BGS Response for emergency and disaster management

CEOS
Committee on
Earth Observation Satellites

A. Novellino, BGS
Agenda Item 6.4
WGISS-61
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Dehradun, India

Outline

- Disaster response, why it matters?
- BGS contribution for different stakeholders.
- Current capabilities
- Recent developments with specific AI/ML examples
- Vision

What is a response and why we are involved?

- Refer to actions taken directly before, during or immediately after an event/disaster (not only geohazards!)

- We provide scientific advice to better understand what happened, its impact and how the situation can unfold

EMDAT, 2024

- On average, we respond to ~10 events per year

What type of role BGS has?

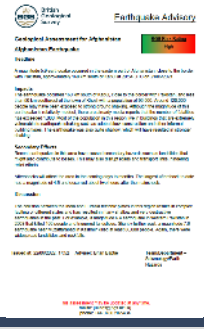
- Develop **novel science** which help decision makers and stakeholders for a better assessment of geohazards
- Collaborative **preparedness** and **response** activities with EU member states (e.g., ARISTOTLE-ENHSP)
- **Forward Look** such as the INHFL (International Natural Hazard Forward Look) and the Natural Hazard Partnership. In this case, we have multi-hazard partnership consisting of UK Government, science agencies and public sector to produce weekly international overview of natural hazards for UK government departments and local authoritie
- MoU with UK government (Foreign, Commonwealth & Development Office) and international institutions (Disaster Charter) to provide science advice in the support of natural hazards worldwide during **disaster response.**

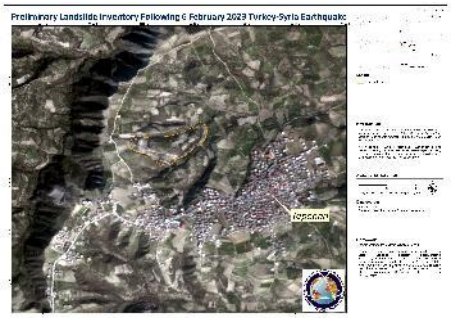
Stakeholders and endusers

- We provide support to a wide range of national and international stakeholders

- Each of these stakeholders has different priorities and interest

- different outputs according to our audience





ARISTOTLE - Emergency Response Mode (ERM)

Reports delivered within 3 hours of event onset or request.

1. Lite (single hazard) reports include information on:
   - Geographic location
   - Event timing
   - Description of activity
   - Future scenarios

2. Full (multi-hazard) reports include contributions from all hazards as well as exposure and impact data.

ARISTOTLE-eENHSP Lite report
Volcanic Hazard Group

Date created: September 19, 2021 - 17:22
Author e-mail: aristotle.ingvoe at ingv.it

Geographic location: Cumbre Vieja, La Palma (Spain)
Event timing: 19 September 2021

Description |

Description of events: The Cumbre Vieja volcano, located in the South of La Palma, began erupting at approximately 15:15 local time on 19 Sept 2021, following eight days of intensifying seismic activity associated with a magmatic intrusion. Early images and videos shared via social media indicate that a fissure opened up on the western flank of Cumbre Vieja, ejecting columns of ash and gas, lava fountains and lava flows. Light ash fall has been reported.

Description of impacts: Vegetation and farmland in the immediate vicinity has been burned and lava flows have cut off a road. Some buildings have been affected. While no exclusion zone has been designated as yet, the La Palma authorities advise the public not to go near the eruption site. Evacuations of nearby communities and animals are underway. Evacuations had begun prior to the eruption, in the communities of Las Manchas (Las Manchas de Abajo, Jedey, San Nicolás and El Paraíso), which includes the municipalities of El Paso and Los llanos de Aridane; El Charco (Fuencaliente), La Bombilla (Los Llanos de Aridane and Tazacorte) and El Remo and Puerto Naos (Los Llanos de Aridane). PEVOLCA have raised the alert level from Yellow to Orange (on a four level scale from Green to Red) The volcano is monitored by the Instituto Volcanologico de Canarias (INVOLCAN). The volcano last erupted in 1971. La Palma is home to approximately 85,000 people.

Sources/references:

Global Volcanism Program: https://volcano.si.edu/volcano.cfm?vn=383010
INVOLCAN: http://www.involcan.org/ INVOLCAN
social media: https://twitter.com/involcan https://www.facebook.com/INVOLCAN
Instituto Geografico Nacional: https://www.ign.es/web/ign/portal/vic-serie-palma
PEVOLCA: https://www.volcanesdecanarias.org/conoce-el-pevolca/
Cabildo de La Palma: https://twitter.com/CabLaPalma

Glossary

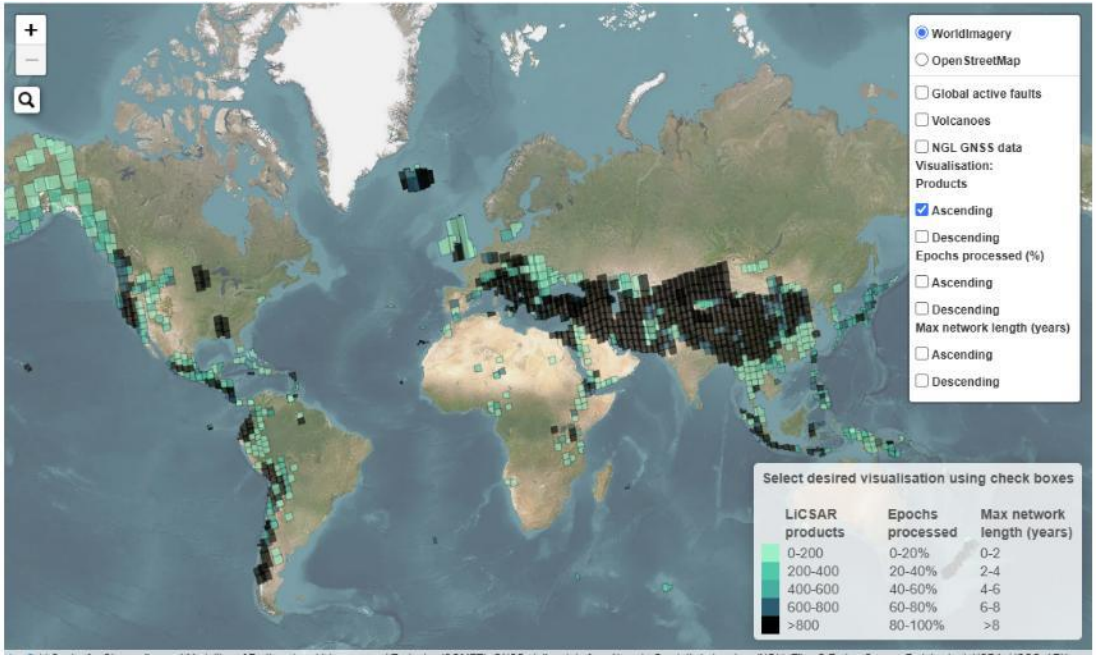
Effusive eruption: eruption that predominantly produces lava flows
Fissure: a linear volcanic vent
Lava flow: flow of molten rock whose flow path
Seismic Tremor: ground vibrations related to movement of magma within the ground

LiCSAR

- Providing ground deformation for the most active volcanic/seismic areas of the world.
- Automatic processing of ~2M interferograms
- Dedicated webpages for large earthquakes and volcanoes

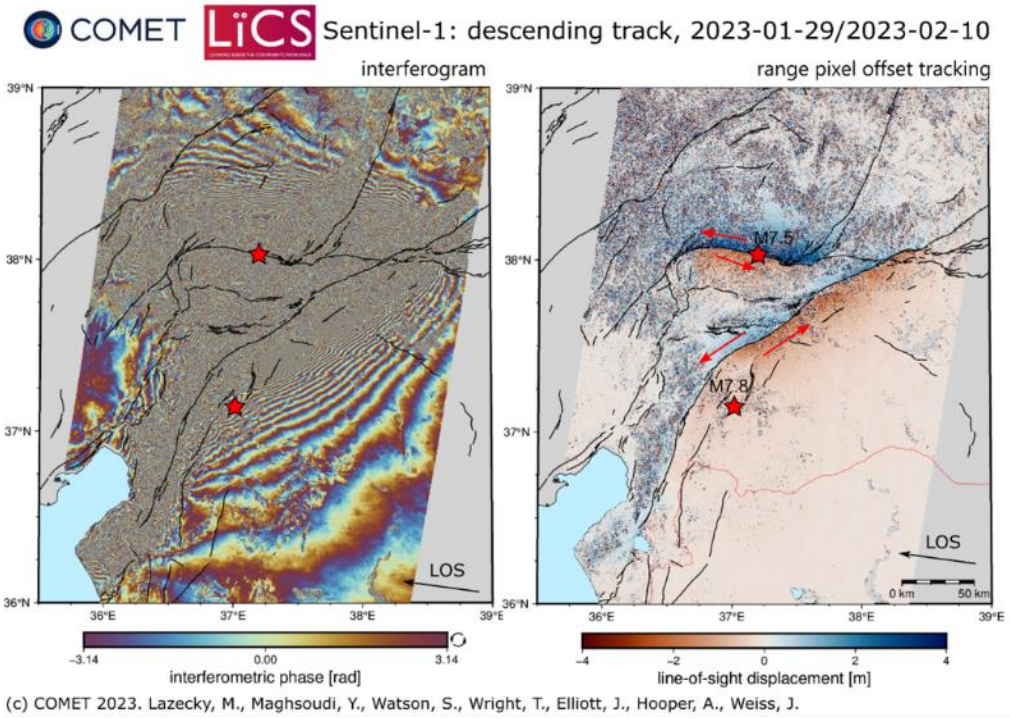
LiCS
LOOKING INSIDE THE CONTINENTS FROM SPACE

COMET-LiCS Sentinel-1 InSAR portal



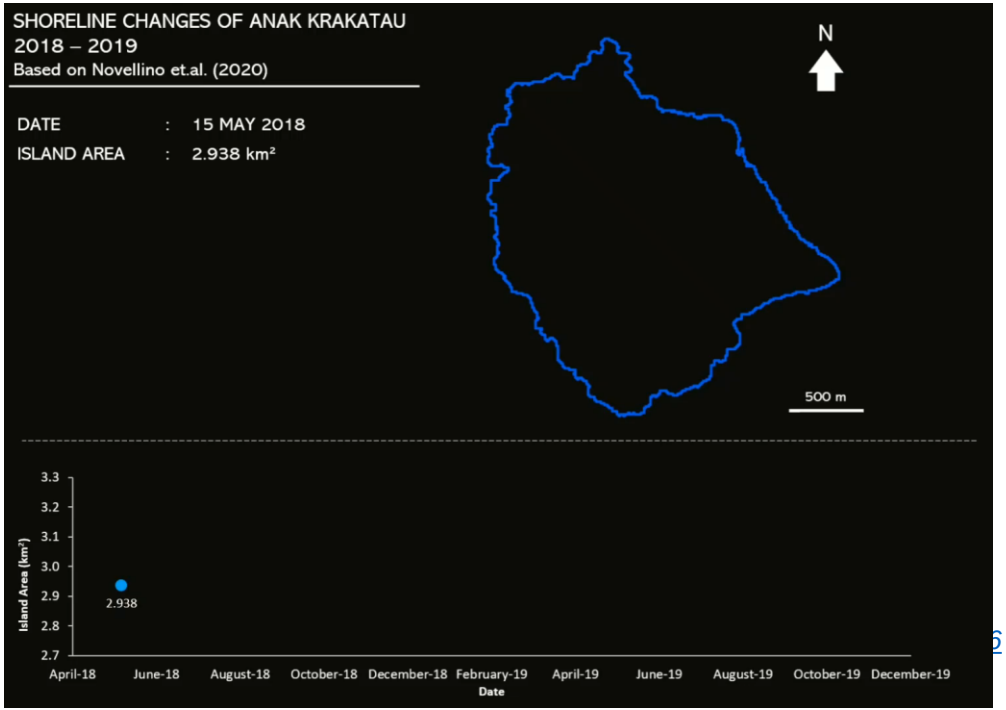
Earthquakes

- Immediate response examples: Turkey - Syria EQ sequence, Feb 2023;
- Communicate with stakeholders (FCDO, aid agencies) on specific events in the days and weeks following major earthquakes
- Written questions or presentations



Tsunami

- In Summer 2018, Krakatau showed intense volcanic activity
- The volcanic island is very remote, far from permanent settlement, air space was then closed
- Satellite data was a key technology to monitor the volcano

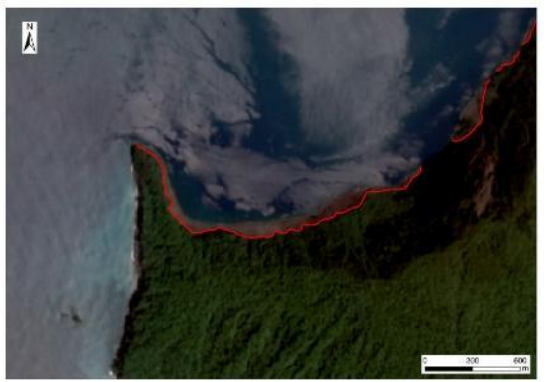


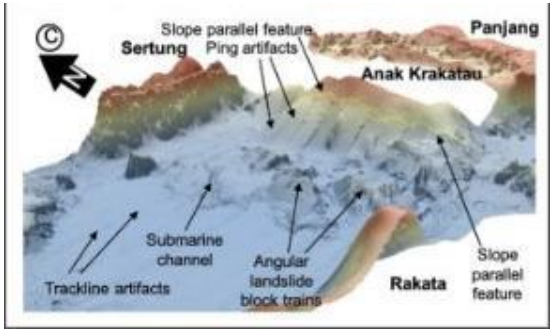
Tsunami

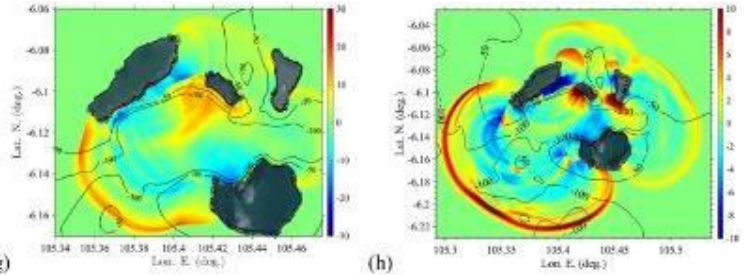
- Some of the response have resulted in funding to be leveraged

- For Krakatau 2018, we mapped tsunami trimlines and combined with bathymetric data to calibrate the tsunami model

- We estimated a collapsed volume of ~0.214 ± 0.036 km3 (>40k times the Big Ben)







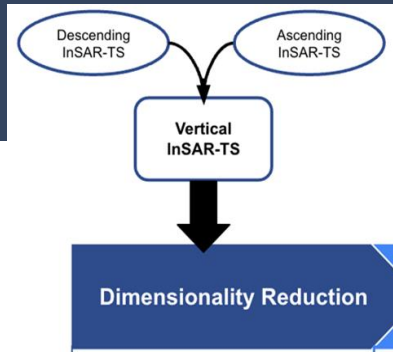
https://doi.org/10.1038/s41467-021-22610-5

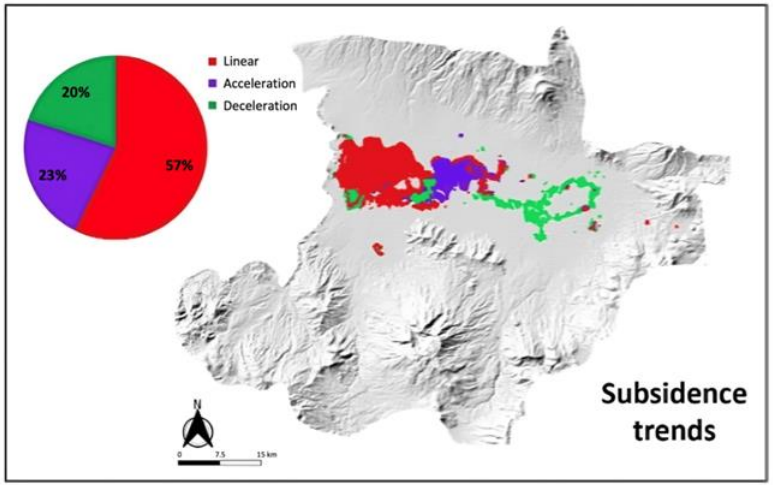
https://doi.org/10.1016/j.margeo.2021.106566

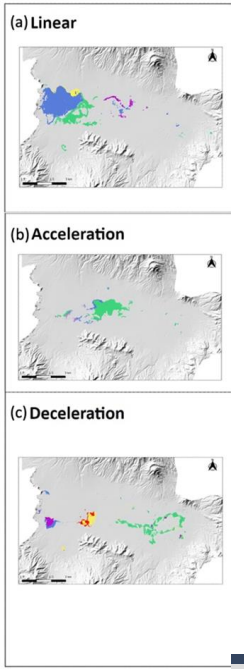
Subsidence

https://doi.org/10.3390/rs15153776

- Large city that has rapidly expanded within the last decades
- Deposits in the basin lacustrine units
- Historically know area for high subsidence rates (exceeding -20 cm/year)
- These areas correspond to groundwater extractions around new settlements and industry

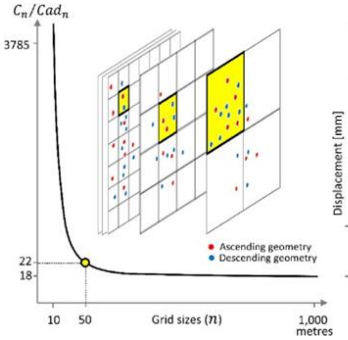


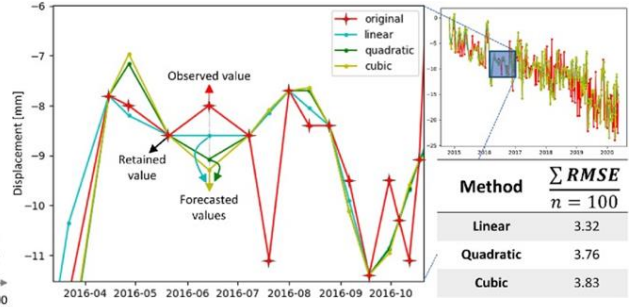




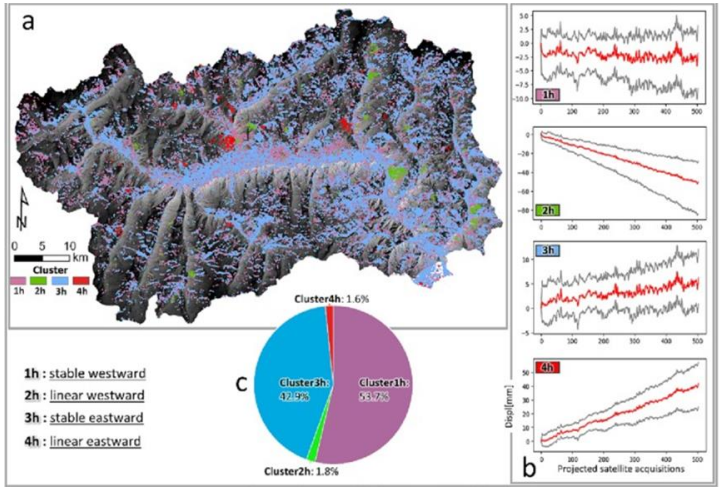
Landslides

- Interpolation of Asc&Desc observation in space and time
- PCA to reduce the dimensionality of InSAR data to main signals.
- Unsupervised clustering for spatial and temporal detection of ground displacements.
- Identification of landslides size and state of activity





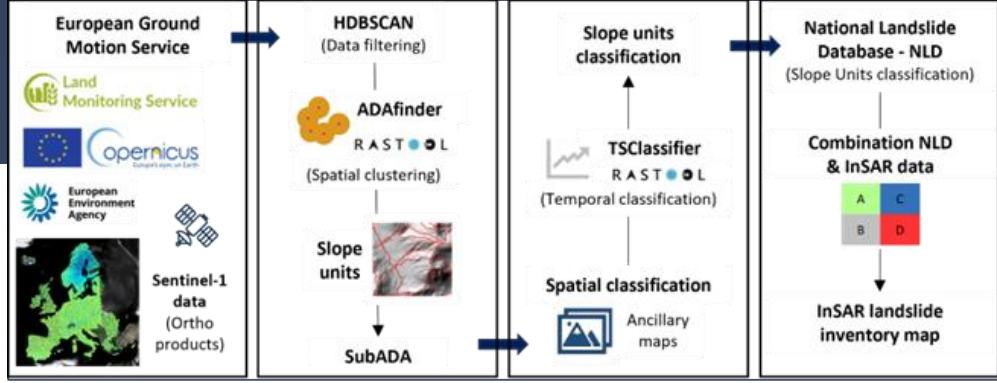
Method	$\frac{\sum RMSE}{n = 100}$
Linear	3.32
Quadratic	3.76
Cubic	3.83



https://doi.org/10.1016/j.jag.2023.103276

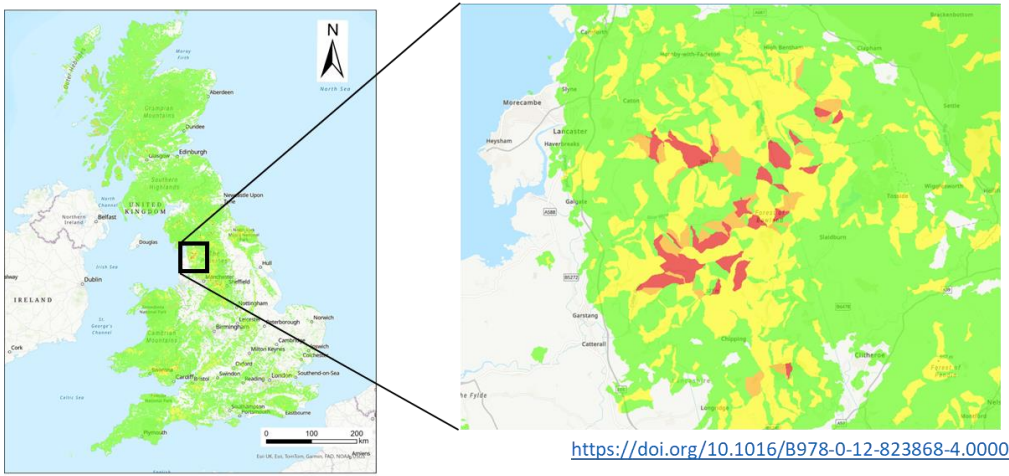
Landslides

- Using ML to support the identification of unstable slopes



- The National Landslides Database for GB is biased towards populated areas

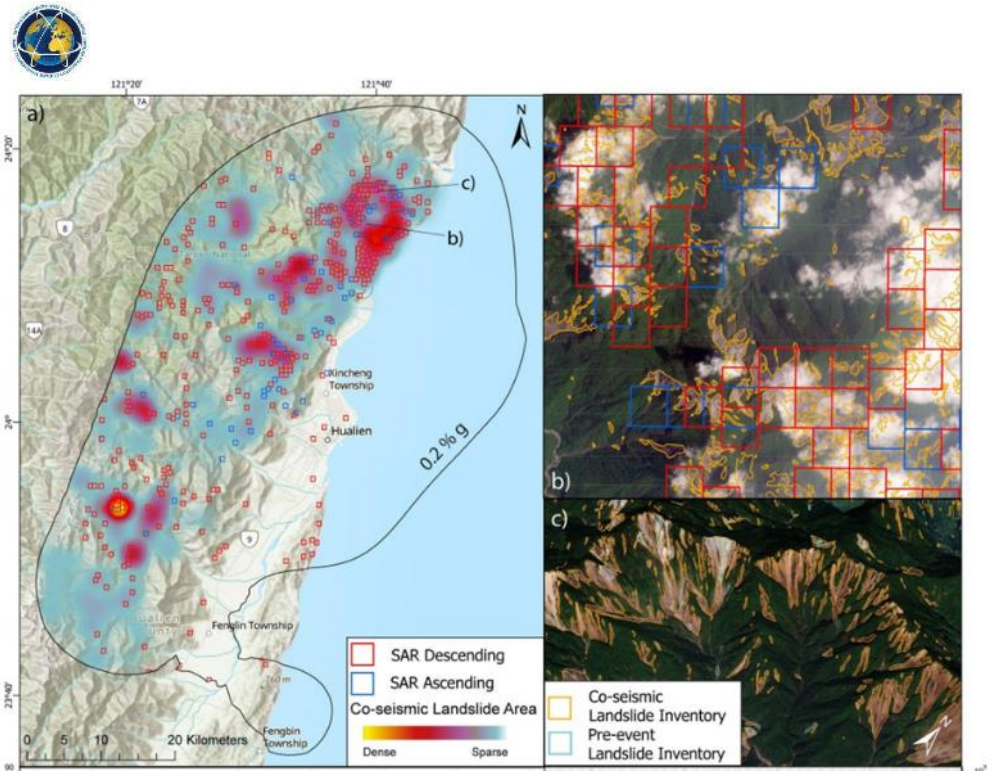
- Our analysis shows that ~5% of the GB slope units are unstable and only 0.1% has a landslides mapped



https://doi.org/10.1016/B978-0-12-823868-4.00005-2

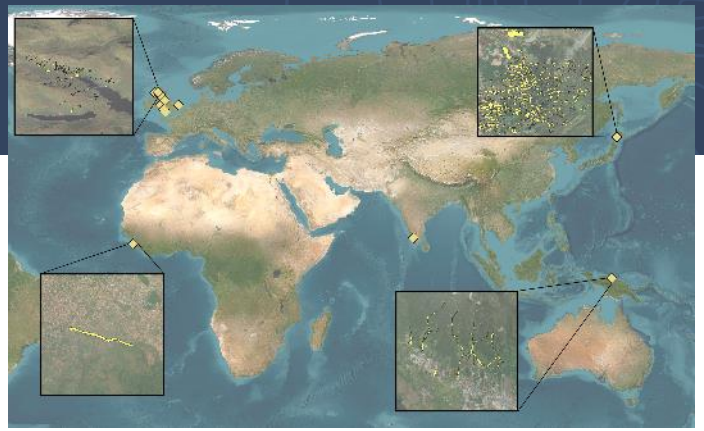
Landslides

- Automatically mapping landslides at large scale following EQ or storms
- Especially useful for the quick production of landslides inventories
- Maps used by stakeholders to assess impact and plan for first responders' activities

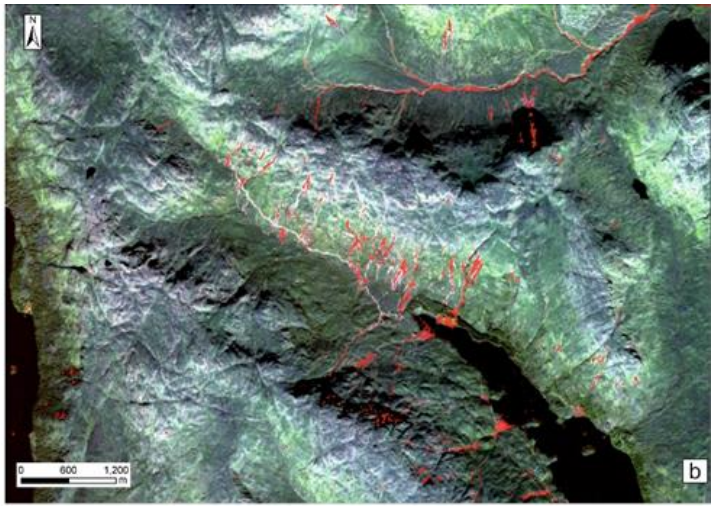


Landslides Tracker

- BGS developed an AI tool for automatically map landslides from freely satellite data (Sentinel-2) as part of the IGRD programme



- The AI model is based on a U-Net approach and trained on >5,000 events occurred worldwide

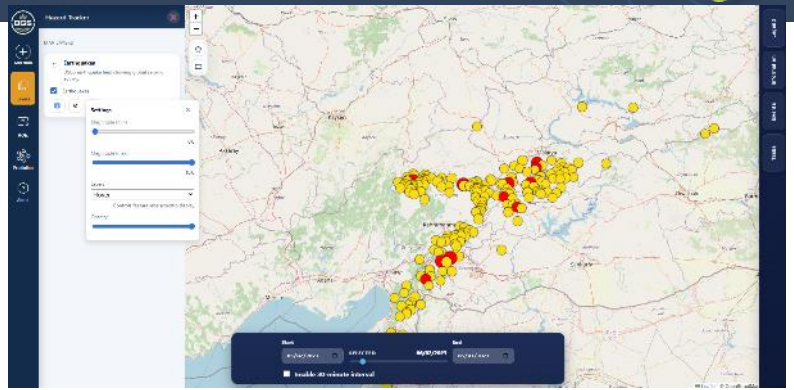


- The tool has been used both nationally, to keep up-to-date the BGS National Landslide Database and internationally, to support disaster response activities.

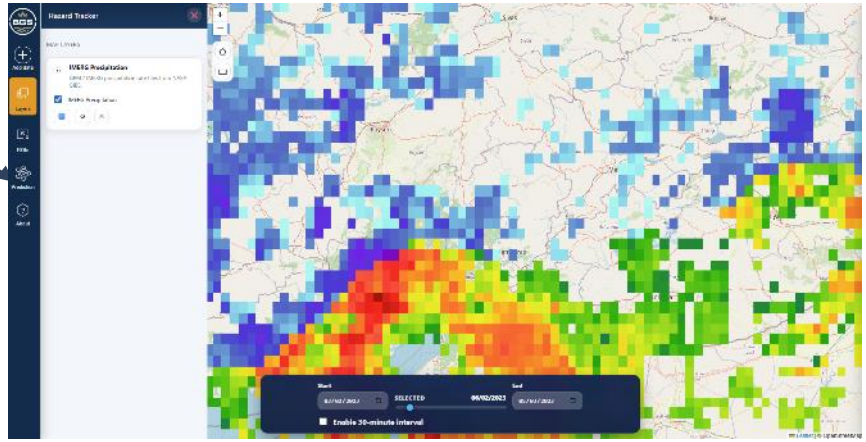
Landslides Tracker

The platform allows:

- to rapidly ingest earthquake data (USGS) and rainfall (NASA) from external datasets

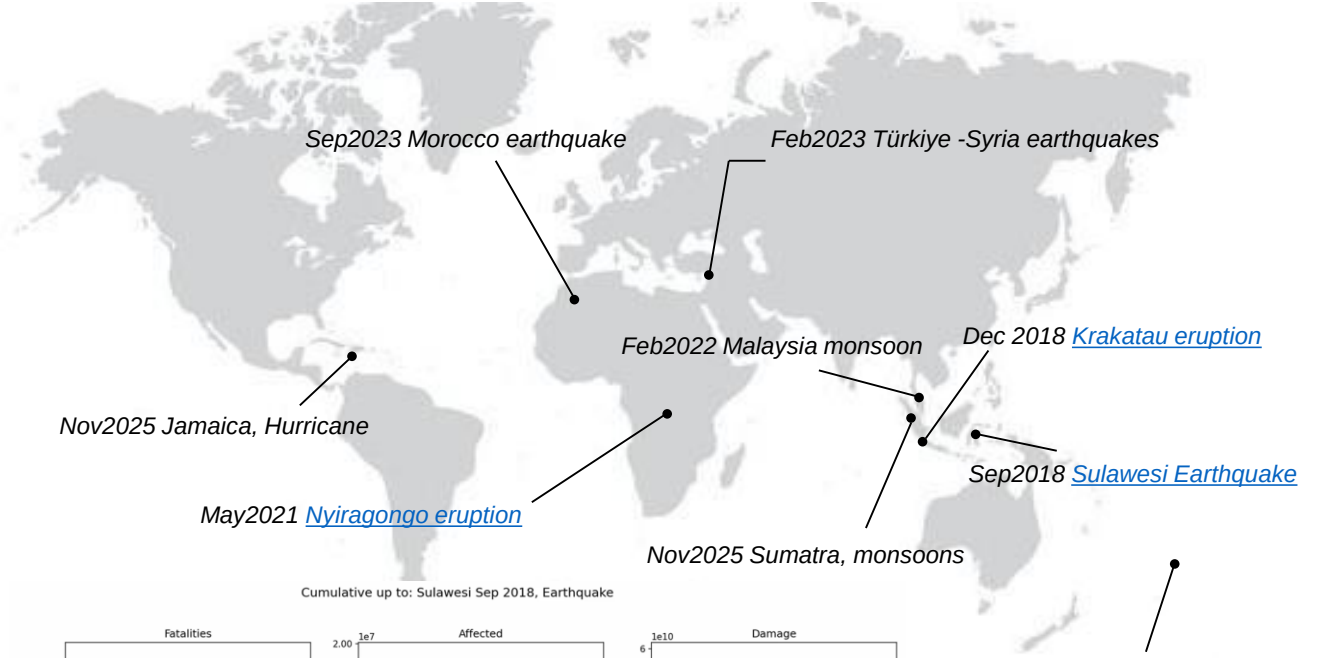


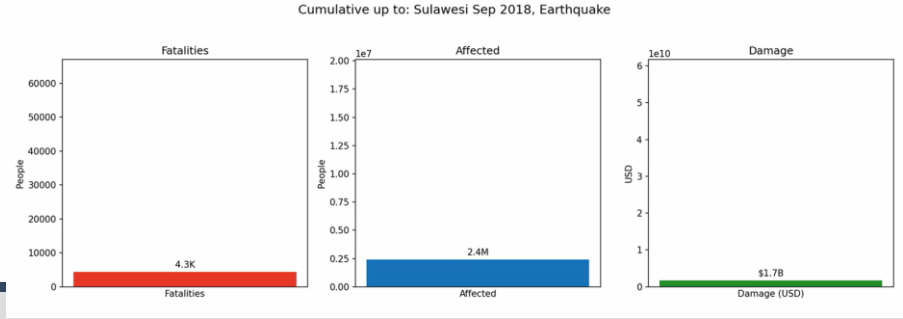
- Using these dataset, we can constrain locations where landslides are likely to have been triggered



- On these restricted locations, we run the AI tool to map landslides

Landslides Tracker

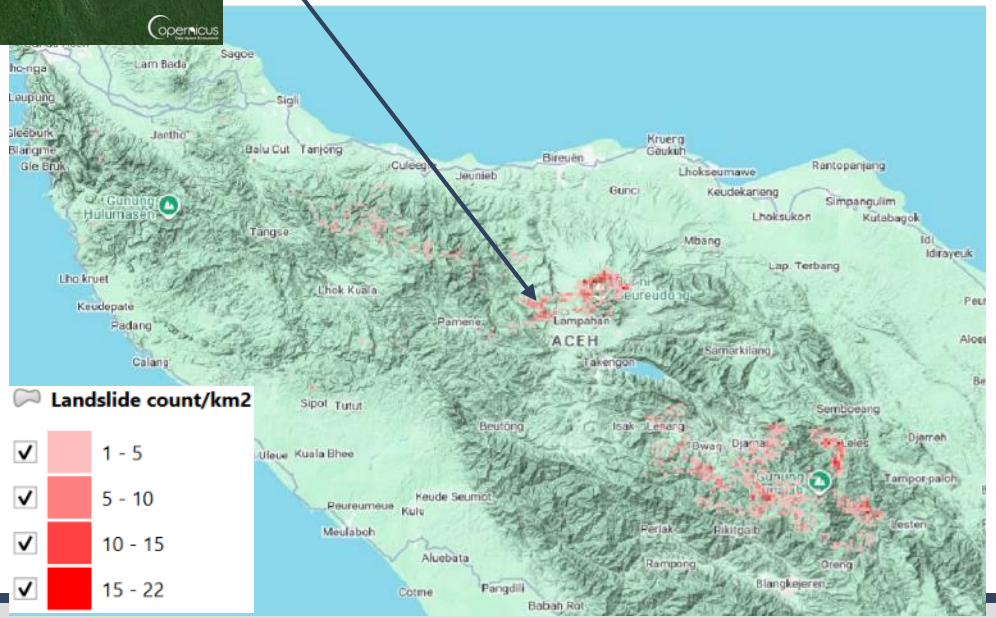




- Landslides tracker has supported UN and European Space Agency through the Disaster Charter
- >10k landslides have been mapped in 8 countries
- It supported rapid impact assessment
- These events resulted in ~64k fatalities, >19M people affected and ~$60B in damage

Landslides Tracker – Indonesia, Nov 2025

- In November 2025 tropical storms hit SE Asia (UN) led to landslides and floods.
- >4,600 landslides mapped & ~650 km2 of floods. They impacted >60km2 of crops and built-up areas
- >600 people have lost their lives, and 1.7 million people have been affected (Relief Web)

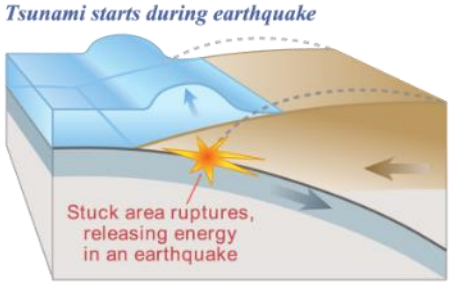


Future developments for BGS disaster response

- Expanding our list of EO datasets to commercial data with higher spatial and temporal resolution. This would allow to derive timeseries of parameters and identify patterns in the data.

- Multi-hazards chains, one hazard can trigger another

(e.g., earthquakes trigger tsunami or landslides)



- Providing information on the relationships across-disciplinary hazards (social-environmental processes). Focusing more on the impact of hazards (people, infrastructure)