Challenges for the Baltic regional environmental research: Reconstruction of changing climate and changing pollution patterns

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General

Environmental research has grown out of a broad range of natural sciences, such as physics, oceanography, hydrology and ecology. Originally its goal was mostly oriented towards identification and understanding of relevant processes in the various environmental systems. BALTEX is and was a prominent and particularly successful example of these efforts. In the course of time, the focus is changing towards a more holistic view of he environmental system in its entirety, and that includes people. People, who use and change the "services" of the environment, exploit the environment as a utility, and sometimes consider it as a threat or risk. There is a gradual transformation of research programs from fundamental to applied dealing with

- Current state and ongoing change of the regional environment
- short-term forecasting
- perspectives of future change
- options for future (sustainable) use in e.g., agriculture, forestry, fishery, traffic,energy, tourism, and deposition of substances.

In fact, IGBP programs such as LOICZ are beginning to embrace and incorporate the human dimension and the application of scientific knowledge about the regional environment for guiding adaptation, mitigation and management in general as goals and integral components.

Applied Baltic regional environmental research

In case of Baltic regional environmental research, the science has matured so that it may be used to advise society and policy about how to deal with the resource "environment" and how to respond to ongoing or expected environmental change. Physical science has made sufficient progress to allow for the application of the knowledge constructed during BALTEX. This does not imply that all problems would have been solved, but that uncertainties have been reduced considerably by BALTEX. Lack of complete knowledge must be dealt with by making the remaining uncertainties explicit. It should not prevent from applying the available knowledge.

The extension of BALTEX to more applied research components may include the physical/dynamical, chemical/ecological, historical/geological, economical/political and sociological "dimensions", supporting science/policy discourse mechanisms such as IPCC or HELCOM. Such an extended BALTEX program will also contribute to LOICZ as well as continuingly to GEWEX.

The knowledge collected and constructed during the BALTEX program has resulted in powerful quasi-realistic models of the regional atmosphere, of the hydrology of the Baltic sea catchment and of the hydrography of the Baltic Sea. Also quality-controlled and homogeneous data sets indicative of changing climatic and environmental conditions have been assembled. It is suggested that these models and data sets should, among others, be used for

- assessing the state of pollution, the pattern and speed of climate change, and the discrimination between anthropogenic and natural climate change; and
- providing scenarios of mitigation of pollution, adaptation to environmental regional change, and of the optimal use of the resource „regional environment".

Examples

Two examples are very briefly shown in the following, illustrated with one diagram.

The *first example* concerns the temporal evolution of salinity in the Baltic Sea. Salinity is a crucial ecological parameter in this brackish, geologically young sea, where it establishes precarious conditions where few marine (high-salinity) or freshwater (low-salinity) species can survive, determines stratification and limited oxygenation through the halocline, and affects the speciation and toxicity of metals. Salinity has been monitored since about 1960 at a variety of locations, but prior to that only episodical data exist. Zorita and Laine (2000) constructed a statistical regression model relating salinity and air pressure fields, using the salinity data available since the 1960s and homogeneous regional air pressure analyses. Air pressure analyses of homogeneous quality and sufficient accuracy are available since the beginning of the 20th century, so that this link may be used for estimating the development of salinity in the Baltic sea since the beginning of the 20th century. The episodically available observations from the first half of the 20th century are used for validation of the method.

The result of the exercise is shown in Figure 1. Obviously, the reconstruction is successful, as is demonstrated by the similarity between the reconstructed and episodical data prior to 1960. Furthermore, the decline in salinity seen in the past few years is beyond the range of normal variation in the preceding decades. It remains to be analyzed if the identified change is continuing and whether it is consistent with the expected changes related to anthropogenic climate change. Also, the ecological implications need to be analyzed.

The *second* example is related to the regional pollution with anthropogenic substances – in this case lead added to gasoline to prevent knocking (von Storch et al., 2002). The emission of lead rose almost unabated since the revitalization of the European economy after World War II, until the first regulation measures were introduced in the early and mid 1970s. In the mid and late 1980s leaded gas was mostly phased out in Europe. The regulation was undoubtedly successful in terms of diminishing the ecological threat and improving the general air quality. At the same time, it did not have the adverse economic effects which had been predicted by some stakeholders (Hagner, 2001, 2002). However, even if the emission of lead by traffic is no longer one of the pressing environmental problems in Europe, the questions remains of what is the current distribution of the large amount of lead that was previously emitted.

In order to quantitatively describe the fate of the gasoline-lead, spatially disaggregated emissions were estimated (Pacyna and Pacyna, 2000) and fed into a 40-year detailed regional weather reconstruction extending from 1958 to 1997 (Feser et al., 2001). In this way, a temporally and spatially high-resolution description of the air concentrations of lead, and of the depositions were obtained. With this data set, budgets can be calculated of how much lead is deposited in certain regions, and where it came from (Costa-Cabral, 2001).

The annual deposition of lead into the Baltic sea, shown in Figure 2, follows a pattern similar to the emissions, increasing until the middle of the 1970s, and decreasing thereafter. Maximum depositions are estimated to have surpassed 3,500 tons in 1974, while by 1995 they were likely only of a few hundred tons. In the 1980s several attempts were made to estimate the depositions over the entire Baltic Sea based on point observations. These estimates, which were provided as an average value over a time window of a few years, are represented by color bars in the diagram. Interestingly, the reconstructions based on the modelling and on the observed data are consistent, adding credibility to the modelling approach.

The example demonstrates that it is possible to subject a political regulation to an a-posteriori analysis about costs and benefits. Lead has served as an example because of its relatively simplicity and the well documented strongly changing emissions. The methodology may be used for other substances, such as Persistent Organic Pollutants, and for the a-priori assessment of proposed regulations (scenarios). For that purpose, the existing models and data of the dynamics of substances in the atmosphere, and in the catchment and the Baltic sea, need to be extended.

References

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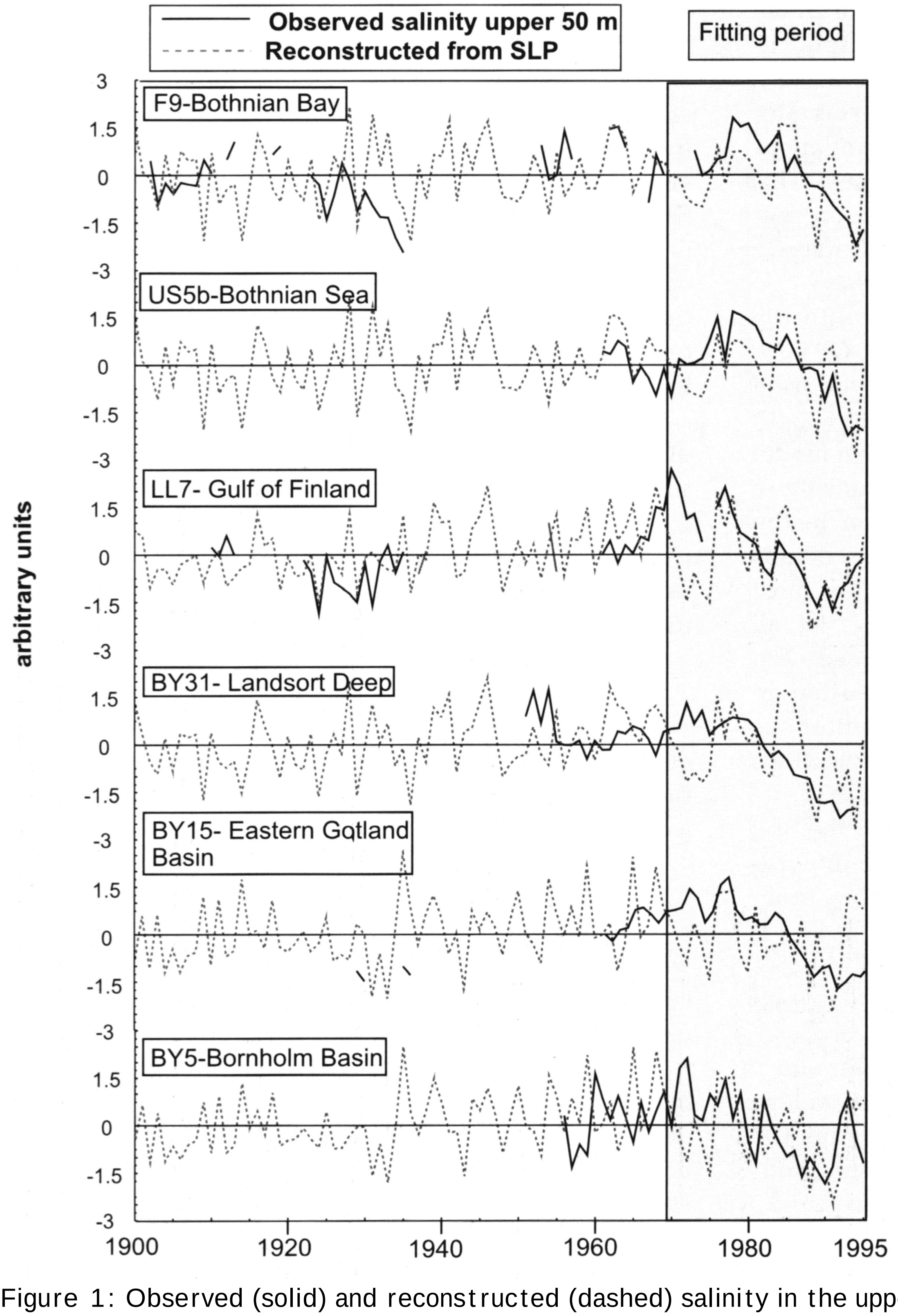

Figure 1: Observed (solid) and reconstructed (dashed) salinity in the upper 50 m of the Baltic Sea at a series of locations. Reconstruction regressing the wintertime SLP field. (Zorita and Laine, 2000)

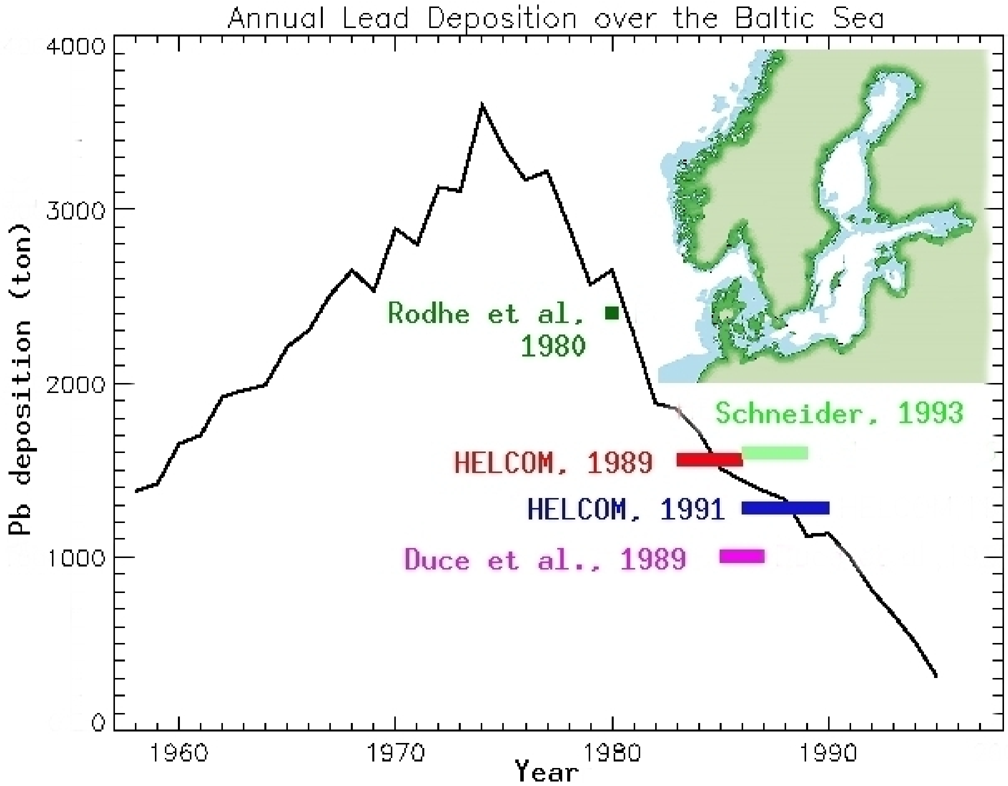

Figure 2: Observed (colored bars) and reconstructed (line) annual atmospheric deposition of lead into the Baltic Sea (von Storch et al., 2002).