



## **Trends in sea level percentiles along the German North Sea coastline compared to regional mean sea level changes**

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Changes in extreme high sea levels have considerable consequences for coastal management and protection. Knowledge of both the historic and potential future changes in extreme events will help to determine the scale and resource required for improved flood risk management, including upgraded coastal protection. For many practical coastal engineering applications, it is often assumed that changes in extreme high sea levels will not significantly differ from the trends observed in mean sea level (MSL). However, if this assumption is false, there are important implications for the design of coastal defences and for flood risk assessments.

In this paper, sea level records from 13 tide gauges along the German North Sea coastline are evaluated to determine if the changes in extreme high sea levels throughout the 20th and early 21st century differ from those observed in MSL. Time series of annual 90th, 99th, 99.9th and 100th (i.e. annual maximum) percentiles are derived from high water records and trends are assessed. The percentile time series are subsequently reduced relative to MSL and a second set of trends are estimated. Linear trends and standard errors are computed for the entire time periods for which datasets are available at each tide gauge site and for the common period from 1953 to 2008. Depending on the considered percentile level, trends in extreme high sea levels across the six sites are between 2.6 and 8.2 mm/yr. Once the percentile time series are reduced relative to mean sea level the trends diminish to 0.6 to 6.4 mm/yr. At all sites, and for most of the percentile levels considered, trends in the extreme high sea levels are found to differ significantly from those in MSL. These results indicate that MSL is not the only factor driving changes in extreme high sea levels along the German North Sea coastline.