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Deformation Monitoring with Terrestrial SAR Interferometry



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1

Content

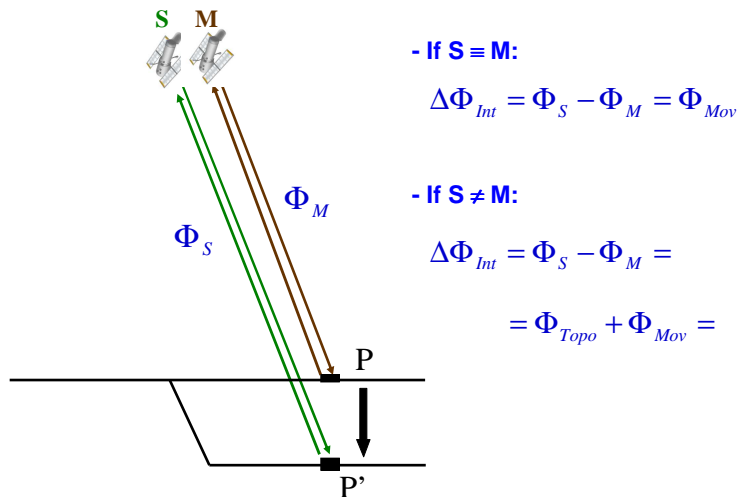
- ❑ Introduction:
 - Satellite-based SAR interferometry

- ❑ Ground-based SAR:
 - Fundamentals
 - Data acquisition characteristics

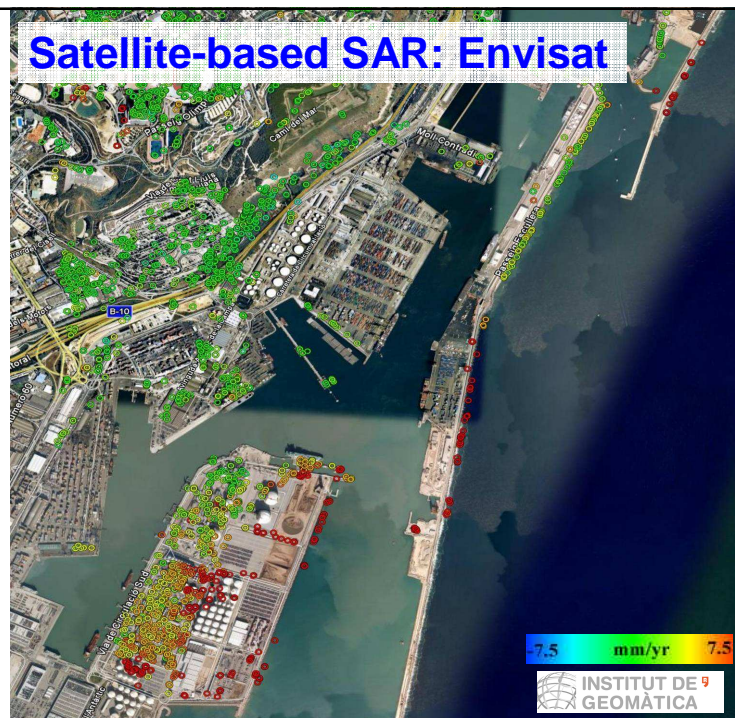
- ❑ Examples of monitoring campaigns

- ❑ Real-aperture-radar

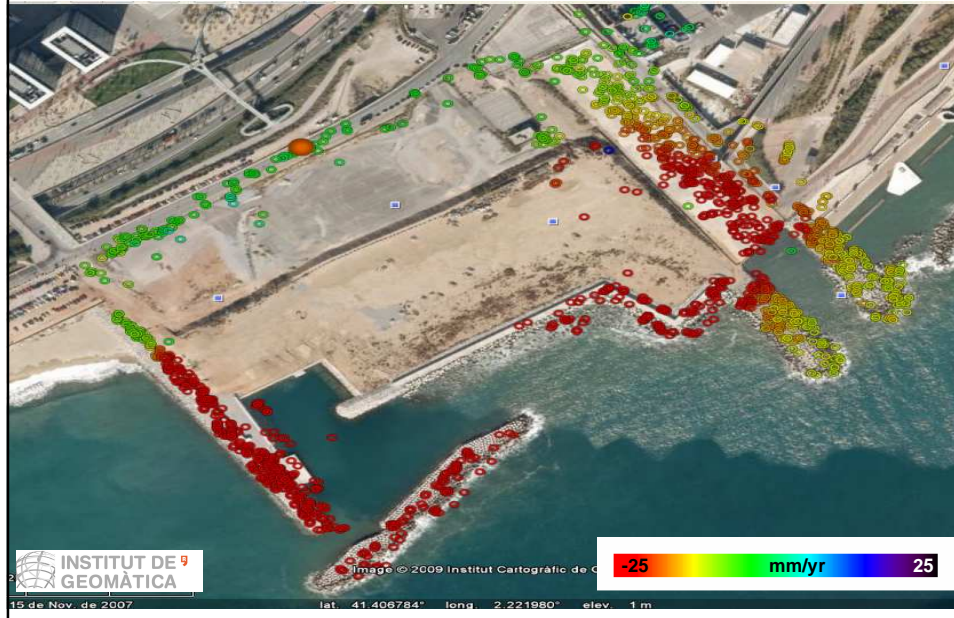
Satellite-based SAR interferometry



Satellite-based SAR: Envisat



Satellite-based SAR: TerraSAR-X

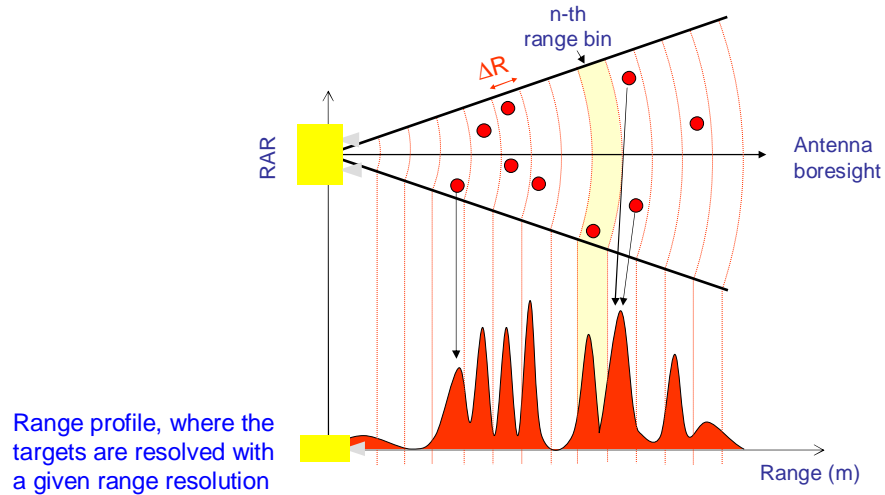


Ground-based SAR

□ Key characteristics:

- It's a radar-based imaging sensor
- Range resolution
- Cross-range resolution - SAR
- Coherent radar
- Interferometric capabilities

GBSAR: range resolution

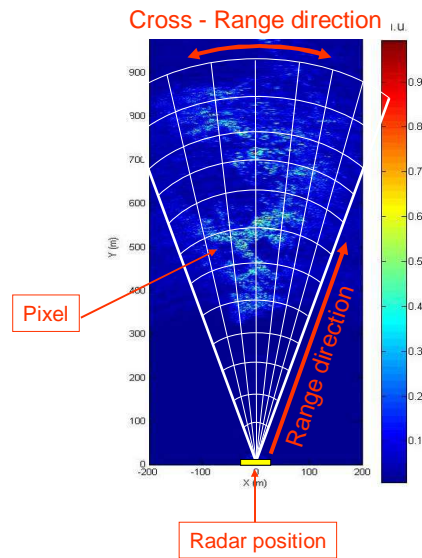


Cross-range resolution: SAR

- The Synthetic Aperture Radar technique enables us to get high cross-range resolution exploiting the movement of the antenna
- The SAR processing of the data collected during the sensor movement of 2 m allows the system to get a cross-resolution of:

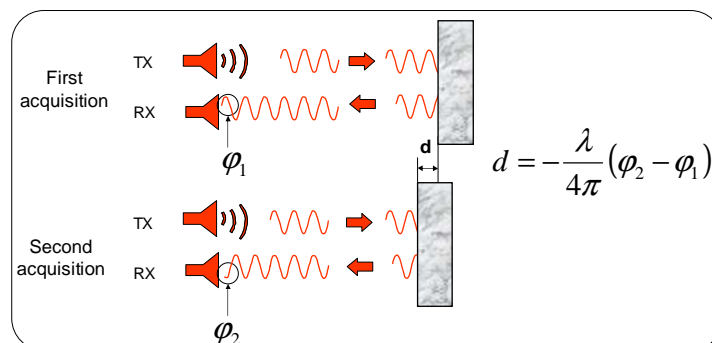
$$\Delta\phi = \frac{\lambda}{2 \cdot L} = 4.3 \text{ mrad}$$



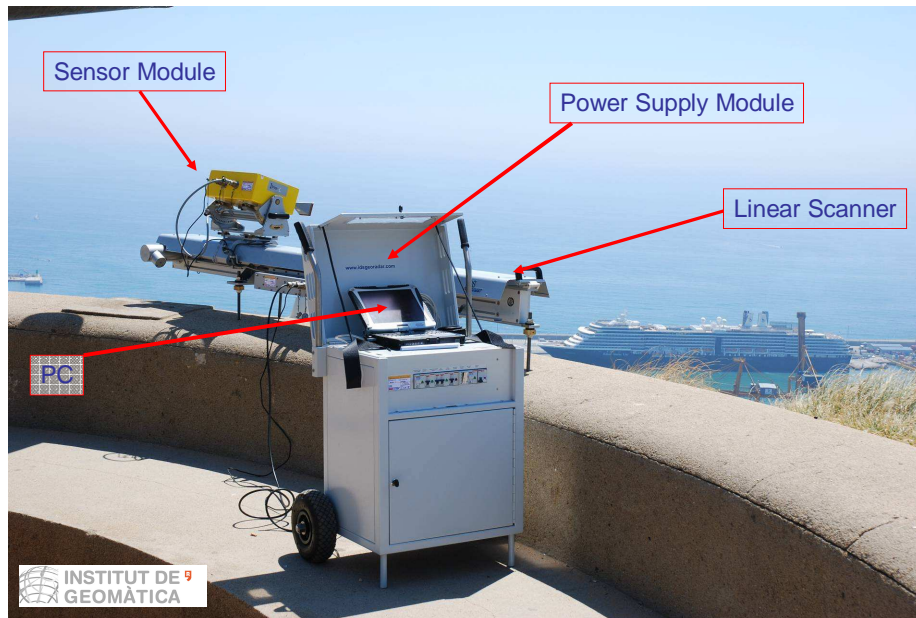


Interferometric phase

- We exploit the phase of the signal.
- In particular, we exploit the difference of phase measured in two or more acquisitions.

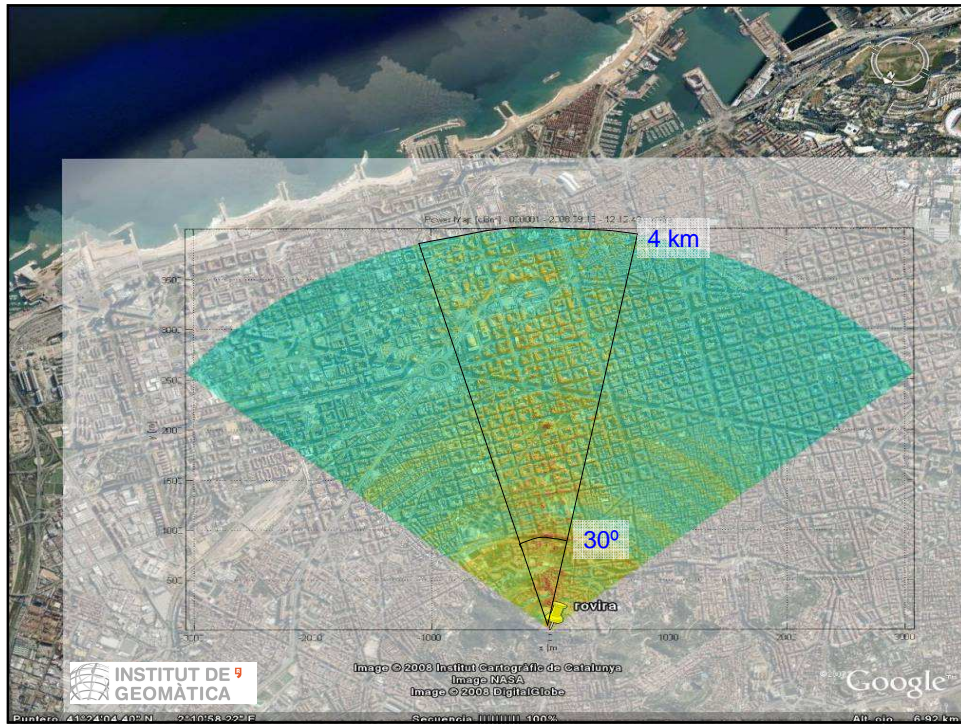


Hardware: example of IBIS-L



GB-SAR – data acquisition

- ☐ Robust, day/night, all weather. High degree of automation
- ☐ Range capabilities: 3-4 km
- ☐ Intrinsically precise: mm, sub-mm
- ☐ Resolution:
 - ex. Ku-band: $\Delta\text{range} = 0.5 \text{ m}$; $\Delta\text{cross-range} = 0.0044 \text{ rad}$
- ☐ Nominal coverage:
 - ex. Ku-band: 30-40°
- ☐ Line-of-sight measurement
- ☐ Heavy instrument



Deformation monitoring example: Formigal landslide (Pyrenees)

Formigal landslide (Spanish Pyrenees)

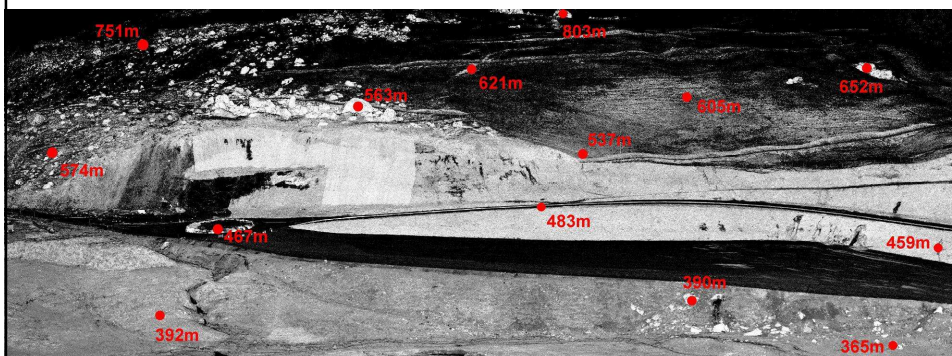


- 3 TLS campaigns: July 06, October 06, June 07
- 1 continuous GBSAR campaign: October-November 06
- Several topographic campaigns: total station & D-GPS



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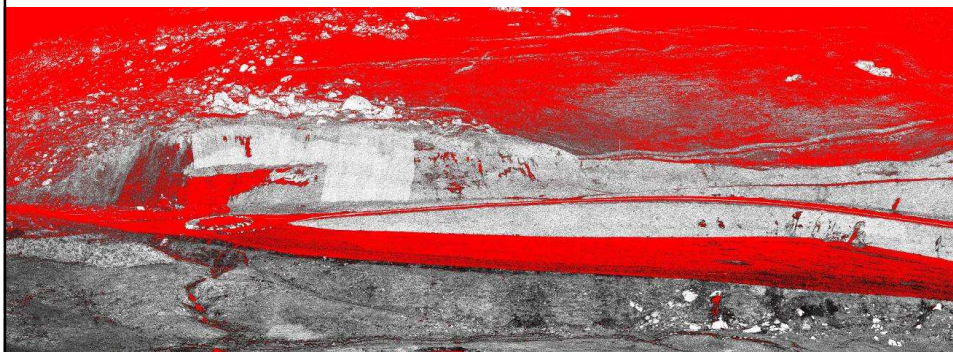
TLS data coverage: Formigal Test Site



July scan intensity image (4-07-2006)



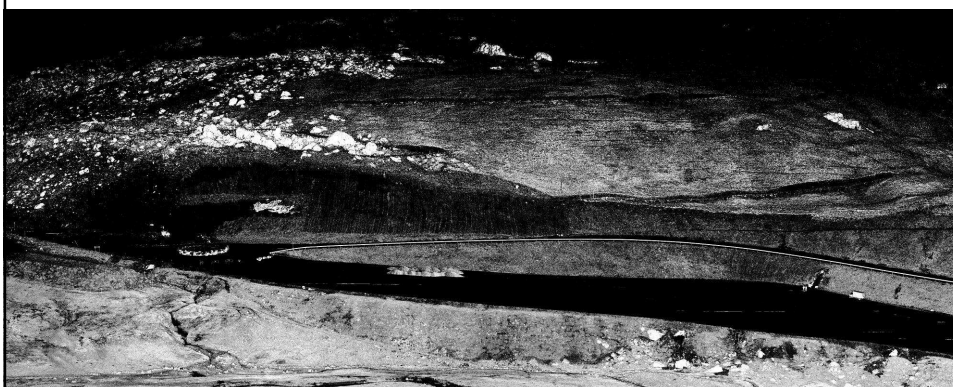
TLS data coverage: Formigal Test Site



July scan intensity image (4-07-2006)

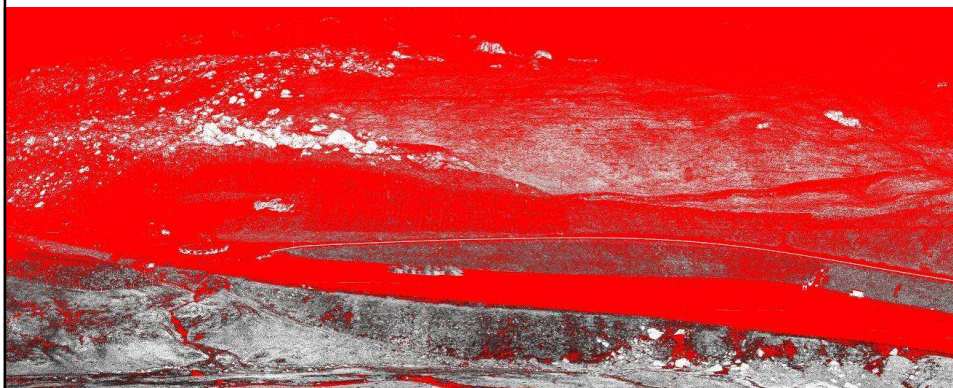
Good point = 60% of total

TLS data coverage: Formigal Test Site



October scan intensity image (5-10-2006)

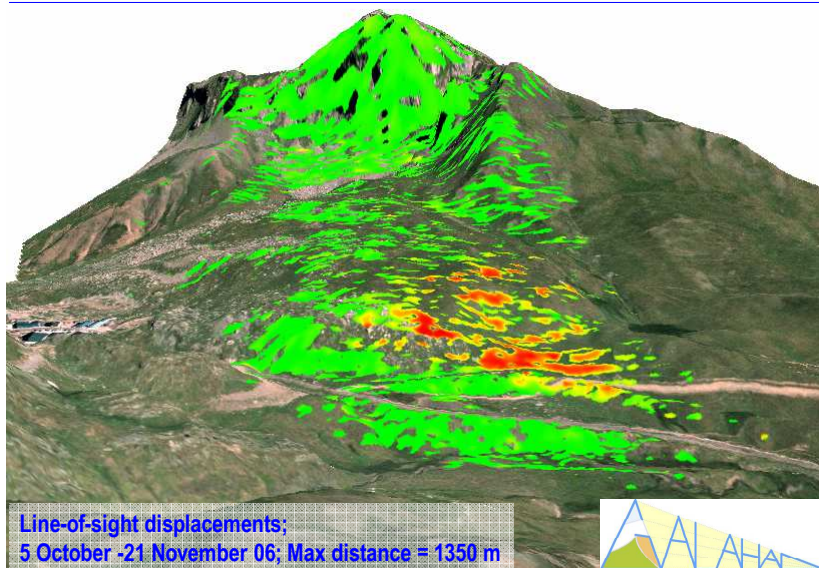
TLS data coverage: Formigal Test Site



October scan intensity image (5-10-2006)

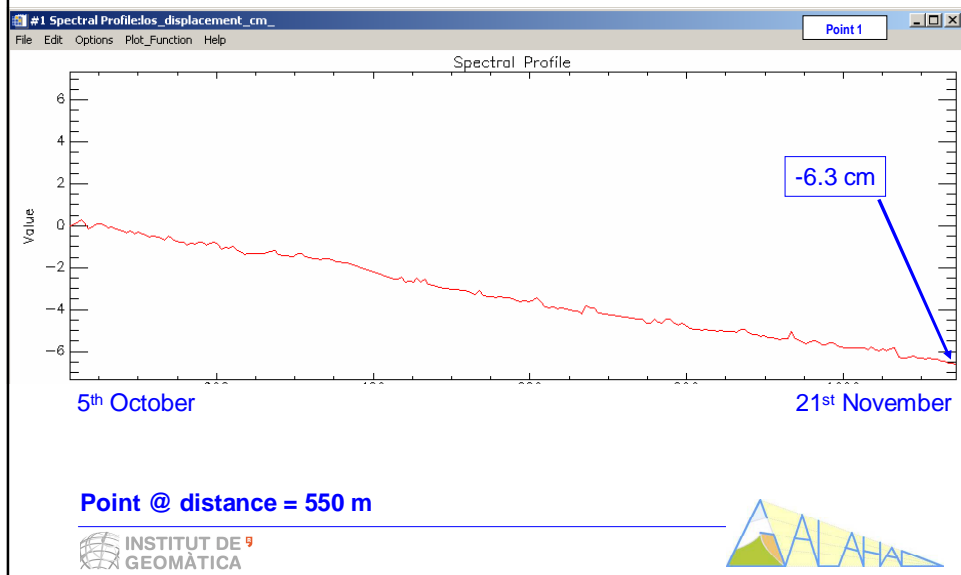
Good point = 36% of total

GB-SAR



Line-of-sight displacements,
5 October -21 November 06; Max distance = 1350 m

GB-SAR



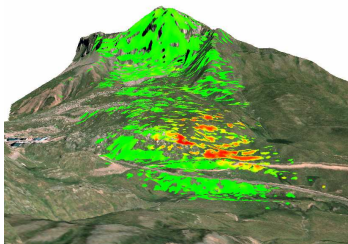
Technical issues
coherence over time

GBSAR – coherence

Continuous GBSAR acquisition

5 October – 21 November 2006

Coherence threshold = 0.9



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GBSAR – coherence

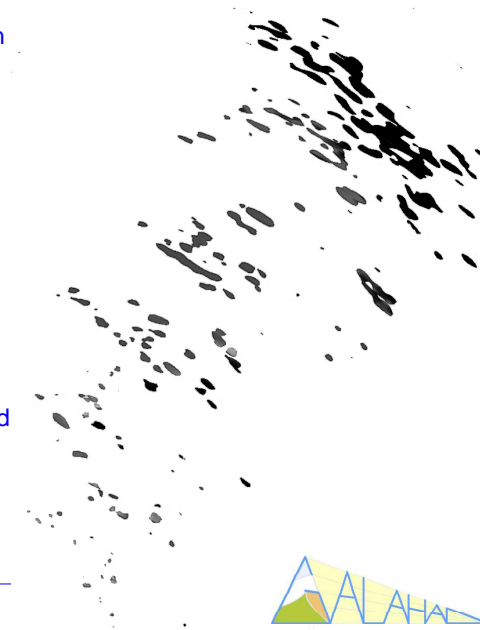
Non-continuous GBSAR acquisition

5 October – 21 November 2006

Coherence threshold = 0.9

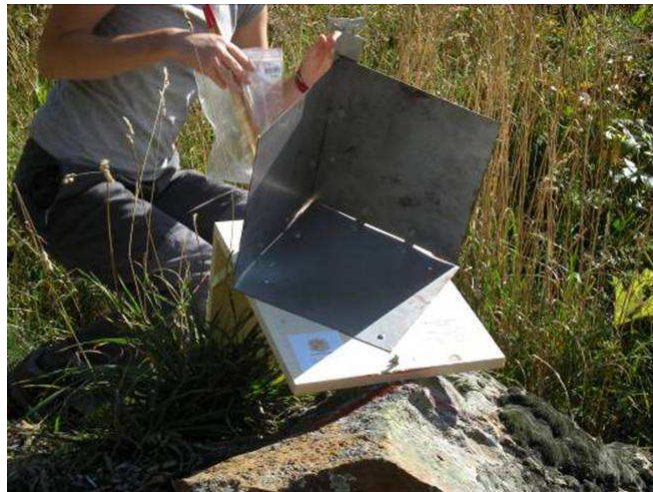
- ☐ The spatial sampling density and coverage are reduced
- ☐ The monitoring feasibility has to be assessed on each site

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Artificial Reflectors

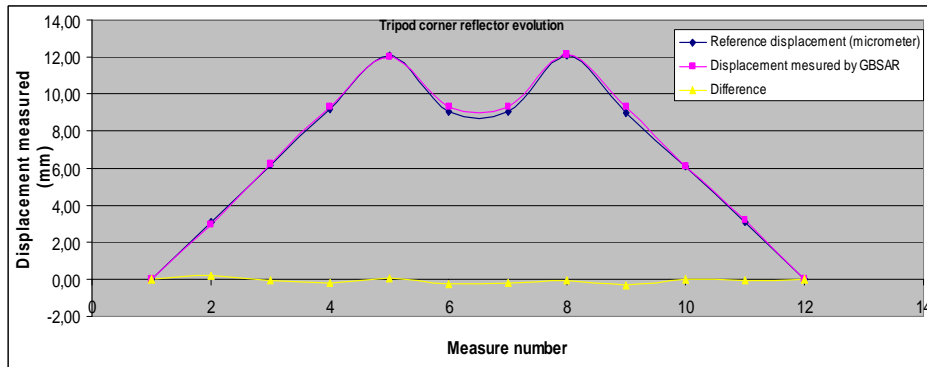
Reflector artificial (triedre)



Technical issue: validation

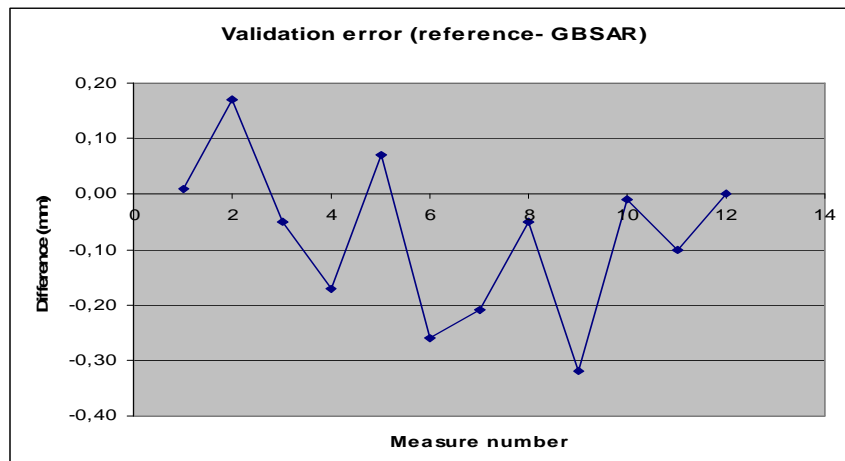


Validation



Sensor to target distance = 44 m

Validation



Sensor to target distance = 44 m

Measurements not corrected for (linear) atmospheric effects

Real Aperture Radar (RAR)

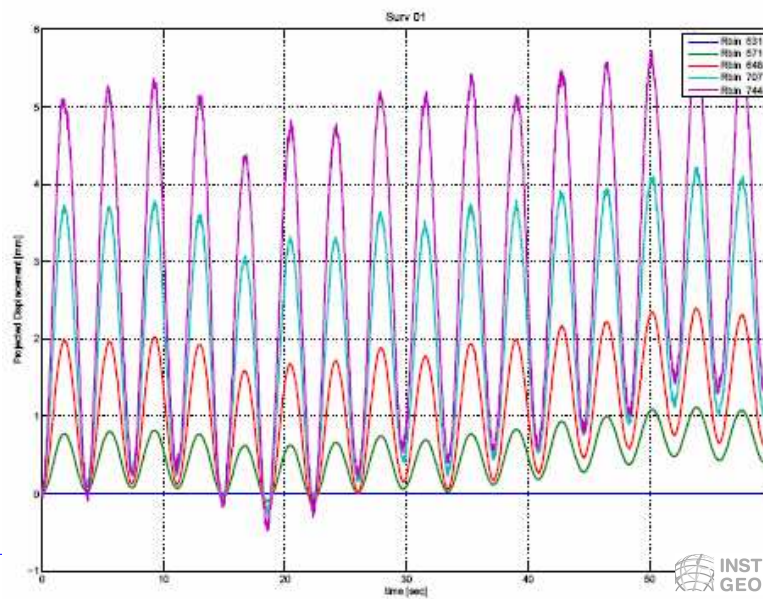


RAR

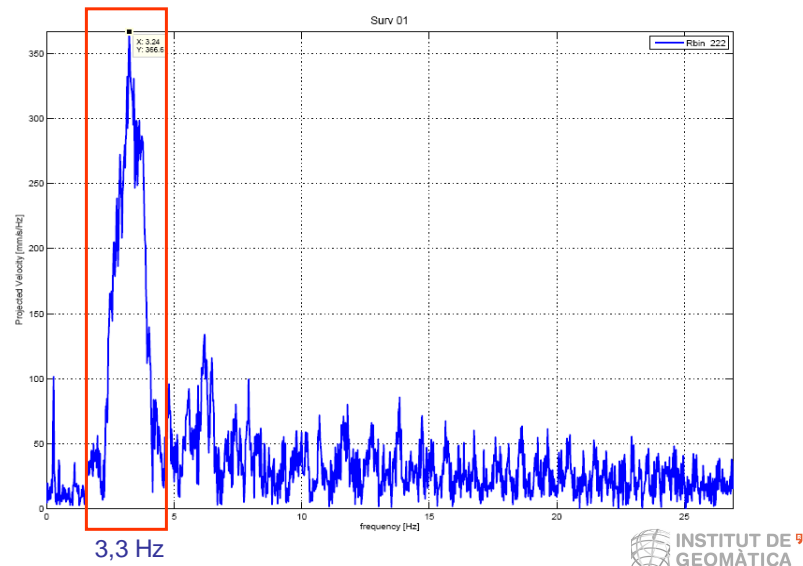
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RAR



RAR



RAR: Cadore bridge



RAR: Cadore bridge

Spectral analysis

