Geophysical Research Abstracts
Vol. 17, EGU2015-192, 2015
EGU General Assembly 2015

Waves and vortices in rotating stratified turbulence

Annick Pouquet (1,2), Corentin Herbert (1), Raffaele Marino (1,3), and Duane Rosenberg (4)

(1) National Center for Atmospheric Research, P.O. Box 3000, Boulder CO 80307, USA, (2) Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder CO 80309, USA, (3) Institute for Chemical-Physical Processes - IPCF/CNR, Rende (CS) 87036, Italy, (4) National Center for Computational Sciences, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge TN 37831, USA

The interactions between vortices and waves is a long-standing problem in fluid turbulence. It can lead to a self-sustaining process that is dominant, for example in pipe flows, and to the prediction of large-scale coherent structures such as baroclinic jets in planetary atmospheres, and it can also be used as a control tool for the onset of turbulence. Similarly, the dynamics of the atmosphere and the ocean is dominated by complex interactions between nonlinear eddies and waves due to a combination of rotation and stratification (characterized respectively by frequencies f and N), as well as shear layers. The waves are faster at large scales, and this leads to a quasi-geostrophic quasi-linear regime in which there is a balance between pressure gradient and the Coriolis and gravity forces. The range of scales in these geophysical flows before dissipation prevails is such that other regimes can arise in which turbulence comes into play, with the eddy turn-over time becoming comparable to the wave period, and for which isotropy recovers for sufficiently high Reynolds numbers.

One may decompose the flow– observational, experimental or numerical, in terms of the normal modes that it supports, i.e. the inertia-gravity waves and the (slow, zero frequency) vortical modes carrying the potential vorticity, thanks to the existence of a small parameter, as for example the fluctuation around a mean flow or the ratio of the wave period to the eddy turn-over time. In this context an ensemble of data sets of rotating stratified turbulence will be analyzed, stemming from accurate direct numerical simulations of the Boussinesq equations at high resolution, up to 4096^3 grid points, using high-performance computing. These flows all support a constant-flux bi-directional cascade of energy towards both the large scales and the small scales. The parameter space includes the Reynolds number, the Prandtl number(s), and the Rossby and Froude numbers, and a universal response to a variety of forcing mechanisms at different scales is not warranted. These flows consist of a superposition of slanted layers together with localized patches of strong turbulence leading to vertical mixing. The prevalence of wave modes over the slow vortical modes at large scales, and the role of the nonlinear part of potential vorticity relative to its linear part will be examined as a function of N/f and a variety of scaling laws will be discussed.