

Improvement of state estimates and numerical model predictions of the German Bight through the assimilation of Ferrybox Data

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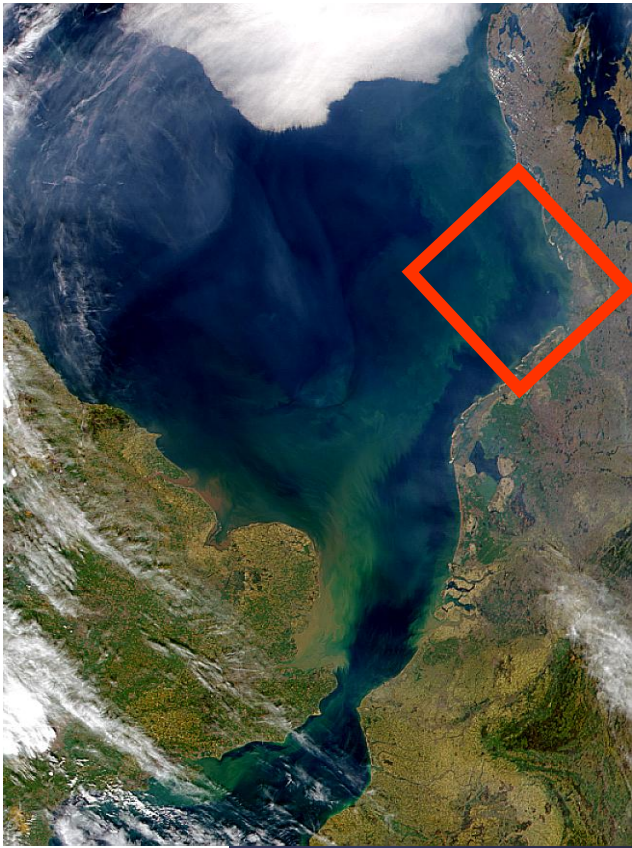
University of Oldenburg, Oldenburg, Germany

JONSMOD 10-12.05.2010, Delft

OUTLINE

- Nested-grid model set-up
- Model-data comparisons
- Evolution of the thermohaline stratification during extreme events (the storm “Britta“ on 01.November.2006)
- Assimilation of FerryBox Data
- Project and conclusions

North Sea German Bight Wadden Sea



Nested modelling system

Atmospheric forcing (6-hr ECMWF data analyses),

river run-off – hourly data

Open BC – tides, T and S

North Sea-Baltic Sea

$\Delta\lambda = \Delta\phi = 3$ nm, Time step = 30 s

2 open boundaries (S and N)

German Bight

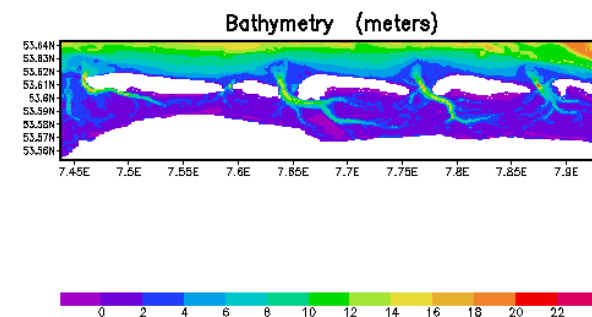
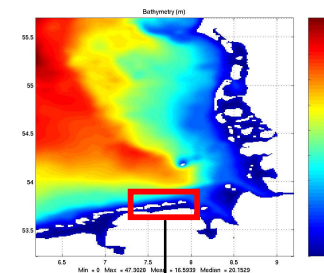
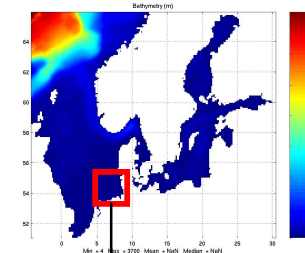
$\Delta\lambda = \Delta\phi = \sim 1$ km, Time step = 10 s

2 open boundaries (W and N)

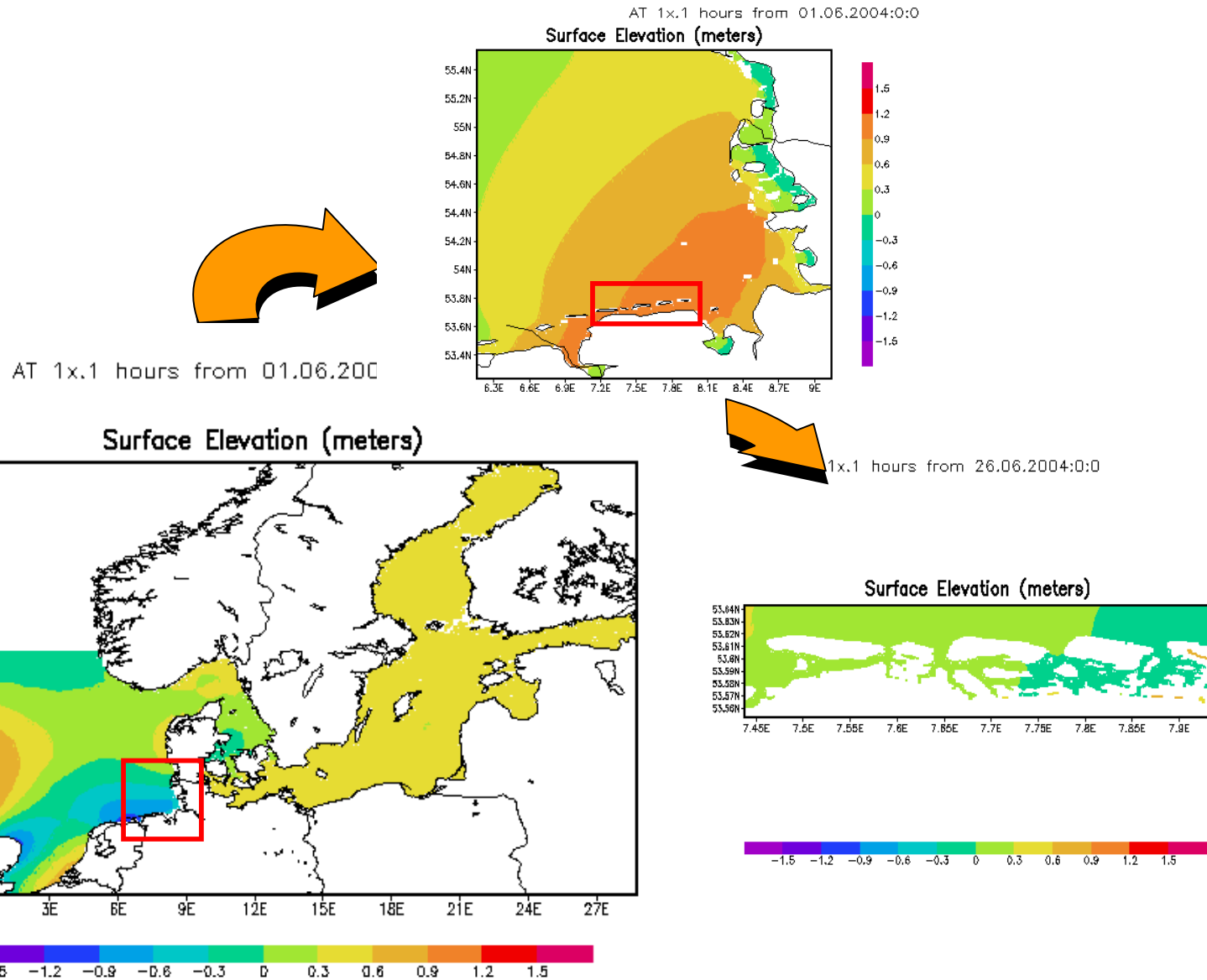
Wadden Sea

$\Delta\lambda = \Delta\phi = 200$ m, Time step = 3 s

3 open boundaries (W, N and E)



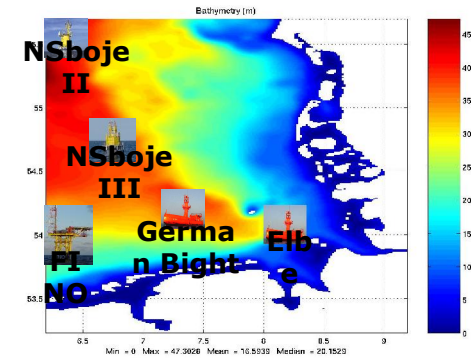
Nested models – Sea level



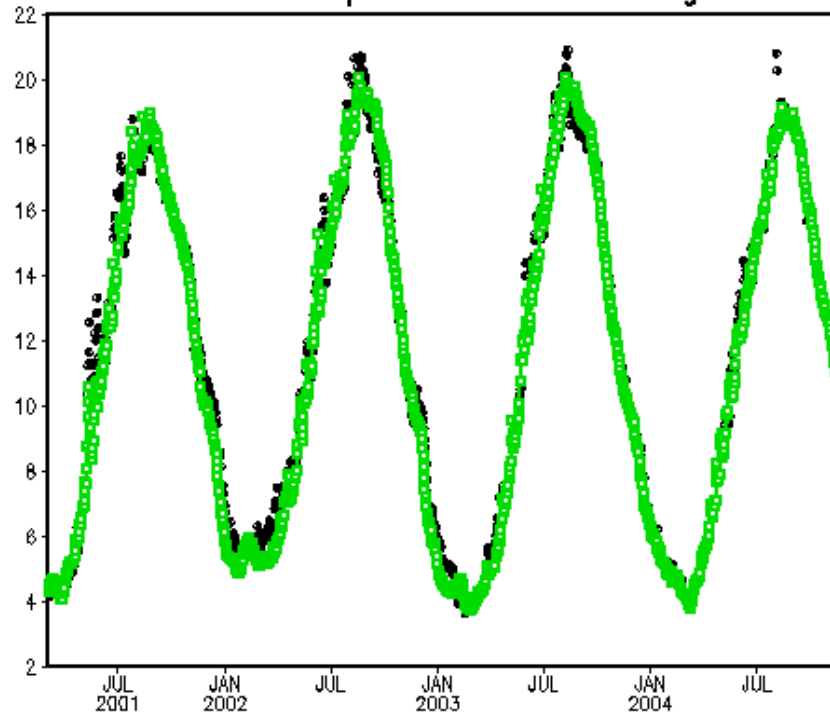
SST MARNET vs. GETM



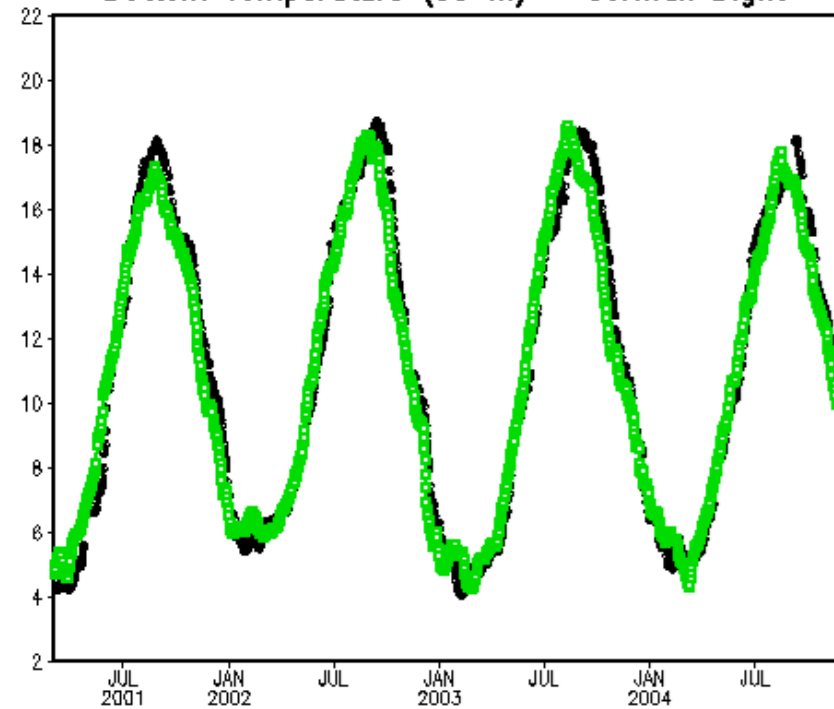
German Bight



Surface Temperature – German Bight



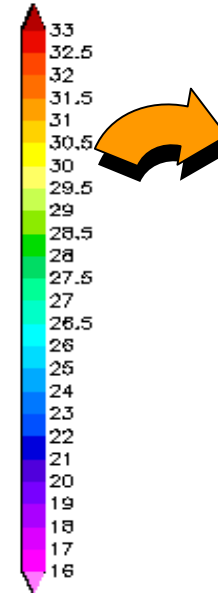
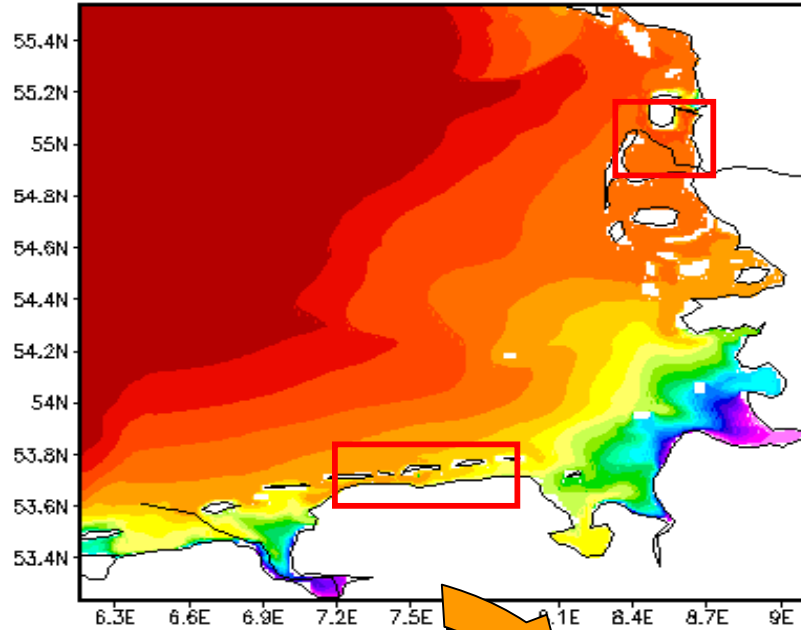
Bottom Temperature (30 m) – German Bight



Nested models – Surface salinity

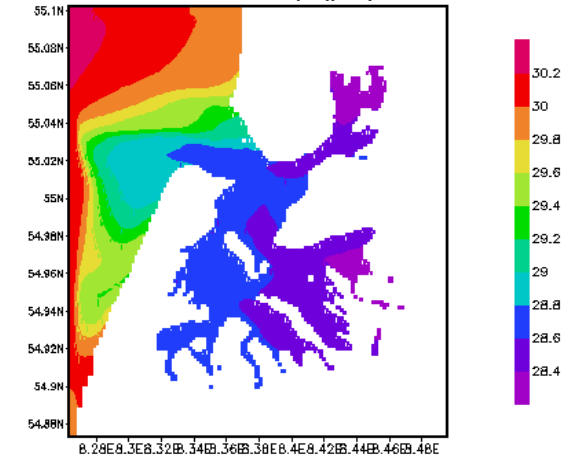
AT 140x.1 hr from 01.03.2005:0:0

Sea Surface Salinity (psu)

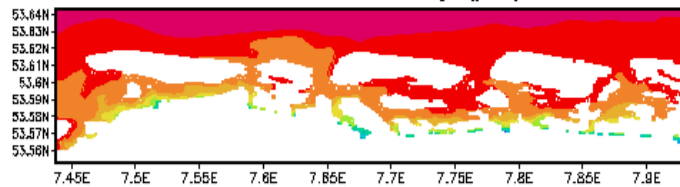


AT 49x.1/2 hours from 26.04.2004:0:0

Surface Salinity (psu)



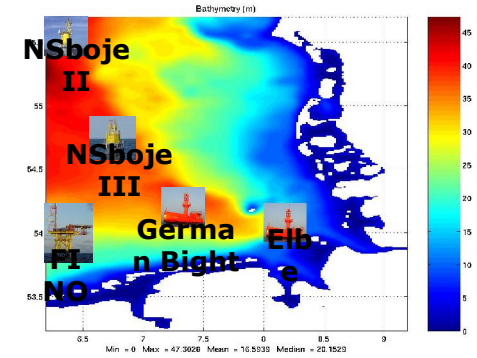
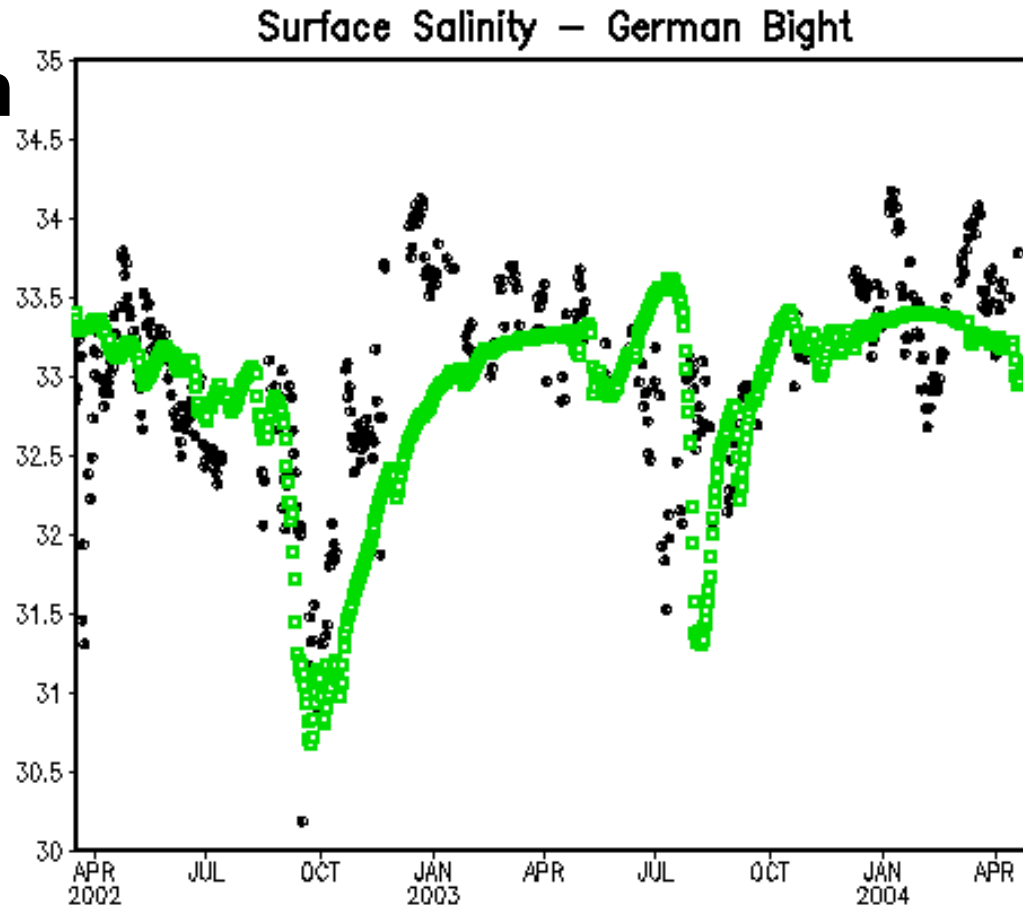
Sea Surface Salinity (psu)



MARNET vs. GETM

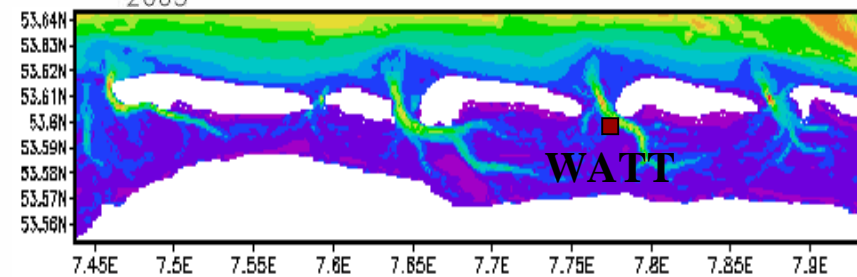
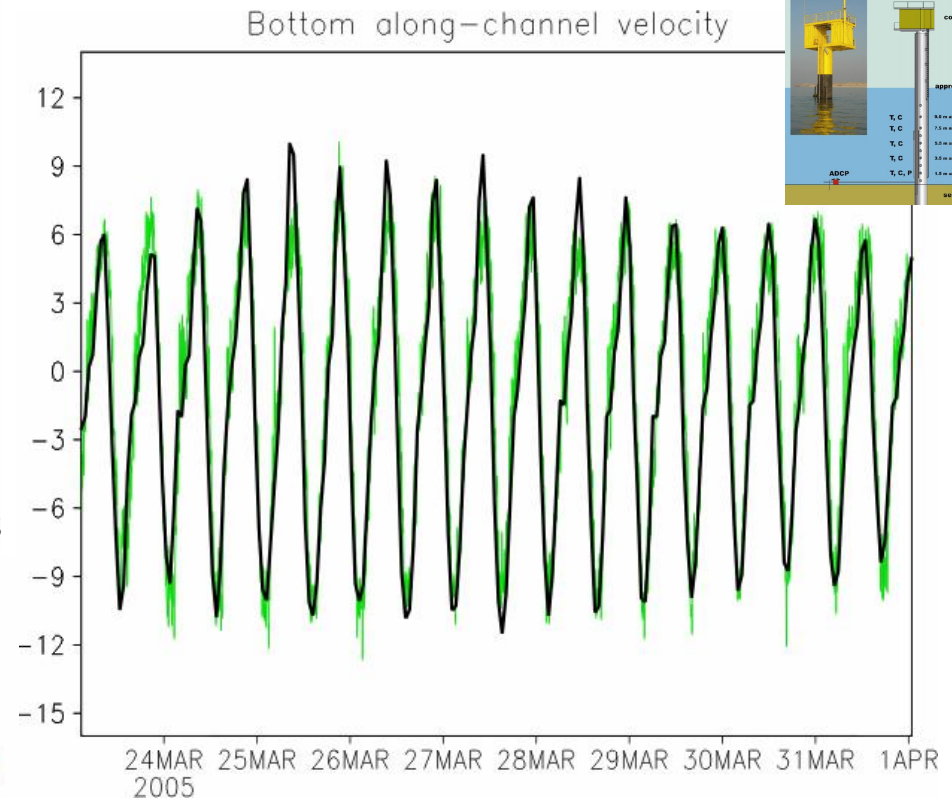
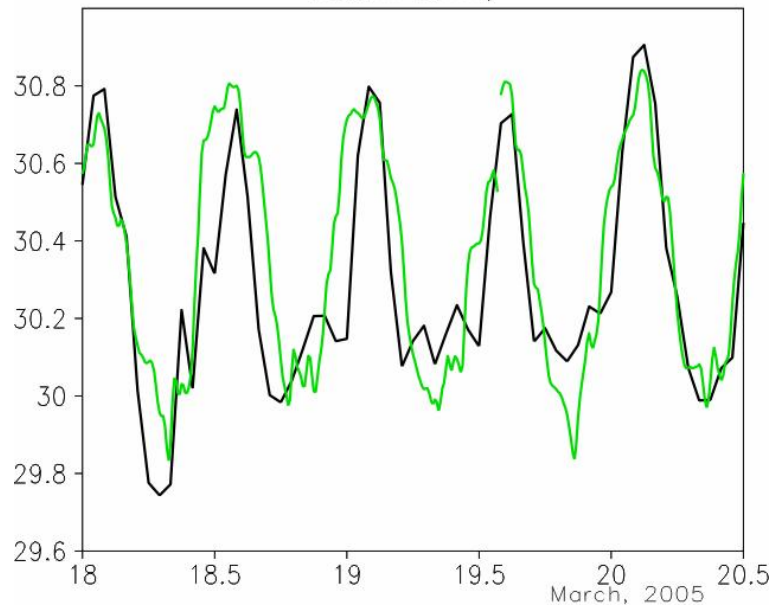
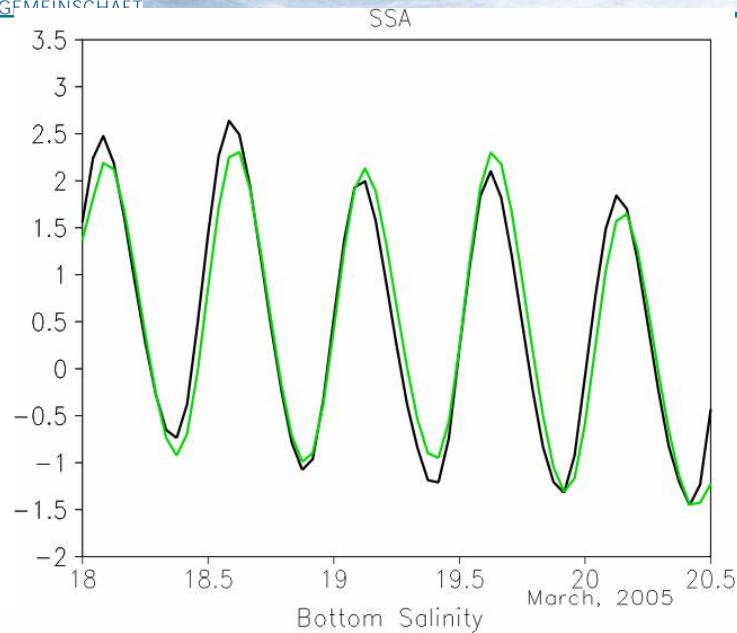


**German
Bight**



Staneva et al. (2008)

Model vs „WATT“ Data

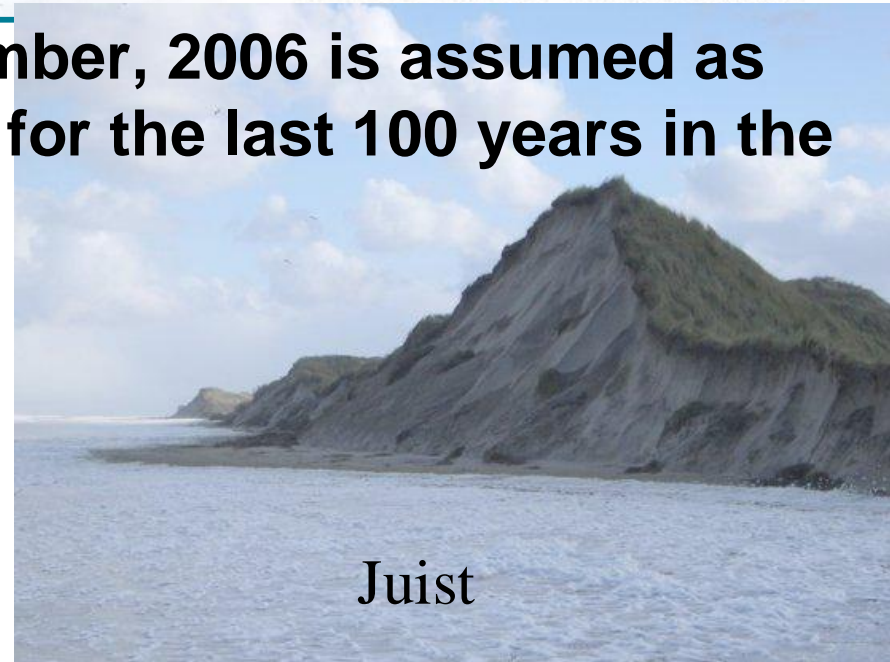


Staneva et al. (CSR, 2009)

The storm „Britta“ on 1. November, 2006 is assumed as one of the worst storm events for the last 100 years in the lower Saxony, German coast



Spikeroog



Juist



Wilhemshaven



Carolinesiel

... Britta at 01.11.2006

In Carolinensiel one caravan is swimming



... or a ship is parked in a car parking place...

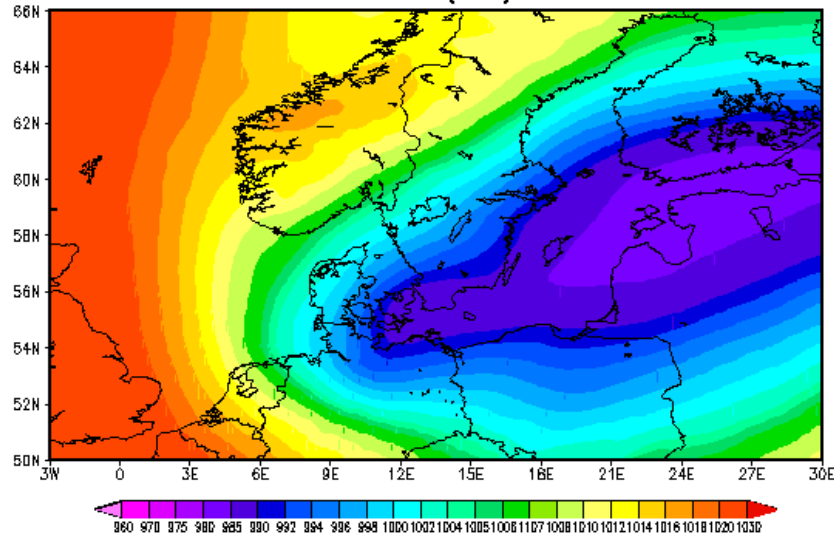


This sign must be respected!

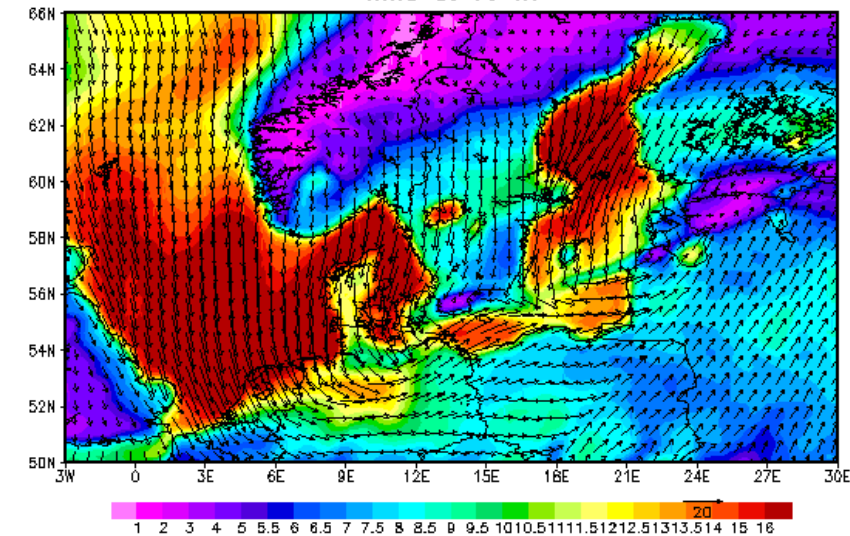
(Hurrikane Brita: 01.11.2006)

AT 1.11.2006:6:0

Mean Sea Level (MSL) Pressure

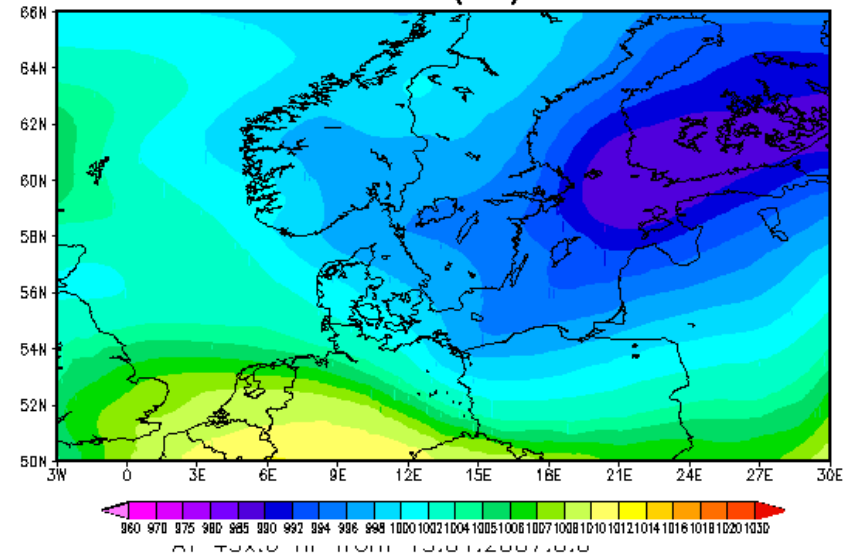


Wind at 10 m

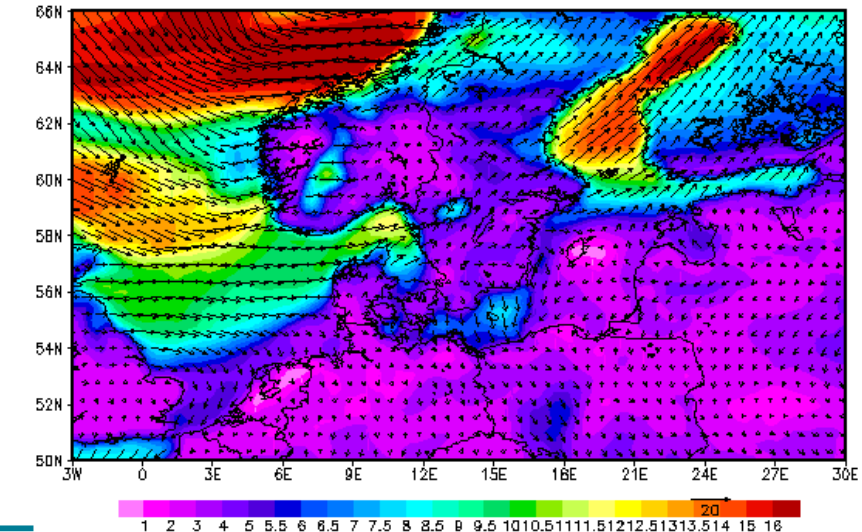


AT 05.11.2006:0:0

Mean Sea Level (MSL) Pressure



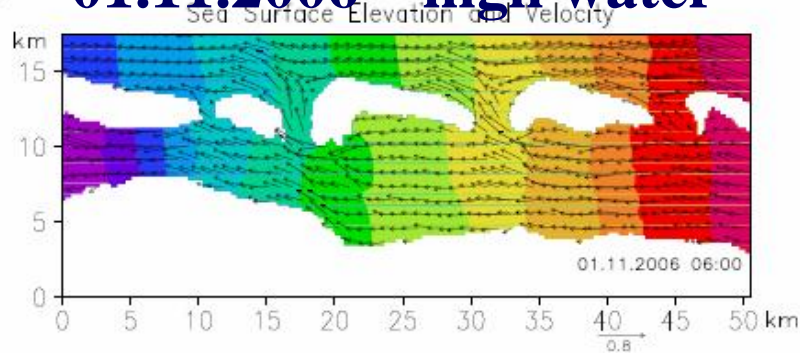
Wind at 10 m



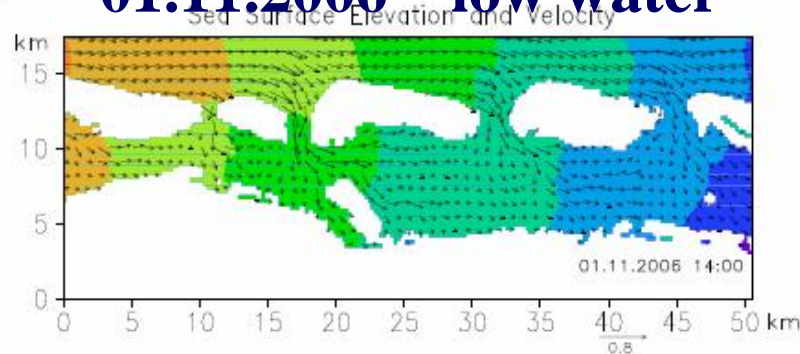
Simulated velocities during ebb and flood (Wadden Sea, GETM).

in der

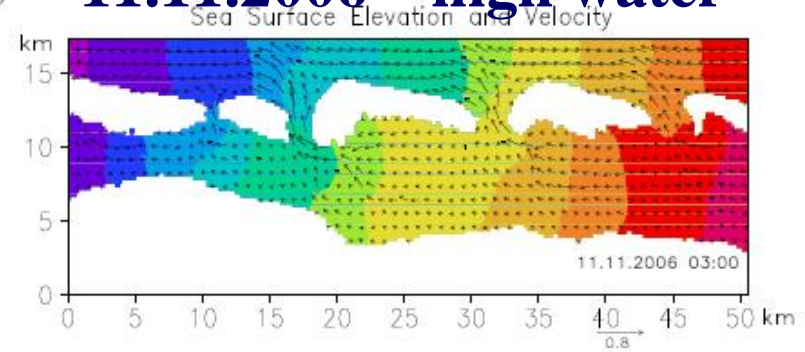
a) **01.11.2006 high water**



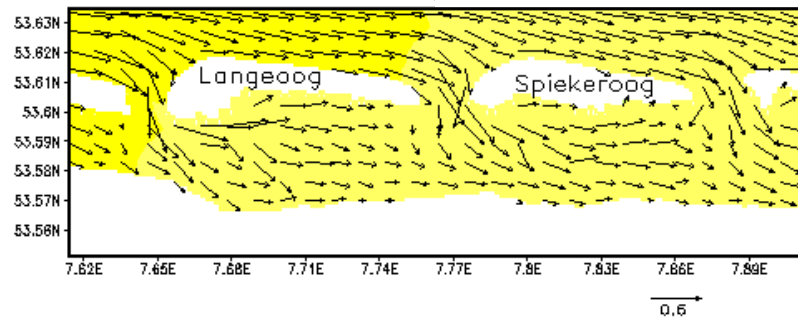
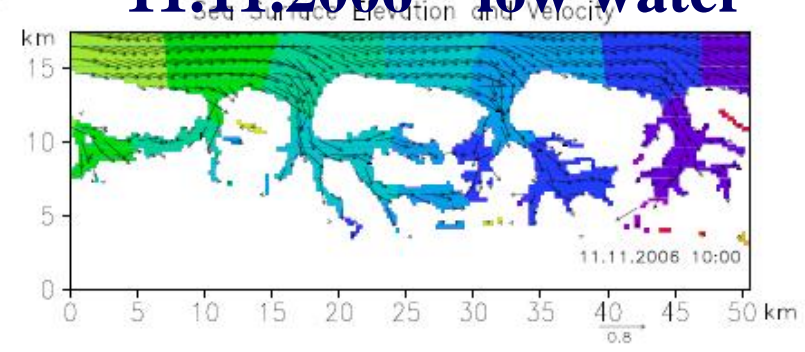
b) **01.11.2006 low water**



c) **11.11.2006 high water**

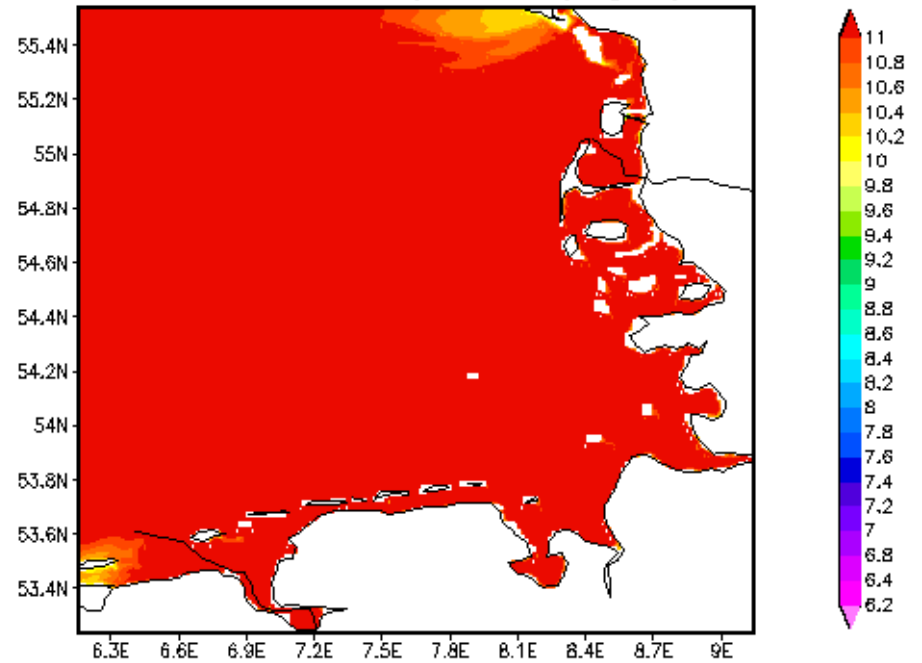


d) **11.11.2006 low water**

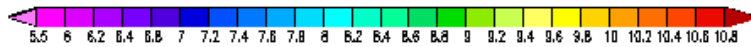
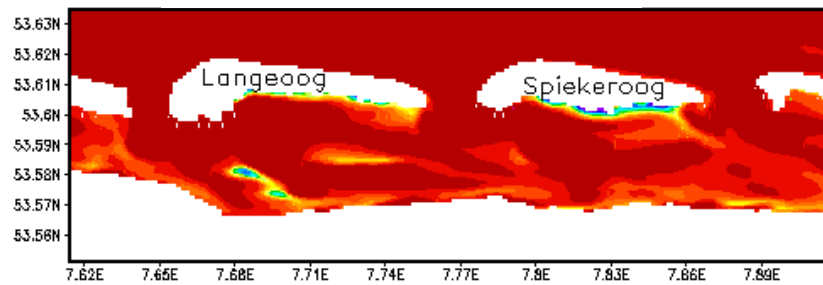


Surface temperature

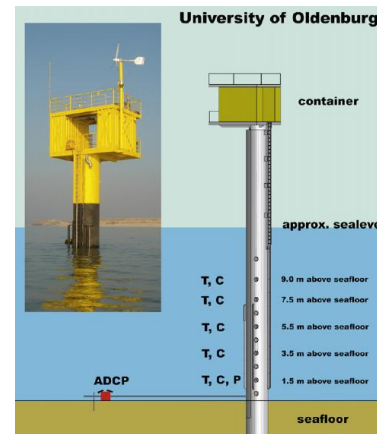
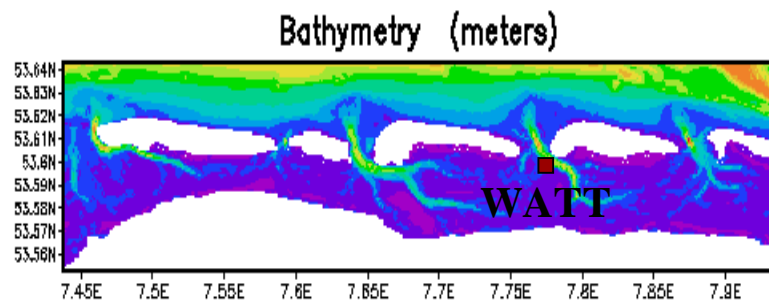
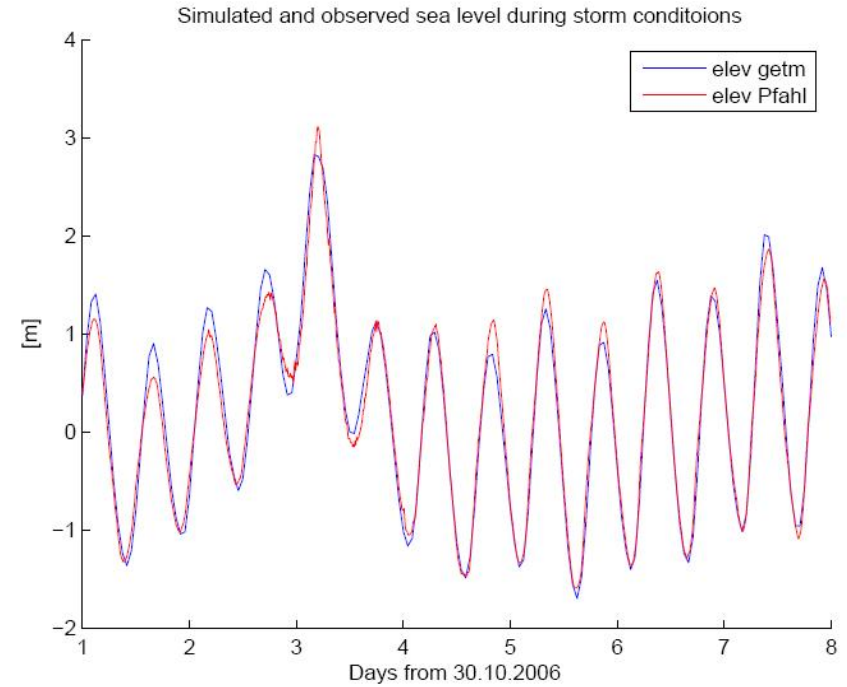
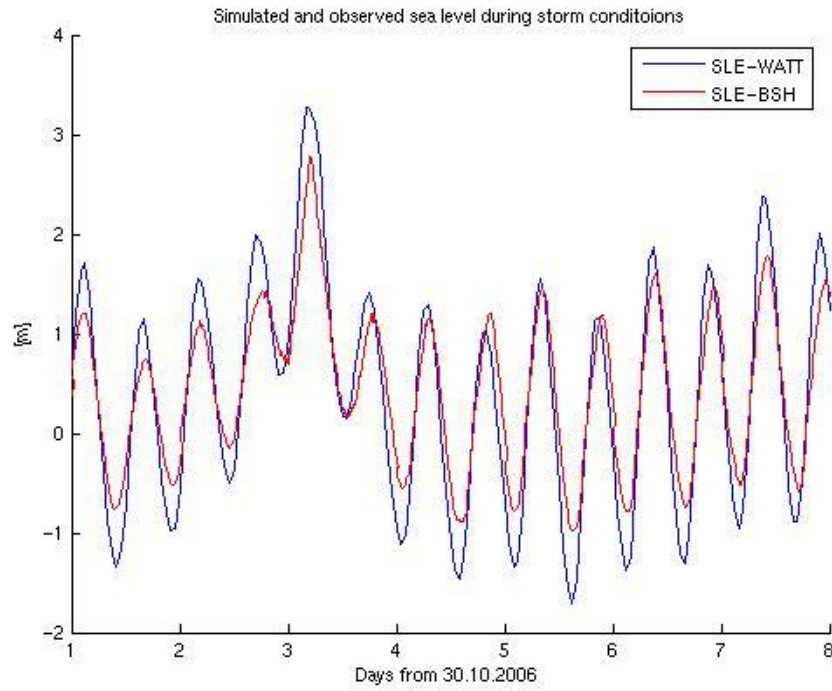
At 1 hr from 01.11.2006
 Sea Surface Temperature (deg. C)



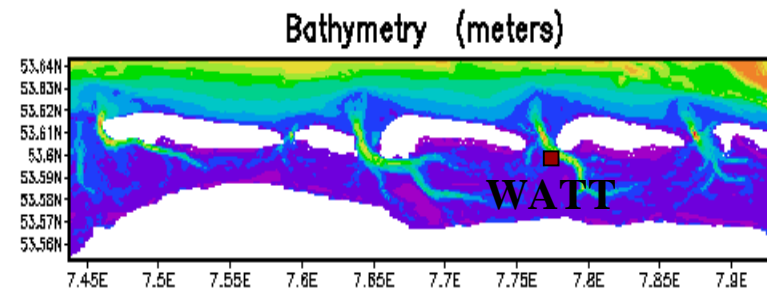
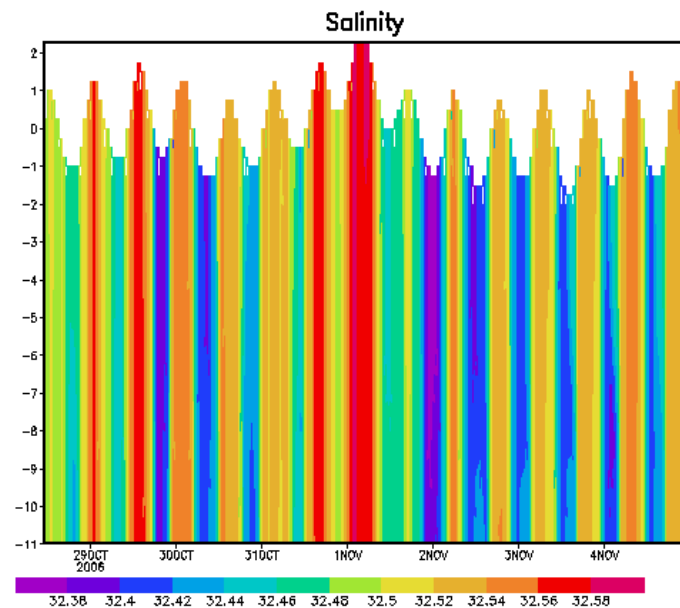
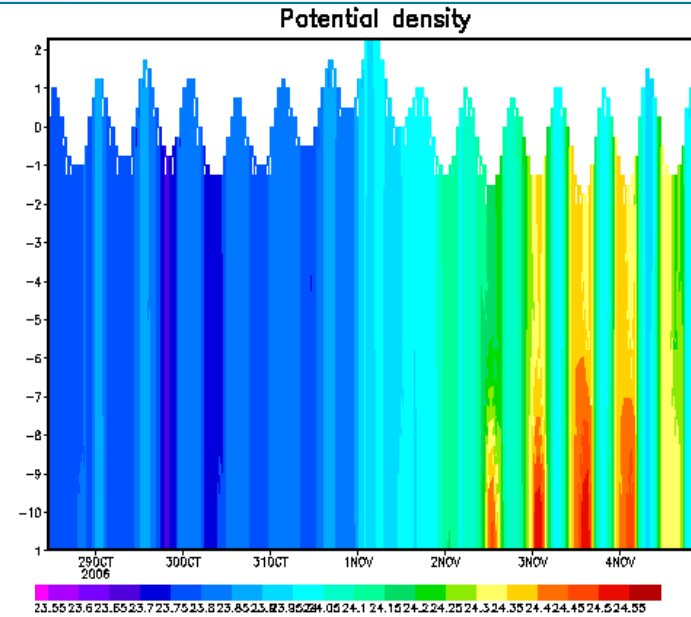
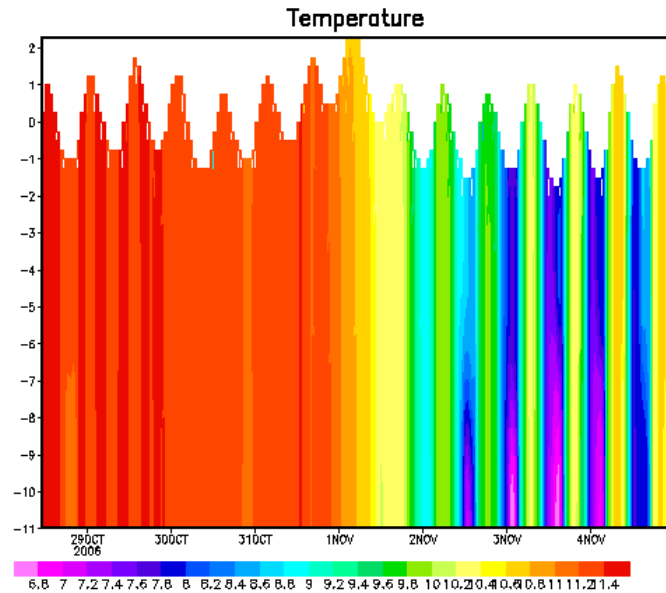
At 1 hr from 01.11.2006



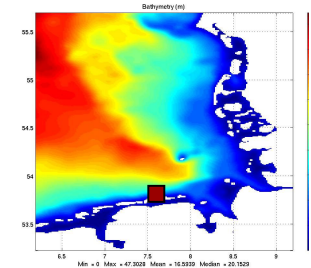
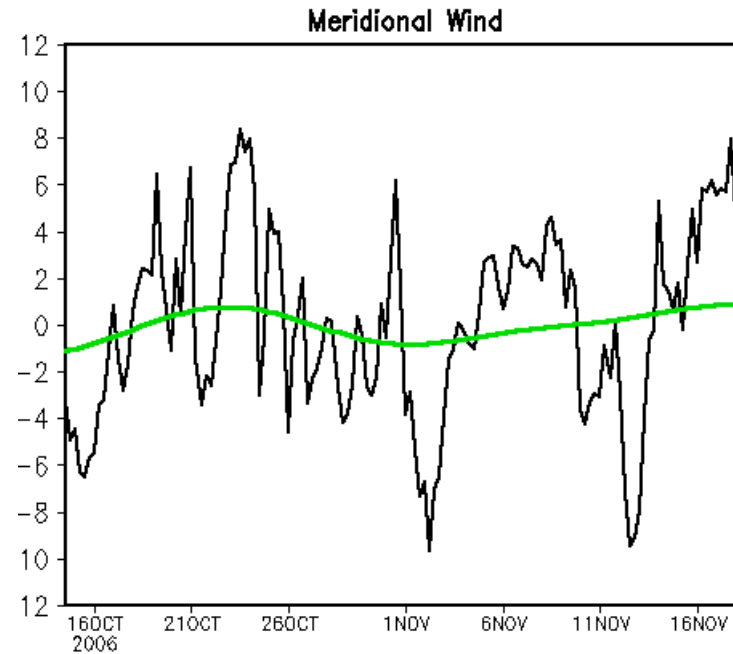
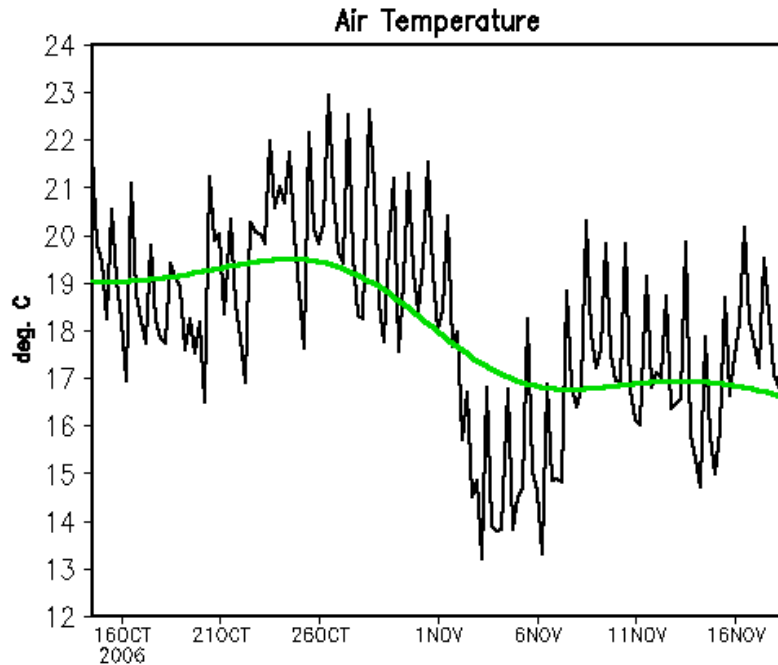
Sea level



Evolution of the vertical stratification „Watt“ Station – Wadden Sea model



Atmospheric conditions during „Britta“



Sensitivity EXPERIMENTS

Air temperature

Wind

EXP1

real

real

EXP2

filtered

filtered

EXP3

real

filtered

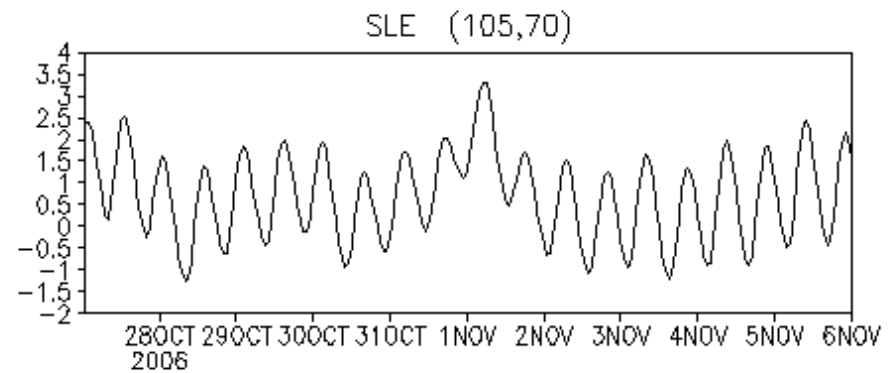
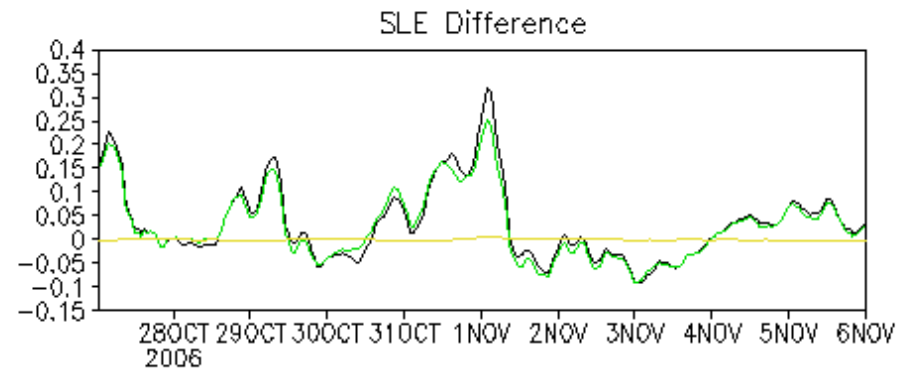
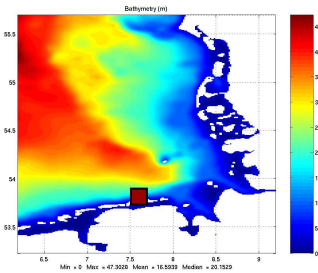
EXP4

filtered

real

Sensitivity experiments

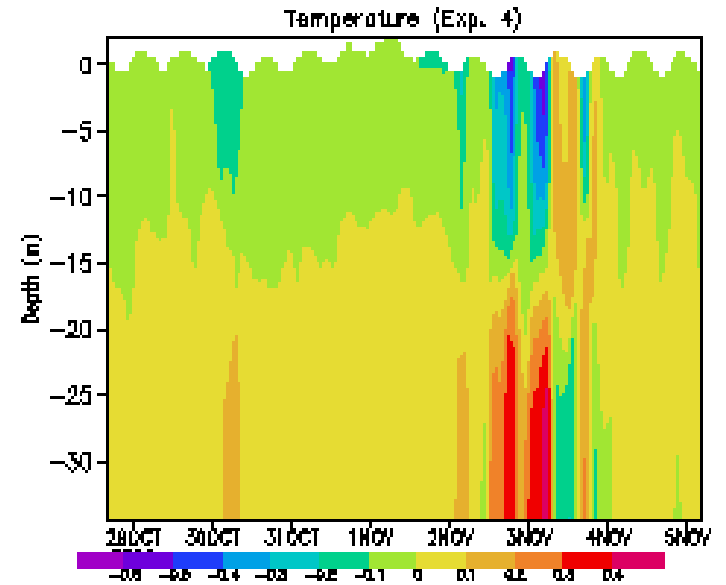
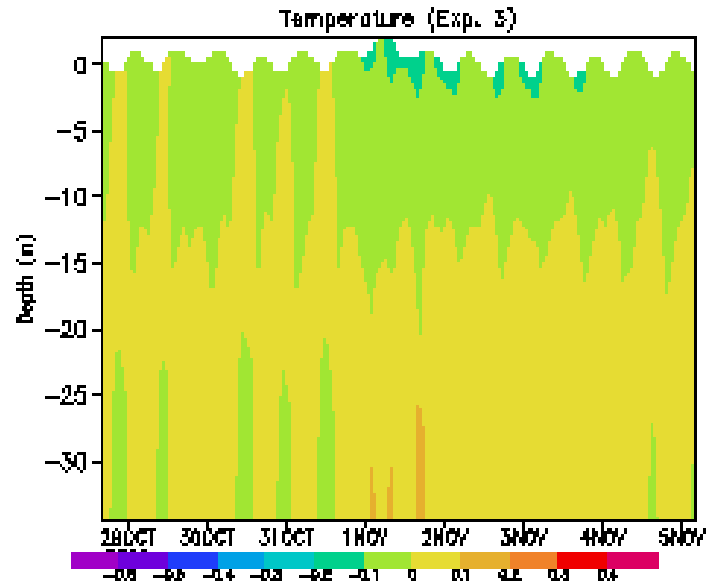
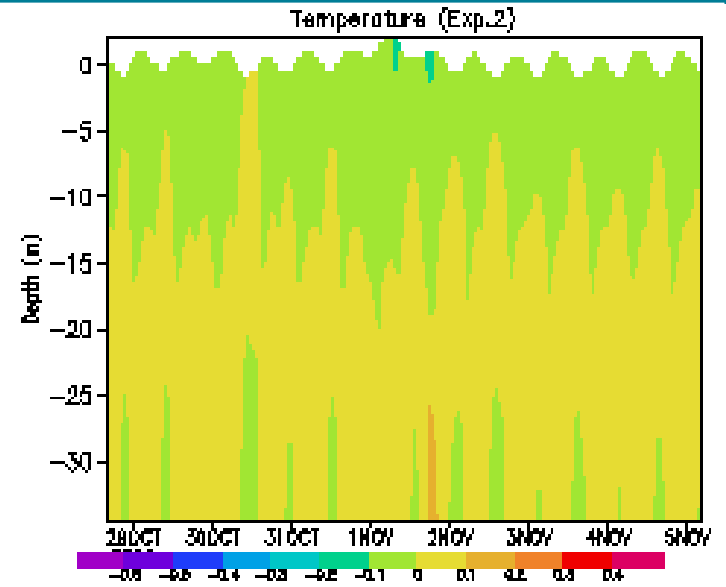
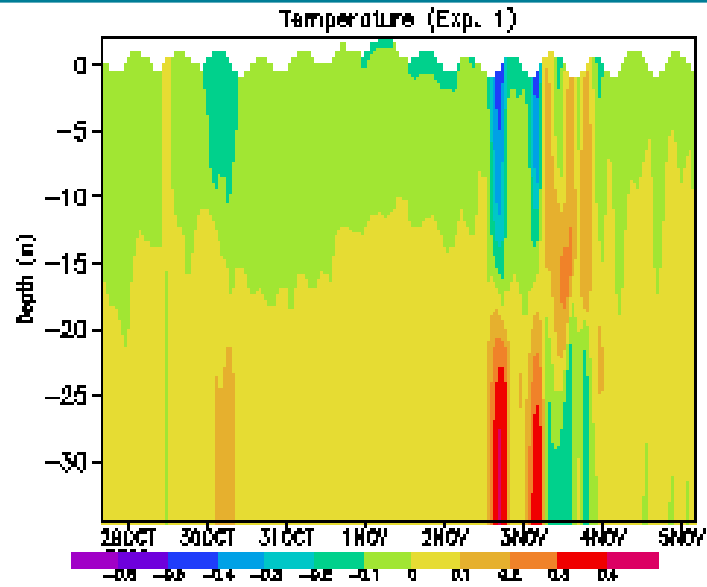
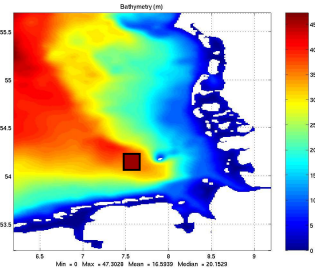
- **EXP1-EXP2**
- **EXP1-EXP3**
- **EXP1-EXP4**



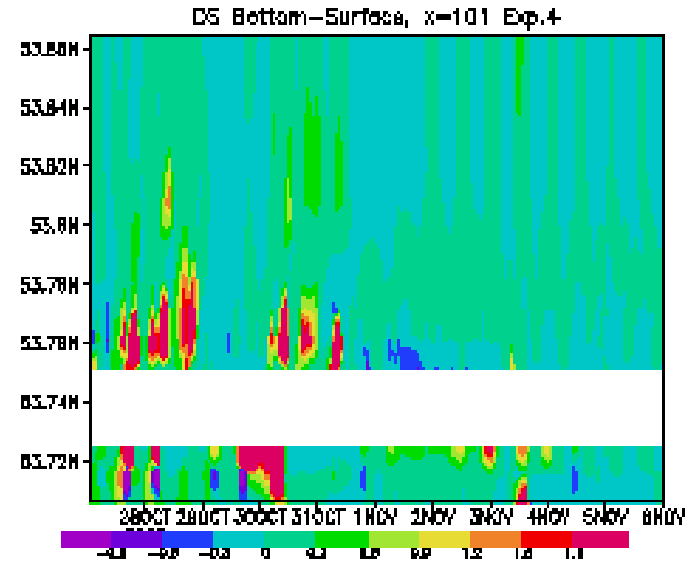
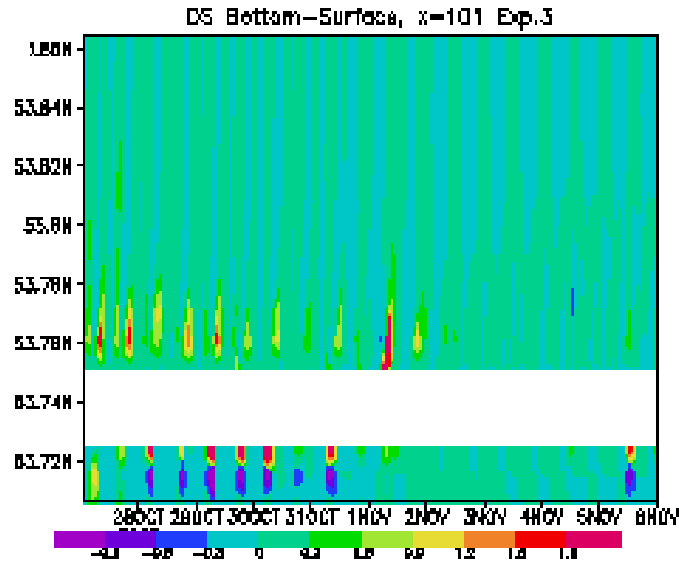
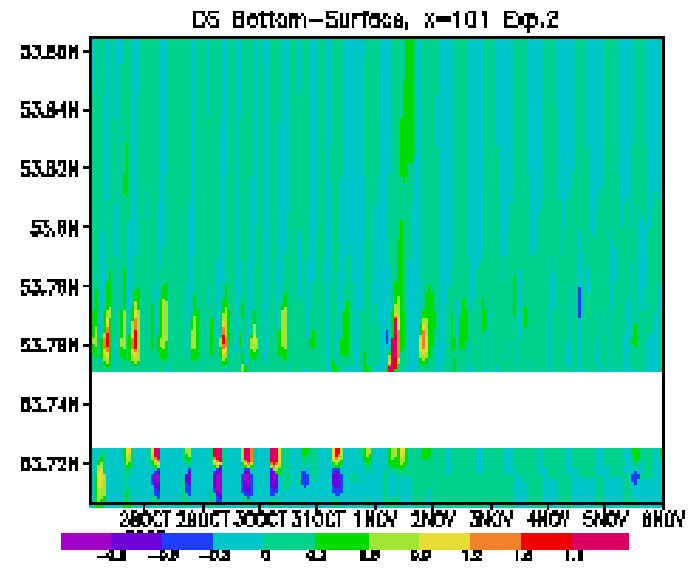
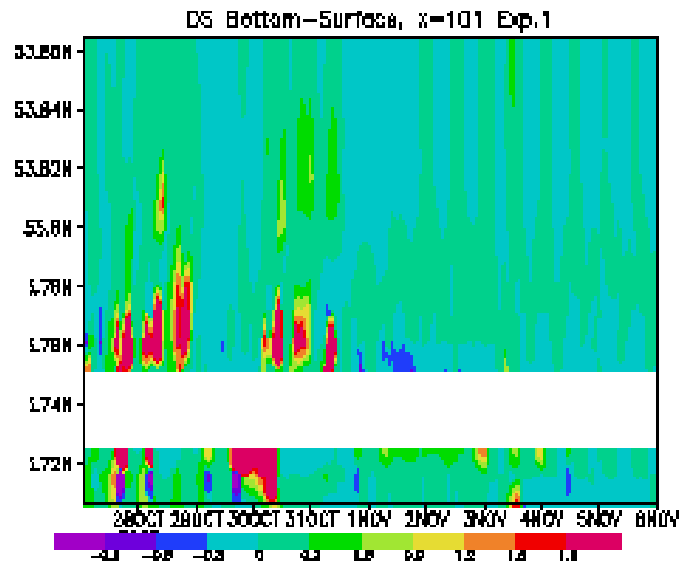
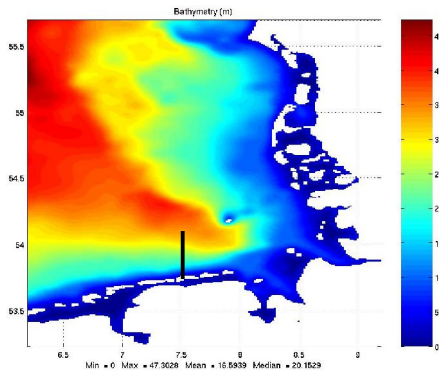
- **EXP1**
- **EXP2**
- **EXP3**
- **EXP4**



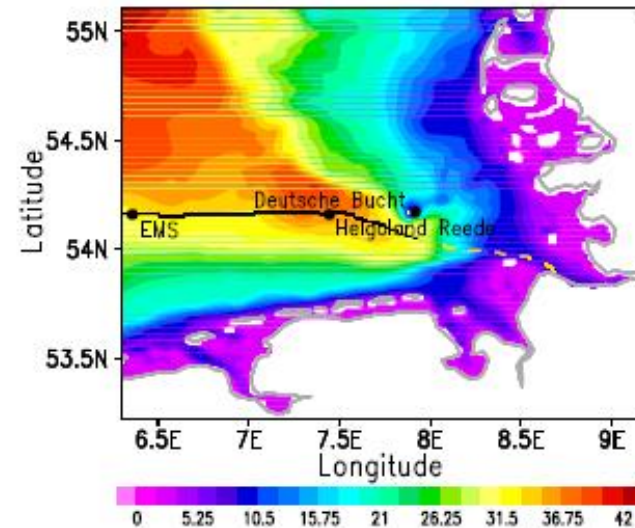
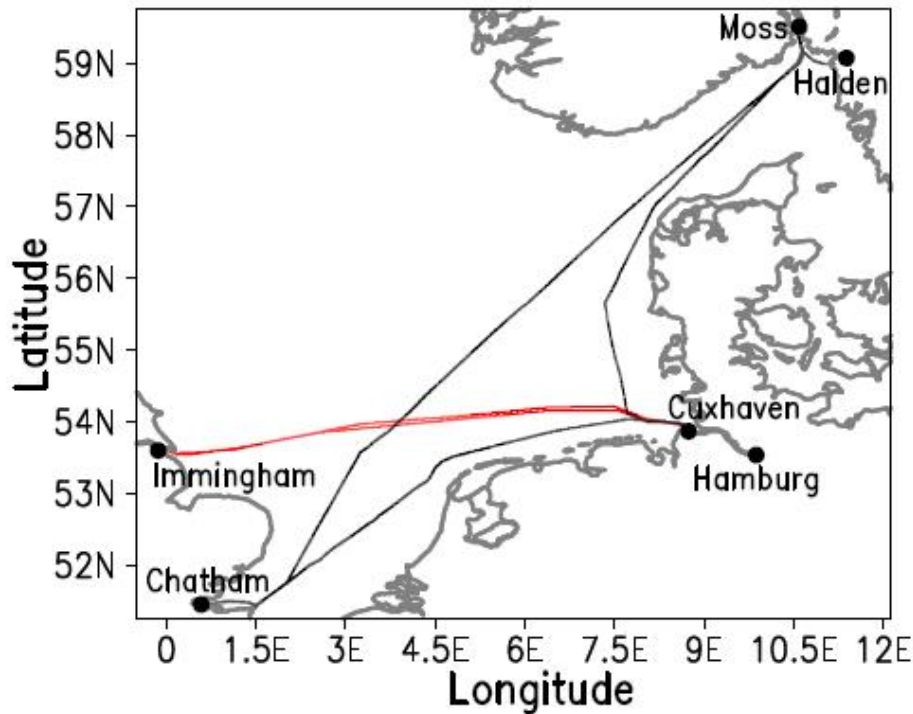
Sensitivity experiments



Sensitivity experiments



FerryBox routes in the North Sea between Cuxhaven- Immingham and Hamburg-Cuxhaven-Chatham-Moss-

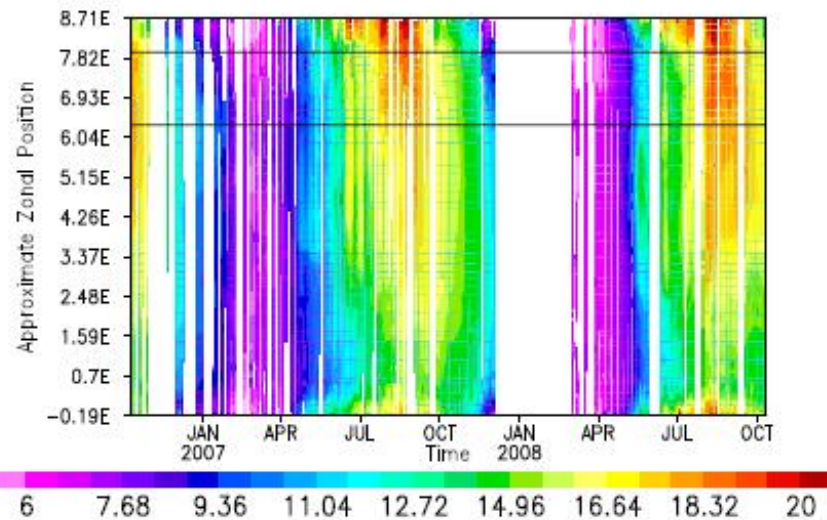


Bottom topography (m) of the German Bight and part of the FerryBox track Cuxhaven-Immingham. The black part of the track is where the bottom is deeper than 30 m. The dots show the positions of Ems, Deutsche Bucht and Helgoland Reede data stations used for estimating the quality of the analysis from the numerical model.

FerryBox SST

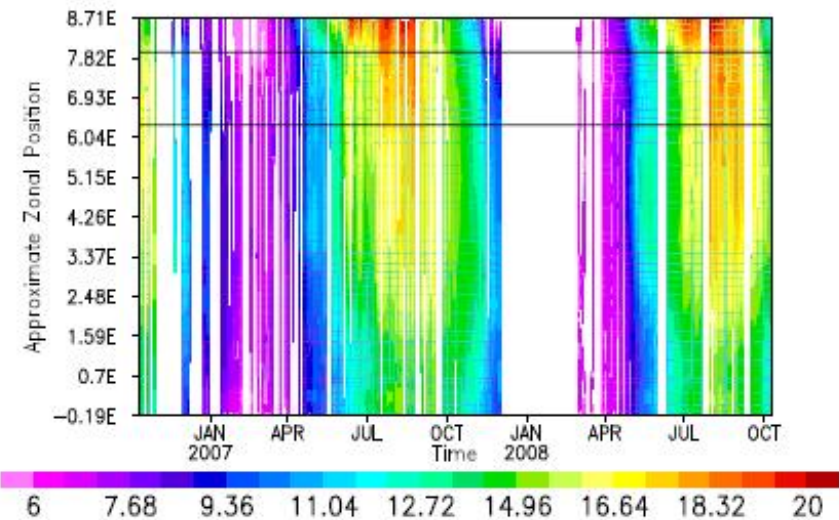
a)

SST from Ferrybox [deg C]



b)

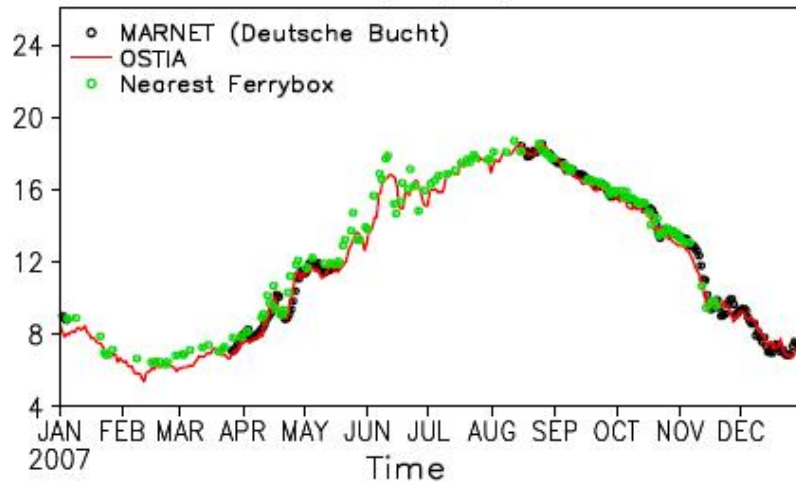
SST from OSTIA [deg C]



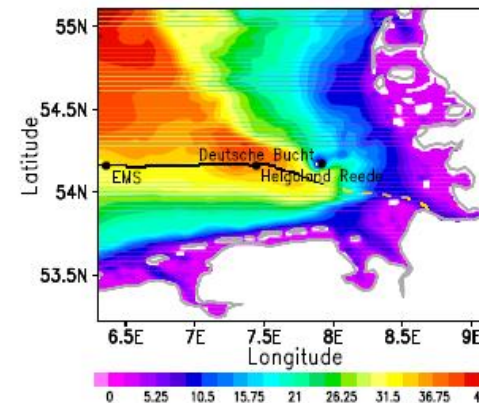
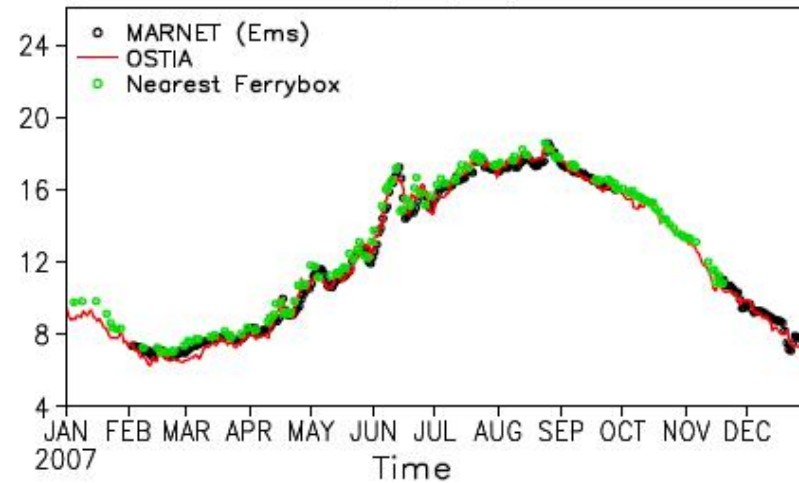
FerryBox SST along the track Cuxhaven-Immingham (a), and OSTIA data (b) sampled along the FerryBox track. The temporal resolution in the plots is 24h. The data analysed and assimilated in the model (in the German Bight) lies between the black lines.

SST (MARNET, OSTIA, Ferrybox)

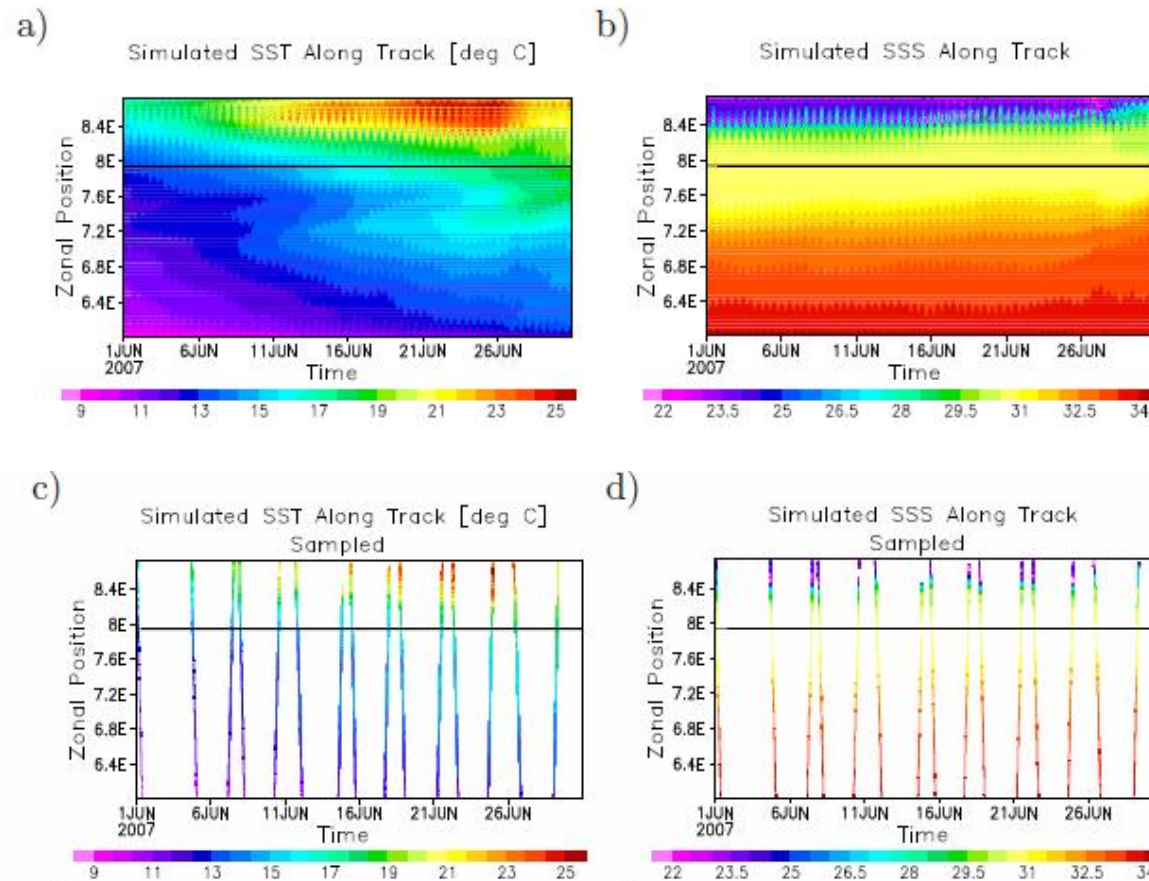
a) Deutsche Bucht Station – 54.17N 7.45E
 SST [deg C]



b) Ems Station – 54.17N 6.35E
 SST [deg C]



Simulated SST and SSS



Simulated SST (a) and SSS (b) along the FerryBox track from Cuxhaven to Immingham during June 2007. (c) and (d) show the data from (a) and (b) sampled in the same way as by FerryBox.

Data Assimilation

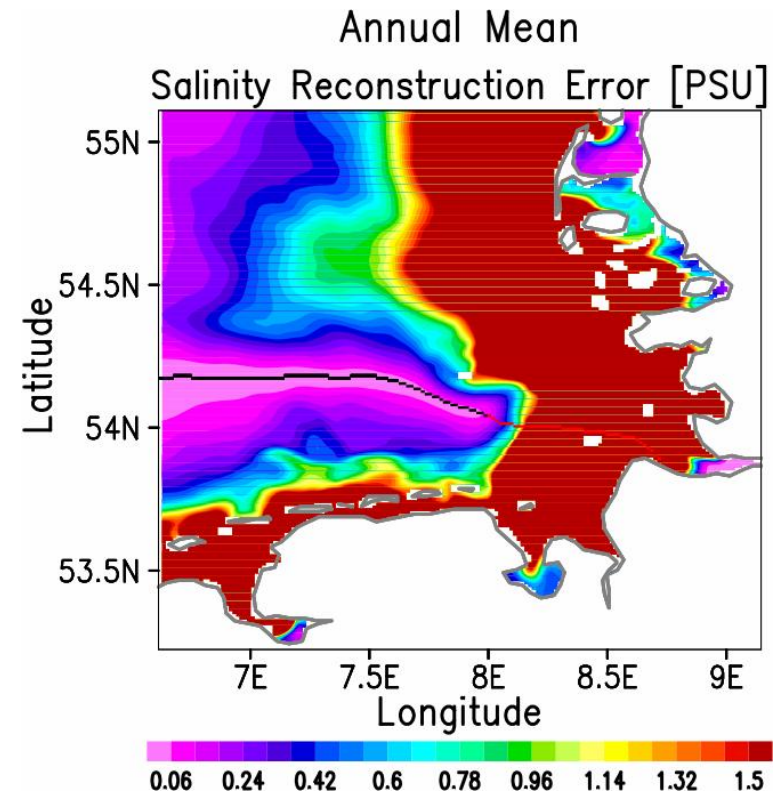
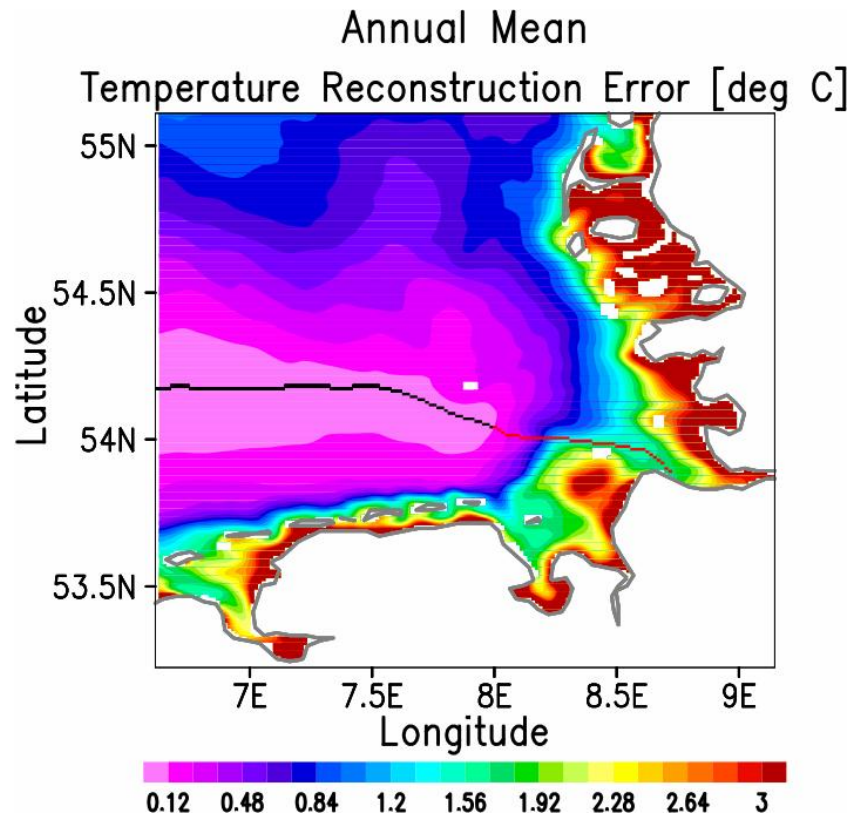
Assimilation Experiment: SST OSTIA /SST & SSS
FerryBox /

using a singular evolutive extended *Kalman filter* (SEEK)

DA-1 OSTIA SST data. The temporal resolution of OSTIA data is 24 hours and its reference time is 12 o'clock. Therefore, we will perform an assimilation step every 24 hours at 12 o'clock UTC.

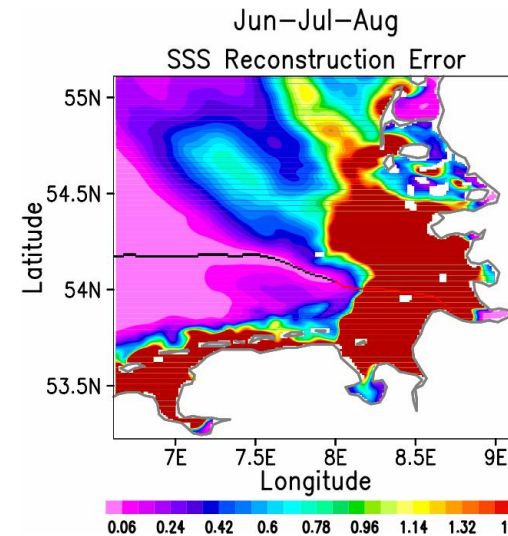
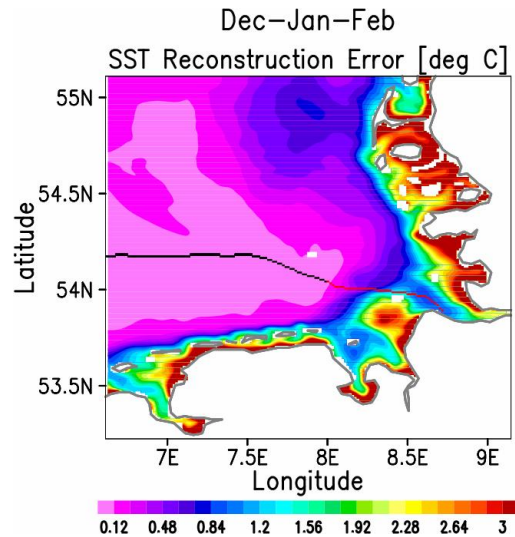
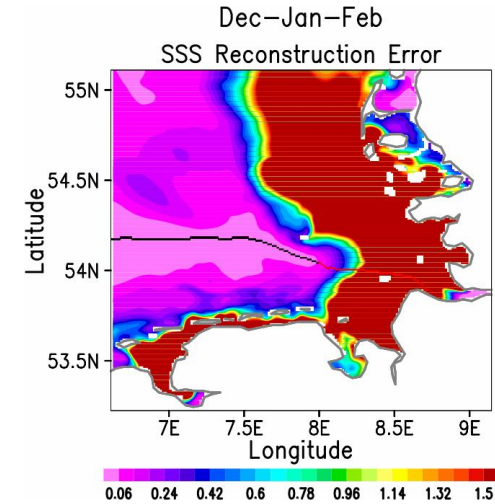
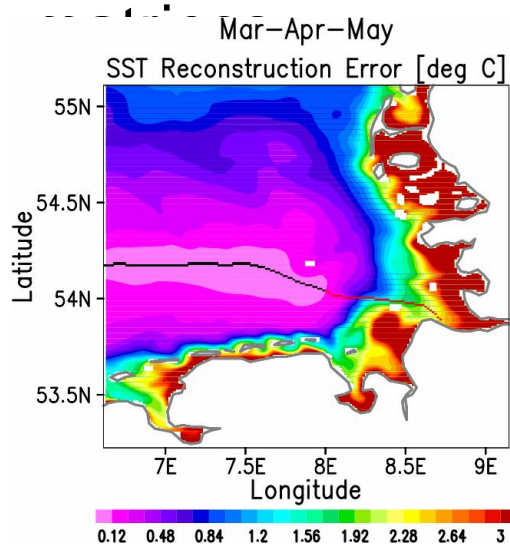
DA-2 FerryBox SST/SSS data. The assimilation interval and analysis time is the same as in DA-1.

RMSE of SST



Annual mean for 2007 of the error range of OSTIA SST (a), RMSE of SST in the free run against the OSTIA SST (b), RMSE of SST in the free run against the OSTIA SST minus RMSE of SST in the DA-1 (c) and DA-2 (d) against the OSTIA SST, respectively.

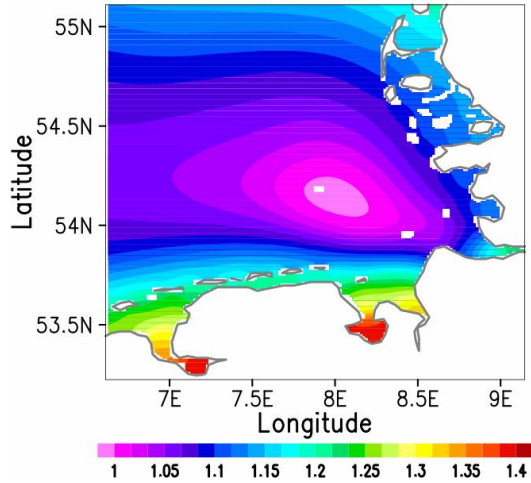
Seasonal averaged SST and SSS reconstruction error estimates used in the localisation of the covariance



RMSE of SST

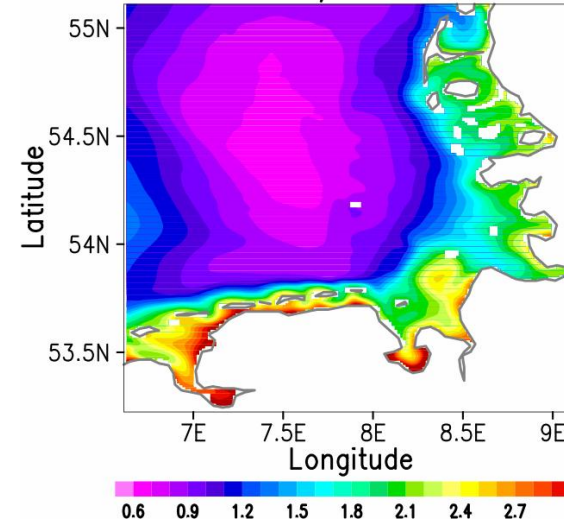
OSTIA SST Error Range [deg C]

Annual Mean



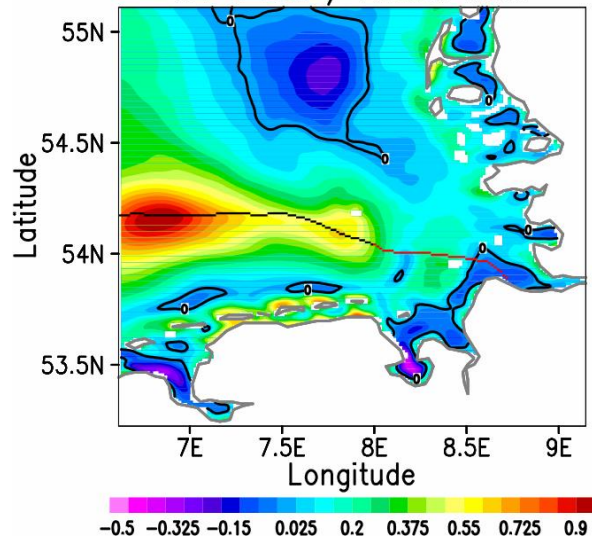
SST RMSE [deg C]

Free Run / Annual Mean



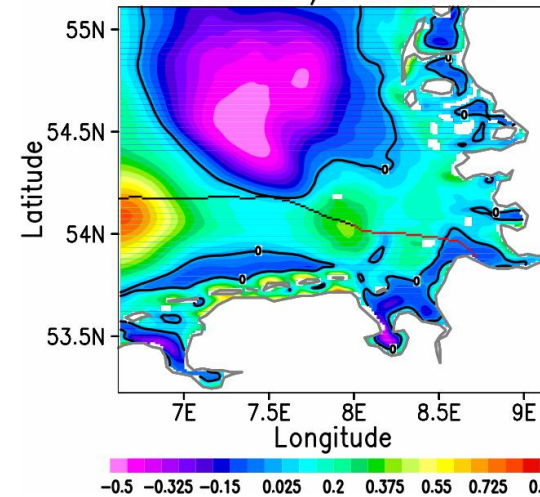
Improvement in SST RMSE [deg C]

DA-1 Run / Annual Mean

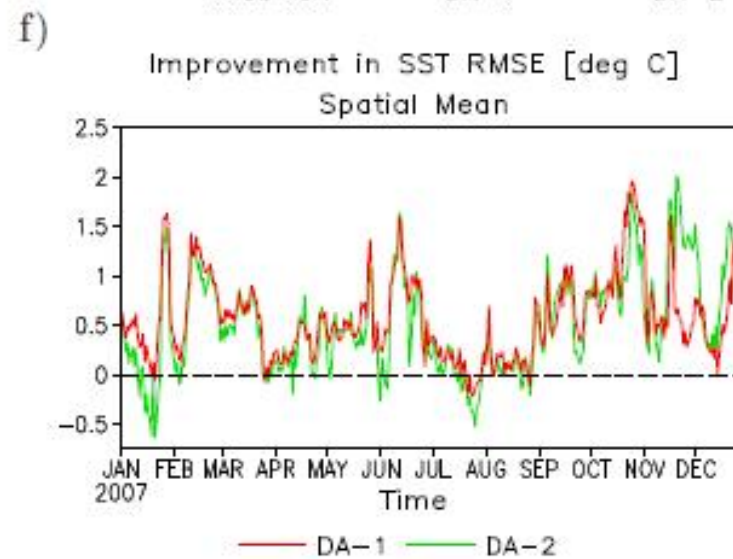
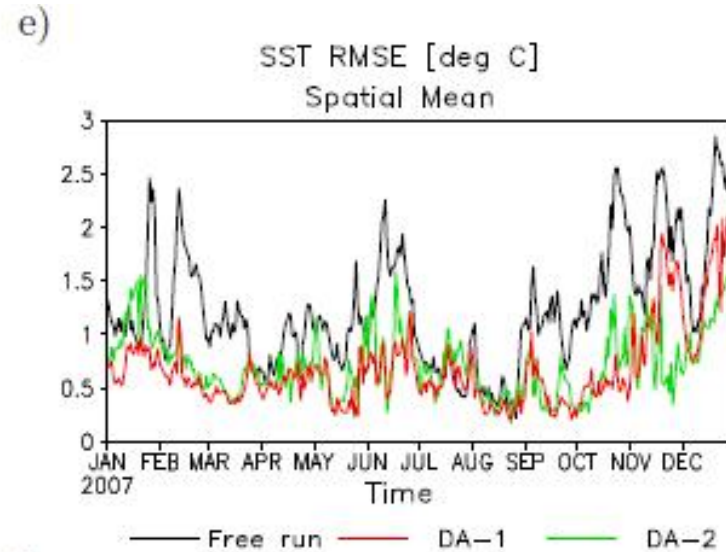


Improvement in SST RMSE [deg C]

DA-2 Run / Annual Mean

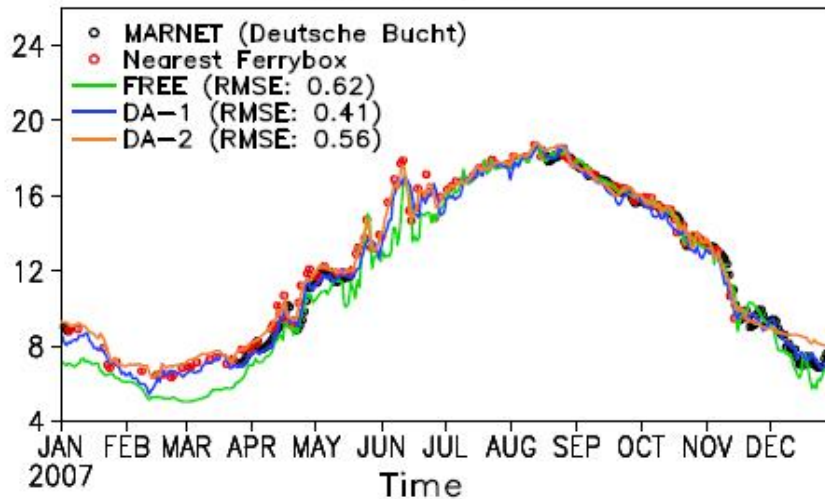


RMSE of SST against OSTIA SST

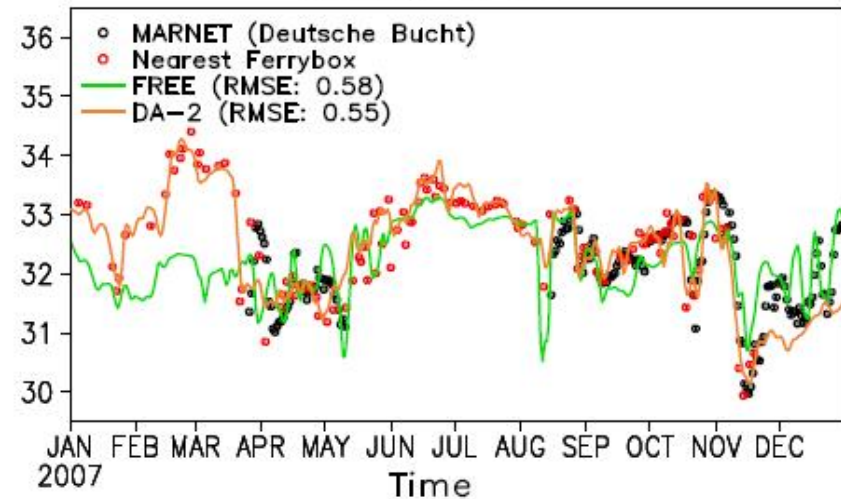


Validation of SST and SSS

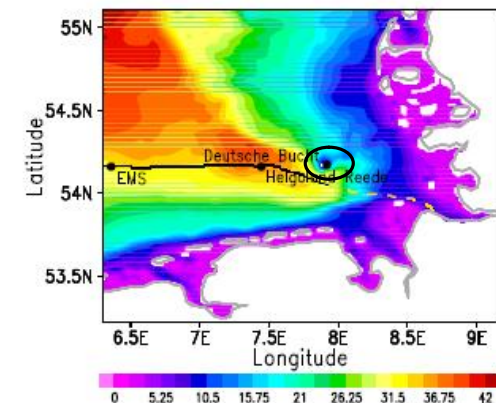
a) Deutsche Bucht Station – 54.17N 7.45E
 SST [deg C]



b) Deutsche Bucht Station – 54.17N 7.45E
 Salinity at 6m



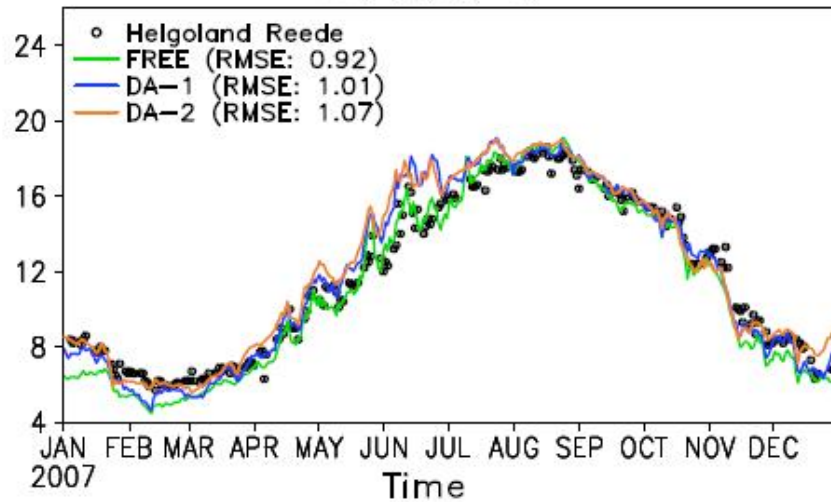
Validation of simulated SST and SSS against MARNET observations.



Validation of SST and SSS

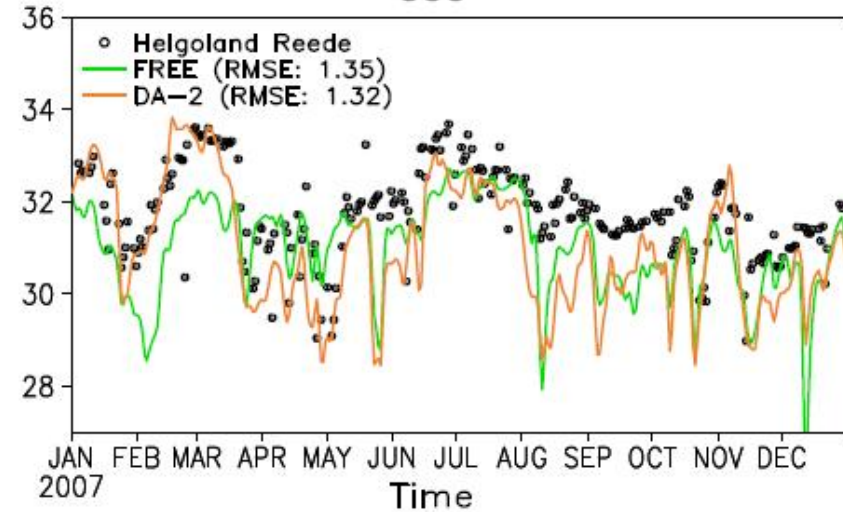
e)

Helgoland Reede – 54.18N 7.88E
 SST [deg C]

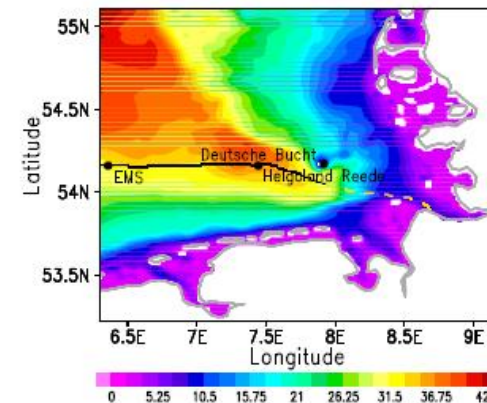


f)

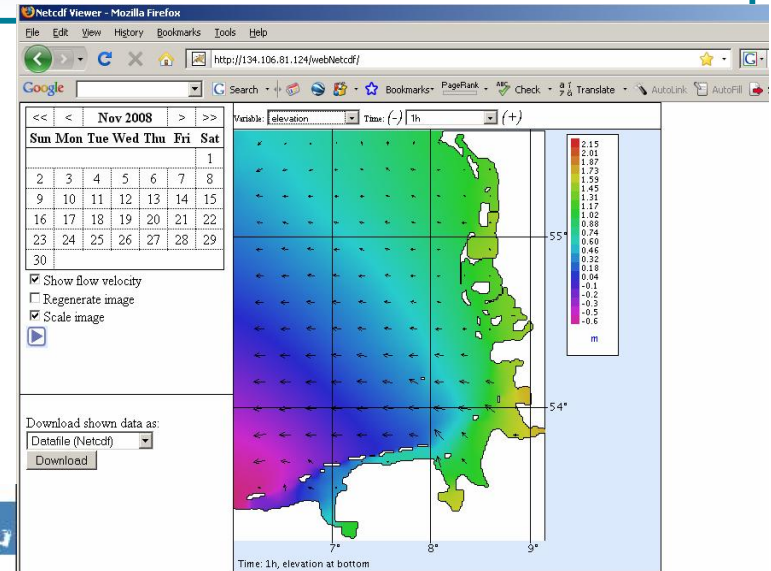
Helgoland Reede – 54.18N 7.88E
 SSS



Validation of simulated SST and SSS against Helgoland Reede observations.

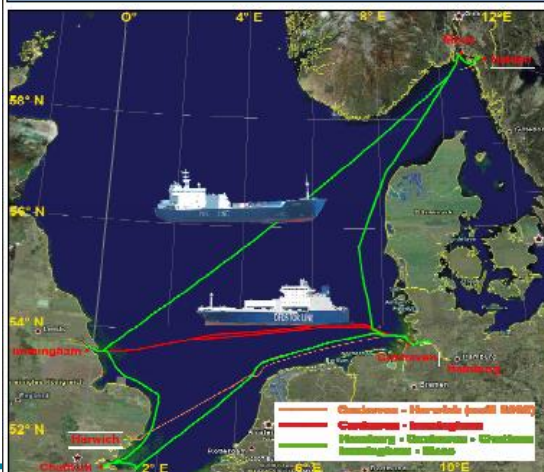


**Toward operational coastal oceanography:
Real time products -
Web page - making
results available**
(www.cosyna.de)



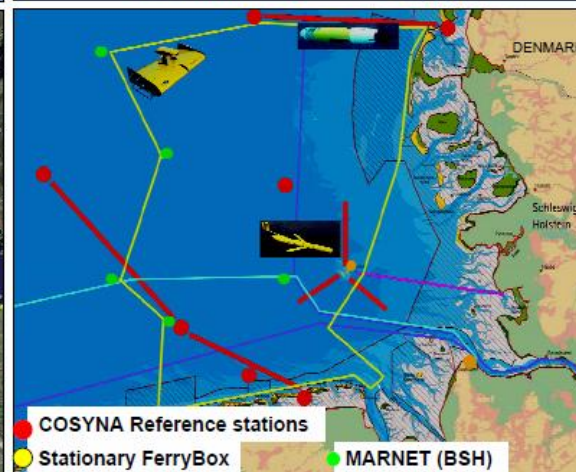
North Sea Scale

Regular FerryBox Routes

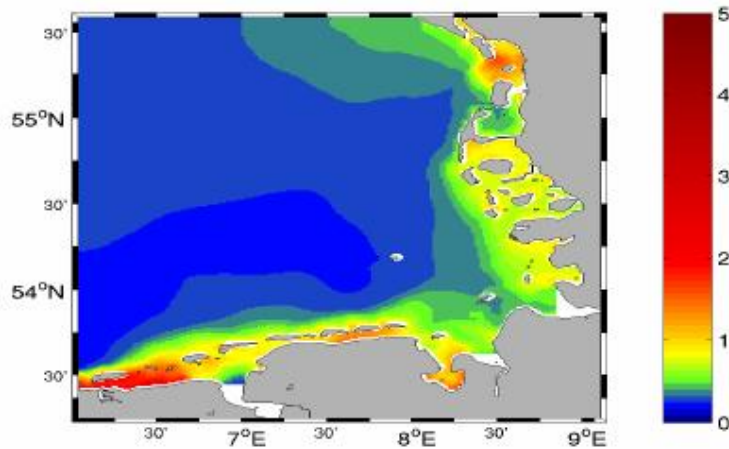


German Bight Scale

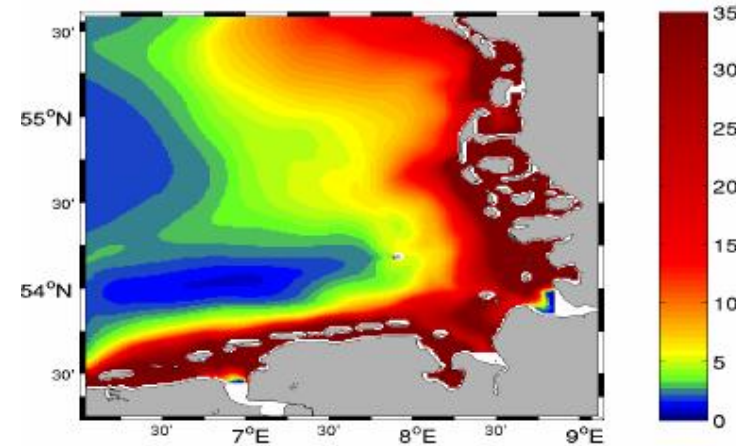
Regular transects for fluxes
 — at the open boundaries with AUV
 — inside the bight with FerryBox
 On demand representativity & internal dynamics
 — Scanfish — Glider



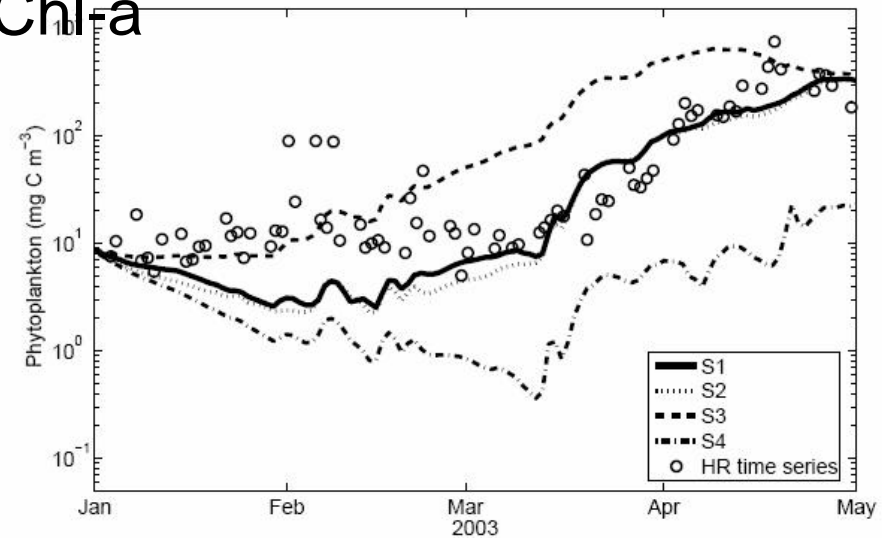
Coupled Physical-Ecosystem Model



Monthly light attenuation coefficient K_d – coupled model

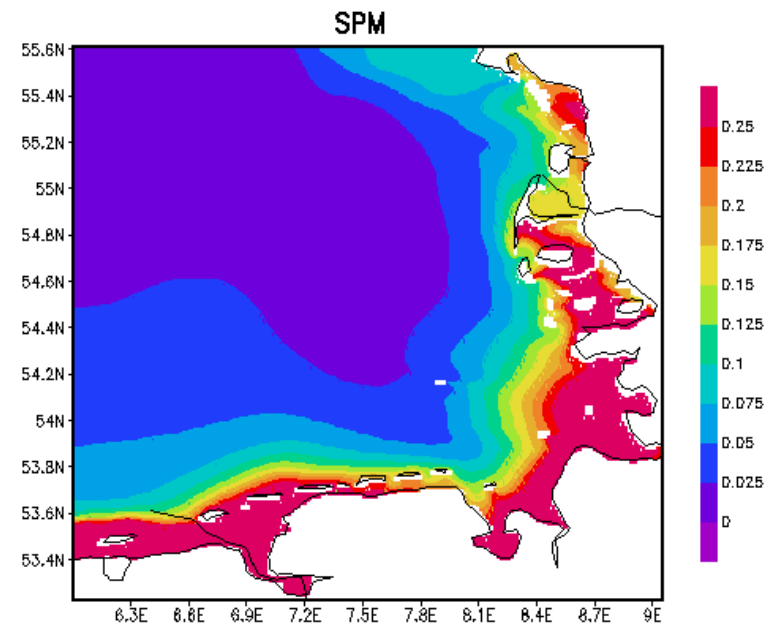
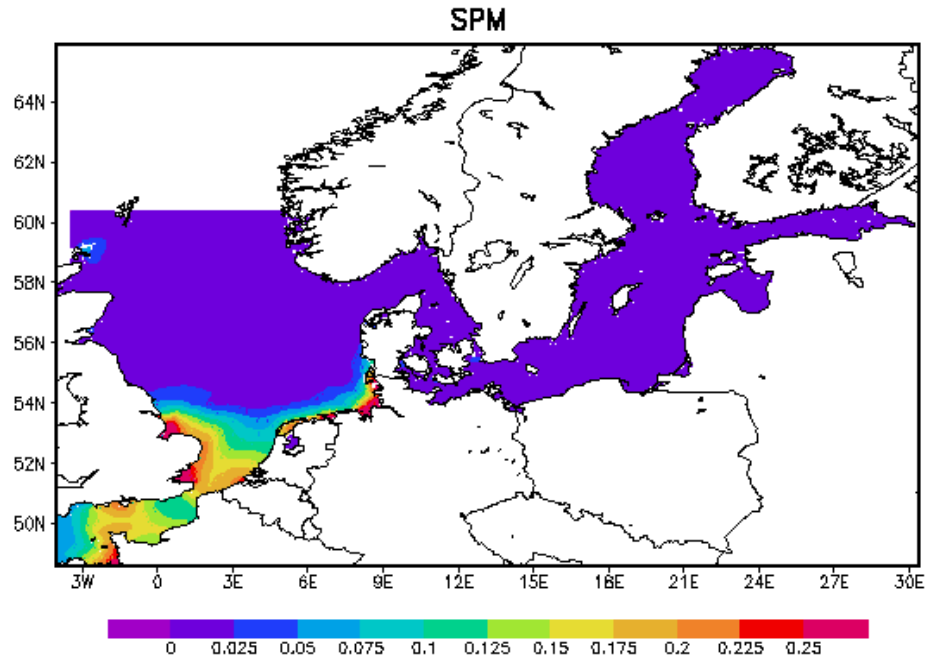


Monthly mean of modelled Chl-a

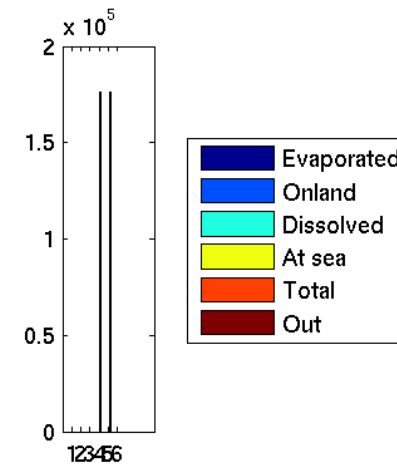
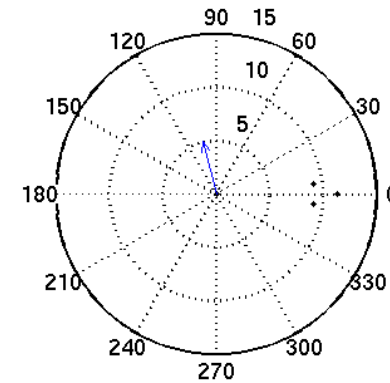
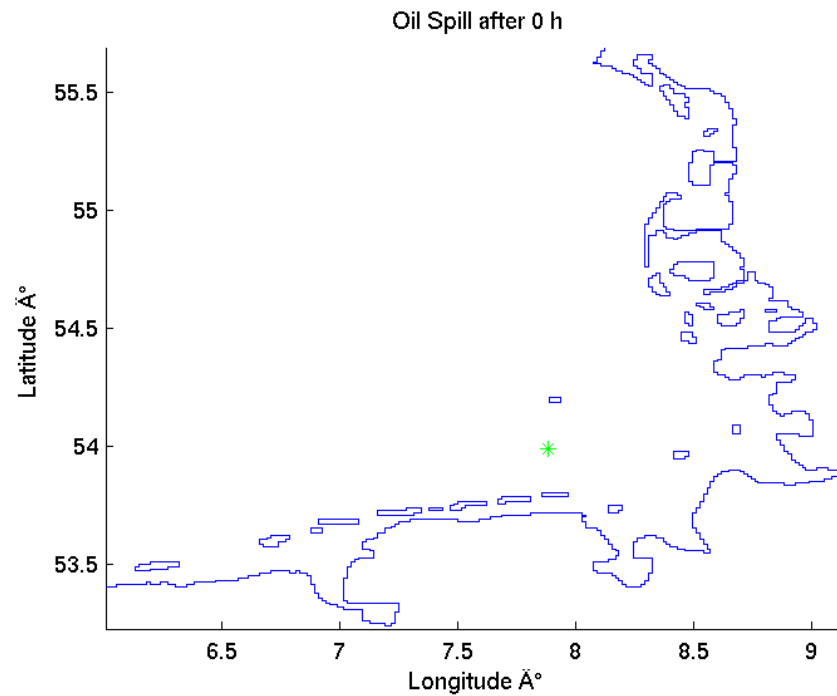


Tian et al. (2009)

Sediment Model



Oil Spill Simulations



Oil spill model

Conclusions

- Nested-grid models are set-up and applied to study the
- circulation and thermohaline evolution of the German Bight
- Synergy between data and modelling shows promising results
- Numerical models produce new knowledge.
- The changes of the stratification during the storm Britta are due to the favourable wind conditions compared to the extreme temperature cooling
- Data Assimilation improves the baroclinicity

Still to do:

Operational coastal oceanography, incl. data assimilation (up to date filters and all available observations)

Improve sediment dynamics, link to biogeochemistry

Thanks for your attention!