

# **MUSAR - DATA FUSION & SMART AUTOMATIC CLASSIFICATION OF SATELLITE MULTISENSOR/MULTIBAND SAR AND OPTICAL DATA**



**SAPIENZA**  
UNIVERSITÀ DI ROMA

**Paolo Mazzanti**

**Earth Technology Expo,  
Firenze 15-10-2021**

## The SPEAKER



**Prof. Paolo Mazzanti, "Sapienza" University of Rome**

**Expert in geotechnical monitoring and remote sensing applied to ground and structures deformation processes**

- **MSc in Geology and PhD in Earth Sciences**
- **Lecturer of Remote Sensing and Geologic Risks at "Sapienza" University of Rome (Italy)**
- **CERI (Research Center for the Forecast, Prevention and Control of Geological Risks)**
- **Organizer of the "International Course on Geotechnical and Structural Monitoring"**
- **Member of the TRB (Transportation Research Board) Engineering Geology Committee**
- **Member of the Executive Board of the FMGM (Field Measurements in Geomechanics) community**
- **Founder and CEO of NHAZCA S.r.l., Startup of "Sapienza" University of Rome.**

# NHAZCA



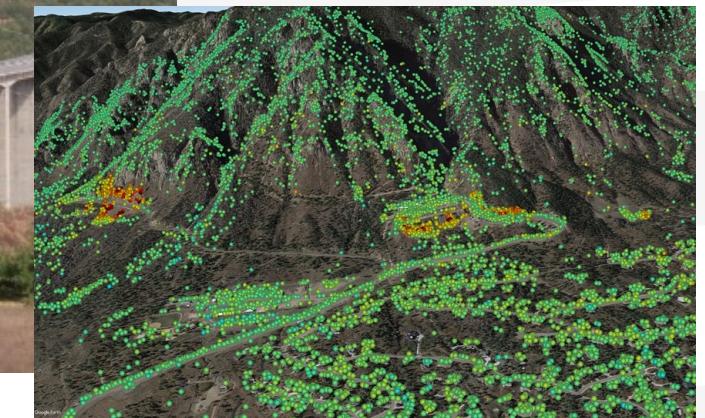
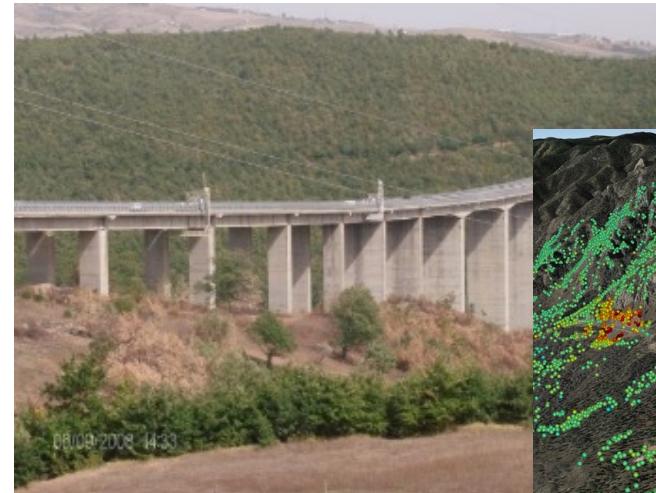
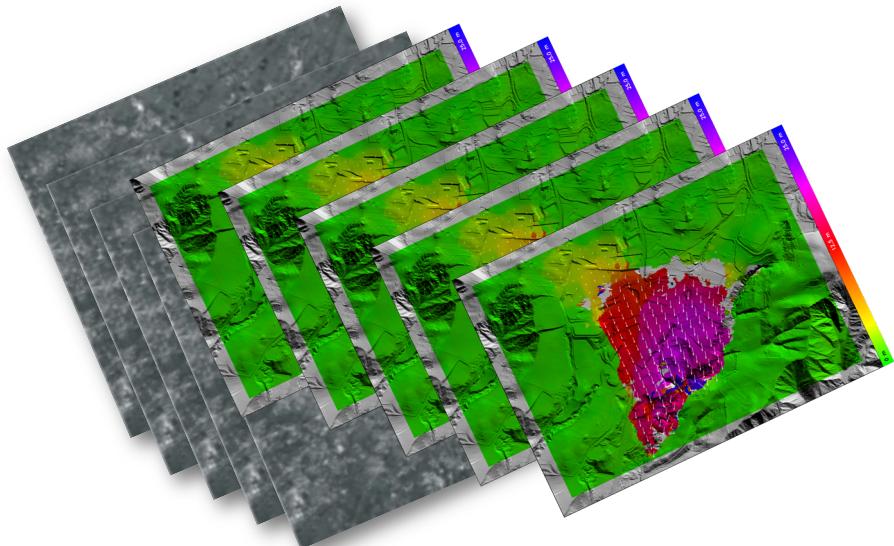
**NHAZCA is a limited company (S.r.l.), Startup of “Sapienza” University of Rome (Italy)**  
**International leader of analysis and monitoring solutions for the management and control**  
**of Infrastructures and Natural Hazards**

- Incubated at **European Space Agency Business Incubation Centre in 2010**
- Integrated team of 30 qualified **professionals, researchers and academics**
- Core technologies:  
**Satellite InSAR, Terrestrial InSAR, PhotoMonitoring™, Laser Scanner, Drones (UAV)**
- Serving more than 400 customers from 40 countries
- ISO 9001:2015 Certification



# OBIETTIVI

**E**stendere lo sfruttamento dei dati EO nell'area di ricerca attinente ai rischi naturali, con particolare attenzione rivolta alle strategie di gestione e manutenzione delle infrastrutture viarie e delle opere d'arte stradali



# INFRASTRUCTURE ASSET MANAGEMENT

## Problem: Geohazards + Aging infrastructures

Investment and budget allocation for maintenance, adaptation and safety measures

- **ANAS S.p.A., Italy:** period 2016-2020, 15,9 billion € (3,8 billion € per year),
- **Autostrade per l'Italia, Italy:** period 2020-2023, 7 billion € (1,75 billion € per year),
- **Colorado Department of Transportation, USA:** period 2021-2022, 972 million \$,
- **RFI - Rete Ferroviaria Italiana, Italy:** period 2016-2021, 10,5 billion € (1,75 billion per year),
- **Deutsche Bahn, Germany:** period 2021-2030, 12.7 billion € (1,2 billion € per year).



## Solution: Predictive maintenance + Asset Management

# ATTIVITA'

## 1. Data Fusion:

- a) Integrazione delle tecniche InSAR Differenziali (DInSAR) e Avanzate (A-DInSAR)
- b) Integrazione dei risultati A-DInSAR multisensore/multifrequenza
- c) Stima del campo di spostamento 3D mediante l'integrazione dei dati SAR e ottici satellitari.

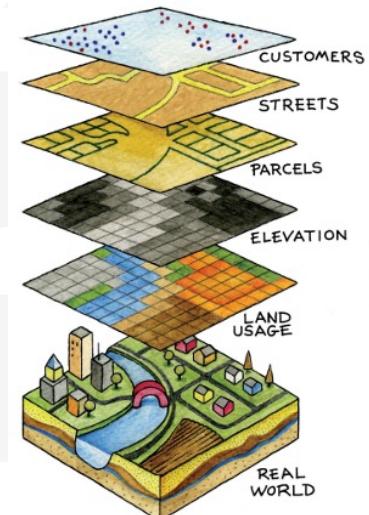
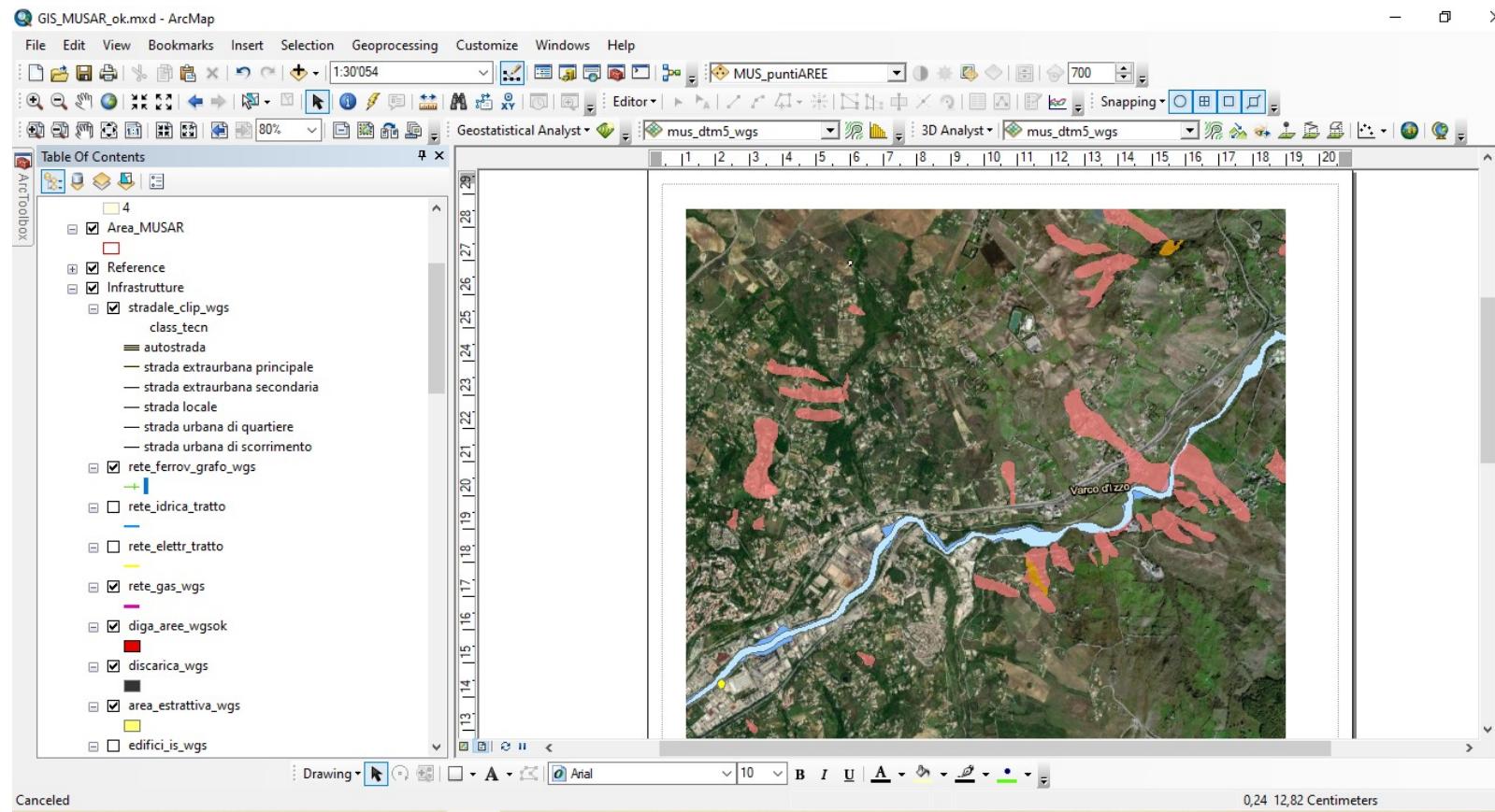
**2. Classificazione smart automatica:** basata su metodi di Machine Learning per l'individuazione e classificazione di processi naturali e antropici sfruttando risultati di analisi di dati EO

## AREA DI STUDIO

Caratterizzato dalla **presenza di differenti tipologie di processi naturali attivi**, dalla presenza diffusa di **diverse tipologie di frane**, da **attività di tipo estrattivo** e di **reiniezione** (Concessioni ENI Val D'Agri e Total Gorgoglione) e **infrastrutture di interesse** (ad es. Diga del Pertusillo)



# SVILUPPO DATABASE TERRITORIALE



# SVILUPPO DATABASE TERRITORIALE

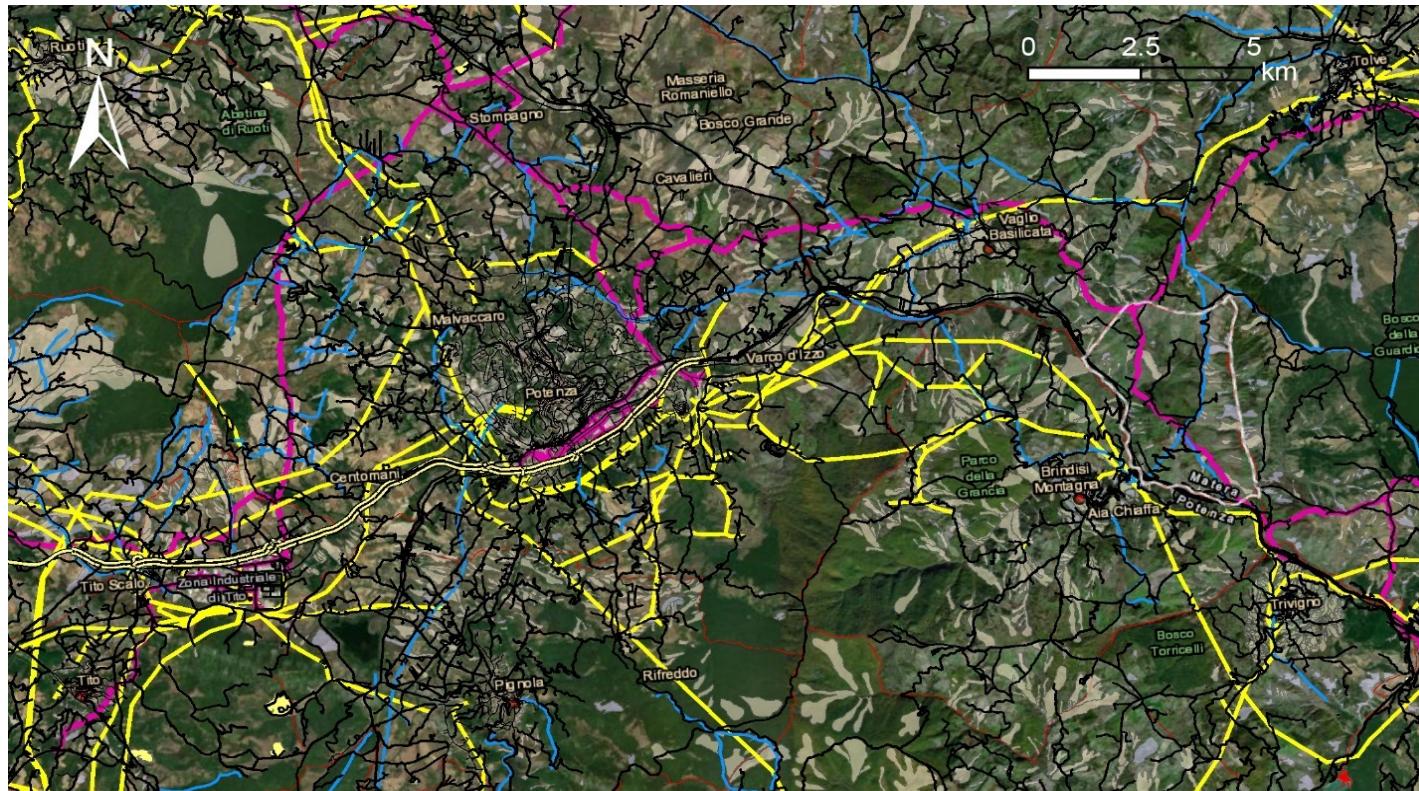
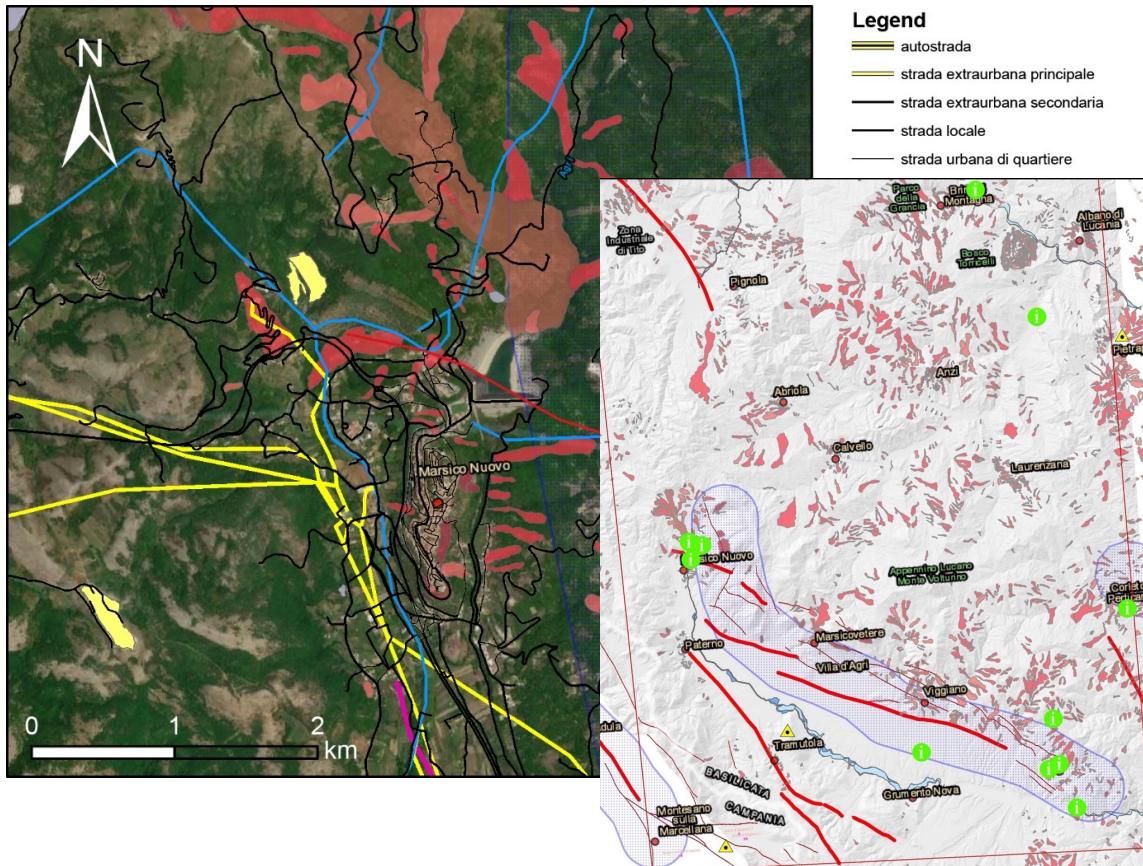


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Layers

- Infrastrutture
  - stradale\_clip\_wgs
    - class\_tecn
  - autostrada
  - strada extraurbana principale
  - strada extraurbana secondaria
  - strada locale
  - strada urbana di quartiere
  - strada urbana di scorrimento
- rete\_ferrovia\_grafo\_wgs
- rete\_gas\_wgs
- diga\_aree\_wgsok
- discarica\_wgs
- area\_estrattiva\_wgs
- edifici\_is\_wgs

# SVILUPPO DATABASE TERRITORIALE

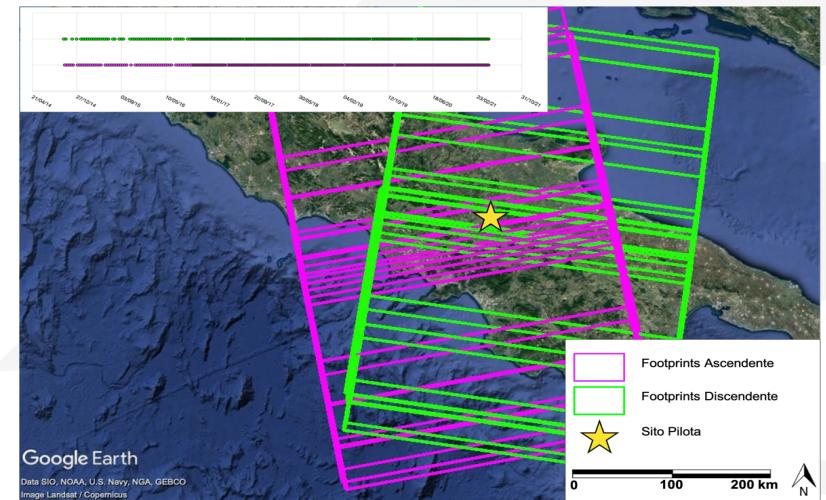
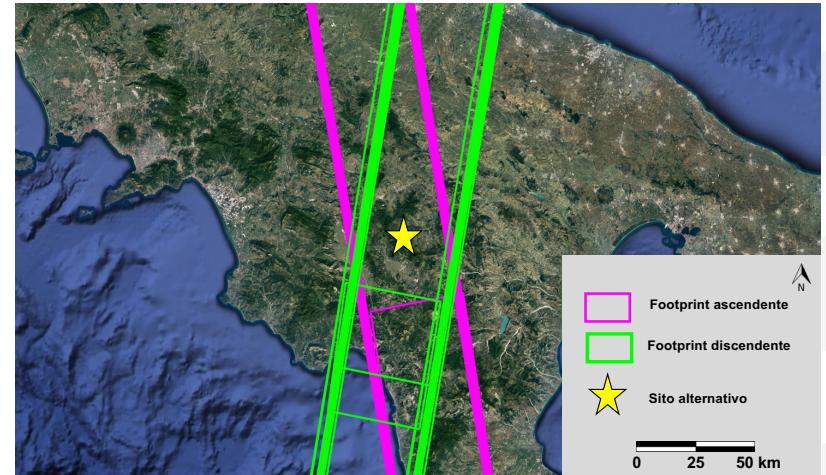


A scala areale sono anche stati consultati i seguenti cataloghi riferibili a processi naturali agenti sul territorio

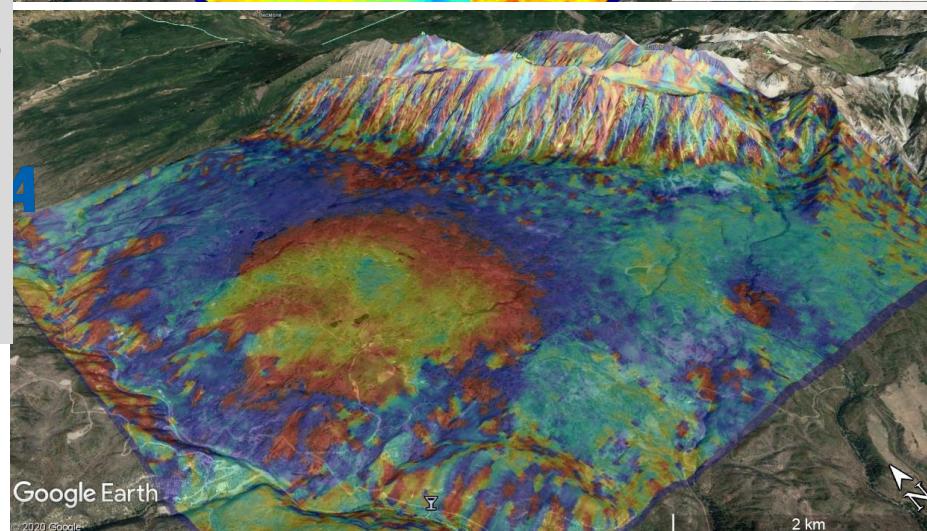
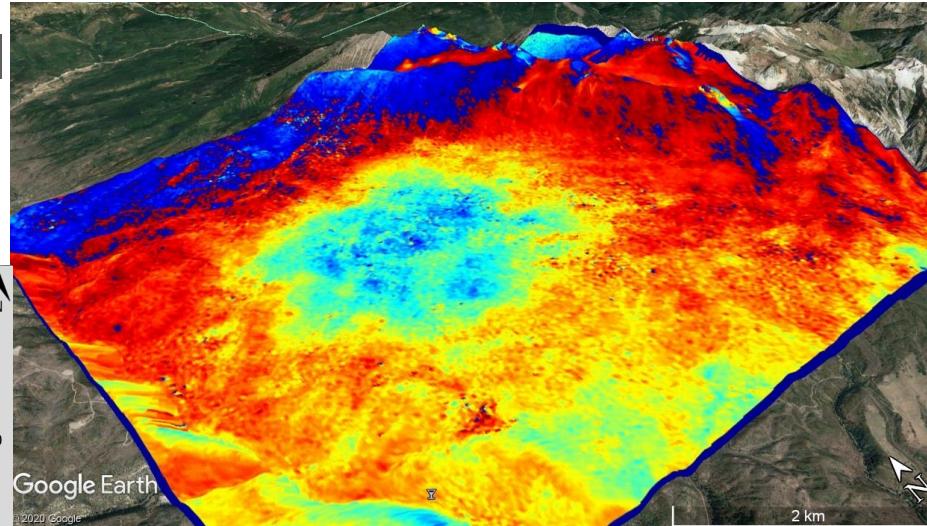
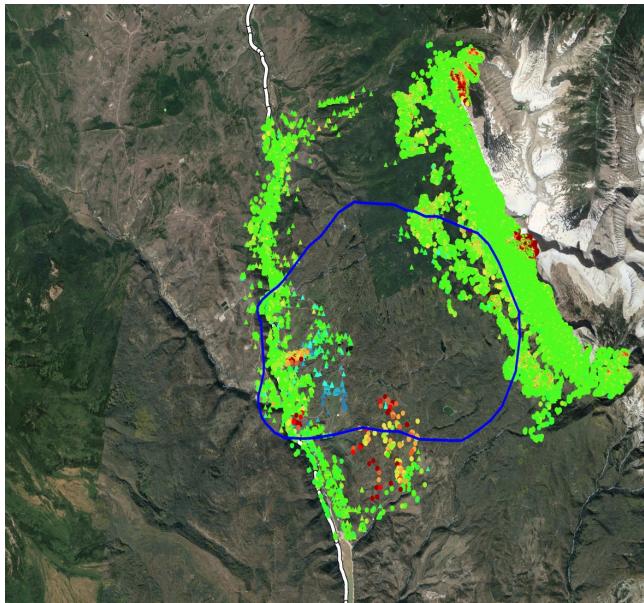
- **Inventario dei Fenomeni Franosi (IFFI)**
- **Arearie a rischio frana (AdB Basilicata)**
- Inventario Frane Italia (Calvello et al., 2018)
- Catalogo Effetti Deformativi Indotti da Forti Terremoti (CEDIT)
- Perimetrazioni delle arre inondabili (Tempi di Ritorno 30, 200 e 500 anni)
- Sinkhole (ISPRA - Regione Campania)
- **Faglie Attive e Capaci (ITHACA)**
- Sismicità Storica
- Sorgenti Sismogenetiche (DISS v. 3.2.1.)

# L'IMPORTANZA DEI DATI SATELLITARI MULTI-FREQUENZA

- **Sentinel-1** (marzo 2014-giugno2021)
- **COSMO-SkyMed** (maggio 2011-luglio 2021)
- **SAOCOM** (ottobre 2020-agosto 2021)



# L'IMPORTANZA DEI DATI SATELLITARI MULTI-FREQUENZA



## Sentinel-1

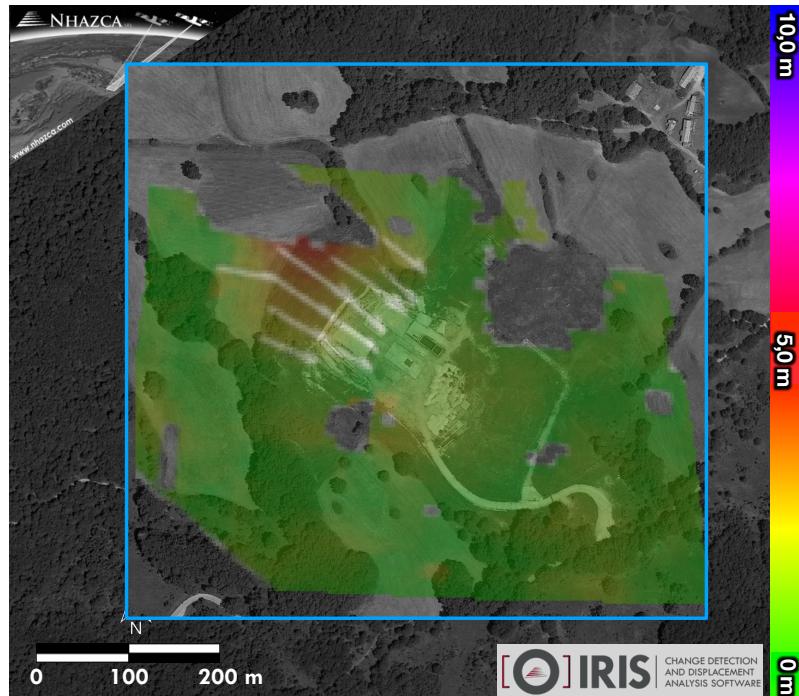
- Period: Sept 2019
- C Band
- Resolution: **5x20 m**

## ALOS-2

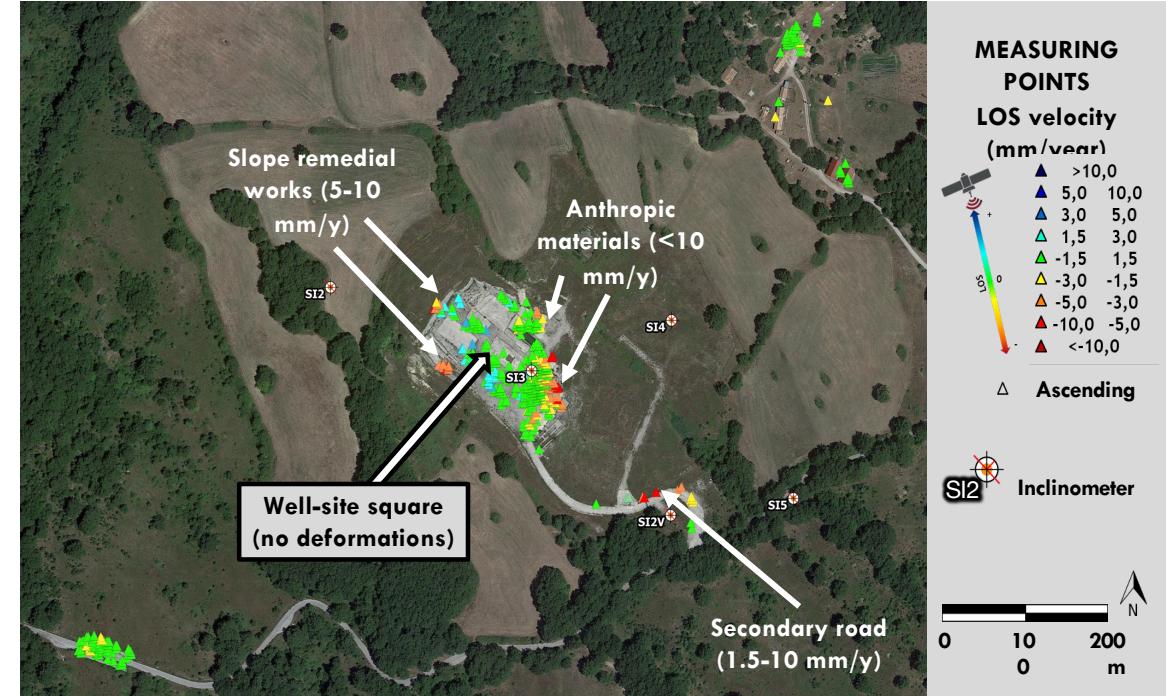
- Period: 2007 – 2010
- L Band
- Resolution: **10x10 m**

# L'IMPORTANZA DI COMBINARE INSAR E PHOTOMONITORING

## Optical analysis with PhotoMonitoring™



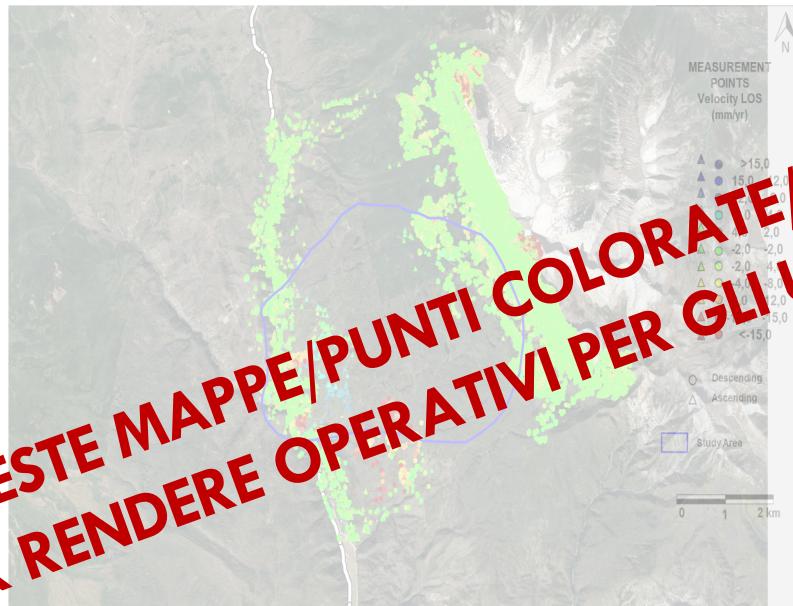
## SAR satellite data analysis



# L'IMPORTANZA DEI DATI SATELLITARI MULTI- FREQUENZA

## Sentinel-1

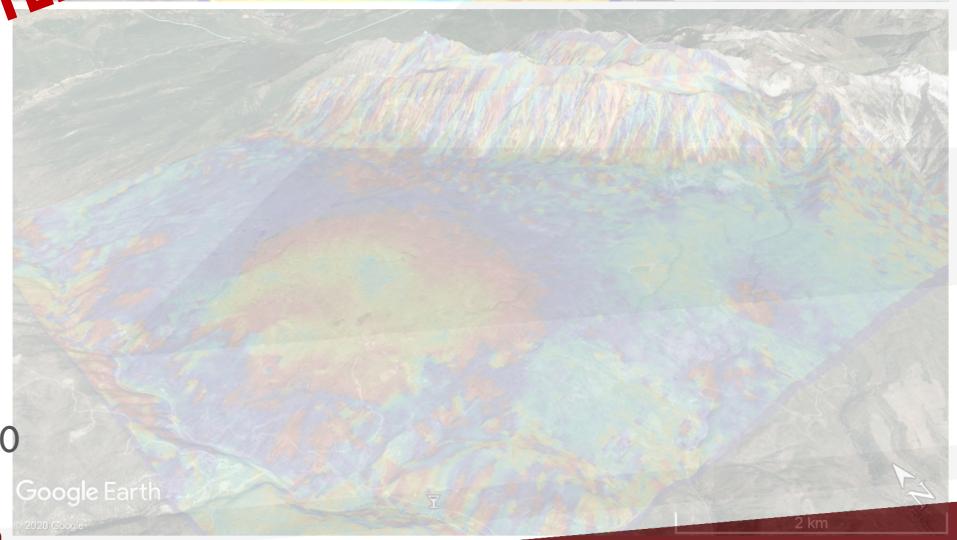
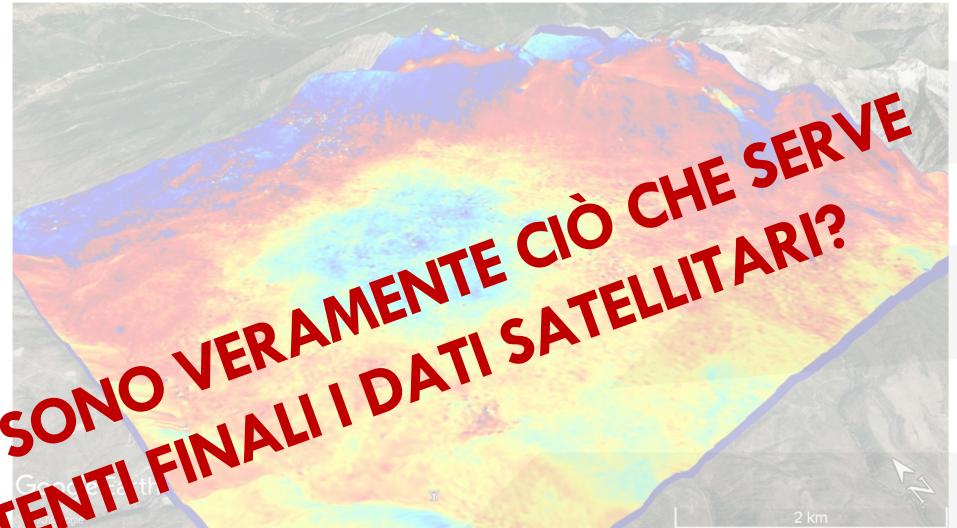
- Period: Sept 2019
- C Band
- Resolution: **5x20 m**



MA QUESTE MAPPE/PUNTI COLORATE/I SONO VEROAMENTE CIÒ CHE SERVE  
PER RENDERE OPERATIVI PER GLI UTENTI FINALI I DATI SATELLITARI?

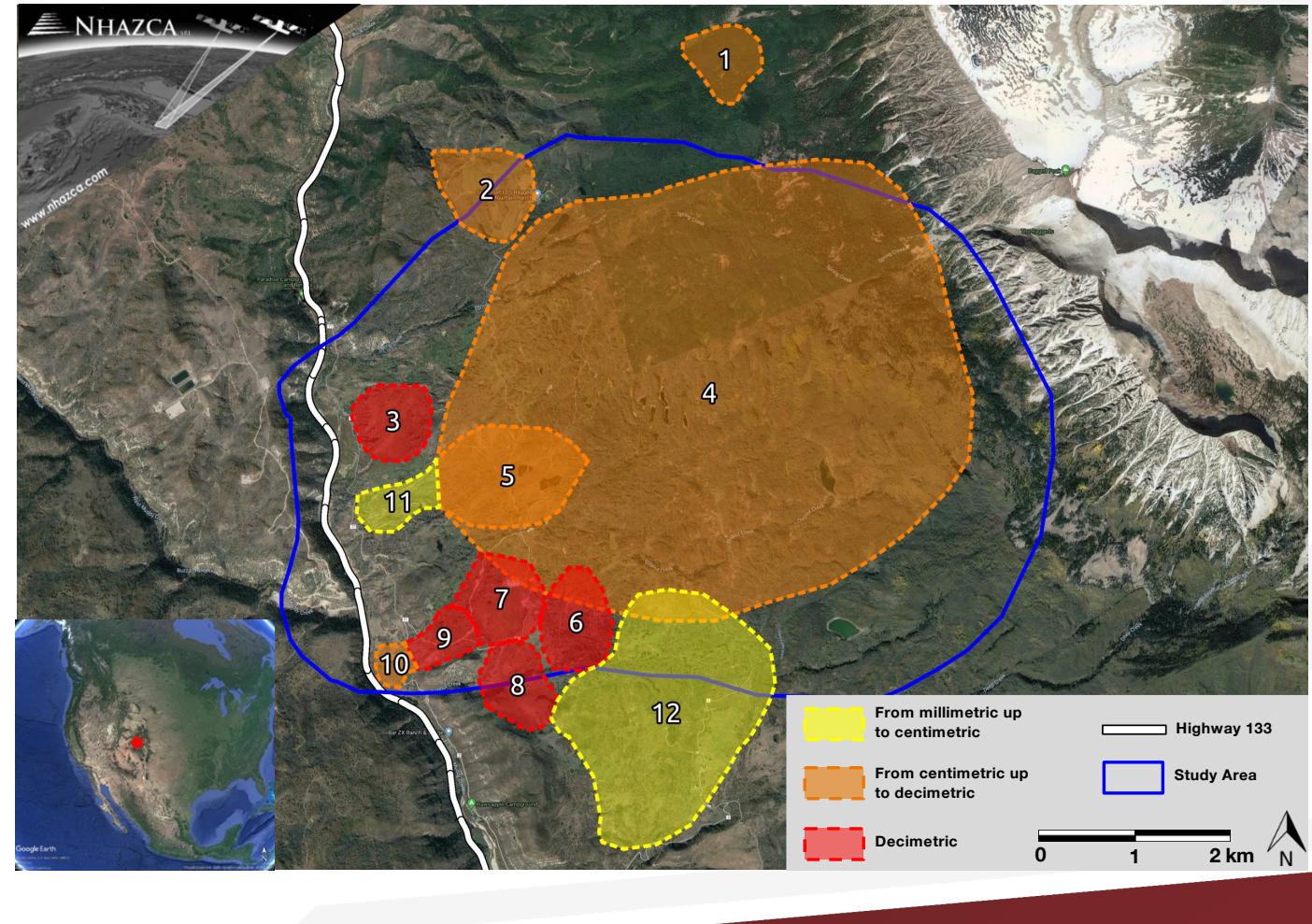
## ALOS-2

- Period: 2007 – 2010
- L Band
- Resolution: **10x10 m**

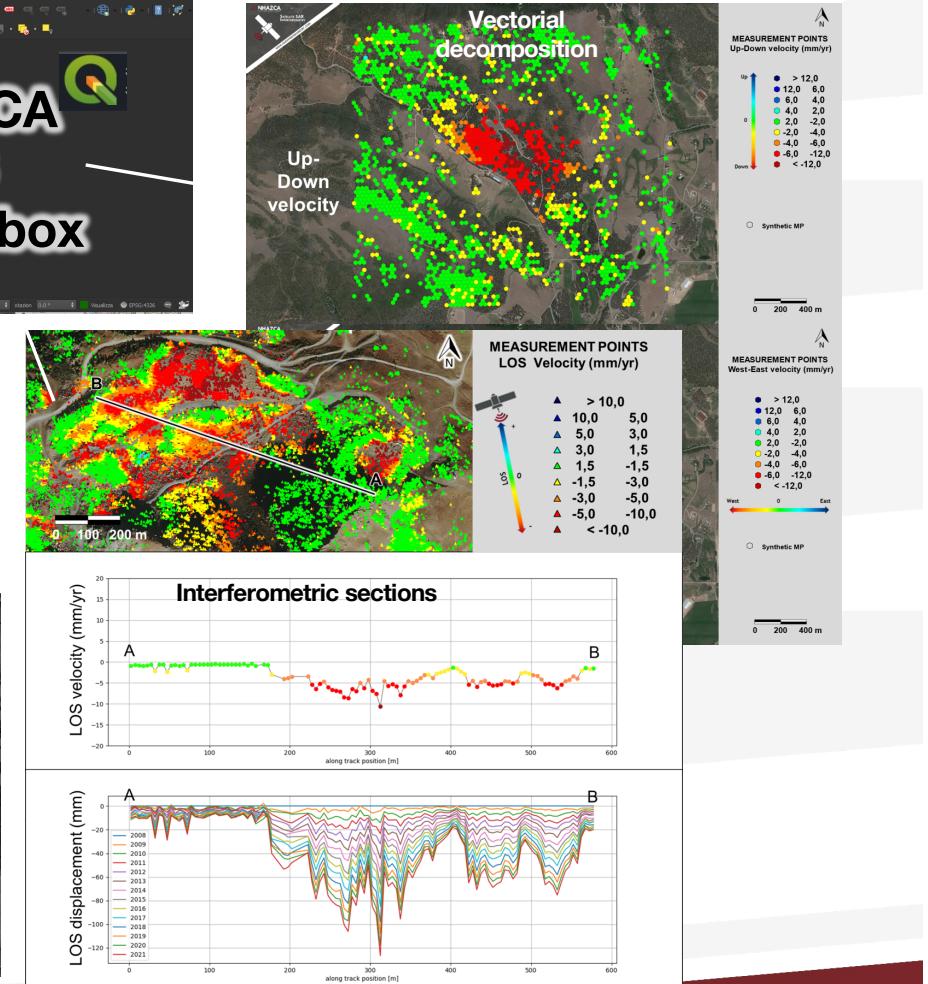
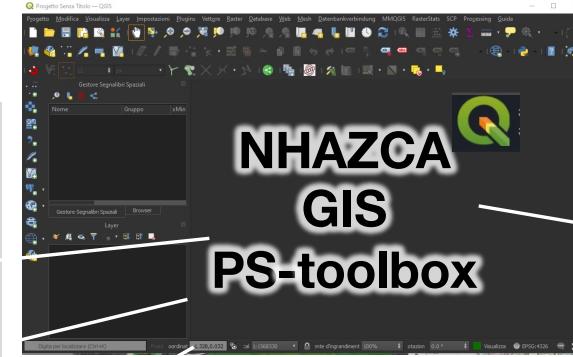
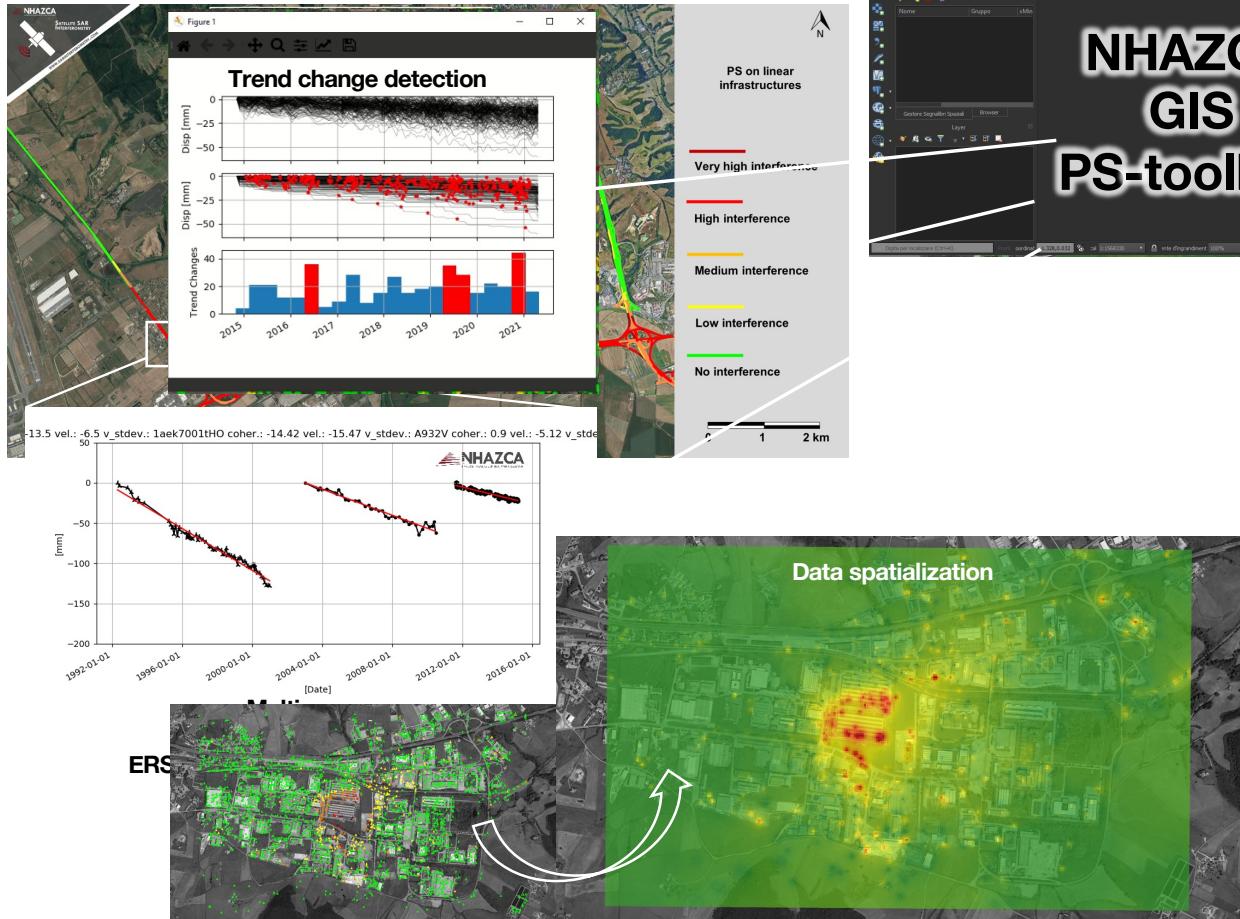


# MAGARI QUALCOSA DEL GENERE PUÒ ESSERE PIÙ UTILE?

## GROUND DEFORMATION MARKERS



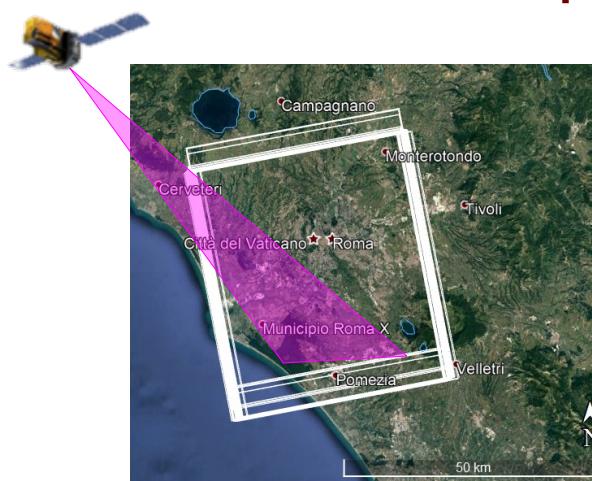
# INSAR PS TOOLBOX



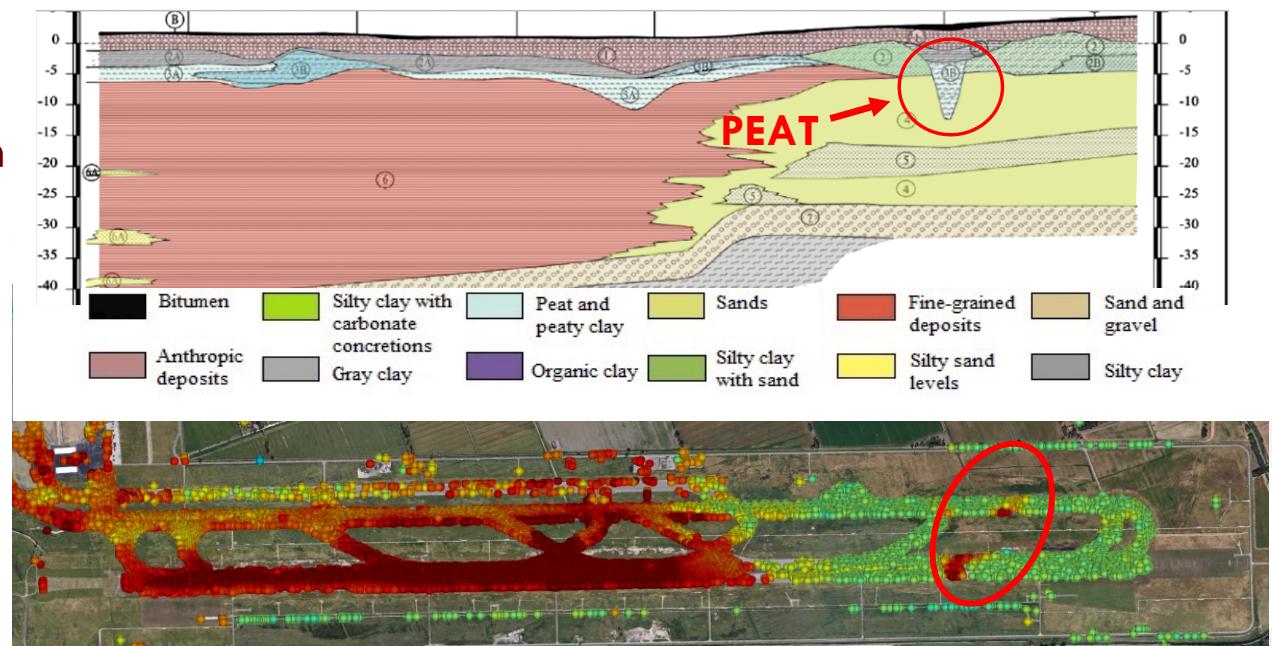
# CLASSIFICATION + INTERPRETATION = UNDERSTANDING & PREDICTION

## COSMO-SkyMed

- Period: Feb 2011 – Dec 2015
- X Band
- Resolution: **3x3 m**



## Data interpretation



# PREDICTION?

## Sentinel-1

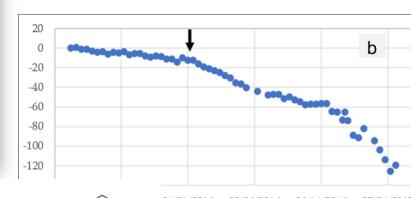
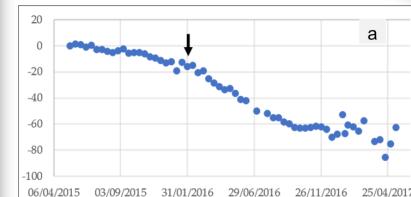
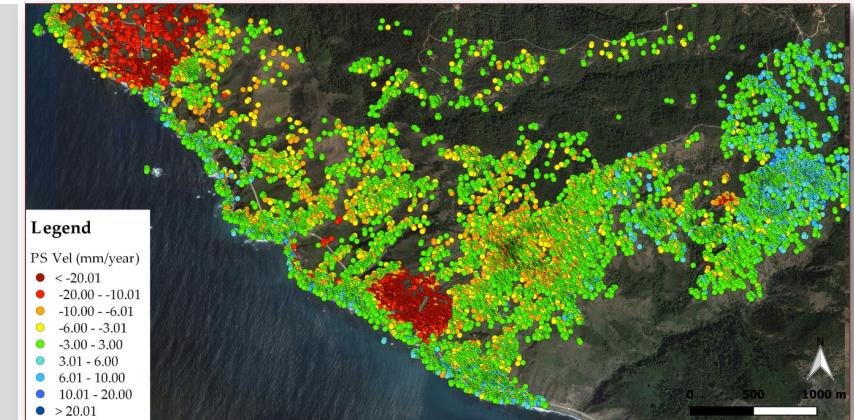
- Period: May 2015 – May 2017
- **C** Band
- Resolution: **5x20 m**



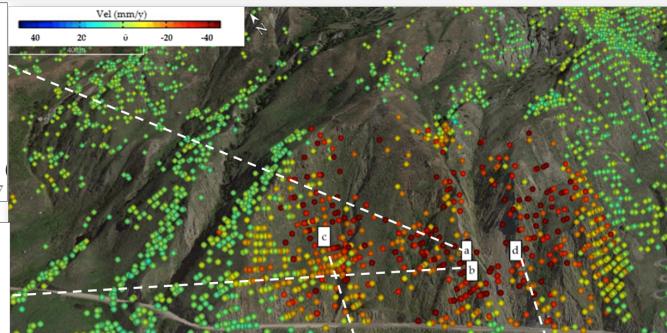
Measurement Points  
Velocity LOS (mm/anno)

▲ ● <-10,0
▲ ● -10,0 -7,0
▲ ○ -7,0 -4,0
▲ ○ -4,0 -2,5
▲ ○ -2,5 -1,5
▲ ○ -1,5 1,5
▲ ○ 1,5 2,5
▲ ○ 2,5 4,0
▲ ○ 4,0 7,0
▲ ○ 7,0 10,0
▲ ○ >10,0

△ Ascending  
○ Descending



31/01/2016 29/06/2016 26/11/2016 25/04/2017

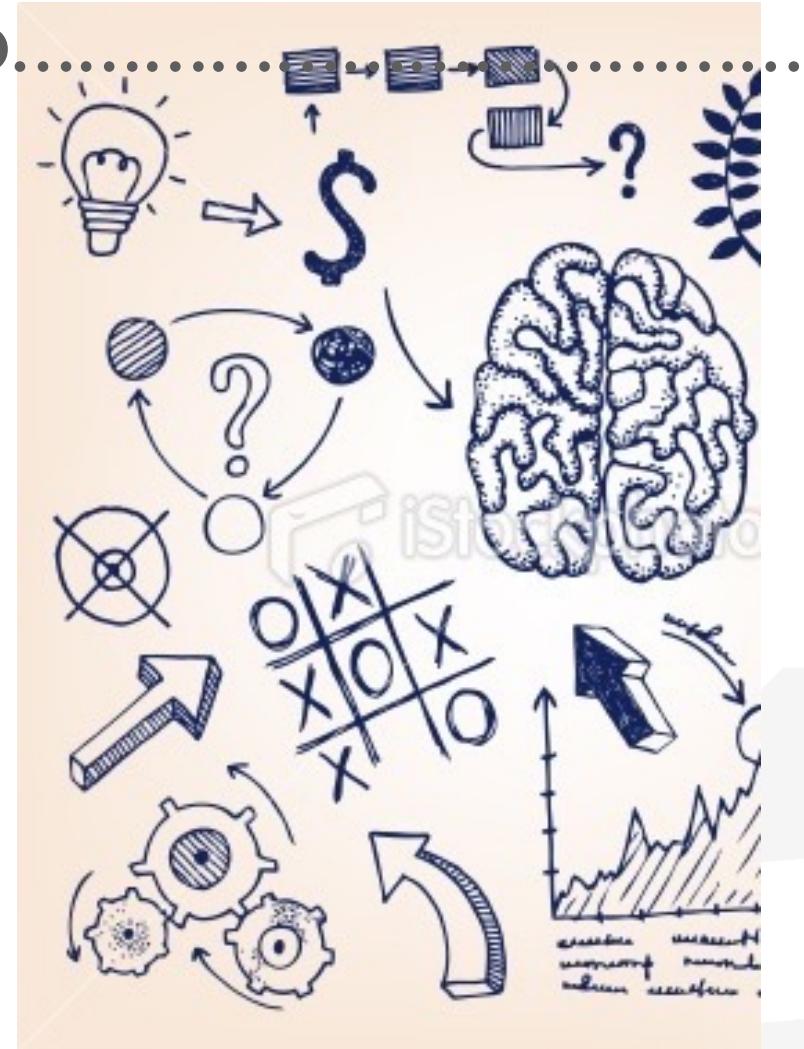


Article

## The Role of Satellite InSAR for Landslide Forecasting: Limitations and Openings

Serena Moretto <sup>1,2,\*</sup>, Francesca Bozzano <sup>1,2</sup> and Paolo Mazzanti <sup>1,2</sup>

## BRIDGING SCIENCE TO.....



# BRIDGING SCIENCE TO.....PRACTICE!

