The BALTEX/Baltic Earth programs: Excursions and returns

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1. Introduction

"The night passed, and the dawn came, and they sailed constantly."

The citation is a famous sentence in Homer Odysseus', where Odysseus sailed home ten years during many dangers and obstacles. This story has been interpreted and rewritten in many ways. It stands as a symbol and a starting point for a large part of our culture, created through literature, art, and philosophy. In philosophy, it is mainly the very structure of excursion and return that have come to develop. The first step is, belonging, the beginning, in the already familiar, in what we recognize ourselves in and start when we encounter something new, different, and exciting. The second step is the excursion itself, to leave home, the familiar, and open up to new experiences, "to put oneself at risk," to, as in a game, forget oneself and open up to other interpretations that lead to a new understanding. Returning home, the third step, is the essential element in a learning process. It is not "putting oneself at risk" but returning home that is the essence of education.

In this presentation, we examine the BALTEX/Baltic Earth programs through the lenses of excursions and returns. Of course, there are many achievements that scientists in a large number of papers and reports have published. But here, we speculated more about the overall achievements starting from the program goals.

2. The BALTEX phase I (1993-2002)

The goals for BALTEX I formulated 1995 were:

- To explore and model the various mechanisms determining the space and time variability of energy and water budgets of the BALTEX region and this region's interactions with surrounding regions.
- To relate these mechanisms to the large-scale circulation systems in the atmosphere and oceans over the globe.
- To develop transportable methodologies to contribute to the basic needs of meteorology, hydrology, oceanography, climate, climate impact, and environmental research.

IPCC started in 1988. Climate models matured for anthropogenic greenhouse gas experiments. In 1990, the First IPCC Assessment Report (FAR) underlined climate change as a challenge with global consequences requiring international cooperation. GEWEX, a core WCRP project, was initiated in 1990 with its phase I from 1990 to 2002 concentrating on water and energy cycles. At the beginning of 1990th, the Soviet Union broke down. Mann, Bradley, and Huges published in 1999 what would be named the Hockey stick graph and created an extensive discussion about global warming, data, and statistical methods. The BALTEX I took part in GEWEX, and the excursion included all countries around the Baltic Sea, joining scientists within meteorology, hydrology, and oceanography. In July 2000, the Öresund bridge opened for traffic. The return after ten years was a new science community addressing studies on heat- and water-balances for the Baltic Sea and its drainage basin, including data and models exchange. The research identified significant discrepancies between observed and climate-modeled water and heat balance components. Feedback mechanisms supported the development of coupled atmosphere-land-ocean models on the regional scale.

3. The BALTEX phase II (2003-2012)

The goals for BALTEX II were:

- Improved understanding of energy and water cycles under changing conditions.
- Analysis of climate variability and change, and provision of regional climate projections over the Baltic Sea basin for the 21st century.
- Provision of improved tools for water management, with an emphasis on extreme hydrological events and long-term changes.
- Biogeochemical cycles in the Baltic Sea basin and transport processes within the regional Earth system under anthropogenic influence.
- Strengthened interaction with decision-makers, with emphasis on global change impact assessments.
- Education and outreach at the international level

GEWEX Phase II 2003-2012 focused on how energy and water cycle processes function and quantify their contribution to climate feedback. In those days, eutrophication dominated Baltic Sea research efforts with a biology dominated community. In 2010 the BONUS program was launched as a Baltic Sea research program supported by the European Council, where science groups in BALTEX became active. The BALTEX II excursion started by increasing the BALTEX I goals by adding climate change and biogeochemistry. The return after ten years was the establishing of BACC as a science service with a first broad assessment of the knowledge about climate, climate change, and impact in the Baltic Sea Basin, and closer cooperation between scientists in many disciplines, mainly natural scientists. Significant improvements in open databases with observed and reconstructed data. Models were extended into biochemistry, starting to include the carbon dioxide cycles. Despite marked progress in Baltic Sea research, several gaps remained in knowledge and understanding. The issue of multiple stressors to the Baltic Sea began attracting attention.

4. The Baltic Earth program (2013 –)

The BALTEX network reorganized itself with a new name, Baltic Earth, a new program, and a broadening of the foci.

Baltic Earth inherited the scientific legacy and networks of BALTEX. The new program identified several grand challenges, in particular:

- Salinity dynamics in the Baltic Sea.
- Land-Sea biogeochemical linkages in the Baltic Sea region.
- Natural hazards and extreme events in the Baltic Sea region.
- Sea level dynamics in the Baltic Sea.
- Regional variability of water and energy exchanges.
- Multiple drivers for regional Earth system changes.

GEWEX Phase III (2013-2022) was formed, building on results and experiences of GEWEX I and II. Future Earth with a background in the International Geosphere-Biosphere Programme, DIVERSITAS, and the International Human Dimensions Programme was officially announced in June 2012 at the UN Conference on Sustainable Development. The Baltic Earth excursion started from the BALTEX I and II programs and the success of BACC I now with inspiration from GEWEX and Future Earth. The research foci were anthropogenic changes and impacts and their natural drivers which served as a network for earth system sciences in the region.

Studies of the climate system got a significant boost by the bestowal of the Physics Nobel Prize 2021 to Klaus Hasselmann for suggesting and demonstrating approaches to deal with the high-dimensional and complex, inhomogeneous climate system, specifically with the Stochastic Climate Model from 1976 and the detection (of climate change) and attribution (of plausible causes of climate change). Even though the laureate was not part of BALTEX and Baltic Earth, his ideas infiltrated the foci of the work, with emphasis on the system, as opposed to many independent processes. While process studies, mandatory and urgently needed, are powerfully pursued by members of Baltic Earth, the system view has gained much attention, with readily available extended data sets of recent and past changes and scenarios of possible futures. A variety of coupled numerical models allow experimentation on the climate system and estimating impacts. Specifically, the role of elevated greenhouse gas concentrations on the regional climate has been assessed. New challenges are the separation of a. variety of signals, ranging from greenhouse gases, aerosols, discharge of various substances into the water body of the Baltic Sea, changing cities and flows of goods and people, and finally, the understanding of the interaction of scientifically constructed knowledge and societal, culturally constrained decision processes.
Through BACC II and forming of EN-CLIME, the cooperation between HELCOM and Baltic Earth developed. The different challenges were addressed in the BEARs article in a special issue in Earth System Dynamics (2021-2022). Increasing insights in multiple stressors through fishery, climate change, eutrophication, etc.

5. Summary and conclusions

After almost three decades of climate and environmental studies of the Baltic Basin within the BALTEX and Baltic Earth programs, we need to evaluate the essence of the vast body of scientifically constructed knowledge and the efforts for improving education. During three decades, we have seen significant progress in observations and available data sets, improved models for regional studies, and increased numbers of international summer/winter schools. The programs have illustrated the need to navigate actively in the European research arena and at the same time remain as an independent science network. The program planning based on decadal time scales strengthens the work in contrat to the often shorter national and European research programs. The well-organized international Baltic Earth secretariat, together with many dedicated scientists, made the excursions safe and successful.

The BALTEX/Baltic Earth learning process relates to improved knowledge about the region's anthropogenic climate and environmental changes and how global warming and regional human activities can be detected outside the natural variabilities. Attribution studies through IPCC on climate change linked to raising greenhouse gases are well established globally. The geographic position of the Baltic Basin, with significant variability in large-scale meteorological circulation, set unique challenges for detecting and attributing regional anthropogenic changes. At the same time, anthropogenic changes of different origins are acting, such as changes in, air pollution and aerosols, large scale atmospheric circulation, eutrophication, land-use change, coastal constructions, cities, fishery, and shipping. Without a clear understanding of the different drivers and how they interact on a regional scale, management may fail. However, many of these aspects can be studied using reliable, homogeneous long-term data sets describing co-variations in the regional atmosphere and the sea, and improved modelling tools developed during pasted decades. Building links to economic, social and human sciences helps transform academic knowledge about the changing environment into a useful basis for constraining regional policies to sustainable development paths.

Homers words echo:
"The night passed, and the dawn came, and they sailed constantly."