Surface albedo observations of Hudson Bay landfast sea ice during melt onset

J.K. Ehn, M.A. Granskog, T.N. Papakyriakou, R. Galley, D.G. Barber

Centre for Earth Observation Sciences, University of Manitoba, Winnipeg, Canada

ArcticNet

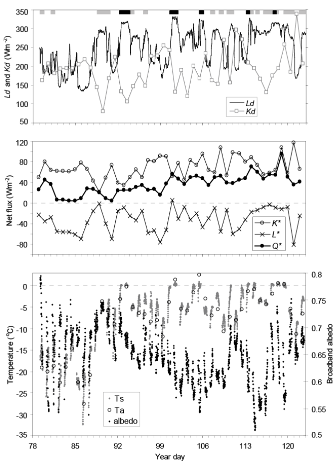
UNIVERSITY OF MANITOBA

INTRODUCTION

The ice albedo feedback mechanism, as a key factor affecting the energy and mass balance of the Arctic, has frequently been emphasized in climate studies (e.g., Curry and others, 1995; Perovich and others, 2002). During the winter, the sea ice surface albedo is generally high (>0.8) since a layer of dry snow covers the sea ice. As the melt commences in the spring the ice is partitioned into multiple surface types ranging from high reflective white ice to absorptive blue ice. The reflectance from these surfaces show significant spatial and temporal variability.

Climate forecasts using GCM's, indicate that we should expect a warmer and wetter winter season in the Arctic regions (Johannessen and others, 2004). In this poster we present a time series of radiative exchange over landfast sea ice in southwestern Hudson Bay. Our observations provide a glimpse of the surface radiation budget's response to such warming conditions.

RADIATION BALANCE

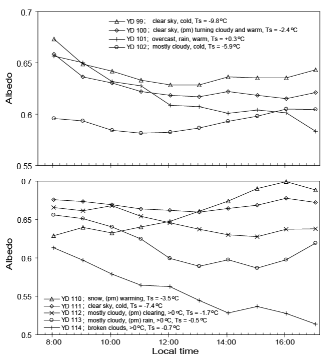


Winter conditions prevailed until YD 88. Within YD's 89-92 conditions changed dramatically when low-pressure systems moved in increasing *Ld* and causing heavy snow (gray mark) and rain fall (black mark). These events mark the beginning of the melt season.

The net all-wave radiation (*Q**) increased as the season progressed. The inverse relationships of its shortwave (*K**) and longwave (*L**) components serve to reduce Q* variability.

The diurnal variations in sea ice/snow surface properties for the melt period were characterized by a daily thaw/night-time refreeze cycle. The surface skin temperature showed cooling during the night and a daytime low in the morning. During the day, surface temperatures increased reaching the melting point.

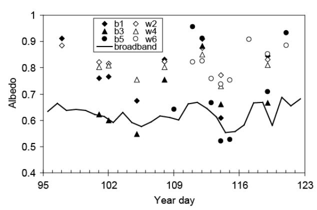
DAYTIME ALBEDO CHANGE



Under clear-sky, the albedo decreased at daytime. Minimum values were reached in the early afternoon, thereafter the albedo incresed (YD 99, 100, 111). This increase can be attributed to decreasing solar zenith angles and *Kd* and changes in surface properties.

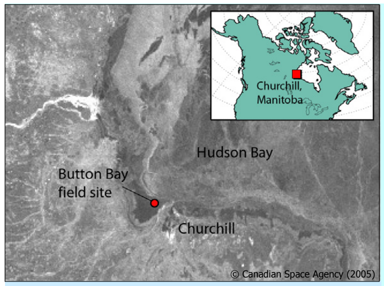
In overcast conditions *Kd* is mainly composed of diffuse radiation and the zenith angle has less effect. When *Ld* is increased, no substantial decrease in all-wave energy input to the surface was observed. During an overcast sky, air temperatures tended to be higher. Thus the albedo decreased even more in overcast conditions.

INTEGRATED ALBEDO

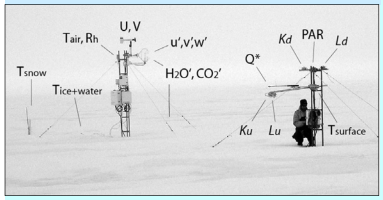


Spatial and temporal variability is illustrated by the wavelength-integrated (350 to 1050 nm) spectral albedo. 'b' denote blue ice and 'w' white ice. The solid line is the daily averaged broadband albedo observed at the meteorological station over a white ice surface.

SAMPLING AREA AND MEASUREMENTS



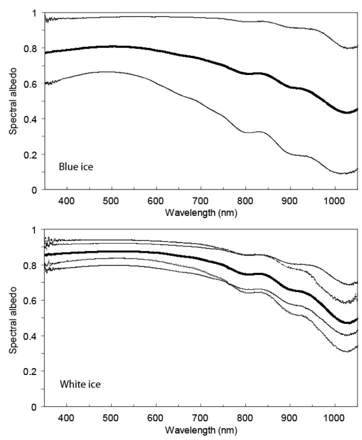
Data was collected on snow-covered 1.5-m-thick landfast sea ice in Button Bay (58º 48.5 N, 94º 17.2 W) near Churchill, Manitoba, in the western Hudson Bay.



Continuous sampling at Button Bay field site from YD 78 (19 March) to 123 (3 May) in 2005. Parameters included air temperature, relative humidity, wind speed, wind direction, turbulent fluxes of heat, water vapour, momentum and CO_2 in the atmospheric boundary layer, ice and snow temperatures using thermocouple strings extending through the ice/snow cover, surface skin temperature and the components of the surface radiation balance.

The spectral albedo was measured repeatedly at six sites using a dual-headed spectroradiometer by alternating between up- and downwelling irradiance measurements. The second cosine collector (180° field-of-view) was used for coincident monitoring of changes in incoming spectral irradiance.

SPECTRAL ALBEDO



The figures show the extremes (thin lines) and averages (thick lines) for spectral albedo observed over blue ice and white ice surfaces between YD 97-121.

Blue ice albedo show larger variations compared to white ice. Areas of blue ice (early stages of melt ponds) caught more of the snow due to larger surface roughness compared to white ice mounds where the snow cover was more affected by erosion by the wind.

High values observed after snow events show little spectral dependence in the visible and a modest decrease in near infrared wavelengths.

Lowest albedos, as a result of warm days and rain events, show more wavelength-dependence. A local maximum is observed at 500 nm and a considerable decrease with wavelength up to ~0.6 (86%).

CONCLUSIONS

- The seasonal evolution of the landfast sea ice surface albedo in Button Bay was found to be affected by synoptic weather events that caused abrupt fluctuations in values. These events can be summarized as a) advection of warm air masses; b) cloud cover; c) precipitation in solid phase; and d) precipitation in liquid phase.
- As melting progressed the overall albedo decreased and spatial variability increased. The surface partitioned into regions of high reflective white ice and absorptive blue ice.
- Precipitation events caused rapid changes in the albedo of roughly ±10 percent.
- In overcast conditions and high air temperatures, extensive surface melting caused the albedo to decrease at daytime.
- Clear skies resulted in daytime melting and a consequent reduction in albedo, however in the afternoon the surface begun refreezing and the albedo increased.
- The daytime change in the broadband albedo over white ice ranged from a 0.01 per hour increase to a decrease of 0.014 per hour.

REFERENCES

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