Joint simulation of runoff and water quality in headwater catchments under climate change

Duration : 24 months
Starting date : 2024 February 1st or upon agreement
Location : Avignon, France
Research institute : INRAE - BioSP
Contact : edith.gabriel@inrae.fr and lionel.benoit@inrae.fr

Job description

The perennial environmental observatory (OPE, https://ope.andra.fr) is a long-term Earth surface monitoring network operated since 10 years by the French national agency for radioactive waste (ANDRA) in order to monitor surface and sub-surface ecosystems around the planned geologic repository for spent nuclear fuel (Cigéo). ANDRA now wants to leverage this dataset to investigate scenarios of the evolution of headwaters stream functioning under the joint influence of climate change and inception of the Cigéo industrial site. To this end, ANDRA started a collaboration with the Geolearning chair (2022-2027, INRAE - Mines Paris, https://chaire-geolearning.org/) which undertakes research on geostatistics, extreme events and machine learning for the climate transition.

In this context, the main goal of this postdoctoral project is to design a multivariate space-time model for stream runoff and water quality in the OPE area. To limit model complexity, we will focus for water quality on the subset of parameters defined by the European water framework directive, namely: dissolved oxygen, dissolved organic carbon, water temperature, nutrients content (phosphorus, nitrates, ammonium), pH and conductivity. The envisioned model will be used to investigate the impact of different scenarios of climate and/or anthropogenic changes on stream environments in the OPE area.

This research will draw on OPE data collected within three headwater catchments in the North-East of France around the village of Bure. This dataset encompasses: (i) continuous stream water samples from six automatic stations measuring a limited number of parameters (conductivity, temperature, dissolved oxygen, PAH, pH, dissolved organic carbon, nitrates and water height), (ii) intermittent stream water samples providing information on a large number of parameters (around 300) characterizing flow rate and water chemistry, (iii) integrated stream water samples measuring the long-term concentration of some pollutants, (iv) groundwater samples coming from 50 wells spread throughout the study area informing the state of the water table and its interaction with the streams, and (v) auxiliary environmental data (mostly land use, land cover and meteorological parameters) to contextualize the stream and groundwater observations.

Based on this dataset, the main **research questions** to address will be:

1. Identifying proxies for stream water quality and streamflow (Messager et al., 2021).

2. Designing a machine learning model able to predict the target hydrological parameters from the environmental proxies (Beaufort *et al.*, 2019). A single-site modeling approach will be followed at first, and then a multi-site modeling will be attempted (Sigrist *et al.*, 2022).

3. Modeling the impact of climate and anthropogenic changes on stream water quantity and quality.

4. Interpolating the outputs of steps 2 and 3 on the hydrological network (Isaak *et al.*, 2014) following a space-time approach (Porcu *et al.*, 2022).

Work environment

This two-years postdoctoral position is founded by the chair Geolearning. The selected candidate will be mentored by Edith Gabriel and Lionel Benoit (INRAE-BioSP) and receive active support from Sylvain Gigleux, Timothée Robineau and Maxime Savatier (ANDRA-OPE). She/he will join the BioSP research team in Avignon, France (https://biosp.mathnum.inrae.fr/). The gross monthly salary ranges from 2640 to 3340 euros depending on experience. Teaching opportunities in collaboration with the University of Avignon could be proposed depending on the interest, motivation and career plan of the candidate.

Profile of the candidate

Applicants must hold a PhD in statistics, machine learning, data sciences or in a related field. They must show strong interest in hydro-climatic applications and water resources management. The successful candidate must have strong analytical skills, as well as good scientific programming (preferably in R or Python) and data handling skills. Good interpersonal skills, willingness to interact with other researchers and students, and ability to present at international conferences are expected. Fluency in English and strong communication skills in speaking and writing are required.

How to apply

Please email your application to edith.gabriel@inrae.fr and lionel.benoit@inrae.fr. Applications must include : a CV, a motivation letter, contact information for three references and the electronic version of one publication (preferably a paper in a peer-reviewed journal, otherwise your PhD manuscript).

Selection for position will continue until the position is filled.

References

Beaufort, A., Carreau, J., and Sauquet, E. (2019). A classification approach to reconstruct local daily drying dynamics at headwater streams. Hydrological Processes, 33(13), 1896-1912.

Isaak, D. J., Peterson, E. E., Ver Hoef, J. M., Wenger, S. J., Falke, J. A., Torgersen, C. E., and Monestiez, P. (2014). Applications of spatial statistical network models to stream data. *Wiley Interdisciplinary Reviews: Water*, 1(3), 277-294.

Messager, M. L., Lehner, B., Cockburn, C., Lamouroux, N., Pella, H., Snelder, T., and Datry, T. (2021). Global prevalence of non-perennial rivers and streams. *Nature*, 594(7863), 391-397.

Porcu, E., White, P. A., and Genton, M. G. (2022). Nonseparable space-time stationary covariance functions on networks cross time. *arXiv preprint arXiv:2208.03359*.

Sigrist, F. (2022). Latent Gaussian model boosting. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 45(2), 1894-1905.