CryoSat-2 Ocean Altimetry Assessment

Marc Naeije[1], Ernst Schrama[1], Jérôme Bouffard[2], Pierre Féménias[3]
[1]Aerospace/TU Delft, The Netherlands [2]RHEA/ESA, Italy [3]ESRIN/ESA, Italy

corresponding author: m.c.naeije@tudelft.nl

Data

- ESA L2 GOP DBL files: April 2015 up to July 2016 (CS_OFFL) and prior data starting February 2012 (CS_LTA), all software/processor ver. IPF2GOP/2.5
- Store in subcycles: CryoSat-2 has the following sequence of revolutions: 4*(29+29+27)+29=369 days (subcycles 24 up to 81)
- Archive in the RADS system in the RADS format choosing the proper data fields
- Take DAC as total IB correction, i.e., LF (static part) and HF part of the tidal and atmospheric signal
- Compose the so-called RADS engineering flags
- Decompose total ocean tide in ocean and load tide
- Take square root of waveform off-nadir-pointing
- Reference orbital altitude, geoid, and mean sea surface to TOPEX (a = 6378136.3m, 1/f = 298.257)
- Copy the other GOP data fields directly (untreated) to the corresponding RADS fields
- Create sea level anomalies (SLA)
- Choose Jason-2 data for comparison and crossover analyses for same time period (cycles 132 to 294)

Geophyisical and media corrections

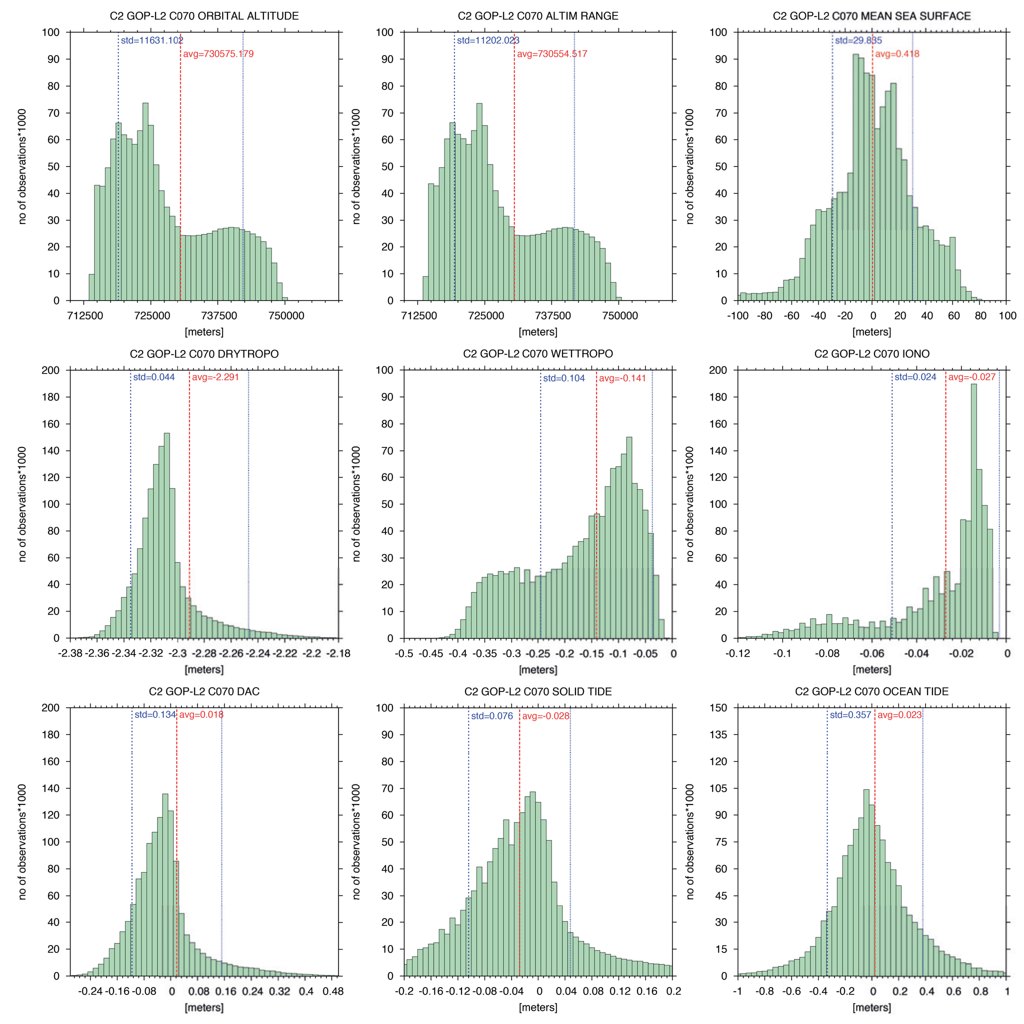

Figure 1: CryoSat-2 GOP L2 data histograms needed to create the SLAs for cycle 70 (16 August until 14 September 2015). All GOP geophysical and media corrections have been compared to the CryoSat-2 RADS and Jason-2 products. We find comparable statistics for all corrections except for sigma0 and wind speed: the sigma0 is too low and consequently the wind speed too high. SSB though seems unaffected.

Sea level anomalies

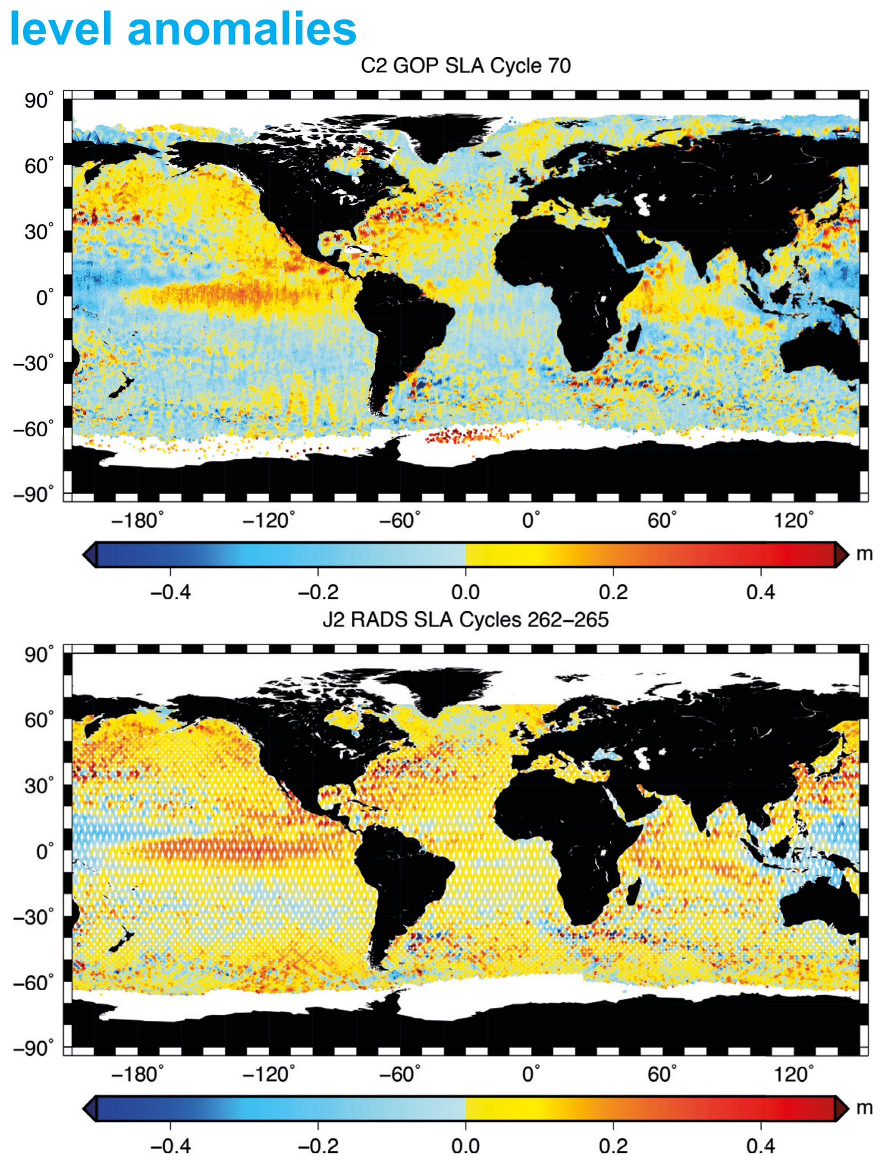

Figure 2: Sea level anomaly for CryoSat-2 GOP cycle 70 (top) and Jason-2, 16 Aug–14 Sep 2015 (bottom). The resemblance is very good: the onset of the 2015 El Niño is clearly visible as a relatively high SLA in the eastern part of the tropical Pacific. The only 'striking' difference is the SLA offset between GOP and Jason-2.

Abstract

CryoSat-2 has been monitoring the Earth's cryosphere and oceans with unprecedented accuracy and precision since its launch in 2010. In this poster we assess the quality of the Geophysical Ocean Product (GOP) by cross-calibration with ocean altimeter data in the RADS database and by comparing the sea level data with a selected set of tide gauges. The goal is long-term monitoring; evaluating the stability of the measurement system and identifiying biases & drifts.

Crossover difference CryoSat-2 and Jason-2

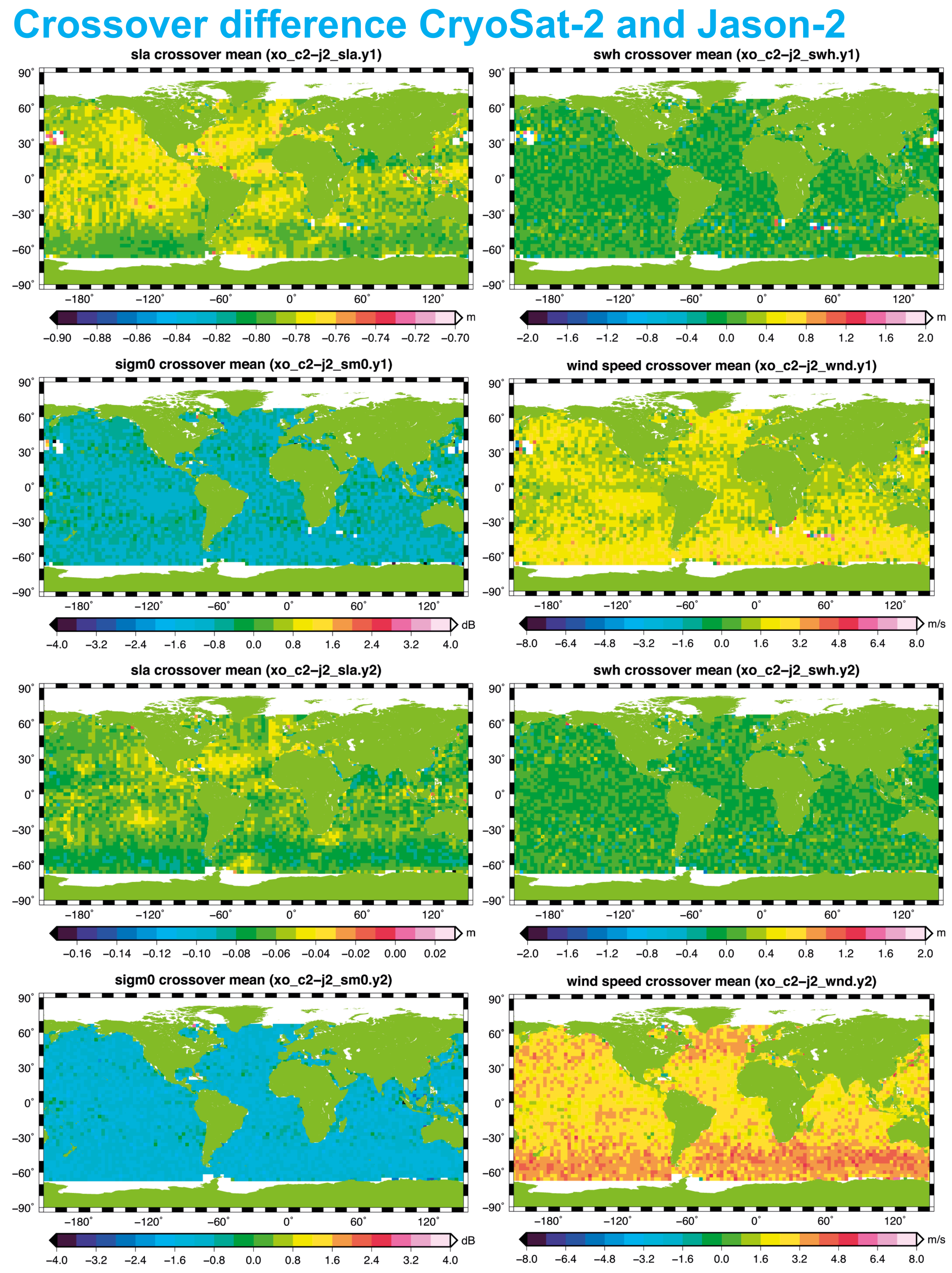

Figure 3: Comparing dual crossovers (XOs) between CryoSat-2 GOP and Jason-2 for 1 year before bias jump of 72cm (y1: June 2013 until June 2014), and 1 year after jump (y2: June 2015 until June 2016). XOs have been edited discarding SLA XO values > 2×σ (stdev), to not incorporate crossovers affected too much by ocean variability. Applying Δt < 2 days would remove too many CryoSat-2 crossovers. Mean XO diffs between CryoSat-2 and Jason-2 provides us the biases between CryoSat-2 and the calibrated Jason-2 (TOPEX reference!). Non-zero biases are found for SLA, sigma0 and wind speed.

Biases

Table 1: XO mean and stdev from CryoSat-2/Jason-2 for SLA, SWH, σ0, and wind speed before (b) and after (a) Feb 2015.

	SLA [m]	SWH [m]	σ_0 [dB]	wind [m/s]
mean (b)	−0.787	−0.011	−0.780	1.890
stdev (b)	0.043	1.202	1.806	4.233
mean (a)	−0.067	−0.009	−1.155	3.129
stdev (a)	0.047	1.253	1.796	4.380

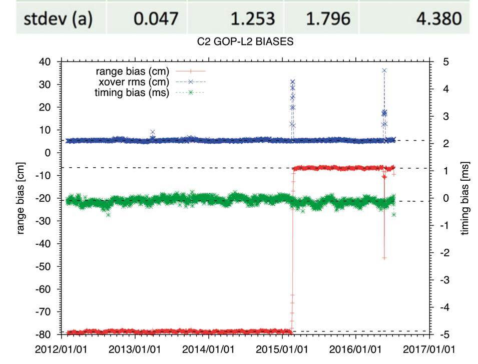

Figure 3: CryoSat-2 GOP range bias (red), timing bias (green), and XO stdev (blue) for Feb 2012 – Jul 2016. Regression lines mark stable biases and XO rms <5cm. Excluding bias switch Feb 2015, the fit suggests SLA drift<0.5 mm/ yr, on par with current general uncertainty in sea level trend estimates.

Summary CryoSat-2 GOP L2

- Complies fully with format specification
- Has steady timing error of −0.11 ms
- Most changes in biases accountable by difference in processor config/cal files before and after Feb 2015
- has stable range bias of −6.7 cm (no marked drift) w.r.t. calibrated J2 = TOPEX reference ellipsoid
- has −0.78 dB sigma0 bias before and −1.16 dB after 21 Feb 2015 => wind speed biases +1.89/+3.13 m/s
- has correlation R=0.85 with 213 selected PSMSL tide gauges (TGs) covering the period 2013−2015
- has mean standard deviation σ=5.61 cm with TGs
- has drift of −0.54 mm/yr w.r.t. TGs, showing stable measurement (no marked reference frame drift!)
- On par with ocean reference mission Jason-2
- See poster CVL-016 (Bouffard) for GOP data status

L2 GOP comparison with PSMSL tide gauges

After subtracting a –72cm bias to the GOP data prior to Feb 2015 a comparison was made with a selected set of PSMSL tide gauges (TG). To ensure the same physical content of the altimetry and the /TG data:

- Use monthly averaged TG data to filter out most of the high frequency tidal and atmospheric signal
- Use the TG Revised Local Reference data
- Use available TG/Altim data and integer number of consecutive years: 2013,2014, and 2015.
- Apply all standard corrections, total ocean tide correction, and the HF part of the atmospheric signal to the altimeter data (leave out the LF static IB)
- Grid monthly altimeter solutions (30 days subcycle): e-folding σ=0.5˚, horizon=3σ, gridspacing=0.25˚
- Use grdtrack (GMT) to produce time series at the TG station locations
- Remove common bias (TG has MSL as reference)

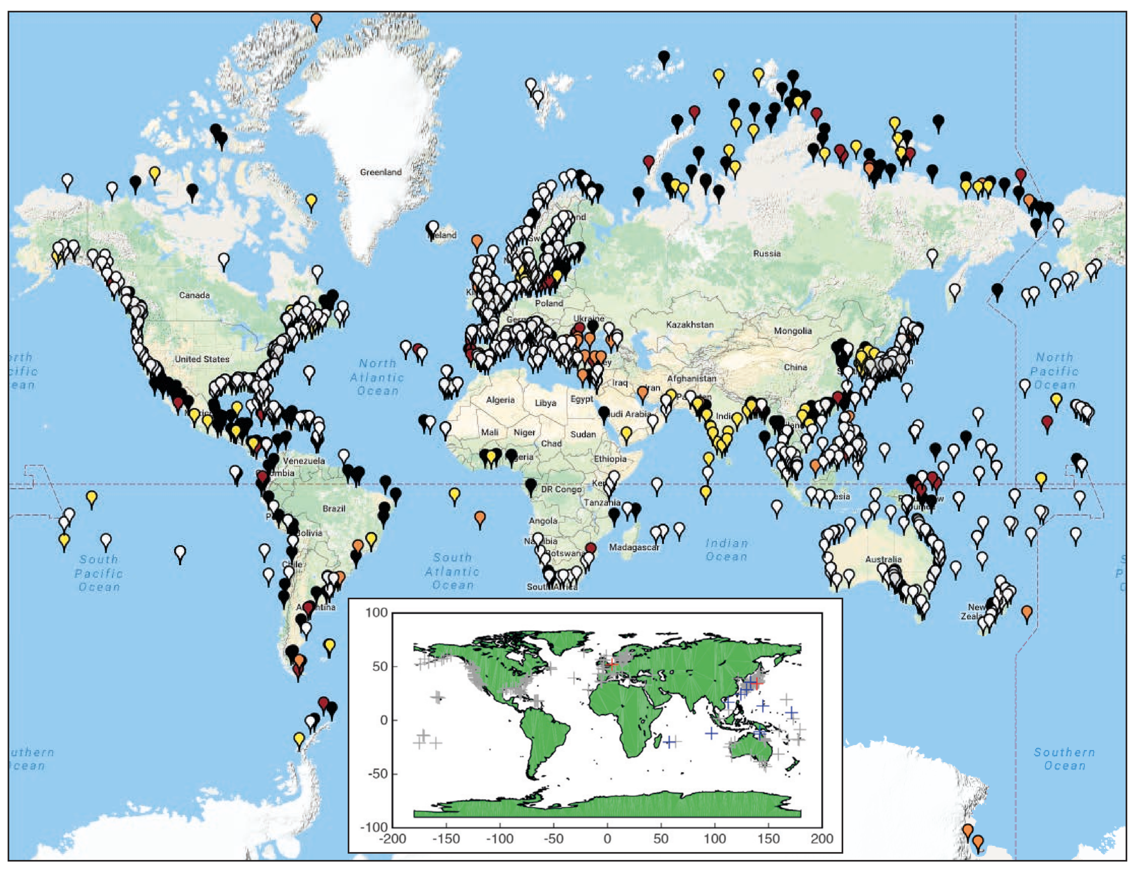

Figure 4: Tide gauge station selection. First data is selected for TGs that have all monthly entries for 2013−2015: 491 remain out of 1468 stations. After aligning with the alt data we only consider stations that have correlation R>0.7 and stdev σ<0.1m (common bias removed): reducing the TG set further to 213 (grey plusses in the inserted map). For these stations we do the comparison and calculate R and stdev: over all 213 stations averaged these are 0.85 and 5.61 cm, resp. The mean tilt of the difference is −0.54 mm/yr (SLA - TG), which is compatible with the number we found for the range stability. Note that we analyse the difference, so any "natural" sea level rise would cancel out. Blue plusses represent the best 10 comparisons and the 2 red the worst.

Tide gauge comparison results

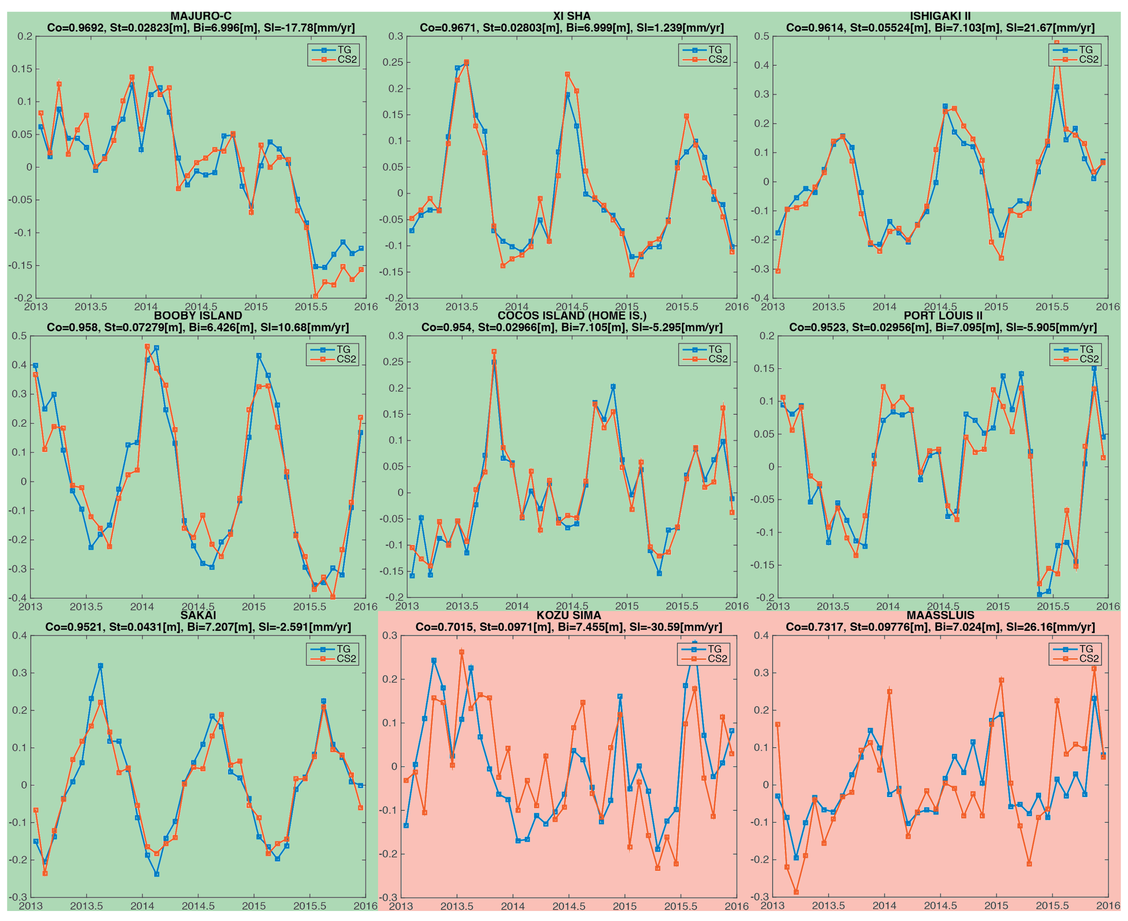

Figure 5: Sea level data comparisons PSMSL tide gauges with GOP C2 altimetry: 7 best in terms of correlation (≥ 0.95) and (bottom right 2) 2 worst in terms of standard deviation (≈ 10cm).

Acknowledgments

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