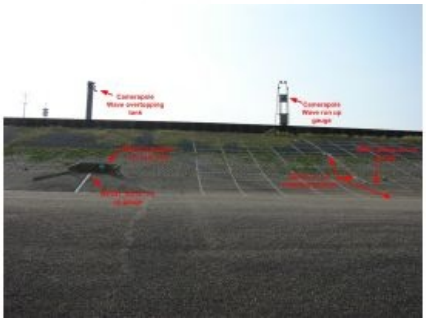
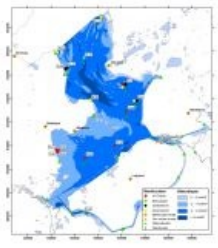
DATA FOR NUMERICAL MODELS TO PREDICT WATER LEVELS AND WAVE CONDITIONS IN EXTREME STORMS

The WTI Field Measurement Programme





Numerical models are used to predict water levels, wave heights and wind fields under extreme storm conditions. This paper aims to give a short overview of the measurements of three field sites in The Netherlands.

Validation material for these numerical models is obtained in a long-running dedicated so-called WTI field measurement programme being carried out in three areas in the Netherlands (see Figure 1):

- Dutch Wadden Sea site: an area enclosed by a series of barrier islands and the Dutch mainland coast with complex bathymetric features.
- Petten dike site: a site with a bathymetric profile typical for the open Dutch coast, starting offshore (> 20m deep) and gently sloping, including some sand banks, towards the dike.
- Lake IJssel site: a large (20 x 60km2) and relatively shallow (~4m deep) lake.

Background and Goal of the Measurements

In the assessment of the Dutch primary water defences against flooding, knowledge of the wind field, water levels and wave conditions under extreme storm conditions is required. Numerical models are used for this purpose: HARMONIE (wind), WAQUA (water levels) and SWAN (waves). A field measurement programme, initiated in 2003, aims to provide validation data for these models. Obviously, the main interest is in obtaining data under storm conditions; if the models perform satisfactorily under these conditions, we trust their performance under extreme storm conditions more.

This field measurement programme was set up by Rijkswaterstaat (a division of the Dutch Ministry of Infrastructure and Environment) within the framework of the WTI program (National Flood Defence Assessment Tools), formerly called the SBW program (Strength and Loading of Water defences).

Measuring Strategy and Techniques

To start with, we would like to make a couple of remarks that pertain to all three sites. Firstly, water levels were already monitored at a large number of stations. Therefore, no additional water level stations were erected within the WTI field measurement programme. Secondly, accurate and up-to-date information about the bottom topography is necessary. Since shipborne depth sounding and airborne laser altimetry campaigns are very accurate, but also time consuming and costly, a lot of effort has been devoted to optimising these campaigns.

Wadden Sea Site

In the Wadden Sea area, see Figure 2, the emphasis of the measurements (since 2003) has been on following the waves from the deep North Sea via the tidal inlets between the islands to the shallow parts near the dikes. The measurement strategy has been discussed in Zijderveld and Peters (2008). Presently, the wave measuring configuration in the Wadden Sea consists of about 25 directional and non-directional wave rider buoys. These buoys are spread out within as well as outside the Wadden Sea area giving good spatial coverage within several parts in the Wadden Sea. Buoys are used because they can be deployed and moved around easily. In the Ameland tidal inlet, three ADCPs are deployed to obtain current-vector profiles over the water column.

In 2008, three new long-term measuring poles situated on dikes became operational: Nes (south of Ameland), Wierumerwad (at Frisian coast) and Uithuizerwad (at Groningen coast). The poles measure waves, wind, water level and current. Furthermore, four wind poles were installed at Pollendam, Kimstergat, Dantziggat and Noorderbalgen. In addition, wind sensors were placed on several already existing poles belonging to LMW (National Water Monitoring Network). These wind measurement extensions were justified by the fact that the existing (predominantly land-based) stations gave insufficient spatial coverage in the areas of interest, and were also not representative enough to measure the wind field over open water.

Another interesting aspect is that a SeaDarQ processor unit has been connected to the microwave marine traffic surveillance radar on the Ameland lighthouse since 2009, showing promising results in displaying wave patterns, current fields and bottom features, see Gautier et al. (2012). Such remote sensing techniques are envisaged to give spatial wave and current field data in this and other specific areas of the Wadden Sea.

Petten Dike Site

The measurement campaign (since 1995) at Petten was devoted to measuring wave conditions at a site typical for the open Holland coastline. This was accomplished by placing a number of measuring stations (poles and buoys) in a transect (see Figure 3a) more or less perpendicular to the dike. The poles were equipped with a suite of sensors (radar level sensors, step gauges, current meters, wind sensors, S4s) to measure a large number of important hydraulic and meteorological parameters. Note that the two offshore buoys are too far (3 and 8km) from the coast to be visible in Figure 3a. The Petten site was also equipped to measure wave run-up and (since 2007) wave overtopping on the sea dike by using several dedicated sensors installed in or on the Petten sea dike itself, see Figure 3b.

Unfortunately, the Petten site has ceased to exist since May 2013 because a major beach nourishment scheme will be carried out soon.

Lake IJssel Site

Since 1997, measurement poles have been deployed in the large Lake IJssel and Lake Marken, both inland lakes, to measure waves, wind and water levels, see Figure 4. Recently, the measurement site has been extended by combining the WTI poles with poles installed for ecological projects. Several of the poles also have an operational purpose (like FL02 and FL09 for ship guidance).

Data Management

All the data (from poles and buoys) is transmitted by radio links in real-time to a few land-based receiving stations and from there to a few central computer stations where the data is processed. The data are checked for possible outliers and staggers using automatic validation algorithms. For validating the wave parameters, use is made of the so-called WAVIX neural network. In case of data loss, the operational measuring and information divisions of Rijkswaterstaat are contacted requesting the repair of malfunctioning equipment (measuring sensors and/or data communication links) as soon as possible. Thus, downtime of instruments is minimised. After the monitoring and validation steps the validated data is stored in the Rijkswaterstaat national data base DONAR. This thoroughly backed-up data base guarantees the integrity of all the measurement data.

Future Developments

It is expected that the wave measurement programme in the Wadden Sea will include more measurement locations in the Eems-Dollard estuary. This area is subject to high water levels in severe Northern storms, as observed on 1 November 2006.

In the long term the entire WTI measurement campaign will be transformed into a monitoring campaign, to fulfil the information needs of several stakeholders. One of the stakeholders is the Dutch Storm Surge Warning Department (SVSD) that is responsible for accurate storm surge warnings for the coastal areas.

Acknowledgements

The authors wish to thank the RWS colleagues Magiel Hansen, André Jansen, Hans Miedema, Peter Verburgh, Albert Huisman, Paul Kramer, Marco Peters and Arjen Ponger for their contributions.

More Information

- Gautier, C., H. Peters and J. van Heesen, 2012. Hydrodynamic data from radar observations. Hydro12 conference, Rotterdam, The Netherlands.
- Zijderveld, A. and H. Peters, 2008. Measurement programme Dutch Wadden Sea. ICCE 2008, Hamburg, Germany.