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Estimating Boreal Fire-generated Ozone over Canada using Ozonesonde Profiles and a Differential Back Trajectory Technique

O. Moeini (1,2), D.W. Tarasick (2), C.T. McElroy (1), J. Liu (3), and M. Osman (2)

(1) York University, Department of Earth and Space Science and Engineering, Toronto, ON, Canada (omidmns@yorku.ca), (2) Environment and Climate Change Canada, Air Quality Research Division, Downsview, ON, Canada, (3) University of Toronto, Department of Geography and Program in Planning, Toronto, ON, Canada

Tropospheric ozone (O_3) is an important short-lived climate pollutant, in addition to its well-known effects on crop production and human respiratory health. Wildfires generate large amounts of O_3 photochemical precursors. The frequency and intensity of boreal forest fires is likely to increase over Canada and the US as a result of climate change. A number of studies suggest that boreal fires can contribute to exceedances of the O_3 air quality threshold concentrations via production and long-range transport of O_3 and its precursors. However, different approaches and datasets used to study ozone production from boreal fires appear to give conflicting results. While dozens of studies suggest some degree of ozone production by wildfires, a number of observations, mainly in boreal regions, show that O_3 is minimally enhanced or even depleted downwind of some biomass burning plumes. In this study, a Differential Back Trajectory (DBT) method was developed, employing HYSPLIT back-trajectories and MODIS fire data to calculate the average difference between ozone concentrations associated with fire-affected and fire-unaffected parcels at 19 ozone sounding sites in North America. The DBT method was applied to more than 900 ozonesonde profiles collected from these sites during campaigns from June to August 2006, 2008, 2010, and 2011. Layers of high ozone associated with low humidity were first removed from ozonesonde profiles to minimize the effects of the stratospheric intrusions in the calculations. The analyses show that none of the stations located at Arctic or far northern latitudes were significantly affected by fires. The ozone enhancement for stations nearer large fires such as Trinidad Head, Bratt's Lake, Kelowna and Stony Plain was up to 1.9±0.5% of the TTOC (Total Tropospheric Ozone Column). Fire ozone accounted for up to 3.9±1.3% of TTOC at downwind sites such as Yarmouth, Narragansett, and Walsingham. On average, fire ozone accounted for 1.1±0.7% of the TTOC at sites nearer large fire activity, while a 2.5±0.7% ozone enhancement was detected at sites further downwind. The results are consistent with other studies that have reported an increase in O_3 production with the age of the smoke plume.