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Impact of aerosol deposition on snow reflectance over the Himalayas by satellite observations

Ritesh Gautam[†]; Christina Hsu; William Lau; Teppei Yasunari
[†] Universities Space Research Association, NASA/GSFC, USA
Leading author: Ritesh.Gautam@nasa.gov

Major sources of natural and anthropogenic emissions in Asia prevail in the vicinity of the Himalayas-Tibetan Plateau snowpack and glaciers. The presence of aerosol deposition over snow cover in the form of dust and black carbon impurities have been indicated by in situ and ice core measurements over a few locations in the Tibetan Plateau. Snow albedo reduction caused by aerosol deposition has been modeled in accelerated seasonal snowmelt, regional climate warming and even perturbations to the monsoonal circulation. This study utilizes multispectral satellite observations of visible to shortwave-infrared (SWIR) reflectivity over the Himalayan snow surface from MODIS to understand the impacts of aerosol deposition on snow albedo reduction. We focus on the pre-monsoon season (may-June) when episodic dust plumes transported from southwest Asian desert/arid regions are advected over western Himalayas resulting in vertically extended brown haze as seen in MODIS imagery. Case studies of dust-capped snow/ice surface as well as intra-seasonal variations of reflectivity at Top-of-Atmosphere are examined at seven wavelengths from 0.47 to 2.1 μm from MODIS to characterize the seasonal change in albedo and infer the residual dust/aerosol contribution to its reduction. The spectral signature yields a significant gradient with shorter wavelengths (visible) being most sensitive to snow contamination while NIR and SWIR spectrum remains largely unaffected by snowpack pollution and is characteristic of snow ageing processes. On the contrary to results over western Himalayas, other relatively clean snow surface areas such as further north in the Karakoram ranges are characterized by snow ageing and melting processes as suggested by the spectrum. The satellite observations of snow-melt and -contamination induced changes in reflectivity seem to be consistent with that predicted from theoretical snow-impurity based radiative transfer calculations. Additionally, our study also utilizes observations from other spaceborne platforms (e.g., Clouds and the Earth's Radiant Energy System) to investigate changes in shortwave fluxes over dust-laden and dust-free snow covered regions. Results from this observational work are anticipated to provide better understanding of the radiative impact of aerosols over snow surface, especially its role in the Himalayan hydrological cycle.