Geophysical Research Abstracts
Vol. 16, EGU2014-4167, 2014
EGU General Assembly 2014

How people and ecosystems organize their storage requirements

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At the start of the Anthropocene, one of the first things human society undertook was to tap water from the natural system: designing wells, diverting river water, harvesting rainwater, tapping groundwater by underground tunnels (qanats), and building canals and aquaducts to convey the water to where it was needed. Although sometimes highly complex engineering works, this was only a first step towards manipulating the natural system. In guaranteeing access to water, people soon realized that it was necessary to create sufficient storage to offset the high variability of hydrological fluxes in the natural system. The building of reservoirs dates back as early as 3000 BC, when the first reservoir was built in the Middle East, not surprisingly in an area with high hydrological variability.

A classical engineering way for designing the size of a reservoir is the Rippl (1883) diagram, where tangents to the accumulated inflow determine the required storage. It is a logical method for people to size the storage required to satisfy the long term water demand. Using this principle, over time, many societies have tried to regulate their rivers, leveling out the natural dynamics of the system. But are people unique in trying to even out unwanted fluctuations or to bridge periods of water shortage? I think that ecosystems do the same.

In contrast to a mechanistic description of the hydrological world, where the maximum storage in the unsaturated (root) zone is simulated by a fixed parameter (often identified by S_{umax}), we have to realize the root zone is actually part of a living ecosystem, which adjusts itself to climatic variability. This so crucial hydrological parameter is alive! It is my hypothesis that ecosystems adjust their root zone gradually to periods of drought or wetness, and that the maximum root zone storage parameter is essentially a function of climate and land cover independent on soil characteristics such as porosity or pF curve. Using a Ripple diagram approach to the unsaturated zone would yield the required root zone storage, and a surviving ecosystem must have created adequate storage to overcome a critical period.

So the concept of Panta Rhei not only applies to the interaction between people and the natural environment, it also applies to the interaction between ecosystem and its climate. Understanding both interactions will be crucial to model water resources systems under changing climatic drivers.