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Statistical analysis of sea state data to identify climate trends and morphodynamic variability in the nearshore area of the East Frisian North Sea

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Many effects of global warming like sea level rise and the possible increase in frequency and intensity of storms exert pressure on the coastal regions of the North Sea. Since waves in the nearshore area often are strongly influenced by bottom topography, scientific knowledge of local change tendencies of the sea state together with morphodynamic processes is of current interest to distinguish between natural variability and climate change signals.

In this study buoy data from eight buoys at the Norderney shoreline over a period of more than 20 years were analysed. Three buoys are located in the nearshore area (two north and one south of the ebb tidal delta (ETD) sandbanks), and five in the Wadden Sea on the other Norderney coastline. All buoy records deliver half hourly data of significant wave height, wave period and wave direction, calculated from the wave spectrum. To relate the buoy data records to morphodynamic processes, aerial photos of the nearshore area were studied.

In a first step, long-term trends of significant wave height were investigated by time series analysis. The variability of long-term trends between the buoys were related to the morphodynamic variability in the nearshore area.

In a second step, statistical approaches were used to quantify the influence of morphodynamic processes on the sea state. Therefore, three clusters of the different buoy positions according to wave height variability were determined with k-means algorithm. Since the buoys in the north of the ETD and the buoy in the south of the ETD were grouped into different clusters, this study concentrates on these buoys to quantify the dynamic effects of the ETD to the sea state variability. Regression and correlation analyses were conducted to quantify the natural variability of the ETD. North of the ETD buoys are highly correlated between each other ($r = 0.94$), but lower correlated with the southern position ($r = 0.82$). Therefore, it was assumed that the sandbanks provide a natural barrier for the approaching swell. Calculated from a Fourier Transformation of each buoy data record, the resulting periodogram also includes information about periodic patterns in the data. Thus, the influence of morphodynamic processes of the banks to the periodicity and sea state in their vicinity can be derived. For example, we identified more lower frequencies at the southern position.

In a third step, the influence of morphodynamic processes on the sea state, especially on the wave direction, was analysed. For this, we separated swell and wind sea from the wave spectrum to concentrate on breaking waves from swell at the banks. In this way, we will be able to understand the influence of the ETD to the sea state more detailed because the morphodynamic variability is separated from climate change signals caused by changing wind climate and other impacts on the sea state, like the tide.

In conclusion, morphodynamic processes seem to overlap with climate change signals.