Semi-Lagrangian Approach to solve the 4D-discrete, Linear Equations of Atmospheric Dynamics with Arbitrary Stratification and Orography

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Numerical solution of the general (elastic, non-filtered), linearized equations of atmospheric dynamics is constructed for optional orography and stratification, described by arbitrary reference temperature $T^r(p)$ and wind vector $\vec{U}(p)$. The solution includes both the stationary and non-stationary case with optional initial conditions.

The four-dimensional (4D), spatially staggered, semi-implicit, Semi-Lagrangian, two time-level discretization scheme is used. The solution is constructed as the 3D (x-y-t) trigonometric series of finite lengths. At that, the series members are treated as continuous trigonometrical functions of discrete arguments, which allows for trigonometrical interpolation of solution to the inter-grid space. Special attention is paid to stationary case. Solution draws back to vertical eigenvector specification for each horizontal orthogonal mode. An efficient method for eigenvalue-problem solution is presented, which takes into consideration the upper radiative boundary condition.

In the meso-scale domain, derived solution can be used for study of stratification effects on the orographic flow pattern and short-wave instability, including the open-air turbulence generation by wave-like motions. For synoptic scales, the non-stationary normal mode solution can be applied for the baroclinic instability investigation.

Solution can be used as a test-tool for the adiabatic cores of limited area NWP models. The approach is also suited for investigation of different numerical effects to the solution accuracy, like the spectral smoothing, Asselin time-filtration, and departure-arrival point de-centring in semi-Lagrangian numerical algorithms.