Quantifying dynamic bedrock vadose zone water storage with time-lapse borehole nuclear magnetic resonance

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Abstract

Hydrologic fluxes such as runoff, recharge, and evapotranspiration are regulated by water storage in the vadose zone. Few methods are available for directly observing water storage dynamics where the vadose zone is comprised of bedrock. For the first time, we demonstrate that time-lapse borehole nuclear magnetic resonance (NMR) well logging is a reliable method for quantifying changes in bedrock vadose zone water storage. Well logs of volumetric water content were obtained with a NMR and a neutron moderation system, simultaneously, in a network of hillslope boreholes at two Mediterranean sites in Northern California before and after the dry summer growing season. We show strong agreement between estimates of dynamic storage derived from both NMR and neutron logging and to mass balance calculations. Given the pore-size sensitivity of the NMR measurement, and the fine-grained nature of the bedrock, the agreement between NMR and neutron estimates of dynamic storage suggests that all seasonally exchanged subsoil water is hosted in fractures—and not the bedrock matrix—at these sites.

Advisor Signature