Evaluation of stubble burning aerosol features over a pristine location using ground-based, model and spaceborne data

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Abstract

This paper reports the results of a study of variations in aerosol optical, microphysical, and radiative properties during biomass (crop residue) burning events recorded at Amity University Haryana (AUH), a rural station, Gurugram (28.31^{o}N, 76.90^{o}E, 285 m above mean sea level), employing ground-based observations of NASA-AERONET Radiometer and Aethalometer, as well as satellite and model simulations during November 2021. Furthermore, smoke events that affected the station during the study period are simulated using the regional Navy Aerosol Analysis and Prediction System (NAAPS) model to assess the role of smoke aerosols in regional aerosol characteristics. Higher atmospheric forcing was observed during smoke periods due to the atmosphere which was apparently attributable to smoke aerosols. In addition, the higher values of Black Carbon (BC) mass concentration and Biomass Burning (BB), and lower values of Absorption Angstrom Exponent (AAE) are also observed during the peak intensity of smoke events. A prominent smoke thick layer extending from surface to an altitude of about ~3 km, whereas the CALIPSO observations of the vertical profile of aerosols agree with the results of AERONET observations. In addition, the transport of a wide-spread agricultural crop residue burning of smoke plumes is observed across the country as evidenced by the MODIS imagery and HYSPLIT back trajectories.

Material and Methodology

Biomass burning (BB) is one of the important sources of atmospheric aerosols and trace gas emissions, which have impacts at local, regional, and global scales with direct short- and long-term climate implications and serious risk to human health (Nastos et al., 2010). Measurements over remote stations yield background levels of aerosols concentration. Hence, it would be possible to observe and examine the extent to which the 'clean' remote areas have been affected by growing urbanization/industrialization. The study site, Amity University Haryana (AUH), (28.31^{o}N, 76.90^{o}E, 285 m above mean sea level), is a rural location, situated around 50 km from Delhi. The site is in an agricultural field 25 km north of Amity University. The experimental site has complex topography with valley-like terrain. The site often suffers from pollution, particularly at night-time when heavy vehicles drive the NH road and wind patterns sometimes lead to pollution affecting the study area. Although the site is primarily a rural station with sparse residential buildings, population, and vegetation fields, it poses sporadic pollution due to the above-mentioned natural and anthropogenic activities. More details of the experimental site can be found in Devara et al. (2017). In this study, we used MODIS and VIIRS satellite images, multi-spectral cloud-screened AERONET level 2.0 data (Holben et al., 1998), BC mass concentration and Biomass Burning (in per cent) and Absorption Angstrom Exponent (AAE) data from AE33 Aethalometer (Sonbawne et al., 2021). In addition, the Navy Aerosol Analysis and Prediction System (NAAPS) (Lynch et al., 2016), the vertical feature mask of CALIPSO products and aerosol sub type images are used to identify the type of aerosols (Winker et al., 2009), and air mass back trajectory analysis (Draxler and Hess, 1998).

Results and Discussion

The results of the analysis of the above-described data are illustrated below:

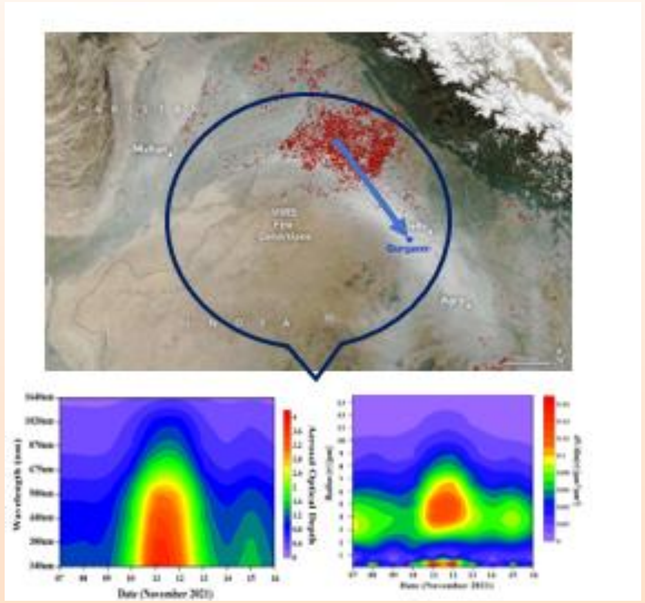

Figure: Fire and smoke aerosol sources, spectral variation of optical depth and derived radius and volume size distribution.

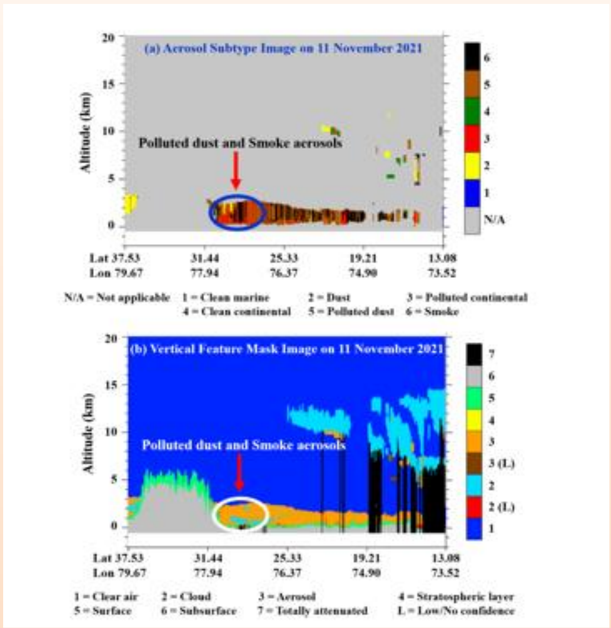

Figure: (a) CALIPSO retrieved aerosol classification (sub-type profile) and (b) Vertical feature mask on 11 November 2021 over the study region

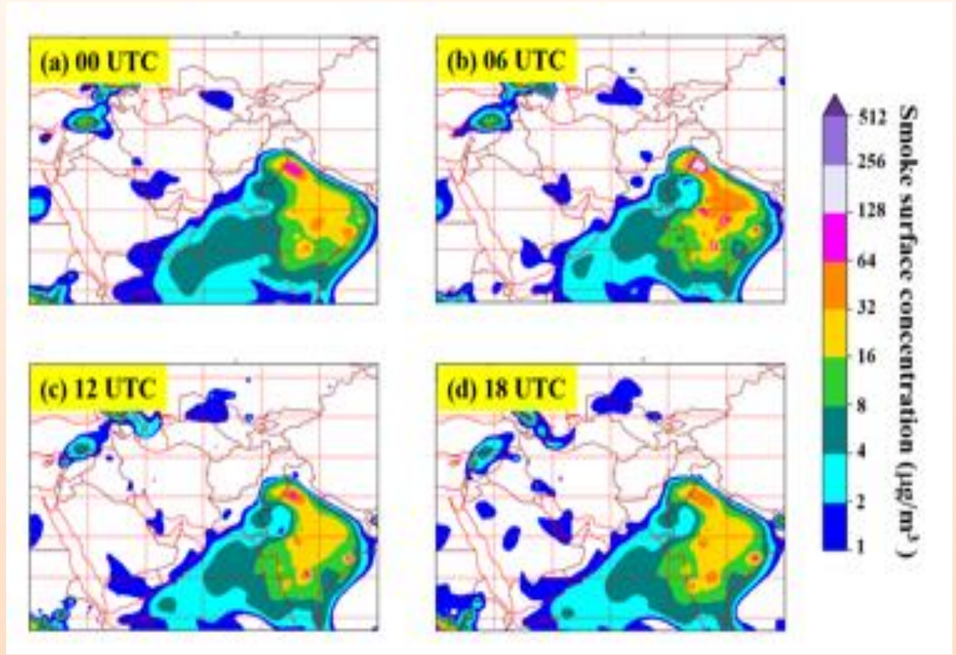

Figure: Concentration of smoke at the surface on 11 November 2021 during 00:00, 06:00, 12:00 and 18:00 UTC.

Conclusions

The results of the study indicated **(a)** Smoke intrusion caused an increase in aerosol optical depth and size exponent, (b) Higher BC, BB, and atmospheric forcing during burning period, (c) CALIPSO satellite revealed smoke and dust aerosols up to ~ 3 km, (d) Air trajectories showed predominant long-range transport of fire and smoke aerosols, and (e) Model images exhibited higher surface-level smoke aerosol concentration.

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Winker et al., 2009: Journal of *Atmospheric* and *Oceanic Technology* 26: 2310–2323. http://dx.doi.org/10.1175/2009JTECHA1281.1