



# balt adapt

Baltic Sea Region  
Climate Change Adaptation Strategy

## Climate Change in the Baltic Sea Region: Precipitation

### BALTADAPT CLIMATE INFO # 2

#### Precipitation climate in the Baltic Sea Region

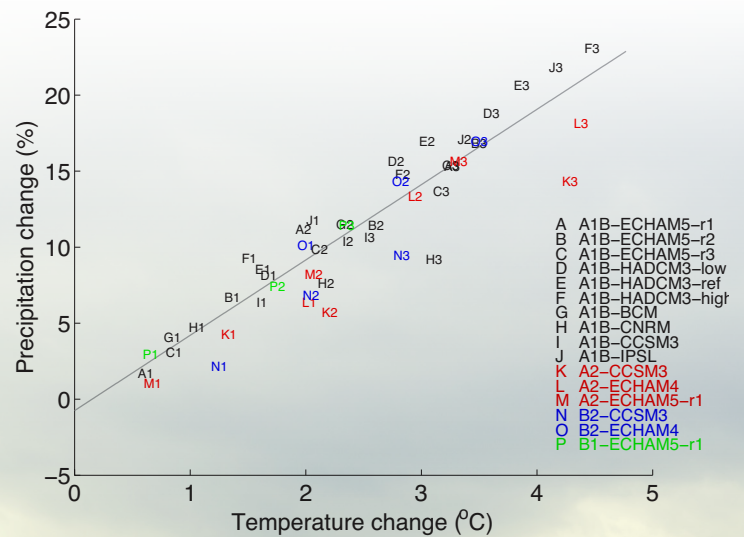
The precipitation climate in the Baltic Sea Region is under strong influence from the large-scale atmospheric circulation. Frequent south-westerly to westerly winds generally bring relatively mild and moist air into the region. The annual amount of precipitation is about twice as large in the southwest as in the northeast. However, there are strong local deviations from this large-scale pattern, most notably in mountainous areas where precipitation locally can be much higher. Precipitation exhibits a pronounced annual cycle with maximum precipitation in July and August and lowest in February to April. Inter-annual variability in the large-scale circulation leads to large differences in precipitation from one year to another. Long-term changes in the climate of the region are related both to overall global temperature change and to changes in the large-scale atmospheric circulation.

#### Simulated climate change signal

In response to a future warmer atmosphere, that can hold more moisture, climate models project an intensification of the global hydrological cycle. On a European scale this implies more precipitation in northern Europe and less in the south in both winter and summer. In between there is a broad zone extending some 500–1000 km or more in the North-South direction where only small changes are projected. This border zone moves with the seasons and is located more to the south in winter and more to the north in summer.



The implication of this migration is increasing precipitation in all of the Baltic Sea runoff region in winter, while in summer increases in precipitation are projected only for the northern parts of the basin. In the south, precipitation is projected to change only little, or even decrease. On an annual mean basis the precipitation in the Baltic Sea runoff region is projected to increase and there is a strong correlation to the increase in temperature (Figure 1). We note here that differences between different climate models concern not just the magnitude of precipitation change but also the sign as the border zone is located differently in different models.



**Figure 1:** Regional climate model projections of change in annual precipitation (%) versus changes in near-surface temperature (°C) over all land in the Baltic Sea runoff region. 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 4.95%/°C and the correlation coefficient  $r$  is 0.93). For details see Kjellström et al. (2011).



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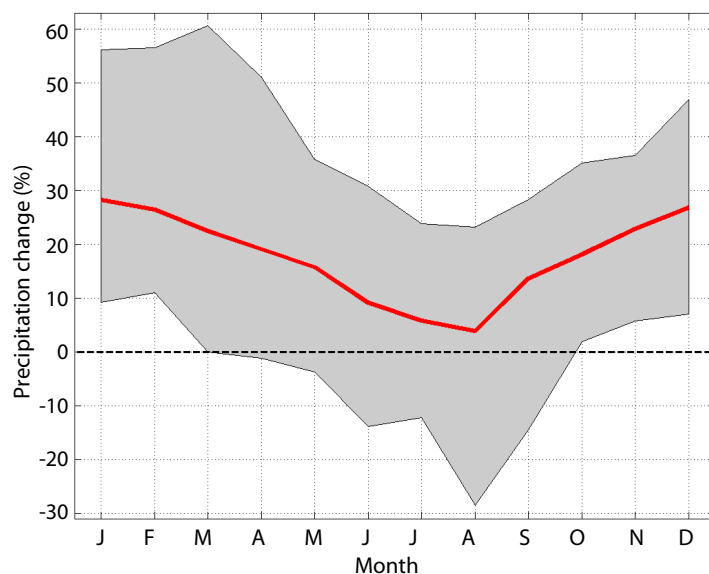
## BALTADAPT CLIMATE INFO #2

Figure 2 illustrates how the seasonal cycle of precipitation in a part of the northern basin is projected to change according to an ensemble of global climate model integrations. The ensemble mean indicates a strong increase in precipitation in the winter half of the year. In summer, changes are smaller, and uncertain in sign as discussed above.

While the large-scale changes are similar in all scenarios, the geographical details of the change in precipitation differ between different simulations as indicated in Figure 3 that shows results from an ensemble of 11 regional climate model runs. The climate change signal is relatively uniform in winter but there are exceptions as some results point to possible decreases in precipitation in the Bothnian Sea and Bothnian Bay and over parts of western Norway. These changes are related to changes in sea-surface temperatures and to large-scale atmospheric circulation characteristics. In summer the differences between the northern and southern parts of the basin are clearly seen in the figure. In particular, we note that the entire basin will experience more precipitation according to some models, while there are models predicting pronounced decreases in the south.

A general tendency in climate change scenarios is that heavy precipitation can increase in a warmer climate as a result of the larger water-holding capacity of the atmosphere. Such a tendency of increasing heavy precipitation events is projected also for the Baltic Sea basin for extreme events of sub-daily, daily and for precipitation integrated over a week. The tendency is evident both for relatively common extremes (e.g. events with a 1-year return period viz. events that takes place once a year in a statistical sense) and for rare events (e.g. events with a 30-year return period). As an example we show results for changes in summertime (JJA) 30-year return periods of daily precipitation extremes from an en-

semble of nine regional climate models in Figure 4. Most of the models show increases in extreme daily precipitation in large parts of the Baltic Sea basin as seen from the median over the models in each grid point. This holds true also for other seasons (not shown). The figure shows that there is an increase in precipitation amount associated with extreme events also in areas where seasonal mean precipitation may decrease (cf. Figure 3). We note, however, that the signal is not spatially uniform in the models, and therefore there is a range spanning from decrease to substantial increase in precipitation at almost all grid points in the entire area.



**Figure 2:** Ensemble mean (red) of projected precipitation change in northern Sweden as calculated based on 20 CMIP3 AOGCMs under the SRES A2 scenario (Lind and Kjellström, 2008). The grey area shows the spread defined by the maximum/minimum precipitation increase from the 20 AOGCMs. 30-year averages of monthly mean data have been compared between 1961–1990 and 2071–2100.

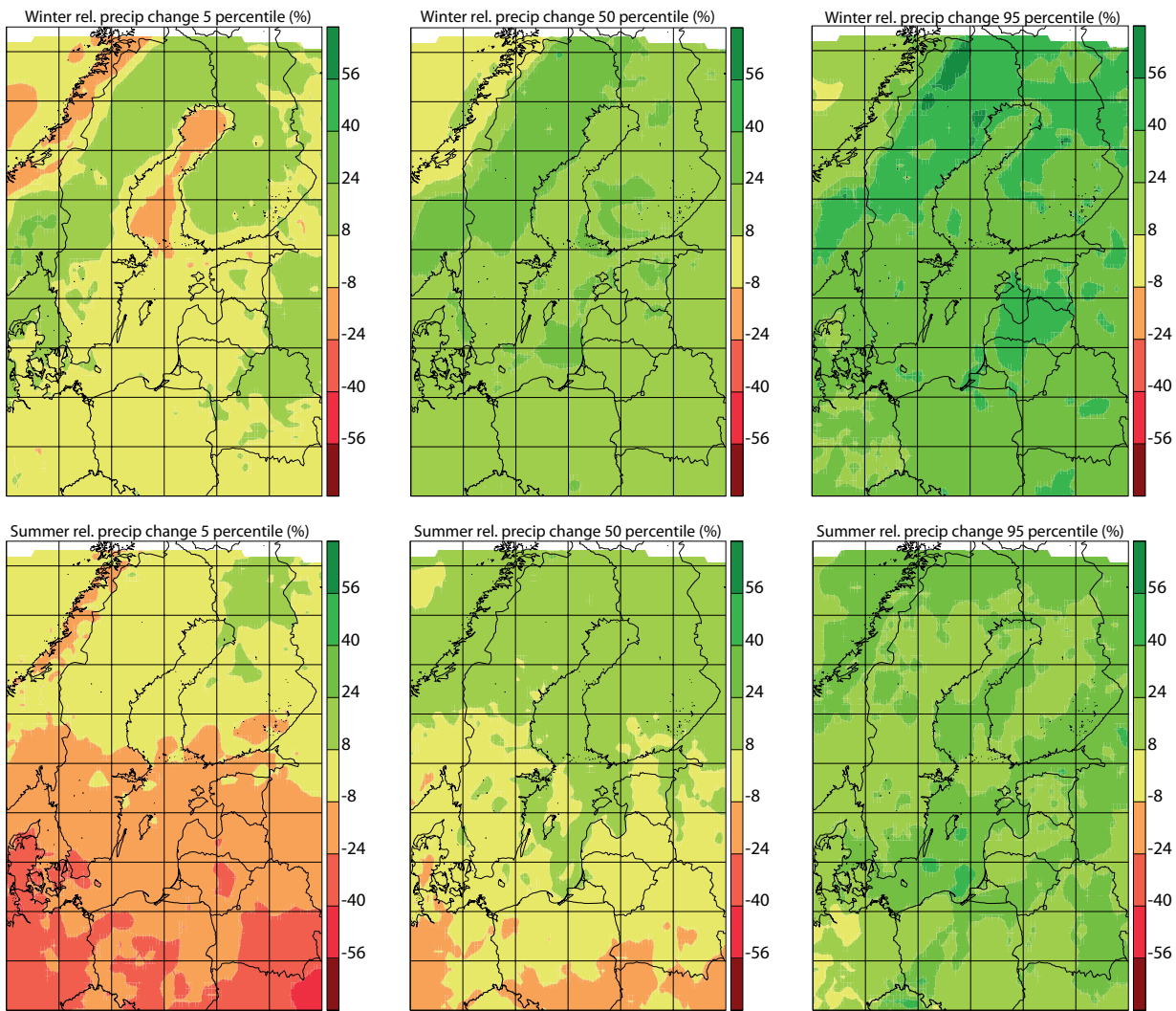


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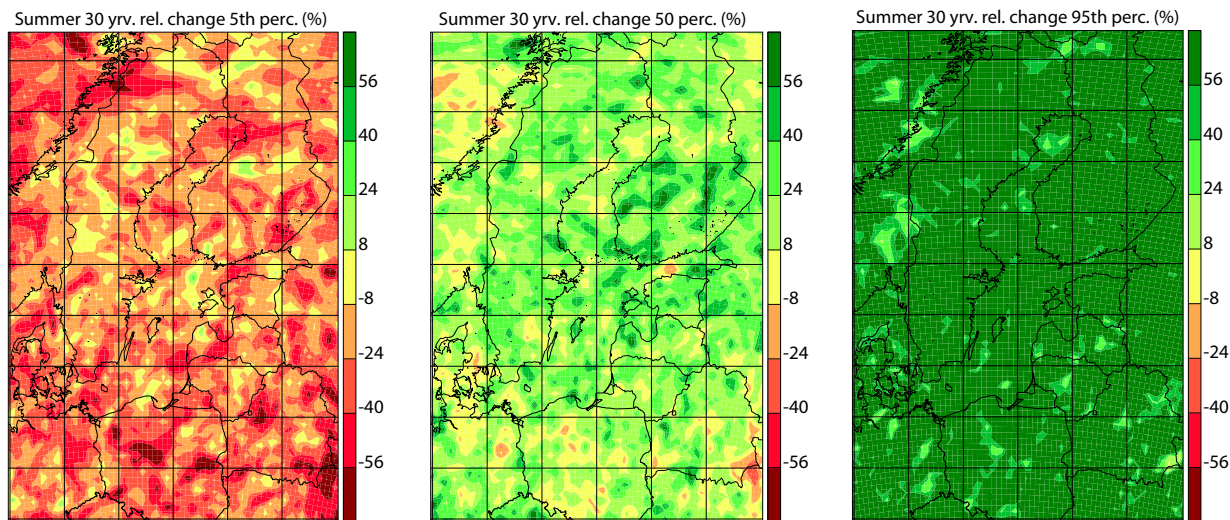
## Summary and outlook

Simulated changes in precipitation in the Baltic Sea Region are large and indicate a wetter climate in the future. The projected increases are largest and most consistent during winter. In summer the scenarios generally show more precipitation in the north and less in the south but there are large uncertainties in this, even concerning the sign of change. Also precipitation extremes is projected to change with time and models show increasing amounts of precipitation associated with such extreme events, also in areas that may experience decreases in seasonal mean precipitation. An intensification of extreme events is noted for a wide range of accumulation times (e.g. hours to days to week) and for common and rare extremes.

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**Figure 3:** Simulated precipitation change (%) 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. The upper row shows winter (DJF) changes and the lower row summer (JJA) changes.



**Figure 4:** Simulated change (%) in 30-year return value of daily precipitation extreme events 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 9 RCMs downscaling different GCMs. Conditions are shown for summer (JJA).

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## Climate scenario data

Results on future changes in precipitation presented in this bulletin are taken from numerical climate models. The global climate models (GCMs) used here were run in the 3<sup>rd</sup> 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) and 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 generally preserve the large scale 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 21<sup>st</sup> 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 21<sup>st</sup> century. RCM simulations for Europe mostly follow the A2, A1B or 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.



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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 all over 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.

