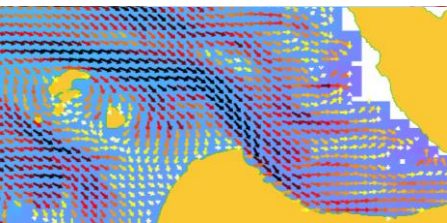


TWCWG 3 Meeting, Viná del Mar, Chile, 16 - 20 April 2018



Integration of oceanographic data into electronic navigation systems - project ImoNav

Luis Becker and Stephan Dick, BSH



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?

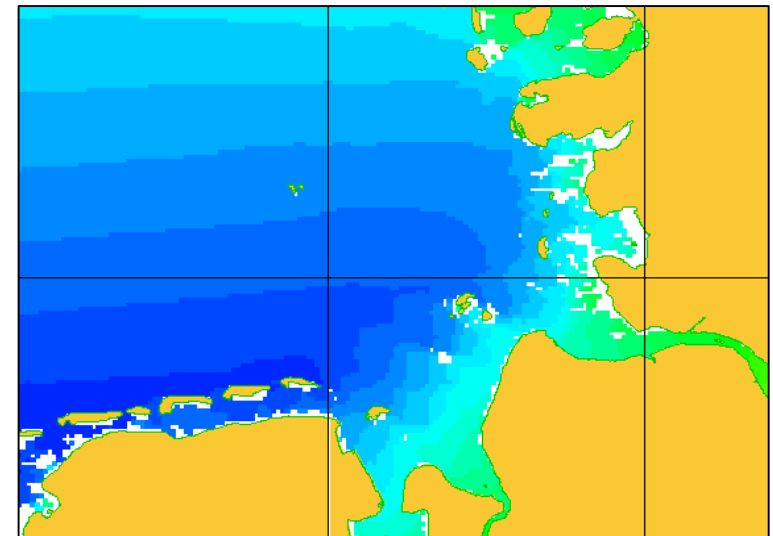
- BSH (coordinator) and two companies (smile consult and SevenCs)



Project objectives



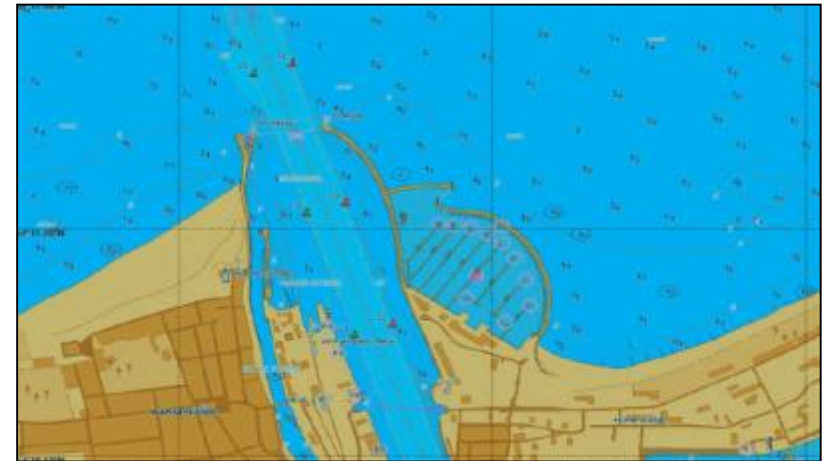
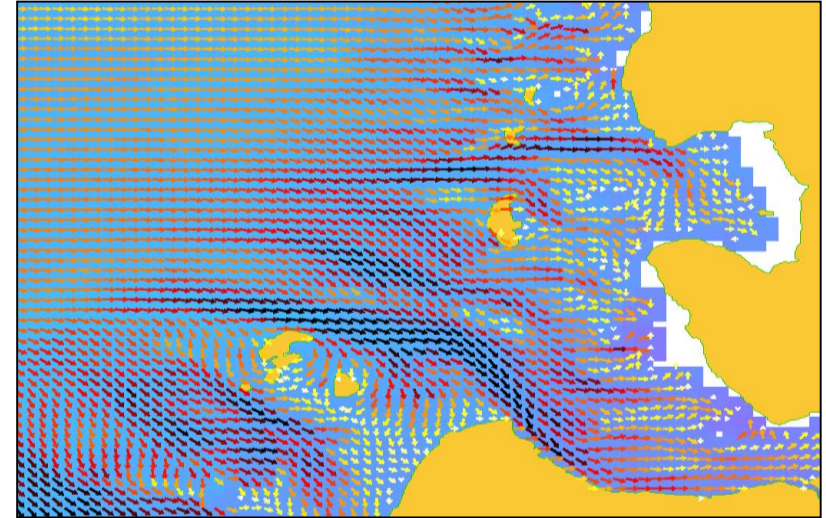
- Develop an innovative high resolution navigation service for (German) marine water ways (e.g. Elbe und Weser estuary and coastal waters)
- Collect and merge high resolution hydrographic data from different institutions
- Combine bathymetric with water level data as well as optimized forecasts
- Provide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



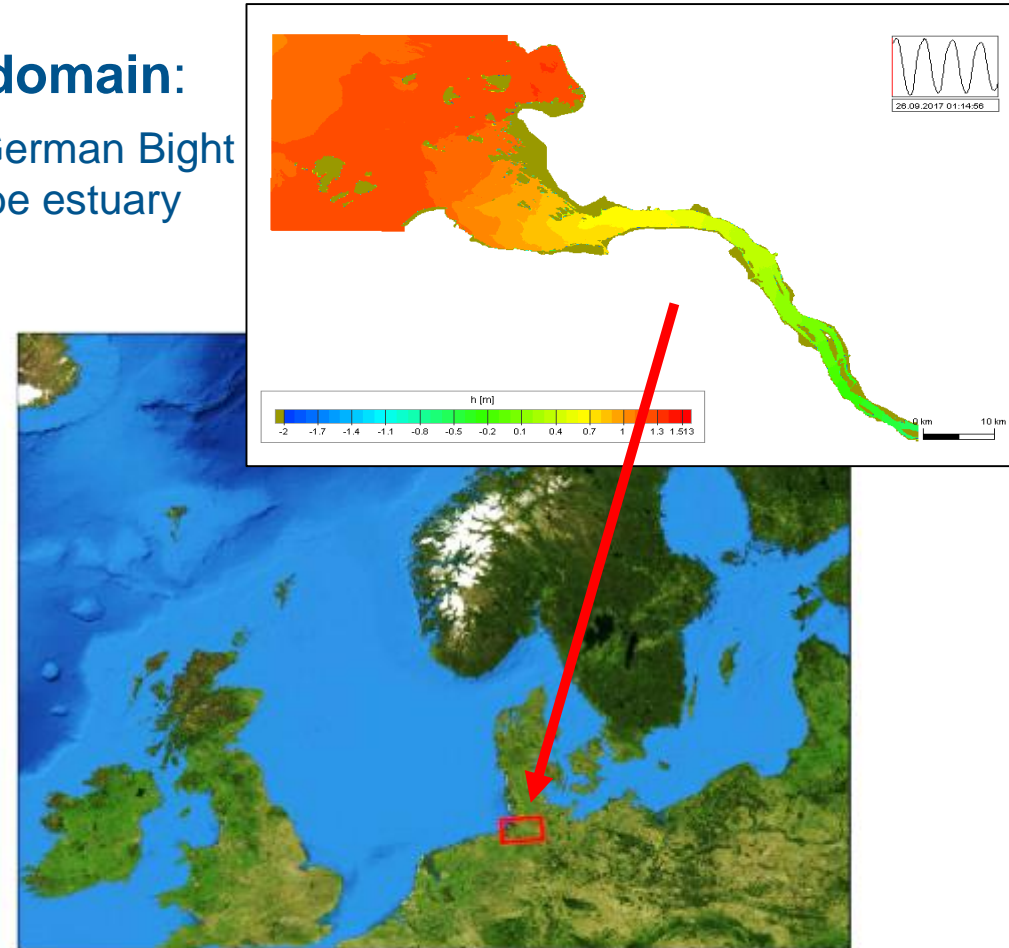
Project structure

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 ENC/ECDIS and demonstration

Test domain:

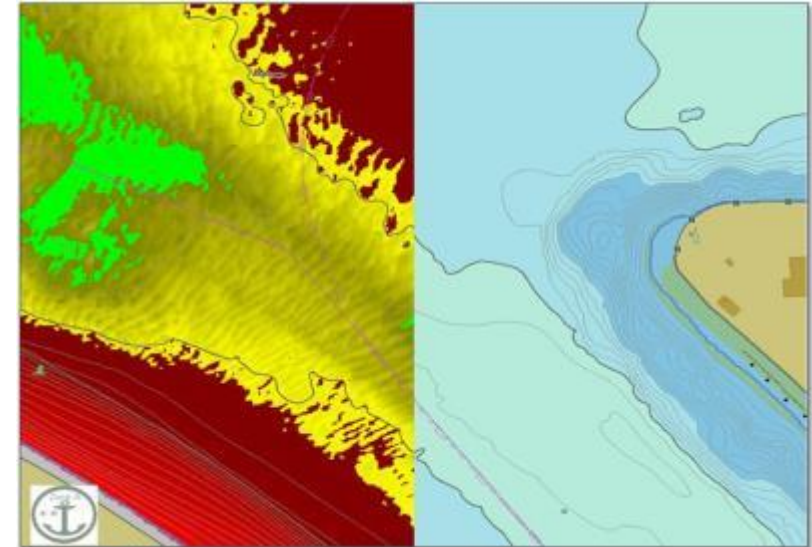
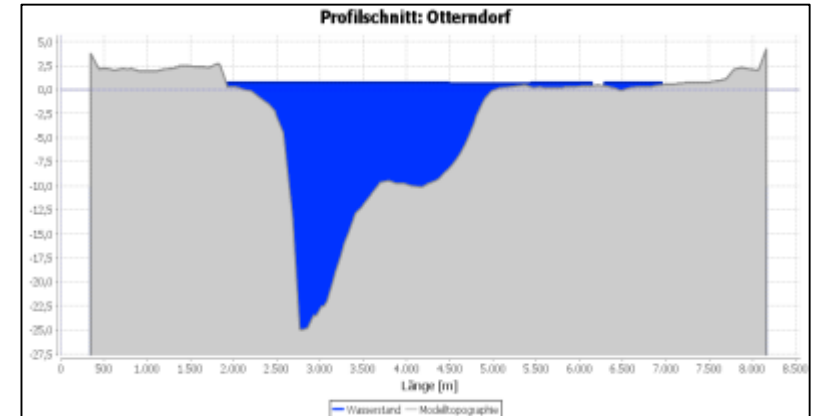
Inner German Bight and Elbe estuary



Products, users and further applications

ImoNav will provide innovative products for navigation and ship routing

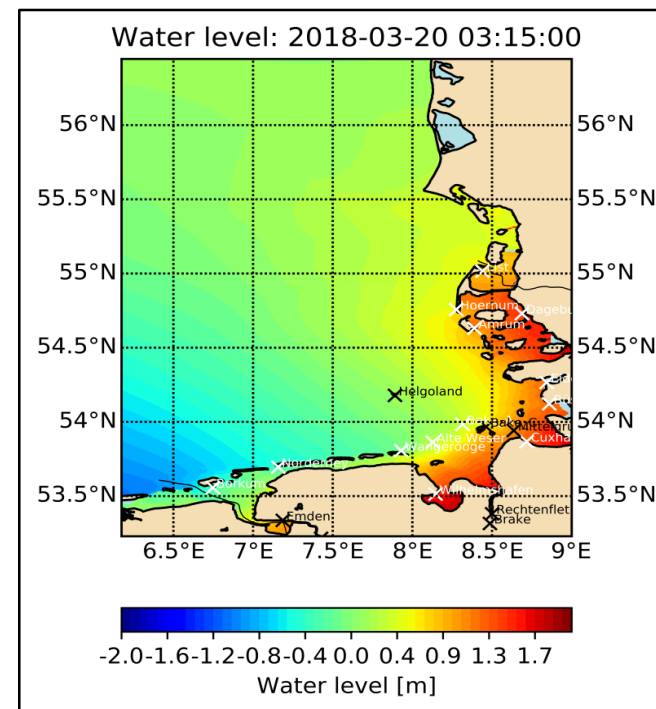
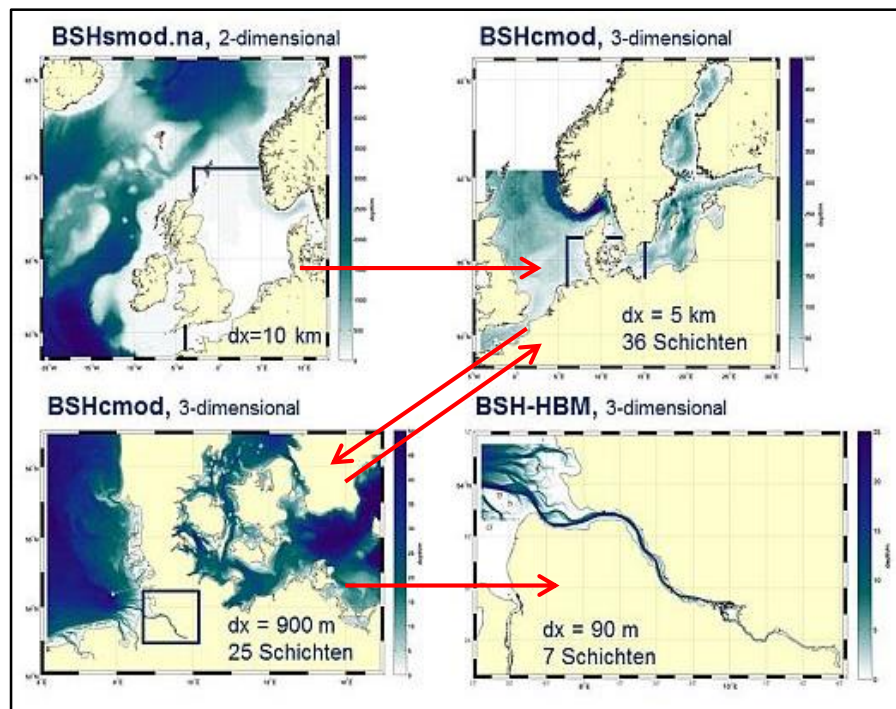
- Output according international (IHO-) standards (e.g. S-100, S-101, S-102, S-104, S-111,...)
- Application for dynamic route planning
- Quality management and safety checks
- Evaluation and demonstration (pre-operational test)
- Main users are shipping companies and administration, pilots, as well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





BSH provides two (automated) water level forecasts

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





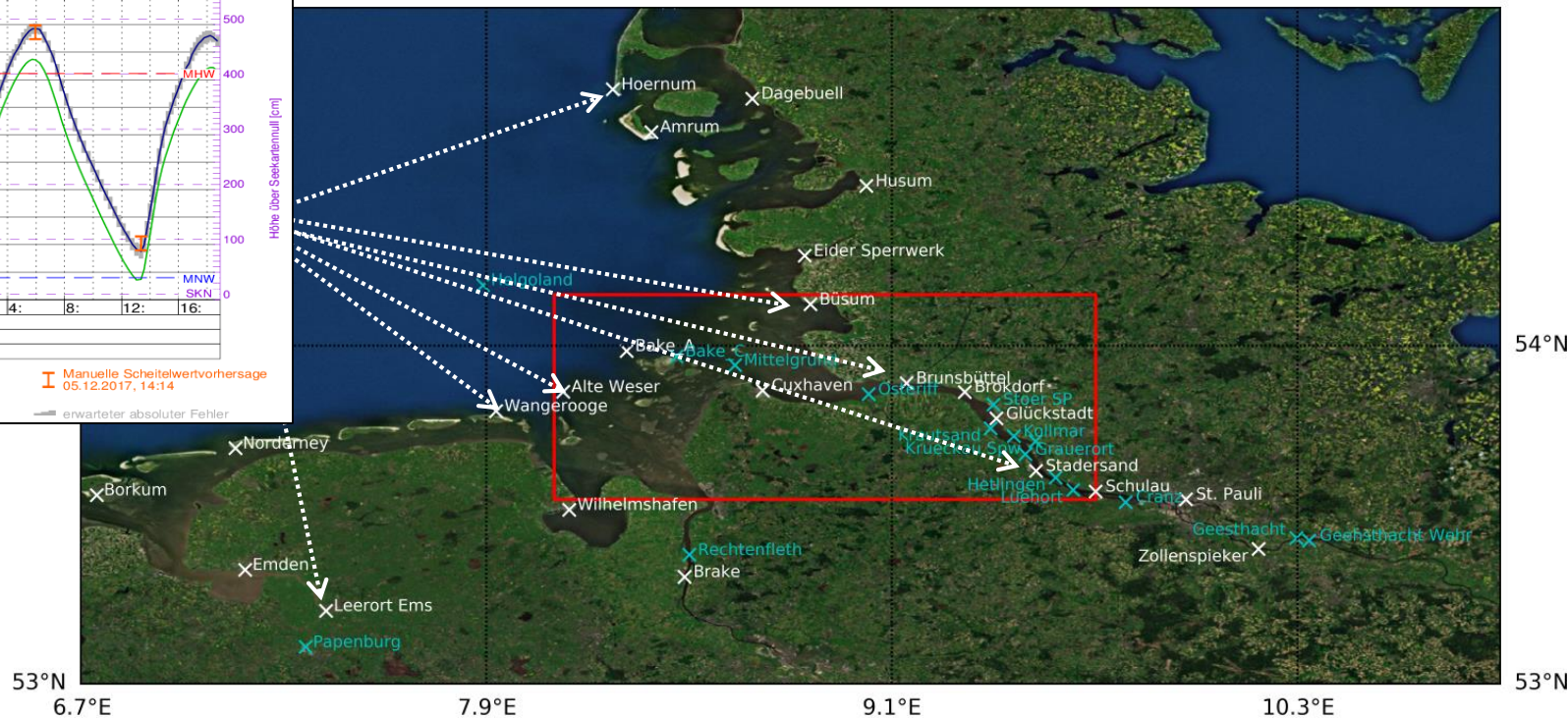
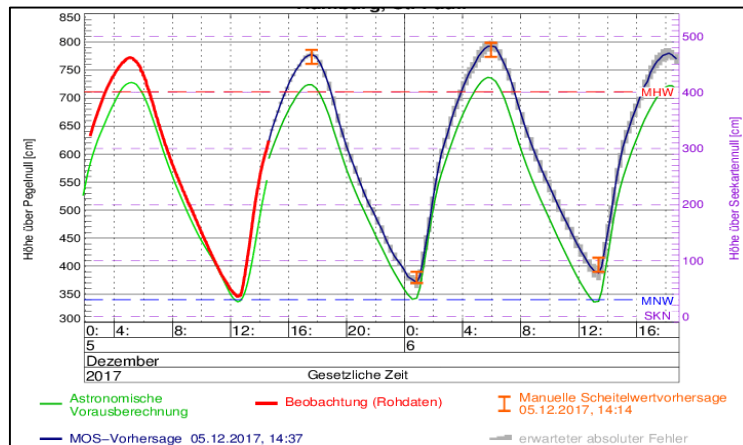
Generation of dynamic water levels surfaces

Data sources: Model output statistics



02

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



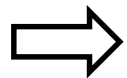


Numerical Model

- + 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



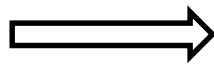
Idea: Subsequent correction of numerical model results by means of generating a correction-surface out of MOS-results



Three-step method:

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

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

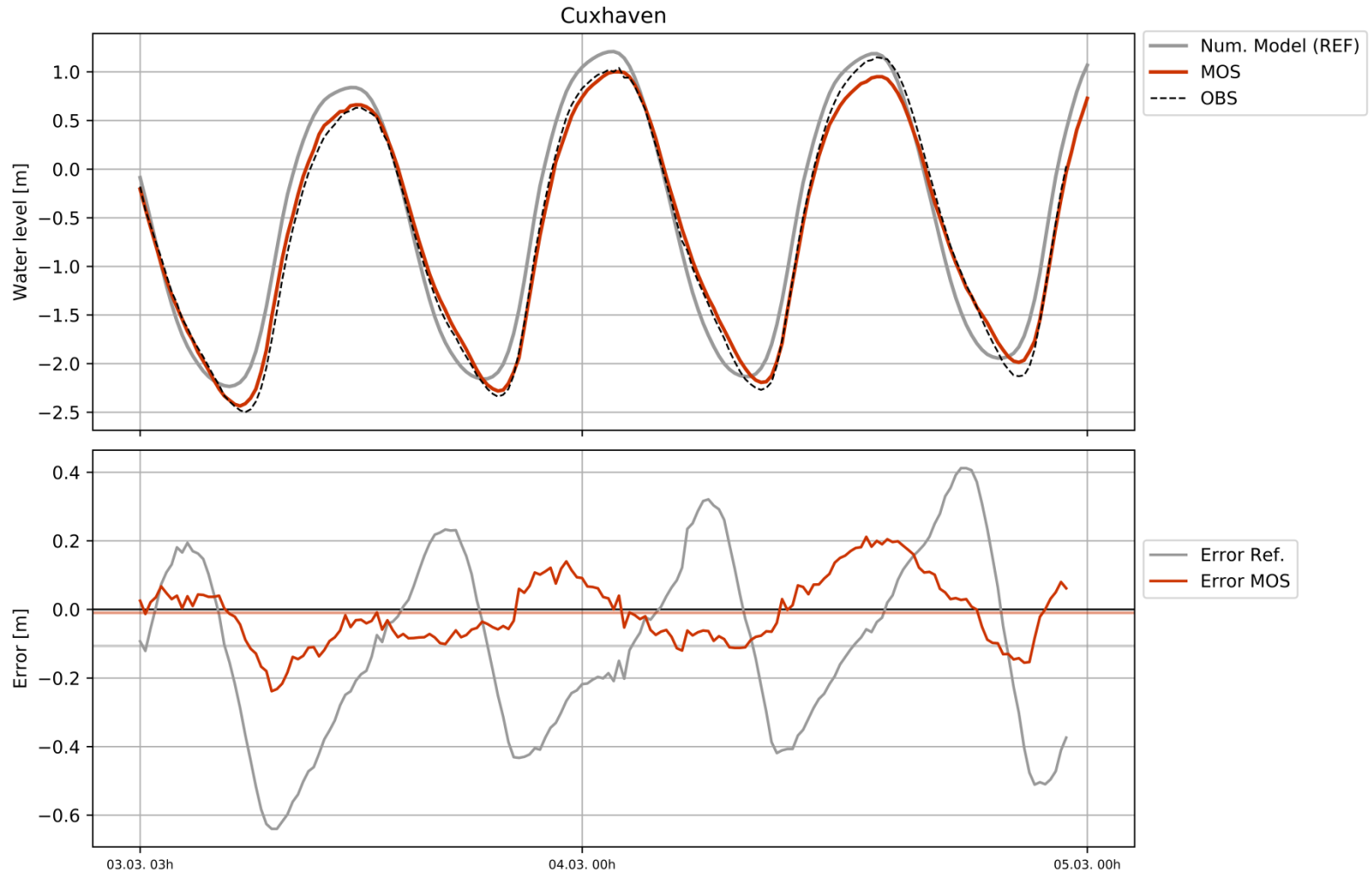


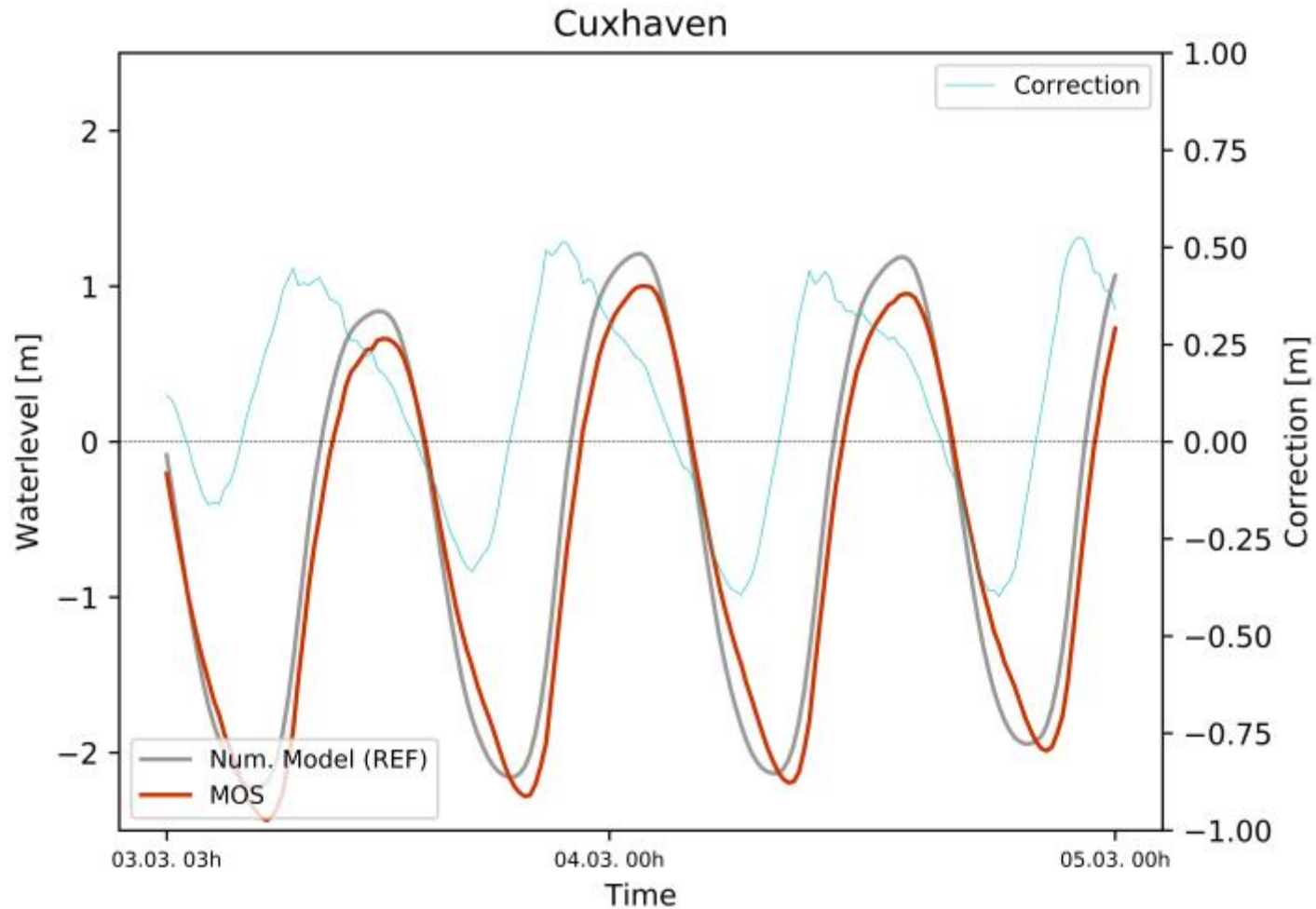
Result: Differences at discrete locations

- 02 Generation of difference-surfaces by means of spatial interpolation
- 03 Correction of numerical model results for water level by subtracting generated difference surfaces



Generation of dynamic water levels surfaces Optimization of state-of-the-art products



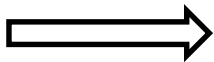




Three-step method:

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)



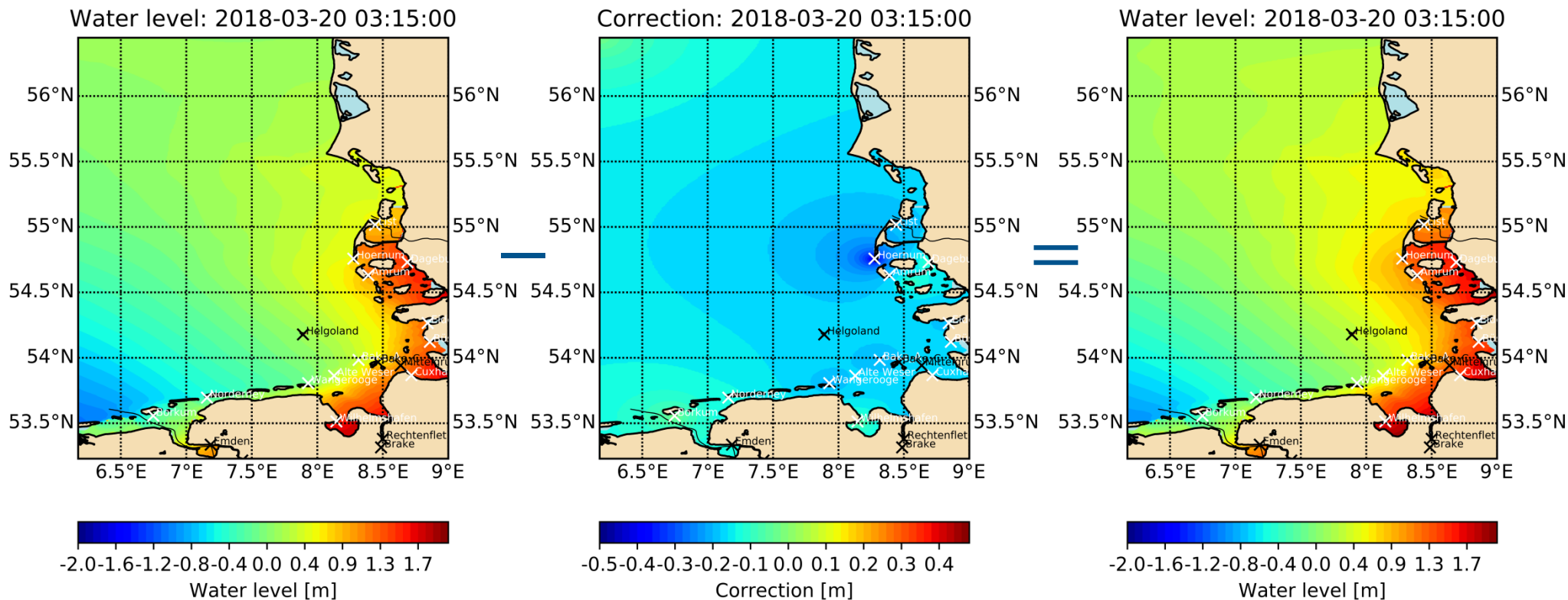
Result: Continuous water level surface

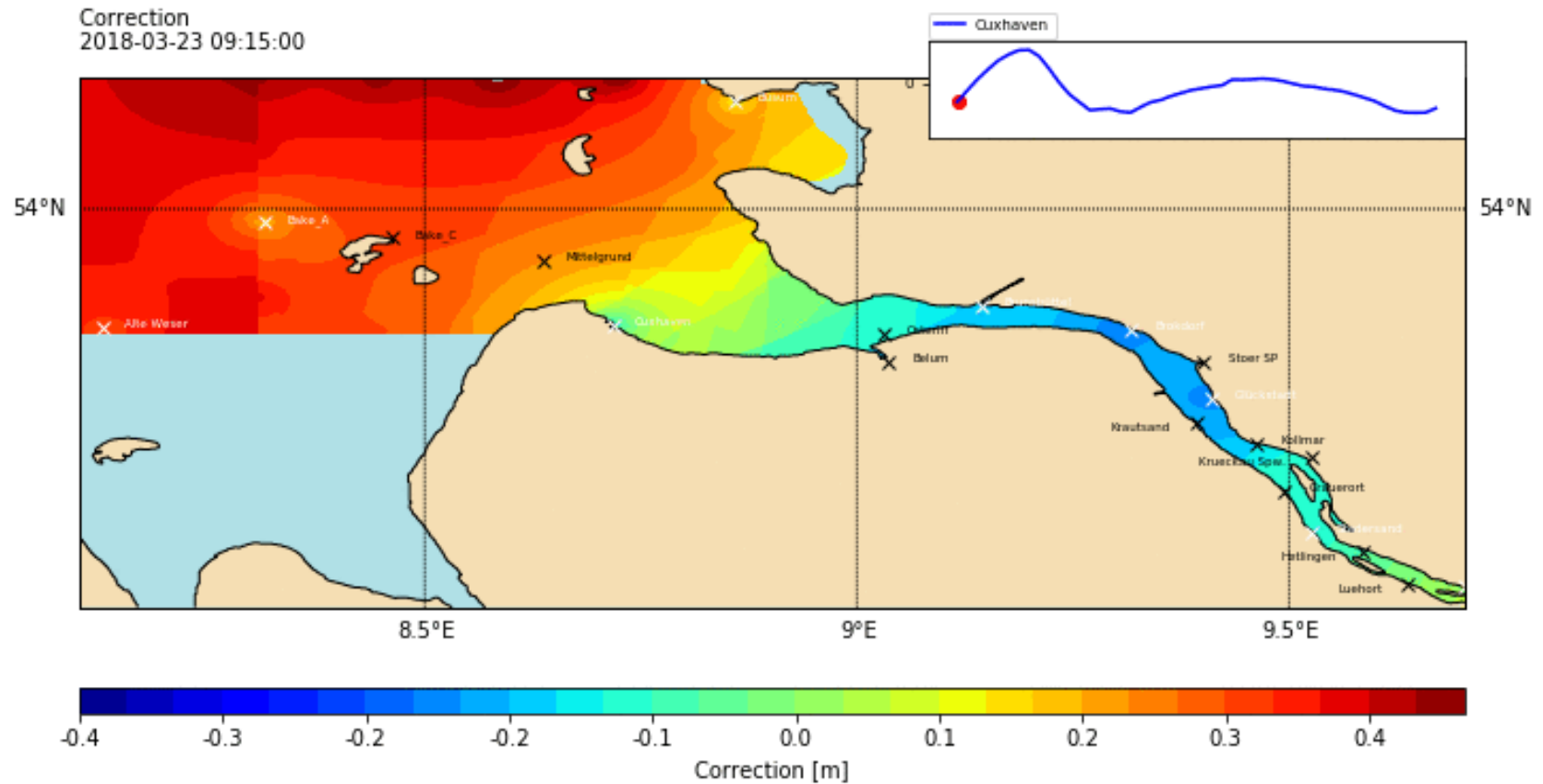
03 Correction of numerical model results for water level by subtracting generated
difference surfaces



3. Surface Correction

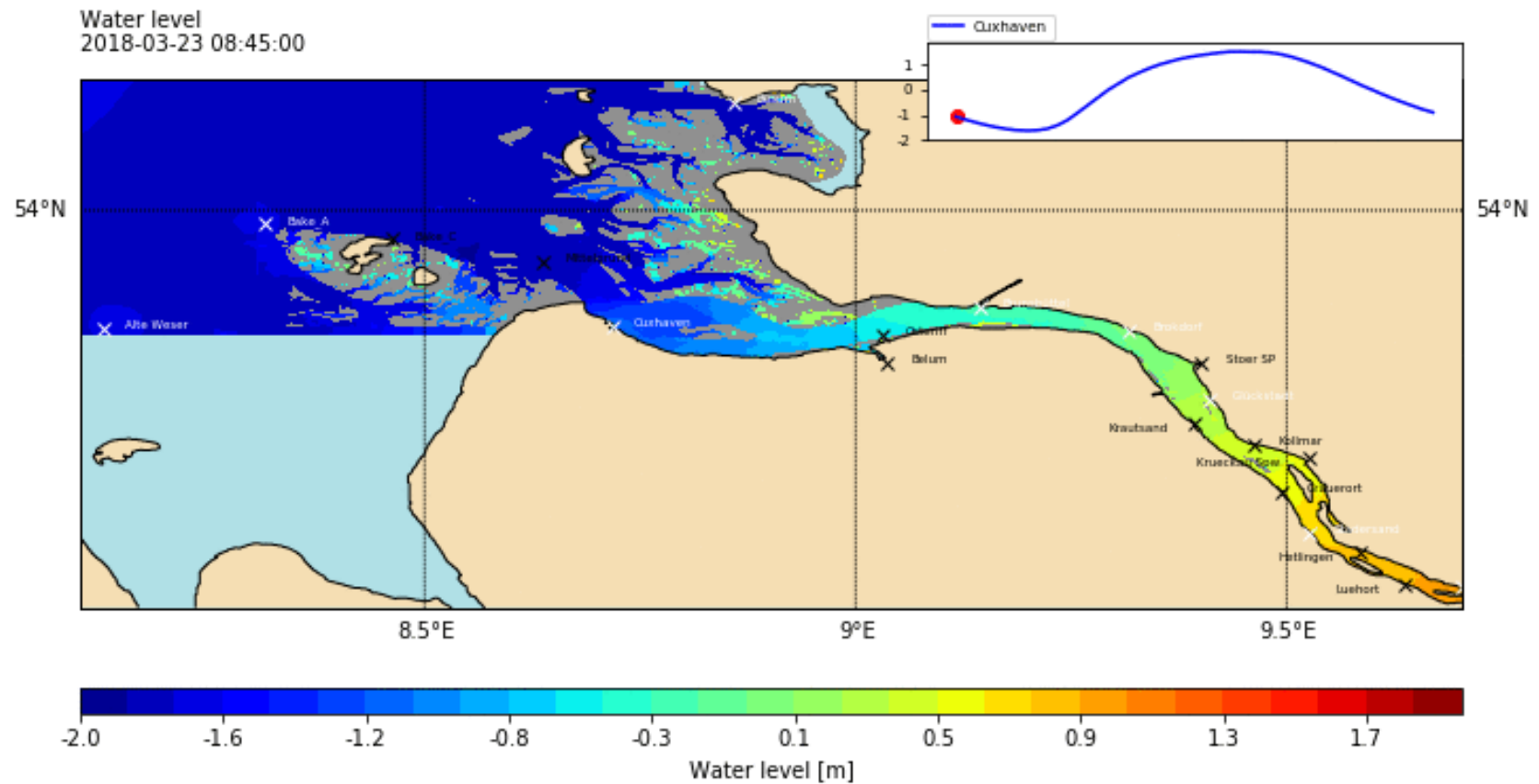
- For each grid point the interpolated correction-value is subtracted from the original model water level surface







Generation of dynamic water levels surfaces Results



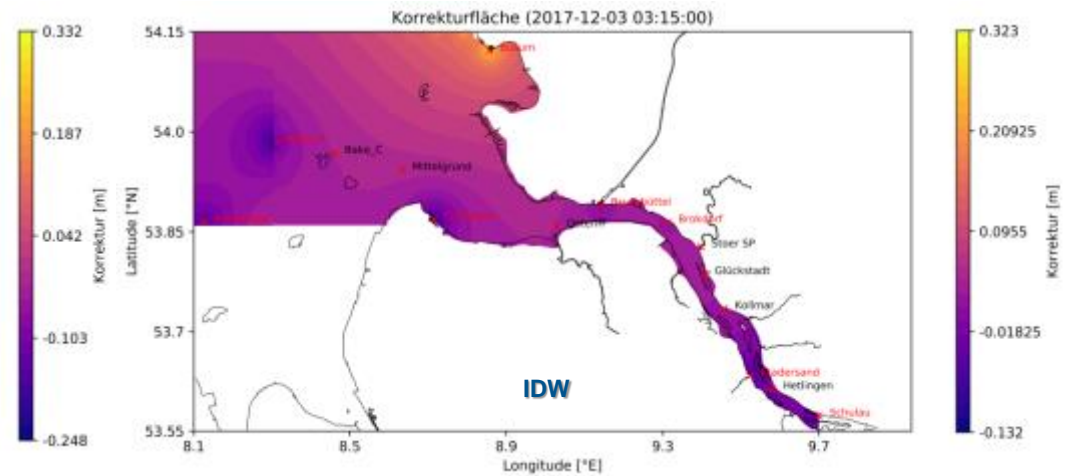
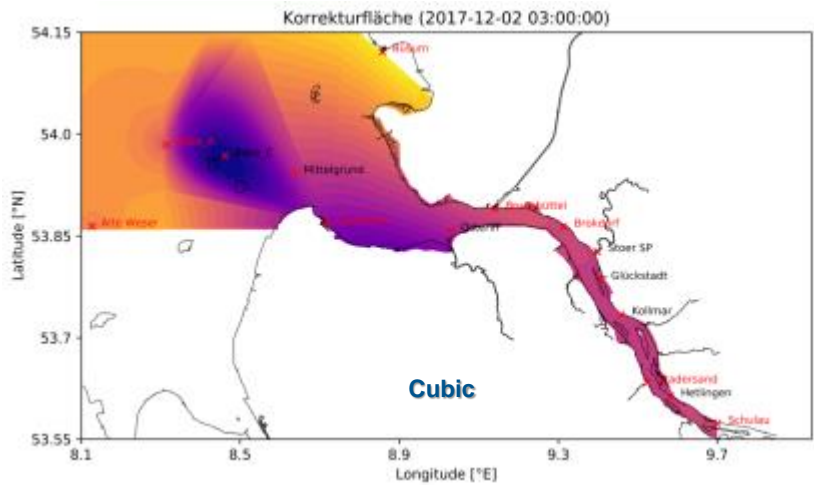
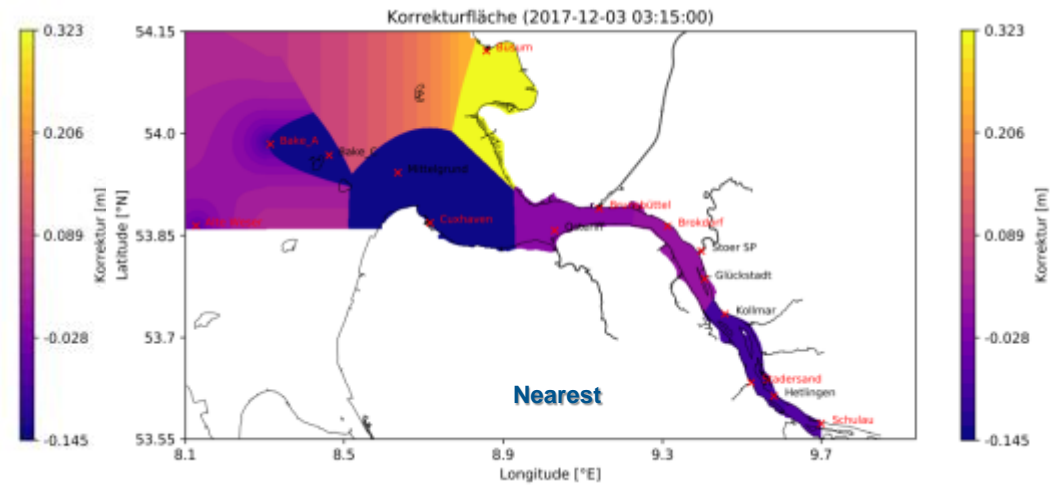
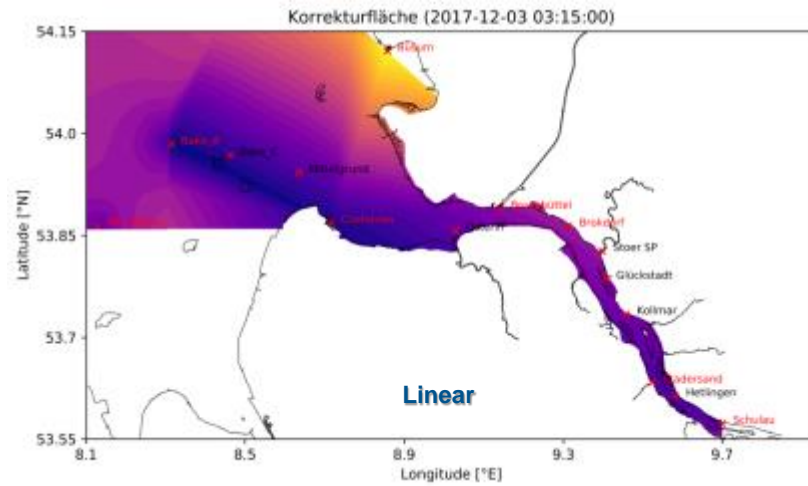


- Validation is performed at those points where observational data are existent and no MOS-data have been integrated
- Different interpolation methods are tested
- Analysis of important statistical values
 - Bias, RMSE, correlations etc.
 - Numerical model forecast serves as reference case



Generation of dynamic water levels surfaces

Validation: Interpolated surface comparison



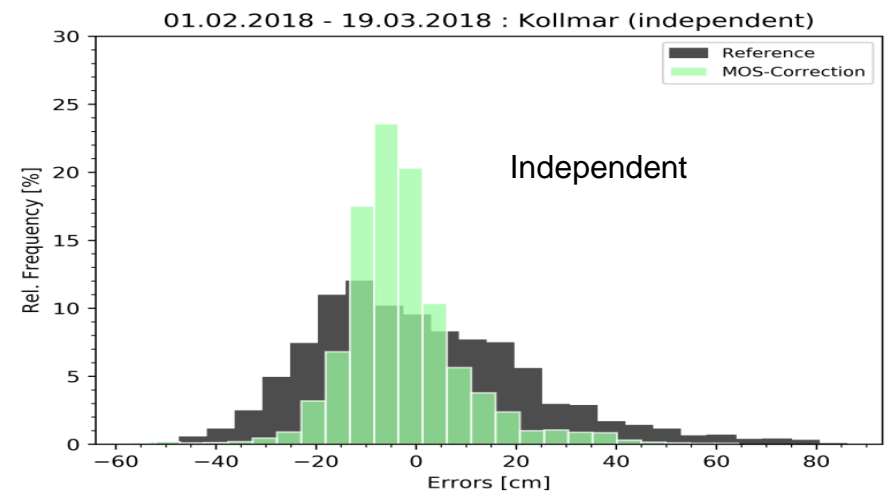
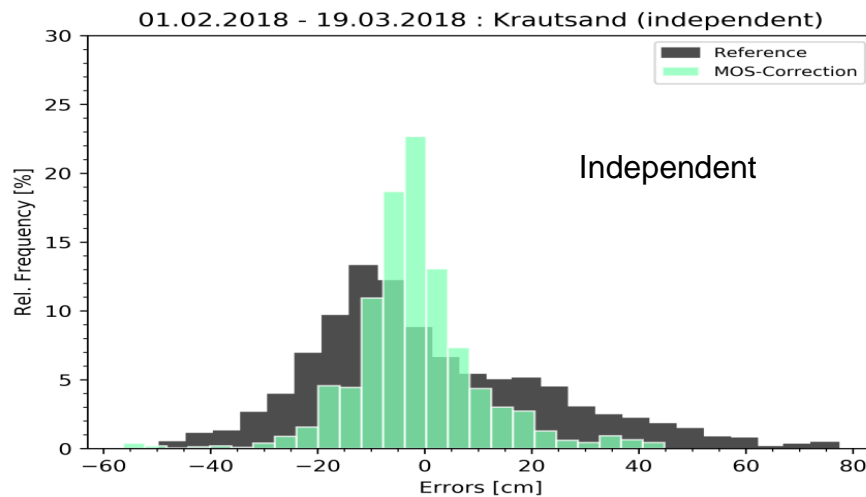
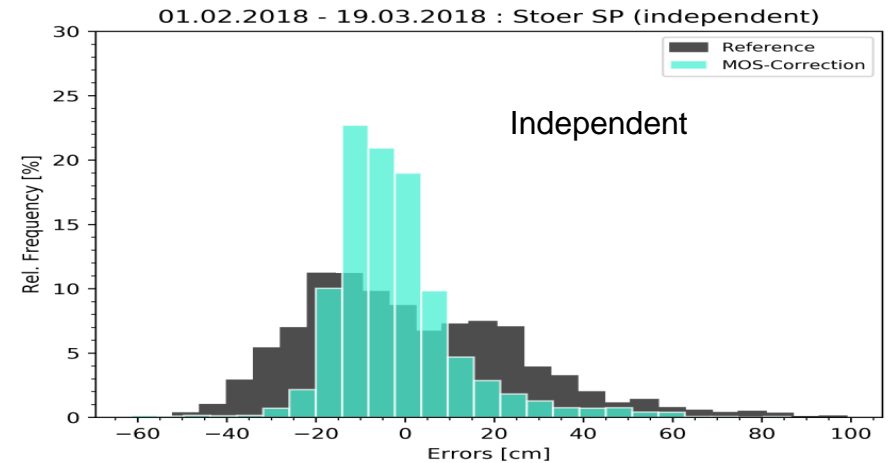
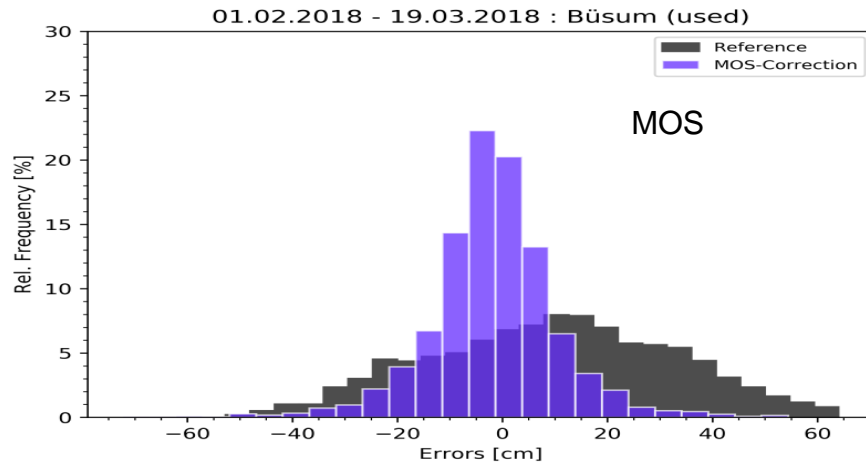


Exemplary validation at selected locations





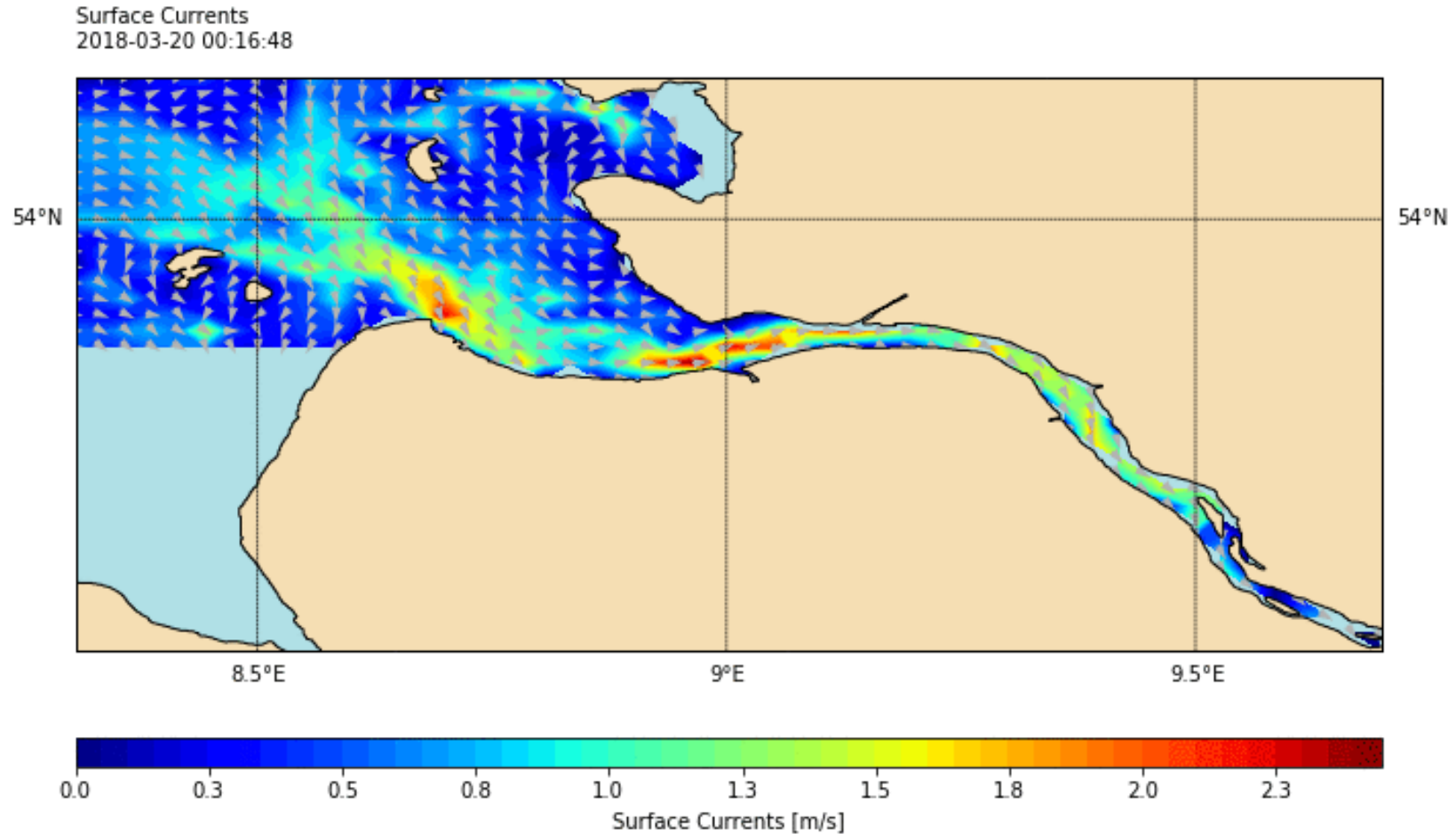
Relative frequency of the forecast-errors [cm] within the 0h-24h forecast interval





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)



- 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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Bundesministerium
für Verkehr und
digitale Infrastruktur

ImoNav - TWCWG 3 Meeting 2018



Federal Maritime and Hydrographic Agency (BSH)

- 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

