PhD project, within the project EDIPI Horizon 2020 Marie Skłodowska-Curie Actions, Innovative Training Network.

Computing climate extreme events using machine learning and rare events algorithms: application for heat waves and storms

Supervised by *Freddy BOUCHET*.
Where: École Normale Supérieure de Lyon - Laboratoire de physique (ENSL-CNRS, Lyon, France).
When: Starting in 2021, after the start of the EDIPI project on March 1st , 2021, preferably in September 2021.
Duration: A three-year PhD project.
Salary and condition: The PhD will benefit excellent salary conditions, training and networking plan, following the European Marie Curie ITN rules (see the 2019 allowance amount).

Scientific description:

This project focuses on the use of new theoretical and numerical approaches for studying extreme climate events. We will develop machine learning algorithms, coupled with the use of rare event algorithms, a completely new approach for studying extremes in complex dynamics. With those tools, we will study extreme events with major impact, that cannot be studied with conventional approaches. We will focus on extreme heat waves, extreme storms, and possibly hurricanes.

We have recently demonstrated that rare event algorithms can lead to a gain of a factor 100 to 1000 in the computational cost required to compute extreme events in climate models, for instance extreme heat waves over Europe [1]. This technique will probably have a huge impact in the future for the study of climate extremes. We demonstrated that this technique is effective for persistent extremes and can be used with IPCC class models.

Making similar advances for other classes of extremes, with a more complex dynamics, requires new theoretical and methodological developments. We need to learn effective dynamics of the large scales of the turbulent flow related to extreme simulations, and from these effective dynamics learn optimal score functions for the rare event algorithms, called committor functions [2].

The aim of this PhD will be to develop and implement the methodology to learn committor functions from already produced climate model outputs, using machine learning and stochastic weather generators [3]. The machine learning approach will be developed in an interdisciplinary team that gathers specialists of computer science, machine learning, climate dynamics, data sciences and statistical physics.

[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] D. Lucente, S. Duffner, C. Herbert, J. Rolland and F. Bouchet, 2019, Machine learning of committor functions for predicting high impact climate events, *Climate Informatics CI2019 proceedings*, *arXiv:1910.11736*, [pdf].
[3] P. Yiou, 2014, AnaWEGE: a weather generator based on analogues of atmospheric circulation, Geosci. Model Dev., 7(2), 531–543, doi:10.5194/gmd-7-531-2014.

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Applications are invited from candidates of excellence wishing to pursue a PhD degree in the field of physics of climate.

The EDIPI project: Students will receive training within a pan-European academic sector research training network, specifically focused on research in climate extreme events.

The positions are posted as part of the EDIPI project - "European weather Extremes: Drivers, Predictability and Impacts" - funded through the Horizon 2020 Marie Skłodowska-Curie Actions programme under Grant number 956396. EDIPI will train young researchers in Europe to address key scientific problems for the study of climate extreme events and their impact.

The EDIPI consortium comprises universities and private entities with researchers who are leading experts on study of climate extremes. In cooperation with the other 14 early stage researchers (ESRs) to be recruited, the researchers will combine a physical understanding of high-impact weather extremes with a practical knowledge of predictability tools and an appreciation of user-relevant information required by the private sector.

The research training will be hosted by universities with a track record of graduate training and industrial partners. It will be composed of an ambitious scientific program with ample opportunity for networking at network meetings, conferences and shared secondments. In addition to training young researchers for the challenges of tomorrow EDIPI will provide, from day one, excellent research with impressive scientific and societal impact.

Eligibility: Applicants must not have resided and not have carried out their main activity (work, studies, etc.) in France for more than 12 months in the 3 years immediately before the recruitment date — unless as part of a procedure for obtaining refugee status under the Geneva Convention.

The applicant must be an Early Stage Researcher (ESR) i.e. at the time of recruitment he/she must be in the first 4 years (full-time equivalent research experience) of his/her research careers and must not have been awarded a doctoral degree.

Further requirements: Candidates should be able to demonstrate motivation and a strong eagerness to learn and have the ability to both work independently and as part of a team. Previous research experience will be a distinct advantage. The fellow must be willing to travel and will be required to complete international secondments.

Application process: Applications must include a cover letter, a CV, any document that might attest the academic results during the last two years, 2 recommendations letters and be sent directly to Freddy.Bouchet@ens-lyon.fr. The closing date is 31st January 2021. After 31st January 2021, please contact Freddy.Bouchet@ens-lyon.fr to know if the position has already been granted or not.