In situ calibration of satellite altimetric missions on the German Bight and Baltic sea coasts

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Abstract

We perform a regional in-situ calibration of the CryoSat-2 and Sentinel-3 altimeter data in Delay Doppler (DD) and pseudo low resolution mode (PLRM) along the German coasts of the German Bight and of the Baltic Sea We assess the data quality close to the coast and characterize at few ground sites the sea surface height (SSH) bias of the new SAR altimeter measurements.

Methods and Data

Data cover the 18 months of Sentinel-3A from June 2016 to December 2017. We use:

- Sentinel-3A SAR MARINE (SAMOSA2 open ocean retracker)
- Sentinel-3A SAR GPOD (SAMOSA+ coastal retracker)
- Sentinel-3A RDSAR (or PLRM) MARINE (open ocean retracker)
- Sentinel-3A RDSAR data from SAR bursts, STAR sub-waveforms coastal retracker
- CryoSat-2 RDSAR with both TALES and STAR sub-waveforms coastal retrackers
- CryoSat-2 SAR GPOD (SAMOSA+ coastal retracker)

We cross-compare sea level anomalies (SLA) and dynamic topography (DOT) against a regional ocean model and in-situ data. Skill metrics are: bias, standard deviation of differences (stdd) and correlation. Test area is the German Coast (GEC) (Fig. 2).

GPODO/SAM2	Common options in GPOD	GPODC/SAM+
	20 Hz	
	Hamming in coastal only	
	Exact beam forming approximated	
	FFT Zero-Padding	
128 range bins (radar receiving window)		256 range bins (radar receiving window)
	No antenna path correction	
	LUT	
SAMOSA2		SAMOSA+

Fig. 1 Options available in GPOD for coastal and open ocean

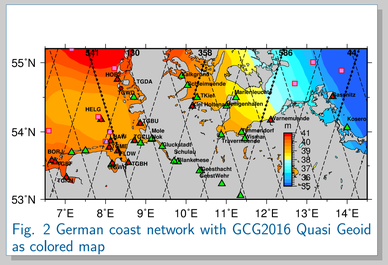

Fig. 2 German coast network with GCG2016 Quasi Geoid as colored map

Noise in coastal zone

Absolute value difference between consecutive 20 Hz sea level anomalies increases at 6 km from coast in RDSAR MARINE and at 2 Km in SAR MARINE.

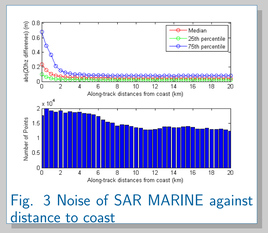

Fig. 3 Noise of SAR MARINE against distance to coast

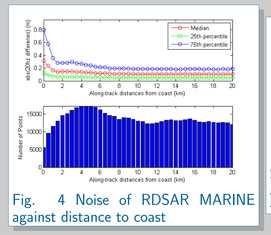

Fig. 4 Noise of RDSAR MARINE against distance to coast

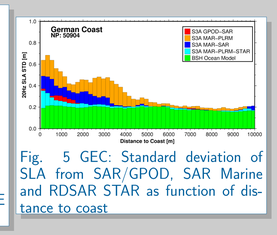

Fig. 5 GEC: Standard deviation of SLA from SAR/GPOD, SAR Marine and RDSAR STAR as function of distance to coast

Bias at tide gauge stations

Absolute value difference between consecutive 20 Hz sea level anomalies increases at 6 km from coast in RDSAR MARINE and at 2 Km in SAR MARINE.

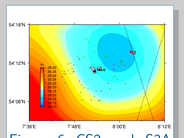

Fig. 6 CS2 and S3A 1 Hz at HELG 2010-2018 and 2016-2018 (green/purple), S3(red)

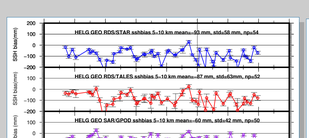

Fig. 7 CS2 minus HELG

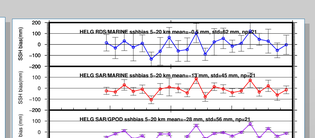

Fig. 8 S3 minus HELG

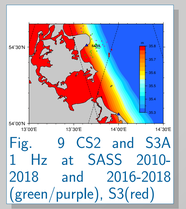

Fig. 9 CS2 and S3A 1 Hz at SASS 2010-2018 and 2016-2018 (green/purple), S3(red)

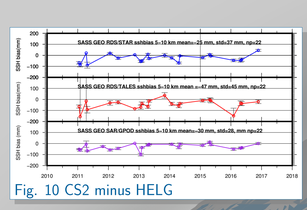

Fig. 10 CS2 minus HELG

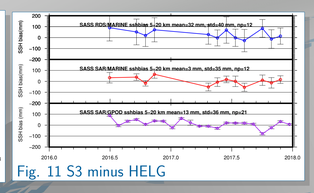

Fig. 11 S3 minus HELG

In-situ Validation open ocean

At distances between 10-20 km (open ocean) from tide gauge HELG, Sentinel-3 SAR MARINE has the best agreement (STDD 4.5 cm) followed by GPOD (STDD 6.1 cm).

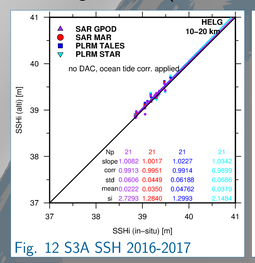

Fig. 12 S3A SSH 2016-2017

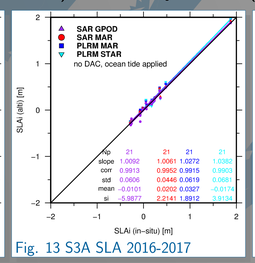

Fig. 13 S3A SLA 2016-2017

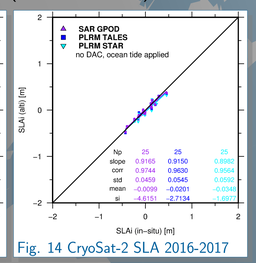

Fig. 14 CryoSat-2 SLA 2016-2017

In-situ validation along-track

The statistics (correlation and standard deviation of differences (20Hz STDD 1km apart)) between Sentinel-3 altimetry and tide gauges SSH is shown for increasing distance to tide gauge. There is clear improvement near coast for the SAR data.

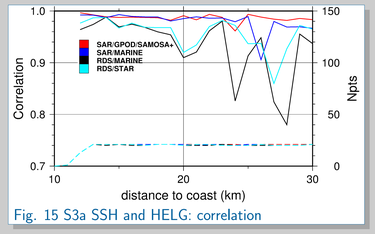

Fig. 15 S3a SSH and HELG: correlation

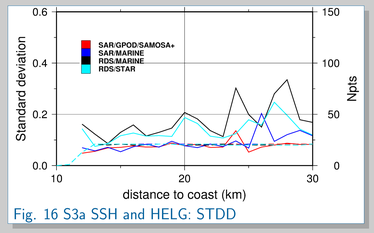

Fig. 16 S3a SSH and HELG: STDD

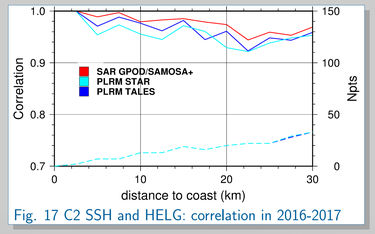

Fig. 17 C2 SSH and HELG: correlation in 2016-2017

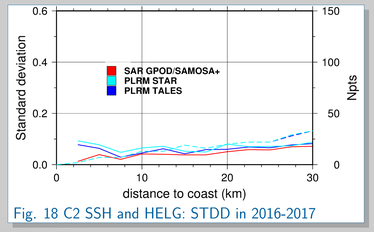

Fig. 18 C2 SSH and HELG: STDD in 2016-2017

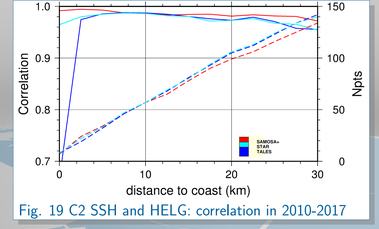

Fig. 19 C2 SSH and HELG: correlation in 2010-2017

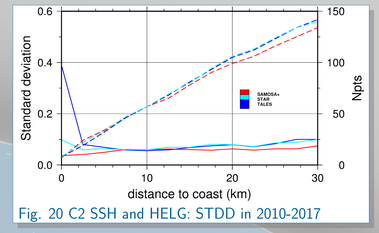

Fig. 20 C2 SSH and HELG: STDD in 2010-2017

Bias between tide gauge and altimetry

The bias is computed as difference between the altimetric and tide gauge ellipsoidal sea surface heights (SSH) using the nearest point between 10-20 km. The STDD of differences over the complete interval is 2 cm in Lighthouse Keil (LHKI) and 4 cm in Helgoland due to the smaller ocean tide amplitude. The mean difference is subtracted in LHKI, bias is absolute in HELG.

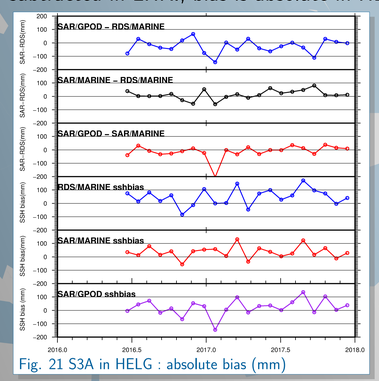

Fig. 21 S3A in HELG : absolute bias (mm)

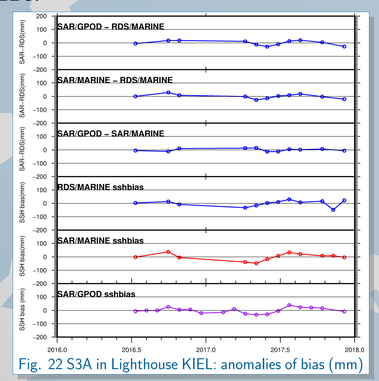

Fig. 22 S3A in Lighthouse KIEL: anomalies of bias (mm)

Conclusions

- Sentinel-3 SAR MARINE is more accurate than RDSAR MARINE
- in open ocean Sentinel-3 SAR GPOD and SAR MARINE are very similar
- SAR limit for coastal altimetry is 2 km with GPOD and 3.5 km with SAR MARINE
- RDSAR MARINE limit for use of coastal altimetric data is 6 km from coast
- dedicated coastal retracker needed for MARINE in SAR and RDSAR products
- bias estimation and stability monitoring suitable at Baltic stations

Acknowledgement

We acknowledge Copernicus, EUMETSAT, the European Space Agency and the ESA GPOD Team for the altimetry data, BfG for the tide gauge and GPS data and BSH for the ocean model data. The study GBS3CVAL (German Bight Sentinel-3 Calibration and Validation) is part of the Sentinel-3 Validation Team.

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