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Enhanced formation of secondary air pollutants and aggravation of urban smog due to crop residue burning emissions in North India

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Biomass burning causes intense perturbations to regional atmospheric chemistry and air quality and is a significant global source of reactive pollutants to the atmosphere (Andreae and Merlet, 2001). In November 2012, large areas in North India including New Delhi experienced several weeks of aggravated smog and poor air quality due to the impact of crop residue burning, which is a biannual post harvest activity that occurs during Oct-Nov and April-May every year in the agricultural belts of North western India.

In-situ high temporal resolution (1 measurement every minute) measurements of a suite of volatile organic compounds measured using proton transfer reaction mass spectrometry (PTR-MS) such as acetonitrile (biomass burning tracer) and aromatic hydrocarbons were performed simultaneously with carbon monoxide, nitrogen oxides, ozone and aerosol mass concentrations (PM 2.5 and PM 10) at a suburban site (30.667°N, 76.729°E and 310 m asl), impacted by air masses that had passed over the burning fields less than 72 hours ago. By using data from the same season but before the post harvest crop residue burning activity had commenced, we were able to quantify enhancements in ambient levels of the measured species due to the crop residue burning activity. When air masses influenced by the fire emissions reached the measurement site, peak values of about 8 ppbV acetonitrile, 4 ppmV CO, 100 ppbV NO_x , 30 ppbV toluene and 15 ppbV benzene were observed which represented a factor of 2-5 increase over their ambient levels in the non-fire influenced period. Emission ratios of aromatic hydrocarbons/CO also showed a marked increase. Non fire event (N.F. E.) influenced and fire event (F.E.) influenced air masses had the following emission ratio enhancements: benzene/CO (N.F.E = 3; F.E. = 5), toluene/CO (N.F.E = 4; F.E. = 8.7) and sum of C8 aromatics/CO (N.F.E = 4; F.E. = 7.3) and sum of C9 aromatics/CO (N.F.E = 2.6; F.E. = 3.4). The OH reactivity of air masses which has strong implications for the oxidizing capacity of the atmosphere increased from an average value of 14 /s (N.F.E.) to 40 /s (F.E.) just due to CO, NO_x and the measured aromatics. The observed increase in ozone was 10ppbV higher after sunrise on the day after the fire plume was sampled and driven by the sudden NO_x availability at a site that normally falls in a NO_x limited ozone production regime.

The strong pollutant enhancements in carcinogenic aromatic hydrocarbons that are also highly reactive and fuel ozone and secondary organic aerosol formation when accompanied by the high NO_x and CO levels resulting from crop residue burning in N. India, clearly highlight the need to address the practice of crop residue burning which strongly alters the composition and chemistry of the atmosphere with adverse effects on both air quality and health. This study is the first from within India to combine fast in-situ PTR-MS VOC emission tracer measurements with online measurements of primary pollutants and MODIS satellite data. Further targeted studies employing a comprehensive measurement suite of both aerosol and gas species are needed to assess the full impact of crop residue burning on atmospheric chemistry and regional air quality.

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