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Linkage between the absorbing aerosol snow darkening effects over the Himalayas-Tibetan Plateau and the pre-monsoon climate over northern India

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A large uncertainty exists today in quantifying the absorbing aerosol snow darkening effects, especially at the regional scale. It is considered as one of the main factors contributing to snow melting and glacier retreat over the Himalayas-Tibetan Plateau (HTP). Using International Centre for Theoretical Physics (ICTP)'s regional climate model - RegCM4 coupled with SNow, ICe and Aerosol Radiation (SNICAR) embedded within Community Land Model (CLM4.5), we examine the possible changes induced by aerosol deposition over the HTP and its dynamical impacts over northern India during the pre-monsoon season, which is critical for the inception and development of the monsoon. Sensitivity experiments without (DRE) and with aerosol snow darkening effects (SDDRE) were carried out over the South Asia - Coordinated Regional Climate Downscaling Experiment (CORDEX) domain for the period 2005-2010. It is found that there is a significant reduction of snow fraction by 10 to 25 % and an increase in surface temperatures (> 4° C) in SDDRE, which improves the model performance when comparing against observations. This response is dominated by a larger portion of dust deposition compared to black carbon. The associated increase in the surface and tropospheric temperature over HTP draws in dry air from central and west Asia towards northern India leading to a decrease in the precipitation in SDDRE. The increase in the northwesterly winds also modulates the dust cycle by enhancing dust emissions over the Thar Desert as well as the columnar burden and depositional fluxes over northern India. As a result of the decrease in precipitation, surface temperature increases and generates a low-pressure system over northern India, which further strengthens the dust transport and partially contributes to the occurrence of dust storms. We also find that the snow darkening effect induces an earlier monsoon onset due to larger temperature gradients initiated over the HTP. Some analysis of precipitation and temperature extremes as well as limitations will be presented. Our study provides evidence that the aerosol snow darkening effects could have substantial impacts over HTP as well as over northern India through feedbacks and hence needs to be considered in climate simulations.