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# CONGRÈS

# DES DOCTORANTS

# 2018

## LIVRET DES ABSTRACTS

## BOOKLET OF ABSTRACTS

## SCIENCES DE LA TERRE ET DE L'ENVIRONNEMENT

COLLÈGE DOCTORAL EUROPÉEN  
46 BOULEVARD DE LA VICTOIRE,  
STRASBOURG

<http://eost.u-strasbourg.fr/stue/>



# PROGRAMME DE LA JOURNÉE

## SCHEDULE OF THE DAY

### 8:45 ACCUEIL - PETIT DÉJEUNER / REGISTRATION - BREAKFAST

### 9:00 MOT D'OUVERTURE / OPENING SPEECH

Jérôme van der Woerd  
(ED 413 Directeur)

9:15 How much crust matters in global seismology

Frédéric Dubois  
(IPGS)

9:30 Inheritance and magmatic processes as the main controls of the evolution of a polyphase rift system: the example of the Mozambique Channel

Simon Tomasi  
(IPGS)

9:45 Study of the Upper Rhine Graben sedimentary cover. Focus on the understanding of the cover–basement transition, a potential geothermal resource?

Coralie Aichholzer  
(IPGS)

10:00 Loess, alluvial terraces and fans in the south-western part of the Upper Rhine Graben: geomorphology and chronology during the Upper Pleistocene

Patrice Wuscher  
(LIVE)

10:15 Microgravity monitoring of Soultz-sous-Forêts and Rittershoffen geothermal reservoirs (Alsace, France)

Nolwenn Portier  
(IPGS)

### 10:30 PAUSE CAFÉ / COFFEE BREAK

11:00 Characterization of groundwater circulation flow in the Strengbach catchment (Vosges Mountain, France): Implication of the CFCs and <sup>4</sup>He dating

Coralie Ranchoux  
(LHyGeS)

11:15 A finite volume method to simulate flow within an explicit fracture network associated with dual porosity

Damien Jacob  
(LHyGeS)

11:30 What can we learn on mineral dissolution from Kinetics Monte Carlo models?

Arnaud Bouissonnié  
(LHyGeS)

11:45 Influence of plant protection products on small streams

Andreas Scharmüller  
(LHyGeS)

12:00 Fate factor of engineered TiO<sub>2</sub> nanoparticles in aquatic and terrestrial natural environments

Aurélie Schulz  
(LHyGeS)

### 12:15 BUFFET - POSTER / LUNCH - POSTER

13:30 Monitoring of natural gas storage in salt caverns using SAR interferometry

Eric Henrion  
(IPGS)

13:45 Mining subsidence detection by remote measurements over the MDP and mining void modelling

Guillaume Modeste  
(IPGS)

14:00 Assessing the soil temperature and moisture dynamics in a Mediterranean slope: an application of fiber optic DTS

Kusnahadi Susanto  
(IPGS)

14:15 Effects of different Earth's structures on W-phase CMT parameters

Catalina Morales-Yañez  
(IPGS)

### 14:30 PAUSE CAFÉ / COFFEE BREAK

15:00 Formalization and parameterization of reservoir models and associated uncertainties for resource evaluation and model calibration

Jean-Baptiste Mathieu  
(LHyGeS)

15:15 Nutrient behaviour in soils located in decline forest (Strengbach catchment, Vosges Mountain, NE France): development of a new experimental approach

Matthias Oursin  
(LHyGeS)

15:30 How avalanches can be hot: induced thermal effects in the propagation of cracks

Tom Vincent-Dospital  
(IPGS)

15:45 The coupling between compaction and pressurization in cyclically sheared drained granular layers: implications for soil liquefaction

Shahar Ben Zeev  
(IPGS)

### 16:00 CLÔTURE - REMISE DES PRIX / CLOSING - AWARDS



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# How much crust matters in global seismology

F. Dubois<sup>1</sup>, S. Lambotte<sup>1</sup>, C. Zaroli<sup>1</sup>, L. Rivera<sup>1</sup>

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Body-wave seismic tomography allows detecting seismic heterogeneities into the Earth's interior induced by potential thermal and/or chemical anomalies. For several years, body-wave measurement methods in seismology evolve from first onset picking to time-residual estimation by cross-correlation. Now the cross-correlation is widely used to estimate the time-shift between two waveforms in ray-theory (RT) as well as in finite-frequency (FF) tomography. Cross-correlation operator estimates the similarity between two different waveforms, such as between a synthetic seismogram and an observed seismogram at different time-lags. So every elements disturbing waveforms is going to influence the cross-correlation function. The crust is probably one of the most heterogeneous parts of Earth and all waves have to cross the crust (at least once) to be recorded at a seismological station. Because of that, we expect to have a non-negligible influence from the crust on body-wave travel-time measurements. When a seismic phase crosses the crust, reflections and conversions occur at interfaces of all layers composing the crust. These reflected/converted phases will reach the seismometer right after the main phase and may arrive close enough to be included in the time window used for the cross-correlation. We will show how crustal phases can distort the waveform and thus ultimately disrupt the travel-time estimated from broadband filtered seismograms.

**Keywords:** body-waves; seismic tomography; wave propagation; crustal structure

# **Inheritance and magmatic processes as the main controls of the evolution of a polyphase rift system: the example of the Mozambique Channel**

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The role of inheritance and deep seated mantle processes has been intensively studied in the past, however, how they interact and control the evolution and final breakup of rifted margins is yet little understood. The aim of this study is to better constrain when, where and how magma is formed before, during and after breakup and how the structural, compositional and thermal inheritance may have controlled the evolution of the conjugate Mozambique-Antarctica margins. More recent studies demonstrating the thermal, compositional and structural influence on the evolution of a rift system (e.g., Manatschal et al., 2015; Chenin et al., 2015) where they proposed that enriched lithosphere during previous Wilson cycle stages could lead to more magmatic budget during the following rifting.

In this study we describe and map rift domains, propose a new rift domain map and investigate different plate kinematic scenarios resulting in different rift and breakup histories with variable budgets of magma and different implications for the reactivation of inherited structures. Although the available data do not allow to favour one scenario, it enables to constrain the limitations of different interpretations and to discuss the consequences and implications of the various interpretations. Identifying the southward jump of localised deformation associated to the switch from magmatic to tectonic-dominated deformation may act as evidence that magmatic budget decreases from an early Karoo peak to constant magmatic budget for oceanic crust creation and that internal parameters (inheritance) have to be involved.

**Keywords:** tectonics, magmatic margins, rifting evolution

# **Study of the Upper Rhine Graben sedimentary cover. Focus on the understanding of the cover–basement transition, a potential geothermal resource?**

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Since many years, the geothermal energy is taking place in the Upper Rhine Graben (URG) with many different geothermal power-plants. One of the last projects is currently drilled at 3000m deep in the Strasbourg area (north east France). These new wells will cross the entire sedimentary cover, from the Quaternary sediments down to the Variscan granitic basement. It is this sedimentary cover – basement interface, which is the geothermal target because it is known that the heat circulates through a vertical fracture network permitting hydrothermal convective cells. After many studies on the geothermal powerplant of Rittershoffen and later Soultz-sous-Forêts, this cover is well constrained in the north Alsace. Although most of the sedimentary cover (excluding faults) is relatively well known, there are still several unknowns for the Strasbourg area. And one of the main ones takes place in the Permian unit between the Paleozoic basement and the Buntsandstein sandstones (geothermal reservoir). Indeed, the transition remains poorly documented mainly because of the great diversity of facies, both for the basement (presence or not of a granitic basement, or metamorphic, whose nature will have a direct impact on the heat exploitation) and for the sedimentary cover (existence or absence of Permian series and nature of these pre-Triassic formations). The real thickness and nature of the Tertiary could be twice thicker and locally more detrital than on the wells in the northern part of the URG. Therefore, many geological field campaigns were conducted in the Vosges region (France) and in the Black Forest (Germany) to try to characterize this transition in term of stratigraphic, sedimentary and structural modalities. Those results associated to recent 2D seismic lines acquired in the Strasbourg area are used to understand more precisely the sedimentary Permian units – crystalline basement interface, to know if it is also a potential geothermal resource like the Buntsandstein.

**Keywords:** stratigraphy; sedimentology; geothermal energy; URG



# **Loess, alluvial terraces and fans in the south-western part of the Upper Rhine Graben: geomorphology and chronology during the Upper Pleistocene (110 000 to 13 500 year Before Present)**

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The Upper Rhine Graben is a Cenozoic intra-plate graben system. It is still active today with occasional earthquakes and responsible for important relief differences. A critical revision of geomorphological and geological maps, the study of available digital terrain models, stratigraphic observations in quarries, logging of several hundred profiles during archaeological rescue excavations, and dating by optically stimulated luminescence (OSL) permit to discuss the respective share of geological, geomorphological and palaeoclimatic factors in the genesis of the current relief during the Upper Pleistocene (110 000 to 13 500 year Before Present).

The first results show that the distribution of Upper Pleistocene loess is controlled by the pre-existing reliefs and by the alluvial dynamics of the Vosges and Rhine rivers while their thickness and pedosedimentary characteristics could be partly related with mechanism of wind deflation and local redistribution of sediments. Distribution and numerical chronology of these loessic formations could be used as a guideline to understand alluvial dynamics. The Rhine occupied the main part of its valley during the major part of the Upper Pleistocene and terraces were formed in the south of the region and around Strasbourg only during the end of the period, around 30 000 years Before Present, and during late glacial and Holocene, after 13 500 years Before Present. Size and shape of the Vosges alluvial fans are controlled by these Rhine alluvial dynamics and by the pre-existing reliefs more than by the geometry of their watersheds. Finally, while it appears that the palaeoclimatic evolution controls the sedimentary balances during the Upper Pleistocene, geomorphology seems to be the main factor for understanding the distribution of the deposits. At this time scale, the effect of neo-tectonic has now to be further investigated.

**Keywords:** Rhine; loess; alluvial fans; Upper Pleistocene.

# Microgravity monitoring of Soultz-sous-Forêts and Rittershoffen geothermal reservoirs (Alsace, France)

N. Portier<sup>1</sup>, J. Hinderer<sup>1</sup>, U. Riccardi<sup>2</sup>, G. Ferhat<sup>1,3</sup>, M. Calvo<sup>4</sup>, Y. Abdelfettah<sup>1</sup>, J-D. Bernard<sup>1</sup>

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We monitor the Soultz-sous-Forêts and Rittershoffen geothermal reservoirs in northern Alsace using microgravity method. Indeed, this study informs us about the underground mass redistributions. The commercial exploitation of the Rittershoffen and Soultz-sous-Forêts geothermal energy has begun respectively in May and June 2016. The Soultz-sous-Forêts enhanced geothermal system produces 1.7 MWe thanks to three wells 5 km deep. The Rittershoffen plant is designed to produce 24 MWth heat power with 2 wells 2.5 km deep. Time-lapse gravity measurements have been performed with a Scintrex CG5 gravimeter since 2014 in order to calculate the gravity double differences. These differences show the gravity variation at each measuring point compared to a reference time and station. Before the beginning of the production in 2016, the stability of the Soultz-sous-Forêts reference station has been monitored through the repetition of absolute gravity measurement. In 2016, regular ties between the reference stations and the Strasbourg gravity observatory have also been performed. To control the vertical ground displacement, leveling measurements have been undertaken simultaneously to each gravity survey. For the Soultz-sous-Forêts network, we notice significant changes in agreement with the position of the injection and the production wells. On the contrary, we do not detect any similar signal for the Rittershoffen network.

**Keywords:** Gravity monitoring; geothermal energy; Soultz-sous-Forêts; Rittershoffen

# Characterization of groundwater circulation flow in the Strengbach catchment (Vosges Mountain, France): Implication of the CFCs and $^4\text{He}$ dating

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In order to better constrain weathering processes in the critical zone (CZO), we propose to localize and characterize the nature, the property and the dynamics of the groundwater flow within the Strengbach watershed. For this purpose, water samples from springs, piezometers (15m deep) and boreholes (50 to 120m deep) were regularly collected, since 2015, at different hydrological periods. These samples were analysed in major and trace element concentrations, in  $^{87}\text{Sr}/^{86}\text{Sr}$  isotope and ( $^{234}\text{U}/^{238}\text{U}$ ) activity ratios, and in CFCs and  $^4\text{He}$  concentration.

The results point to a systematic geochemical difference between “surface waters” (i.e. waters from the upper part of the boreholes, piezometers and springs) and “deep waters” (i.e. waters collected in front of the fractures from deep boreholes). Surface waters are characterized by lower TDS concentrations than deep waters, as well as higher Sr isotopic ratios and lower U activity ratios, proving a different alteration process. This distinction is also observed with the CFCs and  $^4\text{He}$  concentrations. Surface waters are marked by high CFCs concentrations, which indicates recharge of a few months to few years. The CFCs concentrations in deep waters suggest mixings between recent waters with characteristics close to those of spring waters, and older waters, being older than 70 years which is the maximum age given by the CFCs method. Concentrations of  $^4\text{He}$  of these deep waters suggest the occurrence of a potentially old water (>1000y or more). All these data confirm at least two contrasting water circulation pathways within the Strengbach watershed: i) a subsurface water pathway in the highly altered regolith, with a short transit time of a few years or less, and ii) a deep-water circulation in fracture networks of the bedrock with a much smaller transit time, and probably the mobilization of very old waters.

**Keywords:** environmental tracers; residence time; weathering processes

# A finite volume method to simulate flow within an explicit fracture network associated with dual porosity systems

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In the context of modeling the hydrodynamics of a regional karstic aquifer, it appears interesting to account for both diffuse regional flow in a fractured matrix and preferential flow associated with drains or fracture corridors.

An efficient way to simulate flow in a fractured system is dual porosity model overlapping two continua, one describing water and solute conveyed in fractures, while the other mimics storage in the matrix housing the fractures. That said, this approach is only applicable for dense fracture networks and does not account for preferential flow paths irregularly spread over the modeled domain. In a first step of our investigations, we develop a pipe network simulating preferential flow and we integrated it in a current dual porosity model.

A finite volume code computes flow within the pipe network is employed. This method is easy to use even on irregular and distorted mesh, as can be pipe networks superimposed onto a continuous domain. A mixed finite element method computes the flow inside the continuous domain. This mixed finite element method is based on an existing computer program TRACES (Transport of RadioACTIVE Elements in Subsurface - Hoteit H., Ackerer P., 2004.).

To evaluate the exchange between the explicit fractures and the TRACES computer program, we design pumping simulations for dual porosity model describing the explicit pipe network and the matrix domain. With the water table drawdown data, we fit an analytical Theis solution to find the equivalent hydraulic parameters.

**Keywords:** dual porosity; finite volume method; explicit fractures

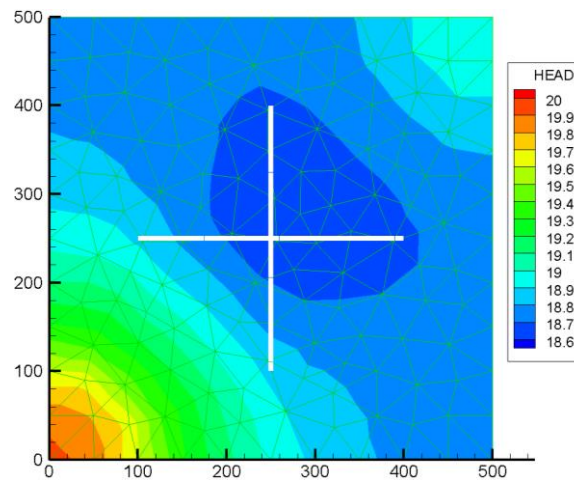


Figure 1: Distribution of the water head inside the matrix. The white lines show the explicit fractures.

# What can we learn on mineral dissolution from Kinetics Monte Carlo models?

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Mineral dissolution is known as one of the main actors of chemical weathering on Earth's surface. Despite decades of studies on mineral dissolution processes and dissolution kinetics, we still have difficulties to link laboratory experiments and field measurements. Indeed, dissolution rates measured in the field are several orders of magnitude smaller than those measured in the laboratory. This is a problem for reactive transport simulations since they use laboratory-based rate laws and apply them on larger space scales such as catchments. Understanding this discrepancy is then becoming essential especially for models. One of the possible solutions consists in tackling the issue of defining the reactive surface areas and the rate constants that are usually implemented. While the shrinking sphere model is generally used for taking into account the temporal evolution of the mineral surface area on the reaction progress, it can represent a bias due to the complexity of the crystal atomic organization. Besides, the "rate constant" constant has been challenged by e.g. White and Brantley (2003), who showed that dissolution rates actually decrease through time because of mineral surface aging.

To address this question, simulations based on kinetic Monte Carlo modelling have emerged in glass and mineral dissolution studies. These models, based on stochastic dissolution, consider atomic bond breaking and have shown their robustness in several studies (e.g., Kurganskaya and Luttge, 2013). However, in these studies, the work is limited to dissolution pattern and not deal with other information that these models can provide such as mean surface retreat, evolution of the surface roughness or crystal dissolution anisotropy. After a brief presentation of the overall framework of our model, I will discuss the first results we got on enstatite dissolution and discuss possible improvements to better bridge simulation outputs with experimental results.

**Keywords:** kinetic Monte Carlo; crystal dissolution; chemical weathering; pyroxenes

## References:

Kurganskaya, I., Luttge, A., 2013. A comprehensive stochastic model of phyllosilicate dissolution: Structure and kinematics of etch pits formed on muscovite basal face.

The effect of time on the weathering of silicate minerals: why do weathering rates differ in the laboratory and field? *Chemical Geology*, 202(3-4): 479-506.

# Influence of plant protection products on small streams

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Streams in agricultural landscapes are strongly affected by environmental stressors including nutrient or pesticide input. Due to their low dilution potential, inputs into small water bodies (SWB) are comparatively more likely to impair the fauna and flora than in larger streams. Although, SWB represent a large fraction of all water bodies, they have received less consideration in water monitoring programs. Within the framework of the German national action plan (NAP) to improve the sustainable use of plant protection products we analyzed nationwide pesticide monitoring data sampled between 2005 and 2015. To specifically address agricultural SWB, we performed statistical analysis of pesticide concentrations in 1302 sampling sites and their upstream catchments (catchment size <30km<sup>2</sup>, land use >40% agriculture) to trace seasonal occurrence patterns of individual substance groups (e.g. fungicides, herbicides and insecticides). To account for non-linear response patterns Generalized Additive Models (GAM) have been used.

Furthermore, endpoints of ecotoxicological tests are often used together with field concentrations of chemicals to quantify adverse effects on aquatic communities. Therefore, in a second step we present a powerful new tool to facilitate ecotoxicological endpoint derivation which cleans, filters and aggregates ecotoxicological test data provided by the US Environmental Protection Agency (EPA). The tool shall serve ecotoxicologists as a data resource for risk assessment.

**Keywords:** ecotoxicology; data analysis; pesticides; statistics

# Fate factor of engineered TiO<sub>2</sub> nanoparticles in aquatic and terrestrial natural environments

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Nanoparticles are defined as nano-objects between 1 and 100 nanometers in size. Engineered TiO<sub>2</sub> nanoparticles are used in several fields like construction, cosmetic and food which leads to an important production and inevitably to emissions generating environmental impacts. In addition, there is currently only regulation for the uses of nanoparticles and not for the release in the environment at the European Union level. To quantify them, the Life Cycle Assessment is a powerful method that is able to characterize TiO<sub>2</sub> NPs according to their fate in environmental media and their effects on ecosystems and human health. In this study, the fate of engineered TiO<sub>2</sub> nanoparticles (TiO<sub>2</sub> NPs) is developed according to two approaches: experimental and by calculation. In this presentation, only the experimental part is presented. For this purpose, it requires firstly to detect and quantify TiO<sub>2</sub> NPs in water, soil and sediment near a production site of TiO<sub>2</sub> NPs in Vieux-Thann (68). Samples were then analyzed by inductively coupled plasma with atomic emission spectrometry (ICP-AES) in order to determine total titanium concentration. First results obtained show that water and sediment samples located near and downstream of the site production are 2,5 to 20 times more concentrated than the upstream point (used as a reference) which imply an impact coming from the production site. However, soil samples are only 1 to 1,5 times more concentrated than the geochemical background. Further studies are needed to determine whether the additional titanium dioxide comes from the production site or not and will confirm or invalidate the presence of TiO<sub>2</sub> NPs manufactured in soils.

**Keywords:** Life Cycle Impact Assessment; Nanoparticle; Dioxide Titanium; Natural Environment

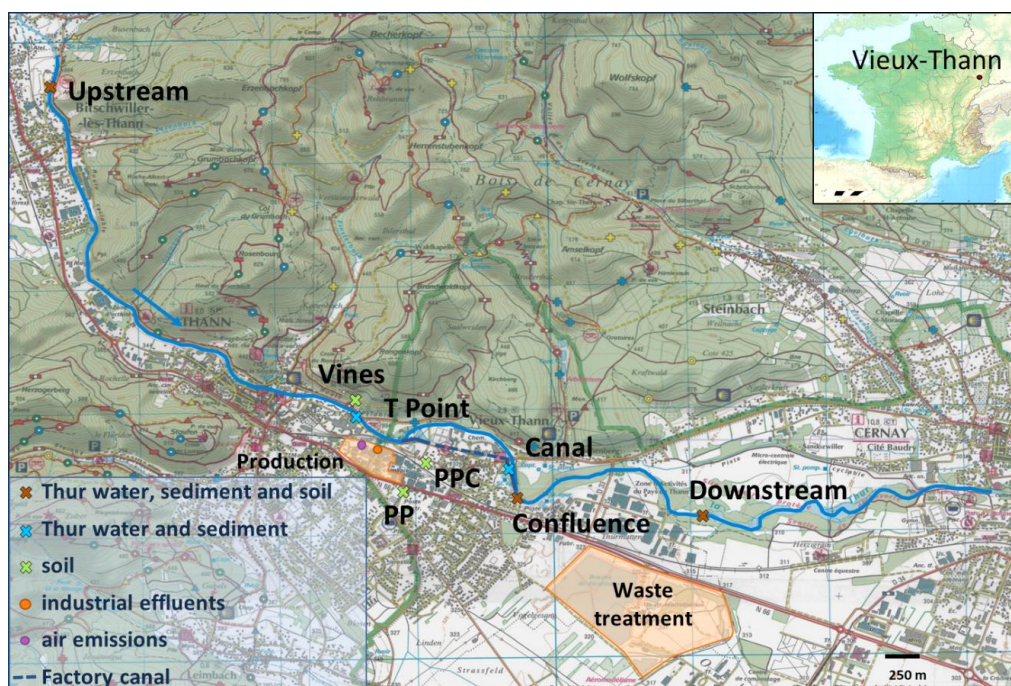


Figure 1: Sampling location of soil, sediment and water near Vieux-Thann (Alsace)

# Monitoring of natural gas storage in salt caverns using SAR interferometry

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Even with a low storage capacity, natural gas storage reservoirs in salt caverns allow a high distribution flow in case of potential peak consumption. Ground surface above the reservoirs might undergo subsidence due to salt creep decreasing the storage capacity at depth. Local authorities impose monitoring of surface displacements by leveling method. Development of remote sensing methods such as radar interferometry offers possibilities to make regular and frequent measurements of induced surface movements above the reservoirs.

We present here a study of a natural gas reservoir belonging to Storengy (affiliate Engie, gas provider in France) and settled into deep caverns at 1500 m underneath the towns of Tersanne and Hauterives (France), whose exploitation started in 1970 and 2012, respectively.

The surface monitoring with SAR interferometry techniques is carried out using the approaches of permanent scatterers and small-baselines subsets. The dataset encompasses C-band SAR image archives acquired by the ERS, Envisat and Sentinel-1 ESA satellites for the 1992-2018 period.

In this agricultural region, the tracking of displacements is possible on well platforms above each cavity and on man-made installations above the whole operation. Between 1992 and 2010, the mean LOS velocity of the subsidence decreases from ~4.9 to ~4.0 mm/yr at Tersanne operation. We show that transient surface movements are correlated over time with volume losses at depth. We include uncertainty estimates based on two analyses: coherence value (which provides an uncertainty for each pixel) and standard deviation of neighboring pixels phase values (that indicates if the movements of adjacent pixels are coherent).

Our results highlight the performance of InSAR for monitoring reservoir-induced surface deformation by precisely determining spatial boundaries of the surface affected by slow-rate movements and following transient displacements with a time resolution not reachable with leveling surveys.

**Keywords:** gas storage, salt caverns, SAR interferometry



# Mining subsidence detection by remote measurements over the MDPA and mining void modelling

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The Mines Domaniales de Potasse d'Alsace (MDPA), located in the south of the Rhine graben near Mulhouse (France), was operational between 1904 and 2002. Two distinct potash layers were exploited over a total average surface of 100 km<sup>2</sup> at a mean depth of 635 m and 655 m and a thickness of 1-2 m and 2-5.5 m, respectively.

We used ERS, Envisat and Sentinel-1 SAR data acquired along both ascending and descending tracks, to estimate the surface deformation during both operational and post-operational periods. Because of the low interferometric coherence due to fields and forests, we used the Stanford Method for Persistent Scatterers (StaMPS) (Hooper et al., 2012) to track the displacements at permanent scatterers and follow the surface evolution using a time series analysis. Doing so, we are able to estimate the displacement rate over about one third of the total area above the full gallery network.

By assuming that the deformation corresponds to vertical displacement, we observe a signal characterized by small patches of subsiding areas up to 36 cm through the period 1995 to 2000, mainly located above the tip of the most recent exploitation but also, nearby small faults previously identified in the southern graben. The time evolution of these displacements fits the available levelling data, consistent with exponential decay over time.

Alongside these surface observations, in-situ LIDAR measurements have been regularly conducted in the underground galleries since April 2017 to estimate the convergence rate of the walls in the salt layer creeping.

After successfully completing in-situ measurement campaigns and remote measurements of the surface displacement field during the different periods of time, we aim to build a geomechanical model of the potassic basin to draw the short and long-term evolution of the mine and its surrounding medium and retrieve other observations.

**Keywords:** InSAR; mining subsidence; geomechanical modelling

# Assessing the soil temperature and moisture dynamics in a Mediterranean slope; an application of fiber optic DTS

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On the most important parameter of the soil is its water content. The knowledge of soil water content has become increasingly popular in various hydrological, agronomical and environmental studies. Recently, some soil measurement has been carried out at Draix Bléone catchment, Alpes-de-Haute-Provence, France. In order to document the temperature and soil moisture behaviour, a 350 m fiber cable was buried by incision at 0 cm, 5 cm, 10 cm, and 15 cm of depth and used as a temperature distributed sensor. The total length of the monitored profile is 60 m through three different soil unit consisting of argillaceous weathered black marls, silty colluvium with grass in top, and silty colluvium under forest. The temperature is measured every 6 minutes at a spatial resolution of 0.5 m. The observation was compared with another soil moisture probe based on electrical properties. However, the application of soil moisture probe does not include the soil temperature for conversion. To fill this gap, in this study we present the temperature contribution for calculating the soil moisture. Hydrological analysis for understanding the soil moisture behaviour and pattern in seasonal and environmental processes are carried out in 21 months. Next steps will consist in developing the direct hydrological modelling.

**Keywords:** FO-DTS; temperature; soil moisture; Draix

# Effects of different Earth's structures on W-phase CMT parameters

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The source inversion of the W-phase has demonstrated a great potential to provide fast and reliable estimates of the centroid moment tensor (CMT) for moderate to large earthquakes. It has since been implemented in different operational environments (NEIC-USGS, PTWC, etc.) with the aim of providing rapid CMT solutions in real time. These solutions are in particular useful for tsunami warning purposes. Computationally, W-phase waveforms are usually synthesized by summation of normal modes at long period (100-1000 s) for a spherical Earth model (e.g., PREM). Although the energy of these modes mainly stays in the upper mantle where lateral structural variations are relatively small, the impact of 3D heterogeneities on W-phase solutions have not yet been studied. In this work, we quantify the impact of lateral heterogeneities and investigate possible bias in W-phase source parameters due to un-modeled complexities in the Earth structure. With this purpose, using the spectral element method, we simulate a global dataset consisting of synthetic seismograms of past large earthquakes that accounts for the Earth 3D structure. We then use the W-phase algorithm to invert earthquake CMT parameters from the synthetic dataset. Results allow us to quantify the effect of 3D structure on inverted source parameters, and investigate the sources of the observed differences. We also analyze the influence of magnitude, seismic noise, filter and data coverage on W-phase solutions. Results show that large centroid mislocations are observed in South America and in the South mid-Pacific Rise due a combined effect of lateral velocity variations and the unbalanced distribution of seismological stations Fig. 1. This research is essential both to assess the accuracy of W-phase CMT solutions and to investigate how 3D heterogeneities could be accounted for in the future.

**Keywords:** W-phase; source inversion; 3D effects; lateral heterogeneities

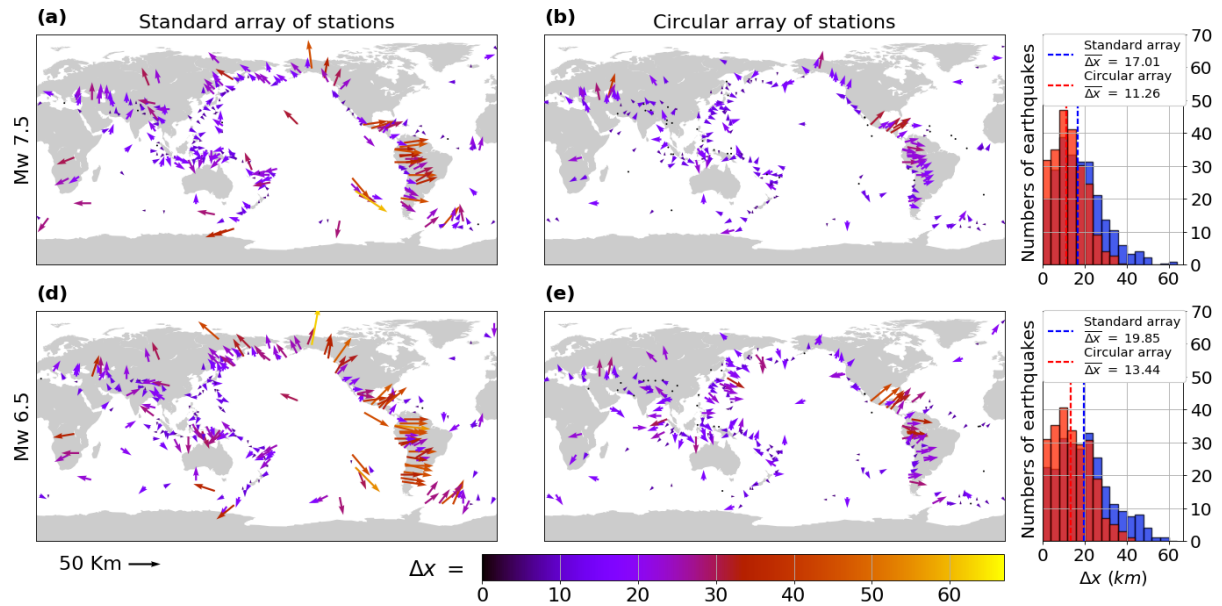


Figure 1: Maps show the horizontal mislocation, correspond to the results of the inversion of synthetic seismograms whit added noise, for regular array and for a circular array created with the S362ANI Earth's model scaled to Mw 7.5 (A,B) and Mw 6.5 (D,E).

# Formalization and parameterization of reservoir models and associated uncertainties for resource evaluation and model calibration

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Any petroleum, geothermal or hydrogeological reservoir model is an uncertain model for which dynamic or physical data of all types (flow, transport, geophysical...) can be used to calibrate the model and reduce model uncertainty. A generic formalization and parametrization of reservoir models is proposed to help define model uncertainties in a general way that facilitates reservoir model calibration whatever its particularity and complexity.

The formalization of reservoir models is based on a decomposition of model information as follows.

1. A reservoir model is comprised of one or several reservoir media.
2. A reservoir medium is comprised of one or several reservoir elements.
3. A reservoir element is comprised of one or several reservoir variables.
4. A reservoir variable is associated with a distribution or correlation model that fully defines it and is based on one or several statistical parameters.
5. A statistical parameter is interpreted differently whether it refers to a parametric or nonparametric distribution or correlation model.
  - Parametric model: the parameter can be deterministic (defined by a single data) or uncertain (defined by multiple data) and can be stationary (data = numerical values) or nonstationary (data = grid properties).
  - Nonparametric model: the parameter can be deterministic (defined by a single nonparametric model instance) or uncertain (defined by multiple nonparametric model instances).

The parametrization of reservoir models is obtained by using “interpolation parameters”, attached to the uncertain statistical parameters, to explore the space of uncertainty of uncertain model variables. For the interpolation of non-stationary statistical parameters, the so-called *gradual probability field deformation* method has been developed and started to be tested.

The different aspects of the proposed approach will be presented. The application to naturally fractured reservoir models will illustrate the formalization and parametrization of reservoir models.

**Keywords:** reservoir model calibration, uncertain model formulation, gradual probability field deformation, naturally fractured reservoir models

# Nutrient (Ca, Mg, K) behavior in soils located in decline forest (Strengbach catchment, Vosges Mountain, NE France): Development of a new experimental approach

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Since 1970, major symptoms of forest decline had been observed worldwide. Acidity from atmospheric pollution can leach and decrease the availability of nutrients in soil. A better understanding of how soil/water/plant interactions can respond to modifications become more and more crucial for a better management of natural and renewable resources.

Traditionally, the quantity of exchangeable cations (such as Ca, Mg), are quantified with extracting agent such as cobaltihexamine. But these measurements are not enough for fully characterize the different processes involve in the mobilization of nutrients. This study aims to identify the different pool of nutrient : their reactivity, their stock and their availability over time.

Experiments have been realized with natural soils from two different plots (beech and spruce stands). Soil samples from 6 horizons (until 80 cm depth) are disposed on batch series with two different acids (hydrochloric acid and oxalic acid). The solutions are analyzed at different time from 24h to 150 days. DRX, SEM, chemical and isotopic (Sr) characterization are determined on soil and solution. Strontium isotope data aimed to decipher mineral weathering, atmospheric deposit and biological activity. The results show highly variable chemical behavior versus element, type of soil, horizons and type of acid. We observed unexpected results for Ca. The total quantity of Ca extracted after 150 days corresponds to a very low proportion of the calcium exchangeable obtained with cobaltihexamine, underlining a complex bioavailability of this nutrient in soil.

Furthermore, extraction with acid oxalic seems to be linked with a set of parameters (OM content, clay content, mineralogy), which are variable versus depth. The differences observed between both acids increase with depth reaching until a ratio of 15 times for concentration in oxalic leachate, except for Na dominated by simple inorganic dissolution of albite. These results highlight the complexity of relationship between exchangeable pool, “chemical availability” and the nature of extractant used.

**Keywords:** Nutrients, Chemical behavior, Strengbach catchment, geochemistry

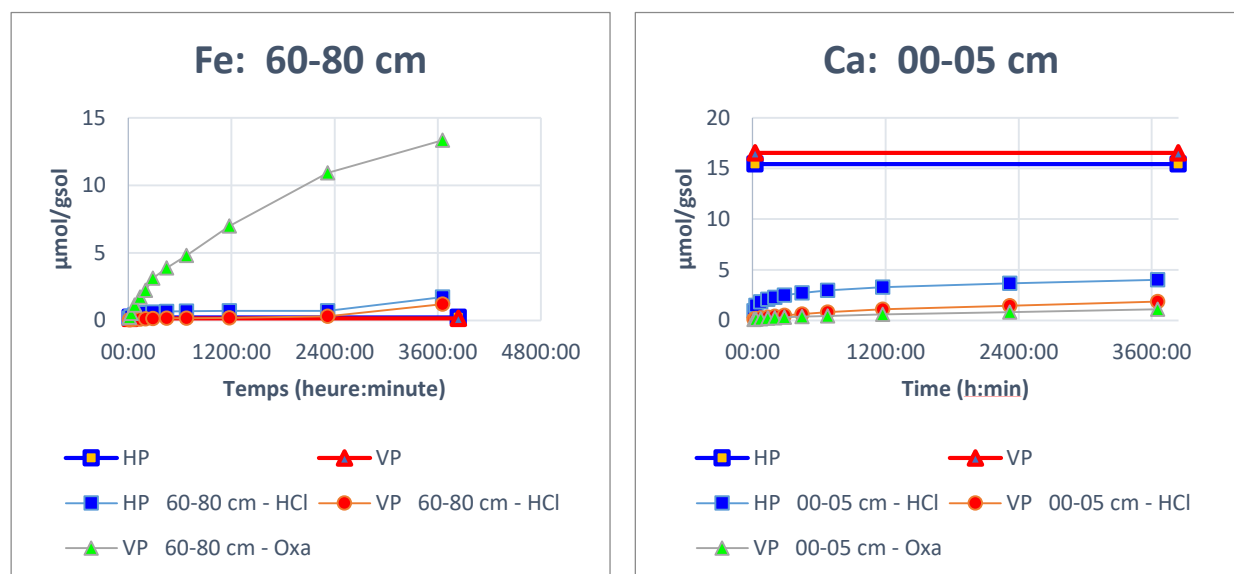


Figure 1 : Cumulative concentration for two elements: iron at 60-80 cm depth (left) and calcium at 00-05 cm depth (right). The blue and red line shows the exchangeable pool (cobaltihexamine) respectively for the beech plot and the spruce plot.

# How avalanches can be hot: Induced thermal effects in the propagation of cracks

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During the propagation of a crack in an elastic medium, some of the system's energy brought by the external load is reversibly stored as elastic energy adapting to the crack morphology, while the rest gets irreversibly dissipated by various processes. One of these processes is the induced Joule heating around the fracture front due to some friction in a damaged zone at the crack tip. The heat hence generated can in return have a significant impact on the physics of the fissure propagation. Such a consideration is notably central in earth science, where the stability of some fault is believed to be controlled by thermal effects, with the possibility of thermo-pressurization of the in situ fluids when the fault activates.

Independently of this pressurization effect, the local rise of temperature of the zone enduring damage could significantly affect its creep rate as understood by statistical physics and an Arrhenius law. We will present such an Arrhenius model in which the temperature elevation is directly related to the crack velocity and we will discuss how compatible it is with previous fracturing experiments in paper sheets and polymers. The results of numerical simulations will also be shown to illustrate how the Joule heating, combined with the medium's disorder, can weaken a crack and trigger avalanches in its propagation, potentially explaining common some stick-slip features observed in rupture processes.

**Keywords:** rupture mechanics; thermal effects; disordered media; numerical simulations

# The coupling between compaction and pressurization in cyclically sheared drained granular layers: implications for soil liquefaction

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The dynamics of saturated granular layers during shaking is controlled by the coupling between grains and fluid. Understanding such systems is crucial for studies of soil liquefaction, seismically induced landslides and shear along faults. This study focuses on the compaction of a near surface well-drained saturated granular layer during seismic shaking. Compaction is known to promote soil liquefaction, but the exact feedback mechanism between compaction and pressurization remains poorly understood. We use Discrete Element numerical simulations composed of coupled solid grains and fluid phases under cyclic horizontal shear of the bottom undrained boundary and a free, completely drained, top layer. We compare the dynamics under two drainage conditions. First, simulations of “infinite” drainage, where the fluid pressure is maintained hydrostatic during the shaking. Second, simulations of “realistic” drainage in a high permeability layer, whereby fluid pressure dynamically deviates from hydrostatic values due to local granular compaction and dilatation. Simulation results shows two end member behaviours, with a transition controlled by the magnitude of shaking acceleration: At low acceleration the system behaves rigidly, compaction is negligible and fluid pressure remains constant even during “realistic” drainage simulations, where it is allowed to evolve. At high acceleration, significant compaction occurs in both cases, but the compaction rate is higher in “realistic” drainage simulations. This rapid compaction trend is temporally correlated to a transient pore pressure increase that reaches lithostatic stress values before it drops back to a lower value. This is an evidence to feedback mechanism in which compaction causes pressure increase that can persist under drained condition as long as the compaction rate is sufficiently high. On the other hand, this very pressure itself promotes the high compaction rate. From this, we conclude that although well-drained soils are considered liquefaction-resistant, dynamic coupling between pore fluid pressure elevation and compaction during seismic shaking provides a previously unrecognized pathway to liquefaction.

**Keywords:** soil liquefaction; granular mechanics; numerical simulations

# Potential field methods applied to the quantification of the magnetization of the oceanic lithosphere

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The most commonly used method to determine the age of the oceanic crust consists in a qualitative study of the magnetic anomalies. The aim of this thesis is to apply quantitative methods to interpret marine magnetic anomalies, and more specifically to determine in an objective way the positions of Earth's magnetic field reversals, and so their age. This point is particularly interesting in order to understand magma-poor rifted margins, where the interpretation of the magnetic anomalies is debated (application to the Australian-Antarctica and Iberia-Newfoundland conjugate margins). Indeed, several anomalies may be linked to other process such as lithospheric break-up. This process is characterized by magmatic events which can lead to magnetic lineations without clear link to the Earth's magnetic field reversals.

The first results of the thesis are focused on the Australia-Antarctica conjugate margins. The first step has been the application of several transformations to the regional magnetic anomaly. The main applied transformations were the reduction to the pole, vertical derivative and upward continuation. The most significant results of transformation are derived from the upward derivation and allow us to observe new magnetic lineations of very large scale (thousands of kilometres) and high amplitude (500 nT) on the Antarctic margin. A joint comparison of a transformed magnetic anomaly formerly interpreted as the isochrone C34 with the gravity anomaly and the seismic profiles of the AG199, AG228 and AG229 on a regional scale then has been realized. This comparison allows us to correlate the regional magnetic and gravity anomalies with the structural limit between the highly-extended crust and mantle exhumation domains on the Antarctic margin. Therefore, this magnetic anomaly is unlikely to be caused by an isochrone and rather by a magnetization contrast between different structural domains.

**Keywords:** magma-poor rifted margins; rifting; oceanization; mantle exhumation; magnetic anomalies



# A generic processing pipeline for the photogrammetric analysis of high frequency terrestrial optical images: application to unstable slopes

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Digital passive sensors (i.e., sensors that operate in the visible light spectrum), such as Single Lens Reflex (SLR) cameras, are increasingly being used for ground-based geohazards monitoring (ice glaciers, volcano flanks, landslides) partly because of their low cost compared to expensive terrestrial laser scanner (TLS) or radar imaging (GB-InSAR) systems. Indeed, due to the large consumer market, sensor resolution is increasing rapidly; for example, inexpensive > 15 megapixel cameras are available, allowing arrays of cameras to be set up in the field.

Passive optical sensors provide qualitative information (identification of changes in the surface morphology, weather conditions, presence and position of snow cover) and to quantitative 3D information using stereo-views (creation of Digital Surface Models, displacement monitoring, and tracking of changes of the surface states).

In the case of slope stability problems, most recent research has focused on the development of image correlation techniques to determine the average spatial shift by maximizing cross-correlation functions between at least a pair of stereo-images. This technique has proven its performance to characterize the displacement fields of ice glaciers and slow-moving landslides at sub-pixel accuracy (1/10th pixels) and generates a pseudo-continuous map of the deformation. Another application consists in the documentation of changes in the morphology of rockfaces with the quantification of erosion rates or the detection of rockfalls scarps and accumulated debris. For the analysis of long time series, automated pipelines are needed to process the amount of data.

The objective of this work is to develop, test and implement an automated image processing pipeline for the analysis of monoscopic and/or stereo-scopie image time series from fixed terrestrial optical cameras. The processing pipeline is based on the open-source photogrammetric library MicMac. It associates modules for the selection of the image sequences, tools for image stack registration and the correction of the camera movement, and tools for change detection.

The pipeline will be presented and its performance evaluated on several cases situated in the French Alps.

**Keywords:** terrestrial optical images; image processing; slope stability problems

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# **Pesticide dissipation at the sediment water interface: Coupling modelling and compound specific isotope analysis**

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The Sediment-Water Interface (SWI) is a biogeochemical zone of intense reactivity that controls pesticide attenuation in relation to hydrological conditions. Both transport and destructive processes result in a decrease of pesticide concentrations whereas only degradative processes actually reduce the remaining mass entering into aquatic ecosystems. Compound Specific Isotope Analysis (CSIA) may then help to assess the contribution of pesticide degradation versus non-degradative processes (i.e., transport, sorption) independently from mass balance and transformation products analysis. However, mechanistic knowledge on pesticide dissipation processes, including abiotic transformations or bio-degradation under different redox conditions, is currently missing. In addition, pesticide exchanges across the SWI for a representative panel of hydrological conditions is poorly understood.

The objectives of my PhD thesis are thus (i) to understand and quantify pesticide abiotic degradation at the SWI using CSIA (microcosm scale), (ii) to elucidate the relative contribution of pesticide transport versus degradation in dynamic systems with numerical modelling and CSIA data (15cm mesoscale river model), and (iii) to identify pesticide sources and persistence at catchment scale over an agricultural season (Souffel catchment, France, 100km<sup>2</sup>). Degradation kinetics and stable isotope fractionation factors of broadly used pesticides were derived from laboratory experiments during hydrolysis (significant enrichment in heavy stable isotopes, slow degradation) and photolysis (negligible enrichment, potentially fast degradation) and implemented in a reactive model. Redox zonation across the sediment was also implemented as it controls degradation rates of pesticides. Mass exchanges at the SWI of rivers for common hydraulic conditions were examined using a coupled reactive transport model computing the Navier-Stokes (overlying water), the Darcy's (porous sediment) and the Darcy-Brinkman equations (SWI), providing an original SWI reactive transport approach.

In the future, accurate investigation of pesticide fate (sources, persistence, prevailing zones and periods of degradation) may be addressed by combining pesticide concentration and isotope fractionation patterns with numerical modelling.

**Keywords:** Compound Specific Isotope Analysis; Sediment-water exchanges; Darcy-Brinkman approach; Reactive Transport Modelling; Agricultural catchment; Pesticides

# Pesticides dissipation at the water-sediment interface: insights from Compound Specific Isotope Analysis (CSIA)

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Freshwater systems recurrently receive pesticide runoff from agricultural lands. In the riverbed, the understanding of pesticide dissipation and accumulation is currently limited. A major issue to evaluate the fate of pesticides at the water-sediment interface is that concentration-based measurements in water or in sediment do not allow teasing apart non-degradative processes from degradative processes. Compound Specific Isotope Analysis (CSIA) has been used for more than one decade to elucidate degradation and identify pathways in aquifers, and may be applied to investigate pesticide dissipation in river compartments.

The objective of this study is thus to investigate degradation pathways and kinetics of a pesticide mixture (Atrazine, S-Metolachlor, Terbutryn, Acetochlor and Metalaxyl) under oxic and anoxic conditions, and in water and sediment compartments.

First, we developed effective methods for water and sediment to extract pesticides without any isotope fractionation. Solid phase extraction (SPE) from water samples enable to extract pesticide with a high recovery (79 to 100%) and without any significant carbon isotope fractionation ( $\Delta\delta^{13}\text{C} > |0.5\text{‰}|$ ). Similar results were obtained for sediment samples using solid-liquid extraction using Pentane: Dichloromethane (3/1, v/v; recovery: 87 to 99%,  $\Delta\delta^{13}\text{C} > |0.5\text{‰}|$ ). Second, we set-up a long-term (300 days) biodegradation experiment under controlled conditions. At time zero, pesticide mixture was spike with pesticides. At each sampling point, pesticides were separately extracted from water and sediment, and quantified by GC mass spectrometry (GC-MS) and C and N isotopic signature are measured on GC-IRMS to evaluate degradation kinetics and infer processes.

Altogether, we anticipate this experiment to demonstrate the usefulness of CSIA to distinguish dissipation processes at the water-sediment interfaces. Such experiment may help to evaluate natural attenuation of pesticides in river, and to determine under which conditions sediment may act as a sink or source of pesticides at the river scale.

**Keywords:** degradation pathway; fresh water system

# Assess and simulate the link between urban morphology and mobility behavior

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In order to tackle climate change and reduce the use of individual cars, it is necessary to define the type of cities which would likely put forward non motorized mode of transports. For some people, the answer to the issues induced by traffic jam are to be found in coherent city which still need to be defined (Massot, Orfeuil, 2007).

This sustainable mobility is to be built on the model of cities which already optimize the use of individual cars. It is necessary to evaluate the complex chains of movement made by the daily movements of people which will also influence their choice of transports (De Witte et al., 2013). In order to characterize the role of morphological and functional factors on the choice of transports, I will present a spatial and interactional measurement analysis of the urban building layout resulting from the REMUS model. This model measures indicators of proximity between buildings and shows phenomena of building's concentration and morphological ruptures at certain distance thresholds. (Badariotti and al., 2007; 2009). In parallel, I work on the scale of Strasbourg Eurométropole by using data from the public consultation on Household and transport. A typology of daily commuters is ongoing and will be compared to the indicators produced by REMUS to qualify the capacity of the different urban areas to generate mobility practices.

Our research postulates that the mobility choices are adapted according to the morphological and functional characteristics of the urban spaces in which the individuals are placed. The final objective will be to produce a method of evaluation existing urban buildings by putting in relation between the location of activities and mobility behaviors in order to find the most favorable structures for non-motorized mobility.

**Keywords:** Sustainable mobility; Urban morphology; Morphological and functional graphs; REMUS.

# Global Sensitivity Analysis for Seawater Intrusion in Fractured Coastal Aquifers

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Seawater Intrusion (SWI) is the subterranean movement of saltwater into freshwater coastal aquifers. It is recognized as a global hazard for coastal aquifers which can result in the salinization of freshwater resources and adversely influencing the lives of millions of people. A large percentage of coastal aquifers around the world are fractured. Fracture networks represent the preferential pathways for fluid flow and transport in the subsurface that can intensify SWI. Therefore, understanding the hydrogeological processes associated with SWI in fractured coastal aquifers (FCAs) are significantly important for prevention of such threats. Although many studies have achieved the modelling of the SWI in fractured coastal aquifers, few have done a thorough analysis of the interrelation of parameters and their influence on the extents of SWI. Thus, the aim of this study is to perform a Global Sensitivity Analysis (GSA) for SWI in an FCA surrogate model. The GSA is developed based on the Polynomial Chaos Expansion. The GSA is performed to provide better physical insights into the effect of fracture location, density, aperture, conductivity and dispersivity on the saltwater wedge. GSA is also helpful to evaluate the influence of the uncertainty imposed by fracture parameters on the problem. This study is based on the Dispersive Henry Problem and is composed of two scenarios. The first scenario deals with one single horizontal fracture and the second test case deals with a network of fractures in the domain. The results show that fracture hydraulic conductivity is the first source of uncertainty on the salinity distribution and imperfect knowledge of fracture location and density affects the toe position considerably. The results provide applicable technical and managerial information regarding control and prevention of SWI in FCAs.

**Keywords:** Seawater Intrusion; Fractured Coastal Aquifers; Global Sensitivity Analysis; Polynomial Chaos Expansion; Dispersive Henry Problem

# Template matching applied to the seismicity induced in the Rittershoffen deep geothermal reservoir

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The deep geothermal site at Rittershoffen (France) was monitored by seismic networks during drilling of the well doublet, stimulation of the well GRT1 and circulation between the two wells. The seismicity induced by these operations can give insight into the geomechanical behaviour of the reservoir and the underground fracture network. To conduct such studies a robust seismic database is needed. In this work the parameter set up for a template matching code which will be used to obtain seismic catalogues from continuous waveforms recorded at Rittershoffen is described. Furthermore, a first overview of the amount of seismic events detected by this algorithm and detection statistics are presented.

The basic concept of the template matching technique is to calculate the correlation coefficient between the waveform of a known event, the template, and the continuous waveform. As template database, we use a manually picked seismic catalogue containing over 1300 events.

Test runs have shown that two parameters influence the results significantly: the detection threshold and the bandpass filter range used to optimize the SNR. To ensure an objective choice of the detection threshold optimized for each setting we implemented an adaptive threshold. To determine the optimal band pass filter range a frequency analysis was conducted. The code was applied to the hydraulic stimulation of GRT1 and the amount and distribution of the detected seismicity evaluated (Fig. 1).

**Keywords:** Induced seismicity; template matching; Rittershoffen deep geothermal reservoir

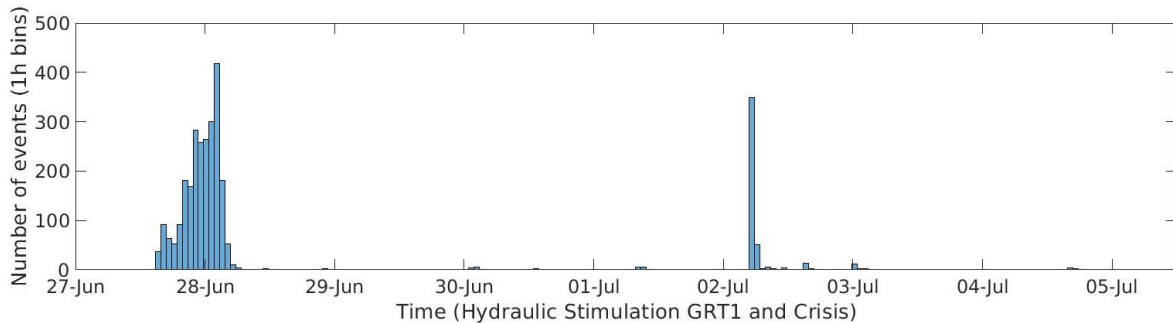


Figure 1: Distribution of the seismicity induced during the hydraulic stimulation of the well GRT1

# Towards monitoring deep geothermal reservoirs in Alsace with ambient seismic noise

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Ability to monitor deep geothermal reservoirs at various stages of their life cycle is crucial for a safe and efficient exploitation. Here we explore a promising monitoring approach based on the cross correlation of the pervasive ambient seismic noise and analyze its potentials and limitations in the context of deep geothermal reservoirs.

Our study focuses on the Rittershoffen geothermal project (northern Alsace, France). Our dataset consists of the continuous seismic records at two short period seismic stations located nearby the site and available since 2012, therefore encompassing the drilling of both wells, hydraulic stimulation of GRT1 and circulation phases.

The noise records are first pre-processed and cross-correlated for every day to produce ambient noise correlation functions (ANCF). We then use a Coda Wave Interferometry (Shapiro & Campillo 2004, Snieder 2004, 2006, Roux *et al.* 2005) method with a stretching approach and using multiple ANCF references (Sens-Schönfelder *et al.* 2014) to estimate velocity variations of the medium in the neighborhood of the two stations.

We analyze our results in three different frequency bands, 0.2-0.5Hz, 1-3Hz and 3-6Hz, corresponding to various sources of ambient noise and various sensitivities with depth, assuming that the coda part of our ANCF is mostly made of surface waves. We observe stable cross correlation functions and coherent velocity variations. But most of these velocity variations are probably not related to the reservoir itself as they can be explained either by temporal changes in the frequency content or the azimuthal directivity of the ambient noise sources or by sub-surface effects like variations of the water table elevation. However, a sudden decrease of coherence, not related to changes in the noise sources, is observed following the hydraulic stimulation in the GRT1 well.

**Keywords:** Ambient noise; monitoring; coda wave interferometry; stretching

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# **Accompanying the voluntary change in the mobility of periurban populations: what information for an effective modal shift tool?**

## **Example of the Strasbourg urban area**

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The information available on the transport offer is plethoric, multi-source and difficult to find even for a volunteer who wants to change his means of transport. In addition, the information describes the transport offer available in a territory while ignoring the specific needs and demands of people.

This project analyses information which contributes to the adoption of more sustainable modal practices among people who are willing to carry a change of modal practices or motivated by reducing their car use. The objective of the project is to determine the relevant combinations of information to favor the sustainable voluntary change of car mobility according to the personal situation of the individual.

Our main working hypothesis indicate that the relevant information pertains to a complex multidimensional system which associate personal aspects, household characteristics and context of residential settlement. In order to identify the information combinations, the study protocol is based on a longitudinal follow-up of volunteers who are willing to give up or reduce their car use and a validity test of the relevant information. This follow-up includes three main steps: 1) Typologies of the voluntary change of the automobile mobility (it means trying to identify the specificities that characterize voluntary people who are more likely to change their automobile mobility in favor of an alternative means of transport), 2) Construction of credible displacement alternatives and identification of the relevant information (through home survey), 3) Test of the relevance information (experimentation of the modal alternative, evaluation of displacement alternatives, test of relevance of information on a control group).

The direct results mainly relate typologies providing targeted and relevant information according to the type of individual, socio-geographic characteristics and heuristic rules of the voluntary and sustainable choice of means of transport based on the segmentation of the suburban population.

**Keywords:** Mobility; Information; Means of transport; Habits



# Water erosion risk mapping using remotely sensed data in central high Atlas, Morocco

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The aim of this study is to develop a methodology using remote sensing and Geographic Information System to map the areas exposed to water erosion risks and highlight the various levels of soil degradation in the Lakhdar river basin (central High Atlas), during the period between 1987 and 2014. This allows producing a map of soil degradation risk, which can be used as reference document for decision-makers.

The methodology develops a geomatics approach based on the processing of satellite images, using the analysis and the interpretation of spectral indices, such as the Form Index, the Coloration Index, the Brightness Index, and the Normalized Difference Vegetation Index (NDVI). The results show that the extent of soil strongly degraded decreased about 900 ha during the period of study whereas the area of soil weakly and moderately degraded was subject of a progressive increase for an approximate total of 2800 ha over 27 years. Moreover, the method of spectral indices allowed to assess and locate soil quantitative loss (organic matter, mineral salts, texture, fertility, etc.) due to the water erosion and climate change. These results show the simplicity and the potential of this approach for water erosion risks mapping. They are also decisive when it comes to establish priority zonation for interventions of erosion control.

**Keywords:** water erosion; spectral indices; remote sensing; Lakhdar river basin; central High Atlas Morocco

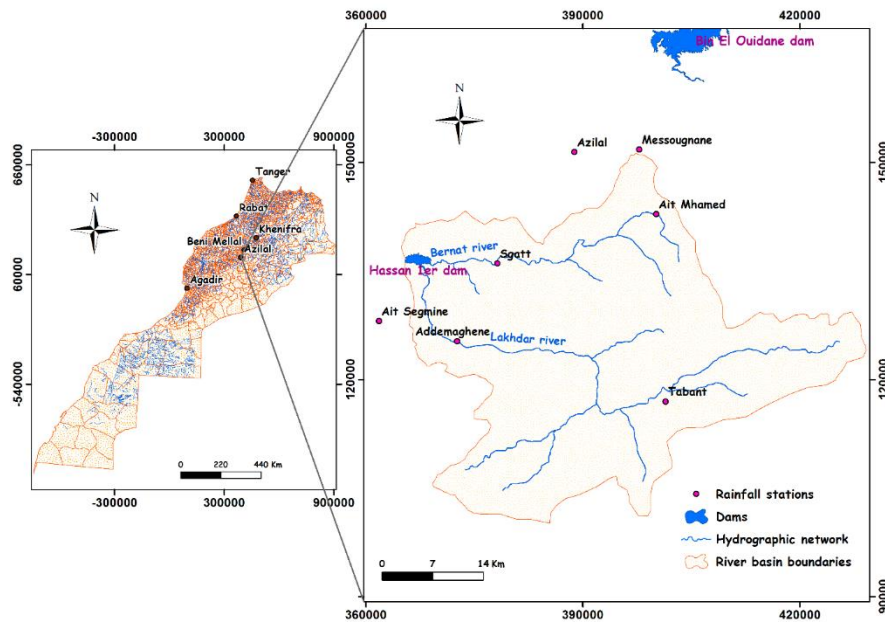


Figure 1: Geographical situation of Lakhdar river basin

## **Lithosphere and crustal necking at rifted margins: what can be seen in seismic reflection data?**

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Lithospheric and crustal necking correspond to one of the key stages in the evolution of hyperextended rifted margins. Although necking has been described in previous studies, the processes of how the lithosphere and crust thin, when and how it occurs and how it is imaged in reflection seismic sections are yet little investigated. The study is based on the observation, interpretation and quantification of necking processes occurring at different rifted margins with different thermal, structural and compositional inheritance. The aim is to describe and quantify the major crustal thinning processes occurring at the transition between the proximal and the distal margin, understand the crustal and stratigraphic architecture and, if present, the link to magmatic additions forming during crustal necking. Understanding the variability of the structures, the controlling parameters and the underlying processes linked to lithospheric/crustal necking is a key to understand the temporal and spatial evolution of rifted margins.

**Keywords:** rifted margins; crustal necking; seismic reflection; observation

# Hydro-morphological study and modelling of the Moselle Sauvage

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The Moselle Sauvage is a regional nature reserve which extends over 12.5 Km between Gripport and Bayon, corresponding to the most dynamic river section of North-East France. This meandering sector is characterized by high lateral and vertical channel dynamics notably resulting from past and/or present human activities (gravel mining, bank protection a diversion dam for electricity generation...). The river morphodynamics exhibit a risk of avulsion which may affect some human constructions such as the bridge of Bainville-aux-miroirs, as well as human activities such as electricity generation. In order to anticipate and assess these impacts, a detailed morphodynamic diagnosis of the river is carried out, according to different spatial and temporal scales. A field monitoring of three years has started in summer 2017, with topo-bathymetric surveys (topo-bathymetric LIDAR), water level monitoring (13 limnimeters), gauging measurements (ADCP) and a survey of sedimentary dynamics (1500 RFID gravel tracers, grain size measurements of both the surface and the subsurface layers, 20 erosion chains, 2 hydrophones, 7 painted bed patches). At the same time, a 1D (HEC-Ras) and a 2D (Telemac/Sisyphe) hydro-sedimentary models are developed to reproduce observed dynamics and anticipate future evolutions of the study reach. On the basis of the two approaches (morphodynamic diagnosis and hydro-sedimentary models), various prospective scenarios of morphosedimentary evolution, for different hydrological forcings and management choices (removal of some bank protections, dam removal...) will be explored to assist managers to choose the most sustainable and efficient management options.

**Keywords:** Moselle sauvage; Morphodynamic; Hydro-sedimentary model; Prospective scenarios

# The potential of the railway network to support the new territorial organization of the regions: modeling of prospective scenarios and accessibility measures on the French Greater East

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The recent modification of the perimeter of the regions by the "NOTRe" law tends to give back to the regional space a coherent area regarding to the evolution of the territorial practices and the spatial representations. However, the French Greater East region remains marked by the juxtaposition of three entities (Alsace, Lorraine, Champagne-Ardenne) where each of them is operated with a specific dynamic.

The networking of these entities represents a means of ensuring a transversal functioning which could be a vector for a greater use of the regional railway network. This networking can be achieved through the rail network itself which is the main instrument of territorial coherence through its dual capacity to support mobility and to determine its emergence.

A decision support tool will be developed in order to highlight the evolutions of the network and the rail services which are needed to address these challenges. An approach by the schedule accessibility, which takes into account the train timetables, will enable the modeling of scenarios previously defined within the prospective part of the thesis.

The results will enable the exploration of strategies for the evolution of regional railway policy. By analyzing the contributions and consequences of some adjustments, a model of a new railway system that answers the initial problematic must be proposed.

**Keywords:** coherence; territories; mobility; modeling; accessibility; railway network; regionalization; Greater East.

# Aquifer parameters inversion using an adaptive multiscale procedure

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The identification of aquifer parameters (i.e. porosity and hydraulic conductivity) is crucial for the process of modeling groundwater flow and contamination. Inversion techniques allow to unravel complex systems heterogeneity, computing parameter fields through an automated minimisation between simulated and measured data (i.e. water head or aquifer parameters).

This study uses an Adaptive Multiscale Triangulation (AMT), which dissociates the parameter grid from the calculation mesh and refines it under zonal minimisation criteria, shortening the computation time while ensuring flexibility in regard to the parameters distribution. Groundwater flow is described by a nonlinear diffusion-type equation, discretised with a 2D nonconforming finite element method, water head data not being suitable to invert 3D parameter fields. Therefore, flow is considered mainly horizontal and the parameters are obtained as average value on the aquifer thickness.

The study area is a single layer alluvial (unconfined) aquifer of 7.6 km<sup>2</sup>, situated in the southern, Mediterranean part of France. The inversion run with a chronicle of 44 piezometers over 5 years (2012-2017). Best converging simulations show few mismatch between calculated and observation values:

mean error 0.07 – 0.22 – 0.82 / error standard deviation 0.01 – 0.15 – 0.25 [min – mean – max of 44 chronicles].

In short notice, these results are destined to constrain a geostatistical procedure, in order to generate 3D parameter fields, required to run contamination models.

**Keywords:** Groundwater flow; Inverse method; Multiscale parametrisation

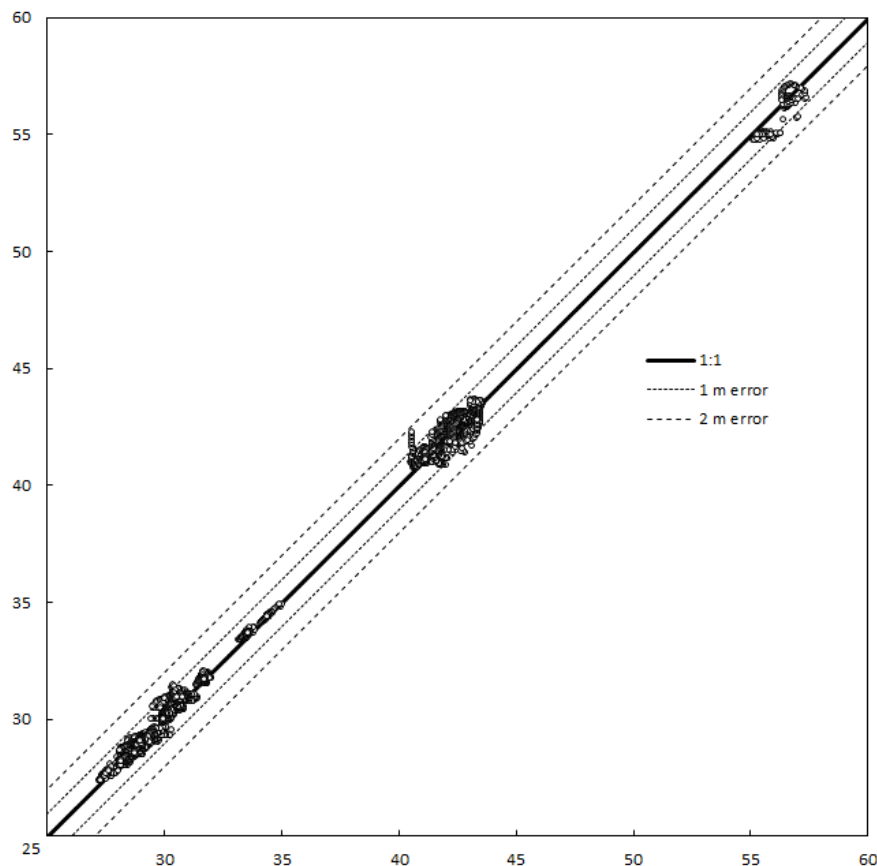


Figure 1: Hydraulic head (m) - observed data (x-axis) vs simulation (y-axis)

# **Toward a better characterization of small to moderate earthquakes seismological pattern in Northeastern France**

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Seismic risk assessment in intraplate regions with low surface deformation, such as Northeastern France, and its border countries of Germany and Switzerland, faces important challenges related to vulnerability due to the : high density of population, numerous industries with sensitive activities (nuclear power plants, mines, quarry blasting, chemical and bacteriological industries), and fragile historical heritage to protect. However, despite being located at the middle of the western Europe, seismic hazard estimation in our study area remains poorly constrained, especially because of lack of knowledge on active structures identification and the nature of the processes responsible for earthquakes. Furthermore, the regional seismicity encompasses significant historical and recent earthquakes (intensity up to IX and X), together with a regular activity heterogeneously distributed over the whole region, and affecting all the main geologic domains: the Upper Rhine Graben, the ancient massifs of the Vosges and the Black Forest, the Jura mountains with the molassic basin and the Alps.

We focus here on the small events, who's the space time evolution and the statistical analysis are important criteria to characterise the seismic behaviour of the region and its potential seismogenetic structures. By taking advantage of an exceptional, recently densified seismic network (development of temporary stations (2015-2020) in the framework of the European AlpArray project, reinforcing the growing permanent national networks of France, Germany, and Switzerland), we are building a new seismic catalogue following a methodology specifically adapted to this network and its low level of detection, the current regional seismicity and the large amount of waveforms analysed. Doing so, we reduce the magnitude of completeness and access to more accurate hypocentral localizations and magnitude estimations, which are crucial for the seismic event classification and a better characterisation of the seismic behaviour of the region.

**Keywords:** intraplate zone, micro-seismicity, automatic detection, automatic discrimination

# Bioretention cells for removal of benzotriazole from urban stormwater runoff

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Benzotriazole is a corrosion inhibitor commonly found in vehicle fluids and antifreeze liquids. It is considered an emerging contaminant due to its resistance to degradation and persistence in the environment. Benzotriazole is found in surface waters around the world and enters the aquatic environment largely through urban stormwater runoff. This study focused on the potential of bioretention cells to limit benzotriazole pollution in urban stormwater runoff.

Adsorption and desorption experiments were conducted over a range of temperatures and salinity levels using engineered bioretention soil and hardwood mulch. Both substrates were collected from an active bioretention cell at the Kortright Centre for Conservation in Vaughan, Ontario.

The results indicated that the soil had a higher adsorption capacity compared to the hardwood mulch. Desorption was observed for both media, where benzotriazole was released back into the aqueous phase. The potential for desorption increased with benzotriazole concentration, nearing completely reversible adsorption at the highest levels. Additionally, lower temperatures yielded both higher adsorption coefficients and a higher potential for desorption at low concentrations of benzotriazole. Adsorption and desorption potential were also seen to increase at higher salinity levels.

The results of these experiments showed that bioretention cells may temporarily remove benzotriazole from urban stormwater runoff via adsorption. Desorption may occur, resulting in remobilization of the contaminant during subsequent rain events. Remobilization of benzotriazole is more likely to occur in colder seasons and in areas where salt is used for de-icing activities; however, this is not expected to have a significant impact in the field due to the low concentrations of benzotriazole observed in urban stormwater. While the efficiency of bioretention cells to control traditional contaminants has been demonstrated, this study shows that bioretention cells can also help mitigate some of the many trace organic chemicals transported by urban stormwater runoff.

**Keywords:** adsorption, benzotriazole, bioretention cell, desorption

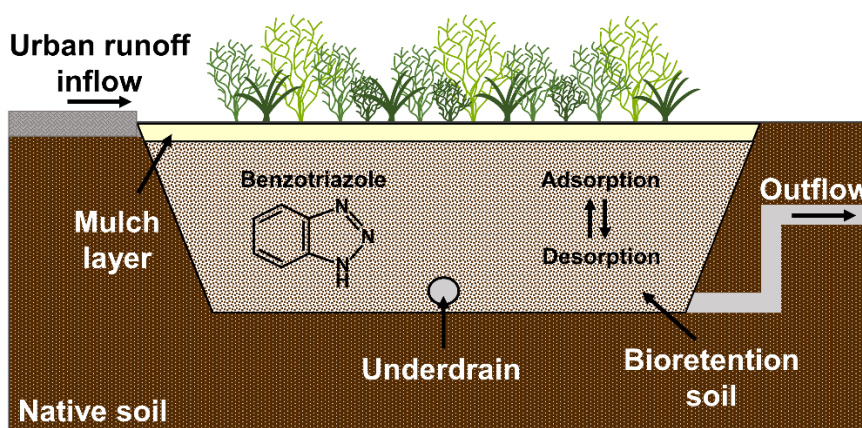


Figure 1: Representation of benzotriazole adsorption and desorption in a bioretention cell

# Integrating urban and regional metabolism into territorial governance: data issues and restitution

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The development of our societies is facing sustainability issues. Resources extraction and waste emissions have reached unsustainable levels, resulting in worrisome loss of ecosystem services and rarefaction of resources. Thus, assessment of human activity impacts has become a requirement in order to reduce these impacts, without compromising a sufficient quality of life to which people aspire.

Territorial metabolism (Figure 1) is one of the approaches for assessing these impacts: we focus our attention on the inputs needs (goods, material or energy) of a territory (which can be a city, a region, a country), their transformation, and the ensuing outputs (waste or exported goods). This tackles environmental issues which are resulting of too high and more or less toxic material flows from our anthropic ecosystems to the natural one, and vice versa.

However, the approach has limits due to the complexity of data retrieval and analysis. Thus, the thesis aims to analyse the methods for evaluating territorial metabolism, through the different steps of data gathering, processing and restitution. This will highlight difficulties, but it is also intended to enlarge the possible applications. We will explore methods to overcome the difficulties and to facilitate the actors over a territory to integrate this accounting into governance of territories.

This work should allow for reducing efforts mobilised during the quantitative analysis of territorial metabolism, and for bringing more information with a better quality to the actors to help them in defining sustainable strategies. The methodologic results will be applied regarding the case of the Grand-Est region.

**Keywords:** Urban and territorial metabolism, Material and energy flow analysis

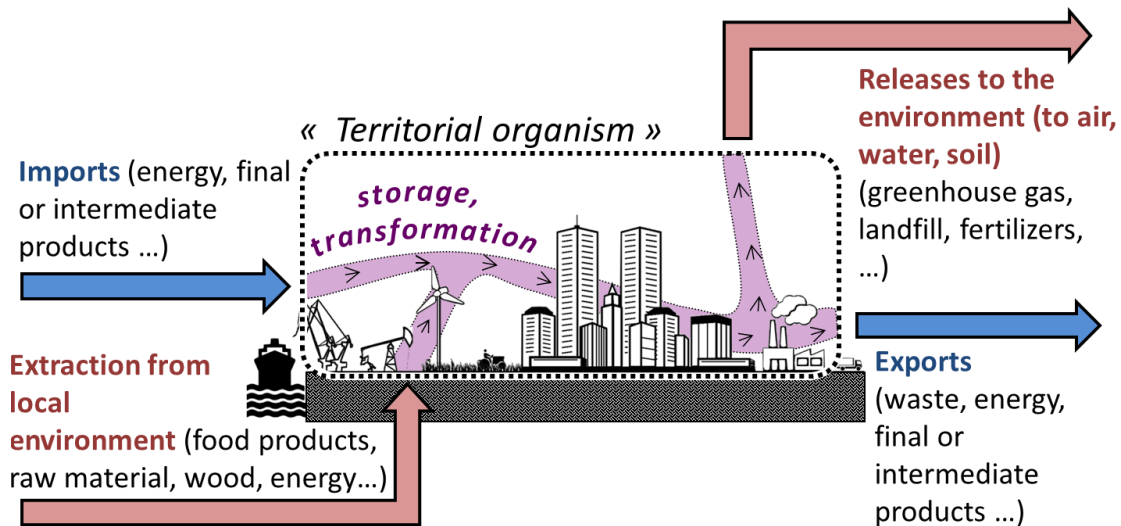


Figure 1: A territory and its metabolism



