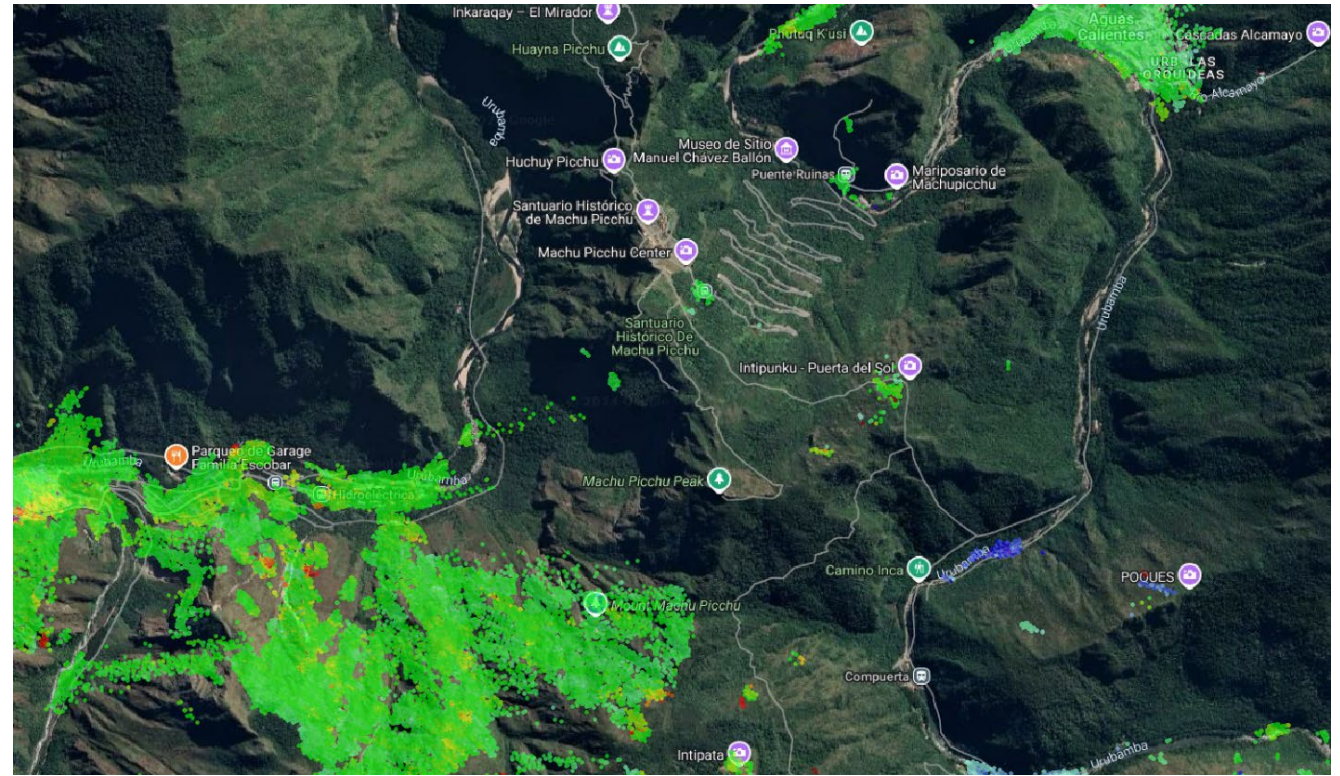
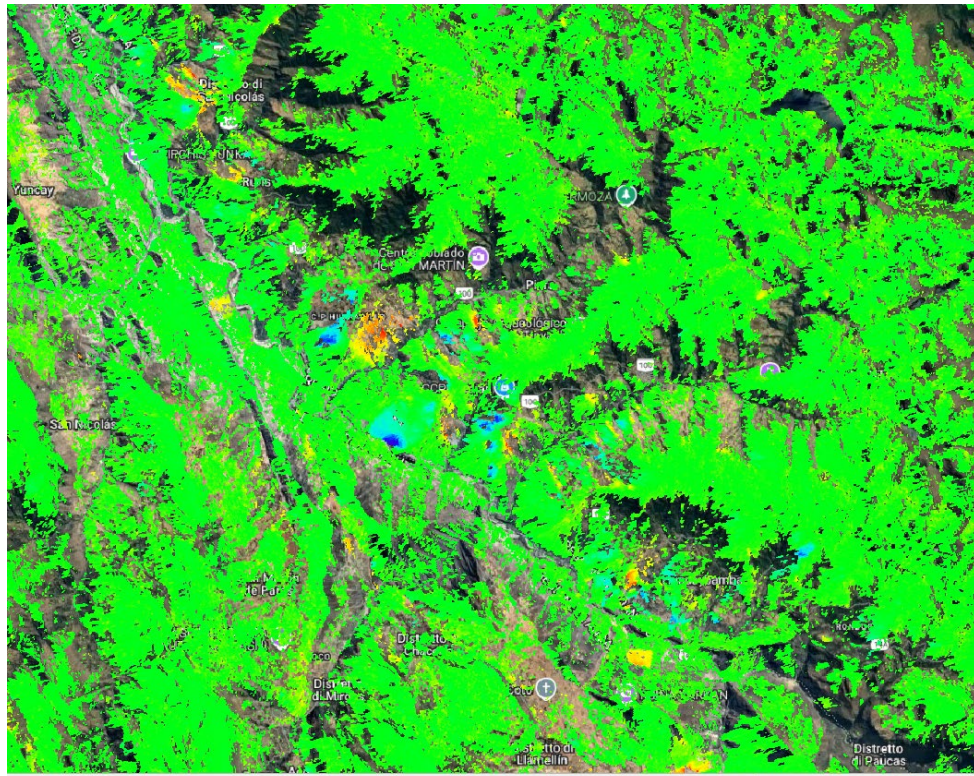


InSAR techniques and multi-risk assessment approach for monitoring Cultural heritage threatened by natural and anthropogenic hazards



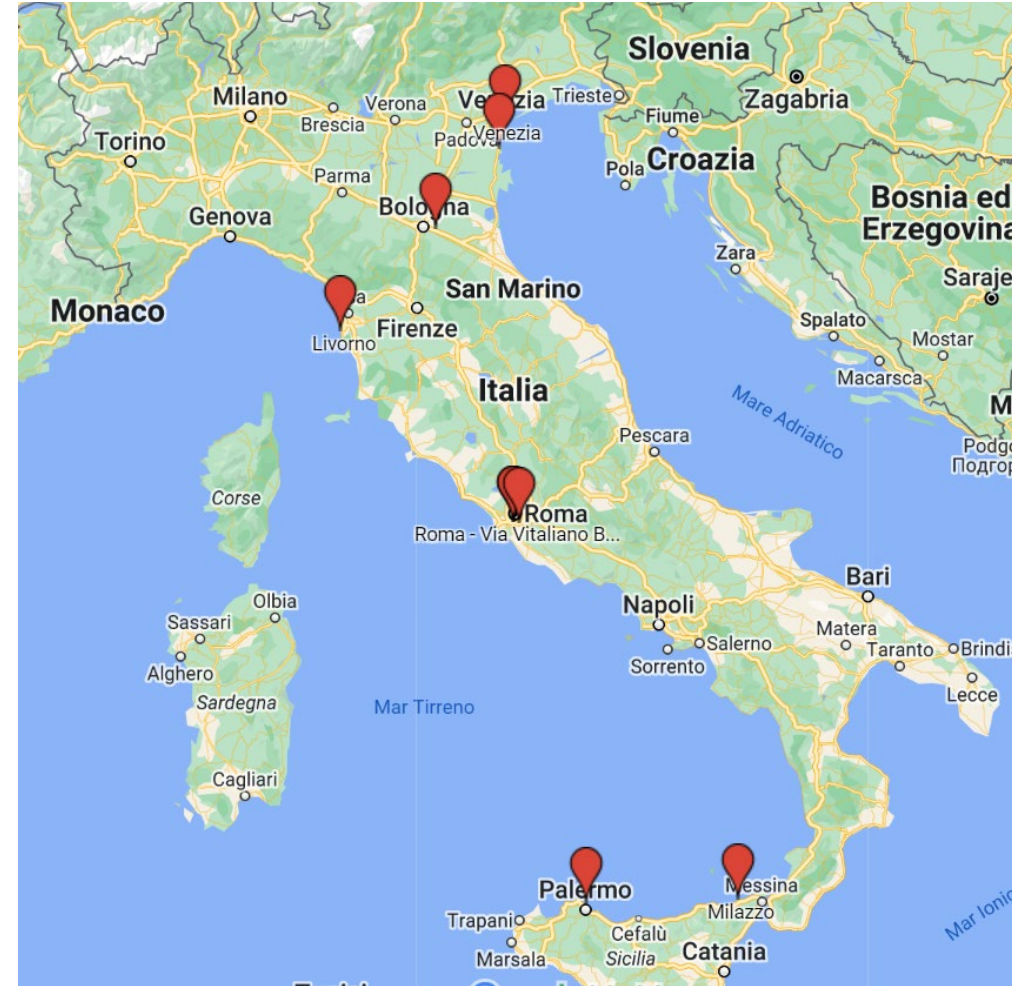
Daniele Spizzichino, Federica Ferrigno, Gabriele Leoni, Francesco Menniti
ISPRA - Geological Survey of Italy

Razionale

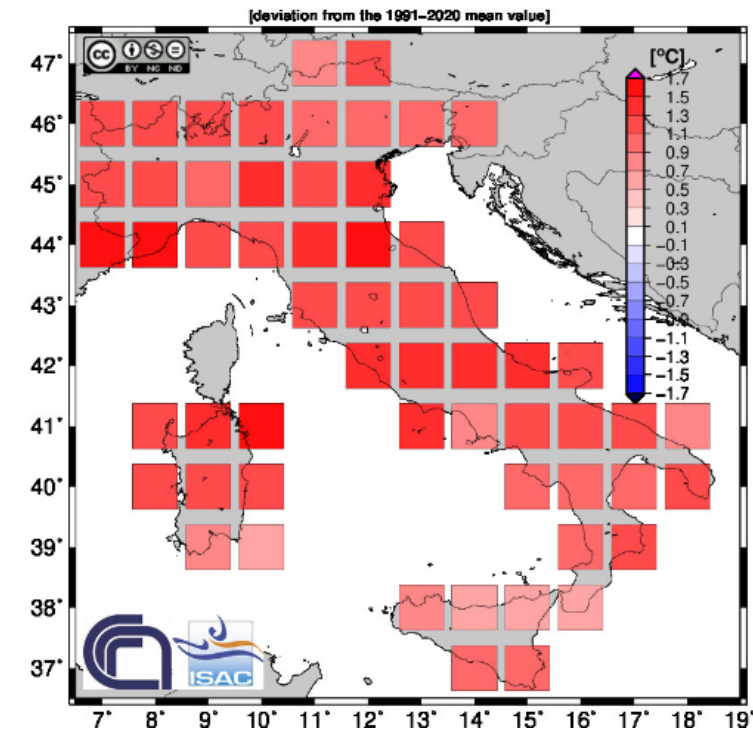
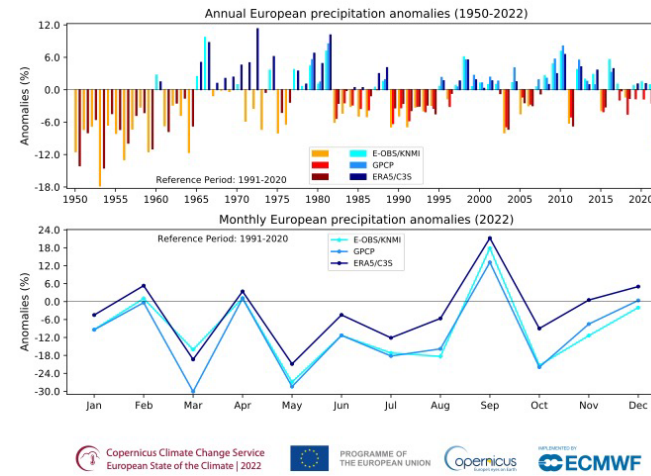
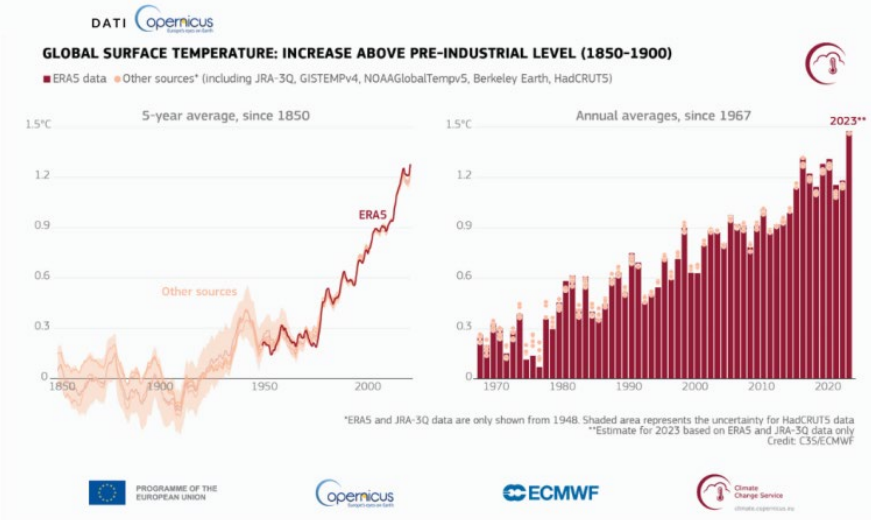
- Who we are and what we do
- threat to cultural heritage: Climate and natural hazards context in Italy
- EO and satellite monitoring for CH
- National Plan for CH monitoring
- Case studies
- FPCUP Action for CH

ISPRA - Italian Institute for Environmental Protection and Research

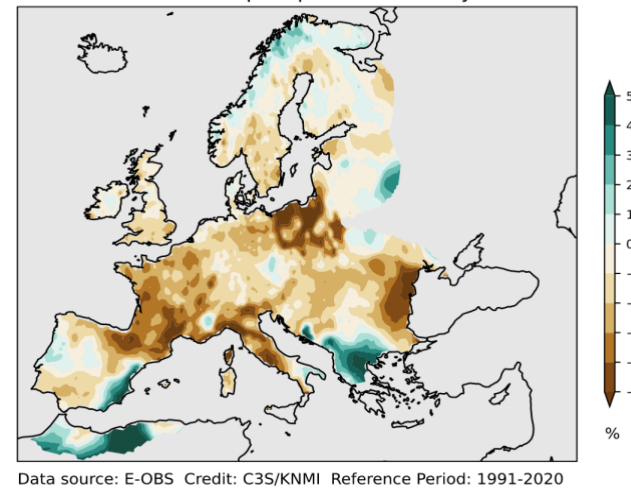
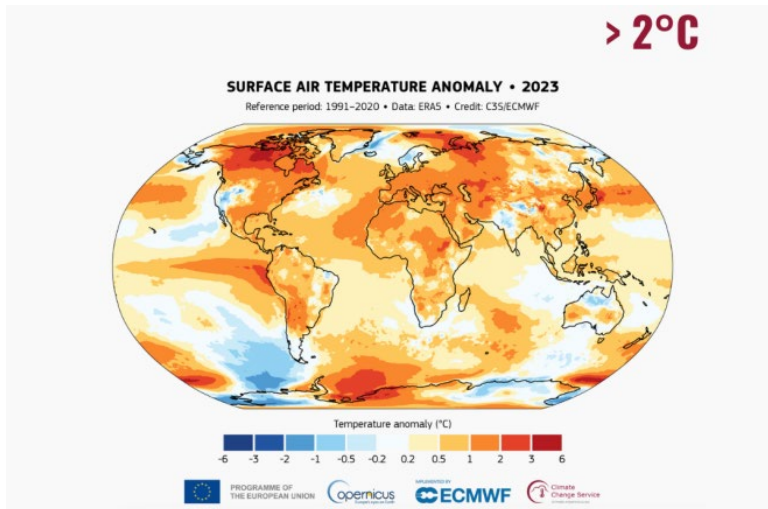
1. National Agency for the monitoring natural and anthropogenic pressures of all the environmental matrices
2. Technical governmental body support to Environmental, Industry, Cultural and Foreign Affair Ministry
3. Copernicus USER Forum National Focal Point
4. Centre of competence for the national civil protection – emergency and crises
5. Department of National Geological Survey
6. Guideline, Regulations, Technical standard, Plan for the environmental issue (e.g. National Plan for Climate change adaptation)



Rationale #1 Climate change in the mediterranean area and Italy

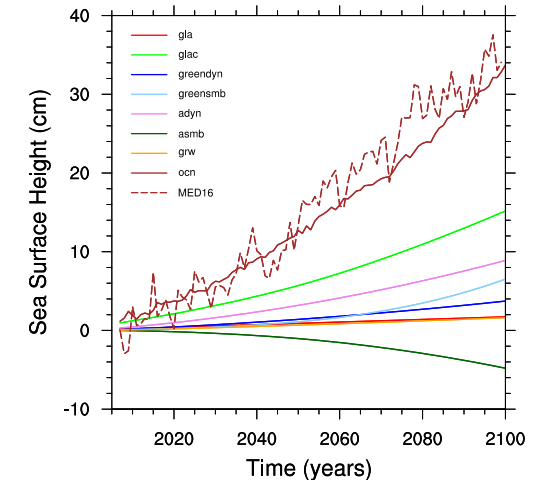


2023 was the hottest year on record (CNR-ISAC, 2024)



precipitation anomalies at Mediterranean scale and national scale (with 21% less since 1961)

If we consider the 10 warmest years for our country, 8 of these are in the last 10 years



With the hottest month recorded at global level (CNR-ISAC, 2024)

Direct and indirect impacts of natural and anthropogenic effects induced by climate change on Cultural Heritage



Hegra – Thermal stress, erosion and geomorphological instability in KSA © Spizzichino



Blackening -Vittoriano (Roma)



Sea level rise - Venice



Surface recession S. Filippo church (Torino)



Vegetation Terme di Baia (Naples) © Spizzichino



Rock facade collapse in Petra (Jordan) and in David Gareja Mocomplex (Georgia) © Spizzichino

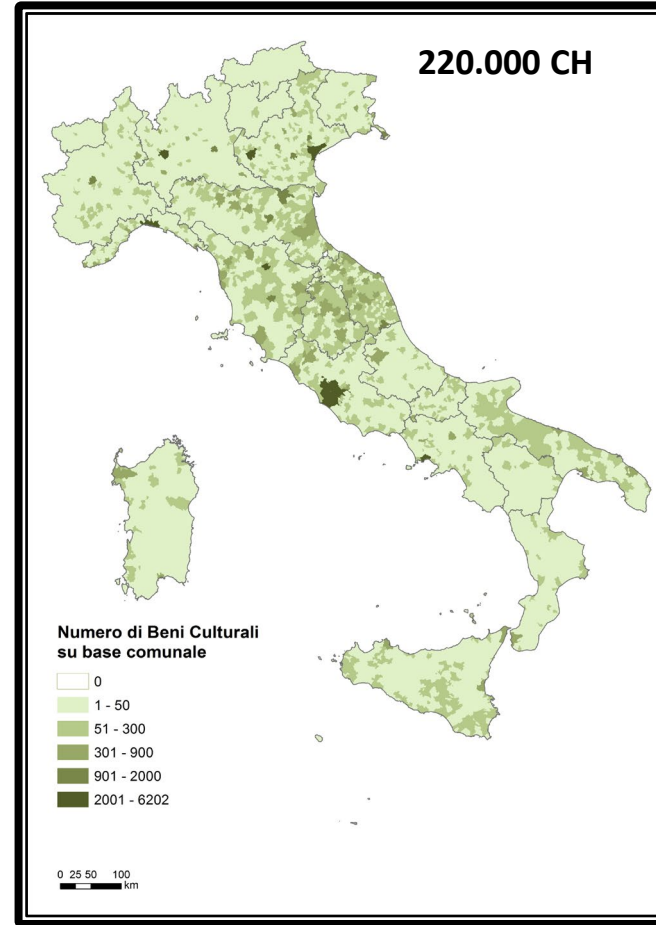


Erosion in Akapana pyramid (Bolivia) © Spizzichino

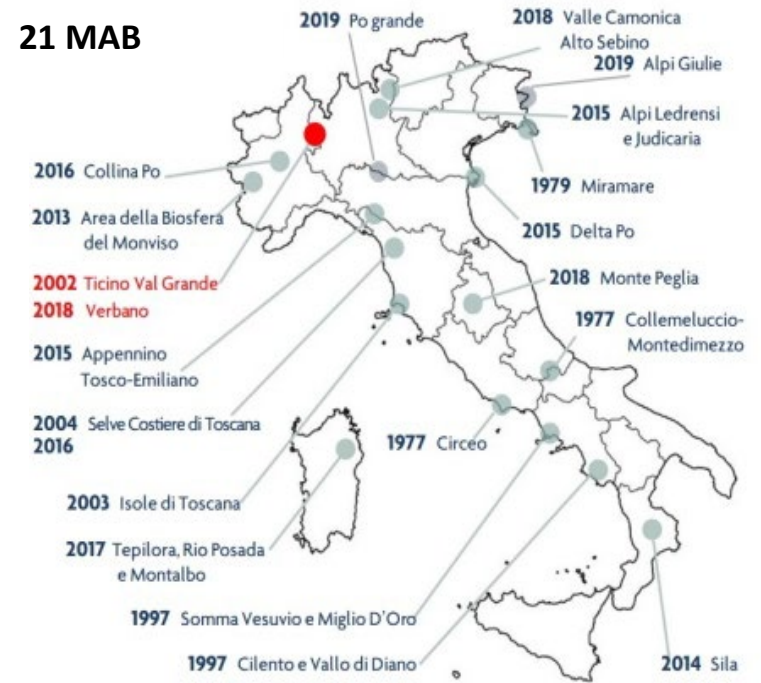


Coastal Erosion Skara Brae © Hist. Env. Scotland

ITALIAN NCH VERY HIGH EXPOSURE, VULENRABILITY and FRAGILITY



21 MAB



12 Geo-parks



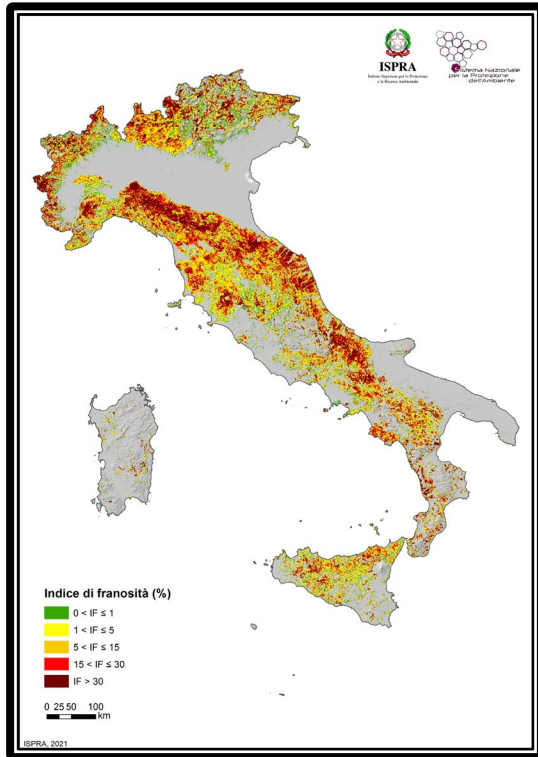
Italian distribution of Natural & Cultural Heritage

60 UNESCO site

 <p>60 Siti del Patrimonio Mondiale</p>	 <p>18 Elementi iscritti nella Lista del Patrimonio Culturale Immateriale</p>	 <p>21 Riserve della Biosfera</p>	 <p>10 Beni italiani iscritti nel registro della Memoria del mondo</p>
	<p>1 Elemento iscritto nel Registro delle Buone Pratiche di Salvaguardia</p>		

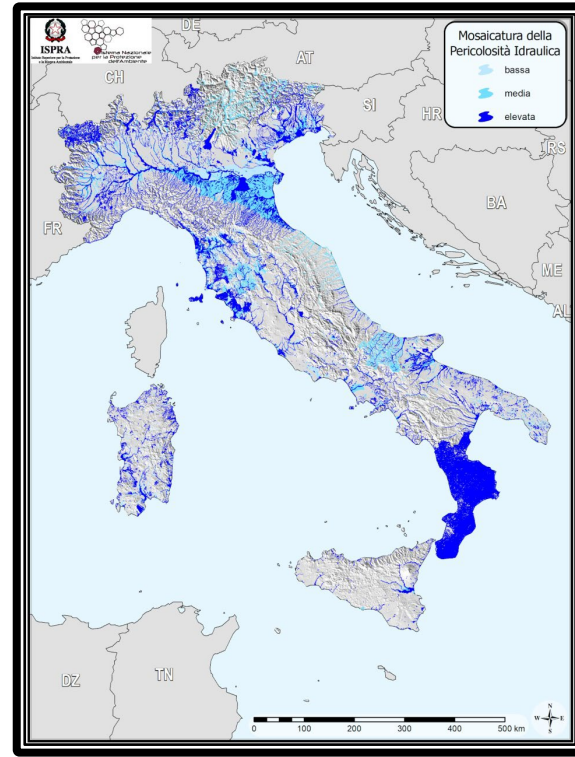
Natural Hazards threatening NCH

Landslide hazard



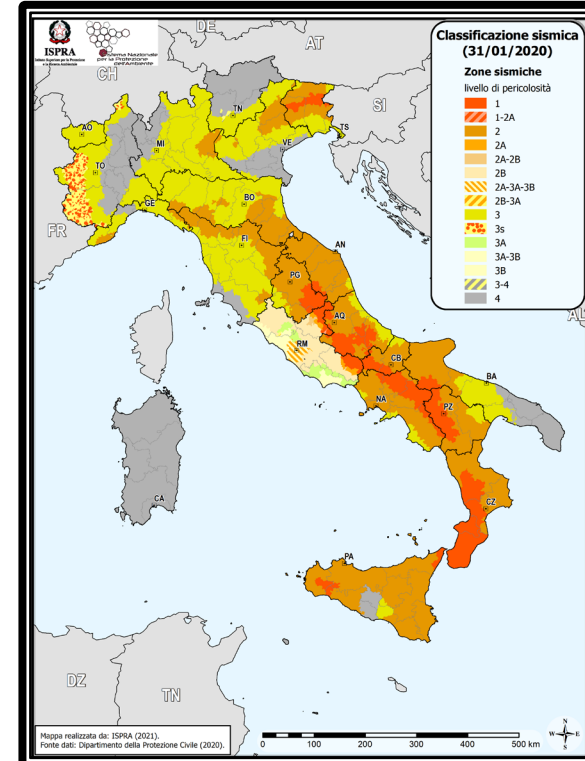
IFFI Inventory - Landslide Index (%)
 Source: Rapporto ISPRA su Dissesto idrogeologico in Italia: pericolosità e indicatori di rischio - Edizione 2021

Flood hazard



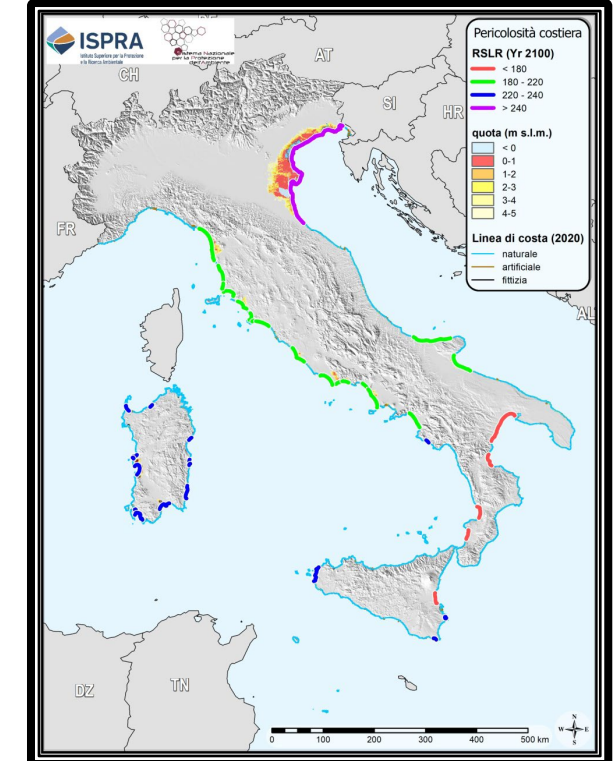
PAI hydraulic hazard mosaic
 Source: Rapporto ISPRA su Dissesto idrogeologico in Italia: pericolosità e indicatori di rischio - Edizione 2021

Seismic Hazard



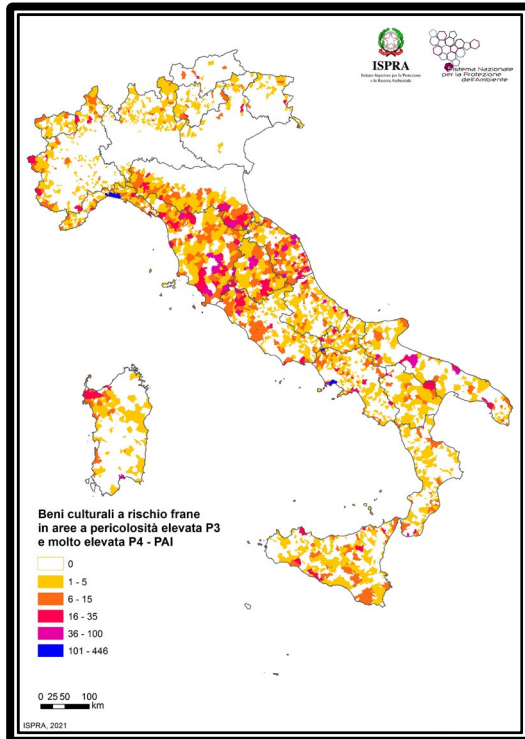
Seismic classification on a municipal basis
 Source: Fonte dati : Dipartimento Protezione Civile - INGV; elaborazione grafica ISPRA
 Riferimento Annuario Dati Ambientali , ISPRA 2020

Coastal hazard

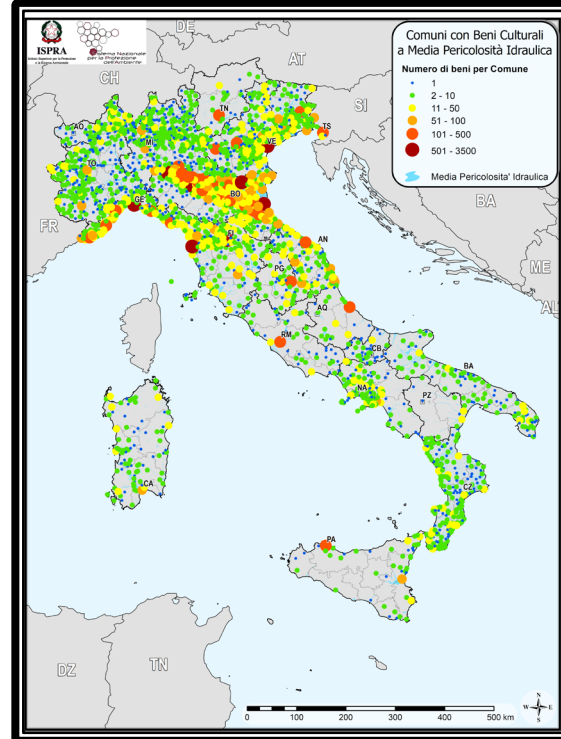


Sea level rise scenarios over some coastal areas
 Source: Fonte dati: UNIBA; Assetto Costiero Italiano. Elaborazione grafica ISPRA.

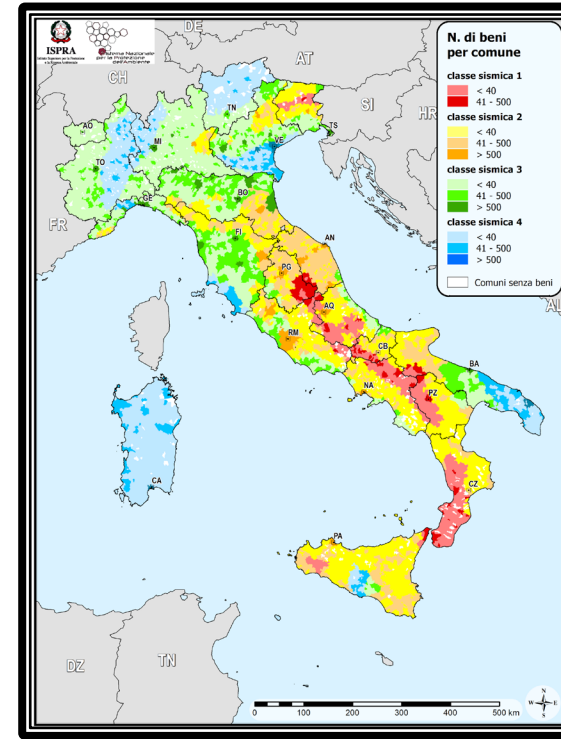
National Simplified risk of CH Vs Natural hazards



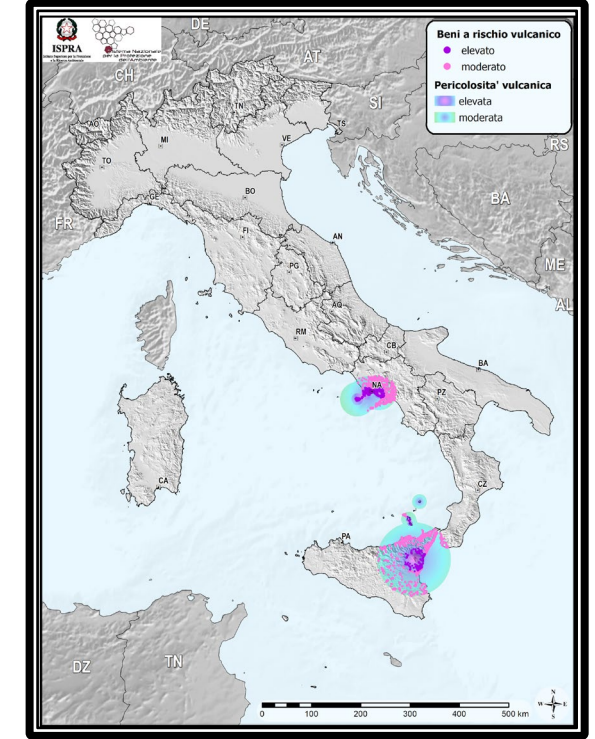
CH at risk landslides on a municipal basis
 Rapporto ISPRA su Dissesto idrogeologico in Italia: pericolosità e indicatori di rischio - Edizione 2021



CH at risk of flooding on a municipal basis
 Fonte dati: Banca dati ViR e CdR ISCR, IdroGEO
 Elaborazione grafica ISPRA - 2022.

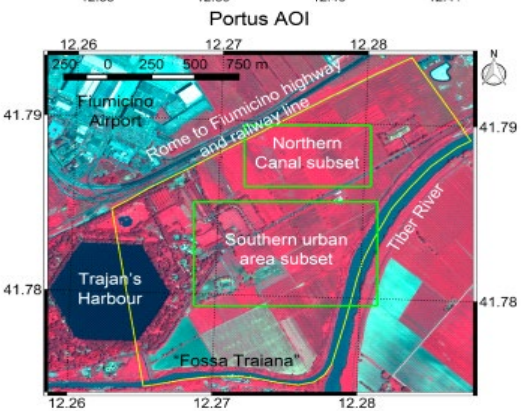
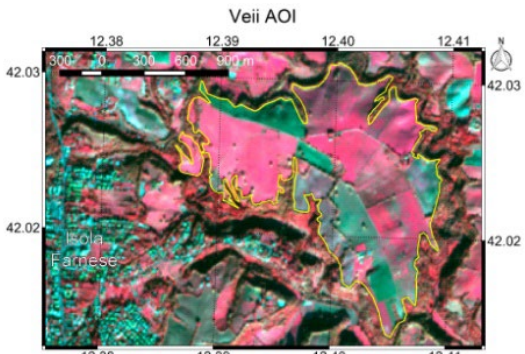


CH by seismic class on a municipal basis
 Fonte Elaborazione ISPRA su dati ISPRA, ISCR e Protezione Civile.
 BBCC in comuni in classe sismica 1 o 2: 92384.
 Riferimento Annuario Dati Ambientali – ISPRA 2020

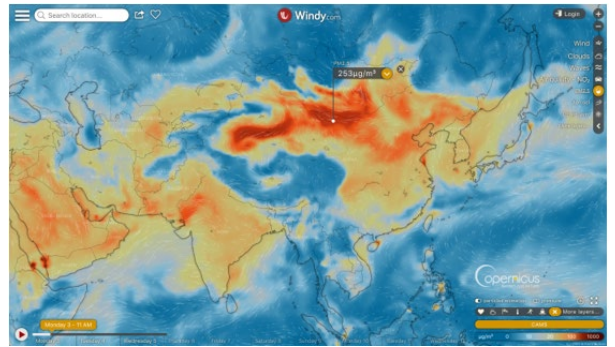
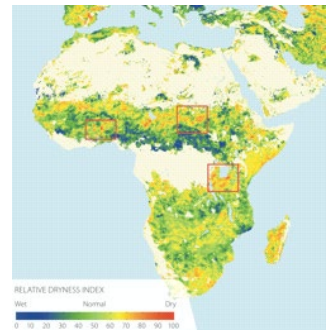


CH and volcanic risk, total
 Fonte: Elaborazione ISPRA su dati ISPRA e ISCR.
 BBCC a Pericolosità Elevata: 4083 (1.9%) BBCC a Pericolosità moderata 7264 beni (3.4%).
 Riferimento: Annuario Dati Ambientali – ISPRA 2020

**OPTICAL images, from data to downstream services
(e.g. multispectral and Hyper spectral analysis)**



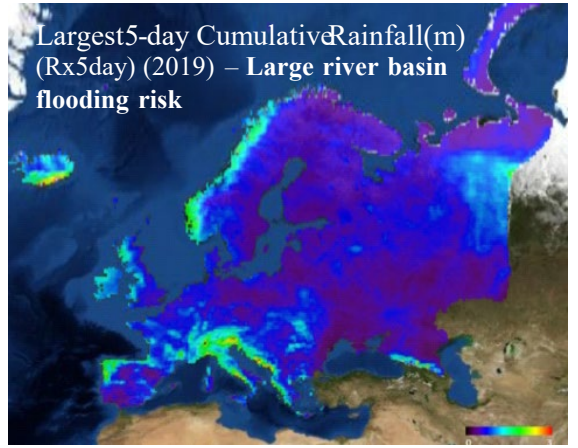
Land use, change detection and buried sites © ESA



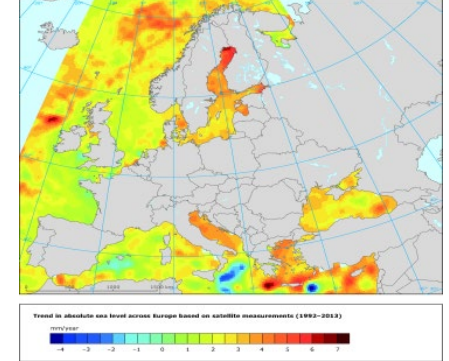
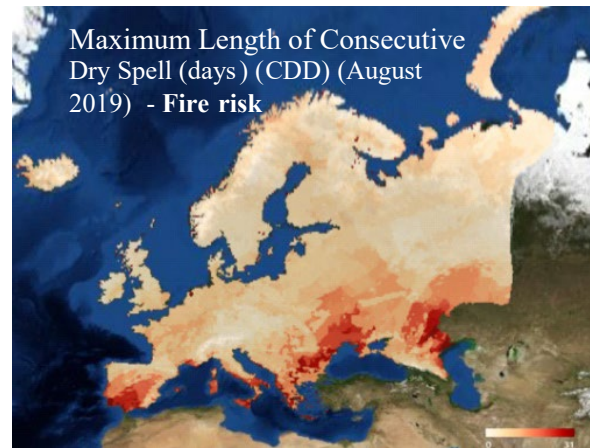
Pollutant concentration © Windy.com



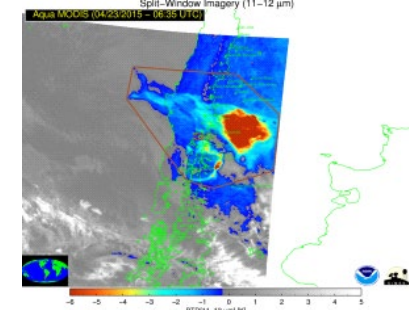
Providing support to emergency response services
Situation maps, reference information



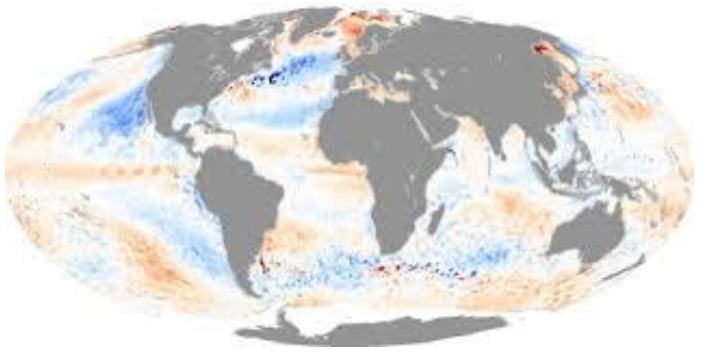
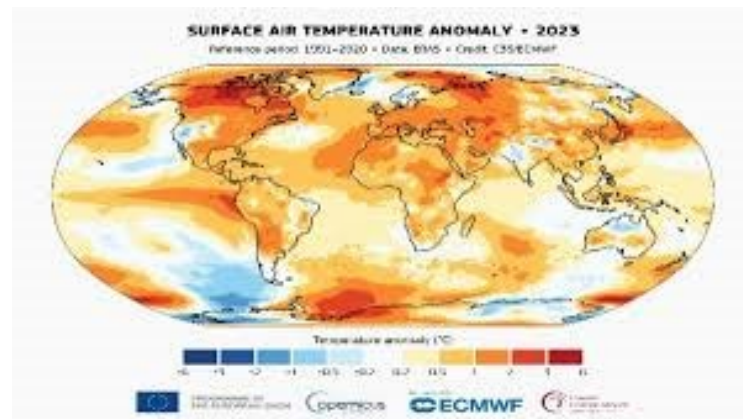
Climate variables and extreme events impact on Cultural Heritage @ ProteCH2save CNR - ISAC Bonazza et al.



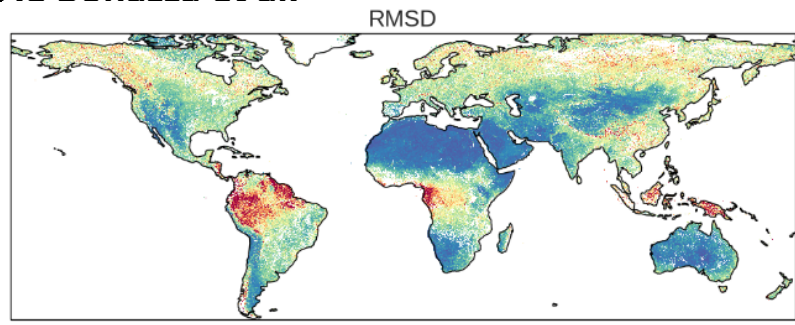
sea level rise © EEA



Volcanic Cloud Monitoring website.

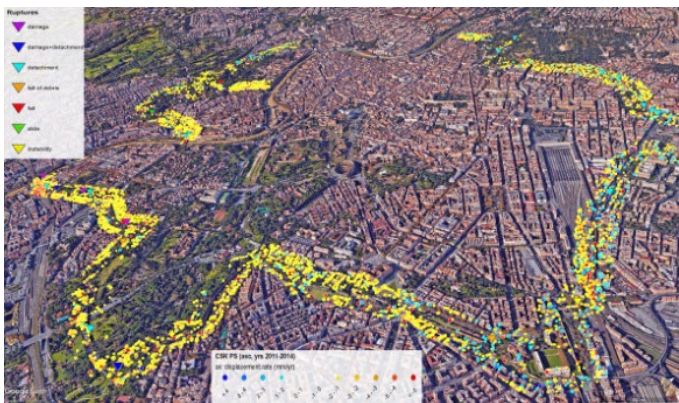


Sea Surface Temperature anomaly © NASA

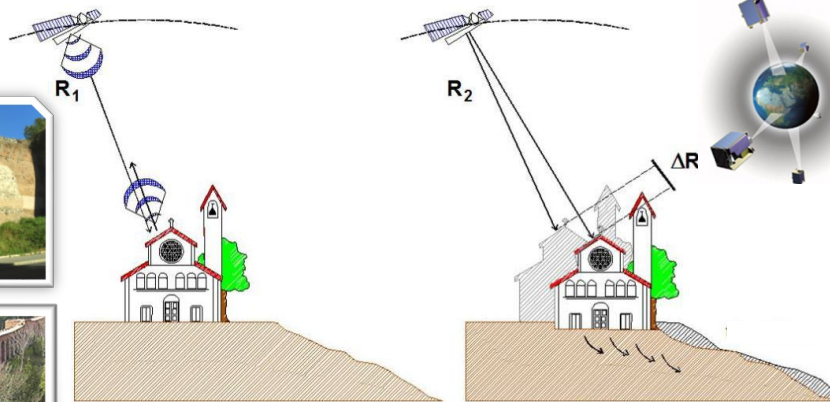


NDVI normalized Vegetation index © Copernicus

RADAR images, data and products
Differential SAR Interferometry (InSAR or DInSAR)



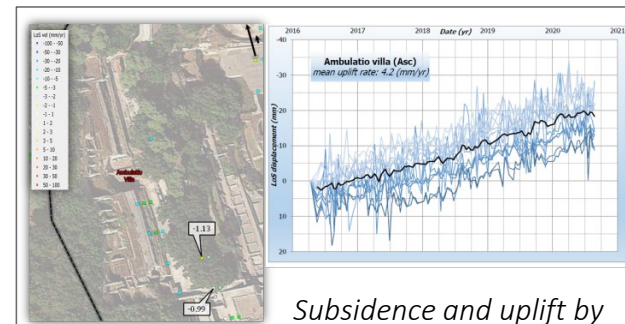
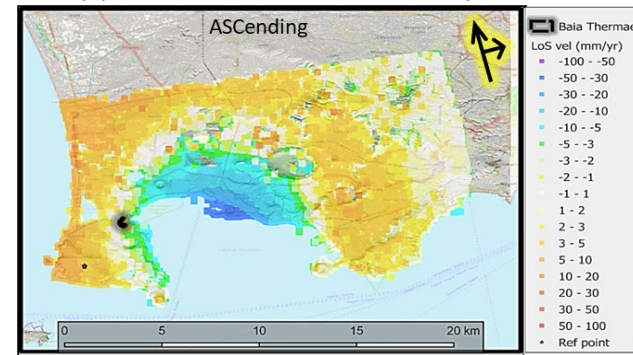
Rome Walls deformation satellite monitoring @ Spizzichino



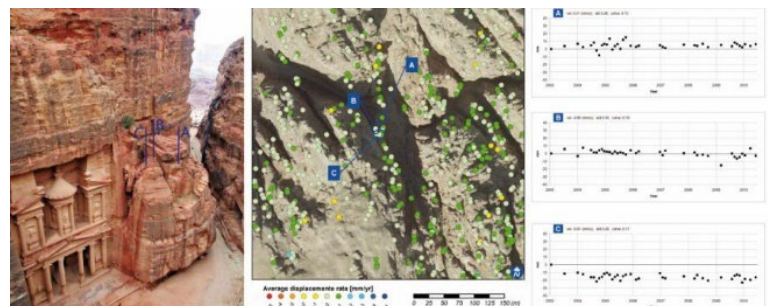
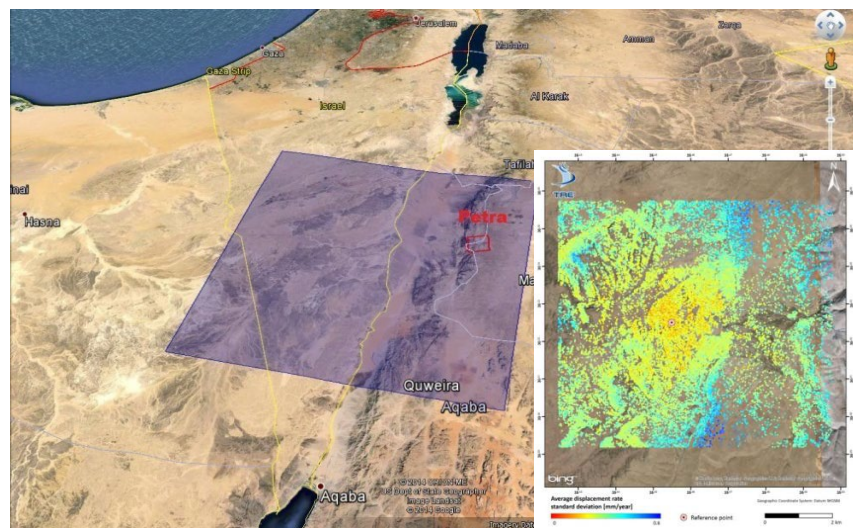
www.prothego.eu collect all the European UNESCO sites where GEO-Hazards and satellite data are already available



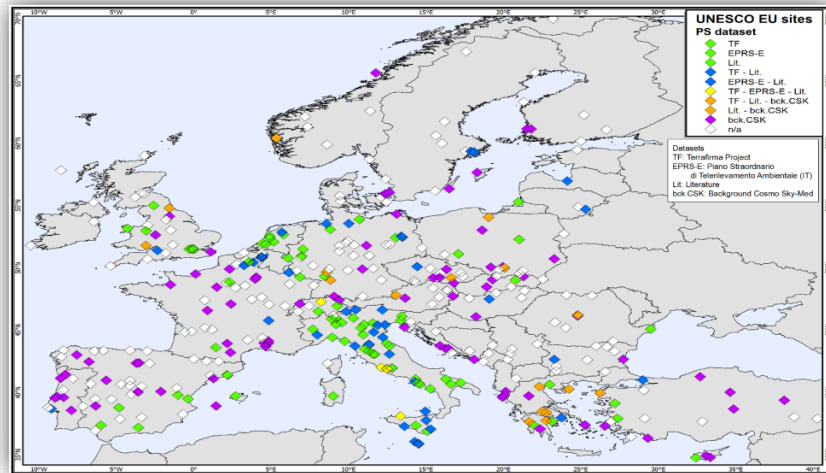
Instability processes and SAR data analysis POMPEI



Subsidence and uplift by satellite analysis PACF Park @ Spizzichino



Surface deformation RADAR satellite images Petra @ Spizzichino



All data after processing, must be calibrated, validate and interpreted by in situ survey in order to be used as support for the mitigation measures



Technical Board institution for the national Parks monitoring DM n. 5 del 19/02/2019, still active until 2025

National Protocol among Ministry of Culture and ISPRA (26/05/2021)

Active agreement:
Extraordinary National Plan for the monitoring and conservation of CH (June 2022 – June 2024) – prolonged till end of 2024.

The National Plan for Monitoring and Conservation of Cultural Heritage: INTEGRATED SATELLITE-TERRESTRIAL MONITORING SYSTEM



Timeline 2023



18 January

**Parco Archeologico
dell'Antico Porto di Classe
di Ravenna**



15 March

**Parco Archeologico dei
Campi Flegrei: Terme
Romane di Baia**

Timeline 2023



27 June

**Centro storico
del Comune di Volterra**



26 september

**Parco archeologico di
Morgantina e della Villa
Romana del Casale**

Timeline 2024



31 January

**Parco archeologico di
Paestum e Velia**



18 March

Borgo di Civita di Bagnoregio

Timeline



19 March

**Centro storico
del Comune di Orvieto**



20 May

**Centro storico
del Comune di Pienza**

Methodological approach

A

CH Background (desk and field study):

investigating the origin,
typology, construction
techniques, restoration
history, evolution in time, etc.



FOUR *steps*

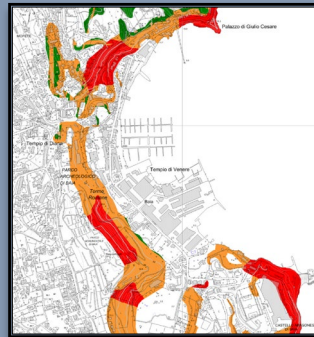
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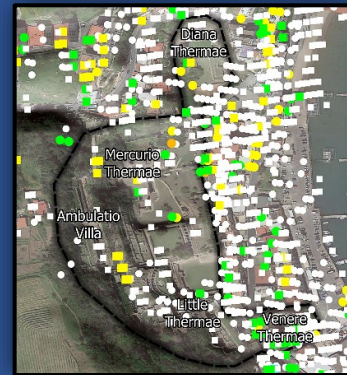
B

Geohazard
assessment
Hazard and risk map
analysis



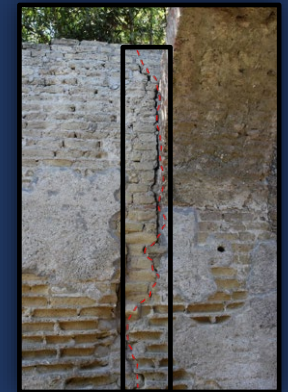
C

SAR Interferometry
Data integration and
services



D

Ground motion
monitoring
Field survey and risk
mitigation plan

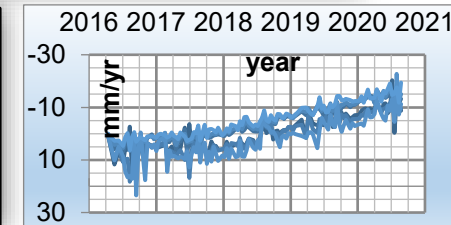
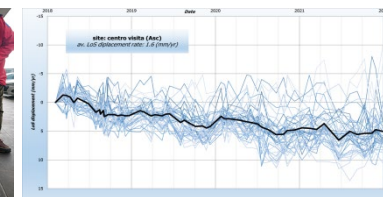
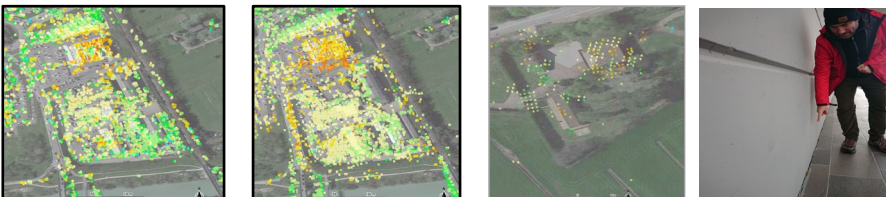
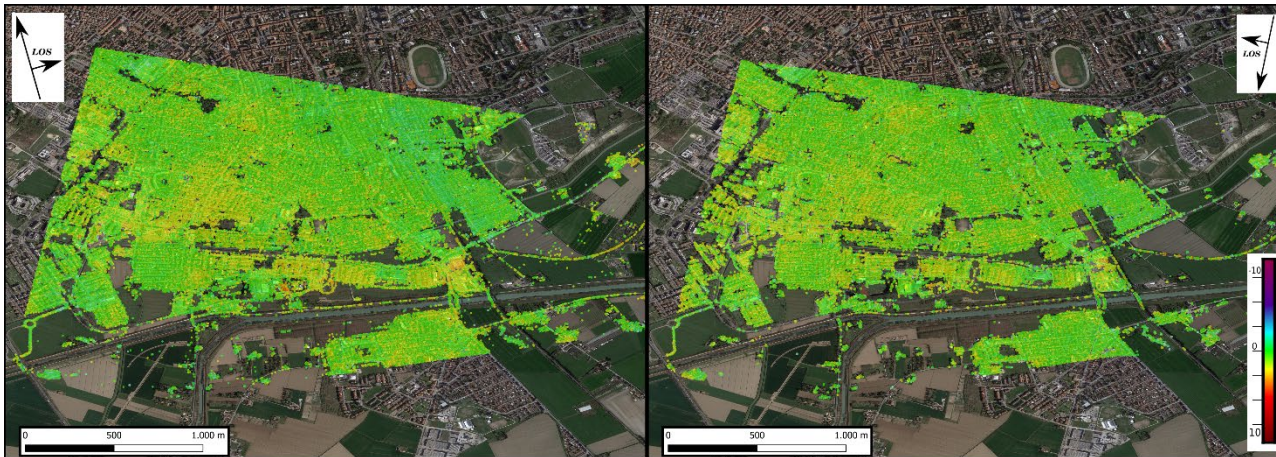
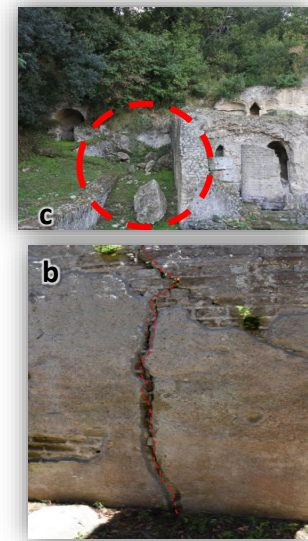
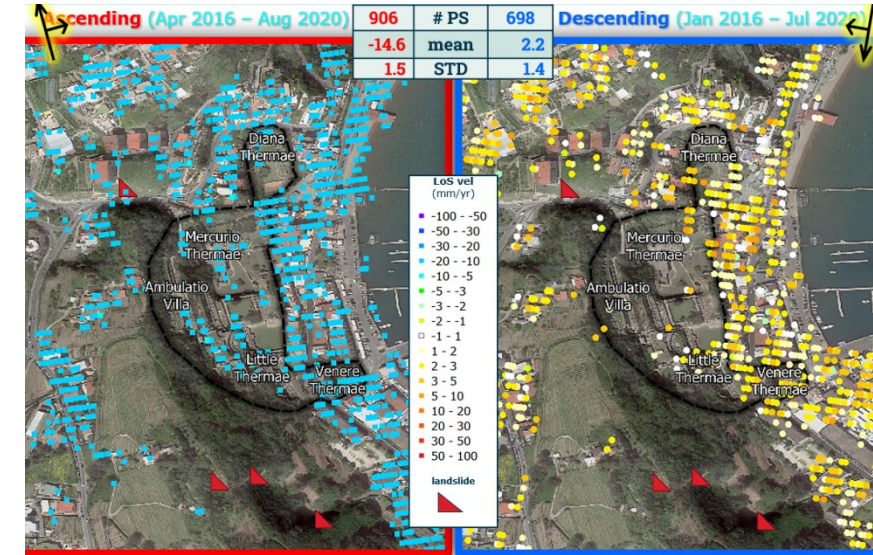
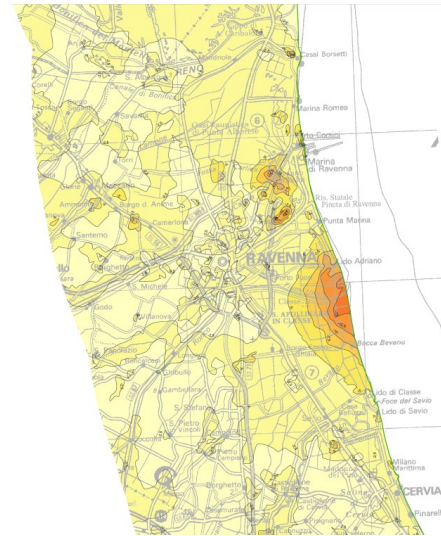
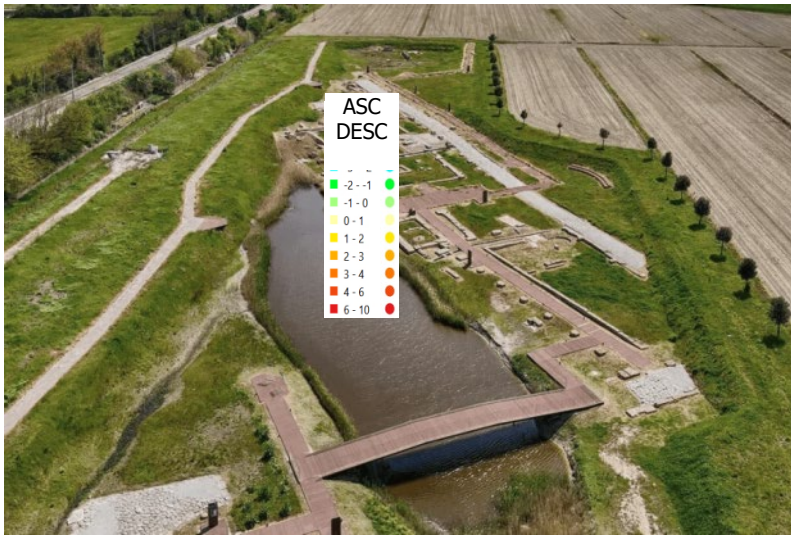


Ravenna pilot: "Archaeological harbor of Classe"

Threats: historical subsidence/differential deformation
SAR Techniques analyses

Campi Flegrei pilot: "Archaeological thermae of Baia"

Threats: uplift, rock fall and sea level rise
SAR Techniques analyses

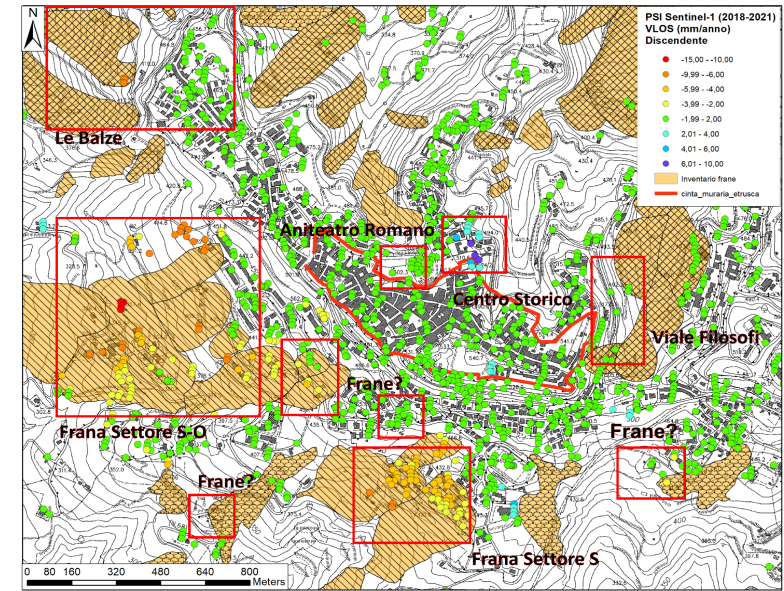
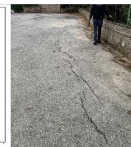
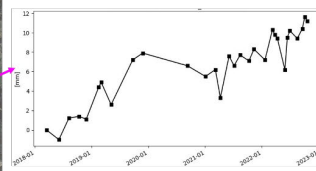
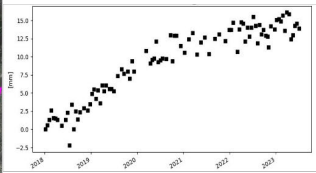
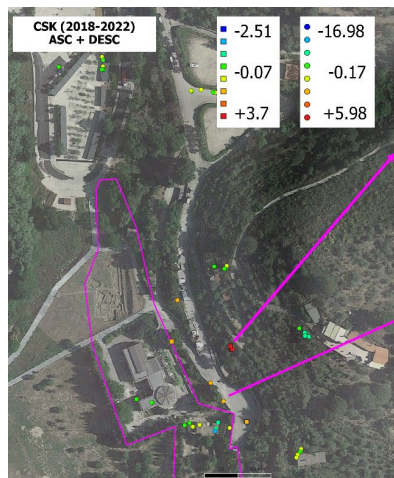
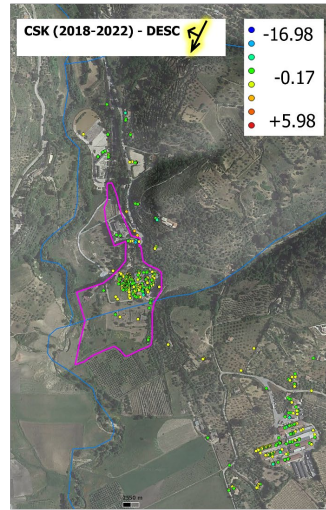
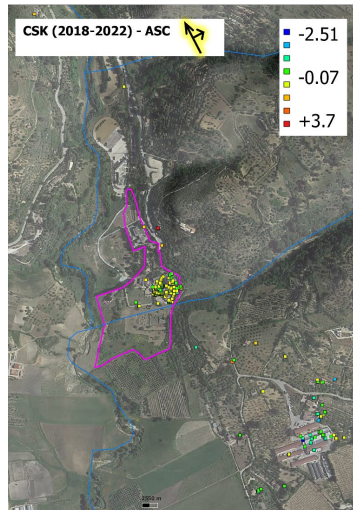


Piazza Armerina pilot: "Roman mosaic"

Threats: slow and rapid landslide; water table fluctuation
SAR Techniques analyses

Volterra: "Historical village and medieval walls"

Threats: slow landslide
SAR Techniques analyses



Orvieto pilot: "Historical small town"

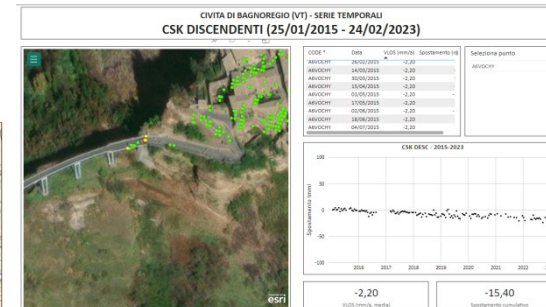
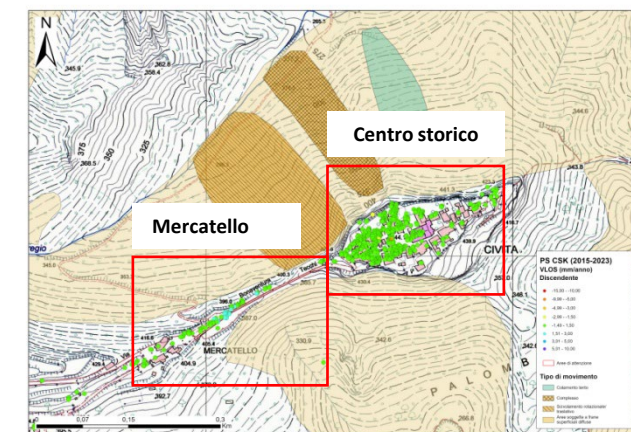
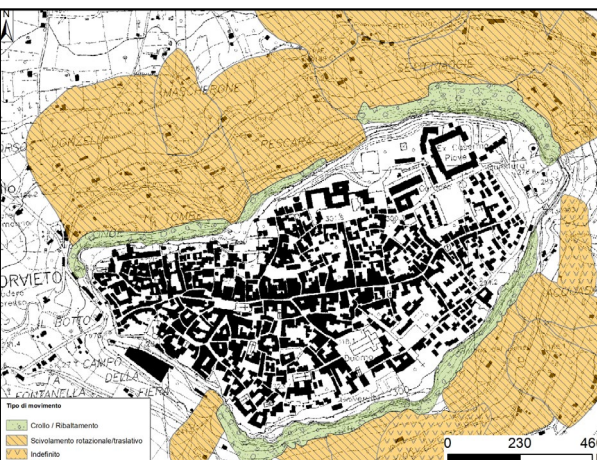
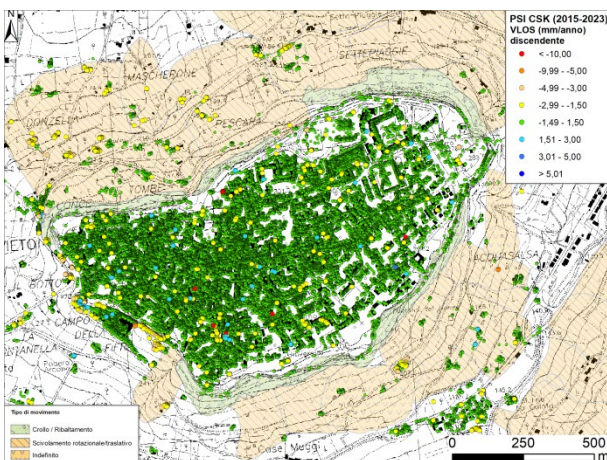
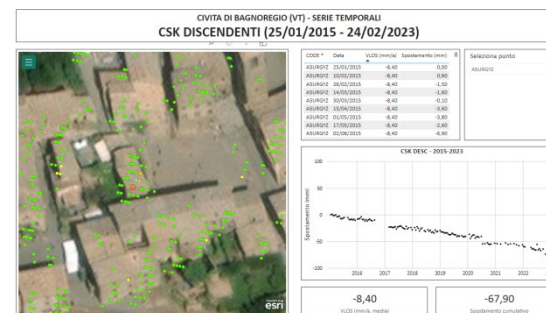
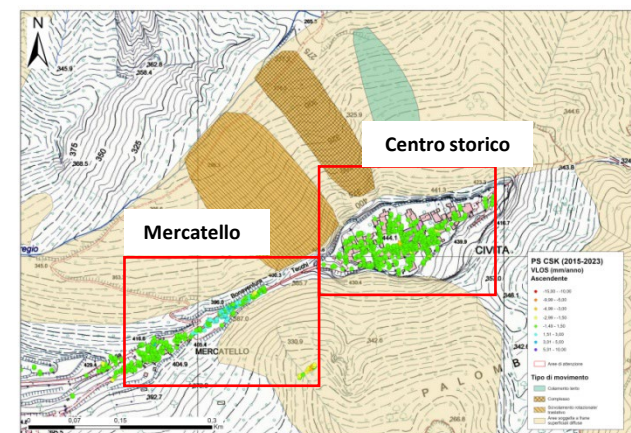
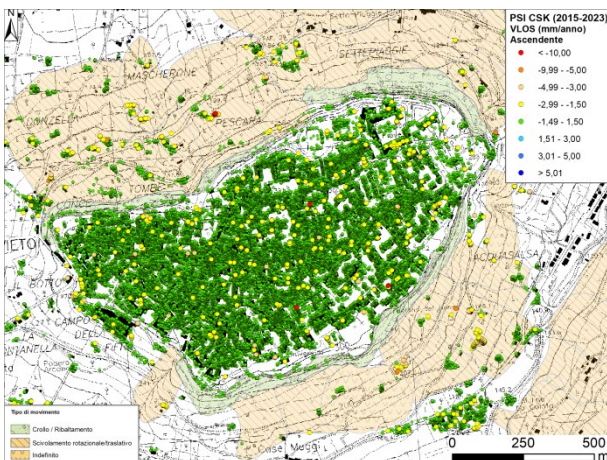
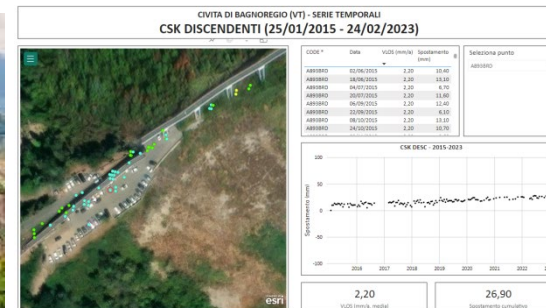
Threats: slow landslide; water table fluctuation

SAR Techniques analyses

Civita pilot: "Historical village"

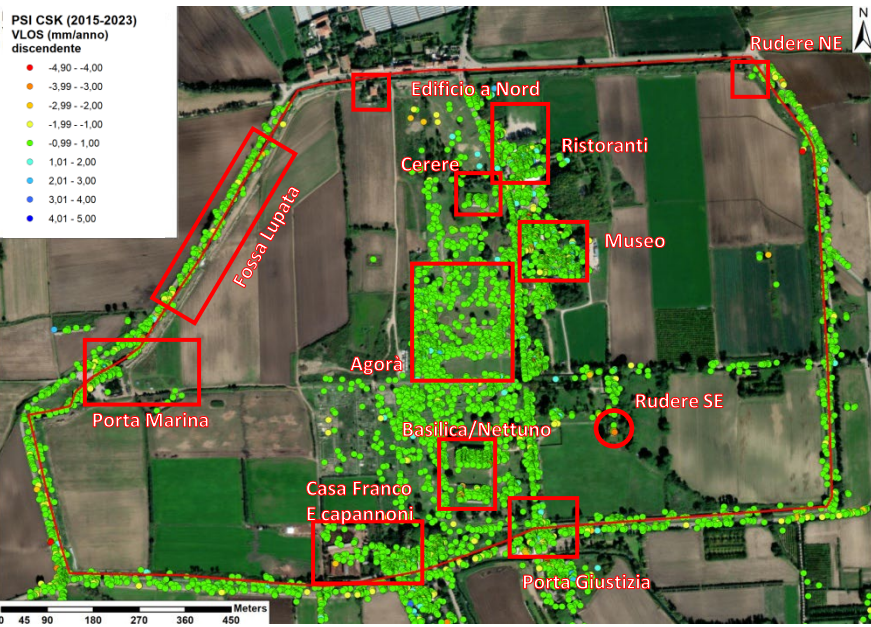
Threats: slow landslide & ground deformations

SAR Techniques analyses



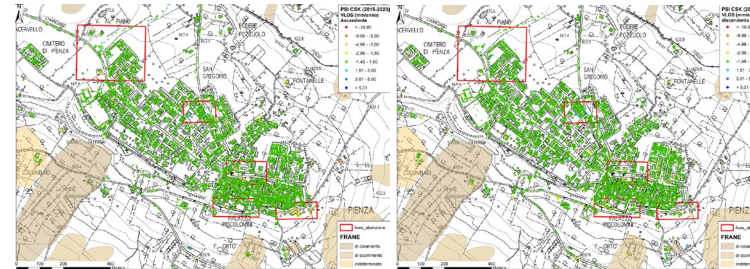
Paestum pilot: "Archaeological roman Park"

Threats: water table fluctuation, weathering, SAR Techniques analyses



Pienza pilot: "Historical small town"

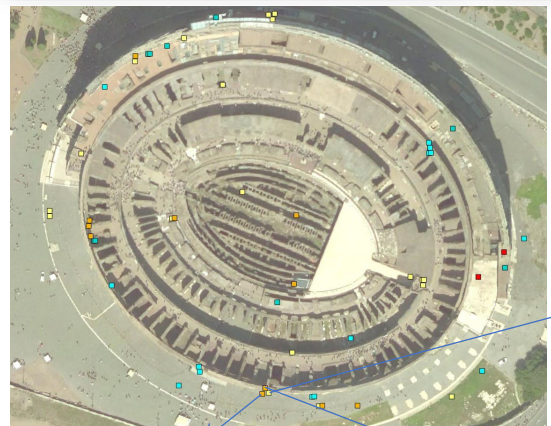
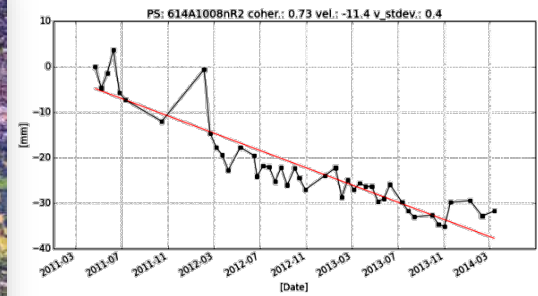
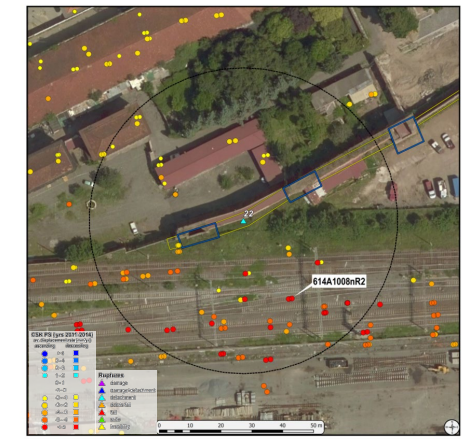
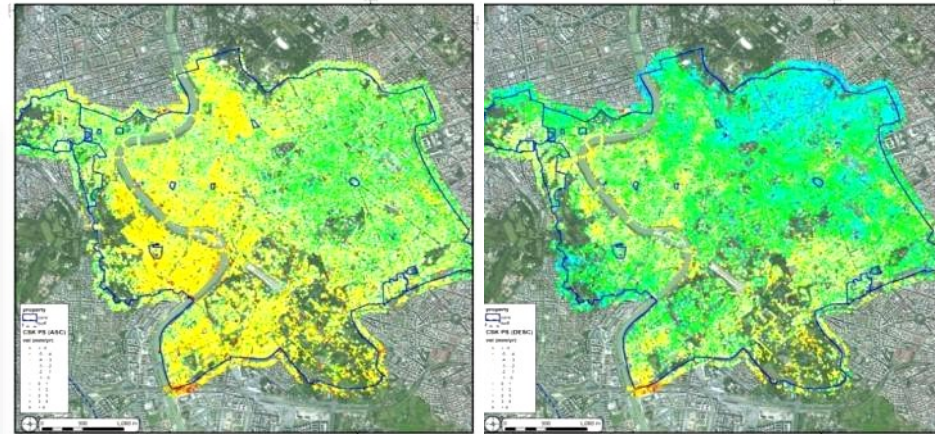
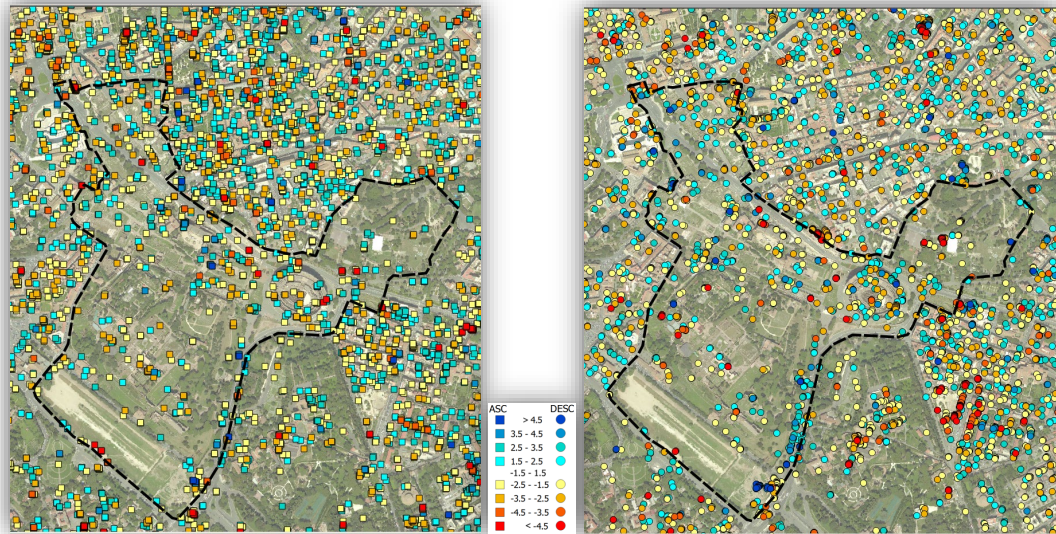
Threats: DGPV/regional fault; structural damage: SAR Techniques analyses



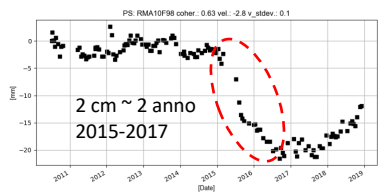
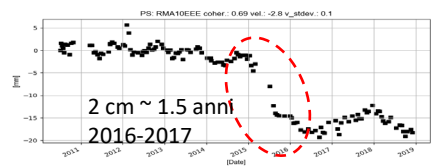
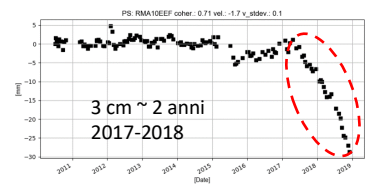
Rome pilot: "Colosseo Park & Aurelian Walls"

Threats: weathering, transportation dynamic interaction, collapses. **SAR Techniques analyses**

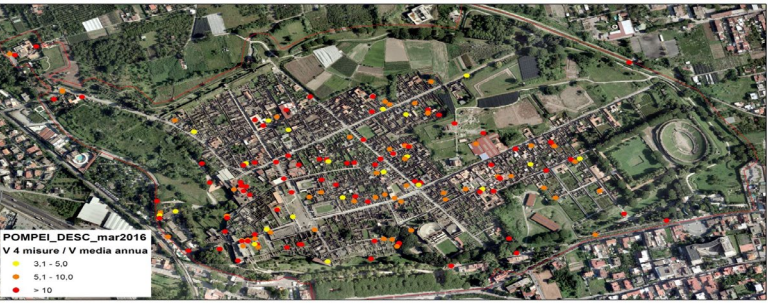
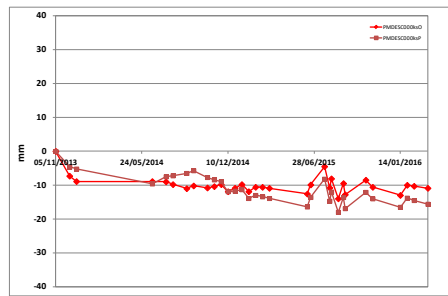
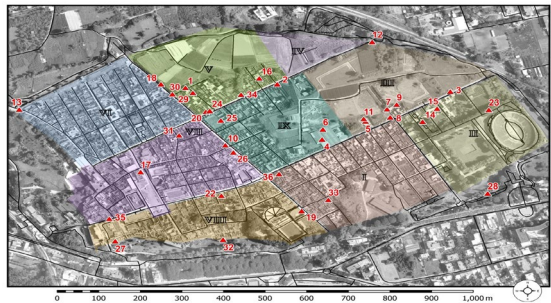
CENTRO storico di Roma



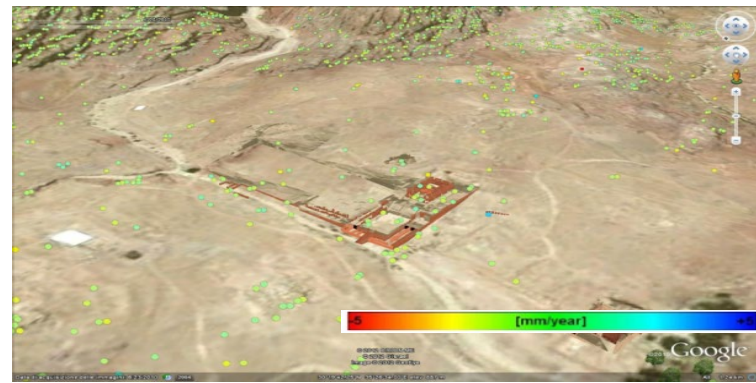
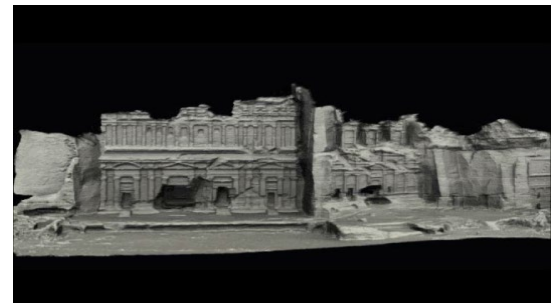
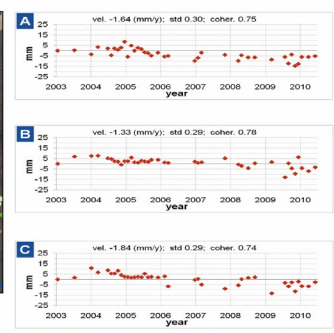
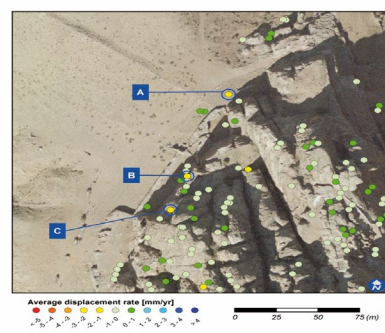
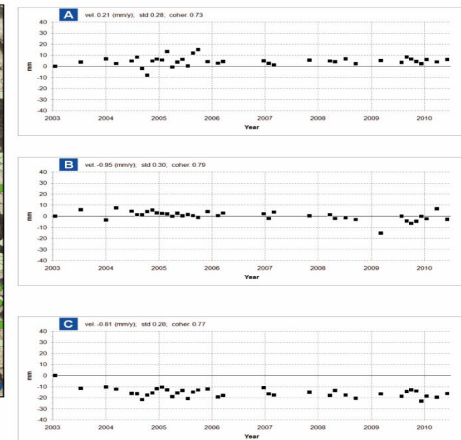
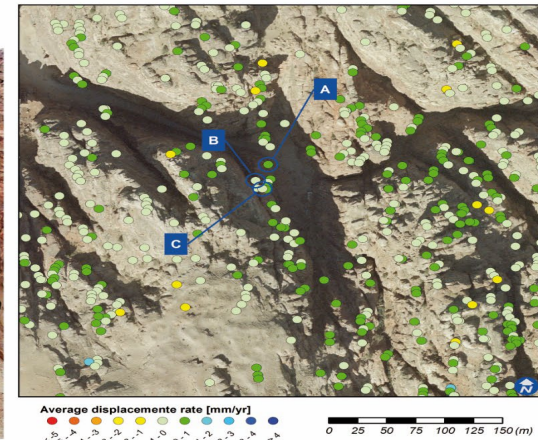
Cosmo Sky-Med, ascending, 2010/11



Pompei -2015

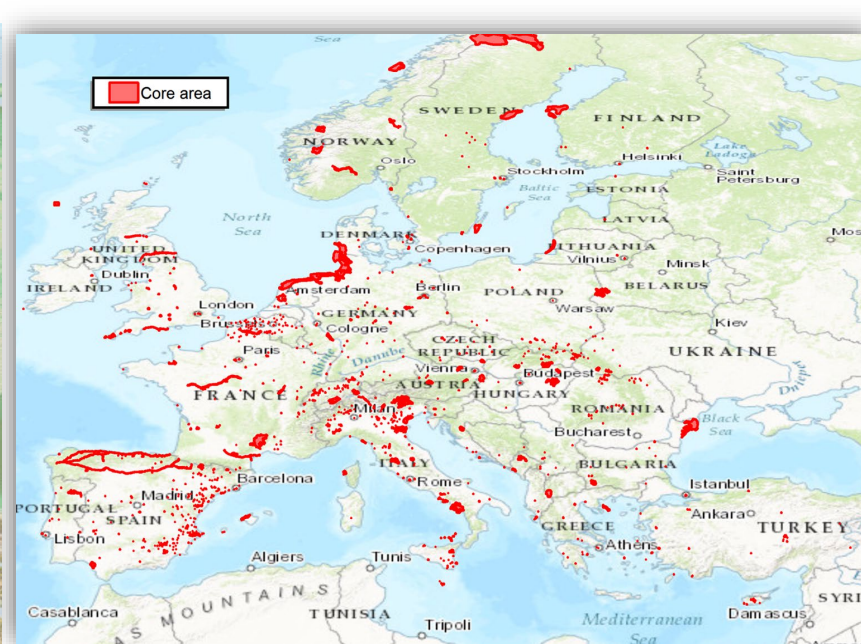
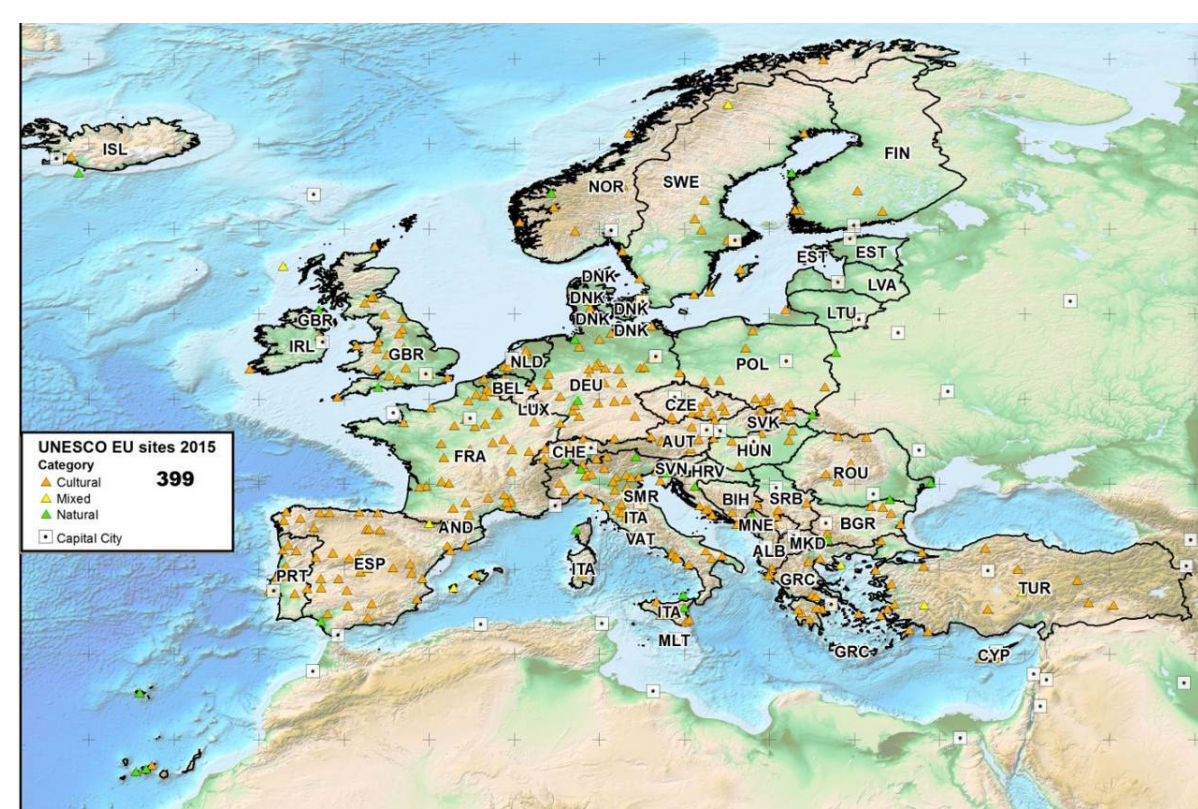


Petra -2012

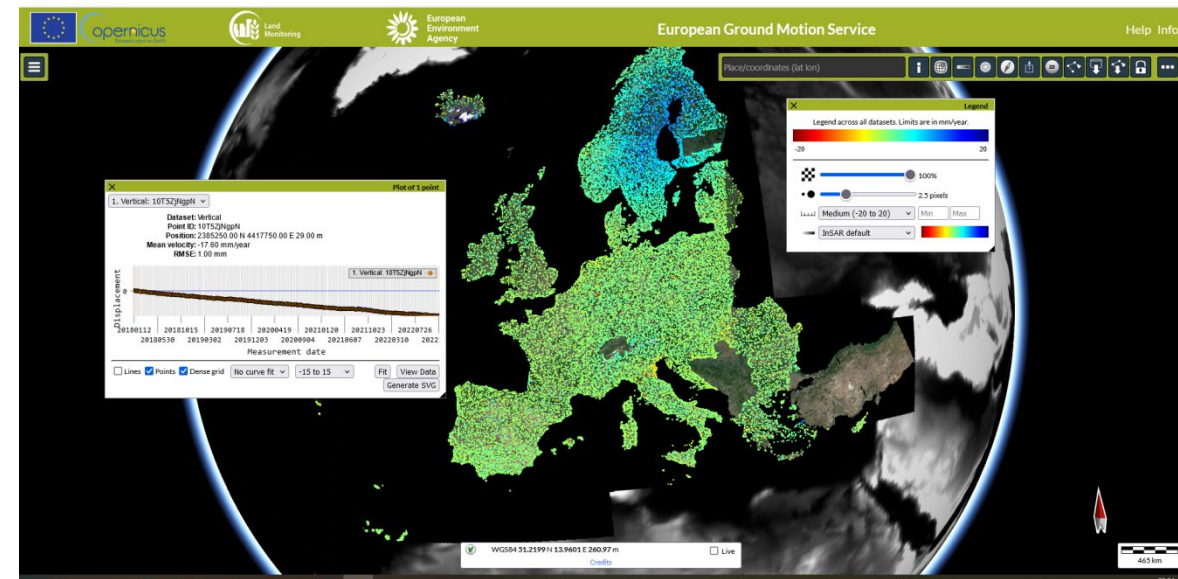
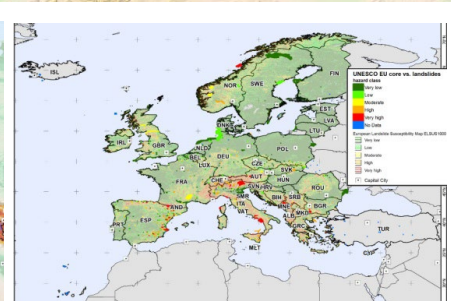
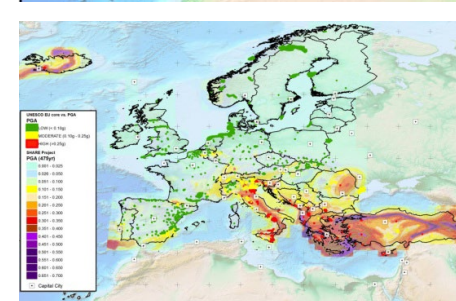


- 51 sq.km,
- 38 images ENVISAT2-V
- from January 2003 to June 2010,
- 61,983 measure points (ca. 1,215 points/sq.km)





WHL Sites	399
WHL Core polygons	2348
WHL parts > 50	5 45 - 700 (50% of tot)
WHL avg. parts	2.7
Min polygon area	5 (m²)
Max polygon area	10 000 (km²)
Avg. polygon area	80 (km²)



Actions presentation 2019-2020 – Training Workshop 5 days



GEO-Hazard monitoring through Ground Motion downstream services based on SAR Interferometry

Actions presentation summer 2022-2024

SUMMER SCHOOL WORKSHOP

ACTION 2020-2-21: COPERNICUS FOR CULTURAL HERITAGE

The Copernicus for Cultural Heritage Summer School Workshops will provide three workshops over the summer of 2023 in: Rome (Italy), June; Oberpfaffenhofen (Germany) – July; Limassol (Cyprus), September



Sept. 2022- Sept. 2025



ACTION 2021-2-26: CULTURAL HERITAGE TECHNICAL GROUP

The main goal of the Action is to establish the Cultural Heritage Copernicus Technical Group (CHCTG), the final aim of which is to represent a European user network in the specific field of NCH conservation, management and sustainable exploitation.



+



Duration: Jan 2023 - March 2025

Actions presentation



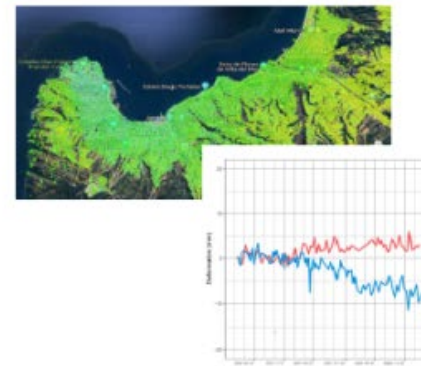
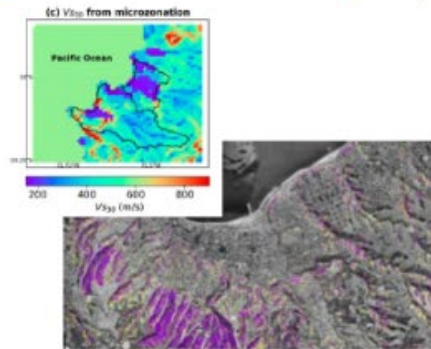
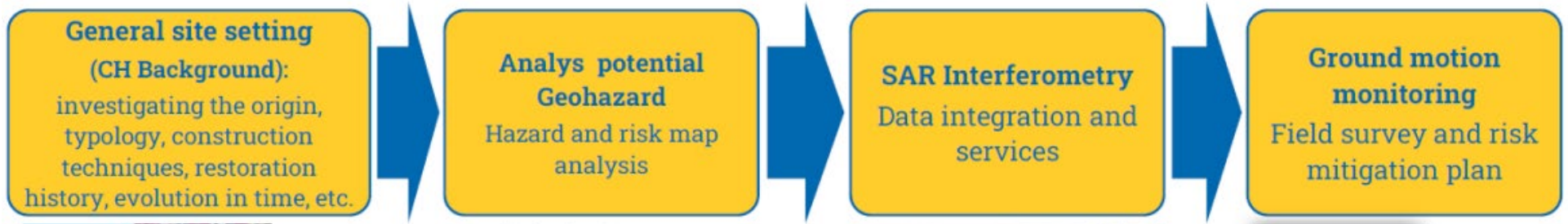
Copernicus Sentinel-1 data for Cultural Heritage monitoring: the Valparaiso case study

Menniti F., Spizzichino D., Ferrigno F., Leoni G.



Department of Geological Survey of Italy

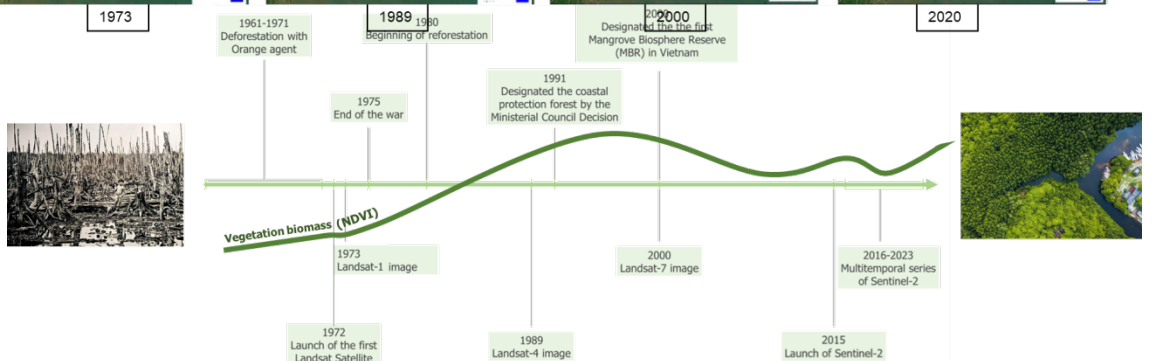
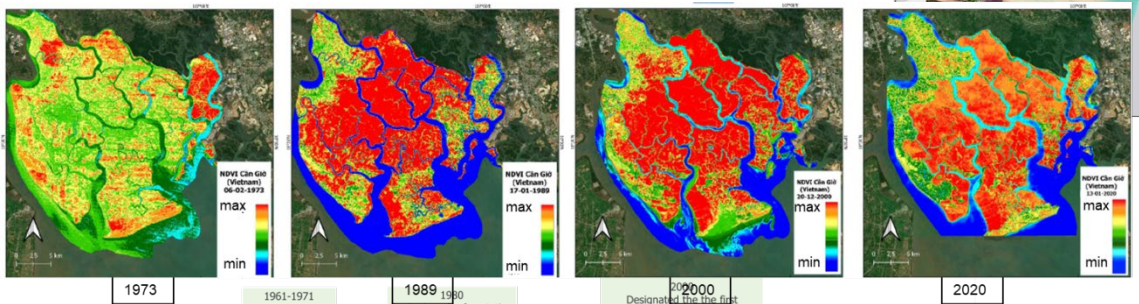
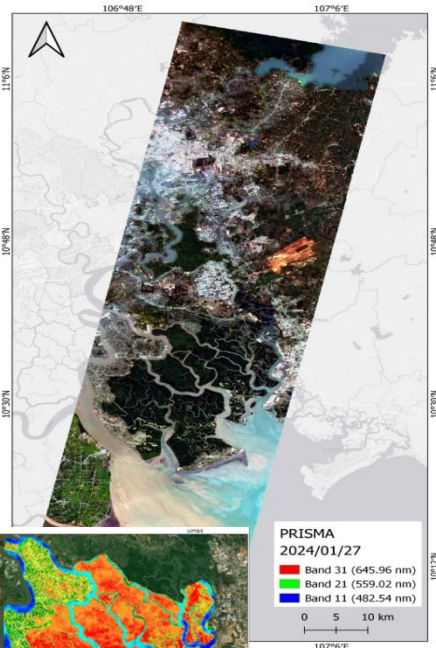
SGA20_WP2021-2-31: *Joint Action User uptake in Central and South America (CBK PAN, CDTI (Coord.), CNIG, IHCantabria, INTA, ISPRA)*



Vegetation cover for mapping NCH: the C n Gi r Biosphere Reserve, VietNam – UNESCO

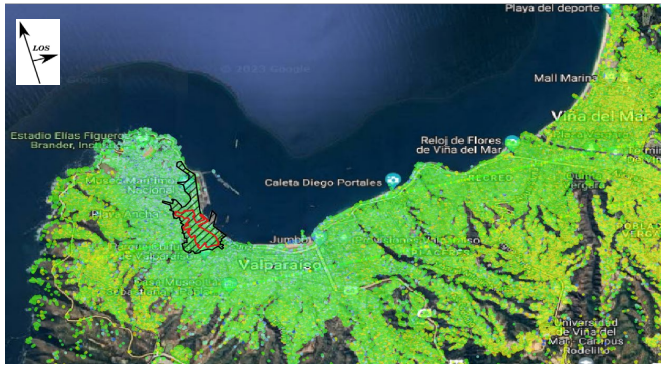
Emiliana Valentini, Andrea Taramelli

C n Gi r Mangrove Biosphere Reserve, is considered one of the most evocative mangrove forest in all the Southeast Asia.



The cultural value of C n Gi r Reserve overlay the natural and the productive value are triggering a paradox:
' the reduced presence of mangrove determines the increase of recreational value and conversely the increased presence of people determines the increase of the exploitation of resources determining a further reduction of mangrove presence '

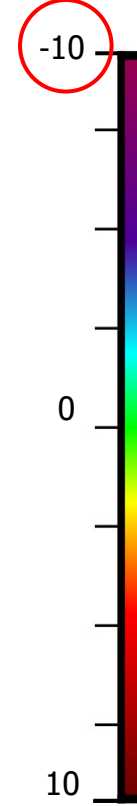
Preliminary InSAR analysis



Platform: SENTINEL 1A/1B
Geometry : Ascending orbit
Time Interval : 2020.01 – 2023.08
Dataset info: 131 SAR images; IW; SLC



Platform: SENTINEL 1A/1B
Geometry: Descending orbit
Time Interval: 2020.01 – 2023.08
Dataset info: 102 SAR images; IW; SLC

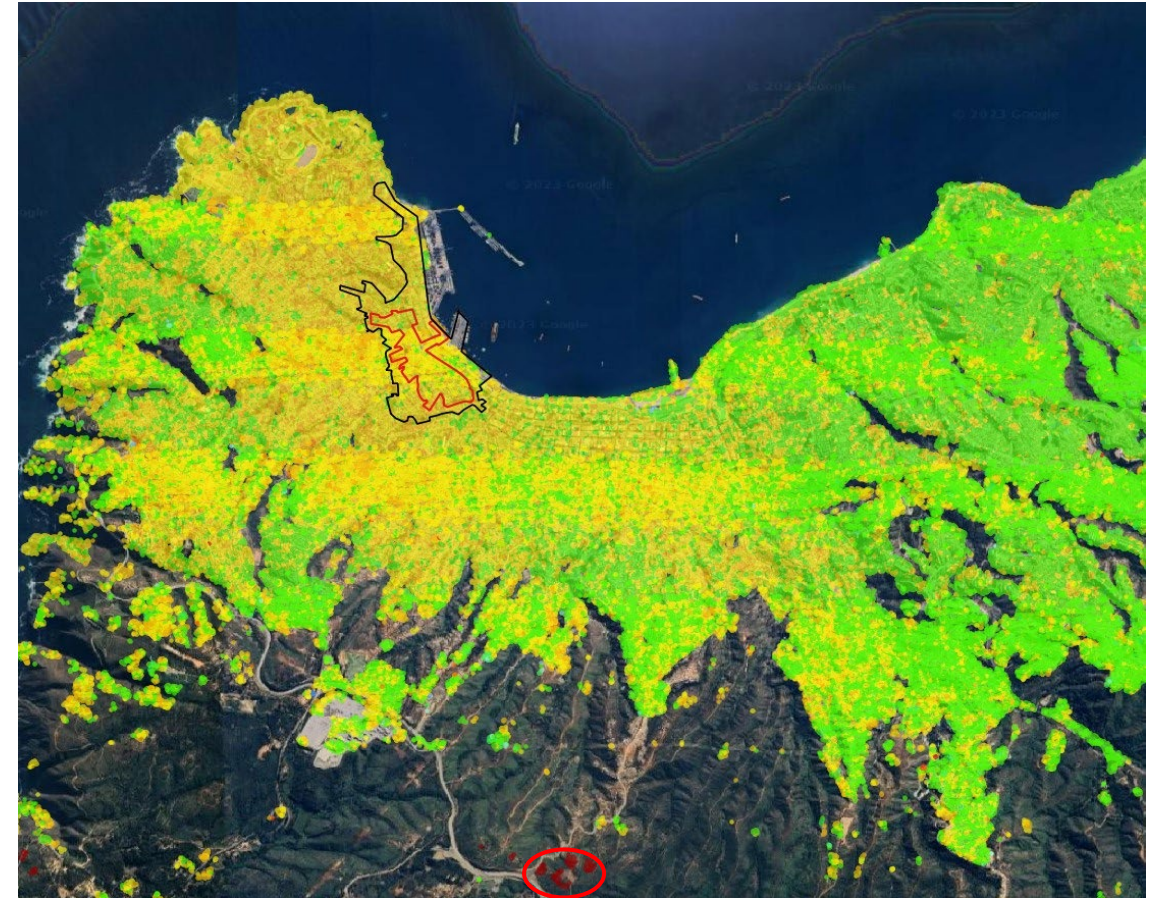


Preliminary InSAR analysis: East and Vertical component

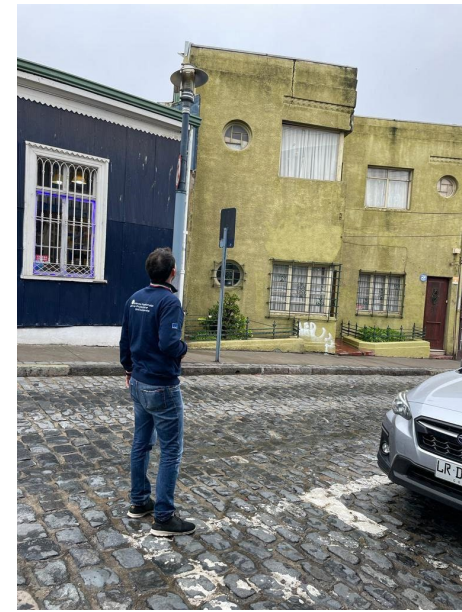
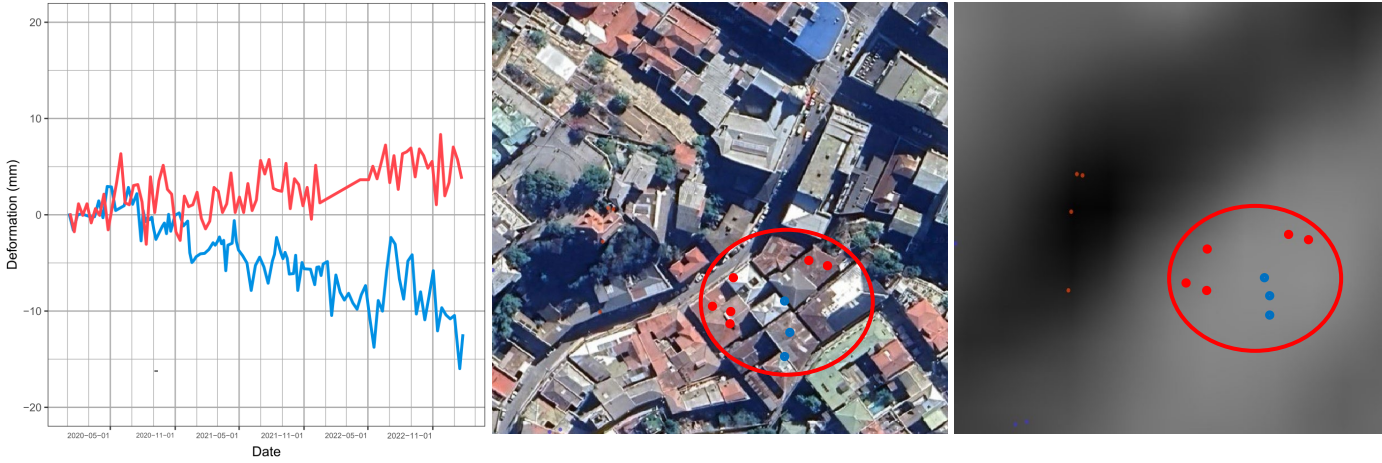
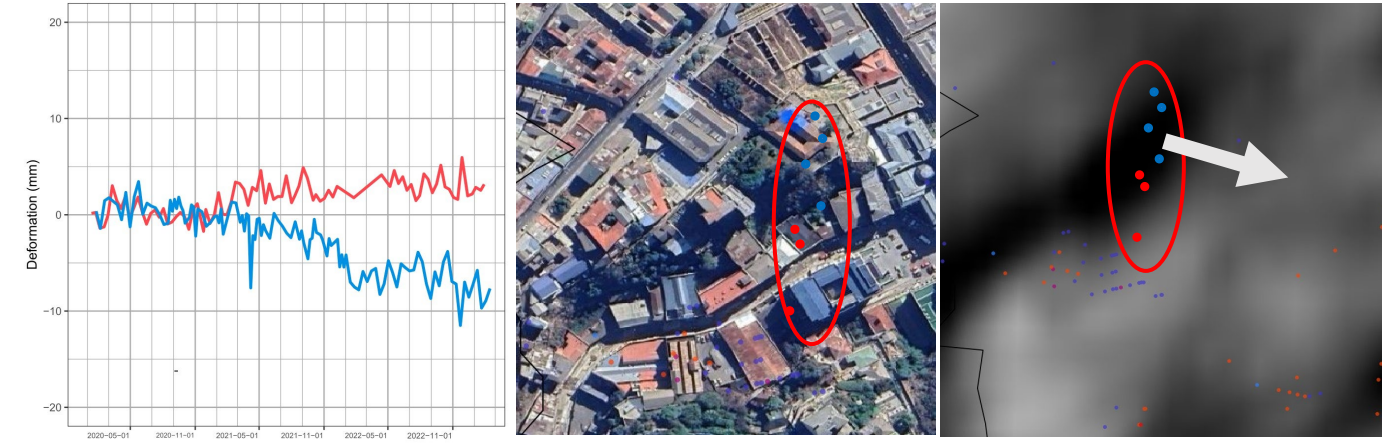
VERTICAL



EAST



Preliminary InSAR analysis: Timeseries



The *HOLISTIC* approach and the new paradigm

NCH as strategic assets must have “Management and Adaptation Plans” that aim to increase the resilience and decrease the vulnerability to the impacts of geo-hazards triggered by climate change by using EO data, products and services

1. Location and type of process and their relative meteo-climatic triggering
2. integrate the approaches that come from earth sciences (phenomena hazard maps) and climatic sciences into national policies with modeling variables and parameters
3. policies for the prevention and control of the effects of climate change are now supported by data from earth observation, which can be used in some cases to reduce the lack of knowledge and calibrate in situ data;
4. after the identification of the most vulnerable assets, and thanks to continuous monitoring, the mitigation interventions must be implemented following priorities. The solutions must be green and blue.

