Statistical Analysis of the relationship between Baltic sea-level and meteorological forcing in the present climate

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http://w3g.gkss.de/staff/huenicke.html/Poster.html

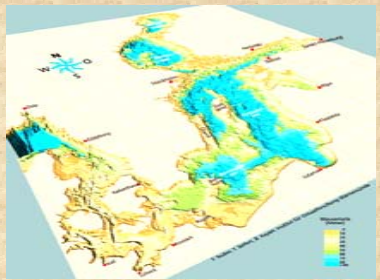

Fig.1 The Baltic Sea Region

Introduction:

The aim is to identify the climate influence on past and future sea-level changes in the Baltic Sea by using statistical methods and global climate models. For this purpose the relevant atmospheric forcings have to be reconstructed by statistical means and the analysis of long dendrochronological time series. These forcing may stem from the atmospheric circulation, e.g. NAO, or from other factors (e.g. sea-level variations in the North Atlantic).

The variability of the atmospheric circulation acts at short (interannual) timescales, but at decadal or longer timescales these other factors may be more important. We aim at identifying these factors in the instrumental record. Therefore we analysed the relationship between Baltic sea-level and meteorological forcing within the instrumental period; taking into account that the evolution of sea-level is composed of a secular trend of geological origin and the influence of atmospheric forcing.

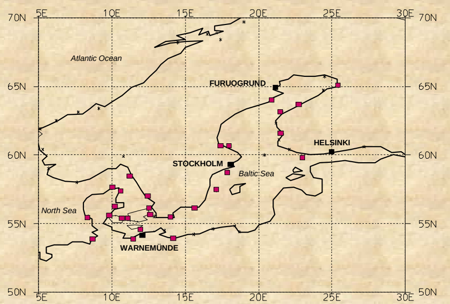

Fig.2 Sea-level stations used for this analysis (data source: PSMSL)

Sea-level-pressure can statistically explain part of the sea-level variability, but its influence is homogenous neither in space or in time. Fig. 3 indicates that the correlation between the NAO index and the mean sea-level (SL) in wintertime has strongly varied in the past. Also, the correlation between the NAO index and individual stations is much stronger in the north than in the south.
Our strategy is to eliminate the influence of the SLP field on sea-level by statistical means, so that other underlying factors can be more easely identified.

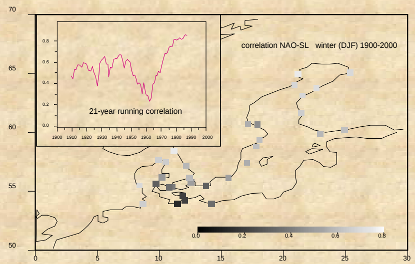

Fig.3 Correlation between the NAO index and the mean SL in wintertime

Decomposition of sea-level variations:

The sea-level anomalies in each station and season are statistically decomposed in two parts: a part linearly associated with the atmospheric circulation and a residual. These residuals are then subjected to a further statistical analysis. To ascertain that the residuals do not contain any information from the SLP field, Fig.4 shows the correlation pattern between the SLP and the sea-level (SL) and the SLP and the residuals (SLR).

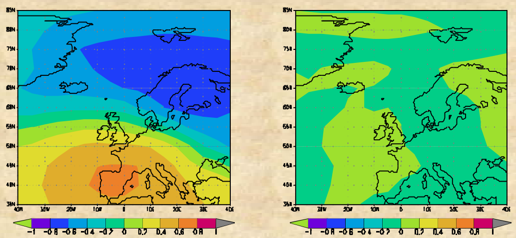

Fig.4 Correlation patterns between SL and SLP (left) and SLR and SLP (right)

Internal correlations among Residuals:

To point out the internal correlations among the Residuals and the SL, we selected three representative stations from north to south (Fig. 5).

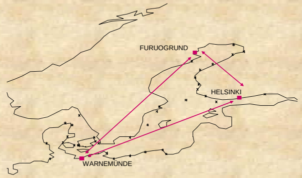

Fig.5 Selected sea level stations: Furuogrund – Helsinki – Warnemünde

Fig.6 shows the mean of the Baltic sea-level (left) and of the Residuals (right) for the winter and summer, smoothed with a 11-year running mean for the period 1900-2000. It can be seen that in wintertime the Residuals show a much higher correlation (0.57-0.93) to each other than SL (0.24-0.72); in summertime they behave more or less similar (0.8-0.9).

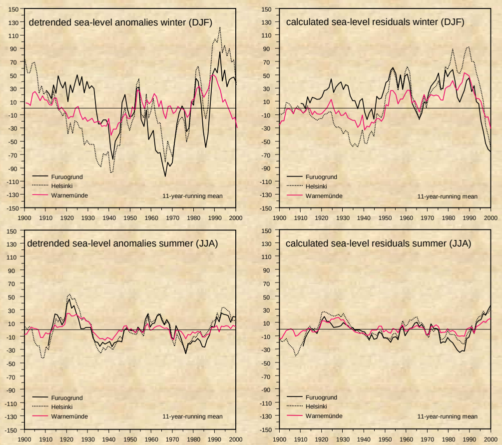

Fig.6 Winter and summer mean of the SL anomalies (left) compared to the calculated sea level residuals (right) for the period 1900-2000

This points to the existence of an underlying factor, independent of the winter atmospheric circulation, that causes spatially coherent sea-level variations.

Another interesting feature of the residuals is the winter-summer correlation. Fig. 7 shows the correlation between summer and the following winter for each station, left for the SL and right for the Residuals.

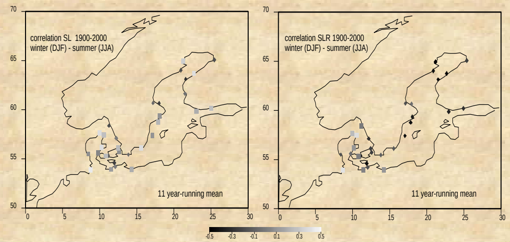

Fig.7 Correlation between the winter and summer mean of the detrended Baltic sea level anomalies (left) and the calculated residuals

Whereas the correlations for the sea-level vary around zero and show no spatial structure, the correlations for the Residuals show a clear north-south dipolar structure. Since the residuals are calculated independently in summer and winter, this indicates the physical existence of this underlying factor.

Conclusions:

Sea-level-pressure (i.e. the NAO) does not completely explain sea-level variations in the Baltic. At timescales longer than interannual other underlying factors can be statistically identified.

Outlook:

A similar statistical analysis between available dendrochronological data and the sea-level gauges is now being carried out for the period when both datasets overlap (last 100-150 years). Since the relationship between proxy data and sea-level data is obviously indirect, the interpretation of the results will have to be more elaborated. The results will yield an estimation of the amount of covariability present in sea-level and proxy data and therefore of the amount of sea-level variability that could be potentially reconstructed with the longer time series of paleoclimatic data sets. For the physical interpretation, secondary analysis between the proxy data and the climate forcing will be performed.