

FIG

FIG WORKING WEEK 2017

Helsinki Finland

29 May - 2 June 2017

Presented at the FIG Working Week 2017,
May 29 - June 2, 2017 in Helsinki, Finland

Exploring new solutions for large areas and long linear structures monitoring INSAR from satellites LIDAR from UAV

Rémy BOUDON – EDF France

Surveying the world of tomorrow -
From digitalisation to augmented reality

Organised by



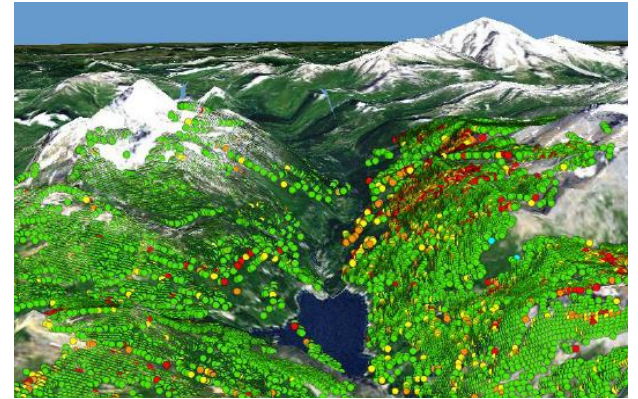
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2 presentations

- **INSAR**

- ▶ Evaluation of the potential of this technology for the monitoring of structures: dams, dikes, industrial sites, landslides...



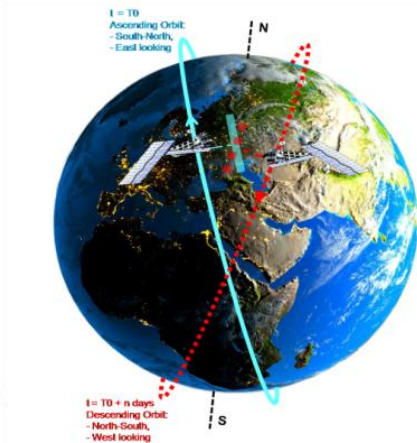
- **LIDAR**

- ▶ Developments of a fit for purpose UAS for the monitoring of long linear of dikes

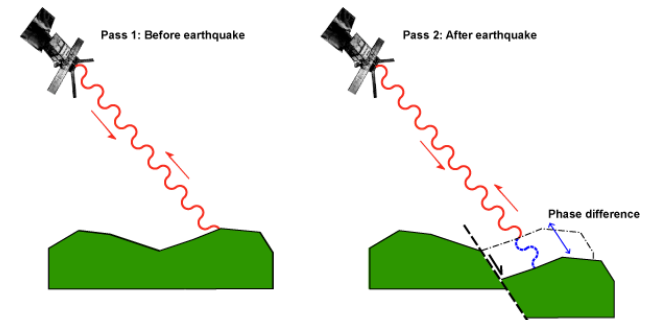
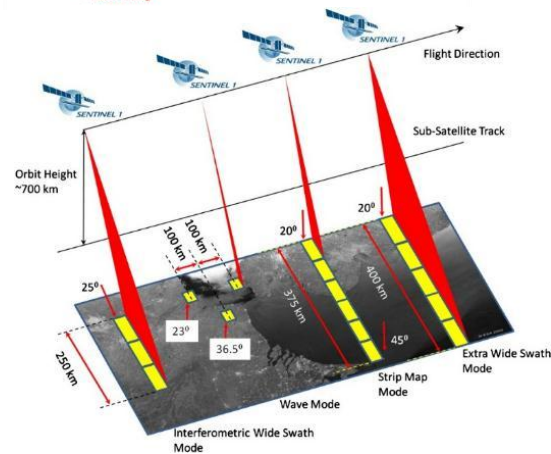


Exploring INSAR from satellites

- Studies with various leading companies in the field
- PhD Thesis in partnership with a research lab



	1992-2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024		
Japon	JERS-1		ALOS								ALOS 2										L-BAND	
Argentine											SAOCOM											C-BAND
ESA	ERS-1	ERS-2	Envisat								Sentinel-1											
Canada	RadarSat-1			RadarSat-2																		RADARSAT Constellation
Allemagne			TerraSAR-X																			X-BAND
				Tandem-X																		
Italie												TerraSAR-X-2										
Espagne																						PAZ



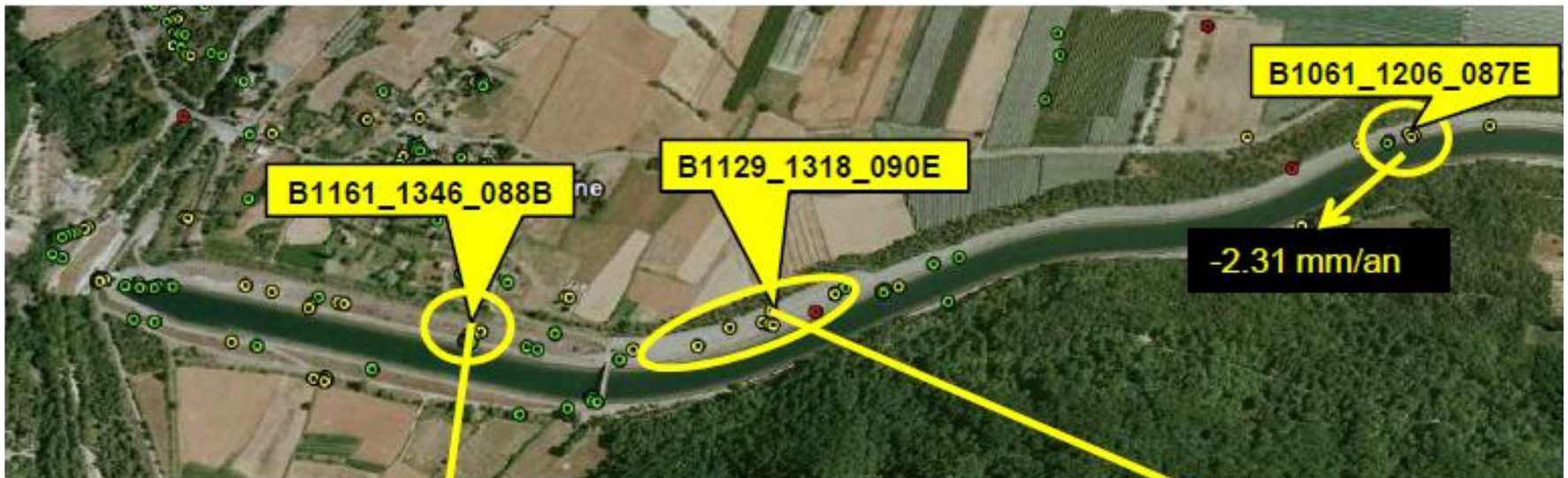
First test in 2009

- In Mont Blanc area using TerraSAR X images
 - ▶ One reflector fixed
 - ▶ Another one placed on micrometric XYZ table
 - ▶ Offset between actual displacements and INSAR processing along LOS < 1mm



2010: INSAR study on a dike site

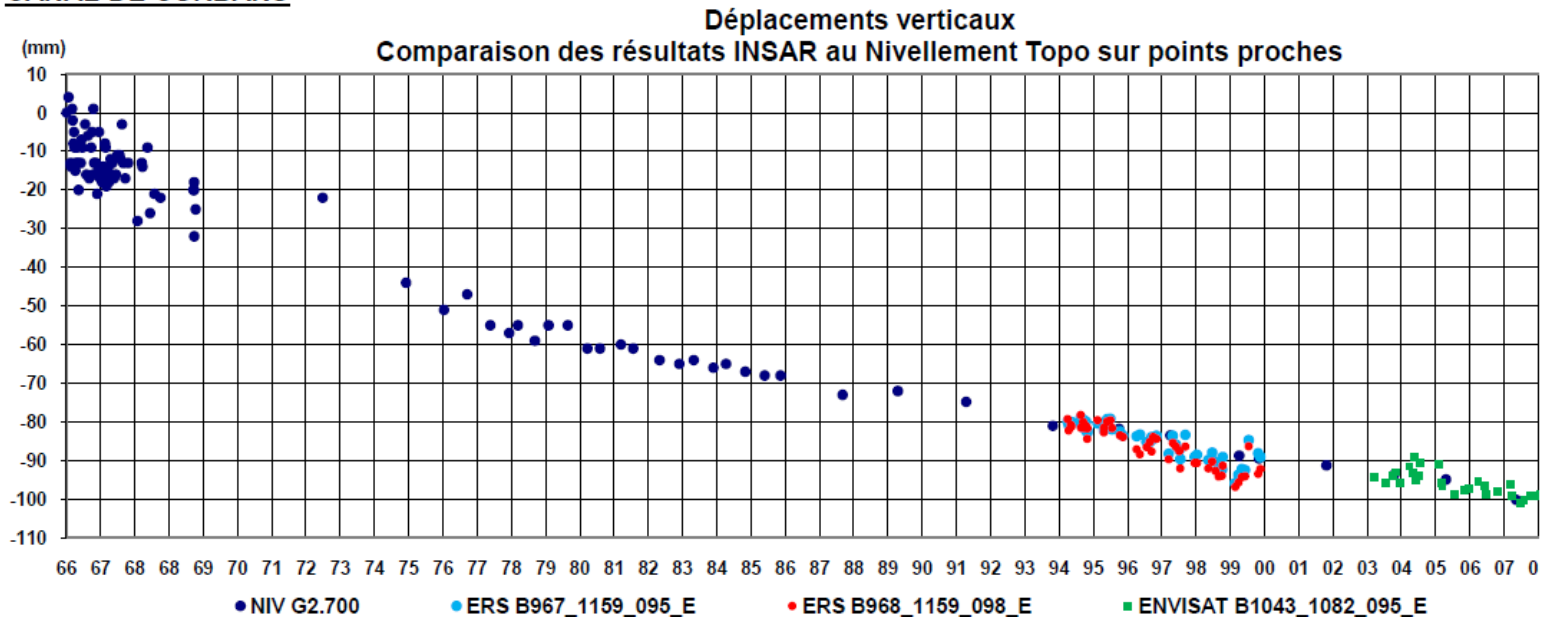
- ERS1/2 and ENVISAT images from 1995-2010
 - ▶ Few points detected along the dike...



2010: INSAR study on a dike site

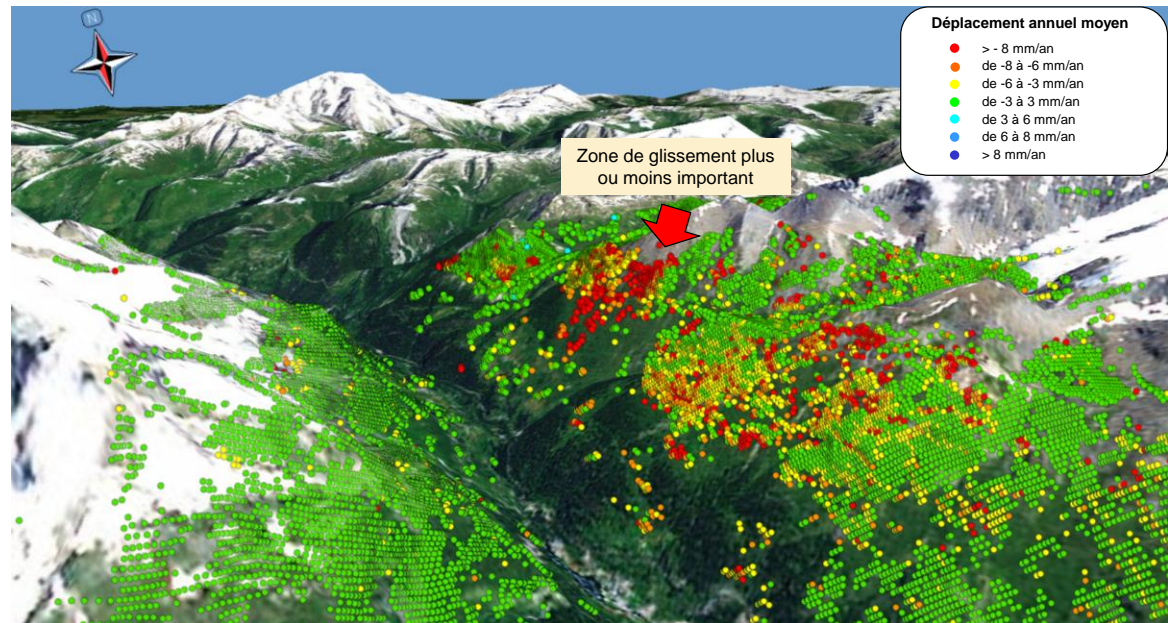
- ERS1/2 and ENVISAT images from 1995-2010
 - ▶ ... but interesting comparison with direct leveling measurement on closed points

CANAL DE CURBANS



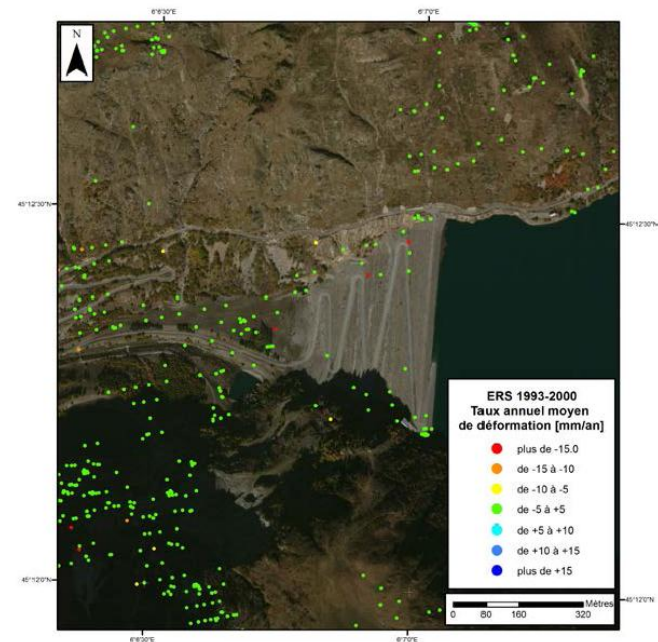
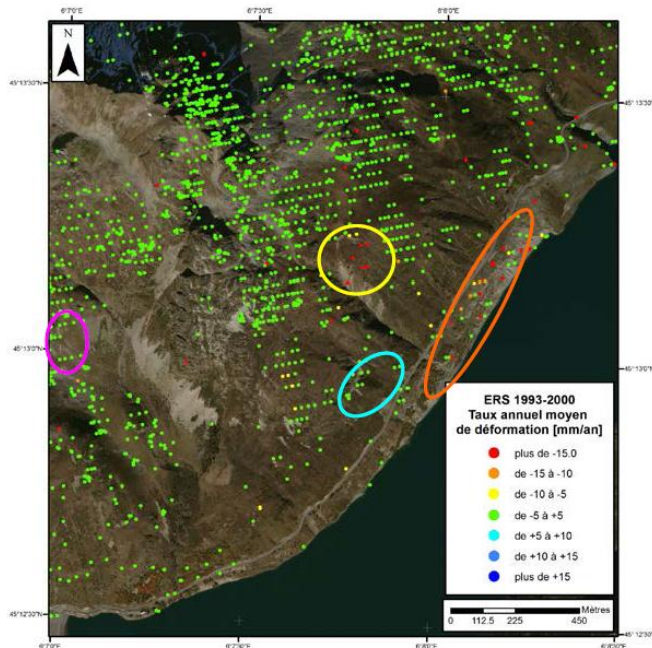
2011: INSAR study on a dam site

- ERS1/2 and ENVISAT images from 1995-2010
 - ▶ Order of magnitude of displacement measured by INSAR similar to the one observed on site
 - ▶ Geological diagnostic consolidated, but in a moraine zone...



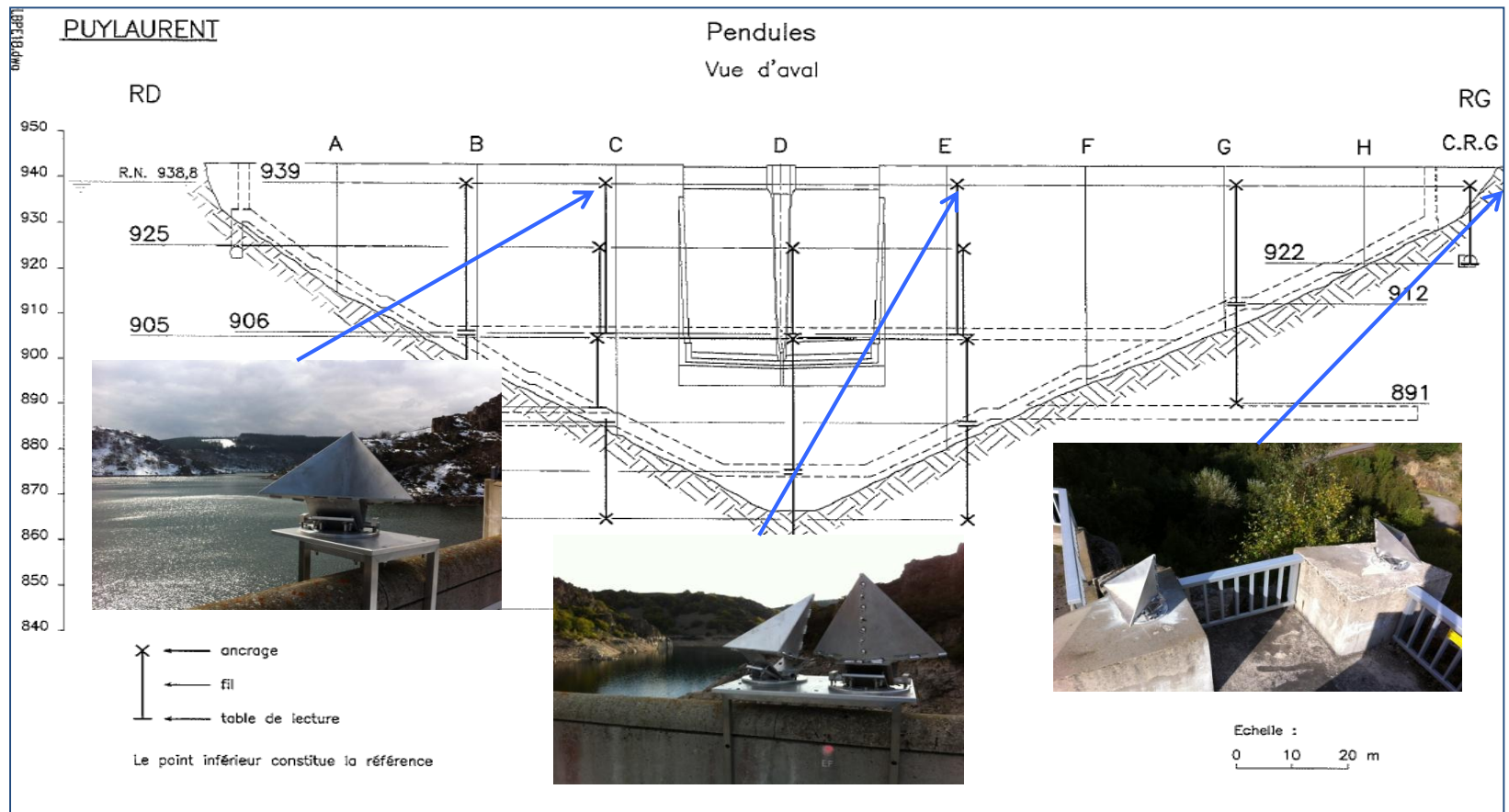
2012: INSAR study on a landslide site

- ERS1/2 and ENVISAT images from 1995-2010
- Alos images from 2006-2010
 - ▶ Very few points detected
 - ▶ Snow (less images available), vegetation...



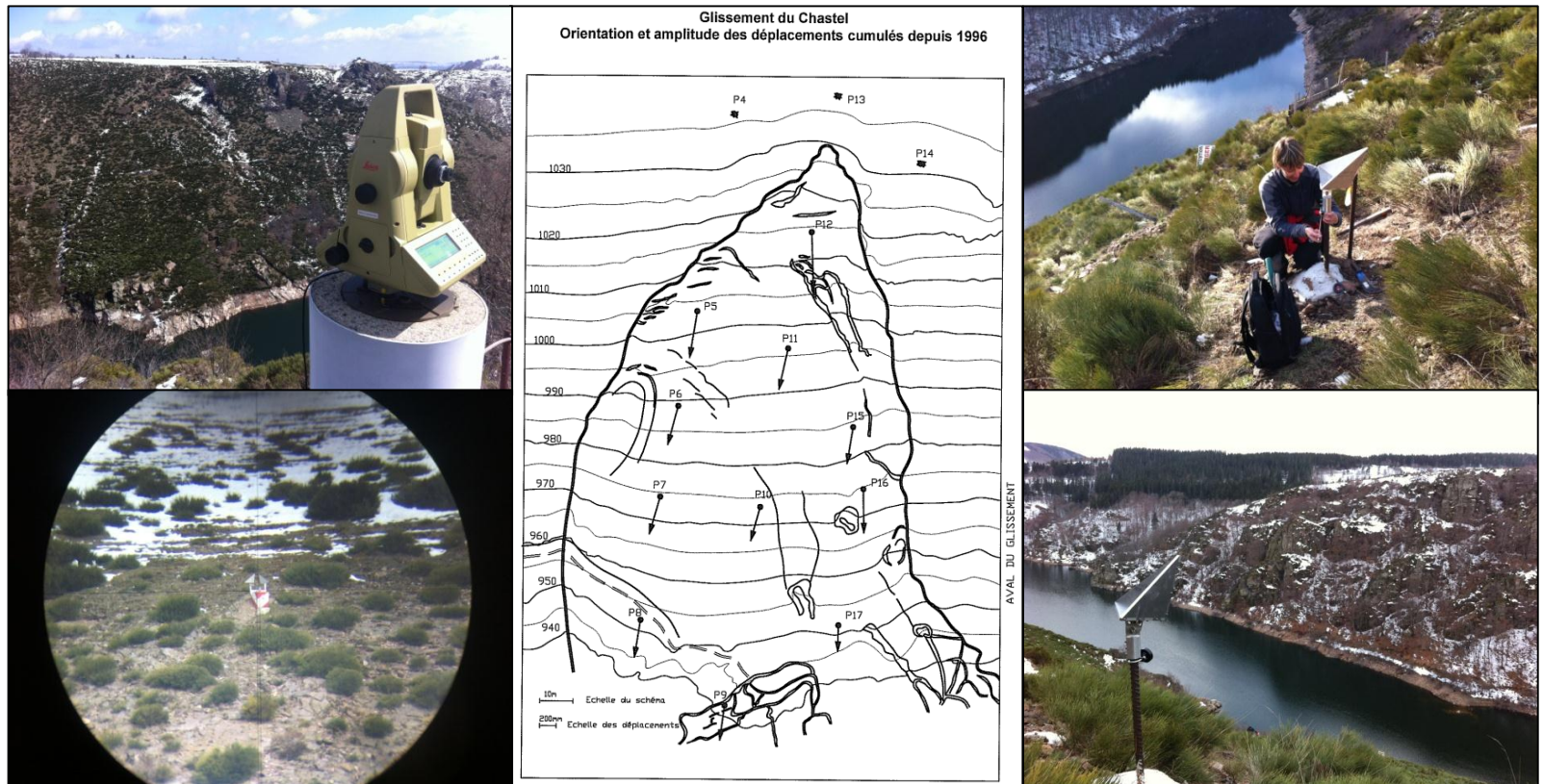
2013-2016: PhD Thesis - qualification

- TerraSAR X images on the period
- On a surveyed dam site:



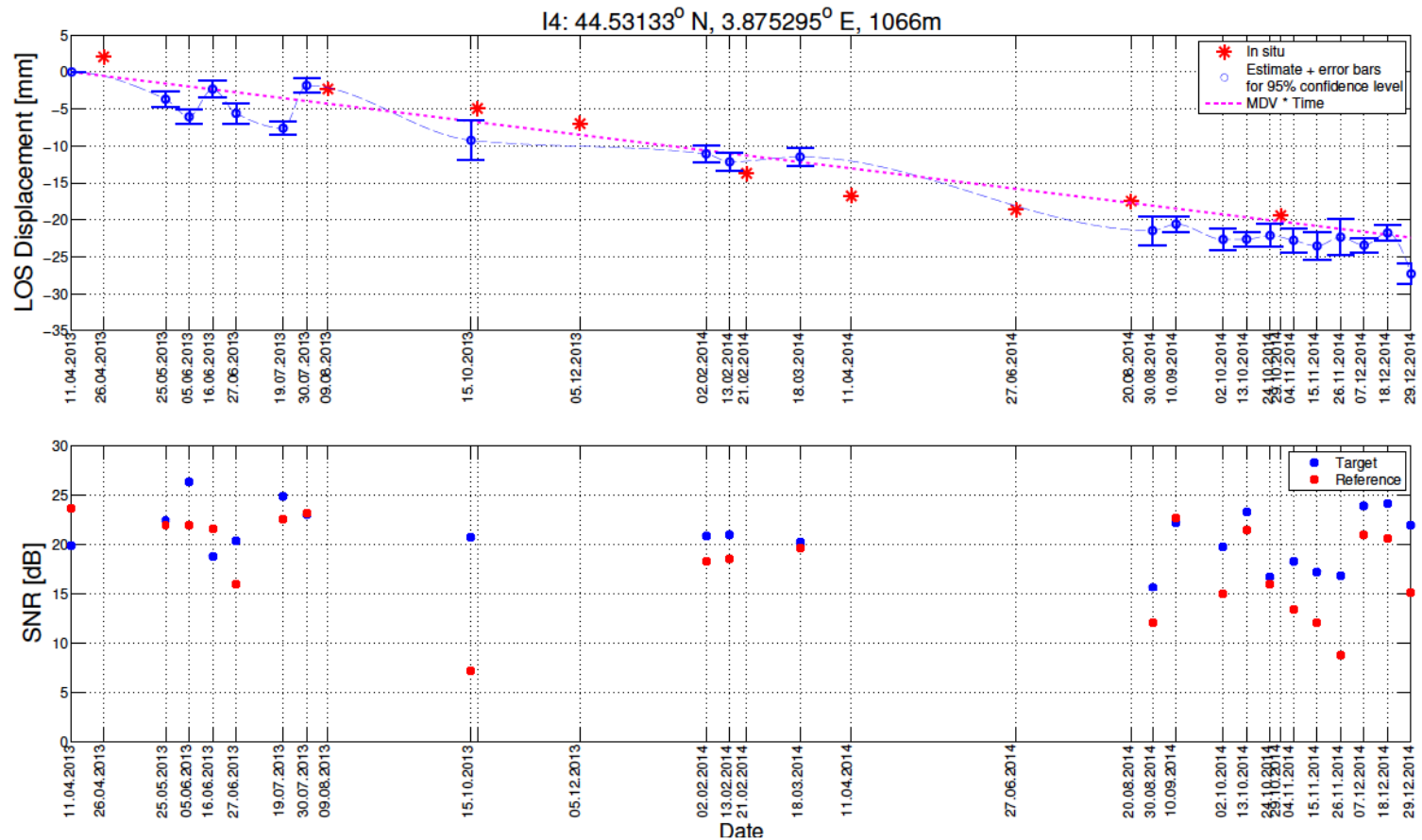
2013-2016: PhD Thesis - qualification

- TerraSAR X images on the period
- And on a surveyed landslide site:



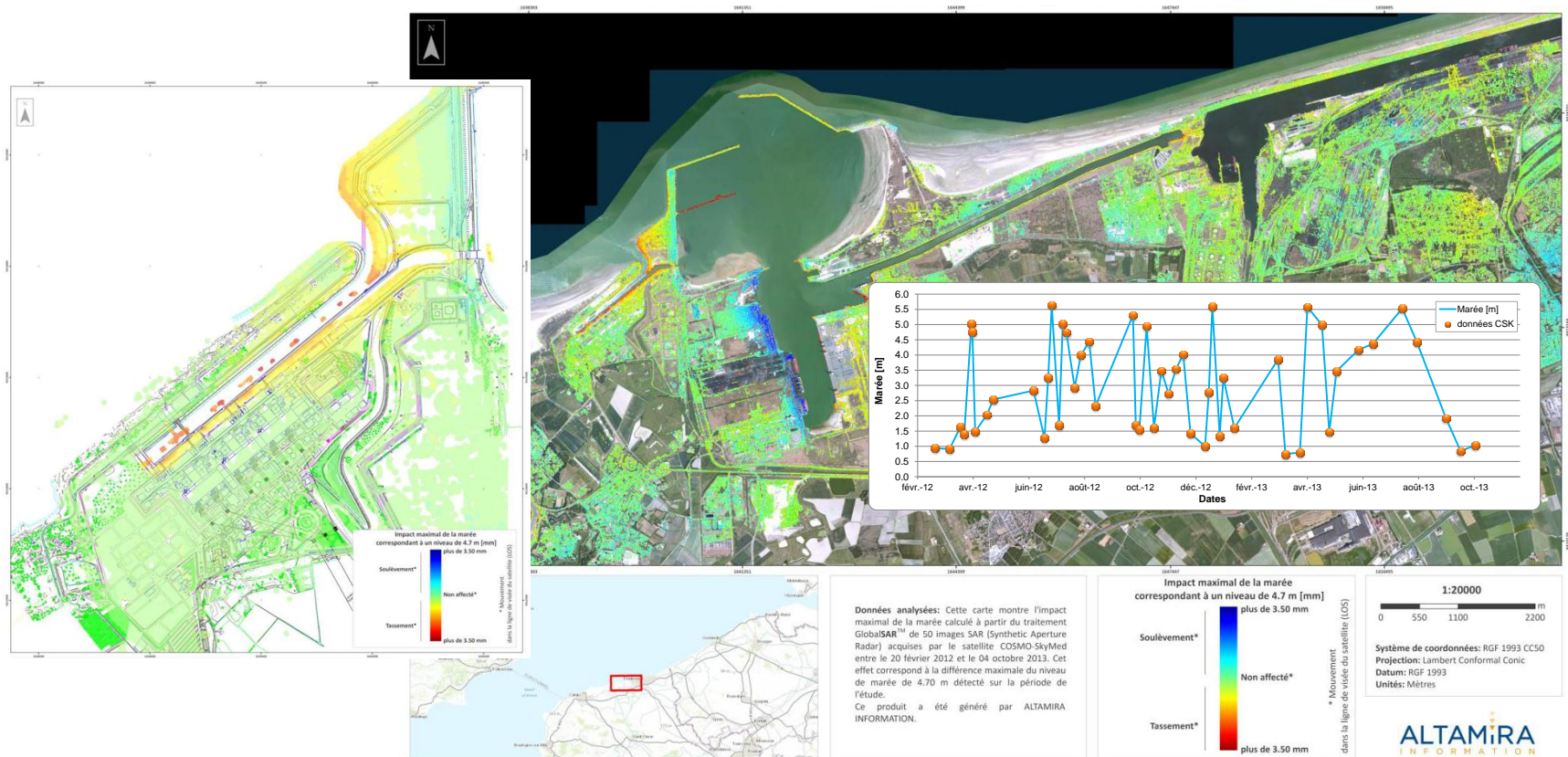
2013-2016: PhD Thesis - qualification

- Differential millimetric accuracy confirmed



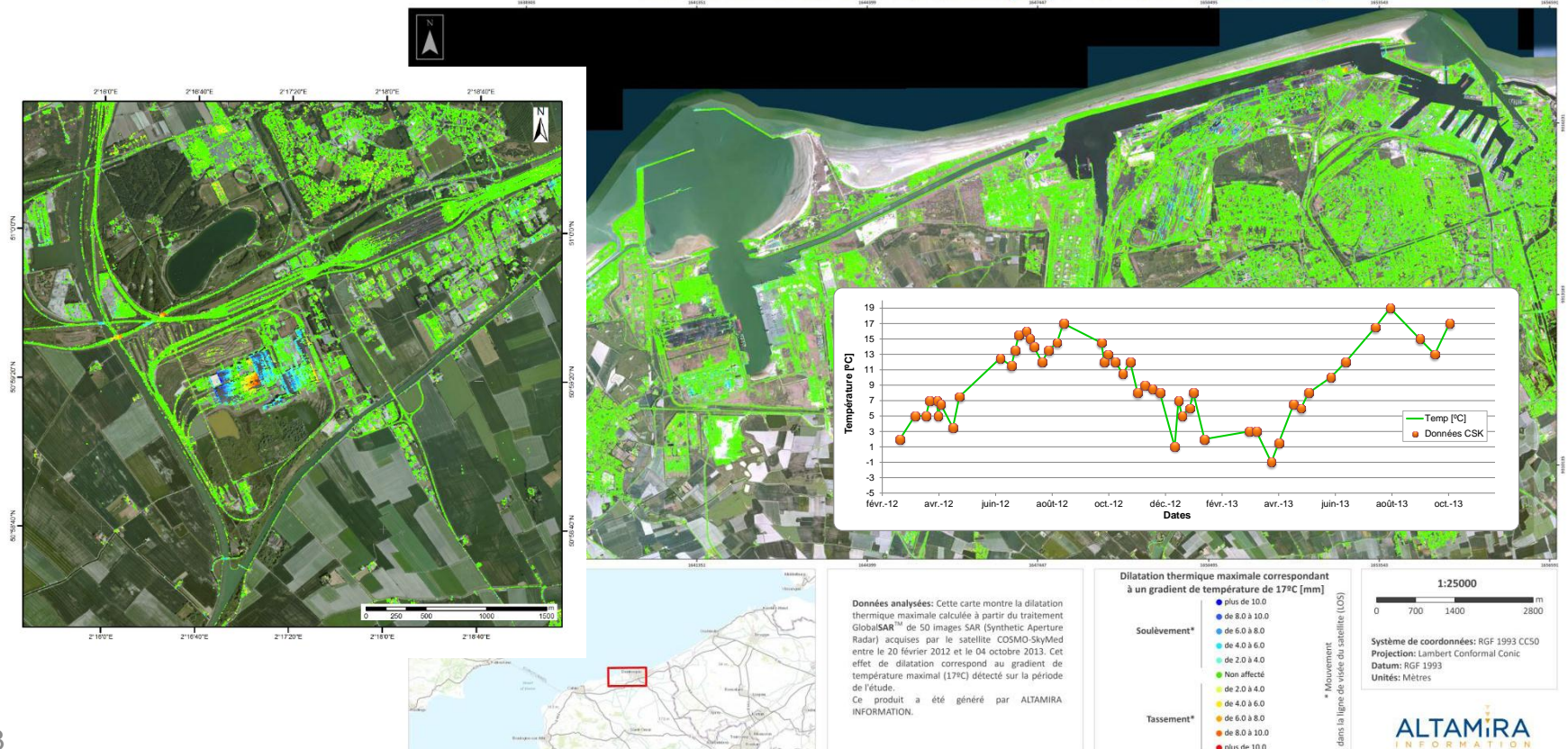
2013: INSAR study on industrial site

- 50 COSMO SkyMed images from February 2012 to September 2013
- Evaluation of local coastal tidal effect:



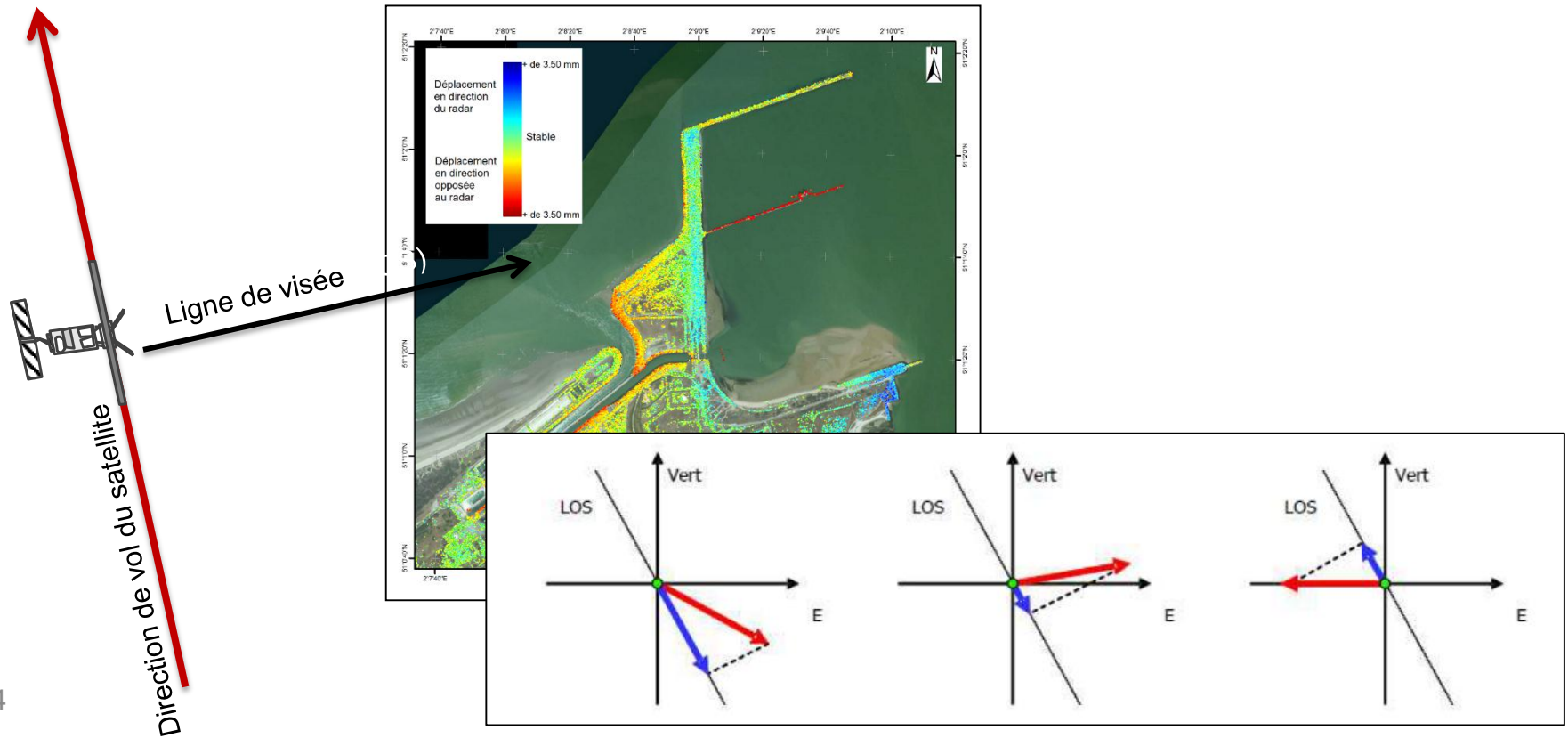
2013: INSAR study on industrial site

- 50 COSMO SkyMed images from February 2012 to September 2013
- Evaluation of thermal effect on buildings:



2013: INSAR study on industrial site

- 50 COSMO SkyMed images from February 2012 to September 2013
 - ▶ Interpretation of D measurements along LOS...



INSAR for monitoring structures?

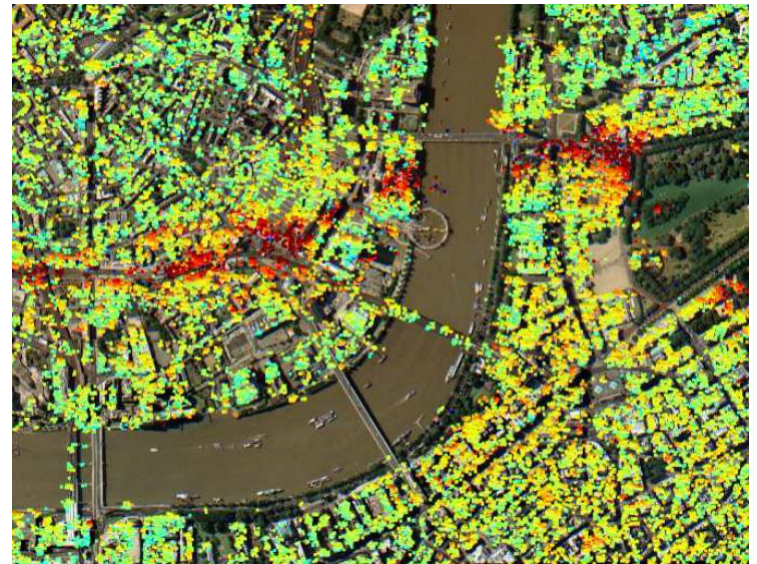
- Yes:
 - ▶ May avoid in situ instrumentation
 - ▶ Allow for a global overview of a structure in its environment
 - ▶ Is not very sensitive to weather conditions
 - ▶ Is a relatively long-term guaranteed service
 - ▶ Allow for interesting frequency (from few days)
 - ▶ May allow a posteriori reconstruction of displacement history if archive exists and if configuration is suitable
 - ▶ Offer levels of accuracy compatibles with monitoring requirements
 - ▶ Is already largely employed for large scale monitoring of global subduction movements

INSAR for monitoring structures?

- But:
 - ▶ Vegetation and snow cover limit its applicability
 - ▶ May require artificial reflectors on identified points of interest, which then need to be set out and maintained
 - ▶ Is a single 1D measurement along LOS, i.e. hypothesis required for physic interpretation (eventually 2D mixing modes, but not 3D)
 - ▶ Remain a differential method from an area considered as fixed
 - ▶ Site topographical configuration may limit visibility from satellites and create geometric distortions -> reduction of potentially covered areas
 - ▶ Sensitivity of LOS measurements to detect actual displacements also depend on site configuration
 - ▶ Require dully qualified service providers to produce reliable deliverables
 - ▶ Long processing time, no real time for the moment

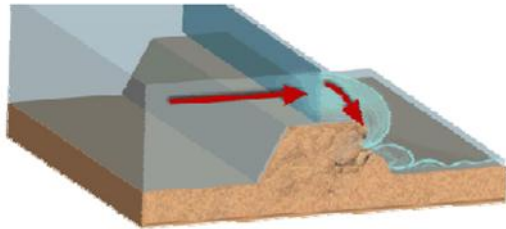
INSAR for monitoring structures?

- A complementary tool
 - ▶ particularly relevant in urban area (tunneling...) in addition to classic surveying techniques
 - ▶ Relevant to follow-up hard to reach areas
 - ▶ Allowing optimization of measurements frequency by relevant combination with classic techniques

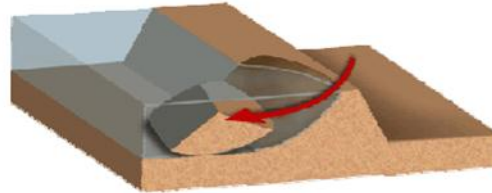


Exploring LIDAR from UAV

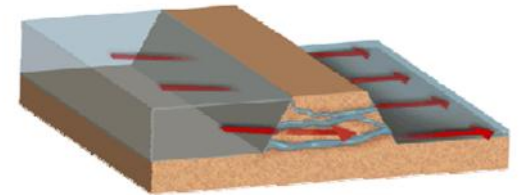
- Context: failure modes of earth dikes



Erosion externe



Cisaillement



Erosion interne

- Shear and Internal erosion: may create local subsidence and sinkhole

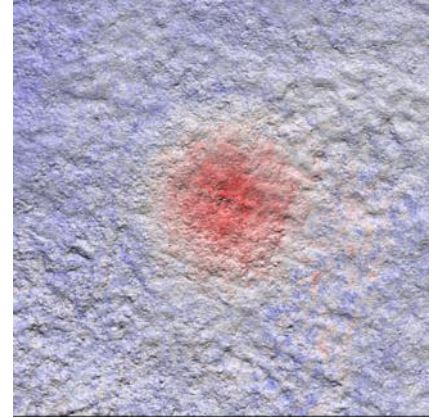


Exploring LIDAR from UAV

- Current monitoring tools:
 - ▶ Geometric leveling *
 - ▶ TLS on limited area when required
 - ▶ Piezometers *
 - ▶ Linkage follow-up when possible at downstream face
 - ▶ Fiber optics when possible (new dams)
 - ▶ Regular visual inspection
- Lacks for long linear of dikes:
 - ▶ * are punctual measurements both in time and space
 - ▶ TLS is not effective on long linear
 - ▶ Linkage collect and/or fiber optics are not always possible
 - ▶ Visual inspection is very time consuming and may be complex on dike faces (slopes)

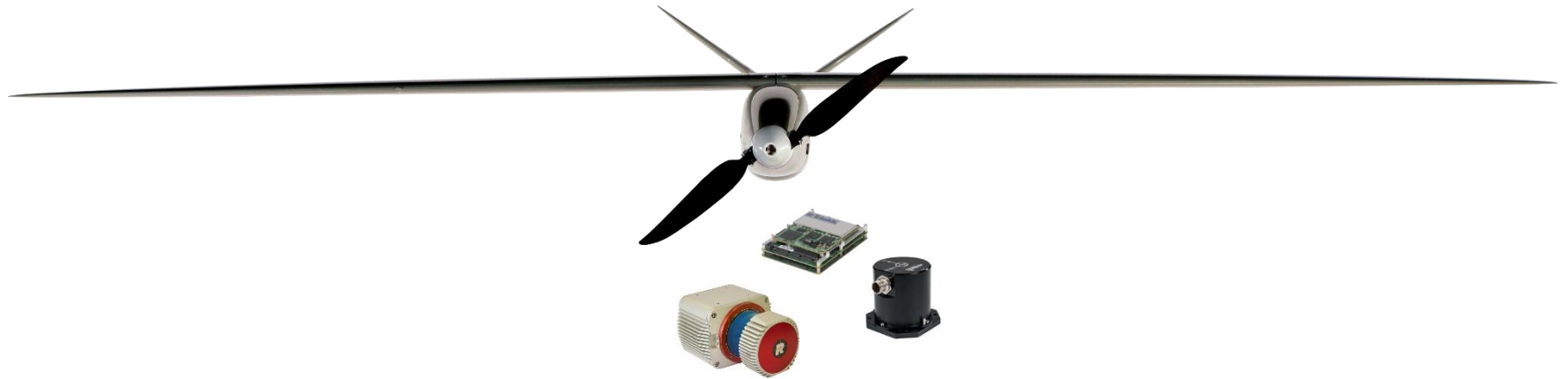
Exploring LIDAR from UAV

- The need:
 - ▶ Get a tool able to detect local subsidence on the surface of the whole dike, easy and cost effective, to be used on a regularly basis on site
- Constraints:
 - ▶ Long distances to cover
 - ▶ Vegetation very often presents on dike faces
 - ▶ Do not require extra survey on site



Exploring LIDAR from UAV

- Development of a “fit for purpose” UAS made of:
 - ▶ A Lidar boarded on a fixed wing UAV
 - ▶ A specific algorithm for localized default detection even if global geo-referencing of each survey is approximate or impacted by “low frequency” bias
 - ▶ A capacity to board other sensors: camera (VI)...



Exploring LIDAR from UAV

- Real dike experimentation: scheduled for july 2017



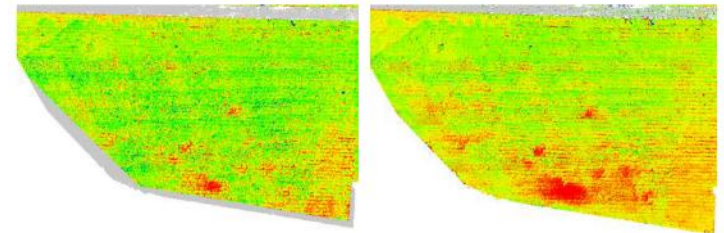
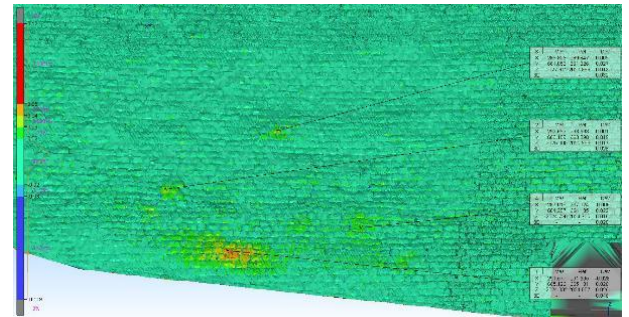
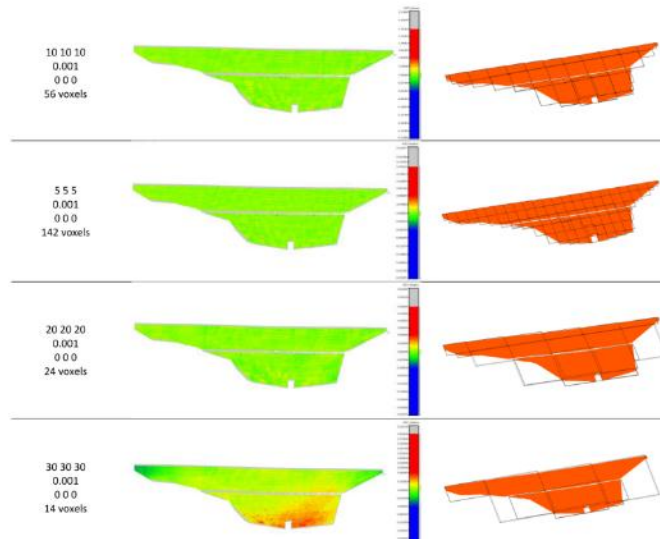
Exploring LIDAR from UAV

- Real dike experimentation: scheduled for july 2017
 - ▶ Prototype: DELAIRTECH DT26X and RIEGL VUX1



Exploring LIDAR from UAV

- On the processing side:
 - ▶ A prototype of algorithm have been tested successfully on a small dam suffering from local deformations (point cloud issued from a UAV photogrammetry)



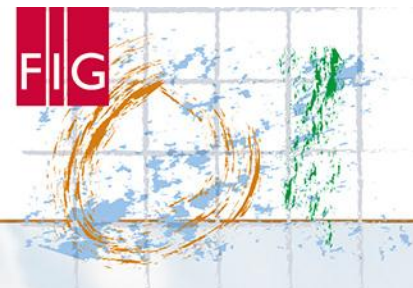


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Thank you for your attention



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