assimilation suite. At the end of the year a work on the assimilation of SEVIRI data has started as well but the results are too much preliminary for any details here.

Surface

At the Czech Hydrometeorological Institute a surface OI scheme (CANARI) has been implemented operationally instead of the former surface blending. The OI analysis is applied with a 6-hour frequency, that is, at each step of the blending cycle after the treatment of the upper-air fields. The operational application of the surface OI analysis was implied by test results showing systematic improvement in the 2m temperature and relative humidity (Fig. 5 and 6).

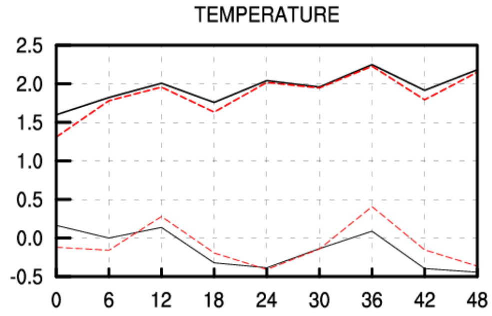

Fig.5 Temperature RMSE (thick line) and BIAS (thin line) scores of the ALADIN/CE model with surface blending (black solid line) and with surface OI (red dashed line)

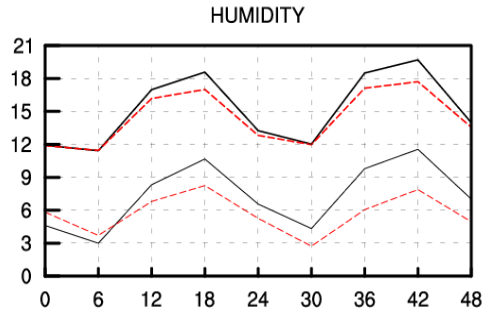

Fig.6 Relative humidity RMSE (thick line) and BIAS (thin line) scores of the ALADIN/CE model with surface blending (black solid line) and with surface OI (red dashed line)

Acknowledgements

The author would like to thank the valuable work of the LACE data assimilation team during the year 2006. This research was partly supported by the Hungarian National Scientific Foundation (OTKA T049579).

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6 Scientific presentations on physics

6.1 M. Bush: Physics improvements in the NAE model, dust forecasting, firefighting and chemistry

Physics improvements in the NAE model, dust forecasting, firefighting and chemistry

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1) NAE model physics upgrade 26th September 2006

The physics package comprises changes to the Boundary Layer (BL) and convection schemes. These changes were initially tested and then implemented in the Global model in March 2006. Also included in the package is a solution to the 'valley cooling problem' (a numerical instability caused by the theta advection scheme). This problem has previously lead to both Global and NAE model failures in places such as Tibet and Greenland where 'bowl' shaped orography has lead to runaway cooling of cold, stable pools of air. The previous solution has been to locally smooth the orography to stop these cold pools from forming in the first place.

Convection changes

The changes to the convection scheme are:

1) mid-level changes - a selection of small modifications primarily aimed at improving the behaviour of mid-level convection
2) adaptive detrainment - the triggering of forced detrainment (Figure 1) is set to be a function of the parcel's buoyancy gradient resulting in a much smoother detrainment profile (Figure 2).

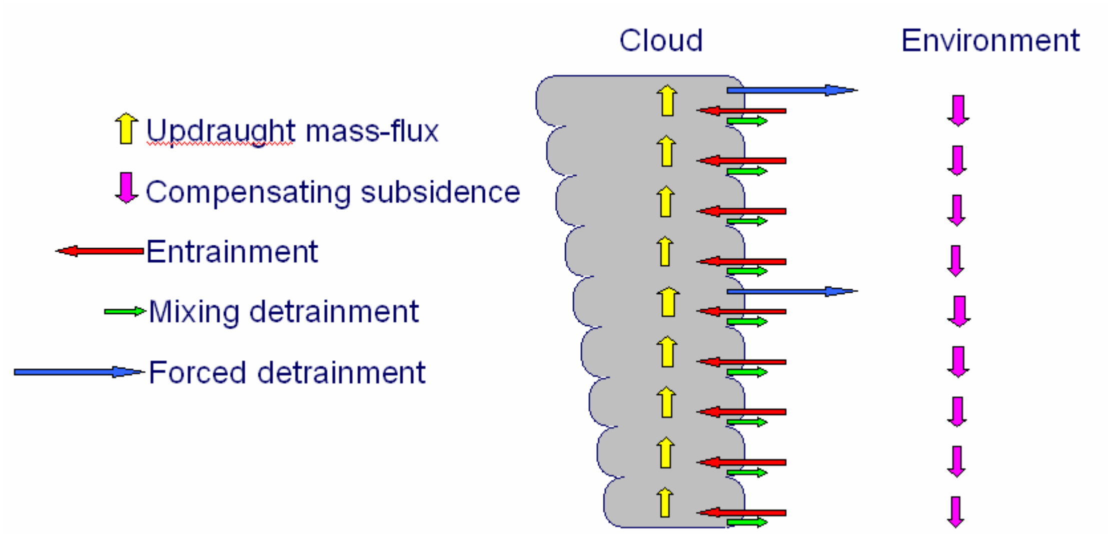


Figure 1: Convection scheme: Updraught

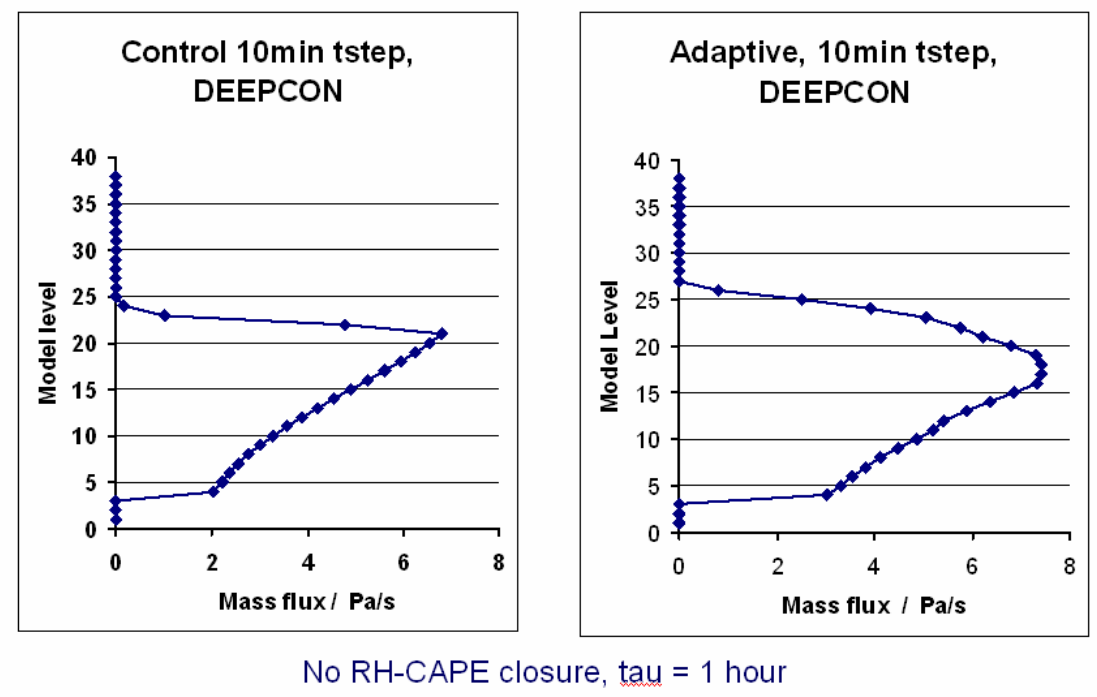


Figure 2: Smoothing of Mass Flux Profile

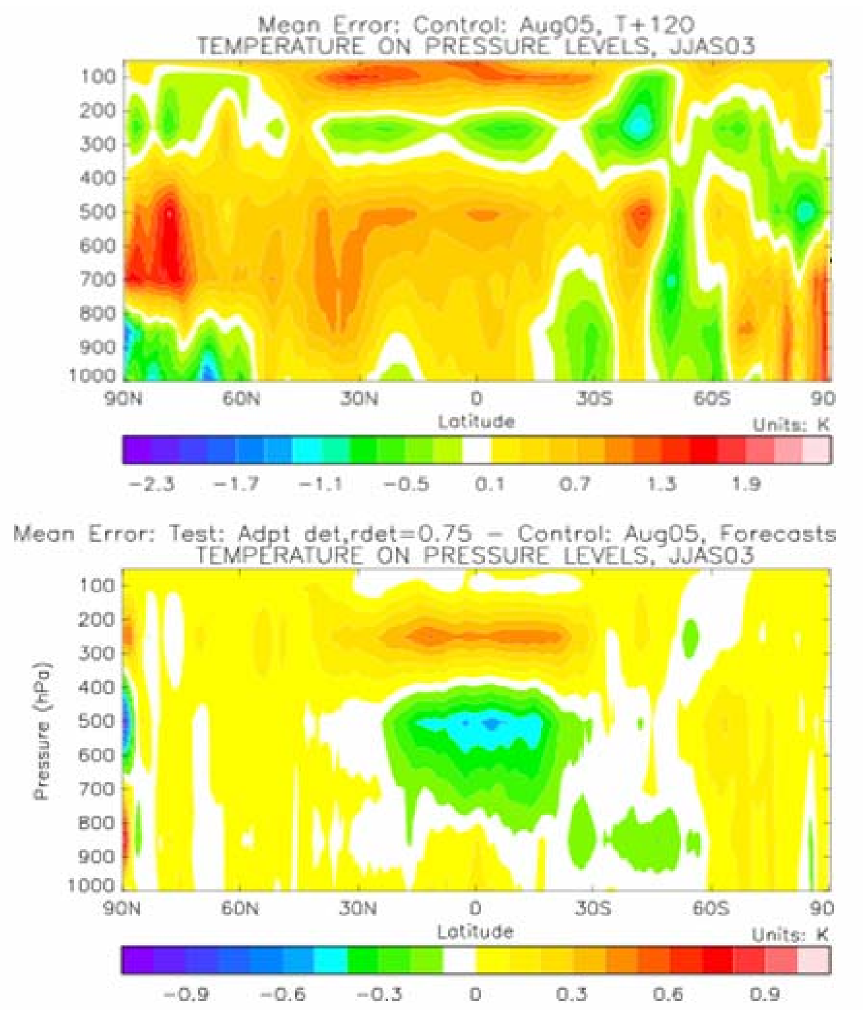


Figure 3: Impact of package on temperature errors (Global model trial).

The top panel in figure 3 shows that we have a warm bias in the tropical mid-troposphere and a cold bias above. The package reduces both these biases (bottom panel in Figure 3) by giving reduced detrainment at the top of the convective plume and more throughout the column.

One disadvantage of adaptive detrainment is that it makes convection more intermittent (switches on and off from timestep to timestep). Following the change, forecasters complained that convection appeared ‘more spotty’ and less organised. Therefore the convective rain and snow rate diagnostics were subsequently changed to give one hour averaged values rather than instantaneous values.

Boundary Layer changes

The changes to the BL are:

1) sharp tails over sea
2) marine BL changes
3) revision to the diagnosis of decoupled BLs
4) correction to diagnosis of cumulus
5) correction to prevent entrainment in stable BLs
6) and the inclusion of non-gradient stress

Marine Boundary Layer changes include a revision to the thermal roughness length over sea. The current operational treatment (using a constant thermal roughness length) leads to an significant increase in the exchange coefficient for heat and moisture with wind speed (Figure 4). This is not observed in field experiments and so the revised treatment gives a much smaller increase in the exchange coefficient

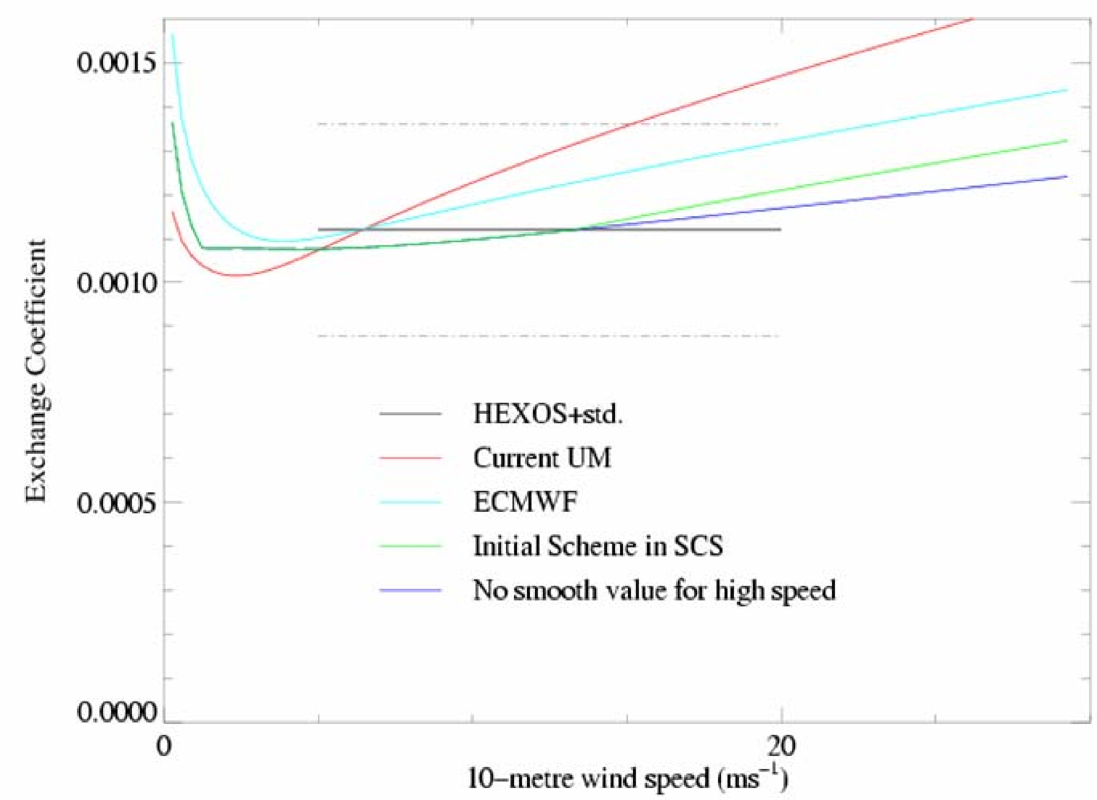


Figure 4: Wind speed dependence of the Exchange coefficient

Solution to the 'Valley cooling problem'

The solution to this problem is the introduction of an 'intelligent limiter' to the advection of theta. This stops theta values at a gridpoint from falling below departure point values.

Figure 5 (top left panel) shows a control run at T+48 with an area of very cold air (150K minimum) that has cooled by up to 37K since the start of the forecast (bottom left panel). A test run with the solution to the problem (top middle panel) has a 191K minimum and does not exhibit the same cooling pattern as the control when looking at the T+48 -T+0 difference (bottom middle panel).

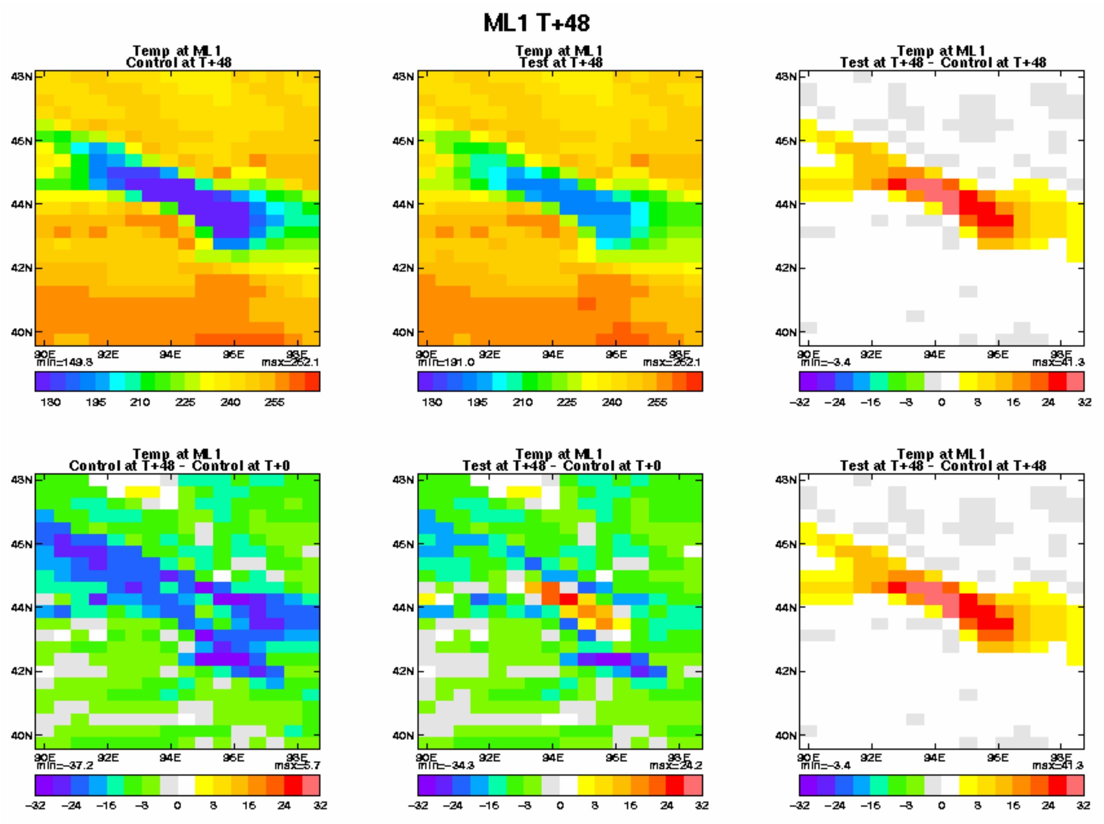


Figure 5: solution to Valley cooling problem

2) Murk aerosol

Why have Murk aerosol?

Visibility is one of 5 weather parameters used as key indicators of model performance.

Visibility is difficult to forecast due to its highly non-linear dependence on relative humidity, cloud liquid water and aerosol and the often localised nature of areas of poor visibility. Surface visibility reports are assimilated using a variational assimilation system, giving increments to moisture, aerosol ('Murk') and temperature.

What is 'Murk' aerosol?

'Murk' aerosol was introduced into the UM (U.K Mesoscale model) as a prognostic variable to improve visibility forecasts. It is now used in the NAE/UK4 configurations.

Murk can be modified by assimilation, advection, source and sink terms and a 'relaxation' term. It can also interact with radiation causing thermal impacts in the boundary layer.

The Murk aerosol is based on the urban-industrial aerosol type (61% water soluble aerosols e.g. sulphuric acid, sulphates, 22% soot (carbon) and 17% dust (quartz, silicaceous clays)

What problems are there with Murk?

- Large values of MURK (“dust storms”) at the beginning of the forecast
  These are due to problems with the assimilation of visibility observations (Figure 6)

- Unrealistically large values of MURK at later forecast ranges due to the “relaxation term”

- Out of date source data again giving unrealistically large MURK values (Figures 11 and 12)

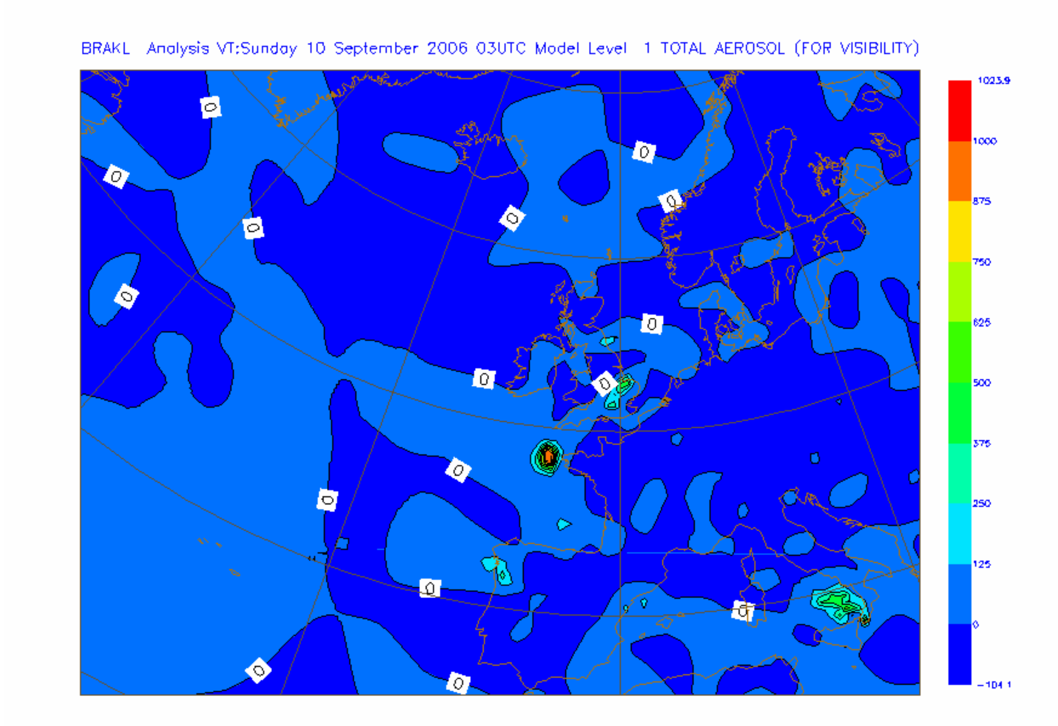


Figure 6: Unrealistically large analysis increment values to Murk aerosol

log10 vis is a very non-linear function of RH (Figure 7) and this causes data assimilation problems. Low visibility obs in the U.K are mostly associated with large RH values (>90%). However if the model background RH is ~60%-70%, the analysis will try and give a large increment to MURK (as changing RH will have little impact on the height of the surface).

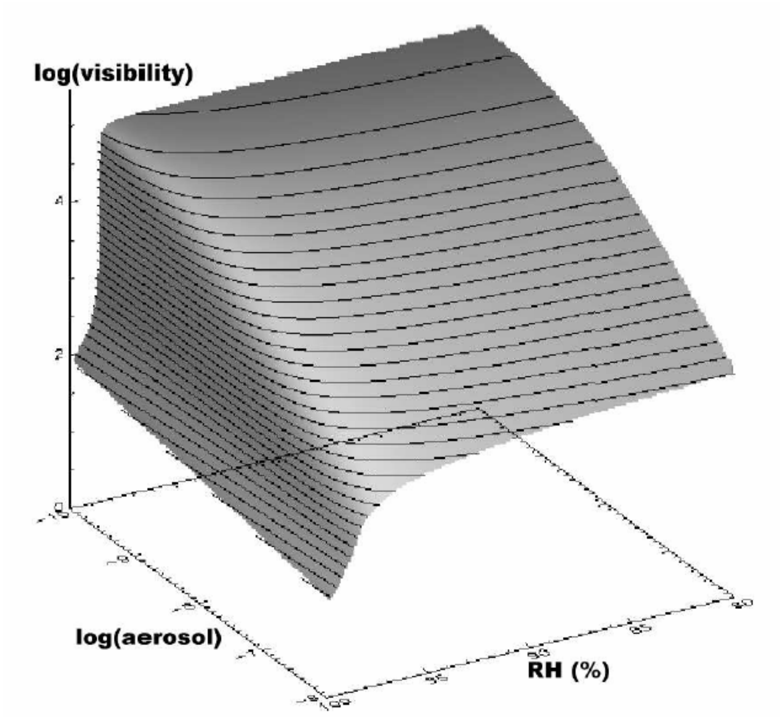


Figure 7: log10 vis as a function of RH

The way to control the relative priority of aerosol and rh increments from vis is via the aerosol background error. This is set to 1.0 in log10 units but we don't have a good handle on this number. A lower value implies it is more difficult to change MURK, however previous tests with a value of 0.3 made fog forecasts worse.

Another simpler way to control these large increments is to simply have a capping limit. This is currently set to 1000 micrograms per kilogram operationally, but tests with a value of 200 micrograms per kilogram (Figure 8) have shown benefit.

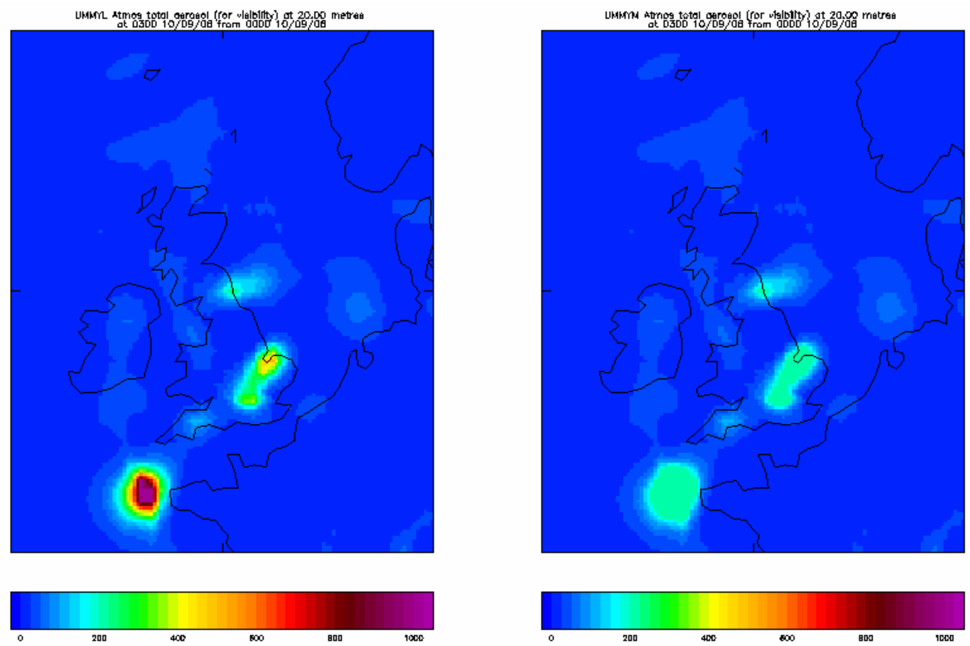


Figure 8: Impact of reducing AEROMAX from 1000.0 (left hand panel) to 200.0 (right hand panel)

Relaxation term

Due to these problems in the assimilation process, a “relaxation term” was added to the model. Aerosol amounts are relaxed to 25 micrograms per kilogram over land and 12.5 micrograms per kilogram over sea with a timescale of 2 days.

The assumption that the aerosol concentrations over most land points are identical was possibly reasonable in the U.K Mesoscale model. However, this assumption is not appropriate in the NAE. The mass mixing ratio over Greenland or Iceland is clearly not going to be identical to the aerosol mass mixing ratio over continental Europe. It would be better to relax to a climatology field rather than fixed land/sea values or scrap the relaxation completely if we could reduce our data assimilation problems.

Murk sources

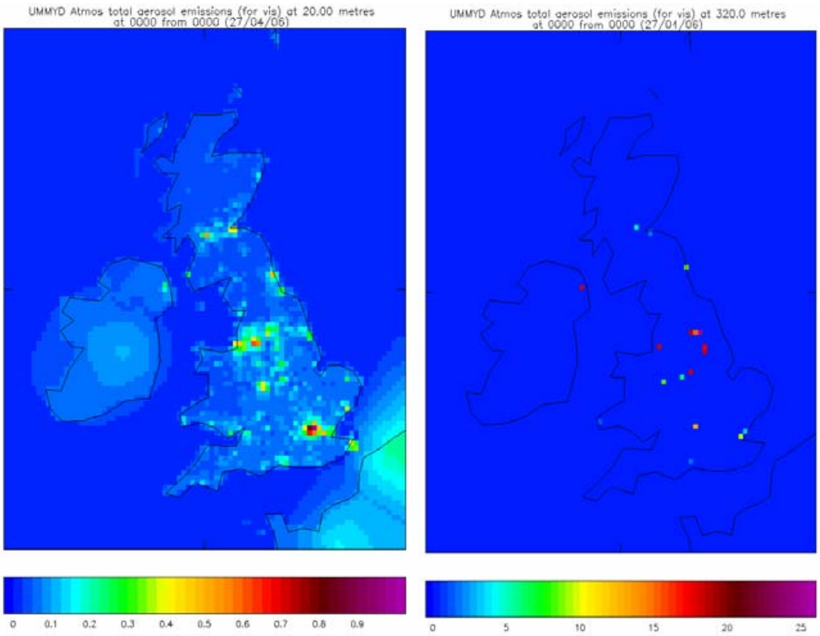


Figure 9: Aerosol emissions at 20.0 metres and 320 metres over the U.K.

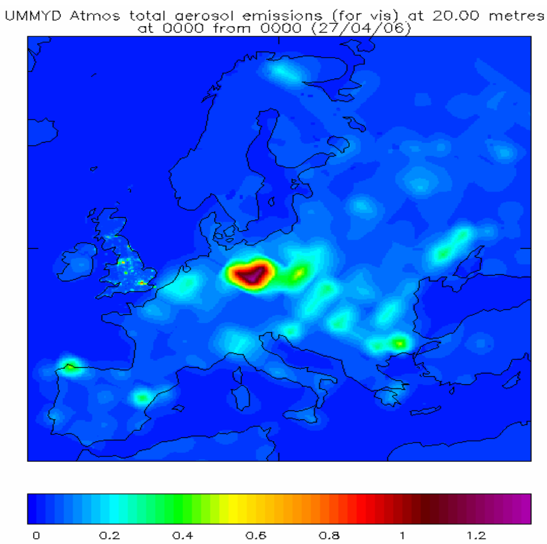


Figure 10: Aerosol emissions at 20.0 metres over Europe

The distribution of the source terms in the UK is based on the Warren Spring Laboratories (WSL) emission inventories (Figure 9).

Outside of the UK (Figure 10) the distribution is based on the EMEP 150 km emission inventories, produced by the Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe. The EMEP 150 km grid covers roughly the same area as the NAE grid and hence should constitute a good representation of the distribution of aerosol sources in the NAE.

The dominant source terms leading to atmospheric aerosol in the NAE model region are sea salt, soil particles and emissions of sulphur dioxide, nitric oxide and nitrogen dioxide.

The man made emissions require some atmospheric chemistry to take place before CCN are formed. Good emission inventories for aerosol sources are provided by WSL for both SOx and NOx. However, under many conditions, which lead to poor visibility, as for example radiation fog, these emissions are well above the boundary layer and do not contribute to the local aerosol. Thus it is important that the source terms are introduced with an initial vertical distribution.

Within the UK area, the WSL inventory has been used, with the assumptions that effective source height is 1.5 times chimney height, to allow for plume rise. The emissions have then been allocated to the appropriate model level.

A simple sinusoidal diurnal variation has been implemented peaking at midday, with an amplitude that is 70% of the mean value. This diurnal variability was created to simulate the variability of pollution from industry and transport.

Emissions have changed significantly in recent years (Figures 11 and 12) and so there is a need to update the source data.

An additional (small) surface term has been added everywhere to allow for natural sources.

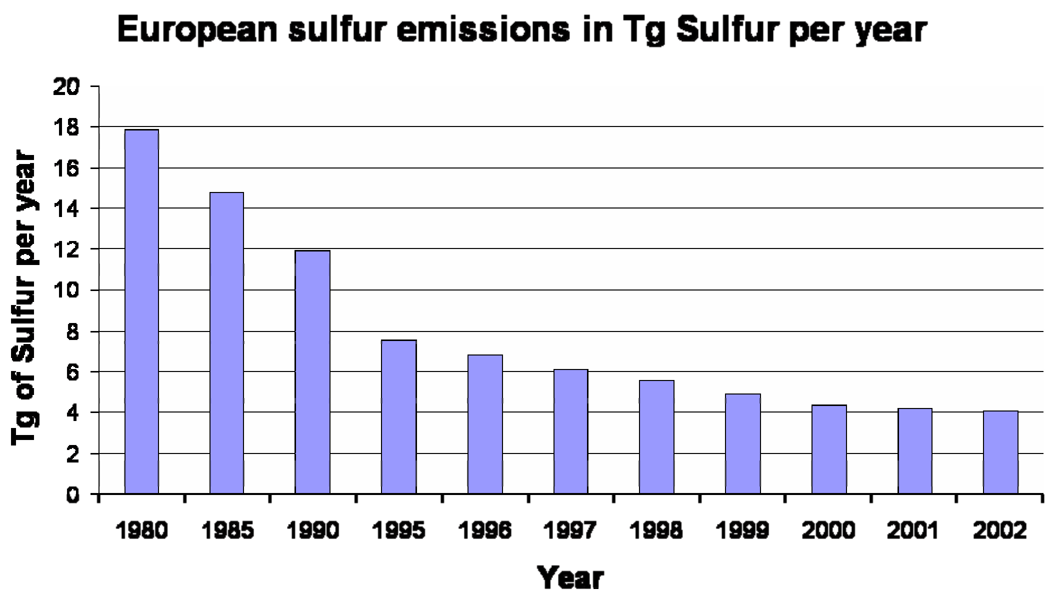


Figure 11: European sulphur emissions in Tg per year

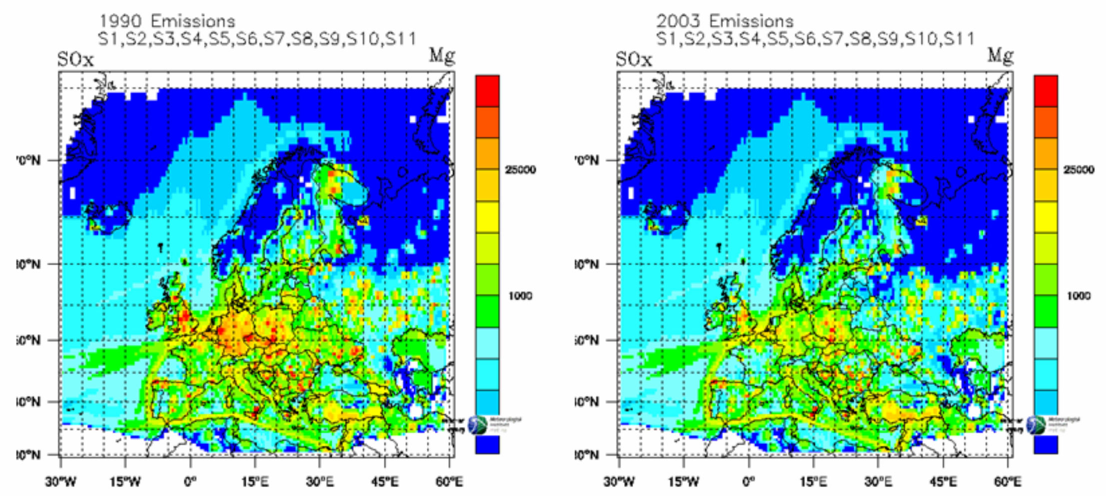


Figure 12: SOx emissions in 1990 and 2003

Comparison of model aerosol amount with aircraft observations

The FAAM aircraft has been used to compare model aerosol amounts with observed aerosol scattering (Figure 13). The results are rather encouraging giving the known shortcomings with the current scheme.

The aircraft measures aerosol scattering using a nephelometer in per metre whilst the model has values in micro grams per kilogram. Therefore to convert we assume an aerosol specific extinction coefficient of 3 metres squared per gram (big assumption!)

Dividing the obs values by the extinction coefficient gives us m-1/(m2 g-1) and dividing by the density of air (assumed to be 1 kgm-3) gives us g/Kg.

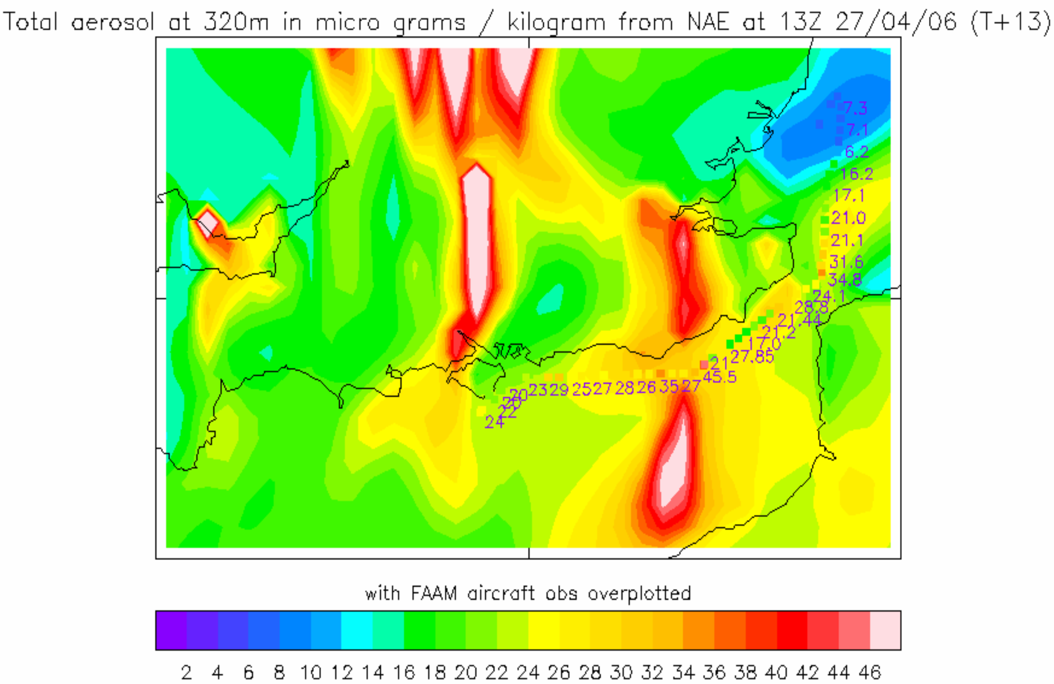


Figure 13: Model level 4 aerosol amount in micrograms per kilogram with FAAM Aircraft measurements overplotted.

Dust forecasting

The aim of the Dust and Biomass burning Experiment (DABEX) was to investigate the physical, optical, and radiative properties of mineral dust and biomass burning aerosols. This allows a better representation of mineral dust and biomass burning events in Met Office models.

In situ validation measurements can be compared against the output from these models. Meanwhile the Dust Outflow and Deposition to the Ocean experiment (DODO) was a specific measurement campaign funded by the university sector with Met Office collaboration

A limited area model over the Sahara was run twice daily in real time to provide prototype dust forecasts to the research aircraft during the DABEX and DODO flight campaigns. Raw model dust output is in Mass Mixing ratios of dust (kg/kg) for each particle size bin (currently 6) on each model level.

An automated post processing system supplied forecast charts to the aircraft giving total dust concentrations (g/m³) at the surface, between 2000-5000ft and 5000-10000ft. Subjectively, the model forecasts compare qualitatively well with large dust events (Figure 14). Future dust amounts and particle size are reliant on significant model evaluation, validation and tuning.

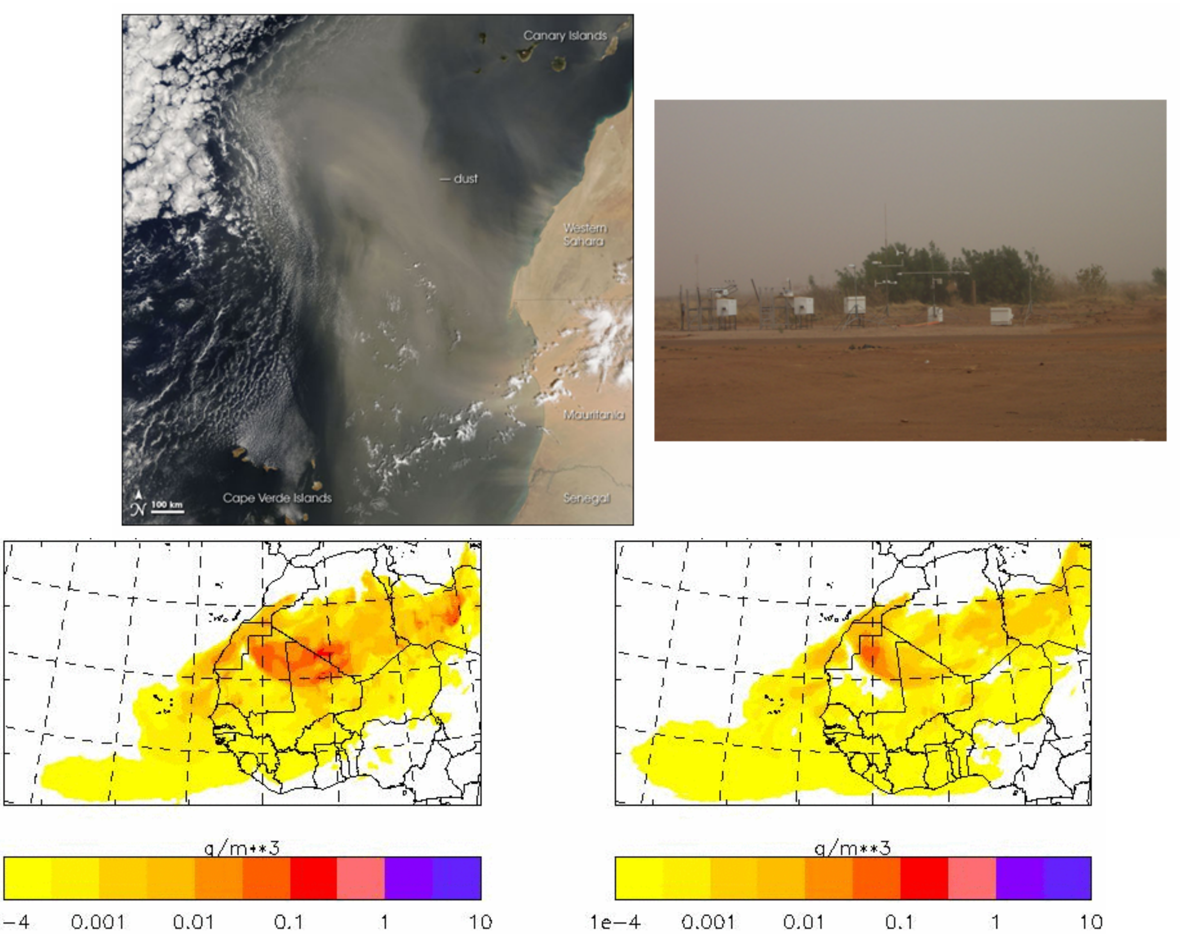
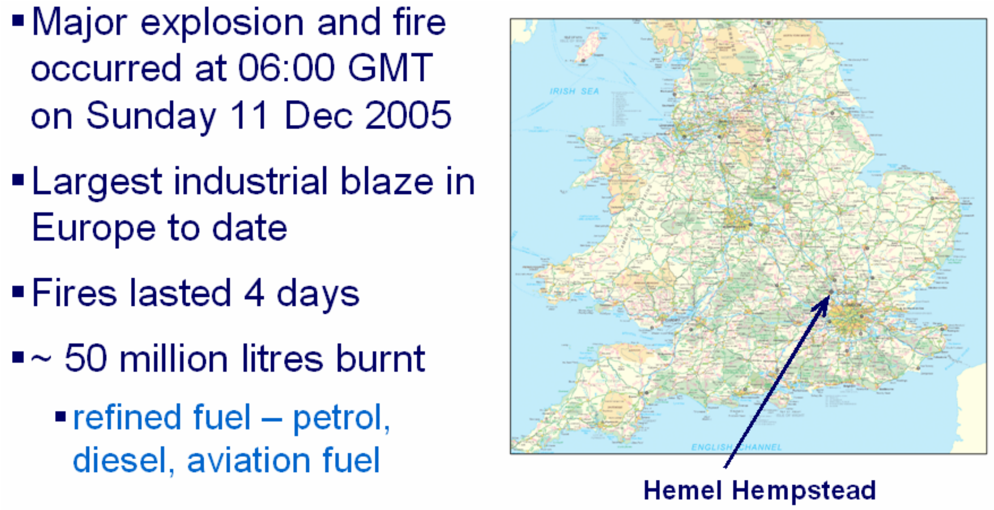


Figure 14: Dust concentration at the Surface (bottom left panel) and 2000ft:5000ft (bottom right panel) at 00Z on 08/03/2006.

Buncefield oil depot fire



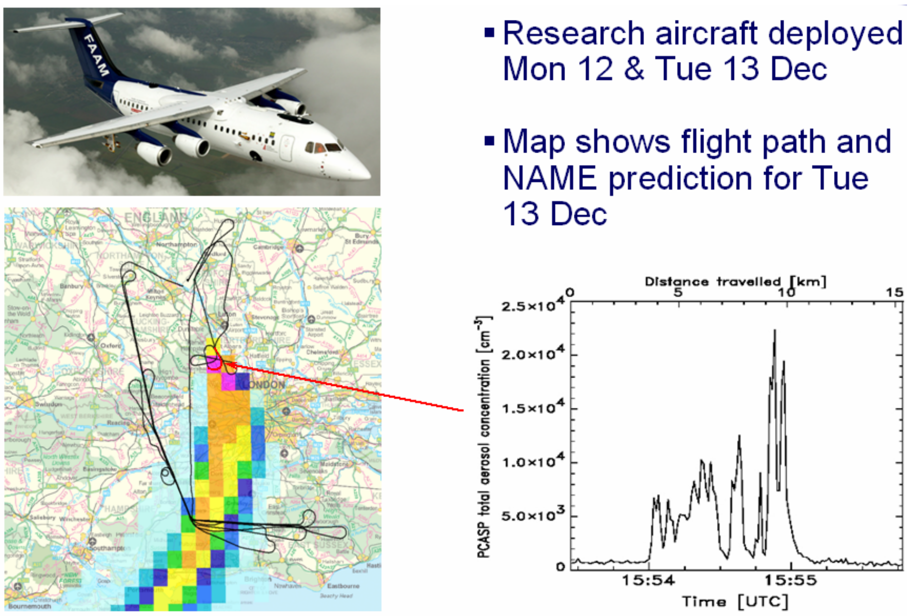


Figure 15: Buncefield (Hemel Hempstead) oil depot fire. NAME (dispersion) model simulations and FAAM research aircraft measurements of total aerosol concentration.

Tropospheric chemistry in the Unified Model

Work is in progress on a pilot project to implement a chemistry package in the operational global and regional versions of the UM.

The chemistry model is the **UKCA**: **UK** **C**hemistry **A**erosol **C**ommunity Model http://www.ukca.ac.uk/ and there are close links with the GEMS EU project.

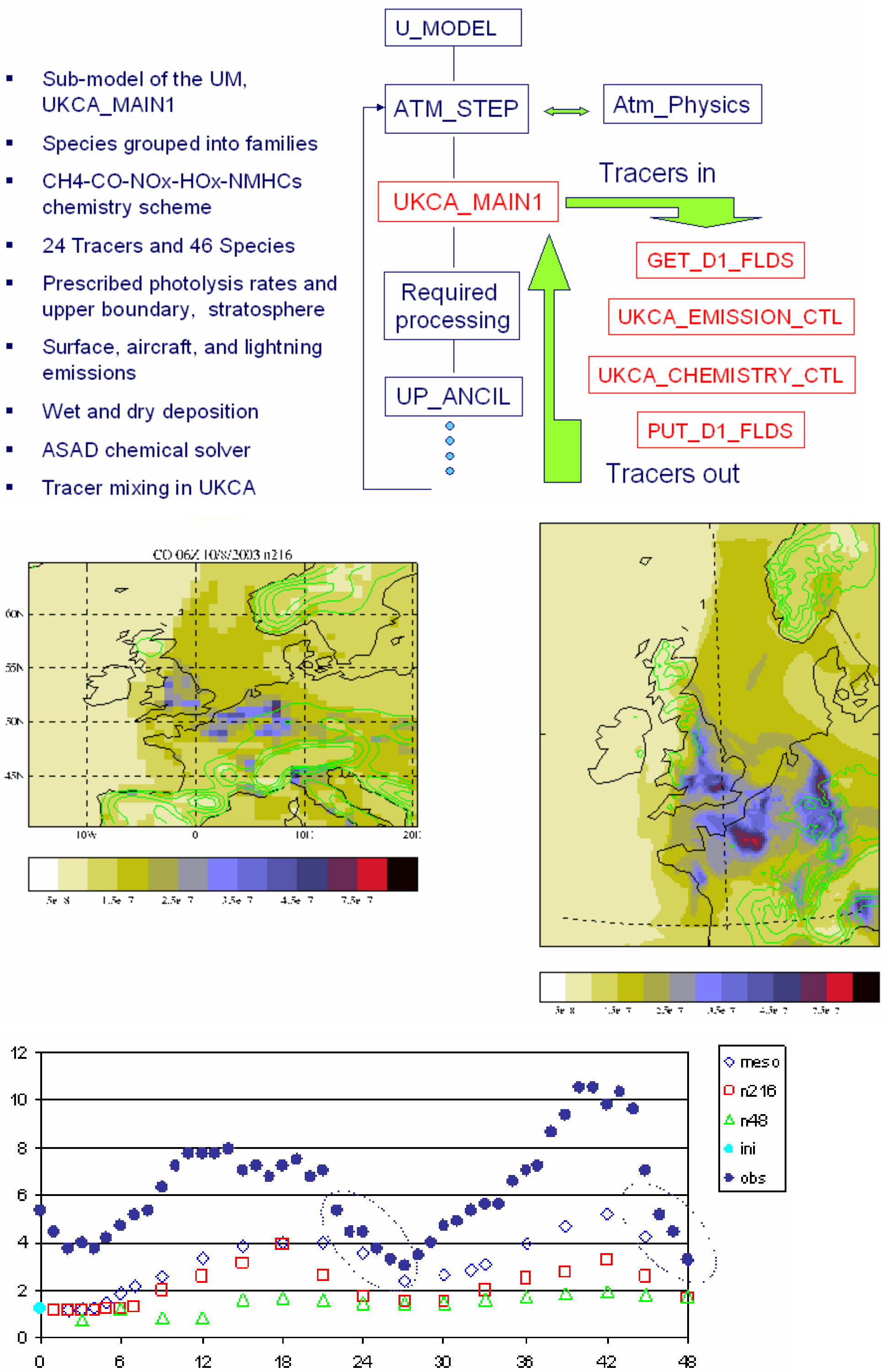


Figure 16: Schematic of how the chemistry model fits into the UM (top). 8th -10th August 2003 case study: Time series of observed carbon monoxide (solid blue circles) for London and 48 hour forecasts from the Global (red squares and left middle plot) and Mesoscale models (blue diamonds and right middle plot).

6.2 P. Clark et al.: The Convective-Scale UM: Current Status, Verification and Physics Developments

The Convective-Scale UM: Current Status, Verification and Physics Developments

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1. Current Status

High resolution NWP is an approach which has potential to improve our ability to forecast deep convection, though precisely how high the resolution needs to be is an open question. Experience suggests that an important step is allowing explicit convection to form in flows which adequately resolve the mesoscale features which lead to triggering and organisation of storms, rather than fully resolving the detail of convective cells. It is anticipated that high resolution will also address other high-impact weather forecasts, such as orographically forced strong winds, fog and low cloud, urban and other surface induced variations in temperature and wind.

At the Met Office, we have developed the Unified Model (UM) for use at convective-scale resolutions, focussing on configurations with grid resolutions of around 1 km. As an intermediate step, work on a 4km grid resolution configuration has shown the benefit of resolving convective storms (at least partially) compared to purely parametrizing the effects of convection at lower resolutions, and a 4km UM has been operational over the UK since 2005. A 1.5km grid resolution configuration of the UM will be operational for a choice of limited area domains over part of the UK (450km x450km) “on-demand” from January 2007 (i.e. the forecaster decides whether or not to run the model for a particular domain dependent on the severity of the weather conditions). A 1.5km model for the whole of the UK is planned to be operational in 2009, after the next major supercomputer upgrade at the Met Office. In the meantime, research is ongoing to increase our understanding of processes at the convective-scale and improve the formulation of the model and data assimilation system.

Figure 1 shows the standard domains that have been used for much of the testing and assessment of the high resolution models. The focus on the southern UK is primarily due to the availability of observational data from the Convective Storms Initiation Project (CSIP), an observational campaign over the southern UK in the summer of 2005, providing a wealth of data on convective storms and their initiation. The initiation of convection is particularly important in our models as different initiation mechanisms, such as surface forced sea-breeze convergence or mid-level initiation by gravity waves, may have very different inherent predictability, which is important to understand when designing and assessing the model. If the model does not correctly initiate convection, then subsequent evolution will be in error and, at best, data assimilation systems will have to address correction of the model error.

Recent evaluation of the high resolution modelling system (see section 2) has concentrated on CSIP cases due to the fact they are well observed and represent most of the 2005 summer convection. A brief (subjective) assessment of performance for the CSIP cases is described in Clark and Lean (2006). As an example, Figure 2 shows a 1.5 km resolution UM forecast of a case study of deep convective storms breaking out in a westerly over most of the UK on 25/08/2006 (CSIP IOP 18). The comparison with the satellite image and radar-derived rainfall show a high degree of consistency with the different meteorological regimes being captured by the model (e.g. streaks of gradually deepening cloud on the west coast; development of regions of deep convective cells with rainfall close to those observed; cirrus anvils). The model also spontaneously develops a squall line over central southern England in remarkably close agreement with the observations. The additional CSIP data have provided, in this case, a remarkably detailed record of the structure of this squall line.

Although the main focus is here is on precipitation from deep convection, other aspects of the model have also been evaluated including fog prediction and orographically forced winds.

2. Assessment of Convective Precipitation Forecasts

2.1 Precipitation Verification Method

Current operational verification methods are of very little value for evaluating the performance of rainfall forecasts from a convective-scale model. The principle reason is that conventional methods verify at either the grid scale of the model (or radar field) or at observation points (i.e. rain gauges) and we do not expect a storm scale model to be accurate at those scales because of the inherent unpredictable nature of small scales (i.e. the scales of the showers themselves). We do, however, expect a convective-scale model to be significantly more skilful over some larger scale (e.g. river catchments) which needs to be determined. A verification method has been developed to determine how forecast skill varies with spatial scale and what scales are useful. This assumes that the detailed location of precipitation below some selected scale can be ignored, but that information on the distribution (pdf) of precipitation at this scale is useful. By varying the scale, the skill as a function of scale can be assessed.

As an example Figure 3 shows a snapshot from ‘Case A’ – a case involving severe convection. This is broadly well forecast; some of the detail is wrong, but the overall placement and amount of rain is correct. Figure 4, on the other hand, shows ‘Case B’, an example of a poor forecast; the forecast rainfall area is almost completely misplaced. Figure 5 shows a score designed to test the spatial distribution of rain (the Fractions Skill Score, FSS). The two curves are in agreement with the visual impression that the Case-A-forecast is considerably more skilful than the Case-B-forecast at all but the very largest scales. The Case-A-forecast reaches satisfactory skill at a scale of 10 km compared to 188 km for the Case-B-forecast, which does not exceed the skill of a random forecast at scales below 86 km.

2.2 Model Performance (including data assimilation)

We have run forecast assessment trials for a number of summer convection cases from 2003, 2004 and 2005. Results from 2003 and 2004 are reported in Lean *et al*, 2005 and Lean *et al* 2006. Forecasts from both spin-up (i.e. initialising from a 12km resolution analysis) and continuous high resolution data assimilation runs are compared.

The current high resolution system has data assimilation based upon the system used in the 12 km UK Mesoscale model, making use of 3D VAR and Latent Heat Nudging (LHN) and the Moisture Observation Processing System (MOPS) to nudge in rainfall and cloud data. At present, 3D VAR increments produced by the 4 km model are reconfigured to 1/1.5km resolution and introduced via the Incremental Analysis Update (IAU) procedure. Work is underway to produce 3D VAR increments via the 1/1.5km resolution background, as well as improved parameters for the MOPS and LHN system.

Some results from the spin-up and high resolution assimilation forecasts are presented here. Figure 6 shows area-averaged rainfall rates over the 1 km domain for 2005 cases. The small domain makes this prone to errors due to large scale errors in position, but the overall signal is generally very similar from case to case. Runs starting from 12 km data show a significant time for rates to grow (as would be expected since the model represents convection through parametrization) and subsequently overshoot before settling down to approximately the correct value. This highlights the need for a continuous system. However, the assimilation runs (including the 12 km runs used to start the spin-up runs) also show over-prediction during the assimilation cycle which decays into the forecast. The large peak around T+2 is particularly noticeable. This is a subject of continuing work but we have some evidence that this is related to the VAR assimilation.

In spite of this bias in amount (and it should be born in mind that the radar observation may have significant error), forecasts show useful spatial skill, as reflected in the FSS discussed above The use of a relative threshold means that the scores are only sensitive to the spatial distribution of the rain rather than any overall bias. Figure 7 shows FSS scores for cases from 2004 and 2005 with and without data assimilation. Without assimilation (dashed lines), a spin-up period at the start of the forecasts is evident which is longer (of order 3 hours) in the 4 km model than in the 1km model. The results with data assimilation are consistently better than without, showing much less evidence of spin-up, better scores at the end of the forecast, and improvements at 1 km over 4 km and 12 km. The 1km model with assimilation gives the best performance for all times after T+1. It is expected that skill will significantly improve upon the introduction of a new nudging formulation in the assimilation and other model developments.

3. Parametrization Developments

Our experience with the UM at grid resolutions of around 1 km through a wide variety of case studies suggests the model is broadly successful with the existing sub-grid parametrizations (1D non-local boundary layer, 3 category ice-phase microphysics, 2-stream radiation). However, there are also some aspects of the model forecasts which consistently do not agree so well with observations and areas where the parametrizations can be improved. There are active developments to all the parametrizations in the model, but two of the most important development areas for high resolution (i.e. turbulent mixing and cloud/precipitation microphysics) are discussed in this section.

Turbulent Mixing

The triggering, number and intensity of convective cells is strongly controlled by the treatment of turbulence. At present we use the standard 1D boundary layer scheme with ∇^4 hyper-diffusion along horizontal model surfaces. This has been tuned to give broadly optimal results, though the value is consistent with the maximum which might be expected from a "Smagorinsky-like" turbulent mixing parametrization scheme. We are moving towards a 3D Smagorinsky-Lilly sub-grid parametrization of turbulent mixing both in the boundary layer and throughout the free troposphere which we anticipate will be required as the resolution of the model increases to the point where deep convective cells are well resolved. Bearing in mind the large horizontal to vertical aspect ratio of the grid, it is not obvious what the best formulation will be. The approach taken in the UM has been to implement the vertical and horizontal components separately allowing an explicit treatment in the horizontal but implicit treatment in the vertical (as per the boundary layer scheme) in order to retain numerical stability for shallow layers and the long timesteps used in the semi-Lagrangian dynamics.

The Smagorinsky-Lilly turbulent mixing scheme in the UM is being tested in a range of idealised and real case studies. In particular, a dry convective boundary layer case, shallow cumulus (BOMEX-type) case and a surface flux forced diurnal cycle of deep convection (GCSS WG Deep Case 4) are being simulated and compared with equivalent simulations with the Met Office Large Eddy Model (LEM). The tests cover a range of grid resolutions from 50 m up to the scale of a few kilometres to test the convergence properties of the solution and allow appropriate modifications to be made to bring the lower resolution models closer to the high resolution solution.

Figure 8 shows the close comparison between the two models for a dry convective boundary layer simulation using a "large eddy resolving" grid of dx=dy=dz=50m.

Figure 9 shows the timeseries of total hydrometeor content for the first few hours of an idealised diurnal cycle of convection case study with the results from a 200m resolution simulation of the Met Office LEM for comparison. With the Smagorinsky scheme the high resolution UM runs are much closer to the high resolution LEM. As the resolution is degraded, there is an increasing delay in the onset of convection followed by an overshoot in the convective intensity. However, the delay and overshoot are substantially reduced with the Smagorinsky scheme compared to the standard 1D boundary layer scheme.

Figure 10 shows an example of the impact of the Smagorinsky scheme for a real case (CSIP IOP1). It is apparent in many convective case studies that the 1 km simulations suffer from an over-prediction of rainfall from small convective cells. Using the Smagorinsky scheme instead of the 1D boundary layer produces fewer vigorous small scale convective cells, closer to that observed from the radar network. Although appropriate at very high resolution, it is probably not the complete answer at resolutions of 1km and coarser. Work is ongoing to investigate other approaches, such as combining the current 1D vertical boundary layer scheme with the Smagorinsky scheme in the horizontal and outside the boundary layer, and use of a shallow convection parametrization scheme to represent the under-resolved small-scale convective cells at this resolution.

Cloud and Precipitation Microphysics

The details of the cloud and precipitation microphysical processes that are parametrized in the model play a vital role in the development of deep convective cells in the forecast, yet there are still uncertainties in many aspects of the parametrization and the degree of complexity of the system that needs to be adequately represented. Observations from CSIP are being used to assess the model performance and suggest improvements to the microphysics parametrization for operational forecasting of deep convection. Particular aspects being investigated include the representation of graupel, the most appropriate way to represent the range of ice particles in the atmosphere from pristine ice crystals to large snow aggregates (i.e. two separate prognostics, double-moment scheme, particle characteristics), the numerics of hydrometeor sedimentation and the impact of latent heat exchange processes on the dynamics. These developments are being informed by comparisons with the Met Office Large Eddy Model with its more complex double-moment 5-category microphysics.

The impact of the microphysics on the dynamics of convective storms is of key importance as it can significantly affect the strength and longevity of a storm and subsequent initiation of daughter cells through the formation and interaction of evaporation-driven cold pools. Given the uncertainty in many aspect of the microphysical parametrization we need to know the impact of particular assumptions on the evolution of the storm dynamics in idealised and real cases and a number of sensitivity studies are currently being performed. This provides information on where to focus the effort to improve the representation of microphysics in the model. Figure 11 shows a snapshot of the rainfall from a convective case study in 2005 (CSIP IOP 6). Figure 12 shows the difference in surface rainfall rate during the simulation when aspects of the microphysics are modified and the correlation of the spatial pattern of rainfall with time. The correlation graph provides an indication of how much each change is affecting the convective dynamics leading to differences in secondary initiation and subsequent evolution.

4. Summary and Future

The Met Office currently has an operational 4km configuration of the Unified Model over the UK, and an "on-demand" 1.5km configuration for parts of the UK from January 2007. Assessment of the UM at these resolutions for convective storm forecasts over a number of UK summer case studies has shown the benefit of high resolution for precipitation prediction when verified over the appropriate scale. The performance of the current configuration of the UM is encouraging and provides a sound basis for further development and refinement. One aspect that requires improvement at 1km resolution is the generation of excessively active clouds when larger cumulus are initially formed (with a corresponding overprediction in rainfall). An improved treatment of turbulent mixing should address this problem. 3D VAR is in the process of being implemented in the 1.5 km model, and is showing promise. 3DVAR plus LHN/MOPS has been more successful than perhaps expected, though it requires careful tuning to work effectively. We plan to experiment with 4DVAR at high resolution, initially at 4 km and eventually in the 1.5 km model.

References

Clark, Peter and Lean, Humphrey, 2006, An Overview of high resolution UM performance for CSIP cases by, NWP Technical Report No. 478.

H. W. Lean, S. P. Ballard, P. A. Clark, M. A. Dixon, Zhihong Li and N. M. Roberts, 2006, The Summer 2004 Reruns with the High Resolution Trial Model by, NWP Technical Report No. 466

H. W. Lean, S. P. Ballard, P. A. Clark, M. A. G. Dixon, Zhihong Li and N. M. Roberts, 2005, The Summer 2003 Reruns with the High Resolution Trial Model NWP Technical Report No. 457

Met Office Technical Reports are available from

http://www.metoffice.gov.uk/research/nwp/publications/papers/technical_reports.

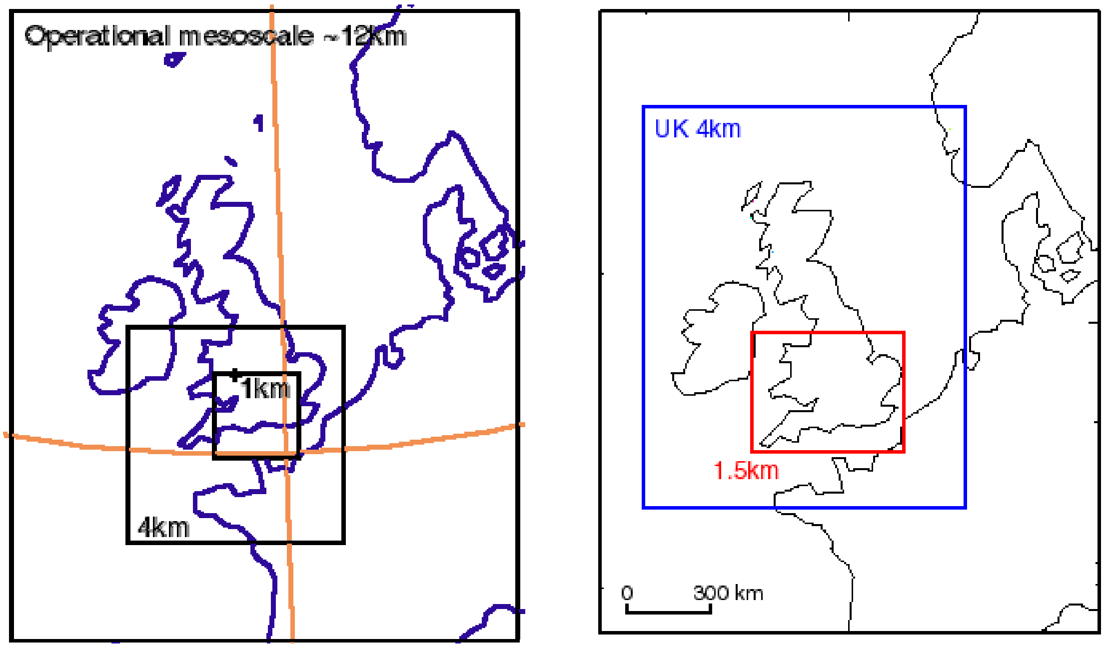


Figure 4 *Domains used in high resolution testing. Left, original 4 km (190x190) and 1 km (300x300) domains. Right, UK 4 km domain and 1.5 km (360x288) domains.*

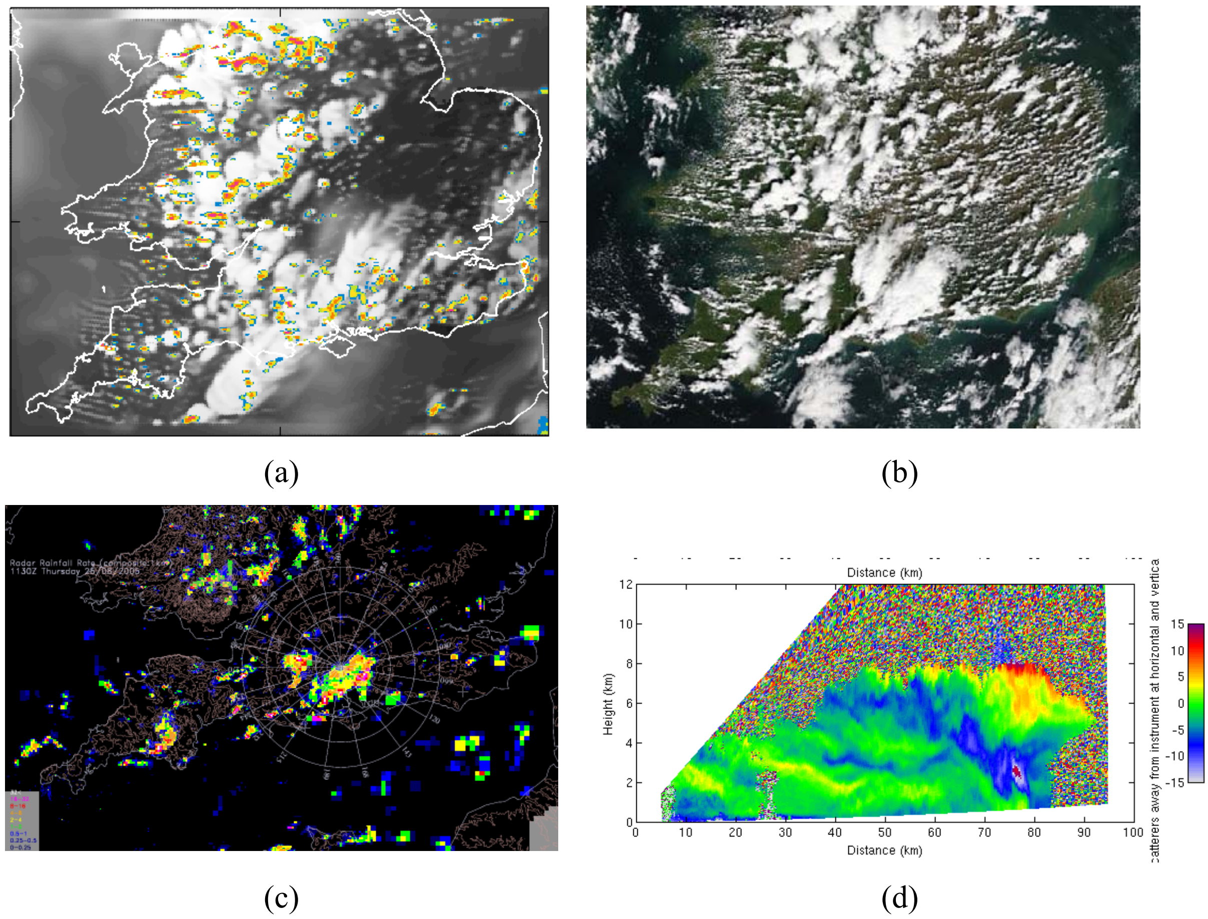


Figure 2 *1125 UTC on 25/08/2005 (CSIP IOP18) showing (a) 1.5km UM 6 hour forecast of rainfall (colours) and outgoing long-wave radiation (B&W) expressed as a radiance temperature, (b) MODIS Terra visible image and (c) radar network rainfall – note squall line over Hampshire (d) RHI from Chilbolton 3 GHz radar at 1229 UTC showing Doppler wind through squall line (Note – there is an offset of ~ 15ms*$^{-1}$ *on the Doppler wind)*

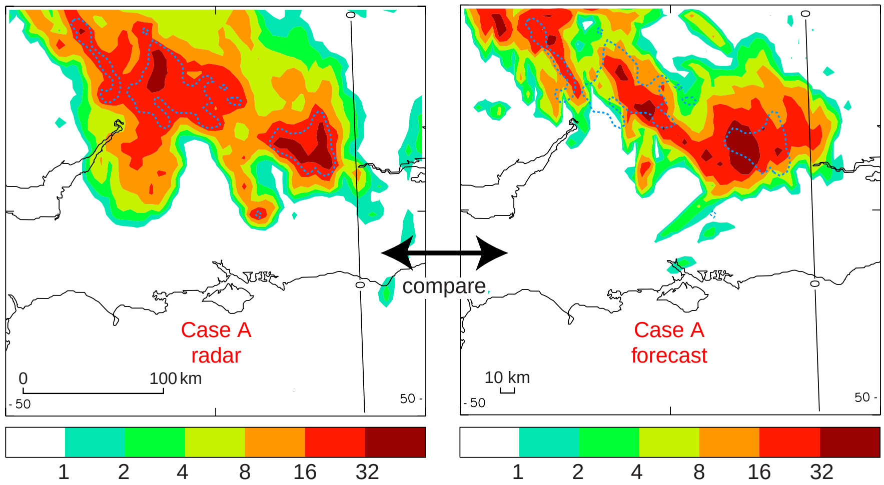


Figure 3 *Case A. Rainfall accumulations (mm) over the period 14 UTC to 20 UTC 3rd August 2004 from radar (left) and a 1-km-model forecast (right). The dashed blue lines enclose the highest 5% of radar accumulations (>~20mm).*

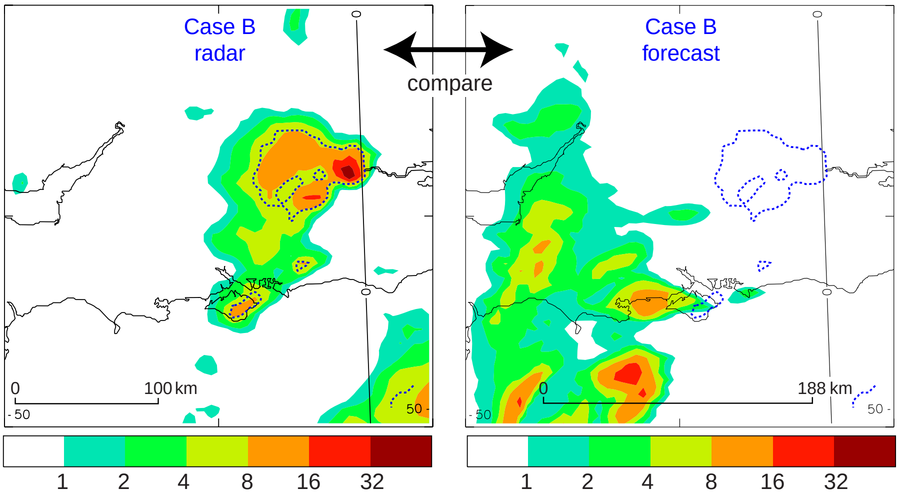


Figure 4 *Case B. Rainfall accumulations (mm) over the period 14 UTC to 20 UTC 27th April 2004 from radar (left) and a 1-km-model forecast (right). The dashed blue lines enclose the highest 5% of radar accumulations (>~7mm).*

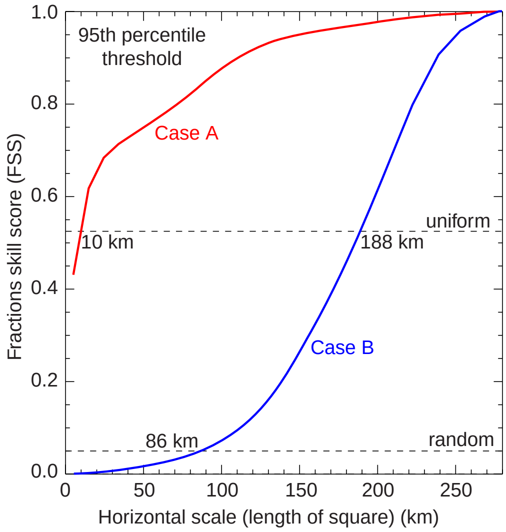


Figure 5 *Graph of Fractions Skill Score (FSS) against spatial scale for Case A (good forecast) and Case B (poor forecast) for the highest 5% of rainfall accumulations within the domain (95th percentile value). The FSS can have values in the range 0 (zero skill) to 1 (perfect skill). The two dashed lines show (1) the skill of a completely random forecast covering 5% of the domain ('random'), and (2) the skill of a forecast with a value of 0.05 (5% chance) everywhere ('uniform'). The 'uniform' forecast provides a target level of satisfactory skill.*

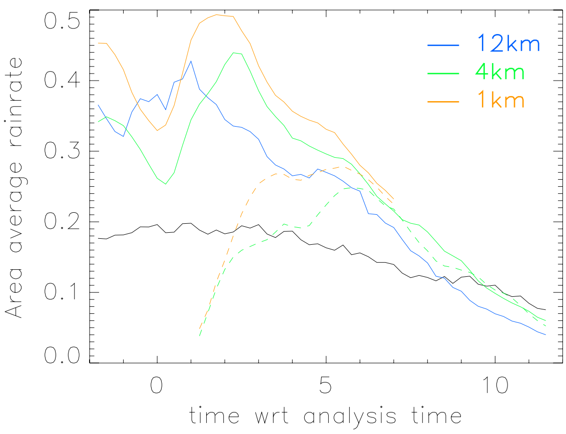


Figure 6 *Area-averaged rainfall rate plotted as a function of time with respect to analysis time for all forecasts run from the summer 2005 cases. In order to make a fair comparison, all cases the area averaging for all models and radar was carried out over the area covered by the 1km model domain. The black line shows the averaged radar rainfall rate and the colours show the models. Solid lines show the runs including assimilation (these lines extend back to T-2 where each run starts) and the dotted lines are the forecasts run from a T+1 12km analysis.*

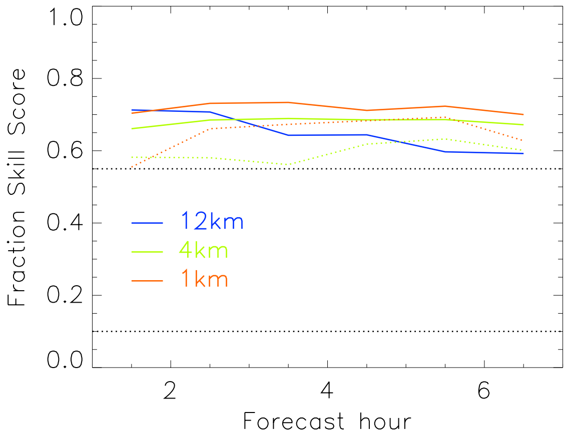
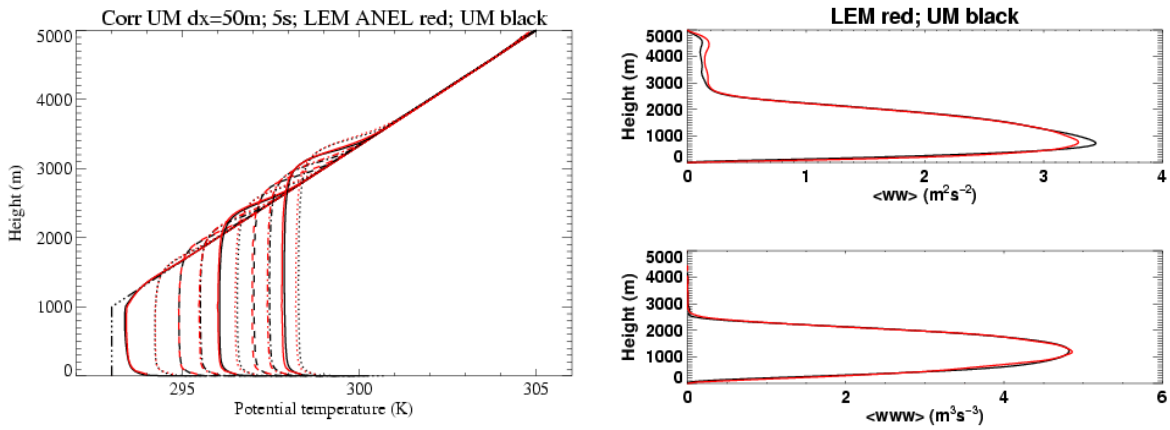
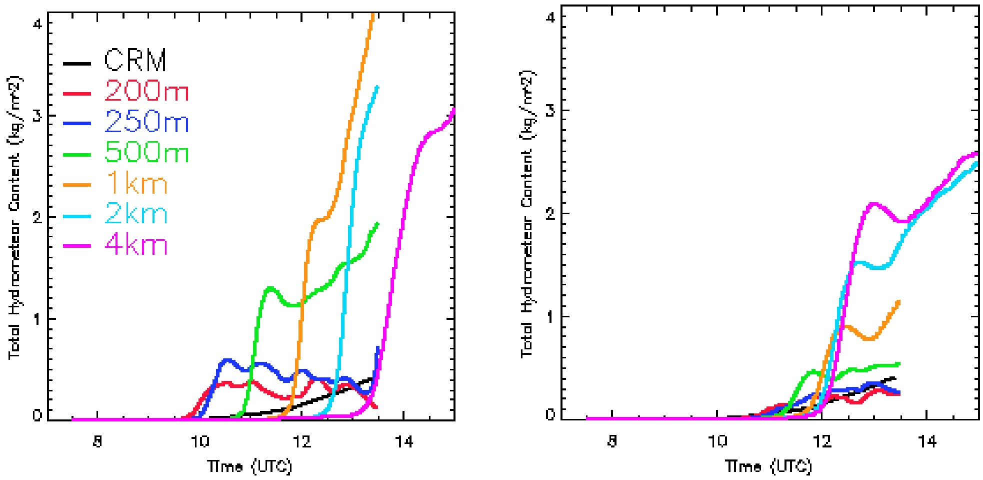


Figure 7 *Fraction Skill scores for hourly accumulations plotted as a function of forecast length for a fixed sampling radius of 52km and a relative threshold of the 90th percentile. The plotted points are shown on the time axis half way at the midpoint of the hour. The solid lines show the scores for the three models aggregated over cases from the summers of 2004 and 2005. The solid lines show the scores for the three models including assimilation. The dotted lines show equivalent curves from 4km and 1km models spinning up each forecast from a 12km analysis*



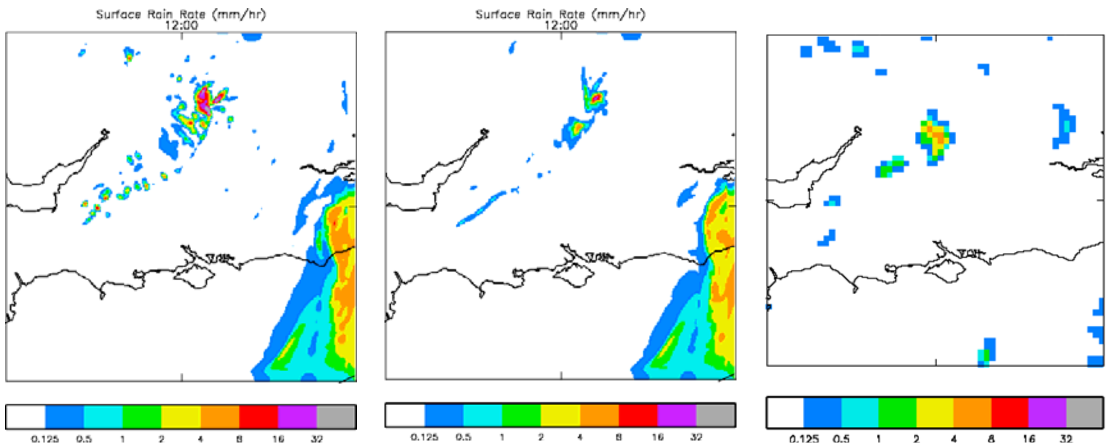
(a) (b)

***Figure** 8 Results from idealised dry convective boundary layer simulations for Met Office Large Eddy Model (red) and the UM (black) with 50m grid resolution and Smagorinsky-Lilly turbulent mixing parametrization. (a) Hourly area averaged potential temperature profiles for a 10 hour simulation. (b) Time-area averaged vertical velocity variance (top) and skewness (bottom) profiles.*



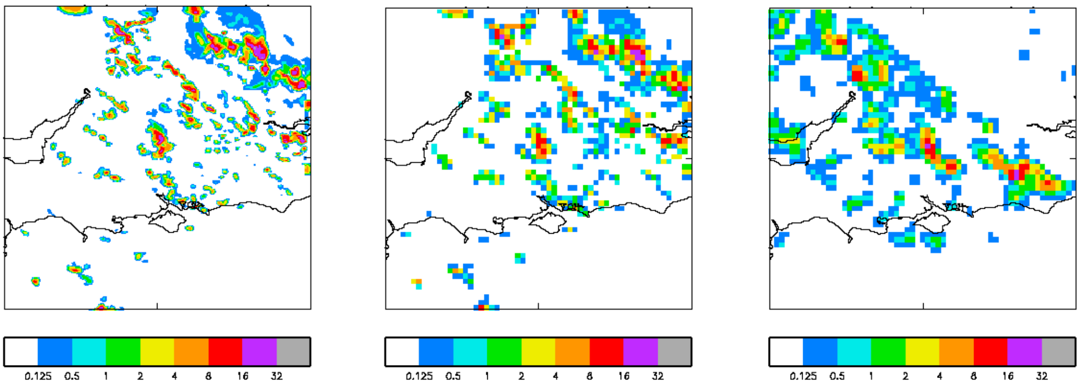
(a) (b)

***Figure 9** Total hydrometeor content for UM simulations of an idealised diurnal cycle of at different horizontal resolutions with (a) the 1D non-local boundary layer scheme and (b) the 3D Smagorinsky sub-grid scheme. Also plotted are the results from the 200m grid length simulation (black line) from the Met Office Large Eddy Model (LEM).*



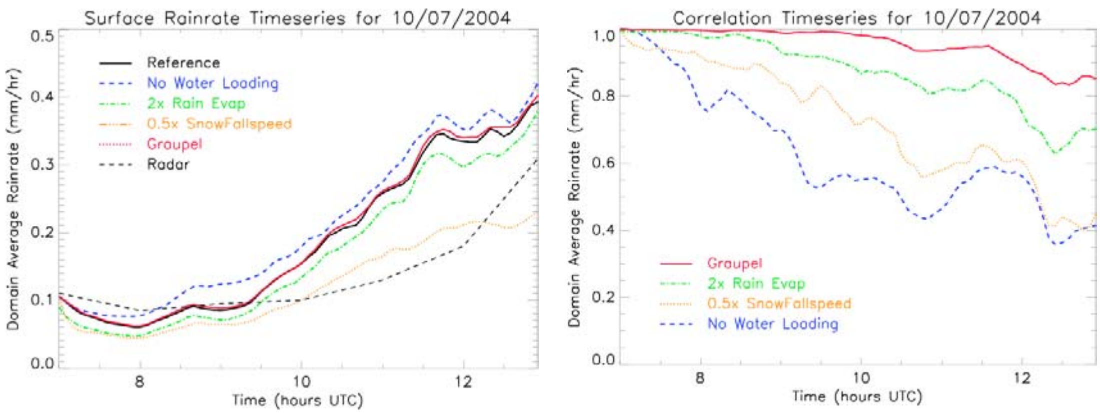
(a) (b) (c)

***Figure 10** Surface precipitation rate at 12UTC on 16/06/2005 (CSIP IOP 1) from (a) the 1 km resolution UM with 1D non-local boundary layer scheme, (b) the 1km resolution UM with 3D Smagorinsky sub-grid turbulence scheme and (c) the radar network on a 5km grid.*



(a) (b) (c)

***Figure 11** Surface precipitation rate at 12UTC on 04/07/2005 from (a) the 1 km resolution UM at the grid resolution, (b) the 1 km resolution UM averaged to the radar 5 km grid, and (c) the radar network on a 5km grid.*



(a) **(b)**

***Figure 12** Timeseries of quantities for different microphysics sensitivity forecasts for the 04/07/2005 case study; (a) domain average surface rain rate and (b) correlation of rain rate with the reference forecast.*

6.3 S. Tijm: HIRLAM Physics developments

HIRLAM Physics developments

Sander Tijm, HIRLAM project leader for physics

Introduction

The physics developments in HIRLAM are distributed over the synoptic scale and the mesoscale. In 2006, the synoptic scale developments still received the most attention, but it is planned that the emphasis of the work will shift more and more on the mesoscale in 2007 and beyond, as this will become the most area for LAM-NWP. As HIRLAM has chosen to cooperate with Aladin to develop the mesoscale model AROME, the mesoscale work is aimed primarily at the development of the schemes in this model.

In this contribution I will describe the main developments of the physics within HIRLAM and in the HIRLAM-Aladin cooperation in 2006. Also a short overview of the plans for 2007 will be given.

Synoptic scale

Surface scheme

One of the major developments in 2006 (continued from many years before) has been the development of a snow/forest scheme. The current ISBA scheme in HIRLAM shows major problems in winter and spring, when the impact of snow and forests on the temperature and fluxes are underestimated substantially.

Due to the inadequate description of the isolating properties of a snow pack, the temperatures do not drop far enough in a clear winter case. Also, the snow melts away too quickly and the temperature rises too quickly after a snow event.

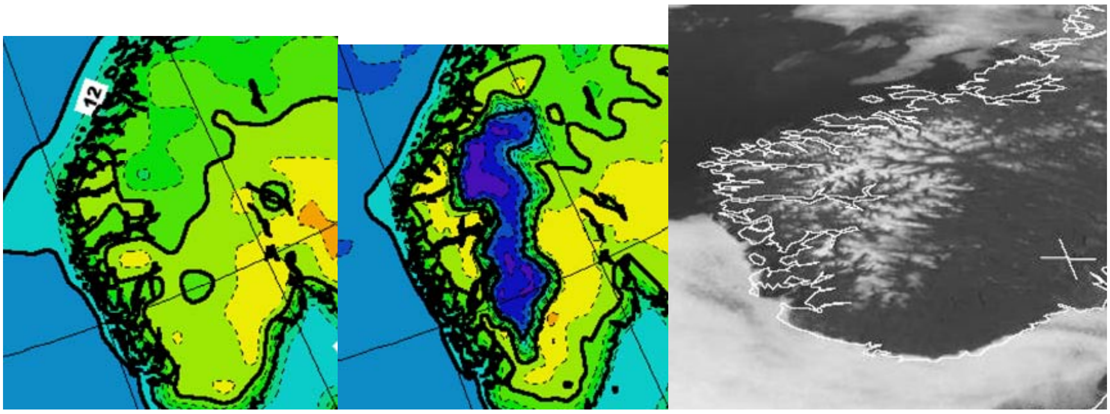


Figure 1: The temperature over the southwest of Norway as forecasted with the old surface scheme (left), the new surface scheme (center) and the verifying MSG satellite image (right) on 10 June 2006, 12 UTC (courtesy Dundee University). Purple is below 4°C, yellow is above 22°C, contour interval is 2°C.

Figure 1 shows the impact of the new surface scheme on the temperatures over southwest Norway on June 10 2006. With the old surface scheme the temperatures in the Norwegian mountains are between 16 and 20°C, while the temperatures are much closer to 0°C in the run with the new surface scheme. The satellite image of that day shows that there is still a lot of snow lying in the mountains after a snow event a few days earlier. The temperature will therefore be much closer to the ones in the new snow scheme than in the old scheme, which clearly has no snow cover anymore. More about the new surface scheme can be found elsewhere in this volume.

Shallow convection

One area of research in which HIRLAM is involved quite heavily is the parametrization of shallow convection. The current schemes in HIRLAM, STRACO and Kain-Fritsch, are not describing shallow convection very well, although the results are improving. Intercomparison studies and 1D ideal cases have led to the development of a new detrainment parametrization. In most current shallow convection schemes the detrainment rate in mass flux schemes has a fixed value, but LES results for e.g. the ARM-case, show that the detrainment is strongly determined by environmental conditions and the depth of the cloud. In the new parametrization, the detrainment is a function of the critical fraction averaged over the cloud depth.

The impact of the new parametrization can be seen very clearly in the mass flux profiles in the ARM-case, see figure 2. In LES a very clear development from many small clouds and a few deeper clouds at the onset of the shallow convection (a quick decrease in mass flux with increasing height) to the later stages of the convection where there is a relatively large mass flux even at the mid level of the total cloud depth. With the old parametrization, the mass flux decreases much more slowly and is not depending at all on the environmental conditions.

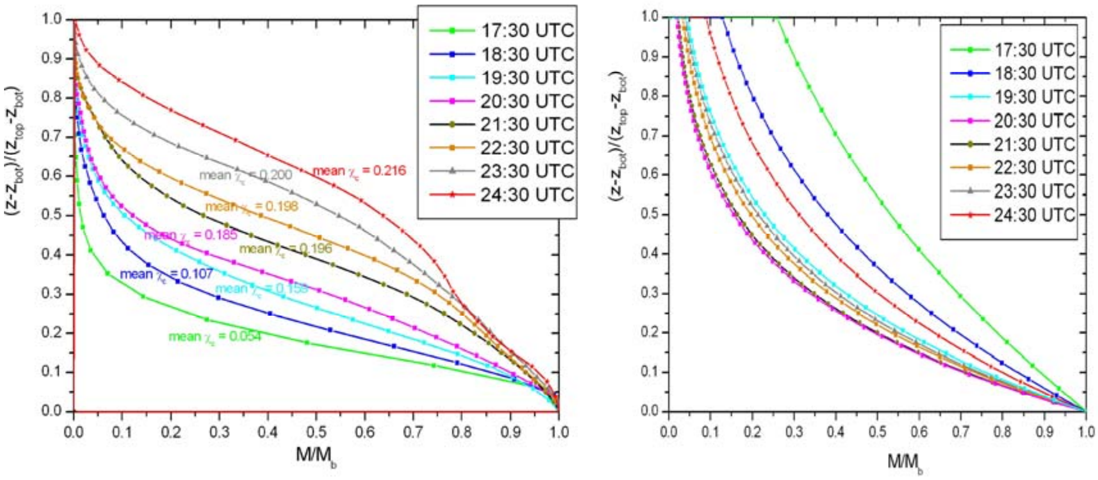


Figure 2: Normalized mass flux profiles from LES (left) and with a fixed detrainment rate (right) for the ARM case.

Overall tuning of synoptic scale HIRLAM

A few features of the current HIRLAM system seem to be linked together and may be resolved by a good tuning of the overall physics. One of these features is the regular occurrence of fog over the sea, especially when the sea is relatively cold in Spring and Summer. In these seasons fog can be found quite regularly in the model while this is not found in the real atmosphere (see figure 3). This may be caused by a too strong evaporation over the sea.

Another thing that can be seen in HIRLAM too often is a too strong development of small-scale systems. Small-scale lows often become too deep, give too much precipitation and too strong winds. This causes a too large false alarm rate for severe weather developments. This overactivity of the model may be associated with a too large evaporation also. A too large evaporation leads to too much moisture being available for condensation and a too strong deepening of small-scale low-pressure systems.

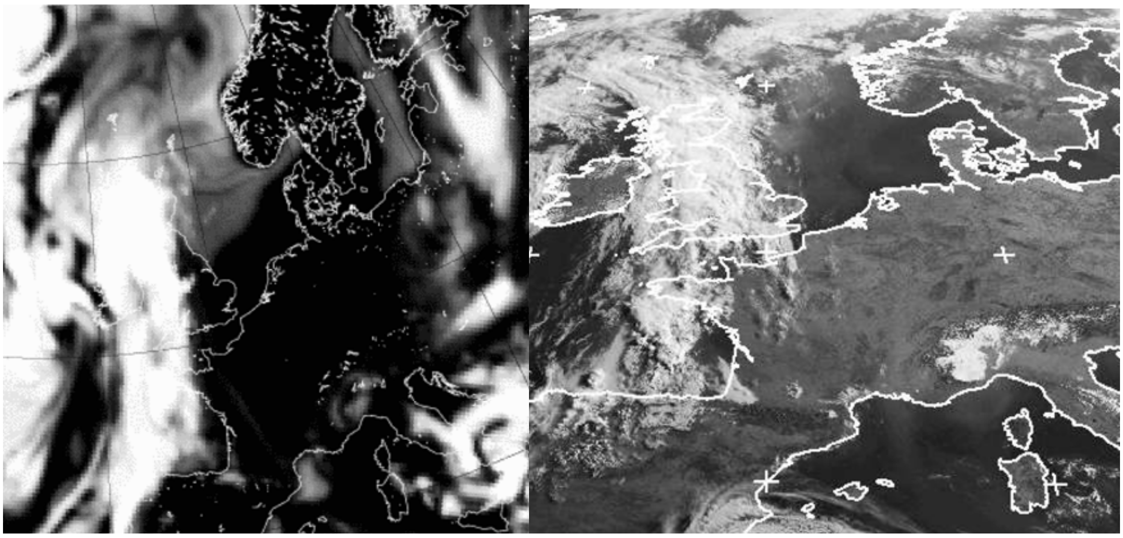


Figure 3: Pseudo visible satellite image of HIRLAM (left, +42h forecast) and the visible satellite image of MSG (Courtesy Dundee University) on 12 June 2006, 06 UTC.

A comparison with Quikscat winds also shows that there is a problem with the 10-m wind direction under certain conditions. A few years ago we introduced a turning of the surface stress to keep the activity of the model in check, because at that time the large scale low pressure systems became too deep systematically. The turning of the surface stress solved this problem and also reduced the wind direction bias considerably, but sometime still very large bias can be found. In earlier HIRLAM versions the too deep cyclones were filled with increased vertical diffusion, but this resulted in vertical profiles that were too well mixed, and absence of the low-level jet and too deep mixing layers, especially under stable conditions.

Through a careful tuning of the vertical diffusion, the removal of the turning of the surface stress and a tuning of the evaporation over the sea we hope to improve the model behaviour considerably. This work started in 2006 and will be continued in 2007.

Other synoptic physics

In addition to the developments mentioned above, a few other parametrizations have been developed or improved in 2006. For the surface scheme, work has been done on a sloping surface radiation parametrization and shown to work. It is clear that the main benefit from this parametrization can be expected at the very high resolution.

Another surface parametrization on which work has been started is a parametrization for snow on ice, which should give better fluxes in the arctic region as well as the Scandinavian seas and lakes.

Further work has been done on the mesoscale orography and the subgrid scale orography parametrization. A further tuning of the system and a verification study have shown that the scheme now performs well and solves a part of the wind speed problem that HIRLAM has in mountainous regions.

Mesoscale physics

In the HIRLAM-Aladin cooperation, the emphasis lies on the development of the mesoscale model AROME. In the development of the physics of this model, HIRLAM will contribute in the turbulence and shallow convection parametrization and in the surface parametrization. Also, HIRLAM helps finding model deficiencies through the quasi-operational runs that are already performed in 3 HIRLAM countries, in circumstances that can differ quite a lot from the ones in France and the other Aladin countries. In the coming years the emphasis of the physics development within the HIRLAM countries will shift from the synoptic scale to the mesoscale.

The main contribution of HIRLAM to the development of AROME in 2006 has been in the development of an EDMF (Eddy Diffusion Mass Flux) scheme. The mesoscale model will resolve the deep convection itself, but turbulence and shallow moist convection still are subgrid scale phenomena, so they have to be parametrized. For AROME it was chosen to use a EDMF scheme, that handles the shallow moist convection and the strongest boundary layer eddies through a mass flux scheme and the remaining local diffusion with a TKE scheme.

This EDMF scheme is being developed in close cooperation between HIRLAM, Aladin and ECMWF, and different flavours will be used within the different consortia. Because all the flavours of the scheme are developed within the IFS framework, it is relatively easy to benefit from all the developments of the EDMF schemes. Eventually, when the EDMF scheme is built into AROME and if it works as it should, we also want to include it in HIRLAM because it is very beneficial if the model that generates the boundaries for the mesoscale model uses the same physics as the nested model.

The very nice thing about the EDMF scheme is that it is capable of representing the average boundary layer structures, that are unstable in the bottom part and slightly stable in the upper part. Due to the mass flux part of the scheme, relatively strong mixing can occur, even in slightly stable conditions.

Other contributions to the jointly developed mesoscale system are still in the planning phase. A few of the HIRLAM developments in the surface are interesting to also be built in into SURFEX, the surface scheme of the mesoscale model. The most important candidates to be included in SURFEX are the forest scheme, which allows a much quicker heating of the atmosphere in winter and spring, the lake scheme FLAKE, to give a much better description of the surface conditions over lakes because the lake temperature becomes a prognostic parameter, and also the formation of lake ice can be described much better with this scheme. A third possibility for inclusion in SURFEX is the snow scheme of HIRLAM and a fourth possibility is the snow on ice parametrization that is being developed within HIRLAM at this moment.

In addition to the mesoscale physics developments, a working group for mesoscale verification has been started, that must focus on the average day to day weather, which is a challenge for the physics parametrizations. Here one has to think about e.g. cases with fog, shallow cumulus, stratocumulus, a very stable boundary layer, a daily cycle of relatively light precipitation, inland penetration of convection in winter. All these weather types are not very extreme, but they are very important to forecast correctly. If the model is capable of forecasting extremes very well, but not the normal day to day weather, then the forecasters will not trust the model output and not use it much or not at all. The working group has a website where the progress of the work can be followed: http://www.knmi.nl/~tijm/Verif/Verifworkg.html

So far, the descriptions of the cases have been collected and now a base line verification will have to be made for all the cases. This will enable a comparative verification with older model versions and make it easy to see if an updated version of a model is still or better capable of representing the weather in the cases that are collected, as a sort of sanity check of the model and model development.

6.4 S. Gollvik: Snow, forest and lake aspects in the Hirlam surface scheme

Snow, forest and lake aspects in the Hirlam surface scheme

Stefan Gollvik

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1 A new surface scheme for Hirlam including snow and canopy temperatures

The new surface scheme originated from the surface scheme of a climate version of the Hirlam model, (Samuelsson et al., 2006), which in turn started from the ISBA-scheme (Noilhan and Planton, 1989), adapted to different tiles. The climate scheme was then adopted in the Hirlam-model, starting from the present tiled scheme, (Rodríguez et al., 2003). The force restore formulation from ISBA is only kept in the soil mosture, while the temperatures, now are described, using heat conduction in the soil or ice. The most important changes are, that we now have prognostic temperatures for snow and canopy. This is necessary, since the heat conduction in the soil, must involve real soil temperatures, and not average snow/canopy/soil-temperatures, which is the case in a force restore formulation. Due to the large differences between the snow development in the forest and on open land, it was also necessary to have two different snow-packs. For the sea ice, a separate snow temperature has not yet been included, but are in the plans. The main features of the surface scheme are:

- Totally 7 tiles: sea, ice, open land, low vegetation, forest, open land snow and forest snow.
- For all land tiles: 3 prognostic temperatures, the soil depths of which are 1 cm, 7.2 cm and 43.2 cm. The heat conduction is dependent on soil type, soil water and (parameterized) soil ice. Climatological forcing from below.
- The forest tile has a common canopy temperature, for the snow free and snow covered forest floor.
- Two separate 1-layer snow packs, with separate evolution of temperature, snow amount, liquid water suspended in the snow, density and albedo.
- Sea ice has at present 2 layers. The ice thickness is assumed to be 1 m in the open sea, and 0.5 m in the baltic. Het flux at the bottom from the water.
- At present no lake model, but the use of *Flake*, (Mironov, 2005), is planned.

2 The snow tiles

The surface analysis, SPAN, (Rodríguez et al., 2003; Cansado et al., 2004), is performing an OI analysis of snow depth. The first guess is relaxed towards climatology. Using the first guess snow density, the snow depth is transformed to the model variable, snow water equivalent. The analysis increment (for the open land snow) is also added to the ice tile and the forest tile multiplied with an ad hoc factor of 1 and 0.5 respectively.
It is necessary to estimate, not only the snow amount, but also the snow fraction. In

a more physical scheme, where the snow has a separete temperature, the evolution is strongly dependent on snow depth, which in turn is a function of the size of the area the available snow is covering. In a simpler scheme the snow fraction is only affecting grid average values like albedo etc.
At present we have a very simple relation between snow depth and snow fraction

$$frsn(x, y, t) = sn(x, y, t)/sncrit(x, y, t)$$

By letting *sncrit* vary over the year it is possible to parameterize the hysteresis effect, that the snow fraction is smaller during the melting season, for the same snow amount. Here we also let it vary with latitude, to simulate a more uneven distribution in the northern parts. The idea is to also analyse the snow fraction, using e.g. satellite information, and compute the current *sncrit*, which hopefully is a slowly varying variable. This model has

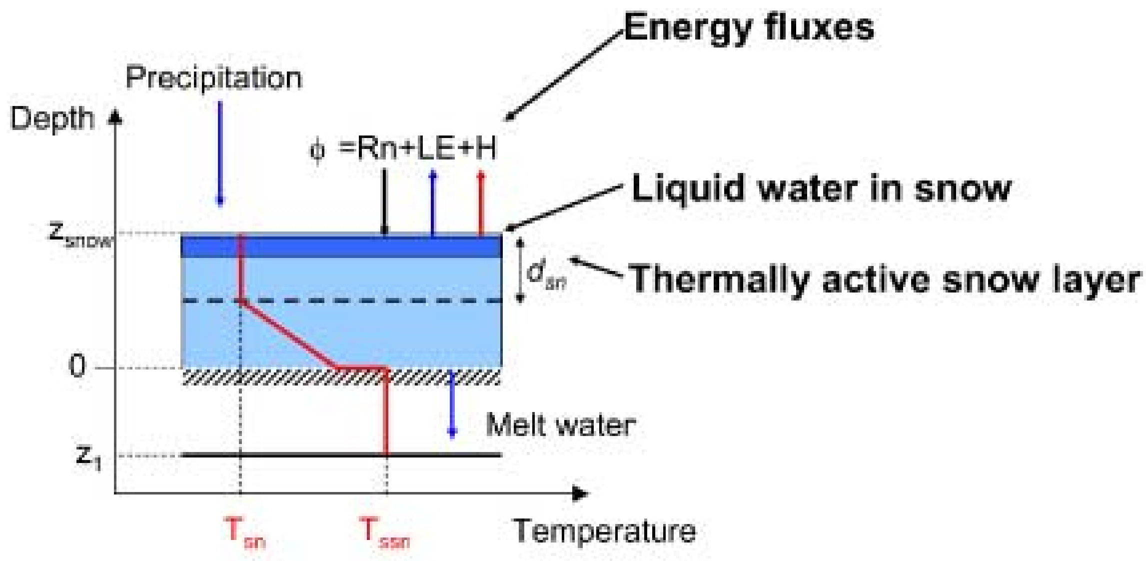


Figure 1: The snow scheme in HIRLAM

only one layer of snow, with a depth Z_{snow}, but only the upper part is thermally active, in case of large depths:

$$\frac{\partial T_{sn}}{\partial t} = \frac{1}{(\rho C)_{sn} z_{sn}} \left[\Phi_{sn} + \Lambda_{sn}(T_{sns} - T_{sn})\right]$$

Here $z_{sn} = min(z_{snow}, d_{sn})$, defines the thermally active depth. $(\rho C)_{sn} = (\rho C)_{ice}\rho_{sn}/\rho_{ice}$ is the volumetric heat capacity of the snow and $(\rho C)_{ice}$ is the volumetric heat capacity for ice. $\Phi_{sn} = Rn_{sn} + H_{sn} + E_{sn}$ is the sum of the energy fluxes at the snow surface, net radiation and sensible and latent heat fluxes, respectively. The snow temperature in the layer below the thermally active layer is in principal unknown which means that the heat transfer at the snow-soil interface is parameterised using a heat transfer coefficient Λ_{sn} between the snow and the underlying soil layer. Basically it is assumed that the heat transfer at the snow-soil interface decreases with the depth of the snow layer. Λ_{sn} is simply a weighted average of the heat transfer coefficients of snow and soil, respectively, defined as

$$\Lambda_{sn}^{-1} = 0.5\,\frac{z_{sn}}{\lambda_{sn}} + 0.5\,\frac{z_{T1}}{\lambda_T}$$

where $\lambda_{sn} = \lambda_{ice}(\rho_{sn}/\rho_{ice})^{1.88}$, λ_T is the heat conduction coefficient for the soil, and $\lambda_{ice} = 2.2$ W m^{-1} K^{-1}.

2.1 Snow density

The snow density is thus influencing both the heat conduction and the heat capacity of the thermally active layer. The snow density is calculated by a weighted value of three components:

- "dry" snow
- water in the snow
- ice due to frozen water in the snow, and rain freezing on cold snow (at present not stored as a separate variable)

The dry snow is, in turn, composed of old snow, with gradually increasing density (Douville et al., 1995), and newly fallen snow with a density of ρ_{min}, (100 kg/m3). The amount of water which can be suspended in the snow, before going to the soil, $wsat$, (fraction) is a function of the snow density:

$$wsat = 0.12 - 0.08(\rho_{sn} - \rho_{min})/(550 - rho_{min})$$

2.2 Phase shift within the snow

The total energy available for the snow per unit time is: $\Phi_{tot} = \Phi_{sn} + \Lambda_{sn}(T_{sns} - T_{sn})$

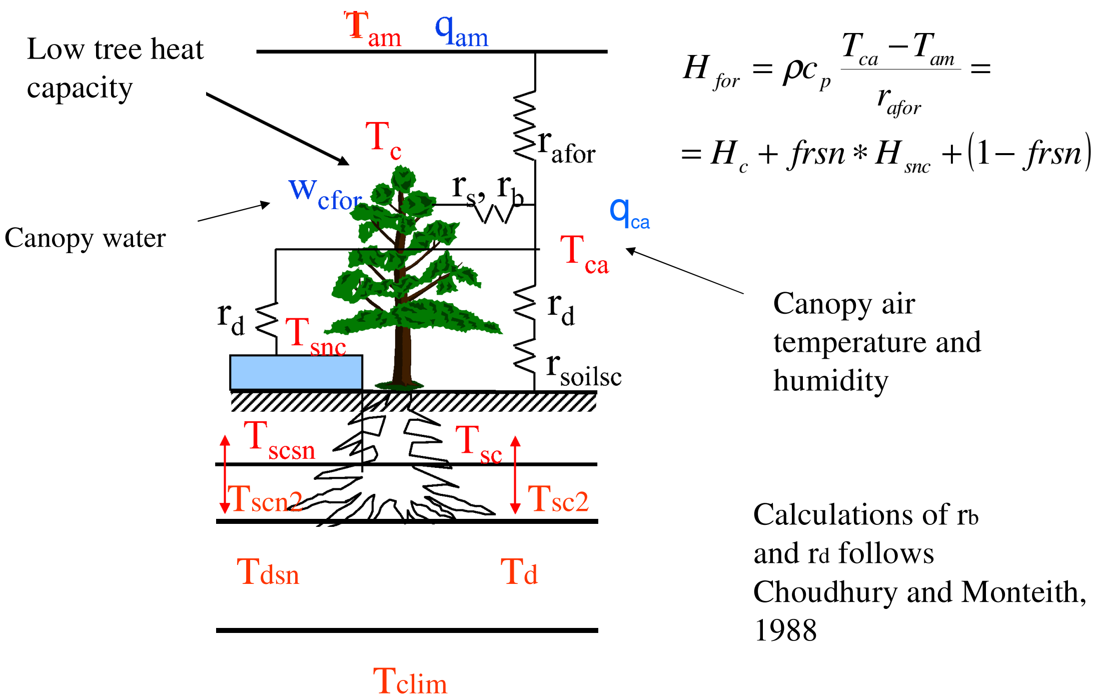
if $\Phi_{tot} > 0$, the timestep is divided into two parts, first the time it takes to increase the temperature to melting point, and then the rest of the timestep, the energy goes to melting, and the heat conduction is done with the temperature of the melting snow as upper boundary condition.

if $\Phi_{tot} < 0$, the timestep can be divided into freezing, followed by cooling. It is assumed that the water is suspended in the snow, and the freezing can penetrate down to a typical depth $snfreeze$ (0.03m). How much of the timestep, that is used for freezing ($freezefrac$), before the cooling takes place, is parameterized as a function of $snfreeze$, the amount of water in the snow, $wsat$, snow depth and density.

3 The forest tile

The basic idea of the forest tile is, that we define diagnostic temperature and humidity, in the air outside the canopy, Tca and qca, respectively, so that the fluxes are zero in this point. There are fluxes between the canopy and the canopy air, and between the forest floor and the canopy air. Thus the only link between the atmosphere and the forest tile is via the canopy air, and here we apply Monin-Obhukov's theory. This means also that we neglect heat flux within the trees. The fluxes between the air and the forest floor follows the formulation of Choudhury and Monteith (1988). Since we use a common canopy for the snow covered and no snow part of the forest floor, their fractional contributions, are used when the iterative values of the canopy air temperature and humidity are calculated.

We also have canopy water as a variable, and the evapotranspiration is based on Jarvis (1976). At present no canopy storage of snow is included in the forest tile.



$$H_{for} = \rho c_p \frac{T_{ca} - T_{am}}{r_{afor}} = $$
$$= H_c + frsn * H_{snc} + (1 - frsn) H_{sc}$$

Figure 2: The forest tile in HIRLAM

3.1 Radiation in the forest

We define a "view factor" *viewfs* , defined as how much of the incoming SW radiation is passing the canopy and reaching the forest floor. This parameter is a function of LAI, solar angle and total cloudcover. The corresponding factor for long wave radiation, *viewfl*, is only a function of LAI. Then we calculate the radiation as usual between soil and atmosphere, but also between the canopy and the forest floor, both for snow covered and snow free parts, separately.

4 Heat conduction in the soil

Since the force-restore formulation is replaced by heat conduction, the behaviour will be different dependent on soil type and soil water/ice. Dependent on the fractions of clay, silt and sand the soil is classified into 11 classes. Dependent on the class, the porosity and amount of quartz is estimated, and the heat conductivity is calculated, taking into account the amount of soil water and the soil ice, at present estimated as a function of temperature (Viterbo et al., 1999). This parameterization follows Peters-Lidard et al. (1998).

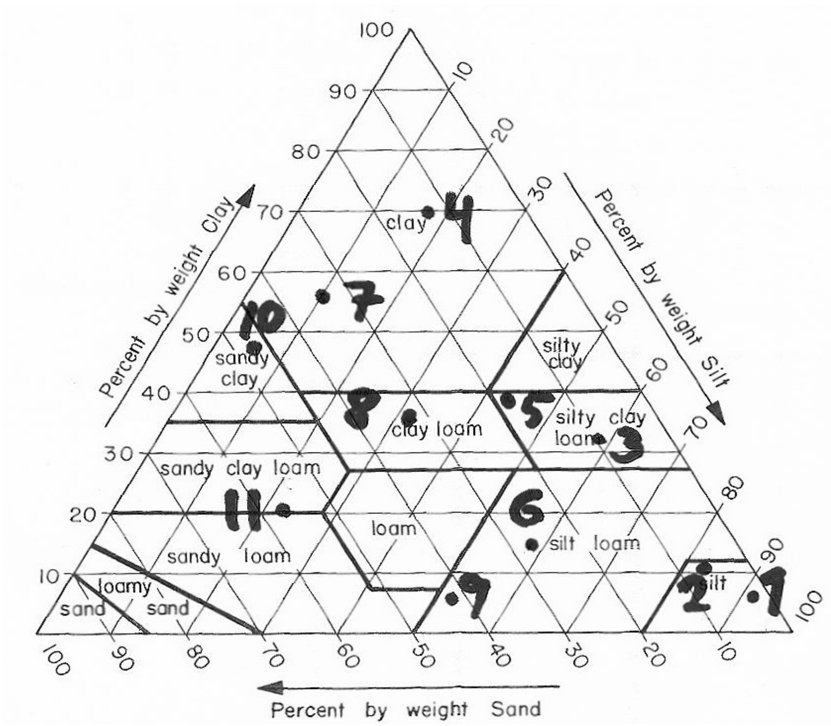


Figure 3: Textural triangle, showing the percentages of clay (below 0.002 mm), silt (0.002-0.05 mm) and sand (0.05-2.0 mm)

5 Some HIRLAM verifications

Here we show results from two different months, March 2006 and June 2005.

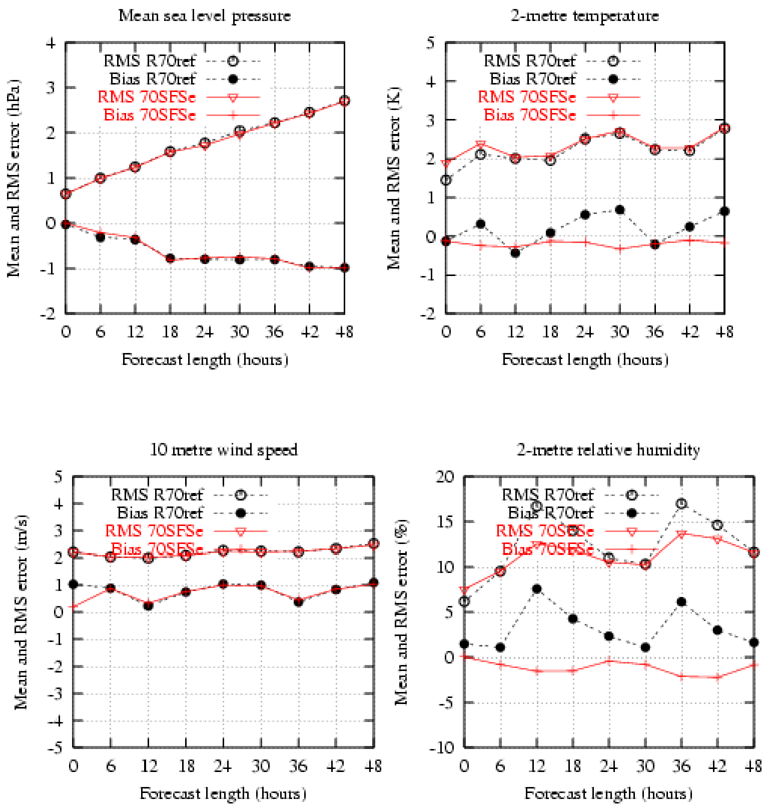


Figure 4: Comparisons between the new surface scheme (70SFSe) and the Hirlam reference (R70ref) for different forecast lengths, March 2006, forecasts starting at 12Z

It can bee seen from the figure the the bias of the 2m-temperature in the reference during daytime is significantly reduced with the new scheme, which is also shown on the maps:

There are still some problems with a cold bias, during summer. It can be seen that the bias is large also in the beginning, and it has probably to do with, the estimation of surface temperatures, using T2m-analyses:

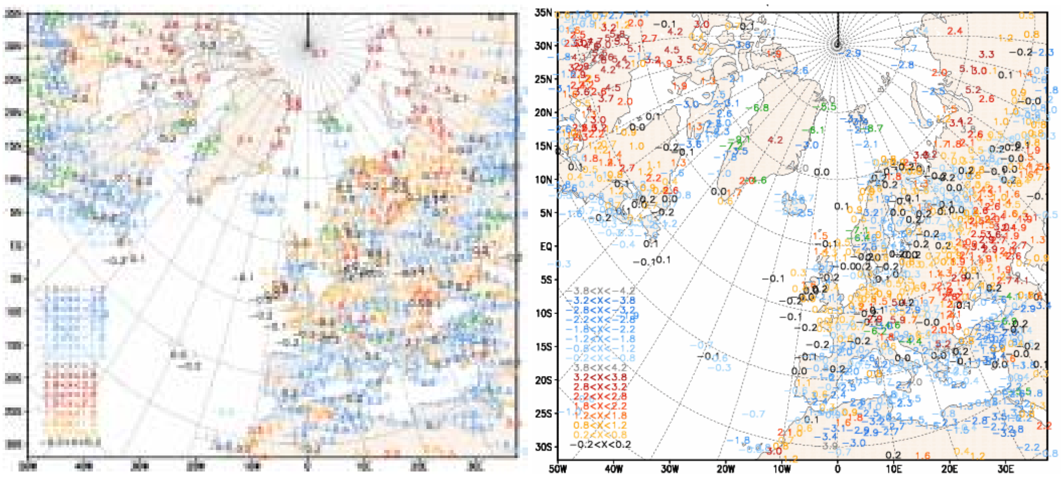


Figure 5: T2m bias, left= new surface scheme, right= reference, March 2006, forecasts at 12+48H

6 Plans for lake model in Hirlam

As alreay mentioned we are planning to use *Flake*, (Mironov, 2005) as the lake model in Hirlam. based on two-layer parametric representation of the temperature profile and self-similarity concept which makes it numerically efficient and it can be coupled to Hirlam each timestep. Experiments with this model, with promising results, has been done within the climate research at SMHI (Kourzeneva, 2005).

7 Nearest future plans for the surface modelling in Hirlam

- Tuning of the surface scheme, in connection with the other physical parameterizations.
- Start the work of externalization
- Compare this scheme with SURFEX
- Start work of interaction between the surface analysis and 4D-var
- Improve the changes of surface temperatures in Span, to better fit the T2m-analysis (variationl approach)
- Work is under way, to implement Flake in HIRLAM
- Add snow on sea ice, and urban area (from Aladin)

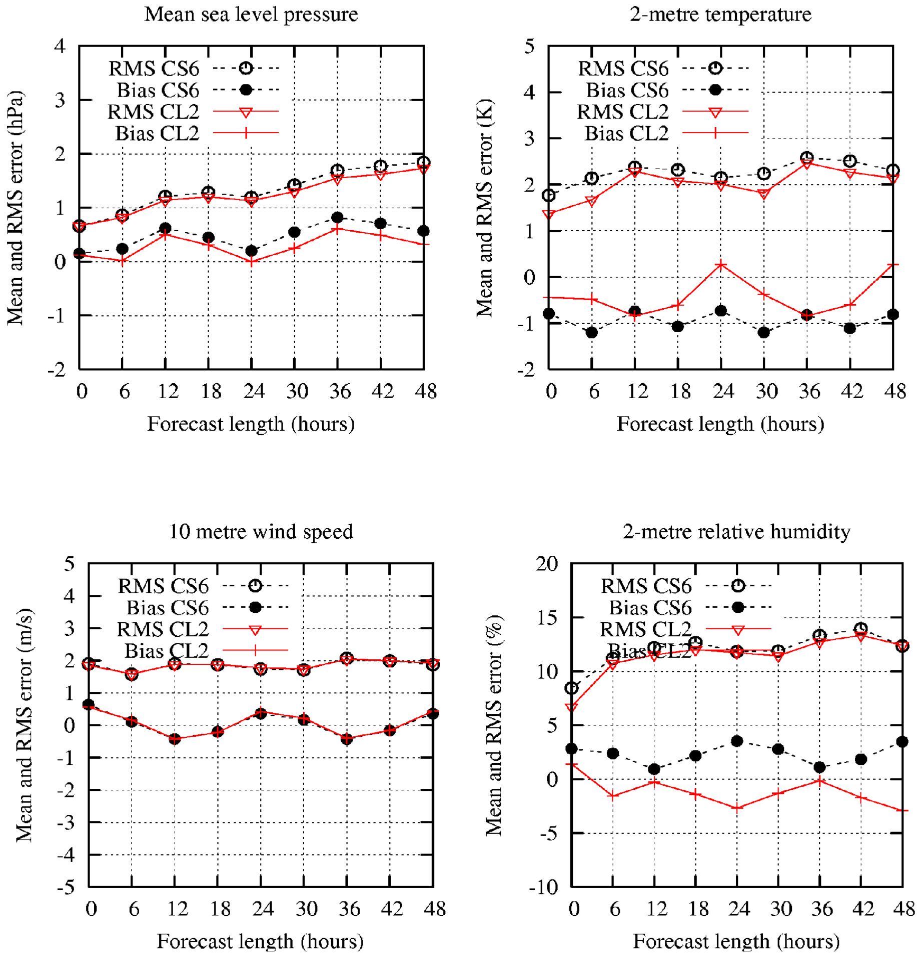


Figure 6: Comparisons between the new surface scheme (CS6) and the Hirlam reference (CL2) for different forecast lengths, June 2005, forecasts starting at 00Z

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6.5 N. Pristov et at.: ALARO-0 Physics developments at LACE in 2006

ALARO-0 Physics developments at LACE in 2006

Neva Pristov, Ján Mašek, Jure Cedilnik, André Simon

In this paper the developments in some physics parameterization, made by scientists from the LACE consortium are presented. The contributions are commonly termed ALARO-0. ALARO is seen as a continuous transition from ARPEGE/ALADIN towards AROME (continuity and improvements), while 0 indicates a base-line version and also that the development is scale-independent. With this approach to physics we also aim to treating the processes in the 'grey-zone', i.e. around 3-7 km mesh size. Emphasize is given to economical computation, numerical efficiency and algorithmic flexibility and this combined with the developments in physics is supposed to make a good basis for further developments.

Inside LACE group main developments were made inside the radiation (Mašek and Geleyn, 2006, Pristov, 2006) and turbulence scheme (Geleyn et al.,2006, Simon, 2006). Short description is included in this paper. Moist processes parameterizations (3MT Modular Multi-scale Microphysics and Transport framework) are mostly developed in ALADIN non-LACE countries. A lot of effort was made for including all the developments into the base-line code, bearing in mind the computational efficiency. Here it can be pointed out (among others) that i) new prognostic and diagnostic variables (TKE, hydrometeors, cloud fraction for the updrafts/downdrafts, convective vertical velocity of the updraft/downdraft, ...) have been included and that ii) a way of describing the water cycle, where the interaction between the various parameterisations' takes place, is neither fully parallel nor fully sequential.

1 Radiation

Current radiation scheme divides electromagnetic spectrum in only 2 bands - solar and thermal. In each band it applies δ-two stream approximation of radiative transfer equation. A new algorithm for cloud transmissivity and reflectivity, and a more complex statistical method for the weighting function between maximum and minimum inter-layer gaseous exchange terms are the main improvements and are shortly presented.

1.1 Parameterization of cloud optical properties for ALARO-0

Availability of prognostic cloud water and ice calls for more sophisticated treatment of cloud optical properties. Main objectives were to introduce dependency of absorption coefficient k^{abs} and scattering coefficient k^{scat} on cloud water content and to make so called saturation effect dependent on cloud thickness and geometry. In order to keep the new scheme as cheap as possible, division of spectra in just two bands (solar and thermal) was preserved.

Dependency of absorption and scattering coefficients on cloud water content was fitted using experimental sample of 7 liquid and 16 ice clouds. In each spectral band, fitting was done for number of individual wavelengths, using simple linear regression with suitable scaling. Unsaturated broadband values k_0^{abs}, k_0^{scat} were then evaluated as weighted averages over given spectral band. Used weights were either incoming solar flux at top of atmosphere (solar band) or blackbody radiation with reference temperature 255.8 K (thermal band). Final dependency of broadband optical coefficients k_0^{abs}, k_0^{scat} on cloud water content was fitted using Pade approximants of order at most (3, 3), again with suitable scaling.

Saturation effect was evaluated explicitly in idealized framework. It employed δ-two stream radiative transfer model with N layers. Each layer could contain cloud free and cloudy part, overlaps between adjacent cloud layers being either maximum or random. Effect of gases and aerosols was neglected, i.e. cloud free parts of layers were completely transparent. In solar band, both diffuse fluxes and direct solar flux took part, but there was no emission. There isn't any direct flux in thermal band, where on the other hand emission takes place. Thermal computations assumed isothermal profile with reference temperature.

In idealized simulations, cloud was illuminated from one side by direct flux (solar band) or diffuse flux (thermal band) and radiative transfer was computed wavelength by wavelength. Resulting monochromatic fluxes were then summed up to get reference broadband values. Next step was to find such broadband values k^{abs}, k^{scat}, which would give the same broadband fluxes as the reference monochromatic computations. In special case of single homogeneous cloud layer (and cosine of solar zenithal $\mu_0 = 0.5$), inversion of outgoing broadband fluxes to saturated coefficients k^{abs}, k^{scat} could be done analytically. Having both saturated and unsaturated values of absorptions and scattering coefficients, it was possible to determine saturation factors c^{abs}, c^{scat} defined as their ratios ($c^{abs} = k^{abs}/k_0^{abs}$, $c^{scat} = k^{scat}/k_0^{scat}$).

In the heart of the new parameterization there is expressing the saturation factors c^{abs}, c^{scat} as functions of unsaturated cloud optical depth. These dependencies were fitted on sample of 1-layer homogeneous clouds. Results for solar band are shown on figures 1. They were obtained for 5 values of solar zenithal angle θ_0 (with $\cos(\theta_0)=\mu_0=0.1,0.3,0.5,0.7,0.9$) It can be seen that dependency is quite sharp in wide range of cloud optical depths and can be fitted with simple function (blue line on the plots). Moreover, dependency on solar zenithal angle is rather weak and it does not cause too much extra spread. In thermal band dependency becomes much less sharp for bigger optical depths (not shown), but this does not pose a serious problem since in such situation fluxes are close to blackbody radiation.

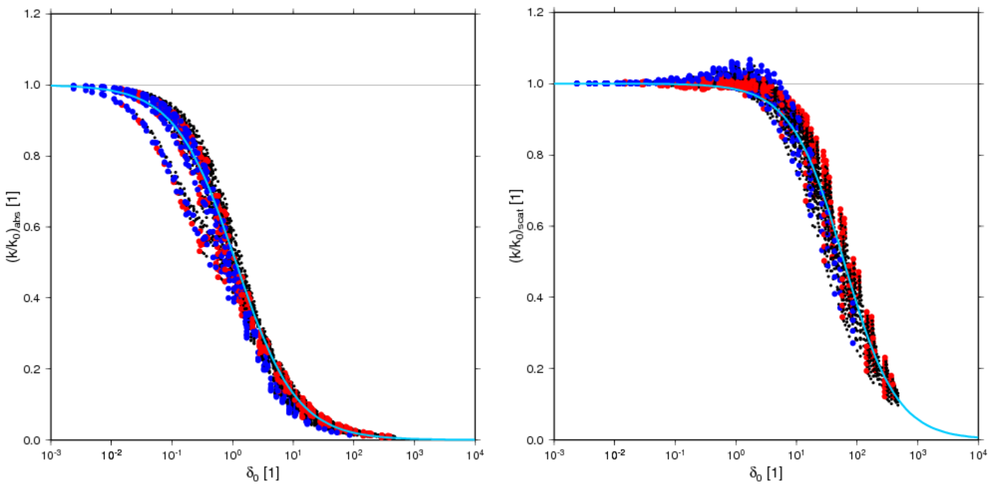

Figure 1: Dependency of saturation factors c^{abs} (left) and c^{scat} (right) on unsaturated optical depth in solar band. Sample of homogeneous clouds, solar band, 5 solar zenithal angles. Red dots -liquid clouds, blue dots - ice clouds, black dots - mixed cloud, blue lines -fitted dependencies.

Afterwards, dependency of saturation factors c^{abs}, c^{scat} obtained on sample of 1-layer homogeneous clouds was tested in more complex environment, using samples of multi-layer inhomogeneous clouds and multi-layer clouds with nontrivial geometry (in this case concept of cloud optical depth had to be generalized, in order to account for cloud geometry). Broadband fluxes leaving the cloud in parameterized version were compared against their reference values computed wavelength by wavelength. This approach enables avoiding the inversion of broadband fluxes to saturated coefficients k^{abs}, k^{scat} in multi-layer case, which would have to be done numerically and becomes extremely costly. Performance of the old and new schemes is compared on figures 2, showing parameterized versus reference total cloud reflectance for sample of 3-layer inhomogeneous clouds. New scheme is clearly superior to the old one in this simplified context.

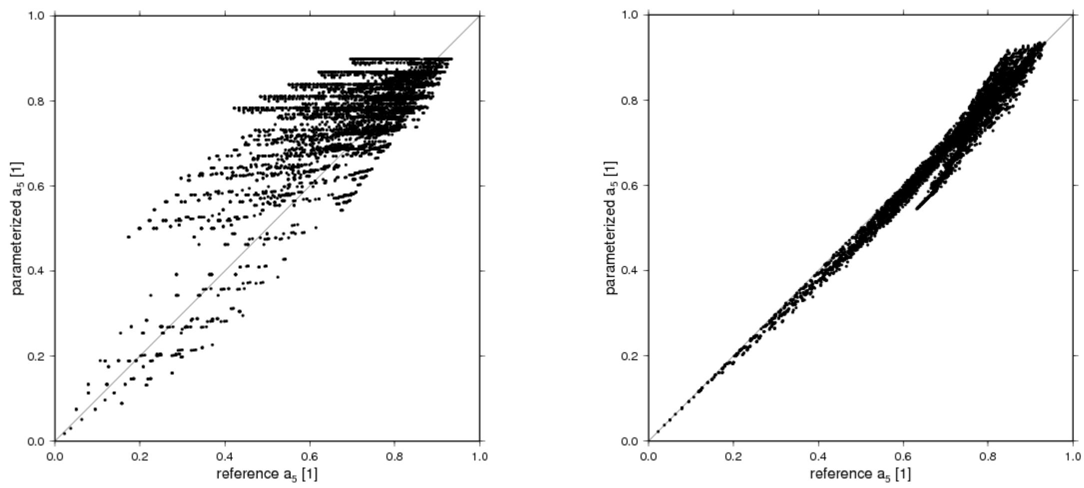

Figure 2: Dispersion diagram between parameterized and reference reflectance for old scheme (left) and new scheme (right). Sample of non-homogeneous 3-layer clouds, solar band, 5 solar zenithal angles.

Final step was coding the new scheme into the full 3D model and testing it on real cases. To prevent complicated feedbacks with microphysics, first tests were done with diagnostic cloud water content. In order to account for vertical dependency of solar saturation inside cloud, solar saturation factors c^{abs}, c^{scat} were made functions of cloud optical depth between the cloud top and current cloud layer (instead of total cloud optical depth). Dependencies of solar saturation factors c^{abs}, c^{scat} had to be retuned consistently with this ad hoc modification of final scheme.

Real case experiments revealed two problems. First problem was too strong backward scattering resulting in too high cloud albedo. After literature survey the problem was mitigated by reducing (1 – g) by 20%, since original values of asymmetry factor g were too low compared to other schemes. This retuning is purely empirical, but it should account at least partially for effects caused by cloud nonuniformity. Second problem is shown on figure 3, where vertical profiles of solar absorption for old and new schemes are displayed. As expected, new scheme makes upper cloud layers more opaque and lower cloud layers more transparent compared to the old one. However, absorption peak around model level 20 is too strong, leading to excessive heating of relatively thin layer of air around 400 hPa level during daytime. As a remedy, more physically motivated vertical dependency of saturation factors c^{abs}, c^{scat} was tried, but without much success so far. It is therefore possible that diagnostics of cloudiness will have to be retuned as well. Anyway, solving this problem should lead to final shape of the new scheme.

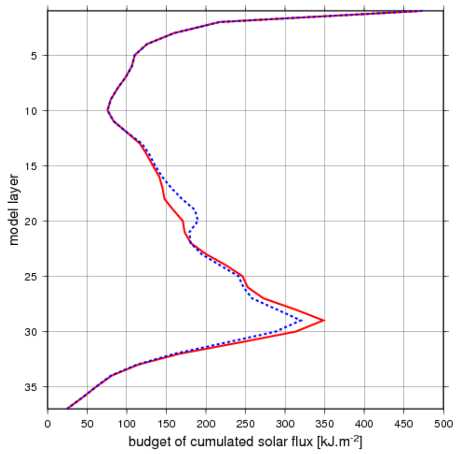

Figure 3: Vertical profiles of solar absorption (within 24 hours) for old scheme (red) and new scheme (blue).

1.2 Statistical approach for the computation of inter-layer gaseous exchange terms

The method for thermal radiation computations is based on the Net Exchanged Rate (NER) formalism (Green, 1967). NER allows stratifying the N(N+1) /2 thermal exchange terms between primary and secondary ones, where N is the number of discrete layers along the vertical. For a more accurate computation, besides the primary ones treated exactly, the secondary terms, although smaller, should not be neglected. To avoid of an unacceptable increase of computation time an approximate treatment of these additional terms was introduced. We can gain from the fact that the optical thickness under which layer is seen from any part of the gas-only atmosphere is between two limits already computed, so we are able to bracket the truth for additional terms between two computations (one with maximum and one with minimum estimated optical thickness for the additional fluxes between layers). The best possible estimate can be defined statistically, so a statistical parameterisation of the local values of the weighting coefficient α between min (α =0) and max (α =1) has been investigated. Stratifying a big amount of data, we found that α increases when the local gas absorption potential increases, i.e. lower in the atmosphere as well as when there are strong changes of the basic vertical temperature gradient, i.e. in inversions.

When such interpolation is applied to fluxes, the statistical fit works very well (see below the dispersion diagram of fluxes between their exact and retrieved values).

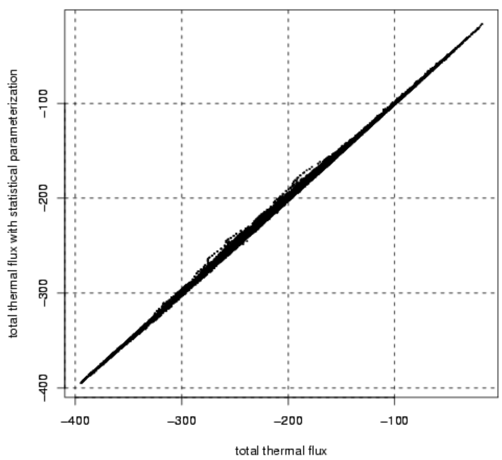

Figure 4: The dispersion diagram thermal fluxes between exact and retrieved values for one example.

2.1 Pseudo prognostic turbulent kinetic energy scheme (pTKE)

The aim of this scheme is to simply use the old well tuned scheme, which is a Louis type one, and add the missing features of the full TKE scheme (advection of TKE, shear, buoyancy terms and dissipation) in a simplest possible way. The reasoning is that the stationary solution of a full TKE scheme should be close to the values obtained by diagnosing this value from local vertical gradients of wind and potential temperature and we are looking for a prognostic equation of which stationary solution would yield exactly those diagnosed values.

The idea is to replace the full TKE equation with a simplified (pseudo) one (1), where the diagnosed values of the coefficients are used to compute $\tilde{E}$ (TKE), K_E (TKE self-diffusion coefficient) and τ_ε (relaxation time scale of the dissipation process for TKE). The three terms on right hand side are: advection, TKE self-diffusion and the last term is a simple way of describing the balance between shear and buoyancy production and destruction on one hand and dissipation on the other.

$$\frac{\partial E}{\partial t} = Adv(E) + \frac{1}{\rho}\rho K_E \frac{\partial E}{\partial z} + \frac{1}{\tau_\varepsilon}(\tilde{E} - E) \qquad (1)$$

After obtaining the new TKE values, the new K coefficients are obtained by simply inverting the process.

The scheme was tested in ALADIN model and it gives neutral or slightly improved scores for the winds at the top of the PBL. The results of testing of the scheme with GABLS II experiment are shown on figure 5. The pTKE is much better in simulating the evolution of PBL height compared to the operational scheme (full TKE considered as reference). The constant difference between the pTKE and the full scheme is due to the value of asymptotic mixing length parameter and can be reduced with better tuning.

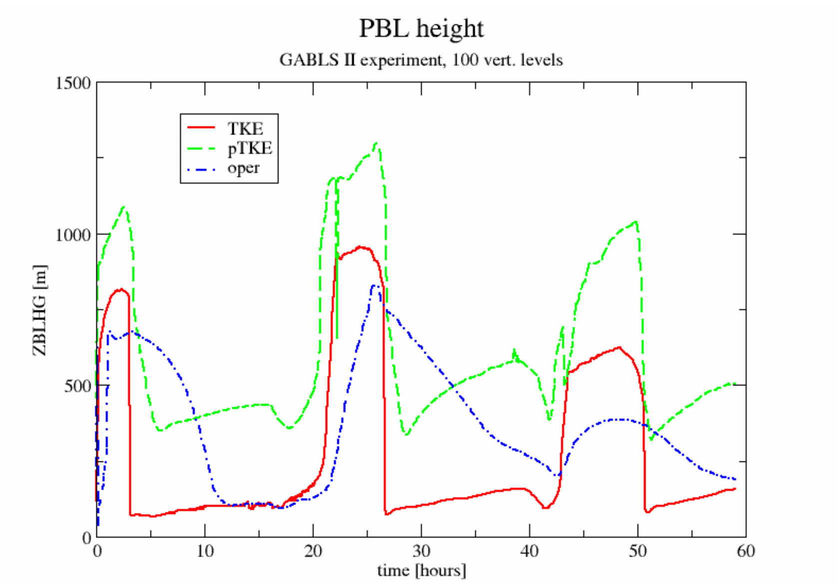

Figure 5: GABLS II experiment - comparison of PBL height computed with full TKE, pseudo TKE and operational (diagnostic) scheme.

2.2 Mixing length parameterisation in ALARO -0 (preliminary results)

The way of the mixing length formulation appears to be very important in current ALARO–0 model that uses the first order closure pseudo-TKE parameterisation of turbulent fluxes (Geleyn et al., 2006, Redelsperger et al., 2001). Classical first order closure turbulence schemes in ARPEGE/ALADIN were using constant profiles of mixing length based on observational studies and on the knowledge of the typical variation of eddy viscosity in the atmosphere (e.g. O` Brien, 1970). A new empirical formulation was introduced in 2005 by J.-F. Geleyn and J. Cedilnik (Cedilnik, 2005, hereafter GC05) which made the mixing length profile dependent on the height of the planetary boundary layer (PBL). The formula for the mixing length for momentum/enthalpy $l_{m/\theta}$ yields:

$$l_{m/\theta} = \frac{\kappa\left(z+z_{0/\theta}\right)}{1+\frac{\kappa\left(z+z_{0/\theta}\right)}{\lambda_{m/\theta}}\left(\frac{1+\varepsilon_{m/\theta}}{\beta_{m/\theta}+\varepsilon_{m/\theta}}\right)}, \qquad (2)$$

where κ is the Von Kármán constant, z_0 is the roughness length and $\varepsilon_{m/\theta}$ is an exponential function prescribed as:

$$\varepsilon_{m/\theta} = e^{-\alpha_{m/\theta}\sqrt{\frac{\left(z+z_{0/\theta}\right)}{h_{PBL}}}+\beta_{m/\theta}} \qquad (3)$$

Parameter h_{PBL} is the diagnostic height of the PBL (Ayotte et al., 1996).The profile of $l_{m/\theta}$ can be further modified via parameters $\lambda_{m/\theta}$, $\alpha_{m/\theta}$, $\beta_{m/\theta}$. Minor modifications of this formulation were tested in 2006 in order to have a faster decrease of the mixing length over h_{PBL} and a dependency of the asymptotic mixing length $\lambda_{m/\theta}$ on the height of the PBL.

The pTKE parameterisation using the formulas (2) and (3) for mixing length was tested in single column model on second GABLS experiment (see e.g. Cuxart et al., 2006). It provided satisfactory results for stably stratified PBL (e.g. further improvement of the PBL height diagnostics). However, the GC05 type of mixing length and its modification do not match well situations with large mechanical production of turbulent kinetic energy above PBL that occur in the region of strong jet stream (figure 6, left). The mixing length parameterisation dependent on TKE and integral buoyancy calculation seemed to be better for this purpose (Bougeault and Lacarrère, 1989, hereafter BL89). Nevertheless, direct application of the BL89 type of mixing length in the pTKE turbulence scheme has a consequence of TKE overestimation and further, rather negative impact on certain meteorological parameters (too strong surface wind and wind gusts). Hence, a combination of the empirical GC05 and BL89 formulation was tested to achieve a reasonable compromise. The resulting formula yields:

$$l_{m/\theta} = l_{0_{m/\theta}} + k_{m/\theta}\left(l_{BL89} - l_{0_{m/\theta}}\right) \qquad (4)$$

Here $l_{0_{m/\theta}}$ denotes a first-guess for the mixing length represented by the GC05 parameterisation (2) and (3), l_{BL89} is the BL89 formulation, which gives information about the

TKE and the integral buoyancy of the transported parcel. Function $k_{m/\theta}$ is used to modulate the rate of the l_{BL89} influence and it is prescribed by empirical formula.

3-D experiments with formulation (4) showed more production of TKE in areas of strong jets or low static stability against the reference GC05 mixing length (figure 6, right). This improvement was achieved without exaggerating the values of TKE in the PBL or at the tropopause (which could violate the stability of the computation).

Conclusion: Preliminary results on case studies achieved with the merged empirical and Bougeault-Lacarrère parameterisation show rather neutral impact on surface meteorological quantities (wind, mean sea level pressure). Differences can be observed rather on parameters, which are very sensitive on turbulent fluxes (e.g. on vertical profiles of diagnosed TKE). However, some properties and non-local aspects of this scheme seem to be promising and their influence will be further evaluated.

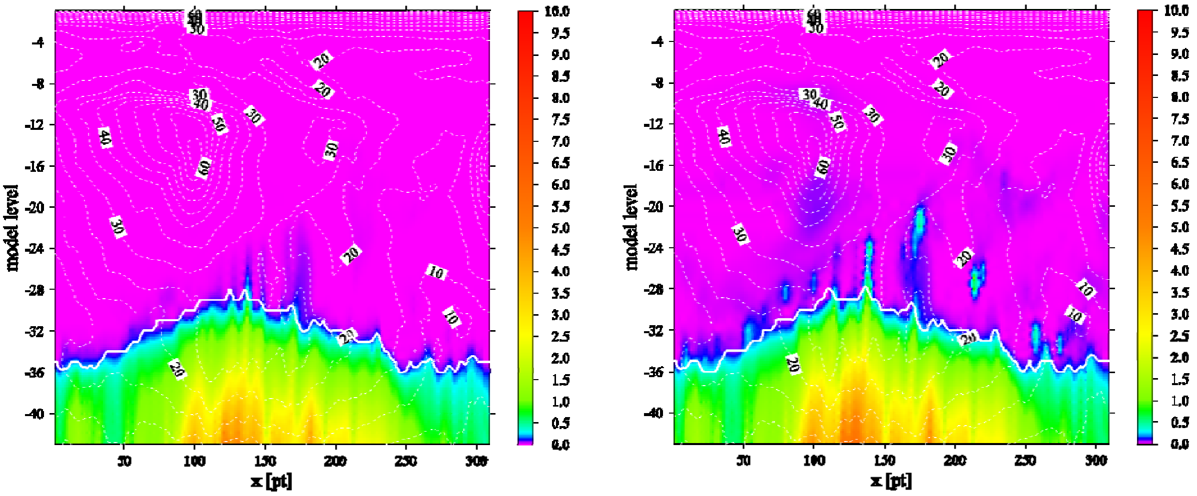

Figure 6: Vertical cross-section of wind velocity (isotachs, dashed, every 5 m/s) and turbulent kinetic energy (in color, kg . m^2 . s^{-2}) in 12 hour forecast valid to 15 December 2005 from the reference experiment with modified GC05 scheme of mixing length (left) from experiment with for the merged GC05 and BL89 parameterisation. Thick solid line denotes the height of the PBL. The cross-section is zonal, nearly following the 51.5° N latitude.

Acknowledgment

Contribution of other ALARO-0 developers D. Banciu, M. Bellus, R. Brožková, B. Carty, D. Drvar, K. Essaouaini, J.-F. Geleyn, L. Gerard, M. Janoušek, I. Stiperski, A. Trojaková, M. Tudor, F. Váňa, J.-M. Piriou is acknowledged.

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7 Scientific presentations on predictability and EPS

7.1 Y. Wang: LAMEPS Development of ALADIN-LACE

LAMEPS Development of ALADIN-LACE

Y. Wang, ZAMG, Austria

1. Introduction

During the recent years, Limited Area Model Ensemble Prediction System (LAMEPS) has become more important as a scientific tool for improving meso-scale short-range probabilistic prediction, especially the prediction of the high impact weather, for identifying model error sources and developing methods for reducing the forecast errors. However, due to very limited experience on meso-scale predictability, LAMEPS with high quality, in particular such a system which has more added values to its counterpart, the global EPS system, remains as one of the most challenging subject in NWP.

Within the LACE countries, some works have been done on LAMEPS in the last year for developing ALADIN Limited Area Ensemble Forecasting (LAEF) system.

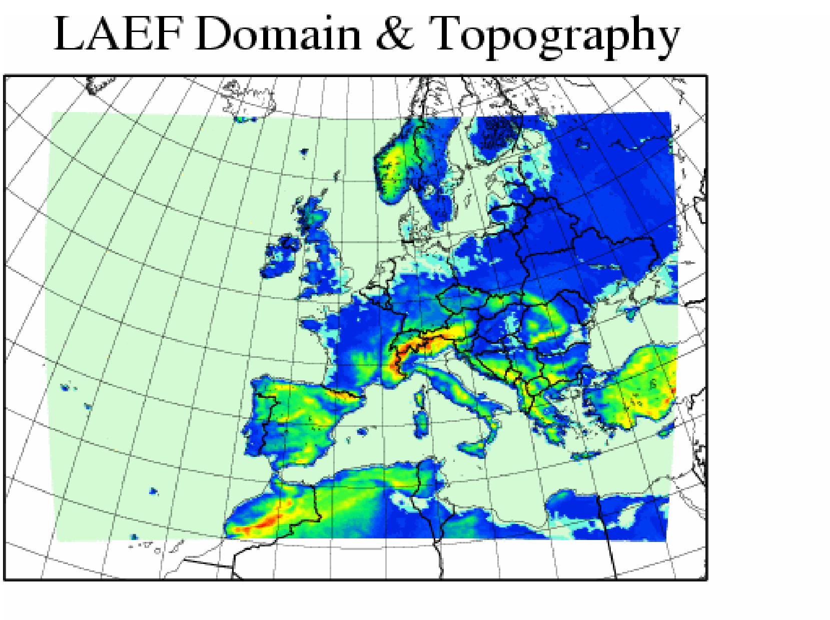


Figure 1. LAEF domain and topography.

2. Research and development

The efforts for research and development on predictability are focused on dealing with the uncertainties in analysis, in lateral boundary conditions, and in the model. Other works related LAMEPS, like dynamical downscaling, post-processing and common verification have been also started. Many experiments have been carried on over the domain shown in Fig. 1.

2.1 Dealing with uncertainties in initial condition

- **Breeding /ETKF /ET**

To compare those methods for generating the initial perturbation, a cold-case study (***one winter month, 1-28.Feb. 2006***) has been carried out with Breeding, ETKF and ET. 10 ensemble members were chosen for each method. A preliminary comparison of the spread of 500hPa geopotential and 850hPa temperature as a function of forecast time with using Breeding, ETKF and ET has been shown in Fig. 2. Those three methods show very similar performance. This is likely due to ensemble size (10 members) is not large enough. Differences between the ET/ETKF and breeding are only likely to be significant as the ensemble size exceeds the number of directions in which breeding ensembles maintain variance.

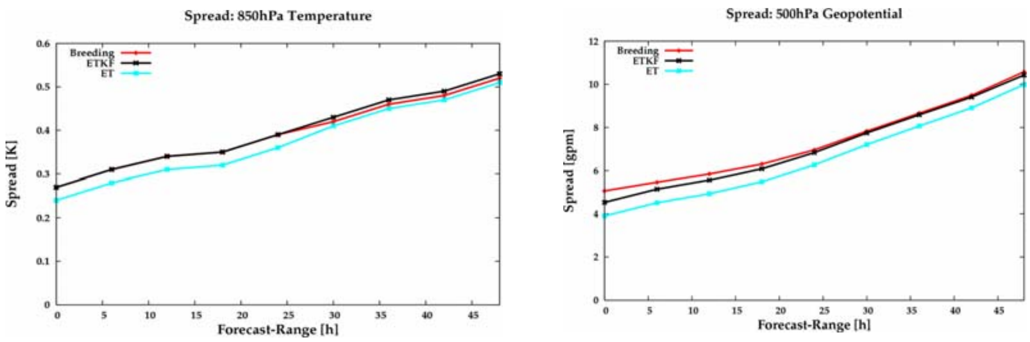


Figure 2. Comparison of the spreads of 850hPa Temperature and 500hPa Geopotential with using Breeding, ETKF and ET. All the experiments are with 10 members.

Based on the theory of ETKF, we expect that ETKF ensemble would maintain error variance in all amplifying normal modes, but the Breeding would only in the direction related to the most rapidly amplifying modes. To demonstrate this, we compute the mean spectra of eigenvalues of ensemble-based 12h forecast covariance matrices normalized by observation error covariance for the 10 member ETKF and the Breeding, which is shown in Fig. 3. It is found that the spectrum of ETKF eigenvalues is flatter than the norm from Breeding.

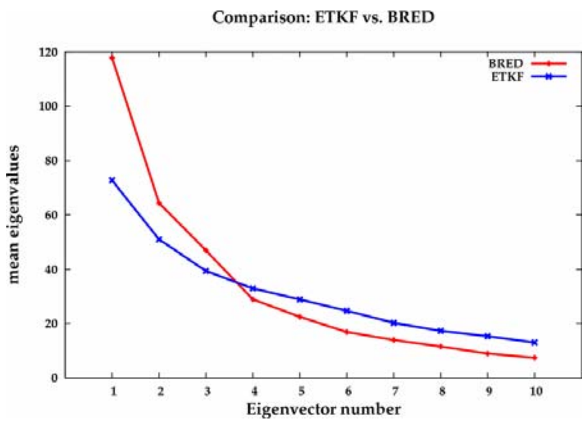


Figure 3. Comparison between Breeding and ETKF: mean eigenvalue

- **ALADIN Singular Vector (** by A. Horanyi and E. Hagel**)**

Research with singular vectors computed with the ALADIN model started in 2006 at the Hungarian Meteorological Service. As a first step different ALADIN configurations were used and tested. After these first tests started the work when results were analyzed not only computationally but from a meteorological aspect as well.

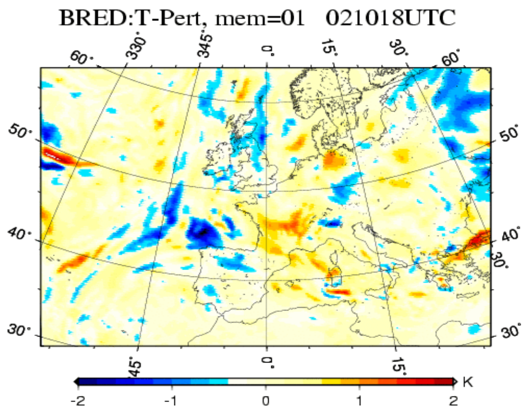
Speed of the convergence (during the singular vector computation), as well as CPU time and memory usage was analyzed. These are quite important issues, since the number of iterations performed determines the accuracy of the computed singular values/vectors.

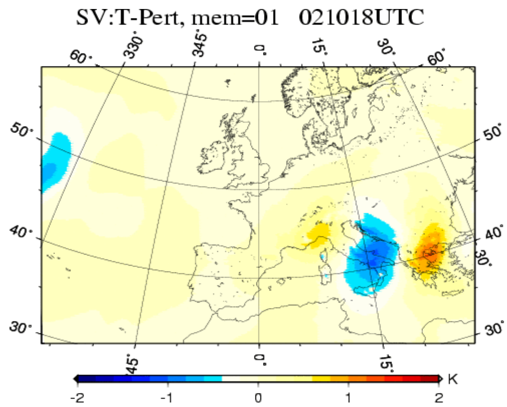
The more iterations performed, the more precise the results we get. On the other hand more iterations require more CPU time and memory, therefore a compromise solution is needed.

More detailed information about the result is available by A. Horanyi and E. Hagel.

- **Blending ARPEGE PEARP and ALADIN LAEF (**by M. Bellus**)**

Spectral blending on ARPEGE singular vector members and ALADIN Breeding members has been implemented. Some basic set-up of low spectral resolution used in the procedure and tuning of DFI filtering was done as well. The first blending results are quite satisfactory (shown in Fig. 4), since the blended initial states inherited the large scale perturbations from ARPEGE singular vectors (which were not present in ALADIN breeding files), while still kept the small scale perturbations generated by breeding. The main profit from the blending procedure is, that the blended initial conditions (needed for further limited area ensemble forecast integration) suppose to be now more compatible with the appropriate APREGE PEARP coupling files.





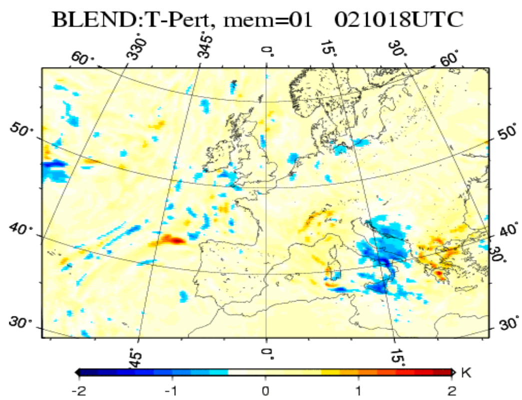


Figure 4. 850hPa Temperature perturbation for Breeding, SV and after Blending.

2.2 Dealing with uncertainties in lateral boundary conditions

- **Impact of the inconsistent LBC perturbation with IC perturbation**

For investigating the impact of the inconsistency in the generation of ensemble lateral boundary conditions from global EPS system with the generation of the ensemble initial conditions from the limited area ensemble system itself, experiments of ALADIN LAEF with perturbations of lateral boundary conditions from different global ensemble systems NCEP (with Breeding) and ARPEGE (with singular vector) superimposed on control lateral boundary conditions, e.g. from ARPEGE have been done for the cold case study. The method of the initial conditions perturbation used in LAEF is Breeding. The results are shown in Fig. 5.

The performance of the LAMEPS system is very sensitive to the LBC generated by different perturbation methods in the global EPS system. It is shown that LAEF couples with NCEP breeding perturbation has more diversity than LAEF couples with ARPEGE SV perturbation.

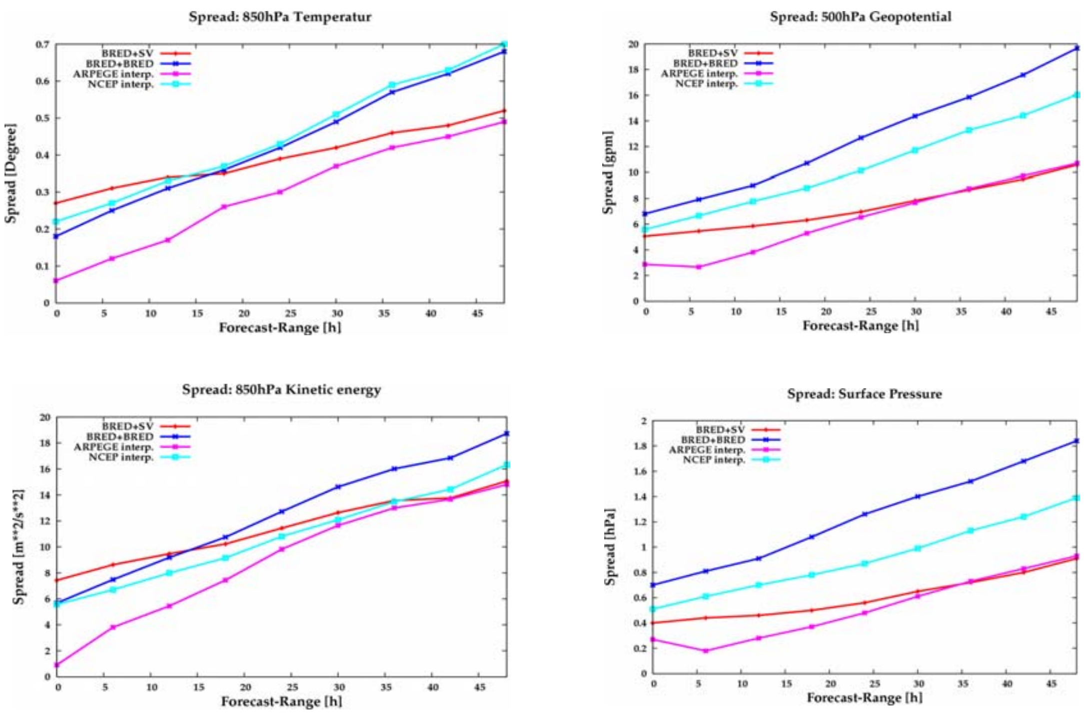


Figure 5. Comparison of the spreads of 850hPa Temperature and kinetic energy, 500hPa Geopotential, surface pressure, LAEF Breeding coupling with ARPEGE EPS and NCEP EPS.

2.3 Dealing with uncertainties in model physics

- **Multi-physics parameterization**

ALADIN dynamical downscaling of ARPEGE PEARP members with and without multi-physics options has been carried out. 11 combinations of different physics parameterizations and tunings in ALADIN have been chosen for dealing with the

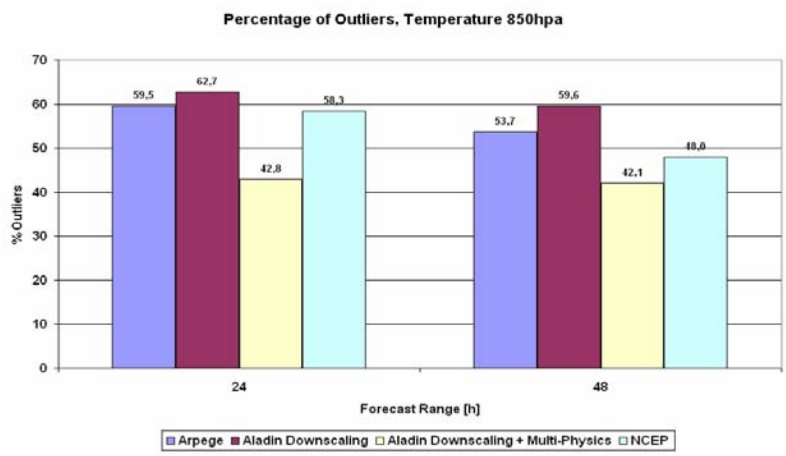


Figure 6. Percentage of outliers of LAEF experiment with and without multi-physics.

uncertainty in the model physics, they are: Bougeault-type scheme of deep convection, the modified Kain-Fritsch deep convection scheme, moisture convergence and CAPE closure in the convection scheme, Kessler-type scheme for large scale precipitation, Lopez microphysics scheme, tuning of the mixing length, entrainment rate, and the computation of the cloud base. The results are shown in Fig. 6-7.

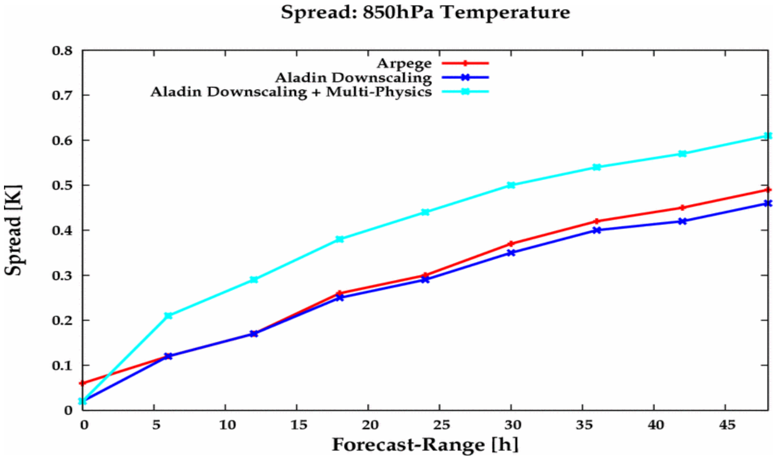


Figure 6. 850hPa Temperature spread of the LAEF experiments with and without multi-physics.

The results demonstrate that the multi-physics option in the LAMEPS brings much benefit for improving the diversity of the system

2.4 Dynamical downscaling of ECMWF EPS (by Ivatek-Sahdan, Brankovic, Matjacic, Pistotnik, Szintai, Ihasz, Kertesz)

The computational framework for dynamical downscaling the ECMWF EPS members with ALADIN at ECMWF has been started to implement. A large part of the work necessary to establish the facility to run ALADIN – a deterministic run as well as ensemble runs – on the high performance computing facility at ECMWF has been done. However, still some additional work is needed until a technically working ALADIN LAEF system becomes useable and enables the conduction of case studies and performance tests.

In Crotia, during 2005 and 2006 Studies of the ECMWF EPS downscaling were done. First clustering of the global model results (ECMWF-EPS), and afterwards, clustering of EPS forecasts downscaled with ALADIN NWP model. Four cases with Severe weather (precipitation and wind) in 2003 and 2004 were studied. 5 day forecasts of the full set of 50+1 ECMWF EPS members were downscaled with ALADIN on old LACE domain (12.2 km horizontal resolution 37 levels).

Results from both systems were manipulated in the same way (interpolated to 0.5°x0.5° grid) to determine the impact of dynamical downscaling. Comparison with ECMWF analysis was done on same resolution. Clustering was done using the Metview SW and a lot of Macros were developed for that purpose. Unfortunately clustering on the Lambert projection was not possible with Metview.

First results for the chosen severe weather events in Croatia show that downscaling is a useful tool, especially if topography is the triggering effect and it is promising that good

ECMWF EPS forecast were not spoiled with downscaling. The two measures of modeling error with respect to ECMWF operational analysis (mean absolute difference and mean deviation), defined over the downscaling domain indicate that the errors in ECMWF and ALADIN EPS upper-air fields are comparable.

Clustering on different base parameters were done for Z500, Z700, T850, wind 850, RT500/1000, RT700/1000, omega500, omega700. In principle a lot of common cluster members were found in most populated clusters members for ECMWF and ALADIN EPS. It seems therefore that in the case of dynamical downscaling many common members do not necessarily guarantee similarity between clusters from the two different populations (Fig. 7).

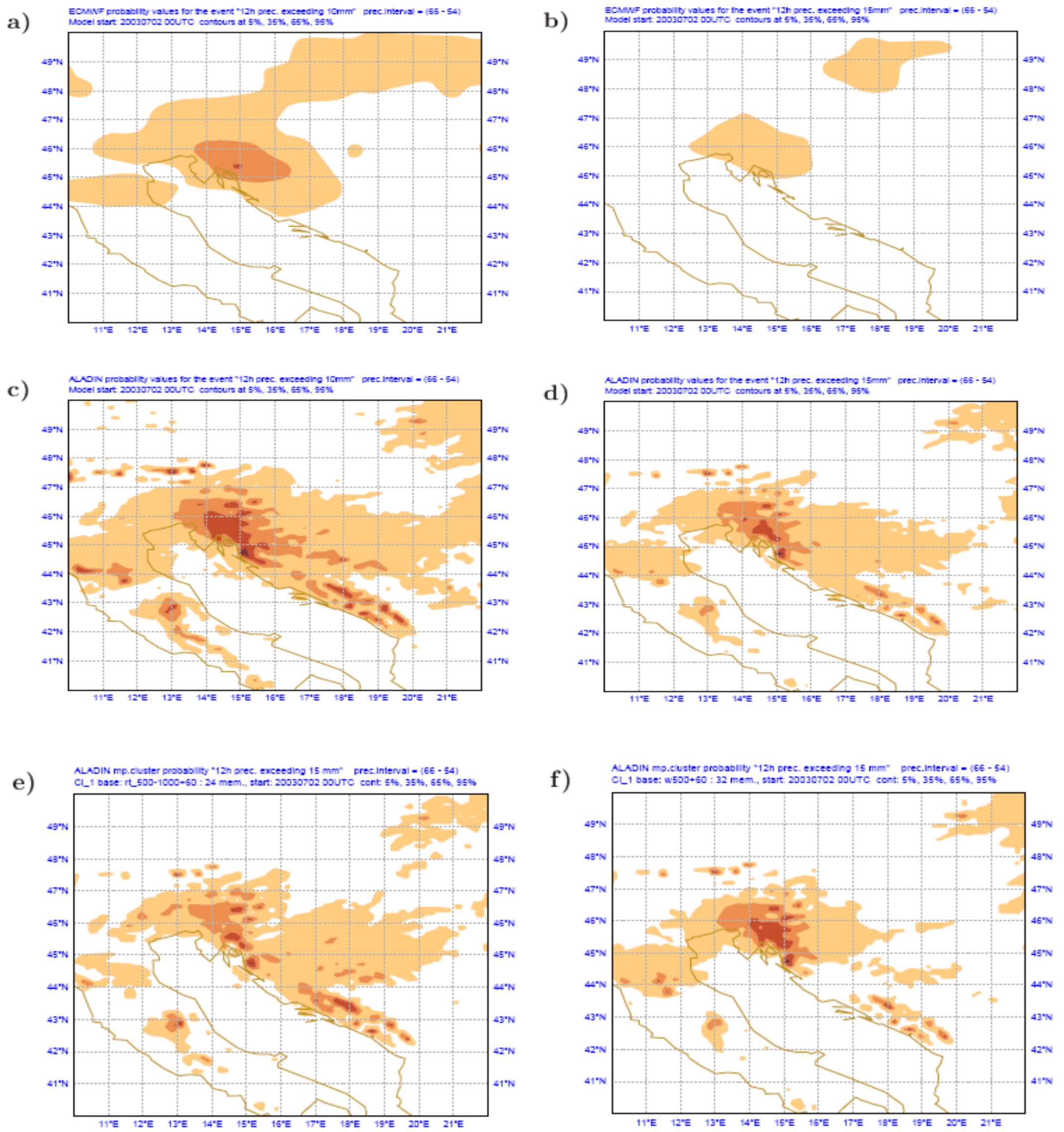


Figure 7. Probability of the 12-hour accumulated precipitation (between T+54 and T+66) in the SU1 case for ECEPS (top) and ALEPS (middle) for the thresholds 10 mm/12 hr (left) and 15 mm/12 hr (right). Same probability for ALEPS and the 15-mm threshold for most populated clusters based on e) RT 500/1000, and f) ω500. Contouring at 5, 35, 65 and 95%.

In Budapest, dynamical downscaling of ECMWF EPS with

• 10 clusters with representative members from 51 and then 102 EPS members, clustering at +60h and 84h

• ALADIN integration: 84h

• Verification: 3 case studies (precipitation events)

has been done. The results show that on the basis of the first subjective and objective evaluations of the ALADIN downscaling ECMWF EPS system, the ALADIN EPS system in the examined limited number of cases could bring benefit on top of the global ECMWF EPS system (Fig.8)

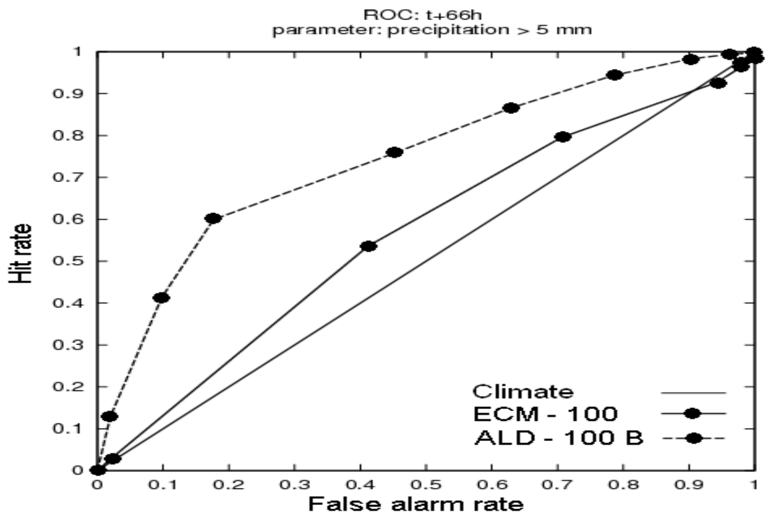


Fig. 8. ROC diagrams for 5mm/24h threshold for +66h forecasts calculated from the first three case studies. Thick solid line is relative to ECMWF EPS (100 members), dashed line is relative to ECMWF/ALADIN (10 representative members from the 100 global members, bigger domain), the diagonal line represents the climate. The black dots represent the different probability thresholds. ROC areas: 0.6 (ECMWF EPS); 0.77 (ECMWF/ALADIN).

2.4 Downscaling of ARPEGE EPS (by R. Mladek)

In Prag, evaluation of 18 cases with the largest model errors in precipitation forecast over Czech republic from the period 2003-2006 has been started. It was found that no real improvement in the recent studies related to the direct dynamic downscaling of global EPS by the ALADIN with high resolution.

3. Conclusions and future plan

Within LACE works have been done for developing ALADIN LAMEPS (LAEF). Focuses have been put on dealing with uncertainties in initial conditions, lateral boundary conditions and model physics, Also the dynamical downscaling of global EPS system, like ECMWF and ARPEG has been investigated. The results can be summarized as follows:

a. ETKF with 10 members has very similar performance to Breeding. It is also true for ET perturbation. The reason is might be due to the small ensemble size.

b. Blending method seems to be promising. It is more compatible with the appropriate APREGE EPS coupling files.

c. The performance of the LAMEPS system is very sensitive to the LBC generated by different perturbation methods in the global EPS system. It is shown that LAEF couples with NCEP breeding perturbation has more diversity than LAEF couples with ARPEGE SV perturbation.

d. Multi-physics option in the LAMEPS brings much benefit for improving the diversity of the system.

e. Limited case studies show that dynamical downscaling of ECMWF EPS with using ALADIN is beneficial for the short range probabilistic forecast.

More works are planned for the next years, the focuses will be on the ALADIN SV, and blending method, ECMWF EPS downscaling etc. Some studies on downscaling ARPEGE EPS system will be also continued.

Acknowledgements

The work is part of the LACE development on predictability of 2006. I gratefully acknowledge all the LACE colleagues who has involved the LACE LAMEPS development in the last years, especially Kann, Wittmann, Pistotnik, Ivatek-Sahdan, Brankovic, Matjacic, Horanyi, Hagel, Szintai, Ihasz, Kertesz, Mladek, Tascu. etc.

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7.2 J. García-Moya et al.: Recent Experiences with the INM Multi-model EPS scheme

Recent Experiences with the INM Multi-model EPS scheme

García-Moya, J.A., Callado, A., Santos, C., Santos, D., Simarro, J., Orfila, B.

Modelling Area – Spanish Met Service INM

1. Introduction

Forecast of weather risk is the goal for both Medium and Short Range Prediction (Palmer, 2002), being key for this purpose the accurate forecasts of surface weather parameters and extreme events (convective precipitation, gales…). The probabilistic character of these forecasts makes convenient trying to see how several Short Range Ensemble Prediction Systems may help to forecast these events (Hou D. et alt 2001). That was present when in April 1999 INM included in its NWP plans the aim to prepare a Limited Area Short Range Ensemble Prediction System. The SAMEX experiment was the reference followed for its initial development. Along 2001 to 2005 a convenient set of operational well tested limited area models were imported into INM and implemented in the INM computing System, which was progressively upgraded until the current CRAY1E. The triggering and consolidation of the current INM SREPS System have been possible thanks to:

i) the availability of enough computer power;
ii) the stable staff team gathered, which has allowed to overcome the technical difficulties related to the adaptation of the models to the platform, storage aspects, database software (MARS like the ECMWF one), post processing, maintenance, monitoring and verification; and
iii) the following of the recommendations of the workshops and meetings attended.

A description of SREPS at INM with examples of the monitoring procedure and displays of some products are included in section 2. Description and some results of a verification exercise both against observations and analyses is covered in section 3. Further work, the envisaged future of INM SREPS and some conclusions close this presentation.

2. SREPS at INM

The aim of INM SREPS is preparing four times a day, at 00, 06, 12 and 18 UTC, a set of 20 forecast from five limited area models fed each one with boundary conditions from four global models, and combining the last four ensembles (HH to HH-18) to get a time-lagged Super-Ensemble of 80 members every six hours.

The five model used are:

- Hirlam (http://hirlam.org).
- HRM from DWD (German Weather Service).
- MM5 (http://box.mmm.ucar.edu/mm5/).
- UM from UKMO (United Kingdon Meteorological Office).
- LM (Lokal Model) from the COSMO consortium.

and the four global models providing the boundaries are:

- ECMWF (European Centre for Medium Range Weather Forecasts)
- UM from UKMO (United Kingdon Meteorological Office)
- AVN from NCEP (U.S. National Weather Service)
- GME from DWD (German Weather Service)

Currently the size of the super ensemble is limited to 40 members, because only two sets of integrations at 00 and 12 UTC are undertaken.

Fig. 1 shows the integration areas used for each of the models. Horizontal resolutions of the used configurations are about 25 km or 0.25º latxlon. Forty levels in vertical are used for each of them. Figure 2 shows the common Europe-North Atlantic area where the forecast fields are interpolated with a resolution of 0.25º and 40 levels. The number of grid points is so 480x184x40. The computer time requirements for this exercise are high, and the integration uses a substantial part of the CRAY X1E vector machine with 16nodes with 8MSP's each, equivalent to a 2.4 Tf peak (sustained performance about 800 Gf).

Part of the postprocessing is undertaken in a couple of enhanced PCs with Linux. The post-processing makes wide use of the ECMWF Metview package and is additional local developments.

To monitor the system in real time a website has been developed (accessible by the time being only from the INM intranet) where both deterministic and probabilistic products are shown in real time. An example of it is the stamps chart of model by boundaries for geopotential height and temperature of 500 hPa, figure 3. It is internally used for monitoring when the completion of each member run has been achieved. Figure 4 presents an example of probability maps of 2m temperature 24 h. trend, and figure 5 shows a deterministic output where the ensemble mean and the spread of 500 hPa height for a concrete projection are presented. An example of probability maps for 6h accumulated precipitation higher than >= 1, 5, 10 and 20mm thresholds, and the verifying map is given in figure 6. Also, 10m wind speed probabilistic maps and EPSgrams are regularly prepared.

3. Objetive Verification

Verification of the twice a day ensemble runs for the period January to June 2006 both against observations and ECMWF analyses are undertaken. Results are computed to check, on one hand, the ensemble calibration for the synoptic variables Z500, T500, Pmsl; and, on the other hand, the ensemble response to binary events like 10m surface wind and 6h and 24h accumulated precipitation higher than specific thresholds.

The performed verifications presented in figure 7 show the Spread-skill diagram for the 6 to 72 hour 500 hPa forecasts and the rank histogram for the 24 hours Geopotential Height of 500 hPa forecast. They are computed against ECMWF analyses and use the EWGLAM reference synoptic network of surface and upper air observations.

For the synoptic variables (here Z500) the spread-skill and rank histograms against observations show that the ensemble is under-dispersive and a bit under-forecasting. The same against ECMWF analysis is very good.

The evolution of Bias and RMSE with forecast length for all members and for the ensemble mean are computed for the model synoptic variables Z500, T500 and Msl Presure, although not shown. The bias and RMSE of the ensemble mean are lower than the each member ones.

An example of the response of the system to binary events is given in figure 8, where for 24 hours accumulated precipitation a stamp map of reliability and sharpness, ROC and ROC area scores, temporal evolution of the Brier Skill score, and Relative value diagrams, versus observations and ECMWF analyses is presented. Results that expands also to the other verified surface variables indicate that 24h accumulated precipitation against observations (top) show medium/quite good reliability and good resolution, degrading with threshold (clearly) and forecast length, being much better the verification against ECMWF analyses.

4. Conclusions

Since the year 2001 an experimental Multi-model-Multi-boundaries Short Range Ensemble Prediction System has been developed at the Spanish INM. Currently it is preoperational.

Verification results against both observations and the ECMWF analyses for the first half of 2006 have been performed in order to check ensemble calibration with synoptic variables Z500, T500, Pmsl and to estimate the ensemble response to binary events. Results look very promising: verification against ECMWF analyses shows very good results; verification against observations, although less good, performs well; the ensemble is a bit under-dispersive and gives a good response to binary events.

5. Further work and future issues

The ensemble performance could be improved with some post-processing, today under development. Using Bayesian Model Averaging (BMA) seems to be the right tool to make bias correction as well as calibration of the multi-model SREPS.

Progress undertaken since 2001 and next scheduled activities are collected in table I.

2001-2004	Research to find the most suitable ensemble system for the Short Range	
Jun 04 – Jun 05	Building Multimodel System	
Jun 05-Dec 05	Mummub n/16 members	Daily run non-operational
Mar 06	Mummub 16/16 members	Once a day
Jun 06	Mummub 20 members	Twice a day
July 06	Obs verfication	
September 06	**40 member lagged Super-ensemble**	**Twice a day**
October 06	BMA Calibration	
January 07	Broadcast products	Experimental

Table I INM/SREPS progress and next scheduled activities

Additional issues to be tackled with in future cover:

i) Use of Aladin and WRF as additional forecasting models.
ii) Consideration of methods for multiple initial conditions. They could be the used of Multi analyses from the HIRLAM 3DVAR model with a first guess from each ensemble member, or of an Ensemble transform Kalman filter.
iii) Verification against observation of high resolution precipitation network over Europe.
iv) Developing more post-process software (clustering).
v) Apply statistical downscaling methods to SREPS outputs.
vi) Convergence with GLAMEPS and regional THORPEX.
vii) Data policy aspects.

6. References

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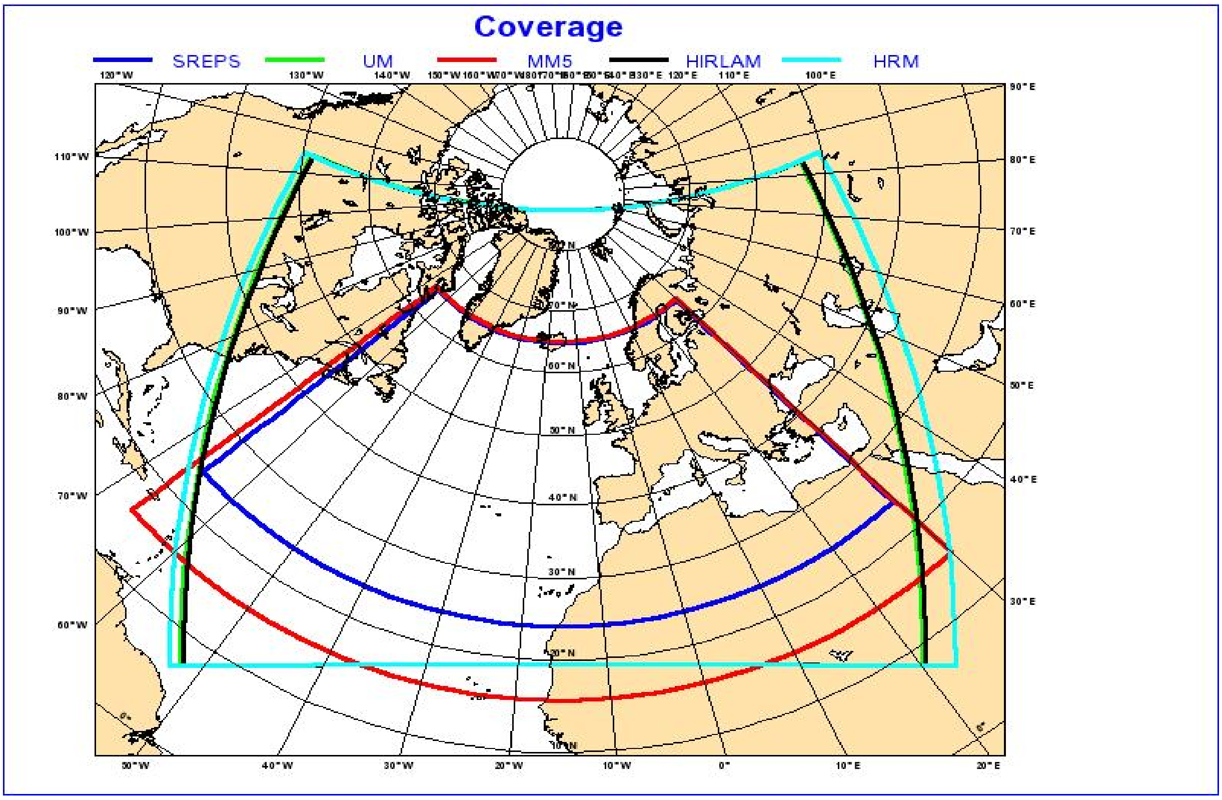

Figure 1 Integration areas used by each model

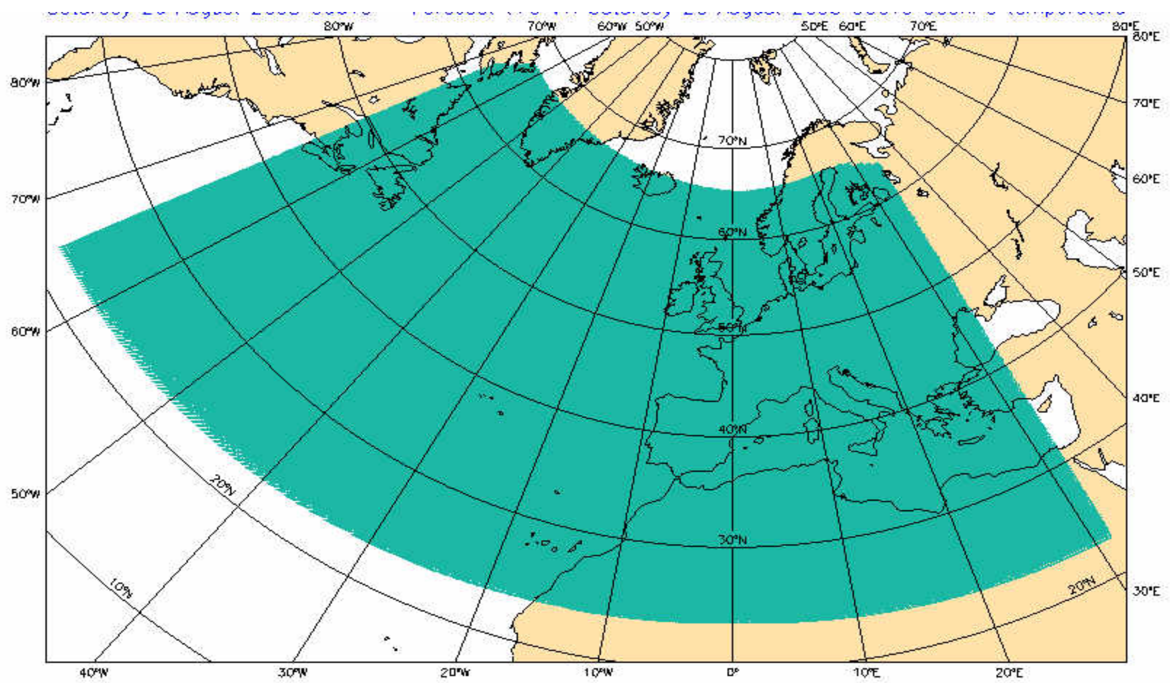

Figure 2 Area common to all integrations

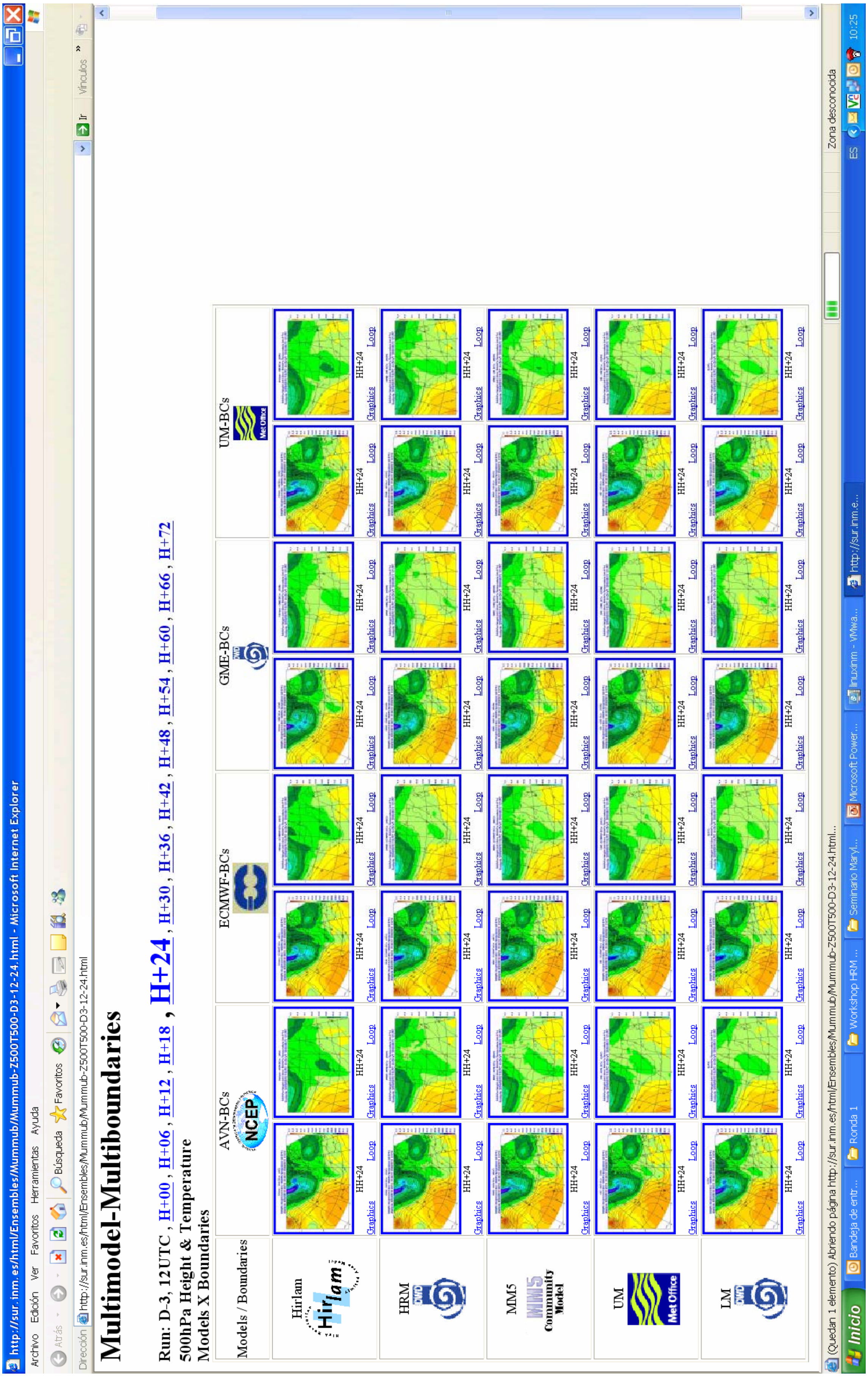

Figure 3 Example of a stamp chart of model by boundaries for geopotential height and temperatures of 500 hPa

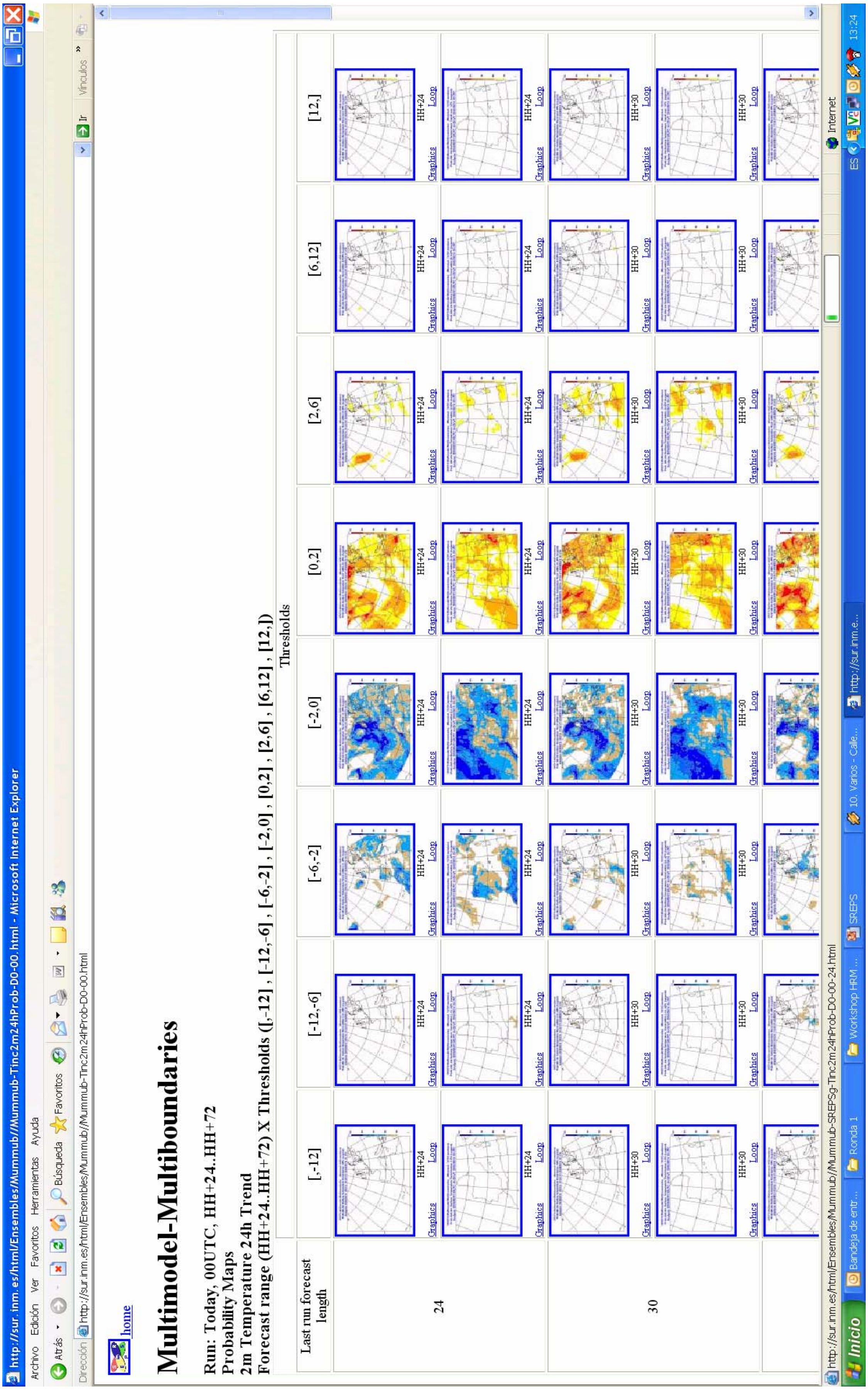

Figure 4 Example of probability maps of 2m temperature 24h trend

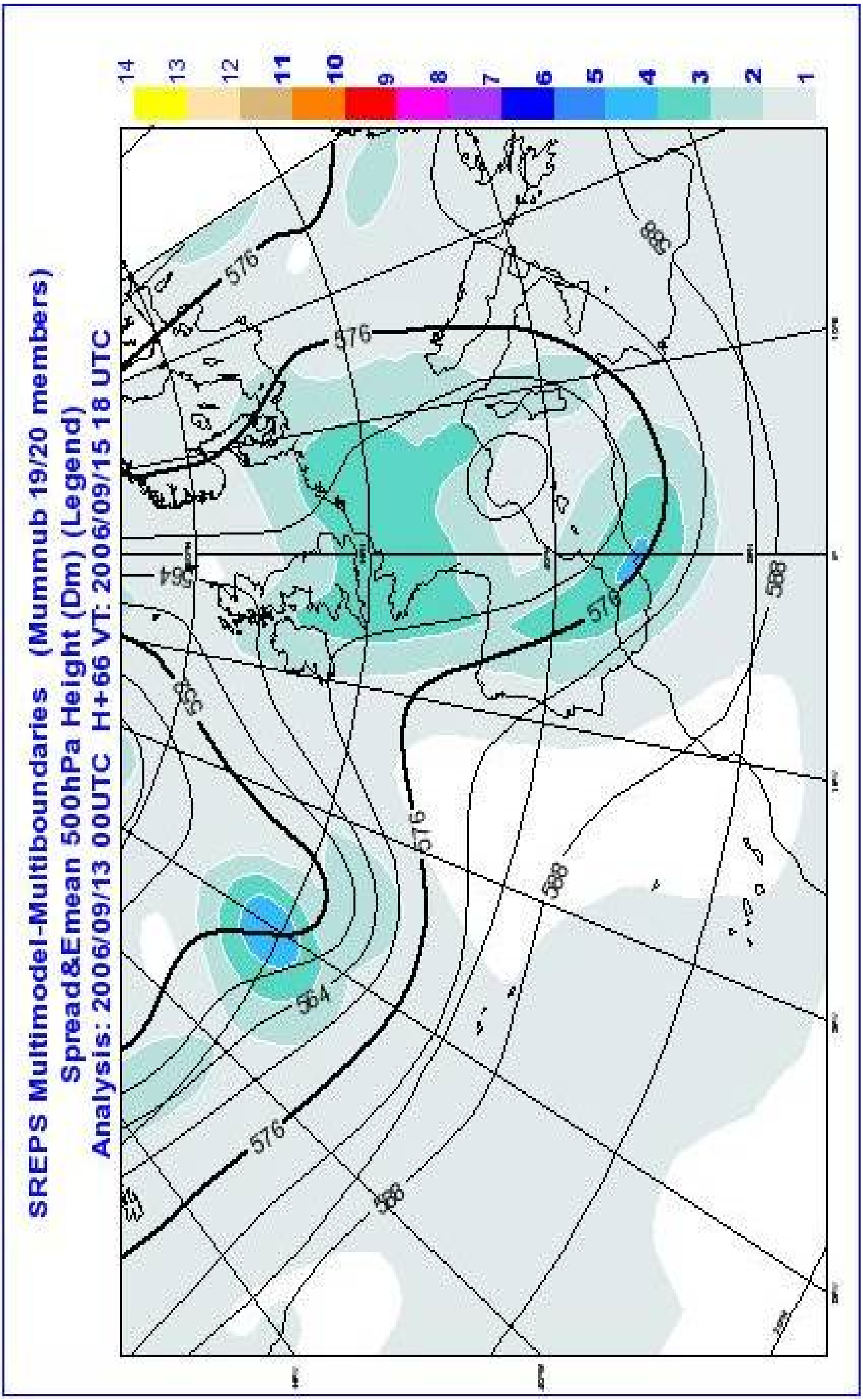

Figure 5 Example of one deterministic output of overlayed ensemble mean and spread

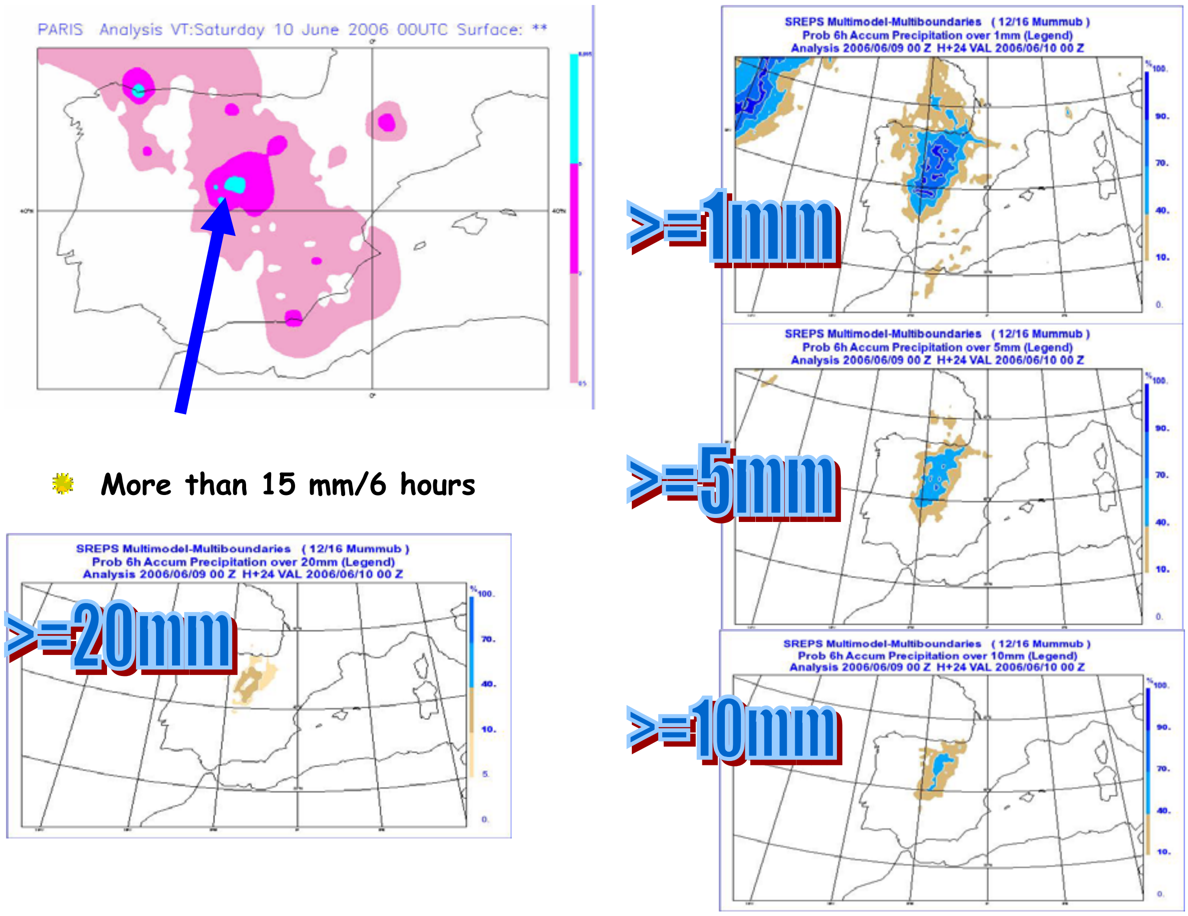

Figure 6 Results of a case study. It presents probability maps of 6h accumulated precipitation higher than specific thresholds and the verifying map

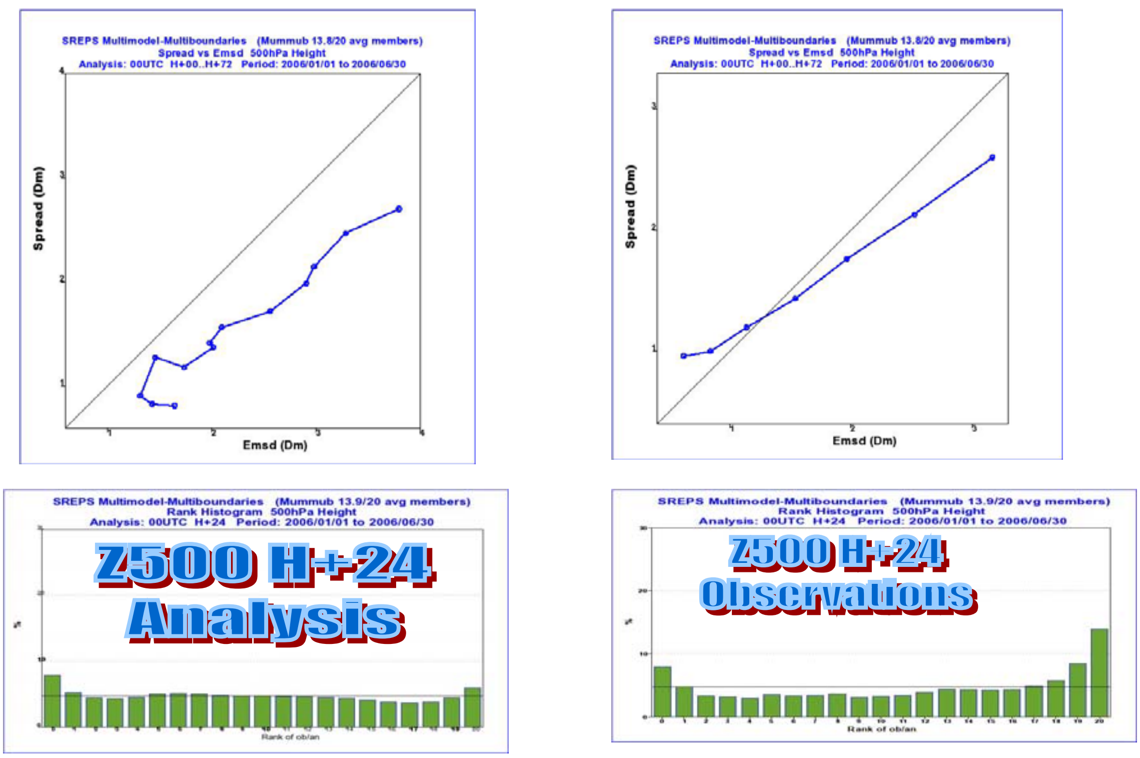

Figure 7 Spread skill diagram for the 6 to 72 hours 500 hPa forecasts and the rank histogram for the 24h geopotential height of 500 hPa forecasts computed against observations and ECMWF reanalysis

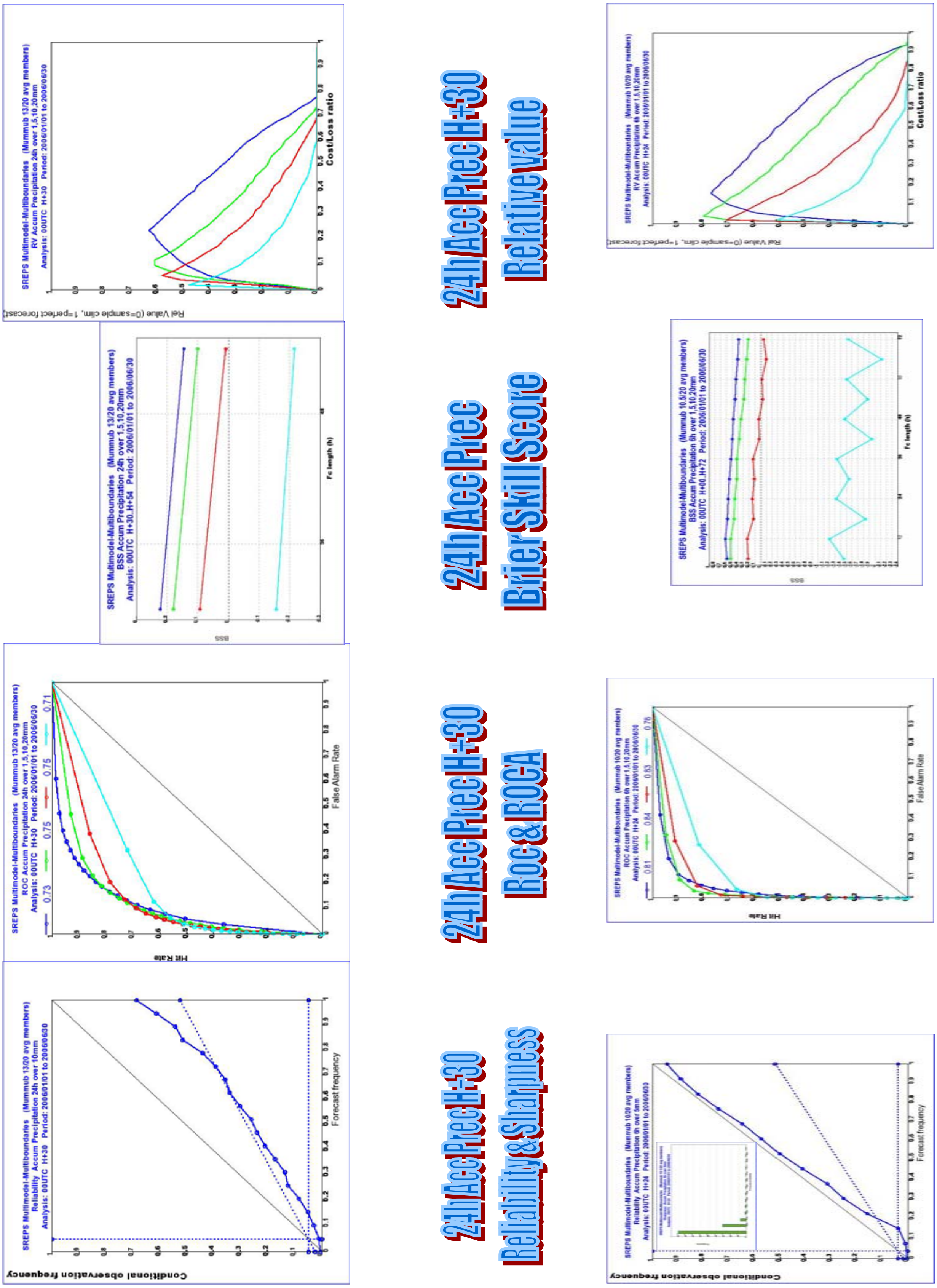

Figure 8 Stamp map of reliability and sharpness, ROC and ROC Area scores, temporal evolution of the Brier Skill score, and Relative value diagrams, versus observations and ECMWF analyses.

7.3 C. Marsigli et al.: The COSMO SREPS project

The COSMO-SREPS project

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1 Introduction

A strategy to provide high-resolution meteorological ensemble forecasts for the short-range (up to three days) is here presented. Different sources of forecast errors have been considered, trying to describe the uncertainties affecting the scales of interest in the high-resolution quantitative precipitation forecast at the considered time range. The error in the initial conditions has been considered, together with error in the boundary conditions, being the ensemble based on a limited area model, the non–hydrostatic Lokal Modell (LM, horizontal resolution of about 10 km). To accomplish this, the Multi-Analysis Multi–Boundary SREPS system of INM has been chosen as driving ensemble. In particular, initial and boundary conditions are provided by 4 LM integrations, run at 25 km over an Euro–Atlantic area and driven by 4 different global models, with 4 independent analyses. Since the system aims at taking into account smaller-scale uncertainties and errors within the LM formulation, limited-area model perturbations have also been applied. The values of the parameters included in the schemes for the parameterisation of the sub-grid processes are randomly modified from run to run within their range of variability.

Results are presented for one precipitation event in terms of ensemble spread and skill. The performance of the ensemble is compared with that of the COSMO–LEPS system, an operational mesoscale ensemble which uses the same limited–area model and can be regarded as a dynamical downscaling of the ECMWF EPS. Results show that this approach allows to increase the spread of the ensemble forecasts in terms of surface variables. Furthermore, for the selected case study, the impact of changing initial and boundary conditions gives the main contribution to the spread, with respect to the parameter perturbations.

2 The COSMO–SREPS project

The development of COSMO–SREPS (Short-Range Ensemble Prediction System) is carried out within a Priority Project of the COSMO Consortium by ARPA–SIM, with the collaboration of a number of COSMO scientists. The project deals with the development and implementation of a short–range ensemble based on LM. This system is built to fulfil some needs that have recently arisen in the COSMO community:

- to have a short–range mesoscale ensemble to improve the support to the forecasters, especially in situations of high impact weather;
- to have a very short-range ensemble for variational data assimilation purposes (1D-Var), to estimate a flow–dependent error covariance matrix;
- to provide initial and boundary conditions to the very high resolution ensemble EELKM (Experimental Ensemble LM-K) of DWD.

The strategy to generate the mesoscale ensemble members proposed by this project tries to take into account several possible sources of uncertainty and then to model many of the possible causes of forecast error. The proposed system would benefit of: perturbations of the initial conditions, perturbations of the boundary conditions, perturbations within the limited–area model.

In the COSMO–LEPS system (Montani et al., 2003), the perturbations are ingested mainly through the boundary conditions, which are provided by some selected members of the operational ECMWF EPS (Molteni et al., 2001; Marsigli et al., 2001). The EPS spread comes from two main contributions: perturbations to the initial conditions, generated using the Singular Vector technique, designed to guarantee the maximum spread in the medium-range on a global scale (Molteni et al., 1996), and perturbations to the model, generated by a random perturbation of the physical tendencies (Buizza et al., 1999), which are more local in nature. Being the COSMO–LEPS perturbations derived from the EPS ones, the system is useful especially in the early medium range (day 3-5). In order to ensure a smaller scale variability to the mesoscale ensemble, another kind of perturbations is added to the system, by allowing a random choice of the scheme to be used for the parameterisation of the deep convection (either Tiedtke or Kain–Fritsch) in the LM runs. A preliminary study (Marsigli et al., 2005) suggested that the perturbations applied in this way play a minor role with respect to the perturbations at the boundaries, which explain the major amount of the spread.

The necessity of using a probabilistic approach also for the short–range and for the smaller scales can be understood in the light of the recent model developments. Despite the possibility to explore the scale of the order of few kilometres, the capability of numerical models to correctly forecast local and intense precipitation is still nowadays limited. This is true even at short time–range, up to 48 hours, due to the loss of atmospheric predictability going down to small spatial and temporal scales. At this scales (1 to 10 km), it is not completely satisfactory just to reproduce precipitating structures, but a correct localisation in space and time is required together with realistic peak values. These considerations introduce the need of a quantification of the predictability associated with a forecast which has been until now considered better provided by a deterministic very high resolution model. The scales at which the uncertainty needs to be quantified are influenced by phenomena which are only marginally considered in the generation of the perturbations for the global ensemble. In order to design an ensemble system for these purposes, the use of perturbations which can generate a reasonable spread in the short-range and of perturbations that act on a more local scale and is explored.

In the design on a LAM ensemble system, it is not possible to neglect the contribution of the boundary conditions. In order to take into account the error of the global model that comes from the boundaries, a multi–model approach is adopted. A MUlti-Model MUlti-Boundaries (MUMMUB) ensemble system is currently run by INM, where five different limited–area models (UM, HIRLAM, HRM, MM5, LM) are driven by the four global models (IFS, GME, UM, NCEP) which provide both initial and boundary conditions. The four LM runs nested on the four different global models are provided to the COSMO partners. The integration domain is shown in Fig. 1, the horizontal resolution being about 25 km.

The four INM–LM runs are used in the SREPS project to drive 16 LM runs at higher resolution (10 km). Each of the 25 km LM runs provides initial and boundary conditions to 4 higher resolution LM runs, differentiated by the use of 4 different model perturbations (Fig. 2). Within the project, it has been planned to apply three different techniques for the model perturbations: (1) use of different parameterisation schemes, (2) perturbation of the parameters of the schemes, (3) perturbation of the surface fields.

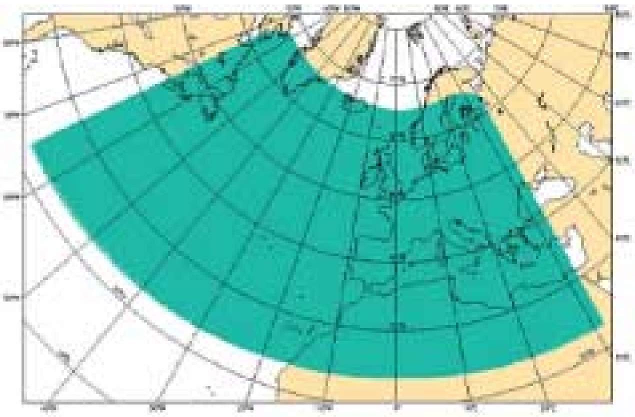

Figure 1: INM SREPS domain. (Courtesy of INM)

The reasons leading to the choice of the perturbation type (1) are based on the difficulty to establish which scheme is better able to parameterise a particular physical processes or to approximate the true solution. As for perturbation type (2), a number of parameters are included in the Lokal Modell formulation, especially in the schemes used for the parameterisations of the physics and, to a lesser extent, in the numerical schemes. Generally, these parameters are assigned a fixed value chosen within a range, describing the uncertainty around the best estimate of the parameter. Therefore, model perturbations are added by varying, in the different model runs, the value assigned to the parameter within its range. For this purpose, the range of variability has to be carefully specified and made available by the scientists involved in the development of the schemes. Perturbation type (3) will be studied in a second phase of the project.

At a later stage of the project,it is also planned to introduce mesoscale perturbations to the initial conditions by using an ETKF (Ensemble Transform Kalman Filter) scheme.

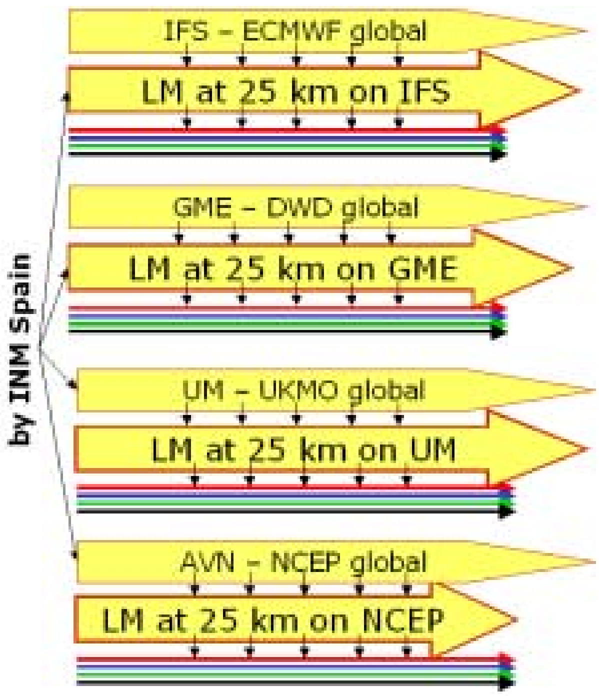

Figure 2: Scheme describing the COSMO–SREPS set–up.

COSMO–SREPS is a 16–member ensemble, run over the same area of the COSMO–LEPS system, at a horizontal resolution of about 10 km and with 40 vertical levels. The considered forecast range is 72 hours.

3 Results

The first run of the COSMO–SREPS system has been performed for the 13 May 2006 event, when precipitation of moderate intensity have affected northern Italy and Switzerland. The run has started at 00 UTC of the 13 May 2006.

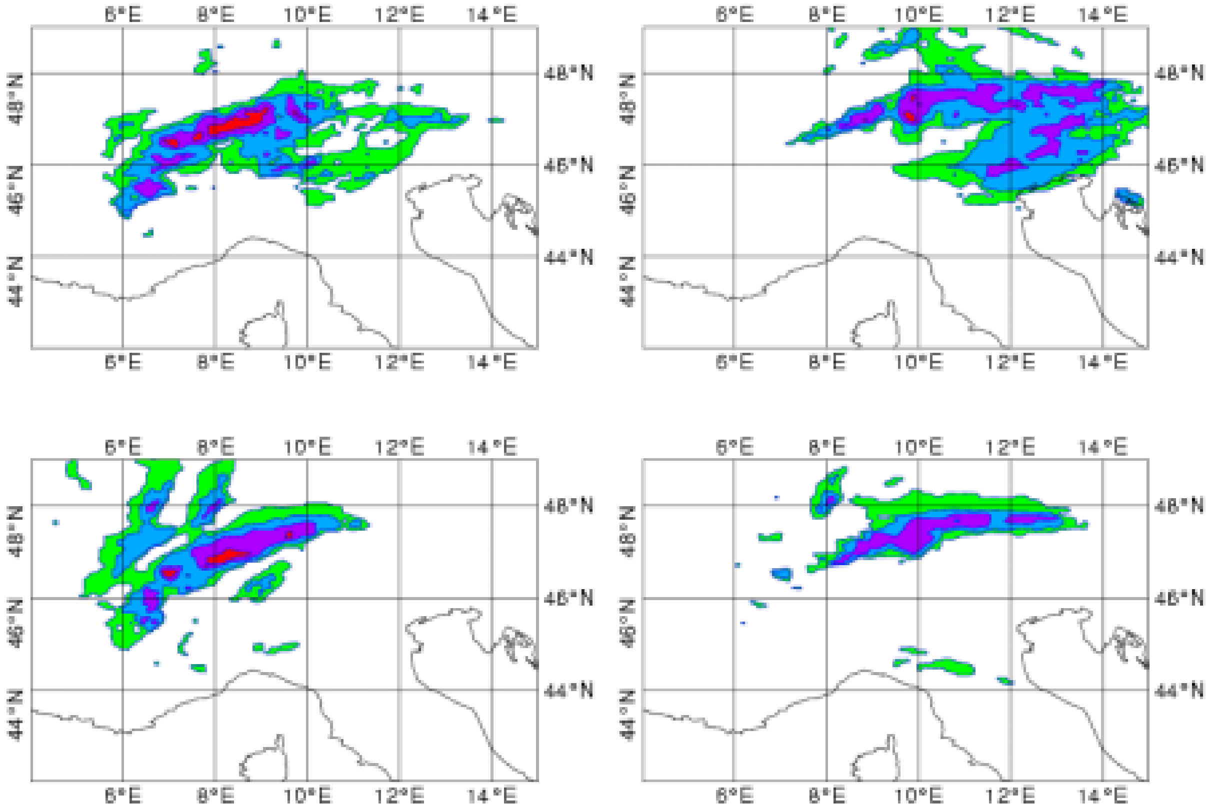

Figure 3: COSMO–SREPS (top) and COSMO–LEPS (bottom) probability maps for the 10mm/6h threshold, for the periods 18-24 UTC of the 13 May (left) and 00-06 UTC of the 14 May (right). Isolines are relative to 10 (green), 30 (blue), 60 (violet) and 90 (red) %.

The COSMO–SREPS probability maps relative to the event "precipitation exceeding 10mm/6h" for the two 6–hour periods 18-24 UTC of the 13 May (18-24 h forecast range) and 00-06 UTC of the 14 May (24-30 h forecast range) are shown in the two top panels of Fig. 3. In the two bottom panels are shown the COSMO–LEPS probability maps for the same period, relative to the run started at 12UTC of the 13 May, the forecast range being respectively 06-12 h and 12-18 h. In the first 6-hour period precipitation was observed mainly on the north–western Alps, in the Ticino and Lago Maggiore area (not shown). Both probabilistic systems indicate as likely to be interested by precipitation exceeding 10mm/6h an area including the one where precipitation was actually observed. In the second 6-hour period, heavy precipitation was occurring over the plain of the Veneto region, approximately around 12E - 46N, with moderate precipitation spreading over the central part of the Alps (not shown). For this period, only the COSMO–SREPS forecasts assign a probability exceeding 30% to the occurrence of precipitation over the plain, while COSMO–LEPS maps indicate as likely to be affected by rainfall the central Alps area only.

In Fig. 4 it is shown how the spread, computed in terms of 2m temperature, among ensemble members varies according to the criterion used to group the members.

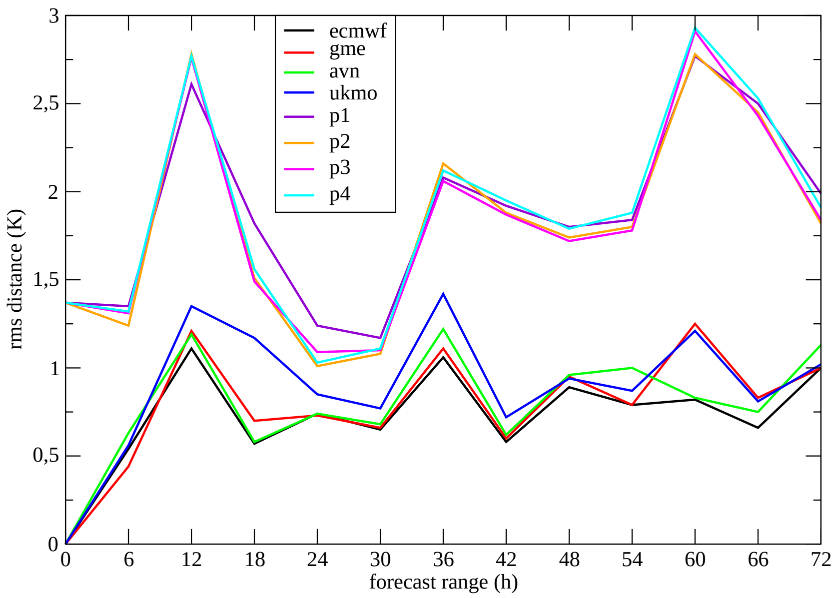

Figure 4: Root–mean–square distance, in terms of 2m temperature, among 8 different groups of ensemble members: the 4 members with the same ECMWF father in black, the 4 members with the same GME father in red, the 4 members with the same NCEP father in green, the 4 members with the same UKMO father in blue, the 4 members with the same p1 model perturbation in violet, the 4 members with the same p2 model perturbation in orange, the 4 members with the same p3 model perturbation in magenta and the 4 members with the same p4 model perturbation in cyan.

As an example, the black line is relative to the root–mean square distance among the 4 ensemble members which have received initial and boundary conditions from the ECMWF–LM run. Then, the differences among these 4 members come only from the perturbations applied to 4 model parameters. On the other hand, the violet line is relative to the root–mean square distance among the 4 ensemble members which have the same model formulation, the parameter p1 having been changed in the same way in all the 4 runs. It is clear that the spread among members having different values of physics parameters but the same driving model is always lower than the spread among members having different driving models but the equal LM formulation.

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7.4 P. Eckert: COSMO ensemble systems

COSMO ensemble systems

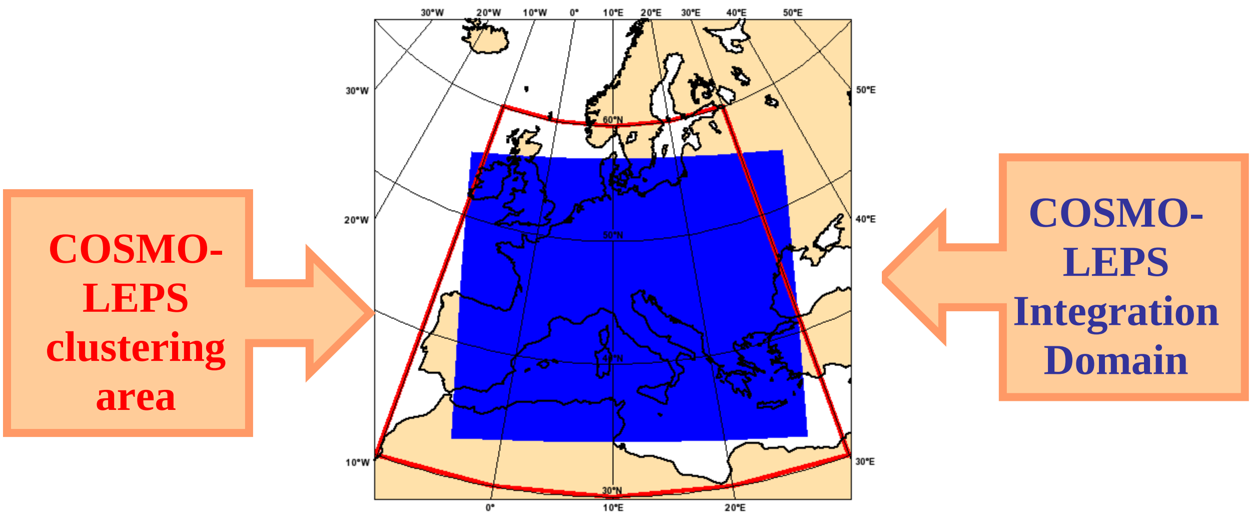
Pierre Eckert, MeteoSwiss Geneva

Overview

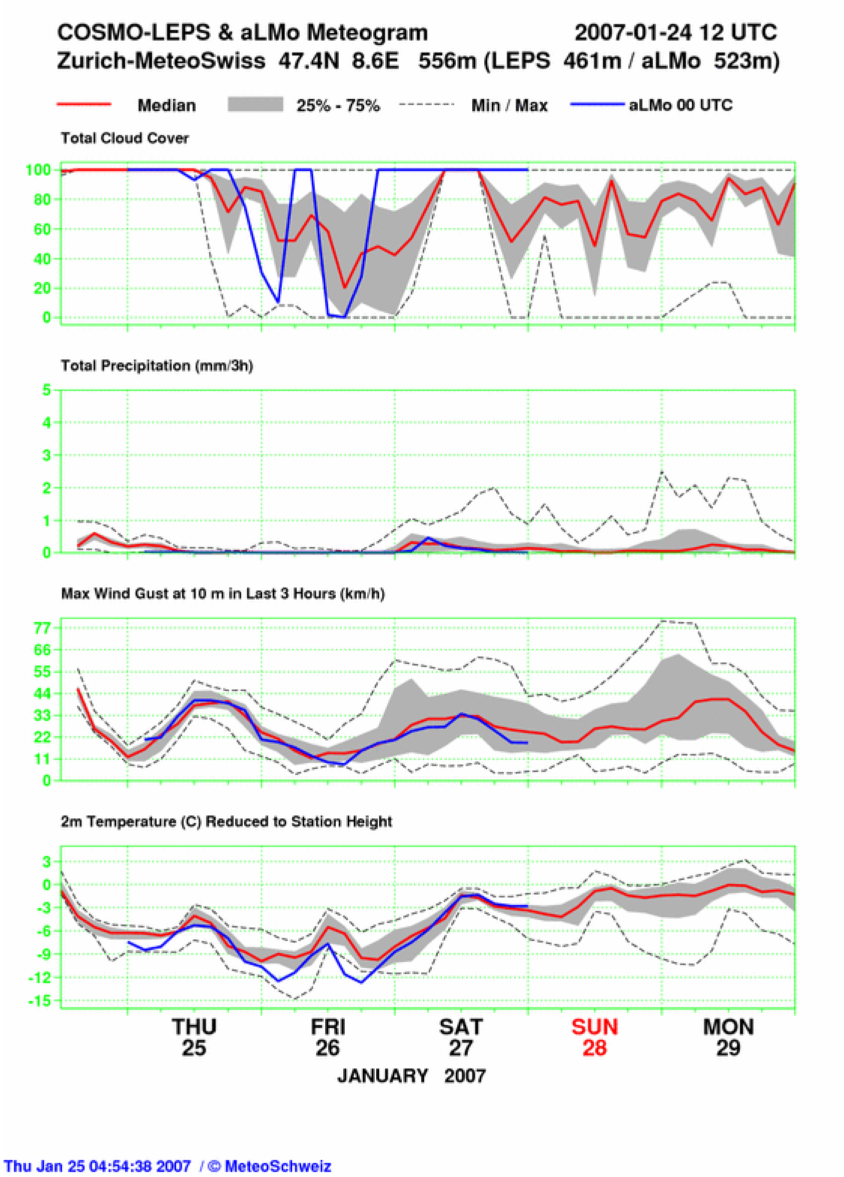
Cosmo develops different kinds of ensembles systems. One of them is the COSMO LEPS developed at ARPA SIM (Bologna), representing mainly a downscaling of the ECMWF EPS. Multimodel ensembles have also been investigated at ARPA Piemonte and also have been used at the 2006 Olympic games in Torino. A project SREPS for a short range ensemble, including perturbations in the initial state and in the physics is also under way and is reported on by C. Marsigli in the same conference. Plans to run ensembles at very small scale (2-3 km) like the DWD EELMK also exist but will not be presented here.

The COSMO LEPS

The system is designed so as to provide a 10 km resolution ensemble forecast targeted on days 3 to 5. Two consecutive ECMWF (00z and 12z) EPS forecasts provide an ensemble of 102 members. These members are clustered on the days 4 and 5 and on the variables geopotential, u component of the wind, v component of the wind and specific humidity at levels 500, 700 and 850 hPa. In the present configuration, 16 representative members (RMs) are chosen from the clustering, and are used as initial and boundary conditions for 16 LM runs covering central Europe (cf. next figure) with a resolution of 10 km and 40 model levels. No proper analysis is done. For the integration two convection schemes (Tiedke or Kain-Fritsch) are randomly chosen



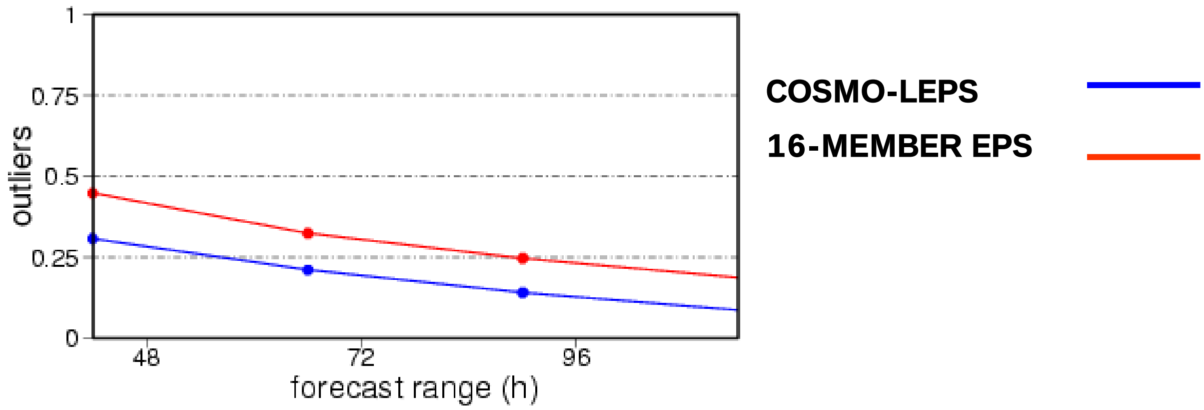
Various probabilities, meteograms and guidance for warnings are generated. Probabilities are normally computed by weighting the values given by one member be the size of the cluster it represents. Some studies show that especially in extreme cases non weighting (each member counts for 1/16th) gives better results, respectively higher probabilities for the given event. But the results are not conclusive. An example of meteogram is shown on the next page.



Verification of COSMO LEPS

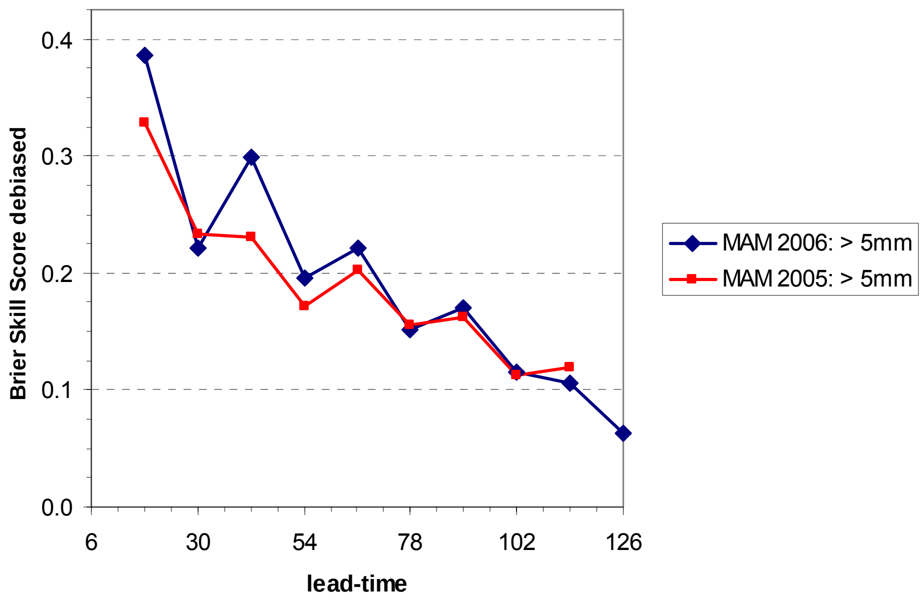
The COSMO LEPS has been verified with respect to several parameters and regions. The most interesting and spatially variable is indeed precipitation. In order to acquire knowledge on the observed precipitation at high resolution, it is important to gather also non-synoptic sums from rain gauges, usually 12 or 24 hour sums. Since the configuration of the system changed in February 2006, the verification period is rather short. The old system (10 members, 10 km resolutions 32 levels) showed the following features: the ECMF EPS is usually slightly better for low thresholds, (frequent events), but the COSMO LEPS is clearly better for high thresholds (rare events). For precipitation the crossover typically happens at around 10mm/day.

As an example of verification from spring 2006, we show the amount of outliers in 24 hour precipitation carried out by C. Marsigli at ARPA SIM. The observations come from the high resolution rain gauges of Germany, Switzerland and northern Italy. The outliers are defined as the proportion of observations lying outside the ensemble. The gain of the COSMO LEPS over the same size ECMWF EPS is evident. The reason comes from the ability of the COSMO LEPS to produce more localized precipitations and also to predict better higher amounts.



An objective verification of the European synop stations has also been carried out by André Walser at MeteoSwiss. The eventual improvement of the new 16 member system versus the old 10 member system has been tested by comparing the sprint 2006 to the spring 2005. A crucial question that has to be tackled is the fact that some probabilistic scores improve by the simple fact that the amount of ensemble members increase. This artificial bias can be removed by a debiasing technique investigated by A. Weigel et al. (Weigel et al. 2006, Mon. Wea. Rev.). For instance for the Brier Skill Score:

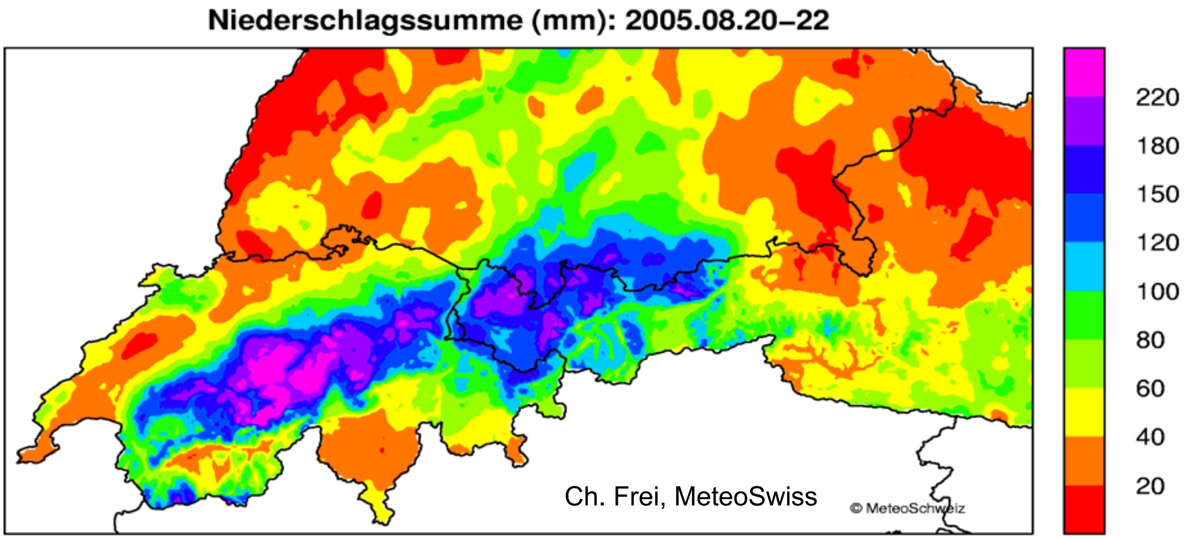
$$BSS_D = 1 - \frac{BS}{BS_{REF} + D} \qquad D = \frac{1}{M}\bar{o}(1-\bar{o}) \qquad \text{M: Ensemble size}$$



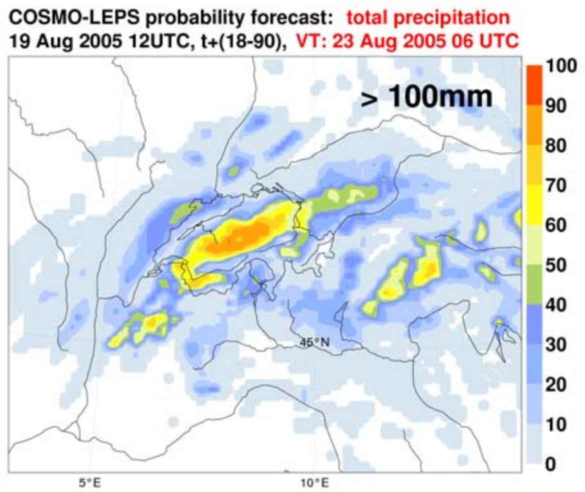
The diagram shows a better performance of the new 16 member system. The threshold here is 5 mm/day. At 1mm/day, the effect is not visible.

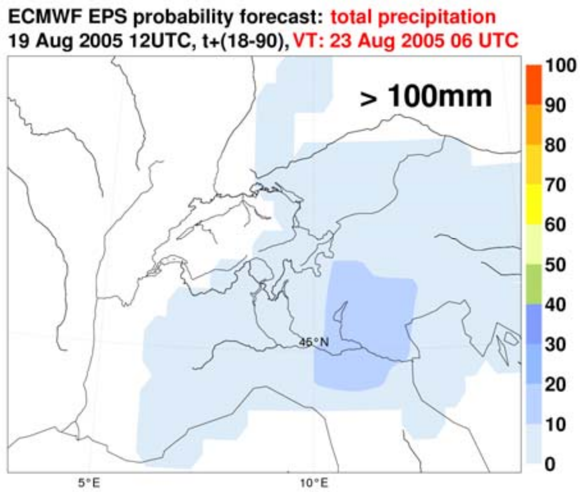
Flooding of August 2005

A severe flooding took place in Switzerland North of the Alps. Locally more than 300 mm have been observed in the three day period ranging from the 20st to the 22nd August. The distribution of the observed precipitation is shown below.



The verifying COSMO LEPS and ECMWF EPS forecasts are next shown:





The correspondence between the observation and the COSMO LEPS probabilities is astonishingly good. The lower resolution EPS not only is unable to generate the right quantities but also places the maximum activity at a wrong place.

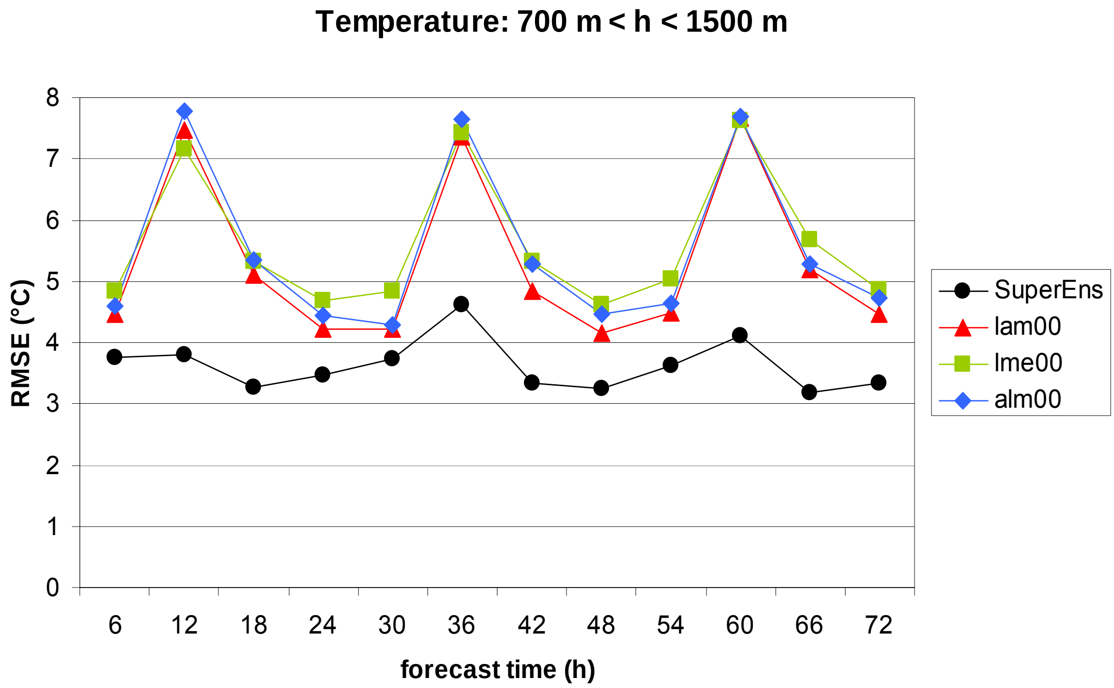
Multimodel ensemble and the 2006 Olympic games in Torino (Cane, Milelli)

In November 2005 ARPA Piemonte signed an agreement with MeteoSwiss and DWD for the operational use of the meteorological models LM-aLMo and LM-E during the Winter Olympic Games of Torino 2006. The data have been used for the forecast of some parameters with the Multi-Model Super-Ensemble technique. The theoretical bases of the system are described in the following papers

1) Krishnamurti T.N. et al.: Multi-model Super-Ensemble forecasts for weather and seasonal climate, J. Climate 13, 4196-4216, 2000.

2) Cane D. and Milelli M.: Weather forecasts obtained with a Multi-Model Super-Ensemble technique in a complex orography region. Meteorologische Zeitschrift, Vol. 15, No. 2, 207-214, 2006

The used models are LAMI (Italy), aLMo (MeteoSwiss) and LME (DWD). The dynamical training period for the coefficients is 90 days. The system has been used for wind intensity, 2m temperature and relative humidity.



The single models all show significant errors with a strong diurnal cycle. The use of the super ensemble is able not only to reduce the errors by being better than each of the single models, but also is able to erase the diurnal cycle of errors.

8 EWGLAM final discussion

28th EWGLAM Meeting

9-11 October 2006, Zurich (Switzerland)

Minutes of the Final Discussion

Participation

56 participants from 25 European NMS.

Presentations shown at the meeting

As we do it each year, the posters displayed and the presentations given at this year's meeting will be accessible on the Programme web site from the page http://srnwp.cscs.ch/Annual_Meetings/2006/entrypage2006.htm

If you would like to send to MeteoSwiss a new or a corrected version of your Poster/Presentation, you can do it per mail attachment to the address "ewglam2006@meteoswiss.ch" if your contribution is smaller than 4 MB. Larger files must be transfered by ftp to the host "ftp.meteoswiss.ch" (log in with user "ewglam2006" and password "ewglam4mch") and MeteoSwiss must be informed by e-mail at the address "ewglam2006@meteoswiss.ch" with indication of the name of your file.

Newsletter

It has been decided to produce a Newsletter under electronic form that everybody will be able to download and print if he or she wishes to do so.

The different contributions are limited to the following number of pages:

- Reports of the Consortia: 6 pages per Consortium
- Report of the ECMWF: 12 pages
- National reports: 4 pages for each NMS
- Scientific presentations: between 6 pages for the 15 minute presentations and 12 pages for the 30 minute presentations.

Contributions have to be sent either in MS Word or in Latex to "ewglam2006@meteoswiss.ch" till the 30th of November 2006. If your contribution is larger than 4 MB, it must be transfered by ftp to "ftp.meteoswiss.ch" (log in with user "ewglam2006" and password "ewglam4mch") and MeteoSwiss must be informed by e-mail at the address "ewglam2006@meteoswiss.ch" with indication of the name of your file.

SRNWP Workshops

The Programme Manager showed the list of the SRNWP Workshops for the rest of 2006 and for 2007. It has been necessary to move the "Third Workshop on Short-range EPS" from March 2007 to the autumn 2007. An updated list of the SRNWP Workshops can be seen under "http://srnwp.cscs.ch/Lead_Centres/LC_Workshops_with_reports.html"

Next SRNWP Meetings

At the invitation of the NMS of Croatia, the 29th EWGLAM Meeting together with the 14th SRNWP Meeting will take place in Dubrovnik the 9 - 12 October 2007 following the format defined at the 27th EWGLAM Meeting and applied with great succes at the Zurich Meeting.

Already many thanks to the DRŽAVNI HIDROMETEOROLOŠKI ZAVOD

The Representative of the INM has invited the Assembly to hold its 30th EWGLAM Meeting and its 15th SRNWP Meeting in Spain in 2007.

Already many thanks to the

Instituto Nacional de Meteorología España

For the minutes:

Jean Quiby

9 SRNWP business meeting report

13th SRNWP Meeting
12 October 2006, Zurich (Switzerland)
Lists of Decisions and Minutes

Decisions concerning the choice of the SRNWP Projects

1. Three topics have been selected as SRNWP Projects that should accompany the SRNWP Programme, with a dedicated financing for each Project. They are:

- Interoperability

- Model Verification

- European multi-model LAM EPS

2. For each Project, a "Redaction Committee" will be formed for the preparation of the corresponding Project Proposal. Each Consortium communicates to the Programme Manager till the end October 2006 the name of its representative for each of the 3 Redaction Committees.

3. When the names of the Consortium representatives are known, the Programme Manager will contact the members of each Redaction Committee for the organisation of the work.

Decisions concerning the new governance

1. *The Lead Centres are dissolved and replaced by Working Groups (WG) centred on NWP topics.*
2. *The SRNWP Workshops are maintained and their organisation goes under the responsibility of the WG. Each WG will have the responsibility to organise workshops on the field of its competence when it judges it appropriate. The rule "a workshop every two years" is abandoned.*
3. *The EWGLAM Meetings remain annual. They follow the format defined at the 27th EWGLAM Meeting (2005 in Ljubljana). The idea to organise together with Academia "European Conferences on dynamical meteorology and NWP" is abandoned.*
4. *A "SRNWP Advisory Committee" will be created to better represent the Consortia in the Programme and to support the Programme Manager in his work.*
5. *A "Programme Redaction Committee" will be formed for the preparation of the Programme Proposal. Each Consortium communicates to the Programme Manager till the end October 2006 the name of its 2 representatives.*
6. *When the names of the Consortium representatives are known, the Programme Manager will contact the members of the Programme Redaction Committee for the organisation of the work.*

Minutes of the Meeting

Participation

- 56 participants from 25 European NMS.

- The EUMETNET CO, Jean-Pierre Chalon, participated to the meeting and explained how the financing of Programmes and Projects works by EUMETNET.

The entry page for the "List of Participants" is to be found under http://srnwp.cscs.ch/Annual_Meetings/2006/entrypage2006.htm

Aim of the Meeting

The aim of the Meeting was to take important decisions concerning the goals and the governance of the third phase of the EUMETNET SRNWP Programme starting January the 1st, 2008.

Goals for the 3rd phase of the Programme: Projects chosen

New for the third phase of the Programme will be the submission to Council of Projects on precise topics which should accompany the Programme with a dedicated financing for each Project.

The comments written and circulated as reactions to the draft Programme Proposal distributed by the Programme Manager contained a wealth of proposals where the Programme should be active.

All these proposals have been summarized by the Programme Manager in its presentation.

Discussion of the goals

The proposals received could be classified in 5 chapters:

- Enhancement of the operational cooperation
- Enhancement of the scientific cooperation
- European multi-model LAM EPS
- Diffusion of the NWP knowledge
- Training and education activities in NWP

See slides 11-16 of the Manager's presentation http://srnwp.cscs.ch/Annual_Meetings/2006/MainPresentation.htm

Enhancement of the operational cooperation

Numerous proposals have been made under this heading in the comments received. During the meeting it became immediately clear that the priority must be given to the ***interoperability***.

Under the general term "interoperability" we must understand primarily the definition or the harmonization of standards for the input and output of the

- data assimilation schemes (this implies agreement on formats for the observations)

- models

- post-processing packages (at least for the input in order to allow exchange of postprocessing programmes).

Interoperability was also the most prominent theme identified for collaboration at the First Vision Workshop (15-17 March 2006). This underlines the absolute necessity to become active in this field if we want to significantly increase collaboration.

We should also add to our choice "interoperability" the proposals made under the same theme at the Vision Workshop:

- A more general use of ECMWF software in the operational suites of the NMS

- A common approach to the framework for running NWP systems (cf. PRISM for example).

Enhancement of the scientific cooperation

Among the several propositions made, ***common model verification and model comparison*** stood in the fore front.

The wish to compare our main LAM models (HIRLAM, ALADIN, Local Model and Unified Model) has been already expressed by our Directors in the ICWED Meetings as well as in EUMETNET Council Meetings. But this was considered in the past as a ticklish issue, although it was accepted that model comparison could bring much for model improvement.

The Vision Workshop has also recognized the importance of model verification and has proposed to "Initiate a project to enable us to work closer on verification of models and user benefits".

European multi-model LAM EPS

As for the two propositions above, the Assembly has chosen as third proposition a theme which has also been selected at the Vision Workshop: ***European multi model LAM EPS***.

It is hoped that the result of this Project will be the European contribution to TIGGE-LAM, a future component of the THORPEX initiative.

Diffusion of the NWP knowledge

All the comments received as well as the remarks made during the meeting stipulated that this activity - which is the main activity of the present programme - should continue.

The wish has been expressed that the liaison role of the Programme should be reinforced - particularly with the ECMWF - and extended to the climate community.

But it has been decided not to make a dedicated Project of this activity as it will remain the basic activity of the NWP Programme.

Training and Education Activities in NWP

It has been considered important that the SRNWP Programme becomes active in this field: activity in training and education was proposed in all the comments and has been stressed again during the meeting. Several ideas have been suggested, for example the organisation of summer schools for the NMS and Academia.

Although considered as important, it has been decided not to make a dedicated EUMETNET Project of this activity. But inside SRNWP, a small WG should be formed to deal with this topic.

Submission of the Project Proposals

For each of the following Project
- interoperability
- common model verification and model comparison
- European multi model LAM EPS

a Project Proposal stipulating among other things
- the objectives of the Project
- the deliverables and their benefits for the users
- the milestones
- the budget
- the Responsible Member
- the participating NMS in case of a group

has to be written down and submitted to the EUMETNET Council.

The three Project Proposals must be sent to the EUMETNET Secretariat end of April 2007 at the latest if the Projects, after acceptance by Council, are going to start at the beginning of 2008.

It has been decided at the meeting to form a small "Redaction Committee" for each Project.

Constitution of the Redaction Committees for the Projects

Number of persons

At the meeting, we agreed on 2 persons per Consortium.

We have 5 Consortia. This would give 10 persons plus the help of the Programme Manager for each Redaction Committee.

As there is a steadily growing number of meetings and workshops where Consortia have to be represented and as the travelling budgets are in the NMS everywhere very tight, I think that *one person per Consortium is sufficient.* This would give for each of the 3 Projects a group of 5 persons for the formulation of the Proposal, with the Programme Manager helping to format the Proposals according to the EUMETNET practice.

Choice of the persons (opinions of the Programme Manager)

Although not discussed at the meeting, allow me the following remarks, knowing that the choice of the Consortium Representatives is of the sole responsibility of the Consortia.

Redaction Committee for Interoperability

In my view, the persons responsible of the maintenance and operation of the model reference versions would be very suitable for this work.

Redaction Committee for Common model verification

As we hope to use common verification schemes not only for biases and rmse, very experience scientists in verification with an interest for new and unconventional methods should be chosen.

Redaction Committee for the European multi-model LAM EPS

Most of the LAM EPS specialists will participate at the ALADIN-HIRLAM LAM EPS Workshop of Vienna (13-14 Nov. 2006). At this meeting, we should discuss the European participation to TIGGE-LAM. It would be efficient if the "redactors" could be chosen among the participants to this meeting: they would have the latest information and we could organise the first meeting of this Redaction Committee in Vienna after the ALADIN-HIRLAM Workshop.

The names of the Consortium Representatives have to be communicated to the SRNWP Programme Manager till the 31st of October 2006.

After, reception of the names, the Programme Manager will liaise with the 3 groups in order to organise the work.

It has been said at the meeting that a first report will be provided at the end the year.

New Governance for the 3rd phase of the SRNWP Programme

At the meeting, we discussed the future role of the
- Lead Centres
- SRNWP Workshops
- EWGLAM Meetings
- Advisory Committee

Replacement of the Lead Centres (LC) by Working Groups (WG)

Three functions or duties have been defined for the Lead Centres when they have been created in 1999:

1. Organise every two years a workshop on their topic of responsibility

This function has been entirely fulfilled.

2. Inform regularly the other NMS on the state of the art in their topic of responsibility

This function has been only partially fulfilled.

It was foreseen that the LC would report at the annual EWGLAM/SRNWP meetings. But because of agenda constraints, only 15 minutes could generally be put at the disposal of a LC for its report.

These reports were very divers, from very short to comprehensive. Many LC have simply reported on their activity of workshop organisers.

A thorough fulfilment of such a function necessitates resources: it is necessary to spend time studying the literature as well as to participate to conferences and workshops also outside Europe. This function is not at all supported financially by the Programme.

3. Act as consultant for the NMS in their topic of responsibility

This function has never been activated.

The reason for this is that in the last 6-8 years, the collaboration between the NMS inside the Consortia has steadily increased. Thus the interlocutor that a NMS would primarily consult for a scientific problem was, and still is, its Consortium.

In view of the experiences made in the past and considering that it will not be possible for EUMETNET to support financially the NMS hosting a Lead Centre, the Assembly decided to replace the Lead Centres by ***Working Groups*** centred on NWP topics.

Unfortunately, we had no time at the meeting to define the number of Working Groups we would like to have and the fields they should cover.

In order to save time and be ready for January 2008, we suggest mentioning in the Programme Proposal only a limited number of WG, as it will always be possible later for the Advisory Committee to modify this choice. The "Programme Redaction Committee" will make a first choice mirroring the topics of the Consortia Working Groups or Project Teams.

Functions of the Working Groups

- Existence of Working Groups made of specialists in a specific field will permit to much more easily find out what the possibilities of cooperation between Consortia in each particular field would be.

- It will be the responsibility of the WG to organise SRNWP Workshops in their field. The rule "a workshop every two years" is abandoned. Each WG will decide when it is appropriate to organise a workshop.

- It will be the responsibility of the Chairperson of each WG to present each year at the EWGLAM Meeting the state-of-the-art in the field of competence of his/her WG.

- As there will be at least one representative of each Consortium in each Working Group, the function of consultancy for the NMS is implicitly fulfilled.

SRNWP Workshops

The SRNWP Workshops are an important activity of the Programme.

These workshops are of a high scientific level and well attended as this can be seen from the workshop reports in the Programme web site.

For each of the following topics
- variational methods in data assimilation
- non-hydrostatic modeling
- numerical techniques
- soil processes and assimilation of soil and surface variables

- statistical and physical adaptation of model results
- verification of high resolution model results
- short-range ensemble prediction systems

we have as a rule that a workshop should be organised every two years.

Two of these workshops are characterised by a regular participation of scientists outside Europe (mainly from Canada, USA and Japan):
- workshops on non-hydrostatic modeling
- workshops on variational methods in data assimilation.

It has been decided to keep the SRNWP Workshops in existence. The responsibility to organise them goes to the WG. Each WG will have the duty to organise workshops in the field of its competence when it judges it appropriate. The rule "a workshop every two years" is abandoned.

EWGLAM Meeting

It has been decided to keep the EWGLAM Meeting annually, following the format defined at the 27th EWGLAM Meeting (2005 in Ljubljana) and applied for the time this year with great success at the Zurich Meeting.

The idea to organise together with the Academia "European Conferences on dynamical meteorology and NWP" is abandoned.

SRNWP Advisory Committee (AC)

This point gave rise to the longest discussion when the Assembly discussed the different aspects of the new governance. A vote took place and the set-up of a SRNWP Advisory Committee has been accepted by 20 votes again 2. The Advisory Committee will allow a better representation of the Consortia in the Programme and a better support of the activity of the Programme Manager.

Constitution of the SRNWP Advisory Committee

It appeared clearly that to constitute it with one Representative per SRNWP Member (27 NMS!) would give far too large a group. The Advisory Committee has to be centred on the Consortia even when the latter have no legal existence in EUMETNET (only the NMS are legal Members).

We had unfortunately no time to discuss the size of the AC: either a very small group in the sense of a "daily management group" or a larger group that would concentrate its work on the important questions only. There has also been no time to discuss the rule or the formula to be used for the representation of the Consortia in the AC. The factors to be considered could or maybe should be the number of Members of the Consortia and its overall financial contribution. The "Programme Redaction Committee" will study the question.

Contacts with the Academia

In his draft Programme Proposal the Programme Manager has raised the issue of the low degree of collaboration between the SRNWP Programme and the Academia. Quote: "In Europe, the collaboration of the NMS with Academia should be intensified. This was also the wish of the NWP Vision Meeting of March 2006 at the ECMWF which has passed a recommendation in order to develop better working relationship with Academia".

As the idea of common European Conferences on NWP will not be followed, it has been proposed at the meeting that the contact in NWP between the NMS and the Academia should be realised through the Working Groups. The WG members will know in their field of research their colleagues of the Universities. A good starting point for an enhanced collaboration would be to open the SRNWP Workshops to the relevant specialists working at Universities.

Preparation of the Programme Proposal and Programme Decision for the EUMETNET Council

The present phase of the SRNWP Programme ends the 31st of December 2007.

The Programme Proposal and the Programme Decision have to be sent to the EUMETNET Secretariat the ***30th of April 2007 at the latest***.

We can presently forget about the Programme Decision which can be considered as a summary of the Programme Proposal and can be rapidly prepared if the Programme Proposal treats accurately all the relevant issues.

It has been decided at the meeting to form a "Programme Redaction Committee" for the preparation of the Programme Proposal. We agreed on 3 persons per Consortium. This would give of group of 15 persons, 16 with the Programme Manager. This is too large a group. Two representatives per Consortium would give together 11 persons. This would be more than enough.

The review of the present report by the Local Organizer of the Zurich Meeting is cordially acknowledged.

For the report:

Jean Quiby

SRNWP Programme Manager