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An improved conceptual understanding of snowmelt and groundwater dynamics in the semi-arid Andes

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The contribution of snowmelt to groundwater has long been recognized as an important component of the hydrological cycle in semi-arid northern central Chile (29º-32ºS). Despite its importance as a water resource, this transition to groundwater remains poorly understood. Climatically, the High Cordillera in northern central Chile receives approximately 10 times as much annual precipitation as the valley bottoms, falling almost exclusively as snow above 3500 m during the winter months. Geologically, the High Cordillera is characterized by steep topography and a highly dissected landscape underlain by bedrock. Groundwater stores in the mountain headwaters are assumed to be constrained to the valley bottoms. The current working hypothesis of watershed processes in the High Cordillera describes fluxes of spring melt moving through the hillslope via local flowpaths to valley aquifers that recharge streams throughout the headwater reaches.

Previous studies in the region indicate Pre-Cordilleran aquifers, located in lower elevation dry ephemeral valleys, are hydrologically disconnected from the High Cordillera. These watersheds have no seasonal snowpack, and recharge occurs primarily during infrequent rain events. These isolated Pre-Cordilleran aquifers serve as an important water resource for rural residents and infrastructure.

We present stable isotope, geochemical, and groundwater level data from the wet El Niño winter of 2015 that suggests a topographically disconnected aquifer in the Pre-Cordillera received considerable recharge from High Cordillera snowmelt. These novel findings are indicative of deep groundwater flow paths between the Pre- and High Cordillera during the wet winter and spring of 2015, and improve the conceptual understanding of hydrological processes in the region. Additionally, these results will directly benefit groundwater management in the Pre-Cordillera and better inform modeling efforts in the High Cordillera. While this study is limited to northern central Chile it highlights the interconnectivity of stores and fluxes across time and space, and that straightforward geochemical and isotopic analysis can greatly improve a limited conceptual understanding of hydrological processes.