Preliminary Surface Heat Budget Results from SHEBA

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Introduction

A joint program is under way to measure spatial and temporal variability of the components of the surface fluxes and their bulk variables during the Surface Heat Budget of the Arctic (SHEBA) experiment, which is being conducted from an icebreaker frozen for one year in the Arctic sea ice about 350 nm north of Prudhoe Bay, Alaska. A central 20-m-tall tower with five levels of instruments and a small distributed network of four National Center for Atmospheric Research (NCAR) Portable Automated Mesonet (PAM) stations are being used for the basic measurements. Measurements were begun about November 1, 1997. In this paper, we will describe some results of measurements from the central tower through January 7, 1998. Details on the entire SHEBA experiment can be found on the SHEBA website: *http://sheba.apl.washington.edu/*.

The scientific goals of the flux group encompass four major issues:

1. Characterization of flux partitioning over an annual cycle, including the balance of turbulent, radiative ground fluxes as surface and subsurface evolve in the presence of clouds.

2. Local surface flux parameterizations of roughness (stress, sensible, latent) in terms of surface properties (snow, ice, water, etc.) and their link to radiative properties and albedo.

3. Stable stratification issues such as flux representation, gustiness, and the enhanced sensitivity of flux partitioning in models that don't resolve the planetary boundary layer (PBL).

4. Scaling-up issues, such as the representation of the average effect of complex surface properties, blending height, and mosaic flux methods.

Measurements

A 10-m scaffold and a 20-m tower have been instrumented with five levels of direct flux and mean profile instruments (details on the instruments can be found in the Andreas abstract in the SHEBA website). The measurements include mean wind speed and direction, air temperature and humidity, and turbulent covariances and variances of winds, and temperature at 2 m, 3 m, 5 m, 9 m, and 15 m height above the surface. Near the tower, a single level of instruments provides upward and downward longwave and shortwave fluxes, snow surface radiative temperature, ice-snow interface temperature, precipitation, and snow depth. An optical scintillometer provides estimates of fluxes on a 300-m horizontal path.

Single-level measurements of similar information are obtained at remote sites using NCAR PAM stations specially engineered for Arctic operations. Three PAMs have been deployed at different ice types in the near vicinity (5 km) of the ship; a fourth is deployed near the ice camp tower. Their data is processed on board the system and transmitted every 5 minutes to a base station on the ship.

The system reached full operation on November 1, 1997, and has run continuously except for interruptions caused by loss of power associated with movements of ice in the camp. Average values of a few parameters are given below for the first 2 months of the measurements:

- 10-m wind speed 5.22 m/s
- Sensible heat flux -4 W/m^2
- 10-m air temperature -26.15° C
- Stress 0.058 N/m^2
- 10-m spec. humidity 0.445 g/kg
- Down longwave 178.6 W/m^2
- Surface temperature -27.8° C
- Up longwave 206.5 W/m^2.

Preliminary Results

Figures 1 and 2 show the time series of longwave radiation and net longwave for the period from November 1, 1997, to January 7, 1998. Near-zero net longwave radiation is associated with low clouds, while large negative values occur during essentially clear skies. Figures 3 to 5 show a sample of indirect cloud interactions with surface turbulent fluxes. A 2-day time section is given that is initially cloudy, is then clear for more than a day, and then clouds up again (as inferred from the behavior of the net longwave flux). Note how quickly the air and snow surface temperatures react to the clouds (Figure 4). The sensible heat flux (Figure 5) initially reacts to the clear skies, but then it tends to recover toward zero as hydrostatic stability effects cut off the turbulent fluxes. The average feedback between net longwave and sensible heat flux is shown in Figure 6 where heat flux divided by mean wind speed is plotted versus net longwave. The slope of a line through the data is 0.054 s/m. At a typical wind speed of 5 m/s, this indicates that about 25% of cloud surface longwave forcing is canceled by heat lost to the atmosphere.

Acknowledgments

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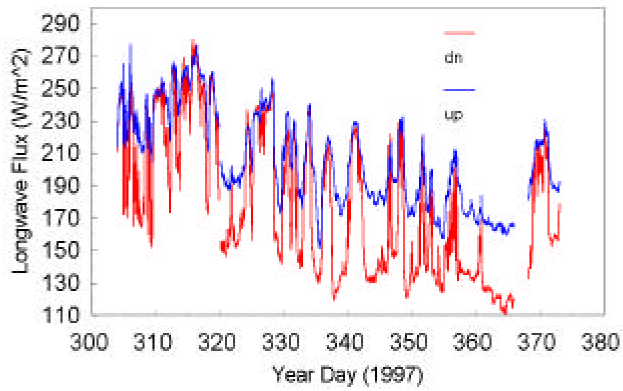

Figure 1. Time series of upward and downward longwave flux. (For a color version of this figure, please see *http://arm.gov/docs/documents/technical/conf_9803/fairall-98.pdf.)*

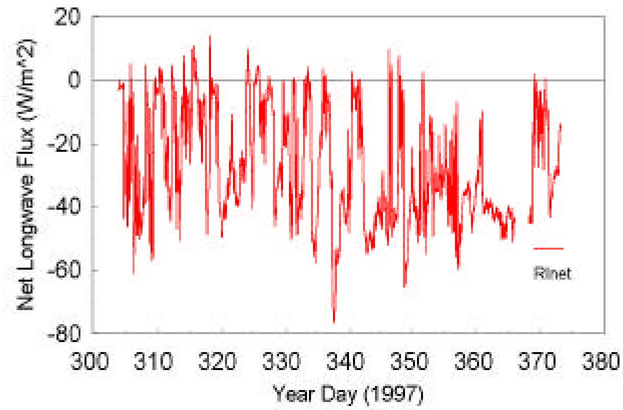

Figure 2. Times series of net longwave flux. (For a color version of this figure, please see *http://arm.gov/docs/documents/technical/conf_9803/fairall-98.pdf.)*

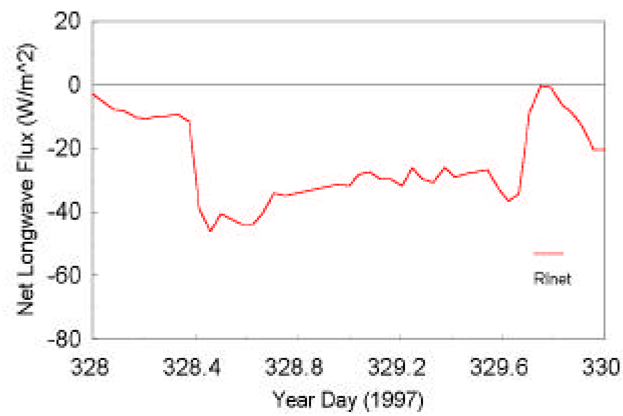

Figure 3. A 2-day time series of net longwave flux. (For a color version of this figure, please see http://arm.gov/docs/documents/technical/conf_9803/*fairall-98.pdf.)*

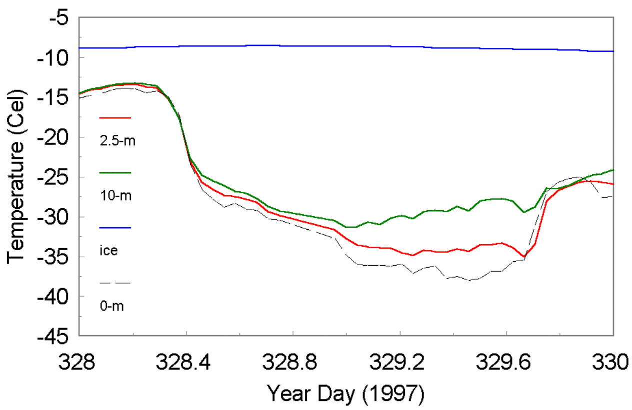

Figure 4. A 2-day time series of air and snow/ice temperatures. (For a color version of this figure, please see *http://arm.gov/docs/documents/technical/conf_9803/fairall-98.pdf.)*

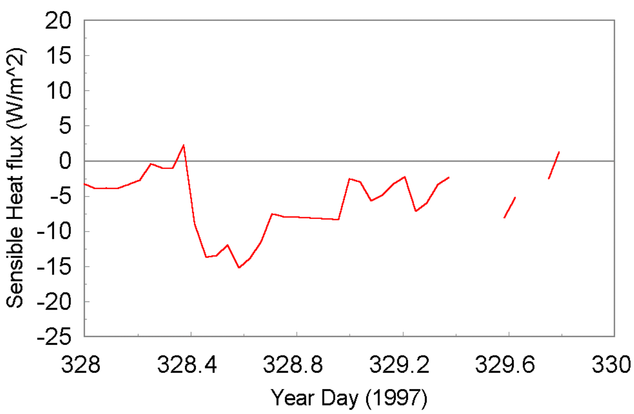

Figure 5. A 2-day time series of sensible heat flux. (For a color version of this figure, please see http://arm.gov/docs/documents/technical/conf_9803/*fairall-98. pdf.)*

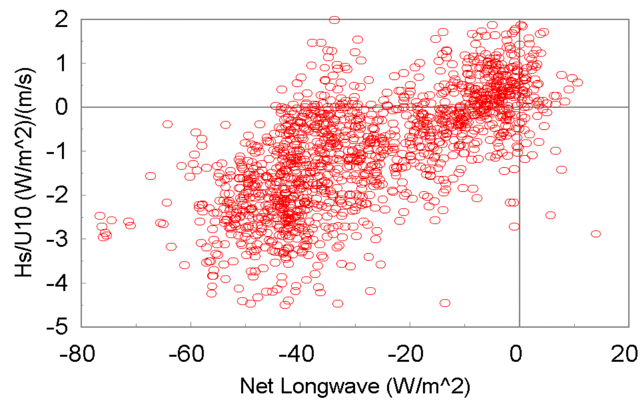

Figure 6. Normalized sensible heat flux versus net longwave flux for the entire record. (For a color version of this figure, please see *http://arm.gov/docs/documents/technical/conf_9803/fairall-98.pdf.)*