Corsica: a multi-mission absolute calibration site

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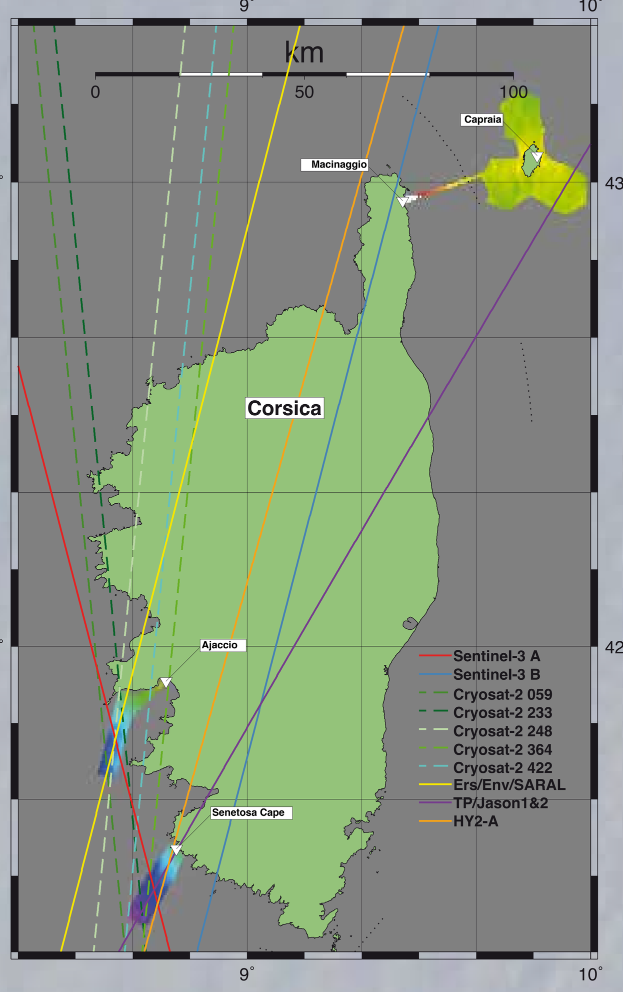
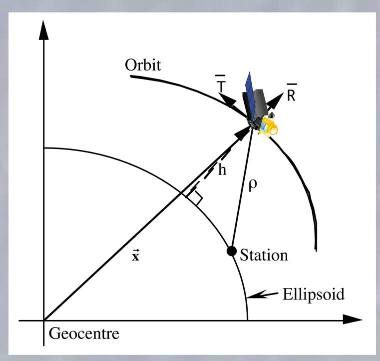
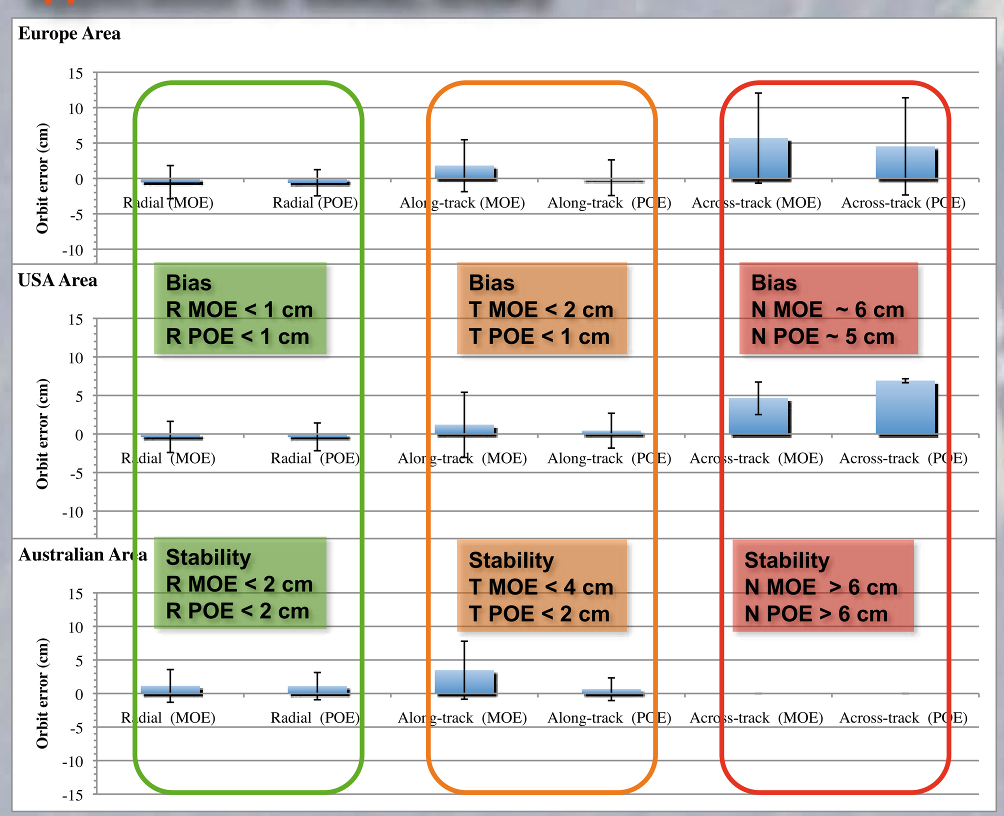


Orbit



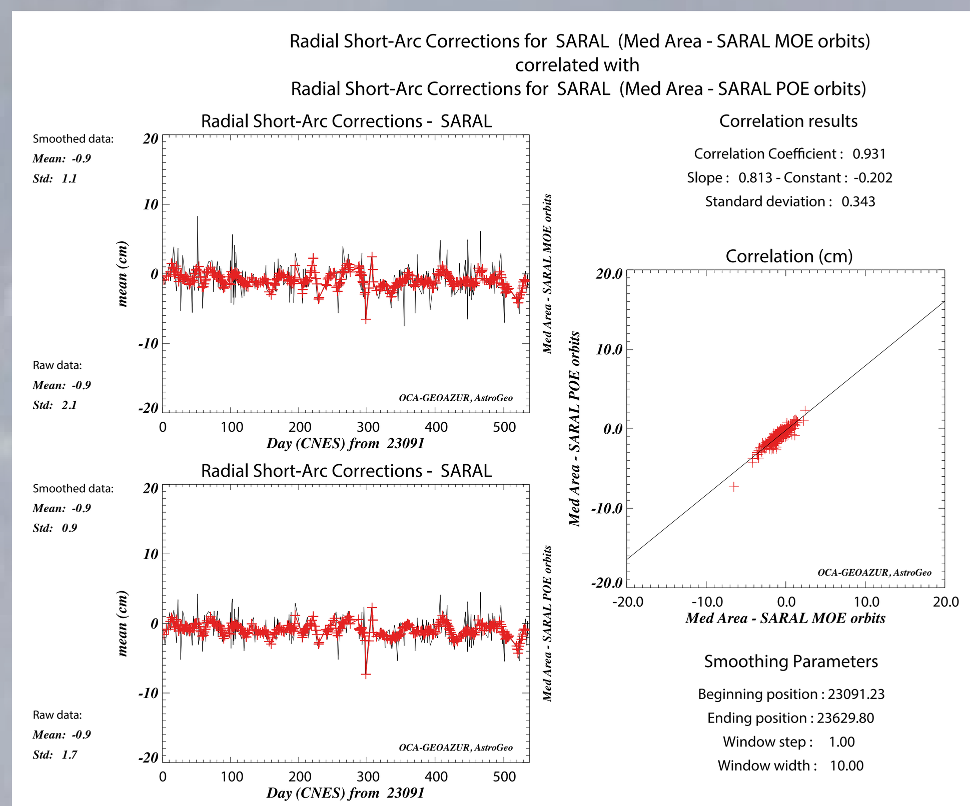
The Short-arc orbit technique is a laser-based geometrical approach to compute radial (R), along-track (T) and across-track (N) orbit errors from SLR residuals.

Application to SARAL/AltiKa



Radial orbit & Along-track orbit errors are very small for both POE and MOE:
Maybe a small hemispheric effect: -8 mm (Europe/USA) / +15 mm (Australia)

Across-track orbit errors:
A large bias of ~5 cm for both POE and MOE
Instrument referencing (CoM position)? Correlation with beta angle (Radiation pressure)?



Radial orbit precision is very close for both MOE and POE
Over Europe: Correlation = 93% / Slope = 0.8

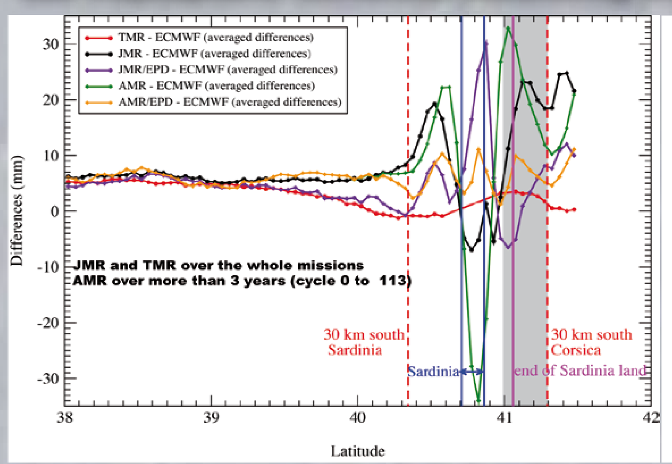
Detailed and routinely updated analysis for SARAL/AltiKa orbits can be found at:

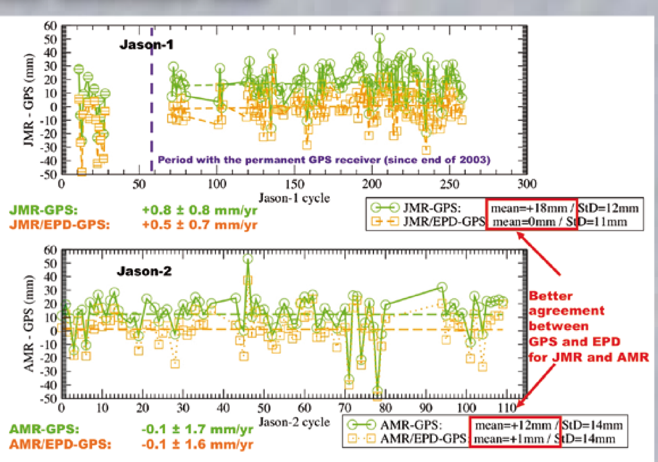
For POE and MOE:
over Europe and USA: http://www.geoazur.fr/gmc/tpsa/SRL_MOE_POE_i08_med_usa/SRLSA_home.html
over Australia and Asia: http://www.geoazur.fr/gmc/tpsa/SRL_MOE_POE_i08_aus_asi/SRLSA_home.html

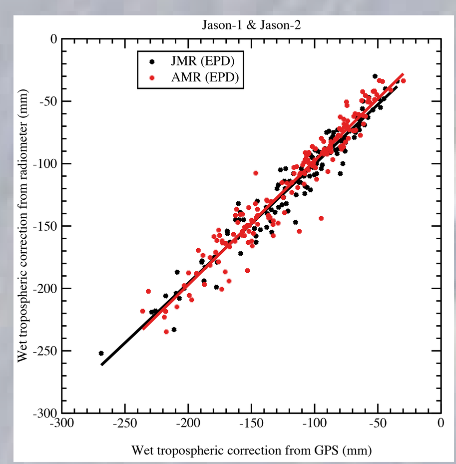
For MOE and DIODE (orbit computed on board):
over Europe and USA: http://www.geoazur.fr/gmc/tpsa/SRL_MOE_DIO_i08_med_usa/SRLSA_home.html
over Australia and Asia: http://www.geoazur.fr/gmc/tpsa/SRL_MOE_DIO_i08_aus_asi/SRLSA_home.html

Wet tropospheric correction

TOPEX/Poseidon, Jason-1 and Jason-2 wet tropospheric correction monitoring from Senetosa site







Radiometers minus GPS wet troposphere correction

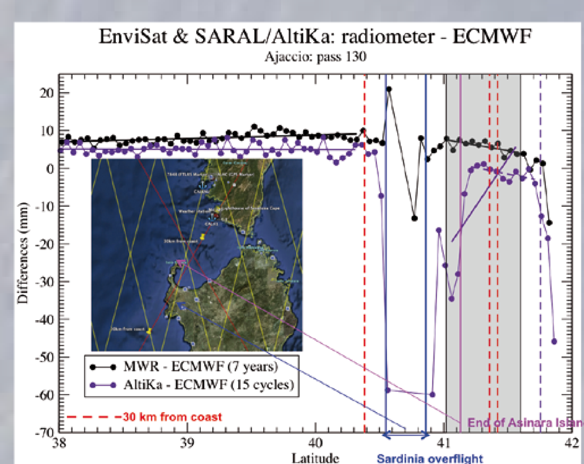
Instrument	Mean (mm)	σ^* (mm)	Drift (mm/yr)	Formal error (mm/yr)	Correlation (%)	Slope
JMR/EPD** - GPS	0	11	+0.5	0.7	97.2	0.95
AMR/EPD** - GPS	2	12	-0.2	0.6	96.5	0.99

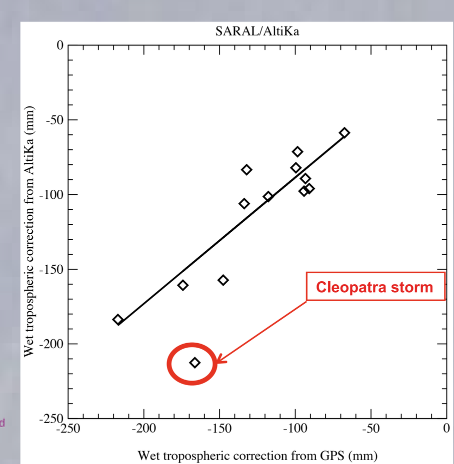
$^*\sigma$ is the standard deviation.
**Enhanced Path Delay (EPD) for AMR (Advanced Microwave Radiometer) onboard Jason-2 and JMR (Jason-1 Microwave Radiometer) onboard Jason-1.

EPD = Enhanced Path Delay developped by Shannon Brown and included in GDR-D and future GDR-E products: it reduces the radiometer land contamination. On the plots above, for Jason-2 the studied period corresponds to GDR-T (test products) that were stopped on cycle 113 when Jason-2 were reprocessed in GDR-D standard.

On the whole set of data, JMR and AMR using the Enhanced Path Delay (EPD) product developed by Brown (2010) agree with GPS at the millimeter level in an averaged sense (0 mm for JMR and +2 mm for AMR) with a standard deviation of 11 and 12 mm respectively. The long time series of JMR & AM vs. GPS comparisons at the Corsica site also permits monitoring of drifts in the path delay measurements. The use of the EPD products also shows an improvement in term of stability and the estimated drift for JMR & AMR is negligible (respectively +0.5 ±0.7 mm/yr and -0.2 ±0.6 mm/yr), as the associated standard error is at the same level. For AMR the stability is improved compared to the study performed over the first 114 cycles.

SARAL/ALtiKa wet tropospheric correction monitoring from Ajaccio site



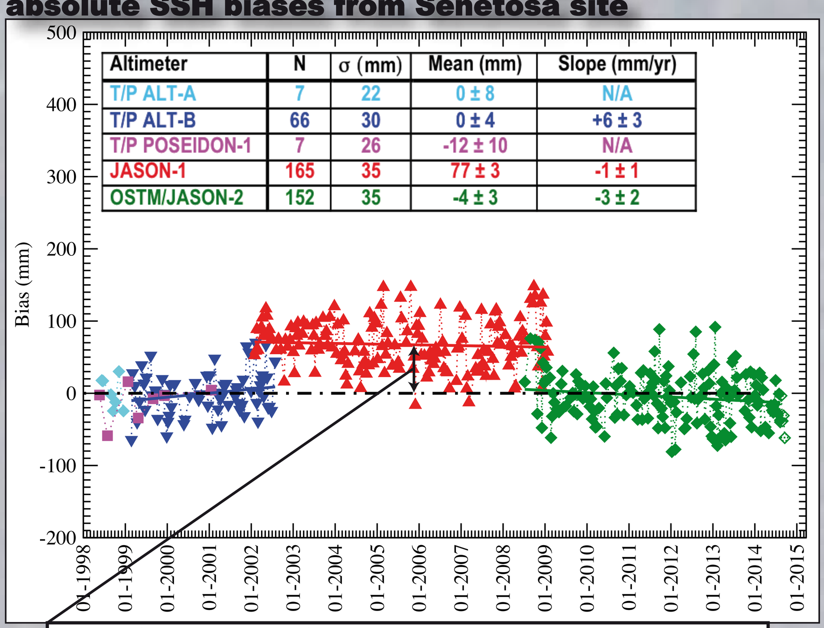


Using GPS data from permanent receiver (AJAC) and pressure from Ajaccio weather station, the wet tropospheric correction is computed and compared to radiometer (no GPS data for cycle 1):
- Cycle 8 clearly departs from the series: heavy rain during the Cleopatra storm
- Without cycle 8, Correlation: 91% (slope = 0.85 / bias at origin = -4 mm)
- Without cycle 8 radiometer exhibits a -10mm bias (dryer) compared to GPS; relatively strong standard deviation (~24 mm) compared to Jason-2 AMR (12 mm) but the number of cycle is small.

Sea Surface Height and Significant Wave Height

SSH biases

TOPEX/Poseidon, Jason-1 and Jason-2 absolute SSH biases from Senetosa site

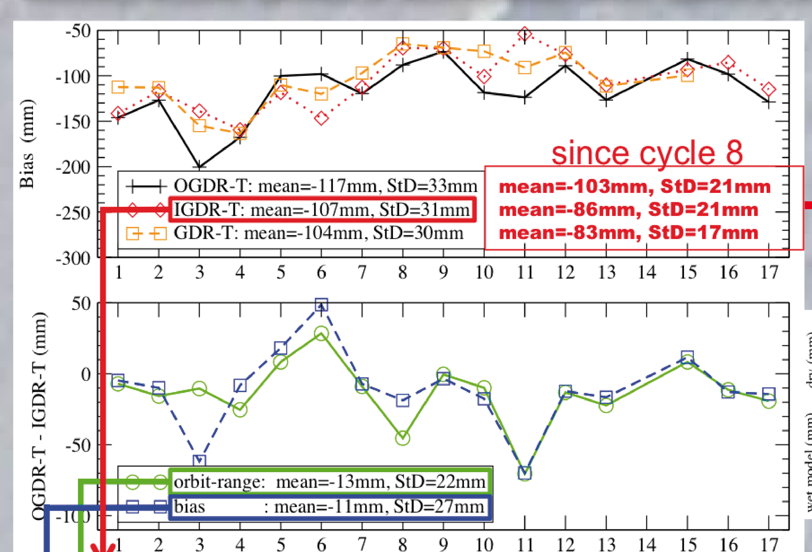


Altimeter	N	σ (mm)	Mean (mm)	Slope (mm/yr)
T/P ALT-A	7	22	0 ± 8	N/A
T/P ALT-B	66	30	0 ± 4	+6 ± 3
T/P POSEIDON-1	7	26	-12 ± 10	N/A
JASON-1	165	35	77 ± 3	-1 ± 1
OSTM/JASON-2	152	35	-4 ± 3	-3 ± 2

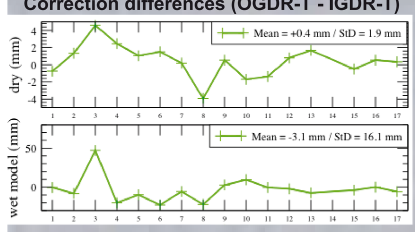
-81 mm (Jason-2 – Jason-1) to be compared to instrumental errors discovered by CNES project team:
117.02 + 3.16 – 180.92 = **-60.74 mm**
- wrong altimeter internal path delay value used on Jason-1
- wrong altimeter PRF applied in the ground segment on Jason-1 (truncation effect)
- antenna internal Path Delay reference error

-81 mm is reduced to -71 mm when improving SSB and wet radiometer correction for Jason-1. This will be corrected in Jason-1 GDR-E.

SARAL/ALtiKa absolute SSH biases from Ajaccio site



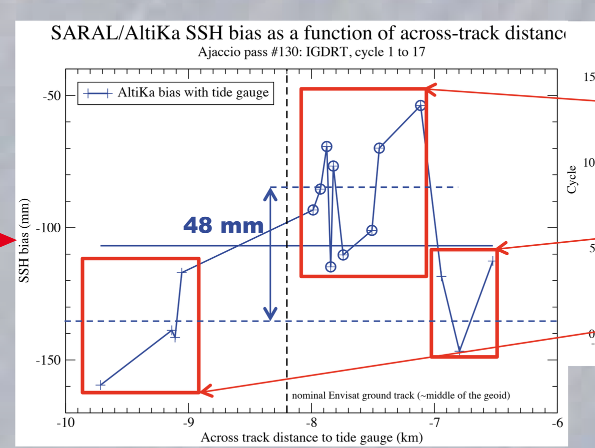
Correction differences (OGDR-T - IGDR-T)

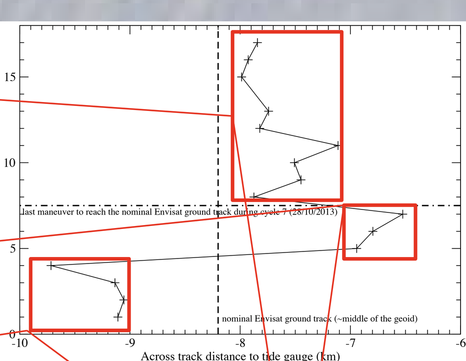


Standard deviation (31 mm) compararable to typical Jason-2 one (~35 mm)

Mean radial orbit differences between DIODE and MOE (-13 mm): comparable to orbit errors analyzed over Europe using short-arc orbit technique (-20 mm)

Differences between OGDR-T and IGDR-T SSH bias are due to dry and wet tropo and linked to differences between predicted and computed ECMWF model



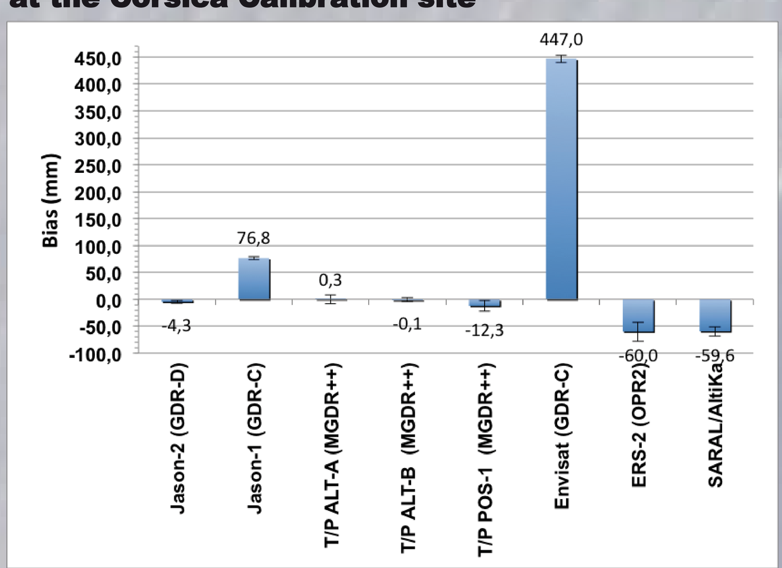


Several maneuvers were needed to reach the nominal ground track, it can be divided into 3 parts:

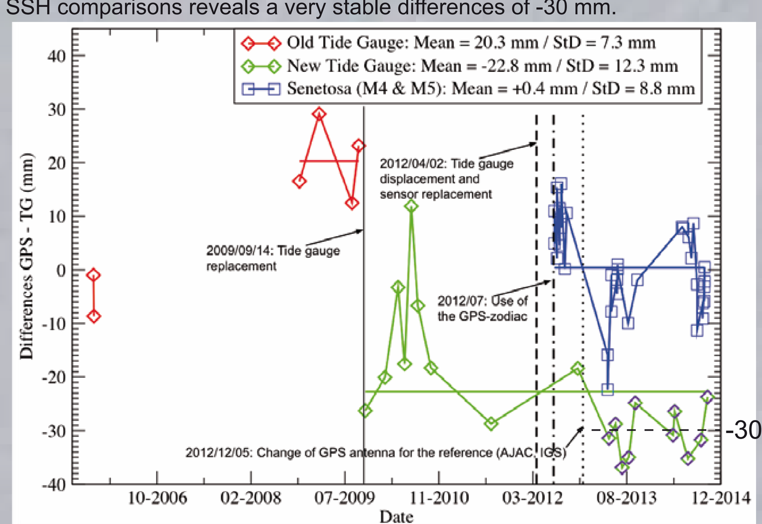
1- cycle 1 to 4: ground track located in the western part
=> contamination from "Sanguinaires islands"
2- cycle 5 to 7: ground track located in the eastern part
=> contamination from "Capu di muro"
3- from cycle 8: ground track located in the center part
=> no a priori contamination except very close to the coast in the northern part

Impact on the averaged SSH bias: 48 mm
(SSH bias cycles 1-7 compared to cycles 8-17)
Better stability since cycle 8: 20 mm rms
(31 mm rms on the whole set)

Absolute SSH biases for all the missions monitored at the Corsica Calibration site



At Ajaccio, both tide gauge and GPS-based (GPS-zodiac) instruments are used to determine the SSH biases. When placed close to the tide gauge, the SSH comparisons reveals a very stable differences of -30 mm.



Comparison between tide gauges and GPS-zodiac results (using IGDR-T products):
Tide gauge: -86 ±7 mm (indirect method) (cycles 8-17)
GPS (mean): -53 ±12 mm (semi-indirect method)
GPS (PCA): -60 ±9 mm (direct method)
26 mm difference between tide gauge and GPS (PCA) methods/instruments
- 30 mm comes from instrumental differences (comparisons @ tide gauge location): this remains unsolved
- Other effects: ocean dynamics? A high resolution model is in development to estimate the impact but it should be small

We are more confident with our from GPS (PCA) result because it is indepedent from geoid correction and any ocean dynamics (GPS-zodiac placed at CALENV and direct SSH comparison is performed).

AltiKa SSH bias is thus: -60 ±9 mm

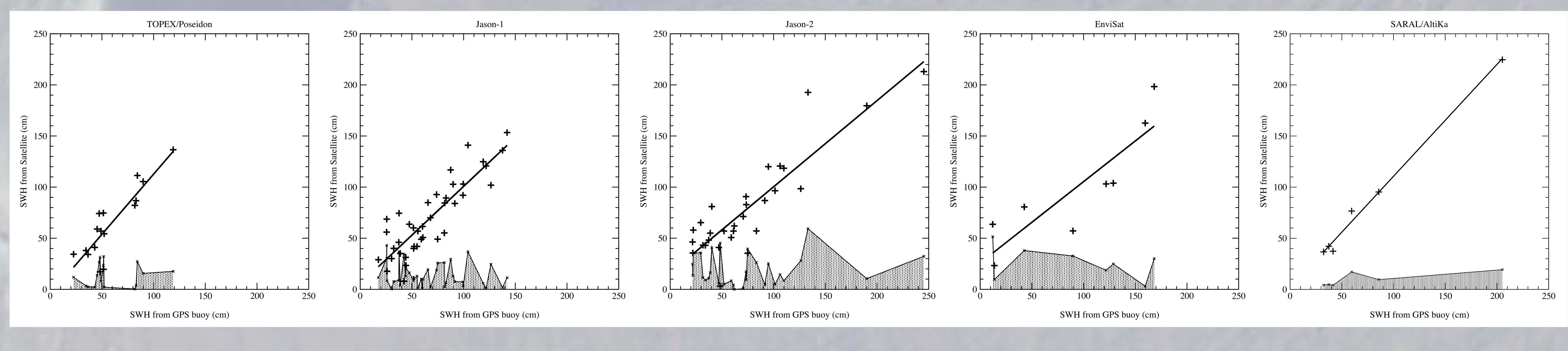
SWH from altimetry versus GPS buoy SWH

SWH differences: GPS - Altimetry

Satellite	Correlation (%)	Slope	σ^* (cm)	Mean (cm)	Number
T/P	87	1.18	17	5	16
Jason-1	87	0.95	18	2	39
Jason-2	88	0.84	24	4	30
T/P	87	1.18	17	5	16
Envisat	87	0.80	31	7	8
SARAL/AltiKa	99	1.09	9	9	6

GPS buoy measurements also provide the sea height variations due to waves. Because GPS buoy is drifting during the calibration pass (about 1 hour of measurement centered on Time of Closest Approach), filtered sea height is removed to avoid sea height variations due to geoid slope. Standard deviation on the GPS buoy sea height residuals is then computed (σ_{shr}). GPS buoy measurements have also their internal error which have been estimated during quasi-static session to be at the level of 2.6cm (σ_{gps}). The standard deviation on the GPS buoy sea height residuals is then the root square sum of σ_{gps} and σ_{wave} (where σ_{wave} is the standard deviation of GPS buoy measurements due to waves). SWH (or $H_{1/3}$) is then deduced from the formula: $SWH_{buoy} = 4.\sigma_{wave}$ (where $\sigma_{wave} = \sqrt{(\sigma_{shr}-\sigma_{gps})}$).

SWH differences reveal biases from 2 to 9 cm with standard deviations from 9 to 31 cm. The correlations ranges from 87 to 99%.



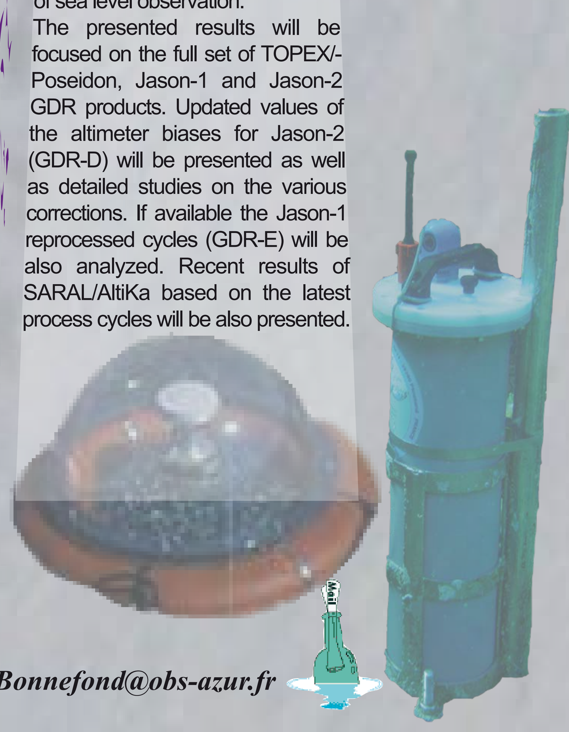
Abstract

In collaboration with the CNES and NASA oceanographic projects (T/P and Jason), the OCA developed a verification site in Corsica since 1996. CALibration and VALidation embraces a wide variety of activities, ranging from the interpretation of information from internal-calibration modes of the sensors to validation of the fully corrected estimates of the reflector heights using in situ data. Now, Corsica is, like the Harvest platform (NASA side), an operating calibration site able to support a continuous monitoring with a high level of accuracy: a 'point calibration' which yields instantaneous bias estimates with a 10-day repeatability of around 30 mm (standard deviation) and mean errors of 3-4 mm (standard error). For a 35-day repeatability (ERS, EnviSat, SARAL/AltiKa), due to a smaller time series, the standard error is about the double (~7 mm).

In-situ calibration of altimetric height (SSH for ocean surfaces) is usually done at the vertical of a dedicated CAL/VAL site, by direct comparison of the altimetric data with in-situ data. Adding the GPS buoy sea level measurements to the "traditional" tide gauges ones, it offers the great opportunity to perform a cross control that is of importance to insure the required accuracy and stability. This configuration leads to handle the differences compare to the altimetric measurement system at the global scale: the Geographically Correlated Errors at regional (orbit, sea state bias, atmospheric corrections...) and local scales (geodetic systematic errors, land contamination for the instruments, e.g. the radiometer).

Our CAL/VAL activities are thus focused not only on the very important continuity between past, present and future missions but also on the reliability between offshore and coastal altimetric measurement. With the recent extension of the Corsica site (Capraia in 2004 and Ajaccio in 2005), we are now able to perform absolute altimeter calibration for ERS-2, EnviSat, HY-2A and SARAL/AltiKa with the same standards and precision than for T/P and Jason missions. The upcoming Sentinel-3 mission will naturally be included in our CAL/VAL activities. This will permit to improve the essential link between all these long time series of sea level observation.

The presented results will be focused on the full set of TOPEX/Poseidon, Jason-1 and Jason-2 GDR products. Updated values of the altimeter biases for Jason-2 (GDR-D) will be presented as well as detailed studies on the various corrections. If available the Jason-1 reprocessed cycles (GDR-E) will be also analyzed. Recent results of SARAL/AltiKa based on the latest process cycles will be also presented.



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