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An exploration of the potential of using storm characteristics from long synthetic time series of wind and water levels for operational forecasting

Paulina Kindermann[1,2], Oswaldo Morales Napoles[1], and José Antonlínez[1]
[1]Delft University of Technology, Faculty of Civil Engineering and Geosciences, Hydraulic Engineering, Delft, Netherlands (p.e.kindermann@tudelft.nl)
[2]HKV Lijn in Water, Delft, the Netherlands

The Dutch coast is characterized by dikes, dunes, and structural barriers with low-lying, densely populated hinterland, which makes the area very vulnerable to coastal flooding. Therefore, the reliability of flood forecasting models is of great importance: accurate short-term forecasts (up to 2 weeks lead time) are necessary for operational decision-making processes (e.g. closing the storm surge barriers on time), while mid-term forecasting (seasonal) is useful for the planning of maintenance, for example. However, the uncertainty of forecasts naturally increases with longer lead times, which means that the extent of a storm is often only known on short term, leaving little time to take safety measures (Pardowitz et al., 2016). With a changing climate, the uncertainty in forecasting might even increase. Improving our understanding of the characteristics of storm evolutions in present and future climate plays a fundamental role to reduce uncertainty in forecasting models.

In recent years, research into storms and resulting extreme sea levels along the Dutch coast has been boosted by the availability of long time series of meteorological data in the current climate, from the seasonal forecasting system (SEAS5) by the European Centre for Medium-Range Weather Forecasts (ECMWF) (ECMWF, 2021). For these synthetic time series of wind data, the Royal Dutch Meteorological Institute (KNMI) calculated corresponding sea levels (van den Brink, 2020). As a result, a period of 8,000 years of simulated meteorological and hydraulic data of the current climate have become available for many Dutch coastal locations. Compared to the limited availability of measurements from coastal stations (up to 50 or 100 years for a limited number of stations) these long time series are a great source of synthetic storm information.

The aim of this study is to explore the potential of using storm characteristics derived from these long synthetic time series of wind and corresponding water level for operational forecasting at the Dutch coast. First, physical and statistical properties of storm characteristics and their mutual correlations are analyzed. Storm characteristics consist of the temporal and spatial evolution of wind speed, wind direction and surge height, the duration of wind speed and storm surge above a certain threshold and the phase difference between the maximum storm surge and high tide. Mutual correlations between these characteristics are derived using copulas. Previous analyses

result in strong correlations between wind speed and surge height, although it varies significantly depending on the location and combination of wind direction, duration and phase (Caspers & Kindermann, 2023). Still, this strong correlation suggests potential to be used for the forecasting of resulting storm surges from wind speed. Consequently, the correlations and other storm evolution properties found from these synthetic time series are compared to the observations of storms in recent years to investigate whether the findings from synthetic data agree with the characteristics of observed storm evolutions, in order to explore their potential for the short and mid-term forecasting of storm impact at the Dutch coast.