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InSAR Corner Cube at GRSM.

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

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

Title : InSAR Corner Cube at GRSM.

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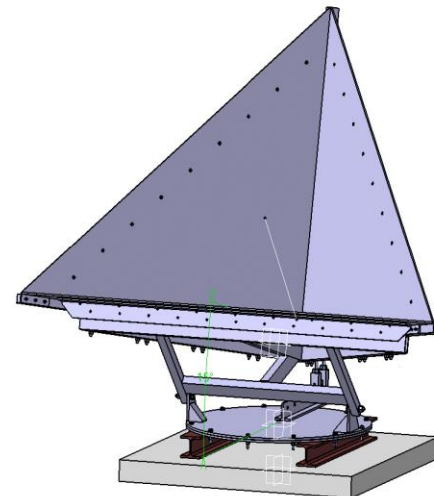
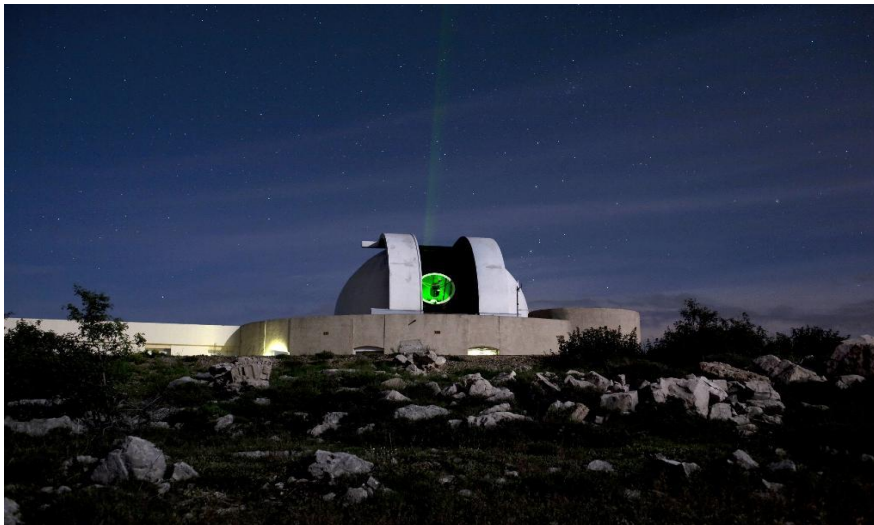
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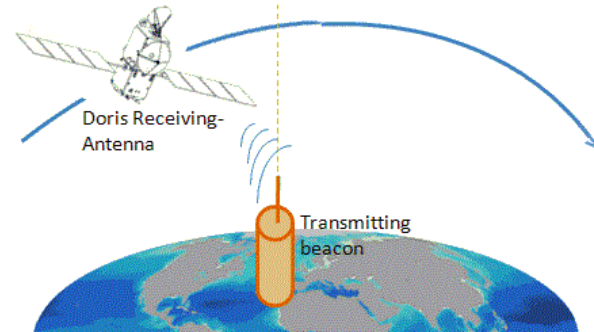
⁶ Laboratoire L.E.S., UMR7266 – Univ La Rochelle and CNRS, La Rochelle, France.



1 – Context : Geodetic observatories.

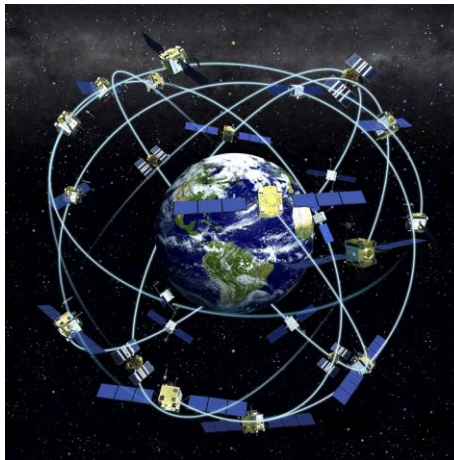
A geodetic observatory consists of four technics :

VLBI
(Very Long
Baseline
Interferometry)



DORIS
(Doppler Orbitography by Radiopositioning
Integrated on Satellite)

GNSS
(Global Navigation
Satellite Service)



SLR / LLR
(Satellite/Lunar
Laser Ranging)

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

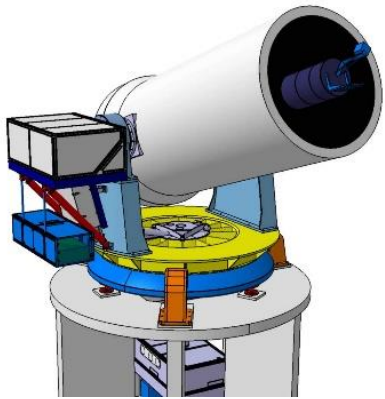
Celestial frame		XXX			
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Gravity field	high wavelengths (statistical)		XXX	XX	X
	short wavelengths (statistical)		XX	XXX	XX
	temporal variations		XX	X	

2 – Calern's multitechnical geodetic observatory :

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

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



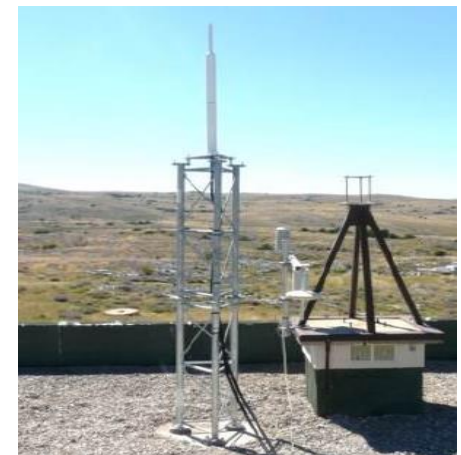
MéO



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) :

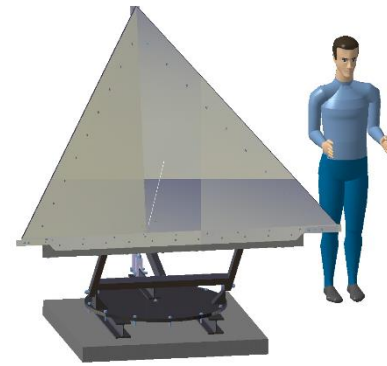
- CC is a passive instrument (doesn't need any energy) ;
- ESA provides freely SAR images from Sentinel 1A & 1B (Copernicus program) ;
- SAR images acquired day and night, at all weather (C-band) ;
- Monitoring the local stability, and ground displacement in our co-location site ;
- Monitoring the seasonal 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.



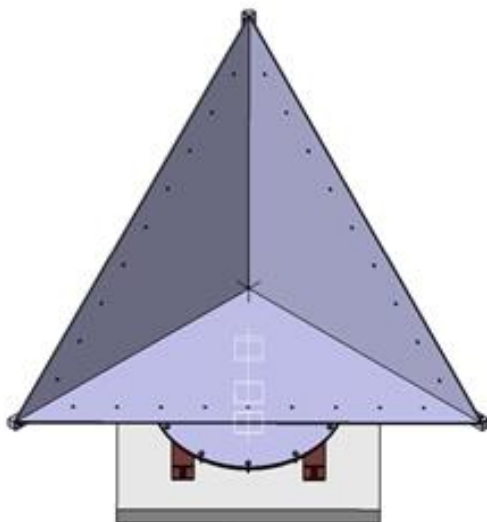
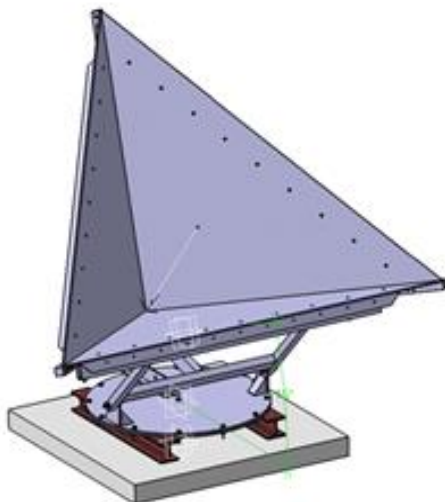
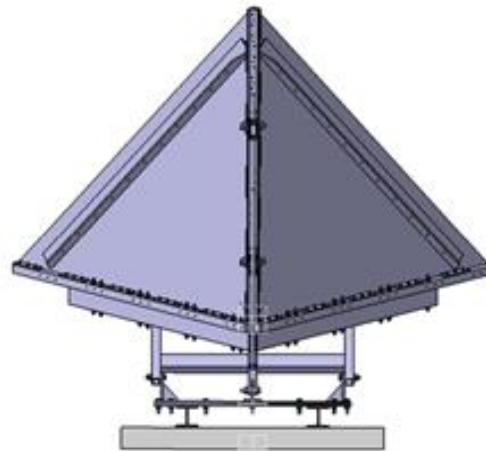
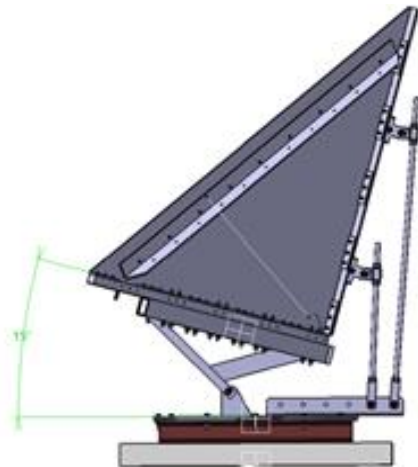
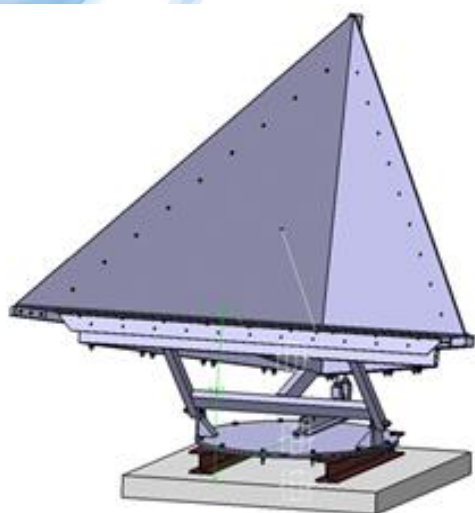
5 – Design of the Corner Cube :

- To measure displacement $< 0,5\text{mm}$ in C-band :
CR side length = $1,5\text{m}$ (hypotenuse side = $2,12\text{m}$) ^[3] ;
- To resist to the wind up to 150km/h : thickness = 8mm ;
- To maximize the signal backscattered :
 - Flatness default (plate) $< 0,75\text{mm}$;
 - Perpendicularity default (plates between them) $< 2\text{mm}$,
- Plate materiel : aluminium, powdercoated (grey color) ;
- Orientable in azimuth and elevation ;
- Fixed on a $1\text{m} \times 1\text{m}$ concrete slab (totally hidden by the CC to prevent additional reflection) ;



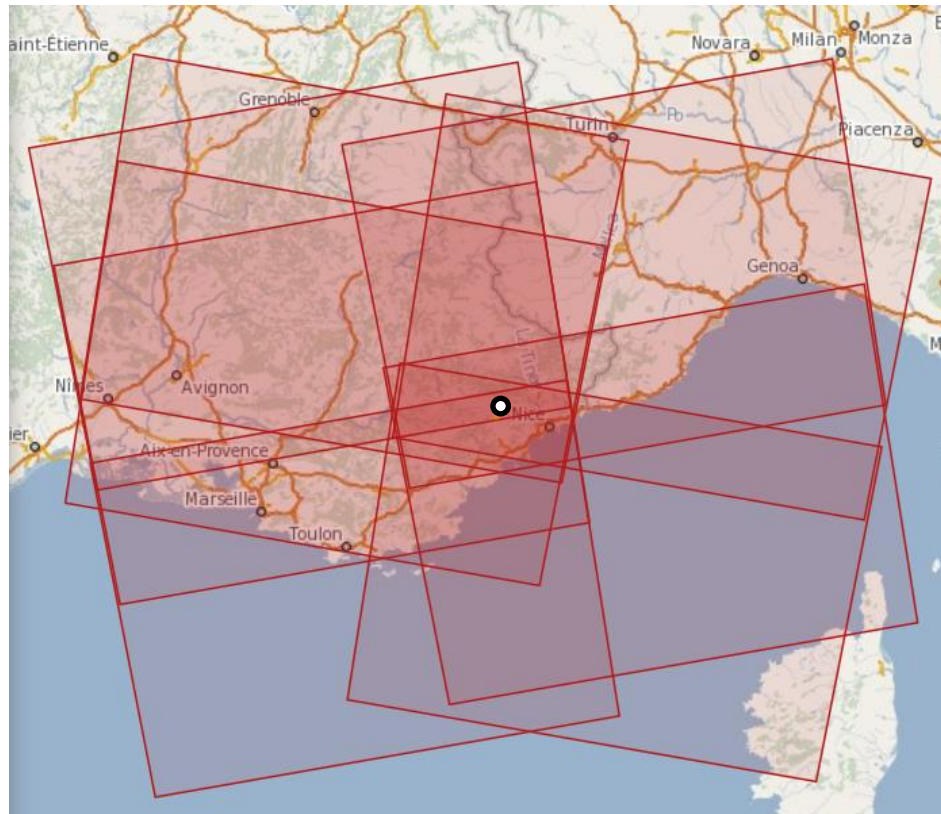
[3] : The Design of Radar Corner Reflectors for the Australian Geophysical Observing System. A single design suitable for InSAR deformation monitoring and SAR calibration at multiple microwave frequency bands (Garthwaite and al, Geoscience Australia record, 2015/03, 2015b) ;

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] :

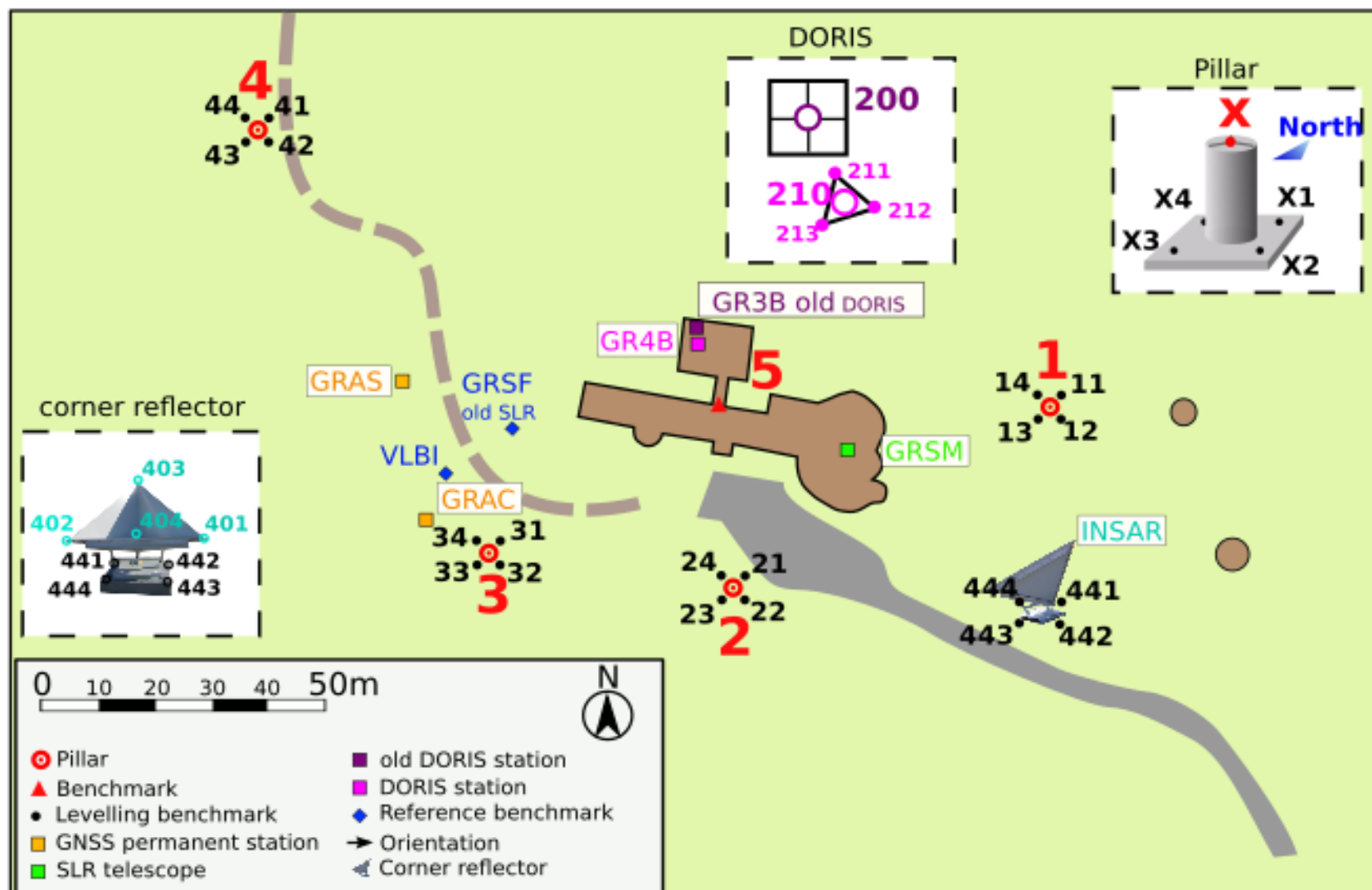
- Clear sky visibility toward East and West ;
- No additionnal multipath for GNSS stations, or DORIS station ;
- Low radar backscatter signal prior the installation ;

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 :

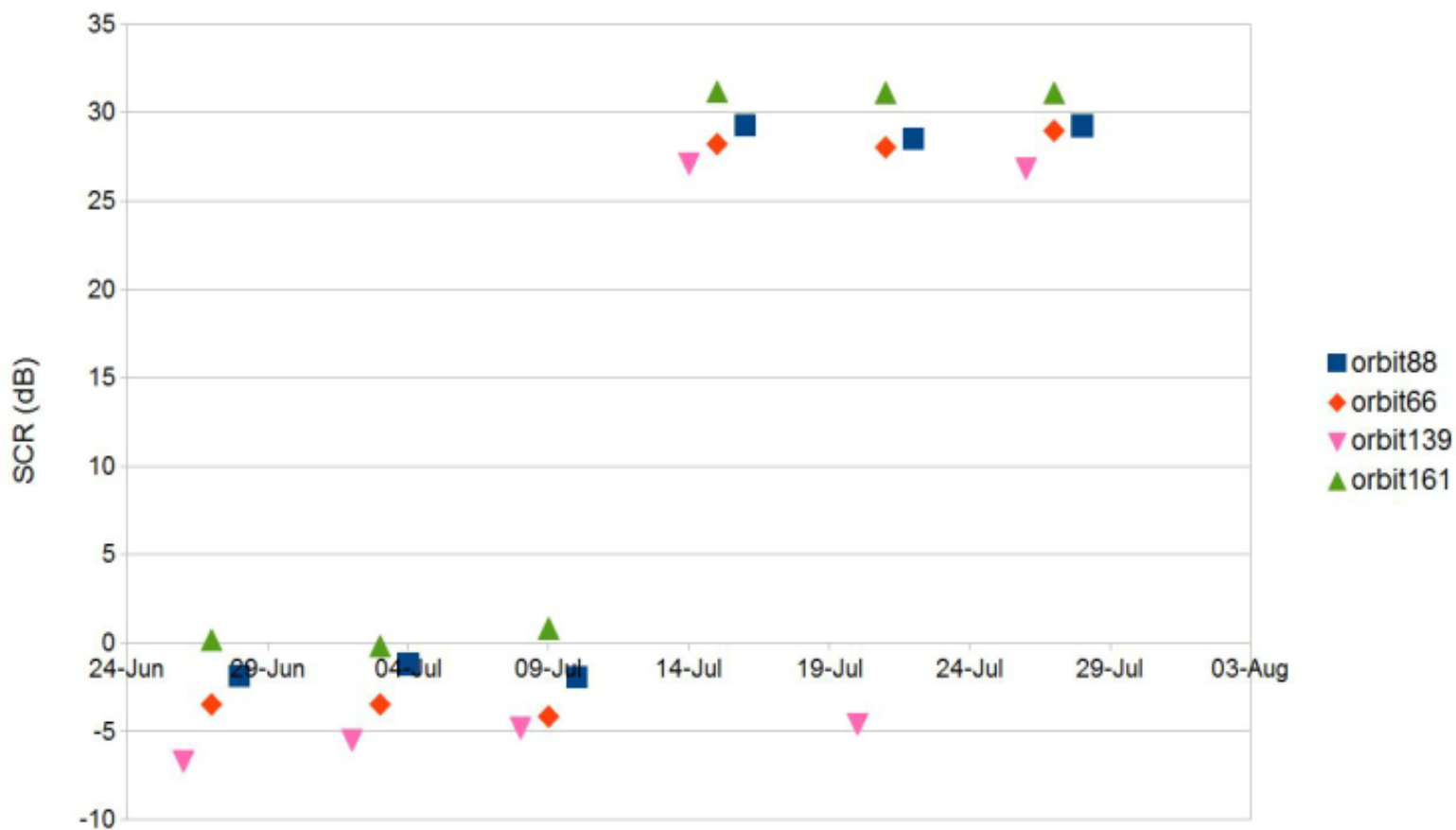


Map of Calern geodetic observatory and its geodetic benchmarks.



7 – Site selection and validation :

SCR before/after the installation of the CC.





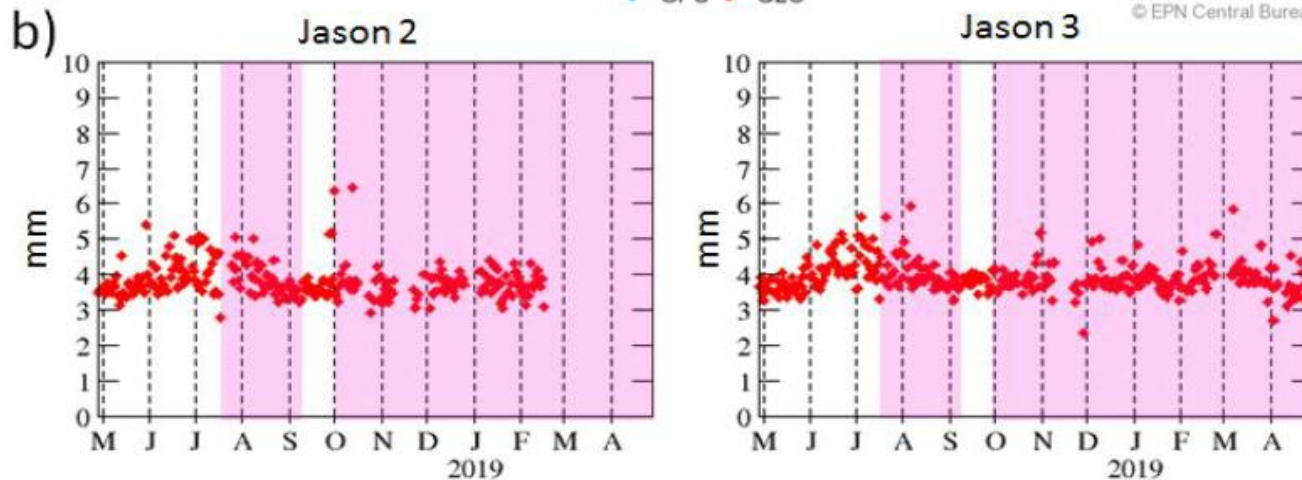
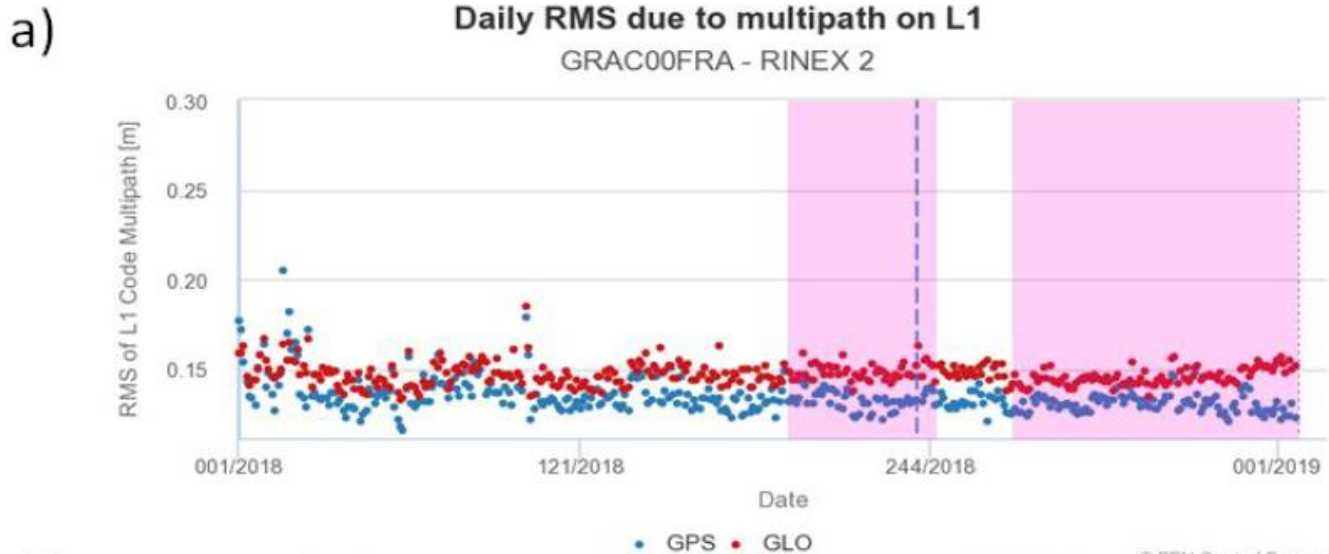
7 – Site selection and validation :

- 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 definitively 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) ;





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 → theoretical 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 ;

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- 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.