Contribution of tide gauges to altimeter calibration in the Spanish sites

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Abstract

In this work the contribution of the tide gauges to the experiences on space altimeter calibration are summarized. In the Spanish Western Mediterranean several cal/val campaigns of the TOPEX-side B and Jason-1 altimeters have been conducted in the areas of Begur Cape and Ibiza island. The three Begur Cape experiences on radar altimeter calibration and marine geoid mapping were made on 1999, 2000 and 2002 with support of l'Estartit and Llafranc tide gauges. One campaign has also been made in June 2003 at the Ibiza island area. In this case the marine geoid has been used to relate the coastal tide gauge data from Ibiza and San Antonio harbours to off-shore altimetric data. All of these campaigns have been supported by the Spanish Ministery of Science and Technology under projects of the National Space Program ref: ESP1997-1816-CO4-03 and ESP2001-4534-PE.

1.- Cape of Begur calibration site

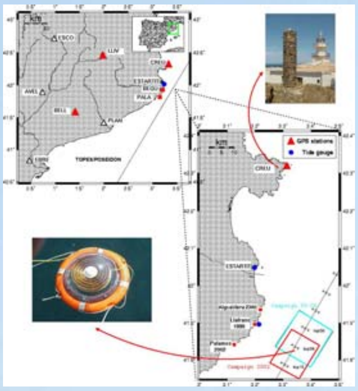


Figure 1. General distribution of Begur calibration site. The GPS network of the ICC in Catalonia and the calibration area offshore Begur Cape indicating the surveying points on both the 1999-2000 and the 2002 campaigns. It is represented the nominal T/P ground track in the center and the parallel internal and the external ground tracks for the mapping of the sea surface.

1.1.- GENERAL DESCRIPTION

The instrumentation consists on the reference station at the coast and the GPS buoys. The near tide gauge is only used when performing the indirect method. The reference station close to the satellite ground track is needed in order to achieve kinematic buoy solutions within centimeter accuracy level, which is the typical error assumed for the range measurement of the altimeter [3].

In all the campaigns, the buoy solution has been computed by using a differential kinematic strategy with short baselines, assuming common atmosphere corrections (ionosphere and specially troposphere) between the fix receiver and the rover. The mean value of the baselines is of 14.3 km and 14.9 km in 1999 and in 2000, respectively, and of 22.4 km in 2002. Previously, the coordinates of the fiducial site at the coast (triangles in Fig. 1) have been fixed by computing the free-network solution [7] that involves several permanent IGS-ITRF stations of the ICC in Catalonia (squares in Fig. 1).

Apart of the tide gauge at l'Estartit, two ancilliary sensors were temporally installed at Llafranc harbor in 1999 in order to study the spatial and temporal variability of the tides in that area from the simultaneous records.

In 1999 and 2000 campaigns the direct estimation of the altimeter bias was realized during the overflight of the TOPEX/POSEIDON onto a point marked as TOP-08 and in the 2002 campaign the overflight occurred onto TOP-11, in Fig.1. Overflight times have an uncertainty of about 10 sec.

1.2.- TIDE GAUGE AT L'ESTARTIT

The advantage of using l'Estartit record is the continuity and the length of its time series (the record valid for all the three campaigns). L'Estartit tide gauge is a classical floating tide gauge set up in l'Estartit harbour. Data are taken in graphics registers, from which a data each two hours is recorded in electronic support. This two hour data are interpolated to one hour data to do a good harmonic analysis of the astronomical tide. Tide gauge is controlled each week to get correct and accuracy data and the tide gauge maintenance has the same periodicity. A quality control to ensure the self-consistency of the records has been made. The tide gauge heights are geo-referenced to a benchmark of the Cartographic Institute of Catalonia (ICC). The coordinates of this geodetic mark have been calculated in 1999 by a precise leveling survey in order to connect the benchmark to the local EUREF sub-network that includes the permanent GPS IGS-ITRF station at Cap de Creus.

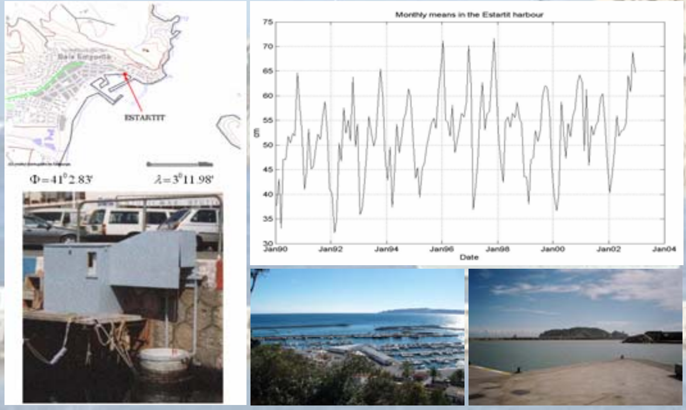


Figure 2. Old tide gauge installation at l'Estartit harbor (left) and exact location at the jetty (ICC map server), the coordinates of their benchmanks and time span. Some views if l'Estartit bay and harbor. Monthly mean time serie of the tide gauge record.

1.3.- DETAILS OF THE NEAR FUTURE INSTALLATION AT L'ESTARTIT

The tide gauge radar to be installed at l'Estarit harbour is an affordable tide measuring and data transmission system, consisting on the following two main parts:

- Data Acquisition and Transmission Unit model 3000C with built-in GSM/GPRS radio-modem and GPS receiver, plus antennae.
- Water level microwave (RADAR) sensor, model WLPULS-62

The main function of the system is to measure the sea water level. However, the Data Acquisition Unit 3000C, allows the coonnection of additional hydrological, meteorological or environmental sensors, up to a total of 4.8 or 16 analog channels, plus other parameters such as precipitation and wind speed, etc., profiting other digital inputs available.
Tide data is stored in the internal memory at programmable time intervals and transmitted to a Central Station via any of the available communication ways, such as direct radio link, GSM/GPRS cellular network and via Internet or satellite.
The Central Station may interrogate any number of remote measuring tide gauge stations at any time, using the GEONICA SUITE software package installed on the Central Computer. Data can be retrieved in real or delayed time, according to the user requirements.

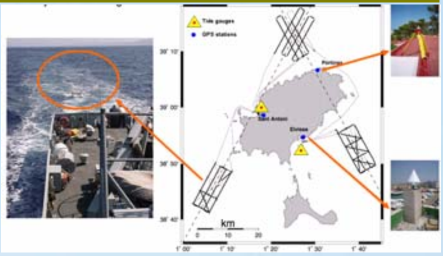
The tide gauge unit is powered by internal batteries to be recharged by an optional solar panel or by the mains 220 / 110 V – 50/60 Hz. In the case of mains failure, the internal batteries will allow the unit to still continue to work during several days, depending on the power drain conditions and sensors installed.
In order to assure a high accuracy of the internal clock, very important for tide data intercomparison, the TIDE-GAUGE tide recorder incorporates a GPS receiver for automatic clock synchronization. This allows a time accuracy in the order of 40 nanoseconds, suffering only a short but constant synchronization delay of some milliseconds.

Figure 3. Radar tide gauge devices ready to be installed at L'Estartit harbour. This modern installation will work in a parallel way to the classical floating gauge active since 1992. Details of the electronics are shown in the images above and a final deployment is presented in the image below (exemple of the installation at Villagarcia de Arosa Port; Spain). Images and deployments provided by Geonica sl, Earth Sciences.

2.- Ibiza calibration site

General deployement if Ibiza cal/val site is shown al right.

Two tide gauges are installed at the Ibiza and San Antonio harbour. Puertos del Estado (Spanish harbours) installed a new tide gauge station at Ibiza harbour between 2002 and 2003. The station belongs to the REDMAR network, composed at this moment by 21 stations distributed along the whole Spanish waters, including also the Canary islands (http://www.puertos.es).



The San Antonio tide gauge was deployed by IMEDEA institute by the beginning of 2002 in the framework of the calibration and validation activities for the ENVISAT radar altimeter RA-2.

Data from both, Ibiza and San Antonio tide gauges, have been analysed for the period with data available, in order to obtain harmonic constants and mean sea levels (Fig.4). This zone presents a very small tide and is characterized as microtidal, that is one of the reasons to select this area for the altimeter calibration and validation.

The quality of monthly mean sea levels have been checked for the whole 2003 year at Ibiza, a comparison was also made with the monthly means obtained for the Valencia station (in the Peninsula coast, in front of Ibiza. The evolution of monthly means are due to a great extent to regional meteorological conditions, so it has to be rather similar between stations not too far away. The annual mean sea level at Ibiza for the 2003 year is 327.8 mm with respect to the tide gauge zero (from a 91% of valid data, the most important gap occurring in January).

Monthly means during 2003 in Valencia, Ibiza and San Antonio tide gauge agree reasonably.

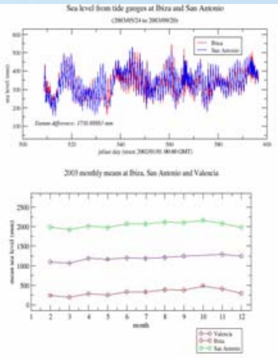


Figure 4. Monthly means during 2003 in Valencia, Ibiza and San Antonio tide gauge agree reasonably.

3.- Altimeter calibration results

3.1. Begur campaings

The GPS data have been processed with the GIPSY/OASIS-II software (JPL). In the three campaigns the GPS data processing has been split in two parts: First, positioning of the reference station at the coast near the calibration area (free-network solution) and, second, differential positioning of the buoy respect to the reference (fiducial) site off the coast (differential kinematic solution).

	Overflight (UTC time)	Cycle	SSH_{GPS} (m)	SSH_{alt} (m)	SHH_{BIAS} (cm)	Alt. product
1999	18/03 at 08:45:41	T/P 239	0.319	0.04	32.10	M-GDR TOPEX-B
			0.323	0.04	32.60	
2000	07/07 at 07:34:47	T/P 287	0.074	0.04	7.96	M-GDR TOPEX-B
2002	28/08 at 15:37:07	J 23	0.061	0.08	10.35	I-GDR Jason-1

	SWH_{GPS}(cm)	SWH_{alt}(cm)	WS(km/h)
1999 UPCB	128.0	130.0	31.0
1999 JPLB	129.0	130.0	31.0
2000	21.0	20.0	17.0
2002	27.5	28.0	10.0

Table 1. Left, SSH_{BIAS} estimation by single point experiments over point TOP-08 (Fig. 1) for TOPEX-B and over point TOP-11 for Jason-1 radar instruments. The two values in 1999 correspon to both similar GPS buoys used simultaneously at that campaign (UPCB and JPLB buoys, respectively). Right, SWH at the overflight and the in-situ wind speed.

3.2. Ibiza 2003 campaign

	Statistics of the Jason-1 Altimeter bias for passes 187 and 248 using Ibiza and San Antonio tide gauges			
	Ibiza		San Antonio	
Pass	Mean (mm)	s (mm)	Mean (mm)	s (mm)
187	169,0	33,4	119,0	23,4
248	177,0	24,5	122,0	27,4

Table 2. The statistics of this analysis are summarized. The bias found at San Antonio is very close to that found at other calibration sites notably the Corsica one where the geographically correlated errors should be comparable (orbit, sea state,..): +138 ± 7 mm at Harvest, +120 ± 7 mm at Corsica [1] and +131 ± 11 mm at Bass Strait.

However, the one derived from Ibiza tide gauge data exhibit a difference of about +50 mm. This confirms the difference of 48 mm found in the GPS sea height versus tide gauge sea level at Ibiza.

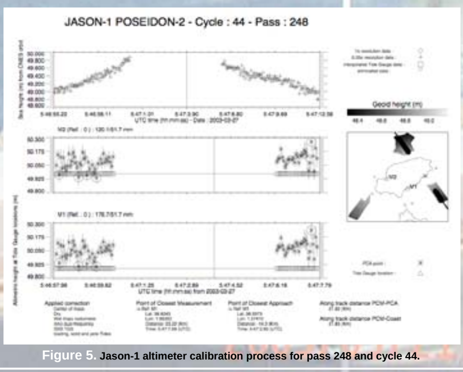


Figure 5. Jason-1 altimeter calibration process for pass 248 and cycle 44.

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