



## Postdoc position on Data assimilation and Machine learning

### Advisors.

- Serge Gratton, professor at l'INP-ENSEEIH, director ANITI.
- Sixin Zhang, associate professor at l'INP-ENSEEIH.
- Vincent Chabot, researcher at Météo France.
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**Laboratoire.** INP-ENSEEIH-IRIT (UMR CNRS 5505)

**Duration of postdoc :** 2 years (with possible extension)

**Keywords :** Data assimilation, deep learning, generative model

### Context.

Deep learning has recently unleashed the ability to learn surrogates of complex and high-dimensional dynamical systems mostly from data, with spectacular applications to geophysical fluids and numerical weather predictions such as GraphCast [1] and AIFS [2].

However, these forecast systems rely crucially on an efficient data assimilation system, which is a set of methods combining a numerical evolution model and observations of dynamics to compute the reanalysis data such as ERA5. It has recently been shown that data assimilation systems can be learned by deep-learning surrogate models, as well in an approach called data assimilation networks [3, 4].

Based on these developments, we aim to improve and generalize these surrogate models to large-scale problems, by focusing on their representation of uncertainty. This will enable the community to design disruptive, novel, but frugal stochastic models and data assimilation algorithms for numerical forecasting in geoscience.

We shall focus on the following aspects of the problem :

- Design data assimilation networks for high-dimensional dynamics ;
- Extension to graph neural networks to resolve irregular domains ;
- Interpretation of data assimilation networks ;
- Consideration of physical constraints in the dynamics ;

In all cases, efficient numerical implementations and high-quality scientific publications are expected. The project gathers partners at the forefront of

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these questions, with expertise in applied mathematics (ENS, ANITI/IRIT) and methodological geosciences (ENPC, ANITI/Météo-France).

## Références

- [1] Remi Lam, Alvaro Sanchez-Gonzalez, Matthew Willson, Peter Wirnsberger, Meire Fortunato, Ferran Alet, Suman Ravuri, Timo Ewalds, Zach Eaton-Rosen, Weihua Hu, Alexander Merose, Stephan Hoyer, George Holland, Oriol Vinyals, Jacklynn Stott, Alexander Pritzel, Shakir Mohamed, and Peter Battaglia. Learning skillful medium-range global weather forecasting. *Science*, 382(6677) :1416–1421, 2023.
- [2] Simon Lang, Mihai Alexe, Matthew Chantry, Jesper Dramsch, Florian Pinault, Baudouin Raoult, Mariana C. A. Clare, Christian Lessig, Michael Maier-Gerber, Linus Magnusson, Zied Ben Bouallègue, Ana Prieto Nemesio, Peter D. Dueben, Andrew Brown, Florian Pappenberger, and Florence Rabier. Aifs – ecmwf’s data-driven forecasting system, 2024.
- [3] Pierre Boudier, Anthony Fillion, Serge Gratton, Selime Gürol, and Sixin Zhang. Data assimilation networks. *Journal of Advances in Modeling Earth Systems*, 15(4) :e2022MS003353, 2023.
- [4] Marc Bocquet, Alban Farchi, Tobias S. Finn, Charlotte Durand, Sibongwe Cheng, Yumeng Chen, Ivo Pasmans, and Alberto Carrassi. Accurate deep learning-based filtering for chaotic dynamics by identifying instabilities without an ensemble. *Chaos : An Interdisciplinary Journal of Nonlinear Science*, 34(9) :091104, September 2024.