PhD: Towards a general framework for assessing the vulnerability of reservoir water management under global change - Application to Lac de l'Oule (French Pyrenees)

1. Context

Issues related to water management require new models able to represent human influence on water resources and relevant methods to address the vulnerability of current management rules to global change.

Hydrologists have long been focusing on modelling of the natural component of the water cycle. In order to go beyond the sole natural component, the PANTA RHEI initiative of the International Association of Hydrological Sciences (Montanari *et al*., 2013) is now promoting the integration of the human interactions with water resources within hydrological models. Simulating human interventions is essential for examining the impact of global change on water management (availability of natural resources, satisfaction of needs, etc. under both climate and socio-economic changes) before outlining efficient adaptation strategies.

Understanding the impact of a changing water cycle on water uses is needed. This implies identifying the facets of climate and/or river flow regime each user is most sensitive to (e.g. severity of drought for abstraction in summer, flood seasonality for fish reproduction, snow cover extension for ski resorts...) and the tolerance level to changes in average flows or in extreme values, etc. Research is required to identify these continually evolving links between hydrology, management rules and water demand. Thereafter vulnerability can be assessed based on the likelihood of critical changes for different future time slices (beginning, middle or end of the 21st century).

2. Objectives

This thesis is a scientific contribution to the Interreg PIRAGUA project (2018-2020) and new developments will be illustrated on the Lake Oule, a reservoir located in the Aure Valley in the French Pyrenees (lake elevation: 1819 m.a.s.l.). The sustainability of the current water management optimised for hydropower production and downstream irrigation will be investigated on this small mountain catchment. This work will be carried out in close collaboration with SHEM (Société Hydroélectrique du Midi, http://www.shem.fr/fr/) – a subsidiary of ENGIE – which manages this reservoir along many others in the Pyrenees.

Lac de l'Oule (source https://fr.wikipedia.org/wiki/Lac_de_l%27Oule)

The two main objectives of the thesis are:

- Developing and improving water use models as pieces of an integrated hydrological modelling framework: the thesis is an opportunity to implement models that may reproduce reservoir operations to produce hydroelectricity and to moderate low flows. An analysis will be carried out to identify drivers that control water releases and storages. The developed structure will be flexible enough to be combined with different hydrological models that simulate water resources, and to be transposable to a wide range of water management contexts. The regulatory aspects will also be included, in particular the compliance of environmental flows and the decision making process that leads to water restriction orders included in drought management plans.
- Characterizing the vulnerability of the management mode of reservoirs: there is a growing concern on the ability of reservoirs to cope with altered climates. The thesis will investigate their vulnerability based on the approach adopted by Sauquet *et al*. (2018). This method will require identifying the water management failures, particularly in terms of storage objectives, ability to meet high peak demands for energy, and correlating the respective intensity or frequency of failures to those of hydro-meteorological hazards (unanticipated flooding, severe low flow, etc.). These failures will be interpreted within a critical hydrological or climatic context and their likelihood under perturbed climate conditions will characterize the vulnerability of the system. The developed models will be forced by perturbed climates to estimate the likelihood considering current management rules and adaptation strategies, in order to assess the efficiency of adapted rules able to reduce the vulnerability.

3. Academic environment

The student will be supervised by E. Sauquet (PhD, HDR) and J.P. Vidal (PhD).The position will be based at Irstea Lyon-Villeurbanne (France, http://www.irstea.fr/en/institute/centers/lyon-villeurbanne-centre). This PhD position is financially supported by the Interreg PIRAGUA project. The PhD student will fully contribute to the PIRAGUA project, including meetings and field trips. He will interact closely with the PIRAGUA associated partners, in particular from SHEM and ENGIE.

4. References

Montanari *et al*. (2013) "Panta Rhei—Everything Flows": Change in hydrology and society—The IAHS Scientific Decade 2013–2022. Hydrological Sciences Journal, 58(6): 1256-1275.

Sauquet *et al*. (2018). Water restrictions under climate change: a Rhone-Mediterranean perspective combining 'bottom up' and 'top- down' approaches. Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2018-456, in review.

5. Profile

The candidate will have a Master's Degree or equivalent. Applicants must have a strong quantitative background in hydrology or/and climatology. Experience with relevant programming, modelling and scripting platforms and the ability to manipulate and analyse large date set is desirable. An interest in issues related to water management, climate change impact and multidisciplinary approach will be appreciated.

6. Application instructions:

For further information regarding the advertised position, please contact: Eric Sauquet: eric.sauquet@irstea.fr, Jean-Philippe Vidal: jean-philippe.vidal@irstea.fr.

Candidates are invited to send an application including (1) a cover letter outlining your interest in, and suitability for, the position, and (2) a curriculum vitae which describes your complete personal details. Applications will be reviewed as soon as they are received, and the position will remain open until filled.