Geophysical Research Abstracts
Vol. 14, EGU2012-6686, 2012
EGU General Assembly 2012

Albedo of cold sea ice with precipitated salt on the tropical ocean of Snowball Earth: field measurements and laboratory experiments

B. Light (1), T. Black (1), R. Carns (1), R. Brandt (1), R. Dadic (2), and S. Warren (1)

(1) University of Washington, Atmospheric Sciences, Seattle, United States (sgw@uw.edu), (2) Victoria University of Wellington, New Zealand

During the initial freezing of the tropical ocean on Snowball Earth, the first ice to form would be sea ice, which contains salt within liquid brine inclusions. At temperatures below -23 C, significant amounts of salt begin to crystallize within the brine inclusions. These crystals scatter light, increasing the ice albedo. The most abundant salt is hydrohalite, $NaCl.2H_2O$. A dry tropical atmosphere promoting ice surface sublimation would cause a salt crust to be left on the surface as a lag deposit. Such a high-albedo surface could be crucial during the snowball initiation. These processes must be considered when assigning albedos to sea ice in a climate model of Snowball Earth.

Precipitation of salt within brine inclusions was observed on windswept bare ice of McMurdo Sound at the coast of Antarctica (78 S) in late winter. Consequently the albedo was higher at lower temperature. The precipitation process exhibited hysteresis, with hydrohalite precipitating at about -30 C and dissolving at about -23 C. The causes of the hysteresis are being investigated in laboratory experiments; they may involve biological macromolecules.

Nowhere on the modern Earth does sea ice undergo sublimation at low temperatures for long enough to develop a salt crust before the summer melt begins, so this process is being investigated in our laboratory. A 1000-liter tank is used to grow artificial sea ice, and a system has been built to measure its albedo. A diffusely reflecting hemispherical dome of diameter 1.2 m is placed on top of the tank and illuminated from within. The interior of the dome illuminates the ice surface as well as serving as a platform for detecting the incident and backscattered radiance fields. The diffusely reflecting surfaces of the ice and the dome make it straightforward to estimate incoming and reflected irradiance as angular integrals of the radiance measurements.

The albedo of the bare, cold (below -23 C) ice is 0.8 at visible wavelengths, decreasing toward the near-infrared but remaining higher than that of warmer ice. The salt crust has very high albedo, >0.9 for wavelengths 300-1000 nm, and remains much higher than snow across the near-infrared. Halite (NaCl) is nonabsorptive throughout the solar spectrum, but the hydrohalite crust contains two waters of hydration and does show water-absorption features at 1500 and 2000 nm, as expected. When the crust was warmed to -20 C, saline puddles formed and the albedo dropped dramatically. The spectral albedos are integrated over wavelength, using a solar spectrum appropriate for the tropical snowball ocean, to obtain broadband albedos. Preliminary values for the broadband albedos are 0.89 for the salt crust, 0.56 for bare subeutectic ice without a crust, and 0.32 for puddled melting ice.