



Isotopes reveal old water discharge in the Californian Sierra Nevada.

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From 2012 to 2016 a five year intensive drought occurred in the Californian Sierra Nevada. This drought period presented us with the opportunity to investigate how catchment water storage, mixing and transit times change from extremely wet to extremely dry conditions. We have collected long term datasets of river discharge, evapotranspiration, and water quality, complemented by an extensive set of cosmogenic radioactive and stable isotopes (^3H , ^2H , ^{18}O , ^{22}Na , ^{35}S). Characteristic features of the test catchment (4.6 km², altitude 1660-2117 m) include a thick (>5m) unsaturated zone in weathered granite mountain soils, high intensity rainfall and snow melt events, dry summers and numerous wetland meadows along the stream.

Our isotope data combined with model analysis (StorAge Selection approach) reveal that under both wet and drought conditions this catchment predominantly discharges its older water and stores new rainfall. As a result the discharge has a mean transit time >5 years. This is the first time that this type of storage-discharge behavior is identified but it is likely to be typical for many catchments with steep slopes, thick unsaturated zones and a Mediterranean climate. Moreover, we found that the combination of stream water tritium and ^{18}O is able to constrain model estimates of storage that contributes to discharge to around 3.5m of water.

Concentrations of weathering products such as sodium correlate strongly to discharge transit times up to 10 years. As such, we hypothesize that the preference for old water discharge in this catchment enhances weathering of the bedrock (compared to more common young water preference) and thus can be seen as a positive feedback (i.e a thick unsaturated weathering layer [U+FOE0] longer transit times [U+FOE0] more weathering). Although after the drought the catchment fills up rapidly to pre-drought storage conditions, we show that the water transit time and water quality will contain drought signs for several years to come.

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