A Two-Scale Approximation for Wave-Wave Interactions in an Operational Wave Forecast Model

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Abstract

The two-scale approximation (hereafter, TSA) to the full Boltzman integral representation of quadruplet wave-wave interactions has recently been presented as a new method to estimate nonlinear transfer rates in wind waves, and has been tested for idealized spectral data, as well as for observed field measurements. TSA has been shown to perform well for wave spectra from field measurements, even for cases with directional energy shearing, compared to the Discrete Interaction Approximation (DIA), which is used in almost all operational wave forecast models. In this presentation, TSA is implemented in a modern operational wave model, WAVEWATCHIII® (WW3). Tests include idealized wave spectra based on field measurements, as well as additional tests for fetch-limited wave growth, and waves generated by hurricane Juan (2003). Generally, TSA is shown to work well when its basic assumptions are met, when its first order, broad-scale term represents most of the spectrum, and its second order term is a perturbation-scale residual term representing the rest of the spectrum. These conditions are easily met for test cases involving idealized JONSWAP-type spectra, and in time-stepping cases when winds are spatially and temporally constant. To some extent, they also appear to be met in more demanding conditions, when storms move through their life cycles, with winds that change in speed and direction, and with complex wave spectra, involving swell-windsea interactions, multiple peaks f_{p1}, f_{p2}, …and directional shears. In these cases, we show that TSA can be generalized (e.g. double, or multiple TSAs) and work reasonably well when the spectrum is partitioned according to individual spectral peaks. In this situation, TSA's basic assumptions are met in each segment of the spectrum (each spectral peak region), in terms of its first order broad-scale, and second order perturbation-scale terms.