Hyperspectral Reflectance and Chemical Composition of Pre- and Post-Fire Soils from Three Western USA Megafires

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Recently, wildfire activity and intensity in the western U.S. have increased, mainly due to a warming climate, population growth, and fuel accumulation. Wildfires modify physical and chemical soil properties and can cause Fire-Induced Soil Hydrophobicity (FISH), which reduces water infiltration into the soil and accelerates runoff during precipitation events. This may induce cascading disasters including flooding, landslides, and deterioration of water quality. To predict and mitigate such disasters, FISH is generally quantified at a few fire-affected locations using a manual infiltration test. However, this limited spatial coverage poorly represents FISH on a watershed scale as needed for prediction and mitigation purposes.

Watershed-wide, high-resolution monitoring of FISH can be conducted using airborne or satellite-based remote sensing, for example utilizing solar reflectance spectra. Such spectra depend on light scattering and absorption at the soil surface. For this study, we have sampled ash, burned, and unburned soils, fresh (0 month), 1 year, and 2 years after three 2021 California (US) megafires: the Dixie (3,890 km^2), Caldor (897 km^2), and Beckwourth Complex (428 km^2) fires and characterized the optical and chemical properties of all our samples. Optical hyperspectral reflectance spectra (350–2,500 nm) were obtained using natural solar (blue sky) illumination and a spectroradiometer (ASD FieldSpec3), operated in reflectance mode. For all three fires, the results show that 700 nm wavelength reflectance of ash samples collected 1 and 1.5 years after the fire decreased between 36% and 76% compared to that of samples collected right after the fires. Additionally, significantly higher visible reflectance has been found for unburned compared to burned soil samples. Fourier-transform infrared (FTIR) measurements were used to characterize the carbonate content of soil and ash samples demonstrating a positive relationship between carbonate content and visible reflectance, indicating a possible contribution of carbonate to the reflectance of soil/ash samples.