

BALTEX ASSESSMENT OF CLIMATE CHANGE for the Baltic Sea basin (BACC)

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Keywords: Climate Change, Baltic Sea catchment, Assessment of published literature

Abstract: A voluntary group of about 80 scientists from 12 countries has reviewed and assessed the published literature on climate change in the Baltic Sea region; here, the term „climate change“ refers to all changes of weather statistics, in the atmosphere, Baltic Sea and cryosphere, whether they are related to human action or due to natural variability. After two years of work, which includes external and internal review, a conclusion has been arrived at – in almost all aspects, this conclusion represents a common assessment; only in minor aspects disensus was found and documented. The overall assessment will be published in a book later this year; the conclusions of the assessment have been accepted by HELCOM as a suitable analysis of the state of knowledge. In this short article, the key findings are summarized and illustrated with a few key diagrams on past developments and expected future developments. Also the background of the BACC initiative is described.

Background of BACC

The **purpose** of the BACC assessment is to provide the scientific community and the public with an assessment of ongoing and future climate change in the Baltic Sea region – that is the Baltic Sea water body and the catchment. This is done by reviewing the scientific literature and the published knowledge about climate change in the Baltic Sea region. The

BACC Project integrates available knowledge of historical, current and of expected future climate change. Similar to the IPCC process, BACC is not pursuing its own scientific analysis but is merely reviewing what is “out there”.

An important element of the BACC assessment is the comparison with the historical past (until about 1800) to provide a framework for the severity and unusualness of the change. Another important aspect of BACC is the combination of evidence on climate change and related impacts on marine, freshwater and terrestrial ecosystems in the Baltic Sea basin (catchment and water body).

BACC addresses the problem of “climate change”, which is unfortunately differently understood in different quarter (cf. Barring, 1993). The problem is that “inconstancy” is an inherent property of the climate system. The Framework Convention on Climate Change (FCCC) defines climate change as “a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and that is in addition to natural climate variability over comparable time periods.” By contrast, the Intergovernmental Panel on Climate Change (IPCC) defines climate change broadly as “any change in climate over time whether due to natural variability or as a result of human activity.” Obviously, it is rather important which definition is used, in particular when communicating with the public and the media. BACC has decided to essentially follow the IPCC-definition, i.e., “any change in climate over time whether due to natural variability or as a result of human activity.”

BACC is the first systematic scientific effort for assessing climate change in the Baltic Sea region. More than 80 scientists from 12 countries have contributed on a voluntary basis. The results have not been influenced by either political or special interests.

BACC was “invented” during a BALTEX meeting in Roskilde in September 2004, installed on an ad-hoc basis by selecting a steering group in November 2004, and later formally accepted and endorsed by BALTEX as a BALTEX-project. At the same time, it was agreed that HELCOM would consider the BACC assessment as a basis for its own assessment. This cooperation between HELCOM and a major research programme of the World Climate Research Programme is unique and is of mutual benefit.

After having formed four groups of lead authors, who are responsible for one of the four chapters and after having identified the contributing authors in a bottom-up approach, draft assessments were established. The BACC draft material was reviewed internally at two meetings in Helsinki and Warszawa in 2005. An external review followed, organized under guidance of the BALTEX SSG. The publication of the “BACC Book” (BACC, 2007) with the summary for policymakers, the detailed assessment chapters and a number of annexes explaining technical background and terminology is presently completed..

In this article, we first present the official summary of the key findings of the assessment, agreed among the chairs of BACC¹ and its lead authors².

Summary statement

In the past century there has been a marked increase of **temperature** of more than 0.7 °C in the region, which is larger than the global mean temperature increase of 0.5 °C. Consistent with this increase in mean and extreme temperatures, other variables show changes, such as increase of winter runoff, shorter ice seasons and reduced ice thickness on rivers and lakes in many areas. These trends are statistically significant but they have not been shown to be larger than what may be expected from natural variability. In addition, no robust link to anthropogenic warming, which on the hemispheric scale has been causally related to increased levels of greenhouse gases in the atmosphere in “detection and attribution” studies, has been established. However, the identified trends in temperature and related variables are

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² Raino Heino, Heikki Tuomenvirta, Bo Gustafsson and Valery Vuglinski for the chapter “Past and Current Climate Change, Detection and Attribution”; Phil Graham for chapter “Projections of Future Climate Change”; Benjamin Smith for the chapter “Climate-related Change in Terrestrial and Freshwater Ecosystems”; and Joachim Dippner and Ilppo Vuorinen for chapter “Climate-related Change in Marine Ecosystems”

consistent with regional climate change scenarios prepared with climate models. Therefore, it is plausible that at least part of the recent warming in the Baltic Sea basin is related to the steadily increasing atmospheric concentrations of greenhouse gases. Efforts are needed which systematically examine the inconsistency of recent trends with natural variability, circulation changes as well as the consistency with elevated greenhouse gas concentrations as a potential cause.

The situation is much less clear regarding **precipitation**: in the past, a spatially non-uniform pattern of upward and downward trends has been observed, which can hardly be related to anthropogenic climate change. For the future, intensified winter precipitation may emerge later in this century over the entire area, while summers may become drier in the southern part – but this expectation is uncertain for the time being. For the water body of the Baltic Sea, a tendency towards lower **salinity** is expected. Similarly, no clear signals, whether for the past or for the scenarios, are available with regard to **wind** conditions.

In view of the large uncertainty in our knowledge about the changing climatic conditions, it is not surprising that knowledge about ecological implications of ongoing and future climate change is far from complete and also very uncertain. The observed changes in temperature in the past have been associated with consistent changes in **terrestrial ecosystems**, such as earlier spring phenological phases, northward species shifts and increased growth and vigour of vegetation. In lakes, higher summer algal biomasses have been found. These trends are expected to continue into the future; induced species shifts may be slower than the warming which causes it. In the **marine ecosystem** of the Baltic Sea the assessment is particularly difficult because of the presence of strong non-climatic stressors (eutrophication, fishing, release of pollutants) related to human activities. Changing temperatures have been related to various effects, in particular to the composition of species. A lowering of salinity is thought to have a major influence on the distribution, growth and reproduction of the Baltic Sea fauna. Freshwater species are expected to enlarge their significance, and invaders from warmer seas (such as the zebra mussel *Dreissena polymorpha* or the North American jelly comb *Mnemiopsis leidyi*) are expected to enlarge their distribution area. The expected changes in

precipitation (and thus river runoff) may have additional detrimental effects on the problem of eutrophication.

Illustrations

In the following some of the key findings of past developments and possible future developments (scenarios) are illustrated with a few diagrams; further details are provided in the forthcoming BACC-book (BACC-Group, 2007).

1. Figure 1 shows the development of annual mean air temperatures in the Baltic Sea region, namely a steady increase both in the north (north of 60N; in blue) and in the south (south of 60N, in red).³ The temperatures at the end of the 20th century are more than 1° warmer than at the beginning of the record in 1871.
2. The warming is also reflected in increased run-off from rivers in winter – as is exemplified by the run-off from the Finnish territory into the Baltic Sea in February displayed in **Fehler! Verweisquelle konnte nicht gefunden werden..**
3. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the duration of ice coverage of a Russian lake since 1946 – the duration is shortened by more than 25 days since then.
4. That this may be part of a longer development is demonstrated by **Fehler! Verweisquelle konnte nicht gefunden werden.**, which shows the date of ice break up in a Finnish lake, which is documented since 1693. Interestingly, the trend does not seem to accelerate at the end of the record.

³ Dots indicate annual values of which the smooth curves are obtained by applying a Gaussian filter (with $\sigma=3$), which highlights variability longer than 10 years.

5. At the same time, summer water temperatures in lakes, for instance in Finland, rose. An example is the August temperature series for Lake Saimaa in the **Fehler! Verweisquelle konnte nicht gefunden werden..**
6. Seasonal precipitation ratios between the two 25-year periods 1976-2000 and 1951-1975 based on VASCLimO data (**Fehler! Verweisquelle konnte nicht gefunden werden.;** Beck et al. 2005). The southern part became somewhat drier in summer (JJA) in the second 25 years, while the north was in many parts drier in winter (DJF) then earlier.
7. The annual precipitation amount over Denmark saw, after suitable smoothing, a steady increase by about 1/6 during the instrumental period 1874-2004 (Cappelen and Christensen 2005; **Fehler! Verweisquelle konnte nicht gefunden werden.**).
8. Possible, future summer (JJA) states are displayed for temperature in **Fehler! Verweisquelle konnte nicht gefunden werden.** and for precipitation in **Fehler! Verweisquelle konnte nicht gefunden werden..** Shown are changes 2071-2100 vs. 1961-1990 generated by two different regional climate models, which have been exposed to global changes generated by two global climate models. The emissions scenarios used is SRES A2. All four maps are equally probable, even if the enhanced warming of the Baltic Sea surfaced may be an artifact of one of the models. The entire region warms up with at least 2°C until the end of the century, with largest values (up to 7°C) in the south and smallest in the North. Precipitation is reduced in all four cases in the southern part, whereas the northern part becomes wetter in these simulations. Obviously, spatially very detailed statements make little sense; only statements about coarsely defined areas are consistent across different scenarios.
9. The change of terrestrial ecosystems is illustrated by **Fehler! Verweisquelle konnte nicht gefunden werden.,** which displays the rate (days per year) in birch (*Betula pendula*) leaf unfolding over southern and eastern parts of the Baltic Sea basin for 1951-1998 (Ahas et al. 2002).

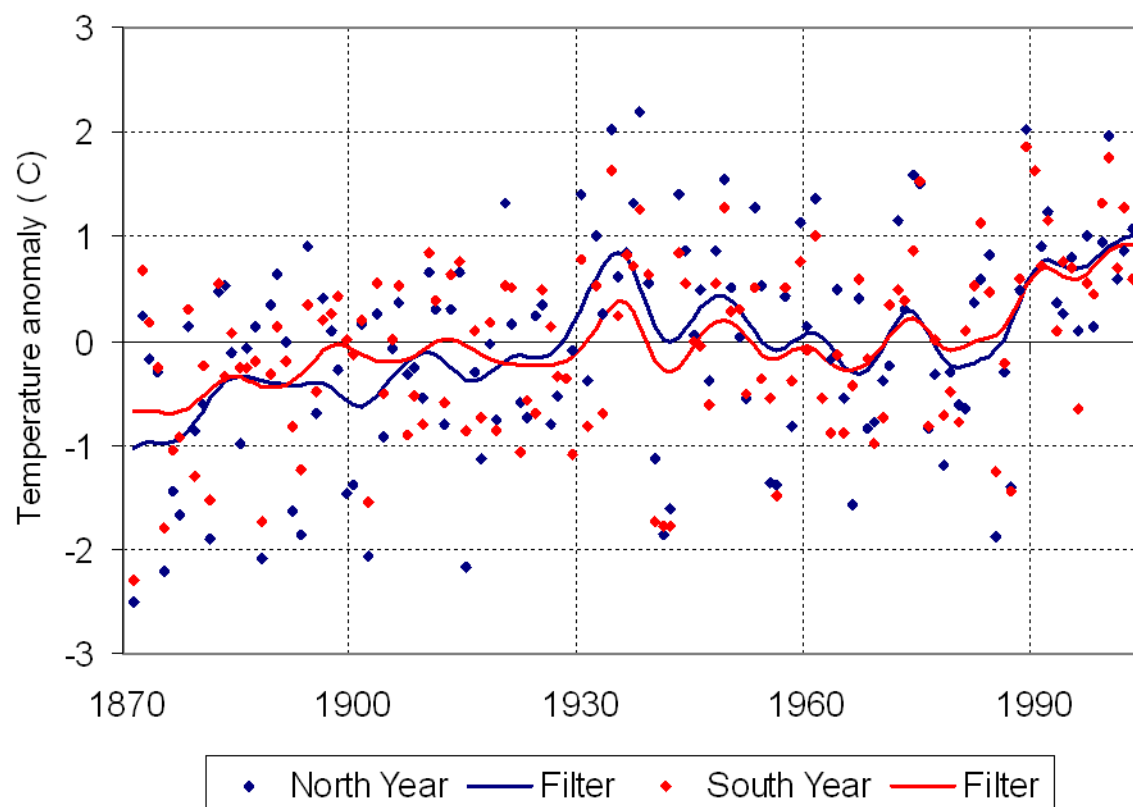


Figure 1

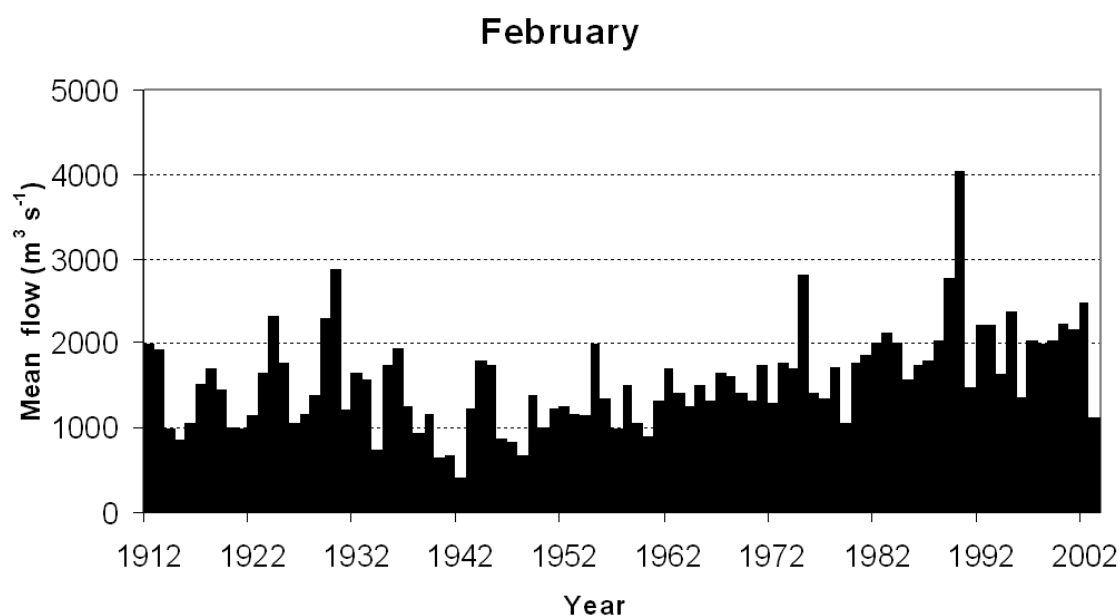


Figure 2

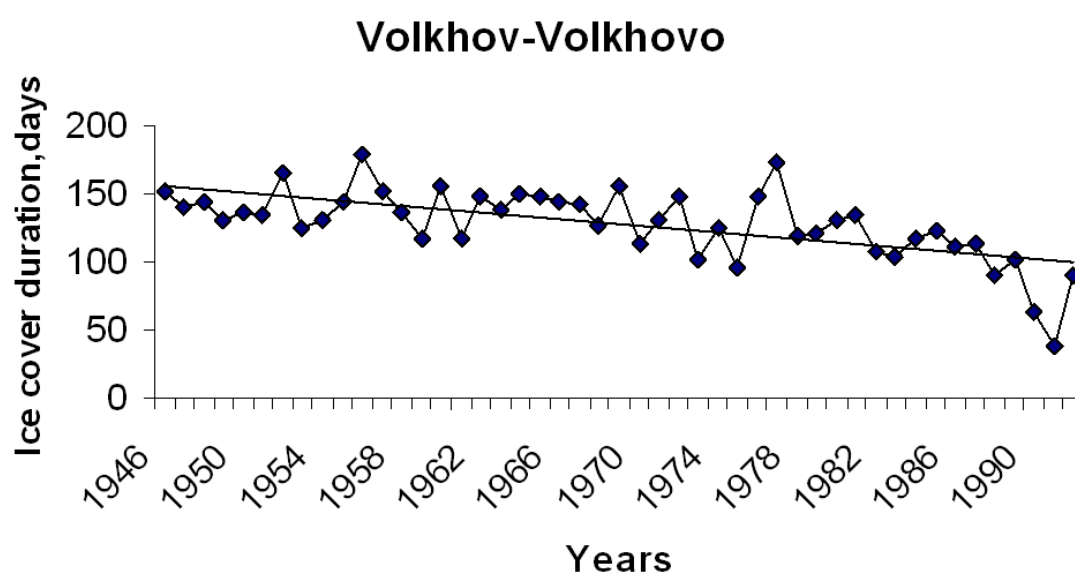


Figure 3

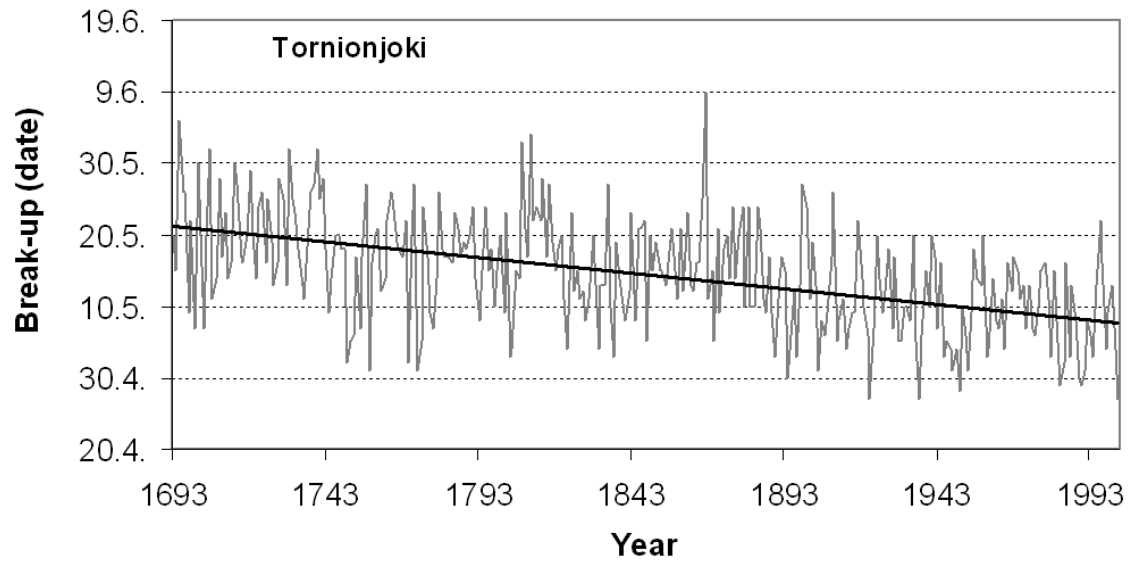


Figure 4

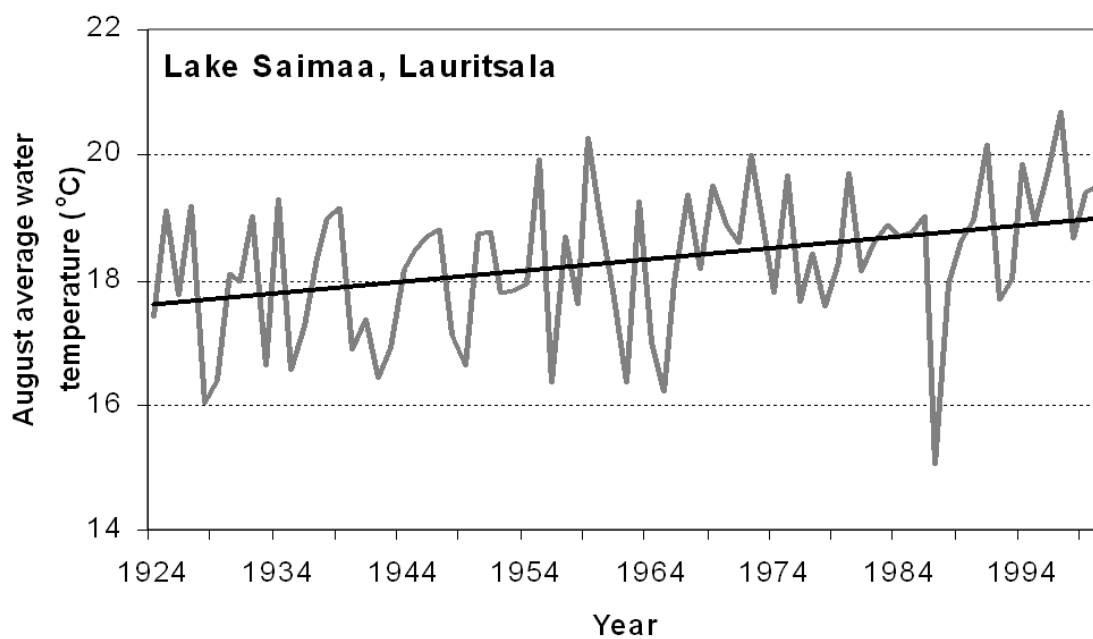


Figure 5

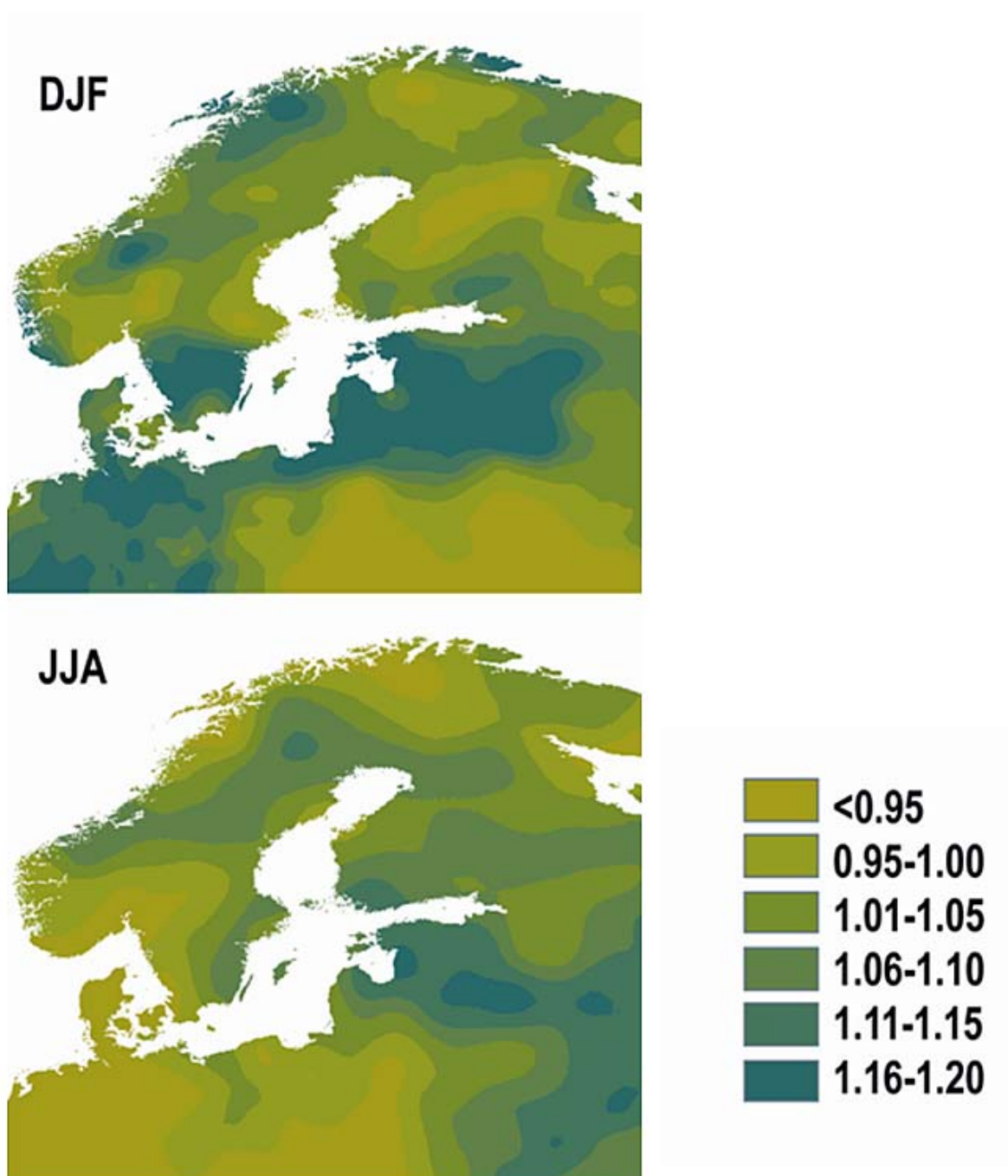


Figure 6

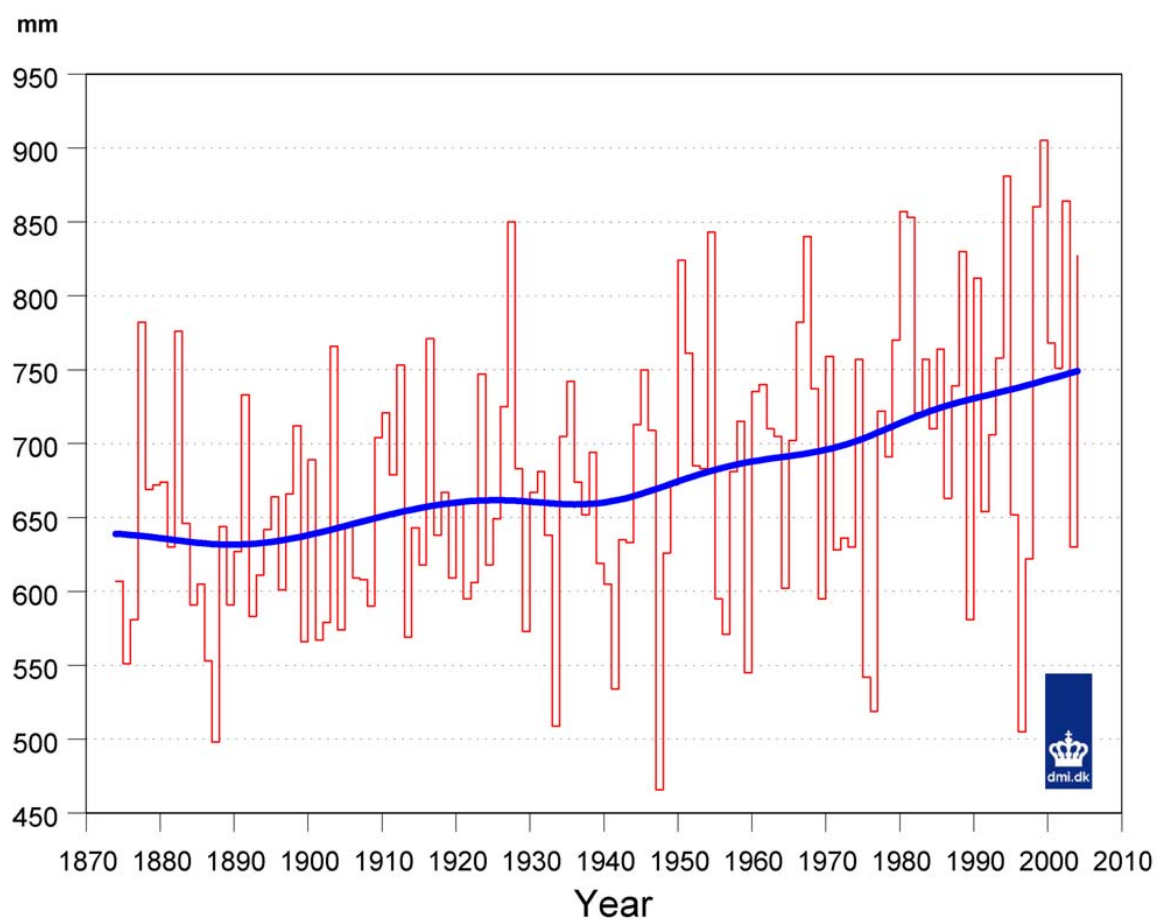


Figure 7

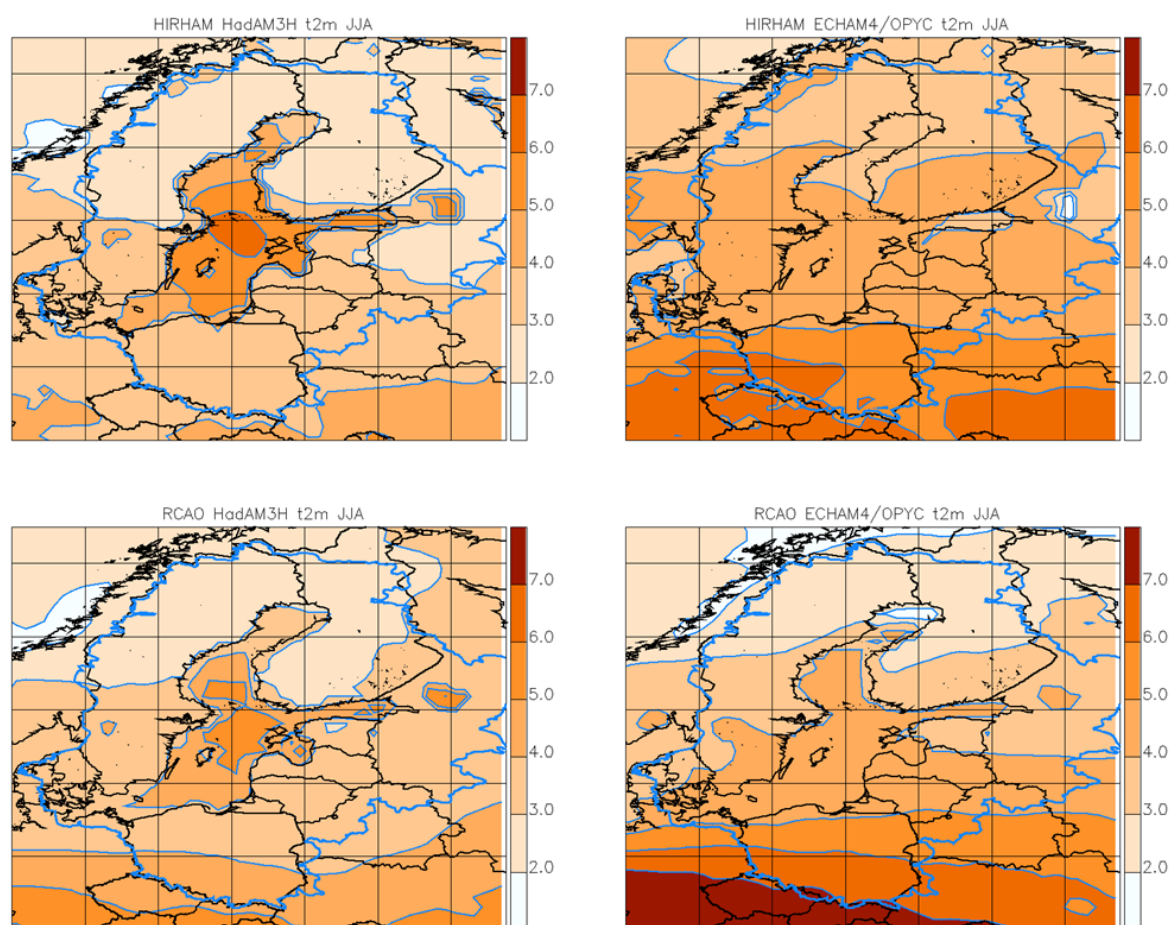


Figure 8

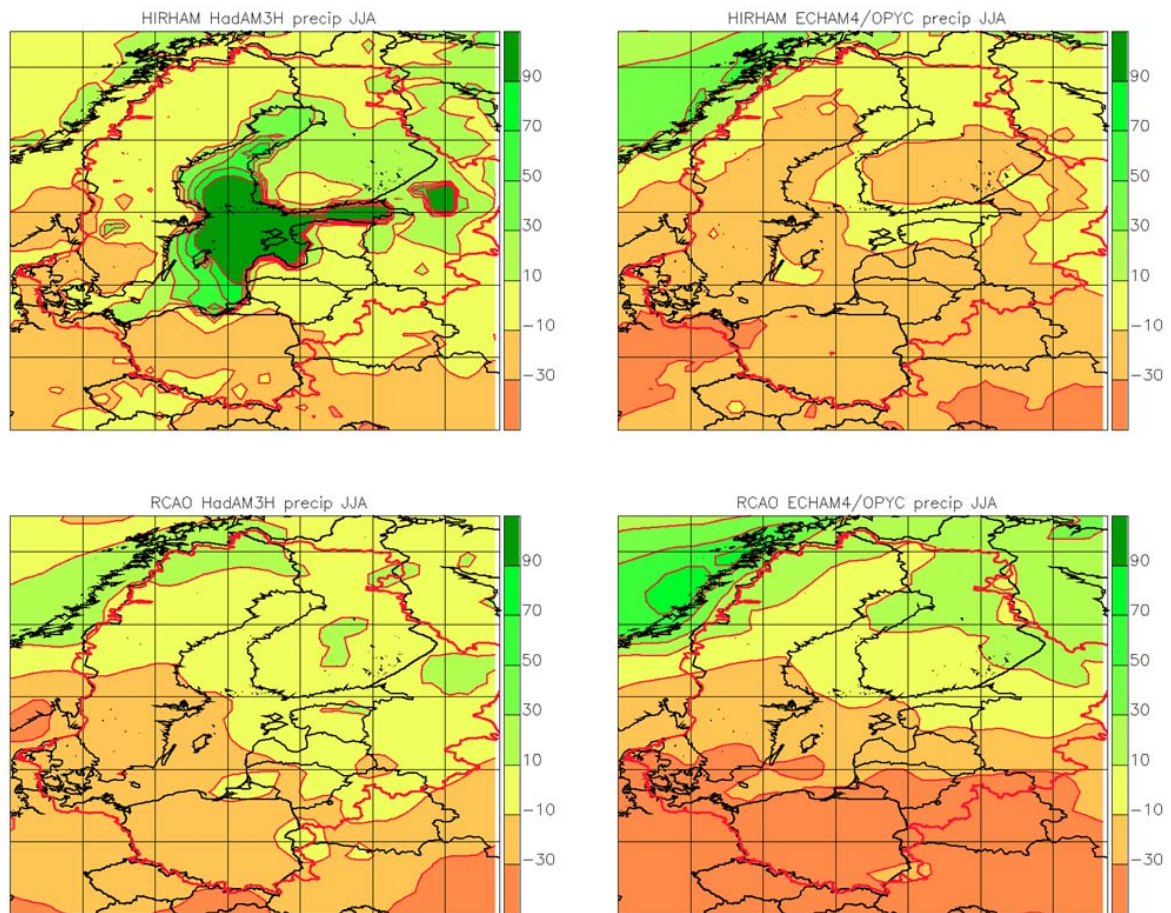


Figure 9

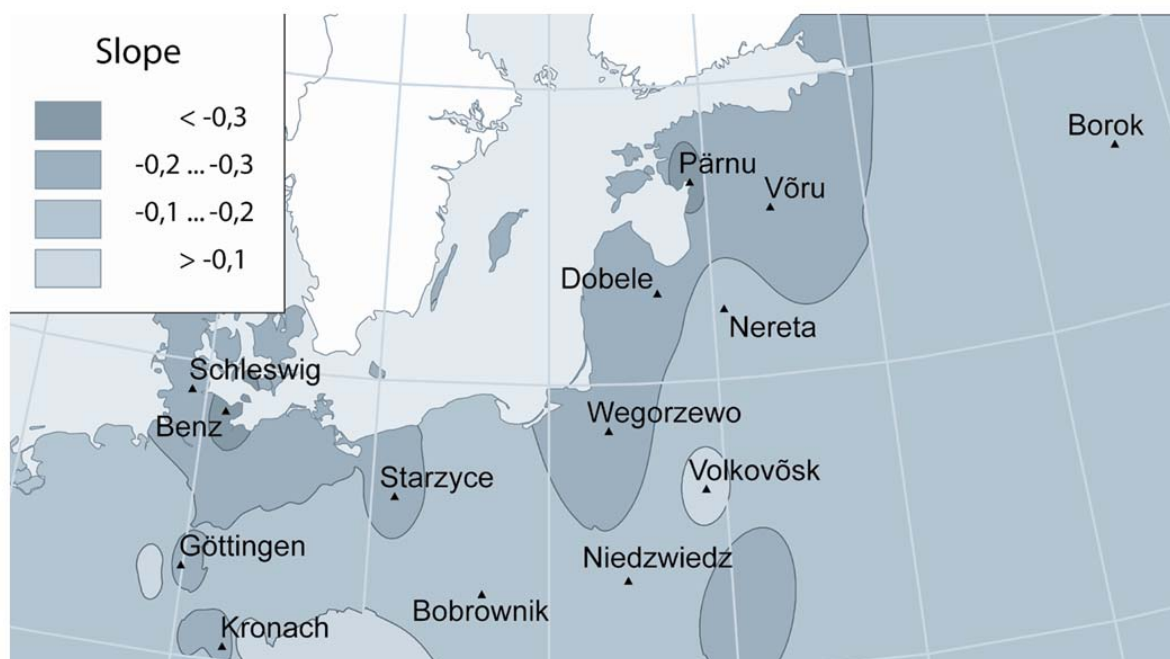


Figure 10

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