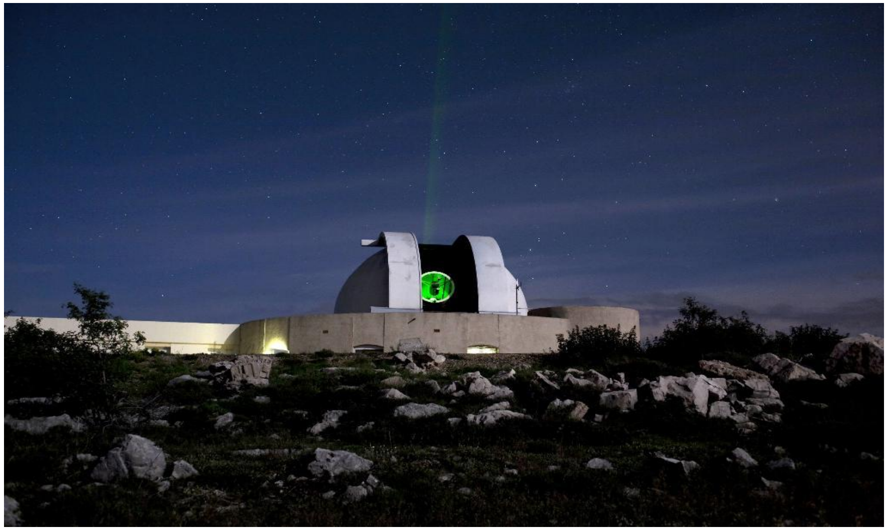
ILRS TECHNICAL WORKSHOP 2019
(Stuttgart 21st – 25th October)

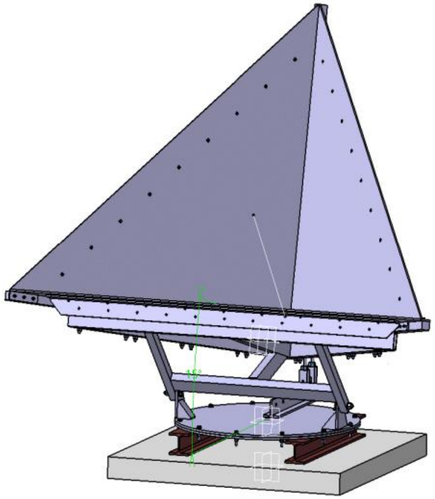
Session 2 : Improving current station performance (Local ties).

Title : InSAR Corner Cube at GRSM.

Mourad Aimar [1], Clément Courde [1], Xavier Collilieux [2,3], Bénédicte Fruneau [4], Guillaume Schmidt [3], Isabelle Delprat [3], Damien Pesce [5], Fabien Bergerault [5], Pierre Cumerlato [5], Guy Wöppelmann [6].

[1] UCA, CNRS, OCA, IRD, 06460 Caussols, France.
[2] Université de Paris, IPGP, CNRS, IGN, F-75005 Paris, France.
[3] ENSG-Géomatique, IGN, F-77455 Marne-la-Vallée, France.
[4] LaSTIG, Université Paris-Est, UPEM, IGN, Marne-la-Vallée, France.
[5] INIGF, Saint-Mandé, France.
[6] Laboratoire L.E.S., UMR7266 – Univ La Rochelle and CNRS, La Rochelle, France.

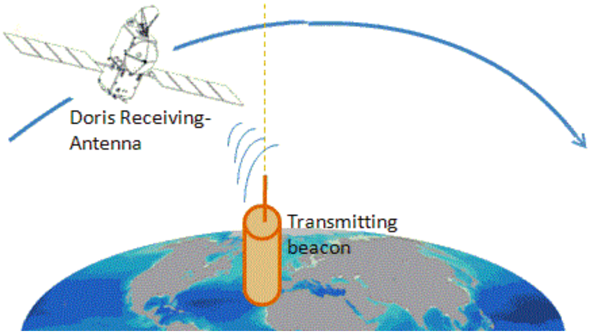




1 – Context : Geodetic observatories.

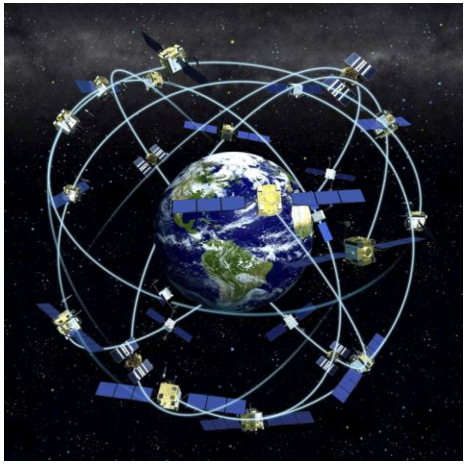
A geodetic observatory consists of four technics :

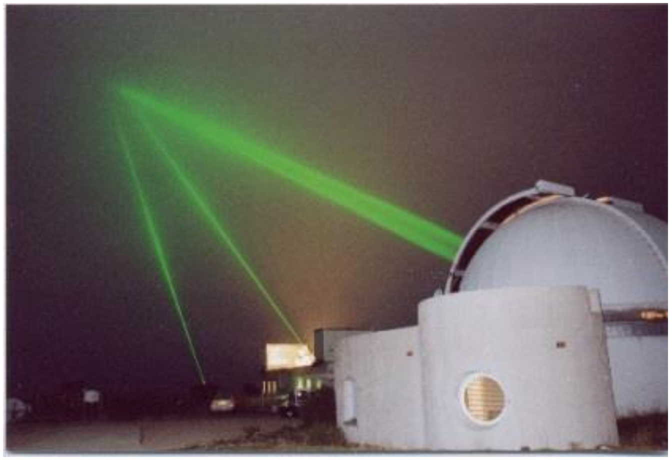
VLBI
(**V**ery **L**ong **B**aseline **I**nterferometry)



DORIS
(**D**oppler **O**rbitography by **R**adiopositioning **I**ntegrated on **S**atellite)

GNSS
(**G**lobal **N**avigation **S**atellite **S**ervice)





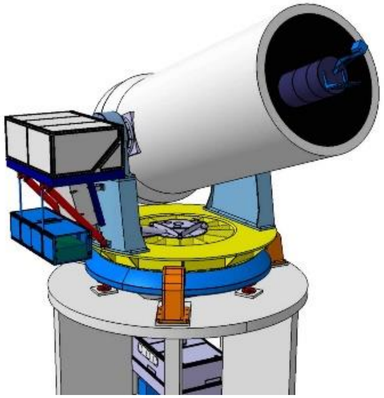
SLR / LLR
(**S**atellite/**L**unar **L**aser **R**anging)

1 – Context : Geodetic observatories.

	Product	VLBI	SLR	GNSS	DORIS
Earth rotation	length of day	XXX	X	XXX	
	movement of pole	XXX	XX	XXX	X
	nutation	XXX		X	
	UT1	XXX			
Terrestrial frame	coverage homogeneity	X	X	XX	XXX
	center of mass		XXX	X	X
	center of figure	XX			
	tectonic movements	XXX	XX	XXX	XXX
	densification		X	XXX	XX
Celestrial frame		XXX			
Gravity field	high wavelengths (statistical)		XXX	XX	X
	short wavelengths (statistical)		XX	XXX	XX
	temporal variations		XX	X	

2 – Calern's multitechnical geodetic observatory :

Co-location site which host three different spatial geodesy technics **:**

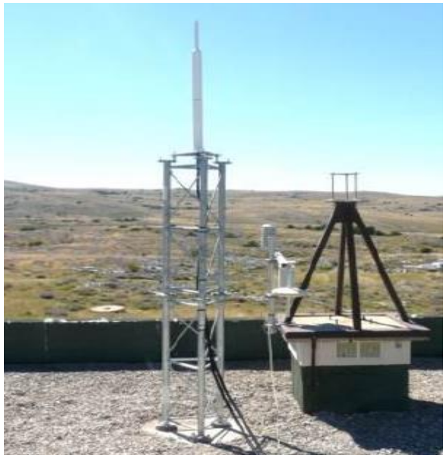


MéO

- → SLR/LLR station (MéO) ;
- → 2 GNSS receivers : GRAC and GRAS ;
- → DORIS beacon : permanent station since september 2018 ;

GRAC

GRAS



DORIS Beacon

2 – Calern’s multitechnical geodetic observatory :

→ Located in south of France, the site was inaugurated in 1974 ;

→ Calcerous plate of 20 km² in the Grasse hinterland :

- ➢ Altitude : 1270m (longitude 6,9230°E ; latitude 43,750° N) ;
- ➢ Good compromise between accessibility (20 km of Grasse) and astronomical quality ;

3 – Improving current station performance :

Various arguments led us to install an InSAR Corner Cube :

→ Local ties : 1x/year, IGN (France) carry out the local ties in our co-location site. But, if there are deformation of soils ? An Insar CC allows to monitor the local stability and ground displacement ;

→ Seasonal hydraulic load : InSAR method demonstrate its very good hability to measure vertical effects (8-9 mm North and Est component) [1]. With an InSAR CC, we can reach a better accuracy ;

→ Tide gauges : an InSAR CC can improve the measure for a tide gauge near from the coast and who can't be equipped with a GNSS receiver [2] ;

→ Global Geodetic Observing System (GGOS) : millimetric accuracy, and stability better than 0,1mm/year ;

[1] : Multi-geodetic characterization of the seasonal signal at the CERGA geodetic reference station, France (A. Memin and al, EGU, 2017) ;

[2] : Calibrating the SAR SSH of Sentinel-3A and CryoSat-2 over the Corsica Facilities (P. Bonnefond and al, Remote Sensing, 2018) ;

4 – Advantages of a Corner Cube (CC) :

→ CC is a passive instrument (doesn't need any energy) ;

→ ESA provides freely SAR images from Sentinel 1A & 1B (Copernicus program) ;

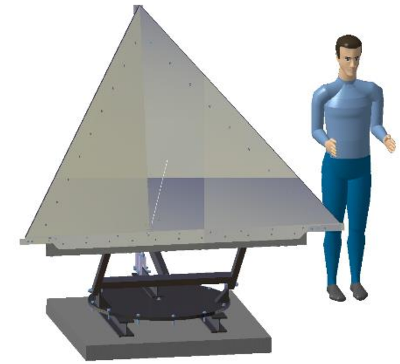
→ SAR images acquired day and night, at all weather (C-band) ;

→ Monitoring the local stability, and ground displacement in our co-location site ;

→ Monitoring the seasonnal hydraulic load in our site, with a better accuracy ;

A corner reflector represents an identifiable physical point scatter, exhibiting a strong signal in radar images with a stable phase through time, allowing a good precision of displacement measurement.

5 – Design of the Corner Cube :



→ To measure displacement < 0,5mm in C-band :
CR side length = 1,5m (hypotenuse side = 2,12m) [3] ;

→ To resist to the wind up to 150km/h : thickness = 8mm ;

→ To maximize the signal backscaterred :

- Flatness default (plate) < 0,75mm ;
- Perpendicularity default (plates between them) < 2mm ,

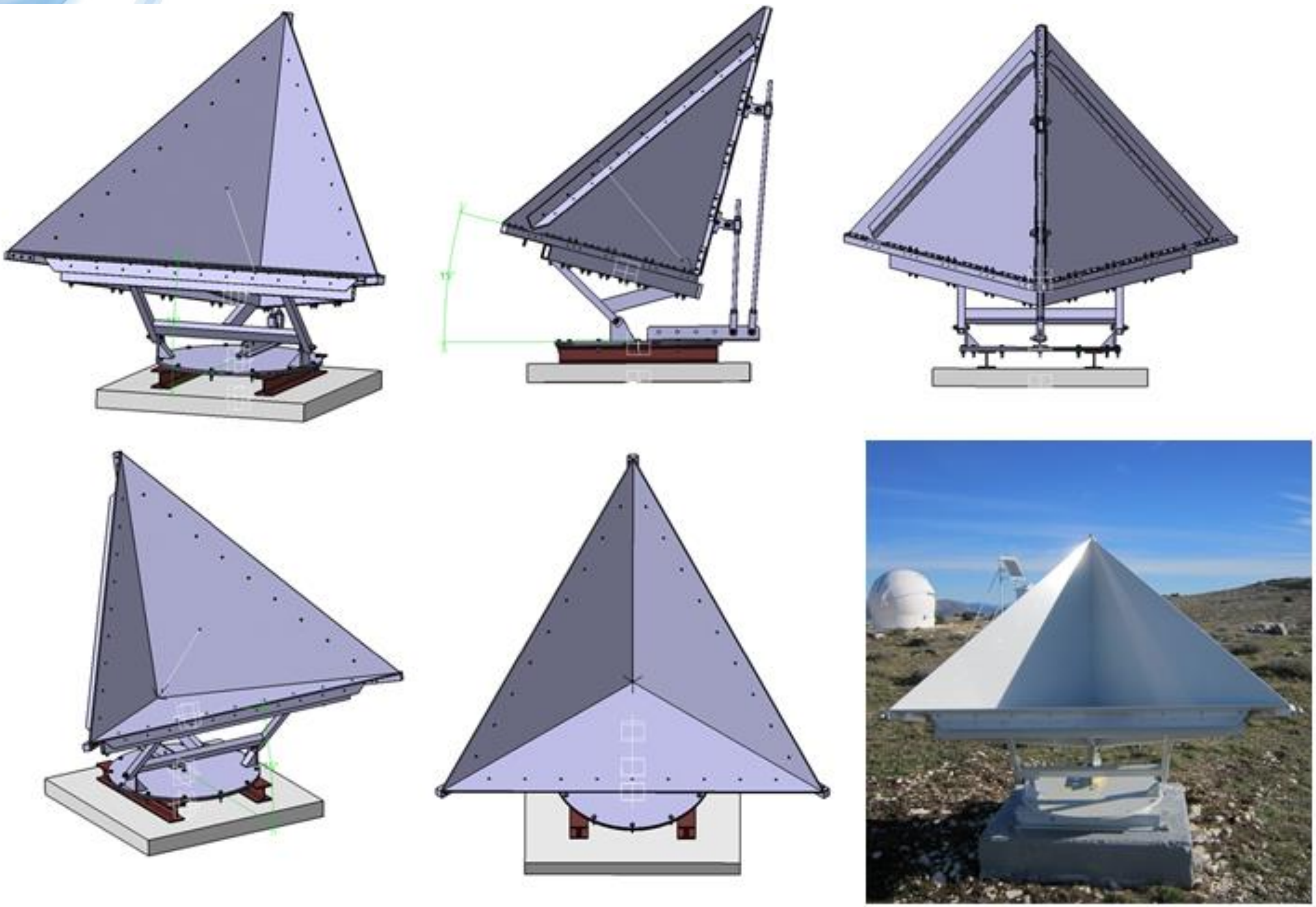
→ Plate materiel : aluminium, powdercoated (grey color) ;

→ Orientable in azimut and elevation ;

→ Fixed on a 1m x 1m concrete slab (totally hidden by the CC to prevent additional reflection) ;

[3] : The Design of Radar Corner Reflectors for the Australian Geophysical Observing System. A single design suitable for InSAR deformation monitoring and SAR calibration at multiple microwave frequency bands (Garthwaite and al, Geoscience Australia record, 2015/03, 2015b) ;

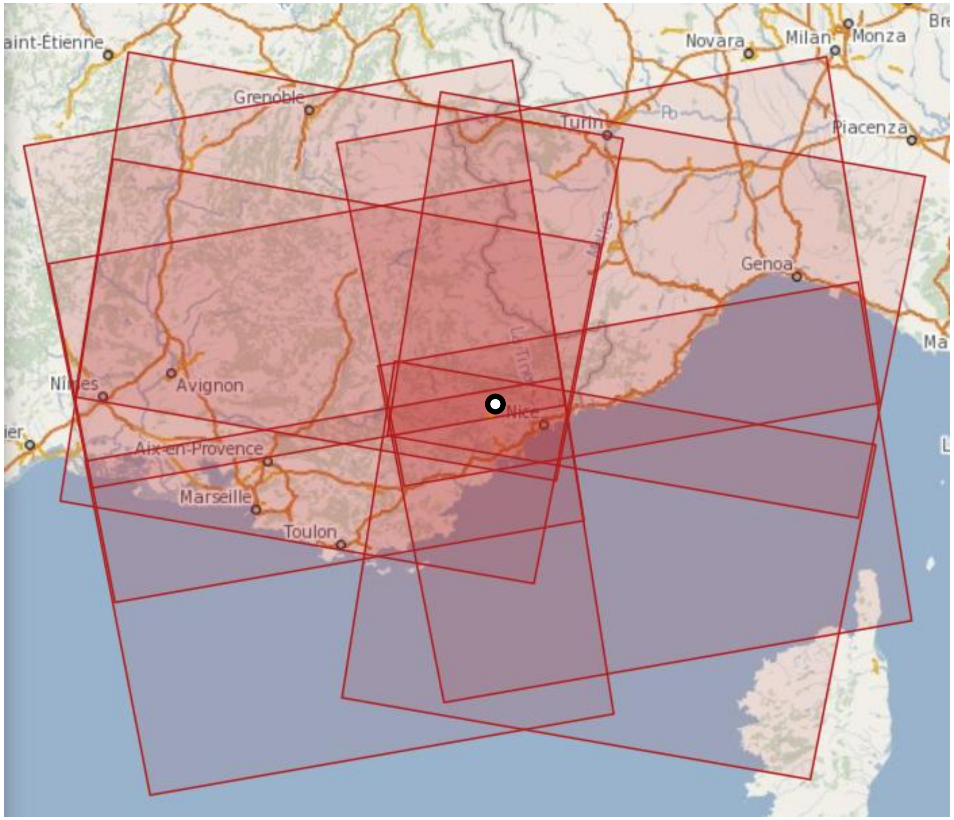
5 – Design of the Corner Cube :



6 – Sentinel 1A et 1B :

→ Calern site is visible by S1A and S1B from 4 distinct relative orbits :

- 2 ascending (88, 161) and 2 descending (66, 139) ;
- With a time revisit of 6 days ;
- Provides 5 images for S1A, and 4 images for S1B ;



https://scihub.copernicus.eu/dhus/#/home

7 – Site selection and validation :

The choice of the site, different constraints must be followed [4] :

→ Clear sky visibility toward East and West ;

→ No additionnal multipath for GNSS stations, or DORIS station ;

→ Low radar backscatter signal prior the installation ;

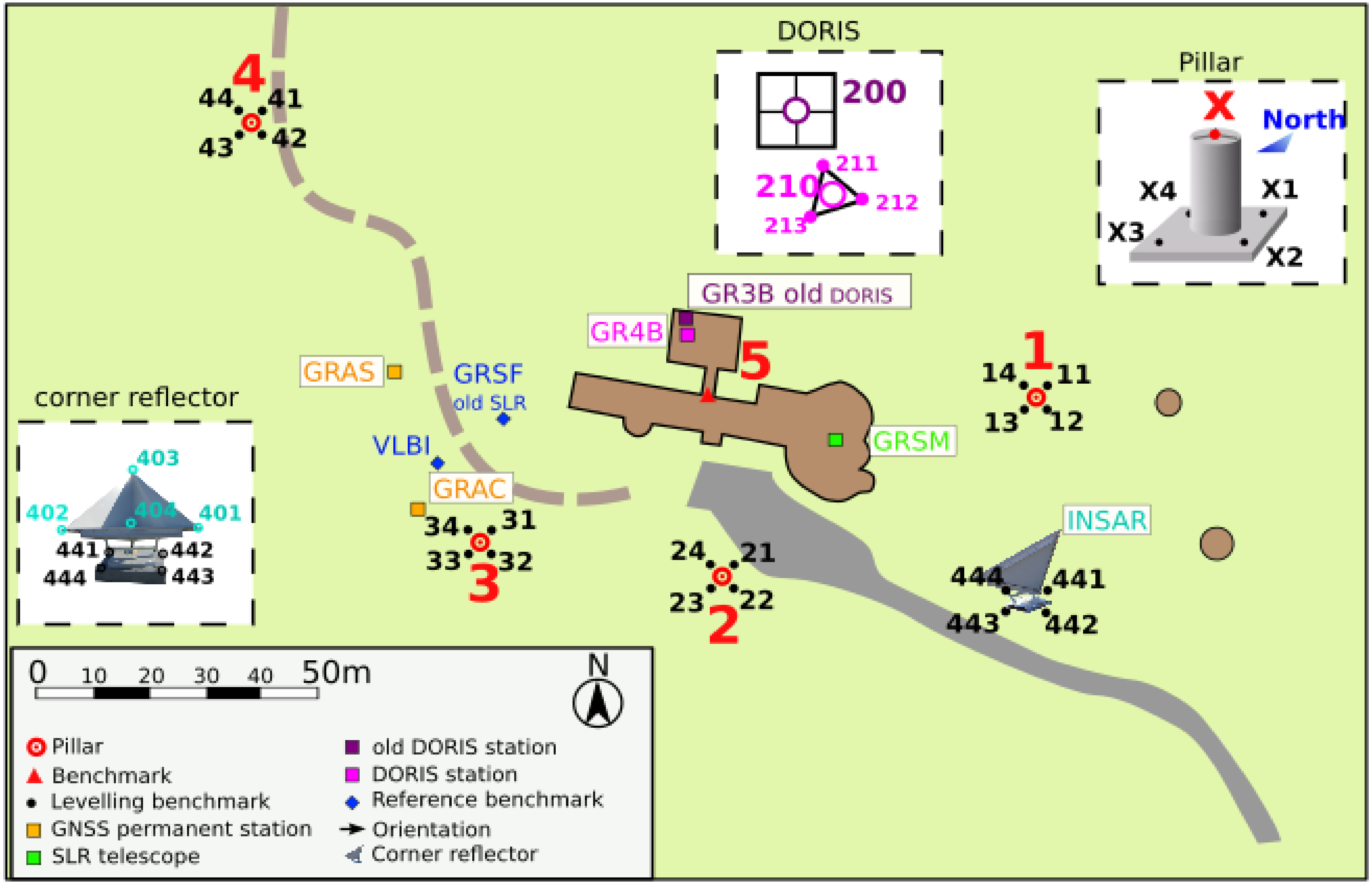
After a test phase (summer 2018) in differente locations, regarding the different Sentinel-1 orbits, we have choose the one which is close to the CATS stations :

→ Located at 100m from the closest GNSS station ;

→ 70m from the DORIS station ;

[4] : Practical Considerations before Installing Ground-Based Geodetic Infrastructure for Integrated InSAR and cGNSS Monitoring of Vertical Land Motion (Parker and al, Sensors 2017) ;

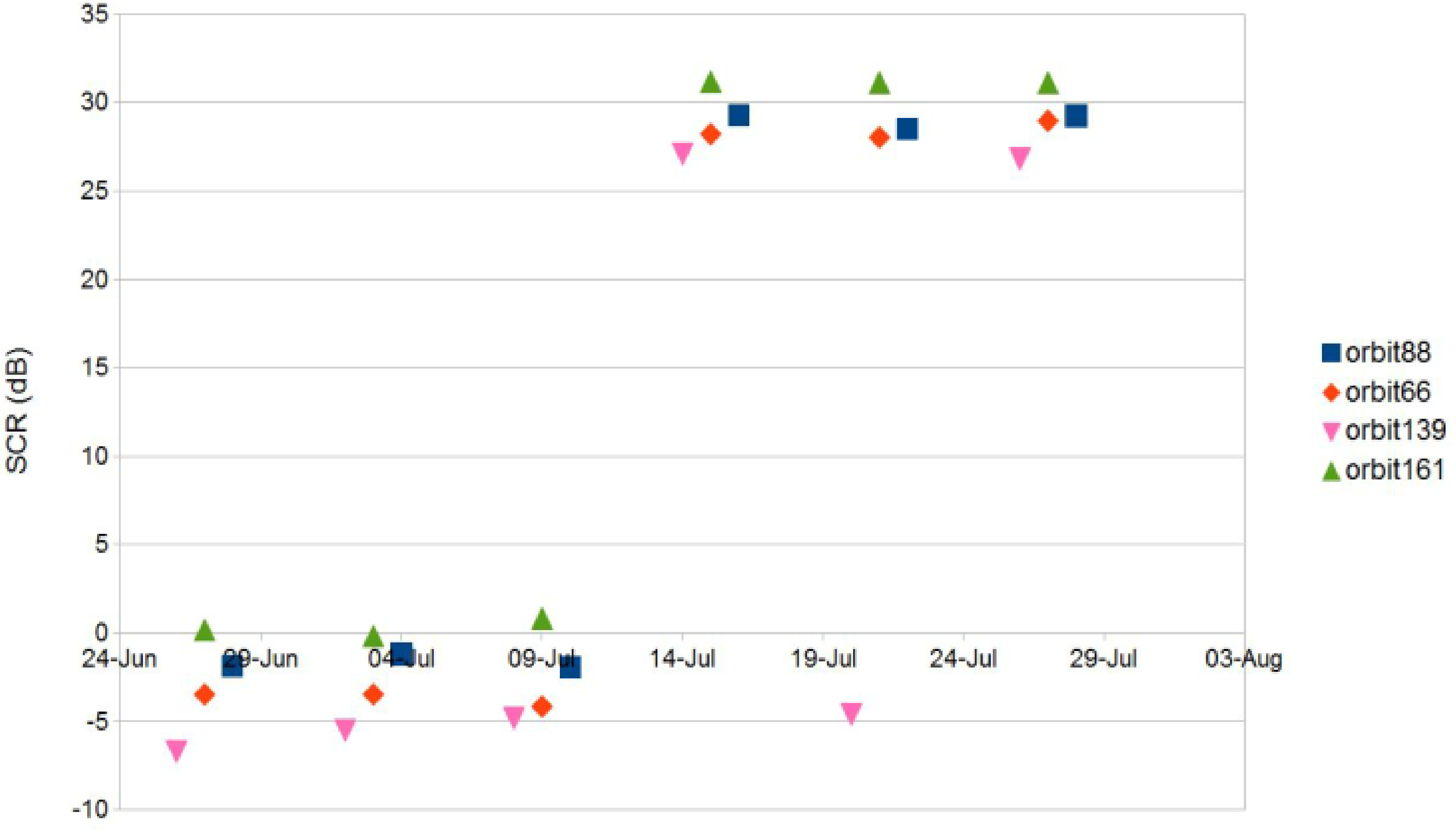
7 – Site selection and validation :



Map of Calern geodetic observatory and it geodetic benchmarks.

7 – Site selection and validation :

SCR before/after the installation of the CC.



7 – Site selection and validation :

→ These results validate our choice of location for the CC (close to the CATS stations) ;

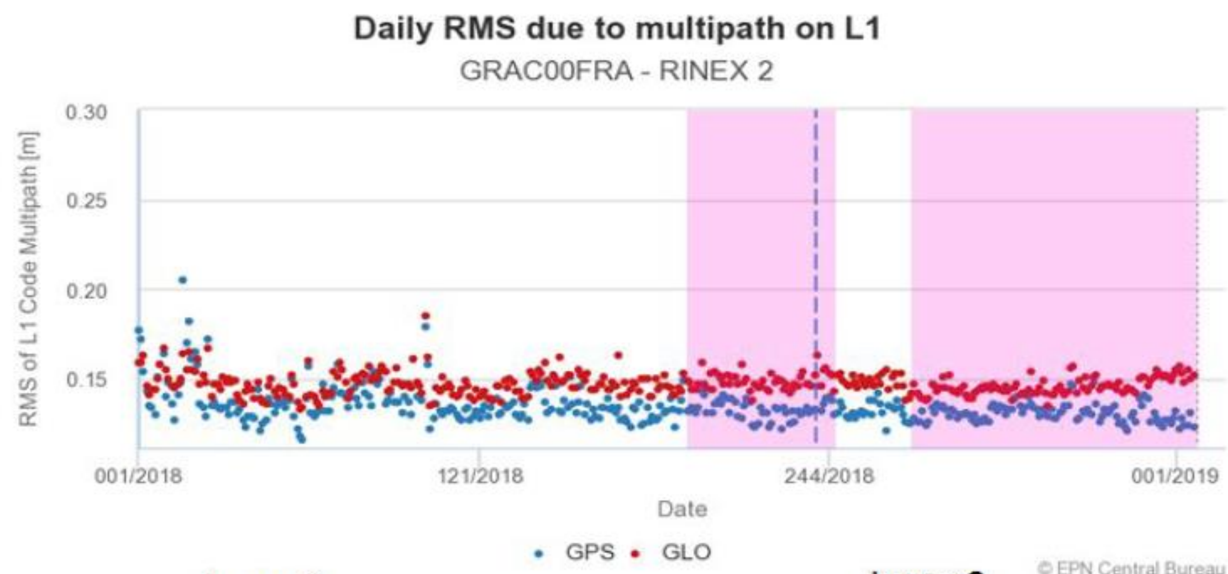
→ We decided to keep the CC toward the relative orbit 88. Its small incidence angle (35°) makes InSAR more sensitive to the vertical component of the deformation ;

→ The CC was defenitively anchored on its concrete slab, the 3rd December 2018 ;

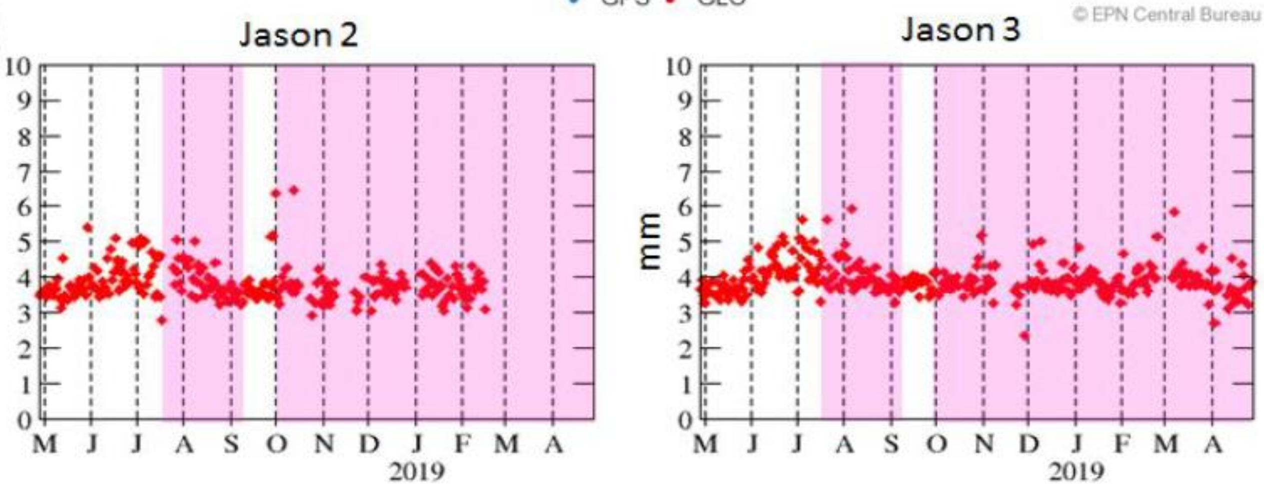
8 – Impact on GNSS and DORIS stations :

→ There is no multipath impact on GNSS permanent stations (a), and the DORIS permanent station (a) ;

a)



b)



Conclusion :

→ We have installed a permanent CC, new geodetic instrument, at the Calern Geodetic Observatory ;

→ No multipath impact on GNSS and DORIS stations ;

→ The SCR > 27dB ➔ theoritical measurement precision of 0,1 mm ;

→ It will be surveyed regularly to monitor its stability ;

→ The CR designed to be versatil : it can be oriented toward differents satellites orbits ;

Acknowledgment :

→ PN GRAM, BQR OCA, BQR GEOAZUR wich funded the CR ;

→ S2M (OCA) for the design, the manufacture, and the implementation ;

Collilieux X., C. Courde, B. Fruneau, M. Aimar, G. Schmidt, I. Delprat, D. Pesce, F. Bergerault, P. Cumerlato and G. Wöppelmann (2019) Validation of a Corner Reflector installation at OCA multi-technique geodetic Observatory, Journal of Applied Geodesy, submitted.