

## POSTDOC OFFER 2025

# Advancing lake temperature simulations in response to climate change: accounting for water-level fluctuations in lakes and reservoirs at the national-scale

**Application deadline:** 15/12/2024. Applications will start to be reviewed immediately as earlier selection will facilitate the hiring process. However, the application will remain open until the position is filled.

**Starting date:** 01/01/2025

**Duration:** 1 year, renewable up to 4 years

## Work environment, missions and activities

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The INRAE CARRTEL Center, Thonon-les-bains, France, is a leading limnological institute with a large, diverse and welcoming community of researchers, students, and support staff (<https://fr-carrel.lyon-grenoble.hub.inrae.fr/unite>). CARRTEL contributes to the understanding of how human and climate change affect fundamental resources and ecological functions within lake systems and their watersheds, and how this affects ecosystem services like food, drinking water, biodiversity, maintenance of aquatic fauna and flora, water flow regulation, transfer and sequestration of nutrient or pollutants. CARRTEL has two locations: Technolac campus near Lake Bourget, and a limnological station near Lake Geneva, where the candidate will be located. At the institution level, various in-house technical groups will support the project. The successful candidate will be fully integrated into the institute, and benefit from full participation in various interactions facilitated by seminar programs, discussion groups and lab meetings, as well as monthly interdisciplinary keynotes given by high-profile researchers.

The project is funded through “pôle ECLA” (<https://professionnels.ofb.fr/fr/pole-ecla-ecosystemes-lacustres>), a research cluster gathering three institutions: the French biodiversity agency (OFB), INRAE, and University Savoie Mont-Blanc. “Pôle ECLA” has four locations: the two CARRTEL locations as well as a team in Aix-en-Provence and a team in Bordeaux. Together, there are over 70 scientists working on diverse projects and the candidate will have the opportunity to participate to the meetings and seminar of “pôle ECLA”.

### *Context*

The majority of water bodies around the world are subject to the growing pressure of climate change, profoundly altering all physical, chemical, and biological components. These changes pose many challenges in terms of managing and maintaining water quality. To anticipate the future effects of climate change, modelling has become an essential tool, complementing field monitoring, to shed light on the expected changes, the nature of disturbances, their synergies, and their magnitude across the different compartments of lakes.

Recently, new generations of high-performance hydrodynamic and ecodynamic models have been developed, enabling better characterization of the thermal regime evolution in lakes. These models provide valuable insights into aspects such as the evolution of water temperatures, stratification regimes, the frequency and intensity of winter mixing, the depth of the thermocline, and the duration of ice cover. However, despite the increasing number of prospective studies, there is still a lack of detailed characterization of the thermal evolution of water bodies on a national scale for the previous and coming decades, while these data are essentials to characterize communities’ response to multiple stressors.

To bridge that gap, “pôle ECLA” has been working on better characterizing waterbodies response to climate change through in situ monitoring (a network of buoys with autonomous thermistors has been deployed in 2013 and is still expanding), integration of satellite imageries, and modelling. Currently, a model is available at the national scale for 401 lakes and provide a simplified representation in two

compartments (epilimnion and hypolimnion) (Prats & Danis, 2019; Sharaf *et al.*, 2023). These data have proven to be useful to contextualize freshwater biodiversity sampling efforts (e.g., Leclerc *et al.*, 2023; Rocha *et al.*, 2023). However, the semi-empirical model outputs limit the ability to represent certain key thermal variables, such as thermocline depth. Besides, the model does not account for water level fluctuations, which impact habitat available and thermic response to air temperature. These limitations hinder scientific progress on critical issues related to the effects of climate change on French lakes, such as the occurrence of cyanobacteria blooms or greenhouse gas (GHG) emissions, which strongly depend on the daily and seasonal variations in the vertical and spatial temperature profiles.

To address these gaps, it is essential to refine daily-scale estimates and develop a continuous representation of the vertical structure of the water column. These improvements would provide managers with a more accurate description of the evolution of thermal regimes and habitats, while supporting ongoing programs aimed at predicting blooms and GHG emissions.

The objective of this project is to refine the thermal evolution of water bodies and model thermocline depths to better define lake habitats, and to publish a paper in which the simulations results will be compared to in-situ and existing simulations. Furthermore, the candidate will be invited to join on other projects using these data.

### **Missions**

The objective is to use GLM (Hipsey *et al.*, 2019), a 1D model that will provide, in addition to the thermal trajectories of the water bodies, an estimate of the thermocline. These data are expected by scientists and managers responsible for studying the distribution of species in water bodies according to their thermal preferences. The candidate will also include water levels, with data from in-situ sensors and from another project that aims at estimating water level fluctuations from satellite imagery.

In line with the objectives of the pôle ECLA to provide data to managers and scientists at a large scale, the goal will be to find a trade-off between data required and number of lakes to which the model can be applied.

In parallel to that main question, the candidate will contribute to updating the time series available for epilimnion and hypolimnion temperature, with more recent year, but also extend these data series using CMIP6 data (<https://esgf-node.ipsl.upmc.fr/projects/cmip6-ipsl/>) and to calculate warming indicators for the water bodies in the dataset. The goal is to complete the work and provide indicators with an associated reference. The data will also be compared with other available studies (e.g., Desgué-Itier *et al.*, 2023) and in situ data from the French National Temperature Monitoring Network (RNT) for water bodies (<https://professionnels.ofb.fr/fr/node/453>).

The candidate will be joining a team with several PIs with expertise on satellite imagery, freshwater ecology, food-web ecology.

## **INRAE presentation**

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The French National Research Institute for Agriculture, Food, and Environment (INRAE) is a major player in research and innovation. It is a community of 12,000 people with 272 research, experimental research, and support units located in 18 regional centres throughout France. Internationally, INRAE is among the top research organisations in the agricultural and food sciences, plant and animal sciences, as well as in ecology and environmental science. It is the world's leading research organisation specialising in agriculture, food and the environment. INRAE's goal is to be a key player in the transitions necessary to address major global challenges. Faced with a growing world population, climate change, resource scarcity, and declining biodiversity, the Institute has a major role to play in building solutions and supporting the necessary acceleration of agricultural, food and environmental transitions.

## OFB presentation

The French biodiversity agency (OFB) created on the 1<sup>st</sup> January 2020 is a public institution operating under the supervision of the ministries in charge of Ecology and Agriculture & Food to protect and restore biodiversity in metropolitan France and its overseas territories. The Agency's roles include, among other things, the development and the dissemination of knowledge and scientific expertise about species, habitats and services provided by biodiversity, and the threats it faces. Thanks to its expertise, OFB notably contributes to the development and the implementation of European directives, national action plans and management strategies regarding the monitoring and the assessment of biodiversity and habitat state, as well as the development of solutions to restore habitat.

## Training and skills

- PhD, preferred training: aquatic modelling;
- Knowledge of GLM;
- Coding in python and R;
- Initiative.

## How to apply

How to apply	Please send your resume (CV) and a cover letter to the contacts below. In your email, explain how your profile aligns with the research proposed in the offered position. Application can be written either in English or French.  Please name the file: "postdoc_2025_PREDILAC_NameFirstname.pdf"
Deadline	15/12/2024
Contacts	<b>Rosalie BRUEL</b> <sup>1,2</sup> – <a href="mailto:Rosalie.Bruel@ofb.gouv.fr">Rosalie.Bruel@ofb.gouv.fr</a> <b>Jean-Philippe JENNY</b> <sup>2,3</sup> – <a href="mailto:Jean-Philippe-Jenny@inrae.fr">Jean-Philippe-Jenny@inrae.fr</a> <b>Thierry TORMOS</b> <sup>1,2</sup> – <a href="mailto:Thierry.Tormos@ofb.gouv.fr">Thierry.Tormos@ofb.gouv.fr</a>  <sup>1</sup> OFB, Direction de la Recherche et de l'Appui Scientifique (DRAS), Service « Fonctionnement, préservation et restauration des écosystèmes aquatiques » <sup>2</sup> Pôle R&D ECLA (ECosystèmes LAcustres) <sup>3</sup> INRAE CARTEL

## References

- Desgué-Itier O., Melo Vieira Soares L., Anneville O., Bouffard D., Chanudet V., Danis P.A., *et al.* (2023). Past and future climate change effects on the thermal regime and oxygen solubility of four peri-alpine lakes. *Hydrology and Earth System Sciences* **27**, 837–859. <https://doi.org/10.5194/hess-27-837-2023>
- Hipsey M.R., Bruce L.C., Boon C., Busch B., Carey C.C., Hamilton D.P., *et al.* (2019). A General Lake Model (GLM 3.0) for linking with high-frequency sensor data from the Global Lake Ecological Observatory Network (GLEON). *Geoscientific Model Development* **12**, 473–523. <https://doi.org/10.5194/gmd-12-473-2019>
- Prats J. & Danis P.-A. (2019). An epilimnion and hypolimnion temperature model based on air temperature and lake characteristics. *Knowledge & Management of Aquatic Ecosystems*, 8. <https://doi.org/10.1051/kmae/2019001>
- Sharaf N., Prats J., Reynaud N., Tormos T., Bruel R., Peroux T., *et al.* (2023). A long-term dataset of simulated epilimnion and hypolimnion temperatures in 401 French lakes (1959–2020). *Earth System Science Data* **15**, 5631–5650. <https://doi.org/10.5194/essd-15-5631-2023>