Post-Doctoral Position. TipHyc project (exploring Tipping points in the West African Hydrological Cycle)

Deadline for application (*extended*) : May 7th , 2022

Job type:
24-month fixed-term contract, full-time ; post-doctoral position

Contract period :
From July 1st, 2022 to June 30, 2024

Location:
IGE (Institut des Géosciences de l'Environnement)
OSUG B 460 Rue de la piscine
38400 Saint Martin d'Hères
Grenoble, France

Presentation of the host institution

The Institute for Geosciences and Environmental research (IGE, https://www.ige-grenoble.fr/?lang=en) is a public research laboratory in Earth and Environmental Sciences, under the supervision of the National Center for Scientific Research (CNRS), the French Research Institute for Sustainable Development (IRD), Grenoble Alpes University (UGA) and Grenoble Graduate Schools of Engineering and Management (Grenoble-INP). IGE employs approximately 255 people, including 155 permanent members (researchers, teacher-researchers, engineers) and about 100 phD students, post-doctoral fellows and staff on fixed-term contracts. The laboratory also welcomes several dozen trainees and scientific visitors each year.

The work will take place within the framework of the TipHyc project (exploring Tipping points in the West African Hydrological Cycle), funded by the French National Research Agency (ANR). The post-doc will work in the PhyREV team of the IGE (Hydrological Processes and Vulnerable Water Resources) composed of about 30 people (researchers, teacher-researchers, PhD students and contract researchers) covering the different compartments of the hydrological cycle (from hydrogeology to climate) and focusing on the West African region.

The TipHyC Project

In a dynamical system with positive feedbacks, an abrupt change to an alternative state can occur in response to a gradual change in external forcing. In this type of transition (regime shift), the system can remain in the alternative state even if the forcing returns to its initial value. The tipping point describes the conditions under which the change of state occurs. Many environmental systems exhibit this type of behaviour (Scheffer 2009).

West Africa is a hotspot of global change (IPCC, 2021, 2014; Toreti et al., 2013) where adaptation challenges are strong. By 2050, an additional temperature increase of about 1°C and increased climate variability are projected under medium greenhouse gazes emission scenarios (IPCC, 2021). The West African population is the fastest growing in the world and is expected to double by 2050 (UN, 2017). As a result, cultivated areas are expanding (Eva et al., 2006), leading to land clearing, which is often accompanied by soil degradation. All these trends could have serious impacts on the land surface and the water cycle, which are strongly coupled. Loss of agricultural production (Sultan et al. 2019) and increased exposure of populations to flooding (Di Baldassarre et al., 2010) are early signs of the impact that global change could have in this region.

The central hypothesis of the project is that climate and land use changes could trigger the passage of tipping points on the scale of a few decades, and cause regime shifts in the West African hydrological cycle. These would result in a perennial increase in the runoff capacity of watersheds associated with a change in vegetation cover, a change in water redistribution in the hydrological compartments, and an increase in flood risk. This type of behaviour is clearly present in long-term hydro-meteorological observations (1950-current) in the Sahel (the most arid part of the region), where current the hydrological regimes significantly differ from those observed before the 1970s-1990s regional drought, despite a relative recovery in annual rainfall totals. These observations strongly suggest the existence of eco-hydrological tipping points. If such tipping mechanisms were proven, global change adaptation strategies should be rethought in light of these potential shifts, which could have significant impacts on human living conditions.

The objective of the project is to study, at the regional scale (West Africa), if, where and when tipping points have been crossed in the past and could be crossed in the future, and to identify thresholds that should not be crossed to avoid unacceptable consequences (Rockström et al. 2009), or conversely, tipping points that could bring desirable changes (Torou et al. 2013).

The first stage the project focused on the development of a system dynamics model, based on the representation of feed-back loops between hydrology and the vegetation dynamics, and allowing to explore the possibility of tipping points in the hydrological cycle. This modelling approach, validated in a recent work (Wendling et al, 2019) is mainly driven by atmospheric (rainfall) and land cover forcings. The model is currently being applied to a dozen contrasting watersheds, ranging from the Sahel to the Atlantic coast, to explore potential regime shifts since the 1950s.

The work proposed for this post-doctoral position will focus on exploring regime shifts and tipping points crossing that could occur by 2100 under different climate and land use scenarios.

References cited

Di Baldassarre, G. et al, 2010. Flood fatalities in Africa: From diagnosis to mitigation. Geophysical Research Letters 37, L22402. https://doi.org/10.1029/2010GL045467

Eva, H.D. et al 2006. Monitoring land cover dynamics in sub-Saharan Africa. A pilot study using Earth observing satellite data from 1975 and 2000. European Commission ; Joint Research Centre ; Institute for Environment and Sustainability.

IPCC, 2021. AR6 Climate Change 2021: The Physical Science Basis — IPCC [WWW Document]. URL https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/ (accessed 9.24.21).

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Scheffer, M., 2009. Critical Transitions in Nature and Society. Princeton University Press.

Toreti, A et al, 2013. Projections of global changes in precipitation extremes from Coupled Model Intercomparison Project Phase 5 models. Geophysical Research Letters 40, 4887–4892. https://doi.org/10.1002/grl.50940

Torou, B.M. et al, 2013. Constraints and opportunities for groundwater irrigation arising from hydrologic shifts in the Iullemmeden Basin, south-western Niger. Water International 38, 465–479. https://doi.org/10.1080/02508060.2013.817042

UN, 2017. World Population Prospects. The 2017 Revision. Key Findings and Advance Tables (No. ESA/P/WP/248). United Nations, Department of Economic and Social Affairs, Population division.

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Objectives :

The objectives of the work are: (i) to assess the possibility of tipping points by 2100 in West African hydrosystems, (ii) to characterize their consequences on water resources and hydrological risks, in order to (iii) be able to anticipate their implications on adaptation and development policies. These objectives imply:

1. the definition of plausible and coherent scenarios of climate and land use evolution by 2100, adapted (e.g. disaggregated) to the project area (a dozen watersheds representative of West African hydrosystems), based on the IPCC/CMIP6 climate scenarios, and two land use projections that consider different demographic and Greenhouse Gas emission scenarios: the Agrimonde-Terra prospective (Mora et al. 2020), and the projections from the Shared Socioeconomic Pathways (Popp et al. 2017);

2. conducting numerical simulations (parallel computing, ensemble approaches) with different combinations of disaggregated climate and land use scenarios driving the system dynamics model developed for the project, in order to estimate which conditions could lead to regime shifts and tipping points crossing, to attribute causes/identify triggers, and to assess the impacts on hydrological risks and water resources;

3. translate these results into “narratives” (eg. ”what if ?“ scenarios) and compare them with the discourses of the development stakeholders regarding the future of the water resources and hydrological risks (droughts, flooding).

The work will be supervised by Dr. G. Panthou (IGE/U. Grenoble, hydroclimatologist) and Dr. O. Mora (DEPE/INRAE, agronomist), and will be carried out in close collaboration with the HydroSciences Montpellier laboratory (project leader) and the other project partners. Regular travel to Montpellier, Paris and Toulouse are planned.

Expected results :

- Publication of scientific papers in peer-reviewed journals, including at least one in a high impact journal ;
- Dissemination of results to the scientific community at international conferences;
- Publication of “policy briefs" so as to inform public decision-making, popularization of the results to development stakeholders (NGOs, decision-makers, development agencies), to the general public, and schoolchildren (in Africa and in France)

Expected professional skills:

- PhD in system dynamics modelling, system analysis or environmental sciences (climatology, hydrology, agronomy, geography);
- Computer skills appreciated: numerical methods on a computer server, handling of large databases, Python, R or other programming language, unix/linux environment;
- Interest in systemic approaches and dynamic models;
- Strong interest in multi-disciplinary studies;
- Fluent written and spoken English (B2 level or higher, as defined by the Common European Framework of Reference for Languages).

Expected know-how :

- Scientific curiosity
- Autonomy and rigour in work
- Ability to interact with scientists from different disciplinary fields.

Salary:

2395 € gross per month or higher, depending on experience and qualification. The automatic contribution to the French social protection system is included in the salary, which allows almost free health care.

Contact / application :

send a résumé and letter of application to :

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and
Christophe Peugeot (project leader): christophe.peugeot@ird.fr