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Characteristic dissimilarities during high aerosol loading days between western and eastern Indo-Gangetic Plain

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HIGHLIGHTS

- The occurrence of high aerosol loading days over western IGP is roughly two times of total high aerosol loading days over eastern IGP.
- The strong westerly wind favours the transport of dust aerosols from the desert regions over western IGP, whereas weaker wind over eastern IGP facilitates the accumulation of aerosols.
- The high aerosol burden induces additional warming (~1 Wm^{-2}) in the atmosphere over EIGP.

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ABSTRACT

This study investigates the long-term (2003–2019) variations of high aerosol loading days and their radiative impacts over the western Indo-Gangetic Plain (IGP) and eastern IGP during pre-monsoon season (March-April-May-June). The Aerosol Optical Depth (AOD) climatology from MODIS (Terra and Aqua) and MERRA-2 reanalysis shows high aerosol burden across the IGP region during the pre-monsoon season. The high aerosol loading days are identified based on a standardized AOD anomaly approach, from MODIS and MERRA-2. The frequency of high aerosol loading days over the western IGP is roughly twice that of the total number of high aerosol loading days over the eastern IGP. The area-averaged percentage differences in AOD between high aerosol loading days and normal days over western IGP is always higher, about 6–8%, than eastern IGP from Terra, Aqua and MERRA-2. The natural (mainly dust) and anthropogenic aerosols (particularly sulfate, black carbon and organic carbon) are majorly contributed to total AOD over western IGP and eastern IGP. Furthermore, the MERRA-2 and ERA5 composite surface and 850 hPa wind anomalies show that strong westerly winds dominate, transporting dust aerosols from arid regions to the western IGP. On the other hand, weak prevailing winds and background pre-monsoonal cyclonic circulations over eastern IGP favor the accumulation of regionally emitted aerosols. During high aerosol loading days, the decrease in ventilation coefficient indicates the high aerosol burden (less dispersion) over both the regions, leading to the deterioration of air quality. The enhanced aerosol loading induced potential atmospheric radiative forcing (19.78 Wm^{-2} over western IGP and 20.77 Wm^{-2} over eastern IGP) during high aerosol loading days compared to normal days (11.12 Wm^{-2} and 12.9 Wm^{-2}).

1. Introduction

The natural dust aerosols are the most common in the Earth's atmosphere and are mainly generated by wind erosion from the arid and semi-arid regions (Ginoux et al., 2012; Jin et al., 2018, 2021). The globally emitted dust aerosols show the major contribution from the natural sources (~75%) compared to anthropogenic (~25%) (Ginoux et al., 2012). About 70% of these emitted dust aerosols get transported far away from the source regions (An et al., 2018). These dust aerosols can directly affect the Earth's radiation budget by scattering and absorbing solar and terrestrial radiation (e.g., Schulz et al., 2006) and indirectly by modulating the cloud properties (e.g., Seinfeld et al., 2016; Pandey et al., 2020). Apart from the radiative impacts, the dust aerosols have a wide range of impacts on the local and regional climate (Ravi

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