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An innovative early warning system for floods and operational risks in harbours

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Early Warning Systems (EWS) are nowadays becoming fairly standard in river flood forecasting or in large scale hydrometeorological predictions. For complex coastal morphodynamic problems or in the vicinity of complex coastal structures, such as harbours, EWS are much less used because they are both technically and computationally still very challenging. To advance beyond the state-of-the-art, the EU FP7 project Risc-KIT (www.risc-kit.eu) is developing prototype EWS which address specifically these topics. This paper describes the prototype EWS which IMDC has developed for the case study site of the harbour of Zeebrugge.

The harbour of Zeebrugge is the largest industrial seaport on the coast of Belgium, extending more than 3 km into the sea. Two long breakwaters provide shelter for the inner quays and docks for regular conditions and frequent storms. Extreme storms surges and waves can however still enter the harbour and create risks for the harbour operations and infrastructure.

The prediction of the effects of storm surges and waves inside harbours are typically very complex and challenging, due to the need of different types of numerical models for representing all different physical processes. In general, waves inside harbours are a combination of locally wind generated waves and offshore wave penetration at the port entrance. During extreme conditions, the waves could overtop the quays and breakwaters and flood the port facilities. Outside a prediction environment, the conditions inside the harbour could be assessed by superimposing processes. The assessment can be carried out by using a combination of a spectral wave model (i.e. SWAN) for the wind generated waves and a Boussinesq type wave model (i.e. Mike 21 BW) for the wave penetration from offshore. Finally, a 2D hydrodynamic model (i.e. TELEMAC) can be used to simulate the overland flooding inside the port facilities.

To reproduce these processes in an EWS environment, an additional challenge is to cope with the limitations of the calculation engines. This is especially true with the Boussinesq model. A model train is proposed that integrates processed based modelling, for wind generated waves, with an intelligent simplification of the Boussinesq model for the wave penetration effects. These wave conditions together with the extreme water levels (including storm surge) can then be used to simulate the overtopping/overflow behaviour for the quays. Finally, the hydrodynamic model TELEMAC is run for the inundation forecast inside the port facilities. The complete model train was integrated into the Deltares Delft FEWS software to showcase the potential for real time operations.