AN INNOVATIVE EARLY WARNING SYSTEM FOR FLOOD/OPERATIONAL RISKS IN HARBOURS

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INTRODUCTION

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. State-of-the-art EWSs for coastal storm hazards that include both hydrodynamic and morphodynamic processes have begun to recently emerge in both the USA (CoSMoS; Barnard, 2014) and Europe (MICORE project, Ciavola, 2011). 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.

BACKGROUND & STEPS FORWARD

In general, waves inside harbours are a combination of locally wind generated waves and offshore wave penetration at the port entrance. 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 offshore wave penetration. Finally, a 2D hydrodynamic model (i.e. TELEMAC) can be used to simulate the overland flooding inside the port facilities.

To reproduce these processes under 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 inundations inside the port facilities. The complete model train was integrated into the Deltares Delft FEWS software for scenario simulating to showcase the potential for real time operations.

APPLICABILITY

The EWS as developed for the harbour of Zeebrugge can be used as a plug-in of larger hydro-meteorological models. The input for the model train of the EWS consists of water levels at the model boundaries, wind or pressure fields and wave spectra at the boundaries. This input is coming from larger models, such as continental shelf models, and global forecasting systems (e.g. GFS or ECMWF). Within the model train of the EWS the wave climate in the harbour, the overtopping discharges at the quay walls and the spatial variability of the water depths and flow velocities inside the harbour facilities are calculated. These output variables can be used for a range of applications, both in operational as well as during planning phase.

With the EWS, offshore (storm) conditions can be translated to wave climate conditions in the harbour. The output of hydro-meteorological prediction model can be used as an input for the EWS with which the wave climate in the harbour and overland flooding inside the port facilities can be calculated. The prediction of the harbour wave climate is very useful for all kind of harbour activities, such as vessel

manoeuvrability or the operation of locks. Another output of the EWS is the (possible) overland flooding in case a storm is forecasted. This information can be used by port authorities and companies active in the port to prepare themselves for an upcoming storm. It is possible to give an indication of areas at risk for the upcoming storm and mitigation measures can be focused on these areas.

Figure 1 The port of Zeebrugge extending more than 3 km into the sea.

CONCLUSIONS

An Early Warning system (EWS) is developed for the port of Zeebrugge within the EU FP7 project Risc-KIT. The model train of the EWS is implemented in the Delft-FEWS software and consists of different models (SWAN, MIKE21 BW, overtopping, TELEMAC) which translate offshore wave conditions to overland flooding in the harbour. The model train of the EWS developed for the harbour can be used as a plug-in for larger of hydro-meteorological models. These kind of operational models can serve multiple purposes, both in operational phase (normal conditions and storm events) as well as in the planning phase to prepare for extreme conditions, and organize the necessary preparedness, prevention and protection measures.

REFERENCES

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