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Baltic Earth Workshop on

Coupled atmosphere-ocean modeling for the Baltic Sea and North Sea

Leibniz Institute for Baltic Sea Research Warnemünde, Germany
7-8 February 2017

Programme, Abstracts, Participants

Leibniz Institute for Baltic Sea Research Warnemünde

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Front page photo: Baltic Sea coupled with Atmosphere (Marcus Reckermann)

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Leibniz Institute for Baltic Sea Research Warnemünde, Germany

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Co-Organized by

Scope

The workshop aims to bring scientist interested in coupled modeling of the Baltic Sea and North Sea regions together to discuss scientific results, recent progress in model development, technical challenges, coordinated experiments and common publications. The idea is to have some brief presentations from all groups working with coupled modeling on new scientific and technical results and intensive discussions on coordinated experiments. The latter will hopefully result in a work plan for coordinated experiments supported by several groups and with results summarized in common scientific publications. The workshop participants are invited to propose ideas for coordinated experiments solving scientific questions that can hardly be addressed by just one coupled atmosphere-ocean model.

Venue

The seminar will take place at the Leibniz Institute for Baltic Sea Research in Warnemünde, Germany (IOW).

Organizers

Markus Meier, Leibniz Institute for Baltic Sea Research Warnemünde, Germany
Ha Ho-Hagemann, Helmholtz-Zentrum Geesthacht, Germany

Find up-to date information on the Baltic Earth website: http://www.baltic.earth/caom2017

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Baltic Earth
Earth System Science for the Baltic Sea Region

Leibniz Institute for Baltic Sea Research Warnemünde

Baltic Earth Workshop on coupled atmosphere-ocean modeling for the Baltic Sea and North Sea

start:	Tuesday, 7 February 2017, 10:00 h
end:	Wednesday, 8 February 2017, 15:00 h
venue:	Leibniz-Institute for Baltic Sea Research Warnemünde (IOW) Seestrasse 15 18119 Rostock-Warnemünde

Agenda

Tuesday, 2017-02-07		
From 09:30	*Registration, coffee and tea*	
10:00-10:30	Markus Meier and Ha Hagemann	Welcome and introduction
10:30-10:50	Jennifer Brauch, Trang Van Pham, Jennifer Lenhardt, Barbara Früh	Coupling COSMO-CLM and NEMO-Nordic for the North and Baltic seas
10:50-11:10	Matthias Gröger, Ole Bøssing Christensen, J. Brauch, C. Dieterich, H. Hagemann, H.E.M. Meier, S. Schimanke, T. Tian and T.V. Pham	Interactive air-sea coupling in the Baltic Sea – A stepstone towards regional earth system modelling
11:10-11:30	Ha T.M. Ho-Hagemann, M. Gröger, B. Rockel, M. Zahn, B. Geyer, H.E.M. Meier	Effects of air-sea coupling over the North Sea and the Baltic Sea on simulated summer precipitation over Central Europe
11:30-11:50	Moritz Mathis and Uwe Mikolajewicz	Downscaling anthropogenic climate change for the North Sea
11:50-13:00	*Lunch*	
13:00-13:20	Jian Su, Hu Yang, Christopher Moseley, Alberto Elizalde, Dimitry Sein and Thomas Pohlmann	Ocean feedback mechanism in a coupled atmosphere-ocean model system for the North Sea
13:20-13:40	Stephan Dick, Dr. Frank Janssen, Dr. Birgit Klein	BSH activities on coupled ocean modeling in the North Sea and Baltic

13:40-14:00	Joanna Stanevaa, Victor Alari, Øyvind Breivik, Jean-Raymond Bidlot, Ha T. M. Ho Hagemann, Luciana Fenoglio Marc, Wolfgang Koch, Kristian Mogensen, Emil V. Stanev, Kathrin Wahle and Oliver Krüger	The added value of coupling of atmosphere and circulation models with waves for the North Sea-Baltic Sea
14:00-14:20	Claudia Frauen and Markus Meier	Towards a new coupled regional earth system model for the Baltic Sea region - plans and progress at IOW
14:20-14:40	Axel Andersson, Lydia Gates, Birger Tinz	Observational data for model evaluation over the North and Baltic Sea from the DWD Marine Climate Data Centre
14:40-15:00	Questions to the presentations	
15:00-16:00	Poster session (*see below) and *Coffee break*	
16:00-18:30	Discussion on coordinated experiments	
18:30	*Dinner at IOW*	

Wednesday, 2017-02-08	
08:30-09:30	NEMO side meeting (chaired by Jennifer Brauch)
09:30-15:00	Discussion on coordinated experiments *with breaks 10:30-11:00 and 12:30-13:30*

***Posters**
Anika Obermann-Hellhund, Naveed Akhtar, Jennifer Brauch and Bodo Ahrens: Europe between its northern and southern marginal seas
Trang Van Pham, Jennifer Brauch, Barbara Frueh, Bodo Ahrens: Added predictive skill of decadal hindcasts with coupled model COSMO-CLM/NEMO
Jaromir Jakacki, Anna Przyborska, Jan Andrzejewski, Michał Białoskórski, Bartosz Pliszka: Implementation of Community Earth System Model in coupled ice-ocean configuration for the Baltic Sea

Abstracts in first author alphabetically order

Observational data for model evaluation over the North and Baltic Sea from the DWD Marine Climate Data Centre

Axel Andersson, Lydia Gates, Birger Tinz

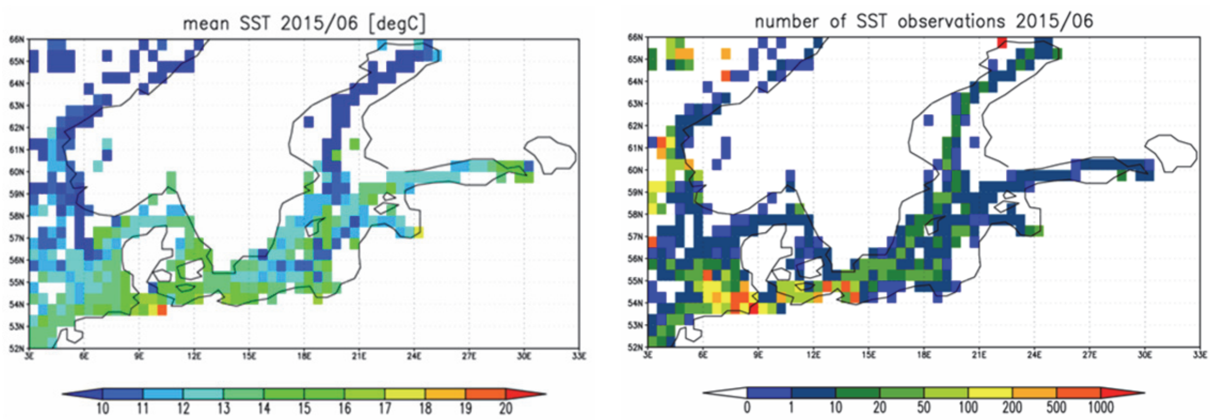
Deutscher Wetterdienst, Hamburg, Germany

The Marine Climate Data Centre of Deutscher Wetterdienst (DWD) maintains an extensive climatological archive of global marine observations. Apart from recent data, the archive consists of a large amount of historic data ranging back to the mid-19th century. Several data streams are combined into a consolidated archive with regular additions of data. Real-time data from ships, buoys and other marine measurement platforms are automatically retrieved from the Global Telecommunications System (GTS), and are consolidated in near real-time for long-term archival. Additional important data sources are Voluntary Observing Ships (VOS) that are collected and redistributed in delayed mode. Data from stationary measurements, such as from the research platforms in the North and Baltic Sea (FINO 1,2,3) complement the available data base.

To ensure the maximum degree of reliability, all observations undergo a flagging procedure based on several quality checking standards. These procedures do not only check the individual observation, but also implement checks on a sequence of observations from a specific observation platform in order to identify data errors of location and their time evolution.

The presentation will give an overview of the available in-situ data with a specific focus on SST and near surface atmospheric variables. Application examples will be given highlighting benefits and also caveats when using in-situ data for model evaluation.

In addition to the marine in-situ data, the presentation will also cover satellite data products that are available from the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF). The CM SAF is hosted by DWD and produces a variety of climate data records derived from satellite data. These data sets comprise a range of variables that are important for model evaluation such as ocean surface fluxes, radiation and cloud properties.



Sea surface temperature from marine in-situ observations archived in the Marine Climate Data Centre of Deutscher Wetterdienst (DWD). The left panel shows the mean SST for June 2015 derived from raw, unhomgenized observations. The corresponding number of observations is shown in the right panel.

Activities with COSMO-CLM and NEMO for the North and Baltic seas at DWD

Jennifer Brauch, Trang Van Pham, Jennifer Lenhardt, Barbara Früh

Deutscher Wetterdienst, Hamburg, Germany

Regional climate predictions and projections are very important to provide future climate information for stakeholders and politicians. At DWD, the regional climate model COSMO-CLM is one tool to provide this information.

In the first phase of the national project Miklip, it was shown, that there is an added value of using a regional climate model for decadal predictions. In the second phase of Miklip, the added value is further investigated by analysing and improving the initial- and lateral boundary conditions for the coupled ocean-atmosphere model (CCLM with ocean model NEMO) and by introducing a river runoff scheme to close the hydrological cycle in close cooperation with Goethe university. The aim of these studies is to improve the understanding of the high resolution interactions between ocean, atmosphere and land surface, and to represent more regional feedback mechanisms while using the coupled regional modelling system. The single-model atmosphere-only CCLM ensemble for regional decadal predictions is augmented with the coupled models as an additional physics perturbation member.

At Goethe University and DWD, we have established a regional atmosphere-ocean model for the North and Baltic Seas (ROAM). The setup up of NEMO for the North and Baltic seas was designed by SMHI. Both models are coupled via the OASIS3-MCT coupler. This coupler interpolates heat, fresh water, momentum fluxes, sea level pressure and the fraction of sea ice at the interface in space and time.

In a new pilot project on climate and water (ProWas) DWD and the Federal Maritime and Hydrographic Agency (BSH) plan to improve the ocean component even further and we will provide reference data sets with the coupled climate model for the recent past and the future.

BSH activities on coupled ocean modelling in the North Sea and the Baltic

Stephan Dick, Frank Janssen, Birgit Klein

Bundesamt für Seeschifffahrt und Hydrographie (BSH), Hamburg, Germany

To compute short term forecasts for water levels, currents, temperature, salinity, sea ice as well as dispersion of substances in the North Sea and Baltic Sea, the Federal Maritime and Hydrographic Agency (BSH) operates a three-dimensional baroclinic circulation model which runs on nested grids. The circulation model is interactively coupled to a sea ice model and is forced by weather forecasts of the German Weather Service (DWD), tidal predictions and river runoff. Various methods of model coupling to wave and dispersion models have been investigated in case studies and different research projects. Atmosphere-ocean coupling will be an activity in BSHs involvement in the Copernicus Marine Environment Monitoring Service (CMEMS).

In the framework of KLIWAS, funded by BMVBS, climate studies had been initiated by BSH which used either regional coupled shelf models or a global model with increased resolution over the North Sea. Climate runs from these models had been analysed to assess climate change in the North Sea and appropriate adaptation measures. The comparison of the KLIWAS models aimed at the analysis of coupling effects and the influence of boundary conditions in the regional models. Further studies on the marine component of climate change will be carried out in projects as RACE investigating the recent RCP scenarios and decadal prediction within MiKlip.

In a new pilot project on climate and water (ProWas) BSH will be engaged in coupled atmosphere-ocean modelling. Focus of BSH activities will be on the marine component of long hindcasts for the North Sea and Baltic which will be carried out by DWD with the coupled ocean atmosphere model ROAM. BSH will concentrate on the interaction with the North Atlantic as well as the improvement of processes as e.g. sea ice dynamics or the falling dry and flooding of tidal flats. Reference data sets and boundary data for the project partners BAW and BfG will be created in close cooperation with DWD.

Interactive air-sea coupling in the Baltic Sea - A stepstone towards regional Earth system modelling

Gröger M.[1], Christensen Ole B.[2], Brauch J.[3], Dieterich C.[1], Hagemann H.[4], Meier H.E.M.[1,5], Schimanke S[1], Tian T.[2], Pham T.V.[3]

1 Swedish Meteorological and Hydrological Institute, Norrköping, Sweden
2 Danish Meteorological Institute, Copenhagen, Denmark
3 Deutscher Wetterdienst, Offenbach am Main, Germany
4 Institute for Coastal Research, Helmholtz Zentrum Geesthacht, Germany
5 Leibniz Institute for Baltic Sea Research Warnemünde, Germany

During the past regional high resolution ocean models were driven mostly by prescribed atmospheric forcing fields obtained either from reanalysis data sets or from global climate model output. This strategy ensures most realistic results for the hindcast period as the reanalysis data sets assimilated observations and thus act as quasi artificial restoring term that prevents the ocean model to drift too far from reality.

During the recent period, regional ocean atmosphere models were interactively coupled so that the atmospheric boundary is no longer tied to observations. Thus, with less observational constraints the performance of any ocean model must be expected to worsen. We will test this hypothesis in ERA40/Interim simulations from at least four different high resolution models.

Despite the expected higher bias with prescribed forcing however, we will demonstrate that the dynamics of ocean – atmosphere heat exchange is only realistically represented when interactive coupling is allowed and discuss the consequences for climate scenarios. Moreover, we will show that in simulations with prescribed atmospheric boundary fields important feedback loops in air sea heat fluxes are not represented. In turn, we will examine specific cases where those air sea feedbacks can help to improve the modelled sea surface temperature even in hindcast simulations.

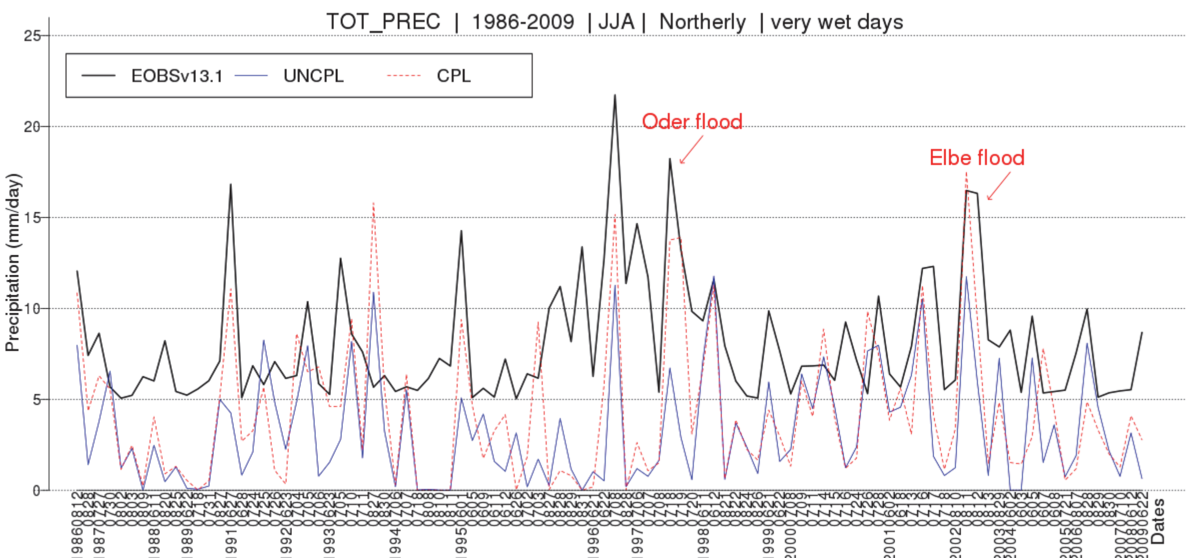
Effects of air-sea coupling over the North Sea and the Baltic Sea on simulated summer precipitation over Central Europe

Ha T.M. Ho-Hagemann[1], M. Gröger[2], B. Rockel[1], M. Zahn[1], B. Geyer[1], H.E.M. Meier[3,2]

1 Institute of Coastal Research, Helmholtz Zentrum Geesthacht, Germany
2 Swedish Meteorological and Hydrological Institute, Norrköping, Sweden
3 Leibniz Institute for Baltic Sea Research Warnemünde, Germany

This study introduces a new approach to investigate the potential effects of air-sea coupling on simulated precipitation over Central Europe. We present an inter-comparison of two regional climate models, the COSMO-CLM (hereafter CCLM) and RCA4 models, which are configured for the EURO-CORDEX domain in the coupled and atmosphere-only modes. Here, two versions of the CCLM model, namely, 4.8 and 5.0, join the inter-comparison being almost two different models. Because of many changes in the dynamics and physics of CCLM 5.0 compared with 4.8, the simulated summer precipitation strongly differs between the two versions. The coupling effect on the prominent summer dry bias over Central Europe is analysed using seasonal (JJA) mean statistics for the 30-year period from 1979 to 2009, with a focus on extreme precipitation under specific weather regimes.

The comparisons of the coupled systems with the atmosphere-only models show that coupling clearly reduces the dry bias over Central Europe for CCLM 4.8, which has a large dry summer bias, but not for CCLM 5.0 and RCA4, which have smaller dry biases. This result implies that if the atmosphere-only model already yields reasonable summer precipitation over Central Europe, not much room for improvement exists that may be imposed by the air-sea coupling over the North Sea and the Baltic Sea. However, if the atmosphere-only model shows a pronounced summer dry bias because of a lack of moisture transport from the seas into the region, the considered coupling may create an improved simulation of summer precipitation over Central Europe, such as for CCLM 4.8. For the latter, the benefit of coupling is evident if extreme precipitation is considered, particularly under Northerly Circulation conditions, in which the airflow from the North Atlantic Ocean passes the North Sea in the coupling domain.



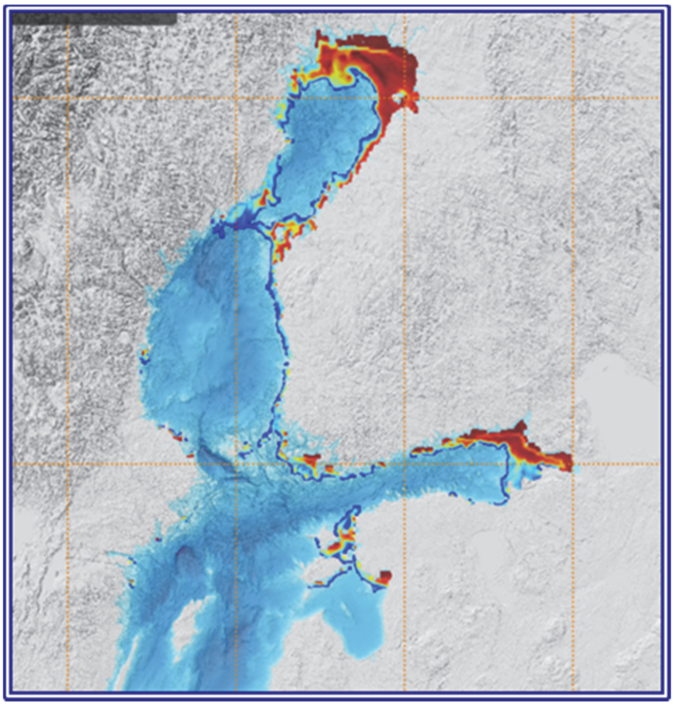
Daily precipitation (mm/day) of the E-OBS data version 13.1 (solid thick black line), uncoupled (solid thin line) and coupled (dashed line) simulations of CCLM 4.8 averaged for Central Europe for very wet days of the Northerly Circulation Type in JJA 1986-2009.

Implementation of Community Earth System Model in coupled ice-ocean configuration for the Baltic Sea

Jaromir Jakacki[1], Anna Przyborska[1], Jan Andrzejewski[1], Michał Białoskórski[2], Bartosz Pliszka[2]

1 Institute of Oceanology Polish Academy of Sciences, Sopot, Poland
2 Academic Computer Centre of Technical University of Gdańsk (CI TASK), Gdańsk, Poland

Recently developed coupled ice-ocean model for the Baltic Sea has been adapted and implemented. The model consists of two active components (Parallel Ocean Program and Community Ice CodE (POP and CICE respectively)). The models are drive by atmospheric forces based on regional implementation of Weather Research and Forecasting Model (WRF). The POP is a z-level coordinates, general circulation ocean model (GCM) that solves the 3-dimensional primitive equations for stratified fluid, using the hydrostatic and Boussinesq approximations. The ocean model is coupled through the flux coupler (also called cpl7) with the sea ice model. The CICE uses an elastic-viscous-plastic ice rheology [3]. The Los Alamos CICE model is the result of an effort to develop a computationally efficient sea ice component for a fully coupled atmosphere-ice-ocean-land global climate model. The models have been successfully adopted and validated for the Baltic Sea whole area including Kattegat. The sea ice and ocean models have about 2.3 km horizontal resolutions. Vertical resolution of the ocean model is 5 meters. Several simulations have been performed and operational version of this model has been also implemented. Comparison between modelled prognostic variables and observations is going to be presented. As an example current (16-01-2017) sea ice concentration from operational version of the model (note: there is no assimilation in the model) for Baltic Sea is presented in the figure below.



Operationally modelled sea ice concentration for 16-01-2017

This work has been partially supported by the Applied Research Program under the Grant: ID PBS3/A3/20/2015, founded by the National Centre for Research and Development.

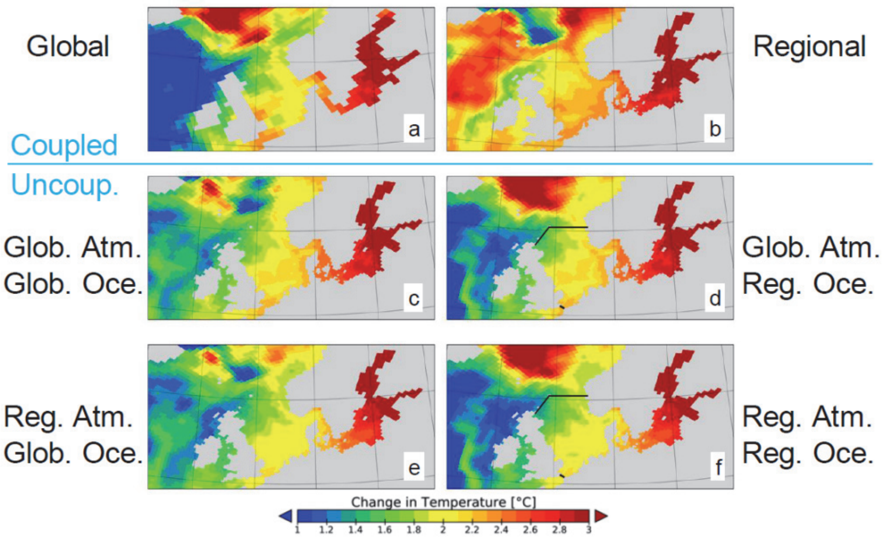
Downscaling anthropogenic climate change for the North Sea

Uwe Mikolajewicz and Moritz Mathis

Max-Planck-Institute for Meteorology, Hamburg, Germany

Regional information is essential for an assessment of the impacts of projected anthropogenic climate change in the North Sea. Global models used to simulate climate effects of different scenarios are too coarse for this purpose and do not include relevant shelf sea processes such as tides. For ocean downscaling, various techniques have been uses ranging from fully coupled regional climate system models, over successive downscaling with regional atmosphere and ocean models, to the direct use of atmospheric forcing (or anomalies) from global models. However, a systematic investigation of the pros and cons of the various approaches is lacking. In the first part of the presentation, we use the regional climate system model MPIOM/HAMOCC/REMO to downscale one global scenario simulation to the Northwest European Shelf, mimicking various approaches used in published studies.

We found that uncoupled downscalings tend to reproduce SST changes of the parent global simulation because of the strong influence of the atmospheric forcing. Coupled downscalings, by contrast, are able to simulate their own model-specific SST signals. Changes in salinity, however, can be downscaled adequately also by an uncoupled simulation, since they more depend on a proper representation of the ocean circulation rather than on coupled air-sea interaction. However, a too small domain of the regional ocean model tends to introduce substantial errors arising from ocean forcing prescribed at the open boundaries. In the second part, we present downscaled changes in SST, salinity and primary production from a high-resolution version of the regionally coupled climate system model and discuss these results with respect to the natural variability of the corresponding preindustrial control simulation. An ensemble of three global realizations has been utilized to increase statistical significance. Our results indicate that the projected decrease in on-shelf primary production is dominated by the drop in North Atlantic nutrient concentrations.



SST change signals from a global climate projection and various dynamical downscalings (RCP8.5 2071-2100 minus 1971-2000). (a) parent global climate projection by MPI-ESM; (b) regionally coupled downscaling by MPIOM/HAMOCC/REMO; (c) uncoupled downscaling with atmospheric forcing taken from the parent global simulation; (d) same as (c) but with ocean restoring towards the parent global simulation outside the North Sea and Baltic Sea to mimic prescribed open lateral boundary conditions; (e) uncoupled downscaling with atmospheric forcing taken from an atmosphere-only downscaling; (f) same as (e) but with ocean restoring towards the parent global simulation outside the North Sea and Baltic Sea.

Europe between its northern and southern marginal seas

Anika Obermann-Hellhund[1], Naveed Akhtar[1], Jennifer Brauch[2], Bodo Ahrens[1]

1 Goethe University Frankfurt, Germany
2 Deutscher Wetterdienst, Hamburg, Germany

To make use of interactively coupled regional ocean-atmosphere models in decadal predictions, a system with Northern Sea, Baltic Sea, and Mediterranean Sea is implemented. The ocean components northern NEMO-BN and Mediterranean NEMO-MED12 are coupled to the atmospheric model COSMO-CLM via OASIS on the EURO-CORDEX domain. At the moment, three coupled systems are tested: NEMO-MED12/CCLM, NEMO-BN/CCLM, and NEMO-MED12+NEMO-BN/CCLM.

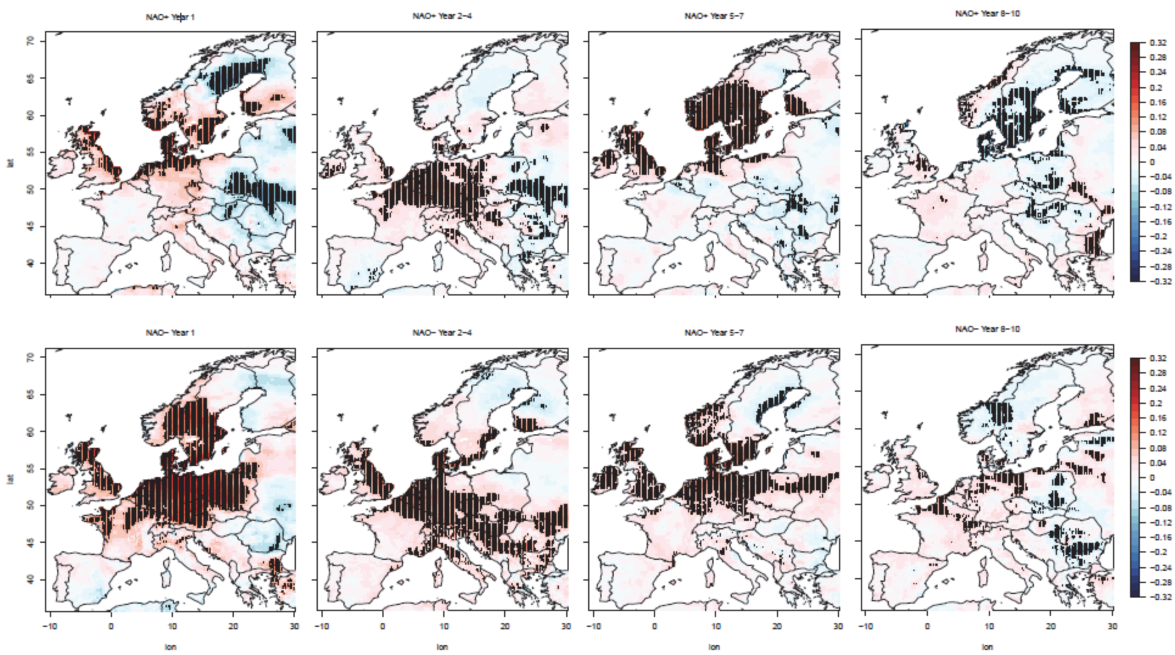
We show results on the impact of the multi-coupled system compared to the single NEMOBN/ CCLM simulations. Initialization experiments with NEMO-MED/CCLM were performed. Results on the impact of initial conditions on the ocean state (winter/summer climatology) and the start time of the simulation (January/July) in 20year simulations are presented.

Added predictive skill in decadal hindcast with coupled model COSMO-CLM/NEMO

Trang Van Pham[1,2], Jennifer Brauch[1], Barbara Früh[1], Bodo Ahrens[2]

1 Deutscher Wetterdienst, Offenbach am Main, Germany
2 Institute for Atmospheric and Environmental Sciences, Goethe University Frankfurt, Frankfurt am Main, Germany

Climate forecasting on decadal scales requires good boundary conditions. Regional climate models often rely on global models such as MPI-ESM to get the boundary conditions. However, global models cannot provide good information over the ocean because with the coarse resolution of MPI-ESM-LR (approximately 200 km) the North and Baltic Seas are not well presented, the straits of Kattegat and Skagerrak connecting the two seas cannot even be resolved. We aim to achieve better decadal forecasts by coupling the regional model COSMO-CLM with an ocean model NEMO-NORDIC for the North and Baltic Seas. With the coupled atmospheric-ocean-ice model, we carried out five decadal hindcasts from the 1960s to 2000s. Each decadal run was initialized on January 1st of the first year and ended on December 31st of the last year. The results were compared with the hindcasts from the global model MPI-ESM-LR itself and with the downscaled simulation with COSMO-CLM stand-alone forced by MPI-ESM-LR. Our results show that coupling an active ocean for the North and Baltic Seas leads to better predictive skills (compared with global model and regional uncoupled model) for 2 m air temperature especially at the southern coast of the North and Baltic Seas. The forecast quality reduces by lead year as expected. During the weak phase of the North Atlantic Oscillation (NAO), the coupling effect is more pronounced; therefore, better added predictive skill from the coupled model was seen. During winter when the impact of NAO is knowingly strong over Europe, COSMO-CLM/NEMO shows added skill in limited area and not as obvious as in spring or summer.



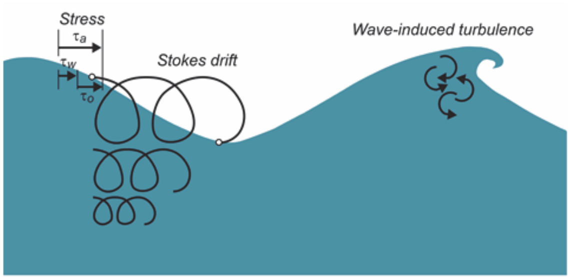
The added value of coupling of atmosphere and circulation models with waves for the North Sea-Baltic Sea

Joanna Staneva[1], Victor Alari[2], Øyvind Breivik[3], Jean-Raymond Bidlot[4], Ha T. M. Ho Hagemann[1], Luciana Fenoglio Marc[5], Wolfgang Koch[1], Kristian Mogensen[4] , Emil V. Stanev[1], Kathrin Wahle[1], and Oliver Krüger[1]

1 Institute of Coastal Research, Helmholtz Zentrum Geesthacht, Germany
2 Marine Systems Institute, Tallinn University of Technology, Tallinn, Estonia
3 Norwegian Meteorological Institute and Geophysical Institute, University of Bergen, Norway
4 European Centre for Medium-Range Weather Forecasts (ECMWF), Reading, United Kingdom
5 Institute of Geodesy and Geoinformation, University of Bonn, Germany

The coupling of models is a commonly used approach when addressing the complex interactions between different components of earth systems.

First, a coupled model system is used to study the effects of surface ocean waves on a circulation model (NEMO) for the North Sea and Baltic Sea regions. The additional terms accounting for wave-current interaction that are considered in this study are the Stokes-Coriolis force and the sea-state dependent energy and momentum fluxes. The individual and collective role of these processes is quantified and the results are compared with a control run without wave effects (CTRL experiment) as well as against current and water level measurements from coastal stations. We find a better agreement with observations when the circulation model is forced by sea-state dependent fluxes, especially in extreme events compared to the model run without wave processes. The results indicate a pronounced effect of waves on surface temperature, on the vertical distribution of temperature and on upwelling. Overall, when all three wave effects are accounted for the estimates of temperature improved compared to the CTRL run.



Wave-ocean interaction mechanisms

Second, we study the effects of coupling between an atmospheric model (COSMO) and a wind wave model (WAM), which is enabled through an introduction of wave induced drag in the atmospheric model. The numerical simulations use a regional North Sea coupled wave-atmosphere model as well as a nested-grid high resolution German Bight wave model. The two-way coupling leads to a reduction of both surface wind speeds and simulated wave heights. In this study, the sensitivity of atmospheric parameters, such as wind speed and atmospheric pressure to the wave-induced drag, in particular under storm conditions and the impact of two-way coupling on the wave model performance is quantified. Comparisons between data from in situ and satellite altimeter observations indicate that two-way coupling improves the wind and wave parameters of the model and justifies its implementation for both operational and climate simulations.

Ocean feedback mechanism in a coupled atmosphere-ocean model system for the North Sea

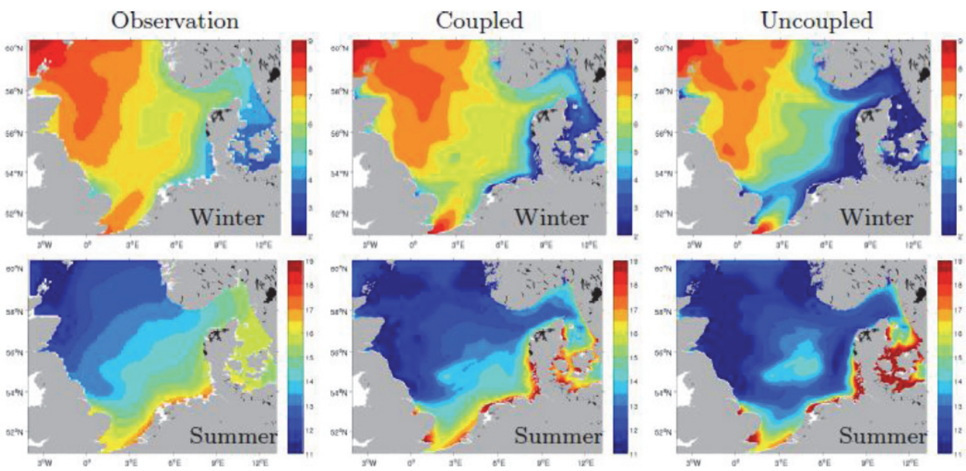
Jian Su[1], Hu Yang[1], Christopher Moseley[2], Alberto Elizalde[3], Dimitry Sein[4], Thomas Pohlmann[1]

1 Institute of Oceanography, University of Hamburg, Germany
2 Climate Service Center, Hamburg, Germany
3 Max-Planck-Institut für Meteorologie, Hamburg, Germany
4 Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

Choosing an interactive coupling between atmosphere and ocean models was widely practiced in regional climate study over the last decades. The added value of the coupling is attributed to providing regional details and incorporating the feedback of the ocean in regional climate downscaling. Such coupled model system serves for a variety of purpose, such as detailed process studies, air-sea interaction studies and long-term simulations. However, the necessity of including the ocean component in the regional climate downscaling is still under evaluation. Here we present a coupled model system applied to the North Sea, comprising a regional ocean model HAMSOM (resolution 3 km), an atmospheric model REMO (resolution 37 km) and the coupler OASIS.

The assessment presented in this study focused on the reaction of the ocean component. The uncoupled model experiment used the sea surface temperature (SST) from the global model as boundary input for the atmospheric model. The comparison of SST data revealed that spatial pattern of SST in coupled model simulation showed no major deviation from observations (Figure 1). In the uncoupled model simulation, a drift from observations was found when integrating the model for more than 10 years. This led us to revisit the individual years (1997 and 1999) to look for the mechanism of better performance in coupled model. We found that the cloud cover was responsible for correcting the heat flux errors in the uncoupled run. Therefore, we concluded that the local air sea interaction processes are responsible for damping these errors, in particular at the coastal waters, which leads to a better ocean model results.

The coupled model simulation shows no major deviation from observations, thus it can serve as a tool for a free climate-model run. In the uncoupled model simulation, we found a drift from observations when integrating the model for more than 10 years. This drift is due to the accumulation of latent heat flux errors. The interactive coupling could damp these errors in a long-term simulation. Finally, it provides a better simulation in the coastal waters.



Fourteen years mean SST (°C) of observations (Janssen et al, 1999, left column), coupled (middle column) and uncoupled (right column) experiments in February and August.

Participants

Bodo Ahrens	Goethe University Frankfurt, Germany bodo.ahrens@iau.uni-frankfurt.de
Naveed Akhtar	Goethe University Frankfurt, Germany naveed.akhtar@iau.uni-frankfurt.de
Helén Andersson	Swedish Meteorological and Hydrological Institute, Norrköping, Sweden; helen.andersson@smhi.se
Axel Andersson	Deutscher Wetterdienst, Hamburg, Germany axel.andersson@dwd.de
Jennifer Brauch	Deutscher Wetterdienst, Hamburg, Germany jennifer.brauch@dwd.de
Sandra Brunnabend	Leibniz Institute for Baltic Sea Research Warnemünde, Germany sandra.brunnabend@io-warnemuende.de
Bronwyn Cahill	Leibniz Institute for Baltic Sea Research Warnemünde, Germany bronwyn.cahill@io-warnemuende.de
Ole B. Christensen	Danish Meteorological Institute, Copenhagen, Denmark obc@dmi.dk
Evridiki Chrysagi	Leibniz Institute for Baltic Sea Research Warnemünde, Germany evridiki.chrysagi@io-warnemuende.de
Ute Daewel	Institute for Coastal Research, Helmholtz Zentrum Geesthacht, Germany; ute.daewel@hzg.de
Stephan Dick	Bundesamt für Seeschifffahrt und Hydrographie, Hamburg, Germany stephan.dick@bsh.de
Christian Dieterich	Swedish Meteorological and Hydrological Institute, Norrköping, Sweden; christian.dieterich@smhi.se
Claudia Frauen	Leibniz Institute for Baltic Sea Research Warnemünde, Germany claudia.frauen@io-warnemuende.de
Lydia Gates	Deutscher Wetterdienst, Hamburg, Germany lydia.gates@dwd.de
Ulf Gräwe	Leibniz Institute for Baltic Sea Research Warnemünde, Germany ulf.graewe@io-warnemuende.de
Matthias Gröger	Swedish Meteorological and Hydrological Institute, Norrköping, Sweden; matthias.groger@smhi.se

Alexandra Gronholz	MARUM - Zentrum für Marine Umweltwissenschaften der Universität Bremen, Germany; agronholz@marum.de
Stefan Hagemann	Max-Planck-Institute for Meteorology, Hamburg, Germany stefan.hagemann@mpimet.mpg.de
Ha Ho-Hagemann	Institute for Coastal Research, Helmholtz Zentrum Geesthacht, Germany; ha.hagemann@hzg.de
Jaromir Jakacki	Institute of Oceanology Polish Academy of Sciences, Sopot, Poland jjakacki@iopan.gda.pl
Birgit Klein	Bundesamt für Seeschifffahrt und Hydrographie, Hamburg, Germany birgit.klein@bsh.de
Madline Kniebusch	Leibniz Institute for Baltic Sea Research Warnemünde, Germany madline.kniebusch@io-warnemuende.de
Oliver Krüger	Institute for Coastal Research, Helmholtz Zentrum Geesthacht, Germany; oliver.krueger@hzg.de
Markus Meier	Leibniz Institute for Baltic Sea Research Warnemünde, Germany markus.meier@io-warnemuende.de
Uwe Mikolajewicz	Max-Planck-Institute for Meteorology, Hamburg, Germany uwe.mikolajewicz@mpimet.mpg.de
Jens Möller	Bundesamt für Seeschifffahrt und Hydrographie, Hamburg, Germany jens.moeller@bsh.de
Selina Müller	Leibniz Institute for Baltic Sea Research Warnemünde, Germany selina.müller@io-warnemuende.de
Anika Obermann-Hellund	Goethe University Frankfurt, Germany obermann@iau.uni-frankfurt.de
Tran Van Pham	Deutscher Wetterdienst, Hamburg, Germany trang.pham-van@dwd.de
Manja Placke	Leibniz Institute for Baltic Sea Research Warnemünde, Germany manja.placke@io-warnemuende.de
Marcus Reckermann	International Baltic Earth Secretariat, Helmholtz Zentrum Geesthacht, Germany; marcus.reckermann@hzg.de
Gregor Rehder	Leibniz Institute for Baltic Sea Research Warnemünde, Germany gregor.rehder@io-warnemuende.de
Burkhardt Rockel	Institute for Coastal Research, Helmholtz Zentrum Geesthacht, Germany; burkhardt.rockel@hzg.de

Torsten Seifert	Leibniz Institute for Baltic Sea Research Warnemünde, Germany torsten.seifert@io-warnemuende.de
Dmitry Sein	Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany; dmitry.sein@awi.de
Andreas Sterl	Royal Netherlands Meteorological Institute (KNMI), De Bilt, Netherlands; sterl@knmi.nl
Jian Su	Institute of Oceanography, University of Hamburg, Germany jian.su@uni-hamburg.de

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