On the modelling of long wave penetration in tidal inlet systems

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The prediction of wave conditions under storm conditions is difficult and challenging in complex tidal inlet systems such as the Wadden Sea in the Netherlands. Over the last couple of years significant improvements in the wave modelling with SWAN have been made (see Van der Westhuysen et al., JGR 2012). One of the remaining issues is the underestimation of computed penetration of North Sea waves, under storm conditions in the range of 0.03 - 0.20 Hz, as observed in hindcasts of waves penetrating the Eastern Scheldt and the Dutch part of the Eastern Wadden Sea.

Previous analyses of the penetration of long waves into the Dutch Eastern Wadden Sea have shown that the underestimation of low-frequency wave energy near the mainland coast is caused by a combination of refraction and dissipation effects. It was shown that the model-data agreement improves if bottom friction is deactivated, the refraction on the low frequency waves is reduced, quadratic frequency-dependent wave breaking is applied and/or the water level is increased. Computations with both SWAN and Pharos, based on the mild-slope equations, showed that the effect of diffraction was local and has a negligible effect on the amount of energy that penetrates towards the mainland.

Additional laboratory experiments have been conducted to verify the hypothesis that SWAN overestimates the refraction of long waves when propagating from the deeper channel to the shallow flats. If true, the assumption is that the energy will dissipate on the flats before being able to reach the mainland (in SWAN). However, the laboratory experiments and successive computations with SWAN and the Boussinesq-type model Triton did not lead to verification of the hypothesis. Concluding, an explanation for the reported underestimation of the low frequency components could not be given.

Very recently, laboratory experiments were conducted where oblique long waves propagate over a channel. The wave direction typically deviates 30 degrees from the channel orientation. Whereas in the laboratory experiments the wave height in the channel is only slightly smaller than the incident wave height, most energy is stuck to the channel banks in the successive SWAN computations. This raised the hypothesis that under oblique angles SWAN is not sufficiently able to transport the energy into the channel. Evidence is found in hindcasts in the Eastern Scheldt and Wadden Sea that verified this hypothesis. Already at the entrance of the estuaries SWAN underestimated the energy level at the primary spectral peak significantly for those conditions leading to oblique incidence to the entrance channel.

Additional computations were performed with the Boussinesq-type wave model Triton. They showed similar results as observed in the laboratory experiments. Consequently, the dominant physical processes explaining the differences between SWAN and laboratory measurements are included in Triton, whereas they are missing in SWAN. At present, the Triton results are being analysed in order to pinpoint these dominant processes. Preliminary findings point towards the strong effect of diffraction on the refracted and reflected wave components.

The analysis will be an important part of the presentation. The conclusion that SWAN, or any phase-averaged model might not be suitable for computing the propagation of relatively long waves, at least compared to the locally generated waves, into tidal inlet systems may be an interesting topic of discussion.