PhD position in France (Chatou, near Paris)

Improving the efficiency and robustness of numerical models for environmental monitoring of aquifers

Keywords: hydrogeology; solute transport; numerical simulation; uncertainty quantification; optimization; decision making; MODFLOW.

Objectives:

- Parameter estimation by history matching with a numerical groundwater model dedicated to the prevention and management of groundwater contamination near an industrial site.
- Data worth analysis to improve the design of an observation network to reduce predictive uncertainty.
- Quantifying the uncertainties associated with variables important to the considered risks.
- Optimising solutions to mitigate environmental risk.

Abstract:

EDF, the world's leading producer of carbon-free electricity, continually works to improve numerical models used to manage its production facilities. Groundwater flow and solute transport models are key components in the environmental monitoring of soils and aquifers that surround its industrial sites. These models are used to prevent, analyze, and mitigate the potential release of contaminants into the environment. The Ph.D. aims to better quantify and reduce uncertainties associated with these models to strengthen decision-making processes. Four axes of research are proposed.

The first axis focuses on the estimation of the uncertain model parameters (such as hydraulic conductivities or specific storages) from field data (piezometric measurements especially), using existing algorithms (GLM, IES) and high-performance computing. An ensemble-based, probabilistic approach will be considered, bearing in mind the operational constraints of the end users (e.g., computation time). The second axis will be dedicated to "data-worth" analysis, i.e., to the improvement of data collection to reduce predictive uncertainties.

The third axis is dedicated to identifying model inputs that cause significant uncertainty in the output variables of interest (e.g., travel time of contaminants or final concentrations at the outlet). This identification will be carried out in two steps: first discarding variables whose uncertainties appear negligible (screening), then ranking the remaining variables according to their impact on the model outputs (sensitivity analysis).

The purpose of the last axis is to provide support for the selection and design of mitigation solutions. This task should be conducted ideally using a method of optimization under uncertainty to ensure the robustness of the proposed solutions.

Suggested skills:
A master's degree is required. The ideal candidate should have a background in geosciences, preferably in hydrogeology or hydro-informatics. Applications from students with an applied mathematics, computer science or mechanical engineering background are also welcome. Familiarity with programming languages (Python) and the computing Linux environment would be of great value. The candidate should be strongly motivated to work in a collaborative environment and to communicate their work to the scientific community.

Research team and environment:
The PhD mission will be based at EDF Lab Chatou, near Paris. The PhD will be supervised by:

- Alexandre Pryet and Olivier Atteia, lecturers and researchers, members of the UMR EPOC, Bordeaux INP (http://www.bordeaux-inp.fr, France);
- Marc Kham, Mathieu Couplet, and Raphael Lamouroux, research engineers, EDF R&D, Chatou (France);
- Frédéric Lalbat and Guillaume Grignard, hydrogeologists, Industrial Direction of EDF, Aix-en-Provence (France).

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Application: CV and letter of motivation are required. A letter of recommendation would be a plus.

Bibliographic references:

Coulon, C., White, J. T., Pryet, A., Gatel, L., and Lemieux, J.-M. (2023), An ensemble-based approach for pumping optimization in an island aquifer considering parameter, observation and climate uncertainty, *Hydrol. Earth Syst. Sci. Discuss.* [preprint], https://doi.org/10.5194/hess-2023-38, in review.

Pryet, A., Matran, P., Cousquer, Y. and Roubinet, D. (2022), Particle tracking as a vulnerability assessment tool for drinking water production, *Front. Earth Sci.* 10:975156, https://doi.org/10.3389/feart.2022.975156.