EnvSeis Newsletter
Spring 2024-2025

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Contents

1 Workshop2 in Milano

1.1 Short Course 5: Theoretical seismology

From April to May 2024, we engaged in a comprehensive series of five online courses. These courses began with a mathematical view of seismology and progressed to more advanced subjects like rheology and seismic source theory. Expert lecturers from different prespectives shared their knowledge, providing us with valuable insights and a strong foundation in the principles of seismic phenomena.

From May 26th to May 30th, 2024, we gathered in person to further expand on these topics. The first day was led by Professor Heiner Igel from LMU Munich. His session focused on numerical tools and waveform modeling, extending from the fundamentals of wave propagation to 1D and 2D numerical modeling techniques. We explored methods such as finite difference and finite element methods, with hands-on implementations using Jupyter Notebooks.

In the second half of the day, we shifted our focus to Shallow Flows Modeling and Numerical Simulation, guided by Professors Enrique D. Fernández-Nieto and Gladys Narbona Reina from Universidad de Sevilla. They demonstrated how to translate research questions into numerical modeling problems, complemented by Jupyter Notebook experiments. This approach helped us understand parameter influences, making it practical for solving real-world problems.

1.2 Workshop 2: Discussion

Following the short course, we transitioned into our Workshop 2 from the afternoon of May 28th to the morning of May 30th. This workshop was a fantastic opportunity for each PhD candidate in our network to present their progress and current research. We had poster sessions where we could share our work and get feedback from the supervisors.

The final afternoon of the workshop is a special session on Science Communication led by our invited guest, Dr. Andrea Geipel. Andrea's session was engaging and informative, highlighting the importance of effectively communicating our scientific findings to different audiences. We had a lot of engaging discussions, and everyone truly enjoyed the sessions.

2 Follow up on the individual ESR's project

2.1 Stefania Ursica

Over the past months, my efforts have been centered around developing an unsupervised hybrid approach to detect, augment, and model in a probabilistic framework both mass wasting activities and climatic phenomena, specifically rainfall, for the Illgraben in Switzerland. This approach required extensive learning, developing, and optimizing data-based methods that are not available off the shelf. I integrated deep learning with machine learning, employing novel optimization techniques to enhance the accuracy and efficiency of our models.

The primary objective was to extend and refine an existing catalogue of debris flows and other mass movements, initially compiled by several researchers from WSL. This is based on the collaboration with Fabian Walter' s group and the stakeholders on a common project about Illgraben. I systematically collected additional data, pruned it to remove redundancies, and augmented it to ensure a comprehensive dataset that retained its integrity without losing critical information through slicing. This rigorous data curation process was essential to maintain the quality and reliability of the dataset, providing a robust foundation for subsequent analyses.

With a well-curated dataset, I trained the various hybrid models I developed, utilizing six years of collected data. These models are designed with predictive abilities and potential insight into the temporal evolution of mass wasting events, their complex dynamics, and the pivotal role of rainfall in triggering such phenomena in a steep active mountain catchment. The integration of deep learning techniques allowed for the identification of structural patterns within the data, while machine learning provided the analytical power to model these patterns effectively.

The outcomes of this research have been promising. The hybrid models demonstrated significant predictive capabilities, offering perspectives into the behaviour and triggers of mass wasting events. Although these models are still under development and the results remain preliminary, they have already started to reveal the relationship between climatic factors, particularly rainfall, and geomorphic responses.

2.2 Sibashish Dash

Over recent months, my primary focus has been on implementing a random forest classifier for automated detection and classification of sub-surface seismic events and surface rockslides. This effort is critical for enhancing early warning systems for hillslope failures. Our observations highlight that in the build-up to the final collapse, initially the seismic activity in the unstable rock mass was driven by precipitation, however after a threshold is breached, seismic activity is primarily driven by internal dynamics rather than external weather forcing.

In March, I was in Sikkim (India) as a field assistant to investigate the sedimentary deposits of a recent GLOF. I also did fieldwork in Brienz in April, downloading data and carrying out routine seismic station maintenance work.

2.3 Aiswarya Padmadas

Switzerland! Here I am. I've joined WSL for my secondment with Fabian. We are planning to find solutions to two problems that I face in my research. One is to pinpoint the exact location of seismic noise, starting with beamforming using triangulation and then modifying the technique further. The second problem is finding a better averaging technique that can be used to convert the rotational component of velocity into actual velocity components for use in calculating Turbulent Kinetic Energy (TKE). I'm also considering gaining a better understanding of the influence length to improve our understanding of signal coherence. Later, it might be easy to couple clustering and artificial intelligence to produce final output. Hoping to achieve better results.

2.4 Guilherme de Melo

Since Newsletter 2, Guilherme has continued the research to investigate strong oceanic strike-slip earthquakes using hydroacoustic records of the instrument array deployed close to Ascension Island. Guilherme has been doing tests in the application of computer code with other types of signals, such as seismic records of seafloor volcano activity. Guilherme intends to try the code with another record as Iceberg breaking. At this moment, Guilherme is working on the manuscript about the results obtained along the earthquake rupture length analysis, and it should be submitted to the Geophysical Research Letter journal by the end of June.

2.5 Sophia Laporte

This winter, we collected field data from both river sites (Sävarån, Mjellejohka) during the ice-covered season: flow velocity using an Acoustic Current Doppler Profiler (ADCP), which we inserted under the ice layer through a drilled hole, ice thickness, and water depth. We also ran an active seismic experiment by dropping a rock of known mass onto the frozen ground, in order to calibrate the wave propagation velocity of the medium during the frozen period. Following the river ice-break-up in spring, we attempted to calibrate bedload transport on Mjellejohka by deploying two Bunte samplers on fast-flowing sections of the river. However, we did not collect any bedload during the 12-hour measurement. We will try to be more flexible with field dates next year in order to maximize our chances of collecting bedload during the snowmelt season! We are also discussing the option to install another type of continuous sensor to measure bedload transport. On another note, I am preparing for my 6-month secondment in Grenoble next September, where I will focus on processing the seismic data acquired this year, and carry out a flume experiment about pressurized flows.

2.6 Selina Wetter

This spring, I was engaged in the exploration of different grouping methodologies (i.e., the sorting of individual signals from various stations into a unified event). For purposes of this study, I employed only a one-month data set. Upon manual examination of the spectrogram, it was observed that, irrespective of the grouping algorithm employed, a considerable number of classified Glacial Earthquakes (GEQ) would not necessarily be classified as a GEQ by a human eye. Consequently, it is necessary to undertake a manual review of the events to facilitate their categorisation into distinct categories according to the associated uncertainty. Nevertheless, for the one-month dataset, it is possible to identify approximately seven times more events than what was previously published in the merged catalogue produced by Tsai and Ekström (2007), Veitch and Nettles (2012), and Olsen and Nettles (2017). My objective is to identify ten times more events, which is an excellent start. At this point, I am preparing to search for GEQ during the year 2023, with the aim of extending the search as far back in time as possible.

Furthermore, I had the opportunity to present my project and the results for this one-month period at the European Geosciences Union (EGU) 24th General Assembly. It was a valuable experience, as I enjoy presenting my work in front of a large audience. Additionally, I may have found potential future collaborative opportunities.

2.7 Juliane Starke

Juliane gladly participated in this year's EGU in Vienna. There, she presented her research on the impact of rainfall on the stress state of a rock column. The month of May is busy with workshops from the SPIN- and EnvSeis-ITN. Afterwards, she looks forward to advancing her simulations and exploring acoustic probing in rock outcrops.

2.8 Samidha Venkatesh Revankar

Since the end of January, I have been analyzing data from 80 geophones deployed along a 600-meter breach of the Sevraisse River in the French Alps. These sensors, grouped in subarrays, have provided

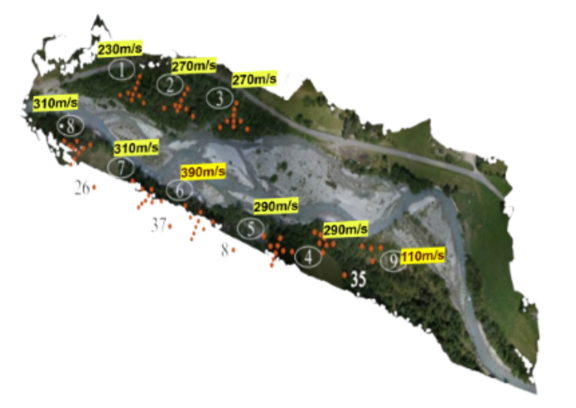

Figure 1: Local phase velocities at different subarray locations

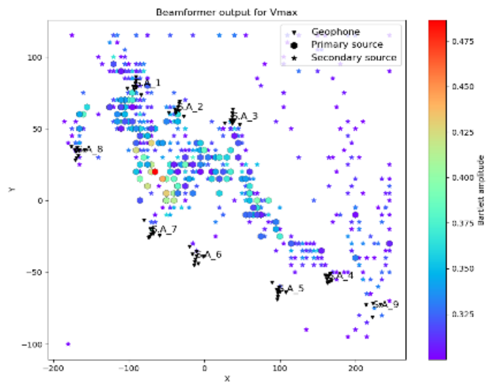

Figure 2: Seismic source locations as observed at "optimal velocity"

invaluable insights into the seismic activity associated with river processes.

The July 2019 flood event was luckily captured by all 80 sensors and I am using Matched Field Processing (Beamforming) to localize my seismic sources both in space and time. I am looking at the phase delays between the seismic signals observed by different sensors to localize the seismic sources.

My focus has been on the frequency range of 15-25 Hz, which is particularly sensitive to the energetic bedload movements within the river. During the analysis, I observed lateral heterogeneity in phase velocity. To address this, I defined an "optimal phase velocity" approach, which has significantly enhanced the resolution of seismic source localization.

Currently, this analysis encompasses about 40 seismic events. Moving forward, I aim to use high-performance computing to analyze a much larger number of events. This will allow statistical evaluation of the results and gain deeper insights into the seismic activity associated with river dynamics.

2.9 Amandine Missana

I continue taking courses this semester. The first course is to develop more knowledge in methods for statistical analyses and the second is the EnvSeis course in seismic theory. In parallel, I am working with the team from ISTerre on the collection of the (hopefully) most important data of my PhD. The geophones have been reinstalled for two more months (May and June) while the broadbands keep recording. We chose those two months as the start of the snow melt seems to be the annual trigger of the most active phase of the rockslides that I study.

2.10 Gwendal Léger

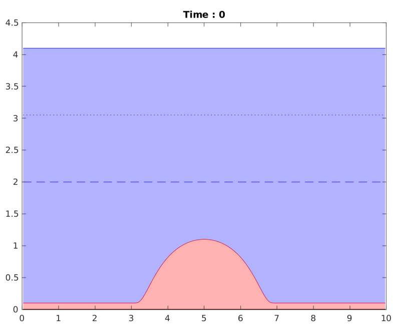

Figure 3

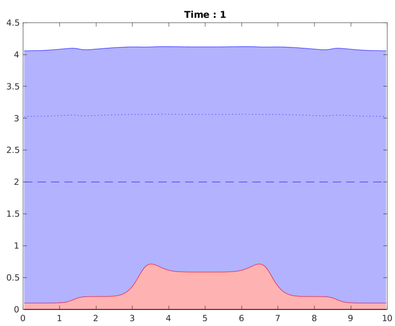

Figure 4

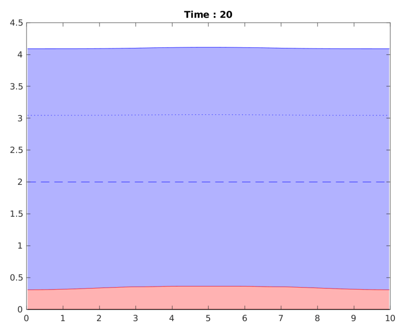

Figure 5

Since last newsletter, I have completed the first code, which is the implementation of a simple 2-water-layers model, before implementing an model with an arbitrary number of layers.

I am now implementing the model I wrote which includes the avalanche layer, and although not everything works perfectly fine at the moments, the results look promising. The figures present a simulation result of an underwater avalanche collapse. We can see, it collapses but on the second picture there are "horns" forming on the collapsing material that should not be there and we still don't know why they appear. This is most likely due to an error in the code that we wouldn't have found yet, but it could also be a limitation of the model. This is why further investigation will be needed.

I am also preparing for the CEDYA (Partial Differential Equation And Applications Congress) in late June in Bilbao. There I will present my work and be able to discuss with a lot of mathematicians, as well as enjoying basque gastronomy!

2.11 Eva Wolf

The past three months of my PhD project were dedicated to preparing a big field project in this summer. We are planning to use several different techniques (seismic, RFID, hydrological gauging) to localize, access and track the subglacial channel and its bedload transport activity on Glacier d' Otemma in Valais, Switzerland.

The preparations focus on three main points: First of all, we are using Distributed Acoustic Sensing to characterize the subglacial conditions and trying to localize the subglacial channel. Therefore, we are employing a fiber optic cable in different orientations and patterns on the glacier surface. This part of the work needs intense theoretical preparations, as we need to figure out what we could expect from such a signal by running simulations. Luckily, we are cooperating with experienced seismologists from IPGP by our side here. Aside of that, we are analyzing data of a DAS experiment from Rhone glacier conducted by a research group from WSL. We want to be prepared on details like wavelengths, frequency bands and methods to identify our signal of interest to adjust our experiment in the field to the data we expect to find. This first step is a preparation for our second part of the project: We are interested in installing borehole seismometers down in the ice of Glacier d' Otemma to capture the subglacial river signal close to its source. Therefore, we need to drill into the glacier, at locations which we can hopefully derive from our DAS survey. For this step, a lot of equipment will be needed, which we maintain and prepare for shipping/flying to the glacier. And finally, in case of successful steps A and B, we are planning to drill to the ground of the glacier, into the subglacial river. Here, we want to insert bedload particles with RFID tags. These could then be tracked through an antenna system on top of the glacier. These tracking systems are currently tested, programmed and maintained.

To summarize: You can imagine me with three different kinds of tools in each hand! I had a great time!

2.12 Jiahui Kang

In April, I attended EGU24 for my first conference in Vienna. It was a fantastic experience where I saw a lot of inspring research and connected with peers studying similar topics.

Back to the Brienz project on automatic detection of slope failures with DAS and machine learning, we proposed a semi-supervised neural network tailored to screen DAS data related to a major rock collapse on 15 June 2023 and its precursory failures. This approach achieves window-wise event detection through two interconnected models: a representation learning model and a classification model. Our dataset, which spans from 16 May to 30 June 2023, includes Doppler radar data for ground-truth labeling and result evaluation.

Our algorithm can distinguish between rock-slope failures and background noise, such as traffic activities, with a detection precision of over 90%. It identifies hundreds of precursory failures and maintains consistent detection even hours before and during the major collapse. Furthermore, we identified key dependencies for our model' s performance: event size and signal-to-noise ratio (SNR). The DAS-detection algorithm adapts to urban and less noisy environments, making it a valuable tool for seismic hazard monitoring.

2.13 Nicolas De Pinho Dias: Guest from IPGP

Previously, I was comparing results of experiments from the literature to 2D and 3D simulations of iceberg capsize against a glacier terminus. Experiments were conducted in a water tank with plastic icebergs put vertically in water and released by hand. They then rotate due to buoyancy forces and finish their motion in horizontal position. Three different cases were studied: one in "open ocean" (no glacier), one of a capsize against a "floating glacier" and one against a "grounded glacier". It is necessary to notice that, in this last case, the iceberg is much closer to the ground/ tank bottom. It was noticed that the flow confinement (under or on the iceberg side) has an important effect on the capsize dynamics. Figure 6 shows iceberg rotation angle as a function of the time during the capsize. The three cases are represented in red, black and blue respectively for "open ocean", "floating glacier" and "grounded glacier". Dots, dashed lines and full lines correspond to experiments, 2D and 3D simulations. We can notice, despite some uncertainties on initial conditions, a good agreement for open ocean and floating glacier cases. However, the grounded glacier experiment illustrates the necessity of running 3D simulations. Indeed, as there is only a small gap between the iceberg and the ground, water flowing on the iceberg sides is non-negligible compared to water flowing under. As the side flow is not accounted for in 2D, the experiment results cannot be reproduced accurately without 3D. Once the iceberg-to-side-wall gap is correctly tuned. 3D simulation results almost perfectly overlap with experimental ones (blue dots and full line).

In fact we show on figure 7 that the flow confinement is a key parameter for the dynamics. Here, t=0 is the time at which iceberg rotation angle is 80 degrees. Dark blue dots correspond to grounded glacier experiments, dashed line to 2D simulation and full lines correspond to several 3D tests. The wider iceberg-to-side-wall gap studied was 16mm, it is represented in purple. One can see that this curve is more "rounded" while the 2D curve has an almost linear regime (between -10 and -4 s). As a result, 2D capsizes are much slower than in 3D. Also, one can notice that all the other curves are between the 2D and the 3D-16mm ones. Furthermore, simulations with iceberg-to-side-wall gap of 3.5 mm and 5.5 mm were checked. The 3.5 mm one fit the description of Murray et al. 2015 apparatus. However, even by adding a Coulomb-type tangential friction force at the iceberg-glacier contact. Results remain far from expected ones. Taking however a 5.5 mm gap on the iceberg side gives the right fit. Confirmation of number rounding errors in the paper were provided by J. Burton (email exchanges).

Therefore, we can say that iceberg-glacier friction does not play a significant role in the capsize while flow confinement does.

In a side project in collaboration with Biologists from Hokkaido University, we studied ocean layer mixing and applied it to redistribution of bird food after an iceberg capsize. Figures 8 and 9 show particle distribution before and after capsize with their paths. Overall, we can say that particles are advected to the initial iceberg position as water fills the gap left. Some of them (mainly the black ones) are also advected 10 to 20 meters upward. It means, if these particles are fishes of shellfishes, that this simulation is consistent with field observation: after a capsize, birds gather on the surface to feast on easy preys from deeper ocean layers.

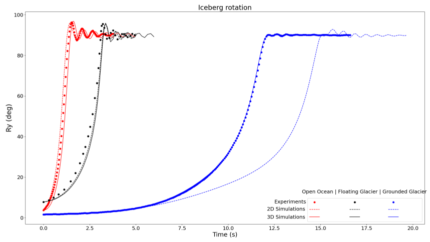

Figure 6

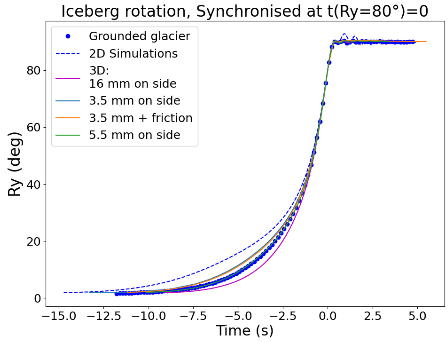

Figure 7

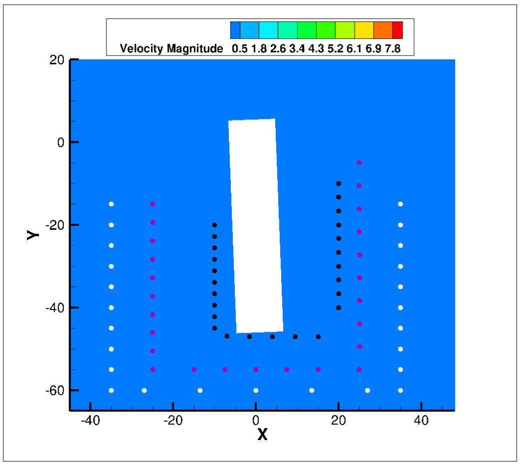

Figure 8

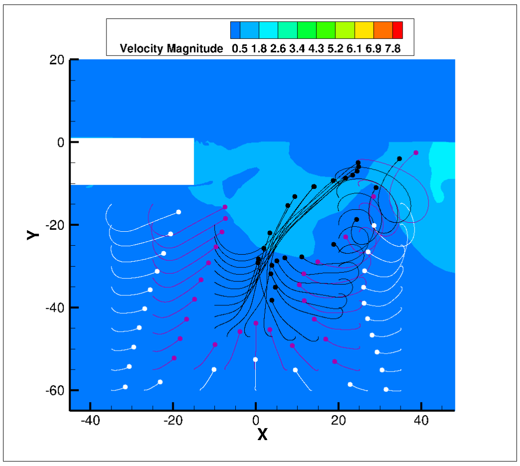

Figure 9

3 What's Next?

3.1 Workshop 3: Progress Monitoring

This workshop is likely to be held in early 2025. During the event, ESRs will share updates and early results from their projects through oral presentations. They' ll receive feedback from scientific supervisors, media and stakeholder partners, and external Supervisory Board members.