

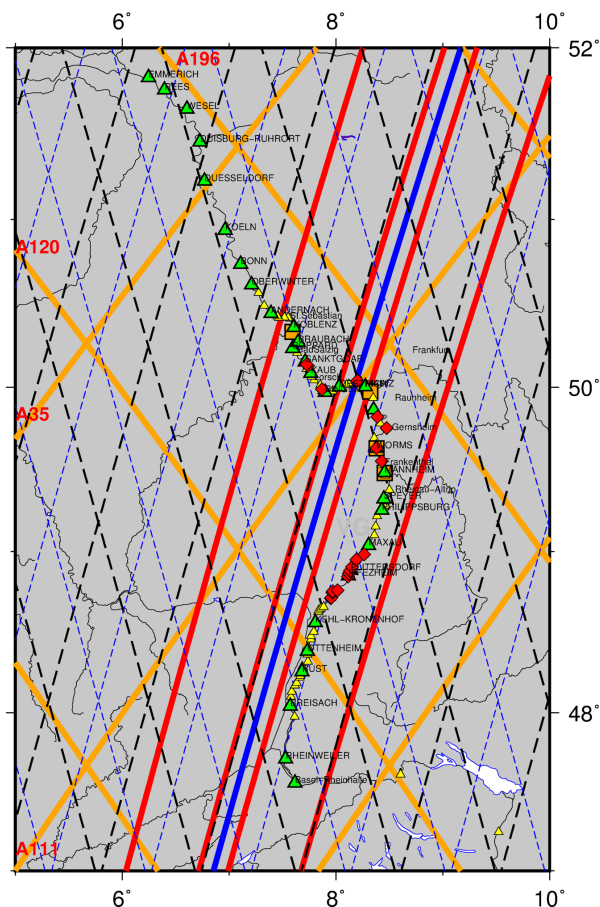
Evaluation of Sentinel-6 Unfocused and Fully-Focused SAR altimetry over Open Ocean and Inland Water

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Outline

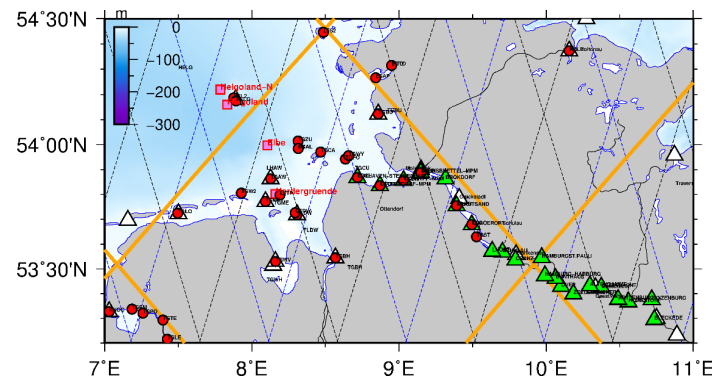
- Overview
- Scientific questions
- Methodology
- Major results
- Conclusions



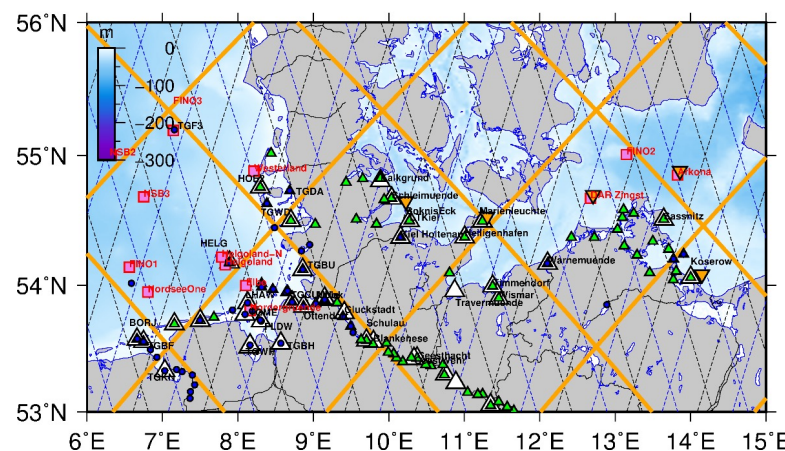
ROI1 : Rhine Catchment
(Rhine & tributary Main)

Scientific questions

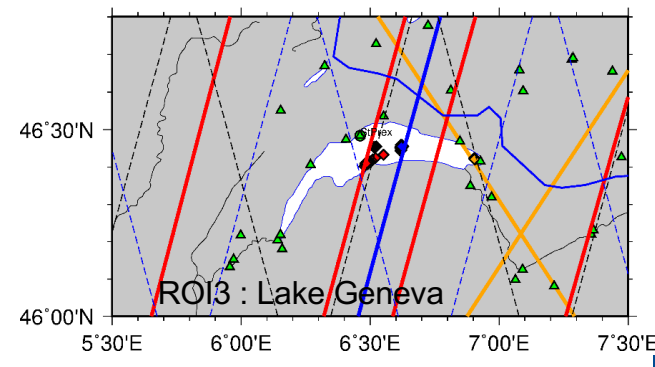
- Quality of Sentinel-6 data (SSH, SWH)
- FFSAR versus UFSAR
- UFSAR 20 Hz STD (ocog/ocean) vrs UFSAR Samosa+



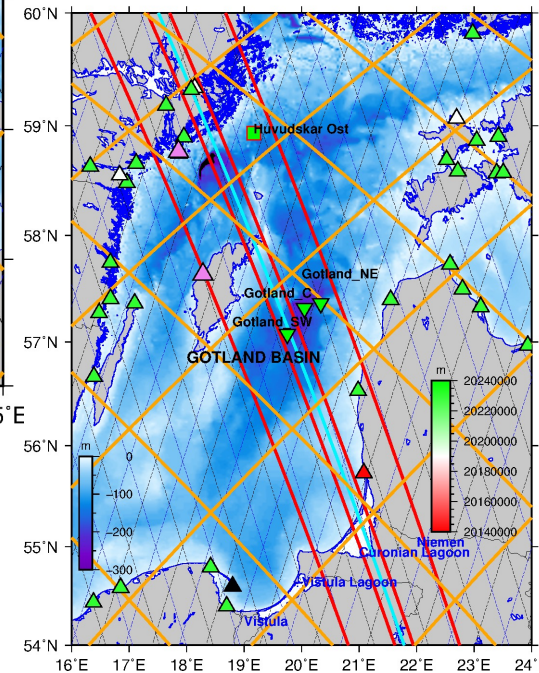
ROI2 : Elbe Estuary and River



ROI5 : North Sea



ROI3 : Lake Geneva



ROI4 : Baltic

Methodology:

S6_NT_STD_F08 2020-2023

L1a → L1b, UFSAR 140 Hz
L1a → L1b omega-k FFSAR 140 Hz

→ L2 Samosa+
→ L2 Samosa+
L2 Official products 20 Hz (ocog, ocean)

L3 -- time-series

Analysis : L1: signal radargram

L2 versus gauges, ts WSE, SWH (tshydro, virtualpass) → accuracy (STDD)

→ bias

Data:

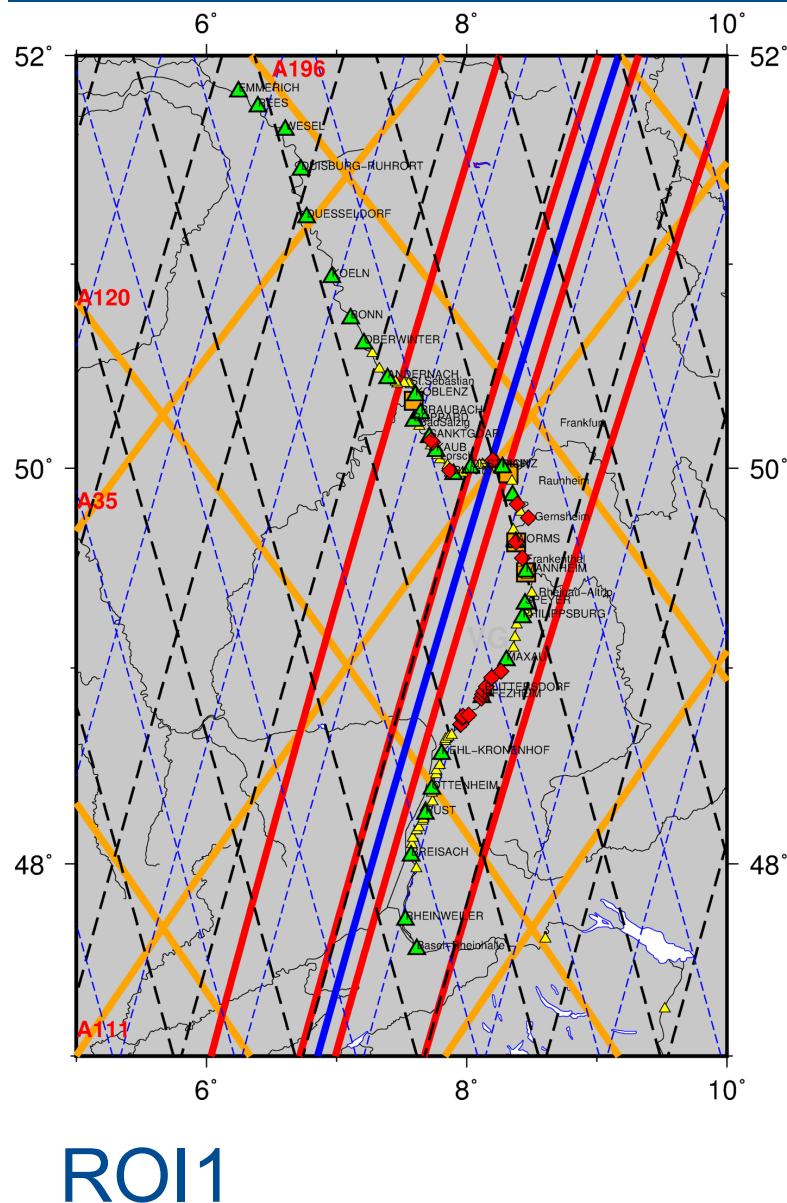
L1A: JASON_CS_S6A_L1A_ALT_HR_NTC_F08

from PODAAC 2020.12-2023.01

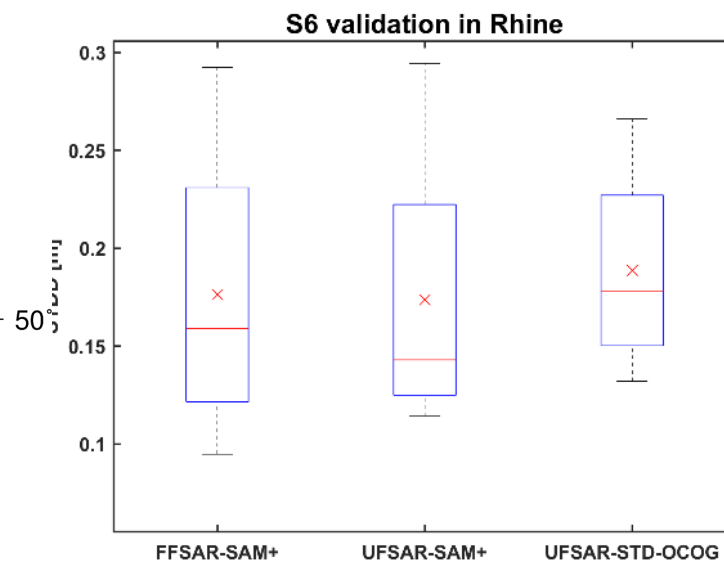
L2: JASON_CS_S6A_L2_ALT_HR_STD_OST_NTC_F08
JASON_CS_S6A_L2_ALT_HR_STD_OST_NTC_F08_UNVALIDATED
S6A_P4_HR_STD__NT_*_*_REP_NT

from PODAAC 2023.01-2023.05

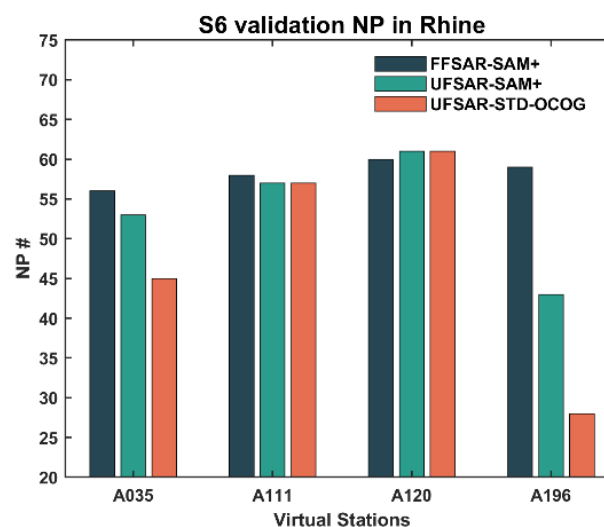
from EUMETSAT 2020.12-2022.12



We have four S6A ground-tracks in the Rhine basin.
The statistics against gauges is computed at the four virtual stations



Stdd 15 cm



A035: Dusseldorf (Rhine)
A111: Mainz (Rhine)
A120: Ottenheim (Rhein)
A196: Frankfurt (Main)

Fig. 1. STDD and Number of retained obs. per station

Our preferred location in reach Wiesbaden/Mainz is at the intersection of Sentinel-3 and Sentinel-6 ground tracks.

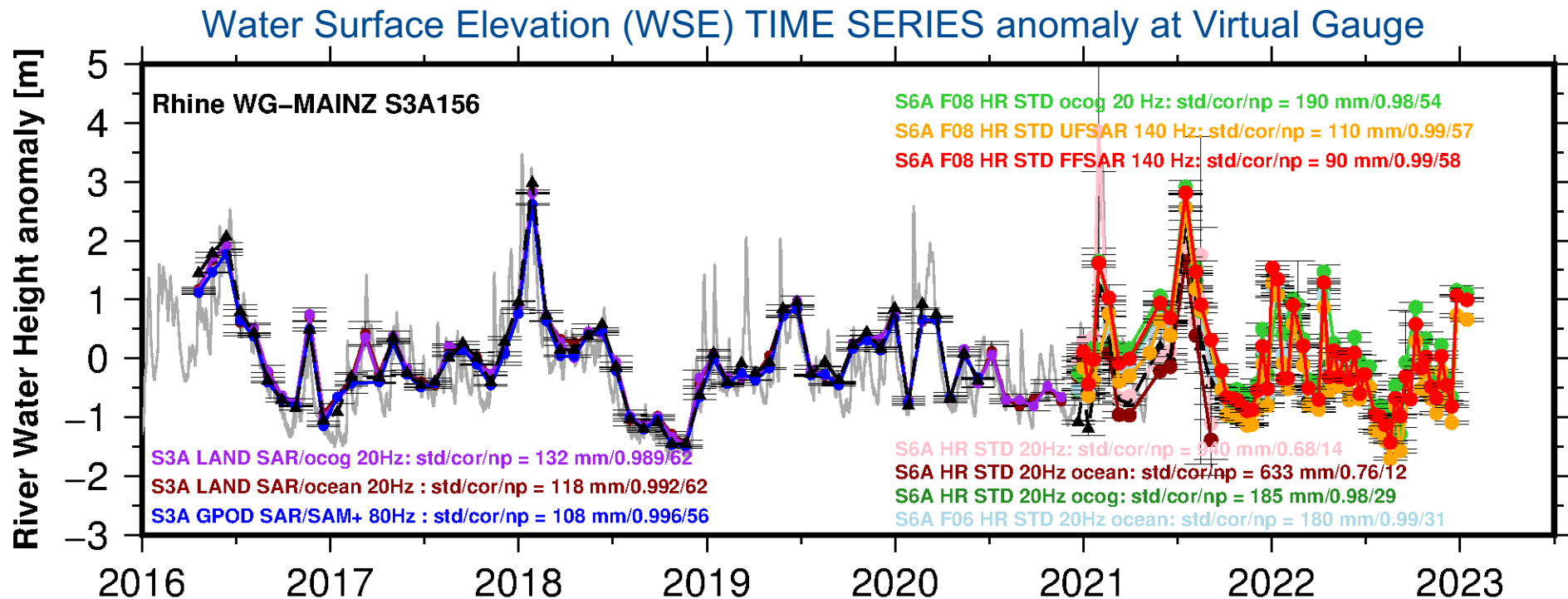
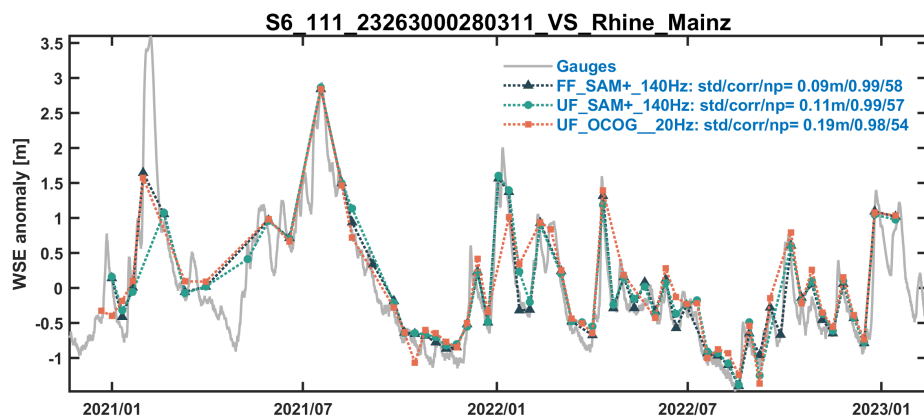


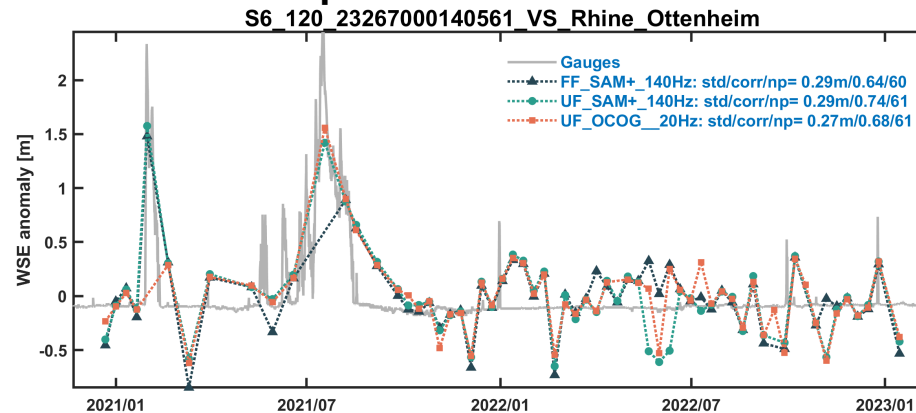
Fig. 2. VG Wiesbaden and MAINZ station (distance more than 10 km)

Each stations has different characteristics, e.g. regulated level (Ottenheim), width < 100 m (Frankfurt), meanders (Düsseldorf).

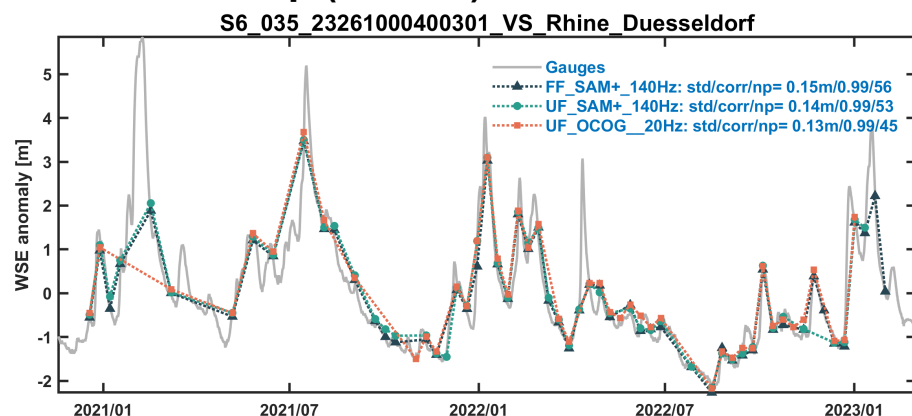
STDD 9cm/58np (FFSAR)



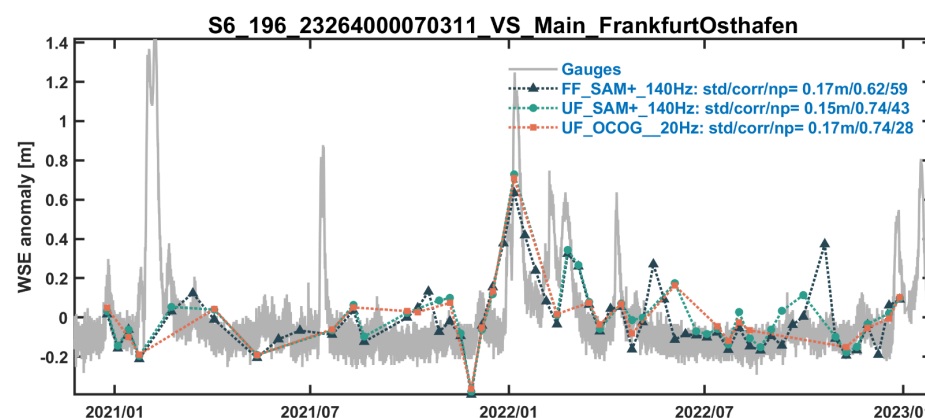
STDD 29cm/60np



STDD 15cm/56np (FFSAR)



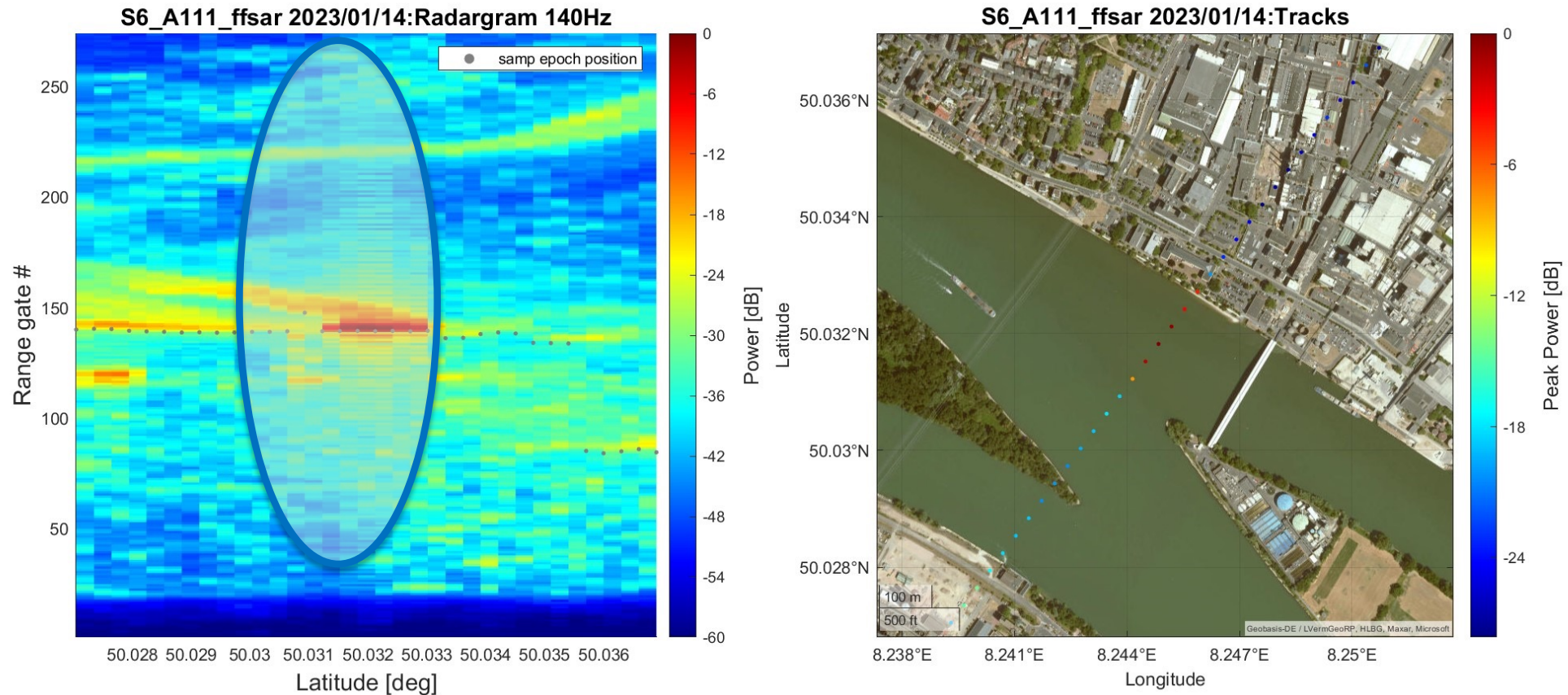
STDD 17cm/59np



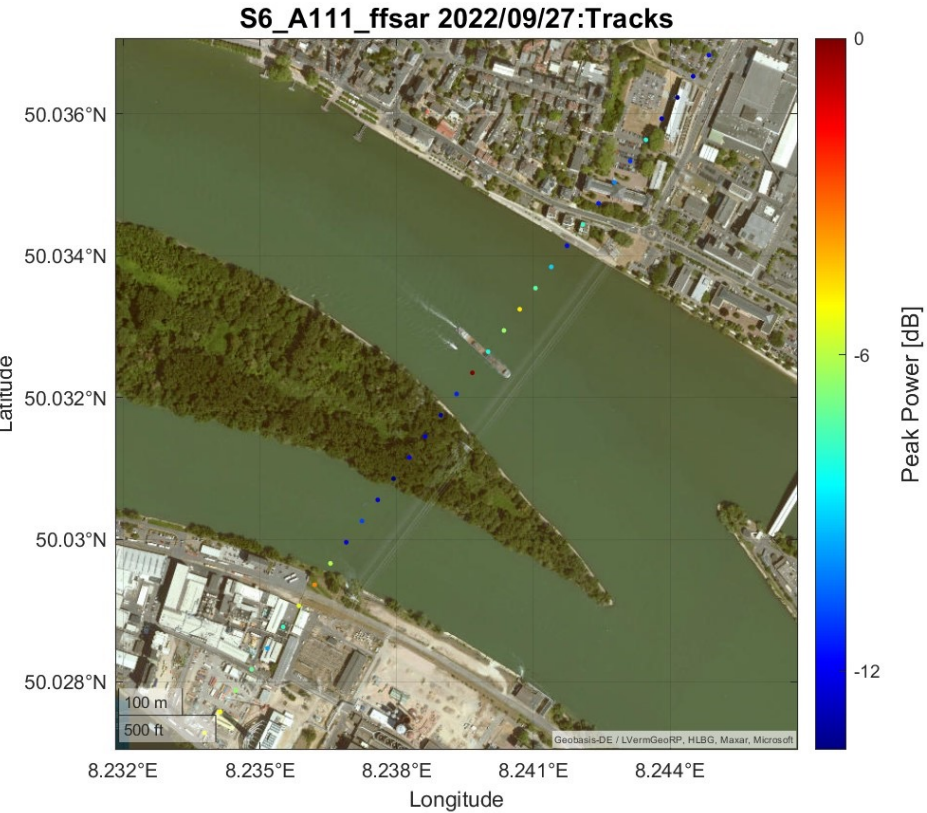
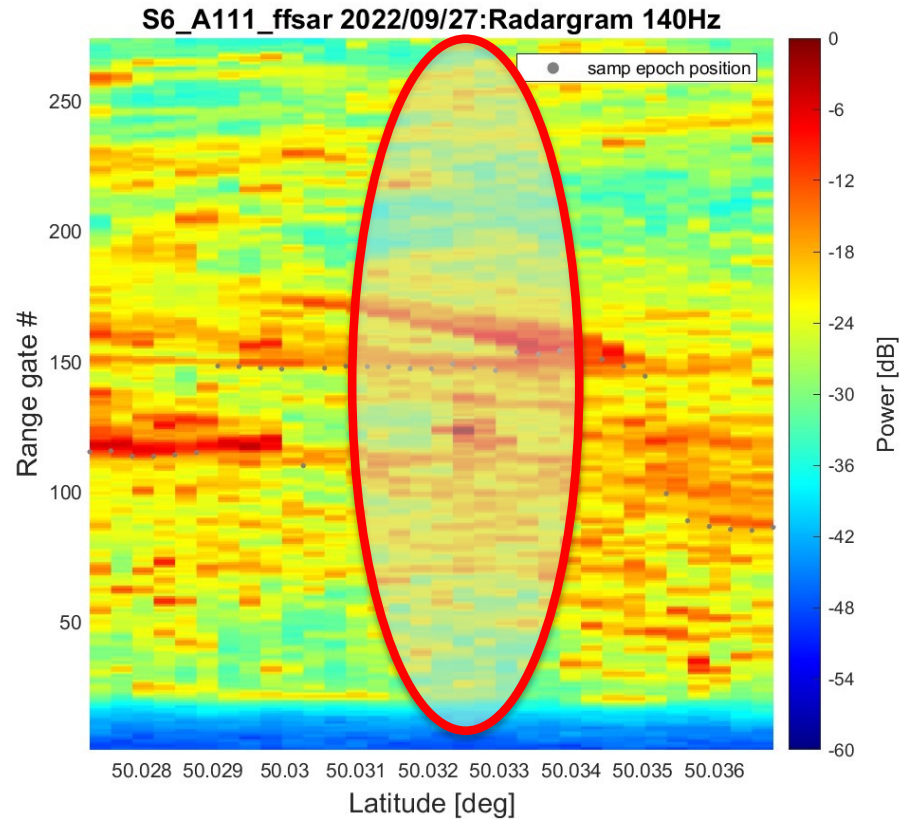
ROI1: S6A vrs gauges : FFSAR vrs UFSAR 140 Hz & 20 Hz

Fig 3. Time-series validation against in-situ

MAINZ: Example of a good FFSAR radargram



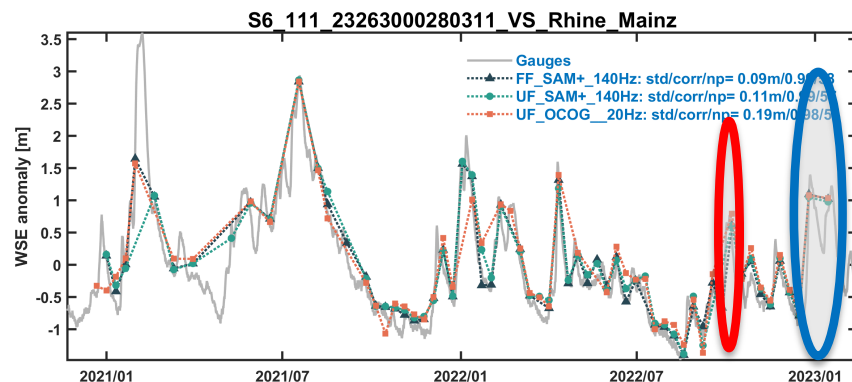
MAINZ: Example of a **bad** FFSAR radargram



What can we do to extract a good value: mask of bright targets

MAINZ: some UFSAR radargrams contaminated by bright targets external are **REJECTED**

A111 & Port (replica in FFSAR), Missing point in UFSAR 140Hz/20Hz



STDD 9cm
/58np (FFSAR)

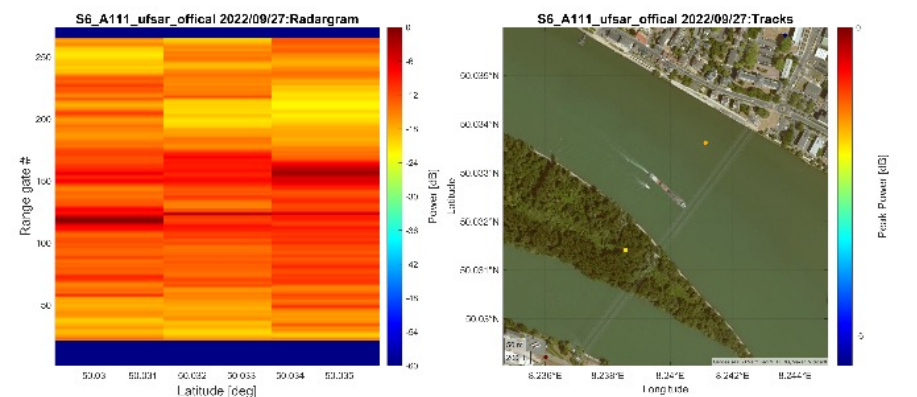
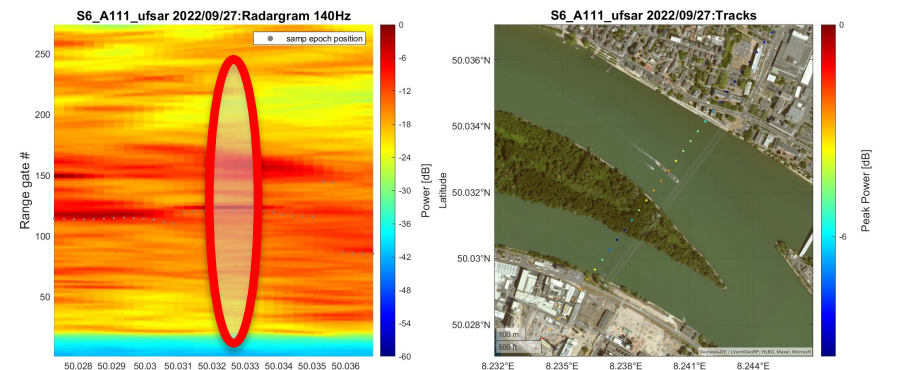
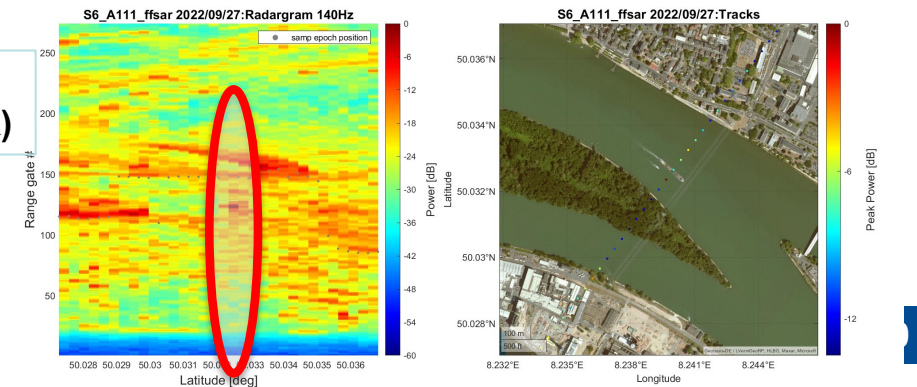
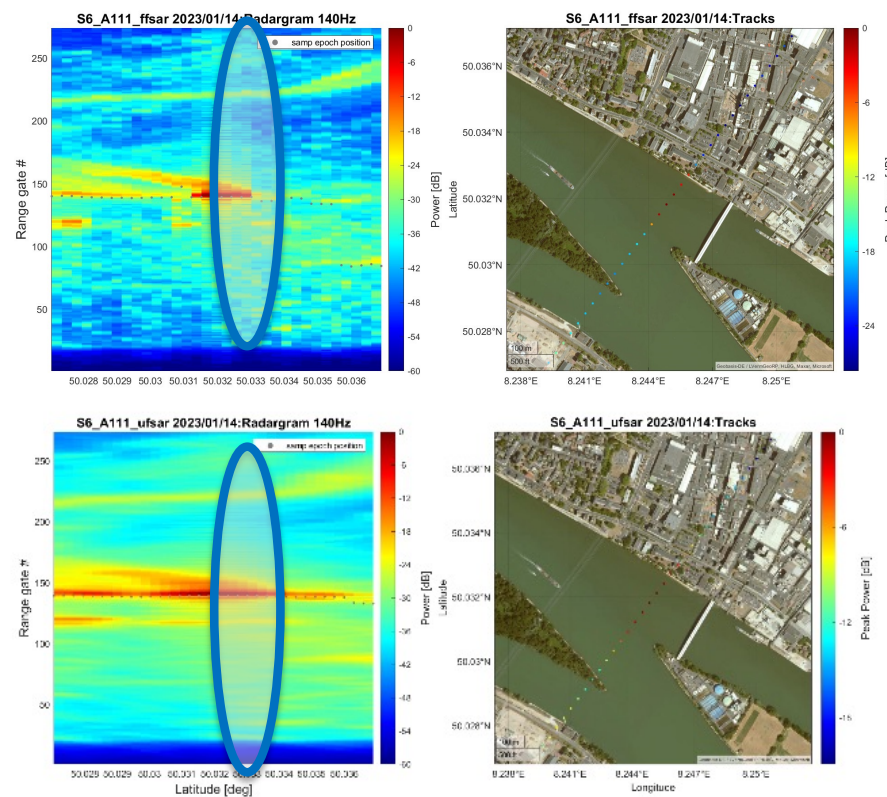
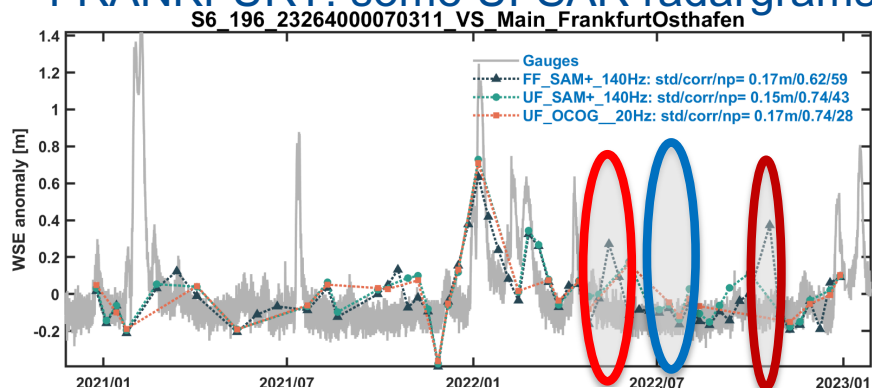
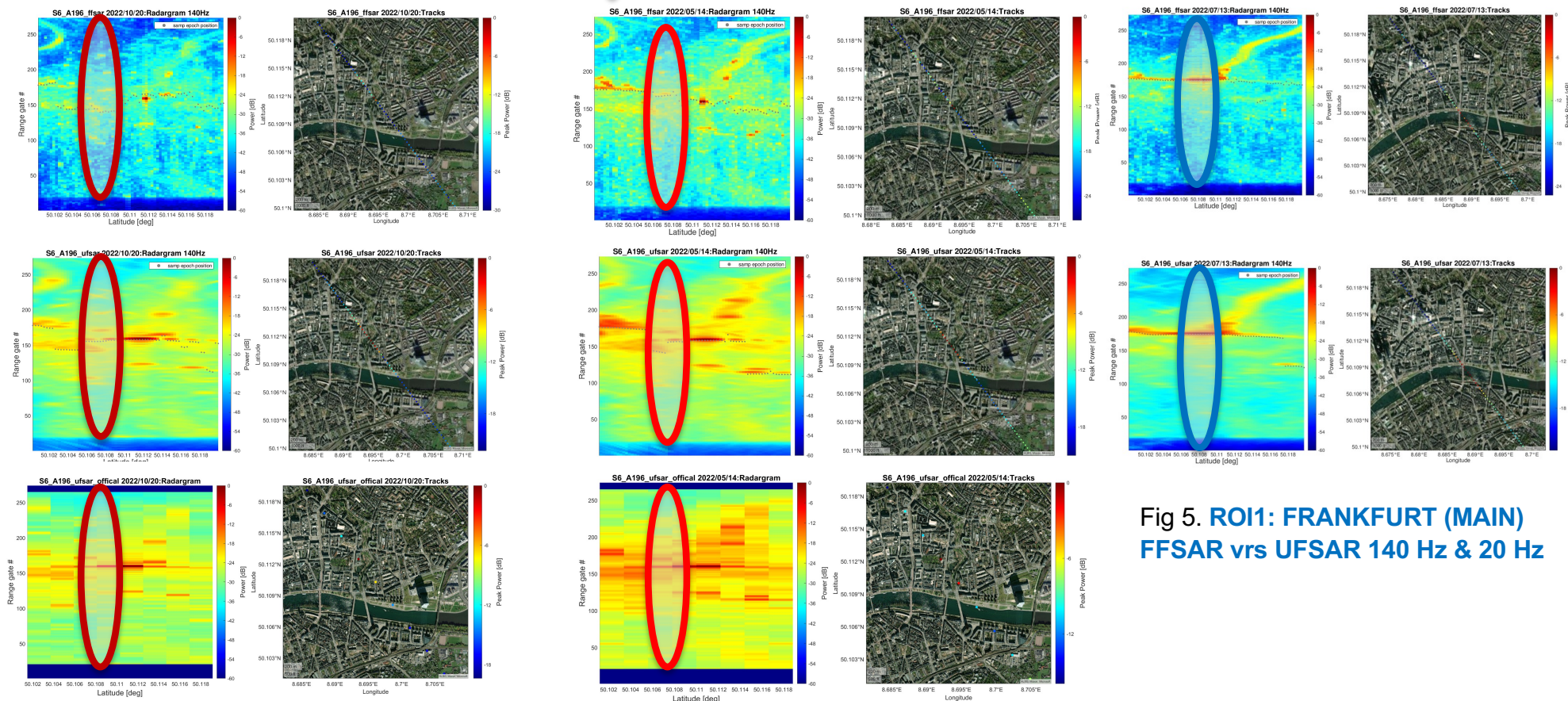


Fig 4

FRANKFURT: some UFSAR radargrams are contaminated by bright targets external to river



A196 & Pool in Park Good points in FFSAR
Missing point in both UFSAR 140Hz & 20Hz



ROI2 includes Elbe Estuary and tidal river (70 km, meso-tides 3-4m range)

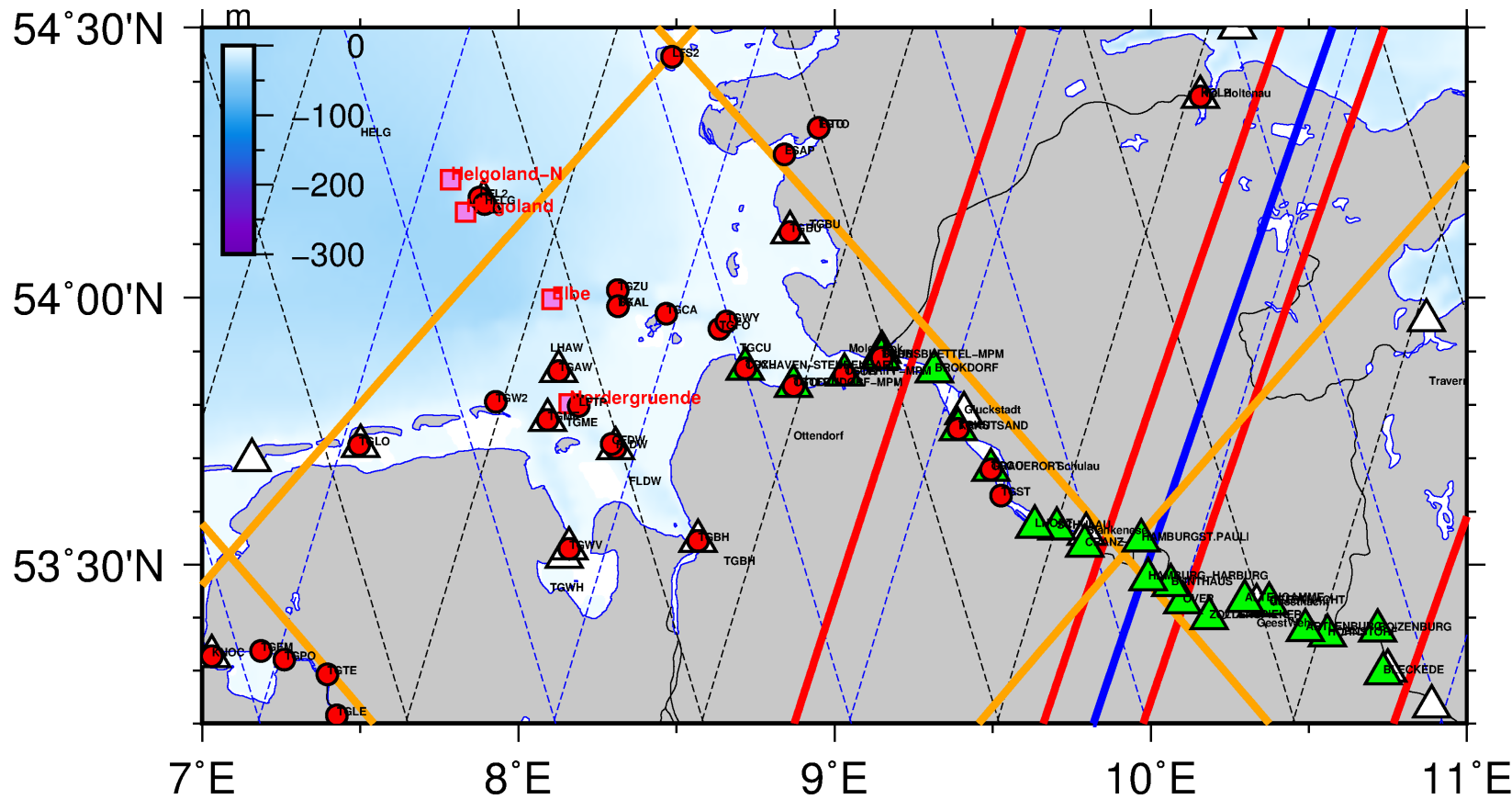
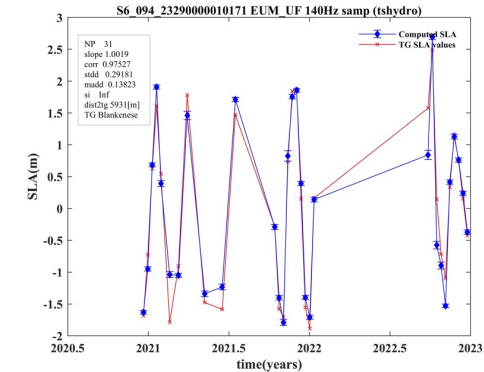
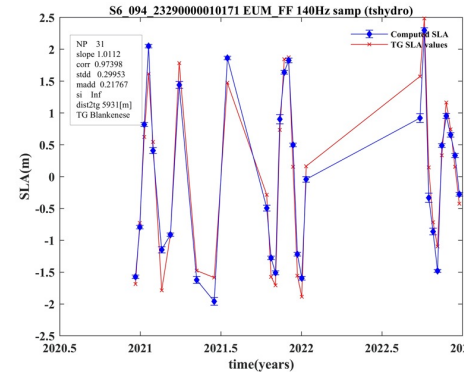
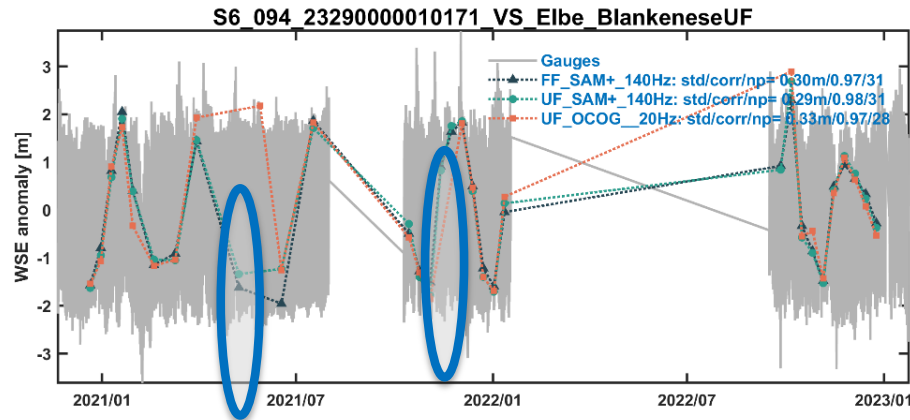


Fig. 6 In-situ data (tg-triangle and GNSS-circle)

Elbe near gauge Blankenese has two branches outside the main river, difficult for signal restitution and for comparison of altimetry versus gauges. Here STDD difference is 20-30 cm



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ROI2: ELBE FFSAR & UFSAR 140 Hz, UFSAR 20 Hz

STDD 20-30 cm

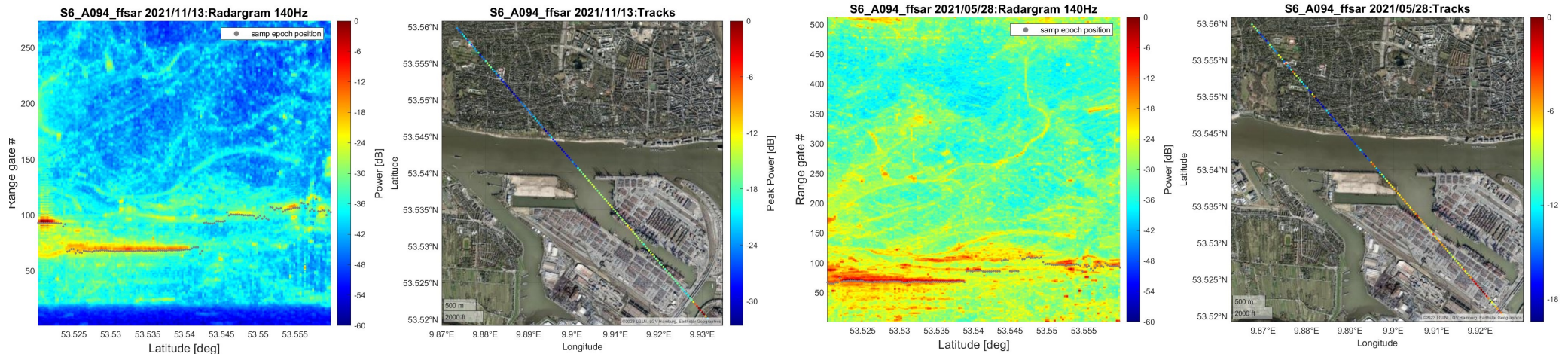


Fig. 7 Complex location – with port
STDD of 20-30 cm for all FFSAR & UFSAR 140 Hz and 20 Hz

Elbe near gauge Blankenese has two branches outside the main river, could explain lower agreement between SWOT L2 LR in Blankenese than at other gauges in the Elbe river

STDD 20-30 cm in Glückstadt, 70 cm in Blankenese

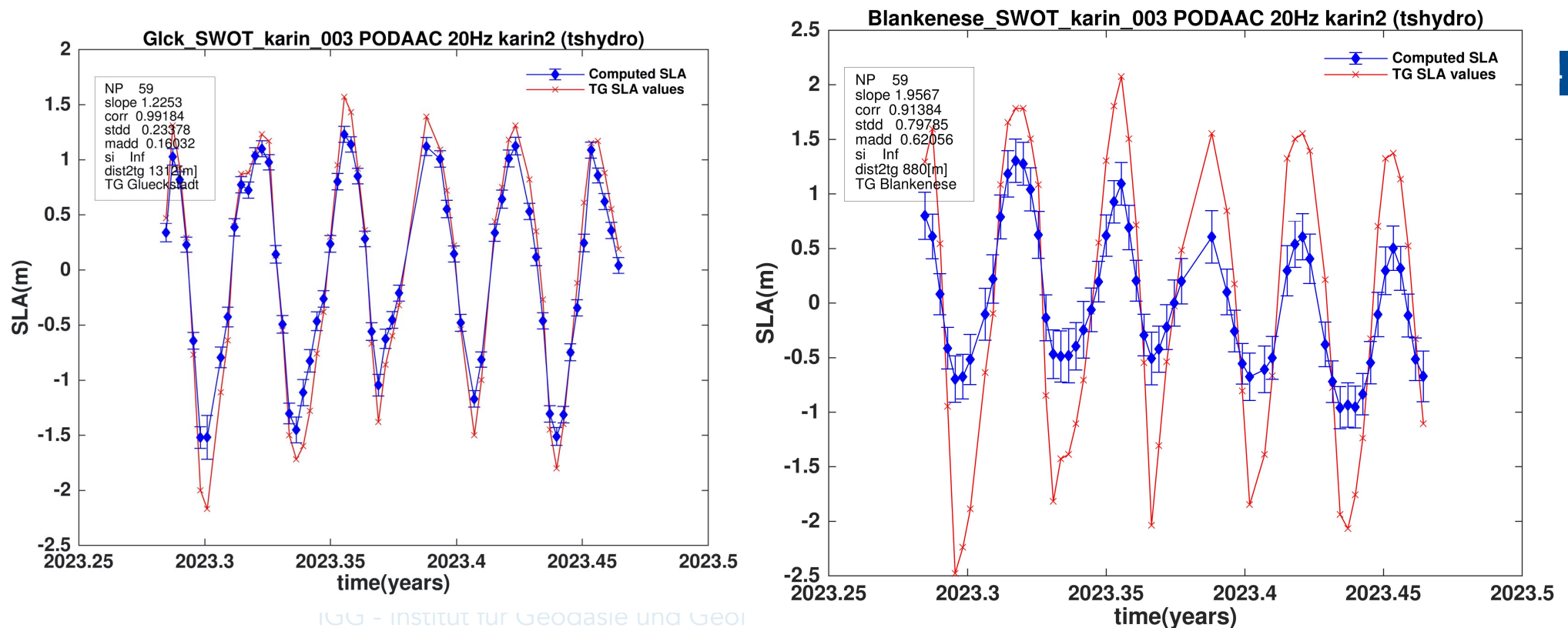
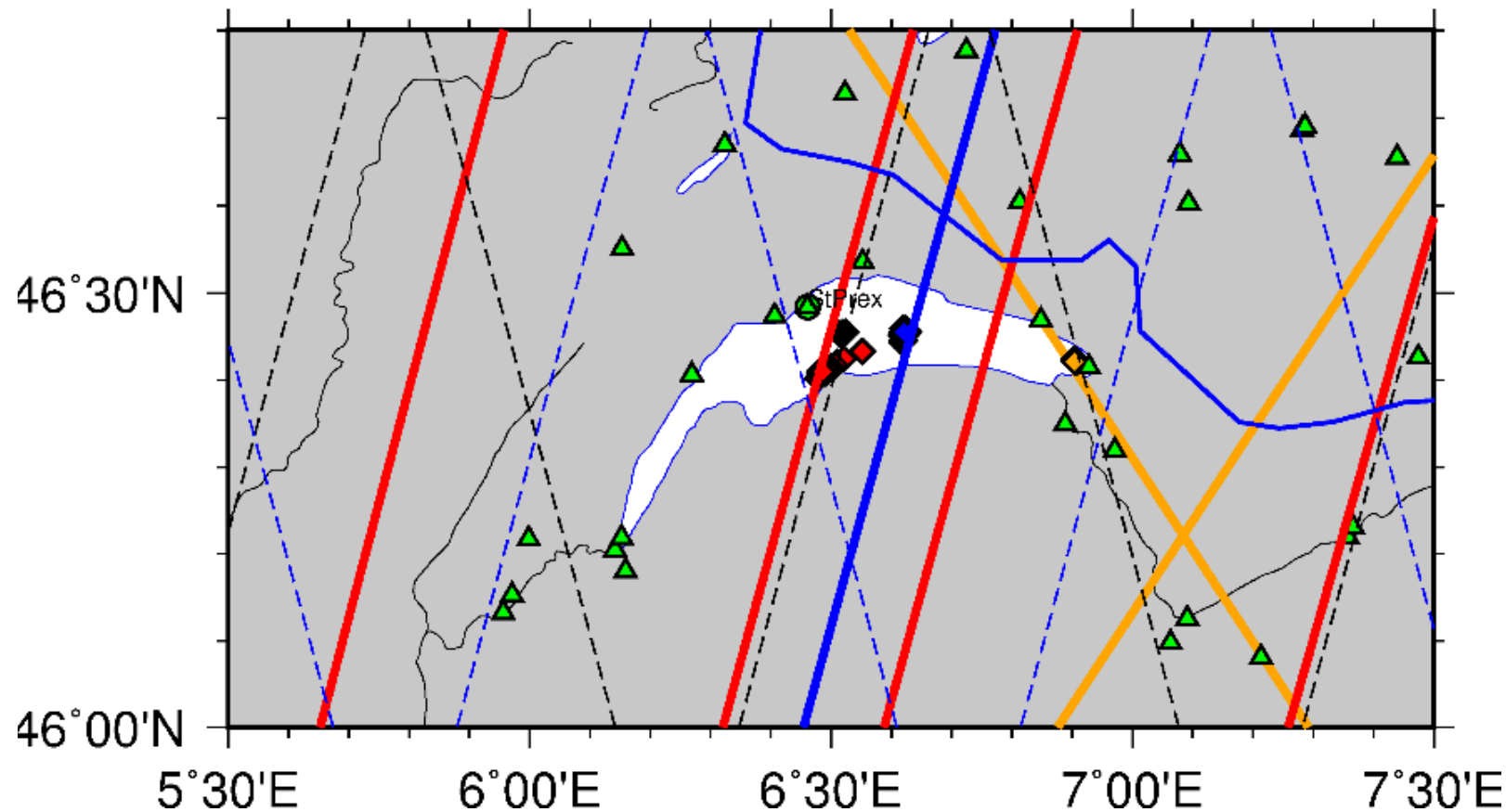


Figure 8: Elbe in Glückstadt (left) and Blankenese (right)

ROI3 include lakes in Switzerland



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Fig. 9 In-situ data (gauge-triangle)

Lake Geneva: Example of radargram S6A

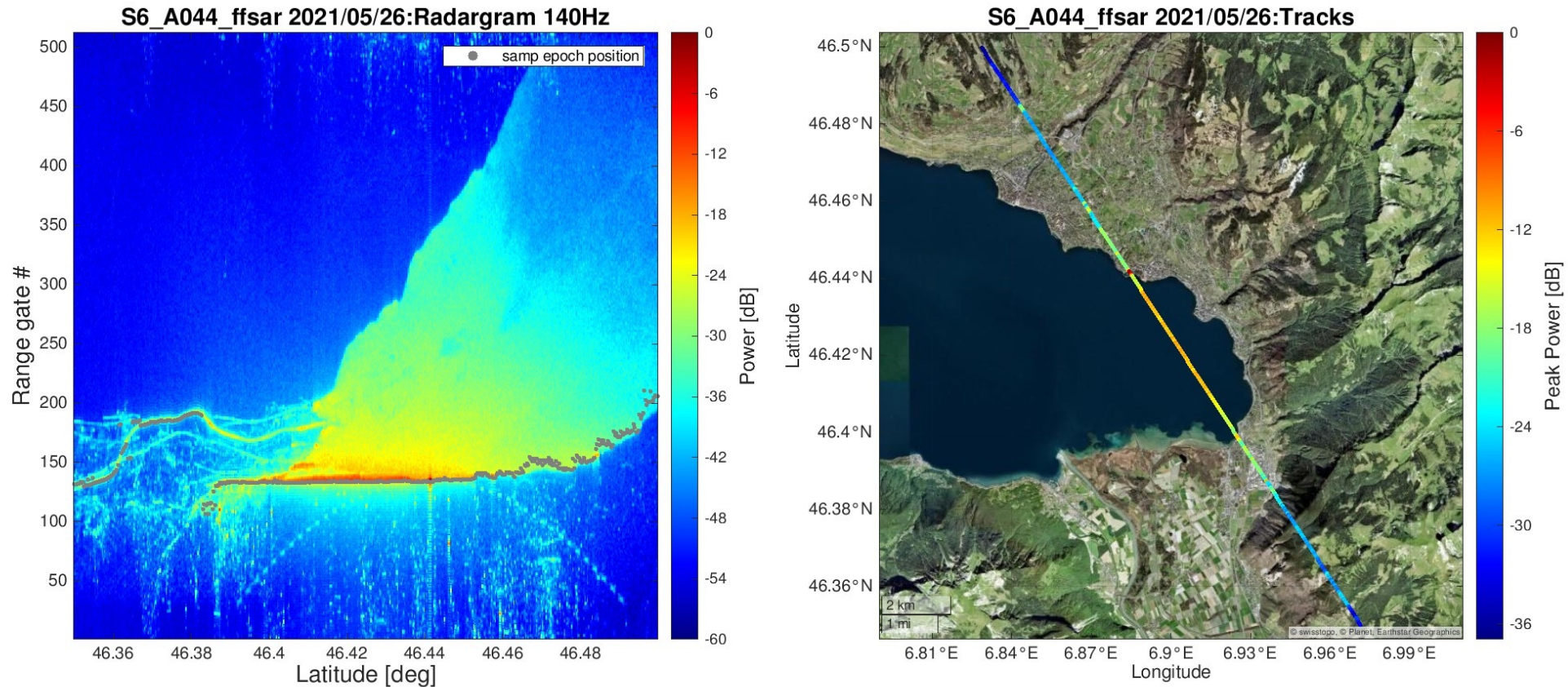
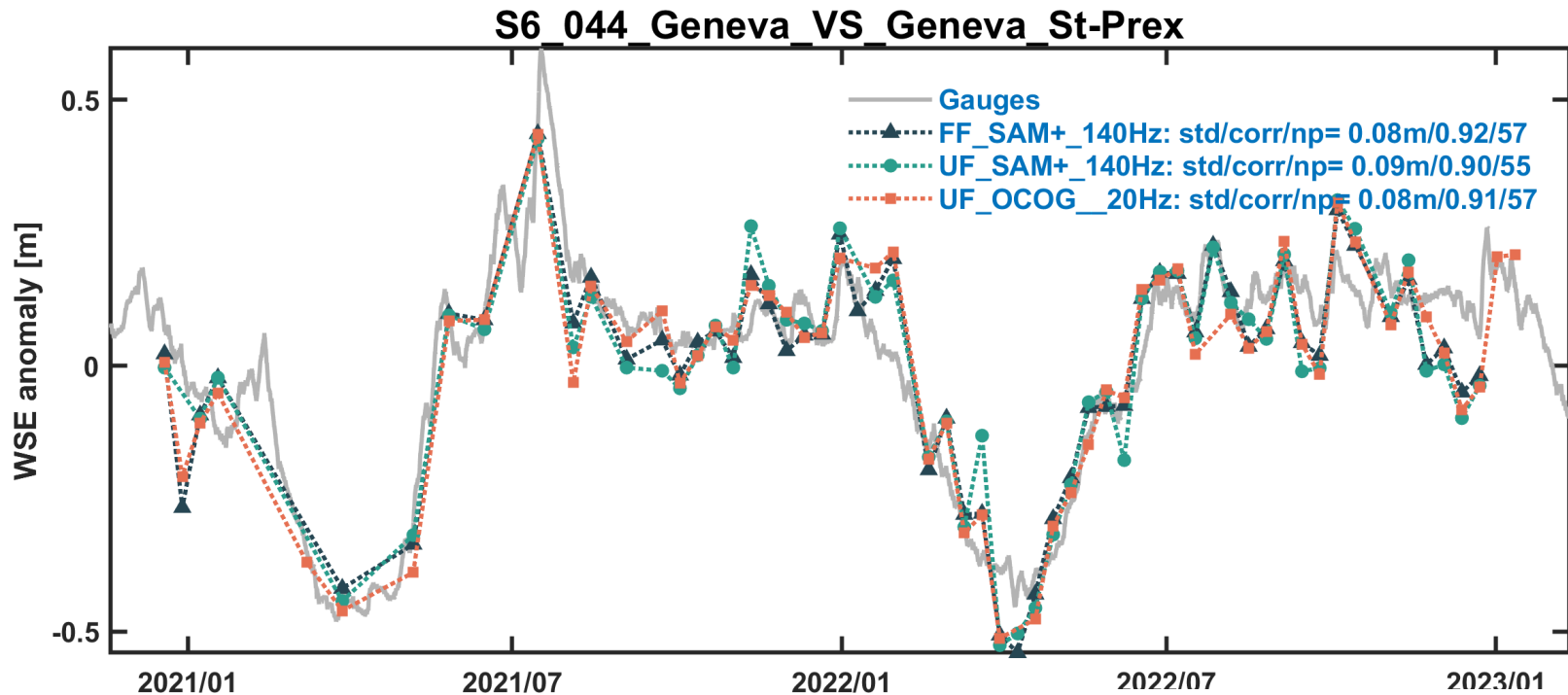


Fig. 10. Lake Geneva: STDD 8-9 cm, Stable results for all FFSAR/UFSAR

In Lake Geneva S6A has STDD against gauges of 8 cm for all processing



**STDD 8cm
/57np**

**FFSAR and
UFSAR 140 Hz
& 20 Hz**

17

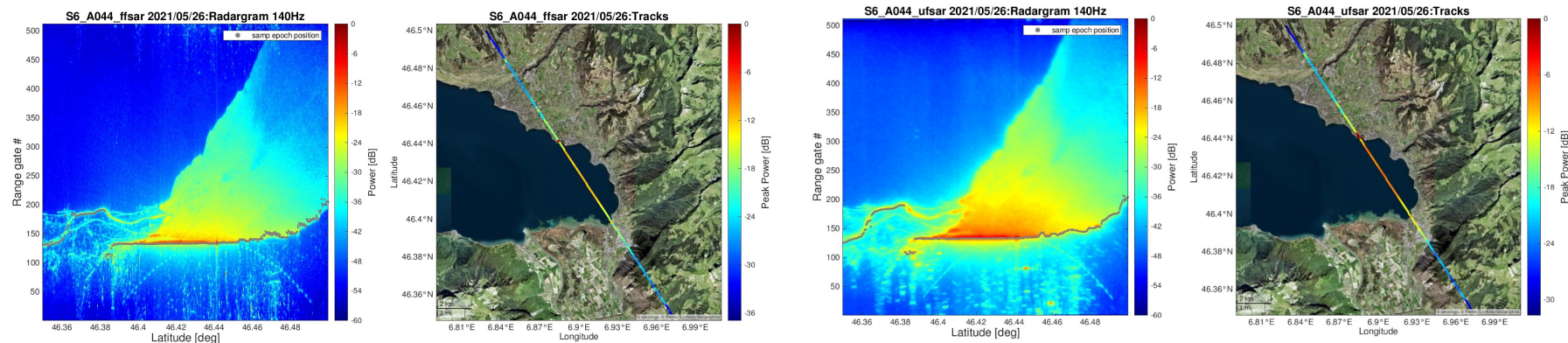


Fig. 10. Lake Geneva: STDD 8-9 cm, Stable results for all FFSAR/UFSAR

In Lake Geneva S6A STDD against gauges is 2 cm using SWOT L2 LR
With the nadir-altimeter we have :

STDD 2 cm Sentinel-6 & SWOT karin LR L2 (2km x 2km)

STDD 5 cm SWOT nadir

STDD 7 cm Sentinel-3

Note that average is above different water regions (the all lake for SWOT-KaRIn)

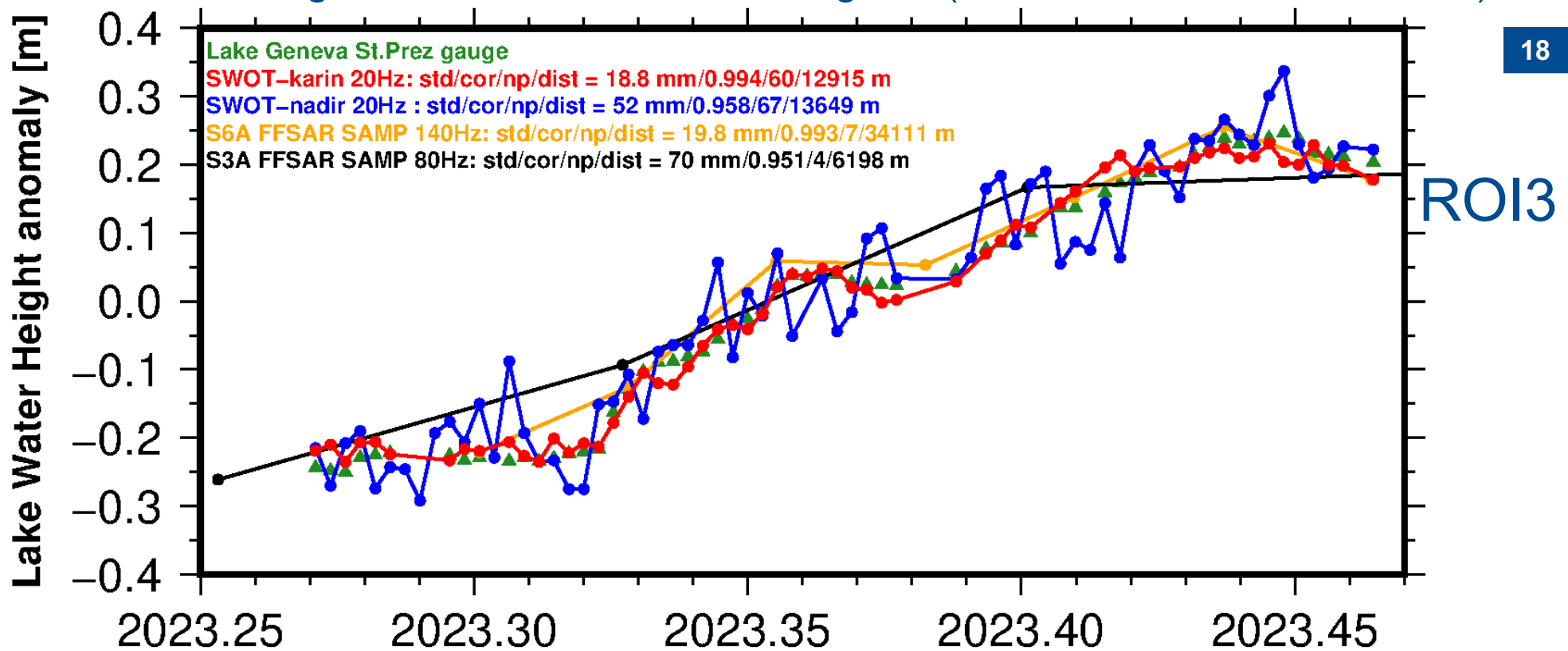


Figure 11: Lake Geneva STDD in 1-day SWOT Interval comparison against in-situ

Example of radargram in Baltic Sea

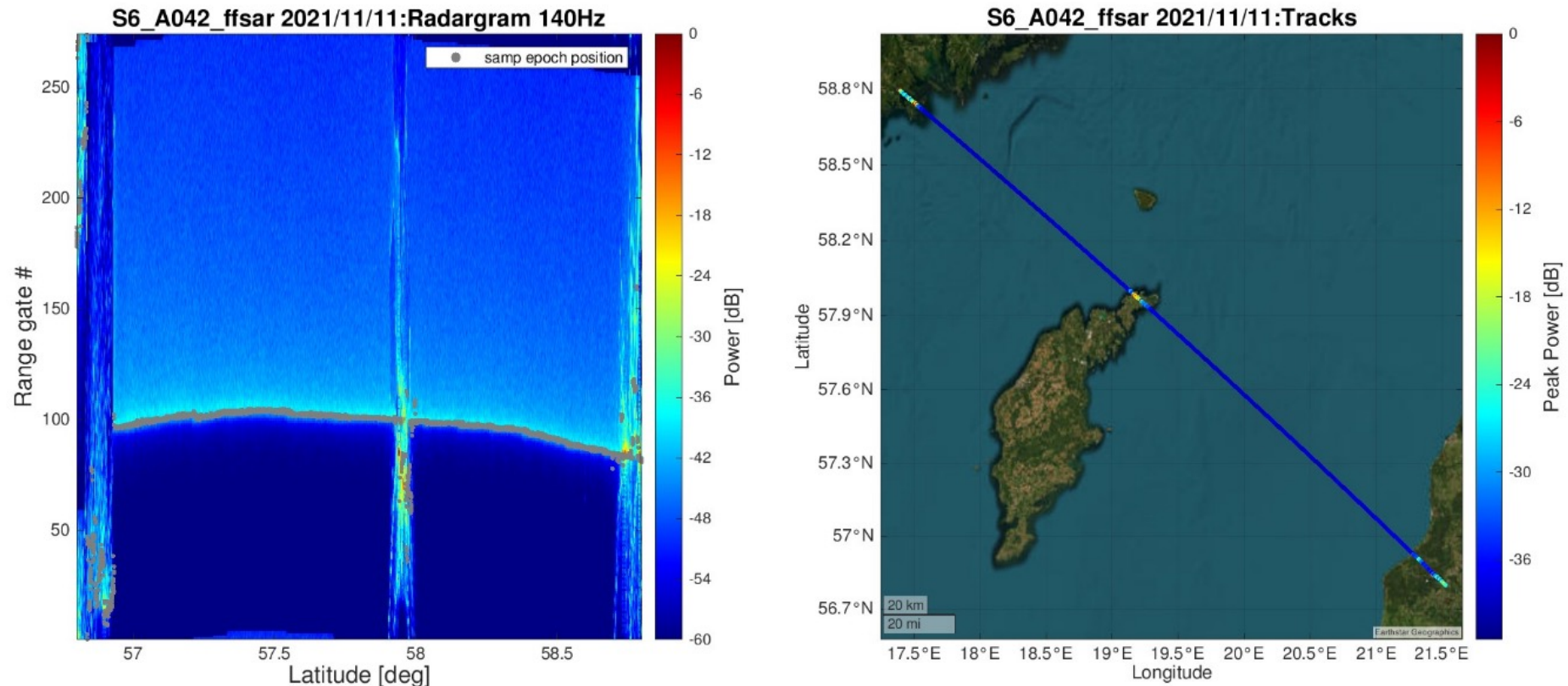


Fig. 12 Radargrams very similar
FFSAR 140 Hz

ROI4

In Baltic open sea radargrams from FFSAR/UFSAR 140 Hz & 20 Hz are similar

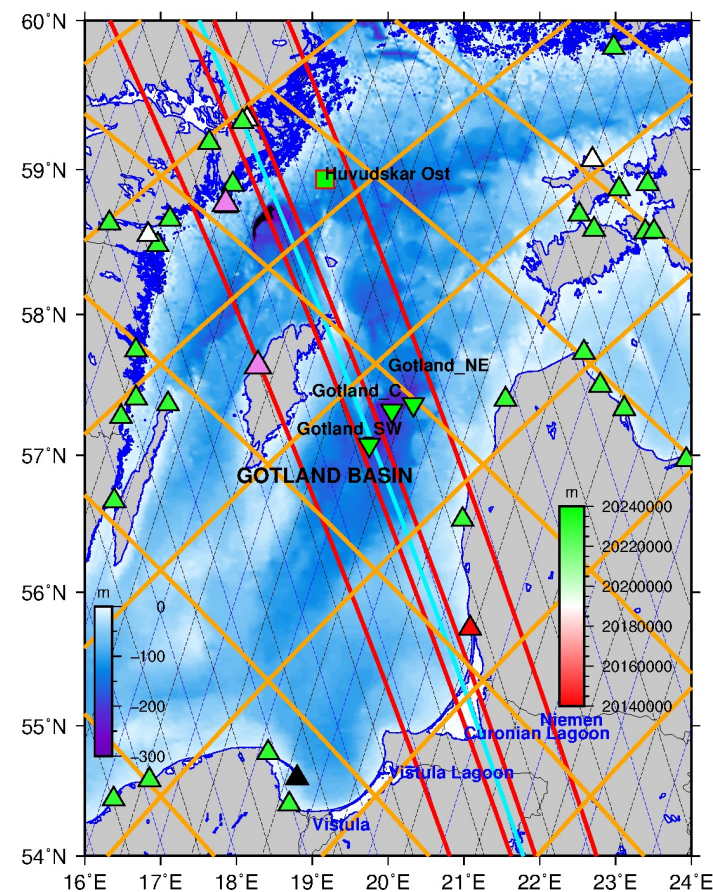
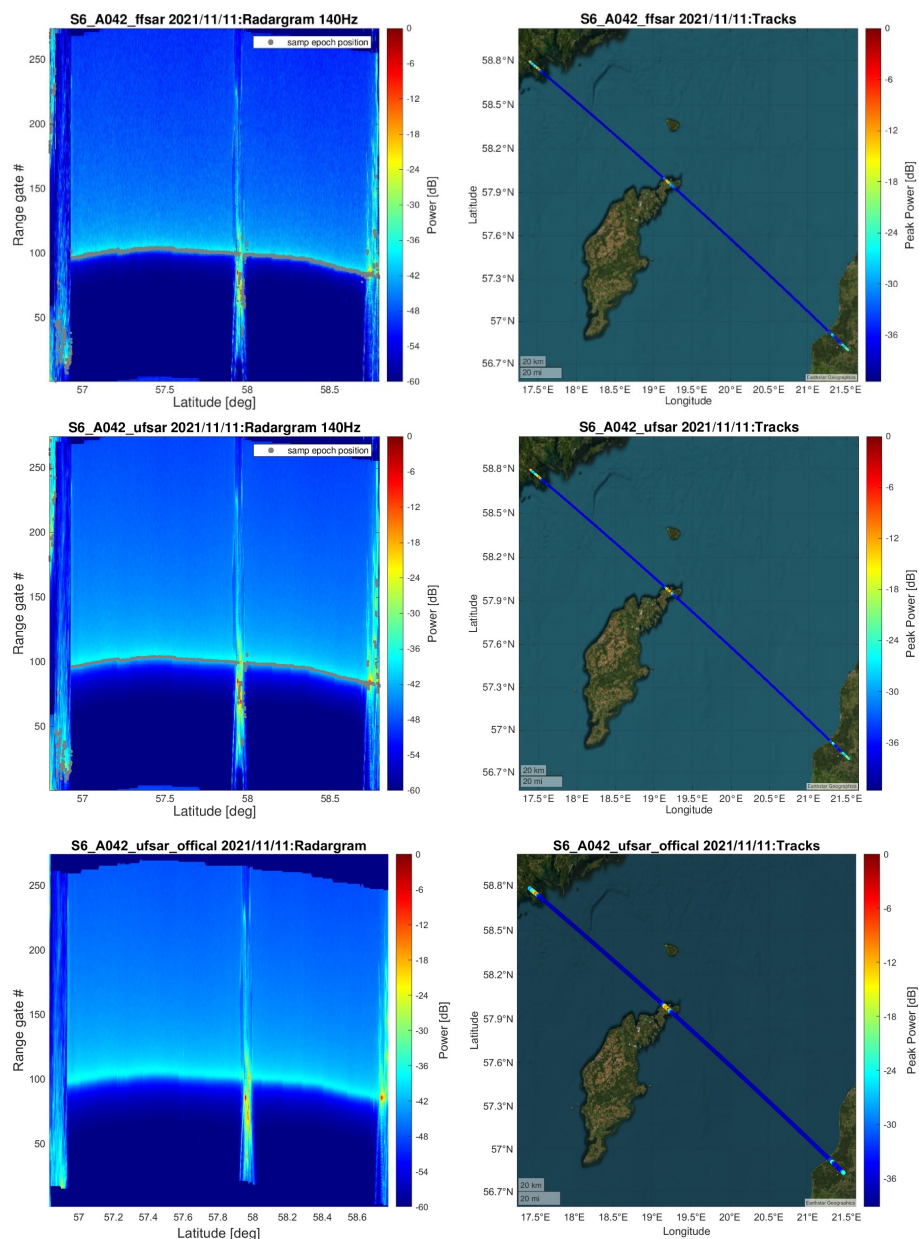
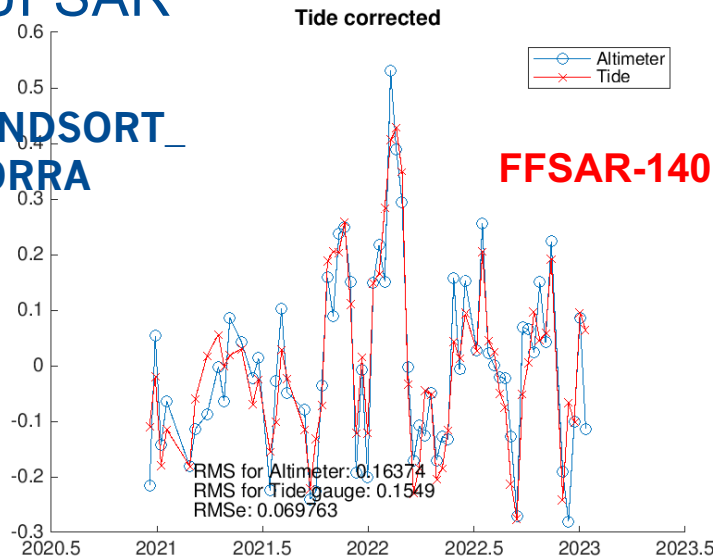


Fig. 12 Radargrams very similar
FFSAR 140 Hz
UFSAR 140 Hz
UFSAR 20 Hz

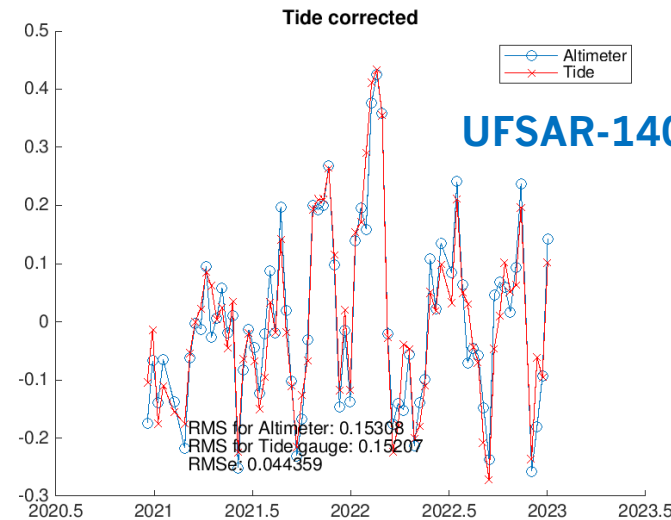
ROI4

STDD of SLA is 5-6 cm in the Baltic with all processing, slightly better with UFSAR

LANDSORT_
NORRA



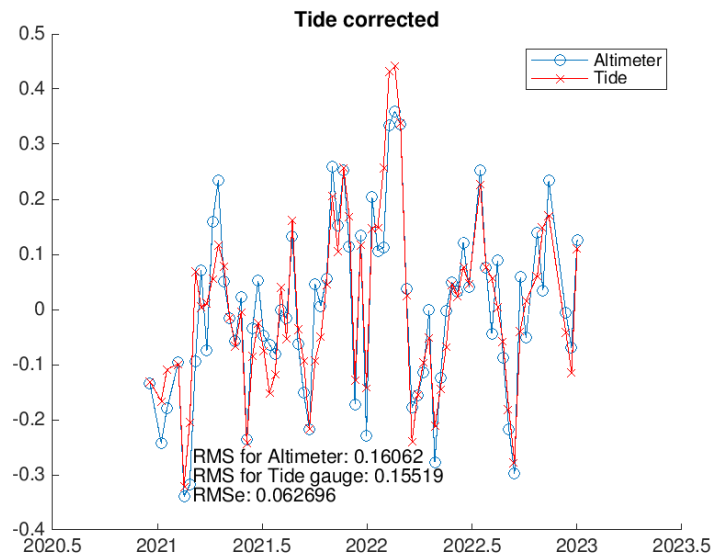
FFSAR-140Hz



UFSAR-140Hz

STDD

VISBY



6 cm FFSAR

5 cm UFSAR

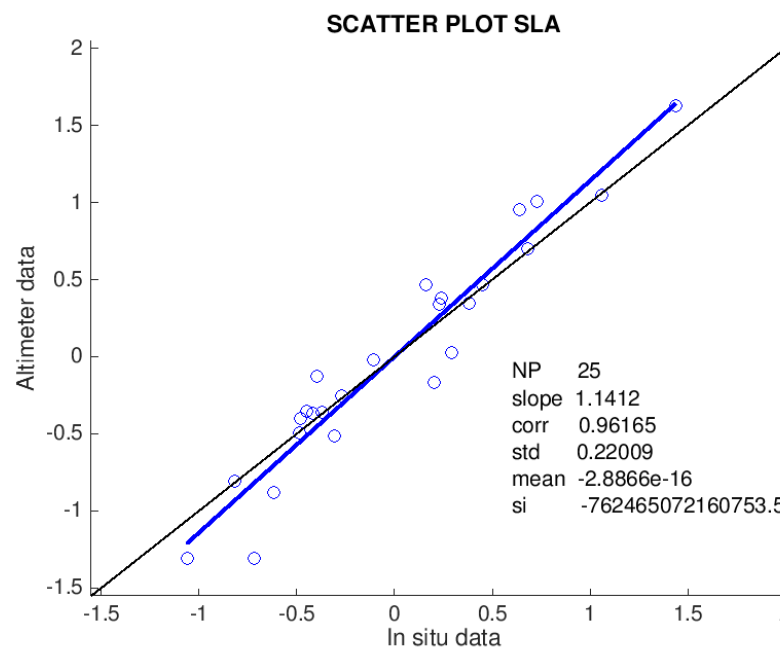
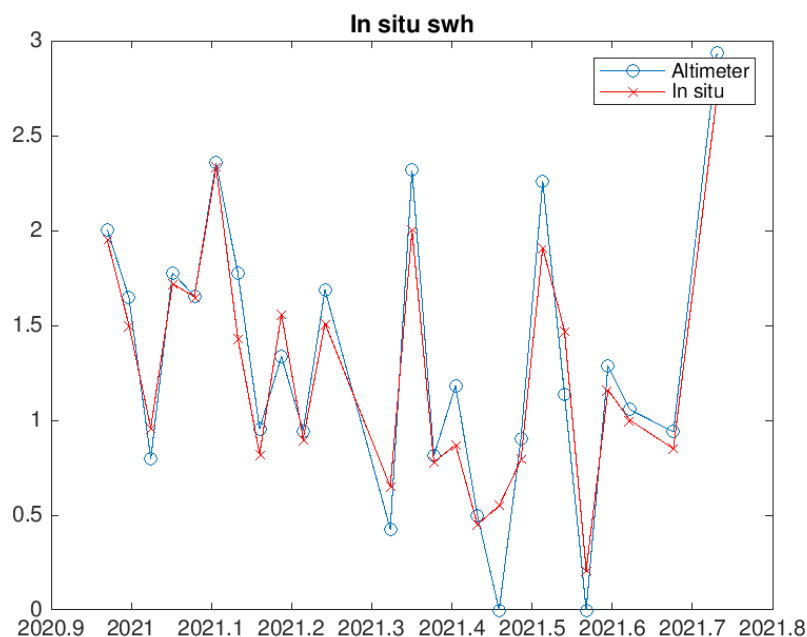
ROI4

Fig. 13 Comparison of time-series against gauges

OSTST2023 S6VT 7-10 November 2023

STDD of SWH is 22 cm with UFSAR 20 Hz
Not improvement to previous versions of data

ROI5: SWH 20 Hz HR_ALT_STD_NTC F08



STDD 22 cm UFSAR

Fig. 13. SWH of 20Hz time-series and scatterplot S6A094 with buoy FINO3

- Not Time Constraint (NTC) products evaluated in rivers, lake and coast
- Water Surface Elevation (WSE) in **rivers** : improved accuracy in Inland Water
 - using FFSAR (e.g. STDD 09 cm Mainz, width 100 m), more NP
 - using Samosa+
- WSE In **large lakes**: similar results for UFSAR and FSAR 8 cm STDD
- WSE in **coastal zone**: preferred is UFSAR/FFSAR STDD 140 Hz 4-6 cm
- SWH in **coastal zone** : UFSAR 20 Hz STDD 22 cm
- Higher frequency for **products for hydrology** than 20Hz official data
 - Best results from FFSAR products at 140 Hz