# The North Atlantic Oscillation since 1500 A.D. Climate Anomalies & Human Affairs

**Frederik Schenk[1,2], Wolf Dieter Blümel[1], Eduardo Zorita[2], Sebastian Wagner[2] and Daniel Hansson[3]**

**contact:** ***frederik.schenk@gkss.de***

*1: University of Stuttgart, Germany. - 2: GKSS Research Centre, Geesthacht, Germany. - 3: University of Gothenburg, Sweden.*

## 1 Introduction

A detailed comparison of long-term vs. short-term climate variability in Europe reveals extraordinary big differences in the month-to-month and year-to-year variability for the Little Ice Age (LIA 1550-1900) whereas (multi-)decadal changes are low-key. We directly relate these short-term climate fluctuations to societal developments emphasizing the true variability and intensity of the anomalies which are underestimated by more than factor of 2 due to the loss of informations by reconstructions (*von Storch et al. 2004*). We can show that the GCM ECHO-G is very useful for the estimation of climate variability studies for the LIA. Nevertheless, the non-stationarity in the relationship between the atmospheric circulation (here NAO) and the near-surface climate on the local/regional scale, expressed by multi-decadal running correlations (RC), is high in observations as well as in reconstructions. This poster will show some mind maps about - *how trustworthy are reconstructions?* - on shorter time scales.

## 2 Data & Model

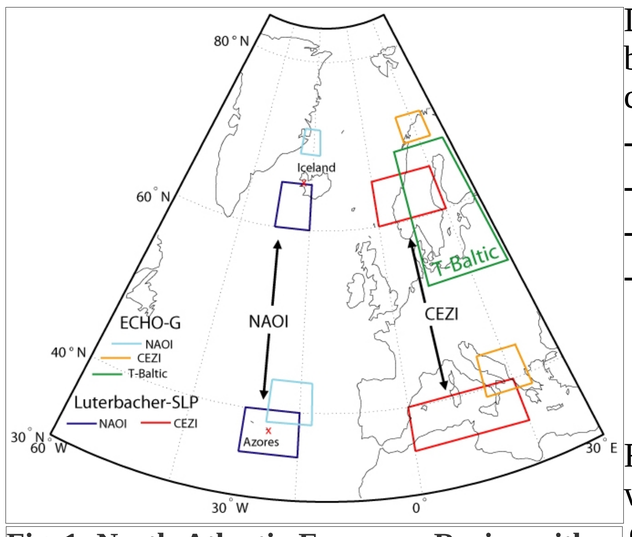


**Fig. 1: North-Atlantic-European Region with the Baltic catchment (67-52°N; 0-35°E) and the position of the different zonal indices.**

Detailed studies were made for the relationship between the NAO and the climate of the Baltic catchment using different data sets:

- historical measurements (t2m, gauge, ice)
- NAO of Azores Iceland (*Jones et al. 1997*)
- SLP reconstruction (*Luterbacher et al. 2002*)
- Max. sea-ice extent of the Baltic Sea (MIB), simulated by the process oriented model PROBE-Baltic (*Hansson & Omstedt 2007*)

For comparison studies in a surrogate climate we used different simulations of the global climate model **ECHO-G** for 1000-1990.

**Model description:**

- atmospheric model **ECHAM4** with a horizontal resolution of 3,8°x3,8° (~T30)
- ocean model **HOPE-G** with a horizontal resolution of 2.8°x2.8° (~ T42er)
- external forcing of past solar variations (reconstructed sun-spots number, $Be^{10}$ in polar ice cores), volcanic activity (acidity measurements in polar ice cores) and greenhouse gases (from trapped air bubbles in polar ice cores).

## 3 North Atlantic Oscillation vs. Central European Zonal Index CEZI

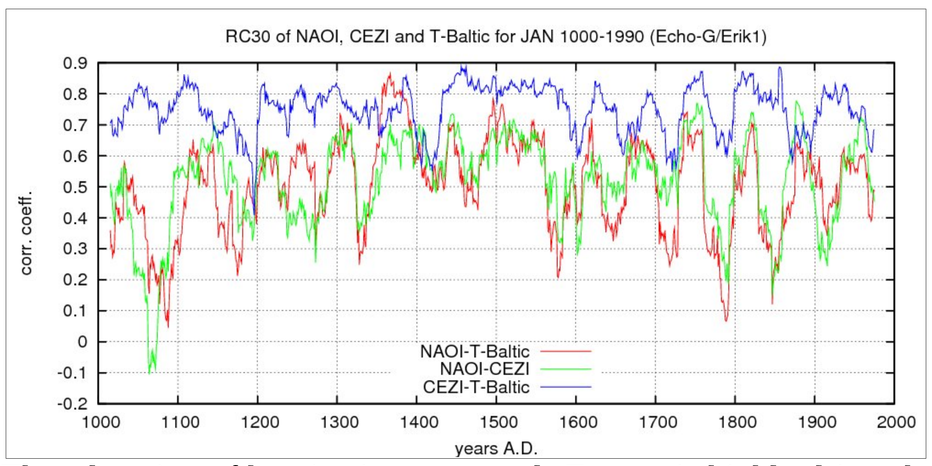


**Fig. 2: RC30 with T-Baltic and the NAOI and with the CEZI as well as the RC30 between the NAOI and the CEZI (ERIK1).**

The differences in the relation t2m-NAOI and t2m-CEZI are high due to the long distance between the NAO and its regional impact on the near-surface climate.

The advection of heat/moisture towards Europe is highly driven by the NAO i.g. in winter. The climate impact on-shore can be described by the CEZI which is the impact of the NAO modulated by *events* downstream from off-shore towards the region (like e.g. atmospheric blockings etc.). Because blockings are the most important events for extreme climate anomalies, higher horizontal resolutions are mandatory on the model side.

## 4 Climate Anomalies and Human Affairs

**Abrupt changes between extremes of opposite sign** related to a significantly **higher short-term variability of the NAO** were found to be an important returning feature of LIA both in GCM simulations and proxy-reconstruction, whereas the variability after 1900 and before 1550 is lower coinciding with ameliorated climate conditions. Changes in the **mean climate or seasonal values** are found to be **not useful** to describe the variability of the NAO and impacts on human affairs. The Maunder-Minimum e.g. with its severe famines in Finland (25-33% dead) and Estonia (20%) (1690-1700) are highly coincident with the monthly reconstructed NAO by Luterbacher et al. 2002. As historical human affairs were mostly dependent on short-term climate variability, model studies on these variabilities should be carried out to overcome the **lack of reduced variability in reconstructions**.

## 5 Simulations vs. pseudo-proxy reconstructions

All simulations were driven by the same external forcing. Because the initial conditions in year 1000 are unknown **ERIK1** started with a warm ocean (like 1990), **ERIK2** with a cold ocean (Late Maunder Minimum 1756).

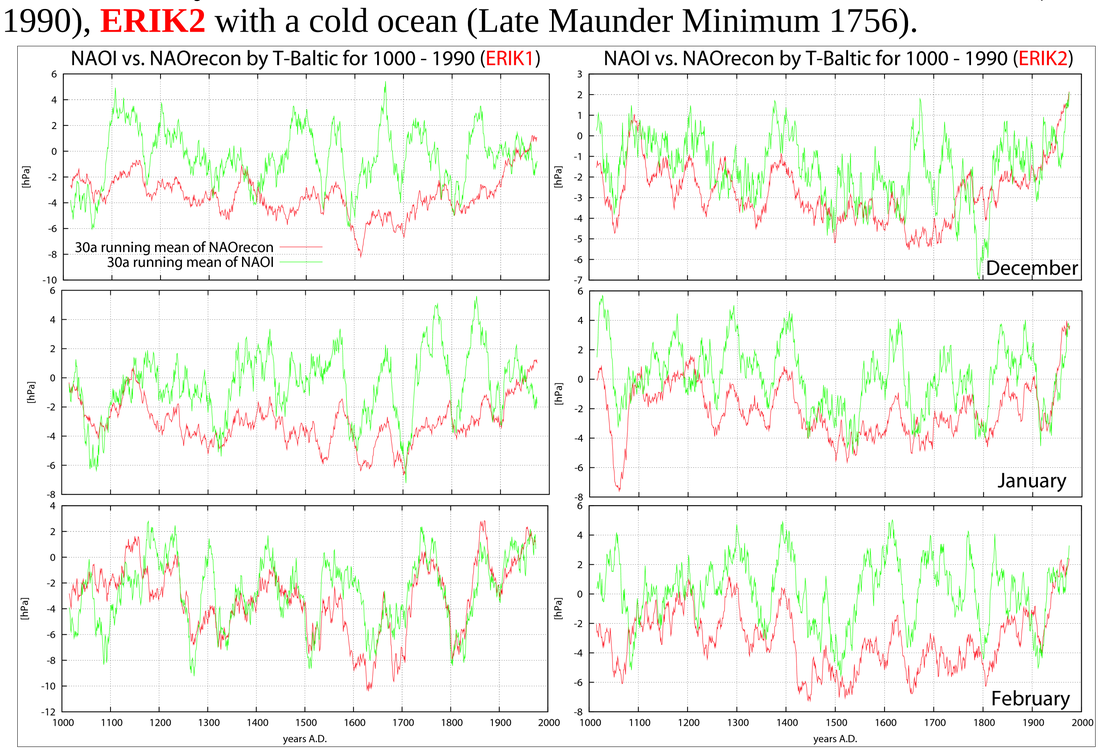


**Fig. 3: NAO index calculated as the difference MSLP of Azores (43°-39°N; 22°-10°W) - Iceland (72°-67°N) (cf. fig. 1) simulated with ECHO-G for 1000-1990 starting with warm ocean (ERIK1) and cold ocean (ERIK2) respectively compared with the reconstructed NAO from t2m of the Baltic catchment.**

Reconstruction by simple linear regression:

$$\hat{NAO}(t)_{recon} = \alpha_{cal} \cdot T(t)^{s}_{Baltic} \cdot \sigma_{NAO,cal}$$

predictor (pseudo-proxy):
geographical weighted avg. of T-Baltic, detrended, normalized to cal. period
calibration period: 1900-90, validated for 1900-49 and 1950-90

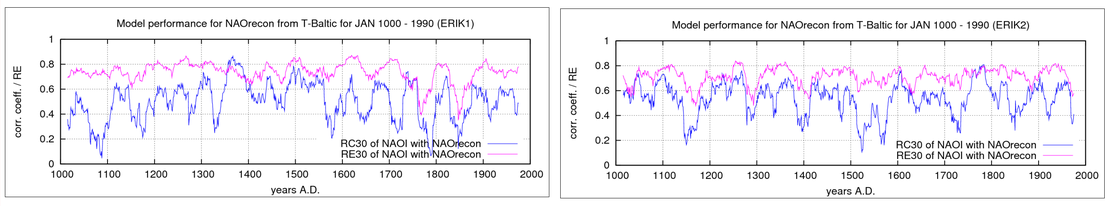


**Fig. 4: Performance of the statistical regression model, expressed through running correlations (RC30) and running reductions in error (RE30). Whereas the high RE shows the high skill of the used regression model, the lower and unstable RC indicates the high non-stationarity between the NAO and its impact on regional t2m.**

## 6 Non-stationarity in observations

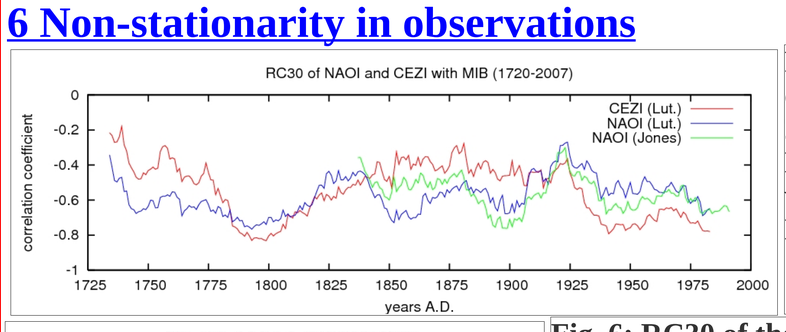


**Fig. 5: RC30 of the observed MIB (1720 - 2007) with the observed NAO (1824 - 2007) and with the reconstructed NAOI and CEZI (1720 - 1999), respectively.**

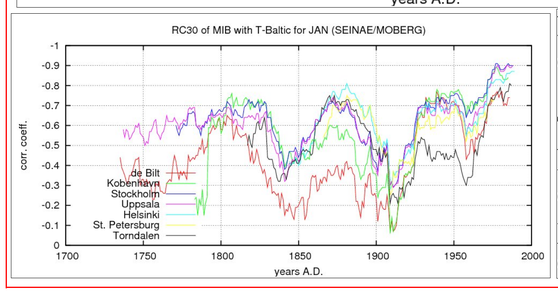


**Fig. 6: RC30 of the observed MIB with observed historical station temperatures.**

The temporal variability in the RC30 is very homogeneous in space over the Baltic catchment. Possible reasons like shifts in the pressure centers, causing different advection of heat, have to be studied in future.

## 7 Discussion

The relevance of mean climate or seasonal means are very theoretical for both, the impacts on human affairs/ecosystems as well as the understanding of short-term to decadal atmospheric mechanisms like the NAO or atmospheric blocking etc. The combined use of at least monthly climate reconstructions with model simulations should be mandatory for the understanding of the (internal) processes behind the historical climate anomalies and climate impact studies. The reasons for the strong non-stationarities between the NAO and the near-surface climate are presently investigated.