ABSTRACT FOR WISE 2013

Gerbrant van Vledder
Delft University of Technology, The Netherlands

The future of the DIA

Third generation (3G) wave prediction models like WaveWatch III, SWAN or WAM rely on simple parameterizations of the non-linear four-wave (quadruplet) interactions. The most successful parameterization is the Discrete Interaction Approximation (DIA). Despite the fact that the present DIA considers only wave number configuration out of many, it significantly contributed to the success of present day 3G wave prediction models. However, with increasing requirements to the performance of 3G wave models, it becomes more and more apparent that the last days of the DIA are in reach. In this presentation, recent insights in the deficiencies of the DIA are outlined, and possible successors are described.

In a nutshell the computation of non-linear four-wave interactions, according to the theories of Klaus Hasselmann and Vladimir Zakharov, is simply the evaluation of the exchange of wave energy between an infinitely number of possible configurations of pairs of four waves in wave number space. In discrete spectral models this involves discretization techniques leading to a finite set of resonant wave number configurations. Instead of evaluating thousands of configurations, the DIA essentially picks just one, seemingly the most important configuration, and is still able to do a good job. This is really surprising and therefore deserves further attention.

The first DIA was developed in 1985 by Klaus and Susanne Hasselmann and originally consisted of two configurations with λ=0.25 and λ=0.15. The second configuration was dropped as the added accuracy did not outweigh the additional computational requirement. This consideration, and the question whether a more accurate parameterization of the non-linear transfer integral is a guarantee for improved model performance, are central themes in the development of viable alternatives to the DIA.

Quadruplet interactions have a large effect on the spectral shape, both on the peakedness and on the directional spreading. In addition, quadruplets play a large role in directional properties of wind wave spectra, especially in turning wind and slanting fetch situations. These properties are getting more and more attention in the evaluation of model performance, stressing the need to find a replacement to the DIA. Recently, Rogers and Van Vledder (2013), based on a hindcast in Lake Michigan, have shown that the DIA is primarily responsible for the too broad frequency spectra.

The DIA is not able to properly handle narrow directional (swell) spectra as it tries to artificially broaden the spectrum due to the fact that all interactions are forced into an up-scaled one. This became evident in the simulation of nearly uni-directional wave propagation in a wave flume experiment by Luigi Cavaleri. In contrast, applying the nearly exact WRT method did not show this deficiency. This indicates that adding additional configurations will be an improvement over the DIA.

Another elusive issue in wave modeling is the dependence on spectral resolution. For example, refining the frequency resolution degrades the results of model performance. Understanding this seemingly counter-intuitive result, and its dependence on directional resolution, is the crux of improving upon the DIA. The baseline is to include additional wave number configurations that fill in a certain sense wave number space with a network of interaction configurations. Extending the DIA by selecting the best next configuration is very hard, but a few promising methods have recently been developed. One of them is the genetic approach developed by Hendrik Tolman as applied to his Generalized Multiple DIA. Another approach is based on the exact WRT method using the Lumped Quadruplet Approximation leading to sets of interacting wave number configurations. Both approaches lead to scalable methods in terms of accuracy and requirements.

Results and properties of both approaches will be presented in relation to spectral resolution, the balance between improved accuracy (transfer rate as well as model performance) and computational requirements.