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Laboratory Study of Smouldering Peat with Samples from Peatlands in Flow Country, Scotland

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Abstract

Northern peatlands store approximately one-third of global terrestrial carbon and are important to maintain the global carbon cycle. As a consequence of ongoing climate change, northern peatlands are becoming more vulnerable to fires in terms of frequency and severity due to drier soil and increasing global atmospheric temperature. Smouldering is the dominant mechanism of these megafires in peatlands, but poorly studied in the literature. Scotland holds the majority of peatlands in the UK, and the blanket bog peat in Flow Country has been estimated to be the largest single expanse in Europe. In May 2019, a wildfire in Flow country burned around 53.8 km^2 of peatland, causing damage to the natural soil ecosystems and deteriorating regional air quality. Six months after the fire event, we conducted a field study in burnt areas, and collected peat samples in adjacent unaffected peatlands. Samples were taken from peatlands with three different field conditions: pristine, drained, and restored peatlands, and based on the depth of burn in the peat fire, each site in three depth ranges: shallow (0 - 10 cm), median (10 – 20 cm), and deep (20 – 30 cm). Characterisations of physical and chemical properties of each sub-sample were conducted in the lab. Samples naturally dried to 100% moisture content in dry basis were ignited in an open-top reactor (internal dimension 20×20×10 cm) under controlled laboratory conditions, measuring real-time mass loss, soil temperature profile, visual and infrared signature, transient concentrations of 20 gas emission species, and mass of size-fractioned particle emissions (PM10, PM2.5 and PM1). These measurements allow quantification of the smouldering propagation dynamics, fire severity, and emissions. The results show that drained peatland experiences the highest carbon loss and longest thermal residence time above 300 ℃, indicating higher severity and worse soil sterilization. Pristine peatland experienced lower carbon loss compared to drained and restored peatlands, but showed higher smouldering fire spread rate. The averaged emission factor of particles in the combustion of drained and restored peat was nearly twice as high as that of pristine peat. Samples from drained peatland had slightly lower averaged emission factors of CO_2 and

CO and higher averaged emission factor of CH_4 compared to pristine and restored peat. This work contributes to linking lab-scale and field-scale fire dynamics and emission investigations, estimating fire severity and environmental impact, and developing strategies to mitigate peatland fires.

Keywords: Wildfire, Peatland, Emission, Carbon Loss, Smouldering Dynamics, Fire Severity

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