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Rapid method for reconstructing the maximum soil surface temperature and its spatial distribution using reflectance spectroscopy

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Soils that are exposed to wildfire are affected in such a way that major soil properties are changed (e.g., hygroscopic moisture, organic matter, carbonate content, aggregate stability, particle size, specific surface area, mineralogy, and more). The degree of changes in soil properties is a function of the burn severity, characterized by the peak temperatures and the fire duration. Part of the changes in the soil properties are irreversible and occur over a wide range of temperatures. Accumulated knowledge regarding heat-induced changes in soil minerals has been gathered over the years using a variety of laboratory techniques such as DTA, DSC, and TGA. A recent study has demonstrated that reflectance spectroscopy under controlled conditions and limited spectral regions may also be able to assess soil heat interactions, and it has opened up a new frontier for more studies to come.

In the current study, we went a step farther and investigated the spectral properties, across the entire solar insulation region (400-2500nm), of post-burned Loess soil under a controlled heterogeneous fire event. For this purpose, a net of 16 thermocouples was used to record the spatial distribution of the soil surface temperature during the fire event. A spectral cube of the natural and burned areas was generated and the spectral changes were mapped spatially. The observed spectral changes were all related to well-known soil chromophores. The relationship between the maximum soil surface temperatures and the soil spectral reflectance was characterized by a quantitatively significant performance (r^2=0.96; RMSEP$<$13.1ºC; RPD$>$5). An important finding was that the estimation of the maximum surface temperature using the soil reflectance information was not affected by the thin layer of scorched organic matter presented on the surface. Use of spatial-spectral changes to characterize the post fire consequences is challenging and important because it has the potential to provide a map of hazards for decision makers. Further utilization of this method is of great importance due to its ability to reconstruct the severity of the fire induced areas (or maximum temperature) over the burned soil's surface on a pixel-by-pixel basis, using hyperspectral remote sensing means (long after the fire event), which is the scope of another ongoing activity in our group that is based on these reported results.