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When four or more (tracers) are better than one and why you should ski (to sample)

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We measured a combination of natural tracers of water at a high frequency, including stable isotope compositions (δ^2H, $\delta^{17}O$, $\delta^{18}O$), electrical conductivity, and water and soil temperature to characterize hydrological processes in a snow-dominated Alpine catchment and to understand the diversity of streamflow sources and flow paths. Previous work metabarcoding eDNA from stream samples led us to suppose that subsurface connectivity was a primary driver of genetic richness in the water of an alpine catchment, however our process understanding was limited. By diving into temperature measurements in soil and water, electrical conductivity, and stable isotopes, we start to weave together the complexity of this subsurface connectivity. Of particular interest in this alpine catchment is the seasonality of connectivity, which is mainly, in different forms, in melt periods occurring in spring and during rain-fed runoff events in summer and rain-on-snow events in winter. This is dramatically different than in non-mountain, low-elevation environments where connectivity is observed in the cold or winter season. In this presentation, we will compare and contrast what we learn from each tracer and highlight findings that could only be learned by bringing them all together. We will reveal how these tracers inform our understanding of the timing of snow presence and melt, the existence of sub-snowpack local flow, the magnitude of subsurface exchange, and the mixing of snowmelt with groundwater. These insights into the details of streamflow generation in such a dynamic environment were only possible due to the intense, year-round field work.