

## **Reconstruction of Baltic Sea data**

Hans von Storch

Institute for Coastal Research, GKSS Research Centre

Geesthacht, Germany

The reconstruction of the history of weather and climate in the Baltic Sea region is not only an intellectual challenge but also of practical importance for societal planning and decision making. One aspect concerns the statistics of extreme events, which may be estimated much more reliably if longer time series are available. This is in particular so since extreme events tend to emerge in clusters and not in well separated time intervals. Thus, 40 years of data will in many cases be insufficient of determining rare but possible events (such as the extraordinary storm surge in the Western Baltic sea and the end of the 19<sup>th</sup> century, which was much stronger than anything else since then). The other application is related to the detection of climate changes not related to natural climate variability, and the plausible attribution of such changes to human causes such as increased greenhouse gas concentrations.

### **1. Reconstructions based upon instrumental and proxy data**

Historical climatology (e.g., Pfister et al., 2001) is an expanding field within climate research. In this interdisciplinary community, a variety of data sets, both instrumental, documentary and indirect, is used to reconstruct past weather and climate variations. Examples are Rutgersson et al.'s (2002) 1901-1988 analysis of river runoff, maximum ice extent and derived net precipitation, using instrumental data, whereas Koslowski and Glaser (1999) have used documentary material to reconstruct ice conditions in the western Baltic sea since the early 18<sup>th</sup> century (Figure 1). Obviously, marked variations have taken place in the past. Sometimes these variations may be related to anomalies in the forcing of the climate system (as in case of the Late Maunder Minimum at the end of the 17<sup>th</sup> century (Zinke et al., 2003); see figure 1), but many episodes of extended reduction or excess intervals of ice extent can not be related to a specific "cause".

Many historical data can be successfully be used for reconstructing seasonal mean conditions (e.g. Pfister et al., 1998), but the frequency and intensity of extreme events is more difficult to reconstruct. One of the problems is that the impact of extreme events is not stationary but dependent on the social organization. For limited pre-modern times, such assessments can be reliably made (e.g., dyke damages in the Netherlands (de Kraker, 1999); or river flooding in the Alpine region (Pfister, 1999)). These studies demonstrate convincingly the temporal clustering of extreme events on time scales of decades of years. However, they hardly provide a quantitative reference for modern or even contemporary extreme events.

In case of wind-storms a number of indicators have been developed, mainly based on local air pressure observations (WASA, 1998). One such indicator for the strength of the storm climate is the width of the distribution of the short term temporal change of air pressure changes ( $\sigma_{p/t}$ , with  $\sigma$  several hours, often 12 hours) at a fixed location. Barring (1999) has examined the distribution at Lund, in Southern Sweden, since 1780 (Figure 2). According to this storm indicator, storminess in Southern Sweden has not undergone significant changes in the past 200 years, even if at the very end of the time series, a slight increase in the 95%iles can be seen. The apparent increase in storminess in the late 20th century has caused some

concern, but when compared to the history of storminess, this increase appears all but significant.

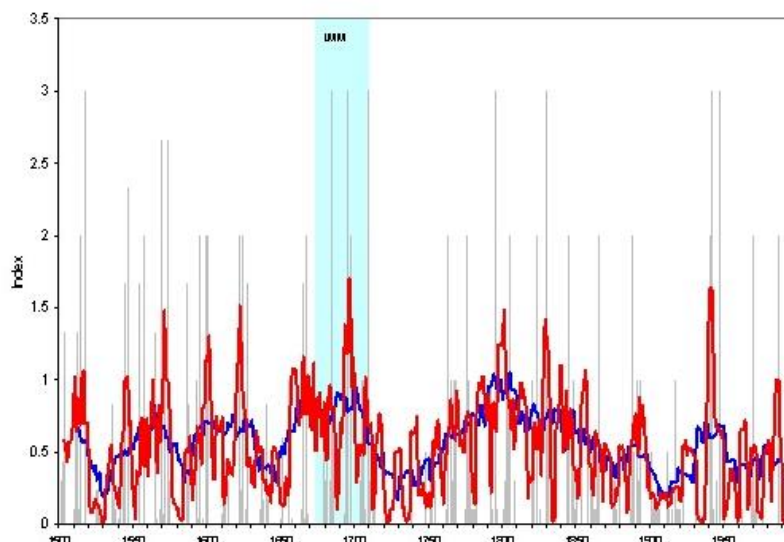


Figure 1: Severity of ice conditions in the Western Baltic Sea (grey vertical bars). Two smoothed curves are added as well. The Late Maunder Minimum episode is marked. From Koslowski and Glaser (1999).

Lund pressure tendency ( $\Delta p/\Delta t$ ), monthly percentiles  $P_{05}$  and  $P_{95}$

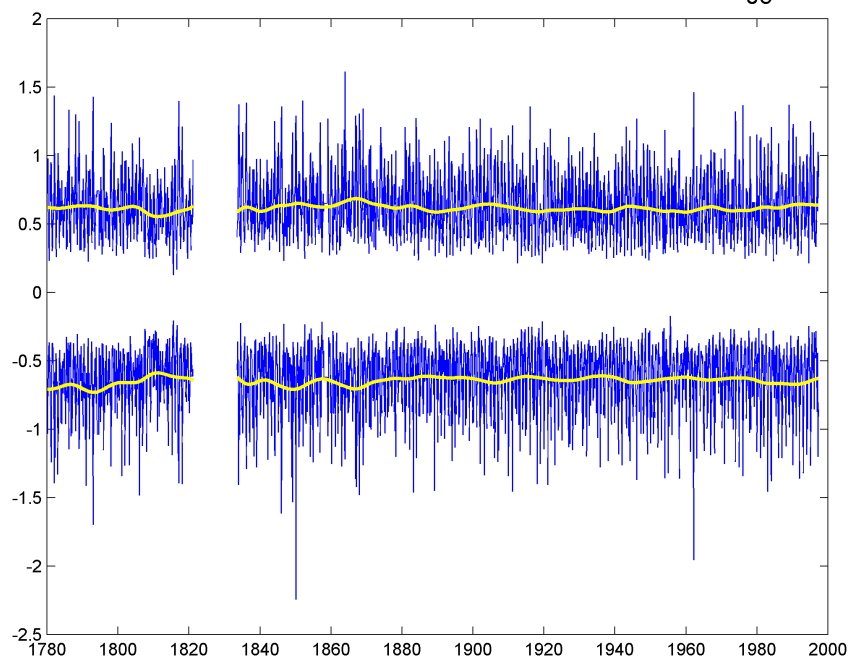


Figure 2: Monthly 5% and 95%iles of daily air pressure tendencies recorded at Lund, Southern Sweden for the years 1780 until 1997 (Bärring, 1999). During 1820 and 1840 the timing of the observations is insufficient.

## 2. Reconstructions with climate models

Downscaling, i.e. the estimation of regional or local characteristics using information about the large scale state (von Storch, 1995), can be achieved with statistical models and with

dynamical models of the regional climate. A variety of downscaling methods have been used to deal with the climate in the Baltic Sea catchment, such as Busuioc et al. (2001). Also dynamical methods are routinely used (Christensen et al., 2001).

The success of such simulations for the simulation of extreme event is presently examined (Christensen et al., 2001). Here we present a case dealing with wind storms and associated ocean wave heights in the North Sea (Weisse and Feser, pers. comm.). First a regional climate model was integrated using the NCEP re-analyses 1958-1997 with the spectral nudging method; then the resulting wind field were used to force the WAM model for ocean surface waves. The results for the location Ekofisk in the middle of the North Sea in terms of annual 50, 90, 95 and 99%iles of wind speed and significant wave height is shown in Figure 3. For comparison, earlier estimates form the WASA project (1998) as well as percentiles derived form local observations are added. The curves agree generally fine, but the observations are affected by some problems in the early 1980s; also, the WASA estimate, extending only until 1985, exhibit a slight overestimation since about 1980. Consistent with the findings of WASA (1998) and Barring (1999), does the regional climate model not point to a recent widening of the tails of the distributions of wind speeds.

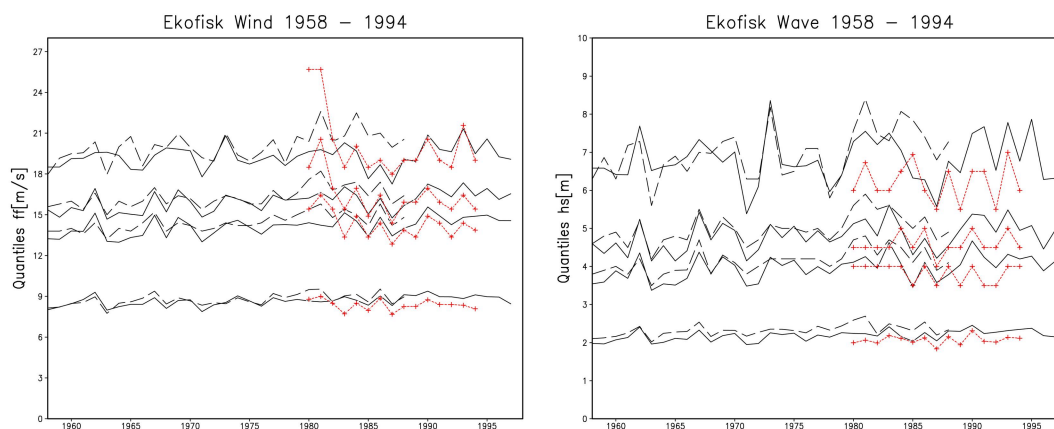


Figure 3: Annual 50, 90, 95 and 99%iles of wind speed and significant wave height at Ekofisk. Red: observations. Dashed: WASA project results (based on high res. DNMI analyses). Solid: Results obtained from regional climate model (Weisse and Feser, pers. comm.)

Historical climate can to some extent be reconstructed with global climate models, when external forcing in terms of solar output, and atmospheric loads of volcanic aerosols and greenhouse gas are given. One such integrations with ECHAM4/HOPE-C has recently be completed for the time 1550-2000 (Fischer-Bruns et al., 2002). In the end of the 17<sup>th</sup> century, a marked, almost global cooling emerges, which coincides with the observed phenomenon “Late Maunder Minimum”. Figure 4 shows the winter temperature anomalies, relative to a 1550-1800 normal, as simulated as estimated from historical evidence (Luterbacher, pers. comm.). The hatching in both figures indicates the confidence in the reconstruction, in terms of statistical significance (model) and proportion of variance described (historical data). Obviously, the model results are rather similar to the historical reconstruction. Presently, regional climate simulations are made to dynamically downscale the climatic anomalies during the Late Maunder Minimum (Müller, pers. comm.) to allow for an assessment of changing extreme conditions.

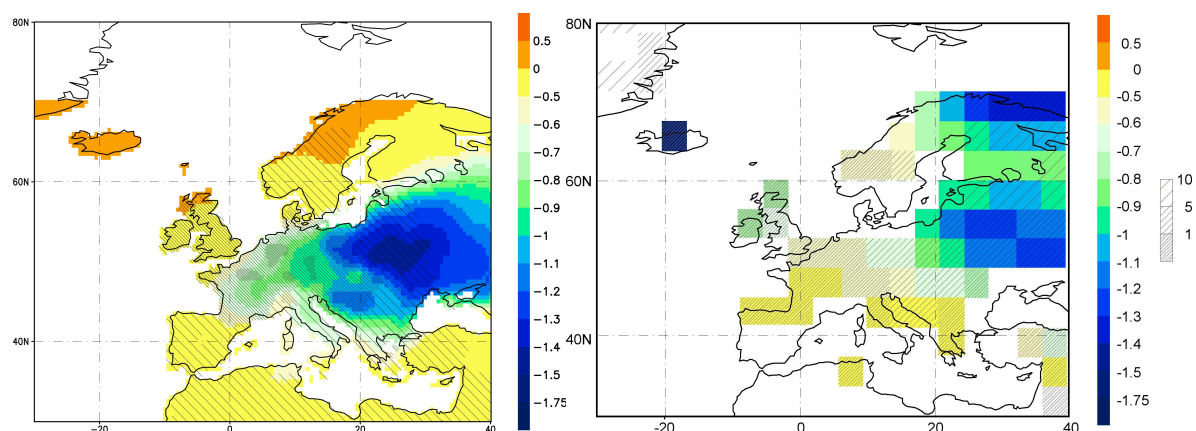


Figure: Winter temperature anomalies during the Late maunder Minimum (1675-1710) compared to a 1550-1800 preindustrial normal. Left: Estimate based upon historical evidence; right: model result. the hatching indicates the confidence in the data.

## References:

Barring, L., 1999: Preliminary analysis of pressure tendency variability in the Lund record (1780-), southern Sweden. proceedings Int. Conf. Climate Change & Variability - Past, Present & Future, Tokyo, Japan, 13-17 September, 1999.

Busuioc, A., D. Chen, and C. Hellström, 2001: Performance of statistical downscaling models in GCM validation and regional climate change estimates: Application for Swedish precipitation Int. J. Climatology, Vol. 21, 557-578

Christensen, J.-H., Räisänen, J., Iversen, T., Bjørge, D., Christensen, O. B. and Rummukainen, M. 2001, A synthesis of regional climate change simulations. A Scandinavian perspective. Geophys. Res. Lett. 28 1003-1006.

Christensen, O. B., Christensen, J. H., and Botzet, M., 2001: Heavy Precipitation Occurrence in Scandinavia Investigated with a Regional Climate Model. In M. Beniston (ed.): Implications of climatic change for the hydrological cycle and for water management, Advances in Global Change Research, 10. Kluwer Academic Publishers, 101-112.

De Kraker, A.M.J., 1999: A method to assess the impact of high tides, storms and storm surges as vital elements in climate history. The case of stormy weather and dikes in the Northern part of Flanders, 1488-1609. Climatic Change 43: 287-302

Fischer-Bruns, I., U. Cubasch, H. von Storch, E. Zorita, J. F. Gonzáles-Rouco and J. Luterbacher, 2002: [Modelling the Late Maunder Minimum with a 3-dimensional OAGCM](#), CLIVAR exchanges 7, 59-61

Koslowski, G., and R. Glaser, 1999: Variations in reconstructed ice winter severity in the Western Baltic from 1501 to 1995, and their implications for the North Atlantic Oscillation. Climatic Change 41: 175-191

Pfister, C., 1999: Wetternachhersage. 500 Jahre Klimavariationen und Naturkatastrophen 1496-1995. Haupt, Bern Stuttgart Wien, pp 304

Pfister, C., R. Brazdil, B. Obrebska-Starkel, L. Starkel, R. Heino and H. von Storch, 2001: [Strides made in reconstructing past weather and climate](#). EOS 82, 248

Pfister, C., J. Luterbacher, G. Schwarz-Zanetti and M. Wegmann, 1998: Winter air temperature variations in western Europe during the early and High middle ages (AD 750-1300). Holocene 8, 535-552

Rutgersson, A., A. Omstedt and J. Räisänen, 2002: Net precipitation over the Baltic Sea during present and future climate conditions. *Clim Res.* 22: 27-39

von Storch, H., 1995: Inconsistencies at the interface of climate impact studies and global climate research. - *Meteorol. Zeitschrift* 4 NF, 72-80

WASA, 1998: Changing waves and storms in the Northeast Atlantic? *Bull. Amer. Met. Soc.* 79, 741-760

Zinke, J., H. von Storch, B. Müller, E. Zorita, B. Rein, H. B. Mieding, H. Miller, A. Lücke, G.H. Schleser, M.J. Schwab, J.F.W. Negendank, U. Kienel, J.F. González-Ruoco, Christian Dullo and Anton Eisenhauser, 2002: Evidence for the climate during the Late Maunder Minimum from proxy data available within KIHZ. *KIHZ Proceedings*. Springer Verlag. (in press)