Monitoring of SAR-altimeter missions at non-dedicated tide gauge stations in the German Bight

Saskia Esselborn and Tilo Schöne

GFZ, Helmholtz Centre Potsdam

GFZ Helmholtz-Zentrum Potsdam

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

Outline

Goal: assessment of precision and accuracy of recent altimeters in the SE North Sea

Method: comparison instantaneous SSH/ total water envelope from altimetry and tide gauges in the German Bight (2013-2021)

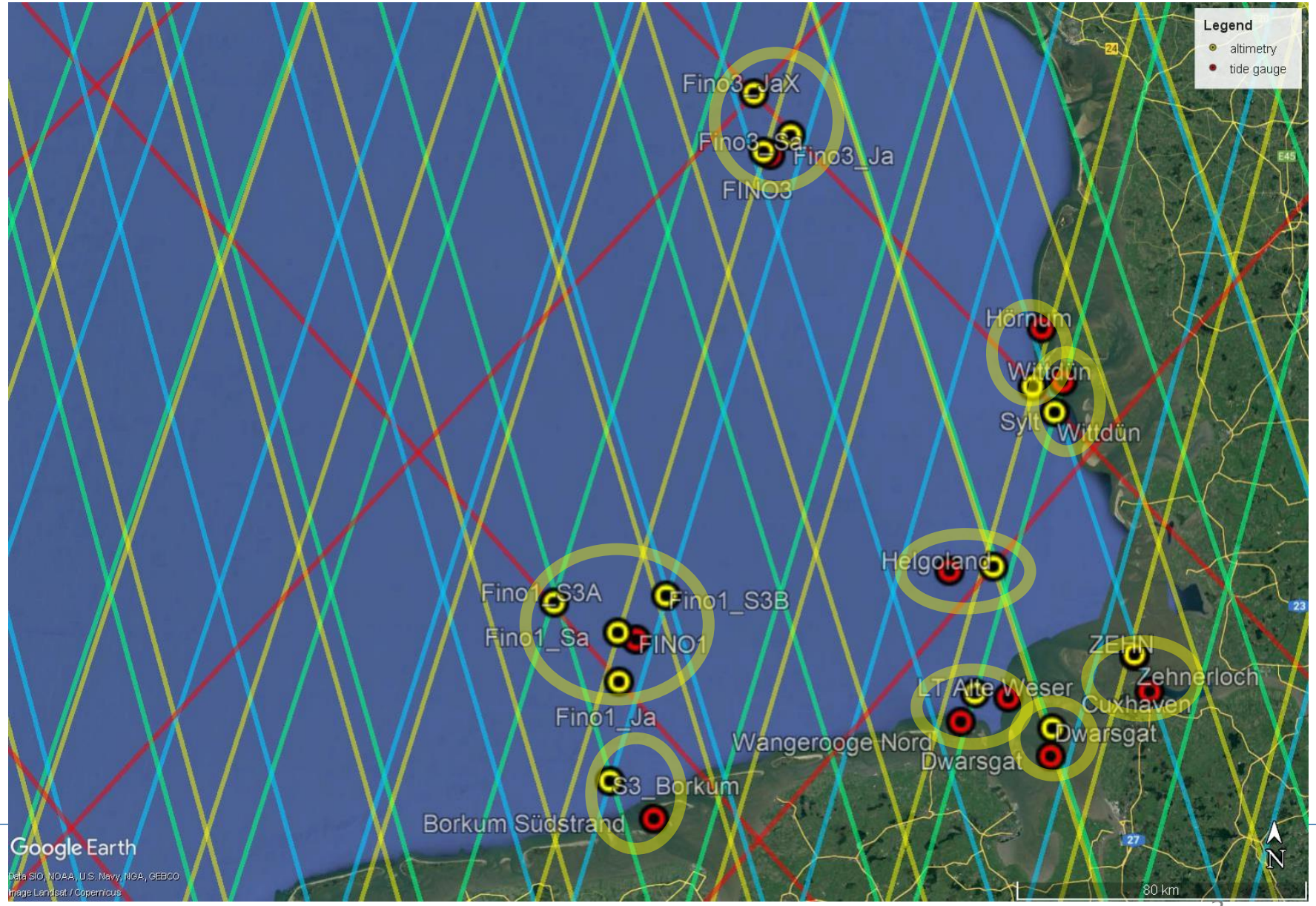
- Stations are not exactly collocated

  $\Delta SSH_{obs} = Bias_{regional} + \Delta MSSH + \Delta SLA + \varepsilon$

  ΔSLA: time variable position correction (tides)

  $\Delta MSSH$: Mean position correction
- RMS differences as proxy for precision
- Regional mission bias based on recent MSS models

Tide Gauge Stations and Satellite Tracks



Jason-3/ Sentinel-6MF

Saral

Sentinel-3A

Sentinel-3B

tide gauges

altimetry

Data (01/2013 – 11/2021)

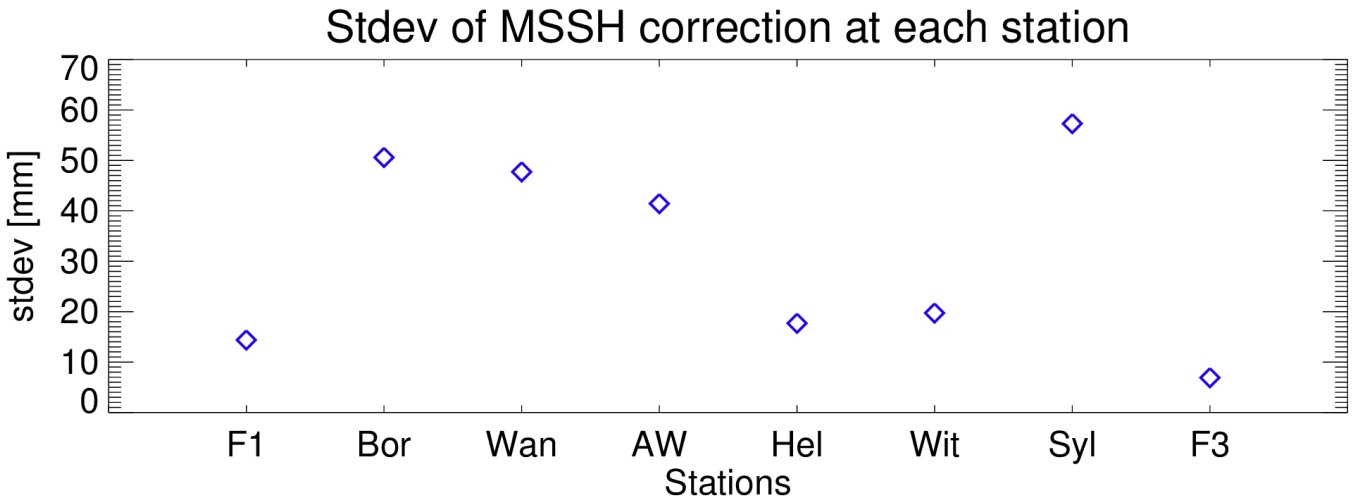
Altimetry (5 missions): Sentinel-6MF, Jason-3, Sentinel-3B, Sentinel-3A, Saral

- High frequency level 2 altimetry data, standard retrackers
- Total Water Level Envelope: no corrections for ocean tides and dynamic atmosphere (not sufficiently known close to the coast)
- Coastal correction models (ionosphere and wet troposphere)
- Outlier elimination and filtering (20km): interpolation to virtual stations close to gauges (2-13 km)

Tide gauges (11 stations):
open water: FINO1, FINO3, Helgoland
coast: Borkum, Wangerooge, LT Alte Weser, Dwarsgat, Cuxhaven, Zehnerloch, Wittdün, Hörnum

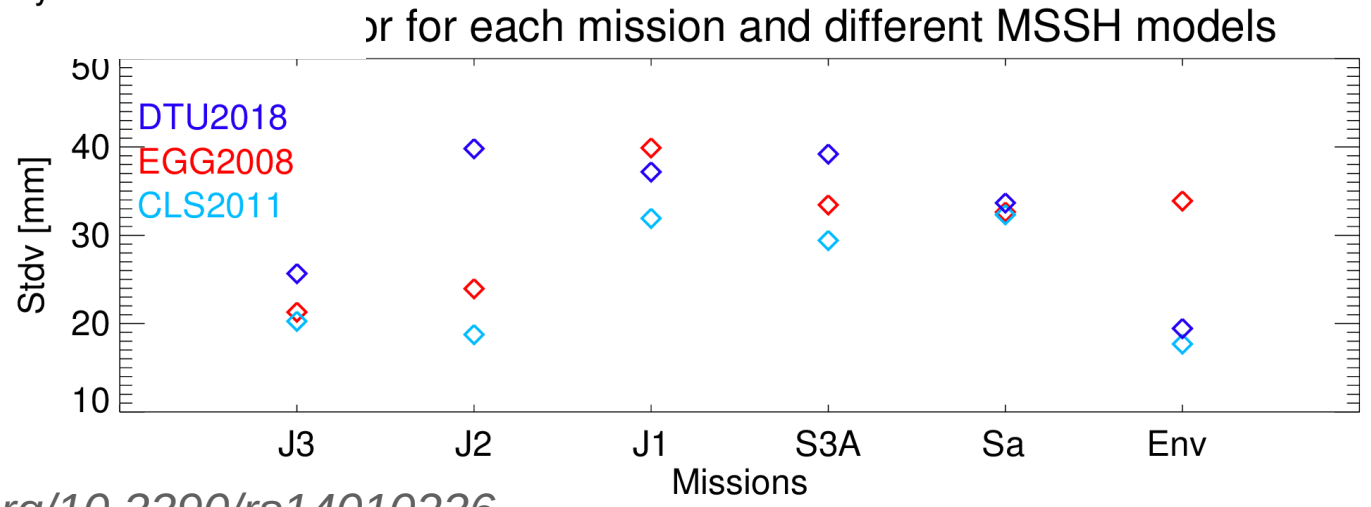
- georeferenced by GPS
- data every minute
- outliers eliminated

Mean position correction
adjust for MSSH differences



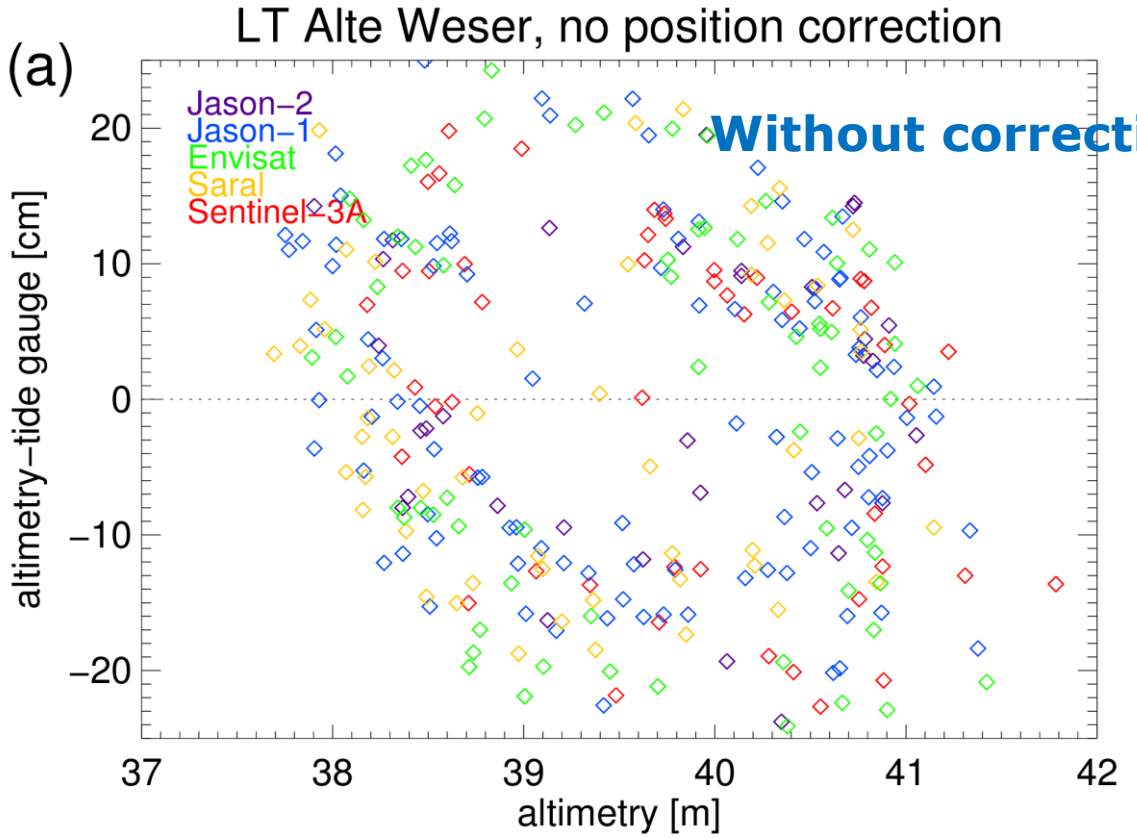
At some stations estimates of ΔMSSH differ by up to 10cm between MSSH models

Regional mission biases at stations match best for MSSH CLS2011

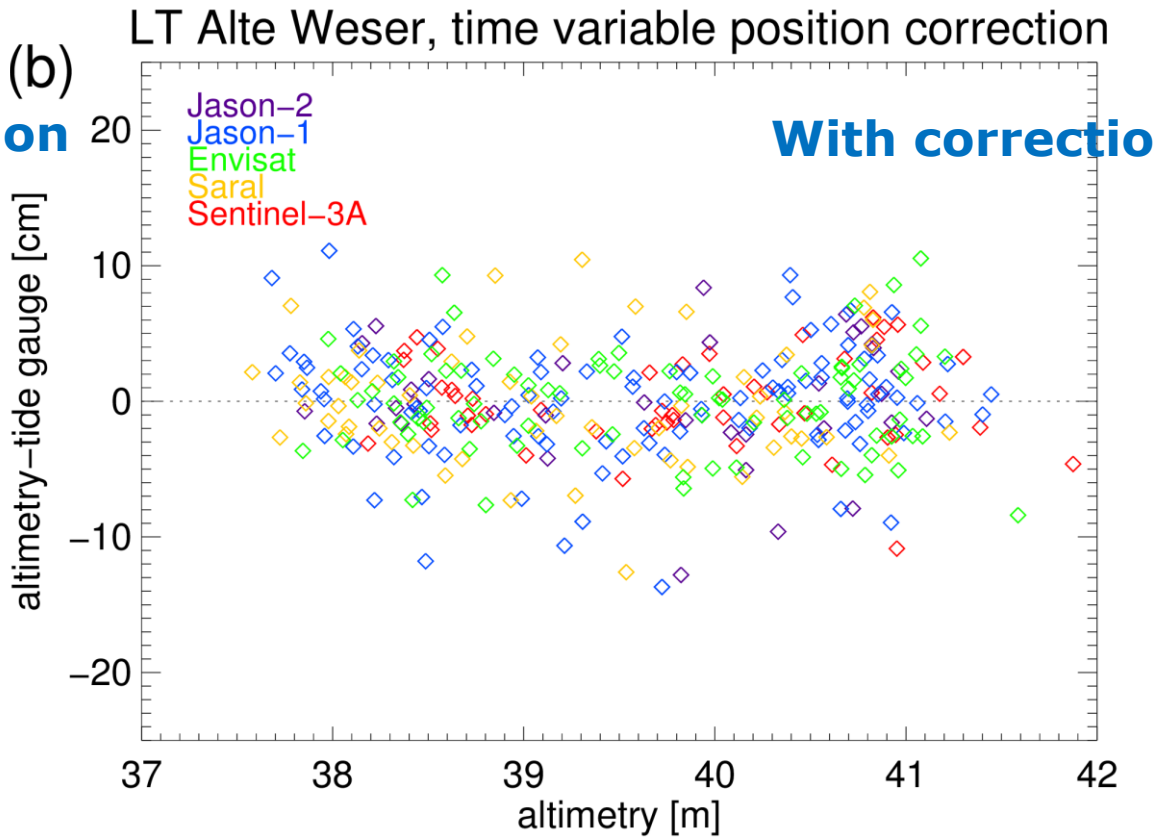


Esselborn et al., Remote Sens. 2022, *https://doi.org/10.3390/rs14010236*

Time variable position correction
adjust amplitude and arrival time



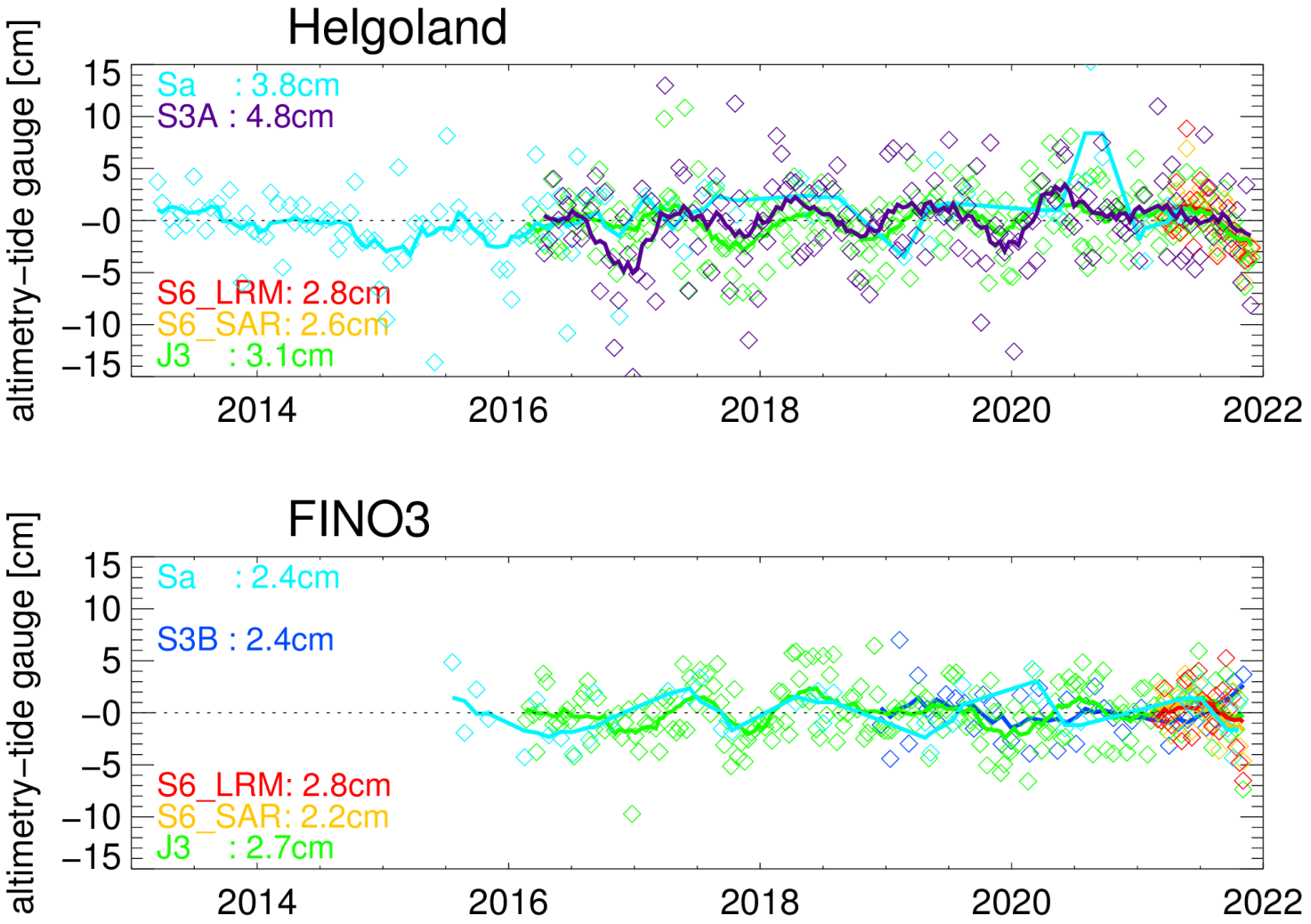
ΔSLA depends on SSH



Δt=14-19min, scale=1.02–1.06

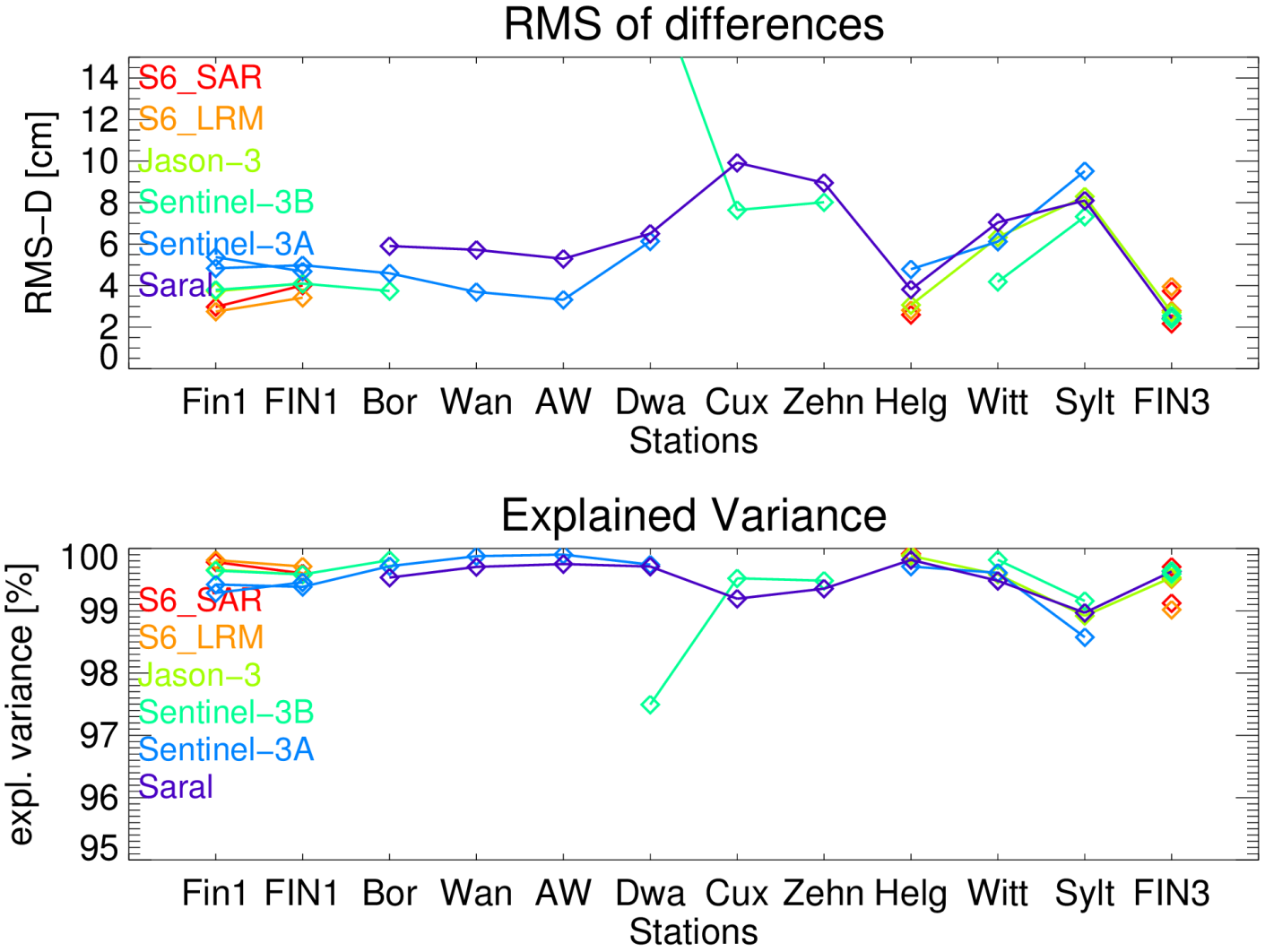
Esselborn et al., Remote Sens. 2022, *https://doi.org/10.3390/rs14010236*

Difference Gauge/Altimetry & RMS



Solid line:
3-months boxcar
Numbers:
RMS-difference

RMS error and explained variance (counter-clockwise along coast)



open water
RMS-D: 2 - 3 cm
coast
RMS-D: 3 - 10 cm

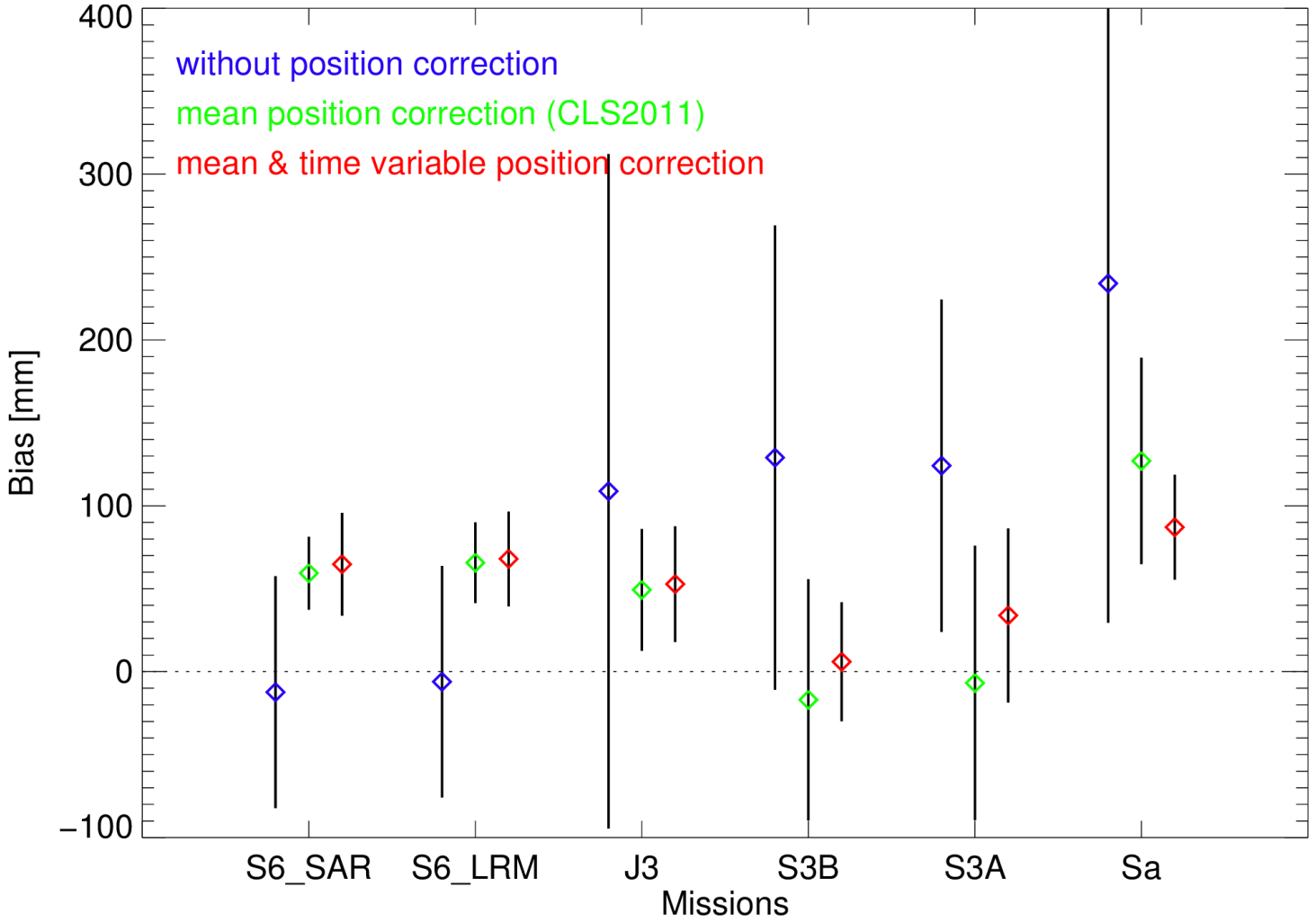
Fino1/FINO1:
different sensors
and periods

Best fitting stations - Lowest RMS differences

Tide gauge	Mission	RMS diff [cm]	Expl. Var. [%]	Distance [km]	Collocated values
FINO3	Sentinel-6 SAR	2.2	100	2	23
FINO3	Sentinel-6 LRM	2.8	100	2	24
FINO3	Jason-3	2.7	99	2	203
FINO3	Sentinel-3B	2.5	99	7	78
LT Alte Weser	Sentinel-3A	3.3	100	9	74
Fino1	Saral	3.4	100	2	57

RMS difference: combined precision of tide gauge, altimeter and position correction

Regional mission bias
averaged over gauges



Mission	Bias [cm]	No. gauges
S6 SAR	4.8±2.6	4
S6 LRM	5.1±2.2	4
Jason-3	4.5±1.7	6
S3B	0.4±2.3	6
S3A	3.0±3.4	7
Saral	8.4±2.8	9

Summary

- Assessment of accuracy /precision for 5 altimeter missions (2013-2021) relative to 11 tide gauges in the German Bight
- Regional mission bias: uncertainty 2-3 cm, longer time series necessary, limited by MSS uncertainty
- Lowest RMS differences: 2.2-3.4 cm (~1.5-2.7 cm precision), higher RMS-D at the coast (up to 10 cm)
- Sentinel-3: at some locations close agreement near the coast (LT Alte Weser and Wittdün)
- Sentinel-6: SAR more precise than LRM
- Details on the method: Esselborn et al., Remote Sens. 2022, *https://doi.org/10.3390/rs14010236*