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Mean and extreme sea level changes in the southwestern Baltic Sea

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Motivation

In the BMBF Project „AMSeL Baltic Sea“ (Project Number 03KIS114) funded by the Federal Ministry of Education and Research (BMBF) in Germany mean and extreme sea level changes over the past 150 years in the southwestern Baltic Sea are analysed. As a result, detailed knowledge of the spatial and temporal variability in sea level along the German Baltic coast will be available. Furthermore, a knowledge gap in comparison to the German North Sea coast, that consists in a lack of detailed analyses of all available data, will be closed. One aim is to investigate the interrelationship between the North and Baltic Sea basins, which are connected through narrow and complex straits between Denmark, Norway and Sweden. Another aim is to identify long-term changes associated with global climate change. By doing so, the basis for deriving more resilient regional sea level projections for this low-lying and vulnerable area will be developed.

Datasets

- 96 tide gauges from the PSMSL data set (Holgate et al., 2013; PSMSL, 2016) and 44 tide gauges from other sources (e.g. WSV, UHSLC, etc.)
- GIA corrections from the ICE5G model provided by Peltier (2004)

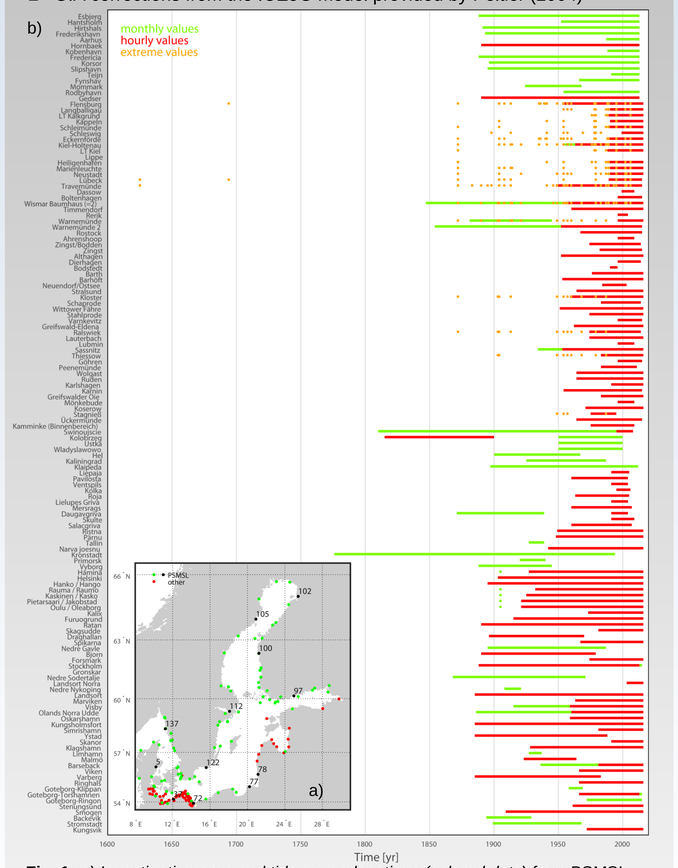


Fig. 1: *a) Investigation area and tide gauge locations (colored dots) from PSMSL (green and black dots) and other sources (red dots). b) Temporal availability of sea level data (the colors show different temporal resolutions).*

Results: Tide gauge correction

Seasonal cycle and GIA

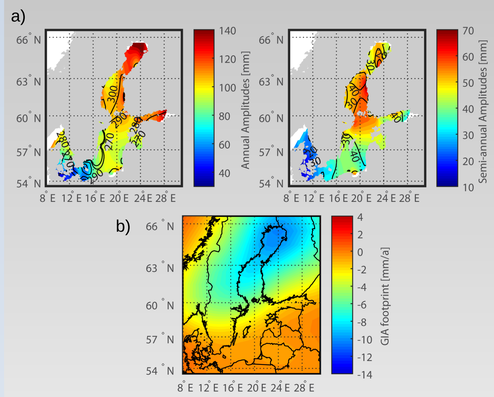


Fig. 2: *a) Amplitudes (colors; mm) and phases (isolines; degree) of annual and semi-annual components of the seasonal fluctuations of mean sea level in the Baltic Sea (Interpolated from data at tide gauges). b) GIA fingerprints from ICE5G as suggested by Peltier (2004).*

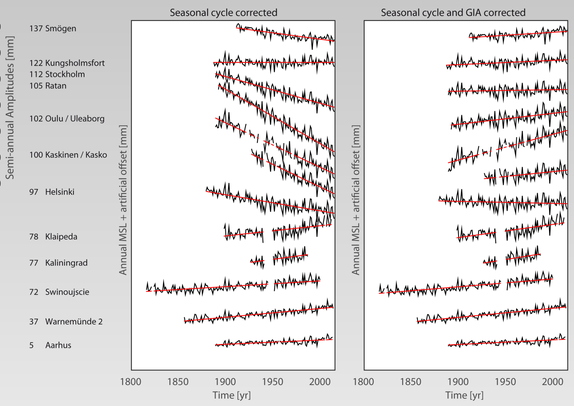
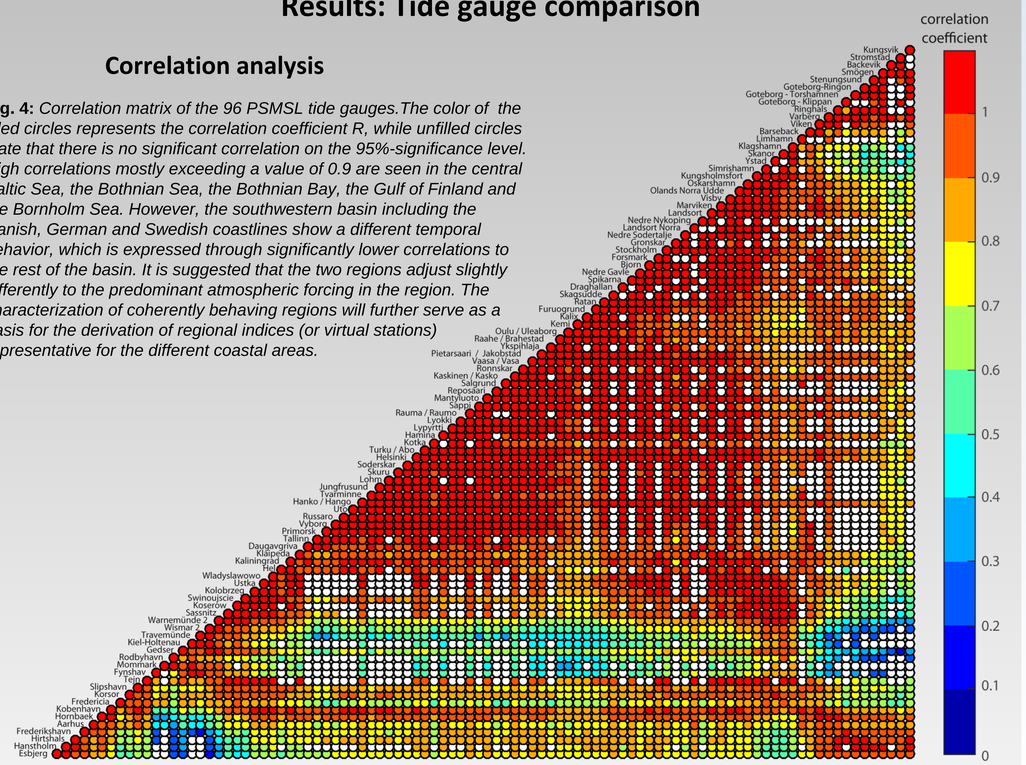


Fig. 3: *Annual mean sea level changes at 12 exemplarily selected tide gauges. Linear trends (red) are calculated based on ordinary least squares fitted to deseasoned (left) and deseasoned and GIA corrected (right) time series. Vertical land motion is the dominating effect contributing to relative sea level changes in the Baltic Sea region. The GIA correction even changes the sign of the observed trends at some stations.*

Results: Tide gauge comparison

Correlation analysis

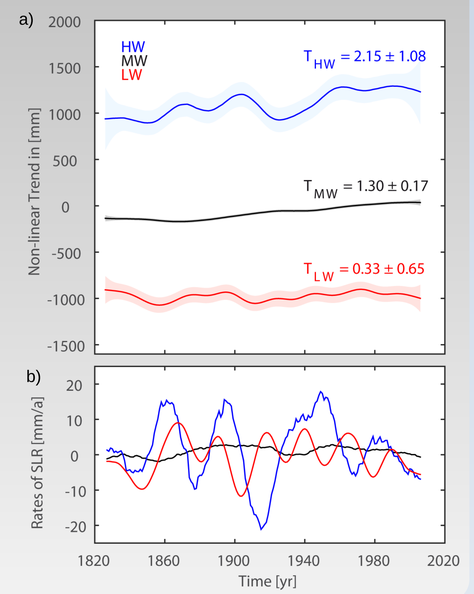
Fig. 4: *Correlation matrix of the 96 PSMSL tide gauges.The color of the filled circles represents the correlation coefficient R, while unfilled circles state that there is no significant correlation on the 95%-significance level. High correlations mostly exceeding a value of 0.9 are seen in the central Baltic Sea, the Bothnian Sea, the Bothnian Bay, the Gulf of Finland and the Bornholm Sea. However, the southwestern basin including the Danish, German and Swedish coastlines show a different temporal behavior, which is expressed through significantly lower correlations to the rest of the basin. It is suggested that the two regions adjust slightly differently to the predominant atmospheric forcing in the region. The characterization of coherently behaving regions will further serve as a basis for the derivation of regional indices (or virtual stations) representative for the different coastal areas.*



Results: Extrema

Singular System Analysis (SSA)

Fig. 5: *a) Non-linear Trend in [mm] for low water (LW), mean (MW) and high water (HW) at the tide gauge Travemuende. b) Rates of SLR in [mm/a]. NW, MW and HW time series of tide gauge Travemuende were analysed with a non-parametric data adaptive filter, the Singular System Analysis (SSA). The results point towards a divergent trend development between extreme and mean sea level, which is consistent with recent evidence from literature (Barbosa, 2008)*



Outlook

- **The variability of mean and extreme sea levels in the southwestern Baltic Sea is still not completely understood.**
- **By digitizing and analyzing further high-resolution tide gauge data and individual extreme event observations, the data base in the Baltic Sea will be significantly improved (focus: southwestern German coastline).**
- **The trend assessments will be applied to mean and extreme sea levels independently to prove whether observed changes in extremes are either due to changes in mean sea levels or changes in storminess (like Dangendorf et al., 2014), or both. Also the spatial and temporal variability of sea level will be further investigated.**
- **It is planned to integrate the new data set into the North Sea data base and compare the interrelationships between the two basins (sea level exchanges, time lags, processes, etc.)**

References

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