Influence of temperature and wind on Baltic Sea level within the instrumental period

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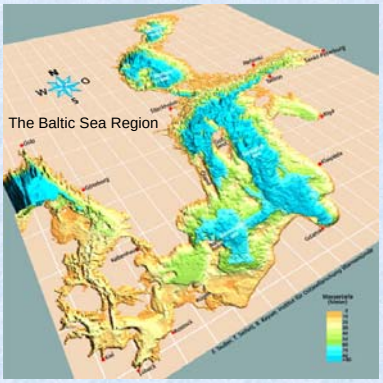
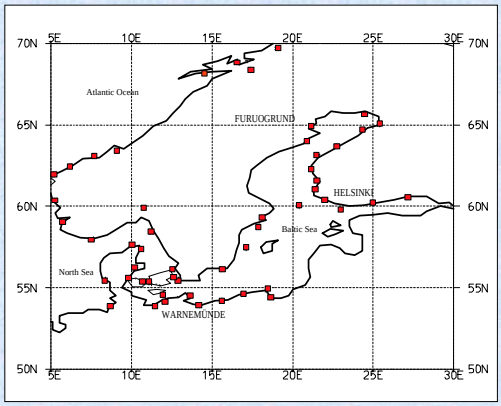


Introduction:

The aim is to identify the climate influence on sea-level by using statistical methods and global climate models to reconstruct and understand the climate sea-level variations in the past 2-3 thousand years.

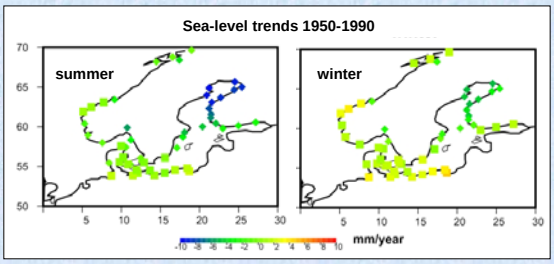
Long-term variations of sea-level in the Baltic Sea have been caused in the past by different sources, mainly geological and climatological. The observations describing these variations, either suitable geological records or long measurements, contain both types of variation sources.

We try to find a relationship between the main components of the North Atlantic air-pressure and sea-level anomalies at several Baltic Sea gauges and in winter and summer.

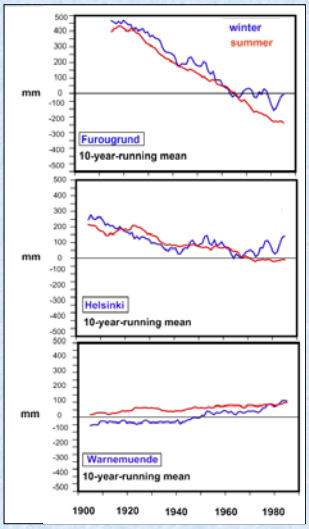


Investigation of sea-level measurements

Sea-level time series from the Permanent Service for Mean Sea Level (PSMSL) in the last century have been statistically analysed. 53 stations were selected which reported between 1850 to 2002 (see figure).



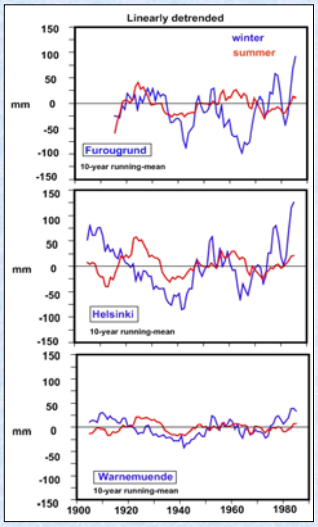
The sea level time series show a clear downward trend in the Northern Baltic Sea and a weaker, but discernible, upward trend in the Southern Baltic Sea. The behaviour shows clear differences between the summer season (JJA) and the winter season (DJF). This points to an influence of long-term climate factors that cannot be ignored.



The downward trend from the northern stations disappears from the year 1960 onwards, in some of them (e.g. Helsinki) this trend is reversed. Additionally, large decadal deviations from the long-term trend are clearly discernible.

Sea- level time series

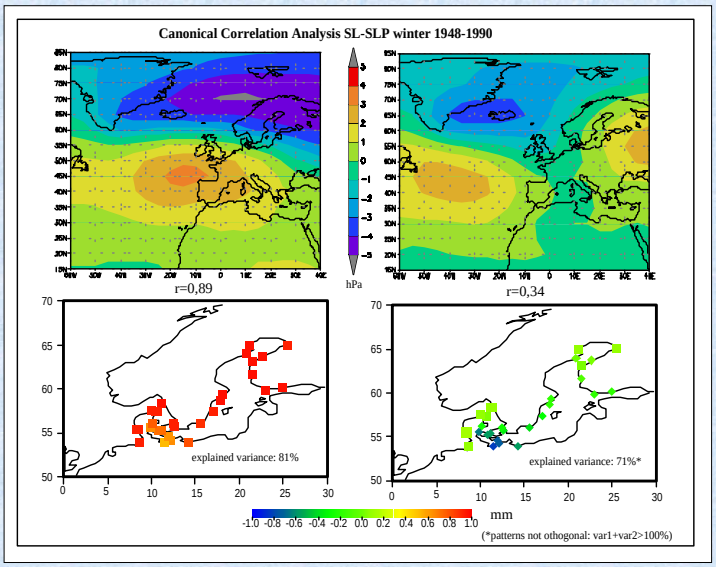
This behaviour may indicate the climate forcing may be responsible for large decadal variations, but also long-term trends in this century. To identify the relationships between sea-level and climate forcing, the long-term linear trend has been substracted from all time series.



Statistical relationship between sea-level (SL) and air-pressure (SLP)

Air-pressure as a large-scale parameter contains information about wind strength, wind direction and advection of other parameters, which all influence sea-level. To establish a statistical relationship between sea level and air-pressure we used reanalysis data (5° by 5° grid) from the National Centre for Atmospheric Research (NCAR). Our basic calibration period is the second period of the 20th century. For the validation we utilised the Trenberth SLP analyses.

We describe the interannual and decadal variations of the detrended SL data by fitting a linear regression model with SLP as predictor and SL as predictand.



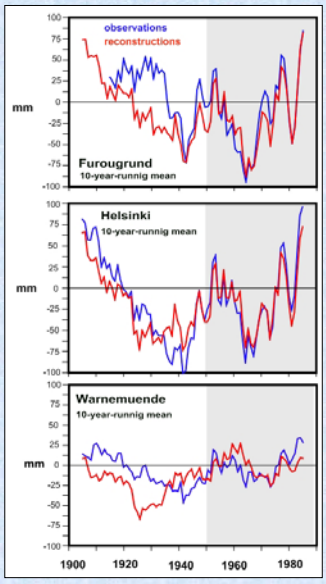
After performing an EOF-analysis, we selected the leading SL EOFs and the leading SLP EOF-patterns to perform a canonical correlation analysis (CCA), revealing two pairs of corresponding pattern.

For the winter season the first pair shows a NAO in the air-pressure pattern. Its time series is correlated with r=0.89 to the time series of a sea-level pattern which describes a simultaneously rise of all Baltic gauges.The second pair shows a heterogenic structure in the local pattern.The associated time series are correlated with 0.34.

The influence of the atmospheric circulation is most important in wintertime and in the Northern Baltic Sea, and weaker but non-negligible in summertime and in the Southern Baltic Sea.

Observations – reconstructions

SL time series winter, validation period: 1900-1947



Conclusion and Outlook:

The evolution of sea-level is composed of a secular trend of geologic origin and the influence of atmospheric forcing. An empirical regression model between sea-level and sea-level pressure can explain most of the deviations from a linear long-term trend through the influence of climate factors.
Our long term goal is to use statistical relationships to reconstruct the climate-related variations of sea-level in the last millenia. For this purpose the relevant atmospheric forcings, such as those represented by the NAO, will be reconstructed by statistical means and the analysis of long dendrochronological time series.