FEB 2026

Newsletter n°1

GEOLEARNING

MINES PARIS | PSL | INRAE

DATA SCIENCE for the environment

ON THE AGENDA

Presenting the Geolearning team

- The team
- Welcome to our new PhD students & team members

International conferences

- Spatial Statistic 2025
- Workshop on Stochastic Weather Generators

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- Return periods for compound events
- Analyzing extreme events using point processes
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SAVE THE DATE

Geolearning event

8th of April, 2026

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EDITO

Welcome to the Geolearning Newsletter!

We are thrilled to launch the first edition of the Geolearning newsletter! Twice a year, we will share insights from our research at the intersection of geostatistics, extreme events, and machine learning, all in service of the climate transition.

Climate change is causing unprecedented extreme climate events, from devastating heat waves to catastrophic floods and radical change in precipitation patterns. At Geolearning, we develop innovative methods to better understand, quantify, and respond to these threats. Our work bridges traditional boundaries: combining the spatial precision of geostatistics with the predictive power of machine learning and the rigor of extreme event theory.

This collaboration between Mines Paris and INRAE brings together two leading teams with a shared vision: breaking down barriers between disciplines to tackle real-world problems in environmental and climate sciences. Through doctoral research, open-source software, and knowledge transfer, we are building a new field—one we call «Geolearning.»

In these pages, you will discover a selection of our latest research, meet our team, and learn how our methods are making a difference. We are excited to bring you along on this journey.

Thank you for joining us!

Denis Allard & Thomas Romary
Chair Holder & Co-Holder

PRESENTING THE GEOLEARNING TEAM

This chair brings together two leading research teams that have established a long-standing collaboration through the supervision of doctoral theses, joint scientific projects, the coordination of a scientific network and teaching.

- The **Statistics and Images (STIM) center** of **Mines Paris - PSL**
- The **Biostatistics and Spatial Processes research unit** (BioSP) **MathNum Department** at INRAE

Denis ALLARD

Research director - INRAE
Geolearning Chair holder

Doctor in geostatistics from Mines Paris, Denis Allard is Research Director with the Biostatistics and Spatial Processes (BioSP) Research Unit of the National Research Institute for Agriculture, Food and the Environment (INRAE).

His research covers a wide range of topics in statistics for the modeling and analysis of spatiotemporal data, with applications in geosciences, environment and climate sciences. Recent applications cover the analysis and simulation methods for extreme climatic events, in connection with the climatic risks induced by climate change.

Denis Allard is part of the steering committee of the XRISQUES meta-program at INRAE, the objective of which is to develop interdisciplinary research around multiple risks in a context of global change.

Thomas ROMARY

Professor - Mines Paris PSL
Geolearning chair Co-holder

Doctor of mathematics from Pierre and Marie Curie University (Sorbonne University), Thomas Romary is professor in the Statistics and Images (STIM) center of Mines Paris PSL.

His research focuses on the development of statistical methods and their application to issues arising from earth and environmental sciences. Among his recent contributions, we can mention the application of data assimilation methods in water quality, spatio-temporal geostatistics by Stochastic Partial Differential Equations and the development of deep generative models for various problems in geosciences.

Thomas Romary is also in charge of the probability course in the first year of the civil engineering cycle at Mines Paris PSL and co-responsible for the Geostatistics and Probability option.

WELCOME TO OUR
NEW PhD STUDENTS

Alexandre LORET

Effective methods for inferring spatio-temporal models

Alexandre Loret began his graduate studies with a double degree in mathematics and computer science at Paris-Saclay University, followed by a master's degree in statistics "Math and AI".
The goal of his thesis is to find efficient methods for estimating the parameters of stochastic models for spatio-temporal data.

Tiziano FASSINA

Generative AI for extreme events

Tiziano Fassina is a PhD researcher in generative artificial intelligence at Mines Paris. With a background in mathematics, philosophy, and deep learning, he sees science as a driver of innovation and deeper understanding of the world.
His research focuses on modeling extreme climate events, such as heavy rainfall, using modern generative models.

AND TO OUR
NEW TEAM MEMBERS

Nicolas LAFON

Permanent researcher, BioSP, INRAE

Author of a PhD thesis in statistical learning for geosciences, Nicolas investigates the interactions between generative methods and the mathematical theory of extreme values in order to better model and assess risks related to natural disasters.

Ahmed BOUALAM

Software developer, BioSP, INRAE

Ahmed has a generalist background in mathematics and computer science, having studied at Telecom Paris and University College London. His experience ranges from 3D physics simulations to Data Science combining statistics and the latest technologies like deep-learning.

PARTICIPATION TO
INTERNATIONAL CONFERENCES

Spatial Statistic 2025: *at the dawn of AI*

Denis Allard was one of the co-chairs of the "Spatial Statistics 2025: at the dawn of AI" conference which took place in Noordwijk, Netherlands, 14th-18th of July, 2025.

The Geolearning Chair hosted a dedicated session with presentations given by **Lucia Clarotto**, **Gabriel Victorino Cardoso** and **Thomas Romary** and organized a pre-conference tutorial class on Denoising Generative Models, given by **Gabriel Victorino Cardoso**.

Members of the Geolearning Chair at the Spatial Statistics Conference.

Two researchers participating in the Geolearning Chair, **Edith Gabriel** and **Mike Pereira**, have addressed keynote presentations.

PARTICIPATION TO
INTERNATIONAL CONFERENCES

Workshop on Stochastic Weather Generators

Members of the Geolearning Chair contributed to the success of this event with six presentations and one poster.

Stochastic weather data generators are essential components of many studies, such as agricultural and hydrological risk studies, stochastic downscaling of climate models, or infrastructure safety studies.

Sponsored and co-organized by the Geolearning Chair, SWGEN 2025 brought together a broad panel of more than 80 researchers, practitioners and graduate students in statistics, applied mathematics, hydrology, atmospheric sciences, climate and energy sciences to discuss and disseminate state-of-the-art methods and recent applications of stochastic weather data generators.

Applications included hydrology, renewable energies, environmental engineering as well as the insurance sector.

FOCUS ON OUR
RESEARCH PROJECTS

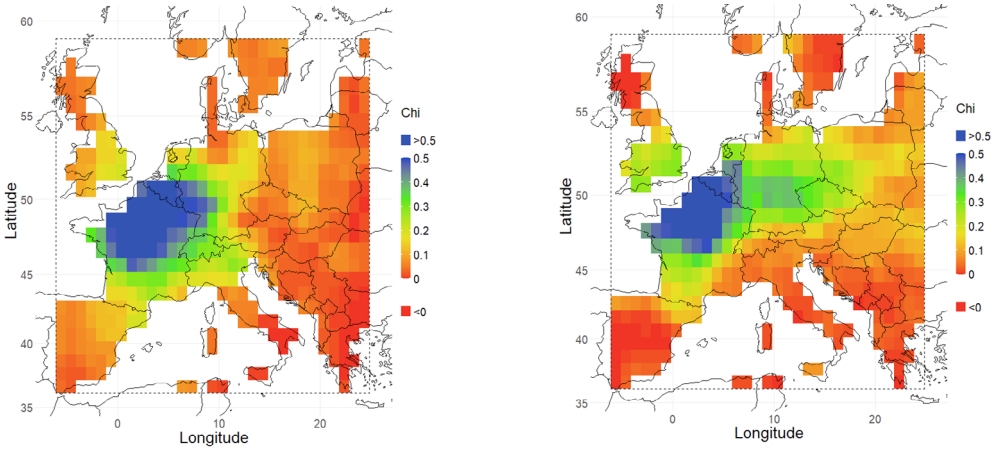
Return periods for compound events

Recent decades have witnessed a number of climate extreme events of considerable severity, which have been attributed to the confluence of multiple climate variables across substantial spatial and temporal extents. These phenomena, designated as compound events, correspond to specific combinations of climate variables that present patterns of space-time interdependencies and interactions between the variables.

The central aim of Grégoire Jacquemin's PhD project is to establish a statistically well-grounded methodology to estimate the return period of high-impact extreme compound events from the large-scale structures that are their triggers. 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.

Two examples have been considered to set up the methodology:

- the joint flooding of the Seine and the Loire rivers in France (May/June 2016) caused by heavy rainfall accumulating over several days
- and the flooding of the Ahr river in Germany in July 2021.



Extremal dependence (from 0 to 1) between extreme precipitation in Paris and rest of Europe, computed using the bi-GPD approach. Left: 1992-2021 (ERA5 reanalysis data); right: 2071-2100 (IPSL-CM6A-LR climate simulation).

For projecting in future climate, the bi-GPD approach is associated with bias correction methods to correct for possible biases in the climate models. Our findings indicate that, after bias correction, a possible reduction of the return period for the two selected events towards the end of the 21st century. The most accurate bias correction method is identified as the multivariate bias correction based on optimal transport.

The bi-GPD method has been published in Environmetrics and can be freely downloaded at: doi.org/10.1002/env.70063. Jacquemin, G., Allard, D., Freulon, X., & Vrac, M. (2026). Return Period of Nonconcurrent Climate Compound Events: A Nonparametric Bivariate Generalized Pareto Approach. Environmetrics, 37(1), e70063.

Grégoire JAQUEMIN

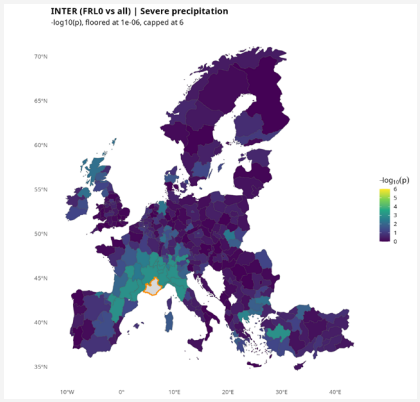
3rd year PhD student
Mines Paris - PSL

A selection of these results were presented by Grégoire at the *15th International Meeting on Statistical Climatology*.

Grégoire will defend his PhD thesis ont the 7th of April at Mines Paris.

Antoine HERANVAL

Postdoctoral researcher at INRAE



Inter-regional dependence maps for precipitation (Provence vs. all other regions).

Analysing extreme events using point processes

This project aims to merge probabilistic methods for marked point processes, extreme events, and spatial graphs to propose a new framework for a better understanding of spatial and temporal interactions between different types of extreme events in the climate system.

The climate system results from the interaction of processes acting across multiple spatial and temporal scales. Understanding the co-occurrence, temporal clustering, and spatial organization of extreme events is essential to assess compound and cascading climate risks. This project proposes a unified framework based on marked point processes and extreme value theory to analyze the spatio-temporal dynamics of climate extremes.

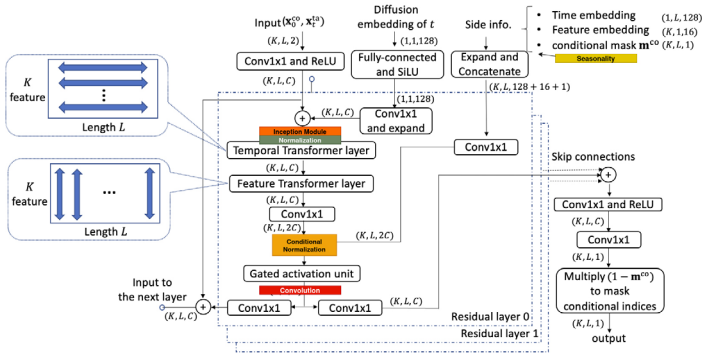
Each extreme episode (e.g. temperature, precipitation, wind) is represented as a spatio-temporal point, with marks describing its main characteristics such as intensity, duration, or spatial extent.

First- and second-order statistics of point processes are used to identify multi-scale structures and dependencies between events and European regions.

Generative AI for hydro-meteorological time series

The Permanent Environmental Observatory (OPE) near Bure, measures water quality (surface and groundwater) using regular sampling that provides information on a large number of parameters. The objective of this project is to develop joint prediction of headwater flow and water quality using a generative AI approach.

To achieve this, a generative diffusion model is fitted to multi-site and multi-variable time series and adapted to allow training on incomplete data and simulation in the following contexts: gap-filling, nowcasting, synthetic time series generation, and conditional simulation with covariates.

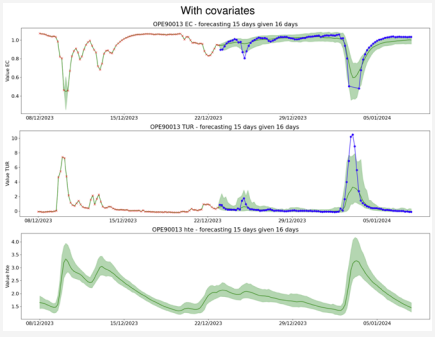


Architecture of the neural net

The outputs of this diffusion model will be used to study the impact of different climate change and/or anthropogenic scenarios on headwater hydrosystems and to emulate certain hydro-meteorological parameters used as inputs for impact models (hydrogeology, stream ecology, etc.).

Ferdinand BHAVSAR

Postdoctoral researcher at INRAE



Probabilistic water-quality forecasting via our diffusion model. The green regions represent the predictive distribution, for Conductivity (EC) and Turbidity (TUR) over 15 days.

FOCUS ON OUR
TEACHING ACTIVITIES

Mines Paris study trip

The Geostatistics and Applied Probability option is aimed at third-year students from Mines Paris who wish to **develop their data science skills**, acquired through the school's various courses, for use in environmental applications.

MINES PARIS | PSL

During the program, a **three-day study trip** to the south-east of France is organised to raise student awareness of the **current challenges faced by various institutions in this field**, with the support of the Geolearning Chair.

The Geostatistics and Applied Probability option in Fontaine-de-Vaucluse, October 2025

This year's cohort of **25 students** had the opportunity to meet researchers at BioSP INRAE and spend a day discussing their research topics. They were also introduced to the territory's water resource issues through an intervention by Leila Serene, a postdoctoral researcher from the GeEAUde chair, and had the chance to visit the Low-Noise Underground Laboratory (LSBB – UAR3538).

Finally, they were welcomed at CEA Cadarache, where they learnt about the practical applications of their skills in the field of energy and discovered some of CEA's most spectacular demonstrators, including the WEST tokamak, where fusion experiments are conducted.

Geolearning Chair partners' seminar

As part of the program of teaching activities proposed for the option, a half-day seminar is dedicated to the partners of the Geolearning Chair.

The students were given the opportunity to meet with one representative from each partner organisation:

- Julien Cotton from Andra
- Valentin Kammes from BNP Paribas
- François Reynal from CCR
- Henry Bovy from SCOR

The presentation and subsequent discussion of the industrial activities associated with the research program of the chair constituted a vivid illustration of the **synergy between research and industrial applications.**

SAVE THE DATE

Geolearning event

Ecole des Mines de Paris

8th of April, 2026

Opening at 16h45; Starting at 17h15

The Geolearning Chair opens its doors for an open seminar dedicated to **scientific advances and their industrial applications**.

Discover how our research in geostatistics, machine learning and spatial modelling of extreme events is transforming data analysis and the prediction of key values in the environmental and climate risk sectors.

PLEASE REGISTER HERE

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