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## **FTLRS Ajaccio campaigns : operations and positioning analysis over 2002/2005**

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### **Abstract**

*In the framework of JASON-1 project especially for Cal/Val aspects, Ftlrs has been deployed in Ajaccio for a six months campaign in 2005.*

*In the continuation of previous operations on the same site in 2002 the observations programs were carefully tuned to be pertinent on both aspects of scientific goals with new tools to optimize sky coverage for the data and technological issues like maintenance and operational costs.*

*In this paper, we'll present reports and results concerning station positioning with a very interesting combination of LAGEOS -1, -2, STELLA, and STARLETTE observations and comparison over 2002 and 2005 campaigns. An estimation of final accuracy will be discussed in such experiments of multi occupation site and operational issues will be commented.*

### **1. Introduction and Operational issues for Corsica campaigns**

*The Ajaccio site is the main calibration site of the satellite altimeters in the Mediterranean area*



*Typical setup of the station (Corsica 2002 and 2005 )*

The SLR technique is the major contributor to the altimeter calibration: SLR data of the whole network are used to derive ultra precise orbit of altimeter satellites (in combination with DORIS and GPS data) and FTLRS conducts comparative laser distance measurements between the facility and satellite radar altimeters.

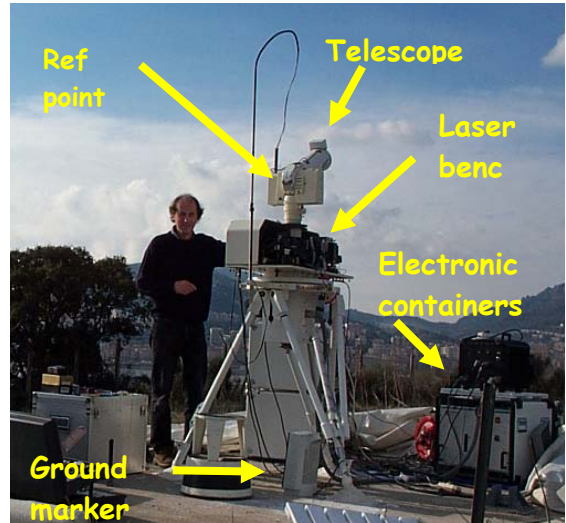
The objectives are the following :

- Absolute Sea level monitoring, altimeter calibration and orbit validation (CAL/VAL) of the Topex/Poseidon, Jason-1 and Envisat satellites from the Ajaccio site (Corsica-France)
- Estimation of the satellite altimeters biases and drifts

- Need for carrying out accurate SLR positioning from geodetic satellites observations

The FTLRS is a highly mobile Satellite Laser Ranging (SLR) system dedicated to the tracking of geodetic satellites equipped with retroreflectors. This instrument was developed by the Observatoire de la Côte d'Azur (OCA) and the Centre National d'Etudes Spatiales (CNES) in collaboration with the Institut National des Sciences de l'Univers (INSU) and the Institut Géographique National (IGN)

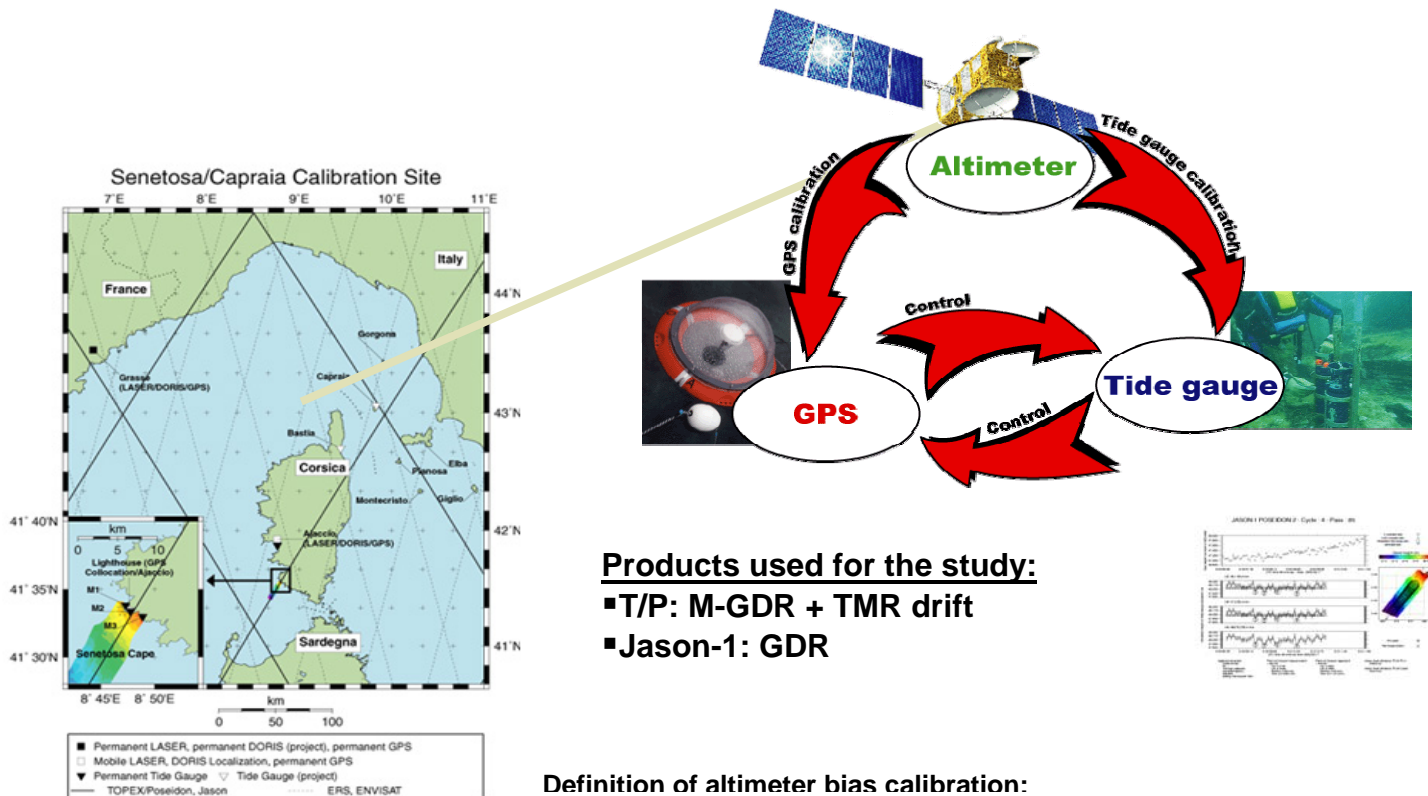
For these campaigns, Ftlrs system is deployed inside a French naval base near Ajaccio on a hill, close the sea and at some thirty kilometer from Senetosa Cape where are installed tide gauges and performed GPS buoys experiments near exact calibration point.



**Two major campaigns have been organized at this site: January-September 2002 for 10 months and May-October 2005 for 5 months.**

**2. Jason1 absolute calibration/validation configuration :**

- A geodetic site at Ajaccio with FTLRS settled for some months.
- An in-situ site at Senetosa cape under the track N°85.



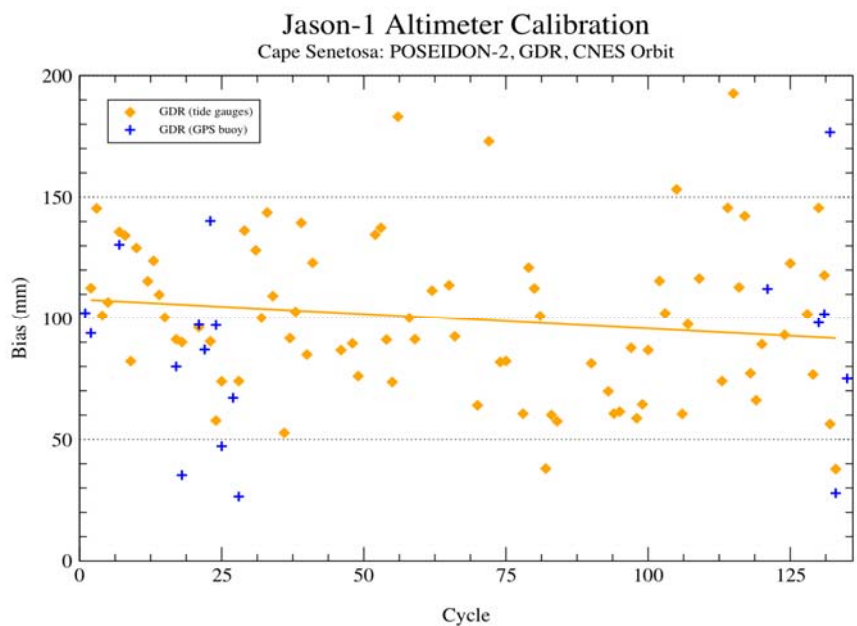
$$\text{sea height bias} = \text{altimeter sea height} - \text{in situ sea height}$$

Sea height bias < 0 meaning the altimetric sea height being too low (or the altimeter measuring too long)  
 Sea height bias > 0 meaning the altimetric sea height being too high (or the altimeter measuring too short)

The Senetosa site allows performance of altimeter calibration from tide gauges as well as from a GPS buoy.

At Senetosa **POSEIDON-2** altimeter bias is **+100 ±4 mm**, based on the whole set of GDR-A products (135 cycles).

The large negative trend is due to JMR (Wet Troposphere) in GDR-A and has been solved in recent analysis works



### 3. Scientific investigation for Positioning

#### ➤ Positioning with 4 geodetic satellites



**Lageos-1**  
**Lageos-2**

**Starlette**  
**Stella**



#### ➤ Goals of this positioning :

- To maintain geodetic accuracy of the FTLRS position in Ajaccio site (Corsica) between the two campaigns
- To provide high accuracy local orbits for the Jason-1 altimeter calibration

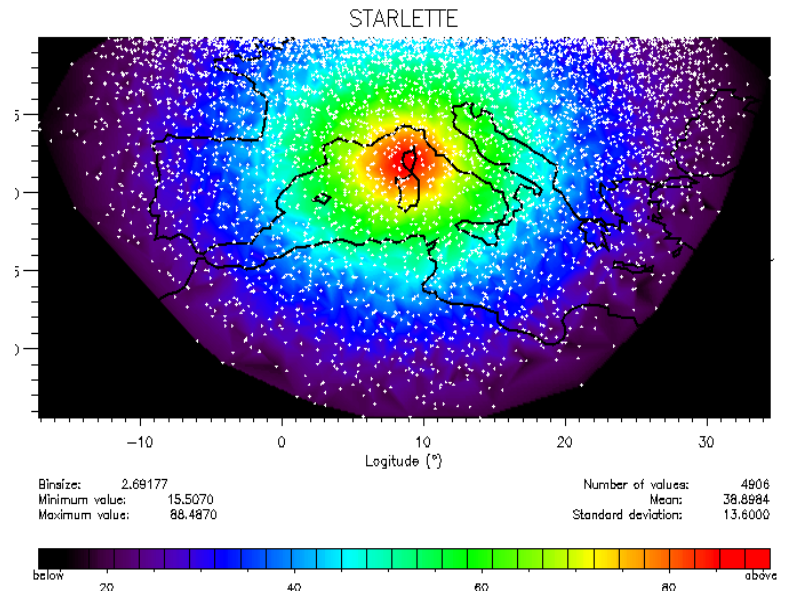
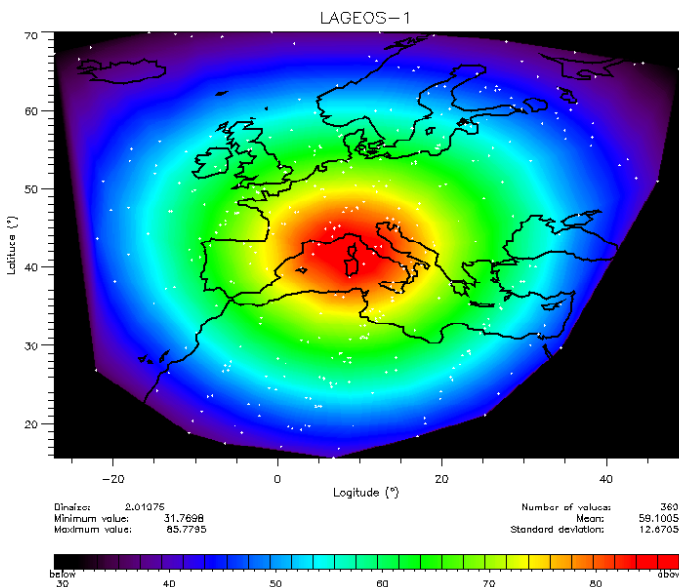
#### ➤ Main steps of the work methodology

- Orbit computation
- Positioning of the FTLRS Station with Multi satellite combination.

#### Npts data on the sky for 2005 campaign :

- High Elevation Orbiting Satellites:  
Few measurements on Lageos satellites, particularly at low elevation (40°), and irregular distribution of these data over the Ajaccio site
- Low Elevation Orbiting Satellites:  
Ten times more range data on Starlette/stella relative to Lageos, and homogeneous distribution of the range data over the Ajaccio site

The quality of FTLRS positioning is very dependent on the accuracy of orbits, and Starlette and Stella are more sensitive to remaining uncertainties in the dynamic models (gravitational and non gravitational effects).



**Maps of the range data distribution during the 2005 campaign (05 months) above Ajaccio site**

Since few years, thanks to new space mission like Grace, the community got an improvement of the gravity field models. The method in our analysis is to use an accurate field gravity model for the LEO computation and a multi-satellite combination.

**A. Parameters for orbit computation :**

**-Gins software (developed by CNES)**

**-Dynamical models used :**

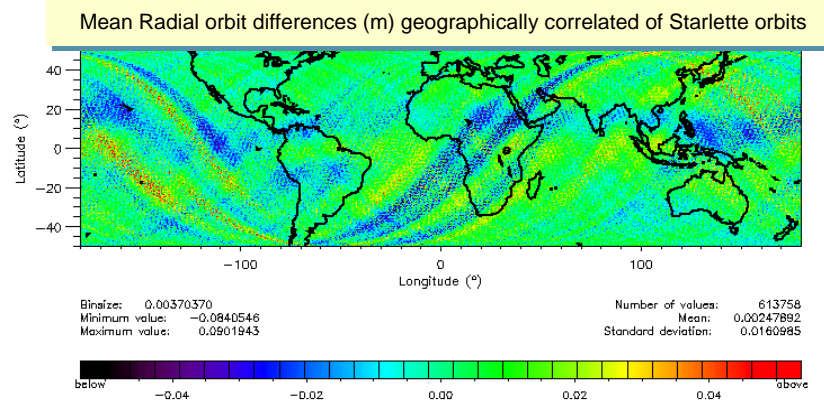
Model	Designation
Gravity field	<i>Grim5-c1 or Eigen-Grace03s</i>
Atmospheric pressure	<i>ECMWF</i>
Solar flow	<i>Acso12</i>
Atmospheric Density	<i>Dtm-94bis</i>
Ocean tides	<i>Fes-2002</i>
Planets	<i>De403bdlf.ad.ibm</i>
Earth Orientation Parameters	<i>Eop-c04</i>

**-Terrestrial reference frame : ITRF 2000**

**-Computation by successive arcs** (9 days for Lageos 1/Lageos 2 and 6,5 days for Starlette/Stella ) with overlapping periods (1 day for Lageos 1/2 and 0,75 days for Starlette/Stella) allowing to control the orbits quality of successive arcs and to limit the “butterfly effect” on the arc computation.

**-Effect of gravity field model :**

On 32 arcs of Starlette/Stella in 2005, it appears that the Mediterranean area is less affected by a permanent effect.



The Lageos orbits are more precise and less affected by the change of gravity field model, but for Stella/Starlette, we have an improvement of orbit precision of +/- 5mm with Eigen-Grace03s model.

Satellite	2002 campaign		2005 campaign	
	GRim5-c1	Eigen-Grace03s	Grim5-c1	Eigen-Grace03s
LAGEOS-1	13	-	11	11
LAGEOS-2	10	-	10	09
Starlette	23	18	23	18
Stella	23	19	21	16

## B. Positioning of Ftlrs station :

### -Matlo Software (developed by OCA) (Coulot 2005)

This software dedicated to laser positioning (coordinates updates+ range bias/satellite) in a multi-satellite combination compute a global solution and Time series solution.

Range bias	$B_{LAG-1}$ (mm)	$B_{LAG-2}$ (mm)	$B_{STAR}$ (mm)	$B_{STEL}$ (mm)	Coordinate updates	$d\phi$ (mm)	$d\lambda$ (mm)	$dh$ (mm)	$\rho_{dh-Bias}$ (%)
Glob. Sol. (1)	+12.0	+12.2	-3.9	-6.4	Glob. Sol. (1)	+4.3 ± 0.6	-10.1 ± 0.6	+11.7 ± 1.8	94.4
Glob. Sol. (2)	+4.8	+4.6	-4.9	-4.9	Glob. Sol. (2)	+4.3 ± 0.5	-3.6 ± 0.4	+3.0 ± 1.4	94.4
7d. Sol. (1)	+11.7	+13.8	-4.6	-5.4	7d. Sol. (1)	+4.4 ± 0.6	-8.6 ± 0.5	+13.8 ± 0.6	55.4
7d. Sol. (2)	+4.9	+3.3	-5.6	-4.3	7d. Sol. (2)	+4.1 ± 0.4	-2.9 ± 0.4	+4.0 ± 0.4	55.4

The Main objective has been to reduce the correlation between the range bias and the vertical component. To do that, we compared a global solution (with coordinates and range biases estimated with the whole data) and 7 days solution (with bias/sat supposed constant remain estimated with the whole data). In the Global solution, the correlation remains to high between biases and dh, some parts of the bias may move to dh and vice versa.

**In the 7 days solution, the correlation decreases significantly (55%), this solution is finally held**

## C. Results and Analysis: adjusted Ftlrs parameters over 2002 & 2005 campaigns:

with :

-Time series solution

-Eigen-Grace03s model

Coordinate updates	$d\phi$ (mm)	$d\lambda$ (mm)	$dh$ (mm)	$\rho_{dh-Bias}$ (%)
2002	-0.8 ± 0.7	+1.6 ± 0.7	+0.2 ± 0.8	55.8
2005	+4.1 ± 0.4	-2.9 ± 0.4	+4.0 ± 0.4	55.4

	Lageos-1 (mm)	Lageos-2 (mm)	Mean Lageos-1&2 (mm)	Starlette (mm)	Stella (mm)	Mean Starlette/Stella (mm)	Global mean (mm)
2002	-5	-7	-6	-13	-13	-13	-10
2005	+5	+3	+4	-5	-5	-5	0

- **The difference between Lageos and Starlette/stella biases** are probably coming from satellite signature and Ftlrs detection process.
- **adjusted values of Ftlrs range bias in 2002 campaign of -10 mm explained a posteriori:**
  - o Non linearity of Stanford chronometer not modelised at this epoch : -4.2 mm
  - o Geometrical path for external calibration not adjusted : - 3mm
  - **Total : 7.2mm**
- **The adjusted values of Ftlrs mean range bias for last campaign 2005 is very small and confirm agreement between analysis and technological corrections applied ( Stanford non linearity, ground target measurements,..)**

## D. Solved coordinates

Geographical coordinates differences from (Exertier et al., 2004) solution:

Coordinates differences	$\Delta\varphi$ (mm)	$\Delta\lambda$ (mm)	$\Delta h$ (mm)
2002	+0.5 ± 0.7	+2.7 ± 0.7	-1.2 ± 0.8
2005	+4.1 ± 0.4	-2.9 ± 0.4	+4.0 ± 0.4

Stability :

Campaign	Number of solution	$\sigma_\varphi$ (mm)	$\sigma_\lambda$ (mm)	$\sigma_h$ (mm)	$\sigma$ (mm)
2002	28	14.6	13.1	10.5	12.
2005	20	7.5	12.3	10.5	10.

-Global mean of bias (-5mm): very close to the published one (-7mm)

-Coordinate updates values for 2002 and 2005 are at 3mm level in average relatively to previous solution.

-Coordinates differences are very small at level of residuals errors in the ITRF2000 velocities

-No significant differences between 2002 and 2005 coordinates (at level of the tectonic movement): FTLRS point is locally stable.

### 4. Conclusion and Prospects:

- **Multi-satellite combination** has allowed to palliate lack of measurements on high satellites
- The improvement of the dynamical models, notably of the terrestrial gravity field (thanks to the GRACE satellite data ( *Eigen-Grace03s*) has permitted a precise computation of the orbits, in particular for the low satellites, and so a more precise geographical positioning,
- **Interesting decorrelation (~ 40%)** is obtained between the range bias and the station vertical component, using the time series solution (MATLO),
- **The station position is stable** between the two observation campaigns,
- In conclusion, the FTLRS has allowed a **precise terrestrial positioning**. That confirms its importance for the absolute calibration process of oceanographic satellites.