

NONLINEAR INTERACTIONS AMONG OCEAN INTERNAL WAVES IN THE WAKE OF A MOVING CYCLONE

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The nonlinear dynamics leading to the generation of superinertial internal waves in the ocean, in the wake of a cyclonic storm, is investigated by means of theoretical arguments and of numerical integration of the hydrostatic Boussinesq equations in a simplified realistic open-ocean setting. The velocity fields are first decomposed into internal baroclinic modes and then the energy transfer across modes and at different frequencies is computed. The well known triangle condition for (k'_z, k''_z, k'''_z) triad interactions in vertical wavenumber space, $|k'_z \pm k''_z| = k'''_z$, in the case of realistic (i.e. non constant) stratification can be transposed to a condition on the interacting triads in baroclinic mode-number space. This confirms that the (n, m, l) triad of modes interacts when $|n \pm m| = l$ and highlights that other mode-number triads can be resonant and that even the interaction of a mode with itself becomes possible. The energy transfer across modes is dominated by the advection of high mode (m) waves by the second mode wave ($n = 2$), which is the most energetic, and this results in the excitation of the $l = m - 2$ mode wave at the double inertial frequency. The analyzed nonlinear interactions lead to a transfer of energy from the near-inertial waves, directly excited by the storm, to the superinertial waves, which typically propagate faster and further than their lower frequency parents and can lead to internal mixing even at large distances from the region of the large air-sea momentum fluxes.

References

- [1] Danioux E. and P. Klein, *A resonance mechanism leading to wind-forced motions with a 2f frequency*, J. Phys. Oceanogr. **38**, 2322-2329 (2008).
- [2] Nilsson J., *Energy flux from traveling hurricanes to the oceanic internal wave field*, J. Phys. Oceanogr. **25**, 558-573 (1995).
- [3] Niwa Y. and T. Hibiya, *Nonlinear processes of energy transfer from traveling hurricanes to the deep ocean internal wave field*, J. Geophys. Res. **102**, 12469-12477 (1997).
- [4] Ripa P., *On the theory of nonlinear wave-wave interactions among geophysical waves*, J. Fluid Mech. **103**, 87-115 (1981).
- [5] Zedler S. E., *Simulations of the ocean response to a hurricane: nonlinear processes*, J. Phys. Oceanogr. **39**, 2618-2634 (2009).