Damping of Geostrophic Fronts by Oceanic Internal Waves, Critically Reflecting off the Sea Surface

Nicolas Grisouard*†[1]

[1]Department of Physics (UofT Physics) – Department of Physics, 60 St. George St., Toronto, Ontario, M5S 1A7, Canada, Canada

Abstract

Within oceanic fronts, due to the sloping isopycnals and associated thermal wind shear, the possible directions of the group velocity of inertia-gravity waves (IGWs) depart from the classical St Andrew's cross. However, waves oscillating at the Coriolis frequency, f, keep one of these directions horizontal, while the other direction allows for vertical propagation of energy. This implies the existence of critical reflections of such inertial waves off the sea surface, after which incident wave energy cannot escape. This is analogous to the classical critical reflection of IGWs in a quiescent medium off a sloping bottom. We present a series of numerical experiments exploring parameter space that highlight properties of critical (frequency = f), forward (frequency > f), and backward (frequency < f) reflections. In particular, we report on irreversible energy exchanges between IGWs and geostrophically-balanced frontal flows that are enabled by friction and the modification of IGW-physics at fronts. We also show analytically that this is exacerbated during critical reflections where intense frictional effects under the surface induce a net transfer of energy from the balanced flow to ageostrophic motions, which are subsequently dissipated. Forward reflections are also favorable to triadic resonant interactions and therefore to turbulence which is weak in our simulations, but likely to be fully developed under oceanic conditions. The existence of this non-linear flow activity further increases the extraction of geostrophic energy from the front. On the other hand, backward reflections inhibit triadic interactions and, consequently, such "spectacular" energy exchanges.

*Speaker

†Corresponding author: nicolas.grisouard@physics.utoronto.ca