Development of the DCTA triad source term in SWAN

M.Sc. Graduation project

The spectral wave model SWAN plays an important role in the evaluation of wave loads on the primary flood defences in the Netherlands. To determine these loads for the dikes along the Waddenzee, an accurate representation of the penetration of waves into the tidal inlet system is required. A persistent inaccuracy is the underestimation of the wave period close to the coastline. Possible causes are the underestimation of wave penetration of long waves, the overestimation of the effects of wave interactions in the breaker zone or the underestimation of bottom friction effects.

Nonlinear wave interactions play an important role in the first two processes. The inadequacy of a linear representation of refraction over the steep slopes of the tidal channels is indicated as a possible source for underestimating wave penetration into complex areas. Nonlinear triad interactions are known to significantly affect the wave period in shallow water.

The current default triad source term in SWAN, the lumped triad approximation (LTA), excels in its robustness and computational efficiency but omits some phenomena associated to nonlinear triad interactions. Important deficiencies are the absence of energy transport to lower frequencies (energy is only transported to higher frequencies), interactions between non-collinear waves and the associated broadening of the wave spectrum. Another point of attention is the scaling of the strength of the interactions. In the current implementation, they are based on pragmatic arguments with limited physical basis.

In SWAN, is the distributed collinear triad approximation (DCTA) is available as an alternative. This source term represents energy exchange between higher and lower frequencies by including sub-harmonic interactions. Its current implementation offers room for improvement, which is the topic of this graduation thesis. The purpose is to improve the DCTA source term in terms of its representation of important phenomena and its computational demand. The improvements will be investigated for their ability to improve the assessment of wave loads (particularly in terms of the wave period) along the coastline.

The improvements aim at the accurate representation of phenomena associated with nonlinear triad interactions, such as self-interaction of the spectral peak, sub-harmonic energy transfer and broadening of the wave spectrum. For each improvement of the source term, not increasing the computational demand too much is an important aspect. Reductions can be achieved by making optimal use of precomputed quantities, such as interactions which can be excluded beforehand due to their mismatch with the dispersion relation or evaluating all triad interactions based on the calculation of a few. Such techniques are currently successfully implemented in SWAN for the evaluation of the nonlinear quadruplet interactions. All proposed modification are to be implemented in SWAN and calibrated using measurements to qualify the improvements. The current calibration of the DCTA is based on laboratory measurements by Smith (2005).

Arcadis is looking for a candidate with strong affinity with wave related processes. Additionally affinity with programming and interest in numerical modelling are vital. Experience with either Matlab, Python or similar are essential for the analysis. Experience with FORTRAN is beneficial, but not essential as Arcadis will provide the necessary support.

The candidate will work be based in the Ports and Waterways group of Arcadis and work primarily (minimal 2 days/week) from our office in Zwolle. The work will be supervised by Matthijs Bénit (see contacts below).

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