SURFACE ENERGY BUDGET AND ATMOSPHERIC EFFECTS OF A FREEZING LEAD

AMS abstract

Evolution of reopened lead near Atlanta on May 6, 1998:

On May 6th the "Atlanta" lead reopened sometime around 1700 UTC under strong along-lead winds. The strong winds and long fetch allow frazil mats to form floes before reaching the downwind edge of the lead. This prevents compaction of the frazil on the downwind edge of the lead allowing pools of open water to persist in the new ice cover [Smith et al., 1988]. The along-lead winds and this pooling effect allowed areas of open water to persist for more than 10 hours. Continuous measurements of the radiometric properties of the new ice surface were obtained from 0308 UTC on 7 May to 1848 UTC on 8 May.

Discussion

The surface shows a transition from snow-covered multiyear ice to uncongealed frazil ice over a horizontal distance of 10 m (Fig. 1). The new ice in the lead is evident in the upper portion of the snapshot. Snow has drifted onto the new ice along the edge of the lead a distance of 2 m. The new ice shows a gradation from snow- and frost flower-covered gray ice to congealed frazil ice with frost flowers to uncongealed frazil ice (upper right corner). The frost flowers, which have a complex and delicate structure, markedly change the albedo and skin temperature of the new ice. Eventually the entire lead has frozen over and the new ice is covered with frost flowers.

A 2 m long boom was extended out from the Mobile Radiometric Platform (MRP) to study the evolution of radiative properties of the freezing lead. The radiation fields were monitored over a complete diurnal cycle. The higher frequency variations in the downward shortwave fluxes obtained at the flux-PAM station (see Figure 2) indicate that an inhomogeneous cloud field was present much of the time. The high frequency flucuations are also evident in the upward shortwave radiation detected by the Licor pyranometer. An image from the DABUL cloud lidar indicates that a brief clearing took place between 0530-0900 UTC on Julian Day 127. The cloud field had a sharp trailing edge, as denoted by the negative jump in the trace obtained by both instruments just before fractional Julian Day 127.4. Because of the occurrence of clear skies and large solar zenith angles, only the first 2.5 hours of the albedo difference can be used to reliably to infer the 24 hour albedo change. During this period the upward shortwave flux has increased by as much as a factor of 2. The true change in the surface albedo is determined from the calibrated Licor data (see AMS 1999 extended abstract).

The air temperature at the edge of the lead is compared with that obtained at a remote observation site ("Baltimore" flux-PAM station) that was not influenced by the open lead. The radiometric skin temperature of the new ice surface in the lead tracks the remote site air temperature for the first 12 hours of the MRP observation period. The initial rapid decline in the surface skin and air temperatures is related to strong IR cooling to space under clear skies. The new ice skin temperature dropped over 5 C until the low cloud cover returned. The temperature increase when low clouds move back into the region, then gradually decrease until an equilibrium temperature of about -13 C is reached. The lead edge air temperatures appear to be influenced by the open lead during two periods; however, on closer inspection it is found that the initial warming is caused by a heating of the censor by direct solar radiation. The second period of warming may be explained by localized heating of the atmosphere by the lead. The air warmed by as much as 1.6 K. The winds were from the NNW and becoming more northerly (veering) with time. The NNW component was nearly parallel to the lead resulting in a maximum fetch with the MRP sensor loacted downwind. Wind speeds were greatest (4.0-5.5 m s-1) during a 6 hour period beginning 1800 UTC, Julian Day 127 and slowing with time. The temperature difference decreased as the winds slackened and became more northerly, reducing the fetch. A more complete description of the factors influencing the downwind air temperature is given in the AMS 1999 extended abstract.

Lead edge near the "Atlanta" flux-PAM site on 7 May 1998

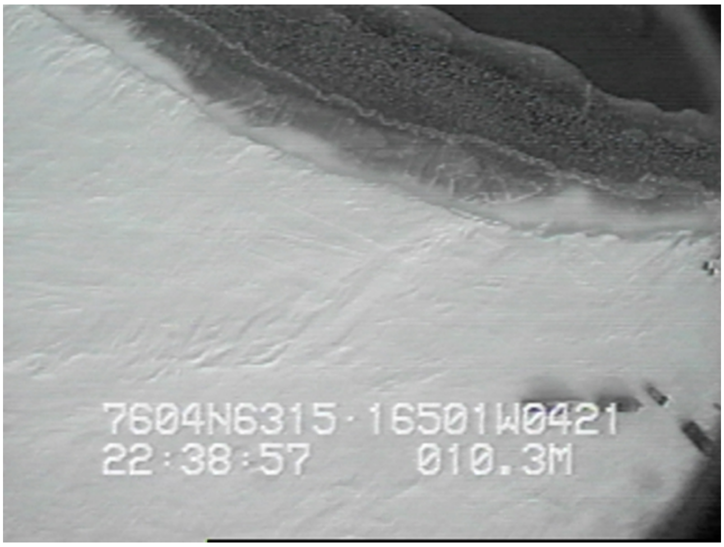

Figure 1. Remote site where the Mobile Radimetric Platform monitored a freezing lead. This video snapshot was obtained during NCAR C-130 flight RF02 on 7 May 1998 (Jday 127). The latitude, longitude and altitude (inaccurate- the actual altitude determined from radar altimeter was 40 m) of the aircraft given in the snapshot are obtained using GPS. The latitude and longitude are in degrees and minutes. Time is UTC. Snow machines are evident in the lower-right hand corner of the snapshot.

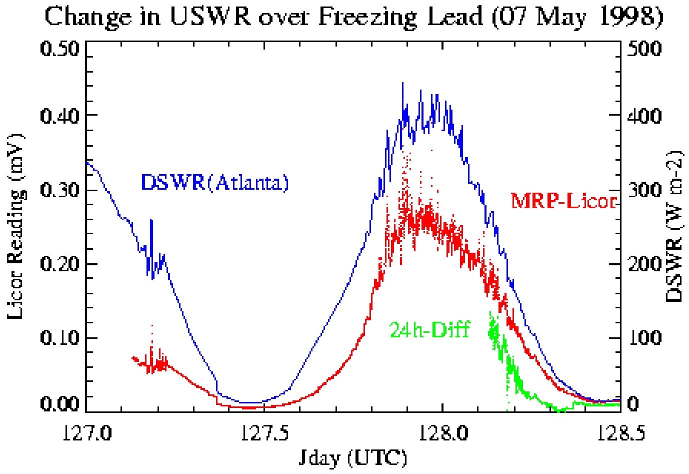

Figure 2. Time series of downward shortwave radiation at the "Atlanta" flux-PAM site (blue) and raw signal detected by a downward-looking Licor pyranometer mounted on a 1.5 m boom extended from the MRP (red). The flux-PAM data are 5-min averages while the Licor data are recorded every 10 s. The 24-hour change in the upward shortwave flux over the lead as measured by the Licor pyranometer is given by the green curve.

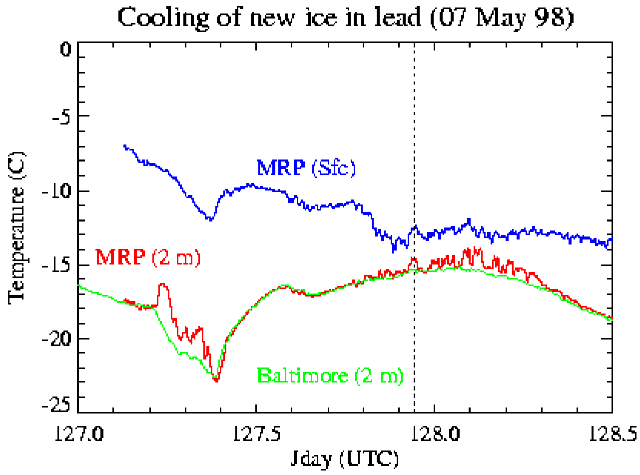

Figure 3. Time series of surface skin temperature of new ice in the lead obtained with a KT-19 radiometer (blue) and air temperature (red) on a 1.5 m boom extended over the lead and of 2-m air temperature at the "Baltimore" flux-PAM station (green). The flux-PAM data are 5-min averages while the Licor data are recorded every 10 s. The "Baltimore" site was located several kilometers away so that it was unaffected by this lead. The dashed line denotes the time of a C-130 overpass.