Water Isotopic Composition Traces Source and Dynamics of Water Supply in a Semi-Arid Agricultural Landscape

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Abstract

Climate forecasts for semi-arid landscapes suggest changes in seasonality and form of precipitation. These shifts are expected to alter the structure and function of grassland and steppe ecosystems and present challenges for land management and crop production in regions like the Northern Great Plains, North America. Precipitation in lower-elevation, semi-arid areas provides a local supply of soil water that drives biogeochemical cycling, agricultural production, and groundwater recharge. However, studies of the fate of precipitation are far less common in lower-elevation areas compared to studies of the fate of seasonal snowpack and runoff in alpine areas. This research uses isotopic composition of water ($\delta\ ^{18}O$ and $\delta\ ^{2}H$) to explore the sources and fate of soil water in lower elevation areas of the Judith River watershed, in the headwaters of the Missouri River in Montana, USA. Extensive non-irrigated crop production in this area occurs on well-drained soils and depends on careful water management. Agricultural fertilization and organic matter mineralization have resulted in excessive nitrate leaching from cultivated soils into shallow aquifers and streams. Our observations indicate that colder precipitation contributes isotopically distinct water to cultivated terrace soils relative to downgradient groundwaters and streams. Riparian waters also exhibit isotopically distinct contributions from colder precipitation. Apparent contributions from colder precipitation in terrace and riparian soil waters suggest that snowmelt is an important component of water supply to these systems. In riparian waters, influence of evaporation is also evident, suggesting sufficient residence times and atmospheric exposure for local processing to occur. The evolution of isotopic composition from soils to shallow aquifers to stream corridors indicates source water partitioning as precipitation moves through a semi-arid agricultural landscape. Mixing processes apparent in landscape water isotopic compositions reveal source water dynamics that facilitate plant uptake, solute processing, and contaminant leaching.

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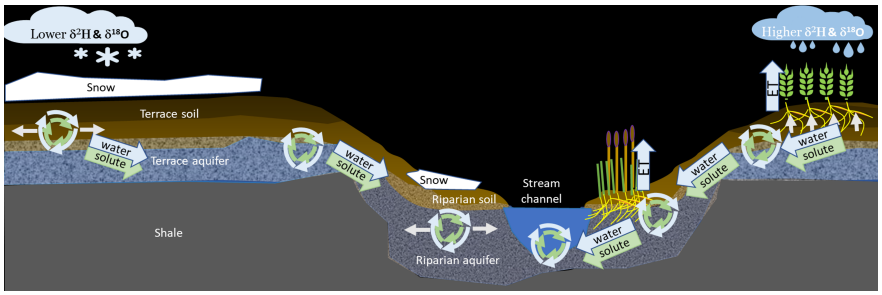

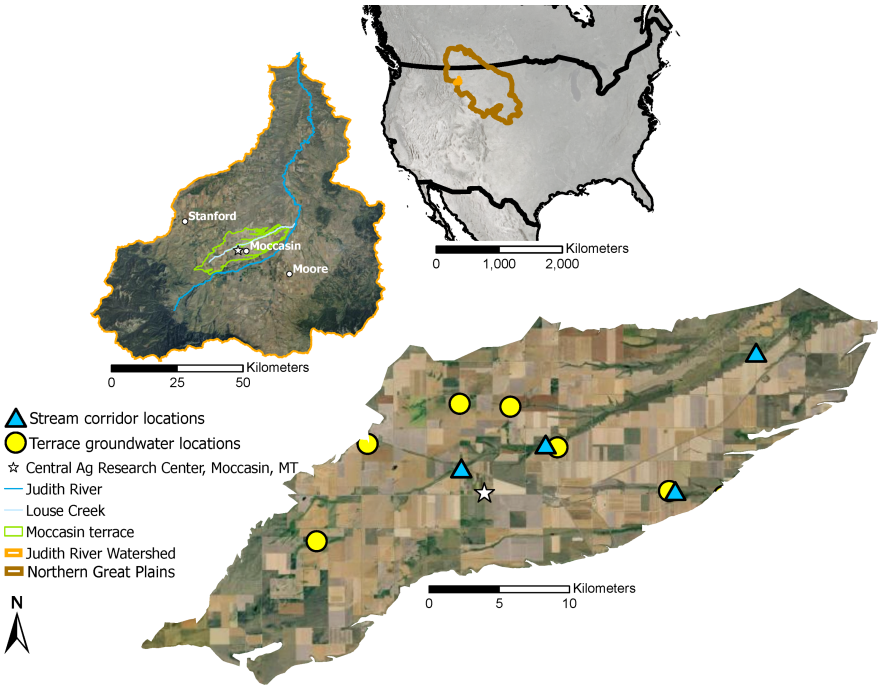

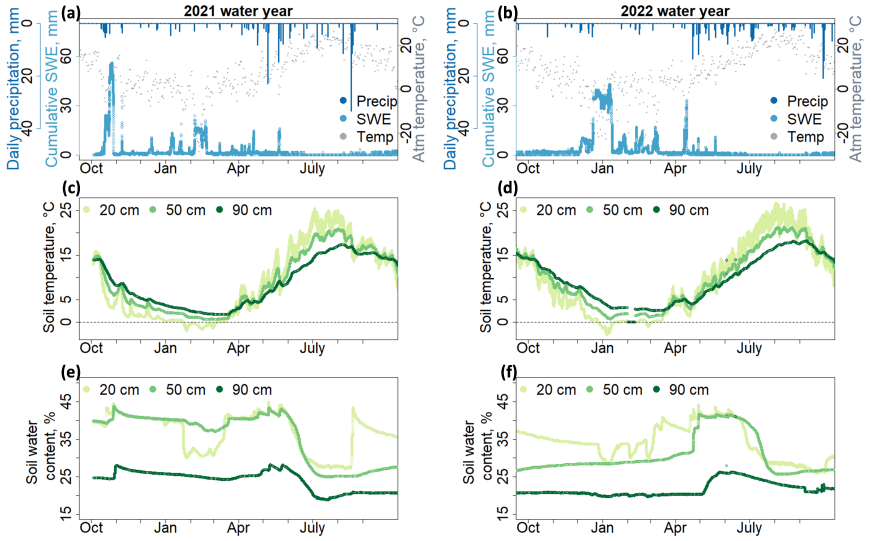

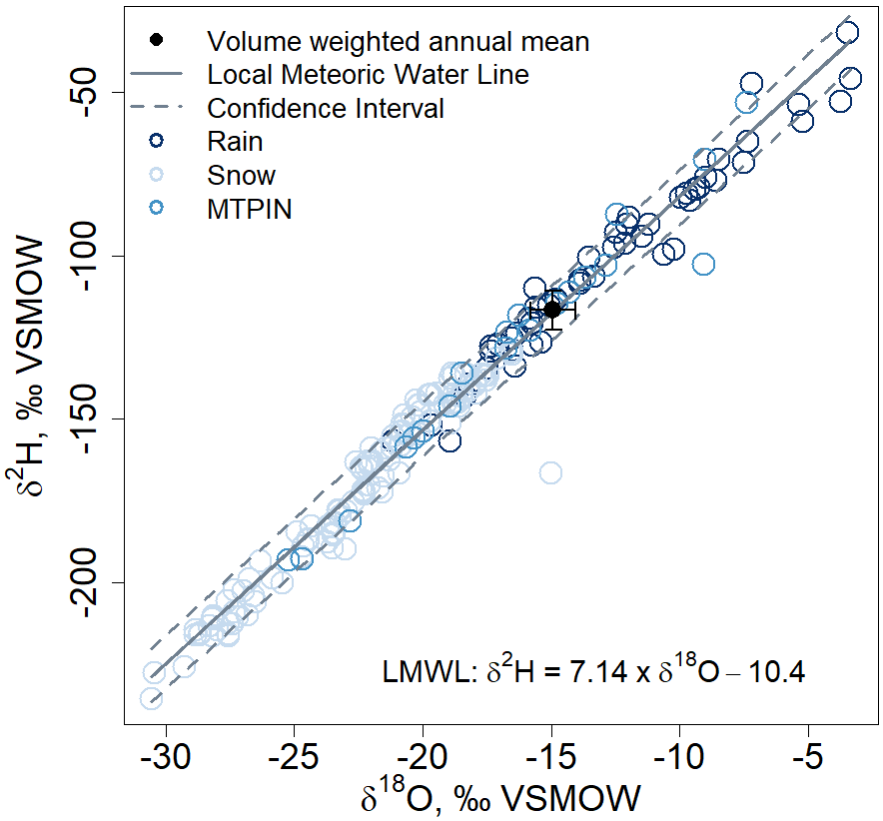

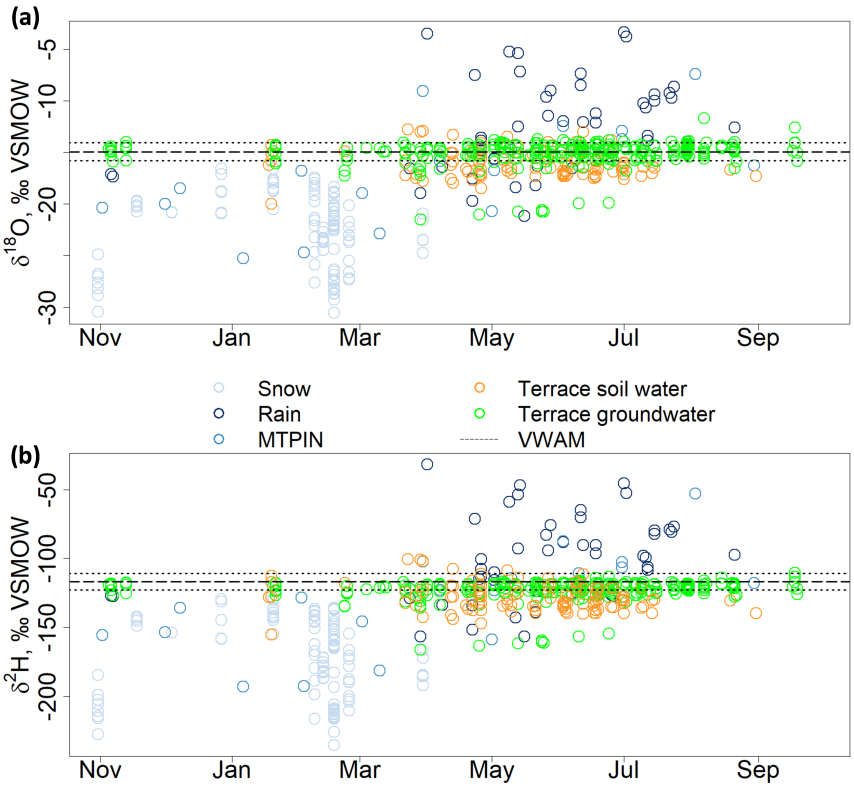

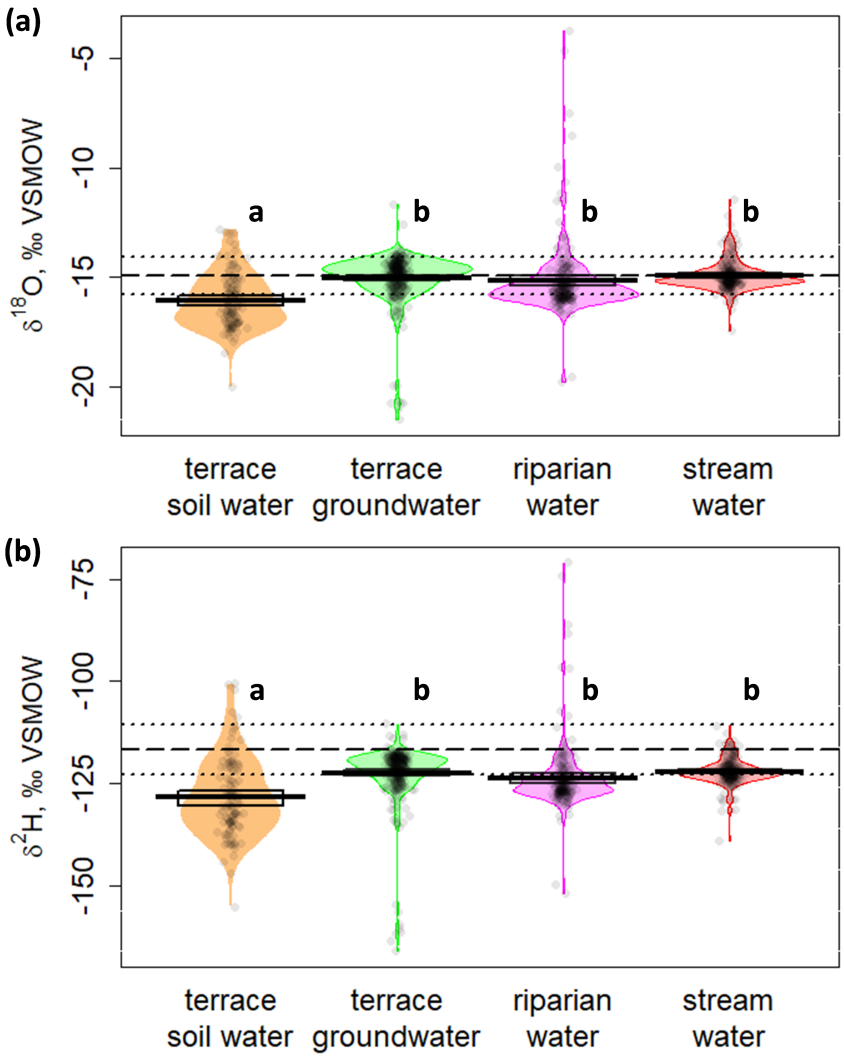

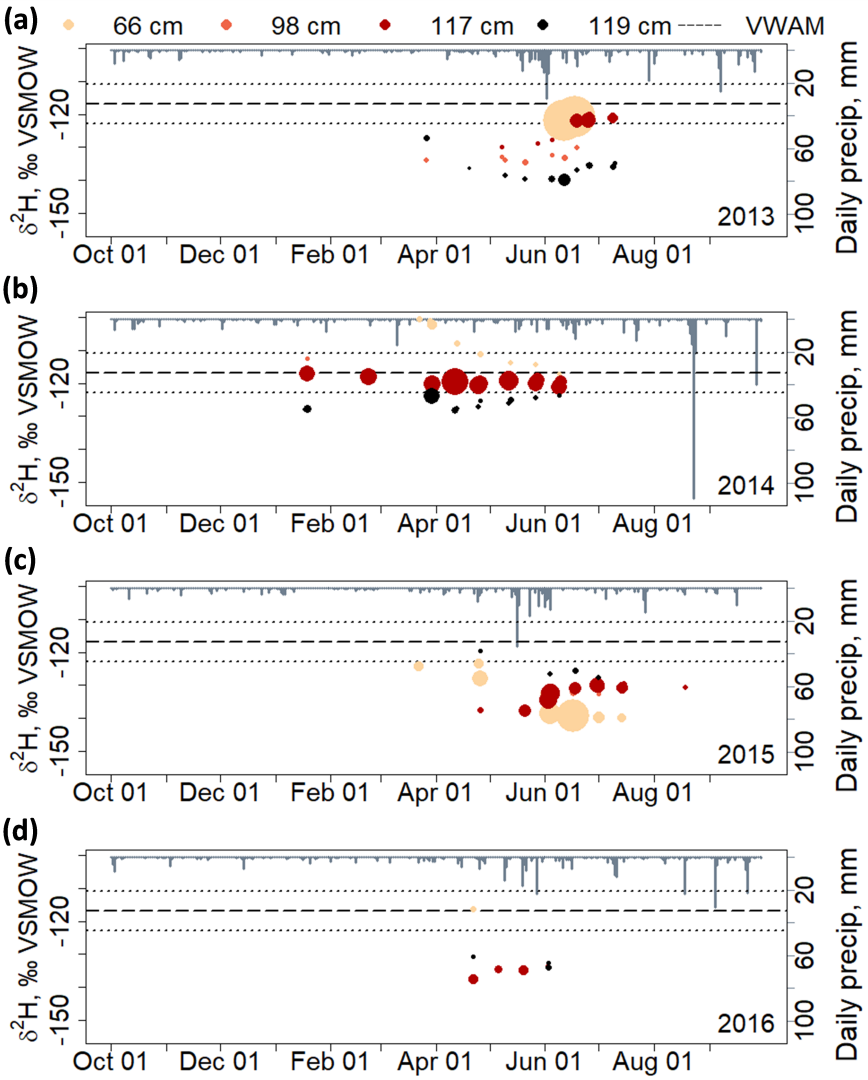

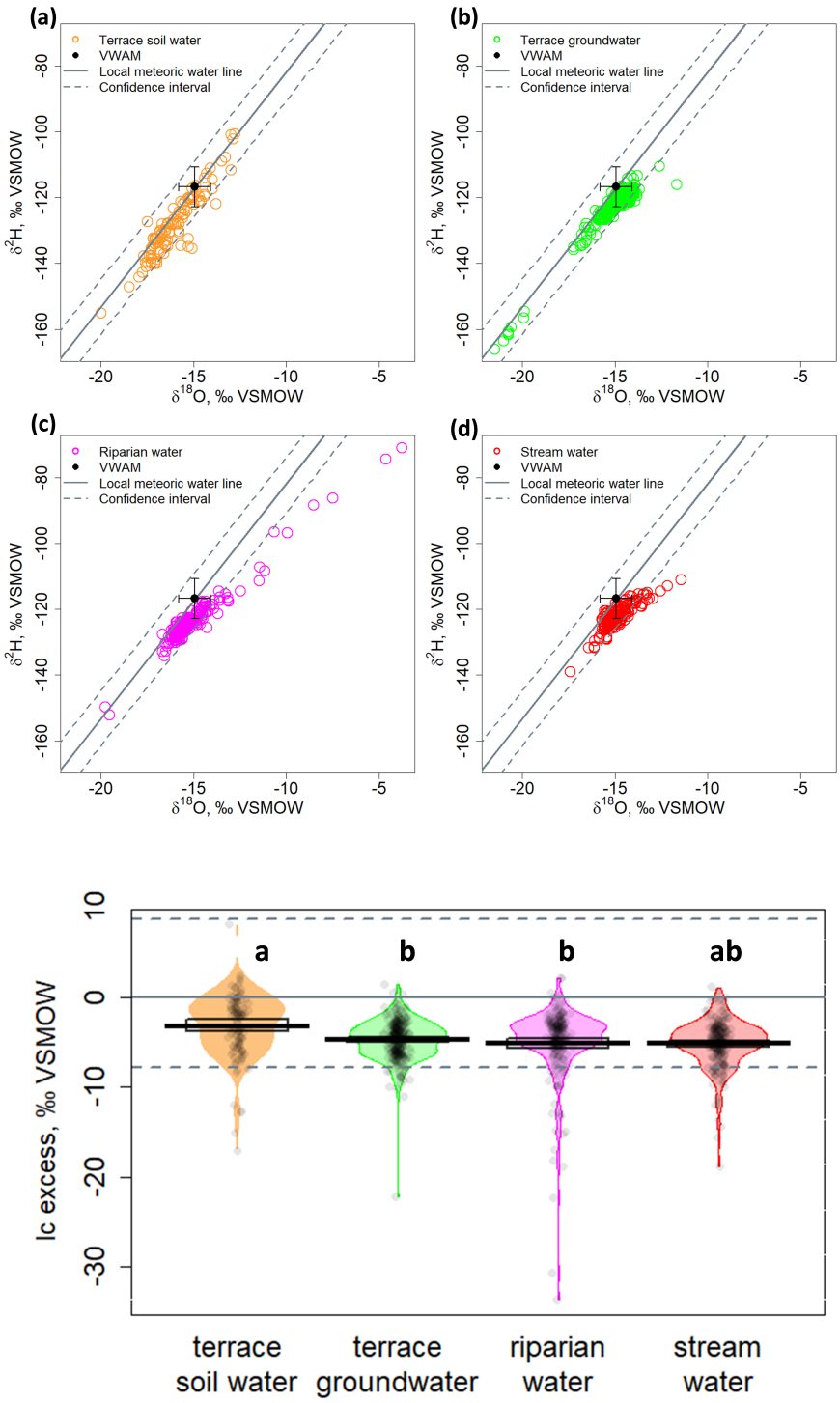

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