Interest and complementarity of physical and chemical monitoring to model the critical zone

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General context:

Critical zone, extending from surface basins to deep aquifers, constitutes a complex system where water cycle occurs. Understanding at several spatiotemporal scales hydro(geo)logical processes such groundwater recharge or chemical reactions will allow an integrate and sustainable management of the resource. Particularly because the impact of the increasing human pressure and future climates remains unclear on water availability and quality. The aim of critical zone observatories is to monitor systems response in different contexts at long-term and several frequencies. These observables, like groundwater levels, rivers flow rate, GPS deformation or hydrochemistry, describe directly or indirectly processes occurring in a system whose boundary conditions are partially known. Next, informative content of physical and chemical observations can be explored through physically-based modeling. Transient measured data can inform locally or integrate a large scale response or both, but also help to assess the system’s boundary conditions ie. geological structures, evapotranspiration, river connections and groundwater recharge.

The field site of Ploemeur/Guidel:

Here, we try to assess the informative content of pluridisciplinary measured data on the H+ observatory of Ploemeur/Guidel site (Britany, France). An interesting point is that the observatory is constituted of two comparable sites in fractured context; one being pumped at a rate of 1.1 Mm$^3$/year since 1991, the other one is still in a natural state. Climate, vegetation, topography, geology and topographic basin area (4 km²) are quite similar but on one side the pumping wells, lowering groundwater table of around 15m, are the only output, on the other side groundwater table outcrops the topography involving more complex relations with the surface. From several years of measured hydraulic heads (Figure 1), GPS-inclinometry deformations, CFC concentrations and river discharges, we refine our understanding of the system. These field data are recorded thanks to a boreholes network sampling different hydrogeological compartment, one GPS station and one inclinometer.

![Figure 1 : Groundwater levels on the Ploemeur site: mean (left) and transient (right).](image)

Each data type allows to better constrain models. The aim of such models is to predict the behavior of hydrological systems in response to climate variability and estimate the destabilization induced by pumping. In transient state representation, we show the importance of boundary conditions compared to soil heterogeneity. First step was to represent piezometry with analytical and numerical models, then, mechanical and chemical components have been added. In a last step, informative content of river flow data is explored for the Guidel site.

Finally, bringing back to the theoretical and measurements framework, parameters set exploration permits to extract interesting information about hydrological processes in fractured system. So, this work brings understandings on hydrodynamic parameters of specific sites, but also more generally, on boundary conditions and heterogeneity impact on long-term hydrological response.