Postdoctorate fellow position at CEREA
Understanding generative AI models for numerical weather forecasting
(24 to 32 months)

About CEREA laboratory

CEREA is a world-renowned atmospheric sciences research laboratory, a joint laboratory of École nationale des ponts et chaussées, Institut Polytechnique de Paris, and EdF R&D (https://www.cerea-lab.fr). CEREA specialises in the development and application of advanced numerical methods for simulating atmospheric processes, environmental assessment, and weather prediction. By combining expertise in computational modelling, data assimilation, and deep learning, the DAML team of CEREA drives scientific advancements in Earth system modelling and atmospheric sciences.

Job description

CEREA laboratory is seeking a motivated and talented PhD with expertise in machine learning and atmospheric/environmental sciences with optional experience in data assimilation, statistical physics, or Earth system modelling for a 24 to 32 months postdoctorate fellow. The postdoc fellow will work in the framework of the DRUIDS project, funded by the PEPR MathsVives, at the frontier of applied mathematics, machine learning (ML) and numerical weather prediction.

Scientific context

Numerical weather prediction (NWP) has recently been revolutionised by the development of data-driven AI models which can be as accurate as the best NWP physical models while being orders of magnitudes faster [1]. A second step in this revolution is currently the development of generative/stochastic AI models such as GenCast [2] for NPW and GenSIM for sea-ice forecasting [3]. They are meant to be more stable, robust, and physically consistent as opposed to the first generation of deterministic surrogate models. In the coming years, these generative models, based on denoising diffusion models and generative flows, are likely to become the new references for NWP. Yet, how their neural networks actually operate remains puzzling, which hampers their developments. The goal of this project is to understand their inner workings using applied mathematical and ML tools.

Postdoc focus

Using a generative AI-based NWP model learned from the ERA-5 meteorological dataset, the researcher will leverage and develop explainable AI tools to understand how the model operates [4, 5]. In particular, it is conjectured that such models can build an internal representation of meteorological features, which we will seek to expose.

These stochastic surrogate models are endowed with their own uncertainty quantification. However, it is still unclear whether generative AI models typically based on denoising diffusion and generative flow techniques, can accurately and reliably represent uncertainty, especially when applied to NWP. Hence the second goal of the postdoc is to clarify and understand critical aspects of this uncertainty representation and possibly improve on them.

It is expected that these investigations and their results will usher significant improvements of the AI-based stochastic models for geofluid forecasting and NWP.

Postdoc environment

The postdoc will be hosted at **École nationale des ponts et chaussées** (East of Paris), with frequent exchanges and close collaborations with our partners are **École normale supérieure/Collège de France** (Paris), and **Université de Toulouse/ANITI/Météo-France** (Toulouse).

Requirements

- A **PhD** in either machine learning, data assimilation, applied mathematics with applications to the geosciences.
- At least one publication in (or under review at) major computer science/computational geosciences journals (e.g., IEEE Trans, JAMES, QJRMS, MWR, GMD) or leading AI conferences (e.g., Neurips, ICLR, ICML).
- **Desirable fields of expertise**: computer science, deep learning, data assimilation, dynamical systems, harmonic analysis, uncertainty quantification, generative AI, explainable AI, meteorology, numerical weather prediction, Earth system modelling, statistical physics, ensemble forecasting.

Start and salary

The position will start in the Fall of 2025. Depending on the candidate experience and expertise: 2000 to 2400€ net a month.

Supervisors

To apply, please submit your CV (including any relevant project or research experience), a brief cover letter in English or French, to

Prof. Marc Bocquet, marc.bocquet@enpc.fr

Dr. Sibo Cheng, sibo.cheng@enpc.fr

Dr. Tobias Finn, tobias.finn@enpc.fr

Selected candidates will be contacted for further discussions.

The DRUIDS project

The DRUIDS project (2025-2029) is funded by **PEPR MathsVives**, part of the **Programme d'investissements d'avenir France 2030**. It aims at better understanding (and improving upon) the generative AI models of dynamical systems with a focus on uncertainty quantification. The project gathers partners at the forefront of these questions, with expertise in applied mathematics (École normale supérieure/Collège de France, ANITI/IRIT) and methodological geosciences (ENPC, ANITI/Météo-France).

References

[1] I. Price *et al.*, "Probabilistic weather forecasting with machine learning," *Nature*, vol. 637, pp. 84–90, 2025, doi: 10.1038/s41586-024-08252-9.

[2] R. Lam *et al.*, "Learning skillful medium-range global weather forecasting," *Science*, vol. 382, pp. 1416–1421, 2023, doi: 10.1126/science.adi2336.

[3] T. S. Finn, C. Durand, A. Farchi, M. Bocquet, P. Rampal, and A. Carrassi, "Generative diffusion for regional surrogate models from sea-ice simulations," *J. Adv. Model. Earth Syst.*, vol. 16, p. e2024MS004395, 2024, doi: 10.1029/2024MS004395.

[4] Z. Kadkhodaie, Guth. F., Simoncelli. E. P., and S. Mallat, “Generalization in diffusion models arises from geometry-adaptive harmonic representations,” 2024. [Online]. Available: https://openreview.net/forum?id=ANvmVS2Yr0
[5] Z. Kadkhodaie, F. Guth, S. Mallat, and E. P. Simoncelli, “Learning multi-scale local conditional probability models of images,” 2023. [Online]. Available: https://openreview.net/forum?id=VZX2I_VVJKH
[6] T. S. Finn et al., “Efficient Arctic-wide Sea-Ice Modelling with Generative Flows,” To be submitted to “Nature Geoscience,” 2025.