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Ministero dell'Università e della Ricerca

Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

# Spoke 5 - ENVIRONMENT & NATURAL DISASTERS – Presentazione dello status delle attività

Roberto Bellotti – Dipartimento di Fisica & INFN - Bari

Bologna, Kick-off Meeting, 25/26 Novembre 2022

## Sommario

- Gruppo di lavoro: Università ed Enti
- Campi di Azione ed Obiettivi
- Work Packages e Ruoli secondo il Programma proposto
- Primi output:
  - identificazione di Filiere di Azione tra i WP per diverse Fenomenologie fonte di Disastro

- **Kick off meeting** 25/26 novembre 2022, Bologna

ISTITUZIONI PARTECIPANTI

1. UNIBA (Spoke Leader): 20 ricercatori
2. UNIVAQ (Spoke Co-Leader): 25 ricercatori
3. CNR: 15 ricercatori
4. ENEA: 16 ricercatori
5. Istituto Nazionale di Geofisica e Vulcanologia: 6 rice.
6. POLIBA: 9 ricercatori
7. Sapienza Università di Roma: 12 ricercatori
8. UNIFI: 12 ricercatori

**DIPARTIMENTI - ISTITUTI**

1. **UNIBA** (Spoke Leader): Dipartimento di Farmacia - Scienze del Farmaco; Dipartimento Interateneo di Fisica; Dipartimento di Matematica; Dipartimento di Informatica; Dipartimento di Scienze Agro Ambientali e Territoriali; Dipartimento di Scienze del Suolo, della Pianta e degli Alimenti; Dipartimento di Scienze della Terra e Geoambientali.
2. **UNIVAQ** (Spoke Co-Leader): Ingegneria e scienze dell'informazione e matematica; Scienze fisiche e chimiche; Ingegneria civile, edile - architettura e ambientale; Ingegneria industriale e dell'informazione e di economia (DIIE)
3. Consiglio Nazionale delle Ricerche (**CNR**): Istituto per il Rilevamento Elettromagnetico dell'Ambiente (IREA); Istituto di Metodologie per l'Analisi Ambientale (IMAA); Istituto per le Tecnologie della Costruzione (ITC) Istituto di Geologia Ambientale e Geoingegneria (IGAG); Istituto di Ricerca per la Protezione Idrogeologica (IRPI); Istituto di Matematica Applicata e Tecnologie Informatiche (IMATI).
4. **ENEA** (Agenzia Nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile): Laboratorio Analisi e Protezione delle Infrastrutture Critiche (TERIN-SEN-APIC); Laboratorio tecnologie per la dinamica delle strutture e la prevenzione del rischio sismico e idrogeologico (SSPT-MET-DISPREV)
5. Istituto Nazionale di Geofisica e Vulcanologia (**INGV**)
6. **POLIBA**: Dipartimento di Ingegneria Civile, Ambientale, del Territorio, Edile e di Chimica (DICATECh).
7. **Sapienza** Università di Roma: Dipartimento di Ingegneria Strutturale e Geotecnica (DISG); Dipartimento di Scienze della Terra (DST); Dipartimento di Ingegneria dell'Informazione, Elettronica e Telecomunicazioni (DIET).
8. **UNIFI**: Ingegneria dell'Informazione; Fisica; Scienze della Terra; Scienze e tecnologie Agrarie, Alimentari, Ambientali e Forestali; Statistica, Informatica, Applicazioni; Biologia.

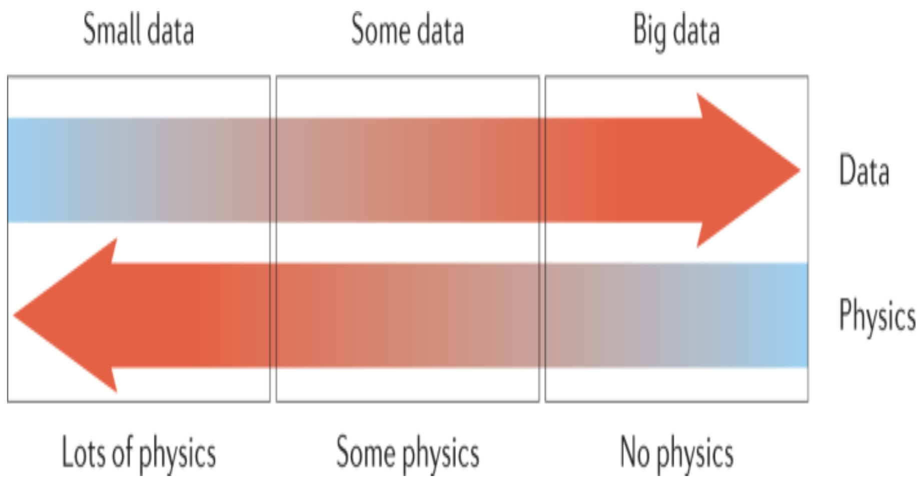
**WP**

**WP0 Project Management**
Leader: UNIBA & Co-leader: UNIAQ
**WP1 Dynamical hazard scenarios assessment**
Leader: CNR & Co-leader: UNIAQ
**WP2 Vulnerability inventory of elements at risk**
Leader: UNIFI & Co-leader: UNIBA
**WP3 Modelling of disaster-inducing processes**
Leader: INGV & Co-leader: POLIBA
**WP4 Modelling of environmental disasters**
Leader: ENEA & Co-leader: CNR
**WP5 Multi-hazard modelling and analysis estimation of engineering and geophysical parameters of damages and losses**
Leader: POLIBA & Co-leader: SAPIENZA
**WP6 Analysis of citizen preparedness and ecosystems resilience to disasters**
Leader: UNIVAQ & Co-leader: UNIFI
**WP7 ML, Quantum Computing and AI platform to design and exploit Digital Twins**
Leader: UNIBA & Co-leader: INGV
**WP8 Impact assessment and modelling of alternative risk mitigation strategies**
Leader: SAPIENZA & Co-leader: ENEA
**WP9 Dissemination**
Leader: UNIBA & Co-leader: UNIVAQ

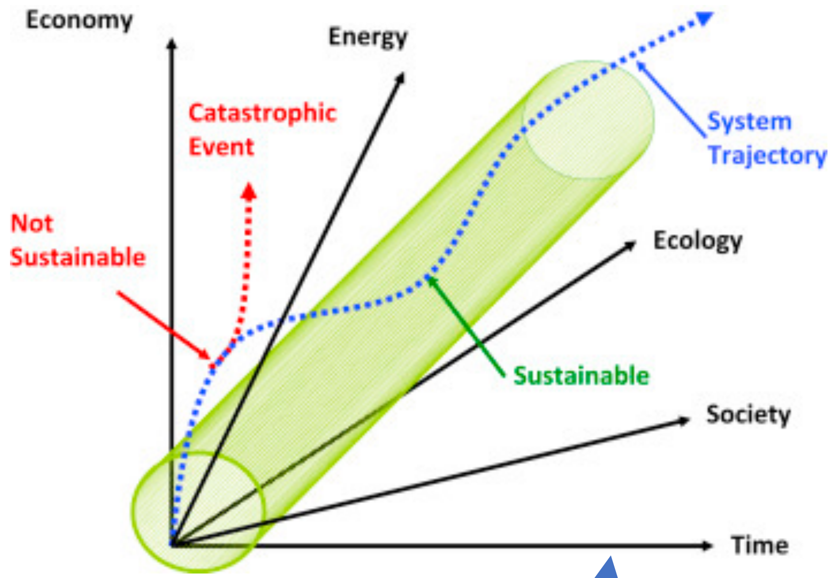
**Campo di AZIONE**

## OGGETTO: Fenomeni Naturali fonte dei Disastri e Vulnerabilità dei Sistemi Esposti

## OBIETTIVO: Mitigazione e Gestione Sostenibile del Rischio




[Nat Rev Physics, 3, 422 (2021)]




HPC
Machine Learning
XAI
Quantum Computing

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Campo di AZIONE

## OGGETTO: Fenomeni Naturali fonte dei Disastri - *System Trajectory*

- Terremoti: Sorgente del Sisma, Propagazione Sismica e Risposta Sismica Locale, Danni sulle Strutture e Infrastrutture
- Eruzioni Vulcaniche
- Frane: Cause innescanti, Meccanismi di Rottura, Propagazione della massa franosa, Danni sulle Strutture e Infrastrutture Interagenti
- Tsunami: Cause innescanti, Propagazione dell’Onda e Impatto sulle Coste
- Alluvioni: Eventi climatici estremi, processi idrologici dal bacino all’efflusso in mare
- Ondate di calore e Incendi boschivi
- Identificazione degli Elementi Esposti, Scenari di danno e Valutazione delle perdite economiche
- Stima della Vulnerabilità del Patrimonio costruito edilizio e infrastrutturale esistente e dei beni culturali
- Salute delle coltivazioni e risposta delle comunità biologiche alle variazioni ambientali

Campo di AZIONE

# OBIETTIVO: Mitigazione e Gestione Sostenibile del Rischio

## System Trajectory

- Gestione Sostenibile: Innovazione delle Procedure per la Zonazione del Rischio
- Gestione Sostenibile: Integrazione delle Zonazioni con la Conoscenza delle Tipologie di danno atteso e delle Cause su cui intervenire (es. archiviazione digitale dei dati di indagine, monitoraggio e interpretazione, esistenti e futuri, modellazione dei fenomeni per la previsione del disastro)
- Mitigazione: Interventi per il miglioramento della Resilienza dei Sistemi naturali attraverso Soluzioni Green (*Nature-based solutions*) e Sostenibili
- Mitigazione: Interventi locali e globali di Miglioramento/Adeguamento Sismico delle Costruzioni Esistenti
- Mitigazione: Interventi di protezione del Territorio dai processi di Propagazione del Disastro
- Mitigazione: Caratterizzazione della Resilienza delle Infrastrutture, delle Reti e delle Comunità

Inventory of factors and disasters at Regional Scale; Regional Scale Risk Modelling.

**WP 1**

**Dynamical hazard scenarios assessment**

**Leader: CNR**
**Co-leader: UNIAQ**

**CNR:**

**Rainfall-related** extremes detection for the geo-hydrological processes forecast.

High resolution seismostragraphic proxies' assessment for **ground motion** modelling at national scale using HPC. Stochastic modeling of time evolution of the seismic process based on variations in the probability distribution of seismic factors.

**UnivAQ**:

**Urban planning** accounting for climate changes **and** extreme climate events.

**ENEA:**

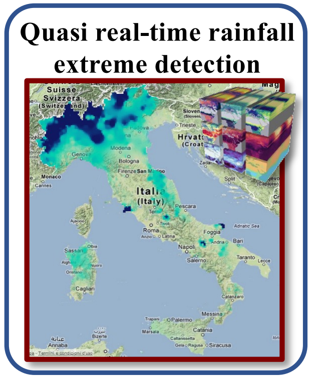
Multidisciplinary approach for the **seismic hazard assessment** of earthquakes induced and/or triggered by the **human activity** (mining activity,…). Modelling of interdependencies among infrastructures and the physical and natural environments they are embedded in.

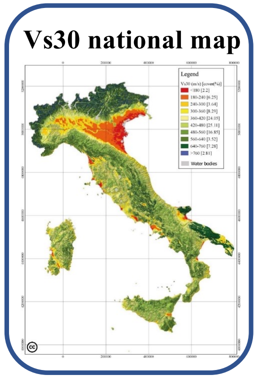
**UniFI:**

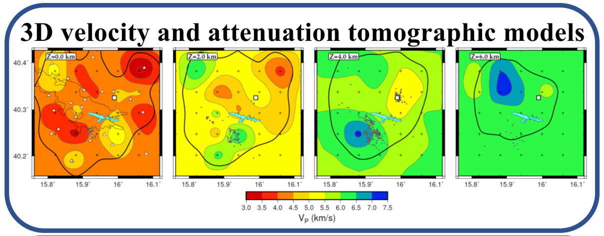
Dynamics of complex geological systems between variability and resilience. simulation behaviour of pollutants in space and time in riverine systems.

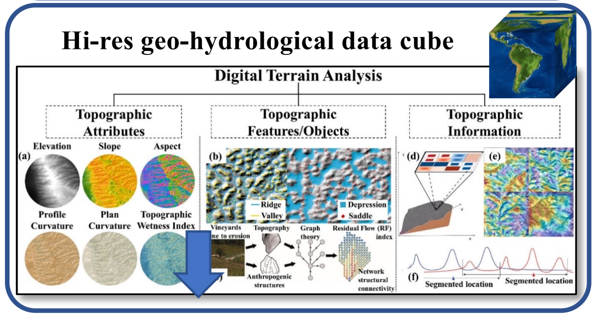
**UniBA:**

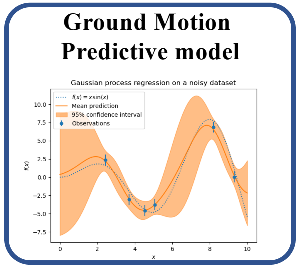
Simulations and models of: explosive volcanic eruptions and/or gravity flows, high-resolution time-dependent single phase earth flows. Probabilistic hazard assessment: Volcanic ash dispersal and fallout, Volcanic gas dispersal, Volcanic plume simulations.

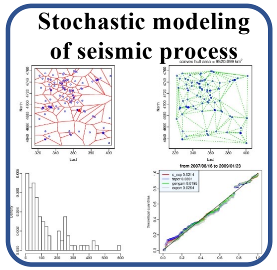


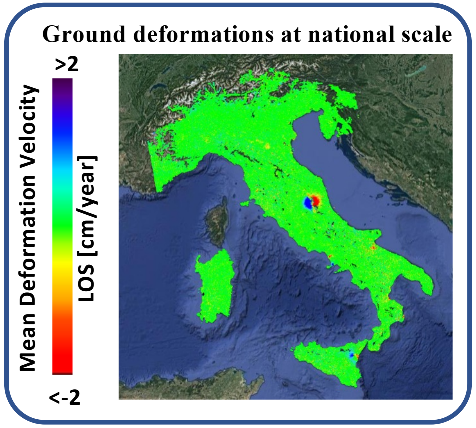



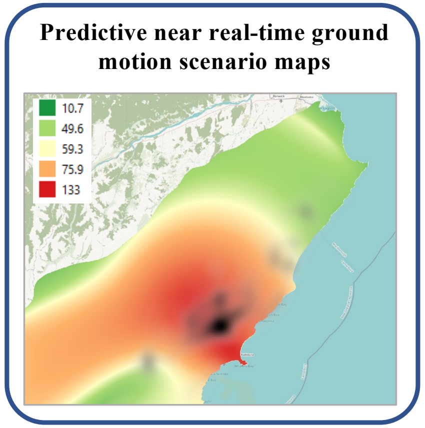
# WP 1 Dynamical hazard scenarios assessment

High resolution dynamical hazard scenario maps of natural disasters threatening the Italian territory and ecosystem

**CNR:**

Generation, update and analysis of national scale ground displacements through medium resolution satellite DInSAR measurements and **HPC infrastructures**. Production of near real-time high resolution seismic ground motion scenario maps.




**UnivAQ:**

Development of spatial information systems towards the integration of **different types of data** and the implementation of diagnostic tools.

**COMMON TO ALL UNITS:**

**USE OF HPC FACILITIES FOR THE ENANCHED REGIONAL MAPPING OF THE FACTORS AND EFFECTS OF THE DISASTROUS EVENTS**

WP 1

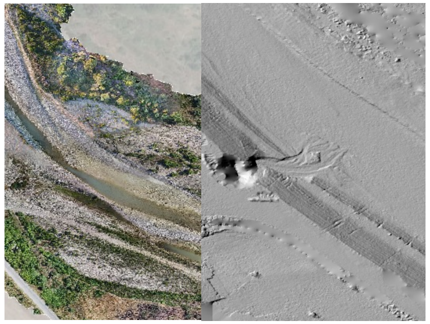
# ARDAS

## Advanced Remote Detection & Analysis System

Geomatics on the Move

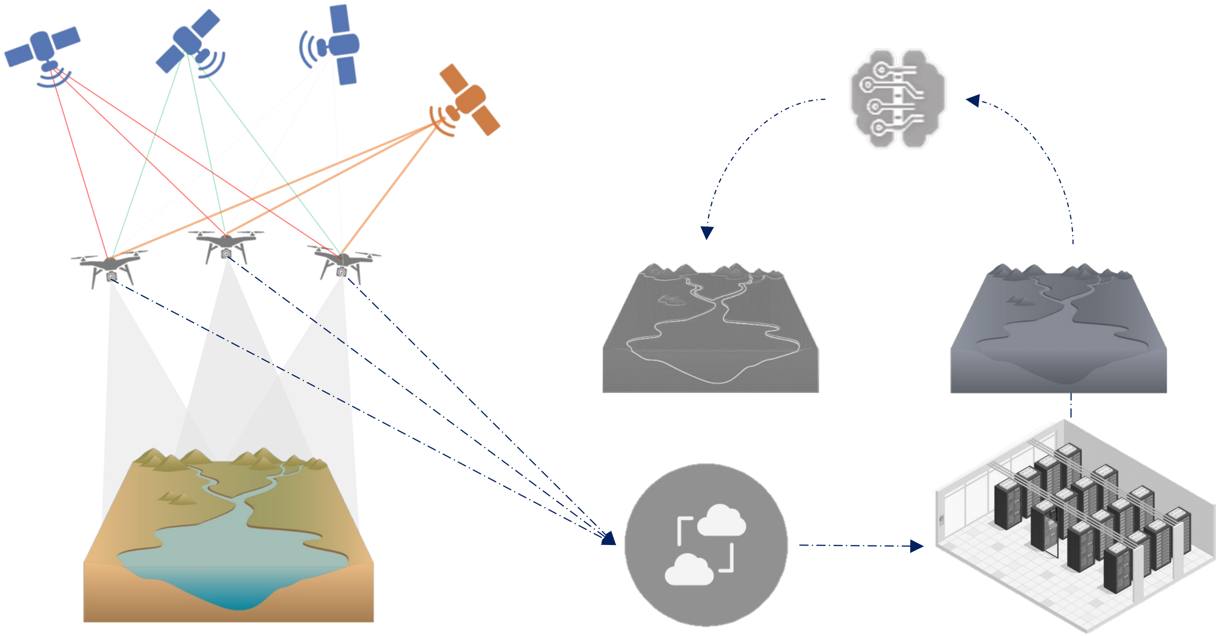
EUSPA European Union Agency for the Space Programme

**DETECTION OF WIDE AREAS**



**HIGH-RESOLUTION PRODUCTS**

**TIMELY SUPPORT TO HAZARD ASSESSMENT**



1. GNSS receivers (Galileo and GPS)
2. EGNOS system: augmentation of the original GNSS signals
3. Fleet of UAVs
4. Real-time UAVs-to-Cloud data transfer
5. Cloud computing environment
6. Data center (parallel computing over cluster nodes)
7. SfM process outputs (DEM)
8. Artificial Intelligence algorithms
9. Extrapolation of features and parameters

Elaborazione di 3000 immagini acquisite da flotte di droni in un

# WP 2

## Vulnerability inventory of elements at risk

**Leader: UNIFI**
**Co-leader: UNIBA**

# Vulnerability Inventory of Elements at Risk

WP 2 – Objectives - Data - Methods

- Critical Infrastructures (electricity/gas)
- Complex historical buildings
- Forestry & Agriculture
- Human health
- Complex geological systems

*responding to*

- Endogenous e.g. Earthquakes
- Climatic e.g. Heat waves/rainstorms /drought
- Anthropogenic e.g. pollution

WP 2 - Data

- Private data (Terna e-distribuzione, etc.)
- High resolution DEM/BIM (territory/buildings)
- Satellite data (Modis, Landsat, Copernicus)
- Climatology (ERA5/ECMWF, ISPRA)
- Sensor data (local monitoring system)

WP 2 - Methods

- Machine Learning models
- Extensive array processing
- Time series forecasting
- Pattern recognition

# Incendi

UNIFI
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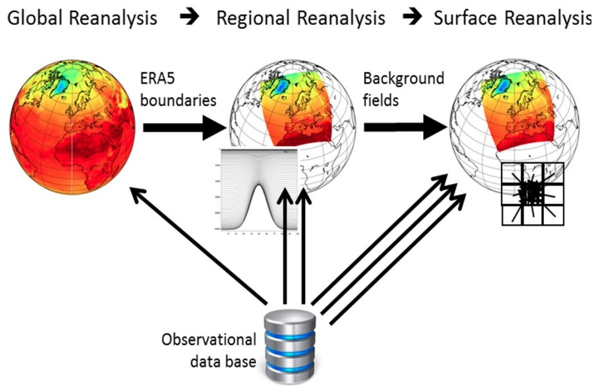
UNIBA

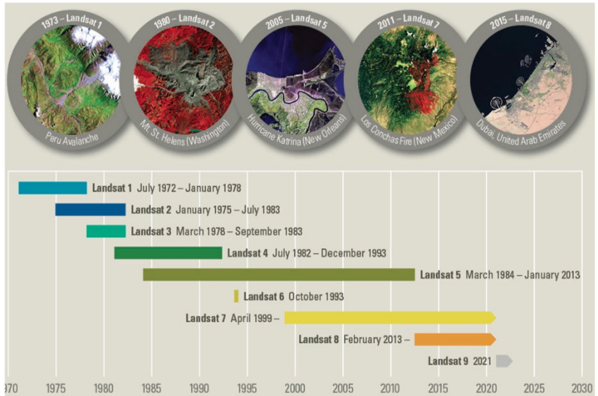
### obiettivi scientifici

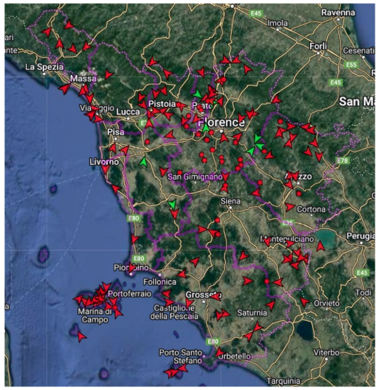
Analyse ERA5 reanalysis dataset of meteorological data coupled with landsat mission images series to elaborate and calibrate models to forecast drought induced forest stress conditions

Stress related conditions will be compared to on field measuremets by means of dendrometers to record variations of information related to plant phisiology

Wildfire allert by means of webcam image analysis
**(Open Call to be considered for this purpose)**



# Incendi – Catena di Analisi

UNIFI
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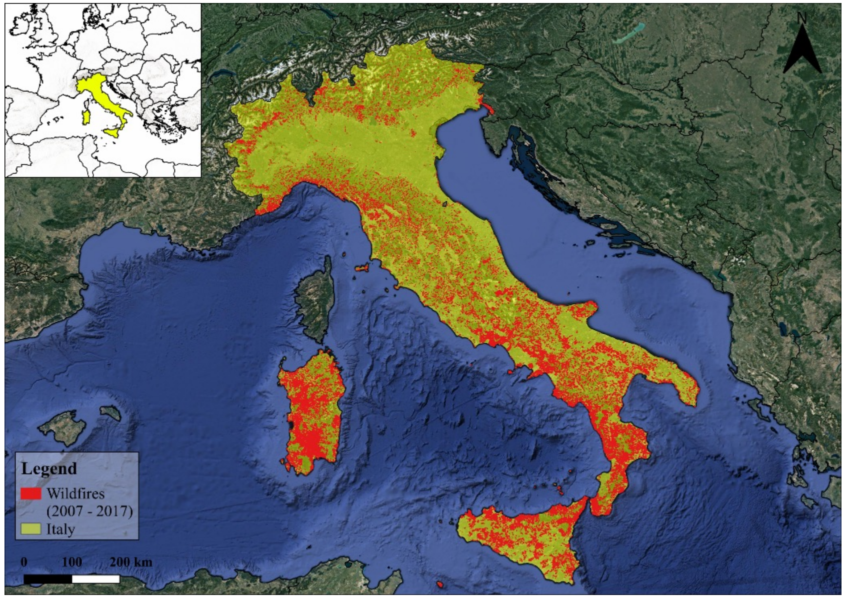
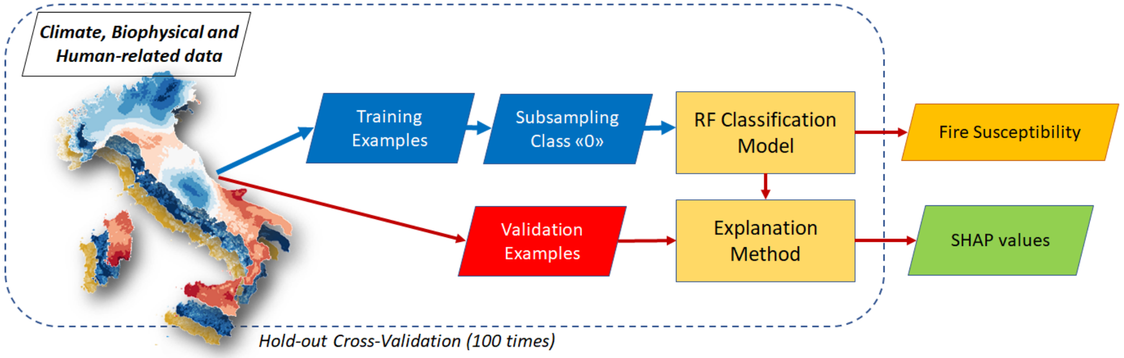
UNIBA

- ROI: Penisola Italiana
- Periodo riferimento: dal 2007 al 2017
- Input (driver): variabili climatiche, biofisiche e legate ad attività umane (medie periodo riferimento)
- Output: Occorrenza incendi (binaria)




- Complessità Temporale e Spaziale algoritmi su High Throughput Computing cluster (Set f = 17 feature ed N = 80,000 esempi, risoluzione spaziale 2km, output binario)
    - Analisi distribuita su 100 nodi CPU, 8GB RAM
    - Singolo Round RF + SHAP – 3-6 ore
    - Feature Selection con algoritmo wrapper: – 12-16 ore




*Cilli, R., Elia, M., D'Este, M. et al.* Explainable artificial intelligence (XAI) detects wildfire occurrence in the Mediterranean countries of Southern Europe. ***Sci Rep*** *12, 16349 (2022).*

## Modellazione deterministica ad elevato carico computazionale

**WP 3**
**Modelling of disaster-inducing processes**

⬇

**WP 5**
**Multi-Hazard Modelling and Analysis of Damages and Losses**

⬇

**WP 7**
**Machine Learning, Quantum Computing and AI Platform to design and exploit Digital twin Activities**

⬇

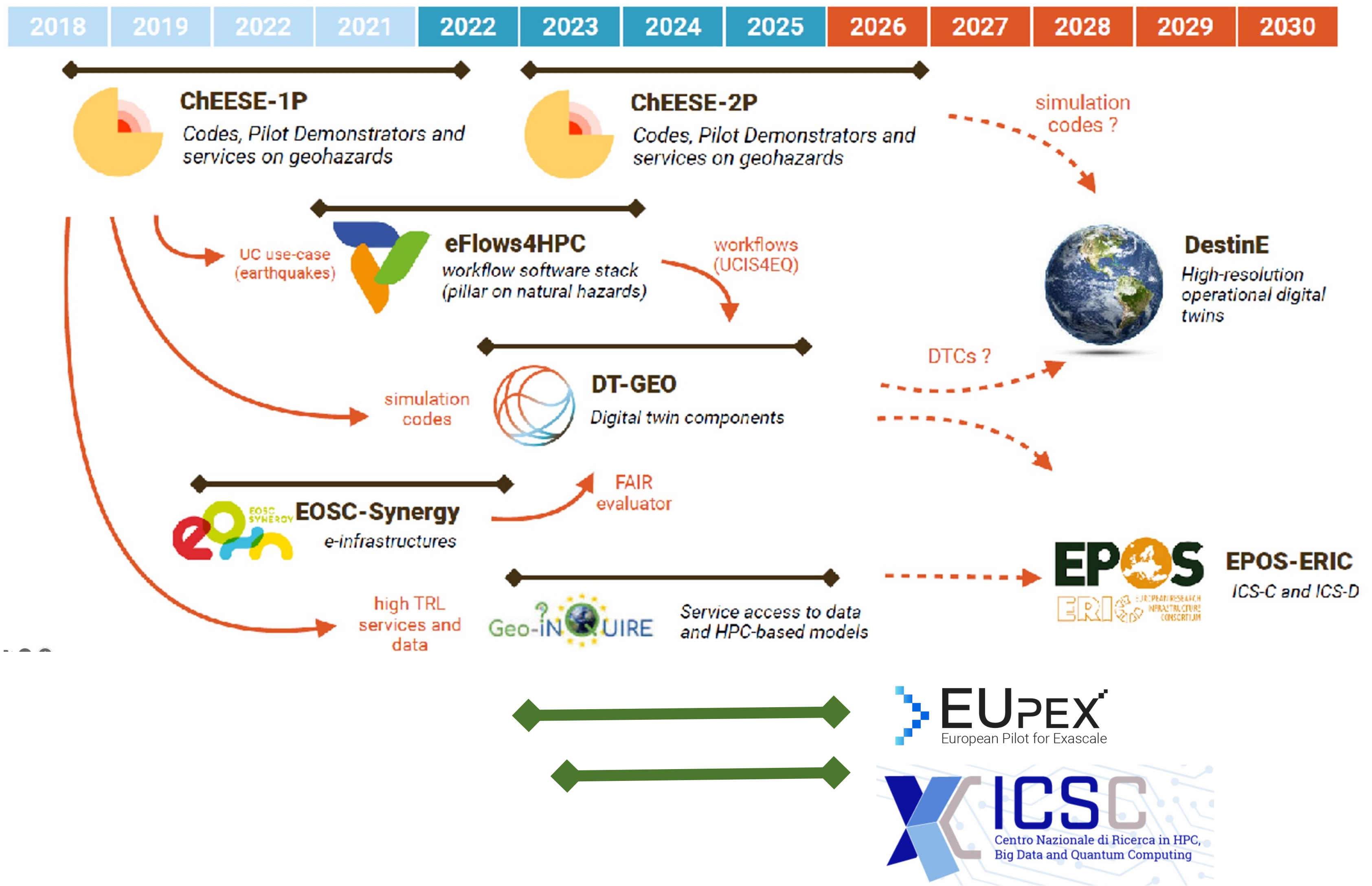
**WP 8**
**Impact Assessment and alternative mitigation strategies**

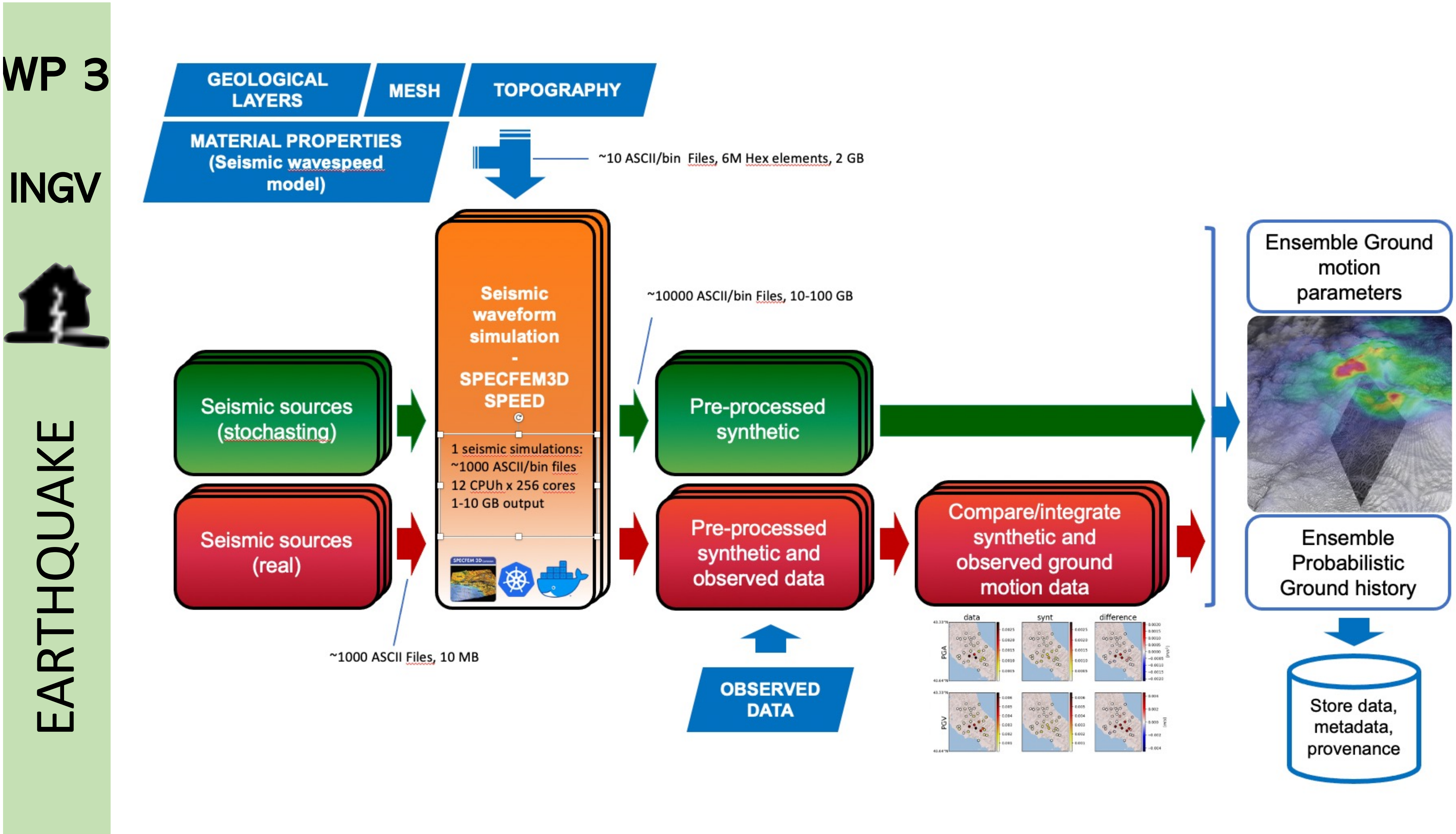
WP 3

INGV

EARTHQUAKE

# INGV - HPC EU ecosystem: a DIGITAL TWIN for GEO extremes




WP 3
INGV
EARTHQUAKE
GEOLOGICAL LAYERS
MESH
TOPOGRAPHY
MATERIAL PROPERTIES (Seismic wavespeed model)
~10 ASCII/bin Files, 6M Hex elements, 2 GB
Seismic waveform simulation - SPECFEM3D SPEED
1 seismic simulations:
~1000 ASCII/bin files
12 CPUh x 256 cores
1-10 GB output
~10000 ASCII/bin Files, 10-100 GB
Seismic sources (stochasting)
Seismic sources (real)
~1000 ASCII Files, 10 MB
Pre-processed synthetic
Pre-processed synthetic and observed data
OBSERVED DATA
Compare/integrate synthetic and observed ground motion data
data
synt
difference
PGA
PGV
Ensemble Ground motion parameters
Ensemble Probabilistic Ground history
Store data, metadata, provenance

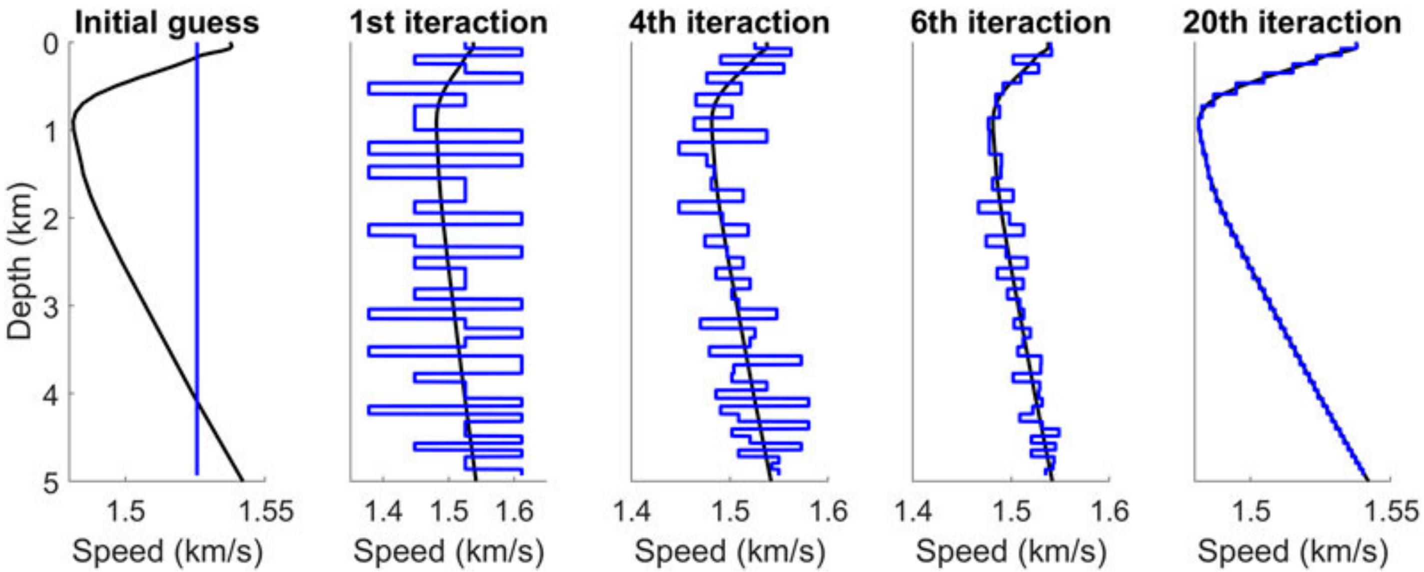
WP 7

INGV

QUANTUM COMPUTING

Among the quantum algorithms, the quantum annealing has been applied in seismic inversion as tomography or seismic source definition.

**The scientific project is to explore and encode quantum algorithm of classical geophysical problems, toward the application of quantum computing paradigm to real case in particular in tomographic imaging and seismic source inversion.**



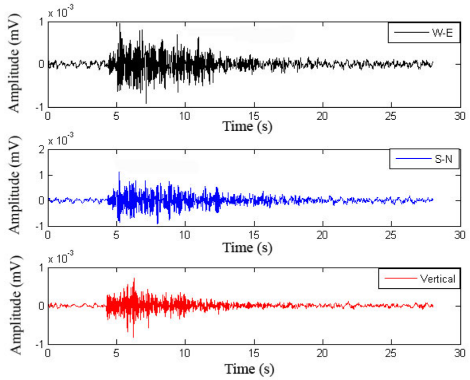

Souza et al. 2022, https://doi.org/10.3389/fphy.2021.748285

UNIBA

# Multiscale 3D high resolution velocity, attenuation and resistivity tomographies and high precision 3D earthquake locations for the High Agri Valley and Gargano areas and thermo-rheological model using High-Performance Computing

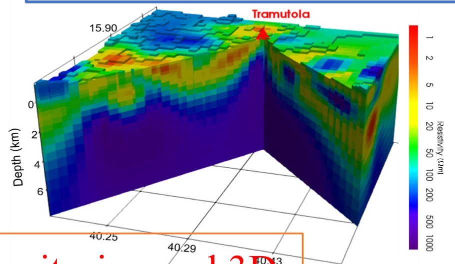
Possible requirements:

- System: Atos BullSequana XH2000
- Max Floating point performance, double: 6.2 Petaflop
- Node number: 1344
- CPU type: AMD® Epyc™ "Rome" 2.25GHz
- CPU cores in total: 172032
- CPU cores per node: 128
- Memory in total: 336 TiB
- Memory per node: 256 GiB
- Total disk capacity: 2.6 PB
- Interconnect: InfiniBand HDR 100, Dragonfly+ topology

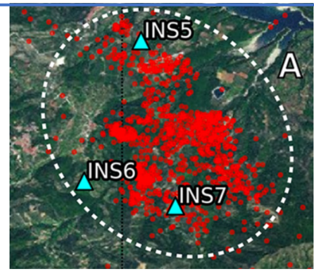



Continuous data streams from Seismic and Geodetic networks

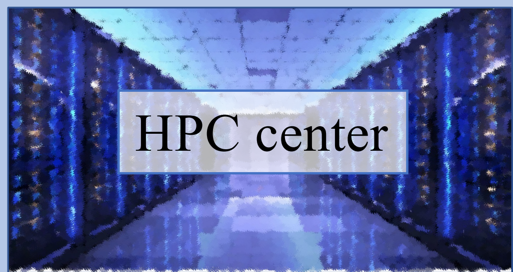
Phase picking and event detection using DL approaches



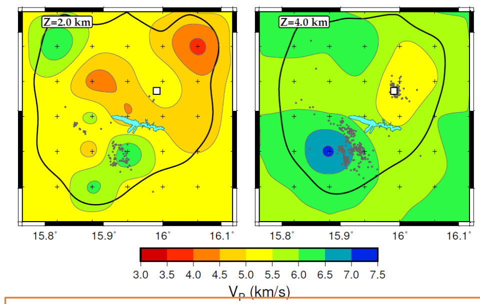

MT monitoring and 3D resistivity modelling



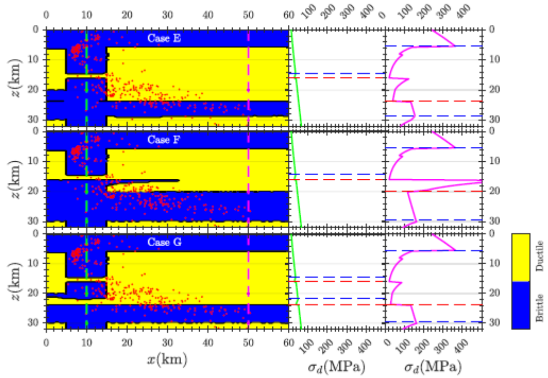

High precision 3D earthquake locations




HPC needs: GPU and multicore HPC infrastructure, data and result storage capacity




3D velocity and attenuation tomographic models




3D Thermo-Rheological models

WP 3

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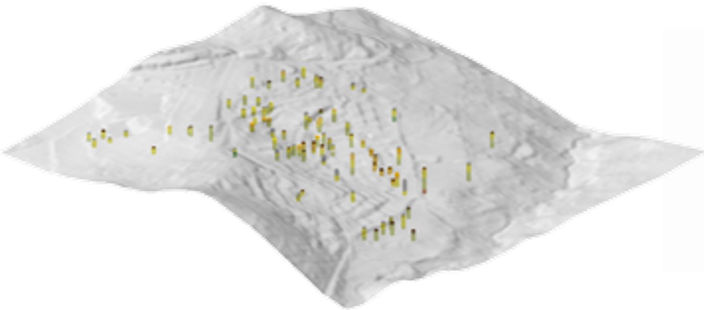
# GEOTECHNICAL SYSTEMS: LANDSLIDES, EARTHQUAKES

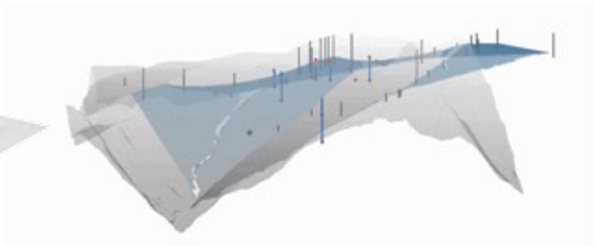
## Multi-source data to build the GEO-HYDRO-MECHANICAL MODEL of SOIL AND SUBSOIL

**3D DATABASE**

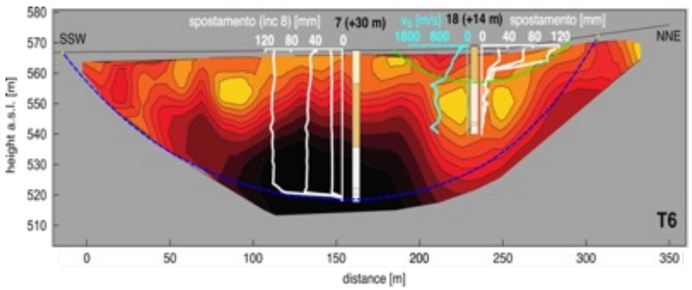
topography and lithological data



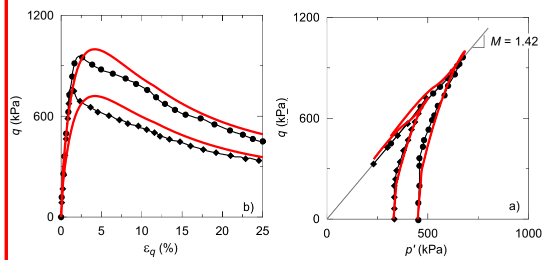
piezometric data



geophysical data integrated with investigation and monitoring data




Mechanical constitutive laws




## DATABASE

- Topographic data (e.g. LiDAR-based DEMs)
- Lithological data
- Geophysical data
- Surface geological-geomorphological data
- Geotechnical lab and field data (mechanical, hydraulic, thermal)
- Surface and deep displacements
- Piezometric data
- Soil suction
- Water content
- Climatic variables (rainfall, wind, net radiation, RH, temperature)
- Vegetation survey

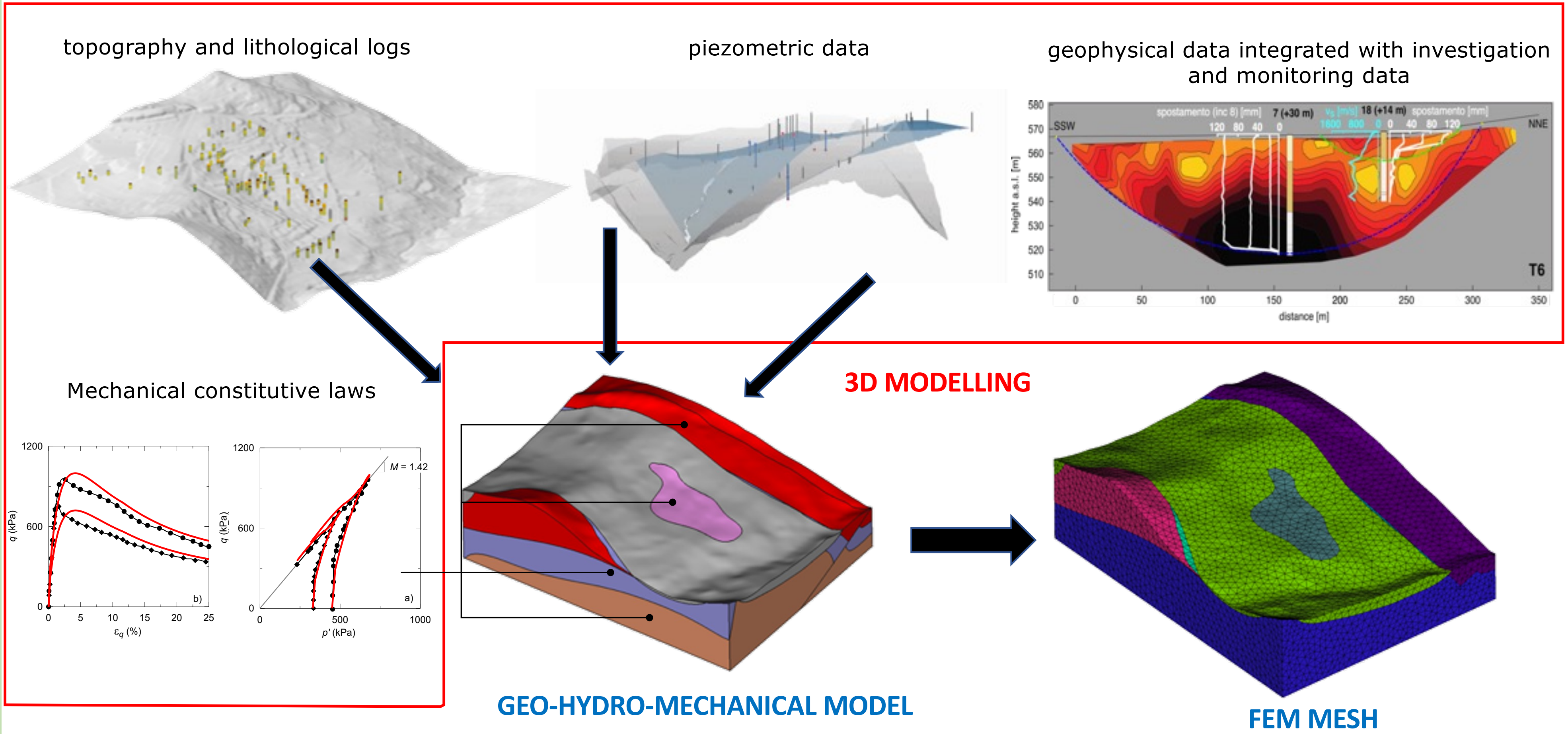
*WP3 Modelling of disaster-inducing processes*

**WP 3**

**POLIBA**
**-**
**UNIVAQ**

# GEOTECHNICAL SYSTEMS: LANDSLIDES, EARTHQUAKES

## Multi-source data to build the GEO-HYDRO-MECHANICAL MODEL of SOIL AND SUBSOIL




*WP3 Modelling of disaster-inducing processes*

WP 3

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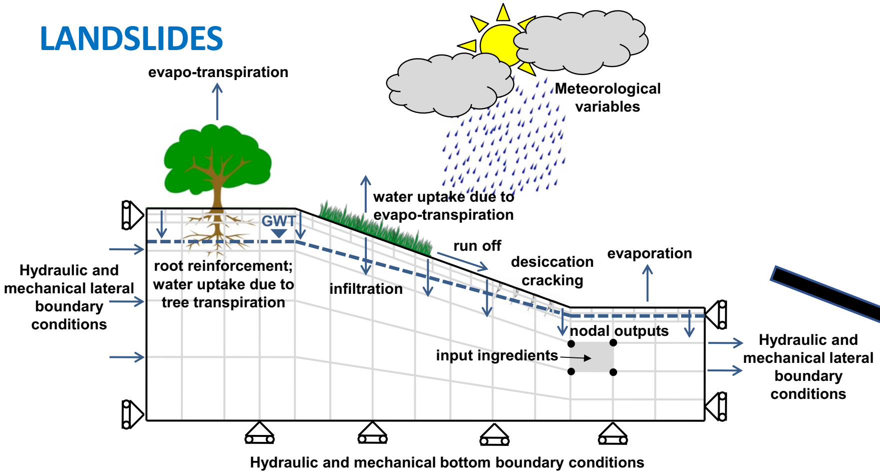
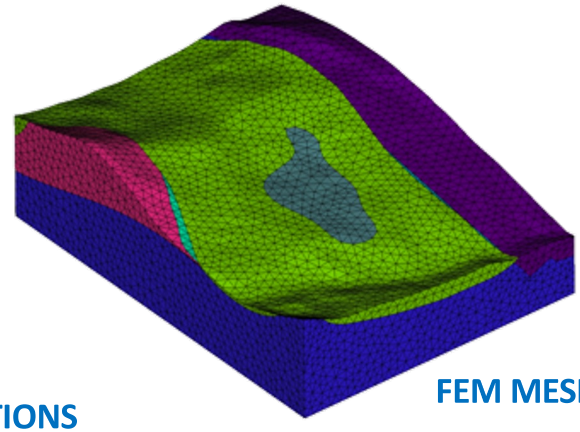
# GEOTECHNICAL SYSTEMS: LANDSLIDES, EARTHQUAKES

## Geo-Thermo-Hydro-Mechanical Governing Equations

### LANDSLIDES



FEM MESH

### COUPLED FIELD EQUATIONS

water mass balance $$\frac{\partial}{\partial t}\left(\theta_l^{\mathrm{w}} S_l n + \theta_g^{\mathrm{w}} S_g n\right) + \nabla \cdot \left(\boldsymbol{j}_l^{\mathrm{w}} + \boldsymbol{j}_g^{\mathrm{w}}\right) = f^{\mathrm{w}}$$

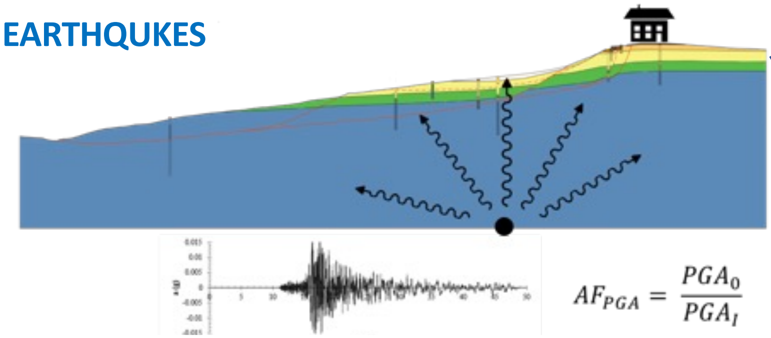
air mass balance $$\frac{\partial}{\partial t}\left(\theta_l^{\mathrm{a}} S_l n + \theta_g^{\mathrm{a}} S_g n\right) + \nabla \cdot \left(\boldsymbol{j}_l^{\mathrm{a}} + \boldsymbol{j}_g^{\mathrm{a}}\right) = f^{\mathrm{a}}$$

solid mass balance $$\frac{\partial}{\partial t}\left[\theta_s (1-n)\right] + \nabla \cdot \left(\boldsymbol{j}_s\right) = 0$$

energy balance $$\frac{\partial}{\partial t}\left[E_s \rho_s (1-n) + E_l \rho_l S_l n + E_g \rho_g S_g n\right] + \nabla \cdot \left(\boldsymbol{i}_c + \boldsymbol{j}_{Es} + \boldsymbol{j}_{El} + \boldsymbol{j}_{Eg}\right) = f^{Q}$$

momentum balance (equilibrium) $$\nabla \cdot \boldsymbol{\sigma}_t + \boldsymbol{b} = 0$$

### EARTHQUKES



$$AF_{PGA} = \frac{PGA_0}{PGA_I}$$

**EFFICIENT NUMERICAL SCHEMES AND HPC TOOLS REQUIRED**

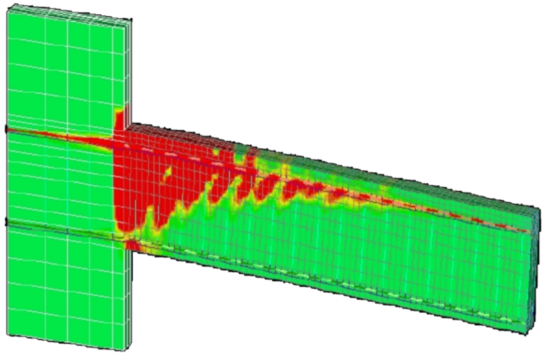
**INPUT from other Spoke Partners**

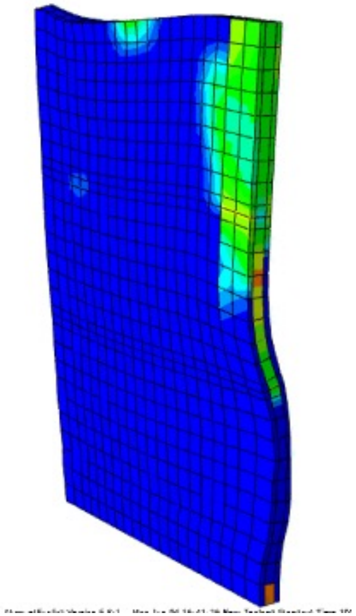
*WP5.3 Modelling of disaster-inducing processes*

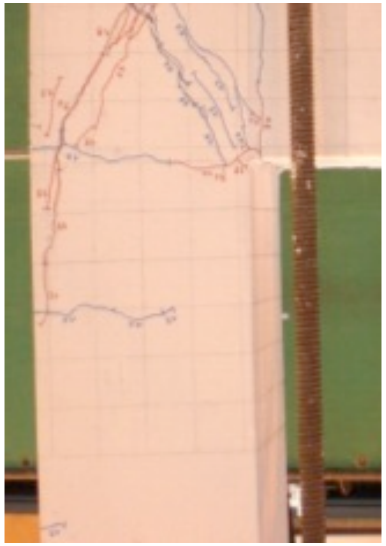
WP 5

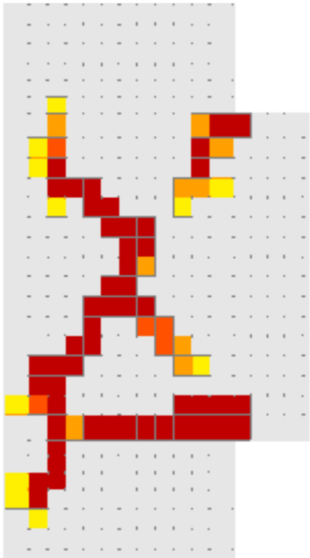
SAPIENZA

# EARTHQUAKES : modelling of vulnerability, damage and losses









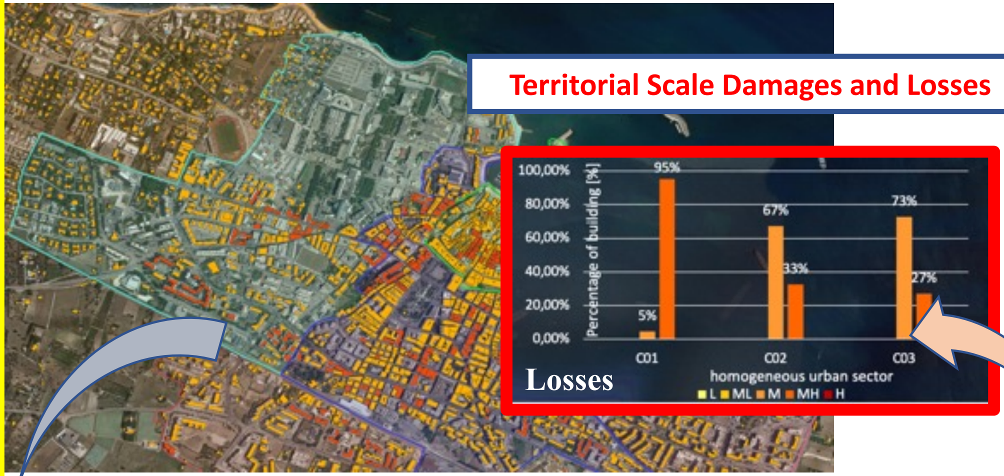
WP 5

POLIBA - UNIVAQ

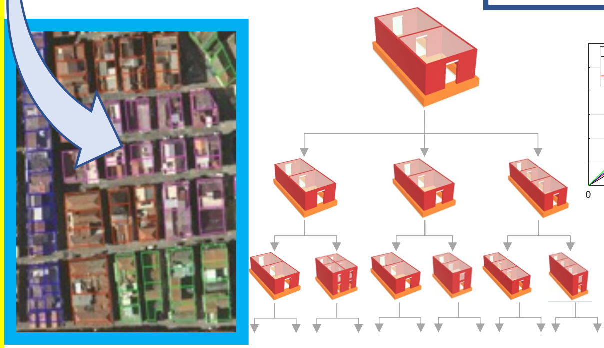
# EARTHQUAKES : modelling of vulnerability, damage and losses

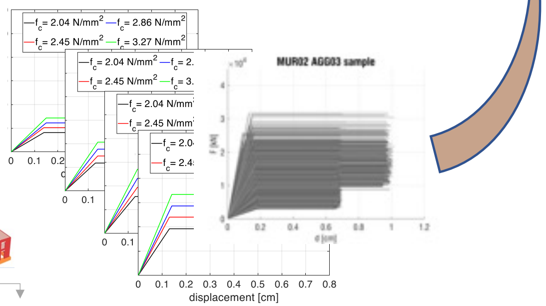
- Low accuracy
- Extensive computations

**Territorial Scale Damages and Losses**



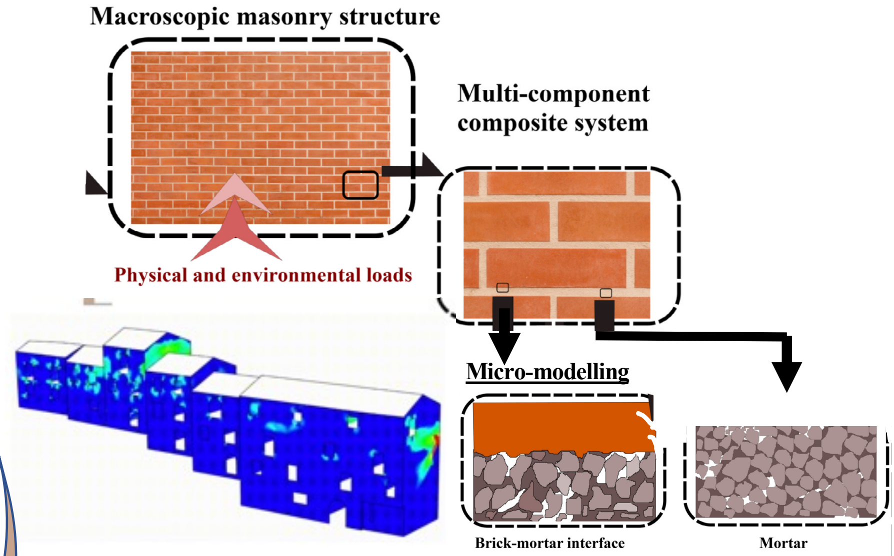

**Probabilistic vulnerability models**

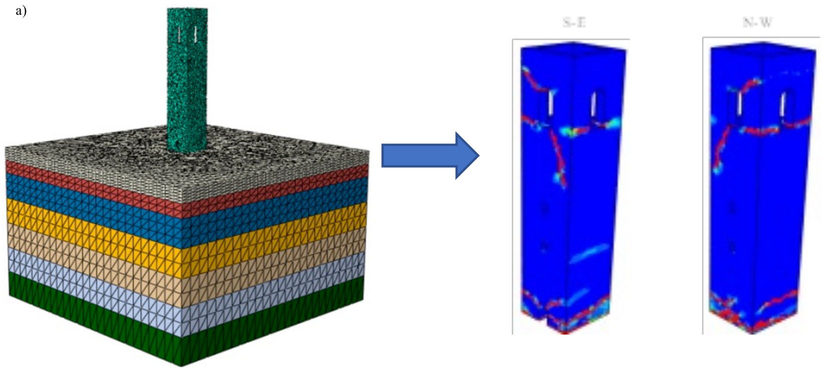





**Site specific advanced modelling**

- High accuracy data
- Computationally intensive analyses



WP 5

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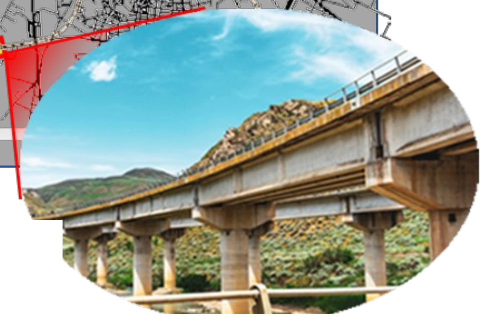
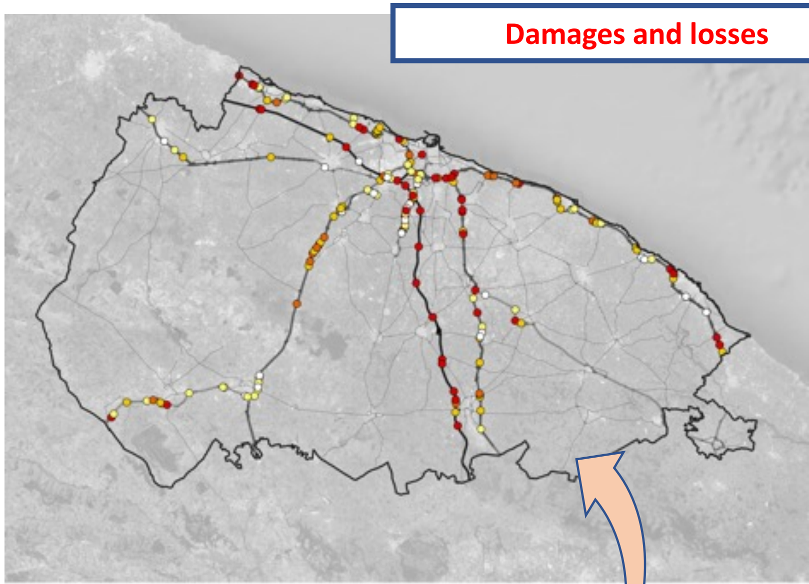
# EARTHQUAKES : modelling of vulnerability, damage and losses

- Low accuracy
- Extensive computations

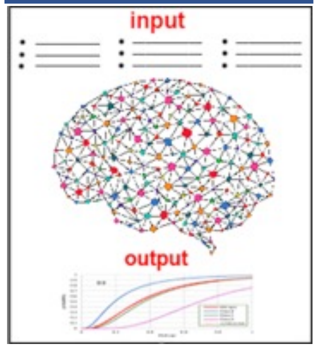


**Damages and losses**



HPC
Machine Learning
XAI
Quantum Computing

**Meta-models**

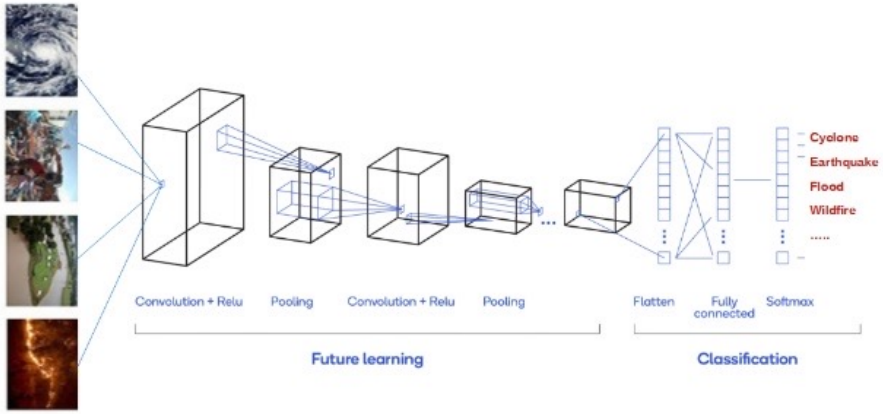


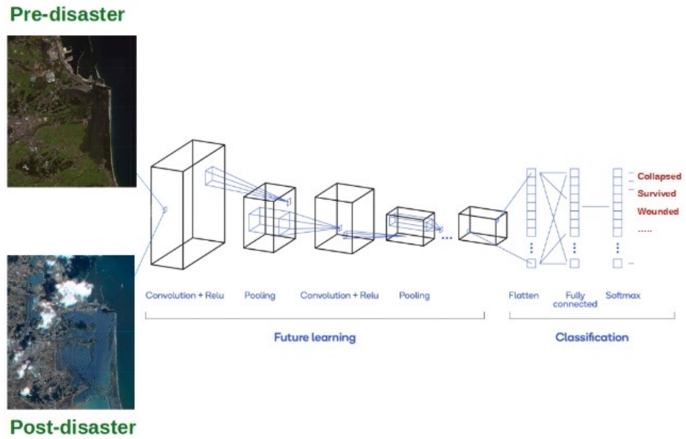

*WP5.7 Multi-hazard modelling and analysis of damages and losses*

WP 5

SAPIENZA

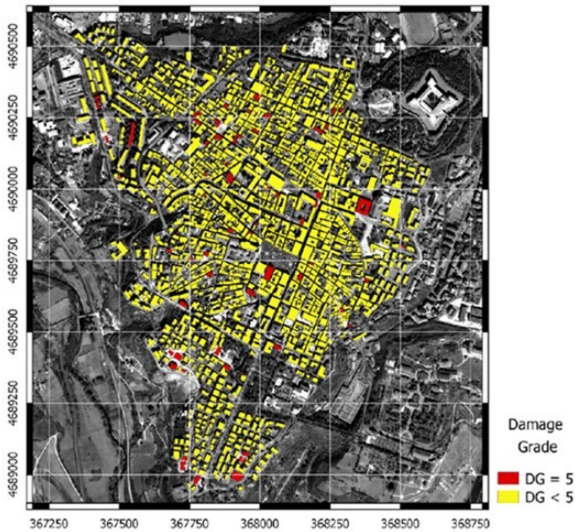
# EARTHQUAKES : Event classification and damage assessment




- Event detection and classification from images taken by drones, planes, and satellites
- Exploiting of Deep Learning techniques.

- Damages evaluation from images
- Using deep learning approaches to compare pre- and post-disaster images.

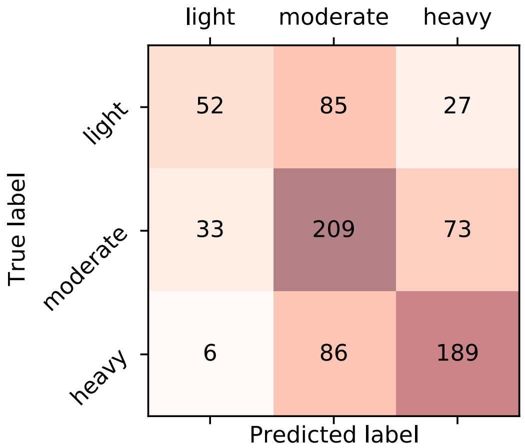



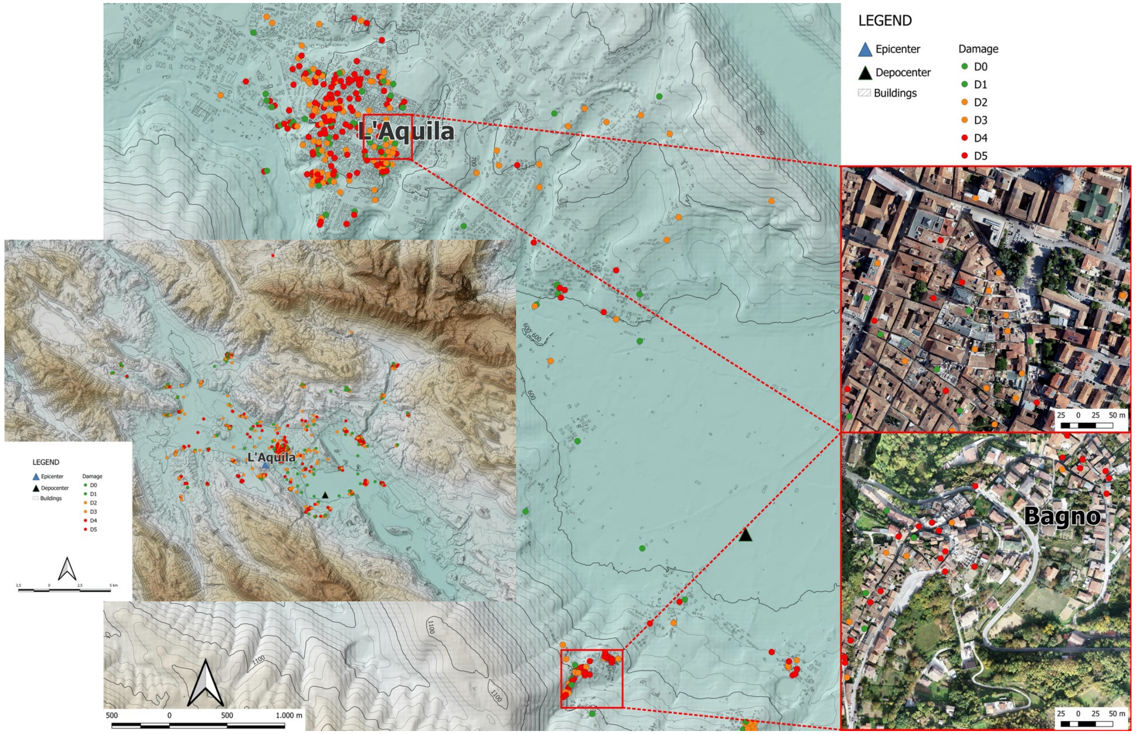
# WP 2 - 5 - 8 Impact assessment and modeling of alternative risk mitigation strategies - Valutazione del danno agli edifici usando tecniche di AI

UNIVAQ

2536 edifici – 21 features

D0-D1 light damage (546)
D2-D3 moderate damage (1050)
D4-D5 heavy damage (936)




A Machine learning tool for damage classification: the case of L'Aquila 2009 earthquake.
F. Di Michele, E. Stagnini, D. Pera, B. Rubino, R. Aloisio, A. Askan , P. Marcati. Submitted

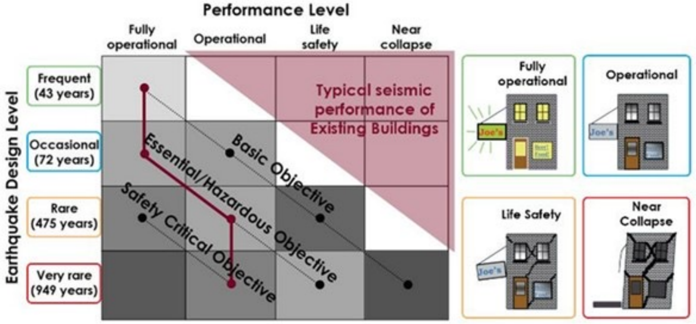
- Data dimension: Current data set 1Mb (small test)
- Time execution : around 10 minute on 100 CPU cores (Intel I9).
- Increasing the data set dimensions we estimate longer computational times on CPU shared memory architectures or GPUs

WP 8

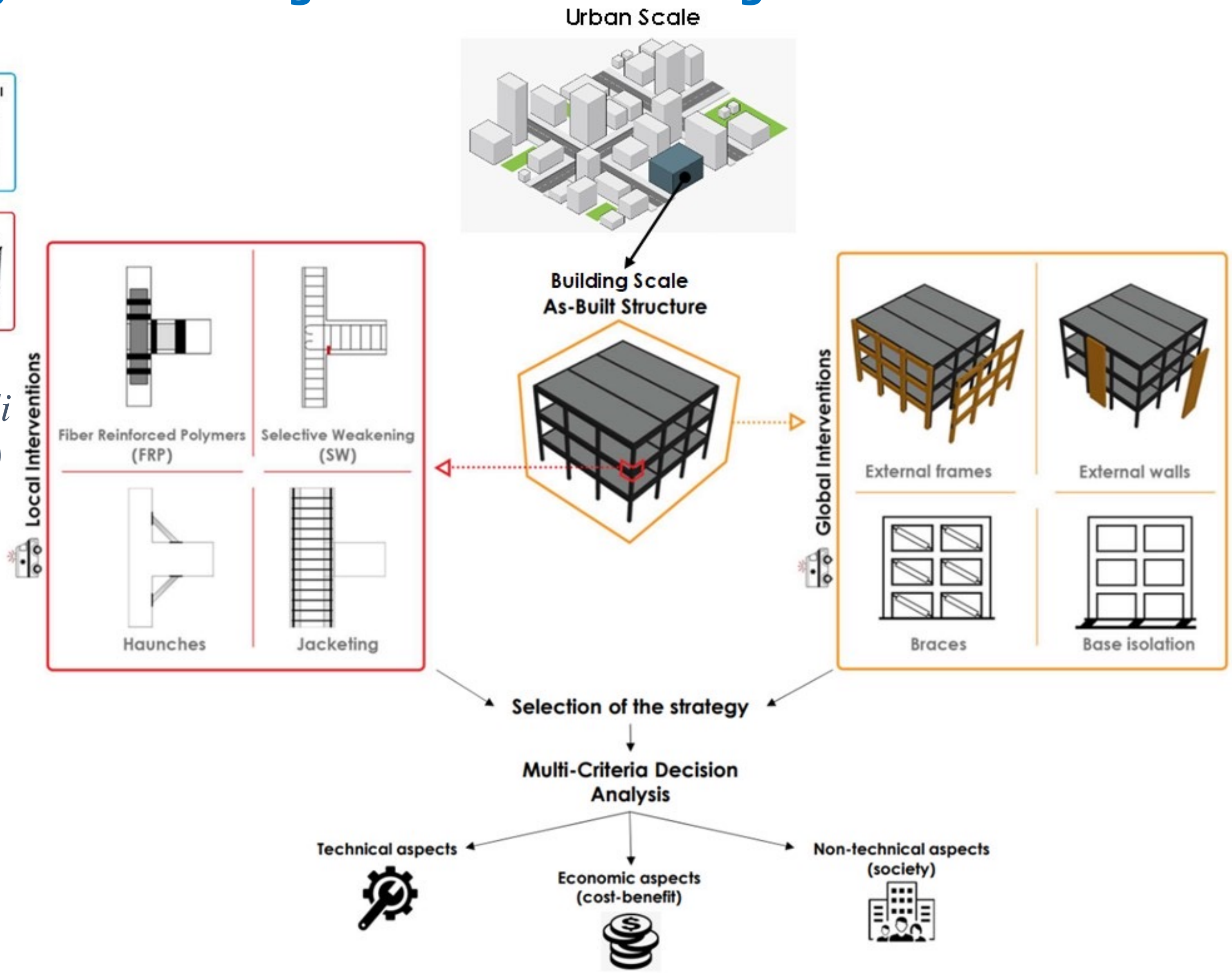
SAPIENZA

# EARTHQUAKES :

## dall'Analisi di Danno alla progettazione degli Interventi di Mitigazione




*Matrice prestazionale (sinistra), e livello di danno atteso per i vari stati limite (destra)*




*Interventi locali (sinistra) e globali (destra) di miglioramento/adeguamento sismico delle costruzioni esistenti*

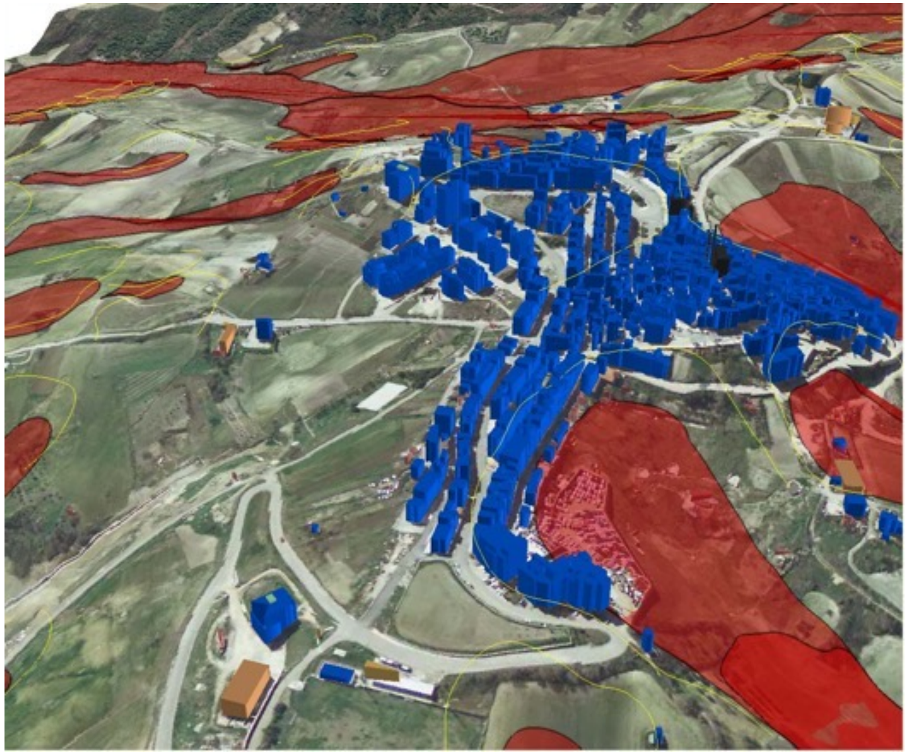
WP 5

POLIBA

# LANDSLIDES

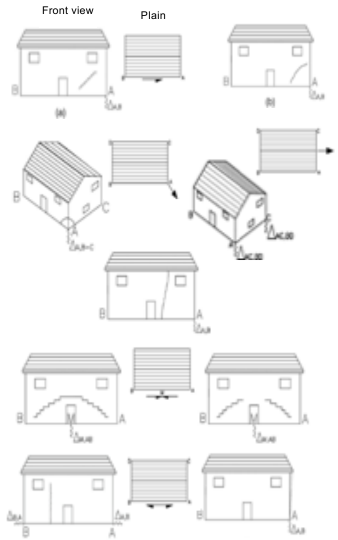
## 3D modelling of landslides interacting with structures and infrastructures

3D model of buildings interacting with landslides



database of damage on buildings

masonry / mixed-material buildings




concrete framed buildings

*WP5.5 Multi-hazard modelling and analysis of damages and losses*

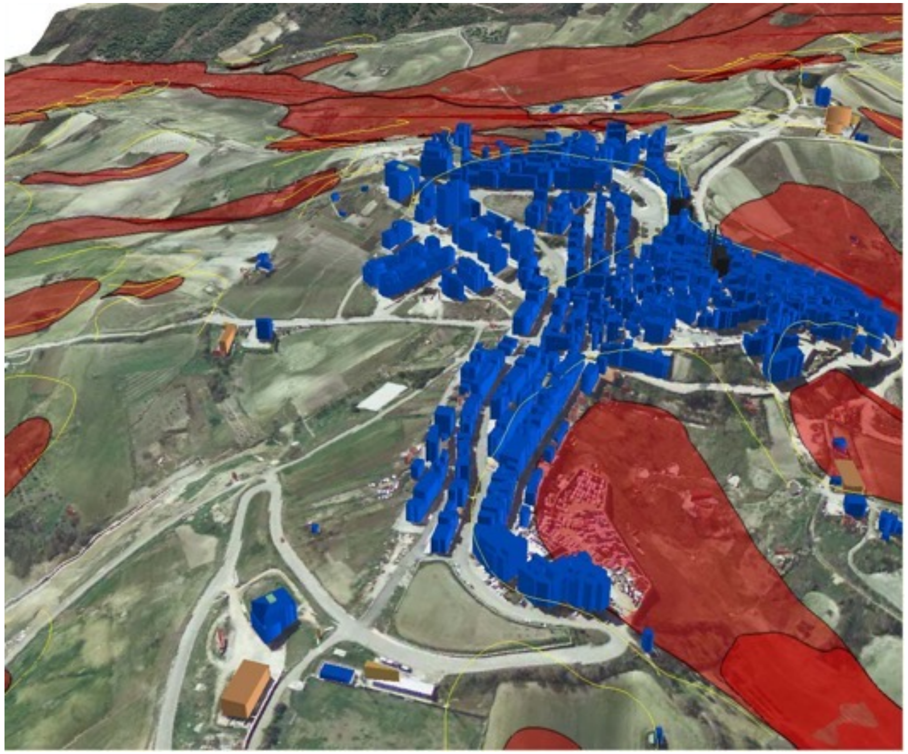
WP 5

POLIBA

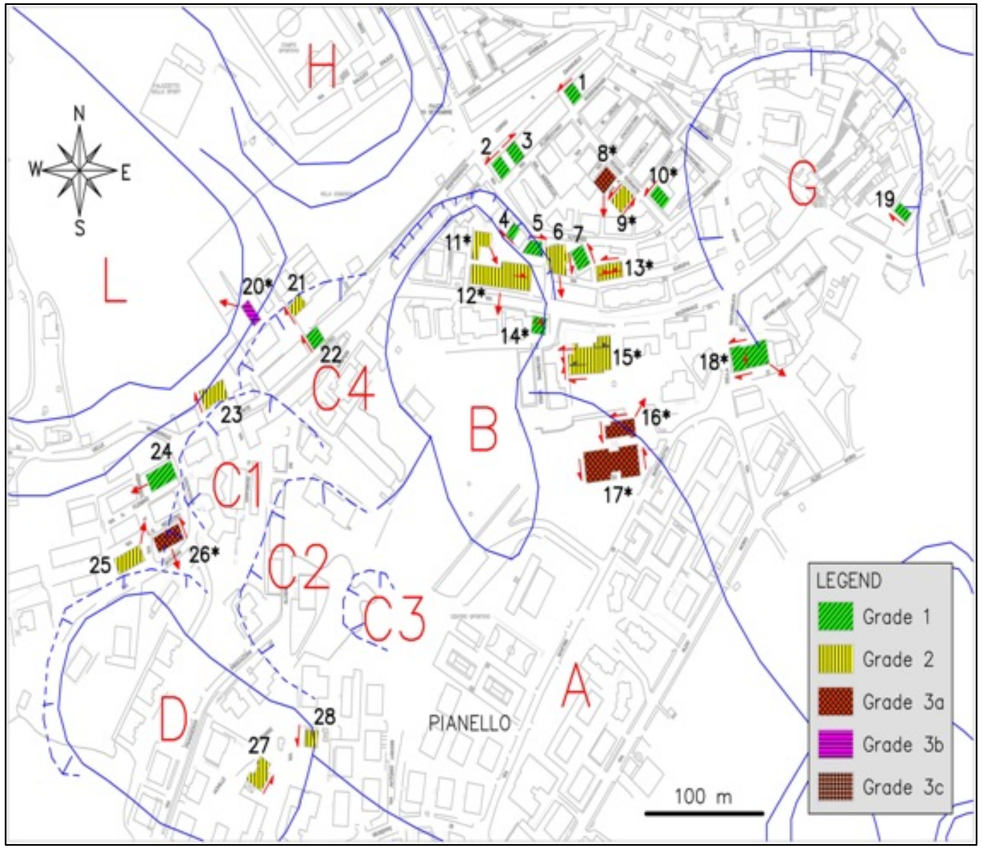
# LANDSLIDES

## 3D modelling of landslides interacting with structures and infrastructures

3D model of buildings interacting with landslides



geotechnical landslide damage map




*WP5.5 Multi-hazard modelling and analysis of damages and losses*

WP 8

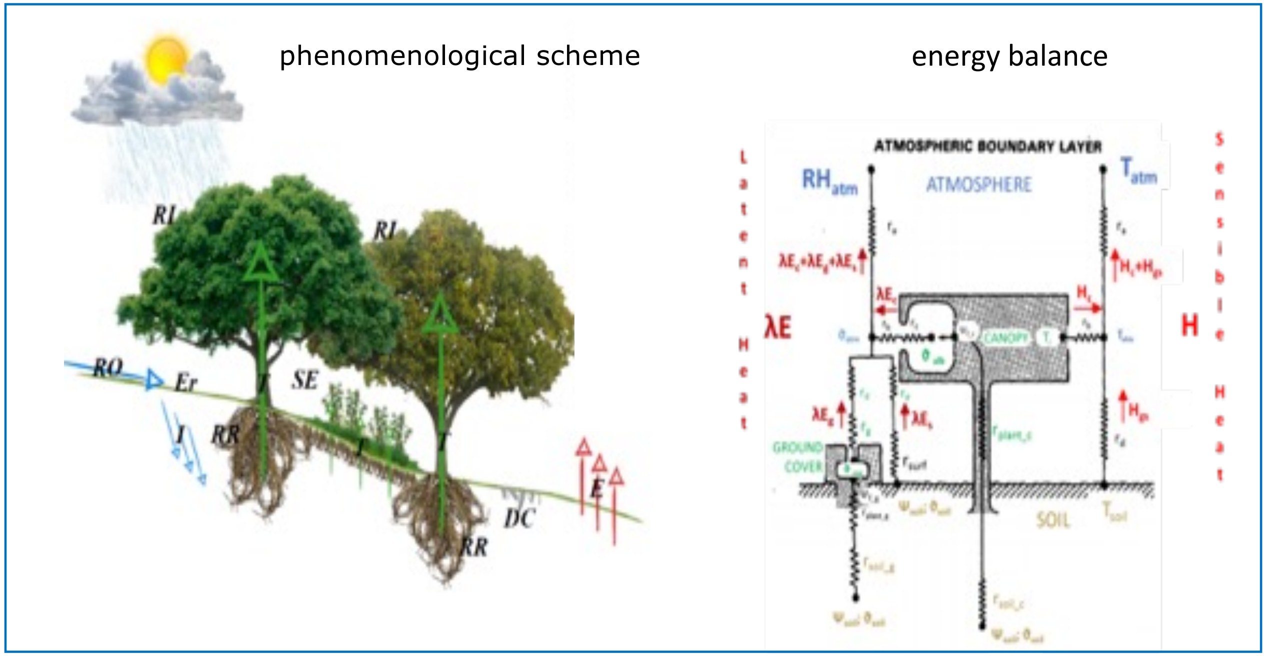
POLIBA

# LANDSLIDES

## 3D modelling of slope-vegetation-atmosphere interaction for the design of sustainable mitigation measures

### NATURE-BASED SOLUTIONS

Selected and deep-rooted vegetation to reduce the overall water infiltration in the soil




*WP5.8 Impact assessment and modelling of alternative risk mitigation strategies*

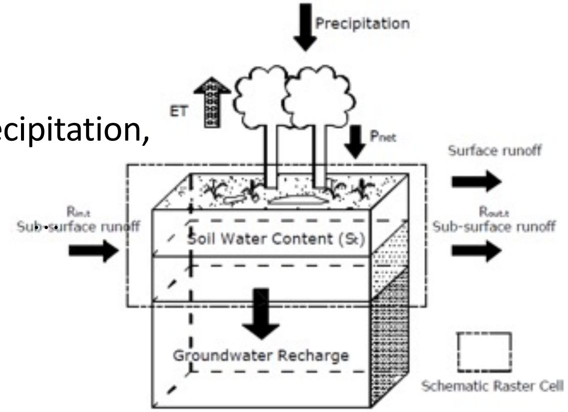
# FLOODS

## Coupled Hydrological-hydrodynamic modeling at the basin scale

WP 3

POLIBA

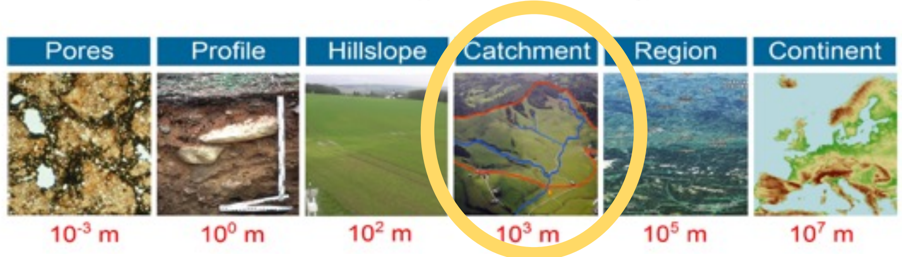
**Multi-source data required:**
Topography (LiDAR-based DEMs), Soil Moisture (e.g. Soil water Index), Radar-based Precipitation, Temperature, Detailed Land Use maps, Vegetation Cover (e.g. Leaf Area Index), Pedological database, Hydrometric measurement (for calibration),



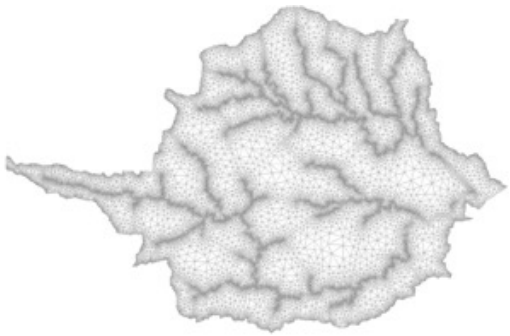

(Manfreda S., et al., 2005)

*Input for*

**Depth-averaged 2D Hydrodynamic model**
Finite volumes or Finite Differences schemes
Courant–Friedrichs–Lewy (CFL) "*numerical stability constraint*"




**Goals:**
- **Run HPC** hydrological-hydrodynamic **simulations**
- **Flood Hazard estimation & mapping** *(for different probabilistic rainfall scenarios)*
- Step forward hydrological **Digital twins**
- Promote **climate change adaptation**
- Supporting **political and civil protection decision**



(Cea L., et al. 2022) IBER+

*WP5.3 Modelling of disaster-inducing processes*

WP 5

POLIBA

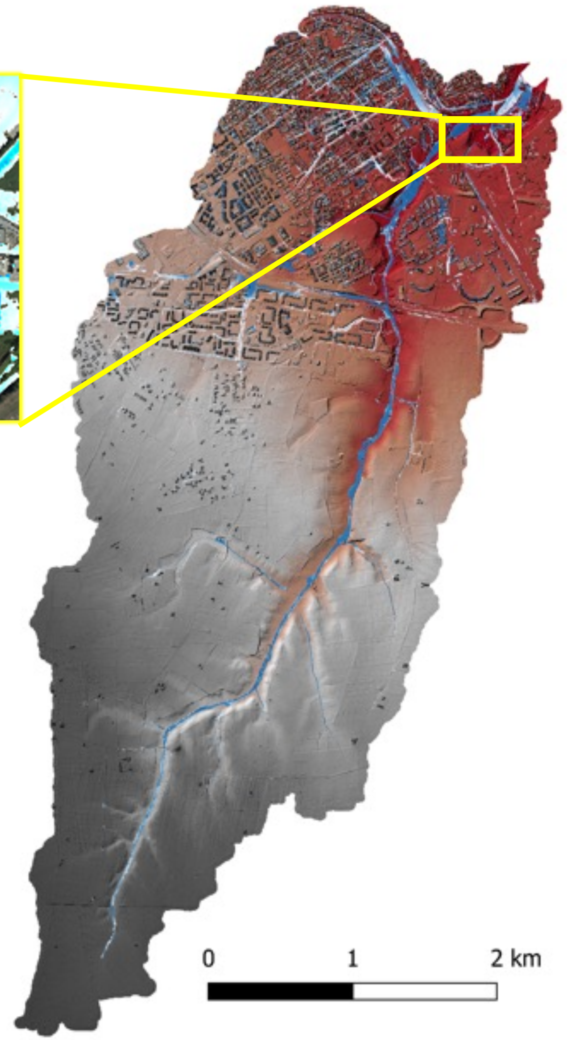
# FLOOD VULNERABILITY

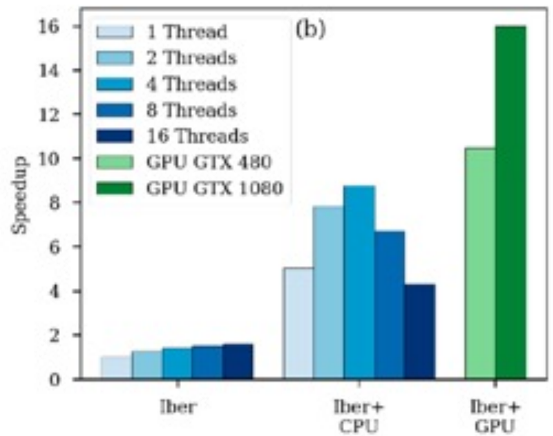
*Hydrological and Hydrodynamic models of Flood impact on urban areas*

**HPC simulations:**

- Basins of hundreds or thousands of km²
- Millions of computational cells
- Tenths of seconds 'time step'

*Expected Data Dimension*:
hundred of GB or few TB, for each simulated scenario

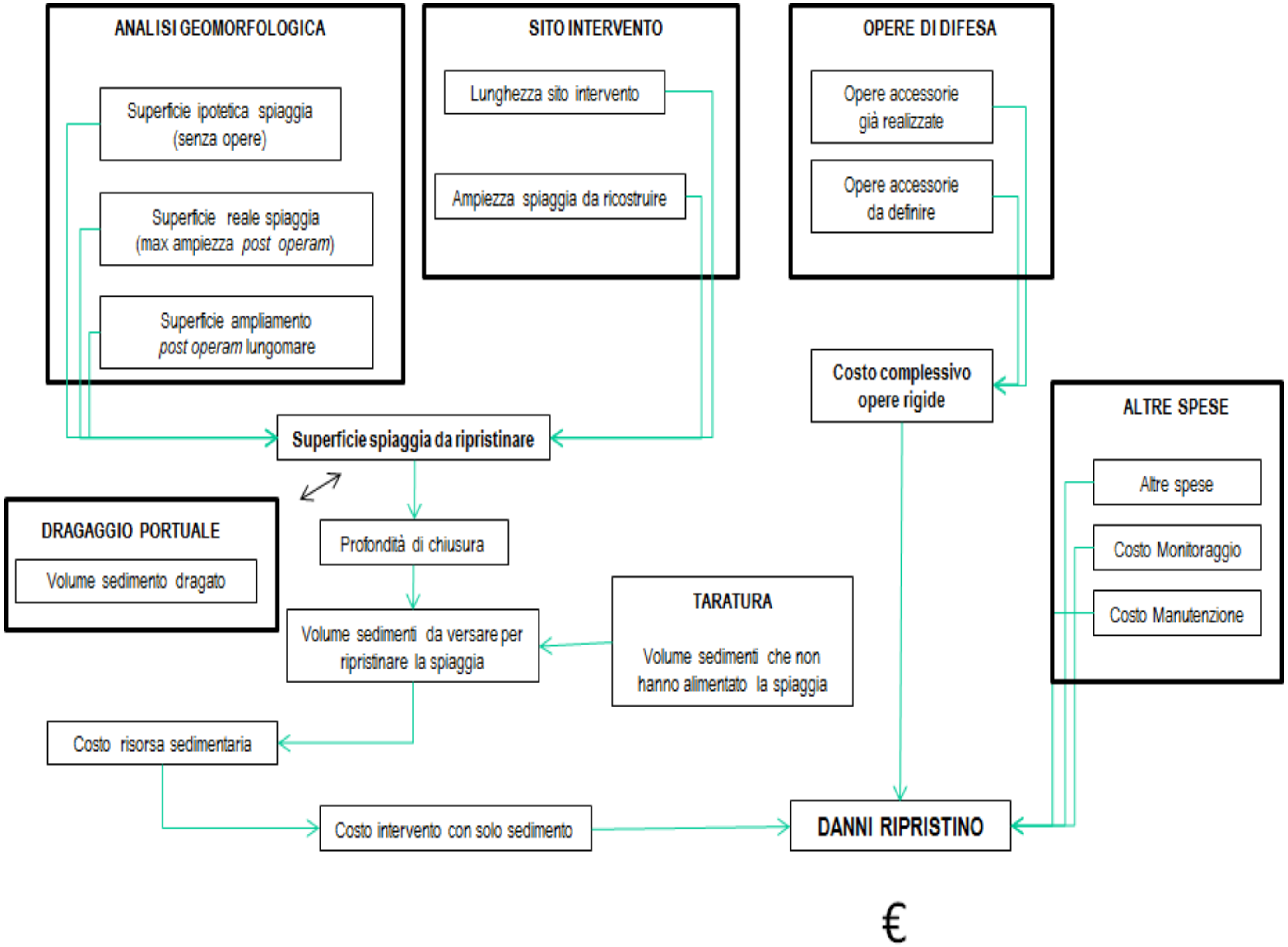




(Orlando García-Feal et al, 2018)

*WP5.5 Multi-hazard modelling and analysis of damages and losses*

# WP 5

Studi su cambiamento climatico ed erosione costiera


## OBIETTIVI SCIENTIFICI

Implementare un modulo di calcolo tecnico economico per determinare la vulnerabilità, il rischio, l'evoluzione dell'ambiente costiero e quantificare i danni alle infrastrutture critiche e/o al capitale naturale (spiaggia emersa)

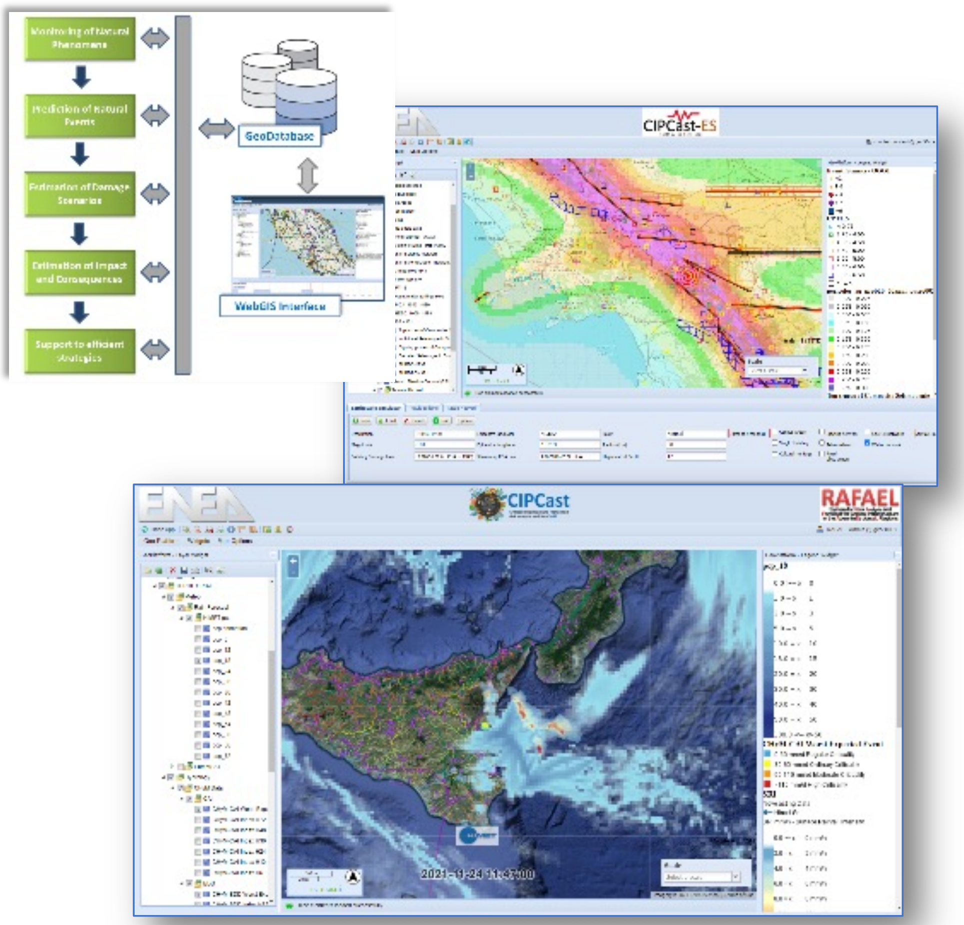
WP
8

ENEA

## Models and tools for assessment of risks and impacts induced by environmental disasters

**CIPCast**

- DSS per **<u>l'analisi del rischio sulle Infrastrutture Critiche (IC)</u>** in caso di eventi naturali calamitosi.
- Si basa su <u>metodologie e procedure GIS</u>, mentre per il suo utilizzo interattivo è stata realizzata una specifica interfaccia WebGIS.
- Fornisce una **stima dei danni attesi e delle conseguenze sulle IC monitorate** su dati reali e dati **simulati**




**Attività**

Implementazione in CIPCast di nuove tecnologie e metodologie di <u>analisi del rischio</u>, attraverso:

- L'acquisizione dei dati delle IC, dei sensori e degli altri **strati informativi prodotti dallo SPOKE 5**, e la conseguente **integrazione** con vari dati territoriali ed ambientali.
- L'elaborazione di tali dati per la produzione di <u>mappe di rischio e scenari di danneggiamento atteso</u>.
- La **<u>condivisione</u>** degli strati informativi e dei risultati attraverso interfaccia WebGIS.

# WP 4

## Modelling of environmental disasters

Leader: ENEA

Co-leader: CNR

# WP 4 - Objectives

## Modelling and monitoring of risk and impacts induced by environmental disasters

Remote Sensing

Proximal sensing

Risk Assessment Models

Active surveillance

GIS Based Decision Support System

Situational Awareness maps

Risk and Impacts Maps

What-if analysis

Emergency Management/ Response

WP 4 - Data

# Modelling and monitoring of risk and impacts induced by environmental disasters

Internet of Things (IoT) sensors; fiber optic sensors, MEMS-based sensors.

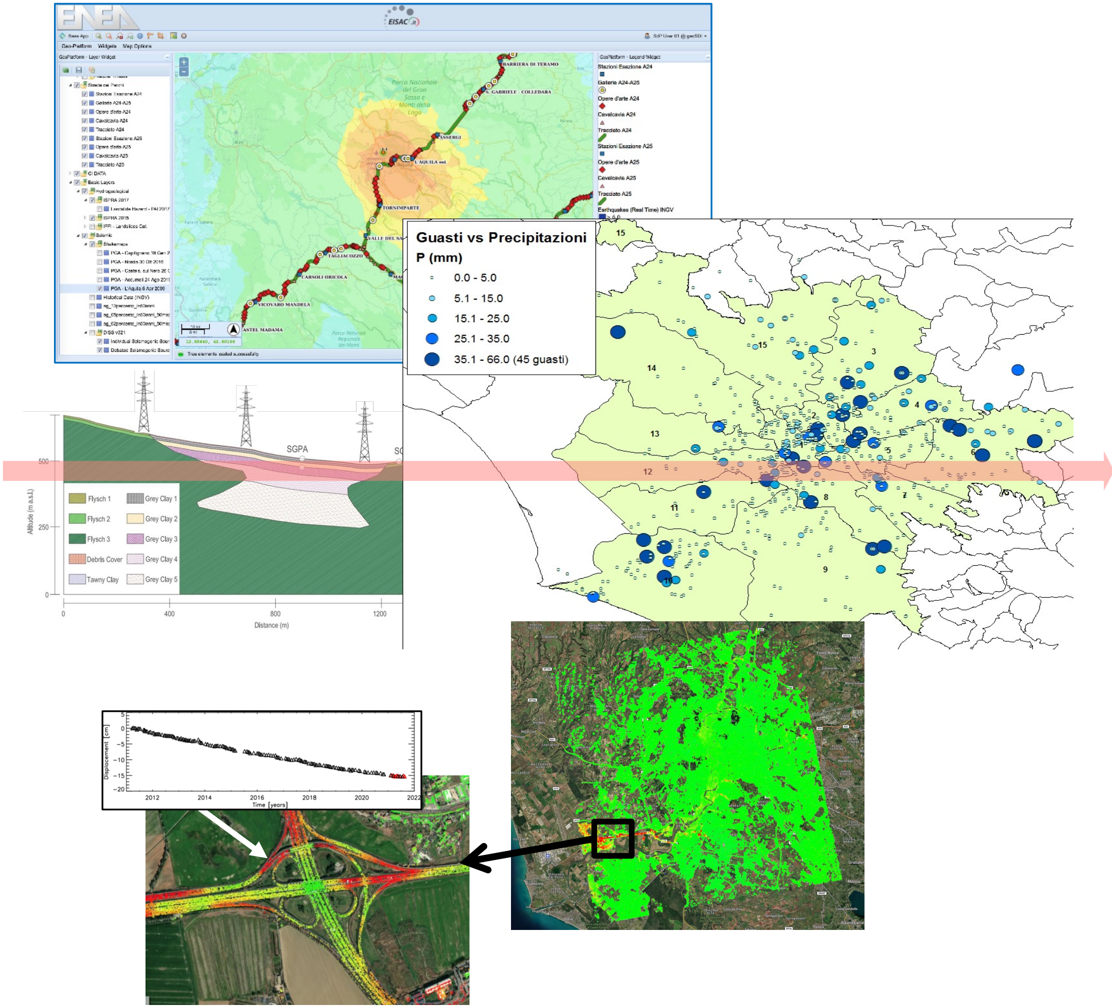
Historical data

DInSAR measurements

structural health monitoring

Infrasound signals

Meteo climate hydro cryosphere marine pollution data




Remote Sensing

Proximal sensing

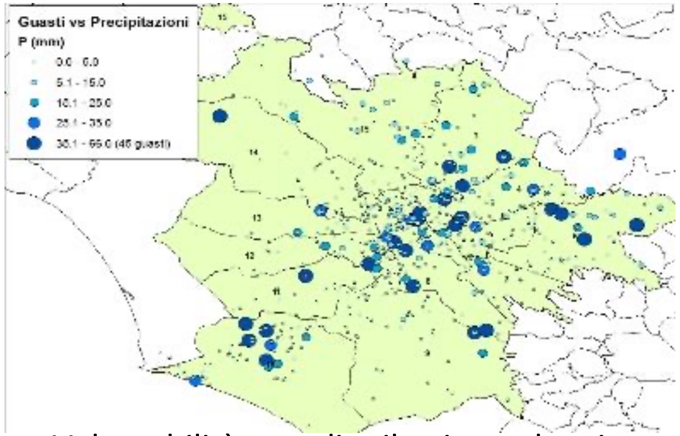
Risk Assessment Models

Active surveillance

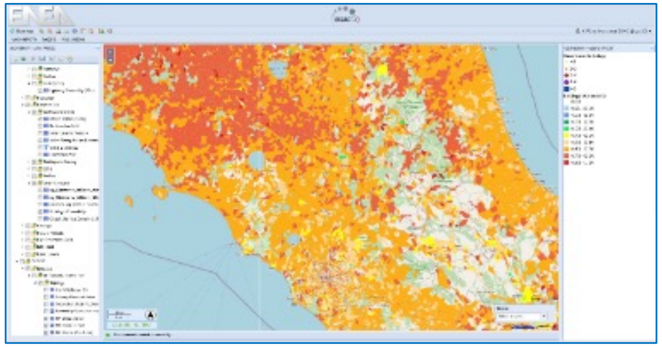
WP 4

ENEA

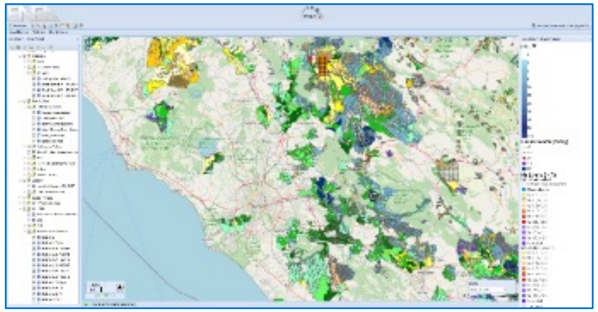
## Models and tools for assessment of risks and impacts induced by environmental disasters – Mappe di rischio




Vulnerabilità rete distribuzione elettrica

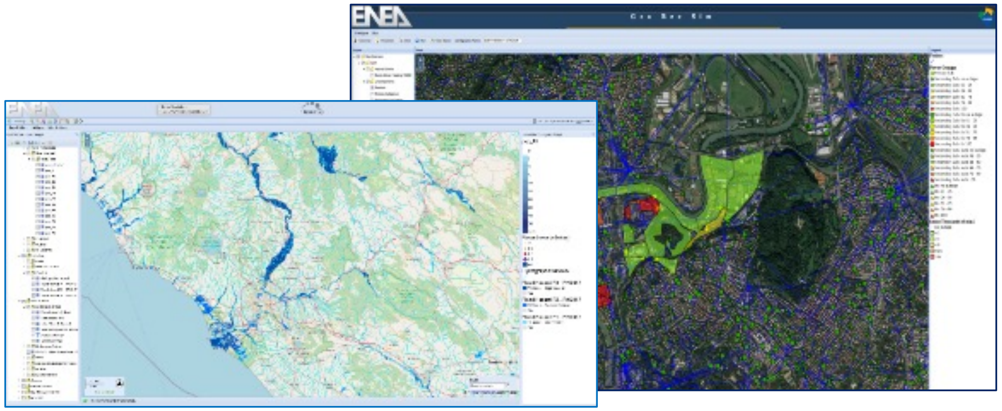


Vulnerabilità sismica dell’edificato



Microzonazioni sismiche (MS)

*Shake map* sismiche in *overlay* GIS su un’autostrada



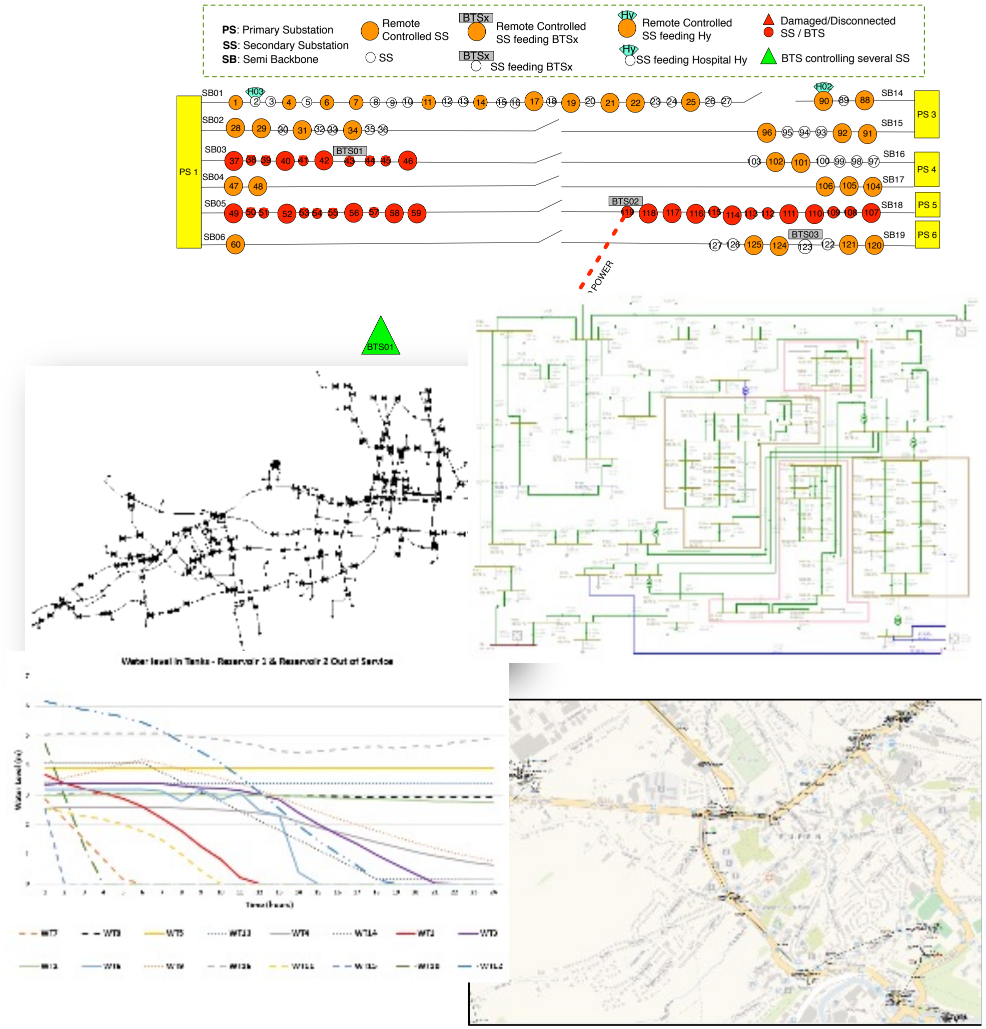
Pericolosità alluvioni (PAI-ISPRA)

Estensione e durata di un blackout prodotto da una esondazione (Scenario severo, con tempo di ritorno 200 anni) del Tevere nell’area nord di Roma

WP 4

ENEA

# Models and tools for assessment of risks and impacts induced by environmental disasters - Infrastrutture Critiche




Modellazione e simulazione dell'<u>interdipendenza tra Infrastrutture Critiche</u>

Modelli di reti elettriche, idriche, gas. <u>**Dati protetti da NDA**</u>

**Reti Elettriche**

**Reti Idriche**

**Reti Gas**

**Reti trasporti (sinergia con altri progetti)**

# WP 6

## Analysis of citizen preparedness and ecosystems resilience to disasters

Leader: UNIAQ
Co-leader: UNIFI

HPC
Machine
Learning
XAI
Quantum
Computing

# WP 7

**Machine learning, Quantum Computing and AI platform to design and exploit Digital Twins**

**Leader: UNIBA**
**Co-leader: INGV**

ICSC
Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

## *<u>WP 7</u> Computational infrastructure and integrated software as a service*

## *<u>UNIAQ contribution:</u> Open Science Infrastructure*

SoBigData RI strives to deliver a distributed, Pan-European, multi-disciplinary research infrastructure for big social data analytics, coupled with the consolidation of a cross-disciplinary European research community, aimed at using social mining and big data to understand the complexity of our contemporary, globally-interconnected society.

SoBigData RI will push the FAIR (Findable, Accessible, Interoperable) and FACT (Fair, Accountable, Confidential and Transparent) principles. It will also orient resources from multiple perspectives: e-infrastructures and online services developers; big data analytics and AI; complex systems focussed on modelling social phenomena; ELSEC (Ethical, Legal, SocioEconomic and Cultural) aspects of data protection (as defined by the HLEG-AI); privacy preserving techniques.

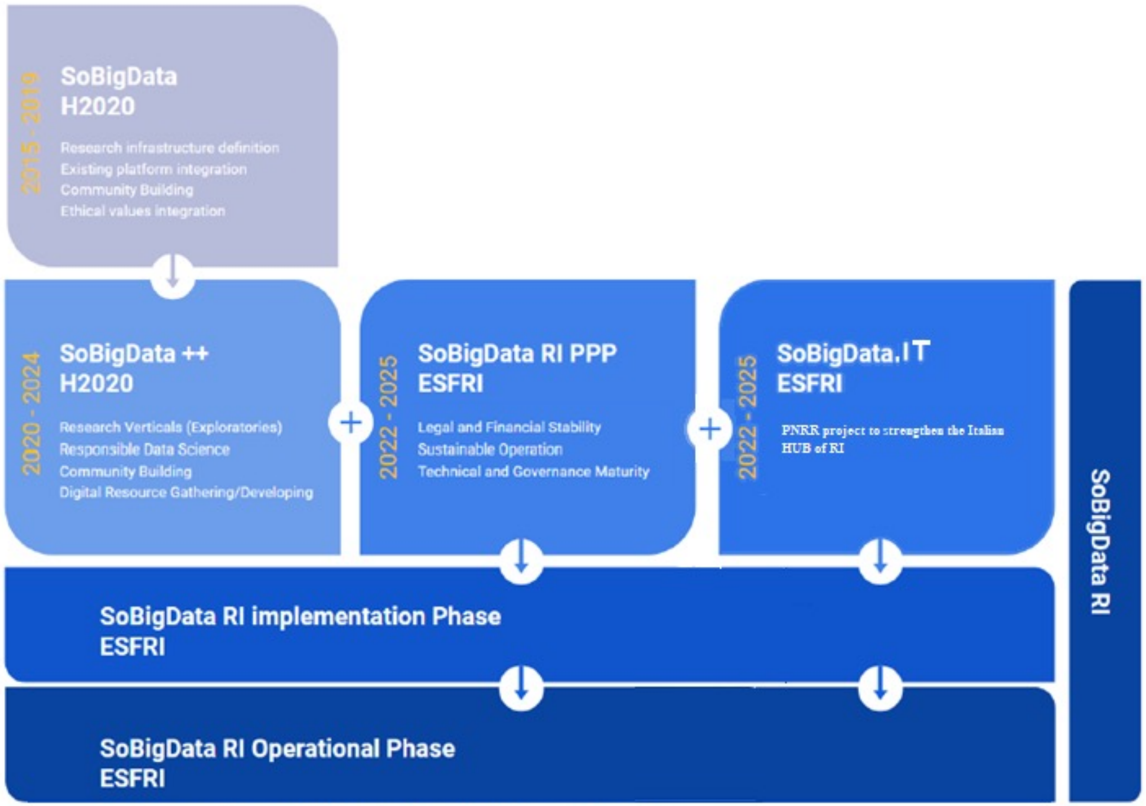


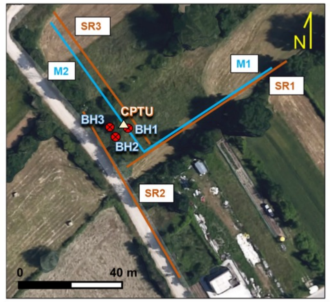

*Figure 1.1 Overall view of SoBigData RI construction and related projects*

Grazie
per l’attenzione

MORE

# CN-HPC – Spoke 5 – WP5.3/WP5.4/WP5.5 UniAq Activities

P. Monaco, M. Tallini – DICEAA - Ingegneria civile, edile - architettura e ambientale



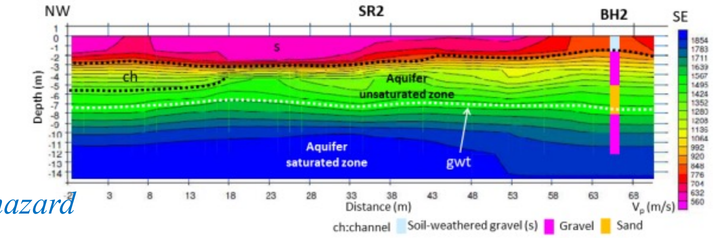

**WP5.3** Modelling of disaster-inducing processes

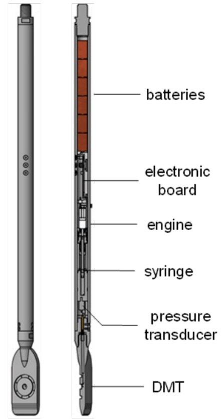
<u>*Task 5.3.2*</u> Modelling disaster-inducing processes

<u>*UniAq contribution*</u>*: Modelling of earthquake-induced phenomena to estimate the seismic hazard*

Selection of  the pilot areas where the modelling of environmental disaster-inducing processes will be carried out based on the seismichazard level and presence of buildings & strategic infrastructures; GIS data collection of the existing geophysical, geological and geotechnical data.

<u>*HPC needs*</u>*:* GPU and multicore HPC infrastructure, data and result storage capacity



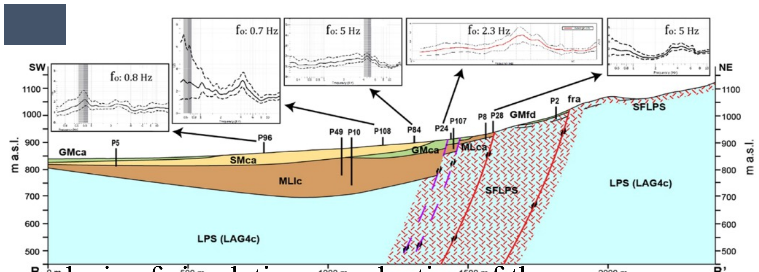

**WP5.5** Multi-hazard estimation of engineering and geophysical parameters and losses

<u>*Task 5.5.1*</u> Typological-mechanical estimation of engineering and geophysical parameters.

<u>*UniAq contribution*</u>*: Modelling of earthquake-induced phenomena to estimate the seismic hazard*

Definition of the key model parameters and definition of the numerical values to these parameters. Innovative approaches for the estimation of engineering parameters of soil deposits & rocky units in multi-hazards sensitive areas, aiming to fill the gap of the existing practice due the extreme variability of the soil/rock properties and/or specific soil/rock behavior that requires the use of advanced constitutive models.

<u>*HPC needs*</u>*:* GPU and multicore HPC infrastructure, data and result storage capacity




**WP5.4** Modelling and monitoring of risk and impacts induced by environmental disasters

<u>*Task 5.4.2*</u> Models and tools for assessment of risks and impacts induced by environmental disasters

<u>*UniAq contribution*</u>*: Modelling of earthquake-induced phenomena to estimate the seismic hazard*

Execution of the numerical simulations with the high power computing (HPC) resources; sensitivity analysis of simulations; evaluation of the results through the comparison between numerical and experimental data. Tools for improving the predictive ability of numerical modeling for the ground response, especially when permanent deformations are expected (i.e., soil liquefaction, slope instability, cave collapse).

<u>*HPC needs*</u>*:* GPU and multicore HPC infrastructure, data and result storage capacity

# CN-HPC – Spoke 5 – WP5.3 UniAq Activities

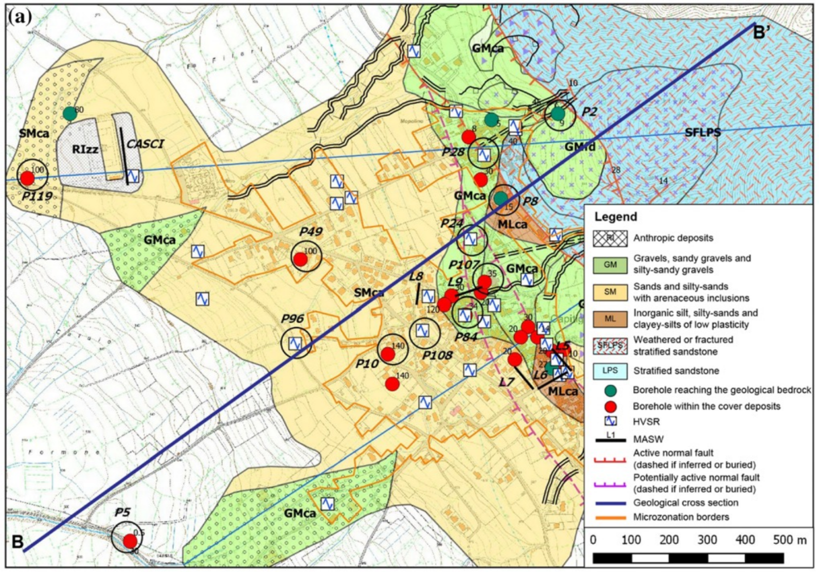
**WP5.3** Modelling of disaster-inducing processes

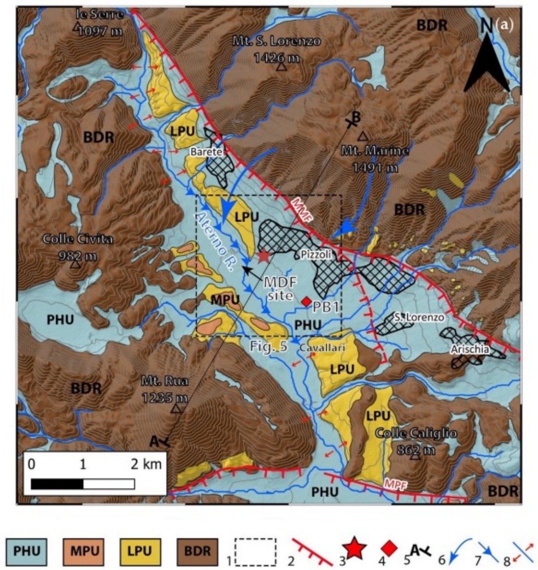
<u>*Task 5.3.2*</u> Modelling disaster-inducing processes

<u>*UniAq contribution*</u>: *Modelling of earthquake-induced phenomena to estimate the seismic hazard*

Selection of the pilot areas where the modelling of environmental disaster-inducing processes will be carried out based on the seismic hazard level and presence of buildings & strategic infrastructures; GIS data collection of the existing geophysical, geological and geotechnical data.

<u>*HPC needs*</u>: GPU and multicore HPC infrastructure, data and result storage capacity



# CN-HPC – Spoke 5 – WP5.5 UniAq Activities

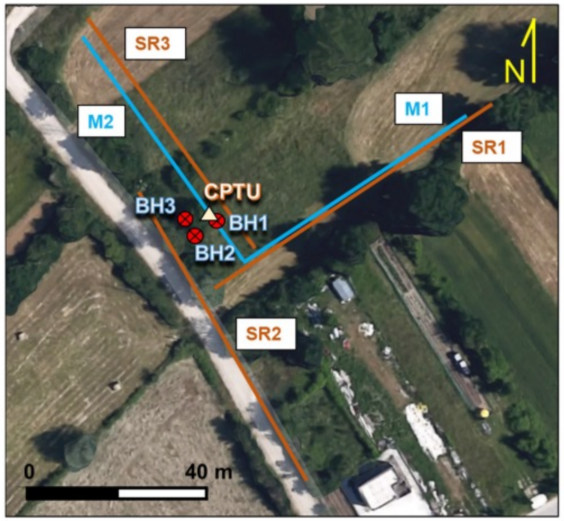
**WP5.5** Multi-hazard estimation of engineering and geophysical parameters and losses

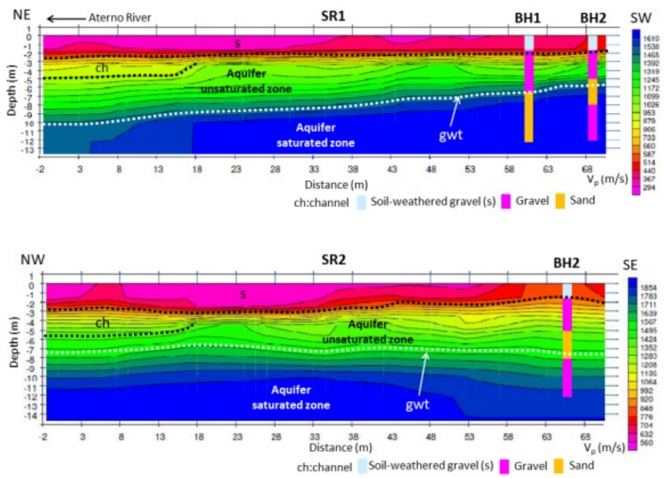
<u>*Task 5.5.1*</u> Typological-mechanical estimation of engineering and geophysical parameters.

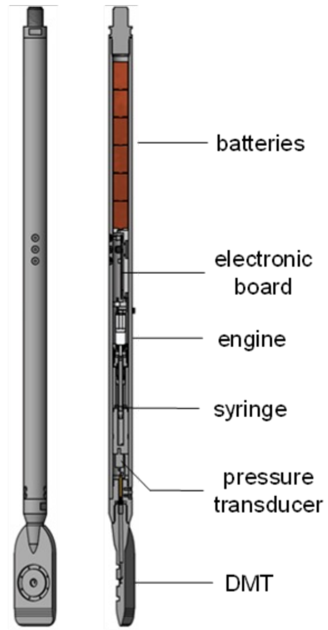
<u>*UniAq contribution*</u>: *Modelling of earthquake-induced phenomena to estimate the seismic hazard*

Definition of the key model parameters and definition of the numerical values to these parameters. Innovative approaches for the estimation of engineering parameters of soil deposits & rocky units in multi-hazards sensitive areas, aiming to fill the gap of the existing practice due the extreme variability of the soil/rock properties and/or specific soil/rock behavior that requires the use of advanced constitutive models.

<u>*HPC needs*</u>: GPU and multicore HPC infrastructure, data and result storage capacity



# CN-HPC – Spoke 5 – WP5.4 UniAq Activities

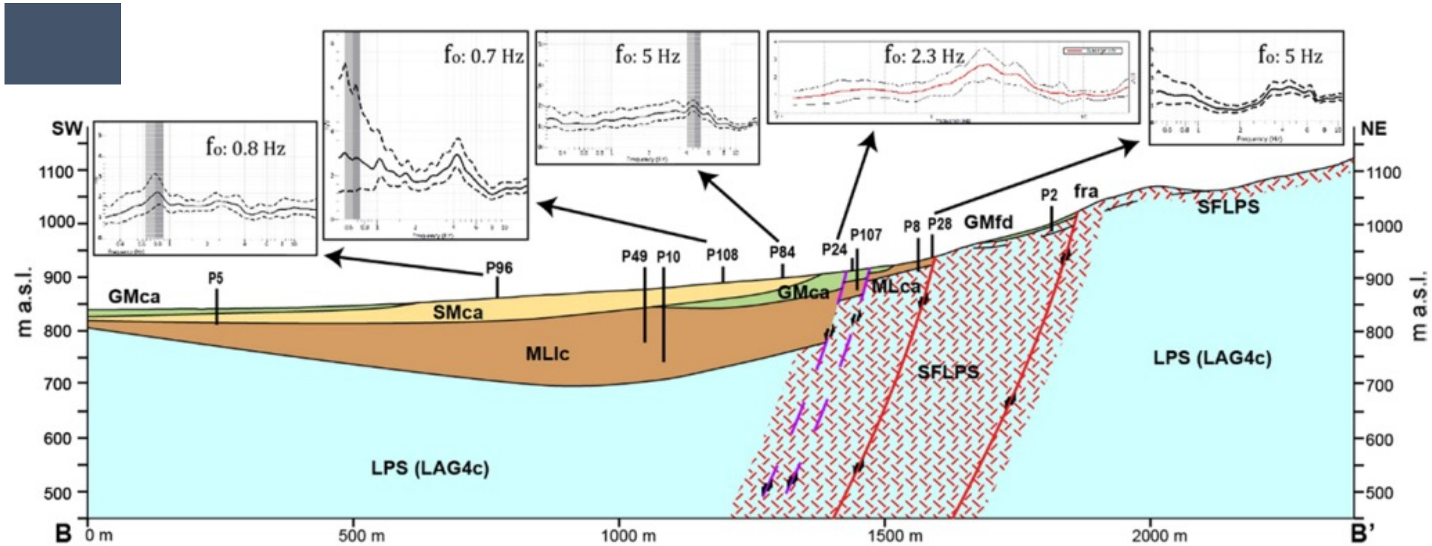
**WP5.4** Modelling and monitoring of risk and impacts induced by environmental disasters

*Task 5.4.2* Models and tools for assessment of risks and impacts induced by environmental disasters

*UniAq contribution: Modelling of earthquake-induced phenomena to estimate the seismic hazard*

Execution of the numerical simulations with the high power computing (HPC) resources; sensitivity analysis of simulations; evaluation of the results through the comparison between numerical and experimental data. Tools for improving the predictive ability of numerical modeling for the ground response, especially when permanent deformations are expected (i.e., soil liquefaction, slope instability, cave collapse).

*HPC needs:* GPU and multicore HPC infrastructure, data and result storage capacity



# WP 1 - 4 - 6 UNIVAQ Activities

**WP5.1** Dynamical hazard scenarios assessment

*(WP5.4 Modelling and monitoring of risk and impacts induced by environmental disasters- Task 5.4.1 )*

*(WP5.6 Analysis of citizen preparedness and ecosystems resilience to disasters- Task 5.6.3 )*

*Task 5.1.1* Assessment of the driving hazard factors for the Italian territory

*UP DICEAA contribution:* ***Urban planning and gisbased technologies for integrated risk management***

New planning uses innovative and technologically advanced tools through a continuous flow of data and simulations of possible scenarios. In this application context, approaches based on gisbased technologies and methodologies play a fundamental role, both in vulnerability assessment and in supporting decision-making processes as a whole, in the analysis of risk, impact and consequences. The gisbased approach to spatial planning allows to benefit from ICT technologies. In particular, the new research activities in this area concern the application of engineering techniques of indicators aimed at identifying appropriate indices able to return information on the reaction of urban tissues with respect to environmental disturbances that determine risk scenarios. Impact models on pollutant and odor dispersion, building energy requirements, anthropogenic emission top-down estimation will complete the themes covered. The synergy of the Territorial Sciences with the other scientific sectors of reference is expressed in the role of control and coordination that these, supported by the support of new technologies, can express in the conceptual and technological stitching between Urban Planning and city regeneration. The areas of research in this direction can be summarized as follows:

- design of indicators aimed at highlighting the relationships between sustainable development of urban transformations
- machine and deep learning for urban studies
- geospatial services
- *HPC needs*: Advanced simulation and big data analysis and management in gisbased platform; tools for spatial analysis and fast monitoring ; urban settlement analysis; mitigation of climate-altering effects; improvement/increase of ecosystem services; evaluation of the carbon balance.

# WP 1 CETEMPS-UNIVAQ Activities

DSFC – Dip. Scienze fisiche e chimiche

CETEMPSCentro di Eccellenza in Telerilevamento E Modellistica Previsionale di eventi Severi

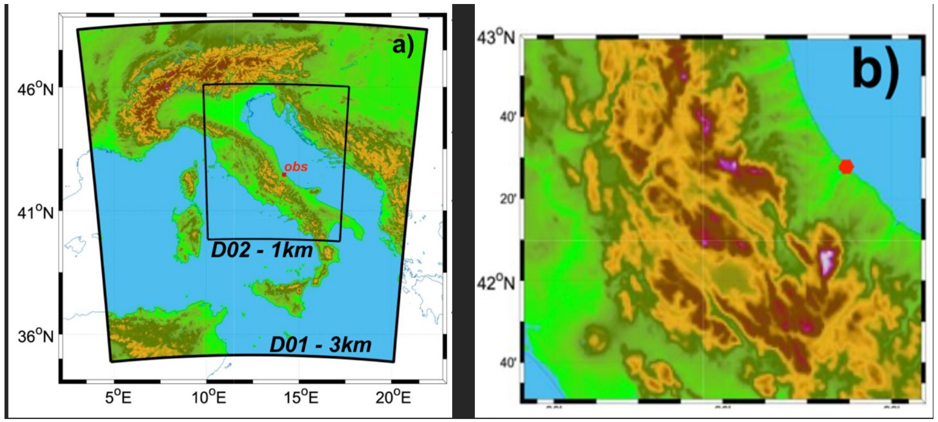
**WP5.1** Dynamical hazard scenarios assessment

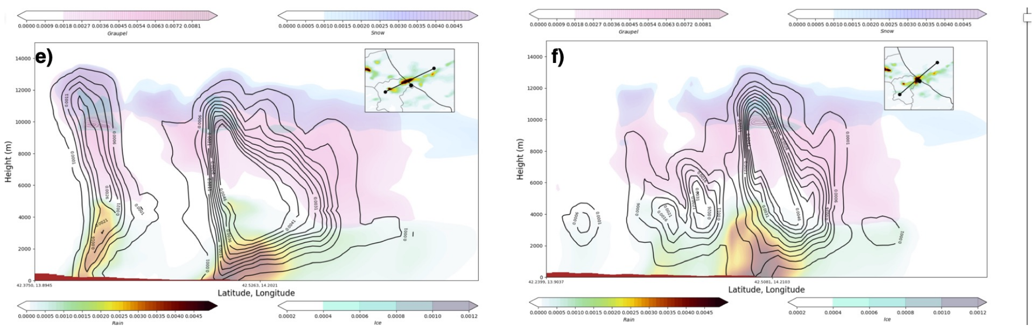
<u>*Task 5.1.1*</u> Assessment of the driving hazard factors for the Italian territory

<u>*CETEMPS contribution by Ferretti,  Redaelli:*</u> *Assessing key parameters for severe weather events on short and long terms*

Studies of severe weather events, climate extremes both in terms of cold and warm spells and atmospherically unstable and stable conditions, using a coupled system in the short term for assessing the key physical parameters, will be performed using a state-of-the-art high resolution  numerical model. This will allow for reproducing the most relevant hazards for the Italian territory such as: floods, heat waves, coastal erosion, wind and wave storms, and drought.

<u>*HPC needs*</u>: 500 core multi-processor  1.800.000 computing time. Need for  porting the code to CUDA, then using GPUs there is a gain of 60%; large store capability order of 10Tb



# WP5.1 CETEMPS-UNIVAQ Activities

**WP5.1** Dynamical hazard scenarios assessment

<u>*Task 5.1.2*</u> Modelling the impact of hazard factors on the Italian ecosystem

<u>*CETEMPS contribution by Ferretti, Curci, Redaelli, Tuccella:*</u> *Implementing a high- resolution Ensemble prediction system, a fully coupled atmosphere-ocean system, a snow-pack and land-slide systems*

high resolution numerical model coupled with the ocean will be implemented. This will allow for reproducing the most relevant hazards for the Italian territory such as: floods, heat waves, coastal erosion, wind and wave storms, and drought. Once the improvements have been established a high resolution ensemble prediction system will be also implemented. In this frame, an improvement of the snowpack numerical model is also desirable for reproducing the snow avalanche hazard depending on side and aspect, and flooding associated with sudden melting. Finally, impact models on pollutant and odor dispersion, building energy requirements, anthropogenic emission top-down estimation will complete the themes covered. A few operational systems related to the above-mentioned activities will be implemented:

- coupled ocean-atmosphere-biosphere model; operational high resolution (3km) ensemble prediction; operational wildfires numerical model

<u>*HPC needs*</u>: 500 core multi-processor 1.800.000 computing time. Need for porting the code to CUDA, then using GPUs there is a gain of 60%; large store capability order of 20Tb

<u>*Task 5.1.3*</u> High resolution dynamical hazard scenario maps of natural disasters threatening the Italian territory and ecosystem

<u>*CETEMPS contribution by Redaelli, Curci, Tuccella, Ferretti:*</u> *Generation of long term high resolution simulation*

longer term simulations ranging from 1- to 3-month climate predictions will be performed at high resolution (10-3km) to define probabilistic maps informing about risks such as: floods, heat waves, wildfires coastal erosion, wind and wave storm, drought, avalanches, acute odor annoyance, peak energy demand from cities and related pollutant emission.

The following operational system will be implemented:

- regional ensemble seasonal climate prediction

<u>*HPC needs*</u>: 350 core multi-processor 1.600.000 computing time; large store capability order of 40Tb

# WP 3 CETEMPS_UNIVAQ Activities

**WP5.3** Modelling and monitoring of risk and impacts induced by environmental disasters

*Task 5.3.1* Gathering multi-source Big Data for the characterization of disaster-inducing processes.

*CETEMPS contribution by Ferretti, Redaelli, Curci, Tuccella: Generation of short and long term high resolution simulation*

UNIVAQ will contribute to this WP with the output of the numerical simulation produced with the meteorological, climatic, hydrological, cryospheric, marine and pollution models described in WP5.1.

# WP5.4 CETEMPS-UNIVAQ Activities

**WP5.3** Modelling and monitoring of risk and impacts induced by environmental disasters

*Task 5.4.1* Remote sensing and proximal sensing models for environmental disasters

*CETEMPS contribution by Curci, Tuccella, Redaelli, Ferretti: Generation of remote sensing maps*

The meteo-climate-hydro-cryosphere-marine-pollution group will contribute to this WP by producing remote sensing maps of the disaster to be investigated.

*T5.4.2:* Models and tools for assessment of risks and impacts induced by environmental disasters

*CETEMPS contribution by Ferretti, Curci, Tuccella, Redaelli: Forecast of Fire, oil spill, snow cover, pollutant release etc…for preventing health hazard*

The meteo-climate-hydro-cryosphere-marine-air-pollution group will contribute to this WP by producing fire, oil spill & Save And Rescue, snow cover, and pollutant release forecast to help monitoring and preventing health hazard

*T5.4.3:* Active surveillance for effective and rapid emergency management/response

*CETEMPS contribution by Ferretti, Curci, Tuccella, Redaelli : Forecast of Fire, oil spill, snow cover, pollutant release etc…for the emergency management*

The meteo-climate-hydro-cryosphere-marine-air-pollution group will contribute to this WP by producing fire, oil spill & Save And Rescue, snow cover, and pollutant release forecast for the emergency management

# WP 8 CETEMPS-UNIVAQ Activities

**WP5.8** Impact assessment and modeling of alternative risk mitigation strategies

*Task 5.8.1* Evaluation and design of alternative risk strategies.

*CETEMPS contribution by Redaelli, Ferretti, Curci, Tuccella: Generation of short and long term high resolution simulation*

- Numerical model simulations using different landuse indexes, modified to simulate urban and extra-urban mitigation techniques.
- Numerical studies with the help of fully coupled

atmosphere-ocean-waves-sediment-seabed vegetation models to estimate the vegetation impact

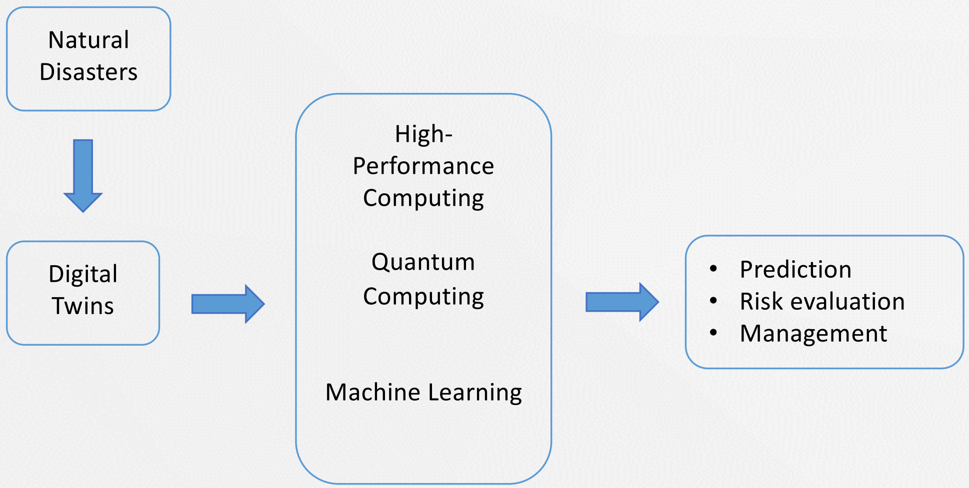
*HPC needs*: 500 core multi-processor 1.000.000 computing time. Need for porting the code to CUDA, then using GPUs there is a gain of 60%; large store capability order of 10Tb

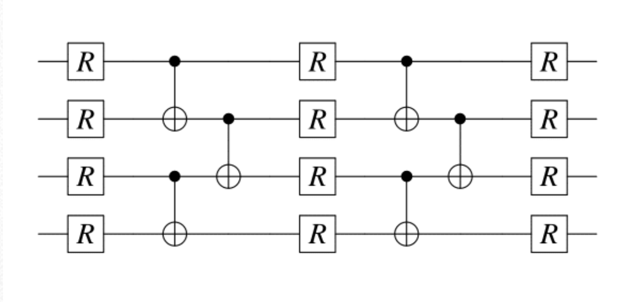
# WP5.7 Machine learning, Quantum Computing and AI platform to design and exploit Digital Twins

L. Guidoni – UNIVAQ
DSFC – Dip. Scienze fisiche e chimiche

## Context:

- Quantum Computers and quantum algorithms represent a potentially disruptive paradigm for the simulations of complex systems in the following years, even in the early phase of quantum advantage, in which quantum error correction will not be available. In particular, optimization techniques and AI classical and quantum neural networks are a valuable scalable solution to solve problems related to risk evaluation and managements of natural disasters.
- Since Quantum Computers are not general purpose computers, they will bring a huge impact only in fields which are suitable to be described by a hybrid classical/quantum algorithm. This requirement depends on two issue: the definition of the mathematical model for the Digital Twin and the efficiency and implementation of the algorithm itself. In this WP we will explore both these issues.
- Classical Machine learning AI techniques will be also used for disaster analysis. Several models will be evaluated to determine the best ones fitting the extra-functional and quality requirements, mainly trustworhiness, imposed by disaster analysis. Trustworthiness is a multi-dimensional quality attribute of the AI model that combines explainanbility, interpretability, fairness, bias mitigation and privacy assurance of the people. As AI models we mainly concentrate in machine learning, information retrival and visual analytics. Such analysis techniques are eventually improved to increase their trusthworthiness.




*An example of empirical ansatz in Quantum Computing VQE algorithm*

## Goals:

- Identify Digital Twins models that can be in principle being tackled by hybrid High-Performance-Computing / Quantum Computing facilities. The identification the mathematical models will be carried out in strict collaboration of other working packages.
- Develop efficient mixed classical / quantum algorithms to tackle the Digital Twins. Algorithms may include Variational Quantum Eigensolver (VQE), Quantum Approximate Optimization Algorithm (QAOA) and Quantum Machine Learning.
- Build an integrated platform between traditional HPC infrastructure and Quantum Computers to apply the developed algorithms on prototypical and realistic Digital Twins.
- Identify AI techniques which are more suitable for disaster analysis

## Key Enabling Technologies:

- Development of Quantum Computing hardware technologies
- Infrastructure between HPC and Quantum Computing
- Software platforms to facilitate the use of HPC/Quantum Computing facilities by reducing the gap between the definition of the Digital Twin and the quantum algorithm usage
- AI infrastructure for disaster analysis

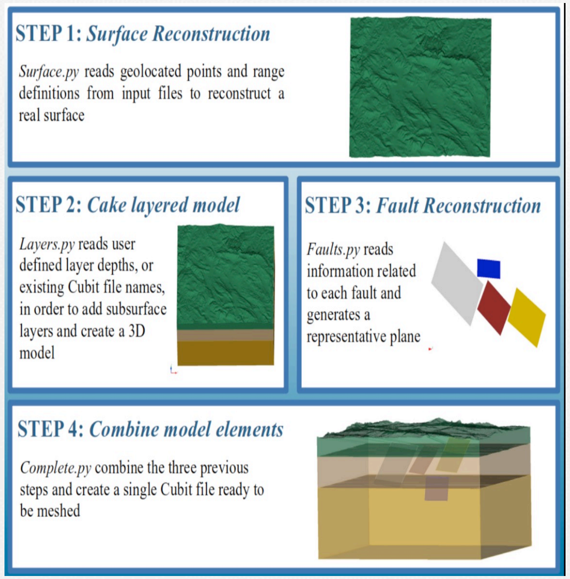
# WP 5.2/5.5/5.8 Impact assessment and modeling of alternative risk mitigation strategies

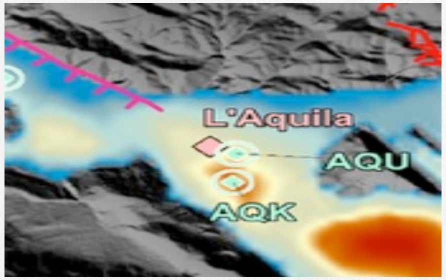
**B. Rubino, D. Pera, F. Di Michele, S. Fagioli, M. Colangeli**
**DISIM–UNIVAQ Dip. Ing. e scienze dell'informazione e matematica**

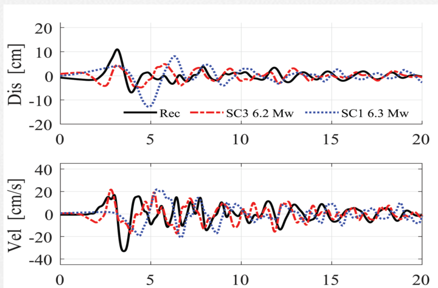
## Contest: Evaluation of geophysical parameters related to earthquake dynamics.

### Fault domain reconstruction and numerical simulation on HPC clusters of L'Aquila earthquake, 6 April 2009 MW 6.3 .

F. Di Michele, J. May, D. Pera, V. Kastelic, M. Carafa, C. Smerzini, I. Mazzieri, B. Rubino, P. F. Antonietti, A. Quarteroni, R. Aloisio, P. Marcati
Spectral elements numerical simulation of the 2009 L'Aquila earthquake on a detailed reconstructed domain. Geophysical Journal International, Volume 230, Issue 1, July 2022, Pages 29-49, https://doi.org/10.1093/gji/ggac042




- May, J., Pera, D., Di Michele, F., Aloisio, R., Rubino, B., Marcati, P. CUBIT-Python tool for highly accurate topography generation and layered domain reconstruction. 29th International Meshing Roundtable- doi.org/10.5281/zenodo.5559059

## Goals:

- HPC simulations/applications/workflows: development and optimization of HPC and Quantum computing simulations, multi-scale and multi-physic models, ensemble simulations, inverse problems for geophysical and geotechnical phenomena as extreme weathers, earthquakes, tsunamis, volcanic eruptions, hydro-geological disasters, wildfires, space weather;
- Supporting political and civil protection decisions, informed by data analysis and scientific modeling;
- Promoting participatory reconstruction planning, economic growth and sustainable development;

Production of artificial seismograms related to the numerical simulation of multiple earthquake scenarios based on the domain and fault reconstruction.

According to the knowledge of building positions in the studied area will be possible to estimate (for each simulated seismic scenario) physical parameters (disp,vel,acc) providing potentially useful information for engineering applications and civil protection.

Preliminary public results are available here : https://opendatalaquila.it/APPS/CUIM-sisma/

Design and simulations of evacuation strategies coupling seismology models with traffic and pedestrian models based on real dataset obtained be positions from both GPS on vehicles and mobile phone technologies.

## Key Enabling Technologies:

- Advanced simulation and big data analysis and management;

All numerical simulation are based on High Performance Computing techniques and realized on the HPC-BIGData DISIM UNIVAQ Lab.

Data dimension: 4 milions FEM elements for seismic scenario, storage 50 GB (per seismic scen.)

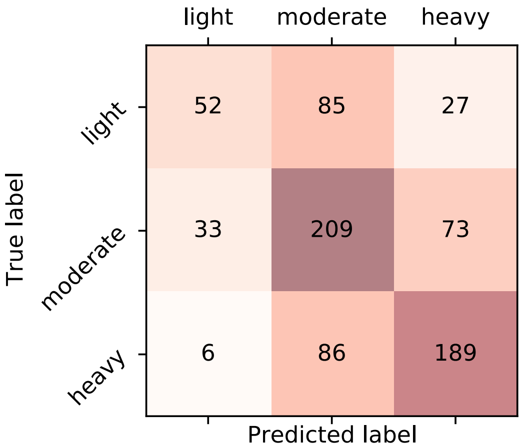
Time execution: 60 hr (with time step 0.00025 s and final time T = 30 s) using 140 cores (CPU distributed memory arch.) HP Proliant DL 580 Gen 10 with 4 CPUs Intel Xeon Gold 6140M 2.30 GHz RAM 512Gb.

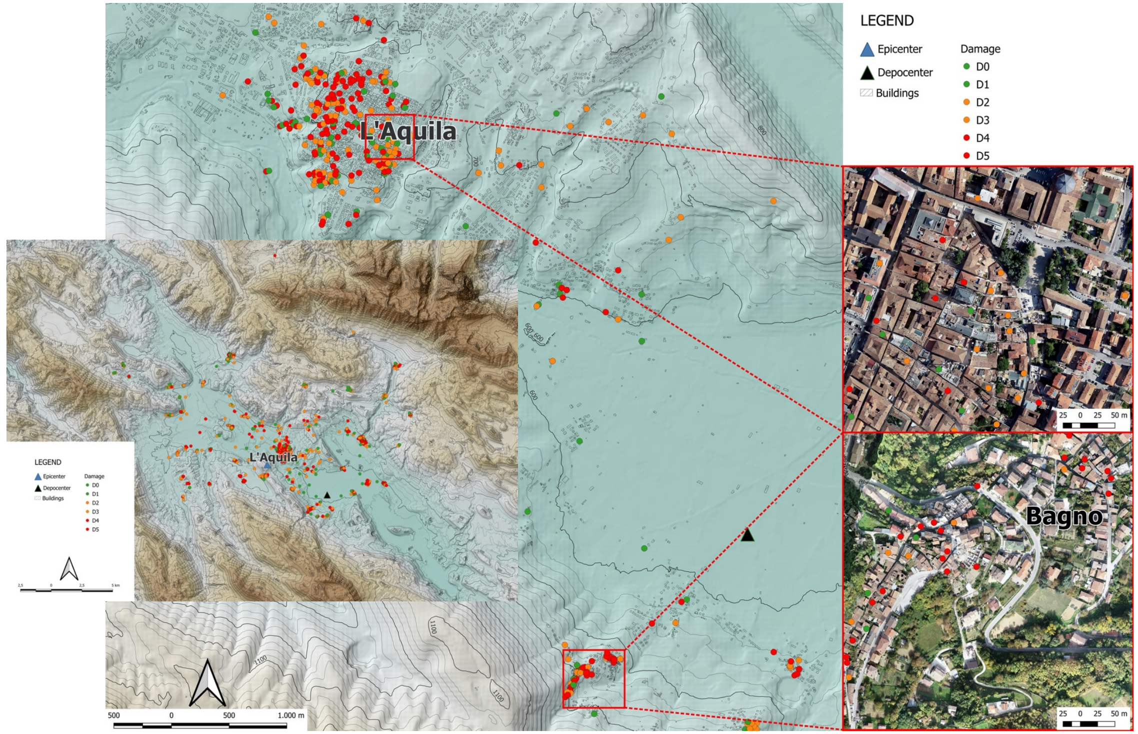
# WP 5.2/5.5/5.8 Impact assessment and modeling of alternative risk mitigation strategies (B. Rubino, D. Pera, F. Di Michele, S. Fagioli, M.Colangeli)

## Valutazione del danno agli edifici usando tecniche di AI

2536 edifici – 21 features

D0-D1 light damage (546)
D2-D3 moderate damage (1050)
D4-D5 heavy damage (936)



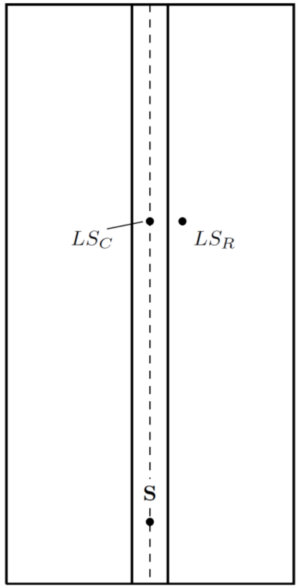

A Machine learning tool for damage classification: the case of L'Aquila 2009 earthquake.
F. Di Michele, E. Stagnini, D. Pera, B. Rubino, R. Aloisio, A. Askan , P. Marcati. Submitted

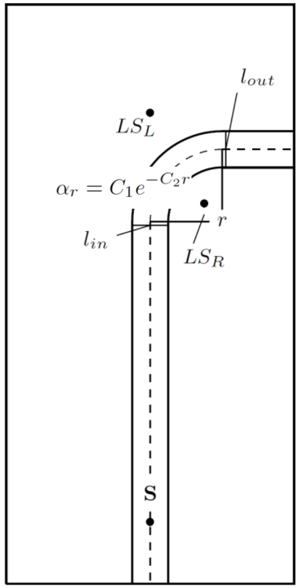
- Data dimension: Current data set 1Mb (small test)
- Time execution : around 10 minute on 100 CPU cores (Intel I9).
- Increasing the data set dimensions we estimate longer computational times on CPU shared memory architectures or GPUs

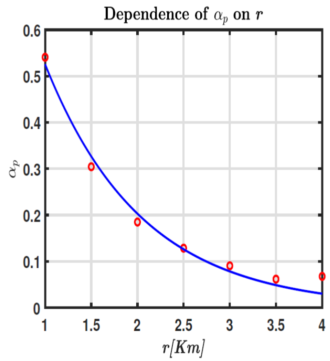
# WP 5.2/5.5/5.8 Impact assessment and modeling of alternative risk mitigation strategies (B. Rubino, D. Pera, F. Di Michele, S. Fagioli, M. Colangeli)

## 2D Semi-analitical and Numerical Model for trapped waves.

Fault shape effect on SH waves using finite element method
Federica Di Michele, Andriy Styahar , Donato Pera, Jon May , Roberto Aloisio , Bruno Rubino, Pierangelo Marcati
*Journal of Seismology*, 2022, 1-21.




(b) $V_{FZ} = 600$ m/s

### SH wave Equation

$$\frac{\partial^2 u}{\partial t^2} - V_{SH}^2 \left( \frac{\partial^2}{\partial x_1^2} + \frac{\partial^2}{\partial x_2^2} \right) u = S.$$

### Source

$$S = \delta(\mathbf{x} - \mathbf{x_s}) M(t)$$

$$M(t) = M_0 \frac{t}{\tau^2} exp(-t/\tau)$$

Data dimension: This study will improve the simulation reported above but will lead to heavy computational costs, so we estimate more than 4 milions FEM elements for seismic scenario with more than 50 GB (per seismic scen.) for the storage.

Time execution: More than 60 hr (with time step 0.00025 s and final time T = 30 s) using 140 cores (distributed memory arch)

HP Proliant DL 580 Gen 10 with 4 CPUs Intel Xeon Gold 6140M 2.30GHz, RAM 512Gb (estimated).

**WP 5.2/5.5/5.8 Impact assessment and modeling of alternative risk mitigation strategies**
(B. Rubino, D. Pera, G. Stilo)

# HPC – BIGData Lab. Univaq Hardware and Software

**Hardware:**

a) 8 servers HP DL 585 Gen 7 con 4 procs (8 cores) AMD Opteron 2.0 GHz da 64 a 256 Gbyte RAM
b) 6 servers DELL R730 con 2 procs (20 cores/40threads) Intel Xeon E5 2698 v4 2.2 GHz 256 Gbyte RAM
c) 3 server HP DL 580 Gen 10 con 4 procs (18 cores/36 threads) Intel Xeon Gold 6140M 2.30GHz 512 Gbyte RAM
d) 1 server Intel Buchanan (4 nodes, tot. 8 proc Intel Xeon Gold 5218R da 20core/40threads 2.1 GHz 256Gb RAM)
e) 2 Dell PowerEdgeC6400 con 4 x DELL PowerEdge C6525 2 procs AMD EPYC 7282 16C 128 GB Ram
f) 1 sistema Supermicro JBOD 826SJBOD 12 HD 8TByte 3.5”
g) 1 switch Netgear M4300-24X
h) 1 switch Infiniband 56Gbit/s (Mellanox SX6036)
i) 1 sistema di cooling da 24 KW (Leonardo Uniflair)
j) 2 GPU PNY NVIDIA A100 80GB
k) 4 GPU PNY NVIDIA A30 24GB

**Software:**

a) Rocks Cluster 7 (Linux CentOS 7)
b) GNU , Intel , PGI compilers
c) MPI (openmpi, mpich)
d) OpenMP
e) NVIDIA CUDA lib.
f) Python
g) SGE scheduler
h) CUBIT/TRELIS
i) SPEED MOX
l) MATLAB, COMSOL

# CN-HPC – Spoke 5 – WP5.1 UNIAQ Activities

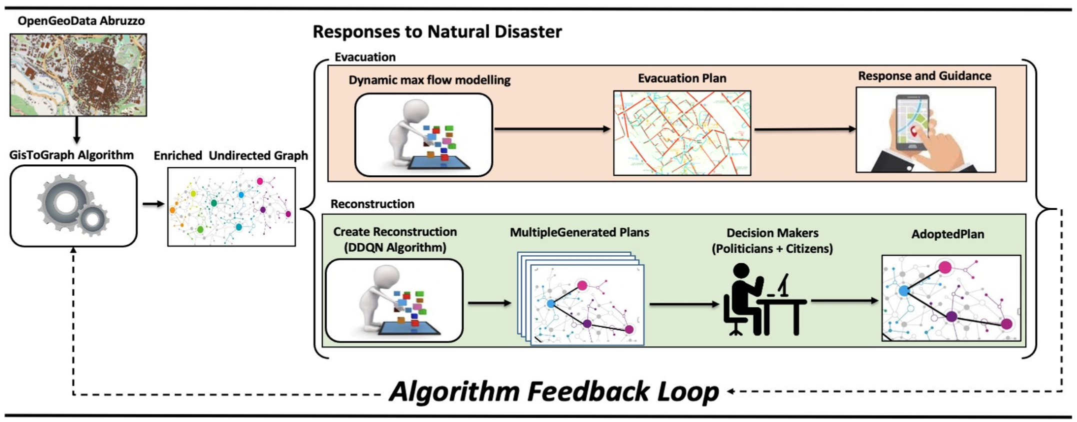
**WP5.3** Dynamical hazard scenarios assessment

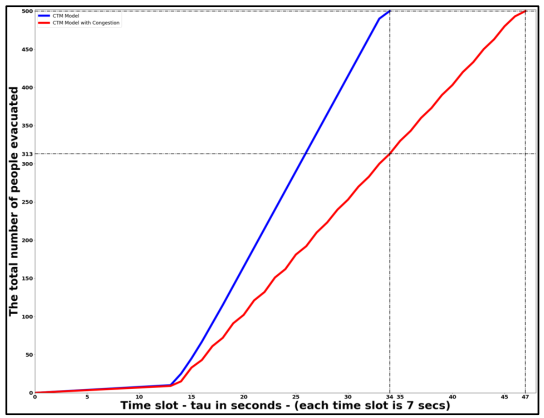
_Task 5.3.3_ Design of resilience strategies

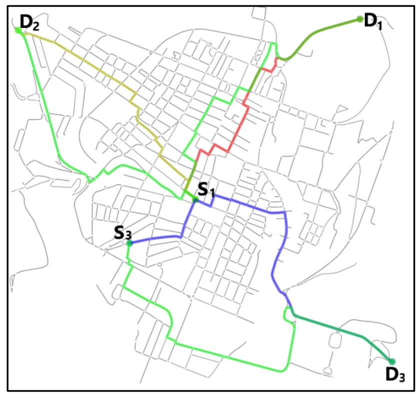
_UNIAQ contribution:_ *Evacuation plan: a Data Science Approach*

The activity will build on timed and flow optimization models and AI models that will allow to: (i) Determine the time needed to evacuate the population; (ii) Determine if safe points are satisfactory to ensure quick and easy evacuation; (iii) Identify safe path to follow in case of emergency; (iv) Evaluate different evacuation plans and strategies.

_HPC needs_: to move to real-life and rescue systems, we need code parallelization for big area and quasi-real time data analytics that also capture human behaviors (i.e., citizens and rescue teams); GPU and multicore HPC infrastructure, data and result storage capacity





- G. Mudassir, et al. **Toward Effective Response to Natural Disasters: A Data Science Approach**. IEEE Access journal, Volume 9. 2021
- Ghulam Mudassir, Antinisca Di Marco. **Social-based City Reconstruction Planning in case of natural disasters: a Reinforcement Learning Approach**. COMPSAC 2021 (IEEE).
- E. Etrue Howardet al. **Definition of an enriched GIS network for evacuation planning**. 7th International Conference GISTAM. *Best paper award candidate.*

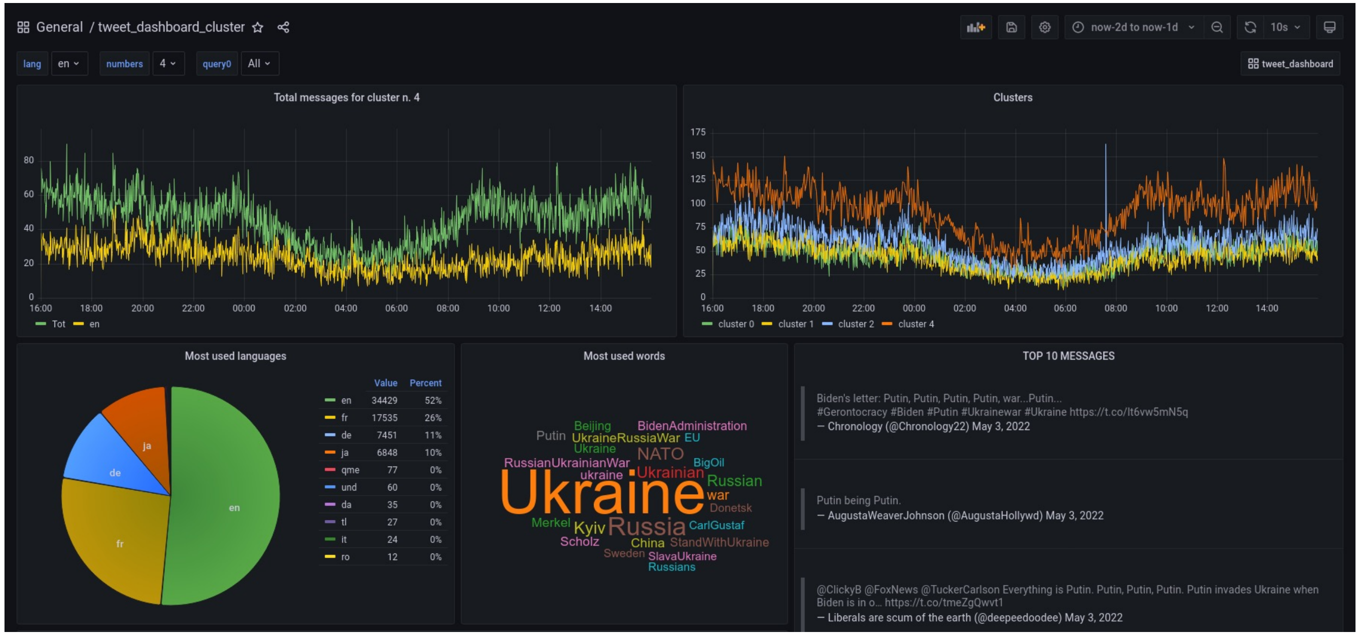
# CN-HPC – Spoke 5 – WP 6 UNIAQ Activities

*<u>Task 5.6.1</u>* Gathering and integrate multi-source data

*<u>UNIAQ contribution:</u> Disaster Monitoring*

The research project Disaster Monitor has the aim of exploring the monitoring of natural disasters. More precisely we want to focus on the gathering, preprocessing and visualization of multi-source streaming data. Thus, the study will be focused, at first, on social streams and their analysis and lately can be extended to other types of streams and additional data sources (e.g., Open Data). Thus, part of the project will be dedicated to studying the most flexible model to specify the kind of event that we want to monitor. Then we are interested in exploring the methods and techniques able to effectively store and retrieve the collected data. Finally, we explore the mechanism devoted to the effective visualization of the multi-source streaming data.

*<u>HPC needs</u>*: GPU and multicore HPC infrastructure, data and result storage capacity

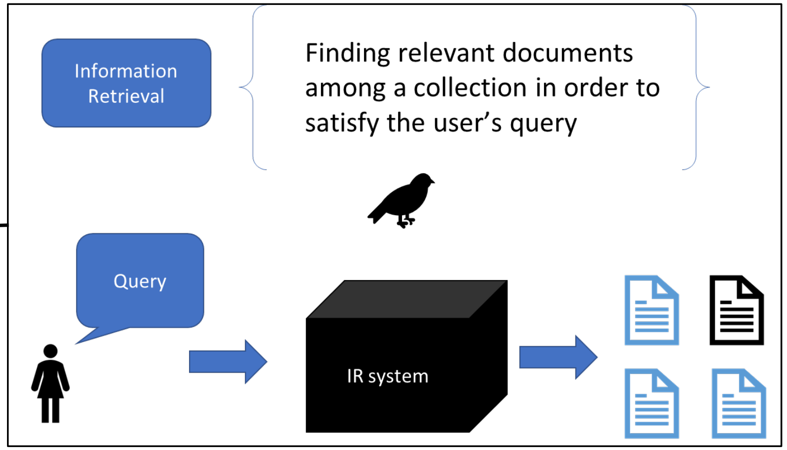



Disaster Monitor: Analisi, Design e Implementazione.
https://territoriaperti.univaq.it/download/3810/?tmstv=1668375848

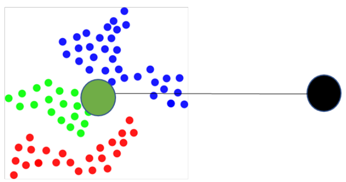
# CN-HPC – Spoke 5 – WP5.6 UNIAQ Activities

*Task 5.6.3* Gathering and integrate multi-source data

*UNIAQ contribution: Information Retrival vs Density retrieval*

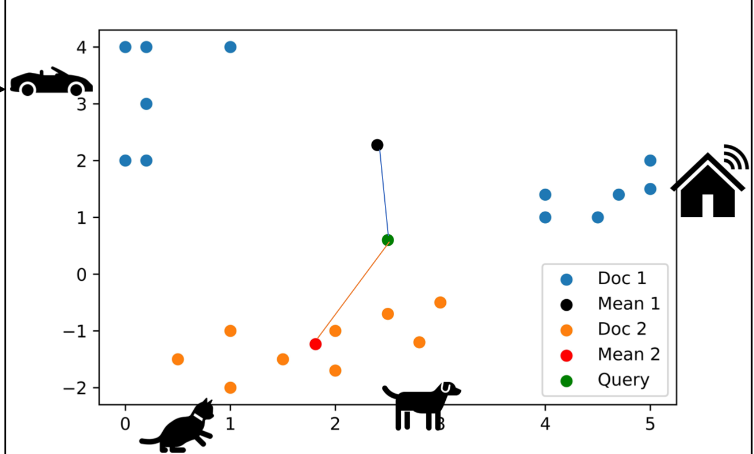



First basic approach would be to compute the mean of the embeddings of the document and of the query, and then score the document as the distance between those two points.




$$\text{Score(document)} = \text{distance}\left( \frac{\sum_{i=1}^{|Cloud|} Cloud_i}{|Cloud|}, \frac{\sum_{j=1}^{|Query|} Query_j}{|Query|} \right)$$

This model does not perform well when the document contains multiple topics.



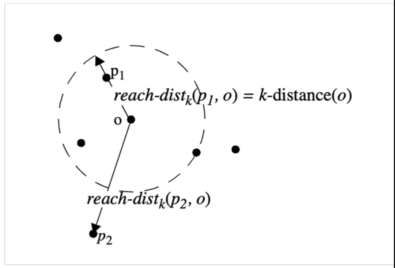

We need a density metric in order to implement the previous algorithm.

K-distance:
For any positive integer k, the k-distance(p) of p is the distance(p,o) such that:

- For at least k objects o' ∈ D \ {p}, d(p,o') <= d(p,o)
- For at most k-1 objects o' ∈ D\{p}, d(p,o') < d(p,o)

Reachability distance:
Let k be a natural number. The Reachability distance of an object p is defined as:

$$reachdist_k(p,o) = \max\{\, kdistance(o), d(p,o) \,\}$$




K-distance neighborhood:
$N_k(p) = \{\, q \in D\backslash\{p\} \mid d(p,q) <= kdistance(p) \,\}$

$$LRD_k(p) = \frac{1}{\frac{\sum_{o \in N_k(p)} reachdist_k(p,o)}{|N_k(p)|}}$$

Our model minimizes the loss of information caused by compressing a set of vectors into its mean. Relevance scores are thereby computed via a density metric that makes use of all the vectors at our disposal.

*HPC needs*: GPU and multicore HPC infrastructure, data and result storage capacity

# CN-HPC – Spoke 5 – WP5.6 UNIAQ Activities

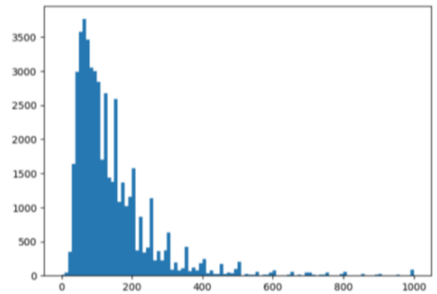
*<u>Task 5.6.1</u>* Gathering and integrate multi-source data

*<u>UNIAQ contribution:</u> Visual Analytics*

In visual analytics, the analyzes are guided by vast sets of data acquired from different sources. It is therefore necessary to use robust and scalable analyzes that go beyond available data management systems.

In visual analysis, the data query, exploration and visualization phases are combined in a single process, helping to interpret the data more easily. We are developing a new Visual Analytics system, in the form of a Web App, aimed at analyzing generic workflows. Our current use case concerns the performance analysis of micro-service systems.

Such kind of complex visual analytics interactive processes need to quickly respond to users' query. However, the usage of big data and the weight of analytics demand for a very powerful infrastructure to solve query and visualize results of analytics in a reasonable time, that is of the order of a few tens of seconds.




*<u>HPC needs</u>*: GPU and multicore HPC infrastructure, data and result storage capacity

Disaster Monitor: Analisi, Design e Implementazione. https://territoriaperti.univaq.it/download/3810/?tmstv=1668375848

# CN-HPC – Spoke 5 – WP5.6 UNIAQ Activities

*Task 5.6.1* Assessment of citizen preparedness and ecosystems resilience to disasters

*UNIAQ contribution: Sustainble and preparedness indicators*

Design of indicators aimed at highlighting the relationships between sustainable development of urban transformations, resilience of settlement systems and their potential to adapt to different economic and environmental stresses. The use of micro-data extracted from existing administrative archives, together with big data generated by the activities of individuals and enterprises, will allow an in-depth analysis of the structural economic features of local ecosystems and their international relationships, in order to assess their resilience to disasters as well as a serious econometric assessment of the impact of local development policies. The new research activities in citizen preparedness and ecosystems resilience to disasters concern the application of engineering techniques of indicators aimed at identifying appropriate indices able to return information on the reaction of urban tissues with respect to environmental disturbances that determine risk scenarios. In particular, for what concerns asseessment techniques, we exploit machine learning and analysis approaches that guarantee fairness, explainability, interpreatbility and citizens privacy (i.e . Trustwothiness). Some examples of indicators follow.

**Air Quality Index measures the effects of the post-earthquake reconstruction on the city air quality.** INPUT DATA: Sentinel-2 L1C Products Sentinel-3 SYNERGY Level 2 AOD products Aerosol Optical Depth of AERONET, OUTPUT: neural network predicting the Aerosol Optical Depth at 10m.

**Walkability Index measuring how it is agile to walk long a road or area during the city reconstruction**. INPUT DATA : Local geospatial databases, Satellite images: WorldView 02 Bundle 4 bande; Streets graph in gpickle and/or JSON formats, Air Quality index. OUTPUT: predictive approach that estimates the walkability as a pair of indicators, one subjective and the other objective, both in the range [1,5]

**Service accessibility index that, from air quality and walkability, considers the architectural barriers.** INPUT DATA: Local geospatial databases; Satellite images: WorldView 02 Bundle 4 bande; Streets graph in gpickle and/or JSON formats, Air Quality and Walkability indices. OUTPUT: predictive approach that estimates the accessibility as a pair of indicators, one subjective and the other objective, both in the range [1,5].

*HPC needs*: GPU and multicore HPC infrastructure, data and result storage capacity

# CN-HPC – Spoke 5 – WP5.7 UNIAQ Activities

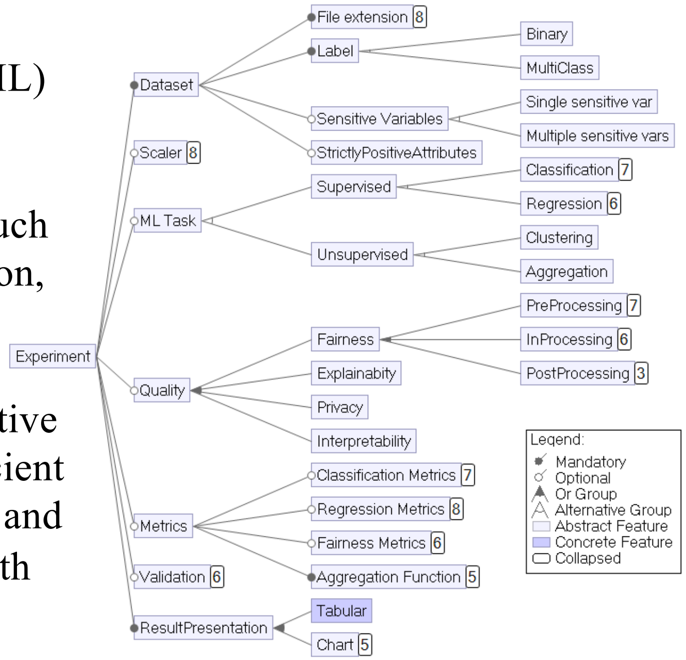
*<u>Task 5.7.1</u> Efficient classical and quantum AI models for disaster analyses*

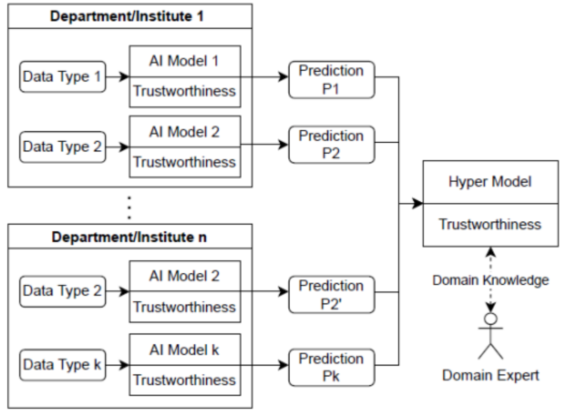
*<u>UNIAQ contribution:</u> Quality AI models*

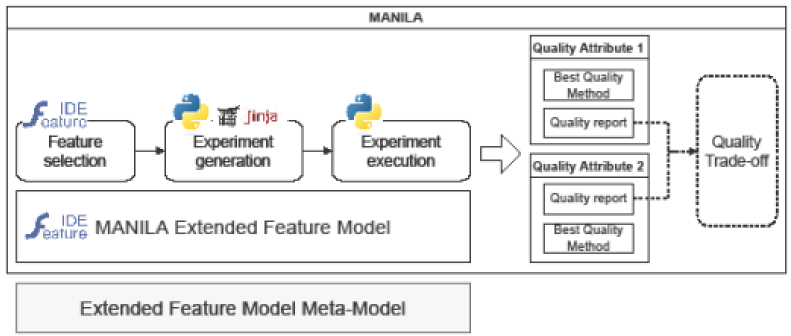
Artificial Intelligence (AI) and Machine Learning (ML) systems help stakeholders addressing challenges in several domains. To this aim, a huge amount of heterogeneous data is available and can be fed into such systems to solve different tasks (like image recognition, data predictions and so on). However, managing the complexity and multi-modality of data is always a complex task. Moreover, nowadays developing effective (i.e., accurate) AI and ML systems is no longer sufficient to have a system which is of high quality. Indeed, AI and ML systems must be fair, explainable, and private with respect to sensitive information of the user (in other words, trustworthy).

OBJECTIVE: We are working on an approach to allow the trustworthy predictions based on AI, ML and multi-modal data.

*<u>HPC needs</u>*: GPU and multicore HPC infrastructure, data and result storage capacity, investigate how to redesign the AI and ML systems on Quantum computing



# CN-HPC – Spoke 5 – WP5.7 UNIAQ Activities

*Task 5.7.3 Computational infrastructure and integrated software as a service*

*UNIAQ contribution: Open Science Infrastructure*

SoBigData RI strives to deliver a distributed, Pan-European, multi-disciplinary research infrastructure for big social data analytics, coupled with the consolidation of a cross-disciplinary European research community, aimed at using social mining and big data to understand the complexity of our contemporary, globally-interconnected society.

SoBigData RI will push the FAIR (Findable, Accessible, Interoperable) and FACT (Fair, Accountable, Confidential and Transparent) principles. It will also orient resources from multiple perspectives: e-infrastructures and online services developers; big data analytics and AI; complex systems focussed on modelling social phenomena; ELSEC (Ethical, Legal, SocioEconomic and Cultural) aspects of data protection (as defined by the HLEG-AI); privacy preserving techniques.

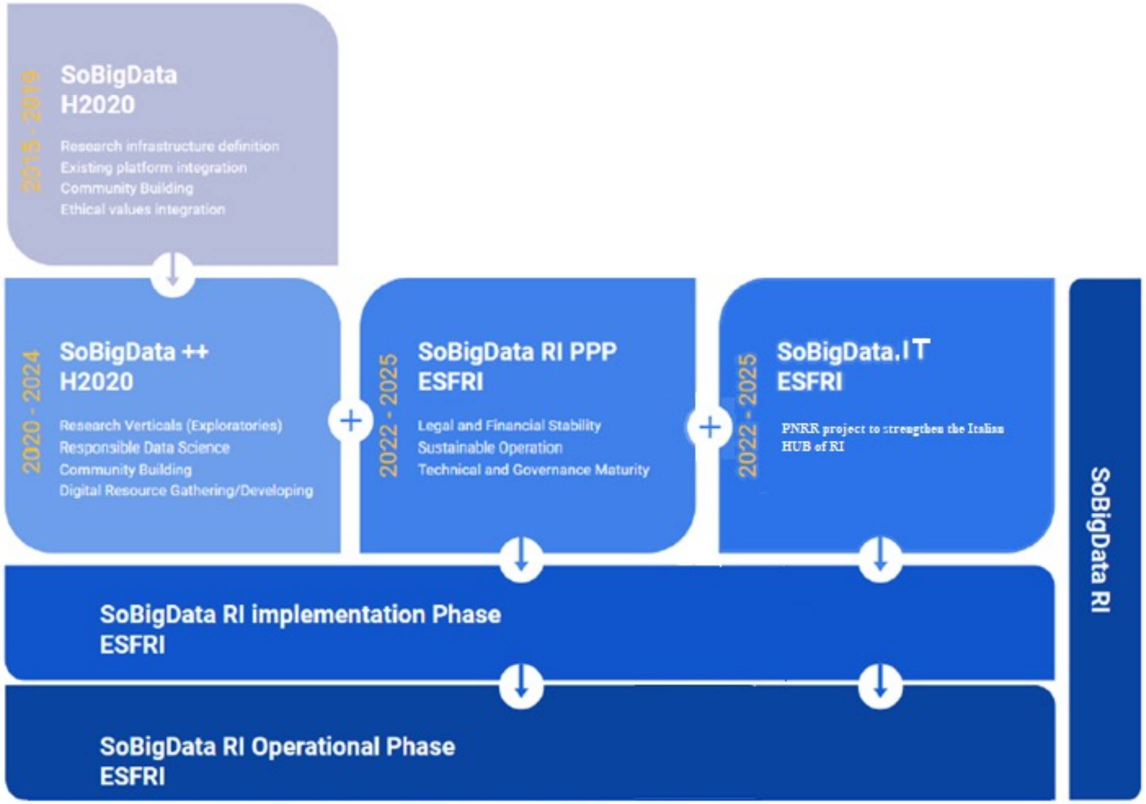
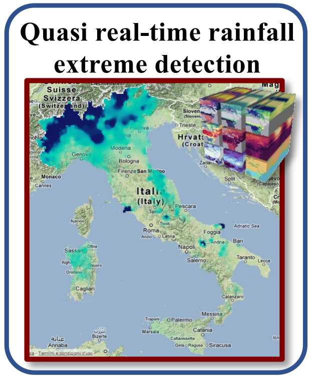
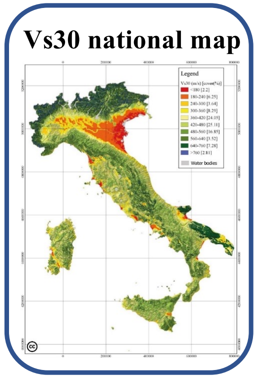



*Figure 1.1 Overall view of SoBigData RI construction and related projects*

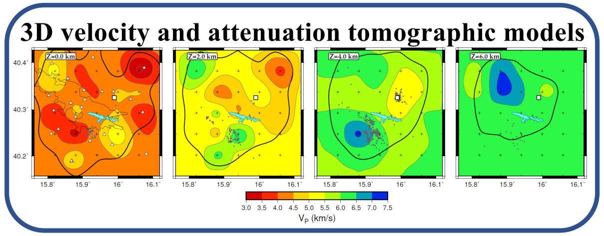
# WP 1 Dynamical hazard scenarios assessment

Assessment of the driving hazard factors for the Italian territory




CNR: Near-real time **rainfall-related** extremes detection for the geo-hydrological processes forecast. High resolution seismostragraphic proxies' assessment for ground motion modelling at national scale. Multiscale 3D high resolution velocity and attenuation tomographies and high precision 3D **earthquake locations** for the High Agri Valley and Gargano areas using High-Performance Computing.




UnivAQ: Spatial analysis and fast monitoring tools for **urban resilience**, the redevelopment of sensitive areas for combating **hydraulic and hydrogeological risk**, for mitigating climate-altering effects, for improving/increasing ecosystem services, for assessing the carbon balance. Studies of **severe weather events**, climate extremes both in terms of cold and warm spells and atmospherically unstable and stable conditions.

# WP 1 Dynamical hazard scenarios assessment

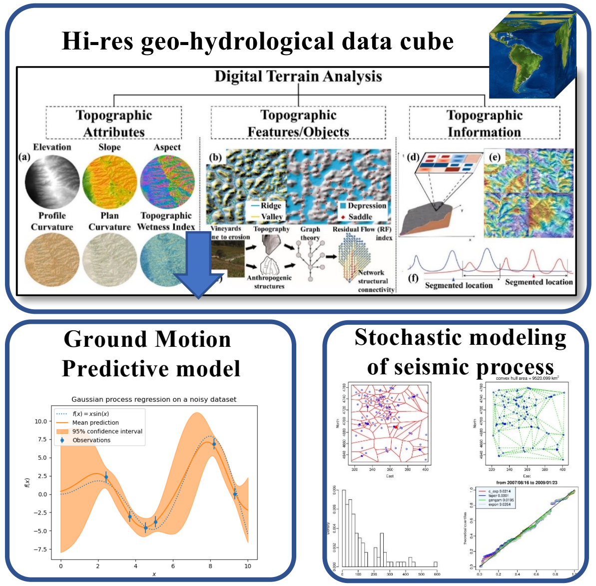
Task 5.1.1 Assessment of the driving hazard factors for the Italian territory

ENEA: Multidisciplinary approach for the seismic hazard assessment of earthquakes induced and/or triggered by the human activity (mining activity, enhanced geothermal systems, injection/withdrawal of fluids into/from the ground associated with the gas storage, geological CO2 sequestration, exploitation of natural gas and oil, wastewater disposal from hydrocarbon production, etc.)

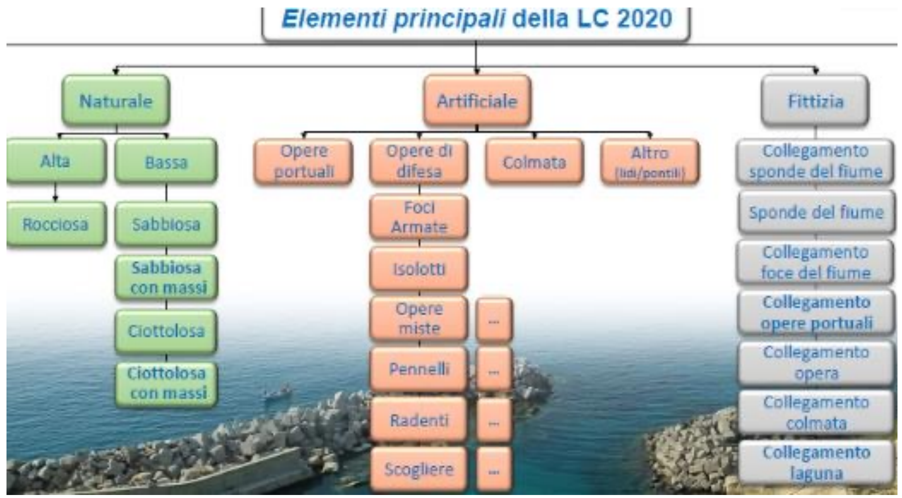
UniFI: Dynamics of complex geological systems between variability and resilience: investigation of hidden patterns, correlations, cause-effect relationships for which conventional analytical methods face limitations or challenges.

Modelling the impact of hazard factors on the Italian ecosystem

**CNR:** Building a hi-res geo-hydrological data cube to support dynamic routing-based hazard disaster modelling. Developing an innovative predictive model to produce near real-time seismic ground motion scenario maps. Stochastic modeling of time evolution of the seismic process based on variations in the probability distribution of seismic factors.




**UnivAQ**: Experimentation and scenario building using ML and algorithms to increase the interpretative capabilities of the urban mosaic and generate sustainable city configurations. Improvement of outcomes of task 5.1.1 to better reproduce localization, timing and intensity. Implementation of a high resolution numerical model coupled with the ocean for reproducing the most relevant hazards: floods, heat waves, coastal erosion, wind and wave storms, and drought.




STATO dell’ARTE

In 50 anni,1750 km di costa arretrati mediamente 23 m.
Sono circa 40 milioni m$^2$ di spiaggia scomparsi.
Pari a 9 campi di calcio per ogni comune costiero (645).

# WP 1 Dynamical hazard scenarios assessment

Modelling the impact of hazard factors on the Italian ecosystem

ENEA: Analysis of cascading effects to critical infrastructures and economic activities of the identified hazards. Modelling of interdependencies among infrastructures and the physical and natural environments they are embedded in. Model implementation to calculate the economic/environmental damages generated by coastal infrastructures. Earthquake-induced landslide hazard.

UniBA: Simulations and models of: explosive volcanic eruptions and/or gravity flows, high-resolution time-dependent single phase gravity flows, high-resolution time-dependent meteorological model. Probabilistic hazard assessment: Volcanic ash dispersal and fallout, Volcanic gas dispersal, Volcanic plume simulations.

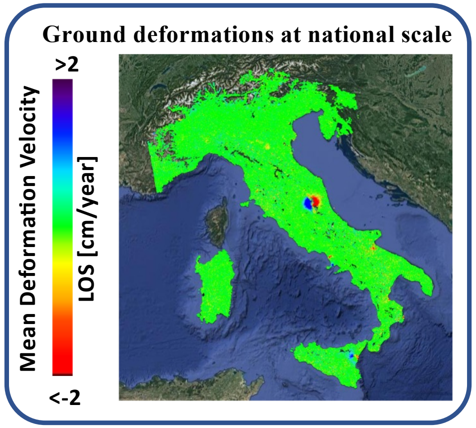
UniFI: Dynamics of complex geological systems between variability and resilience: simulation behaviour of pollutants in space and time in riverine systems.

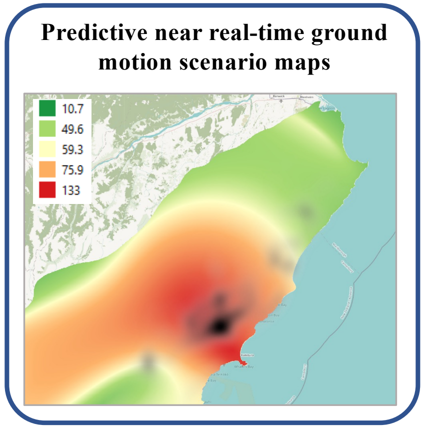
**Tools:** Ansys Fluent (commercial), MFIX (open-source), FLO2D (commercial), IMEX-SfloW2D (open-source), WRF-ARW (open-source), FALL3D (open-source); DISGAS, TWODEE (open-source); FPLUME (open-source)

# WP 1 Dynamical hazard scenarios assessment

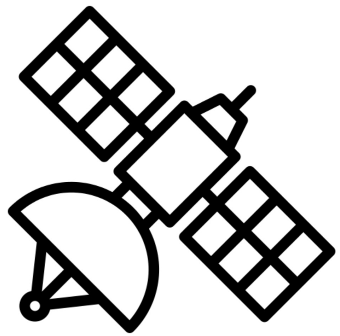
High resolution dynamical hazard scenario maps of natural disasters threatening the Italian territory and ecosystem

<u>CNR</u>: Generation, update and analysis of national scale ground displacements through medium resolution satellite DInSAR measurements and **HPC infrastructures**. Production of near real-time high resolution seismic ground motion scenario maps.



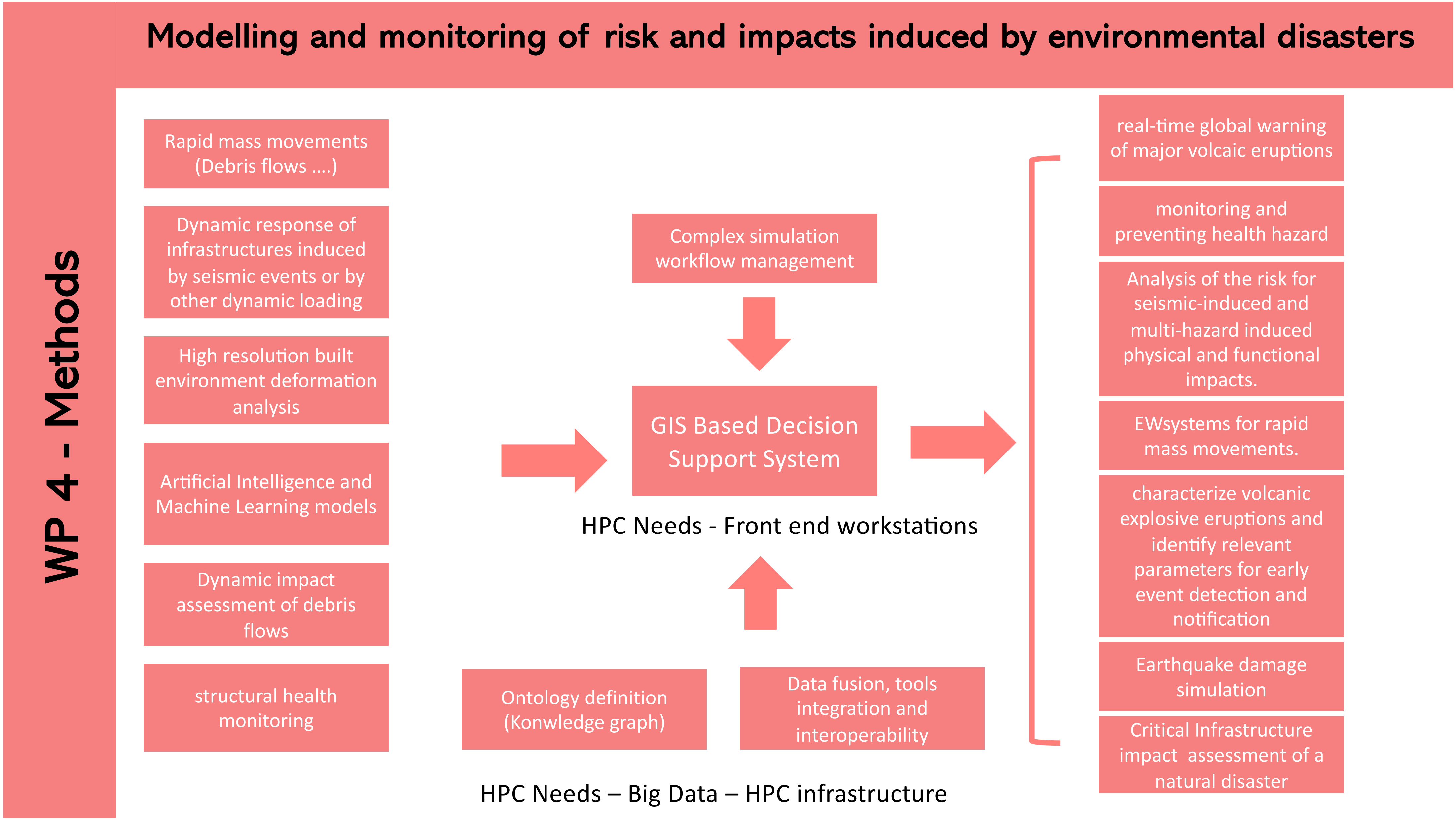

<u>UnivAQ</u>: Integrated procedures and fast monitoring to promote the use of innovative technologies for data collection and processing. Development of spatial information systems towards the integration of **different types of data** and the implementation of diagnostic tools. The use of RPAS (remotely piloted aircraft system), of EO web-services, of gisbased platforms for the advancement of the digitalization process of the public administration. High resolution climate predictions to define probabilistic risk maps.



# WP 1 Dynamical hazard scenarios assessment

High resolution dynamical hazard scenario maps of natural disasters threatening the Italian territory and ecosystem

ENEA: Starting from susceptibility maps of the initiation areas, a GIS based geometric approach leads to the identification of pathways, runout distances and size of mobilized mass by the debris flows. The interconnection of sparse and remote, traditional and innovative, local monitoring ground stations, can strongly enhance the opportunity provided by extended soil moisture maps generated by satellite SAR images. Coupling traditional rainfall data with advanced soil moisture products, may drive to significant innovations in the production of dynamic hazard maps and, finally, to the implementation of site-scaled high performance DSS for early warning systems. **< -- Troppo lungo, propongo di ridurre.**


WP 4 - Methods
Modelling and monitoring of risk and impacts induced by environmental disasters
Rapid mass movements (Debris flows ….)
Dynamic response of infrastructures induced by seismic events or by other dynamic loading
High resolution built environment deformation analysis
Artificial Intelligence and Machine Learning models
Dynamic impact assessment of debris flows
structural health monitoring
Complex simulation workflow management
GIS Based Decision Support System
HPC Needs - Front end workstations
Ontology definition (Konwledge graph)
Data fusion, tools integration and interoperability
HPC Needs – Big Data – HPC infrastructure
real-time global warning of major volcaic eruptions
monitoring and preventing health hazard
Analysis of the risk for seismic-induced and multi-hazard induced physical and functional impacts.
EWsystems for rapid mass movements.
characterize volcanic explosive eruptions and identify relevant parameters for early event detection and notification
Earthquake damage simulation
Critical Infrastructure impact assessment of a natural disaster

WP 4

ENEA

# T5.4.2: Models and tools for assessment of risks and impacts induced by environmental disasters - HPC Needs…..

**Monitoraggio fenomeni naturali**

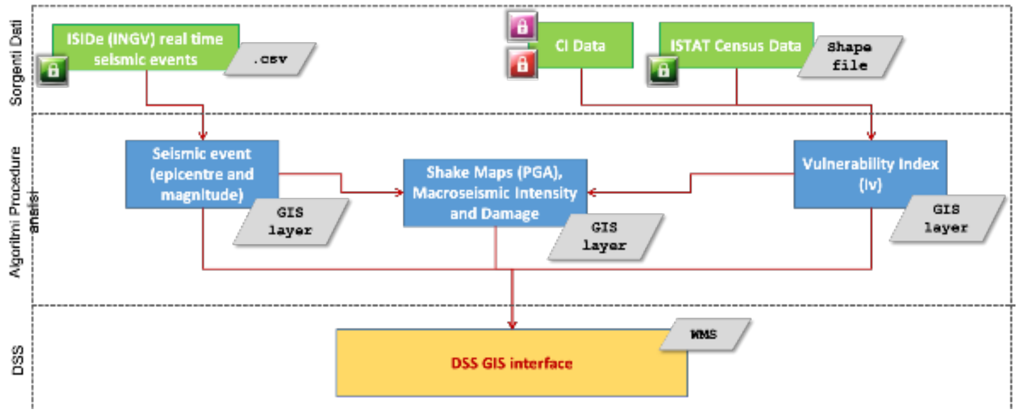
- Implementazione della catena operativa di HIMET su sistema di calcolo scientifico ad alte prestazioni CRESCO 6 di ENEA, per la produzione di previsioni metereologiche ad alta risoluzione.

**Web Crawling**

- Web Crawling basato sul software BUbiNG del Politecnico di Milano ed integrazione nel codice sorgente di un filtro semantico sviluppato da ENEA gruppo APIC.
- Condivisione su rete geografica dei file system per consentire l'analisi dei risultati.


**Database**

- Integrazione database per la raccolta dei dati prodotti nello Spoke ed implementazione di procedure per la loro gestione
- Definizione di aree specifiche per la raccolta, conservazione e backup dei dati. Definizione ed implementazione della catena di acquisizione.
- Realizzazione dell'architettura per il Data Lake di progetto per la raccolta dei dati grezzi prodotti dai sensori.
- Raccolta dati prodotti nel Data Lake di progetto.



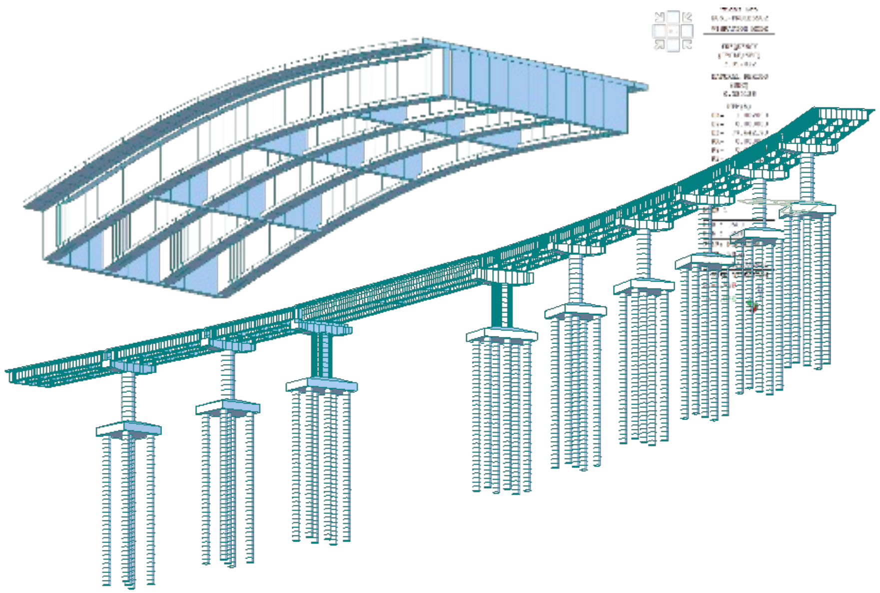

Sfide: gestione di workflow di simulazione complessi, integrazione e gestione dati, gestione ambienti di simulazione eterogenei (simulatori commerciali, open source), visualizzazione dati IoT

WP 4

ENEA

# T5.4.2: Models and tools for assessment of risks and impacts induced by environmental disasters - SHM e modellazione

- Obiettivi scientifici: Nel contesto dello *Structural Health Monitoring* (SHM), utilizzare tecniche innovative basate sulla *AI* tipo *Machine Learning* (ML) al fine di indentificare posizione ed entità di un eventuale danneggiamento in strutture civili e/o posizione ed entità di carichi viaggianti, sulla base di dati acquisiti mediante sensori. Sviluppo di modelli ad elementi finiti o al continuo quali repliche di strutture reali (*Digital Twins*).
- Dati disponibili: Dati acquisiti nel progetto RAFAEL.



WP 4

CNR

# CN-HPC – Spoke 5 – WP5.4 IREA Activities

**WP5.4** Modelling of environmental disasters

_Task 5.4.1_ Remote sensing and proximal sensing models for environmental disasters

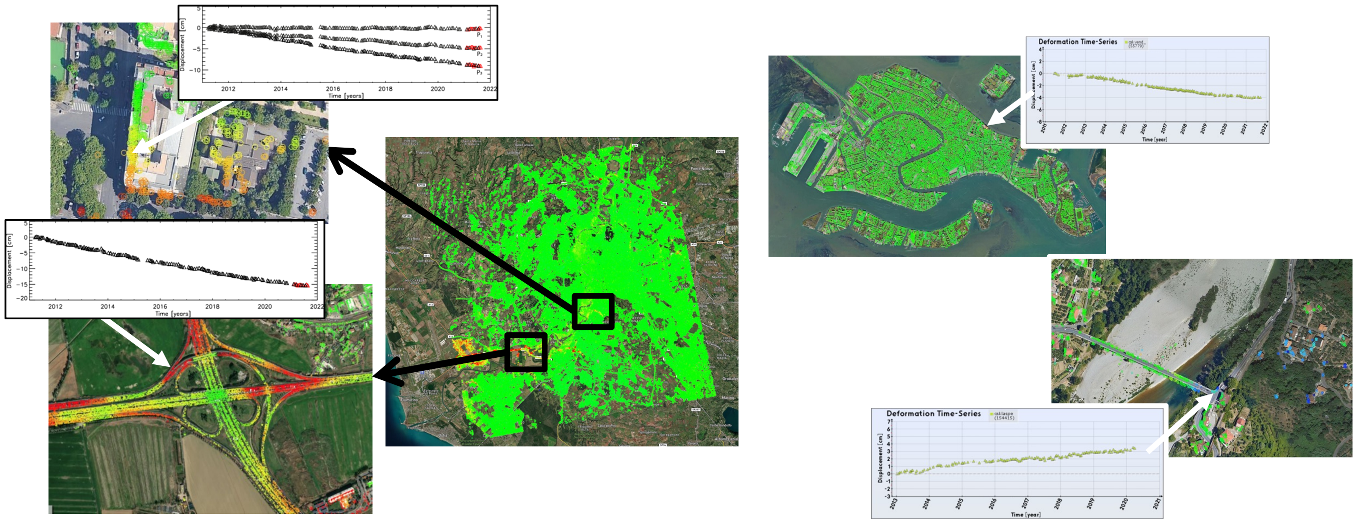
*IREA contribution:* *Regional and local scale built environment deformation analysis through high resolution satellite DInSAR measurements and HPC infrastructures*

The activity is aimed to effectively exploit advanced ICT technologies based on CPUs and GPUs HPC facilities to massively generate DInSAR displacement time series at high spatial resolution. A pre-operative service, based on extensive exploitation of HPC environments, will be developed and deployed to perform regional scale deformation analyses. The service concerns the massive processing of full resolution first and second generation COSMO-SkyMed data archives, collected over the most important cities of the Italian territory from 2009, by means of the advanced DInSAR technique known as full resolution Small Baseline Subset (SBAS) approach.

The achieved full resolution DInSAR products can be efficiently exploited in civil protection scenarios contexts to improve the built-up environment monitoring at local scale and for risk assessment strategies.

_HPC needs_: Full resolution DInSAR processing code optimization, GPU and multicore HPC infrastructure, Full resolution DInSAR result storage capacity.

FULL RESOLUTION DINSAR PRODUCTS AT NATIONAL SCALE



WP
4

CNR

# CN-HPC – Spoke 5 – WP5.4 IMATI Activities

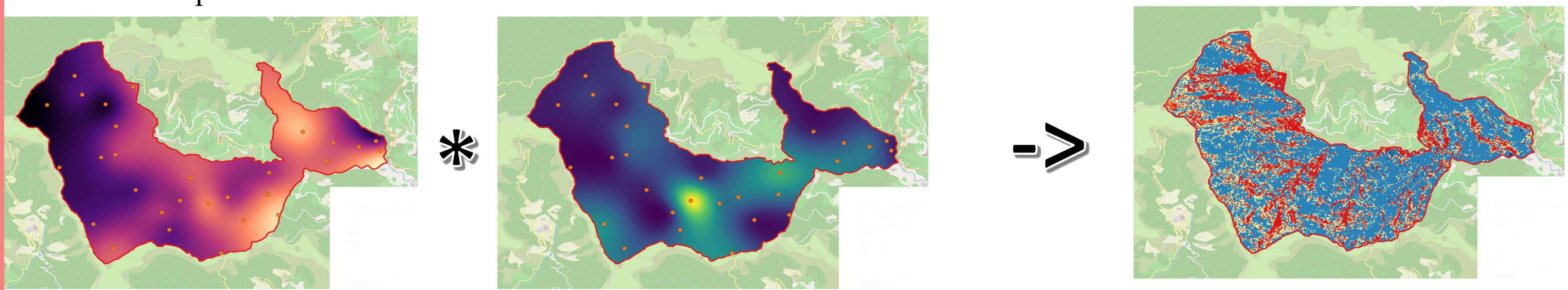
**WP5.4** Modelling of environmental disasters

*Task 5.4.1* Remote sensing and proximal sensing models for environmental disasters

*IMATI contribution: Heterogeneous data integration and context-oriented 3d modeling and visualization*

The activity will exploit the geostatistical techniques to reconstruct both in the space domain and in the time domain the distribution of variables sampled in a discrete way taking into account the uncertainty of the estimation process and the error associated to measurements. The integration of uncertainty together with the visualization of the variable, even in 3d contexts allows a better understanding of the reliability of the reconstruction of scalar fields.

*HPC needs:* geostatistical techniques are resource demanding when applied on large dataset, they can benefit from their optimization for HPC systems even by the optimization of the underlying 3d model tailored to the addressed problem.



WP
4

CNR

# CN-HPC – Spoke 5 – WP5.4 ITC Activities

ITC contributes with *Structural and Geotechnical Engineering Applications*

**WP5.4 Modelling of environmental disasters -** *task 5.4.2 Models and tools for structural health monitoring (Soil – Structure – Interaction)*

- Elevated structures
- Foundations
- Foundation soil

*SW environment adopted:* ***Opensees***

OpenSees

- Open-source object-oriented SOFTWARE FRAMEWORK
- Development of sequential and parallel FE applications to simulate the response of structural and geotechnical systems under seismic loadings

WP 4

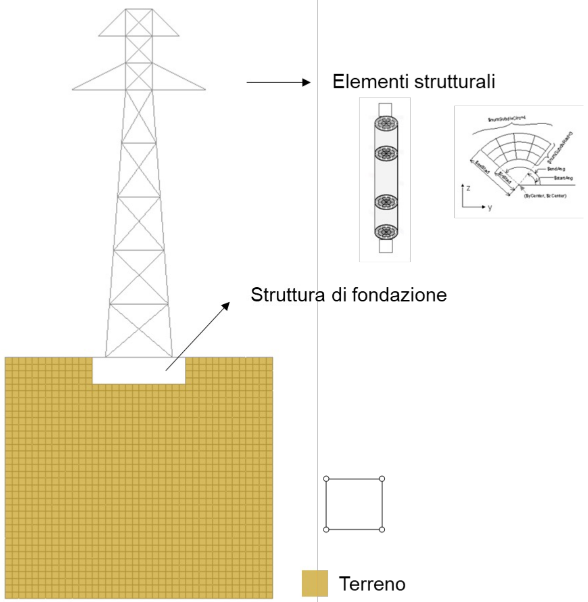
CNR

# CN-HPC – Spoke 5 – WP5.4 ITC Activities

*Structural and Geotechnical Engineering Applications*

## Pre-processing

Gid+OpenSEES interface

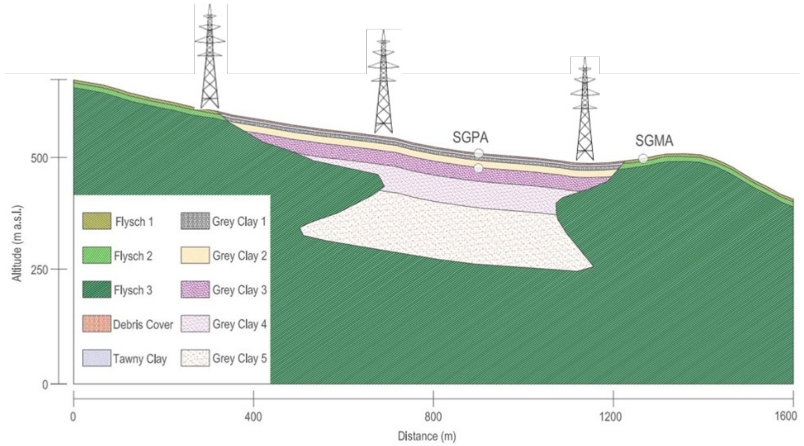



## Analyses

- Open-source object-oriented SOFTWARE FRAMEWORK
- Development of sequential and parallel FE applications to simulate the response of structural and geotechnical systems under seismic loadings

## Post-processing

Routines written in Python



WP 4

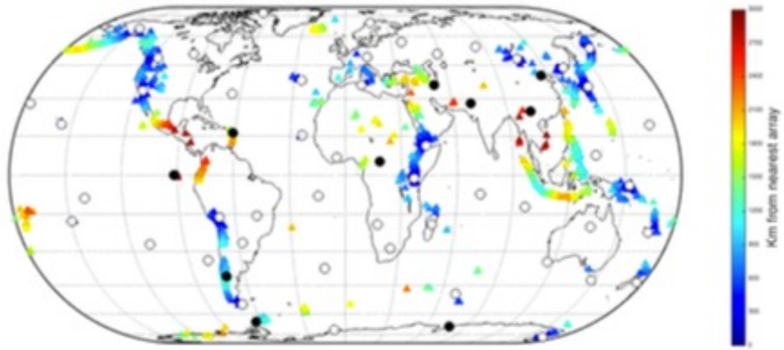
## Infrasound based Volcanic Information System

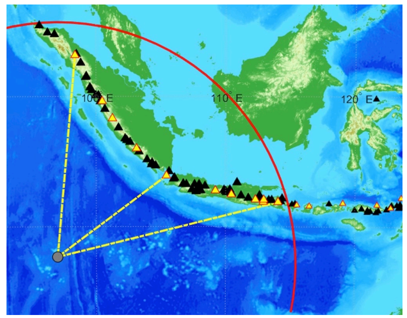
Researchers: Emanuele Marchetti - DST - University of Florence
Partner: Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), ARISE ???

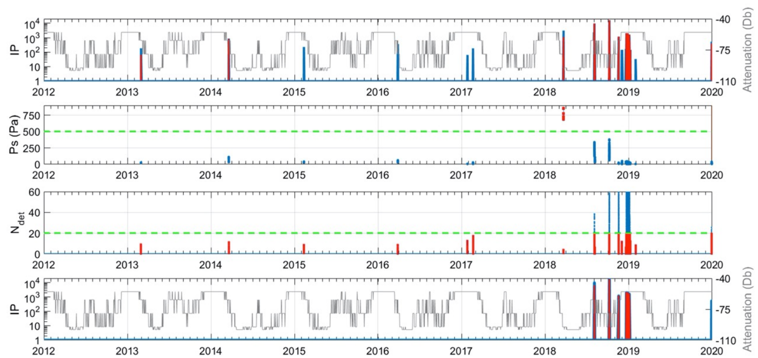
- ❑ **obiettivi scientifici**
  Major volcanic eruption produce infrasound signals that can be recorded globally. We plan do analyse global infrasound data from the IMS network recorded during the past 20 years to identify and characterize volcanic explosive eruptions and identify relevant parameters for early event detection and notification. Design and test a monitoring system for real-time global warning of major volcanic eruptions based on the IMS infrasound Network.

- ❑ **dati già disponibili**
  IMS infrasound array data.

- ❑ **tecnologie (HPC o altro) che si intendono utilizzare**
  Extensive array data analysis (xcorr, cpsd, FK) and developing procedure (Machine Learning, wave parameters) for event recognition.



**WP**
**4**

**WP4 –** Modelling and monitoring of risk and impacts induced by environmental disasters

## Mass Movement analysis with Infrasound arrays

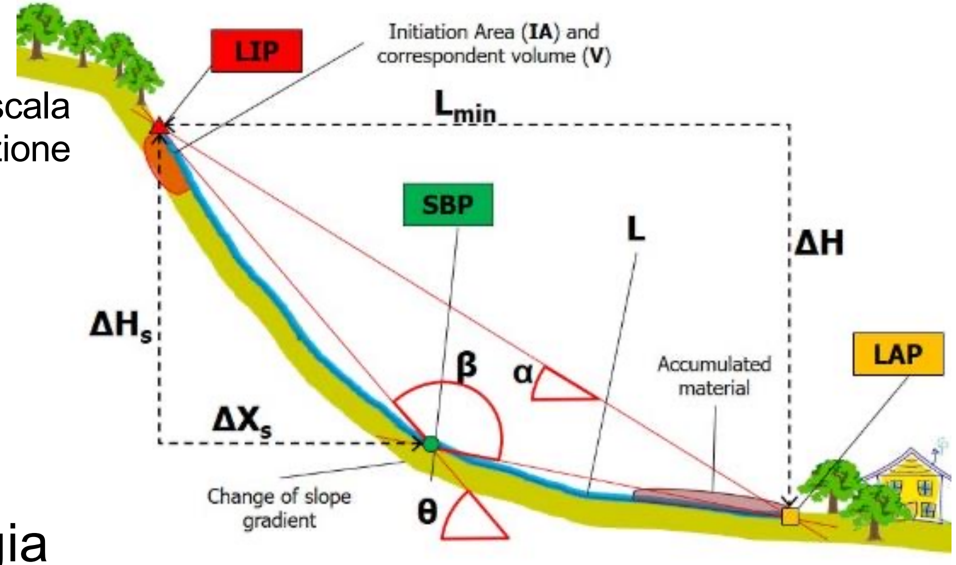
Researchers: Emanuele Marchetti - DST - University of Florence
Partner: Fondazione Montagna Sicura, WSL

- **obiettivi scientifici**
  Rapid mass movements (Debris flows, glacier calving, snow avalanches, pyroclastic flows) radiate seismic and infrasound signals that recorded with arrays can be used to detect the event and track the front evolution. Analysis of archived data will be performed for developing solutions for monitoring and hazard assessments.

- **dati già disponibili**
  > 10 years of infrasound array data for various types of events.

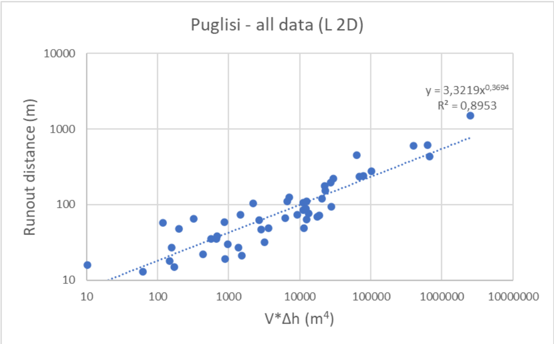
- **tecnologie (HPC o altro) che si intendono utilizzare**
  Extensive array data analysis (xcorr, cpsd, FK) and developing procedure (Machine Learning, wave parameters) for event recognition.

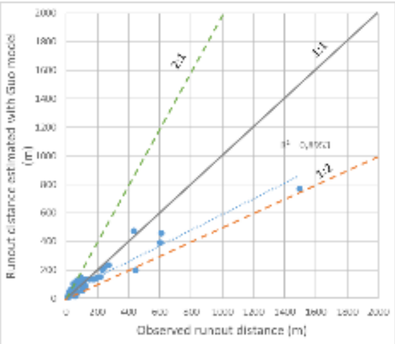
# Propagazione colate rapide




## Obiettivi scientifici

Sviluppo di GIS tool per la stima della propagazione di colate rapide, a scala vasta (da bacino a regionale) a supporto di strumenti di pianificazione territoriale (PAI, PRG) e sistemi di allerta rapida (Protezione Civile)




## Metodologia

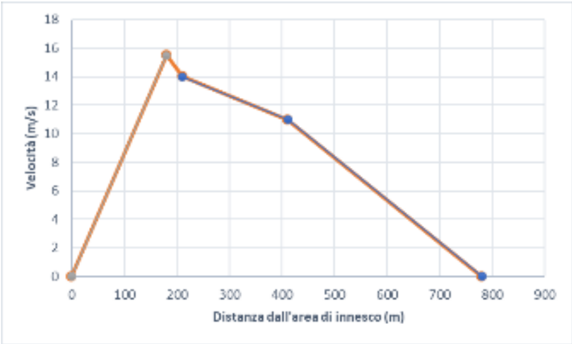
Approccio empirico-geometrico per la stima del runout

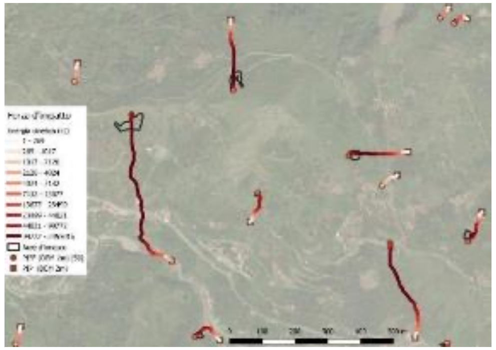
## Dati disponibili

Banca dati di colate rapide nell'area di Messina

## Software

QGIS, ArcGIS

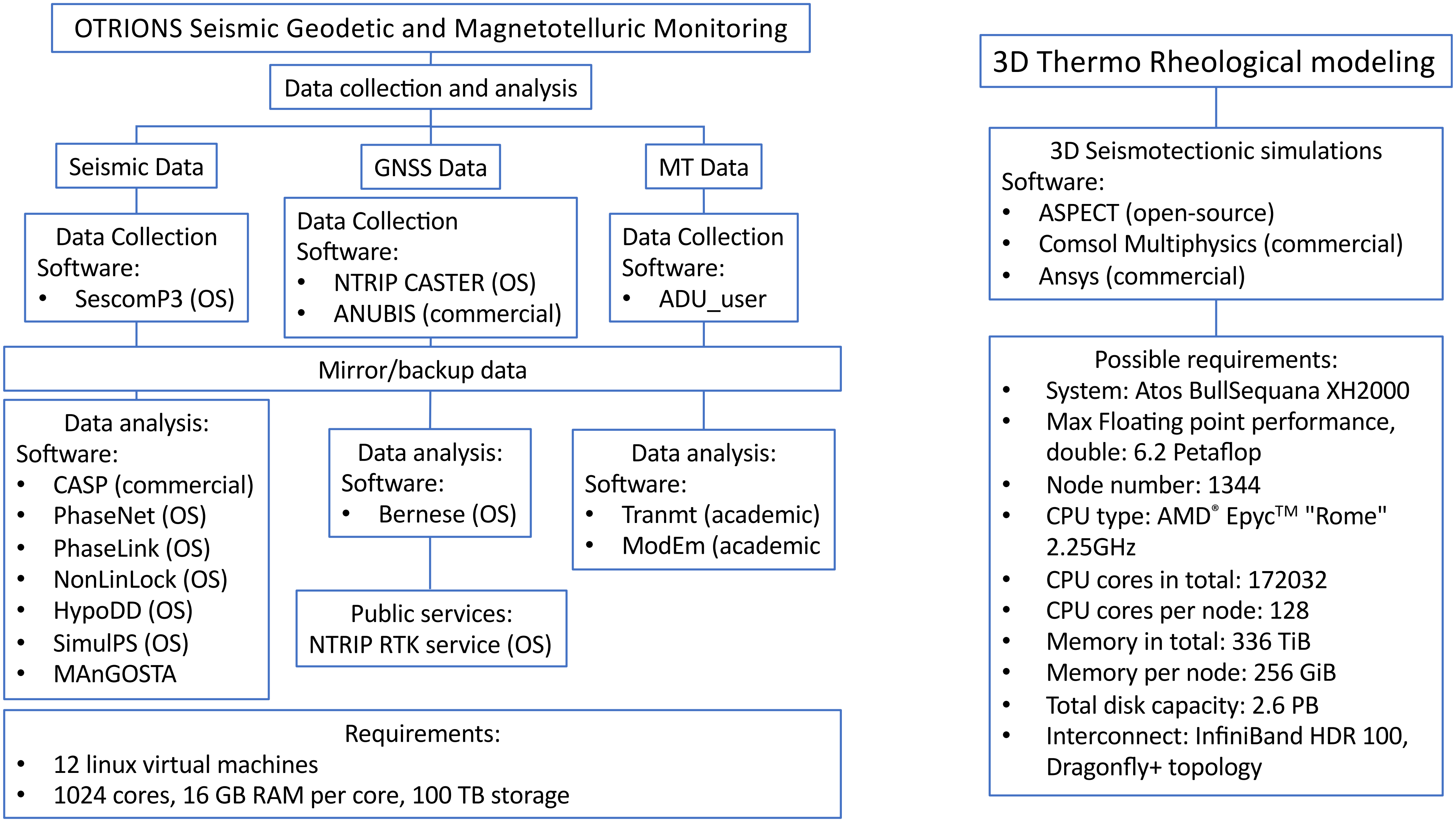


WP 3

UNIB A

# Seismic Geodetic and Magnetotelluric monitoring, data collection, analysis and modeling



## WP 3

**Modelling of disaster-inducing processes**

**Leader: INGV**
**Co-leader: POLIBA**

## WP 5

**Multi-hazard modelling and analysis estimation of engineering and geophysical parameters of damages and losses**

**Leader: POLIBA**
**Co-leader: SAPIENZA**

WP
6

UNIVAQ
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## Sociodemographic survey to measure citizen preparedness

Researchers: Silvia Bacci, Bruno Bertaccini - DISIA - University of Florence
Partner: da individuare **(open call)**

- **obiettivi scientifici**
  implementare un disegno di campionamento per la conduzione di una indagine a copertura nazionale per valutare quanto la cittadinanza sia preparata nella gestione di disastri naturali ed altre emergenze correlate.

  Indagine da condursi attraverso questionario con valutazione psicometrica ed una APP dedicata per la simulazione di scenari di rischio

- **dati già disponibili**
  nessuno

- **tecnologie (HPC o altro) che si intendono utilizzare**
  Sviluppo di una Risk Management Game APP

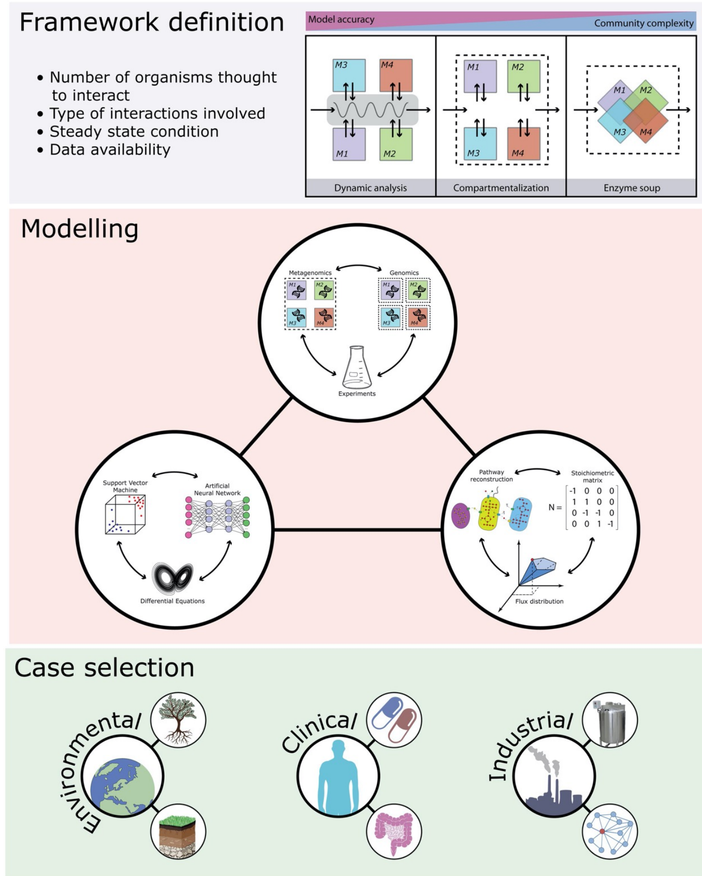
WP 6

UNIFI

# Modelling environmental perturbations of microbial communities

## obiettivi scientifici

Microbial communities are complex biological entities that are crucial in all natural and human-associated ecosystems. Several computational challenges are encountered when trying to predict **the dynamics of microbial communities in time, especially after the occurrence of external (environmental) perturbations**; We use computational modelling to detect community level patterns in stable microbial communities during environmental perturbation




UNIVERSITÀ DEGLI STUDI FIRENZE
BIO DIPARTIMENTO DI BIOLOGIA

WP 4

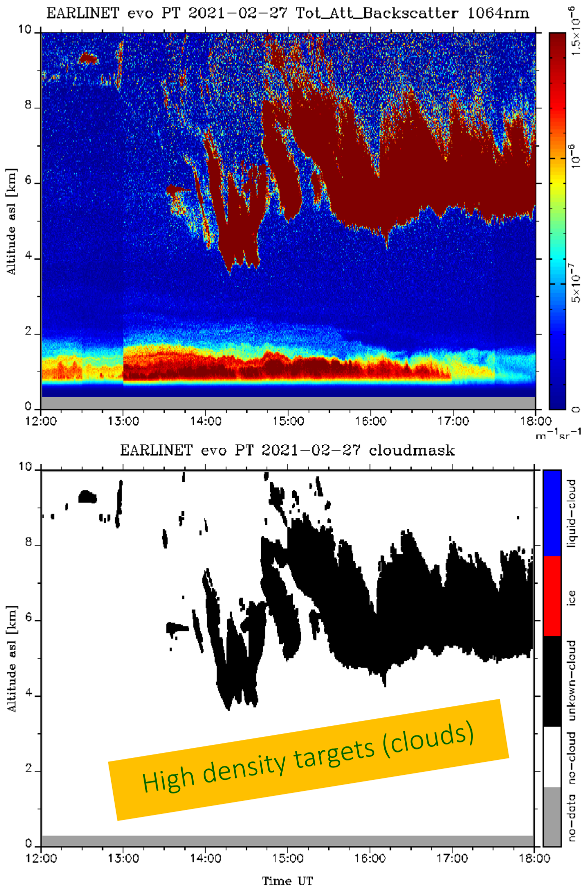
ENEA

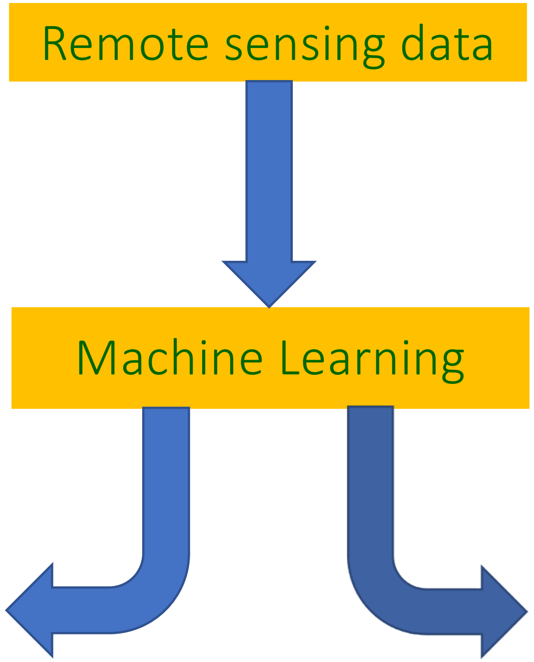
# Dati disponibili

- Dati territoriali di base: limiti amministrativi, Corine Land Cover (CLC), Digital Elevation Model (DEM) del territorio nazionale (risoluzione 10 m e 30 m) , idrografia, geologia, litologia, dati censuari (Fonti varie);
- DEM (risoluzioni variabili a seconda dell'area);
- Mappa della pericolosità sismica (ag – probabilità di eccedenza 2%, 5% e 10% in 50 anni - Fonte: INGV);
- Database delle sorgenti sismogenetiche e delle faglie sismiche attive (DISS, Fonte: INGV);
- Eventi classificati nel Catalogo Parametrico dei Terremoti Italiani (CPTI15, Fonte: INGV);
- Classificazione Sismica dei Comuni Italiani (Fonte: DPC);
- Mappatura Microzonazione Sismica e Condizione Limite per l'Emergenza (Fonte: CNR);
- Mappa della Vs30 - velocità media di propagazione delle onde di taglio nei primi 30 metri di profondità (Fonte: CNR-DPC).
- Mosaicatura nazionale pericolosità alluvioni (Fonte: ISPRA – Idrogeo)
- Mosaicatura nazionale pericolosità frane (Fonte: ISPRA – Idrogeo)
- Inventario dei Fenomeni Franosi in Italia - IFFI (Fonte: ISPRA – Idrogeo)
- Mappatura della modellazione idrologica ed idraulica delle aree inondabili del reticolo secondario in area romana (Fonte: Roma Capitale - ABT)
- Dati Open/proprietari su dislocazione e topologia infrastrutture di trasporto, elettriche, idriche e del gas (Fonti varie);
- Dati previsione meteo (precipitazioni a 72 ore) e nowcasting (solo in aree specifiche a 60 minuti).
- Indici di stress idrologico (Fonte: CETEMPS)
- Bollettini Criticità idro-meteo (Fonte: DPC)

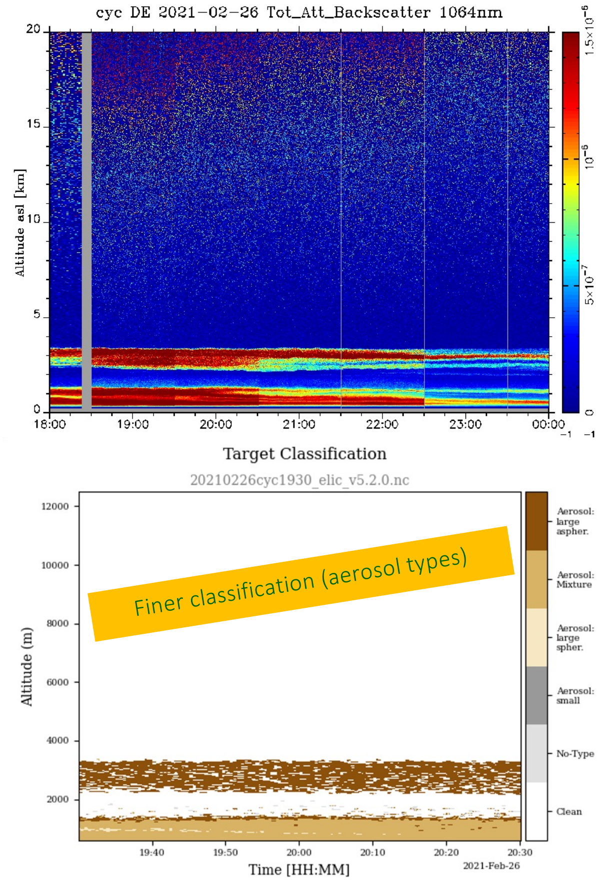
WP 7
CNR
IMAA

# Machine learning techniques for atmospheric target classification using High-Performance Computing




*HPC needs*: GPU and multicore HPC infrastructure, data and result storage capacity

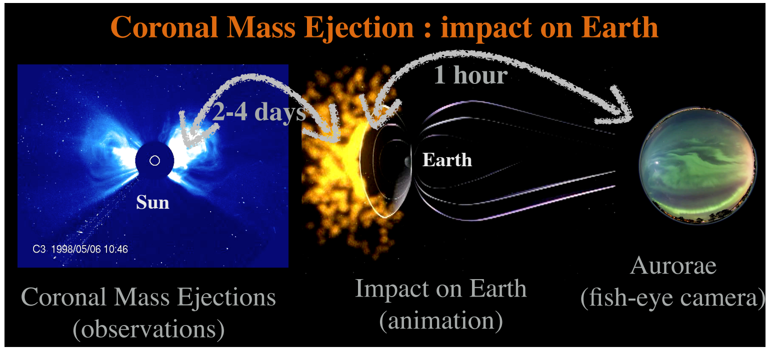


# Model impact of Coronal Mass Ejection on Earth

DEPARTMENT OF PHYSICS

**obiettivi scientifici**

Correlation analysis between time series of geomagnetic indexes and CME plasma properties (spacecraft data). Simulate CME propagation in terms of the physics of its interaction with solar wind. Realize a simplified operative model to nowcast CME arrival time from observations.

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