Leibniz Institute for Baltic Sea Research Warnemünde
IOW

A regional coupled Earth system model to study climate variations in the region of the Baltic Sea

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MedCORDEX-Baltic Earth-COST Workshop Regional Climate System Modelling for the European Sea Regions Palma de Mallorca

14 to 16 March 2018

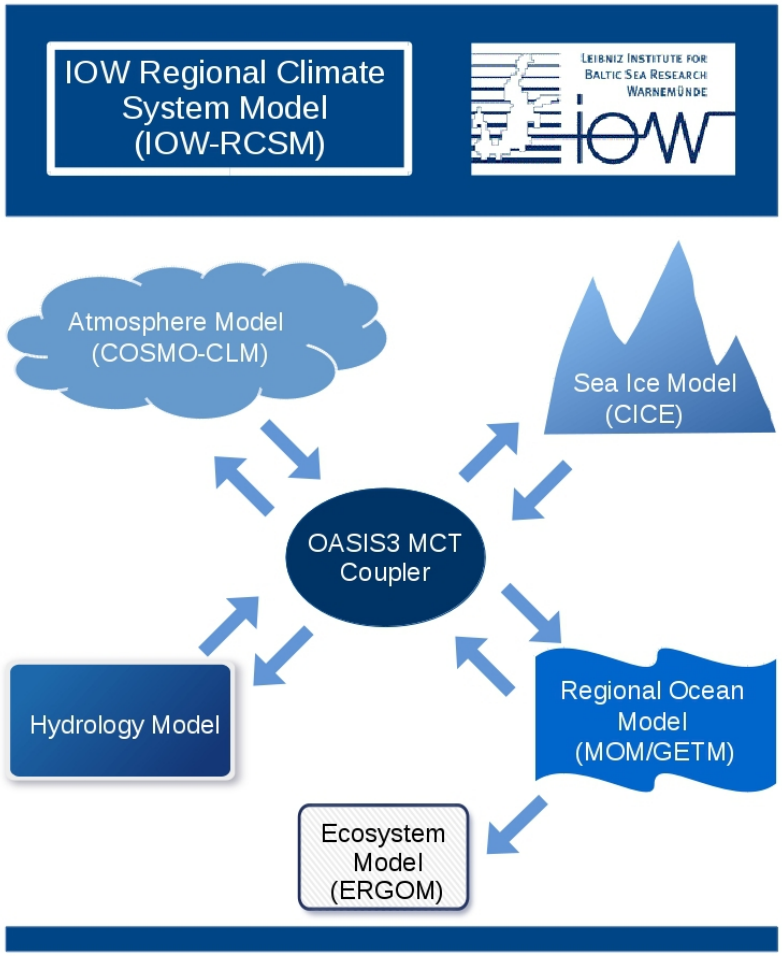
Introduction

- regional climate models are needed
  - to understand how a changing climate has impacted the marine ecosystem in the past
  - to predict the consequences of future climate change
  - to resolve local air-sea interactions incl. feedback
- different regional climate model are developed, e. g. *Döscher et al. (2002), Gröger et al. (2014), Ho-Hagemann et al. (2013), Will et al. (2017)*, and others
- Baltic Sea accommodates a complex marine ecosystem
- hypoxic areas exist in current climate in the Baltic Sea
- reliable long term observations are limited

IOW Regional Climate System Model

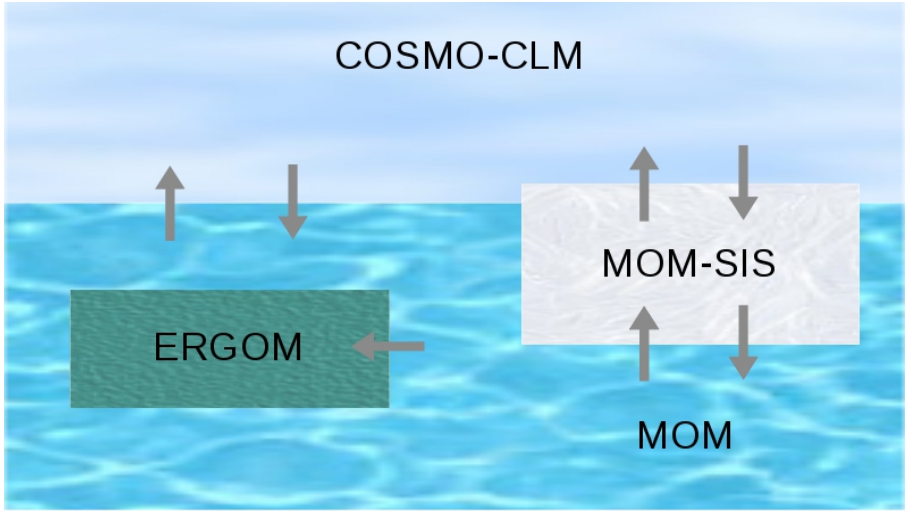
- IOW-Regional Climate System Model (IOW-RCSM)
- components: atmosphere, ocean, sea-ice, hydrology, bio-geochemistry
- coupler: OASIS3-MCT

- model development, simulations and validation are performed with resources provided by the North-German Supercomputing Alliance (HLRN)



Status of the coupling work

- model components
  - Atmosphere: COSMO-CLM *(Rockel et al., 2008)*
  - Ocean: MOM-5 *(Griffies, 2012)*



- communication between atmosphere and ocean (2 executables) through sea-ice model
- coupler: OASIS3-MCT *(Valcke et al., 2015)*
- incorporation of a sea-ice and bio-geochemical model via an internal coupler in MOM-5 (1 executable)

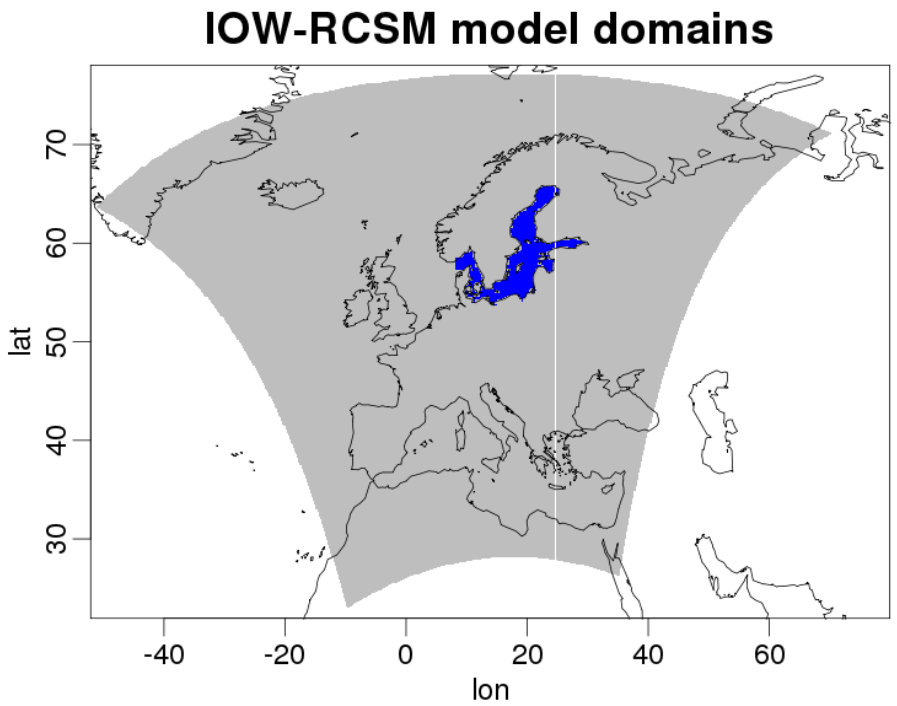
MOM-5

- as ocean component for IOW-RCSM: MOM-5 *(Griffies, 2012)*
- thermodynamic/dynamic sea-ice model SIS *(Winton, 2000)*
- bio-geochemical model ERGOM *(Neumann (2009); Neumann et al. (2017))*
- river runoff: HELCOM assessments *(www.helcom.fi)*
- resolution: 8nm
  (~14.8km)
- 100 vertical z-levels
- domain: Baltic Sea
  (including Skagerrak)
- time step: 1200s

COSMO-CLM

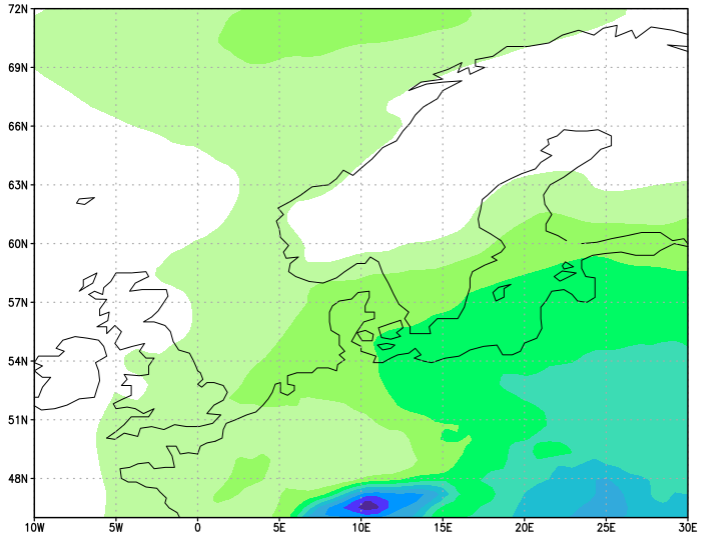
- atmospheric component for IOW-RCSM: COSMO-CLM 5.0 *(Rockel et al., 2008)*
- resolution: 0.22°(~25km)
- domain: EURO-CORDEX
- sponge zone of 10 grid points at the lateral boundaries

- 40 vertical levels
- time step: 150s
- initial setup forced by ERA-Interim reanalysis *(Dee et al., 2011)* data at lateral boundaries

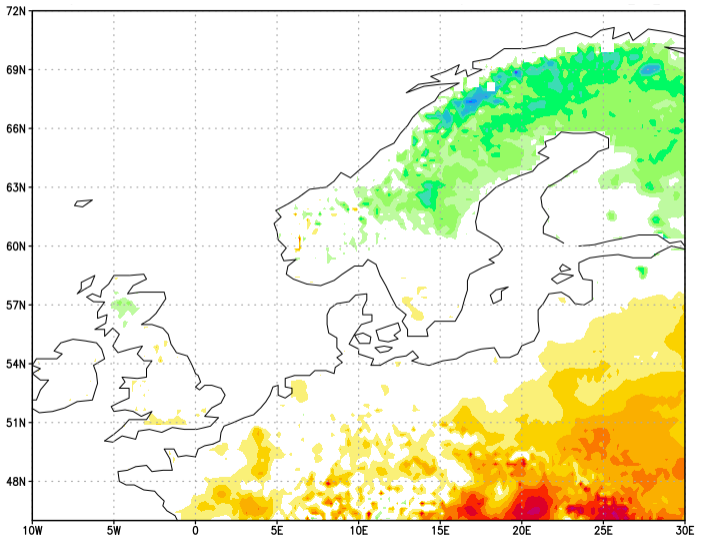


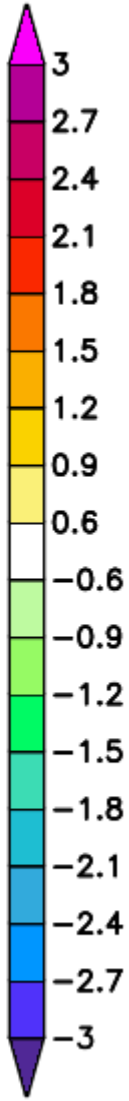
COSMO-CLM

1980-1989 JJA mean SLP bias [hPa]

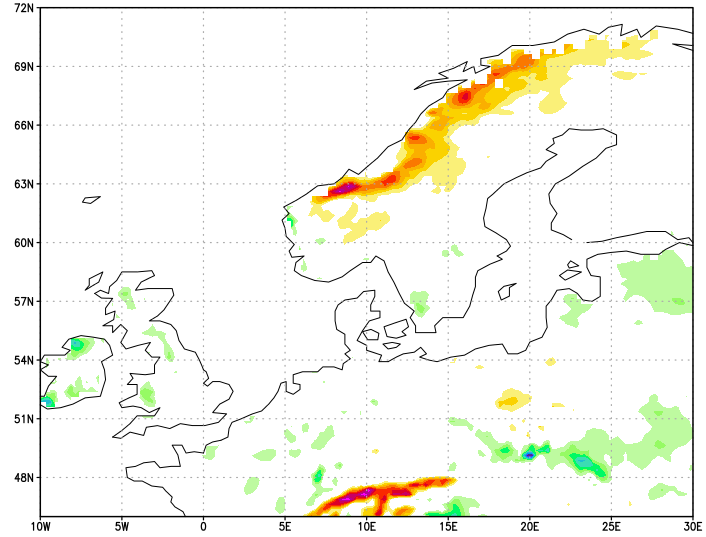


1980-1989 JJA mean temperature bias [K]





1980-1989 JJA mean precipitation bias [mm/day]



- sea level pressure (SLP) bias w.r.t. ERA-Interim
- 2m temperature and precipitation biases w.r.t. E-OBS *(Haylock et al., 2008)*

ERGOM (https://ergom.net)

- ERGOM: bio-geochemical model, developed at Leibniz Institute for Baltic Sea Research Warnemünde, by T. Neumann and W. Fennel
- simulates the bio-geochemical processes in the Baltic Sea, including three phytoplankton groups and a dynamically developing zooplankton variable *(Neumann, 2009)*
- considers the nitrogen and phosphorus cycle
- incorporates processes related to hypoxia and anoxia, i.e. to the bio-geochemical oxygen and sulfur development *(Neumann et al., 2017)*

OASIS3-MCT

- OASIS3-MCT *(Valcke et al., 2015)* provides the coupling (two-way online) and interpolation methods

- exchanged mean variables (bi-cubic interpolation):
  - ocean to atmosphere: sea surface temperature and sea-ice area fraction
  - atmosphere to ocean: freshwater and heat fluxes, sea level pressure, velocities

- interface to coupler:
  - atmosphere component: existing *(Brauch et al., pers. comm.)*
  - ocean component: implemented

- coupling frequency: 1 hour

Summary

- the IOW-RCSM is under development using OASIS3-MCT as coupler

- first version uses COSMO-CLM as atmospheric component and MOM-5 as ocean component, which includes a sea-ice (SIS) and the bio-geochemical model (ERGOM)

- current status of the development:
  - OASIS3-MCT interface within COSMO-CLM has been adapted for coupling to MOM-5
  - OASIS3-MCT interface within MOM-5 has been implemented
  - currently the implementation of the coupled run is tested

Outlook

- validation of the IOW-RCSM results using observations and other models
- long-term paleo-simulations to study e. g. the variability of Major Baltic Inflows and its relation to large-scale atmospheric circulation
- future scenario simulations to study the impact of global climate change on the Baltic Sea ecosystem
- contribute to the coordinated experiments in the Baltic Earth framework