DARES LOOKING FORWARD

Ground displacement monitoring exploiting multi-temporal stacks of SAR images

LUXEMBOURG EARTH OBSERVATION AND INTEGRATED APPLICATIONS DAY

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www.dares.tech

esa business incubation centre Barcelona

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OUR
Motivation

The Earth Surface is affected by a wide range of deformation phenomena

Glaciers

Earthquakes & Volcanoes

Landslides

Mining

Oil and Gas

Infrastructures

Development of reliable EO techniques to ensure the safety of people and the integrity of infrastructures in such areas

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OUR Vision

- We measure ground deformation using radar satellites (InSAR technology).
- Our measurements are of HIGHEST QUALITY and AFFORDABLE.
- We reduce operational costs and contribute to safety of operations.
- Leaders providing displacements maps with S1 sensor.

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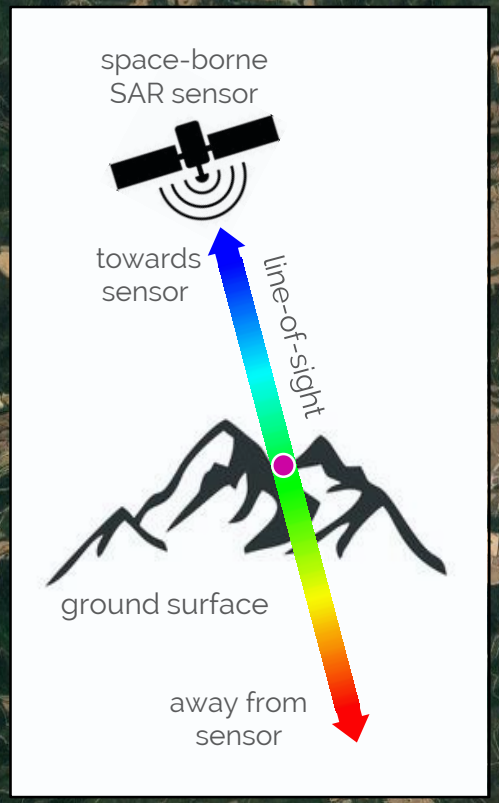
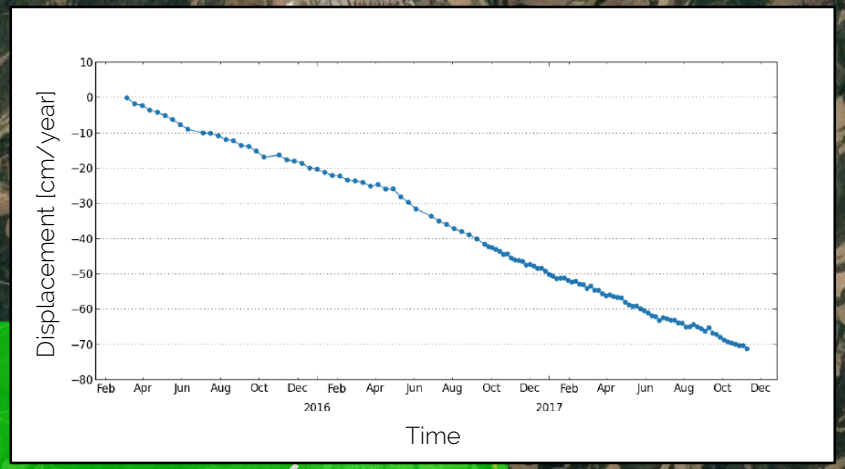
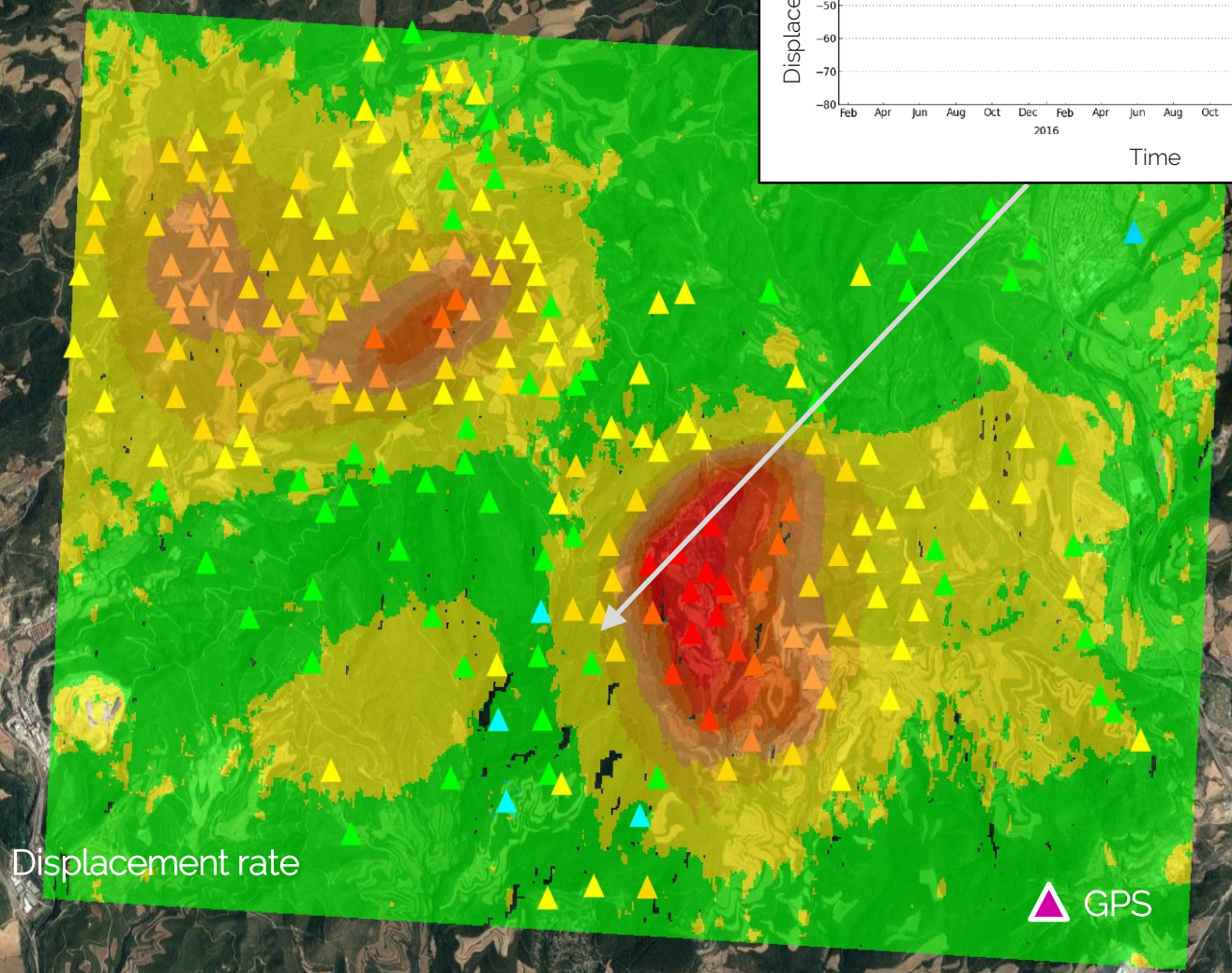
OUR
Products



Time-series





Displacement
cm/year

- inf - -30.0
- 25.0 - 30.0
- 20.0 - 25.0
- 15.0 - 20.0
- 10.0 - 15.0
- 5.0 - 10.0
- 1.5 - 5.0
- -1.5 - 1.5
- -5.0 - -1.5
- -10.0 - -5.0
- -15.0 - -10.0
- -20.0 - -15.0
- -25.0 - -20.0
- -30.0 - -25.0
- 30.0 - inf

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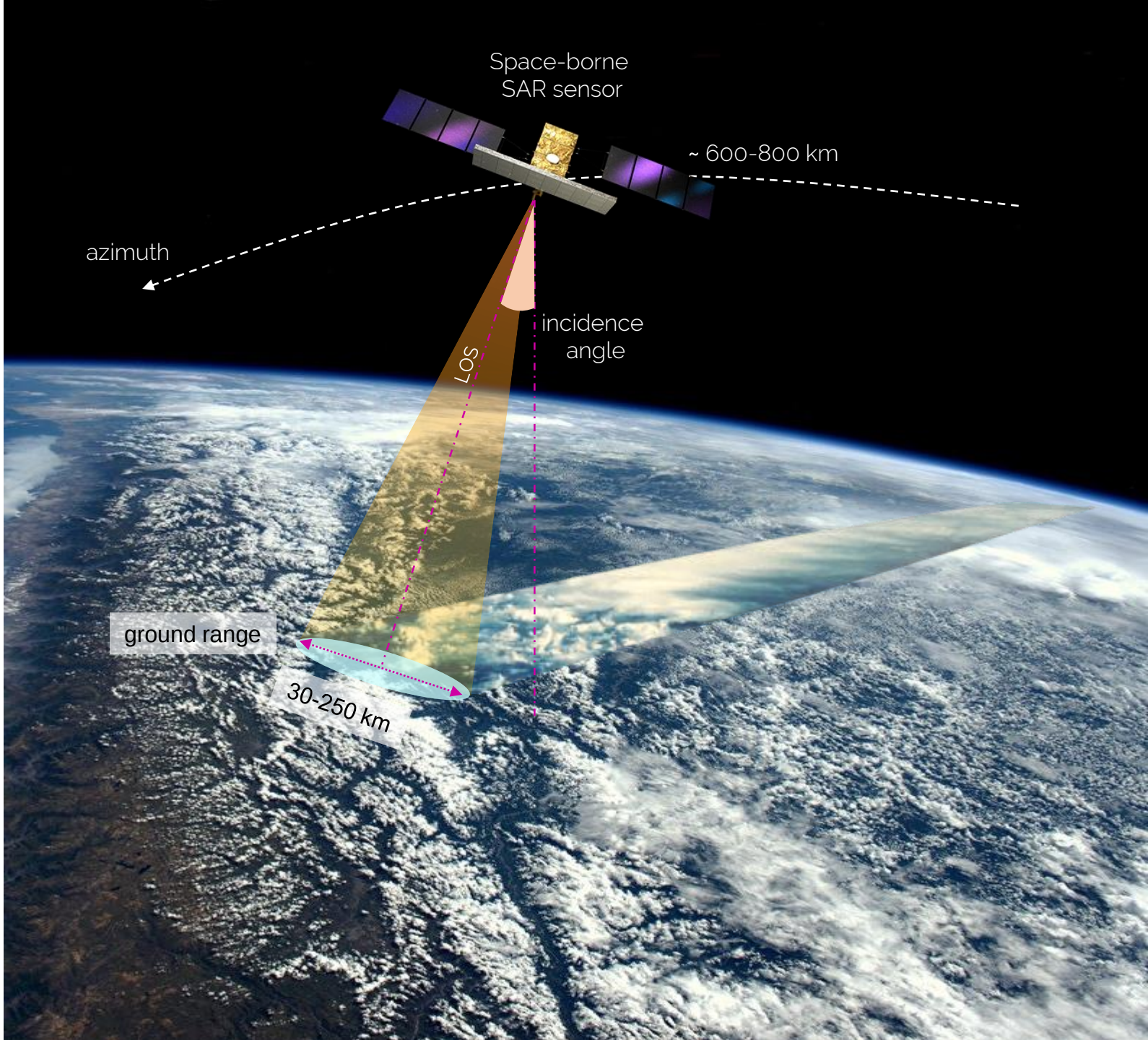
Introduction

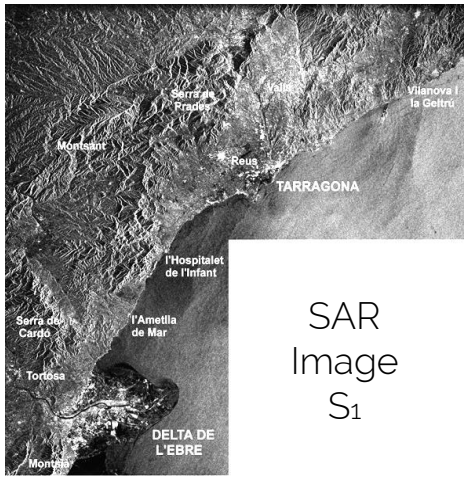
SAR Sensors

- Active sensor that produces its own source of illumination.
- High resolution radar system.
- Independent of atmospheric effects, day and night cycles and weather conditions.

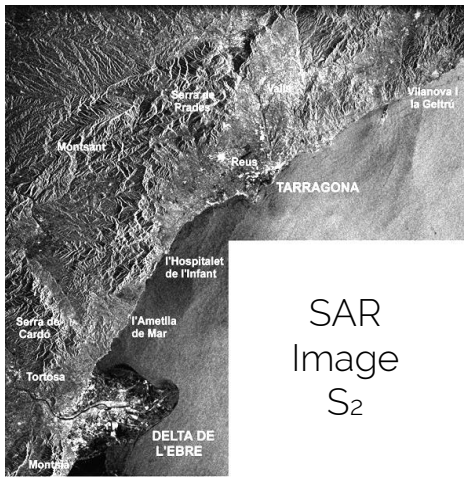


Introduction

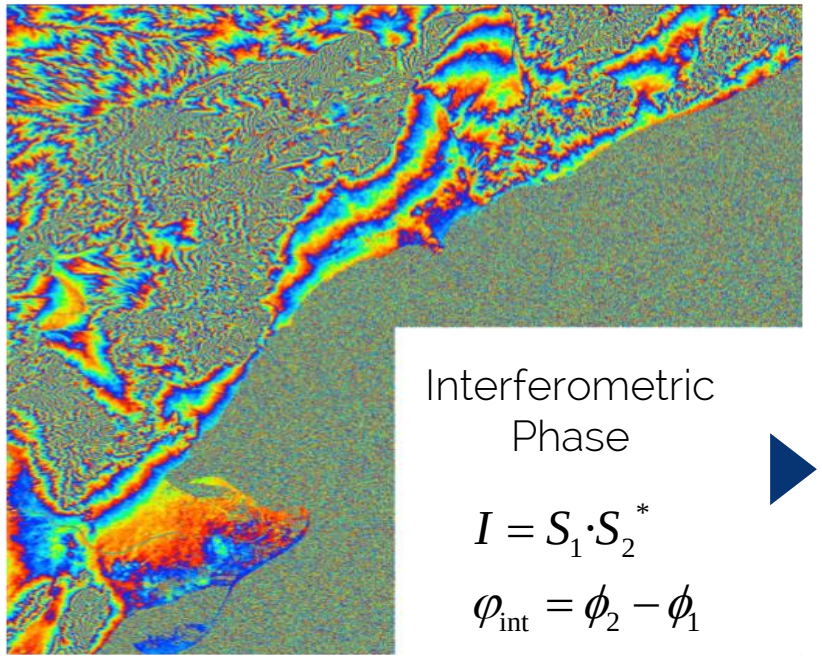
Interferometric Phase



SAR Image S_1



SAR Image S_2



Interferometric Phase

$$I = S_1 \cdot S_2^*$$

$$\varphi_{\text{int}} = \phi_2 - \phi_1$$

$$\Delta\varphi_{\text{int}} = \frac{4\pi}{\lambda r_0 \tan\alpha}\Delta r + \frac{4\pi}{\lambda r_0 \sin\alpha}\Delta h + \frac{4\pi}{\lambda}\Delta r + \Delta\varphi_{APS} + \Delta\varphi_{N}$$

Interf Phase	Flat-Earth	Topo.	Disp.	APS+Noise

Applications

Sensitive to the topography if the spatial baseline is significant.

Sensitive to displacement phenomena if the temporal baseline is significant.

But...

There are undesired artifacts such as decorrelation, APS or the noise inherent to the SAR sensors.

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InSAR

DEM

Rationale

Interferometric pairs with:

- Large spatial baseline
- Short temp. baseline

Sensitivity to topography

Flow Chart

Mont Fuji Example

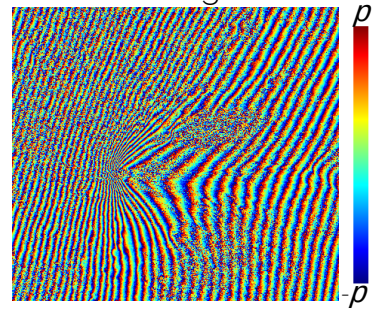
ALOS-PALSAR | Bperp: 300 m | Btemp: 46 days

$$Dj_{int} = \frac{4p}{l\, r_0 \tan a}\, Dr + \frac{4p}{l\, r_0}\frac{B_n}{\sin a}\, Dh + \frac{4p}{l}\, Dr + Dj_{APS} + Dj_N$$

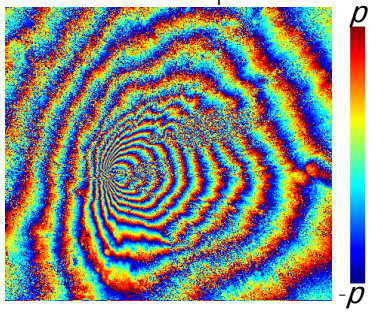
Interf | Flat-Earth | Topo. | Disp. | APS+Noise

SAR Amplitude

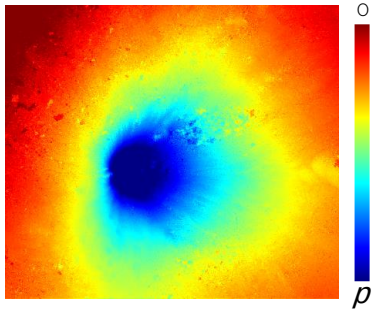
Interferogram

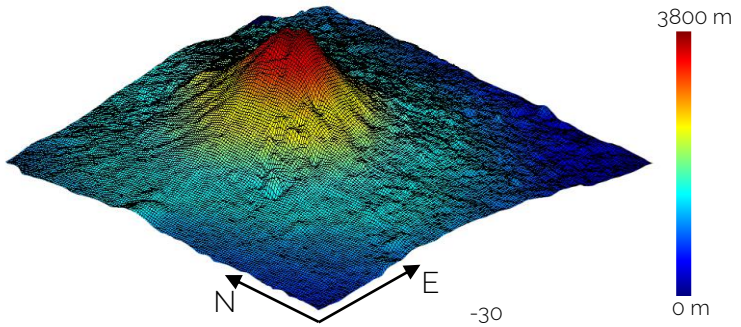


Flat Earth Compensation



PhU





DInSAR

Motion

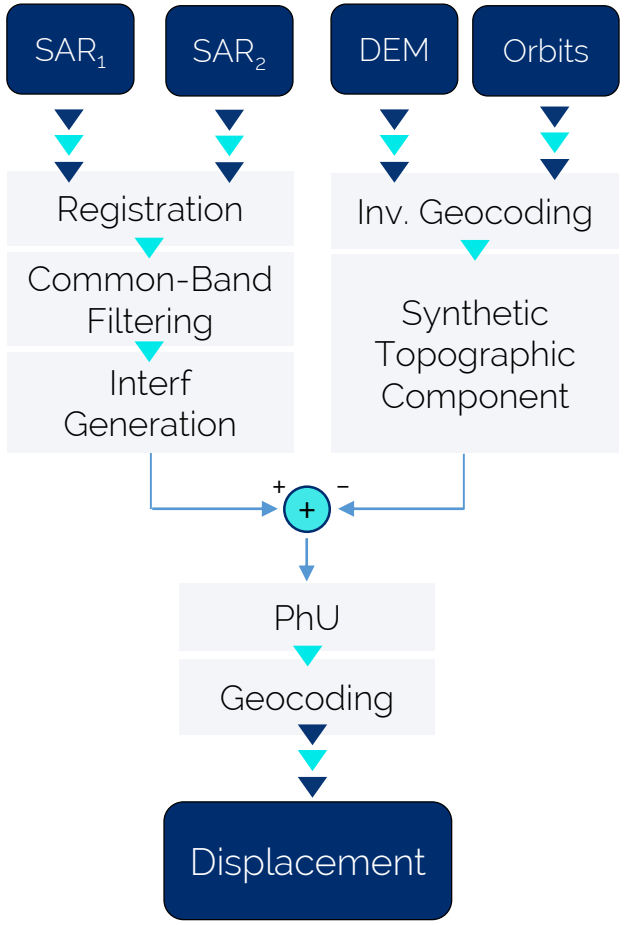
Rationale

Interferometric pairs with:

- Short spatial baseline
- Large temp. Baseline

Sensitivity to displacement

Flow Chart

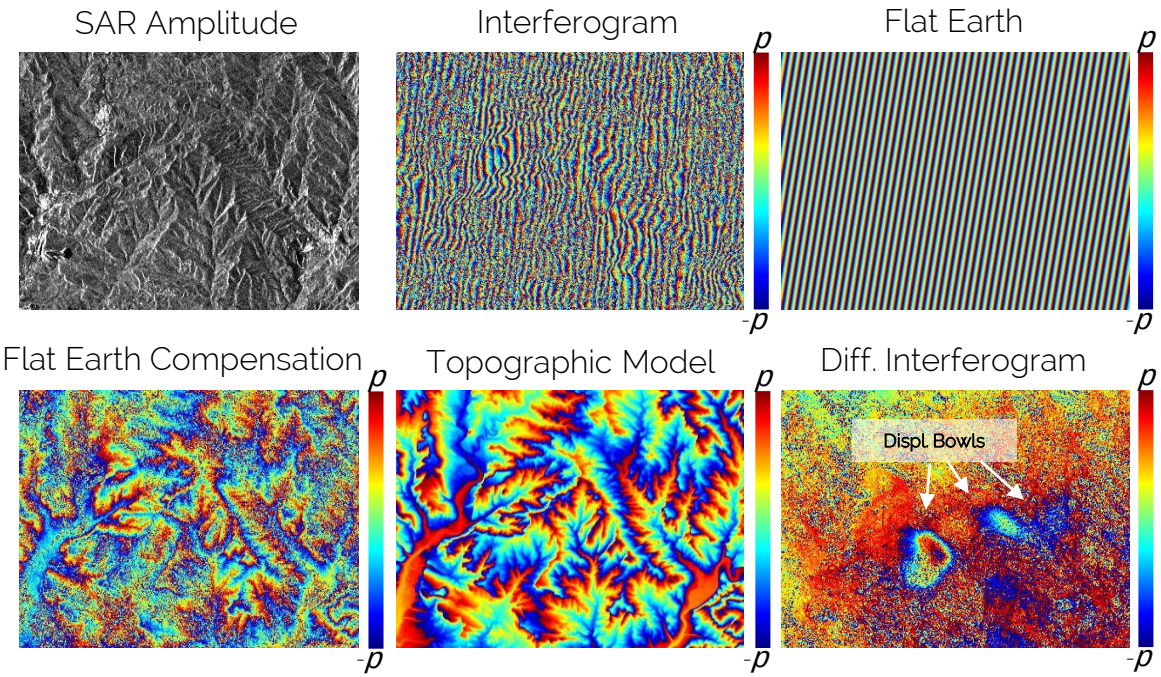


Central Catalonia Example

Sentilel-1 | Bperp: 100 m | Btemp: 60 days

$$\Delta\varphi_{int} = \frac{4\pi}{\lambda r_0 \tan\alpha}\Delta r + \frac{4\pi}{\lambda r_0}\frac{B_n \Delta h}{\sin\alpha} + \frac{4\pi}{\lambda}\Delta\rho + \Delta\varphi_{A} + \Delta\varphi_{N}$$

Interf | Flat-Earth | Topo. | Disp. | APS+Noise



Interferometric Phase Quality

Coherence

$$\gamma = \frac{E\left\{S_1 S_2^*\right\}}{\sqrt{E\left\{\left|S_1\right|^2\right\} E\left\{\left|S_2\right|^2\right\}}}$$

stationary ergodicity

$$\hat{\gamma} = \frac{\sum_{i=1}^{L} S_1(i) \cdot S_2(i)^*}{\sqrt{\sum_{i=1}^{L}\left|S_1(i)\right|^2 \cdot \sum_{i=1}^{L}\left|S_2(i)\right|^2}}$$

Small correlation length errors:

- Misregistration
- Geometric decorrelation
- Doppler decorrelation
- Volumetric decorrelation
- Temporal decorrelation
- Thermal noise

▶▶▶ Affect Coherence

Long correlation length errors:

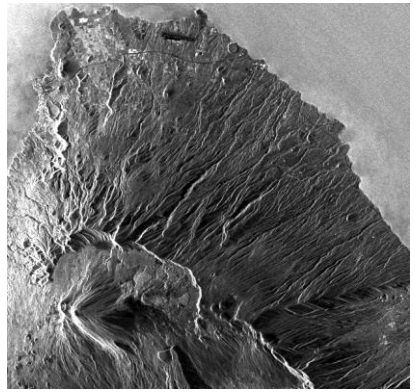
- Orbital errors
- Atmospheric artifacts

▶▶▶ Not Affect Coherence

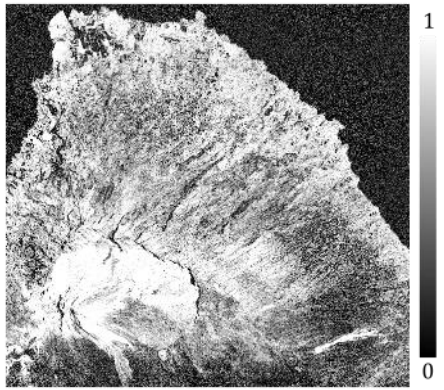
Tenerife Island Example

C-Band Envisat satellite

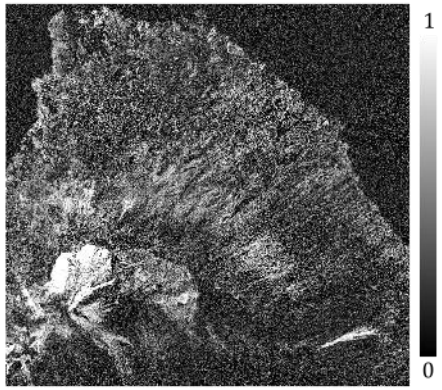
Amplitude



Temp Baseline: 35 days



Temp Baseline: 560 days



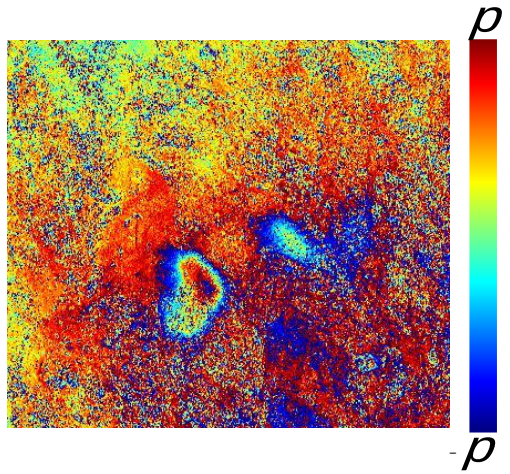
Quality Phase degradation due to temporal decorrelation

Persistent Scatterers Interferometry

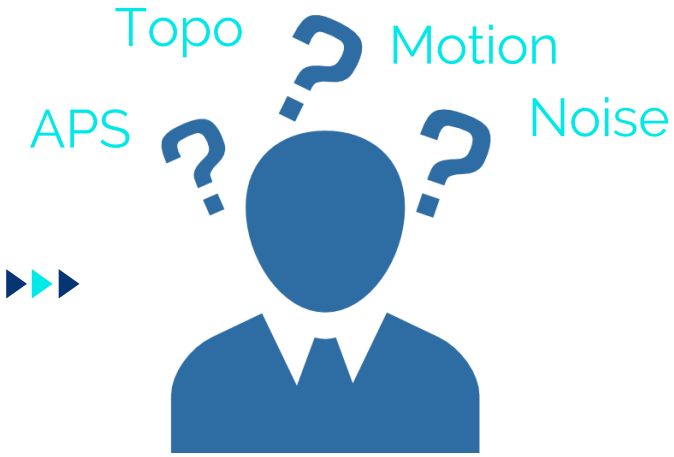
Multi-Temporal Explotation

DInSAR Limitations

- Not all the points provide reliable information.
- Topographic residue in the differential phase.
- Presence of Atmospheric Phase Screen (APS).

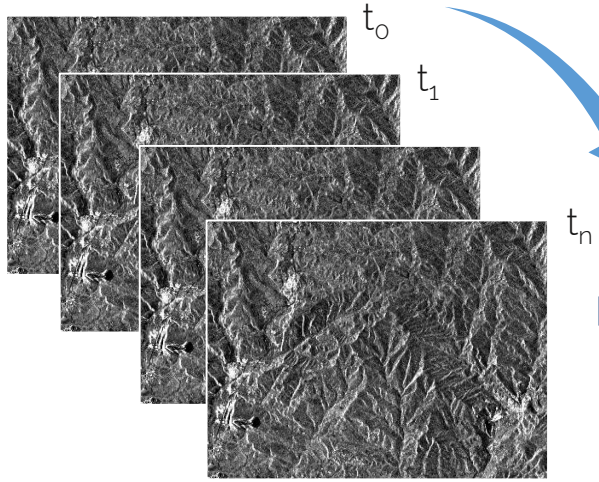


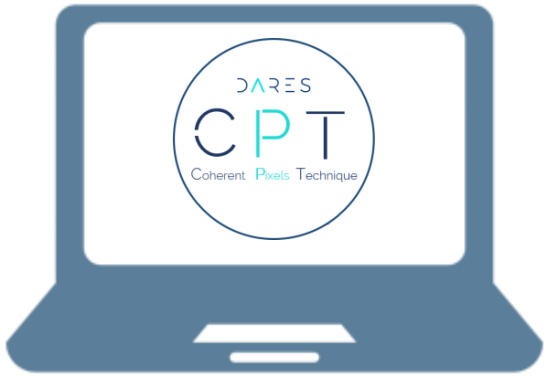
One full cycle is equivalent to half the wavelength displacement but there are more fringes…



Persistent Scatterers Interferometry

Exploitation of a multi-temporal stack of differential interferograms to obtain the linear and non-linear components of displacement, the topographic error, as well as the atmospheric artifacts.





Coherent Pixels Technique

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DARES CPT Coherent Pixels Technique

Persistent Scatterers Interferometry

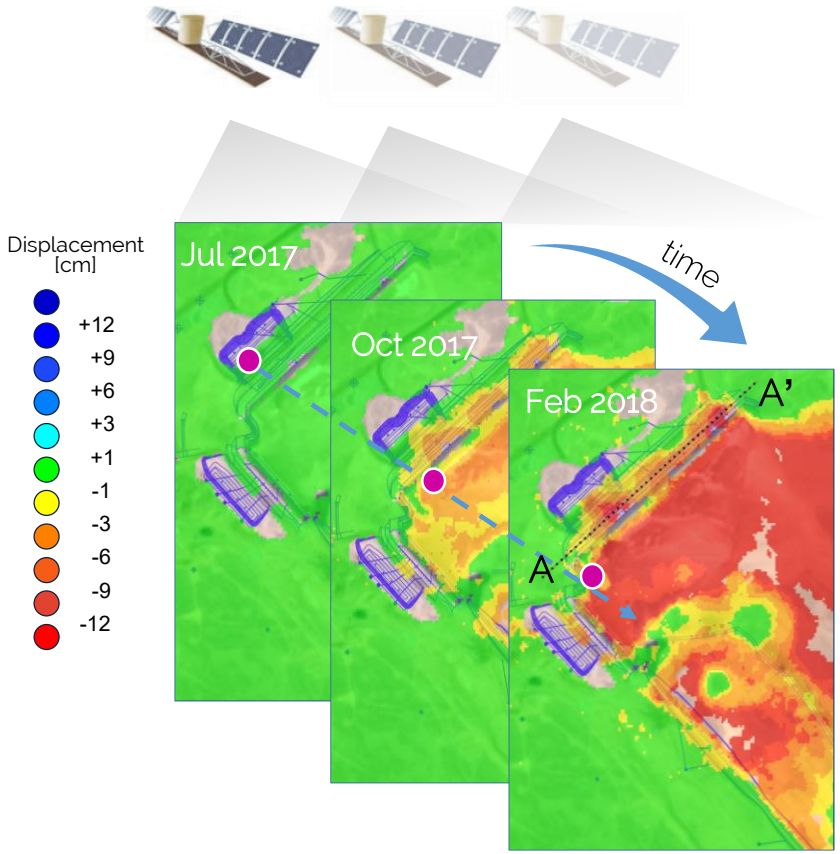
Products

Dares Technology employs the Coherent Pixels Technique (CPT).

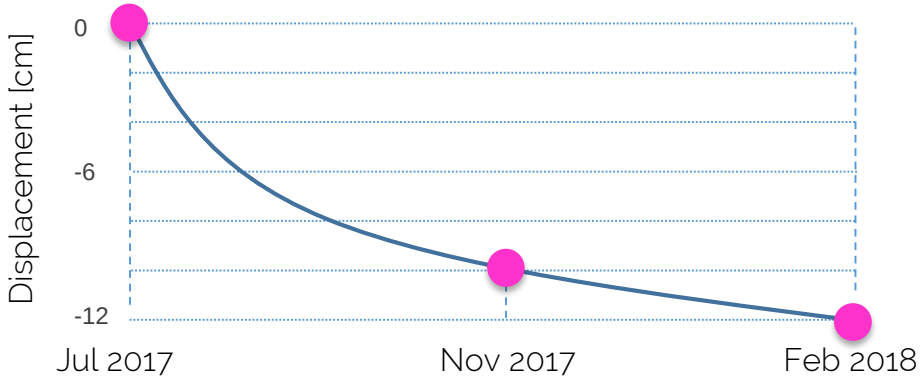
This PSI technique has been developed by the Remote Sensing Laboratory of the Universitat Politecnica de Catalunya since 2002.

CPT allows the estimation of the linear and non-linear components of displacement, the topographic error, as well as the atmospheric artifacts.

Accumulated Maps



Time Series



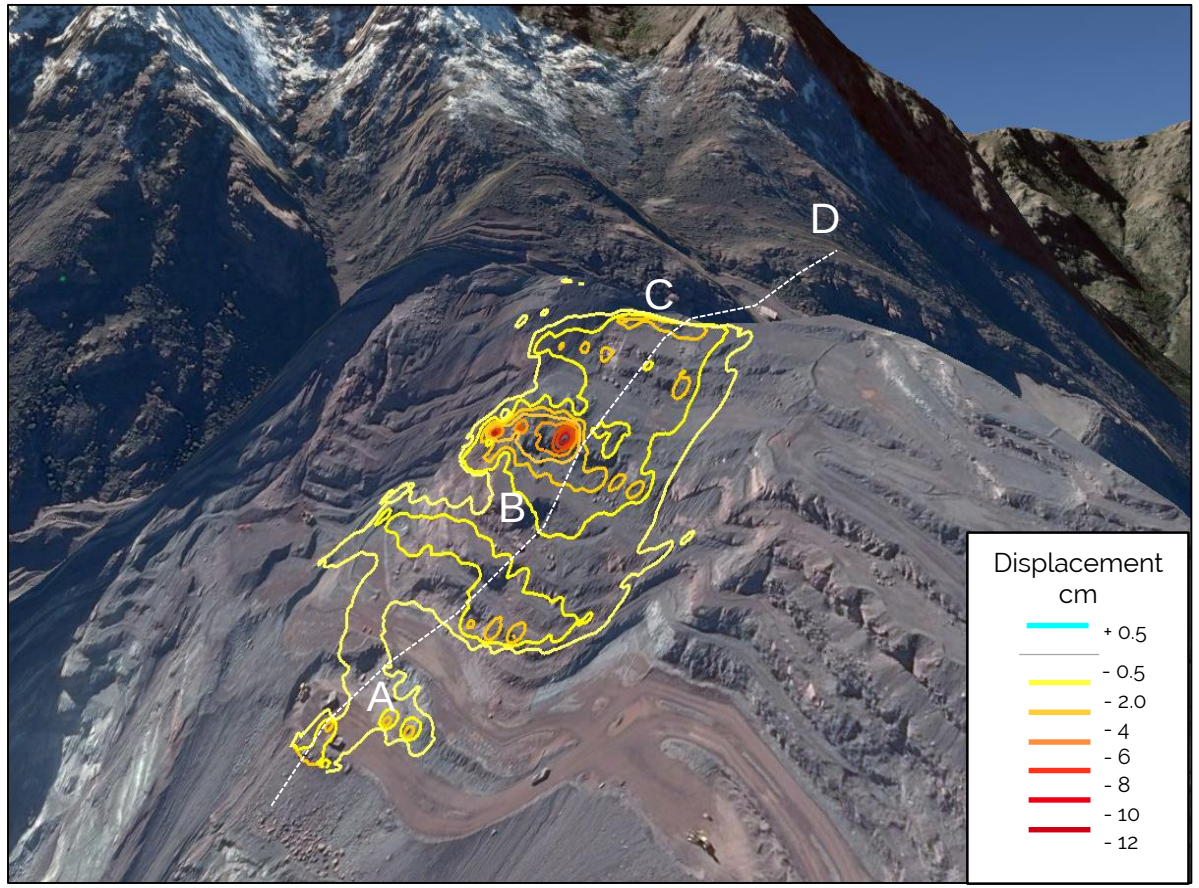
Cross Section

Displacement over time and topography

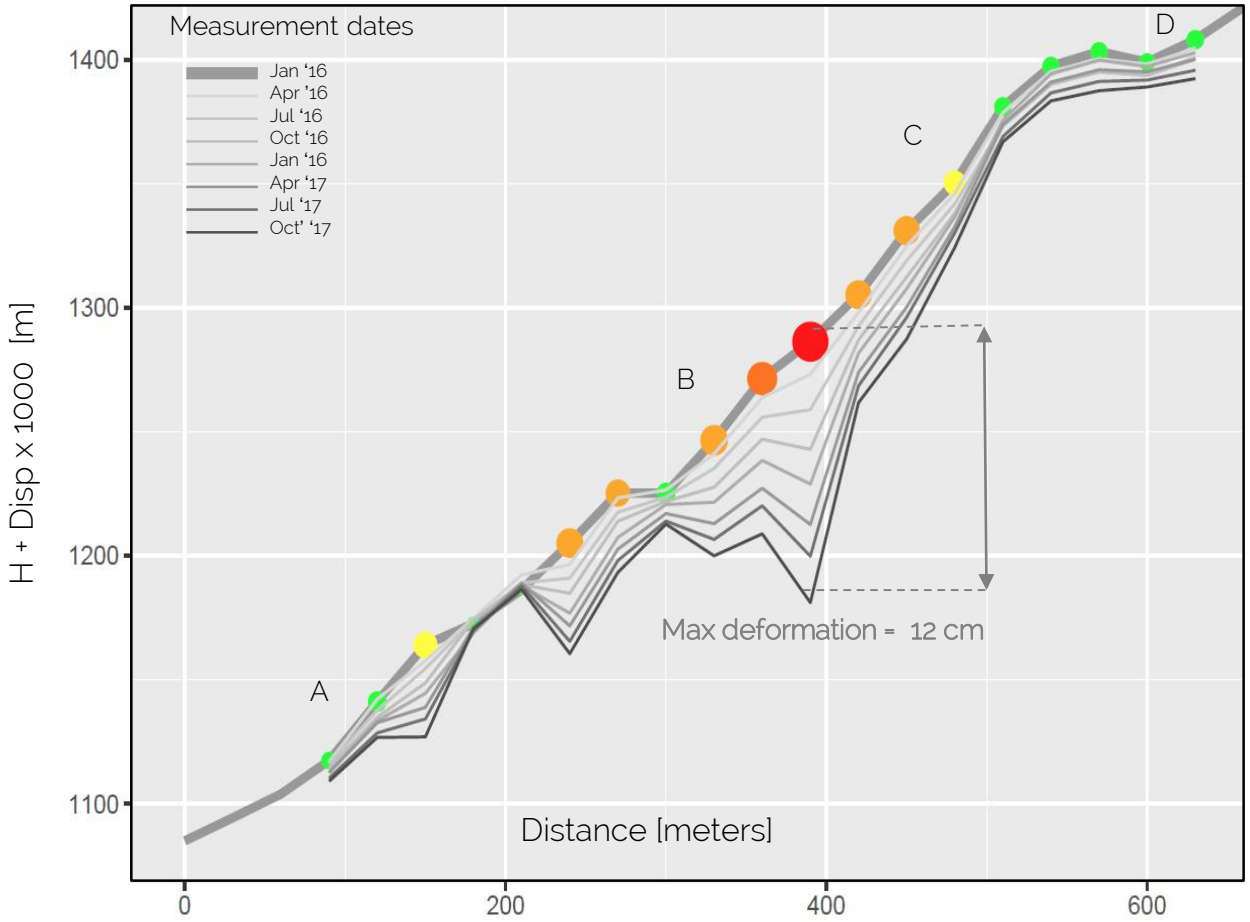
Case Studies

Displacements over slopes

Displacement over slopes



Cross section



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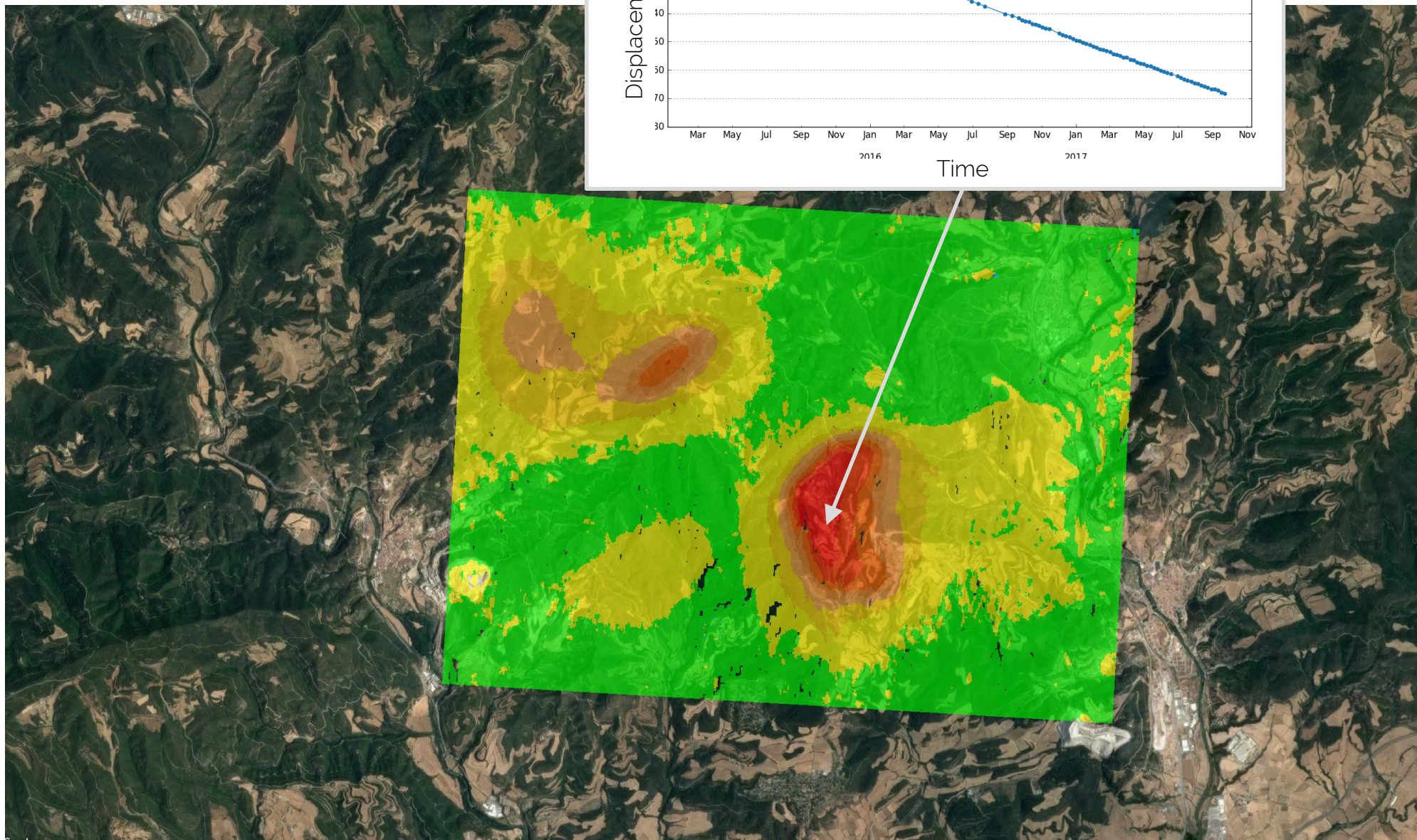
Case Studies

Mining



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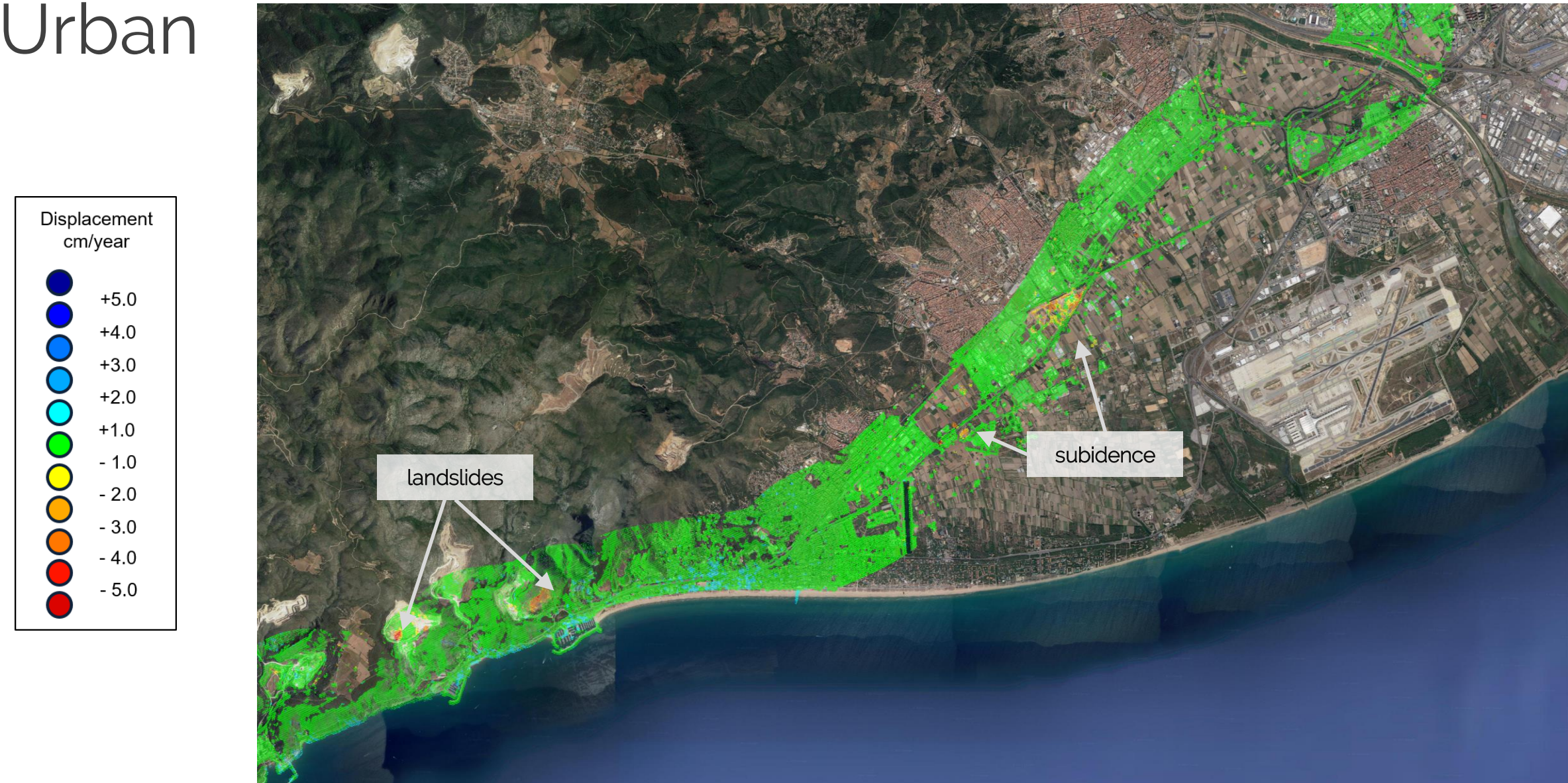
Case Studies

Urban



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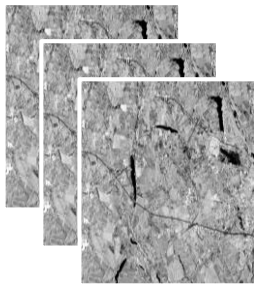
Mapping

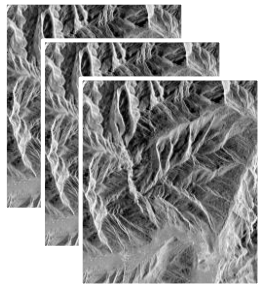
SinCohMap

Develop, analyse and validate novel methodologies for **LAND COVER & VEGETATION MAPPING using SENTINEL-1 INTERFEROMETRIC COHERENCE EVOLUTION**

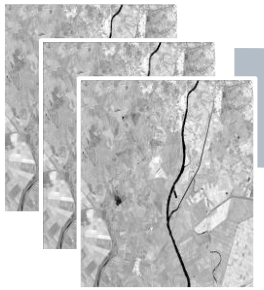
Pre-processed InSAR stack sites



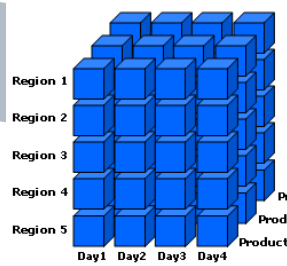
West Wielkopolska (Poland)



South Tyrol (Italy)



Doñana (Spain)



rasdaman raster data management

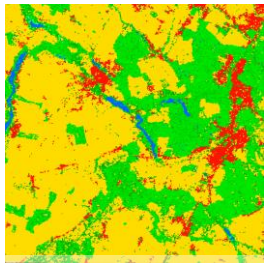
OGC Making location count.

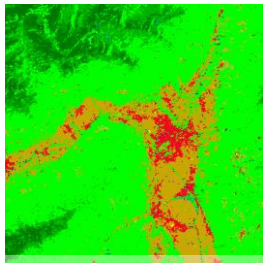
eurac research | Sentinel Alpine Observatory

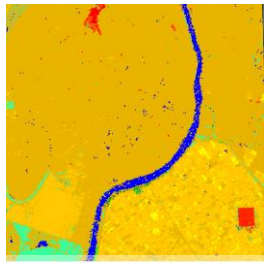
OpenNebula

WCS/WCPS

jupyter R python





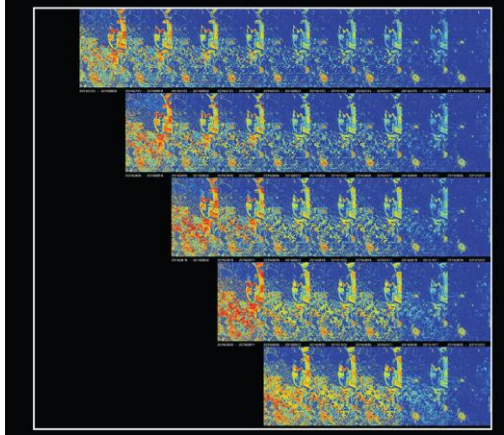


Classification accuracies around **70 – 80 %** based on **coherence** for 16 Level 3 CLC

https://sincohmap.org/

1 year multi-temporal coherence matrix Doñana (Spain)

Land-cover dynamics captured by the interferometric coherence evolution



EGU

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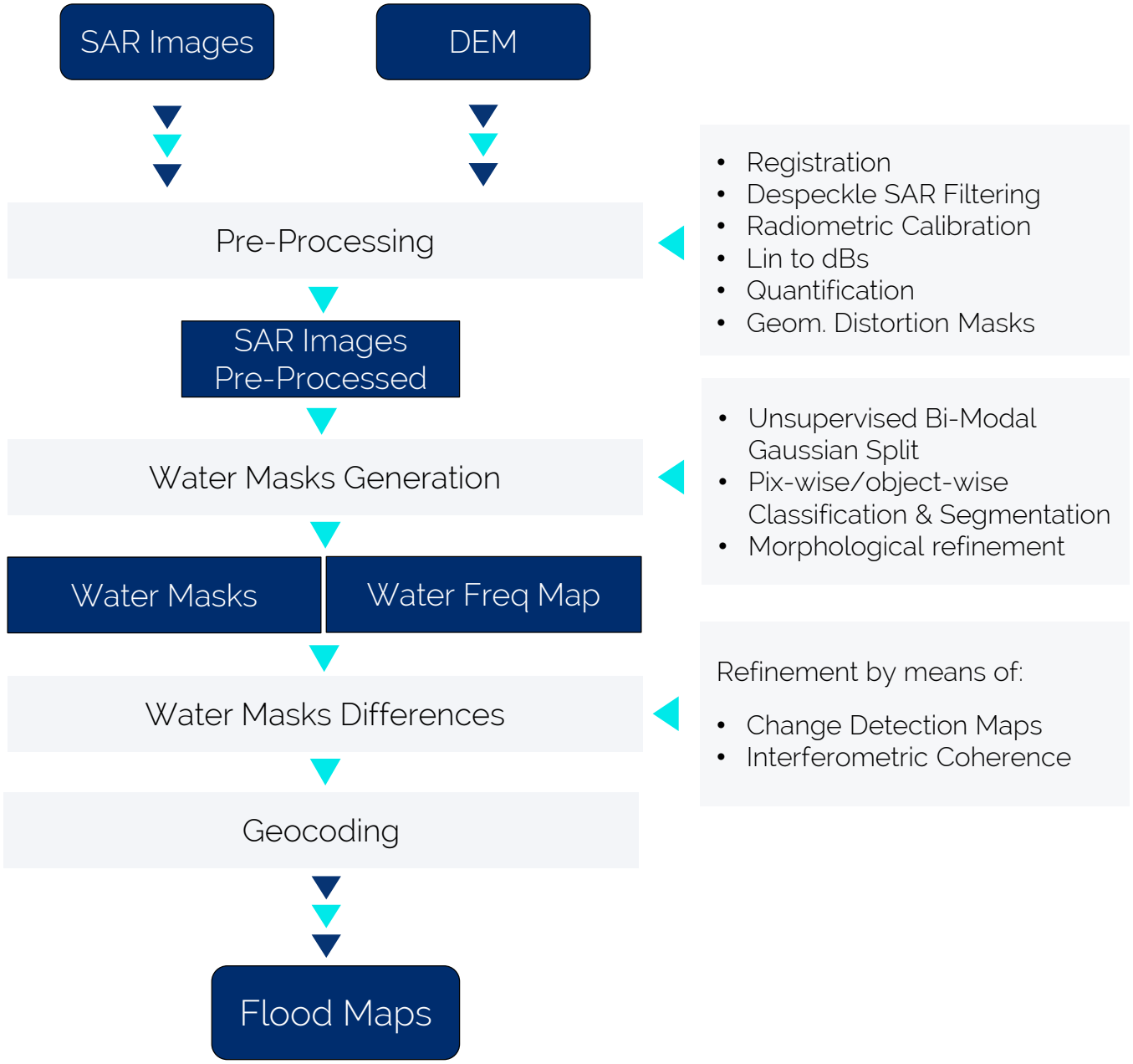
Mapping

FLOODS

Dares Technology Key Points

- Robust Interferometric chain.
- We work in radar geometry.
- Adaptive advanced SAR filters.
- Advance classification + segmentation strategies.
- Change detection expertise.
- Use of interferometric parameters such as the interferometric coherence.



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Case Study

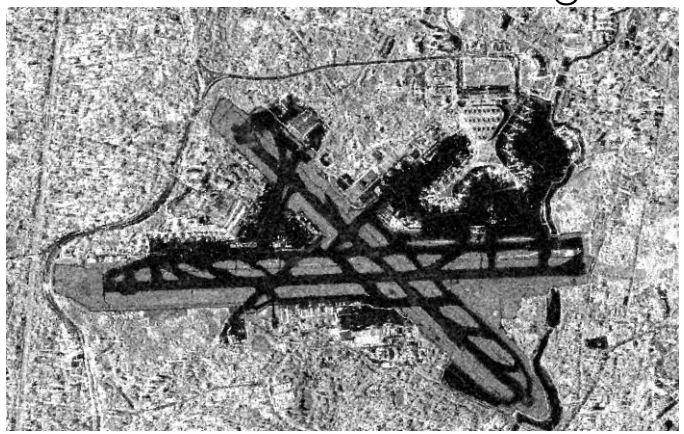
Mumbay Floods

Flooding that occurred on August 29, 2017 due to heavy rainfalls.

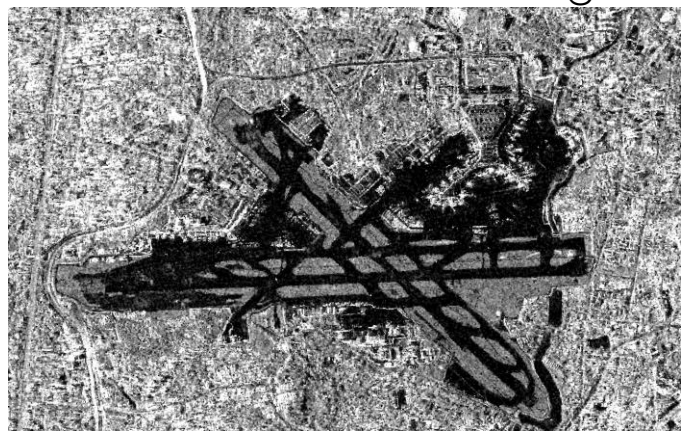
Transport systems were unavailable through parts of the city as trains and roadways were shut. Power was shut off from various parts of the city to prevent electrocution.

Detail over Chhatrapati Shivaji International Airport

Pre-Event S1 SAR Image



Post-Event S1 SAR Image



Detected Floods in red

DARES

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