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Spatial variability and changes in storage-discharge relationships of crystalline catchments: implications for resilience and water resources management

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While it is well understood and accepted that climate change and growing water needs affect the availability of water resources, the identification of the main physical processes involved remains challenging. It notably requires to filter interannual to interdecadal fluctuations and extreme events to isolate the underlying trends. Metropolitan areas are specifically subject to growing pressures because of the significant and increasing demand, combined with the strong anthropization of land uses.

The Meu-Chèze-Canut catchment supplies the city of Rennes with drinking water (680 km² - 500 000 users, Brittany, France). In this field laboratory, we explore the dynamics of the water cycle and water resources availability. In this context, water supply is mostly coming from reservoir storage for which levels shows a medium-term vulnerability in response to frequent relatively dry years. Based on retrospective data analysis, we describe the relationship between climatic forcing (precipitation, temperature) and water availability (aquifer storage, river discharge and reservoir storage) in different parts of the catchment that are characterized by distinct lithological and topographical settings. We then evaluate the resilience of both surface and groundwater resources, their past evolution and their resilience to climate change and increasing societal needs.

Water resources availability in these catchments relies on two geological formations with distinct hydrodynamics properties: the Armorican sandstone and Brioverian schist. To assess the resilience of the system, we specifically analyzed the relationships between monthly effective precipitation and stream discharge within nine sub-catchments over the past 30 years. We observe annual hysteresis relationships - that is, a time lag between precipitation and discharge highlighting the capacity of the landscape to temporarily store water - with significant variability in shapes across the catchments. We argue that topographic and lithological factors play key roles in controlling this variability through their impacts on subsurface storage capacity and characteristic drainage timescales. We propose perspectives based on the complementary use of calibrated groundwater models to leverage these results and provide adaptive water management strategies.