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Evolution of small-amplitude gravity wave packets in a non-uniform background

Christopher Pütz and Rupert Klein
Freie Universität Berlin, Institut für Mathematik, Berlin, Germany (christopher.puetz@fu-berlin.de)

We present a method to compute the evolution of a gravity wave packet in a non-uniform background under the Boussinesq approximation.

Gravity waves play an important role for atmospheric circulation. In particular, their interaction with the tropopause, a region with varying stability and strong jet winds, is vitally important. Their evolution is very well described by the Boussinesq equations. Up to now, only direct numerical simulations of these equations could describe the movement of internal gravity wave packets in such non-uniform media. The main idea of our research is to find an approximate solution for the linearised Boussinesq equations that does not require numerical simulations. The method is based on two aspects. The first one is a Fourier transformation for the time dimension, which then makes it easy to reduce the Boussinesq equations to a single equation. With the second aspect, we get rid of the vertical dependence of the background by modelling the atmosphere as a multi-layer fluid with constant approximations of stratification and wind in each layer. This yields an equation for each individual layer that can now be solved explicitly. Using the dispersion relation, it is possible to use wave packet initial data in the Fourier-transformed equation to model the wave packet as a superposition of finitely many plane waves. To obtain a time-dependent solution, the inverse Fourier transformation is computed numerically, which finally yields a full spatio-temporal evolution of the wave packet. The method is tested favourably against simulations of the full Boussinesq equations that were conducted with the atmospheric flow solver PincFloit. A major advantage of the method presented here is that we can directly give the solution for arbitrary stratification and wind at any point in time for given initial data.