

Master's Thesis offer (Stage M2 ou equivalent)

Transfer learning for Physics Informed Deep Learning to forecast water quality in lakes

Main adviser: [David Métivier](#) is researcher (*chargé de recherche*) at [INRAE Montpellier MISTEA](#).

When: Starting February 2027 (flexible) for 6 months. Possibility to continue with a Ph.D. on similar topics starting September 2027.

Location: [UMR MISTEA](#) (Mathematics, Informatics, and Statistics for Environment and Agronomy), 2 Pl. Pierre Viala, 34000 Montpellier, France.

Teaser: Can we transfer knowledge from one lake to another to forecast water quality with limited data using hybrid models?

Contact: Please send your application with a CV and a few motivational lines to: david.mativier@inrae.fr. You are encouraged to include links to your scientific projects, report, presentations, Git repositories, etc. Don't hesitate to ask questions (**do read the whole announcement first!**).

Context

Lakes are critical ecosystems and water resources, yet harmful algal blooms—often driven by cyanobacteria—are becoming more frequent with warming and eutrophication, making bloom anticipation a key issue for water managers and public health. Traditional lake models rely on physical and ecological equations: they are interpretable but complex, with many parameters to calibrate. Conversely, data-driven approaches such as deep learning capture complex patterns but need large datasets, extrapolate poorly, and act as black boxes. Hybrid models combine the strengths of both. In particular, **Universal Differential Equations** (UDE) embed a neural network inside a differential equation,

$$\frac{du}{dt}(t) = f_{\phi}^{\text{PHY}}(u(t)) + f_{\theta}^{\text{NN}}(u(t)),$$

where f_{ϕ}^{PHY} is a reduced-physics model, f_{θ}^{NN} a neural network learning the missing dynamics and u the variable of interest e.g. water temperature. At MISTEA, we have developed such hybrid models to forecast water temperature in Lake Créteil (Paris region), where they outperform both the physics-only and the neural-network-only models, with only a few hundred parameters. However, they have so far been trained on a *single* lake and may not generalize to lakes with different characteristics.

Internship objectives and expected work

This internship explores **transfer learning across lakes**, focusing on *surface water temperature*: it is the variable measured in a lot of lakes, and it largely controls its state. The work will proceed in two steps:

- **Multi-lake dataset.** Gather monitoring data from several lakes (French, Swiss and U.S. networks) and bring them into a single clean and well-documented dataset.
- **Transferability study.** Get familiar with the existing models and code, then test the temperature model on these new lakes: how much accuracy is lost on a lake never seen before, can the errors be explained by the characteristics of the lake, and how can a model trained on well-monitored lakes be adapted to lakes with few data?

Perspectives The results of this work may be published in a scientific article and lead to developing an open source package. A **Ph.D.** on similar topics will begin in September 2027.

Required Skills

- Knowledge in Machine Learning (deep learning), mathematical modeling and statistics, differential equations.
- Skills and interest in scientific programming. The main programming language will be **Julia** (no prior knowledge required, but at least look up what it is).
- Interest in environmental and/or climate issues.

Terms of the internship

The intern will work at MISTEA (Montpellier) with David Métivier and collaborate with other researchers Loïc Chalmandrier (RECOVER), Céline Casenave (MISTEA), and Brigitte Vinçon-Leite (LEESU). The intern receives a “*gratification*” around €600/month. The canteen is subsidized.