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ANALISYS AND STRATEGIES APPLIED TO THE GPS BUOYS DATA FOR THE TOPEX ALT-B ABSOLUTE CALIBRATION IN THE NW-MEDITERRANEAN

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ABSTRACT

In the last two years, several GPS buoys campaigns have been conducted in the Spanish NW-Mediterranean in order to contribute to the calibration of the TOPEX ALT-B in the region of Begur Cape (Catalonia Coast, Spain).
These campaigns fit in the frame of several experiences preparing the future JASON-1 absolute altimeter calibration (CATALA campaigns conducted in March 1999 and July 2000). In this work, the analysis of the GPS data collected and the strategies applied are presented.
The GPS buoys data processing has been carried out by using the GIPSY-OASIS II software developed at the Jet Propulsion Laboratory (Caltech, Pasadena). The positioning of the buoy at sea has been performed by using a precise differential kinematic technique relative to a in-land site. This reference station has been preciously fixed by using an small permanent network of GPS receivers.

From the estimated sea surface heigths (SSH) at the buoy during the overfligth of the altimetric satellite, the absolute calibration of the TOPEX ALT-B has been realized obtaining the BIAS of the radar altimeter (campaigns in 1999 and in 2000). In the last calibration campaign, the mapping of the mean sea surface (mss) undernearth the T/P sub-satellite track has been performed. Also the Significant Wave Height (SWH) during the oveflight have been derived from the buoys measurements and compared with the SWH measured by the radar altimeter.

FIGURE 1. The light buoy used for collecting the GPS observables in the CATALA-2000 campaign is an improved design of the original Colorado University (Boulder) prototype used in the first CATALA experience in 1999. The buoy is provided with a TRIMBLE DORNE MARGOLIN antenna connected to a receiver onto the boat. The cable connection is tied to a loose rope provided with several small ringfloats.

INTRODUCTION

The set of GPS buoy data used to estimate the SSH comes from the CATALA-2000 campaign. It has been considered to perform both the so called direct calibration (estimation of the BIAS of the radar altimeter during the overflight of the T/P onto the buoy) and the so called indirect calibration (estimation of the bias of the mss derived from all T/P cycles, respect to a considered 'truth' mean surface, which is accurately estimated from the GPS buoys mapping the area underneath the T/P track).
In this campaign the ascending ground track of the 287 T/P cycle offshore the Begur Cape coast was monitorized from 7:29 UTC to 16:57 UTC at 6th July 2000. The points nearby the T/P sub-satellite track where the mss was mapping for the indirect calibration are shown in FIG.3 and the overflight was at 7:34:47 UTC (point TOP-08 in the same figure).Apart from the GPS data collected by the buoy working at 1obs.Hz, the data from a reference site at the coast (BEGU, station placed at Begur Cape) and the data provided by the permanent GPS network belonging to the Cartografic Institute of Catalonia (ICC) were available for the period between 4th-7th July at the same sample rate (FIG.2).

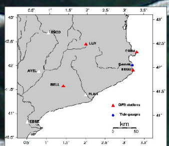

FIGURE 2. The GPS permanent network sites from the ICC used in the data processing (in full color). Also other sites of the ICC in Catalonia (empty marks).

	BEGU			BELL		
Date	E(cm)	N(cm)	V(cm)	E(cm)	N(cm)	V(cm)
4-July	0.0824	0.189	0.612	-0.0655	-0.0568	-0.1610
5-July	0.0545	-0.032	0.195	-0.0475	0.0340	-0.0591
6-July	-0.0695	0.105	0.115	-0.0471	0.0229	-0.0330
7-July	-0.0112	-0.340	-0.802	0.2230	-0.0055	0.1380
RMS(cm)	0.0606	0.202	0.326	0.1209	0.0351	0.1113
	CREU			LLIV		
Date	E(cm)	N(cm)	V(cm)	E(cm)	N(cm)	V(cm)
4-July	-0.0719	-0.0577	-0.346	0.0722	0.085	0.197
5-July	-0.0226	0.0411	-0.105	0.0344	-0.087	-0.048
6-July	0.1470	0.0092	-0.070	0.0303	-0.210	-0.096
7-July	-0.0874	0.0221	0.443	-0.1580	0.270	-0.239
RMS(cm)	0.0934	0.0374	0.288	0.0898	0.181	0.164

TABLE 1. Daily repeatibilities of the free-network solution respect to the combined four-days solution.

THE GPS REFERENCE SEITES IN-LAND

For the positioning of the buoy several in-land GPS sites have been considered (FIG.2). The GPS data from a small network consisting of three permanent ICC sites (BELL, CREU and LLIV) and the GPS station BEGU installed during the campaign, have been processed using a daily free-network strategy.
This solution provides with the accurate coordinates of the observation sites (averaged on the 24 hours), the station clock delay and also the Wet Zenith Tropospheric Delay (WZTD) of every station at 1sec rate. The accurate IGS satellite orbits every 5min. and clock delays every 30sec. have been used.

An indication of the internal consistency of the daily solutions is shown in TABLE 1, where the repeatibilities of the 24hours East-North-Vertical (ENV) coordinates for every station (time of span 4th-7th July) respect to an averaged four days network solution (combined four days solution) and also the RMS of every component have been computed.The agreement between the day-by-day solutions respect to the combined solution in all the stations is good, falling less than 2mm in the East component, less than 4mm in the North component and less than 5mm in the Vertical one, and with an RMS about 1mm, less than 2mm and 1-3mm, respectively.

THE KINEMATIC DATA ANALYSIS

A short range differential kinematic technique (DKGPS) has been used for the positioning of the GPS buoy taking as reference site the most stable-clock station in-land, BELL. No significant differences in the positioning of the buoy have been observed when using the closest site of this network respect the buoy location, BEGU, instead of BELL.
The precise IGS orbits every 5min and the WZTD of the fixed stations estimated in the step before every 1sec has been used as input.
The buoy coordinates, the WZTD and the satellite clock delays (all at 1sec rate) has been the estimated parameters.
The stations of the small network BELL, BEGU and CREU have been involved in the GPS buoy data processing, where their site coordinates has been fixed (small apriori sigma).
Following the DKGPS strategy, the SSH above the World Geodetic System 1984 reference standard ellipsoid (WGS84) has been estimated.
In FIG.4 the SSH estimated from the GPS buoys measurements at the overflight point is ploted. The ellipsoidal heights present a centimeter drift along the observation time of span (from 7:29UTC to 8UTC) and the RMS of the heights respect to their mean value for that period is also at centimeter level. The formal sigma of the estimated heights is about 4.5cm.

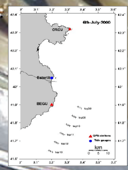

FIGURE 3. Calibration area near Begur Cape on 6th July 2000. The T/P sub-satellite track is the crossed points in the center. The adjacent points for mapping the mss on the parallel internal and external ground tracks are also ploted.

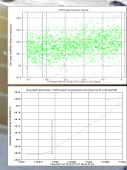

FIGURE 4. Above, the SSH estimated from the GPS buoy observables at the overflight point. Ellipsoidal heights above the standard WGS84. Below, the buoy height averaged in a 5min time window around the overflight point and a fifth order polynomial fit of the T/P heights nearby.

Campaign	Reference and software	BIAS
CATALA 1999	[GLH Kruizinga, 1999] GIPSY	5.1 +/- 6cm
CATALA 1999	[CK Shum, 1999] KARS	6.8 +/- 10cm
CATALA 1999	[M.Martinez-Garcia, 2000] GIPSY	4.7 +/- 9cm and 7.6 +/- 7cm
CATALA 2000	[M.Martinez-Garcia, 2000] GIPSY	3.7 +/- 4.9cm

TABLE 2. Estimated BIAS of the TOPEX ALT-B computed from the two campaigns.

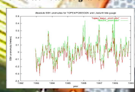

FIG.5 The agreement between the altimeter SSH anomalies along the T/P ground track and the SSH anomalies provided by the tide gauge at L'Estartit are shown for the period between 1993 and 1999. The main differences between these two anomalies in some epochs can be due to some harbor effects onto the tide gauge installation. Image provided by GLH Kruizinga.

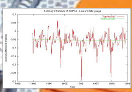

FIG.6 The two anomalies subtracted from each other. There is a systematic height difference between the sea underneath the T/P ground track and L'Estartit harbor (it is supposed the large scale ocean tides and oceanographic variability has been removed). The time serie presents an absolute drift of about 1mm/year. Image provided by GLH Kruizinga, JPL.

THE SEA SURFACE ANOMALIES

The SSH anomalies (the residual between the instanteanous sea surface and the mean sea surface) are due in this region mainly to the ocean tide more than to the inverse barometer effect (atmospheric pressure) or to the ocean surface topography variability (currents, eddies, etc). This corrections needed for the indirect calibration will be derived from a permanent tide gauge installed at L'Estartit harbor (see FIG.3). The residuals between instanteanous sea level measurements at the gauge and the long term media calculed over an eight years serie of the sea heights records (from 1992 until 2000) it is supposed to be the correction to apply to the instateanous heights estimated with GPS.

MAPPING THE MSS

The instanteanous sea level at every point of mapping in FIG.3 have been estimated. Correcting these heights with the SSH residuals computed from the tide gauge measurements the mss is obtained independently from Altimetry.

Significant Wave Height (SWH)	
TOPEX	GPS
30cm	30.1cm

TABLE 3. A comparison of both the SWH estimated from the altimeter and the SWH estimated from the instanteneous GPS around the overflight point, where SWH_GPS = 4.01 * RMS_heights.

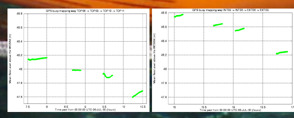

FIGURE 7. The mean sea surface mapped by the GPS buoy nearby the T/P ground track. Running averaged instantaneous SSH corrected by the dynamic effects at every point of FIG.3.

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Further information, publications and data about the CATALA Experiences at the address *http://www-fa.upc.es/catala.html*