CONWEST-DYCO- Estuarine and coastal water level and hydrodynamic

L.Fenoglio[1], H.Uyanik[1], J. Chen[1], R. Ferrari[2], J. Staneva[3], J. Kusche[1]

1) Inst. of Geodesy and Geoinformation, University of Bonn 2) Noveltis, France
3) Hereon, Germany, contribution by K.Larson (Uni-Bonn), O.Roggenbuck (BKG)

Motivation

Beside the ADAC site in Central Baltic (poster P1) the CONWEST-DYCO project investigates fine scale variability and hydrodynamic processes in Elbe Estuary and German coasts of North and Baltic Sea near-shore. Research questions are:

- Can we observe sub-mesoscale structures, currents and hydrodynamic processes near coast?
- Can we track the water exchange between inland waters and coastal zone?

We distinguish the Elbe estuary and mouth in the North Sea from the estuarine Baltic coasts, both under SWOT 1-day Track 3.

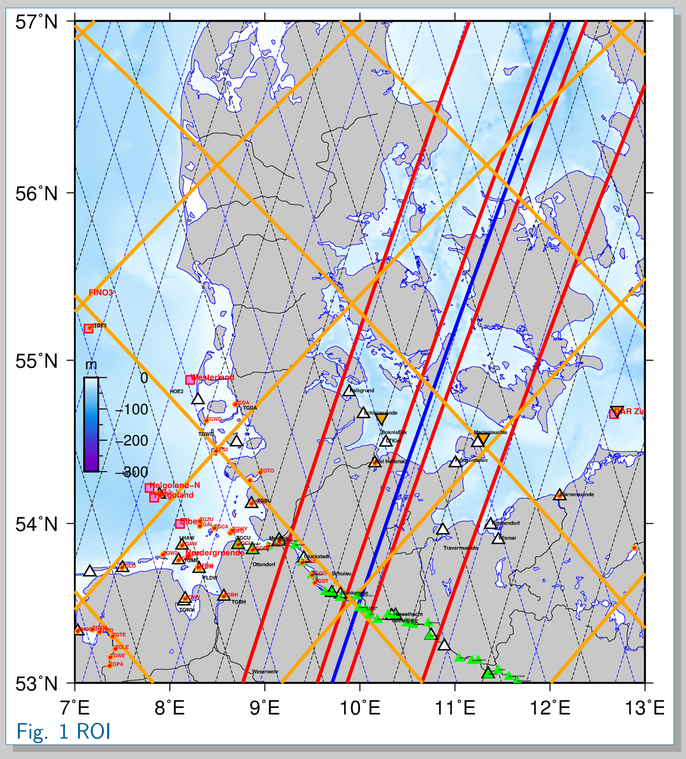

Fig. 1 ROI

The Elbe Estuary

The ROI includes the Elbe Estuary and the Elbe tidal river, which is 70 km long with meso-tides in 3-4m range. A large network of fiducial reference measurements and model data made available by the german national agencies (BfG, BKG, and BSH). See in situ measurements and Sentinel-3 and Sentinel-6 tracks in Fig. 2 . Topics are:

- Discharge and tides interaction
- River plume
- Contribution to sea level change
- Wind effect, air-sea interaction

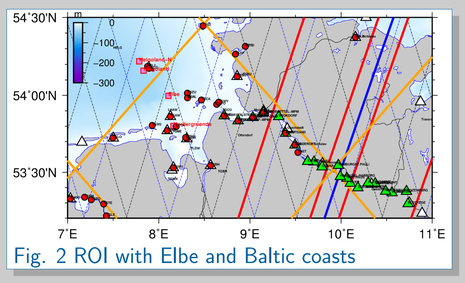

Fig. 2 ROI with Elbe and Baltic coasts

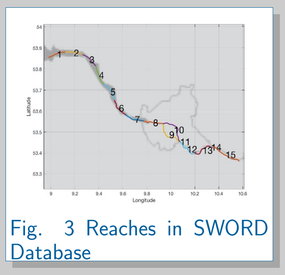

Fig. 3 Reaches in SWORD Database

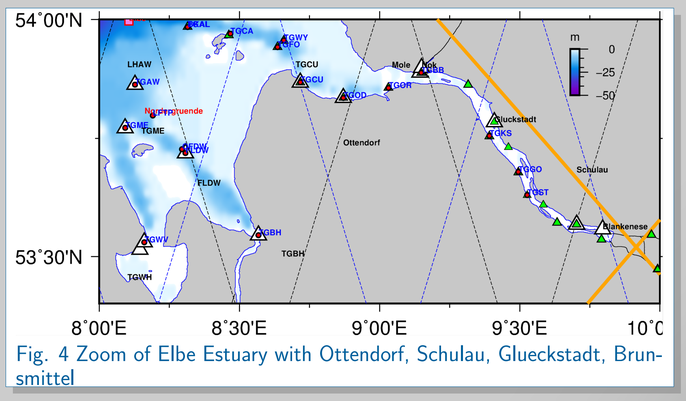

Fig. 4 Zoom of Elbe Estuary with Ottendorf, Schulau, Glueckstadt, Brunsmittel

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International Altimetry Team (2021). Altimetry for the future: Building on 25 years of progress, Adv. Space Res.,68, pp. 319–363, https://doi.org/10.1016/j.asr.2021.01.02

Larson, Reflections Code Package for GNSS interferometric reflectometry (GNSS-IR) (2023) https://github.com/kristinemlarson/gnssrefl

WSE from space techniques

Satellite altimetry observes water surface elevation (WSE), here WSE is not corrected for the ocean tide. The STDD between altimetric binned SLA and gauges is larger than 0.5 m (Fig. 9) due to land contamination and currents. The radargrams indicate disturbance in correspondence to the largest STDD (Fig. 7, 8).

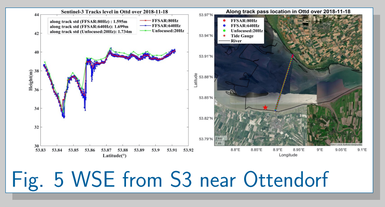

Fig. 5 WSE from S3 near Ottendorf

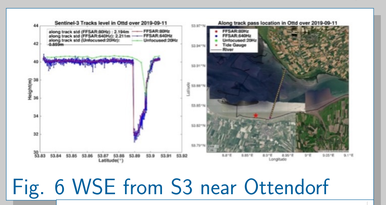

Fig. 6 WSE from S3 near Ottendorf

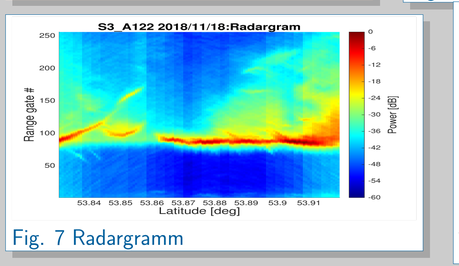

Fig. 7 Radargramm

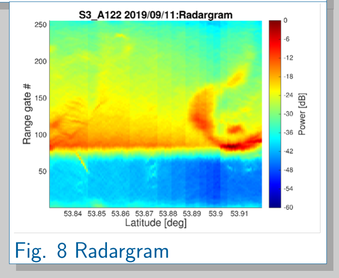

Fig. 8 Radargram

The STDD values depend on the processing (Fig. 10), the highest accuracy is obtained in Fully Focused SAR (FFSAR) with the SAMOSA+ (SAMP) retracker.

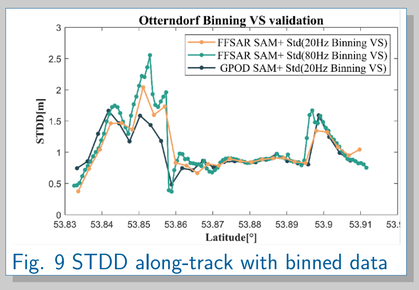

Fig. 9 STDD along-track with binned data

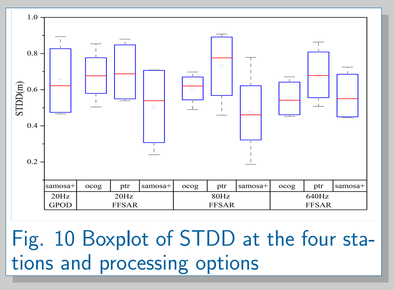

Fig. 10 Boxplot of STDD at the four stations and processing options

WSE from GNSS-IR

WSE anomalies are estimated from geodetic GNSS stations co-located with gauges of Elbe and North-Sea (Fig.1) from open source code for GNSS interferometric reflectometry (GNSS-IR) (Larson (2023). At the TGGO station the subdaily and daily anomalies agree with in-situ gauge with stdd 20 cm and 6 cm. BKG National Agency results (O. Rogenbuck) are similar (Fig. 11). The tide gauge station GrauerortReede is co-located to TGGO.

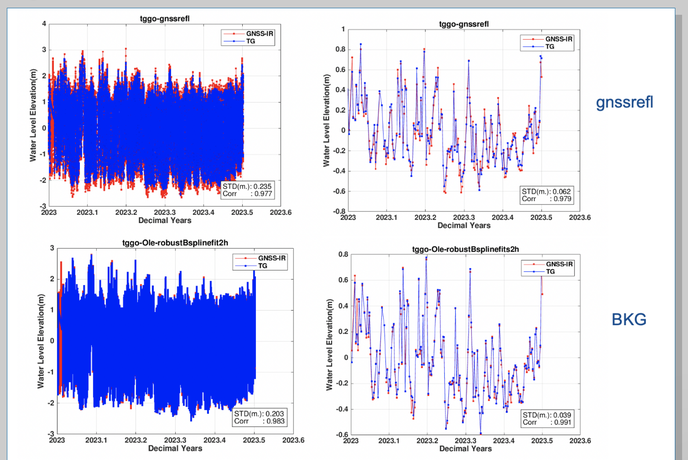

Fig. 11 WSE anomalies at ElbeTGGO from gnssrl and BKG processings, subdaily (right) and daily (left)

SWOT First Results

We use SWOT L2 NALT IGDR, SWOT L2 LR SSH 1.1 Ex- pert Product and L3 LR SSH. Time-series of SWOT-karin data compared to gauges with STDD of 0.29 m at GrauerortReede, 0.22 m at Glückstadt and 0.30m at Schulau agree with the GNSS-IR statistics. In Blankenese the STDD is larger.

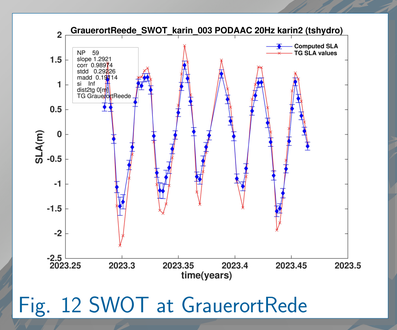

Fig. 12 SWOT at GrauerortRede

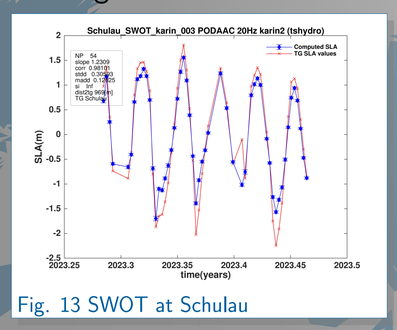

Fig. 13 SWOT at Schulau

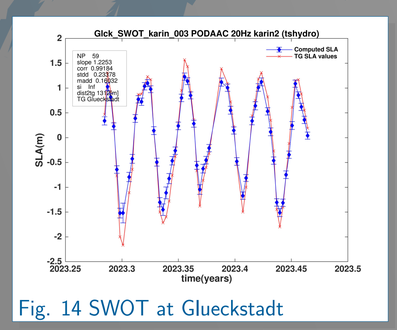

Fig. 14 SWOT at Glueckstadt

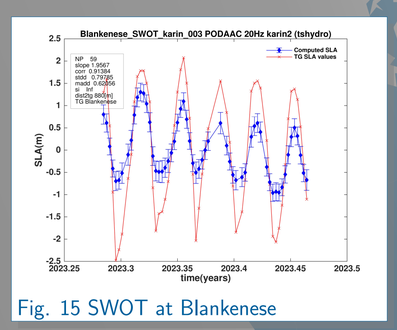

Fig. 15 SWOT at Blankenese

WSE from models

Data available are:

- WSE from altimetry (S3,S6,CS2, ICESAT-2), in-situ (WVF, GNSS-IR)
- WSE from ocean models SCHISM(HZG DA,10-400m Elbe), BSH (90m), TUGO (WSE,
- T, S, vel. from models
- DTM
- river discharge (RC)

Accuracy of TUGO free run is 20 cm, Fig. 16, of TUGO assimilated run 2 cm, RMS larger for open sea (Fig. 17). STDD of SCHISM HR with gauges is larger than 50 cm, 20 cm when tidal corrected.

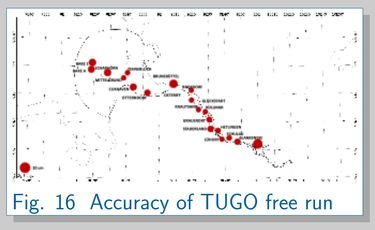

Fig. 16 Accuracy of TUGO free run

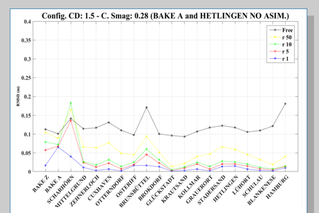

Fig. 17 STDD TUGO and gauges

Fig. 18 WSE Ottendorf and tide

	Dist(LR)	Corr(LR)	Stdd(LR)	Corr(HR)	Stdd(HR)
Blankenese	0.089	0.841	0.448	0.850	0.233
Brunsbuttel	0.120	0.920	0.312	0.870	0.204
Cuxhaven	0.105	0.929	0.239	0.880	0.194
Gluckstadt	0.136	0.924	0.341	0.868	0.213
Nok_Brunsbuttel	1.017	-0.075	0.820	-	-
Ottendorf	0.045	0.921	0.261	-	-
Schulau	0.102	0.866	0.396	0.849	0.235
GeestWehr	-	-	-	0.880	0.358
Geesthacht	-	-	-	0.524	0.674

Fig. 19 STDD of SCHISM HR and gauges

Tidal and river discharge

Method of Curbature relates downstream discharge Qtot to Upstream river discharge Qr and water storage per unit of time (Bourgault and Matte, 2020), Fig. 21. In the Elbe Qr and water height reach maximum in early Spring and late Summer. We have evaluated the tidal discharge using the wetted area change simulated the SCHISM HR and TUGO models (Figs. 22 and 23). Wetted area and height changes are also observed by SWOT.

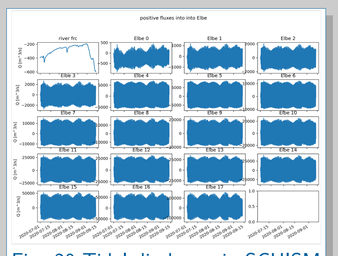

Fig. 20 Tidal discharge in SCHISM LR

$$Q_{tot} = \sum_r Q_r - \int_\Omega \frac{\partial h}{\partial t} d\Omega$$

Fig. 21 Relation between tidal, river and total discharge

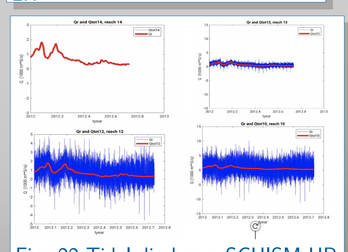

Fig. 22 Tidal discharge SCHISM HR

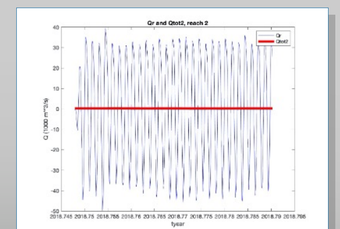

Fig. 23 Tidal discharge TUGO model

Conclusions

- The accuracy of SAR nadir-altimetry in the Elbe estuary is 0.46 cm for FF-SAR SAMP and 0.62 cm for UF-SAR SAMP
- The accuracy of WSE GNSS-R is stdd 20 cm (sub-daily)and stdd 6 and 4 (daily) in TGGO
- SCHISM model accuracy vrs gauge is 20 cm (de-tided)
- TUGO model accuracy vrs gauge is 20 cm (free run)
- Tidal discharge from SCHISM noisier than from TUGO, other SCHISM model runs and other ocean models to be considered
- Challenging region for wide-swath mission

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Contact
Luciana Fenoglio,
fenoglio@uni-bonn.de,
www.igg.uni-bonn.de/apmg