CUROP Summer Research Internship Abstract/Summary: Air Quality Impacts of Increasing Smouldering and Flaming Combustion in Canada's Boreal Forest and Peatlands Using Available TROPOMI Earth Engine Data

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Background: Climate change is driving harmful and accelerating drying and burning in Canadian peatlands (Hu et al. 2018). These trends will allow for deeper burns, destroying peatland carbon stocks; as a result, significant impacts on air quality are contributing to a devastating feedback loop, impacting human health (Turetsky et al. 2015; Thompson et al., 2019). Continuing previous research I conducted focused on comparing fire intensity among wildfires in peatlands and forests, this project aimed to use remotely-sensed air quality datasets to examine the impact of Canadian peatland fires and forest fires on the atmosphere. The objective of this research was to examine spatiotemporal variability in the concentrations of greenhouse gases following fires occurring in peatlands compared to forested areas.

Methods: The European Space Agency's Sentinel 5-P satellite's TROPOMI (Tropospheric Monitoring Instrument) can be used to analyze geochemical impacts from fire, industrial processes, and even the impact of COVID on air quality (Venter et al, 2020). TROPOMI estimates tropospheric concentrations of multiple atmospheric gases of environmental concern including nitrogen dioxide (NO2). TROPOMI data was initially examined for fire events using a configurable Earth Engine application (Braaten 2021), and was further analyzed in scripted time-series analyses and visualizations for multiple fire events. Local air quality sensors were also used to compare change in air quality from TROPOMI to data from ground sensors.

Results: Fires in peatlands produced significantly more air pollution, including CO and Methane (or CH4) (in particular), aerosol optical depth (thickness of smoke plume/emission cloud), SO2, and NO2 when compared to forest land-type fires. The reaction is clear in time-series charts of pre-fire and post-fire concentrations in 2021, as well as when compared to previous years. Peat-heavy fires in Tomahawk, Alberta, and Gypsumville, Manitoba in particular showed heavy emissions of carbon monoxide and sulfur dioxide, typical in peat fire emissions (Hu et al. 2018). Certain fires showed a distinct lack of change in reaction to the blaze. With the high levels of aerosols (AOD) measured for these fires immediately following fire events, a possible blocking effect from heavy smoke plumes was observed. Ground-based verification of TROPOMI-based findings showed mixed results; some urban-based air quality measurements may have been too far from the selected fires, or could be obfuscated by the effect of urban dynamics on air quality. Ground-based sensors in appropriate proximity did show a reaction to fire events in Tomahawk and Gypsumville, and were moderately correlated with trends seen in TROPOMI. Levels of particulate matter (PM 2.5s), CO2 levels, and NO2 levels increased, alongside air quality 'ratings' decreasing following fire events in local and regional air quality ground sensors.

Applications and Recommendations for Future Research: The findings have usefulness in their ability to further the study and knowledge in a topic of increasing spotlight and environmental concern. Evidence showing a link between significant air quality impacts from peatland fires was produced; similar leveraging of scripts and spatiotemporal analyses could be applied to identify and discover air quality degradation resulting from fire events. The use and creation of Earth Engine applications to complement the process of identification and analysis could provide great value, particularly in initial stages of research. Connection between wildfire impacts at multiple scales, from local to global, requiring use of multiple sensors will further understanding of their contributions to feedback loops in peatlands. Climate change will continue to affect these landscapes at a frightening pace, and the impacts of air quality degradation on ecosystems, the atmosphere, and human health remains of great importance.