Regional CALVAL method in Corsica
Validation of the Jason-1, Jason-2 and Envisat missions at non-dedicated sites

M. Cancet[1], E. Jeansou[1], P. Bonnefond[2], O. Laurain[2], F. Lyard[3], P. Femenias[4], E. Bronner[5]

[1]NOVELTIS, Toulouse, France - [2]OCA/GEOAZUR, Grasse, France - [3]OMP/CNRS/LEGOS, Toulouse, France - [4]ESA/ESRIN, Frascati, Italy - [5]CNES, Toulouse, France

Corresponding author: mathilde.cancet@noveltis.fr

CONTEXT

The *in situ* calibration allows insuring **regular and long-term control of altimeter sea surface height** (SSH) time series **with independent records**. Usually, *in situ* calibration of altimeter SSH is performed at the vertical of a specific CalVal site by direct comparison of the altimeter data with the *in situ* data. In the framework of CNES and ESA oceanographic projects, the OCA established the Senetosa and Ajaccio calibration sites in Corsica, respectively in 1998 and 2005. Both sites are equipped with tide gauge instruments. **The Senetosa site is dedicated to** the absolute calibration of **the Topex/Jason nominal orbits**, whereas **the Ajaccio site was used for the Envisat mission** up to its orbit change in October 2010.

At the same time, NOVELTIS developed a **regional CalVal technique**, which aimed at increasing the number and the repeatability of the altimeter bias assessments by determining the bias both on overflying passes and on satellite passes located far away from the calibration site. The strong interest of this principle is to extend the single site approach to a wider regional scale. It is also a mean to keep on calibrating a mission when good-quality *in situ* data happens to be missing at its dedicated calibration site. The method was used to compute the biases of the Jason-1 and Jason-2 missions in Senetosa, as well as the Envisat mission bias in Ajaccio, before its orbit change.

In order to evaluate the stability and generality of the method, an **exercise of cross-calibration** was also carried out where the biases of both **Envisat and Jason-2 missions were quantified at the two Corsican calibration sites**. All these experiments show the robustness and the adaptability of the regional calibration method, and consequently its high advantage for monitoring missions on new orbits such as Envisat before its loss, CRYOSAT-2, HY-2A, Jason-1 end-of-life or the future Sentinel-3 mission.

The regional CALVAL method: combining absolute and offshore *in situ* validation techniques

Absolute CALVAL: Direct comparison between the altimeter SSH and the tide gauge measurements (point C on *Figure1*).
- ✓ Only for satellite passes flying over the calibration sites.
- ✓ Comparable to the bias estimations at the other calibration sites (Harvest, Bass Strait, Gavdos…)

Offshore CALVAL: Computation of the bias on offshore passes
- ✓ Following a succession of accurate mean sea surface profiles, combining several missions
- ✓ Using a high resolution mean surface to link the *in situ* and altimetry SSH

Possible ways of improvement:
- ✓ Good-quality SSH data (altimetry / *in situ* measurements)
- ✓ Accurate mean sea surface profiles
- ✓ High resolution *in situ* mean surface
- ✓ Ocean dynamics corrections: ocean tide and atmospheric effects between the offshore passes and the coast

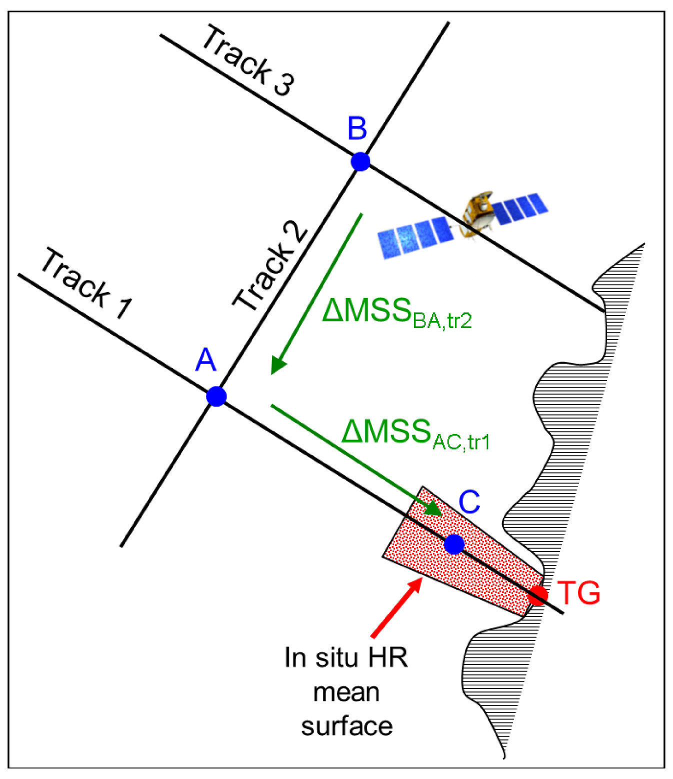


Figure 1: Generic diagram of the regional in situ calibration method

Generic method:

➔ Calibration of missions on new orbits

The regional CALVAL method can be used to compute the bias:
- ✓ of missions right after an orbit change (ex: interleaved Jason-1, Envisat since October 2010)
- ✓ for orbits without dedicated calibration sites (ex: Sentinel-3).

➔ Calibration of non-repetitive orbits

It can be as well adapted to estimate the bias for missions on quasi non-repetitive or shifting orbits (ex: Cryosat), at various calibration sites.

Applicable to others sites: Harvest Platform, Bass Strait, Gavdos…

$$bias_{alti,tr3}(t) = (SSH^{alti}_{B,tr3}(t) - dyn_{B,tr3}(t)) - (SSH^{gauge}_{TG,tr1}(t) - dyn_{TG,tr1}(t)) + (\overline{SSH}^{insitu}_{TG,tr1} - \overline{SSH}^{insitu}_{C,tr1}) + (\overline{SSH}^{alti}_{C,tr1} - \overline{SSH}^{alti}_{A,tr1}) + (\overline{SSH}^{alti}_{A,tr2} - \overline{SSH}^{alti}_{B,tr2})$$

Results of the cross-calibration experiment in Corsica

Altimetry missions parameters

Wet/dry troposphere: ECMWF model

Ionosphere: GIM (available for the whole Envisat period, provided by the CTOH)

Solid, polar, and load tides, and SSB: models available in the GDR products

Tide gauge datasets

Senetosa:
- 4 tide gauges (2 couples of twin instruments), since 1998

➔Redundancy to avoid gaps in the bias series

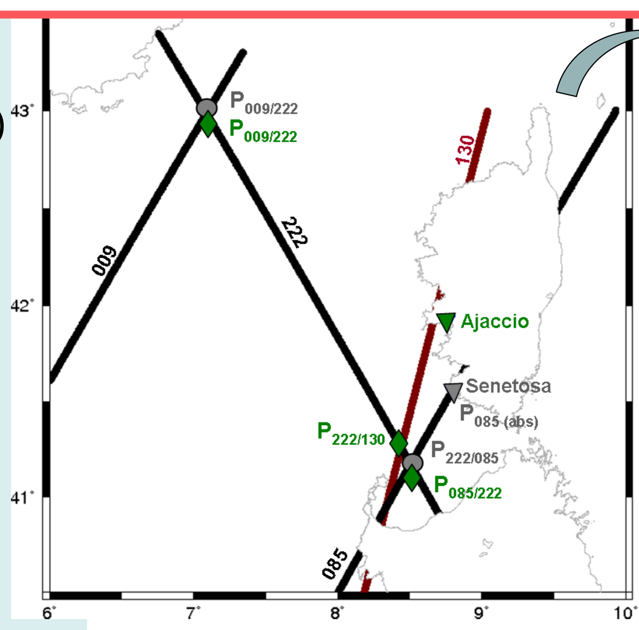
Ajaccio:
- 1 tide gauge (Sept. 2000 to Feb. 2011)
- 1.5-year of bad quality data (March 2008 to Sept. 2009)

➔No absolute CALVAL for Envisat from cycles 66 to 82

Ocean dynamics correction

DAC: regional TUGO simulation (LEGOS)

Ocean tide: regional tidal atlas (COMAPI, CNES project)



Envisat bias GDR-A, B & B with new POE Cycles 10 to 93	No ocean dynamics correction			With ocean dynamics correction		
	Mean bias (cm)	Std (cm)	Number of cycles	Mean bias (cm)	Std (cm)	Number of cycles
In Ajaccio						
Track 130 (absolute method)	45.8 ± 0.4	3.0	52	47.1 ± 0.4	3.1	50
Regional bias	45.7 ± 0.5	4.0	53	47.0 ± 0.6	4.0	51
OCA absolute bias (track 130)	45.4 ± 0.8	3.9	22			
In Senetosa						
Regional bias	45.0 ± 0.4	3.7	76	44.3 ± 0.4	3.6	76

***Figure 2:** Configuration for the estimation of the Envisat bias in Ajaccio (diamonds) and Senetosa (circles).*

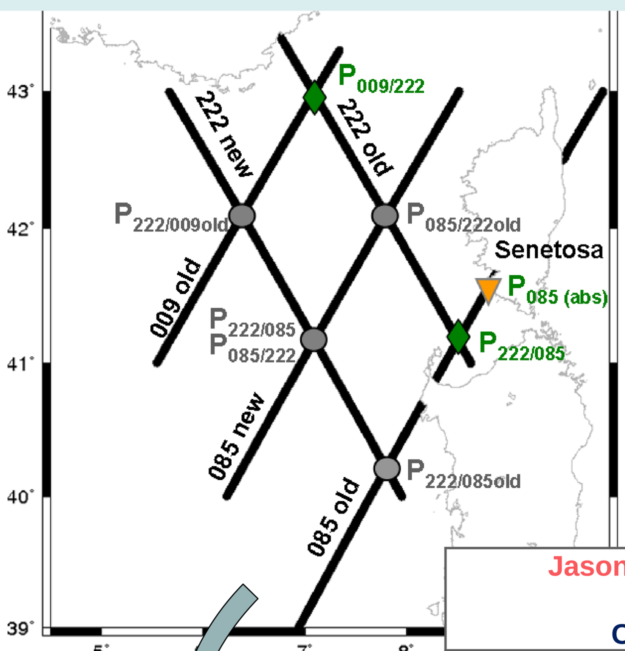


***Figure 3:** Configuration for the estimation of the Jason-1 bias in Senetosa, at crossover points on the nominal (diamonds) and on the interleaved (circles) orbits.*

In Senetosa, for the three missions

Very coherent results, in agreement with the estimates of the other groups

→ Jason-1/2 in Senetosa, Harvest, Gavdos and Bass Strait, Envisat in Ajaccio

For both sites and Jason-2 and Envisat missions
- ✓ More homogeneous results when applying the tide correction (lower variability in the bias estimates)
- ✓ Coherent results for Envisat on both sites without the tide correction

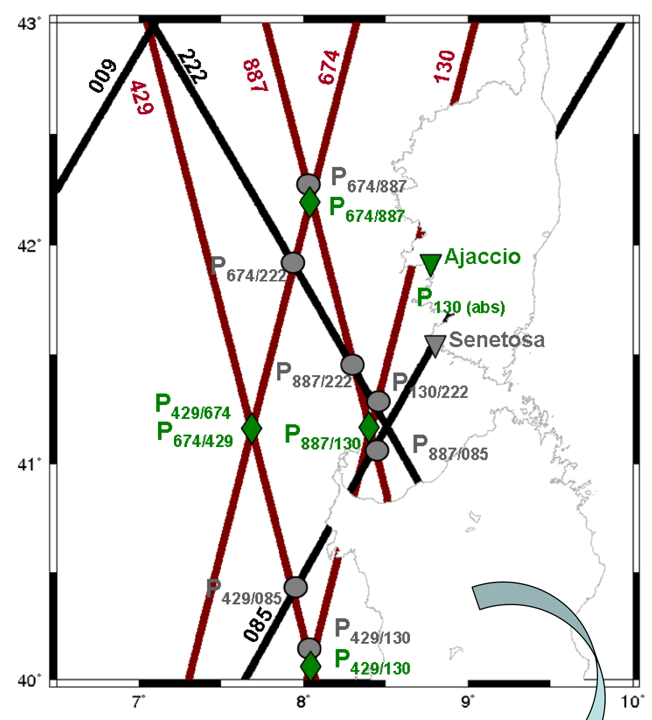
In Ajaccio, for both missions (Jason-2 & Envisat)

Increase of about 1.5cm in the bias when using the ocean dynamics correction (2cm with a harmonic analysis applied to the tide gauge time series, due to bad quality data) ➔ Still under investigation

This exercise demonstrates the capacity of the regional CALVAL method developed by NOVELTIS to quantify any mission's bias, at any calibration site. Finally, by multiplying the number of estimates, this method reduces the noise in the mission bias quantification.

➔ Cancet et al., 2012, published in ASR, special issue on Altimetry Calibration

***Figure 4:** Configuration for the estimation of the Jason-2 bias in Ajaccio (diamonds) and Senetosa (circles).*



Jason-1 bias in Senetosa GDR-C Cycles 1 to 259		No ocean dynamics correction			With ocean dynamics correction		
		Mean bias (cm)	Std (cm)	Number of cycles	Mean bias (cm)	Std (cm)	Number of cycles
Nominal orbit							
Track 085 (absolute method)		9.4 ± 0.2	3.4	247	8.9 ± 0.2	3.3	247
Regional bias		8.7 ± 0.2	3.2	240	8.2 ± 0.2	3.1	240
OCA absolute bias (track 085)		9.6 ± 0.3	3.5	165			
Interleaved orbit							
Regional bias	Jason-2 mean profiles	8.1 ± 0.4	3.6	64	7.2 ± 0.4	3.5	64
	Jason-1 mean profiles	8.1 ± 0.4	3.5	63	7.4 ± 0.4	3.4	63

Jason-2 bias GDR-C Cycles 1 to 93	No ocean dynamics correction			With ocean dynamics correction		
	Mean bias (cm)	Std (cm)	Number of cycles	Mean bias (cm)	Std (cm)	Number of cycles
In Senetosa						
Track 085 (absolute method)	17.0 ± 0.3	3.3	92	17.0 ± 0.4	3.5	92
Regional bias	16.7 ± 0.3	3.2	91	16.4 ± 0.3	3.2	91
OCA absolute bias (track 085)	17.6 ± 0.4	3.3	58			
In Ajaccio						
Regional bias	18.4 ± 0.4	2.5	49	19.1 ± 0.4	2.8	49

PERSPECTIVES 2012+

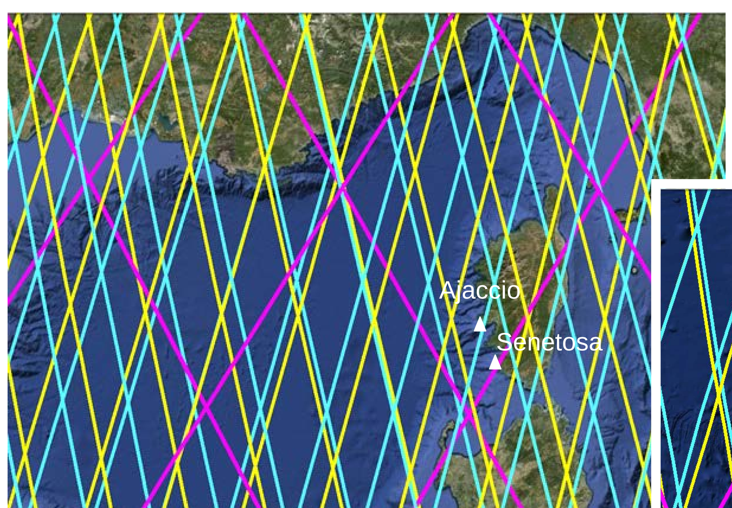
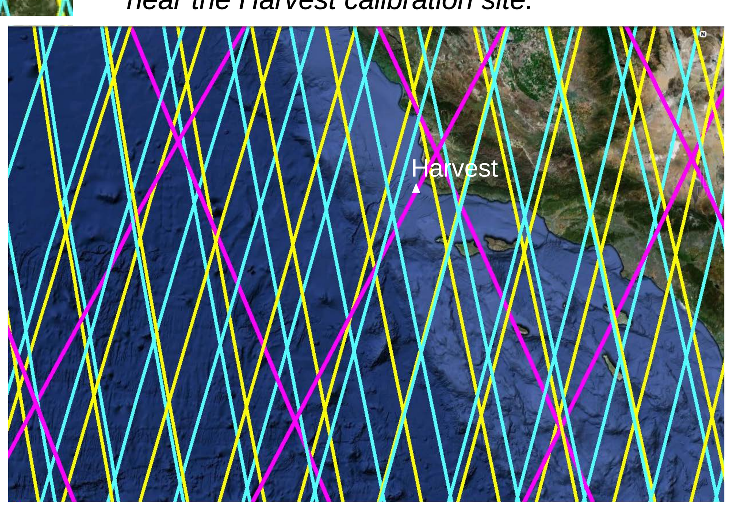


***Figure 5:** Theoretical ground-tracks of the Jason-2 mission (pink) and the Envisat nominal (light blue) and shifted (yellow) orbits near the Corsican calibration site.*

***Figure 6:** Theoretical ground-tracks of the Jason-2 mission (pink) and the Envisat nominal (light blue) and shifted (yellow) orbits near the Harvest calibration site.*



Calibration of new orbits

The regional CALVAL method can be used to compute the bias of missions right after an orbit change (ex: Envisat since October 2010).

➔ Future work (2012-2013):
- ✓ Calibration of Envisat shifted orbit in Corsica
- ✓ Calibration of Envisat nominal and shifted orbits in Harvest
  - → Different ocean dynamics conditions
  - → More local points of comparison with the global CALVAL

Calibration of non-repetitive orbits

It can as well be adapted to estimate the bias for missions on non-repetitive orbits (ex: Cryosat-2), at various calibration sites.

This efficient method should consequently be considered for the calibration of recent and future missions such as AltiKa, Cryosat-2, Sentinel-3, Jason-3, Jason-CS…

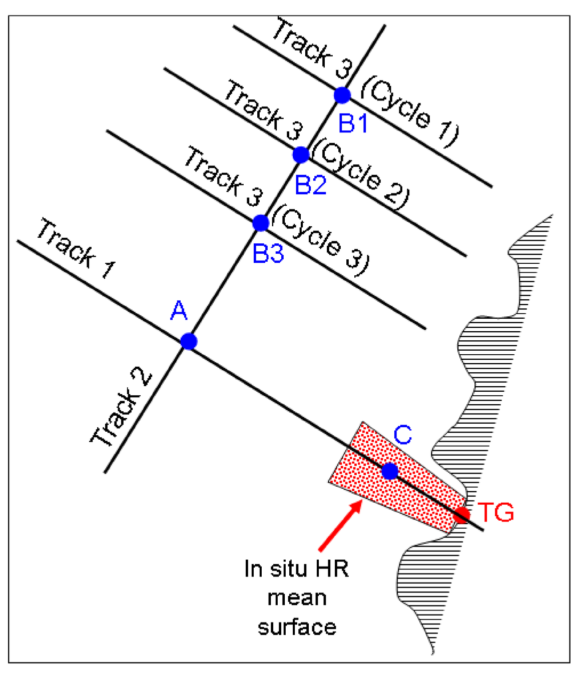


***Figure 7:** Diagram of the regional CALVAL method adapted to a non-repetitive orbit*

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