Towards Radiative Power-Based Emission Estimates for Wildland Fires

Olusanya Onamuti, University of Nevada, Las Vegas (onamuti@unlv.nevada.edu)

Mentor: Dr. Lung-Wen Antony Chen. (antony.chen@unlv.edu)

Abstract

In natural and managed fires, a high-temperature flame front rapidly traverses a fuel bed, followed by sustained low-temperature smoldering combustion. Fire radiative power (FRP) quantifies the instantaneous rate of energy release and can be integrated over time to yield total fire radiative energy (FRE), a metric often correlated with biofuel consumption. This study aims to establish relationships between real-time fuel weight loss, CO_2 emissions, and FRP as measured by a thermal imaging camera. Experiments were conducted in a controlled combustion chamber at the Desert Research Institute in Reno between October 15 and 18, 2024. The investigation focused on fuels representative of the Great Basin ecosystem, including pine needles, sagebrush, and rabbitbrush. Fuels were weighed before combustion and monitored throughout each 40-minute burn period, while gaseous and particulate components (CO_2, CO, NO_x, SO_2, black carbon, and brown carbon) were quantified in real time. Thermal images captured from a nadir perspective using a radiometric thermal camera (VUE Pro, Teledyne FLIR LLC) positioned approximately 1 meter above the fire provided *in-situ* temperature data, from which FRP was computed using Planck's equation. The CO/CO_2 ratio offered insights into combustion efficiency, and measurements of black and brown carbon enabled evaluation of FRP-based emission factors. Establishing these relationships is essential for characterizing combustion and understanding the energy output and emissions profiles of different fuel types. Preliminary results indicate significant differences in energy output and emissions, as well as strong agreement between CO_2 and FRE time series. The findings of this research have potential applications in the remote sensing of wildland fires and can refine emission models for various burning scenarios using thermal imagery from unmanned aircraft systems and satellites.