ORAL SUBMISSIONS

DO BACTERIA PARTICIPATE DIRECTLY IN THE BIOGEOCHEMICAL CYCLE OF CALCIUM IN SOILS?

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Bacteria are a key component of the critical zone, because of their role in the nutriment availability for the vegetation. There is still little knowledge on the direct role of bacteria on Ca storage/leaching in soils while it is an essential macronutrient for vegetation growth. In recent years, the Ca stable isotopes have shown their potential in understanding the Ca biogeochemical cycle. Preliminary studies have shown that in presence of soil bacteria, the plant uptake of nutrients is increased by improvement of the mineral dissolution and that the soil solutions of the nutritional reservoir are not isotopically fractionated in Ca, while without soil bacteria, they are. The focus is now to verify if the adsorption and incorporation of Ca in/ on soil bacteria induce such isotopic fractionation. For this purpose, we have characterized the calcium interaction with ubiquitous species in natural soils: *Pseudomonas aeruginosa* (vegetative form), a Gram-negative bacterium, and *Bacillus subtilis* (vegetative and spore forms), a Gram-positive bacterium. Whatever the experimental conditions (pH, kinetic, optical density of bacteria, interaction time, dead/alive bacteria…), there is no observable isotopic fractionation induced during calcium/bacteria contact experiments. On the other hand, the sporulation process of *B. subtilis* induces one. We also have separated bacterial cell-compartments of these bacteria (vegetative form) to identify more specifically where Ca is localized after the adsorption procedure, to precise the physical adsorption, the metabolic ways, etc. but also the involved functional groups for Ca adsorption. It results from this work that Ca is mainly stored in the bacterial wall compartments, with differences between *P. aeruginosa* and *B. subtilis*, resulting from their wall specificities. These results suggest that (1) Ca adsorption on vegetative bacteria does not induce any isotopic fractionation, whatever the experimental setup, (2) Ca storage in spore forms of bacteria induces an isotopic fractionation (3) calcium storage in soil bacteria is likely to impact the calcium biogeochemical cycle when they exist in their spore form.

Keywords: bacteria, calcium, isotopic fractionation, adsorption, absorption, sporulation

PETROLOGICAL AND GEOCHEMICAL EVOLUTION OF PERMIAN MAGMATISM IN THE CENTRAL ALPS (SE SWITZERLAND, N ITALY)

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Whereas mechanisms causing magmatic differentiation are constrained for magmatic arc systems, their understanding in post-orogenic contexts remains superficial, even though this context is common to many phanerozoic continental domains. Understanding which processes are active and quantifying their relative influence during differentiation remains a major challenge.
These processes can either involve magmas and their crystallization products or involve crustal contamination through various vectors. Whereas the influence of these processes can be presumed by field evidences, this needs to be constrained and quantified. We focus on Central Alps (N Italy, SE Switzerland), where a complete, Permian, crustal-scale, and post-orogenic magmatic system has been documented from lower crustal (Malenco unit) and mid-crustal intrusives (Campo unit) to upper crustal intrusives and extrusives (Bernina unit).

A great lithological diversity is observed in the middle crust, ranging from Ol-gabbro to granitoid, and showing evidence of numerous exchanges between magmas and their host rocks. Magmatic rocks comprise Ol-gabbro and gabbro (45-50 wt.% SiO_2, Mg# 35-90, 0-3 wt. % K_2O), alkali-rich diorites (50-60 wt.% SiO_2, Mg#: 40-55, 0.5-2 wt.% K_2O), and granitoids (50-85 wt.% SiO_2, Mg#: 5-50, 1-6 wt.% K_2O). Bulk compositions indicate that magmatic rocks follow a composite trend between tholeiitic and calc-alkaline series. The diversity of major element compositions emphasizes that most of the differentiation occur in the middle crust. In order to better constrain differentiation trends, we explore the role of equilibrium and fractional crystallization using melt-minerals thermodynamic modeling, starting from a parental troctolite. Whereas some correlations between the composition of our samples and the modeling results can be observed, strong disparities remain regarding SiO_2 and K_2O contents. Thus, the compositional diversity cannot be attributed to fractional crystallization only: the high K_2O content at high Mg# suggests a major role of crustal contamination. Differentiation trends will be further constrained by improving thermodynamic modeling and by integrating trace element composition of magmatic rocks and host-rocks to better constrain the source and extent of crustal contamination.

Keywords: Central Alps, magmatic system, thermodynamic modeling, crystallization, crustal contamination

EVALUATION OF THE QUATERNARY STABILITY OF MID-ALTITUDE MOUNTAINS IN A LOW DEFORMATION CONTEXT BY MORPHOMETRIC AND GEOCHEMICAL ANALYSIS: THE CASE OF THE VOSGES

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Contrary to the Alps or the Himalayas, which result from the convergence of lithospheric plates characterized by important seismic and tectonic activity, the mid-altitude mountains are often devoid of intense tectonic activity and yet have summits at 1000 – 1500 m, which have experienced glaciations. This project aims – through the example of the Vosges – to study the origin and the buildup of the topography of European mid-altitude mountains.

Located in NE France, the Vosges is characterized by north-south and east-west topographic, geological, climatic and geomorphological gradients. The topography of this massif is uplifted in two phases with the formation of the Rhine graben in the Eocene-Oligocene and a general flexure of the lithosphere induced by the Alpine-Jura thrust during the Miocene. The current lack of activity along the Upper Rhine Graben boundary faults, and slow or no Alpine convergence associated with the moderate seismicity of the region with essentially strike-slip mechanisms raise questions about the driving forces behind the maintenance or formation of the Vosges relief, especially in the South where it is the highest.

In order to quantify the Quaternary dynamics of the Vosges, this study is organized into two parts. The first part consists in performing a morphometric analysis of the topography of the Vosges. This will establish the morphometric variability of the relief and reveal possible morphological perturbations of the rivers, hillslopes and ridges. For that, morphometric indexes were extracted to quantify those landforms and a numerical toolbox was developed in order to connect those metrics. This allowed us to show dynamic processes affecting the Vosges relief such as basin captures, a westward migration of the main drainage divide and knickpoints migrations.

To discuss the recent dynamic of the Vosges relief, a second part consists to measure millennial denudation rates in targeted areas. We will measure the concentration of ^{10}Be cosmogenic nuclide in river sands, which depends on erosion. The stability of drainage divides will be investigated as well as morphometric disturbances revealing potential geomorphic responses to tectonic or climatic forcing.

Keywords: Morphometric analysis, Cosmogenic nuclides, Denudation rates, Mid-altitude mountains, Relief stability, Vosges

ASSESSING METHOXYCHLOR POLLUTION AND NATURAL ATTENUATION IN A CONTAMINATED AQUIFER USING ISOTOPIC TOOLS

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Methoxychlor is an insecticide that was widely used until it was withdrawn from the European market in 2002 (91/414/EEC). Its high persistence and high tendency to adsorb in particles causes methoxychlor to be widespread and frequently detected in surface and groundwater. For these reasons, it is imperative to develop methods for monitoring methoxychlor and elucidating its degradation in the environment so water management and remediation actions can be improved.

The goals of this work are to detect the methoxychlor contamination hot spots and to find evidence of degradation in a polluted site. To these ends, periodic concentration and compound specific isotope analyses (CSIA) have been conducted. CSIA is a useful tool to evidence degradation independently of concentration data since molecules with light isotopes in the reactive position are degraded at different rates than molecules containing heavy isotopes. Consequently, temporal and spatial shifts in isotope ratios are indicative of degradation and enable tracking degradation processes[1].

The methods for extraction, preconcentration and analysis of methoxychlor in environmental water and soil samples have been set-up for concentration analysis and CSIA. For water samples a Solid Phase Extraction method, adapted from EPA method 525.33, has been validated for 500 mL samples, for concentration analysis, and upscaled and validated for 20 L samples, for isotopic analyses since a higher analyte mass is required. For soil samples a method[2] has been adapted and validated for concentration and isotopic analysis.

Hot-spots of methoxychlor contamination and different degradation products have been detected in groundwater. Those degradation products may be the result of different degradation processes. The compound specific isotope ratios are currently being analyzed. The CSIA results may allow to confirm the degradation processes that are releasing those different metabolites and determine others. All this information will be useful in the future remediation decision making process.

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Keywords: Pesticides, Isotopes, Groundwater, Remediation

IMPACT OF TOPOGRAPHY ON POTENTIAL EVAPOTRANSPIRATION

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Hydrological models use climatic forcing to simulate water flow and aquifer-river exchanges. One of the most important of these is drainage resulting from precipitation and evapotranspiration, as it allows the calculation of water quantity that can be stored in the studied watershed. Climatic can be extracted from databases such as SAFRAN from Meteo-France but the estimation of potential evapotranspiration (PET) requires models that use, in particular, solar radiation, albedo, temperature and atmospheric pressure. Some parameters can be easily retrieved from the SAFRAN database, but others, like solar radiation, are more difficult to estimate. Even though formulas exist to estimate the average radiation at the scale of a SAFRAN mesh of 8km², they do not consider the topography of the terrain, such as the orientation, slopes and shadow effects although irradiation is one of the most determining factors for plants' water needs. Therefore, the estimation of PET is a major issue to obtain consistent and reliable hydrological models. The objective of this work is to distribute the evapotranspiration by a more realistic estimation of the solar radiation considering the direct, diffuse and reflected radiation, considering the local characteristics of the land.
Scharmer and Greif (2000) equations, implemented in the r.sun package of QGIS is used to compute the relative position of the Earth and the Sun, as well as the interaction between solar radiation and the atmosphere. Thus, the model calculates the 3 components of global radiation: direct, diffuse: radiation from scattering in the atmosphere, reflected: radiation reflected by surrounding surfaces; for clear sky conditions. The model considers the local relief to estimate the sky obstruction in mountainous areas for example. By default, the model calculates the angle between the horizon and the Sun every 30 minutes, defines the sunny areas, and calculates the diffuse and reflected radiations. Albedo has been estimated using the Corine Land Cover database which provides information on land use (vegetation types, urban areas, water...) and tables from the bibliography. Finally, r.sun gives the global sunshine over a day in any point of the studied area for a clear sky.

The formulas to estimate the radiation from SAFRAN data, although less distributed, have the advantage of being able to consider the weather conditions of each day over the year. The choice was therefore made to adjust the radiation computed by r.sun to the average value given by SAFRAN assuming proportionality between both. The proportionality coefficient varies locally between 0.2 and 2.5, which shows that the local impact of topography on radiation is very significant. Using this correction coefficient in the Penman Monteith formula, the relative difference in evapotranspiration is respectively -80% and +180% from the mean for the shaded areas and the sunniest areas.

Keywords: Hydrology, potential evapotranspiration, solar radiation

ANALYSIS OF THE IMPACTS OF DROUGHTS ON THE WATER QUALITY OF THE ANTHROPOGENICALLY IMPACTED LAUTER CATCHMENT

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Current state-of-art studies have been largely focusing on analysing how headwater catchment characteristics influence the sensitivity of the water yield in response to climate change. However, there has been little research combining both hydrological analysis with in situ water quality assessment and understanding how extreme climate events could influence the water quality of the headwater catchment, especially under anthropogenic stress. Therefore, this research aims at understanding the mechanisms of how different types of droughts modify the water quality of an anthropogenically impacted catchment.

The research is performed on the Lauter river, which takes its source from two headstreams, the Scheidbach and the Wartenbach in the Palatinate Forest, Rhineland-Palatinate and flows between the French-German border and ultimately flow into the Rhine River. We will present the methodology of the research and current updates on the progress. The research is planned to proceed in three steps, 1) understanding the water partitioning mechanism and defining different drought types by using the SWAT (The Soil & Water Assessment Tool), 2) studying the water quality behavior under different hydrologic scenarios by conducting in situ water quality monitoring experiments, 3) predicting the water quality trend under future climate change and anthropogenically impacted scenarios. Current results include water quantity trend analysis based on the daily flow rate data at the Salmbacher Passage measuring station on the Lauter river and a primary catchment modeling result with the SWAT.

Keywords: Drought, Water quality, SWAT model, Headwater catchment

GRACE, THE GRAVITY-FIELD VARIATIONS FOR NEW INSIGHTS ON THE EARTH'S CORE

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Space gravity GRACE and GRACE Follow-On (GRACE-FO) missions have been measuring the temporal mass variations at the Earth's surface and within the mantle since 2002. GRACE products enable to study continental hydrology, oceanic and atmospheric loading, post-glacial rebound, glaciers, earthquakes and other phenomena that involve mass variations. The Earth's interior, particularly the Earth's fluid outer core possesses a broad dynamics of processes involving mass variations. Theoretical modeling indicates that low degrees of the gravity field might indeed contain some inter-annual signals of core origin. We can mention for instance dynamic pressure changes at the Core Mantle Boundary (CMB) associated with core flows reconstructed from geomagnetic observations, reorientation of the inner core controlled by gravitational coupling with the mantle. We also consider the hypothetical effects due to some dissolution/crystallization at the CMB introducing a time-varying roughness of the interface.

To verify the capacity of detecting Earth's core signature into GRACE time series, we generate synthetic core signals that we incorporate into GRACE gravity products. Then, we aim to retrieve these synthetic signals through different analysis methods. We use decomposition methods such as wavelet and Empirical Orthogonal Function analyses. In the case of gravity-field perturbation due to geomagnetic jerks, we consider an approach based on the correlation with the geomagnetic field observations. We then discuss the required amplitudes for a possible detection in space-gravity time-series in regards with uncertainties linked to other sources of mass variations that we removed from GRACE data.

Keywords: Gravity field, gravito-elasticity, Earth's core, GRACE mission, MHD simulations, geomagnetic field

SURFACE WAVE TOMOGRAPHY OF THE PACIFIC UPPER MANTLE USING BACKUS - GILBERT INVERSION

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Seismic tomography models play a key role in visualizing and discussing the internal structure and dynamics of the Earth. However interpreting these models is complicated by seismic data uncertainties and imperfect coverage that produce model uncertainties and uneven resolution (leading to biases and artifacts). Large-scale data fitting inversions struggle to compute and/or constrain the model uncertainties and resolution, making even harder to interpret their tomographic models. A fundamentally different type of inversion recently introduced in seismic tomography, the Backus–Gilbert SOLA inversion, provides direct control on the model uncertainties and resolution and produces them together with the model solution. In this presentation I aim to apply the SOLA inversion to surface wave tomography to improve the interpretations about the upper mantle structure, with a particular interest on the Pacific region.

Firstly the SOLA inversion is applied in the framework of ray-theory. Path-averaged S-wave velocity data are inverted to obtain two-dimensional tomographic models at discrete depths. An interpretation workflow that accounts for the model uncertainties and resolution is designed and applied to discuss some structures in the Pacific upper mantle. However, this first approach suffers from certain limitations: (i) data uncertainty estimates are poor and (ii) the SOLA inversion is only two-dimensional.

Secondly the SOLA inversion is applied in the framework of finite-frequency theory which allows to invert phase-delay data directly into a three-dimensional S-wave velocity model. A measurement process is developed and another method to estimate data uncertainties is used. Since this approach relies on relatively new concepts, it is applied in a synthetic case . Though the method can be further improved (e.g. considering higher modes, using better data uncertainty estimates), it produces reliable results. It should be applied soon with real data to interpret robustly the three-dimensional structure of the Pacific upper mantle.

Keywords: Seismic Tomography, Inverse Theory, Surface Waves, Pacific Region

THE NEED FOR A SECOND NUCLIDE: FORMER GLACIATIONS IMPACT THE VALIDITY OF BE-DERIVED DENUDATION RATES IN THE VOSGES MOUNTAINS (NE FRANCE)

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Assessing the rates at which mountain ranges erode is fundamental to disentangle interactions between the various factors controlling their denudation. Measurements of in situ-produced cosmogenic nuclides in modern riverborne sediments allow inferring catchment-wide denudation rate averaged over several thousand years. However, the validity of this method depends on several assumptions. One of these is the cosmogenic steady-state for which it is assumed that the nuclide production equals the nuclide removal by erosion. Paired-nuclide analysis consisting in measuring the concentrations of two different nuclides from the same sampling material allows testing the validity of this assumption. Although this was commonly undertaken in the early days of the method, the overwhelming majority of cosmogenic-derived denudation rates now settle on a single nuclide, which is ^{10}Be.

This study thus aims to test the validity of the cosmogenic-based approach by sampling 22 catchments draining the whole Vosges Mountains (NE, France) for a paired-nuclide analysis (^{26}Al-^{10}Be). Lithological, morphometric and climatic characteristics were also quantified for each catchment. Our results show that almost half (10/22) of the samples violate the steady-state assumption. Interestingly, a vast majority of these unsteady catchments are located in the south of the massif which was massively and repeatedly glaciated during cold stages. The impact of former glaciations on the cosmogenic steady-state was confronted with the surface of glacial and fluvio-glacial deposits in each catchment. The negative relation suggests a complex exposure history in the formerly glaciated catchments (i.e., bedrock inheritance and/or sediment reworking). Whilst this unsteadiness prevents the disentanglement of the factors potentially controlling denudation rates in the Vosges Mountains, it importantly emphasizes the importance and need for using a second nuclide to infer reliable denudation rates at the massif-scale when glacial erosion is involved.

Keywords: ^{10}Be-derived denudation, glaciations, Vosges Mountains

EVALUATION OF THE INTERMITTENCY OF SOLAR AND WIND SOURCES FOR AN EFFECTIVE AND SUSTAINABLE ENERGY TRANSITION FOR CUBA

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The case of Cuba is interesting for analyzing energy transition strategies due to three main reasons: its energy demand is already low and with small variation projected in the future due to “embargo”, it has no energy exchanges with its neighbors, and it has a large amount of RES potentials. Solar and wind energy sources are interesting alternatives for energy transition since they are zero direct emission technologies, widely available, and with large potential in many regions. Even so, these sources are intermittent, i.e., the energy is produced only during sunny and windy hours. Therefore, during periods of low energy production from intermittent the energy supply must be ensured by using sources capable of following the variations of the demand (controllable sources) or with the use of energy storage systems. This research aims to evaluate the effects of the introduction of the intermittent sources on the system’s characteristics, considering scenarios with and without storage. To model the storage in scenarios when it is needed, two storage energy management methods were used: direct release based on the use of the stored energy as soon as the intermittent sources are not available, and the peak shaving method based on using the stored energy to cover peak demand.

Keywords: solar energy, wind energy, analysis of scenarios, energy transition, climate change

MONITORING INDUCED MICRO-SEISMICITY IN URBAN CONTEXT USING VERY SMALL SEISMIC ARRAYS: THE CASE STUDY OF THE VENDENHEIM EGS PROJECT

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Monitoring the seismicity induced by fluid injections in deep geothermal reservoirs is often limited by the significant anthropogenic ambient noise level inherent to most EGS projects in urban contexts. We report on the performance of a monitoring network made of three small aperture (72m) seismic arrays composed of 21 3D-nodes. We tested the setup during four months of the Strasbourg sequence of induced earthquakes (2019-2022) related to the EGS Georhin project (Vendenheim, France). The deployment started a few days after the Mlv=3.6 induced earthquake of December 4th, 2020 and covered the shut-in period of the wells. We use beamforming techniques to characterize the main noise sources, which consists in slow apparent velocities surface waves emitted from mobile anthropogenic sources (motorway and railway traffic). As the arrays are located on the top of induced seismic events hypocenters, their wave fronts illuminate the arrays with a significantly higher apparent velocity, which makes the phase-weighted stacking method efficient for event detection. Earthquakes associated to these detections are located using a Matched Field Processing (MPF) technique. The obtained catalog includes 216 seismic events which represents four times more events than the reference catalog from the BCSF-Renass and a reduction of the completeness magnitude from 0.7 to 0.1. Clustering of the seismicity has been analyzed using waveform correlation. The enriched catalog reveals an intermittent seismic activity during a slow and continuous decrease of the fluid pressure after shut-in and before the largest induced event of the sequence (Mlv=3.9 on 26 June 2021).

Keywords: Induced seismicity, Deep Geothermal Energy, Urban context, Monitoring

ENVIRONMENTAL DNA: A PLANT DIVERSITY AND ENVIRONMENTAL INDICATOR FOR FRESHWATER ECOSYSTEMS

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Within a decade, environmental DNA (eDNA) has become an accepted tool in many countries for studying biodiversity, from detecting target species to describing entire communities (Taberlet et al. 2018). This expanding research takes advantage of the democratization of high-throughput sequencing to massively sequence residual DNA fragments extracted from different matrices (e.g., water, soil, faeces, sediments, archaeological remains). Recent proofs of concept describe this molecular approach as complementary, equivalent, or even more efficient than traditional field surveys for describing fish, amphibian (Valentini et al. 2016), and invertebrate (Elbrecht et al. 2016; Meyer et al. 2020) communities. Conversely, applications using eDNA remain rare for plant communities in aquatic environments, with less than 30 papers to date. Our work aims to develop a methodology for the detection and recognition of plant species based on residual DNA fragments found in aquatic environments. We have initiated a first application of this method as a biomonitoring tool in the monitoring of stream restoration in the Northern Vosges Regional Natural Park. This 'classical' eDNA metabarcoding approach is accompanied by the development of a DNA barcode database of more than 500 wetland plant species for the Grand-Est Region, including threatened, invasive, and unknown species (bryophytes, Characeae). In parallel, water samples from the old Rhine River and the Rhine canal were taken to test the limits of the method on larger hydrosystems compared to headstreams. River dynamics and water physicochemical properties influence eDNA concentration and quality hence its ability to provide a comprehensive signal of the species present. This project is also structured around the dismantling of the nuclear power plant in Fessenheim aiming to test the responsiveness of the method to a quickly changing system. All in all, comparison of the eDNA signal from different hydrosystems informs on the utility of this method as a monitoring tool for aquatic vegetation.

Keywords: eDNA, metabarcoding, aquatic plants, biodiversity, molecular ecology

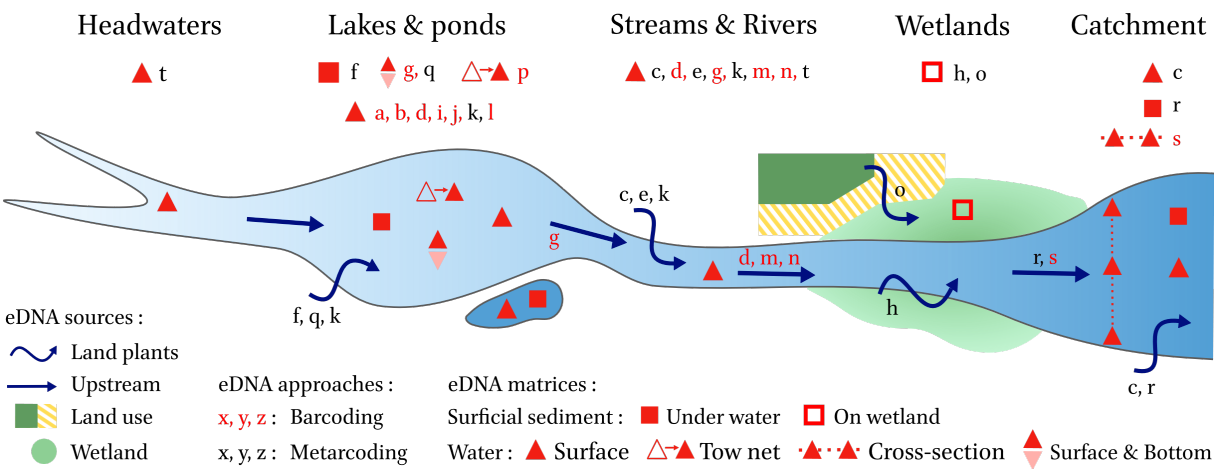

Figure: Sampling methods and sources of eDNA in freshwater systems studied using eDNA (meta)barcoding. (A. Espinosa Prieto, 2022)

SPATIAL VARIABILITY OF DENUDATION AND WEATHERING RATES IN THE STRENGBACH WATERSHED

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The Strengbach watershed, about 10 km long and 3 km wide (29 km²) upstream of Ribeauvillé, extends on the eastern flank of the Vosges massif from about 1000 masl near the crest line to 250 m in the Rhine river valley. It comprises contrasted lithologies such as granite and sandstone, and landscape perturbations highlighted by knickpoints in the stream network. The aim of this project is to investigate the role and dynamic of these perturbations in the denudation processes at millennial scale as well as in more recent time. After a detailed morphometric analysis, we estimate sub-catchment average denudation rates from cosmogenic in situ ^{10}Be from sediments collected at 12 sites. In parallel, a geochemical analysis of the waters was carried out to estimate the present-day average weathering flux in each sub-basin.

Morphometry indicates that the main stream is not in geomorphic equilibrium. It rather presents three differentiated zones: a high altitude zone above 700 m and a low altitude zone below 500 m showing contrasted slopes, reliefs and steepness index and a third transition zone in between marked by a major knickpoint whose dynamics and influence on denudation is studied in more detail. The ^{10}Be denudation rates indicate minor variations within the watershed except for two sub-basins with higher values. Lithology, rather than geomorphology, may explain part of this spatial variability, possibly related to the larger extend of the lower Bundsandstein formation.

Actively migrating or instable knickpoints result in an increase in denudation rates. This is not observed in our watershed. This indicates that if the knickpoint is migrating upwards, the velocity of migration is too slow to be detected within the millennial timescale implicit in the denudation estimation from cosmogenic nuclides. Finally, the denudation correlates positively with TDS (total dissolved solutes) from water geochemistry, which suggests that factors controlling the denudation process at the cosmogenic nuclide temporal scale (millennial scale) still have place in the present.

Keywords: basin-wide denudation rate, morphometry, geology, weathering, knickpoint

WEIGHT OF UNSATURATED ZONE IN INTRINSIC VULNERABILITY IN INDEX BASED METHODS

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More and more drinking water supply wells are impacted by diffuse contamination. Locally, concerted actions are being taken to set up protection measures in the borehole catchment area. These actions depend on the knowledge of the hydrosystem.

Since the 1980s, multi-criteria evaluation methods have been developed to assess the intrinsic vulnerability of aquifers in borehole catchments areas. These methods have the advantage of being a good compromise between rather cumbersome process-based methods and statistical methods that do not allow the causes of vulnerability to be linked to consequences.

Multi-criteria approaches give a strong weight to the properties of the Unsaturated Zone (UZ) by looking at parameters directly (soil type, UZ thickness, infiltration capacity) or indirectly (effective precipitation, topography and/or runoff) related to its properties.

The research work presented in this talk aims to understand what roles the UZ have in the vulnerability of aquifers in porous media. The methodological development that accompanies this objective seeks to enable stakeholders to build effective strategies to reduce the influx of contaminants to the borehole.

To achieve these two objectives, five sites located in the Vosges foothills and in the centre of the Alsace Plain are being studied. The presentation will address the means implemented and the methods considered to achieve the above objectives.

Keywords: Vulnerability, Borehole Catchments Areas, Unsatured Zone, Methodology.

COLLECTIVE BEHAVIOR OF ASPERITIES BEFORE LARGE STICK-SLIP EVENTS

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The multi-scale roughness of a fault interface is responsible for multiple asperities that establish a complex and discrete set of real contacts. Since asperities control the initiation and evolution of the fault slip, it is important to explore the intrinsic relationships between the collective behavior of local asperities and the frictional stability of the global fault system. However, such a mechanism is still elusive due to the difficulty of imaging an exhaustive spatiotemporal variability of a fault interface at depth, and the limited computational efficiency of the numerical models with heterogeneity over a large time and space domain. Here we propose a novel analog experimental approach, which allows us to capture the temporal evolution of the slip of each asperity on a faulting interface. We link the collective behavior of asperities with the mechanical response of the whole fault interface. We find that many destabilizing events at the local asperity scale occurred in the frictional strengthening stage which is conventionally considered as the stable regime of a fault. We compute the interseismic coupling to evaluate the slipping behaviors of asperities during the fault strengthening stage. Based on a high-resolution topographical map of the fault surface, we evidence that the interseismic coupling is not only dependent on the normal load and the peak height of asperity but also can be affected by the interactions between asperities through the embedding soft matrix. Furthermore, we quantify the spatiotemporal interactions of asperities as slip episodes. The significant characteristics and scaling-laws observed in natural earthquakes, such as the magnitude-frequency distribution and the moment-duration scaling, are reproduced through the catalog of slip episodes to demonstrate the effective upscaling. We give geophysical implications for the physics and mechanics of natural faults and discuss some limitations of our experimental setup.

Keywords: Asperities, Aseismic, Stick-slip, Fault topography

SEISMIC EVIDENCE OF AN ASEISMIC SLIP EVENT PRECEDING AND FOLLO ING THE 2017, VALPARAISO, M 6 EARTHQUAKE

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Understanding the processes that lead to large earthquakes remains one of the key goals in seismology. This is central to our understanding of seismic hazard, including the long controversial issue of earthquake predictability. Recently, Slow Slip Events (SSEs) have been identified before a few large earthquakes, which might reveal the nucleation process of the main rupture. However, the current space and time resolution of geodetic measurement makes detection and monitoring of SSEs difficult. SSEs are believed to drive their own seismicity. A fine monitoring of such seismicity may help monitor SSEs and understand their link with the rupture process. Here, we study the case of the 2017 Valparaiso earthquake that was preceded both by an SSE and an intense seismicity. We build a high-resolution catalog (Mc=2) of the region using a deep-learning phase picking model and by locating detected earthquakes in a local 3D Earth model. The resulting catalog consists of more than 100 000 events from 2015 to 2021 (compared with the ~8000 events reported by the Centro Sismológico Nacional over the same time-period). The temporal evolution of the seismicity is tested against a modified Epidemic Type Aftershock Sequences model that accounts for short-term incompleteness (Hainzl 2021). We show that an over-productive earthquake rate emerges within the foreshock sequences, continuing at least for several days after the mainshock. This transient background activity seems unaffected by large magnitudes observed during the sequence. In addition, we identify several repeater events between 2016 and 2021 using waveform cross-correlation and double difference relocation. The strongest repeater activity is observed within the foreshock seismicity and seems to decelerate over a few months. These observations support the idea that a part of the seismicity surrounding the mainshock differs from the usual earthquake triggering processes. The joint observation of an SSE, a transient background seismicity and a strong repeater activity initiating during foreshock times suggest a close connection between the SSE and the seismicity. Such connection seems to persist momentarily after the sequence, enhancing the aftershock activities. Therefore, we believe that analyzing high resolution seismicity helps to monitor the activity of the rupture process preceding and following large earthquakes, and can provide new insight for real-time seismic hazard assessments.

Keywords: Seismology, Statistic, Foreshock, Mainshock, Aftershock, Aseismic slip

ORBITAL FORCING IN THE SEDIMENTARY RECORD OF THE MULHOUSE BASIN (UPPER RHINE GRABEN, EARLY RUPELIAN)

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The Upper Rhine Graben (URG) is a Cenozoic intracontinental rift system divided in sub-basins. The Mulhouse basin, in the south, is characterized by three evaporitic formations, Eocene to Oligocene in age. The "Zone Salifère Supérieure" (ZSS; early Rupelian, ~500m thick) is made of thick marls-evaporites alternations (~5m). The seemingly cyclic recurrence of these alternations involves important questions: Are they forced by astronomical cycles? If so, can they be used to create a high-resolution age model?

Well-log responses of four wells have been used to perform well-log correlations to document the lithostratigraphy, and to follow the alternations' evolution across the basin. The ZSS was also investigated with the methods of cyclostratigraphy (e.g. multi-taper method, evolutive fast Fourier transform, Tanert-Hilbert filtering) to determine if the repetitive patterns could be attributed to any known astronomical cycles.

The marls-evaporites alternations are interpreted as the result of alternating periods of relative lake-level rise, major-ion recharge, and deposition of marls (relatively humid interval) and periods of relative lake-level fall which result in the saturation of brines and precipitation of evaporites (relatively arid interval). Spectral analysis of the Gamma-Ray signal of the DP-211 well reveals significant spectral peaks of 23.5m above the 95% confidence interval and of 9.5m and 5m above the 99% confidence interval. The ~5:2:1 ratio between those spectral peaks in the depth domain are coherent with the ratio of short eccentricity, obliquity, and precession in the time domain, suggesting that the marls-evaporites alternations were forced by precession through cyclic changes in insolation. Similar results are found across the other wells. The well-log correlations show that most beds and gamma-ray trends correlate across the basin and are coherent with the astronomical filters, suggesting no major basin-scale heterogeneities. The cyclostratigraphy results account for a minimum duration of 1.8 Myr for the ZSS.

Keywords : Evaporites, Cyclostratigraphy, Paleoclimates, Upper Rhine Graben, Rupelian

POSTERS

A PROCESSING CHAIN FOR CLASSIFICATION OF CONTINUOUS DISTRIBUTED ACOUSTIC SENSING SIGNAL

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Using Distributed Acoustic Sensing (DAS) technology, one optical fiber can be turned into hundreds to thousands of equally spaced acoustic sensors. This very high sensor density offers geoscientists the ability to observe natural and anthropogenic seismic events at an unprecedented level of spatial and temporal resolution. Unfortunately, the very high amount of data generated involves several methodological problems for monitoring applications, as storing continuous DAS data over several days or weeks requires large storage capacity (several terabytes per week) and exploration of this data set by an operator after acquisition is very time consuming.

This study presents an approach based on a supervised Machine Learning method to automatically classify continuous DAS recording among several classes of anthropogenic sources (footsteps, excavations, leakages, etc.). The entire process works on windowed signals, allowing to process the data in quasi real time. It uses the Random Forest algorithm in combination with a set of fifty-three curated features to classify temporal acoustic signal, and a Random Markov Field algorithm to accommodate spatial and temporal information redundancy.

We developed and tested this new processing chain with a set of simulated seismic anthropogenic sources that can be recorded while monitoring pipelines to detect intrusions and leaks. We acquired signals at the FEBUS Optics test bench in South-West France. We choose to focus on six anthropogenic seismic sources: footsteps, impacts, backhoe, compactor, and leaks. To simulate water and air leaks, we use electrovalves of two different diameters (3mm and 5mm). Calling “accuracy” the good classification rate among the dataset, this study has shown that good results can be obtained using Machine Learning for real-time signal classification (accuracy of 83%) and the use of the post-processing step increases the final accuracy by 4% (accuracy of 87%). The improvement is clearly visible in the reconstructed segmentation map, as most of the isolated signals are removed but the synchronous events taking place nearby are retained.

Keywords: DAS, Fiber Optic, Machine Learning, Random Forest, Random Markov Field

OPTIMIZATION AND PROCESS DESIGN TOOLS FOR ESTIMATION OF WEEKLY EXPOSURE TO AIR POLLUTION INTEGRATING TRAVEL PATTERNS DURING PREGNANCY

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A growing number of international studies have highlighted that exposure to air pollution contributes substantially to the burden of preterm birth and infant death. Several other epidemiological studies have also suggested associations between air pollutants' concentrations and adverse birth outcomes including low birth weight and preterm birth. To do so, researchers need to estimate exposure levels to air pollution throughout everyday life. In the literature, the most commonly used estimate is based on home address only or taking into account, in addition, the work address. However, several studies have shown the importance of daily mobility in the estimate of exposure to outdoor air pollutants.

In this context, we developed an R procedure that estimates individual exposures combining home addresses, several important places, and itineraries of the principal mobility during a week. It supplies researchers a useful tool to calculate individual daily exposition to air pollutants weighting by the time spent at each of the most frequented locations (work, shopping, residential address, etc.) and while commuting. This task requires the efficient calculation of travel time matrices or the examination of multimodal transport routes. This procedure is freely available from the Equit'Area project website: (www.equitarea.org).

This procedure is structured in three parts: the first part is to create a network, the second allows to estimate mains itineraries of the daily mobility and the last one tries to reconstitute the level of air pollution exposure. One main advantage of the tool is that the procedure can be used with different spatial scales and for any air pollutant.

Keywords: Travel pattern, Road network, Air Pollution Exposure, optimization tool, process design

BREAKUP THE CONTINENTAL LITHOSPHERE: A MANTLE PERSPECTIVE

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Previous studies from the Iberia margin enabled to describe the evolution of the mantle lithosphere during rifting based on the study of magmatic and mantle rocks that were dredged and drilled along the Western Iberia margin. These data, together with those from the Alps and the Pyrenees, enable to distinguish various mantle types and propose models for the tectono-magmatic evolution of rift systems going to breakup. However, key questions remain that include how, when, where and how much magma is produced, how does it percolate and interact with the overlying subcontinental mantle, how and when does magma focus and how is it extracted and how do these magmatic processes interact with the extensional processes operating during breakup. Answering to these questions is a prerequisite to understand lithospheric breakup and the formation of a new plate boundary, which is among the least understood plate tectonic processes at present.

The current PhD thesis is a part of the ANR project FirstMove (2022-2025), which aims at understanding and characterizing tectonic and magmatic processes occurring at magma-poor rifted margins and their evolution to steady state seafloor spreading. The study will focus on the Western Iberia margin, including drilled and dive-recovered samples from the Galicia Bank (Galinaute I and II), and the Iberia abyssal plain (IODP legs, proposal 943).

The PhD project will include tasks that enable to respond to key scientific questions:

- Document the tectono-magmatic evolution along the Western Iberia margin;
- Compare with existing data from Iberia, the Pyrenees and the Alps, but also new data from the present-day Australia-Antarctica margins,
- Determine how and when magmas are channelized to reach the seafloor and reveal the relation between magma emplacement, mantle exhumation,
- Build conceptual models that enable to get a more process-driven view of the continental breakup.

Keywords: petrology, geochemistry, isotopy

TOWARD NEW AGRICULTURAL PRACTICES UNDER CLIMATE CHANGE: COUPLED SOCIAL AND MODELLING METHOD

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The Trajectories project aims to test the effect of an original lever of mobilisation in favour of the transition towards resilient socio-hydrosystems by using projections of the agrosystem over various time horizons. The originality of this approach is to mix socials and modelling approach that means building scenarios for changing agricultural practices which are co-constructed with local stakeholders and test the into models. The participatory process is extensively studied because it is an example of action research. It allows to exchange with stakeholder to try to find answers combining agricultural and hydrological issues.

To do this, the project uses foresight, which is a mean of investigating a plurality of possible futures, including potential breaks with the conventional model. Tools related to foresight, i.e. scenarios and modelling, are mobilised to support the participatory process with local stakeholders. There is a multitude of future scenarios, which will be questioned regarding the quality of water bodies and sustainable agricultural practices. The trajectories of these scenarios will also be investigated in order to determine the temporalities of changes. To model the catchment response we use IAMs with various modules such as agronomy, hydrology, economics. They account for the complexity of the field, which is not always easily perceptible, and thus evaluate in a robust manner the different scenarios co-created with the stakeholders.

This work combines different tools from various disciplines in order to cover a multitude of subjects (water cycle (surface and groundwater hydrology), nitrogen cycle, pesticide cycle, advanced agronomy...).

Keywords: Trajectories, Co-construction, Agro-hydrological models, Participatory research

ENERGY VULNERABILITY AND URBAN INEQUALITIES: SOME INSIGHTS FROM STATISTICS

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In a context of rising housing prices, lower and middle class French households have tended to move to peripheral areas characterized by less access to jobs and public services (Lambert, Gobillon, Pellet, 2019). As energy prices fluctuate due to the war in Ukraine, economic disparities have widened between neighborhoods, but also between workers. The most car-dependent pay - in proportion to their incomes - very high costs related to housing and mobility, fueled by unpopular carbon taxes. Many families, whether new homeowners or renters, face heavy costs to finance decent housing.

The ambition of this study is to: 1/ Collect and harmonize data on housing, mobility and economic opportunities in several European urban areas. 2/ Measure neighborhood exposure by considering households' motility and adaptability. 3/ Identify links between residential strategies, urban policies and energy vulnerabilities.

To do so, we propose to combine different disciplinary approaches by estimating housing exposure and accessibility potentials for several social categories. The idea is to identify several clusters based on the French Classification of occupations to perform specific calculations. Using georeferenced data-bases (FIDELI, BPE and FLORES) on housing, amenities and employment, we conduct a regional analysis in Alsace based on cumulative multimodal accessibility metrics, using the routing engine R5. Consistent with the reconsideration of utilitarian-only approach, this study draw on the capability theoretical framework, which includes personal data as components of accessibility (Pereira et al. 2016). Innovatively, the conceptual background is co-created with decision-makers and NGOs, drawing on various concepts previously used to incorporate equity concerns into urban planning, including sufficientarianism (Martens et al. 2014). The whole procedure results in comparing energy poverty levels and accessibility scores in various urban contexts. Thus, it tracks significant gaps hindering inclusive cities. Finally, the study draws conclusions on energy justice (Jenkins et al, 2016).

Keywords: Energy, Equity, Housing, Transport, Alsace

PARTIAL MELTING AND REFERTILIZATION AT LITHOSPHERIC BREAK-UP: INSIGHTS FROM THE DIAMANTINA ZONE (SW AUSTRALIA)

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How continents break, separate, and how, when, and where magma is produced during breakup is yet little understood. Studies of exhumed mantle rocks from the N-Atlantic and the fossil-Alpine Tethys ocean-continent transitions (OCT) show that partial melting, percolation and refertilization of inherited mantle are intimately related to lithospheric thinning and tectonic exhumation during final rifting. Here we present new petrological and geochemical data from mantle peridotites dredged along the Diamantina OCT (SW Australia), show modelling results of mineral-melt exchange, discuss element partitioning related to refertilization and partial melting and compare results with those described from the OCTs in the Alps.

The major and trace element concentrations of minerals composing spinel and plagioclase-lherzolites were measured by µ-XRF and LA-ICP-MS. Clinopyroxenes show two distinct populations that, consistently with those observed in the Alpine-Tethys ophiolites, are representative of two mantle domains: the inherited-subcontinental mantle, with higher content of Na_2O ; and the refertilized domain characterized by lower Na_2O content and higher equilibration temperatures (1100°C±100°C) highlighting the entrapment of melts in the plagioclase stability field (~5kbar). Interestingly, few spinels found in inclusions in large orthopyroxene-porphyroclasts in samples from the refertilized domain display the same chemical compositions as those from the inherited domain. This observation enables to establish, for the first time, a direct genetic link between inherited and refertilized domains.

Geochemical modeling and pyroxene thermo-barometry suggest that lithospheric break-up in this region is preceded by exhumation of subcontinental mantle from the spinel to the plagioclase stability field in the presence of a high geothermal gradient, similarly to the observations previously documented from the Alpine Tethys. Thus, despite of the different pre-rift evolution and inheritance, the exhumation process and related magmatic evolution may be similar at the Diamantina and Alpine Tethys margins, which is in line with the observed magma-magma poor evolution of both margins.

AUTOMATED CLASSIFICATION OF DENSE SEISMIC NETWORK DATA WITH SUPERVISED MACHINE LEARNING. APPLICATION TO THE SUPER-SAUZE LANDSLIDE (FRENCH ALPS)

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In the context of climate change, the occurrence of geohazards such as landslides or rockfalls might increase. Therefore, it is important to have the ability to characterise their (spatial and temporal) occurrences in order to implement protection measures for the potential impacted populations and infrastructures. Nowadays, several methods including Machine Learning algorithms are used to study landslides-triggered micro-seismicity and the associated seismic sources (eg. rockfalls and slopequakes). Those innovative algorithms allow the automation of the processing chains used to build micro-seismicity catalogues, leading to the understanding of the landslide deformation pattern and internal structure.
Unfortunately, each landslide context has its own seismic signature which requires the use of the most complete and handmade training samples to train a Machine Learning algorithm. This is highly time consuming because it involves an expert that needs to manually check every seismic signal recorded by the seismic network, which can be thousands per day.

The aim of this study is to develop semi-supervised and unsupervised clustering methods to characterise the micro-seismicity of landslides in near real time. Here, we present the preliminary results obtained for creating a landslide micro-seismicity catalogue from the analysis of a dense network of 50 seismic stations deployed temporarily at the Super-Sauze landslide (French Alps). First, we present the performance of supervised Random Forest and XGBoost trained models on the event signals. Then, an approach aimed at processing streams of raw seismic data based on 18s-length windows is explored. Finally, we discuss the several clustering possibilities for the follow up of the analysis and the transferability of the approach to other landslides and even environments (glaciers, volcanoes).

Keywords: Supervised Machine Learning, Landslide, Environmental Seismology, Random Forest

CLIMATE VARIABILITY AND FLOOD HAZARDS IN YAOUNDE-CAMEROON: IMPACTS AND POLICY IMPLICATION

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Floods give rise to problems and disasters in many basins around the world, especially in developing countries, where discharge data are not available to establish efficient management tools to deal with flood hazards. Indeed, most Cameroonian cities are confronted with the problem of anarchical urbanisation with rapid population growth, competition, pressure and high cost of land at the heart of the city, many poor and vulnerable populations are obliged to occupy marginal and flood risk areas. According to the Yaounde City Council, over 180 floods struck the capital in the past three decades, causing economic damage, health problems and more than 100 deaths.

This study aimed at determining the different causes and consequences of flooding in vulnerable communities of Yaounde, especially climate variability on flood patterns. Also, highlight the coping strategies developed by populations and bring out actors involved in flood management in Yaounde. Lastly, map the dynamics of land use in flood-prone areas and develop flood modelling and forecast. To achieve these objectives, we carried out survey, interview and field observation. Weather and climate data were obtained from the Yaounde Agroecological station and ERA5. Water samples were analysed to isolate bacteria from flooded water and stream flow and velocity obtained.

This study reveals that there is a high occupation of flood prone zones by very low income earners (44.3%). Flood occurrence in Yaounde is aggravated by very dense hydrographic network, climate variations, discharge of solid waste in rivers and streams and the poor maintenance of existing waterways. Recorded flooding days within the year of study matched with heavy rainy days. Putting in place of a flood modelling and forecast could be a sustainable management tool to mitigate floods in Yaounde (Cameroon).

Keywords: Flood hazard, climate variability, invasion of marshy area, flood preparedness failure, Yaounde, Cameroon.

MODELING WATER TRANSFERS IN THE SOIL-PLANT-ATMOSHERE CONTINUUM: COMPARISON OF APPROCHES, LINKS BETWEEN SIMULATIONS AND MEASUREMENTS

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Often included as a simple boundary condition in subsurface hydrological models, evapotranspiration is nevertheless a key process in the water cycle. Thus, interactions involving several complex hydrological and ecophysiological processes control the dynamics of continental hydrosystems. The representation of these interactions in models remains an important challenge to better understand and describe the dynamics of the unsaturated zone. Our goal is to find a parsimonious representation of the soil-plant-atmosphere continuum, for a realistic coupling between a physically-based subsurface hydrological model and the vegetative layer, while being numerically efficient.

SoVegIM (Soil Vegetation Interaction Model) is a 1D model of hydraulic transport in the soil-plant-atmosphere continuum at the ecosystem scale. It assumes that water flow in the soil, root system and tree trunk (plant stems) is analogous to that of a one-dimensional porous medium. Hydraulic transport in the continuum is thus represented by a system of Richards' equations (with constitutive relations specific to each compartment) coupled by different exchange terms representing the processes of transpiration and root water withdrawal.

Two formalisms used to represent the root compartment are presented and compared. The first form adopts a resolution of the Richards equation in the soil and root compartments, explicitly representing the root exchange by a coupling term. The second form alleviates the coupling and numerical resolution by assuming a hydrostatic hydraulic load profile in the roots.

A synthetic test case allows: (i) to apprehend the capacity of the models to reproduce the mechanisms of hydraulic redistribution and hydraulic compensation; (ii) to study their sensitivities to different parameterizations of the employed submodels and (iii) to evaluate the level of spatial discretization of the continuum necessary for a good representation of the root uptake and transpiration

The use of real data from sap flow measurements and flow towers, in several different soil and climatic contexts, supports the ability of the models to reproduce the transpiration dynamics of real ecosystems using minimal parameterization.

Keywords : water-soil-plant interactions, mechanistic modeling, porous media, critical zone

ARCHITECTURAL CHARACTERIZATION OF A BRAIDED FLUVIAL SYSTEM AND ITS PERMEABILITY HETEROGENEITIES: CASE STUDY OF THE LOWER TRIASSIC BUNTSANDSTEIN SANDSTONES, EAST FRANCE

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Clastic sedimentary processes are studied in scales that range from single facies foreset laminae up to stratigraphic cycles that affect an entire depositional system. All processes govern fluid-flow heterogeneities in porous media; therefore, their understanding is a common practice in the petroleum industry. However, the hydrogeology industry has lagged behind when it comes to discretising porous sedimentary aquifers into flow, heat and transport models. In East France, the Lower Triassic Buntsandstein is an important source of drinking, industrial and geothermal water, composed dominantly by sandstones deposited by a braided fluvial system within an arid alluvial plain with limited preserved flood plain deposits. The stacking pattern is influenced by climatic events, sometimes making fluvial processes secondary, with aeolian processes dominating sediment transport. In spite of those facies association changes, the sedimentation remains dominated by sand, which results in a common mistake of defining the entire package of sandstones as a single hydrostratigraphic unit. The aim of this study is to understand to which extent sedimentological and stratigraphic processes generate significant 3D heterogeneities/ anisotropies to fluid-flow and transport models, using outcrops of the Lower Grès Vosgien Formation, Middle Buntsandstein, as analogues to the Buntsandstein aquifer. Classical sedimentological characterisation, coupled with 3D drone models and handheld air permeameter data are used to quantify heterogeneities/anisotropies. Previous results show that the Lower Grès Vosgien presents Froude-subcritical and transcritical flow sedimentary structures, characteristic of an intermediate discharge variance alluvial system. Permeability data reveals that differences of more than one order of magnitude can be found in variable scales as: in a single facies, between different facies of the same facies association, and between facies associations. Despite the major role played by diagenetic processes in permeability contrasts, they are governed by primary depositional features.

AUTOMATED LANDSLIDE DETECTION AT THE SCALE OF THE EUROPEAN ALPS THROUGH THE USE OF SEISMOLOGY AND MACHINE LEARNING

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Recent large landslides in many parts of the World (Nuugaatsiaq, Greenland; Taan-Tyndall, US; Culluchaca, Peru) as well as the increase in the frequency of gravitational instability in the European Alps (e.g. collapse of the Drus, Mont Blanc Massif, France) revealed the threat of such events to human activity. Seismology provides continuous recordings of landslides activity on long distances. The objective of this work is to present a method to automatically construct instrumental landslide catalogs from seismological data.

The detection method applied to the seismological observations consists of computing the energy of the signal between 2 and 10 Hz on which a STA/LTA method is applied. Then, a supervised Random Forest classifier is used to identify the source of the event (earthquakes or landslides). To train and test the seismological detection and identification methods, we compiled a database of 65 landslides and 4515 earthquakes (of MLv > 0.1) recorded by seismic stations deployed in the European Alps. The dataset is composed of 2221 seismological traces of landslides and 17353 traces of earthquakes. Tests of the Random Forest identification method gave us a rate of good identification of around 100% for landslides and 96% for earthquakes. Tests on 65 days of continuous data allow us to find 235 new landslides including 61 over 65 reference events.

The model is then applied on continuous seismic data (~ 400 stations) acquired over the European Alps since 2000. We define a processing chain to reject as many noise detections as possible. The first derived instrumental catalog is composed of ~ 183.000 potential landslides. We are working on a localization method which will help us to review the catalog, reject possible false detections and interpret the inventory. A first order of the localisation is given by a spatial clustering of seismological stations that have detected the signals associated with the events. We will use the NonLinLoc software (Lomax et al. 2000) and pre-processed travel times to refine the localisations. The methodology and preliminary results of localization will be presented and discussed.

Keywords: Landslides, Seismology, Machine learning

ACTIVE DEFORMATION IN TUNISIA FROM GNSS MEASUREMENTS

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Tunisia is located in the limit of the African plate and in a seismically active area near the Eurasian plate boundary, which means that Tunisia's active tectonics is controlled by the convergence between Africa and Eurasia.

Although this region is generally characterized by moderate seismicity, it is known for its historical and instrumental seismic activity that has resulted in human and materiel losses, such as in Utique 408 AD, Kairouan 859 AD, Tozer 1997 and recently in March 2018 between Tunis and Bizerte (M_w 5).

A partnership between the National Office of Mines (ONM) and ITES is being set up to develop spatial geodesy work using GNSS measurements to characterize and quantify the active deformation of Tunisia alongside previous tectonic and seismotectonic works.

A network of already existing 21 GNSS stations spread over the Tunisian territory is managed by OTC (Office of topography and cadaster) so in the framework of this project 6 days/year of records from 2012 to 2019 has been purchased.

To improve the resolution of the acquired data and fill the gaps between the OTC stations, a national network consisting of 24 mobile stations is set up and two campaigns of 3 days of records in 2019 and 2021 have already been carried out and a third campaign in 2023 is planned.

In 2022, four more permanent stations have been installed to provide a continuous flow of data.

Two target areas, Gafsa and Kairouan have been chosen to install regional networks consisting of 16 sites each around active faults. Two campaigns in 2021 and 2022 have been carried out and two more are planned in 2023 and 2024 to detect the deformation in those areas.

All these data will allow the calculation of a precise velocity field of Tunisia based on GPS trends and the establishment of the strain rate distribution across continental Tunisia.

Keywords: Active Tectonics, GPS, Seismotectonics, Tunisia

MULTI-MODAL SEMANTIC SEGMENTATION AND SCENE CLASSIFICATION DATASET FOR REMOTE SENSING APPLICATIONS

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Since the emergence of deep learning and its constant use by the remote sensing community, one of the major problems encountered is the low availability of datasets, either for semantic segmentation, scene classification or object detection applications. Modern deep learning models require a large amount of data to achieve good generalization performance. Moreover, the objects contained in remote sensing data are much more difficult to extract and interpret than in classical photographs and datasets derived from multi-source satellite imagery are still rare despite the interest of researchers for data fusion, especially optical and radar imagery.

In this context, MultiSenGE dataset has been produced, both for scene classification and semantic segmentation. MultiSenGE consists in the segmentation of the Grand-Est region (Figure 1) into a pair of Sentinel-2 and Sentinel-1 patches with a spatial resolution of 10 meters. Sentinel-2 satellite data are downloaded from the Theia/Muscate database (https://www.theia-land.fr/) and 10 spectral bands are available for each sensor. Sentinel-1 satellite data are downloaded and preprocessed using the s1tiling processing chain developed by CNES. The retained products are acquired in Ground Range Detected (GRD) and Interferometric Wide (IW) swath mode with dual VV+VH polarization. Each patch is 256 x 256 pixels and a reference data, BDOCSGE2©GeoGrandEst produced by the Grand- Est region in France, is resampled and reworked to agree with the satellite spatial resolution. BDOCSGE2©GeoGrandEst is produced by visual interpretation of aerial photography and is declined in five levels of class for urban areas and four levels of class for natural areas. In total, this represents 53 LULC classes over the region. The roads proposed by this first reference data are not consistent at 10m spatial resolution. Thus, to maximize this consistency at 10m spatial resolution, a second vector database (BDTOPO©IGN) was used for the extraction of main roads (primary and secondary roads).

The reference data in vector format was pre-processed in 5 steps to provide a result in 14 land use classes, 5 classes for urban areas and 9 classes for natural areas for the entire Grand Est region at 10 meters spatial resolution. Once the reference data has been pre-processed, it is a matter of slicing the patches on the satellite data and the rasterized reference data to form multi-temporal optical/radar pairs of patches. The ten Sentinel-2 bands and the two Sentinel-1 bands (vv and vh) are each stacked to form an optical patch and a radar patch of the same footprint. The last step removes the overlapping patches between tiles to have a spatial independence of each of them so that users can separate their training, validation and test datasets for their machine learning models. In addition to the Sentinel-1/Sentinel-2 patch pairs and the reference data patches, a

JSON file is produced for each patch and contains several information such as the projection (wkt), the land use land cover (LULC) classes present in the patch for scene classification, the name of the corresponding patches for Sentinel-1 and Sentinel-2.

The dataset is freely accessible and downloadable for the research communities through a unique link on our dissemination plateform (A2S - https://a2s-earthobservation.eu) and the urban Scientific Expertise Centre of THEIA. Also, it is possible to access the dataset through its webpage (https://multisenge.github.io/).

Keywords: Semantic segmentation, Sentinel-2, Sentinel-1, Multitemporal, Dataset

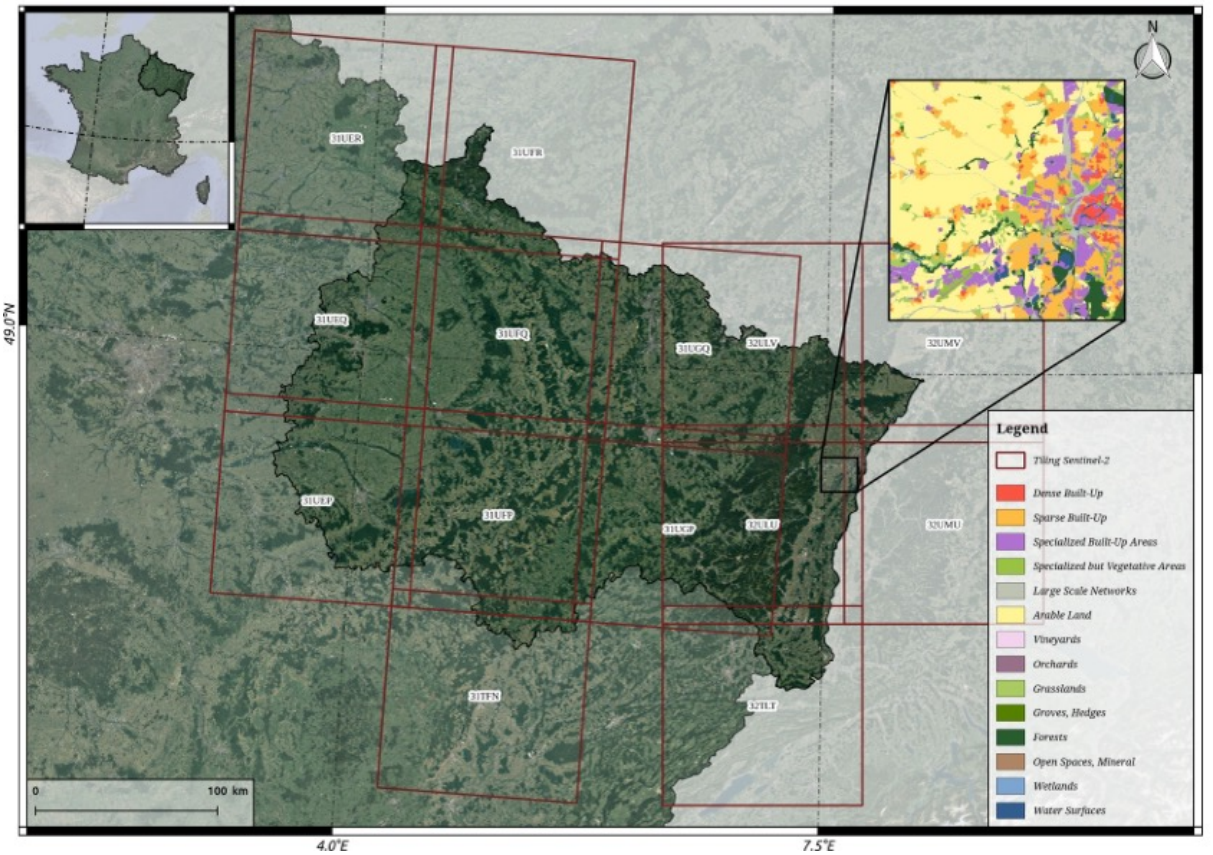

Figure: Study area with ground reference subset
(R. Wenger, 2022)