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Deposition of brown carbon onto snow: changes of snow optical and radiative properties

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Light-absorbing organic carbon aerosol – colloquially known as brown carbon (BrC) – is emitted from combustion processes and has a brownish or yellowish visual appearance, caused by enhanced light absorption at shorter visible and ultraviolet wavelengths (0.3 μm ≤ λ ≤ 0.5 μm). Recently, optical properties of atmospheric BrC aerosols have become the topic of intense research, but little is known about how BrC deposition onto snow surfaces affects the spectral snow albedo, which can alter the resulting radiative forcing and in-snow photochemistry. Wildland fires in close proximity to the cryosphere, such as peatland fires that emit large quantities of BrC, are becoming more common at high latitudes, potentially affecting nearby snow and ice surfaces.

In this study, we describe the artificial deposition of BrC aerosol with known optical, chemical, and physical properties onto the snow surface and we monitor its spectral radiative impact and compare it directly to modeled values. First, using small-scale combustion of Alaskan peat, BrC aerosols were artificially deposited onto the snow surface. UV-vis absorbance and total organic carbon (TOC) concentration of snow samples were measured for samples with and without artificial BrC deposition. These measurements were used to estimate the imaginary part of the refractive index of deposited BrC aerosol with a volume mixing rule. Single particle optical properties were calculated using Mie theory, and these values were used to show that the measured spectral snow albedo of snow with deposited BrC was in general agreement with modeled spectral snow albedo using calculated BrC optical properties. The instantaneous radiative forcing per unit mass of BrC deposited to the ambient snowpack was found to be 1.23 (+0.14/-0.11) W m^{-2} per ppm.