# LES AND DNS OF INERTIA-GRAVITY WAVE BREAKING

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## ABSTRACT

The breaking of inertia-gravity waves is an important process in maintaining the circulations in both the atmosphere and the ocean. However it is still not well understood because of the wide range of scales involved, from the relatively large scale of the wave and the primary instability structures to the turbulent small scales where energy and momentum are dissipated.

We investigate the breaking of monochromatic inertia-gravity waves with "2.5 dimensional" simulations (where the velocity field is three-dimensional but depends on only two spatial dimensions) using the Adaptive Local Deconvolution Method (ALDM) [1], an implicit LES method wherein the truncation error in the discretization of the governing partial differential equations 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. The initial conditions for the simulations are obtained from normal mode and singular vector analysis [2]. Both low- and high-frequency waves, with amplitudes both above and below the threshold for static stability, are considered. The ALDM results compare favourably to standard LES schemes and to direct numerical simulations (DNS).

In addition we present results from three-dimensional DNS of a breaking low-frequency inertia-gravity wave. The DNS is made tractable by choosing the triply periodic domain dimensions to correspond to the wavelengths of the wave and its leading primary and secondary instability modes [3]. A fully resolved DNS of a breaking inertia-gravity wave is an essential requirement for validating candidate LES schemes as well as gravity-wave-drag parameterizations.

## REFERENCES

[1] S. Hickel, N. Adams and A. Domaradzki, 2006. An adaptive local deconvolution method for implicit LES. *J. Comput. Phys.*, **213**, pp. 413-436.

[2] U. Achatz, 2007. The primary nonlinear dynamics of modal and nonmodal perturbations of monochromatic inertia-gravity waves. *J. Atmos. Sci.*, **64**, pp. 74-95.

[3] M. D. Fruman and U. Achatz, 2012. Secondary instabilities in breaking inertia-gravity waves. *J. Atmos. Sci.*, **69**, pp. 303-322.