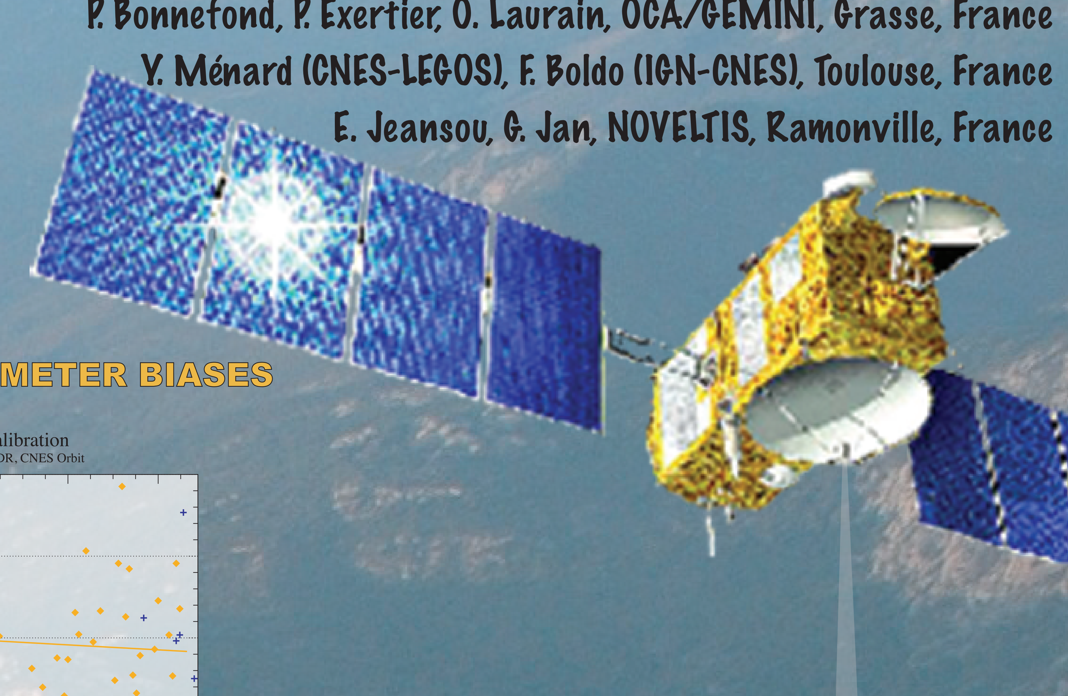
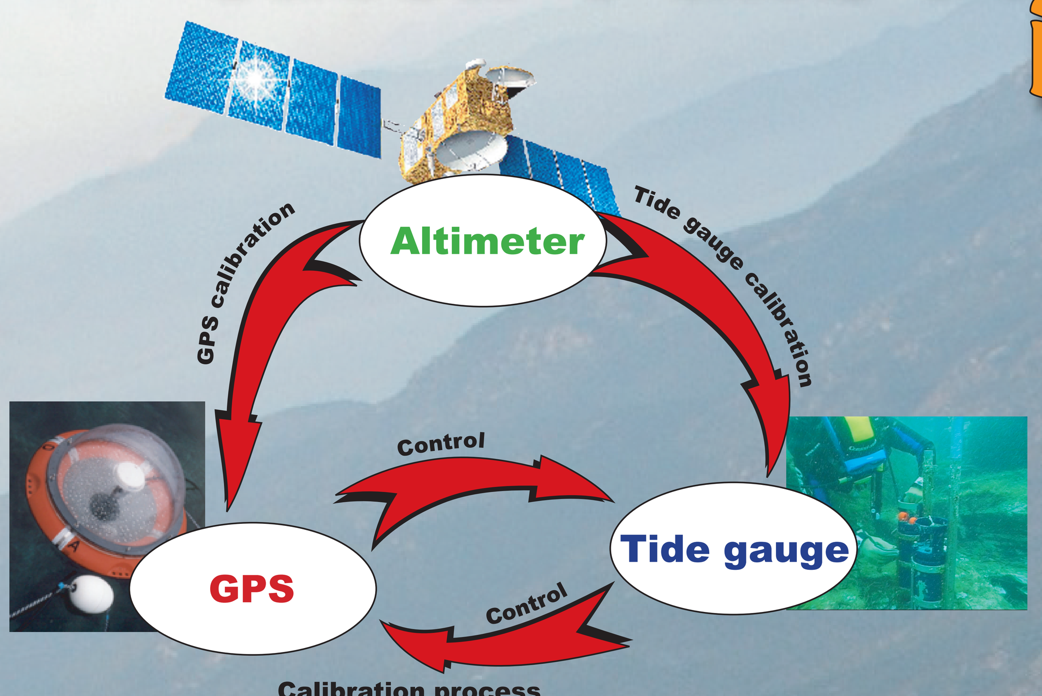
Absolute Calibration of Jason-1 and TOPEX/Poseidon Altimeters in Corsica

P. Bonnefond, P. Exertier, O. Laurain, OCA/GEMINI, Grasse, France
Y. Ménard (CNES-LEGOS), F. Boldo (IGN-CNES), Toulouse, France
E. Jeansou, G. Jan, NOVELTIS, Ramonville, France



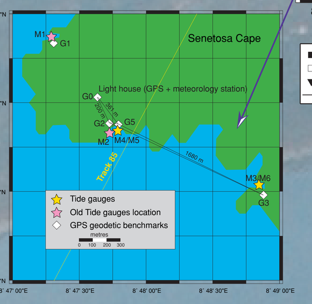


Calibration process

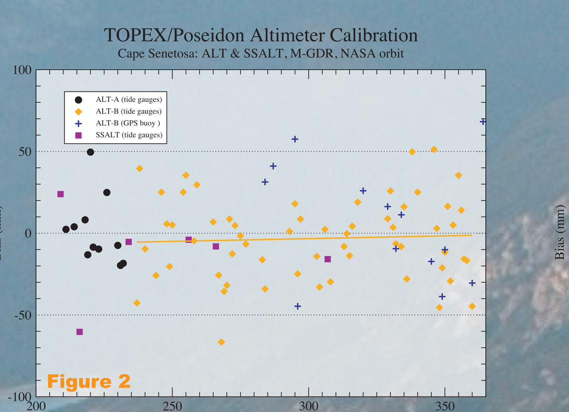
The calibration principle is to compute the difference between the sea surface height (ssh) measured with the altimeter and the ssh recorded by the tide gauge. These two ssh are located at two distant points. The link between the two ssh is partly the geoid slope from offshore altimetric measurement 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. Details can be found in Bonnefond et al. (2003a and 2003b).

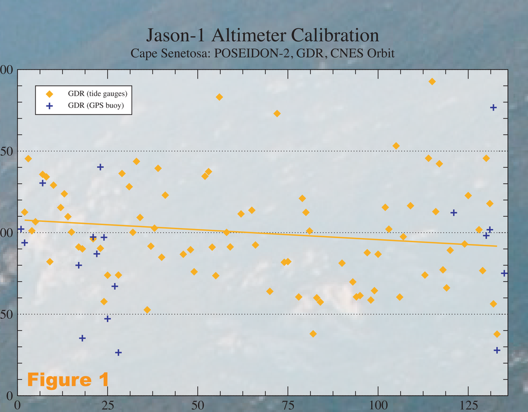
Bonnefond, P., P. Exertier, O. Laurain, Y. Menard, A. Orsoni, G. Jan, and E. Jeansou, Absolute Calibration of Jason-1 and TOPEX/Poseidon Altimeters in Corsica, Special Issue on Jason-1 Calibration/Validation, Part 1, Marine Geodesy, Vol. 26, No. 3-4, 261-284, 2003a.

Bonnefond, P., P. Exertier, O. Laurain, Y. Menard, A. Orsoni, E. Jeansou, B. Haines, D. Kubitschek, and G. Born, Leveling Sea Surface using a GPS catamaran, Special Issue on Jason-1 Calibration/Validation, Part 1, Marine Geodesy, Vol. 26, No. 3-4, 319-334, 2003b.



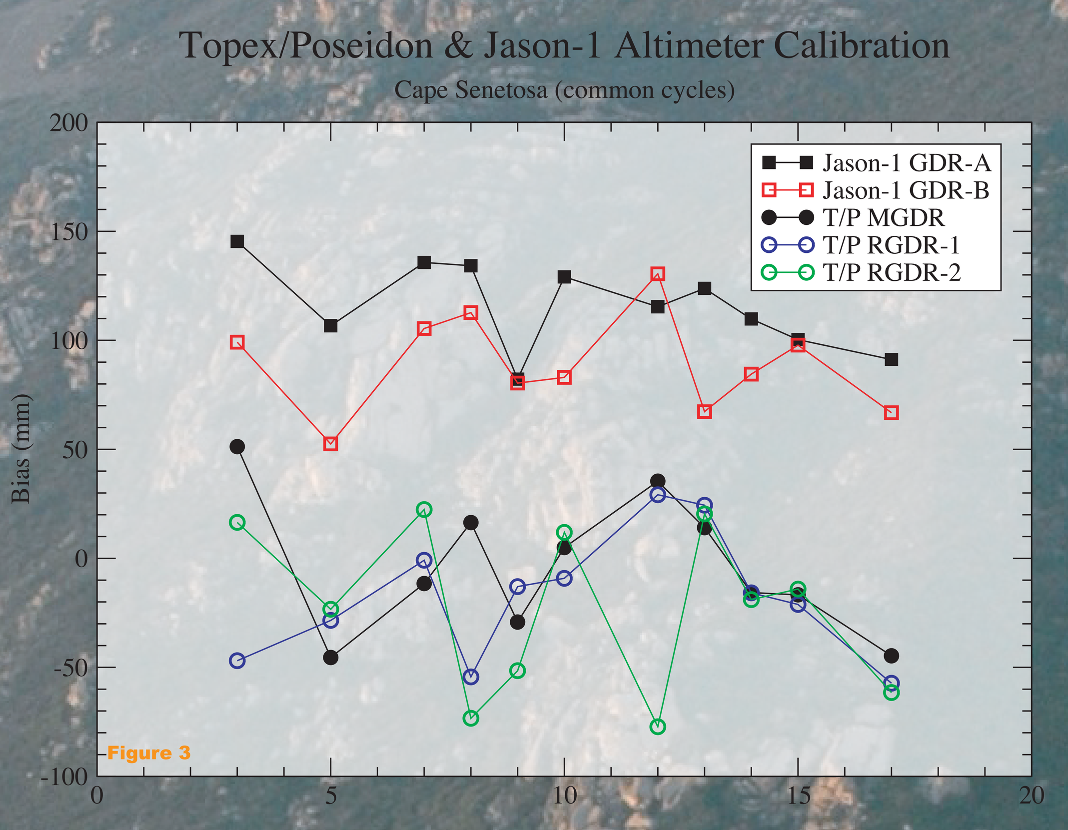
TOPEX/POSEIDON (MGDR) AND JASON-1 (GDR-A) ALTIMETER BIASES

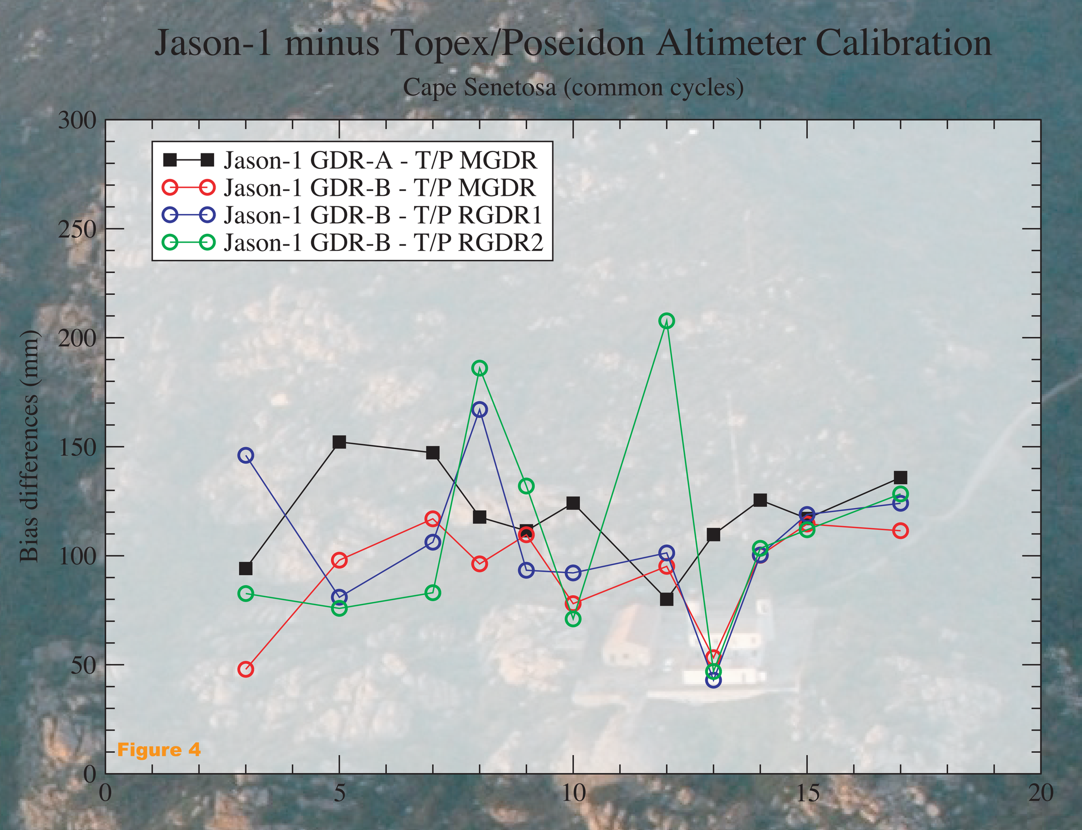




The above Figures show Jason-1 (right) and TOPEX/Poseidon (left) altimeter bias determination for the three tide gauges settled at Cape Senetosa and for the GPS buoy. Jason-1 cycle 22 corresponds to the last T/P over flight (365, 14th august 2002). Bias for ALT-B altimeter (T/P) based on tide gauge data is -3.2 ±3.2 mm while the GPS buoy gives +7.8 ±10.1mm. Concerning Jason-1 (POSEIDON-2 altimeter) the bias is +99.8 ±3.5mm compared to tide gauges measurement while it is +88.7 ±9.0mm when using the GPS buoy. When taking into account only the common cycles where both techniques are used the differences in term of altimeter bias are +5mm either for T/P or Jason-1. These results show the very good agreement between both techniques.
The origin of the linear trend in the Jason-1 altimeter bias time series (Figure 2) is due to JMR and will be discussed in the "Wet Tropospheric Correction Analysis" section.

TOPEX/POSEIDON AND JASON-1 FORMATION FLIGHT PHASE ANALYSIS





The new products availables for both TOPEX/Poseidon and Jason-1 during the formation flight phase (cycle 1 to 21) have been compared to the "old ones" (repectively MGDR and GDR-A for T/P and Jason-1). In this study we have used the GDR-B for Jason-1 and the Retracked GDR for T/P. For TOPEX/Poseidon, retracking values are given for the two types of retracking: Least Squares (LSE, RGDR1) and Maximum a Posteriori (MAP, RGDR2). No other correction has been applied except for T/P for which the TMR drift has been applied (increase of the bias by about 6 mm on this period). Figure 3 shows the time series of Jason-1 and T/P altimeters biases while Figure 4 shows the relative bias between the two satellites. Results are given below:

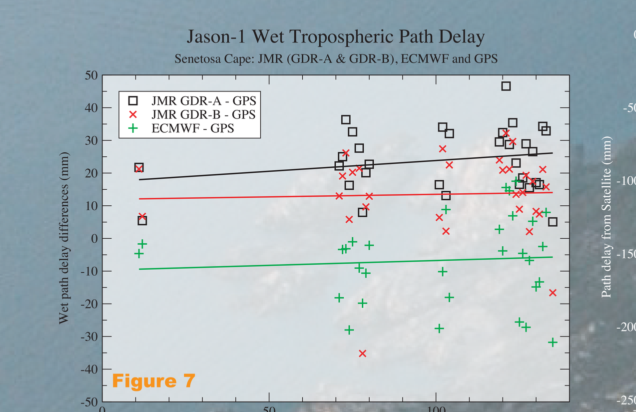
Absolute biases (cycle 1 to 21):

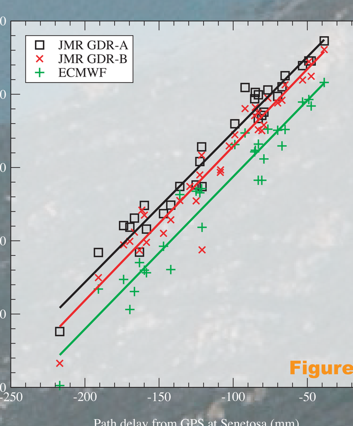
Poseidon-2 GDR-A:	+111.6 ±4.9 mm
Poseidon-2 GDR-B:	+87.0 ±6.0 mm
TOPEX ALT-B MGDR:	-4.6±8.1 mm
TOPEX ALT-B RGDR1:	-23.5±7.5 mm
TOPEX ALT-B RGDR2:	-37.2±11.3 mm

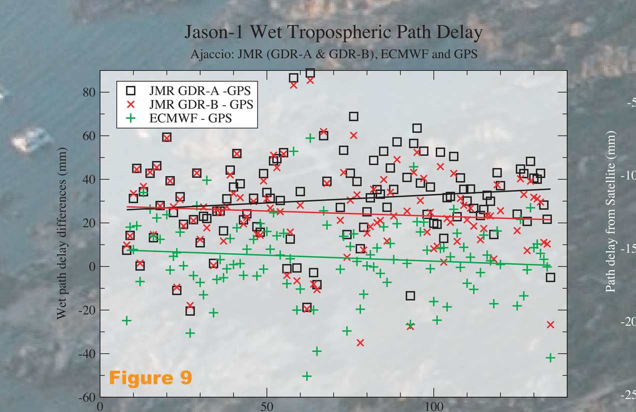
Relative biases (cycle 1 to 21):

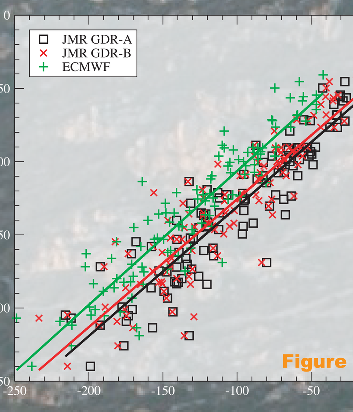
(Poseidon-2 GDR-A) - (TOPEX ALT-B MGDR):	+119.6 ±6.4 mm
(Poseidon-2 GDR-B) - (TOPEX ALT-B MGDR):	+92.8 ±7.1 mm
(Poseidon-2 GDR-B) - (TOPEX ALT-B RGDR1):	+106.7 ±9.9 mm
(Poseidon-2 GDR-B) - (TOPEX ALT-B RGDR2):	+111.7 ±14.9 mm

WET TROPOSPHERIC CORRECTION ANALYSIS

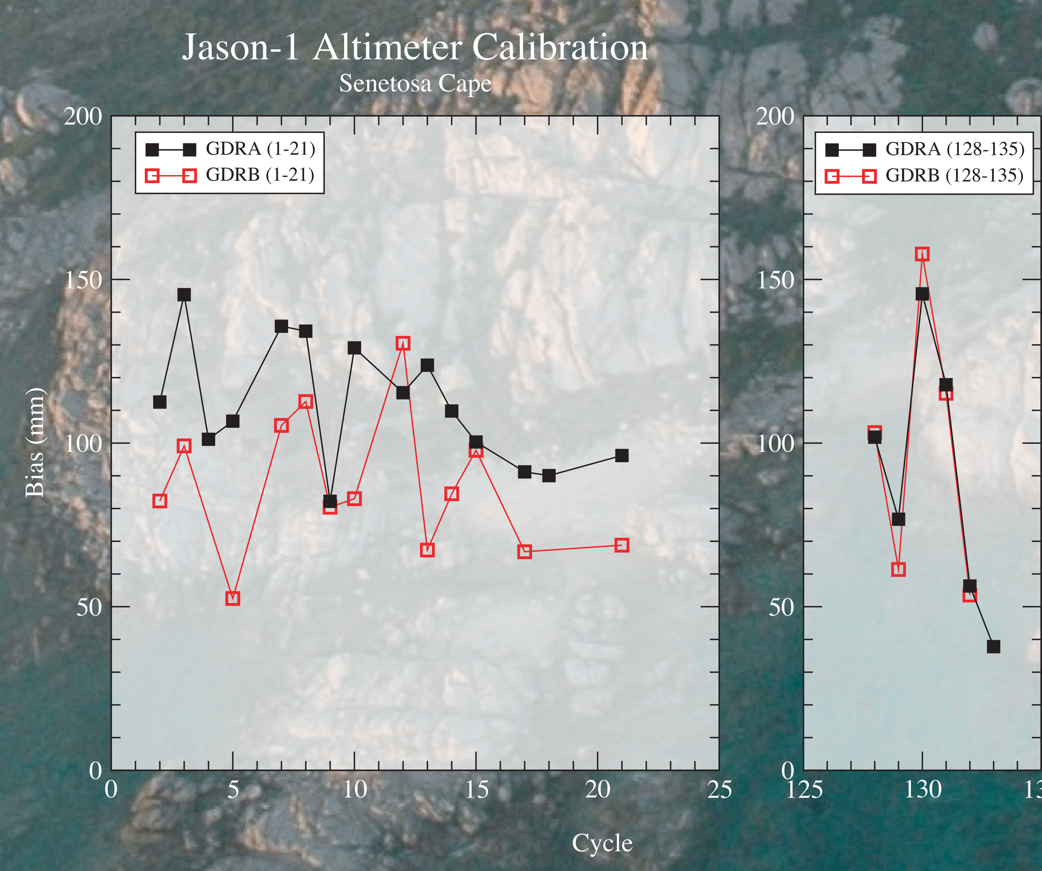








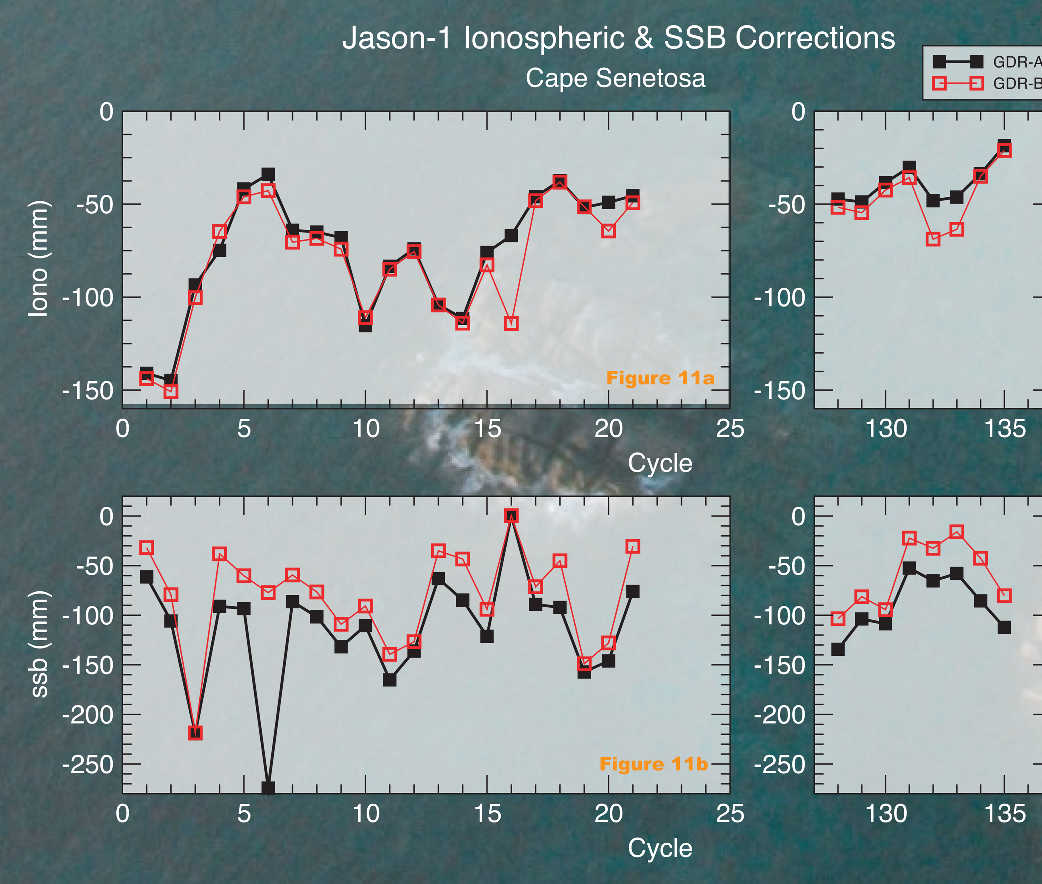
A permanent GPS receiver is installed at Ajaccio (AJAC IGS station, 40km north of Cape Senetosa) since 1999 close to the EnviSat track #130, and we have settled another one close to T/P-Jason-1 track #085 (Cape Senetosa lighthouse) since end of 2003. Using GPS data from our geodetic reference point (Senetosa lighthouse) and Ajaccio, the wet troposphere path delay is computed with GAMIT software.
In the Figures 7 and 8, the wet tropospheric path delays (correction to be applied to the altimetric range) issued from Senetosa GPS data are then compared to Jason-1 Microwave Radiometer (JMR, GDR-A and GDR-B data) and ECMWF model tropospheric corrections. The agreement between GPS and ECMWF is pretty good (-7mm) while JMR (GDR-A) exhibits a bias (+24mm) and a drift (+2.4 ±2.0 mm/yr). This drift effect is due to steps in the JMR calibration coefficients and clearly affects the Jason-1 altimeter bias time series (Figure 2). The future release of Jason-1 altimetric data includes new calibration coefficients and then this drift is removed (see JMR GDR-B on Figure 7). However, a bias of +13mm and +20mm remains when compared respectively to GPS and ECMWF. This is probably due to coastal approach and needs to be discussed during the OSTST meeting.
In the Figures 9 and 10, the same analysis has been performed with the wet tropospheric path delay issued from Ajaccio GPS data. The drift for JMR GDR-A is at the same level (+2.7 ±1.8 mm/yr) than from comparisons with Senetosa data. The observed drifts for JMR GDR-B and ECMWF (Figure 9) are not statistically distinguishable from zero.
From Senetosa and Ajaccio results, the wet tropospheric path delay derived from GPS data demonstrates that it is a very powerful and accurate method to monitor on board radiometers. However, to determine any bias, only data very close to the altimetric measurements should be used. Indeed, we have observed that the path delay correction (negative) at Ajaccio is on the average biggerby about 8mm compared to Senetosa one, probably due to the 40km distance between sites. On the other hand, while the correlation is on the average 97% (Figure 8) at Senetosa it is only 91% at Ajaccio (Figure 9).



JASON-1 GDR-A AND GDR-B ANALYSIS

The POSEIDON-2 altimeter bias has been analyzed on the full set of GDR-A and GDR-B data available (cycle 1-21 and 128-135). Figure 5 shows the time series for both data sets and for the two time periods. On the average, the altimeter bias is +105.2 ±6.0 and +90.1 ±6.6 respectively for GDR-A and GDR-B. However, Figure 5 clearly shows a different behavior between these two periods. Indeed, GDR-A bias changes from +111.6mm to +99.7mm (decrease of 14.3mm) while GDR-B bias changes from +87.0mm to +98.2mm (increase of 11.2mm). The GDR-A decrease is probably due to JMR steps in the calibration coefficients and corresponds roughly to the effect of the slope identified with GPS (2.4mm/yr over 3 years, see Figure 7). However, on the GDR-B release the JMR do not reveal any significant trend.
We need to study GDR-B over a longer period of time to avoid such kind of epiphenomenon.

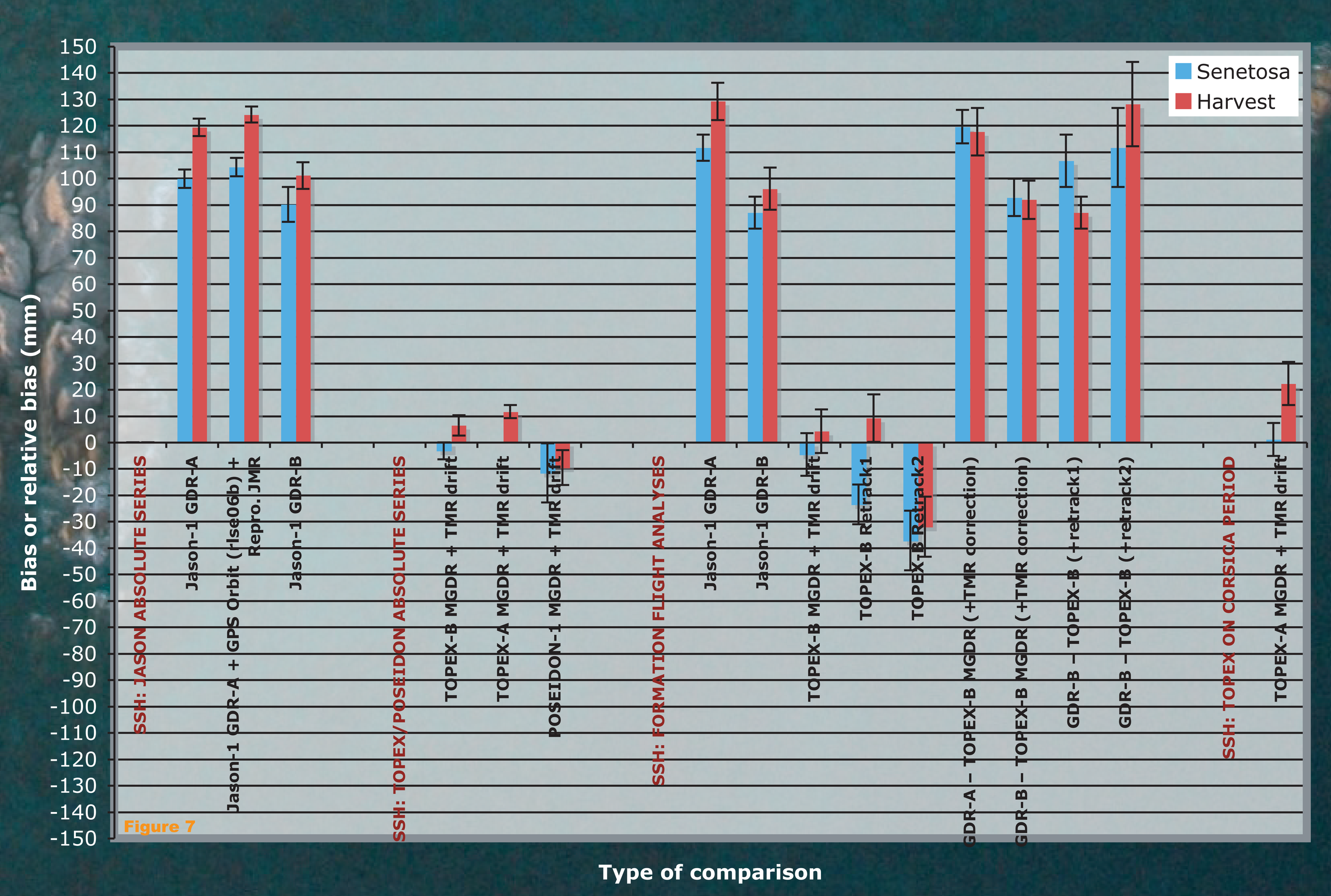
IONOSPHERIC AND SSB CORRECTIONS ANALYSIS



We have also analysed the two other most important corrections in the absolute bias determination process namely the ionospheric (Figure 11a) and Sea State Bias ones (Figure 11b). This analysis is based on the full set of GDR-A and GDR-B data available (cycle 1-21 and 128-135).
Concerning the ionospheric correction the differences are on the average -4.5mm (GDR-A correction is smaller than GDR-B one) and exhibits a standard deviation of 6.0mm.
On the SSB side, the differences are higher with a mean of +25.3mm (this time GDR-A correction is bigger) and a standard deviation of 13.3mm.
The effect of these two corrections should then decrease the Jason-1 altimeter bias by about 30 mm. However, the retracking of GDR-B data (MLE4 + 2nd order Brown model) also affects the absolute sea level and the difference between GDR-A and GDR-B is not at this level (see "Jason-1 GDR-A and GDR-B analysis).

TOPEX/POSEIDON AND JASON-1 RESULTS FROM SENETOSA AND HARVEST

All these analyses have been realized in a joint effort with Harvest calibration site in order to adopt common standards. Figure 6 resumes all the computed biases for both calibration sites along with their error bars. Results presented here are divided into 3 main sections: the Jason-1 absolute altimeter bias (ssh: JASON absolute series), the TOPEX/Poseidon absolute altimeters biases (ssh: TOPEX/Poseidon absolute series) and the absolute biases (or relative biases) during the formation flight phase (ssh: formation flight analyses). The last section only concerns the aging period of the ALT-A altimeter which occurs less than one year after the creation of the Corsica calibration site in 1998 (ssh: TOPEX on corsica period).



ABSTRACT

The Corsica site, which includes Ajaccio, Aspretto, Senetosa Cape, and Capraia (Italy) in the western Mediterranean area has been chosen to permit the absolute calibration of radar altimeters. Thanks to the French Transportable Laser Ranging System (FTLRS) for accurate orbit determination and to various geodetic measurements of the local sea level and mean sea level, the objective is to measure the altimeter biases and their drifts. The expected outputs of this on site verification experiment are dedicated obviously to the determination of the calibration bias of T/P and Jason-1. On the other hand, it is also an opportunity to contribute to the tracking of oceanographic and geodetic satellites and to the analysis of the different error sources which affect them. In the field of positioning, we expect to contribute also to the decorrelation between the possible vertical displacements of our site (Earth crust) and the Mediterranean mean sea level. The double geodetic site in Corsica (Aspretto, near Ajaccio and Senetosa Cape 40 km south under the Jason-T/P ground track N° 85) has been used to calibrate the 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. Two dedicated tracking campaigns of the French Transportable Laser Ranging System have been realized in 2002 and 2005. Results of the last campaign, in term of calibration, are presented. At Senetosa cape, permanent geodetic installations have been installed since 1998 and different campaigns have been conducted in view of Jason-1 mission. Four tide gauges are installed at the Senetosa Cape and linked to ITRF using GPS and leveling. In parallel, since 2000, a GPS buoy is deployed during overflights at Senetosa (10 km off-shore). Moreover, since 2003, a permanent GPS has been installed to monitor possible vertical displacements of our site. In addition, using a local weather station, we derived the wet tropospheric path delays from GPS measurements which are compared to the Jason Microwave Radiometer ones at the overflight times.
T/P altimeter calibration has been performed from cycle 208 to 365. All the produced Jason-1 GDR cycles have been also analyzed in the altimeter calibration process. However, a detailed analysis has been performed for the reprocessed (GDR-B) cycles 1 to 21 which have been compared to T/P improved MGDR (TMR, orbit, …). In addition, new JMR (as included in GDR-B) path delay has been compared for all the available cycles to the ECMWF and GPS derived tropospheric correction.
Our semi-permanent experiment is planned to last over several years in order to detect any drift in the space borne instruments.