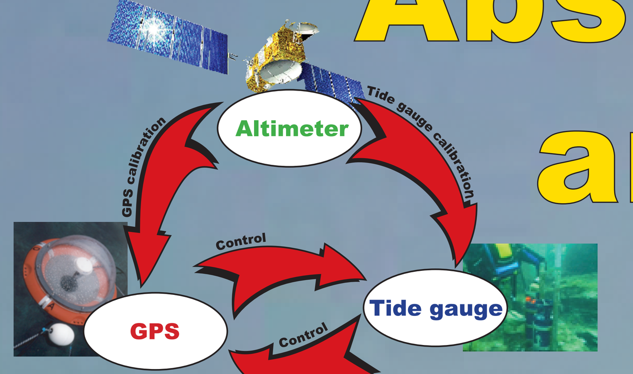

Absolute Calibration of Jason-1 and TOPEX/Poseidon Altimeters in Corsica

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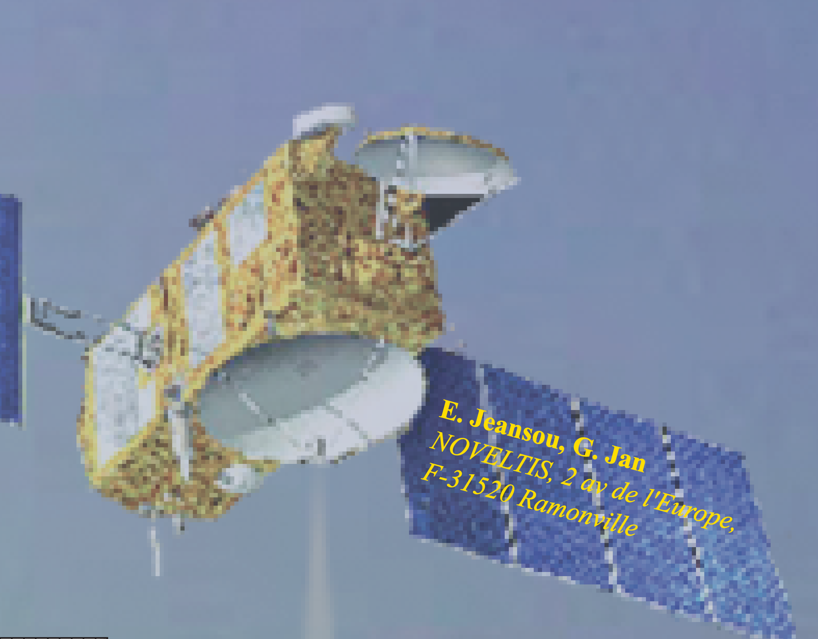
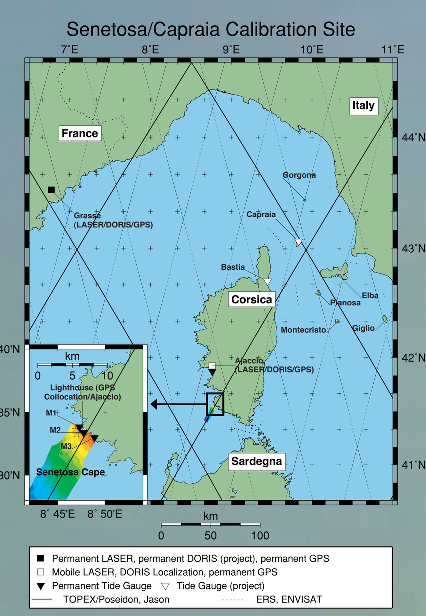


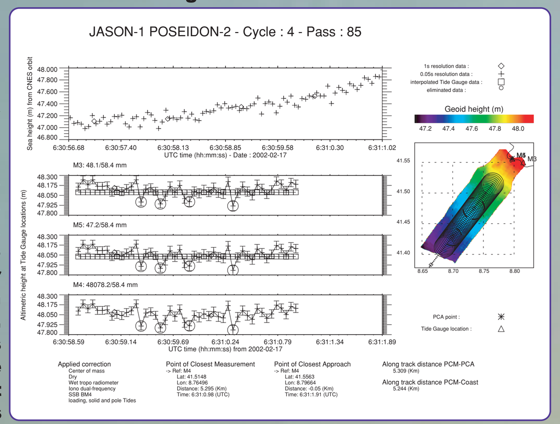
GENERAL OVERVIEW

Calibration process



The Senetosa calibration site provides in situ sea height estimations and local condition parameters (tide gauges, GPS buoy, meteorology station), that are compared to altimetric data.

The calibration principle is to compute the difference between the sea surface height (ssh) measured with the altimeter and the ssh recorded by the tide gauge. These two ssh are located at two distant points. The link between the two ssh is partly the geoid slope from offshore altimetric measurement to tide gauges locations. The situation of the Corsica calibration site implies to take it into account. This slope is 6 cm/km on average and a specific GPS campaign has been realized in 1999 in order to determine a geoid map of about 20 km long and 5.4 km wide centered on the satellites ground track.



In a first step, high-rate (10 Hz for T/P and 20 Hz for Jason-1) altimetric sea heights (see upper panel of the Figure) are corrected from geoid slope by computing the geoid height differences from the altimetric data location to each tide gauge location (3 lower panels). At each altimetric data location, the mean geoid height is computed inside the footprint area (right panel) which size is defined by the formula given in Chelton et al. (1989).

In a second step, tide gauges data are interpolated at the high-rate altimetric data time using a linear regression over a time span of 30 min centered on the time of closest approach. The mean values of sea height differences, and the associated standard deviations, are then computed (Haltimeter - Htide gauges) for each tide gauge. Same process for geoid slope correction is used for the GPS buoy but the location of the buoy is about 10 km off shore: the altimetric sea heights are then compared to filtered GPS sea heights.

Definitions on products and processes

Products Main Differences for Calibration		
	TOPEX/Poseidon	Jason-1
IGDR	Orbit from NASA (SLR+GPS) Pole tide correction is set to zero Sea state bias from TGS Wallops correction not included* Range bias of +15 mm is not applied Wind Speed	MOE from CNES (DORIS only) 20 Hz data are not corrected from Doppler effect (before cycle 28) all process and corrections are homogeneous with GDR since cycle 46
GDRT	POE from NASA Sea state bias from TGS Wallops correction not included* Range bias of +15mm is applied Wind Speed	
M-GDR	POE from NASA and CNES	POE from CNES

MOE: Medium precision Orbit Ephemeris
POE: Precise Orbit Ephemeris
*Range bias changes for the NASA radar altimeter of the TOPEX/POSEIDON mission

The sea-height bias is thus defined by the following difference: altimeter sea height - in situ sea height. For example, a positive sea-height bias means that the altimetric sea height is erroneously high or the altimeter is measuring too short. Statistical computations for the sea-height bias have been realized using the following rules: (i) the bias for each overflight is obtained by averaging all the bias determinations from available tide gauge data, and (ii) the overall bias for each radar altimeter (POSEIDON-2, ALT-A, ALT-B and SSALT) corresponds to the mean (or median) of the estimates computed from all participating overflights (i.e, cycles).

For all analyses, we have chosen to use data products provided by the T/P and Jason-1 projects. The principal assumptions are summarized below:

Jason-1:

- Adopt Jason-1 GDR product as baseline
- Other orbits (GPS Reduced Dynamic from JPL and short-arc orbits from CERGA) have been used for comparisons only.

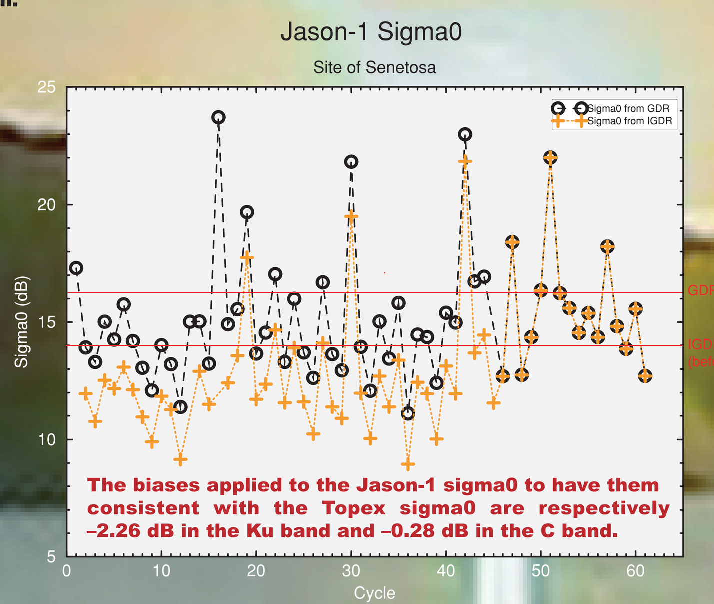
TOPEX/Poseidon:

- T/P M-GDR product is baseline. NASA precise orbit ephemeris has been chosen (Satellite Laser Ranging and DORIS data are used)
- Correct for drift in TOPEX Microwave Radiometer (TMR) data from 18-GHz channel instability [Ruf and Brown, 2002]

Finally, the altimeter bias time series are obtained after applying two-selection criterion :

Only overflights with a sigma naught below 14 dB (16.26 dB for Jason-1) are kept avoiding a possible sigma bloom effect (see Figure below) . This criteria leads to reject about 27% of the ALT (T/P), 36% of SSALT (T/P) and 14% of POSEIDON-2 (Jason-1) altimeters data.

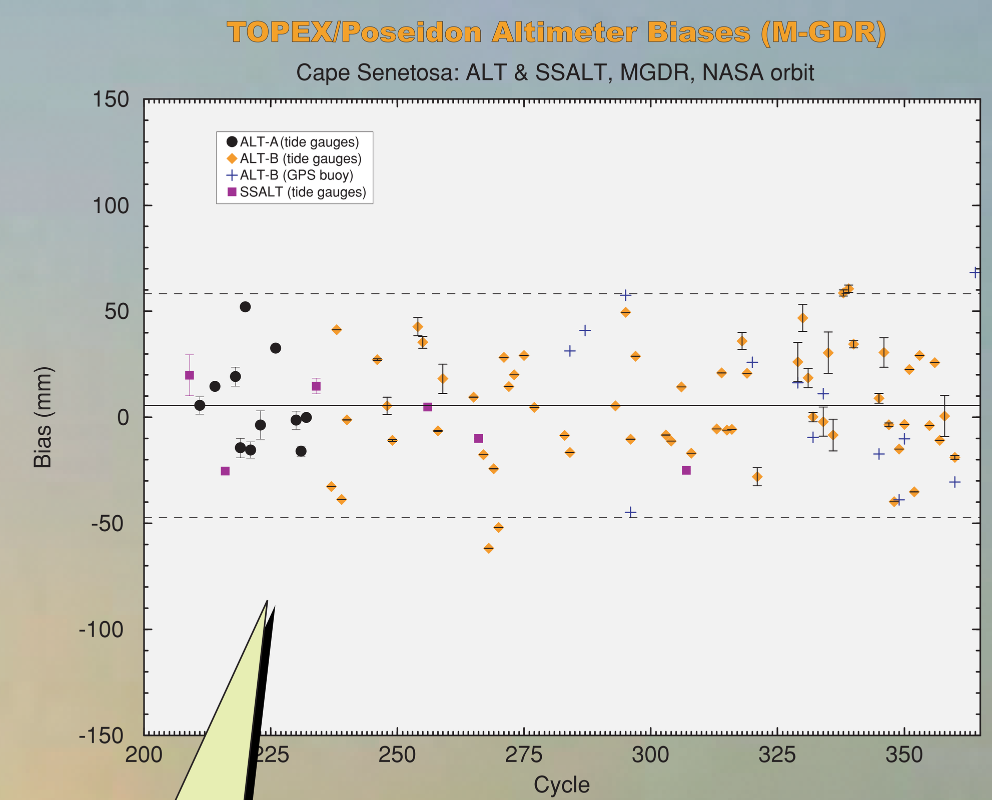
To avoid erroneous tide gauges data, all cycles for which the standard error (issued from the averaging of tide gauges determinations) is higher than 10 mm are rejected (about 10%). This value has been chosen taking into account that the individual tide gauge measurement precision is better than 10 mm.



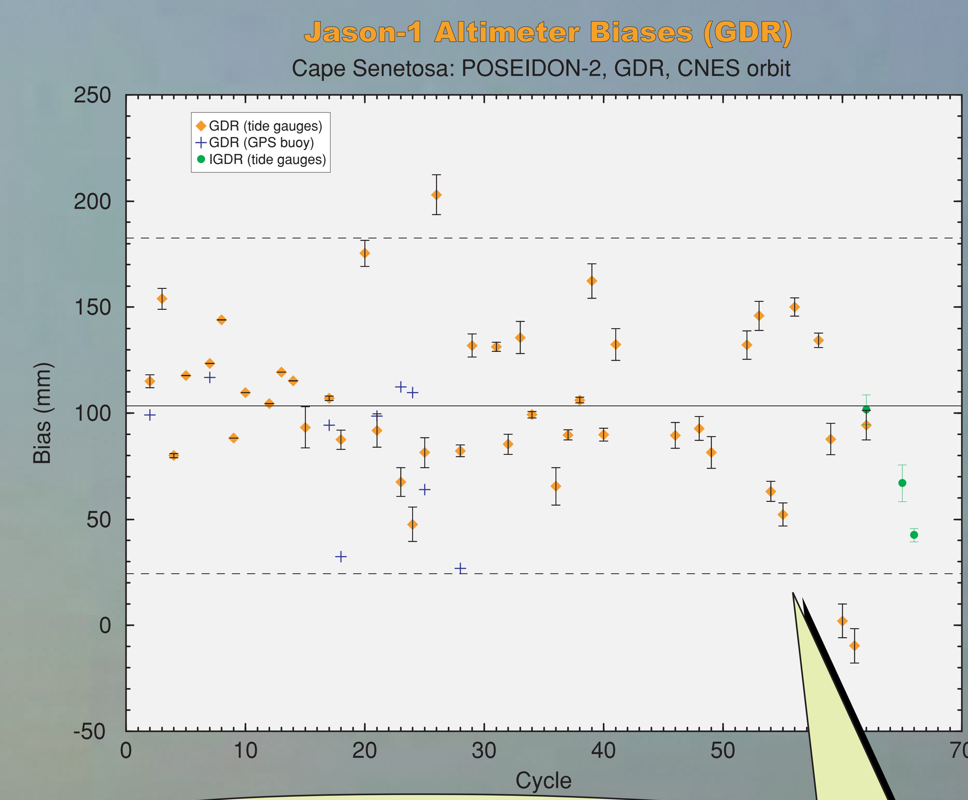
The biases applied to the Jason-1 sigma0 to have them consistent with the Topex sigma0 are respectively -2.26 dB in the Ku band and -0.28 dB in the C band.

Altimeter Biases Time Series

TOPEX/Poseidon Altimeter Biases (M-GDR)



Jason-1 Altimeter Biases (GDR)



TOPEX/Poseidon altimeters (ALT-A and ALT-B) have been calibrated from 1998. Results show a great coherence between both altimeters +7 ±7 mm, +6 ±3 mm and -3 ±8 mm for ALT-A, ALT-B and SSALT respectively. Moreover, results are very consistent with those obtained from the Harvest Platform (differences of few millimeters).

For the 10 cycles in common, the tide gauges and GPS buoy determinations are respectively +2 ± 7 mm and –3 ± 10 mm. Results obtained by the two techniques thus show a very high consistency at the millimeter level, within the error bars.

POSEIDON-2 altimeter bias is +104 ±6 mm, based on 62 cycles of GDR products . Consistency of both techniques appears to be lower than for T/P. However, this effect is only due to the time distribution of the GPS buoy: half of the set is during relatively low values of Jason-1 altimeter bias (cycle 20 to 25). Indeed, when comparing the time series on common cycles, tide gauges determination only differ by few millimeters (5 mm higher). Thus, once again GPS buoy determination appears to be a very promising and powerful technique.

However, the standard deviation of the Jason-1 altimeter bias is higher than for TOPEX/Poseidon by about 15 mm (dotted lines on the above Figures). Indeed, a running average on the whole T/P bias time series with a window size of 62 cycles (Jason-1 sample size) even shows a very stable standard deviation of 25 mm. Considering that the ground measurement system is the same for both satellites, it means that the satellite measurements (range and corrections) are more noisy for Jason-1.

Analysis of Jason-1 Altimeter corrections

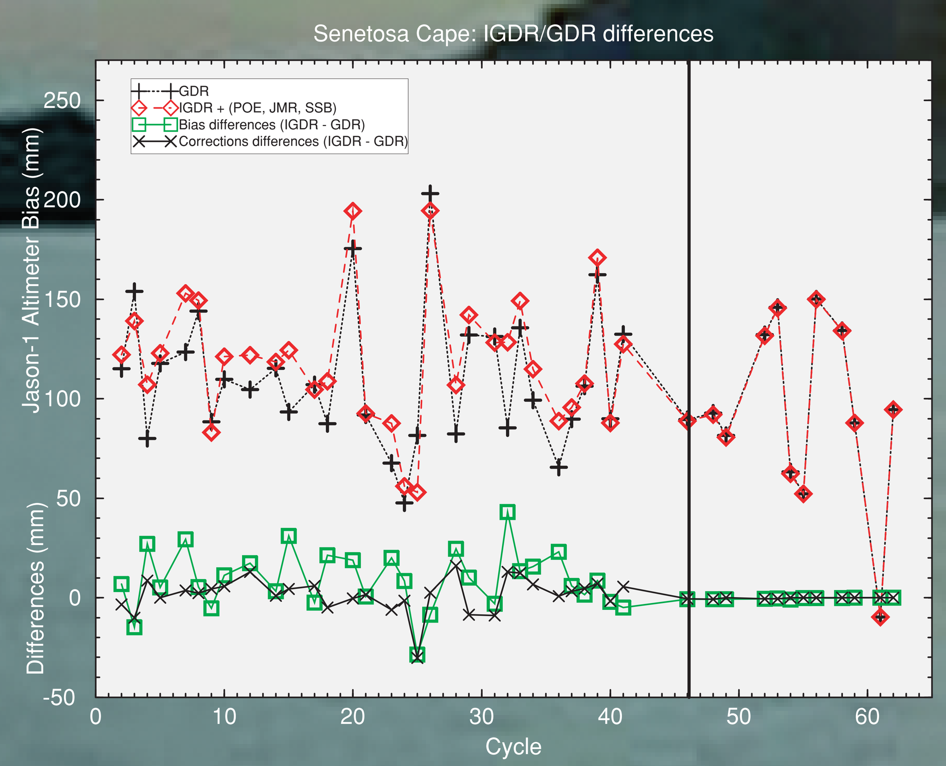
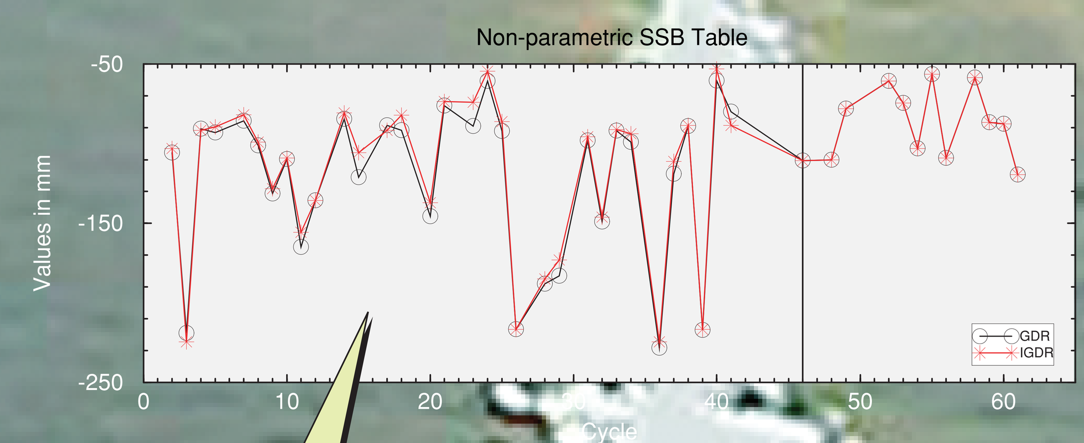


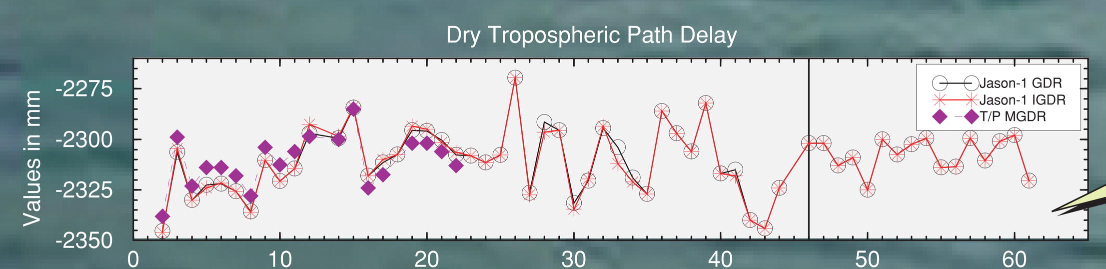
Figure at right shows the differences between GDR and IGDR products. To avoid impact of orbit quality differences and then to focus on the impact of corrections we have replaced the MOE orbit in IGDR products by the POE orbit. Moreover, JMR and SSB have also been replaced by models close to those now used in the reprocessing. Results shows that since cycle 46 IGDR and GDR products are in perfect agreement. However for cycles before, differences between corrections exist: on average the impact on Jason-1 bias due JMR correction is +3 mm (GDR-IGDR) while the SSB contribution is -3 mm. The total contribution is then on average negligible. On the other hand, the remaining differences coming from the altimeter range (retracking improvement) it self implies an increase of the altimeter bias of 6 mm when using IGDR (for cycles before 46).

Sea State Bias

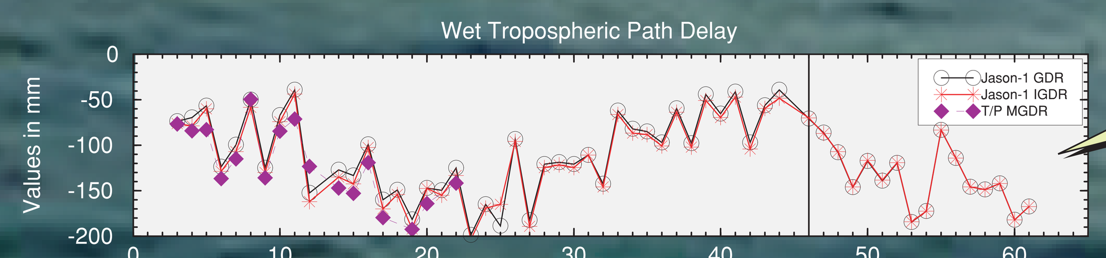


The SSB correction we used in replacement of the IGDR one comes from S. Labroue study (CLS) and is implemented in IGDR production since cycle 46. The differences we observe before cycle 46 are in fact the differences in the SWH and wind speed which are used to compute SSB. The total contribution of these differences is +3 mm (bias computed from GDR is increased by 3 mm).

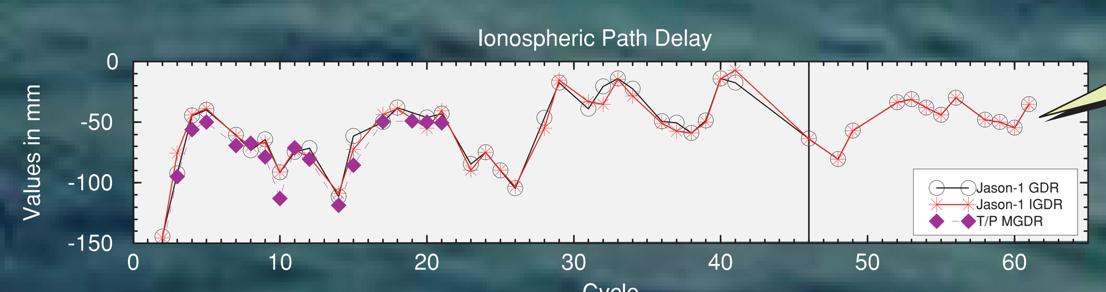
Atmospheric Corrections



Averaged differences between GDR and IGDR is zero. When comparing with T/P during the tandem phase the path delay is higher by 2 mm for Jason-1.



Averaged differences between GDR and IGDR is -3mm. When comparing with T/P (TMR) during the tandem phase the path delay is lower by 13 mm for Jason-1 (JMR).



Averaged differences between GDR and IGDR is zero. When comparing with T/P during the tandem phase the path delay is lower by 8 mm for Jason-1.

Geophysical Corrections:

They are in perfect agreement for both IGDR and GDR products as well as for T/P (MGDR product)

Impact of the Corrections

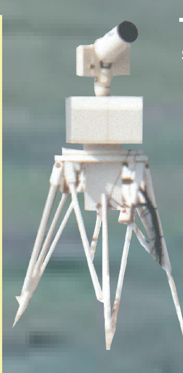
The total contribution of the differences between IGDR and GDR is negligeable.

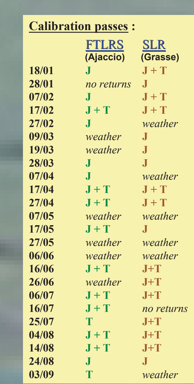
However, the differences between T/P and Jason–1 corrections imply that POSEIDON–2 altimeter bias should be higher by 20 mm if T/P corrections are used in place of Jason–1 ones. The detailed contribution is:

- -2 mm from dry tropospheric path delay
- +13 mm from wet tropospheric path delay
- +8 mm from dry ionospheric path delay

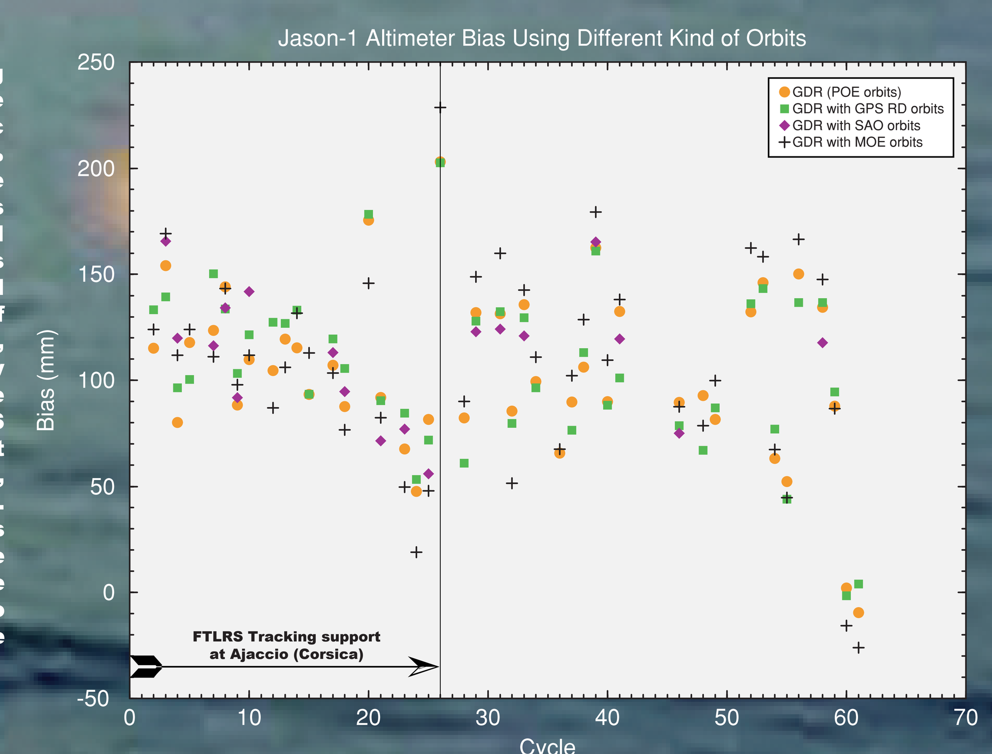
The higher contribution is from JMR. Based on previous studies we have shown that the wet tropospheric path delay determined from GPS is very close to TMR (~4 mm). This suggests that even with the recent improvements the JMR is measuring shorter by about 10 mm, at least in this area.

Impact of Orbit on Calibration





Thanks to the FTLRS tracking support and the effort made by the European SLR network, short-arc orbits have been computed for 60% of the Senetosa overflights. The radial accuracy of short-arc orbits is strongly dependent to vertical station coordinate and range bias in the measurements: the total root sum square contribution of these parameters, for the FTLRS, has been estimated to be below 3 mm. Figure at right shows the Jason-1 altimeter bias for GPS Reduced Dynamic (GPS RD, JPL), Precise Orbit Ephemeris (POE, CNES) and Short-Arc Orbits (SAO, CERGA) and Medium Orbit Ephemeris (MOE, CNES). The distribution of the biases from short-arc orbits is very coherent with POE and GPS RD. This Figure also shows that the tracking support was more efficient during the Cal/Val phase, thanks to FTLRS, than for the following period (40% of the overflights).



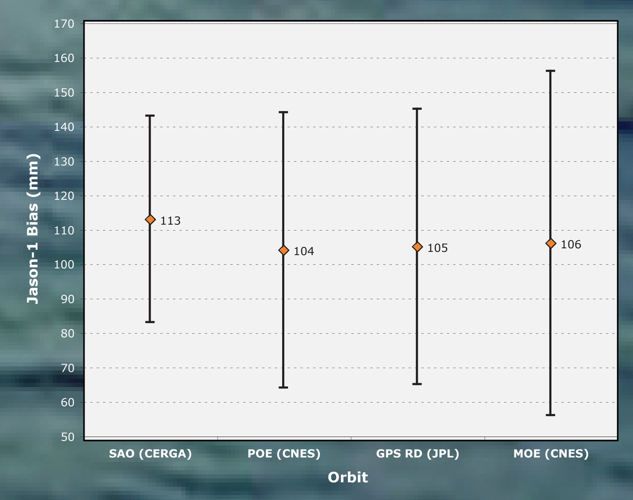


Figure at left shows the mean value and the standard deviation of the Jason-1 altimeter bias for each kind of orbits. All the results are within few millimeters and the relatively high value for short-arc orbits is due to the high density of determinations during the validation phase. For comparison, on cycle 1 to 26 mean bias from short-arcs and POE differs by only 4 mm. On the other hand, the short-arc solutions exhibit a standard deviation lower by 10 mm showing the high consistency and accuracy of the short-arc technique.
More details on orbit impact, notably due to Geographycally Correlated Errors are given in the poster:
Validation Activities for Jason-1 and TOPEX/Poseidon Precise Orbits

The whole calibration process (Tide gauges and GPS buoy) have been validated with TOPEX/Poseidon over 4 years of data and results are very consistent with the Harvest ones. For Jason-1 all the GDR (62 cycles) have been analysed:

- TOPEX/Poseidon (ALT-A): +7 ±7 mm
- TOPEX/Poseidon (ALT-B): +6 ±3 mm
- TOPEX/Poseidon (SSALT): -3 ±8 mm
- Jason-1 (POSEIDON-2): +104 ±6 mm

Relative bias between Jason-1 and TOPEX/ missions is close to +100 mm.
Results will be continuously updated through Jason-1 mission and can be consulted on the web site:
http://grasse.obs-azur.fr/cerga/gmc/calval/alt/

Abstract

The double geodetic site in Corsica (Aspretto, near Ajaccio and Senetosa Cape 40 km south under the Jason-1/T/P ground track N° 85) has been used to calibrate the TOPEX/Poseidon (T/P) altimeters from 1998, and the Jason-1 ones since the beginning of the mission. Permanent and semi-permanent geodetic equipments are used to monitor these calibrations. Concerning the Aspretto site, a permanent GPS station and an automatic tide gauge have been installed since 1999. From January to September 2002, the French Transportable Laser Ranging System has been settled and its tracking support has permitted to locally improve orbit. A Senetosa cape, permanent geodetic installations have been installed since 1998 and different campaigns have been conducted in view of Jason-1 mission. Three tide gauges have been installed at the Senetosa Cape and linked to ITRF using GPS and leveling. In parallel, since 2000, a GPS buoy is deployed every 10 days at Senetosa (10 km off-shore). Besides, two GPS campaigns (1998 and 1999) have been performed to measure the marine geoid slope from the coast to 20 km off Senetosa cape - in this area the geoid slope can reach 6 cm/km. T/P altimeter calibration has been performed from cycle 208 to 365 using MGDR, and Jason-1 calibration has been performed from cycle 1 to 62 using GDR products. All the produced IGDR cycles have been also analysed with all the upgraded corrections used for GDR production (SSB, JMR, POE orbits). Our semi-permanent experiment is planned to last over several years in order to detect any drift in the space borne instruments.

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