



Albedo reduction by soot-contaminated snow: measurements and implications

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Industrial and biomass burning emissions of black carbon (BC) from low- and mid-latitudes dominate the radiative forcing by absorbing impurities trapped in snow and ice at mid- and high-latitudes. Correct model representation of albedo reduction by BC-contaminated snow is crucial because our GCM simulations show that dirty snow can explain about 30% of the observed 20th century Arctic warming. Current model representations apply Mie, aspherical, or geometric particle scattering theory to the snow grain/BC particle matrix.

We have conducted the first measurements of the direct effect of BC-contamination on snow albedo in a controlled environment. Optical measurements of industrial grade BC mixed into natural snow were conducted at multiple visible and near-infrared wavelengths. Snow albedo is measured in a (portable) integrating sphere system. Snow grain size is estimated from the near-infrared albedo. Snow density, temperature, and BC properties were known a priori. The albedo measurement reproducibility is about 1% for natural snow.

Our measurements agree with model predictions that albedo decreases 5–70% for BC concentrations from 1–200 ppm. This experimental confirmation of the modeled albedo reduction is limited: First, BC contamination of polar snow and ice is typically 1–10 ppb, 2–3 orders of magnitude smaller than our albedo sensitivity. Second, BC deposited in polar regions may be aged, hygroscopically coated, and/or

internally mixed with snow grains. Hence our results are an early step toward evaluating and improving model representation of BC effects in the complex cryosphere. Moreover, the fast, lightweight system makes possible in situ measurements of snow albedo in remote locations during IPY.