Workshop

Uncertainties of scenario simulations

Hörsalen, SMHI, Norrköping 14 October 2010

PROGRAMME	
09:00 - 09:15	**Welcome and introduction** Markus Meier, SMHI, Sweden
Morning session Chair: Karin Borenäs, SMHI	
09:15 - 10: 00	**Uncertainties in projections of climate change** *Invited speaker* Jouni Räisänen**,** Department of Physics, University of Helsinki, Finland
10:00 - 10:45	**How to handle uncertainty in future projections?** *Invited speaker* Samu Mäntyniemi, University of Helsinki, Finland
10:45 - 11:15	**Coffee break**
11:15 - 11:30	**Major uncertainties in scenarios of Baltic Sea eutrophication – response to changes in the drainage basin** Bo Gustafsson, Christoph Humborg, Carl-Magnus Mörth and Oleg Savchuk**,** Baltic Nest Institute**,** Stockholm Resilience Centre**,** Stockholm University**,** Sweden
11:30 - 11:45	**Baltic Sea fishery management: Bayesian uncertainty communication** Robert Aps, Mihhail Fetissov**,** University of Tartu, Estonian Marine Institute, Estonia

11:45 – 12:15	**Identification of uncertainties in regional climate projections over the Baltic region** *Invited Speaker* Grigory Nikulin, SMHI, Sweden
12:15 – 12:45	**Exploring the concept of assigning relative weights to regional climate models Experiences from the ENSEMBLES project** *Invited Speaker* Erik Kjellström, SMHI, Sweden
12:45 – 13:00	**Uncertainty analysis of the modelling chain from GCM to flood inundation** Fredrik Wetterhall, SMHI, Sweden
13:00-13:05	**Benthic nitrogen and phosphorus fluxes in a seasonally hypoxic channel in the Western Baltic Sea (Boknis Eck, Kiel Bight): current trends and long term perspectives** *Introduction of Poster* T. Schorp, A. W. Dale, S. Sommer, O. Pfannkuche, H. P. Hansen, H. W. Bange and K. Wallmann, Leibniz Institute of Marine Sciences, IFM-GEOMAR, Kiel, Germany
13:05 - 14:00	**Lunch**
Afternoon session Chair: Bo Gustafsson, BNI	
14:00 - 14:15	**Quality assessment of atmospheric surface fields over the Baltic Sea from an ensemble of regional climate model simulations with respect to ocean dynamics** H. E. Markus Meier[a,b], Anders Höglund[a], Ralf Döscher[a], Helén Andersson[a], Ulrike Löptien[a], and Erik Kjellström[a] [a]Swedish Meteorological and Hydrological Institute, Norrköping, Sweden, [b]Department of Meteorology, Stockholm University, Stockholm, Sweden
14:15 – 14:30	**Uncertainties in Hydrological Predictions for the Baltic Sea: In Today's and a Future Climate** Chantal Donnelly, Johan Strömqvist, Joel Dahné, Wei Yang, Patrik Wallman och Berit Arheimer, SMHI, Sweden
14:30 – 14:45	**Scenario simulations of the state of Baltic Sea ecosystem in a future climate using the St.Petersburg Baltic Eutrophication Model** V. Ryabchenko[1], L. Karlin[2], I. Neelov[1], T. Eremina[2], O. Savchuk[3], R. Vankevich[2] and A. Isaev[2] [1]St.Petersburg Branch, P.P. Shirshov Institute of Oceanology, Russia, [2]Russian State Hydrometeorological University, St.Petersburg, Russia, [3]Baltic Nest Institute, Resilience Centre,

	Stockholm University, Sweden
14:45 - 15:00	**Analysis of dynamically downscaled climate simulations over the Baltic Sea drainage basin** Björn Carlsson[1], Ida Sjöström[1], Anna Rutgersson[1] and Anders Omstedt[2], [1]Department of Earth Sciences, Uppsala University, Sweden, [2]Earth Sciences Centre, University of Gothenburg, Sweden
15:00 – 15:15	**Comparative retrospective assessment of biogeochemical model outputs for fish and foodweb modelling in the Baltic Sea** Brian R. MacKenzie[1, 2, 3], Kari Eilola[4], Bo Gustafsson[5], Ivan Kuznetsov[6], Markus Meier[4],Thomas Neumann[6], Anders Nielsen[1], [1]National Institute for Aquatic Resources, Technical University of Denmark (DTU-Aqua), Denmark, [2]Department of Marine Ecology, University of Aarhus, Denmark, [3]Center for Macroecology, Evolution and Climate, Department of Biology, University of Copenhagen, Denmark, [4]Swedish Meteorological and Hydrological Institute, Sweden, [5]Baltic Nest Institute, Resilience Centre, Stockholm University, Sweden, [6]Baltic Sea Research Institute Warnemünde, Germany
15:15 - 15:30	**Biological Ensemble Modelling of climate effects on food-webs – impacts of model uncertainty and ensemble averaging** Anna Gårdmark[1], Stefan Neuenfeldt[2], Martin Lindegren[2], Thorsten Blenckner[3], Eero Aro[4], Outi Heikinheimo[4], Bärbel Müller-Karulis[5], Susa Niiranen[3], Maciej Tomczak[2], Anieke van Leeuwen[6], Anders Wikström[7] and Christian Möllmann[8]**,** [1]Institute of Coastal Research, Swedish Board of Fisheries, Sweden, [2]National Institute of Aquatic Resources, Dept. of Marine Fisheries, Denmark [3]Baltic Nest Institute, Stockholm Resilience Center, Stockholm University, Sweden, [4]Finnish Game and Fisheries Research Institute, Finland, [5]Latvian Institute of Aquatic Ecology, Latvia, [6]Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, The Netherlands, [7]Department of Theoretical Ecology, Lund University, Sweden, [8]Institute of Hydrobiology and Fisheries Science, University of Hamburg, Germany
15:30 – 15:45	**Expert systems on optimization of Baltic Environmental Management Model** John Haluan, Dept. Fishr. Res. Utl, Bogor Agricultural University, Indonesia
15.45 – 16:15	**Coffee break**

16:15 – 17:15	**Discussion in working groups (WG1 & WG2)** **Topic: How can we best estimate and handle projection uncertainties in current projects?** **<u>WG1</u>** **Chair: Samu Mäntyniemi, University of Helsinki** **Rapporteur: Chantal Donnelly, SMHI** **<u>WG2</u>** **Chair: TBA** **Rapporteur: TBA**
17:15 – 18:15	**Plenary discussion and summary**
18:30	**Dinner**

Abstracts

Uncertainties in projections of climate change

Jouni Räisänen
Department of Physics, University of Helsinki, Finland

Projections of future climate change are affected by three main sources of uncertainty, namely (1) uncertainty about future anthropogenic emissions, (2) errors in climate system models and (3) natural climate variability. The relative importance of these uncertainties depends on the time scale, spatial scale and variable considered.

For century-scale projections of global mean temperature change, natural variability is very small compared with the other two sources of uncertainty. In its 4th Assessment Report, the IPCC projected a 21st century global mean warming of 1.1-2.9°C for the lowest (B1) and 2.4-6.4°C for the highest SRES emission scenario. This implies that, in this case, the emission scenario uncertainty and modelling uncertainty are of similar importance. However, the quantification of both of these is conditional on the assumption that the range of scenarios considered and climate model results used adequately capture the actual uncertainty.

Natural climate variability grows larger with decreasing spatial scale – for example, temperatures in northern Europe vary much more from year to year and decade to decade than the global mean temperature does. For many meteorological variables, natural variability still constitutes only a minor part of the century-scale uncertainty in regional climate change.

When focusing on the more short-term future, the picture changes. Emission scenario uncertainty is modest for the next few decades to come, because the projected emissions diverge slowly between the scenarios and because of the lagged response of the atmospheric concentrations. Modelling uncertainty also matters less – as far as the anthropogenic forcing is weak, the simulated climate response is in absolute terms less sensitive to model errors. By contrast, natural variability is substantial even on relatively short time scales. Thus, in regional projections for the next few decades, the uncertainty is generally dominated by natural variability and, at least for variables other than temperature, even the sign of the near-term changes is often quite uncertain.

Finally, there is an issue that might be called *climatic nowcasting*. The operational description of the prevailing climate is based on past observations from a 30-year normal period such as 1971-2000 or (for some purposes) a longer period of time. However, in a world with ongoing global warming, past observations give a potentially biased estimate of the actual present-day climate and the climatic conditions that can be expected in the near future. This difference seems to be quite significant for the interpretation of some recent temperature extremes, such as the cold winter and (in Finland and western Russia) extremely warm summer observed in the year 2010.

How to handle uncertainty in future projections?

Samu Mäntyniemi
University of Helsinki, Finland

Fisheries and Environmental Management group (FEM), Department of Environmental Sciences, University of Helsinki
This talk considers three aspects of uncertainty related to future projections. In the first part of the talk I discuss the nature of the concept of uncertainty: what is uncertainty, how it can be measured and whether we can find out the true uncertainty is? As an outcome of this discussion I present the basic principles of the Bayesian inference, which will be utilized throughout the rest of the talk.
The second aspect to be dealt with is the correlation of parameter estimates. Ho w the correlation emerges and what is the consequence of that correlation when making future projections? The correlation appears to be highly relevant for the uncertainty about the future. After the more general approach, I will outline couple of practical techniques by which the correlation can be taken into account in simulations.
Finally, I deal with the issue of model uncertainty. Typically alternative hypotheses exist about the causal relationships inherent in the natural phenomenon of interest. Each hypothesis may lead to a structurally different model. This uncertainty about the model structure can be consistently handled within the Bayesian framework. The relative credibility of each model structure can be assessed and updated gradually as new data becomes observed, and used automatically to weight the model structures when making forward projections.

Major uncertainties in scenarios of Baltic Sea eutrophication – response to changes in the drainage basin

Bo Gustafsson, Christoph Humborg, Carl-Magnus Mörth and Oleg Savchuk
Baltic Nest Institute, Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden

Scenarios of the future development of the eutrophication of the Baltic Sea involve a series of major uncertainties ranging from fundamental assumptions on socioeconomic development in the catchment to parameterizations of fundamental physical and biogeochemical processes both on land and in the sea. In this study, we use Baltsem to explore the time-dependent impact from changes in nutrient loads on the major eutrophication indicators, e.g., modeled primary production, N2-fixation etc., in different sub-basins of the Baltic Sea. The response to recently produced scenarios of changes in nutrient loads due to climate change and life styles will be assessed.

Baltic Sea fishery management: Bayesian uncertainty communication

Robert Aps, Mihhail Fetissov
University of Tartu, Estonian Marine Institute, Tallinn, Estonia

The Baltic Sea fishery system is an obvious example of coupled human and natural systems. Systems approach is used to analyse the holistic and complex fishery system. Uncertainty is an endemic condition of the fishery that is exacerbated by the overexploitation of resources, the depletion of stocks, and the volatility of market demand, especially in relation to export markets. The Dynamic Bayesian Network (DBN) is used to model the fishery system's performance. Three feedback loops of the Baltic Sea fishery system are identified: 1) the internal biological loop of the renewable fishery resource dynamics, 2) the harvest feedback loop (harvest is affecting the fishery resource, and in a wider context the ecosystem), and 3) the market feedback loop where the landings are transformed into the revenue. Actual fishery management is concentrated on the market feedback loop with four regulatory positions: 1) limited entry controls, indirect methods of fishing mortality control including restrictive licensing, 2) output controls, catch limits control based on Total Allowable Catches (TACs), 3) monetary controls (royalties, fees, taxes, charges but also financial support programmes and subsidies), 4) new fishing capacity entry controls (limited licensing as a right of entry). DBNs are used to communicate uncertainty associated with introducing the Individual Transferable Quota (ITQ) system as a basis for the Baltic Sea fishery management that would contribute into achieving both the Maximum Sustainable Yield (MSY) and the Maximum Economic Yield (MEY) objectives through the actual removal of excess fishing capacity. It is shown also that the ITQ system would create and enforce the missing negative feedback loop that will be constantly pushing the fishery system towards higher economic efficiency and ecological sustainability.

Identification of uncertainties in regional climate projections over the Baltic region

Grigory Nikulin
SMHI, Sweden
TBA

Exploring the concept of assigning relative weights to regional climate models Experiences from the ENSEMBLES project

Erik Kjellström
SMHI, Sweden
TBA

Benthic nitrogen and phosphorus fluxes in a seasonally hypoxic channel in the Western Baltic Sea (Boknis Eck, Kiel Bight): current trends and long term perspectives

T. Schorp, A. W. Dale, S. Sommer, O. Pfannkuche, H. P. Hansen, H. W. Bange and K. Wallmann

Leibniz Institute of Marine Sciences, IFM-GEOMAR, Kiel, Germany

Marine sediments underlying hypoxic water bodies represent key sites for reactive nitrogen (N) and phosphorus (P) regeneration from phytodetritus. However, benthic geochemical cycles tend to be highly coupled and determined to a large extent by the site-specific redox conditions. Consequently, reactive N and P regeneration and their transport to the water column in hypoxic regions are not well established. To address this issue, in February 2010 we initiated a 12 month sampling campaign in Boknis Eck channel (25 m water depth) which experiences severe bottom water oxygen depletion during late summer. We employ a combination of benthic porewater data, flux measurements and numerical modeling of seafloor dynamics to analyze the pathways of organic matter recycling and the processes controlling the return flux of N and P from sediments. In this communication our findings representative of winter 2010 are presented. A time-series established at this site in 1957 further indicates that the extent and duration of this oxygen depletion is increasing year-on-year. The potential alteration of nutrient fluxes in response to more intense and prolonged hypoxia over coming decades, as predicted by the model, is also presented.

Uncertainty analysis of the modelling chain from GCM to flood inundation

Fredrik Wetterhall

SMHI, Sweden

This study set up novel techniques for tracking uncertainties through a modelling framework of extreme floods under a climate change. More specifically, it attempts to (1) assess future flood inundation impacts and extent as well as its hazards and (2) quantifying the cascading uncertainties in a modelling framework. The study was setup over a catchment in the River Severn in bordering between Wales and England. The modeling framework consists of statistically and dynamically downscaled meteorological input from an ensemble of GCMs and RCMs. The climate input is further driving a set of rainfall-runoff models, in this case LISFLOOD-RR and HBV. The hydrological models provide modelled discharges which are fed through two flood inundation models, LISFLOOD-FP and HECRAS. Uncertainties in climate impact modelling are many, for example input errors in observations, impact model parameter and structural uncertainties, parameterisation and resolution errors in climate models and the underlying future scenarios. The uncertainties are cascaded through the modelling chain and it is important to rigorously estimate this uncertainty at all levels. The overall aim of this study was to incorporate all these uncertainties at the very end of the chain in a flood risk map.

The main research questions are (1) how sensitive is the cascade setup to the downscaled meteorological input from the GCMs, particularly with respect to
extreme events; (2) how is the climate change signal affected by the downscaling technique; (3) how can we quantify the sources and magnitude of uncertainties when simulating flood inundation within the context of climate change; (4) how do we deal with multi-scale multi-source uncertainties whilst taking into account the limitations of our observed measurements; (5) how do we develop strategies that improve the efficiency of sampling such a cascaded

modeling structure to characterise the uncertainties and most importantly; (6) how do we convey the information to stake holders and policy makers?

Quality assessment of atmospheric surface fields over the Baltic Sea from an ensemble of regional climate model simulations with respect to ocean dynamics

H. E. Markus Meier[a,b], Anders Höglund[a], Ralf Döscher[a], Helén Andersson[a], Ulrike Löptien[a], and Erik Kjellström[a]
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Climate model results for the Baltic Sea region from an ensemble of eight simulations using the Rossby Centre Atmosphere model, version 3 (RCA3) driven with lateral boundary data from global climate models (GCMs) are compared with results from a downscaled ERA40 simulation and gridded observations from 1980-2006. The results showed that data from RCA3 scenario simulations should not be used as forcing for Baltic Sea models in climate change impact studies because biases of the control climate are significant affecting simulated changes of future projections. For instance, biases of the sea ice cover in present climate affect the sensitivity of the model response to changing climate due to the ice-albedo feedback. From the large ensemble of available RCA3 scenario simulations two GCMs with good performance in downscaling experiments during the control period 1980-2006 have been selected. In this study, only the quality of atmospheric surface fields over the Baltic Sea was chosen as selection criterion. For the greenhouse gas emission scenario A1B two transient simulations for 1961-2100 driven by these two GCMs have been performed using the regional, fully coupled atmosphere-ice-ocean model RCAO. It was shown that RCAO has the potential to improve the results in downscaling experiments driven by GCMs considerably because surface fields and air-sea fluxes over the Baltic are simulated more realistically when RCA3 has been forced by reanalysis data compared to when it has been forced by GCMs. The reason is that within RCAO sea surface temperature and sea ice concentration are calculated more realistically than surface boundary data from GCMs. For instance, the seasonal 2m air temperature cycle is closer to observations in RCAO than in RCA3 simulations. However, the parameterizations of atmosphere - sea ice fluxes in RCAO need to be improved.

Uncertainties in Hydrological Predictions for the Baltic Sea: In Today's and a Future Climate

Chantal Donnelly, Johan Strömqvist, Joel Dahné, Wei Yang, Patrik Wallman and Berit Arheimer
SMHI, Sweden

The hydrological research unit at Sweden's Meteorological and Hydrological Institute, SMHI, has produced high-resolution simulations of daily discharge and nutrient loads from all land areas running off to the Baltic Sea both in today's and a future climate. These simulations were made using the BALT-HYPE application of the HYPE model (Lindström et al. 2010). In this talk, the uncertainties in estimating these nutrient loads and discharges on these scales are discussed for today's climate. Uncertainties to be discussed include those associated with the available input data for modelling on this scale, how that input data is interpreted within the hydrological model framework, the processes modelled, and how the model is then parameterised to match measured data in today's climate. The uncertainties in then extending

these simulations to a future climate scenario are also discussed, including the uncertainties related to defining scenarios for the future as well as the assumption that model process descriptions are valid in a future climate.

Scenario simulations of the state of Baltic Sea ecosystem in a future climate using the St.Petersburg Baltic Eutrophication Model

V. Ryabchenko[1], L. Karlin[2], I. Neelov[1], T. Eremina[2], O. Savchuk[3], R. Vankevich[2] and A. Isaev[2]

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1. Introduction

The purpose of this study is to estimate the changes in the basic non-biotic and biotic components of the Baltic Sea ecosystem in coming 100 years which are due to scenarios of climate change in the 21st century. The estimation is based upon a recent version of St. Petersburg Baltic Eutrophication Model (SPBEM) and scenarios of climate change for the Baltic Sea region.

2. The coupled hydrodynamic-ecosystem model

SPBEM includes 3D hydrodynamic ocean-sea ice module (Neelov et al., 2003) and biogeochemical cycles (BGC) module (Savchuk, 2002). The BGC module describes nutrient cycling in the coupled pelagic and sediment sub-systems and contains 12 pelagic (zooplankton, diatoms, cyanobacteria, flagellates, nitrogen, phosphorus and silica detritus, ammonium, nitrite + nitrate, phosphate, silicate and dissolved oxygen) and 3 sediment (benthic nitrogen, phosphorus and silica) state variables. The current model version has horizontal resolution 2 nm and 78 levels of thickness of 2m in the upper 30-meters and of 6m below.

3. Set-up of simulations

Climate changes in the Baltic Sea region (53-68º N, 8-32º E) in 2001-2099 were estimated as slices of global forecasts for the region. The forecasts were obtained using general atmosphere-ocean circulation models which were participated in the climate model inter-comparison project CMIP3. These regional slices of global model solutions were obtained for runs performed in accordance with scenario A2 (maximal CO_2 emission) and scenario B1 (minimal CO_2 emission). Here we consider the results of a run with the SPBEM using the forecast of atmospheric meteorological forcing of model ECHAM5/MPI-OM for scenario A2 which demonstrates the maximal near-surface air temperature increase in the Baltic Sea region. Initial distributions of physical and biogeochemical fields in the Baltic Sea were constructed from the data available in the Baltic Environmental Database (http://data.ecology.su.se/Models/bed) for 3 wintertime months (January – March) of 3 consecutive years (1998-2001). Riverine discharges and nutrient land loads were prescribed as mean monthly values obtained by averaging throughout the period of 1996-2000. They remained the same during the whole period considered.

4. Results

According to results, water temperature in the Baltic Sea will increase in the 21st century in such way that the clearly expressed thermal stratification of the sea excluding only a thin seasonal thermocline will disappear after 2045 and an intensive heating of the whole water column will start. The low temperatures below the thermocline in the Bornholm Deep and Gotland Deep where the cold North Sea water occasionally penetrate in will exist longer than in other parts of the sea. The sea surface temperature growth in the central Baltic Sea by the end of the 21st century will be about 2 ºC over the Bornholm Deep and almost 3 ºC over the Gotland Deep (Fig.1). The changes in salinity of the Baltic Sea will be small so that the vertical salinity stratification will be practically the same during the whole century. The future changes in dissolved oxygen, phosphate and nitrate show that there is an alternation of stagnation periods when hypoxic conditions, increased phosphate concentration and lowered nitrate concentrations are typical and ventilation periods when, as a result of the advective transport of cold North Sea water, near-bottom oxygen and nitrite concentrations increase and phosphate concentration decreases. According to model results, the longest stagnation period (about 8 years) will be after 2050.Different algae will respond in different ways to temperature increase in the upper sea layer. The primary production of flagellates will grow during the whole century; the growth of production of green-blue algae in the first half of the 21st century will be changed by its lowering in the second half of this century (Fig. 2). The production of diatoms will drop that could be explained by increase in water temperature limiting the growth of spring cryophile diatoms.

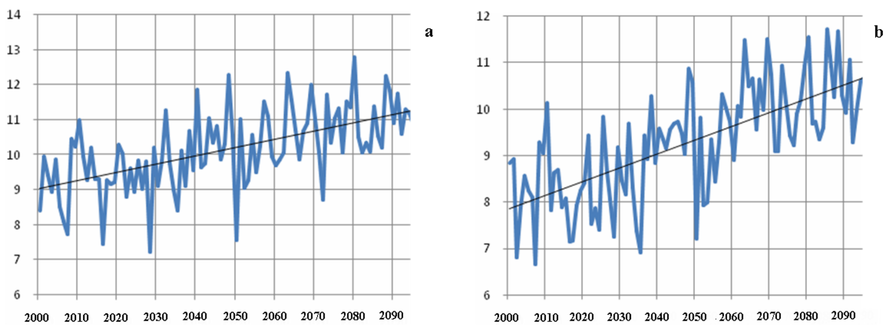

Fig.1. Mean annual water temperature (ºC) at the sea surface over the Bornholm Deep(a) and Gotland Deep (b) in 2001-2099.

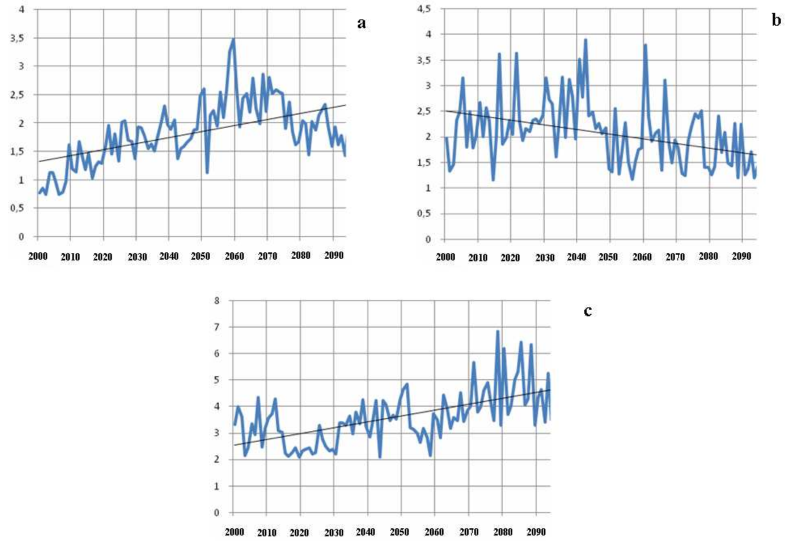

Fig.2. Mean annual, area-averaged primary production ($gN \cdot m^{-2} \cdot y^{-1}$) of blue-green algae (a), diatoms (b) and flagellates (c) in the euphotic layer of the Baltic Sea in 2001-2099.

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Analysis of dynamically downscaled climate simulations over the Baltic Sea drainage basin.

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The Baltic-C project (http://www.baltex-research.eu/baltic-c/index.html) is aiming at closing the carbon budget and to predict the future biochemical and acid-base state of the Baltic Sea drainage basin in a holistic approach. In this system of models, the Baltic Sea model PROBE-Baltic (Omstedt and Axell, 2003), the run-off model CSIM (Mörth et al., 2007) and the vegetation model LPJ-GUESS (Smith et al. 2001) requires atmospheric forcing describing present and future climate.

The climate data were retrieved from the Rossby Centre at SMHI where a climate change ensemble for the European area (Kjellström et al., 2009) was done within the ENSEMBLES project (Hewitt and Griggs, 2004, http://www.ensembles-eu.org/). Coupled global atmospheric and oceanographic climate models (AOGCMs) were dynamically downscaled to a 0.44° x 0.44° (c. 50 x 50 km) grid using the regional atmospheric climate model RCA3 (Kjellström et al., 2005). The following models were chosen for the present study: ECHAM5/OPYC3 (scenarios A1B, A2, B1), HadCM3 (scenario A1B) and CCSM3 (scenario A1B). The ERA40 global re-analysis were also downscaled to compare the output with present climate.

In the present investigation the relevant atmospheric parameters for the carbon cycle model system are analysed over the Baltic Sea drainage basin, namely geostrophic wind, temperature and humidity at 2 m, precipitation and cloudiness. For future climate three types of analysis are done:
Model variation: A1B (3 AOGCMs: ECHAM5, HadCM3, CCSM3)
Scenario variation: ECHAM5 (3 scenarios: A1B, A2 and B1).
Natural variation: ECHAM5 A1B (3 different initializations).
In addition to means, extremes and spread, also the significance in the changes is investigated.

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Comparative retrospective assessment of biogeochemical model outputs for fish and foodweb modelling in the Baltic Sea

Brian R. MacKenzie[1, 2, 3], Kari Eilola[4], Bo Gustafsson[5], Ivan Kuznetsov[6], Markus Meier[4],Thomas Neumann[6], Anders Nielsen[1]
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The BONUS+ project ECOSUPPORT has the objective to calculate the combined effects of changing climate and changing human activity (nutrient load reductions, coastal management, fisheries) on the BS ecosystem. This will be done by linking and combining outputs from several climate, biogeochemical, fish population and foodweb models. Responses (e. g., expected cod biomass in last quarter of the 21st century) will be variable and uncertain due to several factors, including not only the chosen combination of CO2 emission, nutrient loading or fishery exploitation scenario, but also due to the choice of climate, biogeochemical and fish/foodweb models, as well as the incomplete knowledge of ecological processes in the sea. The project will therefore use different models to assess and quantify some of this uncertainty. Model outputs will be compared with field data for a hindcast period to assess model quality. Some preliminary results of these comparisons with two biogeochemical models (RCO-

SCOBI and ERGOM) forced by a climate model will be presented and discussed at the workshop. The biogeochemical model outputs include variables (a combined salinity-oxygen concentration variable and sea temperature at different depths) which previously have been shown to affect recruitment in two commercially important fish species (cod, sprat) in the Baltic Sea. The analyses illustrate ways to potentially link climate variability through the foodweb into higher trophic levels.

Biological Ensemble Modelling of climate effects on food-webs – impacts of model uncertainty and ensemble averaging

Anna Gårdmark[1], Stefan Neuenfeldt[2], Martin Lindegren[2], Thorsten Blenckner[3], Eero Aro[4], Outi Heikinheimo[4], Bärbel Müller-Karulis[5], Susa Niiranen[3], Maciej Tomczak[2], Anieke van Leeuwen[6], Anders Wikström[7] and Christian Möllmann[8]
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One key to understanding food-web responses to further climate change are scenario analyses using mathematical models of population dynamics. With growing interest in ecosystem-based approaches to fisheries management, diversity and complexity of models used for simulating fish stock- as well as food-web responses to management have increased. Yet, the structural uncertainty associated with alternative models is rarely accounted for. Here we present the biological ensemble modelling approach (BEMA) to investigate and communicate such model uncertainty. Using an eight-model ensemble to simulate the response of Eastern Baltic cod to alternative fisheries management and climate scenarios, we illustrate how the technique can be used to disentangle model uncertainty from the statistical uncertainty of climate predictions. Further, we illustrate the impact of ensemble averaging across models on the perceived response to a particular scenario. Finally we show how the BEMA provides a means to (i) present the full set of projected stock responses, (ii) assess whether these imply different conclusions on e.g. management, and (iii) draw general conclusions valid across all models used.

Expert Systems on optimization of Baltic Environmental Management Model

John Haluan
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Expert Systems are computer programs that are derived from a branch of computer science research called Artificial Intelligence (AI). AI's scientific goal is to understand intelligence by building computer programs that exhibit intelligent behavior. It is concerned with the concepts and methods of symbolic inference, or reasoning, by a computer, and how the knowledge used to make those inferences will be represented inside the machine.
BALTEX Phase II (2003 – 2012) Objectives are:
1. Better understanding of the energy and water cycles over the Baltic Sea basin, 2. Analysis of climate variability and change since 1800, and the provision of regional climate projections

over the Baltic Sea basin for the 21st century, 3. Provision of improved tools for water management with an emphasis on more accurate forecasts of extreme events and long-term changes, 4. Gradual extension of BALTEX methodologies to air and water quality studies, 5. Strengthened interaction with decision-makers, with emphasis on global change impact assessments, 6. Education and outreach at the international level.

Objectives 1 to 4 are basically addressing science issues, while objectives 5 and 6 are related to strategic and political issues which will have to be pursued as cross-cutting activities in the context of all four science objectives.

Expert Systems on Optimization of Baltic Environmental Management Model (ESOBEMM) is designed to support the no. 5 and 6 BALTEX Phase II Objectives. The results should be suggestions to the decision-makers for optimum actions on global change impact assessment and education knowledge as the outreach at the international level.