« Ftlrs Ajaccio campaigns : opérations and positionning analysis over 2002 and 2005 campaigns

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- **Introduction and Operational issues for Corsica campaigns**
- **Jason1 calibration/validation data**
- **Scientific investigation and results for positionning**
- **Conclusion and prospects**

Ftlrs
Oca-Grasse

Introduction

The Ajaccio Site (Corsica) is the main calibration site of the satellite altimeters in the Mediterranean area.

Objectives :

- **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 an accurate SLR positioning from the geodetic satellites observations

Notice:

Altimeter calibration = precisely compare

- **altimeter data**
- **satellite altitude above the sea level**

LASER campaigns in Corsica

Geographical situation :

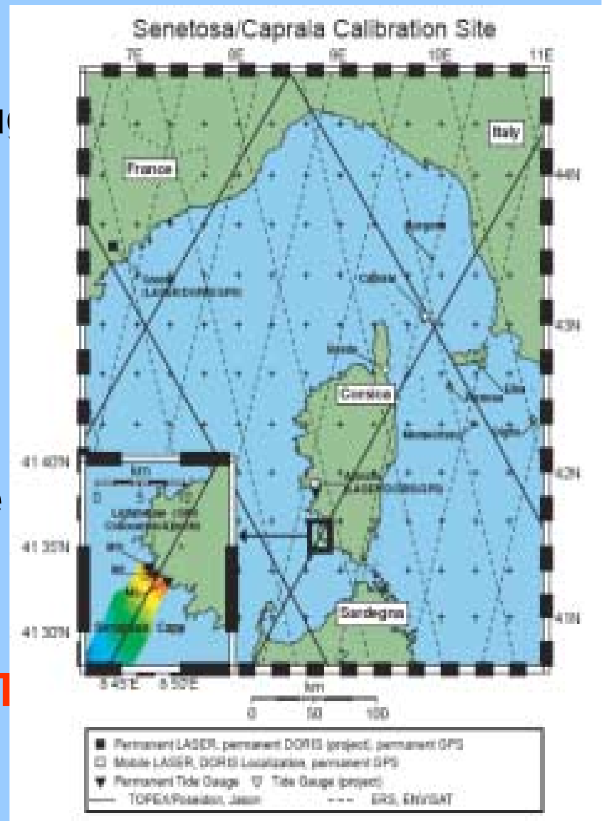
- Naval base at Aspretto (Ajaccio)
- *In situ* instruments at Senetosa Cape : Tide gau
- GPS buoys, meteo station,..

Laser campaigns :

- January – September 2002 **(10 months)**
- May – October 2005 **(5 months)**
- 4 satellites used : combination multi-satellite

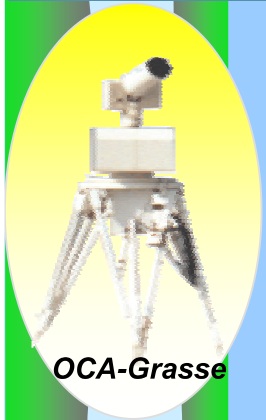
Instrument :

French Transportable Laser Ranging System (FT

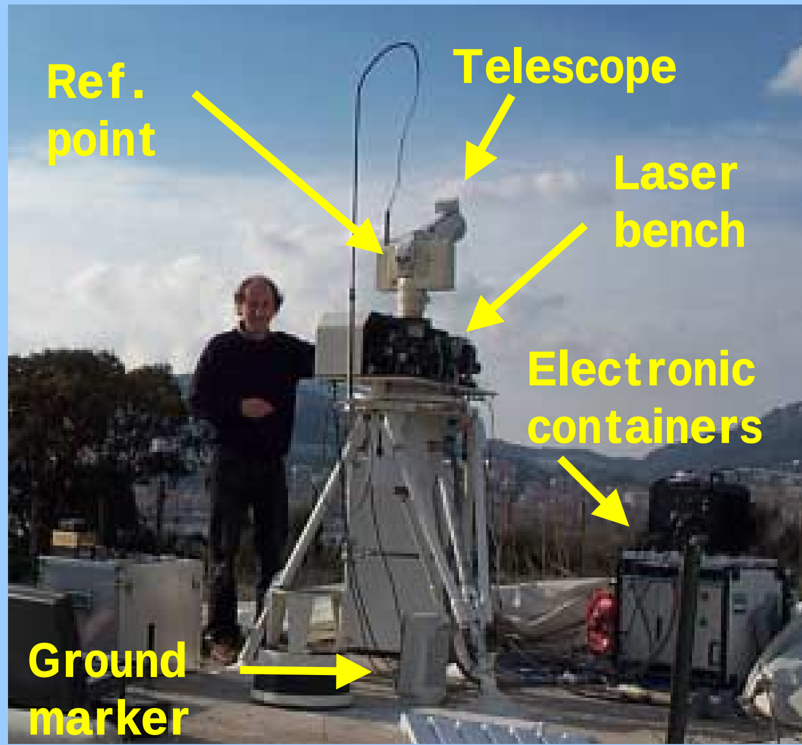


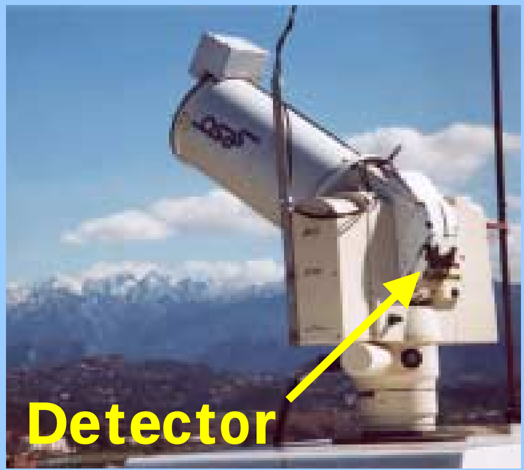
Mai/October 2005 : Ajaccio/ Calibration Jason1

FTLRS : French Transportable Laser Ranging System



- Very small SLR system in operation for 5 years
  - 350 Kg
  - ∅ tel = 13 cm (emission/reception)
  - Time = GPS steered rubidium
  - LEO satellites to Lageos-1&-2





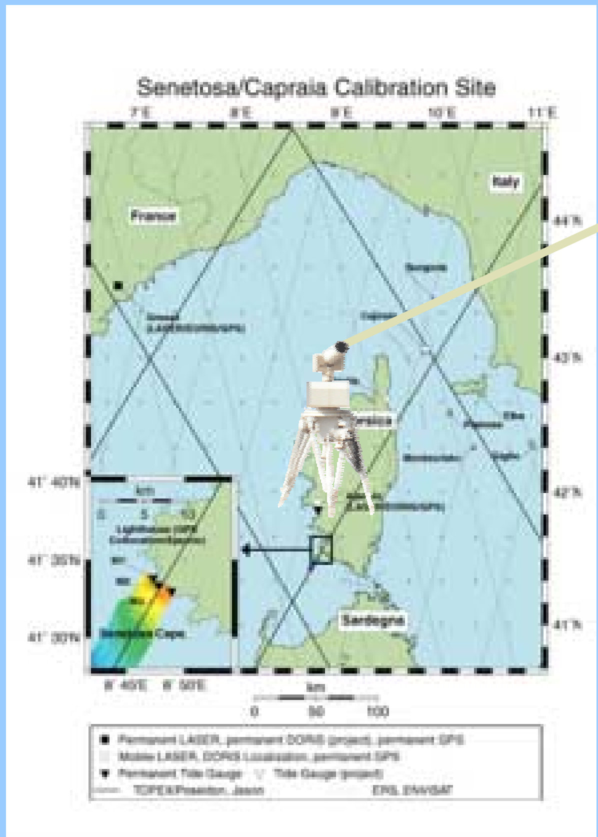
Applications

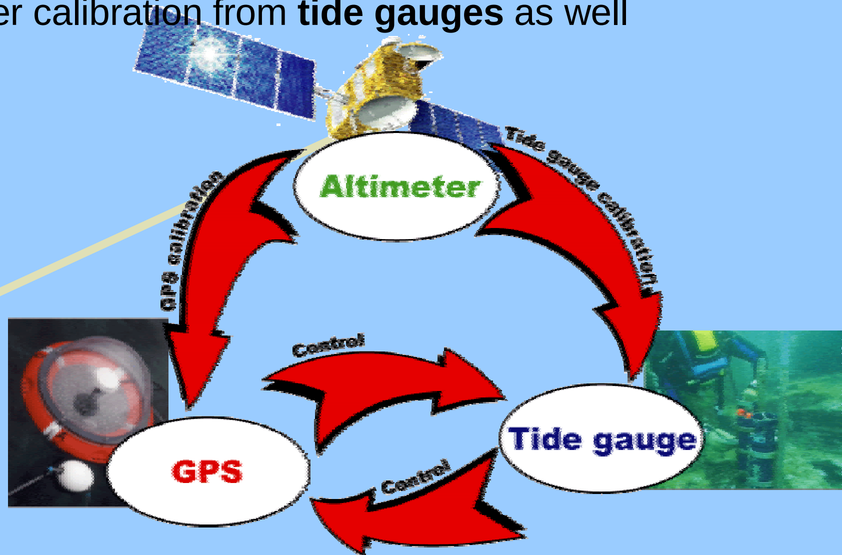
- Satellite Altimeter Calibration
- Reference Frame
- Charge Effects
- Co-localisation Mono or Multi-techniques

Configuration for absolute calibration

- **A geodetic site at Ajaccio: FTLRS has been settled** from January to September 2002 and **from May to October 2005.**
- **An in-situ site at Senetosa cape** under the track N°85

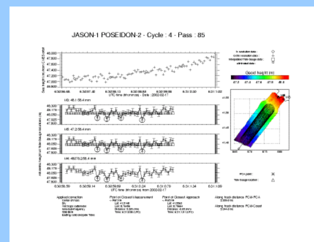
The Senetosa site allows to perform altimeter calibration from **tide gauges** as well as from a **GPS buoy**.





Products used for the study:

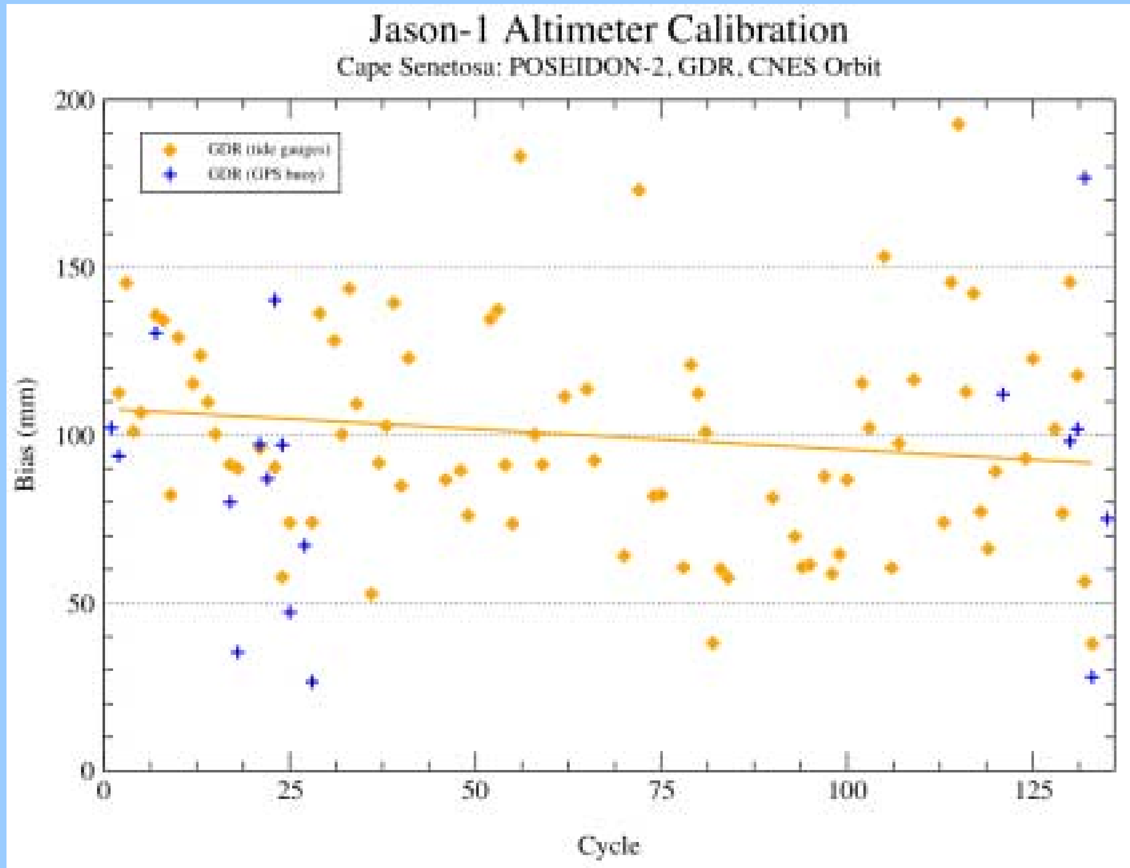
- **T/P: M-GDR + TMR drift**
- **Jason-1: GDR**



Definition of altimeter bias calibration:

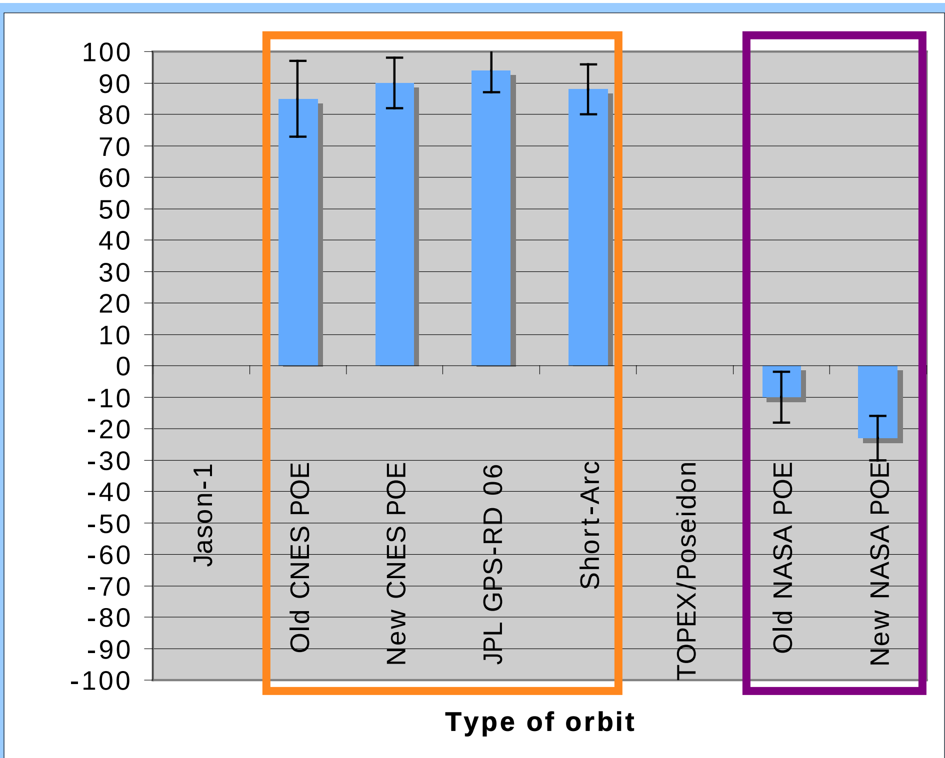
sea height bias = altimeter sea height - in situ sea height

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)



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 in GDR-A and will be discussed in the “GDR-A/GDR-B” and “Wet Troposphere” sections.

This drift effect is due to steps in the Jason-1 Microwave Radiometer calibration coefficients and clearly affects the Jason-1 altimeter bias time series. The future release of Jason-1 altimetric data includes new calibration coefficients and then this drift is removed (see JMR GDR-B).



For **Jason1**, the **new CNES POE** really shows an improvement in term of **standard deviation** with a **decrease of 18 mm** in term of root square difference compared to the old one. The same level of improvement is obtained with the Short-Arc orbits. The **GPS Reduced-Dynamic orbits have the lower standard deviation** with a decrease of 10 mm compared to the new CNES POE or the Short-arc orbits. For **T/P**, the **level of improvement on the standard deviation is a little less** (**13 mm**) than for Jason-1. Concerning the value of the **altimeter bias** itself, it **decreases by -13mm** so 8 mm more than between the old and new POE for Jason-1.

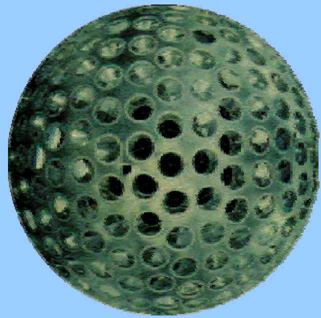
Orbit	Bias	Standard Deviation	Standard Error	Number
Jason-1	Based on GDR-B products			
Old CNES POE	85	26	12	5
New CNES POE	90	19	8	5
JPL GPS-RD 06	94	16	7	5
Short-Arc	88	19	8	5
TOPEX/Poseidon	Based on RGDR-1 products			
Old NASA POE	-10	29	8	14
New NASA POE	-23	26	7	14

Scientific Investigation for Positionning

Positioning with 4 geodetic satellites :

LAGEOS-1

LAGEOS-2



STARLETTE

STELLA

Goals :

- Maintain the geodetic accuracy of the FTLRS position in Ajaccio site (Corsica) between the two campaigns

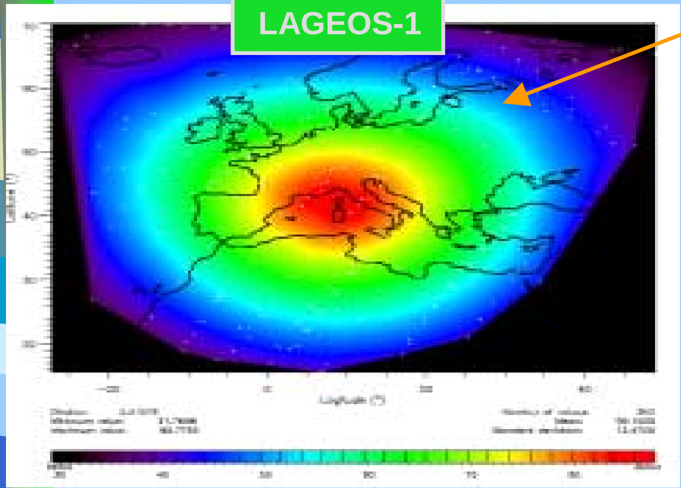
- Provide high accuracy local orbits for the Jason-1 altimeter calibration

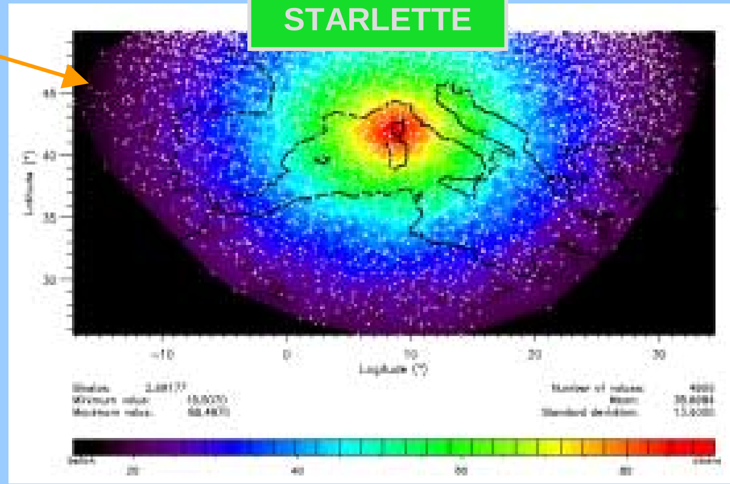
Main steps of the work methodology :

a – Orbit computation

b – Positioning of the FTLRS Station

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





LAGEOS :

❖ Few measurements on LAGEOS satellites, particularly at low elevation **(40°),** and irregular distribution of these data over the Ajaccio site

❖Are difficult to reach by the FTLRS laser (high altitude)

❖ Low number of normal points collected : not enough to perform 3D geocentric positioning (**σ <±1cm**)

Starlette / Stella :

❖Ten times more range data on Starlette/Stella relative to LAGEOS, and homogeneous distribution of the range data over the Ajaccio site.

Problematic

Problematic ?

➔ **Quality of the FTLRS positioning depends on the accuracy of the orbits.**

➔ **Starlette / Stella : More sensitive to remaining uncertainties in the dynamical models (gravit. & non gravit. Effects).**

Solution :

- ✓ **Since few years: Improvement of the field gravity model (GRACE mission)**
- ✓ **Adoption of an accurate field gravity model for the LEO computation**
- ✓ **Multi-satellite Combination**

a. Orbit Computation

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

- **Dynamical Models used :**

Model	Designation
Gravity field	*Grim5-c1* or *Eigen-Grace03s*
Atmospheric pressure	*ECMWF*
Solar flow	*Acsol2*
Atmospheric Density	*Dtm-94bis*
Ocean tides	*Fes-2002*
Planets	*De403bdlf.ad.ibm*
Earth Orientation Parameters	*Eop-c04*

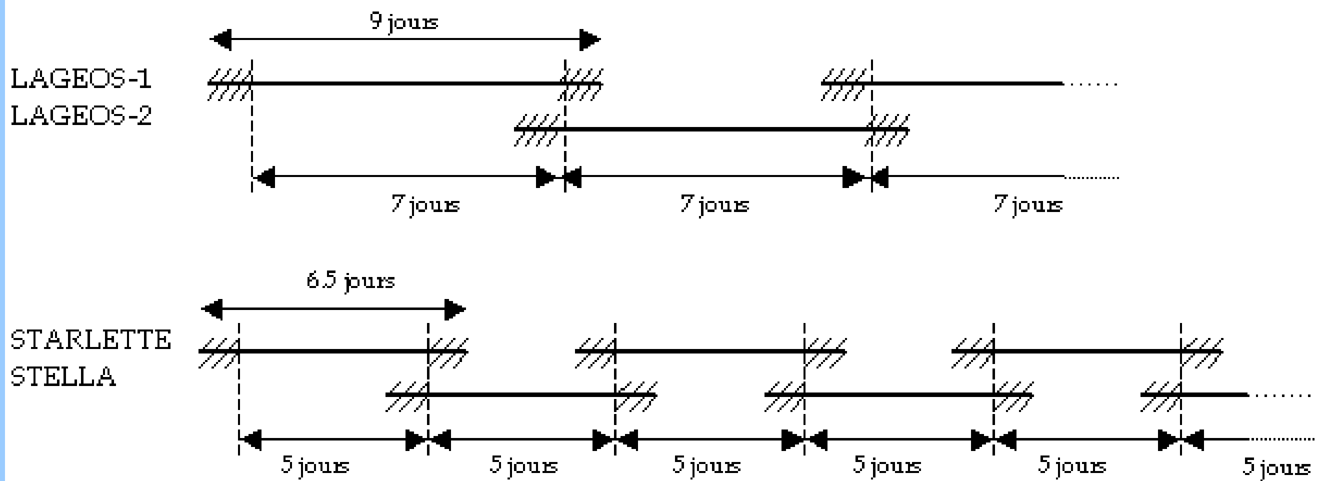
- **Terrestrial reference frame : ITRF2000**

a. Orbit Computation

❑ **Computation by successive arcs with overlapping periods**

Nom du satellite	Longueur de l'arc (jours)	Recouvrement début + fin d'arc (jours)	Durée de l'arc conservée (jours)	Nombre de révolutions du satellite par arc	Nombre d'arcs pour la campagne 2005	Pas d'intégration (secondes)
LAGEOS-1	9	1 + 1	7	45	22	90
LAGEOS-2	9	1 + 1	7	45	22	90
STARLETTE	6,5	0,75 + 0,75	5	50	32	45
STELLA	6,5	0,75 + 0,75	5	50	32	45

❖**Overlap principle :**



- ➢ **Overlap periods allow to control the orbits quality of successive arcs**
- ➢ **To limit the "*butterfly effect*" on the arc computation.**
- ➢ **To improve the arc computation**

a. Orbit Computation

● Effect of the gravity field model on the quality of the orbits :

- Grim5-c1 (Gruber et al., 2000)
- Eigen-Grace03s (Reigber et al., 2005)

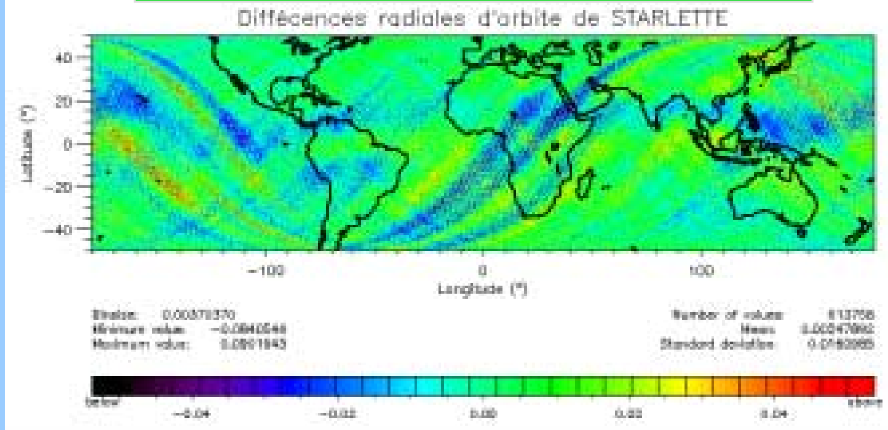
Radial orbit differences :

$RMS_{Starlette}$ = +/- 15 mm

RMS_{Lageos} = +/- 5 mm

☞ The Mediterranean area seems to be less affected by a permanent effect

STARLETTE (32 arcs / 2005)



Mean Radial orbit differences (m) geographically correlated of Starlette orbits

● RMS (mm) of satellites orbits :

☞ LAGEOS orbits are more precise & less affected by the change of the gravity field model

☞ Eigen-Grace03s: improvement of the Starlette / Stella orbits precision (+/- 5mm)

	2002 campaign		2005 campaign	
Satellite	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):**

- Dedicated to laser positioning (coordinate updates + range bias/satellite ?)
- Multi-Satellite Combination
- Global solution & Time series solution :

Initial coordinates :

X (m)	Y(m)	Z (m)	ITRF-yy
4696993.369	724001.714	7239672.762	ITRF-97
4696993.311	724001.825	7239672.837	ITRF-02

- **Position based** … ates and range biases are estimated with the whole data

❑ **FTLRS tracking data (02 campaigns 2002 & 2005)**

- **Position estimated every 7 days (7d.Sol)** while bias/sat (supposed const.) remain estimated with the whole data – *Temporal decorrelation method*

Satellite	2002 Campaign	2005 Campaign
LAGEOS-1	301	377
LAGEOS-2	323	235
Starlette	3413	5294
Stella	1731	2069
TOTAL	5768	7975

☞ **Objective :** **Reduce the correlation between the range biases and the vertical component (dh)**

Results & Analysis

Adjusted FTLRS parameters

(2005 Campaign)

Range bias	B_{LAG-1} (mm)	B_{LAG-2} (mm)	B_{STAR} (mm)	B_{STEL} (mm)
Glob. Sol. (1)	+12.0	+12.2	-3.9	-6.4
Glob. Sol. (2)	+4.8	+4.6	-4.9	-4.9
7d. Sol. (1)	+11.7	+13.8	-4.6	-5.4
7d. Sol. (2)	+4.9	+3.3	-5.6	-4.3

Gravity field models :

(1): Grim5-c1

(2): Eigen-Grace03s

Coordinate updates	$d\varphi$ (mm)	$d\lambda$ (mm)	dh (mm)	$\rho_{dh-Bias}$ (%)
Glob. Sol. (1)	$+4.3 \pm 0.6$	-10.1 ± 0.6	$+11.7 \pm 1.8$	94.4
Glob. Sol. (2)	$+4.3 \pm 0.5$	-3.6 ± 0.4	$+3.0 \pm 1.4$	94.4
7d. Sol. (1)	$+4.4 \pm 0.6$	-8.6 ± 0.5	$+13.8 \pm 0.6$	55.4
7d. Sol. (2)	$+4.1 \pm 0.4$	-2.9 ± 0.4	$+4.0 \pm 0.4$	55.4

- **Glob.Sol :** Correlation remains too high between biases and *dh* (94%) - Some part of the bias may move to dh and vice versa
- **7d.Sol :** Correlation decreases significantly (55%) → This solution is held
- Statistically, the estimates of coordinates updates with Eigen-Grace03s model are better than those with Grim5-c1 model.

Results & Analysis

Adjusted FTLRS parameters

(over 2005 & 2002 Campaigns)

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

With:

- ☑ **Time Series Sol.**
- ☑ **Eigen-Grace03s**

Range Bias	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

- Differences between Lageos & Starlette/Stella biases : target response and FTLRS detection process
- The adjusted values of the FTLRS range bias in 2002 of ~ - 10 mm explained :
  - Non linearity of Stanford Chronometer not modelised at this epoch : ~ - 4.2 mm
  - Geometrical path for external calibration not adjusted : ~ - 3 mm
    - Total : 7.2 mm
  - Remaining correlation (~50%) between the range bias and the altitude update

-New coordinates (from 2002 & 2005 data sets) along with -5 mm mean range bias : validating the latest Jason-1 precise orbits (Bonnefond et al., 2006)

Results & Analysis

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

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

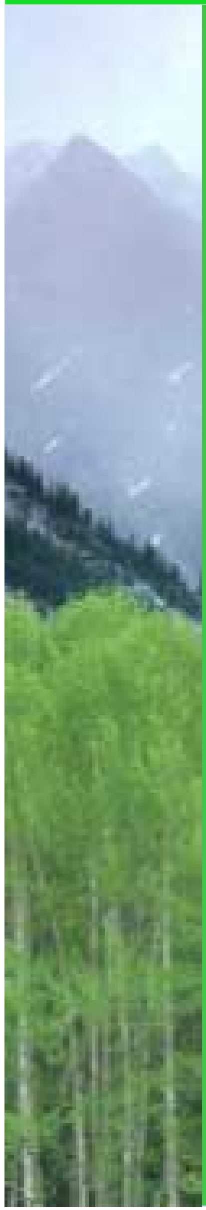
Stability :

Campaign	Number of solution	$\sigma\varphi$ (mm)	$\sigma\lambda$ (mm)	σh (mm)	σ (mm)
2002	28	14.6	13.1	10.5	12.9
2005	20	7.5	12.3	10.5	10.3

- Global mean of bias (-5mm): very close to the published one (-7mm) (Exertier et al., 2004)
- Coordinate updates values for 2002 and 2005 are at 3mm level in average relatively to (Exertier et al., 2004) 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.

Conclusions & Ftlrs Prospects

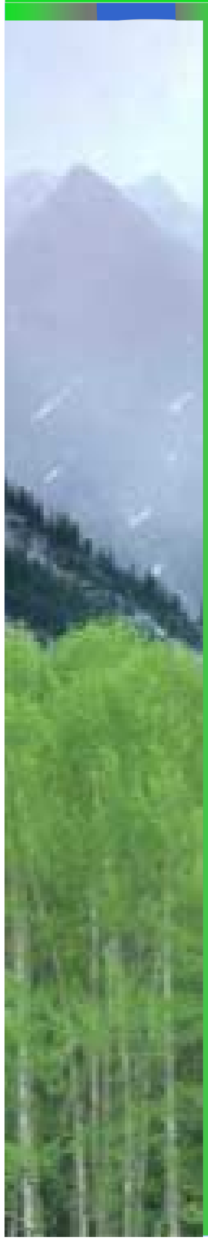
Conclusions :



- ✓ Multi-satellite combination has allowed to palliate the lack of measurements on the high satellites (Lageos),
- ✓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,
- ✓Considerable 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.

Conclusions & Prospects

Ftlrs Prospect :



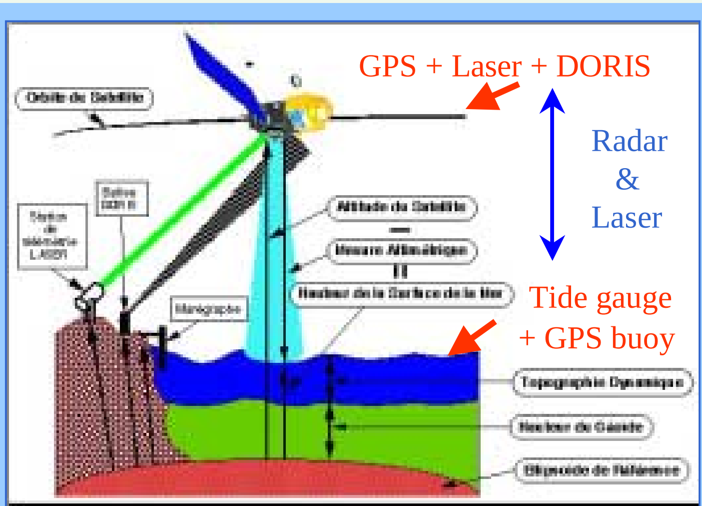
✓ New laboratory built in Grasse Observatory to achieve technology upgrade and slr tracking between “fields campaigns”

Wednesday presentation *: “Grasse Laser stations in evolution to future“*

✓Laser upgrade to multi pulse concept (~+70 *% energy*) to increase link budget and facilitate Lageos acquisition

✓“Australian Collaborative Research Infrastructure” proposal for Ftlrs campaign

Jason 1 Calibration on Tasmania site in 2007

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