InSAR-based operational procedure in the Tuscany Region (Italy)

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UNIVERSITÀ DEGLI STUDI FIRENZE
Dipartimento di Scienze della Terra
Eccellenza 2023-2027

Online Information Day

06/06/2025

Project co-funded by the European Union, Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO)

UCPM-2024-KAPP-PP - 101193210

University of Florence

What we do - activities & organization

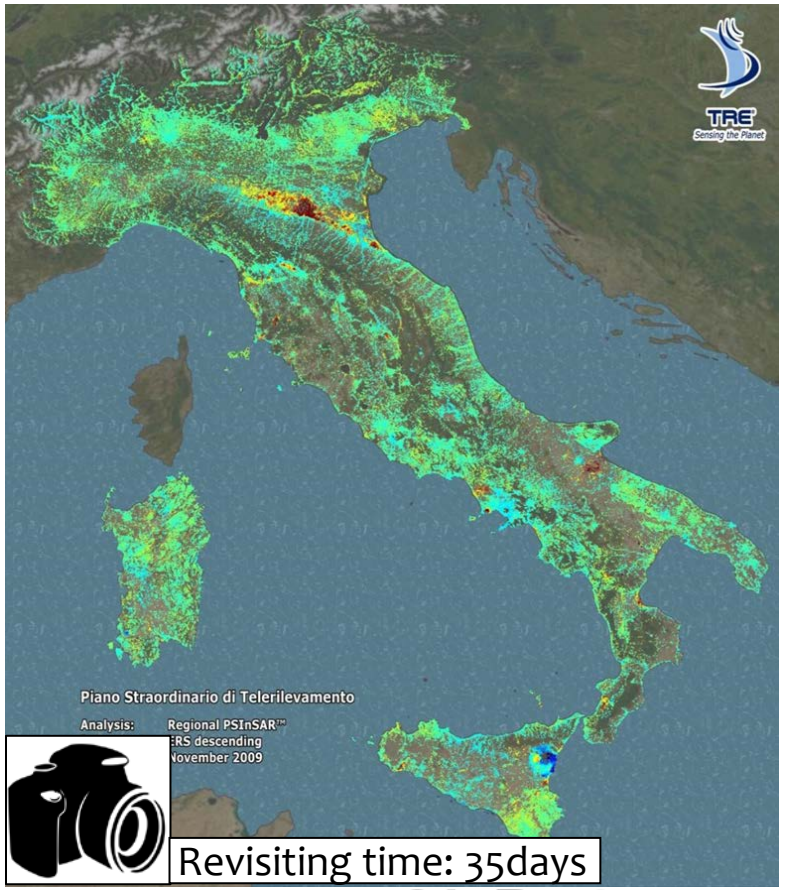
- Earth Sciences Department
- Italian Civil Protection Centre
- UNESCO Chair

  Prevention and Sustainable Management of Geo-Hydrological Hazards

Continuous PS streaming

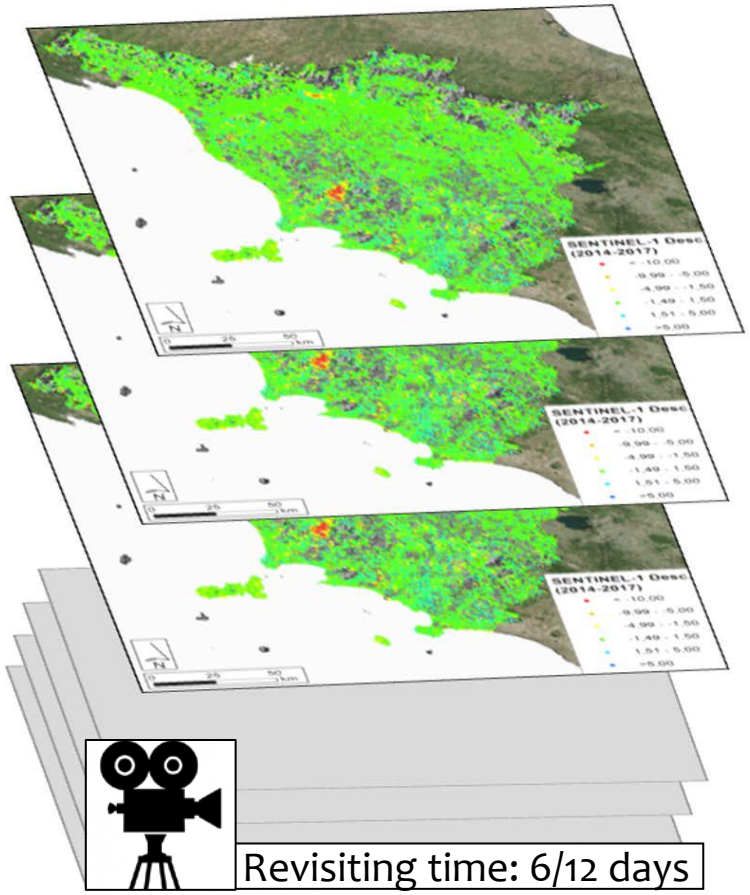
From a static historical satellite data analysis to a dynamic continuous monitoring

ERS1/2 & ENVISAT esa



Revisiting time: 35days

sentinel-1 esa



Revisiting time: 6/12 days

MTInSAR data operational uses

PS Mapping

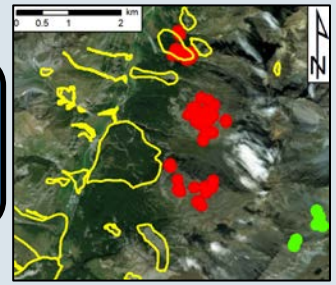
Processing of the historical image archive

Deformation maps

Velocity filtering

Hotspot mapping and elements at risk

Territorial planning and land management



PS Monitoring

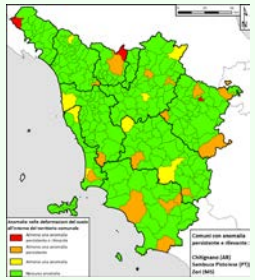
SAR processing every 2 Sentinel-1 acquisitions

Displacement Time Series analysis

Anomalies

Municipality classification

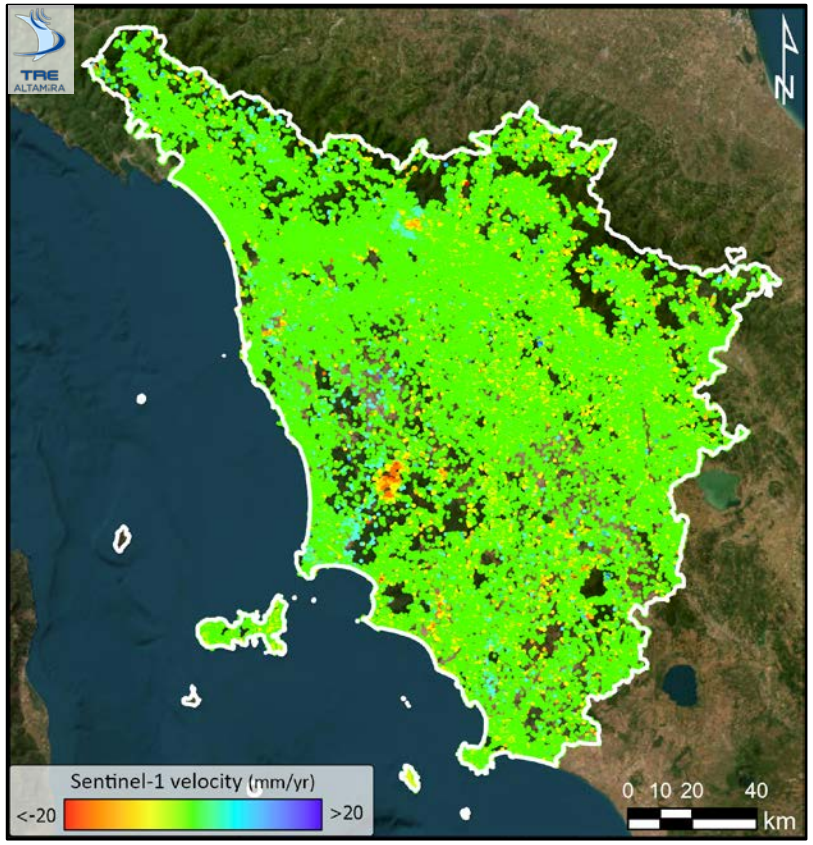
Periodic release of monitoring bulletins



PS Mapping - Spatial clustering

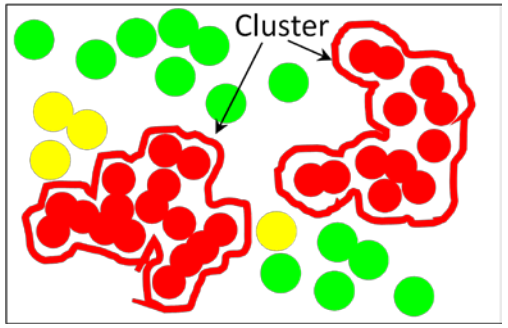
- **Wide area scanning** to spot active deformation zones

Deformation maps - Millions of points

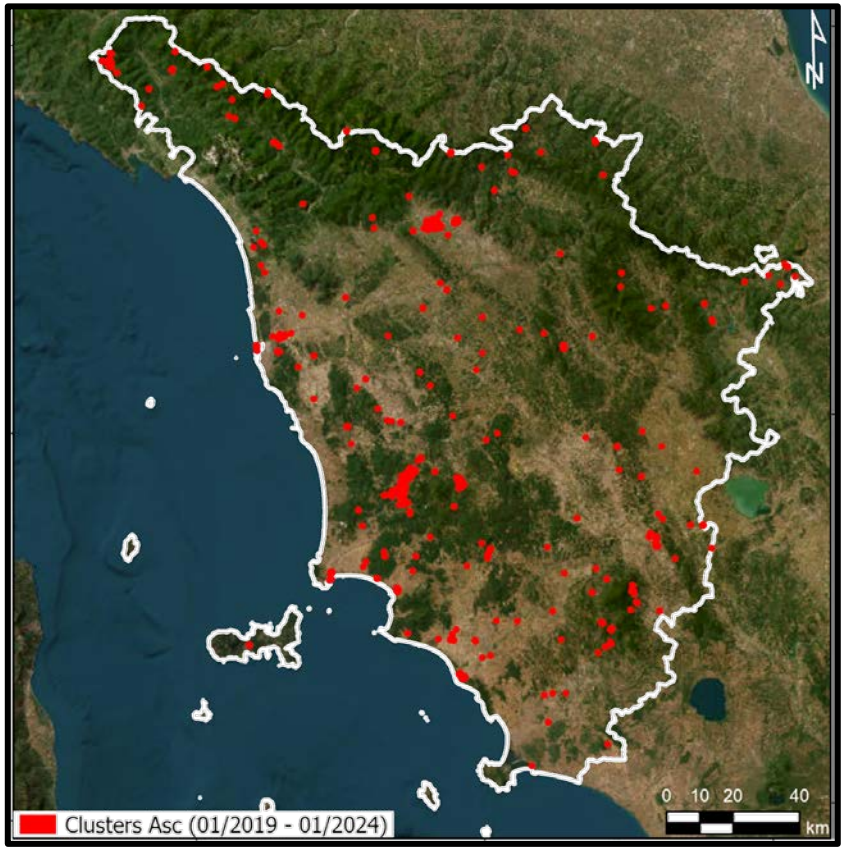


MAClustering

GIS tool
Spatial clustering of points with high velocity



High-moving areas - a few thousand points



PS Mapping - Risk assessment

Clusters classification

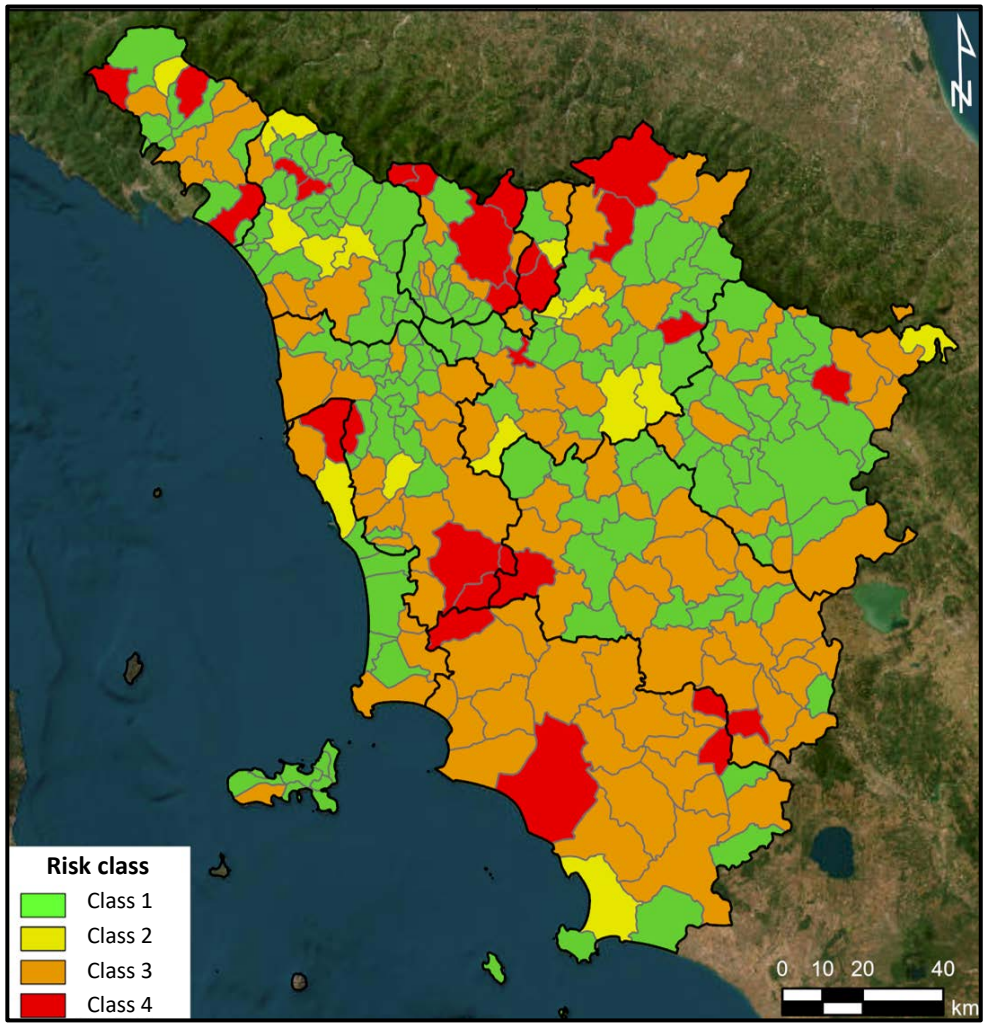
Deformation cause

Slope instability	Geothermal activity
Subsidence	Mining activity

Intersection with Elements at risk

1	No elements at risk within the active areas
2	Isolated elements at risk within the active areas
3	Distributed elements at risk within the active areas
4	Several elements at risks within the active areas

Municipalities classification

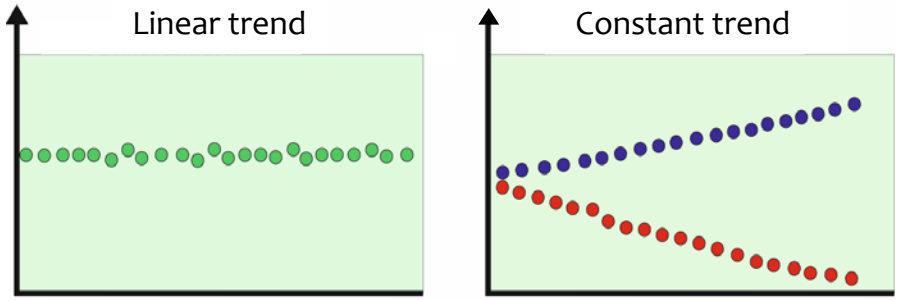


PS monitoring - Anomalies identification

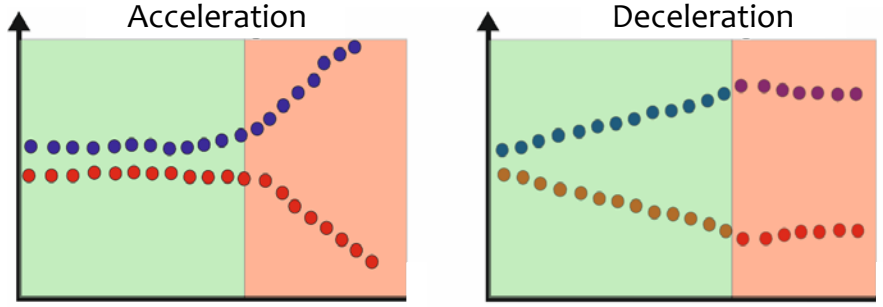
Tuscany region was the first one worldwide to implement in 2016 a **continuous regional-scale monitoring service** based on Sentinel-1 data

Screening of the displacement time series → Automatic identification of **anomalies of movements** - velocity variations greater than 10 mm/year in a time interval of 150 days

Not anomalous point

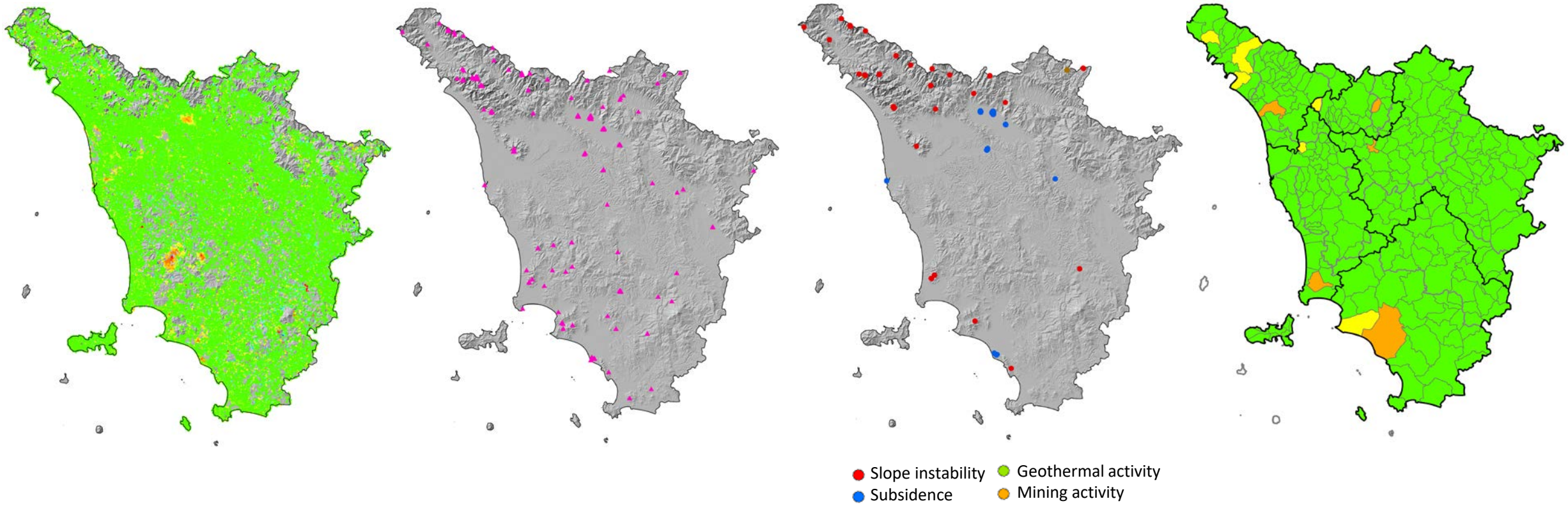


Anomalous point



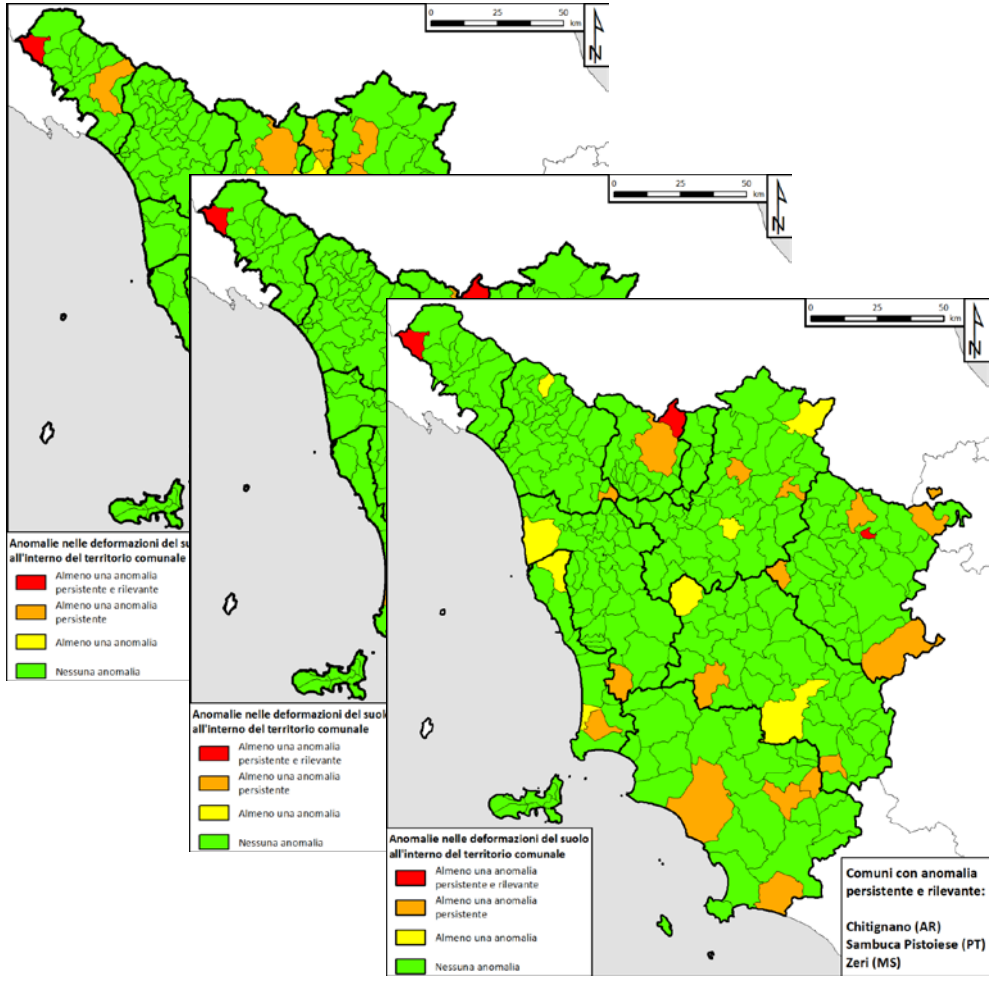
PS monitoring workflow

Sentinel-1 data → Anomalies of movement → Anomalies classification → Monthly bulletin



PS monitoring output

Monthly bulletin with municipalities classified based on the presence or absence of anomalies



Class	Description
1	No anomaly within the municipality
2	At least one anomaly within the municipality
3	At least one persistent anomaly within the municipality
4	At least one persistent and relevant anomaly within the municipality

Information on **persistent** and **relevant** anomalies

Recurring anomaly in the same area or surroundings across subsequent Sentinel-1 acquisitions.

Relevant anomaly which intersects elements at risk.

Operative procedures

ORDINARY PROCEDURE

Persistent and relevant anomalies

Release of monitoring bulletin

Within 10 days

Join field survey (UNIFI, Region, municipality)

URGENT PROCEDURE

Relevant and intense anomalies ($\Delta V > 150$ mm/yr)

Immediate report to Regional Authorities

Within 72 hours

Join field survey (UNIFI, Region, municipality, Civil Protection)

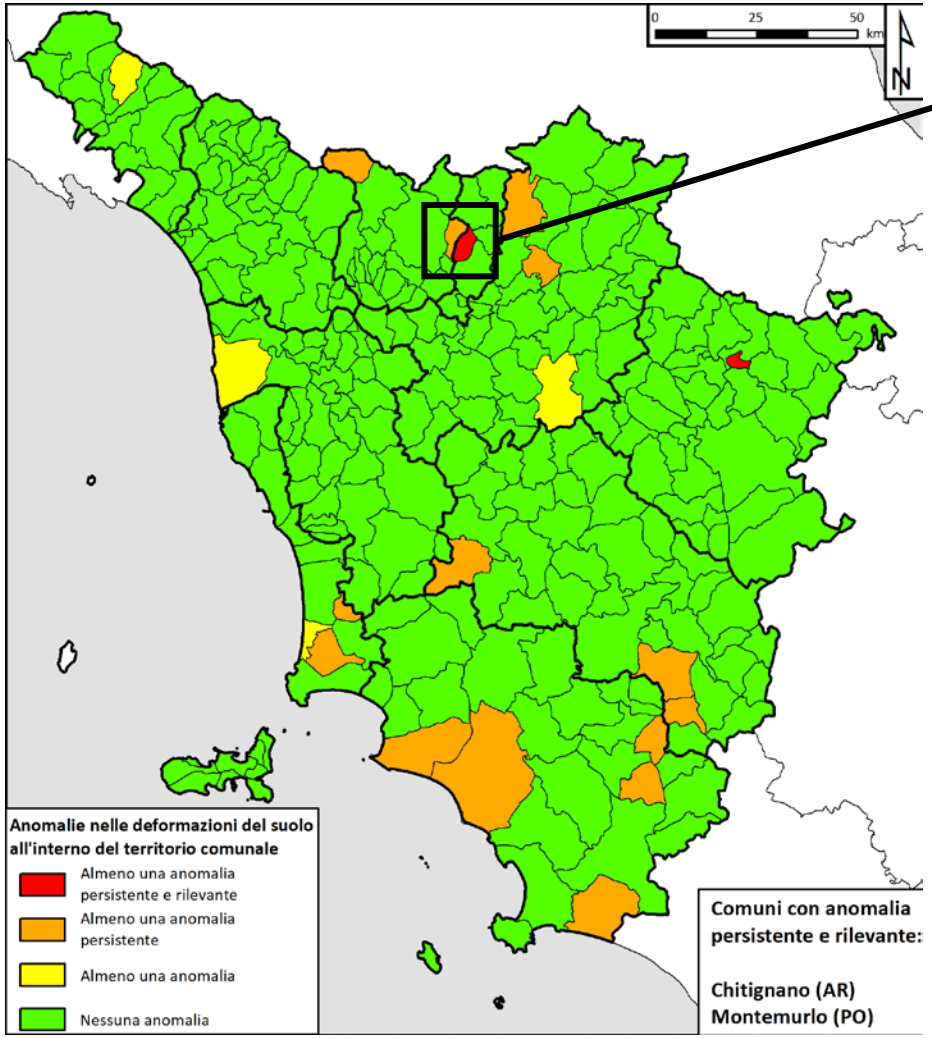
Preparation of the report and the field survey scheme:
- Risk assessment
- Suggested actions

Delivery of the documentation to the involved municipality

Municipality is committed to take actions and to follow suggestions. Actions funded by the Tuscany Region (DODS document)

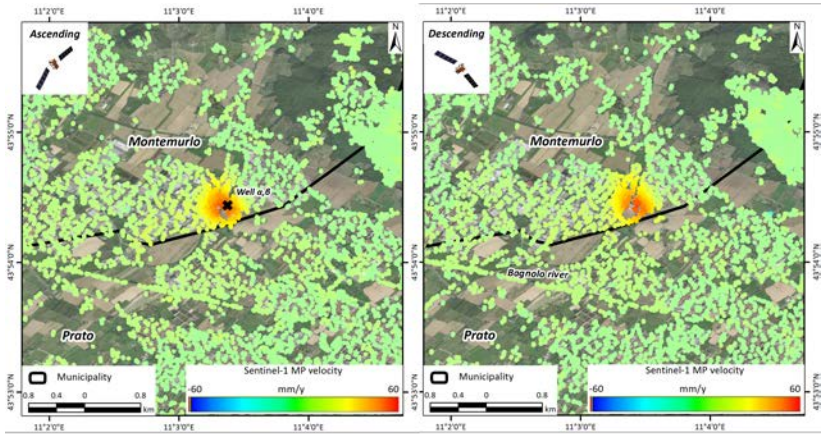
Municipality adopts immediate countermeasures, when necessary, including interdiction

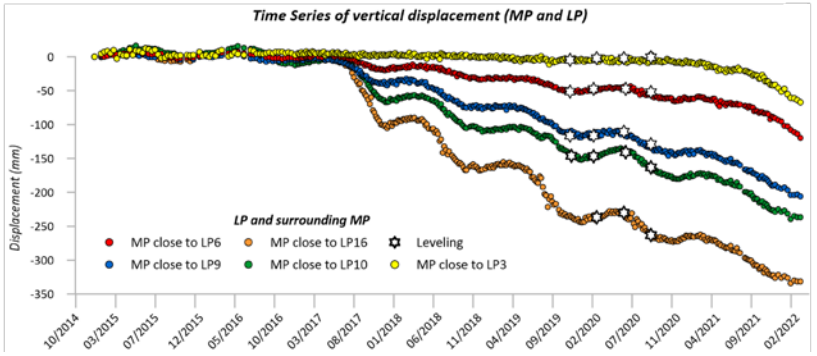
Operational example

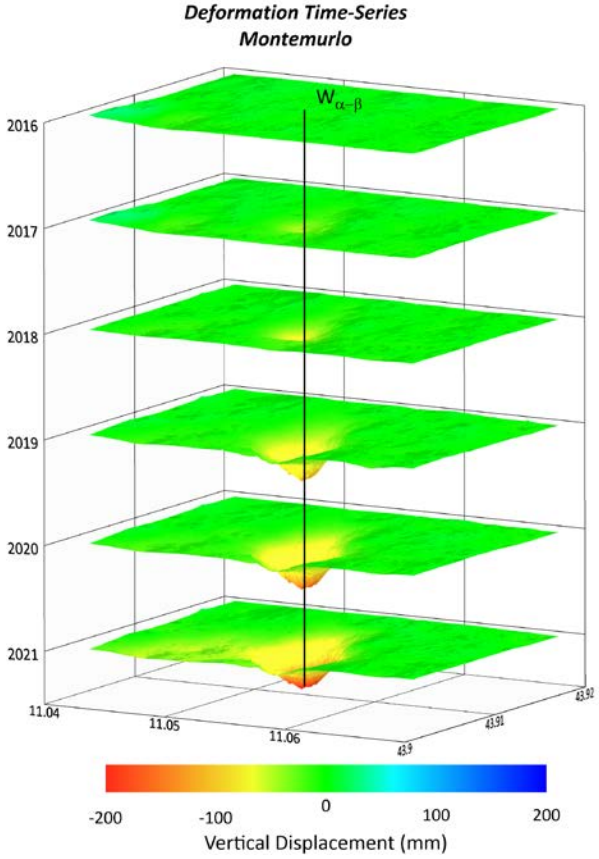


Acceleration recorded in the **Montemurlo** municipality (Prato province) since 2017

- Detailed Sentinel-1 data analysis





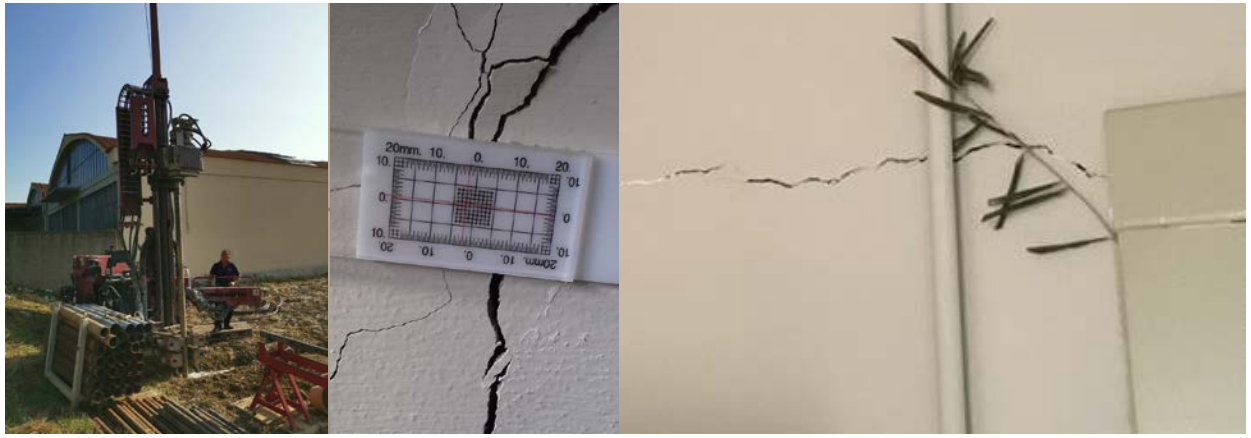


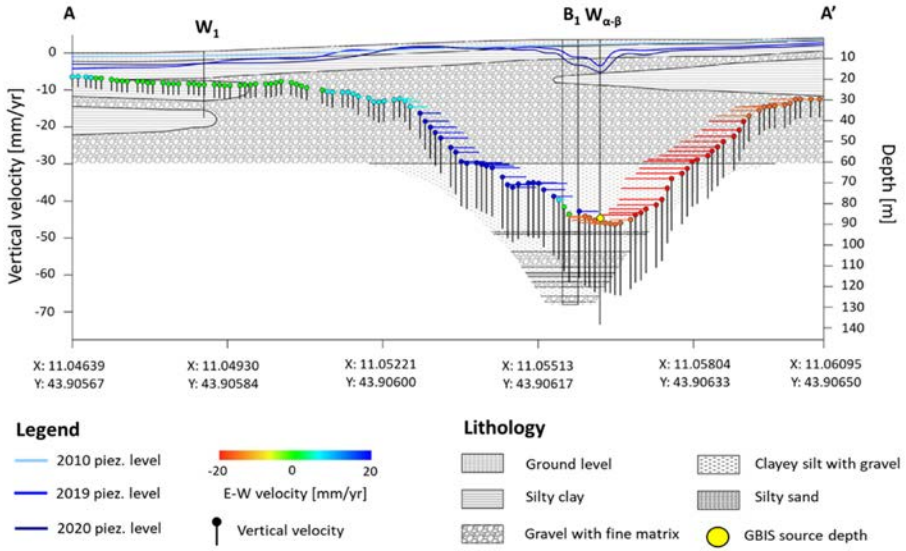
Operational example

- Further investigations
  - Building damage assessment
  - Water pumping rates
  - Settlement gauge
  - Topographic levelling
  - Corner reflector
  - Hydrogeological modelling

The integration of multiplatform monitoring data allows the characterisation of an **overexploitation induced subsidence**

→ **Mitigation measures**





Summary

InSAR data for mapping and monitoring ground deformations

Mapping

- Detection of active deformation areas
- Spatial clustering of high-velocity points
- Support for ground movement risk assessment

Monitoring

- Continuous operational service
- Automatic detection of anomalies of movement
- Regular bulletins to inform the in-charge authorities

Advantages of InSAR data

- Systematic, wide-area, and frequent coverage (6–12 days revisiting time)
- High precision and continuous updates
- Integration with in-situ investigations for validation and mitigation

InSAR data are a key tool for preventing, managing, and mitigating geohazards. They enables reliable, timely, and large-scale monitoring and mapping, essential to support decision-making and prioritise targeted interventions in high-risk areas.

Thank you for your attention !

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