Contribution of Cape Begur site to the Jason-1 altimeter calibration: mapping of the marine geoid and integration of the continuous GPS monitored tide gauge at l'Estartit

Marina Martinez Garcia[1], Juan Jose Martinez Benjamin[1], Miquel Angel Ortiz Castellon[2]

(1) Universitat Politecnica de Catalunya, ETSECCPB/UPC, Barcelona, Spain, benjamin@fa.upc.es
(2) Institut Cartografic de Catalunya, Barcelona, Spain

Abstract

After several GPS buoys campaigns conducted in 2002, 2000 and 1999, the sea surface along the ascending 23 ground track of the Jason-1 satellite (corresponding to the old 239 and 287 ascending T/P ground tracks, respectively) in front of Begur Cape (Spanish NW Mediterranean coast) has been mapped.

Thanks to the ESEAS-RI project, the tide gauge placed at l'Estartit will be upgraded by providing the site with a continuous GPS monitoring station and with an accurate high rate pressure sensor that works simultaneously to the old tide gauge already existing.
These new features jointly with the upcoming GPS catamaran campaigns in that area will allow to upgrade Begur Cape at the level of reference calibration site in this part of the Meditarrenean for Jason-1and the future NASA/CNES altimeter missions.

Besides the role of the tide gauge contributing to the connexion between the marine geoid and the instantaneous sea surface, the site at l'Estartit has become a station of the global permanent network of tide gauges in studies of sea level variability and trends from terrestrial measurements thanks to the ESEAS-RI project.

1.- Introduction

The area offshore the Begur Cape (in the Spanish North Western Mediterranean) has been the site chosen to perform several experiments of radar altimeter calibrations in 1999, 2000 and 2002.

The main purpose was to test the capability to develop a permanent calibration site in this part of the Mediterranean by using wave rider buoys equipped with GPS antennas.

Two techniques have been tested: first, the single point calibration at the overflight and, second, the indirect calibration using the geophysical information provided by near tide gauges.

Next ocean mapping campaigns are planned for summer 2006. These campaigns will allow to redo the surveying performed in 1999-2000 and 2002 by using a GPS catamaran in order to obtain a more continuous sea surface shape.

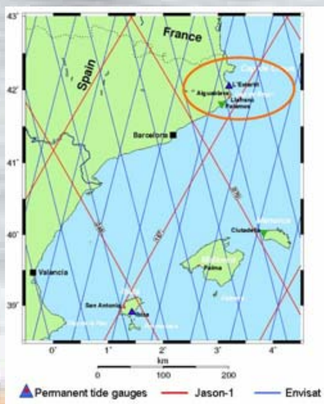


Figure 1. Spanish Mediterranean sites.

2.- Calibration techniques

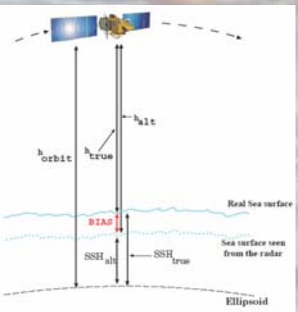


Figure 2. Direct calibration principle.

2.1.- In-situ method

The first technique, also denoted as direct calibration because the buoy is physically under the satellite track when the pass, has been performed for both the TOPEX side-B altimeter in 1999 and 2000 (ascending tracks of the 239 and 287 cycles, respectively) and also for the Jason-1 altimeter in 2002 (ascending track of the 23 cycle).

M-GDR products (in 1999 and in 2000) and I-GDR products (in 2002) have been used when the comparison between the GPS derived sea surface (computed from the buoys) and the respective altimeter measurements.

The kinematic solution (differential kinematic positioning) for the buoy placed in the open sea, underneath the satellite ground track, has used precise GPS orbits and the estimates of the wet zenith tropospheric delay computed at a fiducial GPS station placed in the coast (less than 10 km far from the calibration area).

Results of the point calibrations are in agreement with the official values obtained in single point experiments with buoys, which range several centimeters. Thus, for the TOPEX side-B single calibration, the range bias was estimated in +6.5 cm with 32.1 cm of rms and +3.7 cm with 32.6 cm of rms in 1999 (Selective Availability still on) and in +3.43 cm with 7.9 cm of rms in 2000, and for the Jason-1 in +10.52 cm with 10.35 cm of rms in 2002.

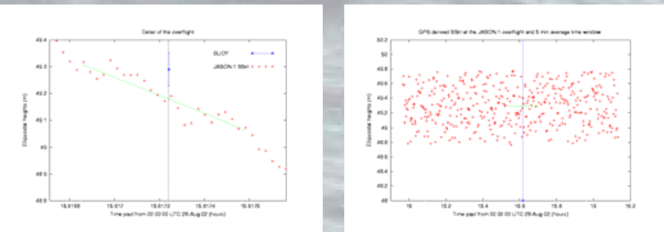


Figure 3. Campaign 2002, example of Jason-1 single point calibration.

Campaign	Overflight (UTC time)	Cycle	SSH_{GPS} (m)	SSH_{alt} (m)	BIAS (mm)	Altimeter product
1999	18/03 at 08:45:41	T/P 239	49.118 ± 0.319 49.090 ± 0.323	49.052 ± 0.04 49.053 ± 0.04	$+65.2 \pm 321.4$ $+37.1 \pm 325.6$	M-GDR TOPEX-B
2000	07/07 at 07:34:47	T/P 287	49.243 ± 0.074	49.209 ± 0.04	$+34.3 \pm 79.6$	M-GDR TOPEX-B
2002	28/08 at 15:37:07	J 23	49.289 ± 0.061	49.184 ± 0.08	$+105.2 \pm 103.5$	I-GDR Jason-1

Table 1. Altimeter BIAS estimation by single point experiments over point TOP-08 for TOPEX-B and over point TOP-11 for Jason-1 radar instruments. The two values in 1999 corresponds to both similar GPS buoys used simultaneously at that campaign (UPCB and JPLB buoys, respectively.

2.2.- Indirect method

The second calibration technique, the indirect method, consist into obtain the terrestrial measurement of the instantaneous sea height at satellite nadir from an absolute and accurate mean sea surface computed along the satellite ground track (which is time independent).

This absolute mean surface is corrected by the sea level anomaly corresponding to the instant of the overflight, obtaining the true instantaneous sea surface at nadir at that time.

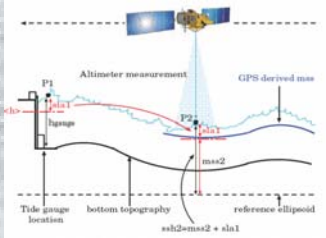


Figure 4. Indirect calibration principle.

The mean surface have been obtained from pelagic buoy surveying previously performed in the area along the satellite ground track. The sea anomalies applied to the translate the mean profile into instantaneous sea heights are provided by a near long-term tide gauge record, which is placed at l'Estartit (several kilometers far from the calibration area).

The advantage of this technique is that it makes possible to perform several point calibrations at every pass, over the collection of surveyed points. This improves significantly the statistics and, consequently, the computation of the bias that results the average of all the single estimations. Also the economic effort and the manpower supply is considerably reduced as only is necessary to keep working the tide gauge installation (once the mapping of the mean sea surface has been performed).

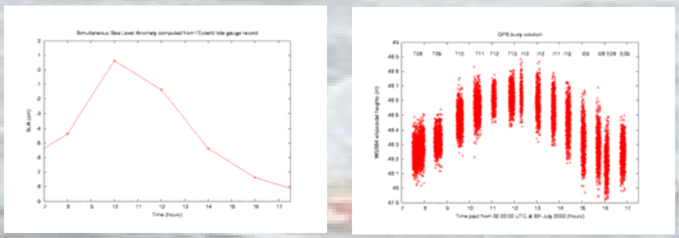
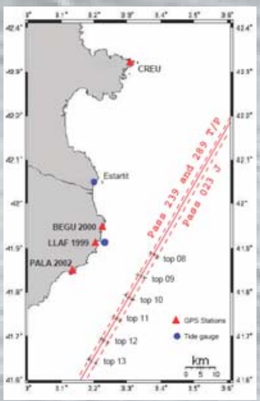
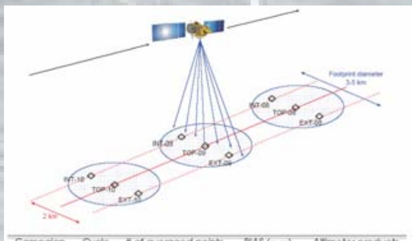


Figure 5. Left, the GPS hight rate solution for the buoy 6th July 2000. The plot shows the WGS84 ellipsoidal heights (SSHGPS computed at every single point as function of time. Right, the simultaneous SLA computed from the tide gauge long-term record at l'Estartit.

Both the campaigns in 2000 and in 2002, the indirect technique has been contrasted with the direct one. The second method provides in 2000, with only the T/P 287 cycle, with 6 estimations of the range bias, giving a mean value of +2.3 cm and rms of 6.5 cm. In 2002, with only the Jason-1 23 cycle, 4 estimations of the range bias were obtained, resulting a mean value of 10.12 cm and rms of 6.23 cm.

Thus, it is expected that with more passes monitored and by increasing the sea surface mapping along the satellite ground track in front of Begur Cape, the estimations of the altimeter bias will improve from repeated measurements as well as their computed rms will decrease.





Campaign	Cycle	# of averaged points	BIAS (mm)	Altimeter products
2000	T/P 287	6	$+23.3 \pm 65.1$	M-DGR TOPEX-B
2002	J 23	4	$+101.2 \pm 62.3$	I-DGR Jason-1

Figure 6. Right, the altimeter BIAS estimation by the indirect method for TOPEX-B and Jason-1 radar instruments in only one pass. Left, distribution of the calibration site at Begur Cape. The permanent GPS of the ICC at Creus Cape and the calibration area offshore Begur indicating the sea surface mapping points. It is represented the nominal T/P ground track in the center and the parallel internal and the external ground tracks.

REFERENCES

[1] Bonnefond, P., Exertier, P., Laurain, O., Menard, Y, Orsoni, A., Jan, G., and Jeansou, E., 2003,
Absolute Calibration of Jason-1 and TOPEX/POSEIDON altimeters in Corsica,
Special issue in Jason-1 Calibration/Validation,
Marine Geodesy, vol. 26, num. 3-4, p. 261-284, July-December 2003,
Ed. by G.H. Born.

[2] Born, G.H., 1994,
Calibration of TOPEX altimeter by using a GPS buoy,
J. Geophys. Res., 99, C12, 24517-24526.

[3] Fu, L.L., and Cazenave, A., 2001,
Satellite Altimetry and Earth Sciences,
International Geophysics Series, vol. 69, Academic Press.

[4] Haines, B., Dong, D., Born, G. and Gill, S., 2003,
The Harvest experiment: Monitoring Jason-1 and TOPEX/POSEIDON from a California offshore platform,
Marine Geodesy, vol. 26, no. 3-4, 239-260, 2003.

[5] J.J. Martinez-Benjamin, M. Martinez, S. Gonzalez, A. Nuñez, F. Buill, M. Espino, J. Lopez, J. Martin Davila, J. Garate, C. Garcia, P. Bonnefond, O. Laurain, A. Baron, M.A. Ortiz, J. Talaya, B. Perez, E. Alvarez, G. Rodríguez, D. Gomis, M. Marcos, Y. Menard, G. Jan, E. Jeansou, F. Lyard and L. Roblou,
Ibiza Absolute Calibration Experiment: Survey and Preliminary Results,
Marine Geodesy, Vol 27, pp.657-681, Taylor&Francis, December 2004.

[6] Zumberge, J.F., Heflin, M.B., Jefferson, D.C., Watkins, M.M., and Webb, F.H., 1997,
Precise point positioning for the efficient and robust analysis of GPS data from large networks,
Journal of Geophysical Research, 102, B3, 5005-5017.

ACKNOWLEDGMENTS
Special thanks to Josep Pascual for the maintenance and data collection of the tide gauge at l'Estartit and to R.Leszczynski and Puertos del Estado for technical support of the temporal tide gauges installed at Llafranc in 1999. Our gratitude to G.L.H.Kruizinga and S.Desai for the support and the orientation in the field campaigns and also in the data processing along 1999-2002. A mention to E.Jeansou for the interesting exchange of technical knowledge about wave rider buoys and to C.K.Shum for the comparative analysis of the buoy solution for the 1999 campaign performed with KARS software (Ohio State University). The three campaigns have been developed in the frame of two projects of the Spanish Space Program (Ministery of Science and Technology), ESP1997-1816-C04-03 and ESP2001-4534-PE. The tide gauge data form l'Estartit have been supported by the EU project ESEAS-RI.

OSTST meeting
Venice, 16-18 March 2006