Improvement of seasonal forecasts of groundwater resources in France carried out as part of the Aqui-FR project on France.

Context

The Aqui-FR project[1] aims at deploying groundwater resource modelling coupled with both flow simulation and recharge estimation via the Surfex surface scheme (Masson et al. 2013). Aqui-FR is based on the integration of a set of existing hydrogeological applications and generally developed in connection with water managers. Today, Aqui-FR covers more than a third of the sedimentary aquifers in France, karstic aquifers, and some basement aquifers. (Vergnes et al. 2020). It is used for applications on past historical reconstitution, real-time monitoring of the aquifer situation, seasonal forecasts and climate projections (Habets et al. 2019; Leroux et al. n.d.; Vergnes et al. 2020). Seasonal forecasts have been evaluated over a 25-year period, and have shown a good capacity to anticipate groundwater resources and in particular drought zones 6 months in advance, mainly for forecasts covering the summer period, with particularly satisfactory results at the end of the summer (Leroux et al. n.d.). Thus, since January 2020, seasonal forecasts are made in real time, and have been used in particular to anticipate the droughts of 2020[2].

Objective of the work

The aim of the postdoctoral fellowship is to improve the potential of these predictions. A first step is to evaluate the predictions of groundwater-river exchanges, which could provide a useful prediction of minimum low flows. A second step will be to improve this potential by refining the simulation of river flows through the implementation of a homogeneous river network over the whole metropolitan territory. Initial work has been carried out with the RAPID routing model (David et al. 2011) and the RHT river network (Pella et al. 2000). The whole system must now be connected to the hydrogeological applications included in Aqui-FR. These improvements will be tested on the new operational forecasting system. Indeed, the seasonal forecasting system used, based on the Arpege atmospheric model (Batte and Deque 2016) evolves very regularly. The next system will integrate corrections for precipitation, which is particularly interesting for water resource forecasting. This work will be carried out in close collaboration with the Aqui-FR research group, in particular with the Météo-France service operating these forecasts in real time, in order to ensure that diagnostics and development can be integrated in operational terms, with the hydrogeologist modelers (BRGM, CNRS, MinesParistech) both for the model aspects and for the links with the work carried out in parallel on the feedback from the 1st year of forecasting and on the development of a piezometric data assimilation, and finally, with the French Biodiversity Office which is funding the project.

The work will be carried out at the CNRM-UMR3589 (Météo-France/CNRS) in Toulouse.
The proposed contract is for a period of 18 months, divided into a first phase of 6 months and a second phase of 12 months, due to funding.

Application deadlines: 1st February 2021 – **Contract duration:** 6+12 months

Requested skills

- PhD in geosciences, hydrology or meteorology

1 http://www.geosciences.ens.fr/aqui-fr/

2 https://www.ecologie.gouv.fr/anticipation-secheresse-emmanuelle-wargon-fait-point-sur-situation-hydrologique-en-france

- Environmental modelling skills
- Python programming skills, Linux system
- Knowledge of statistics and data processing
- Ability to work independently and as part of a team
- Experience in scientific writing for the valorisation of works in scientific journals

Management team
The work will be carried out under the principal direction of Simon Munier and Patrick Le Moigne at the CNRM and Florence Habets at the ENS Geology Laboratory with fellow experts contributing to the Aqui-FR project and experts in seasonal forecasting.

Salary
As this is a CNRS contract, the salary varies with seniority. The gross monthly amount is between 2648€ and 3768€ depending on experience.

Application procedure
Applications must include a letter of motivation, a CV, and the contacts of at least 2 referees. They must be sent before 1st February 2021 to Simon Munier (simon.munier@meteo.fr), Patrick Le Moigne (Patrick.LeMoigne@meteo.fr) and Florence Habets (Florence.Habets@ens.fr).

References

Batte, Lauriane and Michel Deque. 2016. "Randomly Correcting Model Errors in the ARPEGE-Climate v6.1 Component of CNRM-CM: Applications for Seasonal Forecasts." *Geoscientific Model Development* 9(6):2055–76.

David, C. H., F. Habets, D. R. Maidment, and Z. L. Yang. 2011. "RAPID Applied to the SIM-France Model." *Hydrological Processes* 25(22).

Habets, Florence, Nadia Amraoui, François Besson, Delphine J. Leroux, Jean-Pierre Vergnes, and Pascal Viennot. 2019. "Quelles Ressources En Eau Pour Demain ?" *Géosciences, BRGM* Hors série:30–37.

Leroux, Delphine J., Simon Munier, François Besson, Florence Habets, Pierre Etchevers, Jean-pierre Vergnes, Nadia Amraoui, and Fabienne Rousset. n.d. "Seasonal Forecast of the Groundwater Resources over France with the Aqui-FR Platform Seasonal Forecast of the Groundwater Resources over France with the Aqui-FR Platform." *En Préparation*.

Masson, V., P. Le Moigne, E. Martin, S. Faroux, A. Alias, R. Alkama, S. Belamari, A. Barbu, and A. Boone. 2013. "The SURFEXv7.2 Land and Ocean Surface Platform for Coupled or Offline Simulation of Earth Surface Variables and Ocean Fluxes Science." 929–60.

Pella, Hervé, Jérôme Lejot, Nicolas Lamouroux, and Ton Snelder. 2000. "Le Réseau Hydrographique Théorique (RHT) Français et Ses Attributs Environnementaux The Theoretical Hydrographical Network (RHT) for France and Its Environmental Attributes."

Vergnes, Jean-Pierre, Nicolas Roux, Florence Habets, Philippe Ackerer, Nadia Amraoui, François Besson, Yvan Caballero, Quentin Courtois, Jean-Raynald de Dreuzy, Pierre Etchevers, Nicolas Gallois, Delphine J. Leroux, Laurent Longuevergne, Patrick Le Moigne, Thierry Morel, Simon Munier, Fabienne Regimbeau, Dominique Thiéry, and Pascal Viennot. 2020. "The AquiFR Hydrometeorological Modelling Platform as a Tool for Improving Groundwater Resource Monitoring over France: Evaluation over a 60-Year Period." *Hydrology and Earth System Sciences* 24(2):633–54.