Annual Report 2025

EUROPEAN CENTER FOR GEODYNAMICS AND SEISMOLOGY (ECGS)

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INTRODUCTION

ECGS collaborates intimately with the Geophysics/Astrophysics section of the National Museum of Natural History (Mnhn). The permanent staff of the Earth Science research group of ECGS and the Mnhn is composed of four scientists (Dr. Adrien Oth, Dr. Julien Barrière, Dr. Delphine Smittarello and Dr. Nicolas d'Oreye), two technical engineers (Gilles Celli and Maxime Jaspard) and one administrative assistant (Yannick Breh). In January 2025, an additional post-doctoral research fellow joined our team, Dr. Francesco Rappisi, coming from the University of Leeds. Dr. Rappisi is working on seismic tomography studies at ECGS, with particular emphasis on the Kivu region, where ECGS has a vast database available in view of its more than 15-years long work in that area.

In 2025, we continued among many other aspects to work on the maintenance, development and optimisation of the Luxembourg National Seismological Network (LuxSNet), which is currently composed of 13 real-time broadband seismic stations. We installed one new broadband station in Wincrange and are actively exploring four more sites for additional stations, most of which are in the final assessment stages and will likely be instrumented in the course of 2026. Besides our seismological monitoring and research activities on the national level, we are involved in international seismological research works using datasets from various regions around the World and act as CTBTO National Data Centre (NDC).

The year 2025 was also in particular marked by the AFR-FNR INTER[1] funded project SLIDE (*Assessing the contribution of slow-moving landslides to erosion in the Himalayas*, see dedicated section below). This project is a collaboration between our French partners from the University of Lorraine and ISTerre and ECGS and officially started on 1 December 2024. In the course of 2025, two field missions were carried out to Central Nepal and the geophysical landslide monitoring network was installed successfully. Besides these ground-based components of the project, all the remote-sensing components are also well on track. Dr. Quentin Glaude has been hired for the post-doctoral position related to the SLIDE project and will join the ECGS team on 1 January 2026.

We keep in constant development our real-time seismological processing and data archiving chain, as well as the tools for automatic monitoring of ground deformation by satellite radar interferometry (AMSTer software). This allows for the systematic monitoring of several targets for studying deformation of natural (e.g., volcanoes, tectonic activity, landslides) and anthropogenic (e.g., mining activities) origins in various regions of the World (Luxembourg national territory, Nepal, Chile-Argentina, Guadeloupe, Comoros, La Réunion, DR Congo).

As usual, ECGS/Mnhn was involved in a range of strong international collaborations, which are the living proof of the wide recognition of its expertise. In 2025, ECGS/Mnhn researchers published 12 articles in international peer-reviewed scientific journals and (co-)authored 21 contributions at international conferences. In his function as European Seismological Commission (ESC) Secretary General, the ECGS Scientific Director plays an important role in the planning and organisation of the ESC bi-annual general assemblies, with the next one to be held in September 2026 in Istanbul[2,3]. ECGS/Mnhn also successfully organised the 103rd edition of the Journées Luxembourgeoises de Géodynamique (JLG)[4] in November 2025, which was dedicated to the scientific developments for the study and monitoring of slow-moving landslides, with a special focus on Central Nepal in view of the SLIDE project. This meeting brought together 29 participants from Luxembourg, France and Belgium.

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[1] https://www.fnr.lu/funding-instruments/inter/
[2] https://www.esc2026.org
[3] http://www.esc-web.org
[4] https://www.ecgs.lu/103rd-jlg-dedicated-to-slow-moving-landslides-with-a-special-focus-on-central-nepal/

SLIDE: Assessing the contribution of slow-moving landslides to erosion in the Himalayas

SLIDE is a 4-years project with the Centre de Recherches Pétrographiques et Géochimiques (CRPG) from the University of Lorraine in Nancy, the ISTerre (Grenoble), the Centre Spatial de Liège (Belgium) and ECGS. It is co-funded by the ANR (France) and the FNR (Luxembourg).

The project aims at studying the **contribution of slow-moving, deep-seated landslides in the denudation and evolution of mountain landscapes in the Central Himalayas** using InSAR time series, optical imagery, GNSS, seismic and infrasound methods. As such, it involves all research specialties present at ECGS and constitutes a multi-disciplinary key project of the institute.

During the first year of the SLIDE project, we achieved the following:

❖ Processing and Analysis of Sentinel-1 SAR Data for Central Nepal (2014-2025)

We processed the complete Sentinel-1A, B, and C SAR archives covering the 22,000 km² Central Nepal region, spanning from 2014 to 2025. This dataset comprises over 24 TB of raw images acquired in five geometries. From these, we generated more than 4,500 interferometric pairs at the highest resolution (approximately 30 m), resulting in about 20 TB of processed data. This enabled the production of thousands of deformation maps in the satellites' five lines of sight (LoS) and nine vertical/horizontal decompositions.

To ensure timely analysis, we established an automated processing pipeline for each new Sentinel-1 image as soon as it becomes available from the European Space Agency and made available through the Luxembourg Space Agency. The pipeline was specifically adapted to address the unique challenges of Central Nepal, including the high relief of the Himalayas, dynamic land cover changes (due to vegetation, snow, and land movements), and the impact of monsoon conditions.

We also prepared the processing methodology for the other satellites that will be included (archives and upcoming acquisitions), i.e., ENVISAT, ERS, PAZ, ALOS, NISAR, etc.

❖ Methodological Development and Validation

To optimize our approach, we conducted preliminary tests on a smaller area in the Mustang region, northwest of Central Nepal (Figures 1 & 2). We compared ground deformation time series—derived from MSBAS inversions in line of sight (LoS), 2D (EW/UD), and 3D (EW/UD/NS)—with optical imagery measurements provided by Laureen Maury for the Gayu Kharka slow-moving landslide. Given the rapid deformation rates observed, we prioritized the use of short spatial baselines, despite the potential risk of signal fading bias (Ansari et al., 2021). We also evaluated the impact of ionospheric, geodetic, and tropospheric corrections (using Sentinel-1 ETAD products; Gisinger et al., 2022) on displacement measurements and geocoding accuracy. While these corrections improved the quality of some interferometric pairs, they degraded others. Preliminary results indicate that applying ETAD corrections across all pairs—without further refinement or selection—does not significantly alter the measured deformation rate over the test landslide but may significantly reduce the standard deviation. However, since ETAD data are only available from 2023, additional testing is required to fully assess their impact and refine the procedure.

❖ Field Campaigns and Data Integration

The processed data are structured to support the development and application of machine learning tools for landslide detection, tracking, and monitoring. In order to validate the remote sensing results, the project contains a component of ground-based geophysical measurements at a two test sites in Central Nepal. **Two field missions** were conducted in May (M. Jaspard) and October (M. Jaspard and J. Barrière) 2025, installing more than 15 GNSS and seismic stations on two slow-moving landslides selected as test sites (Bolde and Tapgaon, Figure 3). Initial GNSS datasets from the Bolde landslide were compared with preliminary results from our automatic InSAR processing, enabling first attempts of cross-validation of remote and ground-based measurements.

The **first mission**, scheduled in May 2025, aimed at exploring the selected target landslides for the ground-based datasets of our project. In this first phase, the focus was on the installation of three pilot stations to assess the situation and challenges of the site, since for the final planned network, more than 15 stations needed to be installed on this slow-moving landslide covering an area of 1 square kilometer, with an average slope of about 35%. Each station includes a seismic sensor, a GNSS receiver with antenna, and a self-powered system (battery + solar panel) (see example in Figure 3).

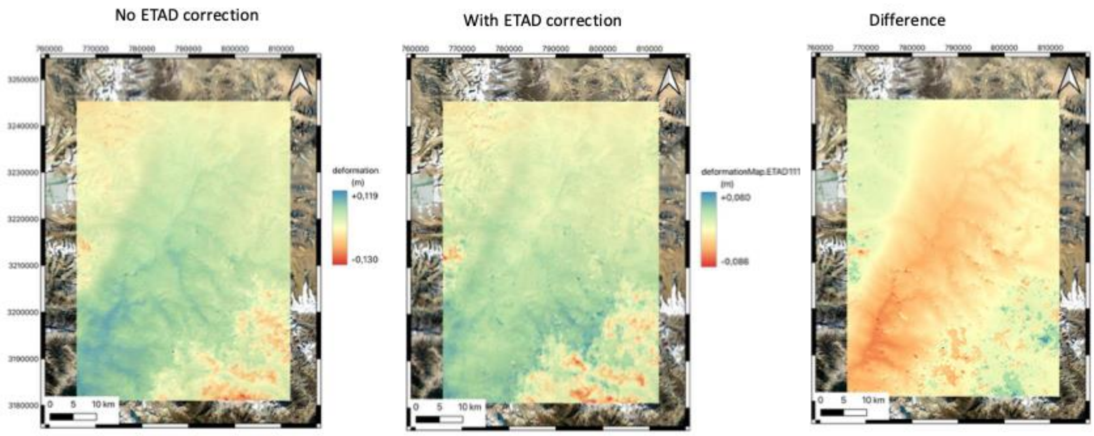

Figure 1: Deformation map (LoS) derived from the interferometric pair of Sentinel-1 images acquired on 2024-09-29 and 2024-10-23 (ascending orbit 158) over the Mustang area. This pair exhibits a misclosure effect exceeding 1.5 cm (mean value calculated over the Gayu Kharka slow-moving landslide). Left: Deformation map without ETAD correction. Centre: Deformation map after applying ionospheric, geodetic, and tropospheric corrections using Sentinel-1 ETAD products. Right: Difference between the two deformation maps. The ETAD corrections effectively reduce topographically correlated artifacts in this case.

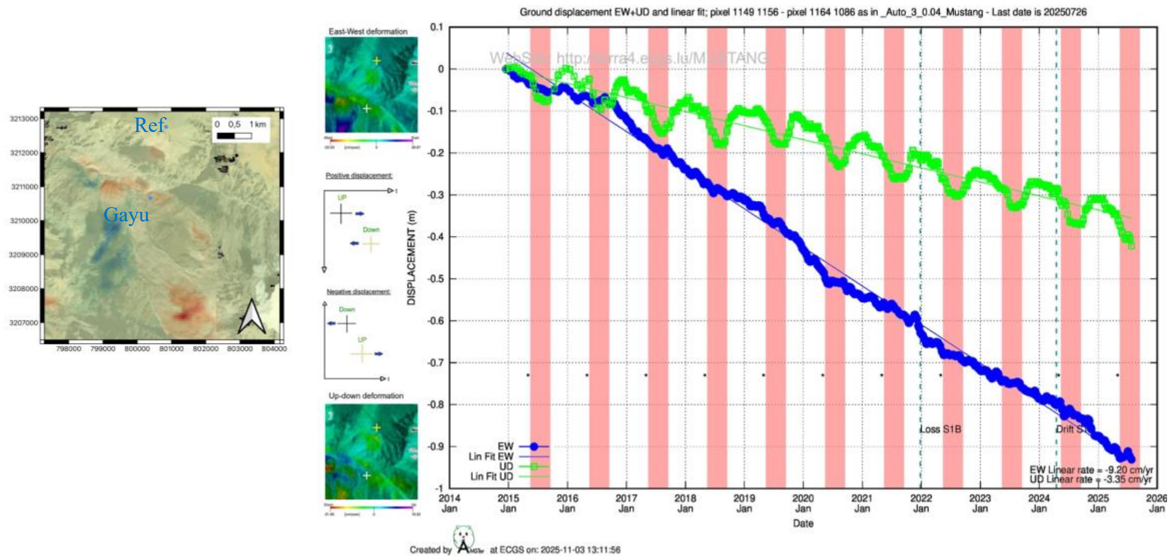

Figure 2: Differential ground deformation time series from 2014 to 2025 measured between a reference point located outside of the Gayu Kharka landslide and the base of the landslide (see marked small blue dots on the deformation map to the left, or white and yellow squares in the insets of the time series plot to the right). Green: vertical displacement (about 3.3 cm/yr downward). Blue: East-West displacement (about 9.2 cm/yr Westward). Red rectangles highlight the approximate monsoons epochs.

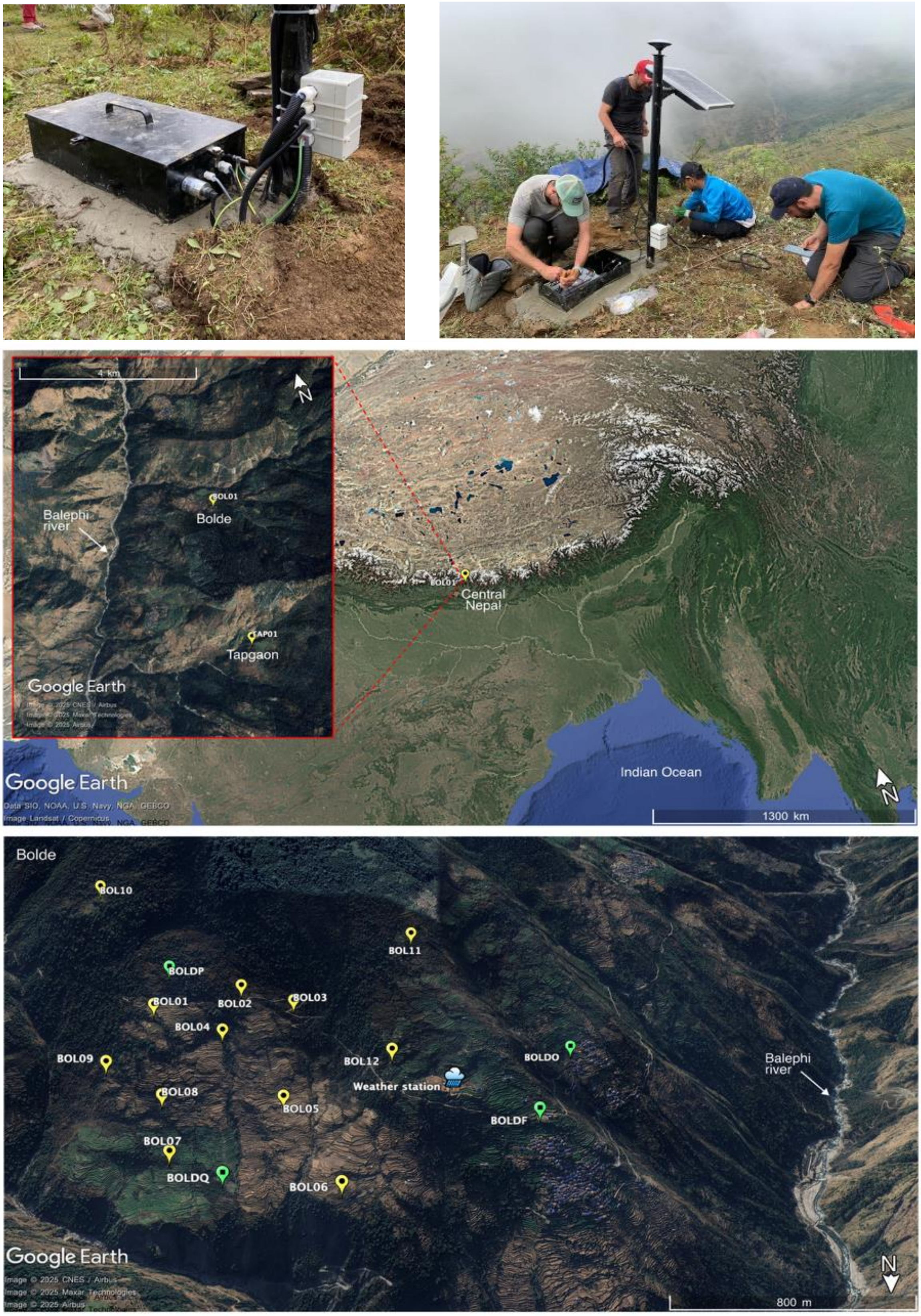

Figure 3: Top: Installation of a GNSS and seismic station on the Bolde landslide, Central Nepal (Photos: M. Jaspard). Middle: Map situating Central Nepal in Himalaya at the boundary between the Indian plains and the Tibetan plateau. The inset contoured in red shows a zoom in the field sites (Bolde and Tapgaon villages). Bottom: Geophysical stations deployed at Bolde, most of them being installed on the moving part of the landslide. The inhabited areas are located below the stations BOLDF and BOLDO. All are equipped with GNSS receivers and 3-components seismic sensors (4 broadband seismometers - green markers - and 12 short-period geophones - yellow markers).

The selected landslide, located near the large village of Bolde, is approximatively 90% cultivated. Therefore, during this mission we focused on the following points:

- Informing villagers, farmers, and local authorities about the project;
- Clearly identified all necessary authorizations;
- Evaluation the security of the future stations in this area;
- Identifying suitable locations for the stations with permission from the landowners;
- Another objective of this first field mission was the installation of three pilot stations and one weather station, designed to assess the following points:
    - Testing scientific equipment under field conditions;
    - Providing data during the first monsoon of the project;
    - Validating the solar panel and battery size for energy efficiency;
    - Checking the security of the stations;
    - Evaluating the time required for station installation to anticipate larger-scale deployment;
    - Assessing the availability of local accommodation.

In view of the large number of planned stations, we decided to work with ‘low cost’ GNSS receivers from the company Septentrio, which have been highlighted in the recent scientific literature. These GNSS receivers appear to be as efficient as high-class geodetic system, but must be programmed manually, which requires some extra time. Short period seismic sensors from Smartsolo have also been tested in advance to become familiar with the programming software, the data harvesting system etc…

Regarding the hardware material for the stations, we contacted a company in Kathmandu and ordered all the hardware material that we couldn’t bring by plane (metal boxes, masts, solar panels, earthing equipment, batteries and all mounting accessories). It was also very important to test this equipment at a couple of stations before ordering it in larger quantities.

Maxime Jaspard (ECGS) travelled with Jérôme Lave from CRPG (Nancy). In the field, they successfully installed the three pilot stations and the weather station. The contact with local authorities and villagers was positive. Access to the site by car is not easy, but it is possible in dry weather. A local guide has been trained to harvest data in August. Accommodation near the site is possible; it is basic but acceptable.

The recorded data of the three pilot stations were collected after the monsoon (during the second mission discussed below). The displacement measured by the one GNSS stations during the monsoon exceeds two meters (Figure 4), confirming the values obtained from remote sensing analysis and thereby validating the site selection for landslide monitoring. The chosen combination of solar panel and battery maintains a stable voltage level during the monsoon. GNSS and seismic data are of good quality and no vandalism was observed on any of the pilot stations. The hardware material (metal enclosure, mast, mounting accessories) provided by the local company turned out to be too heavy and too big with complicated mounting elements, as well as expensive. One pilot station only functioned for 3 weeks due to an electrical contact issue within the box.

Following this first exploratory mission, we had to plan the main, more challenging installation mission, aimed at installing 14 additional stations within one week. This **second mission** was scheduled in late October / early November 2025. This field campaign involved two people from ECGS (Maxime Jaspard and Julien Barrière), three people from CRPG (Nancy) and one from ISTerre (Grenoble). As ECGS oversees the station installations, we prepared and organized everything from Luxembourg. We decided to change the design of the enclosure to reduce the total weight of equipment to carry on site, to reduce the cost, and to improve the ease of installation.

In order to handle all authorizations and maintain effective communication with villagers, farmers, and local authorities, we coordinated with the Nepal Mountain Academy (NMA, government body) to implement a communication programme, beginning with an initial visit prior to our installation. This programme is managed by NMA personnel.

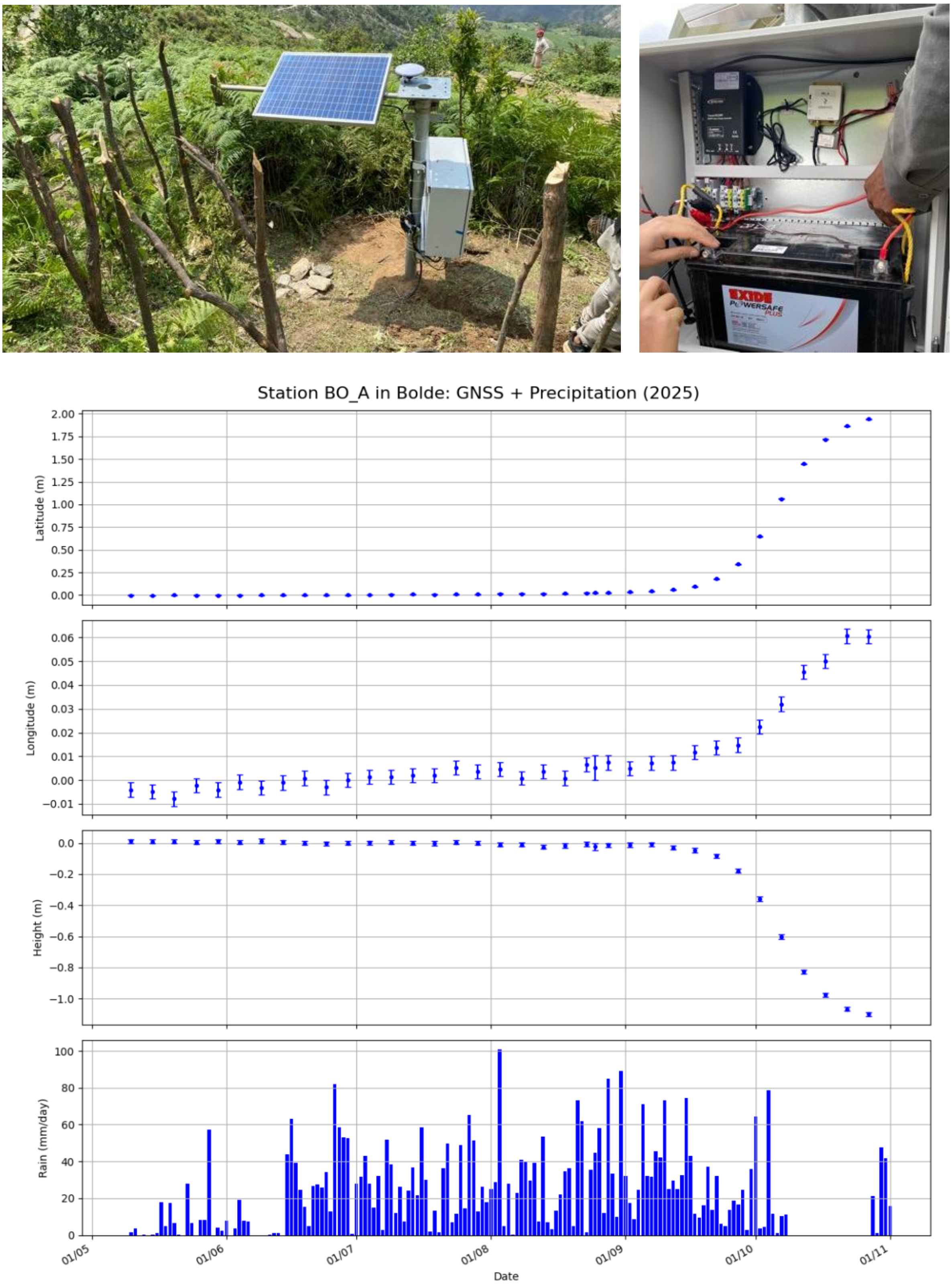

Figure 4: Top row: Photos of a pilot site at the Bolde landslide, Central Nepal (M. Jaspard). Bottom plots: Initial processing of GNSS data and obtained displacements along latitude, longitude and height (from May – December 2025). The lowest plot shows the precipitation recorded by the installed weather station.

Regarding the technical design for the station, a mechanical workshop in Kathmandu constructed the enclosures based on provided schematics. They also designed a mast and mounting components for the solar panels. The enclosures are designed to be partially buried in concrete rather than mounted on poles. Other components, such as batteries, solar panels, and grounding equipment, were sourced locally in Kathmandu. A local guide serves as the liaison between us and the workshop.

The hardware preparation in Luxembourg consisted in the following aspects:

- Program and test all scientific equipment (Seismic + GNSS);
- Build the enclosures for GNSS receivers;
- Build a lightning protection box for each station;
- Prepare all coaxial and power cables with appropriate connectors;
- Prepare and sort all cables, wires, and accessories for each station;
- Label and pack all components to minimize field installation time;
- Prepare schematics for mechanical workshop in Kathmandu to design an enclosure which holds electronic components and battery;
- Maintain frequent discussion with local guide to source all materials in Kathmandu;
- Design two stations with 4G modems for real time data transmission;
- Design ten stations with short period sensor;
- Design four stations with broadband seismic sensor.

The ECGS team travelled to Kathmandu on the 22 October. After two days of preparation, during which all hardware was checked and the field campaign was coordinated with our local guide, the team moved to Bolde. Despite poor weather conditions, all 14 additional stations were successfully installed within eight days, with a team comprising six people from Luxembourg and France, one guide, one student from NMA, and two drivers. Two porters were hired to assist in transporting sand, cement, gravel and water to each installation site.

Each system required specific installation techniques and careful site selection to ensure stable measurements and long-term performance. Field operations were challenged by difficult access, variable road conditions, limited power availability, and unpredictable weather. Beyond technical challenges, community engagement is essential and close collaboration with local residents guided several site choices.

A brief training was conducted onsite for the guide in charge of data collection. This guide will return in January to collect the first 3 months of data. The GNSS data are post-processed using specific software and precise orbit data provided by the constellation operator. The first results, which report a displacement of two meters within one month, were processed using online tools. While these online tools are suitable for post-processing a few sample files (requiring one manual request per daily file), they are not practical for processing all data from each station.

In the past, ECGS used the Bernese software to post-process GNSS data for the network that was operated in the Kivu region until 2022. We updated our Bernese license to the latest official version to process data from the SLIDE project accordingly. Implementing a new network processing workflow in this software will require some time and training over the coming months.

❖ Geophysical monitoring of Bolde landslide

Satellite methods offer unrivalled spatial coverage of surface displacements on a weekly scale for monitoring Himalayan slopes highly exposed to landslides, primarily triggered by earthquakes and monsoon precipitation. However, they do not directly provide details of deformation at depth, nor do they offer sufficient temporal resolution to elucidate the continuity or intermittent nature of the landslide deformation during phases of heavy rainfall, strong rise in the water table or during intermediate seismic shaking. To address these issues in the context of the ANR/FNR project SLIDE, we have deployed the geophysical network at the level of one active, km-scale cultivated landslide in Nepal (Bolde landslide) consisting in 16 co-located seismic and GNSS stations and a weather station (wind, rain) as outlined above (see Figure 3). An additional geophysical station (one seismic + one GNSS station) was deployed at the nearby Tapgaon village to monitor a landslide that moved significantly after the catastrophic Gorkha earthquake (M_W 7.8) but has remained stable since then (Lacroix et al., 2022).

One important aspect of this so-called passive seismic survey relies on the analysis of the seismic ambient noise continuously recorded by the sensors to infer changes in the landslide's properties (i.e., weakening, reconsolidation) with time, e.g. following rainfalls or large earthquakes (e.g., review by

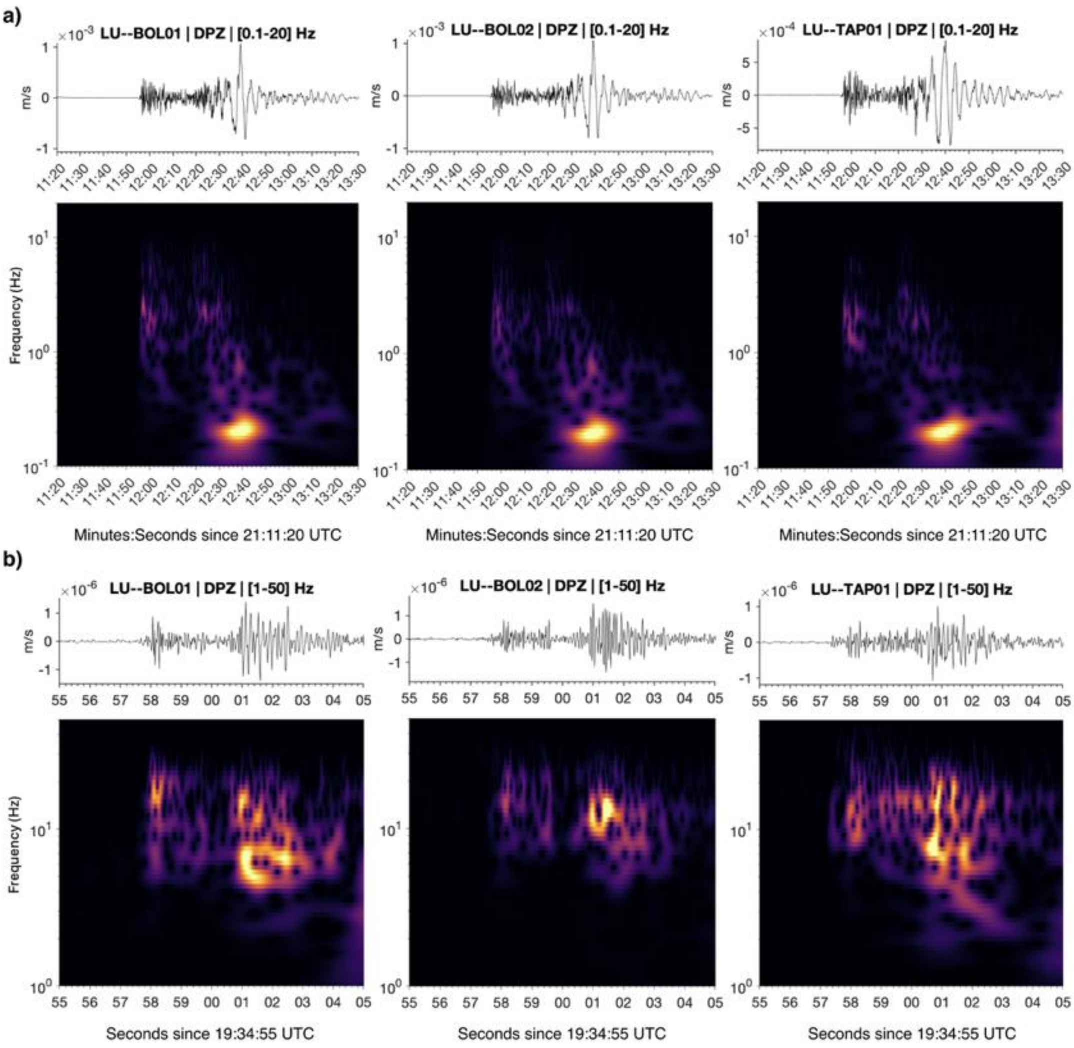

Figure 5: **a)** Vertical component records at BOL01, BOL02 and TAP01 (see Figure 3) of an M_W 5.5 regional earthquake (Tibet) occuring on 11 May 2025 in Tibet. Note that the low-frequency wave train below 1Hz is well retrieved despite the use of short-period (5 Hz) geophones. **b)** Vertical component records at BOL01, BOL02 and TAP01 of a local earthquake on 13 May 2025. Based on the observed S-P times, this event occurred around 20-30 km away from the three sensors with a local magnitude ranging between 2 and 3 (using the standard California scale).

Le Breton et al., 2021, and references therein). Additionally, the same network of geophones can be used to locate microseismicity in the area. In complement to the measurements of ground deformation provided by the co-located GPS stations, the seismic signals (e.g., slope quakes, tremor) provide information on how the deformation propagates at depth, whether it affects the entire slip plane simultaneously or more restricted areas (e.g., Provost et al., 2017).

Because three sensors were deployed in May 2025 (two in Bolde, one in Tapgaon), only records from these three stations could be analysed after collecting the data during the second field mission in October 2025. The first dataset including records over several months for all stations should be obtained in early 2026. The very first preliminary results (Barrière and Oth, 2025) of data acquired in 2025 already show the potential of the recorded seismic signals, either for monitoring local to regional seismicity (Figure 5) or for characterizing the seismic ambient noise sources between dry and monsoon periods (Figure 6). The significant increase of seismic power (Power Spectral Density, PSD) above 2 Hz during the monsoon corresponds to the increase of noise coming from the nearby river and potentially from its tributaries around the landslide. Indeed, neither the rain nor the wind variations can explain the changes in seismic PSD, which likely conveys noise sources originating from turbulent flow and bedload transport in nearby streams/rivers, in line with other observations in fluvial seismology at any scale, whether during large Glacial lake outburst floods (GLOFs) in Central Nepal (Cook et al., 2010) or during summer floods in small rural streams in Luxembourg (Barrière et al., 2015). Characterizing the temporal and spatial variability of this noise will be of great importance both for inferring surface processes (flow conditions in river, tributaries and gullies on the landslide) and to better constraint the interpretation of subsurface velocity changes based on ambient noise interferometry (e.g., Le Breton et al., 2021). It should be noted that a destructive GLOF that occurred on 7 July 2025 was equally observed on a broadband seismic station of the permanent national network near Kathmandu and on the geophones deployed in Bolde and Tapgaon at tens of kilometers from the seismic source (i.e., the flood), proving once again the high sensitivity of these seismic measurements to changes in environmental surface processes (Barrière and Oth, 2025).

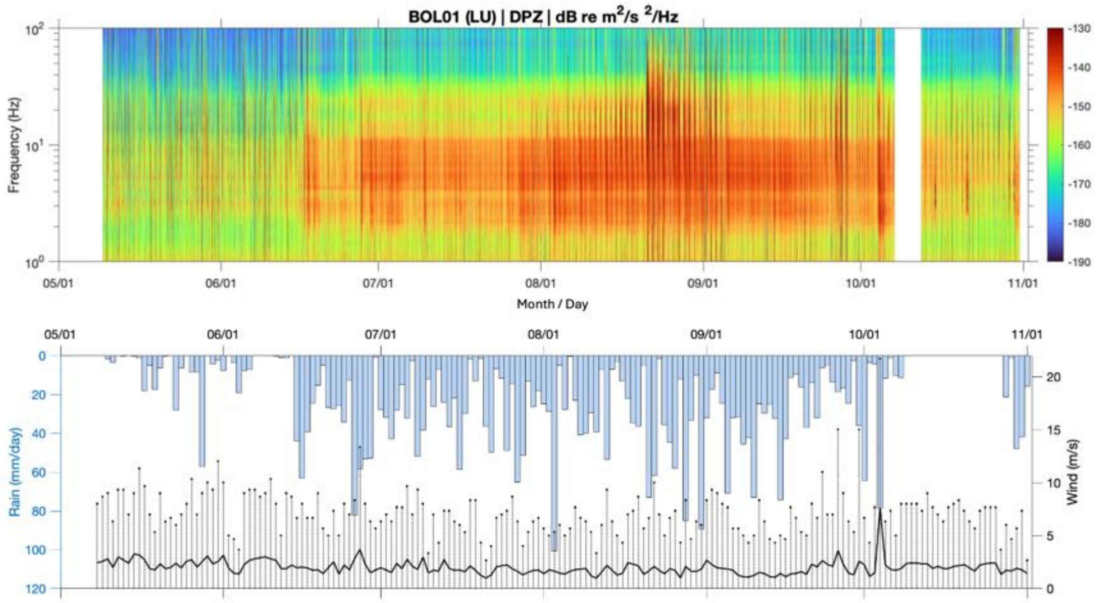

Figure 6: **a)** Seismic PSD (Power Spectral Density, in dB re $m^2/s^2/Hz$) at BOL01 between May and October 2025. **b)** Rainfall (mm/day, blue histogram) and wind (m/s, max and mean in black) measured at the weather station (see Figure 3). The increase of seismic PSD follows the increase of rainfall but a closer look shows a lag between both timeseries, which likely corresponds to the lag between the increase of rainfall and the increase of water level in the nearby river and tributaries.

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Seismological Research & Monitoring Activities

❖ Seismological monitoring infrastructure operated by ECGS

The **Luxembourg National Seismic Network (LuxSNet)** is designed to provide adequate coverage with high-quality broadband seismic stations throughout the entire country for monitoring the seismic activity within and around Luxembourg's territory. The current status of LuxSNet is shown in Figure 7, which includes the information of the temporary stations deployed in 2022-2023 in the framework of the Large-N project in the Eifel[5] coordinated by the GFZ German Research Centre for Geosciences in Potsdam, as well as four additional station sites currently under planning.

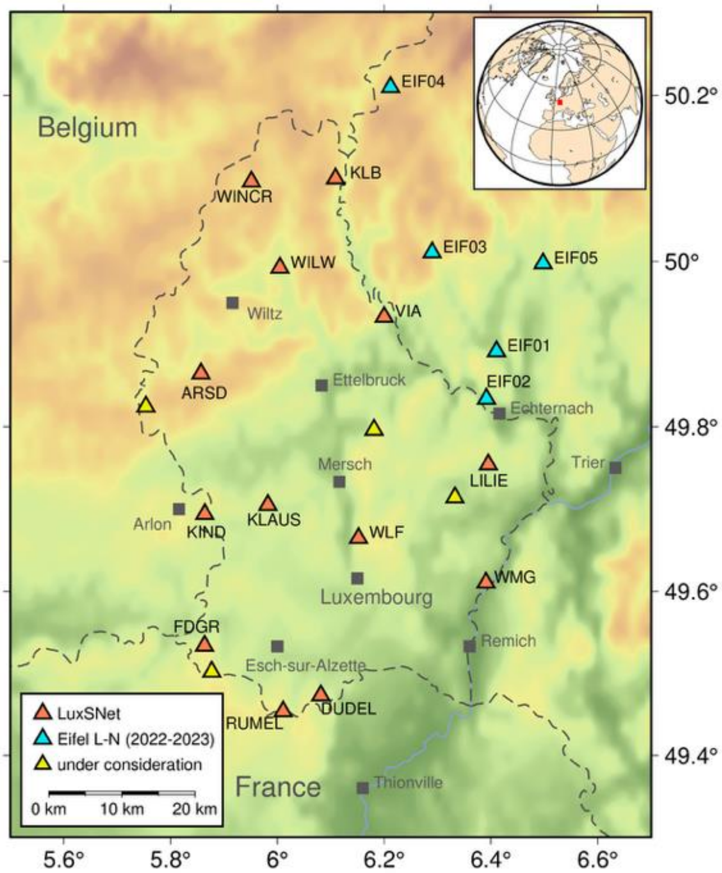

Figure 7: Current status of LuxSNet. The temporary stations EIF01 – EIF05 have been dismantled at the end of August 2023 after one year of operation.

Luxembourg is a region of overall low seismic activity and hazard, as it is located well within the Eurasian Plate, far away from its boundaries. However, even though the Luxembourgish territory does not show significant present-day or historical seismicity, this is not the case for regions as close as 100 – 150 km from the Grand Duchy. For instance, the Roermond earthquake in 1992, which took place close to the border of the Netherlands and Germany and had a magnitude of 5.4, was also widely felt in Luxembourg. We will discuss the new scientific results of our monitoring activities in Luxembourg here below.

ECGS was involved as a partner institution in a large-scale seismological experiment covering the Eifel region in western Germany, a project coordinated by the GFZ German Research Centre for Geosciences. To obtain new insights into the volcanic system of the Eifel, nearly 500 sites were instrumented with seismic stations operating between August 2022 and August 2023, recording earthquakes as well as continuous ambient background noise. ECGS participated in this so-called Large-N seismic experiment by (1) providing five broadband stations for temporary deployment as well as the data from the LuxSNet network and (2) as cooperation partner, for instance in projects such as SURVIVE project lead by GFZ[6].

The permanent LuxSNet network currently counts 13 active broadband seismic stations (Figure 7), covering the entirety of the Grand-Duchy. Regarding the sites under consideration for new stations, the aim is not necessarily in every case to increase the number of stations of LuxSNET, but also to look for improved station locations as compared to the current situation in some areas of the country, with the long-term aim to replace some existing sites of lower recording quality.

A new broadband seismic station was installed in the former slate quarry managed by the municipality of Wincrange, located in the north of the country (station WINCR in Figure 7). We received the authorisation from ANF for "Protection de la Nature" and subsequently installed the station in June

[5] https://geofon.gfz.de/waveform/archive/network.php?ncode=6E&year=2022
[6] https://www.gfz.de/en/section/physics-of-earthquakes-and-volcanoes/projects/survive-follow-the-co2-pre-site-survey-by-large-n-passive-seismology

2025. The sensor is positioned approximatively 150 meters from the mine entrance, ensuring an adequately low noise level.

LuxSNet is under continuous development for 16 years now (Figure 8), which allows for a better understanding, year by year, of the natural seismicity in Luxembourg. Further four station sites are currently under consideration/planning:

1. *Differdange*
   The work on this site involves the installation of a borehole seismic station on a communal plot that already hosts a weather station. The site is relatively far from roads and protected by a fence, but no buildings are available. Consequently, a self-powered enclosure will be installed for electronics, while the sensor will be installed in a borehole at an expected depth of 10 m. Authorization has already been obtained from ANF and the municipality. A formal agreement is being prepared between ASTA (weather station owner), the municipality of Differdange, and ECGS. The implementation of this project is expected in the first half of 2026.

2. *Nommern*
   This is a small village located away from major roads, where low seismic noise is expected. With the support of the municipality, we identified a field near a water source suitable for installing a seismic station. Authorization has been obtained from the municipality, ANF and the "Administration de la gestion de l'eau" due to proximity of the water source. This project is expected to be implemented at the beginning of 2026.

3. *Breinert/Weydig*
   With the assistance of R. Colbach (Service Géologique, Admin. Ponts et Chaussées), the municipality of Biwer granted permission to install a seismic sensor in a disused water reservoir. The building is located in a dead-end street, sufficiently far from major roads. Recordings were conducted over 3 days and the signal-to-noise ratio (SNR) appears promising. As no specific authorizations are required, the final installation is planned in the first quarter of 2026.

4. *Haut-Martelang*e
   With the assistance of R. Colbach (Service Géologique, Admin. Ponts et Chaussées), we are in contact with "Musée de l'ardoise" regarding a project to install a seismometer inside the slate quarry. Within this mine, which is now a tourist site, there are galleries approximatively 40 meters deep where the sensor could potentially be installed. No recordings have been performed yet, but the project looks very promising.

All LuxSNet data are transmitted in real time to the ECGS office in Walferdange and evaluated with the real-time, automatic SeisComP software package developed by scientists at the GFZ Helmholtz Centre for Geosciences and the company Gempa. Since early 2024, ECGS also operates a SeisComPro system with a set of a few additional commercial modules by Gempa, with the aim to further strengthen LuxSNet's real-time detection and location capabilities.

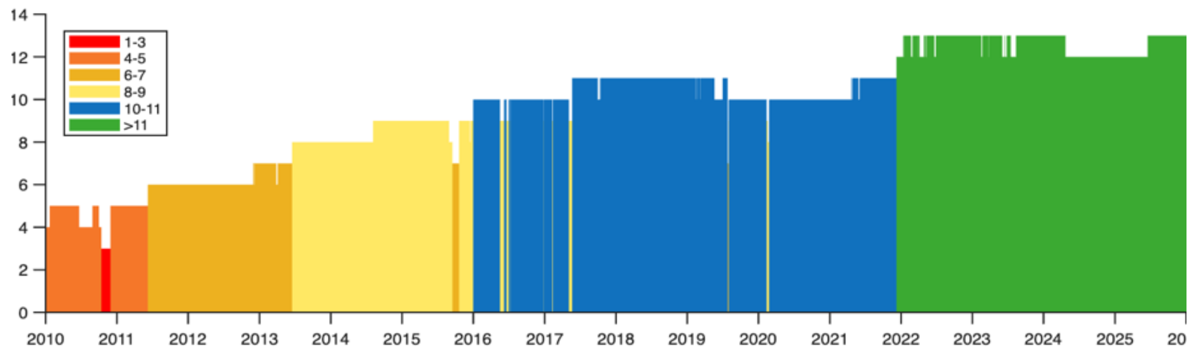

Figure 8: Timeline of data availability (number of operational permanent stations per day) for the Luxembourgish seismic network since 2010.

ECGS shares seismic data of its broadband network with the Royal Observatory of Belgium (a decades-long collaboration exists already for the seismic stations in Kalborn and Vianden), the Erdbebendienst Südwest (Rheinland-Pfalz & Baden-Württemberg) and the Bensberg Observatory of the University of Cologne in Germany.

On the German side, we have real-time access to stations RIVT close to Trier and MUEZ at the German-Belgian border near Bleialf, as well as to several stations from the Bensberg observatory towards the north of Luxembourg and towards Koblenz, while we provide data from our stations WMG, KLB, VIA and WILW to the German colleagues. All data from the Belgian National Seismic Network are available in real-time via the ORFEUS Data Center (ODC)[7] (since 2024), and we use in particular stations DOU, HOU, RCHB and MEM to improve our azimuthal coverage on the Belgian side. In turn, we provide our colleagues in Brussels with access to real-time data from our stations KIND and WILW. Furthermore, we also make use of the openly available seismic data of the French RESIF network[8] that are located in the vicinity of our borders. Since late September 2025, we also have real-time access to eight stations of the 2D network in the Eifel, recently installed as a collaborative effort between GFZ and Landesamt für Geologie und Bergbau Rheinland-Pfalz in the framework of the Eifel Central European Volcanic Province (CVO) Observation Network[9,10].

The benefits of data sharing between Luxembourg, Belgium and Germany can be well illustrated by the location of a "multiplet" of earthquakes (i.e., occurence of events at the same location in a short period of time). These 6 similar events of magnitudes (local magnitude M_L) ranging between 0.7 and 0.9 occurred on 31 December 2025 about 20 km away from the northern boundary of Luxembourg in the Belgian Ardennes. Each map in Figure 9 represents a location solution obtained with the grid-search cross-correlation based location routine XCloc developed at ECGS (see previous reports). The excellent station coverage around the earthquakes, providing high-quality P- and S-wave observations, allows to determine with good accuracy the epicentre and the depth range estimated between 20 and 24 km b.s.l.

Since early 2025, all LuxSNet data since the beginning of network deployment in December 2009 are openly available without embargo or restrictions on the GFZ Eide node[11].

Since 2020, ECGS assumes the role of National Data Centre in the framework of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) on a best-efforts basis, for which we were approached by the Ministry of Foreign Affairs in 2019 as potential scientific partner in the framework of a Benelux Memorandum of Understanding. In this context, ECGS's scientific director regularly participates in the WG-B meetings of CTBTO in Vienna (or remotely) and we maintain close contacts and collaboration in particular with our colleagues from the Dutch NDC at KNMI. Since mid-2024, ECGS also has a functioning GCI connection with the CTBTO International Data Center (IDC) and is acquiring some of the seismic data from the International Monitoring System (IMS) in real time.

Since October 2025, ECGS/Mnhn operates a seismic and geodetic network in Central Nepal on the slow-moving landslide of Bolde, and one station on the landslide in Tapgaon (see SLIDE section above and Figure 3 for further details). All our monitoring efforts benefit vastly from our experience made in the Kivu region in Central Africa. Until mid-2022, ECGS/Mnhn operated a dense network of seismic, geodetic and infrasound instruments there in collaboration with several local and European partner institutions, with primary application to the scientific study of the Virunga Volcanoes, in particular Nyiragongo and Nyamulagira (see previous reports for more detailed information).

❖ Natural (Tectonic) Seismicity in Luxembourg

The Luxembourgish seismic picture is dominated by anthropogenic activity (quarry blasts, road traffic, industrial activities, etc.) but some small-scale tectonic activity has repeatedly occurred in the same faulted areas (Figure 10). We provide here the yearly update of the manual revision of the seismic catalogue based on results from the automatic XCloc event location software developed at

[7] https://www.orfeus-eu.org/data/odc/
[8] https://seismology.resif.fr/networks/#/FR
[9] https://www.gfz.de/en/scientific-infrastructure/research-infrastructures/regional-observatories/central-european-volcanic-province-observatory-cvo
[10] https://geofon.gfz.de/waveform/archive/network.php?ncode=2D&year=2021
[11] https://geofon.gfz.de/waveform/archive/network.php?ncode=LU

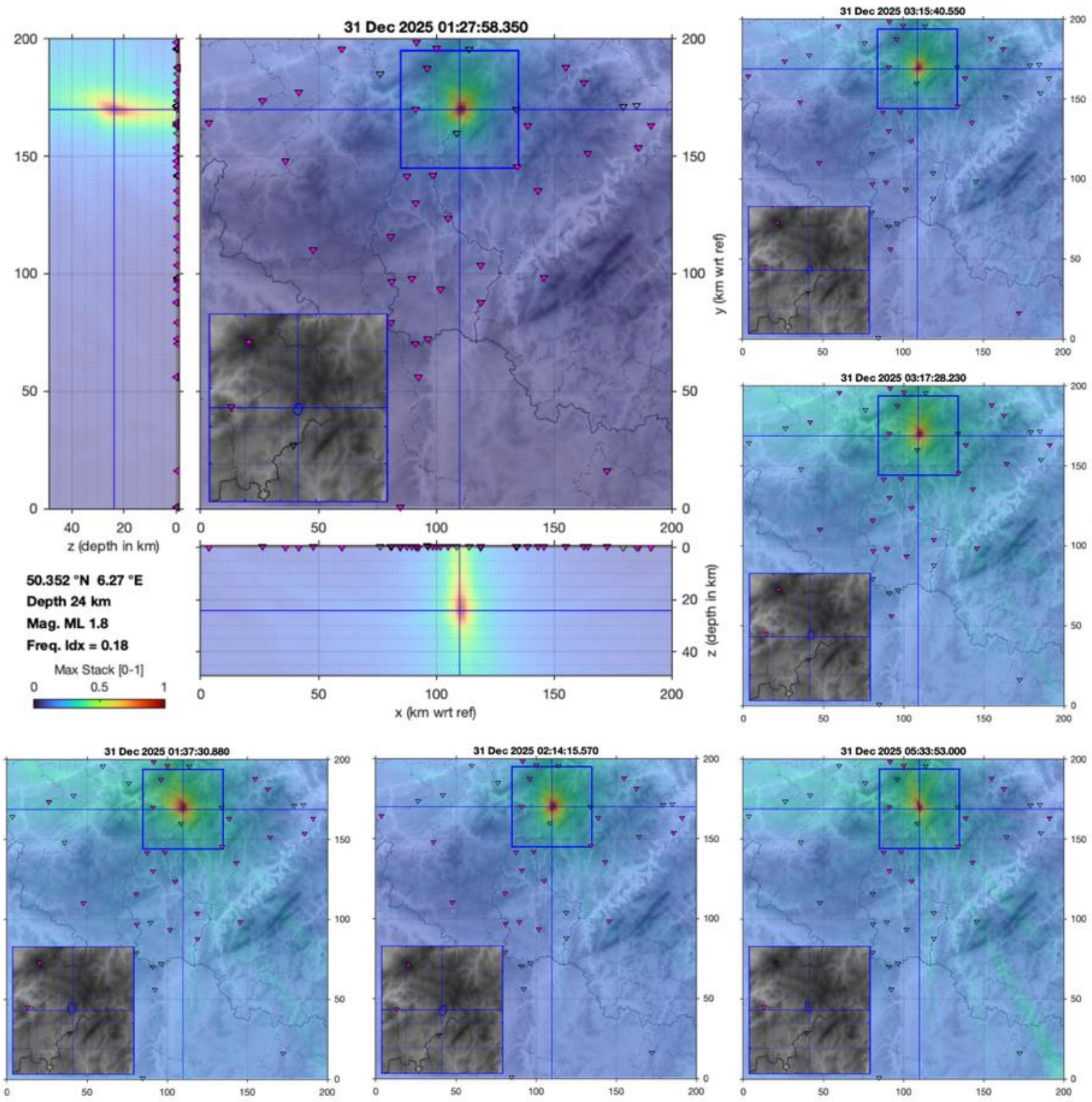

Figure 9: Location maps of the "Amel (Belgium)'s multiplet" on 31 December 2025 constituted of one main shock at 01:27 UTC (M_L 1.8) and 5 successive events of lower magnitude at 01:37 (M_L 0.8), 02:14 (M_L 0.9), 03:15 (M_L 0.9), 03:17 (M_L 0.9) and 05:33 (M_L 0.7). Stations are represented by inverted triangles and those used for the location are filled in magenta. The detailed hypocentre maps (longitude-latitude-depth) for the first event are plotted on the top left and the longitude-latitude maps for the 5 other events are plotted around. The colour scale ("Max Stack") corresponds to the "network response" obtained for each event, which can be understood as the location likelihood varying between 0 to 1 (the most probable location). The spatial distribution of the network response (i.e., the smearing of the red part) gives clues about the location uncertainty. For each panel, a zoom of 50x50 km around each epicentre solution is provided in inset, where only the maximum value of the network response (crossing of blue lines) and the 68% confidence ellipse (in blue, computed from values of the network response exceeding 0.8) are plotted. Note that the centre of the ellipse and the maximum value are not necessarily co-located, but a strong discrepancy should imply a large location error, which is not the case here.

ECGS, leading to the detection and location of 17 natural earthquakes occurring on Luxembourg's territory or nearby (within 10 km from the boundary). For the sake of brevity, the interesting readers can find more detailed and technical information about the general seismic patterns in Luxembourg and the location software XCloc in the previous reports, e.g. 2023 and 2024. Following these previous reports, we give below a summary regarding the located events in the period 2010-2026:

- One additional tectonic event (M_L 0.7) was detected in 2025 in the northern cluster of earthquakes (see event coloured in light green);
- None of the above-mentioned events were felt by humans;

- The two most energetic events occurred around Mondorf/Schengen (M_L 2) and Hesperange/Alzingen (M_L 1.9), both in 2019. A smaller replica of the Mondorf/Schengen's event occurred in April 2022;
- The smallest magnitude event (M_L 0.6) occurred around Mertert/Wasserbillig;
- 15 highly similar events belonging to the Grünewald multiplet occurred over 10 years at the same location between 2013 and 2023 (see 2023 report). Only two of magnitude M_L 1 and 1.1 could be detected on national network scale and thus located, while the remainder was detected using a template matching approach with records from the closest station WLF.

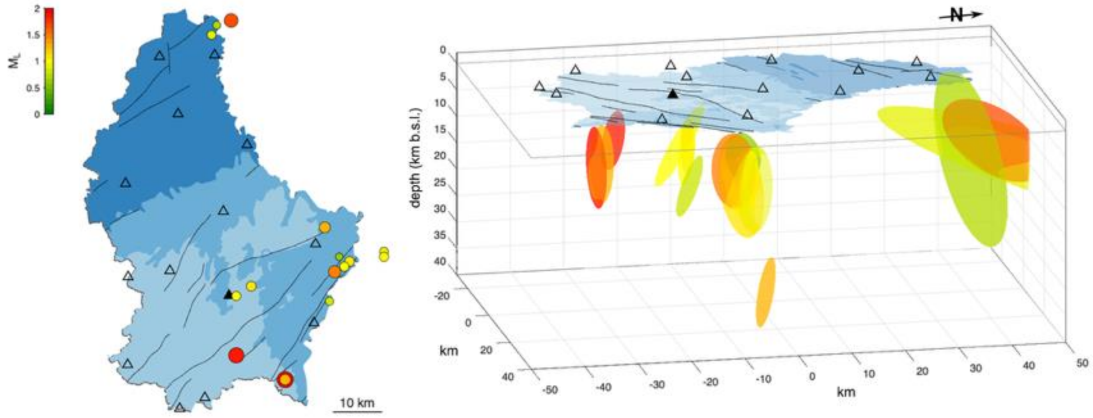

Figure 10: (Left) Natural (tectonic) earthquakes located in Luxembourg using the automatic XCloc event location software. Size and colour of the round markers (i.e., maximum likelihood estimation of epicenters) are proportional to the magnitude M_L. The three main bedrock geological units of Luxembourg (Devonian-Trias-Jurassic) are coloured from dark to light blue, respectively, and the main geological faults are depicted in solid black lines (source: geoportail.lu). LSN stations (network code LU) are depicted with unfilled triangles. The Walferdange station (WLF, network code GE) is represented by the filled black triangle. (Right) 3D view of the same events but represented by their corresponding 68% confidence ellipsoids coloured according to their magnitude (see colour scale on the left). Note that the location errors are generally much larger along depth and too large ellipsoids at the limits of the selected domain can be clipped.

❖ Seismo-acoustic research in the Kivu Rift region

<u>The details of the 2021 Nyiragongo eruption using infrasound</u>

In a study published in "Nature Communications Earth & Environment" in November 2025 (Barrière et al., 2025), we show the power of infrasound as a crucial volcano monitoring tool, complementing other techniques such as seismic or satellite measurements. This work was a collaboration with the Royal Netherlands Meteorological Institute of the Netherlands (J. Assink, L. Evers).

Eruptions at continental basaltic volcanoes can take and combine various forms, including lava lakes, lava flows and fountaining, explosions or structural collapses. Recording seismicity is widely recognized as essential for tracking magma movements at depth but must be complemented with other observations for monitoring eruptions, which are by essence atmospheric processes. Aside from a few well-instrumented cases worldwide, accurately reconstructing the precise eruptive mechanisms and chronology is hampered by the lack of detailed visual observations in space and time. However, because they emit low-pitched inaudible sound, called infrasound, any changing and potentially hazardous eruptive activity can be inferred with specialised microphones.

On 22 May 2021 in D.R. Congo, the drainage of Nyiragongo's long-lived and world's largest lava lake was accompanied by lava flows from eruptive fissures toward a one-million urban area composed of the cities of Goma (D.R. Congo) and Gisenyi (Rwanda). After 1977 and 2002, this was the third known flank eruption and the first one adequately monitored with seismic and geodetic instruments to understand magma movements at depth. A probable scenario supported by these geophysical

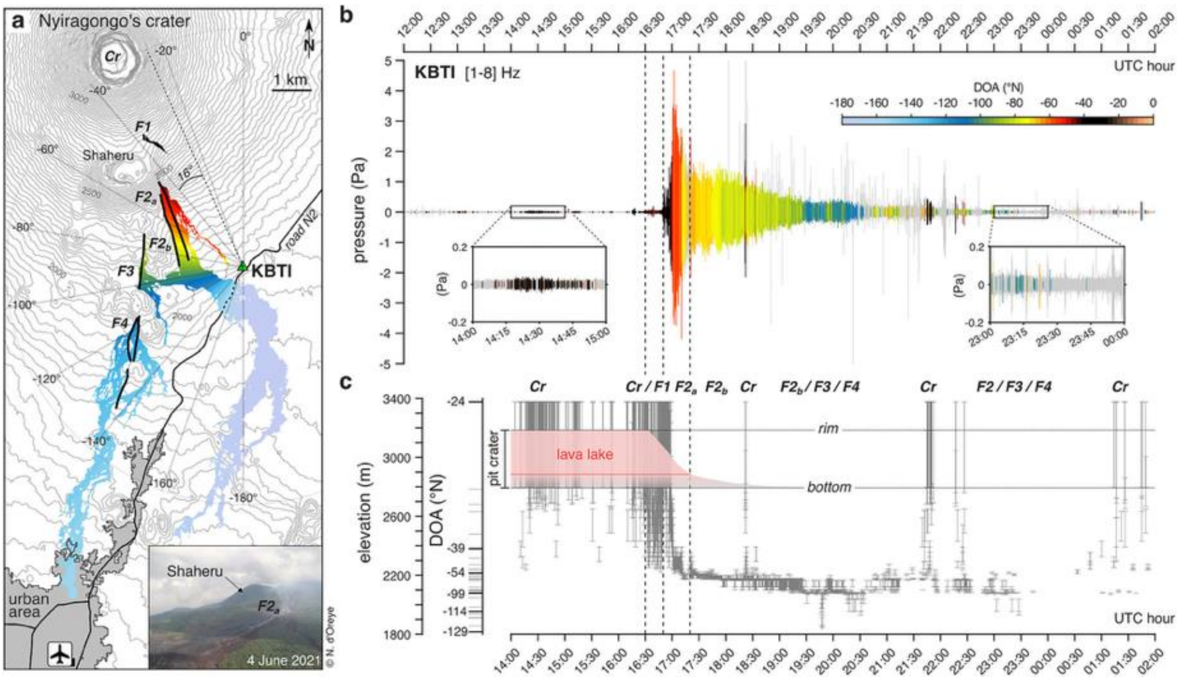

Figure 11: *(After Barrière et al., 2025).* **a**) Map of Nyiragongo's flank from the northern limit of the urban area (in grey) including the airport to the south, up to Nyiragongo's summit crater to the north. The background topography (contour lines) is derived from SRTM data with 1 arc-second resolution (NASA/USGS). The abbreviation Cr denotes Nyiragongo's crater and the main eruptive fissures are numbered F1, $F2_{a,b}$, F3 and F4 from highest to lowest elevations respectively. A picture taken from a helicopter on 4 June 2021 shows the Shaheru adventive crater and the fissure F2a (inset). The lava flows are coloured (from blue to red) according to the Direction of Arrival of the infrasound signals (DOA, °N) with respect to KBTI station (green triangle). Intra-crater activity (CR) and F1 corresponds to DOA coloured in black. Considering the location of eruptive fissures, DOA that do not correspond to potential eruptive sources are coloured in light blue/magenta and light brown. The corresponding colour scale is plotted in (**b**). **b**) Infrasound record at KBTI coloured according to DOA. Vertical dashed lines indicate 16:30, 16:50 and 17:20. **c**) Observed DOA converted into elevation along the fissures axe from Nyiragongo's crater to F4 plotted as error bars. The drainage of the lava lake contained within the summit pit-crater is reproduced as the transparent red-to-grey area limited by the pit-crater rim on top and the maximum depth of the pit crater after the eruption on bottom (see Barrière et al., 2025 for details).

observations is the rupture of the edifice, starting around 15:57 UTC, draining the lava lake during a short-term (~6 hours) flank eruption and initiating a week-long magmatic intrusion (dyke) in the Earth's crust.

Using acoustic numerical modelling, we converted infrasound records from local distance (< 20 km) up to Kenya (more than 800 km away from Nyiragongo) into high-resolution time-lapse observations of this catastrophic lava-lake drainage. The emitted infrasound also provided unprecedented insights into the timing of fissure openings and lava eruptions on the volcanic flank, occurring simultaneously with the lava lake drainage (Figure 11). This striking example highlights how decoding each specific volcano's acoustic signature provides unique information inaccessible to other ground-based instruments, which can be integrated to monitoring and multi-hazard early warning systems.

Hydroacoustic observations during the 2021 Nyiragongo dyke intrusion under Lake Kivu

This work is a collaboration between B. Roche (Univ. libre de Bruxelles, ULB), J. Barrière (ECGS), C. Caudron (ULB) and F. Darchambeau (KivuWatt) leading to an article submitted to *Seismica* in late 2025, which shows evidence of lakebed degassing and blowout events in lake Kivu. The text here below is adapted from this submitted article.

The 2021 eruption of Mount Nyiragongo raised concerns about a potential limnic eruption in Lake Kivu, which would threaten millions of lives. A large dyke intrusion was tracked migrating southward beneath the lake, prompting fears of increased magmatic gas release or direct magma injection into the water column which could trigger an overturning event. To investigate these risks, a hydrophone was deployed to monitor hydroacoustic activity during ~12 hours on 31 May 2021. Analysis of the recorded data has provided fresh insight into magmatic degassing in the region including the observation of pulsed lakebed seeps releasing small clouds of bubbles into the water column, both long period and short duration events indicative of fluid flow in the sediment (Figure 12) and three explosions (Figure 13). In addition to the sustained seismicity of magnitude below 4 at that time, one moderate earthquake (M_L 4.6) occurred only a few kilometres from the hydrophone, which was the only local event above magnitude 4 during the experiment. It is noteworthy that the three major hydroacoustic explosions occurred all within approximately an hour after this earthquake, yet trying to establish any cause-and-effect relationship between the earthquake and the explosions would be too hasty considering the short duration of the hydrophone recording. These explosions were most likely caused by blowouts from lakebed gas pockets. Whether these events are regular occurrences or a result of increased magmatic gas from the underlying dike is unclear. Notably, these events occurred without detection by the local seismic network (Figure 13), underscoring the limitations of land-based monitoring systems. While no limnic eruption did occur, important insights were gained including the need to integrate hydroacoustic monitoring into limnic eruption risk assessments to improve early warning capabilities.

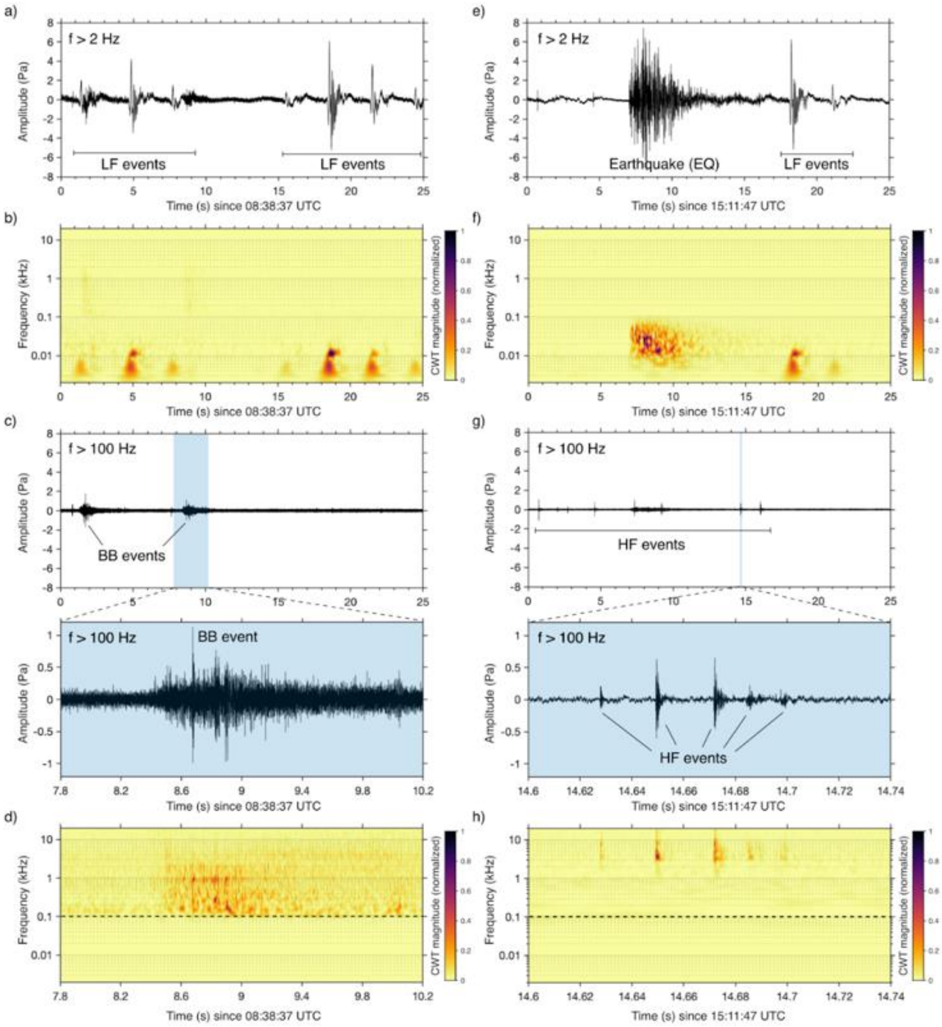

Figure 12: *(After Roche et al., submitted).* Two examples of 25-s continuous recordings depicting the event types identified using manual and automatic detection approaches across the whole frequency range 2Hz – 20 kHz (see text). a) First example of high-pass filtered record above 2 Hz showing repetitive low-frequency events, further called LF events based on their time-frequency representation (Continuous Wavelet Transform, CWT) represented in b. c) Same signal as in a) but high-pass filtered above 100 Hz highlighting the presence of two events of lower amplitude, further called BB events because of the relatively broadband frequency signature (from 0.1 to a few kHz) without clear maxima. A zoom of 2.4-s length for the second event is provided (blue graph) and the corresponding CWT is depicted in d. e) Second example of high-pass filtered record above 2 Hz showing a local earthquake and LF events. f) CWT of the signal in e showing the different frequency content between earthquakes and LF events below 100 Hz. g) Same signal as in a but high-pass filtered above 100 Hz highlighting the presence of numerous high-frequency signals, further called HF events. A 0.14-s window zooming into one sequence of HF events is provided (blue graph) and the corresponding CWT is depicted in h.

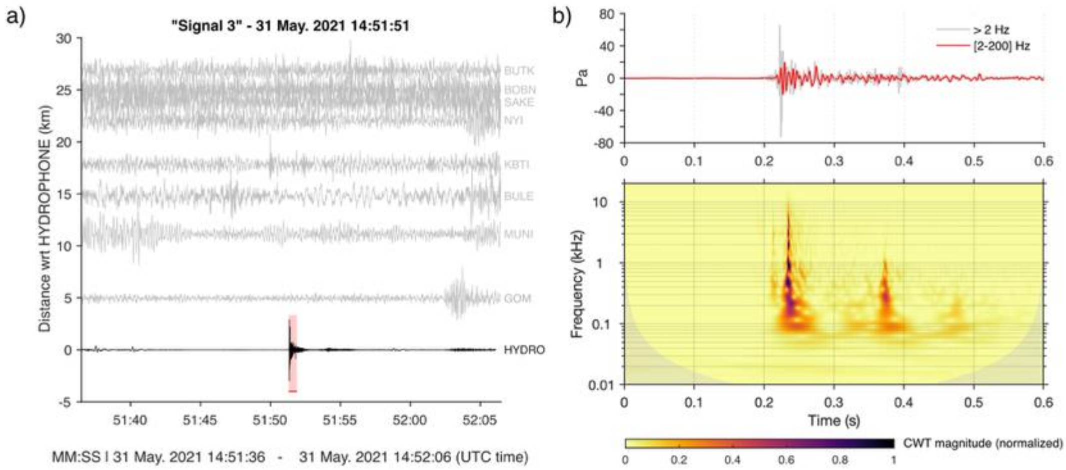

Figure 13: *(After Roche et al., submitted).* Recordings for one submarine explosion occurring at 14:51 UTC. **a**) The hydroacoustic signal (band-pass filtered 2-200 Hz) is displayed in black and seismic signals (bandpass filtered 2-20 Hz) from the KivuSNet stations are displayed in grey and plotted along the y-axis with regard to the hydrophone location. The coloured boxes around the hydroacoustic signals are zoomed in the right panel (**b**). High-pass (>2 Hz) and band-pass (2-200 Hz) filtered signals are plotted in grey and colour, respectively. The Continuous Wavelet Transform (CWT) of the high-pass signals are plotted below (the edges masked in grey corresponds to areas in the CWT affected by boundary effects, known as "cones of influence").

❖ Environmental Seismology in northern Italy

This on-going work has been conducted by M. V. Gangemi (PhD student at Univ. Catania) in collaboration with J. Barrière and A. Oth (ECGS) and Italian universities/institutes (Univ. of Catania, Univ. of Trieste, INGV and OGS). M. V. Gangemi was research visitor at ECGS during 4 months in 2025. Following his stay at ECGS he submitted an article to "Geophysical Journal International" in late 2025. The text here below is adapted from the abstract of this submitted article.

Understanding river dynamics during flood events is critical for effective hazard mitigation and water resource management, especially as extreme weather events become increasingly frequent. Environmental seismology, which consists in monitoring natural surface processes with seismic instruments, has gained considerable attention over the past two decades. During floods events continuous seismic signals, also called seismic noise in this context, are generated by the turbulent flow and the transported bedload on the riverbed. If recorded at nearby seismic stations (i.e. from the riverbank to a few hundred meters), these seismic data can become an important source of information complementing traditional methods (e.g., stream gauge, bedload basket sampler) to improve models and early warning systems. Despite the increasing number of case studies worldwide, the potential of seismic monitoring to capture flood-induced natural river processes in the Alps remains underexplored, particularly regarding the opportunistic use of existing stations from permanent network(s) originally deployed for earthquakes monitoring.

This study investigates the potential of records from permanent seismic stations relatively far from the river (up to ~3km) to assess bedload discharge and river flow dynamics during flood events in one of the rare morphologically preserved alpine rivers, the Tagliamento River in northern Italy. Seismic data from three selected stations at the subwatershed scale (i.e., spaced by about 20 km at maximum) were analysed together with hydrological and meteorological measurements such as water height, rain rate, and wind velocity, hence allowing to identify specific frequency bands for which seismic amplitude timeseries correlate with weather and river components. For particular frequencies, we notably observe a hysteresis behaviour between seismic amplitudes and the rising and falling phases of flood event, suggesting seismic source mechanisms related to turbulent flow and/or the movement of coarse sediments. The study demonstrates that even stations not specifically positioned close to the riverbed can capture valuable information on flood dynamics, thereby providing an early indication of flood propagation. These findings highlight the potential for incorporating seismic monitoring into flood forecasting and river management strategies, contributing to enhanced hazard mitigation efforts in the context of increasingly frequent extreme meteorological events. More specifically, the present study also helps in gaining information about Tagliamento catchment response and relative seismic signatures during flood events for further investigations in developing early warning system based on seismic data.

❖ Post-doctoral research of Francesco Rappisi

The post-doctoral research of Dr. F. Rappisi focuses on seismic imaging and waveform analysis to investigate the internal structure and dynamic processes of the Earth. The primary aim of Dr. Rappisi's post-doctoral work at ECGS is the usage of seismic tomography approaches to non-invasively resolve the subsurface architecture of volcanic systems and tectonically active regions, including subducting slabs, convergent margins, and divergent plate boundaries. In addition to tomographic imaging, his work involves numerical simulations designed to validate methodological developments prior to their application to real data, and to test geological or geophysical hypotheses that arise from observed results. A further component of this research concerns the statistical analysis of seismic waveforms to identify signal characteristics associated with specific geological processes—such as fluid-related deformation, slow slip, or aseismic creep—thus providing independent constraints on subsurface dynamics. This line of research contributes to a better understanding of volcanic hazards, earthquake genesis, and lithospheric deformation, and supports risk mitigation strategies in geodynamically active regions.

The target regions and collaborations include:

- Kivu and Virunga volcanic region— in collaboration with the University of Padua and the University of Leeds;
- Campi Flegrei volcanic area— in collaboration with the University of Padua, the University of Leeds, and INGV;
- Mexican subduction zone— focusing on identifying potential precursory signals of earthquakes and tsunamis from waveform characteristics, in collaboration with the University of Leeds;
- Additional collaborative work is ongoing with University College London (UCL, UK), Los Alamos National Laboratory (USA), and Kangwon University (S. Korea) in the frame of the research work "*Adjoint seismic sensitivity kernels to the full elastic tensor for a 3D seismo-geodynamic model*" led by Dr. M. Desiderio and supervised by Prof. A.M.G. Ferreira (UCL);
- MODEM project: active collaboration with international colleague within the ERC *proof of concept* "MODEM" project aiming at improving 4D anisotropic tomography and integrating it into active monitoring and surveillance system of volcanoes.

This year was marked by extensive processing and analysis of seismic datasets from these multiple tectonic and volcanic settings. This included waveform preprocessing, event selection, quality control, and the extraction of diagnostic waveform features for both tomographic and statistical investigations. These efforts also led to several important methodological innovation products. Dr. Rappisi developed a Python-based waveform analysis toolkit to support studies on tsunami and earthquake hazards, enabling automated extraction and classification of waveform segments associated with particular source processes (https://doi.org/10.21203/rs.3.rs-7260983/v1).

The work also led to the production and release of a modified version of SPECFEM, expanding its capabilities for numerical simulations. This version has been made publicly available online to facilitate its use by the wider seismological community (https://doi.org/ 10.5281/zenodo.17341802). Numerical simulations were carried out to test tomographic approaches and to validate interpretative hypotheses derived from observational datasets. These simulations played a central role in refining the robustness of the methodologies before applying them to field data.

Overall, Dr. Rappisi's 2025 research activities integrated data analysis, methodological development, and computational modelling within an international collaborative framework, contributing to a deeper understanding of volcanic and tectonic processes in multiple regions worldwide. These major research lines initiated in 2025 will continue throughout 2026, with several projects entering advanced or final stages.

The tomographic study of the Kivu and Virunga volcanic provinces is now well advanced (Figure 14). The submission of a manuscript on this study is expected within the first months of 2026. The work on the Campi Flegrei volcanic area will move toward finalization in 2026. Preliminary findings suggest a potentially significant involvement of magma in the current unrest phase, which poses a substantial hazard to the densely populated surrounding region. Ongoing work focuses on validating this hypothesis through targeted numerical simulations. These simulations explore multiple scenarios, including the ascent of deeper magma and its role in heating the overlying hydrothermal system, potentially driving both intense ground deformation and seismic–aseismic activity.

Finally, during 2026, the manuscript *"The detection of transient subduction zone interface properties using teleseismic data"* is currently under review in *Geophys. Res. Lett.* Additionally, revisions will be carried out for the manuscript *"SubRidge: a 3-D Subduction-to-Ridge Model with Synthetic Seismic Waveforms for Benchmarking"*, which is currently under review in the journal *Seismica*.

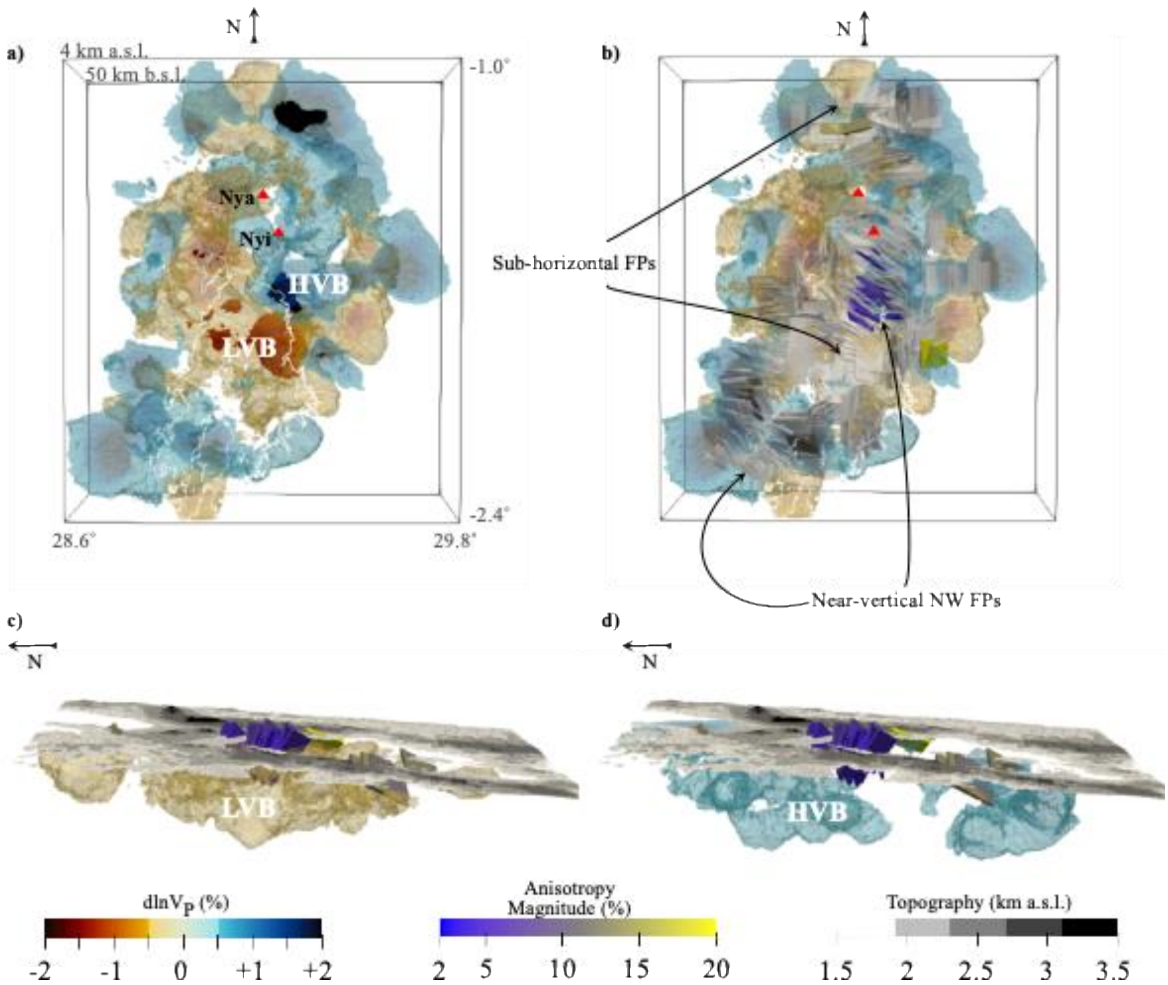

Figure 14: Kivu and Virunga Volcanic Province Seismic tomography. 3-D model of the main isotropic and anisotropic features from (a-b) top view and (c-d) lateral views. c-d) show isolated low velocity (LVB) and high velocity bodies (HVB), respectively. Relative P-wave velocities (with respect to 1D velocity model) are plotted above 0.5 % and below -0.5 %. Velocity anomalies are reduced in opacity where the relative standard deviation (RSD) is higher than 0.7. Anisotropic fast planes (FPs) are colored according to anisotropic magnitude, and plotted in gray with 50%< DB< 75% (i.e., medium-uncertainty; DB: directional bias). In panel b), medium-uncertainty anisotropic patterns have reduced opacity. Solid white line (in a-b) shows Lake Kivu's coastlines.

❖ Various international seismological collaborations

- **BSSA Special Section on *Improving Measurements of Earthquakes Source Parameters***

Based on a the work of a Technical Activity Group (TAG) that was set up back in 2021 in the framework of the *Statewide California Earthquake Center (SCEC)*, A. Oth was involved as guest editor, together with his colleagues A. Baltay (USGS, USA), R. Abercrombie (Boston University, USA) and T. Uchide (AIST, Japan) in editing a Special Section on Improving Measurements of Earthquake Source Parameters in *Bulletin of the Seismological Society of America*, which was published in June 2025[12]. The 39 articles in this Special Section address the need for better insights into the large variability in earthquake source parameters observed across many studies, and to better gauge their physical and methodological origins in order to improve the usefulness of these parameters for ground motion prediction. Adrien Oth co-authored two studies in this Special Section, as well as its Introduction.

- **Impact of seismic attenuation corrections on source parameter estimation**

This study is a collaboration between D. Bindi (GFZ Helmholtz Centre for Geosciences, Germany), M. Picozzi (OGS, Italy), A. Oth (ECGS) and D. Spallarossa (University of Genoa, Italy). This study was published in the journal *Seismica* in 2025[13]. The text here below is adapted from the abstract.

The main aim of this study was to investigate how strongly the assumptions made about simple propagation models influence retrieved source parameter estimates. To that end, the stress drop for 551 earthquakes from the 2019 Ridgecrest sequence in Southern California is estimated using a spectral decomposition. A 2D cell-based approach that accounts for lateral attenuation variations is applied and the results are compared with previous models using hypocentral distance (HYPO) and a set of attenuation models depending on source depth (EpiH).

While the 2D model reveals significant azimuthal variations, the overall stress drop distribution remains similar to that from the HYPO model, at least for the analysed data set. High stress drop is observed for the 2D model near the M7.1 and M6.4 events, while lower values appear at shallower depths, especially toward the Coso region and near the left-lateral fault junction of the M6.4 sequence. Although spatial comparisons among models reveal some localized differences, the most significant impact arises when depth dependence is included in the attenuation model (EpiH), which effectively removes the increase of the average stress drop with depth.

- **Interevent variability in ground motion prediction models: the role of source parameters selection**

This study is a collaboration between D. Bindi (GFZ Helmholtz Centre for Geosciences, Germany), A. Oth (ECGS), S. Parolai (University of Trieste, Italy), M. Picozzi (OGS, Italy), and D. Spallarossa (University of Genoa, Italy). This study was published in the journal *Bull. Seismol. Soc. Am.* in 2025[14]. The text here below is adapted from the abstract.

While the previous study aimed at investigating the effect of attenuation model assumptions on retrieved earthquake source parameters, this study here looks at the effect of source parameters selection on ground motion modelling.

The authors investigate the dependence of interevent residuals on the choice of source parameters used in ground-motion prediction models calibrated for peak ground acceleration, peak ground velocity, and peak ground displacement. Using a dataset of 877,566 recordings from 1586 earthquakes with magnitudes ranging from 1 to 6.5 in central-southern Italy,

[12] https://pubs.geoscienceworld.org/bssa/issue/115/3
[13] https://doi.org/10.26443/seismica.v4i2.1651
[14] https://doi.org/10.1785/0120250098

multiple mixed-effects regressions are performed, exploring different approaches for the source scaling component. The interevent standard deviation of models is compared based on various source parameters, including moment magnitude, local magnitude, radiated energy, source spectral value at 3 Hz, moment magnitude with stress drop, and moment magnitude with apparent stress.

The study results show that combining moment magnitude with either stress drop or apparent stress yields the lowest variability across all peak parameters, as expected. In addition, using local magnitude effectively captures the stress-drop-related component of variability. For the analysed magnitude range, the source spectral amplitude at 3 Hz performs similarly to local magnitude in this regard, without saturating for large magnitudes. These findings suggest that source parameter choices complementary or alternative to moment magnitude can help reduce interevent variability. However, the suitability of models based on parameters other than moment magnitude depends on the specific application.

- **GITPy: A Python Implementation of the Generalized Inversion Technique**

This study is a collaboration between P. Morasca and F. Pacor (INGV, Italy), D. Spallarossa (University of Genoa, Italy), D. Bindi (GFZ Helmholtz Centre for Geosciences, Germany), M. Picozzi (OGS, Italy), and A. Oth (ECGS). This study was published in the journal *Seismol. Res. Lett.* in 2025[15]. The text here below is adapted from the abstract.

GITpy is an open-source object-oriented Python software package implementing the well-established Generalized Inversion Technique (GIT), a spectral decomposition approach to isolate the source, propagation, and site contributions from S-phase Fourier amplitude spectra (FAS). This is field of particular expertise of A. Oth (ECGS), who developed a Matlab® package to this effect many years ago, and this work here ports this implementation to Python, improves its computational efficiency and expands it.

GITpy applies a nonparametric (i.e., without imposing any a priori parametric models on the different terms), one-step inversion procedure. GITpy offers the possibility to: (1) simplify the attenuation and source modelling process by providing configuration files and interactive procedures allowing for rapid testing of different models; (2) choose between different levels of attenuation modelling complexity (geometrical spreading and anelastic attenuation); (3) select among different source spectrum modelling options, including the use of a homogeneous or heterogeneous crustal model, as well as the ability to define the frequency range for the model fitting; (4) calculate station-specific apparent source spectra by correcting the input FAS for site amplification and nonparametric attenuation obtained from the inversion, and then fit them. This can be particularly useful for directivity studies. Furthermore, this module can be used independently for a rapid estimation of source parameters in case of a strong event; (5) provide several source parameters including radiated energy, apparent stress, and radiation efficiency alongside seismic moment, corner frequency, and stress drop.

The versatility of GITpy is presented by applying it to the well-documented 2016–2017 seismic sequence in central Italy, showcasing the software's capabilities through specific modules for source and attenuation modelling, as well as for calculating apparent source spectra. To achieve this, a comprehensive dataset including 355 stations and 8534 events was assembled, allowing for the evaluation of the software's performance in handling large-scale datasets.

[15] https://doi.org/10.1785/0220250042

Remote Sensing, Volcanology and Ground Deformation Modelling

❖ Development of software: "AMSTer: SAR & InSAR Automated Mass processing Software for Multidimensional Time series"

AMSTer is a software for SAR and InSAR processing and computation of ground deformation time series (see details below), written by Nicolas d'Oreye, Dominique Derauw, Sergey Samsonov, Delphine Smittarello, Maxime Jaspard and Gilles Celli (Derauw et al. 2020; d'Oreye et al. 2021; Smittarello et al. 2022; Smittarello et al. 2023).

Since 2025, AMSTer is licensed under the GNU Affero General Public (AGPL) License as published by the Free Software Foundation, either version 3 of the License, or any later version. See the GNU Affero General Public License[16].

In 2025, we also continued AMSTer's development. The most recent version (December 2025) was updated on the public GitHub repository[17]:

The **principal improvements** are:

- Adaptation of new AMSTer Engine functionalities:
    - Upgraded to process the data from the upcoming new NISAR satellite;
    - Upgraded to process Sentinel ETAD for Ionospheric, Geodesic and Tropospheric corrections and improved geocoding;
    - New licensing (from CC BY-NC-SA 4.0 to AGPL license).
- AMSTer Toolbox scripts:
    - Upgraded to process the data from the upcoming new NISAR satellite;
    - Upgraded to process Sentinel ETAD for Ionospheric, Geodesic and Tropospheric corrections and improved geocoding;
    - Ability to perform asymmetric zoom and geocoding;
    - Creation of a new "DiagToolbox" to perform several automated diagnostics of the AMSTer processes, including listing and comparing of CSL and MSBAS data, and graphical tools to help defining the pair selection parameters;
    - Python scripts now make use of Python3 installed in a virtual environment;
    - Several new scripts for creating figures (e.g. Cloud Optimized GeoTIFF, kmz figures with color scale…), for assisting checking and debugging, for cleaning and correcting processes etc;
    - New licensing (from CC BY-NC-SA 4.0 to AGPL license).
- AMSTer Documentation:
    - Update of manuals according to points above. Manual version 6.5 is now 325 pages long.

In 2025, AMSTer fuelled the following **international collaborations or opportunities**:

a. With the European Space Agency (ESA): Contribution to a new project led by the Centre Spatial de Liège (Contract No. 4000147545/25/I-DT-bgh): "*E-Coh*" aims at developing the **coherence tracking technique** within the AMSTer environment. That E-Coh project also includes a Contract Change Notice (CCN) aiming at implementing **AMSTer on the GEP platform** (Geohazard Exploitation Platform[18]).

b. With the Centre Spatial de Liège: to assist in the project "*Automatic Ground Displacement Monitoring (AUDIMAT)*", we processed the Sentinel-1 data from 2017 to 2025 over a **4.000 km^2 area in Belgium** extending from South of Mons, to Bruxelles, and up to the North of Boom. Results allowed to identify several ground deformations from natural origin (e.g.

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16 https://www.gnu.org/licenses/
17 https://github.com/AMSTerUsers/AMSTer_Distribution
18 https://geohazards-tep.eu/#

sediments compaction or subsidence above the covered Senne river crossing Bruxelles) or human origin (e.g. related to water pumping around breweries). Results were presented at a BELSPO event on September 19, 2025, Liège, Belgium.

c. With the Laboratoire Magmas et Volcans, Université Clermont Auvergne (France), and École et Observatoire des Sciences de la Terre (EOST), University of Strasbourg: Sentinel-1 data were processed to analyse ground deformation and atmospheric artifacts over the **Galeras volcano** (Colombia). Sindy Lizarazo (CNES Postdoc at LMV) and Ethel Maillard (M2 student at EOST) were trained to the AMSTer processing and analysis of these data. Ground deformation time series are shared on the ECGS dedicated web page. Results were presented at the "Rencontre Scientifique Volcanologique 2025" (Le Bourget du Lac, France, June 25-27, 2025) and the "2025 IAVCEI Scientific Assembly" (Geneva, Switzerland, June 29-July 4, 2025).

d. With the University of Grenoble-Alpes: in the frame of her PhD, Laureen Maury came at ECGS for a short traineeship (23 Aug. - 12 Sept. 2025) to learn AMSTer and use it to study the **landslides in the Mustang area** (Nepal). Several tests were processed in 2D and 3D. Specific processing using the ETAD atmospheric and ionospheric corrections layers for Sentinel-1 data were also performed. Results are shared on the dedicated ECGS web page and preliminary results were presented at the "103rd Journées Luxembourgeoises de Géodynamique" (18-21 November 2025, Luxembourg).

e. With the Space Agency of Argentina (CONAE): we continued the collaboration with CONAE over the **Laguna Fea region (Argentina)**. Results from the monitoring using Sentinel-1 and SAOCOM data and their comparison were presented at the "IEEE 2025 XXI Workshop on Information Processing and Control", (17-19 sept 2025, San Francisco, Argentina), and published in an IEEE Conference Journal.

f. With the Laboratoire Magmas et Volcans, Université Clermont Auvergne (France), and Vrije Universiteit of Brussels and Africa Museum (Belgium): we continued the systematic processing of Sentinel 1 images acquired over the **Karthala volcano in Comoros Island**. The ground deformation associated with the 2021 seismic crisis recorded on the volcano is still under study with the additional results obtained with CosmoSkyMed images. A paper is in preparation with Valerie Cayol and her former Master student Alexis Hautecoeur (among others). Preliminary results were also presented at the Colloque "Le volcan Karthala comme vecteur de développement" (Moroni, Comoros, January 20-22, 2025), at the "Rencontre Scientifique Volcanologique 2025" (Le Bourget du Lac, France, June 25-27, 2025) and at the "2025 IAVCEI Scientific Assembly" (Geneva, Switzerland, June 29-July 4, 2025).

g. With the Africa Museum (Belgium), the Université Officielle de Bukavu (Democratic Republic of Congo) and the Centre de Recherche et d'Information sur les Risques Naturels, i.e. CIRRINA (Democratic Republic of Congo): AMSTer is used to routinely provide authorised users with 2D and 3D ground deformation **time series of the Funu landslide in Bukavu** (South Kivu, Democratic Republic of Congo) computed using Sentinel-1 images and shared through the dedicated web pages.

h. With the Institut de Physique du Globe de Paris (France) and Laboratoire Géoscience Réunion (Université de la Réunion, France): AMSTer is used to compute **2D and 3D ground deformation time series of landslides** in vegetated areas in **La Réunion Island**. Results were published in the journal *Geomorphology* by Colline Hopquin, who finished her PhD at IPGP on that topic, and presented at the "103rd Journées Luxembourgeoises de Géodynamique" (Luxembourg, November 18-21, 2025). The collaboration continues with Nicolas Villeneuve (Université de La Réunion) and a new PhD student, Loris Honorat, jointly supervised by LGR and BRGM (France). InSAR ground deformation time series computed with AMSTer are automatically shared on a dedicated web page.

i. With the Institut de Physique du Globe de Paris (France): AMSTer is used to process Sentinel-1 and TerraSAR-X data over **the Soufrière volcano** (Guadeloupe). The preliminary results were presented at the "2025 IAVCEI Scientific Assembly" (Geneva, Switzerland, June 29-July 4, 2025) and "Rencontre Scientifique Volcanologique 2025" (Le Bourget du Lac, France, June 25-27, 2025). A student in Master 2 will also come to Walferdange early in 2026 for working on that topic.

For all these collaborations and the projects described here after, we carry on with our systematic processing of InSAR ground deformation time series over several targets for:

- volcano monitoring (e.g. on Comoros Island, Guadeloupe Island, La Réunion Island, Domuyo, Laguna del Maule and Laguna Fea regions in Argentina and Chile, Galeras in Colombia, …),
- landslides (e.g. in the Democratic Republic of Congo, La Réunion Island, Central Nepal…)
- other deformations of anthropogenic and natural origins (e.g. in Luxembourg).

The results from all these automatic incremental processing routines are available on dedicated web pages[19]. Moreover, the recent developments of AMSTer motivated in 2025 the following education and training activities and remote assistance:

- The organization in Walferdange of a **three-weeks traineeship (Aug. 23 – Sept. 9, 2025)** for a postdoc from Laboratoire Magma et Volcans
- The remote assistance for several colleagues and users.

Visibility of AMSTer toolbox: At the time of writing this report, GitHub shows 12 unique clones over the past 14 days (the longest available reporting period), excluding untracked ZIP downloads, and a total of 164 views.

Reminder: AMSTer is aiming at:

- Processing automatically and incrementally a large number of interferometric pairs and feeding and running the MSBAS processor [Samsonov and d'Oreye, 2012, 2017; Samsonov et al., 2017, 2020] in order to obtain the desired 2D or 3D deformation maps and time series;
- Performing individual differential interferograms (for deformation measurement or DEM creation purposes);
- Creating time series of coherence or amplitude maps coregistered on a Global Primary (both in radar geometry or in geographic coordinates), e.g. for land use or geomorphological changes tracking.

AMSTer can process any type of SAR data (ERS1 & 2, EnviSAT, ALOS, ALOS2, RadarSAT, CosmoSkyMed, TerraSAR-X, TanDEM-X [incl. bistatic mode], Sentinel1 A & B [incl. SM mode], Kompsat5, PAZ, SAOCOM, ICEYE, NISAR...). AMSTer Engine (a command line InSAR processor derived from the Centre Spatial de Liege (CSL) InSAR Suite (CIS) [Derauw, 1999; Derauw et al, 2019]) is optimized to fit the needs of the AMSTer Toolbox, which benefitted from some of its unique specificities.

AMSTer comes with a ~325 pages detailed manual in constant evolution to follow the developments of the software.

Finally, we implemented quicklook and comparison tools that enable efficient evaluation of different processing strategies, allowing systematic comparison of alternative parameter settings and processing chains. An additional toolbox was developed to perform singular value decomposition (SVD) and independent component analysis (ICA) of the time series, enabling advanced analysis and interpretation of deformation signals. Its application to Karthala volcano is shown in Figure 15. Another tool aims to integrate the Mango toolbox into AMSTer, enabling the computation of atmospheric corrections based on GNSS-derived zenith total delay (ZTD) estimates (Figure 16).

❖ MUVE: Suivi SAR multi-capteurs des processus de versant" (2024-2025)

In collaboration with the Centre de Recherches Pétrographiques et Géochimiques (CRPG) from the University of Lorraine in Nancy and the ISTerre (Grenoble), the MUVE projects aims at studying displacements along steep slopes in Nepal using Sentine-1, PAZ, TerraSARX SAR images and Pleiades, SPOT, Landsat-8, Sentinel-2 optical images. Results obtained from the studied regressive slow-moving landslide in the Marsyandi and Khudi valleys were presented at the "*103rd Journées Luxembourgeoises de Géodynamique" (Luxembourg, November 18-21, 2025*) and a paper is under review.

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19 https://terra4.ecgs.lu/

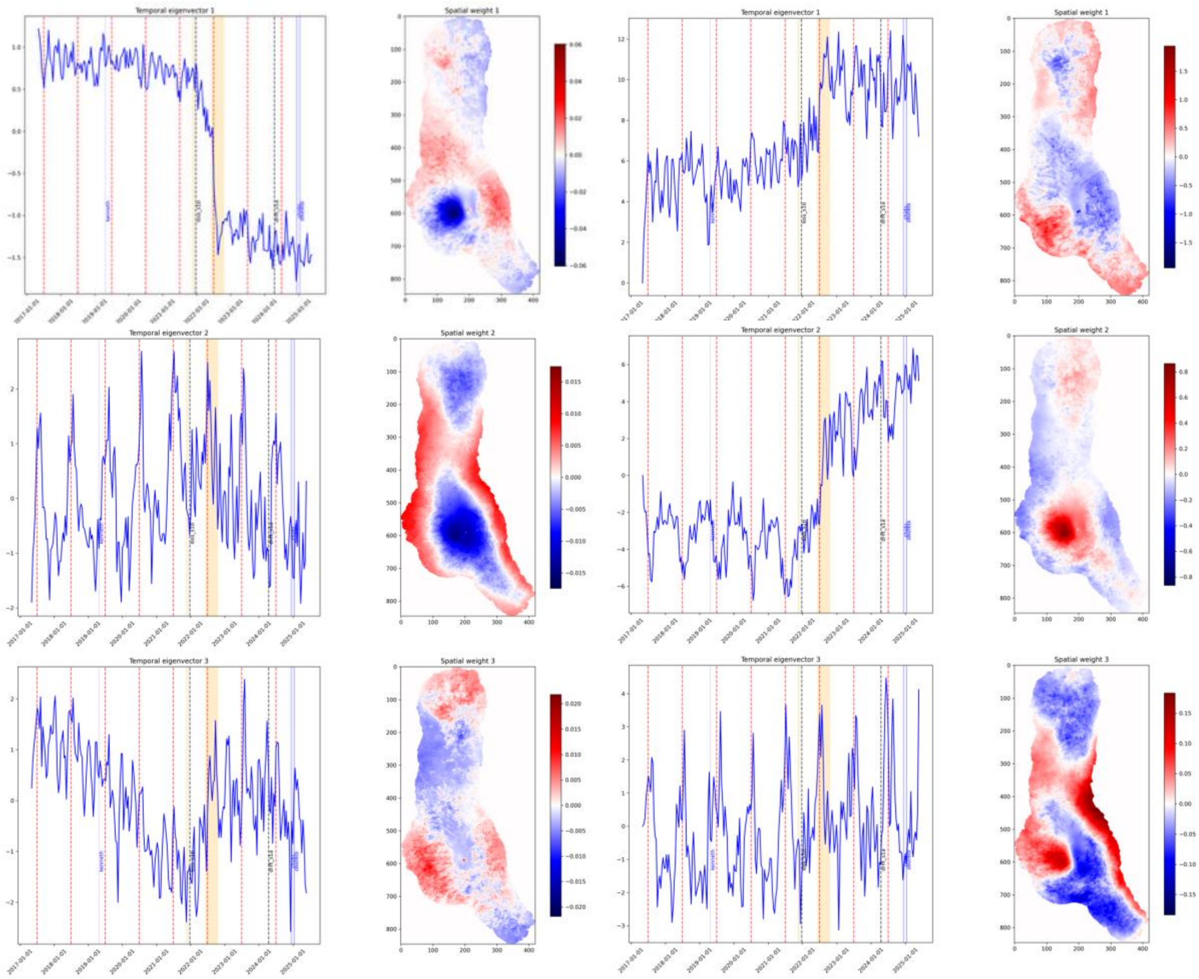

Figure 15: First three components of ICA (left) and SVD (right) decomposition of InSAR timeseries over Karthala volcano. Such decomposition helps to distinguish between volcanic deformation, and cyclic seasonal changes.

❖ SLIDE: Assessing the contribution of slow-moving landslides to erosion in the Himalayas" (2024-2028)

Please refer to the dedicated section for the SLIDE project (pages 4-11).

❖ "ALOS2: studying inter-eruptive ground deformation at Piton de la Fournaise using ALOS2 data." (2024-2025) and "ALOS4: High-Resolution, High-Frequency InSAR Monitoring of Volcanic Activity at Piton de la Fournaise Using ALOS-2/-4 Spotlight Data" (2025-2028)

These two projects are conducted in collaboration with the Laboratoire de Géologie de Lyon (Université Jean Monnet, Saint-Étienne), the Magmas & Volcanoes Laboratory (Clermont Auvergne University), the Institut de Physique du Globe de Paris (IPGP), and several other international teams.

Following the successful JAXA EO-ERA3 project (2024–2025), "ALOS2: Studying Inter-Eruptive Ground Deformation at Piton de la Fournaise Using ALOS2 Data," the new EO-ERA4 project (2025–2028) is now underway. Titled "High-Resolution, High-Frequency InSAR Monitoring of Volcanic Activity at Piton de la Fournaise Using ALOS-2/-4 Spotlight Data," this initiative has been granted an exceptional quota of 60 ALOS-2 and 60 ALOS-4 images per year—significantly exceeding the standard allocation for the AO framework.

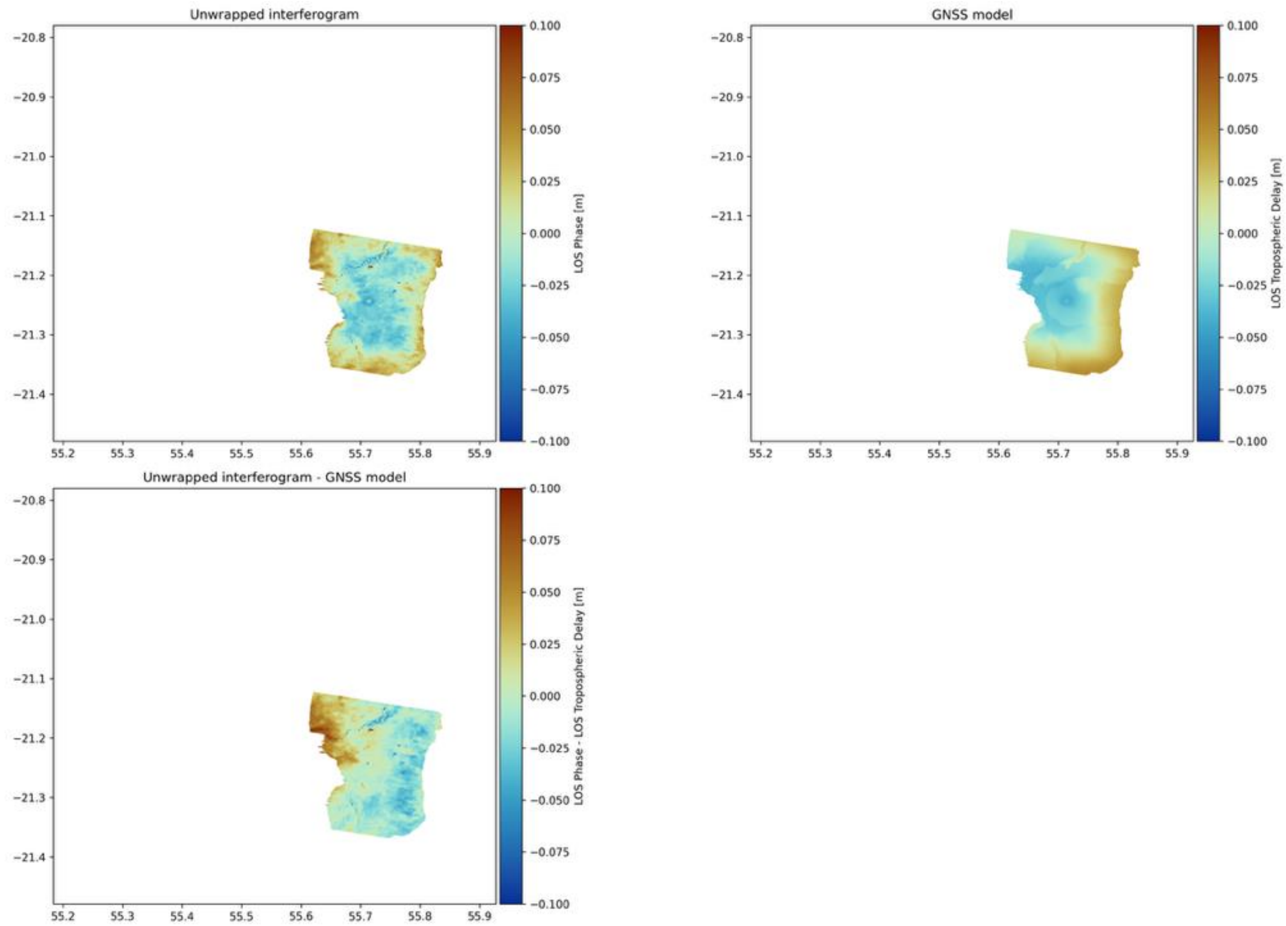

Figure 16: Three-panel illustration of the interferogram correction process. The top panel shows the raw unwrapped interferogram. The middle panel displays the modelled correction derived from GNSS zenith total delay (ZTD) estimates. The bottom panel shows the corrected interferogram after application of the GNSS-based atmospheric correction.

Using that exceptionally dense dataset of ALOS-2 and ALOS-4 images acquired from 27 different incidence angles in both right- and left-looking modes, the project aims to measure 3D inter-eruptive displacements at Piton de la Fournaise using InSAR, cross-referenced with GNSS measurements. From the 2,325 available ALOS-2 SpotLight images (August 2014–November 2025), approximately 2,000 images from 22 viewing geometries were selected, yielding nearly 9,000 interferograms. These were inverted to produce 3D deformation time series. To refine the analysis of inter-eruptive deformation, the study focuses on the most densely monitored period: 2021 to present. Co-eruptive displacements from the five eruptions between 2021 and Today (2025) were modelled, projected into the satellite line-of-sight for each acquisition geometry, and removed from the deformation maps. This process enables a more accurate analysis of inter-eruptive deformation. Ongoing validation and comparison with GNSS data from the Piton de la Fournaise Volcano Observatory are currently in progress.

Preliminary results were presented at the “Rencontre Scientifique Volcanologique 2025” (Le Bourget du Lac, France, June 25–27, 2025), the “Cafés ISDeform” (Gières, France, January 24, 2025), and the 2025 IAVCEI Scientific Assembly (Geneva, Switzerland, June 29–July 4, 2025).

❖ S1 and TSX Time Series on Soufrière de Guadeloupe

Within the framework of a collaboration with IPGP and the SNO ISDEFORM, we performed InSAR time series analyses using Sentinel-1 and TerraSAR-X images over the Soufrière de Guadeloupe. We demonstrated the capability of the AMSTer toolbox to detect low-amplitude deformation signals (on the order of centimeters) in challenging environments characterized by tropical vegetation and steep topography (Figure 17). Those results will be used in 2026 in the framework of C. Palmieri’s internship for validation against GNSS network and modelling of the deformation source.

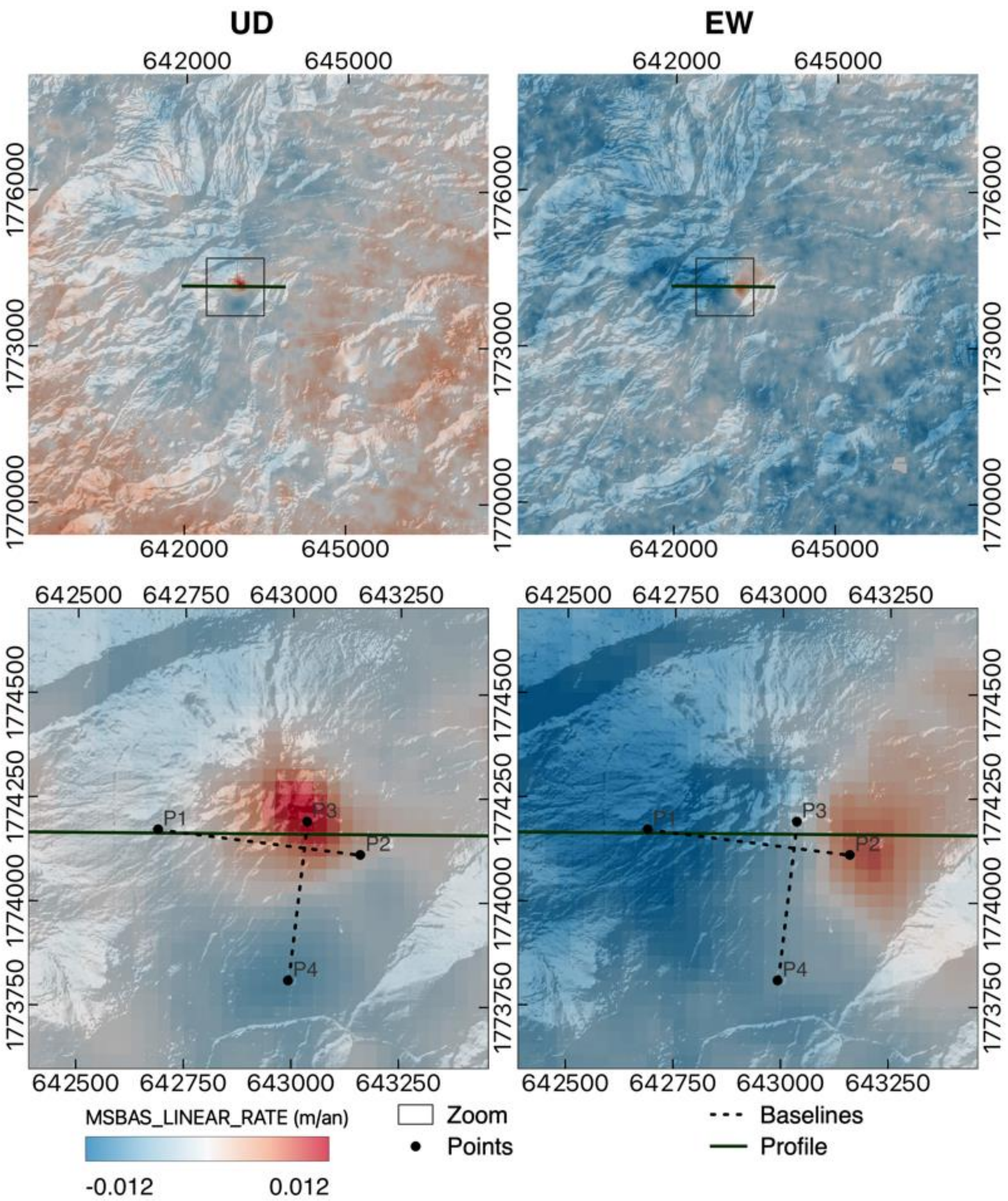

Figure 17: Sentinel-1 InSAR linear velocity maps over the Soufrière de Guadeloupe, showing localized steady inflation and east–west extension of the summit dome.

❖ Side projects

- **Karthala Volcano (Grande Comoros Island):** Study of the 2021–2022 unrest phase using InSAR time series, SVD decomposition, and DEFVOLC inverse modelling, conducted within the framework of A. Hautecoeur's Master internship. InSAR-derived deformation indicates a magmatic intrusion beneath the Karthala volcanic edifice that did not reach the surface. Manuscript in preparation.
- **Landslides in La Réunion Island:** Beginning of collaboration with the University of La Réunion and BRGM within the framework of Loris Honorat's PhD. Validation of 2D and 3D InSAR time series for monitoring slow-moving landslides in a densely vegetated tropical environment.
- **InSAR Time Series and AI:** Beginning of collaboration with LISTIC (Annecy, France) on the development and application of AI-based methods for improving InSAR time series.
- **Galeras:** Collaboration with Sindy Lizarazo, V. Cayol (Univ. Clermont Auvergne) in the framework of E. Maillard's Master internship. Computation of InSAR timeseries on Galeras volcano (Colombia) and modelling with DEFVOLC.

Walferdange Underground Laboratory for Geodynamics (WULG)

The Underground Laboratory for Geodynamics in Walferdange, hosted in the former gypsum mine at 100m depth, remains an exceptional station for high quality seismic and geophysical measurements and tests.

Following the first seismic measurements obtained with three Sprengnether from 1973, the WULG was equipped with a Lennartz 3D short period seismometer in 1987 and a broad-band STS-2 GEOFON in 1994, providing us with more than 40 years of uninterrupted high-quality seismic observations. The data from the STS-2 very broadband seismometer are an important component of the national seismic network operated by ECGS as well as the global GEOFON seismic network operated by the GFZ Helmholtz Centre for Geosciences.

The University of Luxembourg carries out the maintenance of the superconducting gravimeter installed in the WULG since the beginning of the twenty-first century. Between 2010 and 2018, Prof. Dr. Manfred Bonatz established and operated the Walferdange Geodynamical Laboratory (*GeoDynLab*) in a dedicated section of the WULG, operating various measurement devices for measuring gravity, rock dynamics (tilt), atmospheric pressure and chamber temperature for metrological investigations.

Given its outstanding quality, the WULG remains an exceptional measurement and test site for geophysical instrumentation in a highly stable environment since 1968. The interest in using the WULG as a high-quality test site for instrumentation is unbroken. Following a request in 2020, Mr. Bruno Pagliccia from the private company SeisBEE established in Luxembourg carried out instrumental performance studies for MEMS-based accelerometers in the WULG in collaboration with ECGS staff. In July 2022, the Luxembourg-based company FIRIS tested a new autonomous drone for carrying out 3D scans of underground structures in the WULG. In 2023, a request was addressed to ECGS/Mnhn by the University of Luxembourg PhD student Gabriel Garcia, SnT) for carrying out experiments in the WULG in order to test autonomous navigation algorithms for robotic vehicles in underground settings. These experiments were carried out in 2024 and 2025.

Continuous radon (Rn) measurements in the Laboratory and the entrance gallery have also performed during the past decade. These data, along with the very long data base already acquired over the previous decades, allow for an assessment of the long-term evolution and the seasonal variations of Rn. It also allows monitoring transient signals or assessing gas transport into the underground environment and link them with external causes (e.g., changes in air circulation conditions). ECGS collaborator A. Kies continued to carry out these measurements and analysis in 2025 (see short report below, pages 31-32).

For several years now, issues regarding the stability of the entrance have been noticed and discussed among the administrations and ministries involved (see previous reports). Following a number of meetings and analyses by the *Inspection du Travail et des Mines (ITM)* and their collaborators over the past years, including among others a 3D scan of the mine carried out in early 2023 in order to get a better overview of its situation, the ITM presented their report on the security situation of the mine entrance to the Minister of Culture in 2024. In addition, in a letter from 1 July 2024, the rector of the University of Luxembourg (Uni.lu) confirmed the university's keen interest in the continuation of their activities within the WULG, in particular in the context of the Interdisciplinary Centre for Socio-Environmental Systems that is being established at Uni.lu.

No final conclusions on how to proceed have yet been reached. For this reason, access is currently still restricted to ECGS/Mnhn and Uni.lu staff for instruments operation and maintenance purposes only, following strict security regulations.

❖ Radon measurements in the WULG during 2025

Prof. em. Antoine Kies

We report from radon data recorded continuously in the mine at four locations (Figure 18):

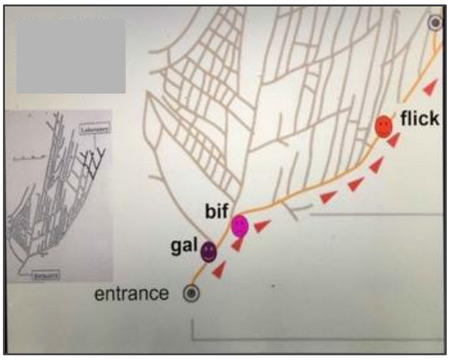

Figure 18: Radon observation sites in WULG.

- **'flick'** in the main gallery, representing the mine interior (except the geophysical laboratory separated by doors and the less ventilated gallery endpoints);
- **'gal'** endpoint of a collapsed lateral gallery joining the entrance gallery between the entrance and the first bifurcation;
- **'bif'** at the first bifurcation;
- **'end'**, the most remote and shielded gallery of the geophysical laboratory.

Furthermore, we rely on the meteorological data from MeteoLux.

Figure 19 shows radon and external temperature: compared to 2024, we see a similar short 'radon season' without very high radon levels and no 'Indian Summer' maxima. For interpretation of the radon patterns, the knowledge of the constant mine temperature (black line) is crucial. Especially night temperatures below 10°C have a great influence on radon accumulation in the mine. Radon in the mine exceeding 2500 Bq/m^3 originates from the influx of radon-charged air at 'gal'. Combined studies of ‚gal-bif-flick' and external temperature are regularly done and were discussed in previous reports.

As compared with the radon levels measured in 2022 as a reference, radon concentrations in the warm season 2024 were low and of shorter duration. This happened rarely since continuous radon monitoring started in the mine. Even the October Indian summer high, clearly visible on the radon measurements in 2022, was missing in 2024.

Figure 20 documents at 'gal' and 'flick' the influence of temperature on radon levels during the delivery transition of no/low to high radon-charged air into the mine. Two different periods can be defined, before 1 June and after 12 June, with in-between a transition period. In the first period at 'gal' radon and temperature are not correlated or even anti-correlated whereas in the second period they are correlated; temperature peaks and lows precede slightly those of radon.

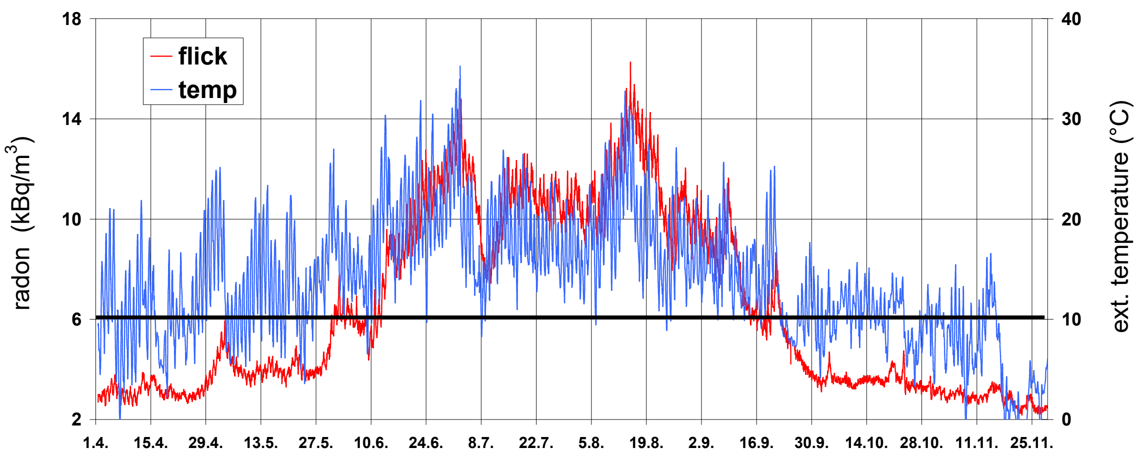

Figure 19: Radon concentration at 'flick' from 1 April June to 30 November 2025 (red) and external temperature (blue). The constant mine temperature is indicated as a black line.

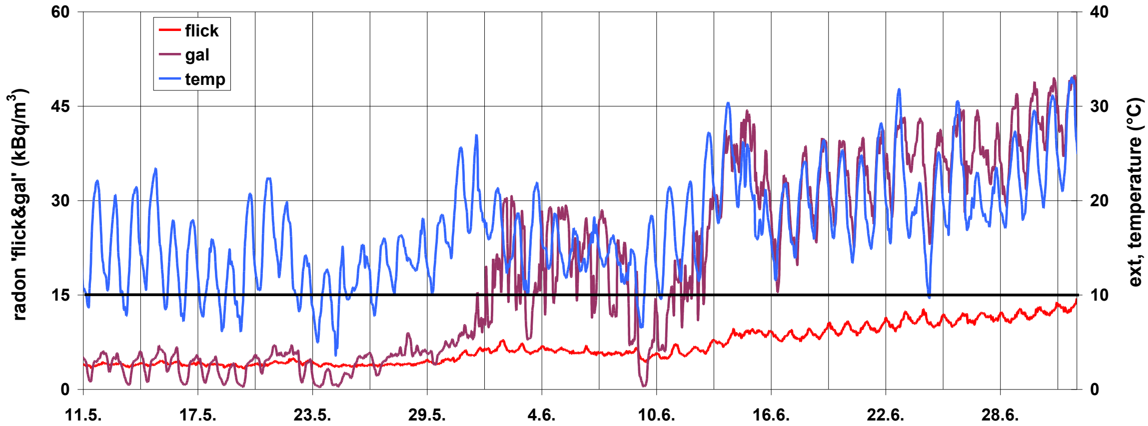

Figure 20: Radon concentration at 'flick' (red) and at 'gal' (purple) from 11 May to 30 June 2025, plotted together with external temperature (blue curve).

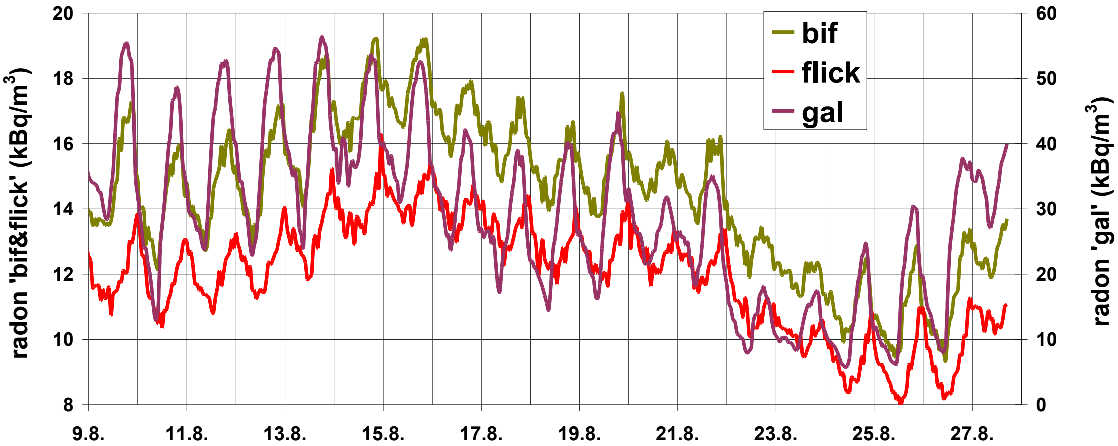

Figure 21: Radon concentration at 'bif' (dark green), 'flick' (red) and 'gal' (purple) from 9 August to 28 August 2025.

Figure 21 shows that part of the radon charged air moves from 'gal' to 'bif' and 'flick' with time delays and changes in amplitudes, roughly 30 Bq/m^3 at 'gal', 4 Bq/m^3 at 'bif' and 3 Bq/m^3 at 'flick'. The time delays are unusually short. In past years sometimes 'gal' and 'flick' radon were anti-correlated (12 hours delay). No explanation can be specified.

The 2025 report highlights the important influence of atmospheric pressure on radon concentrations measured at 'flick'. The large quantity of burden material in the galleries allows, besides the walls, supplementary high contact surface and as a consequence increased ore-gas exchange possibility.

For some time a radon detector was moved from 'gal' to 'end', the most remote part of the geophysical laboratory.

In 2025, the natural air movements in the mine were partly restored, which had been disturbed since the application of the plastic sheets closing all annexing galleries to the main gallery. Normal air circulation, verified by numerous cigar smoke experiences, showed air flow from 'bif' along the main gallery (red arrows) entering into the last lateral gallery before the door to the geophysical laboratory. Air returns through the different lateral galleries with a strong outflow at 'bif'. After destroying the plastic sheet at the mentioned last gallery, an important air inflow into this gallery started to set in.

103rd JOURNEES LUXEMBOURGEOISES DE GEODYNAMIQUE

From 19 to 21 November 2025, ECGS organised the 103rd edition of the *Journées Luxembourgeoises de Géodynamique* (JLG).

This 103rd edition of the JLG was dedicated to the subject of **Slow-Moving Landslides with a special focus on Central Nepal**. This subject is the key focus of the recently started project SLIDE, co-funded by ANR and FNR (see pages 4-11), and hence was a natural choice as a topical framework for the 103rd edition of the JLG. The meeting discussed, among others, the application of various cutting-edge remote sensing approaches to slow-moving landslides and other targets of interest, as well as ground-based geophysical monitoring techniques (seismic, GNSS, etc.) of these phenomena. The 103rd JLG gathered **29 participants** from Luxembourg, Belgium and France at the DoubleTree by Hilton Hotel in Luxembourg to discuss these questions and the ways forward.

Conveners

- Dr. Nicolas d'Oreye, Mnhn & ECGS
- Dr. Adrien Oth, ECGS
- Dr. Jérôme Lavé, Univ. de Lorraine

Local Organizing Committee

- Dr. Nicolas d'Oreye
- Dr. Delphine Smittarello
- Dr. Julien Barrière
- Dr. Adrien Oth
- Yannick Breh
- Maxime Jaspard
- Gilles Celli

The programme was designed to be as interactive as possible and included 19 oral presentations and various discussion sessions.

More information and the full scientific programme (including the abstracts) can be found on the website[20] of the meeting.

[20] https://www.ecgs.lu/103rd-jlg-dedicated-to-slow-moving-landslides-with-a-special-focus-on-central-nepal/

OUTREACH & MEDIA COVERAGE

- Training course given to members of the Humanitarian Intervention Team (HIT) of the CGDIS explaining the fundamental concepts of major earthquakes and their impacts. 27 March 2025 (Adrien Oth)
- Article published in "De Piwitsch" (Ministère de l'Education nationale, de l'Enfance et de la Jeunesse): *Tremblement de terre au Myanmar – nous expliquons ce phénomène naturel!*, 2 April 2025[21]. (Julien Barrière)
- Reportage about the Walferdange Underground Laboratory for Geodynamics by Binsfeld for the municipality of Walferdange, 23 April and 21 May 2025 (Nicolas d'Oreye)
- Reportage about the Walferdange Underground Laboratory for Geodynamics by the *Tageblatt* newspaper. 23 October 2025 (Nicolas d'Oreye)

PUBLICATIONS & PRESENTATIONS

❖ Peer-reviewed Journal Publications & Proceedings

Abercrombie, R. E., A. Baltay, S. Chu, T. Taira, D. Bindi, O. S. Boyd, X. Chen, E. S. Cochran, E. Devin, D. Dreger, W. Ellsworth, W. Fan, R. M. Harrington, Y. Huang, K. B. Kemna, M. Liu, **A. Oth**, G. A. Parker, C. Pennington, M. Picozzi, C. J. Ruhl, P. Shearer, D. Spallarossa, D. Trugman, I. Vandevert, Q. Wu, C. Yoon, E. Yu, G. C. Beroza, T. Eulenfeld, T. Knudson, K. Mayeda, P. Morasca, J. S. Neely, J. Roman-Nieves, C. Satriano, M. Supino, W. R. Walter, R. Archuleta, G. M. Atkinson, G. Calderoni, C. Ji, H. Yang and J. Zhang (2025), Overview of the SCEC/USGS Community Stress Drop Validation Study Using the 2019 Ridgecrest Earthquake Sequence, *Bull. Seism. Soc. Am., Special Section: Improving Measurements of Earthquake Source Parameters,* 115, no. 3, 734–759, doi: 10.1785/0120240158.

Baltay, A., R. E. Abercrombie, **A. Oth**, and T. Uchide (2025). Introduction to the Special Section on Improving Measurements of Earthquake Source Parameters, *Bull. Seism. Soc. Am., Special*

[21] https://piwitsch.lu/fr/erdbeben-in-myanmar-wir-erklaeren-dieses-naturphaenomen/

Section: Improving Measurements of Earthquake Source Parameters, 115, no. 3, 723–733, doi: 10.1785/0120250055.

Barrière, J., **A. Oth**, J. Assink, **N. d'Oreye**, and L. Evers (2025). Infrasound reveals detailed eruptive processes at Nyiragongo volcano and enhances monitoring capabilities during unrest periods, *Nature Commun. Earth Environ.*, 6, no. 1, 978, doi: 10.1038/s43247-025-02937-3.

Bindi, D., K. Mayeda, D. Spallarossa, M. Picozzi, **A. Oth**, P. Morasca, and W. R. Walter (2025), Numerical Tests to Evaluate the Effect of Constraining the Spectral Shape of Reference Events on Source Parameter Scaling, *Bull. Seism. Soc. Am., Special Section: Improving Measurements of Earthquake Source Parameters,* 115, no. 3, 1062–1071, doi: 10.1785/0120240132.

Bindi, D., **A. Oth**, S. Parolai, M. Picozzi, and D. Spallarossa (2025). Interevent Variability in Ground-Motion Prediction Models: The Role of the Source Parameter Selection, *Bull. Seism. Soc. Am.*, 115, no. 6, 2857–2866, doi: 10.1785/0120250098.

Dahm, T., M. Iskend, C. Milkereit, C. Sens-Schönfelder, F. Eckel, X. Yuan, M. Reiss, G. Petersen, S. Cesca, **A. Oth**, G. Rümpker, L. De Siena, P. Büyükakpinar, P. Laumann, H. Zhang, B. Knapmeyer-Endrun, S. Mikulla, R. Bauz, S. Busch, M. Hensch and B. Schmidt (2025). A seismological large-N multisensor experiment to study the magma transfer of intracontinental volcanic fields: The example of the Eifel, Germany, *Seismica*, 4, no. 2, doi: 10.26443/seismica.v4i2.1492.

Del Piccolo, G., B. P. Vanderbeek, M. Faccenda, R. Lo Bue, O. Cocina, M. Firetto Carlino, E. Giampiccolo, L. Scarfí, **F. Rappisi**, T. Gerya and A. Morelli (2025). Pressurized magma storage in radial dike network beneath Etna volcano evidenced with P-wave anisotropic imaging. *Nature Commun. Earth Environ.*, 6, no. 1, 405. doi: 10.1038/s43247-025-02328-8.

Hopquin C., E. Gayer, L. Michon, A. Lucas, **D. Smittarello**, **N. d'Oreye** and N. Villeneuve (2025). Unveiling tropical slow-moving landslides response to season-ality and extreme meteorological events using a combination of InSAR and optical imagery: the case study of Grand Eboulis (Réunion island). *Geomorphology,* 489, 109695*,* doi: 10.1016/j.geomorph.2025.109965.

Morasca, P., M. D'Amico, D. Spallarossa, D. Bindi, M. Picozzi, **A. Oth**, and F. Pacor (2025). GITpy: A Python Implementation of the Generalized Inversion Technique, *Seism. Res. Lett.*, 96, no. 6, 3866–3879, doi: 10.1785/0220250042.

Parolai, S., D. Spallarossa, **A. Oth**, and M. Picozzi (2025). A Proposal for a High-Frequency Earthquake Magnitude (m3Hz) for Seismic Hazard and Rapid Damage Assessment, *Seism. Res. Lett.*, 96, no. 3, 1665–1674, doi: 10.1785/0220240226.

Rappisi, F., R. Lo Bue, B. P. Vanderbeek, J. M. Confal, C. Erman, P. Baccheschi, S. Pondrelli, T. Eken, S. Yolsal-Çevikbilen and M. Faccenda (2025). 3-D mantle flow and structure of the Mediterranean from combined P-wave and splitting intensity anisotropic tomography. *Journal of Geophysical Research: Solid Earth*, 130(6), e2024JB030883, doi: 10.1029/2024JB030883

Solorza R., D. Derauw and **N. d'Oreye** (2025). SAOCOM-1 Time Series Confirm Active Deformation at Laguna del Maule Volcanic Field (LdMVF), Southern Andes. *IEEE 2025 XXI Workshop on Information Processing and Control (RPIC), 17-19 September 2025, San Francisco, Argentina, eCF Paper Id: RPIC2025-48.*

❖ Preprints & Under Review

Gangemi, V.M., **J. Barrière**, A.M. Borzi, A. Cannata, F. Cannavò, **A. Oth**, S. Parolai, M. Picozzi, C. Spampinato, L. Zini, G. Barisone and F. Panzera. Seismic analysis of bedload discharge at Tagliamento River during flood events. Submitted to *Geophys. J. Int.*

Parolai, S., D. Spallarossa, M. Picozzi, R. Amiri Fard, **A. Oth**, D. Bindi and A. Rovida. The high-frequency magnitude (m3Hz) of Italian earthquakes from intensity data – the ICEM catalogue. Submitted to *Scientific Data*.

Rappisi, F., T. Craig and S. Rost (2025). The detection of transient subduction zone interface properties using teleseismic data. *Preprint*, doi: 10.21203/rs.3.rs-7260983/v1.

Rappisi, F., M. Faccenda, M. Witek, S.-J. Chang and A.M.G. Ferreira. SubRidge: a 3-D Subduction-to-Ridge Model with Synthetic Seismic Waveforms for Benchmarking. Submitted to *Seismica.*

Roche, B., **J. Barrière**, F. Darchambeau and C. Caudron. Hydroacoustic observations during the 2021 Mount Nyiragongo dyke intrusion under Lake Kivu – evidence of lakebed degassing and blowout event. *Submitted to Seismica.*

❖ Software & Datasets

Rappisi, F. (2025). Modified version of SPECFEM3D_GLOBE supporting external fully anisotropic models [Software]. Zenodo, https://doi.org/10.5281/zenodo.17341802.

Description: This repository provides a modified version of SPECFEM3D_GLOBE[22] that was developed to simulate fully anisotropic seismic wave propagation using 21 independent elastic constants (Cij).The code was used in Rappisi et al. (2024) and Rappisi et al. (under review) to compute synthetic waveforms for the *SubRidge* geodynamic benchmark model, which integrates dynamically consistent mantle flow with LPO-derived seismic anisotropy.

Rappisi, F. (2025). SubRidge: a 3-D Subduction-to-Ridge Model with Synthetic Seismic Waveforms for Benchmarking [Dataset]. Zenodo, https://doi.org/10.5281/zenodo.16634304.

Description: This repository contains the SubRidge benchmark dataset, consisting of a 3D geodynamic model and a suite of synthetic seismic waveforms. The model simulates the co-evolution of a mid-ocean ridge and two flanking subduction zones, providing spatially variable elastic properties, including 21 elastic constants derived from LPO-based anisotropy simulations. Synthetic seismograms were computed using the spectral-element method (SPECFEM3D_GLOBE) and represent a wide range of source-receiver configurations. The dataset enables testing of seismic imaging methods in a physically realistic and tectonically complex environment, supporting periods down to ~10 seconds.

❖ Conference Presentations and Abstracts

Barrière, J., **A. Oth**, J. Assink, **N. d'Oreye** and L. Evers (2025). Imaging lava eruptions and crater morphology changes at a basaltic volcano using infrasound. *Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO): Science and Technology Conference 2025 (SnT2025),* Vienna, Austria, September 8-12, 2025.

Barrière, J., **A. Oth**, J. Assink, **N. d'Oreye** and L. Evers (2025). Imaging lava eruptions and crater morphology changes at a basaltic volcano using infrasound. *2025 IAVCEI (International Association of Volcanology and Chemistry of the Earth's Interior) Scientific Assembly*, Geneva, Switzerland, 29 June – 4 July, 2025.

Barrière, J., **A. Oth**, J. Assink, **N. d'Oreye** and L. Evers (2025). Time-lapse imaging of eruptive processes at Nyiragongo volcano using infrasound. *IAGA-IASPEI (International Association of Seismology and Physics of the Earth's Interior) Joint Scientific Assembly*, Lisbon, Portugal, 31 August – 5 September, 2025.

Barrière, J. and **A. Oth** (2025). Monitoring slow-moving landslides with seismic sensors: Preliminary insights from an instrumental deployment on a km-scale landslide in Nepal, *103rd Journées Luxembourgeoises de Géodynamique,* Luxembourg, Grand Duchy of Luxembourg, 28-21 November, 2025.

d'Oreye, N., **D. Smittarello**, D. Derauw, **M. Jaspard**, S. Samsonov, **G. Celli** and L. Maury (2025). Slow-Moving Landslides in Central Nepal: Strategy for Mass Processing of InSAR Time Series. *103rd Journées Luxembourgeoises de Géodynamique, Luxembourg,* Grand Duchy of Luxembourg, 18-21 November, 2025.

d'Oreye, N., D. Derauw, S. Samsonov, M. Jaspard, D. Smittarello and G. Celli (2025). Automatic Multi-Satellite and Incremental InSAR Mass Processing chain for ground deformation time series. *Automatic Ground Displacement Monitoring (AUDIMAT) Information Day*, Liège, Belgium, 19 September, 2025.

Froger, J.-L., **D. Smittarello**, **N. d'Oreye**, D. Derauw, Q. Dumont, M.O. Chevrel, N. Villeneuve, A. Peltier, F. Albino, A. Hrysiewicz, R. Grandin and J Kubanek (2025). High-Resolution, High-Frequency InSAR Monitoring of Volcanic Activity at Piton de la Fournaise using ALOS-2

[22] https://github.com/SPECFEM/specfem3d_globe

Spotlight Data + some news of ALOS-2 and ALOS-4 ,"*cafés ISDeform",* Gières, France, 24 January 2025.

Hopquin, C., É. Gayer, L. Michon, **D. Smittarello**, and A. Lucas (2025). Dynamics and controls of a tropical slow moving landslide measured by remote sensing: the study case of Grand Éboulis, Réunion Island. *103rd Journées Luxembourgeoises de Géodynamique,* Luxembourg, Grand Duchy of Luxembourg, 28-21 November, 2025.

Jaspard, M. (2025). Field Deployment of a Multi-Instrument Monitoring Network for "SLIDE" project in Nepal: Technical and Community Insights. *103rd Journées Luxembourgeoises de Géodynamique,* Luxembourg, Grand Duchy of Luxembourg, 28-21 November, 2025.

Leder, F., S. Daout, J. Lavé, P. Lacroix and **N. d'Oreye** (2025). Recent satellite-based radar and optical monitoring of the activity of retrogressive slow-moving landslides in Nepal during monsoon. *103rd Journées Luxembourgeoises de Géodynamique,* Luxembourg, Grand Duchy of Luxembourg, 18-21 November, 2025.

Letellier, L., S. Daout, J. Lavé and **N. d'Oreye** (2025). 34-Yrs of Satellite-based Monitoring of a Slow-moving Retrogressive Landslide in Central Nepal. *VGC 2025, Geosciences Reimagined: Digital Innovations for a Changing World,* Lausanne, Switzerland, 9-12 September, 2025.

Letellier, L., S. Daout, J. Lavé and **N. d'Oreye** (2025). 34-Yrs of Satellite-based Monitoring of a Slow-moving Retrogressive Landslide in Central Nepal. *Journées Aléas Gravitaires 2025,* Aoste – Italy, 2-3-25 September, 2025.

Letellier, L., S. Daout, J. Lavé and **N. d'Oreye** (2025). 30+ Yrs of Satellite-based Monitoring of Slow-moving Landslides in Central Nepal using Pixel Tracking. *103rd Journées Luxembourgeoises de Géodynamique,* Luxembourg, Grand Duchy of Luxembourg, 28-21 November, 2025.

Rappisi, F., **J. Barrière**, **N. d'Oreye**, **D. Smittarello**, G. del Piccolo, M. Faccenda, B.P. Venderbeek and **A. Oth** (2025).Crustal Structure And Stress Beneath The Kivu Rift Segment From P-Wave Anisotropic Tomography. *43rd Course: "Frontiers In Geophysics For The Third Millennium" 2025*, Erice, Sicily, 22-26 September, 2025.

Smets, B., A. Hautecoeur, V. Cayol, **N. d'Oreye**, J.-L. Froger and **D. Smittarello** (2025). Déformation du sol observée par interférométrie radar au volcan Karthala (Grande Comoros), entre 2017 et 2024. *Colloque «Le volcan Karthala comme vecteur de développement»*, Moroni, Comoros, 20-22 January, 2025.

Smets, B., A. Hautecoeur, V. Cayol, **N. d'Oreye**, J.-L. Froger and D. Smittarello (2025). Origine des déformations du sol récemment observées au Karthala (Ngazidja, Union des Comoros). *Rencontre Scientifique Volcanologique 2025*, Le Bourget du Lac, France, 25-27 June, 2025.

Smittarello, D., **N. d'Oreye**, D. Derauw, J.-L. Froger, R. Grandin, V. Cayol and A. Hautecoeur (2025). Detecting Subtle Deformation on Tropical Volcanic Islands: Advanced InSAR Time Series Techniques for Enhanced Monitoring. *2025 IAVCEI (International Association of Volcanology and Chemistry of the Earth's Interior) Scientific Assembly*, Geneva, Switzerland, 29 June 29 – 4 July, 2025.

Smittarello, D., **N. d'Oreye**, R. Grandin, J.-L. Froger, D. Derauw, V. Cayol, A. Hautecoeur and B. Smets (2025). Détecter les déformations du sol des volcans insulaires tropicaux par séries temporelles InSAR. *Rencontre Scientifique Volcanologique 2025*, Le Bourget du Lac, France, 25-27 June, 2025.

Solorza, R., D. Derauw and **N. d'Oreye** (2025). SAOCOM-1 Time Series Confirm Active Deformation at Laguna del Maule Volcanic Field (LdMVF), Southern Andes*IEEE 2025 XXI Workshop on Information Processing and Control (RPIC),* 17-19 September 2025, San Francisco, Argentina, eCF Paper Id: RPIC2025-48.

Subira, J., **J. Barrière**, C. Caudron, **A. Oth**, **N. d'Oreye**, A. Hubert-Ferrari and F. Kervyn (2025). Seismological Models and Seismicity Patterns in the Kivu Rift and Virunga Volcanic Province (D.R. Congo / Rwanda). *2025 IAVCEI (International Association of Volcanology and Chemistry of the Earth's Interior) Scientific Assembly*, Geneva, Switzerland, 29 June – 4 July.

Subira, J., **J. Barrière**, C. Caudron, **A. Oth**, **N. d'Oreye**, A. Hubert-Ferrari and F. Kervyn (2025). Seismological Models and Seismicity Patterns in the Kivu Rift and Virunga Volcanic Province (D.R. Congo / Rwanda). *IAGA-IASPEI (International Association of Seismology and Physics of the Earth's Interior) Joint Scientific Assembly*, Lisbon, Portugal, 31 August – 5 September.

MEETING ATTENDANCE & WORK VISITS

Adrien Oth

- Kick-off Meeting for SLIDE Project, Université de Lorraine, Nancy, France (13 January)
- KNMI Supervisory Board Meeting, De Bilt, The Netherlands (4 April)
- Thesis defence of Margaux Buscetti (Université Grenoble Alpes), Grenoble, France (20 June)
- IAVCEI 2025 Scientific Assembly, Geneva, Switzerland (29 June – 4 July)
- IAGA & IASPEI Joint Scientific Meeting 2025, Lisbon, Portugal (31 August – 5 September)
- ESC ExeCom Meeting, Lisbon, Portugal (3 September)
- ORFEUS Board of Directors Meeting, Lisbon, Portugal (24 September)
- EMSC Executive Council & General Assembly, Lisbon, Portugal (24 & 25 September)
- KNMI Supervisory Board Meeting, De Bilt, The Netherlands (10 October)
- EPOS Seismology & Geo-INQUIRE Workshop, Athens, Greece (24 – 27 November)
- 103rd Journées Luxembourgeoises de Géodynamique (JLG) 2025, Luxembourg (19 – 21 November) **as organiser**
- Work visits & visitors at ECGS, virtual meetings:
    - Virtual ESC ExeCom Meetings (14 January, 3 March, 8 September, 24 September, 13 November)
    - Virtual EPOS TCS Seismology Meeting (23 January)
    - Virtual Associate Editor meetings of Seismological Society of America (4 February, 13 March, 16 July)
    - Virtual meeting with Valerio Gangemi, Alfio Marco Borzì, Andrea Cannata, Francesco Panzera (Univ. Catania) (6 February 2025)
    - Virtual ORFEUS Board of Directors Meeting (8 February)
    - Virtual SCEC Stress Drop Validation Study Workshop (25 February)
    - Virtual ICDP Workshop regarding the Eifel (27-28 March)
    - Virtual meeting for SLIDE project (2 April)
    - 4-months visit of Valerio Gangemi (PhD student, Univ. Catania, Italy) (9 May-9 July, 15 September-17 November 2025)
    - Virtual participation in CAIAG Scientific Advisory Board (4 June)
    - Virtual Meetings of SSA Editor-in-Chief Search Committee (8 July, 23 September, 7 October, 13 November, 17 November, 2 December, 17 December)
    - Visit by Sajad Tabibi (Uni.lu) (9 July)
    - Visit by R. Colbach (Service Géologique, Admin. Ponts et Chaussées) for discussing the Luxembourg Seismic Network & new station sites (16 July)
    - Visit of Administration du Cadastre et de la Topographie for the permanent GNSS station in Walferdange (23 September)
    - Visit of Administration des services techniques de l'Agriculture (ASTA) at ECGS for discussing potential of meteorlogical station in Walferdange and potential seismic installations at ASTA sites (28 October)
    - Virtual BSSA Assessment Meetings (17 November, 16 December)
    - Virtual EFEHR General Assembly (10 December)

Nicolas d'Oreye

- Kick-off Meeting for SLIDE Project, Université de Lorraine, Nancy, France (13 January)
- Training session AMSTer software. 28 August – 12 September, 2025, ECGS, Walferdange, Luxembourg
- Centre Spatial de Liège, "AUDIMAT information day" (19 September)
- 103rd Journées Luxembourgeoises de Géodynamique (JLG) 2025, Luxembourg (19 – 21 November) **as organiser**
- Africa Museum, conference-débat « Vivre avec les risques des éruptions du Nyiragongo » (10 December)
- Work visits & visitors at ECGS, virtual meetings:

- Visit by Simon Daout and Léo Letellier (Université de Lorraine) for the SLIDE project (11 February)
- Virtual meetings for ongoing research on Galeras volcano (Colombia) (18 February, 24 March, 13 May)
- Virtual meetings for ongoing research on landslides in Mustang (Nepal) (1 April)
- Virtual meeting of Leo Letellier's PhD thesis committee (4 July)
- Virtual meeting of Bastien Wirtz's PhD thesis committee (7 July)
- Virtual meeting for SLIDE project (5 February, 24 October)
- Virtual meeting with Léo Letellier in the frame of the MUVE and SLIDE projects (27 February, 2 March)
- Virtual meeting for Scientific Committee of the French "Service National d'Observation (SNO) ISDeform" (12 June)
- Virtual meeting for the preparation of the 2026 edition of the "Colloque MDIS - Mesure de la Déformation par Imagerie Satellitaire" co-organised by Université de Lorraine and ECGS and which will take place from 14 to 18 September 2026 at the École Nationale Supérieure de Géologie (ENSG) in Nancy (2 days of training) and Xonrupt-Longemer in the Vosges (3 days scientific meeting) (1 July, 1 September, 4 December)
- Virtual meeting with ESA and CSL for the E-Coh project (8 July).
- Visit by Sajad Tabibi (Uni.lu) (9 July)
- Virtual meeting with the LISTIC (Laboratoire d'Informatique, Systèmes, Traitement de l'Information et de la Connaissance, Université Savoir-Mont-Blanc) about use of AI (22 July)
- Visit by R. Colbach (Service Géologique, Admin. Ponts et Chaussées) for discussing the deformations mesured by radar interferometry in Luxembourg (13 August)
- Virtual meeting with VUB and CSL for possible new PhD opportunities (14 November, 16 December)

Julien Barrière

- Kick-off Meeting for SLIDE Project, Université de Lorraine, Nancy, France (13 January)
- 2ième Rencontre Scientifique Volcanologique, Le Bourget-du-Lac, France (25-27 June)
- IAVCEI 2025 Scientific Assembly, Geneva, Switzerland (29 June – 4 July)
- CBTB SnT Conference, Vienna, Austria (9 – 12 September)
- Field trip to Nepal in the context of the SLIDE project, full instruments installation (22 October – 3 November)
- 103rd Journées Luxembourgeoises de Géodynamique (JLG) 2025, Luxembourg (19 – 21 November) **as organiser**
- Africa Museum, conference-débat « Vivre avec les risques des éruptions du Nyiragongo » (10 December)
- Work visits & visitors at ECGS, virtual meetings:
    - Virtual meeting with Valerio Gangemi, Alfio Marco Borzì, Andrea Cannata, Francesco Panzera (Univ. Catania) (6 February 2025)
    - Virtual meetings with B. Roche and/or C. Caudron (Univ. Libre de Bruxelles) (3 February, 20 February, 7 March, 2 April, 30 April, 16 May, 11 June, 3 October, 8 October, 28 November)
    - 4-months visit of Valerio Gangemi (PhD student, Univ. Catania, Italy) (9 May-9 July, 15 September-17 November 2025)
    - Virtual meetings with Josué Subira (GVO, Univ. Goma) (26 November, 17 December)
    - Visit by Sajad Tabibi (Uni.lu) (9 July)
    - Visit of Jerôme Lavé (CRPG Nancy), Tanka Paudel (NMA, Nepal), Ananta Prasad Gajurel (Tribhuvan University, Nepal) at ECGS (5 September)
    - Virtual meeting with Bhairab Sitaula (Apex adventures, Nepal), Jerôme Lavé (CRPG) and Maxime Jaspard (ECGS) (24 September)

Delphine Smittarello

- Kick-off Meeting for SLIDE Project, Université de Lorraine, Nancy, France (13 January)
- IAVCEI 2025 Scientific Assembly, Geneva, Switzerland (29 June – 4 July)
- 2ième Rencontre Scientifique Volcanologique, Le Bourget-du-Lac, France (25-27 June)
- EURISY EUSPA Workshop, Luxembourg (30 October)
- 103rd Journées Luxembourgeoises de Géodynamique (JLG) 2025, Luxembourg (19 – 21 November) **as organiser**
- Work visits & visitors at ECGS, virtual meetings:
  - Visit to IPG Paris, France (12 December)
  - Virtual meeting for SLIDE project (2 April)

Francesco Rappisi

- European Geosciences Union (EGU) General Assembly 2025, Vienna, Austria (27 April – 2 May).
- 43rd Course of the International School of Geophysics, Erice (Italy) (workshop + poster presentation) (22 – 26 September)
- 103rd Journées Luxembourgeoises de Géodynamique (JLG) 2025, Luxembourg (19 – 21 November)

Maxime Jaspard

- Kick-off Meeting for SLIDE Project, Université de Lorraine, Nancy, France (13 January)
- Field trip to Nepal in the context of the SLIDE project, reconnaissance and test instrument installation (3 – 13 May)
- Field trip to Nepal in the context of the SLIDE project, full instruments installation (22 October – 3 November)
- Work visits & visitors at ECGS, virtual meetings:
  - Visit by R. Colbach (Service Géologique, Admin. Ponts et Chaussées) for discussing the Luxembourg Seismic Network & new station sites (16 July)

SCIENTIFIC COMMUNITY SERVICE

Adrien Oth

- European Seismological Commission (ESC) **Secretary General** (2022 – present)
- European Seismological Commission (ESC) **Titular Member** for Luxembourg
- **ESC Representative** in EPOS TCS Seismology, ORFEURS Board of Directors, EMSC Executive Council, EFEHR
- **ECGS Representative in EFEHR consortium**
- International Association of Seismology and Physics of the Earth's Interior (IASPEI) **National Correspondent** for Luxembourg
- **Associate Editor** of *Bulletin of the Seismological Society of America* (November 2017 – present)
- Member of the **Supervisory Board** of the **Koninklijk Nederlands Meteorologisch Institutt (KNMI)**, Netherlands
- Member of **Science Advisory Board** of the **Central Asian Institute for Applied Geosciences** (CAIAG), Kyrgyz Republic
- **Reviewer** for *J. Geophys. Res.: Solid Earth*
- **Member** of Seismological Society of America, IAVCEI, Deutsche Geophysik. Gesellschaft
- **Mentorships & Supervision**
  - Committee member for Margaux Buscetti's PhD thesis (Univ. Grenoble Alpes)

- Internship of Sally Bausch from Utrecht University, six months from 15 December 2024 to 15 June 2025
- Co-supervision of Valerio Gangemi (PhD student at Univ. Catania) during his stay at ECGS (4 months in 2025)

Nicolas d'Oreye

- International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) **National Correspondent** for Luxembourg (until October 2025)
- IAVCEI Board member of the Volcano Geodesy Commission
- **Scientific Committee Member** for *ESA Fringe workshop*
- **Scientific Committee Member** for French "Service National d'Observation (SNO) ISDeform"
- **Member** of American Geophysical Union, European Geosciences Union, IAVCEI & Academy of Sciences Luxembourg
- **Mentorships & Supervision**
  - Committee member for Bastien Wirtz's PhD thesis (Univ. Strasbourg)
  - Committee member for Leo Letellier's PhD thesis (Univ. Nancy)
  - Support to PhD thesis performed by Loris Honorat (Université de La Réunion), Laureen Maury (Université Grenoble-Alpes)
  - Support to Master thesis at École et Observatoire des Sciences de la Terre (Univ. Strasbourg): Ethel Maillard

Julien Barrière

- **Associate Member Representative** for ECGS at EarthScope Consortium
- **Reviewer** for *G^3 (Geochemistry, Geophysics, Geosystems), Journal of Volcanology and Geothermal Research, Journal of African Earth Sciences*
- **Member** of IAVCEI and European Geosciences Union
- **Mentorships & Supervision**
  - Co-supervision of Valerio Gangemi (PhD student at Univ. Catania) during his stay at ECGS (4 months in 2025)

Delphine Smittarello

- International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) **National Correspondent** for Luxembourg (since October 2025)
- **Organiser** of *Workshop 18: Inverse modelling of deformation data*. IAVCEI Scientific Assembly, Geneva, Switzerland, July 2025. (https://sa2025.iavceivolcano.org/workshop-18/)
- **Reviewer** for *J. Volc. Geotherm. Res., Bulletin of Volcanology*
- **Member** of IAVCEI

Francesco Rappisi

- **Reviewer** for *Global and Planetary Change*, *J. Geophys. Res: Solid Earth, U.S. National Science Foundation – Marine Geology and Geophysics Program*
- **Member** of Scientific Board BeGeo 3rd Conference (https://www.begeos.it/conference/)