BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

ImoNav

Integration of oceanographic data into electronic navigation systems - project ImoNav

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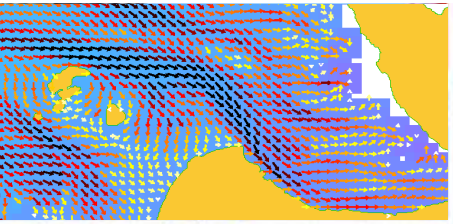




What is ImoNav?

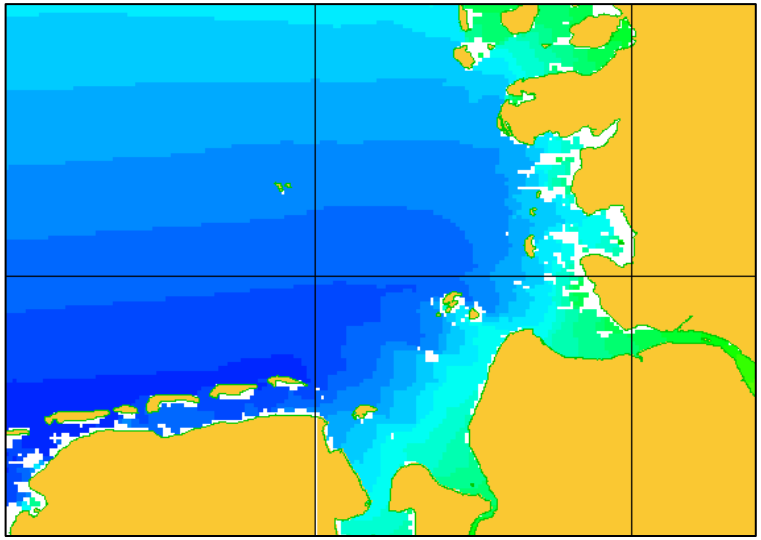
- National project to develop a new navigation service for (German) marine water ways
- ImoNav - Integration of high resolution marine geodata into electronic navigation systems
- Duration: 3 years
- Start: 01.06.2017

Who is Involved?

- BSH (coordinator) and two companies (smile consult and SevenCs)

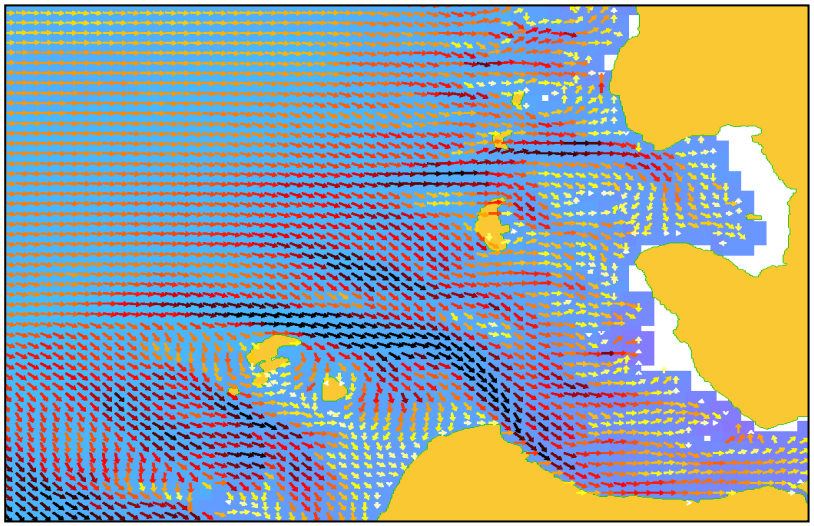
Project objectives

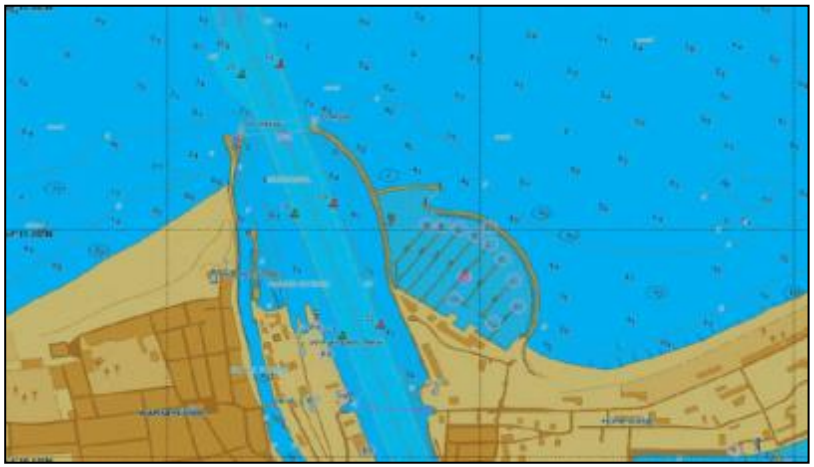
- Develop an innovative high resolution navigation service for (German) marine water ways (e.g. Elbe und Weser estuary and coastal waters)
- Collect and merge high resolution hydrographic data from different institutions
- Combine bathymetric with water level data as well as optimized forecasts
- Provide additional oceanographic data (currents, water temperature, waves…)



Project objectives

- Provide new products for bathymetry, water depth and oceanographic data according to IHO standards
- Automate all processes for operational production
- Portray the data in electronic chart and information systems (ENCs and ECDIS)
- Develop a communication concept for land - ship data transfer
- Execute a pre-operational demonstration and test with users





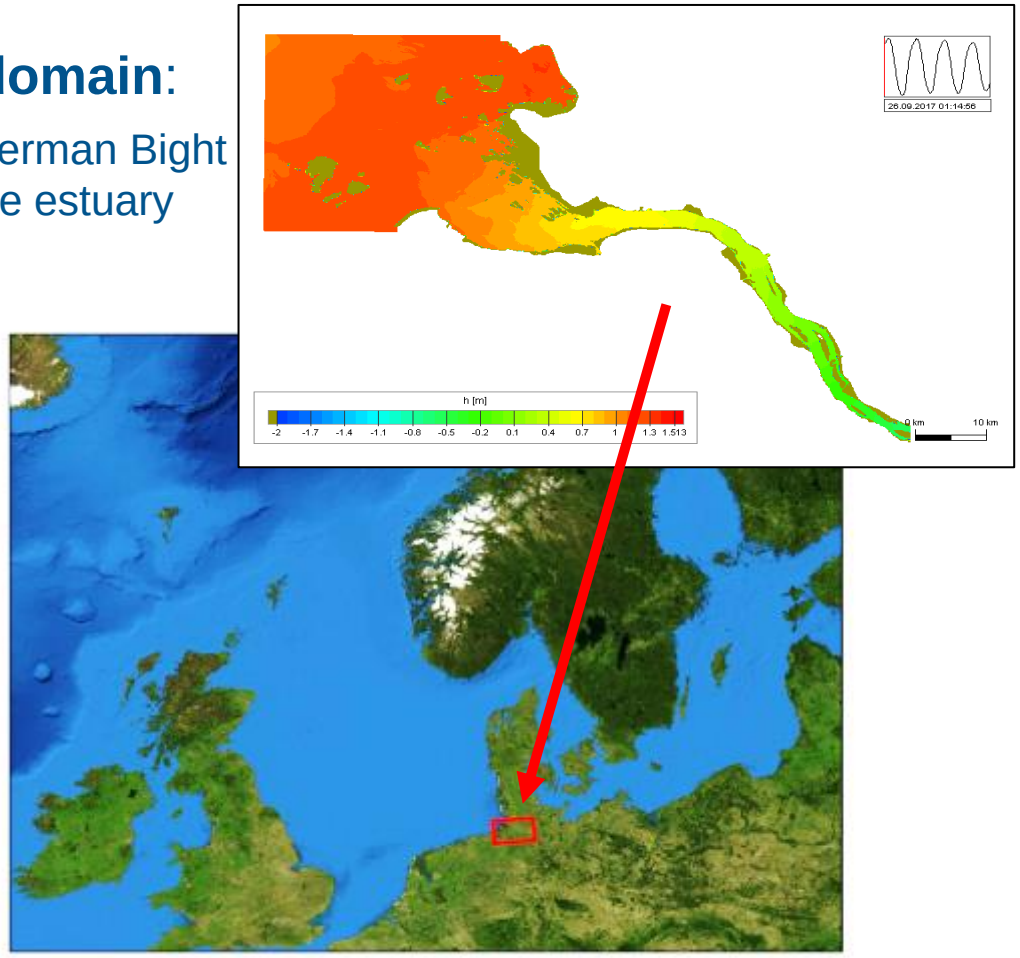
Project structure

Work Packages:

1. **Project management (BSH)**
2. **Oceanographic data (BSH)**
   - Provision of optimized water level and other oceanographic data
3. **Bathymetry data (BSH)**
   - Provision of high resolution digital bathymetry
4. **Automatic processing and merging of data (smile consult)**
   - new product for water depth
5. **Communication and presentation (SevenCs)**
   - Data transfer land - ship
   - Portrayal in ENCs/ECDIS and demonstration

Test domain:

Inner German Bight and Elbe estuary

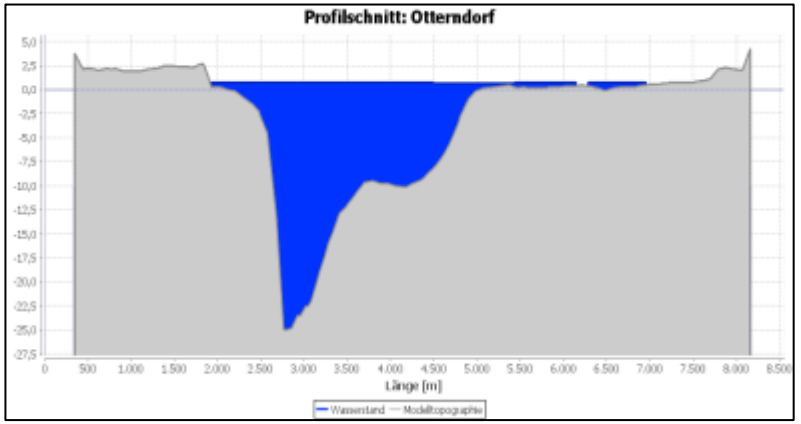


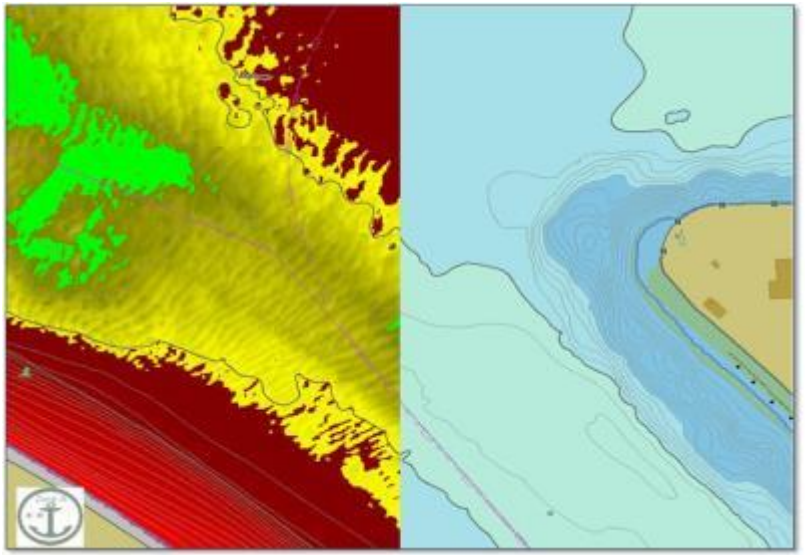
Products, users and further applications

ImoNav will provide innovative products for navigation and ship routing

- Output according international (IHO-) standards (e.g. S-100, S-101, S-102, S-104, S-111,…)
- Application for dynamic route planning
- Quality management and safety checks
- Evaluation and demonstration (pre-operational test)
- Main users are shipping companies and administration, pilots, as well as harbor and water way management

- Further applications: protection of marine environment, support of offshore and coastal activities, coastal protection …
- Method can also be used for the correction or reduction of soundings concerning water elevation



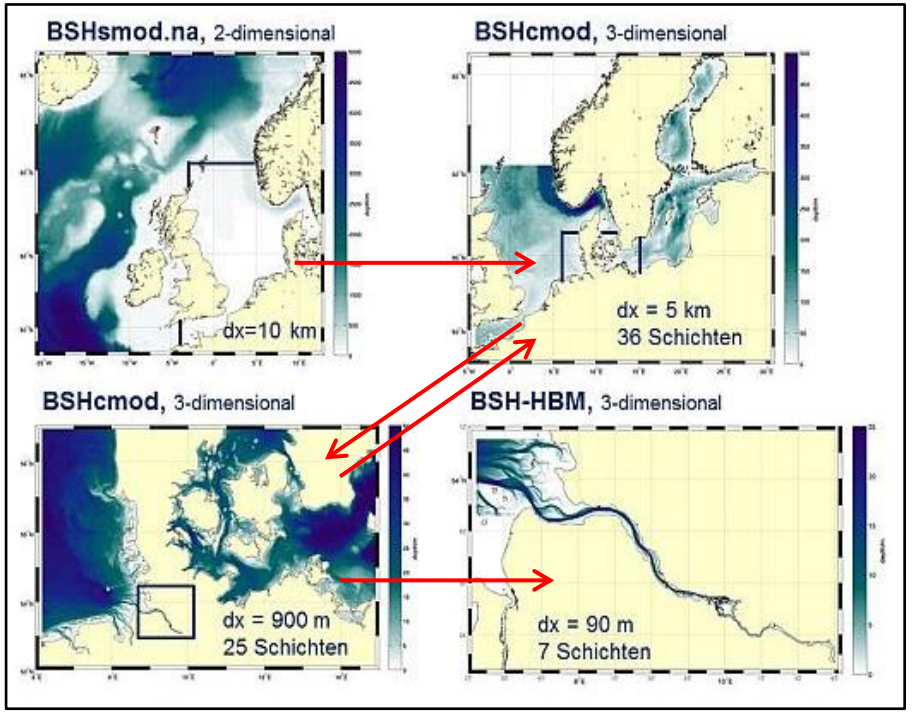


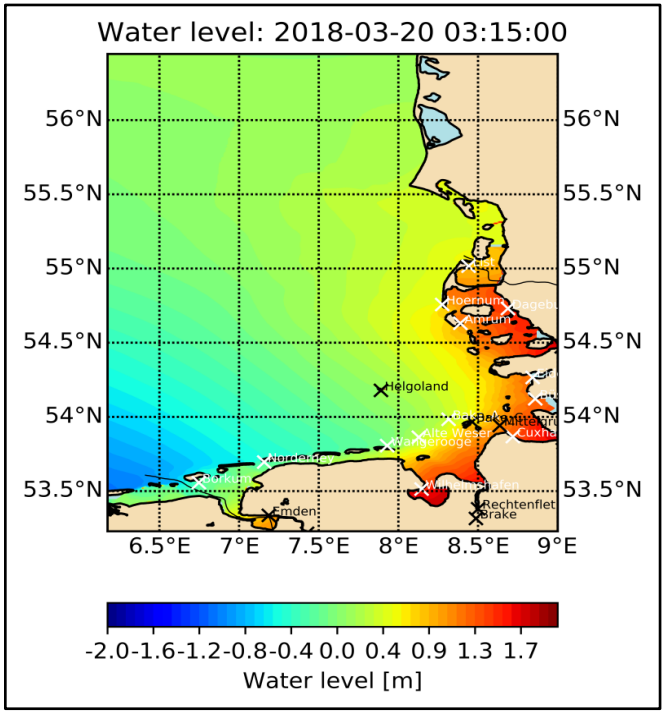
Data sources: Numerical Model
Water level forecast: Grid nesting of BSH circulation models

ImoNav

BSH provides two (automated) water level forecasts

01 Numerical Model: continuous water level surface of a 3D ocean forecast model

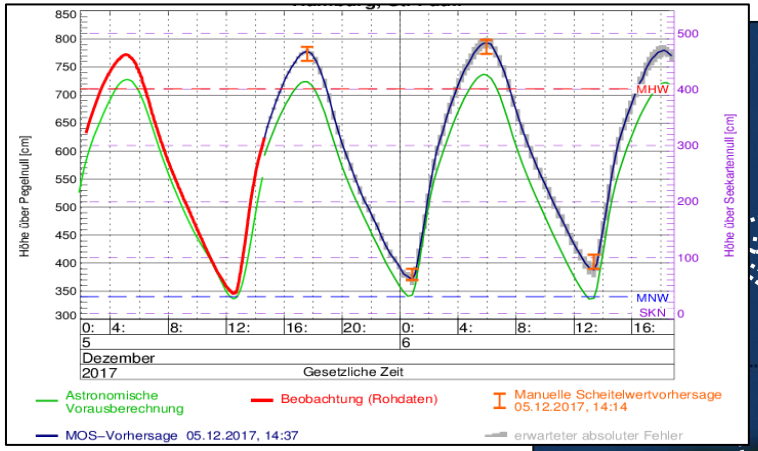


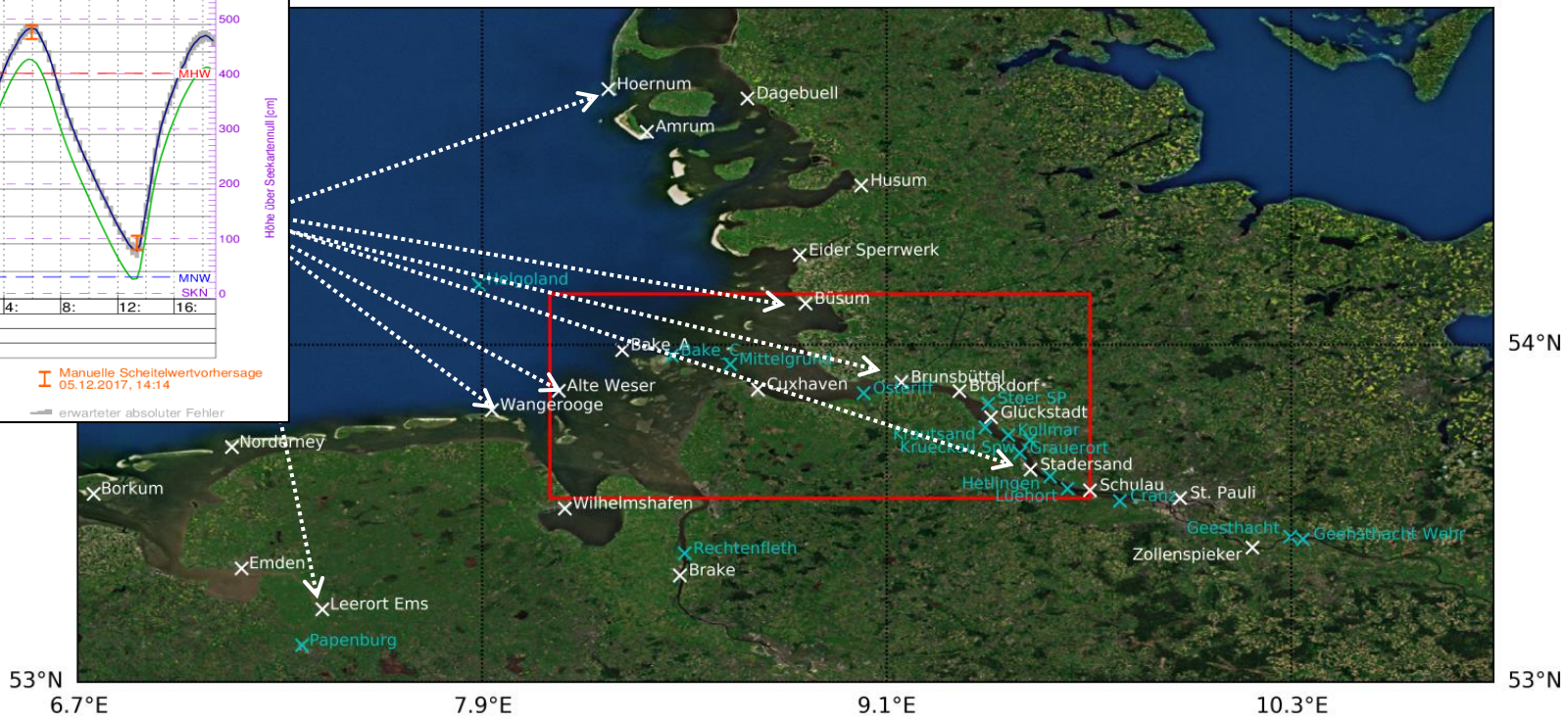


Data sources: Model output statistics

02

Model output statistics (MOS):
empirical method for some discrete locations:
model results are statistically post-processed and optimized





Data sources: Comparison

Numerical Model

+ Continuous water level surface
+ High (relative) accuracy
+ Strong performance in representation of extreme events

- No integration of observational data (water levels)
- Lower timeliness of data

MOS (Model Output Statistics)

+ Integration of observational water level data
+ Frequent update (every 15 minutes)
+ Reduction of forecasting error (especially within the first hours)

- Requirement: long observation time series (min. 10 continuous years)
- Discrete results for some locations
- Occasionally larger error in extreme event forecast

⇨ Idea: Subsequent correction of numerical model results by means of generating a correction-surface out of MOS-results

Three-step method:

01 Calculation of differences between numerical model output and MOS results at discrete locations

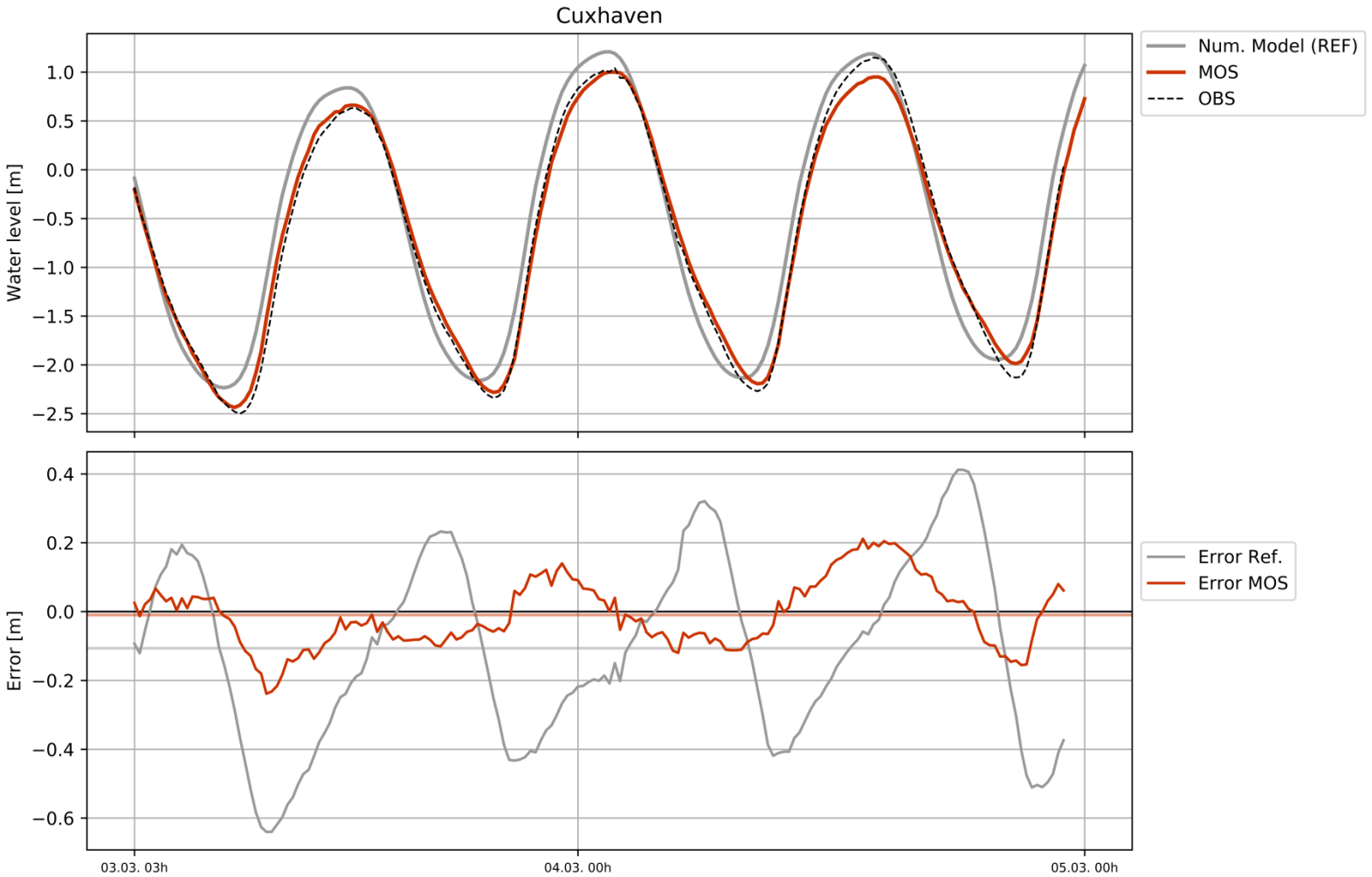
$$\text{Correction}(t) = z_{Model}(t) - Z_{MOS}(t)$$

⟹ **Result: Differences at discrete locations**

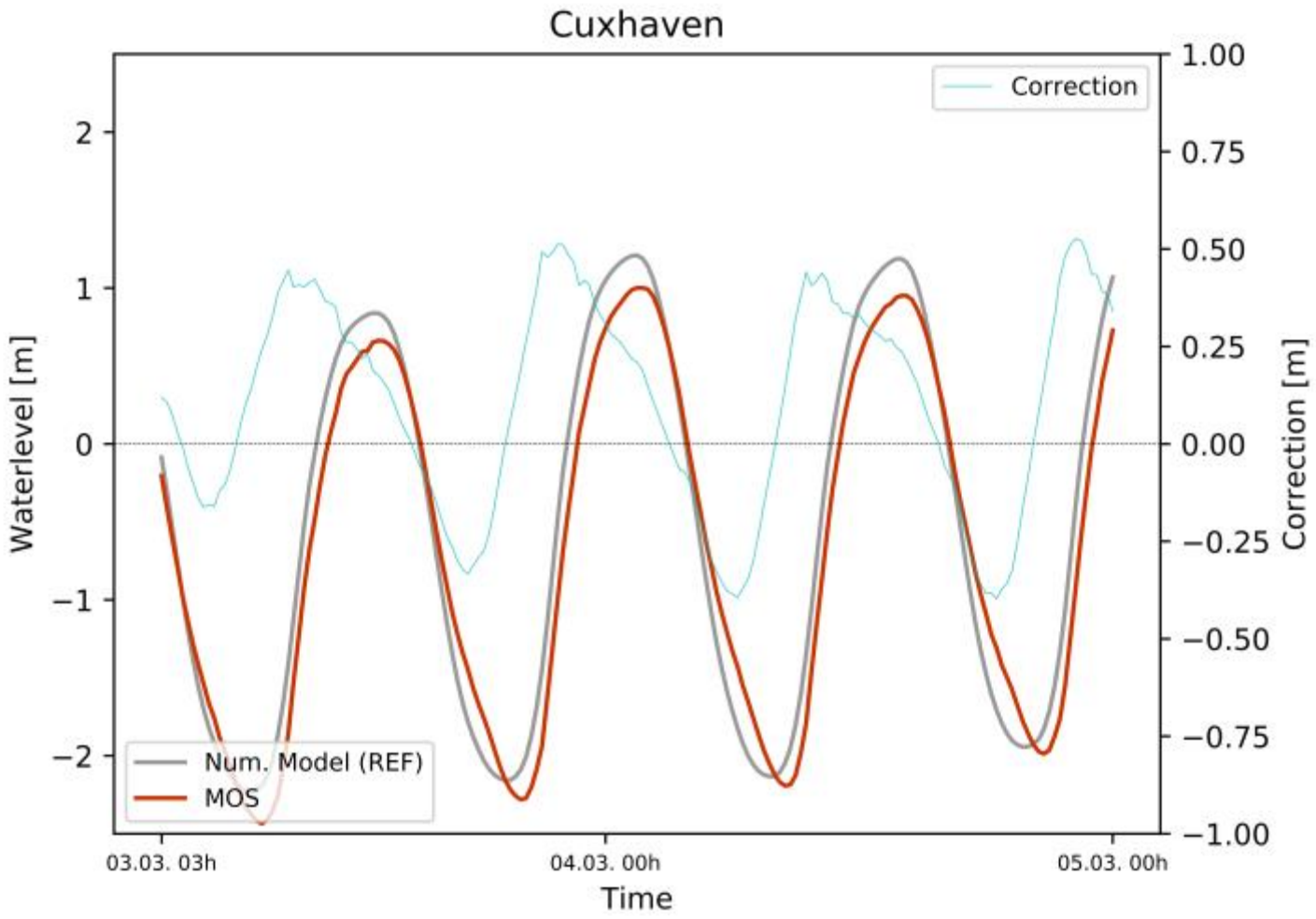
02 Generation of difference-surfaces by means of spatial interpolation

03 Correction of numerical model results for water level by subtracting generated difference surfaces

Optimization of state-of-the-art products



Optimization of state-of-the-art products



Three-step method:

01 Calculation of differences between numeric Model-output and MOS-results at discrete locations

02 Generation of difference-surfaces by means of spatial interpolation

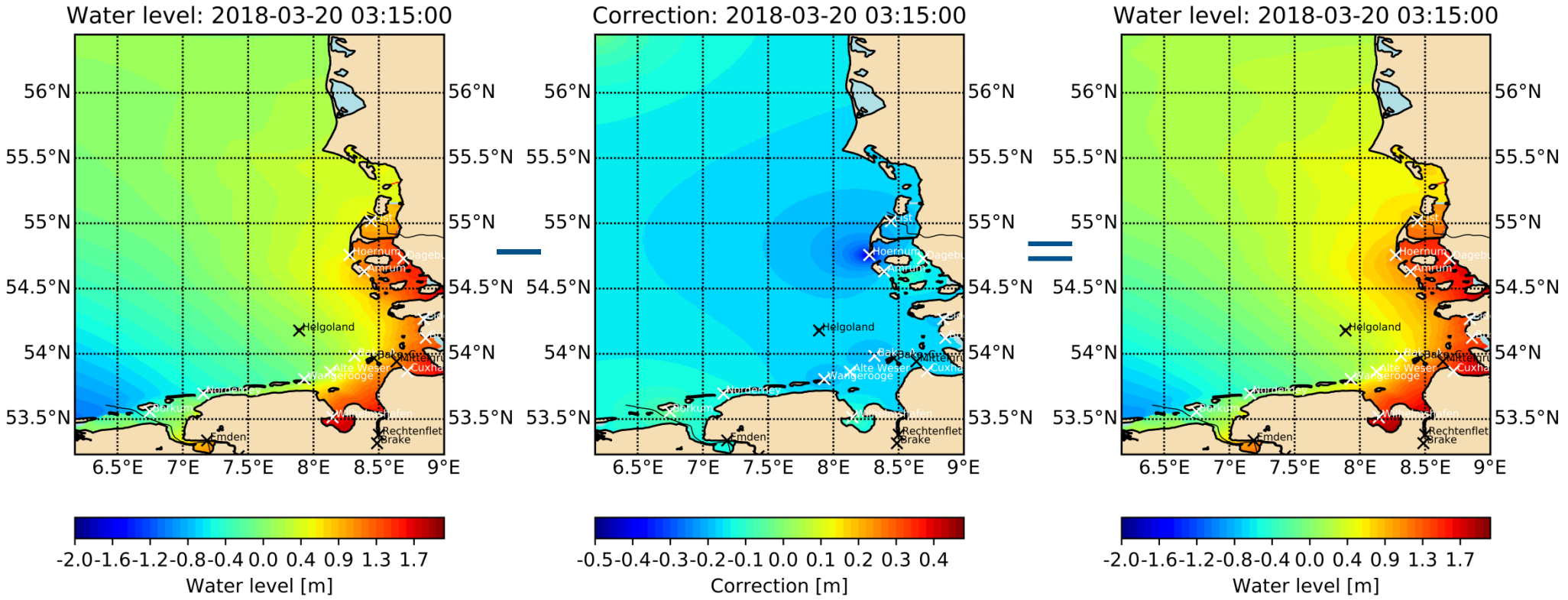
Method: Inverse Distance Weighting (Hartkamp et al. 1999)

⟹ **Result: Continuous water level surface**

03 Correction of numerical model results for water level by subtracting generated difference surfaces

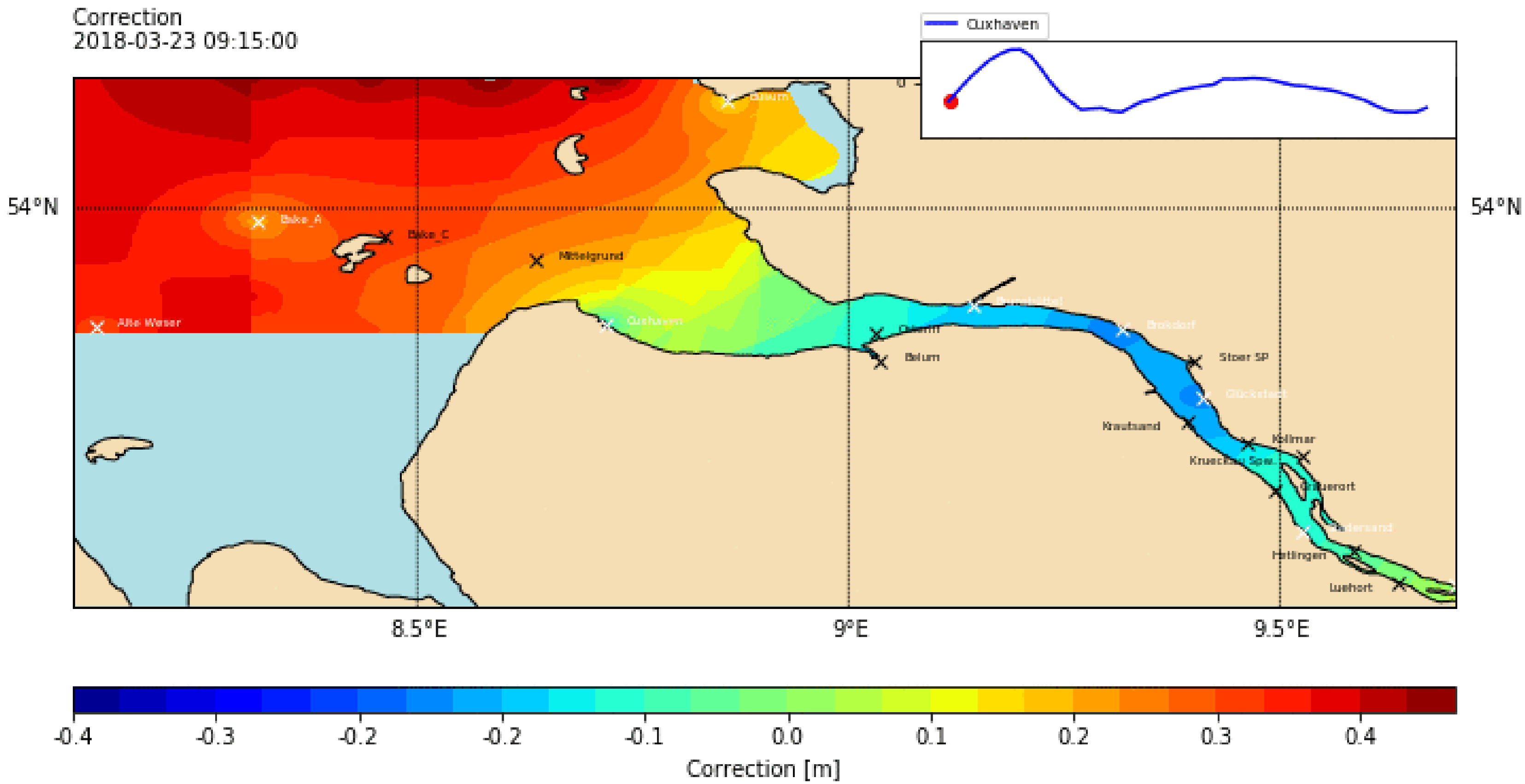
3. Surface Correction

- For each grid point the interpolated correction-value is subtracted from the original model water level surface

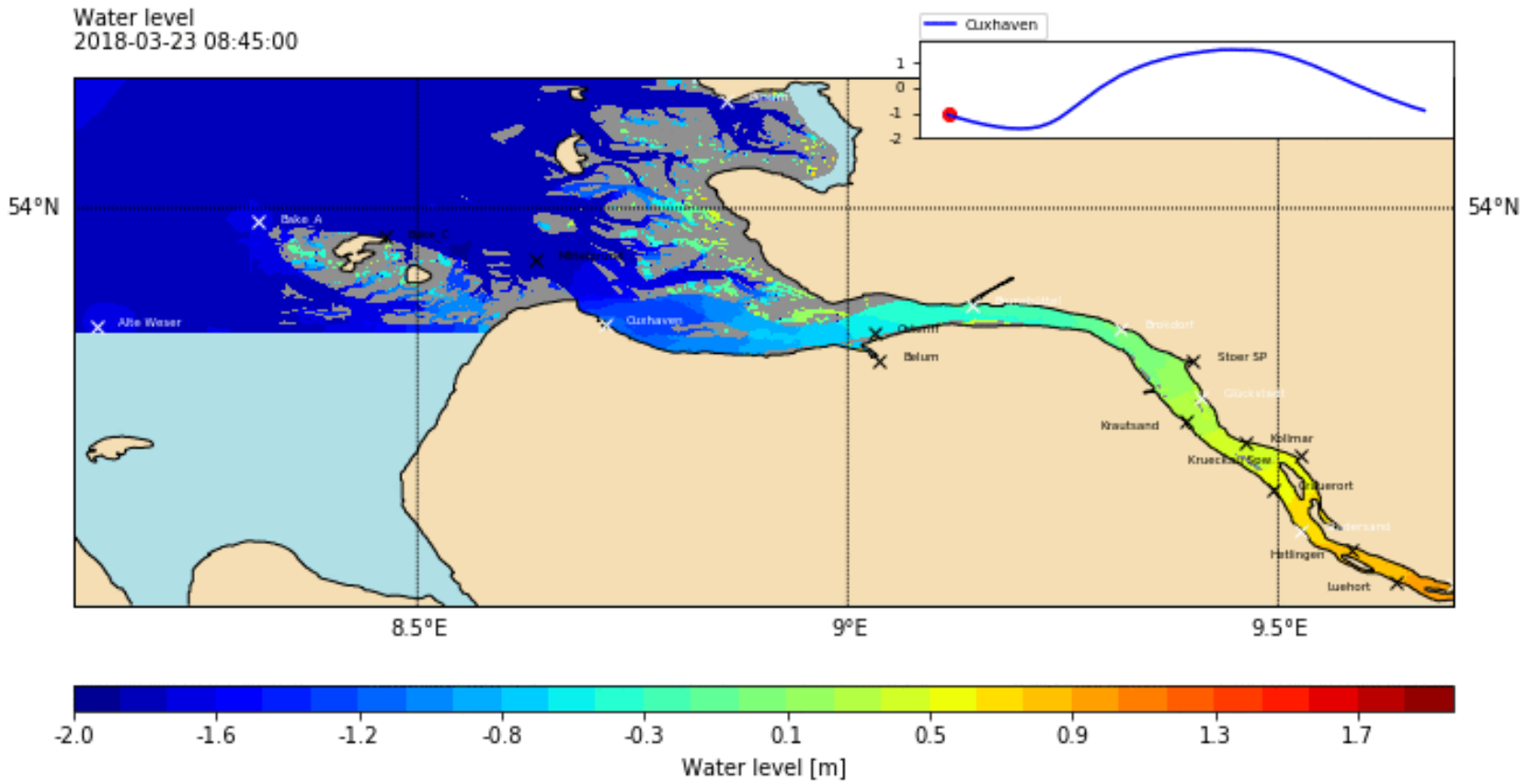


Generation of dynamic water levels surfaces

Results



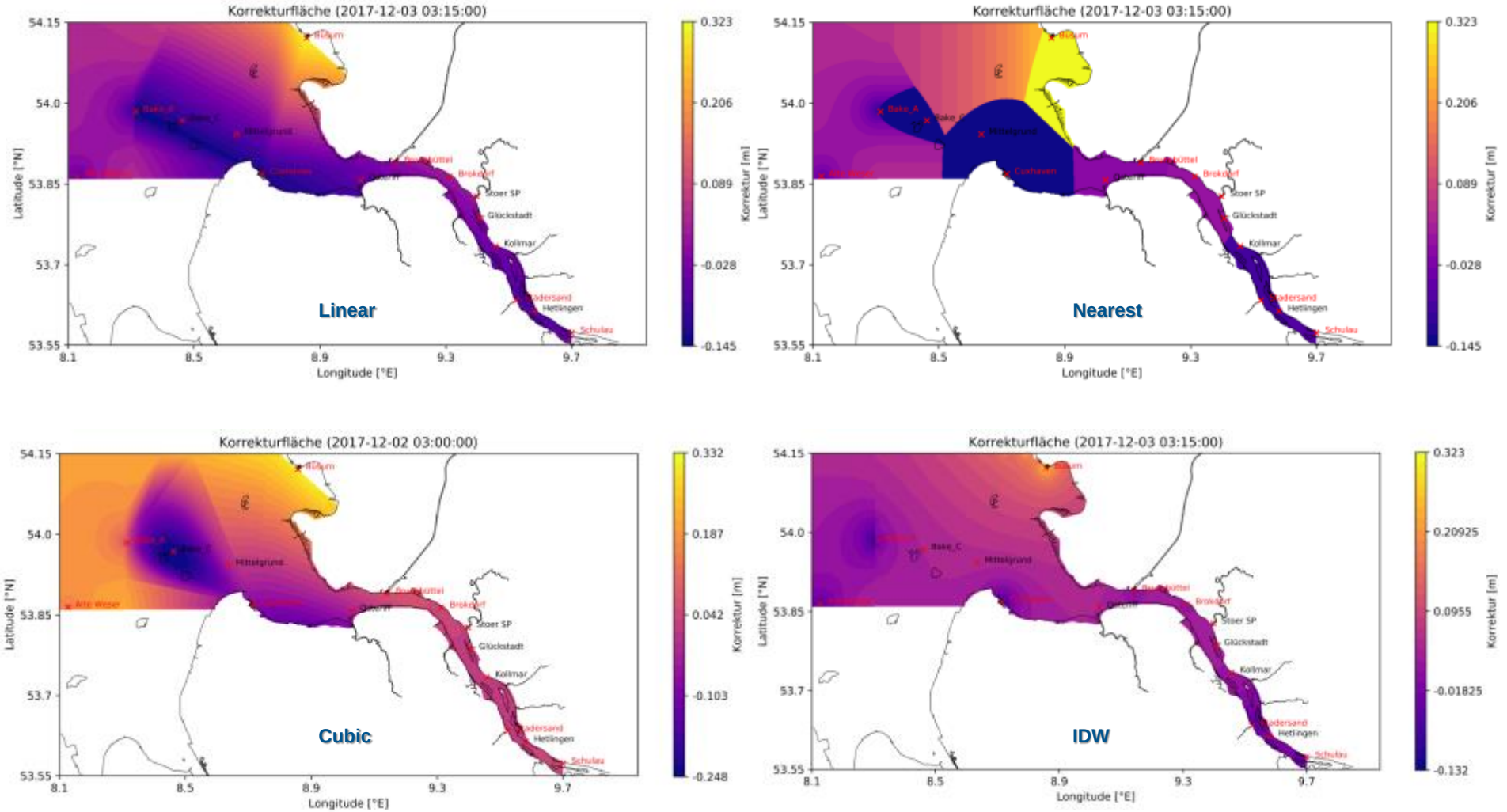
Results


Water level
2018-03-23 08:45:00
Cuxhaven
1
0
-1
-2
54°N
54°N
Bake A
Bake C
Alte Weser
Cuxhaven
Belum
Brokdorf
Stoer SP
Krautsand
Kollmar
Hetlingen
Lueehort
8.5°E
9°E
9.5°E
-2.0
-1.6
-1.2
-0.8
-0.3
0.1
0.5
0.9
1.3
1.7
Water level [m]

Validation

- Validation is performed at those points where observational data are existent and no MOS-data have been integrated
- Different interpolation methods are tested
- Analysis of important statistical values
  - Bias, RMSE, correlations etc.
  - Numerical model forecast serves as reference case

Validation: Interpolated surface comparison

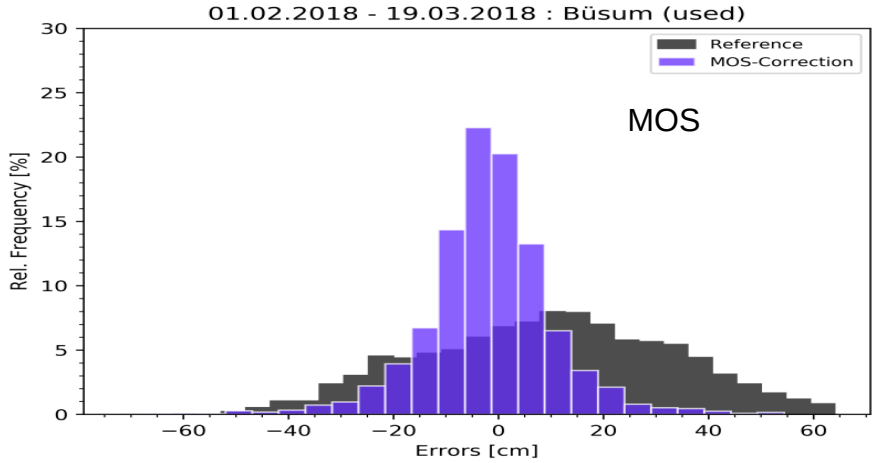


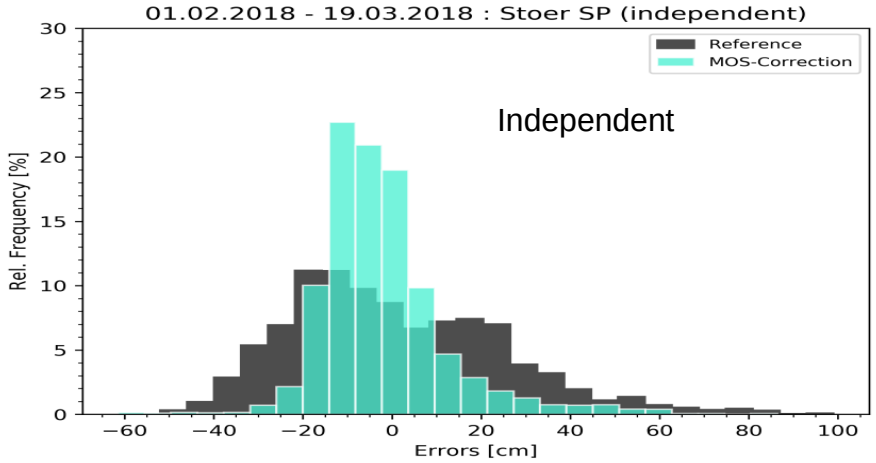
Validation: Inverse distance weighting (IDW)

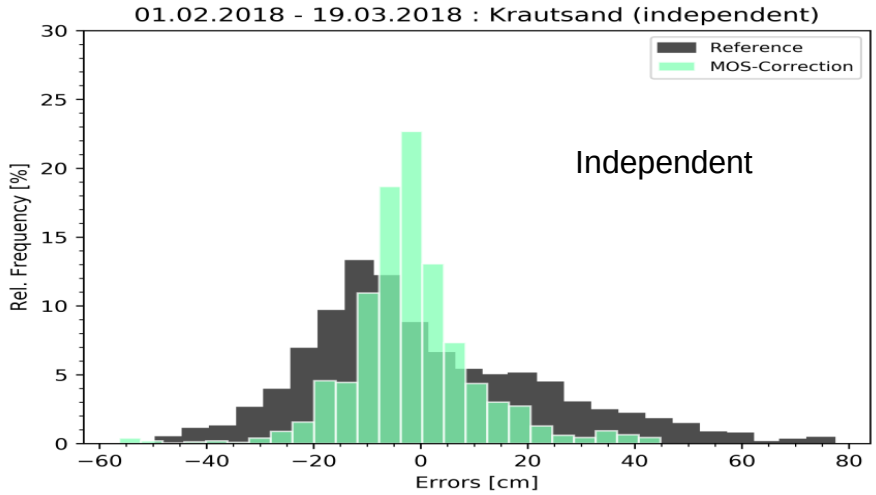
Exemplary validation at selected locations

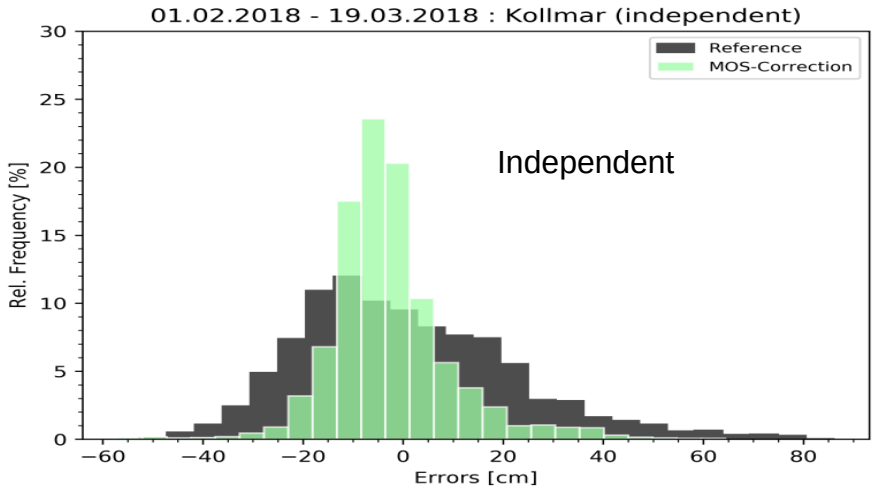
Validation: Inverse distance weighting (IDW)

Relative frequency of the forecast-errors [cm] within the 0h-24h forecast interval





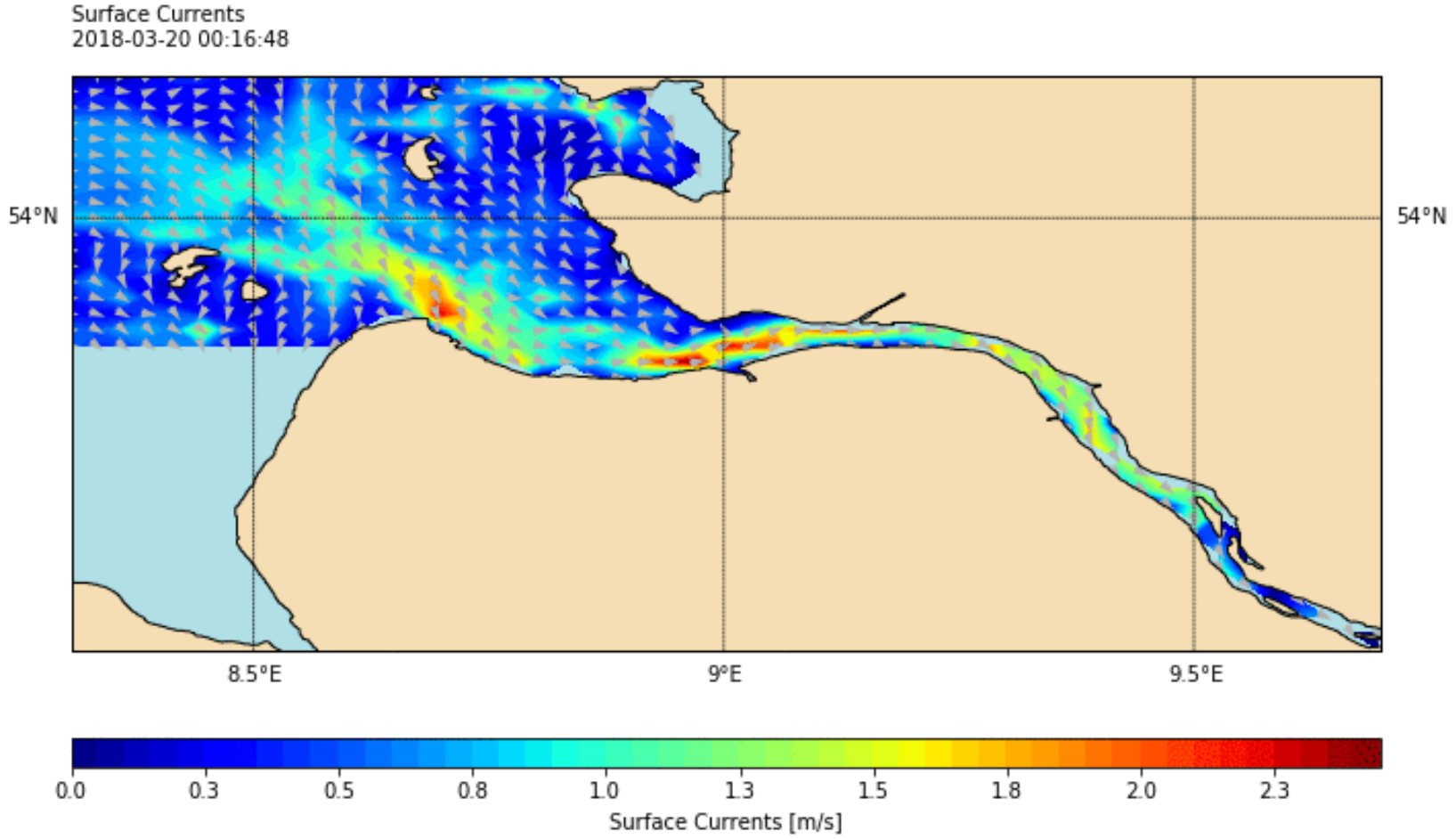




Sea surface currents

- Processing of numerical model output for sea surface currents
- Generation of test data for different areas
  - NETCDF4
- Graphic representation and provision of datasets for our project partners
- Conversion into HDF5 in order to prepare for the IHO-standards
  - E.g. S111 (Sea surface currents)

Sea surface currents



Outlook

- Continuation of validation procedure
  - Longer period under consideration, more locations
  - Estimation of uncertainties (method, underlying forecast)
  - Run procedure with observational data to analyze method error
- Conversion in IHO-compatible formats
  - S104 (Water level), S111 (Sea surface currents)
- Automation
  - Preoperational establishment
- Extension of area of interest
  - German Bight, Western Baltic Sea

Thank you!

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Federal Maritime and Hydrographic Agency (BSH)

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

- Maritime authority of the Federal Republic of Germany
- Maritime government research agency in the Federal Ministry of Transport and Digital Infrastructure
- Five departments:
  - Maritime security and general services to shipping
  - Nautical and hydrographic information services
  - Marine Science and Services
  - Management of the Sea
  - Central department

BSH Hamburg