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The Radiation Budget of Sea Ice during the Springtime Melt

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The energy budget of sea ice in the melt season has significant spatial variability at scales much smaller than a model cell or satellite pixel. This variability results primarily from albedo variation caused by different surface characteristics such as melt ponds of varying depth, snow of varying thickness, and sediment content within the snow, ice, or surface water. There may also be variation in the longwave energy emitted by the surface, mostly resulting from temperature variations. Understanding this variability and how it affects the progress of the melt is necessary for improving energy-budget parameterizations in models or retrievals from satellite sensors.

To gain a better understanding of this variability, we have developed a radiation sled that quickly measures the upwelling and downwelling broadband longwave and shortwave radiation, along with the spectral albedo. In addition, it photographs the sky and surface at the time of the measurement, measures the surface temperature with a narrowband infrared thermometer, and records the measurement location and the air temperature and humidity. The sled is set up to allow many measurements in an area to be made during a short period by one or two people. From this we can see the large scale effect of small scale variations in the surface energy budget.

This sled was deployed for the first time during the first two weeks of June 2011. Data were collected every 5 m along a 200-m line located on fast ice about 3 km southwest of Point Barrow, Alaska. Observations were made around local noon each day from 5 to 13 June, when the progression of the melt forced us to bring the instruments back to land. During most of the observation period, we had refreezing of melt ponds that were prevalent at the start. Midway through, there was some light snowfall, before melt resumed on the last days. The line included a variety of surfaces, including bare ice with a scattering layer, melt ponds of varying depths with a refrozen layer on the surface, and deep, sediment-laden melt ponds that remained open throughout the period.

Broadband albedos varied from 0.15 to 0.73, with temporal variations at individual locations of about 0.2 to 0.25. Some locations showed almost no temporal variation, however, so that while the large scale albedo increased as ponds refroze and new snow fell, some areas were unaffected, allowing melt to continue in those areas.

The net radiation budget was always positive (net gain by the ice) during our measurements, even on days when the surface remained dry during the midday hours. Net absorption ranged from 75 to 530 W m-2. Spatial variability in the net radiation was dominated by spatial variability of albedo, while temporal variability was dominated by temporal variability of incoming solar radiation, which varied from 265 to 925 W m-2. From these data, the role that clouds and surface temporal and spatial variability play in affecting the progression and spatial distribution of melt will be examined.