Data-based inference of ecosystem memory and dynamics – Post-doctoral position

Contacts : *Nicolas Brodu <nicolas.brodu@inria.fr>, Yao Liu <yao2.liu@northumbria.ac.uk>*

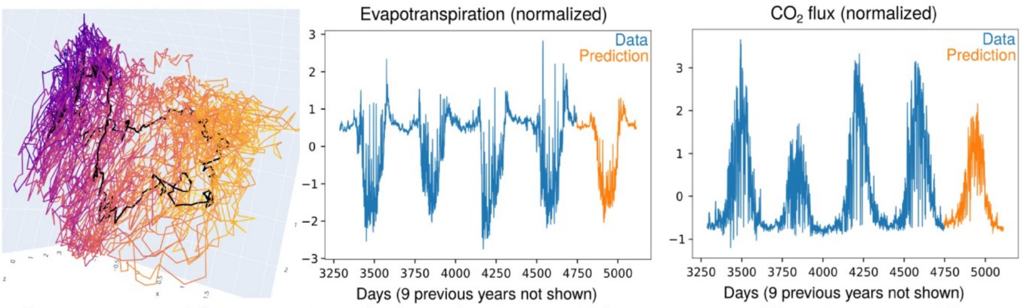
Scientific research context

Predicting the impact of climate change on ecosystems presents a major challenge due to ecosystems' complexity and adaptive dynamics. Importantly, ecosystem responses are not only driven by current environmental conditions, but show "memory" to conditions in the past [1]. In some cases, this "memory" may reflect how plants adapt to short-term stressors to maintain function and avoid damage in a fluctuating environment. There is an increasing need to quantify, model, and predict memory effects in different vegetation types and in relation to environmental fluctuations. As the statistics (frequency, duration, magnitude, and regularity) of environmental fluctuations change under climate change, it is also important to understand the role of memory in ecosystem responses to novel fluctuation patterns. Addressing these research needs will improve our ability to predict and manage for the health and resilience of the biosphere, a critical component of the global carbon cycle, in the face of changing climate and weather patterns. This project will make progress towards this goal by examining how complex systems (such as ecosystems) store and process information in their dynamics and display memory, at multiple time scales.

Work description

You will join an active team of multi-disciplinary research and must be prepared to work both on theoretical aspects of dynamical systems inference, as well as ecological aspects that form the natural process we are trying to model and quantify. This work is part of an on-going collaboration described on this page : https://team.inria.fr/comcausa/terrestrial-carbon-water-fluxes/

Our approach is based on computational mechanics and more precisely the method detailed in [2]. It consists in identifying the internal states of the natural process, states with the same causal influence, and how they evolve through time. These dynamical states are embedded in a low-dimensional state space, corresponding to the main influential parameters. These should also correspond to some combination of ecological factors driving the ecosystem. This approach allows us to reconstruct attractors and make predictions along their trajectories :



Left: Representation of the process attractor for the Bartlett experimental forest, reconstructed from Temperature, Solar energy influx, Precipitations, Soil water content, Evapotranspiration and CO_2 exchanges. The colors indicate the time of year. Middle and right: predictions made using this method

You will apply this method to Ameriflux and NEON data in order to build predictive models, and in particular models of carbon and water fluxes in terrestrial ecosystems. In order to best build these predictive models, you will explore how each ecological factor influences the dynamical reconstruction and affects predictions. Time dependencies are encoded both within the dynamical system evolution operator, but also explicitly as scales for causal relations. You will explore how these two aspects encode and recover know forms of ecosystem "memory" (e.g., water retention, ecological resilience…). In addition, ecosystems are driven by natural processes with multiple characteristic time scales (e.g., day/night cycles, seasons…). From a dynamical systems perspective, the challenge is to account for these interactions in the reconstruction of a self-consistent set of models at multiple time scales. You will participate to this effort, using for example a renormalization of the method in [2]. Fitting these models to half-hourly data measured over multiple years would provide novel insights into the complex dynamics of natural systems.

[1] Liu, Y., Schwalm, C.R., Samuels-Crow, K.E. and Ogle, K., 2019. Ecological memory of daily carbon exchange across the globe and its importance in drylands. Ecology letters, 22(11), pp.1806-1816.
[2] N. Brodu, J.P. Crutchfield : Discovering Causal Structure with Reproducing-Kernel Hilbert Space ε-Machines. https://arxiv.org/abs/2011.14821

About Inria and the Geostat research team

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Geostat is an Inria project located at Bordeaux. The team makes fundamental and applied research in the analysis of complex natural signals. This position is based at Inria Bordeaux under the supervision of Nicolas Brodu, but strong collaborations are expected with all our team members and especially with co-supervisor Yao Liu based at Northumbria University.

General Information

Location : Inria Bordeaux
Starting date : 2021-11-01
End date : 2022-12-31
Salary: 2653€/month **before tax**
About 1900€/month after tax, maybe more depending on your situation. Benefits include social security (= medicare).

Instructions to apply

Deadline to apply : 2021-04-30

Prerequisites : A PhD in either computational sciences or environmental sciences. Candidates from either background are encouraged to apply, but must show a strong interest in both disciplines. A commitment to multidisciplinary and collaborative research is required.

Online application :
You *must* apply online with the link below, but please *contact us* in addition to applying to : https://jobs.inria.fr/public/classic/en/offres/2021-03559