

Job Description

Work: Mapping recharge and modelling groundwater dynamics on a regional scale - application to southern Madagascar

Functions: Postdoctoral position in hydrology / hydrogeology

Duration: 24 months

Funding: DIGAP - ANR

The following activities could evolve due to the scientific knowledge and experimental findings.

Sorbonne University

Sorbonne University: To transfer knowledge, understand the world and meet the challenges of the 21st century, a new university was born on January 1, 2018, from the merger between the universities Paris-Sorbonne and Pierre & Marie Curie. Sorbonne University is a multidisciplinary, research-intensive, world-class university. Based in the heart of Paris and present in other regions, Sorbonne University is involved in students' success and is committed to addressing the scientific challenges of the 21st century.

Presentation of the structure

Description: The postdoctoral fellow will be integrated in the **METIS** laboratory (UMR 7619). METIS is mainly active in the research domain of continental surfaces, working on water, nutrients and contaminants circulation in environments that can be strongly impacted by human activities. The H2GS2 (hydrology, hydrogeology and subsurface geophysics) team is a leader in the development of hydrogeophysical approaches to characterize the critical zone.

Localisation: Sorbonne University, Pierre and Marie Curie campus, METIS laboratory (approximately 2 months or more of fieldwork in Madagascar)

Missions and principal activities

Context : the DIGAP project:

The DIGAP project confronts a problem observed in the field by Malagasy partners and humanitarian actors: the difficulty of anticipating humanitarian crisis situations linked to droughts. DIGAP argues that a consideration of groundwater status is crucial to anticipating water scarcity-related humanitarian crises in semi-arid regions that are almost devoid of surface water. In fact for some years environmental markers have provided scientific evidence on the hydric situation (e.g. rainfall deficit, drop in piezometric levels). We seek to determine how we can better use water status and more specifically groundwater status, in anticipating humanitarian crises.

First (work-package 1, in which the postdoc will be involved), we will develop an innovative methodology based on remote sensing and modeling to characterize groundwater dynamics at the regional scale in an area that lacks basic documentation. Second (work-package 2), we will quantify the associations among various environmental factors and food security, in addition to human health indicators through the use of a multi-level epidemiological modeling approach. We expect that our results will unravel the effects of environmental and anthropic factors in the development of drought-related humanitarian crises and thereby sustainably strengthen Madagascar's early warning system.

Work program:

In the semi-arid southwest Madagascar region, permanent streams are essentially absent. These conditions allow us to assume that the precipitation minus evapotranspiration (P-ET) term should be a valid proxy for estimating groundwater recharge. We will therefore be able to estimate recharge in a spatialized manner (1*1km) for the entire southern region by subtracting ET from precipitation (resulting from another part of the project). Propagation of the precipitation and ET uncertainties will provide recharge uncertainty.

This recharge estimate can be evaluated at two spatial scales: i) at the regional scale through GRACE (Gravity Recovery and Climate Experiment) satellite monitoring, which provides a resolution of 300*300km (thus, the entire southwest region will be considered a single entity). We will use specific maps from the GRACE processing chain that provide mass variations related to hydrological dynamics and which are expressed in millimeters (Prevost et al. 2019); ii) at the local scale by comparing P-ET with recharge calculated using GROSoM piezometric monitoring (Carrière et al. 2021). Half of the piezometric dataset (dataset 1) will be used here and the remainder (dataset 2) will be used later. We will construct ten new piezometers in the vicinity of existing boreholes to perform long-term pumping tests to estimate the storage coefficient, a key parameter for expressing in millimeters the recharge calculated by piezometric monitoring. Pumping test interpretations will be performed using the OUAIP software developed by BRGM (French Geological Service). We will use the ESPERE-v2 software to calculate recharge according to the water table fluctuation (WTF) approach.

To finish, we will reproduce the general groundwater dynamics at the municipality and district scale through a simplified and robust reservoir-modeling approach. We will use recharge (P-ET) as an input signal into the model. Calibration and validation of these models will be done with the second part of the GROSoM dataset (dataset 2), which was not used in the previous step. The groundwater dynamics will allow us to consider multi-year effects such as the accumulation of dry years.

Main activities:

- Characterization of aquifer hydrodynamic properties (select drilling company, drilling monitoring, pumping tests in Madagascar and interpretation).
- Involvement in the preparation of the GROSoM observatory's hydrogeological newsletter (3 to 4 times a year) in close collaboration with local partners.
- Analysis and modeling of piezometric time series (interpretation and gap filling).
- Estimating recharge from piezometric time series (e.g. WTF method).
- Estimate recharge from GRACE data.
- Comparison of different recharge estimates and quantification of associated uncertainty.
- Regional "reservoir-type" hydrogeological modeling based on global products and calibration/validation with GROSoM data.

Knowledge and skills**Transversal knowledge needed:**

The candidate should have a PhD in hydrological sciences or hydrogeology.

He/she will have experience in modeling or hydrology on a regional scale.

An experience in a developing country would be a plus.

The candidate will need to be able to present scientific work, in both oral and written forms.

Skills:

Hydrogeology, hydrology, modeling (bucket type), drilling follow-up, programming (R and/or Python).

Social skills:

Openness to interdisciplinary work, curiosity, autonomy, ability to work in a poor country with difficult field conditions (we plan around 2 months in Madagascar)

Starting date : beginning 2024 (the exact date can be discussed)

Application

Send to: Simon Carrière: simon.carriere@upmc.fr

- CV
- cover letter
- name of three referees

Application analysis: first round : November 20th

References

Carrière, S.D., Heath, T., Rakotomandrindra, P.F., Ollivier, C., Rajaomahefasoa, R.E., Rakoto, H.A., Lapègue, J., Rakotoarison, Y.E., Mangin, M., Kempf, J., Razakamanana, T., Chalikakis, K., 2021. Long-term Groundwater Resource Observatory for Southwestern Madagascar (GROSoM). *Hydrological Processes* e14108. <https://doi.org/10.1002/hyp.14108>

Prevost, P., Chanard, K., Fleitout, L., Calais, E., Walwer, D., van Dam, T., Ghil, M., 2019. Data-adaptive spatio-temporal filtering of GRACE data. *Geophysical Journal International* 219, 2034–2055. <https://doi.org/10.1093/gji/ggz409>