Post-doctoral position.

Theory and methodologies to improve rare events algorithms for studying rare and extreme climate events, using machine learning and emulators

Supervised by *Freddy BOUCHET*.
Where: École Normale Supérieure ENS/PSL Paris and IPSL – CNRS - Laboratoire de Météorologie Dynamique (LMD).
When: Starting date is flexible.
Duration: A two-year post-doctoral position with a possible extension.

Scientific description:

This project aims to develop new tools which will be key for future studies for extreme climate events and their impact.

In our group, we have recently demonstrated that rare event algorithms can lead to a gain of 100 to 1000 times in the computational cost required to compute rare events in climate models, for instance extreme heat waves [1,2,3]. This technique will probably have a huge impact in the future for the study of climate extreme events, allowing to compute transition trajectories [4] and computing the probabilities of extreme events which cannot be estimated otherwise.

We have also developed new machine learning [5,6] and emulator methodologies, aimed at determining precursors. Such prediction tools are critical to drive rare event simulations.

The goal of this project will be to develop new theoretical and mathematical approaches to use machine learning, emulators, coupled to rare event simulation. The aim will be to improve the methodology for rare event simulations, such that we will be able to study classes of rare events which are yet out of reach with this technique.

These new methodologies will be tested for a choice of relevant climate rare events, extreme heat waves, droughts or trajectories leading to tipping points.

[1] F. Ragone, J. Wouters and F. Bouchet, 2018, Computation of extreme heat waves in climate models using a large deviation algorithm, Proceedings of the National Academy of Sciences, vol 115, no 1, pages 24-29, [pdf].

[2] F. Ragone and F. Bouchet, 2021, Rare event algorithm study of extreme warm summers and heat waves over Europe, Geophysical Research Letters, 48, e2020GL091197., *arXiv:2009.02519*, [pdf].

[3] C. Le Priol, J.M. Monteiro, and F. Bouchet, 2024, Using rare event algorithms to understand the statistics and dynamics of extreme heatwave seasons in South Asia Authors, accepted for publication in Environmental Research: Climate., arXiv:2404.07791

[4] F. Bouchet, J. Rolland, and E. Simonnet, 2019, A rare event algorithm links transitions in turbulent flows with activated nucleations, Phys. Rev. Lett. 122, 074502, https://doi.org/10.1103/PhysRevLett.122.074502, arXiv:1810.11057, [pdf]

[5] G. Miloshevich, B. Cozian, P. Abry, P. Borgnat, and F. Bouchet, 2023, Probabilistic forecasts of extreme heatwaves using convolutional neural networks in a regime of lack of data, Phys. Rev. Fluids 8, 040501, doi.org/10.1103/PhysRevFluids.8.040501 and *arXiv:2208.00971*, [pdf].

[6] D. Lucente, J. Rolland, C. Herbert and F. Bouchet, 2022, Coupling rare event algorithms with data-based learned committor functions using the analogue Markov chain, J. Stat. Mech. 083201, *arXiv:2110.05050*, [pdf].

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Profile: Applications are invited from candidates with a PhD degree, either in the fields of physics, climate, mathematics, or computer and data sciences. The motivation of the candidate for climate studies within a multidisciplinary environment will be essential.

Application process: Applications must include a cover letter, a CV, 2 recommendations letters and be sent directly to Freddy.Bouchet@cnrs.fr.