FOAM: FROM OCEAN TO INLAND WATERS ALTIMETRY MONITORING

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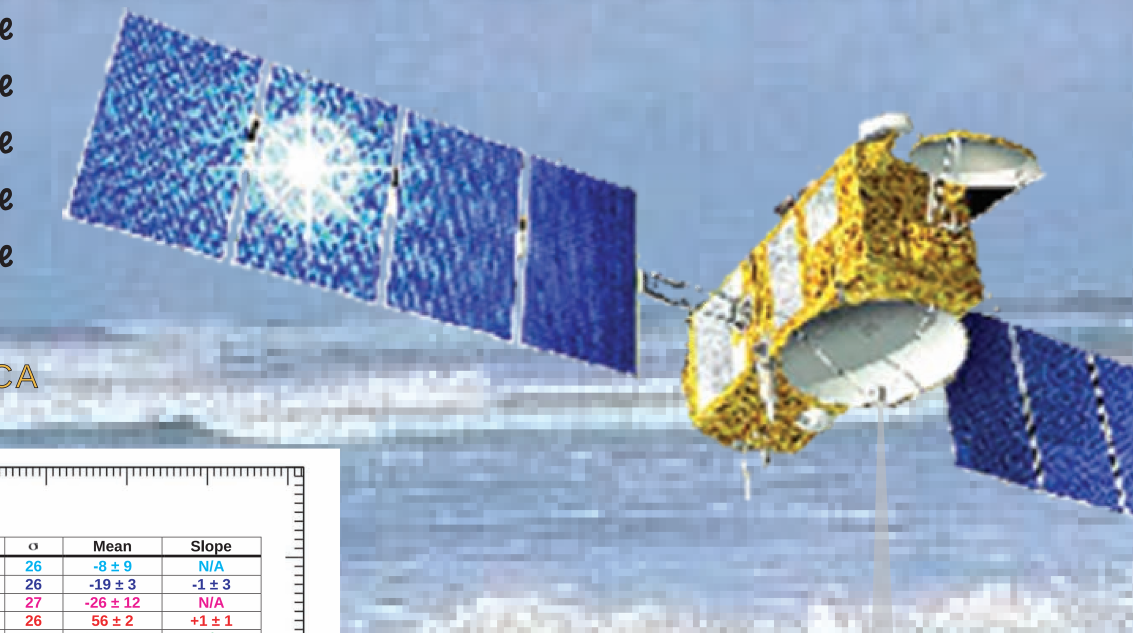
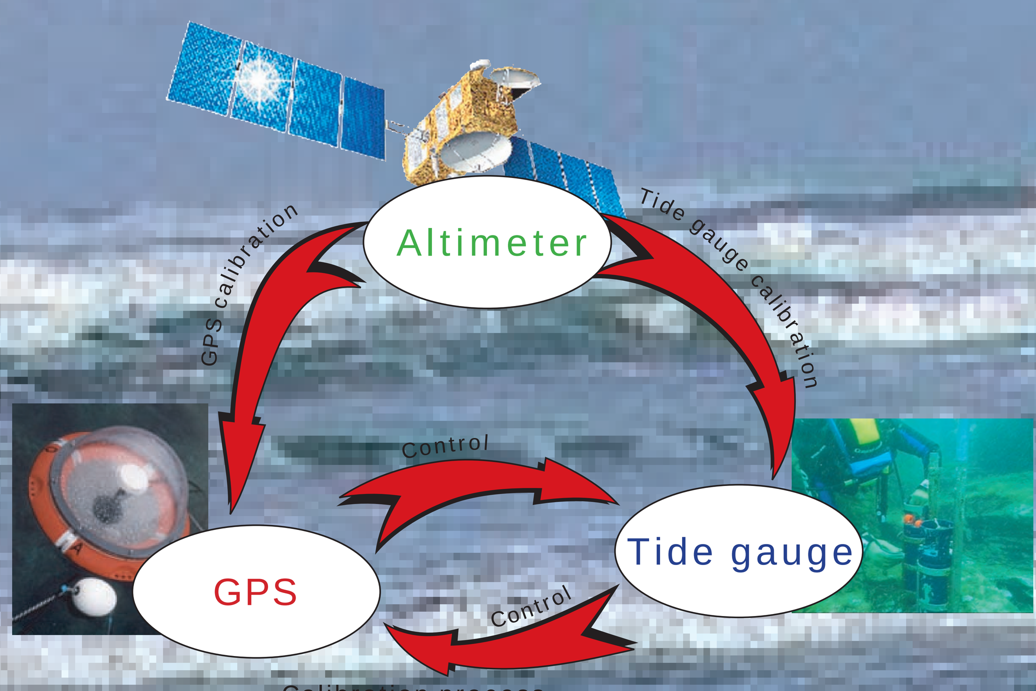


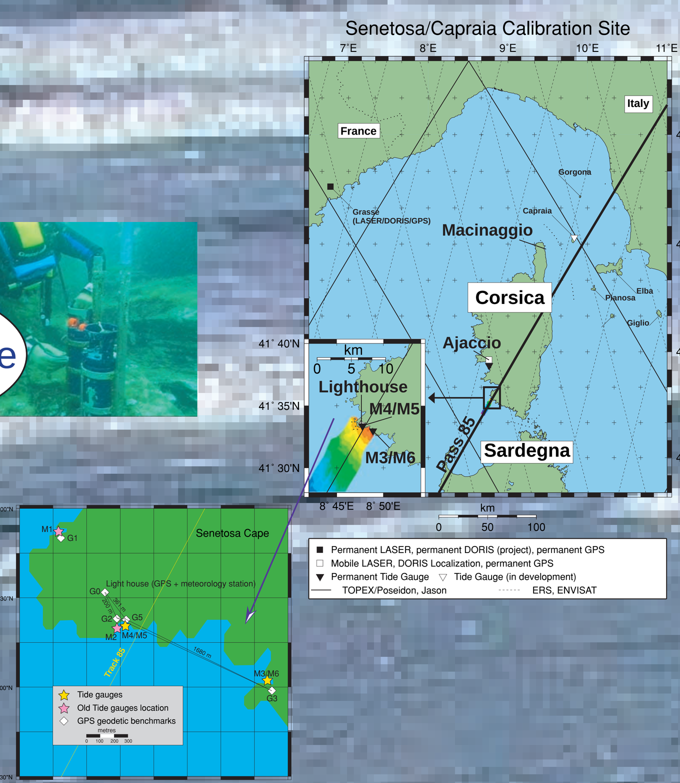


Calibration process

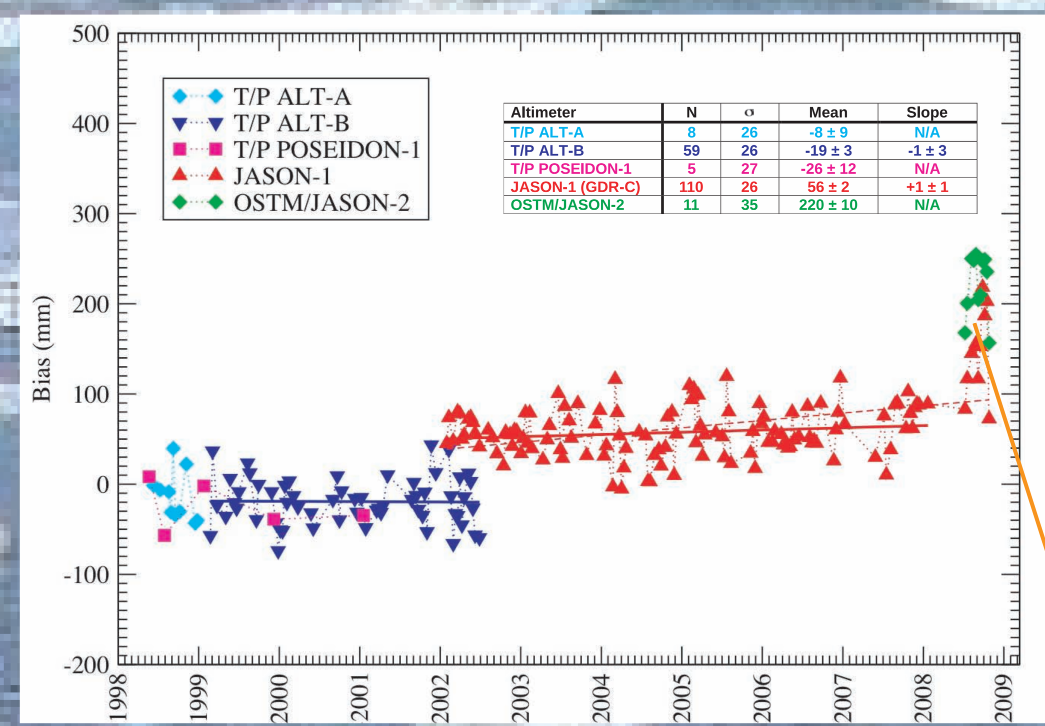
The calibration principle is to compute the difference between the sea surface height (ssh) measured with the altimeter and the ssh recorded by the tide gauge. These two ssh are located at two distant points. The link between the two ssh is partly the geoid slope from offshore altimetric measurement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

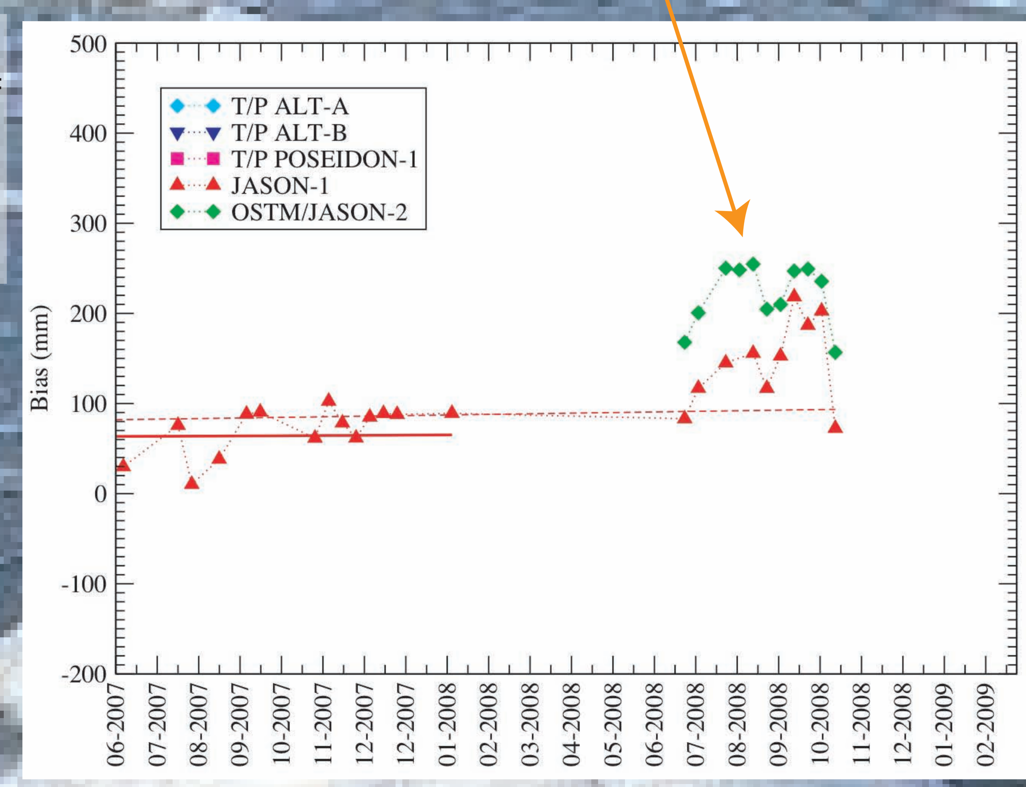


ABSOLUTE CALIBRATION IN CORSICA



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 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 bias for which we have at this stage no explanation… See poster #49 for more details on this anomaly :
Session I-a: Local and global calibration/validation (mostly in situ)
ABSOLUTE CALIBRATION OF TOPEX/POSEIDON, JASON-1 AND JASON-2 ALTIMETERS IN CORSICA
BONNEFOND Pascal et al. Observatoire de la Côte d'Azur FRANCE



In collaboration with the CNES and NASA oceanographic projects (T/P and JASON-1), the OCA developed a verification site in Corsica snce 1995 CALibration/VALidation embraces a wide variety of activities, ranging from the interpretation of information from internal-calibration modes of the sensors to validation of the fully corrected sea-level estimates using in situ data. Now, Corsica is, like the Harvest platform (NASA side), an operating calibration sites able to support a continuous monitoring with a high level of accuracy: a 'point calibration' which yields instantaneous bias estimates with a 10-day repeatability of around 30 mm (standard deviation) and mean errors of 3-4 mm (standard error).

In-situ calibration of altimeter sea surface height (SSH) is usually done at the vertical of a dedicated CAL/VAL site, by directly comparing altimetric data with in-situ sea level data. This configuration leads to handle the differences compare to the altimetric measurement system at the global scale: the Geographically Correlated Errors at regional (orbit, sea state bias, …) and local scales (geodetic systematic errors, land contamination for the instruments, e.g. the radiometer). We thus intend to include other existing sites (Vanuatu, Kerguelen, …) where the conditions are somewhat different from the Mediterranean sea and where instruments and infrastructures already exist.

In order to increase statistically the sea surface bias estimation but also to cover larger areas, we suggest to extend the calibration opportunities by using, not only over-flying passes, but also satellite passes located far away from the CAL/VAL site (few hundreds kilometers). This CAL/VAL method has been developed since 2003 and validated on the Corsica tide gauges network dedicated to Jason-1 CAL/VAL activities. In such a case, two main effects interfere in the SSH bias determination, the geoid slope and the ocean dynamics. In order to correct from the geoid slope, distant SSH altimetric data are propagated along a succession of known mean sea level profiles up to the in-situ reference site. The ocean dynamics differential effect can increase with the distance from the CAL/VAL site. It is corrected by using an ocean numerical model (T-UGOm).

Due to the increasing need of altimetry to monitor inland waters and in preparation to future missions (e.g., AltiKa, SWOT) we propose to integrate the calibration activities on the oceanic domain with those on different water bodies such as rivers and lakes. CAL/VAL activities on rivers and lakes enable to avoid the contributions of the SSB and liquid tides in the range calibration and to address other problems such as the performance of the various tracking/retracking algorithms and more globally assess the quality of the geophysical corrections. The proposed CAL/VAL activities are thus focused not only on the important continuity between past, present and future missions but also on the reliability between offshore, coastal and inland altimetric measurement. Purpose is to aggregate the past effort of several groups, in order to notably establish a homogeneous network of calibration site geographically distributed for more robust characterization of the existing and future radar altimeter system instrument biases and their drift.

KERGUELEN CALIBRATION EXPERIMENT

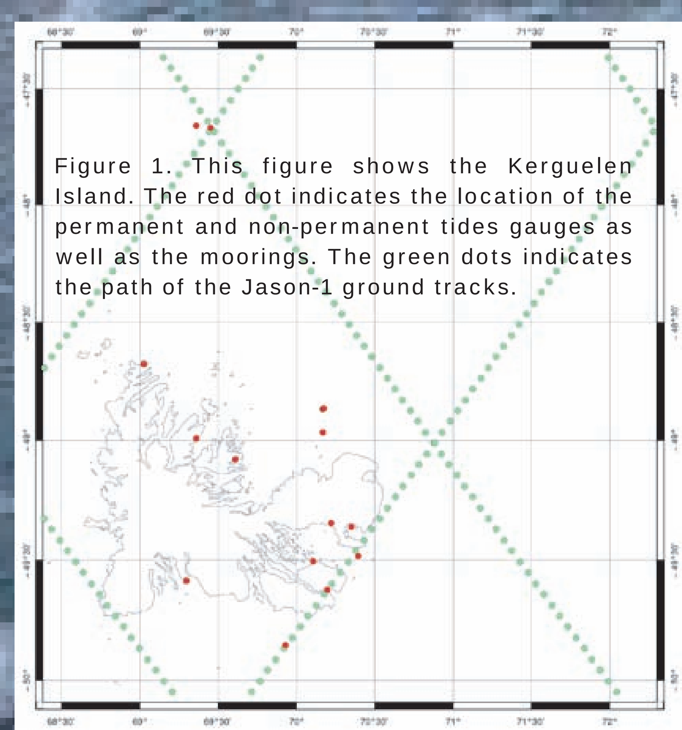


Figure 1. This figure shows the Kerguelen Island. The red dot indicates the location of the permanent and non-permanent tides gauges as well as the moorings. The green dots indicates the path of the Jason-1 ground tracks.

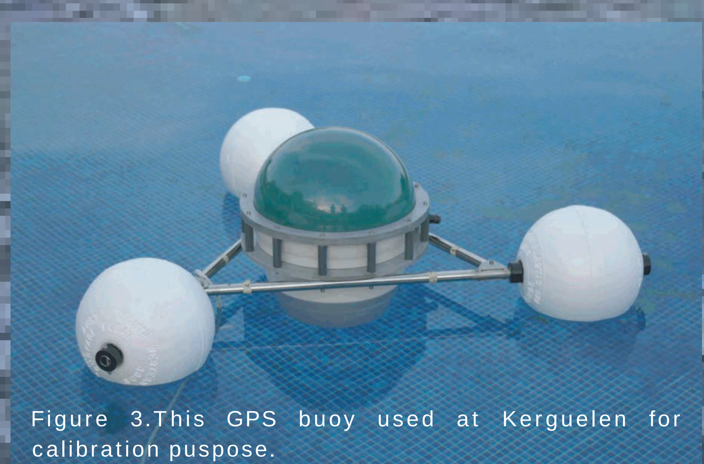


Figure 3.This GPS buoy used at Kerguelen for calibration puspose.

The LEGOS is in charge for many years now of the Observation Service ROSAME tide gauges network (Réseau d'Observation Antarctique et Sub-antarctique du niveau de la MEr: http://www.legos.obs-mip.fr/observations/rosame/). This network is composed of four permanent tide gauges located on islands in the southern part of the Indian Ocean in Kerguelen, Crozet and Saint-Paul and in Dumont d'Urville in Antarctica and are included in the GLOSS Global Sea Level Observing System. The Kerguelen tide gauge, fully operational since 1993, transmits its data in real time.

The tide gauge site is less than about 25 km from the nearest Jason ground track 179 (Figure 1).
The Kerguelen Island has an IGS (International GPS Service) permanent GPS station, 3 km away from the tide gauge at the CNES station, as well as a DORIS beacon and a permanent meteorological station. A semi-permanent GPS was installed in 2003 50 m away from the tide gauge location. It was operating for few months. GPS buoy sessions were in 2007 and 2008 in order to calibrate the tide gauge and to tie it to a global reference frame.

We have installed a mooring at the entrance of the bay of Kerguelen directly under a Jason-1 track and plan to intall a new one in november 2008 more in the south of the Island in order to estimate the difference of oceanographic behavior between Port-aux-Français, the entrance of the bay and the open sea. This mooring will also be used to improve the local barotropic model.

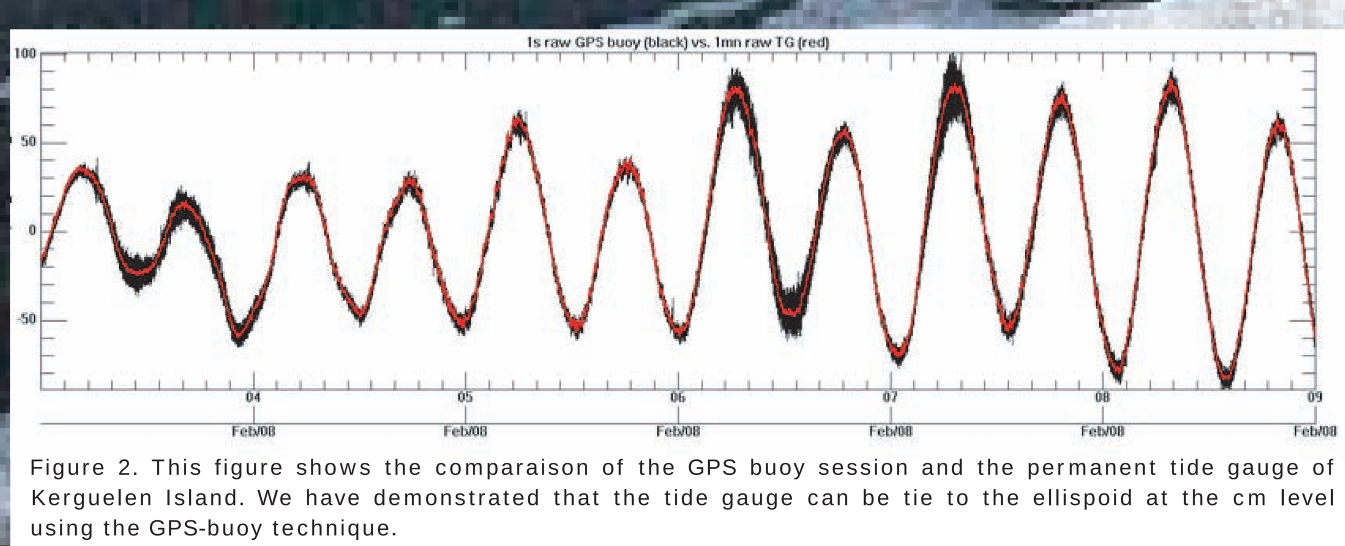
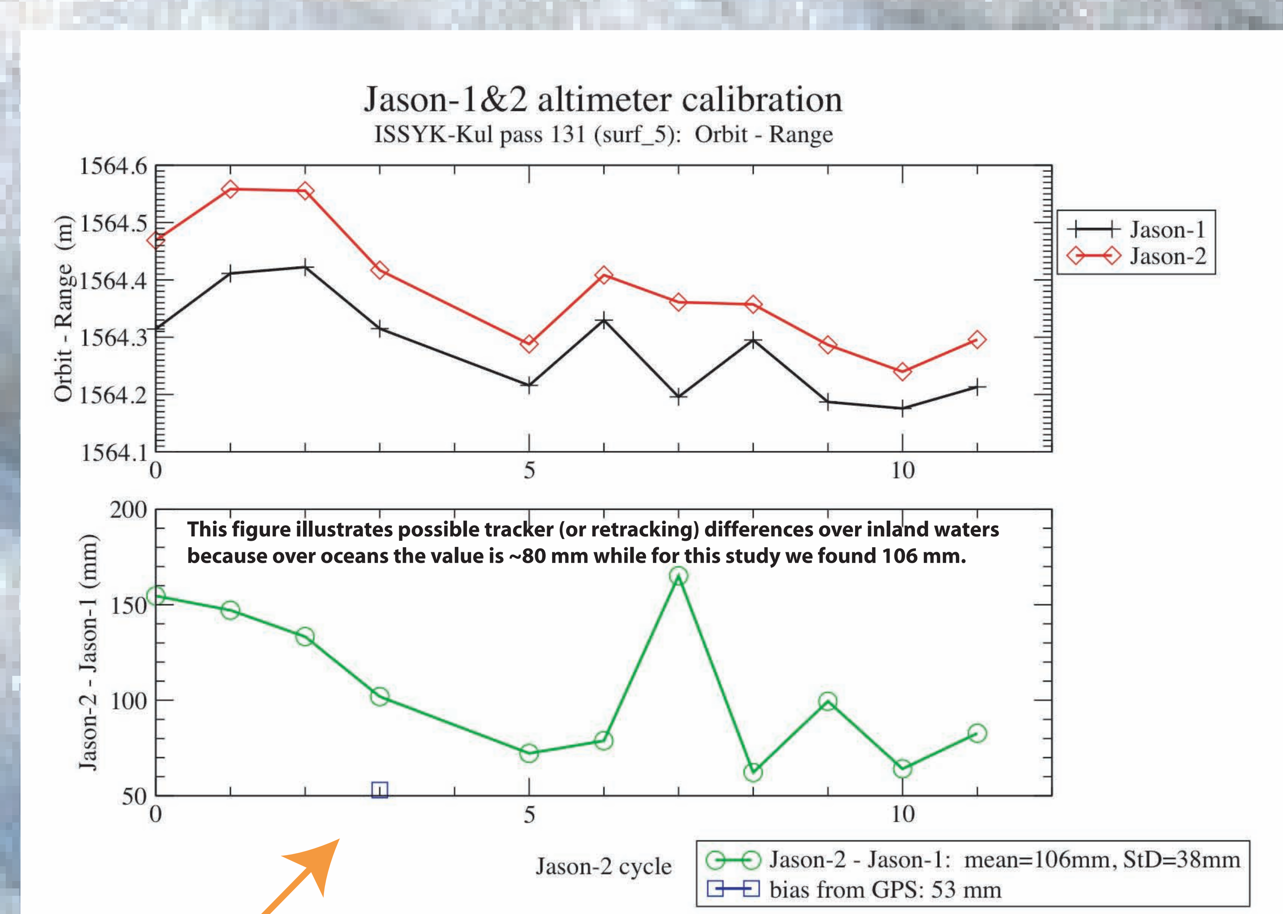


Figure 2. This figure shows the comparaison of the GPS buoy session and the permanent tide gauge of Kerguelen Island. We have demonstrated that the tide gauge can be tie to the ellipsoid at the cm level using the GPS-buoy technique.

CALIBRATION FROM DISTANT CAL/VAL SITES:
multi-missions biases using the OST-ST calibration site in Senetosa

Part detailed in the poster:
102 Session II-a: Local and global calibration/validation (mostly global)
CONSISTENCY BETWEEN JASON-2/JASON-1 DATA AND 2008 IMPROVEMENT ON THE CALVAL PROCESSING SOFTWARE
JAN Gwenaële et al., Noveltis, FRANCE



VANUATU ABSOLUTE CALIBRATION EXPERIMENT

Vanuatu archipelago is located 500 km northeast of New Caledonia. Installation of equipment dedicated to satellite calibration started in late 1999 with the mooring of a pair of pressure gauges on topographic highs at ~11m depth. The main gauge is fixed on the Wusi bank at a multi-mission crossover point, on the west coast of Santo Island [*Calmant et al*., 2004]. It is at about 3 km away from the center of the T/P/Jason footprints at closest approach (Figure 4). Noteworthy, T/P footprint of the shifted orbit was approaching the gauge even closer, and a GFO track runs about 2.5 km East of the gauge. It is thus a place where inter-mission calibration is enabled with limited (< 3 km) spatial interpolation. In particular, if Jason-1 is placed after the validation period of Jason-2 on the same shifted orbit as T/P was, the Wusi site will offer a good opportunity for a continuous tracking of the altimetry series. In addition, detailed bathymetric data as well as shipboard kinematic GPS measurements of the sea surface height [*Bouin et al*., in prep.], have been collected during the last two cruises in 2005 and 2006. These data will be used to compute the very short wavelengths (< 0.5 km) of the local geoid, parameter that is required for an analysis of the range noise at high sampling rates, e.g. 20 Hz. Besides, we plan to compute a global geoid in the area by combining for example a GRACE solution as a long-wavelength reference, mean altimetric profiles for intermediate wavelengths and the component computed from bathymetry and kinematic GPS for the shortest wavelengths.
The gauge equipment has been completed by the installation of a permanent GPS and meteorology station in 2002 at the Wusi village. The vertical component of this site motion has been finely computed in the frame of N. Bergeot's thesis (2007). However, the GPS equipment at Wusi underwent many failures and has to be replaced (replacement planned in October 2007). This station has been tied to the benchmark that is regularly surveyed since 1997 during 3-days campaigns. In this area, plate tectonic is extremely active and vertical deformation may vary significantly over short distances. Thus, in order to insure that the vertical motion recorded by the GPS is actually the same than the one undergone by the gauge, we plan to install a third gauge at the foot of the GPS station in October 2007.
The second gauge has been immerged on the Sabine Bank, in the vicinity of an EnviSat crossover point that permits a calibration with twice as much measurements (Figure 5). Noteworthy, EnviSat orbit has a spread of more than 1 km on both sides of its mean. Thus, some measurements approach the gauge very closely.

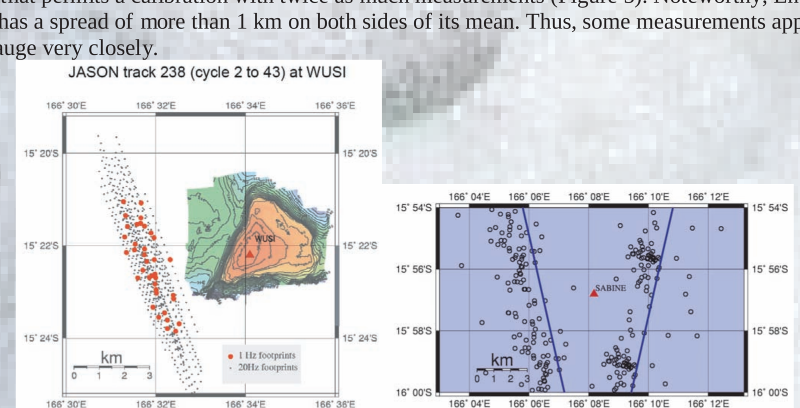
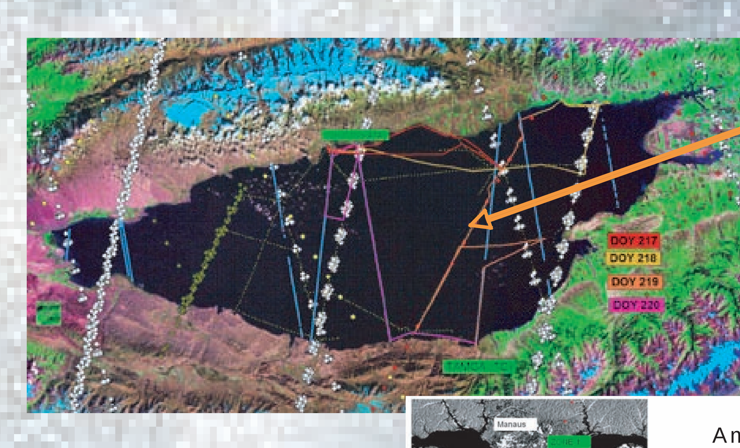


Figure 4. Left: Jason-1 footprints at closest approach to the Wusi gauge (marked by a star). Right: same for EnviSat, close to Sabine.

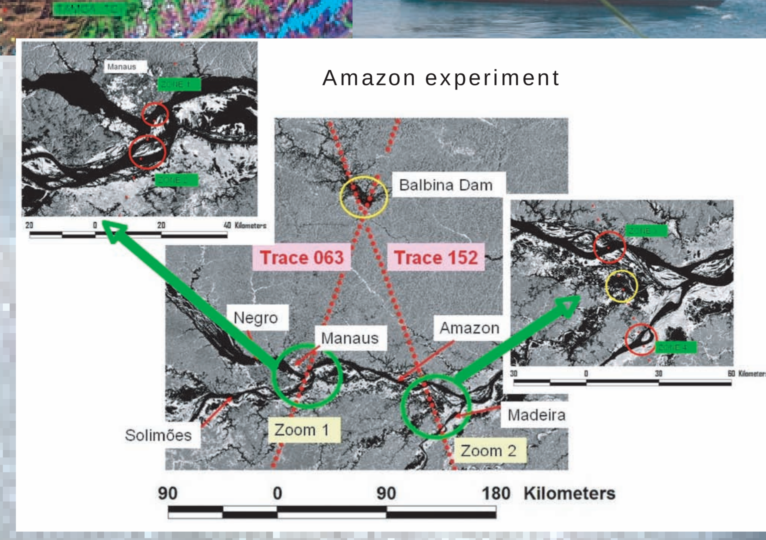
A total of three GPS buoy experiments have already been conducted in this area during cruises conducted by IRD to service the tide gauges. The first one was only a feasibility test and is not of interest for altimetry calibration. For the other two, two floating devices were considered: a buoy floating for hours over the gauges and the vessel itself. In October 2007, we will again service the two tide gauges and collected kinematic GPS data over the tide gauges. Special care will be given to the Wusi site which offers a short enough GPS baseline to give suitable accuracy on the vertical

CALIBRATION OVER INLAND WATERS



Lake Issyk-kul
Jason pass 131

CAL/VAL activities on rivers and lakes enable to **avoid the contributions of the Sea Surface Bias (SSB)** and liquid tides in the range calibration and to **address other problems** such as the performance of the various **tracking/retracking algorithms** and more globally assess the quality of the geophysical corrections.



More and more scientific studies are using satellite altimetry to monitor inland waters and the number and quality of data should be increased taking the advantage of the Diode adaptative tracker on-board Jason-2/OSTM. However, same as for ocean studies, linking time series from different mission require to accurately monitoring the biases and drifts for each parameter contributing to the final estimate of the reflector height. The objective of this study is to perform the absolute calibration over selected lakes and rivers: it should allow identifying and quantifying the main sources of differences between measurements over ocean and inland waters and then better characterizing the altimeter bias (or biases given that several estimates of the range are expected for these missions). Indeed, same as over oceans but much more pronounced. For example, the tracking/retracking algorithms affect the range measurement and the corrections behavior is different (radiometer measurements over land, lack of SSB, tides, …). On another hand calibration over lakes surface for example present several interesting characteristic in a frame of CAL/VAL activities: waves are generally low, ocean tides are absent, and to summarize, dynamic variability is much smaller than in the oceanic domain. Thus, the calibration activity over inland waters will be two-fold: perform calibration for parameters interesting directly the computation of inland water heights and also analysis of parameters of use only over ocean waters but also available over inland waters. As far as the first axis is concerned, we will focus on the following parameters: tracker bias for different trackers (at least the Jason and EnviSat trackers), and atmospheric corrections. The second axis mostly concerns the auxiliary parameters derived from the waveform analysis such as SSB (which can partly corrupt the range estimates as shown by *Sandwell et al*. (2005).
CAL/VAL of radar altimetry over rivers is at its infancy. Some studies have been conducted by comparing radar series of water stage with in situ series in a close vicinity [*Frappart et al*., 2006] (see also examples in ESA's R&L website http://earth.esa.int/riverandlake/description.htm) but up to now, no site has been dedicated to the calibration of altimetry in this peculiar context. We propose to install such sites in the Amazon basin where we have long-term expertise of fieldwork and local collaborations that insure availability of in-situ measurements.