An Observational Framework for Quantifying Post-Fire Runoff and Water Quality Response

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Abstract: Wildfires are a complex and widespread problem across the western U.S., dramatically increasing constituents in catchment runoff such as sediment, nutrients, and dissolved organic matter. However, few studies exist that quantify the relationship between wildfire characteristics and water quality. To address this gap in research, we developed laboratory-scale rainfall and wildfire simulators to measure the hydrologic and chemical constituent responses from soils subject to a range of burn severities, rainfall intensities, and terrain slopes. Greater understanding of the relationship between these drivers and post-fire runoff constituent fluxes will serve as a basis for the creation of post-wildfire water quality predictive models.

Exploring Post-Wildfire Water Quality: the Photodegradation of Pyrogenic Carbon

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Abstract: Nearly 80% of the United States' freshwater originates in forested landscapes at risk of wildfires, which influence both the terrestrial landscape and hydrologic regime by introducing a heterogeneous spectrum of thermally altered carbon compounds, known as pyrogenic carbon (PyC). Given the projected increase in both wildfire frequency and intensity, understanding the coupling of hydrologic transport and chemical fractionation that wildfires impose on water sources is critical. PyC can be quite mobile and reactive with turnover time of decades or years in soils rather than previously assumed millennia timescales, emphasizing the importance of dissolved PyC (DPyC) translocation from soils to rivers. While riverine PyC transport has been identified as a key component of the global PyC cycle, the extent to which photodegradation contributes to both short-term and long-term DPyC chemical fraction has yet to be resolved. We investigate the role of photodegradation as a major driver altering aquatic PyC physical and chemical properties. Artificial PyC was made by burning organic matter at various temperatures to isolate distinct portions of the PyC spectrum. The organic matter, including leaves and soils, was collected from Great Smoky Mountain National Park where ongoing research was being conducted following the 2016 Chimney Tops 2 wildfire. Each temperature range of the PyC spectrum was separately leached, filtered, and the dissolved fraction was placed outside and exposed to natural sunlight for various exposure times ranging from zero to 28 days. This photodegradation experiment took place in Boulder, Colorado during the summer months to maximize daily sun exposure. Photochemistry was confirmed by monitoring the photochemical formation of hydrogen peroxide via fluorescence spectroscopy. The dissolved organic matter was characterized using excitation-emission matrix (EEM) fluorescence spectroscopy and total organic carbon analysis. By isolating distinct portions of the PyC spectrum, we will better be able to anticipate the fate of PyC in watersheds effected by wildfires.

Incorporating the Seasonal Snowpack into Thermo-Hydrologic Modeling of Frozen Ground at Niwot Ridge, CO

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Abstract: Niwot Ridge, CO is one of the most intensely-studied alpine sites in the world and, with long-term climate and ground temperature observations, serves as an ideal location for analyzing the occurrence of frozen ground and its hydrologic effects under a changing climate. Frozen ground is important for understanding changes in hydrology: recent work has attributed increasing autumn streamflow in this watershed to permafrost thaw and suggested that frozen ground plays a role in determining the timing of groundwater discharge to streams. It is well known, however, that a seasonal snowpack strongly influences the occurrence of frozen ground: a deep snowpack decouples the ground from the atmosphere. Thus, retrospective and future assessment of the hydrologic influence of frozen ground at Niwot Ridge will benefit from physical representation of the snowpack. We have coupled surface energy balance calculations and a physical snowpack model based on the Utah Energy Balance with PFLOTRAN-ICE, a subsurface thermo-hydrologic model that simulates water and energy transport in the subsurface, including freeze-thaw processes. We present results from modeling seasonally frozen ground during 2000-2014 at the alpine D1 (3740 m), Saddle (3530 m), and subalpine C1 site (3020 m) that feature varying degrees of snowpack influence. We simulate how differences in the soil freezing dynamics of snow-covered and wind-scoured ground patches influence infiltration and groundwater recharge. In a future with shifting snowpack dynamics (e.g. increases in peak-season snowfall and decreases in late-season snowfall), high-elevation sites like those at Niwot Ridge will likely experience changes in frozen ground occurrence that may drive shifts in soil moisture.