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Characterization of aerosols and trace gases at the Central Himalayas using long-term ground and satellite observations

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The serene environment of the Himalayas is experiencing adverse impact of air pollution, rising critically with the advent of rapid industrialization and urbanization. However, systematic long-term ground-based measurements are almost nonexistent in this region due to the prevailing extreme conditions and complex terrain.

In this context, we present insights from the long term ground based measurements of aerosols and trace gases carried at ARIES, (29.4°N, 79.5°E, 1958 m a.m.s.l) a high altitude site in the Central Himalayas. We also used satellite observations, back-air trajectories and radiative forcing estimations with these extensive observations to understand the variabilities, sources and radiative impact over this region. The higher temporal resolution online measurements during 2014-2020 revealed that daytime concentrations of OC, EC, CH_4 and CO were twice that of the night-time. It is shown that swiftly varying meteorological parameters along with boundary layer height during daytime are responsible for these changes at diurnal scales. Diurnal observations of EC are used to estimate radiative forcing (RF) and it is shown that atmospheric RF during afternoon is about 70% higher than the forenoon RF.

Residence time and concentration weighted trajectory analysis along with OC/EC ratio and fire estimates from MODIS show the influence of biomass burning in spring (MAM). Seasonal minimum for all the species occurs in the monsoon (JJA) due to extensive wet scavenging at the site. During winter (DJF), influence of local burning activities for heating and cooking, to aide in lower temperatures is shown.

Source apportionment estimate is used in BC and multiple regression approach is used in CO to segregate their biomass (BC_{bb}/ CO_{bb}), fossil fuel ($BC_{ff/}$ CO_{ff}) and background components (CO_{bgd}) components. The results reveal the dominance of fossil fuel emissions in BC (BC_{ff} ~76% BC_{bb} ~24%) and background component in CO followed by fossil fuel emissions (CO_{bgd} ~59%, CO_{ff} ~26%, CO_{bb} ~14%). Principal component analysis (PCA) applied to 23 chemical constituents of PM10 samples collected during October 2018−February 2019 identified the contribution of crustal/soil dust, biomass burning and industrial emissions at the site. Further, long term (2006-2020) aerosol

properties acquired from the CALIPSO is used to study the vertical structure of aerosols and their subtypes and it is shown that the fine mode aerosols with particle depolarization ratio < 0.2 dominate the site.

The study thus utilizes the long term dataset to precisely segregate the role of local meteorological conditions, transport, fossil fuel, biomass burning and local emissions impacting the site in different seasons and shows its particular importance in terms of radiation budget and constraining emission sources.