Climatology of extreme winds for the Dutch coastal areas

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Introduction
Wind is an important driving force for wave growth and surge. Knowledge of extreme wind speed levels in the coastal regions of the Netherlands and over inland water bodies is therefore of vital importance for determining the risks of flooding. Every 5 years, Dutch authorities require updates of the required safety levels for the sea and river dikes, the so-called hydraulic boundary conditions. The KNMI-HYDRA project aims at providing an updated wind climatology for the Dutch coastal zone (including extremes) on the basis of a thorough analysis of historical time series of surface wind speed observations.

Objective
Levels of wind speed with return periods from 0.5 year up to 10,000 years are requested for offshore locations and over the inland water bodies of the Netherlands. To accomplish this, extreme value theory has to be applied to series of past surface wind speed measurements. This will yield marginal statistics for individual wind direction sectors and seasons, as well as omni-directional, yearly statistics. In addition, an interpolation method is required to translate the wind speed statistics from the observation sites to relevant locations in the land-water transition zone. The newly derived wind climatology is intended to replace the previous assessment by Wieringa and Rijkoort.

Results
A high quality dataset has been prepared comprising time series of hourly-averaged wind speed and direction from 51 Dutch meteorological stations. All series are corrected for time-dependent observational changes and changes in local disturbances. From this dataset, 31 stations with at least 19 years of data since 1950 have been selected for extreme value analysis. In each series, independent storm events are identified. They have been modelled using the conditional Weibull distribution (CWD) and the generalised Pareto distribution (GPD) (see Figure 1). The statistical analysis has clarified many obscurities in the analysis performed by Rijkoort and Wieringa.

The interpolation method has enabled the inclusion of detailed surface roughness information in the wind climatology. The spatial interpolation from the observation sites to the required coastal locations has been performed using the two-layer model of Wieringa. The model parameters have been derived from a newly developed high-resolution surface roughness map, which is produced by evaluation of land-use maps with a simple footprint model. It turns out that the resulting wind speed estimates over open water are considerably higher than former estimates.

The integration of the statistical analysis and the interpolation method has not yet been entirely successful. The spatial dimension of high wind speed events is often small compared to the density of the measuring network. The smoothing effect of the interpolation method then leads to strong underestimation of wind speed extremes. This effect can be avoided by applying the statistical analysis first and interpolating the derived extreme

Figure 1. Observed storm maxima and modelled storm maxima using the conditional Weibull distribution (CWD) and the generalised Pareto distribution (GPD) for station Eelde.
wind speed levels, rather than interpolating the underlying time series. As an example, the resulting geographical pattern of the wind speed with return period 10,000 years is plotted in Figure 2 for a subset of the data (19 stations, period 1972–2001). Comparison with statistical estimates at the station locations without interpolation (Figure 3) shows large differences in particular in the southwest coastal region of the Netherlands. This implies that the geographical pattern of extreme wind speed levels cannot be fully understood from differences in surface roughness only.

Outlook
Proper integration of wind statistics derived from station locations and spatial interpolation to areas of interest is expected to reduce statistical uncertainties significantly. The relatively low extreme wind speed levels found in the southwest coastal region of the Netherlands demand a better understanding of the physical nature of the selected storm events. Confidence in the interpolated wind speed estimates over water and in the land–water transition zone can be enhanced by in situ verification.

4) Detailed HYDRA-documentation, the complete high-resolution dataset and roughness map information can be found at: www.knmi.nl/samenu/hydra