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A scalable method for computing quadruplet wave-wave interactions

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Non-linear four-wave interactions are a key physical process in the evolution of wind generated ocean waves. The present generation operational wave models use the Discrete Interaction Approximation (DIA), but it accuracy is poor. It is now generally acknowledged that the DIA should be replaced with a more accurate method to improve predicted spectral shapes and derived parameters. The search for such a method is challenging as one should find a balance between accuracy and computational requirements.

Such a method is presented here in the form of a scalable and adaptive method that can mimic both the time consuming exact Snl4 approach and the fast but inaccurate DIA, and everything in between. The method provides an elegant approach to improve the DIA, not by including more arbitrarily shaped wave number configurations, but by a mathematically consistent reduction of an exact method, viz. the WRT method.

The adaptiveness is to adapt the abscissa of the locus integrand in relation to the magnitude of the known terms. The adaptiveness is extended to the highest level of the WRT method to select interacting wavenumber configurations in a hierarchical way in relation to their importance. This adaptiveness results in a speed-up of one to three orders of magnitude depending on the measure of accuracy.

This definition of accuracy should not be expressed in terms of the quality of the transfer integral for academic spectra but rather in terms of wave model performance in a dynamic run. This has consequences for the balance between the required accuracy and the computational workload for evaluating these interactions.

The performance of the scalable method on different scales is illustrated with results from academic spectra, simple growth curves to more complicated field cases using a 3G-wave model.