GIS GEOLab R&D activities

Politecnico di Milano – DICA | GEOlab
March 2023

esa ACEO
European Space Agency

UN-GGIM
ACADEMIC NETWORK

isprs
Information from imagery

OSGeo

ICA ACI

UN Open GIS
INITIATIVE

youthmappers

Copernicus
Academy

https://www.gisgeolab.polimi.it

Citizen Science

GIS & Geodata

EO

- User engagement
- Data collection, governance and verification
- Training and dissemination

- Software development
- Data Integration
- Data processing
- Quality assessment

- Risk assessment
- Susceptibility mapping
- Energy
- Environmental quality

Citizen Science

Citizen Science - Mobile apps and data dashboards development

Interreg
ITALIA SVIZZERA · ITALIE SUISSE · ITALIEN SCHWEIZ
Fondo Europeo di Sviluppo Regionale
UNIONE EUROPEA

SIMILE

https://github.com/interreg-simile/mobile-application

SIMILE Dashboard

SIMILE Mobile App

SIMILE - Monitorag
Politecnico di Milano
★★★★☆

Mobile
Application

✔ Administrative tool for management, visualisation, and editing of citizen science data shared through the mobile app.

Carrion, D., Pessina, E., Biraghi, C. A., and Bratic, G.: CROWDSOURCING WATER QUALITY WITH THE SIMILE APP, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLIII-B4-2020, 245–251, https://doi.org/10.5194/isprs-archives-XLIII-B4-2020-245-2020, 2020.

✔ Users can support the monitoring of the lakes by publishing a picture and additional details on the observation.
✔ The system is free and open source.

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LandslideSurvey App *(mobile, plugin and web)*

Overview:
A platform for landslide surveys that can be used by both professionals and non-professionals to map landslides and add useful information.

Usage:
Create new and keep up-to-date landslide inventories;
Improve the usability of the databases for hazard assessment and risk mitigation strategies.

Main goals:
help users with prior geological knowledge to collect relevant data following a well-established procedure;
guide un-experienced users in gathering structured and exhaustive data providing a simplified version of the application.

Advantages:
Free and Open Source;
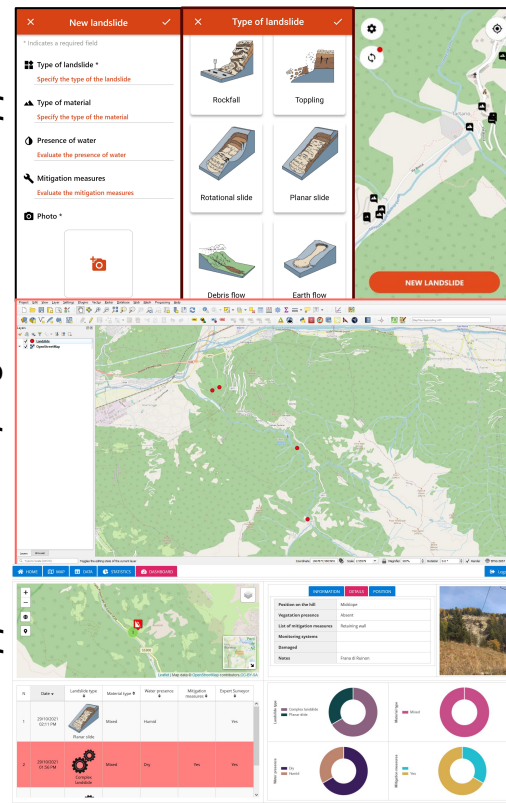Adapted for professionals and non-professionals.
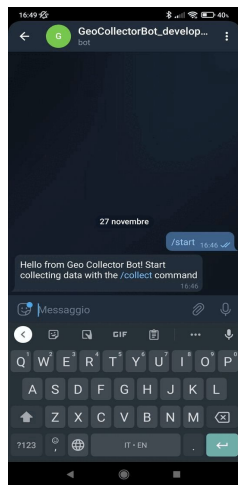Available in English, Italian and Vietnamese.

GEO LM IV

Geoinformatics and Earth Observation for Landslide monitoring Italy – Vietnam (GEOMILV)

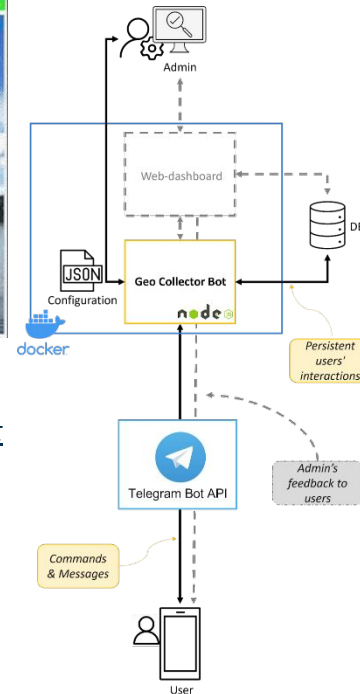*Mobile app*

QGIS plugin

Web app

Geo Collector Bot

configurable chatbot enabling the dispatching of data collection forms (including coordinates) that can be filled through Telegram chats

github.com/opengeolab/geocollectorbot

✔ Cross-platform (and FOSS)
✔ No mobile client development or maintenance
✔ No need (likely) to install additional apps to contribute to data collection

Oxoli, D., Pessina, E., and Brovelli, M. A.: GEO COLLECTOR BOT: A TELEGRAM-BASED OPEN TOOLKIT TO SUPPORT FIELD DATA COLLECTION, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVIII-4/W1-2022, 351–356, https://doi.org/10.5194/isprs-archives-XLVIII-4-W1-2022-351-2022, 2022.

- **Combination of AI and Citizen Science to:**
  - Increase Public Engagement
  - Simplify Data Validation
  - Improve Data Quality

- **Case study: Validation of biodiversity data in our citizen science project:**
  - Train models of species distribution using existing citizen science data
  - Use the trained models to validate location of new observations in real-time
  - Generate real-time feedback to the participants based on the likelihood of observing an species in a particular location

- **Results:**
  - Real-time feedback increased participants' motivation to continue contributing
  - Data quality improved as participants learned from the given feedback
  - Data validation phase was faster as a result of automatic filtering
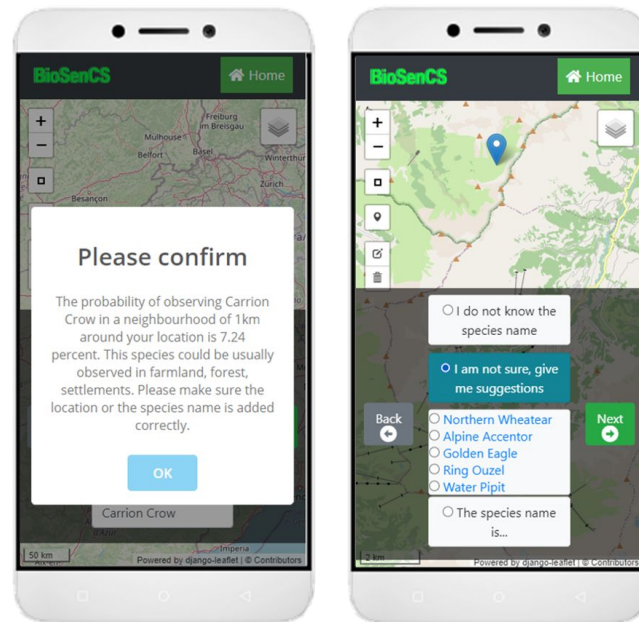
Lotfian, M., Ingensand, J., and Brovelli, M. A.: AN APPROACH FOR REAL-TIME VALIDATION OF THE LOCATION OF BIODIVERSITY OBSERVATIONS CONTRIBUTED IN A CITIZEN SCIENCE PROJECT, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVIII-4/W1-2022, 271–278, 2022.
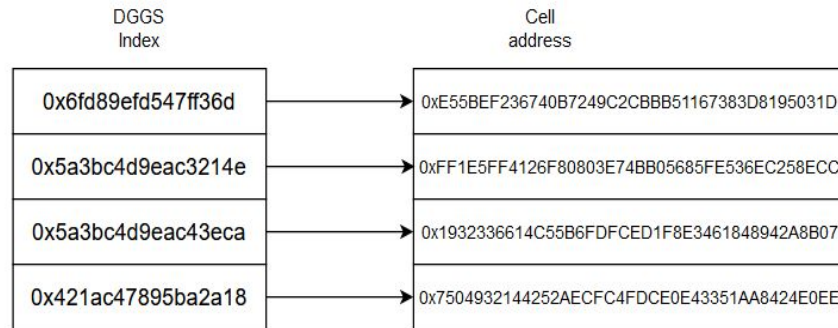
Geospatial Blockchain as a data sharing infrastructure

Blockchain has the following advantages:

Immutable + Decentralized + Consensus Based + Traceable

Blockchain architecture for the sharing and peer validation of citizen collected data in the context of SIMILE project

Map each discrete portion of the Earth (DGGS addresses) to an address of the blockchain. Each address contains only the data relative to that area

Users can upload their observations and vote the ones uploaded by others. The data and votes are directly connected to the users through their blockchain wallet address

| DGGS Index	Cell address
0x6fd89efd547ff36d	0xE55BEF236740B7249C2CBBB51167383D8195031D
0x5a3bc4d9eac3214e	0xFF1E5FF4126F80803E74BB05685FE536EC258ECC
0x5a3bc4d9eac43eca	0x1932336614C55B6FDFCED1F8E3461848942A8B07
0x421ac47895ba2a18	0x7504932144252AECFC4FDCE0E43351AA8424E0EE

Meta Data for Good

https://dataforgood.facebook.com
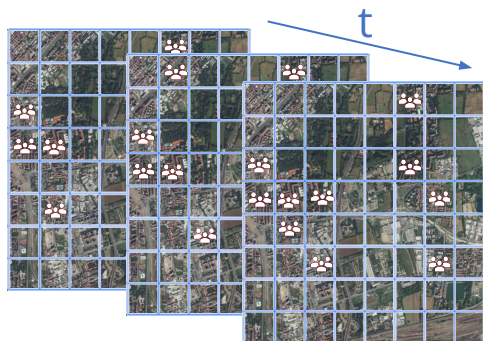
Investigation of space-time patterns of people presence/antropic pressure using social media-derived data (*Facebook Population Maps*)
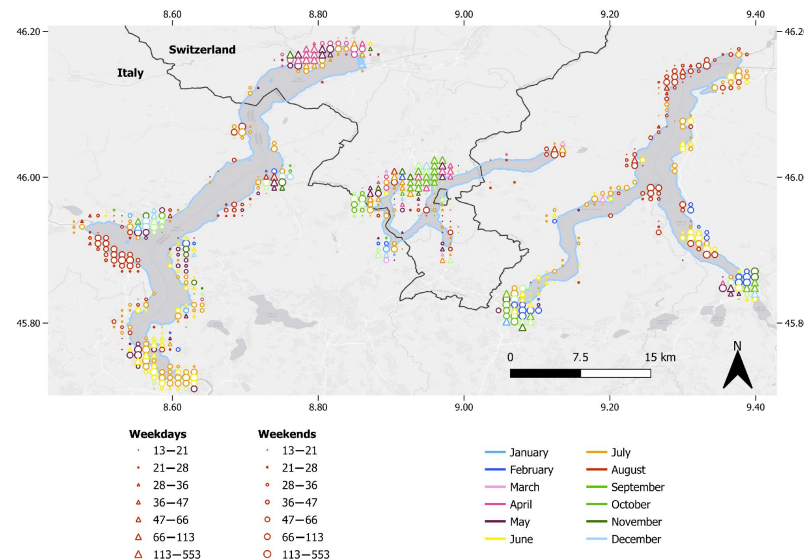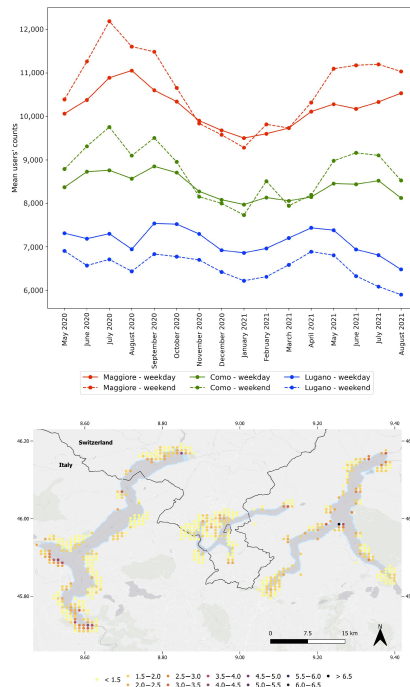
Vavassori A, Oxoli D, Brovelli MA. Population Space–Time Patterns Analysis and Anthropic Pressure Assessment of the Insubric Lakes Using User-Generated Geodata. ISPRS International Journal of Geo-Information. 2022; 11(3):206. https://doi.org/10.3390/ijgi11030206

Motivation

Analysis of ground air temperature measurements for microclimate studies (e.g., UHI) in the Metropolitan City of Milan, by integrating:

- official data from **ARPA Lombardia** network,
- crowdsourced data from **Netatmo network** to increase spatial coverage.

However, crowdsourced data are not distributed with quality standard certification.

Objective

Development of an <u>automatic procedure</u> (through Python scripting) for the cleaning of crowdsourced temperature data using official data.

The procedure aims to identify and remove outliers and faulty stations based on statistical comparisons with the official data.

- ARPA
- Netatmo
- Study area
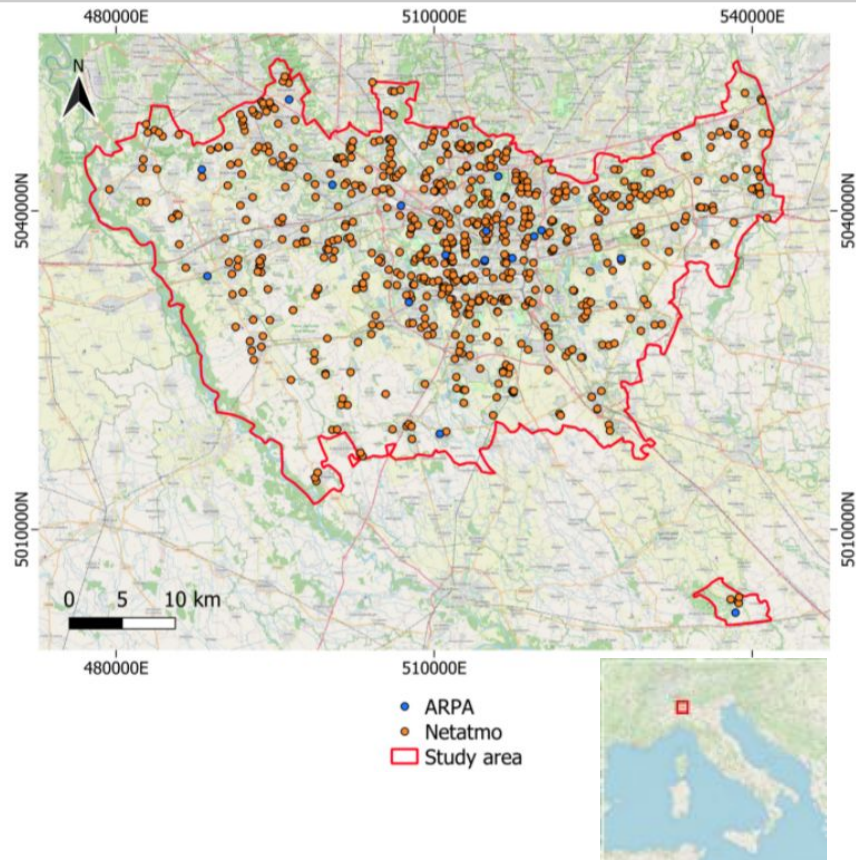
SIMILE (Informative System for the Integrated Monitoring of Insubric Lakes and their Ecosystems)

- Seminars and teaching activities in 13 secondary schools close to Como and Maggiore Lakes, involving around 40 classes.
- The activities are dedicated to lake water quality preservation, to the introduction to SIMILE project and to teaching the use of the SIMILE mobile application for Citizen Science.
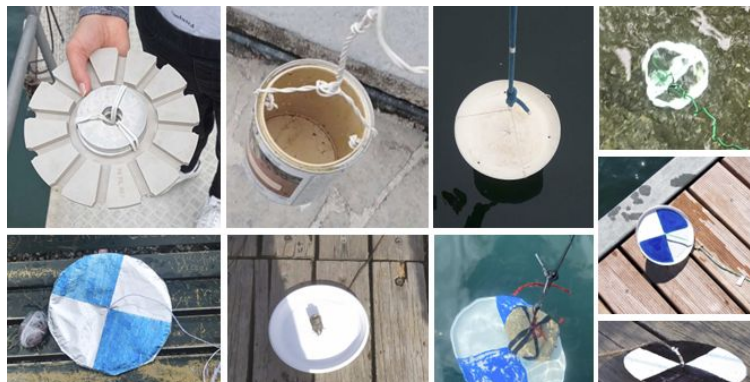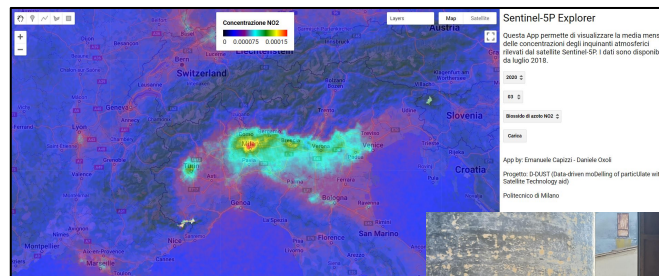

Secchi disks produced by School pupils with recycled material

D·DUST

D-DUST (Data-driven moDelling of particUlate with Satellite Technology aid)

- Seminars with 3 agricultural high school on the impacts of intensive farming activities on air quality
- Workshops to show how to use satellite and sensor air quality data

GIS4SCHOOLS (2020 - 2023)

Improving STEAM (Science, Technology, Engineering, the Arts and Mathematics) Education in Secondary Schools through the development and co-creation of new methodologies for teaching to and exploitation by pupils of GIS products related to climate impact on the environment.

https://gis4schools.readthedocs.io/en/latest
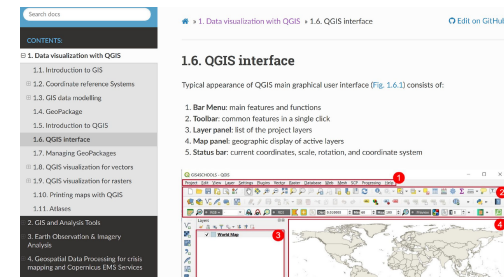
Capacity building for disaster management in Mozambique through teaching public participatory GIS and Spatial Data Infrastructure CIDMA (2020 – 2022)

Building education capacity to improve disaster management in Mozambique, using geospatial information technology by developing innovative and blended courses in GIS/RS for disaster management.
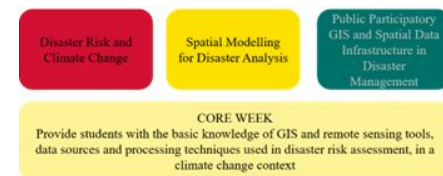
Climate change Adaptation using Digital geospatial twins and Earth Observation CADEO (2023 – 2026)

The project consists of designing, implementing, and blending teaching of four new innovative courses, training of trainers in HEIs of Vietnam, development of required digital infrastructure for Vietnamese HEIs, and dissemination of the results to wider society. Higher education programmes on: *Earth Observation (EO), Digital Twin Earth, Geospatial Web applications and Geospatial Intelligence.*
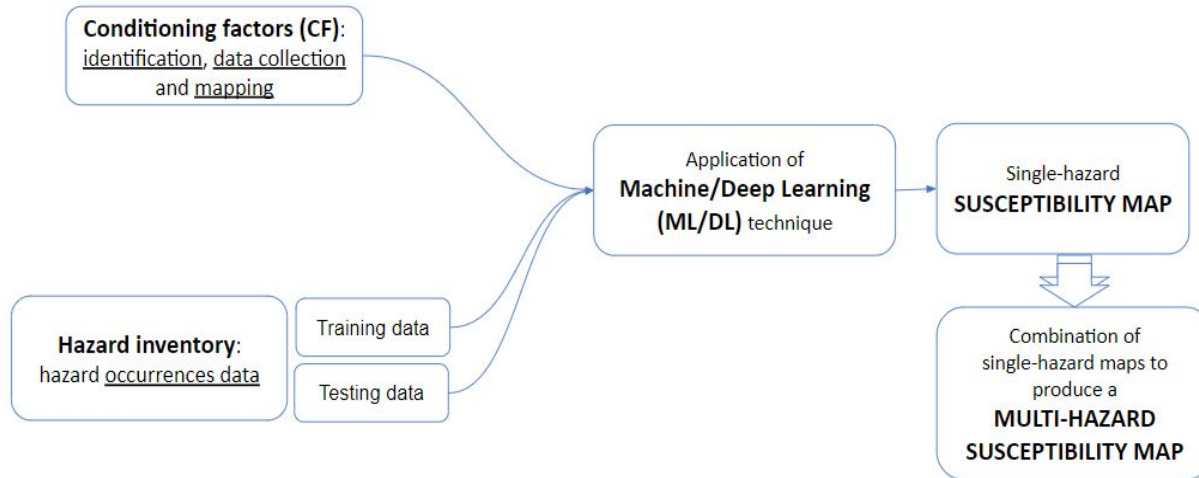
Earth Observation

Harmonia project: development of a support system for improving urban resilience and sustainability with respect to climate change challenges and extreme events. The focus of the project is on the 4 pilot cities: Milan, Sofia, Ixelles, Piraeus.

The goal of our task is the creation of *single and multi hazard susceptibility maps* for various natural and anthropogenic hazards (e.g. Urban Heat Islands, urban floods, air pollution, …) with the use of machine and deep learning techniques.
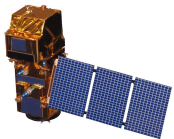
Workflow of our task:

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ASI I4DP Science - Local Climate Zones & Open Data Cube (LCZ- ODC)

Input data

PRISMA (Hyperspectral Imagery)
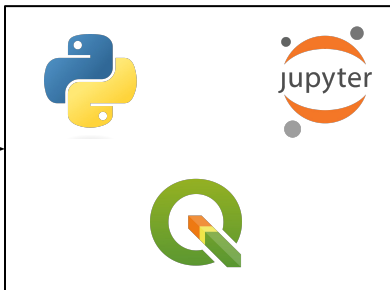
Goal: Identification of **Local Climate Zones (LCZ)** and study of their correlation with air temperature in the Milan Metropolitan City through the integration of geospatial data and Earth Observation technologies in the **Open Data Cube (LCZ-ODC)** environment.
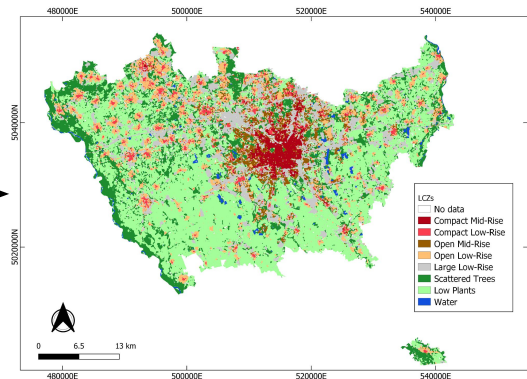
Sentinel-2 (Multispectral Imagery)

Processing Tools

Data Management and Analysis Software

Output LCZ Maps

In-situ Temperature observations

Geoinformatics and Earth Observation for Landslide monitoring Italy – Vietnam (GEOMILV)

GEOLMIV *(from 2021)* - joint project between PoliMi and Hanoi University of Natural Resource and Environment, Vietnam. The Italian side is funded by Ministero degli Affari Esteri e della Cooperazione Internazionale.
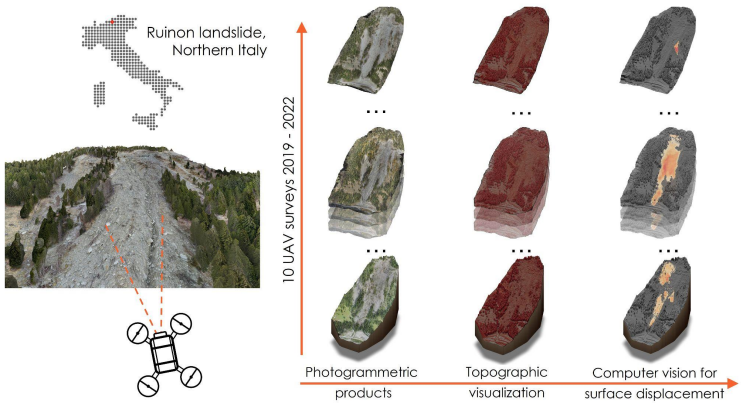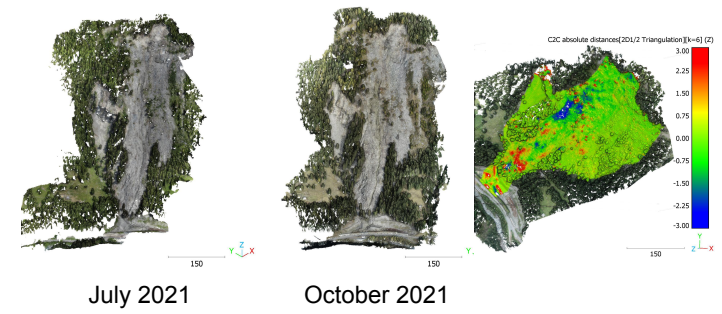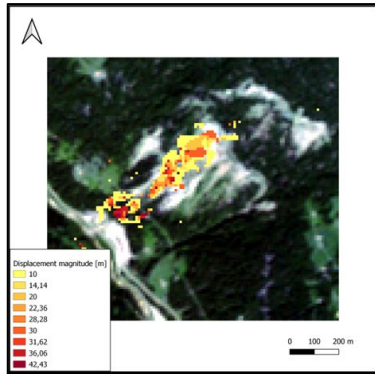
Landslides are affecting:
- lives,
- environment,
- economical aspects.

Hazard mapping and risk mitigation strategies have already adopted ground, air or spaceborne EO techniques and GIS for landslide mapping and monitoring.

Landslide monitoring through air- and spaceborne optical datasets for estimating surface displacements.
- satellites,
- UAVs.

July 2021 October 2021

Ruinon landslide, Northern Italy

10 UAV surveys 2019 – 2022

Photogrammetric products | Topographic visualization | Computer vision for surface displacement

Displacement magnitude [m]
- 10
- 14,14
- 20
- 22,36
- 28,28
- 30
- 31,62
- 36,06
- 42,43
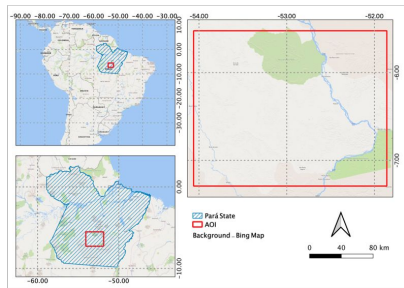
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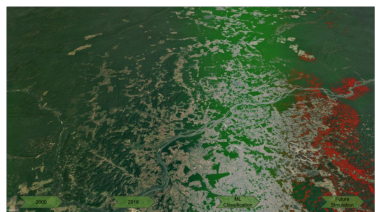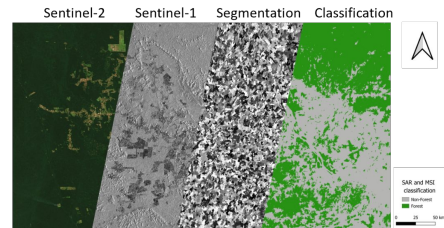# Monitoring Tropical Forest Change Using Multi-Temporal Remote Sensing Data and Machine Learning on Google Earth Engine
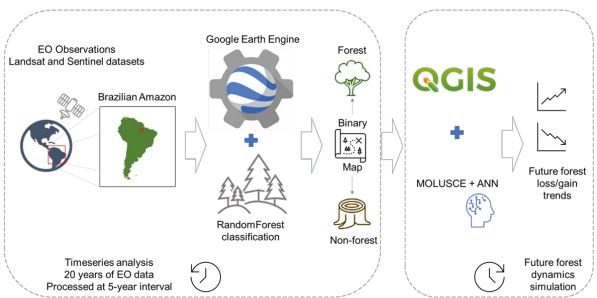
General workflow
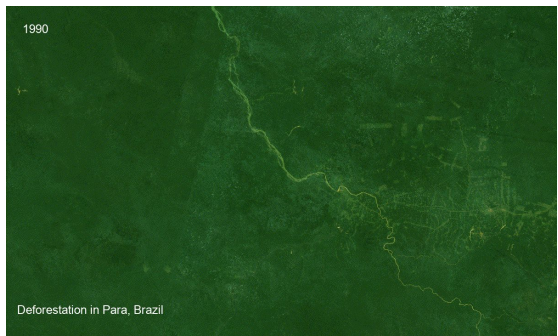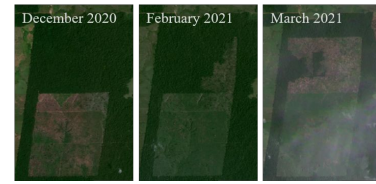
Case study – Pará State, Brazil

Processing
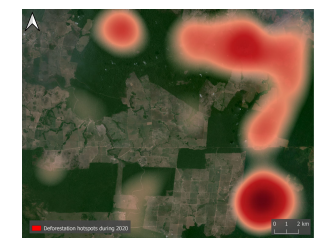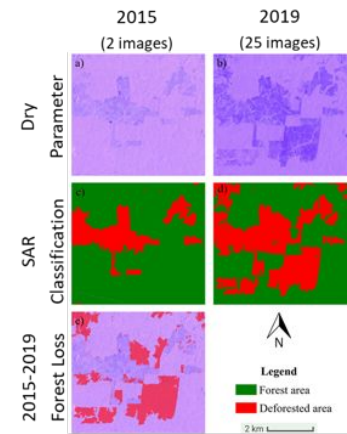
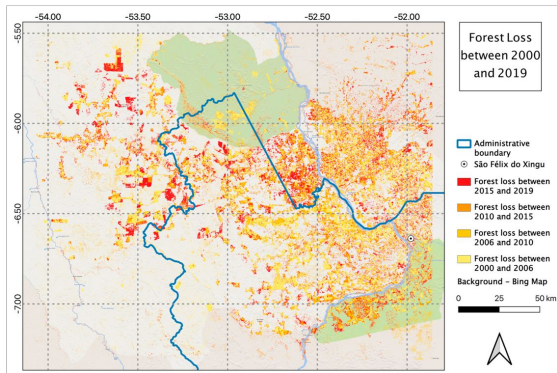Optical MSI pixel-based approach

SAR and MSI object-based approach

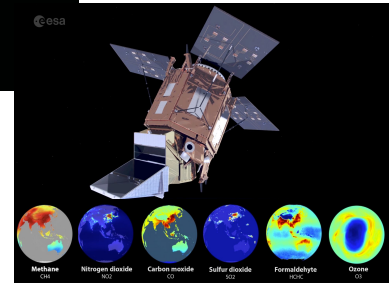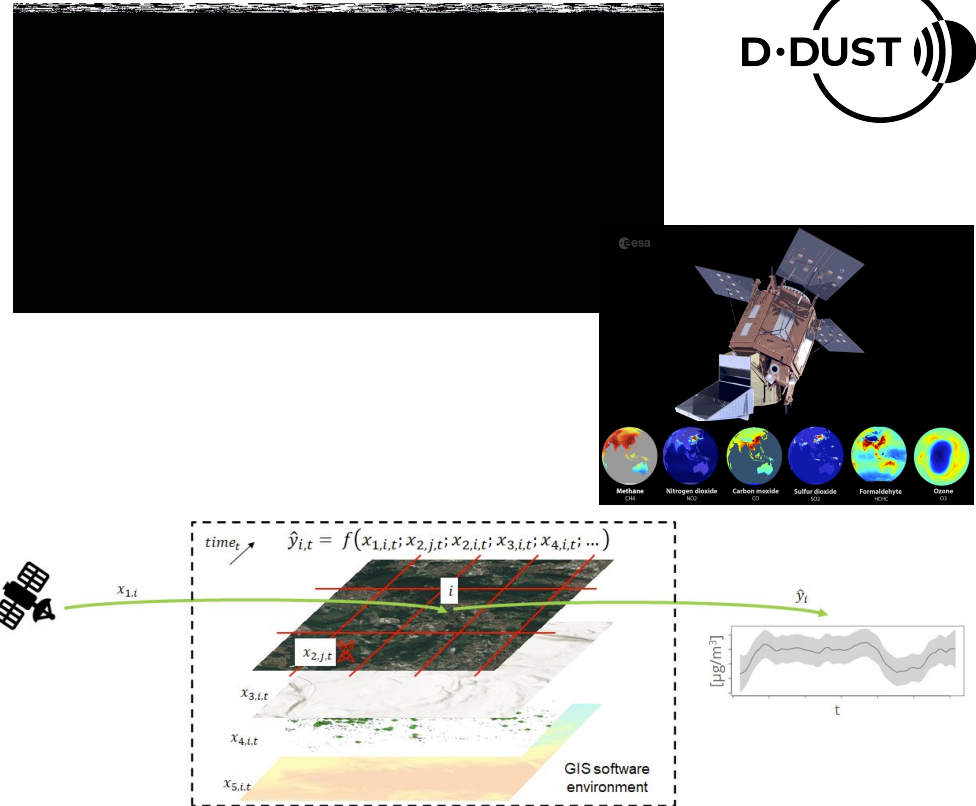**D-DUST** (Data-driven moDelling of particUlate with Satellite Technology aid)

- Multispectral satellite imagery can provide consistent daily high-resolution estimates of tropospheric constituents (including **air pollutants**) on a global scale.

- Their combination with ground-sensor observations is expected to radically change air quality monitoring and airborne pollutants exposure assessment in the coming years.

- Funded by **Fondazione Cariplo** → focus on fine PM emissions from intensive farming activities and Sentinel-5P data (through the integration of ML and geostatistical algorithms)

$$\hat{y}_{i,t} = f\left(x_{1,i,t}; x_{2,j,t}; x_{2,i,t}; x_{3,i,t}; x_{4,i,t}; \dots\right)$$

SIMILE - Water Quality Monitoring

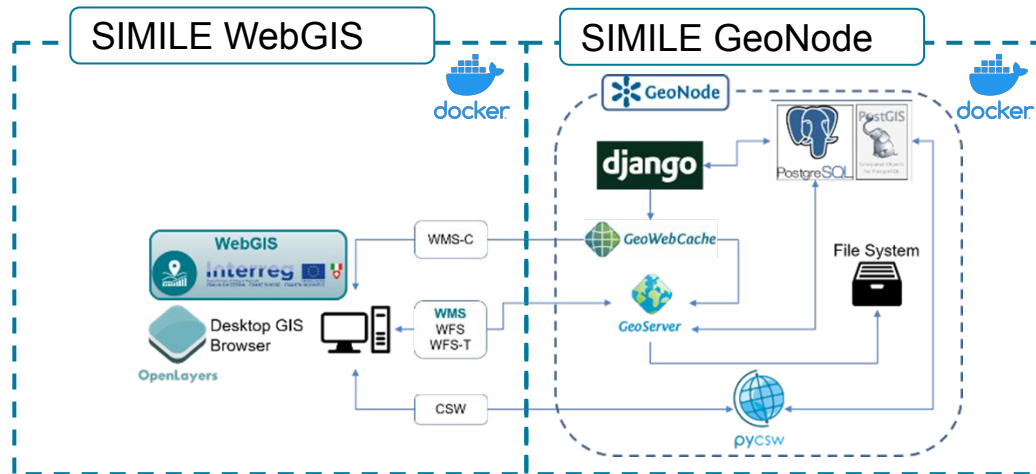https://www.geonode.eo.simile.polimi.it

https://www.webgis.eo.simile.polimi.it

SIMILE WebGIS

SIMILE GeoNode
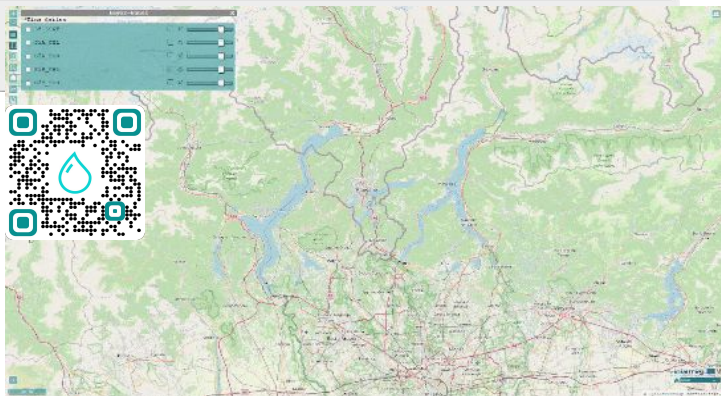
✓ Production of Water Quality Parameters maps obtained processing Sentinel-3 and Landsat-8 imagery in the framework of SIMILE Interreg project (since January 2019).

✓ The maps obtained with satellite monitoring enhance the capacity of traditional sampling campaigns, allowing to go towards a synoptic and high frequency survey

Toro Herrera, J. F., Carrion, D., and Brovelli, M. A.: A COLLABORATIVE PLATFORM FOR WATER QUALITY MONITORING: SIMILE WEBGIS, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLIII-B4-2021, 201–207, https://doi.org/10.5194/isprs-archives-XLIII-B4-2021-201-2021, 2021.

Renewable energy

Analysis of the suitable areas for new photovoltaic plants to be built. With the goal of 30% of the energy produced in Italy with renewable energy by 2030.

Research on the methodologies to identify abandoned agricultural land using satellite images and spectral indices.

Study of the use of applications like agrivoltaics considering the Water-Energy Nexus. Creation of Evapotranspiration maps with the improvement of Sen-ET methodology.
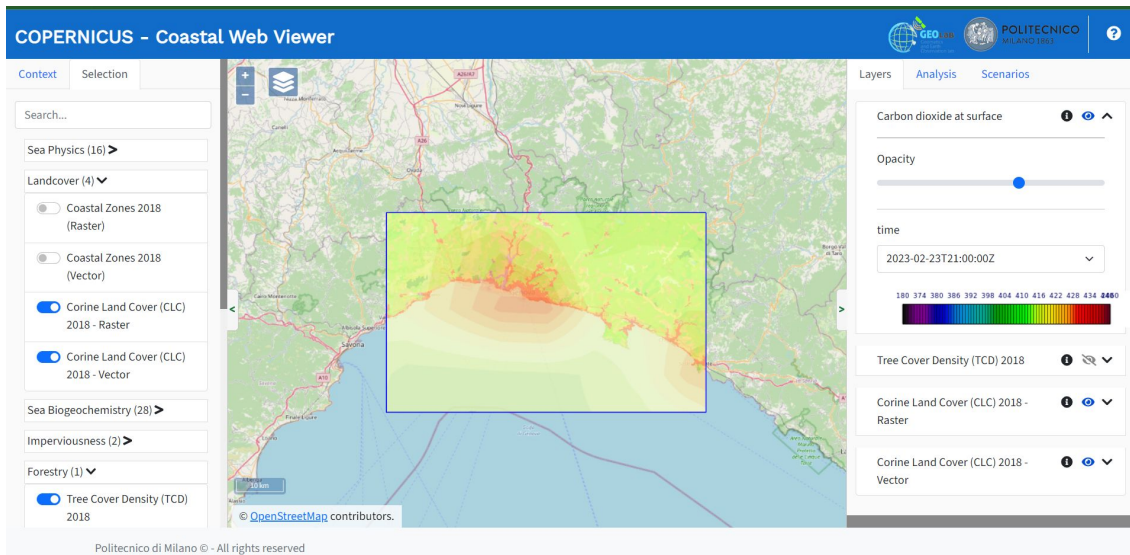
(collaboration with RSE S.p.A)
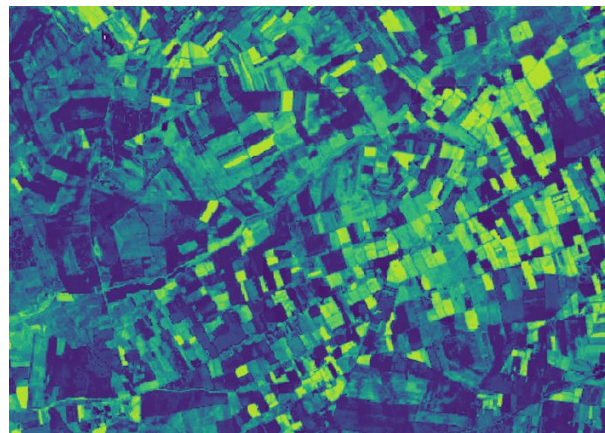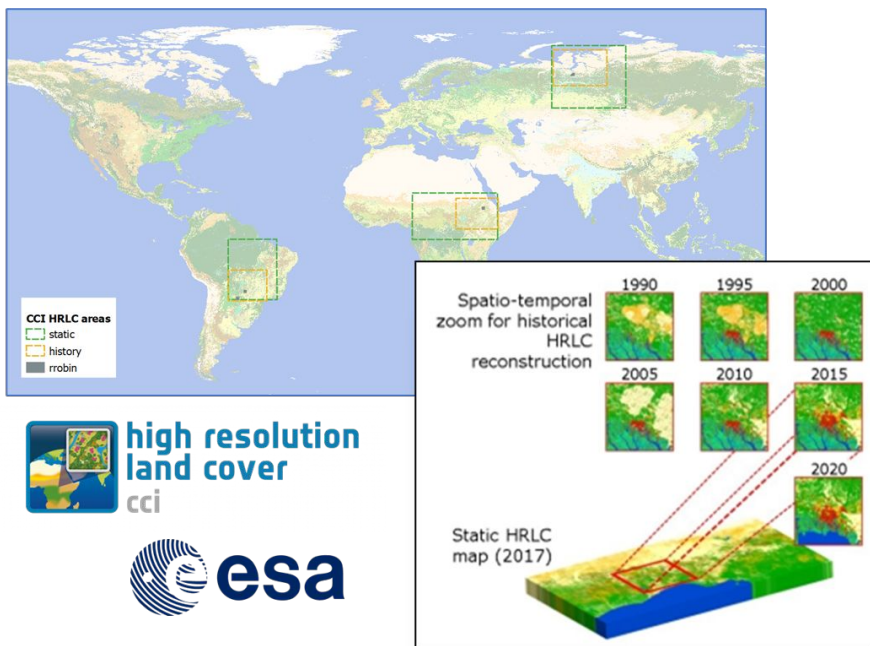
Digital Twins - Coastal Web Viewer

- **Web platform** that integrates over **60** geospatial layers from **different data sources.**
- Allows **parametric visualization and data analysis.**
- **Modular** application that uses the **Mediator/Wrapper** architecture to integrate several data sources, allowing **replication and scalability.**
- Centered on italian coasts, but replicable to other areas.

- Moving towards **Digital Twin Cities**

http://ec2-3-70-64-164.eu-central-1.compute.amazonaws.com/

Temporarily…

CCI HRLC areas
- static
- history
- rrobin

high resolution
land cover
cci

Spatio-temporal zoom for historical HRLC reconstruction

1990 1995 2000
2005 2010 2015
2020

Static HRLC map (2017)

CCI+ HRLC project aims at determining the role of the spatial resolution of LC and LCC to support climate research

Following project outputs are produced for Amazon, Sahel and Siberia:

- A static HRLC at 10m resolution as input to the climate models
- The long-term record of regional HRLC maps at 30m in the regions identified for the historical analysis every 5 years since 1990
- The change information at 30 m and yearly scale
- Two land cover maps produced from optical and SAR processing chain and fused eventually

We are part of the validation team in charge for inter-comparison with existing HRLC.

GIS & GeoData

- **COVID-19:**
  - Analysis of the correlation between the velocity of COVID diffusion and environmental pollution. A spatial characterization of the territory allowed computing clusters of similar areas, resulting in the identification of a correlation with the levels of ammonia

  - Implementation of an early alert model with high granularity, capable of anticipating by a few days the increase in the demand for ambulances in each municipality of the Lombardy region
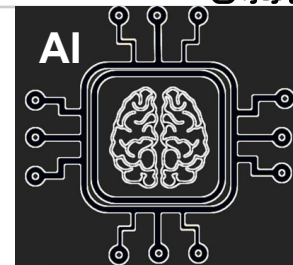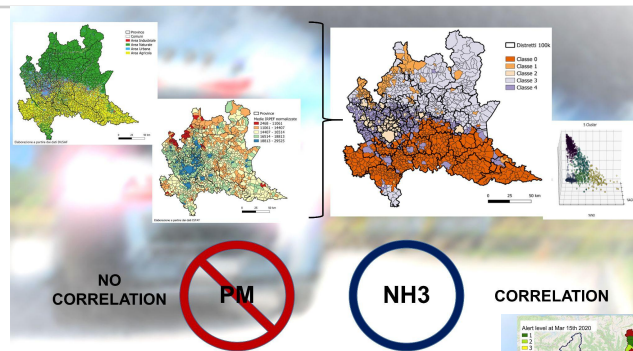
- **Air pollution:**
  - Comparison between daily air quality analyses produced by the Copernicus Atmosphere Monitoring Service (CAMS) and pollutant measurements obtained from the regional environmental agency of Lombardy (ARPA Lombardia)

NO CORRELATION — PM

NH3

CORRELATION
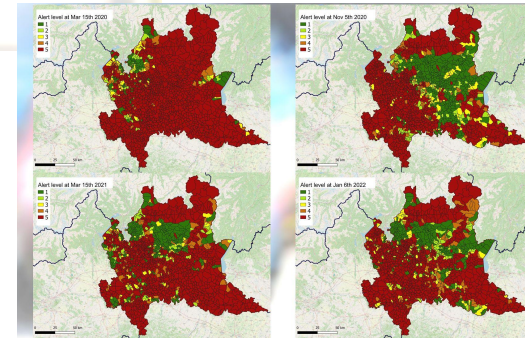
© OpenStreetMap contributors

Atmosphere Monitoring Service
atmosphere.copernicus.eu

ARPA LOMBARDIA

Geoinformatics and Earth Observation for Landslide monitoring Italy – Vietnam (GEOMILV)

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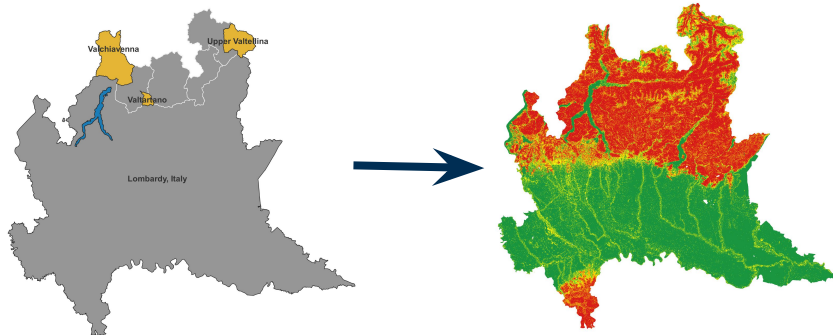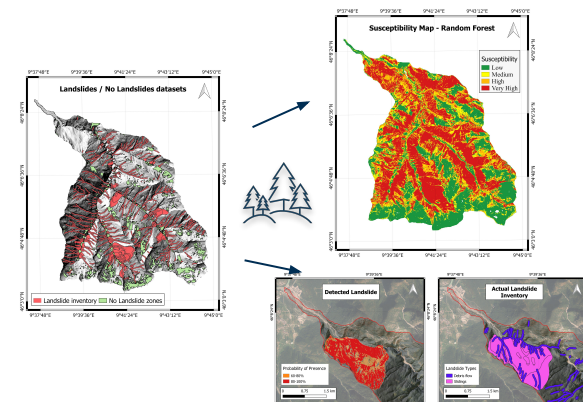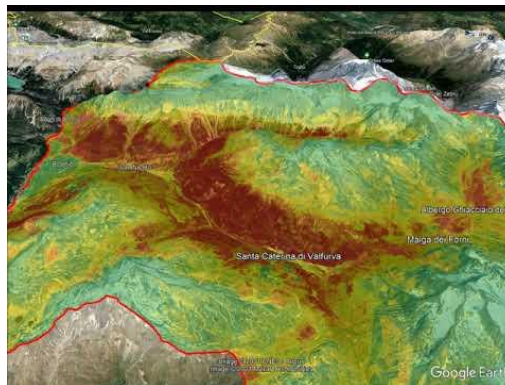
Landslides are affecting:

- lives,
- environment,
- economical aspects.

Hazard mapping and risk mitigation strategies have already adopted ground, air or spaceborne EO techniques and GIS for landslide mapping and monitoring.

Susceptibility mapping (the spatial probability of an event) is the first step in the hazard evaluation.

Modelled using variety of ML algorithms.

Introducing concepts as No Landslide Zonation.

Thank you!

https://www.gisgeolab.polimi.it