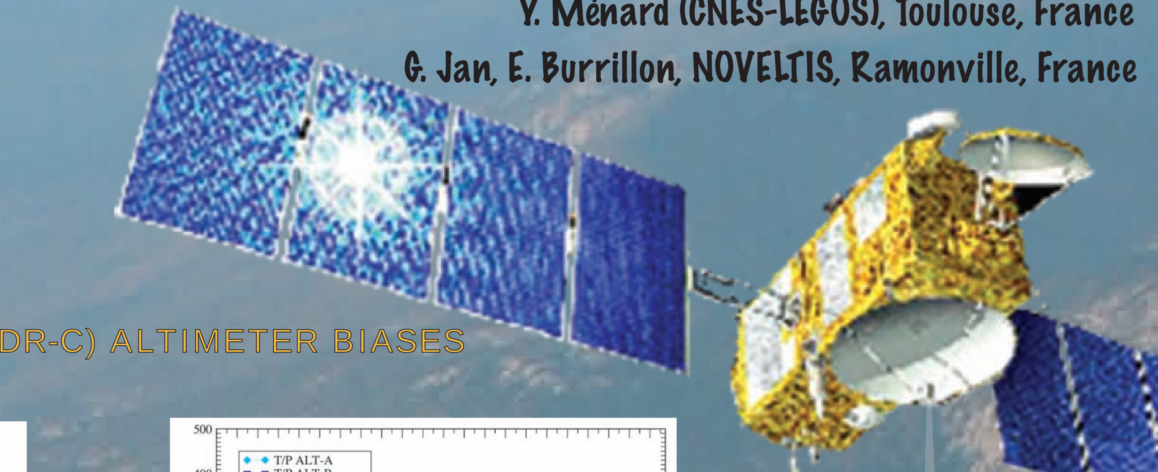
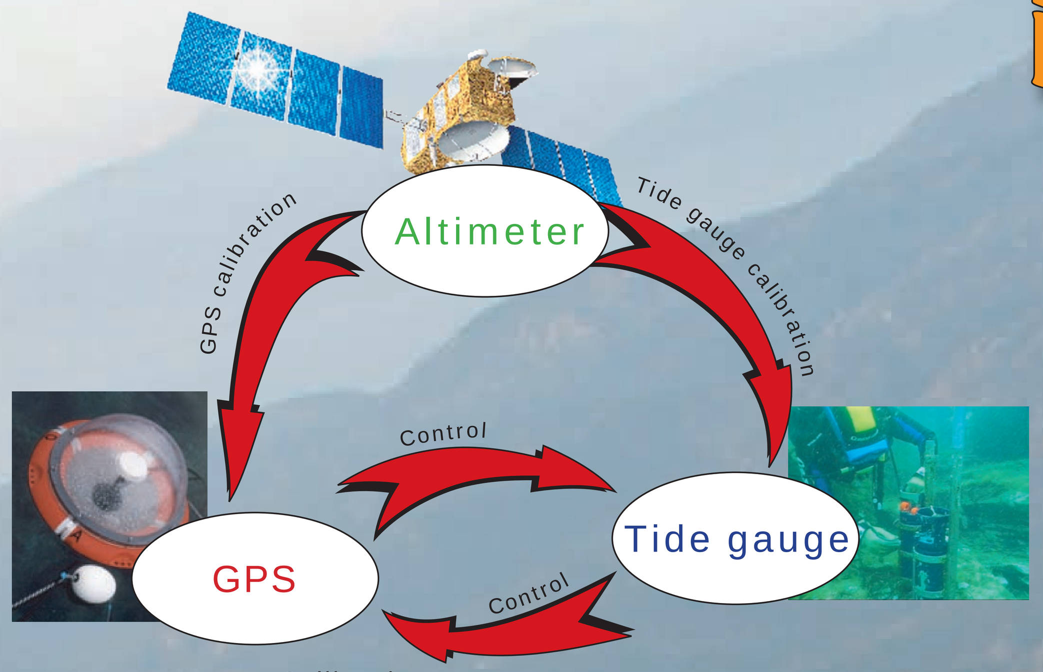
Absolute Calibration of Jason-1&2 and TOPEX/Poseidon Altimeters in Corsica

P. Bonnefond, P. Exertier, O. Laurain, F. Pierron, OCA/GeoAzur, Grasse, France
Y. Ménard (CNES-LEGOS), Toulouse, France
G. Jan, E. Burrillon, NOVELTIS, Ramonville, France



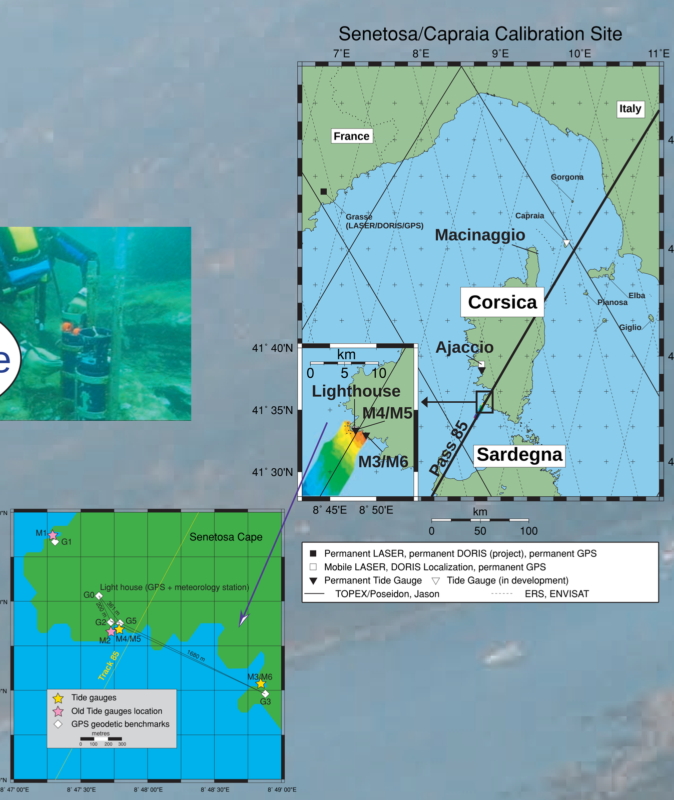


Calibration process

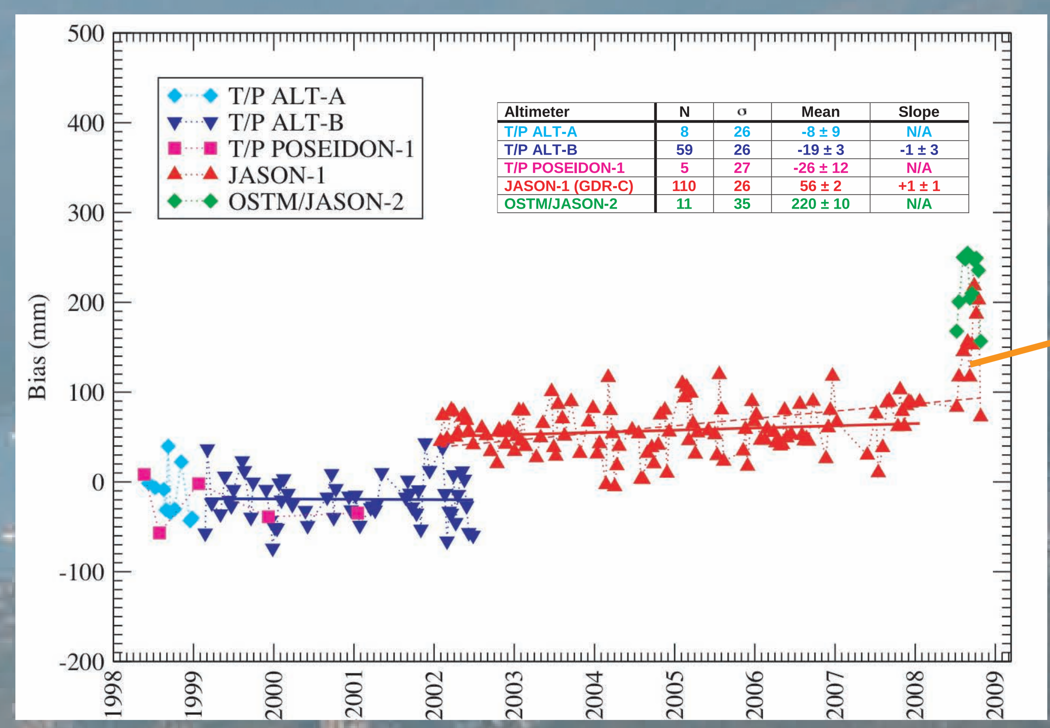
The calibration principle is to compute the difference between the sea surface height (ssh) measured with the altimeter and the ssh recorded by the tide gauge. These two ssh are located at two distant points. The link between the two ssh is partly the geoid slope from offshore altimetric measurement 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.

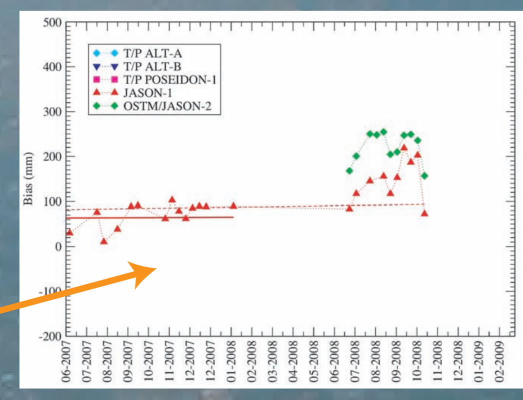
Bonnefond, P., P. Exertier, O. Laurain, Y. Menard, A. Orsoni, E. Jeansou, B. Haines, D. Kubitschek, and G. Born, Leveling Sea Surface using a GPS catamaran, Special Issue on Jason-1 Calibration/Validation, Part 1, Marine Geodesy, Vol. 26, No. 3-4, 319-334, 2003b.



TOPEX/POSEIDON (MGDR+) JASON-1 AND JASON-2 (I/GDR-C) ALTIMETER BIASES



Altimeter	N	σ	Mean	Slope
T/P ALT-A	8	26	-8 ± 9	N/A
T/P ALT-B	59	26	-19 ± 3	-1 ± 3
T/P POSEIDON-1	5	27	-26 ± 12	N/A
JASON-1 (GDR-C)	110	26	56 ± 2	+1 ± 1
OSTM/JASON-2	11	35	220 ± 10	N/A



The above Figure shows TOPEX/Poseidon, Jason-1 and Jason-2 altimeter bias determination for the three tide gauges settled at Cape Senetosa. Jason-1 cycle 239 corresponds to the first Jason-2 over flight (cycle 0, July 5th, 2008). The presented times series has been obtained using the best products available that are close to the future reprocessing except for retracking on T/P and for SSB and ionospheric correction for both satellites:

- TOPEX/Poseidon: MGDR products with the TMR replacement product and the GSFC TVG orbits based on ITRF 2005-rescaled. This will be named MGDR+ in the following.
- Jason-1: GDR-C products (reconstructed for cycle 1 to 212, GDR-C for cycle 208 to 240, and IGDR-C for cycle 238 to 250).
- Jason-2: IGDR-C products (for cycle 0 to 11)

The Corsica experiment is providing a very accurate bias time series for almost ten years which enable also to monitor possible drifts. Since June 2008, we have noticed a strong increase of Jason-1 bias for which we have at this stage no explanation... Details and a tentative explanation will be given in the "Summer 2008 Anomaly" part.

ABSTRACT

The Corsica site, which includes Ajaccio-Aspretto site, Senetosa Cape site, 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 TOPEX/Poseidon and Jason-1. On the other hand, it is also an opportunity to contribute to the orbit tracking of oceanographic and geodetic satellites and to the analysis of the different error sources, which affect altimetry. 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 TOPEX/Poseidon altimeters from 1998, and the Jason 1&2 ones since the beginning of the missions. Permanent and semi-permanent geodetic equipments are used to monitor these calibrations.

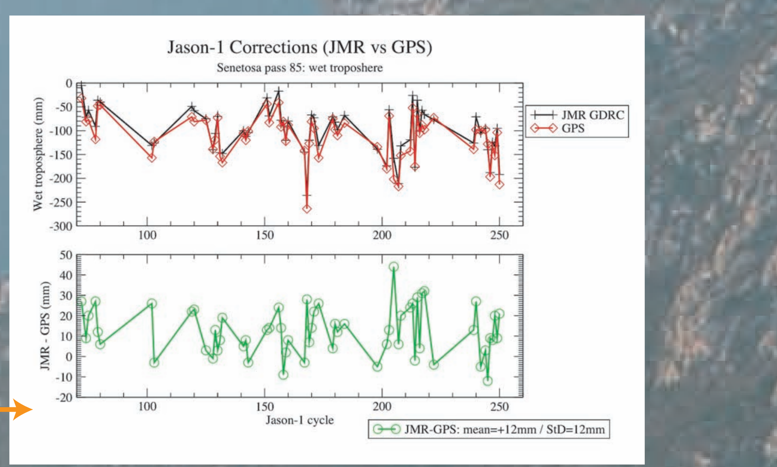
Concerning the Aspretto site, a permanent GPS station and an automatic tide gauge have been installed since 1999. Following the previous 2002 and 2005 campaigns, the French Transportable Laser Ranging System is settled at Aspretto since beginning of July until December 2008. Preliminary results of this 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 delay from GPS measurements which are compared to the Radiometer ones (TMR, JMR and AMR) at the overflight times.

The presented results will be focused on the Formation Flight Phase (also called tandem phase) of Jason-1 and Jason-2 and based on the I/O-GDR products. Preliminary values of the altimeter biases for both Jason-1 and Jason-2 will be presented as well as detailed studies on the various corrections. However, in our presented results, continuity of the long biases time series for T/P and Jason 1 will not be forsaken...

Our semi-permanent experiment is planned to last over several years in order to detect any drift in the space borne instruments.

Thanks to the comparisons with wet path delay derived from GPS, the ~10 mm differences between AMR (Jason-2) and JMR (Jason-1) is clearly due to land contamination that is affecting more JMR than AMR. This is a confirmation of what we have seen all along the Jason-1 mission (see Figure at right). In the past we also have seen that TMR (T/P) was less affected than JMR.

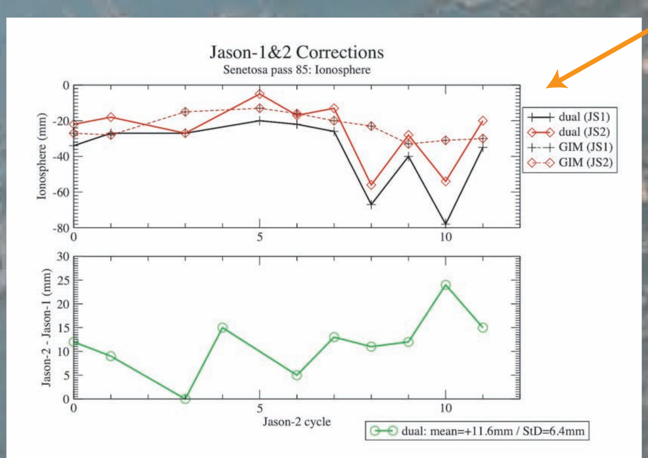


Jason-2 – Jason-1 (corrections):

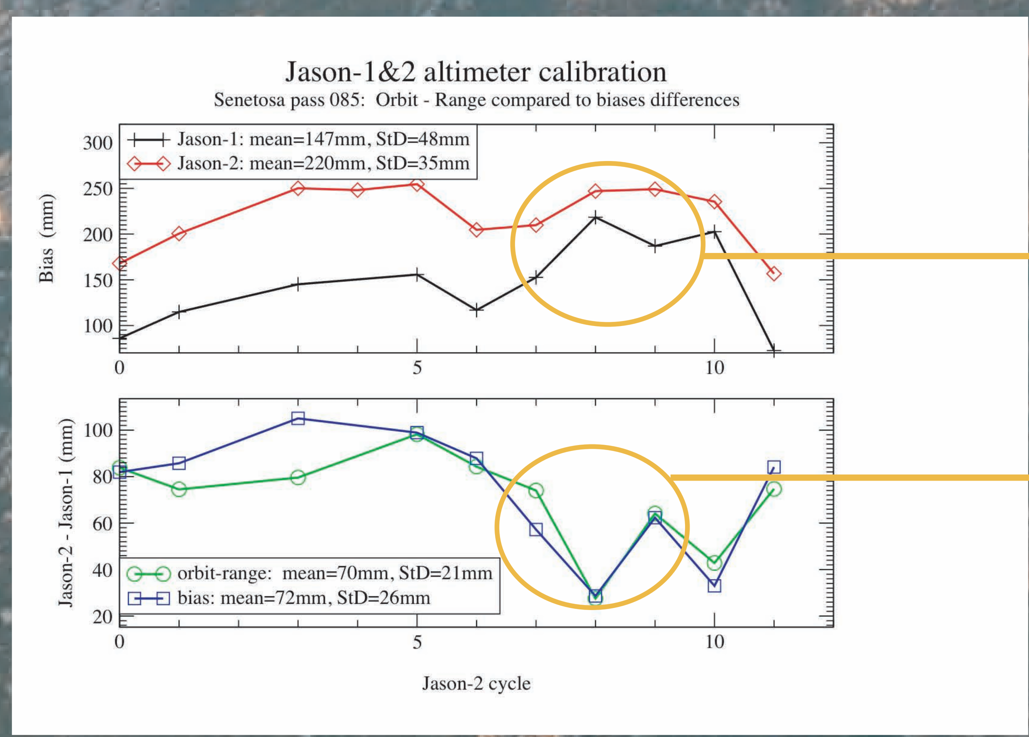
Correction	Mean (mm)	Standard Deviation (mm)
Dry Tropo.	-0.4	2.6
Wet Tropo. (radiometer)	-9.8	7.6
Wet Tropo. (ECMWF)	0.2	0.6
AMR - ECMWF	*21.8*	*17.7*
JMR - ECMWF	*31.6*	*15.0*
AMR – GPS	*-0.5*	*13.2*
JMR - GPS	*+9.3*	*11.9*
Iono. (dual frequency)	+11.6	6.4
Iono. (GIM)	0.0	0.0
JS2 - GIM	*-2.4*	*15.2*
JS1 - GIM	*-14.0*	*16.9*
SSB	-3.6	4.6
Solid Tides	+0.2	0.8
Loading	0.0	0.0
Pole Tide	0.0	0.0
Total	**-2.0**	

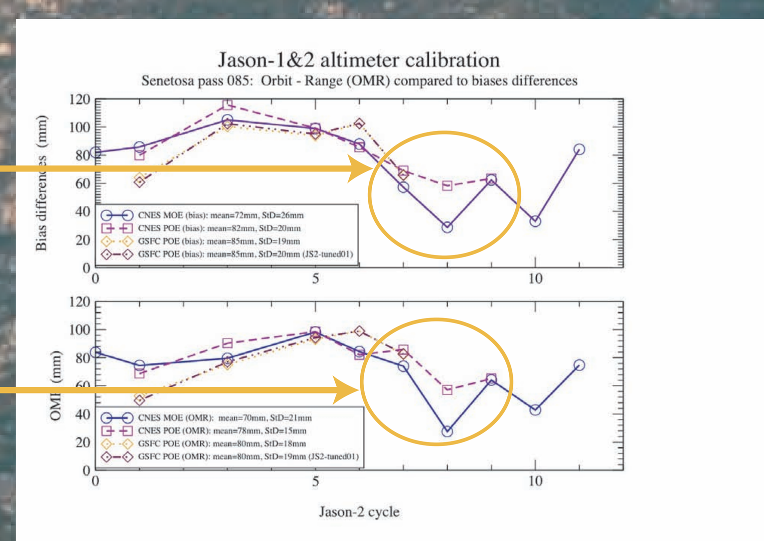
Main contribution comes from Wet tropo (~-10 mm) and iono (~+12 mm)

Other environmental parameters:
- SWH: Mean = +7.7 cm StD = 11.6 cm
- Wind Speed: Mean = +0.5 m/s StD = 0.6 m/s



JASON-1 AND JASON-2 FORMATION FLIGHT PHASE ANALYSIS





From both Orbit-Range and Bias differences we see a decrease that seems to be due to some larger orbit errors on the Jason-1 MOE for cycle 249 and 250 (respectively 8 and 10 for Jason-2). This is confirms when using the CNES POE (see circled area and the above plots).The 2mm between Orbit-Range (70mm) and the Bias differences corresponds to the sum of corrections differences given in the table. Results on the biases are given below:

Absolute biases (cycle 0 to 11):

Jason-1/Poseidon-2: +147 mm ±14 mm
Jason-2/Poseidon-3: +220 mm ±10 mm

Relative biases (cycle 0 to 11, common cycles):

Bias differences (Poseidon-3) - (Poseidon-2): +72 mm ± 8 mm
Orbit-range differences (Poseidon-3) - (Poseidon-2): +70 mm ± 6 mm

ANALYSIS OF THE "SUMMER 2008 ANOMALY"

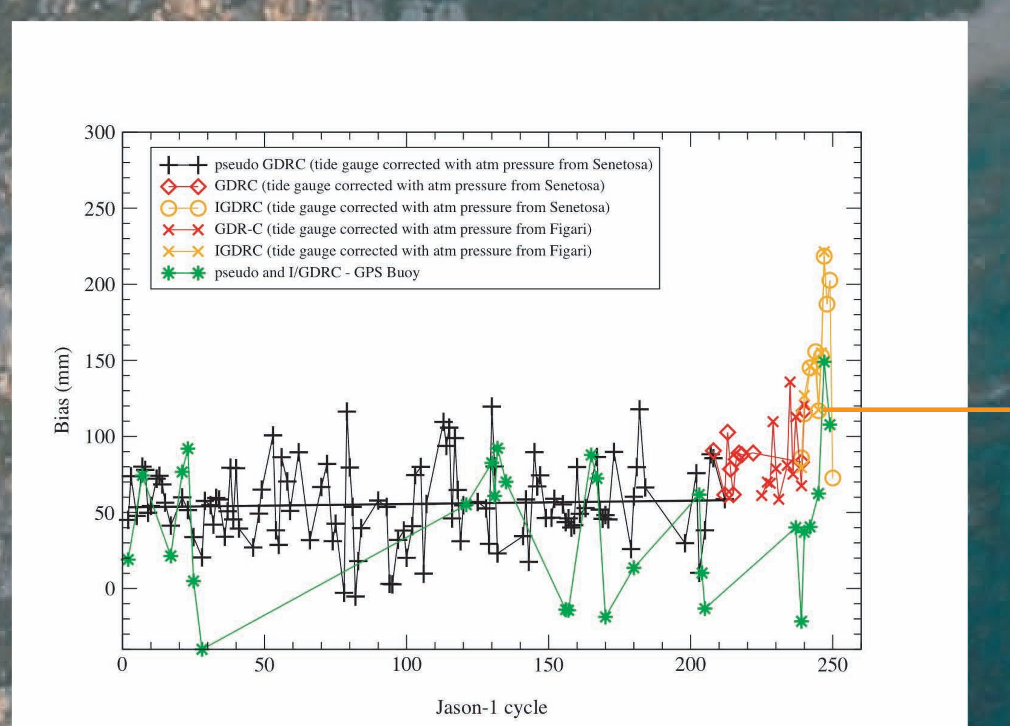
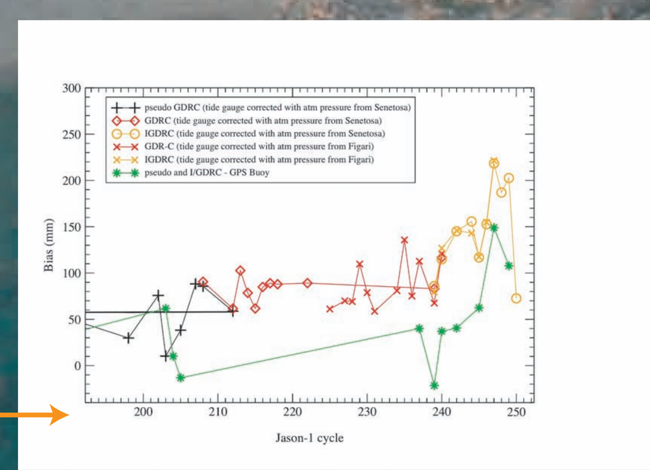


Figure 1



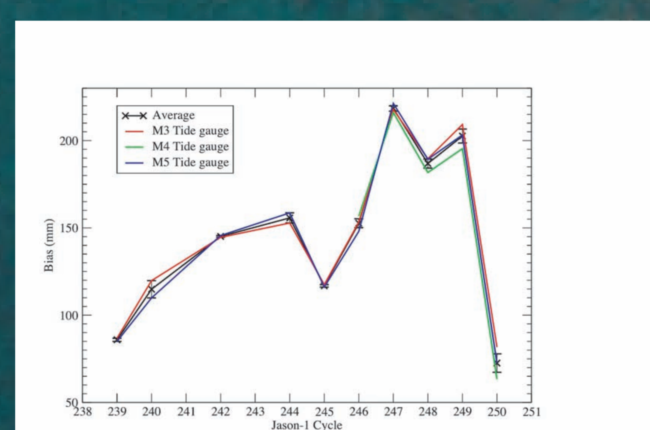


Figure 2

From June 2008, we are seeing a strong increase of Jason-1 bias (up to 10cm from the mean, see Figure 1) for which the signal seems to be also correlated to Jason-2 bias (see zoom at left of the T/P, Jason-1&2 bias series). This should indicates that we are facing a problem with our in-situ instrumentation so we have looked closely at all the parameters to find the sources:

First hypothesis: atmospheric pressure

As the 3 tide gauges gives the same bias (below 10mm differences, see Figure 2) we can supposed that it comes from the atmospheric pressure measured by our local weather station (we encountered some outages from February to May) that is used to correct the pressure tide gauges measurements. So we used the atmospheric pressure from the closest Météo France weather station located at the Figari airport (about 25 km east from Senetosa Cape). The crosses on Figure 1 shows that the biases derived from this process are at the same level than those derived from our local station.
=> It can't come from the atmospheric pressure correction

Second hypothesis: tide gauge measurement

The process used for computing the sea level above the tide gauge used the pressure, temperature and salinity measured by the sensors and the calibration coefficients given by AANDERAA. However, M3 and M5 tide gauges are the same tide gauges since July 2007, and M4 was changed in September 2008, so it is difficult to imagine that they all have the same trouble (see the coherence with the 3 tide gauges since cycle 246 on Figure 2).
However, the biases series derived from the GPS-buoy deployed 10 km off-shore under the satellite ground tracks does not show a similar behavior (green star on Figure 1). Indeed, the two highest values correspond to cycle 247 and 249 (cycle 8 and 10 for Jason-2) for which the MOE shows larger orbit error (see "Jason-1 and Jason-2 Formation Flight Phase Analysis"). Moreover, even if scattered the GPS-tide gauges differences (Figure 5) shows a clear positive step for the corresponding period (cycle 238 to 250) meaning that the tide gauges are supposed to measure a too low sea level and then give an increase of the bias.
=> It could come from the tide gauge process but as it has been completely review to find any bug and was not changed since a long time.

Third hypothesis: corrections applied to satellite measurement

Figure 3, shows the sum of all the corrections applied (Dry and Wet path delay, Ionospheric path delay, SSB, solid, loading and pole tides): each vertical dashed lines marked the beginning of June for each year. Even it shows a sort of correlation with the Jason-1 bias, this correlation can be seen on other time period. Moreover we have, made same graphs for all the corrections independently and none of them can contribute to this bias behavior.
=> It can't come from the corrections applied to the satellite measurement.

Fourth hypothesis: local phenomenon

From either Ajaccio radar tide gauge or Senetosa pressure ones, the annual cycle (steric effect) is less marked in 2008 than for the other years (see Figure 4 and 5) but the temperature variation is at the same level than for the other years. It sounds like the tide gauges are not measuring the steric effect while the satellite does. The lower behavior "seen" by the GPS-buoy (10 km offshore) tends to confirm this.
=> Even very bizarre this hypothesis needs further investigation

N.B.: on the various Figures the "x-1" or "x-1+cste" means that we have multiplied the Jason-1 bias by -1 and add a constant to better see any possible correlation.

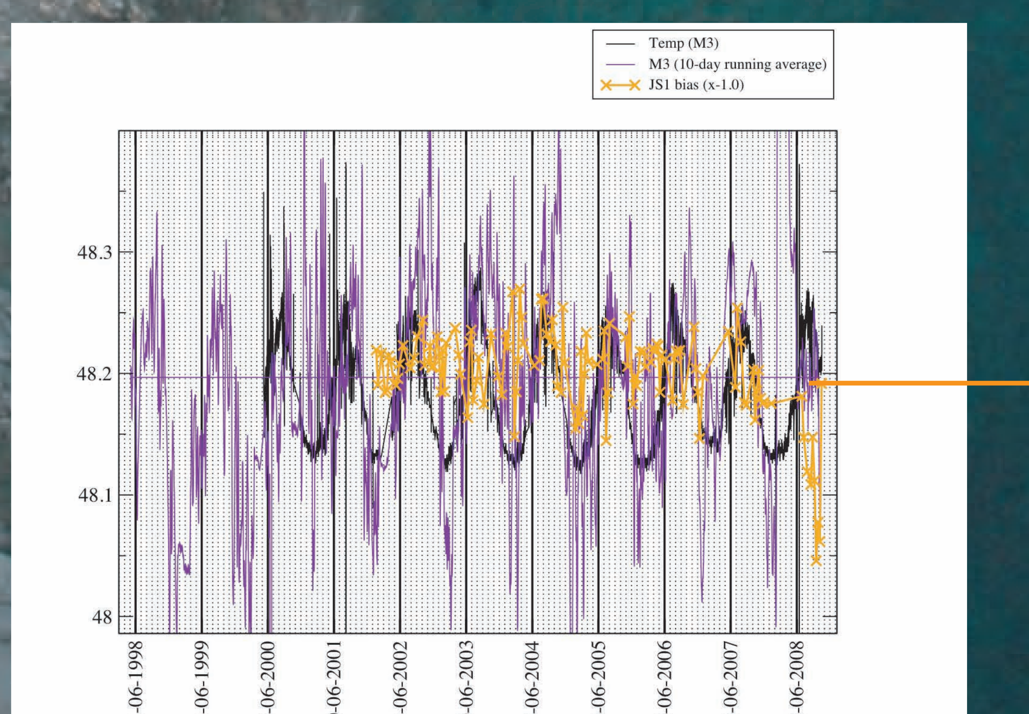
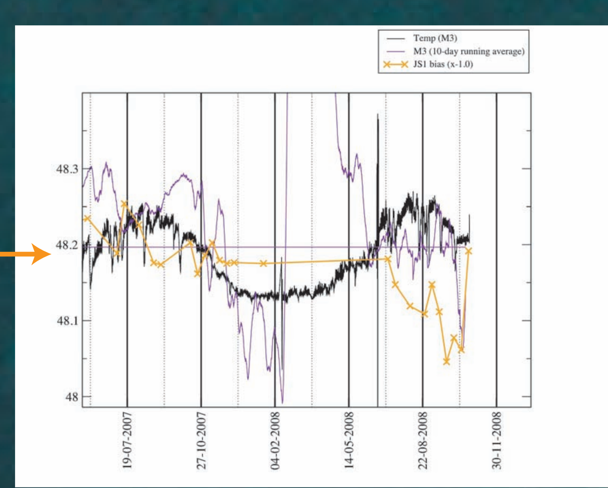


Figure 4



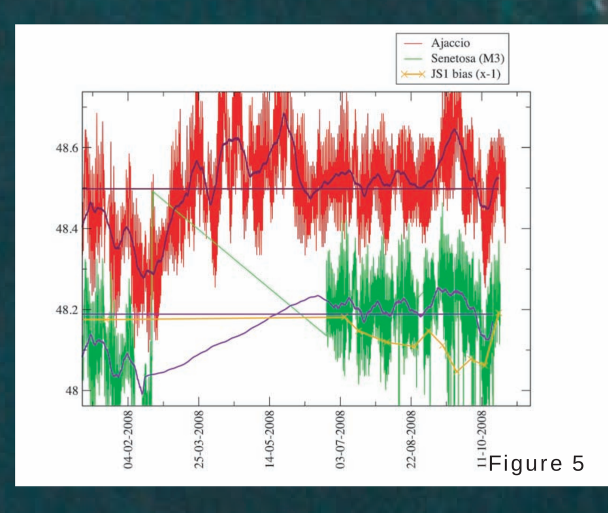


Figure 5

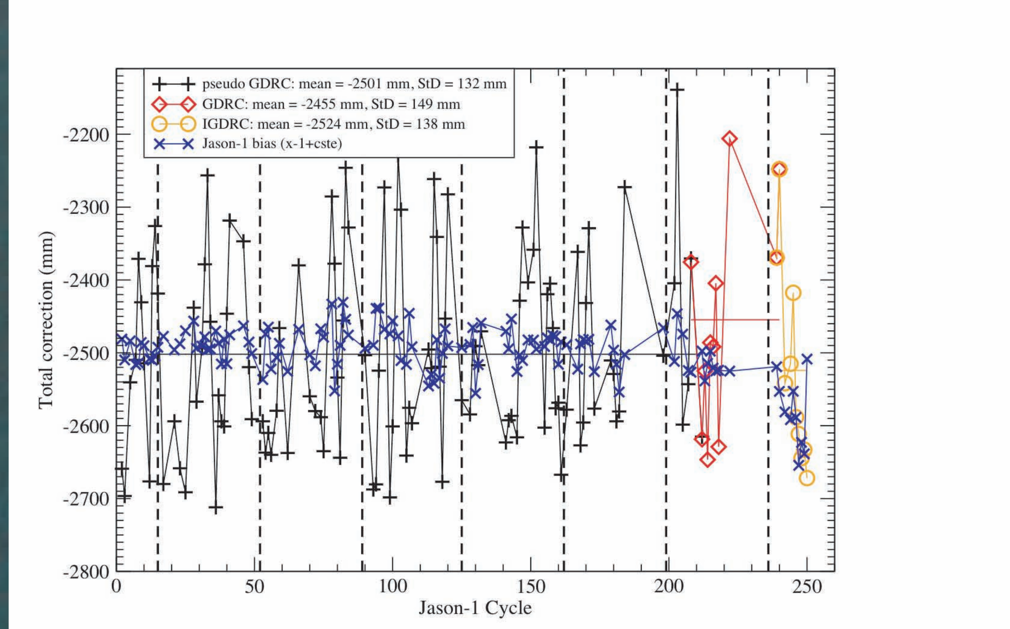


Figure 3

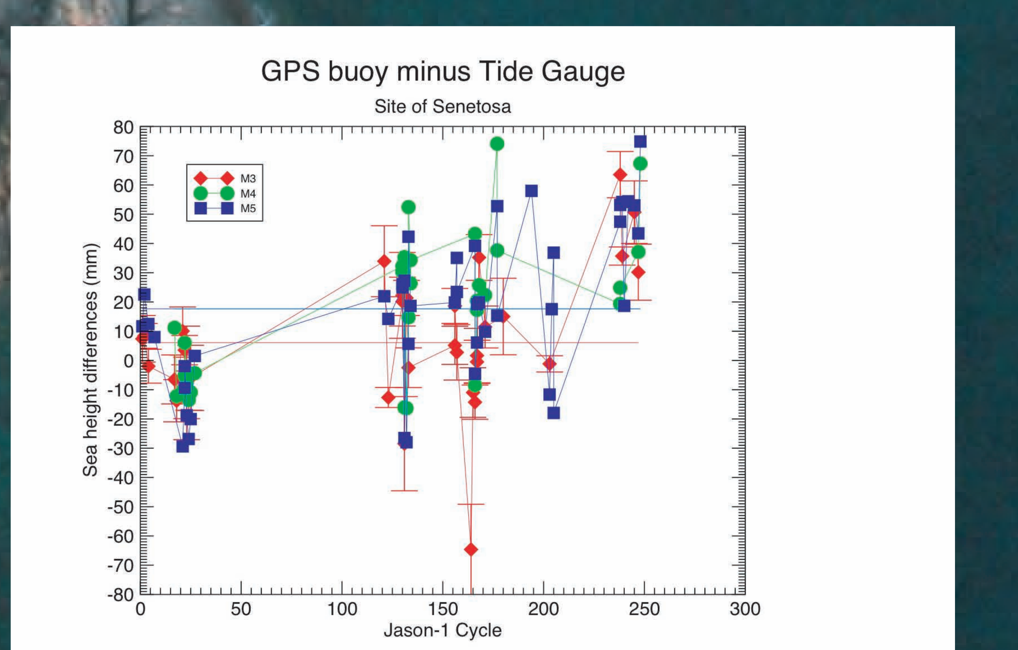


Figure 5