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

HaMMon Project:
innovative tools and technologies for the mitigation of Natural Risks

UnipolSai ASSICURAZIONI · Leitha · sogei

A. Petruccelli

Spoke 3 General Meeting

12-14 Giugno 2023

Dipartimento di Fisica e Astronomia – Università di Catania

HAzard **M**apping and vulnerability **MON**itoring

Project Context

Natural Hazard & AI

Project Target

Aims & Results

Project Innovation

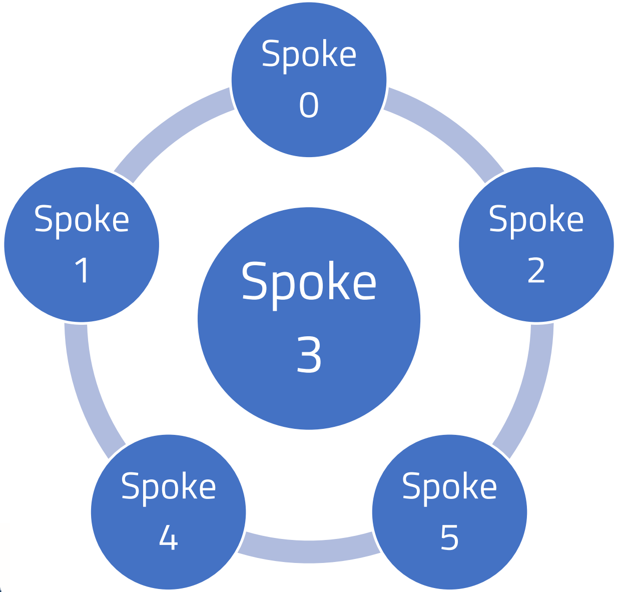
Impact on Insurance and PA

Project Implementation

WPs, Milestones & Budget

Finanziato dall'Unione europea NextGenerationEU
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

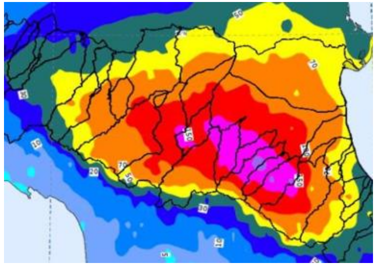
HAzard Mapping and vulnerability MONitoring



Hazard monitoring and vulnerability evaluation

Natural hazards impacts have shown a dramatic increase in recent years, especially along the Italian peninsula.

It becomes then crucial to evaluate local and regional impacts of **floods**, **landslides**, **earthquakes**, **droughts**, **storm surges**, **severe convective storms**, and related **extreme events**, in order to mitigate their risk and related expected losses.



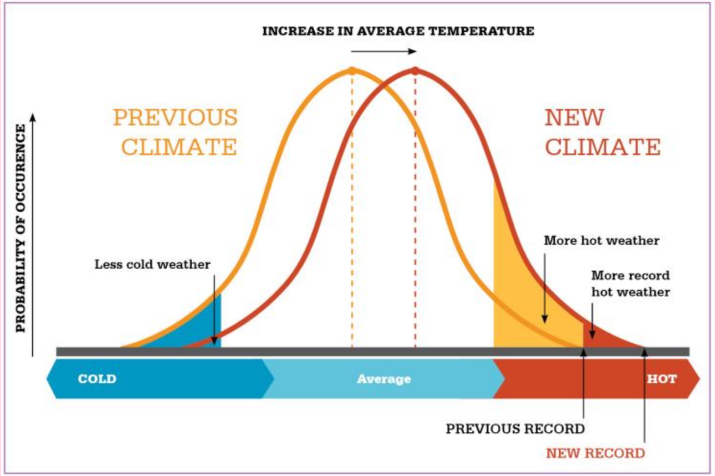
The overall risks from natural hazards does not rely only on hazard component but also on the **exposure** and **vulnerability** of both communities and human environments.

Climate Change and Extreme Weather Events

Climate change is the main driver of such an increase in meteorological extreme events.

Rising temperatures, increased precipitation rates, intense drought, sea-level rise, changes in oceanic and atmospheric circulations, intensified wildfires are some of the main consequences of the modification of climate patterns caused by climate change.

The overall trend shows that climate change is increasing the **frequency** and **intensity** of **extreme weather events** worldwide.



Source: Modified from IPCC, 2007

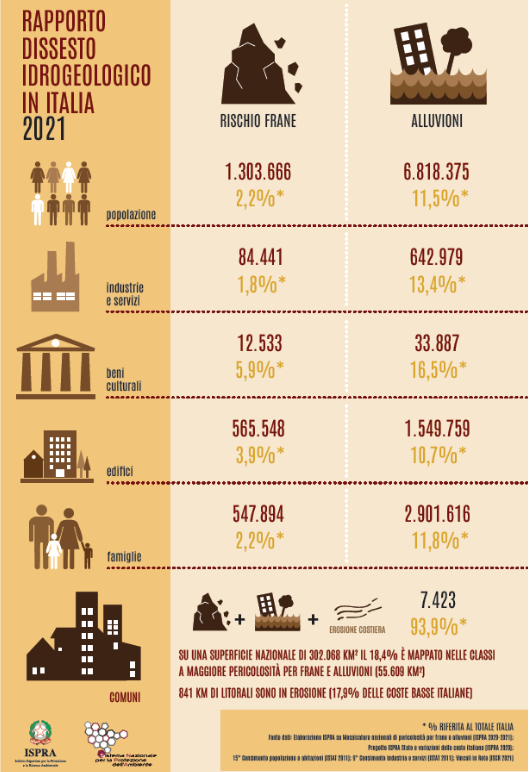
www.climatecommission.gov.au

Flood and landslides

Italy is one of the most prone country in the world to hydrogeological disease.

Among many, the main reasons are to be researched in human activity, soil erosion, disforestation, intense urbanization and inefficient risk-management strategies.

Moreover, climate change conditions make it very difficult to rapidly response to popping emergencies.



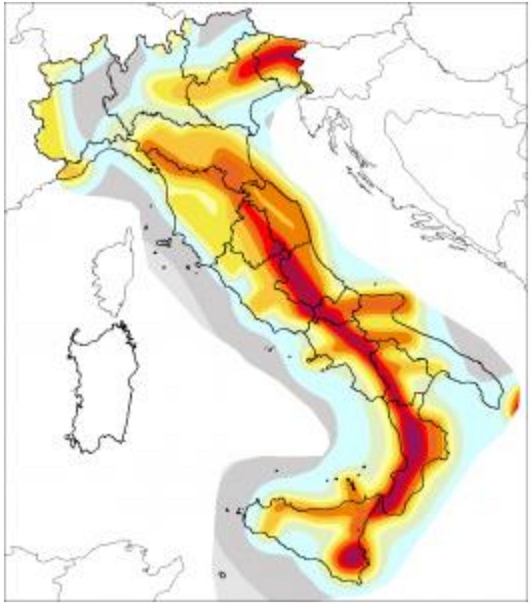
Source: ISPRA, 2021

Seismic Risk

Italy is located within a seismically active macro-region which experiences frequent seismic activity. Because of this, Italy has a long history and tradition of destructive earthquakes dated back to 1000 years ago.

Some regions, such as Central and Southern Italy, are rich of active faults and then particularly prone to seismic events.

Although the return period of destructive earthquakes can vary significantly depending on the specific region within Italy, by looking at historic datasets it is possible to detect at least one destructive earthquake every decade.



The role of Artificial Intelligence

The hazard impact is generally evaluated by means of physics-based and/or probabilistic numerical models.

These approaches strongly rely on large amounts of distinct classes of **data** from different sources.

Nowadays, thanks to the enormous availability of incoming new data and always better performant processing capabilities, artificial intelligence techniques and algorithms represent the ideal candidate tool to explore new horizons in hazard modeling and monitoring and possibly merging with traditional approaches.

Project aims

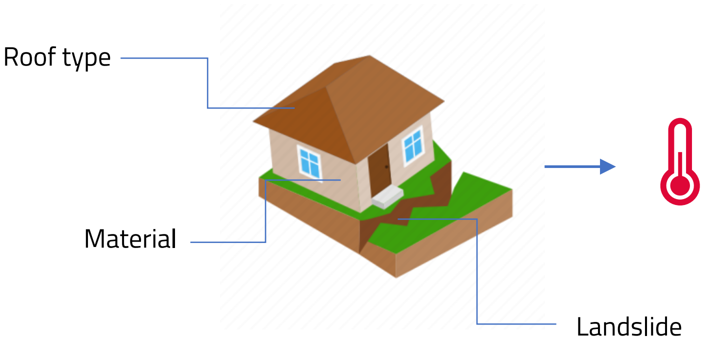
- Develop AI tools and technologies for risk management
- Monitoring, mapping, forecasting and assessing risks
- Extract meaningful information from assets

Project expected results / 1: Web applications

- **Remote inspection of damaged areas impacted by floods, earthquakes or landslides using AI**

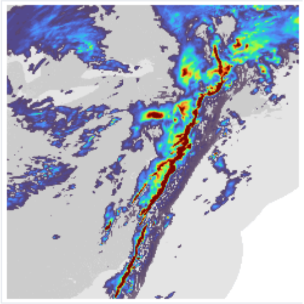
A web application will be designed aiming at the rapid estimate of losses and providing a tool for rescue operations and assistance to impacted areas.

- **3D models for building features extraction and disaster information**



Based on a workflow for the development of digital twins of exposed areas, the web service will expose 3D models to third-party applications with tools for the automatic (or semi-automatic) extraction of building and disaster information.

Project expected results / 2: Softwares



- **Weather Generator for Risk Management applications**

The project will conduct the design and implementation of seasonal forecast tools for the estimation of possible impacts based on short term weather.

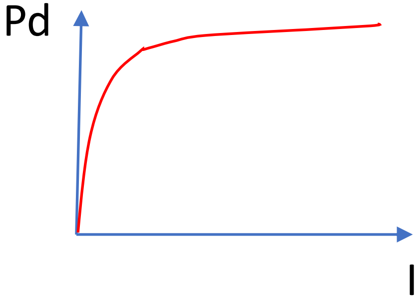
- **Building information based on satellite or street view images**

The main characteristics of the built environment in Italy will be mapped and classified using AI classification algorithms by using multiple data sources .

Project expected results / 3: Models

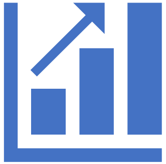
- **Vulnerability Curves Set**

Creation of vulnerability curves for earthquake, landslides and flood perils based on the building features automatically detected by AI models.



- **Seasonal forecasting models**

By evaluating both physical and data-driven approaches, the opportunity of coupling downscaling models to produce higher resolution data will be taken into consideration.



Project Infrastructure requirements

- Creation and configuration of the technological infrastructure to run and deploy the applications
- High availability geographically distributed and flexible solutions for managing and accessing heterogeneous data format and sizes
- Open-source solutions and technologies deployed and used in every Cloud Computing provider

- **Kubernetes**, Spark & Grafana & Jupyter, Cloud Storage with S3 interface, Git, GitLab (CI/CD), Nexus, ArgoWF

- Design and implementation of the HaMMon data archive

Impact on Insurance Business / 1: Post-event Analysis

- Enabling analysis of inaccessible areas affected by extreme natural events that would otherwise not be possible.
- The main impact will be in **claims management**, supporting the activities of claims handlers and adjusters.
- In particular, the latter will be able to consult the results of automatic analyses carried out by the algorithms developed during the project activities.

Impact on Insurance Business / 2: Expected Loss Scenarios

- Based on the results of seasonal forecasts and the output of a stochastic weather event generator, expected loss scenarios can be generated.

- In the insurance context, this will have implications in:
  - optimizing the **pricing** of insurance products
  - having more elements for defining the company's **reinsurance** programme
  - managing the **allocation** of capitals and of human resources.

Impact on Insurance Business / 3: Building Data Enrichment

- More appropriate pricing to the customer's **risk profile**;
- Identification of **potential frauds**, especially if the analysis is repeated on a regular basis
- Reinsurance, particularly in **treaty pricing**.
- Vulnerability curves impact on both **risk management** and **capital management** activities.

Impact on Public Administation (PA)

- **Emergency management and preparedness**

Loss scenarios can help PA authorities anticipate and prepare for potential weather-related emergencies

- **Infrastructure Planning and Maintenance**

Expected loss scenarios can guide PA authorities in infrastructure planning and maintenance.

- **Land Use and Urban Planning**

PA authorities can identify exposed areas and incorporate appropriate actions to mitigate weather-related risks

- **Resource Allocation and Budgeting**

Prioritize investments in susceptible areas and allocate funds to manage and mitigate potential losses

- **Public Communication and Education**

Raise awareness among the general public about weather-related risks, encourage preparedness and provide guidance on how to respond during emergencies.

Project Implementation: Work Packages

WP0
- Management

WP1
- Enabling Infrastructure

INFN, ENEA, Università di Torino, INAF, UNITRENTO, UnipolSai, Leithà

WP2
- Natural Disasters

UnipolSai, Leithà, ENEA, sogei, INAF, Università del Salento

WP3
- Weather Forecast

ENEA, CMCC, UnipolSai, Leithà, Fondazione Bruno Kessler, sogei

WP4
- Building Features

UnipolSai, Leithà, sogei, INAF, Politecnico di Bari, Università degli Studi di Bari Aldo Moro, ENEA

WP5
- Vulnerability Curves

Università degli Studi de L'Aquila, UnipolSai, Sapienza Università di Roma, Leithà, Politecnico di Bari, sogei

WP 0: Management

Objective: Activities coordination and management

Involved partners: UnipolSai, Leithà, Sogei, INAF, INFN, Università di Torino, UniTrento, Fondazione Bruno Kessler, Politecnico di Bari, Università degli Studi di Bari Aldo Moro, CMCC, ENEA, Università del Salento, Università degli Studi dell'Aquila, Sapienza Università di Roma, IREA

Description of work:
- Organization of the General Assembly (GA), Legal-IP Panel (LIP), Work Packages Assembly (WPA), Management Board (MB)
- Coordinate the technical activities of WPs and establishing communication flows and methods
- Ensuring optimal interactions with the ICSC foundation
- Developing and updating plans for long-term sustainability of the project

People involved:
Project coordinator (PI): Antonio Tirri - UnipolSai
Industrial Co-PI: Antonio Ballarin - Sogei
Research Co-PI: Fabio Vitello – INAF
System Engineer (SE): Costantino Cafaro - UnipolSai

WP 1: Enabling Infrastructure

Objective: Creation and configuration of a Kubernetes cluster and a set of services such as data archive, cloud storage, workflow management as well as test, dev and prod environments, with a high-performance approach.

Involved partners:

UNIVERSITÀ DI TORINO, INFN, INAF, UNITRENTO, ENEA, UnipolSai ASSICURAZIONI, Leithà

Task:

- T1.1: Infrastructure for PoC (**Leader: UniTo**; Contributors: INAF, UnipolSai-Leithà)
- T1.2: Infrastructure for production-level operational Services (**INFN**; UnipoSai-Leithà, ENEA)
- T1.3: Data Archive (**UniTN**; Unipolsai-Leithà)

Deliverables and milestones:

- D1.1 PoC level infrastructure (M7 – Nov23 – UniTO)
- D1.2 Use case requirements gathering (M7 – Feb24 - INFN)
- D1.3 Implementation of the first PoC of the Cloud Platform (M8 – Jun24 - INFN)
- D1.4 Implementation of the first integrated version of the Cloud Platform (M9 – Oct24 - INFN)
- D1.5 Implementation of the fully featured high-available Cloud Platform (M10 – Aug25 - INFN)
- D1.6 HaMMon Data Archive design (M7 – Feb24 - UNITN)
- D1.7 Final operational setup of the HaMMon Data Archive (M10 – Aug25 - UNITN)

WP 2: Natural Disasters

Objective:

- Improve damage assessment, claims processing and time needed for on-site inspections after a natural disaster
- Collecting requirements for the remote inspection of areas damaged by natural disasters
- Development of algorithms to identify and classify objects and features within 3D models and 2D images.

Involved partners: UnipolSai Assicurazioni, Leithà, ENEA, Sogei, INAF Istituto Nazionale di Astrofisica, Università del Salento

Description of work:

- T2.1: Workflow for data acquisition and creation of digital twin (**Leader: INAF**, Contributors: UnipolSai-Leithà, Sogei, ENEA)
- T2.2: Design of web application for remote inspection of areas damaged by natural disasters (**UnipolSai-Leithà**; INAF, Sogei)
- T2.3: Development of a web service to expose 3D models to third-party applications (**UnipolSai-Leithà;** INAF, Sogei)
- T2.4: Automatic (or semi-automatic) analysis (**INAF**; UnipolSai-Leithà, Sogei, UniSalento)

Deliverables and milestones:

- D2.1 Produce an algorithm for UAV data acquisition and creation of digital twin (M7 – Feb24 - INAF).
- D2.2 Deliver the design of a web application suitable for remote inspection in the aftermath of extreme vents (M8 – Jun24 - Unipolsai).
- D2.3 Deliver the web service for claim adjusters (M9 – Oct24 - Unipolsai).
- D2.4 Produce an algorithm for automatic or semi-automatic information extraction from digital twin (M10 – Aug25 - INAF).

WP 3: Weather forecast

Objective:
- Developing a system for seasonal forecasting for the hazard assessment of extreme events
- Creation of a weather generator tool for the characterization of climate change risks.

Involved partners: CMCC Centro Euro-Mediterraneo sui Cambiamenti Climatici, UnipolSai Assicurazioni, Leithà, FBK Fondazione Bruno Kessler, Sogei, ENEA

Description of work:
- T3.1 Impact insights from seasonal forecasts (**Leader: CMCC**; Contributors: FBK, UnipolSai-Leithà, ENEA, Sogei)
- T3.2 A weather generator for risk management (**CMCC**; FBK, UnipolSai)

Deliverables and milestones:
- D3.1 Analysis of seasonal forecast products (M8 – Jun24 - CMCC)
- D3.2 Derivation of an operational workflow for predictions of extreme events based on seasonal forecasts (M9 – Oct24 - CMCC)
- D3.3 CMCC - Prototype of a weather generator software for risk management applications (M10 – Aug 25 - CMCC)

WP 4: Building features

Objective:
- Mapping the main characteristics of the built environment in Italy
- Development of algorithms for the classification of the built environment using multiple data sources
- Development of vulnerability curves for a set of hazards by using abovementioned building features

Involved partners:

Description of work:
- T4.1 - Building Feature Extraction from aerial and satellite imagery (**Leader: UnipolSai-Leithà**; Contributors: INAF, UniBA)
- T4.2 - Building Feature Extraction from Street View Images (**UnipolSai-Leithà**; PoliBa, UniBa)
- T4.3 - Development of specific vulnerability curves (**CMCC**, Contributors: PoliBa, ENEA, UnipolSai-Leithà, IREA)

Deliverables and milestones:
- D4.1 Data provider shortlist and building features to monitor (M8 – Jun24 - UnipolSai)
- D4.2 Algorithm selection and dataset for ground truth (M9 – Oct24 - UnipolSai)
- D4.3 Vulnerability curves for seismic and flood risk (M10 – Aug25 - CMCC)
- D4.4 Classification models (M10 – Aug25 - UnipolSai)

WP 5: Vulnerability

Objective:

- Provide vulnerability assessment criteria for damage induced on structures by slow-moving landslides
- Assess future evolution of risk related to slow-moving landslides due to evolving climate

Involved partners:

Description of work:

- T5.1 - Assess risk related to slow-moving landslides for future climate scenarios (**Leader: PoliBA**; Contributors: UnipolSai-Leithà, Sogei, UniRoma1)
- T5.2 - Provide vulnerability assessment criteria for buildings affected by slow-moving landslides (**PoliBa**, UnipolSai-Leithà, Sogei, UniRoma1, UnivAq)
- T5.3 - Derivation of fragility and loss curves for structural and seismic risk for the existing residential building stock (**PoliBA**; UnipolSai-Leithà, Sogei, UniRoma1, UnivAq)

Deliverables and milestones:

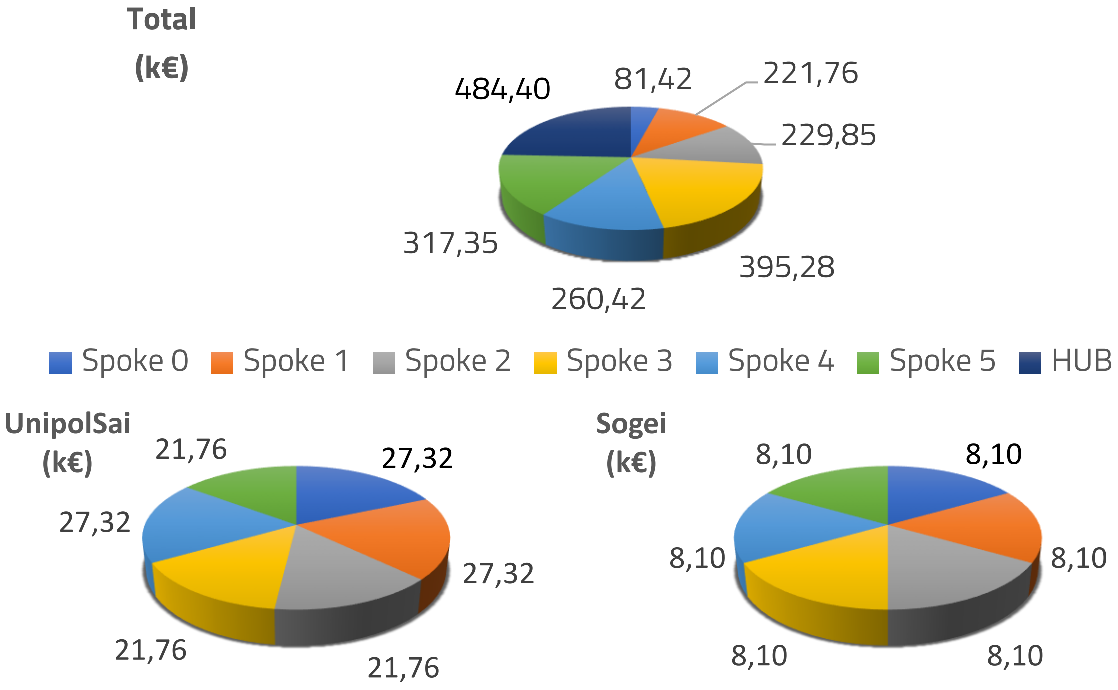
- D5.1 Sample numerical models of slopes affected by slow-moving landslides, endowed with guidelines for construction and initialization of the model, as well as for the application of weather-related boundary conditions. Results of analyses carried out using future climate scenarios (M9 – Oct24 - PoliBA)
- D5.2 Landslide-related damage charts for prototype cases (M9 – Oct24 - PoliBA)
- D 5.3 Fragility and loss curves for specific building typologies for structural and seismic risk. M10 – Aug25 - PoliBA)

Project implementation: Budgets

Project budget: 1.99 M€
Unipol budget (50%): 147 k€
Sogei budget (50%): 48.5 k€
Data acquistition: 300 k€
External assistence: 122 k€

Starting TRL: 5
Ending TRL: 8

46%



Project Implementation: Effort

Spoke	FTE	Level	Company
0	0.5	Impiegato	UnipolSai-Leithà
1	0.5	Impiegato	
2	0.25	Quadro	
3	0.25	Quadro	
4	0.5	Impiegato	
5	0.25	Quadro	
0	0.07	Dirigente	Sogei
1			
2			
3			
4			
5			

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Project implementation: Leithà - People involved

Project coordinator:

Antonio Tirri

System Engineer:

Costantino Cafaro

Data Scientists:

Francesco Lo Conti
Antonio Petruccelli
Glauco Gallotti
Francesco Asaro

UX Designer:

Egidio Scarlata

Thank you!