Hydrological and Biogeochemical response to warming in a high elevation mountain watershed in Colorado

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High-elevation mountain watersheds are undergoing rapid warming and declining snow fractions worldwide, causing earlier and quicker snowmelt. Understanding how this hydrologic shift affects subsurface flow paths, biogeochemical reactions, and solute export has been challenging due to the entanglement of hydrological and biogeochemical processes. This work aims to understand the impacts of shifting climate on water partitioning and stream chemistry in Coal Creek, a high-elevation catchment (2,700 – 3,700 m, 53 km^2) in Colorado. Coal Creek has experienced a higher rate or warming than surrounding low-laying areas [*Zhi et al.*, 2020]. This warming corresponds with dynamic and increased responses from biogenic solutes, whereas geogenic solute and dissolved inorganic carbon (DIC) behavior has remained relatively unchanged. DIC was analyzed along with DOC to incorporate both carbon component products of soil respiration (DOC & CO_2) while also representing chemistry consistent with shifting subsurface flow sources [*Zhi and Li*, 2020; *Zhi et al.*, 2019]. DOC has experienced the largest concentration increase (> 3x). Analysis of annual averages show flow-weighted concentrations are positively correlated with daily minimum air temperature. The contrasting behavior of DOC and DIC indicate climate change and warming are driving changes in organic matter decomposition and increasing concentrations of biogenic species produced in the shallow soil zone, whereas DIC and deep zone species are less affected by climatic changes and more by water partitioning. DOC and DIC data were used along with the reactive transport model BioRT-Flux-PIHM to quantify rates of organic matter decomposition, soil respiration, and subsurface flow path partitioning under different climate forcings at a watershed scale. Preliminary modeling results show that temperature is causing earlier snowmelt, earlier stream flow generation, and lower peak discharge. As stream flow generation occurs earlier so do DOC flushing and DIC dilution events. Additionally, following the post snowmelt times DOC concentrations show a greater increase under warming scenarios. These results indicate earlier melt is partitioning through the shallow zone and warming temperatures are driving increased DOC production. Most process-based studies lack a watershed scale understanding of carbon transformation and flow path alterations. This work shows complex hydrological and biogeochemical coupling at the watershed scale to illustrate how water flow paths and quality are responding to a changing climate in high-elevation mountain watersheds.

References:

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