Climate Change Assessment for the Baltic Sea Basin

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) has had a big impact on the public perception and acknowledgment of global climate change. However, regional climate change assessments are urgently needed to complement the big picture with regional results and scenarios of higher resolution, which local decision makers and stakeholders can use [V Ör dead, 2008; von Storch and Meinke, 2008]. An outstanding example of a regional assessment is the BALTEX (Baltic Sea Experiment-Assessment) Assessment of Climate Change for the Baltic Sea Basin (BACC; http://www.baltex-research.eu/BACC/) which was compiled by a consortium of 84 scientists from 13 countries around the Baltic Sea [BACC Author Team, 2008]. The assessment covers various disciplines related to climate research and regional impacts.

The Baltic Sea is a major intracontinental sea in northern Europe. Its catchment basin, covering around 14% of the European continent, spans different climate and population zones from a temperate, highly populated and industrialized south to a boreal and rural north. The Baltic Sea basin encompasses most of the Scandinavian peninsula in the west, most of Finland and parts of Russia, Belarus, and the Baltic states in the east, and Poland and small parts of Germany and Denmark in the south. The region represents an old cultural landscape, and the Baltic Sea itself is among the most studied sea areas of the world.

Thus, there is a wealth of information, in thousands of publications, concerning past climate conditions in the region. A large part of the information is not in English and also hardly available for western researchers, as the eastern part of the Baltic Sea basin had been behind the iron curtain until the early 1990s. The challenge was to install a writing team that could do “paper mining” in these data sources and compile the material into a comprehensive, well-written assessment book. Besides looking at past and current climate change, the BACC report presents climate projections until the year 2100 using the most sophisticated regional climate models available, and an assessment of climate change impacts on terrestrial, freshwater, and marine ecosystems of the Baltic Sea basin.

The work was organized in four chapters (past and current climate change, projections of future anthropogenic climate change, climate-related changes in terrestrial and freshwater ecosystems, and climate-related marine ecosystem change); a number of annexes that provide background information; and an introductory chapter that places the initiatives in context, clarifies key analytical and modeling concepts, and provides a summary of the assessment. An international steering committee, led by former Director Hans von Storch of GKSS Research Centre Geesthacht, Germany, a coauthor of this article, was responsible for the selection of lead authors, who then formed a team of contributing authors to prepare their respective chapters.

The chapter and annex manuscripts were anonymously reviewed by external experts under the independent supervision of former World Climate Research Programme director Hartmut Grassl.

Main Results of the Assessment

Air temperatures in the Baltic Sea basin already have risen over the past century (time series since 1871), increasing by approximately 1ºC in the northern areas of the Baltic Sea basin and by around 0.7ºC in the southern areas. Consequently, the warming in the Baltic Sea basin is slightly stronger than the global mean temperature increase of 0.75ºC reported by IPCC [2007]. Climate scenarios for the period leading up to the year 2100 suggest that air temperatures could rise by 4–6ºC in northern areas such as Sweden, Finland, and western Russia and by 3–5ºC in southern areas such as Poland and northern Germany. Water surface temperatures in the Baltic Sea could increase by 2–4ºC. Higher water temperatures and decreased salinity would have a great impact on the Baltic Sea’s flora and fauna, affecting the different organisms in the aquatic ecosystem in various ways, including creating altered growth conditions for bacteria and plankton (e.g., leading possibly to increased nuisance cyanobacterial blooms) and changed survival rates of commercially important fish species such as cod. Ecosystems of near-shore and coastal areas—managed forests—could benefit from an extended growing season, but land ecosystems may also become increasingly vulnerable to damage by insect and fungal pests as well as other stresses.

While the northern parts of the Baltic Sea are usually mostly ice covered in today’s winters, a milder climate could by 2100 reduce the ice cover by 50–80%. While these conditions would be beneficial for shipping in the Baltic Sea, they would threaten populations of the Baltic ringed seal, an endemic species that is dependent on ice surfaces to reproduce.

Precipitation is expected to change as well, with possible increases of 20–75% during the winter season over the entire basin. During summer, the northern areas would experience a slight increase (~5% to 45%), while a strong decrease of up to 45% is expected for the southern areas. The combination of reduced summer sea-surface temperature and increased precipitation in summer could threaten water supplies, food production, and forestry in the countries along the southern coast of the Baltic Sea. Another possibility is that increased overall precipitation could lead to a decrease in the Baltic Sea’s mean salinity and possibly also to increased eutrophication and algal blooms. Storm activity in the past has shown a decadal-scale variability, and the regional assessment detected no recent trends toward stronger or less severe storms. Different scenarios for future wind conditions differ considerably so that no robust outlook can be given at this time, but very strong changes are unlikely.

According to IPCC [2007], global sea levels are expected to rise by 20–60 centimeters by the end of the century. As the Baltic Sea is connected to the world ocean, a similar sea level rise can be expected here. Still, no consensus exists concerning future height levels are available for the Baltic Sea. However, a postglacial local land uplift (in the north) and lowering (in the south) are well documented for the Baltic Sea basin. This means that the northern coasts will be less affected by global sea level rise, as they also rise due to postglacial land uplift, while the southern coasts may be more vulnerable to flooding in the future.

Program Studies for the Kuroshio Extension

The Kuroshio Extension system links to North Pacific climate through its role in sub-tropically-subarctic exchange, the formation and distribution of mode waters, and the intensification of the extratropical storm track across the North Pacific. The Kuroshio Extension System Study (KESS) offers a window into these processes through integrated measurements of the oceans and atmosphere and through modeling efforts (Figure 1). The northward flowing waters of the Kuroshio western boundary current leave the Japanese coast to flow outward as a free jet—the Kuroshio Extension. The Extension forms a vigorously meandering boundary between the warm subtropical and cold northern waters. Within its southern recirculation gyre, strong wintertime cooling deepens the mixed layer to form subtropical mode water, STMW (Mumford and Talley, 2001). The recirculation gyre, cross-frontal fluxes, and air-sea interactions (each play an important role in the formation of STMW).

Intense air-sea heat exchanges occur where warm Kuroshio waters encounter the cold dry air masses that flow off the Asian continent. The time-varying strength and eastward penetration of the recirculation gyre and the Kuroshio Extension help maintain and steer storm tracks across the North Pacific. The dynamic state of this system alternates on decadal timescales between weakly and vigorously meandering [Q i u and Chen, 2005]. The KESS field program—consisting of a moored array and the deployment of profiling floats, extensive synoptic surveys, and atmospheric soundings—fortuitously captured this regime transition (Figure 1). The most recent stable pattern, which began in 2001, exhibited the characteristic pattern of two quasi-stationary meanders and a strong meandering elongated recirculation gyre. In December 2004, the Kuroshio Extension switched into its unstable state, its path became highly variable, eddy energy increased dramatically, and the recirculation gyre weakened. Observationally [Q i u and Chen, 2005] and numerically [T a g u c h i et al., 2005], this regime shift has been connected to changes in central North Pacific wind stress curl. Baroclinic Rossby waves generated by this atmospheric forcing sub-sequently alter the stability of the Kuroshio through either a shift in upstream position or a change in its jet's structure.

Kuroshio Extension
Baltic Sea Basin

Assessments

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