Validity domains and parametrizations for white-noise and multiscale models in turbulence and wave-turbulence interactions

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Geophysical fluid dynamics systems generally involve a wide range of spatio-temporal scales. Numerical representation can only simulate some of the scales. The others, at the unresolved scales of motion, must be parameterized for each type of phenomenon (wave, eddy, current), in terms of expected effects on the resolved scales. Most developments then assume that the fluid transport velocity has a time-uncorrelated noisy component with zero mean and stationary statistics. These approximations generally simplify theoretical descriptions, numerical simulations, data comparisons or more recently model error quantifications for data assimilation.

In the present work, we will discuss the applicability of such approximations through two examples: a surface oceanic current dynamics and swell refractions by surface currents.

When the time-decorrelation assumption is valid, we propose simple and tuning-free parametric models to represent the spatial correlations of the white-in-time small-scale velocity to help simulate the geophysical system of interest. These parametric models relies on turbulence space self-similarity and their statistical properties (e.g. spectral slope) can be easily estimated from observations of larger scale fluid velocities.

When the white-in-time approximation is not valid, we extend the previous parametric models to follow self-similarity properties in both time and space.

Numerical simulations will illustrate these theoretical developments along the presentation.