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Oceanic mean flows forced by two- and three-dimensional internal waves

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That internal waves can drive important mean flows where they are dissipated is a well-known fact in atmospheric dynamics. In the ocean however, these theories have been much harder to apply : for instance, the basins have more complicated shapes and the forcing is random in nature. Unfortunately, our knowledge of the large-scale ocean circulations and, more broadly speaking, of the climatic machinery, depends on small-scale processes associated with internal wave dissipation that can't be resolved by current large-scale numerical simulations. Therefore, lacking parametrizations for the internal-wave driven mean flows simply means not including them in those simulations.

The present work is the first attempt that we know of to model analytically mean flow forcings arising from the internal tide and understand some of their basic qualitative features. In a physical domain with constant buoyancy and Coriolis frequencies, a Green's function based model for the radiation of dissipative Boussinesq waves by a barotropic tide flowing over small-amplitude gaussian topography is first derived in 2D (ridge) and 3D (bump). The resulting linear fields allow to derive a lower-order, non-linear, dissipative term that acts on the Lagrangian momentum equation, averaged on a 'fast' time scale (as opposed to the 'slow' time scale on which the mean flow is supposed to evolve). In 2D, a steady mean flow state is reached. In 3D however, the forcing term can resonate with the vortical mode and the mean potential vorticity (PV) can then grow secularly in time. Numerically computed solutions illustrate important qualitative differences between rotating, where the PV acceleration pattern is quadrupolar, and non-rotating settings, where the quadrupolar pattern vanishes and is replaced by an azimuthally invariant pattern. Comparisons between responses to topographies of various elongations are also performed.

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