balt adapt

Baltic Sea Region
Climate Change Adaptation Strategy

Climate Change in the Baltic Sea Region: Wind Climate

BALTADAPT CLIMATE INFO # 3

Wind climate in the Baltic Sea Region

The wind climate in the Baltic Sea Region is to a large degree governed by the large-scale atmospheric circulation. Therefore southwesterly to westerly winds are dominating, most notably during the winter half of the year. Naturally, there is a large degree of variability in the winds in the region, both on spatial and temporal scales. Locally, orography, land-sea contrasts, boundary layer characteristics, etc. modify the general wind direction and speed. Similarly, synoptic, seasonal and inter-annual variability leads to differences in wind from day to day or from one year to another. On the synoptic time scale mid-latitude cyclones are responsible for the strongest wind storms while extreme events on shorter and local scales often can be associated with outbursts from deep convective clouds.

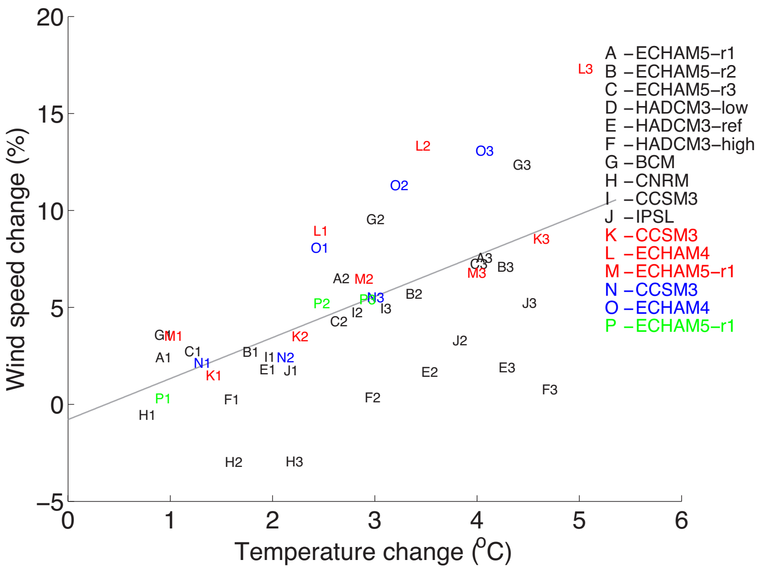

__Figure 1:__ Regional climate model projections of change in annual mean wind speed (%) versus changes in near-surface temperature (°C) over all the southern parts of the Baltic Sea. Emission scenarios and forcing global climate model for each of the 16 simulations are indicated in the legend (A-P). Simulated changes compared to 1961–1990 are shown for three different time periods; (1) 2011–2040, (2) 2041–2070 and (3) 2071–2100. The grey line is a least-square fit to the data (the slope k is 2.1 % / °C and the correlation coefficient r is 0.59). For details see Kjellström et al. (2011).

Long-term changes in the wind climate of the region are mainly related to changes in the large-scale atmospheric circulation. Changes in extreme wind conditions are to a large degree governed by changes in frequency and magnitude of mid-latitude cyclones.

Simulated climate change signal

Most, but not all, global climate models (GCMs) project an increase in the north-south pressure gradient over large parts of central and northern Europe over the 21st century as a result of a decrease of the surface pressure in the Arctic and an increase in the sub-tropics. This is indicative of a northward shift in the mid-latitude storm track and of an increase in the westerly flow on average. The exact area where the north-south pressure gradient is projected to increase differs substantially between different models implying that there is a large uncertainty as to whether wind speed will increase or not (Lind and Kjellström, 2008) in a particular location. Furthermore, the agreement between the GCMs in terms of future changes in the intensity and frequency of mid-latitude cyclones is low (IPCC, 2007). Taken together, the differences between different GCM projections imply that changes in the future wind climate in northern Europe are highly uncertain.

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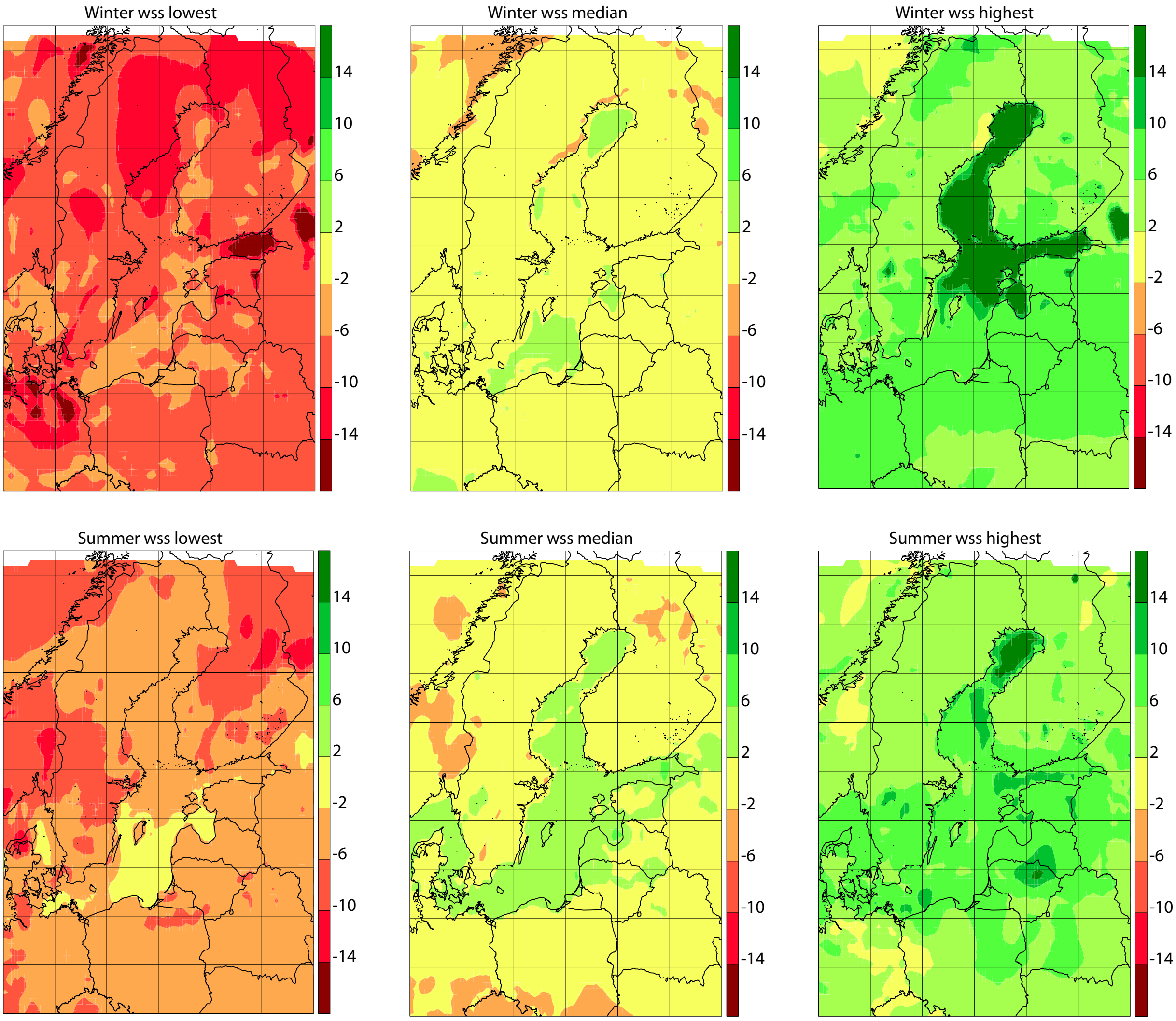

Figure 2: Simulated change in average wind speed (%) between 1961–1990 and 2071–2099 according to SRES A1B. The maps show the point wise most negative (left), median (middle) and most positive (right) climate change signal taken from an ensemble of 13 RCMs downscaling different GCMs. Upper row shows winter (DJF) changes and lower row summer (JJA).

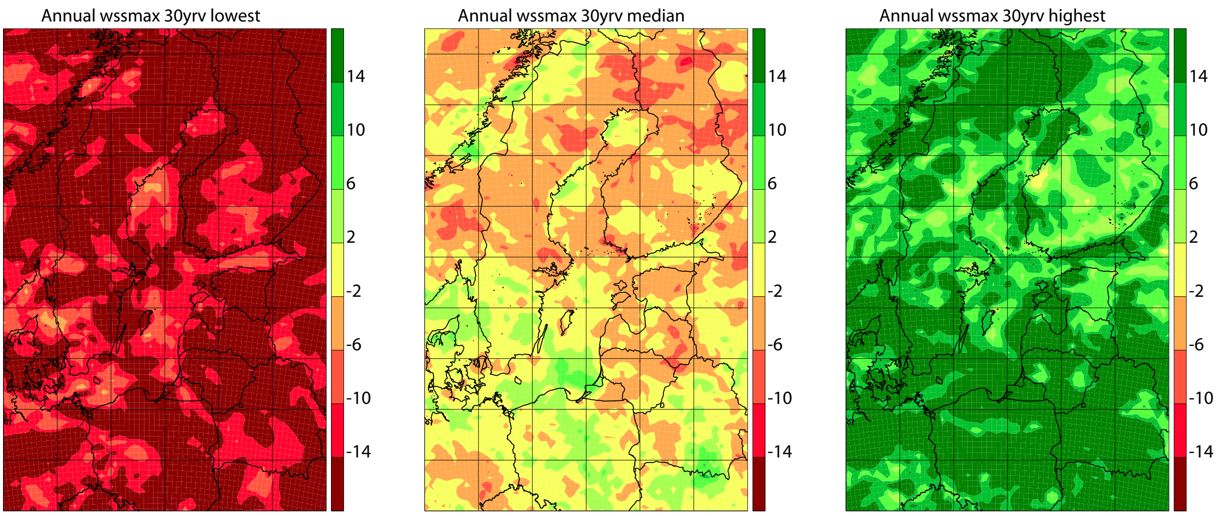

Figure 3: Simulated change in 30-year return value of maximum wind speed (%) between 1961–1990 and 2070–2099 according to SRES A1B. The maps show the point wise most negative (left), median (middle) and most positive (right) climate change signal taken from an ensemble of 13 RCMs downscaling different GCMs.

Climate scenario data

Results on future changes in wind speed presented here are taken from numerical climate models. The global climate models (GCMs) used here were run in the 3rd climate model intercomparison project (CMIP3) that underlies much of the IPCC fourth assessment report on climate change (IPCC AR4, 2007). In addition to the CMIP3 GCMs also regional climate models (RCMs) have been used. Here, results from RCM simulations undertaken within the European FP5 and 6 projects PRUDENCE (Christensen et al., 2007), ENSEMBLES (van der Linden and Mitchell, 2009) and at SMHI (Kjellström et al., 2011) are used. These are performed on a domain covering most of Europe. The RCMs downscale GCM results to a higher spatial resolution: typically 25–50 km, compared to the GCM resolution of 100–300 km. The finer spatial scale in the RCMs implies that impact on climate from land-sea contrasts and altitude of mountains can be described in more detail than in the GCMs. Further, the climate change signal can be studied in finer detail more representative in terms of climate change impacts and adaptation work. We note that even if RCMs have high spatial resolution they preserve many features of the GCM simulations. This implies that uncertainties related to e.g. large-scale atmospheric circulation patterns, climate sensitivity, and/or emission scenarios exist also in the RCM results. The CMIP3 simulations make use of a series of emission scenarios representing different story lines for the future (Nakićenović et al., 2000). These, so called SRES scenarios describe the evolution of the world in the 21st century. Altogether 40 different SRES emission scenarios were constructed based on assumptions about world population, economic development, technological changes etc. Six of these (A1B, A1T, A1FI, A2, B1 and B2) were chosen by the IPCC as marker scenarios. Most CMIP3 model simulations are forced by the A2, A1B and B1 emission scenarios representing: high (A2), intermediate (A1B) and relatively low (B1) increases in greenhouse gas concentrations during the 21st century. RCM simulations for Europe mostly involve the A2, A1B and B2 scenarios.
Presently, autumn 2011, a large number of new global and regional climate model integrations with a set of new emission scenarios are being produced by the international climate modelling community. These will serve as input for the next IPCC assessment report in 2013/2014. A novelty compared to the SRES scenarios is that some of the new scenarios take mitigation into account.

Regional climate model (RCM) scenarios are highly dependent on the choice of forcing GCM. In Figure 1 results from 16 RCM simulations show a general increase in annual mean wind speed over time (as the temperature increases) over the southern Baltic Sea. However, it is clear that not all model simulations show this behaviour; in some cases no increase, or a small decrease, is projected. It is not just the magnitude, but also the spatial pattern of wind speed changes that differ between different scenarios. In Figure 2 results from an ensemble of RCM simulations reveal that many model simulations tend to show a larger increase (or smaller decrease) over the Baltic Sea. This is a result of the warmer sea surface in the scenarios. With a warm sea surface the lower atmosphere is not as stably stratified as in the control climate, thereby promoting higher wind speeds at the surface. The effect is most notable in the northern parts of the Baltic Sea in winter when sea ice to a large extent is disappearing in the scenarios. In this context we note that the sea surface temperatures are taken from global climate models that have a coarse resolution and may not represent conditions in the Baltic Sea in a realistic way.

As GCMs differ in terms of how mid-latitude cyclones may change in intensity and frequency it is difficult to draw any strong conclusions on how wind extremes may change in the Baltic Sea Region. Studies of RCM scenarios show that changes in wind extremes are highly variable in space and that there is little coherence between different simulations as to where wind speed is projected to increase or decrease. One area where there is an indication of increasing extreme winds in several scenarios is the southern parts of the Baltic Sea (Figure 3), but also in that area there are large differences among different simulations (Nikulin et al, 2011; Pryor et al, 2011).

Summary and outlook

Climate change simulations reveal a large spread in changes in wind speed in the Baltic Sea region. A majority of GCMs show an increase of wind speed over the Baltic Sea in a future warmer climate but the uncertainty is large.

Projected changes in wind extremes are quite uncertain, with a slight tendency to an increase in the south and a decrease in the north of the Baltic Sea Region. As an implication of the large uncertainty in projected wind speed changes also changes in wind-driven ocean currents is highly uncertain.

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For further information please contact:

Ole Bøssing Christensen
Danish Meteorological Institute
Lyngbyvej 100
2100 København Ø
Denmark
obc@dmi.dk

Erik Kjellström
Swedish Meteorological and Hydrological Institute
Folkborgsvägen 1
601 76 Norrköping
Sweden
erik.kjellstrom@smhi.se

Baltadapt Lead Partner:

Danish Meteorological Institute
Centre for Ocean and Ice
ocean.dmi.dk

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The Baltadapt project in a nutshell

The Baltic Sea and its coastlines face challenges due to climate change …
Climate change will influence precipitation amounts and patterns, and lead to an increase in terrestrial and sea temperatures and a rise in sea level. The resulting changes will jeopardize the integrity of the ecosystem and increase risks caused by natural disasters.

… it is time to adapt now!
Adaptation strategies are needed to cope with the inevitable consequences of climate change. This is also highlighted in the EU Baltic Sea Region Strategy. Baltadapt is developing a transnational climate change adaptation strategy for the Baltic Sea Region, which focuses on the sea and the coastline.
Baltadapt can't stop climate change but it will help to adapt to its impacts. The project facilitates a knowledge-brokerage process on climate change adaptation between research and policy, thus contributing to improved institutional capacity. This will help decision makers in the Baltic Sea Region to tackle the consequences of climate change.
The project was approved under the Baltic Sea Region Programme 2007–2013 and has a total budget of € 2.86 m. Its partner consortium is led by the Danish Meteorological Institute. Baltadapt is a flagship project under the EU Strategy for the Baltic Sea Region and has been awarded the Baltic 21 Lighthouse Project quality label.

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