One wavy day at the beach

Komijani Homayoon, Jaak Monbaliu, and Hana Ortega Yamamoto

Hydraulic Laboratory, KU Leuven, Kasteelpark Arenberg 40, 01.12, Box 2448, B-3001 Leuven, Belgium
E-mail: homayoon.komijani@bwk.kuleuven.be

Conservation of energy, mass and momentum hold the key to disentangle the complication of the sea dynamics. The usual practice is that the momentum-continuity set of equations are not for total momentum but for mean flow momentum. This way, the momentum and mass transferred by wind induced waves are overlooked. By coupling a spectral wave model (which solves wind induced waves) with a hydrodynamic circulation model (which solves the mean flow), one can take into account the interaction between waves and currents. The wave-current interaction is the state of the art question in the ocean dynamic research. Making an example is the best way of putting this into words.

Remember the last time you were at the sea side and you went for a dip in the sea. Assuming there were a bit of waves. With every crest of waves passing by you, you felt the hand of wave on your chest pushing you toward the coast. This push was due to the momentum of wind induced waves. As these waves shoal in the coastal waters, their energy is dissipated through breaking and bottom friction. This dissipated energy then contributes to the momentum balance and creates what is called set-up. The set-up is the rise of water level due to waves breaking in shallow waters. A proper simulation of wave induced set-up specially at the time of storms can be critical for safety measures. The waves dissipating in shallow waters, does not only create a rise of water level. If the wave crest has an angle with the coast line (which usually it has), the component of the momentum parallel to the coast, enforces a current along the coastline. This along-shore current has an important role in sediment transport along the coast.

Probably you do as well remember that after a wave passed by you toward the coast line, you felt a current of water scouring the sand under your feet. It was sometimes so strong that it could make you feel unstable. This current is called undertow. As packages of energy travel in the sea in the form of waves, the water particles go through an orbital motion. Their speed however decreases with depth. The difference of the speed of water particles at the crest and trough of wave creates a net flux of mass considerable close to the surface. As the rule of conservatively of mass compels, the flux going toward the coast due to waves, has to go back toward the sea. This is the mechanism which creates the undertow. A proper simulation of undertow not only tells us about scouring the sand under the feet of our coastal constructions, but also corrects our estimation of sediment transport systems.

At the Hydraulic laboratory of KU Leuven, we use the high performance computing facilities to numerically simulate coastal processes in the North Sea. We have coupled a well known spectral wave model (SWAN, The-SWAN-team 2008) to a fast growing circulation model (COHERENS, Luyten et al., 1996).

References

Luyten Patrick J., John Eric Jones, Roger Proctor, Andy Tabor, Paul Tett, and Karen Wild-Allen. 1999. COHERENS, A Coupled Hydro-dynamical-Ecological Model for Regional and Shelf Seas, User Documentation.

The-SWAN-team. 2008. SWAN Scientific and Technical Documentation, SWAN Cycle III version 40. 72A. Tech. rep.