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Contribution of non-resonant wave-wave interactions in the dynamics of long-crested sea wave fields

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Gravity waves fields at the surface of the oceans evolve under the combined effects of several physical mechanisms, of which nonlinear wave-wave interactions play a dominant role. These interactions transfer energy between components within the energy spectrum and allow in particular to explain the shape of the distribution of wave energy according to the frequencies and directions of propagation. In the oceanic domain (deep water conditions), dominant interactions are third-order resonant interactions, between quadruplets (or quartets) of wave components, and the evolution of the wave spectrum is governed by a kinetic equation, established by Hasselmann (1962) and Zakharov (1968). The kinetic equation has a number of interesting properties, including the existence of self-similar solutions and cascades to small and large wavelengths of waves, which can be studied in the framework of the wave (or weak) turbulence theory (e.g. Badulin et al., 2005).

With the aim to obtain more complete and precise modelling of sea states dynamics, we investigate here the possibility and consequences of taking into account the non-resonant interactions -quasi-resonant in practice- among 4 waves. A mathematical formalism has recently been proposed to account for these non-resonant interactions in a statistical framework by Annenkov & Shrira (2006) (Generalized Kinetic Equation, GKE) and Gramstad & Stiassnie (2013) (Phase Averaged Equation, PAE).

In order to isolate the non-resonant contributions, we limit ourselves here to monodirectional (i.e. long-crested) wave trains, since in this case the 4-wave resonant interactions vanish. The (stochastic) modelling approaches proposed by Annenkov & Shrira (2006) and Gramstad & Stiassnie (2013) are compared to phase-resolving (deterministic) simulations based on a fully nonlinear potential approach (using a high-order spectral method, HOS). We study and compare the evolution dynamics of the wave spectrum at different time scales (i.e. over durations ranging from a few wave periods to 1000 periods), with the aim of highlighting the capabilities and limitations of the GKE-PAE models. Different situations are considered by varying the relative water depth, the initial steepness of the wave field, and the shape of the initial wave spectrum, including arbitrary forms.

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