

## Abstract

### Structural, Optical, and Structural-Optical Properties in First-Year Arctic Sea Ice

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The optical properties of sea ice have a large impact on the surface heat and mass balance of the Arctic ocean. Observations show large temporal changes in the state of the ice and in its optical properties, particularly during the summer melt season. Absorption and scattering in sea ice are governed by the microstructure of the ice, specifically inclusions of brine, gas, and precipitated salts. In order to predict changes in the absorption and scattering, a better understanding of this microstructure is needed. This paper describes a process study designed to simultaneously collect detailed information on the microstructure of natural sea ice and its optical properties over the temperature range of  $-30$  C to  $-2$  C. An imaging system was used to examine the size distributions for brine and gas inclusions. Number densities for both types of inclusions were observed to be an order of magnitude larger than previously reported. Large changes in the microstructure were observed as samples were cooled to  $-30$  C, and subsequently warmed to  $-2$  C. Interactions between brine inclusions, the disappearance of gas bubbles as the ice cooled, and the precipitation of salt crystals within brine pockets were documented. These observations were used in conjunction with observations of the apparent optical properties of the samples to develop and test a structural-optical model necessary for detailed radiative transfer modeling in sea ice. The optical properties of sea ice were found to: (1) change dramatically at temperatures below  $-23$  C, where they are determined primarily by bulk ice salinity, (2) remain fairly constant between  $-23$  and  $-8$  C, although the magnitude of the optical properties still depend on bulk salinity, and (3) vary only weakly above  $-8$  C due to the temperature dependence of the brine refractive index. We expect this general pattern will be found in most types of natural sea ice, regardless of the exact distribution of inclusions.

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