28*th* IUGG Conference on Mathematical Geophysics, June 7-11, 2010, Pisa, Italy
Session 3: Geophysical fluid dynamics III - Atmosphere and ocean

Gravity wave instability in terms of vorticity inversion and action-at-a-distance

Eyal Heifetz[1], Avinoam Rabinovich[1], Nili Harnik[1], Orkan M. Umurhan[2], François Lott[3]

[1] *Tel-Aviv University, Tel-Aviv, Israel*
[2] *Queen Mary, University of London, London, UK*
[3] *École Normale Supérieure, Paris, France*

Keywords: *gravity wave, stratified shear flow*

The somewhat counter-intuitive effect of how stratification destabilizes shear flows is reexamined, in what we believe to be the simplest example, in terms of action-at-a-distance interaction between "buoyancy-vorticity gravity wave kernels". The setup consists of an infinite uniform shear Couette flow in which the Rayleigh-Fjortoft necessary conditions for shear flow instability are not satisfied. When two stably stratified density jumps are being added, the flow however becomes unstable. At each density jump the perturbation can be decomposed into two coherent gravity waves propagating horizontally in opposite directions. We show, how the instability results from a phase locking action-at-a-distance interaction between the four waves (two at each jump), but can as well be reasonably approximated only by the interaction between the two counter-propagating waves (one at each jump). From this perspective the nature of the instability mechanism is similar to the barotropic and baroclinic ones. Next we add a small ambient stratification to examine how the critical level dynamics alters our conclusions. We find that strong vorticity anomaly is generated at the critical level due to the persistent vertical velocity induction by the edge waves at the jumps. This critical level anomaly acts in turn at-a-distance to decay the edge waves at the jumps. When the ambient stratification is increased, so that the Richardson number exceeds the value of a quarter, this destructive interaction overwhelms the constructive interaction between the edge waves and consequently the flow becomes stable. This effect is manifested when considering the different action-at-a-distance contributions to the energy flux divergence at the critical level. The edge wave interaction is found to contribute toward positive divergence, that is, toward instability, whereas the critical level-edge waves interaction contributes toward an energy flux convergence, that is, toward stability.