Biomass Burning in Northern India: Influences on Ozone and Black Carbon over the Central Himalayas

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Biomass burning is now well recognized as a source of various biologically harmful primary and secondary pollutants (e.g. CO, BC, O_3, OC, NO_x, NMHCs etc.), which impact atmospheric chemistry and global climate on local, regional and global scales. Many studies in the recent past have focused on understanding the impact of biomass burning over Africa, America, Australia and Southeast Asia using ground based and air-borne measurements. In contrast, such studies are very limited over South Asia including India, where biomass burning contributes significantly to the budget of trace species. This study aims at identifying the Northern Indian biomass burning induced changes in ozone and black carbon over the central Himalayas and the subsequent radiative impacts of these changes by integrating in-situ observations (2007-09) of ozone and aerosols from a high altitude site, Nainital (29.37^{o} N; 79.45^{o} E; 1958m amsl) in the central Himalayas with satellite observations and a radiative transfer model. Fire activity over Northern Indian Subcontinent is examined using fires detected by MODIS and analysis of three years (2007-09) fire counts dataset explicitly show highest fire counts in spring over this region. MODIS fire counts are used to identify high and low fire activity periods. Black carbon observations at Nainital are used to separate fire-impacted periods from the background and fire induced enhancements in ozone, black carbon and aerosol optical depth (0.5 μm) are calculated to be ~18 ppbv, ~1725 ng/m^{3} and 0.31 respectively. Significant enhancements (> 30%) in lower tropospheric CO, tropospheric column NO_2 and aerosol parameters are also seen is satellite observations over a region around Nainital. Tropospheric column NO_2 and aerosol optical depth are found to increase by more than 60% over maximum fire activity regions. The clear sky shortwave aerosol radiative forcing at the surface and TOA during fire-impacted periods is seen to increase nearly by a factor of 2.