Formations Universitaires

Samedi 4 Mai 2019, Port-au-Prince, Haiti

Agenzia Spaziale Italiana

Exemples d'applications avec de l'imagerie SAR

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ITALIAN SPACE AGENCY (ASI), SCIENTIFIC RESEARCH UNIT

Presentation outline

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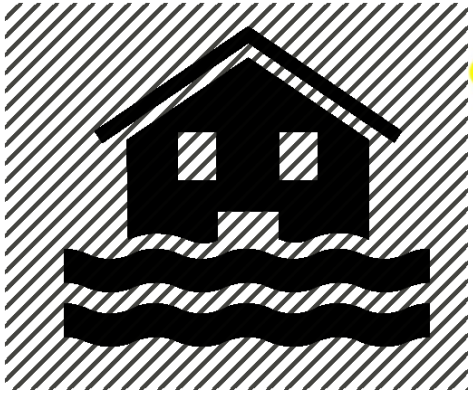
- Mapping and monitoring surface processes and anthropogenic changes with SAR
  - Examples of change detection for flood and landslide hazards
  - Differential InSAR for seismic hazard mapping
  - Multi-temporal InSAR for landslides and subsidence monitoring
- Q&A



Change detection for flood hazards

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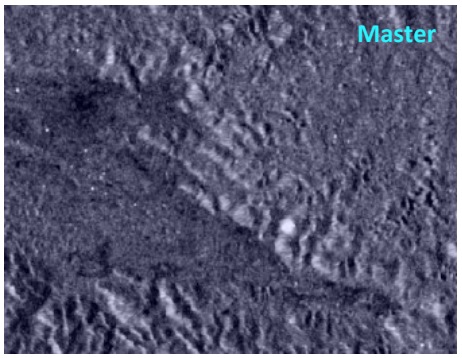
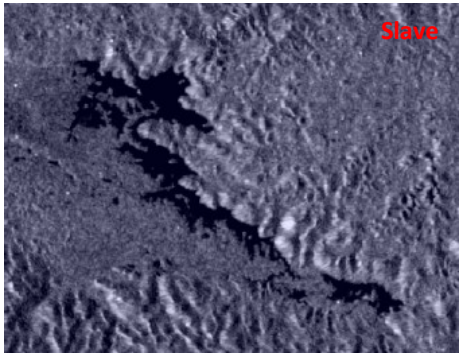
Example of change detection map generated using Sentinel-1 SAR data

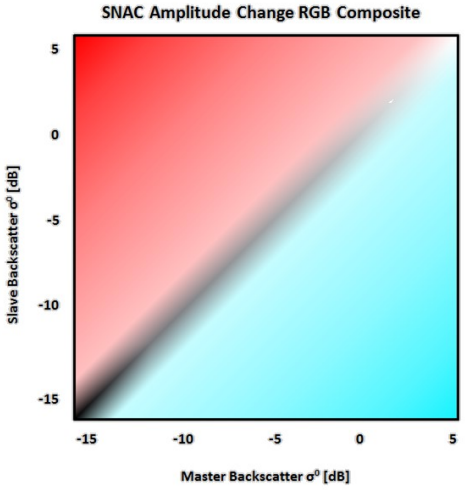
Inputs [*pre vs post Hurricane Matthew*]

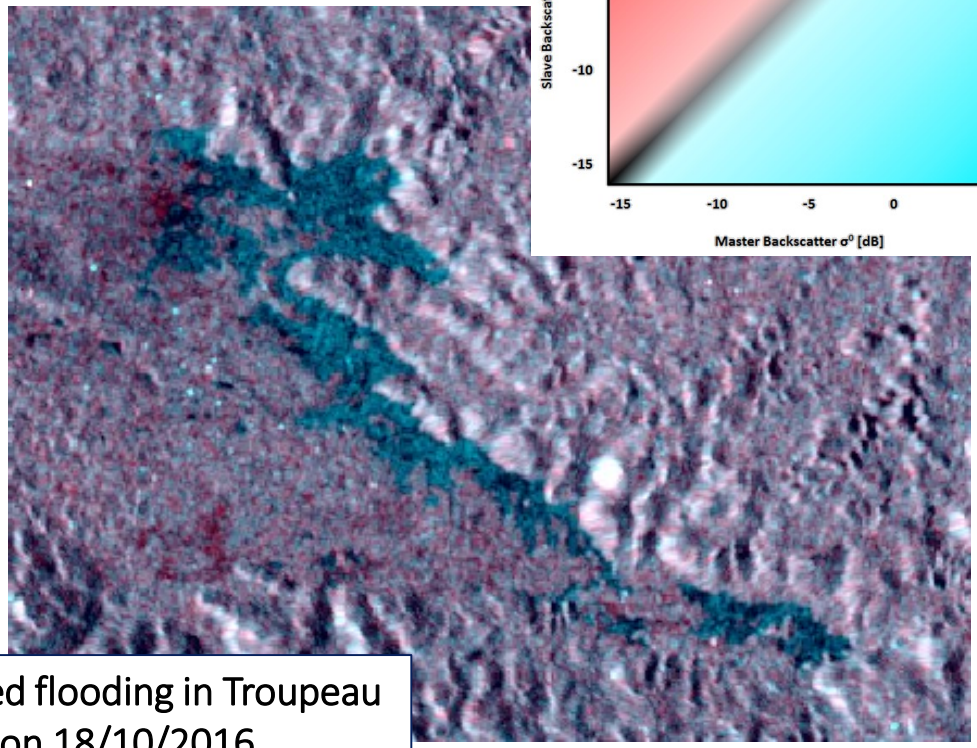
1) Sentinel-1 image 24/09/2016 (master)
2) **Sentinel-1 image** 18/10/2016 (slave)





Output → Red-Cyan color composite





Detected flooding in Troupeau on 18/10/2016

Change detection for flood hazards

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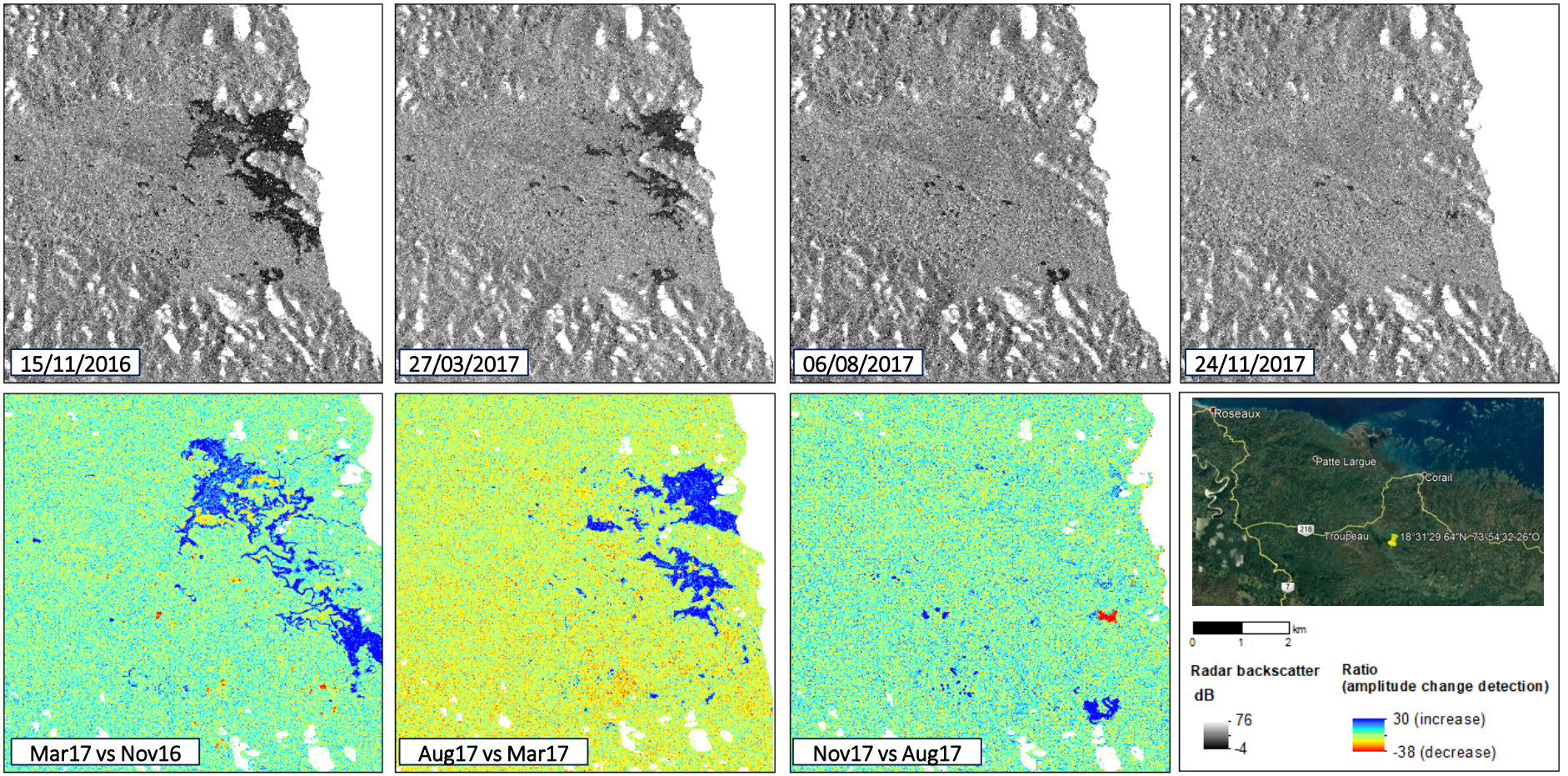
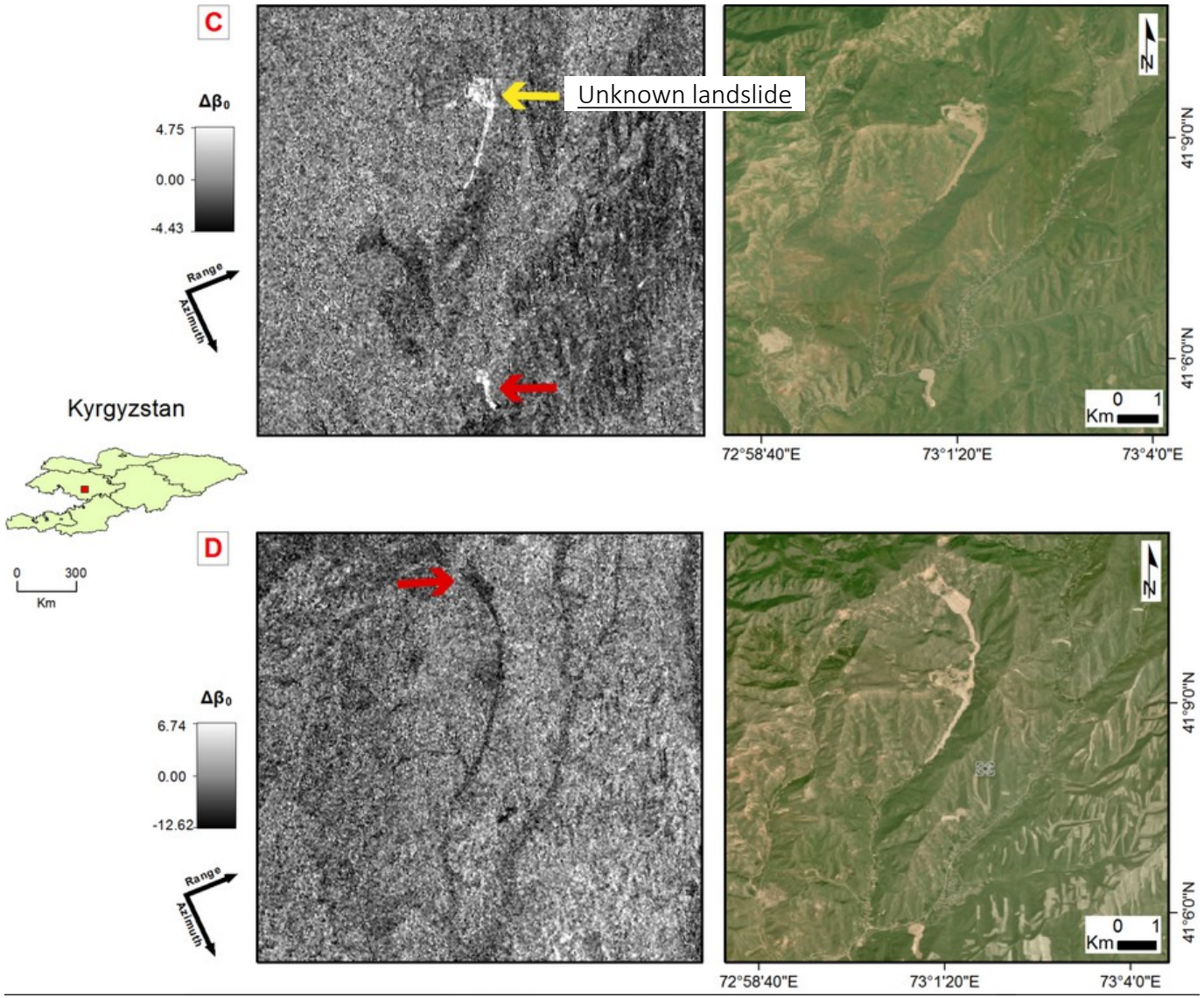
Example of change detection map generated using TerraSAR-X SAR data

Temporal evolution of flooding in Troupeau (1 year)



Landslide detection based on SAR amplitude changes



COSMO-SkyMed for seismic studies - 1

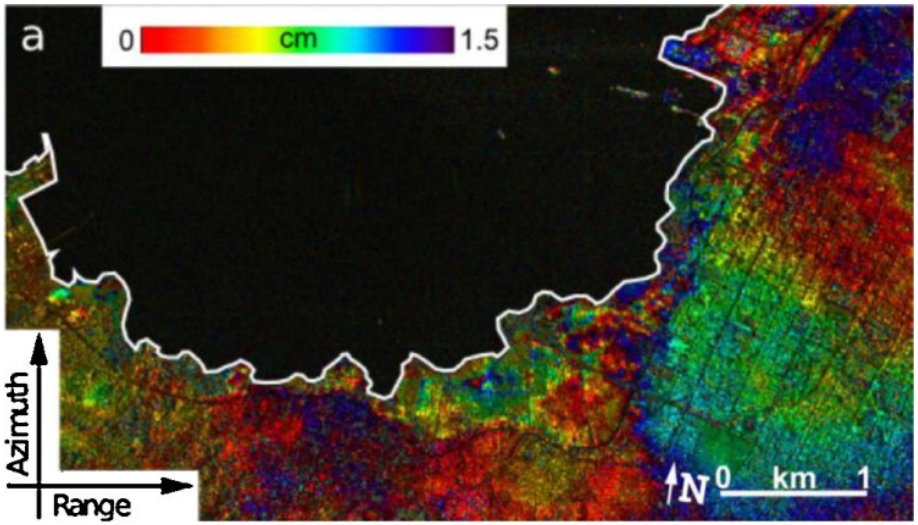
Haiti earthquake – 12 January 2010, Port-au-Prince

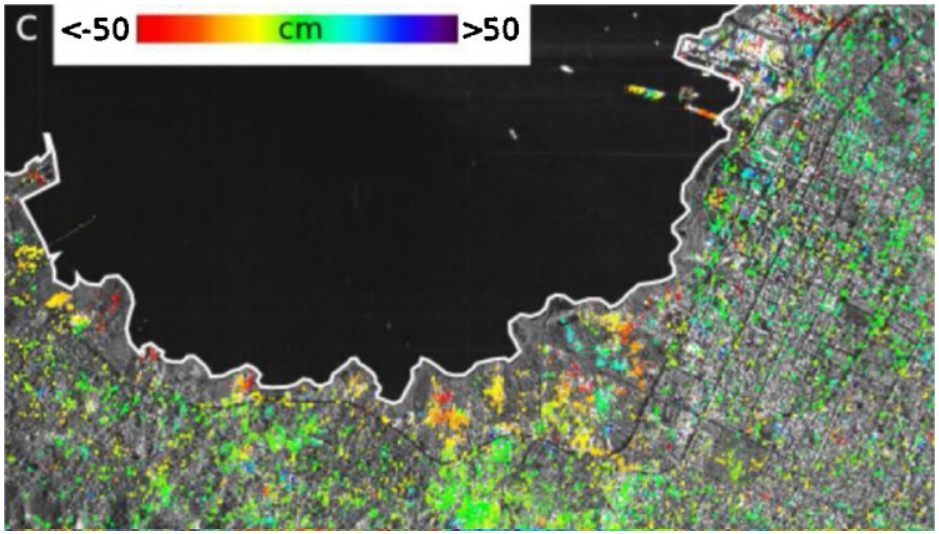
COSMO-SkyMed Spotlight:

(a) post-seismic interferogram (21–29/01/2010, perpendicular baseline 67 m) shows good coherence along the coastline

(b) co-seismic interferogram (12/12/2009–21/01/2010, 280 m) where fringes disappear along the coastline because the deformation signal is too large

(c) amplitude Pixel-Offset range displacement map (12/12/2009–21/01/2010) with displacements retrieved also along the coastline





COSMO-SkyMed for seismic studies - 2

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Ischia earthquake - 21 August 2017, southern Italy

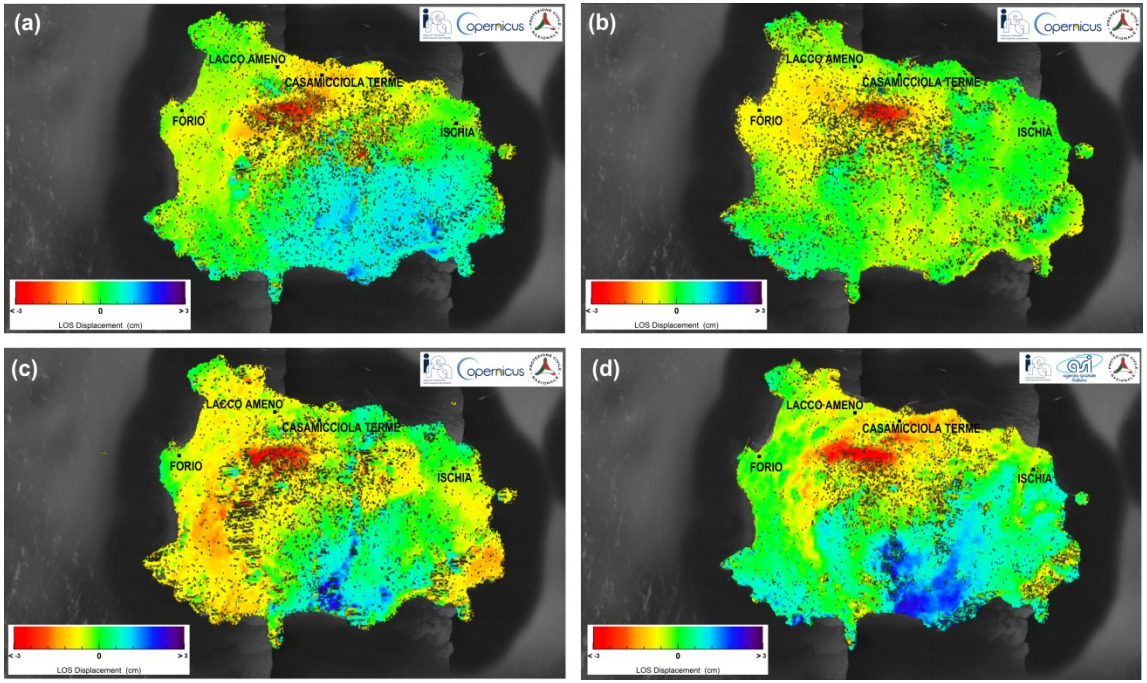
Displacement maps (along the satellite LOS) obtained from Sentinel-1 and COSMO-SkyMed SAR data:

(a) 16082017– 22082017 S1 ascending pair

(b) 16082017–22082017 S1 descending pair

(c) 17082017– 23082017 S1 ascending pair

(d) 19082017– 23082017 CSK ascending pair



InSAR studies of landslides and slope instability

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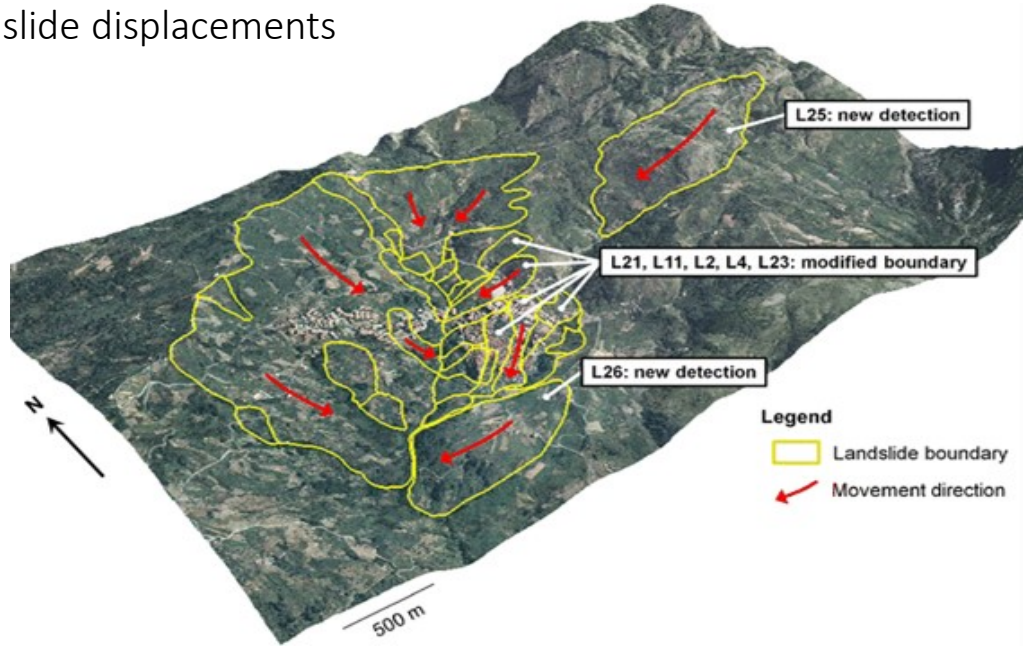
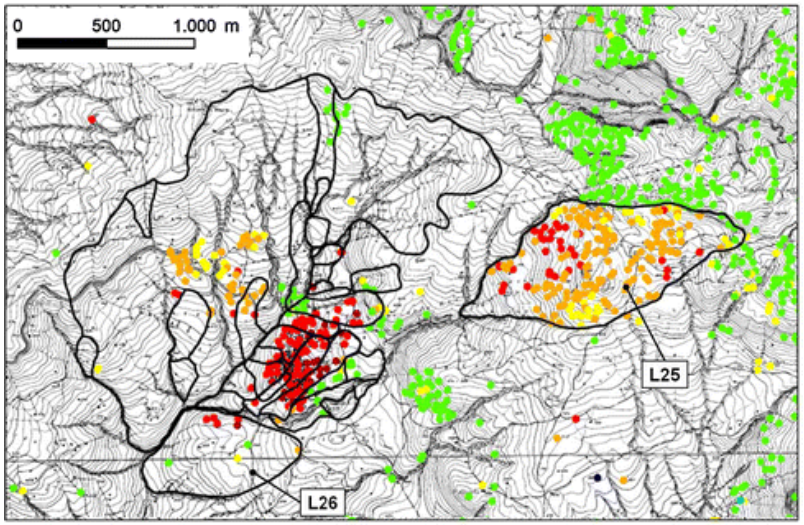
Example of landslide movement estimation and landslide inventorying

Multi-temporal InSAR analysis to estimate landslide displacements and improve landslide mapping in Italy

- Estimation of the **movement velocity** for the already-mapped landslide phenomena
- Detection of 2 **new landslides** (L25-L26)





Updated landslide map

Persistent Scatterers

LOS velocity [mm/yr]

- -65.4 - -20.0
- -19.9 - -10.0
- -9.9 - -5.0
- -4.9 - -2.0
- -1.9 - 2.0
- 2.1 - 5.0
- 5.1 - 20.0

- Possibility to use this information to assess landslide **state of activity** (i.e. active, inactive, dormant, reactivated, satbilized)

InSAR studies of landslides and slope instability

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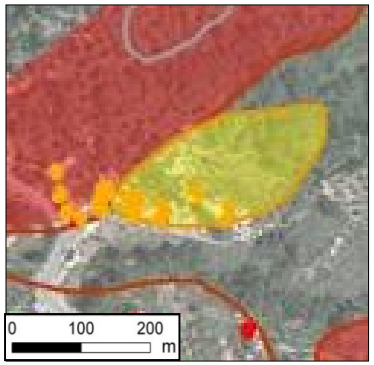
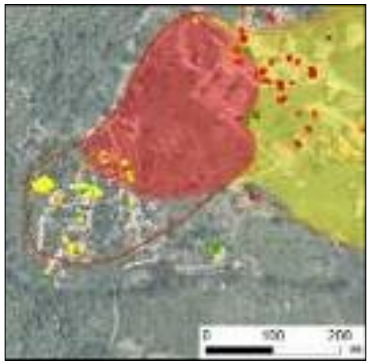
Interpreting PS-InSAR data for landslide mapping and inventorying

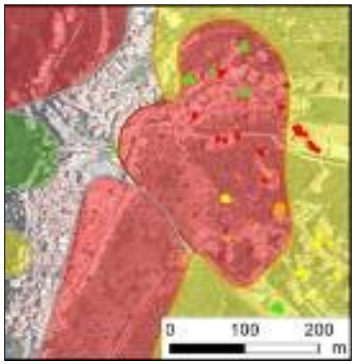
confirmation of the boundaries



change of the boundaries

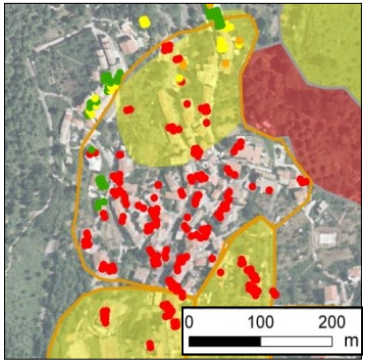


confirmation of the state of activity

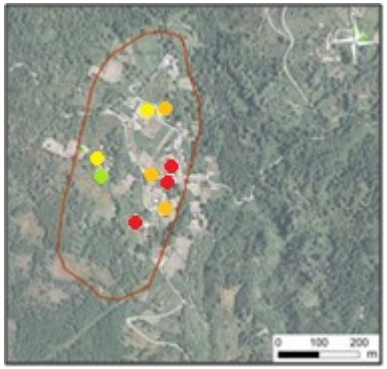


change of the state of activity

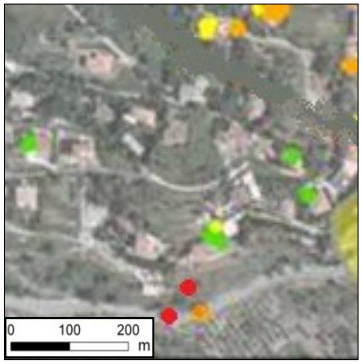
change of the state of activity and boundaries



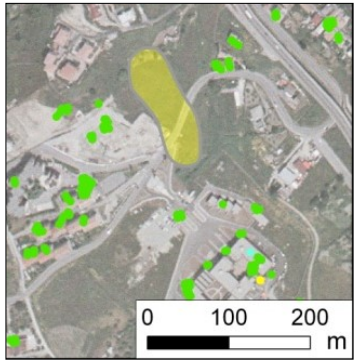
new landslide detection



no additional landslide detection



NO INFO (PS absence)



InSAR studies of landslides and slope instability

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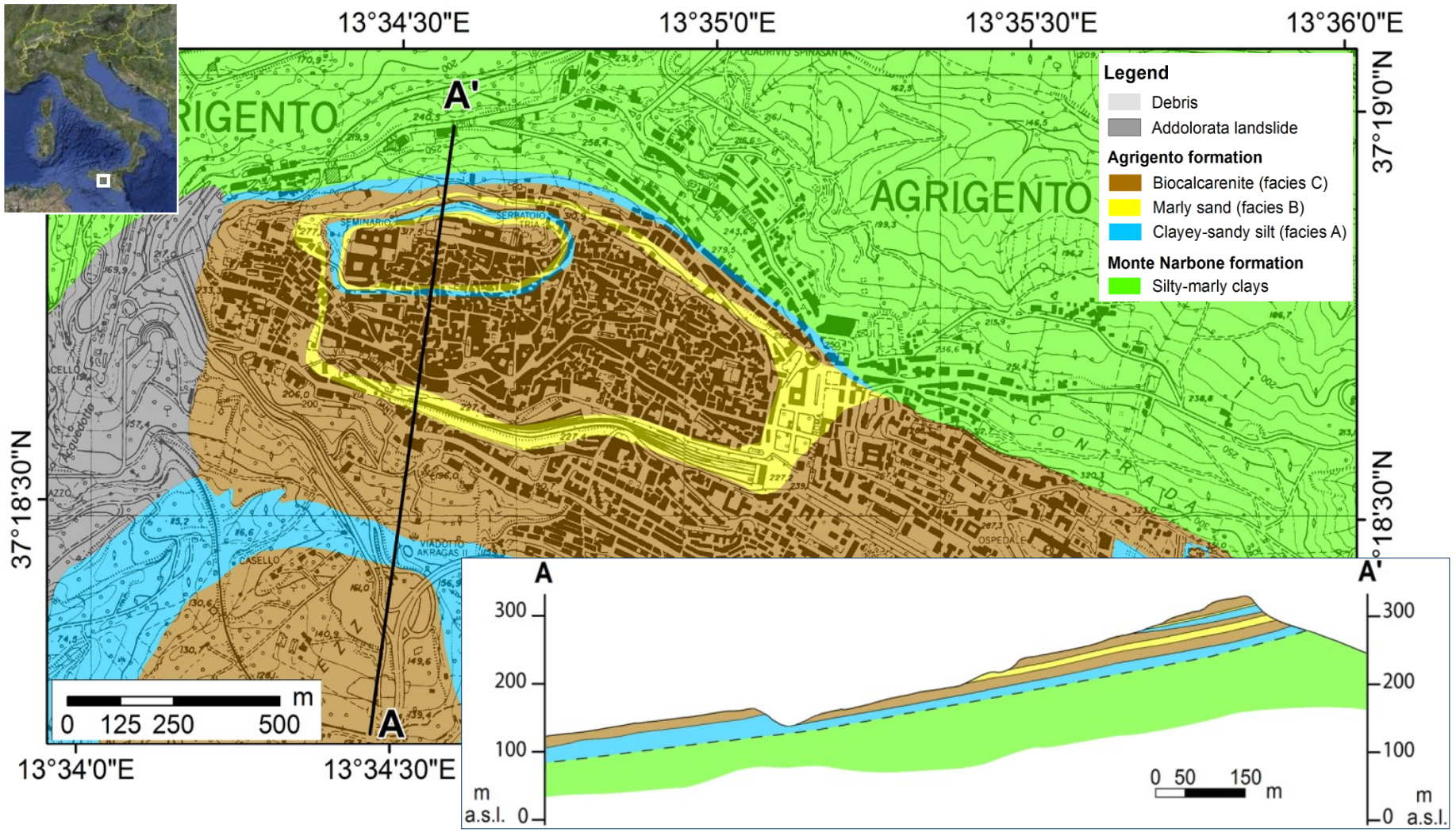

Cigna et al. (2012) *NHESS* 12, 3589-3603. doi: 10.5194/nhess-12-3589-2012

InSAR studies of landslides and slope instability

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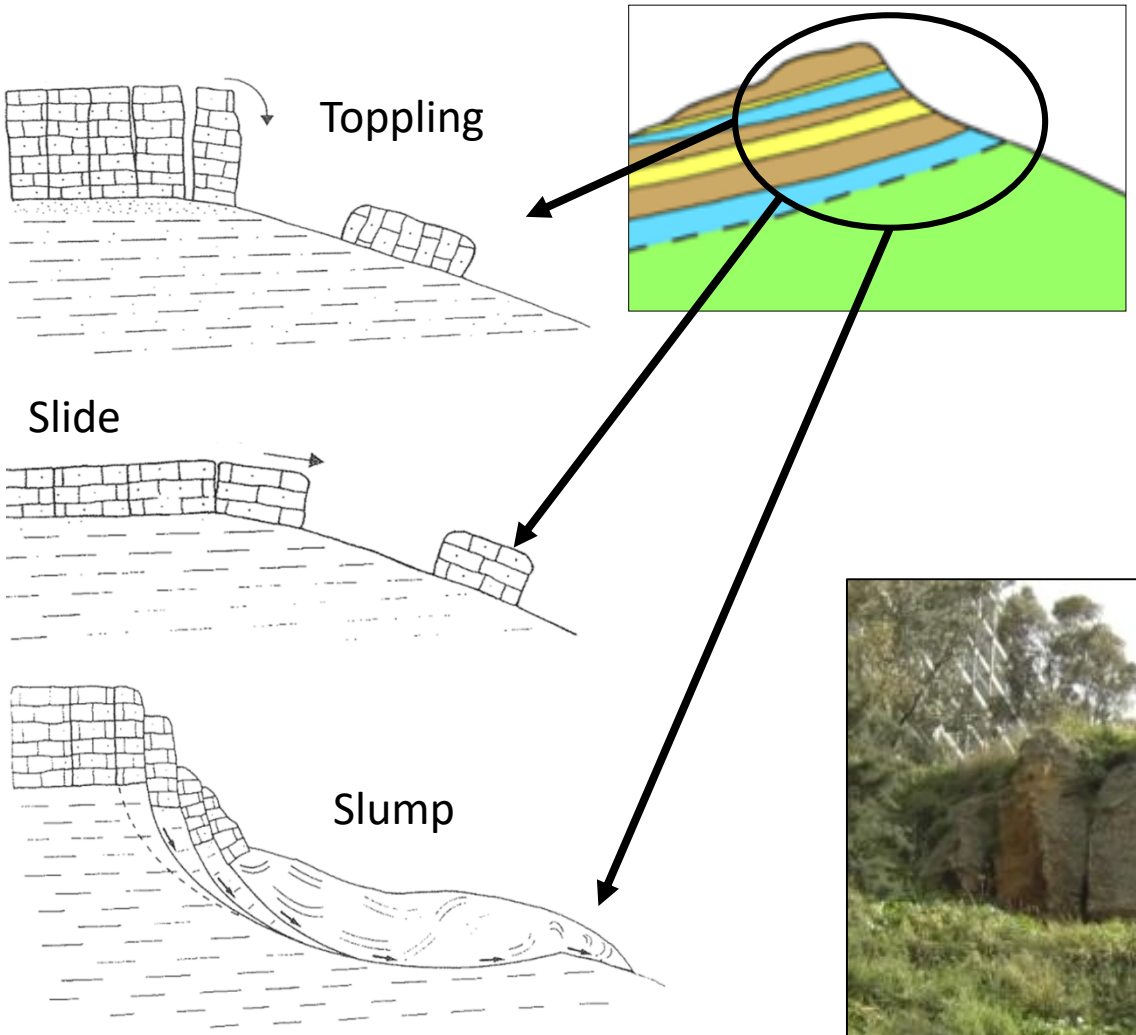
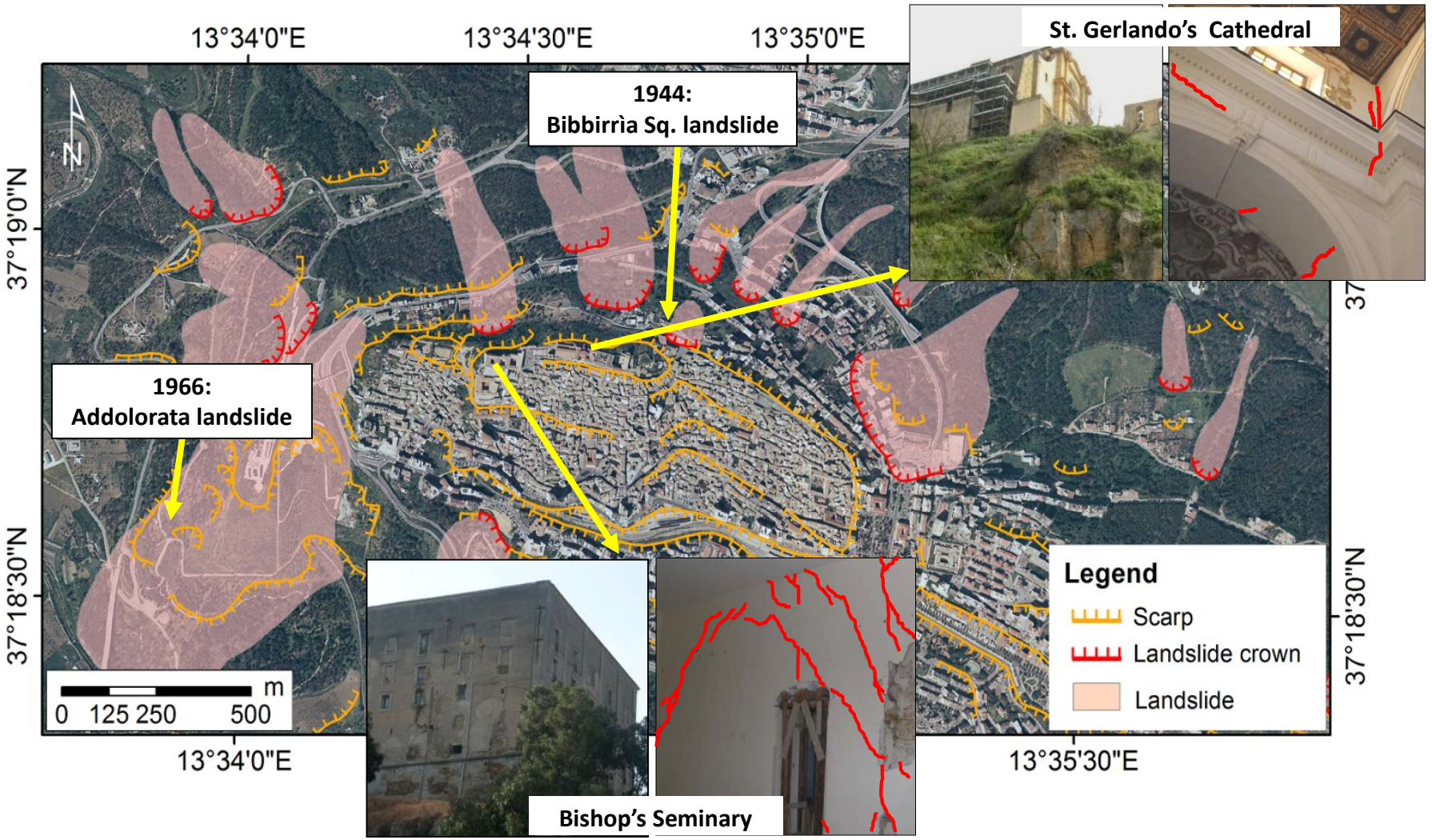


InSAR studies of landslides and slope instability



Cigna et al. (2012) *NHESS* 12, 3589-3603. doi: 10.5194/nhess-12-3589-2012

InSAR studies of landslides and slope instability

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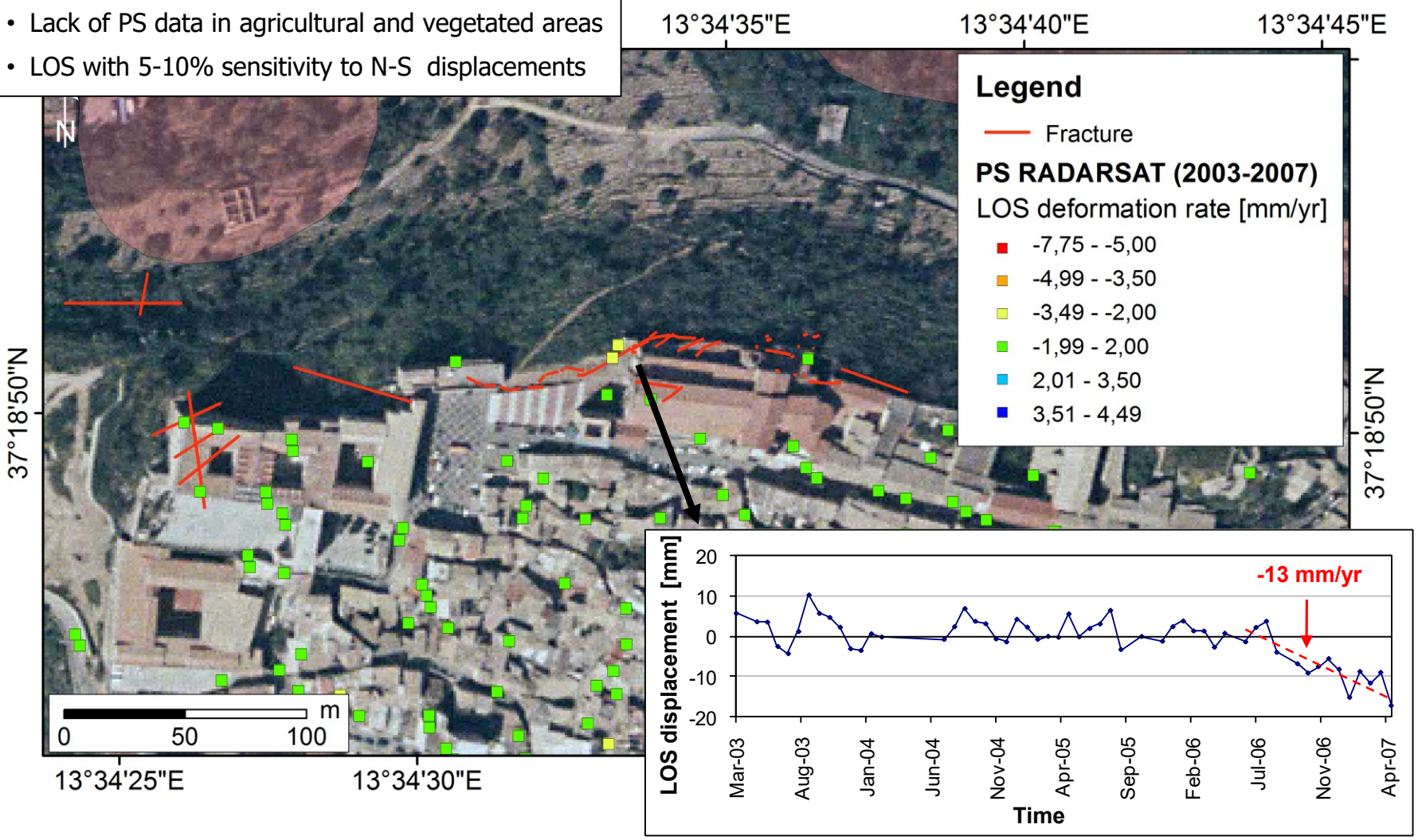
InSAR studies of landslides and slope instability

- Observed acceleration of displacements since 2006
- Lack of PS data in agricultural and vegetated areas
- LOS with 5-10% sensitivity to N-S displacements



Cigna et al. (2012) *NHESS* 12, 3589-3603. doi: 10.5194/nhess-12-3589-2012

InSAR studies of landslides and slope instability

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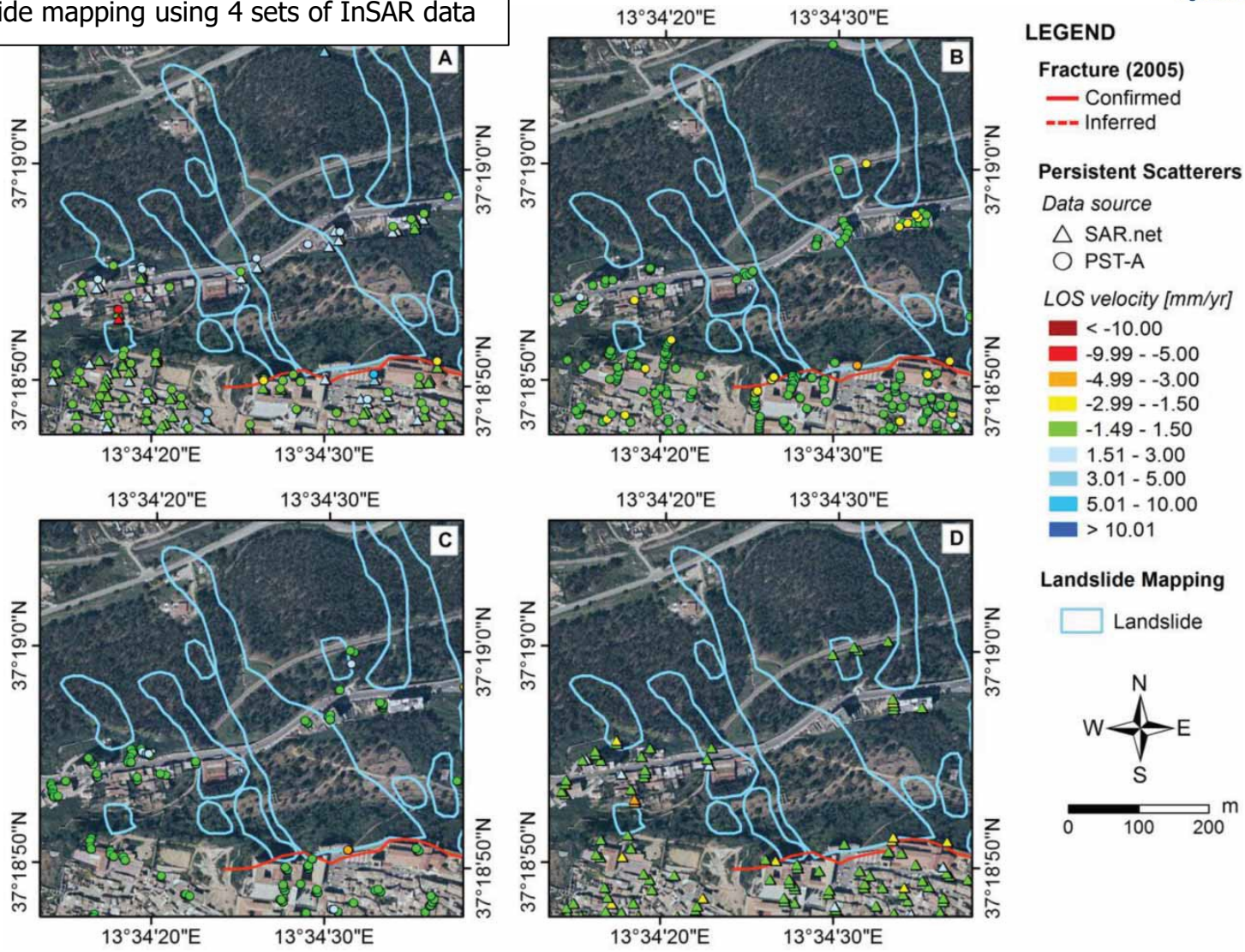
Updated landslide mapping using 4 sets of InSAR data



Ciampalini et al. (2012) *J. of Maps* 8, 136-145. doi: 10.1080/17445647.2012.680775

InSAR studies of landslides and slope instability

Agenzia Spaziale Italiana

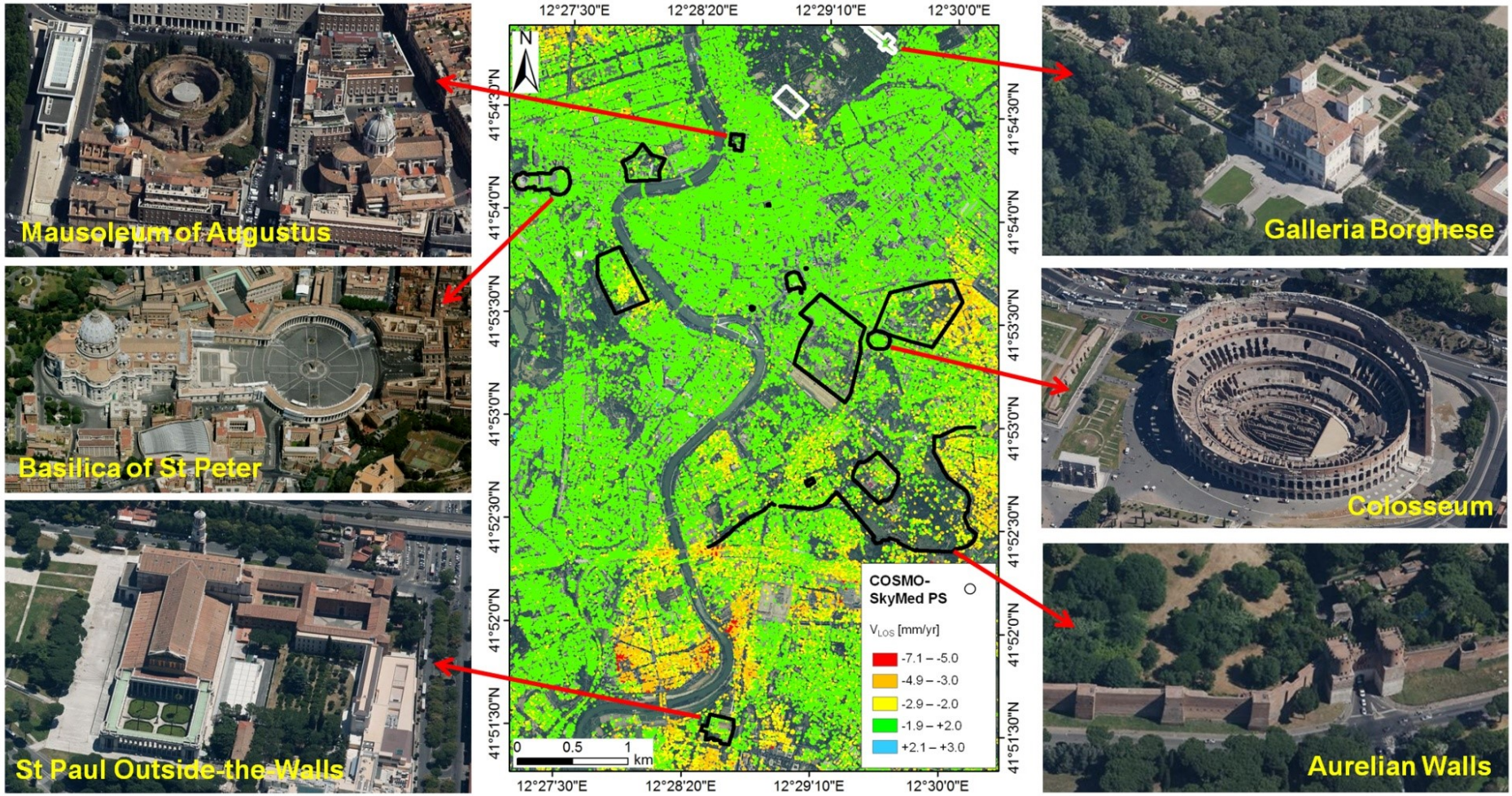
July 2011

The hazard scenario provided by InSAR for the period 1992-2008 anticipated the reactivation of structural instability in 2011

InSAR studies of subsidence in urban areas

Agenzia Spaziale Italiana

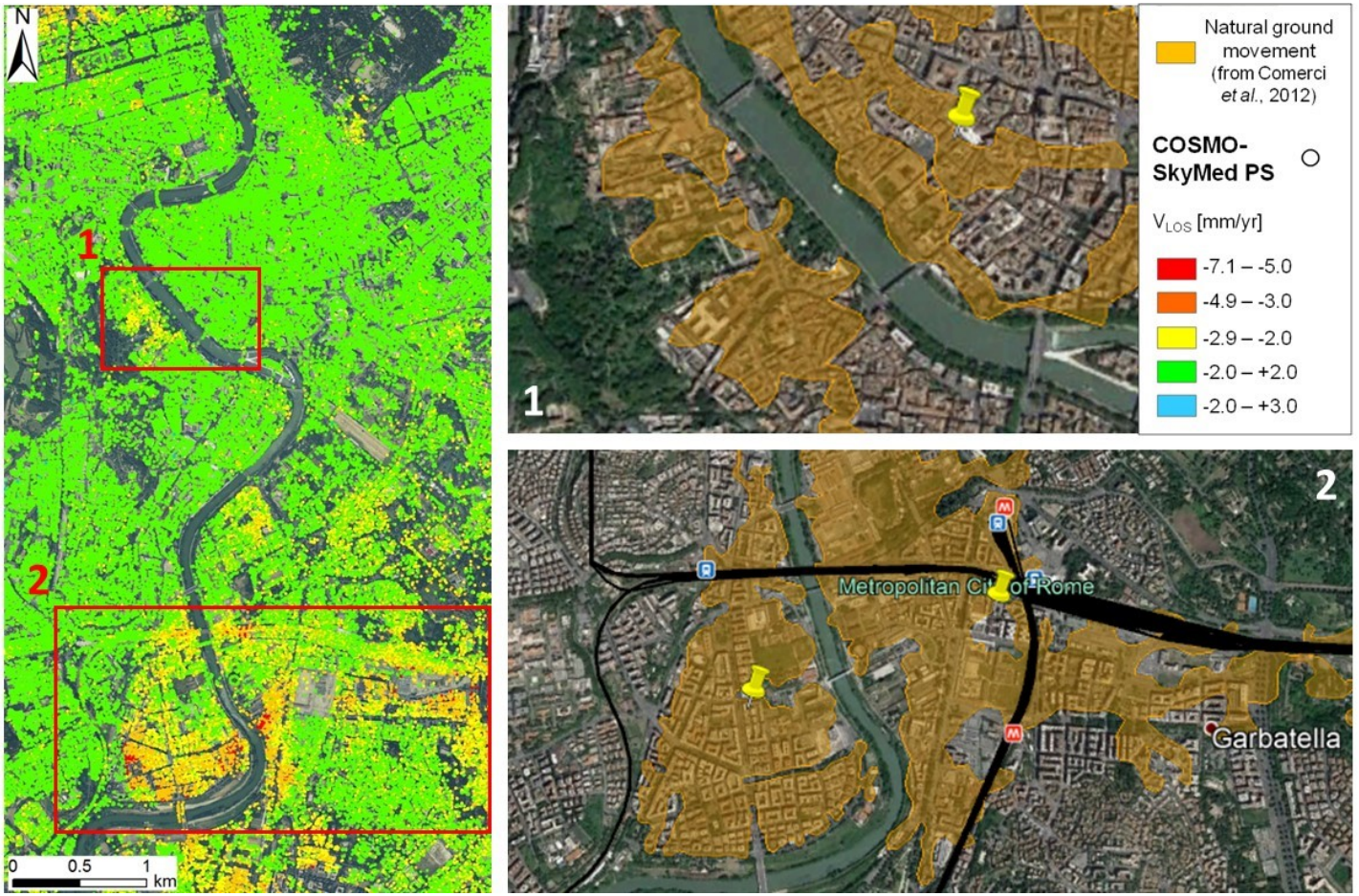
InSAR ground motion monitoring of Rome



InSAR studies of subsidence in urban areas

Agenzia Spaziale Italiana

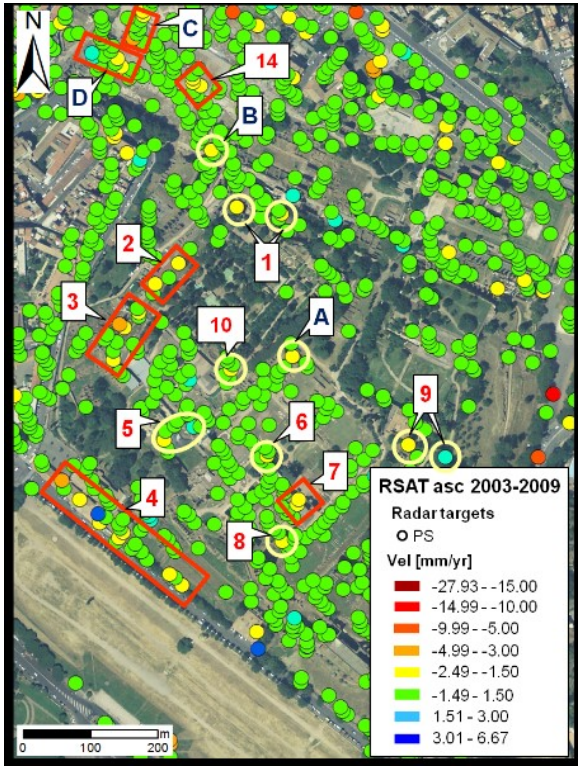
Terrain motion mapping with COSMO-SkyMed time series and correlation with city subsurface and anthropogenic activities

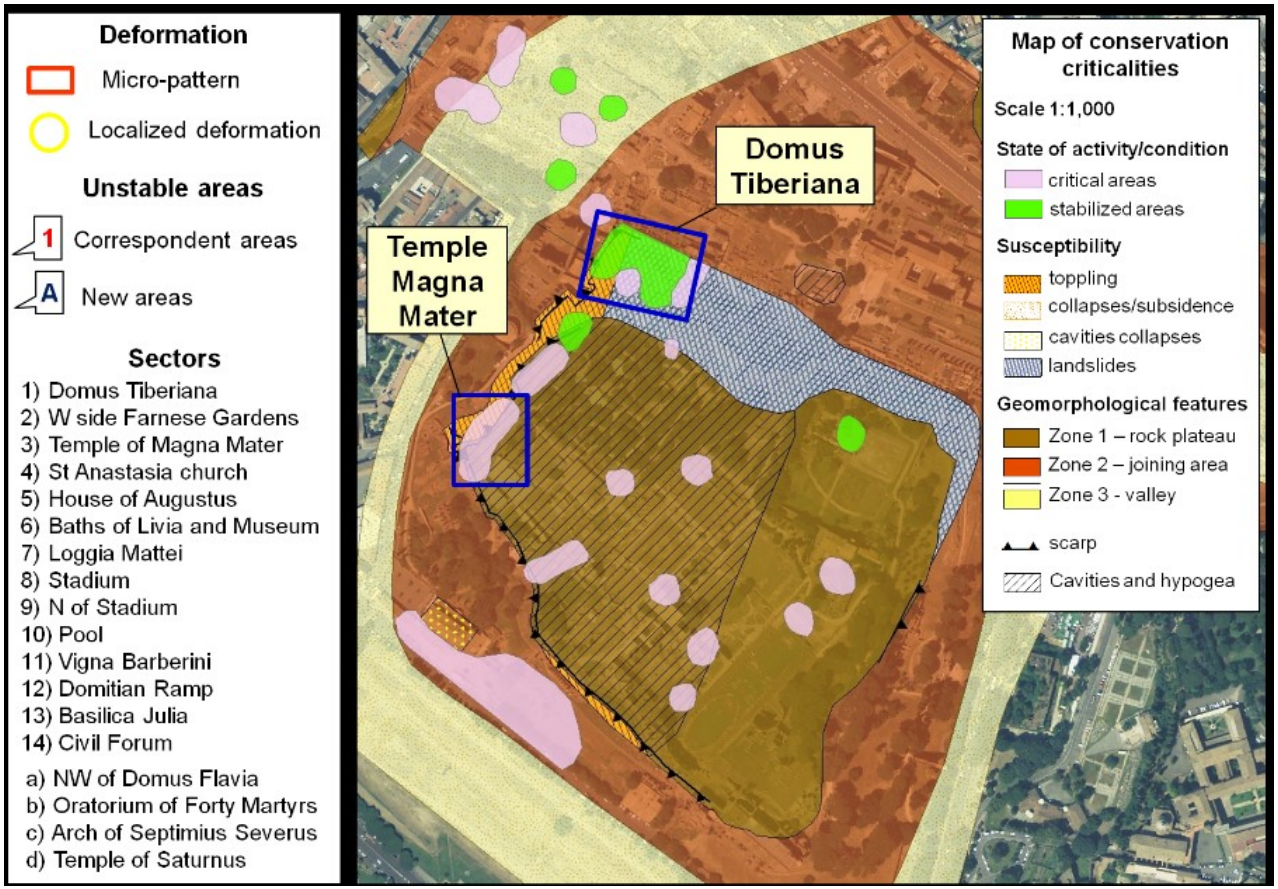


InSAR studies of subsidence in urban areas

InSAR ground motion monitoring of Rome

- Land subsidence and compressible soils (high occurrence across Europe)
- Slope instability, local collapses
- Identification of most endangered sectors

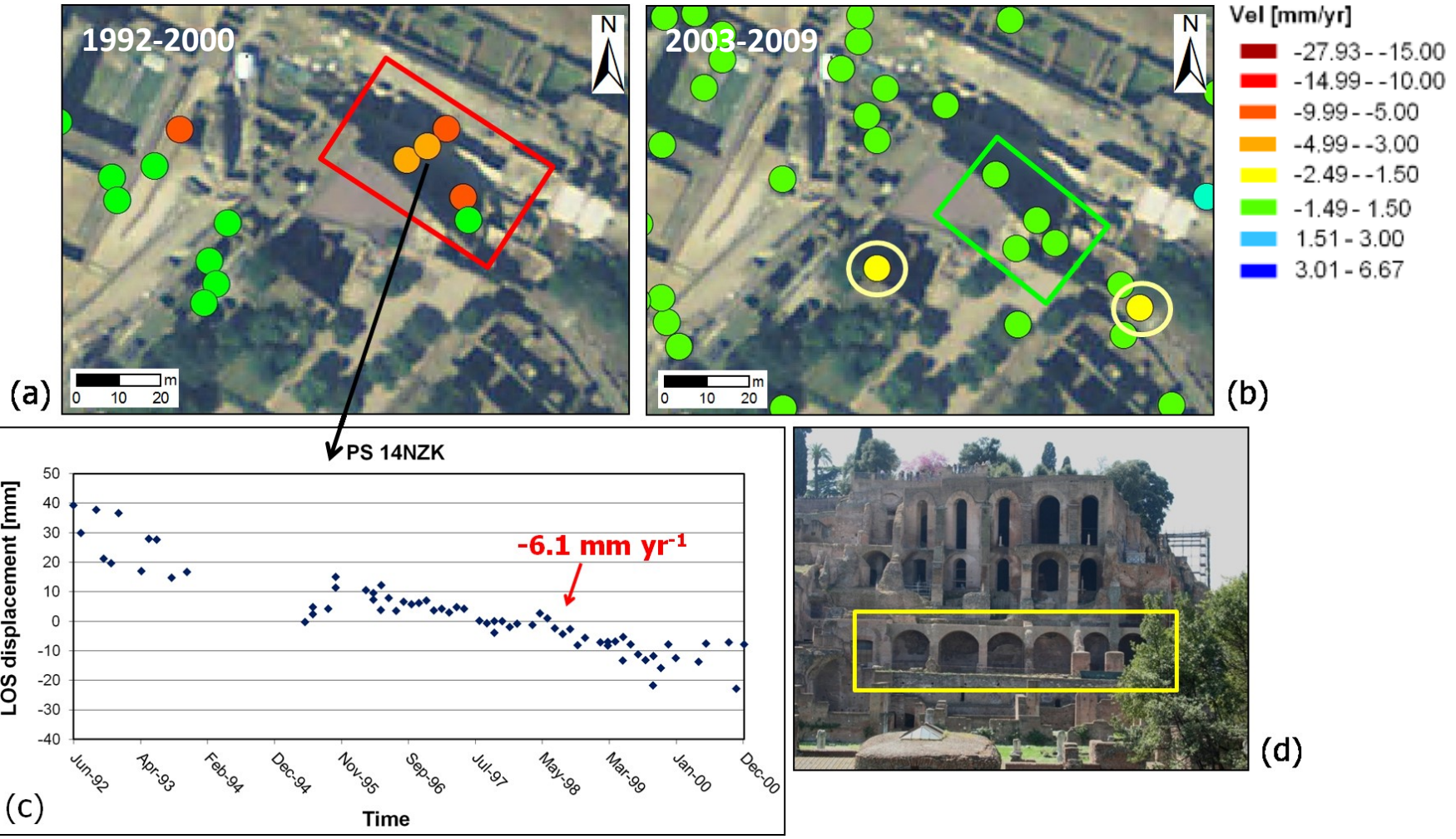




InSAR studies of subsidence in urban areas

Assessment of restoration effectiveness

Domus Tiberiana



InSAR studies of subsidence in urban areas

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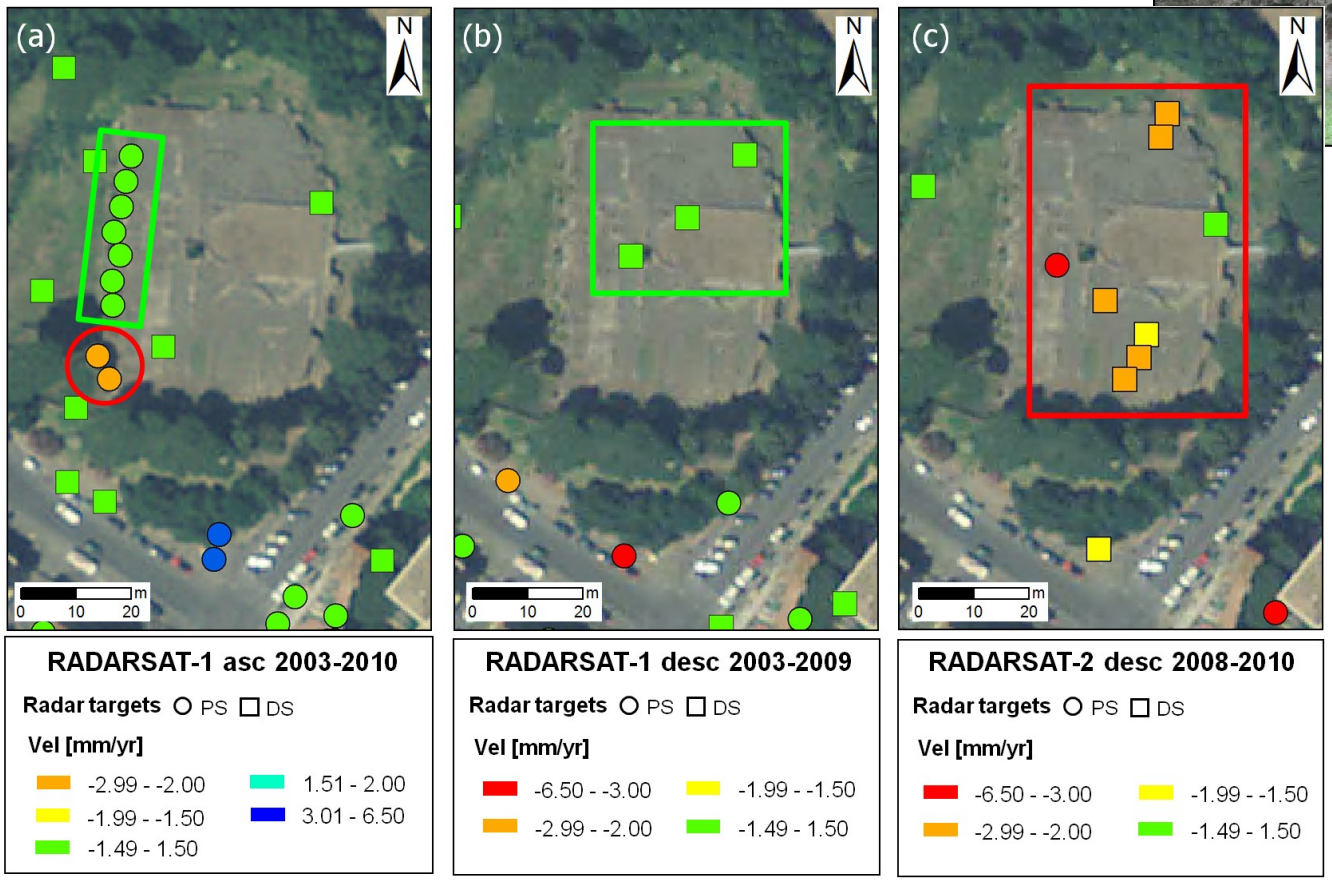
Condition monitoring and assessment

Roman cistern "delle Sette Sale", Baths of Trajan, Oppian Hill



InSAR studies of subsidence in urban areas

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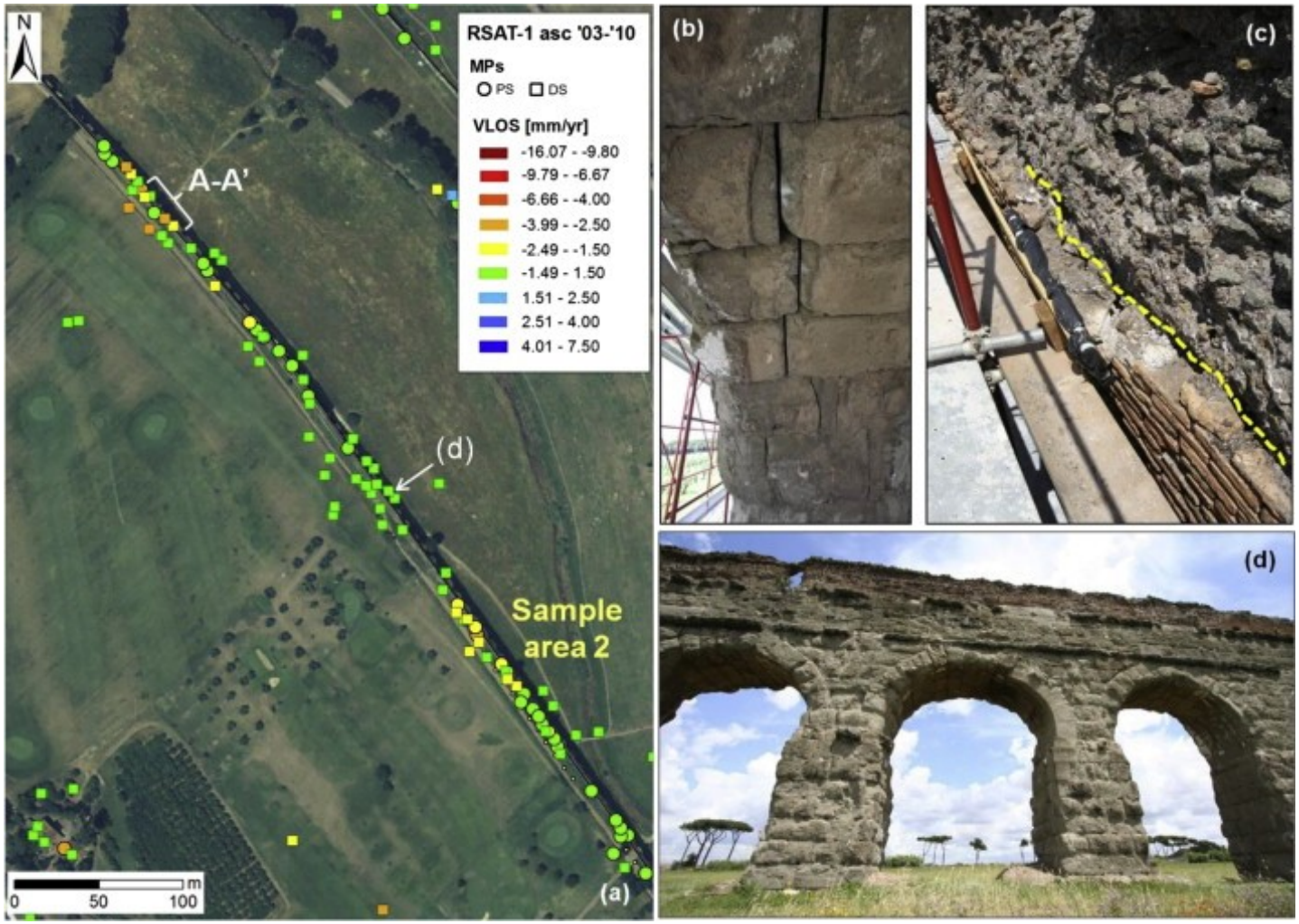
Management and maintenance of linear structures (aqueducts, pipelines, infrastructure)



Experiment with parallel InSAR processing in HPC

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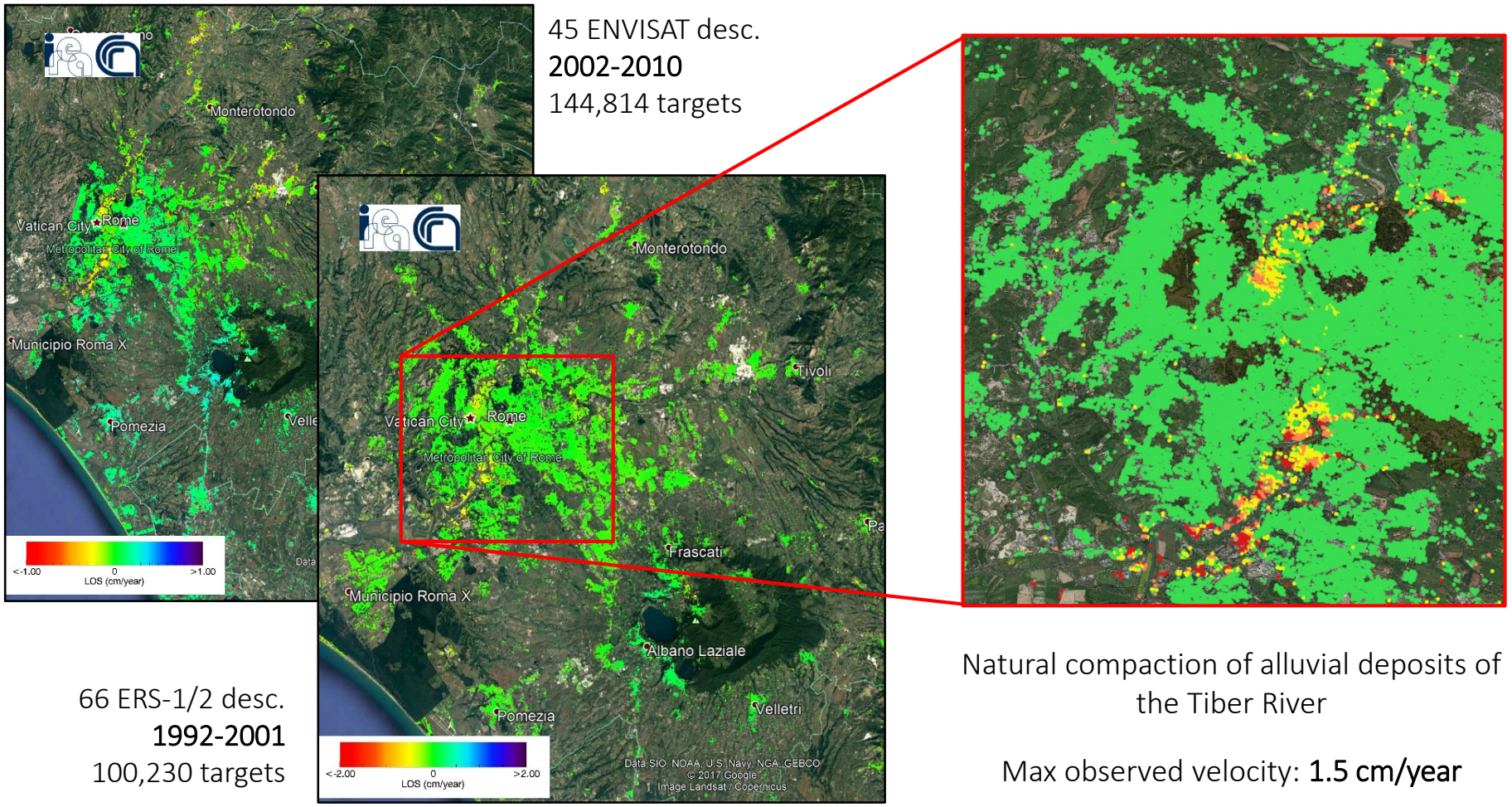
Ground stability and motion in 1992-2001 and 2002-2010



45 ENVISAT desc.
2002-2010
144,814 targets

66 ERS-1/2 desc.
1992-2001
100,230 targets

Natural compaction of alluvial deposits of the Tiber River

Max observed velocity: **1.5 cm/year**

InSAR studies of subsidence in urban areas

Land subsidence in Mexico City

Mexico City's Cathedral

Subsidence has affected the city for over a century

Up to 20-30 cm/year subsidence observed

Population: ~ 9 million inhab.
> 21 million in the metropolitan area

Angel de la Independencia monument (1910 vs. 2010)

InSAR studies of subsidence in urban areas

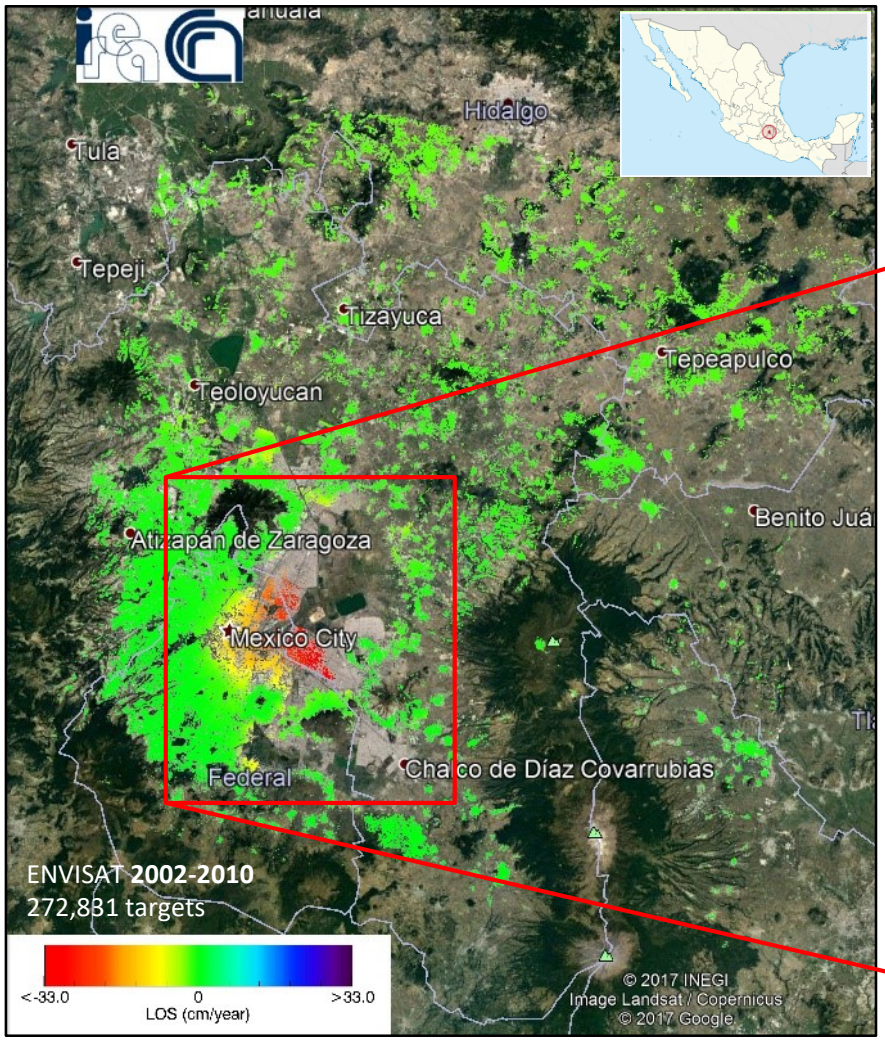
Agenzia Spaziale Italiana

Land subsidence in Mexico City

Undulating rooflines reflect Mexico City's unstable, sinking foundation

InSAR studies of subsidence in urban areas

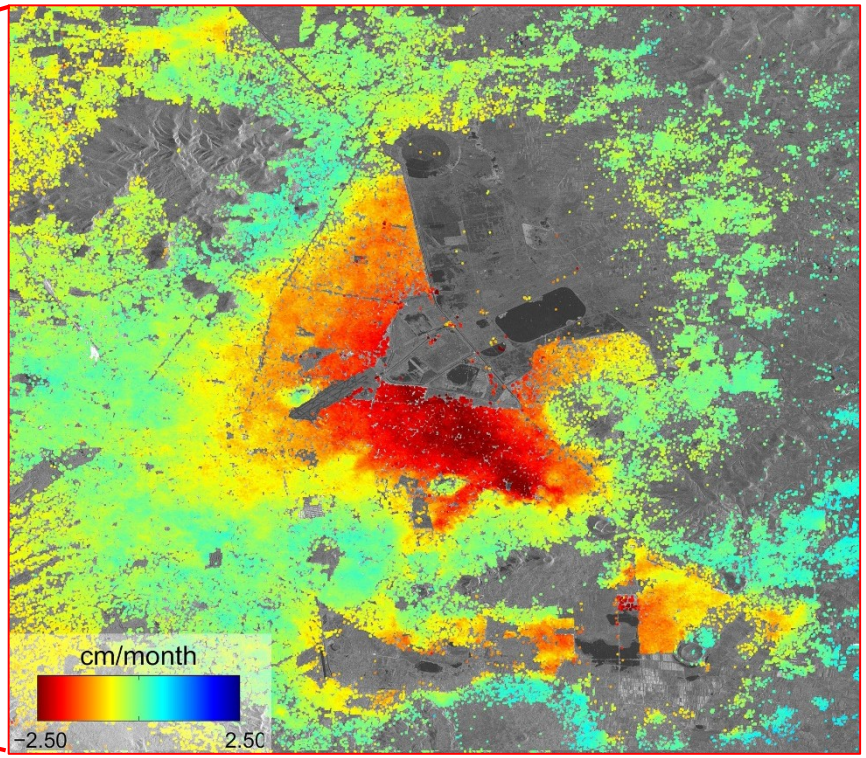
Land subsidence in Mexico City



Sentinel-1 SBAS results 2014

Sentinel-1A radar scenes acquired in Oct-Dec 2014 were combined to derive ground deformation

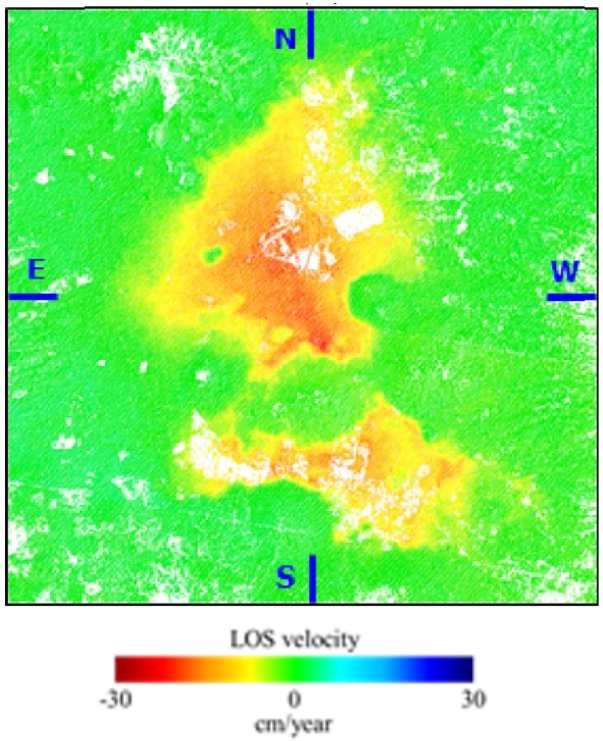
Some areas subside at **up to 2.5 cm/month**



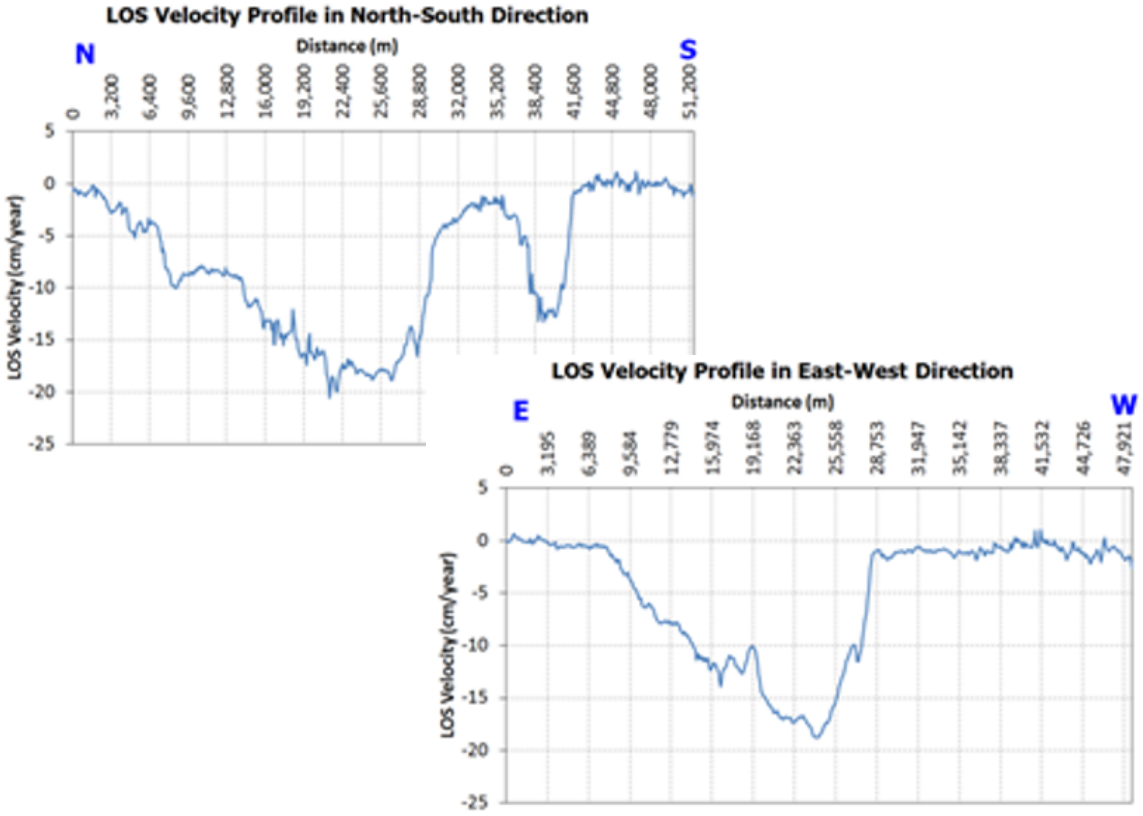
Credit: Copernicus data (2014)/ESA/DLR Microwave and Radar Institute–SEOM InSARap study

InSAR studies of subsidence in urban areas

Land subsidence in Mexico City



Sentinel-1 SBAS analysis of ground motion in 2014-2015

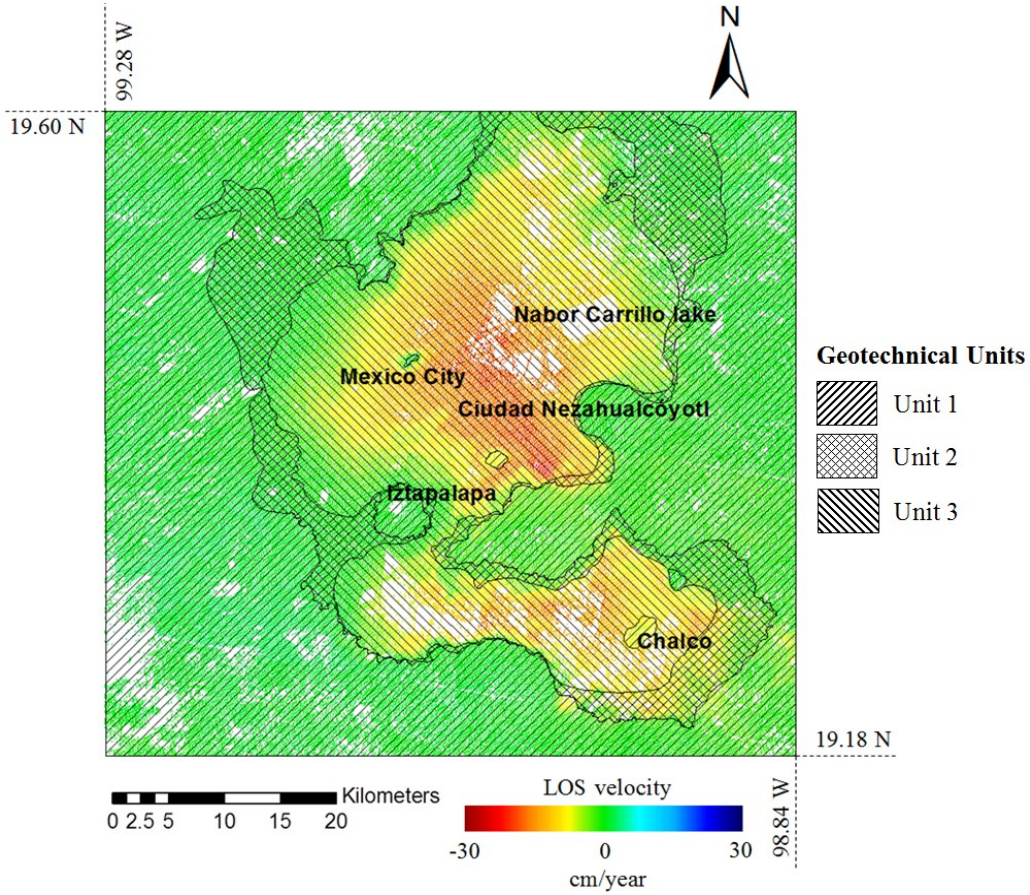


Velocity profiles along N-S and E-W direction.

Sowter *et al.* 2016

InSAR studies of subsidence in urban areas

Land subsidence in Mexico City



Sentinel-1 InSAR results onto geotechnical zoning by GODF (Gobierno del Distrito Federal) 2004

Subsidence rates increase towards the center of the former Lake Texcoco.
Here the soft and compressible Quaternary clay and silt-rich lacustrine sediments (**Unit III**) are thicker (i.e. up to ~350 m)

Negligible subsidence velocities are observed for the hard rock unit (<±6 cm/year), corresponding to basaltic lava flows, tuffs and sandy beds with gravel (**Unit I**)

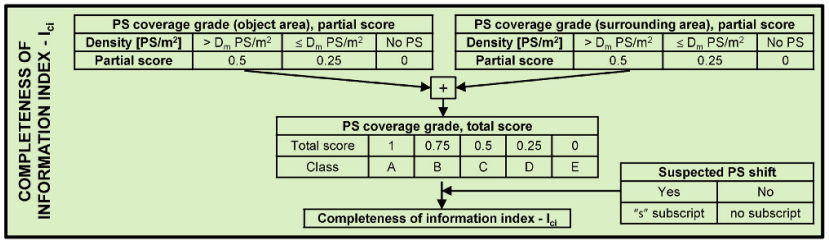
Sowter *et al.* 2016

InSAR studies of subsidence in urban areas

Building classification indices

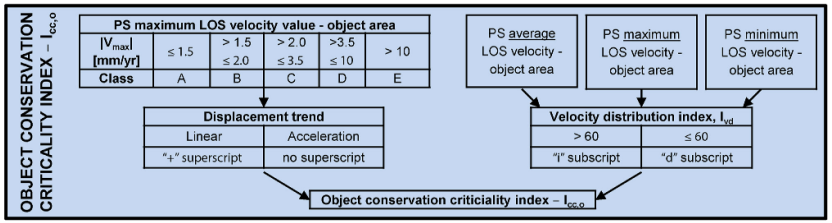
I_{ci}: Completeness of Information Index

Expressing the degree of PS coverage over a building,
i.e. how many PS fall over the building compared with the average density of the whole dataset



Max velocity rating

Maximum velocity observed for each building, classified according to an A to E rating



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Rating health and stability of engineering structures via classification indexes of InSAR Persistent Scatterers

Fabio Pratesi [a,b,*], Deodato Tapete [c], Gloria Terenzi [b], Chiara Del Ventisette [a], Sandro Moretti [a]

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[b] University of Florence, Department of Civil and Environmental Engineering, Via di S. Marta, 3, 50139 Firenze, Italy
[c] Durham University, Department of Geography – Institute of Hazard, Risk and Resilience (IHRR) South Road, DH1 3LE, Durham, UK

Applied Geography 77 (2016) 20–37

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Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

Mapping interactions between geology, subsurface resource exploitation and urban development in transforming cities using InSAR Persistent Scatterers: Two decades of change in Florence, Italy

Fabio Pratesi [a, b, *], Deodato Tapete [c], Chiara Del Ventisette [a], Sandro Moretti [a]

[a] University of Florence, Earth Sciences Department, Via La Pira, 4, 50121, Firenze, Italy
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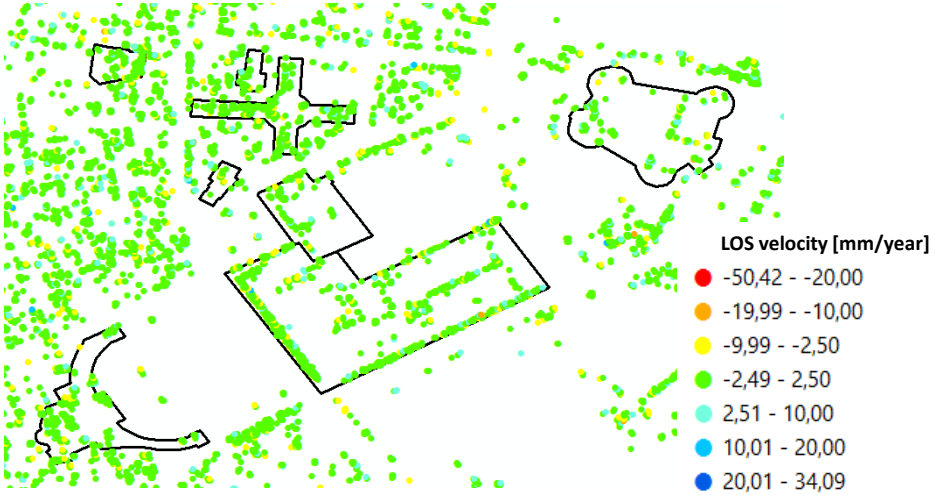
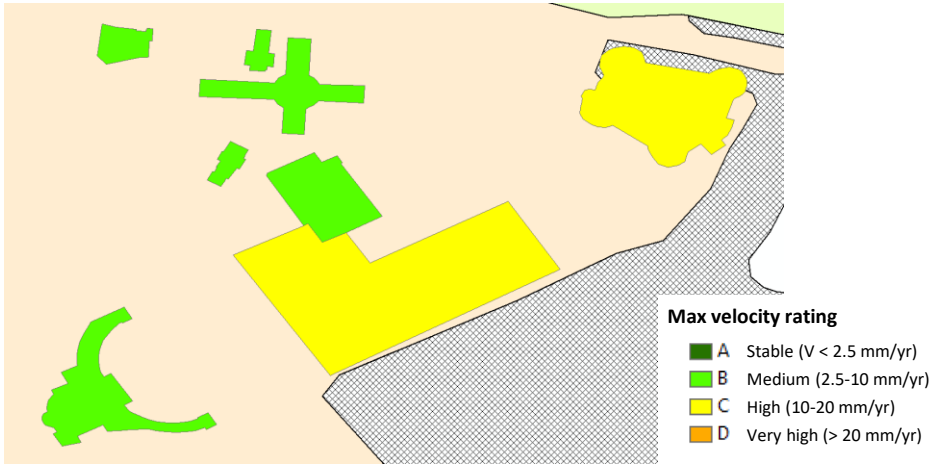
[c] British Geological Survey, Natural Environment Research Council, Nicker Hill, Keyworth, NG12 5GG, United Kingdom

InSAR studies of subsidence in urban areas

Analysis of ground motion trends within the urban area of Naples

Hotspot: Historic buildings





Key assets

1 = San Francesco di Paola Church
2 = Royal Palace
3 = San Carlo Theathre
4 = San Ferdinando Church
5 = Castel Nuovo (Maschio Angioino)
6 = Galleria Umberto I
7 = Santa Brigida Church
8 = Augusteo Theathre

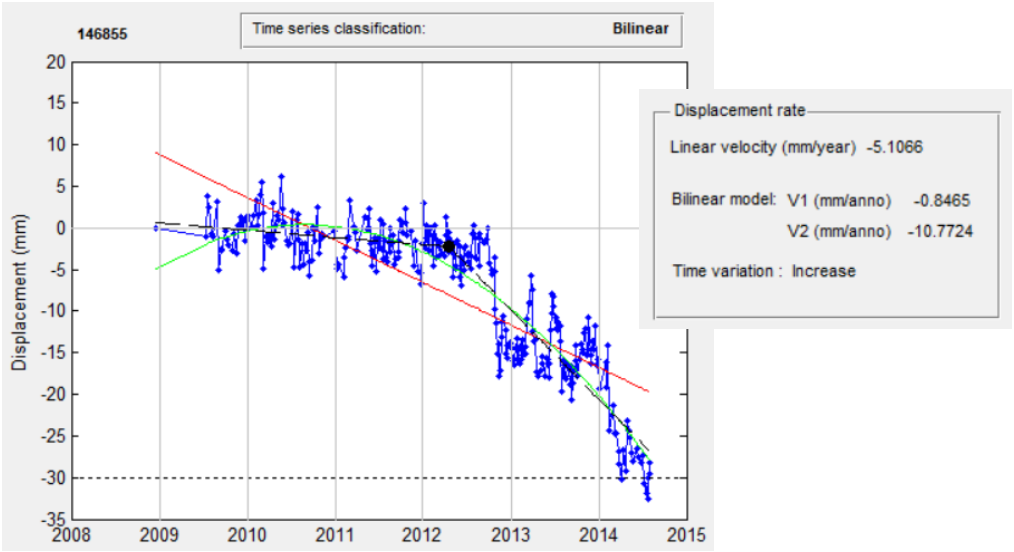
InSAR studies of subsidence in urban areas

Analysis of ground motion trends within the urban area of Naples

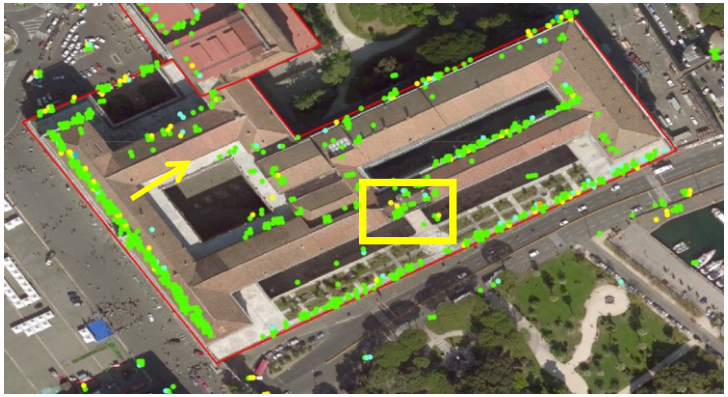
Agenzia Spaziale Italiana

Hotspot: Historic buildings

Maschio Angioino (Castel Nuovo)



Royal Palace



Maschio Angioino

→ Unstable tower (?): a few PS with non-linear trend (bilinear and discontinuous with variable velocity)

→ Engineering works for the construction of the underground?

Royal Palace

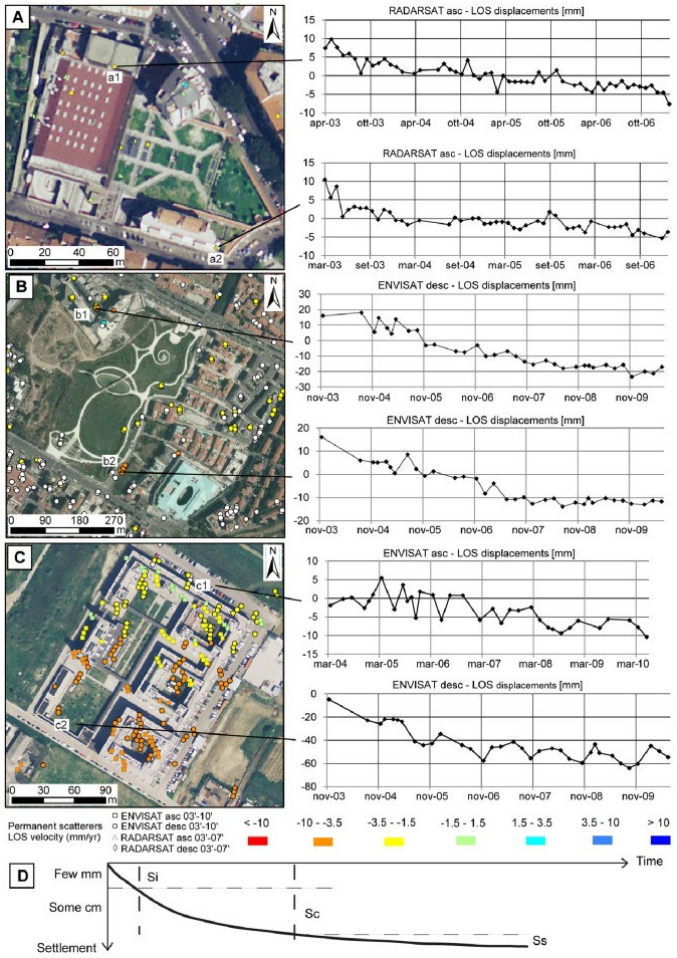
→ In July 2014 some blocks detached from the western facade (V_{LOS} up to -10 mm/year)

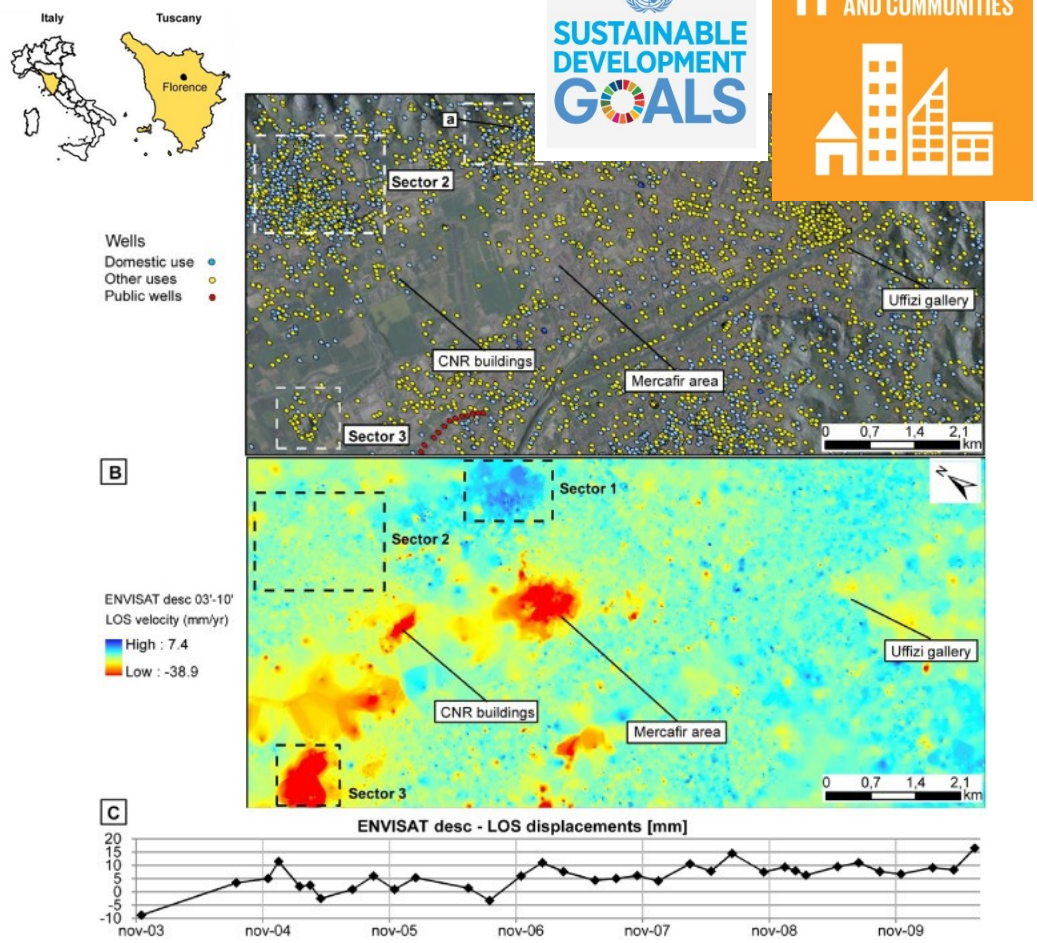
→ Neoclassical Hall: V_{LOS} up to -6 mm/year

InSAR to study urban sustainable development

Agenzia Spaziale Italiana

Quantitative measurements to spatially analyse how cities cope with new urban development and increasing demand for water supply





SUSTAINABLE DEVELOPMENT GOALS

11 SUSTAINABLE CITIES AND COMMUNITIES

Pratesi et al. (2016) *Applied Geography* 77, 20-37. doi: 10.1016/j.apgeog.2016.09.017

THANK YOU FOR YOUR ATTENTION!

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