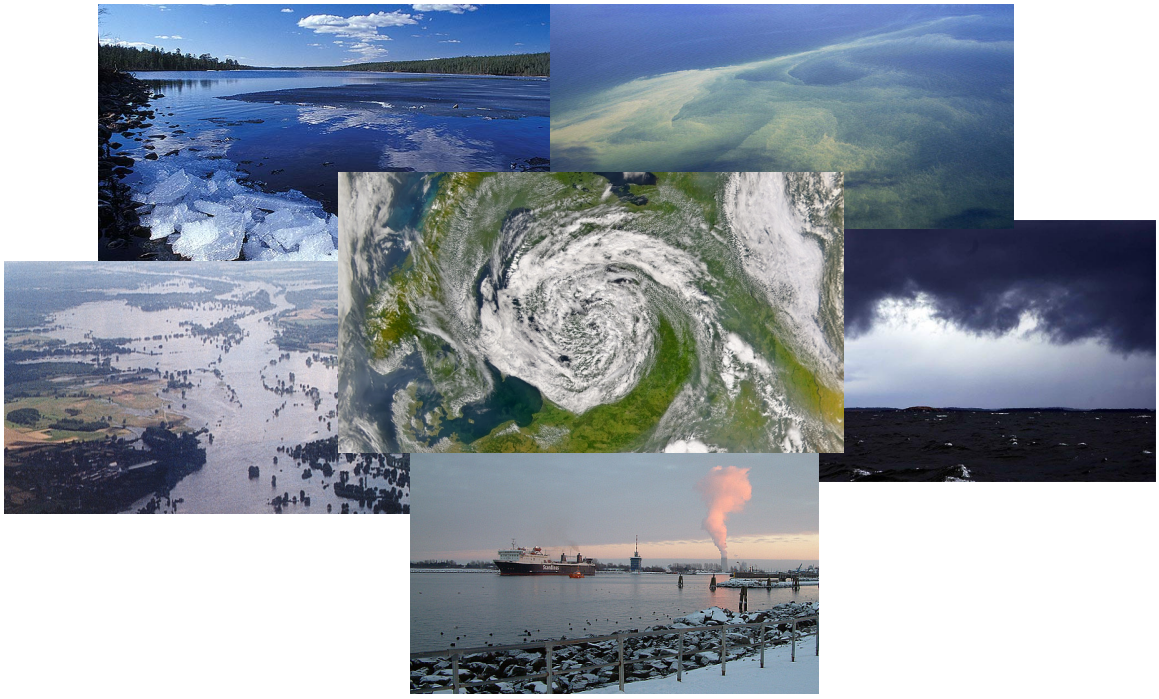
BALTEX Phase II
2003 – 2012



Revised Objectives

A Summary Amendment to the BALTEX Phase II Science Framework and Implementation Plan

Foreword

BALTEX (the Baltic Sea Experiment) was launched in 1992 as a Continental-scale Experiment (CSE, now termed Regional Hydroclimate Project, RHP) of the Global Energy and Water Cycle Experiment (GEWEX) within the World Climate Research Programme (WCRP). During its first phase until 2003, the research focus of BALTEX was primarily 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.

The launch of BALTEX Phase II in 2003 marked a major re-orientation of BALTEX research within the scope of BALTEX as a GEWEX/WCRP related programme. As such it was the first to explicitly include “air and water quality” issues and their feedbacks to the environment into the water cycle. Also, the inclusion of regional climate change, water management issues and the outreach to stakeholders, policy makers and the general public are new aspects on the BALTEX agenda. The new objectives have evolved since 2003, also due to the participation of new steering group members. Some aspects have shown to be outside of what a programme like BALTEX can achieve within its given lifetime; others have gained importance due to the availability of external funding. Thus, a review followed by some adjustments of the new objectives was deemed necessary in the light of these developments and the feasibility to reach the major goals within the current programme phase until the end of 2012.

This document represents an update of the BALTEX Phase II objectives, as defined in the *BALTEX Phase II Science Framework and Implementation Strategy* (2006). It was initiated by the BALTEX Science Steering Group at its 22nd meeting in Norrköping in January 2008. This document takes into account the recommendations given by a task group which was

formed at the Norrköping meeting. Although it should be readable on its own as a comprehensive outline of the updated BALTEX Phase II objectives, it is meant as an amendment to the *Science Framework and Implementation Plan* of 2006, rather than a replacement. Some sections were adopted unchanged from the original document, others were amended or re-formulated.

Again, we would like to stress that the present revised BALTEX Phase II research goals and potential activities outlined here are understood as invitations for joint research activities and cooperation, creating benefit for all involved, striving for a better understanding of the regional Earth system of the Baltic Sea basin.

Finally, we would like to thank the members of the BALTEX Science Steering Group and the task group members (see page 19) for reviewing the *BALTEX Phase II Science Framework and Implementation Strategy* (2006), and for defining the updated objectives laid out in this document.

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Introduction

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. Major goals which have been reached include the 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 establishment 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 have called for an 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 had therefore been published in early 2004, followed by a *Science Framework and Implementation Strategy* document (2006), which defined six objectives to enlarge the scientific scope of BALTEX, and attempting to generate environmental policy- and stakeholder relevant knowledge, as well as information relevant for the public.

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

This update to the *Science Framework and Implementation Strategy* (2006) follows the six major objectives, and briefly states the revisions implied on them, in the light of recent developments and the perspective of the planned termination of BALTEX Phase II in 2012.

Revised BALTEX Phase II Objectives

Objective 1
Improved understanding of energy and water cycles under changing conditions

Objective 2
Analysis of climate variability and change, 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 extreme hydrological events and long-term changes

Objective 4
Biogeochemical cycles in the Baltic Sea basin and transport processes within the regional Earth system under anthropogenic influence

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 partly re-named to indicate new aspects. They basically address 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* (2004) explained the scientific objectives in terms of several related major goals. As the original *Science Framework and Implementation Strategy* (2006), this update takes on these goals and describes *potential activities* as more concrete implementation measures.

Objective 1

Improved understanding of energy and water cycles under changing conditions

The investigation of the energy and water cycle remains the backbone of the programme. Goals are

- to evaluate in increasing detail regional models used for climate and environmental studies, and to develop strategies for climate and environmental impact assessments,
- to obtain better and more comprehensive observations from the entire Baltic Sea basin, including new satellite data, in particular to cope with regional resolution requirements,
- to further develop the numerical regional models for the atmosphere, the land surface including rivers and lakes, and the Baltic Sea including sea ice, and
- to lower the uncertainty when closing the energy and water budgets from measurements.

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. BALTEX research related to this objective therefore mainly contributes 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 high-resolution regional models, with the particular perspective to support climate and environmental studies and to develop strategies for climate and environmental impact assessments. The further development of modules for coupled

regional models for the atmosphere, the land surface including rivers and lakes, and the Baltic Sea including sea ice will be pursued.

Regional analyses and re-analyses of past conditions are needed to validate regional climate model results for the past and the future. An oceanographic gridded data set for the Baltic Sea, comparable to ERA-40, is currently not available. Also, downscaling of atmospheric analyses to coastal regions is a desirable task. Various data sets may be used for this goal: MESAM of SMHI (possibly with improved resolution), ENSEMBLES data with 25 km resolution forced by ERA-40 (1958-2002), ERA-Interim 4DVAR at 80 km horizontal resolution (1989-2008). A new aspect to take into account in re-analyses is land-use change.

More comprehensive observations from the entire Baltic Sea basin are needed, including new satellite data. Moreover, new ground-based remote sensing methods to measure vertical profiles with high temporal and spatial resolution offer new approaches for model validation. Probability density functions of the temporal and spatial variability based on observations and regional climate models may be applied.

Certain problems concerning quantitative precipitation forecasts have not yet been solved, e.g. the accuracy of radar measurements, the required resolution of the gauge network, and related economic implications. Results and methods from large projects in other regions may be adopted for the BALTEX region. National meteorological services have activities in the combined application of radar data, mesoscale analysis techniques (e.g. LAPS), and mesoscale modelling. This yields improved products which may be used also for water management.

Uncertainties remain in estimates of precipitation minus evaporation (P-E) and its variations over the Baltic Sea. Sea water salinity may be used to study whether atmospheric models have a correct water budget, provided river run-off is known at sufficient accuracy. While some basin-wide estimates of atmospheric water transport 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 sometimes show a 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.

Potential Activities

1.1 Regional analyses and re-analyses with a high resolution and time span

1.2 Evaluation and further development of models

1.3 Improvement of quantitative precipitation forecasts

1.4 Quantification of the energy and water budgets on a high level of confidence

Objective 2

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

Goals are

- to contribute to detecting regional climate change,
- to understand the physical mechanisms behind past climate variability and change, whether of natural or anthropogenic origin, in the BALTEX region; and to contribute to attribution studies,
- to study the balance between large-scale control and locally/regionally generated forcing of the regional climate system, and
- to develop projections of future climate variability and change, by means of sensitivity analyses and model studies.

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 contributes 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 has become a major research component in BALTEX Phase II.

A successful BALTEX effort related to Objective 2 was the BALTEX Assessment of Climate Change for the Baltic Sea basin (BACC). An update to BACC is currently in preparation (BACC II). The purpose of BACC is to provide the scientific community with an assessment of ongoing climate variations in the Baltic Sea basin. An important element was the description of atmospheric, hydrological, oceanographic and ecosystem changes due to climate variations. The BACC initiative has generated a large activity around the Baltic Sea with more than 80 authors contributing to the assessment, and a close cooperation with HELCOM was initiated. The resulting BACC book was published by Springer in January 2008 (BACC 2008). This work has been an important step towards reviewing and assessing our understanding of climate change for the Baltic Sea basin, including land and water ecosystems. BALTEX shall play an important role in this work in the future. BACC II is being organised through a BALTEX working group, aiming for a new assessment within 5 years.

Potential Activities

2.1 Reconstruction history of climate in the past 200 years,
as well as detailed re-analysis of "weather" during the past 40 years

2.2 Detection and attribution of climate change

2.3 Scenarios based on evolving global and regional forcing and response

2.4 Assessment of climate change for the Baltic Sea basin

Objective 3

Provision of improved tools for water management, with an emphasis on extreme hydrological events and long-term changes

Goals are

- to further develop and apply coupled atmospheric-hydrological models for improved assessment of the availability of water resources in today's and future climates,
- to develop, validate, and apply different modelling systems 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,
- to assess future risk of water shortage and extreme events by explicitly taking account of the societal use of groundwater and surface water resources, as well as man-made changes of land use,
- to further develop high-resolution observation and data assimilation methods, short-term precipitation forecasts, and flood forecasts,
- to analyse local drivers (e.g. land use changes) for long-term changes in hydrology, and
- to assess past and ongoing hydrological changes.

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 climates. 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. In this respect, water resource studies should be introduced to coastal zone management planning. Further goals are the development of flood forecasting models, impact models on the future potential of hydropower (including an assessment of dam safety), the impact on river and lake ice in the future, and assessments of drought risks.

Potential Activities

3.1 High resolution hydrological modelling including flood forecasting and scenario models

3.2 Improvement of parameter estimates for distributed hydrological models

3.3 Coupling hydrological models to regional climate models

3.4 Analysis of the consequences of climate change for hydrology and water resources management

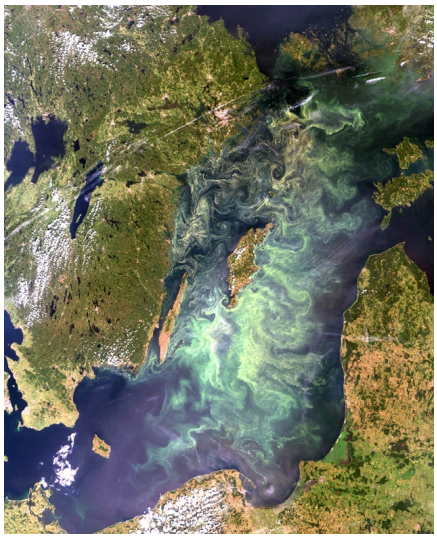
3.5 Hydrological modelling using radar-derived precipitation to improve flood forecasting

3.6 Impact studies on the future hydropower potential with specific consideration of dam safety

3.7 Assessment of the influence of climate change on the occurrence of river and lake ice

3.8 To link water resources studies to coastal zone management

3.9 Assessment of drought risk under changing climate



Objective 4

Biogeochemical cycles in the Baltic Sea basin and transport processes within the regional Earth system under anthropogenic influence

Goals are

- to improve the understanding of biogeochemical processes in the sea with special emphasis on the relationship between nutrients and the cycling of organic carbon and CO_2,
- to identify and quantify biogeochemical transformations on land that affect the input of biogeochemically relevant substances into the Baltic Sea,
- to improve the understanding of processes in the atmosphere and at the air/sea interface that control the deposition of nutrients and acidic substances and the exchange of bioactive gases,
- to incorporate biogeochemical fluxes, from both land and the atmosphere to the sea, into regional coupled atmosphere-land-ocean models including sea ice, rivers and lakes, and
- to foster the coupling of climate and biogeochemical models in order to estimate the consequences of climate change for the regional Earth system of the Baltic Sea basin including the Baltic Sea ecosystem.

The overall aim of this objective is to include biogeochemical processes in the scope of BALTEX research. As biogeochemical cycles are closely interwoven with the hydrological cycle, BALTEX can contribute with its expertise on the water cycle in the Baltic Sea basin. Water as the Earth´s ubiquitous solvent governs the fluxes and reservoirs of biogeochemically

relevant elements on land, in the sea and in the atmosphere. A changing water cycle inherently implies a change in the fluxes and reservoirs of these elements.

This research objective rests on two pillars: Firstly, the investigation of the carbon cycle with special emphasis on CO_2 and organic carbon in the Baltic Sea and its drainage basin, taking into account fluxes across the atmosphere and sediment interfaces. Here, specific goals are to achieve significant progress in marine ecosystem modelling by aligning biomass production and oxygen depletion with CO_2 dynamics, and to assess potential effects of climate change, eutrophication, increasing atmospheric CO_2 concentration, and acidic deposition on the carbon cycling in the Baltic Sea and its catchment area; secondly, the extension and combination of existing regional climate models with biogeochemical and ecosystem models in order to achieve a modelling tool which allows an estimation of climate change impacts on the ecosystems of the Baltic Sea and drainage basin. This, in fact, requires a true interdisciplinary approach, bringing together climate and ecosystem researchers and modellers.

Both research priorities of this objective are being supported by the research projects Baltic-C and ECOSUPPORT, which have received support by BONUS, a new joint funding mechanism for the Baltic Sea region by the European Commission and several EU member states. These projects bundle some research activities within this objective, but do not exclude other activities within the scope of this objective.

Baltic-C will involve the development, evaluation, and application of the first fully integrated model framework for the predictive analysis of the functionning and the dynamics of the Baltic Sea organic/inorganic carbon and oxygen systems. This framework will significantly improve the understanding of the relevant physical, chemical, and biological processes and will be supported by and validated against comprehensive observational data. Outcome of the project will be a new integrated model framework that supports the water management of the Baltic Sea and its ecosystem, addressing the consequences of climate change, eutrophication, increasing atmospheric CO_2 concentration, and acid deposition.

ECOSUPPORT adresses the need for policy-relevant information on the combined future impacts of climate change and industrial and agricultural practices in the Baltic Sea basin on the Baltic Sea ecosystem. The main aim is to provide a multi-model system tool to support

decision makers. The tool is based on scenarios from an existing state-of-the-art coupled atmosphere-ice-ocean-land surface model for the Baltic Sea basin, marine physical-biogeochemical models of differing complexity, a food web model, statistical fish population models, economic calculations, and new data detailing climate effects on marine biota. The expected outcome of ECOSUPPORT is an advanced modelling tool for scenario simulations of the whole marine ecosystem that can support management strategies to ensure water quality standards, biodiversity and fish stocks under the conditions of climate change.

Potential Activities

4.1. Time series measurements and use of historic data for nutrients, organic carbon and CO_2 in the Baltic Sea for process parameterization and model validation;

4.2. Model based (with data assimilation) space-time detailed description of past variability and change in biogeochemical cycles;

4.3. Implementation of the marine CO_2 system into and improvement of biogeochemical models;

4.4. Increasing the spatial and temporal resolution of monitoring of the riverine input and atmospheric deposition of nutrients and organic carbon;

4.5. Studies on the gas exchange transfer velocity using new technologies;

4.6. Integration of biogeochemical models into existing coupled regional climate models;

4.7. Model based scenarios on future biogeochemical cycles under changing anthropogenic pressures

Objective 5

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

The involvement of stakeholders and decision makers is an important aspect in BALTEX Phase II. A prominent and successful example of stakeholder involvement in BALTEX Phase II is the collaboration with HELCOM, the Baltic Marine Environment Protection Agency, in sharing the BACC material for a dedicated HELCOM Report. This collaboration will be further strengthened in the scope of BACC II. Other important stakeholders remain the national hydro-meteorological services, but interaction with other stakeholders such as policy decision makers, international organisations, companies and small enterprises in various sectors should also be strengthened and established. A currently ongoing collaboration with BSSSC, the Baltic SeaStates Subregional Co-operation, represents an interface between the scientific community and a network of politicians on the local (sub-regional) scale, broaching the issue of local impacts of regional climate change. This collaboration is planned to be further developed. The selection of topics for stakeholder and policy maker involvement is driven by societal needs and is therefore a dynamical process.

Potential Activities

5.1 Identification of relevant stakeholders and users

5.2 Intensification of contacts between scientists and stakeholders/users

5.3 Organization of stakeholder/user-relevant workshops

5.4 Responding to information requirements of decision makers, among others by BACC II book

5.5 Elaboration of adaptation strategies to climate change in the BALTEX region

5.6 Identification of fundable research activities

Objective 6

Education and outreach at the international level

The rationale for BALTEX Phase II 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.

Potential Activities

6.1 Organisation of BALTEX-related summer schools as well as the integration of BALTEX relevant topics into national and international study programmes including Master and PhD theses

6.2 Preparation of relevant study material for secondary schools

6.3 BALTEX-related evening lectures

6.4 Establishment of a website dedicated to the general public

BALTEX in context of the GEWEX/CEOP/WCRP framework and cooperation with other international programmes

Since its launch in the early 1990s, BALTEX has been an approved Continental-Scale Experiment (CSE) of the Global Energy and Water Cycle Experiment (GEWEX), a global project of the World Climate Research Programme (WCRP). Through the years, it has successfully contributed to meeting GEWEX objectives, and has also actively participated in the GEWEX Hydrometeorology Panel (GHP). In 2007, the GEWEX GHP merged into the Coordinated Energy and Water Cycle Observations Project (CEOP), and the CSEs were re-defined as Regional Hydroclimate Projects (RHPs). The revised objectives and the planned potential activities outlined in this document are in line with the objectives of GEWEX Phase II, which have been defined for the period until 2012. BALTEX therefore continues to be firmly anchored in GEWEX and WCRP.

It is also obvious that part of BALTEX Phase II objectives go beyond the scope of GEWEX. In particular the extension of BALTEX research activities to biogeochemical cycles and transport processes (Objective 4) 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.

Promising collaborations have developed with regional organisations which are active in the Baltic Sea area. BONUS as the new joint funding mechanism for Baltic Sea research by the European Commission and several EU member states, is currently funding two large BALTEX projects (Baltic-C and ECOSUPPORT, see Objective 4). A further collaboration towards improving a mutual benefit for BALTEX and BONUS is desirable concerning the identification of relevant climate change related research topics for the coming BONUS calls. The collaboration with HELCOM, the Baltic Sea Environment Protection Commission is also strengthening in connection with the coming BACC II activities.

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Acronyms

4-DVAR ..... A four-dimensional variational analysis used in atmospheric modelling
BACC ..... BALTEX Assessment of Climate Change for the Baltic Sea basin
BALTEX ..... The Baltic Sea Experiment
Baltic-C ..... Building predictive capability regarding the Baltic Sea organic/inorganic carbon and oxygen systems (a BONUS project)
BONUS ..... Baltic Organisations Network for Funding Science
BSSSC ..... Baltic SeaStates Subregional Co-operation
CEOP ..... Coordinated Energy and Water Cycle Observations Project
CSE ..... Continental Scale Experiment
ECMWF ..... European Centre for Medium-Range Weather Forecasts
ECOSUPPORT ..... Advanced tool for scenarios of the Baltic Sea ECOsystem to SUPPORT decision making (a BONUS project)
ENSEMBLES ..... An ensemble prediction system for climate change (an FP6 project)
ERA-40 ..... ECMWF re-analysis of the global atmosphere and surface conditions for 45-years (1957-2002)
ESSP ..... Earth System Science Partnership
FP6 ..... 6th Framework Programme of the European Commission
GEWEX ..... Global Energy and Water Experiment
GWSP ..... Global Water System Project
HELCOM ..... Helsinki Commission – Baltic Marine Environment Protection Commission
IGBP ..... International Geosphere-Biosphere Programme
LAPS ..... Local Analysis and Prediction System
LOICZ ..... Land-Ocean Interactions in the Coastal Zone
MESAM ..... An Operational Mesoscale Analysis System of SMHI
RHP ..... Regional Hydroclimate Project
SMHI ..... Swedish Meteorological and Hydrological Institute
WCRP ..... World Climate Research Programme

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Cover: (centre and clockwise from top): A cyclone over the eastern Baltic Sea basin (SeaWiFS Project, NASA/Goddard Space Flight Centre, GeoEye); a blue-green algae bloom in the Gulf of Finland (Riku Lumiaro); a storm front over the Baltic Sea (Riku Lumiaro); Rostock harbour in winter (Marcus Reckermann); the Odra river on 22 July 1997 near Czelin, Poland (A. Kwapiszewski, from: Dubickiego A, Sloty H. and Zielinskiego J. (Eds.): Dorzecze Odry – Monografia Powodzi Lipiec 1997, Instytut Meteorlogii I Gospodarki Wodnej, Poland); melting ice in spring in a Swedish lake (Holger Nitsche). *Page 1*: Withdrawing thunder clouds over the Schlei fjord, western Baltic Sea (Marcus Reckermann). *Page 3*: Approaching rain clouds over the western Swedish archipelago (Marcus Reckermann). *Page 5*: Tännforsen waterfall, Sweden (FreeDigitalPhotos.net). *Page 7*: Winter in northern Sweden (Hans-Jörg Isemer). *Page 9*: Stormy weather (FreeDigitalPhotos.net). *Page 11*: A satellite image of a blue-green algae bloom in the Baltic proper (SMHI Norrköping, Sweden). *Page 14*: Wind mill under a stormy sky (FreeDigitalPhotos.net). *Page 15*: Fishing boats on a beach on Wolin, Poland (Marcus Reckermann). *Page 16*: Agricultural land on Bornholm, Denmark (Marcus Reckermann).

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Copies are available upon request from the International BALTEX Secretariat.