

First results of model sensitivity studies on the influence of global changes on North and Baltic Seas

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Overview

Abstract

ProWaS project /
DAS service

model setup

sensitivity studies

atmospheric forcing
study

sea level study

outlook

Abstract

This contribution is part of the [ProWAS project](#), which provides a regional [model setup](#) for the North and Baltic Seas. To figure out technical issues and to validate the model setups, 20-year hindcast simulations forced with a regional reanalysis (COSMO-REA6 (Bollmeyer et al., 2015)) were carried out. The simulation is used as basis for [sensitivity studies](#) with reference to global change scenarios. To evaluate the effect of global changes on the coastal regions especially in the North and Baltic Seas, model studies regarding global sea level rise, sea water and air temperature increase, salinity decrease, river runoff increase and the influence of atmospheric forcing have been performed. Therefore, boundary conditions of a hindcast simulation are adapted to different change conditions and sensitivity studies for different periods have been carried out. First results of the investigations on model sensitivity studies regarding global [sea level rise](#) and the influence of [atmospheric forcing](#) are presented. These results will be used as a basis for further development of climate projection models.

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Introduction

ProWAS-Project:

- „**P**rojection Service for **W**aterways and **S**hipping“
- pilot study as part of the „German Strategy for Adaption to Climate Change“ (DAS)
- participation of four German Federal Agencies
- main goal: establishment of a forecasting and projection service for climate, extreme weather and coastal & inland waterbodies in Germany
- target area: North Sea and Baltic Sea with focus on the German coastal region and its estuaries



BSH main tasks:

- further development of the ocean component for the operational coupled climate model ROAM
- case studies and scenario runs
- impact of climate change on German coastal regions
- development of service products

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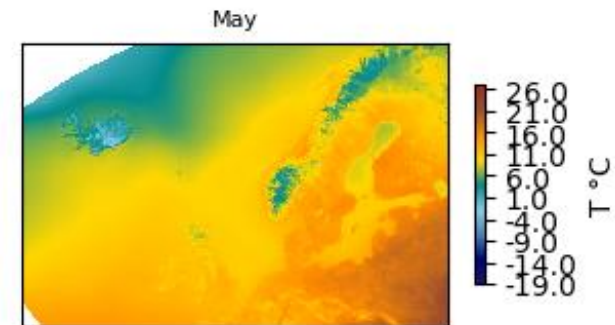
Model setup

HIROMB-BOOS model (HBM) forcing and boundary conditions

| | HIROMB-BOOS model (HBM) |
|---------------------|-----------------------------------|
| atmospheric forcing | COSMO-REA6 |
| river runoff | climatology |
| tides | based on observations |
| boundary conditions | 15 min (SSH) climatology (T,S) |
| model run | 06/1996-12/2015 |
| nesting | ✓ |
| wetting and drying | ✓ |

reference for sensitivity studies:

- hincast run with HBM
- 1996 - 2015

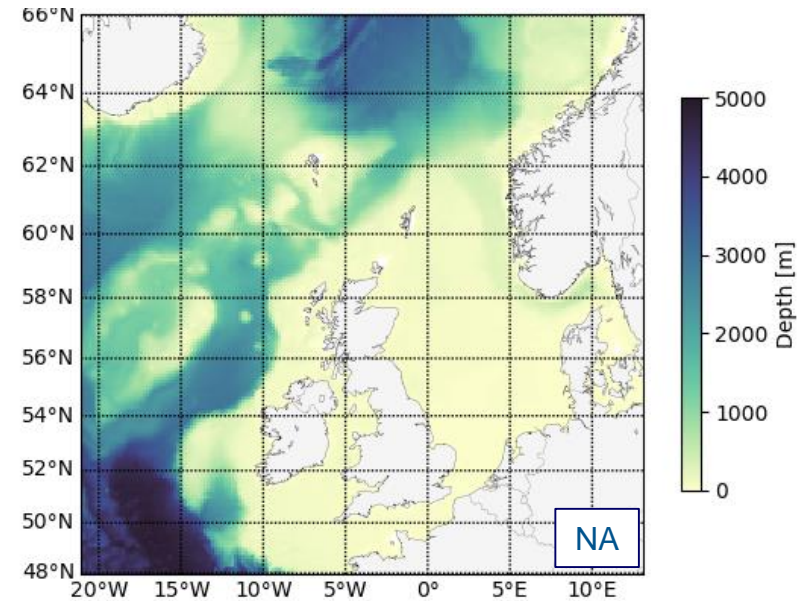
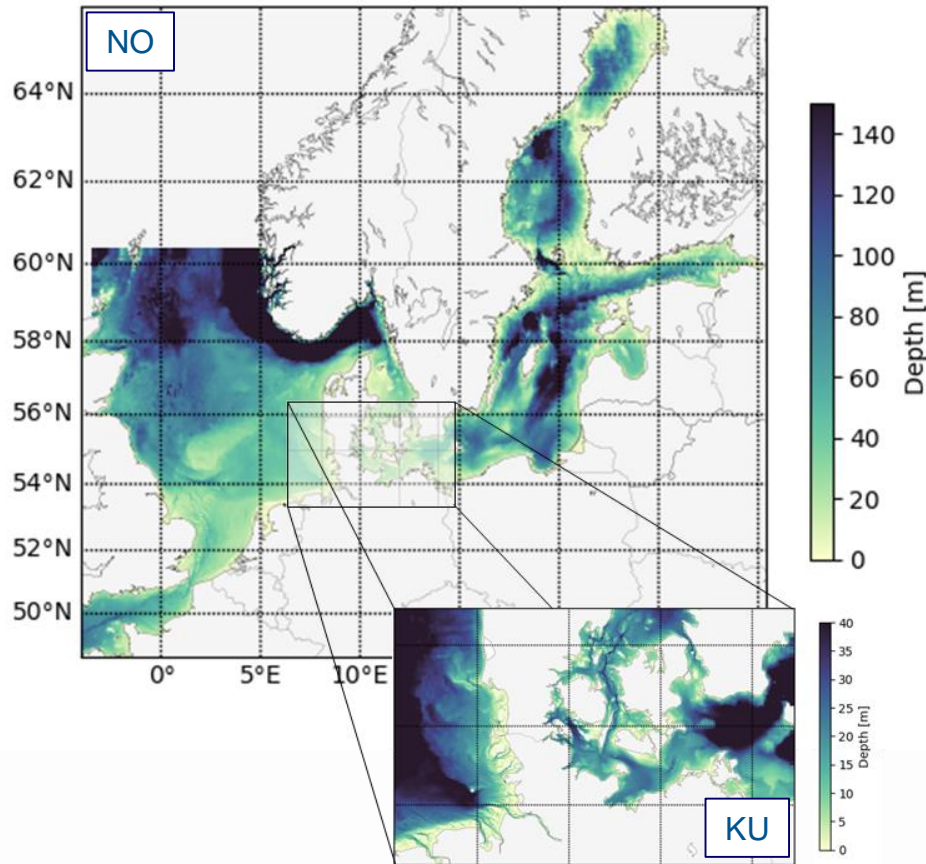


COSMO-REA6 2m air temperature
May 2013

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Model setup

HIROMB-BOOS model (HBM) bathymetry



| model | dimen- sions | horizontal resolution | number layer |
|-------|-----------------|--------------------------|-----------------|
| NA | 2 | 5sm | - |
| NO | 3 | 3sm | 36 |
| KU | 3 | 0.5sm | 25 |

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Introduction sensitivity studies

assumption: global changes of parameteres influence regional model setups through boundary conditions

study goal: learn about the sensitivity of our regional model setup to global changes

approach: change of boundary parameters from the reference model setup (hindcast run)

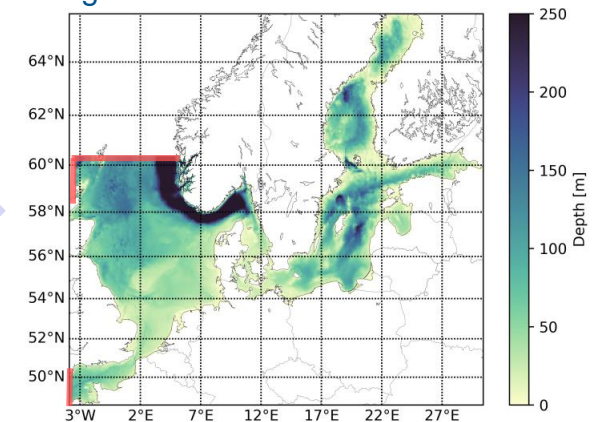


parameter
example

| |
|-----------------------|
| sea level |
| atmospheric forcing |
| salinity |
| sea water temperature |
| 2m air temperature |
| river runoff |

adapt
boundary
conditions

regional model



Summary sensitivity studies

| parameter | change | model setup | year |
|---|--------------------|-------------|-------------------|
| sea level | +1m / +1.74m | HBM | 12/2012 – 12/2013 |
| atmospheric forcing | UERRA- HARMONIE | HBM | 12/2012 – 12/2013 |
| salinity | -1psu | HBM* | 12/2012 – 12/2013 |
| sea water temperature | +2°C | HBM* | 12/2012 – 12/2013 |
| 2m air temperature | +2°C | HBM* | 12/2012 – 12/2013 |
| sea water temperature & 2m air temperature | +2°C | HBM* | 12/2012 – 12/2013 |
| river runoff | +10% | HBM | 12/2012 – 12/2013 |

*HBM sponge layer disabled

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Sensitivity studies: sea level

Sensitivity study approach

- sea level at the open boundary is increased by 1m and 1.74m
- examples of results are shown for North Sea (Cuxhaven) and Baltic Sea (Travemünde)
- to make the sensitivity study results comparable to the hindcast simulation the amount of increased sea level at the regional model boundary is subtracted

First results

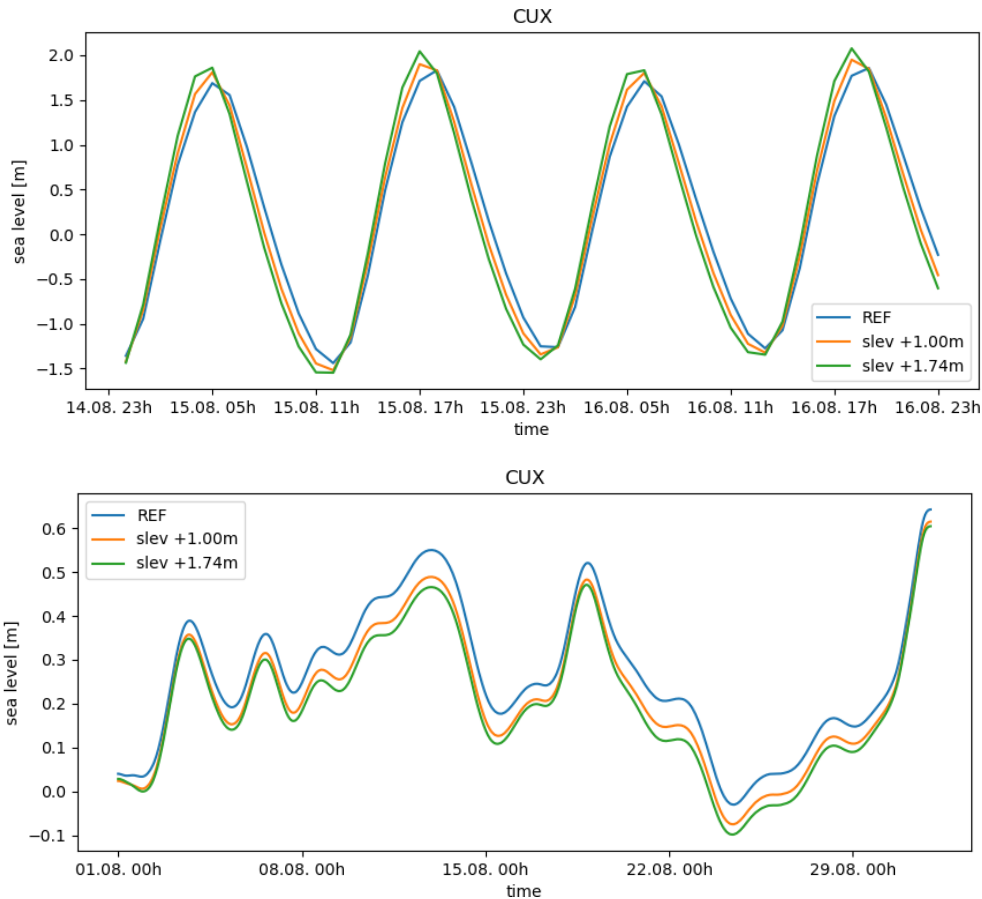
- time series of total and detided signals for North Sea (station [Cuxhaven](#)) and Baltic Sea (station [Travemünde](#))
- scatter plots of total signal and detided signal for North Sea (station [Cuxhaven](#)) and Baltic Sea (station [Travemünde](#))

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study summary](#)

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Sensitivity studies: sea level

North Sea: station Cuxhaven



- sea level at station Cuxhaven at 15th/16th August 2013
- sensitivity study results are corrected for the amount of global sea level rise
- amplitude increases with increased global sea level
- phase shift increases with increased global sea level
- the increased amplitude is observed for the whole time period of the sensitivity study (see [scatter plots](#))

- detided sea level at station Cuxhaven at 15th/16th August 2013
- sensitivity study results are corrected for the amount of global sea level rise
- the higher the global sea level rise, the lower the resulting regional sea level rise
- this is observed for the whole time period of the sensitivity study (see [scatter plots](#))

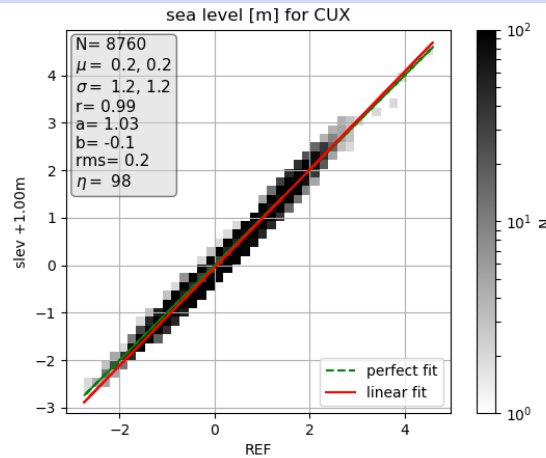
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Sensitivity studies: sea level

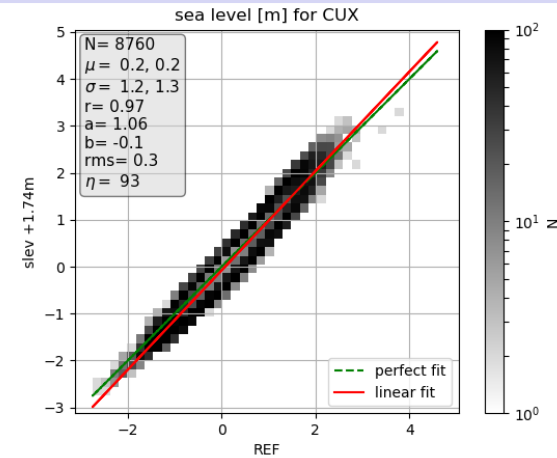
North Sea: station Cuxhaven

sea level

study +1.00m

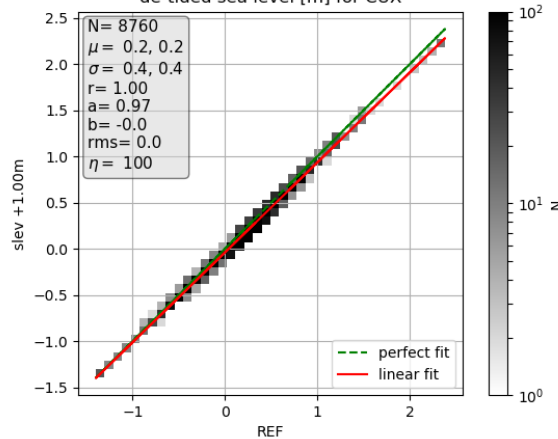


study +1.74m

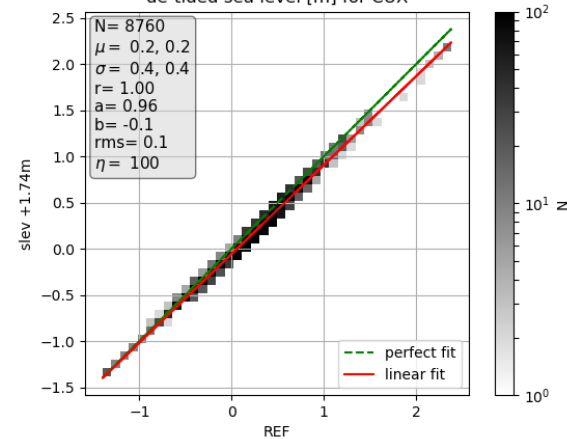


detided sea level

de-tided sea level [m] for CUX

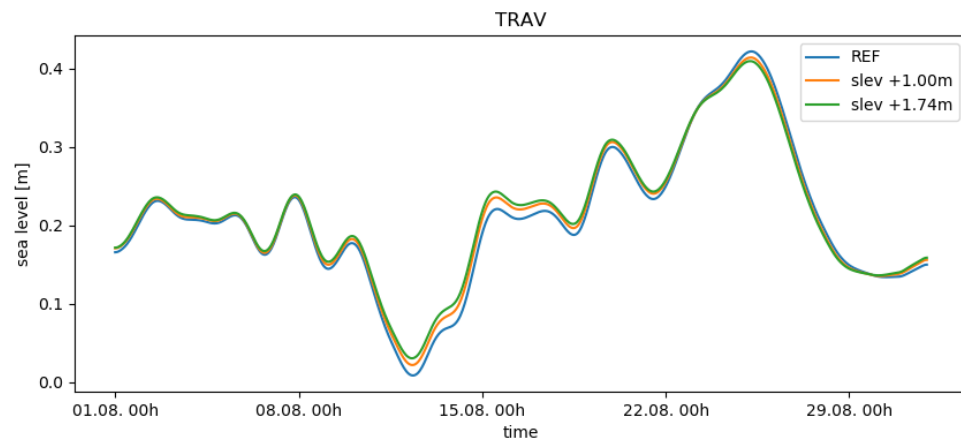
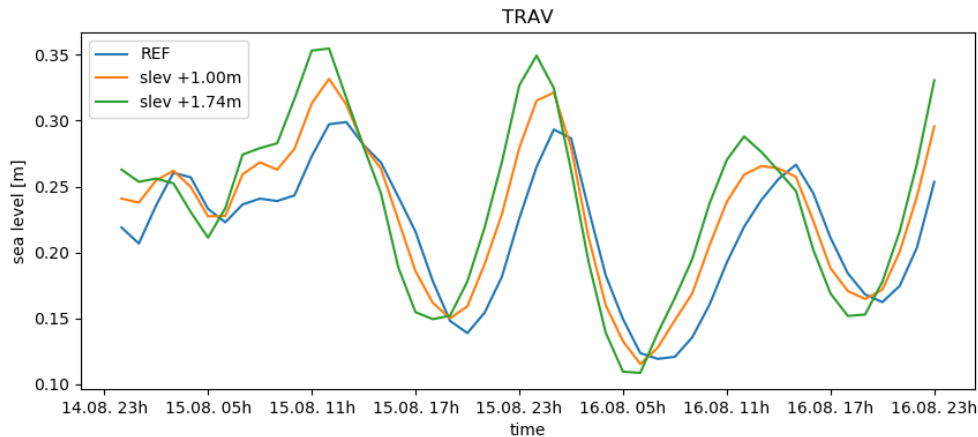


de-tided sea level [m] for CUX



Sensitivity studies: sea level

Baltic Sea: station Travemünde



- sea level at station Travemünde at 15th/16th August 2013
- sensitivity study results are corrected for the amount of global sea level rise
- amplitude increases with increased global sea level
- phase shift increases with increased global sea level
- due to the higher phase shift the increased amplitude cannot be observed in [scatter plots](#) for the whole time period of the sensitivity study

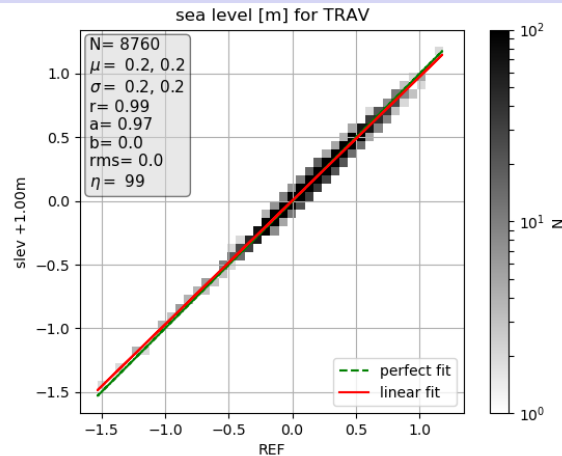
- detided sea level at station Travemünde at 15th/16th August 2013
- sensitivity study results are corrected for the amount of global sea level rise
- the higher the global sea level rise, the lower the resulting regional sea level rise for maximum values
- for minimum values the resulting regional sea level is increased
- this is also observed for the whole time period of the sensitivity study (see [scatter plots](#))

Sensitivity studies: sea level

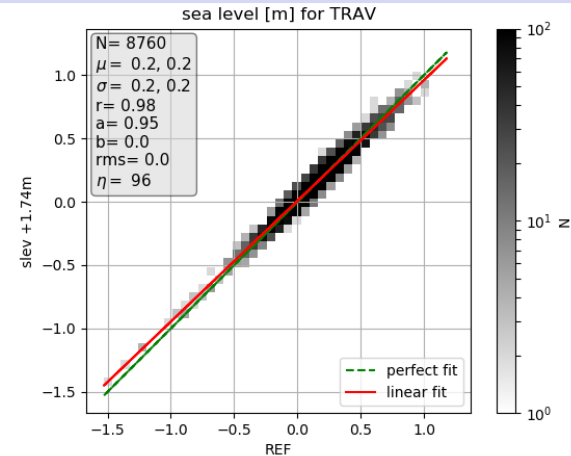
Baltic Sea: station Travemünde

sea level

study +1.00m

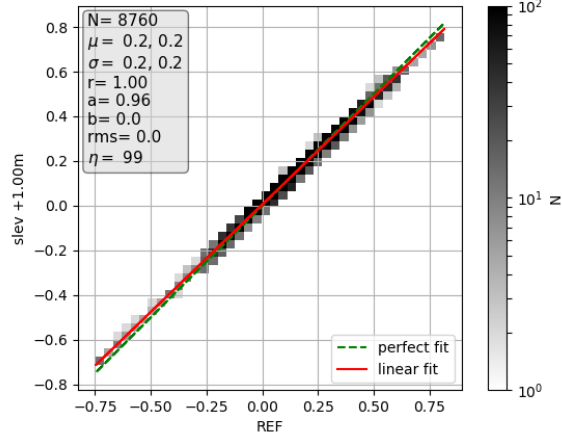


study +1.74m

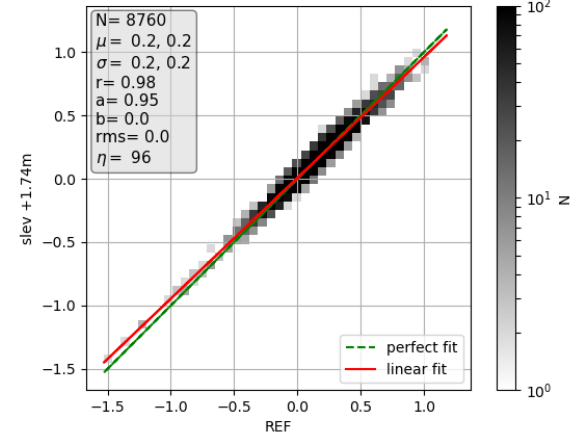


detided
sea level

de-tided sea level [m] for TRAV



sea level [m] for TRAV



Sensitivity studies: atmospheric forcing

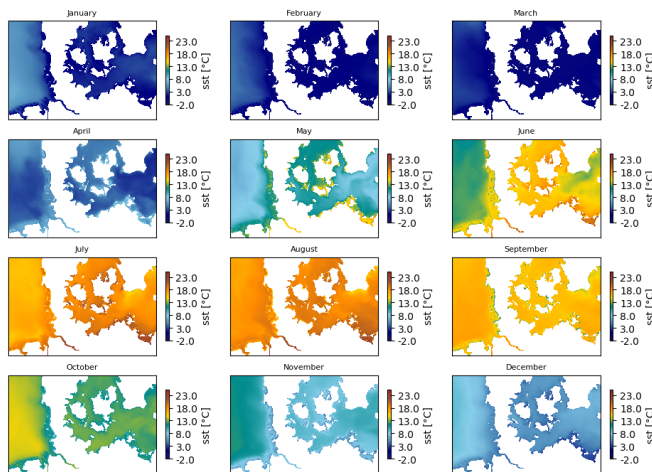
Sensitivity study approach

- COSMO-REA6 reanalysis data from hindcast run is replaced by UERRA-HARMONIE reanalysis data

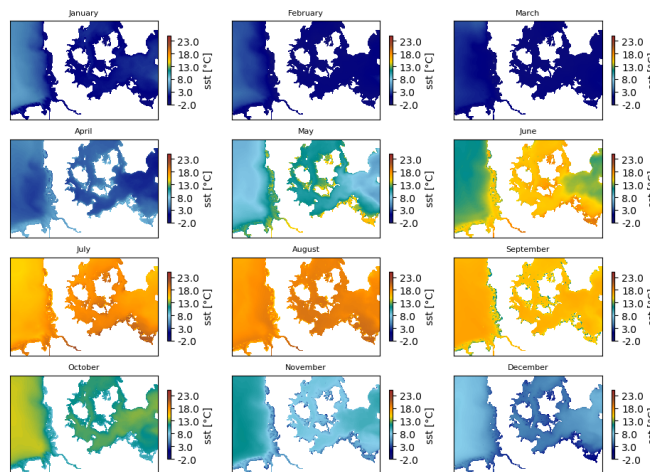
First results

- [comparison of reanalysis data](#) for 2013
- [sea level](#) for 2013
- [sea surface temperature](#) for 2013

monthly mean sst COSMO-REA6 2013



monthly mean sst UERRA-HARMONIE 2013



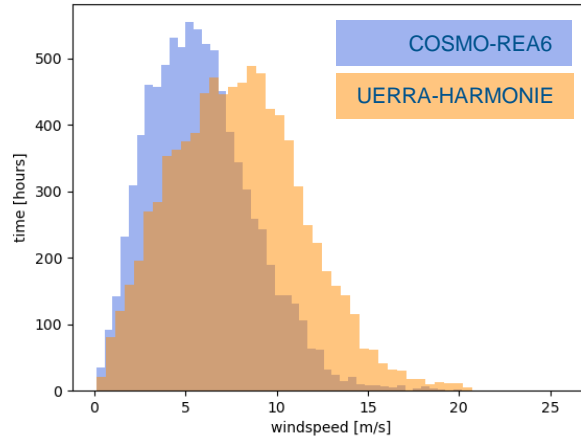
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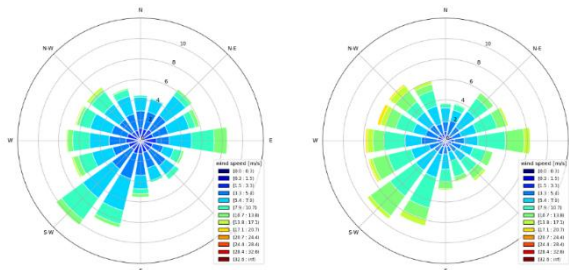
Sensitivity studies: atmospheric forcing

station Cuxhaven 2013

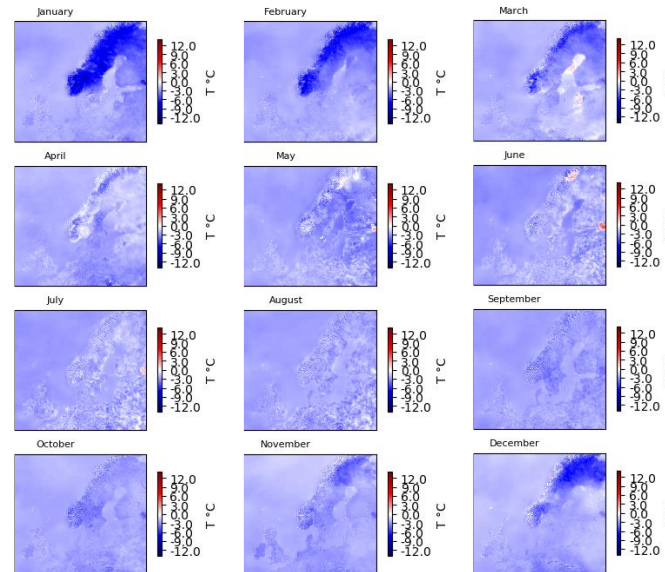
wind speed distribution



wind direction distribution [%]



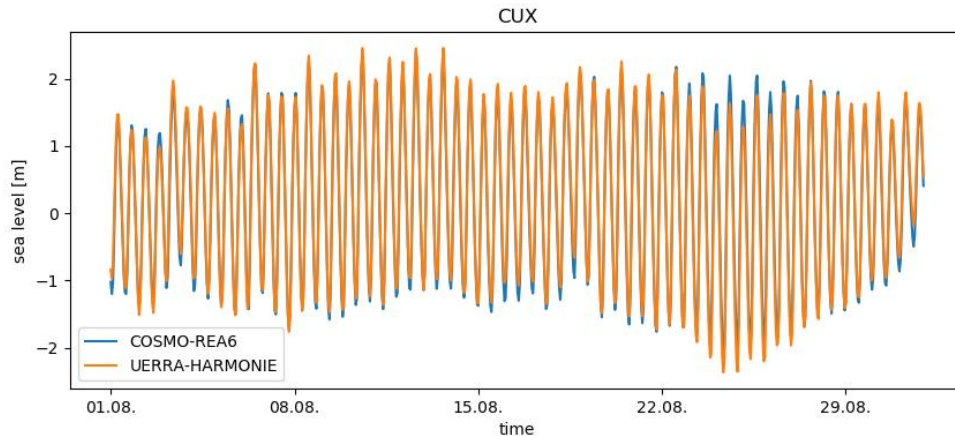
monthly mean temperature difference 2013
UERRA-HARMONIE – COSMO-REA6



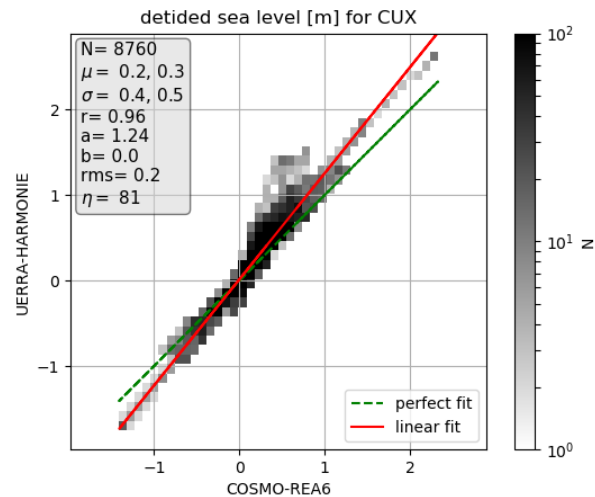
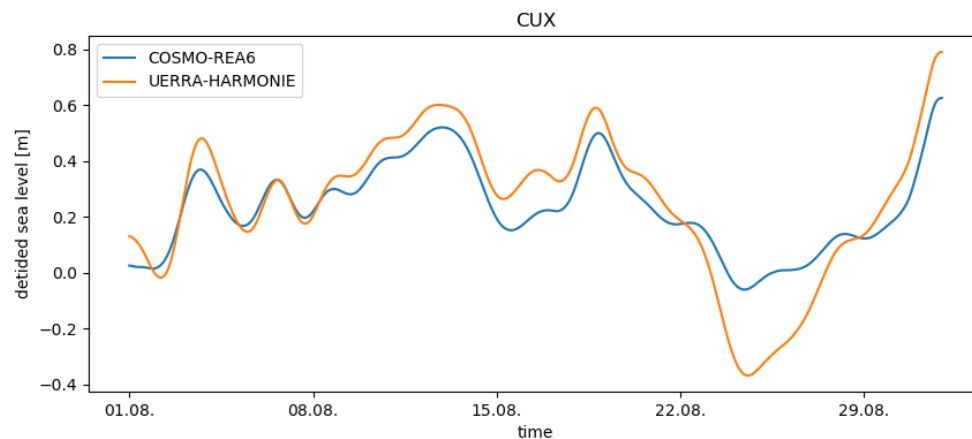
- UERRA-HARMONIE shows higher wind speeds with slightly more westerly wind directions in 2013
- UERRA-HARMONIE provides lower air temperatures for 2013

Sensitivity studies: atmospheric forcing

Sea level North Sea: station Cuxhaven

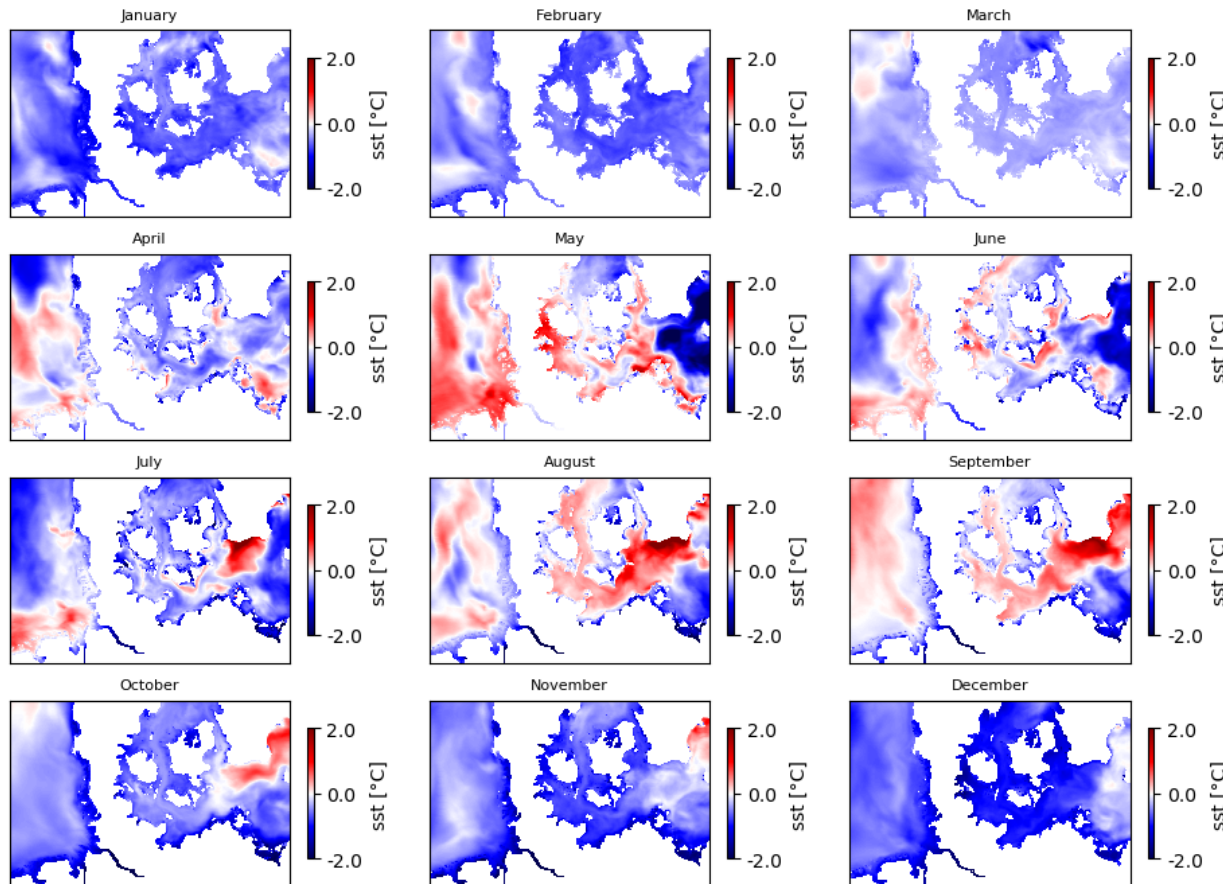


- sea level at station Cuxhaven in August 2013
- tidal signal is shifted due to differences in wind speed and wind direction
- due to the higher wind speeds in the UERRA-HARMONIE reanalysis the wind surge is amplified as displayed in the detided sea level time series and scatter plot



Sensitivity studies: atmospheric forcing

difference of monthly mean sea surface temperature 2013: UERRA-HARMONIE – COSMO-REA6



- from December until March UERRA-HARMONIE sea surface temperature is lower according to the lower air temperature
- although UERRA-HARMONIE results in lower air temperature for the whole year, the sea surface temperature is higher for some areas especially for April until September

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Conclusions & Outlook

Conclusions:

- sensitivity studies are an efficient approach to learn about model response
- the impact of changed parameters and boundary conditions in a reference model for sensitivity is noticeable

Outlook:

- sensitivity studies will facilitate the interpretation of climate projection simulations
- further studies concerning model response to boundary conditions and initial fields are planned

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Thank you!



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