balt adapt
Baltic Sea Region
Climate Change Adaptation Strategy

Climate Change in the Baltic Sea Region: Air Temperature

BALTADAPT CLIMATE INFO # 1

Temperature climate in the Baltic Sea Region

The temperature climate in the Baltic Sea Region is strongly influenced by the large-scale atmospheric circulation. Frequent south-westerly to westerly winds generally bring relatively mild air into the region leading to a maritime climate, most prominently in the south-western part of the region (Denmark and Northern Germany). Farther to the east and north-east the climate gets more continental with a stronger seasonal cycle in temperatures. The annual mean temperature differs by more than 10 °C between the coldest parts of north-eastern Finland and the warmest parts of Germany. Inter-annual variability in large-scale circulation leads to large differences in temperature from one year to another. Long-term changes in the temperature climate of the region are related both to overall global temperature change and to changes in large-scale atmospheric circulation and North Atlantic sea surface temperatures.

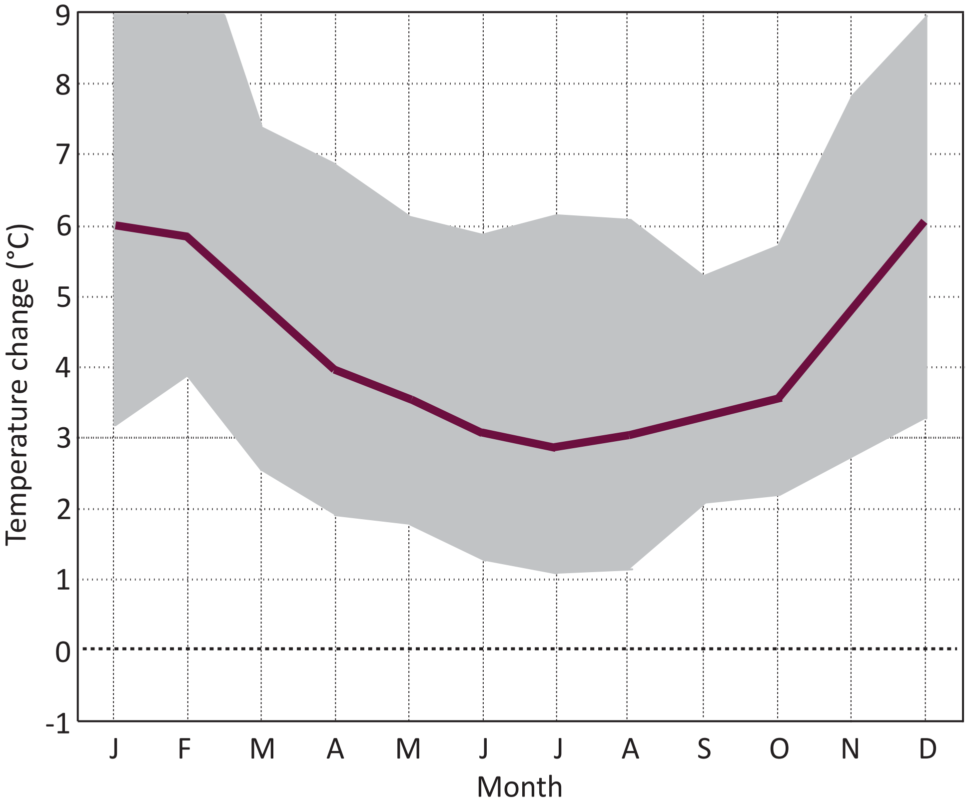

Figure 1: *Ensemble mean (red) and one standard deviation (grey shading) of projected temperature change in northern Sweden as calculated based on 20 CMIP3 AOGCMs under the SRES A2 scenario (Lind and Kjellström, 2008). Thirty-year averages of monthly mean data have been compared between 1961–1990 and 2071–2100. The annual mean global warming for these simulations is slightly less than three degrees.*


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Simulated climate change signal

According to climate model projections, temperatures in the Baltic Sea area are expected to increase with time, and the increase is generally larger than the corresponding increase in global mean temperature. The increase grows with time and after around 2040–2050 there is a marked difference between different emission scenarios with high-emission scenarios leading to exceedingly higher temperatures. The strong increase in the region is to a large degree a result of a strong wintertime temperature increase (Figure 1), which is in turn a result of the feedback mechanism involving retreating snow and sea ice cover. These lead to even higher temperatures through an increased absorption of heat from sunlight and larger heat fluxes between the surface and the atmosphere in absence of an isolating snow cover.

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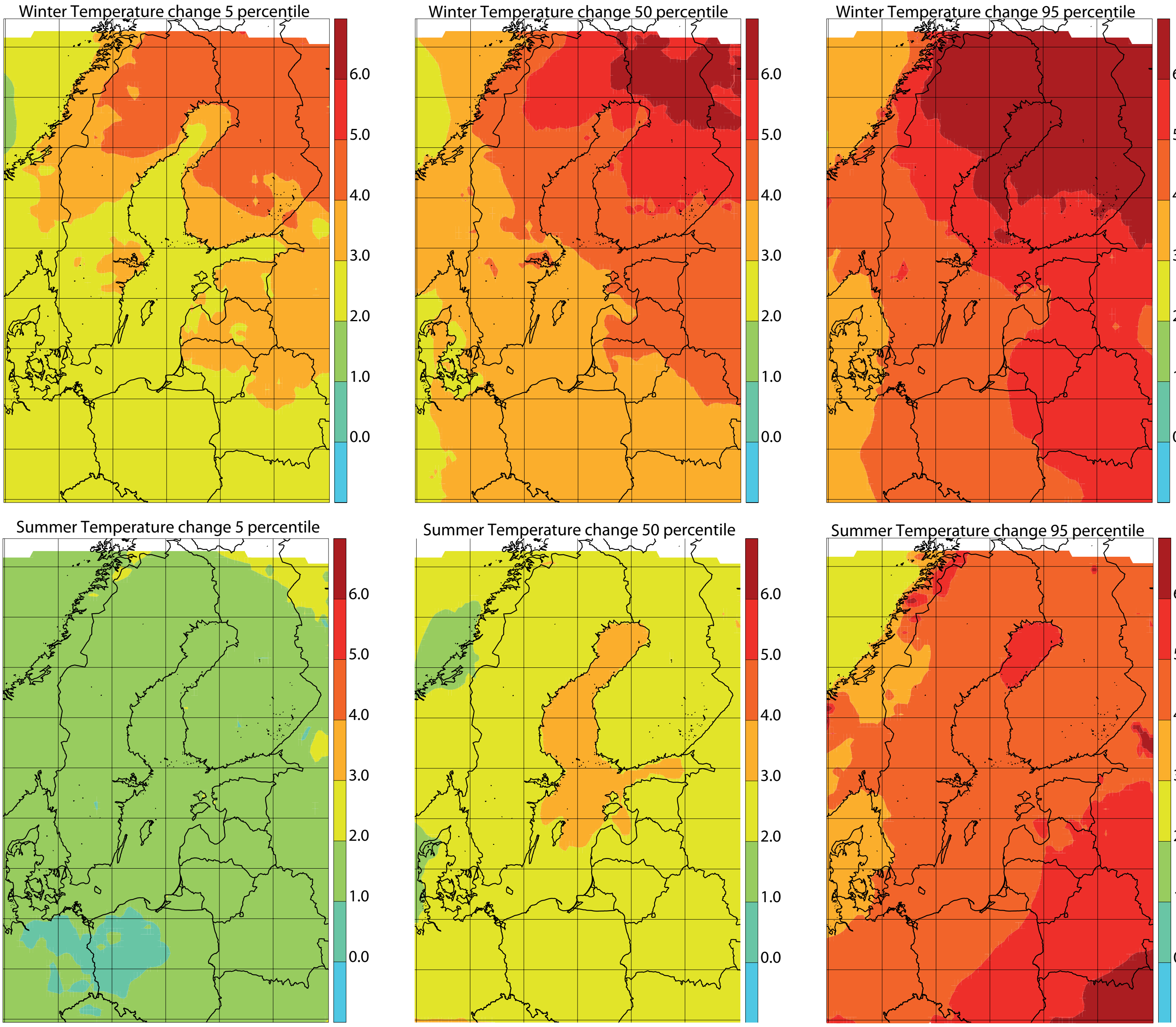

Figure 2: Simulated temperature change (°C) between 1961–1990 and 2071–2099 according to SRES A1B. The maps show the pointwise weakest (left), median (middle) and strongest (right) climate change signal taken from an ensemble of 11 RCMs downscaling different GCMs. Upper row shows winter (DJF) changes and lower row summer changes (JJA).

The spatial pattern of warming in winter shows a larger increase in the north-eastern part of the region (Figure 2), which is again related to the interaction with snow as mentioned above. In summer, the spatial pattern of simulated climate change differs more between different regional climate model (RCM) and global climate model (GCM) combinations. In general, it is more uniform than the winter signal, but in some cases a stronger warming is simulated for the Baltic Sea and in some cases the strongest warming is seen in the southeast of the region. The absolute change in temperature differs between different simulations.

These differences reflect parts of the overall uncertainty related to the climate change signal. We note that even if there is a large spread between different simulations, the simulated climate change signal is strong and statistically significant compared to natural variability.

Not only average temperatures show significant future changes in climate simulations (e.g. Benestad, 2011). The strong increase in wintertime temperatures discussed above for seasonal averages are even more pronounced for the coldest episodes (Kjellström

2004; Kjellström et al., 2007; Nikulin et al., 2011) with a significant decrease in the probability of cold temperatures (Figure 3). In summer, warm extremes get more pronounced than in today's climate. As an example Nikulin et al. (2011) show that the recurrence time for warm extremes, as defined in today's climate, was reduced from 20 years to around 5 years in Scandinavia comparing 2071–2100 with 1961–1990 in an ensemble of six RCM simulations all downscaling GCMs under the A1B emission scenario.

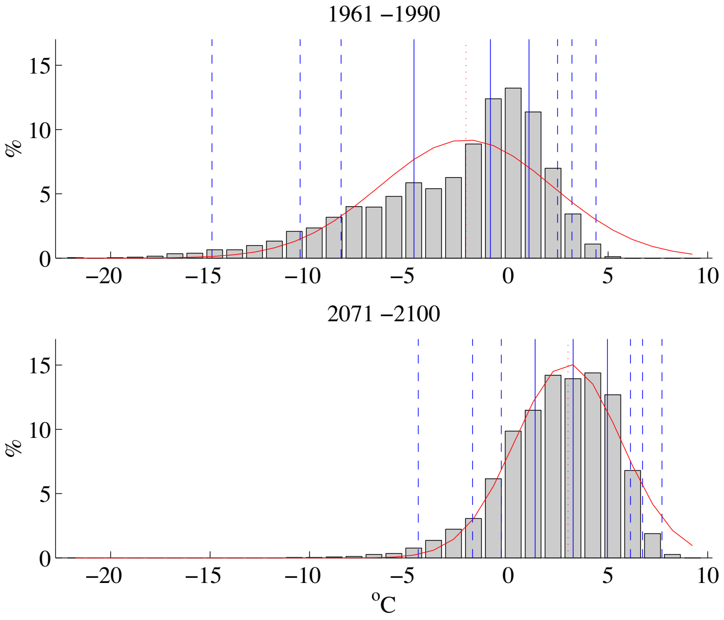

Figure 3: *Probability distributions of simulated daily average winter temperatures for Stockholm (59°21'N, 18°03'E) for 1961–1990 (upper panel) and 2071–2100 under the SRES A2 emission scenario (lower panel) in one RCM (see Kjellström 2004 for details). The mean (dotted), 25th, 50th and 75th percentiles (full line) and 1st, 5th, 10th, 90th, 95th and 99th percentiles (dashed) of the data are shown as well as a Gaussian distribution with the same mean and standard deviation as in the actual distribution. The total data for each plot is about 2700 days (30 model days in December, January, and February for 30 years).*

Summary and outlook

Climate change simulations reveal strong changes in air temperature in the Baltic Sea Region. The simulated increase is already statistically significant in the nearest few decades compared to the most recent past decades.

The changes are largest in winter and most so in the north-eastern part of the domain, where a coupling to a reduction in snow and sea ice is evident. Temperature extremes are projected to change more than long-term averages. In winter this implies that cold extremes in today's climate will get very unusual in a future warmer climate, while summertime hot extremes are expected to be more intense than those today.

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Climate scenario data

Results on future changes in air temperature 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 FP6 projects PRUDENCE (Christensen et al., 2007) and ENSEMBLES (van der Linden and Mitchell, 2009) 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 storylines 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 involves 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.

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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s.Pro – sustainable projects GmbH
www.sustainable-projects.eu

www.baltadapt.eu

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The Baltadapt project in a nutshell

The Baltic Sea and its coastlines face challenges due to climate change. The projected increase in precipitation amounts and temperature will jeopardize the integrity of the ecosystem and increase risks caused by natural disasters. Adaptation strategies are needed to cope with the inevitable consequences of climate change. Baltadapt is developing a transnational climate change adaptation strategy for the Baltic Sea Region. This will help decision makers allover the 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.