**Global Storm Surge Reconstructions (GSSR): Changepoint Detection and Trend Analysis**

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**Abstract**

Understanding how extreme storm surges change over time is crucial for designing and implementing robust adaptation strategies against coastal flooding. Therefore, we investigate trends in the magnitude and frequency of extreme storm surge events globally at 300 tide gauge locations.

We use two centennial and three satellite-era daily storm surge reconstruction datasets from the Global Storm Surge Reconstructions (GSSR) database (<http://gssr.info>). Some spurious trends were observed in the annual variability of the centennial surge reconstructions in some regions. A Bayesian changepoint analysis is carried out to remove data from time periods and locations where such spurious trends were detected. Following the changepoint analysis, trends in higher percentile surges and their frequencies are computed for the 1875-2015, 1900-2015, 1950-2015, and 1980-2010 time periods. Trends from the five reconstructions are compared with trends from observed surges for the overlapping 1980-2010 period.

Our analysis shows that even after applying changepoint detection and removing unreliable data, the GSSR database extends existing storm surge records by several decades for the vast majority of tide gauges in our study. Moreover, storm surge reconstructions from 20-CR and ERA-20C reanalyses show significant positive long-term trends in several locations. We find maximum positive trends in the orders of 2 mm/year and 4 mm/year for 20-CR and ERA-20C reconstructions respectively for the southern North Sea region, for all three time periods. The frequency of annual storm events in any given year above the 95th and 99th percentile thresholds have also increased for several locations. Increasing trends in northwestern Europe since 1950 are correlated with the positive trends of the North Atlantic Oscillation (NAO). However, the long-term positive trends from the surge reconstructions are in contrast to insignificant trends in observed surges in the same region. This might arise from remaining inhomogeneities in the atmospheric reanalyses which were not captured through the automated changepoint detection and as such have to be interpreted carefully.