«FTLRS SUPPORT TO THE GAVDOS PROJECT»

*P. Berio, P. Exertier, **F. Pierron**, J. Weick, D. Coulot, O. Laurain,*
P. Bonnefond and Ftlrs laser staff
Observatoire de la Côte d'Azur

- **Technical developments and previous campaigns**
- **Logistic and installation in Crete**
- **Operational issues**
- **Observations and results**
- **Scientific processing**
  - *Laser positioning and bias estimations*
  - *GPS solutions*
  - *Comparisons and conclusion*

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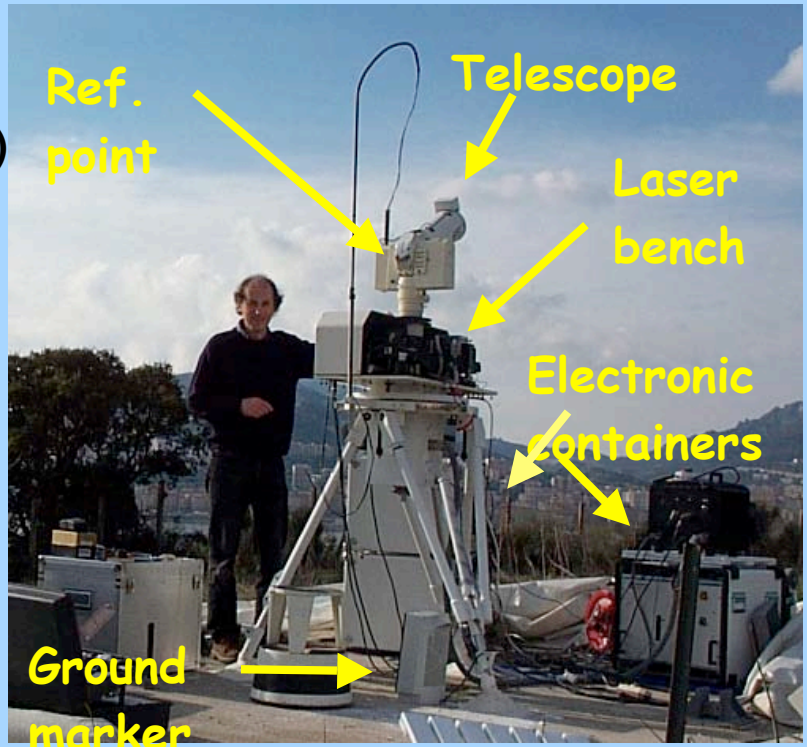
The French Transportable Laser Ranging System

- **The smallest SLR system in operation**
  - **350 kg**
  - **∅ tel = 13 cm (emission/reception)**
  - **Time = GPS steered rubidium**
  - **LEO satellites to Lageos**



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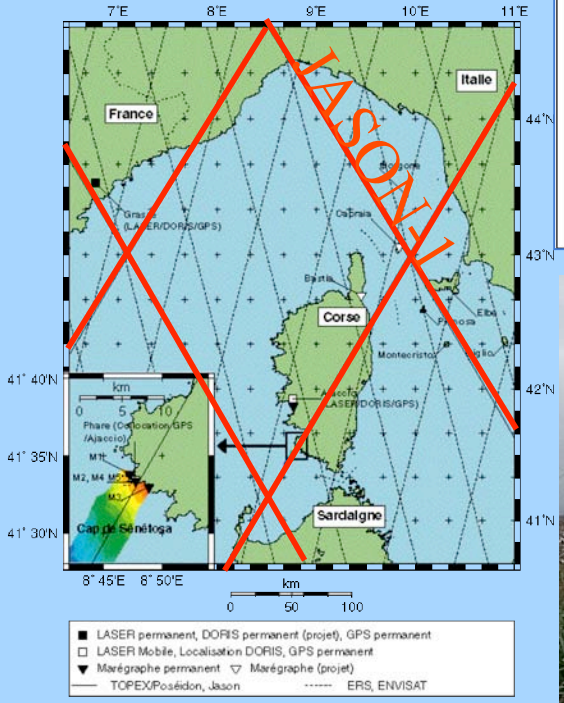
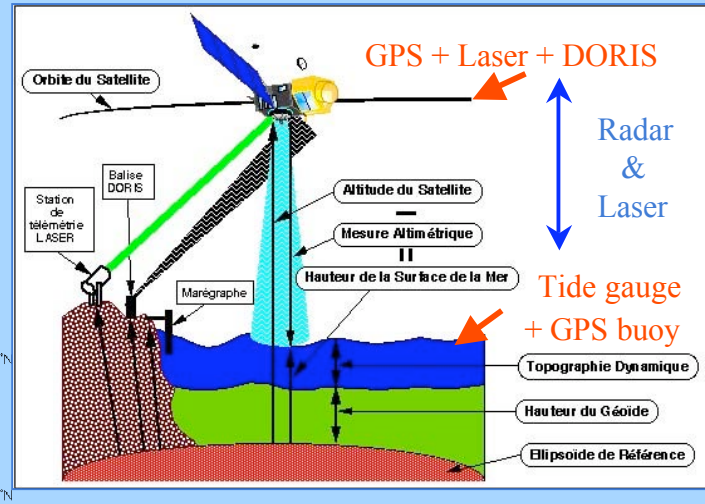
Ftlrs previous campaigns Corsica (2002)

JASON-1 absolute calibration and orbit validation (CAL/VAL) in tandem mission with TOPEX/Poseidon

Precise positioning

Altimeter calibration = precisely compare
- altimeter data
- satellite altitude above the sea level





2003 : The European Gavdos project

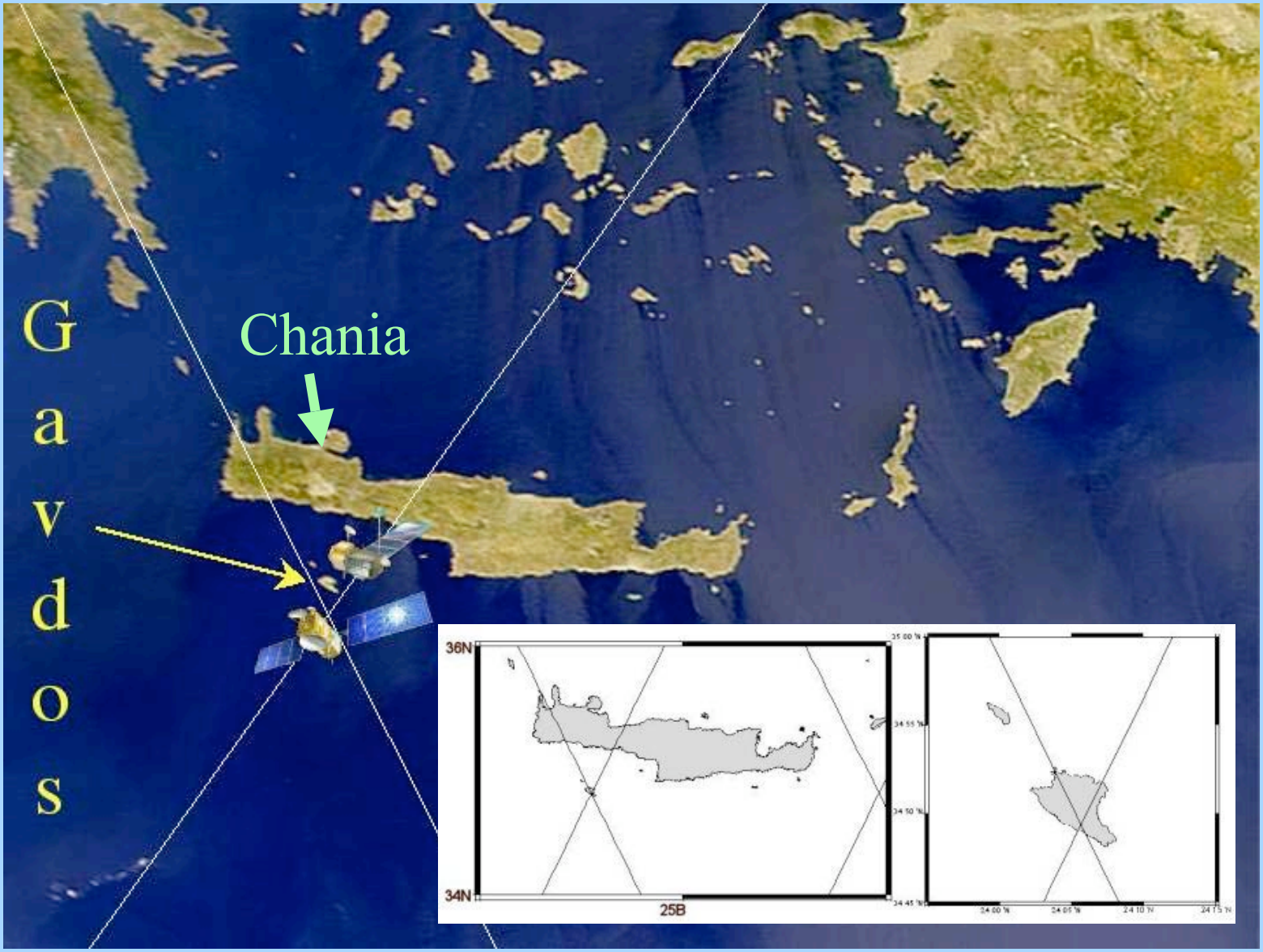
- Establisment of an absolute sea level monitoring and altimeter calibration facility on the isle of Gavdos (south of Crete in Grece

- Estimation of the altimeter satellites biases and drifts

- Determine the mean sea level and the earth ’s tectonic deformation field in the region of Creete with an accuracy of a few millimeters

- On site measurements :
  - tide-gauges
  - Gps and Foris
  - Direct altimeter transponders

Local configuration - Crete and Gavdos



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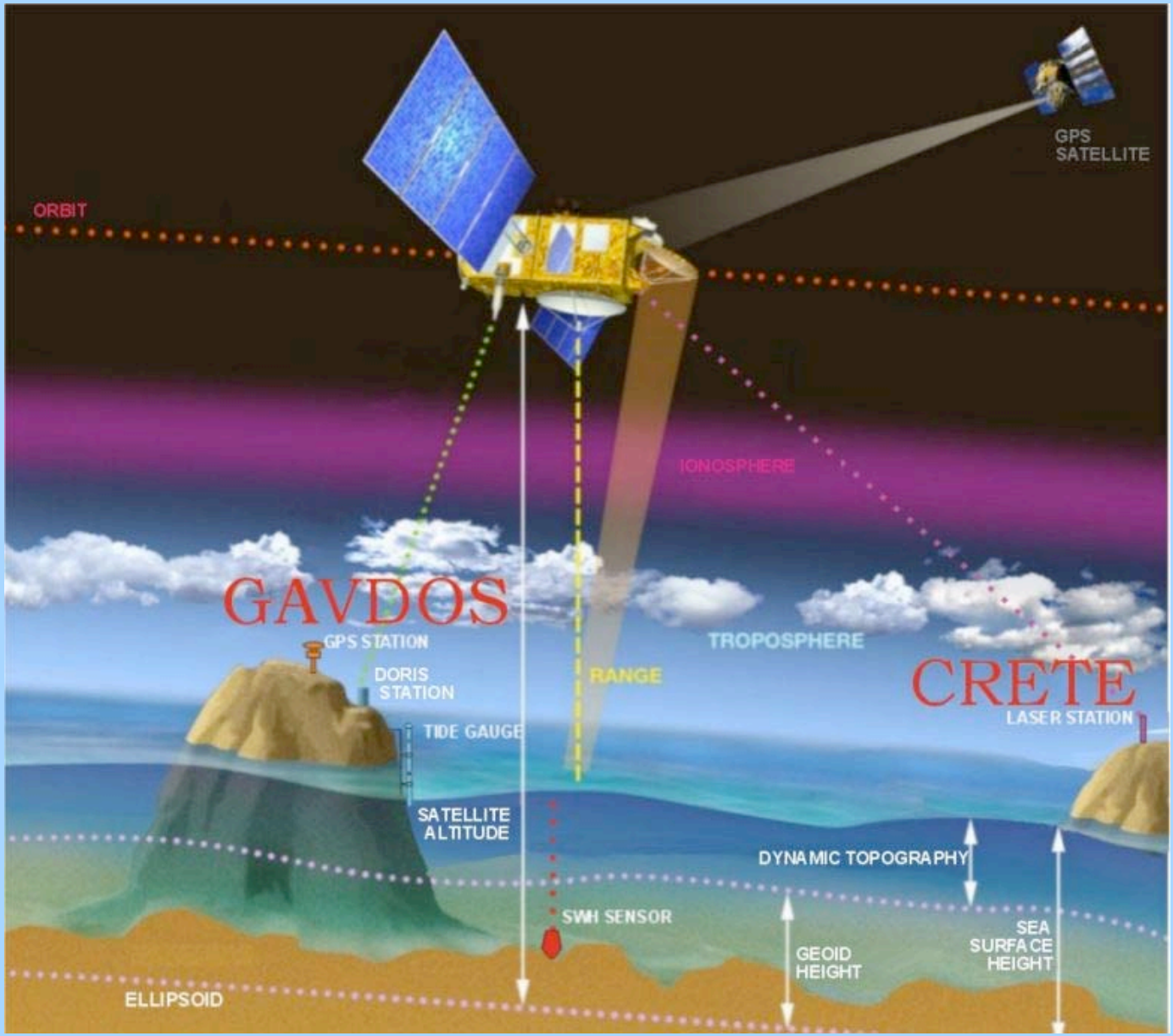
Slr altimeter calibration scheme



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Ftlrs deployment in three days(end of March 2003)

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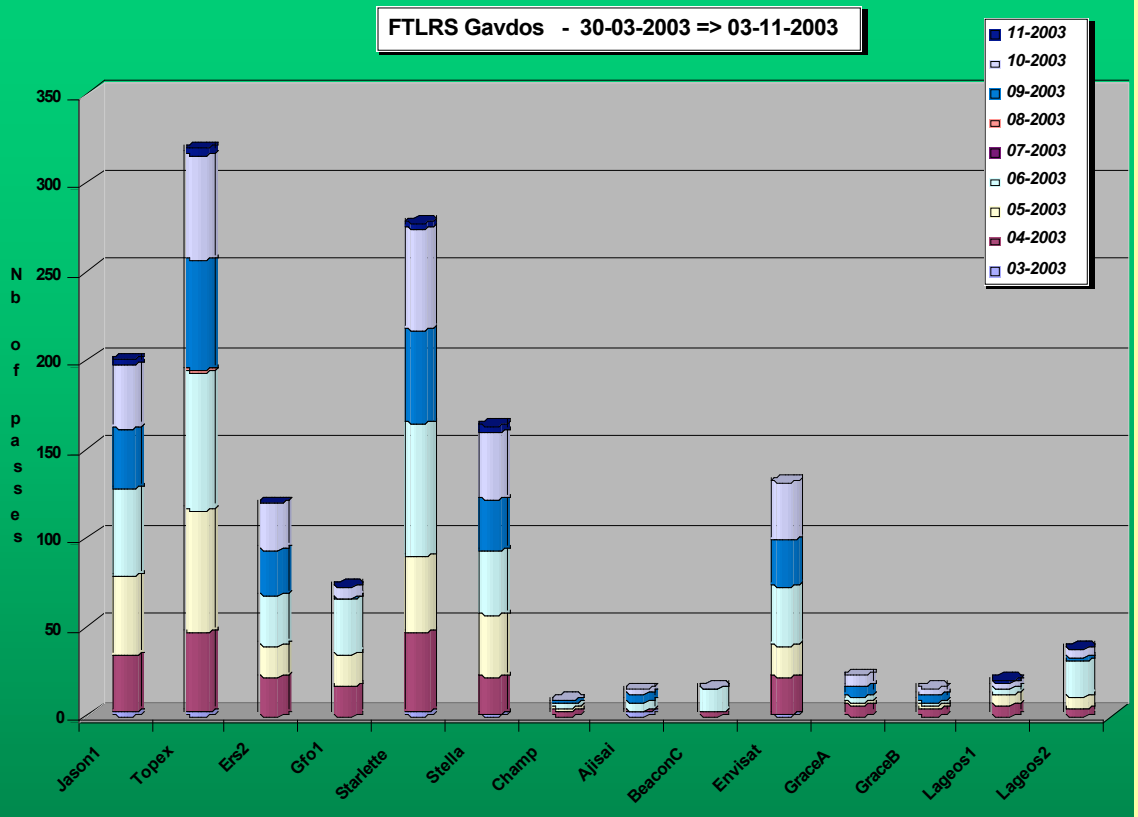
FTLRS GAVDOS CAMPAIGN - 30/03/2003=>3/11/2003



1367 low orbiting satellites
58 Lageos
including ~ 400 passes in tandem with Grasse SLR

Calibration passes :

	FTLRS
07/04	J + T
10/04	J + T
17/04	*weather*
20/04	J + T
26/04	*no returns*
30/04	J + T
06/05	J + T
10/05	J + T
16/05	J + T
20/05	J
26/05	J + T
30/05	J + T
05/06	*weather*
09/06	J + T
15/06	J + T
19/06	J + T
25/06	J + T
28/06	J + T
02/09	J + T
06/09	J + T
12/09	J + T
16/09	*weather*
22/09	J + T
26/09	J + T
02/10	T
06/10	T
12/10	J + T
16/10	J
22/10	J + T
25/10	J + T
01/11	J + T

Scientific analysis

- **Positioning with the 4 geodetic satellites**

  LAGEOS-1 LAGEOS-2 STARLETTE STELLA

- **Goals :**

  - Calculate FTLRS position in Crete

  - Evaluate precision and accuracy of the positioning

  - Compare with our GPS solution

- **Main steps of computation :**

  1 – Orbit calculation

  2 – Laser positioning

  3 – GPS solution

  4 – Comparison Laser / GPS

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ORBIT CALCULATION

- GINS software (by CNES)

- Models chosen : - gravity : *grim5*
  - ocean tide : *fes2002*
  - atmospheric density : *dtm94*
  - earth orientation parameters : *eopc04*
  - empirical forces in R, T, N directions
    (bias + sinusoidal terms at the orbital period)

- Terrestrial reference system : ITRF2000

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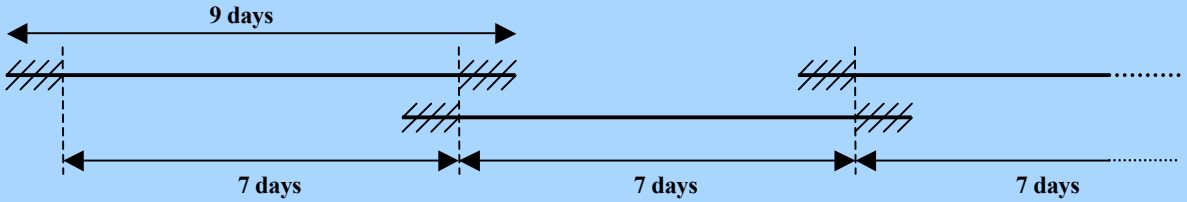
ORBIT CALCULATION

- Calculation by successive arcs with overlapping periods

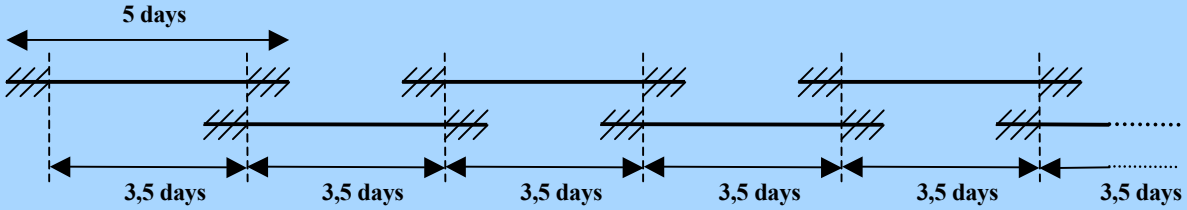
Satellite	Length of the arc (days)	Overlap beginning + end of the arc (days)	Length of the arc useable (days)	Number of arcs for the year 2003
LAGEOS-1	9	1 + 1	7	53
LAGEOS-2	9	1 + 1	7	53
STARLETTE	5	0.75 + 0.75	3.5	106
STELLA	5	0.75 + 0.75	3.5	106

Overlap principle

LAGEOS-1 / LAGEOS-2



STARLETTE / STELLA



Overlap periods allow to control the orbits quality of successive arcs

Mean RMS	LA1 = 1.05 cm	STA = 1.98 cm
	LA2 = 0.82 cm	STE = 2.17 cm

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LASER POSITIONING

-1-

- MATLO software (developed by OCA) : dedicated to laser positioning

Initial coordinates from JCET GPS processing

(July 2003)

X = 4744552.5533 m Y = 2119414.5451 m Z = 3686245.1363 m

- FTLRS tracking data (6 months)

	Total number of NP	Mean number of NP for a 7-day period
LAGEOS-1	108	5
LAGEOS-2	315	15
STARLETTE	2902	138
STELLA	1479	70
TOTAL	4804	228

- Objective : Reduce the correlation between the biases and the vertical component (dh)

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LASER POSITIONING -2-

- Position based on a global solution

Coordinates and bias are estimated with the whole data

d_ = -0,59 cm		± 0,10 cm	(Relative to JCET solution)
d_ = 0,25 cm		± 0,10 cm	
dh = 0,03 cm		± 0,30 cm	
Biases	LA1 = -1,97 cm	± 0,43 cm	Max Correlation (dh/bias) = 0,93
	LA2 = -2,06 cm	± 0,32 cm	
	STA = -2,24 cm	± 0,19 cm	
	STE = -2,83 cm	± 0,19 cm	

- Correlation remains too high between biases and dh

Some part of the bias may move to dh and vice versa

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LASER POSITIONING

-3-

Position estimated every 7 days while biases/sat (supposed constant) remain estimated with the whole data

d_ = -0,58 cm		± 0,35 cm	(Relative to JCET solution)
d_ = 0,16 cm		± 0,33 cm	
dh = 1,25 cm		± 0,28 cm	
Biases	LA1 = -0,96 cm	± 0,21 cm	Max correlation (dh/bias) =0,57
	LA2 = -0,97 cm	± 0,18 cm	
	STA = -1,57 cm	± 0,11 cm	
	STE = -2,02 cm	± 0,11 cm	

Correlation decreases significantly

Estimated station bias is globally lower B = 10 ± 2 mm

→ Final solution held

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LASER POSITIONING

-4-

- **Tests to correct orbits locally with the short-arc technique (CALTIM software)**

  → 17 short-arcs corrected with 3 stations above Europe

  → Slight radial error detected on STELLA's orbit which would explain abnormally high bias value (about 10 mm)

- **Biases values were expected to be around 5 mm (10 mm obtained)**

  → Local tie of the calibration target was determined within 1 cm

  → accuracy of chronometer on short time flight within 5 mm

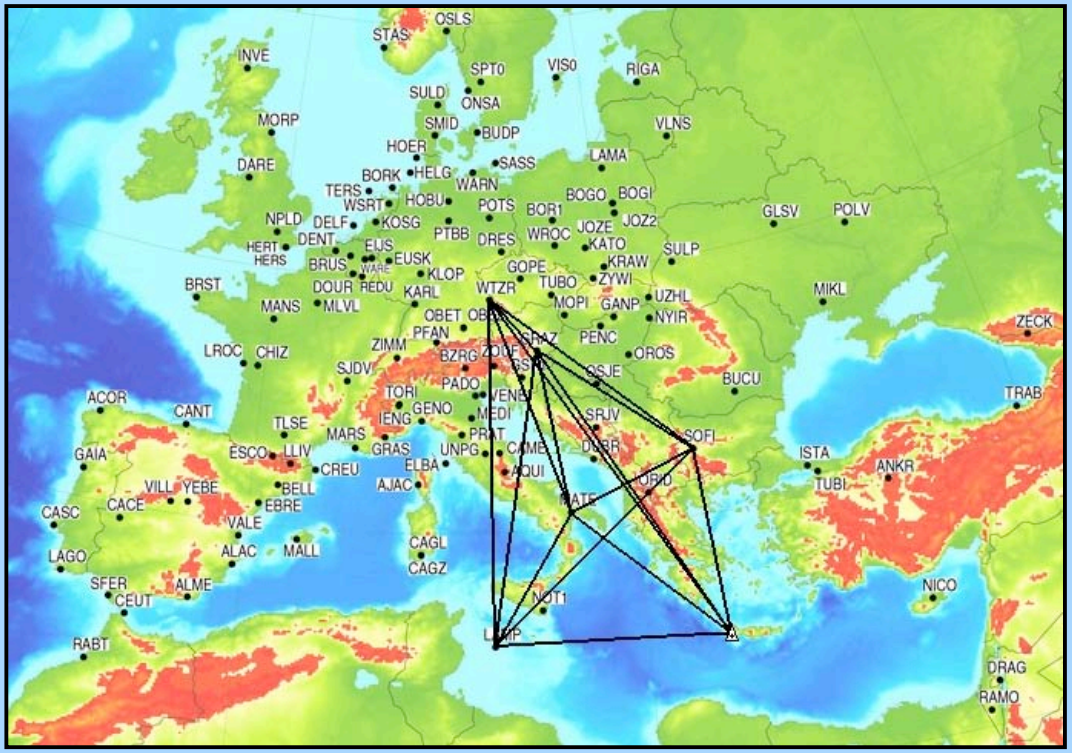
- ***Tests of positioning with JASON-1 → 2 cm eastwards translation***

  → Remains unexplained !

GPS SOLUTION

Network setting up

GAMIT software (developed by MIT)



Observations : March 12th –15th and 20th – 24th 2003 (9 days)

January 28th – February 9th 2004 (13 days)

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GPS SOLUTION

- IGS precise orbits used

- Results 2003 (Relative to JCET solution)

  d_ = 0,26 cm

  d_ =-0,44 cm

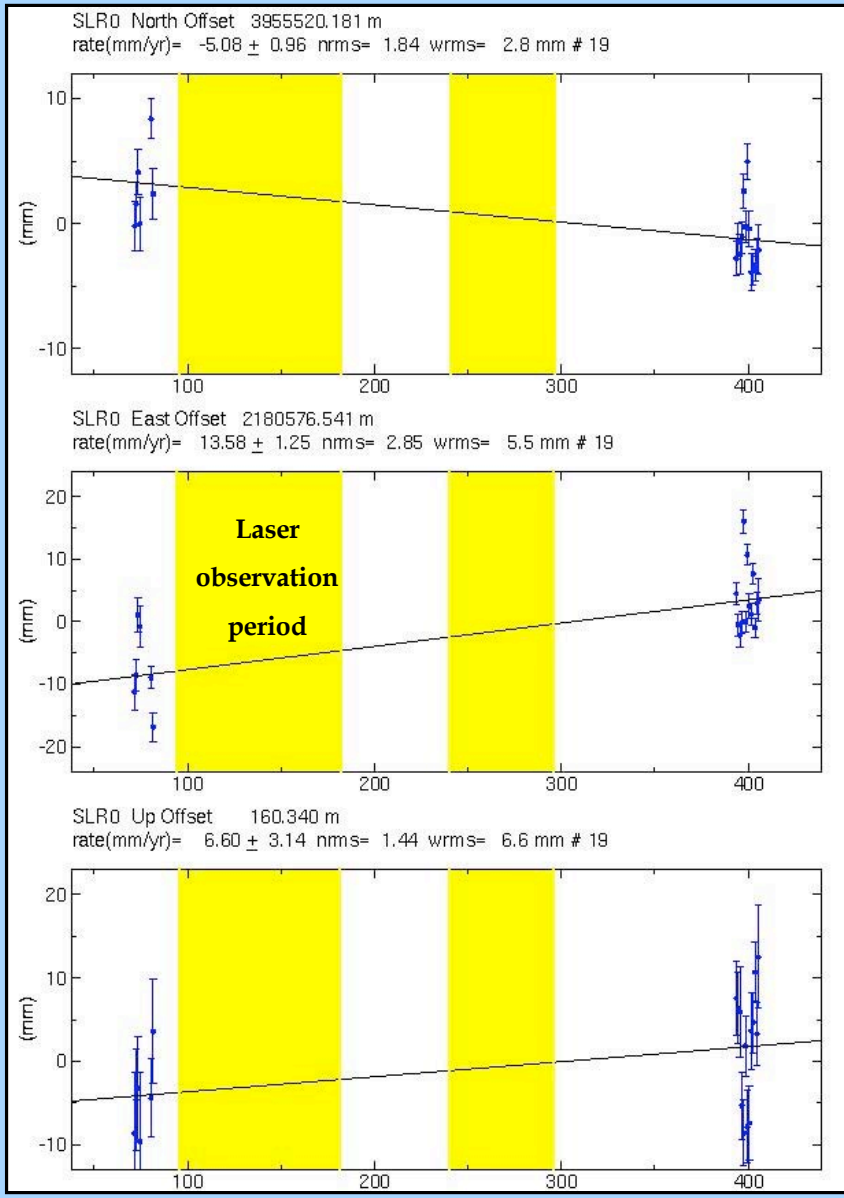
  dh = -0,75 cm

- Results 2004

  d_ = -0,21 cm

  d_ = 0,75 cm

  dh = -0,68 cm



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COMPARISON LASER / GPS

- GPS coordinates have been corrected from estimated plates motions and brought back to the laser measurements average date (July 16th 2003)
- Corrected GPS position compared to Laser position

$$\__{GPS} - \__{Laser} = 0{,}00 \text{ cm}$$

$$\__{GPS} - \__{Laser} = 0{,}32 \text{ cm}$$

$$h_{GPS} - h_{Laser} = -0{,}12 \text{ cm}$$

Homogeneous results between GPS and Laser techniques

→ Less than 5 millimeters difference

	X (m)	Y (m)	Z (m)
Laser position	4744552.5636	2119414.5525	3686245.1388
GPS position	4744552.5614	2119414.5550	3686245.1381

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Conclusion and prospect

- Confirmation and new validation FTLRS performances
- Success of the campaign in a European joined project
- Some millimeter level reached for the orbit validation and the station positioning
- San Fernando colocation experiment in progress

Colocation experiment today in San Fernando / june 2004

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Next campaign - Normandy (2004)

- Objectives :
  - Vertical variations measurement
  - Multi-techniques
  - why normandie
    - High ocean tide
    - Load effect on earth

Campaign dates: September/October 2004

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