A wind direction analysis for the Baltic Sea region: Is it possible to draw conclusions from mean wind statistics on extreme wind statistics?

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Motivation

The study of wind fields is of high interest for many different research disciplines. To investigate extremes on decadal timescales homogeneous time series of observed daily wind data are necessary. Unfortunately such data sets are rarely available. Alternatively, dynamical modeling approaches can be applied to produce regional high-resolution data sets for the recent past. The analysis of such homogenous data sets with statistical methods allow for more robust information and can be very useful for different research communities, for instance for the validation of paleoclimate reconstructions from proxy data or the investigation of changing coastlines due to recent climatic changes and impacts with relevance for regional planning agencies. A literature research within different research disciplines showed that statistics of mean wind changes are often directly applied to changes in extreme wind statistics. However, in the scientific community there is still low confidence in how observed trends in mean wind speed are related to trends in extreme wind (IPCC-SREX: Seneviratne et al. 2012). In the following we try to verify this issue for the Baltic Sea Region. Furthermore, the predominant extreme wind directions and its temporal changes are analyzed.

Data

For our main investigation the reanalysis data set **coastdat2** (Geyer 2013) for the time period from **1948 to 2012** is used. This data set is the result of a regional climate simulation (CLM-Community Land Model) conducted with spectral nudging and driven by the boundary forcing of NCEP (National Centers for Atmospheric Prediction) reanalysis to gain a higher temporal and spatial resolution. Hourly data on a 12,8 * 12,8 (km) grid is available for central Europe, but for this study only daily data was used above the Baltic Sea area (Fig. 1). (www.coastdat.de)

To investigate the temporal changes on longer time scales we used another reconstruction data set. Therefore spatio-temporal **HI**gh **RES**olution **A**tmospheric **F**orcing **F**ields (**HIRESAFF**) (Schenk and Zorita, 2012) for Northern Europe since **1850 to 2009** have been reconstructed using the analog method. The analog method reconstructs daily atmospheric fields from long historical station data of daily SLP and monthly T2m. 'Analogus' fields are searched in a pool of atmospheric fields taken from a regional climate model (RCAO: 1958-2007).

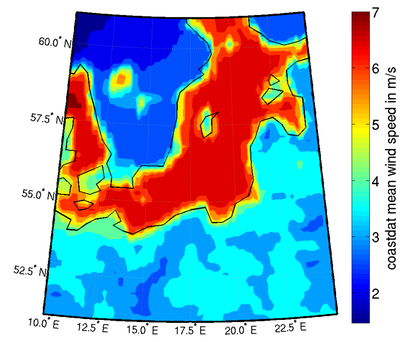

Figure 1. Investigation area: Colors show the mean wind speed in [m/s] of the coastdat2 data set.

Extremes from SW & W

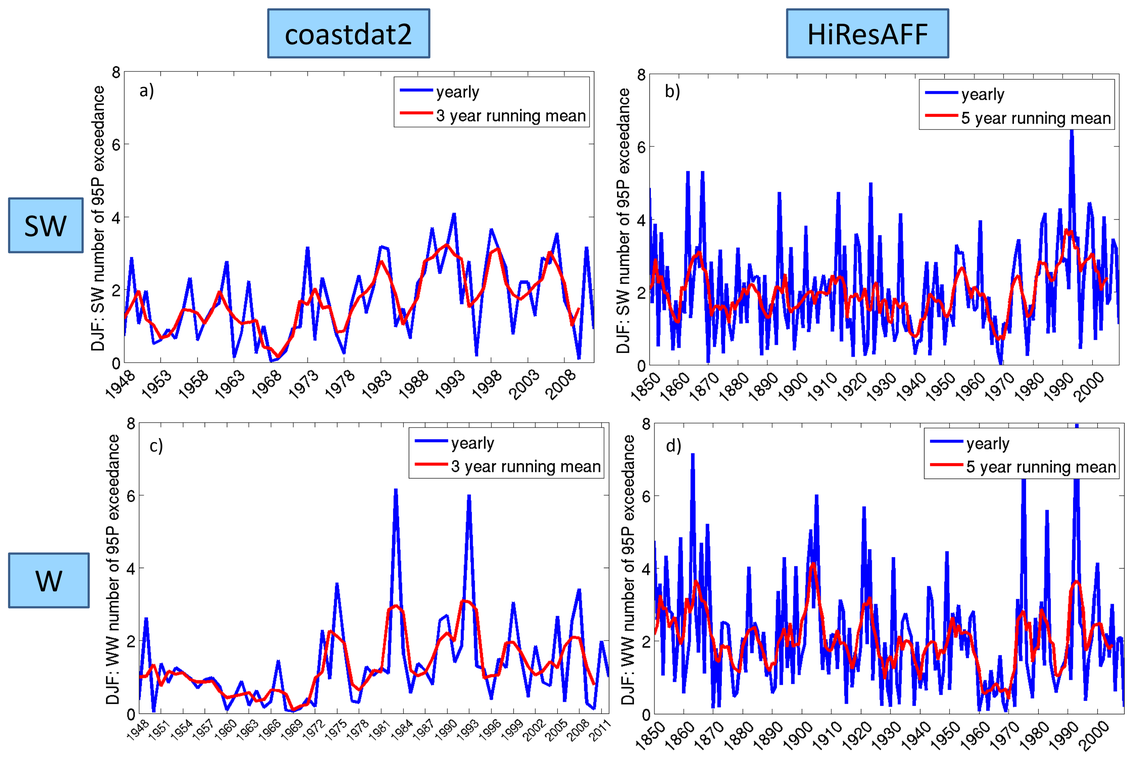

Figure 4. Number of extreme wind events in winter (DJF) from SW (upper panels) and W (lower panels) which exceeds the 95th percentile of wind speed. Left: Yearly (blue) and 3 year running (red) mean of the costdat2 data set. Right: Yearly (blue) and 5 year running (red) mean of the HiResAFF reconstruction data. There is no long term trend, but a significant increase since the early 1970s till the 1990s. This is especially true for SW wind extremes.

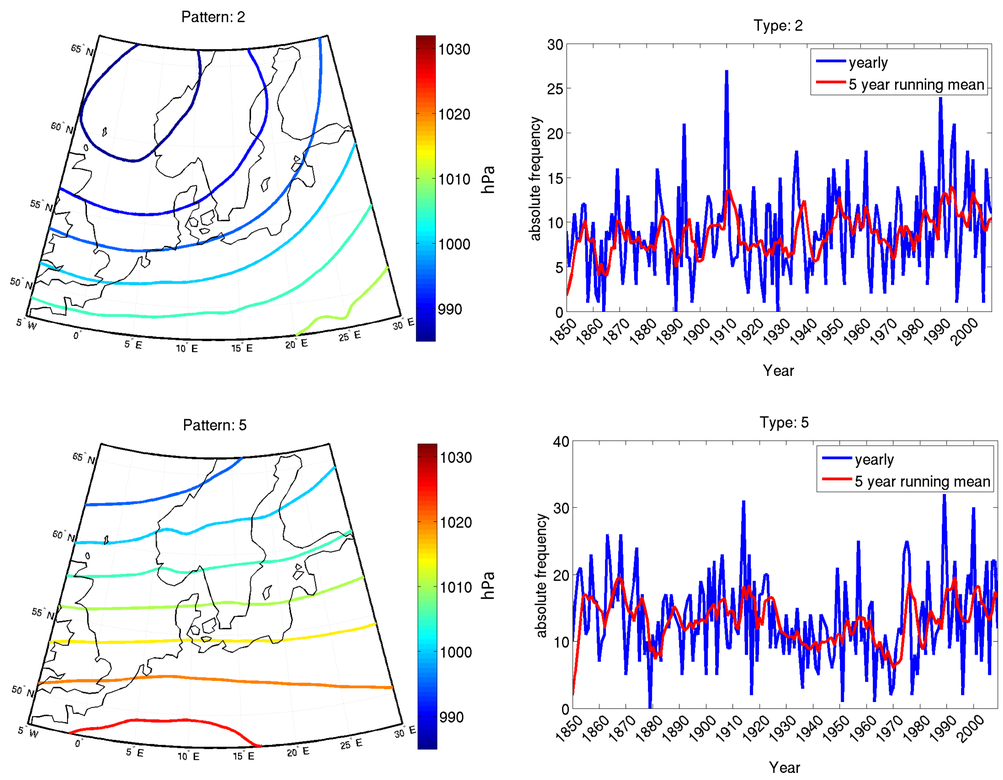

Figure 5. k-mean cluster analysis for winter (DJF) with the principal components of a previous conducted EOF (empirical orthogonal function) analysis of daily sea level pressure from HiResAFF data. Left: Mean pressure field for cluster type 2 (upper panel) and 5 (lower panel) which respectively represents the pressure conditions during SW and W wind over the Baltic Sea. Right: Yearly and 5 year running mean of type 2 (upper) and 5 (lower) frequencies. Especially type 2 shows a good comparability with SW wind extremes (Fig. 4b).

Wind speed & direction

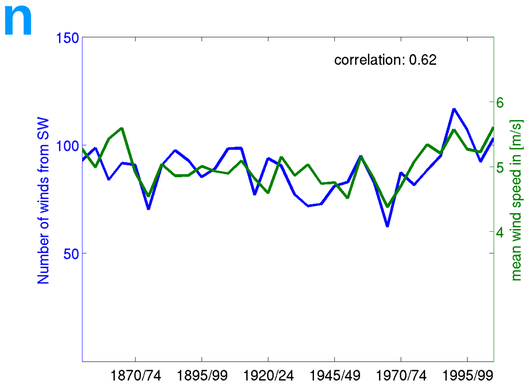

Figure 3. Number of five year sum of SW winds over the south-western Baltic Sea (blue) and five year mean of wind speed (green) both for winter (DJF). Time series have a statistical significant ($p<0.05$) correlation value of 0.62.

Mean and Extremes

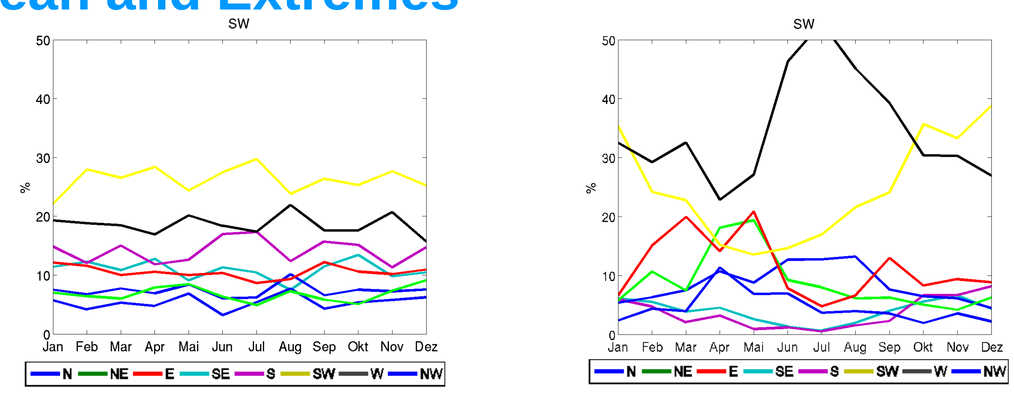

Figure 2. Wind direction frequency per month for the south-western Baltic Sea area. For 3 wind events per month closest to the 50th percentile (left) and for wind events which exceeds the 90th percentile of wind speed (right). Predominant extreme wind directions are SW and W during the whole year.

Conclusion and Outlook

We investigated whether direction-related statistics of extreme wind events follow statistics of mean wind and thus whether changes in mean wind statistics can be used to approximate extreme wind changes. The results show, that this hypothesis is not valid over the Baltic Sea region.

Temporal changes in frequencies of extreme winds from W and SW have been detected. These changes can be related to changes in the occurrence of special circulation weather types. Further investigations will focus on the influence of large-scale phenomena (e.g. sea level pressure patterns). The analysis of the low frequent variability of extreme winds will be extended to millennium time scales due to millennium regional climate model simulations.

References:

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Seneviratne et al. 2012: Changes in climate extremes and their impacts on the natural physical environment. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field et al.(eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change, 109-230.