



## D7.4 DEMONSTRATION TO THE END USERS OF THE INTEGRATED GEOPHYSICAL AND AIRBORNE NETWORKING CAPABILITIES AT THE PILOT SITES



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Reviewed by:	ITINERIS Executive Board
Note:	Report on the meeting "Urban geophysics: a new ground-airborne geophysical instrumental facility" and demonstration activities to end-users including the list of participants, presentations and report on the main outcomes

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## 1. INTRODUCTION

This deliverable aims to document the activities, outcomes, and stakeholder engagement during the demonstration event titled "Urban Geophysics: A New Ground-Airborne Geophysical Instrumental Facility" held as part of ITINERIS WP7 - GEOSPHERE-LANDSURFACE (see the event poster in ANNEX 1). This deliverable contributes directly to Milestone IO7.7 (demonstrations on the pilot sites) and supports the Deliverable D7.4 - Demonstration to the end-users of the integrated geophysical and airborne networking capabilities at the pilot sites.

The ITINERIS project aims to build a cutting-edge national infrastructure for environmental monitoring. Deliverable 7.4 is part of Activities 7.4 and 7.5, which focuses on networking the ground-airborne instrumental facilities purchased by CNR-IMAA and CNR-IREA for subsoil and land surface monitoring.

The event was held on Friday, June 13, 2025, from 9:00am to 3:00pm at the Conference Hall of the Potenza CNR Research Area (Tito Scalo). Technical and scientific presentations alternated with two discussion sessions that involved local stakeholders, policymakers, researchers, and private sector representatives. This was followed by field demonstrations showcasing ground and airborne geophysical surveys.

The event followed the ITINERIS WP3.6 training course held from June 9-12, 2025 "Geophysical instruments and data processing" tailored for the ITINERIS research infrastructures personnel.

The event provided a successful demonstration of the effectiveness of the integrated geophysical-airborne approach for near-surface and land surface monitoring. This conclusion was based on discussions with potential end-users, including the general public, institutional stakeholders, small, medium, and large enterprises, professional organisations, and the scientific community.

In conclusion, the project enhanced collaboration between scientific institutions and relevant stakeholders while facilitating the collection of constructive feedback to inform future developments.

## 2. AGENDA

The agenda of the meeting included:

- the opening with institutional welcome addresses;
- scientific presentations on topics such as near-surface geophysics, seismic risk in urban areas, hydrogeological risk monitoring, geophysical surveys using drones and airborne sensors, GPR, and fibre optics;
- two discussion panels: role of geophysics in urban risk mitigation and public-private collaboration in applied geophysics.
- live demonstrations of advanced instruments and field tests (e.g., drones, fibre sensors, SAR, GPR, seismic nodes, deep electrical resistivity system);
- conclusion by regional representatives followed by a networking lunch.

The detailed agenda is included in ANNEX 2.

### 3. PARTICIPANTS

The Meeting agenda and the registration form for the face-to-face participation have been published into the ITINERIS project website at the following link: <https://itineris.cnr.it/news/urban-geophysics-a-new-ground-airborne-geophysical-instrumental-facility/>.

To allow wider participation and to handle the requests of several users unable to participate in person, the meeting was also accessible from remote using the online meeting tools by Microsoft TEAMS. The meeting was recorded using TEAMS, furthermore RAI3 Basilicata produced a news report broadcast on June 13 at 2:00 p.m.

A good participation was registered with more than 60 people attending the meeting in person (figure 1), while the TEAMS recorded peaks of 22 connected users during the event. The names and affiliations of the participants (in presence) are reported in ANNEX 3.

The Councillor for the Environment & Energy of the Basilicata region, Laura Mongiello, and the Mayor of Tito, Fabio Laurino, were invited for the Institutional welcomes during the opening ceremony. Immediately afterwards, Prof. Oriol Nel·lo from Autonomous University of Barcelona and from the Cartographic and Geological Institute of Catalonia spoke, discussed the importance of urban planning in a context of climate change, recurring extreme events, and increasing anthropogenic pressure. Prof. Oriol Nel·lo was the head of an international delegation hosted by Basilicata region to share the best practice in urban planning. Considering the topic of the workshop, a short communication of Prof. Oriolo Nel lo was included in the program (figure 2).



*Figure 1 – Conference Room at CNR-IMAA: attendees at the workshop.*



*Figure 2 – Institutional welcomes at the workshop.*

## 4. SCIENTIFIC PRESENTATIONS

The main information illustrated by the speakers and the conclusions formalized during the meeting are reported in the following sub-chapters.

### 4.1 Introductory presentations

Introductory talks (figure 3) were given by WP2 leader Dr. Carmela Cornacchia (CNR-IMAA), also participating in representation of ITINERIS project leader Dr. Gelsomina Pappalardo, and WP7 leader Dr. Giuliana Rossi (OGS), connected remotely (ANNEX 4).

The presentation titled "The ITINERIS Project and RI's Potential Socio-Economic Impact on Territories" by Carmela Cornacchia (CNR-IMAA) offers a detailed overview of the ITINERIS project, highlighting its objectives, structure, and the broader impacts of research infrastructures (RIs) in Italy.

ITINERIS, short for the Italian Integrated Environmental Research Infrastructures System, is a project funded under the EU Next Generation EU – PNRR initiative, specifically within Mission 4 "Education and Research". Its primary aim is to establish a coordinated and integrated national system of environmental research infrastructures that address key domains such as the atmosphere, marine environments, terrestrial biosphere, and geosphere.

The project began in November 2022 and will run for 36 months. It is coordinated by Gelsomina Pappalardo and managed by Giuseppe Gargano, both affiliated with the National Research Council (CNR). ITINERIS brings together 22 research infrastructures across Italy, united by the goal of responding to urgent environmental challenges. These include issues such as pollution, land use changes, and climate change, which require an integrated, cross-disciplinary approach to generate actionable scientific knowledge.

Within this context, research infrastructures are defined as essential facilities and services that enable scientists to carry out high-quality research and promote innovation. The project emphasizes the importance of open access to data and services, as well as adherence to FAIR principles, which ensure that data is findable, accessible, interoperable, and reusable.

Central to the ITINERIS initiative is the development of the ITINERIS HUB, a centralized platform that offers seamless access to the resources of Italian environmental RIs. This includes over 500,000 environmental datasets, metadata catalogues, advanced analytical tools, and technology transfer services. The HUB is designed to enhance user experience, simplify access to distributed data and tools, and support both scientific research and policy-making.

The project also supports Virtual Research Environments (VREs), which are digital platforms that integrate data, computational tools, and models across different scientific disciplines. These environments allow researchers, policymakers, and stakeholders to collaborate on complex environmental problems using shared resources. Thematic VREs address topics such as climate indicators, aerosol-biosphere interactions, aquatic biomass, crop and pest monitoring, carbon cycle dynamics, and critical zone processes.

To further support its mission, ITINERIS has established a dedicated training centre offering courses, workshops, and educational programs. These resources aim to build capacity among researchers, technicians, and stakeholders, enabling them to make effective use of the project's tools and data.

In terms of outcomes, ITINERIS seeks to generate value beyond the scientific domain. This includes influencing public policy, as demonstrated by the integration of ACTRIS data and recommendations into the new European Air Quality Directive (EU Directive 2024/2881). The project also fosters innovation through partnerships with industry leaders like Arista Networks and contributes to social inclusion by involving young students in scientific outreach activities, particularly those from underprivileged backgrounds.

Overall, the presentation portrays ITINERIS as a strategic national initiative that aligns with European environmental priorities. It aims to create an integrated and accessible research ecosystem capable of driving innovation, informing policy, and delivering meaningful benefits to society.

The presentation titled "*The activities in the sector Geosphere-Landsurface*", delivered by Giuliana Rossi (OGS) focuses on the activities and objectives of Work Package 7 (WP7) within the ITINERIS project. This work package addresses the geosphere and land surface and aims to provide high-quality, multidisciplinary digital datasets that are openly accessible for scientific, public, and decision-making use.

WP7 integrates the capabilities and data of major research infrastructures, including SMINO, ATLaS, ECORD-ICDP, and EUFAR. These are tested across three pilot areas: the Friuli Venezia Giulia region and the towns of Tito and Potenza in the Basilicata region. The overall goal is to enhance environmental observation and monitoring of the geosphere and land surface using advanced ground-based and airborne technologies.

The scientific objectives of WP7 include harmonizing data according to international standards, ensuring that all data produced or shared meet the FAIR principles (Findable, Accessible, Interoperable, and Reusable). Other objectives involve focusing on deep earth drilling, integrating data from various sources to study near-surface processes, and improving multi-parameter observations through spaceborne and airborne infrastructures.

The activities undertaken in WP7 include improving access to existing infrastructures like ECORD, ICDP, and IODP by facilitating data sharing on boreholes, geophysical and geochemical parameters, and stratigraphic and lithologic characteristics. Additional efforts are directed at upgrading ground-airborne exploration tools and integrating platforms that monitor surface movements and subsurface processes. This includes setting up facilities to access observations from SMINO, ATLaS, and EUFAR.

Several institutions are involved in these activities, such as OGS's seismological and geophysical divisions, CNR institutes (ISMAR, IMAA, IREA), INGV, and the University of Florence's Civil Protection Centre. Each of these plays a role in collecting, analysing, and disseminating the data.

The expected results of WP7 include the release of both existing and new terrestrial, airborne, and drilling datasets. It also entails the development and deployment of state-of-the-art equipment for scientific drilling and geophysical exploration. Notably, WP7 aims to transform EUFAR's capabilities for crustal studies, enhance ATLaS's use in landslide monitoring, and improve SMINO's capacity by integrating a MEDA Buoy, new fibre optic cables, and a sensor calibration centre.

The pilot sites are envisioned as open laboratories for urban geophysics, where innovative technologies such as Distributed Acoustic Sensing (DAS) can be demonstrated to both stakeholders and the public. WP7 also supports capacity-building by recruiting new researchers and technologists and offering PhD fellowships.

Looking forward, the presentation emphasizes the importance of sustaining and expanding these research infrastructures and human resources. It underscores the need to maintain the ITINERIS WP7 community and reinforce national and international collaborations. Long-term impact will be measured through various performance indicators, such as access rates to infrastructures, scientific outputs, and the number of Italian researchers involved in international drilling programs.

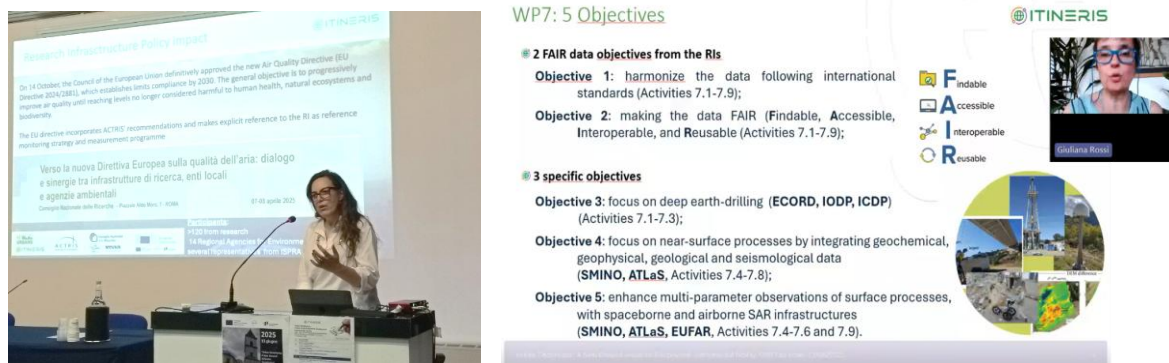


Figure 3 – Introductory talks to the workshop.

## 4.2 Scientific reports

Talks were given by CNR-IMAA and CNR-IREA researchers directly involved into ITINERIS project and in the use of the new geophysical instrumental facility (ANNEX 5). The involvement of young researchers and doctoral students in the various research activities presented at the meeting should be emphasised. All the contributions provided a comprehensive overview of the advancements in near-surface geophysics developed and applied under the ITINERIS infrastructure, focusing on urban and peri-urban environments (figure 4). Furthermore, presentations explored the contributions of these geophysical systems to national research projects (e.g., PRIN initiatives) and their role in supporting civil protection, particularly in microzonation of the Campi Flegrei area and monitoring volcanic activity on Stromboli. These activities certified that the Research Infrastructures can give relevant contributions to better support institutional organizations involved in the programs for mitigating natural risks.

The presentation underscores how the deployment of innovative geophysical methods can inform planning, risk mitigation, and sustainable management in urban settings. These methods are further enhanced through data fusion and machine learning approaches aimed at improving imaging quality and interpretation accuracy. Overall, the slides demonstrate how urban geophysics, enabled by the ITINERIS infrastructure, serves as a critical tool for addressing complex challenges in urban planning, risk mitigation, and environmental monitoring.

In detail, scientific reports were divided into sections. The first section described results from Activity 7.4 and introduced the strategic enhancement of near-surface geophysical techniques, emphasizing their relevance for urban resilience and sustainability (figure 5). They highlight the importance of multidisciplinary approaches combining ground-based geophysical sensors for seismic risk assessment and hydrogeological hazard evaluation (figure 6).



Figure 4 – Scientific talks by CNR IMAA and CNR IREA researchers.

Potenziamento delle attività di «near-surface geophysics» ITINERIS

Instrumental facility



New electrical resistivity tomography system

- Different spatial e temporal resolution by using 2D and 3D tomographic methods,
- investigation depth (from 0-1 m up to 1-10 km depth time-lapse acquisition,
- ML data analysis techniques



Airborne Hyperspectral Imaging Systems (VNIR-SWIR)

- Continuous spectral coverage from 400nm to 2500nm
- Spatial resolution of about 30/40 cm in the VNIR and about 1m in the SWIR

Seismic data from new seismic sensors and fiber optic interrogator

- Nodal systems consisting into velocimeter and accelerometers,
- iDAS interrogator for passive and active seismic surveys, and critical infrastructure monitoring
- ML data analysis techniques



New GB-SAR and GB-RAR

- monitoring surface deformation
- studying the static and dynamic behavior of strategic infrastructure
- Spatial resolution of at least 0.75 m



Figure 5 – New ITINERIS geophysical instrumental facility of CNR IMAA.

Acquisition test at the Tito CNR Research Area ITINERIS

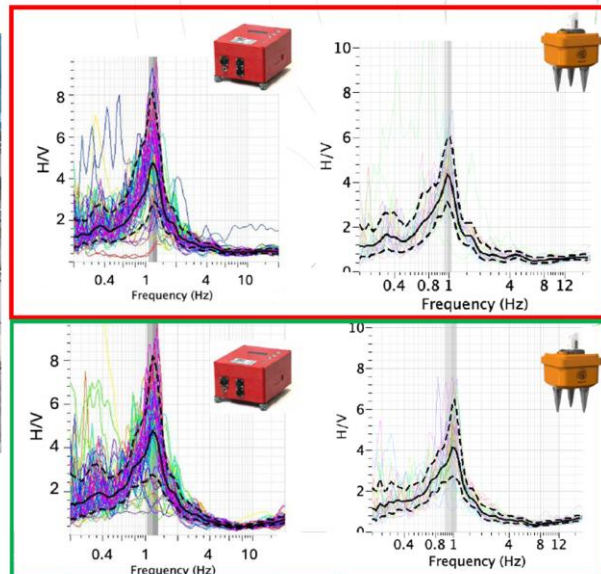


Figure 6 – Test of nodal seismic sensors for ambient noise acquisition at CNR research area Tito pilot site in Basilicata region.

In detail, two presentations by Dr. Angela Perrone and Ing. Giovanni Gangone showcased the activities carried out at the ITINERIS pilot sites Potenza and Tito, Basilicata. The first presentation was focused on the Carlone landslide in Tito, a peri-urban area affected by a slow-moving landslide served as an open-air laboratory for integrating geophysical and hydrological monitoring systems. Surveys included geological and geoelectrical characterizations of the subsurface, as well as the installation of sensors to monitor slope deformation and groundwater dynamics. The aim was to develop a long-term geophysical observatory capable of tracking the evolution of hydrogeological instability in real time (figure 7).

### 3D electrical resistivity model

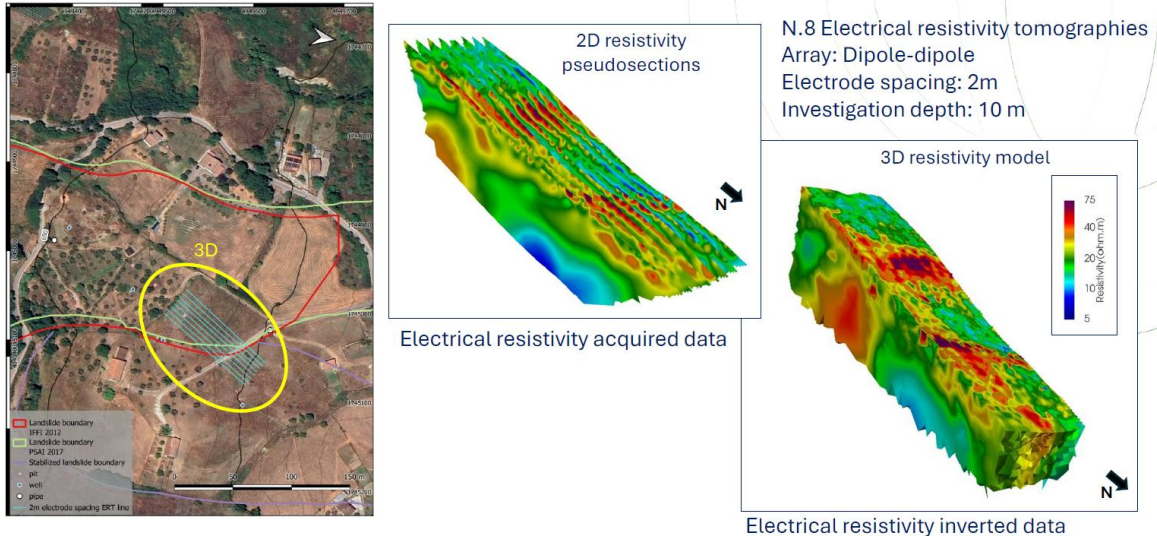


Figure 7 – ERTs for the characterization of Carlone landslides at Tito pilot site in Basilicata region.

The second one highlighted seismic risk assessment in Potenza where a citywide campaign was carried out using microtremor measurements, the results of which were processed to generate frequency maps of both soils and buildings. This analysis allowed researchers to identify zones where resonance effects could amplify seismic risk, providing a useful tool for civil protection and urban planning (figure 8).

### Map of Soil-Building Resonance

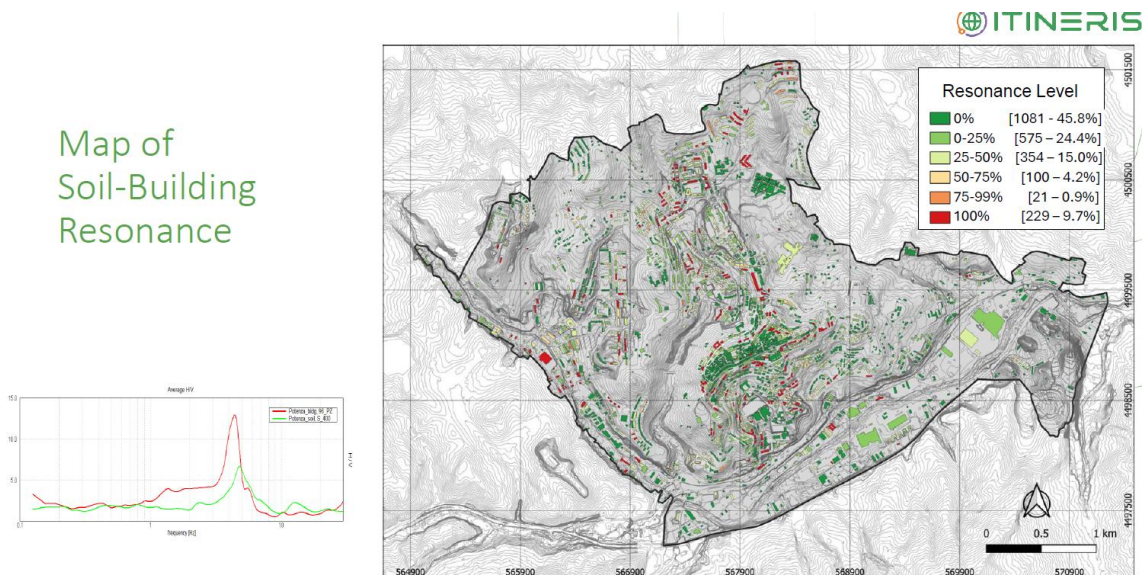


Figure 8 – Soil-building resonance map for the Potenza city in Basilicata region.

The second section, presenting the results of Activity 7.5, illustrates the deployment of advanced instrumentation through UAV-based geophysical techniques, including drone-mounted GPR and magnetometers, and airborne systems (SAR, hyperspectral) for geophysical monitoring in complex urban and natural environments where accessibility is limited (figure 9).

## GROUND- and UAV- BASED INSTRUMENTATIONS

### INFRASTRUCTURE DEVICES

proximal and on-site instruments for data acquisition



**Magnetometer:** system for the total magnetic field and its vertical gradient measurement equipped with 2 QuSpin Gen-2 sensors, which guarantee data acquisition with 200 – 1000 Hz sampling rate and 0.003 nT sensitivity.



**Zond Aero LF:** drone based ultralight ground penetrating radar system equipped with 3 unshielded dipole antennas working at 3 different central frequencies: 100, 150, 300 MHz.



**Geoscope MkIV equipped with the array ground coupled G0908:** multi-channel multi-frequency ground penetrating radar (GPR) for high-density 3D data capturing. Thanks to the step-frequency technology, the system enables optimal penetration and highest resolution simultaneously by sweeping through a wide frequency range (40 MHz – 3GHz) with only one single antenna array.



**OBR 4600 Optical Backscatter Reflectometer:** device for fiber optic distributed strain and temperature sensing, which is able to measure strain and temperature over 2 km distance range with no dead zone, with high spatial resolution (few mm) and high speed (3Hz).

Figure 9 – New ITINERIS geophysical instrumental facility of CNR IREA.

Overall, the presentations emphasized the critical role of UAV and airborne sensors in detecting and analysing both anthropogenic and natural hazards, enhancing the geophysical monitoring capacity for urban resilience, environmental monitoring and disaster risk management (figures 10, 11).

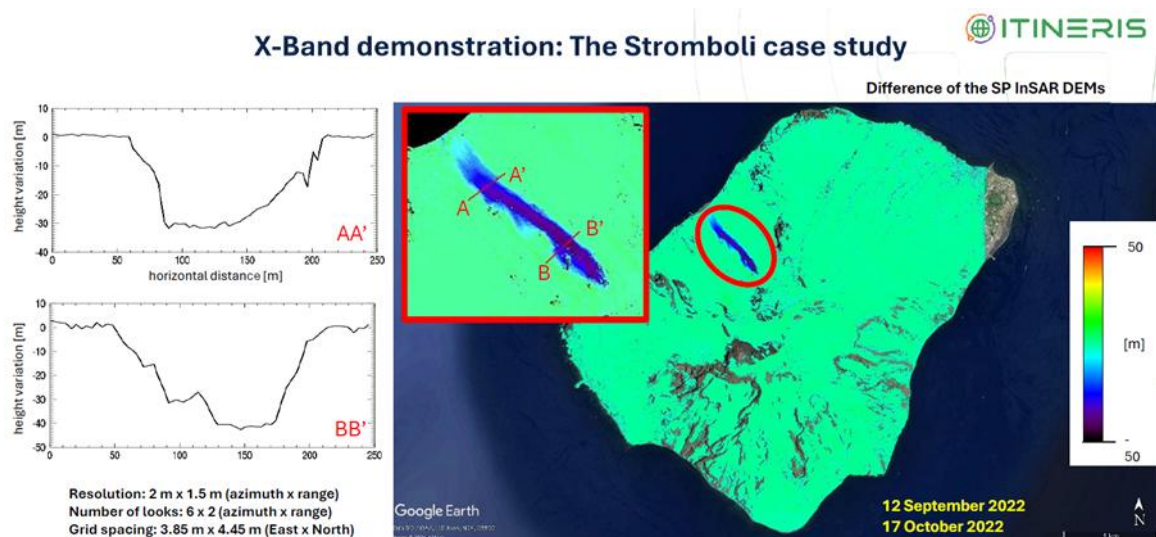


Figure 10 – Results of airborne SAR survey at Stromboli Volcano (Italy).

## Geologia, raw materials

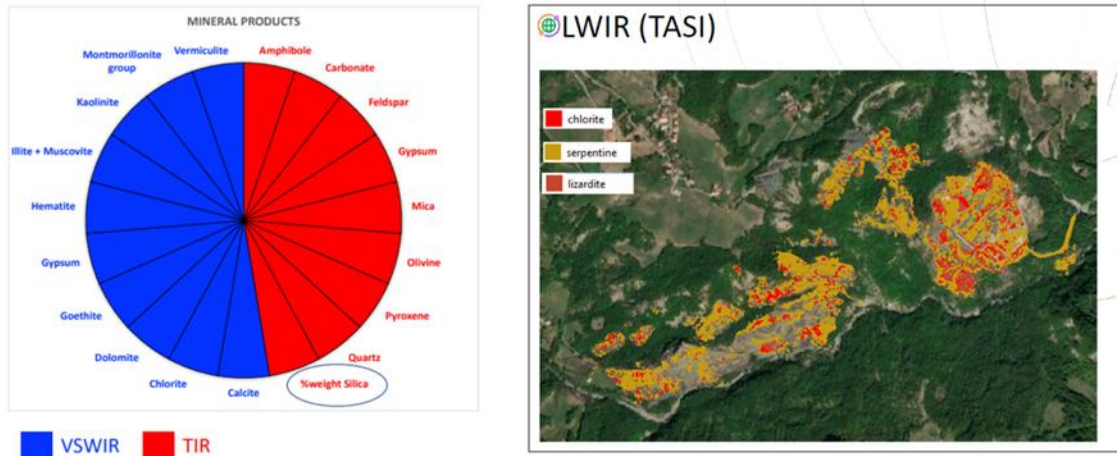


Figure 11 – Results of airborne TASI (LWIR) for raw materials individuation.

One of the contributions focused on UAV-based geophysical investigations conducted at Piano di Verteglia pilot site in Campania region. The acquisition campaigns using UAV-mounted GPR and magnetometry were described in detail, along with the adopted data processing strategies, which included advanced 3D imaging techniques. The discussion highlights both advantages such as remote accessibility, non-destructive data collection, and operational efficiency—and the challenges, including limited payload capacity, radar-GNSS synchronization, and low signal-to-noise ratios. The resulting images successfully revealed buried pipelines and material interfaces, demonstrating a strong correlation between UAV-based and traditional ground-based measurements. Future efforts will concentrate on integrating these data into comprehensive 3D models to further advance urban subsurface characterization (figures 12, 13).

## UAV-based GPR - Experimental Results

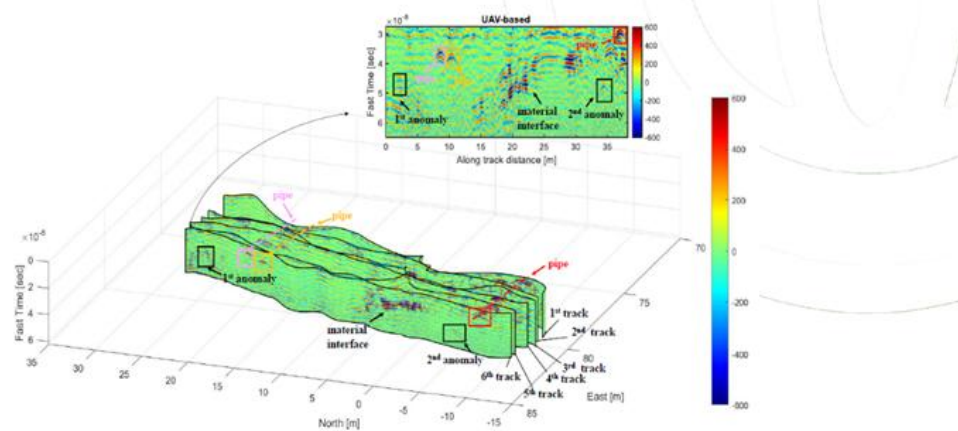


Figure 12 – UAV-based GPR at Piano di Verteglia pilot site in Campania region.

### Experimental Activities: Datasets & Results

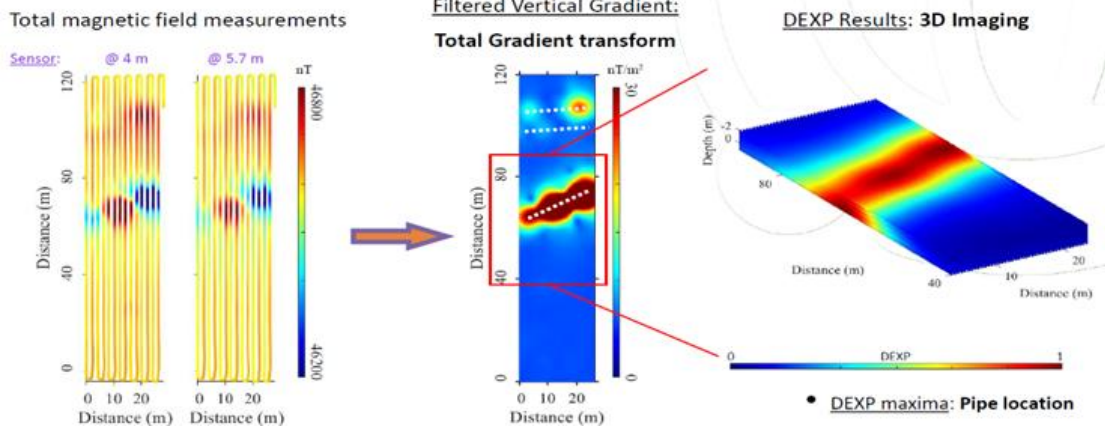


Figure 13 – UAV-based Magnetometer at Piano di Verteglia pilot site in Campania region.

## 5. DISCUSSION PANELS

Talks were given by senior researchers of the CNR-IMAA, CNR-IGAG, and CNR-IREA institutes, institutional stakeholders and invited experts from large private companies, small and medium enterprises, and geophysical instrumentation factories.

### 5.1 The contribution of Applied Geophysics to risk mitigation in urban areas

In line with the objectives of the ITINERIS project, a discussion panel has been organised, with the participation of institutional stakeholders and representatives of professional associations (figure 14). The discussion was chaired by M. Moscatelli, Director of IGAG-CNR, and V. Lapenna, Research Director at IMAA-CNR. They encouraged the panellists to discuss the potential impact of geophysical observation technologies in supporting programmes for the mitigation and prevention of natural and environmental risks. Furthermore, great attention was paid on the identification of new activities that would strengthen collaboration between universities, public research organisations, and stakeholders.

The Director of the Basilicata Region's Agency for Environmental Protection, Dr Ramunno, and technicians from the Basilicata Region's Department of Civil Protection illustrated their main activities in the Basilicata region. These mainly concern programmes for mitigating the effects of landslides and seismic risk, and monitoring environmental problems related to human activities (e.g. new laboratories and instruments to evaluate air and groundwater pollution). Dr. M. Moscatelli, director of the Institute of Environmental Geology and Geoengineering of CNR (IGAG-CNR), gave a short talk in which he discussed the potential of the new airborne and ground-based geophysical facility. In particular, he briefly described the role of the CNR network in supporting institutional stakeholders such as the National and Regional Civil Protection. The discussion mainly focused on strategies for making better use of innovative electromagnetic (GPR) and magnetic sensors installed on unmanned/drone platforms and sensor networks for seismic and electrical subsurface investigations, as part of programmes aimed at making urban areas more resilient and sustainable.

The discussion devoted significant attention to the role of professional orders in programmes for the mitigation and prevention of natural risks. Dr. Geol. M. William, President of the Professional Association of Geologists in the Basilicata region, emphasised the key role of geologists and the need to promote new forms of collaboration with universities and public research organisations. Ing. M. Tolve, President of the Professional Association of Engineers in the Province of Potenza, emphasised the importance of non-invasive, cost-effective geophysical technologies for monitoring strategic civil infrastructure such as bridges, tunnels and energy pipelines. Operating costs could be reduced by making better use of geophysical technologies, which can support the earlier identification of degradation phenomena and consequently help to prioritise maintenance work.



Figure 14 – Discussion panel with institutional stakeholders

## 5.2 The potential of publprivate partnerships in the field of applied geophysics

A second panel was organised to discuss the role of Research Infrastructures in the field of Earth Sciences and to strengthen collaboration between the academic and private sectors (figure 15). Dr. F. Soldovieri, Director of the Institute of Electromagnetic Sensing of the Environment of CNR (IREA-CNR), and Dr. V. Lapenna, Research Director at the IMAA-CNR, chaired the session. The panellists represented leading international companies, small enterprises and public-private consortia. The discussion focused on analysing new opportunities related to geophysical technologies for surface and subsurface investigations.

Dr N. Pajola, global geophysical advisor for ENI company, described how the energy transition can be supported by novel methods of applied geophysics, such as mapping georesources (e.g. geothermal fluids, rare earth minerals and groundwater in arid regions) and identifying and monitoring geological sites for CO<sub>2</sub> storage. He presented ENI's strategic programmes in this sector and confirmed their interest in promoting new collaborations with universities and public research organisations (ANNEX 6).

Ing. A. Monteleone, Chief Technology Officer at NAIS srl – Next Application and Innovative Solutions, emphasised the fundamental role of geophysical surveys in environmental monitoring and the protection of historical buildings. He presented some examples of the integration of satellite remote sensing and ground-based technologies for monitoring urban areas. He stressed the necessity for small enterprises to collaborate with academic institutions and gain access to Research Infrastructures.

Ing. A. Pettinari, Business Developer at GeoMonitoring for IDSGeoradar, spoke about the latest technological developments in georadar technologies and new sensors that can be installed on drones and/or unmanned systems. He discussed the importance of small enterprises promoting industrial research projects, as well as the interest of research infrastructures in testing and validating new sensors and instruments.

Finally, A. Colangelo, President of the public-private TERN consortium (Technologies for Earth Observation and Natural Risks), emphasised that collaboration between small and large enterprises, networks of universities, public research organisations and institutional stakeholders is the key to increasing the competitiveness of local territories and creating regional ecosystems for research and innovation. TERN's long-term national and international experience confirms the validity of this approach. To date, the Basilicata region has played a key role in Earth Observation.

In this context, CNR's new airborne-ground geophysical facility could be a driving force in promoting new public-private partnership projects in Earth and environmental sciences.



Figure 15 – Panel on public-private partnership.

## 6. DEMONSTRATION ACTIVITIES AND FIELD TESTS

The demonstration featured a range of advanced geophysical sensors, including UAV-mounted and in situ Ground Penetrating Radar (GPR), Ground-Based Real Aperture Radar (GBRAR), Distributed Acoustic Sensing (iDAS) systems, and both surface and deep Electrical Resistivity Tomography (ERT and DERT) acquisition systems. To support the demonstration, slideshows and video materials from the training course “Geophysical Instruments and Data Processing,” as well as from recent field campaigns, were presented. During the event, guided tours allowed stakeholders to engage directly with the instrumentation, and they participated actively by asking technical questions (figure 16).



Figure 16 – Demonstration activities and field tests.

## 7. MAIN OUTCOMES

The meeting was structured around the contributions of the WP7 of the ITINERIS project, a significant Italian research infrastructure initiative that is funded by the European Union through the Next Generation EU programme. The meeting showcased how the integration of ground-based and airborne geophysical technologies can address the challenges posed by urbanisation, climate change and natural hazards, such as earthquakes and landslides.

The WP7 of the ITINERIS project included a component aimed at strengthening the near-surface geophysics capabilities of CNR IMAA and CNR IREA. This involved equipping them with advanced instrumentation, including high-resolution ground-based geophysical sensors and remote sensing capabilities via UAVs and aircraft.

The primary objectives of the event are to promote the project's scientific results to a wide range of institutional and private representatives who could potentially be stakeholders. The meeting provided an in-depth overview of the role of applied geophysics in supporting the transformation towards sustainable and resilient cities. It emphasised how advancements in geophysical instrumentation can improve our understanding of, and response to, complex urban subsurface environments and surface processes.

The Urban Geophysics methods introduced at the meeting have significant potential to inform land use planning, risk mitigation and smart city design. The meeting also highlighted the crucial role of geophysics in promoting the resilience and sustainability of urban areas. The need for advanced tools and integrated methods to investigate and monitor the subsurface was discussed, particularly in densely built environments where traditional approaches may be limited.



Finanziato  
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NextGenerationEU



# 2025

## 13 giugno

“Urban Geophysics:  
A New Ground-  
Airborne  
Geophysical  
instrumental  
facility”

CNR – SALA  
CONFERENZE AREA  
TERRITORIALE DELLA  
RICERCA DI POTENZA  
| TITO SCALO



<https://itineris.cnr.it/news/>



# Urban Geophysics: A New Ground-Airborne Geophysical instrumental facility

CNR – SALA CONFERENZE AREA  
TERRITORIALE DELLA RICERCA DI  
POTENZA | TITO SCALO  
13 GIUGNO 2025



<https://itineris.cnr.it>

09:00 **Registrazione**  
09:30 Foyer Sala Conferenze

09:30 **Saluti e apertura lavori**  
09:40 Sindaco di Tito

**Il progetto ITINERIS:**  
09:40 **Impatto socio-economico e potenziali ricadute sui territori**  
10:00 C. Cornacchia - CNR IMAA  
**Le attività nel settore Geosfera/Landsurface**  
G. Rossi - OGS

10:00 **Prima parte – relazioni scientifiche**  
10:40

**Potenziamento delle attività di “near-surface geophysics”**  
V. Giampaolo – CNR IMAA

**Monitoraggio geofisico di aree ad elevato rischio idrogeologico: il caso studio di Tito**

G. Calamita, F. Canora, G. De Martino, L. Martino, A. Perrone, S. Uhlemann – CNR IMAA, UNIBAS, University of Bremen

**Caratterizzazione sismica di tutti i suoli urbani e degli edifici della città di Potenza per una valutazione più approfondita del rischio sismico**

G. Gangone, M.R. Gallipoli, M. Vona – CNR IMAA, UNIBAS

**Le potenzialità degli array sismici per il monitoraggio di aree urbane**

V. Serlenga, M.R. Gallipoli, I. Gaudiosi – CNR IMAA, CNR IGAG

10:40 **Primo panel di discussione**  
11:30

**Il contributo della Geofisica Applicata alla mitigazione dei rischi nelle aree urbane**

Con la partecipazione di: G. Naso - Dipartimento di Protezione Civile (\*); G. Di Bello – Resp. Protezione Civile Basilicata; D. Ramunno – Direttore Generale ARPA Basilicata, M. William – Presidente Ordine Geologi della Basilicata; M. Tolve – Presidente Ordine Ingegneri Provincia di Potenza

Moderano: M. Moscatelli – CNR IGAG; V. Lapenna – CNR IMAA

(\*) in attesa di conferma

11:30 **Coffe break**  
11:40

# Urban Geophysics: A New Ground-Airborne Geophysical instrumental facility



11:40  
12:20

## Seconda parte – relazioni scientifiche

### Potenziamento delle attività di osservazione del suolo e del sottosuolo tramite GPR e telerilevamento da aereo e da UAV

I. Catapano – CNR IREA

### Le potenzialità delle indagini geofisiche da drone: il sito pilota di Piano di Verteglia

A. Barone, G. Esposito, F. Mercogliano, G. Gennarelli, A. Vitale, F. Accomando, P. Tizzani, I. Catapano – CNR IREA

### Telerilevamento SAR da piattaforme aeree

P. Berardino, A. R. Legarda, J. A. Euillades, C. Esposito, A. Natale, S. Perna, R. Lanari – CNR IREA

### Telerilevamento iperspettrale da aereo dal visibile all'infrarosso termico: applicazioni in campo ambientale

S. Pignatti, A. Palombo, S. Pascucci, F. Santini – CNR IMAA

12:20  
13:10

## Secondo panel di discussione

### Le potenzialità della collaborazione pubblico-privato nel settore della Geofisica Applicata

Con la partecipazione di: N. Pajola – Global Geophysical Advisor ENI; A. Monteleone – Chief Technology Officer NAIS Solutions; A. Pettinari – Business Developer Geo Monitoring IDSGeoradar; A. Colangelo – Presidente Consorzio TeRN.

Moderano: F. Soldovieri – CNR IREA, V. Lapenna – CNR IMAA

13:10  
13:30

## Conclusione dei lavori

L. Mongiello – Assessore Ambiente ed Energia Regione Basilicata

13:30  
14:30

## Light Lunch

## Attività dimostrative e test su campo

### Utilizzo della fibra ottica come sensore sismico distribuito

T. A. Stabile – CNR-IMAA, F. Staněk and M. Cogorno – Silixa Ltd

### Array sismici per il monitoraggio geofisico

V. Serlenga – CNR IMAA, I. Gaudiosi – CNR IGAG

### Sistemi per tomografie geoelettriche profonde

Gregory De Martino – CNR IMAA

### GB-SAR e GB-RAR per il monitoraggio in aree urbane e rurali

Angela Perrone – CNR IMAA

### Monitoraggio geofisico multisensore mediante l'utilizzo di droni

I. Catapano – CNR IREA

10:00  
14:00



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## The ITINERIS project and RI's potential socio-economic impact on territories

**Carmela Cornacchia**

Consiglio Nazionale delle Ricerche – Istituto di Metodologie per l'Analisi Ambientale  
CNR-IMAA

**IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System**  
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-  
Mission 4 "Education and Research" - Component 2: "From research to business" - Investment  
3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"



# Outline

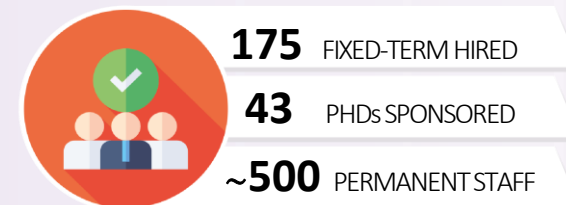
- ITINERIS project: main objectives and outcomes
- What is a European Research Infrastructures?
- Access to RIs and potential socio-economic impact
- Success Stories

## ITINERIS - Italian Integrated Environmental Research Infrastructures System

is a project funded by EU – Next Generation EU PNRR- Mission 4 “Education and Research” – Component 2: “From research to business” – Investment 3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”.



### PROJECT AT A GLANCE



Scientific Coordinator - Gelsomina Pappalardo - CNR  
Infrastructure Manager – Giuseppe Gargano - CNR  
Started in November 2022  
Duration: 36 months.

## ITINERIS builds the Italian thematic network of Environmental Research Infrastructure

for the observation and study of environmental processes in the atmosphere, marine domain, terrestrial biosphere, and geosphere.



Foster a systemic and multi-disciplinary approach for a deeper understanding of environmental processes and for the creation of effective strategies.

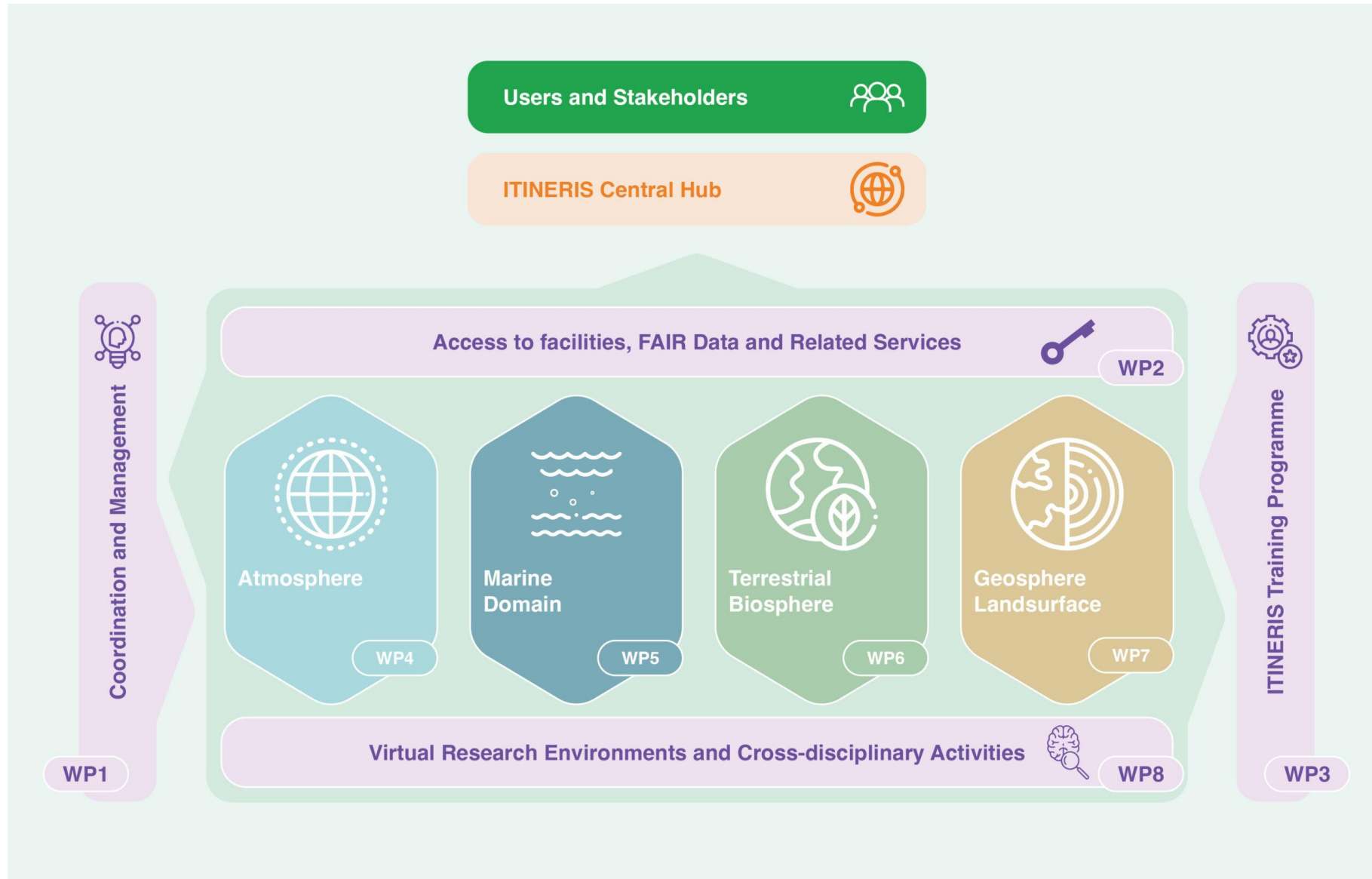


Promote the adoption of common standards and FAIR-enabling practices, to harmonize RIs development and enhance interoperability.



Establish a national access framework to ensure integrated and multifunctional access to Italian Env Ris, and promote sharing of data and research results.

# Work Packages



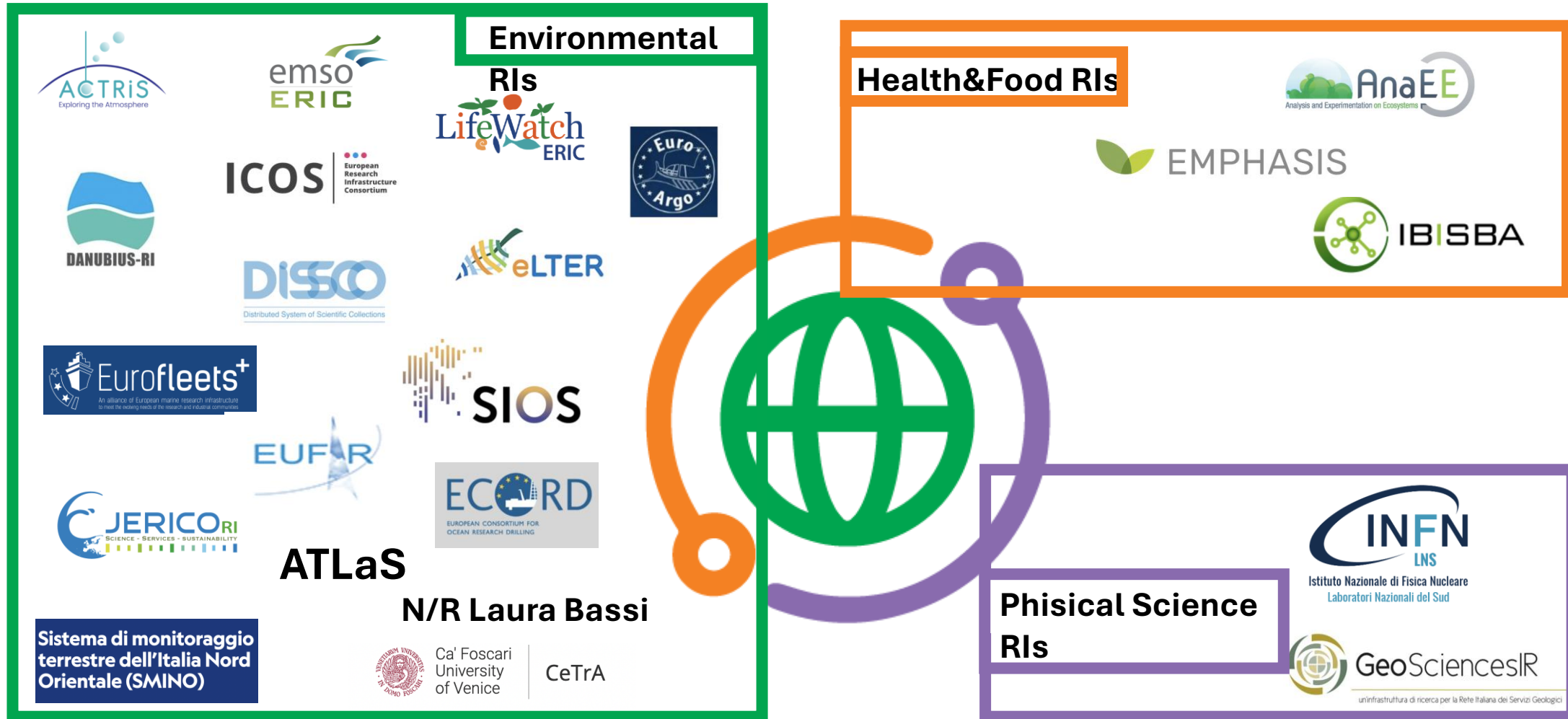
# Comprehensive and integrated approach to environmental challenges

Most critical issues currently faced by our society involve key environmental challenges: pollution, land use and climate change, and their impacts on biodiversity and ecosystem integrity.



Given the complexity of such challenges, a comprehensive and integrated approach at the Earth's system is essential to provide quantitative knowledge to be transformed into actionable strategies

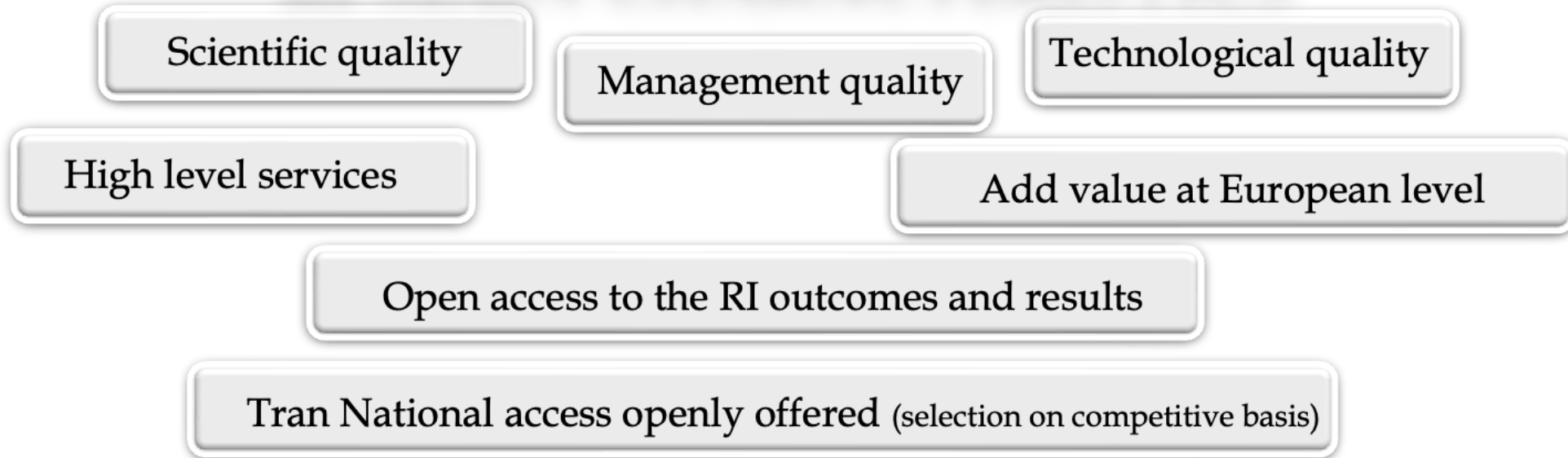
# 22 RIs Participants in the ITINERIS project





Research infrastructures of pan-European interest are defined as "*structures, resources and related services, used by the scientific community to conduct high-quality research and foster innovation in their respective fields, without constraints of institutional or national affiliation*" (Definition of ESFRI -European Strategy Forum for Research Infrastructures).

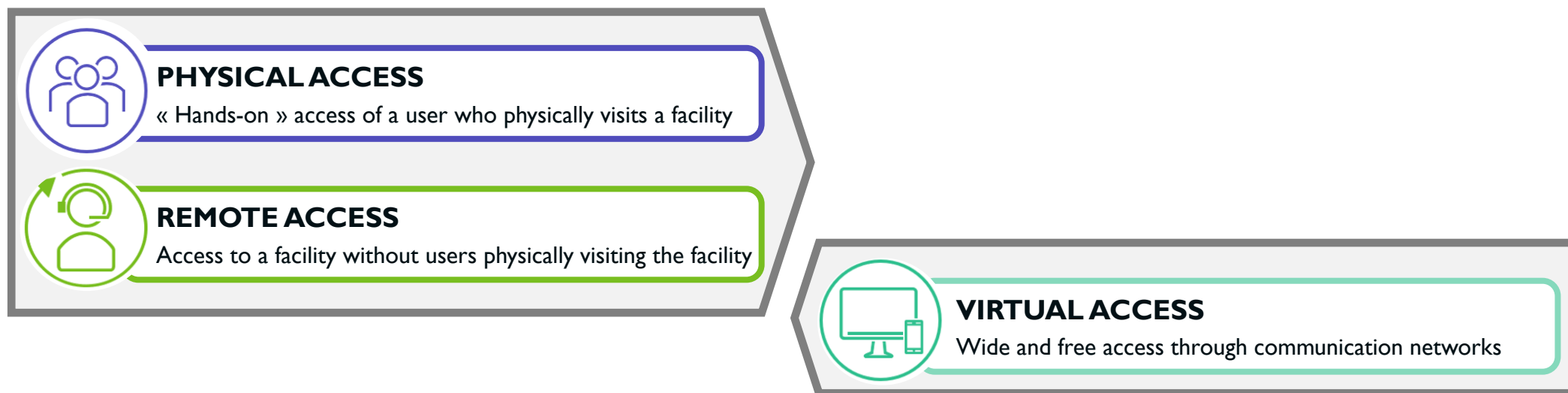
## RI MAIN CHARACTERISTICS



# Access to Research Infrastructures

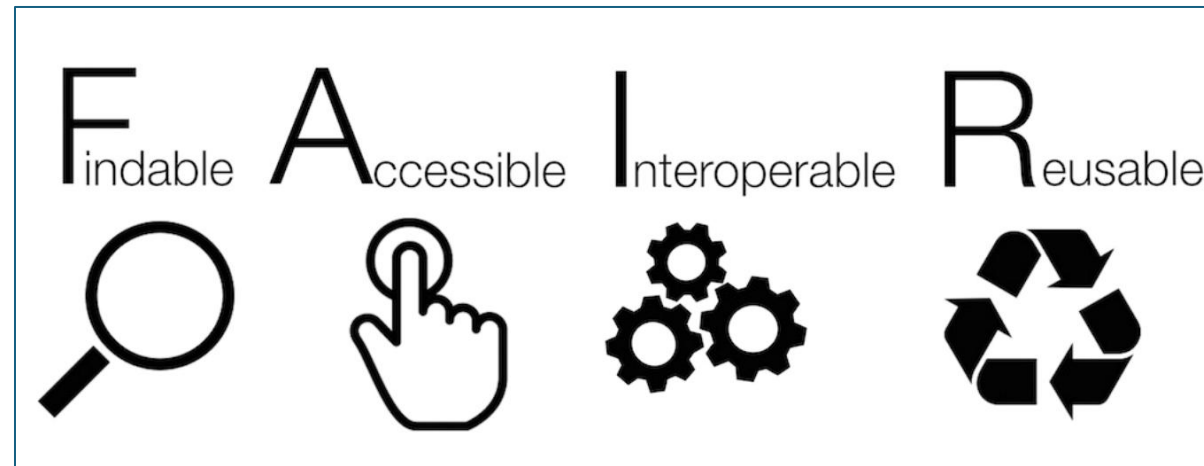
The legitimate and authorised **physical, remote and virtual admission to, interactions with and use of Research Infrastructures and to services offered by Research Infrastructures to users.**

Article 3 (c) of the European Charter for Access to Research Infrastructures



- High quality measurements and data, and fully documented and standardized
- Advanced and standardized measurement platforms for experiments and studies
- Tools to be used for measurement campaigns or particular studies
- knowledge with training, workshops, possibility of degree/doctoral thesis

# Keyword: FAIRness



The **FAIR principles** are intended as a guide, not a standard, to enable digital resources to become more Findable, Accessible, Interoperable and Reusable for **machines** and thus also for **humans**.

The **FAIR principles** have been widely adopted by a broad range of stakeholders (e.g. RIs) who have implemented their own **FAIR solutions**.

However to reach the goal of fully **interoperability**, we need to support convergence towards accessible, robust, widespread and consistent FAIR implementations.

## Data Governance Act



**AgID – Autorità nazionale**



**Riutilizzo di dati protetti**



**Intermediazione dei dati**



**Altruismo dei dati**

*Al fine di facilitare e incoraggiare l'utilizzo dei dati detenuti da enti pubblici a fini di ricerca scientifica, gli enti pubblici sono incoraggiati a sviluppare un approccio armonizzato e processi armonizzati intesi a rendere tali dati facilmente accessibili a fini di ricerca scientifica nell'interesse pubblico.*

(considerando (16), Regolamento (UE) 2022/868)

# The ITINERIS HUB



A single access point providing seamless access to the wide range of data, cutting-edge facilities, analytical tools, and services provided by the Italian environmental Research Infrastructures to support scientific inquiry, policy-making, and innovation.



ITINERIS Catalogue



ITINERIS Access Platform



ITINERIS Virtual Research Environment (VRE)



ITINERIS Training Centre

At the HUB core, the **metadata Catalogue** serves as the comprehensive online registry with a user-friendly interface and advanced search capabilities empowering users with easy discovery and access to data, tools, and services provided by the network of ENV RIs.

This is enabled by essential services that bridge technical and operational disparities between the different RIs and ensure a rigorous implementation of FAIR data management and integration framework.

- FAIR-enabling services: metadata, persistent identifiers (DOI), terminology services ...
- Over 500,000 environmental datasets from Italian ENV RIs.
- Facilities, observatories, specialized labs, advanced instrumentation, research vessels ...
- Analytical and validation services to enhance data processing and research outcomes.
- Digital infrastructures and computational resources ...

# Access platform

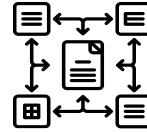
A single platform enhancing access to data and services from the RIs through physical, remote, virtual, and hybrid access types – accommodating diverse user needs within a standardized operational framework.



ITINERIS Catalogue



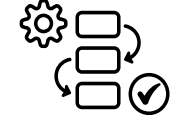
ITINERIS Access Platform



Data Management Plan



Access Policy



Access Management Plan



ITINERIS Virtual Research Environment (VRE)



ITINERIS Training Centre

## ONGOING PILOT INITIATIVES



**157** users

**40%** from EU/ to Italy

**IT 60%** from Italy to EU / Italy



**15** members of science parties

**IT 10** Berths

**IT 5** Shore-based

# ITINERIS Virtual Research Environment (VRE)



ITINERIS Catalogue



ITINERIS Access Platform



ITINERIS Virtual Research Environment (VRE)



ITINERIS Training Centre

Advanced digital platforms designed to empower users with cutting-edge tools for cross-disciplinary environmental analysis. ITINERIS VREs integrate data, models, and computational resources from multiple RIs, enabling researchers, policymakers, and stakeholders to address complex environmental challenges through collaborative and innovative approaches.

## Thematic VREs



Critical Zone Services



Aquatic Biomass Services



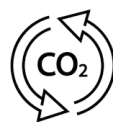
Crops, Plants, and Pests



Essential variables



Aerosol-Biosphere



Carbon Cycle Services



Climate Change Indicators and Impacts



Downstream Effects



Isotope Database



ITINERIS Catalogue



ITINERIS Access Platform




ITINERIS Virtual Research Environment (VRE)




ITINERIS Training Centre


A dedicated platform offering courses, hands-on training, workshops and educational resources to enhance researchers', technicians', and stakeholders' skills in utilizing data, tools, and VREs developed from environmental RIs.

## ONGOING ACTIONS

 **~600** Users on the training platform (PhD, researchers, technicians, faculty, and communication staff)

 **35** training courses delivered / **~650** participants

 New training opportunities await! **40 new courses coming by summer!**

 **Visit the ITINERIS HUB** [hub.itineris.cnr.it](https://hub.itineris.cnr.it) and register to the Training Centre while spots are still open!

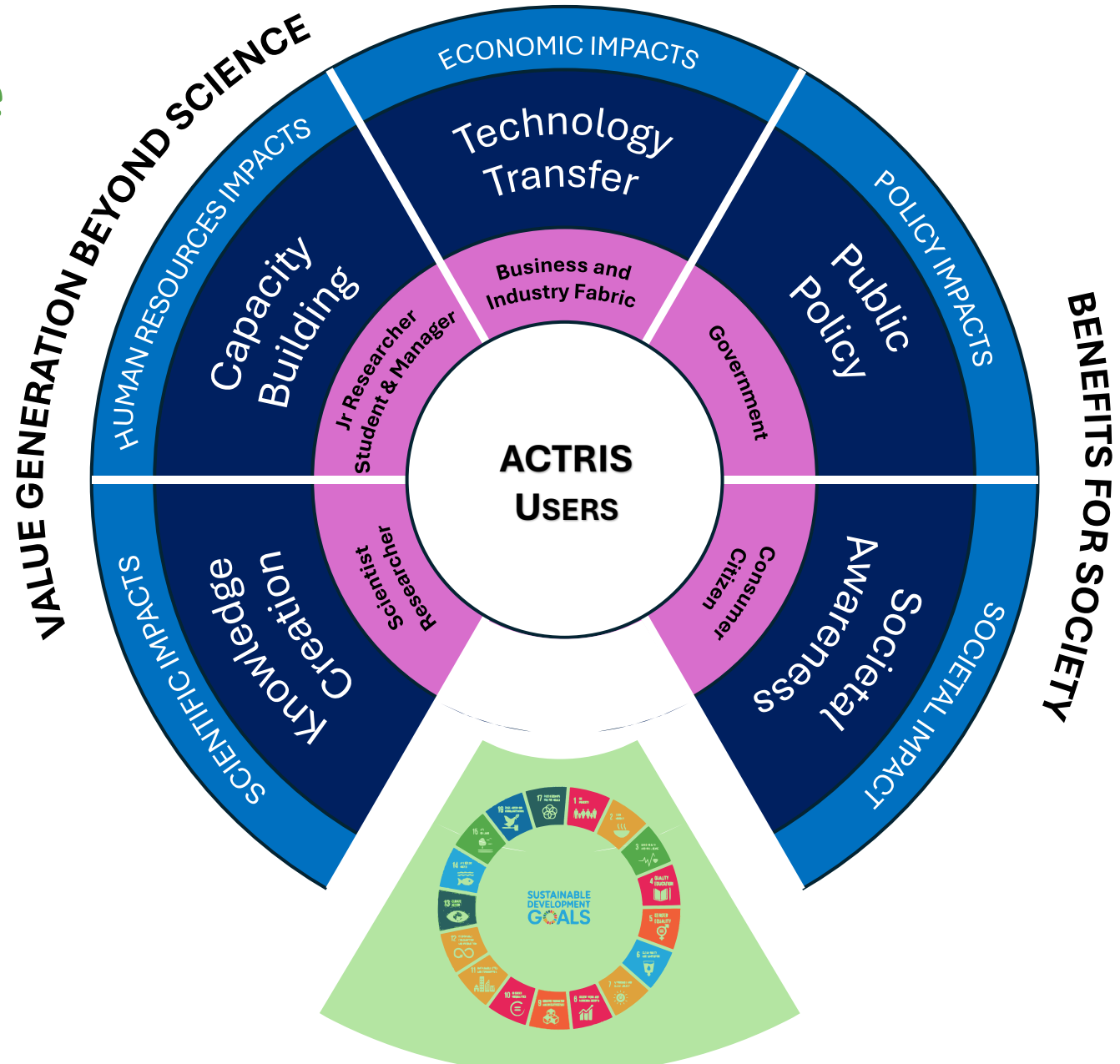
# ITINERIS main expected outcomes



- 🌐 A unified national system of ENV RIs, enabling seamless flow of data, information, and knowledge across ENV sub-domains.
- 🌐 New knowledge on environmental processes through a whole-system approach, emphasizing interconnections often missed by individual RIs.
- 🌐 Cross-disciplinary links with other research areas.
- 🌐 Evidence-based insights to support and inform policy-making.
- 🌐 Wider scientific, economic, and societal effects: (a) promotion of scientific excellence and creation of knowledge and innovation; (b) attraction of new researchers from other territories; (c) attraction of capital and investments in the territory; (d) impact on the competitiveness of enterprises, and more generally in terms of spin-off effect on the territory.

# The Socio-Economic Impact Assessment framework: a multi-stakeholder's perspective

RIs can generate **value beyond science** providing benefits to society, through research-based activities and knowledge transfer processes for different groups of **users/stakeholders**.



<https://www.youtube.com/watch?v=3c1ZsRWn92Q>

On 14 October, the Council of the European Union definitively approved the new Air Quality Directive (EU Directive 2024/2881), which establishes limits compliance by 2030. The general objective is to progressively improve air quality until reaching levels no longer considered harmful to human health, natural ecosystems and biodiversity.

The EU directive incorporates ACTRIS' recommendations and makes explicit reference to the RI as reference monitoring strategy and measurement programme

## Verso la nuova Direttiva Europea sulla qualità dell'aria: dialogo e sinergie tra infrastrutture di ricerca, enti locali e agenzie ambientali

Consiglio Nazionale delle Ricerche - Piazzale Aldo Moro, 7 - ROMA

07-08 aprile 2025

### Participants:

>120 from research

14 Regional Agencies for Environmental Protection

several representatives from ISPRA

# Research Infrastructure Innovation impact



🌐 RI Data Center team in Santa Clara (San Francisco) at the headquarters of Arista Networks to carry out a Proof of Concept on Network Technological Improvements.

🌐 The longstanding synergy 2020 between ACTRIS Data Center and Arista Networks continues with the aim to innovate more and more the network infrastructure, with a look on the emerging Multi-domain Segmentation Services (MSS) and the Zero Trust Networking approach, as well as the CloudVision evolution with UNO (Universal Network Observability).



Arista Networks, a leading company in the networking sector, specialized in building high-performance and low-latency networks for data centers and cloud computing environments.

# Research Infrastructure social impact



Incredible experiences with a special group of young people in education poverty framework had at CNR-IMAA and CNR-IRET. **ACTRIS and Lifewatch** staff participated in engaging educational activity, an initiative aimed at increasing the societal impact of research infrastructures. young students from 10 to 14 years old were scientists for a day.



We firmly believe that access to science and knowledge is a right for everyone, and that Research Infrastructures can play an important role.

The initiative is promoted by **ITINERIS project, University of Bari**, with schools and social services of Salento.





# THANKS!

 [www.itineris.cnr.it](http://www.itineris.cnr.it)

 [#itineris\\_RI](https://twitter.com/itineris_RI)

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# Urban Geophysics: A New Ground- Airborne Geophysical instrumental facility

CNR – SALA CONFERENZE AREA TERRITORIALE DELLA  
RICERCA DI POTENZA | TITO SCALO  
13 GIUGNO 2025

Giuliana Rossi  
Istituto Nazionale di  
Oceanografia e di Geofisica  
Sperimentale -OGS  
grossi@ogs.it



**IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System**  
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# WP7 - Geosphere and Landsurface

🌐 **WP7** aims to provide the scientific community, the public, and decision-makers with a wealth of **multi-disciplinary open digital datasets on environmental observations of the Geosphere and landsurface through 9 Activities, by**

- **Integrating key Research Infrastructure capabilities & related datasets including: **SMINO, ATLaS, ECORD-ICDP, & EUFAR****



- **Testing cutting-edge technologies in three pilot sites: the Friuli Venezia Giulia region, Tito and Potenza in the Basilicata region**

## Pilot sites



# WP7: 5 Objectives

## 2 FAIR data objectives from the RIs

**Objective 1:** harmonize the data following international standards (Activities 7.1-7.9);

**Objective 2:** making the data FAIR (**F**indable, **A**ccessible, **I**nteroperable, and **R**eusable (Activities 7.1-7.9);

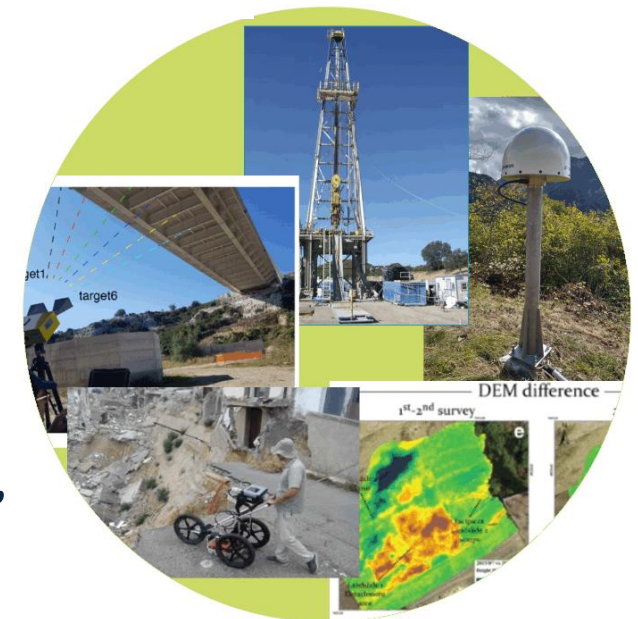


## 3 specific objectives

**Objective 3:** focus on deep earth-drilling (**ECORD, IODP, ICDP**) (Activities 7.1-7.3);

**Objective 4:** focus on near-surface processes by integrating geochemical, geophysical, geological and seismological data (**SMINO, ATLaS**, Activities 7.4-7.8);

**Objective 5:** enhance multi-parameter observations of surface processes, with spaceborne and airborne SAR infrastructures (**SMINO, ATLaS, EUFAR**, Activities 7.4-7.6 and 7.9).



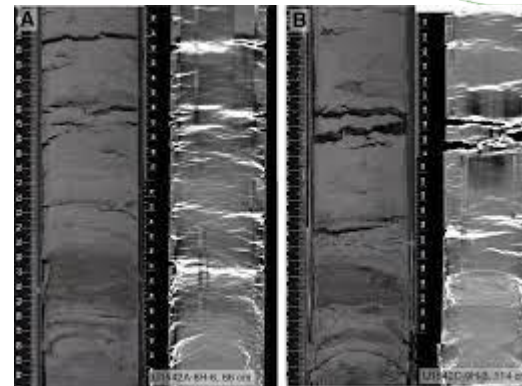
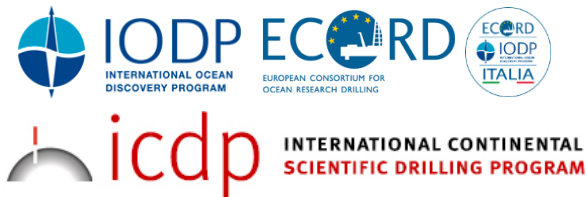
# WP7: Participants in the WP

- 🌐 OGS-CRS: Centro di Ricerche sismologiche  
OGS – Udine RI **SMINO**
- 🌐 OGS-GEO: Sezione di Geofisica OGS – Trieste  
RI **ECORD**
- 🌐 CNR-ISMARBO Istituto di Scienze Marine -  
Bologna RI **ECORD**
- 🌐 INGV-Roma RI **ECORD**
- 🌐 CNR-IMAA Istituto di Metodologie per  
l'Analisi Ambientale CNR
- 🌐 CNR-IREA Istituto per il Rilevamento  
Elettromagnetico dell'Ambiente CNR
- 🌐 UNIFI-CPC Centro per la Protezione Civile –  
RI **ATLaS**



# WP7: Summary of the activities


- 7.1 Improving the access to the ECORD infrastructure and enabling scientific drilling micro-analysis, geochemical and site survey data sharing;
- 7.2 Improving the access to the ICDP infrastructure;
- 7.3 Improving the access to IODP scientific borehole geophysics, subsurface structural data, and stratigraphic/lithologic samples-data sharing;



# WP7: Summary of the activities



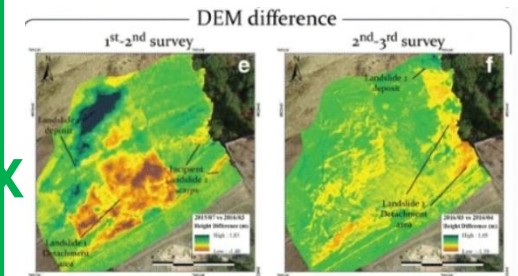
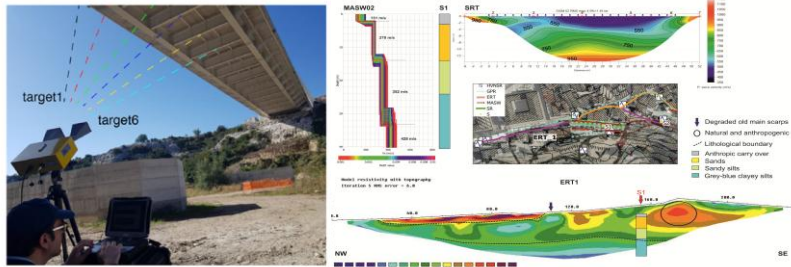
7.4 Upgrade and networking of the ground-based and airborne facilities for geophysical exploration and land surface monitoring; Contribution to **ATLaS, SMINO** & 

7.5 Earth Observation infrastructure based on airborne X/L Band SAR and in-situ geophysical data; Contribution to **ATLaS, SMINO** & 

7.6 Integrated platform for surface movements monitoring;



**ATLaS**



# WP7: Summary of the activities



7.7 Integrated facility for the access to SMINO observations;  
Contribution to **ATLaS**



OGS-CRS

SMINO

7.8 Data integrated facility for the access to geophysical observations on the subsurface;



OGS-GEO

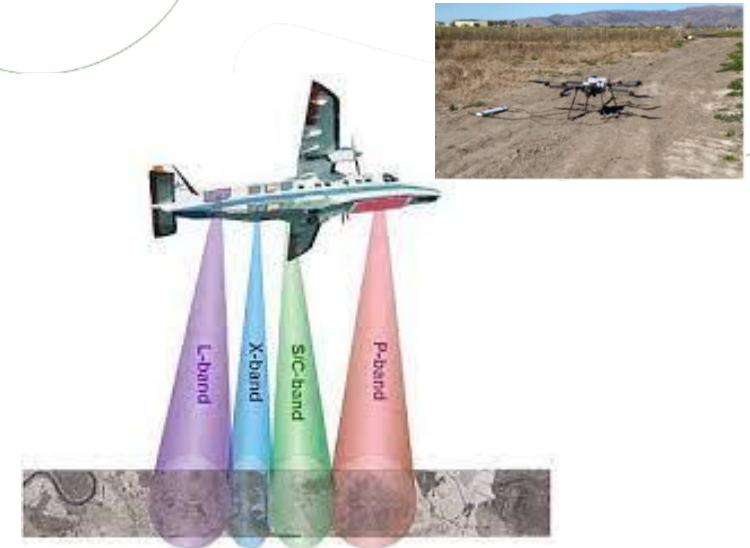
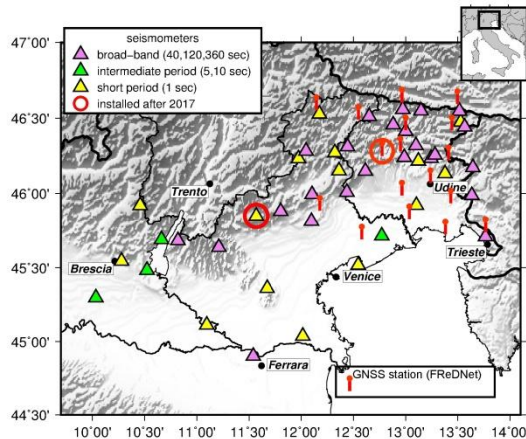
Contribution to **SMINO, ATLaS**

7.9 Integrated facility for accessible airborne geophysical observations;




OGS-GEO

Contribution to **EUFAR**, **SMINO, ATLaS**



# WP7: Major expected outcomes

 We release existing and new terrestrial, airborne and scientific drilling data, while also developing and testing cutting-edge tools for geosphere and landsurface research.

 Asset 1- Provide cutting edge equipment for SMINO, ATLaS, EUFAR & ECORD-ICDP to:

1. transform EUFAR capabilities enabling new shallow to deeper crustal studies
2. increase ATLaS capabilities in landslide monitoring and early warning
3. improve SMINO with a MEDA Buoy & new fiber cable capabilities, a sensor calibration center, and enhance samples analysis & geophysical logging for scientific drilling (ECORD-ICDP)

 Asset 2- Develop 3 pilot sites (Friuli Venezia Giulia, Potenza and Tito) as open laboratories

for urban geophysics, by testing DAS technology & providing demonstrators for stakeholders and general public

 Asset 3- Next generation researchers and FAIR data access

- Recruit 12 next-generation researchers & technologists (34 FTE) and 6 PhD fellowships.

# WP7: the future

## Impact over 10 years evaluated through performance indicators

- **PI 7.5: Number of remote/physical access to the RIs; PI 7.6: Number of virtual access to the RIs; PI 7.7: Number of papers using the data and citing the RIs; PI 7.8: Number of Projects using the RIs and derived data; PI 7.9: Number of Italian researchers involved in ECORD and ICDP**



 **The RIs have to be maintained and further developed**

 **The next-generation researchers & technologists have to be maintained and stabilized**

**HENCE**

 **ITINERIS WP7' s community has to be maintained and the collaborations further strengthened**

 **Common projects –national and international**





# THANKS!

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# Potenziamento delle attività di “near-surface geophysics”

Valeria Giampaolo – CNR IMAA



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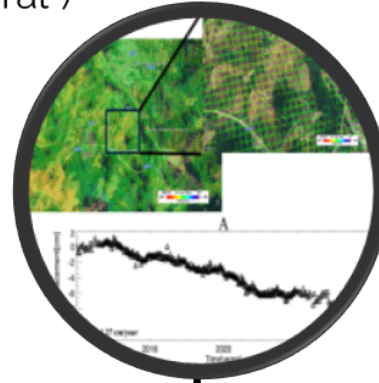


## **Scientific goal**

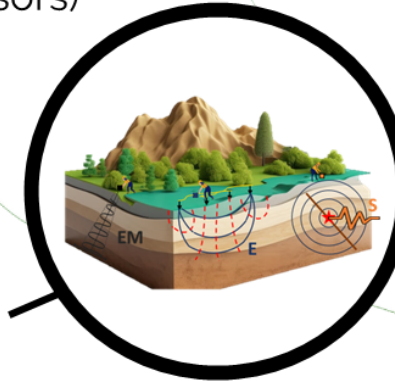
Multi-scale  
(from 0-1 m up  
to 1-10 km  
depth )



Multi-resolution  
(spatial and  
temporal )



Multi-sensor  
(airborne and ground-  
based geophysical  
sensors)

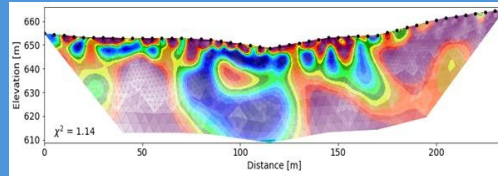


 **Basilicata Pilot-sites**



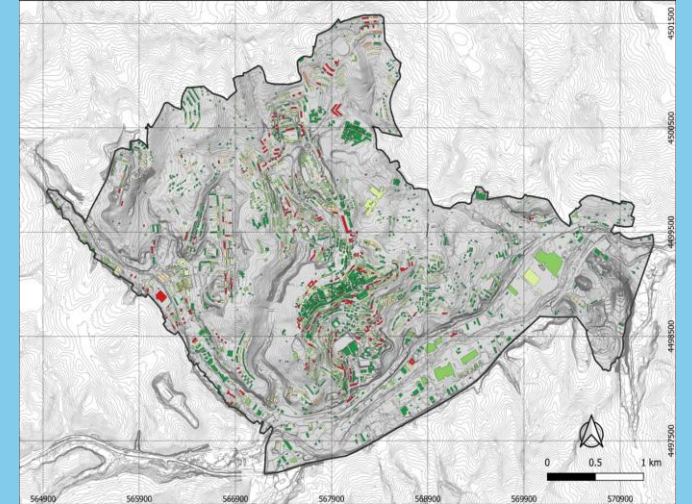
**Tito**

Cutting-edge applied geophysics and data science in the evaluation of hydrogeological risk in urban areas



**Potenza**

Advances in Seismic Risk Assessment of the city of Potenza (Southern Italy)



## Instrumental facility



### New electrical resistivity tomography system

- Different spatial e temporal resolution by using 2D and 3D tomographic methods,
- investigation depth (from 0-1 m up to 1-10 km depth time-lapse acquisition,
- ML data analysis techniques



### Airborne Hyperspectral Imaging Systems (VNIR-SWIR)

- Continuous spectral coverage from 400nm to 2500nm
- Spatial resolution of about 30/40 cm in the VNIR and about 1m in the SWIR

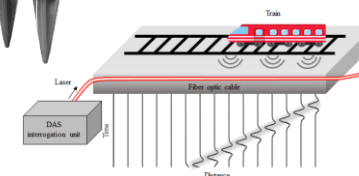
### Seismic data from new seismic sensors and fiber optic interrogator

- Nodal systems consisting into velocimeter and accelerometers,
- iDAS interrogator for passive and active seismic surveys, and critical infrastructure monitoring
- ML data analysis techniques



### New GB-SAR and GB-RAR

- monitoring surface deformation
- studying the static and dynamic behavior of strategic infrastructure
- Spatial resolution of at least 0.75 m



 **The support of ITINERIS infrastructure to other research initiatives**



Characterisation and management of historic centres and heritage buildings  
(PINR 2022 NEW AGE)



**RESILIENT AND  
SUSTAINABLE CITIES**



Deterioration assessment of reinforced concrete structures  
(PRIN 2022 ICARUS)



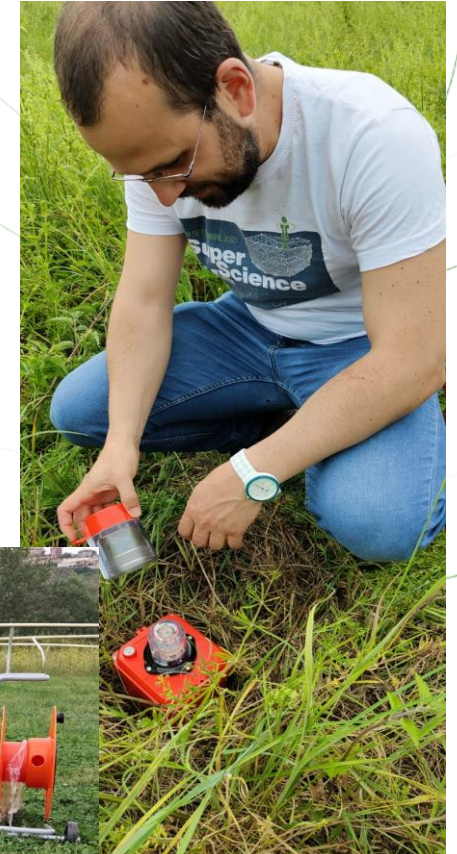
Sustainable use of water resources in coastal areas  
(PRIN 2022 SUBGEO)



Sustainable geothermal energy exploitation  
(PRIN 2022 PNRR TOGETHER)



## The support of ITINERIS infrastructure to other research initiatives



Support to the **Civil Protection Department**, the Campania Region and the municipalities of Naples and the Campi Flegrei area for the **THIRD LEVEL MICROZONATION**

May 2025



# THANKS!

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## Monitoraggio geofisico di aree ad elevato rischio idrogeologico: il caso di studio di Tito

G. Calamita<sup>1</sup>, F. Canora<sup>2</sup>, G. De Martino<sup>1</sup>, L. Martino<sup>1,2</sup>, A. Perrone<sup>1</sup>, S. Uhlemann

1) *Istituto di Metodologie per l'Analisi Ambientale – CNR, Italia*

2) *Dipartimento di Ingegneria – Università degli Studi della Basilicata, Italia*

3) *Università di Brema, Germania*

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# Which factors/parameters?

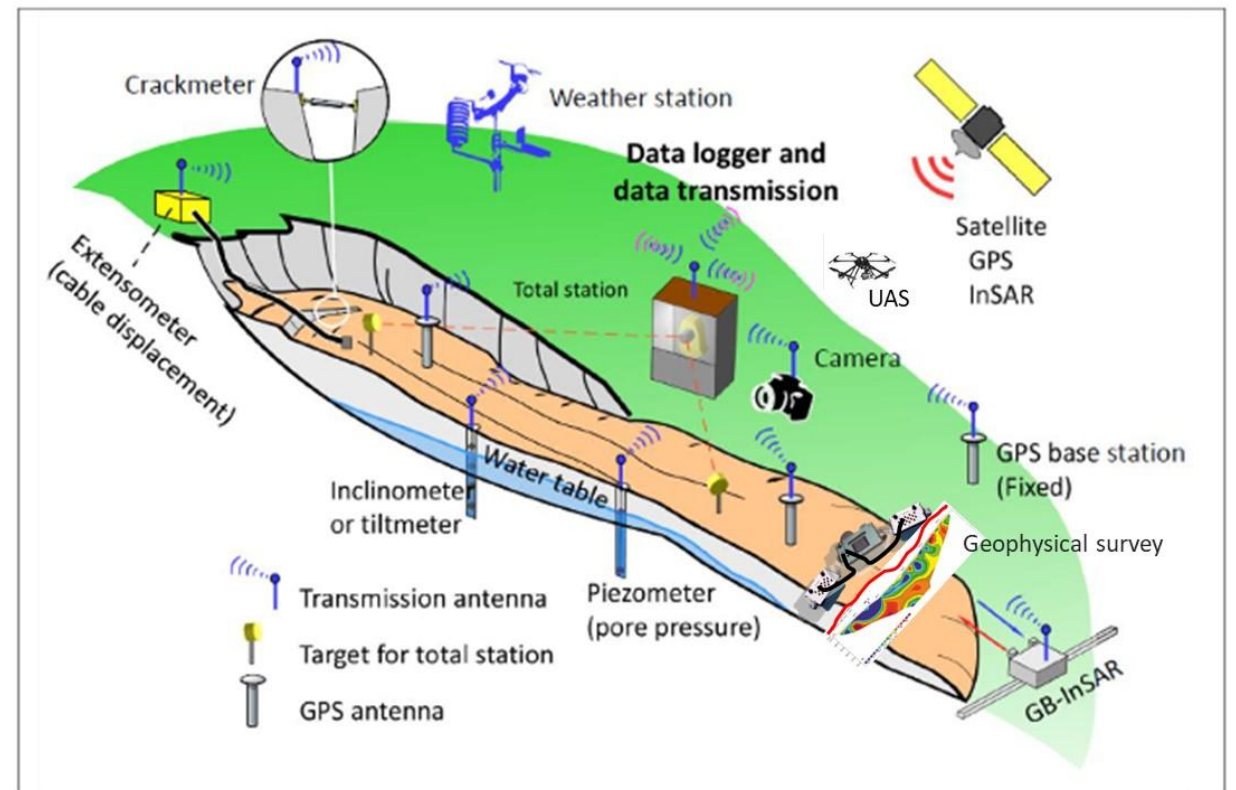
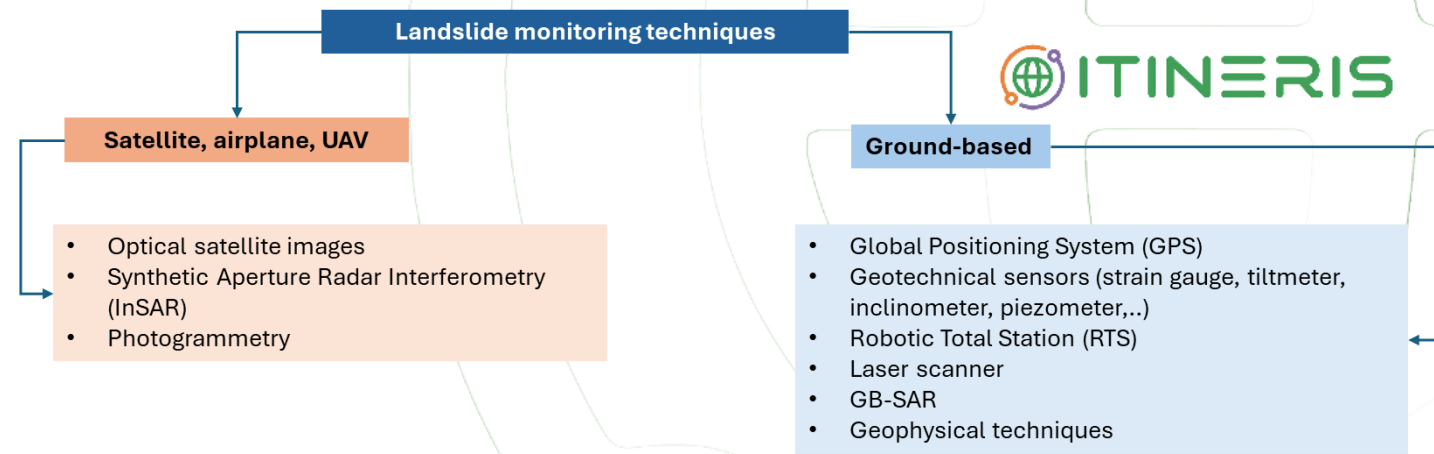
- Typology, velocity, triggering mechanisms
- Aerial extension, volumetric size of landslide body
- Geological, hydrogeological, geotechnical and morphological features

# Which techniques?

A single technique does not allow obtaining all the necessary information.

Best choice: to integrate earth observation techniques (from the ground, plane and satellite) and geotechnical standard sensors.

Sensors can be placed far from the landslide (remote sensors), on the ground surface and in the ground.



Casagli et al., 2017 – Science for disaster risk management (modified)

# How to investigate urban landslides?

Population at risk in areas with very high landslide hazard



[Idrogeo.isprambiente.it](http://Idrogeo.isprambiente.it)



Montescaglioso 2013



Stigliano 2014

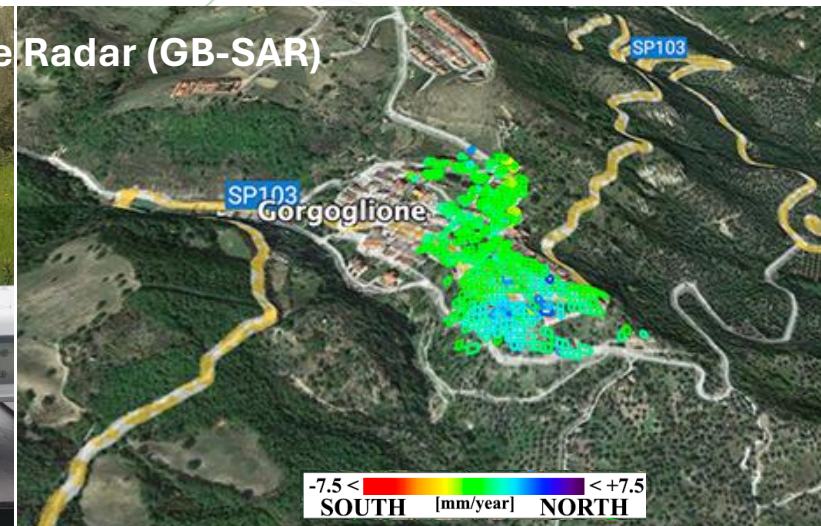
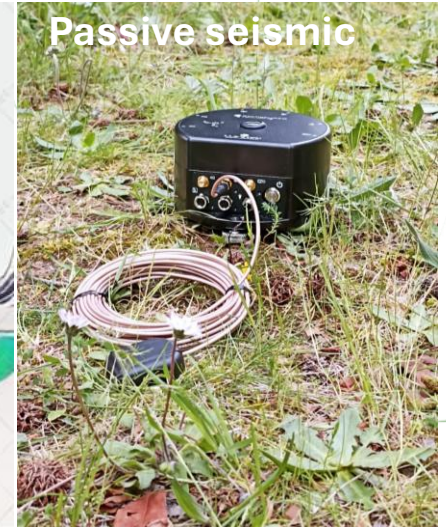
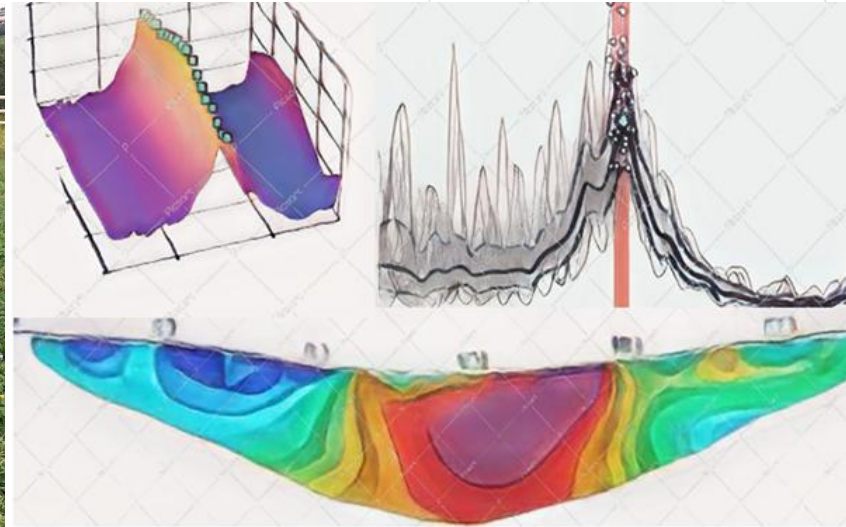


Pomarico 2019

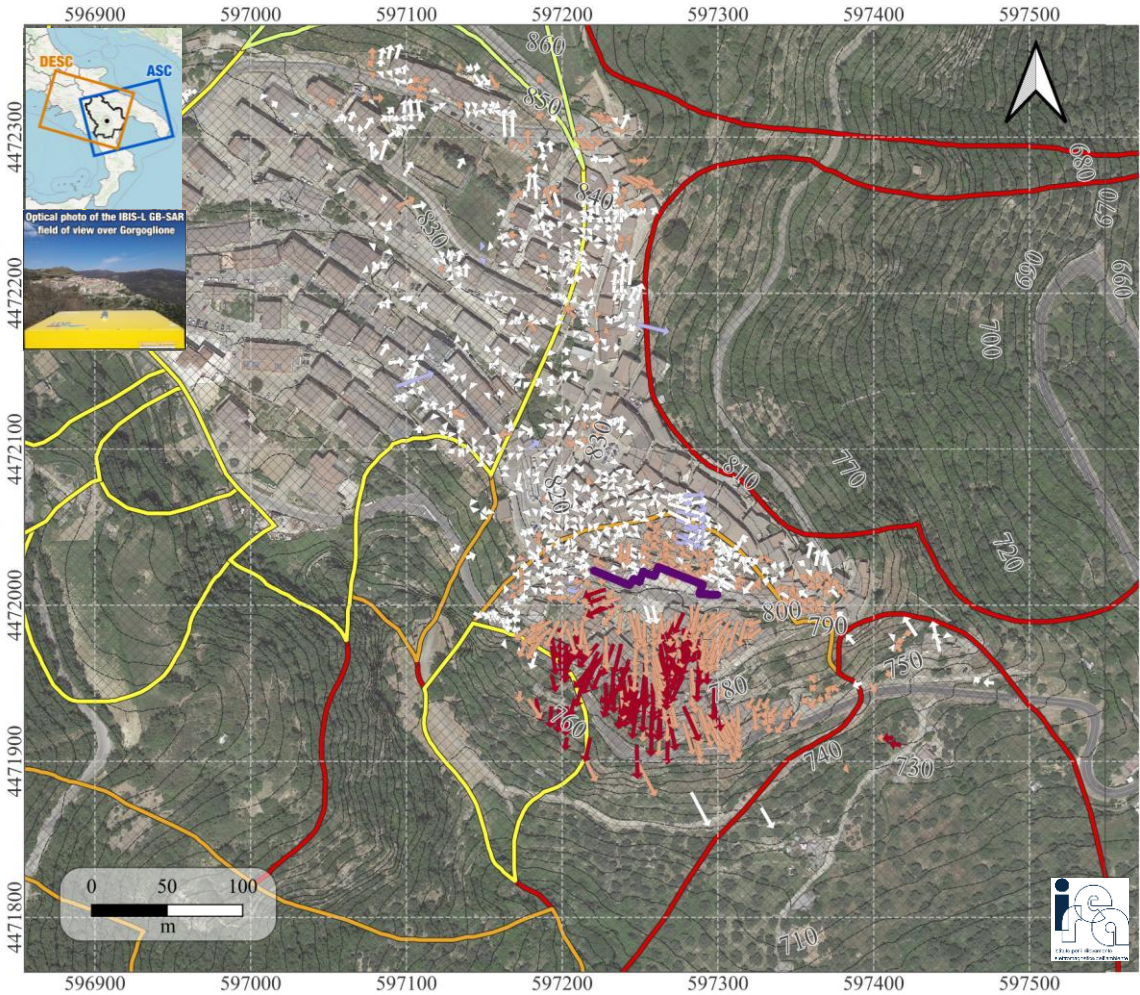


Maratea 2022

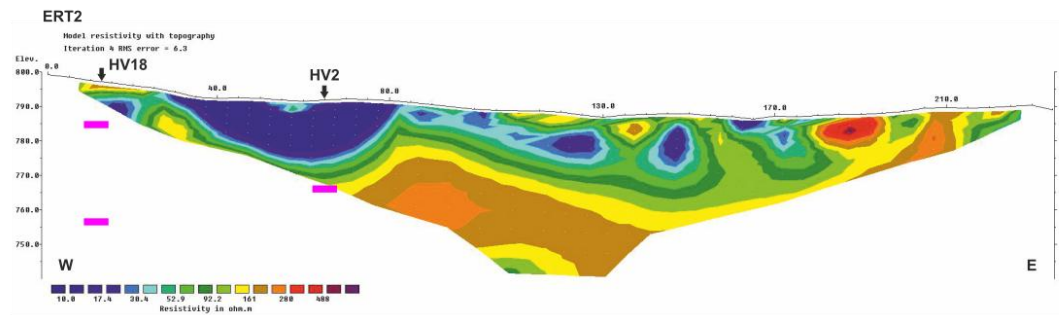
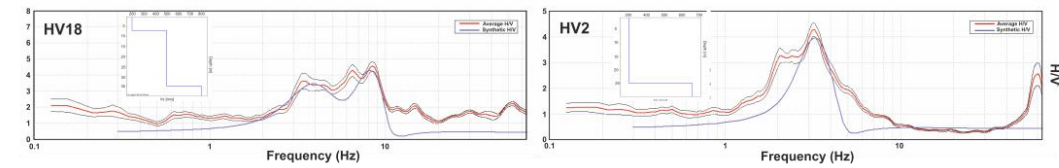
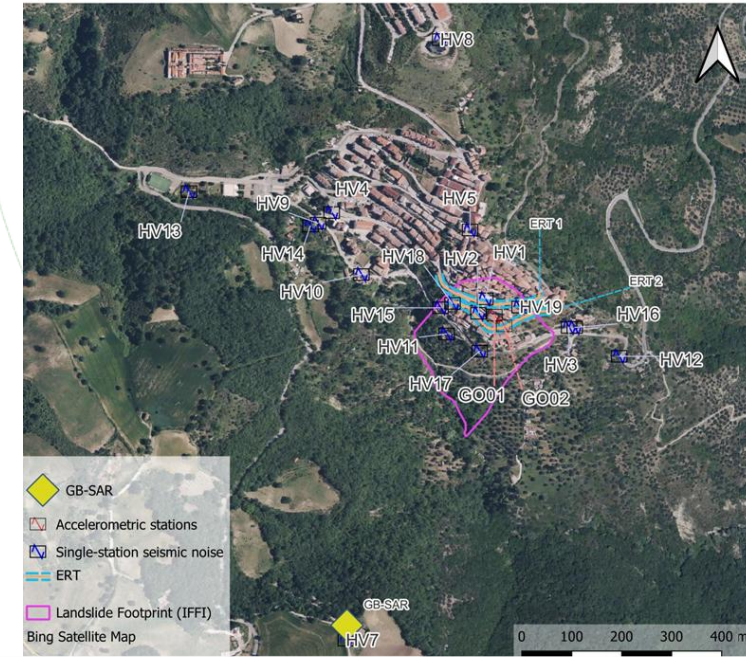
# In situ geophysical techniques and landslides



# Gorgoglione (Basilicata, Italy) urban landslide

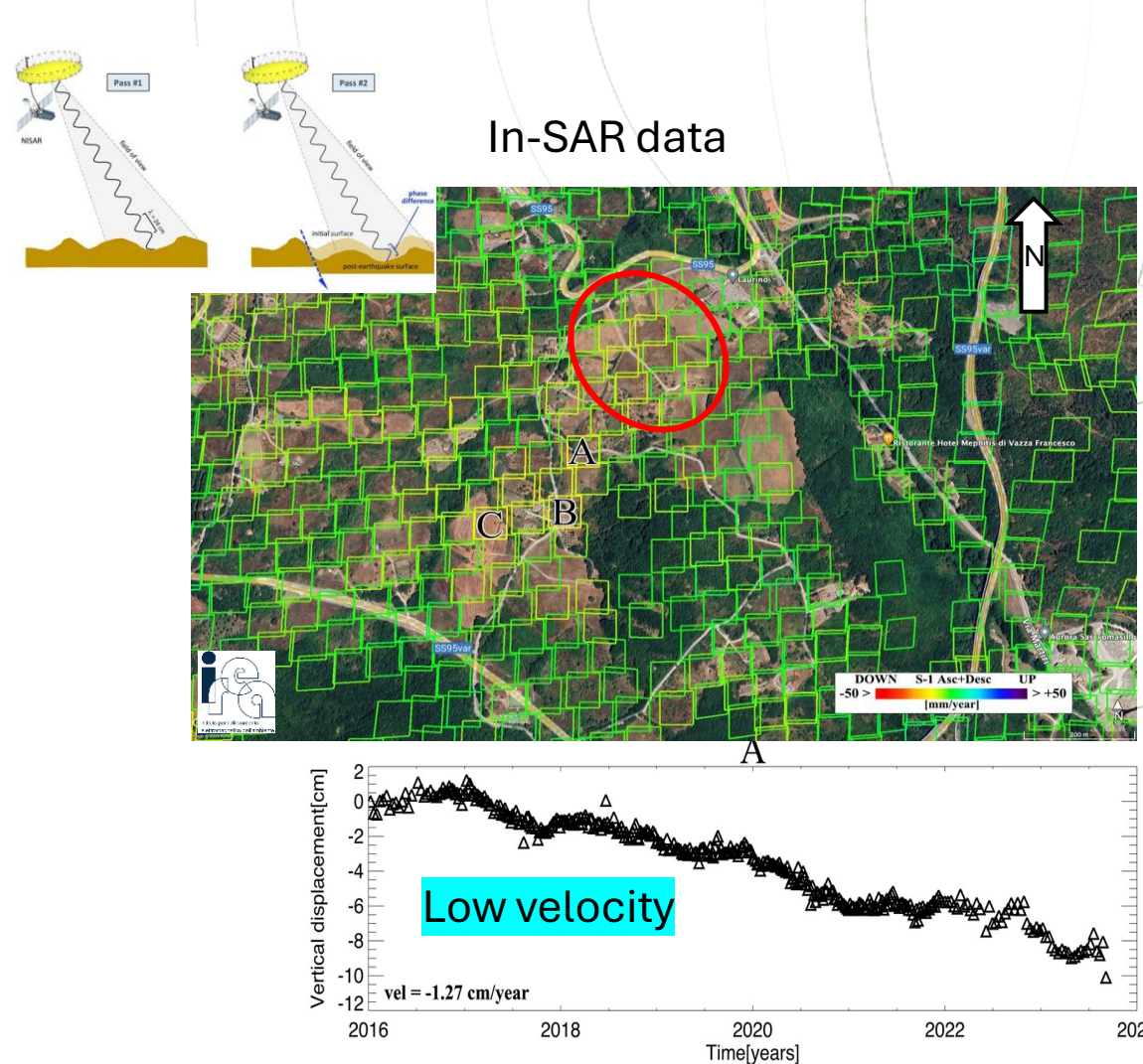
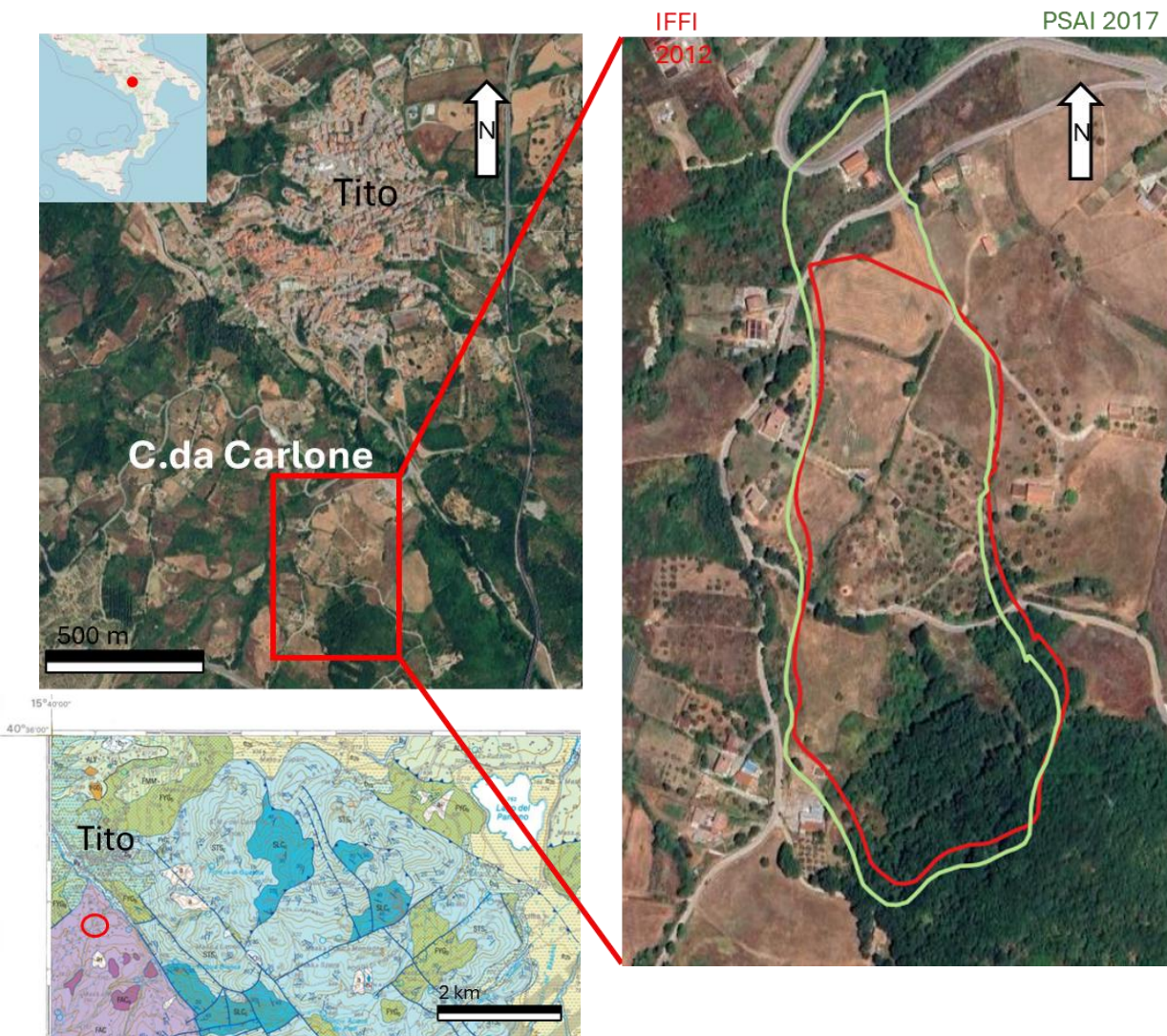


Falabella et al., 2024 -ISPRS

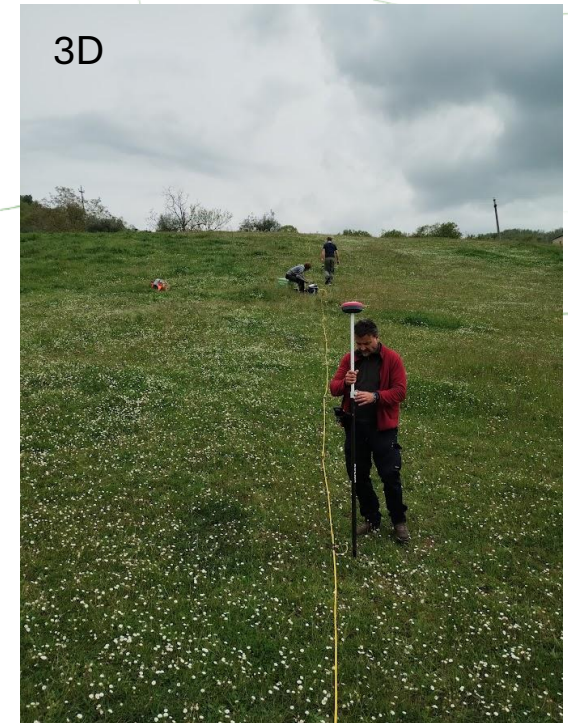
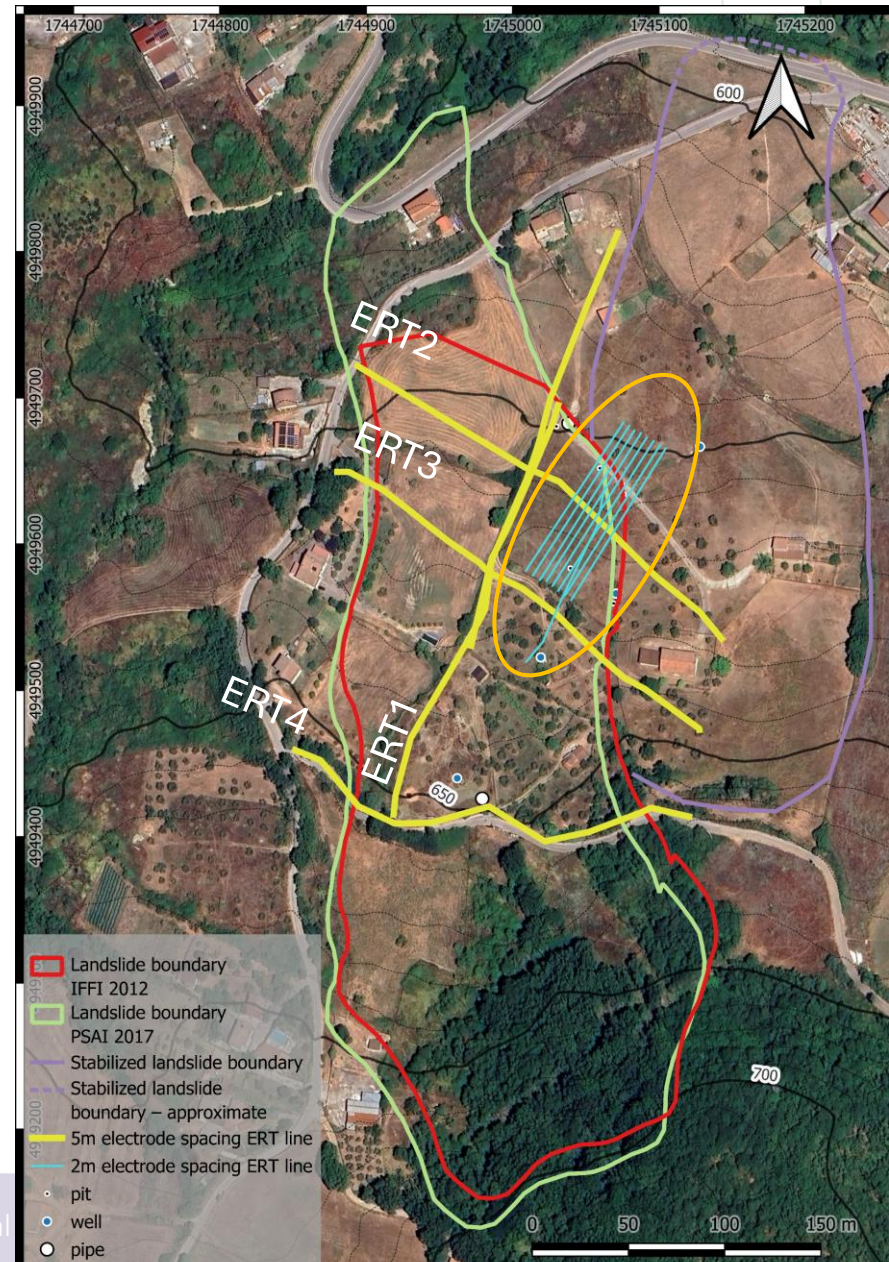


## Carlone landslide in Tito (Basilicata, Italy): case study of ITINERIS Project

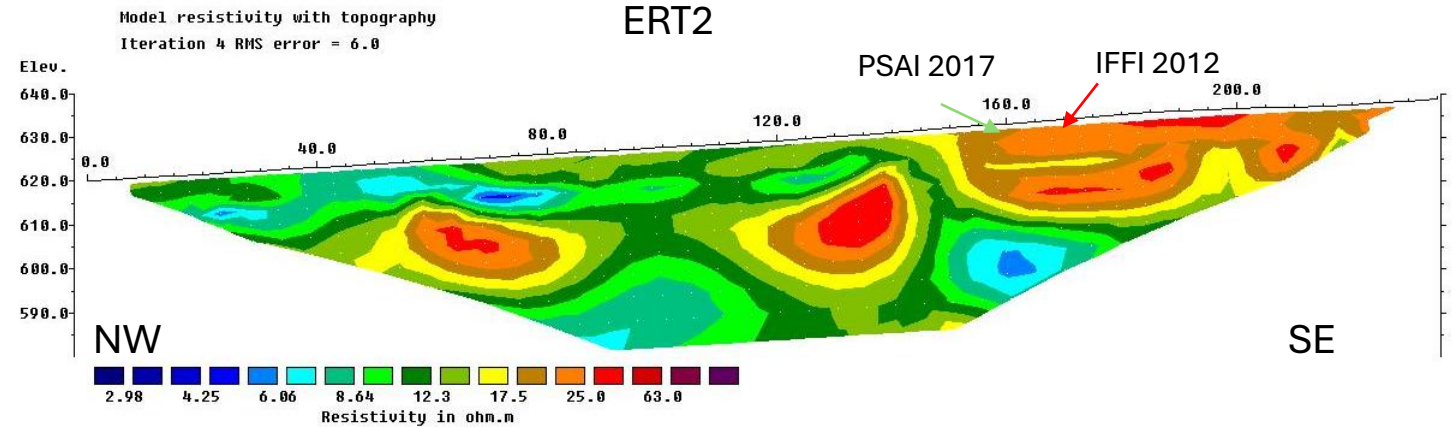
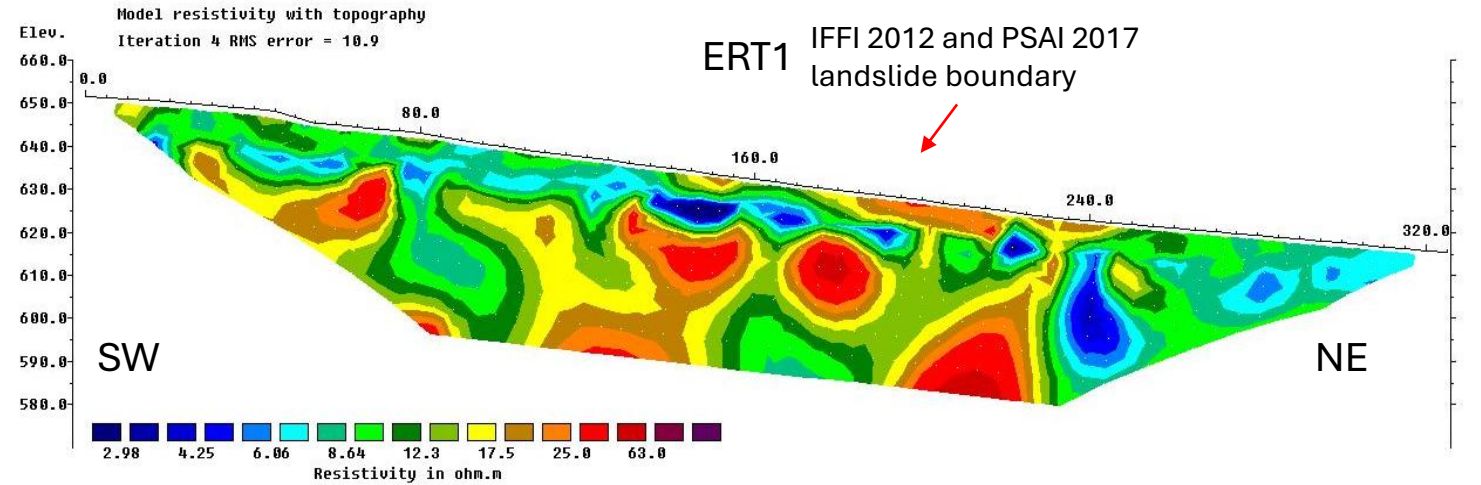
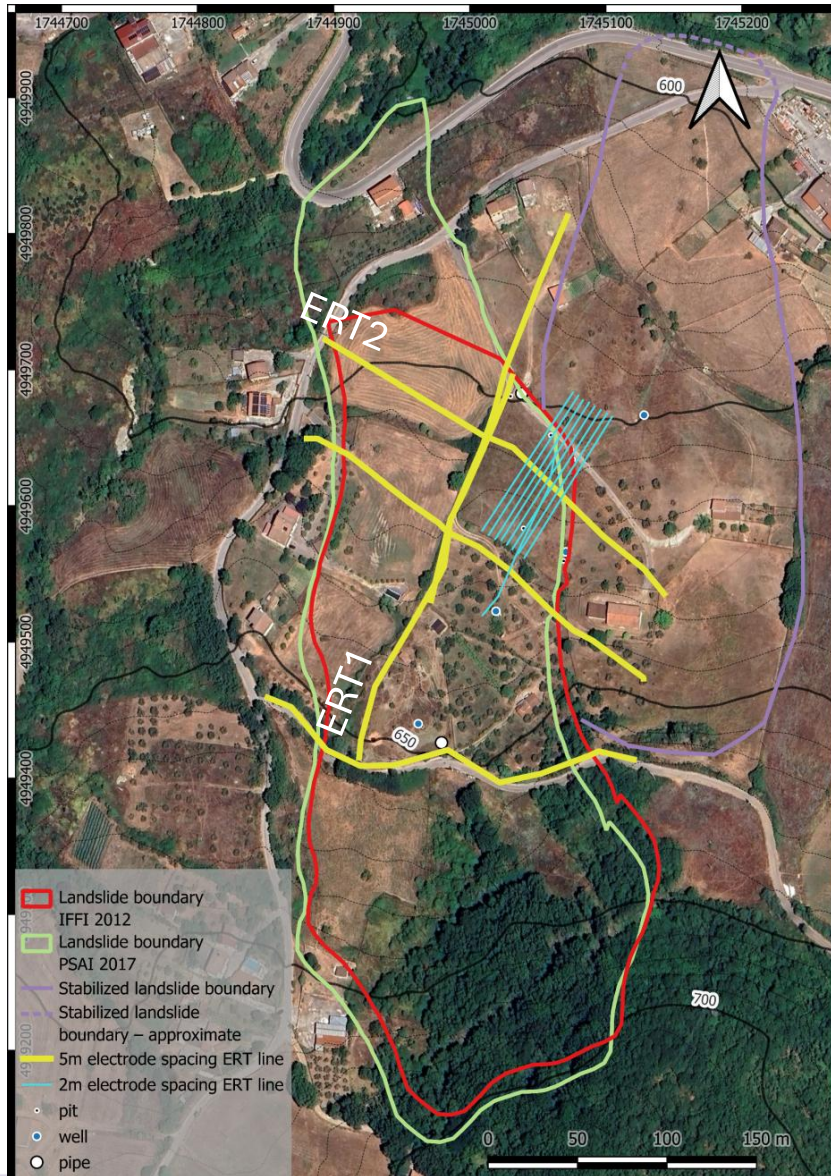
# Satellite SAR interferometry



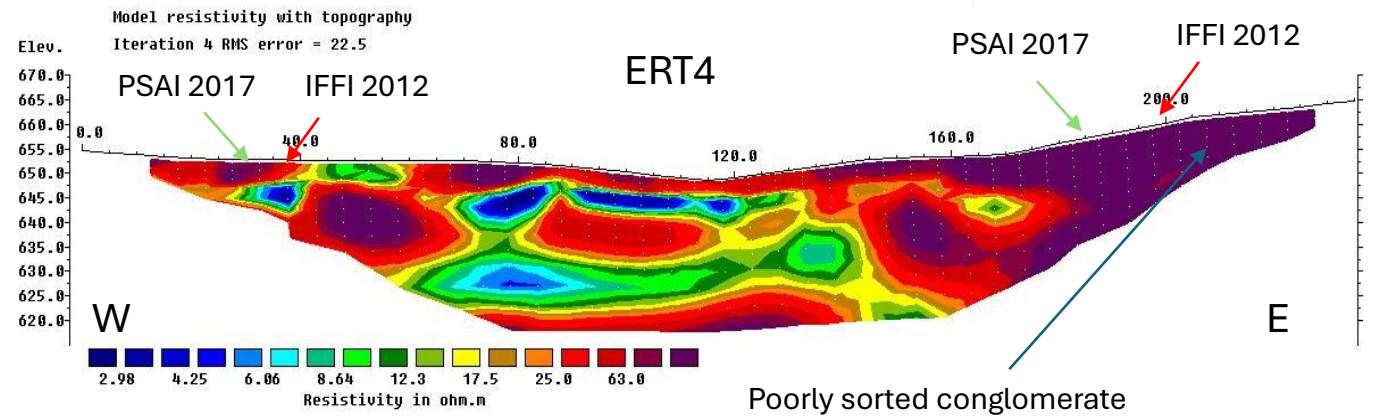
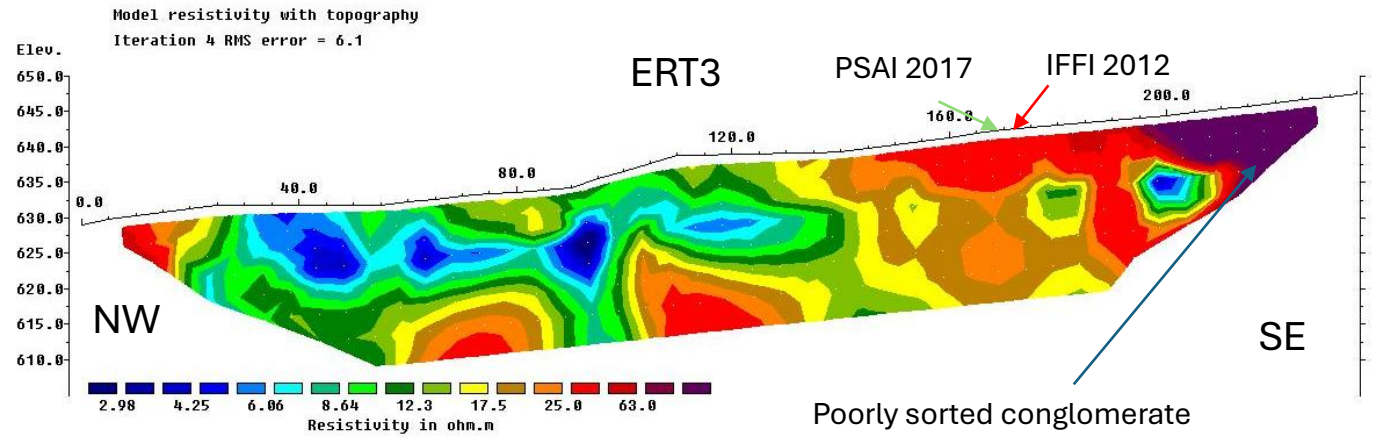
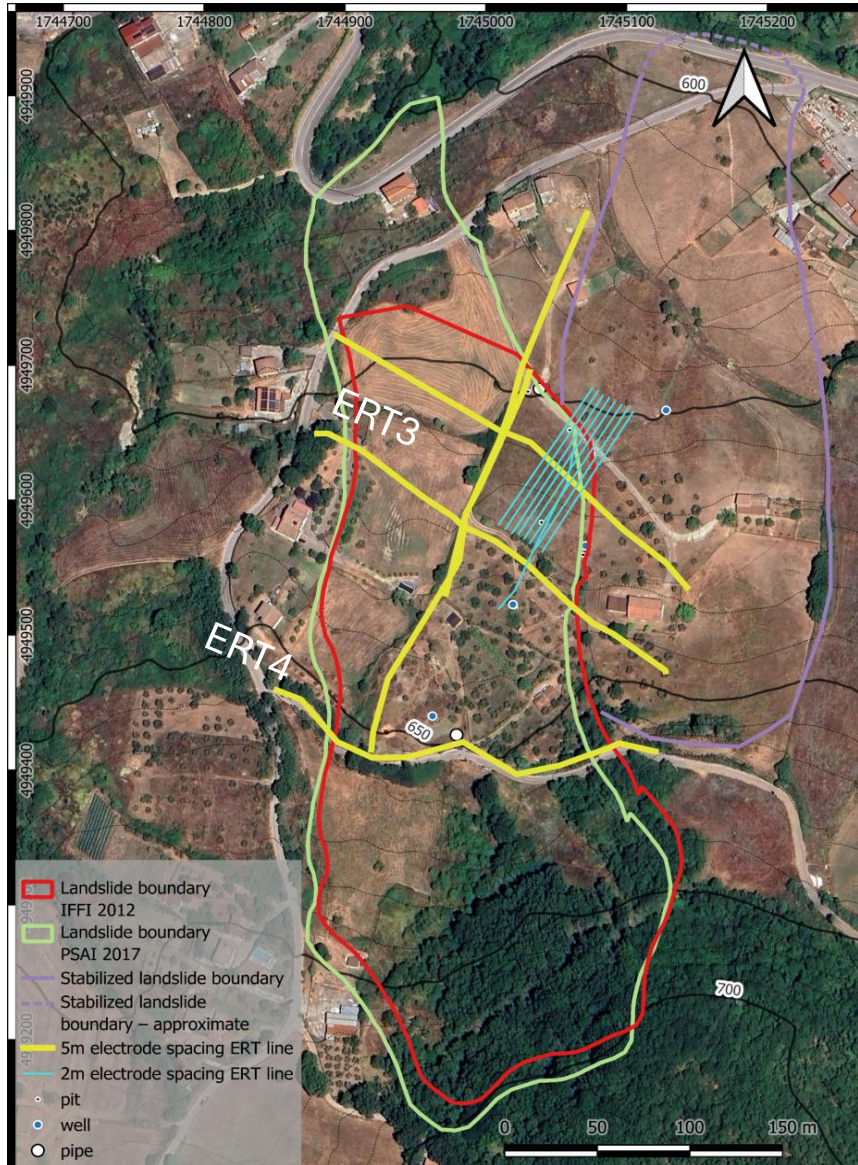
# In situ geophysical survey: electrical resistivity tomographies (ERT)



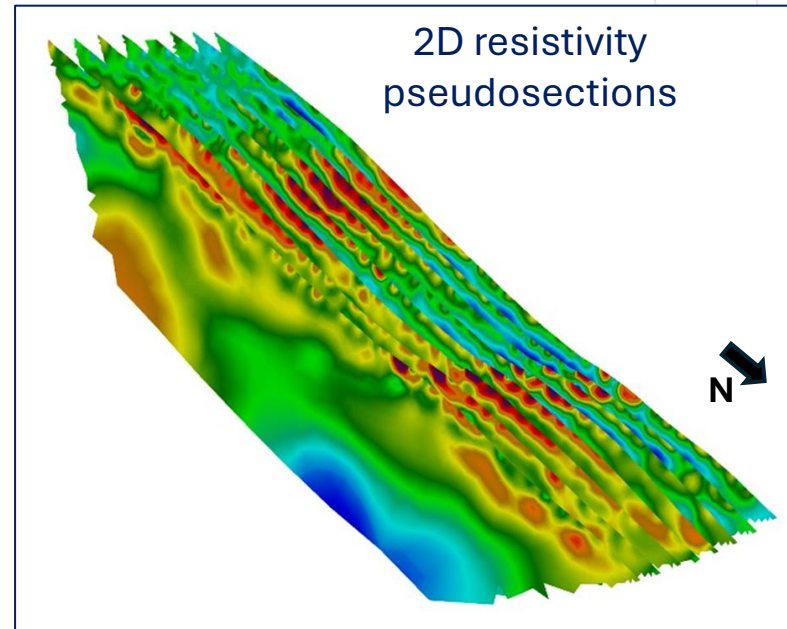
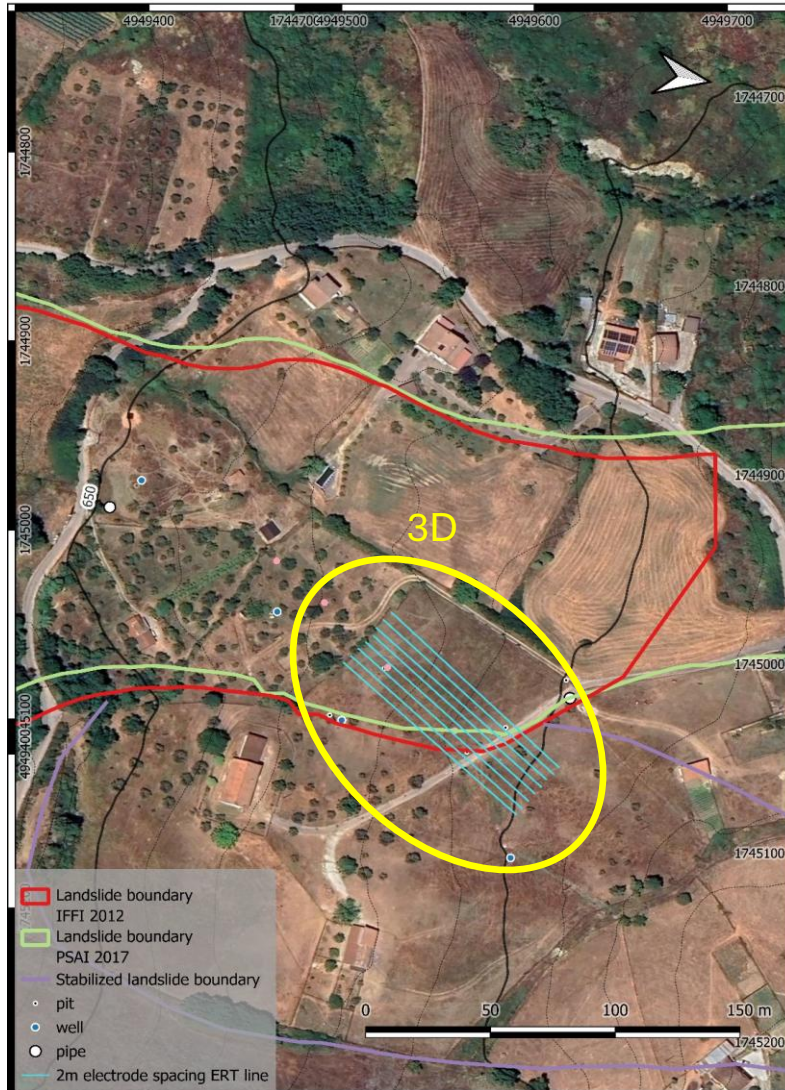
# 2D electrical resistivity tomography



# 2D electrical resistivity tomography



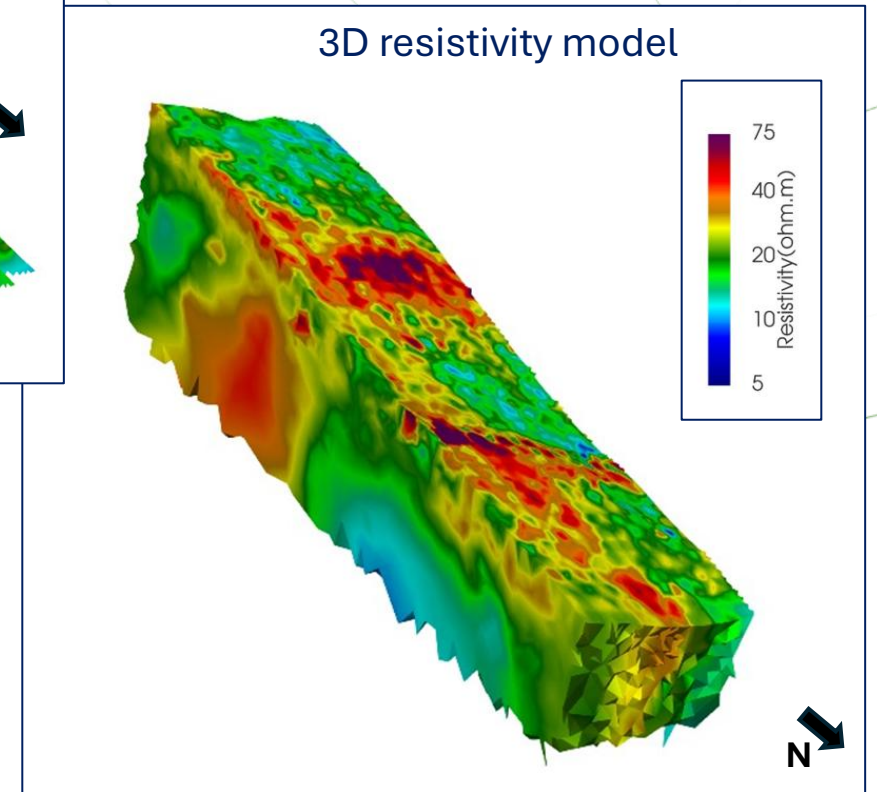
# 3D electrical resistivity model



2D resistivity pseudosections

Electrical resistivity acquired data

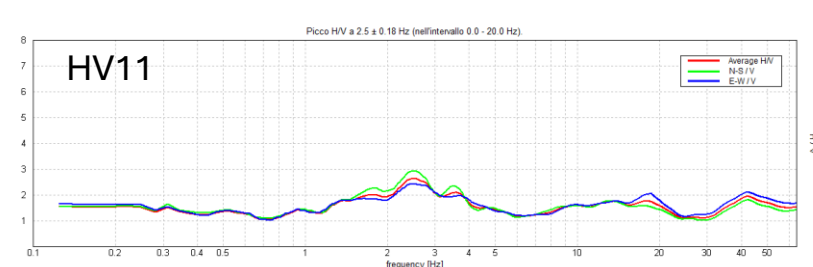
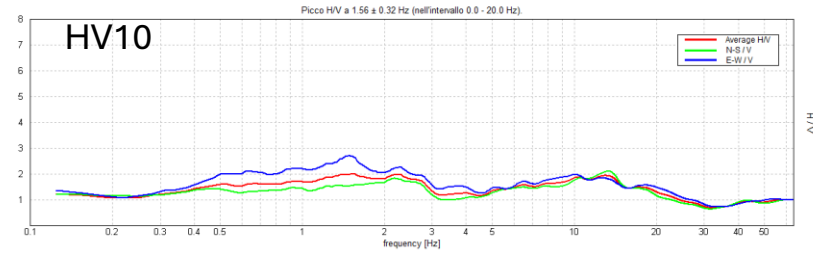
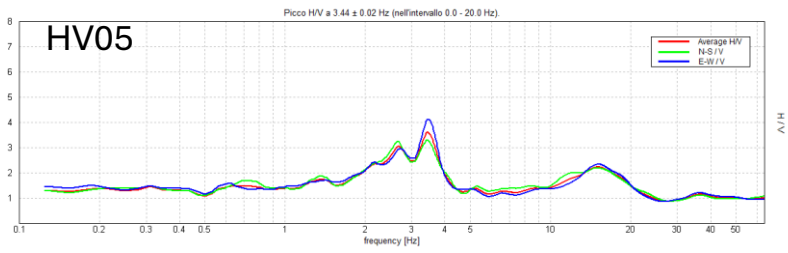
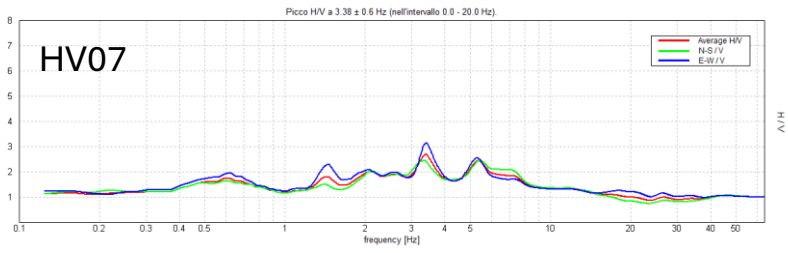
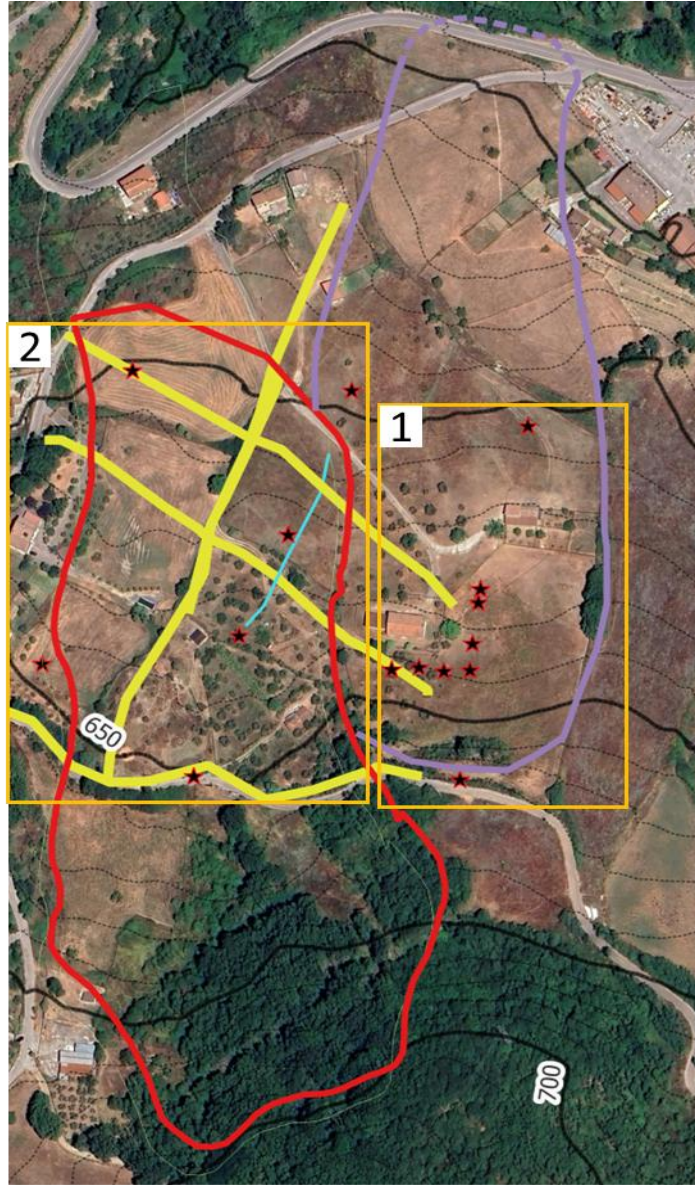
N.8 Electrical resistivity tomographies  
Array: Dipole-dipole  
Electrode spacing: 2m  
Investigation depth: 10 m



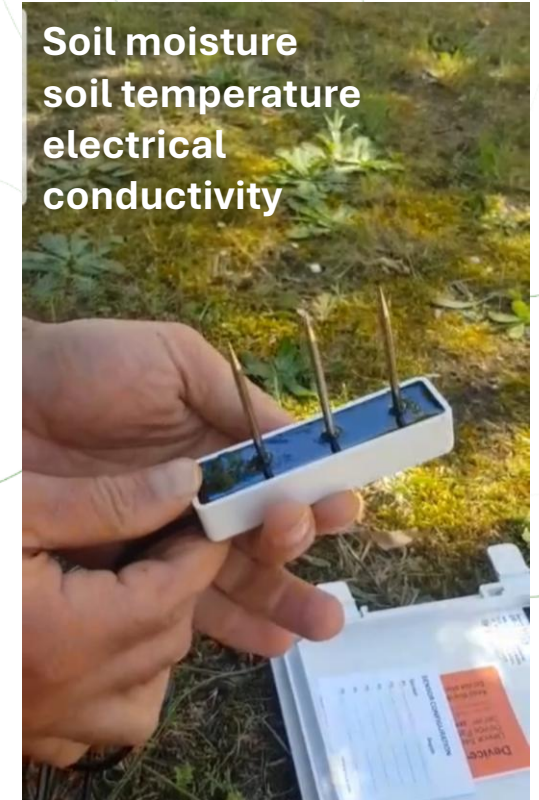
3D resistivity model

Electrical resistivity inverted data

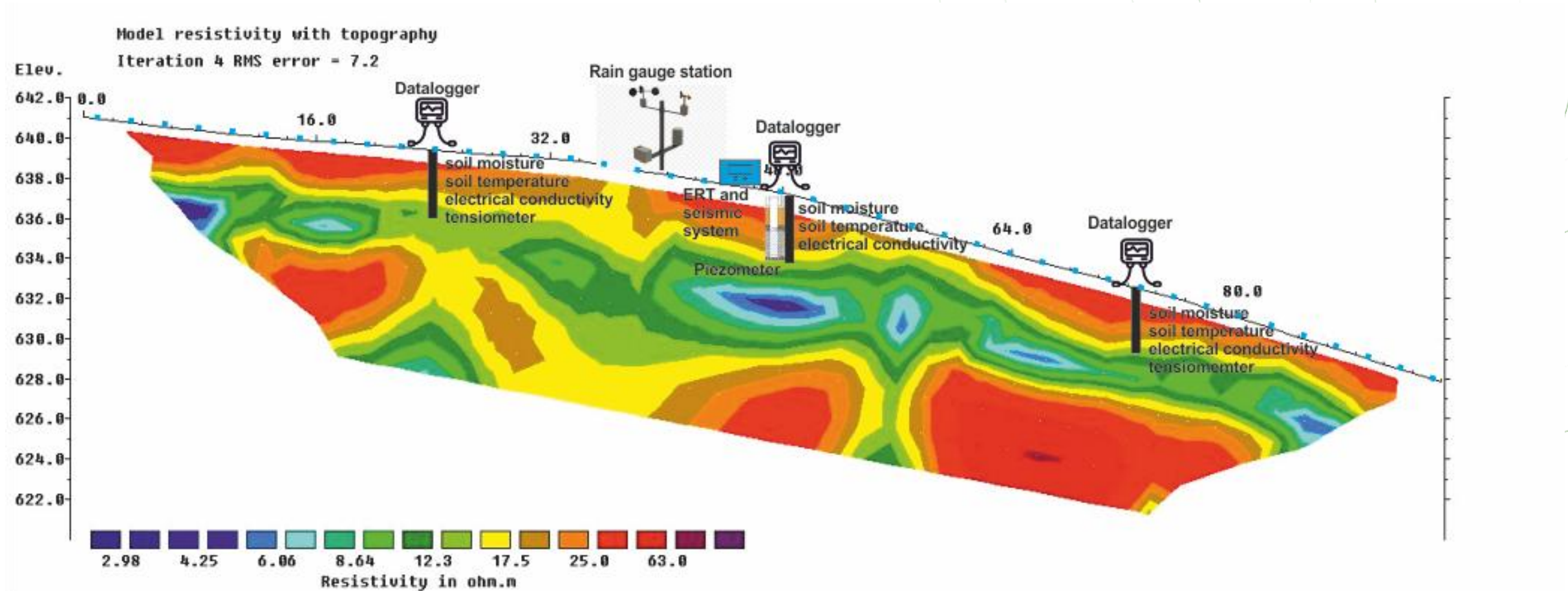
# Passive seismic measurements



# Hydrological sensors...to be installed



# Geophysical and hydrological monitoring system



Petrophysical relationships between direct data (e.g. soil moisture) and geophysical data (e.g. electrical resistivity)



# THANKS!

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# Un nuovo approccio per la valutazione del rischio sismico per l'area urbana della città di Potenza

Giovanni Gangone <sup>1,2</sup>, Maria Rosaria Gallipoli <sup>1</sup>, Marco Vona <sup>2</sup>

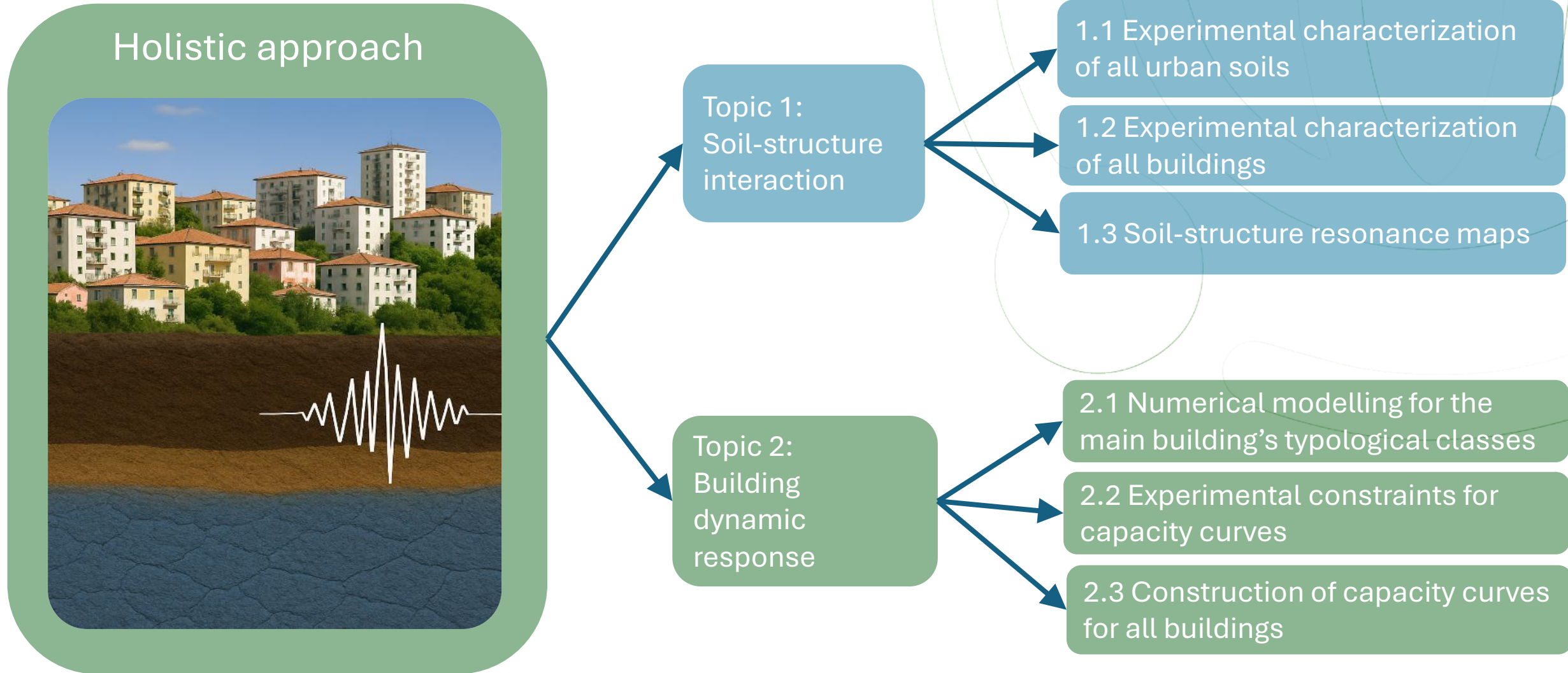
<sup>1</sup> *National Research Council of Italy (CNR-IMAA), Tito Scalo (PZ), Italy*

<sup>2</sup> *Department of Structures, Geotechnics and Geology Applied to Engineering, University of Basilicata, Potenza, Italy*

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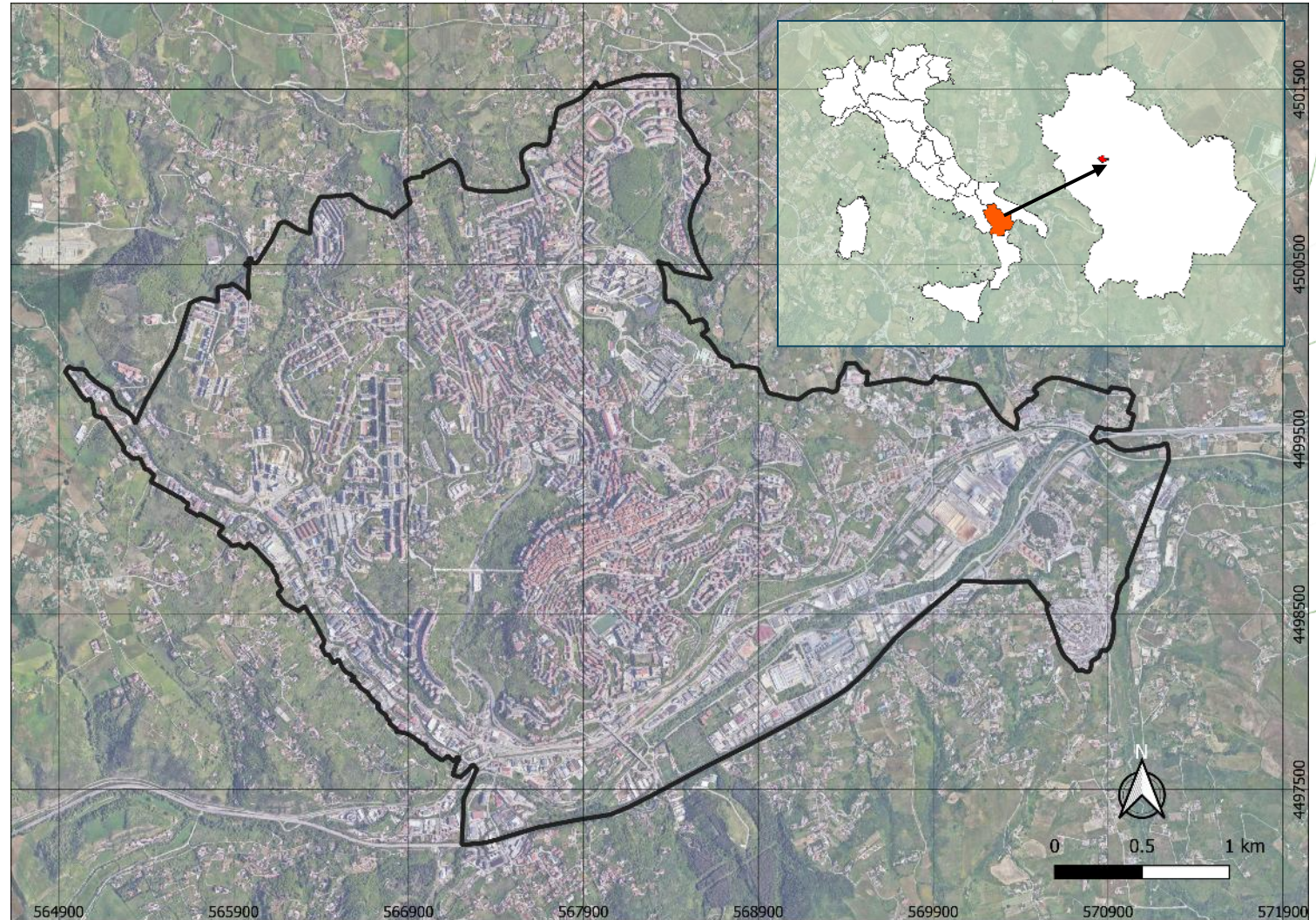


# SUMMARY - URBAN SEISMIC RISK

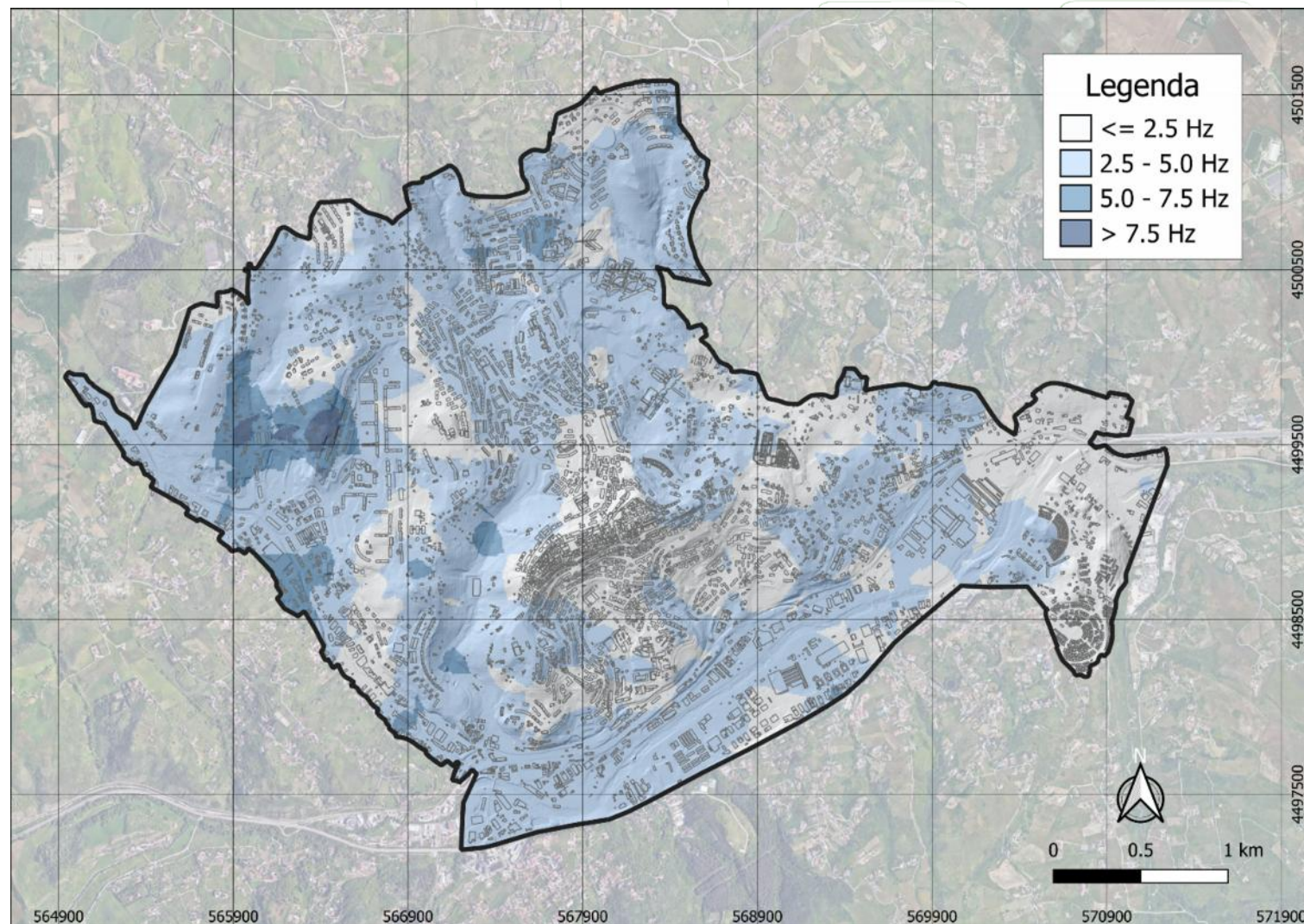
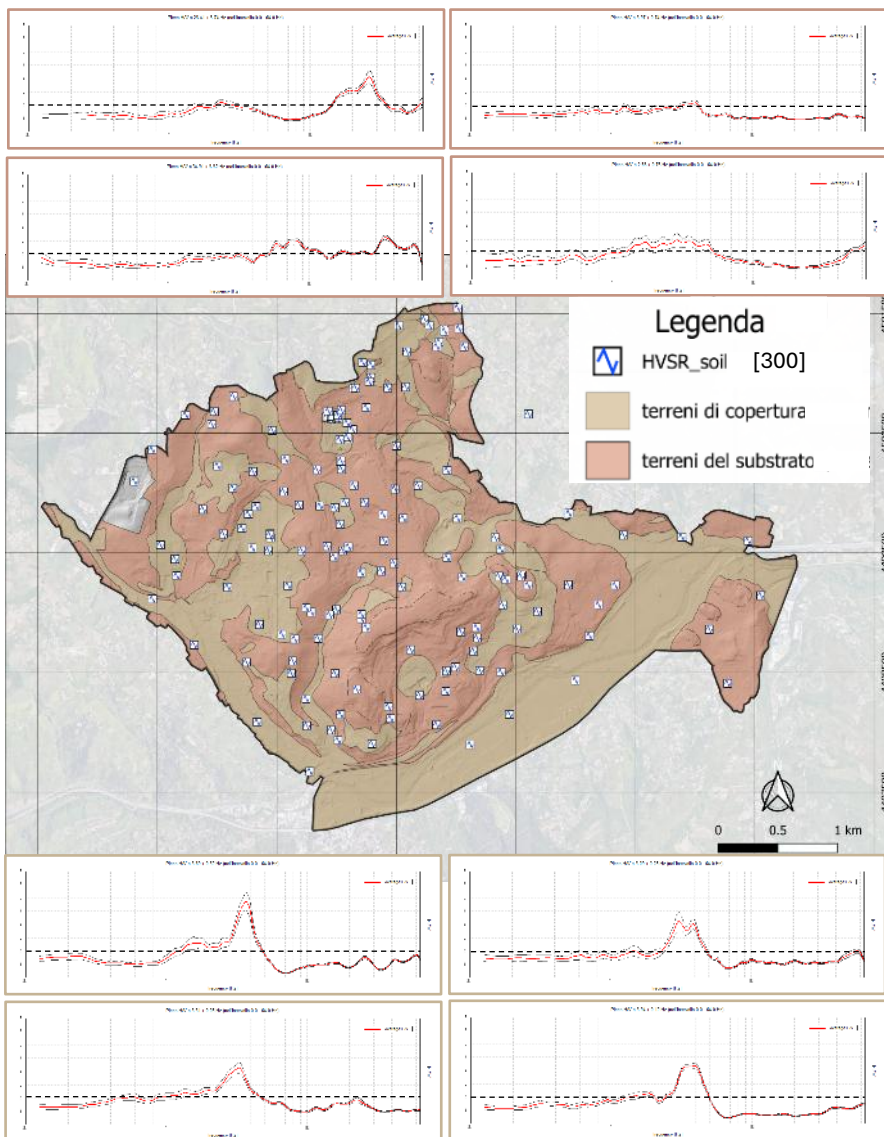


*“predict the effects of earthquakes to mitigate the impact”*

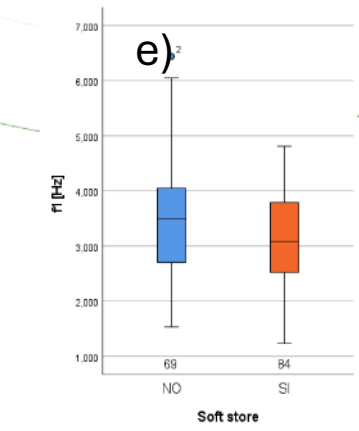
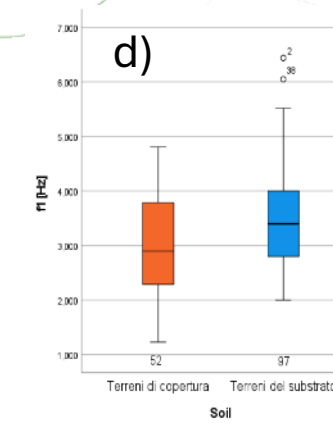
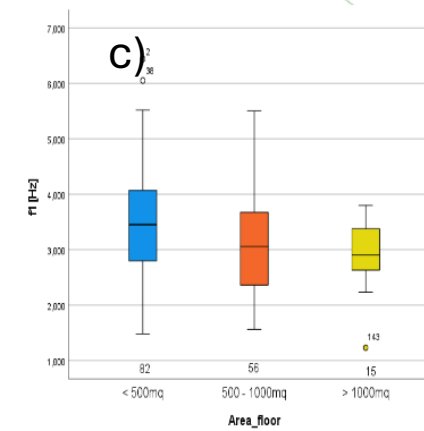
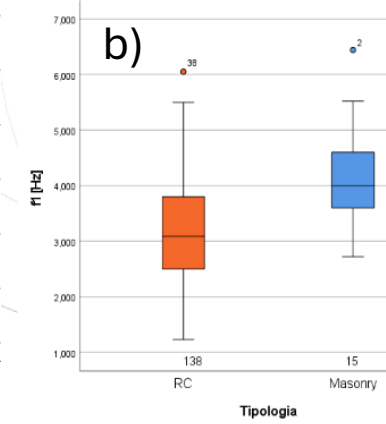
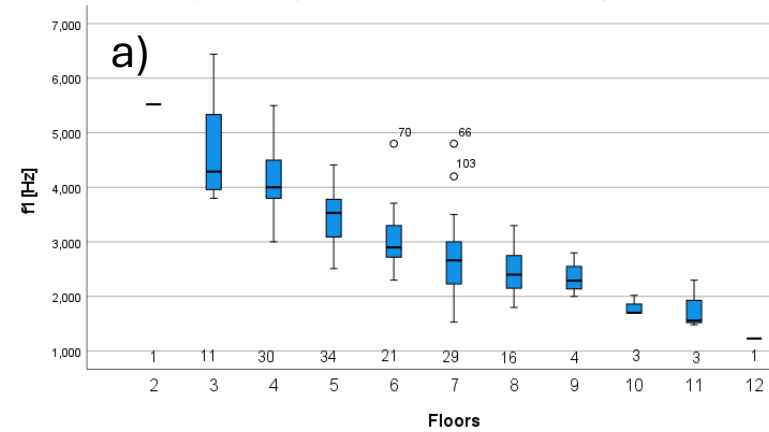
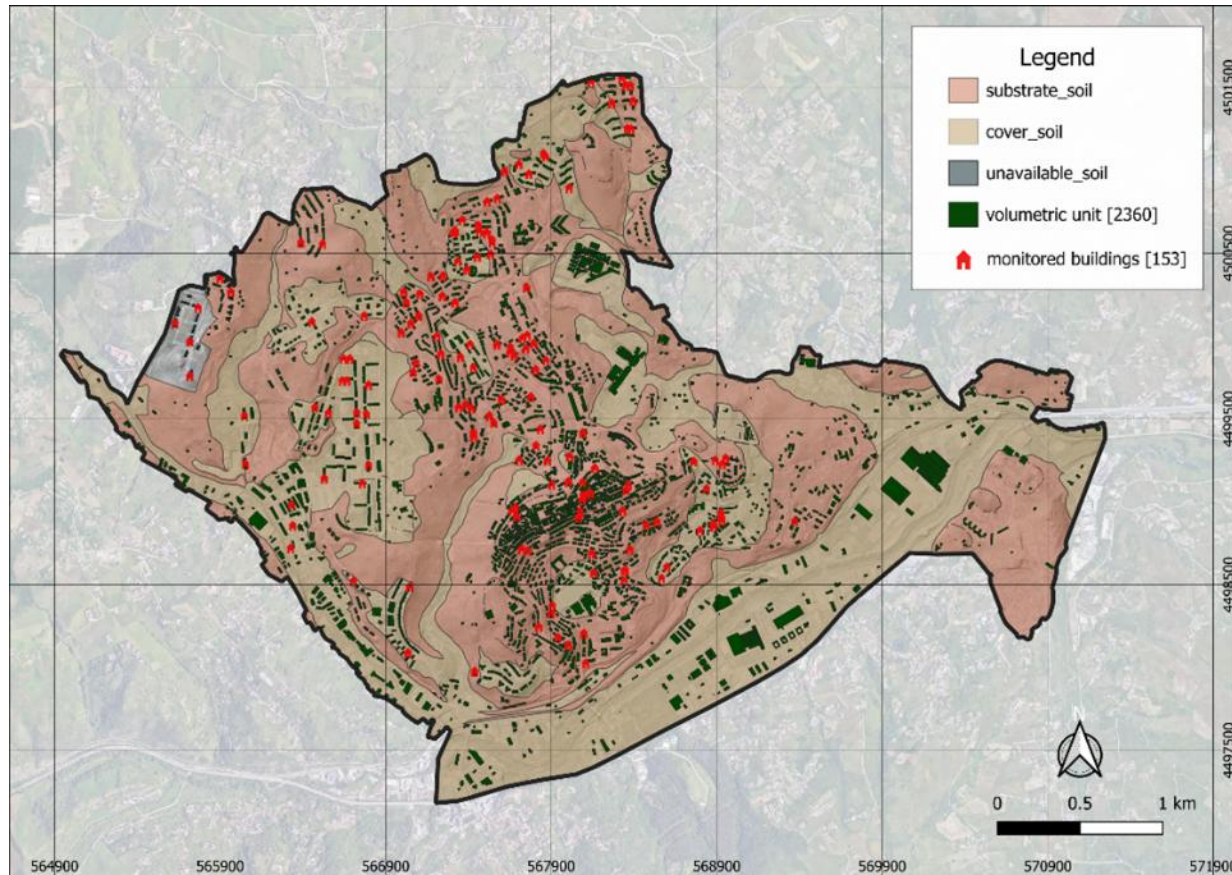
- Site Effects
- Building Behaviour
- Soil-Building Interaction



# HVSR soil surveys and isofrequency map

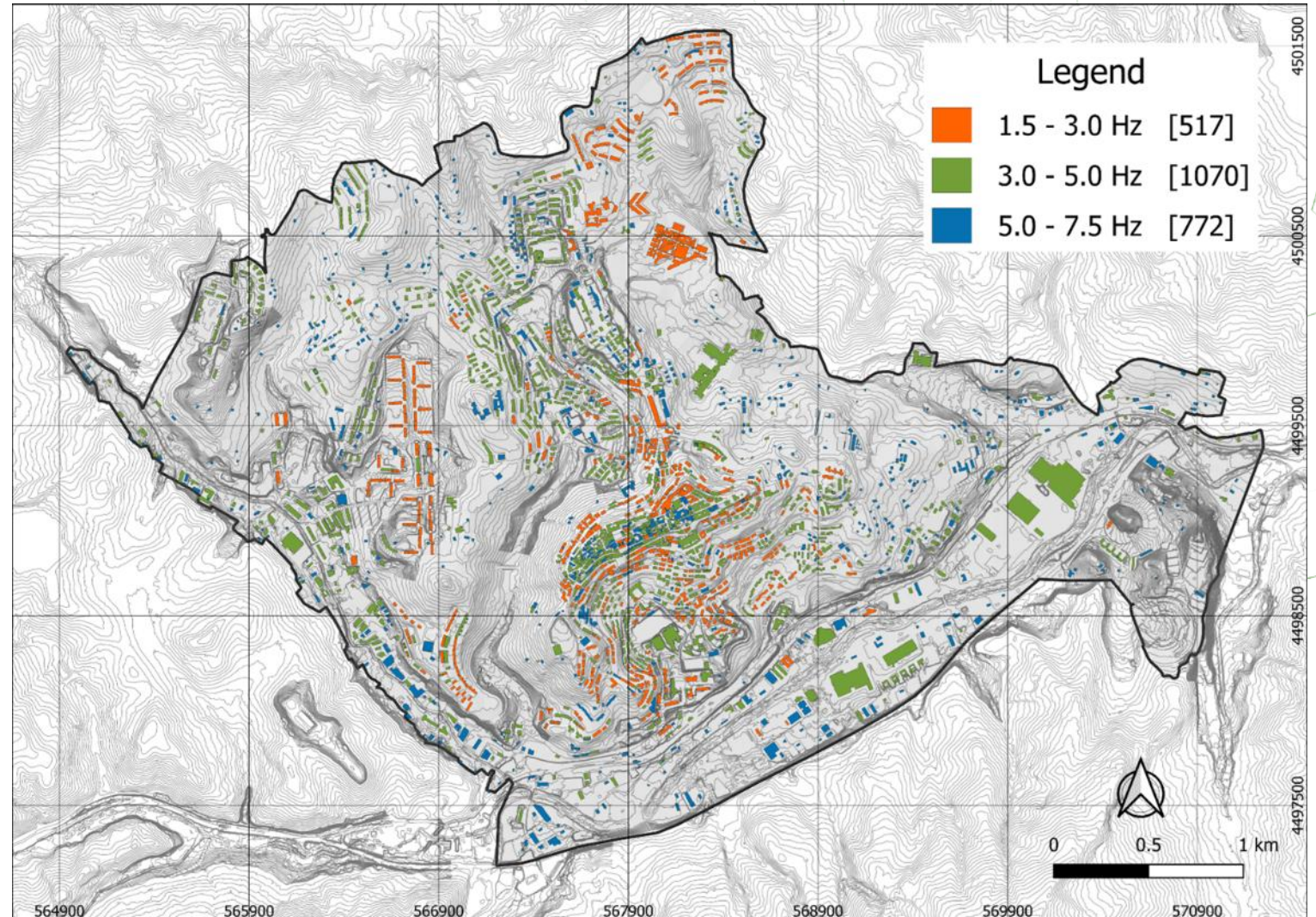
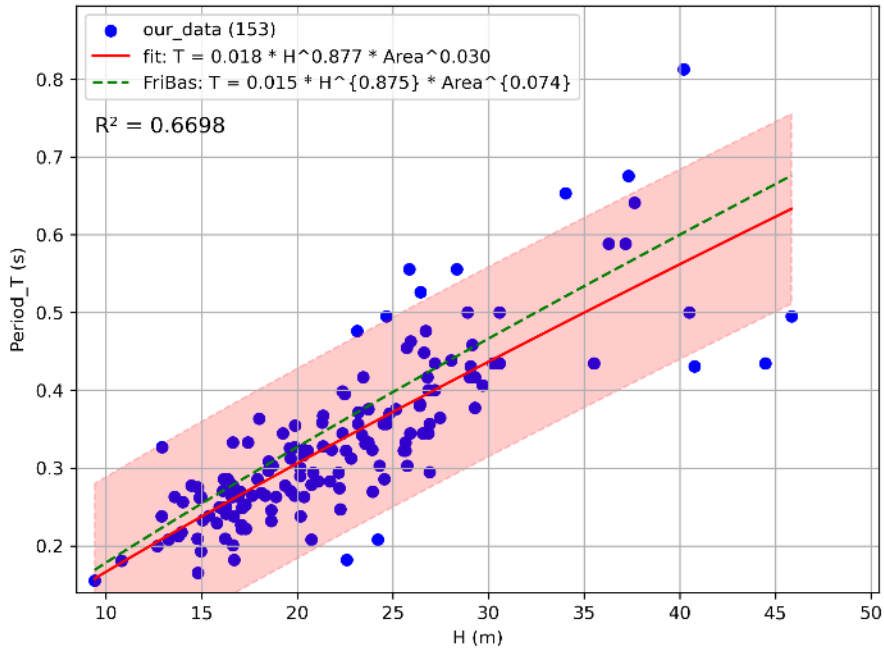


# HVSR building surveys and first results

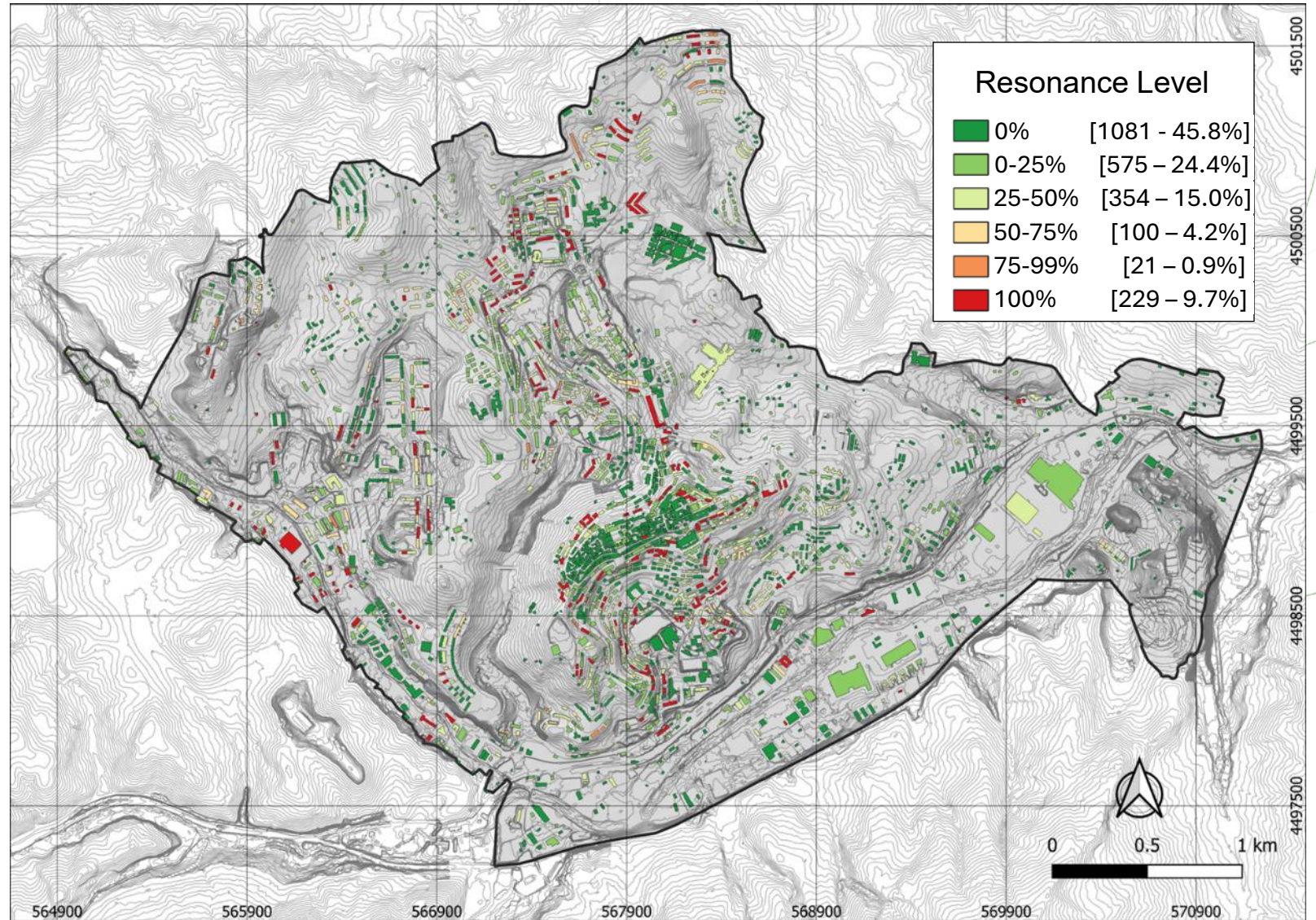
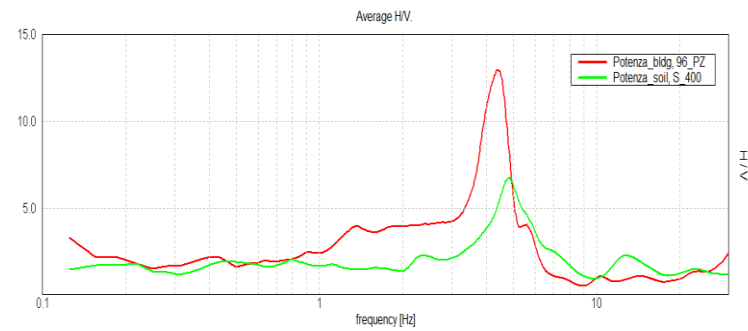


# Experimental relation and frequency of all buildings

$$T = 0.018 * H^{0.877} * A^{0.074}$$

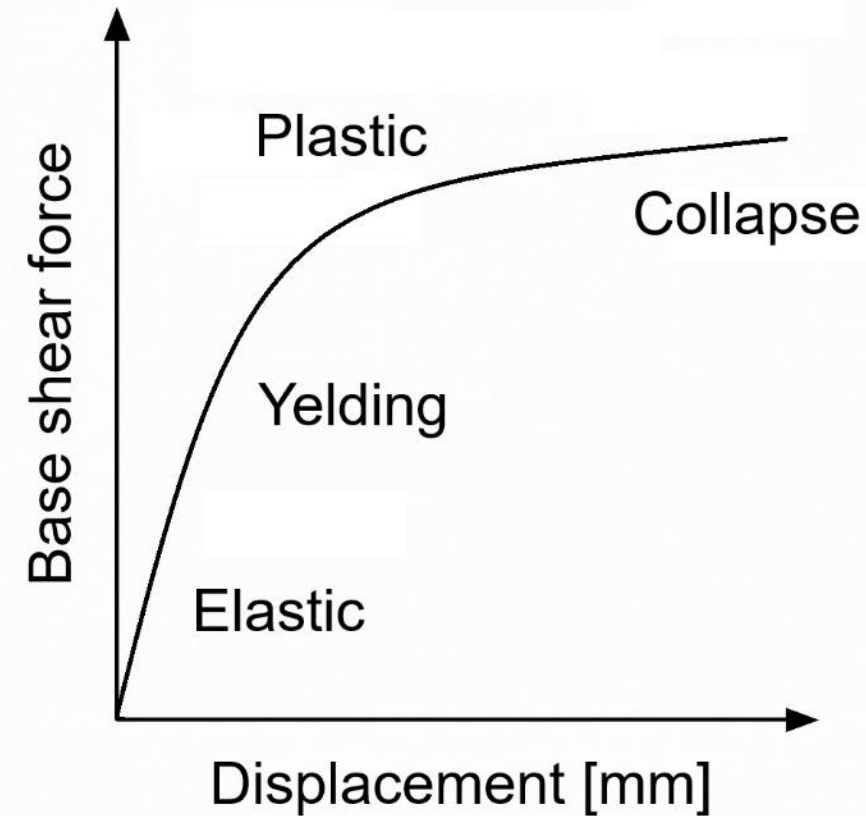
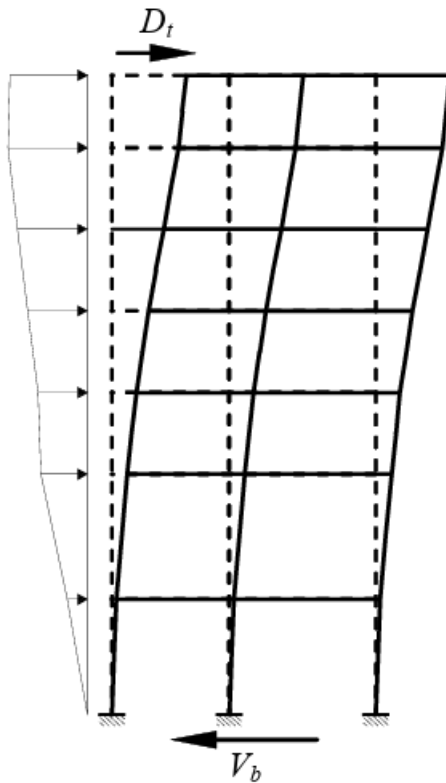


# Map of Soil-Building Resonance

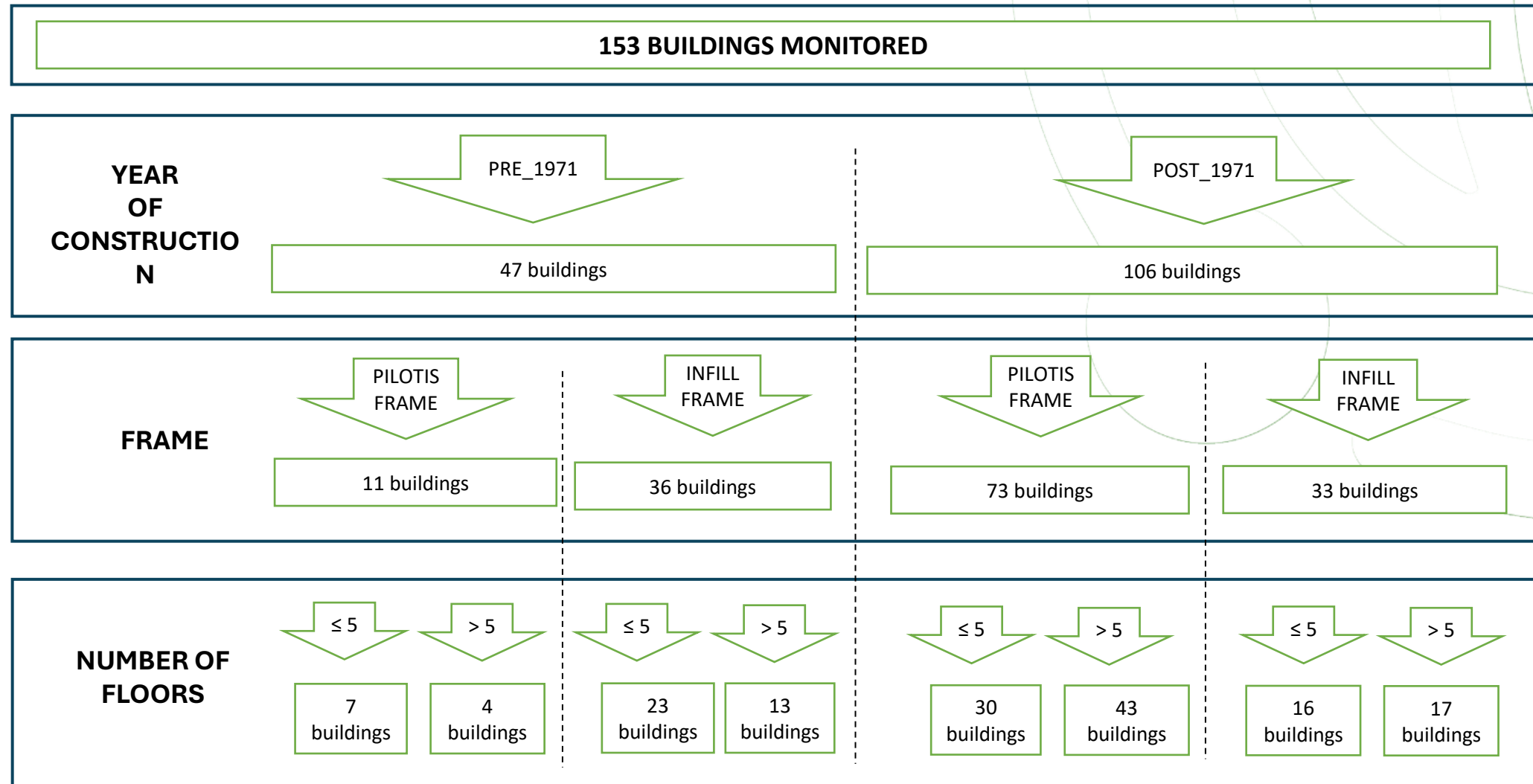


## Part 2: Capacity curve construction

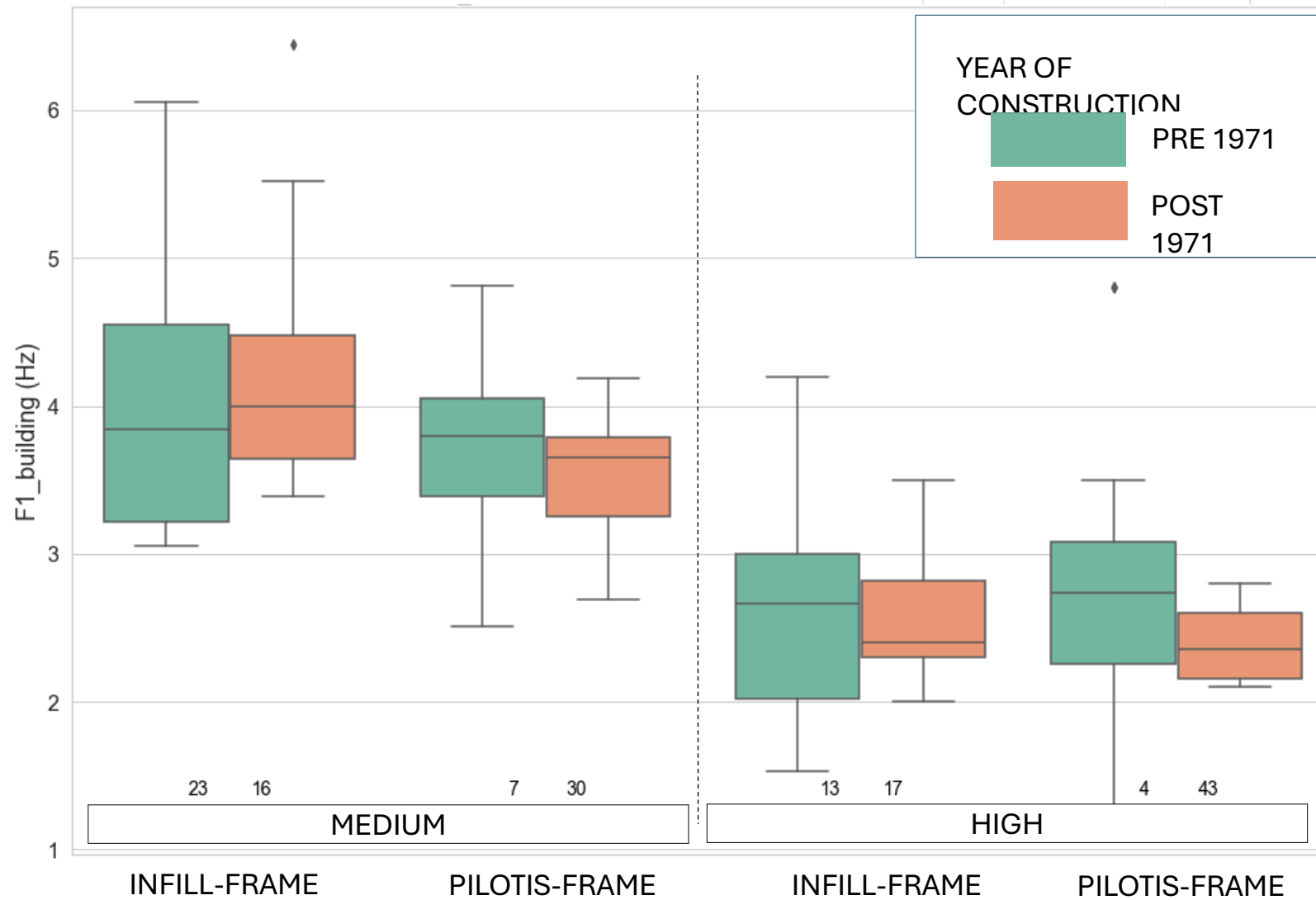
Capacity curves show the dynamic response of a building during seismic action.



# Grouping of buildings into typological classes



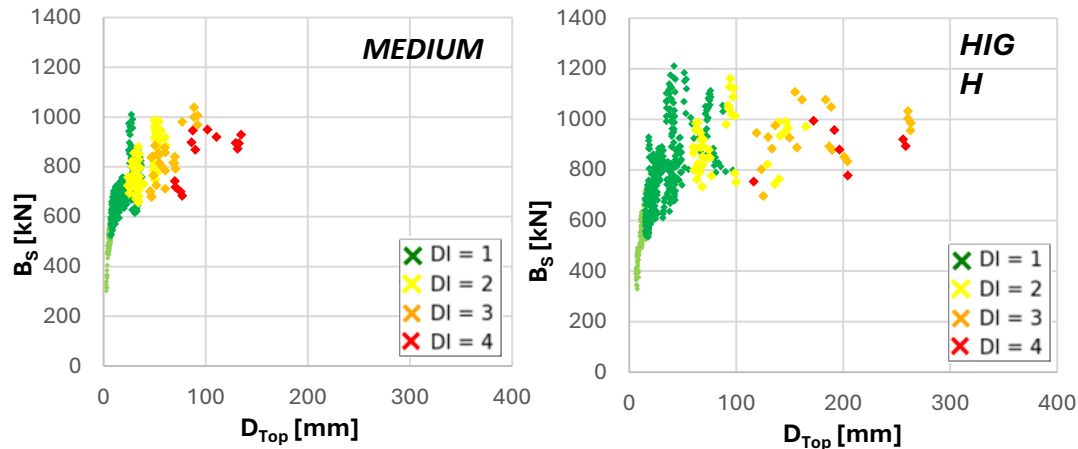
# Fundamental vibrational frequency for each building type class



# Building dynamic for each building type through numerical analyses

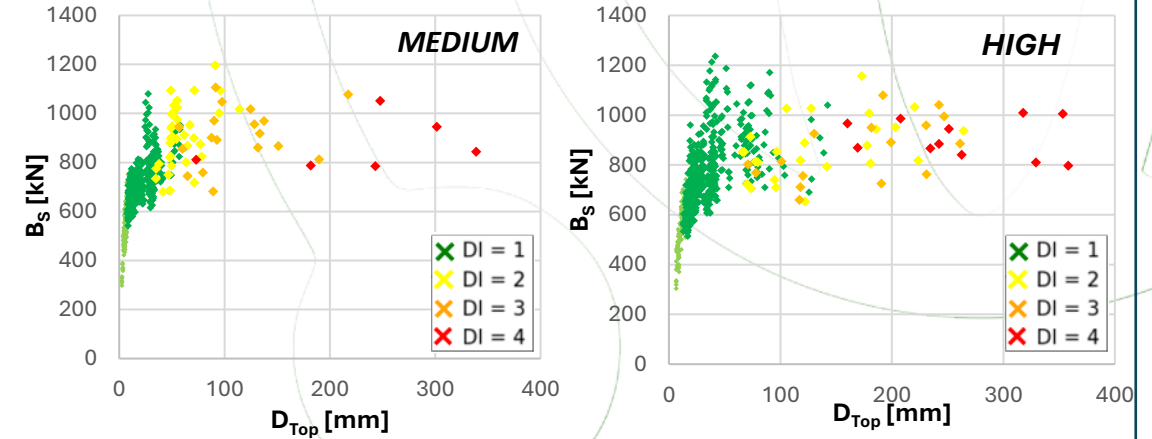
## PRE\_197

### INFILL-FRAME

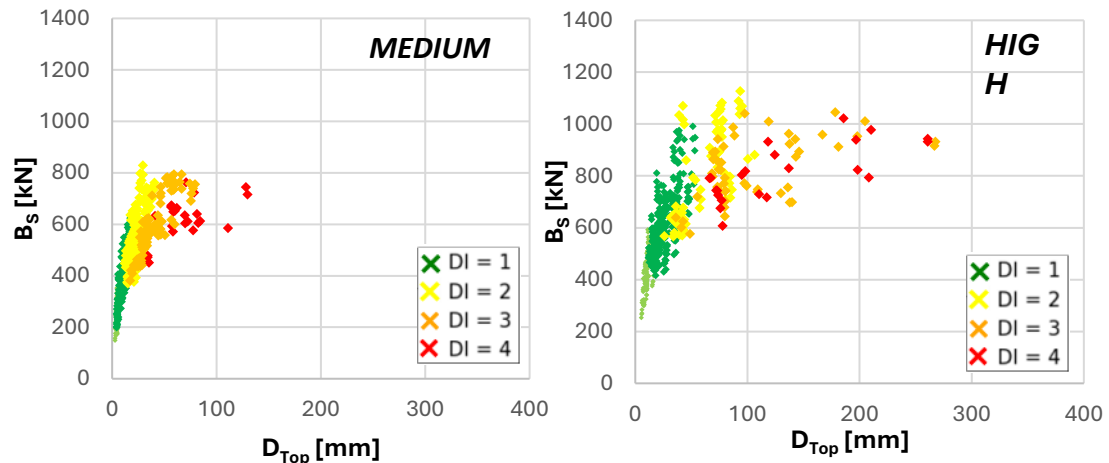


## POST\_1971

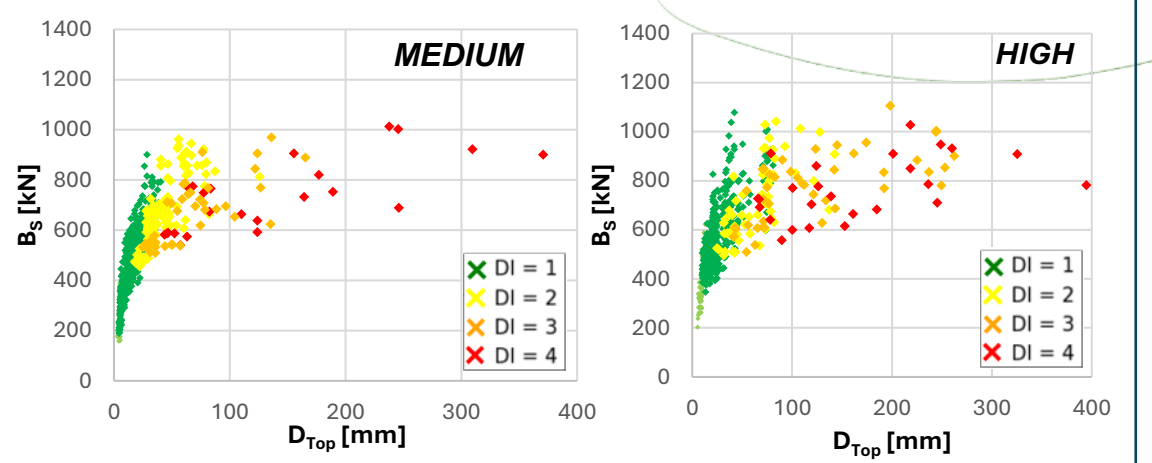
### INFILL-FRAME



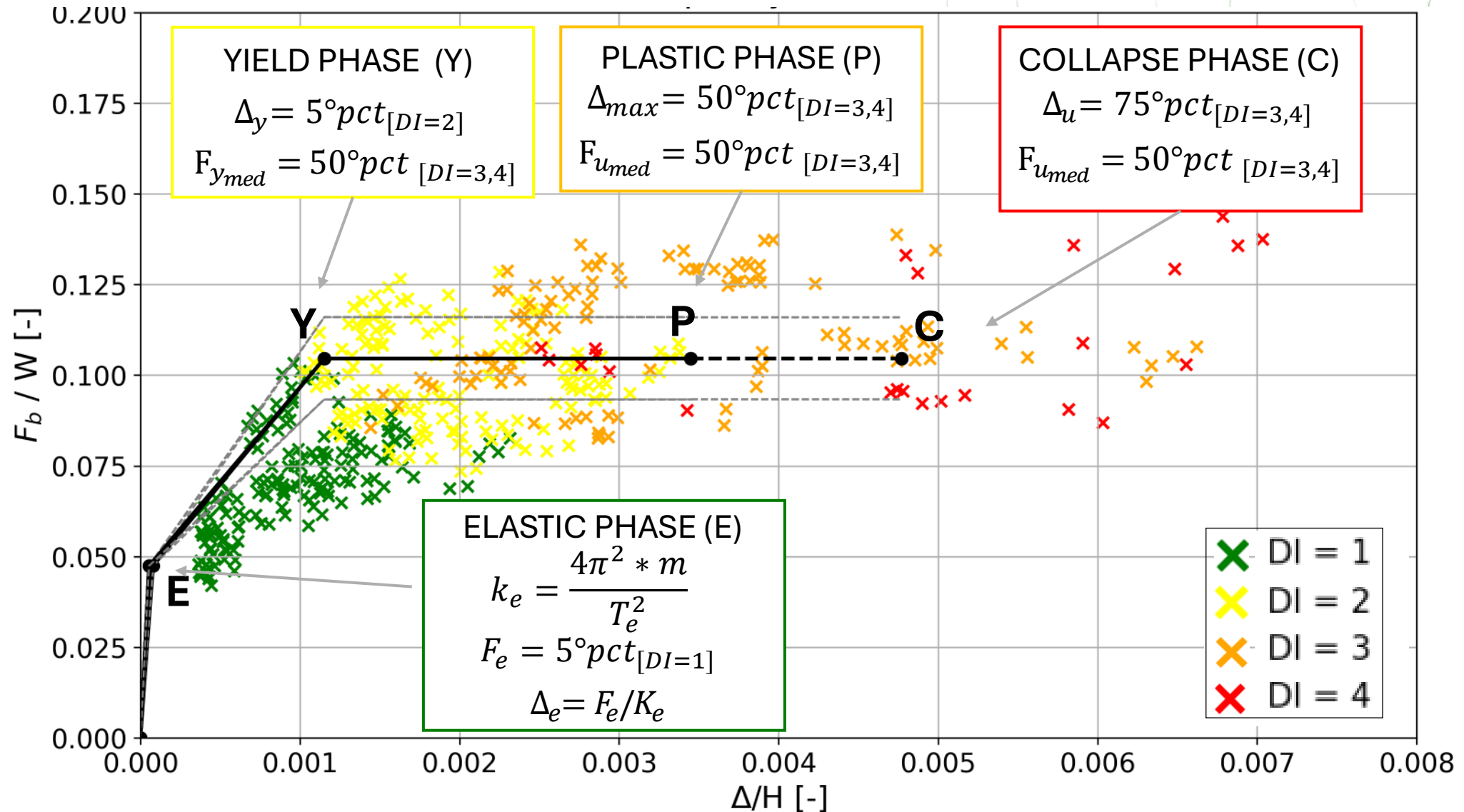
### PILOTIS-FRAME



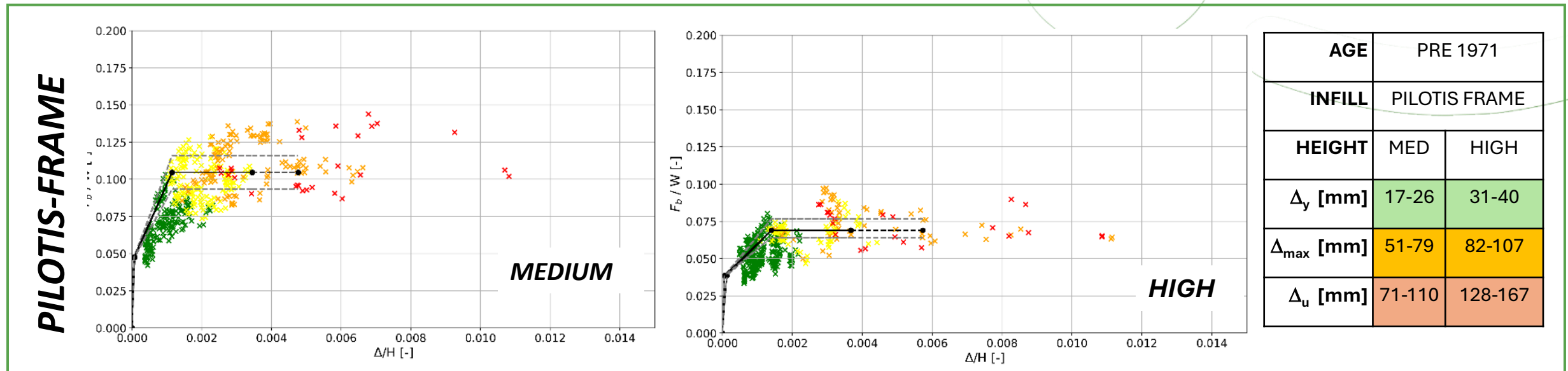
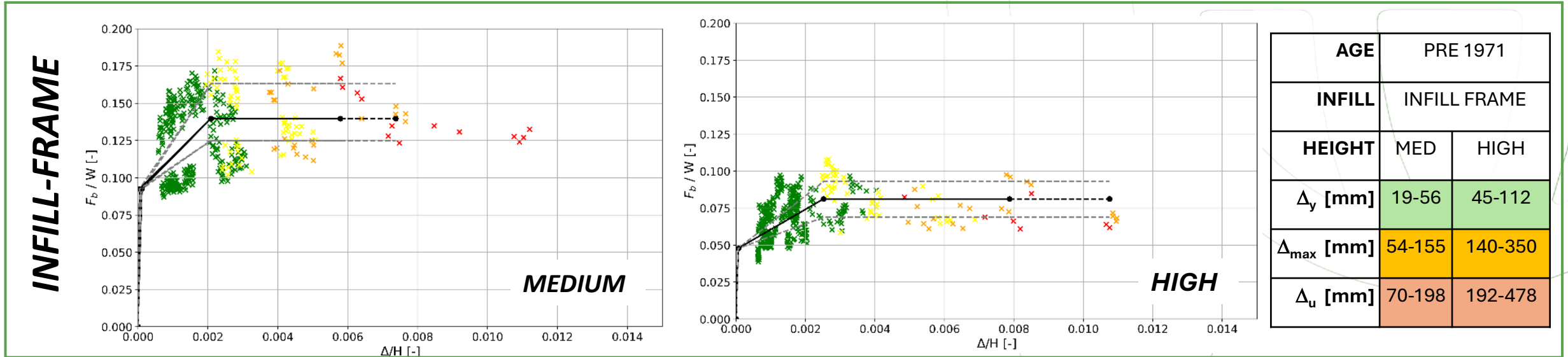
### PILOTIS-FRAME



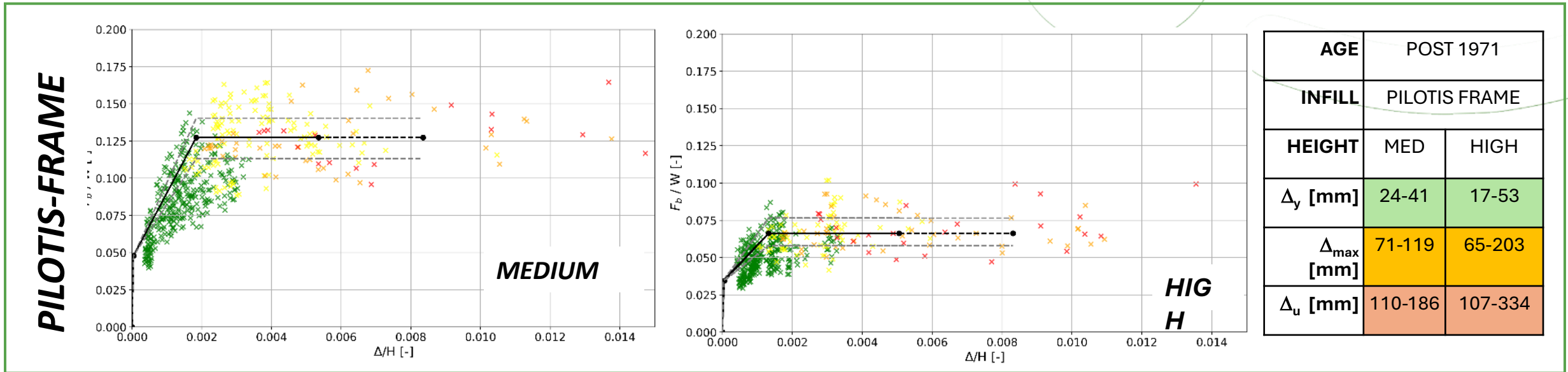
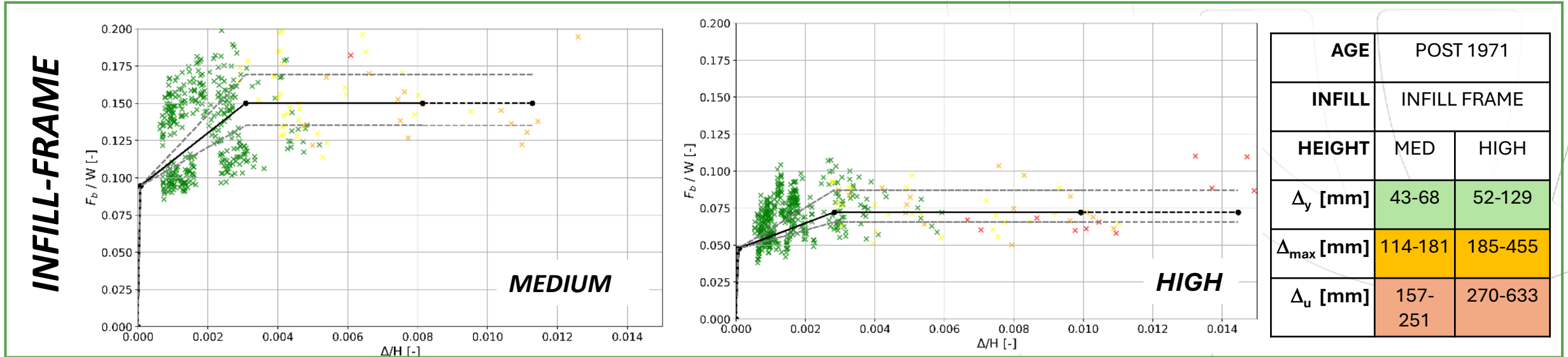
# Construction of a trilinear capacity curve constrained to experimental data



# Capacity curves for PRE 1971 building classes



# Capacity curves for POST 1971 building classes



# Conclusion

- 🌐 Soil-building resonance map represents a “snapshot” of the interaction effect in the linear-elastic domain;
- 🌐 Trilinear capacity curves describe the building dynamic behavior

# Future developments

- 🌐 Development of fragility curves for all buildings;
- 🌐 Site and building specific seismic risk maps;



# THANKS!

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3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”





# Le potenzialità degli array sismici per il monitoraggio di aree urbane

V. Serlenga<sup>(1)</sup>, M.R. Gallipoli<sup>(1)</sup>, I. Gaudiosi<sup>(2)</sup>



(2)



CNR – SALA CONFERENZE AREA TERRITORIALE DELLA RICERCA DI POTENZA | TITO SCALO  
13 GIUGNO 2025

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A seismic array is a set of seismometers deployed so that characteristics of the seismic wavefield can be inferred by analyzing waveforms simultaneously recorded at different sites.



Strategic infrastructures  
characterization and monitoring



Cultural heritage (CH)  
characterization



Shallow subsoil  
characterization  
and soil-structure interaction.

Lower spatial detail

Higher spatial detail

## CABLED ARRAYS



VS

## NODAL/WIRELESS ARRAYS



# Le potenzialità degli array sismici per il monitoraggio di aree urbane



# Contribution to National Research Projects

## Santa Sofia Bell Tower Area (Benevento)



PRIN2022  
NEWAGE



Characterization of the shallow subsoil in the target area, of the building and of its interaction with the surface soils.

Single station and array based methods  
(Sentinel-GEO 0.5 Hz)

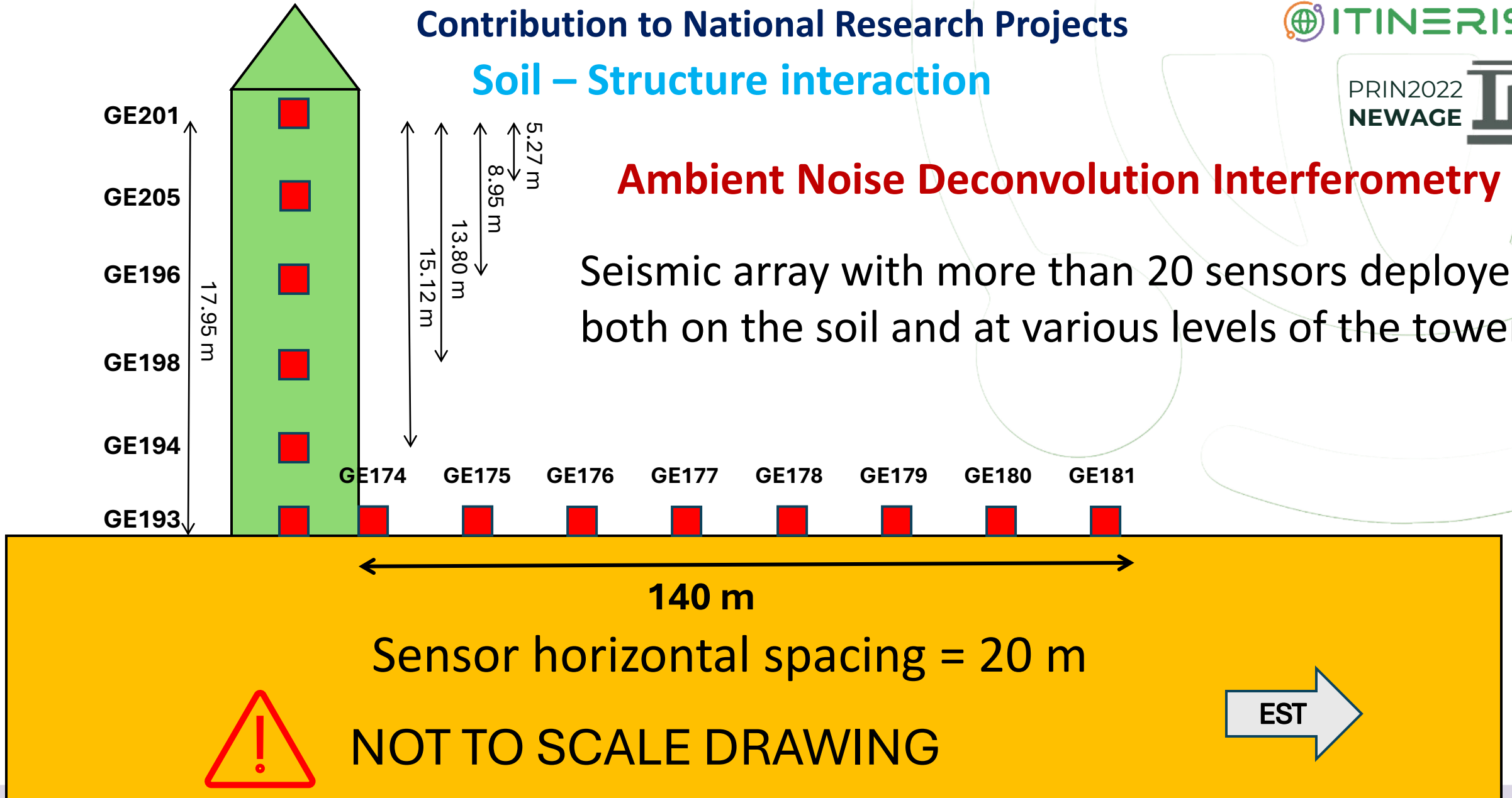


## Contribution to National Research Projects

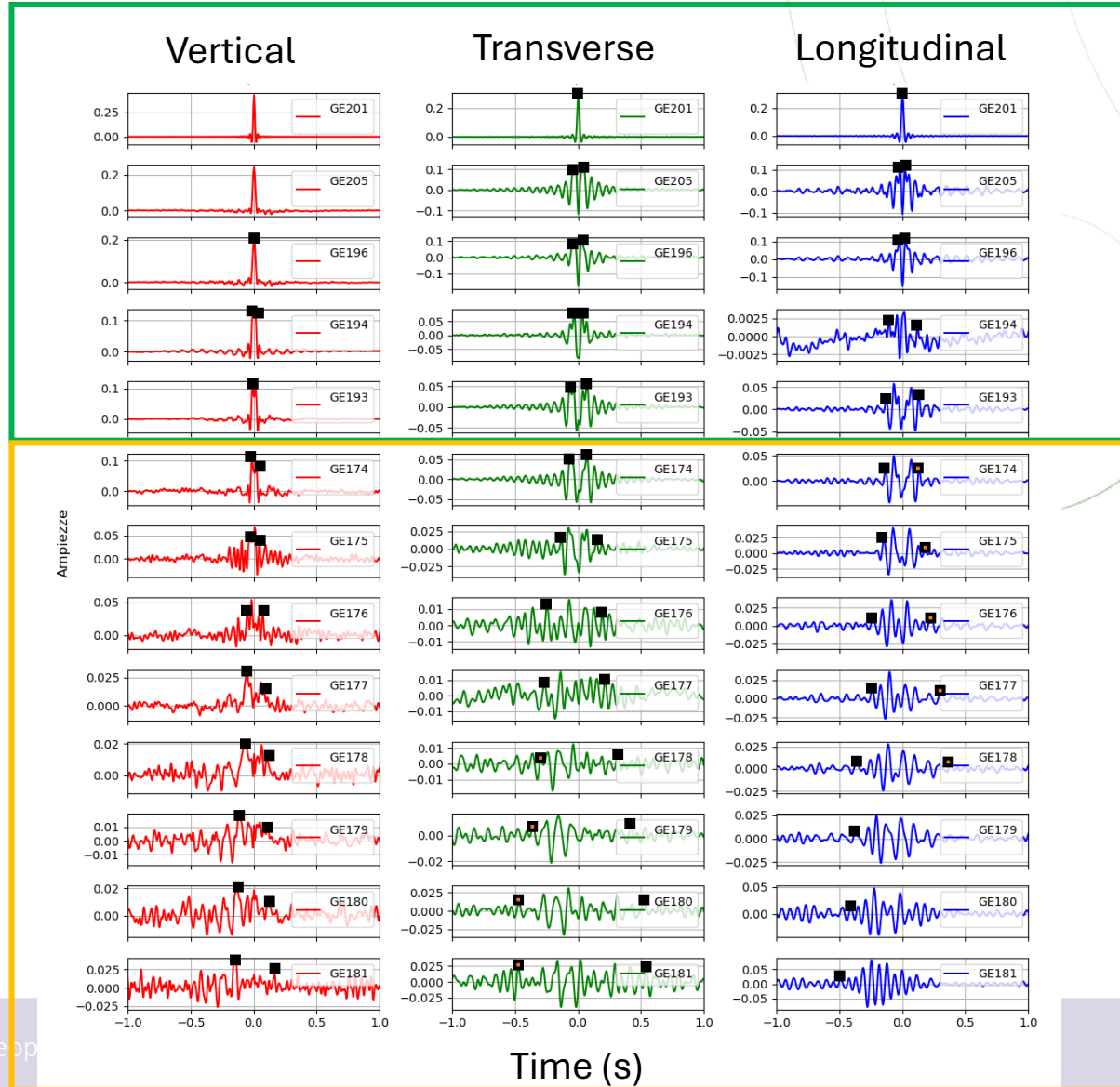
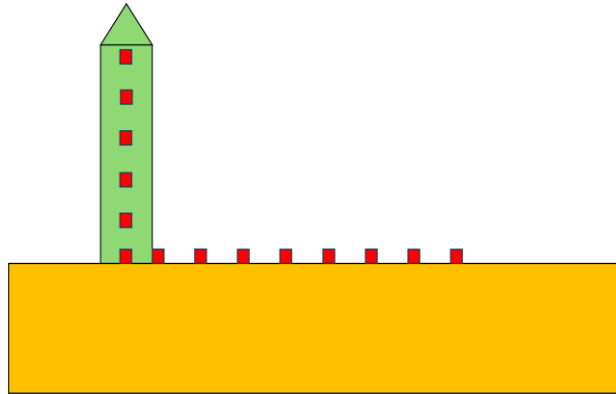
### Soil – Structure interaction

### Ambient Noise Deconvolution Interferometry

Seismic array with more than 20 sensors deployed both on the soil and at various levels of the tower



## Ambient Noise Deconvolution Interferometry

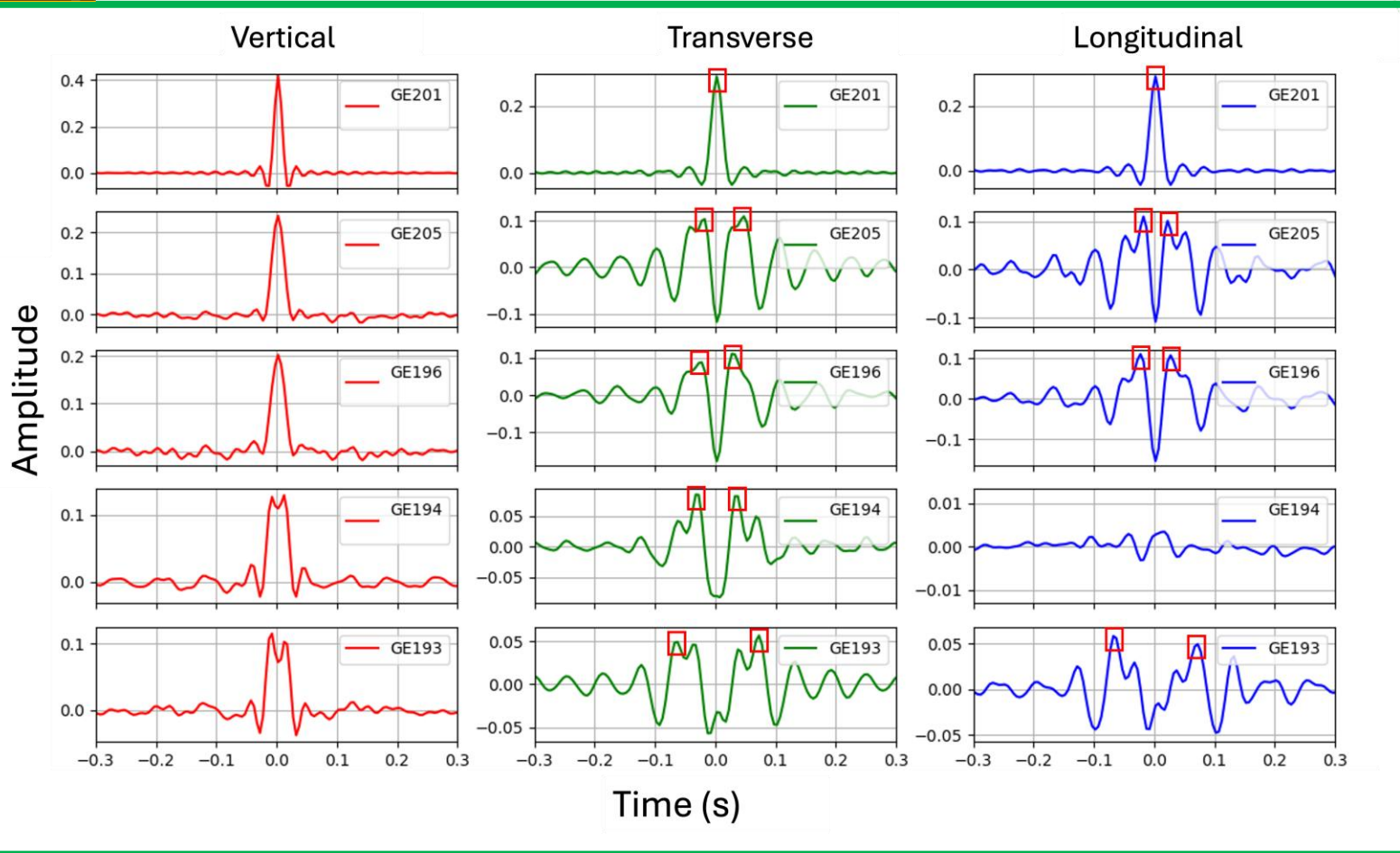


BELL TOWER

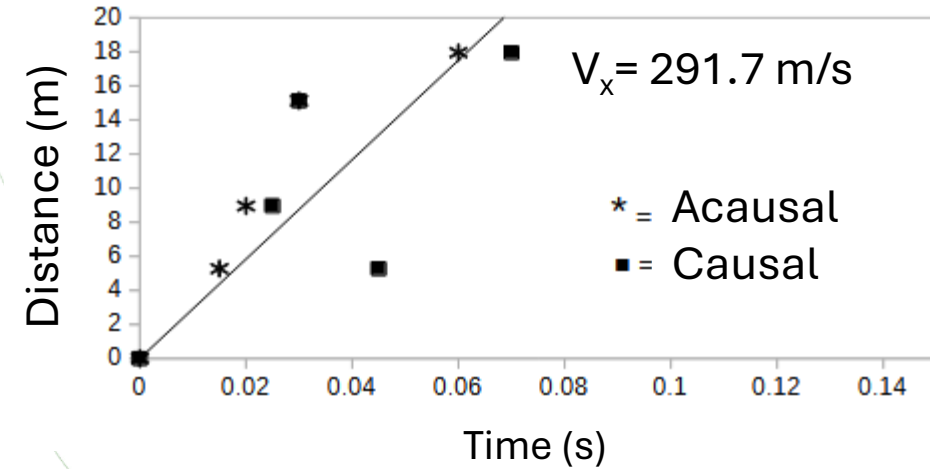
SOIL

Ambient Noise Deconvolution Interferometry

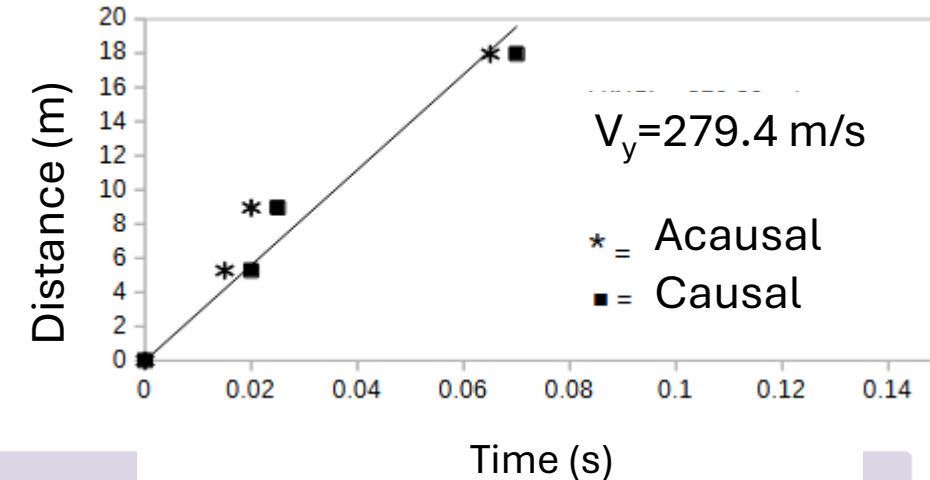
BELL TOWER



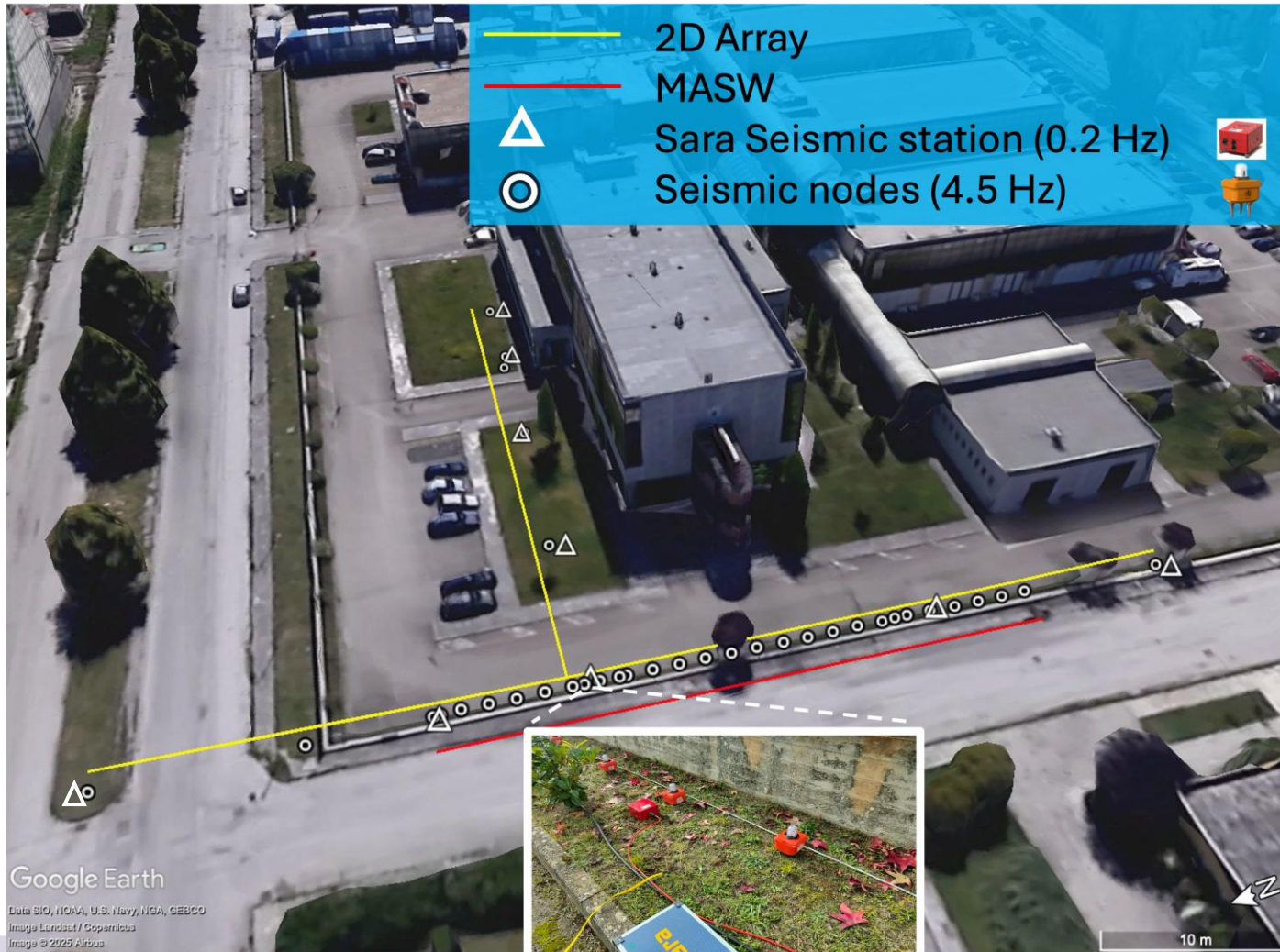
Transverse component



Longitudinal component



# Acquisition test at the Tito CNR Research Area



DATA

- Active seismic
- 1 hour of ambient seismic noise

Similar test was carried out in Parolai et al. 2007

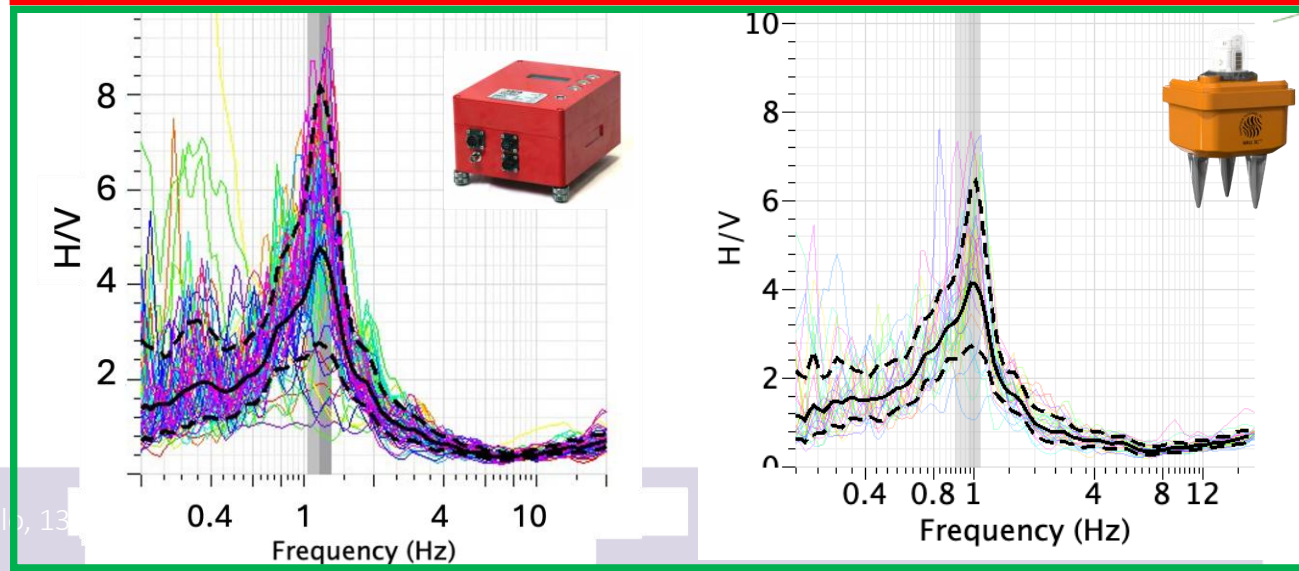
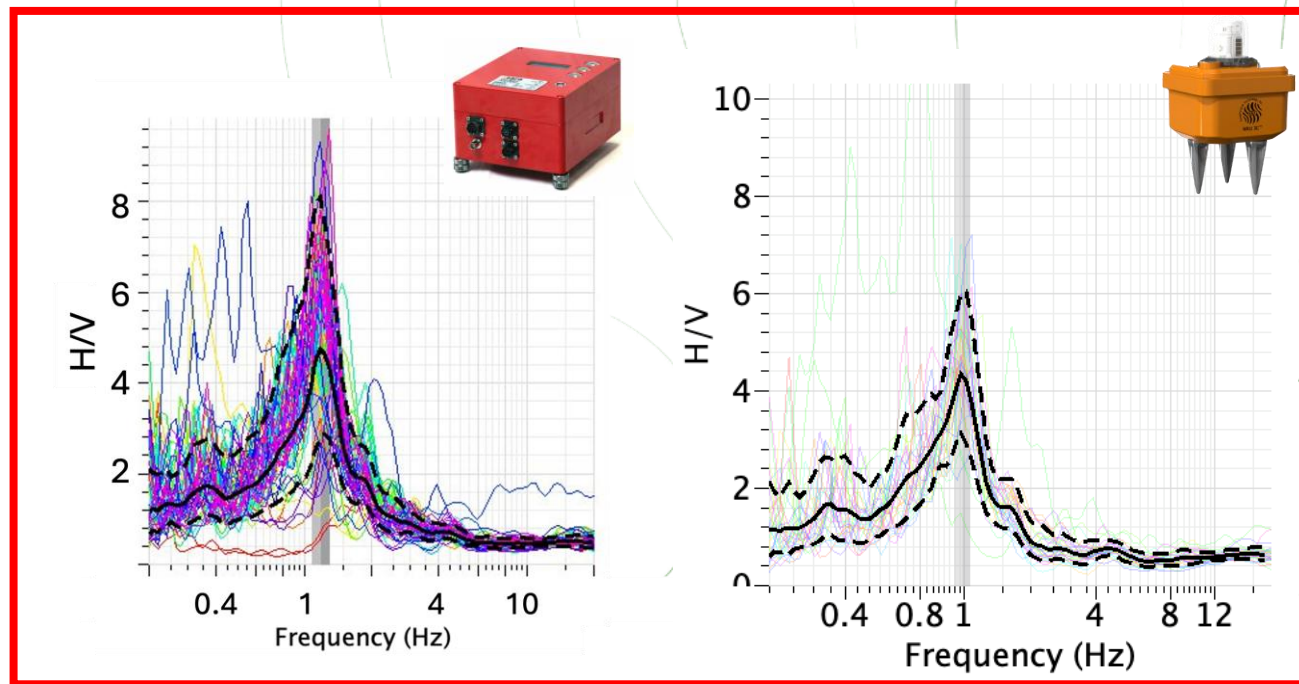
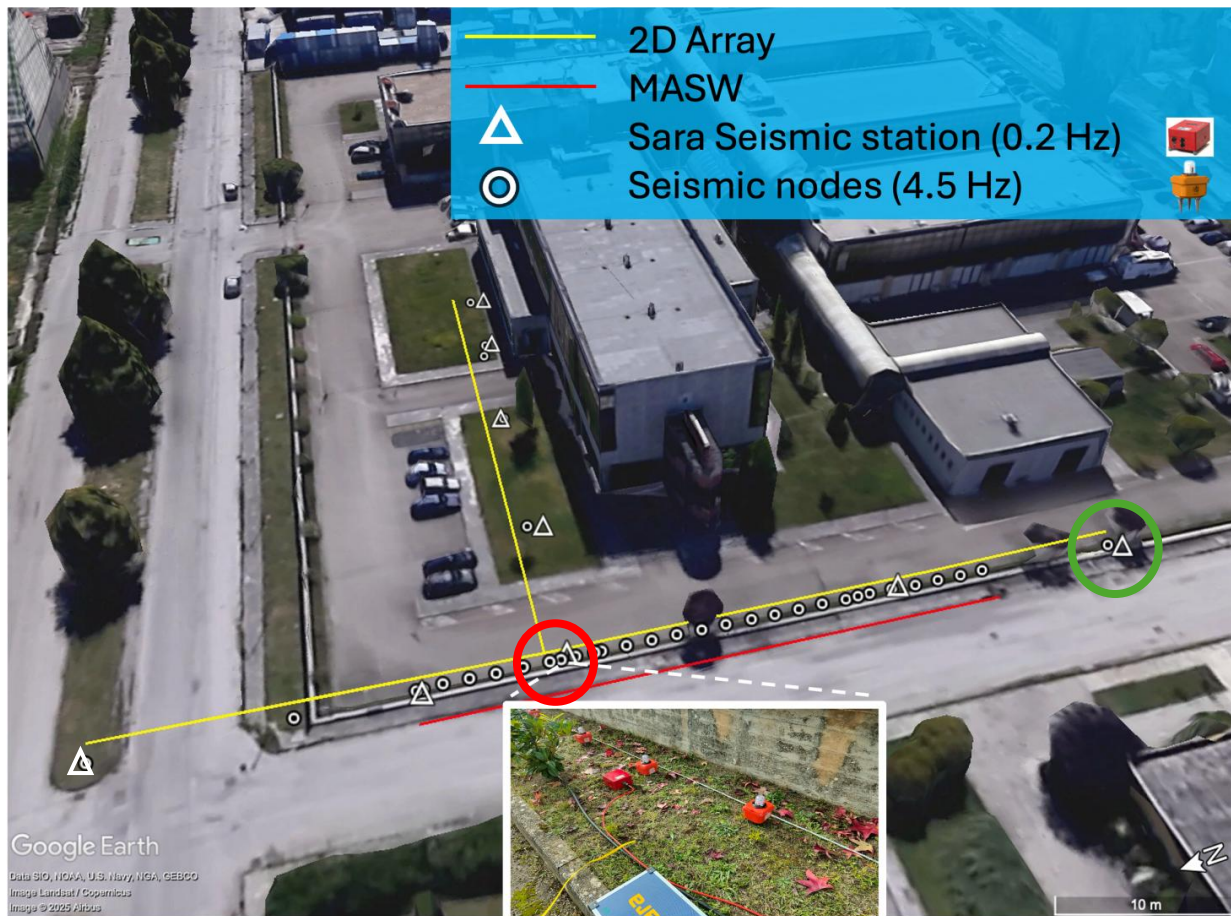
Bulletin of the Seismological Society of America, Vol. 97, No. 5, pp. 1413-1431, October 2007, doi: 10.1785/0120060223

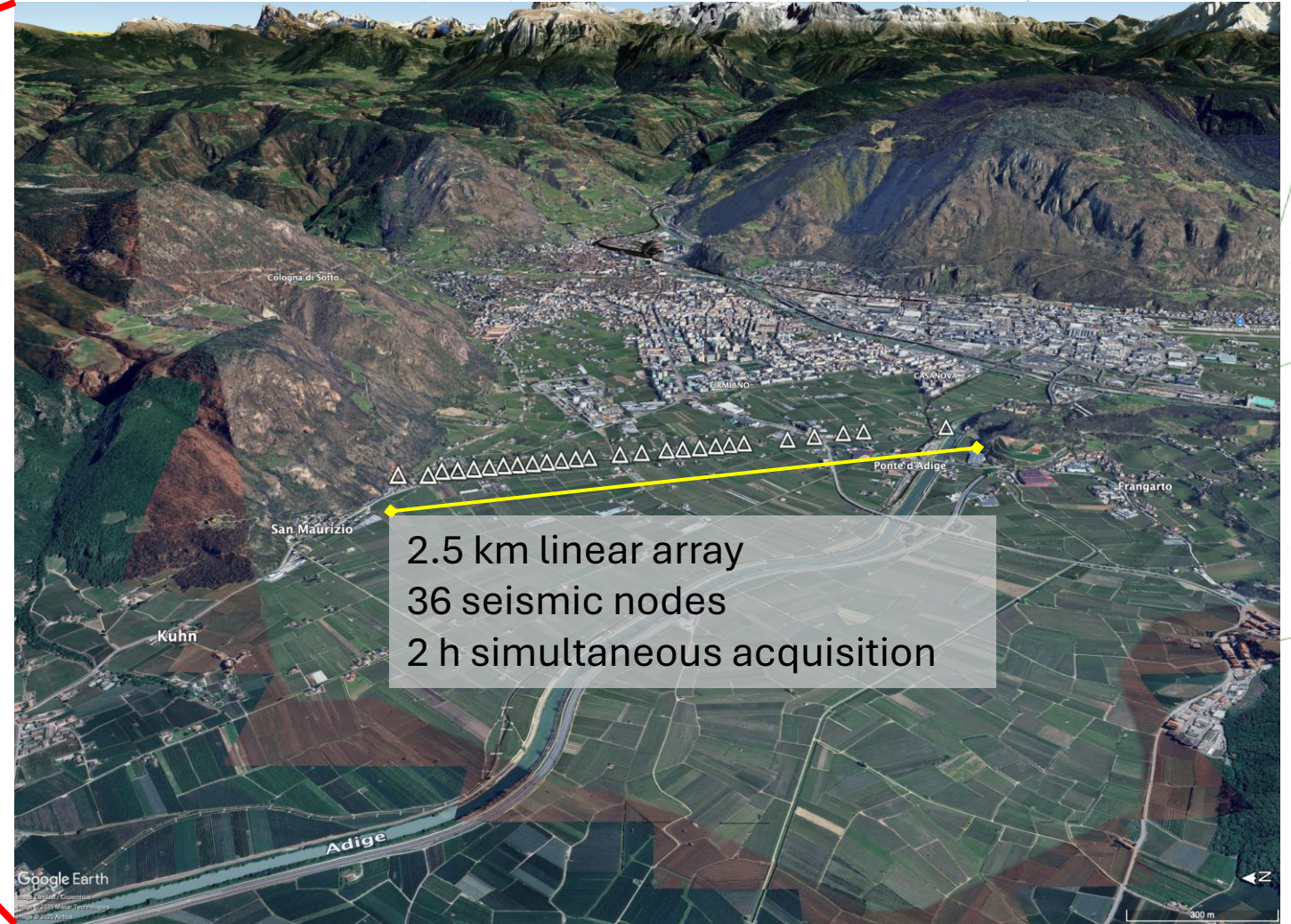
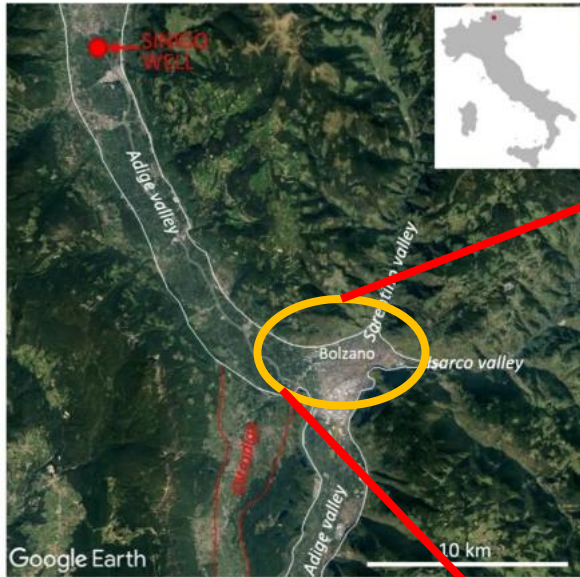
Comparison of Empirical and Numerical Site Responses at the Tito Test Site, Southern Italy

by S. Parolai, M. Mucciarelli, M. R. Gallipoli, S. M. Richwalski, and A. Strollo

Ambient noise acquired by 1 Hz Mark sensors

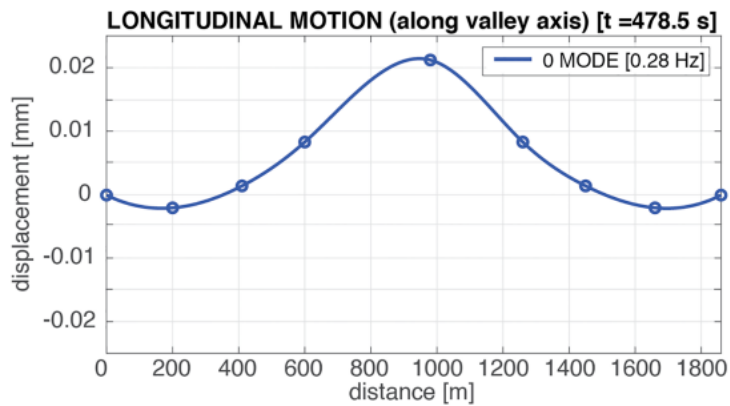
# Acquisition test at the Tito CNR Research Area





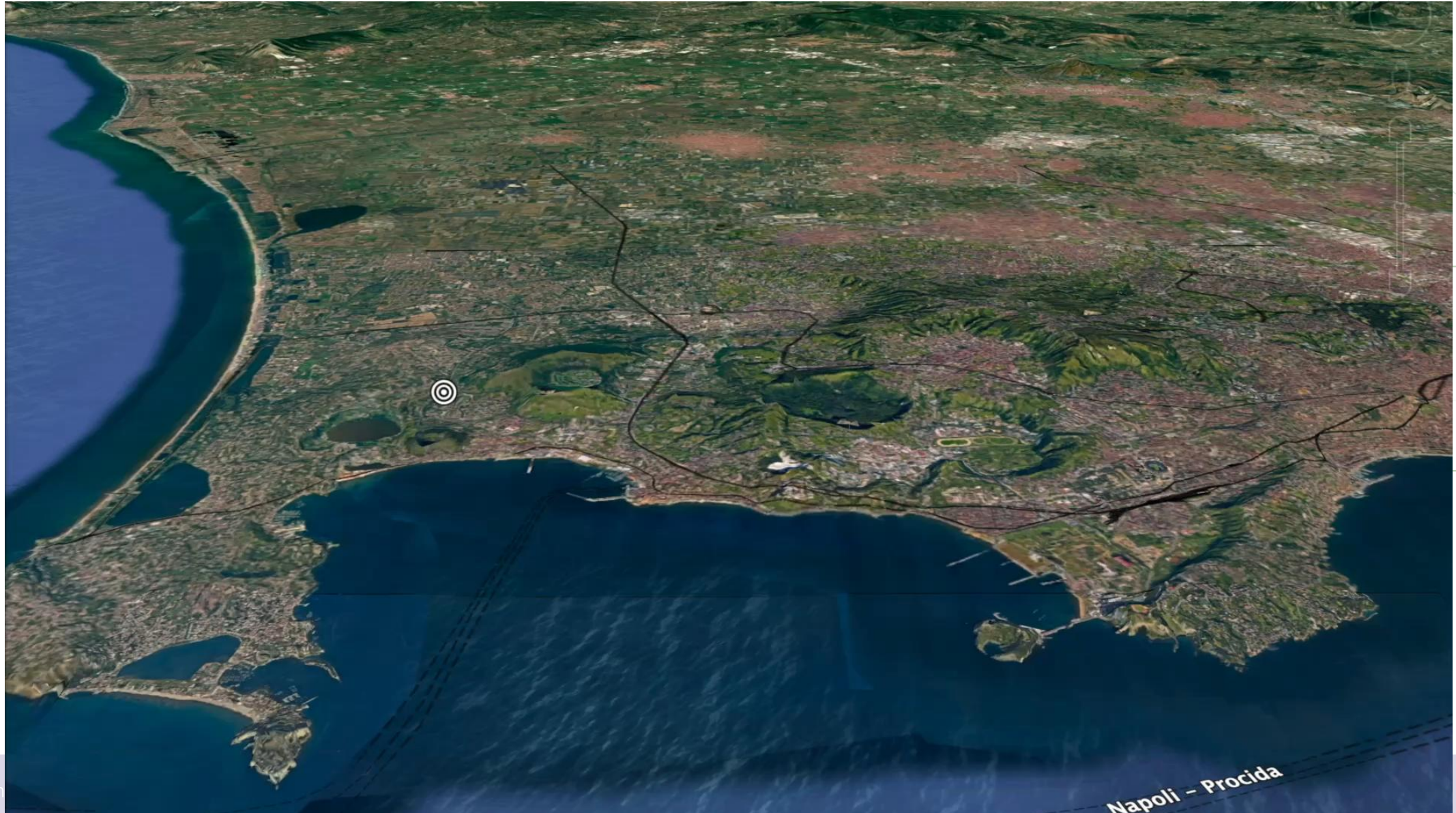
2.5 km linear array  
36 seismic nodes  
2 h simultaneous acquisition

From Sgattoni et al, 2024, P. A. Geophys.



From Sgattoni & Castellaro, 2020, GJI

# Support for third level microzonation of Campi Flegrei Area





# THANKS!

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# Potenziamento delle attività di osservazione del suolo e del sottosuolo tramite GPR e telerilevamento da aereo e da UAV

Ilaria Catapano IREA - CNR

**IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System**  
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# Potenziamento delle attività di osservazione del suolo e del sottosuolo tramite GPR e telerilevamento da aereo e da UAV



## SCIENTIFIC GOAL

exploitation and optimization of technologies for the Soil-Subsoil System (SSS) by using two technological assets:

### ▪ GROUND- and UAV- BASED INSTRUMENTATIONS

#### Advantages:

- ❖ high resolution imaging of subsoil
- ❖ shallow and deep surveys
- ❖ synoptic image of the environmental system

### ▪ AIRBORNE SYNTHETIC APERTURE RADAR

#### Advantages:

- ❖ multi-parameter observation of surface processes
- ❖ suitable for reaching inaccessible areas
- ❖ short revisiting time

High-performance instruments available on the market are equipped with model-based data processing strategies developed by CNR-IREA staff

## INFRASTRUCTURE DEVICES

### proximal and on-site instruments for data acquisition



**Magnetometer:** system for the total magnetic field and its vertical gradient measurement equipped with 2 QuSpin Gen-2 sensors, which guarantee data acquisition with 200 – 1000 Hz sampling rate and 0.003 nT sensitivity.



**Zond Aero LF:** drone based ultralight ground penetrating radar system equipped with 3 unshielded dipole antennas working at 3 different central frequencies: 100, 150, 300 MHz.



**Geoscope MkIV equipped with the array ground coupled G0908:** multi-channel multi-frequency ground penetrating radar (GPR) for high-density 3D data capturing. Thanks to the step-frequency technology, the system enables optimal penetration and highest resolution simultaneously by sweeping through a wide frequency range (40 MHz – 3GHz) with only one single antenna array.



**OBR 4600 Optical Backscatter Reflectometer:** device for fiber optic distributed strain and temperature sensing, which is able to measure strain and temperature over 2 km distance range with no dead zone, with high spatial resolution (few mm) and high speed (3Hz).

# GROUND- and UAV- BASED INSTRUMENTATIONS

## CNR-IREA ADDED VALUE

### vs an optimized use of multi-channel Ground Penetrating Radar

design, implementation and validation of advanced data processing approaches exploiting the increased amount of gathered data for improving the imaging performances

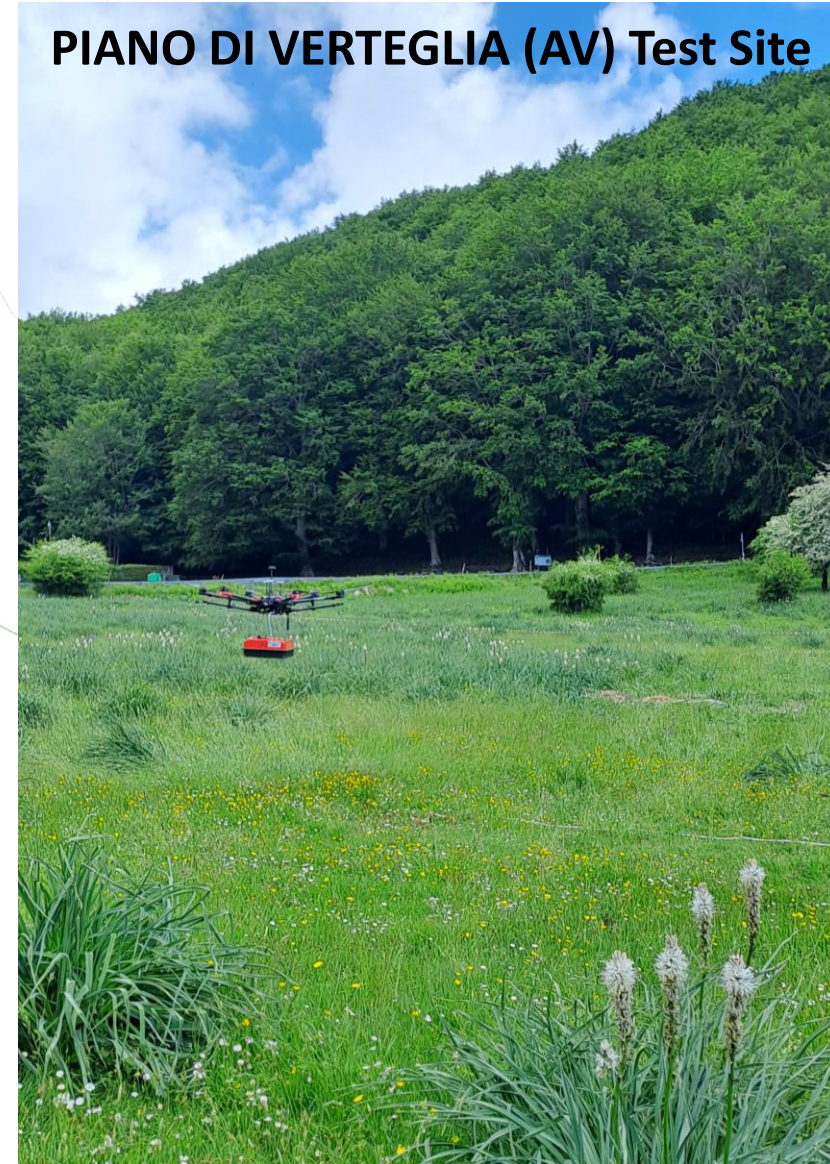
### vs an optimized use of UAV based Ground Penetrating Radar and Magnetometer

design, implementation and validation of data processing approaches accounting for flight positioning information (GPR - Microwave Tomography Imaging approaches compensating platform deviations from the nominal flight trajectory)

### vs an integrated use of electromagnetic methodologies for subsoils investigations

design and implementation of strategies to integrate results provided by different sensors

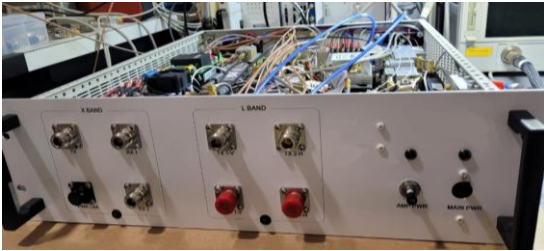
## PIANO DI VERTEGLIA (AV) Test Site



# AIRBORNE SYNTHETIC APERTURE RADAR

## INFRASTRUCTURE DEVICES

Multiband SAR system



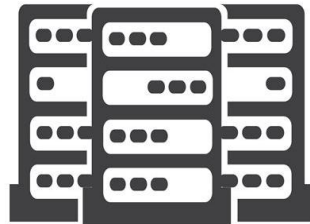
GNSS/INS system PwrPak7D-E2



Flight Management System



Computing resources

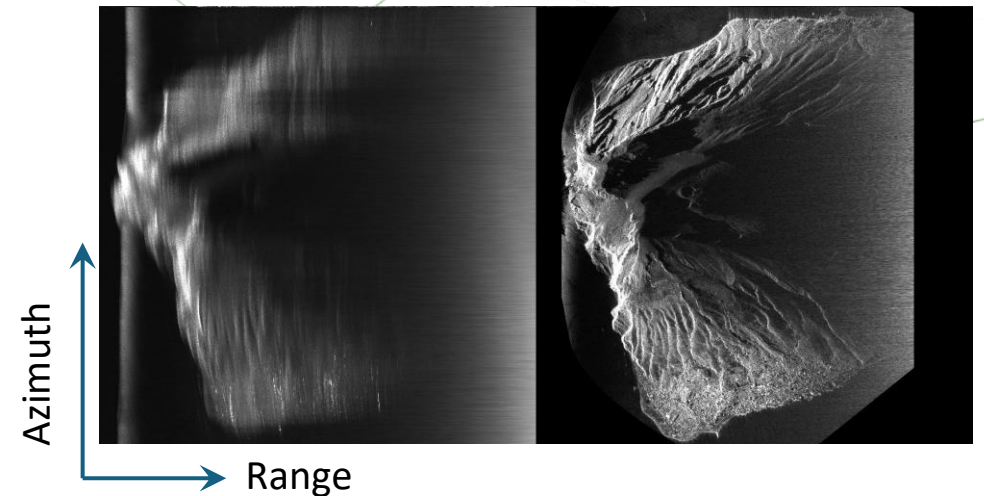


## CNR-IREA ADDED VALUE

adaptation of SAR focusing algorithms for processing data collected by the new instrumentation

**Range Compressed**

**Focussed**



# Potenziamento delle attività di osservazione del suolo e del sottosuolo tramite GPR e telerilevamento da aereo e da UAV



## THE SUPPORT OF ITINERIS TO OTHER RESEARCH ACTIVITIES



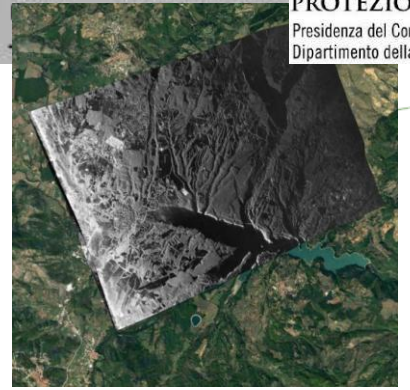
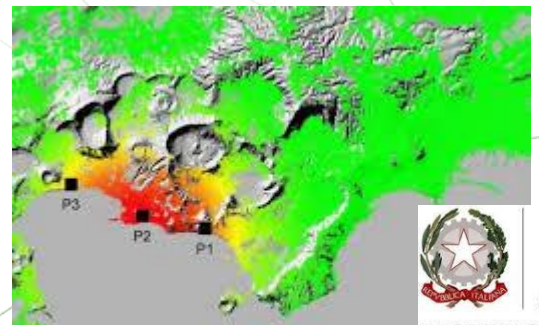
PRIN2022 – ARACNE (grant n. 202225CSP2)  
A RAdar system for Contactless surveys of reinforced concrete



(PRIN-PNRR)—SEAWATCH (CUP B53D23023940001)  
Short-range K-band Wave rAdar system Close to the coast



(PRIN-PNRR)—TR-HA-M  
Relation between 3D Thermo-Rheological model and seismic HAZard for the risk Mitigation in the urban areas of Southern Italy





# THANKS!

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# The potential of geophysical surveys with drones: the pilot site of Piano di Verteglia

A. Barone, G. Esposito, F. Mercogliano, G. Gennarelli, A. Vitale, F. Accomando, P. Tizzani, I. Catapano – CNR IREA





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# Urban Geophysics: what it is & why it matters

Urban geophysics is a branch of applied geophysics that uses non-invasive geophysical methods to study the subsurface of urban areas.

Its main objective is to obtain information about what is under cities (stratigraphies, anthropic structures, cavities, infrastructures, etc.) without resorting to excavations or destructive interventions.

-  Sustainable urban planning
-  Infrastructure management & safety
-  Protection of archaeological heritage
-  Prevention of geological risk



# Urban Geophysics needs

- 🌐 Non-Invasive Exploration
- 🌐 Accessibility to remote/inhospitable terrain
- 🌐 Wide-area coverage & speed
- 🌐 Geolocalization and Data Integration
- 🌐 Multi-application
- 🌐 Cost & Labor Efficiency



UAV-based Ground Penetrating Radar (GPR) and Magnetometry have emerged as effective technologies to address urban geophysics monitoring

# Urban Geophysics needs

- 🌐 Non-Invasive Exploration
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UAV-based **Ground Penetrating Radar (GPR)** and **Magnetometry** have emerged as effective technologies to address urban geophysics monitoring

# UAV-based GPR - Advantages

## Radar Legacy

- Radar works in all weather/light conditions
- Possibility of inspecting the subsoil and/or inner structural features
- Non-destructive inspections

## UAV Legacy

- Possibility of investigating difficult to access areas
- Possibility of vertical take-off and landing
- Ease of use
- Speeding up the data acquisition process

# UAV-based GPR - Challenges

- Payload weight VS Time of flight
- Synchronization of radar and GNSS data
- Working radar frequency selection
- Data collection requirements
- Accurate UAV positions estimation
- Reduced SNR
- Radar processing strategies

# UAV-based GPR - Radar processing strategies

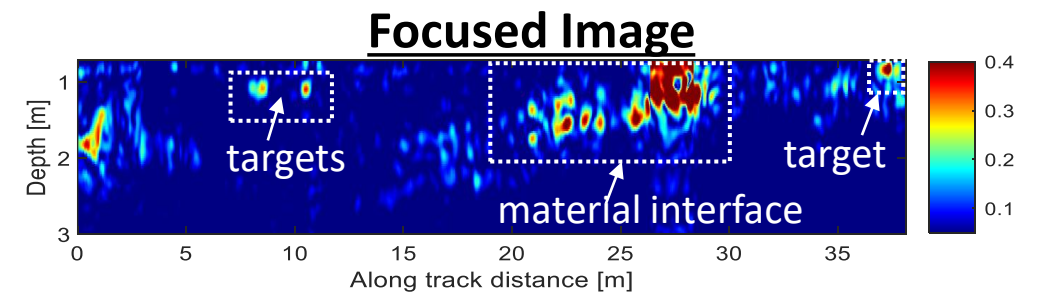
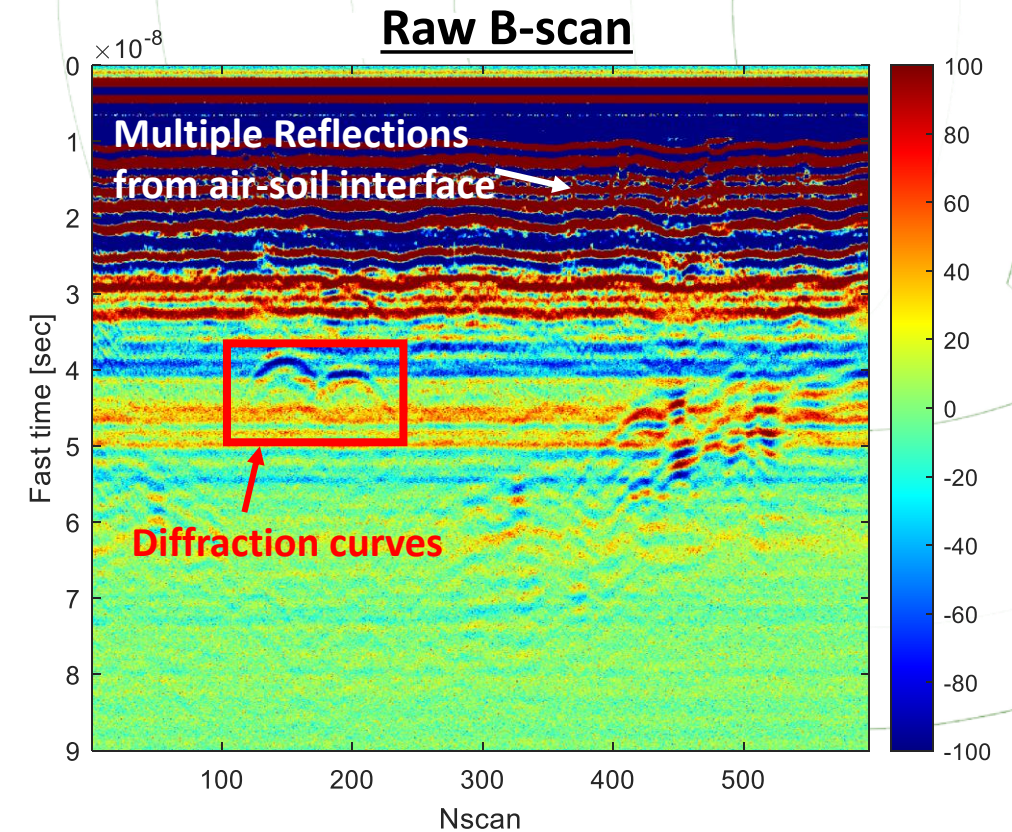
- Strong multiple reflections from air-soil interface can mask shallow targets
- Less EM energy coupled in the soil (low SNR and reduced penetration depth)
- Localized targets appear as diffraction curves that need to be focused to improve interpretability

## Added value



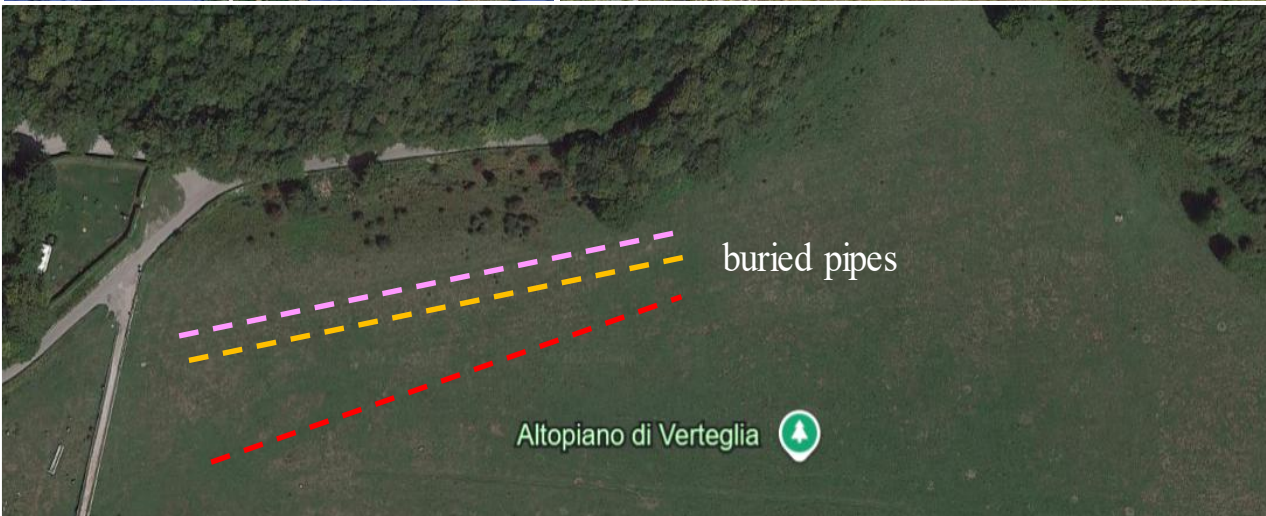
An **image focusing strategy** that takes into account:

- propagation in half-space scenario
- non rectilinear trajectories
- large scale data processing

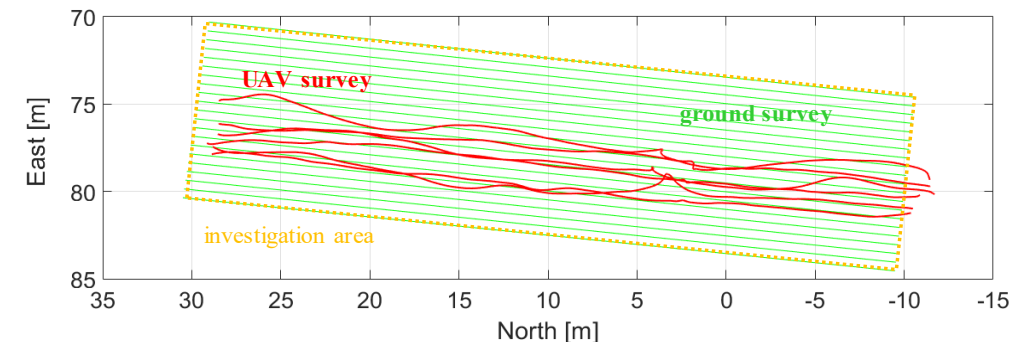
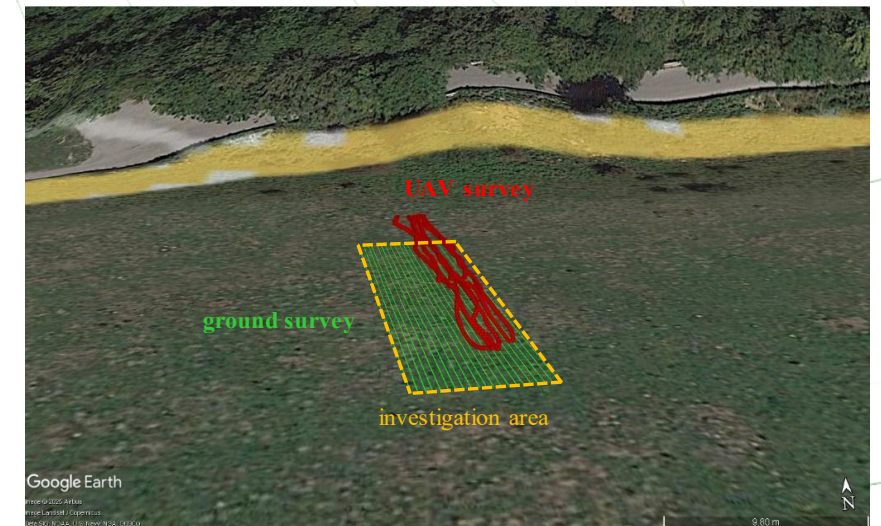


# UAV-based GPR – Experimental Results | Test site

The **Altopiano di Verteglia** (Lat. 40.827866°, Lon. 14.985929°) located in the municipality of Montella, Avellino, Southern Italy



Benchmark: Ground-based GPR data

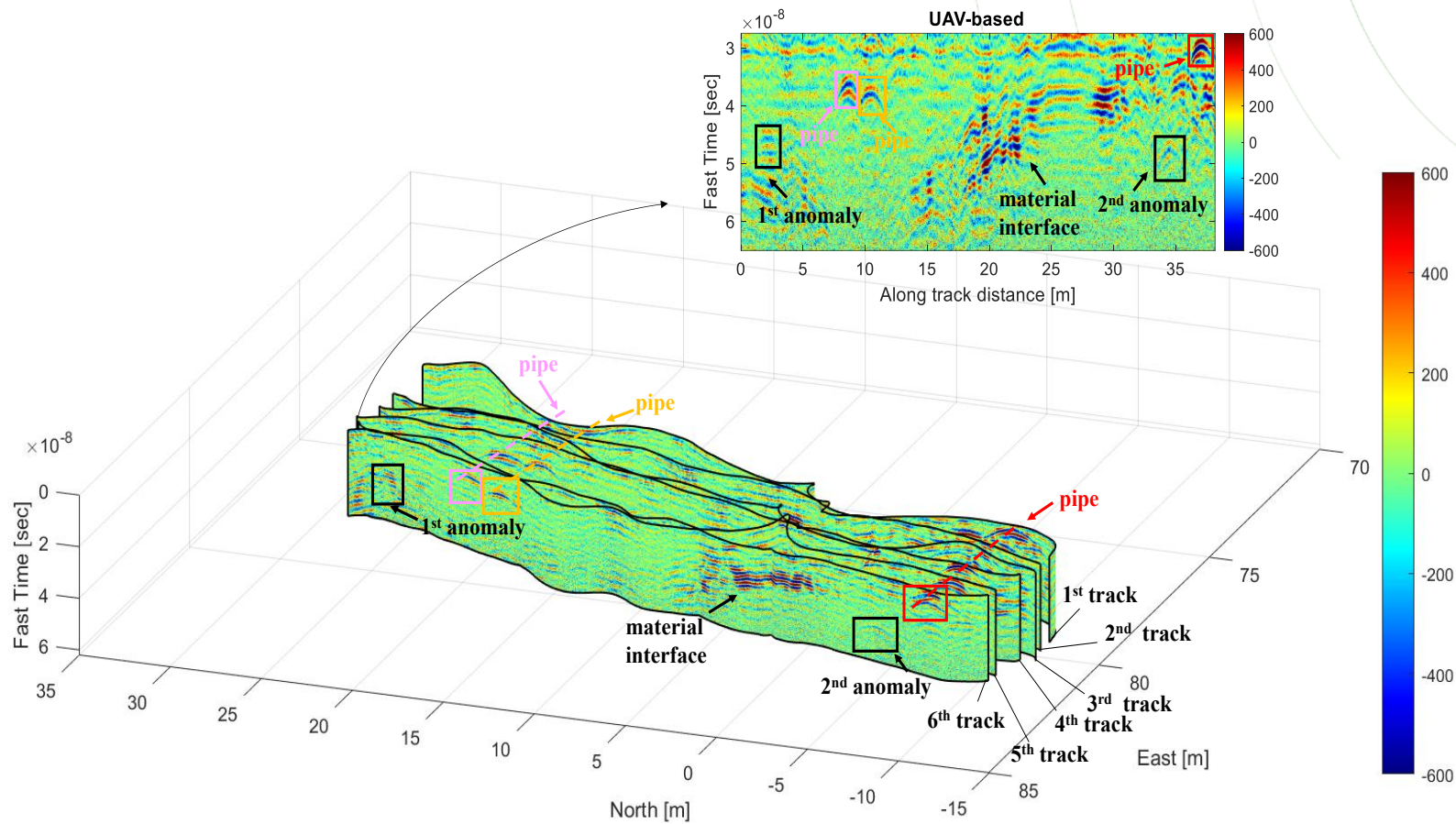


# UAV-based GPR - Experimental Results | GPR System

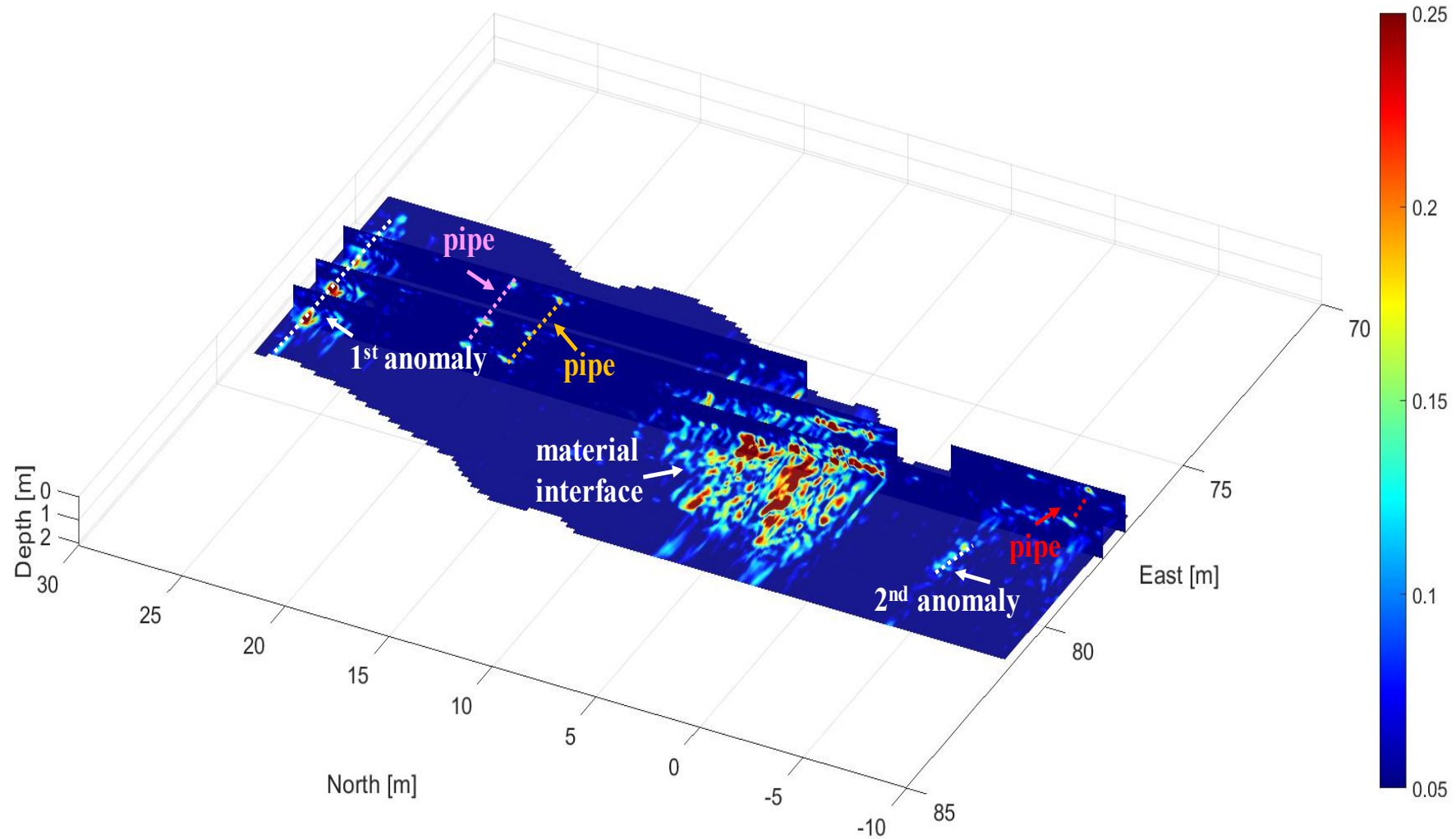


UAV platform	DJI M600 Pro
UAV Maximum takeoff weight	15.5Kg
UAV Batteries	6 × DJI TB47S Intelligent Flight Batteries lipo 4700 mah 6s 25c-50c
UAV Max Flight time	30 minutes with 0.9 Kg payload
On-board Mini laptop	Datalogger SkyHub
Radar module	Radarteam Cobra Plug-In GPR
Radar central frequency	500 MHz
Frequency range	50-1400 MHz
Antennas	Multifrequency CBD GPR Cobra
Laser Altimeter	Lightware SF-11 with terrain following
On-board GNSS module	Emlid Reach M2
On-the-ground GNSS module	Emlid Reach RS2
Ground platform	IDS TH DUAL-F Hi-Mod GPR system
Antennas	Multi-frequency
Central frequency	<b>200 MHz</b> or 600 MHz

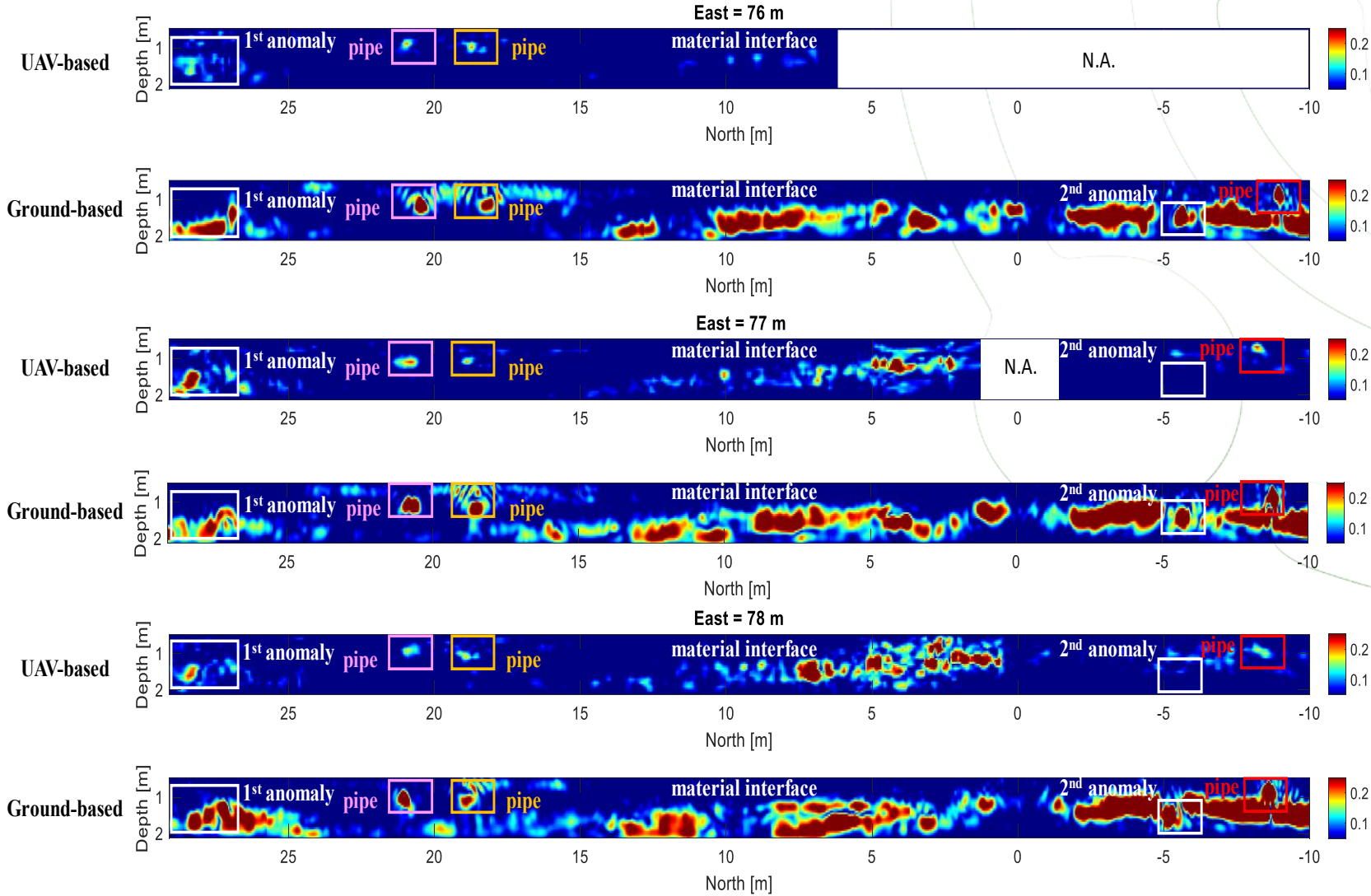
# UAV-based GPR - Experimental Results



# UAV-based GPR - Experimental Results



# UAV-based GPR - Experimental Results



# Urban Geophysics needs

- 🌐 Non-Invasive Exploration
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UAV-based Ground Penetrating Radar (GPR) and Magnetometry have emerged as effective technologies to address urban geophysics monitoring

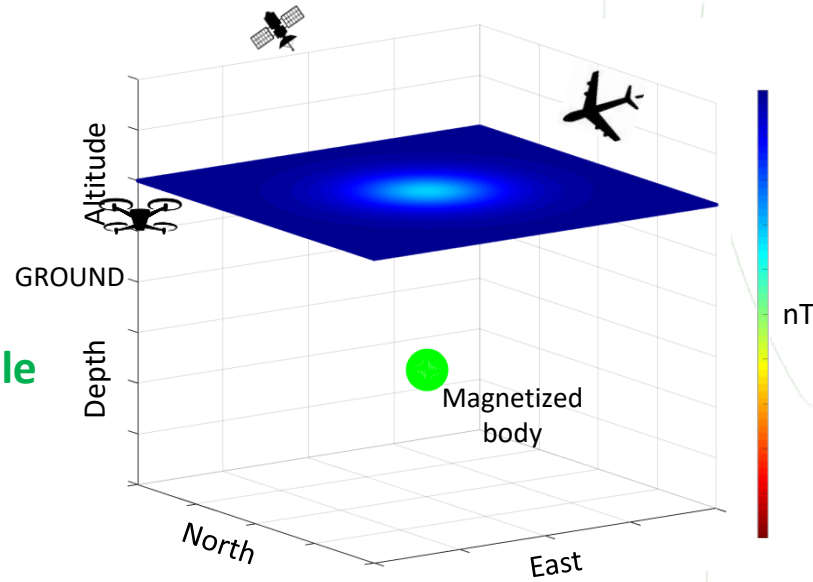
# Magnetometric method

## ADVANTAGES

Investigating difficult-to-access areas  
Reducing survey time and human efforts

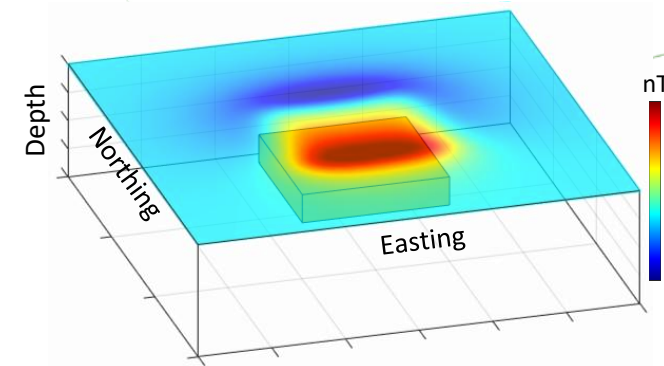
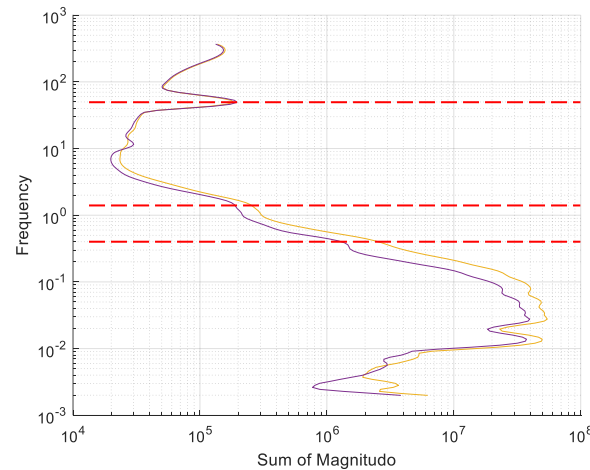
**Versatile in the choice of the observation scale**

- Data Resolution**
- Data Coverage**
- Depth**



## CHALLENGES

- Sensor lightning and miniaturisation
- Accurate georeferentiation (PPK & RTK)
- UAV electromagnetic noise & oscillations
- Heading error
- Dipolar field & Remanent magnetization
- 3D modeling from 2D measurements



**Strategies of data acquisition, processing and modeling**

## DATA COLLECTION

- Measurements: Total magnetic field & Vertical gradient
- Flight positions: RTK & PPK corrections
- Terrain Following: Altimeter & DEM/DSM
- Data sampling: up to 1000 Hz



## DATA PROCESSING

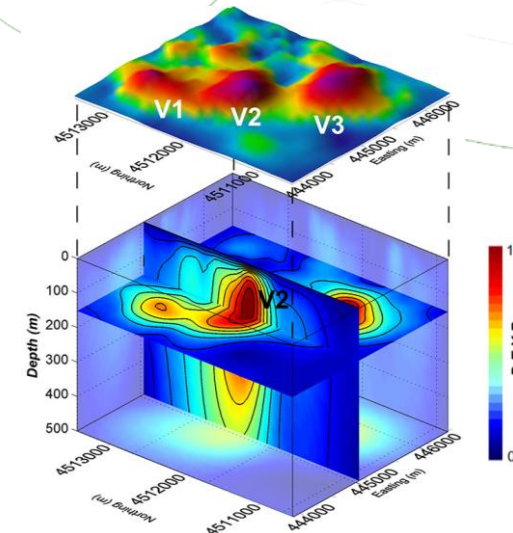
- Low-pass filtering  
UAV electromagnetic noise and oscillations effects
- Directional filtering  
Unconventional DWT method

## DATA ENHANCEMENT

- Upward/Downward continuation
- Directional derivatives
- Monopolar transformations

## DATA MODELING

- Tomographic inversion
- Imaging methods  
**DEXP method** (*Fedi et al., 2007*)



# Experimental Activities



## MAGNIMBUS

Manufacturer: SPH Engineering

Sampling rate: up to 500 Hz

Sensitivity: 0.003 nT

Weight: 1.5 kg

Distance between sensors: 1.7 m

Distance sensors & drone: 1 and 0.5 m

Maximum flight speed: 4 m/s

Powered by: drone batteries

Data collection: on-board computer

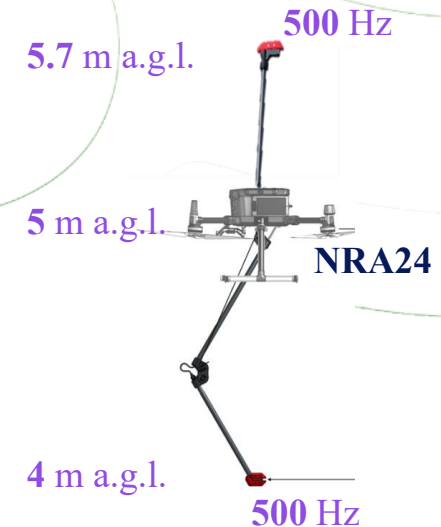
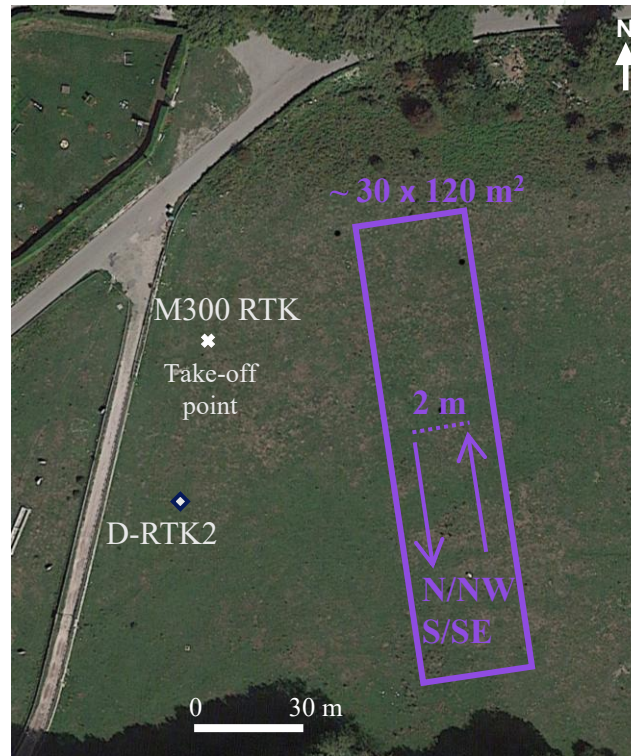
Required tools

DJI M300/350 RTK

UgCS SkyHub

Radar Altimeter

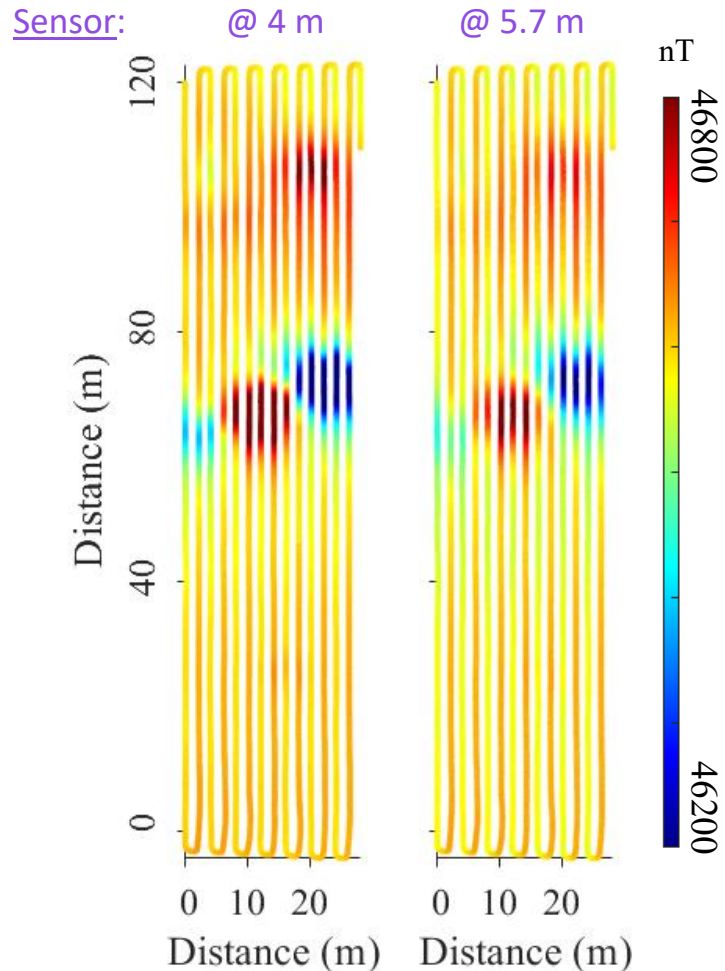
Karst plane of the Altopiano di Verteglia (Montella, AV): **buried pipes detection**



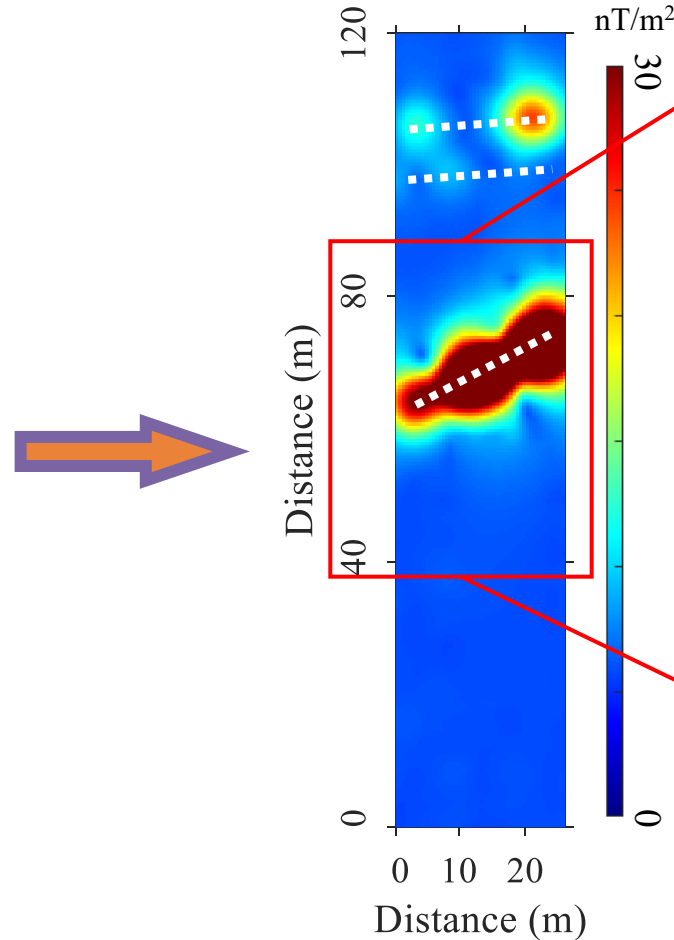
~ 15 minutes  
→  
2 m/s

# Experimental Activities: Datasets & Results

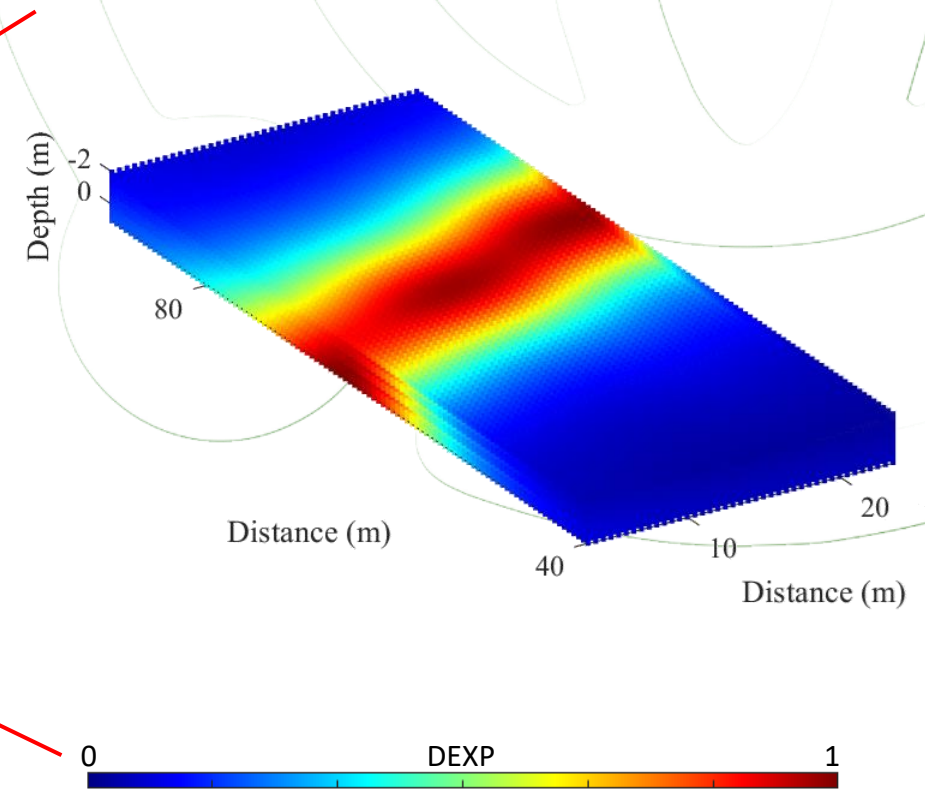
Total magnetic field measurements



Filtered Vertical Gradient:  
**Total Gradient transform**



DEXP Results: 3D Imaging



- DEXP maxima: Pipe location

# Conclusions

- 🌐 UAV GPR & Magnetometric methods are upcoming approaches in urban geophysics:
  - Enabling accurate data collection;
  - Simplifying the survey logistics.
- 🌐 Equipments & know-how of the research group enable to deal with:
  - Data georeferentiation;
  - UAV electromagnetic noise and oscillations;
  - Data processing and modeling.
- 🌐 Experimental activities validate the proposed approaches & strategies:
  - Detecting buried pipe system;
  - 3D modeling of the pipe geometry.
- 🌐 Future developments:
  - Integration of 3D models.





# THANKS!

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**Urban Geophysics:  
A New Ground-Airborne Geophysical  
instrumental facility**

## **Telerilevamento SAR da piattaforme aeree**

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Perna<sup>1,2</sup>, R. Lanari<sup>1</sup>  
<sup>1</sup>IREA – CNR, <sup>2</sup>Università degli Studi “Parthenope”

**IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System**  
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-  
Mission 4 “Education and Research” - Component 2: “From research to business” - Investment  
3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”



### The airborne SAR infrastructure @ IREA-CNR Demonstration

- **L-Band**
  - Polarimetry
  - Repeat pass Interferometry
- **X-Band**
  - Single Pass Interferometry (DEM generation)
  - The Stromboli case study

## The Multiband Interferometric and Polarimetric SAR (MIPS)



**X-band RF layout**



**L-band RF layout**

### Main characteristics of the MIPS system

Band	X	L
Technology	FMCW	
Carrier frequency [GHz]	9.55	1.35
Bandwidth [MHz]	200	125
Number of transmitting antennas (Tx)	1	1
Number of receiving antennas (Rx)	2	1
PRF [Hz]	1200	600
Antennas' sizes (azimuth × range) [cm]	24.6 × 12.6	18.5 × 18.5
Polarization	VV	Quad-Pol
Single-pass interferometry	YES	NOT

### embedding the Applanix Navigation Unit

#### Applanix INS/GPS specifications

Position [m]	0.05
Velocity [m/s]	0.005
Roll & Pitch [deg]	0.005
True Heading [deg]	0.008



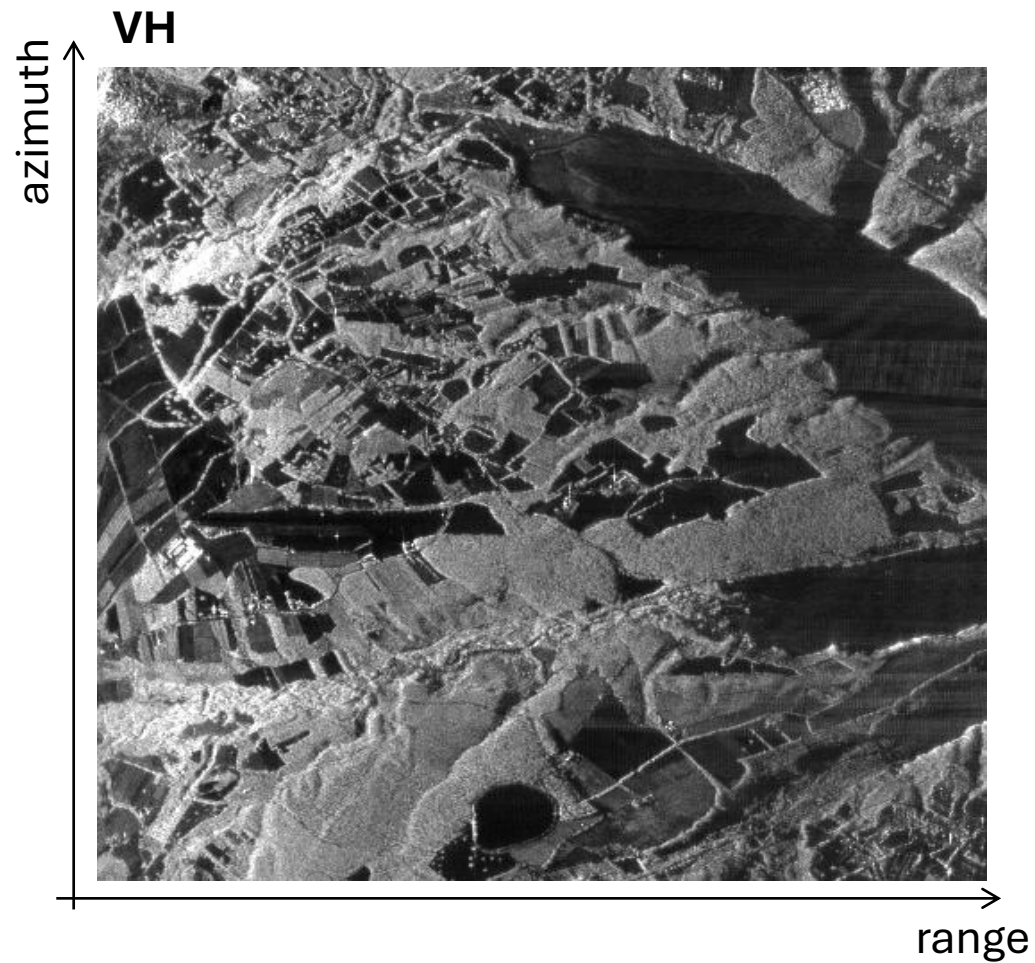
Natale et al., "The New Italian Airborne Multiband Interferometric and Polarimetric SAR (MIPS) System: First Flight Test Results," in proc. IGARSS 2022

Perna et al., "The InSAeS4 Airborne X-Band Interferometric SAR System: A First Assessment on Its Imaging and Topographic Mapping Capabilities," in *Remote Sensing*, 2016, 8, 40.

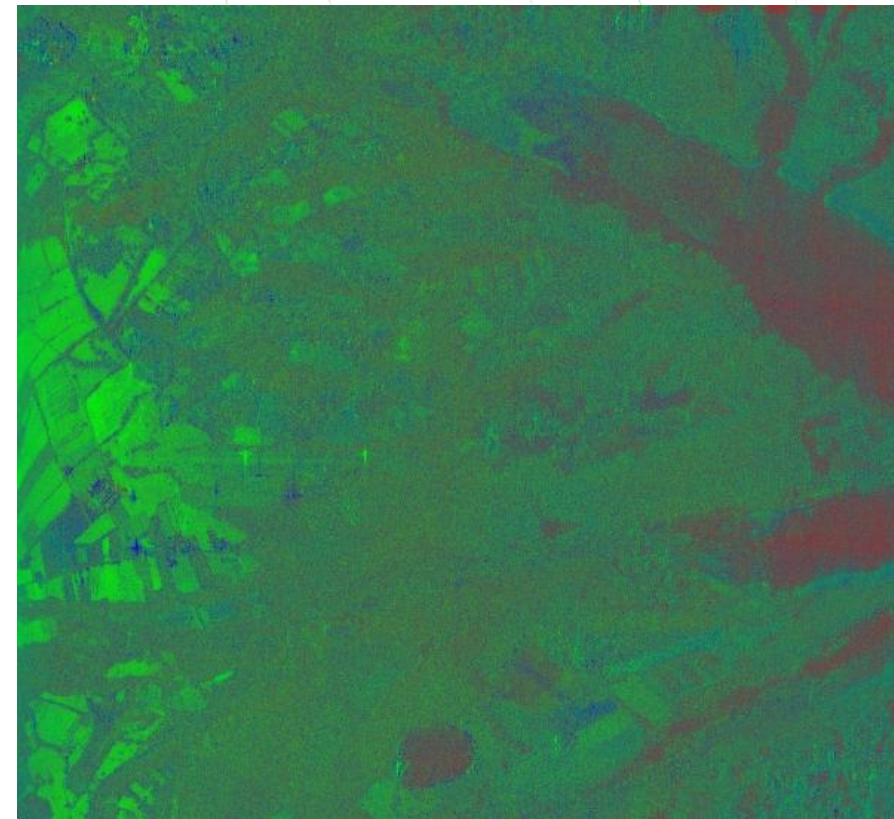
Esposito et al., "On the Capabilities of the Italian Airborne FMCW AXIS InSAR System," in *Remote Sensing*, 2020, 12, 539.

# L-Band demonstration: Polarimetry

## Grumento area



Pauli decomposition map



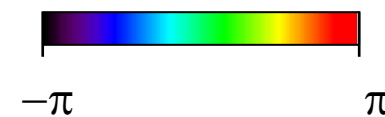
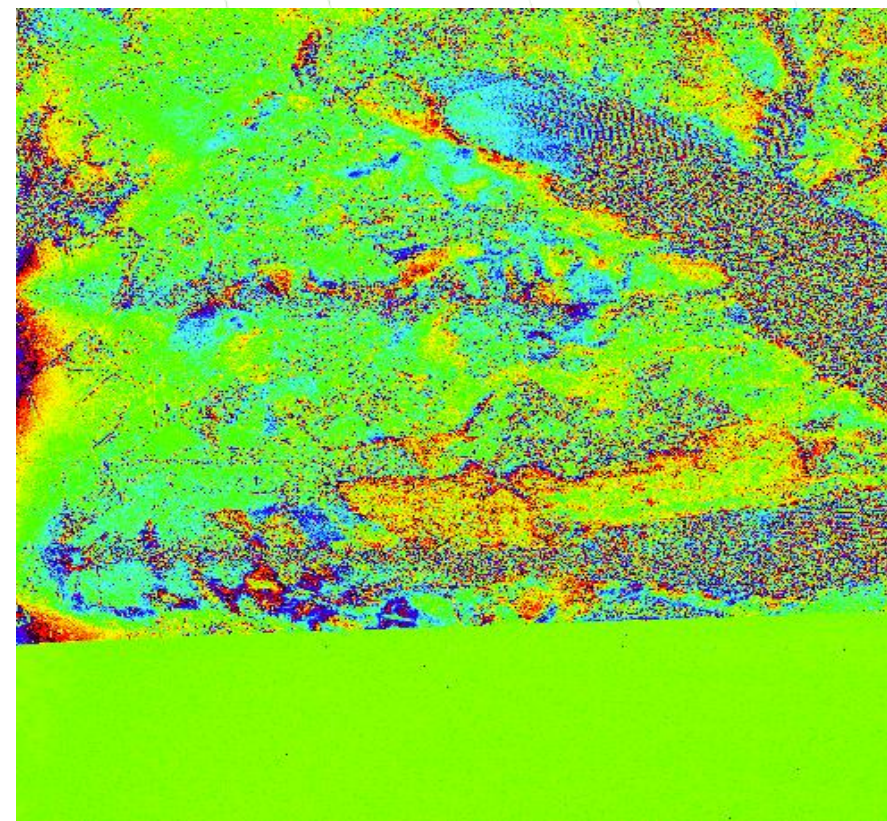
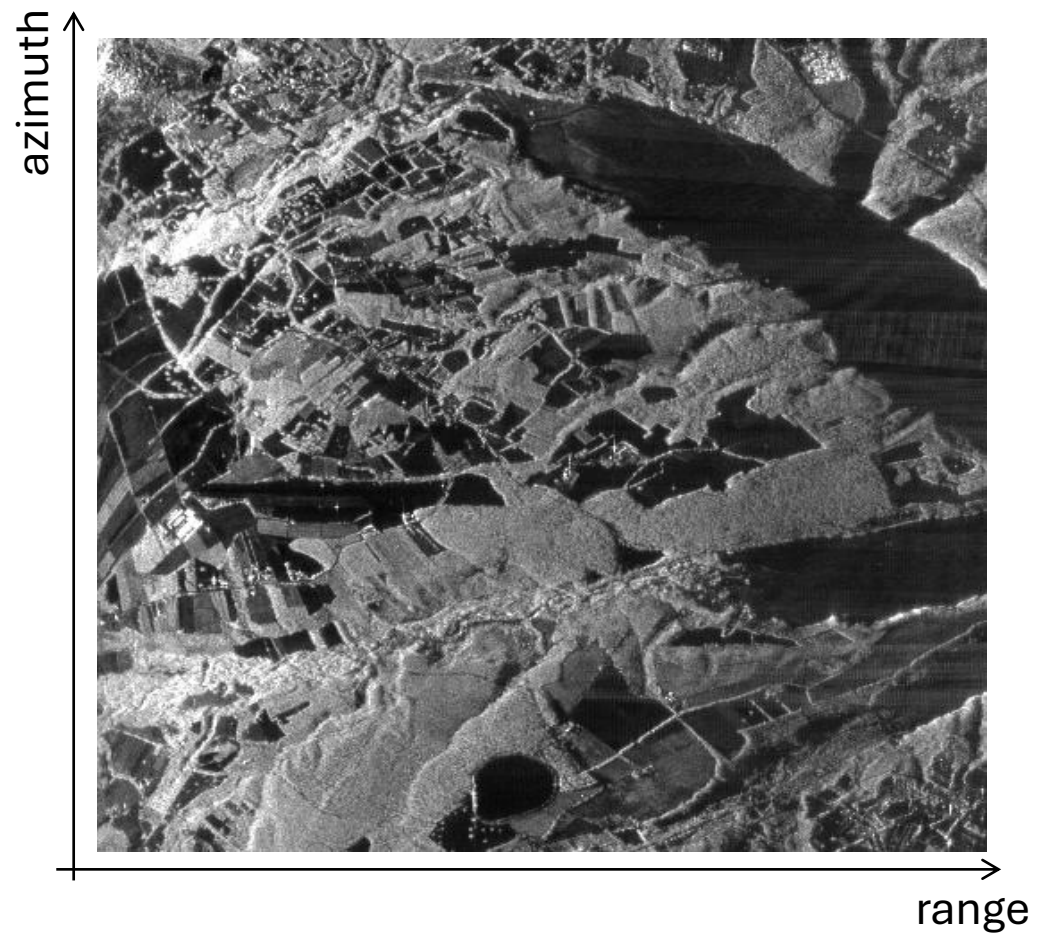
■  $|HH-VV|^2$   
(surface)

■  $|HH+VV|^2$   
(double  
bounce)

■  $|VH|^2$   
(volume)

# L-Band demonstration: Repeat Pass Interferometry Grumento area

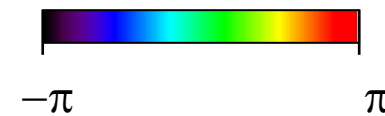
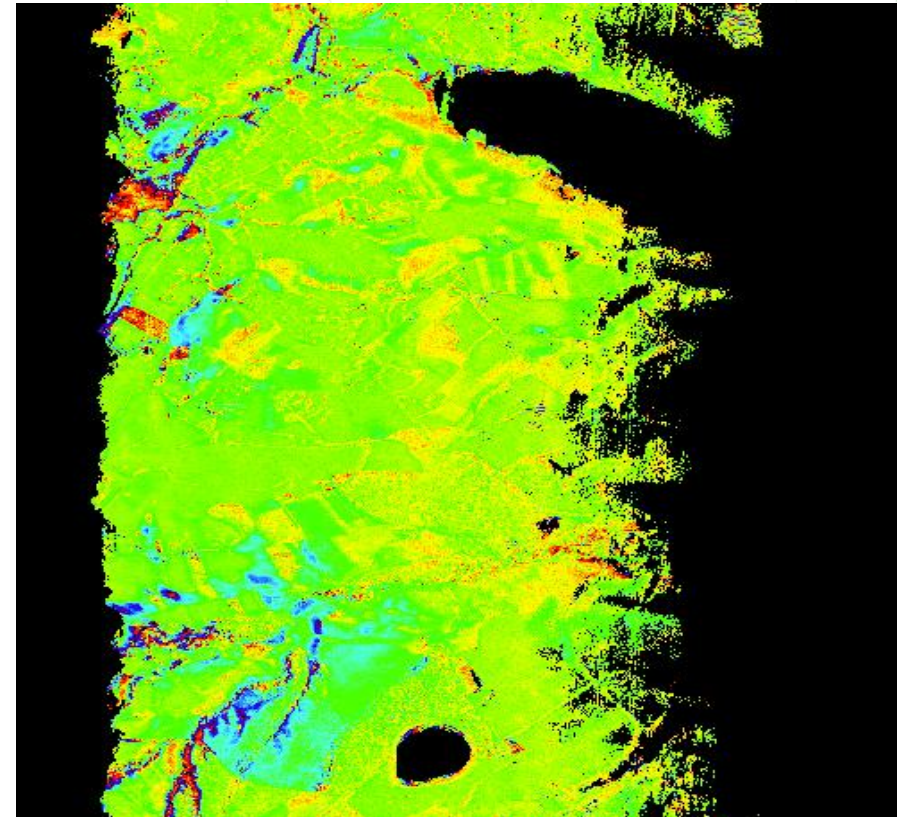
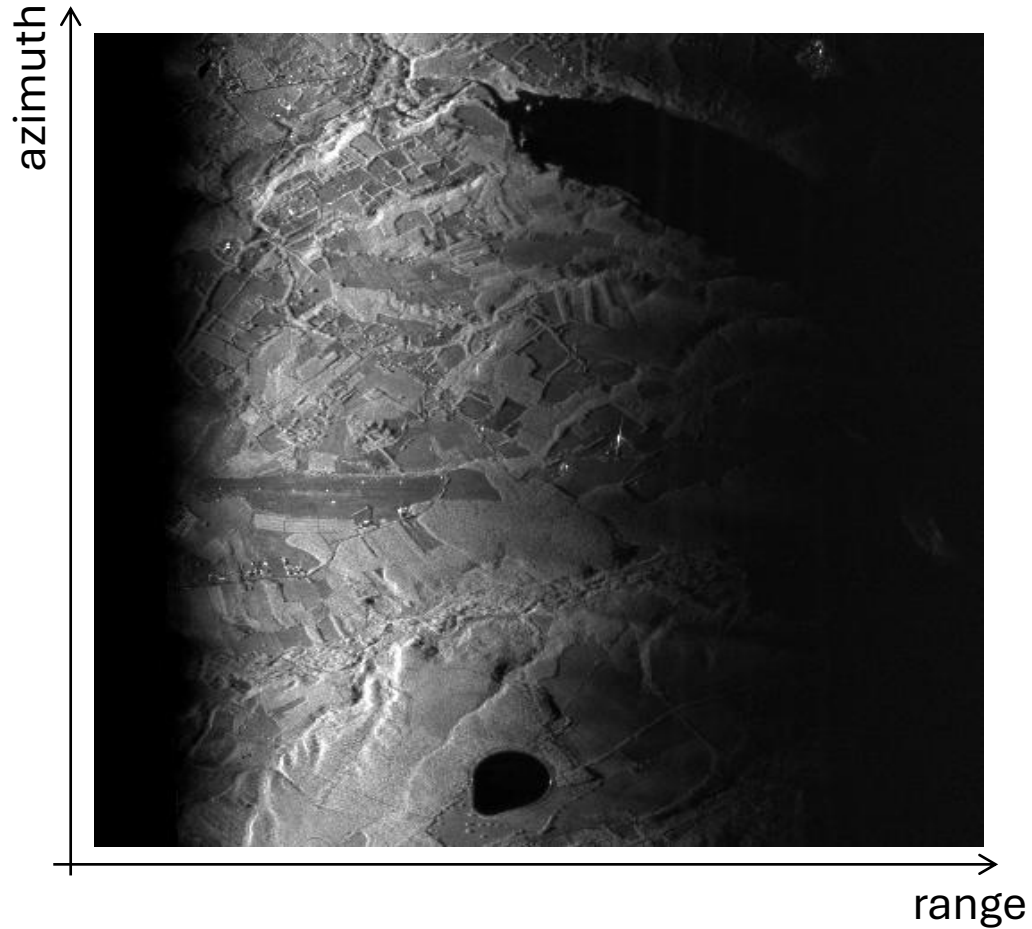
Interferogram



# X-Band demonstration: Single Pass Interferometry

## Grumento area

Interferogram



# X-Band demonstration: The Stromboli case study

July 3,  
2019

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Italy

## Hiker killed after volcano erupts on Italian island

Residents evacuated as fire crews tackle blaze on west coast of Stromboli

Lorenzo Tondo in Palermo and agencies

@lorenzo\_tondo

Wed 3 Jul 2019 19.45 BST

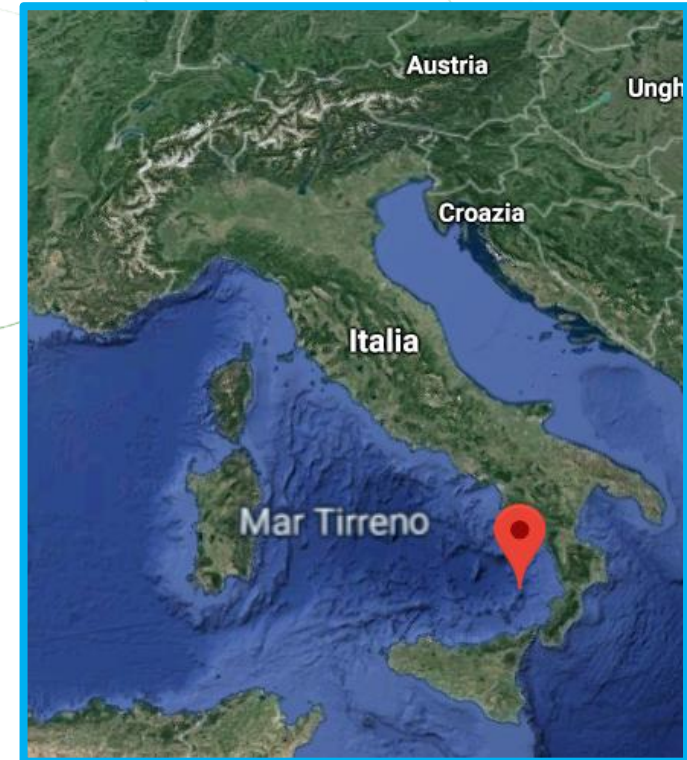


428



▲ Volcano erupts on Italian island of Stromboli - video

*"A volcano on the Italian island of Stromboli has erupted, killing a hiker, throwing ash high into the sky and enveloping the popular tourist destination in smoke [...]. One tourist who was hiking on the volcano was killed and another injured, local firefighters confirmed [...]. Marco Neri, a volcanologist from Italy's National Institute of Geophysics and Volcanology, said eruptions were very rare on Stromboli: the last one was in 2007. "Today's was a very violent explosion. Ash and lapilli [rock fragments] were shot up to two kilometres high before landing on the ground and hitting the sides of the mountain. This has obviously caused numerous fires. Fortunately, the eruptions have settled right down now," he said."*

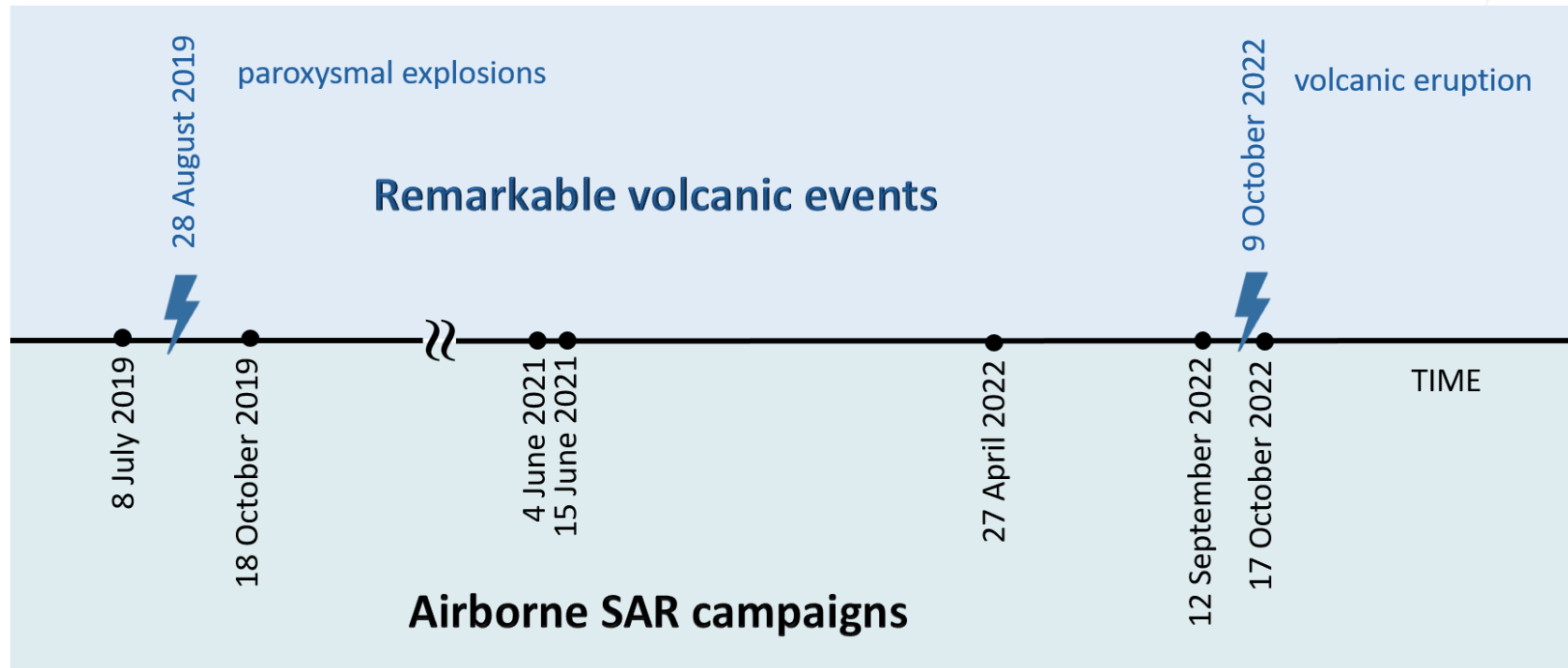


Source: <https://www.theguardian.com/world/2019/jul/03/volcano-erupts-in-italian-island-of-stromboli>

## X-Band demonstration: The Stromboli case study

Agreement between IREA-CNR and the Department of Civil Protection of the Presidency of the Council of Ministers of Italy

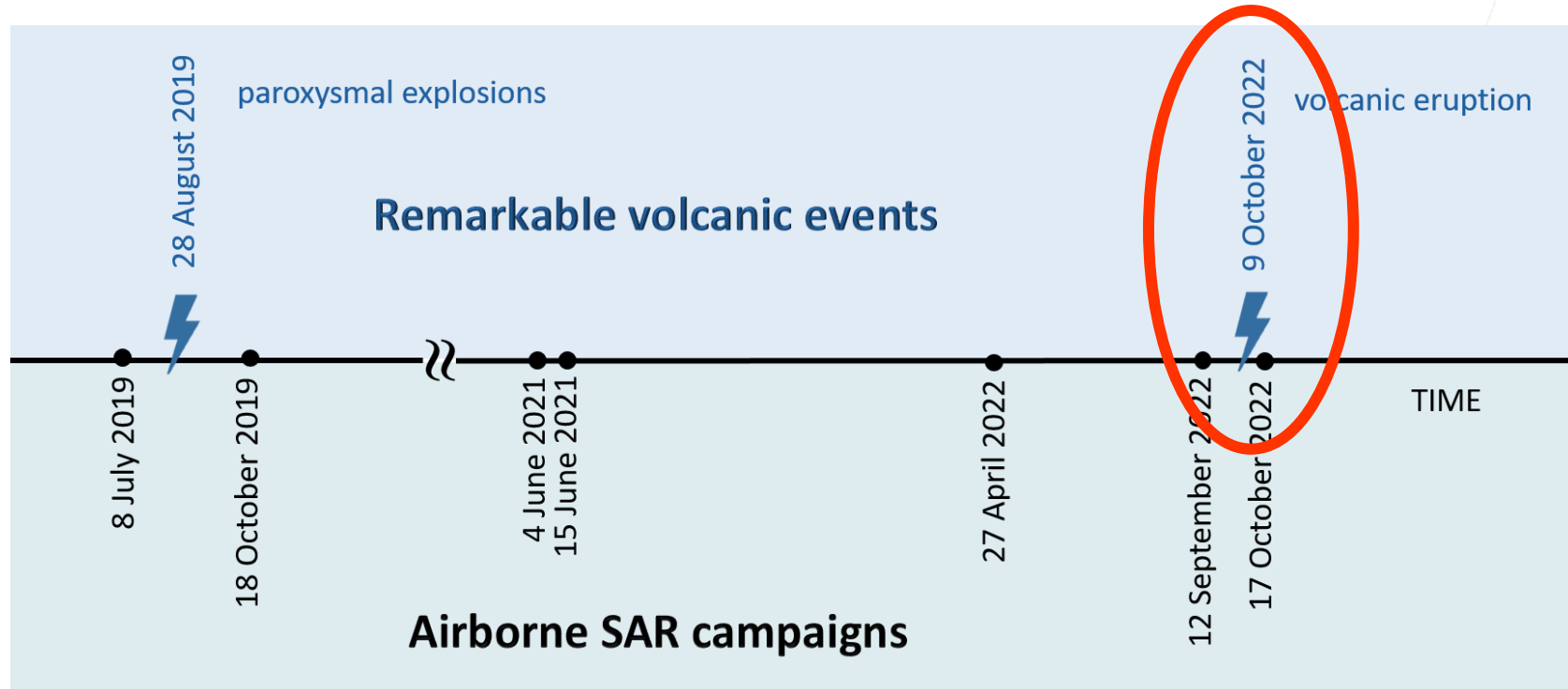
- 7 airborne campaigns between July 2019 and October 2022
- 2 remarkable volcanic events



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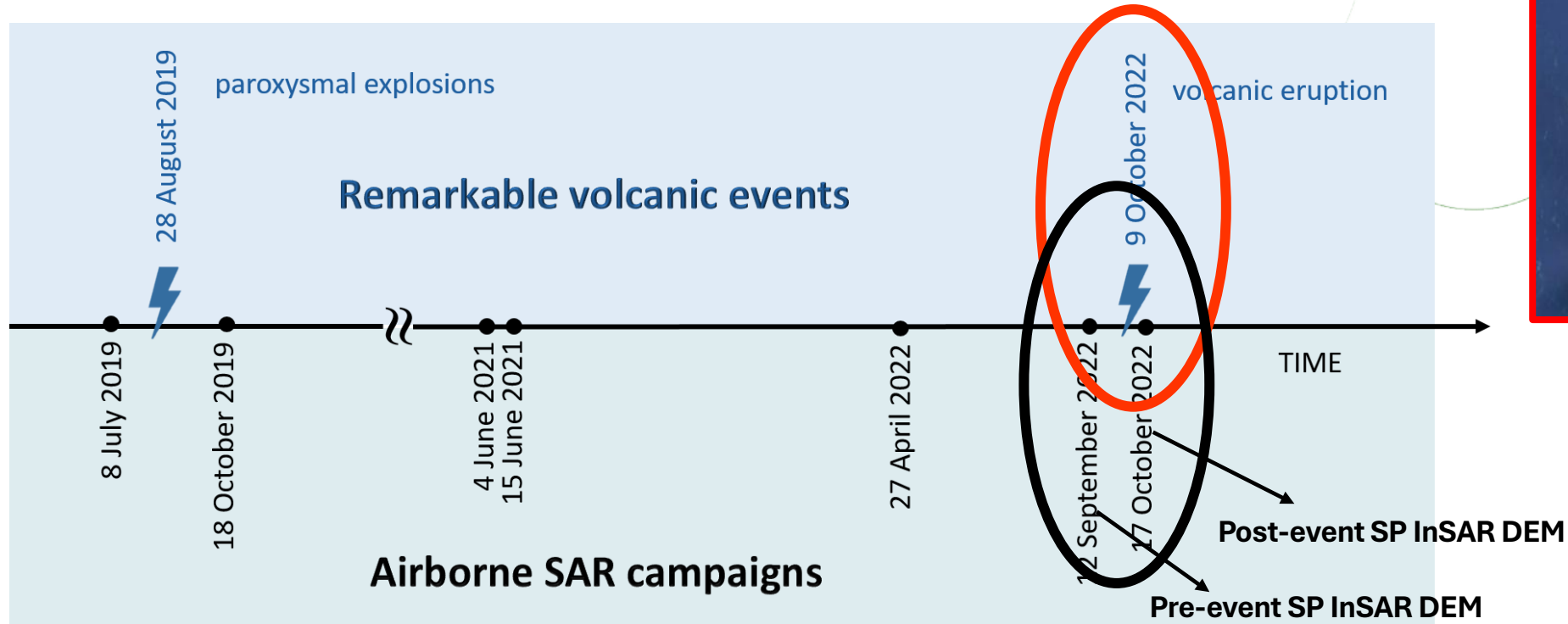
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Agreement between IREA-CNR and the Department of Civil Protection of the Presidency of the Council of Ministers of Italy

- 7 airborne campaigns between July 2019 and October 2022
- 2 remarkable volcanic events



# X-Band demonstration: The Stromboli case study



# X-Band demonstration: The Stromboli case study

Collapse of the NW flank of the volcano  
("Sciara del Fuoco")

~  $6.4 \times 10^6$  m<sup>3</sup> of pyroclastic materials  
poured into the sea



# X-Band demonstration: The Stromboli case study

Difference of the SP InSAR DEMs

Collapse of the NW flank of the volcano  
("Sciara del Fuoco")

~  $6.4 \times 10^6$  m<sup>3</sup> of pyroclastic materials  
poured into the sea



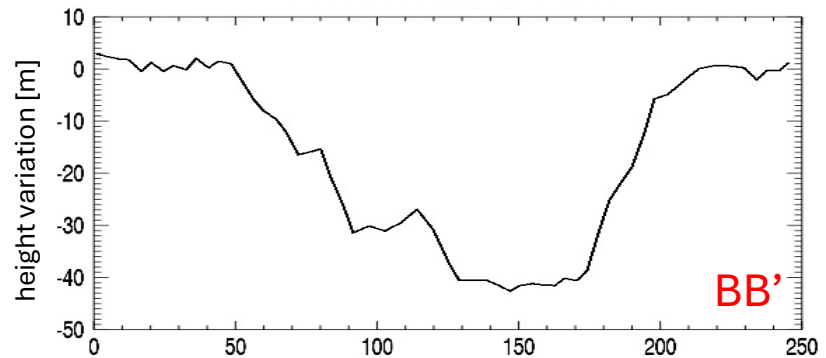
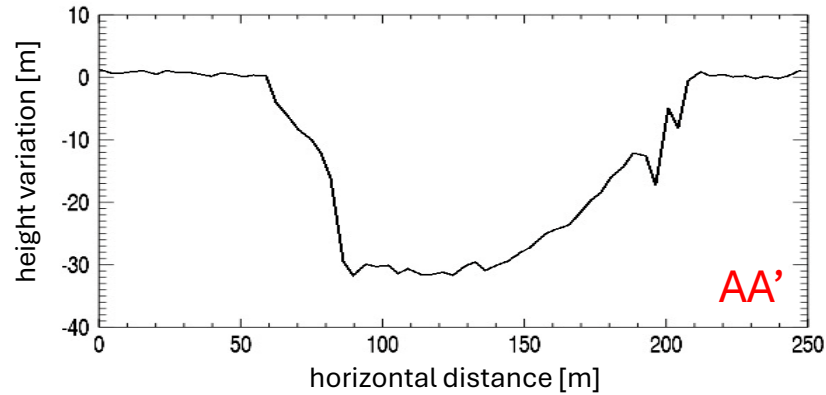
**Resolution: 2 m x 1.5 m (azimuth x range)**  
**Number of looks: 6 x 2 (azimuth x range)**  
**Grid spacing: 3.85 m x 4.45 m (East x North)**

**12 September 2022**  
**17 October 2022**

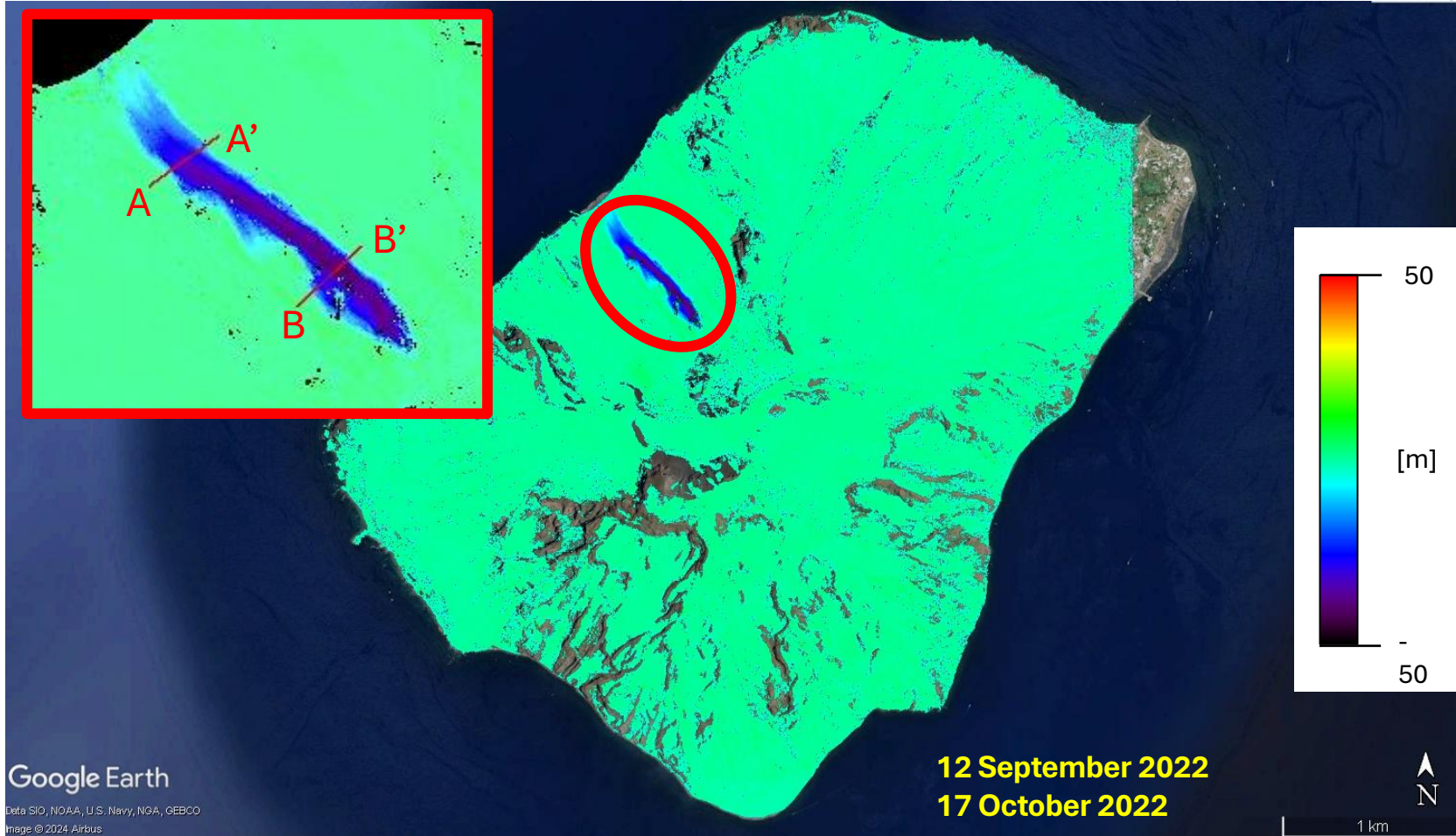
Di Traglia et al., "Generation of deposit-derived pyroclastic density currents by repeated crater rim failures at Stromboli Volcano (Italy)," accepted for publication in *Bulletin of Volcanology*.

# X-Band demonstration: The Stromboli case study

Difference of the SP InSAR DEMs



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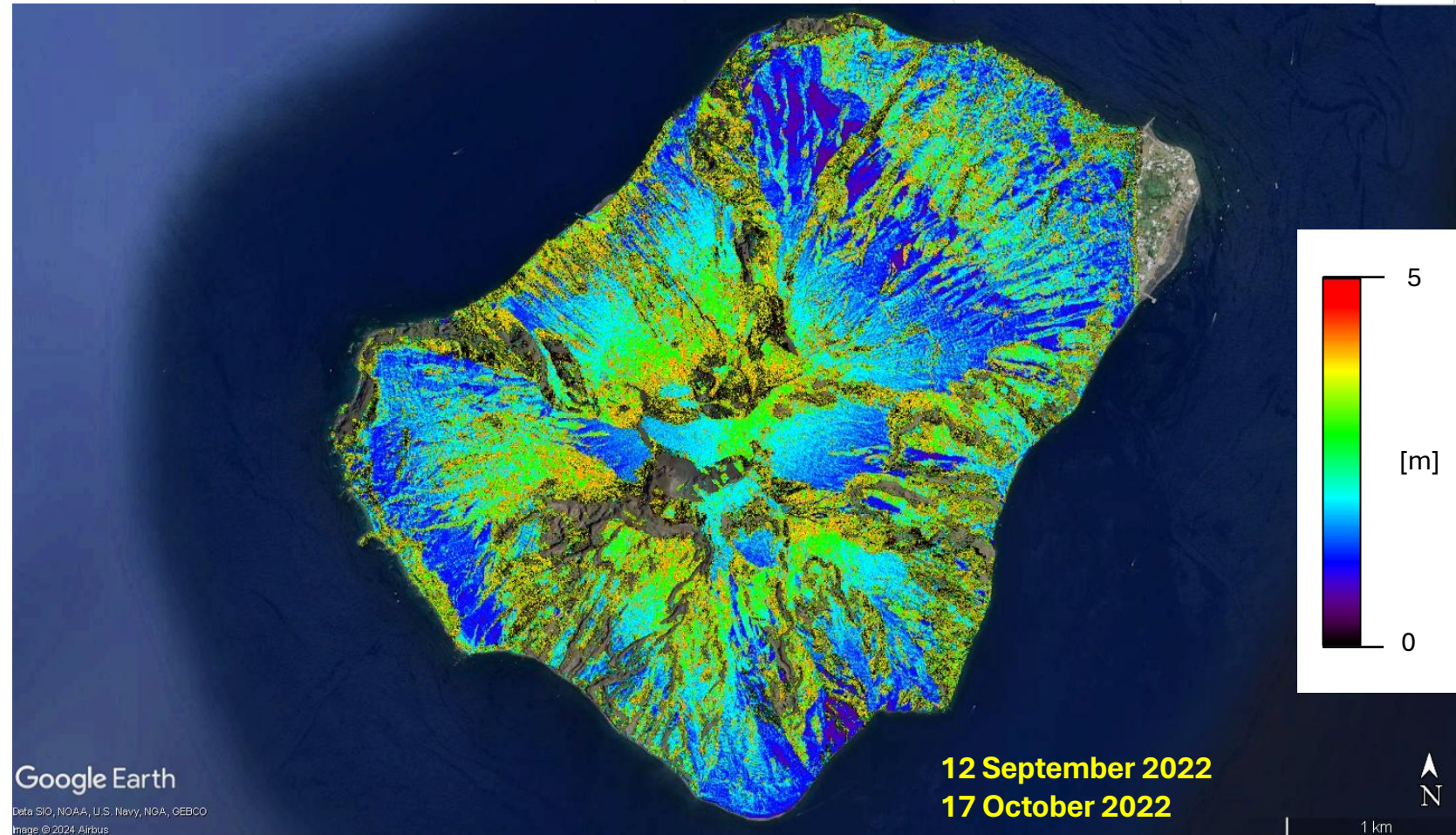
Di Traglia et al., "Generation of deposit-derived pyroclastic density currents by repeated crater rim failures at Stromboli Volcano (Italy)," accepted for publication in *Bulletin of Volcanology*.

# X-Band demonstration: The Stromboli case study

Accuracy of the height differences

...according to the Cramer Rao bound on the phase variance in:

E. Rodríguez and J. M. Martín, "Theory and design of interferometric synthetic-aperture radars," Proc. Inst. Elect. Eng., vol. 139, no. 2, pp. 147–159, 1992.



**Resolution: 2 m x 1.5 m (azimuth x range)**  
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# THANKS!

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# Telerilevamento iperspettrale da aereo dal visibile all'infrarosso termico: applicazioni in campo ambientale

CNR – SALA CONFERENZE AREA TERRITORIALE DELLA  
RICERCA DI POTENZA | TITO SCALO  
13 GIUGNO 2025

**IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System**  
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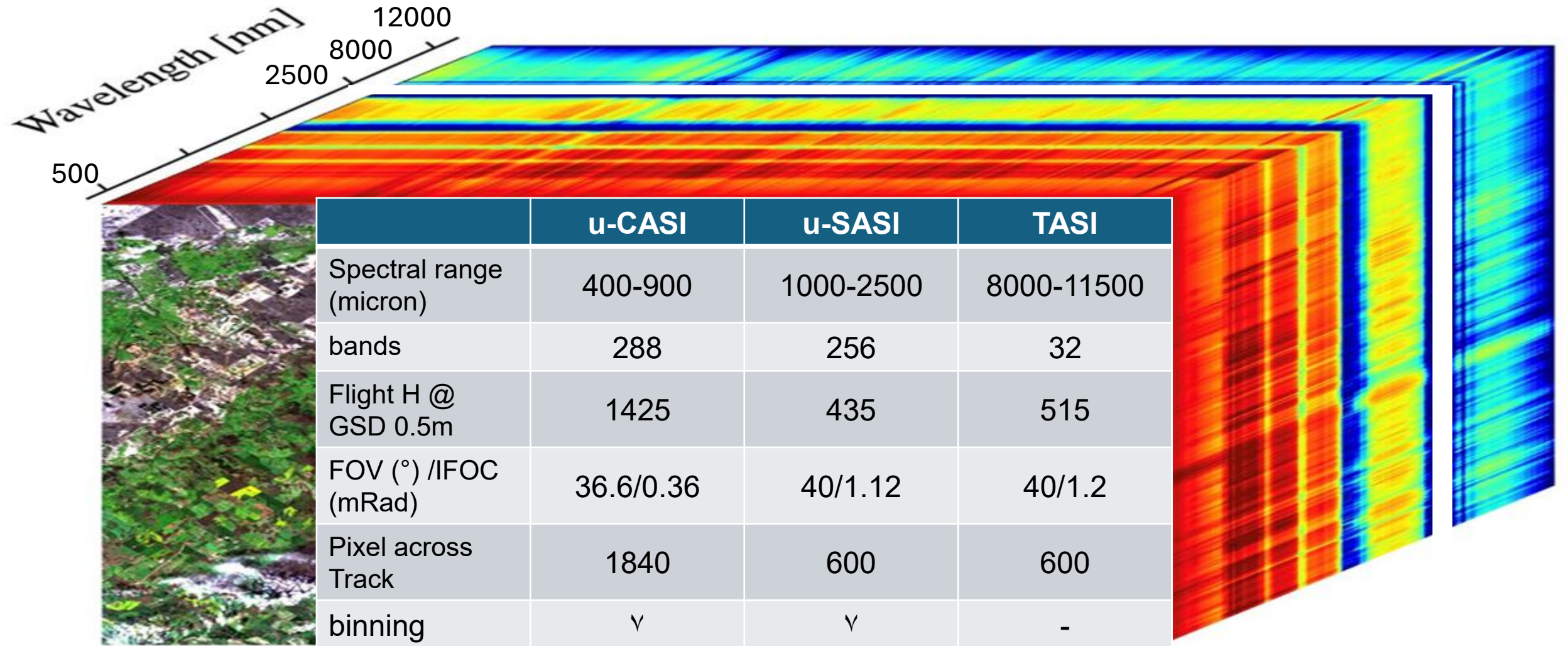
Finanziato  
dall'Unione europea  
NextGenerationEU



Ministero  
dell'Università  
e della Ricerca

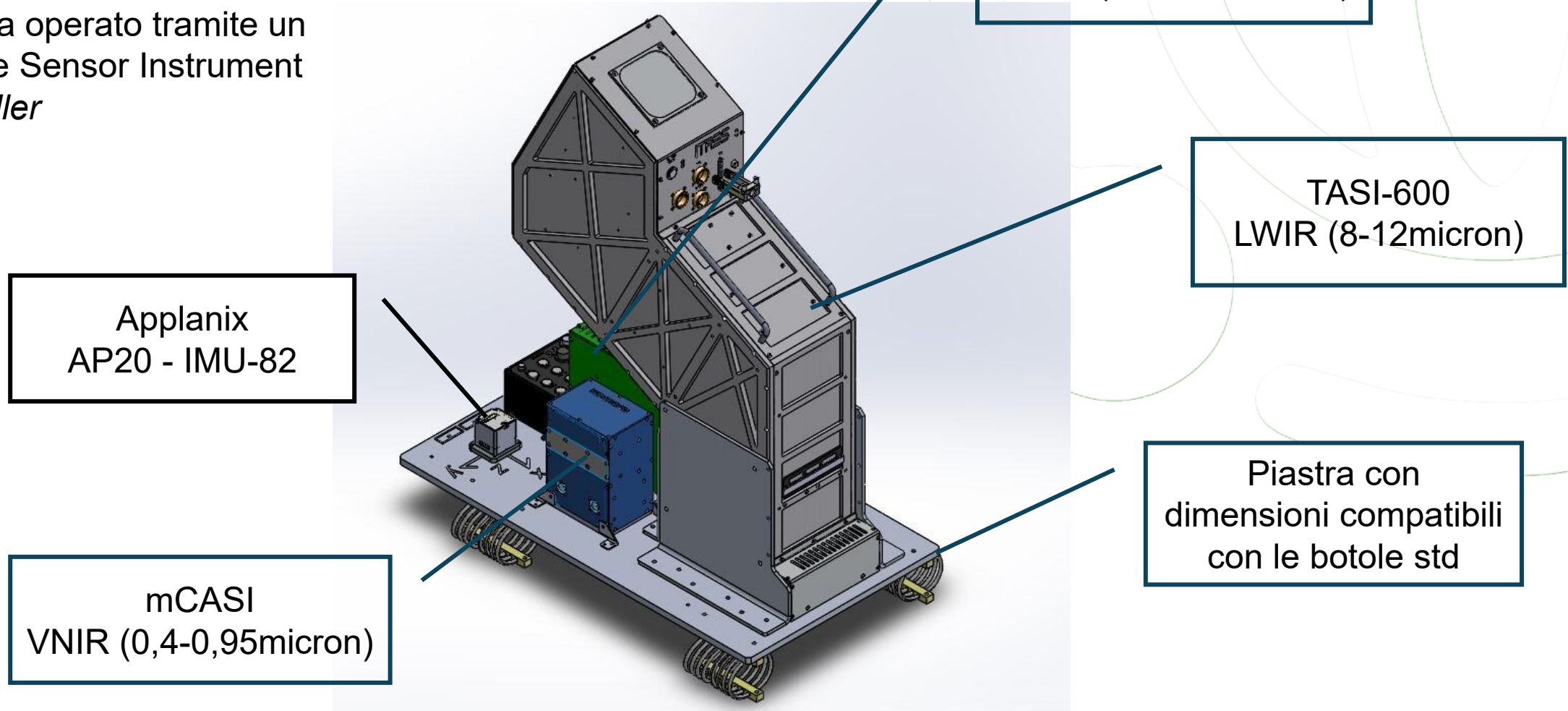


# Sistema VSWIR-LWIR

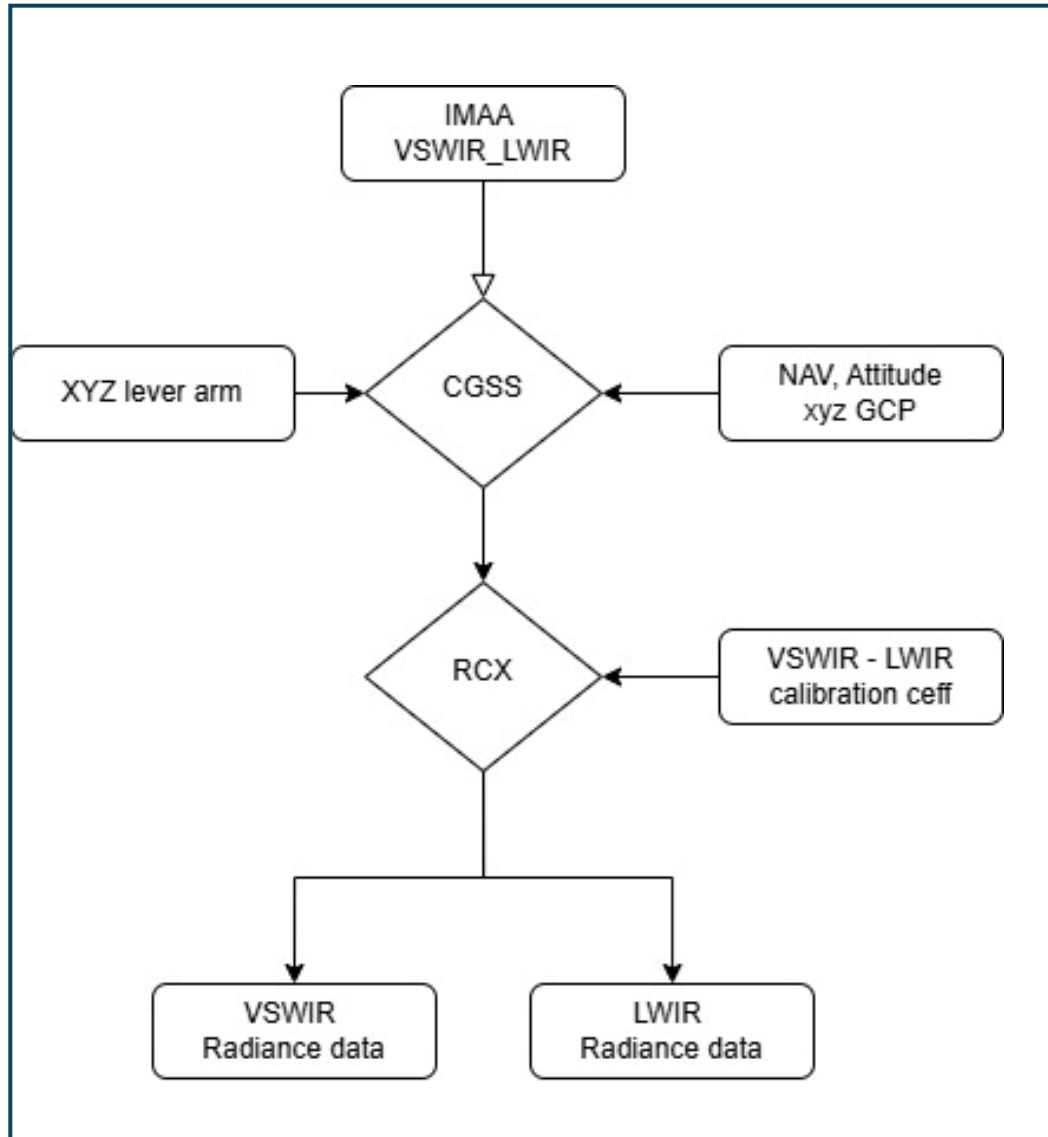


# Integrazione del sistema

Sistema operato tramite un  
Multiple Sensor Instrument  
*Controller*



# processing



microSASI, microCASI e TASI vengono alla fine della procedura di calibrazione ricampionati alla stessa risoluzione spaziale del sensore meno risoluto per ottenere un data set co-registrato che VSWIR al LWIR.

Atteso RMS di un pixel

# Examples data



uCASI-uSASI Fused data set

Sicity, 02.02.2024

0.5m GSD

Display bands

R: 617.2 nm

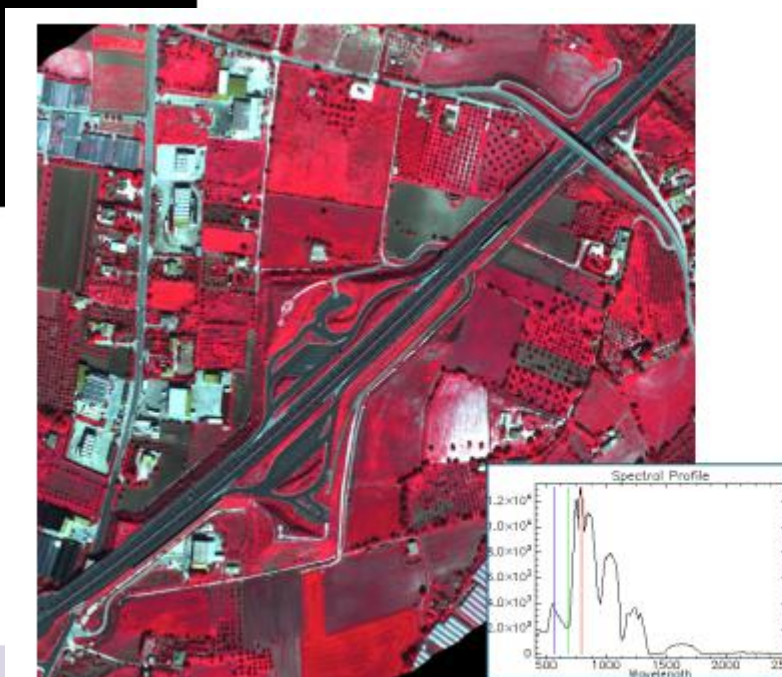
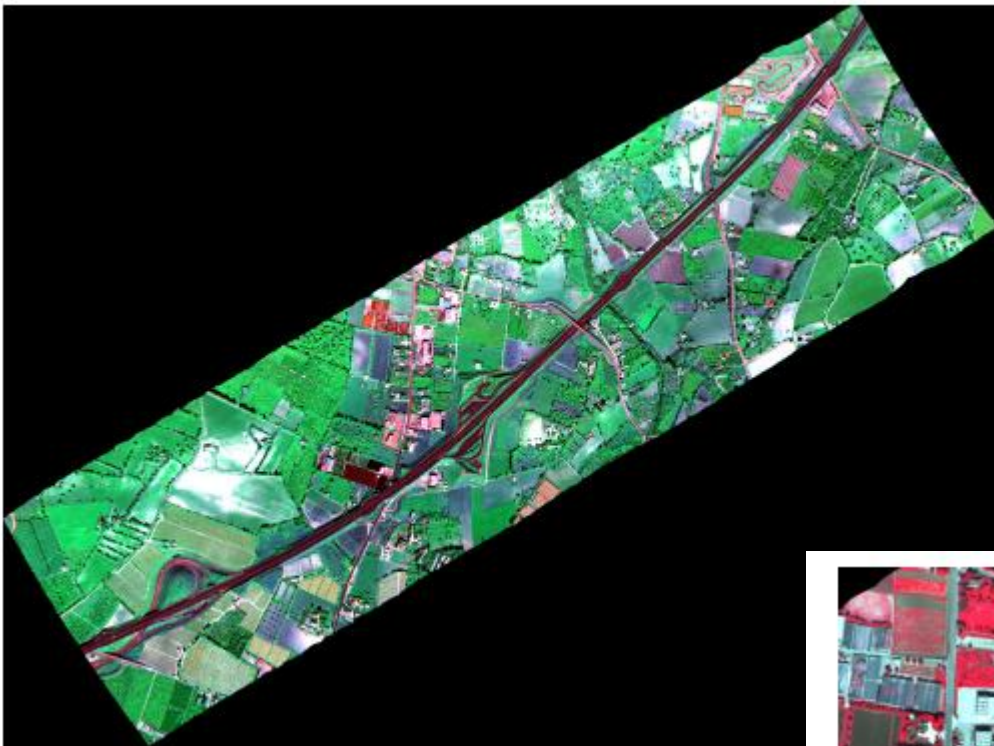
G: 1171.8 nm

B: 1675.4 nm

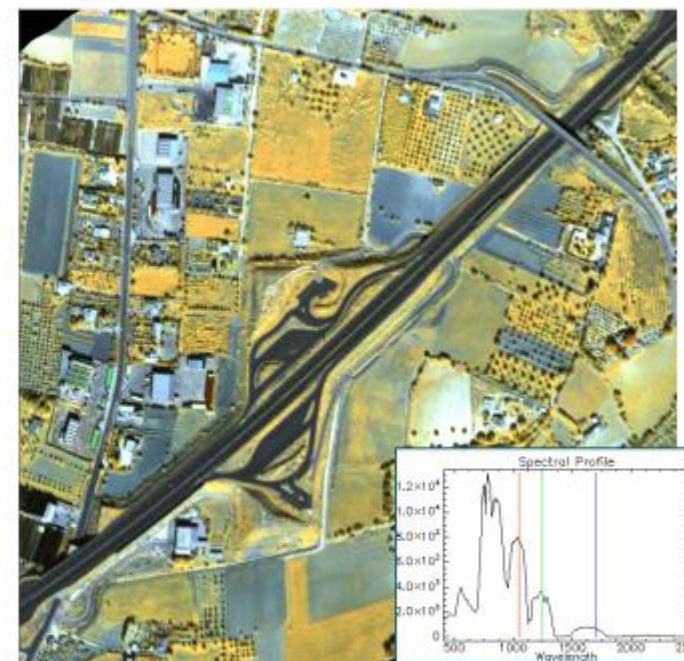
Test flight data

uCASI data bands summed by 6 (48 band data for VNIR)

uSASI data – full spectral resolution



microCASI-1840 Imagery

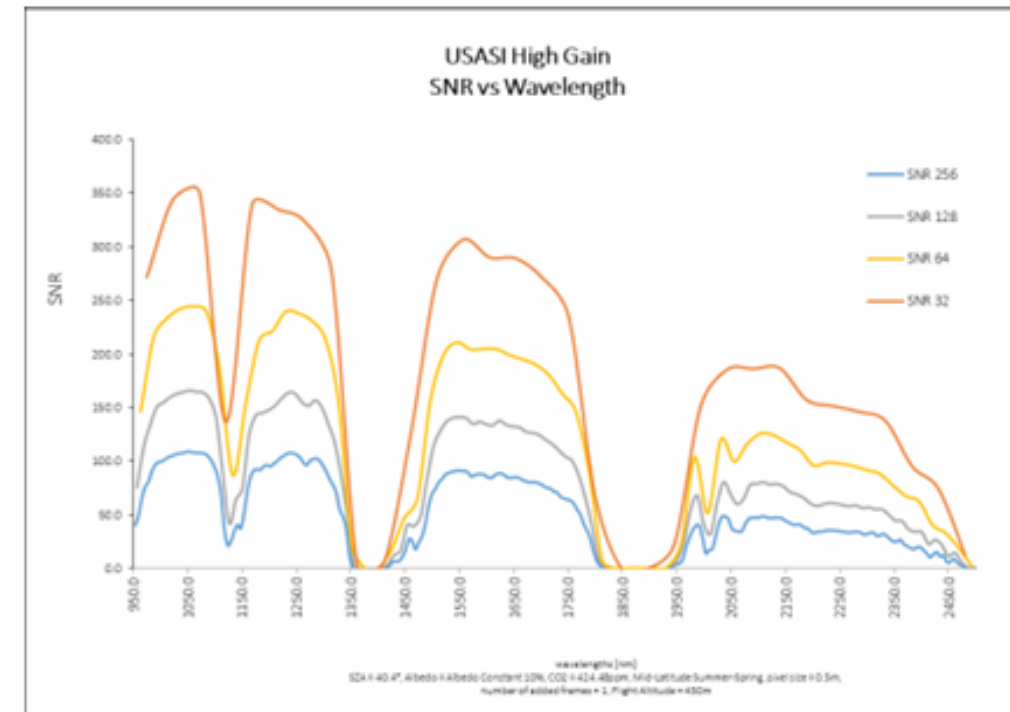
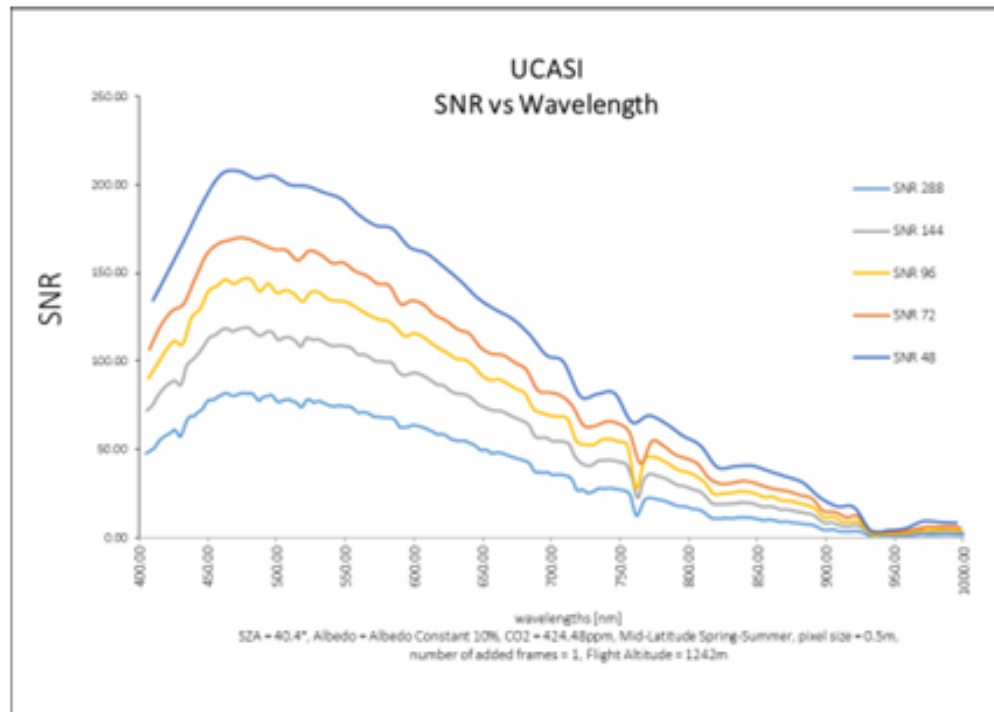


microSASI-640 Imagery

## ALBEDO CONSTANT 10% (21.03)

### UCASI

### USASI HI



## VSWIR IMAA@COR.

**PRISMA tool**

**Sentinel 2 tool**

**MODTRAN Card Manager**

Accquisition parameters: Date: 11/04/2020, Calendar: 40,8270, Longitude: 14,1378

Parameter control table:

MODTRN	1
SPEED	
MODEL	2
ITYPE	
IEMSC1	2
IMULT	-1
M1	0
M2	0
M3	0
M4	0
M5	0
M6	0
MDEF	0
M	0
NOPRINT	0
TPTEMP	0.000000
SURREF	0.0

$$L = A \frac{\rho}{(1 - S\rho_e)} + B \frac{\rho_e}{(1 - S\rho_e)} + L_{pat\ h}$$

basic correction

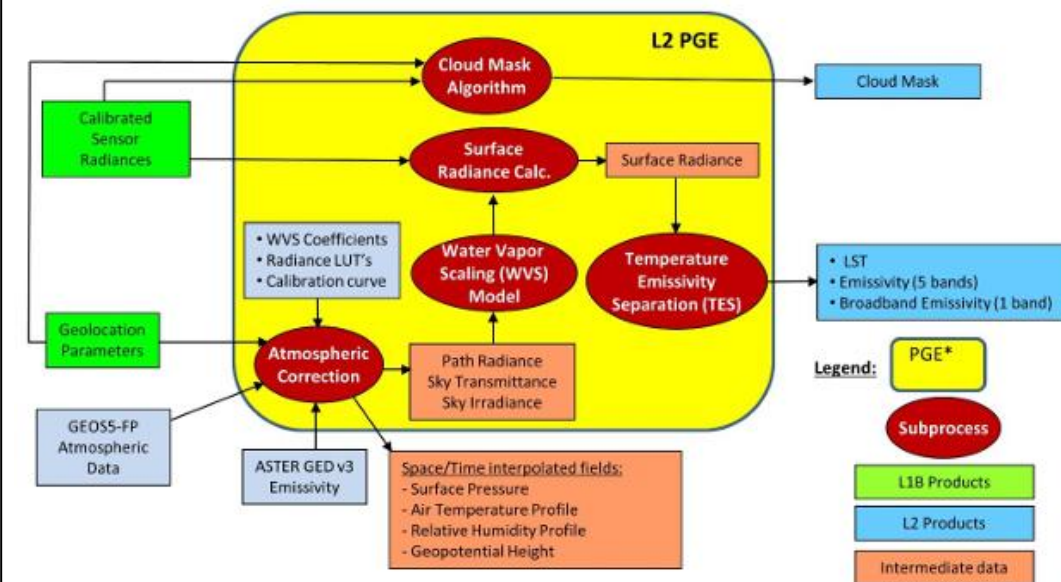
$$L = A_d \rho \cdot \frac{\cos(i)}{\cos(\theta_s)} + [A \frac{\rho}{(1 - S\rho_e)} - A_d \rho] \cdot \frac{(\pi - \alpha)}{\pi} + B \frac{\rho_e}{(1 - S\rho_e)} + L_{pat\ h}$$

adjacency correction included

$$L = A_d \rho \cdot \frac{\cos(i)}{\cos(\theta_s)} + [A \frac{\rho}{(1 - S\rho_e)} - A_d \rho] \cdot \frac{(\pi - \alpha)}{\pi} + B \frac{\rho_e}{(1 - S\rho_e)} + L_{pat\ h}$$

adjacency and topographic corrections included

## LWIR ISAC + TES











# Possibili prodotti L3 con il sistema ottico da aereo

LWIR	VSWIR	VSWIR+LWIR		
<ul style="list-style-type: none"> <li> Elevated temperature features<sup>2</sup></li> <li> Surface mineralogy<sup>3</sup></li> <li> Wildfire risk</li> <li> Vegetation growing days</li> <li> Coastal dynamics</li> </ul>	<table border="0"> <tr> <td style="vertical-align: top;"> <ul style="list-style-type: none"> <li> Fractional Cover<sup>11</sup></li> <li> Snow and Ice fractional cover<sup>11</sup></li> <li> Snow spectral and broadband albedo<sup>11</sup></li> <li> Snow grain size<sup>12</sup></li> <li> Minerals Identification<sup>9</sup></li> <li> Mineral Spectral Abundance<sup>11</sup></li> <li> Top of Canopy Leaf water content<sup>3</sup></li> <li> Equivalent water thickness<sup>13</sup></li> <li> Top of Canopy nitrogen<sup>16</sup></li> <li> Top of Canopy Leaf mass per area<sup>6</sup></li> <li> Aquatic Chlorophyll a<sup>14</sup></li> <li> Phytoplankton Absorption Coefficients<sup>15</sup></li> </ul> </td> <td style="vertical-align: top;"> <ul style="list-style-type: none"> <li> Benthic Fractional Cover<sup>11</sup></li> <li> Chromophoric Dissolved Organic Matter</li> <li> Aquatic Suspended Particulate Matter</li> <li> Aquatic Classification</li> <li> Water biogeophysics</li> <li> Top of Canopy Chlorophyll a + b</li> <li> Top of Canopy Phenolics</li> <li> Top of Canopy Lignin</li> <li> Canopy biophysical properties</li> <li> Cyanobacteria Concentration</li> <li> Volcanic gases and aerosols</li> </ul> </td> </tr> </table>	<ul style="list-style-type: none"> <li> Fractional Cover<sup>11</sup></li> <li> Snow and Ice fractional cover<sup>11</sup></li> <li> Snow spectral and broadband albedo<sup>11</sup></li> <li> Snow grain size<sup>12</sup></li> <li> Minerals Identification<sup>9</sup></li> <li> Mineral Spectral Abundance<sup>11</sup></li> <li> Top of Canopy Leaf water content<sup>3</sup></li> <li> Equivalent water thickness<sup>13</sup></li> <li> Top of Canopy nitrogen<sup>16</sup></li> <li> Top of Canopy Leaf mass per area<sup>6</sup></li> <li> Aquatic Chlorophyll a<sup>14</sup></li> <li> Phytoplankton Absorption Coefficients<sup>15</sup></li> </ul>	<ul style="list-style-type: none"> <li> Benthic Fractional Cover<sup>11</sup></li> <li> Chromophoric Dissolved Organic Matter</li> <li> Aquatic Suspended Particulate Matter</li> <li> Aquatic Classification</li> <li> Water biogeophysics</li> <li> Top of Canopy Chlorophyll a + b</li> <li> Top of Canopy Phenolics</li> <li> Top of Canopy Lignin</li> <li> Canopy biophysical properties</li> <li> Cyanobacteria Concentration</li> <li> Volcanic gases and aerosols</li> </ul>	<ul style="list-style-type: none"> <li> Spatially and temporally integrated VSWIR surface reflectance and TIR LST and emissivity</li> <li> Surface Mineral types, clays, and silicates</li> </ul> <p style="text-align: right;">Physical units</p> <ul style="list-style-type: none"> <li><sup>2</sup> Kelvin</li> <li><sup>3</sup> %</li> <li><sup>11</sup> Unitless fractions</li> <li><sup>12</sup> Micrometers</li> <li><sup>9</sup> Categorical classification map</li> <li><sup>13</sup> cm</li> <li><sup>16</sup> g N/g dry mass</li> <li><sup>6</sup> g/m<sup>2</sup></li> <li><sup>14</sup> ug L<sup>-1</sup></li> <li><sup>15</sup> m<sup>-1</sup></li> </ul>
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# Possibili prodotti L4 con il sistema ottico da aereo

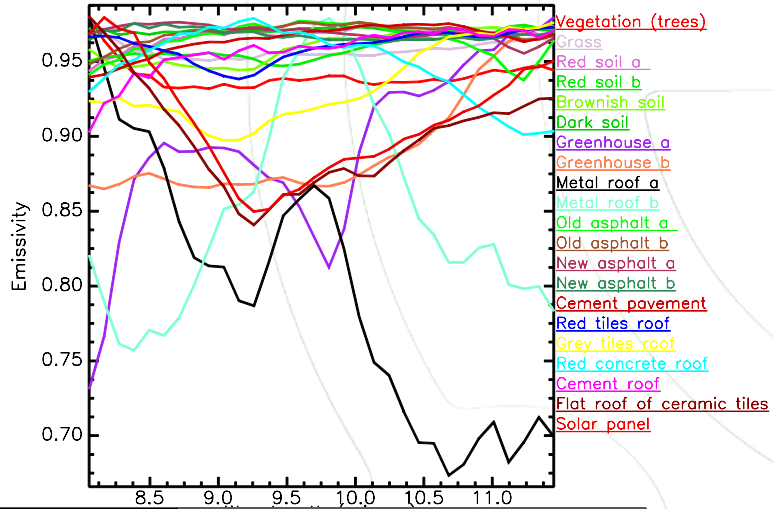
LWIR	VSWIR	VSWIR+LWIR	
<ul style="list-style-type: none"> <li> Water Use Efficiency<sup>4</sup></li> <li> Evaporative Stress Index</li> <li> Evapotranspiration<sup>5</sup></li> <li> Volcanic activity</li> </ul>	<ul style="list-style-type: none"> <li> Global Mineral Maps</li> <li> Coastal and Inland Water Quality</li> <li> Snow Water Equivalent</li> <li> Meltwater Flow Rate</li> <li> Global Commodity Crop Maps</li> <li> Global Vegetation Community Maps</li> </ul>	<ul style="list-style-type: none"> <li> Snowpack conditions, temperature and change, surface water availability, snow melt</li> <li> Surface energy balance, severe weather</li> <li> Large scale Volcanic hazards (aviation, climate)</li> <li> Agricultural inputs, precision agriculture</li> </ul>	<ul style="list-style-type: none"> <li> Forecasting Volcanic hazards</li> <li> Food security</li> <li> Forest and cropland stress</li> <li> Fire risk, prescribed fire</li> <li> Ecosystem physiology: Plant function, GPP, forest and crop condition</li> <li> Water quality</li> <li> Fire behavior</li> <li> Temperature, combustion from flaring operations</li> </ul>
<p>Physical units</p> <p><sup>4</sup> GPP/ET</p> <p><sup>5</sup> mm/day</p>			



# Land Cover

## Volo TASI (LWIR) Pontecagnano

AO 92.15%  
K 0.90

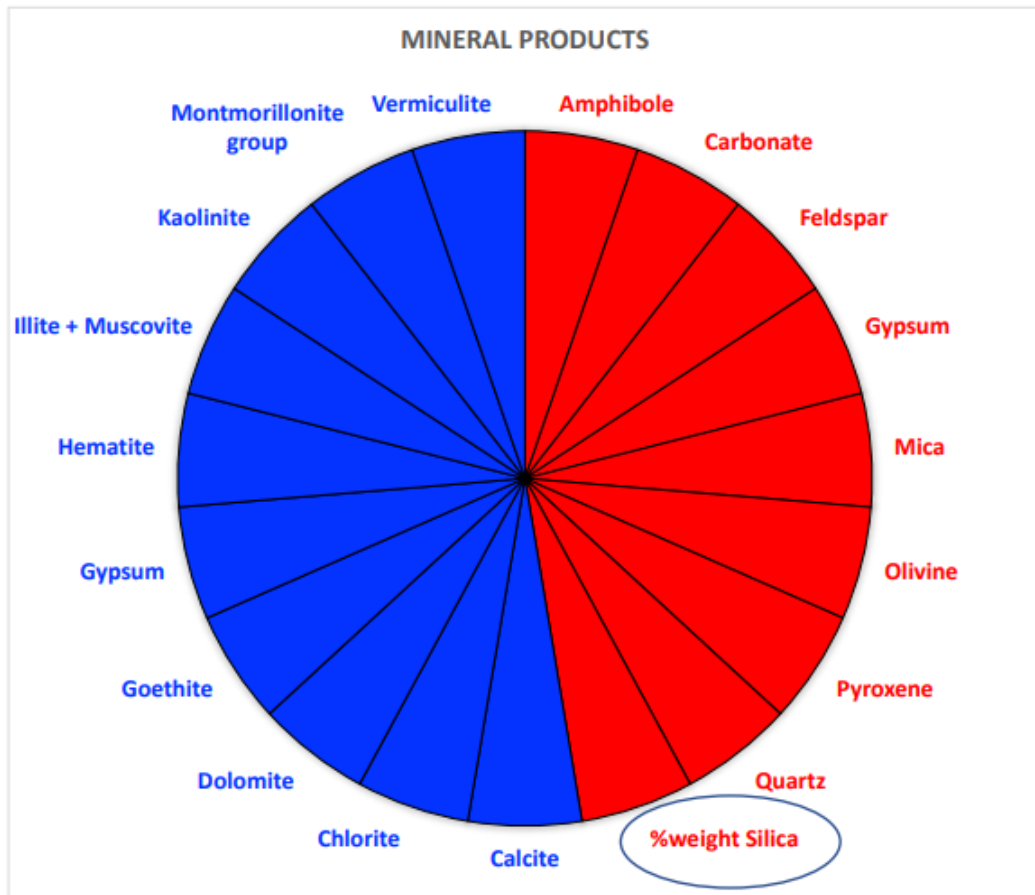


Unclassified	Tetti cemento	Vegetazione	Serre	Tetti rossi	Pannelli solari	Tetti cem. rosso
Tetti metallo	Asfalto nuovo	Asfalto usurato	Suolo	Tetti grigi	Pavim. cemento	Tetti ceramica

RURAL	VEG	Vegetation (trees) Grass		
	SOIL	Red soil a Red soil b Brownish soil Dark soil Greenhouse a Greenhouse b		
		PAVING	Old asphalt a Old asphalt b New asphalt a New asphalt b Cement pavement	
			ROOFING	Metal roof a Metal roof b Red tiles roof Grey tiles roof Red concrete roof Cement roof Flat roof of ceramic tiles Solar panel

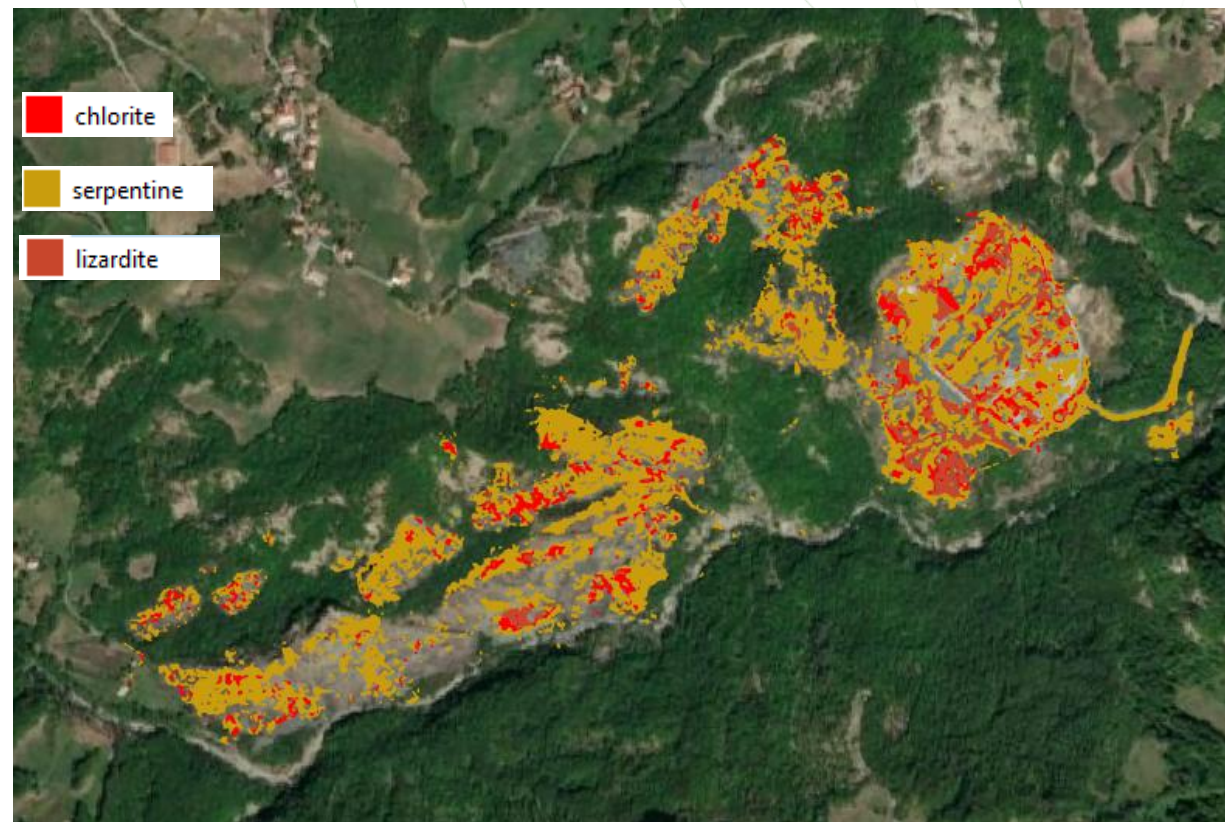


# Geologia, raw materials



■ VSWIR   
 ■ TIR

## LWIR (TASI)





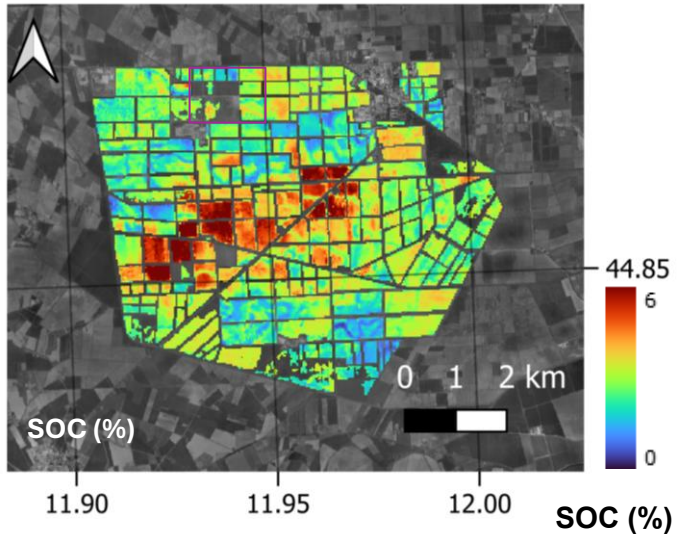
# Caratteristiche del suolo agricolo (SOC, tessitura)

## VSWIR (satellite)

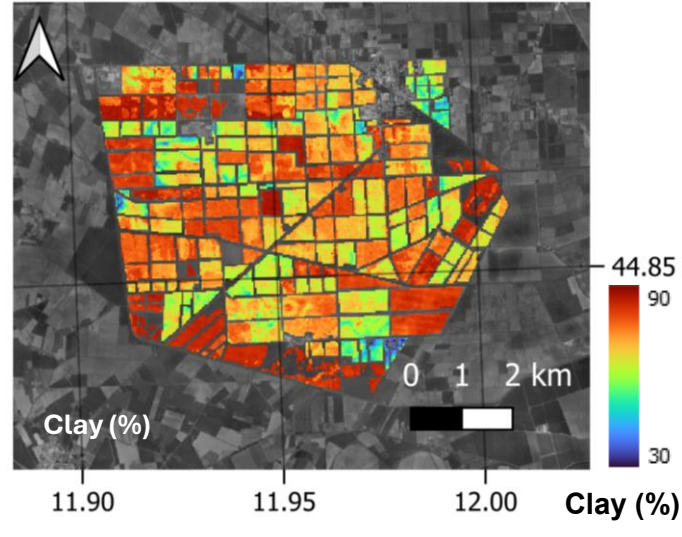
Mappe stimate con immagine di **EnMAP** composita generata mediando il segnale di suolo nudo da una serie temporale (2022-25) di 32 immagini EnMAP acquisite su Jolanda di Savoia (FE).

**Gaussian Proces Regression (GPR) applicato allo Standard Normal Variate(SNV) su Assorbanza**

**Partial Least Square Regression (PLSR) applicato al filtro SG su detrend baseline**



$R^2$  0.68; RMSE 0.84; RPD 1.77

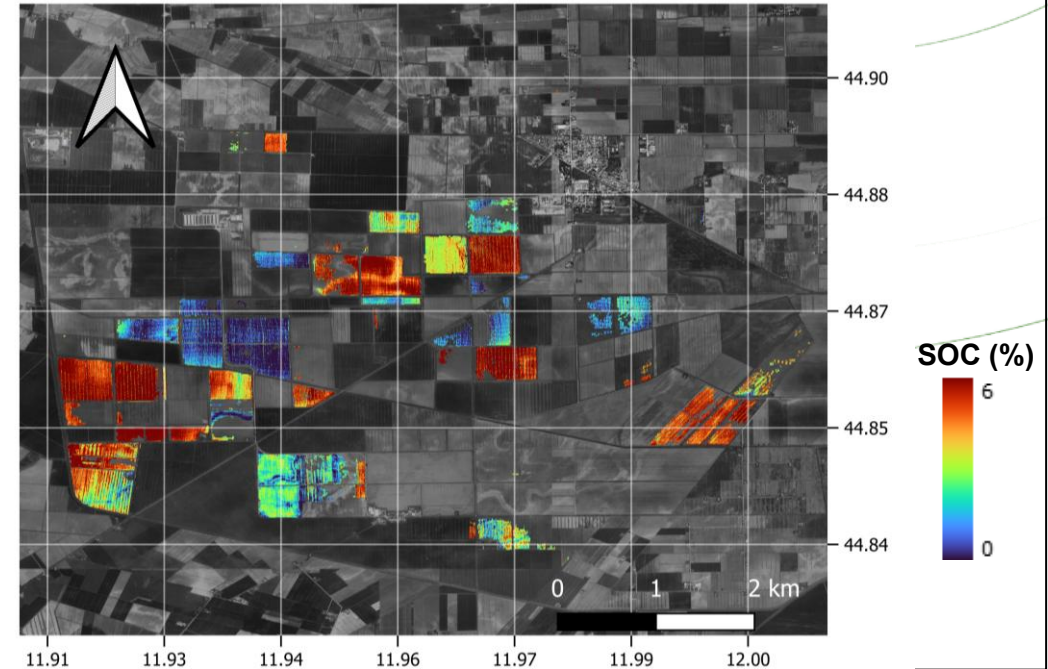


$R^2$  0.62; RMSE 9.50; RPD 1.61

## LWIR (aereo)

Mappa stimata dal mosaico di 11 strisciate HyTES (7.5-12.3micron, 256 bande) su Jolanda di Savoia (FE) del 22/06/2023

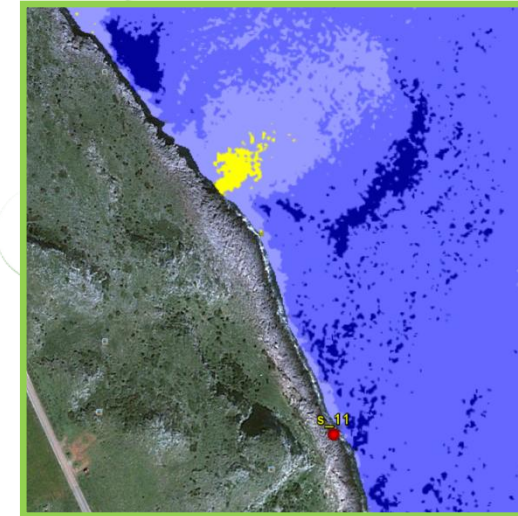
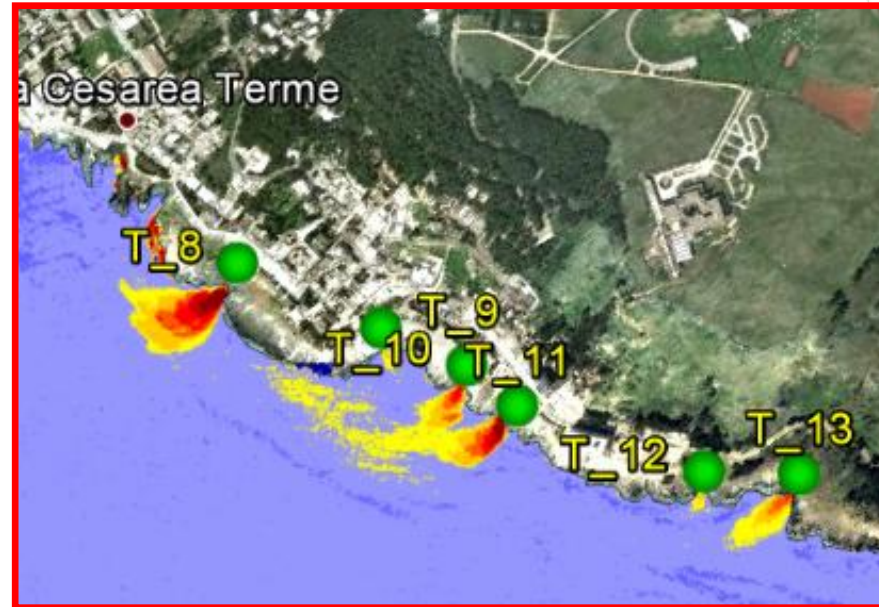
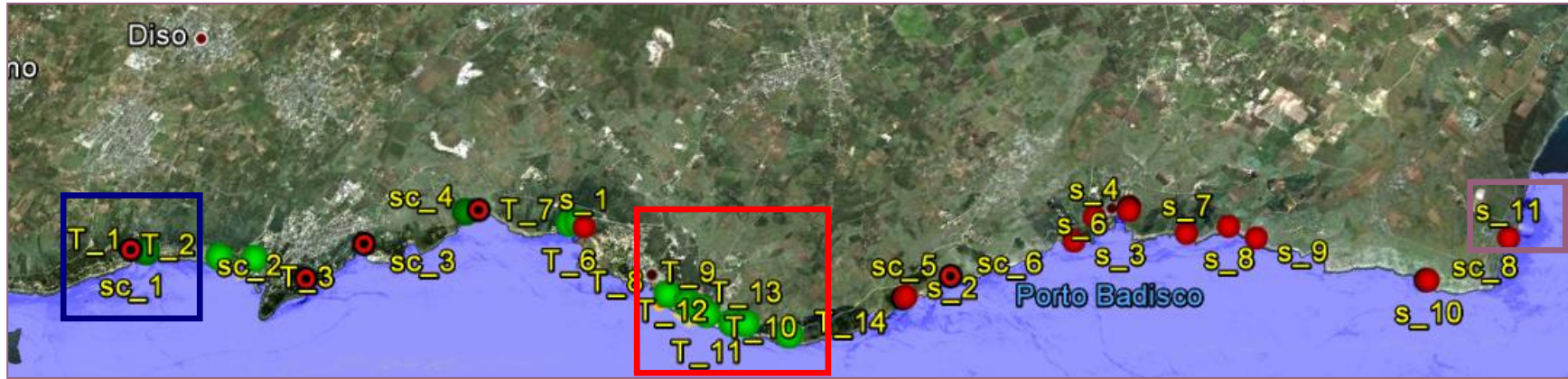
**Support Vector Regression (SVR) applicato alla Riflettanza**



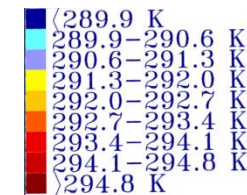
$R^2$  0.80; RMSE 0.6; RPD 2.25



# LST

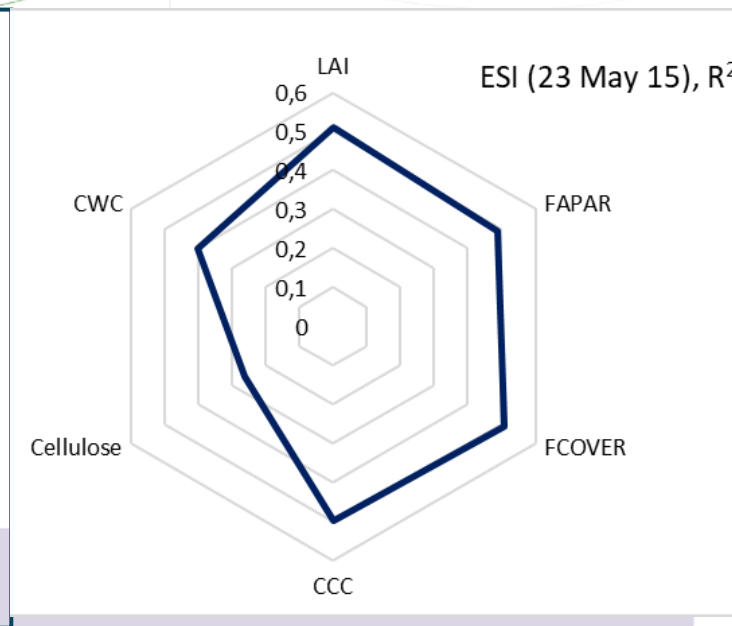
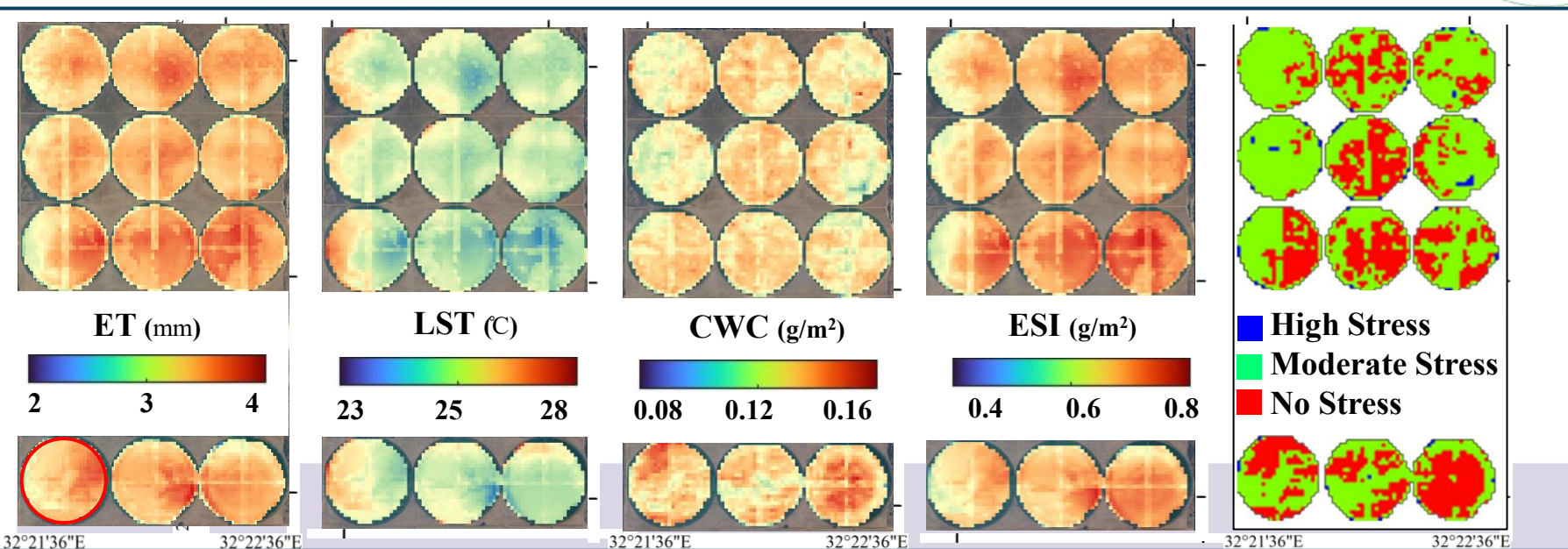
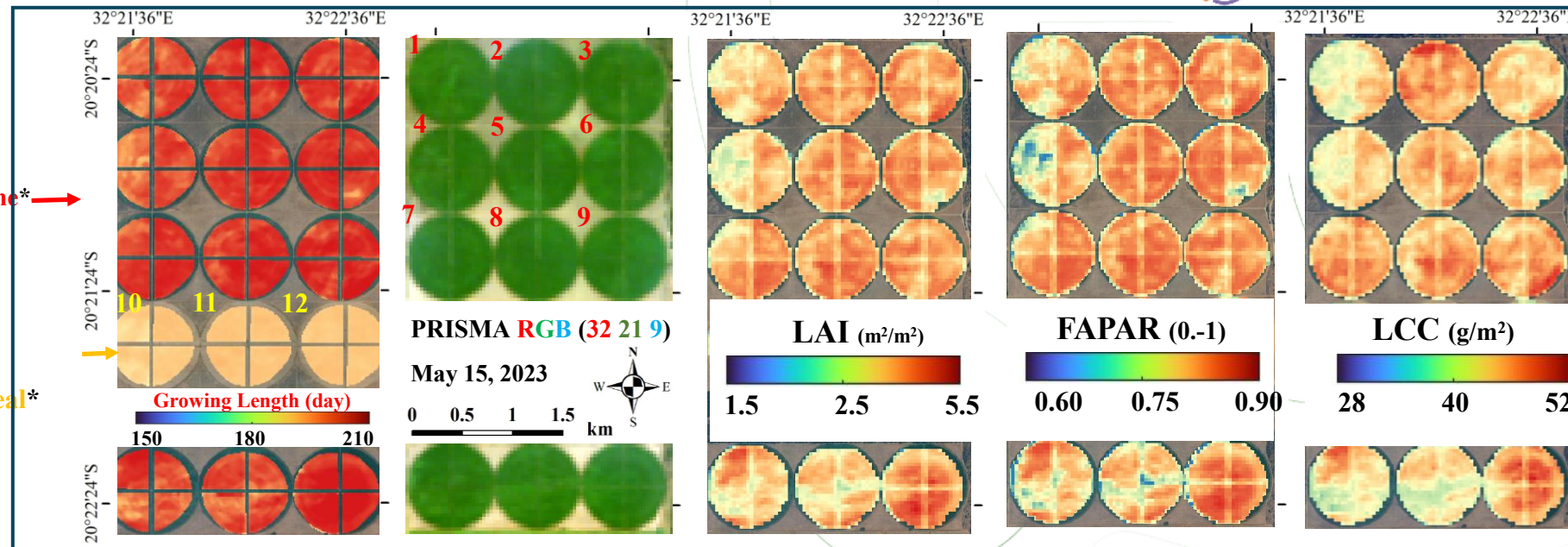
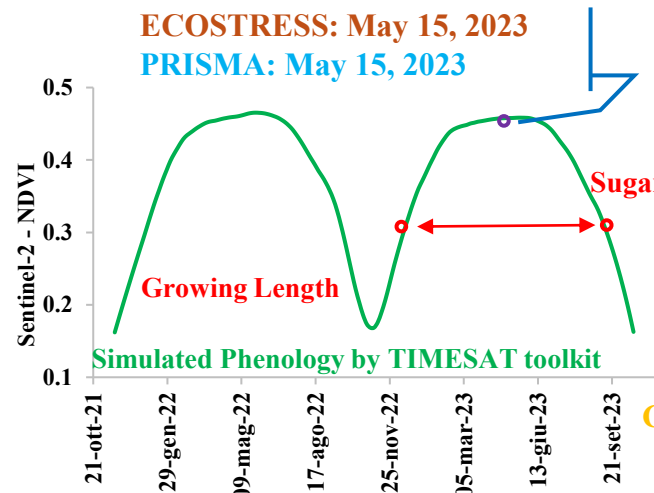


- Sorgenti censite
- Sorgenti indicate
- Anomalie TASI





# ET – CROP Stress



# Potenzialità simulazione nuove missioni

## CHIME (ESA) / PRISMA SG (ASI)

	CHIME	PRISMA-NG
Number of satellites	2	2
Combined revisit (days)	10-12.5	3-6 days (pointing capability $\pm 40^\circ$ )
Nominal Altitude (km)	632	
GSD (nadir) (m)	30	hyperspectral instrument: STRIPMAP $\leq 30$ m SPOTLIGHT $\leq 10$ m  Pancromatic STRIPMAP $\leq 5$ m SPOTLIGHT $\leq 2.5$ m
FOV (degrees)	$\pm 5.8$	
Swath (km)	$\sim 130$	STRIPMAP $\geq 30$ km up to 90 km (mosaic multiple images) SPOTLIGHT $\geq 30$ km up to 60 km (mosaic multiple images)
Coverage	Land	Land
Day/Night	Day	Day
LTDN	10:30-11:30 am	10:30
Spectral range (nm)	400-2500	400-2500
Spectral sampling (nm)	$<10$	$<10$
Signal to Noise, VNIR*		$>200$
Signal to Noise, SWIR*		$>100$

## SBG-TIR (NASA JPL / ASI)

	SBG-TIR
Number of satellites	1
Combined revisit (days)	$\leq 3$ (same obs. angles)
Nominal Altitude (km)	665
Orbit cycle (days)	3
GSD (nadir/edge of scan) (m)	TIR: $\leq 60 / 93$ , VNIR: $\leq 30 / 52^*$
FOV (degrees)	$\pm 34.4$
Swath (km)	935
Coverage	Land and Coastal
Day/Night	Day + Night
LTDN	12:30
LWIR bands (8-12 $\mu\text{m}$ )	6
VNIR/SWIR/MWIR	2/0/2
Accuracy (K)	0.5
NeDT (K)	$<0.2$
Data latency (hours)	$<24$



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THANKS!

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3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”

