

JUL 2026

Newsletter n°2



GEOLEARNING

DATA SCIENCE for the environment



INRAE

ON THE AGENDA

Geolearning news

- Geolearning Scientific Day
- G. Jacquemin's PhD defence
- Successful postdoctoral fellows
- Denis Allard awarded

International conferences

- Extreme events in agriculture and forestry
- 25th Congress of Actuaries
- METMA XII
- 57th Journées de Statistique

Research projects

- Prediction of deformations
- Rainfall scenarios with long dry spell

Recent Publications

- Simulating complex Gaussian processes
- Three new prediction methods

New features in gstlearn

Research seminar

23 - 27 November 2026

see p.12

EDITO

We are pleased to present the second edition of the Geolearning newsletter.

In this issue, we celebrate recent academic successes within Geolearning – the successful first PhD defence and the appointment of two of our postdoctoral fellows as Assistant Professors (Maîtres de Conférences).

We also highlight scientific achievements driven by Geolearning, on topics ranging from spatio-temporal predictions in underground galleries to stochastic simulations of complex patterns. Our research results continue to receive significant attention. As of 30th June, a preliminary assessment indicates 18 scientific publications, and more than 40 contributions to international conferences.

Capitalizing on our success, the Geolearning team is undertaking the renewal of its research Chair for the 2027-2031 period. In close collaboration with our sponsors, we are expanding our scope and priority areas in order to build the future research program.

This strategic vision will materialise in November 2027 during an internal seminar, aimed at structuring our future projects: PhD theses, post-doctoral fellowships, partnerships and software.

Companies wishing to join this research initiative are invited to contact us.

Denis Allard & Thomas Romary
Chair Holder & Co-Holder

FOCUS ON OUR GEOLEARNING NEWS



Geolearning day - 8th April

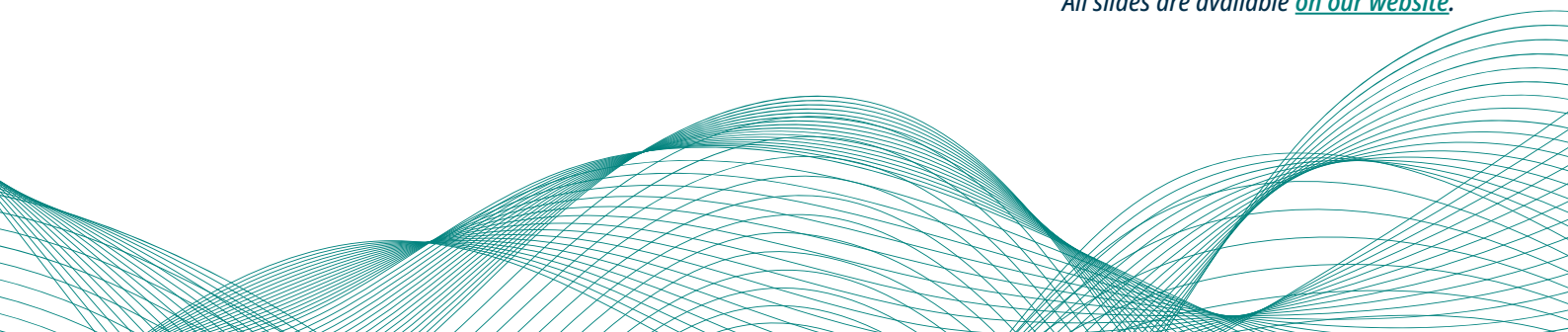
*On 8th April
2026, the
Geolearning
Chair held a
scientific event
at Mines Paris —
PSL.*

On 8th April 2026, the Geolearning Chair held a scientific event at **Mines Paris – PSL**, organised by **Nazanin Ebrahimi**, Head of Funded Research and Chairs at Mines Paris.

- First, the sponsors were presented with various projects supported by the Chair.
- The second part was an open event focusing on state-of-the-art approaches and emerging challenges in physics inspired statistical learning for space-time data, extreme events and generative AI for environmental and climate data.

We warmly thank all participants, particularly those representing our sponsors.

All slides are available [on our website](#).



All participants at Geolearning day, 8th April 2026

SPOTLIGHT ON OUR GEOLEARNING TEAM



Grégoire Jacquemin's PhD Defence

"Compound climate events: statistical modelling and influence of multivariate bias correction on their evolution under climate change"

We congratulate Grégoire Jacquemin who successfully defended his PhD on 7th April 2026 at Mines Paris – PSL.

Grégoire is the very first PhD candidate of the Chair. He was co-supervised by [Denis Allard \(BioSP, INRAE\)](#), [Xavier Freulon \(STIM, Mines Paris – PSL\)](#) and [Mathieu Vrac \(LSCE, CNRS\)](#).

- A novel approach, named **bi-GPD**, employing **cutting-edge extreme value theory** has been proposed and benchmarked to current methods.
- Special attention was given to temporal dependencies and to allow considering spatially distant events that are relatively close in time.
- On reanalysis data, the new bi-GPD approach showed to be more accurate than state-of-the-art methods.

We also refer the interested readers to our [first Newsletter](#) for further details.

Grégoire now holds a **post-doctoral position at ENSAE**, funded by the Chair [CARE \(Assurability of Emergent Risks\)](#) led by [Olivier Lopez](#). He works on the spatial evolution of compound events and the modelling of hailstorm insurance losses with deep learning. We wish him the best of luck in his future endeavours.



Grégoire Jacquemin's PhD defence, 7th April 2026, Mines Paris – PSL

SPOTLIGHT ON OUR GEOLEARNING TEAM

Successful postdoc researchers

We are very happy to announce that **two postdoc researchers funded by the Geolearning Chair have been recently recruited to permanent positions**. We wish Antoine and Charlie every success in their new endeavours and look forward to embarking on fruitful collaborations.



Antoine Heranval

BioSP, INRAE

Antoine will be Assistant Professor at **Devinci Higher Education**.

He will join the new campus of the **École Supérieure d'Ingénieurs Léonard-de-Vinci (ESILV)** in Nantes, where he will teach statistics and actuarial science. He will also develop and coordinate a new specialization in Sustainable Finance & Insurance, which will initially be offered as an option and is expected to evolve into a full Master's program in the future. In parallel, he will continue his research on the statistical modelling of extreme climate events.



Charlie Sire

STIM, Mines Paris — PSL

Charlie will be Assistant Professor at **AgroParisTech**.

He will join the **MIA Paris-Saclay joint research unit**, where he will continue his research on statistical learning for spatial and spatio-temporal phenomena, with a focus on incorporating physical information into the models under consideration. Alongside his research, he will contribute to the school's teaching activities, particularly in statistical methods applied to life and environmental sciences, and agronomy.

Denis Allard awarded IAMG Georges Matheron Lecturer



Denis Allard has been awarded the 2026 **Georges Matheron Lecturer by the International Association for Mathematical Geosciences (IAMG)**.

This award is named after the founder of Geostatistics and former Professor at Mines Paris – PSL.

Denis Allard will give his lecture "**From probability aggregation in geosciences to ensemble aggregation in climate sciences**" at the 24th Annual Conference of the International Association for Mathematical Geosciences in Montreal, Canada, 23th - 28th August 2026. This lecture will include results obtained in an ongoing project funded by the Geolearning Chair on the aggregation of tail distributions in multi-model ensemble outputs.

PARTICIPATION TO INTERNATIONAL CONFERENCES

Extreme events in agriculture and forestry: challenges, methods, applications

An **interdisciplinary international workshop on extreme climate events and their impacts in forestry and agriculture**, such as droughts, heatwaves, wildfires or yield losses, was organised in Avignon in June 2026, with support from the Geolearning Chair. It gathered around 50 participants on-site.

It featured key contributions by leading scientists such as **Freddy Bouchet** (LMD, CNRS), **Dim Coumou** (Vrije Universiteit, Amsterdam), **Christelle Hely** (EPHE-PSL) and **Pascal Yiou** (LSCE, CEA).

Several talks highlighted recent results developed within the Chair, by **Denis Allard** (BioSP-INRAE) on the utility of multivariate spatio-temporal stochastic weather generators and their ability to represent complex extreme-event patterns, by **Antoine Heranval** (BioSP-INRAE) on analysing compound climate events using point processes, and by **Antoine Doizé** (LPSM-Sorbonne University) on modelling the alternation of wet and long dry spells.

All presentations are available to [download](#).



During their different growing stages, agricultural crops can be exposed to a large variety of harmful climate extremes, and to particularly problematic combinations in compound events.

57th Journées de Statistique de la SFdS

The **French Statistical Society's (SFdS) annual Journées de Statistique** took place at the University of Clermont-Ferrand, from 1st to 5th June 2026.

This year's conference featured captivating keynote lectures, including discussions on the future of mathematics in the era of AI and the statistical evaluation of climate accords, alongside specialized sessions on point processes, extreme event modelling, spatial statistics, and diffusion models.

The **Geolearning Chair** was strongly represented at the event, with five of its researchers presenting their work: **Nicolas Lafon** on modelling extreme river flows in Eastern Quebec, **Tiziano Fassina** on short horizon diffusion sampling, **Mike Pereira** on Bayesian prediction for non-stationary spatial data, **Charlie Sire** on uncertainty quantification of predictors using splines on compact Riemannian manifolds, and finally **Gabriel V. Cardoso** on stability in score-based generative AI approaches.

PARTICIPATION TO INTERNATIONAL CONFERENCES

Dedicated workshop at the 25th Congrès des actuaires

During the 25th Congrès des actuaires, the Geolearning Chair hosted a workshop dedicated to extreme weather events. This workshop addressed issues related to compound extreme events, their modelling, and the challenges associated with their integration into risk management frameworks.

The **PhD project by Grégoire Jacquemin** and the **postdoc project by Antoine Heranval**, both funded by the Geolearning Chair, illustrated these concepts through case studies such as simultaneous flooding in two major French watersheds linked to accumulated rainfall, major floods triggered by extreme rainfall on already saturated soils, meteorological precursors to forest fires, the links between storms and floods at the European scale, and large-scale dependencies for certain hazards.

The modelling methods include multivariate extreme value theory, copulas, spatio-temporal approaches, extreme dependency analysis, and the integration of climate projections.

Attendees:



Antoine Heranval
Chercheur Postdoctoral
INRAE BioSP



Marie-Laure Fandeur
Head P&M Reinsurance
SCOR



Denis Allard
Directeur de Recherche
INRAE BioSP



Grégoire Jacquemin
Chercheur Postdoctoral
ENSAE Paris

12th International Conference on Spatio-Temporal Modelling

METMA XII, the 12th International Conference on Spatio-Temporal Modelling, was hosted by Universidad de Zaragoza from 8th to 10th June 2026. This conference aims to **promote the development and application of spatial, temporal and spatio-temporal statistical methods in health and environmental research.**

Four presentations were given by Geolearning Chair researchers:

- Prediction of spatio-temporal data on meshed surfaces using advection-diffusion SPDEs - **Lucia Clarotto**
- Neural Simulation-Based Inference methods for complex spatio-temporal models - **Alexandre Loret**
- Smooth trajectories and long-range dependence: A Fractional SPDE approach for spatio-temporal modelling - **Mike Pereira**
- Non-stationary spatio-temporal modelling by deep kernel learning - **Thomas Romary**

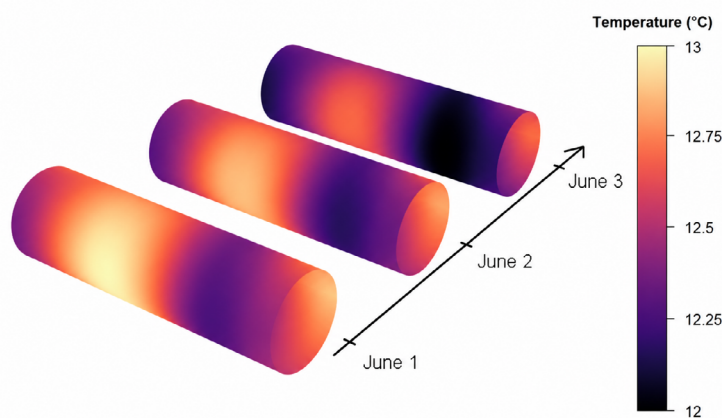


FOCUS ON OUR RESEARCH PROJECTS

Spatio-temporal prediction of deformations in underground galleries

In the context of **nuclear waste disposal**, the **French National Agency for Radioactive Waste Management (Andra)** requires **methods to monitor underground storage galleries**. These cylindrical tunnel-like structures demand continuous tracking of surface temperature and deformation.

Spatio-Temporal Prediction of Surface Temperature on the Cylinder



Spatio-temporal prediction of surface temperature on a cylindrical domain over three consecutive days (1, 2, and 3 June).



Charlie SIRE

*Post-doc researcher
STIM, Mines Paris – PSL*

Charlie will be Assistant Professor at **AgroParisTech** in the **MIA Paris-Saclay joint research unit**.

The postdoctoral project of Charlie Sire addressed the following challenge:

Given sparse sensor measurements collected daily, how can one model spatio-temporal fields of deformation and temperature to predict their value at any point on the surface and at any time?

This problem raises three main challenges:

- accounting for the cylindrical geometry of the galleries, which requires statistical methods on Riemannian manifolds
- handling large spatio-temporal datasets generated by daily observations
- and modelling the physical coupling between temperature and deformation.

To address these issues, the observed signals were decomposed into a deterministic trend and a stochastic residual.

New spline interpolation methods on compact Riemannian manifolds were developed to estimate the trend (see the publication in [Numerical Algorithms](#)), while the residuals were modelled through a system of coupled stochastic partial differential equations (SPDEs), providing an efficient framework that naturally captures both the gallery geometry and the dependence between the two physical quantities.

Joint work with Mike Pereira and Thomas Romary (STIM, Mines Paris).

FOCUS ON OUR RESEARCH PROJECTS

Generating rainfall occurrence scenarios with long dry spells in southern Europe

Prolonged dry spells are among the most consequential climate extremes, reducing crop yields, lowering river flows and straining water supplies. Reproducing them realistically is central to weather simulation. Yet the Markov chain models, traditionally used for scenario generation, systematically underestimate the longest dry spells.

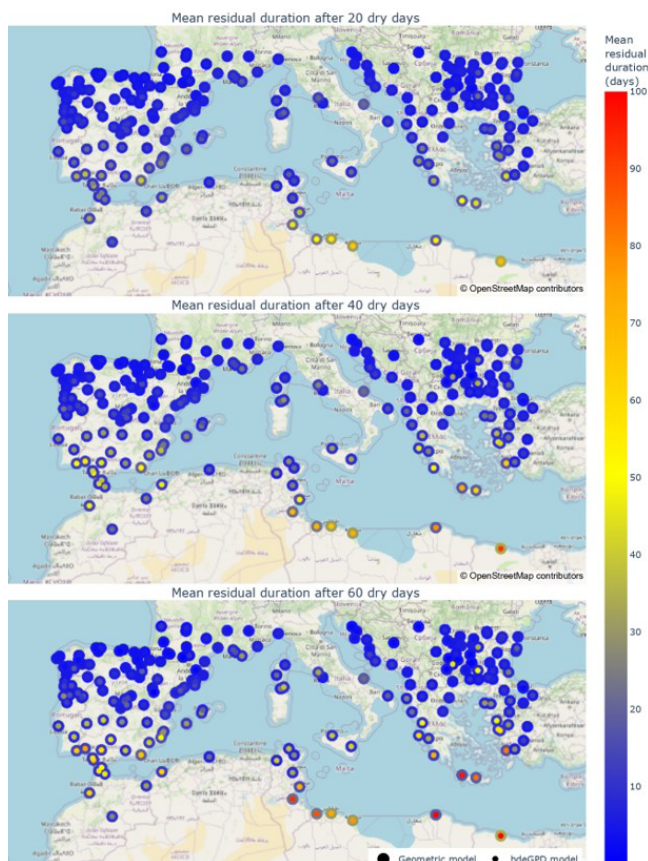
Antoine Doizé proposed a new model, the **Binary Markov Chain with Duration (BMCD)**, and compared it to a baseline geometric model, characteristic of classical two-states first order Markov chains.



Antoine DOIZÉ

*3rd year PhD student, LPSM,
Sorbonne University*

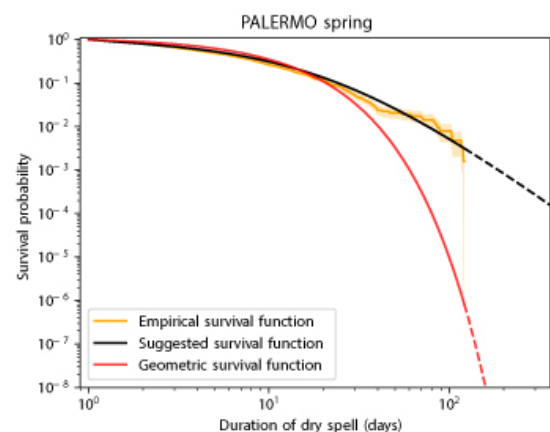
PhD defence will take place in
2027.



Mean residual dry spell duration over Europe (spring).

Both approaches are compared in Palermo, spring: **long dry spells are much more accurately modelled by the BMCD.**

The expected remaining length of dry spells that have already lasted several weeks in spring is shown for 200 stations across southern Europe. The largest differences are concentrated along the Mediterranean coast. For severe dry spells, the standard approach badly underestimates exposure to extreme dry conditions.



Survival function of dry spell length in Palermo (spring).

Joint work with **Denis Allard** (BioSP, INRAE), **Philippe Naveau** (LSCE, CNRS) and **Olivier Wintenberger** (LPSM, Sorbonne University). A submitted manuscript, code, data and figures are available on the following [GitHub repository](#).

FOCUS ON OUR RECENT PUBLICATIONS

SPATIAL STATISTICS AT THE DAWN OF AI the Geolearning Chair in the spotlight

Following the conference **Spatial Statistics 2025: At the Dawn of AI**, held in Noordwijk, The Netherlands in July 2025 (see also the [first Newsletter](#) dated February 2026), a series of papers authored by the Geolearning researchers has been accepted for publication in the dedicated special issue of the Spatial Statistics journal. The primary focus of these contributions is on spatio-temporal modelling with numerous breakthroughs in embedding physics, machine learning or deep learning techniques in spatio-temporal models.

Prediction of spatio-temporal data on meshed surfaces using advection-diffusion SPDEs

Mike Pereira (STIM, Mines Paris), Lucia Clarotto (MIA Paris-Saclay), Nicolas Desassis (STIM, Mines Paris)

The paper presents a computationally efficient framework for modelling and predicting spatio-temporal processes on curved surfaces using advection–diffusion SPDEs. By discretising these equations with a Galerkin method, the authors enable scalable simulation and inference for Gaussian random fields on manifolds. The approach is demonstrated on synthetic data over the sphere and on global aerosol optical depth observations.

Combining machine learning quantile regression and Gaussian random fields: a general framework for modelling and simulating space-time processes

Said Obakrim (IDYST), Denis Allard (BioSP, INRAE), Lionel Benoit (BioSP, INRAE), Grégoire Mariéthoz (UNIL, IDYST)

The paper presents a framework that integrates machine learning quantile regression with Gaussian random fields to model space-time processes with potentially misaligned covariates. The target variable is expressed as a latent Gaussian field adjusted through covariate dependent quantile estimates. The method is demonstrated on synthetic data and on daily maximum temperatures in northeast Switzerland conditioned on seasonal and large-scale atmospheric factors.

Deep kernel learning for geostatistics: Learning spatial deformation with normalizing flows

Thomas Romary (STIM, Mines Paris), Solal Raymondjean (STIM, Mines Paris), Nicolas Desassis (STIM, Mines Paris)

The paper introduces a neural network–based space deformation approach for non-stationary Gaussian processes. Using normalizing flow architectures, it learns a bijective transformation that maps geographic coordinates into a space where stationarity holds, enabling more accurate spatial prediction. The deformation and kernel parameters are jointly optimised via scalable likelihood methods, with results demonstrated on synthetic and real datasets.

Further information at: <https://www.sciencedirect.com/special-issue/1010N546F68>

FOCUS ON OUR RECENT PUBLICATIONS

Simulating complex Gaussian processes

The paper "**Modelling and simulating spatio-temporal, multivariate and non-stationary Gaussian Random Fields: a Gaussian mixtures perspective**" has been accepted for publication in **Statistical Science**, a leading journal whose purpose is to **present contemporary statistical topics accessible to the wide community of practitioners, researchers and students** of statistics, machine learning and data science.

Denis Allard

Research Director, BioSP, INRAE

Lionel Benoit

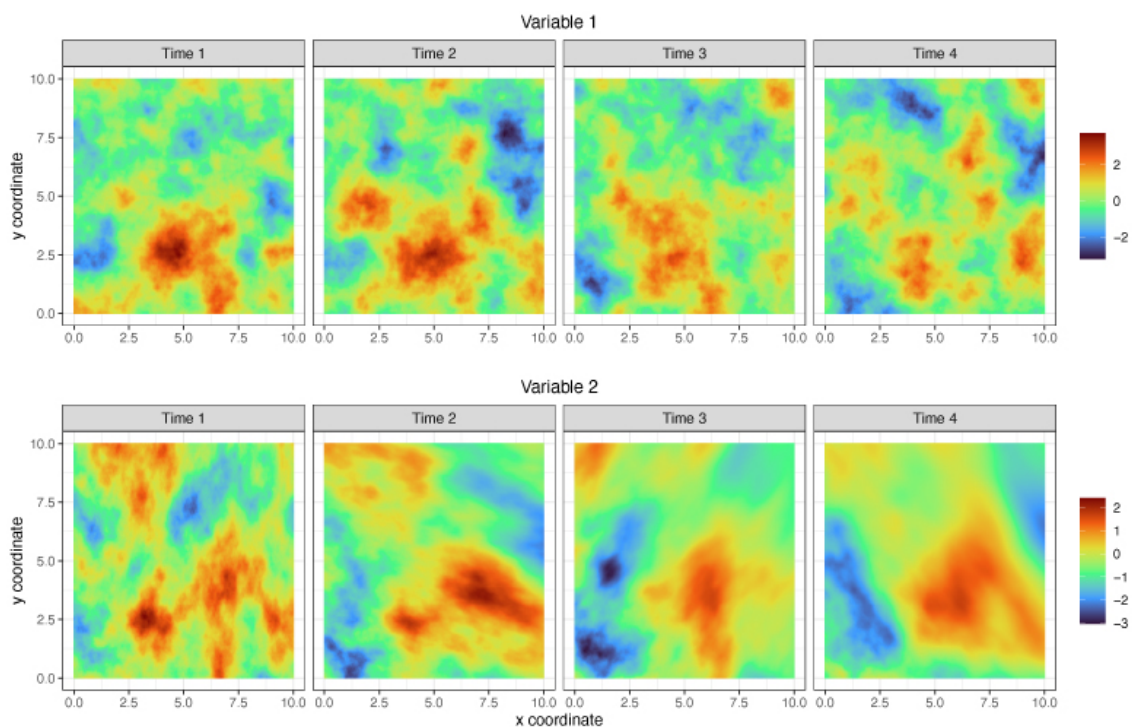
Research scientist, BioSP, INRAE

Said Obakrim

*Postdoctoral researcher in the
GAIA research group, UNIL*

This work leverages the **Gaussian mixture perspective** to propose new classes of covariance kernels for non-stationary (univariate or multivariate) spatio-temporal Gaussian Random Fields, as well as simulation algorithms for those that are currently missing in the framework of spectral simulation.

These theoretical advances are essential building bricks for designing stochastic weather generators in complex settings, with several variables in non-homogeneous contexts.



Realisation of a bivariate random field with non-stationary covariance over four time steps, where the first variable is isotropic and stationary and the second is anisotropic and non-stationary

FOCUS ON OUR SOFTWARE

gstlearn software new features

The new release v1.11.1 of our **Geostatistical and Machine Learning C++ Library** and Packages has been delivered on 19th June 2026 (compatibility with python 3.14 and R 4.6.0).

The **multivariate spatio-temporal models developed by the Chair's researchers** (Allard et al. 2026) have been integrated into the geostatistics toolbox of gstlearn. Additionally, the Vecchia approximation method has been incorporated, enabling the application of covariance-based geostatistics to very large datasets. This complements the SPDE approach, which is now expanding into non-Euclidean spaces, such as spheres and arbitrary manifolds, aligned with the Chair's research themes.

[MORE DETAILS HERE](#)

Nicolas Desassis

STIM, Mines Paris – PSL

Xavier Freulon

STIM, Mines Paris – PSL

Pierre Guillou

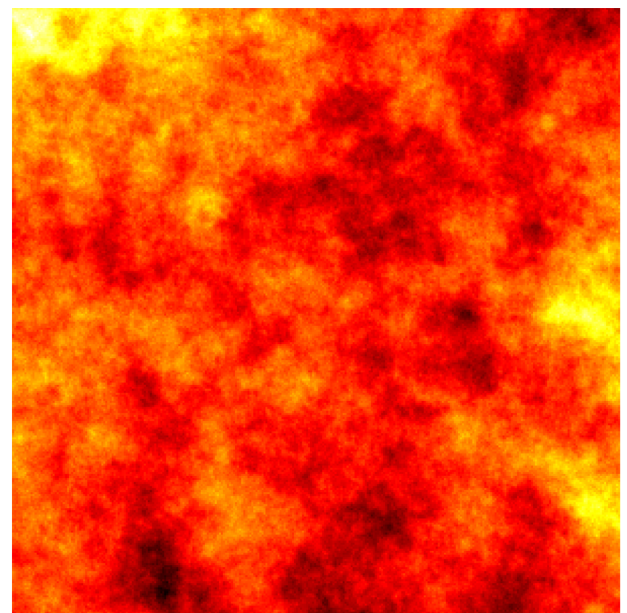
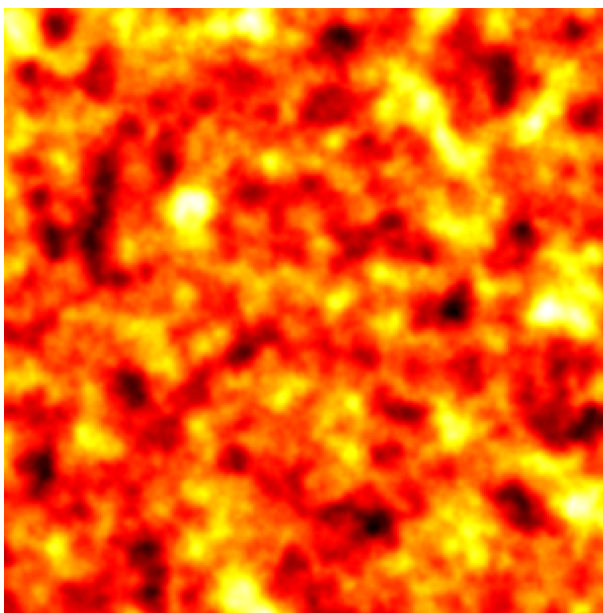
Geosciences, Mines Paris – PSL

Fabien Ors

Geosciences, Mines Paris – PSL

Didier Renard

STIM, Mines Paris – PSL



Example of bivariate Matern covariance with different smoothness parameters



HEADING TOWARDS 2027-2031

The Geolearning Chair is driving forward its renewal for the 2027-2031 period.

2nd Geolearning seminar

Aussois (Savoie, France)

from 23rd to 27th November

This event brings us together to share our latest breakthroughs and spark exciting new research projects to be launched in the fall of 2027.

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