Open PhD Position

Linking Surface Process Dynamics, Groundwater Recharge, and Agricultural Water Use - An Interdisciplinary Approach to Assessing Prospective Scenarios On Cultivated Floodplains

Keywords: hydrology, agrosystems, global change, modeling, infrastructures

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Skill profile:

- An in-depth understanding of hydrological processes at local and regional scales and how to represent them in hydrological models
- Familiarity with agrosystems and water management
- Spatial analysis (working with vectors, rasters, and satellite data in QGIS or ArcGIS)
- Basic coding skills in R, Python, or other scientific languages
- Willingness to do fieldwork, including fieldwork abroad in the Mekong Delta
- Scientific curiosity
- Independence, initiative, and enthusiasm
- Remote sensing using satellite data
- Meteorology or climatology
- Statistics
- General (science) communication skills: interactions with scientific peers and stakeholders, written and oral communication

Project summary:

The aim of this thesis is to explore the link between surface water processes, groundwater recharge, and agricultural water use in potential study areas in the South of France as well as Cambodia. In particular, it aims to gain a better understanding of how these processes and the links between them are affected by ongoing global change as well as shifts in land use and infrastructures.

To attain these goals, this thesis will take a multi-pronged approach combining numerical methods and remote sensing.

It will:

- Characterise surface hydrological processes in the study areas
- Analyse links between surface water bodies, inundated areas, and groundwater recharge
- Explore interactions between water extractions from surface- and groundwater for agricultural production and groundwater recharge from irrigated areas
- Assess the role of infrastructure elements such as resevoirs, canals and irrigation systems
- Evaluate the impact of global change factors on these processes and their interactions

The thesis will be hosted at the UMR G-Eau research unit in Montpellier, France. It includes an estimated volume of 25 weeks of field work.

Context:

This thesis forms part of the broader theme of agricultural adaptations to large-scale global changes. Using a modelling approach, it aims to gain a better understanding of the impact of irrigation infrastructure on the water cycle in agrosystems, and how this will evolve in the context of future changes, including climate change and land-use transitions. More broadly, it is also linked to the themes of food security and sustainable water management. As such, it can be situated within the framework of the United Nations Sustainable Development Goals (SDGs) 2 (Zero Hunger) and 6 (Clean Water and Sanitation), as well as the Unsolved Problems in Hydrology (UPH, Blöschl et al. 2019) No. 1 (Is the hydrological cycle accelerating or decelerating at the regional level in the context of climate and environmental change?) and No. 19 (How can hydrological models be adapted to extrapolate to changing conditions?).

By 2050, the world's population is expected to reach 10 billion, up from 8 billion in 2022 (World Bank 2024). This growth is driving an increase in demand for agricultural products and the expansion of irrigated areas, particularly as climate change has led to more irregular or, overall, lower rainfall in many parts of the world (Konapala et al. 2020). Irrigated areas account for only 20-25% of cultivated land, but over 90% of water consumption (Hoekstra et al., 2012). In France, for example, irrigated areas are expanding once again, having increased by 15% since 2010 (Scotti and Loubier 2024), a trend set to continue as water demand rises due to climate change (France Stratégie 2025). These areas contribute significantly to the volumes of water abstracted and evaporated in the country. At the same time, available water resources are under increasing pressure, again due to the effects of climate change and the rise in other uses (Fu et al. 2022). Mehta et al. (2024) even found that half of the expansion of irrigation in the 21st century has occurred in regions already experiencing water stress. Overall, this leads to crisis situations in which restrictions on water use, or even bans on abstraction, become necessary, as well as the implementation of structural adjustments with controversial environmental impacts. In this context, it is crucial to understand the impact of agricultural water use on the water cycle and to adapt its management so as, on the one hand, to reduce its negative impact and, on the other hand, to enable it to provide a number of ecosystem services, such as groundwater recharge.

Methods:

The overall approach of this thesis will build on work already carried out at the UMR G-Eau on irrigated systems in France, North Africa, West Africa, and South-East Asia (Orieschnig et al. 2021, Orieschnig et al. 2022, Vandôme et al. 2025). It will utilise in situ characterisation, remote sensing and hydrological modelling at all scales.

The planned study areas are the Crau plain in the South of France and the Mekong Delta in Cambodia, a region heavily developed through irrigation and drainage infrastructure (and even river navigation), which significantly affects hydrological flows. This area benefits from a hydrological observation programme led by the IRD and aquifer characterisation work (thesis in progress). The aim is to take into account developments specific to the region, generalise them and integrate them into a simulation tool used on a larger scale.

To this end, the thesis will comprise three general stages:

1- Characterisation of hydrological systems and flows

This section will be based on existing databases, fieldwork, and specific analyses using remote sensing (cross-referencing data to identify water flows, vegetation dynamics linked to hydro-agricultural infrastructure and its management, etc.). This approach will result in a typology of agro-hydrological units (each comprising a set of plots, water bodies, drainage networks, management rules, etc.). It will also enable the characterisation of hydrological flows at different scales, for example by exploring different evapotranspiration products and using thermal remote sensing.

2- Development of a physically-based model

The aim of the model is to represent hydrological processes within the grid cells and interactions with the aquifer (recharge, abstraction). The approach will involve explicitly representing the connections between hydrological units. Transfer functions within these units will be constructed to simulate temporal changes (daily scale) across the entire system.

3 - Simulation and comparison of regional trends

The final component involves applying the developed model to simulate future scenarios involving land-use transitions, climate change, water allocation rules, etc. This will provide a nuanced picture of the role of infrastructure their design and management – focusing on the water cycle and the various flows under different conditions.

Supervision:

Supervision will be provided jointly by Christina Orieschnig (UMR G-Eau, IRD) and Gilles Belaud (UMR G-Eau, Institut Agro).

The intended application context in the Mekong Delta takes place within the framework of a research programme led by two other IRD researchers (Andrew Ogilvie and Sylvain Massuel) who will contribute to the supervision.

The PhD student will be fully integrated into the GHOSTE team (Hydraulic Management, Observation and Simulation of Water Territories) at UMR G-Eau, which specialises in hydrology and remote sensing.

The awardee will have a doctoral contract (2300€/month, three years). He/She will be furthermore encouraged to actively participate in the international hydrological community, for instance by participating in congresses and conferences such as EGU and IAHS. Teaching in MSc programmes will be encouraged too (max. 64h/year, paid ca. 40€/h).

References:

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