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BONUS+ Programme in support of climate change studies in the Baltic Sea region

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The previous issue of the BALTEX Newsletter informed its readers about two research projects belonging to the "BALTEX family" that won the tough competition of the BONUS+ Call: **BALTIC-C**, coordinated by Anders Omstedt of the University of Gothenburg, and **ECOSUPPORT**, coordinated by Markus Meier of the Swedish Meteorological and Hydrological Institute (SMHI). Together with another fourteen projects, these research initiatives will receive BONUS+ funding from the European Community and from national research funding institutions of nine Baltic Sea countries to conduct 3-year studies. The BONUS-169 Science Plan and Implementation Strategy (available at *www.bonusportal.org*) identifies seven research themes:

1. Linking science and policy,
2. Understanding climate change and geophysical forcing,
3. Combating eutrophication,
4. Achieving sustainable fisheries,
5. Protecting biodiversity,
6. Preventing pollution,
7. Integrating ecosystem and society.

All these themes were opened for submission of proposals in the first BONUS+ call – to test the distribution of power, and pave the way for more thematically focused future calls of the Joint Baltic Sea Research Programme (see BALTEX Newsletter 8, page 25).

The response from the Baltic Sea research community was enormous: Altogether 148 letters of intent by international teams of researchers were uploaded to the BONUS Electronic Proposal Submission System (EPSS). The first round of selection resulted in 55 proposers invited to submit a full proposal, 16 of which were ultimately selected for funding based on international evaluation of their scientific quality and potential to produce valuable output to support ecosystem approach to the management of human activities related to the Baltic Sea.

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Merry Christmas and a Happy New Year from the BALTEX Secretariat!

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Commentary

BONUS creating new momentum for Baltic Sea research

Hans-Jörg Isemer, International BALTEX Secretariat

The 16 new international projects with more than 100 participating entities and an expected funding volume of more than 22 million Euros is a major potential for creating innovative results and a significant momentum for Baltic Sea research. While I am writing this commentary, final administrative steps towards contract conclusion for the new projects await completion, some of which appear to be challenging from a project participant's point-of-view. However, we should all have in mind, that BONUS+ denotes an entirely new research funding mechanism at the international level, to my knowledge the only existing important one for truly international research consortia, except, may be, for the European Commission's framework programmes with their low likelihood of success. Kaisa Kononen and the consortium of funding agencies are to be highly commended for this outstanding success of BONUS+!

And the momentum seems to be hold up for a further development of BONUS into BONUS-169, a mechanism according to article 169 of the European Union's Treaty, which basically means a real "common financial pot" with uniform procedures for all participants, rather than a distributed funding with diverse national rules and mechanisms. Besides formal issues to be solved on this way, a key task will be the setup of an updated, targeted work programme as a basis for future BONUS-169 calls which takes into account a careful assessment of both most actual research results and research requirements defined jointly by stakeholders and the R&D communities. It is this step where I see a prominent future role of BALTEX, even stronger than in the past, to contribute to defining revised work programmes and discuss possible options of joining forces of BONUS and BALTEX. Networking of BONUS and BALTEX through individuals is in place, e.g. through BALTEX SSG members holding BONUS functions and acting as coordinator or participant within the new 16 BONUS+ projects. Finally, I have recently been honoured to represent BALTEX in the newly established Advisory Board for the BONUS EEIG, which I appreciate as recognition of the BALTEX achievements, particularly towards understanding of the climate system of the Baltic Sea Basin. I am looking forward to this role with the view of creating benefit – on behalf of and in cooperation with the BALTEX SSG – for future fruitful research dedicated to the Baltic Sea region's ecosystem.

While participants of 16 consortia are currently refining their plans and preparing to commence intensive work in the end of 2008 – beginning of 2009, the BONUS EEIG (European Economic Interest Group, a dedicated legal structure to manage the Joint Baltic Sea Research Programme, with a Secretariat in Helsinki) has published the summaries of projects in its web site *www.bonusportal.org*, and prepares for the Programme Kick-off Conference to be held in Espoo near Helsinki, 13-15 January 2009.

Climate forcing shapes any of the processes and phenomena investigated by the BONUS researchers – both natural and societal. Nowadays, it is difficult to imagine any evidence-based advice to the policy making that would ignore climate dynamics in the coming decades and centuries.

The BONUS theme „Understanding climate change and geophysical forcing" is represented by two projects. **INFLOW**, coordinated by Aarno Kotilainen of Finland's Geology Research Centre, will address one of the fundamental properties of the Baltic Sea physical system: inflows of saline water from the North Sea. By use of sediment proxy data along a Baltic Sea transect, the relationships between long-term instrumental data and signatures of modern sediments will be quantified. These studies will be extended to longer time scales (past 6000 years) and linked to climatic data from the wider North Atlantic to identify the forcing mechanisms of ecosystem changes. Scenarios of the future development of the Baltic Sea will be produced by modelling.

Practical aspects of physical oceanography will be tackled in **BalticWay**, coordinated by Tarmo Soomere of the Institute of Cybernetics, Tallinn University of Technology. This project aims to develop an innovative low-cost technology for environmental management of shipping, extendable to offshore and coastal engineering activities, allowing to place dangerous activities in areas where an accident will pose a minimum threat to vulnerable zones. The project approach makes use of the existence of semi-persistent current patterns that affect the propagation of pollution. The BalticWay consortium involves several participants with rich experience in climate modelling.

For years, eutrophication has been considered as the main threat to Baltic Sea health, therefore it may not surprise that the largest group of BONUS+ projects has the key objective to better understand eutrophication-related biogeochemical processes in the sea and its drainage basin and to develop efficient and cost-effective ways to curb this adverse phenomenon. The goal of the project **AMBER**, coordinated by Joachim Dippner of the Leibniz Institute for Baltic Sea Research Warnemünde, is the implementation and application of the Ecosystem Approach to Management (EAM) in the Baltic Sea with a focus on

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The Baltic Sea States Subregional Co-operation (BSSSC) – City of Hamburg assumes Chairmanship

Carsten Lüdemann, *State Secretary and Commissioner for Federal, European and International Affairs of Hamburg, Chairman of BSSSC 2009 - 2010*

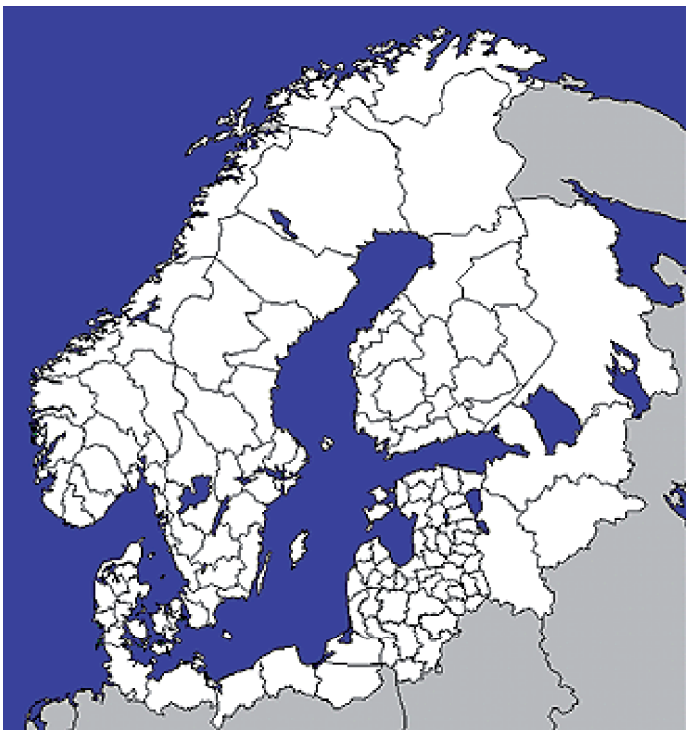
For centuries, the Baltic Sea has formed a natural boundary between countries and cultures of the entire region, but has also been a link for flourishing trade. Since the lifting of the 'iron curtain' in the late 1980s and early 1990s, cross-border and interregional co-operation intensified on all public and private levels, thereby opening huge potential for the development in the region. Out of this, a multitude of bi- and multilateral networks has been established throughout the Baltic Sea region. As a regional partner to the Council of the Baltic Sea States, the Baltic Sea States Subregional Co-operation (BSSSC) was founded in Stavanger, Norway, in 1993. BSSSC is a political network of regional authorities below the national level involving regional authorities of the 10 Baltic Sea littoral states. The objectives of BSSSC are to promote co-operation among subregions around the Baltic Sea, to formulate a coherent Baltic Sea policy on the regional level and to represent the interests of the subregions towards national as well as European and international organisations. More than 100 subregions (counties, Länder, oblasts, etc.) regularly participate in the annual conferences of BSSSC. The yearly event is the main forum of the organisation, where both participating regions and other regional, national and international actors get a unique opportunity to raise issues of importance, exchange ideas, experiences and contribute to policymaking processes.

The main organisation bodies of BSSSC are the Chairman, chosen by the Board on a rotational basis for a two year period, the Board, consisting of two representatives of each country, and the Secretariat which is linked to the Chairman. For the period from 2009 to 2010, the Free and Hanseatic City of Hamburg takes over the chairmanship of BSSSC. The BSSSC Secretariat will be hosted by the Hamburg Senate Chancellery. Hamburg has been working within the BSSSC network since its establishment and has been represented in the BSSSC board right from the start. As both a hub and an engine of Baltic trade, Hamburg has benefited from its good economic, cultural and political relations with cities, regions and states all around the Baltic Sea. Hamburg wishes to contribute to BSSSC its expertise as a metropolitan region, commercial hub and centre of creativity and learning in the Baltic Sea region. Hamburg intends to work within BSSSC to pursue further development of key issues such as climate change and energy, science and education, youth policy, public health and quality of life and the Baltic Sea strategy of the EU.

Although the Baltic Sea region is a prosperous region where economic growth pushes the overall level of activity, it faces big challenges concerning sustainability and the environmental conditions for future development. Thus, one of the BSSSC priorities in the last two years under the Norwegian chairmanship was set on sustainable energy with a special focus on renewable energy sources and energy efficiency. The annual conference in 2007 focused on these issues and as a result, BSSSC took an initiative to start consultations on energy and climate issues with major Baltic Sea Region organisations. In February 2008, a Joint Energy and Climate Platform of Baltic Sea Region organisations was endorsed. The co-operation platform between BSSSC, Baltic Development Forum, Council of the Baltic Sea States (CBSS), Union of Baltic Cities (UBC) Energy Commission, Baltic Islands Network B7, Conference of Peripheral and Maritime Regions – Baltic Sea Commission (CPMR BSC) Energy Working Group and Baltic Sea Parliamentary Conference (BSPC) has set up concrete goals for several activities. The platform will work for a strong co-operation among regional organisations and focus on issues such as integration of the energy markets and the infrastructure, as well as competitive, stable and secure energy supply in the Baltic Sea region and initiatives that can help reduce CO_2 emissions.

Handover of Chairmanship - BSSSC Chairman Arne Ören and upcoming Chairman Carsten Lüdemann

Being a top issue on the European agenda, climate change and environmental issues are of importance for BSSSC. As a political organisation for regional authorities in one of the most industrially developed regions of Europe with more than 110 million inhabitants, BSSSC aims to participate in the global debate on climate-related issues, to promote mutual co-operation and exchanges on best practices and solutions. A close interaction between political decision makers, such as BSSSC, and climate researchers is mandatory, and the BALTEX programme, particularly the BACC initiative is seen as a prominent candidate for future co-operation in the above context. Regions must



The Baltic Sea regions

and can participate in ensuring a sustainable development. Therefore the BSSSC annual conference in October 2009 hosted by the region Sealand / Denmark will give input into the UN Climate Change Conference in Copenhagen, stressing the regional position.

www.bsssc.com

BONUS+ climate change studies

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the coastal ecosystem. Retrospective analyses on long-term data sets, intensive modelling with different types of models combining land-use models and climate models and selected measurements of biogeochemical transformation processes in the near coastal area and the groundwater will be applied and integrated into a sound scientific basis for the development of EAM tools such as ecological quality objectives. The project **Baltic-C** will develop and apply a new integrated ecosystem model framework based on the cycling of organic carbon and carbon dioxide in the Baltic Sea water, drainage basin, atmosphere, and sediments (see page 5 for an extended description). The project **HYPER**, coordinated by Jacob Carstensen of Danish National Environmental Research Institute, University of Aarhus, will synthesize knowledge about processes leading to hypoxia over long time scales and at an ecosystem scale covering wide ranges of salinity, temperature and redox conditions, and investigate the feedback mechanisms of the benthic fauna on biogeochemical nutrient cycling. The project will contribute to the development of the Baltic NEST Decision Support Tool. Another project looking on the phenomenon of hypoxia is **BALTIC GAS**, coordinated by Bo Barker Joergensen of Aarhus University's Department of Biological Sciences. This study aims to understand how climate change and long-term eutrophication affect the accumulation of shallow gas and the emission of methane and hydrogen sulphide from the seabed to the water column and atmosphere. Finally, the project **RECOCA**, coordinated by Fredrik Wulff of Baltic Nest Institute, Stockholm University, will ensure further development of the Baltic NEST decision support tool (*www.balticnest.org*), providing a more realistic representation of the various local to regional scales involved, incorporating cost analysis, and adding hypoxia as an additional indicator of ecosystem response to eutrophication. Even though climate change is not the major issue of the RECOCA project, the nutrient loads are best described by specific runoff, and the river basin models which are building on the regional climate, are fully able to simulate changes in temperature, seasonality and soil properties.

Two BONUS+ projects address the issue of assessment of the biological effects of chemical pollution. **BALCOFISH**, coordinated by Lars Förlin of the University of Gothenburg, will integrate pollutant gene responses and fish ecology in Baltic coastal fisheries and management. This project aims at developing coastal pollution assessment techniques based on biological effects on eelpout population, including the genetic effects. The study object of BALCOFISH – eelpout – is known as a cold water coastal species. Its populations seem to be heavily impacted by global warming.

The pan-Baltic project **BEAST**, coordinated by Kari Lehtonen of the Finnish Institute of Marine Research, promises to develop a set of integrated indicators for chemical pollution, and tools needed to detect and understand human-induced pressure on the Baltic Sea ecosystem. The scope of this project ranges from the genetic responses to organism susceptibility to diseases and parasites. The integrated multi-level toolbox consisting of established and novel biomarkers will enable a sensitive diagnosis of how hazardous substances affect the Baltic Sea ecosystem, also in the context of stress due to varying environmental conditions and climate change.

The concept of biological diversity often is understood as merely a diversity of species. In reality, however, the issue is at least three-dimensional, including both the genetic diversity within a species, diversity of species and diversity of habitats. It can be noted with satisfaction that BONUS+ will work in all of these dimensions. The project **BaltGene**, coordinated by Kerstin Johannesson of Gothenburg University, will identify and map Baltic Sea genetic biodiversity and experimentally test its importance in the functioning and resilience of the ecosystem. This project will also assess the potential threats to the unique diversity from fisheries-induced selection, climate changes,

aquaculture activities and habitat loss. Results will help to set management measures that take into account the demographic and genetic structure of populations.

BAZOOCA, co-ordinated by Peter Tiselius of Gothenburg University, will address the well-known problem of occurrence of non-indigenous species in the Baltic Sea. By use of models, experiments and field studies, BAZOOCA will quantify ecosystem consequences of the occurrence of the comb jelly *Mnemiopsis leidyi* in the pelagic food web - from microbes to gelatinous top predators. Focal topics of the project include predation on cod eggs and larvae, changes in water clarity as possible causes leading to regime shifts from fish to jellyfish, and couplings between zooplankton and microbes. The focus on the food-web effects of the invader will necessitate the BAZOOCA team to examine how the optical environment varies with temperature, salinity and oxygen conditions in the Baltic Sea, and especially target the effect of light as a physical force on the competitive interactions between *Mnemiopsis* and fish.

The project **PREHAB**, coordinated by Mats Lindegarth of the University of Gothenburg, will develop methods for powerful, precise and cost-efficient spatial prediction of the biological properties of coastal habitats, and combine them with scenarios of human pressures to assess effects on coastal ecology, ecosystem goods and services and social benefits associated with alternative management options. Climate change, usually perceived as acting on large spatial scales, may also be manifested at local and regional scales. Thus, the methods of spatial modelling and mapping of habitats to be developed by PREHAB may potentially provide important tools for evaluating ecological and socioeconomic consequences under different scenarios of climate change.

A well represented group of studies will be devoted specifically to one of the most challenging and in the same time vitally important fields: integrating the ecosystem and society. **PROBALT**, coordinated by Tapani Vaahtoranta of the Finnish Institute of International Affairs, focuses on improving the societal conditions for the Baltic Sea protection. The project will analyze the societal conditions and provide tools for the effective protection of the Baltic Sea, with a special emphasis on combating eutrophication. The project **IBAM**, coordinated by Sakari Kuikka, University of Helsinki, will produce an integrative environmental decision model for the Gulf of Finland. This model will incorporate major scientific information in probabilistic terms and will combine the risk management in five levels: fisheries, eutrophication, oil spills, dioxin risks and climate change. Environmental risks will also be the scope of **RISKGOV**, coordinated by Michael Gilek at Södertörn University College. This project will improve understanding of the structures and processes that shape the governance of environmental risks, and suggest a normative framework for improving environmental risk governance in the Baltic Sea. Climate is recognized as one of the most important sources of uncertainties to be taken into account in the environmental risk analysis carried out by RISKGOV.

Finally, perhaps the most ambitious research proposal of the BONUS+ program: **ECOSUPPORT**, that promises to provide a multi-model system tool to support decision makers. ECOSUPPORT is described in more details on page 7 in this Newsletter.

Thus, each of the above BONUS projects either has a potential to produce new knowledge for understanding of mechanisms triggered by climate change and for adaptation to its consequences, or is vitally dependant in its studies on the understanding of these mechanisms and forecasts produced by climate researchers. Hence, there is a clear ground for future stronger collaboration between BONUS and BALTEX. BONUS is already represented in the BALTEX Science Steering Group, and BALTEX has recently been invited to join the BONUS Advisory Board.
No doubt, the next BACC assessment will contain a lot of references to the BONUS-supported studies! It is also anticipated that the BONUS+ projects will contribute to other key objectives of BALTEX Phase II, particularly to water management in coastal zones and a better understanding of the biogeochemical cycles in the Baltic Sea and its catchment.

The following two articles present in detail the BALTEX projects chosen for BONUS funding: Baltic-C (below) and ECOSUPPORT (page 7).

www.bonusportal.org

Baltic-C: Building predictive capability regarding the Baltic Sea organic/inorganic carbon and oxygen system

Anders Omstedt *(anders.omstedt@gvc.gu.se), Vice-chair of BALTEX SSG, Department of Earth Sciences: Oceanography, University of Gothenburg, Sweden*

Introduction

Baltic-C is one of 16 projects selected for funding within the recent BONUS+ call (see article on page 1 of this issue). The project will develop and apply an integrated ecosystem model framework based on the cycling of organic carbon (C_{org}) and carbon dioxide (CO_2) in the Baltic Sea water and drainage basin, taking into account fluxes across the atmosphere and sediment interfaces (Fig. 1). The project is a dedicated contribution to BALTEX with the aim to provide a tool to support the management of the Baltic Sea. The objectives of the project are:

- to achieve significant progress in marine ecosystem modelling by aligning biomass production and oxygen depletion with CO_2 dynamics; and
- to provide the first comprehensive integrated assessment of the potential effects of climate change, eutrophication, increasing atmospheric CO_2 concentration, and acidic deposition on carbon cycling in the Baltic Sea and its catchment area.

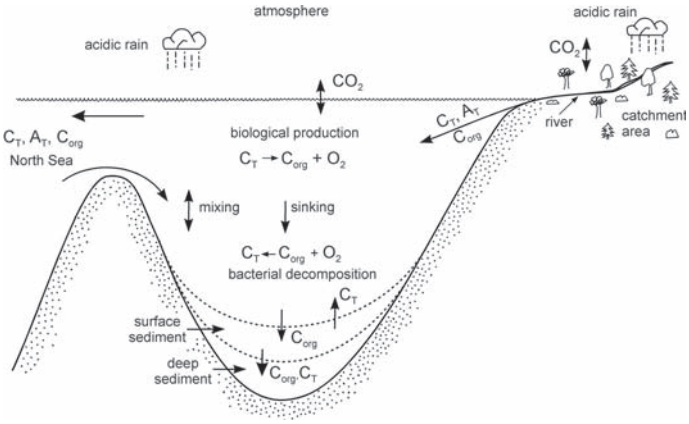


Fig. 1 Basic problems addressed in Baltic-C. C_T=total inorganic carbon, A_T=total alkalinity, C_{org}=organic carbon.

This framework will significantly improve our understanding of the relevant physical, chemical, and biological processes and will be supported by and validated against comprehensive observational data (Fig. 2). The work plan includes the following steps:

- implementation of CO_2 chemistry as part of an existing and well-established Baltic Sea numerical model;
- linking models of the terrestrial carbon cycle and weathering regimes with a hydrological model to describe river carbon runoff to the Baltic Sea model;
- characterizing the Baltic CO_2 system and organic carbon inventories using existing data, data from dedicated research vessel cruises, and data gathered by new automated measurement systems on a voluntary observation ship (VOS);
- a river mouth programme (using new and existing data) to quantify the inputs of alkalinity (A_T), total CO_2, organic carbon, and nutrients;
- measuring CO_2 air–sea fluxes at an existing field station to improve the parameterization of the gas exchange transfer velocity;
- use data from the EMEP long-range atmospheric pollutant transport model to estimate the acid and nutrient deposition in the Baltic Sea and its drainage basin; and
- investigate several available transient scenario runs covering the 1960–2100 period.

Expected outcomes

1. 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.
2. Demonstration applications of the new framework of direct value for management, i.e.:
   - the first realistic quantification of the organic carbon (biomass) production and corresponding oxygen (O_2) depletion in different eutrophication scenarios;
   - far more precise quantification of acidification, in terms of pH changes, which may affect primary production and control the CO_3^{2-} concentrations essential for the survival of organisms forming calcium carbonate shells;
   - the first quantification of the past, present, and future role of the Baltic Sea as a sink/source of atmospheric CO_2;

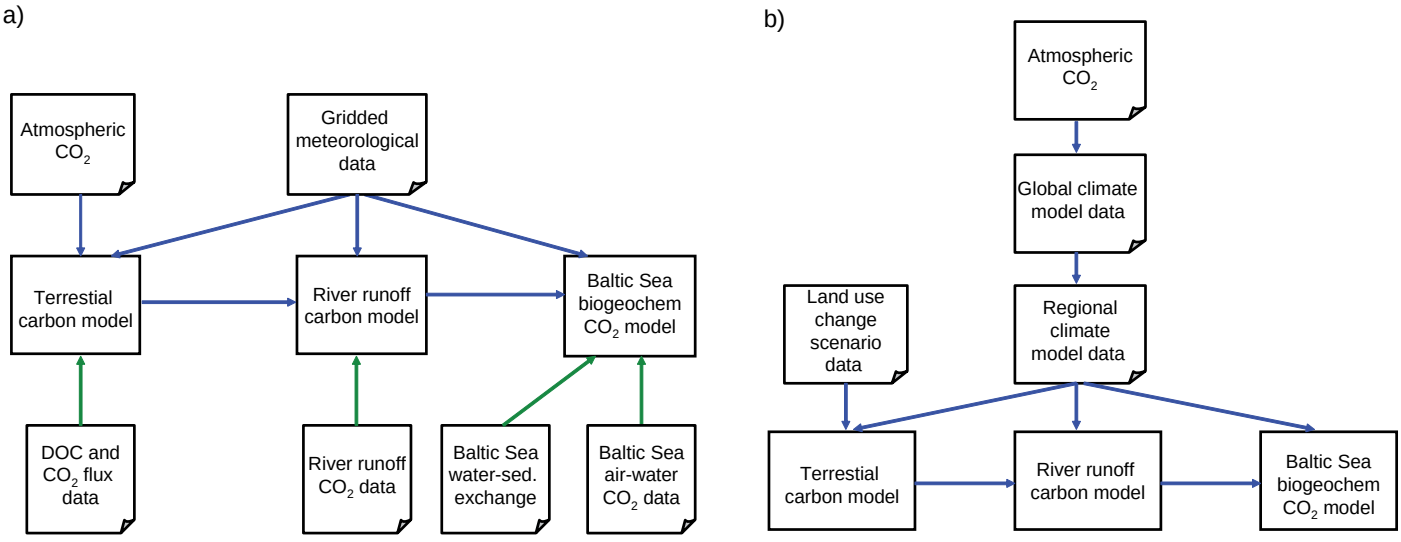


Fig. 2 Baltic-C integrated model framework: The historical/validation phase (a) will consider the 1960–2000 and 1500–2000 periods; the scenario phase (b) will be based on several available transient scenario runs covering the 1960–2100 period. The blue arrows indicate the model data flow, and the green arrows indicate comparison of modelled with observed data.

- the first estimate of the potential costs of eutrophication related to the costs of the Baltic Sea as a sink/source of carbon.

Programme management and structure

The management design and responsibilities of the involved institutions are as follows:

Workpackage 1 (WP1): Programme management (Anders Omstedt, University of Gothenburg, Sweden). Synthesizing and assessing the Baltic Sea CO_2 carbon cycle: past and present state, and possible future changes. Dissemination of results (University of Gothenburg, Sweden, BONUS, BALTEX Secretariat, Baltic Nest Institute, and PhD courses).
WP2: Measuring the Baltic Sea CO_2 system and carbon inventories (Bernd Schneider, Baltic Sea Research Institute, Germany).
WP3: Inventory of river runoff data (Matti Pertillä, Finnish Institute of Marine Research, Finland).
WP4: Mineralization of organic material, deepwater-sediment interaction (Janusz Pempkowiak, Institute of Oceanology, Polish Academy of Sciences, Poland).
WP5: Atmospheric forcing, including air-sea CO_2 interaction, atmospheric deposition of acidic components (H_2SO_4 and HNO_3) over whole catchments, and climate scenario outputs available from other EU programs (Anna Rutgersson, Uppsala University, Sweden).
WP6: Modelling the organic matter input from terrestrial vegetation and soils (Benjamin Smith, Lund University, Sweden).
WP7: Modelling the input of A_T, C_T, Calcium, and C_{org} from all rivers entering the Baltic Sea (Christoph Humborg, Stockholm University, Sweden).
WP8: Modelling the Baltic Sea physical–biogeochemical system based on CO_2/O_2 dynamics and climate change (Anders Omstedt, University of Gothenburg, Sweden).

ECOSUPPORT – An advanced modeling tool for scenarios of the Baltic Sea Ecosystem to support decision making

Markus Meier *(markus.meier@smhi.se), Swedish Meteorological and Hydrological Institute (SMHI), Norrköping, Sweden*

The project ECOSUPPORT will be funded by the BONUS programme and will run for 3 years in 2009-2011. ECOSUPPORT is an inter-disciplinary cooperation between 11 partner institutes from 7 Baltic Sea countries, and fits well to BALTEX Phase II, Objectives 2 and 4. Other research groups with similar objectives than in ECOSUPPORT are invited to join the effort.

Concept, objectives and expected outcome

The main aim is to provide a multi-model system tool to support decision makers. The tool is based upon scenarios from an existing state-of-the-art coupled atmosphere-ice-ocean-land surface model for the Baltic Sea catchment area, 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 concept to achieve the above aim is built on the confidence of the models' capacity to simulate changing climate and includes several steps:

i. assessing the predictive skills of the models by comparing observed and simulated past climate variability (i.e. quantification of model uncertainties) and analyzing causes of observed variations;
ii. performing multi-model ensemble simulations of the marine ecosystem for 1850-2100 forced by reconstructions of past climate and by various future greenhouse gas emission and air- and river-borne nutrient load scenarios (ranging from a pessimistic business-as-usual to the most optimistic case);
iii. analyzing projections of the future Baltic Sea ecosystem using a probabilistic approach accounting for uncertainties caused by biases of regional and global climate models (RCMs and GCMs), lack of process description in state-of-the-art ecosystem models, unknown greenhouse gas emissions and nutrient loadings, and natural variability;
iv. assessing impacts of climate change on the marine biota (e.g. effects of ocean acidification), biodiversity and fish populations (with focus on cod, sprat and herring);
v. calculating the costs of climate change;
vi. generating a free-access database of scenario model results and tools to access the database; and (vii) disseminating the project results to stakeholders, decision makers (e.g. via the Helsinki Commission - HELCOM) and the public (webpage, newsletters, seminars, conferences, etc.).

The objectives are to

1. calculate the combined effects of changing climate and changing human activity (nutrient load reductions [runoff and airborne], coastal management, fisheries) on the Baltic Sea ecosystem,
2. assess the resulting socioeconomic impacts,
3. perform time-dependent scenario simulations from present climate until 2100, and quantify the uncertainties around these future projections,
4. support decision makers and stakeholders with a tool

providing them with relevant and readily accessible information that will help to raise wider public awareness,

5. conduct focused assessments of local-scale impacts of changing climate on coastal areas (with focus on the Gulf of Finland, Vistula Lagoon, and the Polish coastal waters).

The expected outcome is an advanced modeling tool for scenario simulations of the whole marine ecosystem that can underpin and inform management strategies to ensure water quality standards, biodiversity and fish stocks.

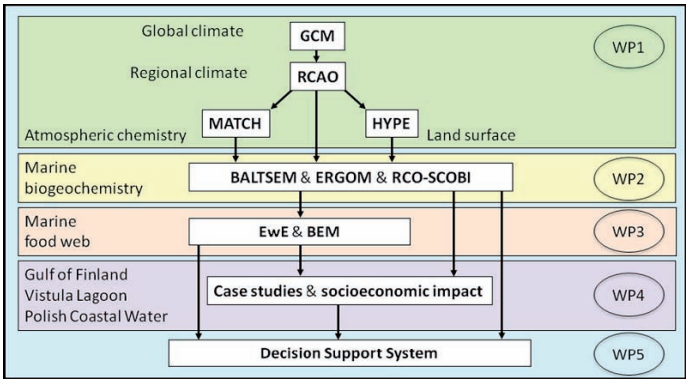
State of the art

Within the recently performed BALTEX Assessment of Climate Change for the Baltic Sea Basin (BACC, www.baltex-research.eu/BACC), it was concluded that "identified trends in temperature and related variables (during the past 100 years) are consistent with regional climate change scenarios prepared with climate models". RCM results suggest that global warming may cause increased water temperatures of the Baltic Sea, reduced sea ice cover, increased winter mean wind speeds causing increased vertical mixing, and increased river runoff causing reduced salinity. The projected hydrographic changes could therefore have significant impacts on the Baltic Sea ecosystem and its biodiversity. Unfortunately, details have not been investigated thoroughly and the complex response of the ecosystem is unknown according to BACC.

First results from physical-biogeochemical modeling, applying the so-called delta approach, indicate that by the end of this century the impact of optimistic nutrient load reduction scenarios and the impact of climate change could be of the same order of magnitude in some regions of the Baltic Sea, emphasizing the urgent need to include climate change into available decision support systems (DSSs) [1]. The DSS NEST (http://nest.su.se/nest) developed in the MARE program (www.mare.su.se) is today the only scientifically-based tool available to support the development of cost-effective measures against eutrophication for the entire Baltic Sea [2]. NEST has been used to set the targets of the Baltic Sea Action Plan (BSAP, www.helcom.fi/stc/files/BSAP/BSAP_Final.pdf); however, NEST does not take the effect of climate change (e.g. changing hydrography or changing carbon cycle) into account. Temperature and salinity changes will have large impacts on species distributions, growth and reproduction of organisms including zooplankton, benthos and fish [3]. These could include the complete loss of entire species and major restructuring of the food web and trophic flows (e.g., if falling salinity prevents cod reproduction or if the multiple anthropogenic impacts make the system more vulnerable to invasions by ecosystem engineers). For example, given that the three fish species in the Baltic Sea which have dominated commercial landings for the past several decades are of marine origin (i.e., cod, herring and sprat), is it realistic to expect that all will continue to support comparable fisheries in future? In addition, acidification of the coastal oceans is an emerging and potentially critical threat to Baltic Sea ecosystems (see also article on page xx of this Newsletter). In the last 150 years, fossil fuel burning has caused the pH of the global oceans to fall by 0.1 units, and by the year 2100, oceanic pH is predicted to be at least 0.4 units lower than at present. Decadal records of pH in the Baltic Sea and Skagerrak show acidification proceeding at rates 2 – 5 times faster than in the open ocean. The effects of these changes and their interaction with other climate variables, in mediating both gradual and state-shifts in Baltic Sea ecosystems, are currently unknown but likely to be considerable. Perhaps the greatest impact of acidification will manifest in the reduced capacity of many marine species to build the calcareous skeletons and shells that are essential for their survival [4]. This will be a particular problem for microscopic plankton and larval stages, causing direct impacts on reproductive success and survival in key ecosystem structuring species within the Baltic Sea such as blue mussels.

Methods

Within ECOSUPPORT, we will apply a hierarchy of existing state-of-the-art sub-models of the Earth system (see figure). The main emphasis is the coupling of these sub-models. This is the key, novel, contribution that ECOSUPPORT will make towards obtaining an integrated predictive understanding of marine ecosystems. No resources are dedicated to the development of models, however, we will profit from other ongoing projects and in kind contributions.



Model hierarchy in ECOSUPPORT and work package structure. The schematic is highly simplified neglecting complex interactions (e.g. fish predation pressure on zooplankton, changing society/policy will affect climate and nutrient load scenarios).

Regional climate modeling

For dynamical downscaling a high-resolution coupled atmosphere-ice-ocean-land surface model (the Rossby Centre Atmosphere Ocean model, RCAO) with lateral boundary data from GCMs will be applied to calculate

future climate of the Baltic Sea region [5]. The regional scenario simulations will differ depending on the applied GCM at the lateral boundaries and depending on the utilized greenhouse gas and aerosol emission scenario.

To calculate future river flow and river borne nutrient loadings a new hydrological model developed at SMHI (HYPE, HYdrological Predictions for the Environment) is used. It simulates a range of hydrological variables including phosphorus and nitrogen in soils, rivers and lakes. The model is a further development of the earlier HBV model [6] using the vast experience of hydrological and water quality modeling during the past 35 years at SMHI. In addition, the results of the watershed model from NEST are available for ECOSUPPORT.

The transient changes in atmospheric near-surface concentrations of trace species, that were simulated with an advanced photochemical transport model (MATCH, Multiple-scale Atmospheric Chemistry and Transport modelling system [7, 8]), will be analyzed to estimate changing airborne nutrient deposition over the Baltic Sea.

Marine biogeochemical modeling

Three state-of-the-art coupled physical-biogeochemical models will be used to calculate changing concentrations of nitrate, ammonium, phosphate, diatoms, flagellates, cyanobacteria, zooplankton, detritus, and oxygen: BALTSEM [9,10], ERGOM [11], and RCO-SCOBI [12,13]. The models are structurally different in that ERGOM and RCO-SCOBI are 3D circulation models comprising sub-basin scale processes while BALTSEM resolves the Baltic Sea spatially in 13 sub-basins. As the horizontal grid resolution in ERGOM is rather high (3 nautical miles), computational limitations allow us to use ERGOM only for selected time slices. The biogeochemical sub-models are of similar type but the process descriptions differ. With the aid of these three models the response of the Baltic Sea ecosystem to different external forcing has been evaluated earlier [11,14,15,16]. RCO-SCOBI has been used to assess climate variability of the past 100 years [17] and to study the impact of future climate at the end of the 21st century (e.g. [18], see the BACC book for a summary). BALTSEM was the main mechanistic model of the MARE program and is now an integral part of the work at the Baltic Nest Institute. For the case studies in the Gulf of Finland and Vistula Lagoon two regional models (based on SCOBI) forced with lateral boundary data from the basin-wide models are used during selected time slices.

Food web modeling

The food web of the Baltic Sea will be simulated by applying the ecological software EwE (www.ecopath.org). An existing food web model for the Baltic Sea has already been used in NEST, and contains 15 functional groups from primary producers to seals and fishery [19]. The model was parameterized with a focus on fish (sprat, herring and cod). EwE is an excellent tool to: a) address ecological questions; b) evaluate ecosystem effects of fishing; c) explore management policy options; d) evaluate impact and placement of marine protected areas; and e) evaluate effects of environmental changes.

At present, statistical models for Baltic Sea fish species can link climatic forcing and lower trophic level processes to fish dynamics. These models will be integrated within ECOSUPPORT by linking them to outputs from physical-biogeochemical models. Dynamics of cod, herring and sprat have been shown to be driven partly by fluctuations in climate, eutrophication and lower trophic level processes, including those which directly affect reproductive success [20], feeding and survival of larvae, and feeding and growth of adults [21].

We will generate Bioclimatic Envelope Models (BEMs) for key species in the Baltic Sea system (and in the models used here) to assess the susceptibility of these taxa to range-extension and possible local extinction arising from climate change. BEMs will be constructed using statistical modeling (CART, [22]) trained with historical distribution data for key taxa, and corresponding oceanographic environmental data [23].

Socioeconomic impact assessment

For the focus study sites, Gulf of Finland, Vistula Lagoon and the Polish coastal waters, we will conduct assessments of the impact of climate change on the regional and local development. The economic assessment of the ecosystem goods and services delivered from key ecosystems/habitats within the Baltic Sea (Fucus beds, mussel beds, seagrass, shallow soft bottom habitats) and processes (benthic-pelagic coupling, filtration) follows the methods of [24,25]. In order to develop management strategies for sustainable use and conservation in the marine environment, reliable and meaningful, but integrated ecological information is needed. Biological valuation maps that compile and summarize all available biological and ecological information can be used as baseline maps for future spatial planning at sea. Rather than a general strategy for protecting areas that have some ecological significance, biological valuation is a tool for calling attention to areas which have particularly high ecological or biological significance and to facilitate provision of a greater-than-usual degree of risk aversion in management of activities in such areas.

The regional results from the focus study sites will be scaled up to the Baltic Sea scale. This will support the charting of socioeconomic implications from different climate scenarios (e.g. [26,27]). Especially, the costs of nutrient load reductions of defined ecological targets of Baltic Sea water quality in present and future climates will be calculated with the NEST economic model [28]. The metric difference between the results will provide us with a first estimate of costs related to changing climate.

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BALTRAD extends the Nordic and BALTEX weather radar networks

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In October 2008, the Monitoring Committee of the EU Baltic Sea Region Programme 2007-2013 approved a proposal called BALTRAD, together with 23 other transnational cooperation projects. In BALTRAD, the current Nordic operational weather radar data network (NORDRAD) will be extended to cover as much of the Baltic Sea Region as possible. The BALTRAD acronym is recycled from the radar activities in BALTEX, where significant experience has been gained over the last 10 years which will surely benefit this new project. The budget of the project is 2.2 Million € and the project lifetime is three years.

EU members (dark blue) and non-EU members (medium blue) in the BALTRAD project. Integrating data from (Northern) Germany, Norway and Lithuania will be considered later as well.

Preparing the BALTRAD project at SMHI, Stockholm in May. (Left to right: Maciej Szewczykowski, Hans Stjärnskog, Markus Peura, Søren Overgaard, Rasphal Gill, Hermann Heich, Ilmar Karro, and Daniel Michelson

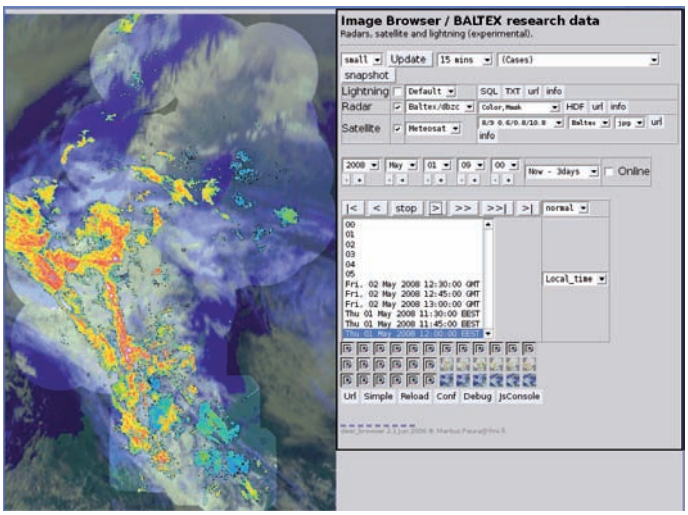
The project partnership constitutes national weather services in Finland and Denmark, with both weather and hydrological services in Sweden, Estonia, Latvia, Poland, Russia, and Belarus. These are the institutes that own and operate the radars in each country, and that will be responsible for ensuring BALTRAD's sustainability at the end of the project. There is also a Finnish end user in the partnership, and active associated organisations in Denmark, Latvia, and Poland.

The project kicks off in February 2009, and consists of the following six workpackages (leader in parentheses):

1. Project Management and Administration (SMHI, Sweden)
2. Communication and Information (FMI, Finland)
3. Core Network (IMGW, Poland)
4. Data Catalogue (EMHI, Estonia)
5. Production Framework (FMI, Finland)
6. Deployment (SMHI, Sweden)
7. Pilots (IMGW, Poland)

„With the introduction of new radars in several BSR countries, and the interest in benefiting from all data in real time, we have also seen that our tools for exchanging and processing data are outdated", explains Daniel Michelson from SMHI, the leader of the project.

Radar data should be exchanged in its most basic form, but this is not feasible with current systems. Additionally, we will work on harmonizing production practises to provide end users with radar products of as high quality as possible - rain rate, wind, and hail warnings. Several weather and hydrological services in the BSR have been in dialogue in recent years about creating such a new radar network, but this has not been possible without external funding.



An outline of a WWW based browsing facility for the Baltic area weather radar data.

The BALTRAD project will contribute the technology for exchange of weather radar data in the World Meteorological Organization Information System, the successor of the GTS being used today.

www.smhi.se/brdc/

Rossby Centre Workshop on Nordic-Arctic Climate Change: Towards an Earth System Approach

Colin Jones *(colin.jones@smhi.se), Head of Rossby Centre, Swedish Meteorological and Hydrological Institute (SMHI), Norrköping, Sweden*

The Rossby Centre at SMHI recently organized a 2-day workshop on Nordic-Arctic Climate Change: Towards an Earth System Approach. The workshop was held in Norrköping, Sweden on 13 and 14 October 2008 and was attended by almost 100 international scientists. The aim of the workshop was two-fold; (i) to introduce and discuss the main priority areas with respect to the emerging discipline of Earth System Modelling and to specifically consider these issues from a Nordic-Arctic perspective; (ii) to present ongoing and planned activities at the Rossby Centre, with respect to understanding and simulating regional climate processes and regional climate change in the Nordic-Arctic region.

At the Rossby Centre there is a long-term plan to further develop our Regional Climate Modelling systems, that presently consider only the physical-dynamical climate system, towards a modelling framework that more fully incorporates key biological, chemical and ecological components of the regional climate. In order to gain guidance from the international community and set our plans into a wider perspective, a number of international experts were invited to Norrköping to present and discuss the latest developments in the field of Earth System Modelling.

Over the 2 days, 11 invited presentations were made on various aspects of Earth System Modelling, ranging from describing ocean and sea-ice processes, through the representation of interactive terrestrial vegetation, to the use of Earth System models in climate impact and adaptation research. The workshop was opened by Dr Ghassem Asrar, Director of the World Climate Research Programme (WCRP), who described the role of WCRP in coordinating international efforts to develop the next generation of Global and Regional Earth System Models. The morning session of the first day was then devoted to a discussion of the modelling priorities in relation to Global Earth System Modelling (e.g. ocean and sea-ice processes, terrestrial vegetation, cloud and aerosol processes). During the second session of day 1, the focus shifted to specific Arctic issues in relation to climate change and Arctic System Models. The final session of day one highlighted challenges related to high-resolution climate modelling over the Nordic region.

Day 2 of the workshop was opened by Professor Pavel Kabat from the University of Wageningen, Netherlands, who presented an overview of Dutch activities in climate impact research and adaptation to climate change. This was followed by a presentation of Professor Markku Rummukainen of SMHI, introducing the Swedish Research Program on Climate, Impacts and Adaptation (SWECIA). Both presentations highlighted the strong link between Climate and Earth System Modelling and the needs of the climate impacts and adaptation communities. The remainder of day 2 was devoted to presentations by SMHI research scientists discussing various aspects of the future development and present use of coupled Regional Climate Models at SMHI. These presentations touched on a number of key issues inherent in modelling the coupled-climate system over the Nordic and Arctic regions; from environmental modelling of the Baltic Sea, to representing interactive climate-vegetation processes specific to the

Dr. Ghassem Asrar, Director of the World Climate Research Programme (WCRP) at the Rossby Centre Workshop.

Nordic region, through to simulating river run-off and water quality over the Nordic and Arctic land masses. The final presentation of Day 2 was made by the Head of the Rossby Centre, Dr Colin Jones, who presented an overview of future research directions at the Rossby Centre in relation to both Global and Regional Earth System Modelling. This plan will now be carefully evaluated in the light of knowledge gained during the 2-day workshop.

Day 2 concluded with an open discussion on the potential benefits and pitfalls in developing a high-resolution, Regional Earth System Model, specific to the Nordic-Arctic region. A lively discussion touched on a range of modelling and computational issues inherent in developing and applying such a system. There was general agreement that such a comprehensive and wide-ranging modelling tool was likely necessary to address the challenges associated with predicting future climate conditions over the Nordic-Arctic region and the response of environmental systems to changing climate variability. There was a clear feeling that development of a comprehensive Earth System Model for the Nordic-Arctic region was best pursued as a multi-institute, multi-national enterprise, with open collaboration across Nordic and European institutes.

For those interested all presentations from the 2008 Rossby Centre Workshop are available for download at: *http://www.smhi.se/cmp/jsp/polopoly.jsp?d=6899&a=37610&l=sv*

www.smhi.se

Symposium on eutrophication in future climate: "Can we save the Baltic Sea?"

Markus Meier *(markus.meier@smhi.se), Swedish Meteorological and Hydrological Institute (SMHI), Norrköping, Sweden*

On 21 October 2008, about 90 scientists joined an international symposium at the Swedish Meteorological and Hydrological Institute (SMHI) in Norrköping on the impact of climate change on the Baltic Sea ecosystem. Seven invited speakers from Sweden and Denmark informed the audience about latest research results of climate change impact studies, SMHI's activities in environmental monitoring and available databases. The aim was to bring together scientists and stakeholders, and to discuss the question ``Can we save the Baltic Sea?´´.

In November 2007, the ministers of environment of all Baltic Sea countries agreed on the Baltic Sea Action Plan (BSAP) to reduce the nutrient loads from land. As the response of the Baltic Sea is slow, an improved state is not expected to occur before several decades after the implementation of the measures. Thus, the question is will the measures against eutrophication also work in future climate.

Available regionalizations of global climate change suggest that the Baltic Sea will be warmer with significantly reduced sea ice during winter time. Due to increased precipitation and stronger westerly winds, the salinity might be lower and the halocline might be deeper compared to present climate. However, salinity scenarios are uncertain. Due to higher water temperatures, the oxygen concentrations of the surface layer might decrease. In the southwestern Baltic Sea, phytoplankton concentrations may increase, and there is a risk that cyanobacteria blooms become more intense. The efficiency of the implementation of the BSAP may differ in future climate. However, the BSAP will likely reduce the phytoplankton concentrations also in future climate.

Another uncertainty factor is the acidification of the oceans, causing a reduced capacity of many marine species to build calcareous skeletons and shells that are essential for their survival. However, acidification scenarios are not yet available for the Baltic Sea.

As physical factors like temperature and salinity may change in future climate, fish species distributions, biodiversity and lifehistory might be affected as well. Some changes are already underway. However, uncertainties about specific species' responses are large and only preliminary general predictions are possible. Impacts on fisheries and management (quotas, spatial and seasonal distribution of fishing effort) are anticipated.

On the symposium, also engineering methods were discussed that might be used as measures against eutrophication on shorter time scales. From a recently performed model study using two state-of-the-art coupled physical-biogeochemical models, it was concluded that feedbacks from oxygen deficiency cause both increased primary production in general, and increased cyanobacteria production in particular. It is not possible to rapidly improve oxygen conditions by any realistic engineering method affecting the exchange through the Danish straits. Only the ventilation of the halocline cannot be ruled out as a measure against eutrophication. Although the models gave consistent and plausible responses, quantitative differences in sensitivity were found, indicating the need to improve in particular sediment parametrizations.

Finally, an advanced modelling tool for scenario simulations of the entire marine ecosystem was presented which can help to establish management strategies to ensure water quality standards, biodiversity and fish stocks (see the ECOSUPPORT project description on page 7).

Tellus-BALTEX Workshop at the University of Gothenburg: Biogeochemical Land and Baltic Sea Interactions driven by Climate and Land Use

Marcus Reckermann *(marcus.reckermann@gkss.de), International BALTEX Secretariat, GKSS Research Centre Geesthacht, Germany, and* ***Leif Klemedtsson****, Tellus Centre of Earth Systems Research at the University of Gothenburg*

The research programmes BALTEX and Tellus both share the vision of an Earth System Model at the regional scale. BALTEX is currently reaching out for marine and terrestrial biogeochemical research communities in the Baltic Sea drainage basin to incorporate matter fluxes into the established BALTEX regional climate model systems. Tellus is a multidisciplinary research programme at the University of Gothenburg, focussing on biogeochemical fluxes in terrestrial and limnic ecosystems (see box).Thus it appeared logical and of mutual benefit to bring the two communities together. A 1 ½ days workshop was organized at the University of Gothenburg on 1 and 2 December 2008. 61 scientists from Sweden, Finland, Lithuania and Germany gathered at the Wallenberg Centre in Gothenburg to discuss issues related to the description and modelling of land and Baltic Sea interactions related to climate and land use changes, which need to be incorporated into an Earth System Model. Ample time was allowed for discussions between the presentation and sessions, which was used extensively.

Contributions ranged from presenting the two programmes Tellus (**Leif Klemedtsson**, University of Gothenburg) and BALTEX (**Joakim Langner**, BALTEX Science Steering Group Chair, SMHI) to detailed descriptions of the complex elemental transformations and fluxes from the catchment to the Baltic Sea.

Tellus

The Centre of Earth Systems Science at the University of Gothenburg

Tellus is a framework for Earth systems research at the University of Gothenburg, supported by its Faculty of Science. Researchers at the departments of Earth Sciences, Biology and Chemistry collaborate in Tellus in order to gain a deeper knowledge and understanding of the functioning of the principal Earth systems in the Baltic Sea and Arctic Regions, how they interact and how this affects life on Earth. Of particular concern is a better understanding of the pathways of nitrogen and phosphorus from the catchment to the Baltic Sea, and their roles in eutrophication. The organisational objective of Tellus is to provide a creative environment at the University of Gothenburg to stimulate scientists within different geophysical fields to form new interdisciplinary research groups tailored for Earth System research. Another important objective is to promote a better knowledge of climate and environmental issues and a deeper understanding of the Earth System approach in the general public.

The integration of biogeochemical processes into existing BALTEX regional climate models was described by **Markus Meier** (SMHI). Presently, these models concentrate on biogeochemical processes in the Baltic Sea, but they will incorporate basin-scale processes at the land surface at a later stage. Within a joint project funded by BONUS (ECOSUPPORT, see page 7), the model system will be extended with other biogeochemical and physical compartments. **Christoph Humborg** (Baltic Nest Institute, Stockholm University) demonstrated a catchment model which is able to simulate nutrient land-sea fluxes from all 105 major watersheds within the Baltic Sea drainage area.

Participants at the Tellus-BALTEX Workshop

The outputs can be used by decision makers to estimate the efficiency of various measures to reduce eutrophication. This model is also used e.g. for defining concrete targets in the context of the HELCOM Baltic Sea Action Plan. Christoph also showed that increasing organic carbon fluxes from the northern Baltic Sea catchment to the Baltic Sea may in the future not only increase CO_2 fluxes to the atmosphere, but may also lock the carbon as bicarbonate in the aquatic phase. **Benjamin Smith** (Lund University) showed that land cover and land use and its changes in the future are expected to have a big impact on how the terrestrial ecosystems react to climate change. Changes in land cover will probably include northerly shifts in the potential natural vegetation zones, upslope tree line shifts, increased primary productivity and growth season length. These changes along with potential land use changes would cause the southern Baltic Sea basin to act as a source rather than a sink for CO_2. **Per-Erik Jansson** (Royal Institute of Technology, Stockholm) and **Hjalmar Laudon** (Swedish Agriculture University, Umea) emphasized on the role of the soil in controlling and altering dissolved important biogeochemical constituents. Especially the riparian zone of small creeks and streams seems to have a large impact on the biogeochemistry of stream water. Phosporus and its transformations and fluxes in the soil and in streams and lakes were the topic of the presentations by **Barbro Ulen** (Swedish Agriculture University, Umea) and **Sirkka Tattari** (Finnish Environment Institute, Helsinki). Their presentations showed how difficult and complex the modelling of P transformations and fluxes is, covering the chain from agricultural sources to the estuaries. A problem seems to be the high spatial and temporal heterogeneity of the processes. **Per Hall** (University of Gothenburg) gave an overview over carbon, nitrogen and phosphorus transformations in the sediments and anoxic deep waters of the Baltic Sea, demonstrating the strong impact of oxygen conditions on the biogeochemical processes in the Baltic Sea. At least for the Gulf of Finland, it was shown that the internal phosphorus load to surface waters, originating from the anoxic deep waters, is clearly higher than the external load from land and atmosphere, meaning that immediate reductions in external inputs would be effective in decades rather than years. This makes immediate action even more urgent. CO_2 fluxes between the sea surface and the atmosphere, and the effects on the acid-base balance in the Baltic Sea was discussed by **Anders Omstedt** and **Leif Anderson** (both at University of Gothenburg), with implications for eutrophiciation and the role of the Baltic Sea as either source or sink for CO_2 in the future.

The workshop demonstrated the complexity of the specific biogeochemical processes governing the fluxes and transformations of carbon, nitrogen and phosphorus within and between the different environments (soil, fresh water, marine sediments and sea water). These processes and the fluxes need to be better understood and modelled in coupled biogeochemical land-sea models as components of a regional Earth System Model for the Baltic Sea basin. The Tellus-BALTEX workshop has successfully contributed to bringing together the terrestrial and marine scientific communities to accomplish this ambitious goal. More information on the workshop including a compilation of presentation abstracts is available at the BALTEX web site.

www.baltex-research.eu/TellusBaltex

www.tellus.science.gu.se

Modelling the Baltic Sea acid–base (pH) balance

Anders Omstedt *(anders.omstedt@gvc.gu.se), vice-chair of BALTEX SSG, Department of Earth Sciences: Oceanography, University of Gothenburg, Sweden*

Introduction

Water and heat balances are at the heart of climate research and have been the main focus of BALTEX Phase I. In BALTEX Phase II, we are now promoting the integration of the carbon cycle into climate models, as it lies at the heart of biogeochemical modelling. Our research group at University of Gothenburg (www.oceanclimate.se) is

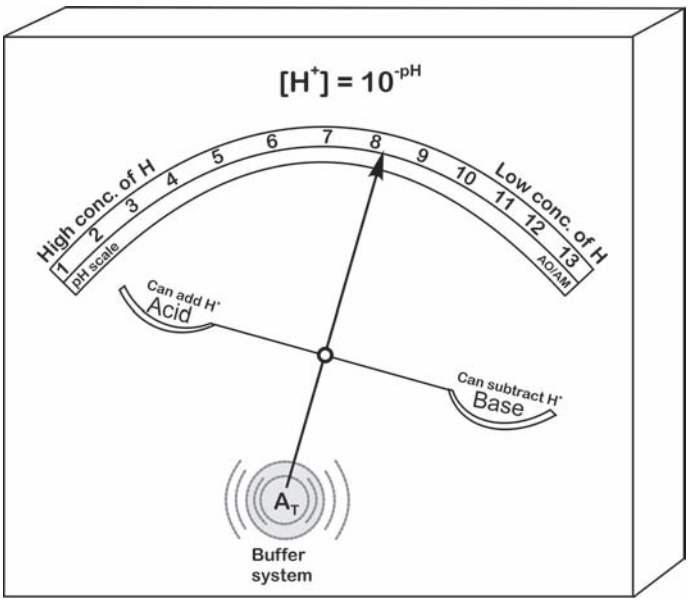


Fig. 1 The acid–base (pH) balance depicted as a balance between the concentration of proton donors and proton acceptors, damped by the buffer system.

now working on fully coupled physical–biogeochemical climate models of the Baltic Sea, using these as tools to study the Baltic Sea CO_2–O_2 system. This modelling includes the interaction between physical (i.e. stratification, temperature, salinity, sun penetration, and ice), chemical (i.e., alkalinity, pH, dissolved inorganic carbon, oxygen, and nutrients), and biological processes (i.e. plankton and dissolved organic carbon).

Rising atmospheric carbon dioxide levels due to human activity have been shown to reduce the ocean pH by 0.1 units and are believed likely to reduce it even more in the future – according to some recent estimates, by up to 0.4 pH units during the coming 100 years (IPCC 2007). There are also suggestions that acid precipitation may increase the acidification of coastal seas, which then may lead to more severe conditions in these areas (Doney et al. 2007) in the absence of other processes damping coastal acidification.

The acid–base (pH) balance is somewhat more complicated than the heat or water balances due to the buffer effect (Fig. 1). The balance is controlled by the amount of protons added to (donors) or subtracted from (acceptors) the balance. The protons, however, also interact with the buffer system, which can be understood as the total alkalinity (A_T). The total alkalinity is a major component of the ocean carbon system, and can be defined as "the excess of proton acceptors over proton donors" (Dickson 1981). Typical proton donors are carbon acid, sulphuric acid, and nitric acid while a typical proton acceptor is limestone. This is illustrated in Fig. 1, which indicates that if we add, for example, limestone to the marine system, we increase the amount of basic material while also strengthening the buffer system, resulting in only a minor increase in pH. On the other hand, if we add carbon acid, the pH does not change as long as the buffer system is strong. The problem, however, is that proton donors also influence and weaken the buffer system, which may lead to a drastic pH reduction if a critical total alkalinity level is reached. This has been observed in lakes due to airborne sulphur acid, though lakes often have much weaker buffer capabilities than do marine systems.

Modelling

Biogeochemical processes are built into our Baltic Sea numerical model (Omstedt et al. 2008), which has been extensively explored and validated. The model is an advanced process-oriented coupled ocean-basin model, allowing the effective modelling of fully coupled physical–biogeochemical processes.

Great effort has been put into the development of forcing functions, and we have now generated realistic forcing under climatic conditions of both the pre-industrial (AD 1500–1750) and the industrial era (AD 1750–present). These forcing data, together with nutrient load data, are used for multi-century model runs in which we assume that eutrophication starts at 1950.

The carbon chemistry dynamics are depicted in Fig. 2. The total alkalinity is modelled at the correct level, but displays less variability than do the observations. The observed and modelled pH values are in close agreement with each other: In the studied period, the mean pH is 8.2 and the seasonal variations are within ±0.3. The modelled partial pressure of CO_2 (Fig. 3) displays good agreement with calculated values based on observations and displays large seasonal variations. Low values are associated with strong plankton growth and high values with strong vertical mixing in the sea.

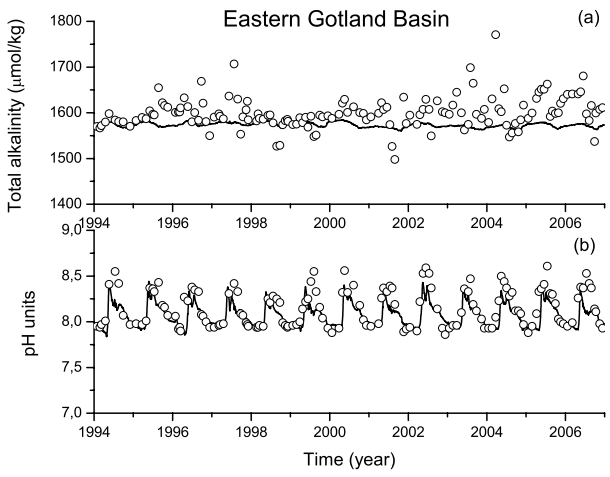


Fig. 2 Observed (circles) and calculated (black lines) surface layer properties (top: total alkalinity; bottom: pH-value) of the central Baltic Sea (from Omstedt et al. 2008).

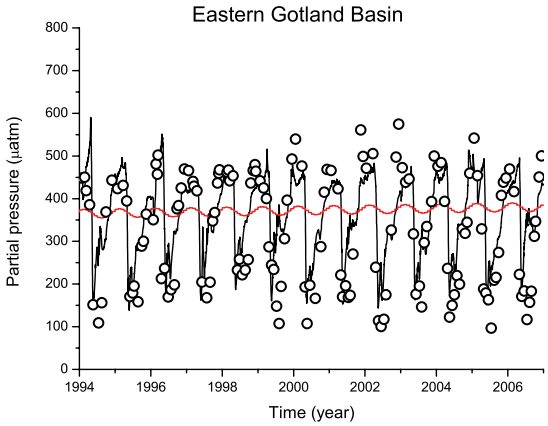


Fig. 3 Calculated surface layer CO_2 partial pressure in the central Baltic Sea, calculated from observed A_T and pH (circles) and from our model equations (black line). Red line represents the atmospheric partial pressure (from Omstedt et al., 2008).

Outlook

From Fig. 3 we can understand that the flux of CO_2 between water and air is strongly dependent on the partial pressure of CO_2 in the water. From a modelling viewpoint, it is interesting that the partial pressure of CO_2 in water is dependent on several physical, chemical, and biological processes, often in a strongly non-linear way. The modelling thus creates many challenges and will be central to the development of Earth System Models in BALTEX Phase II.

The present model system captures major physical–chemical and biological response patterns, evaluated based on observations from the central Baltic Sea, with interesting implications for the coupling between climate change, eutrophication, and the acid–base (pH) balance. In our work, however, we have not yet considered acid precipitation, changes in land use, or future possible projections, nor have we considered the carbon chemistry of anoxic waters. These matters will be addressed in the upcoming BONUS Baltic-C research, which will also examine air–sea exchange processes as well as river and ocean inputs of organic and inorganic carbon, total alkalinity, and nutrients (see page 5 in this Newsletter).

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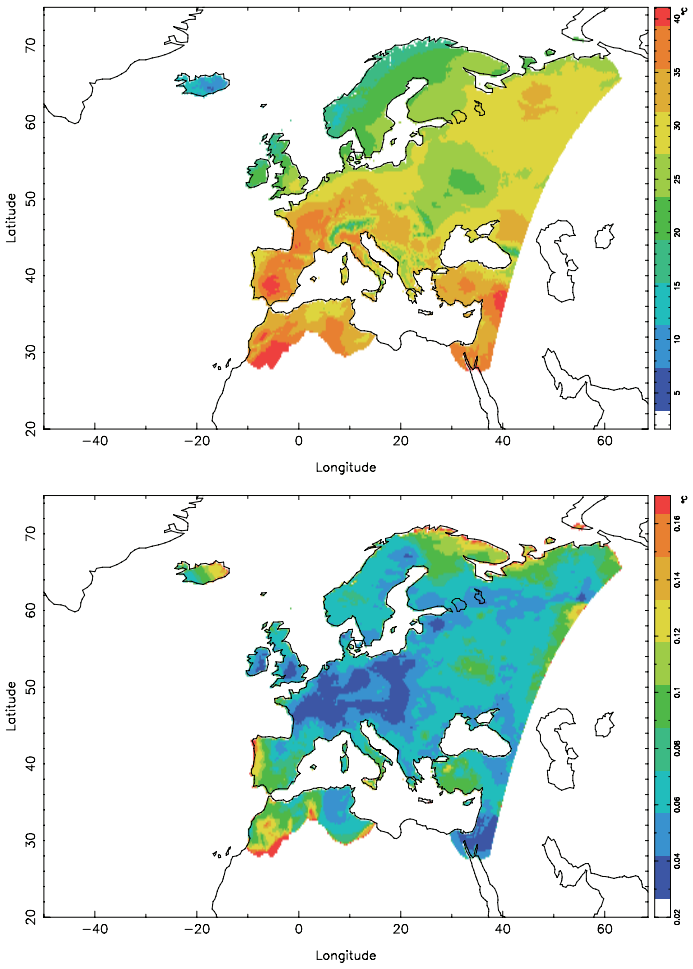
www.oceanclimate.se

ENSEMBLES gridded observational dataset (E-Obs)

Else van den Besselaar *(besselaar@knmi.nl) on behalf of the following partners in the EU-FP6 project ENSEMBLES: Royal Netherlands Meteorological Institute, De Bilt, The Netherlands; School of Geography, Oxford University Centre for the Environment, Oxford, UK; Climatic Research Unit, School of Environmental Sciences, University of East Anglia, Norwich, UK; Federal Office of Meteorology and Climatology MeteoSwiss, Zurich, Switzerland*

The ENSEMBLES gridded observational dataset (E-Obs) is a European land-only daily high-resolution gridded dataset for precipitation and minimum, mean and maximum surface air temperature for the period 1950-now. This dataset improves on other products in its spatial resolution and extent, time period, number of contributing stations, and attention to finding the most appropriate method for spatial interpolation of daily climate observations. A full description can be found in Haylock et al. (2008) and Hofstra et al. (2008).



Top: Maximum temperature on 3 August 2003 in the 0.25 degree regular grid (range: 6.62 - 43.09°C). Bottom: Standard errors for the same day and grid (range: 0.04 - 0.37°C). The box defines the extent of the dataset. White land areas indicate insufficient station data density for interpolation.

The underlying station data are from the daily observations of the European Climate Assessment & Dataset (ECA & D, http://eca.knmi.nl, Klok and Klein Tank 2008).

The gridded datasets are made available on two regular latitude-longitude grids (resolutions 0.25 and 0.50 degrees) and on two rotated pole grids (resolutions 0.22 and 0.44 degrees) with the North Pole at 39.25 °N, 162 °W. They cover the area between 21°N to 75 °N and 49°W to 68°E. The regular grid is the same as the monthly datasets available from the Climatic Research Unit (CRU) and the rotated grid is the same as used in many ENSEMBLES Regional Climate Models (RCMs).

The method has been designed to provide the best estimate of grid box averages rather than point values. This enables direct comparison with RCMs. Apart from the best estimate values, daily standard errors (as a measure of interpolation uncertainty) and surface elevation are provided as well. Please note that the datasets are strictly for use in non-commercial research and non-commercial education projects only. They are available from: http://eca.knmi.nl/ensembles. We intend to update the dataset on a regular basis.

As an illustration of the dataset, the figure shows the 0.25 degree regular temperature grid for the day with the highest average maximum temperature over Europe (28.5°C compared to the 1961-1990 summer average of 22.4°C). This day is 3 August 2003 which was during the heat wave of summer 2003. Europe was dominated by anomalous anticyclonic conditions for a long period, with a marked northward displacement of the subtropical Azores anticyclone, extending from the mid-Atlantic through to Eastern Europe. The blocking systems caused dry and sunny conditions in a large area.

References

Haylock, M.R., N. Hofstra, A.M.G. Klein Tank, E.J. Klok, P.D. Jones and M. New, 2008: A European daily high-resolution gridded dataset of surface temperature andprecipitation. J. Geophys. Res, 113, D20119, doi:10.1029/2008JD10201

Hofstra, N., M.R. Haylock, M. New, P.D. Jones, and C. Frei, 2008: Comparison of six methods for the interpolation of daily European climate data. J. Geophys. Res., 113, D21110 doi:10.1029/2008JD010100

Klok, E.J., and A.M.G. Klein Tank, 2008: Updated and extended European dataset of daily climate observations. Int. J. Climatol., in press

eca.knmi.nl

ensembles-eu.metoffice.com

BALTEX Special Issue

In February 2009, a special issue on BALTEX will appear in **Boreal Environment Research Vol. 14 No. 1**. It will contain 23 papers, which are extended versions, peer-reviewed according to BER standards, of presentations given at the 5th Study Conference on BALTEX in Kuressaare on the Estonian island of Saaremaa in June 2007. Just like the Conference programme, the papers in the special BER issue reflect the wider scope of the BALTEX phase II objectives, with a dedicated focus on climate variability and change as well as Baltic Sea basin environmental topics covered.

Contents:

BALTEX Special Issue

Kowalewska-Kalkowska, H. and Wisniewski, B. 2009: Storm surges in the Odra mouth area during the 1997–2006 decade.

Kundzewicz, Z. W. 2009: Adaptation to floods and droughts in the Baltic Sea basin under climate change.

Laanemets, J., Zhurbas, V., Elken, J. and Vahtera, E. 2009: Dependence of upwelling-mediated nutrient transport on wind forcing, bottom topography and stratification in the Gulf of Finland: Model experiments.

Langner, J., Andersson, C. and Engardt, M. 2009: Atmospheric input of nitrogen to the Baltic Sea basin: present situation, variability due to meteorology and impact of climate change.

Leal Filho, W. and Mannke, F. 2009: Towards policies and adaptation strategies to climate change in the Baltic Sea region — outputs of the ASTRA project.

Lind, P. and Kjellström, E. 2009: Water budget in the Baltic Sea drainage basin: Evaluation of simulated fluxes in a regional climate model.

Madsen, K. S. and Højerslev, N. K. 2009: Long-term temperature and salinity records from the Baltic Sea transition zone.

Rutgersson, A., Norman, M. and Åström, G. 2009: Atmospheric CO2 variation over the Baltic Sea and the impact on air–sea exchange.

Saue, T. and Kadaja, J. 2009: Simulated crop yield — an indicator of climate variability.

Sepp, M. 2009: Changes in frequency of Baltic Sea cyclones and their relationships with NAO and climate in Estonia.

Soomere, T., Leppäranta, M. and Myrberg, K. 2009: Highlights of the physical oceanography of the Gulf of Finland reflecting potential climate changes.

Tedesco, L., Vichi, M., Haapala, J. and Stipa, T. 2009: An enhanced sea-ice thermodynamic model applied to the Baltic Sea.

Venäläinen, A., Jylhä, K., Kilpeläinen, T., Saku, S., Tuomenvirta, H., Vajda, A. and Ruosteenoja, K. 2009: Recurrence of heavy precipitation, dry spells and deep snow cover in Finland based on observations.

www.baltex-research.eu/publications

Announcements

1st Announcement

International Summer School on

Climate Impacts on the Baltic Sea - From Science to Politics

Nexø, Bornholm, Denmark
27 July - 7 August 2009

Scientific knowledge, assessment and advice are needed in order make effective decisions on policy and management actions, which will achieve society objectives for marine ecosystems. All of these may be affected by climate change. The main purpose of this summer school will be to develop skills in and understanding of the observation, modelling, projection and interpretation of physical and biological changes in the Baltic Sea. The course will focus principally on the quantitative scientific aspects, but will also consider the two-way relationship between science and objectives and the communication of science for policy making.

The course is designed to give students opportunities to learn both discipline-specific and interdisciplinary skills. This background will be in demand as the societal pressures on marine ecosystems remain high or perhaps increase while climate change progresses. One of the main objectives of the course will be to demonstrate to students how discipline-specific knowledge can contribute to real management problems at the ecosystem level and how that knowledge can help achieve wider goals related to ecosystem-based approaches to management. Another objective will be to introduce students to problem-solving within individual disciplines via lectures, hands-on exercises and tutorials.

The course will be jointly organized by

DTU-Aqua

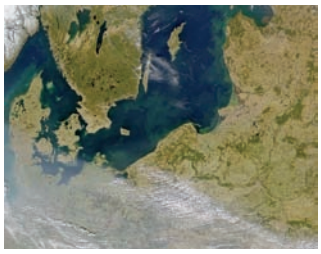
University of Gothenburg

GKSS Research Centre

Detailed information will be available soon at www.baltex-research.eu

Announcements

International Conference on
Climate Change
The environmental and socio-economic response
in the southern Baltic region



Szczecin, Poland
25 - 28 May 2009

Current research on the driving forces and parameters of the climate controlling system are focused on spatial downscaling in order to regionalize the process effects. This includes reconstructions for the Holocene as well as future projections which planning agencies may use for the socio-economic and technical reaction to changing climate. The southern Baltic Sea basin is a good region to be studied in high spatial resolution, because of its special interrelation between climate variations and the effects on the anthroposphere.

The Conference shall bring together scientists, economists, engineers, politicians and managers in order to discuss questions with respect to the following main Conference sessions:

- Marine and terrestrial proxies for reconstructions of paleo-climate
- Modeling of past climate change and future projections
- Climate and anthroposphere interactions
- Prehistoric communities and climate change
- Climate variability and change impacts on Baltic Sea coasts

Abstract Deadline: 15 February 2009
Registration Deadline: 15 April 2009

For more information and registration, see

www.baltex-research.eu/SZC2009

2nd International Lund RCM Workshop

21st Century Challenges in Regional-scale Climate Modelling

Lund, Sweden 4 - 8 May 2009

The conference is a follow-up to the regional-scale climate modelling workshop held in Lund, Sweden in 2004. Developments and progress achieved in the last five years will be presented and discussed along with open issues and expected future challenges related to regional climate modelling. The meeting will cover a wide range of RCM-related topics from basic research - such as theoretical aspects of numerics and parameterizations - to applications such as impact studies in the context of climate variability and change. The workshop is endorsed by the World Meteorological Organization (WMO), its World Climate Research Programme (WCRP), the Global Energy and Water Cycle Experiment (GEWEX) and its Regional Hydroclimate Project BALTEX, as well as by the EU/FP6 project ENSEMBLES and the North American Regional Climate Change Programme (NARCCAP).

Topics:

- Dynamical Downscaling
- New Developments in Numerics and Physical Parameterisations
- From Weather to Climate
- Regional Observational Data and Reanalysis
- Results from Large Projects
- The Future of RCMs
- Impact Studies

Abstract Deadline: 15. Februar 2009
Registration Deadline: 15 March 2009

For more information and registration, see

www.baltex-research.eu/RCM2009

BALTEX is the European continental-scale experiment within the Global Energy and Water Cycle Experiment (GEWEX). It constitutes a research programme focussing on water and energy cycles in the climate system of the entire Baltic Sea basin with contributions of more than 10 countries. GEWEX has been launched by the World Meteorological Organisation (WMO), the International Council for Science (ICSU) and UNESCO's Intergovernmental Oceanographic Commission (IOC), as part of the World Climate Research Programme (WCRP). The scientific planning of BALTEX is under the guidance of the BALTEX Science Steering Group. The BALTEX *Newsletter* is edited and printed at the International BALTEX Secretariat with financial support through the GKSS Research Centre Geesthacht, Germany. It is the hope that the BALTEX *Newsletter* is accepted as a means of reporting on plans, meetings and work in progress, which are relevant to the goals of BALTEX, as outlined in the Science and Implementation Plans for BALTEX.

The editor invites the scientific community to submit BALTEX-related contibutions to be published in this *Newsletter.* Submitted contributions will not be peer-reviewed and do not necessarily reflect the majority's view of the BALTEX research community. Scientific material published in this *Newsletter* should not be used without permission of the authors.

Please, send contributions to the BALTEX *Newsletter,* requests for BALTEX - related documents, suggestions or questions to the International BALTEX Secretariat via

www.baltex-research.eu

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