



UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

**CENTRO  
PROTEZIONE  
CIVILE**



REGIONE DEL VENETO

# L'interferometria radar satellitare negli ultimi vent'anni

Silvia BIANCHINI

# Contenuti

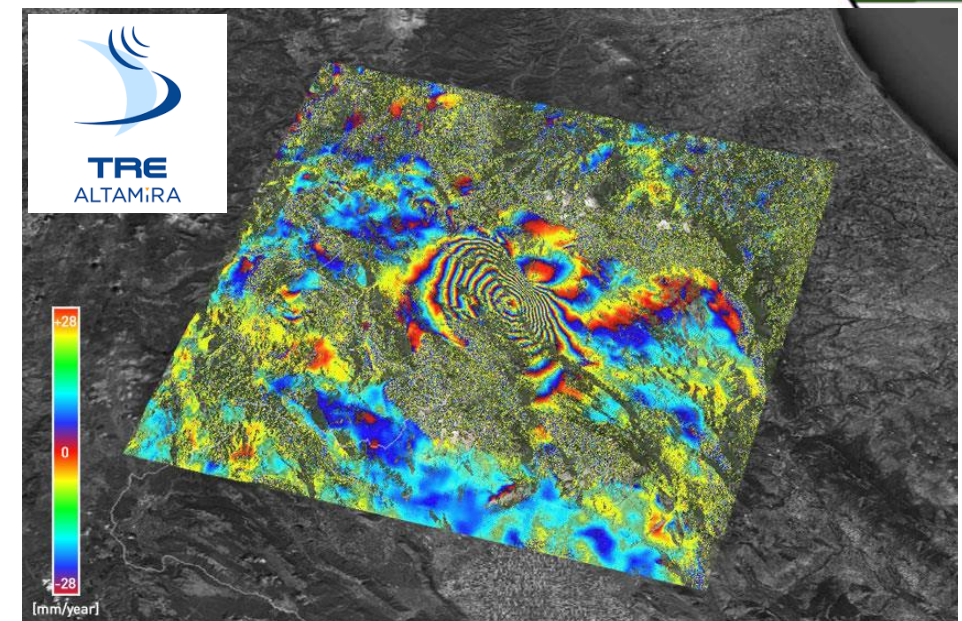
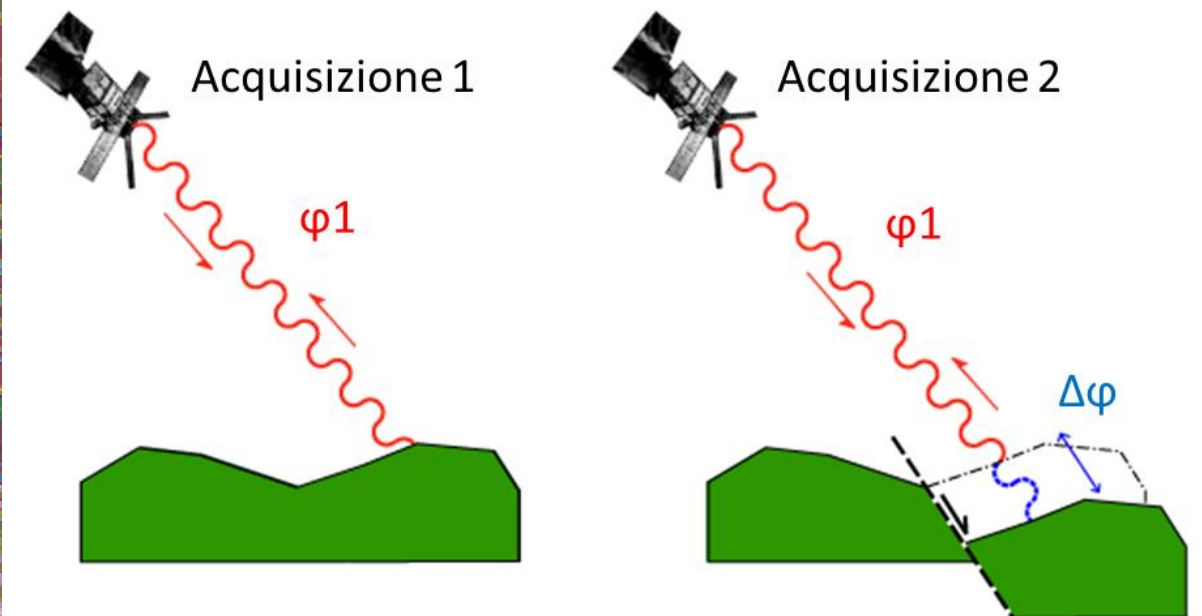
- Panoramica sull'evoluzione storica della tecnica InSAR
- Stato dell'arte InSAR da satellite
- Campi di applicazione

# Interferometria satellitare

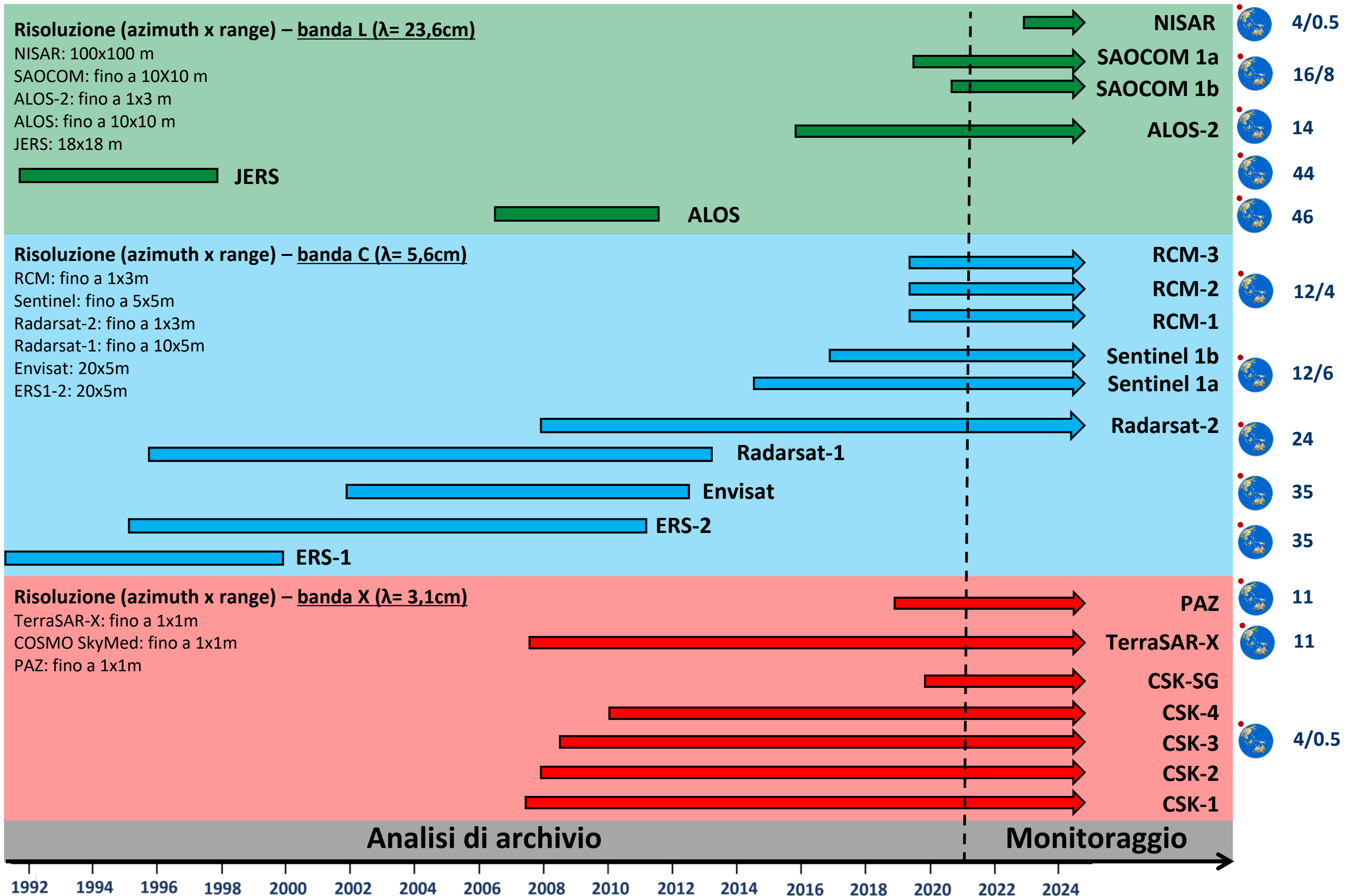


The displacement field of the Landers earthquake mapped by radar interferometry

*Didier Massonnet, Marc Rossi, Cesar Carmona, Frederic Adragna, Gilles Pletzner & Kurt Feigl*

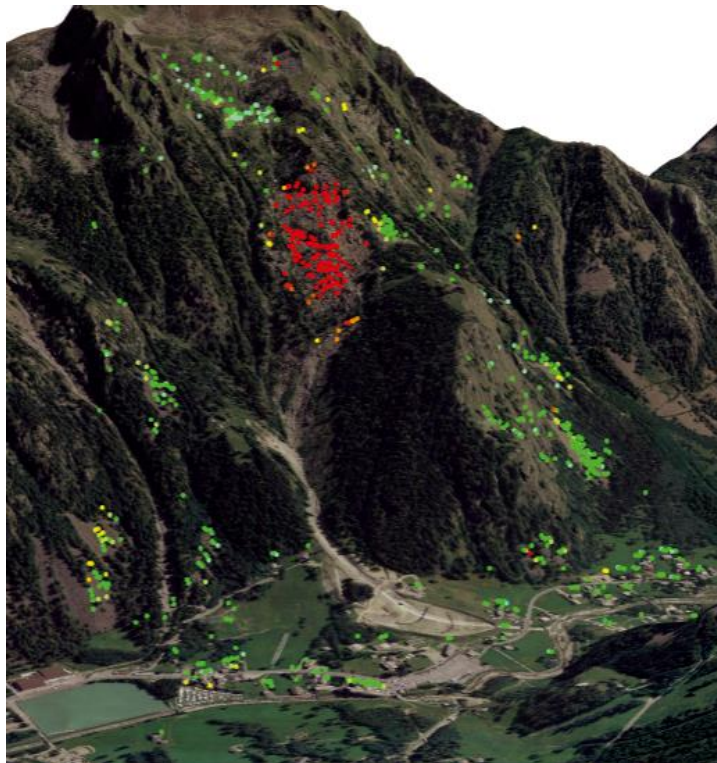


# Interferometria satellitare

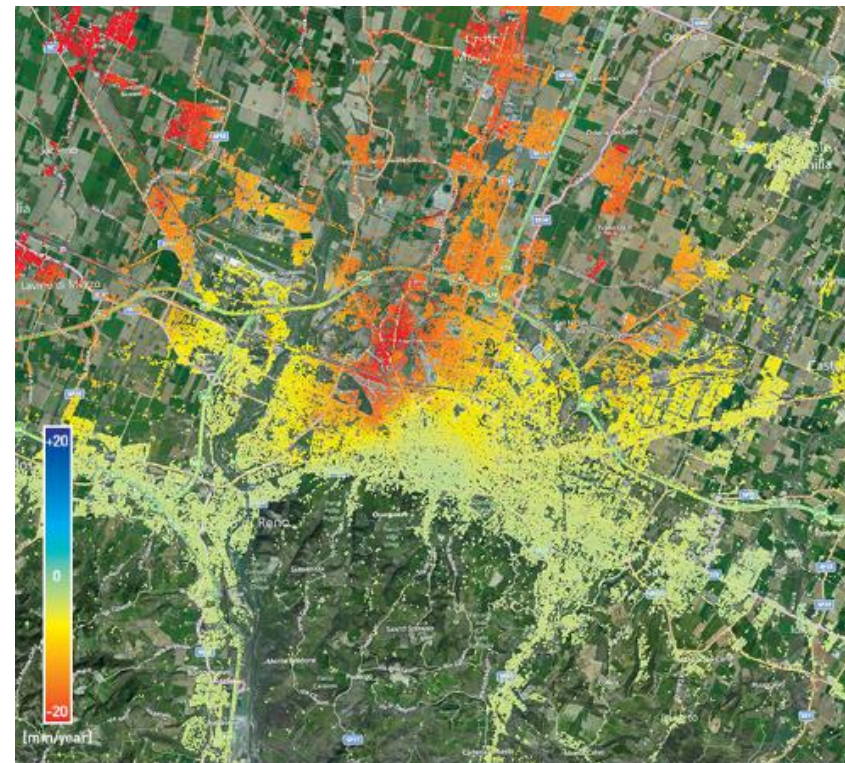




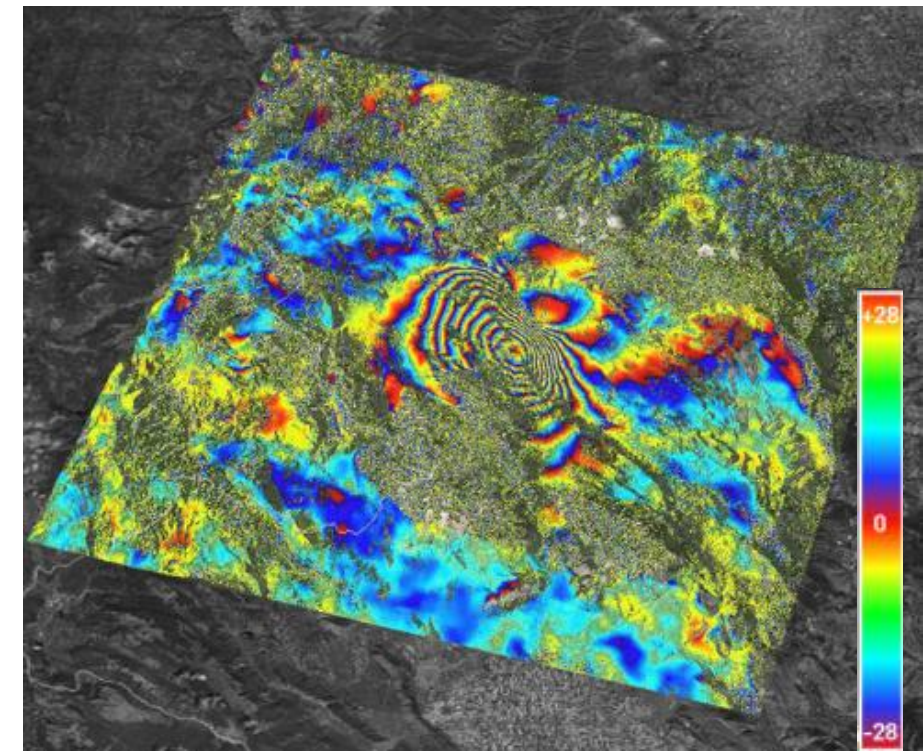
# Campi di applicazione



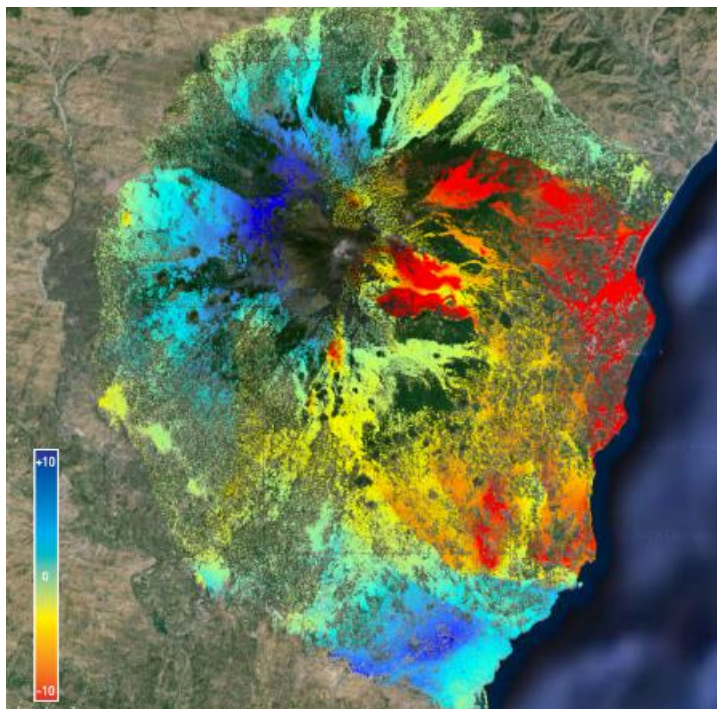
Frane



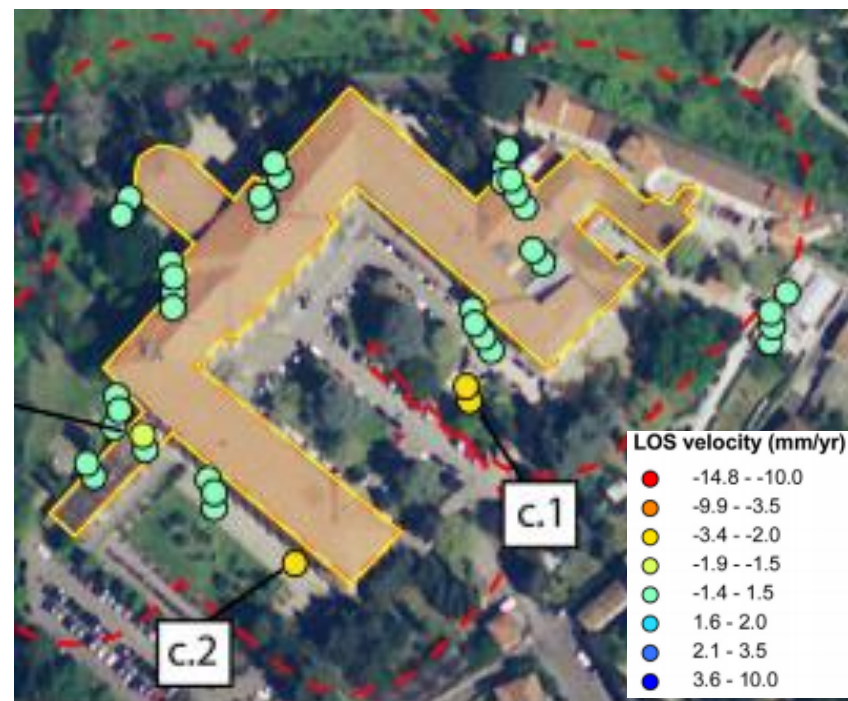
Subsidenza



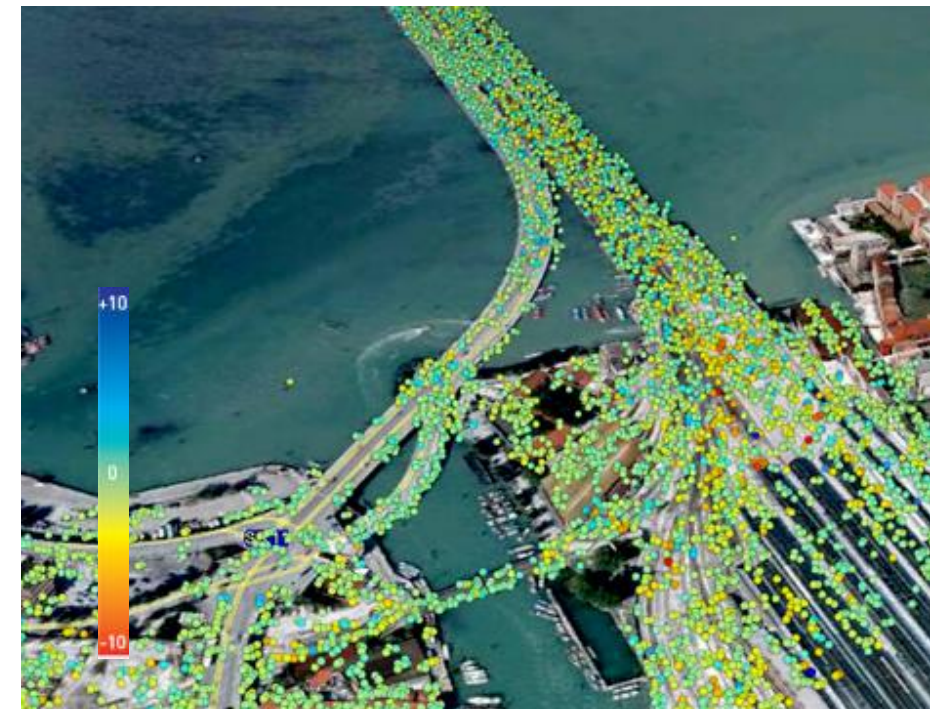
Deformazioni sismiche



Attività vulcanica



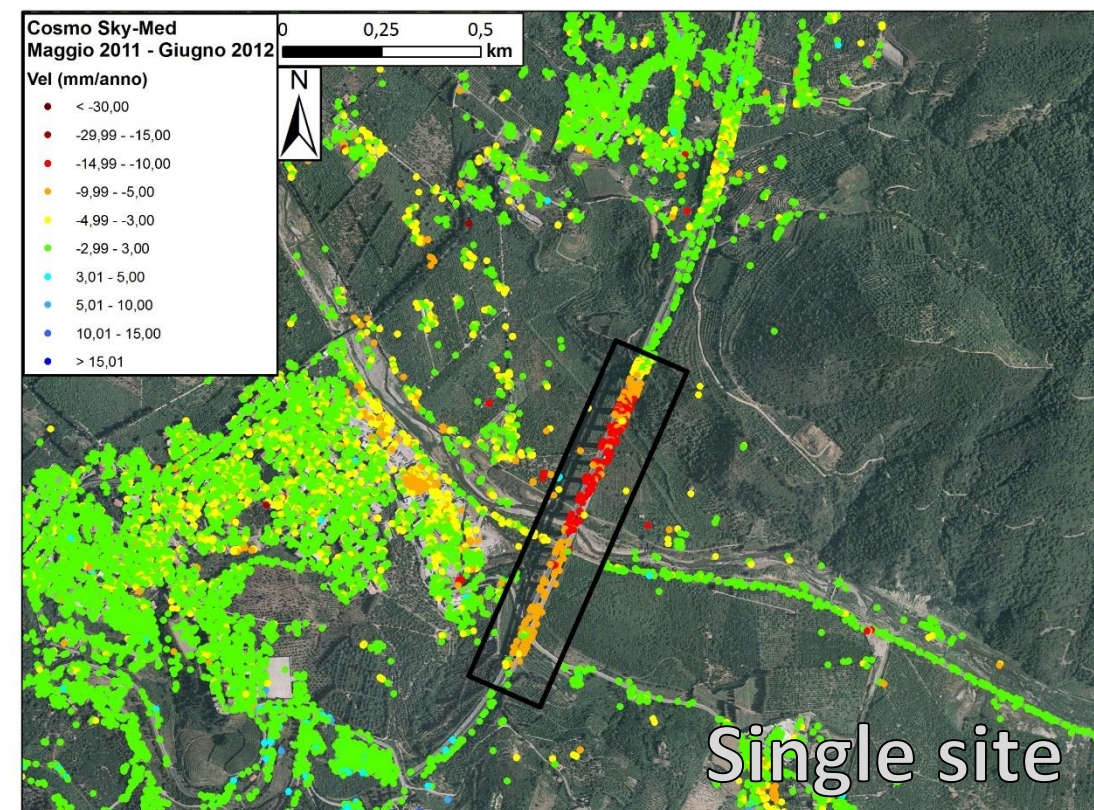
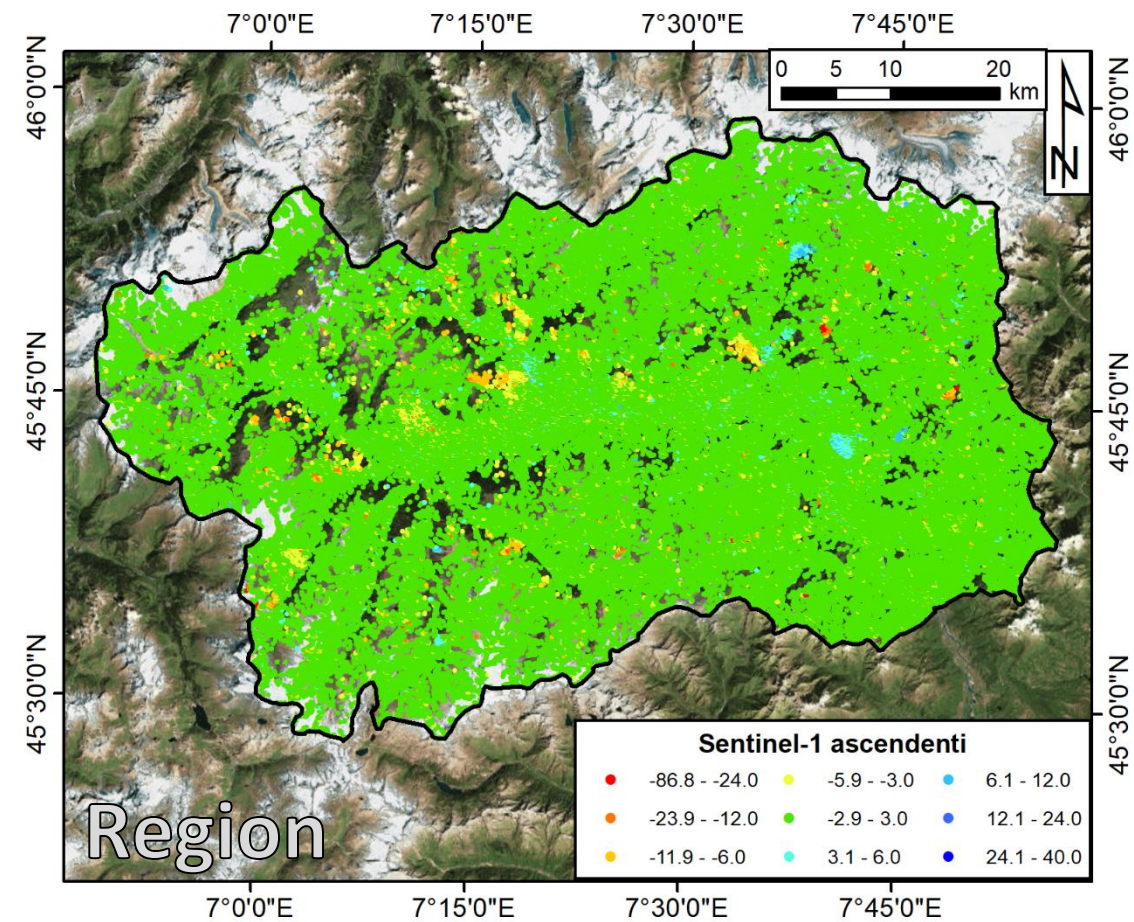
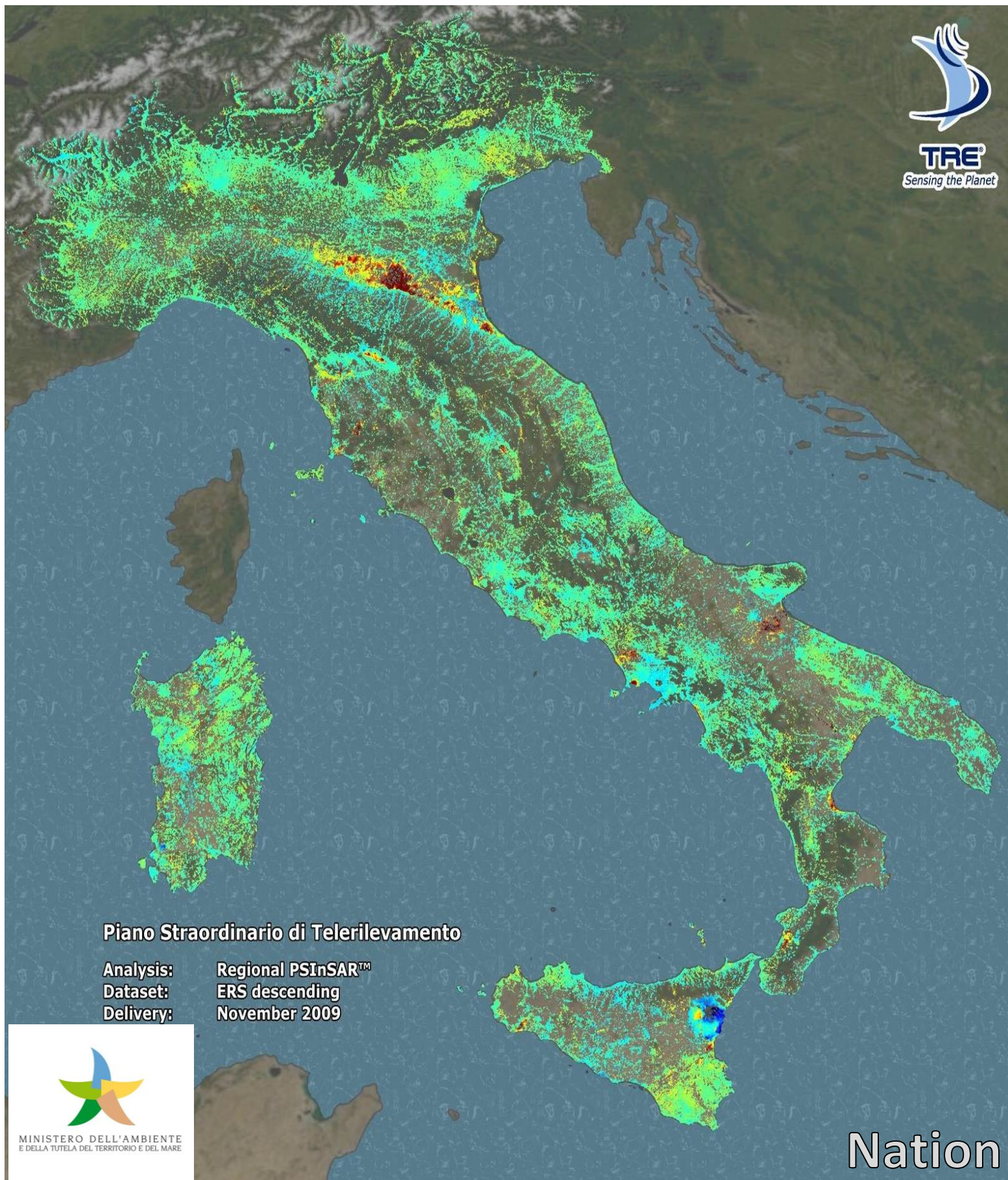
Edifici



Infrastrutture



# Analisi multiscala

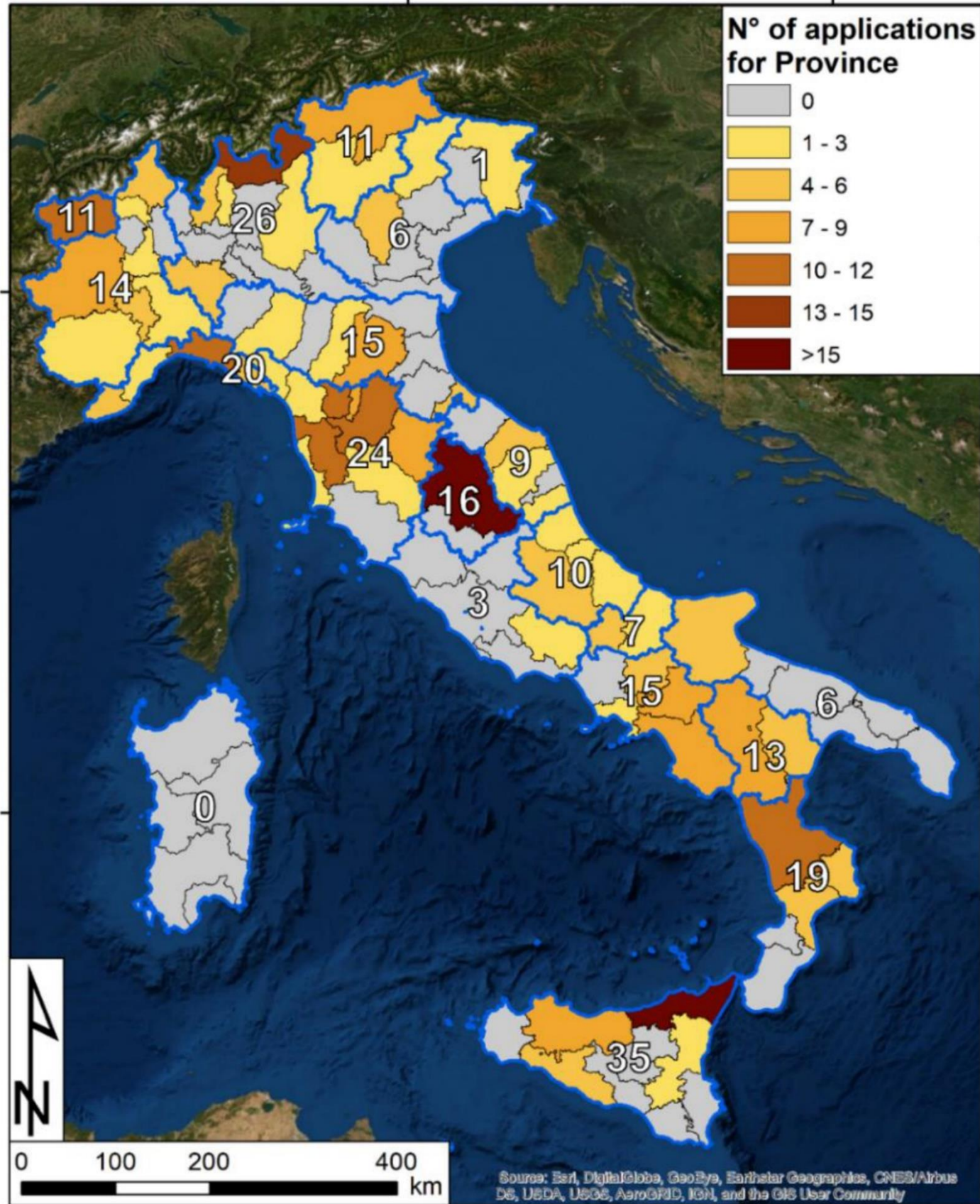




# Interferometria in Italia - Frane

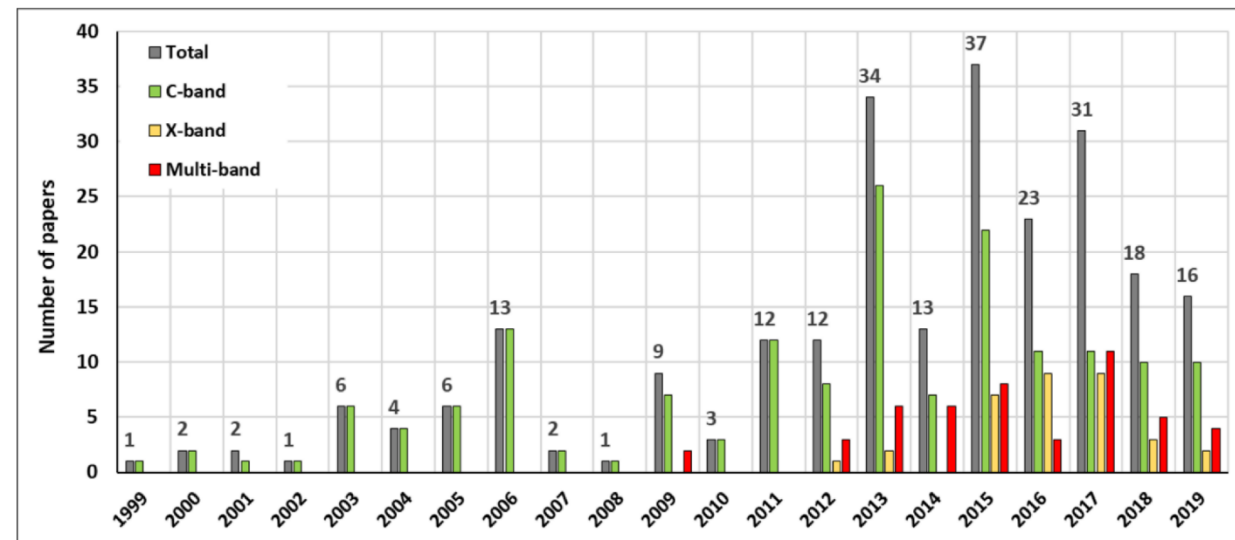
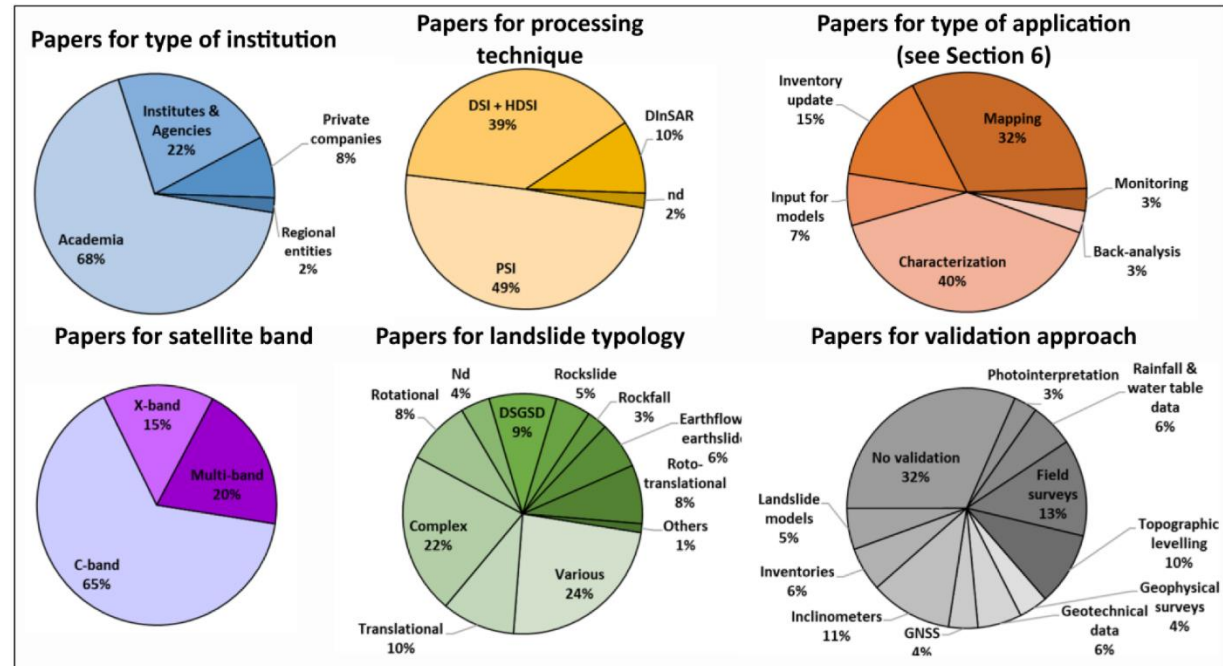
12°0'0"E

18°0'0"E



12°0'0"E

18°0'0"E



remote sensing

MDPI

Review

## Review of Satellite Interferometry for Landslide Detection in Italy

Lorenzo Solari <sup>1,\*</sup>, Matteo Del Soldato <sup>2</sup>, Federico Raspini <sup>2</sup>, Anna Barra <sup>1</sup>, Silvia Bianchini <sup>2</sup>, Pierluigi Confuorto <sup>2</sup>, Nicola Casagli <sup>2</sup> and Michele Crosetto <sup>1</sup>

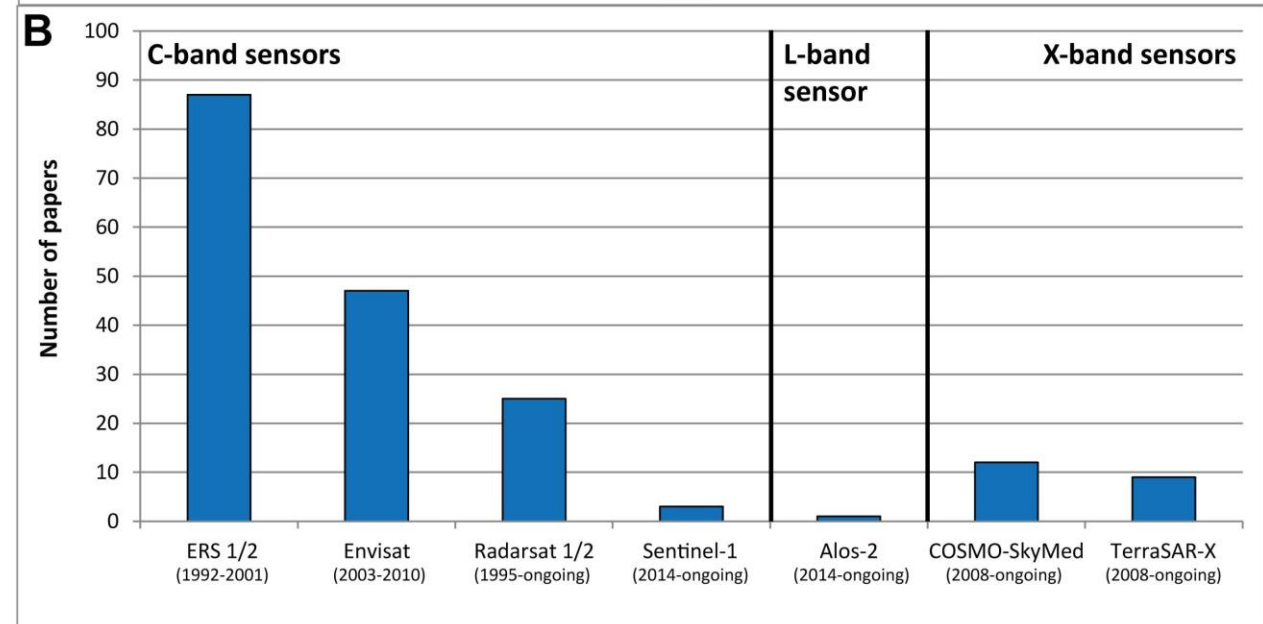
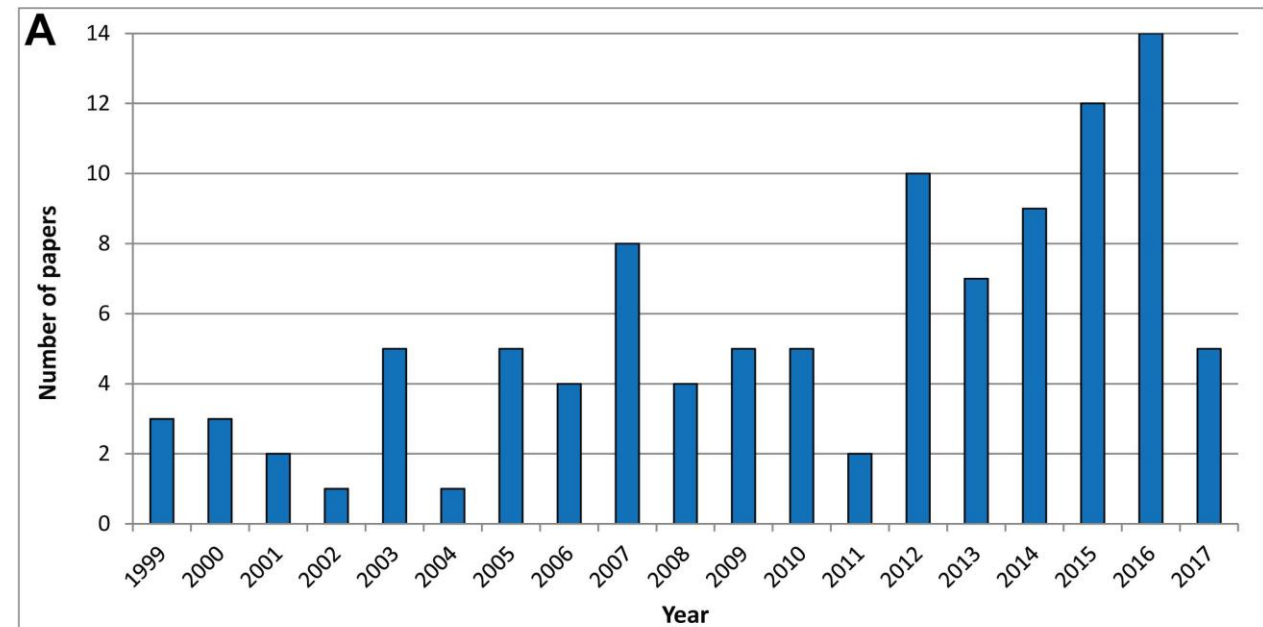
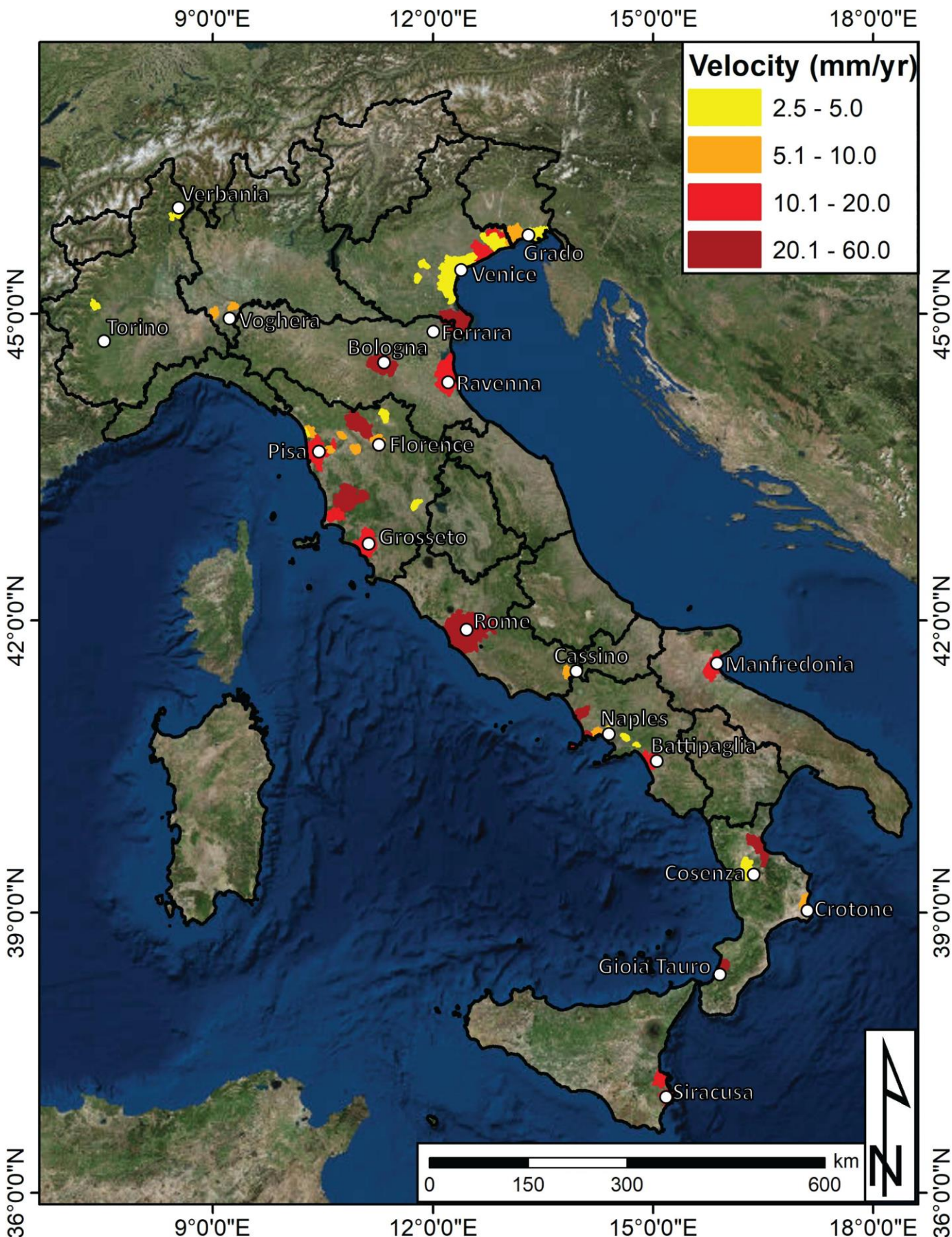
<sup>1</sup> Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Division of Geomatics, Avenida Gauss, 7 08860 Castelldefels, Spain; anna.barra@cttc.cat (A.B.); michele.crosetto@cttc.cat (M.C.)

<sup>2</sup> Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Via La Pira, 4 50121 Firenze, Italy; matteo.delsoldato@unifi.it (M.D.S.); federico.raspini@unifi.it (F.R.); silvia.bianchini@unifi.it (S.B.); pierluigi.confuorto@unifi.it (P.C.); nicola.casagli@unifi.it (N.C.)

\* Correspondence: lorenzo.solari@cttc.cat; Tel.: +34-93-645-29-00



# Interferometria in Italia - Subsidenza



frontiers  
in Earth Science

REVIEW  
published: 04 October 2018  
doi: 10.3389/feart.2018.00149



## From ERS 1/2 to Sentinel-1: Subsidence Monitoring in Italy in the Last Two Decades

Lorenzo Solari<sup>1\*</sup>, Matteo Del Soldato<sup>1</sup>, Silvia Bianchini<sup>1</sup>, Andrea Ciampalini<sup>2</sup>,  
Pablo Ezquerro<sup>3</sup>, Roberto Montalti<sup>1</sup>, Federico Raspini<sup>1</sup> and Sandro Moretti<sup>1</sup>

<sup>1</sup> Department of Earth Sciences, University of Firenze, Firenze, Italy, <sup>2</sup> Department of Earth Sciences, University of Pisa, Pisa, Italy, <sup>3</sup> Geohazards InSAR Laboratory and Modelling Group (InSARlab), Geoscience Research Department, Geological Survey of Spain (IGME), Madrid, Spain





UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

**CENTRO  
PROTEZIONE  
CIVILE**

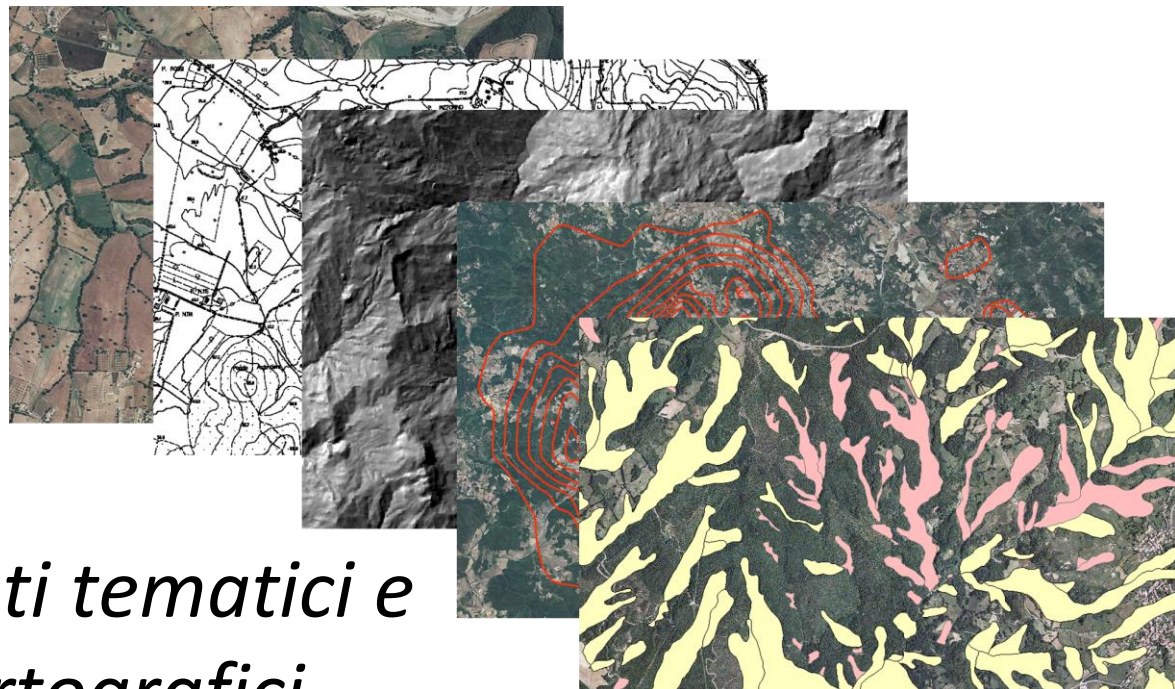
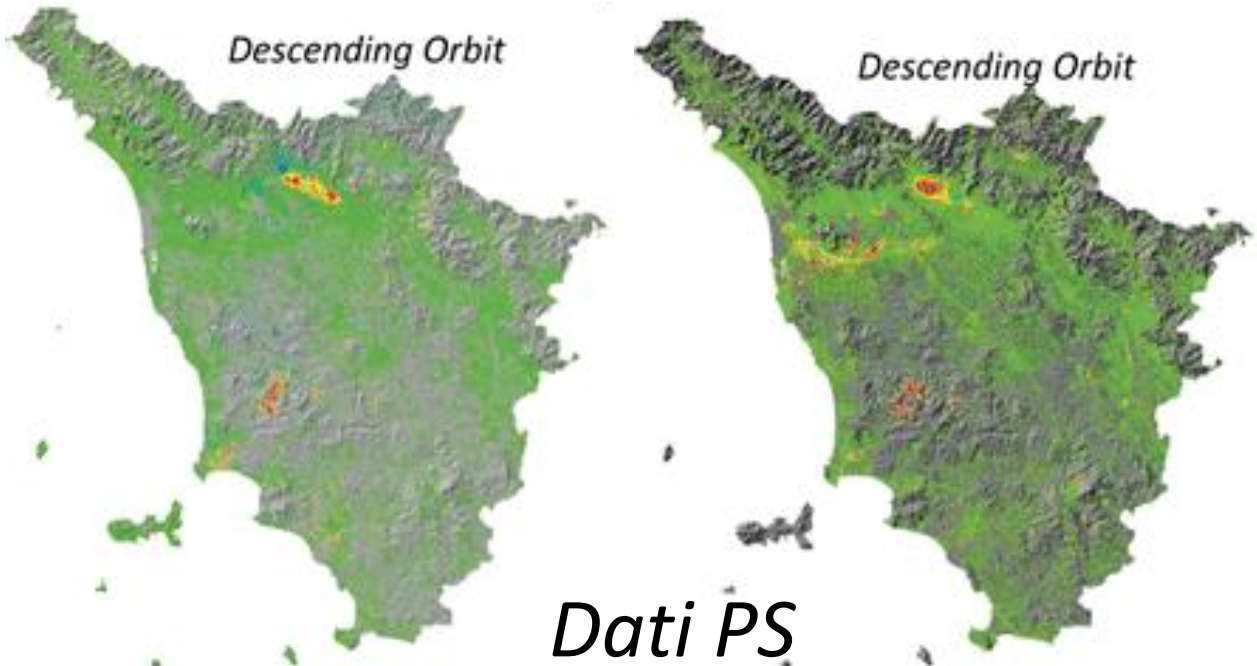
Il passato:  
elaborazioni di archivio

Mappatura e analisi «*one-shot*»

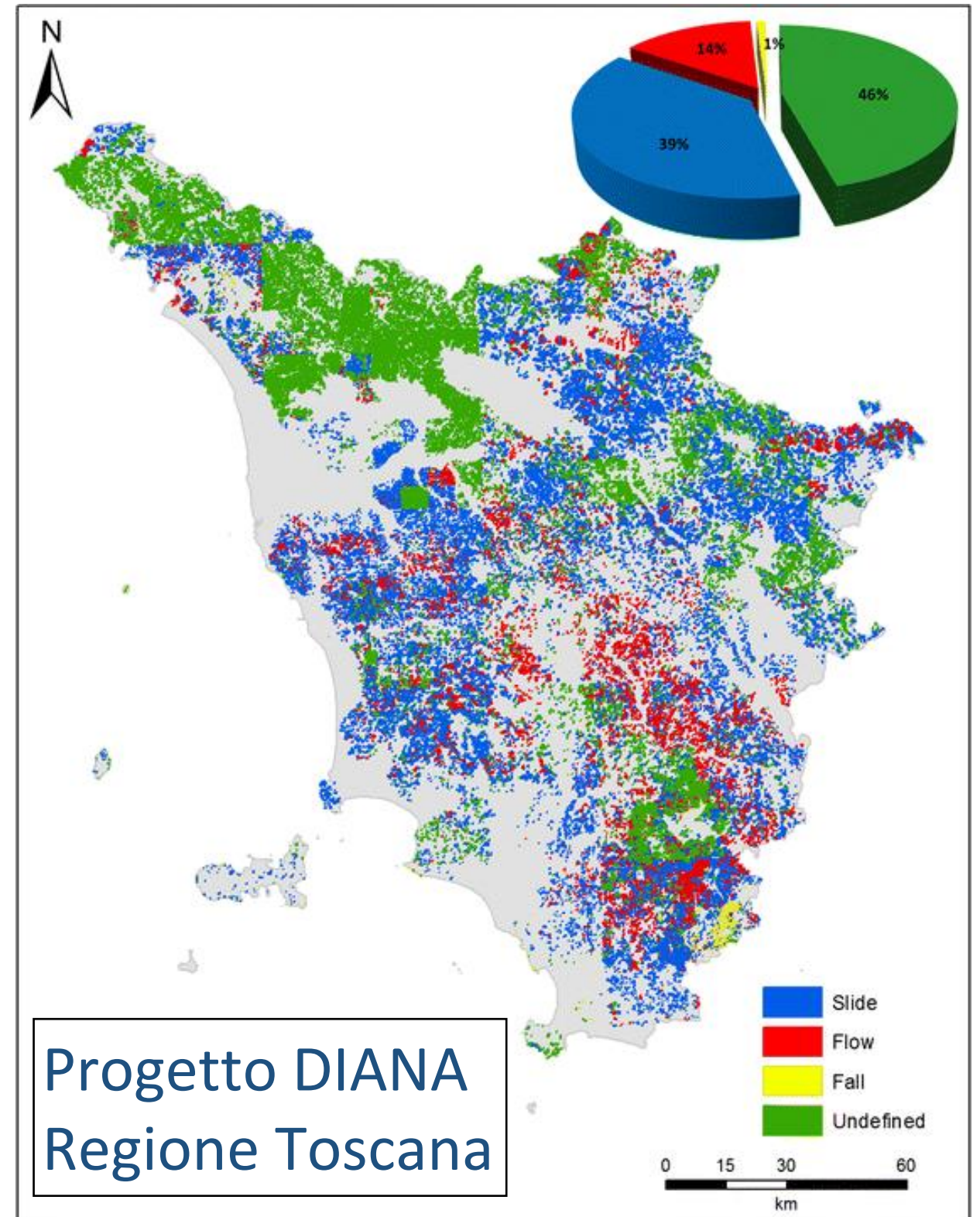


# Mappatura/Aggiornamento inventari frane

ERS coverage (1992-2000) ENVISAT coverage (2002-2010)

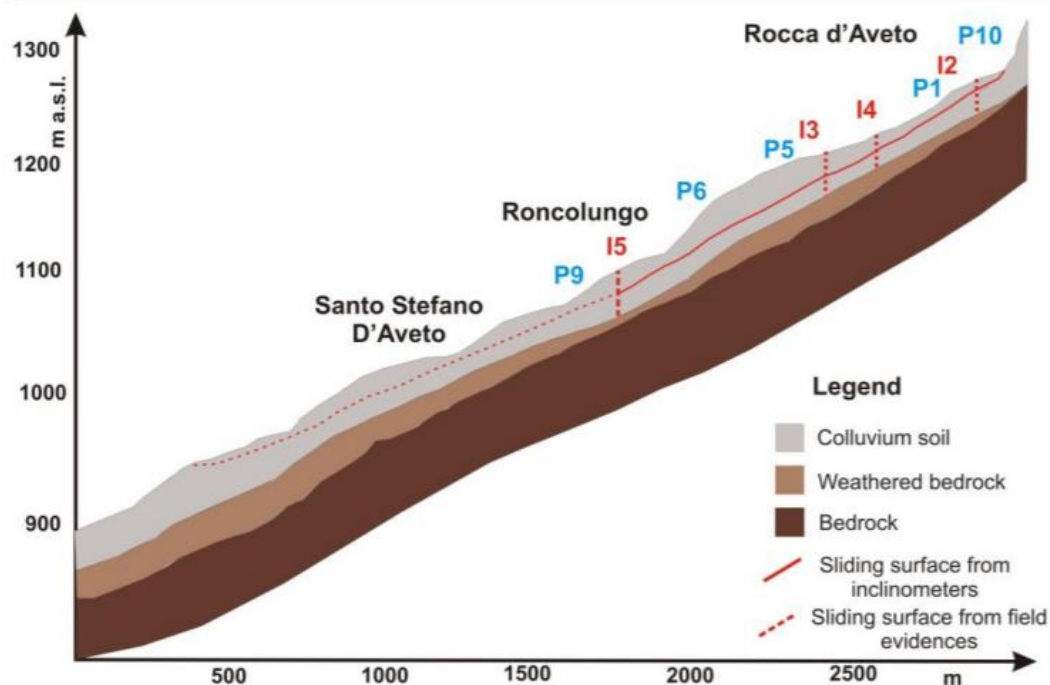
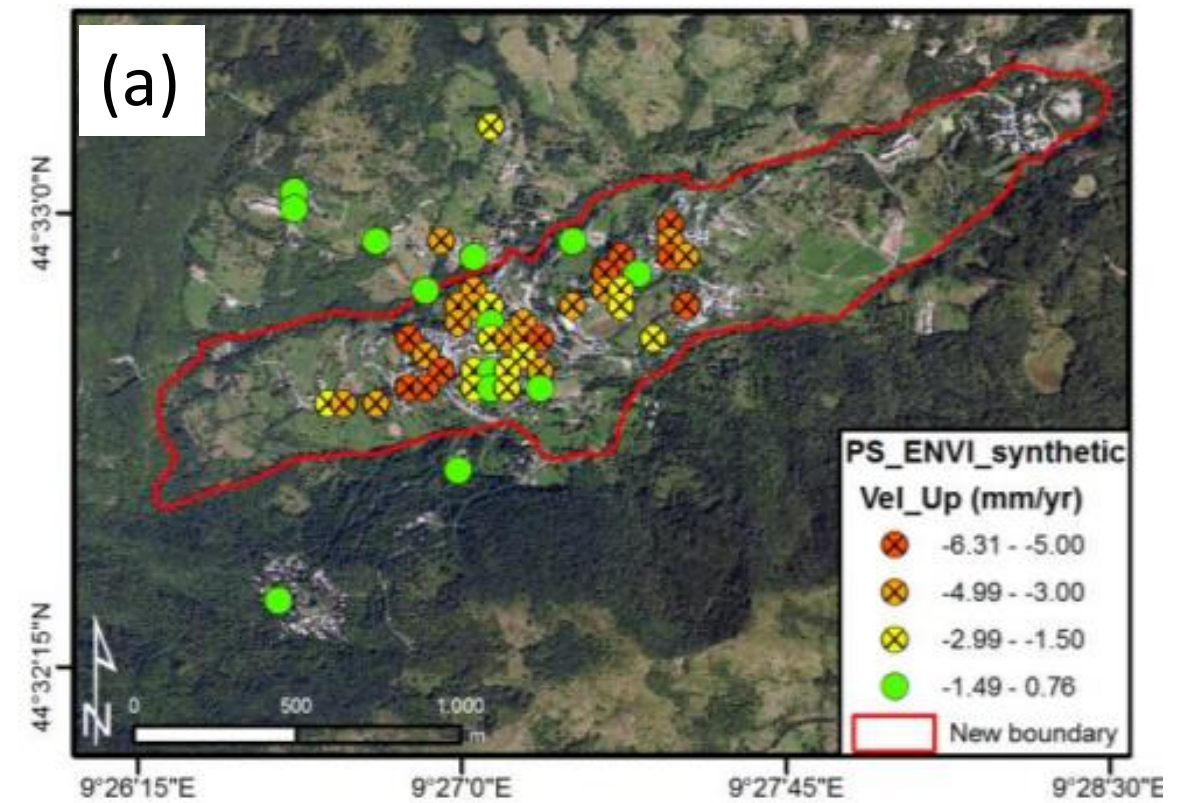
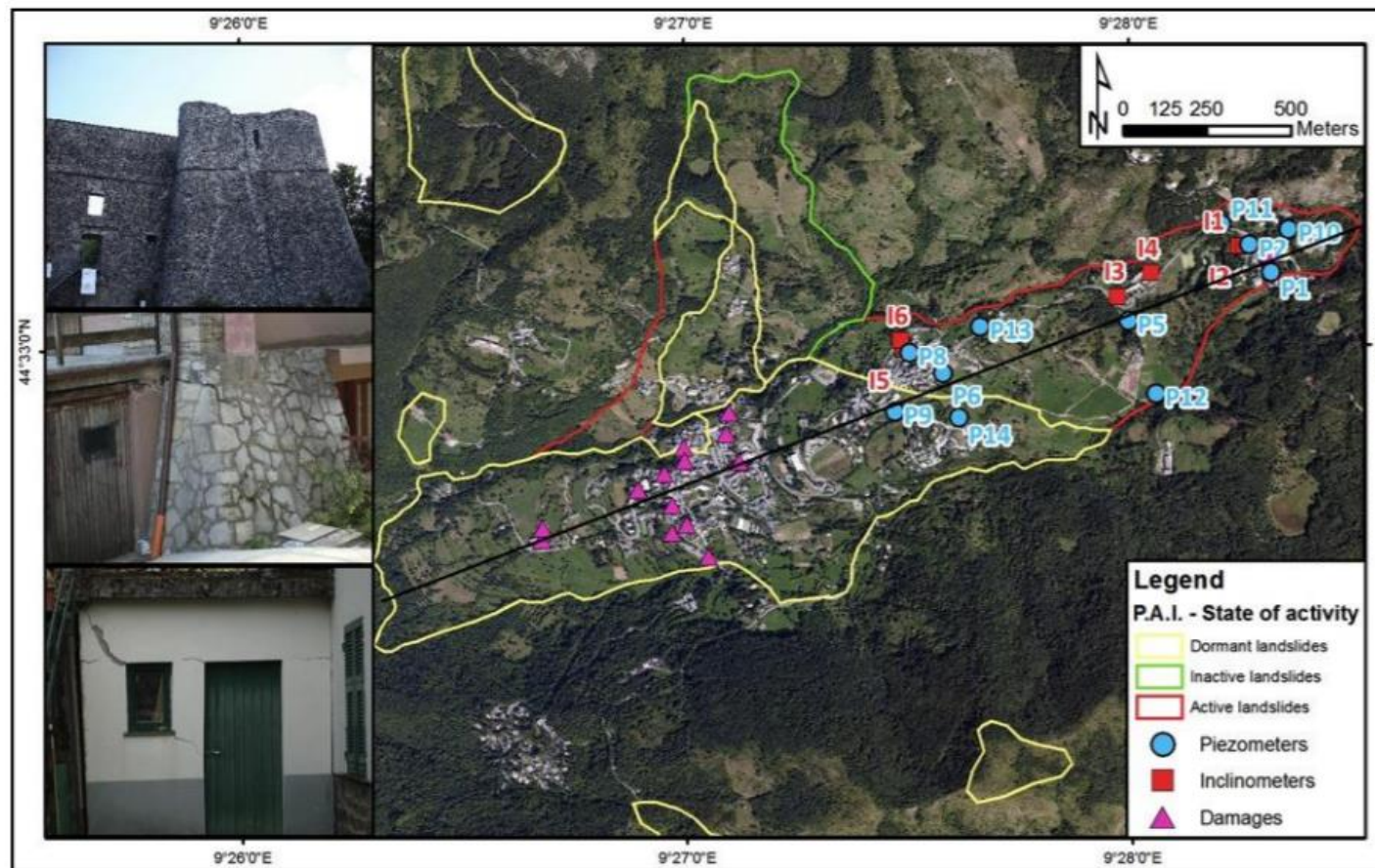


*Dati tematici e cartografici*

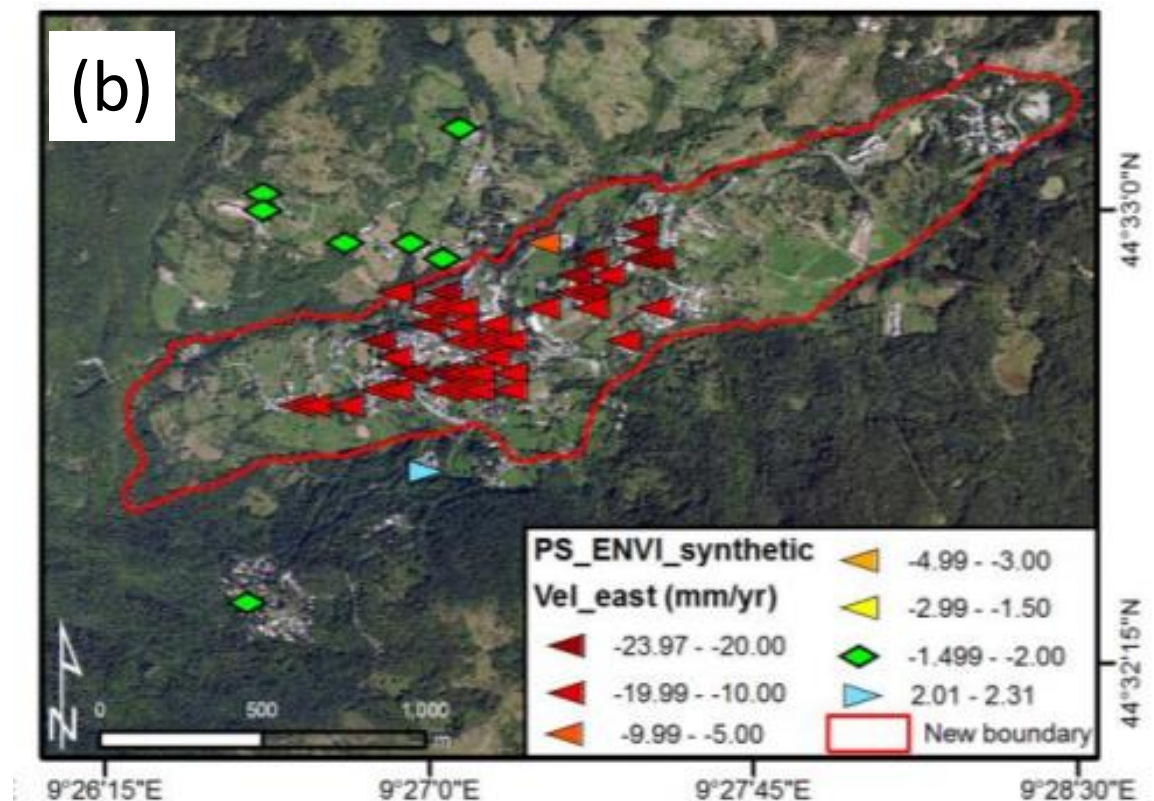




# Analisi su frana singola

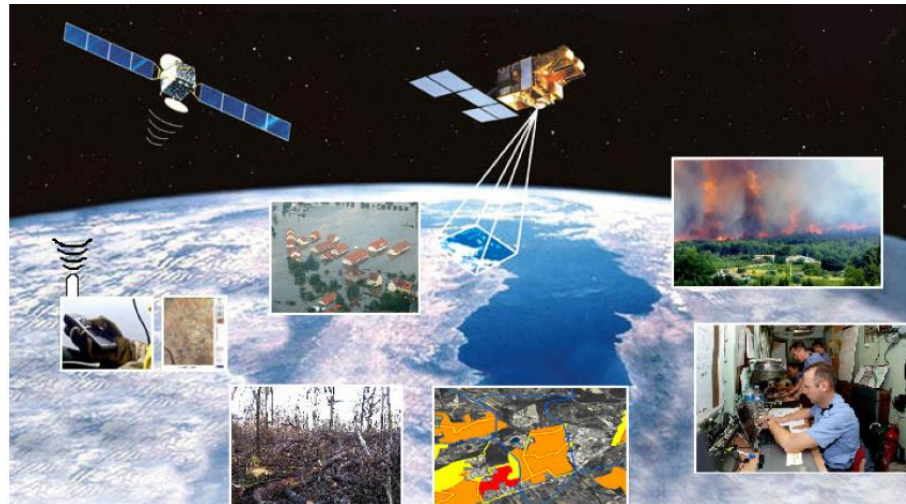


Santo Stefano d'Aveto (GE)

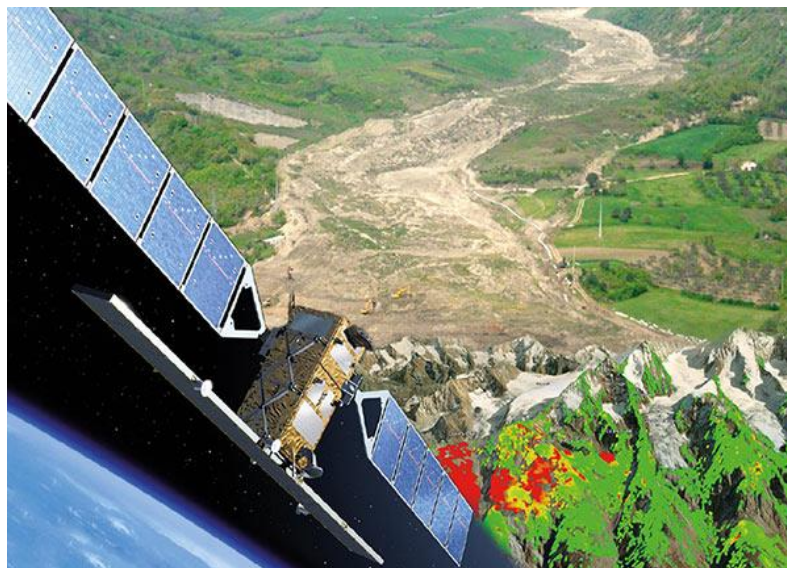
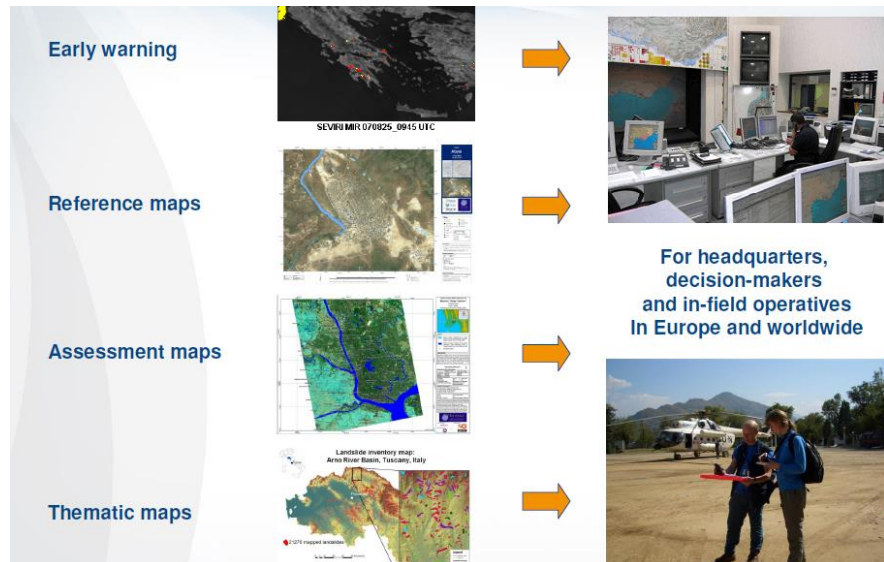
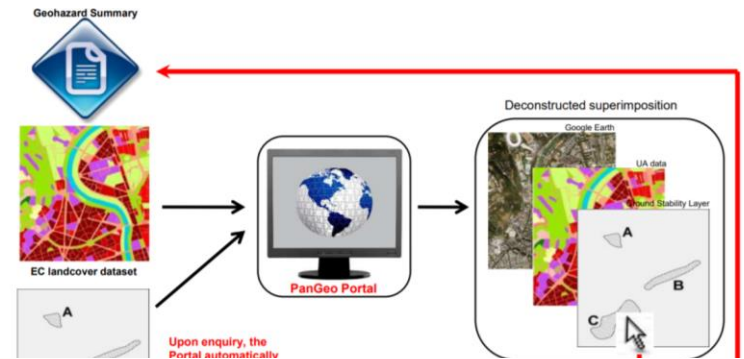
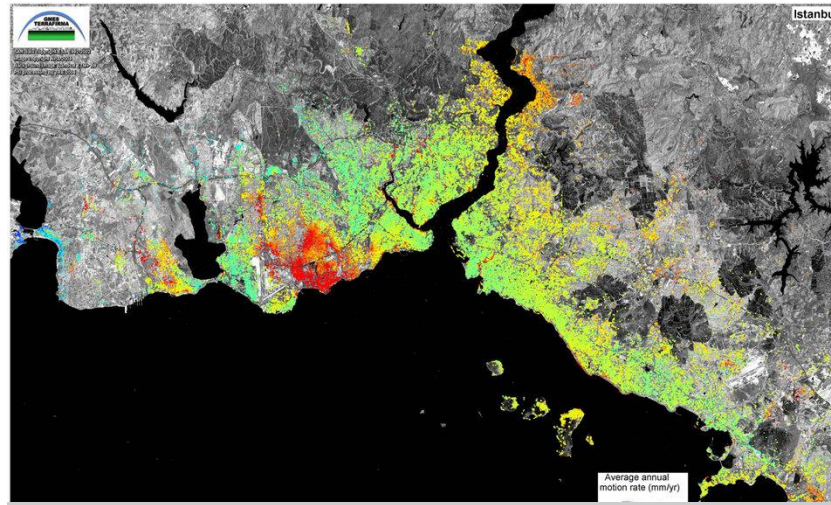




# Progetti Europei

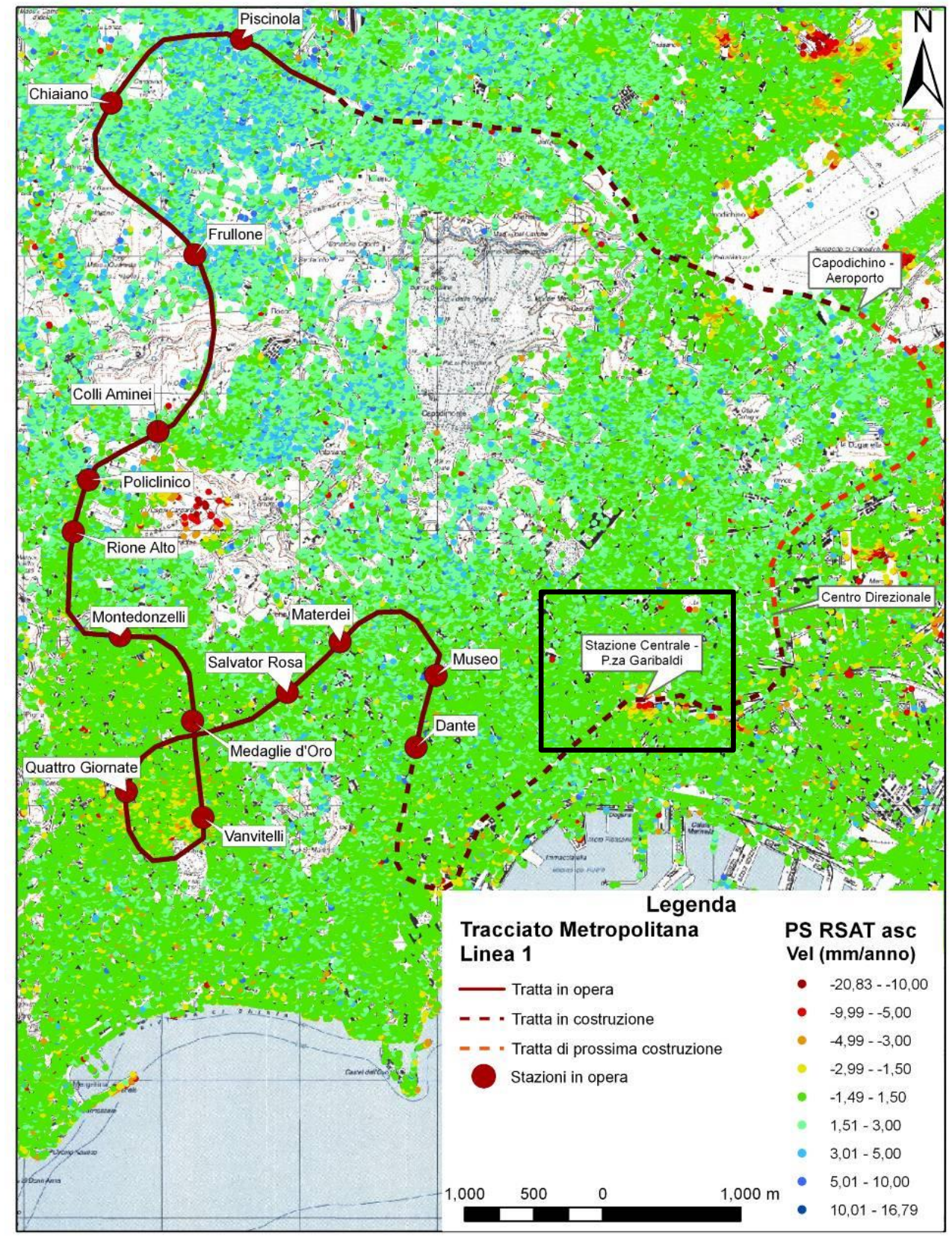
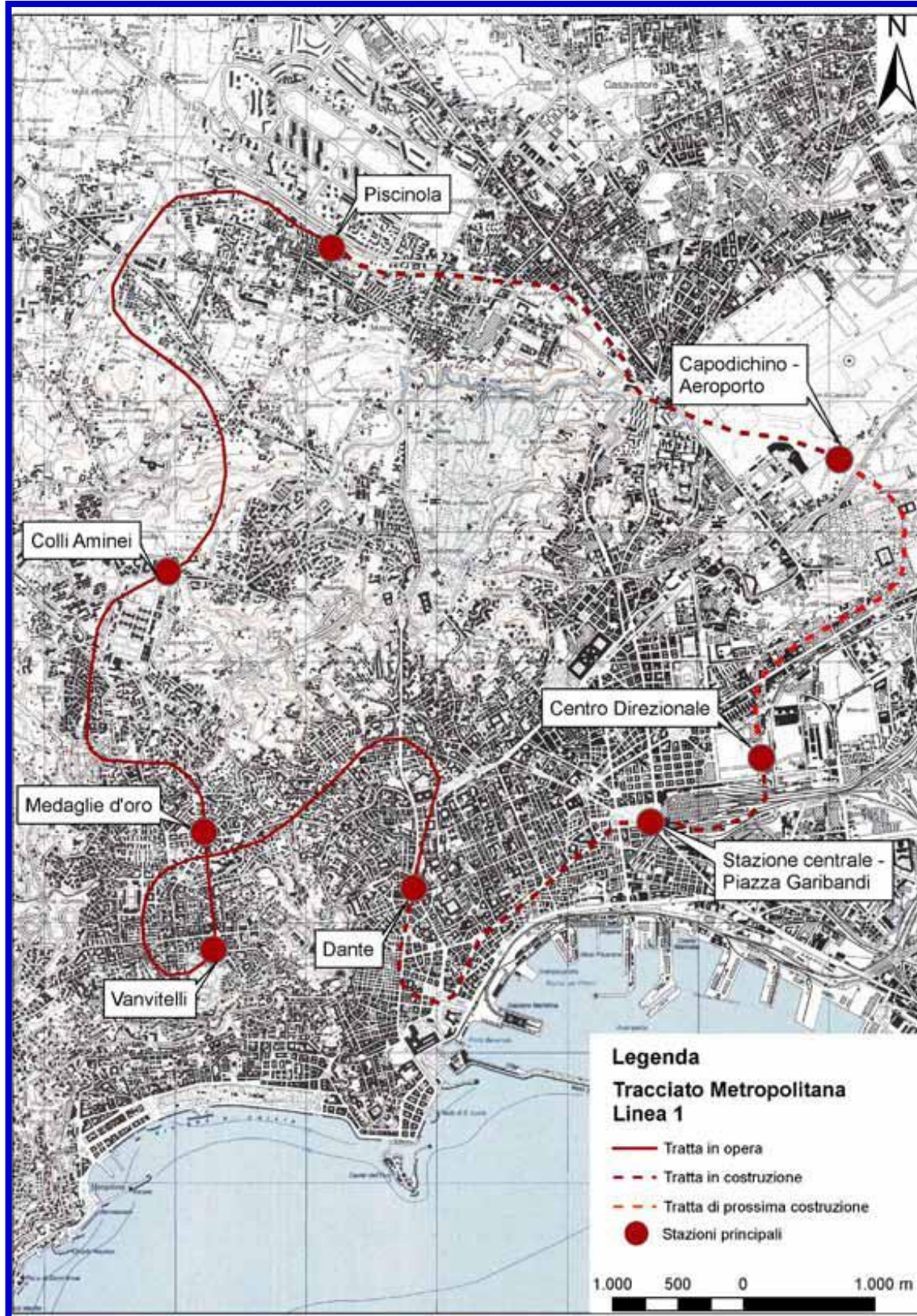


**PREVIEW** PREvention, Information and Early Warning



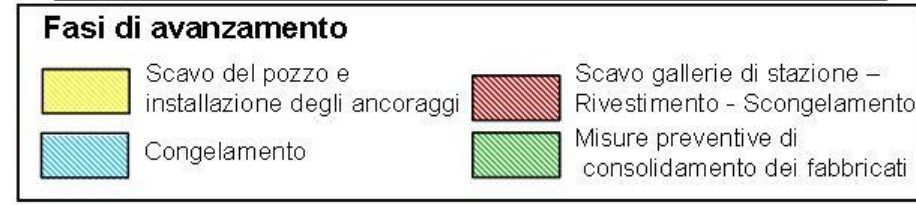
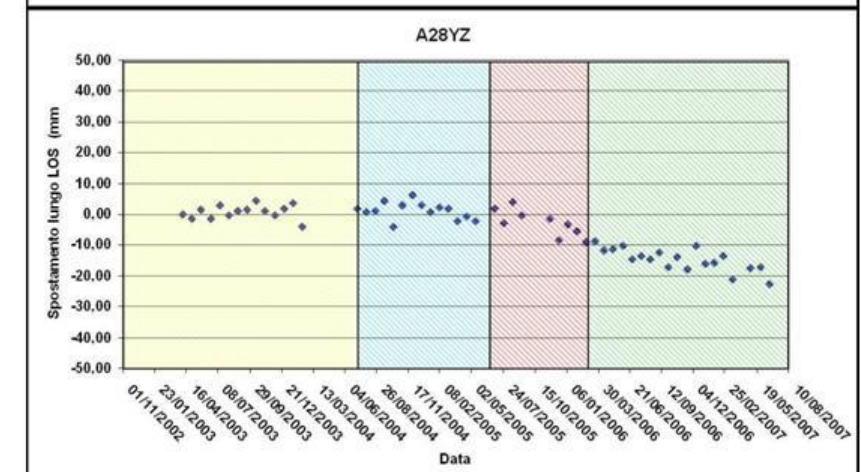
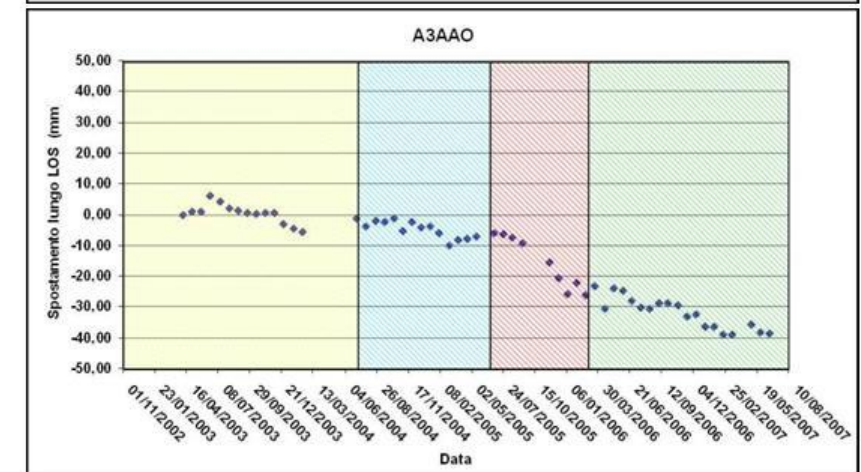
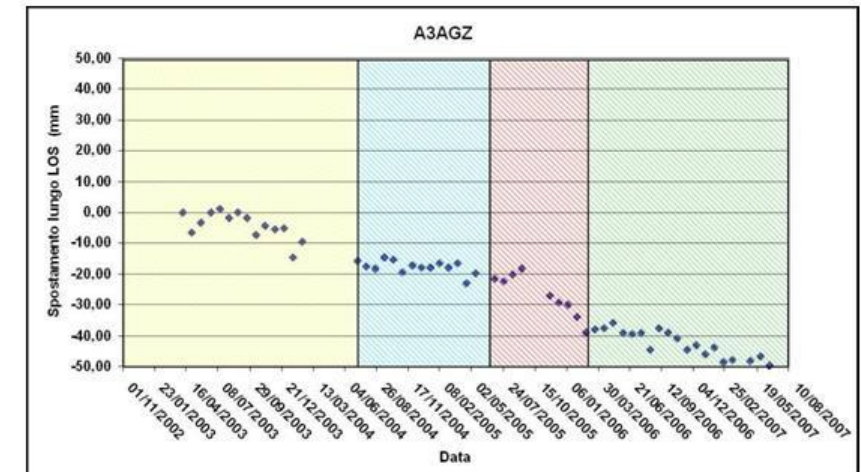
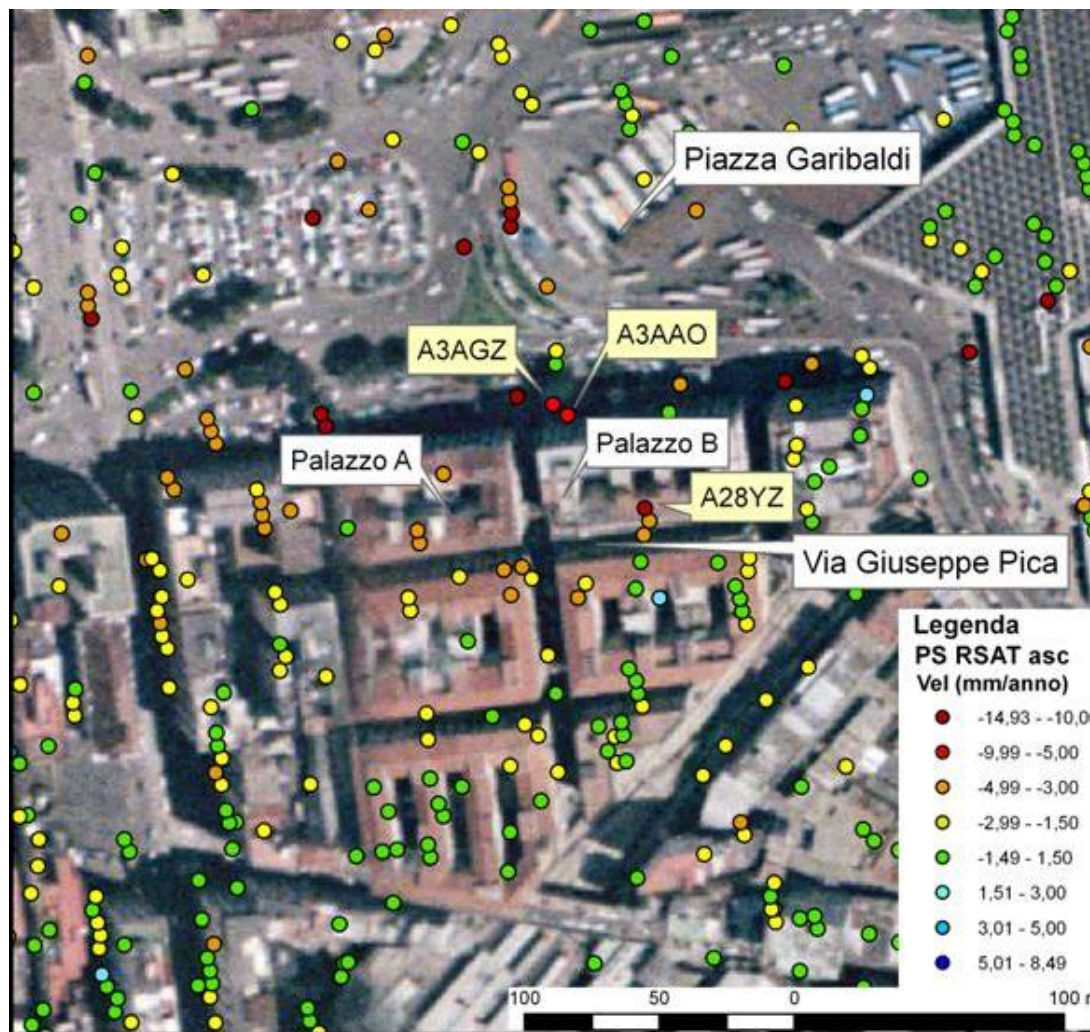


# Effetti dello scavo della Linea 1





# Effetti dello scavo della Linea 1



L'andamento delle serie temporali riflette le diverse fasi di costruzione:

- aumento delle deformazioni con l'avanzare dell'escavazione;
- il “congelamento” del fronte minimizza la propagazione degli effetti deformativi in superficie;
- lo “scongelamento” del fronte e lo scavo dei tunnels della stazione causa nuovamente effetti in superficie;
- il consolidamento degli edifici coinvolti determina una iniziale diminuzione della subsidenza, seguita da una ripresa delle deformazioni dopo 9 mesi circa.





UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

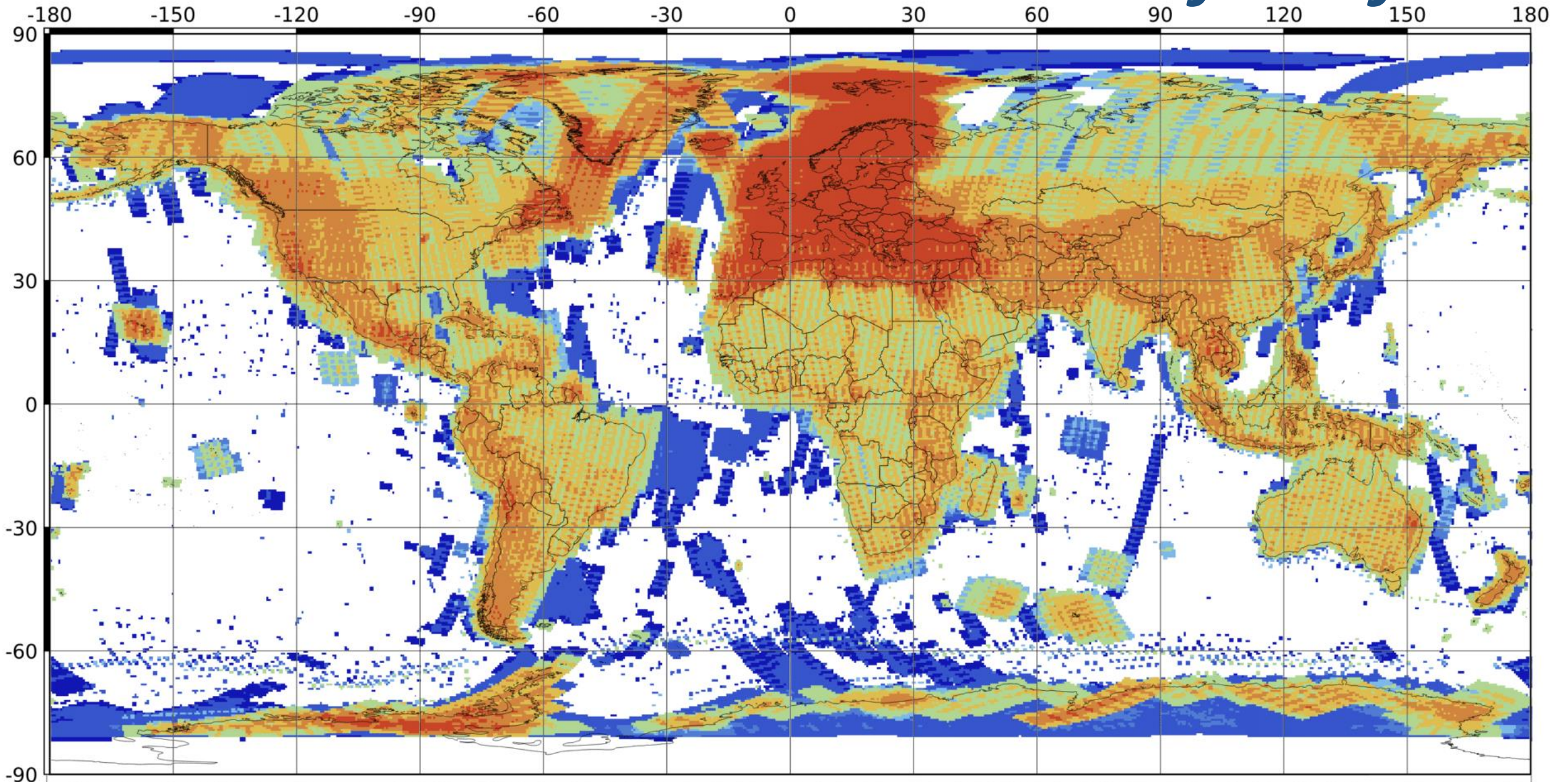
**CENTRO  
PROTEZIONE  
CIVILE**

Il presente:  
monitoraggio in continuo e  
previsione dell'istante di collasso

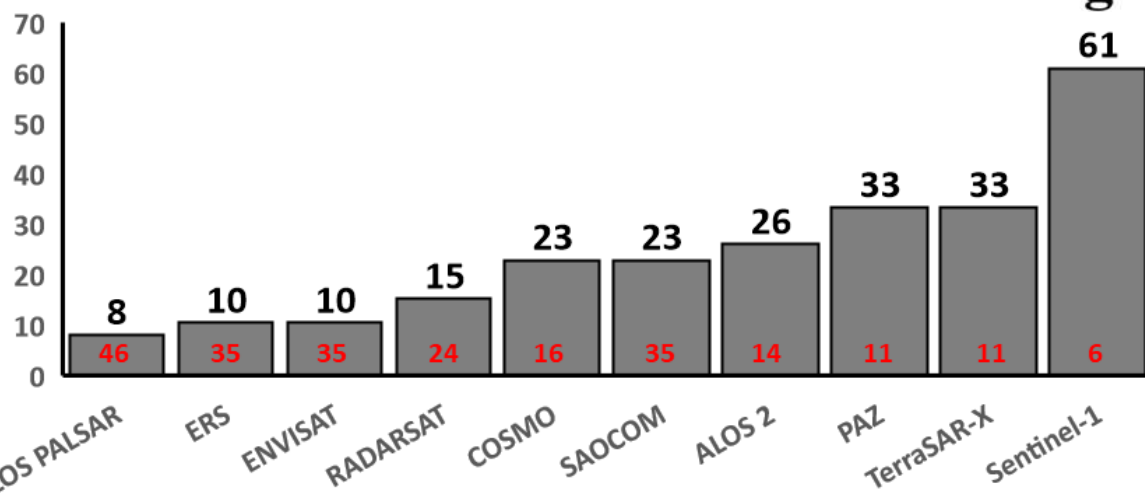
Sentinel-1, il *game changer*



# Sentinel-1: una missione *conflict-free*



## Sentinel-1 Level 1 SLC Data Coverage



Copernicus Sentinel-1A and Sentinel-1B data,  
2014-2020

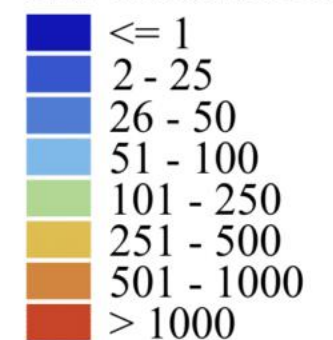
Current: 31 October 2020

Map shows the total of Sentinel-1 SLC product  
global coverage.

Sentinel-1 data are open access and can be  
downloaded using the ASF Data Search portal  
[<https://search.asf.alaska.edu>]

## Legend

No. Observations





# Il progresso tecnologico



**Sentinel-1 (ESA)** progettato per acquisire regolarmente dati di deformazione in continuo su scala regionale e nazionale.



La **tecnologia InSAR** è matura, robusta, capace di garantire l'elaborazione continua dei dati



Catene di elaborazione SAR sempre più **automatizzate** e sofisticate



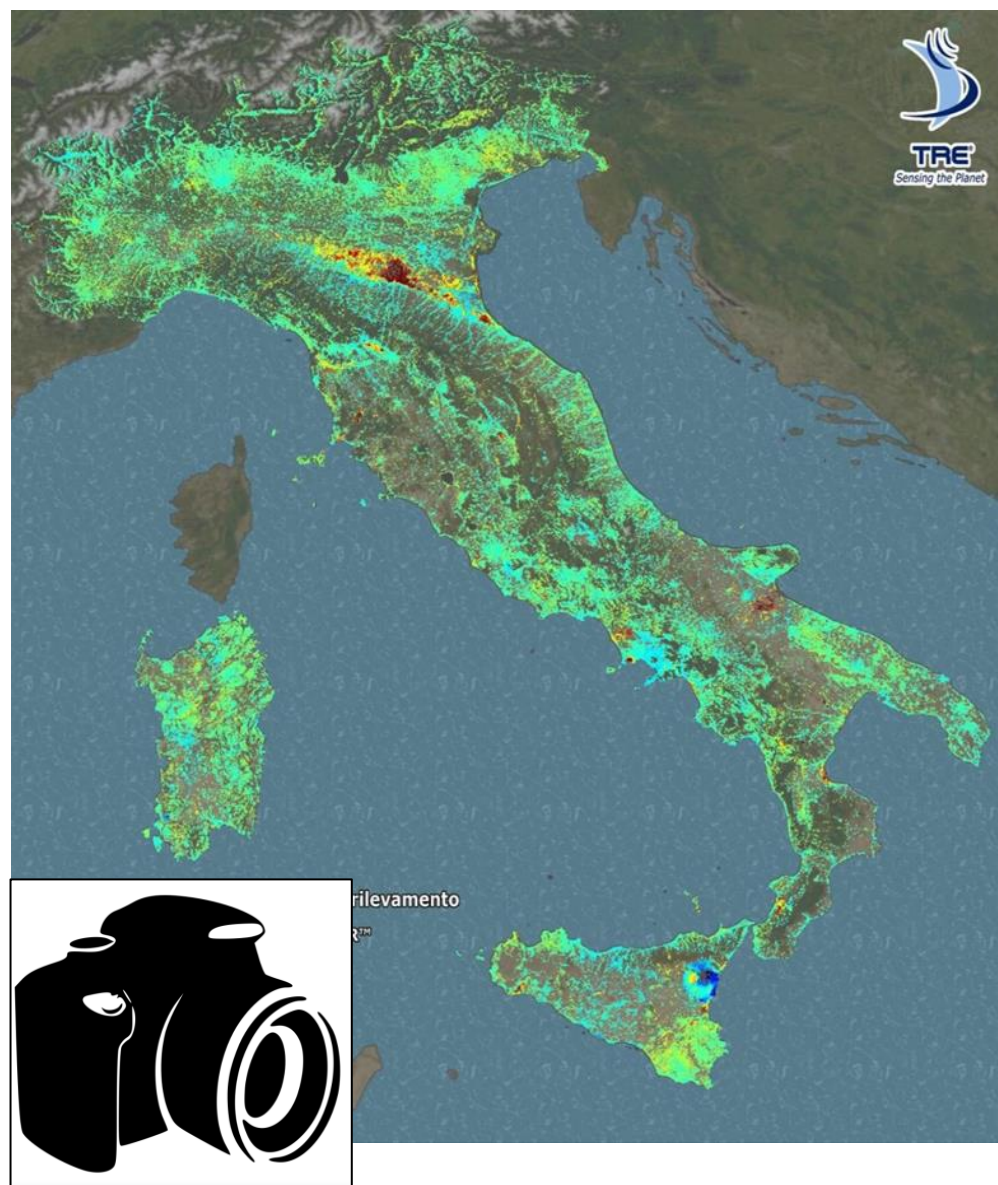
Aumento delle **capacità computazionali** (elaborazioni parallele, *cloud computing*)



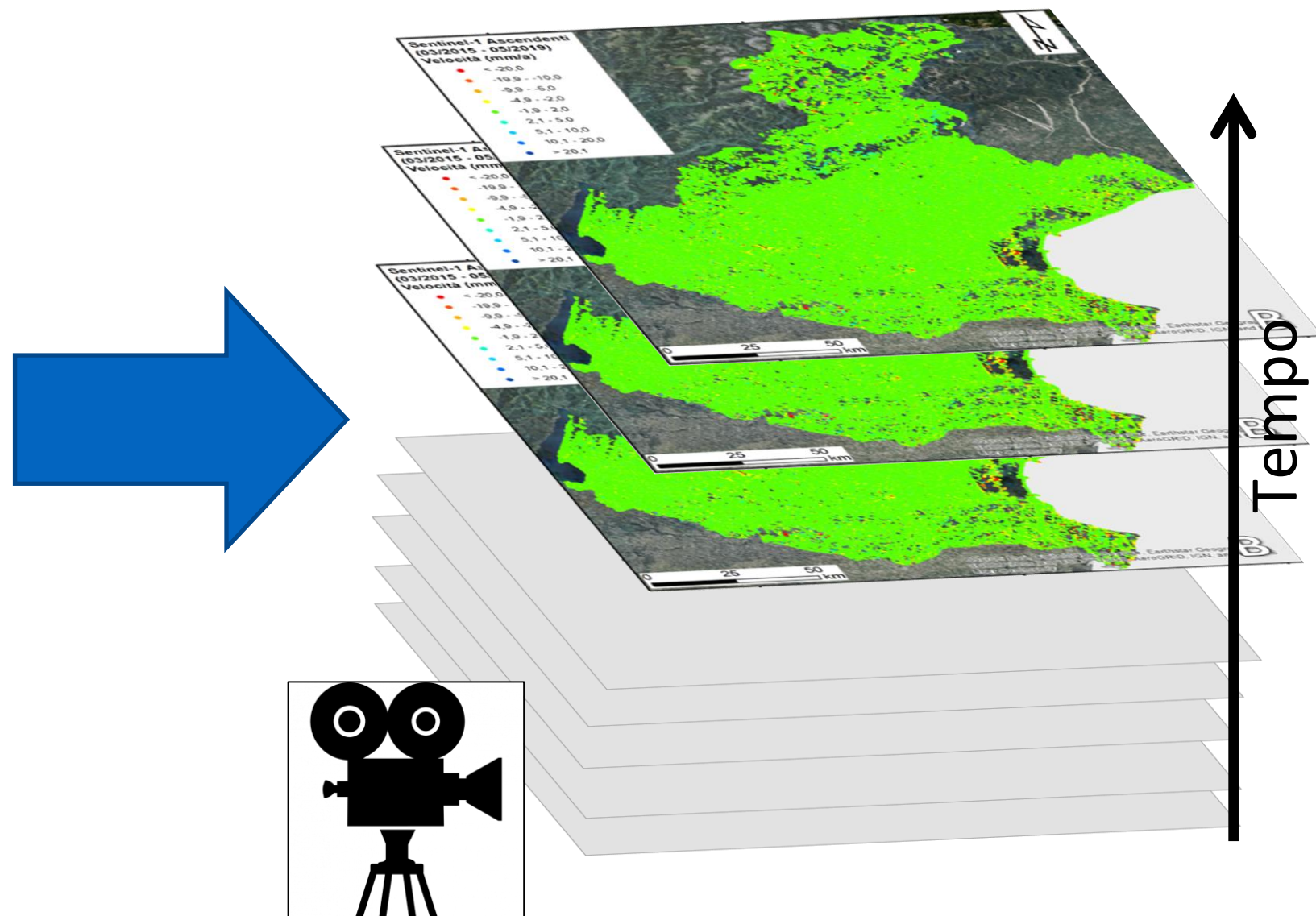
# Monitoraggio *radar* satellitare in continuo (*PS Continuous Streaming*)

Costellazioni  
ERS1/2 & ENVISAT  **esa**

 **sentinel**  **esa**



Tempo di rivisitazione: 35 giorni



Tempo di rivisitazione: 6/12 giorni

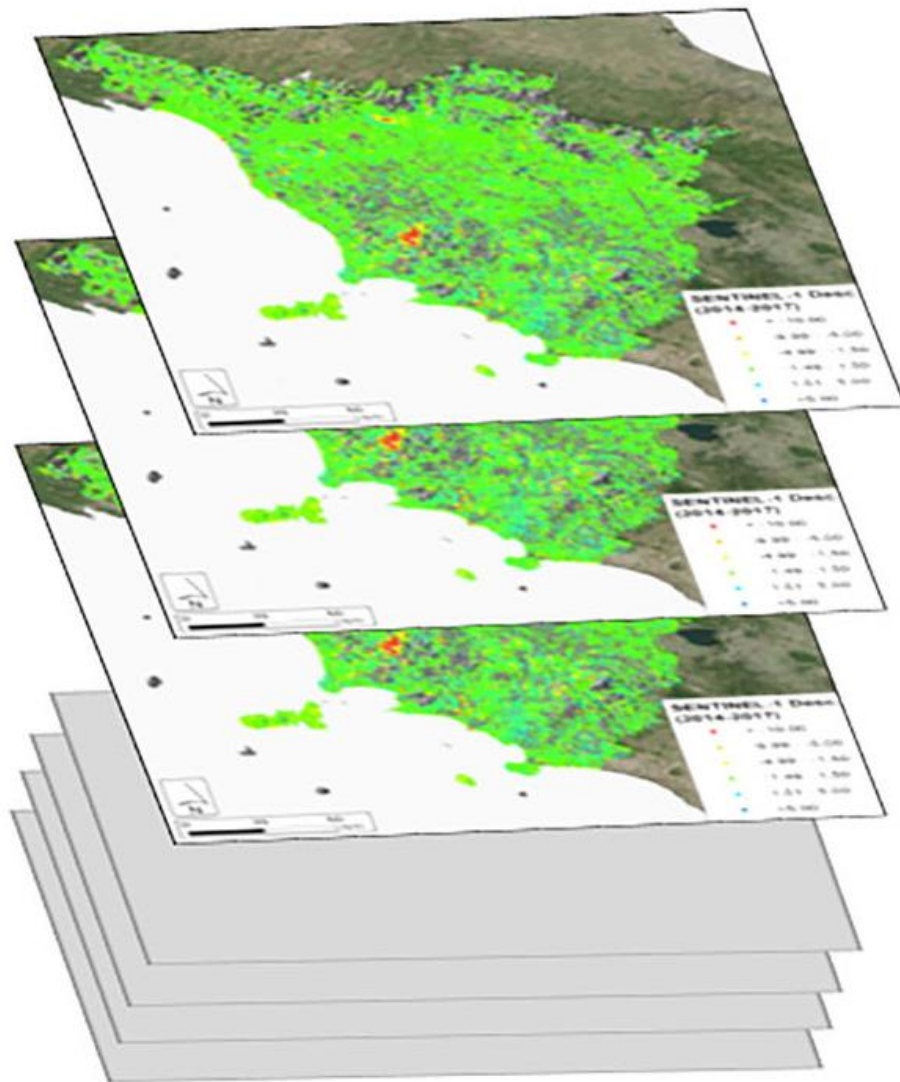


# Servizi regionali



Ottobre 2016

Regione Toscana

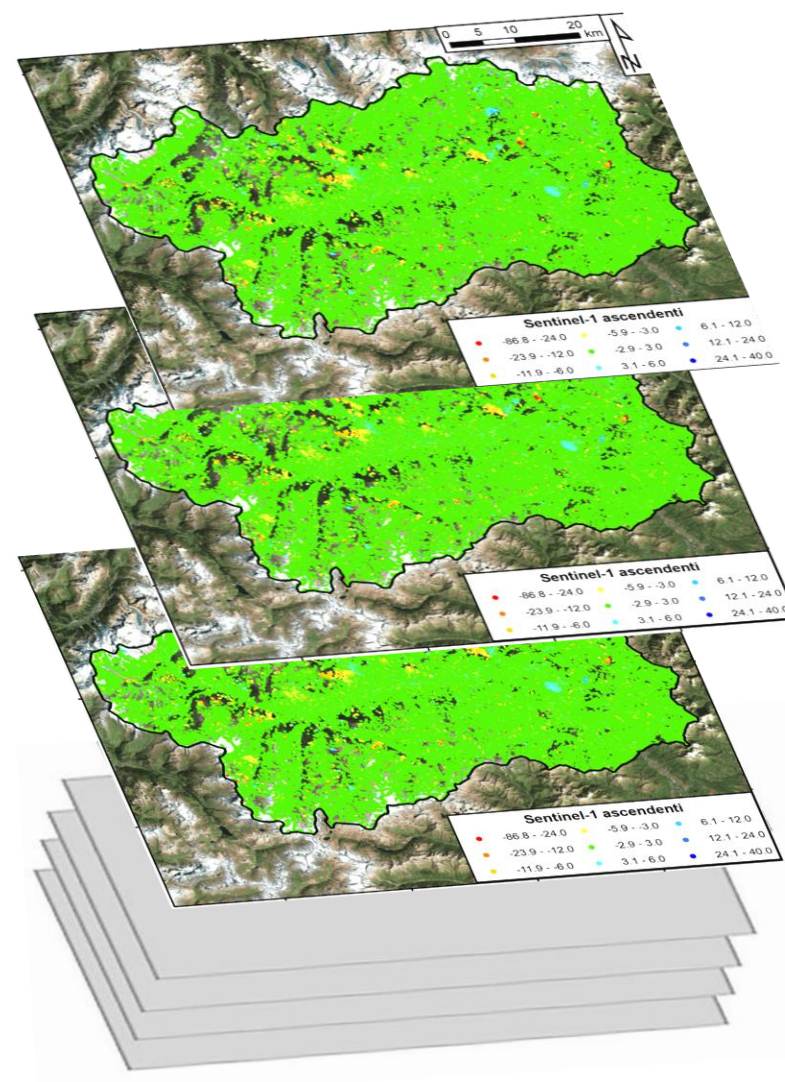


≈ 2.000.000 punti



Gennaio 2018

Regione Valle d'Aosta

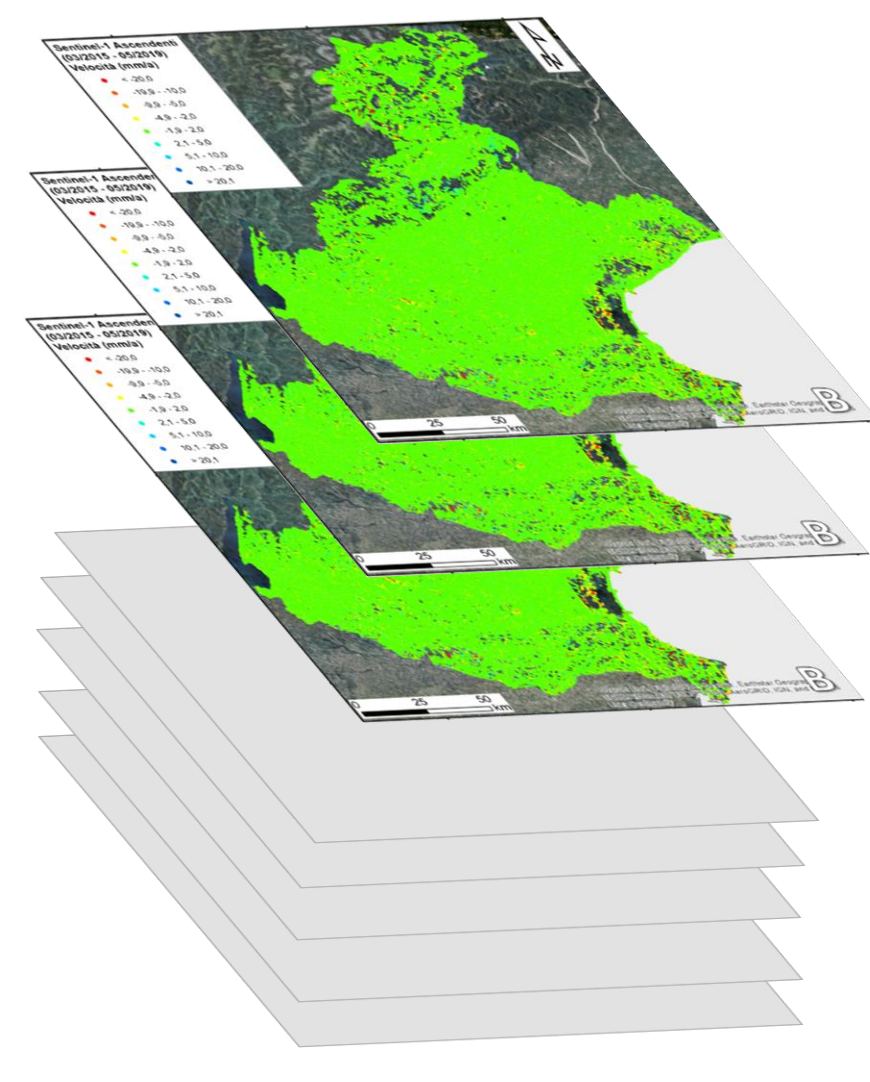


≈ 700.000 punti



Giugno 2019

Regione Veneto

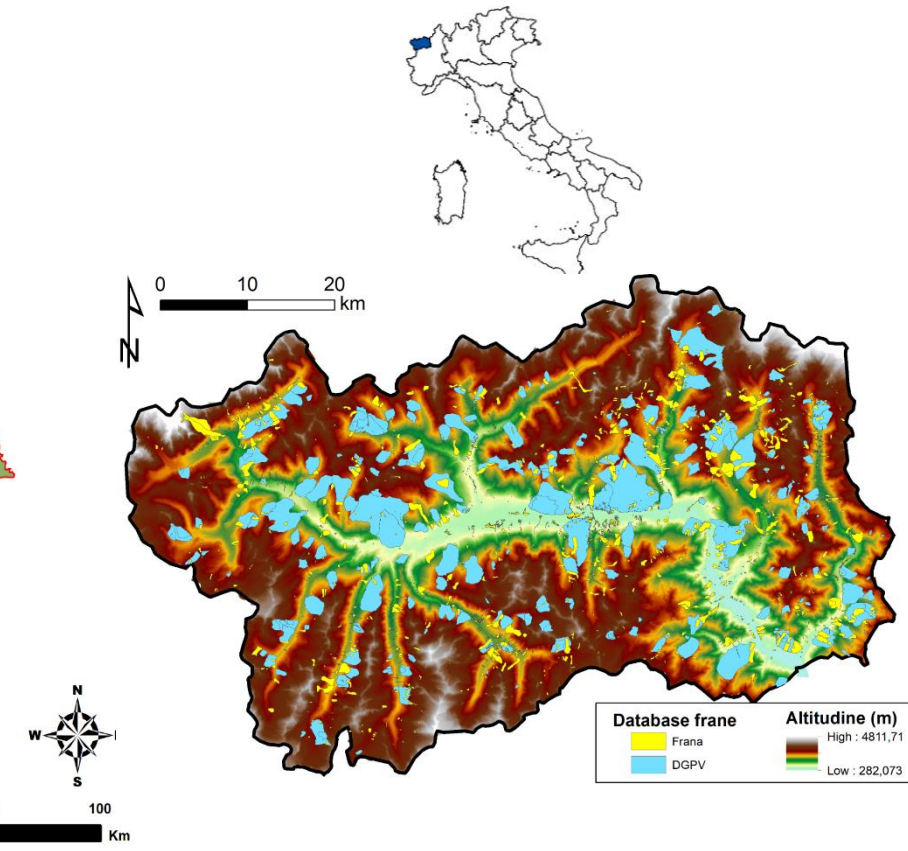
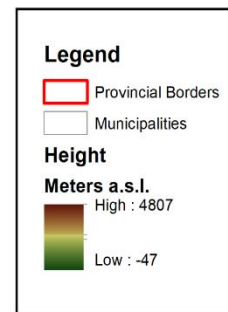
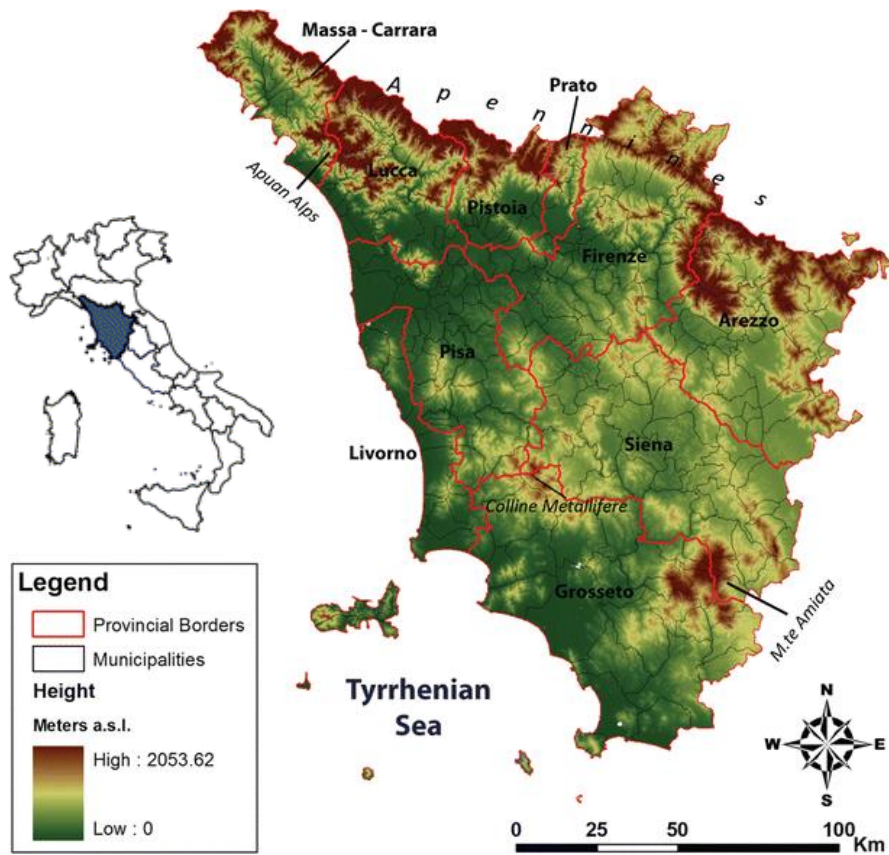


≈ 3.000.000 punti

Passaggio da analisi di archivio ad un monitoraggio sistematico delle deformazioni



# Servizi regionali



Frane compesse e grandi frane in terra.



Frane compesse e grandi colate

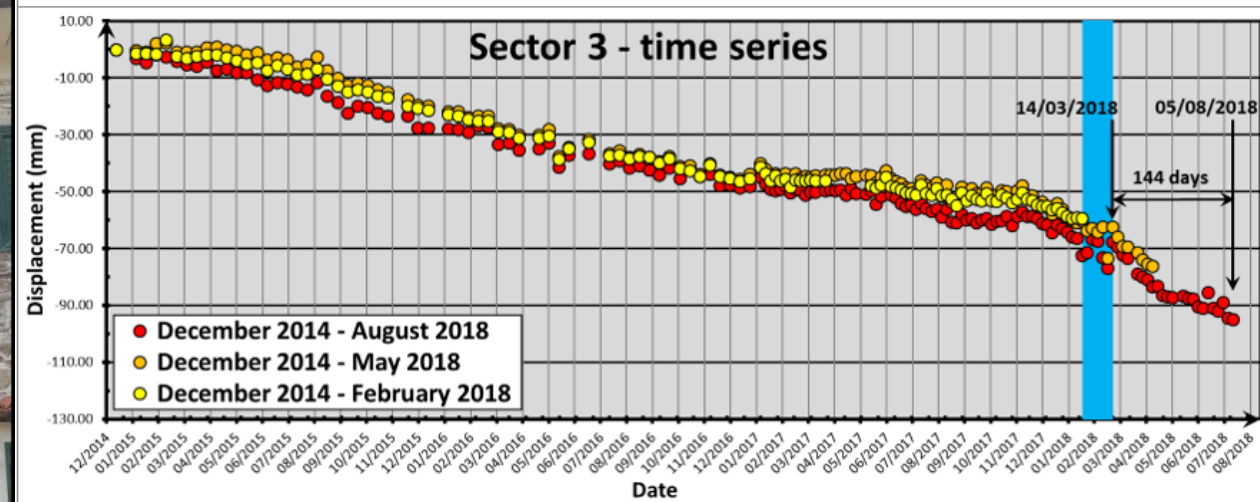
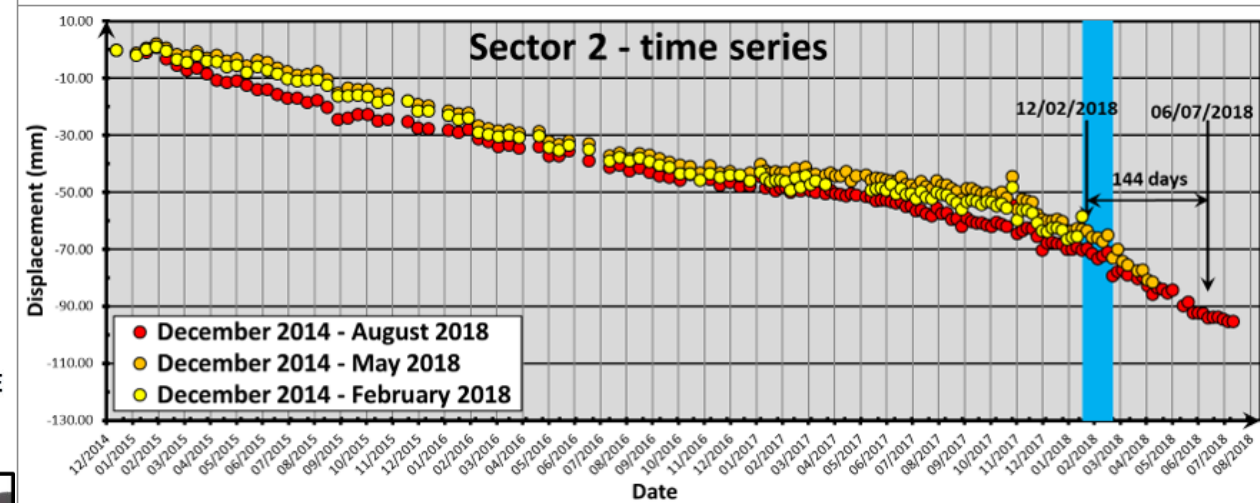
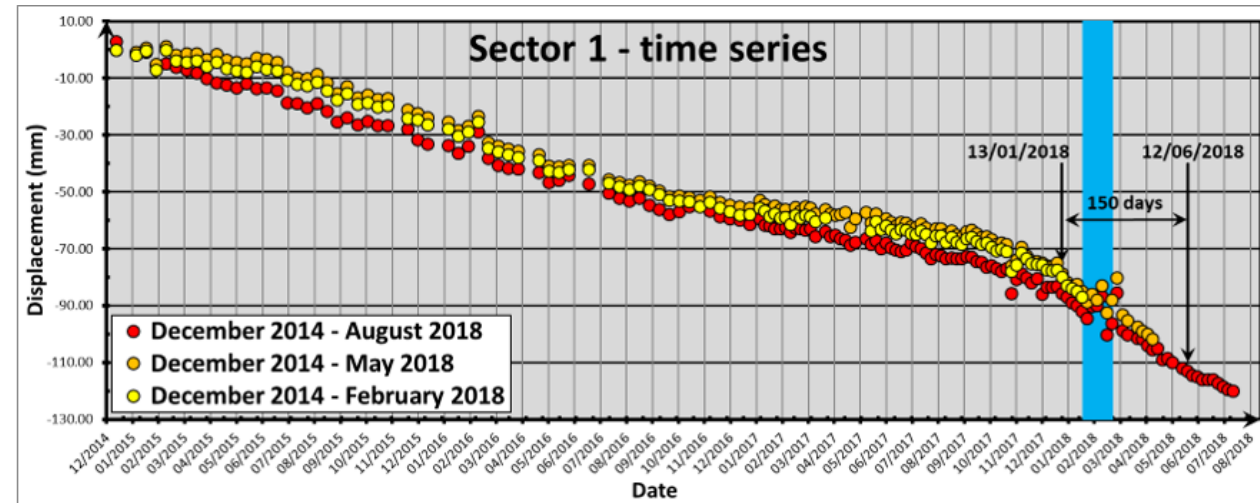
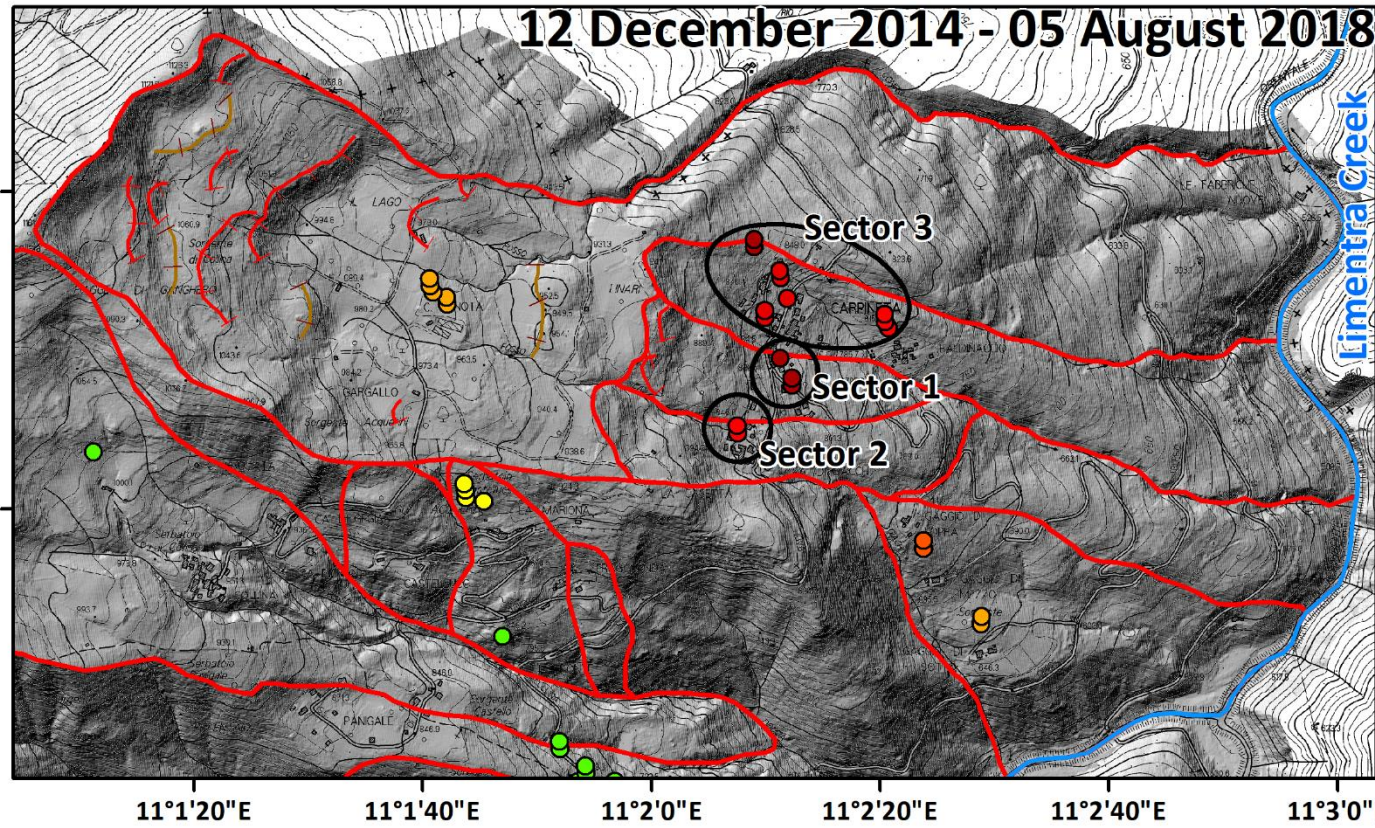


Frane compesse, frane in roccia. DGPV



# Accelerazione frane – Carpineta (PT)

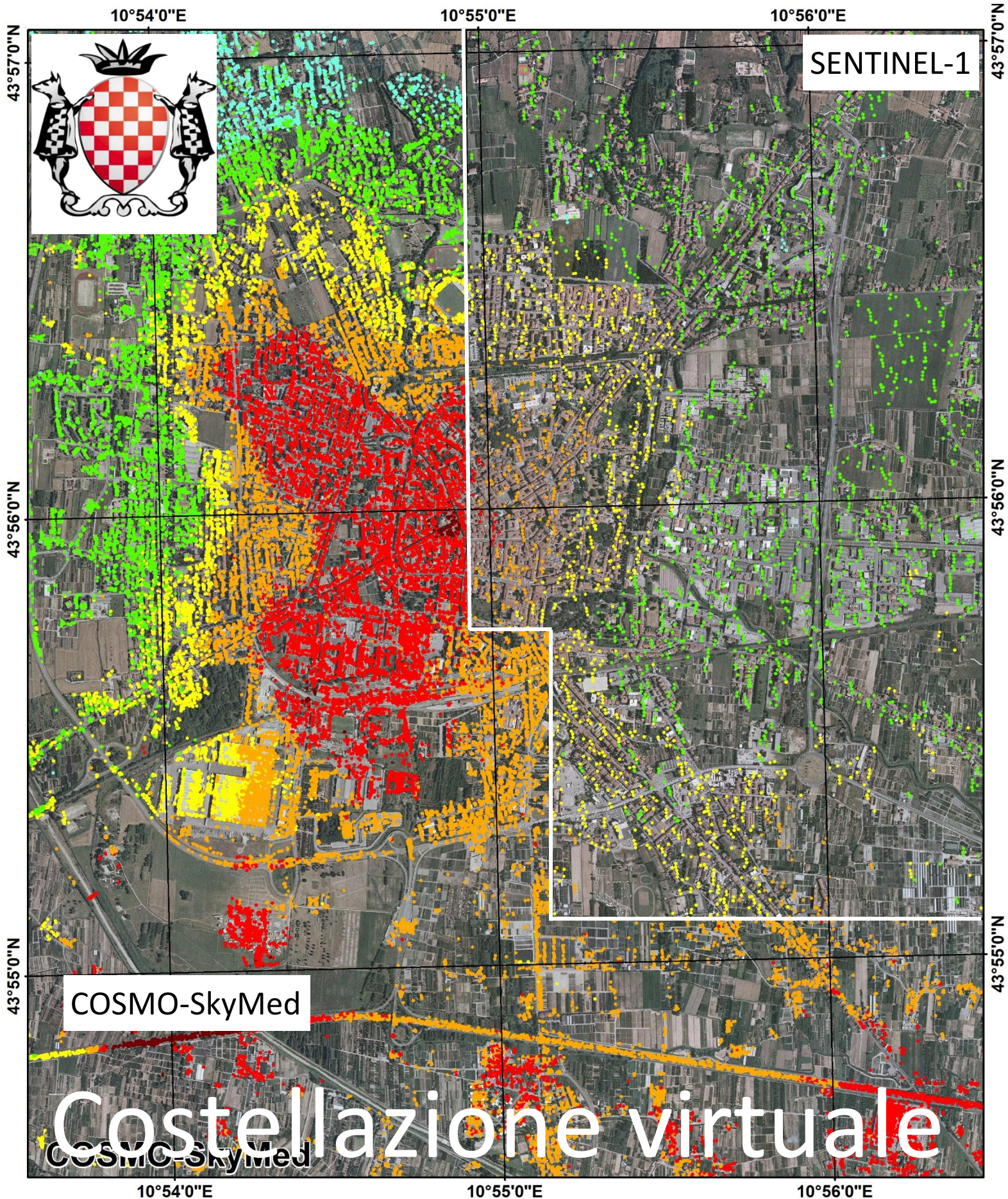
12 December 2014 - 05 August 2018



	Start of acceleration	Latency period	Appearance of anomaly	Disappearance of appearance	Persistency	Life length (days)
<b>Sector 1</b>	13/01/2018	4 acquisitions	06/02/2018	12/06/2018	126	150
<b>Sector 2</b>	12/02/2018	5 acquisitions	14/03/2018	06/07/2018	114	144
<b>Sector 3</b>	14/03/2018	3 acquisitions	01/04/2018	05/08/2018	126	144

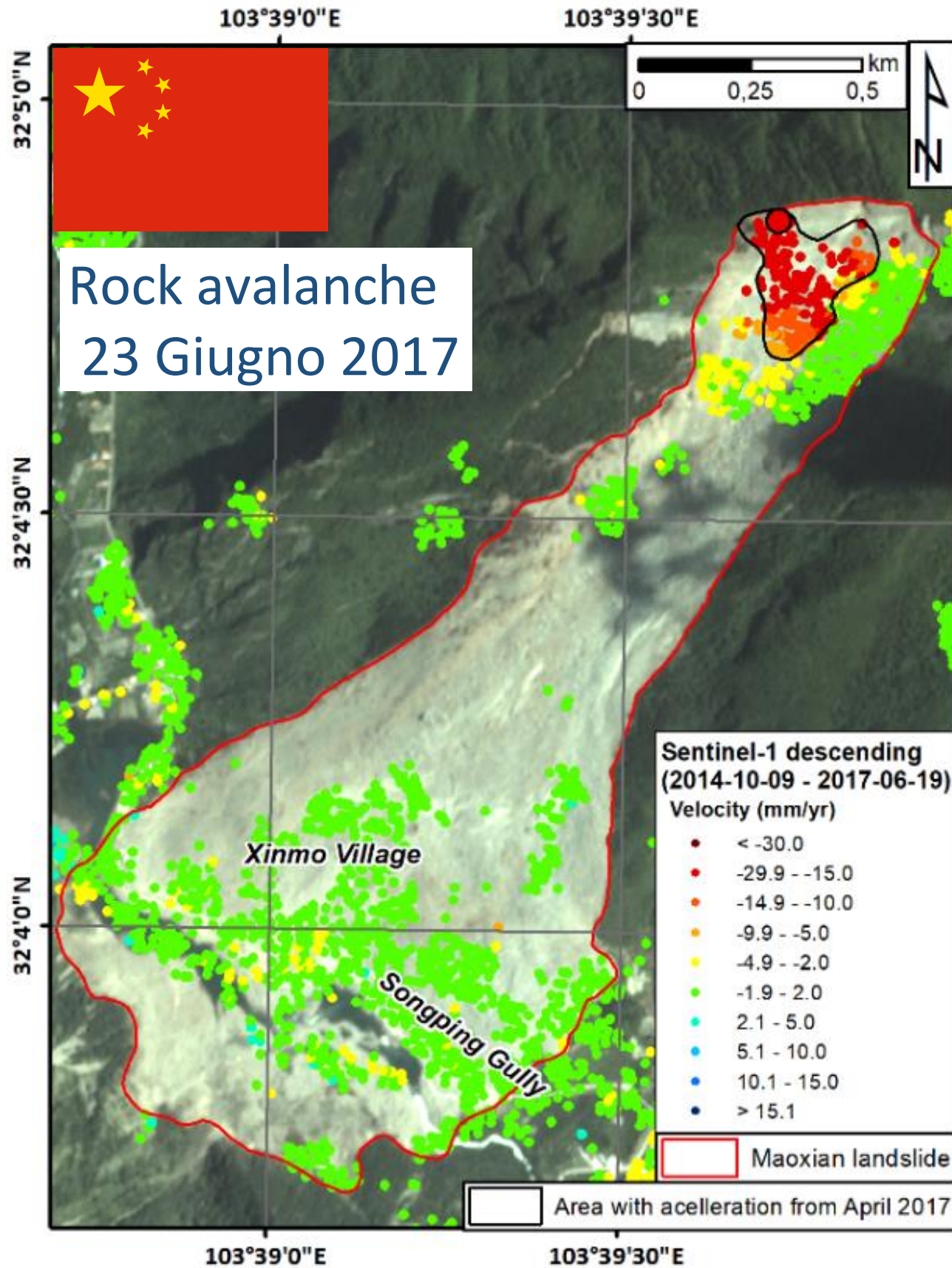


# Subsidenza - PISTOIA

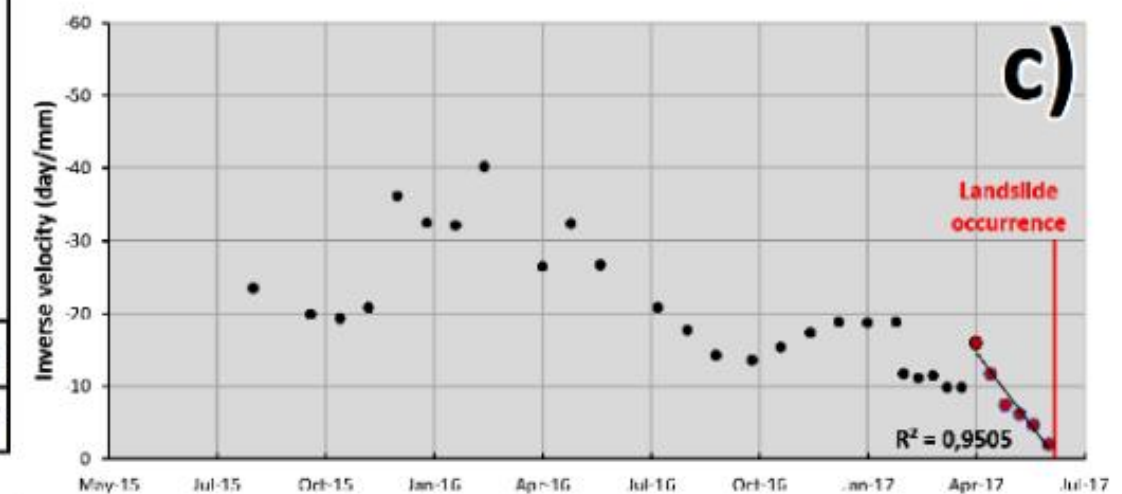
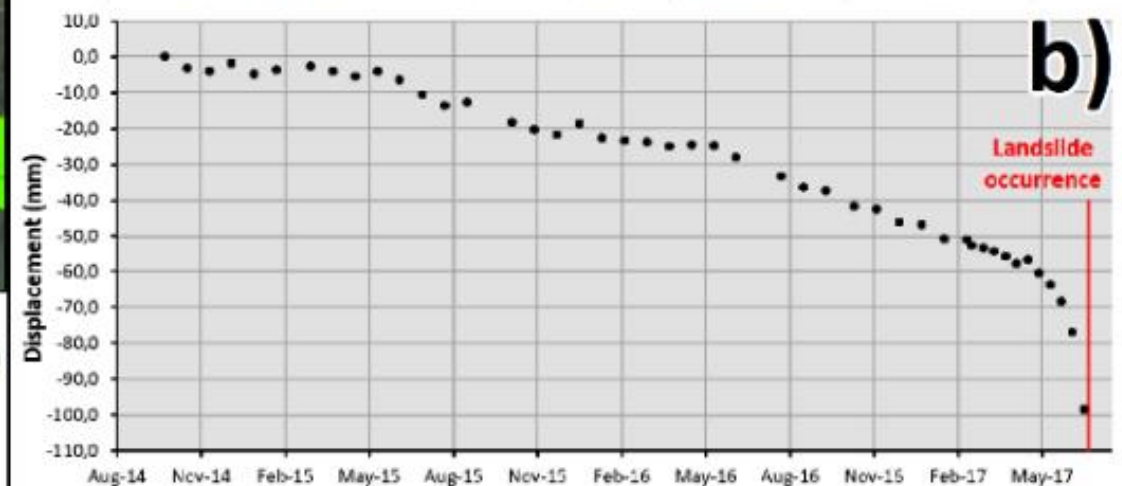




# Istante del collasso (*failure*) - SICHUAN



Intrieri et al., 2018 - Landslides

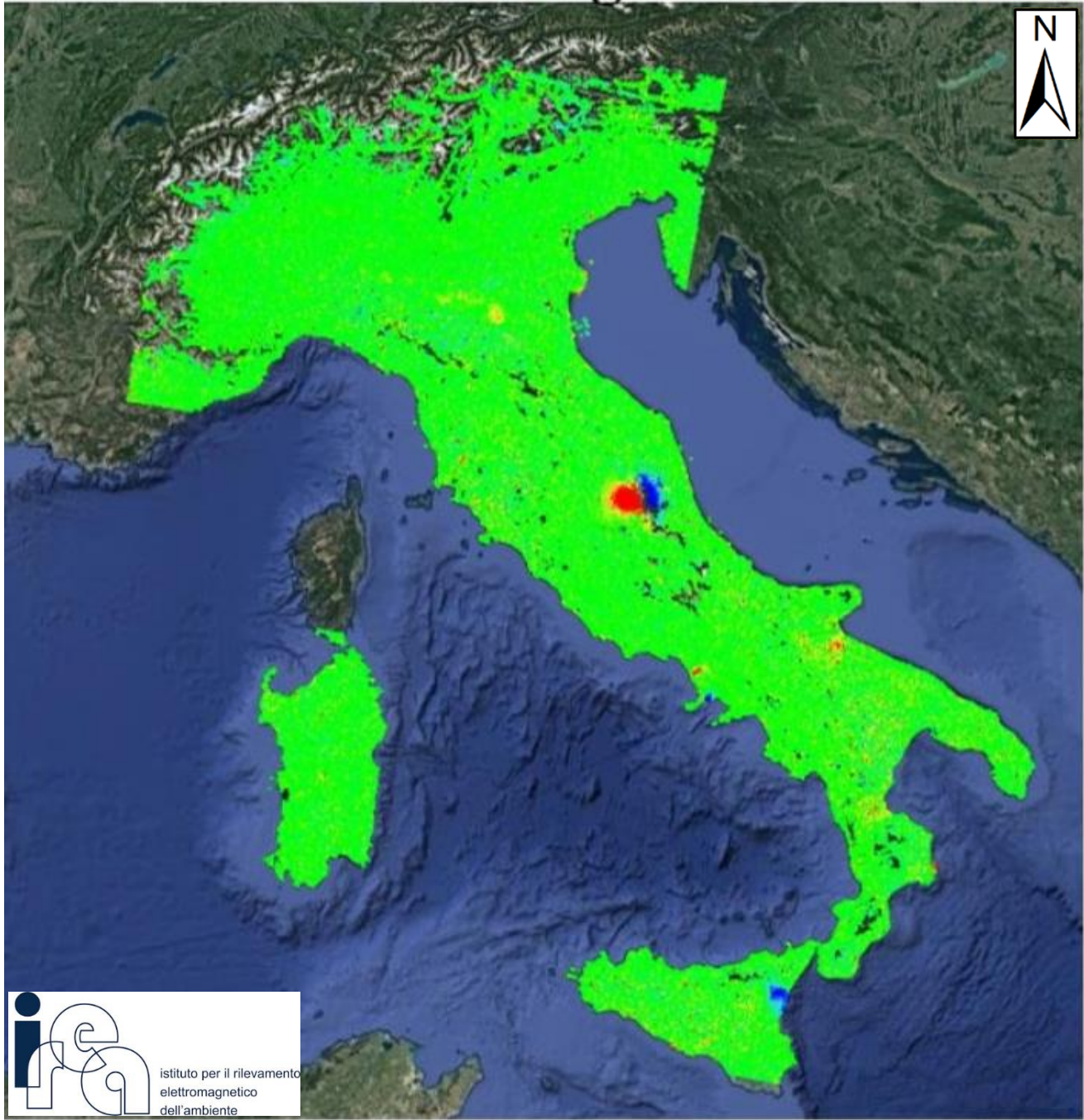


Fattibilità del calcolo dell'istante di *failure* usando le serie temporali Sentinel-1

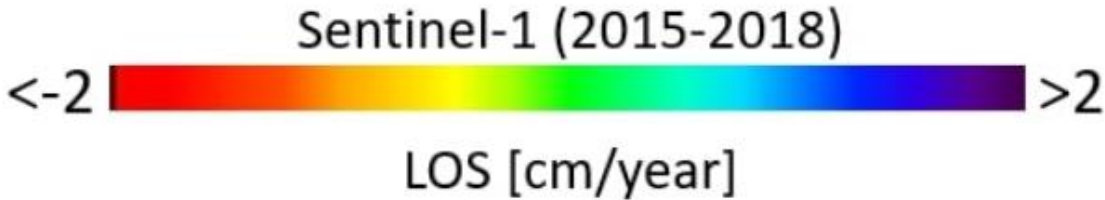
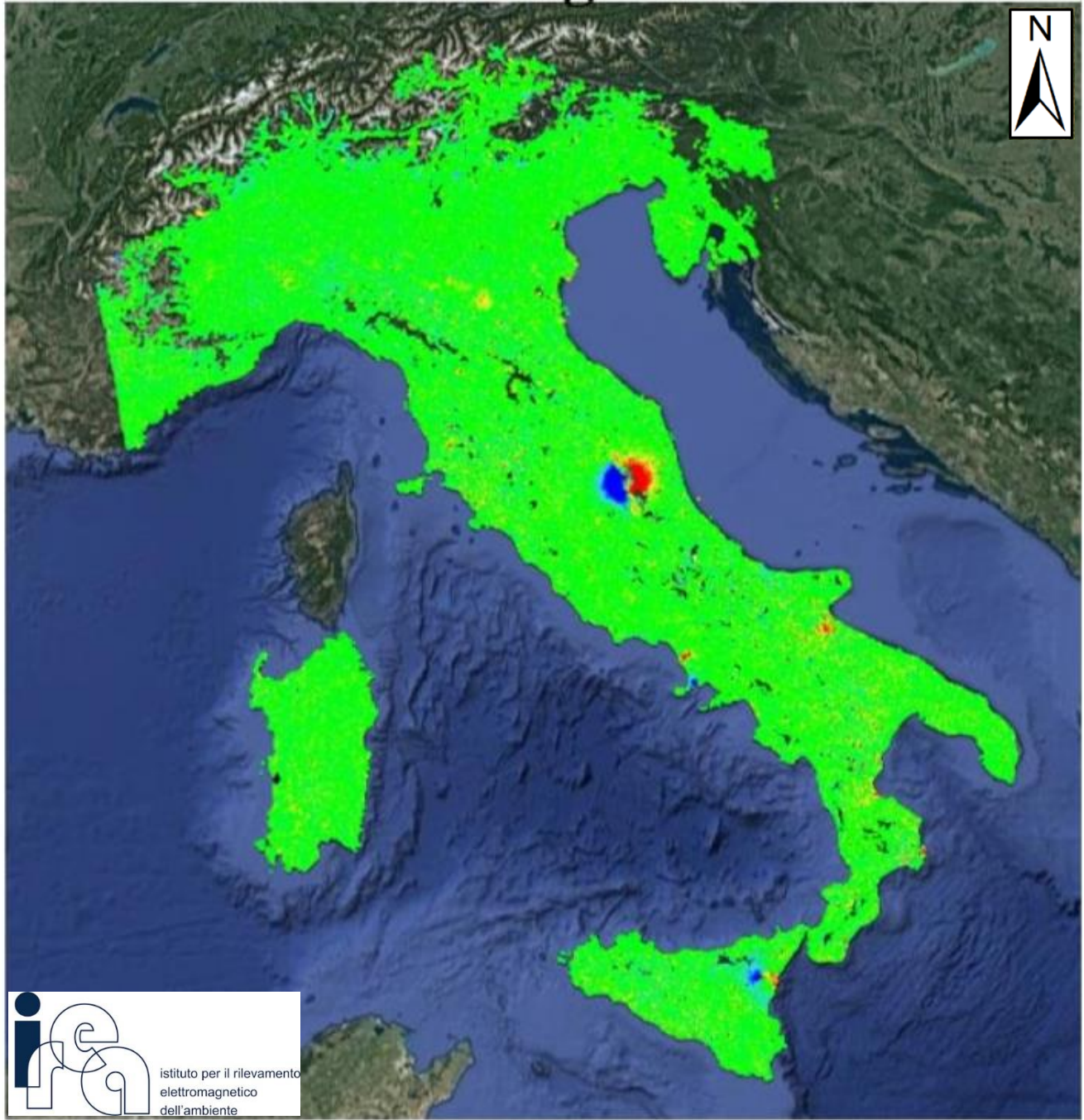


# Analisi a scala nazionale - ITALIA

### Descending Orbits



### Ascending Orbits

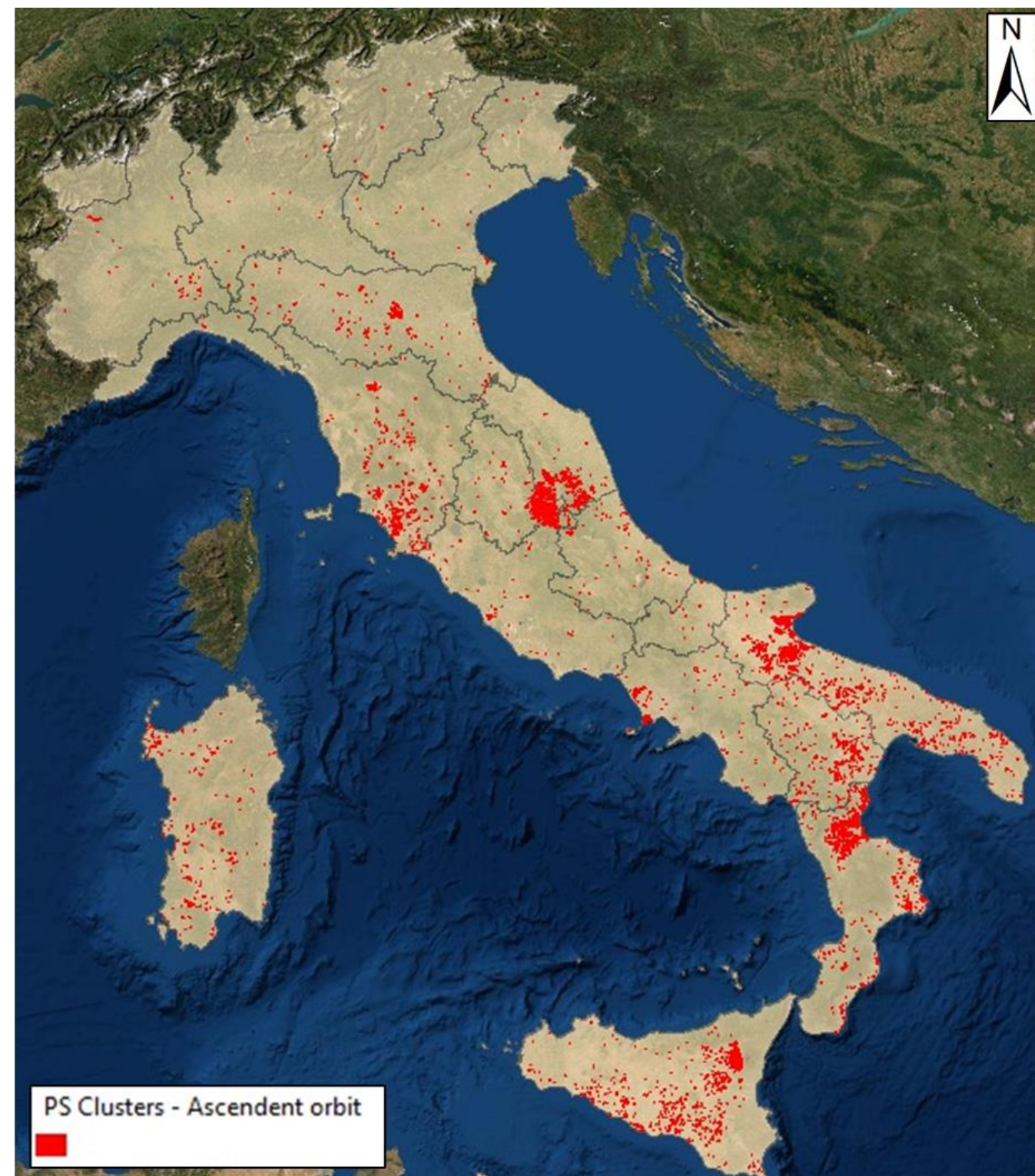




# Analisi a scala nazionale - ITALIA



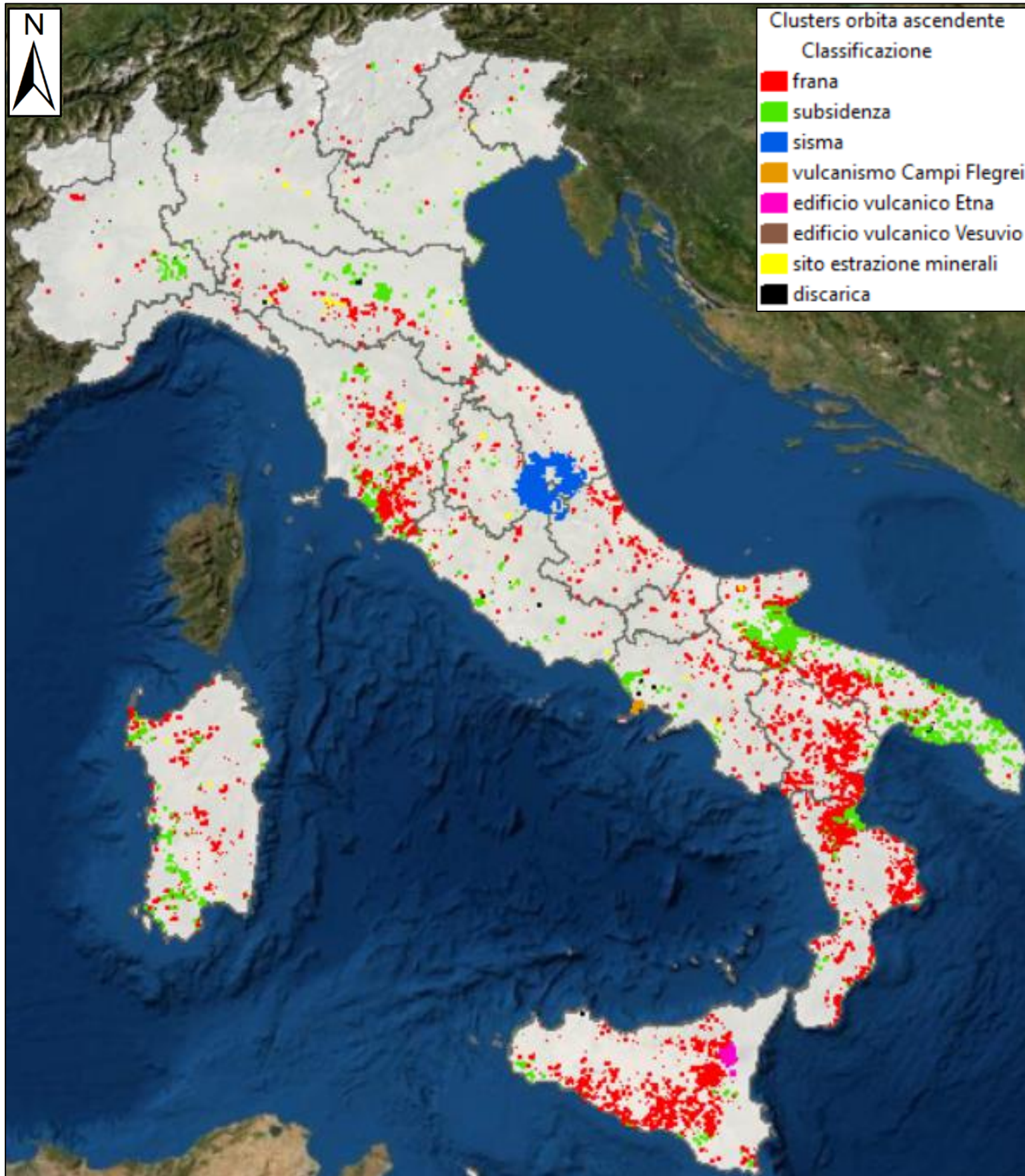
5812 clusters



8075 clusters



# Classificazione dei movimenti - ITALIA

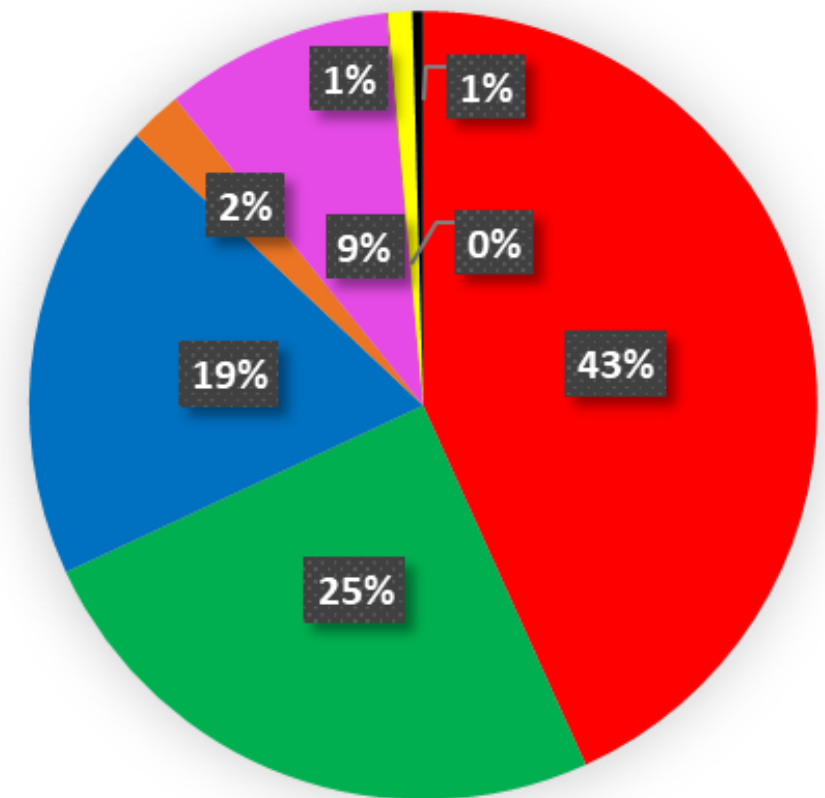


Area totale *clusters*:  
1486  $km^2$

Area occupata per classe  

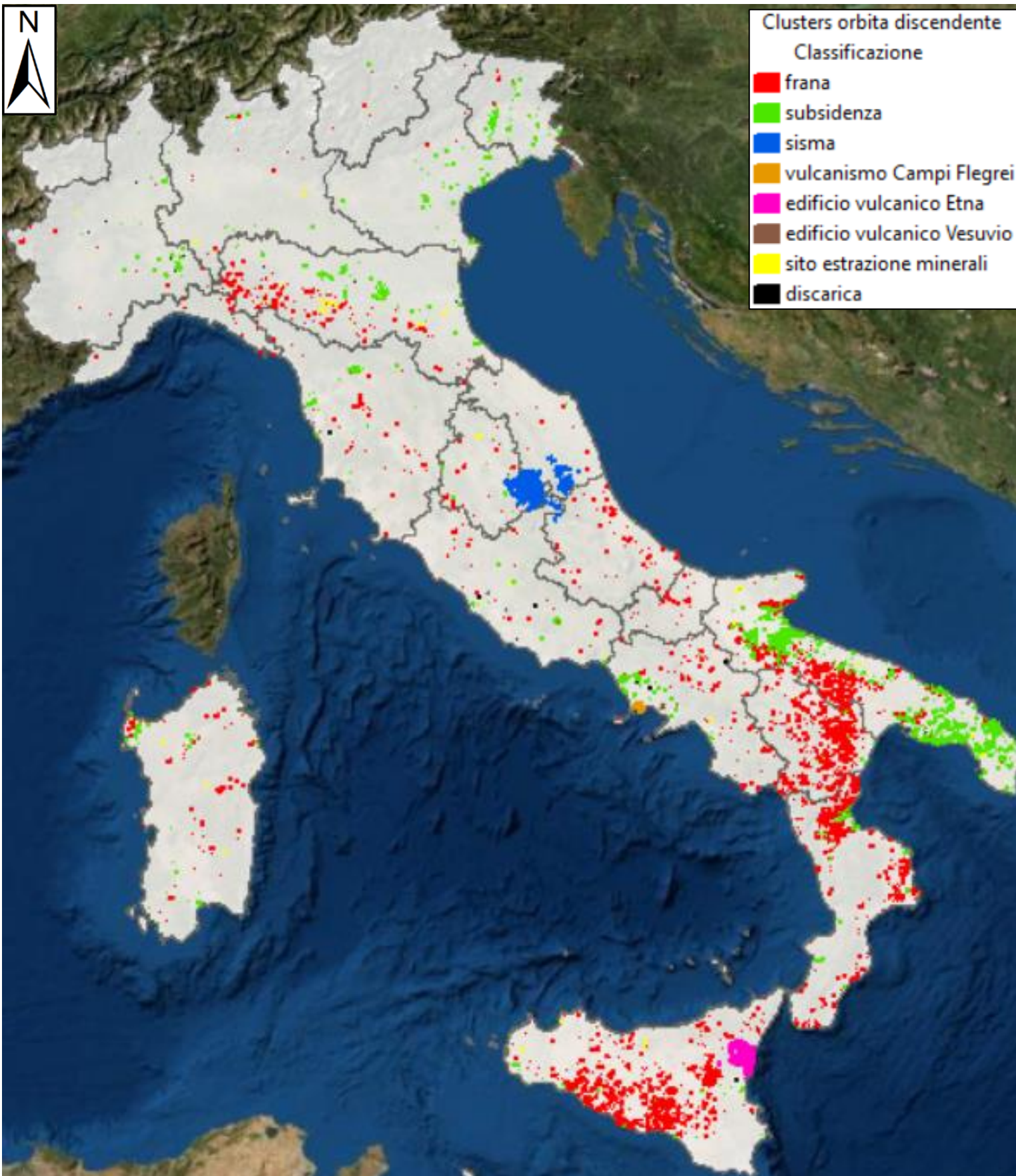
---

Area totale clusters



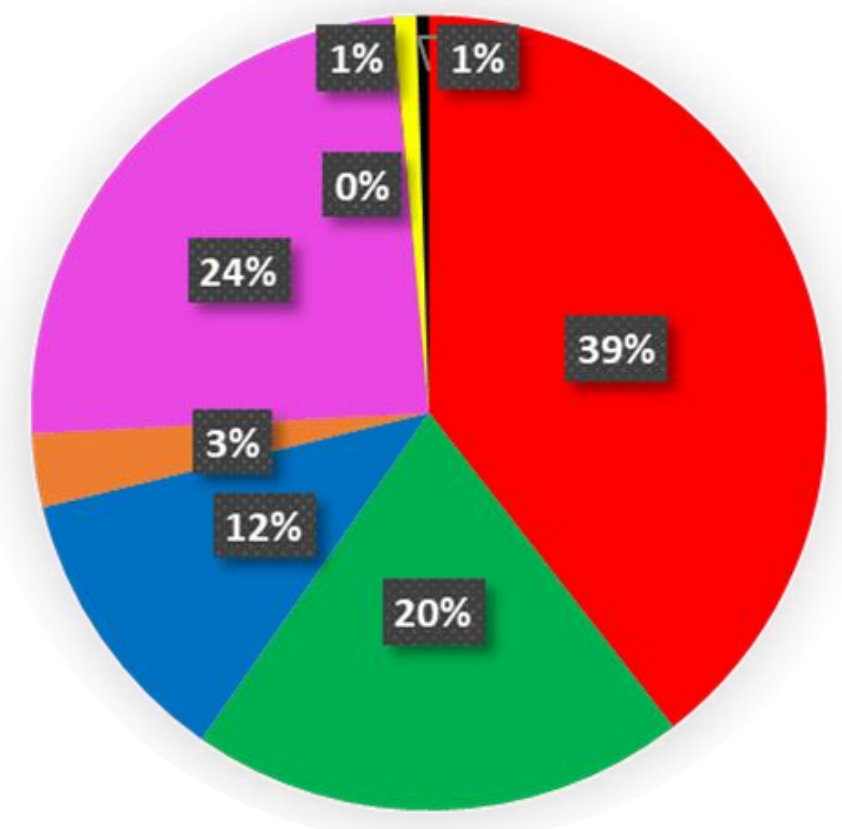


# Classificazione dei movimenti - ITALIA



Area totale *clusters*:  
 $1110 \text{ km}^2$

Area occupata per classe  
Area totale clusters







UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

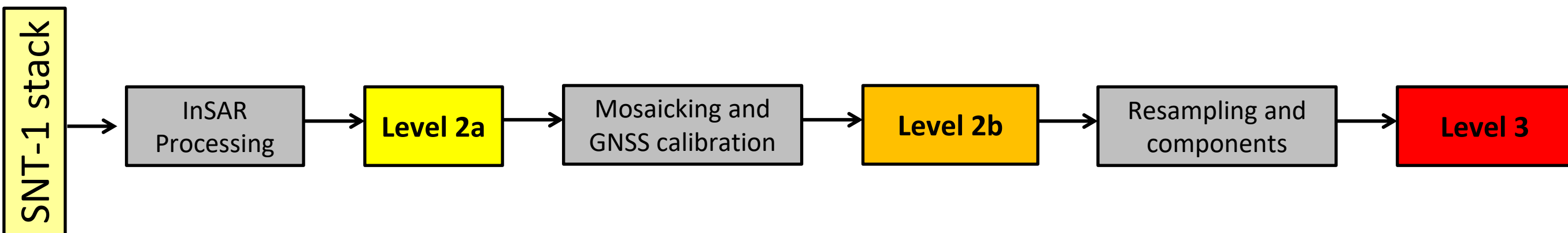
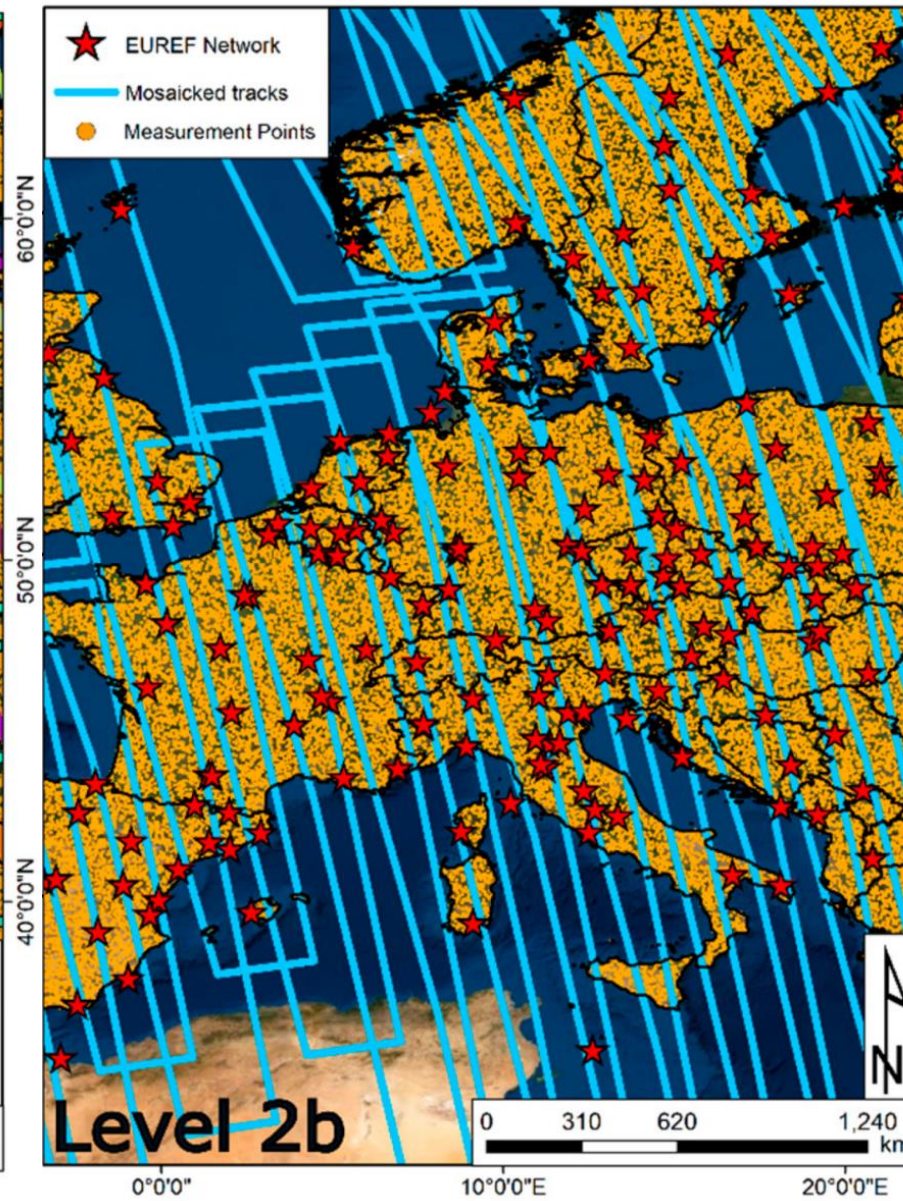
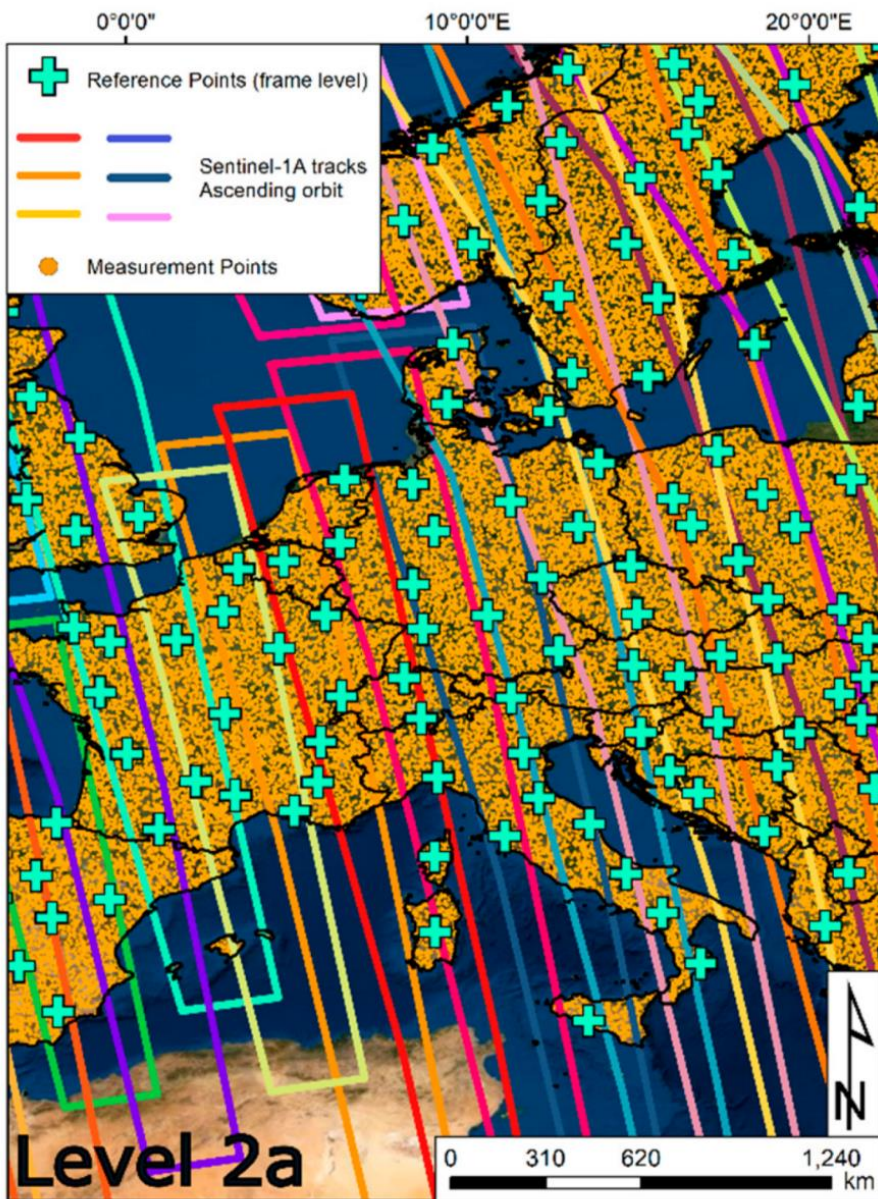
**CENTRO  
PROTEZIONE  
CIVILE**

**Il futuro:  
acquisizioni frequenti a scala  
continentale**

**Sistemi di allertamento basati su  
indicatori di instabilità**

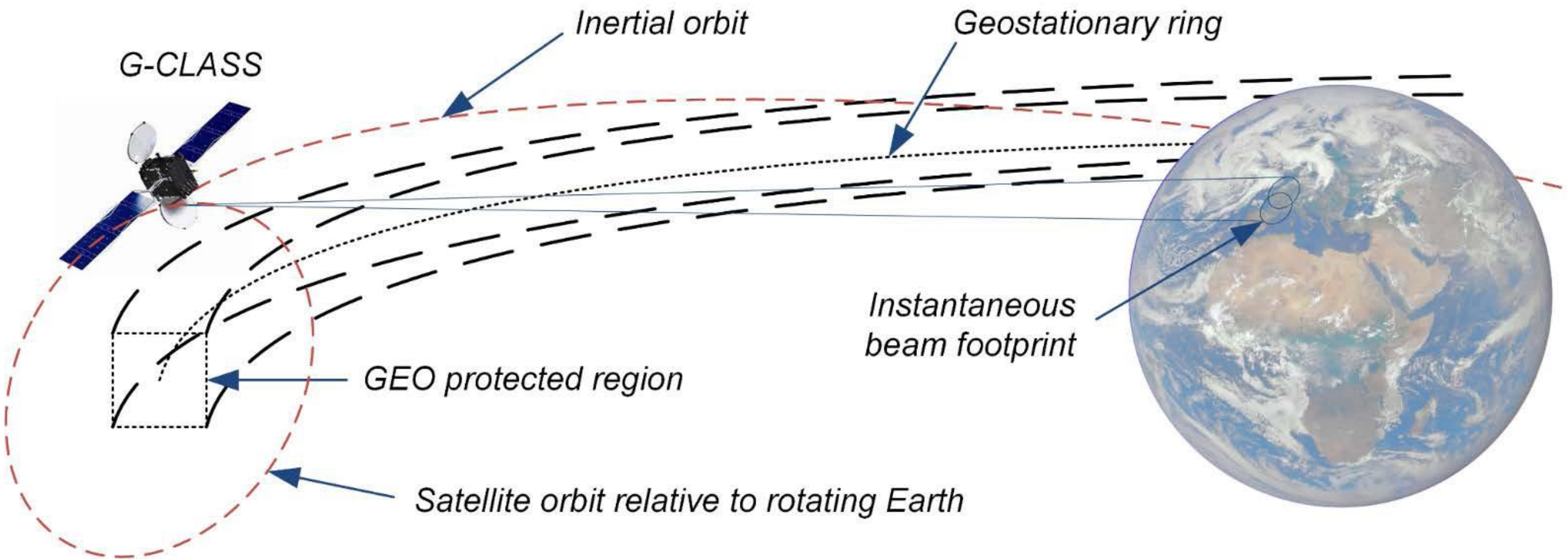


# European ground motion



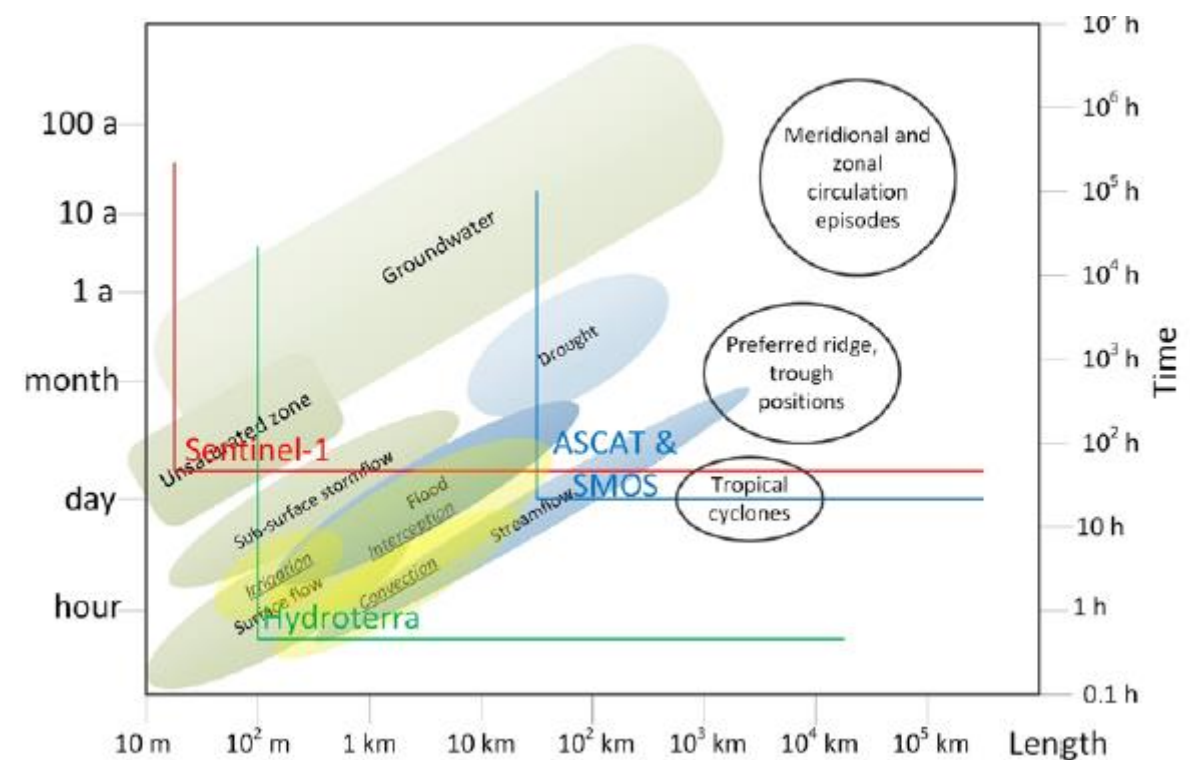


# Satelliti geostazionari: G-CLASS-Hydroterra



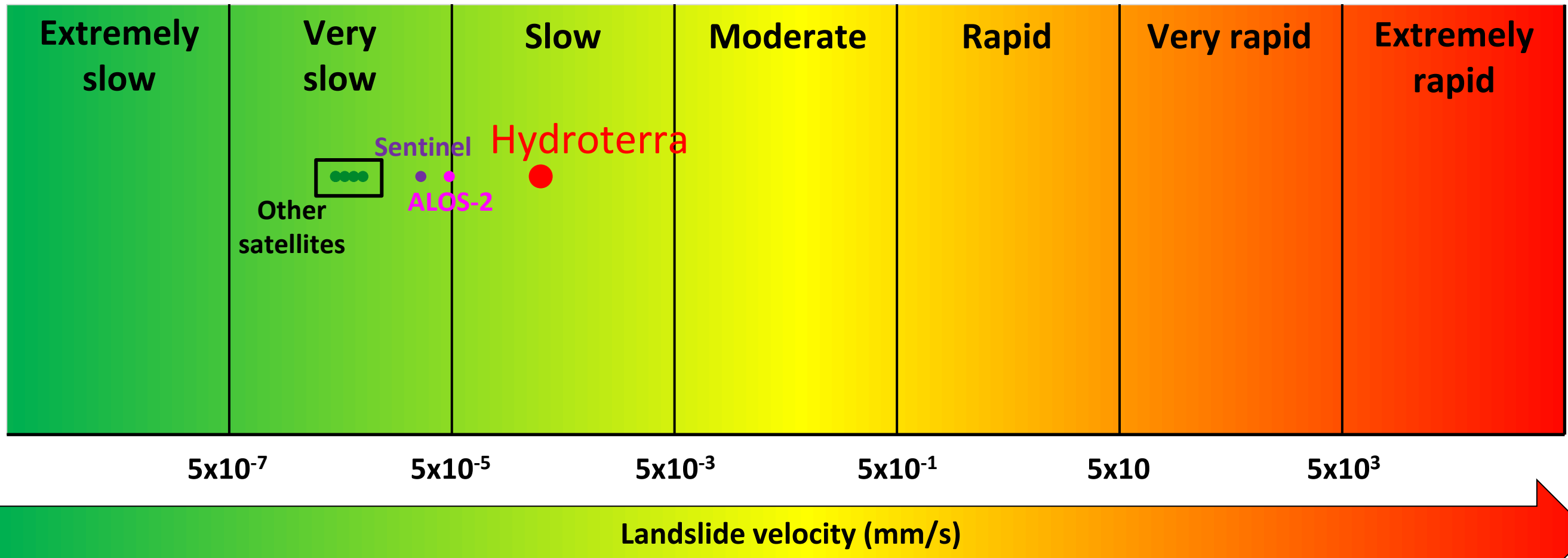
A mission to observe and understand rapid processes of the water cycle over land:

- Hydro-meteorology (intense storms, mitigate weather impacts);
- Surface moisture hydrology (water resource management – agriculture);
- Land cryosphere processes





# Movimenti «veloci», Early warning



Satellite	Maximum measurable velocity
ERS 1/2	14.3 cm/yr
Envisat	14,3 cm/yr
RADARSAT	20,1 cm/yr
TerraSAR-X	25,1 cm/yr
COSMO-SkyMed (16 days)	17,2 cm/yr
ALOS-2	150,0 cm/yr
Sentinel-1 (6 days)	83,0 cm/yr
Hydroterra (12 hours)	996,8 cm/yr





UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

**CENTRO  
PROTEZIONE  
CIVILE**



REGIONE DEL VENETO

Grazie per l'attenzione

Silvia BIANCHINI