EUR-OPA MAJOR HAZARDS AGREEMENT
ACCORD EUR-OPA RISQUES MAJEURS

CERG - European Centre on Geomorphological Hazards
GHHD - European Centre "Geodynamical Hazards of High Dams
CRSTRA - Centre for Scientific and Technical Research on Arid Regions
ECILS - European Centre on Vulnerability of Industrial and lifelines systems
ECNTRM - European Center for New Technologies of Risk Management

Project 2020-2021

Results 2020 and objectives 2021

Operational testing and diffusion of innovative and cost-effective monitoring systems for the monitoring and early warning of geohazards affecting watersheds and critical infrastructures

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Rationale:

Setup of **automated monitoring and assessment criteria** for anticipating **geohazards** and maintaining long-term safety of **critical infrastructures** with:

1) in-situ/remote sensor data acquisitions systems,
2) efficient telemetry systems and databases
3) anomaly detection algorithms and decision support systems.

Objective:

2020 **Demonstration of in-situ sensors for landslides, floods and engineering projects:** Results of operational testing of low-cost sensor systems for the different use cases – Return of experience **Demonstration of remote satellite-based sensors for landslides, floods and engineering projects:** Information on satellite technology for monitoring geohazards/engineering projects deformation, and rainfall triggering events dam and surrounding area deformation
2021 **Prototype multi-parametric data analysis systems integrating:** Delivery of open source computer programs and algorithms for the analysis of sensor data, and for combining all sources of information to detect deviations from normal behaviour. **Dissemination activities:** Manuals describing the use of the technology and organization of an training course *"Low-cost sensors and detection methods for geohazards and infrastructure projects".*

Towards simple and operational guidelines to select the best combination of sensors/instrumentation and processing methods/models for geohazards monitoring and warning

- Characterisation and Monitoring sensors
  - Ground survey
    - Remote-sensing
      - **Passive optical sensors** — *Multi-spectral and visible imagery, etc.*
      - **Active optical sensors** — *Distance-meter, LiDAR, etc.*
      - Passive microwave sensors — *Radiometer, etc.*
      - **Active microwave sensors** — *RaDAR Interferometry, Polarimetry, etc.*
    - In-situ
      - Radionavigation systems — *Navstar GPS, Glonass, Galileo, etc.*
      - Geotechnical systems — *Extensometer, Tiltmeters, etc.*
      - **Other** — *Pluviometers, Stream gauges, etc.*
  - Sub-surface survey
    - Non-intrusive geophysics
      - Seismic — *Seismic refraction, ambiant noise monitoring, etc.*
      - Acoustic — *Multi-beam sonar, etc.*
      - Electro-magnetism — *Electro-resistivity tomography, Magnetism, etc.*
      - Gravity — *Gravimeters, etc.*
      - Radioactivity — *Gamma ray spectroscopy, etc.*
    - Intrusive
      - Drilling and equiped borehole — *Geophysical and core logging, Piezometer, Inclinometer, etc.*

Objective 2020

WP1: Assembling and testing low-cost systems (camera, tils/strain, seismometer) and field installation – Pre-processing of the sensor data.

WP2: Review of existing satellite sensors and processing methods for the analysis of deformation and rainfall properties

WP3: Development of open source computer programs for the analysis of the sensor data, and for the detection of anomalies using machine learning approach – focus on the deformation/rain monitoring data.

WP4: Redaction of the sensor technical documents

Objective 2021

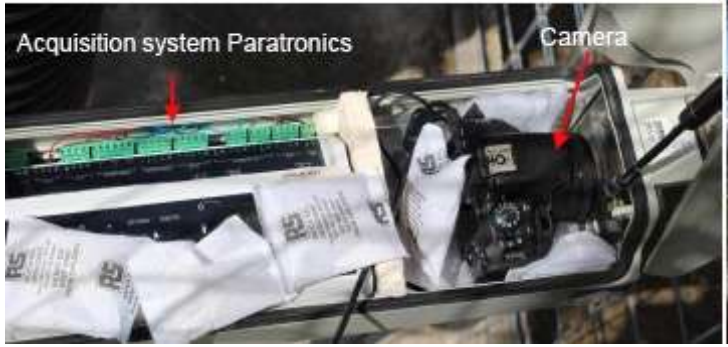
WP5: Final development of the open source multi-sensor analysis programs, release of the user manuals, and of a demonstrator use case (including indicators such as time series and maps).

WP6: Coordination of the redaction of the guidelines (with input of all partners) for the selection of the low-cost sensors and processing methods. Organization of the intensive course *"Low-cost sensors and detection methods for geohazards and infrastructure projects"*

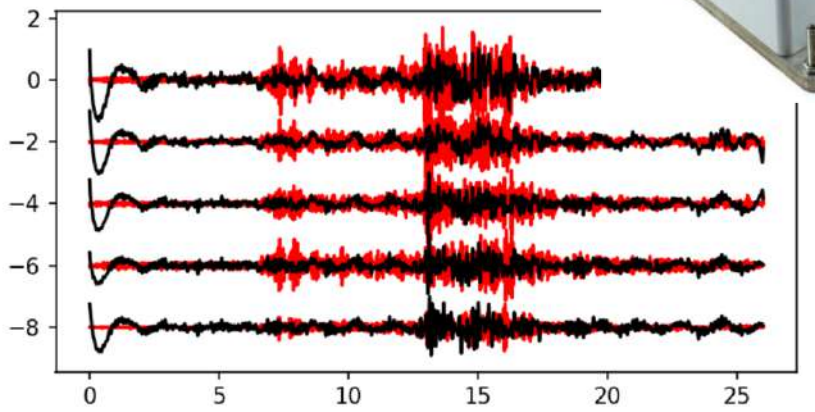
WP1: **Assembling and testing low-cost systems (camera, tils/strain, seismometer) and field installation**
Pre-processing of the sensor data.

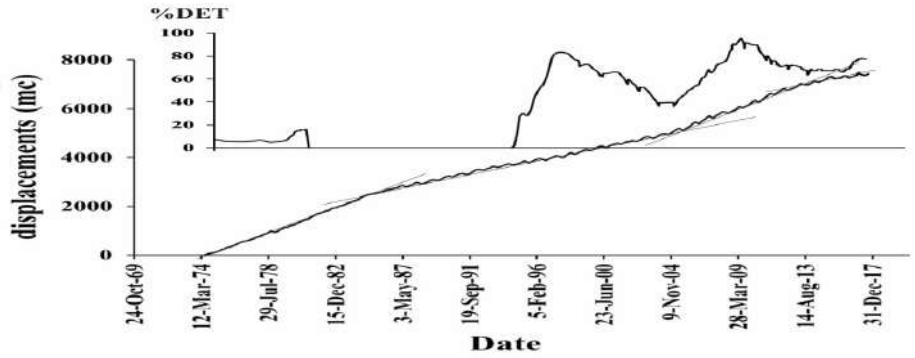
In-situ sensors

Low-cost camera
(ca. 1k€)



Low-cost seismometer
(ca. 1.5k€)

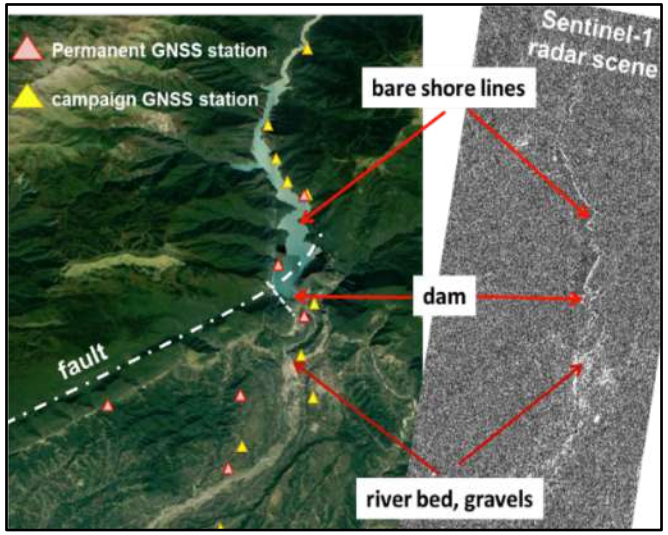




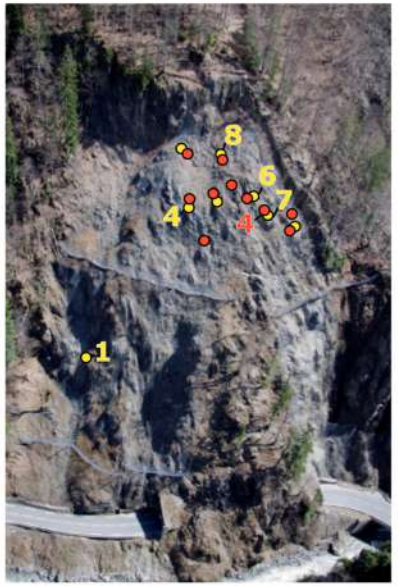
Low-cost strain/tiltmeter
(ca. 1.2k€)

WP1: **Assembling and testing low-cost systems (camera, tils/strain, seismometer) and field installation**
Pre-processing of the sensor data.

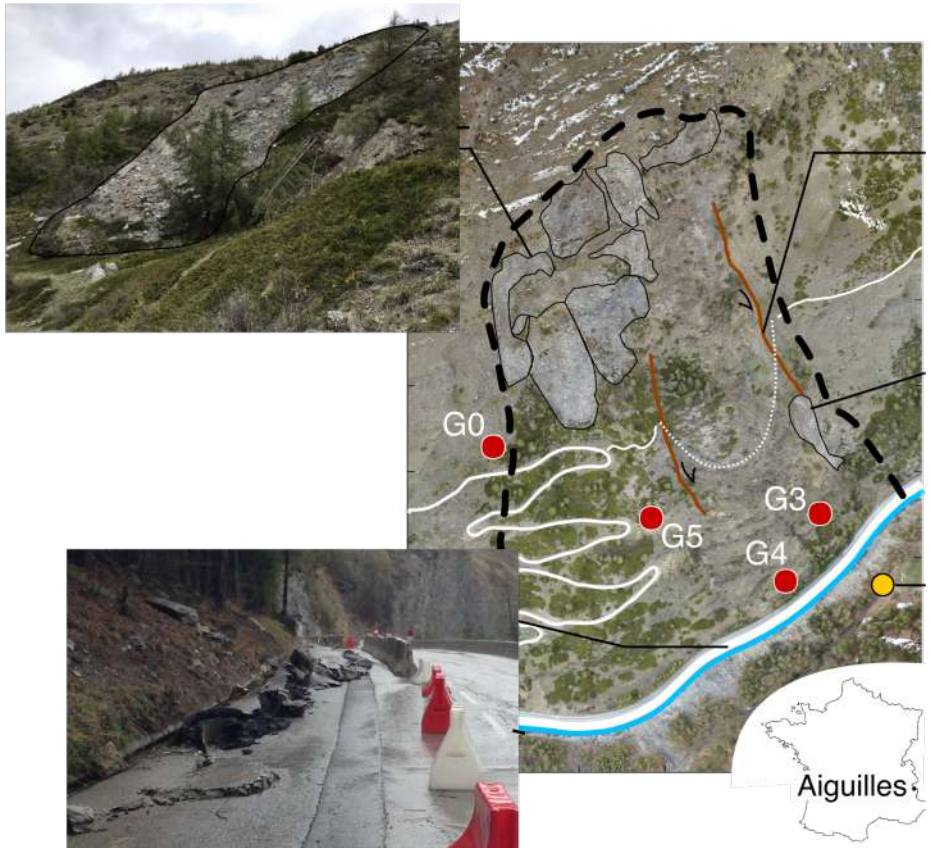
Use cases for operational testing



Enguri Dam (Georgia)



Cliets rockfall (France)

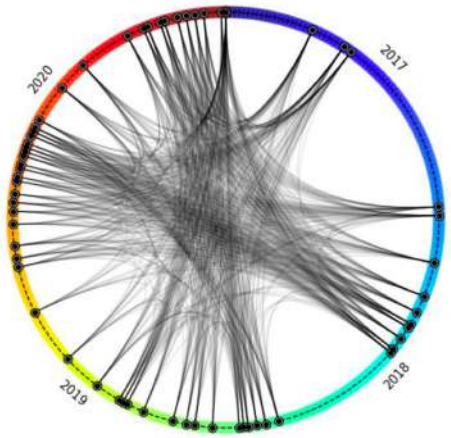


Aiguilles slow landslide (France)

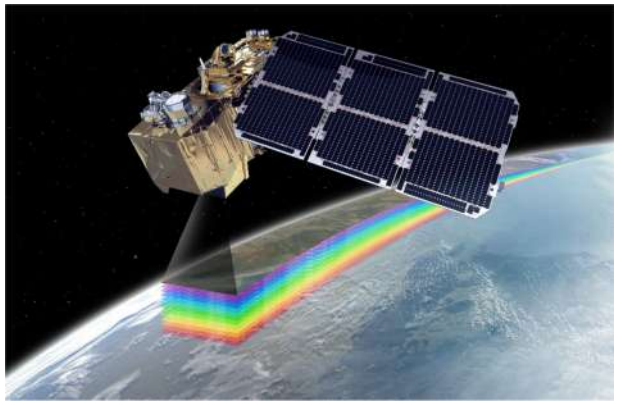
Further testing in 2021 in Algeria (flash flood, CRSTRA) and North Macedonia (landslide, ECILS)

WP2: Review of existing satellite sensors and processing methods for the analysis of deformation and rainfall properties

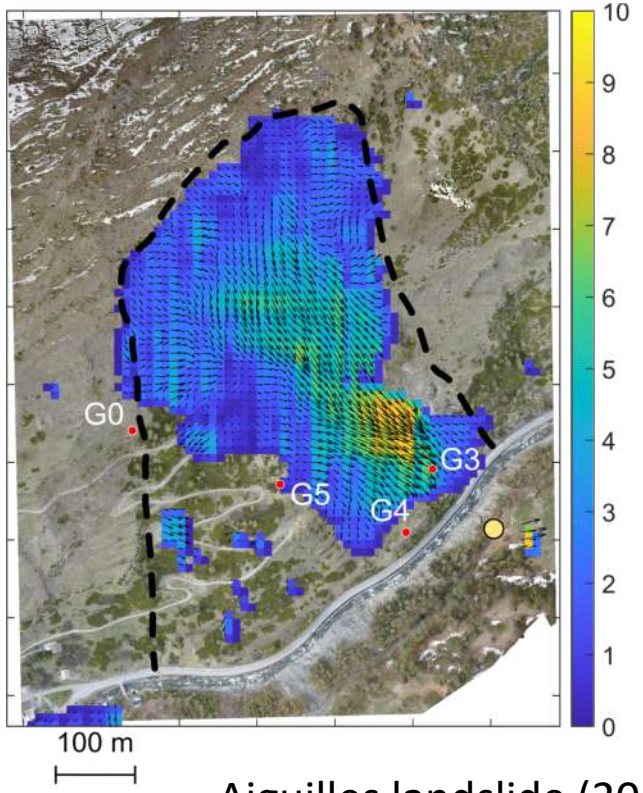
Period: 2016-2020
# of images: 63 *(/93 requested)*
# of pairs: 853
Pair criteria: 500 <deltaT< 1500 days



Copernicus Sentinel-2 satellite image time series



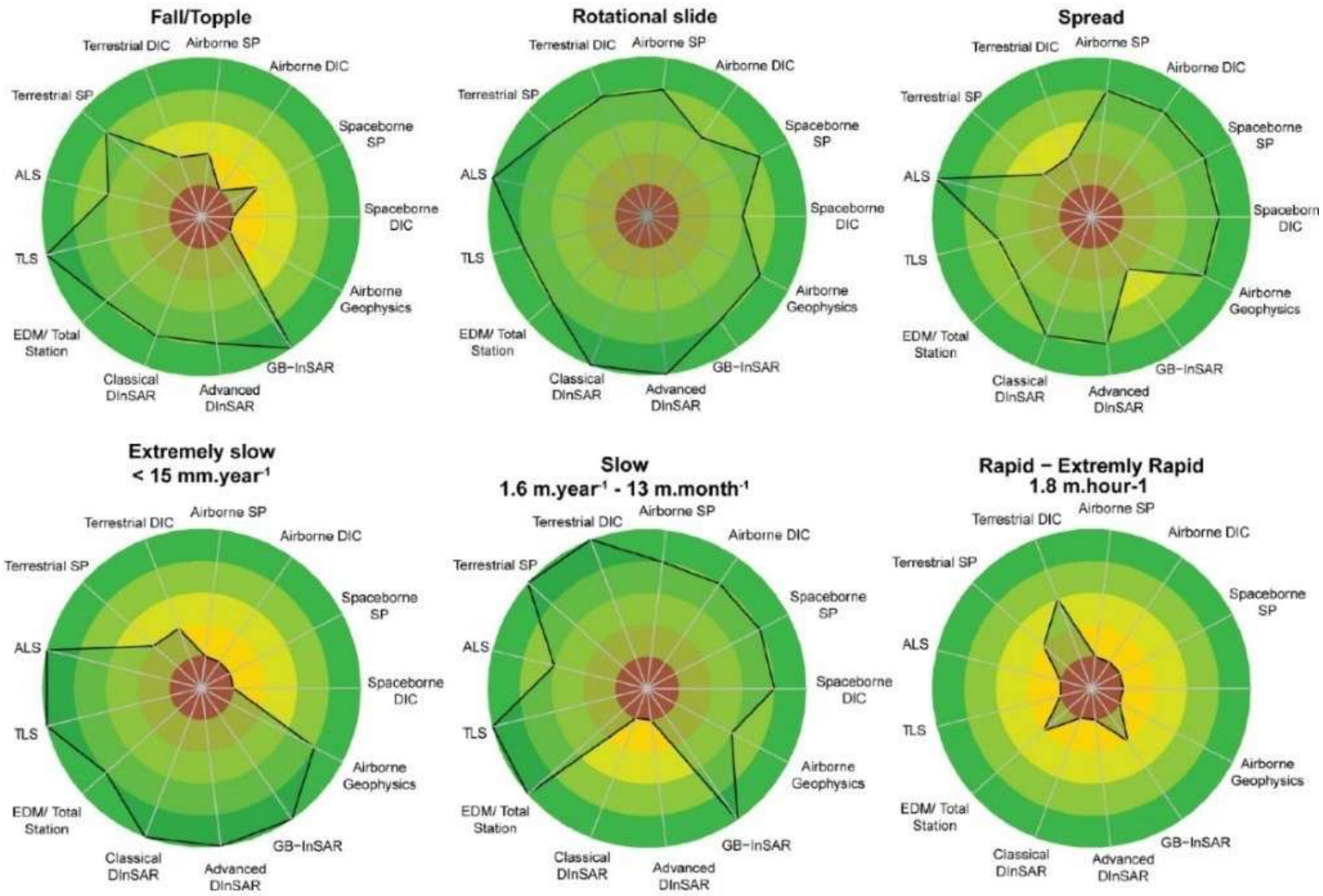
Slumgullion landslide (2016-2002)



Aiguilles landslide (2017-2018)

WP2: Review of existing satellite sensors and processing methods for the analysis of deformation and rainfall properties

Drafting of simple guidelines



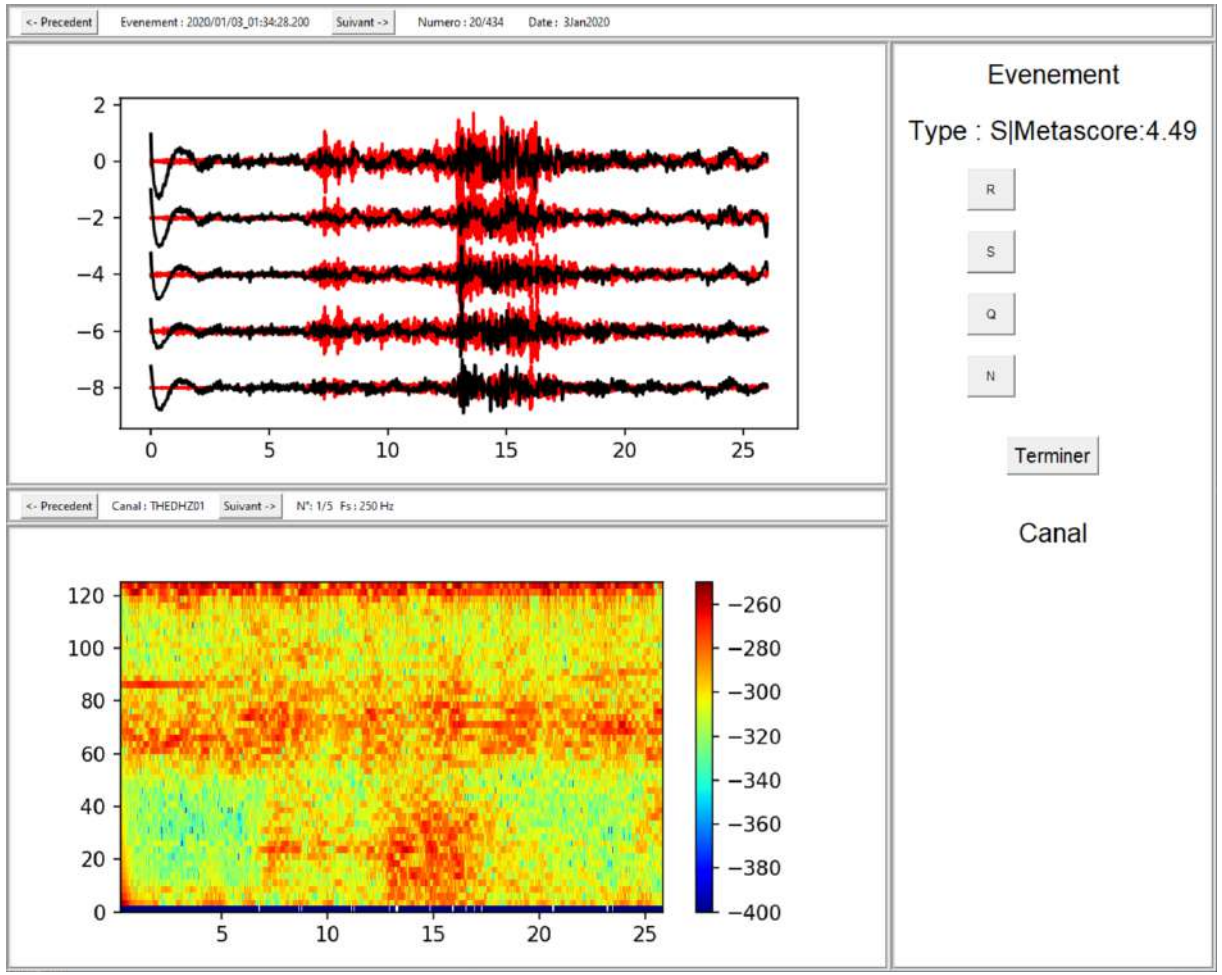
Usefulness of methods per landslide types

Usefulness of methods per landslide velocities

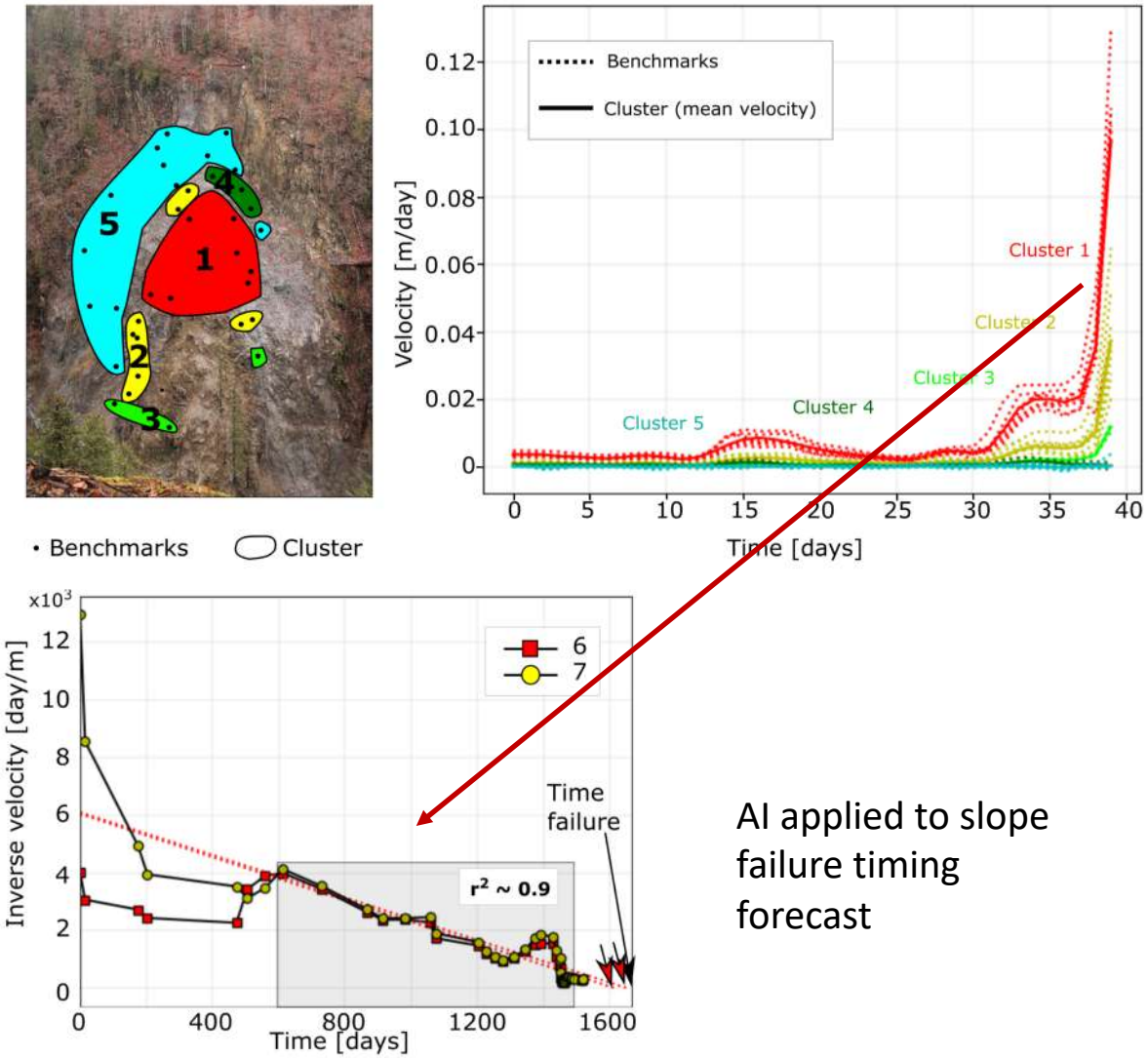
WP3: **Development of open source computer programs for the analysis of the sensor data, and for the detection of anomalies using machine learning approach – focus on the deformation/rain monitoring data.**

Analysis softwares

SEISMIC-Learn software: classification of seismic source with AI



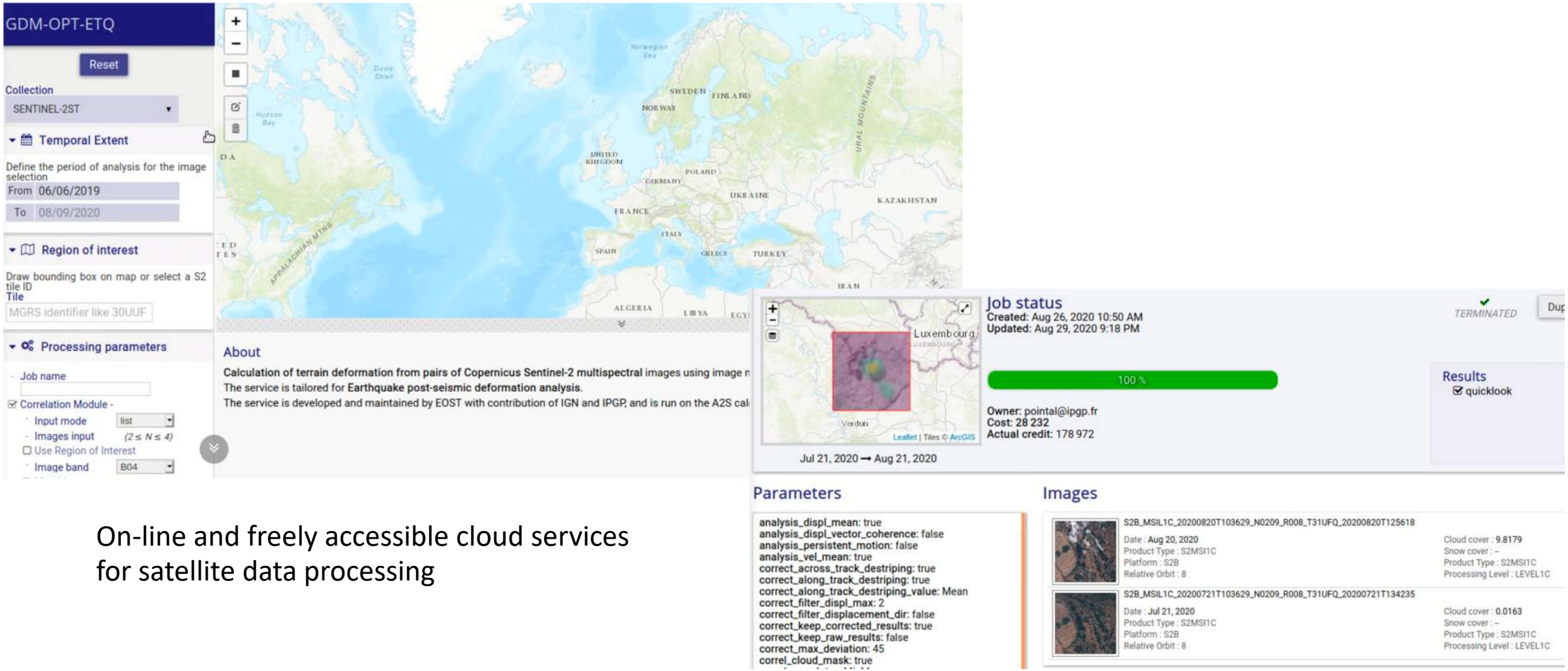
TSM software: analysis of deformation/rain observations



AI applied to slope failure timing forecast

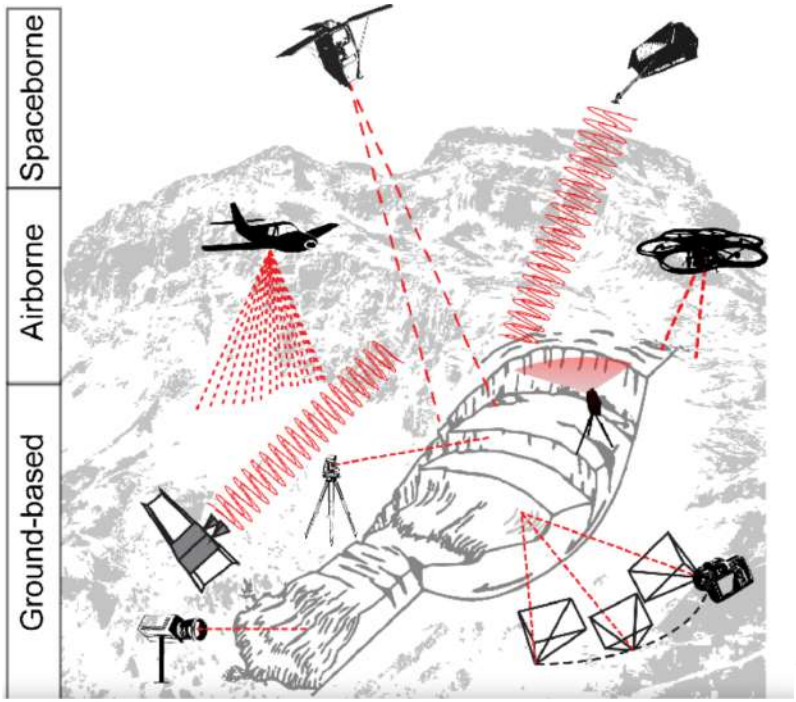
WP3: **Development of open source computer programs for the analysis of the sensor data, and for the detection of anomalies using machine learning approach – focus on the deformation/rain monitoring data.**

Development of webservices



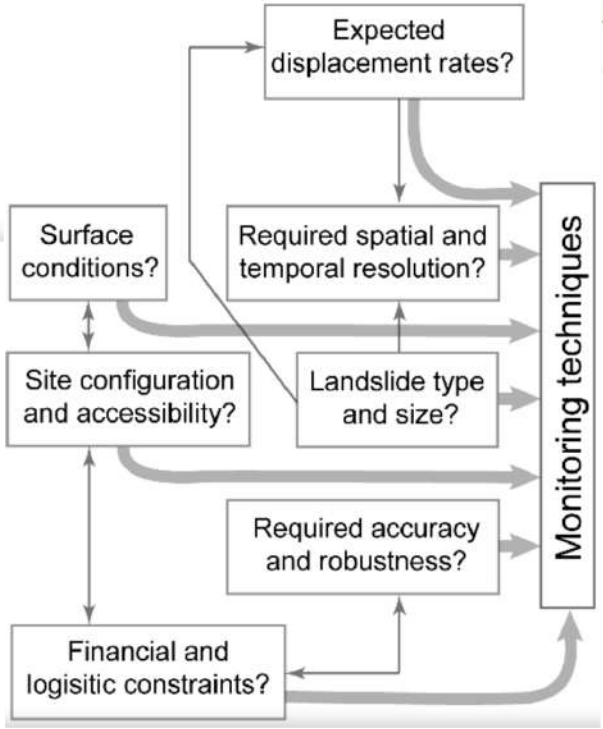
On-line and freely accessible cloud services for satellite data processing

WP4: Redaction of the sensor technical documents



Sensor

How to select?



Technological criteria		
Criteria	**Scale range**	**Explanation**
Spatial coverage	Point, local (e.g. slope), regional	Typical scales at which the measurements are carried out.
Information type	1D	One component of the displacement or change along a spatial axis or along the Line-Of-Sight (LOS) of the sensor.
	2D	2D displacement (mostly horizontal components) at a point or spatially distributed 3D displacement field
	3D	3D displacement at a point or spatially distributed 3D displacement field.
	Volume	Volumes and volume changes of the moving mass.
	Surface features	Time and space evolution of surface features.
Spatial resolution	mm to hm	Typical spacing of individual measurements
Temporal resolution	seconds to months	Typical time lag between individual measurements.
Distance to target	m to km	Distances to target at which the measurement device can be employed. This category is not

Criteria to select

Objective 2021

WP5: Final development of the open source multi-sensor analysis programs, release of the user manuals, and of a demonstrator use case (including indicators such as time series and maps).

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In practice:

- Install the low-cost sensors built in 2020 by the partners in their countries (ECILS, CRSTRA)
- Transfer the processing methods/softwares to the partners for operational testing
- Write the final version of the technological notices / guidelines (in several languages)
- Organize the Intensive Course -> Scheduled date October 2021 (Nice, France)