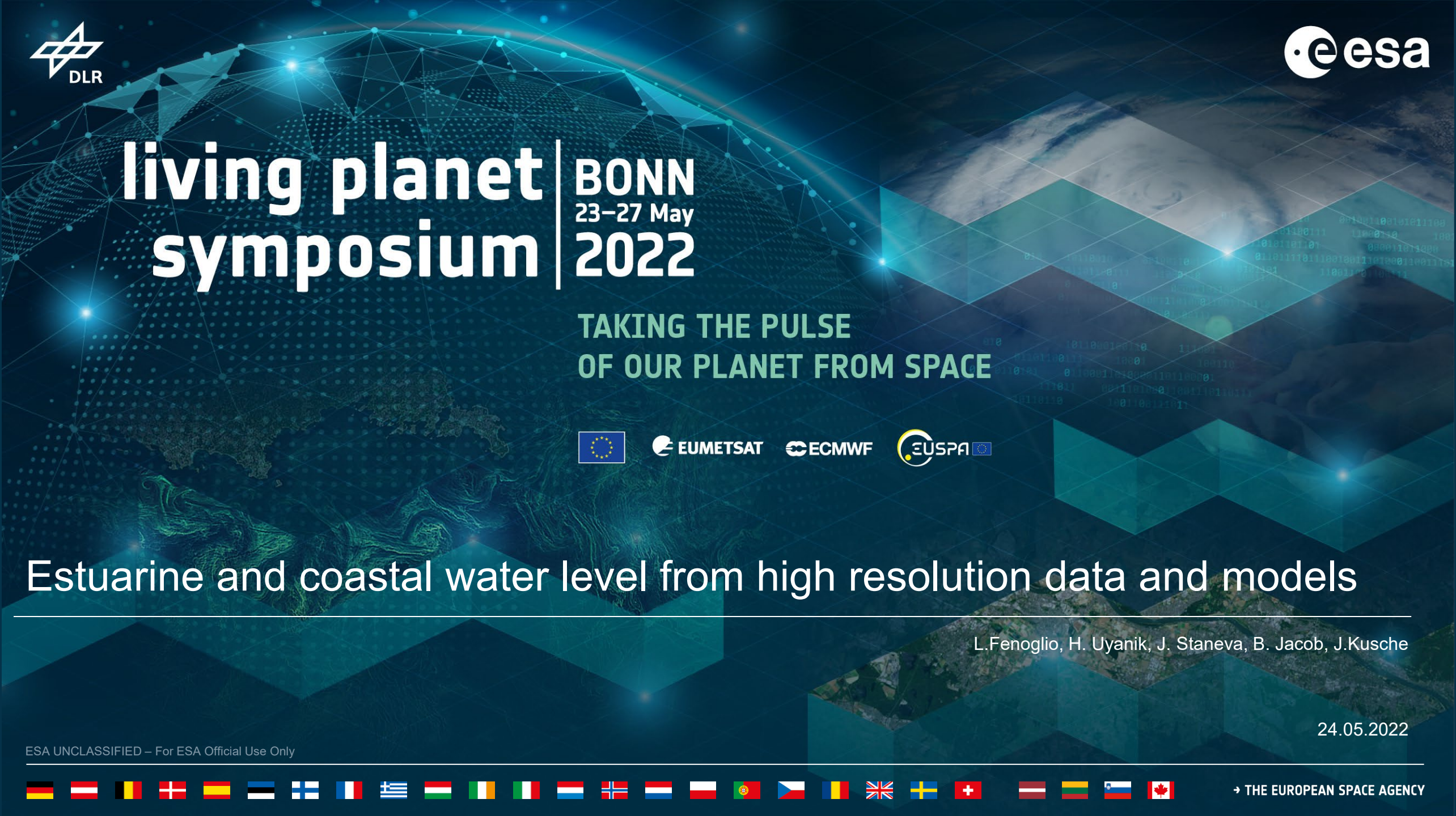


Estuarine and coastal water level from high resolution data and models

L.Fenoglio, H. Uyanik, J. Staneva, B. Jacob, J.Kusche

24.05.2022

MOTIVATION

Coastal areas and estuaries are affected by climate changes and are at multi-risks (coastline retreat, flooding storms and river floods)

New observations: SAR and wide swath altimetry open new challenges in these areas to derive discharge and fine scale variability

New knowledge: What can we achieve with the merging of remote sensing techniques and disciplines? (ocean models, geodetic observations).

- analyse the temporal variability of hydrodynamics
- separation of tides and discharge

OUTLINE

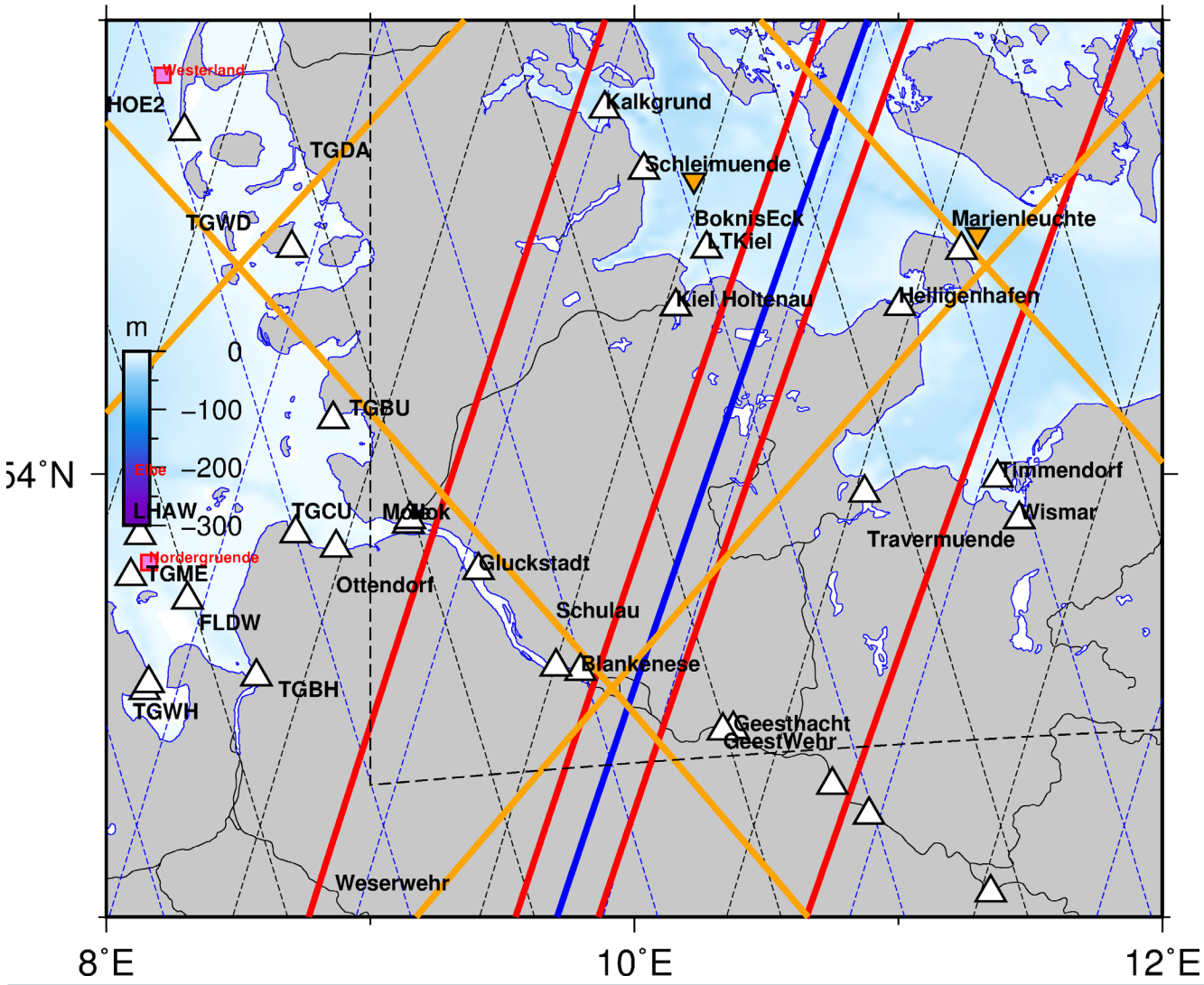
Today available nadir altimeter data

Validation

Simulation of new data

Conclusions

DATA



Satellite Altimetry:

Sentinel-3 A/B
Sentinel-6 A

SWOT

SWORD database for inland water (boundaries inland and coast)

Method: S3 vrs TG

Overpass in Coastal Zone (CZ):
Meth 1. Nearest point at 1 Hz or 20 Hz

Smallest STDD
for SAMOSA+
applied to Sentinel-3A

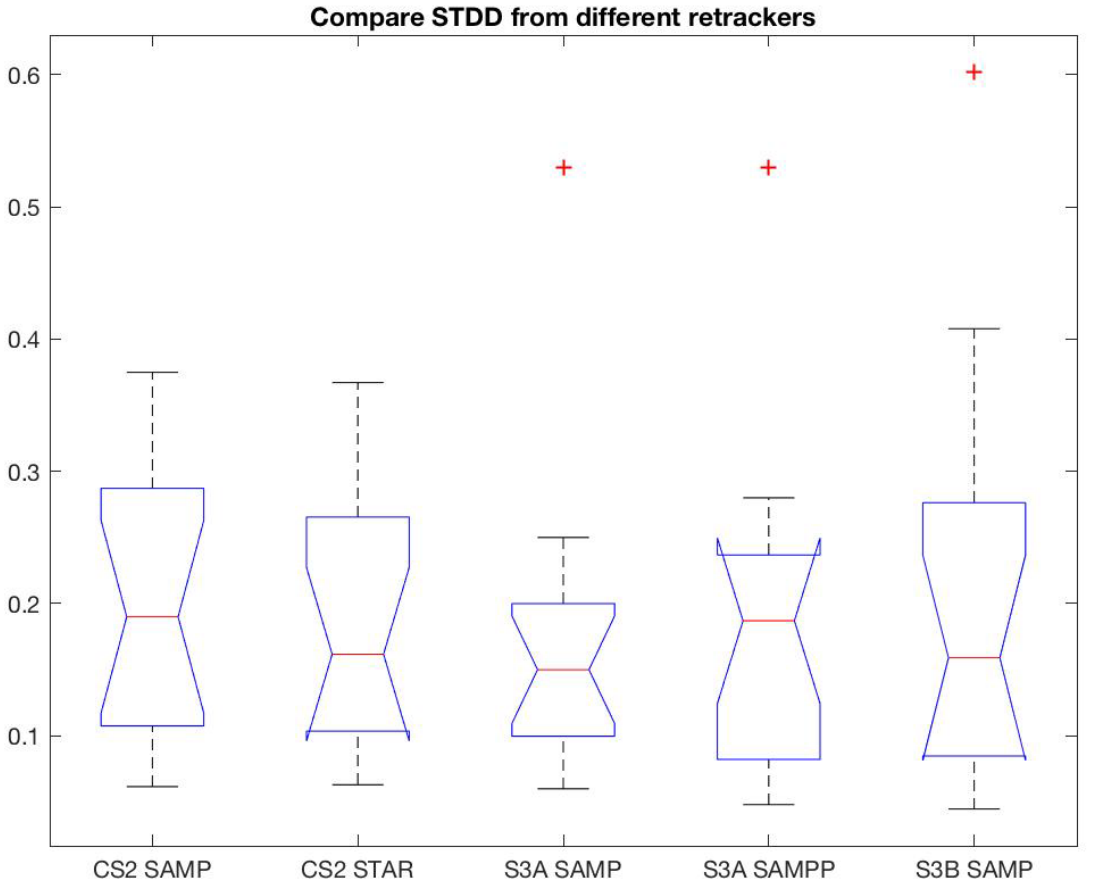


Figure : **Boxplot of standard deviation differences** between the 19 TG stations and altimetry (retrackers SAMOSA+, SAMOSA++ , STAR for CryoSat-2, Sentinel-3A, Sentinel-3B). Central mark is the median, bottom and top edges of the box the 25th and 75th percentiles, extreme data points, '+' symbol indicates the outliers.

Method: S3 vrs TG

VirtualPass in Estuary and Inland Water (EW and IW):

Meth 2. Average over part of the track (more robust for river and estuary)

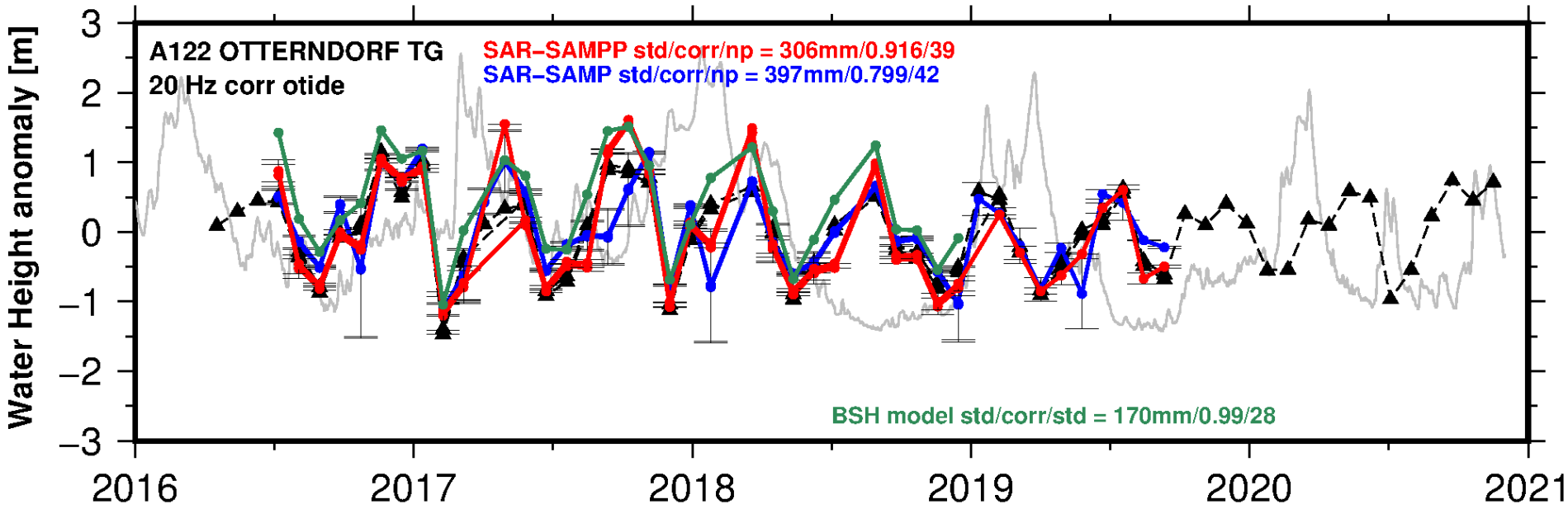


Figure: **Ottendorf: W**SE altimeter and tide gauge sea level heights from Sentinel-3A (all corrections applied)

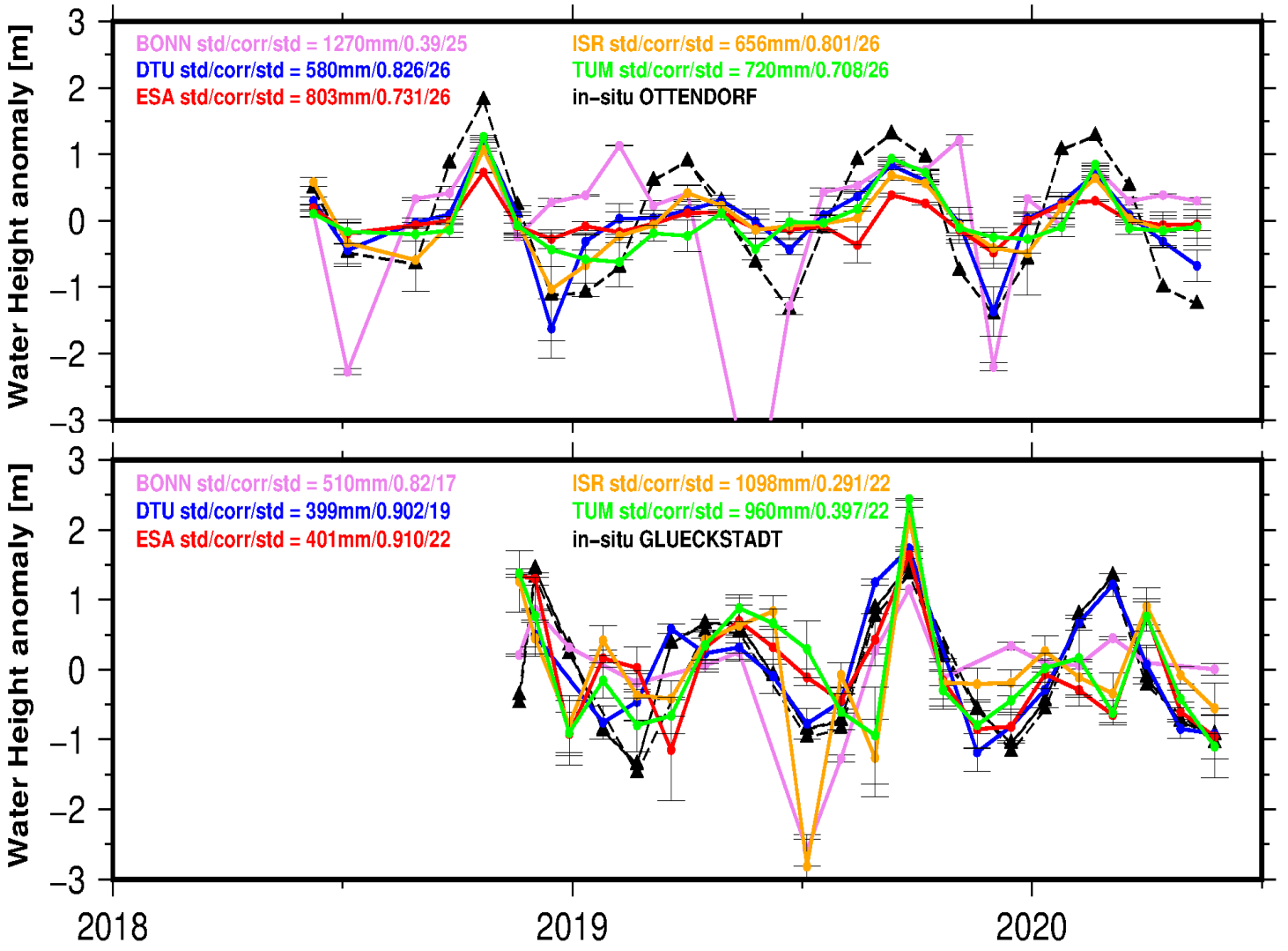
Best accuracy with Retracker SAMOSA++ *(Dinardo et al. 2020; Fenoglio et al., 2020).*

stdd 30 cm (SAM+/ tg)

Tide model errors

Good performance of ocean model vts TG in comparison (17 cm)

Method: S3 vrs TG



Project HYDROCOASTAL :
Coastal dedicated retrackers

All corrections except DAC applied
Meth 2. **VirtualPass**: Average over part of the track (more robust for river and estuary)

stdd 50 cm (DTU inland tg)

stdd 30 cm (DTU inland tg)

→ Limitated use of satellite altimetry in estuaries

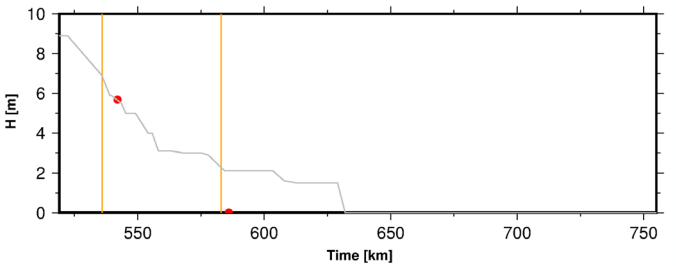
Method: Long Time repeat– CS2 vrs TG

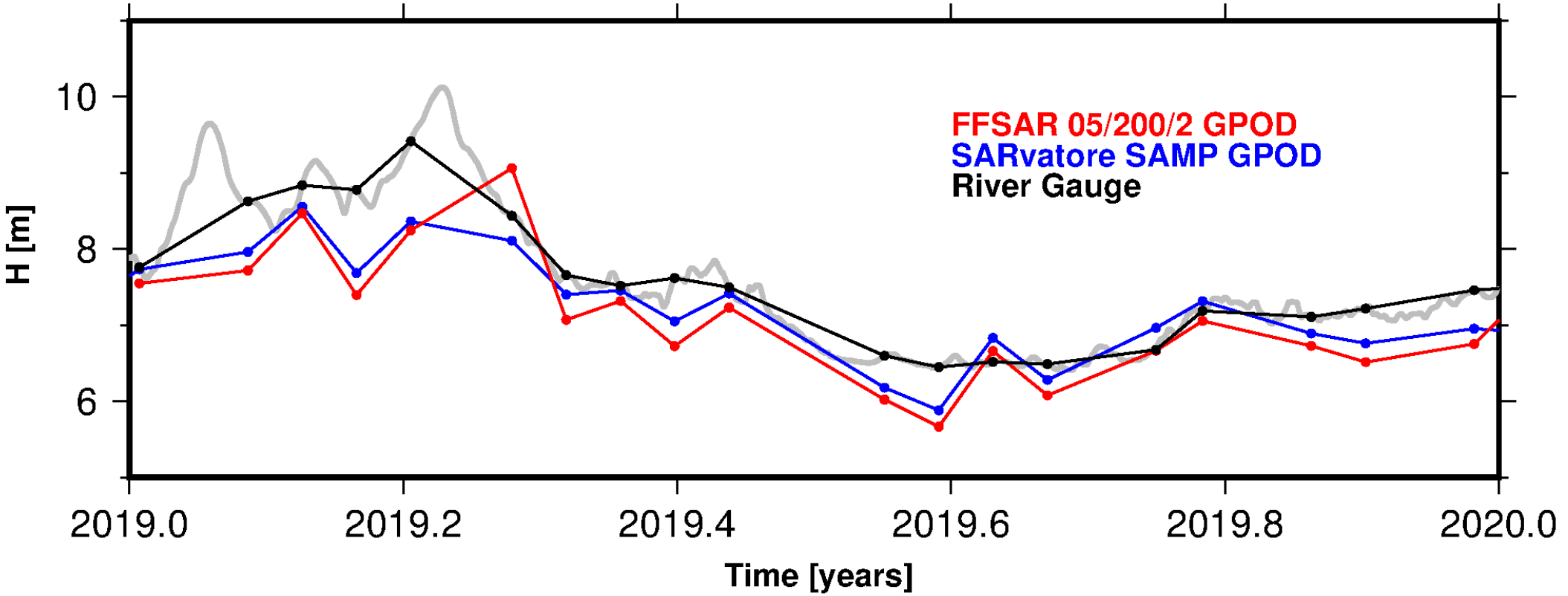
Centerline method:

Migration of measurements along river profile to TG location:

SAR 21 Virtual gauges (STDD 0.92 m, corr=0.62)

FFSAR 21 Virtual gauges (STDD 0.83 m, corr=0.63)



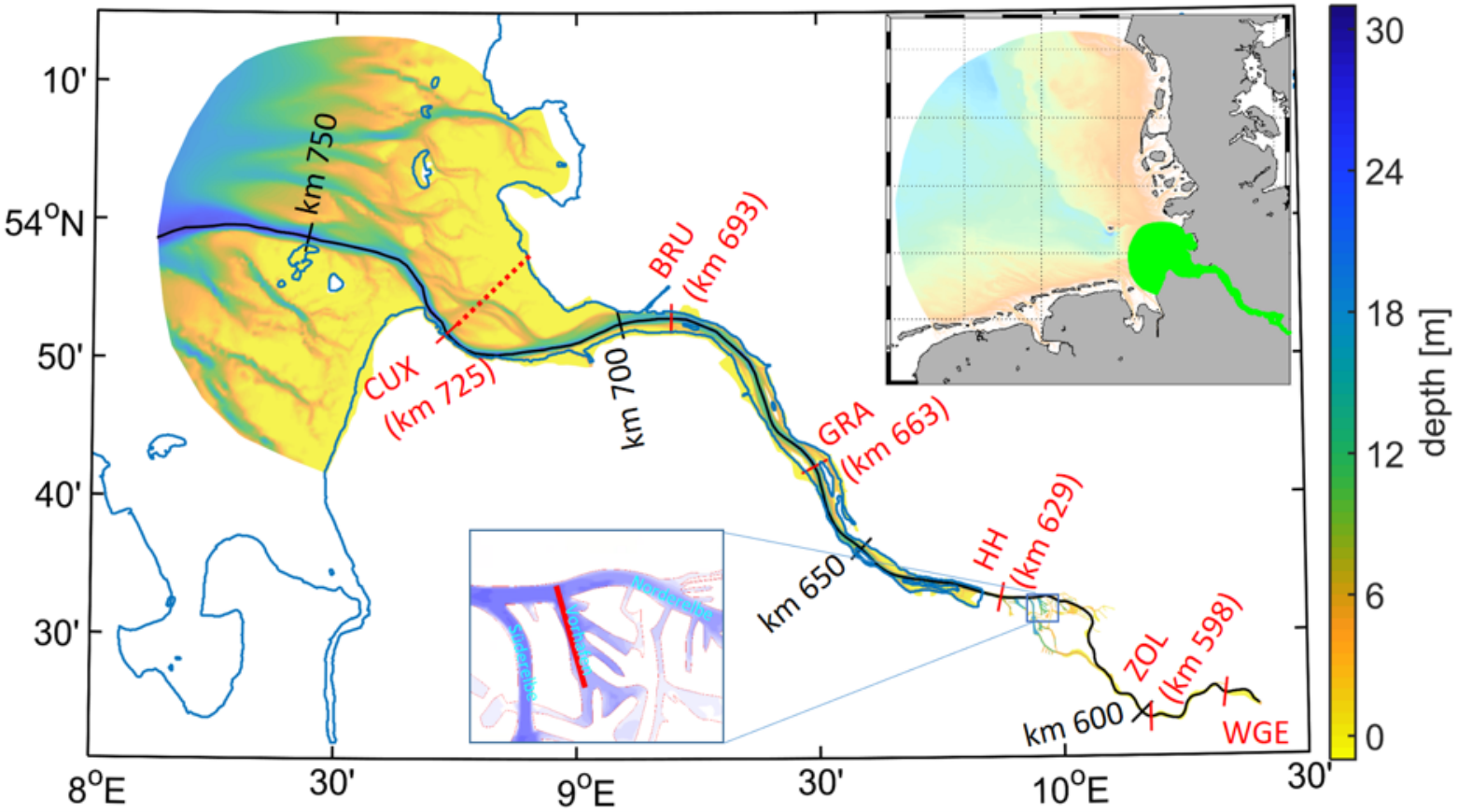


SCHISM HR Model for Elbe

The model domain:

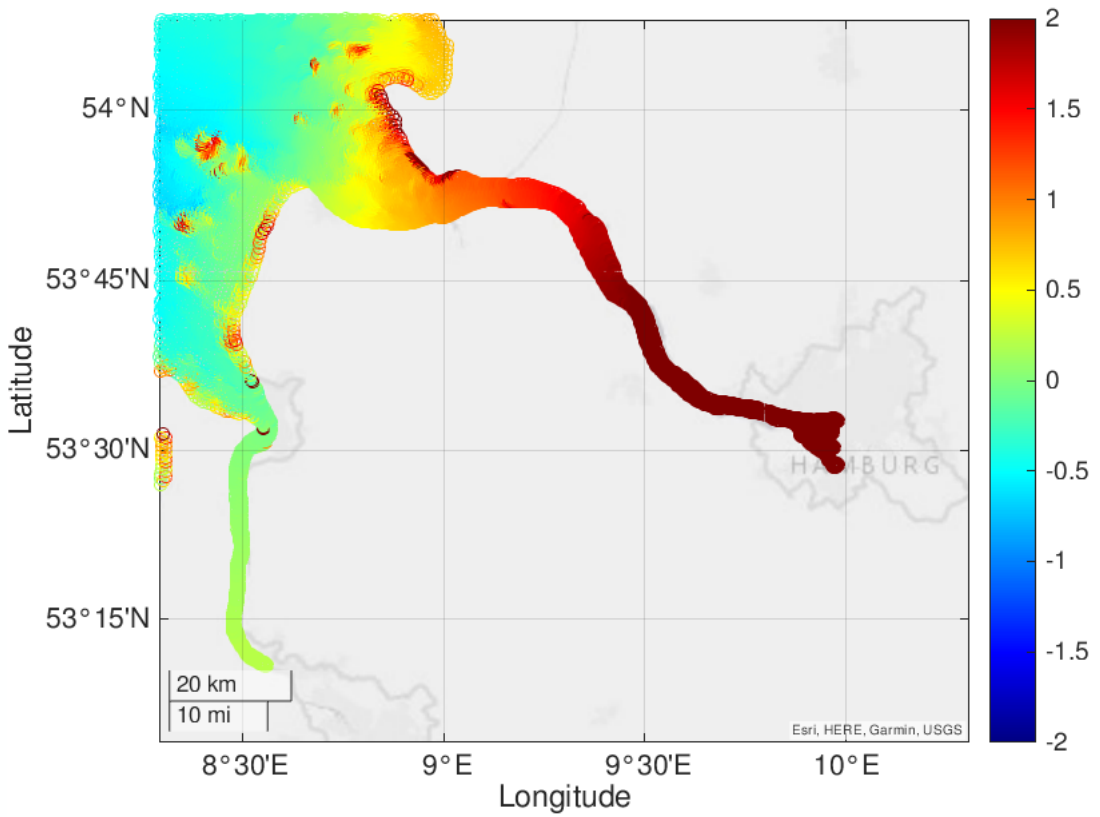
G-COAST SCHISM

- 3 D baroclinic model (res. 10 m to 400 m)
- Tidal constituents specified at the open boundary
- River discharge specified from Gauge at NoaDarchau
- Bottom friction

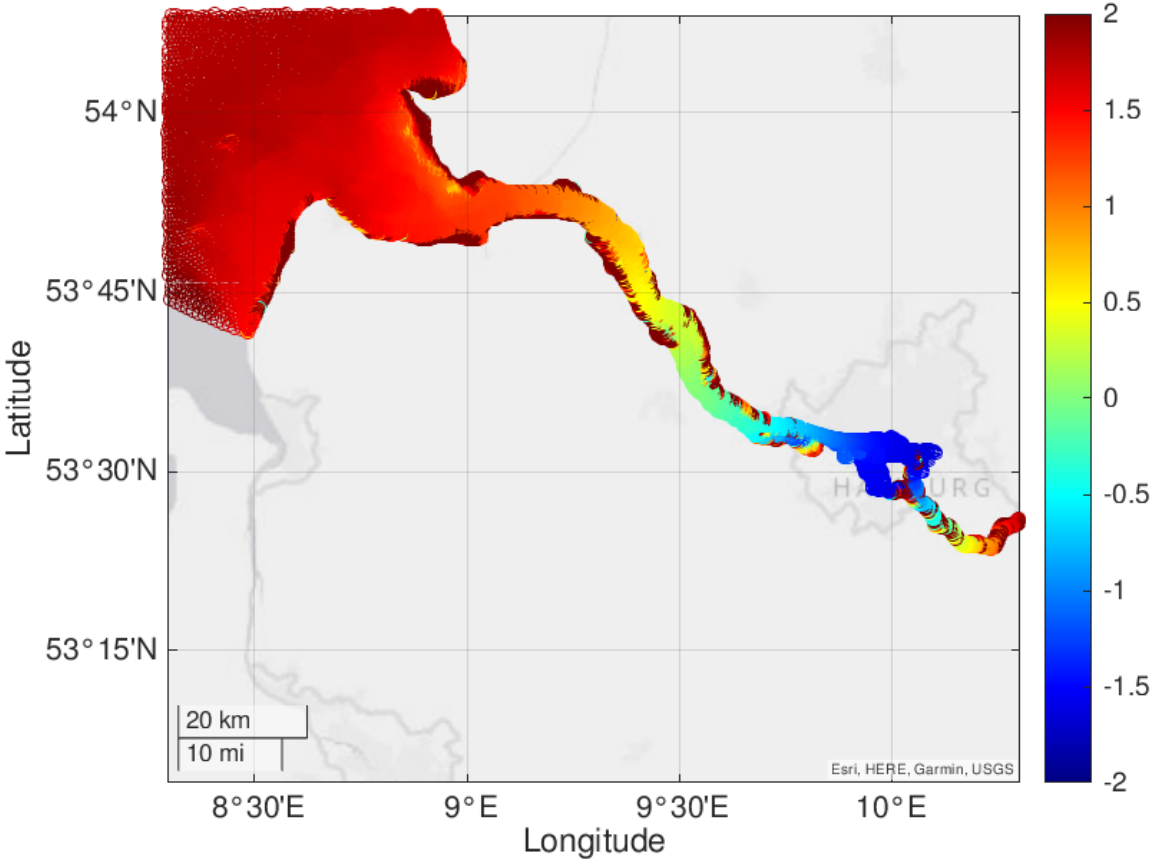


Elbe SCHISM model domain with depth [m] in background. The black transect line indicates the Elbe navigational channel with labels identifying the official Elbe-km. Red labels and associated ticks mark the location of observation stations with respective official Elbe-km.
Central part of the Hamburg harbor area with red solid line marking transect used for dynamical analysis.
The inset at the top right marks the location of the model area (green color) within the German Bight set-up used to force the Elbe-model hydrodynamically (Pein et al. 2021)

SCHISM Models for Elbe (LR and HR)

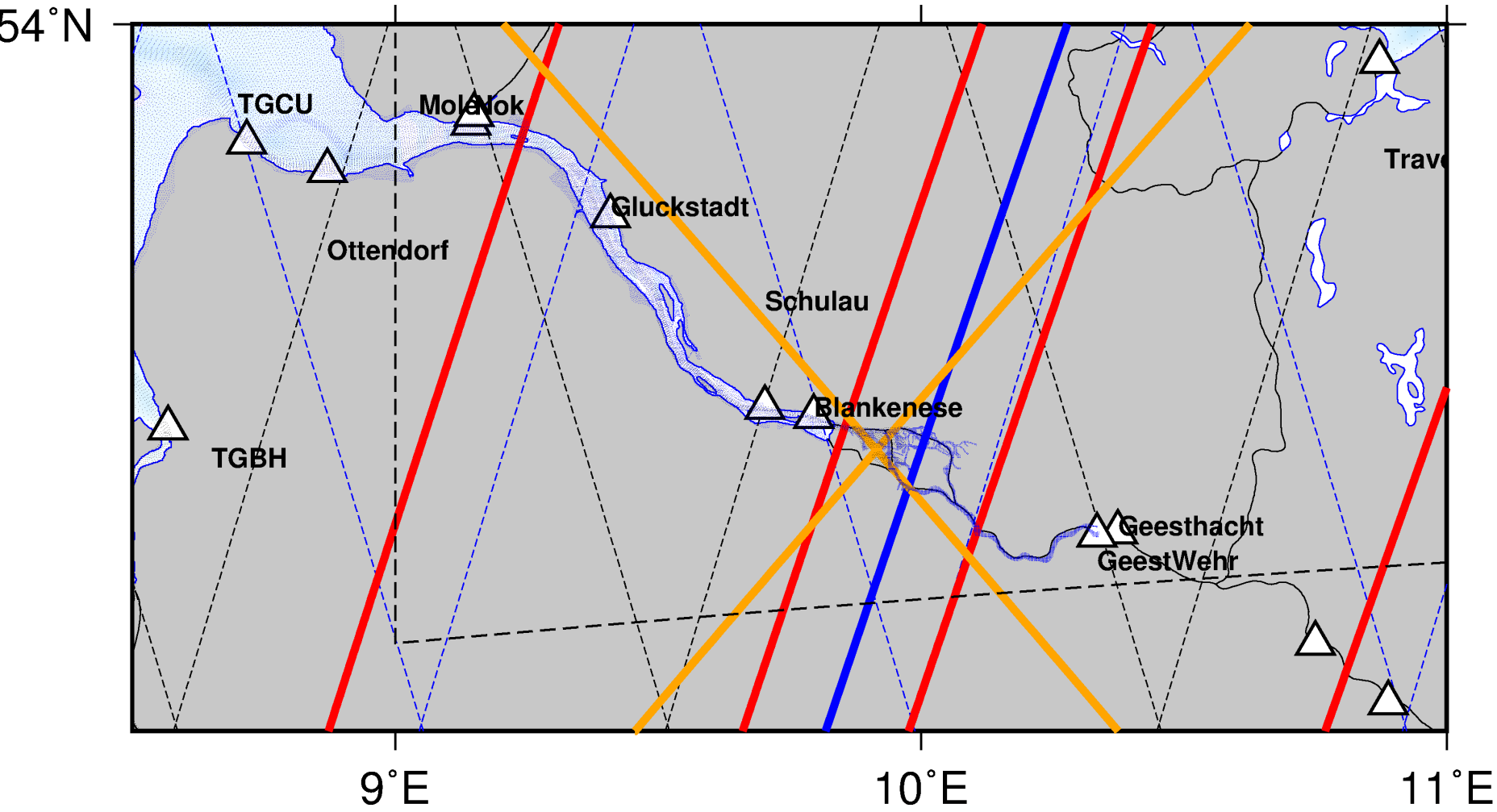


LR 2013 Nov-Dec



HR 2011 Jan-Dec

High Resolution SCHISM HR Elbe Estuary



unstructured grid

The distance from Brünsbüttel to Geerstacht (downstream/upstream gauge) is 110 km

1day cal/val SWOT simulation

Model Validation: SCHISM Model vrs TG

Year 2013 (LR, 3h) and 2012 (HR, 1h), gauge ordered by name

	Dist (LR)	Corr (LR)	Stdd (LR)	Dist (HR)	Corr (HR)	Stdd (HR)
Blankenese	0.089	0.957	0.611	0.027	0.834	0.710
Brünsbüttel	0.120	0.934	0.464	0.100	0.861	**0.545**
Cuxhaven	0.105	0.950	0.397	0.171	0.884	0.535
Glückstadt	0.136	0.950	0.498	0.110	0.867	0.535
Nok_Brünsbüttel	1.017	-0.01	1.291	1.022	-0.145	1.054
Ottendorf	0.045	0.947	0.409	-	-	-
Schulau	0.102	0.962	0.560	0.015	0.834	0.681
GeestWehr	-	-	-	0.0345	0.813	**0.663**
Geesthacht				2.425	0.413	1.039

Root mean square error is 50 cm
Mean relative error is 25%

SWOT Ocean Simulator

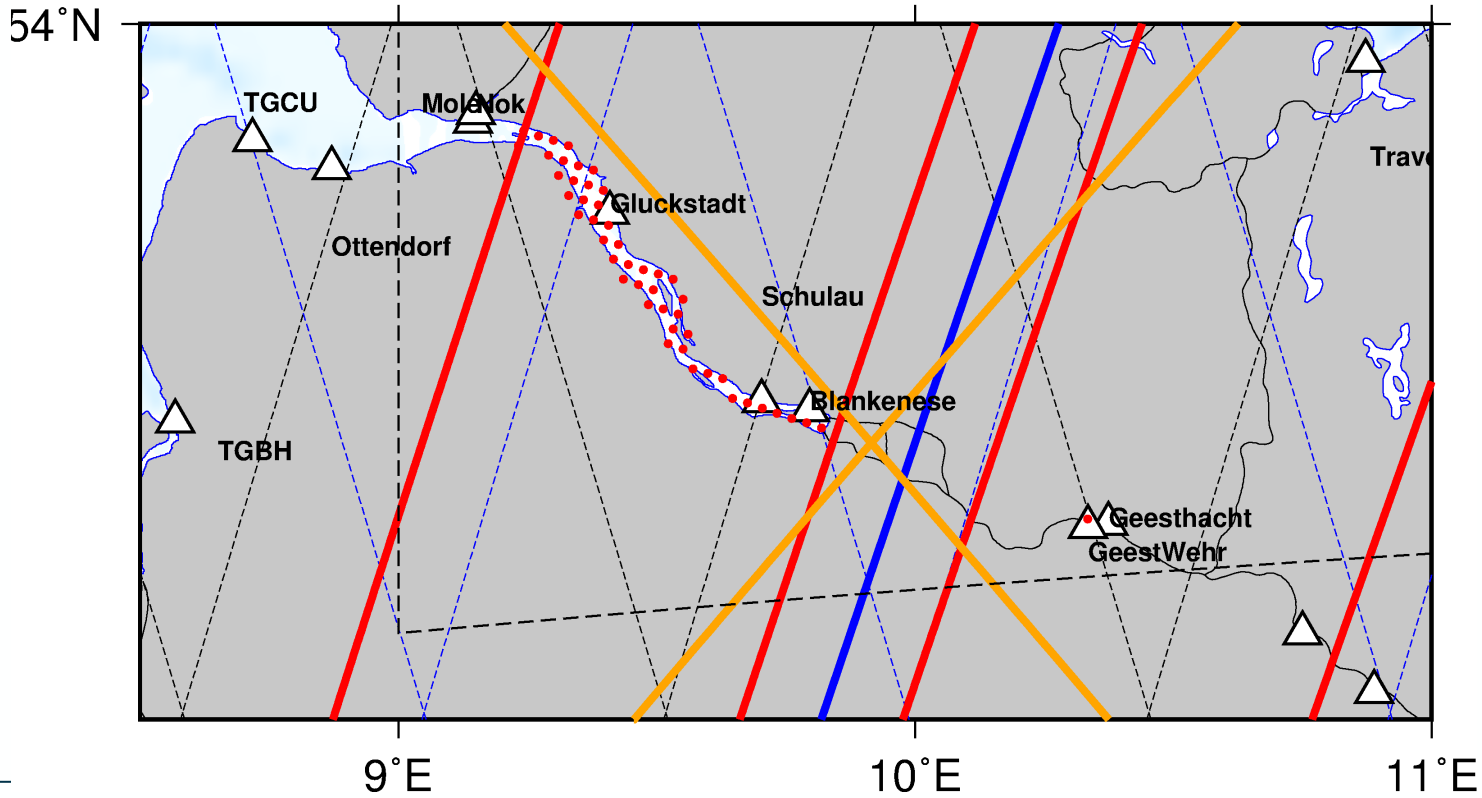
Input: SCHISM HR year 2012 (HR, 1h)

setting simu: 1day repeat (cal/val phase)

2 km output resolution

SWOT error added to model

Output: 48 positions (red dots)



SWOT Ocean Simulator

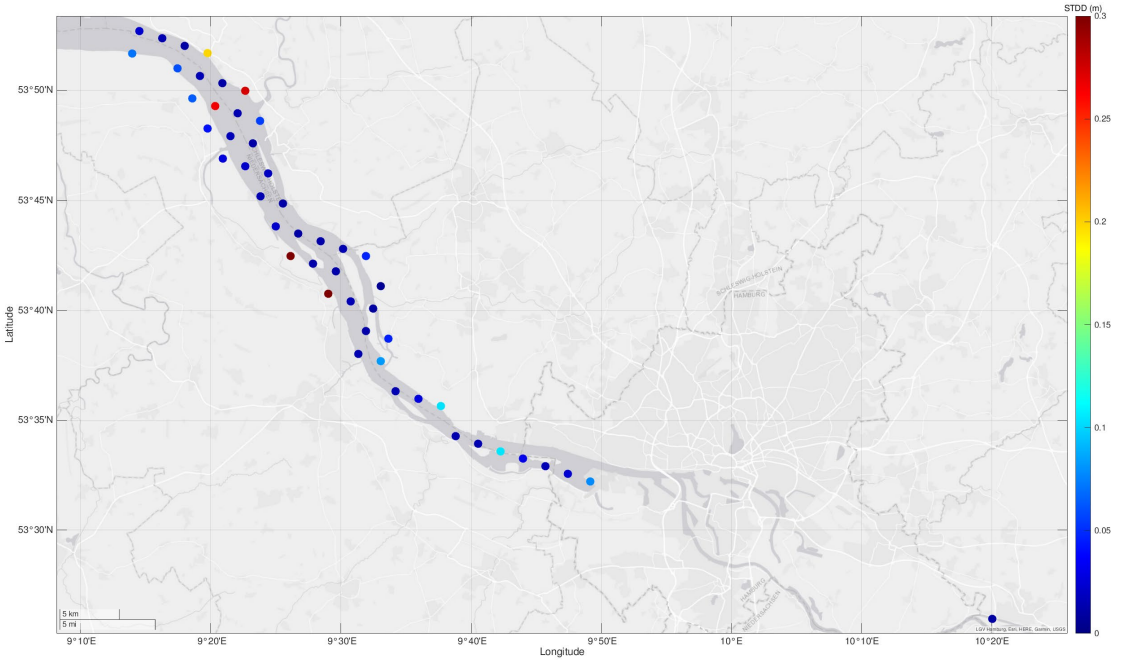
Standard deviation of SWOT Ocean Simulator output (48 points) and nearest SCHISM HR ´(2012, 1h) pts

Colorcoded (stdd: 0-30 cm):

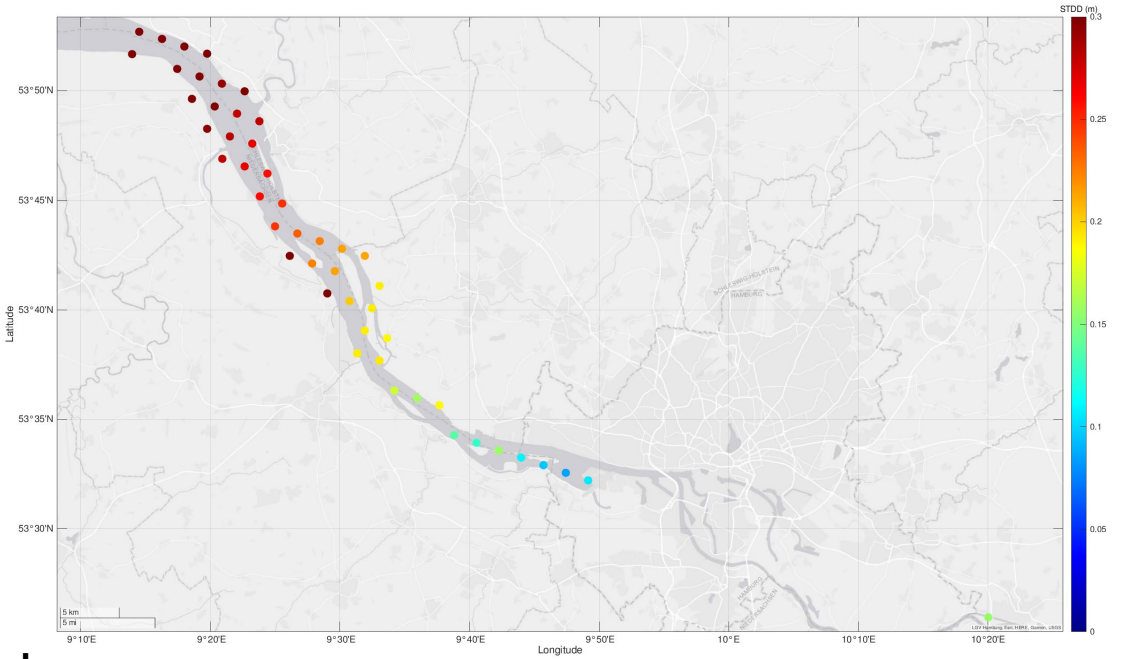
without SWOT error simulated

with SWOT error simulated

Point 2 (2 cm) Brünsbüttel



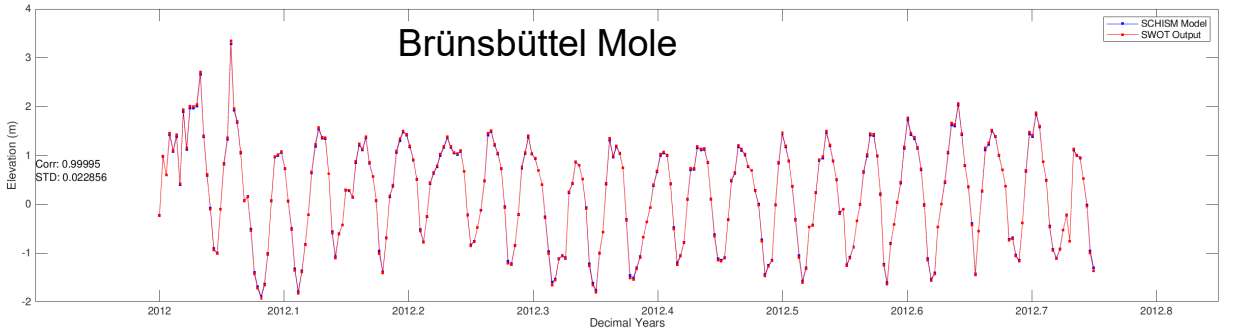
Point 2 (33 cm)

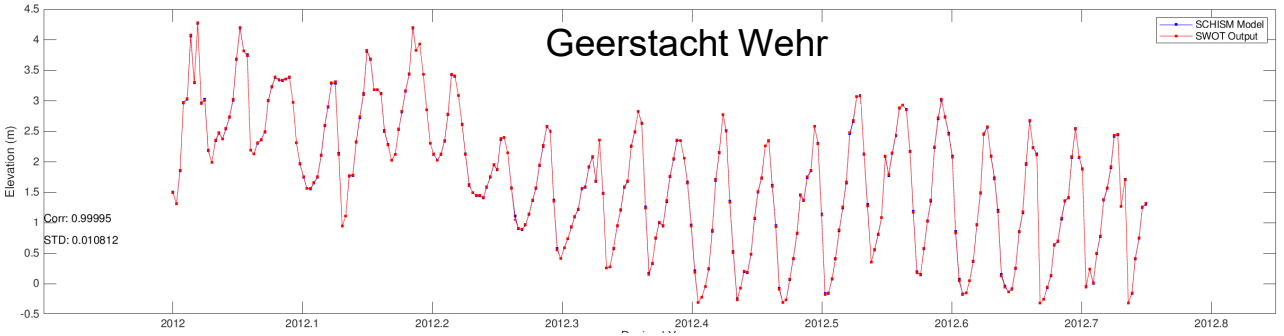


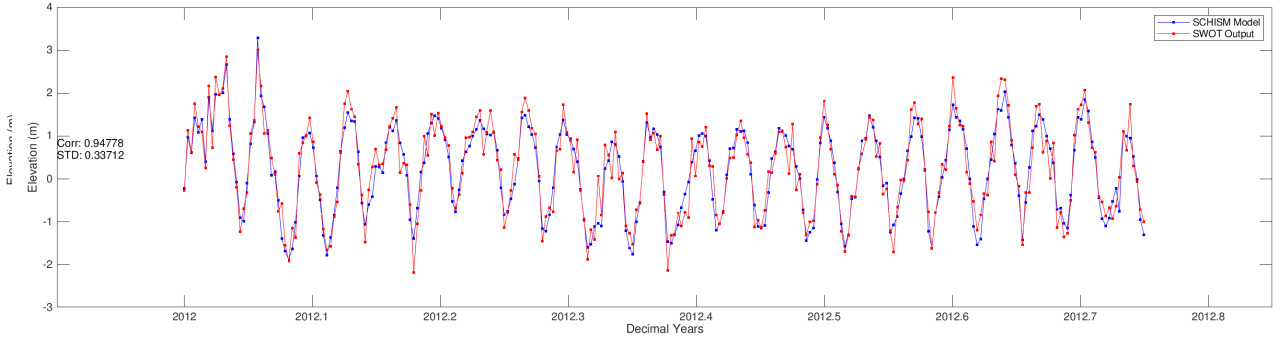
Point 48 (1 cm) GeestWehr

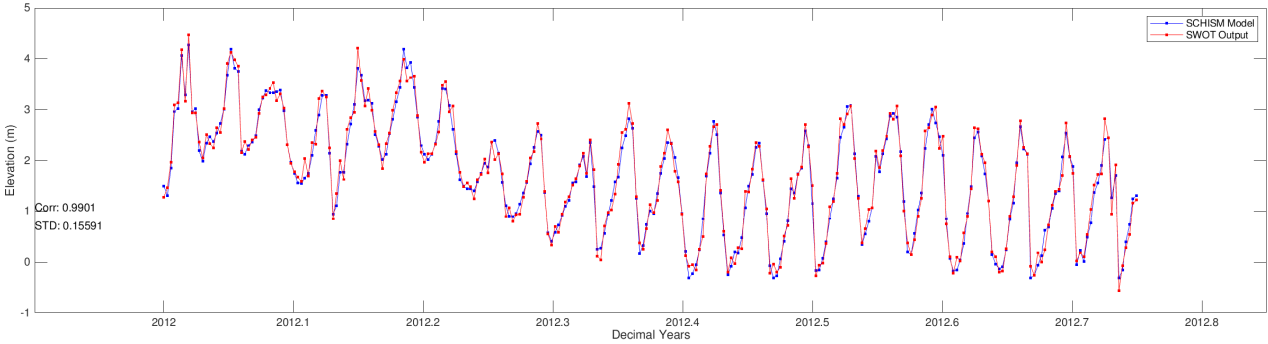
Point 48 (16 cm)

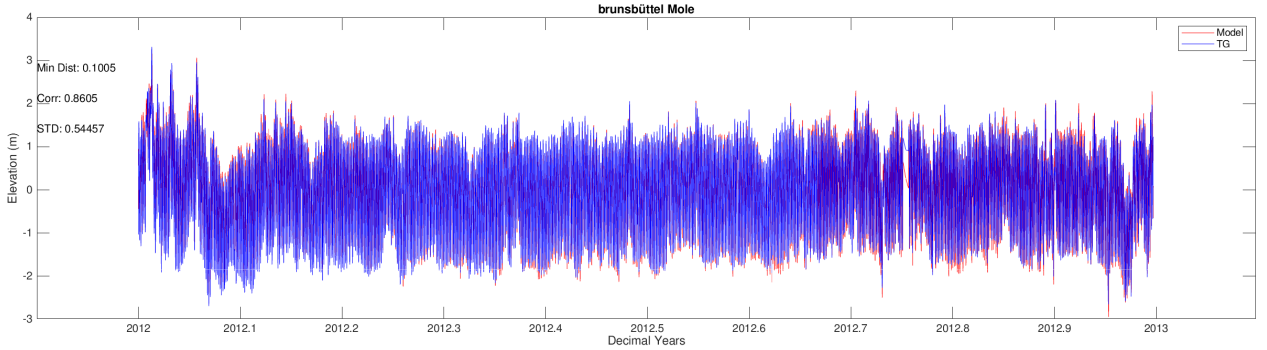
SWOT Ocean Simulator : Points 2 and 48

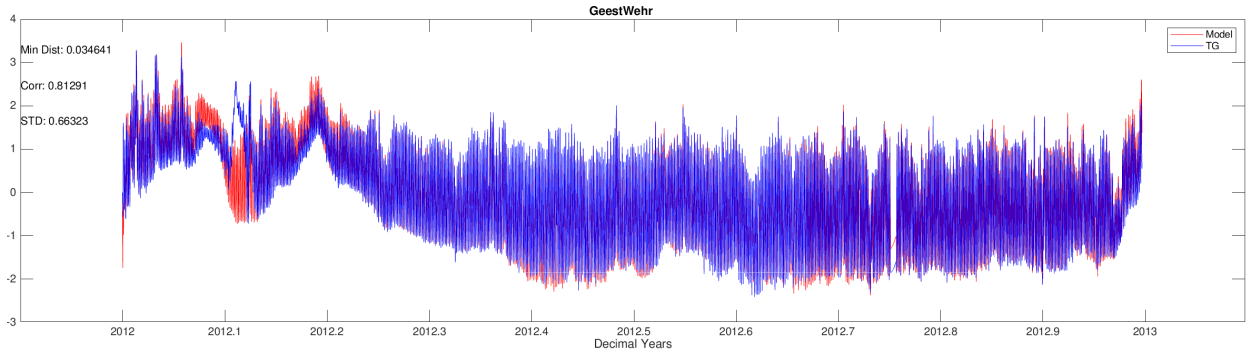












Conclusion and outlook

Accuracy of nadir satellite altimetry is low in estuarine zone (EZ). Mean STDD is 50 cm

Spatial and temporal resolution is low.

SWOT observations have higher spatial and temporal sampling.

Accuracy of SWOT will be assessed in the cal/val

Accuracy of the simulations depends on model accuracy and on SWOT error simulated.

Accuracy of regional model SCHISM HR is 50 cm (against in-situ gauges).

The model does a good job of simulating water levels in the Elbe Estuary, mean relative errors range from 20-25%

Effect of river discharge is visible in the upstream stations, we expect changes in M2 due to the river discharge

Outlook:

Investigate different methods to separate tidal discharge and tidal range in estuaries

SCHISM Model in the Elbe Estuary