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Scavenging Ratio of Black Carbon in the Arctic and the Antarctic

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Abstract

Long-term monitoring of atmospheric aerosols and their interaction with radiation, cloud, and cryosphere over the Arctic and the Antarctic are very important for the global climate change related issues. In this regard, for conducting aerosol measurements, India has extended the concerted efforts to the Indian stations at the Svalbard region of the Norwegian Arctic (Himadri, 78°55′N 11°56′E, 8 m a.s.l.) in the northern hemisphere and the Larsemann Hills of coastal Antarctic (Bharati, 69°24.4′S 76°11.7′E, 40 m a.s.l.) in the southern hemisphere. In the present study, we have examined darkening of snow due to black carbon (BC) deposition in different sunlit seasons and estimated the scavenging ratio of BC over both the poles from simultaneous measurements of atmospheric BC and BC deposited in snow. The study reveals distinct spatio-temporal variability of BC in polar snow, even though the magnitude of BC concentrations is, in general, low (< 12 ppbw, parts per billion by weight). During local summer seasons, the concentration of BC in Arctic snow (median ~ 7.98 ppbw) was higher compared to the values at Antarctica (median ~ 1.70 ppbw). Concurrent with this, the scavenging ratio (SR) also showed large variability over both the poles. Relatively higher values of SR over the Antarctica (mean ~ 119.54 ± 23.04; during southern hemispheric summer) in comparison to that over the Arctic (mean ~ 69.48 ± 4.79; during northern hemispheric spring) clearly indicates the difference in removal mechanisms (aerosol mixing, aging and size distribution) of BC from the atmosphere over distinct polar environments. Measurement of spectral incoming and reflected radiances over the Arctic snow during the early spring season of 2017 indicated the values of surface broadband albedo varying between 0.64 and 0.79. The Snow, Ice and Aerosol Radiative (SNICAR) model simulated values of spectral albedo correlated well with the measured ones and indicated the role of dust absorption, in addition to that of BC, in changing the snow albedo. This information needs to be accurately incorporated in the radiative transfer models for the accurate estimation of snow albedo forcing over the Polar Regions.