2023_05_NowWaves: Real time prediction of coastal waves

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(a) Motivation for the project

Wave forcing and, particularly, extreme waves have profound effects in coastal areas. These include extreme loading on coastal infrastructure, coastal flooding and extreme shoreline erosion events. In addition, the prediction of wave evolution in the coastal zone is notoriously challenging due to the complexity of the hydrodynamic processes involved. However, successful real-time prediction of individual waves would mean that people and assets can be protected from the adverse effects of large waves. For example, the evacuation of a busy coastal beach could be decided before extreme waves reach the shoreline and threaten human lives. Such predictions in real-time are not yet possible using existing numerical models. The main challenge lies in the time-consuming nature of the detailed calculations required to simulate dynamic processes like wave breaking.

The aim of this project is to address this shortcoming by the fusion of experimental and numerical methods. Specifically, data assimilation methods and machine learning in general will be used to combine results from a state-of-the-art numerical model with experimental data generated at the Hydrodynamics laboratory. This will lead into the development of a trained model to predict the evolution of wavefields over sloping seabeds and the ability to forecast individual waves propagating on coastal areas.

(b) Context and background

The project lies at the core of geohazards and climate change research. It provides the tools for the efficient prediction of local and regional weather in coastal areas which is presently impossible due to computational constraints and uncertainty. It will also develop the appropriate framework to identify and track extreme wave events as they evolve in the coastal zone. This is, again, a source of great uncertainty in the estimation of coastal hazards.

Real-time modelling of wave evolution in the coastal zone has not yet been achieved. Experiments provide a very accurate representation of reality but cannot be running continuously to provide real-time predictions. The accuracy of numerical models is directly related to the resolution of the simulation and therefore the computational time. As such, accurate numerical modelling more time than is available for real-time modelling. The most time-consuming process in these calculations relates to dynamic effects, and primarily wave breaking. Therefore, the present project will exclude detailed calculations of wave breaking and introduce a surrogate model based on experiments and machine learning. This will give rise to a fast and accurate model.

(c) Objectives and methodology

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Project length: 10 weeks