Reflectance of solar light from polluted snow: theory versus laboratory experiment

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It is known that black-carbon (BC) contamination of snow contributes to global warming. Therefore, it is of importance to derive simple analytical relationships between the snow reflectance and BC concentration (ng/g). The corresponding relationships can be used in climate models. Hadley and Kirschstetter (2012) have performed the corresponding laboratory experiments and established the rate of snow albedo reduction to the BC contamination of snow. They found that the reduction is larger for larger snow grains. Their results are in close agreement with theoretical calculations based on the radiative transfer theory.

In this paper we propose simple analytical equations, which can be used to estimate the change in solar light reflectance and albedo due to the snow contamination by BC. It is shown that the squared logarithm of albedo is directly proportional to the BC concentration (in the visible). The coefficient of proportionality depends on the size of snow grains, the asymmetry parameter and the BC mass absorption coefficient (MAC). The derived equations can be used to estimate the snow grain size and also the concentration of pollutants for an assumed value of MAC. Alternatively, the value of BC MAC can be found, if the concentration of pollutants is known.

References
O. L. Hadley, T. W. Kirschstetter, 2012: Black-carbon reduction of snow albedo, Nature Climate Change, 2, 437-440.