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I. Oral presentation

Session I. Hydrologie and Geothermal reservoirs.

Geomorphology, geochemistry and geochronology to characterize the trajectory of an anthropized hydrosystem from the 19th century to today.

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As river hydrosystems are particularly sensitive to human activities, it is crucial to assess the evolution of human impacts as well as the effects of some restoration actions implemented during the last decades. This study, which focuses on the section of the Upper Rhine between Neuf-Brisach and Strasbourg, aims at mapping the evolution of the geochemical signal recorded in the fine sediments deposited in response to several river engineering works.

As fluvial deposits vary both spatially and temporally, the selection of the local study sites for drilling relied on an unprecedented hydromorphological reconstruction. This is based on a planform study using former maps of the last 200 years, combined with data concerning the vertical dynamics of the hydrosystem collected on the field. Each core is dated thanks to a set of cartographic and hydrological information, combined with luminescence, ^{137}Cs and ^{210}Pb. The chemical, mineralogical and grain-size characterization of these dated archives provides an accurate picture of the spatial evolution of the composition and quality of the Rhine sediments over the last 200 years. Those results will be discussed in the light of the evolution of the human activities in the catchment.

Keywords: river hydrosystem evolution – fluvial geomorphology - GIS - geochemistry - sedimentary archives - Human impacts – Upper Rhine

Faulting and hydraulic energy balance during fluid injection in the Soultz-sous-Forêts geothermal reservoir

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A better understanding of the reservoir mechanics following fluid-injection is crucial for progress in exploitation of geothermal energy and assess accompanied seismic hazard. Indeed, several projects had been stopped after the occurrence of large induced earthquakes whose prediction represents a major challenge of current research. Predictions of most common models assume that the seismic moment release increases linearly with the total injected fluid volume. Some recent studies furthermore suggest that continuous monitoring of hydraulic and seismic energy budget allows potentially to identify hazardous evolutions and to adapt injection strategy.

Here we propose a different approach, instead of only focusing on the radiated energy that implies an energy radiation outside the reservoir, we investigate the ratio of the faulting energy and hydraulic energy for the numerous injection phases (stimulation and circulation tests) at the Soultz-sous-Forêts geothermal site (France) Indeed, the site has been the host of injections through 4 different wells at two different target depths: R3 (about 3km deep) and R5 (about 5km deep). We first show that the faulting energy grows linearly with the hydraulic energy except for the reservoir parts stimulated a second time which showed a delayed strong increase at higher hydraulic energy until the ratio of previous stimulation phase is reached. This behavior indicates that the hydraulic energy is not immediately transferred to faulting which is probably due to the Kaiser effect. Furthermore, we show that among a type of injection (stimulation or circulation test) the ratio are quite similar and are smaller than 1. This suggests the occurrence of aseismic slips and that the ratio can be a key parameter for seismic hazard assessment.

Ground Penetrating radar's capacity to identify a subsurface's hydrodynamic parameters during an infiltration experiment

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In this research, we want to understand how time-lapse GPR monitoring of a constant head water infiltration experiment can help to estimate the hydrodynamic parameters of a subsurface. To do so, we use a coupled hydrogeophysical model to simulate the GPR responses during a 1D infiltration experiment, of reflections coming from the wetting front and diffracting points of fixed depths. We conduct a variance-based global sensitivity analysis to assess the parameters contributions to the GPR responses variances over time. It allows to see which parameters are more influential at each time step of the experiment.

When considering the reflection on the wetting front and on reflectors of fixed depths, such as small rocks naturally present in the subsurface, the parameters that can be estimated are K_S (hydraulic conductivity at saturation), α (mean pore size related parameter) and θ_s(water content at saturation). The first one is the easiest to assess since it has the strongest influence on any type of signals in the transient section of the experiment, whatever the depth of the water table. The α parameter can be retrieved either from TWT_f, with more ease from the steady state of the last-value padded signal, or from the transient state of TWT signals for fixed reflectors. Finally, θ_s is only determinable from the latter, preferably from its steady state, when the EM waves travel path is fully saturated. This last result highlights the capacity to retrieve the θ_s parameter without knowing the initial condition of the sounded medium.

Modeling of seawater intrusion in coastal aquifer at Kuwait City

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Abstract

Groundwater is the only natural water resource in Kuwait and it is the most important component of drinking water production, as it is mixed with distilled seawater in a fixed ratio to produce drinking water. Groundwater pumping rates increased in Kuwait aquifers during the last two decades to meet the demand of drinking water and agriculture water. And due to the lack of natural replenishment from rainfall and the excessive pumping, ground water levels have declined significantly causing seawater intrusion in the coastal aquifer of Kuwait. As a result, many pumping wells have been terminated and replaced by new pumping wells and this condition is threatening ground water sources.

These scenario will worsen soon due to population growth, increasing urbanization and climate change associated with sealevel rise and decreased precipitation rates.

So the aim of my thesis is assessment of groundwater through the modeling of seawater intrusion in the main coastal aquifer in Kuwait City. Model applications are applied in two steps: calibration and validation of model simulations using COMSOL to assess the groundwater quality in the aquifer, predicting salinity state up to 2050 and suggest nature-based solutions to minimize the impact of the salinization of groundwater.

Interest of the study of heat transfer in the understanding of hydrodynamics in watersheds. Case of the Strengbach catchment.

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In this work, we evaluate the potential of spring water temperature variations to provide information about the corresponding aquifer, as the origin of the spring water, water travel time or physical properties of the aquifer. Therefore, we analyzed series of temperature measured in four springs (CS1, CS2S, CS3, CS4) of the small mid-slope Strengbach catchment and build a vertical two-dimensional unsaturated flow and heat transfer model based on the site's geometry, in order to determine the main parameters controlling heat transfer in this profile.

During 10/09/2013 to 01/01/2017, the air temperature at the soil surface ranged from -9.8 °C to 25.9 °C while spring water temperatures varied over a shorter range from 4.4°C to 9.7°C and experienced a seasonality similar to atmospheric conditions with a delay between one and two months. The calibrated heat transfer model indicates that spring water temperatures is related to the atmospheric temperature variations at the soil surface and a constant temperature zone controlled by the geothermal heat flux at a given depth. Moreover, spring temperature fluctuations are the results of atmospheric variations while the geothermal heat flux conditions the springs average temperature.

Additionally, sensibility analysis indicate that the main heat transfer driver is conduction which depends on soil saturated water content and soil conduction properties. Heat transfer related to convection associated with water movement is negligible. Specifically, for two spring waters (CS1 and CS3) it was found that a high saturated water content of soil (around 50%) could explain the delay while for the other springs (CS2 and CS4) apart of a high porosity, the multiplicity of water fluxes origins could be the reason of the larger time gap exposed on these sites.

Key words: Heat transfer model, conduction, convection, unsaturated flow model, critical zone.

Inventory and morpho-structural analysis of Deep Seated Gravitationel Slope Deformation in the Queyras sector

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Deep Seated Gravitational Slope Deformation (DSGSD) are defined as a set of rock masses characterized by generally slow movement and can affect all sides of a valley or a mountain range (*Agliardi et al., 2001, 2009 ; Panek et Klimes., 2016*). This deep instability is identified in many cases as the area of origin of other major natural hazards such as landslides: example of the La Clapière landslide in the Alpes Maritimes (BigotCormier et al., 2005). DSGSDs represent an important object that we must understand in order to anticipate any gravity hazards associated with them. Indeed, many factors that could be at the origin or controlling the evolution of DSGSD have been identified such as structural inheritance, climate or tectonic activity (*Agliardi 2000 ; 2009 ; 2013 ; Jomard 2006 ; Sanchez et al., 2009 ; Zorzi et al., 2013 ; Panek et Klimes., 2016 ; Ostermann et Sanders., 2017 ; Blondeau 2018*). The long-term and short-term evolution of DSGSDs is still poorly understood but represents an important point for predicting the level of risk of each of them. It is with the aim of better understanding the short term (<100 years) and long-term (> 100 years) evolution of DSGSDs in the French Alpine massifs and the link with the occurrence of landslides, that this project thesis is developed.

The main objective of this project is to propose models of evolution of the DSGSD defining keys of interpretations in order to understand the future evolution of deformations and to locate the zones likely to initiate other hazards. The Queyras study area in the French Alpine massifs was chosen because it represents an area of study gaps for the DSGSD. This zone also has the advantage of having a low lithological diversity making it possible to simplify the identification of the factors influencing the evolution of DSGSD. A geomorphological analysis on satellite and ground data is carried out to locate the DSGSDs and characterize their structure.

Thanks to photo-interpretation of satellite and aerial data, 30 DSGSDs have been identified in the Queyras sector. These 30 objects have been recognized by the use of a set of 6 morphologies commonly encountered in DSGSD and defined and synthesized by numerous authors (*Agliardi et al., 2001, 2009, 2013 ; Panek et Klimes., 2016 ; Crosta et al., 2013 ; Blondeau 2018 ; Zorzi et al., 2013 ; Sanchez et al., 2009 ; Gutiérrez-Santolalla et al., 2005 ; Hippolyte et al., 2006, 2009, 2012.*). On the other hand, a selection of 8 representative objects of the Queyras DSGSD was made for more precise cartographic, structural and deformation evolution studies. These are supplemented by data and observations from three field periods, the synthesis of which is being prepared.

Revisiting the 2015 Mw=8.3 Illapel Earthquake.

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Key Words: Megathrust earthquake, Chilean subduction zone, joint inversion.

The 2015 Mw=8.3 Illapel earthquake is one of the largest mega-thrust earthquakes that have been recorded in the Chilean subduction zone. Previous studies indicate a rupture propagation from the hypocenter to shallower parts of the fault, with a maximum slip varying from 10 to 16 meters. The amount of shallow slip differs dramatically between rupture models with some results showing almost no slip at the trench and other models with signicant slip at shallow depth. In this work, we revisit this event by combining a comprehensive dataset including continuous and survey GPS corrected for post-seismic and aftershock signals, ascending and descending InSAR images of the Sentinel-1A satellite, tsunami data along with high-rate GPS and doubly integrated strong-motion waveforms.

We follow a Bayesian approach, in which we obtain an ensemble of models, and not a unique solution. The kinematic inversion is done using the cascading capability of the AlTar algorithm, allowing us to rst get a static solution before integrating waveform data in a joint model. This approach relies on an error model incorporating measurement and prediction uncertainties. To account for modeling uncertainties of waveform data, we explore the possibility to compute prediction error covariance using a 1st order perturbation approach.

Preliminary kinematic models show a rupture with two main slip patches. Rupture times suggest that an encircling rupture is occurring in the vicinity of the deeper slip asperity as suggested by previous back projection results.

In-depth study of the onset of a major seismo-volcanic sequence: the 2018-2021 seismo-volcanic sequence, east of Mayotte, Comoros islands

Seismology, Seismo-volcanology, Seismic crisis monitoring

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On 10 May 2018, a seismic sequence began 50 km east of Mayotte, followed by a magnitude Mw 5.9 event on 15 May and intense underwater volcanic activity in the following months. Although Mayotte is the easternmost island of the Comoros volcanic archipelago (located in the northern Mozambique Channel, between Tanzania and Madagascar), these seismo-volcanic events were unexpected. Before February 2019 and the on- and off-shore instrumentation survey campaigns (within the framework of INSU-TELLUS, MAYOBS, REVOSIMA), the local seismic monitoring network was poor. Detection and localization of many events, associated to magma migration phases at the beginning of the crisis, were limited (Lemoine et al., 2020). Several stations from several international networks allowed to obtain a disposable monitoring network, before the ReVoSiMa installed better tools, in particular Ocean Bottom Seismometers, since the end of February 2019.

In 2018, we observed most of the cumulated seismic moment of the Mayotte crisis, and the formation of recent structures, including an 800 m high submarine volcano (Feuillet et al., 2021). We ought to better define the seismic and volcanic onset, well illustrated on the new catalog. A migration phase during first weeks (until June 2018, epicenters move south and east) preceded a phase of strong activity (01 to 09 June 2018) until the beginning of an unprecedented eruption (early July 2018, Lemoine et al., 2020). End of September 2018 marked the initiation of another swarm westward, still ongoing after three years (Saurel et al., 2021).

The catalog of events between May 2018 and February 2019 has been completed and reprocessed. We added data from unused regional onshore stations, hence improving the quality and quantity of events and their location. This catalog went from around 1000 events to almost 2900 seismic events localized and allows to better describing the unrest phases of the first months of this sequence.

Role of asperities on the transition from seismic to aseismic slip using an experimental fault slip system

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Abstract:

Faults are common geological structures distributed at various depths within the Earth with different behaviors: from seismic to aseismic. The frictional stability of faults is linked to the properties of asperities that make the contact between fault surfaces. Investigating the interaction between asperities and its link with the frictional stability of faults aims at a better understanding of the intrinsic relationships between the observations of earthquake swarms and the slow local aseismic transient. Here we propose an experimental approach, which allows a customized interface sliding slowly under a well-controlled normal load, to study this problem. This interface consists of asperities modeled by poly-methyl-methacrylate (PMMA) balls in a softer, polymer base representing the parts of the fault that are easily deformed, facing a transparent flat PMMA plate. We employ a high-resolution camera for in-situ optical monitoring of the local deformation of the interface while loaded. We also attach acoustic sensors to capture the dynamics events attesting to local dynamic ruptures. We connect our observations with a mechanical model derived from a high-precision topography of the customized interface. We investigate the effects of various internal parameters of natural fault systems, including the density and size of asperities, their rigidity or the contrast of rigidity compared to the base, on the evolution of the frictional stability under variable normal load and of the behavior of the population of asperities at the transition between seismic and aseismic slip. Our results, bring new observations on the mechanics of swarm and fault transient.

Keywords: asperity; aseismic; fault mechanics and physics

Sink vs. tilt penetration into shaken dry granular matter: the role of foundation

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(Dated: November 2021)

Abstract

We study the behavior of cylindrical objects as they sink into a dry granular bed fluidized due to lateral oscillations. Somewhat unexpectedly, we have found that, within a large range of lateral shaking powers, cylinders with flat bottoms sink vertically, while those with a "foundation" consisting in a shallow ring attached to their bottom, tilt besides sinking. The latter scenario seems to dominate independently from the nature of the foundation when strong enough lateral vibrations are applied. We are able to explain the observed behavior by quasi-2D numerical simulations, which also demonstrate the influence of the intruder's aspect ratio. The nature of the intruder's foundation and its aspect ratio act cooperatively to define the penetration dynamics. Our findings may shed light on the behavior of buildings and other man-made constructions during earthquakes.

Keywords: granular matter, fluidization, intruder penetration.

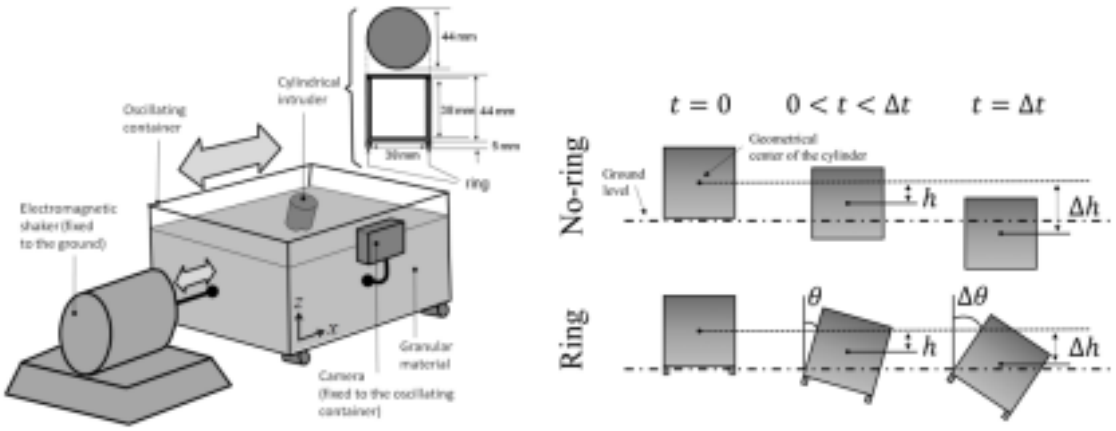

FIG. 1. Experimental setup (left). Sketch of sinking and tilting processes (right): The top row illustrates the sinking process of a No-ring cylinder in three moments during the experimental interval from $t = 0$ to a final time $t = \Delta t$. The bottom row shows the same temporal sequence for a Ring cylinder, which tilts in addition to sink. Corresponding author: alonso-llanes.laciel@etu.unistra.fr laciel.alonso@gmail.com

Cooking fake rocks in the laboratory: preparing “sandstones” with known microstructural attributes

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Regardless of their composition and microstructure, sandstones in the Earth’s crust are subject to a variety of geological processes and deformation mechanisms. However, microstructural attributes play a key role in the manner and extent to which sandstones react to these hydromechanical processes. Therefore, understanding the influence of microstructural geometries on the hydromechanical behaviour of sandstones is necessary to improve model predictions, which are routinely used in many aspects of geoscience and engineering. While studies using theoretical or experimental approaches have successfully provided a good understanding of the key control of microstructural parameters such as porosity on the hydromechanical properties of sandstones, the deconvolved influence of the multitude of microstructural parameters remains unclear. This is because, for natural rocks, differences in porosity are often accompanied by differences in other microstructural parameters, such as grain or pore size. Until now the study of the role of a specific microstructural attribute in isolation has relied heavily on numerical modelling, without the necessary experimental validation. To address this shortcoming, we created precisely controlled synthetic samples by sintering glass beads. The sintering process allow us to control porosity and grain size independently, so that we could deconvolve these microstructural parameters and parameterise specifically for their importance. Our results demonstrate that the hydraulic and mechanical behaviour of our synthetic samples is similar to that of natural sandstones. We were able to reproduce the typical failure modes of sandstones in our synthetic samples during compression tests: brittle failure at low confining pressure and the transition to a ductile failure mode at higher confining pressure, including the formation of compaction bands. Our study thus demonstrates the possibilities that lie in creating synthetic samples using sintering and opens new perspectives for unravelling the contribution of microstructural attributes on the mechanical and hydraulic properties of granular rocks such as sandstones.

Key words: synthetic rocks ; hydromechanical behaviour ; porosity ; grain size ; microstructural control

Numerical investigation on hydro-mechanical properties evolution of a fractured rock due to fracture closure

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Natural or artificial fluid flow in deep tight reservoirs like Enhanced Geothermal Systems (EGS) is dominantly controlled by open fractures which are the key elements of their hydraulic performance. One of the main limitations for flow along these fractures are the sealing deposits owing to mineral cementation that also strongly impact the mechanical behavior of the fracture. Here we study at the field scale, the influence of fracture closure on the permeability and the stiffness of a rough fracture using a well-established self-affine geometrical model of the fracture roughness. The fracture closure is assumed to be caused by two regimes: mechanical effect at low fracture contact area (<20%) and the sealing material at higher contact area (>20%). We develop a finite element model based on the MOOSE/GOLEM framework to account for hydro-poroelastic coupling and conduct numerical flow experiments of a granite reservoir hosting one single large and partially sealed fracture of size 256×256 m². Navier-Stokes flow is solved in the 3-dimensional rough fracture aperture, which is embedded in the poroelastic matrix. In order to mimic the impact of the fracture closure on the physical properties of the fracture rock system, we assume a plastic-rigid rheology for mechanical closure process. For sealing closure process, we sequentially increase the amount of the fracture-filling material in the rough fracture by changing the thickness of the sealing deposits. The evolution of the contact area, fracture permeability, and normal fracture stiffness is monitored during the whole closure. We show that fracture closure induces strong permeability anisotropy and significantly increases the fracture stiffness. Implications for chemical stimulation of fractured reservoir are discussed.

Finite-frequency Rayleigh-wave Backus-Gilbert tomography:

Toward a surface-wave tomographic model with full 3D resolution and uncertainties.

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Abstract

Tomography is a key tool to bring some observations from the Earth interior. However, since most tomographic problems deal with imperfect data converge and noisy data, tomographic images have uncertainties and variable spatial resolution – rarely known – rendering the interpretations complicated. In a previous study (Latallerie et al., in review) we built a model of shear-wave velocity in the Pacific upper-mantle using a Backus – Gilbert-type inversion from Rayleigh-wave data. This inversion provided the full model resolution and uncertainties information to make an enlightened interpretation of the model. However this model suffered from some limitations: forward ray therory (independent 2D layers i.e. no vertical resolution information, inversion in two steps including a non-linear inversion) and poor estimation of the data uncertainties (only assessed from multiple sampling of similar paths).

In this presentation, we introduce choices that we made to overcome the limits encountered in the previous study. We propose to use a finite frequency forward theory based on normal modes that relates linearly phase delays with the Rayleigh-wave velocity within the 3D upper-mantle. We propose som synthetic tests to estimate the data uncertainties due to the poor knowledge of the crust and the earthquake source.

With the improved resolution and uncertainties, we will have robust arguments to discuss the existence of predicted structures in the Pacific such as plume-like upwellings or small-scale sublithospheric convections. The vertical resolution will help to discuss the depth of some structures (e.g. depth location of small-scale sublithospheric convections, lithospheric depth).

Key-words: Seismic tomography, Inverse theory, Surface waves and free oscillations, Pacific Ocean.

Joint one-dimensional inversion of Magnetotelluric Data and Surface-Wave Dispersion Curves using Correspondence Maps

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We use a correspondence map approach to jointly invert surface-wave dispersion curves and magnetotelluric data for subsurface shear velocity and resistivity but also for a possible relationship between them. Our first experiments consisted of inversions of synthetic data computed from models linked by linear and second-order polynomial relationships. Our methodology produced joint inversion model-pairs (resistivity-shear velocity) from where 80% fitted the 'observed' parameter relationship within a 5% error vs only 1% of the separate inversion model-pairs for the linear relationship experiment. For the non-linear relationship synthetic test, 85% of the joint inversion model-pairs fitted the 'observed' relationship within a 5% error while just 4% of the separate inversion model-pairs. This reduced the number of acceptable models without compromising the data fit ('reduction of non uniqueness'). The next experiment involved synthetic data from models of known physical properties, taken from well logs, but without a known relationship. Our approach produced a model closer to the expected result than when separate inversions are used. Having validated the approach with synthetic cases, we applied our methodology to field data. We compared separate inversions and joint inversions using correspondence maps. We found that the 1D subsurface models obtained by joint inversion were more similar to reference models obtained using Bayesian approaches than separate inversion models.

Key words: joint inversion, magnetotelluric, ambient noise, correspondence maps

Assimilating remotely sensed data into a hydrological model

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Abstract:

Global climate change and anthropogenic impacts lead to alterations in the water cycle, water resource availability and the frequency and intensity of floods and droughts. As a result, developing effective techniques such as hydrological modeling is essential to monitor and predict water storage changes. However, inaccuracies and uncertainties in different aspects of modeling, due to simplification of meteorological physical processes, data limitations and inaccurate climate forcing data limit the reliability of hydrological models. Satellite remote sensing datasets, especially Terrestrial Water Storage (TWS) data which can be obtained from Gravity Recovery and Climate Experiment (GRACE), provide a new and valuable source of data which can augment our understanding of the hydrologic cycle. Merging these new observations with hydrological models can effectively enhance the model performance using advanced statistical and numerical methods, which is known as data assimilation. Assimilation of new observations constrain the dynamics of the model based on uncertainties associated with both model and data, which can introduce missing water storage signals e.g., anthropogenic and extreme climate change effects. Assimilation of GRACE TWS data into hydrological models is a challenging task as provision should be made for handling the errors and then merging them with hydrological models using efficient assimilation techniques.

Keywords: Water storage changes, Remote sensing, GRACE, Hydrological modeling Data assimilation

Robust numerical model for reactive-thermohaline convection of CO2 in brine saturated reservoir

***Keywords**:* Geological CO2 sequestration, Reactive thermohaline convection, Geothermal reservoir, Arrhenius equation

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Abstract:

Geological CO2 sequestration process (GCS) as a Reactive THermohaline Convection (RTHC) phenomenon takes place as a multi-physical and multiscale process. Therefore, the robustness and efficiency of the related developed models rely on the employment of advanced and updated numerical schemes. We developed a cutting-edge numerical model based on the combination of the mixed hybrid finite element method (MHFE) for groundwater flow and the discontinuous Galerkin finite element (DGFE) method for mass and heat transfer. Despite the capability of these schemes in improving the computational time while maintaining high accuracy they have never been applied to RTHC problems. The novelty of this work is the application of (MHFE) discretization for flow and (DGFE) discretization for advective and convective terms of mass and heat transfer to RTHC process. The advantage of the advanced developed model is then shown by comparison against a standard Finite Element model. In the second part, we investigate on the variable consideration of reaction rate as a function of temperature both in small scale and field scale. A sensitivity analysis on the activation energy of geochemical reactions has been performed. It has been shown that, in field scale and small scale the capacity of the reservoir is 6 percent overestimated by constant consideration of reaction rate in compare with fast reactive cases (low activation energy) The slow reactive case (high activation energy) is not showing an overestimation in small scale. However, in field scale a 2 percent overestimation is measured in the constant consideration of reaction rate in comparison with variable rate with high activation energy.

Laboratory and Field Scale Experiments to Trace Degradation and Reactive Transport of the Urban Biocide Terbutryn

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Biocides are used worldwide and systematically in construction materials such as render and paint on façades to prevent the growth of algae and fungi. These contaminants can leach from buildings into the urban environment during wind-driven rain, eventually contaminating urban groundwater. Knowledge of degradation kinetics, degradation pathways and potential accumulation of urban biocides in the environment is rare. Here, we carried out reference abiotic hydrolysis, photodegradation and biodegradation experiments to examine kinetics and pathways of dissipation of the triazine biocide terbutryn from facades to surrounding soil. We compare degradation kinetic constants, follow-up the stable isotopic signatures based on Carbon ($\delta^{13}C$) and Nitrogen ($\delta^{15}N$) isotopes and follow the formation of transformation products. Furthermore, we investigate biocide leaching and reactive transport in outdoor artificial facades and lysimeters exposed to environmental conditions. Photodegradation rates under simulated sunlight range from $t_{1/2}$ = 69 ± 12 h to $t_{1/2}$ = 164 ± 50 h (indirect photodegradation in presence of NO_3/ direct photodegradation in pure water, respectively). Biodegradation rates in soil and the sediment-water interface are rather low ($t_{1/2}$ > 200 days), indicating that terbutryn may biodegrade slowly. Evaluated $\Delta C/N$ range from $\Delta C/N$ = -0.99 ± 0.04 for abiotic hydrolysis at pH 1 to $\Delta C/N$ = -2.78 ± 0.4 for photodegradation under UV light, allowing to differentiate degradation pathways. Field scale experiments show the formation and release of transformation products of terbutryn. However, isotope data supports the hypothesis that only a small fraction of terbutryn is degraded under environmental conditions. Our study presents lab-scale experiments to follow urban biocide degradation in the environment and shows the applicability of CSIA to study terbutryn transport in the urban environment. The obtained data can be used in the future to monitor contaminated sites, support model development to predict reactive transport and trace degradation pathways of urban biocides in the environment.

Keywords: Urban biocides, Compound-Specific Isotope Analysis, Multi-element CSIA, degradation, reactive transport

Groundwater table dynamics affect dichloromethane biodegradation: an integrative experimental and modeling approach

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Water table fluctuations have important implications at contaminated aquifers. During biological degradation of organic pollutants, subsurface microorganisms are exposed to the redistribution of electron acceptors (e.g., O_2) and donors (e.g., organic contaminants) as a result of groundwater table dynamics. The response of the bacterial community to hydrochemical variations may affect pollutant degradation extent and pathways. We examined the reactive transport of dichloromethane (DCM), a common volatile halogenated compound, in two-lab-scale aquifers with inner dimensions of 160 cm × 80 cm × 7 cm (length × height × width) and fed with groundwater from a well-characterized industrial site contaminated with halogenated solvents. Fluctuations of the water table were induced in one aquifer (fluctuating condition), while the second aquifer remained under steady-state conditions. High-resolution monitoring of DCM concentrations and stable isotope ratios (i.e.,$^{13}C/^{12}C$ and $^{37}Cl/^{35}Cl$), hydrochemical variations and bacterial diversity was carried out throughout the experiment (150 days). Reducing conditions were observed in both aquifers with O_2-depleted concentrations established in the saturated zone and increasing Fe^{2+} concentrations along the flow path. Higher DCM mass removal (95%) was observed under fluctuating conditions compared to steady-state (42%). Bacterial populations were associated to O_2 gradients and distance from the aquifer inflows. Water table fluctuations increased the relative abundance of potentially associated DCM-degraders (*Peptococcaceae* family). Distinct anaerobic DCM degradation pathways were suggested based on dual C-Cl isotope plots under steady-state ($\Lambda^{C/Cl}$ = 1.92 ± 0.30) and fluctuating conditions ($\Lambda^{C/Cl}$ = 3.58 ± 0.42), respectively. A reactive transport model was implemented integrating dual-element CSIA, bacterial processes in aquifers, and dynamics in redox conditions. Four distinct bacterial populations potentially associated with distinct DCM degradation pathways are currently modelled according to pathway-specific reaction rates and isotope fractionation. Simulations of the contribution of multiple degradation pathways under dynamic hydrogeological conditions will allow to better assess contaminated sites and study the response of bacterial community associated with pollutant degradation.

Adverse Birth Outcomes Related to NO2 and PM Exposure

Valentin SIMONCIC, my thesis takes place in LIVE, Laboratoire Image Ville Environnement (UMR7362-CNRS) of the University of Strasbourg. My thesis directors are Christophe Enaux and Wahida Kihal.

There is a growing number of international studies on the association between ambient air pollution and adverse pregnancy outcomes. Our work try to assess association between maternal exposure during various windows of exposure during pregnancy to nitrogen dioxide (NO2) or particular matter (PM) and the risk of adverse birth outcomes, including low birth weight (LBW) and preterm birth (PTB). The exposure assessment will take into account the daily mobility of pregnant women. In another hand, this work try to assess variation in exposure depending on different socio-economic profile. For this purpose, we work with Amo Grand-Est and University hospitals of Strasbourg to create a cohort of pregnant women. The survey protocols were developing with Mme Hamann who work on the same cohort (PhD student).

The inclusion of pregnant women start on January 2021 and will end on December 2021. Currently I work on a protocol article focusing the cohort recruitment. I also work on a package article, which describe the package who assess the women daily mobility itinerary.

In this presentation I will describe a systematic revue published on 22 September 2020 in the International Journal of Environmental Research and Public Health. I work on this paper with Christophe Enaux, Wahida Kihal and Severine Deguen. This study has been conducted focusing on European countries, to assess the crucial public health issue of this suspected association on this geographical area. A systematic literature search has been performed on all European epidemiological studies published up until 1 April 2020, on the association between maternal exposure during pregnancy to NO2 or PM and the risk of adverse birth outcomes, including LBW and PTB. Fourteen articles were included in the systematic review and nine of them were included in the meta-analysis. Our meta-analysis was conducted for 2 combinations of NO2 exposure related to birth weight and PTB. Our systematic review revealed that risk of LBW increases with the increase of air pollution exposure during the whole pregnancy. Our meta-analysis found that birth weight decreases with NO2 increase (pooled beta = −13.63, 95% confidence interval (CI) (−28.03, 0.77)) and the risk of PTB increase for 10 μg/m3 increase in NO2 (pooled odds ratio (OR) = 1.07, 95% CI (0.90, 1.28)). However, the results were not statistically significant. Our finding supports the main international results, suggesting that increased air pollution exposure during pregnancy might contribute to adverse birth outcomes, especially LBW. This analysis of limitations of the current body of research could be used as a baseline for further studies and may serve as basis for reflection for research agenda improvements.

Keywords: systematic review; meta-analysis; low birth weight; preterm birth; air pollution

Evaluation of strategies toward an effective and sustainable energy transition for Cuba

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Abstract:
Worldwide energy supply is currently dominated by fossil fuels, dependency on these resources is associated with air quality, energy security, and sustainability issues. To reduce this dependency the transition to renewable energy sources (RES) is necessary. Here we analyze different scenarios regarding energy transition on sustainability, environmental, and economic aspects through a set of indicators. To do this the case of Cuba is interesting 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. The designed scenarios are based on an energy demand projection up to 2030 and RES introduction without the installation of new energy storage facilities. These scenarios consider the introduction of solar and wind (intermittent energy sources) as a percentage of the electricity demand (25% and 50%). The results show that fossil fuels imports are reduced to zero with the introduction of intermittent energy sources of 25%. The introduction of intermittent has positive effects on air quality. The higher economy is achieved when the indicators total annual costs (TAC) and levelised costs of energy (LCOE) are reduced due to the retrenchment of fossil fuel consumption, and more importantly, with the reduction of imported primary resources. The replacement of the thermal engine-based fleet by electric vehicles (EVs) is also analyzed based on the availability of local resources and alternative scenarios.

Keywords: scenarios; decision making; energy policy; renewable energy sources

II. Poster Presentations

The Study of the Early Pliocene Reservoir Western South-Caspian Basin, Azerbaijan

Abstract

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Research area located in the central part of the Eurasia continent in the Caspian Sea. The main hydrocarbon-bearing reservoirs of Azerbaijan are entrapped in the early Pliocene sedimentary complex. The early Pliocene sediments, also called a Productive Series, formed during 5,5 - 3,2 Ma in an isolated from the global ocean South Caspian Basin - a relict of the Paleo-Tethys Ocean. The Productive Series is distributed in the South Caspian Basin, the Absheron peninsula and adjacent offshore regions.

According to studies (Reynolds, 1998; Hinds 2001, 2004; Kroonenberg, 2005; Green, 2009) the tectonic, and to a greater impact, the climatic changes during the Early Pliocene led to the development of a fluvial discharge system delivering to the South Caspian Basin a great volume of the sedimentary material. The fluvial system is present by Paleo Volga, Paleo Kura, Paleo Amu-Darya and numerous small rivers.

The initial research result identified facies dominated during deposition of the Productive Series and we were able to reconstruct the fluvial-deltaic system that existed during the Early Pliocene. Research is based on the following database:

-Balakhany-Sabunchi-Ramana field (northeast of the Absheron OGR) - 117 wells,

-Garadag field (the southwestern end of the onshore part of the Absheron OGR)-87 wells and

-Bahar field (southern offshore zone of the Absheron OGR) - 184 wells

-Seismic cross-sections - 19 lines

-Digital core data - 32 samples

Research objectives:

-Evaluate fluvial response to the climate change during early Pliocene, on the Western South Caspian Basin, Azerbaijan

-Reconstruct depositional environment of the early Pliocene based on the core and seismic data

-Create a 3D facies model of the early Pliocene sediments to reconstruct detailed reservoir architecture

Magmatism at rifted margins: oceanization trigger?

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Keywords: magma-poor rifted margin, refertilization, partial melting, mantle-melt interaction

Although magmatic processes are of primary importance for the understanding of lithospheric breakup linking the transition from rifting to seafloor spreading, many first order questions remain, such as: how, when, where and how much magma is produced during final rifting; what are the conditions and controlling processes of magma production; how does magma percolate and interact with the overlying mantle; and how and when does magma focus and how is it extracted and how does it interact with the extensional processes operating during breakup? Answering to these questions is a prerequisite to understand lithospheric breakup and formation of a new plate boundary, which is among the least understood plate tectonic processes at present.

In this study we present preliminary results on the highly valuable and recently acquired sample set from the SW Australian ocean-continent transition (OCT) zone. Our petrological investigations focus on pyroxene and spinel compositionsin peridotites exhumed along the OCT with the aim to identify mantle domains (i.e., inherited subcontinental, refertilized or oceanic mantle domains; Picazo et al., 2016) and track evidence of melt infiltration and mantle-melt reactions.

The chemical composition of clinopyroxenes show two distinct populations: some clinopyroxenes are characterized by low $(Sm/Yb)_N$ ratios and no Eu anomalies, while others show interstitial textures and flat HREE patterns with a deep negative Eu anomaly. In addition, equilibrium temperatures calculated on the two pyroxenes show that the first population of clinopyroxenes was equilibrated at lower temperatures (900°C +/- 30°C) than those of the second populations (1100°C +/- 100°C). We assume that the first population of clinopyroxenes corresponds to primary minerals of the subcontinental mantle equilibrated at depth in the garnet stability field. The second population of clinopyroxenes corresponds to MORB-type melts entrapped at low pressure (~5kbar) in the plagioclase stability field in the ascending peridotite. The exhumation path of these subcontinental mantle peridotites is similar to those observed in refertilized peridotites (Type 2 of Picazo et al. 2016) described from present Iberia and the fossil Alpine Tethys OCT.

Additional investigations, particularly on the nature of magmas and their mantle sources will be done during the Ph.D. thesis. The results will provide parameters and conceptual understanding of magmatic systems that are fundamental to develop innovative numerical/dynamic models of lithospheric breakup.

Micropollutants (bio)dissipation at the sediment-water interface: a microcosm setup approach.

Adrien Borreca

Supervisors: G.IMFELD ITES; S.VUILLEUMIER GMGM.

Emerging contaminants in surface waters raise concerns regarding human and environmental exposure. Such chemicals are found in the environment at low concentrations (ng/L), and thus also called micropollutants. Among them, pharmaceuticals (*e.g.* metformin) and biocides (*e.g.* *(S)*-metolachlor & terbutryn) reach surface waters due to inefficient water treatment or leaching. Following this, at the sediment-water interface, micropollutants face different dissipation processes that can be either biotic or abiotic. We have started to investigate the fate of these 3 micropollutants and their microbial acclimation in dedicated sterile and non-sterile microcosm set-ups. Our project applies novel investigation methods in an interdisciplinary framework based on analytical chemistry and molecular biology. Some preliminary results and perspectives will be presented.

Keywords: *micropollutants; sediment-water interface; microbial acclimation; interdisciplinary research; pharmaceuticals*

Marine to continental transition sequence of a paleo ice-front, the case of the Pentecôte fan (Québec North Shore – Canada)

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Paleogeographic reconstruction of the marine to continental transition of the Laurentide Ice Sheet (LIS) margin is now facilitated by LiDAR and swath bathymetric mapping of the successive stabilization/readvance of the ice front. However, defining the deglaciation sequence at the margin of the ice sheet during this rapid transition from sea to land still remains a challenge. The analysis of the depositional ice-marginal complexes constructed during this transition can provide a record of the different positions reached by the retreating ice margin, but also of punctual events (i.e., proglacial lake outburst, seasonality, and sedimentation rates) related to the reorganisation of the ice sheet and its margin. Here we report and describe a proglacial submarine fan system overlain by paraglacial deposits that developed during the early Holocene in the Pentecôte River area on the Québec North Shore (Eastern Canada) in a context of relative sea-level fall during the northwestward retreat of the LIS. The fan consists of several stratigraphic units showing different phases of stabilisation/re-advance of the ice margin and punctual events. These results allow refining the history of the ice front retreating sequence in this area and may facilitate the correlation of this type of depositional system with the mapping of older stabilization positions at sea and more recent inland, providing a geological record of the transition between a marine- to a continental-based ice margin.

Keywords: deglaciation sequence, sedimentology, Holocene, Québec North Shore.

Contribution of high and very high spatial resolution satellite images for monitoring urban sprawl and characterizing urban fabrics

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Abstract

Since 1970 Algeria has been noted by significant urban sprawl expressed by an urban evolution that differs from classic urbanization due to rapid and uncontrolled population growth. The general issue relates to urban sprawl and the evaluation of its impact in terms of land use change. The two main research questions are (1) the study of land use evolution and land cover in order to analyze urban sprawl at different spatial scales, and (2) the cartography and the informal housing dynamics.

This work raises the question of the data and methods to be mobilized in order to (1) have multi-scale maps of the urban space and (2) to characterize the changes and provide useful information in the development of planning and regional plannings documents. In this work, the ALSAT-2 remote sensing images constitute the privileged source of information (10m spatial resolution in multispectral mode and 2.5m in Panchromatic mode).

To answer the first research question, different supervised learning methods using a pixel approach were tested in the city of Oran. The optimal method in terms of the classification accuracy rate is applied to the 2011 image and validated on a second city. The results are quantitatively evaluated by cross validation and confusion matrix.

An analysis of the dynamics changes in land use patterns between 2011 and 2018 is carried out through the calculation of landscape indices and a transition matrix. This analysis showed that the urban class experienced a growth rate of 20% between 2011 and 2018, particularly in the eastern sectors of Oran city. In order to show the genericity of the method and to check whether these evolutionary trends are identical, the methodology is being applied to the city of Tlemcen, a large city located in the North-West of Algeria.

KEYWORDS: LAND USE, HIGH SPATIAL RESOLUTION, SUPERVISED CLASSIFICATION, ALSAT-2A.

Environmental DNA for monitoring aquatic plants and as an environmental indicator

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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 : environmental DNA, metabarcoding, aquatic plants, monitoring

Induced micro-seismicity monitoring in urban context using seismic arrays

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Fluid injections in deep geothermal reservoirs can generate seismic motions. Their monitoring is a key point to limit the occurrence of impacting events. Generally, this is performed using seismic surface networks, which can be limited by a significant ambient noise level in particular in urban contexts. To reduce the impact of surface noise, a classical approach consists in the installation of borehole stations in the shallow wells. An alternative approach is to operate dense seismic arrays, combined with appropriate data processing, to limit the impact of ambient surface noise. Here we investigate the case of the "Strasbourg induced earthquake sequence", occurring since mid-2018 around the Geoven deep geothermal doublet operated by the Fonroche company in Vendenheim (France). So far, the Bcsf-Rénass (French national observatory service in charge of the seismicity monitoring in France) has recorded 567 induced earthquakes using classical surface local and regional seismic networks. Their catalogue has a magnitude of completeness of Mc=0.6, containing event with a local magnitude (Mlv) up to 3.9, including 22 with Mlv>2 and 4 with Mlv>3. These events are organized into two distinct clusters: a first cluster in the vicinity of the Geoven wells and a second one 4-5km South from it. Although the project has been forced to stop because of the felt induced seismicity, the Northern cluster is still active, with the largest event occurring on the 26th of June 2021. To improve our knowledge of this seismic crisis, we deployed 3 mini seismic arrays of 21 SmartSolo nodes each around the active cluster, recording at a sampling rate of 1000Hz for 4 months starting a few days after the Mlv=3.6 event of 4th of December 2020. The aperture of each array is around 70m, providing a high resolution acquisition in the frequency range of interest for these local seismic events. Beamforming and match field processing techniques allow us to characterize the local ambient noise, which consists mostly in surface waves with slow apparent velocities. As the arrays are located roughly on the top of induced seismic events hypocenters, the front waves illuminate the arrays with a significantly higher apparent velocity. Therefore, stacking the waveforms increases significantly the SNR. We improve it even more by considering the signal instantaneous phase coherency as a parameter during the stacking process, what is called phase-weighted stacking. This allows us to detect events down to magnitude -0.5, which leaves us with 4 to 5 times more events than the BCSF-Rénass catalogue. In parallel, we also investigate how much these arrays can improve event location as a complement to traditional networks.

***Keywords**:* Induced seismicity, micro-seismicity detection, deep geothermal energy, urban context

Measuring ^{10}Be concentrations in stream sediments from the Vosges Mountains (NE France) to explore the respective role of lithologic, topographic and climatic control on massif-wide denudation

Keywords: massif-wide denudation, cosmogenic nuclides, lithology, climate

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Supervisors: Gilles Rixhon & Laurent Schmitt

The Vosges Mountains in NE France belong to the belt of Variscan massifs. This range of low mountains presents three contrasting primary characteristics. Firstly, a bipartite N-S subdivision based on the geological basement: the southern part (crystalline Vosges) composed of Palaeozoic, metamorphic and sedimentary rocks and the northern part (sandstone Vosges) being much more homogeneous given its Triassic sandstone cover. Secondly, a clear E-W topographic gradient characterised by steep hillslopes on the eastern side (Alsace) in contrast to gently-sloping hillslopes on the western side (Lorraine). Finally, the imprint left by Quaternary climatic fluctuations yielded a N-S gradient: whereas the crystalline Vosges hosted abundant valley glaciers, the sandstone Vosges was void of ice cover.

Against these advantageous characteristics, this contribution aims to present the first data of long term massif-wide denudation at the massif-scale and to explore the long-term interactions between denudation, lithological control, morphometry and climatic forcing. This is especially relevant as long-term landscape evolution in the Variscan belt has been regularly disregarded in recent geomorphological studies. Modern stream sediments from 21 river catchments draining the whole massif were sampled for *in situ* ^{10}Be concentration measurements at the outlet of their mountainous reach. Catchment-wide denudation rates were inferred from cosmogenic ^{10}Be concentrations. The mean Channel Steepness Index (k_{sn}) was computed as a morphometric "predictor" of denudation rates. Groups of lithologically uniform catchments were statistically identified. We finally test the relationship between denudation, steepness, precipitations and lithology.

At the massif scale, results show (1) no apparent relation between denudation and steepness, (2) a relation between denudation and precipitations, (3) a clear lithologic control on the relation steepness/denudation and (4) a possible control of the Quaternary glaciations on denudation. Further investigations are required to better understand the respective role played by these controlling factors on long-term denudation.

Impact of topography on potential evapotranspiration

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Hydrological models use climatic forcing to simulate water flow and aquifer-river exchanges. Climatic forcing can be extracted from SAFRAN database, but the estimation of potential evapotranspiration requires models that use, solar radiation, albedo, temperature... Some parameters can be easily retrieved from the database, but others, like solar radiation, are more difficult to estimate. Formulas exits to estimate the average radiation at the scale of a SAFRAN mesh, but they do not consider the topography, 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.

R.sun model is used to compute the interaction between solar radiation and the atmosphere. Thus, the model calculates the 3 components of global radiation: direct, diffuse, reflected; for clear sky conditions. The model considers the local relief to estimate the sky obstruction in mountainous areas for example. Albedo has been estimated using the Corine Land Cover database which provides information on land use and tables from the bibliography. Finally, r.sun gives the global sunshine over a day in any point of the studied area.

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. 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.

The next step of this work is to take care of the temperature variation within a watershed before the hydrological model calibration.

Estimation of tectonic velocity displacements of thrust rupture using SAR interferometry: The 1980 EL-Asnam earthquake (Mw 7.1, Algeria) case study

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The Tell Atlas (Northern Algeria) is characterized by shallow seismicity that results from the oblique convergence of the African and Eurasian plates. In this work, we focus on the study of post-seismic surface deformation across El-Asnam thrust fault, the site of the strongest 20th century earthquakes (Mw 7.1 in 10 October 1980) in northern Algeria and the western Mediterranean region. The area is characterized by the NE SW trending reverse fault with ±40 km long co-seismic surface rupture and 10 km hypocenter depth.

The active deformation is contrained using multiple SAR image acquisitions for time series analysis and interferometric data that leave access to surface slip down to few millimeters accuracy. The objective of PSInSAR method is to map ground deformation in this area, using time-series analysis of all available 26 years of continuous observations of SAR images (i.e., ERS1 and 2, ENVISAT, and Sentinel 1A and B) from 1995 to 2021. In our work, we exploit all historical SAR imagery which documents more than 40 years of active deformation following the large 1980 shock. We show that a surface deformation reaching 1 mm/yr is ongoing across the El Asnam fault and can be correlated to the postseismic tectonic activity that affect the Tell Atlas. The results of the time series analysis reveal that a large area is subsiding SE of the fault while the NW hanging block undergo uplift. The deformation rate is a portion of the total 2 to 4 mm/yr convergence across the Tell Atlas, in agreement with GPS results.

Petrological and geochemical evolution of Permian magmatism in the Central Alps (SE Switzerland, N Italy)

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Keywords : Central Alps, magmatic system, thermodynamic modelling, crystallization, geochemical

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 the differentiation of intracontinental magmatic systems remains a major challenge.

These processes can either involve magmas and their crystallization products (fractional crystallization, reactive melt flow...) or involve crustal contamination through various vectors (bulk assimilation, reactive assimilation, host-rock partial melting...). Whereas the influence of some of these processes can be presumed by field evidence, this needs to be constrained and quantified. This issue can be addressed in the Central Alps (N Italy, SE Switzerland), where a complete, crustal-scale post-Variscan (Permian) magmatic system has been documented from the Moho to the surface from lower crustal (Braccia gabbro, Malenco unit) and mid-crustal intrusives (Sondalo gabbro, Campo unit) to upper crustal intrusives and extrusives (Bernina unit). To estimate the role of the various processes, we combine field work to petrological and geochemical characterization and modelling.

Bulk rock composition shows a complete differentiation trend from primitive intrusive mafic rocks (Ol gabbro and gabbro with 45-55 wt.% SiO_2 and Mg#: 50-90), intermediate intrusive rocks (gabbro-diorite to granodiorite; 50-70 wt.% SiO_2; Mg#: 35-70), and felsic intrusive and extrusive rocks (granite and rhyolite with 70-85 wt.% SiO_2; Mg#: 0-50). Bulk compositions indicate that magmatic rocks form a composite between tholeiitic and calc-alkaline series that differs from typical differentiation trends, and the low abundance of olivine, even for the most primitive rocks indicates that before reaching the lower crust, magma was already fractionated during its ascent through the mantle.

We are first interested in fractional crystallization since this process is fundamental to explain magmatic differentiation in the first place. And so, here, we explore the role of equilibrium and fractional crystallization by applying thermodynamic modelling calibrated for appropriate melts composition using Rhyolite-MELTS v.1.0.2. We first control the composition of the parental liquid by comparing the natural bulk rock dataset with the liquid line of descent for a tholeiitic Ol-bearing basalt at various pressure (from 2GPa to 1atm). In a second stage, we estimate the liquid line of descent of the parental liquid from 1 GPa to 1 atm, for both equilibrium and fractional crystallizations. Our preliminary results show that the observed diversity of natural bulk rock composition cannot be attributed to fractional crystallization alone, and a strong crustal contamination is required, likely occurring at middle-crust levels. The extent of this contamination and its vector remains however to be explored.

Analysis of the 2017 Valparaiso earthquake sequence

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One of the key questions in fault mechanics is how do earthquakes begin ? This is central to our understanding of earthquakes, including the long controversial issue of their predictability. Earthquakes preceding large events are commonly referred to as foreshocks. They are often considered as precursory phenomena reflecting a nucleation process of the main rupture potentially driven by an underlying slow preslip. On the other hand, some studies suggest that foreshock sequences may only be explained by cascades of triggered events. In this work, we choose to test the cascading hypothesis against the foreshock seismicity observed during a previously reported slow slip event preceding the 2017 Mw=6.9 Valparaiso earthquake. We build a very complete 5 years long earthquake catalog of the sequence using refine detection and location algorithms. We test the detected seismicity against the Epidemic Type Aftershock Sequences model. We identify time windows with anomalously high seismic activity compared to what is expected by the typical earthquake interactions. We analyse statistically these anomalies over 5 years to understand if the Mw=6.9 foreshock sequence presents a specific anomalous activity. In addition, using a hierarchical clustering method, we identify earthquakes with similar waveforms to evidence any repeating ruptures. We analyse the time distribution of these clusters over 5 years to understand if unusual rates of repeating events emerge during foreshock time ranges. The conjoint analysis of seismicity rate anomalies and repeating events along with the results of previous pre-slip studies allows to accurately describe the nucleation process and evolution of the 2017 Valparaiso earthquake sequence.

Key-words: Seismicity detection, Earthquakes nucleation and triggering, Mainshocks, Aftershocks.

Impact of irrigation with treated textile effluents on agricultural soils and a forage crop (*Sesbania bispinosa*)

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The arid climatic conditions in the majority of Mediterranean countries, the growing demography and the important needs in water for agriculture and industry, imply an increasing water demand, particularly in Tunisia suffering from water resources scarcity, their poor quality and their unequal distribution within the country. Hence, to overcome this lack of water, adoption of non-conventional water resources in irrigation as alternative resources has given an interest. Treated wastewater released by textile industry is one of these alternative resources. A large number of treatment processes have been developed to treat textile effluents and to meet, then, standards for irrigation purpose. However, few studies have been interested in the impact of irrigation with treated effluents provided by textile dyeing plants, on soils and plants.

The main objective of this thesis is to evaluate the effect of a continuous irrigation with the treated textile effluents on the biological and physicochemical quality of a local Tunisian soil and on a forage plant *Sesbania bispinosa*. The conduct this work, secondary effluents from a Tunisian textile factory have been subject to different membrane processes (Ultrafiltration, Nanofiltration and reverse osmosis) in order to reach, in force, the Tunisian standards for irrigation purposes. The impact of irrigation with this non-conventional water quality on the soil and plant will be assessed through a physicochemical and microbiological characterization of the soil, a monitoring of the *Sesbania* growth parameters and its mineral composition and a genotoxicity evaluation of the treated effluents.

Key words: Genotoxicity, Textile effluents, Treatment processes, *Sesbania,* Soil characterization.

Elementary and isotopic characterization of calcium adsorption on Pseudomonas aeruginosa and Bacillus subtilis.

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Abstract:

Bacteria are a key component of the critical zone, because of their role in the nutriment availability for the vegetation. Therefore, the direct role of bacteria on the Ca stockage/leaching in soils is still little known, while it is an essential macronutrient to the vegetation growth. Recent years, the Ca stable isotopes have shown their potential in the understanding of 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 should now be to verify if the incorporation/adsorption of Ca in/on soil bacteria also induces such isotopic fractionation. In this purpose, we have characterized the calcium adsorption on ubiquitous species in natural soils: *Pseudomonas aeruginosa*, a Gram-negative bacteria, and *Bacillus subtilis*, a Gram-positive bacteria. Batch experimentations have been realized with variations of pH, calcium concentration and interaction times between bacteria and Ca solution. However, even if Ca is adsorbed on the two kinds of bacteria, there is no observable isotopic fractionation. We also have separated bacterial cell
compartments of *P. aeruginosa* to identify more specifically where Ca is localized after 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 than Ca is mainly stocked in the bacterial wall compartments. More specifically, Ca is mainly adsorbed on peptidoglycan and outer membrane but also largely stocked in the periplasmic liquid. These results could suggest than, the stockage of Ca in soil bacteria doesn't lead to a significative isotopic fractionation and that the influence of bacteria in soils only consists in their effects on Ca bioavailability.

Keywords: *Bacillus subtilis*, *Pseudomonas aeruginosa*, calcium, isotopes, adsorption.

The Eocene-Oligocene Transition: A major global climate shift and its record in the Upper Rhine Graben

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Keywords: Sedimentology, Paleoclimate, Continental Environments, Cyclostratigraphy, European Cenozoic Rift System

The Eocene-Oligocene Transition (EOT) marks a turning point from the Eocene greenhouse paleoclimate to near-modern icehouse conditions. This ~790 kyr interval is associated with major shifts in geochemical and sedimentological proxies, biological extinctions, and evolutionary turnovers, in both the marine and continental realms. These archives provide strong evidence for rapid global cooling, reorganization of oceanic currents, and for the onset of a continental-scale icesheet over Antarctica. The main causes invoked for this major global event are the decrease of greenhouse gases concentrations in the atmosphere and the opening of the Southern Ocean gateways, which could have led to the thermal isolation of Antarctica through the onset of the Antarctic Circumpolar Current. The EOT holds keys to the better understanding of Earth's climate, its interactions with ice-masses, greenhouse gases, and climatic thresholds. The Upper Rhine Graben (URG), a complex intra continental rift in the center of the European Cenozoic Rift System, contains syn-rift sediments dating back to the Lutetian. It provides a great window of investigation into late Eocene to Oligocene times in western Europe, and as such a great opportunity to investigate the impact of the EOT on continental landscapes, depositional environments, and ecosystems. Previous studies of the sedimentary infill of the URG allow a broad view into the evolution of climate through the various geological formations and sub-basins of the URG, but the EOT has not yet been directly investigated in this large continental sedimentary basin. This poster will provide an overview of the subject and show the preliminary results of the ongoing investigations.