Presentation of the 2002 Corsica FTLRS Campaign for the Jason-1 CAL/VAL Experiment

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Abstract

The French Transportable Laser Ranging System (FTLRS) was set up in Corsica from January to September 2002. It was the first campaign outside the Grasse Observatory with the FTLRS in its new configuration. The aim of this campaign was to contribute to the orbit validation and to the altimeter calibration experiment (CAL/VAL) of the Jason-1 mission, at the centimeter level, in tandem with the TOPEX/Poseidon mission. The mobile station supported the Precise Orbit Determination and geodetic reference operations. The station also participated in a similar experiment for the Envisat mission, and finally contribute to tracking additional geodetic satellites following the ILRS recommendations. Herein, we present the FTLRS observations obtained during this period, which indicate excellent system performance both in terms of data yield and in observation precision levels. This campaign was also very instructive for the next one scheduled in Crete (Gavdos European project) in 2003.

Introduction

The OCA-CERGA has been involved for many years in oceanographic satellite missions such as TOPEX/Poseidon (T/P) and ERS-1/2, and in particular for altimeter calibration and orbit validation (CAL/VAL experiments). These studies monitor, at the same time and with a high accuracy level, the vertical reference frame, the geoid, and the sea level observed by the radar altimeter and tide gauges deployed at a dedicated site. The aim of a CAL/VAL field campaign is to decorrelate the possible drift of the altimeter instruments and of the associated devices (e.g., water vapor radiometer) from the long-term variability of the mean sea level, at least at a level of 1 mm/year. Now, the Jason-1 altimeter calibration requires a local accuracy better than 1 cm [*Ménard et al.*, 2001].

CAL/VAL experiments require a number of dedicated sites very close to a ground track of the altimetry satellite(s), where geodetic equipment are deployed during the overall mission(s) and, if possible, on a long term basis, that is to say ten years or more (e.g., the Harvest platform in California, USA). In collaboration with the Centre National d'Etudes Spatiales (CNES), the OCA-CERGA has developed a calibration site in Corsica since 1996, where it has been possible (i) to reduce costs and manpower, (ii) to easily transport and install equipment, and finally (iii) to regularly renew campaigns. A first campaign was performed with the FTLRS between November 1996 and February 1997 [*Nicolas et al.*, 1998]. Herein it was shown that this site is extremely well-suited for CAL/VAL experiments on oceanographic satellites.

The French Transportable Laser Ranging System (FTLRS) was developed by the OCA and the CNES in collaboration with the Institut National des Sciences de l'Univers (INSU) and the Institut Géographique National (IGN) [*Nicolas et al.*, 2000]. The capabilities of this laser ranging system have been greatly enhanced between 1997 and 2001 to meet the 1 cm accuracy level required by the new altimetry missions such as Jason-1 and Envisat. The new performance of the FTLRS has been measured firstly via laboratory internal experiments and ground target measurements [*Nicolas et al.*, 2001], and secondly via an external collocation experiment involving three independent laser ranging systems [*Nicolas et al.*, 2002]. As a result of these improvements, the FTLRS successfully demonstrated its new LAGEOS-1 and -2 tracking capability. Notably, these experiments have permitted the

determination of a bias of about 5 mm for the FTLRS relative to the OCA fixed SLR station (7835), and a bias of a few millimeters relatively to the Graz (7839) and to the Herstmonceux (7840) laser systems.

Herein, we present the experiment configuration and the observations obtained with the FTLRS during the Jason-1 validation phase between January and September 2002.

Experiment Site Presentation

The prime CNES CAL/VAL sites are located on the island of Corsica. The Corsica experiment is located at two separated sites: Aspretto near Ajaccio, and Senetosa which is about 40 km south of Ajaccio.

The first reference point, located at the Aspretto Marine and Air base, has been equipped since 1999 with a permanent GPS receiver and with a digital coastal tide gauge which were set up by the IGN and by the SHOM (the French Navy's hydrography and oceanography department), respectively. The FTLRS laser system (see Figure 1) has been located here from 13 January to 8 September 2002 for the validation phase of the Jason-1 mission. There is a Jason-1 and T/P ground track within 25 km of this site, and also an Envisat and ERS-2 ground track located 5 km to the east (see Figure 2). Moreover, this site allows inter-comparison with the regional European laser network that is concurrently supporting altimetry calibration and validation experiments. Finally, the site has logistical advantages in that it is easy to reach for the Grasse SLR team and good cooperation exists with the marine authorities. Since 1996, we have shown that the acquisition of quasi-zenithal laser ranging measurements has allowed a potential reduction of the radial orbit error to about 1 cm, and even less locally, using a geometric laser-based short-arc adjustment technique [*Bonnefond et al.*, 1995].

The second reference point, located at the Senetosa Cape, constitutes the primary sub-satellite experiment site since a Jason-1 and T/P ground track (number 85) reaches landfall at this location. This site is equipped with three permanent tide gauges since 1998 and accompanying GPS markers have been regularly surveyed. In parallel to the continuous tide gauge measurements, a GPS buoy is deployed every ten days at about 10 km from the coast, and is participating in the calibration experiment.

Figure 1. The FTLRS at Ajaccio (2002).

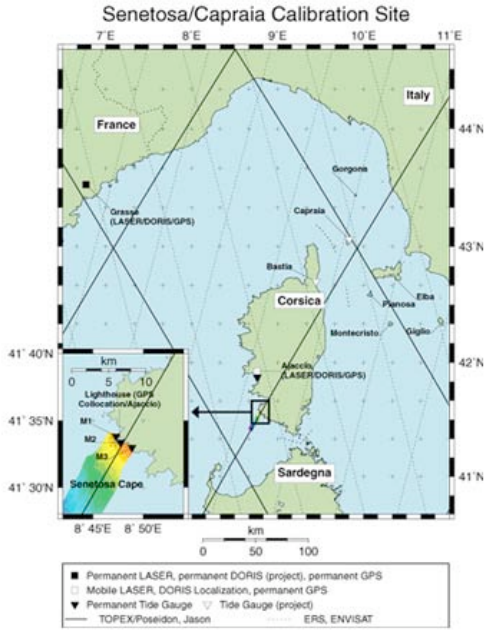

Figure 2. Configuration of the Corsica CAL/VAL sites.

The local ties between all reference points of the different instruments were surveyed by the OCA-CERGA, the CNES, the IGN for Senetosa, and the IGN for Aspretto.

In practice, the FTLRS was set up and tuned within three days. The first observations were acquired on 13 January 2002. The configuration around the FTLRS observation site is shown in Figure 3. The laser system and the electronic devices are set up under a folding tent (in case of rain). The observational point with the tracking screens and the computers are set up in a mobile home. The meteorological station with the GPS antenna (for the GPS steered rubidium oscillator) at its top, is a few meters away from the tent. Figure 3 also shows the permanent GPS receiver and the support location for a DORIS beacon. The ground calibration target used for the SLR system is located about 300 m northwards of the site, at the top of a post. The FTLRS is also connected to the Grasse fixed station via Internet to obtain satellite orbit predictions and information from the Eurolas network, and to send data for distribution.

FTLRS Observations

The campaign was divided into two parts. During the first part, between January and June, we performed a permanent occupation with continuous observations, whereas during the summer there were only observations during a period of two or three days around each Jason-1-T/P 10-day calibration pass. In September, a campaign was planned to increase the number of LAGEOS passes, but we had to stop operation because of both technical and financial problems.

The Corsica campaign observational balance sheet is quite satisfactory and very positive. Figure 4 summarizes, month by month and for each satellite, the number of passes observed by the FTLRS during the whole campaign. Overall, 1,650 passes were acquired by the FTLRS, with 1,563 on the low satellites and 87 passes of LAGEOS-1 and -2. Let us recall, however, that these later passes represent only 45% of the ILRS standards for a fixed laser system during the same time duration.

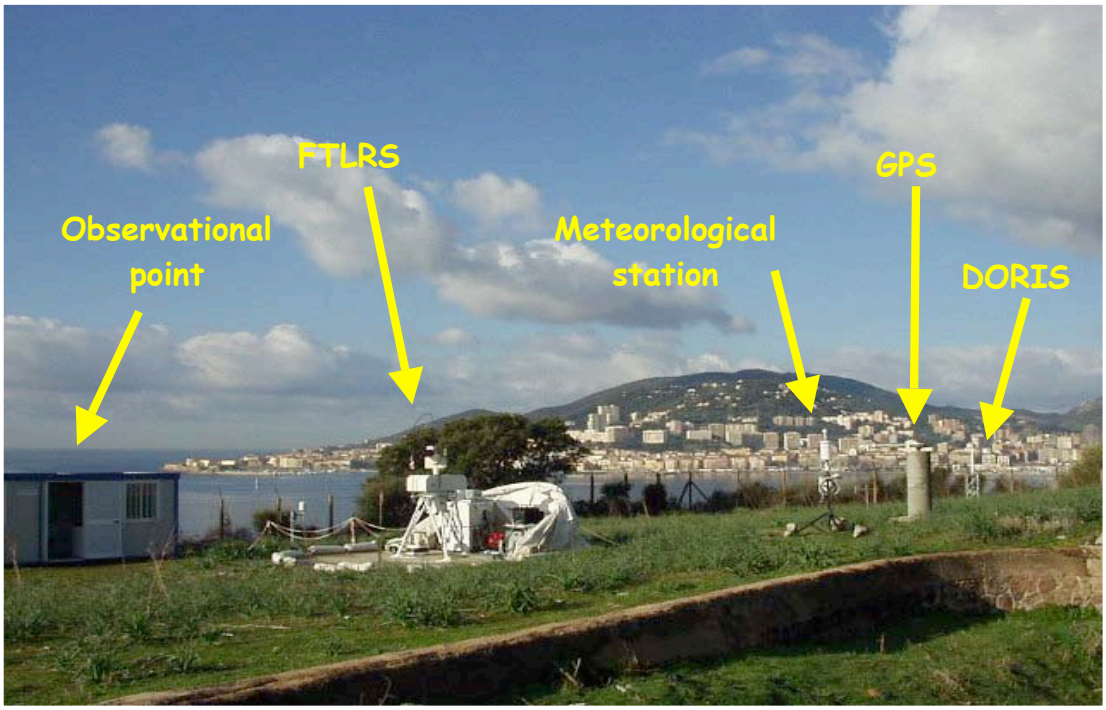

Figure 3. Ajaccio site configuration around the FTLRS. The tide gauge is not shown because it is placed in the harbour at a few 100 m from this site.

During the entire campaign, 467 passes were observed in tandem with the Grasse SLR fixed system. Indeed, a special effort was made during this campaign to obtain the maximum of common observed passes between the FTLRS and the Grasse fixed station. Table 1 indicates the possible calibration passes and whether they were observed simultaneously by both the FTLRS at Ajaccio and the OCA fixed SLR system at Grasse. The 1-σ rms of the normal points are at the few millimeters level as expected from our previous validations (internal and external). For instance, the mean single shot 1-σ rms is 8 mm for Jason-1 and the ERS satellites, and 16 mm for the LAGEOS-1 and -2 satellites. The mean normal point scattering is 3 mm for Jason-1 and 6 mm for LAGEOS. Figure 5 gives the distribution of the Jason-1 observations above the FTLRS Corsica site during the entire period.

The number of passes on all the satellites is quite satisfactory in spite of many cloudy days and of the marine haze during the campaign. For more than 65% of the time, more than five passes were observed per day. The case of no observation occurred only for 12% of the campaign duration, mostly due to meteorological reasons. The mean number of passes per day during the entire Corsica campaign is about ten. There were no instrumental stops for more than two consecutive days, which is also an important result. During this campaign a special effort was realized to observe the oceanographic satellites Jason-1 and T/P simultaneously from Ajaccio and from Grasse. Technological developments were also performed to add the capability of tracking Jason-1 and T/P, during the same pass with a switch time of a few seconds. The instrumental stability of the ground calibration during the whole period was quite good and was estimated at about 3-4 mm over six months.

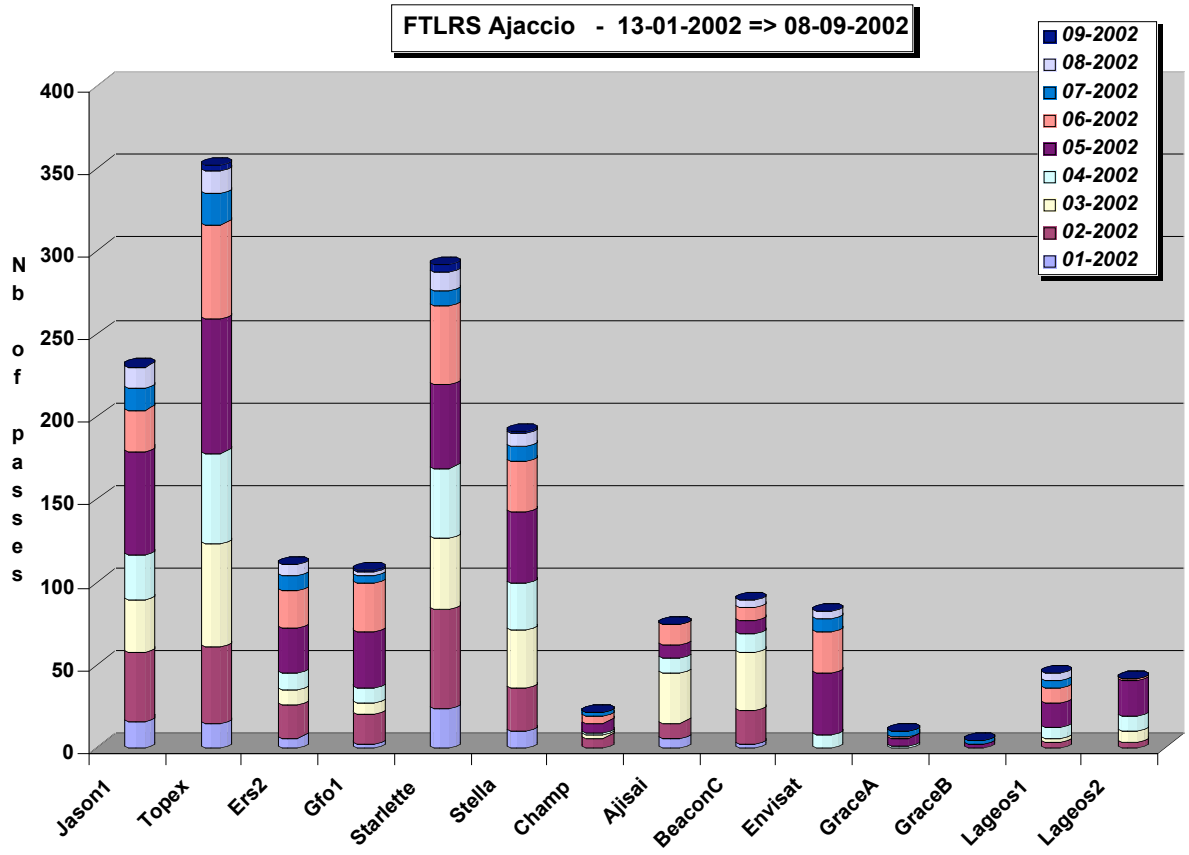

Figure 4. Number of satellite passes observed with the FTLRS in Corsica (Jan. - Sep. 2002).

Concerning the Jason-1 calibration passes (ground track number 85), the number of successful observations is also quite satisfactory with about twice the number of passes acquired than were expected before the campaign.

Indeed, about 60% of these calibration passes were successfully observed. In fact, all the passes that could be observed were indeed observed thanks to the very conscientious work of all observers. The data analyses for the altimeter calibration and for the orbit validation are still in process, with very encouraging first results.

Table 1. The Jason-1 (J) and TOPEX/Poseidon (T) calibration passes observed by the FTLRS at Ajaccio and by the Grasse fixed SLR system.

Date	Ajaccio	Grasse
18/01	J	J + T
28/01	*no returns*	J
07/02	J	J + T
17/02	J + T	J + T
27/02	J	*weather*
09/03	*Weather*	J
19/03	*Weather*	J
28/03	J	J
07/04	J	*weather*
17/04	J + T	J + T
27/04	J + T	J + T
07/05	*Weather*	*weather*
17/05	J + T	J
27/05	*Weather*	*weather*
06/06	*Weather*	*weather*
16/06	J + T	J+T
26/06	*Weather*	J+T
06/07	J + T	J+T
16/07	J + T	*no returns*
25/07	T	J+T
04/08	J + T	J+T
14/08	J + T	J+T
24/08	J	J
03/09	T	*weather*

Concerning the LAGEOS passes, we should make the following remarks. The FTLRS has the new LAGEOS tracking capability, but it still remains difficult, mainly because of the small link budget due to the small telescope diameter (13 cm). Logically, this would imply an increase of the laser energy. On the other hand, this can induce some problems such as the breakdown of flash lamps or of Nd:YAG bars. Moreover, it is difficult to get returns of the LAGEOS satellites at elevations lower than 40°, even when the weather is very clear. Thus, given the importance of tracking such a geodetic target, some ideas have been discussed with CNES, OCA, and IGN (the FTLRS partners) in order to plan the development of a new telescope with a 25 cm diameter for the same laser ranging system.

Finally, this campaign also allowed us to detect some small problems which are to be solved before the next campaign such as a wind protection for the tracking mount and better thermal stabilization of the different components during the summer (the FTLRS instrumentation is continually outside under the sun or under the tent).

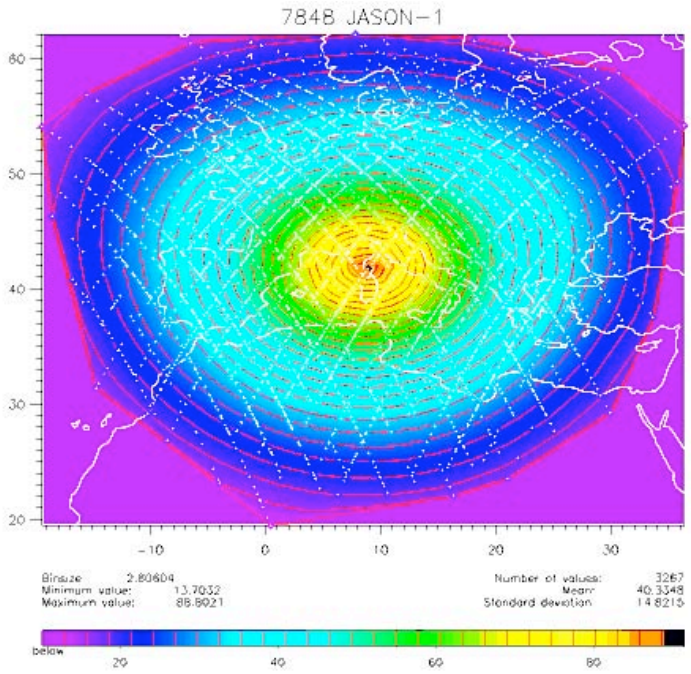

Figure 5: Geographical distribution of the FTLRS Jason-1 observations in Corsica during the entire period (January to September 2002).

Conclusion and Prospects

The Jason-1 CAL/VAL campaign, made in Corsica from January to September 2002, indicates that the FTLRS has demonstrated successful performance. The data yield and their geographical distribution are quite satisfactory. Many spacecraft, including the oceanographic satellites (TOPEX and Jason) and LAGEOS-1 and -2, were successfully tracked, even though more LAGEOS observations would be valuable to satisfy ILRS requirements. The normal point 1- rms is a few millimeters.

The SLR data analysis is still in progress and the first results are quite encouraging. These preliminary results confirm the accuracy of the FTLRS in its new configuration, with the 1 cm level reached for the orbit validation. This experiment was a new step for the FTLRS and provided insight into ways of improving future field campaigns. Future campaigns are already planned, such as the next one in Crete for the Gavdos European project [*Mertikas et al*., 2002] for a new CAL/VAL experiment, with an FTLRS contribution beginning in March 2003.

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