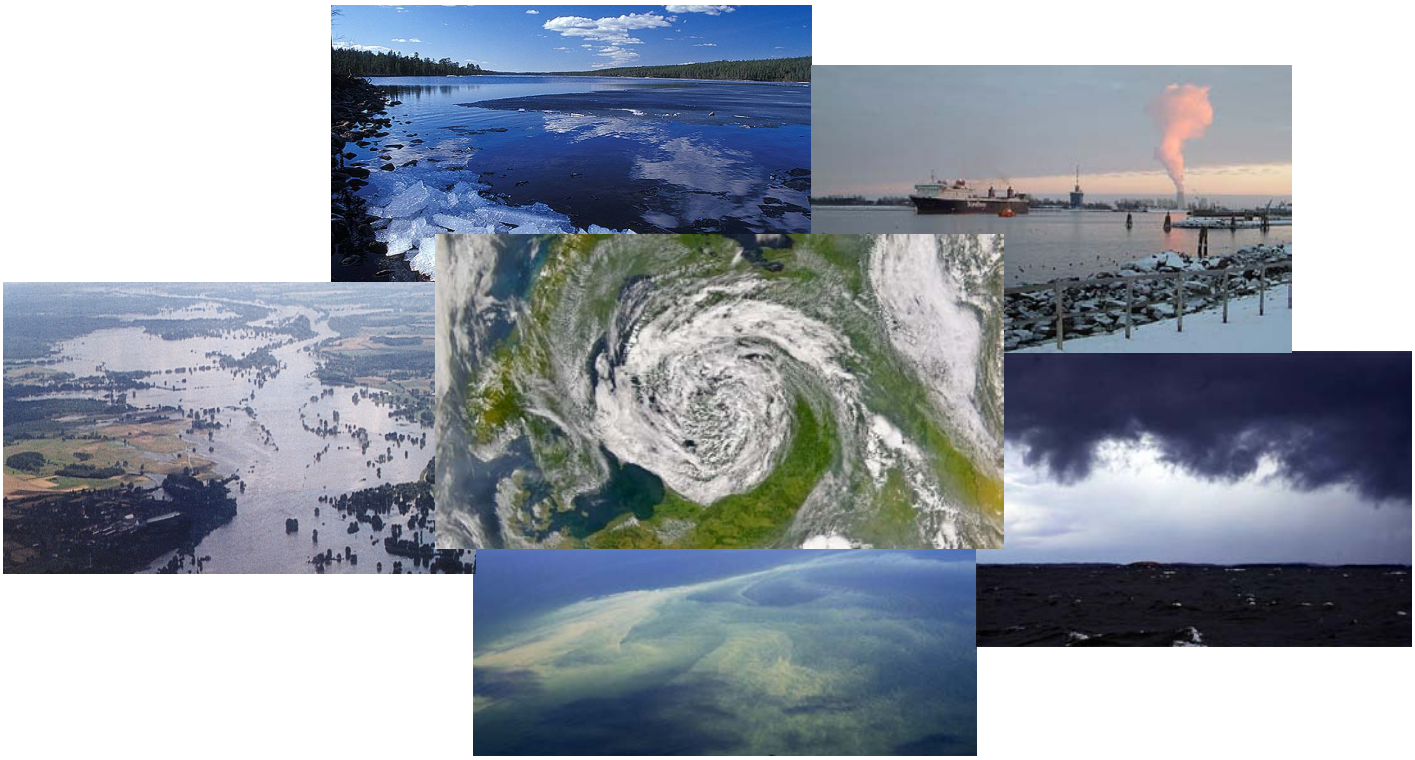
BALTEX Phase II
2003 – 2012



Science Framework and Implementation Strategy

Foreword

BALTEX (the Baltic Sea Experiment) was launched in 1992 as a Continental-scale Experiment (CSE) of the Global Energy and Water Cycle Experiment (GEWEX) within the World Climate Research Program (WCRP). The research focus of BALTEX has primarily been on the hydrological cycle and the exchange of energy between the atmosphere and the surface of the Earth, because they control and regulate the climate in a fundamental manner. The study region of BALTEX is the Baltic Sea and its huge catchment region, which constitutes a unique European water basin, creating specific demands on models and scientific concepts.

Numerous scientific achievements obtained during Phase I of BALTEX now call for application in other areas, where knowledge on and modelling capabilities of the water and energy cycles in the climate system are fundamental. A Science Plan for BALTEX Phase II was therefore published in early 2004 which suggests to enlarge the scientific scope of the programme and strives to contribute to generating not only physical but also environmental policy- and stakeholder-relevant information. The BALTEX Science Steering Group, at its 15th meeting in Risø, Denmark, implemented a writing team with the mandate to establish the present *Science Framework and Implementation Strategy* for BALTEX Phase II. This document intends to work out more details of the scientific background and rationale, and link these to potential implementation activities. Extension of BALTEX research will in particular include areas such as climate variability and climate change studies, scenarios of future climate, budgets and transport of harmful substances, improved understanding and prediction of extreme events like floods, and climate or environmental impact studies that respond to social needs and support decision makers in the broader context of Global Climate Change issues. An important aspect of BALTEX Phase II will be a more holistic approach towards observing, understanding and modelling major environmental and socio-economic aspects relevant for the entire Baltic Sea basin. Parts of the BALTEX Phase II research activities will thus contribute to the build-up of a high resolution integrated modelling capability for Northern Europe, embedded in an Earth System Model.

The intention of this *Science Framework and Implementation Strategy* is to provide a plan readable on its own, taking into account possible repetitions with - but also extensions to - the Science Plan published earlier. It is our wish to thank the writing team members and the numerous scientists who have contributed in various ways to this document. We all like to stress that the BALTEX Phase II research goals and potential activities are understood as invitations for joint research activities and cooperation, creating benefit for all involved, for a better understanding of the entire Earth system, and finally, an accelerated approach to sustainable development.

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Executive Summary

Since its foundation in the early 1990s, the research focus of BALTEX has primarily been the exploration, modelling and quantification of the various *physical* processes determining the space and time variability of the energy and water cycles of the Baltic Sea and its catchment region, the Baltic Sea basin. Numerous goals have been reached in particular in the following areas: Collection and exploitation of *in situ* and remote sensing data, the re-analysis of existing data sets, data assimilation as well as the development of coupled models and the implementation of process studies including field experiments. A particular major success was the building and first applications of two coupled modelling systems for the Baltic Sea - atmosphere - land surface system, including sea ice, lakes and rivers.

The numerous scientific achievements of BALTEX Phase I now call for application in other areas where knowledge on and modelling capabilities of the water and energy cycles in the climate system are fundamental. A Science Plan for BALTEX Phase II has therefore been published in early 2004, which defines 6 major objectives including several specific goals with the overall strategy to enlarge the scientific scope of the programme and to contribute to generating also environmental policy- and stakeholder relevant information.

An important aspect of BALTEX Phase II will be a more holistic approach towards observing, understanding and modelling major environmental and socio-economic aspects relevant for the entire Baltic Sea basin. Parts of the BALTEX Phase II research activities will thus contribute to the build-up of a high resolution integrated modelling capability for Northern Europe, embedded in an Earth System Model.

The structure of this *Science Framework and Implementation Strategy* document follows the six major objectives as defined in the Science Plan for BALTEX Phase II.

BALTEX Phase II Objectives

Objective 1
Better understanding of the energy and water cycles over the Baltic Sea basin

Objective 2
Analysis of climate variability and change since 1800, and provision of regional climate projections over the Baltic Sea basin for the 21st century

Objective 3
Provision of improved tools for water management, with an emphasis on more accurate forecasts of extreme events and long-term changes

Objective 4
Gradual extension of BALTEX methodologies to air and water quality studies

Objective 5
Strengthened interaction with decision-makers, with emphasis on global change impact assessments

Objective 6
Education and outreach at the international level

Objectives 1 to 4 are basically addressing science issues, while objectives 5 and 6 are related to strategic and political issues which will have to be pursued as cross-cutting activities in the context of all four science objectives. The Science Plan explained the scientific objectives in terms of several related major goals. This *Science Framework and Implementation Strategy* suggests how to achieve these goals and describes *potential activities* as more concrete implementation measures. It also specifies additional data needs and highlights the desired involvement of stakeholders.

The objectives of BALTEX Phase II are shortly outlined as follows:

Objective 1:
Better Understanding of the Energy and Water Cycles over the Baltic Sea Basin

Potential Activities

- Regional Analysis and Re-analyses for Different Variables for specific Purposes
- Further Development of Models and Model Improvement
- Closing the Energy and Water Budget on a High Level of Confidence
- Improvement of Quantitative Precipitation Forecast
- Evaluation of Models and Data Sets for their Use in Climate Impact Analysis and Environmental Issues

While BALTEX research has met to a large extent BALTEX Phase I objectives, gaps still exist and further research is needed for a more comprehensive fulfilment of the original BALTEX aims. Future BALTEX research related to this objective will therefore mainly contribute to further improving the physical understanding of processes, related modelling capabilities, and the quantitative estimation of important water and energy cycle parameters. Major goals include the evaluation of regional models with increasing and unprecedented detail with the particular perspective to support climate and environmental studies and to develop strategies for climate and environmental impact assessments. BALTEX will continue to establish and better explore more comprehensive observations from the entire Baltic Sea basin, including new satellite data. The further development of modules of coupled regional models for the atmosphere, the land surface including rivers and lakes, and the Baltic Sea including sea ice will be pursued. While some basin-wide estimates of atmospheric water transport divergence derived from re-analysis data sets, agree coincidentally within 10 to 20 % with basin-wide runoff estimates, individual components of the water and energy cycle show sometimes drastic mismatch and even unphysical direction of fluxes. A major future goal therefore remains to establish more reliable estimates of budgets and fluxes, i.e. to close the energy and water budgets at lower uncertainty.

Objective 2:
Analysis of Climate Variability and Change since 1800, and Provision of Regional Climate Projections over the Baltic Sea Basin for the 21st Century

Potential Activities

- Reconstruction History of Climate in the past 200 Years as well as detailed Re-analysis of "Weather" during the past 40 Years
- Detection and Attribution of Climate Change
- Scenarios based on Evolving Global and Regional Forcing and Response
- Assessment of Climate Change for the Baltic Sea Basin

Extended observations of climate parameters are available in the region, which should be exploited in concert with model studies. As for most regions, there are specific regional challenges of global climate change for the Baltic Sea basin. The combined effects of climate change and socio-economic changes are largely unknown at present. BALTEX Phase II will contribute to the detection of regional climate change in the Baltic Sea basin, and to a better understanding of the physical mechanisms that are behind climate variability and change. One aim is to discern between natural and anthropogenic causes and thus to contribute to attribution studies. Another is to study the contributions of large-scale control and locally/regionally generated forcing on the Baltic Sea basin climate. A further major aim for BALTEX Phase II is to develop projections of future climate variability and change by means of sensitivity analyses and model studies.

Charting past climate variability and change, and providing regional climate projections for the future over the Baltic Sea basin will become a major research component in BALTEX Phase II.

Objective 3:
Improved Tools for Water Management

Potential Activities

- High Resolution Hydrological Modelling
- Improvement of Parameter Estimates for distributed Hydrological Models
- Coupling Hydrological Models to Regional Climate Models
- Analysis of the Consequences of Climate Change for Hydrology and Water Resources Management
- Hydrological Modelling with Radar-derived Precipitation Applications

In the context of BALTEX Phase II research the envisaged improvement of tools for water management aims particularly at assessing how both present and future climate variability impacts on the water resources in the Baltic Sea basin, and how to quantify and reduce the associated risks caused by climate extremes. This objective is therefore closely related to the former one, however, with a specific water-related focus and tailored for a dedicated user and stakeholder community with its specific requirements. BALTEX Phase II goals include the further development and application of coupled atmospheric-hydrological models to be used for improved assessment of the availability of water resources in today's and future climate. Different modelling systems shall be applied in selected river basins to assess the impact of climate variability and change on the hydrological regime including the occurrence and severity of extreme events. BALTEX will consider socio-economic drivers by explicitly taking account of the societal use of groundwater and surface water resources, as well as man-made changes of land use, in studies of the future risk of water shortage and impacts of extreme events. Another goal is to develop further flood forecasting models.

Objective 4:
Gradual Extension to Air and Water Quality Studies

Potential Activities

- Input, Dispersion, Transport and Fate of Nutrients and Pollutants
- Integration of Biogeochemical Models in existing Coupled Regional Climate Models
- Integration of the Complete Carbon Cycle
- Use of Novel Data Sources and Techniques

With this objective BALTEX will explore and establish links between climate and environmental processes and research. The major aim is to gradually integrate environmental modelling into physical modelling concepts obtained in BALTEX Phase I. Whenever necessary - if data and knowledge are missing - BALTEX will define and execute appropriate observation concepts as suggested in the Science Plan for BALTEX Phase II. A particular goal is to enhance the capability to model pollution dispersion by using recent progress in dynamical modelling, particularly through coupled regional models, within the BALTEX community. It is envisaged to start the inclusion of nutrient and carbon cycles into the existing BALTEX modelling platforms. Important aspects of this research area are the exploitation of observational data, but BALTEX will also engage in field experiments that address missing or insufficiently known processes relevant for environmental issues. BALTEX aims at using recent developments in remote sensing of water and environmental parameters and novel flux measuring techniques of environmental components.

Objective 5:
Strengthened Interaction with Stakeholders and Decision Makers

Potential Activities

- Organisation of Dedicated Workshops with Stakeholder Participation
- Identification of Information Requirements of Decision Makers
- Elaboration of Adaptation Strategies to Climate Change in the BALTEX Region
- Identification of Fundable Research Activities

BALTEX Phase II research will take advantage of stakeholder involvement in a more pronounced way compared to Phase I. Important in this context is the involvement governmental organisations such as national hydro-meteorological services, but interaction with other stakeholders such as policy decision makers, international organisations (for example the European Environment Agency, EEA), companies and small enterprises in various sectors will also be strengthened and established. The selection of topics is driven by societal needs and is therefore a dynamical process. BALTEX envisages to install a dedicated working group which will promote a lively and fruitful interaction between scientists and stakeholders.

Objective 6:
Education and Outreach

Potential Activities

- Identification of Relevant Stakeholders and Users
- Intensification of Contacts between Scientists and Stakeholders/Users
- Organization of Stakeholder/User-relevant Workshops
- Organisation of BALTEX-related Summer Schools as well as the Integration of BALTEX relevant Topics into National and International Study Programmes including Master and Ph.D. Theses
- Preparation of relevant Study Material for Secondary Schools
- BALTEX-related Evening Lectures
- Establishment of a Web Site dedicated to the General Public

The rationale for BALTEX Phase II as outlined mainly in Chapters 2 to 5 clearly demonstrates the relevance of the programme for various sectors of the society. BALTEX will maintain a broad programme component with the overall objective to strengthen the education and outreach of BALTEX at all relevant levels, ranging from local to international and global. This component of the programme shall promote and facilitate the dissemination, transfer, exploitation, assessment and broad take-up of past and future programme results. The character of the individual measures include in particular i) the creation of awareness, ii) dissemination of results of the programme, and, iii) dedicated education and training measures. The target groups to be addressed in society can be largely divided into 1) stakeholders and users, 2) scientists, 3) students, and 4) the general public.

Scientific Cooperation and Contribution to GEWEX / WCRP and other International Programmes

Ever since its launch in the early 1990s, BALTEX has successfully contributed to meeting the objectives of the Global Energy and Water Cycle Experiment (GEWEX). As an approved GEWEX Continental-scale Experiment, BALTEX is actively participating in the GEWEX Hydrometeorology Panel (GHP). The revised objectives and the planned potential activities outlined in this document are obviously in line with and support meeting the revised objectives of GEWEX Phase II, which have recently been defined for the period until 2012. GEWEX is a global project of the World Climate Research Programme (WCRP), which has recently launched the *Coordinated Observation and*

Prediction of the Earth System (COPES) initiative with the major aim to facilitate prediction of the Climate/Earth system variability and change for use in an increasing range of practical applications of direct relevance and benefit to society. Through the envisaged contribution to develop a regional component of an Earth System model for the Baltic Sea basin, and also through its climate change and variability research components, BALTEX Phase II has a clearly defined commitment to contribute to WCRP/COPES. BALTEX therefore continues to be firmly anchored in GEWEX and WCRP.

The extended BALTEX Phase II objectives cover aspects of both CLIVAR (Climate Variability and Predictability) and CliC (Climate and Cryosphere), two other major WCRP global projects. In addition, the gradual extension of BALTEX research activities to air and water quality studies opens the option for a closer cooperation with projects of the International Geosphere-Biosphere Programme (IGBP) such as LOICZ (Land-Ocean Interactions in the Coastal Zone). The Baltic Sea basin is currently proposed to become an IGBP Integrated Regional Study Area, where closer links to regional LOICZ studies in the Baltic Sea coastal regions are desirable. The Earth System Science Partnership (ESSP), a joint initiative of all four coordinated global change programmes, including WCRP and IGBP, has the major objective to conduct integrated studies of the Earth system to explore the changes occurring in the system and implications for global sustainability. One of the joint ESSP projects already established is the Global Water System Project (GWSP), where BALTEX intends to contribute to, in cooperation with other in particular IGBP projects. The closer link between BALTEX and LOICZ is seen as a regional cooperation in the global frame of both ESSP and GWSP.

Contents

Introduction

"Our ability to understand and predict weather, climate and global climate change depends critically on our capability to observe and model the processes governing the hydrological cycle and the energy cycle of the climate system. Water vapour is the dominating greenhouse gas, and water in form of clouds plays a major role in controlling the climate on earth. Water, as snow or ice on the ground, on lakes and on the ocean alters drastically the heat, moisture and momentum exchanges between these media and the atmosphere. The fresh water supply to the oceans is of major importance for the circulation in the ocean and the associated vertical exchange of heat and salinity."

The above has been stated at the beginning of the introduction to the Initial Implementation Plan for the Baltic Sea Experiment (BALTEX) published in 1995 (BALTEX, 1995). These statements were – and still are – a basic rationale for the conduction of GEWEX, the Global Water and Energy Cycle Experiment, and its Continental-scale Experiments (CSE) such as BALTEX. In order to address the above cited issues and to reduce the uncertainties in our understanding of the hydrological and energy cycles of the climate system at the regional scale, BALTEX (1995) formulated the following three major objectives:

BALTEX Phase I Objectives, formulated in 1995:

- 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 in order to contribute to basic needs of climate, climate impact, and environmental research

Research in BALTEX has focussed on the study of the regional water and energy cycles over the entire Baltic Sea catchment[1], including the Baltic Sea as a major European marginal sea. Therefore, BALTEX includes a strong marine research component which makes BALTEX a unique CSE in the GEWEX context. Working closely together, meteorologists, hydrologists and oceanographers have considerably improved the understanding of these cycles and thus our ability to model the coupled atmosphere-land-ocean system in the BALTEX region.

With more than 10 years of BALTEX research conducted at the European level since the launch of the programme, it is time to answer questions such as "what have we learnt from BALTEX ?", "what are

[1] This region includes the sea itself and will be referred to as *Baltic Sea basin* or *BALTEX region* throughout this document.

the achievements of BALTEX so far ?" and "what may be concrete implementation measures for the second phase of BALTEX ?" Therefore, a science plan for the second phase of BALTEX (BALTEX Phase II) was recently established (BALTEX, 2004) which defines revised scientific objectives and strategies for the programme. For each of the science objectives, a number of major goals were formulated.

Following definitions in BALTEX (2004), the years 1993 to 2002 will be referred to as BALTEX Phase I and BALTEX Phase II relates to the ten-years period 2003 to 2012 throughout this document.

BALTEX Phase I: 1993 – 2002

BALTEX Phase II: 2003 - 2012

The focus during BALTEX Phase I has been primarily on process understanding and modelling of physical aspects of the water and energy cycles of the Baltic Sea basin. The numerous achievements of BALTEX in these fields have prepared the path for the application of BALTEX model systems in other research areas where the physical understanding and modelling skills of the water and energy cycles are of fundamental importance. Examples for such research areas include climate variability and climate change studies, scenarios of future climate, the transport of nutrients and harmful substances, an improved understanding and prediction of extreme events like floods, and climate or environmental impact studies that respond to social needs and support decision makers in the broader context of Global Climate Change issues, related to the Baltic Sea basin (BALTEX, 2004).

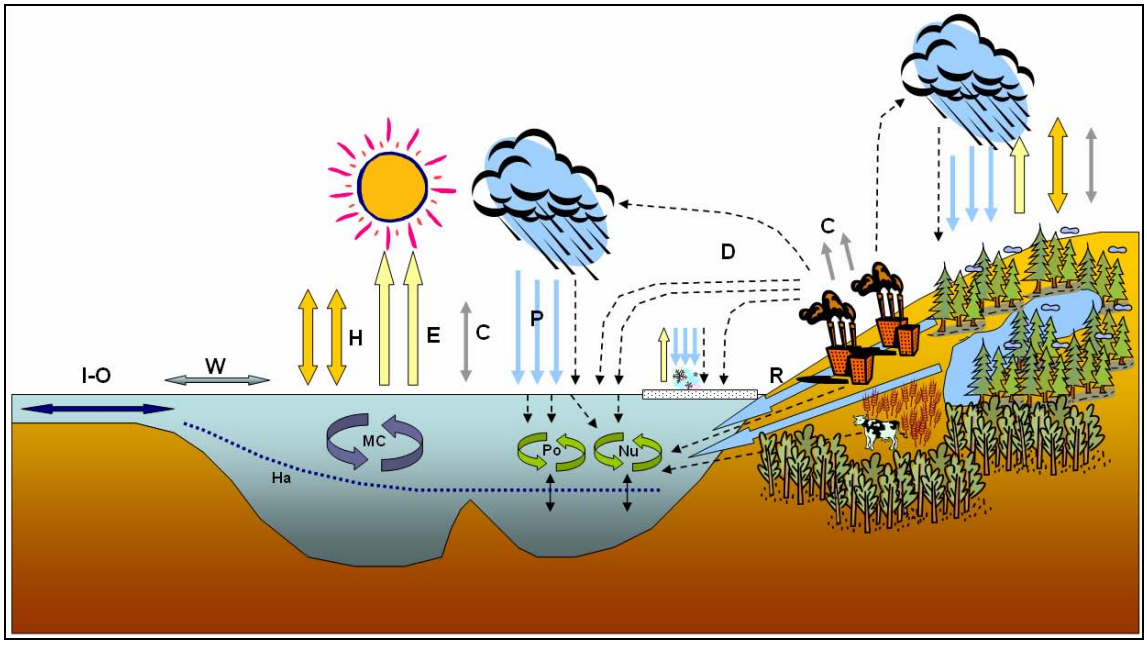

Fig. 1.1 Conceptual sketch of the Baltic Sea basin with major processes in the water and energy cycle, as investigated in BALTEX Phase I. New to Phase II are the integration of pollution, eutrophication and the carbon cycle (Po = Pollutants, Nu = Nutrients, C = Carbon, mainly as CO_2), indicated by dotted and grey arrows. Pollutants include heavy metals and persistent organic pollutants (POPs). Nutrients and pollutants from anthropogenic activities (hoseholds, agriculture, industries) enter the Baltic Sea through atmospheric deposition (mainly nitrogen) and riverine runoff. Climate changes resulting in changed temperatures, runoff and ice cover extent and duration, have a direct effect on these fluxes. I-O = In- and Outflow through the Danish Straits, W = Momentum Flux, H = Heat exchange including radiation, E = Evaporation and Transpiration, P = Precipitation, D = Atmospheric deposition R = Runoff, MC = Mixing and Convection, Ha = Permanent Halocline.

Within BALTEX Phase I, an international network of partnership for research has been created. Four data centres for meteorology, oceanography, hydrology and radar data have been established and are now important centres for information exchange and research. Two coupled atmosphere – land – sea ice – ocean models for climate variability and climate impact studies have been developed. This, as well as the inclusion of a marginal sea, is unique for GEWEX continental-scale Experiments, and make BALTEX developments also applicable to other regions on the globe. Thus BALTEX research is now in a position to take the next step into the development of regional Earth system models for extended applications.

Regional Earth system modelling in turn requires a grid infrastructure for which BALTEX with its international cooperation and contacts has created an ideal basis. The BALTEX region constitutes a perfect test bed not only for model development, validation and developments in satellite techniques but also for grid technologies - ”The Baltic Grid’’ (see Chapter 7.2 for details).

BALTEX Phase II will in particular build upon achievements related to the third BALTEX objective claiming that sufficient progress has been made in developing *transportable methodologies in order to contribute to basic needs of climate, climate impact, and environmental research* (see previous page). BALTEX Phase II will not follow an entirely new research plan but enlarge the scientific scope and thus strengthen the outreach of BALTEX in a significant way. BALTEX Phase II will continue to pursue those objectives and aims from Phase I of the programme that have so far not been met in a satisfactory manner. A main goal in BALTEX Phase II is to provide a solid framework for and execute environmental investigations and more realistic climate scenarios and climate impact studies.

The Baltic Sea Basin

The Baltic Sea basin covers about 2.1 million km^2 or 17% of the European continent, and encompasses territories of 14 countries[2] with a population of 85 millions (Figure 2). Climate conditions vary substantially from sub-arctic regimes in northern Scandinavia to moderately humid temperate zones in southern Poland, thus providing for high spatial and temporal variability. The Baltic Sea basin belongs to those regions in the World with a large north-south gradient in hydro-meteorological characteristics, which makes this region unique among European water basins, creating specific demands on models and scientific concepts. The Baltic Sea itself is a unique brackish marginal sea with complex hydrography and strongly variable sea-ice conditions. The basin‘s net annual water discharge to the Atlantic Ocean is comparable to major river systems such as the Mississippi and Mackenzie Rivers. Recent floods and devastating storms hitting the basin have increased the public and political awareness of the risks that climate and climate change may imply on Northern Europe.

The Baltic Sea and its rivers are not only a resource for fishery, hydropower and transportation; the region is also an area of increasing importance for tourism, leisure and water sports. In view of recent harmful incidents (*e.g.* traffic accidents in the Baltic Sea, and disastrous floods like in Sweden and Poland) research dedicated to the entire Baltic Sea basin for the assessment, mitigation of and adaptation to the risk is urgently needed. The application of coupled regional atmosphere/ocean/land models developed by the BALTEX science community that are nested into global coupled atmosphere/ocean/land models allow more detailed projections of climate change in the Baltic Sea basin for various scenarios of human activities at the global scale. This input is needed for mitigation measures like the enforcements of the Kyoto Protocol but also for adaptation to possible climate change.

Some countries in the eastern Baltic Sea basin have experienced considerable political, industrial and socio-economic changes in recent years. These rapid changes form a new challenge for the sustainable development of the Baltic Sea region and create growing demands for policy-relevant scientific information. In 2004, Poland, Lithuania, Latvia and Estonia became members of the European Union

[2] Clockwise around the Baltic Sea: Denmark, Norway, Sweden, Finland, Russian Federation, Estonia, Latvia, Lithuania, Belarus, Ukraine, Poland, Slovakia, Czech Republic, Germany.

(EU), and therefore eight EU member states now encircle the Baltic Sea, thus increasing the EU research interest in the BALTEX region.

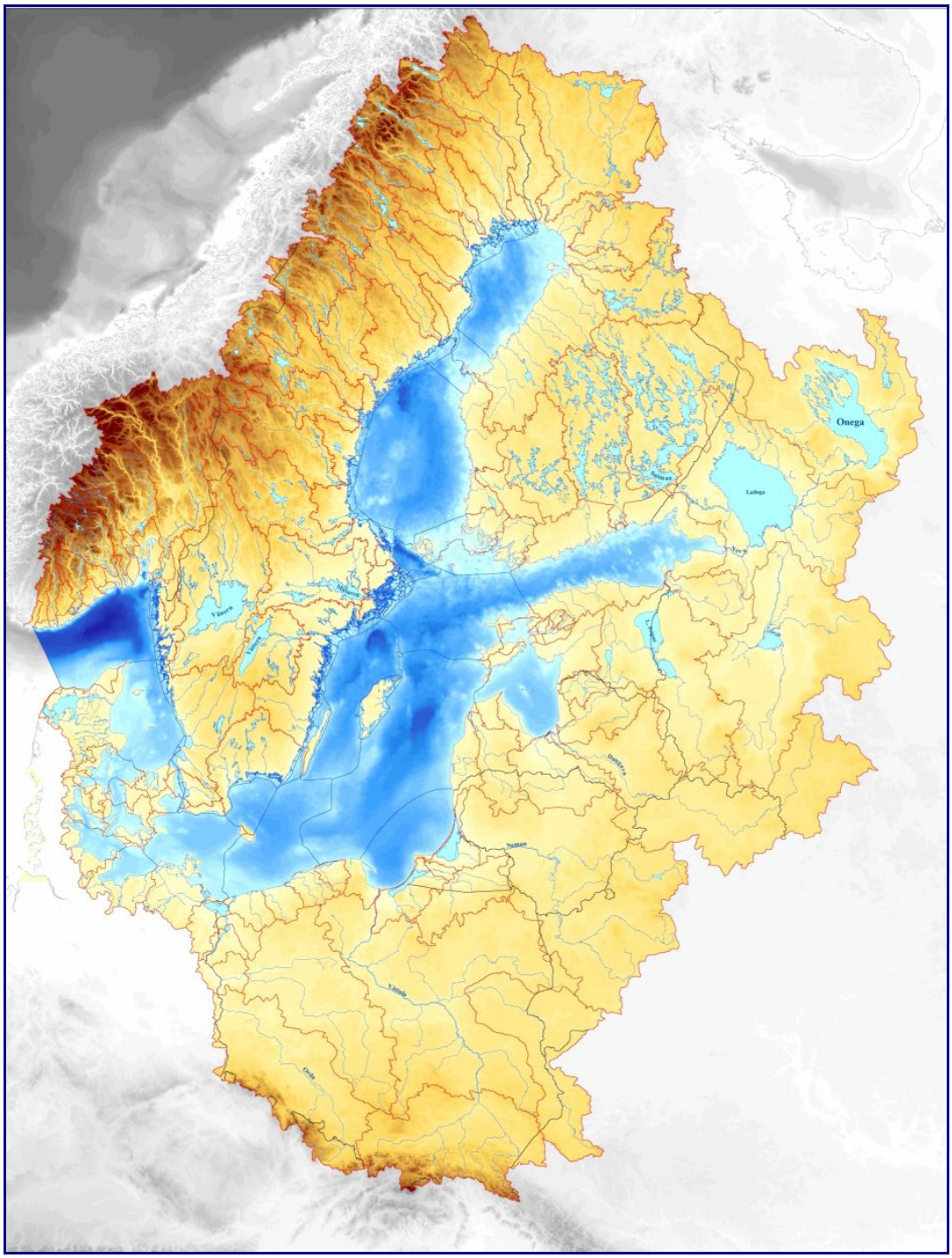

Fig. 1.2 The Baltic Sea basin. Map by courtesy of SMHI, Sweden.

Achievements of BALTEX Phase I

BALTEX Phase I has generated active research covering the whole field of advanced modelling and data studies in meteorology, hydrology and oceanography. Major research elements of BALTEX include the collection of *in situ* and remote sensing data, re-analysis of existing data sets, data assimilation, numerical experiments and coupled modelling and process studies including field experiments. It has brought major results both in scientific knowledge and research infrastructure at the European level.

Phase I Achievements: Atmosphere

- Improved understanding of sea-atmosphere and land-atmosphere interaction in the BALTEX region through observational studies and offline model evaluation and through numerical studies with coupled models.
- Improved knowledge on precipitation and evaporation over the BALTEX region through new instruments, radar estimates and satellite sensors.
- Development of improved remote sensing techniques to determine *e.g.* precipitation rates by weather radar, precipitable water by GPS and cloud climatologies by AVHRR.
- Improvement of understanding and modelling of cloud physics, cloud-radiation interaction and precipitation initiation.
- Development of retrieval methods for cloud liquid water path from passive imagers and optimized estimates of the spatial distribution of liquid cloud water.
- Assessment of model liquid water path, cloud vertical structure and cloud overlap with microwave, lidar and cloud radar observations and the impact on radiation.
- Development of fully coupled atmosphere-land-ocean models of the Baltic Sea basin for present day and climate change applications.

Examples include the first coupled regional models for the entire Baltic Sea basin and improved water budget estimates through newly assimilated data sets. Also special observing periods, such as the Pilot Study for Intensive Data Collection and Analysis of Precipitation (PIDCAP) in 1995, and BRIDGE, the major enhanced observational period within BALTEX during 1999 to 2002 with dedicated additional observations, were conducted in the frame of BALTEX. BALTEX projects are still ongoing in different countries funded mainly by institutional and national sources.

Phase I Achievements: Hydrology and Runoff

- A database of monthly river flow has been compiled and made available through the BALTEX Hydrological Data Centre.
- Large-scale hydrological models of river flow to the Baltic Sea exist.
- Improved communication between meteorologists and hydrologists resulting in a better understanding of the water cycle and the modelling of it.
- Lateral water transport through runoff routing has been applied in climate models.
- Efforts to improve flood forecasting schemes with the help of regional atmospheric models for specific river basins have been made.
- Climate change scenarios of impacts to the water cycle in the Baltic Sea basin have been performed.

BALTEX Phase I has marked a significant advance in research on regional meteorology, hydrology of the Baltic Sea basin as well as oceanography of the Baltic Sea including sea ice. Results of BALTEX are documented in more than 250 peer-reviewed journal articles and numerous reports. Special journal volumes dedicated to the four BALTEX Study Conferences held in 1995, 1998, 2001 and 2004 provide comprehensive insight to BALTEX results. These include issues of *Tellus* (1996, Volume 48 A, No 5), *Meteorologische Zeitschrift* (2000, Volume 9, No 1 and 2), *Meteorological and Atmospheric Physics* (2001, Volume 77, No 1-4), *Boreal Environmental Research* (2002, Volume 7, No 3 and 4), and *Nordic Hydrology* (2005, Volume 36, Issues 4-5). Achievements of BALTEX Phase I have been compiled in a detailed state-of-the-art report (BALTEX, 2005)

Phase I Achievements: Baltic Sea including sea-ice

- Meteorological, hydrological, ocean and ice data are now available for the research community through BALTEX data centres.
- Progress in understanding of the strong impact of large-scale atmospheric circulation on Baltic Sea circulation, water mass exchange, sea ice evolution, and changes in the ocean conditions of the Baltic Sea.
- Progress in understanding of the importance of strait flows in the exchange of water into and within the Baltic Sea.
- Progress in understanding of intra-basin processes.
- Ocean models are introduced to Baltic Sea water and energy studies.
- Development of turbulence models and 3D ocean circulation models for Baltic Sea.
- Advances of thermodynamic and dynamic coupling between the atmosphere, sea ice, and the sea; field experiments and modelling studies have yielded new results on local and regional surface fluxes and the interaction of the atmospheric boundary layer, sea ice, and open water.
- Progress in understanding the interaction between sea ice dynamics and thermodynamics.
- Advanced understanding of effects of river discharge and ice melt on the oceanic boundary layer below sea ice.
- Advanced understanding of the role of the large-scale atmospheric circulation for the ice conditions in the Baltic Sea.

The Objectives of BALTEX Phase II

BALTEX Phase II Objectives

Objective 1
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Objectives 1 to 4 are basically related to science issues, while objectives 5 and 6 address strategic and political issues which will be pursued as cross-cutting activities in the context of all four science objectives. The six major objectives are structuring elements for this Science Framework and Implementation Strategy document with one chapter being devoted to each objective (chapters 1 to 6). *Major goals* for each of the four scientific objectives were formulated in the Science Plan for BALTEX Phase II (BALTEX, 2004); these are summarized and, if required, extended in chapters 1 to 6. The latter elaborate on how to achieve these goals and describe *potential activities* as more concrete implementation measures. They also specify additional data needs, outline aspects of data

management and highlight the desired involvement of stakeholders and plans for education and outreach at the international level.

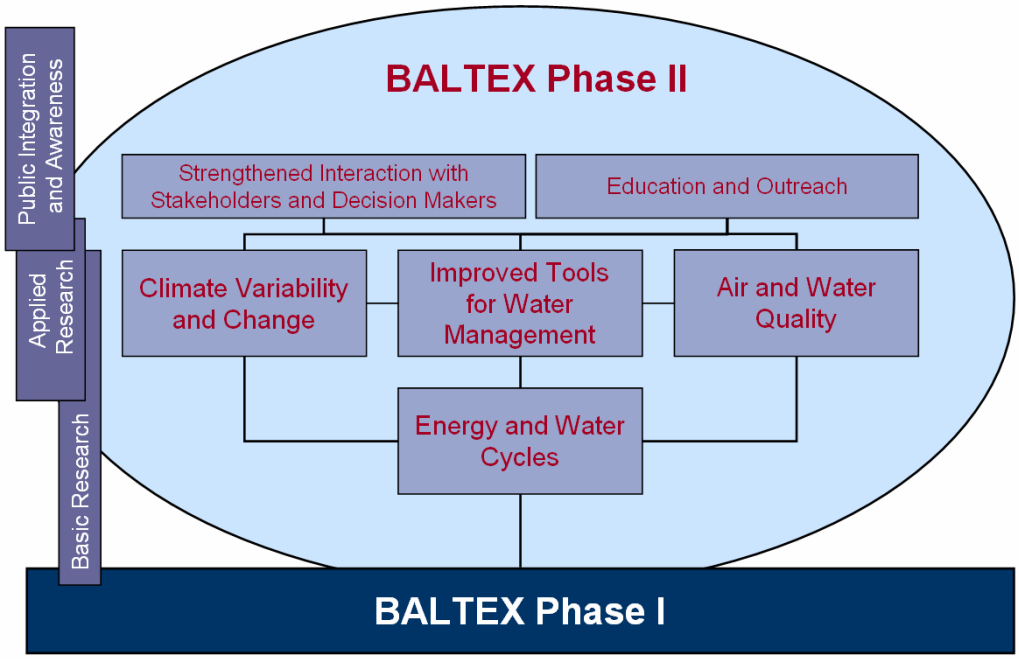

Fig. 1.3 BALTEX Phase II objectives defined as basic and applied research components, and public integration and awareness activities.

Chapters 7 to 10 mainly deal with organizational issues, such as the definition of a road map towards implementing BALTEX II measures until 2012, and the status of ongoing activities (chapter 7), an overview of BALTEX data management provisions and activities (chapter 8), the detailed outline of organisational structures within BALTEX including short descriptions of current and future working groups (chapter 9), and finally the embedding of BALTEX research within the international research arena and the cooperation with related research programmes (chapter 10).