



## **Observational evidence of EHP effects on the early melting of snowpack over the Tibetan Plateau and Indian summer monsoon**

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In this study, observational evidences are presented showing that the Indo-Gangetic Plain (IGP) regions, bounded by the high altitude Himalayan mountains, are subject to heavy loading of absorbing aerosols, i.e. black carbon and dust, which can lead to widespread enhancement warming over the Tibetan Plateau and accelerated snowmelt in the western Tibetan Plateau (WTP) and Himalayas. The two pre-monsoon seasons of high aerosol and low aerosol cases were strikingly contrasting in terms of the aerosol loading over IGP. The warming of the TP in high aerosol cases relative to low aerosol cases was widespread, covering most of the WTP and Himalayas. This warming is closely linked to patterns of the snow melt. Consistent with the Elevated Heat Pump hypothesis, we find that increased loading of absorbing aerosols over IGP in the pre-monsoon season is associated with increased heating of the upper troposphere by dynamical feedback induced by aerosol heating, and enhances the rate of snowmelt over Himalayas and the WTP in April-May, indicating that the heating of the troposphere by elevated dust and black carbon aerosols in the boreal spring can lead to widespread enhanced land-atmosphere warming, accelerated snow melt in the Himalayas and Tibetan Plateau, and enhanced precipitation in May-June over the northern India.