Geophysical Research Abstracts
Vol. 13, EGU2011-11816, 2011
EGU General Assembly 2011

Simulation of breaking inertia-gravity waves using direct numerical simulation and implicit large-eddy simulation

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Understanding the dynamics of breaking inertia-gravity waves is an important problem in climate modeling, where the process must be parameterized. Due to the wide range of temporal and spatial scales involved, from hours and tens of kilometres (period and wavelength of the gravity wave) to seconds and a few metres (scales on which the turbulence is dissipated), direct numerical simulation (DNS) is computationally very expensive. Furthermore, the detailed dynamics of the breaking is sensitive to the amplitude, wavelength and propagation direction of the waves. A reliable large-eddy simulation (LES) scheme is thus an invaluable tool for exploring the parameter space. One such scheme is the Adaptive Local Deconvolution Method (ALDM), in which the truncation error in the discretization of the convective terms is tuned so as to function as an implicit sub-gridscale turbulence parameterization. Although tuned for three-dimensional homogeneous isotropic turbulence, it has been shown to be effective also for stratified flows.

We demonstrate that ALDM as implemented in the model INCA is capable of reproducing the small-scale behaviour in breaking inertia-gravity waves as simulated by DNS at much higher resolution. The initial conditions for the simulations are inertia-gravity waves at amplitudes above and below the threshold for static instability perturbed by leading normal modes or singular vectors obtained from linear stability analysis.