Stochastic models for wave-induced tracer dispersion

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Fluid flow in the ocean is an intertwined mix of fast evolving internal gravity waves and a slow evolving vortical component in geostrophic and hydrostatic balance. A passive tracer evolving in this flow would be stirred by waves and vortices. Although oceanographic observations of passive tracer evolution clearly indicate the presence of internal gravity waves (Ledwell et al. 1993, Shcherbina and co-authors 2015), much of the existing theory for tracer dispersion ignores fast waves and have focused primarily on the role of large scale coherent vortices (Sundermeyer and Price 1998, Smith and Ferrari 2009).

The proposed project is aimed at examining the collective role of high energy internal gravity waves and the vortical mode in stirring tracers, and analyzing the resulting effective turbulent diffusivity. Figure 1, taken from Thomas and Yamada (2019), is an inspiration for this work. The left panel of the figure shows a scenario where the flow field is composed of negligible wave activity. In this case large scale coherent vortices form. The right panel shows a turbulent flow field in the presence of high energy waves; waves break large scale vortices and generate a wide range of fine scale structures. The project is aimed at understanding tracer dispersion in flows such as that shown in the right panel of figure 1 using simple asymptotic and stochastic models (Rodean 1996, Gardiner 1997). The goal is to develop a generic understanding of tracer dispersion and effective diffusivities in wave dominating flows, complementary to the extensive work done for vortical dominant flows (see for example Elhmaidi et al. 1993, Pasquero et al. 2001).

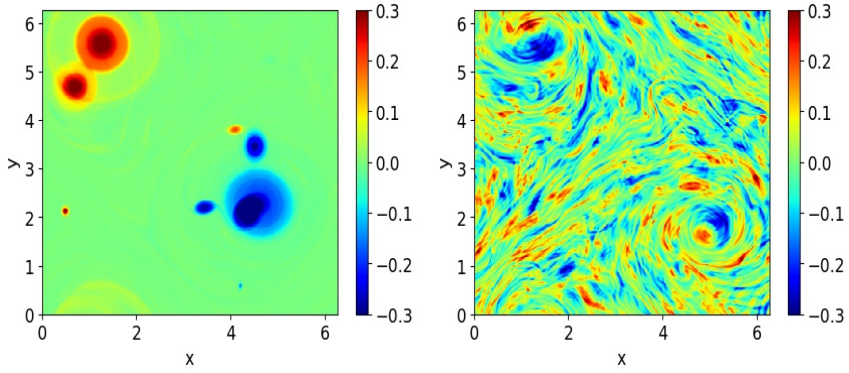

Figure 1: Figure from Thomas and Yamada (2019). Vortical field in the absence of waves (left) showing persistent coherent vortices and in the presence of internal gravity waves, such as tides in the ocean (right) characterized by lack of localized cohernt vortices.

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