HydroSciences Laboratory
University of Montpellier - Hydropolis
15 avenue Flahault
34093 Montpellier

6-month internship – Master 2 Hydrology level – Montpellier

Improving the robustness of hydrological models under changing climate conditions

Subject (abstract)

To assess the impact of climate change at catchment scale, rainfall-runoff models combined with regional climate change scenarios are commonly used. This approach relies on climate future projections and models that are reliable under changing climate conditions. However, the well-known lack of robustness of the hydrological models under changing climatic conditions points to the dependence of the optimal parameter set on the climate characteristics of the calibration period. This leads to increased uncertainty in estimating the hydrological impacts of climate change. This study proposes to develop an original approach to enhance model transferability under climate variability. It assumes that model parameters represent a whole system including both the receiver environment (catchment) and the forcing climate. It seeks to exploit the dependence of the model parameter sets on the climate characteristics of the calibration period in order to better account for changes in the catchment behaviour. Three parsimonious conceptual models differing in their time step (annual, monthly and daily, respectively) and complexity (1, 2 and 4 parameters to calibrate, respectively) will be used in the modelling experiment. Their limited number of free parameters should facilitate the development of the calibration approach thanks to the low dimension of the optimization problem. Furthermore, their increasing degree of complexity will offer the opportunity to test the parametric climate-dependency at various time scales (from annual to seasonal). Hence the models will be calibrated from year to year according to sliding-time windows in order to identify the relationship between the optimised parameters and the characteristics of precipitation, temperature and evaporation. This relationship will be analysed to propose a method to make vary the parameters over time. An in-depth analysis at the seasonal scale will also be conducted based on the two models running at a sub-annual time scale. The proposed calibration approach will be developed and tested as a proof of concept in several catchments with long streamflow measurement chronicles in France. The proposed approach aims to improve model robustness, which is essential for climate adaptation strategies worldwide.

Required profile

- General knowledge in hydrology/climatology,
- Sensitivity to modelling approaches,
- Good skills in programming (R, Matlab…),
- Knowledge of GIS software and mastery of office tools (Excel, Word),
- Reading scientific and technical English,
- Organizational and editorial skills, taste for teamwork, autonomy.

Structure/Location: Laboratory HydroSciences Montpellier

Training period: 6 months in the first half of 2024 (ideally starting in January/February).

Intern conditions: Allowances of approximately €600 gross/month.

How to apply: Applications (CV + cover letter) should be sent by e-mail before December 20, 2023 to Denis Ruelland (denis.ruelland@umontpellier.fr).

Short bibliography

Dakhlaoui, H., Ruelland, D., Tramblay, Y. (2019). A bootstrap-based differential split-sample test to assess the transferability of conceptual rainfall-runoff models under past and future climate variability. J. Hydrol., 575, 470–486.

Fowler, K., Peel, M.C., Western, A.W., Zhang, L. & Peterson, T.J. (2016). Simulating runoff under changing climatic conditions: Revisiting an apparent deficiency of conceptual rainfall-runoff models. Water Resour. Research, 52(3):1820–1846.

Merz, R., Parajka, J., Blöschl, G. (2011). Time stability of catchment model parameters: Implications for climate impact analyses, Water Resour. Res., 47, doi: doi:10.1029/2010WR009505.

Royer-Gaspard, P. (2021). De la robustesse des modèles hydrologiques face à des conditions climatiques variables. Thèse de doctorat, Géosciences, Ressources Naturelles et Environnement, Sorbonne Université, 392 pp.

Singh, R., Wagener, T., van Werkhoven, K., Mann, M. E., Crane, R. (2011), A trading-space for-time approach to probabilistic continuous streamflow predictions in a changing climate–accounting for changing watershed behaviour. Hydrol. Earth Syst. Sci., 15, 3591–3603, doi:10.5194/hess-15-3591-2011.

Stephens, C. M., Marshall, L. A., Johnson, F. M. (2019). Investigating strategies to improve hydrologic model performance in a changing climate. J. Hydrol., 579, doi:10.1016/j.jhydrol.2019.124219.

Vora, A., Singh, R. (2022). Improving rainfall-runoff model reliability under non-stationarity of model parameters: A hypothesis testing-based framework. Water Resour. Research, 58, doi:10.1029/2022WR032273

Zhang, X., Liu, P. (2021). A time-varying parameter estimation approach using split-sample calibration based on dynamic programming. Hydrol. Earth Syst. Sci., 25, 711–733, doi:10.5194/hess-25-711-2021.