5.7 SKIN TEMPERATURE MEASUREMENTS ON SMALL BODIES OF WATER

Robert J. Kurzeja* and M. M. Pendergast**

*Savannah River Technology Center, Aiken, SC
** SMP Enterprises, Martinez,GA

1. INTRODUCTION

The temperature of the top millimeter of a water surface is generally a few tenths of a degree C cooler than the 'bulk' temperature, i.e., the temperature ~1 meter deep, which is routinely measured by buoys and ships. This is because of a daytime temperature gradient between the bulk location and the surface, and because of the thin skin at the surface. This difference is important for climate and weather forecasting because of the atmospheric forcing by the oceans.

2. BACKGROUND

Most studies of the skin temperature depression have involved ocean measurements from ships e.g. Wick et al. (1996) The advantage of these measurements is the nearly stationary atmospheric and oceanic conditions. On the other hand the range of variability is limited and the ship can substantially influence the flux data.

The Savannah River Technology Center has measured the skin temperature over small bodies of water to validate satellite measurements of the water surface temperature. However, these measurements present special problems because of the variability of the boundary layer and advective effects. On the other hand, the small amplitude waves allow instrument placement much closer to the water, which reduces these effects and allows for shorter averaging intervals.

3. INSTRUMENTATION

The skin temperature apparatus is shown in Fig.1. It is a transparent frame, ~1.5m on a side, with floats at each corner. It is deployed by connecting to an anchored buoy and rotates with the wind to position the sonic anemometer and IR radiometer always into the wind. It has been operated in wind speed of up to 10m/s. The instruments are described in Table 1:

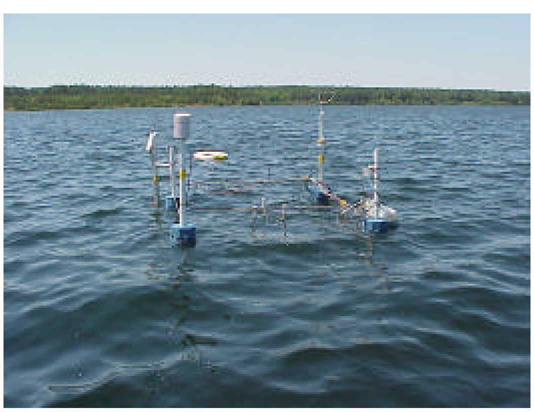

Figure 1: Skin temperature apparatus

Instrument	Elevation
Heiman KT15.82 IR radiometer	0.6 m
Met One uv sonic anemometer	1.0m
Vaisala Temp/RH	0.8m
Thermocouple water probes	1,10,and 50cm
Electronic compass	1 meter

Table 1: Instruments on the skin temperature apparatus.

The skin temperature was measured by comparing the IR temperature of surface water with that of water pumped every few minutes from a depth of 10cm to a point under the radiometer. In this way instrumental errors and sky effects can be eliminated since they affect both ambient and pumped water in the same way. Typically, the pump was turned on for 10 seconds every 2 minutes and the IR '10cm' temperature was the average of the middle three IR temperatures. Samples were collected every 2 seconds but only one-minute averages will be discussed in this report.

4. DATA

The skin temperature was calculated following Fairall et al., 1996a using the bulk parameterization described in Fairall et al., 1996b. The skin temperature and fluxes of momentum and heat were calculated with one-minute averages of the temperature, humidity and wind speed and direction. This averaging time is much shorter than the ½ hour recommended for bulk studies. This interval was selected because of the close proximity of the instruments to the water and to explain the temporal variability in the observed skin temperature.

A 4-hour period of data from a small lake at the Savannah River Site on May 4, 2000 was analyzed. The site is shown in Fig. 1 and for these observations the fetch was ~750 meters. The wind speed varied between 1 and 6 m/s during this period and the skies were clear.

5. RESULTS

Since the one-minute averaging time is much smaller than commonly used for surface layer studies it is important to assess its validity. A good indicator of this validity is to compare the one-minute heat fluxes (sensible plus latent) with the temperature of the surface water (1 cm). The assumption here is that the minute to minute variations in the heat flux should be apparent in the minute to minute changes in the temperature of the near-surface water.

---

*Corresponding author address: Robert J. Kurzeja, Savannah River Technology Center, Aiken, SC. 29808
E-mail: robert.kurzeja@srs.gov.

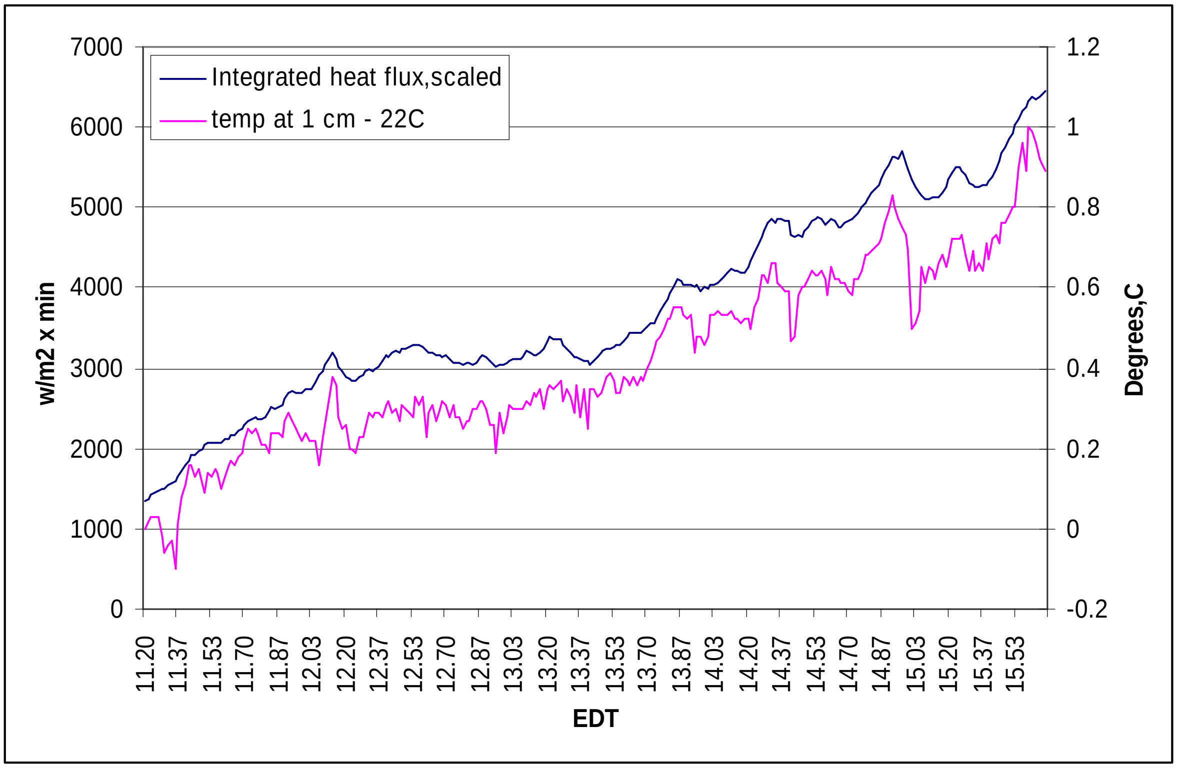

Figure 2: Comparison of the integrated heat flux with the 1 cm water temperature.

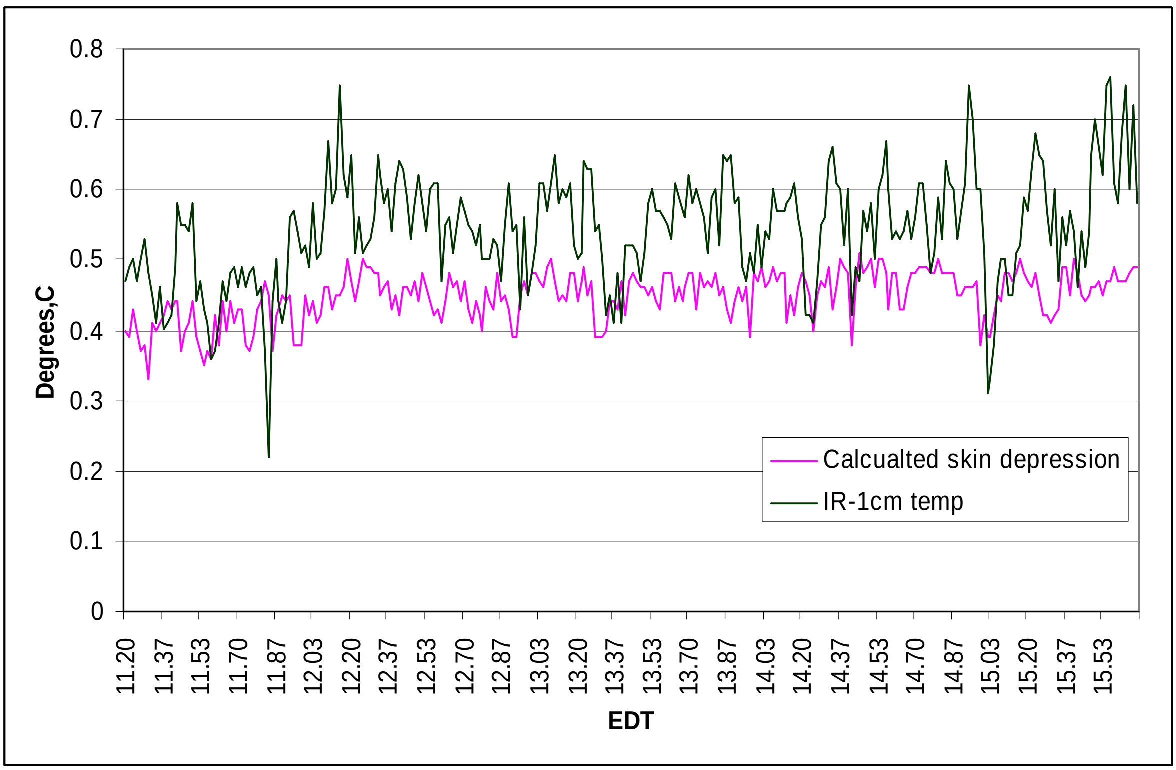

Figure 3: Calculated and measured skin temperature depression.

Fig. 2 shows the integrated heat flux compared with the water temperature at 1 cm deep. The heat flux data have been scaled to account for solar heating. This figure shows good qualitative agreement between the integrated heat flux and the water temperature near the surface. This suggests that the one-minute heat fluxes are significant, i.e., correspond to actual heating and cooling of the water. Similar agreement should be expected for momentum fluxes as well.

Fig. 3 shows the skin temperature depression calculated as in Fairall et al. (1996b) and that determined by subtracting the 1 cm temperature from the IR temperature. This figure shows reasonable agreement between the theory and the measured values but does not display the same minute to minute agreement seen in Fig. 2. This implies that the skin depression formulation may not reflect the actual temporal variability seen in the data.

The discrepancy between the calculated and measured skin temperature might be explained by variability in the lake current, which was not considered in the calculation shown in Fig. 3.

6. CONCLUSIONS

Heat and momentum fluxes determined with the bulk parameterization method with data from a floating apparatus on a small inland lake resulted in reasonable agreement between the calculated and measured skin temperature depression. However, The short-term temporal agreement was not as good as seen with the heat flux and water temperature. This suggests that the formulation of the skin temperature depression could be improved.

7. REFERENCES

Fairall, C.W., E.F.Bradley, J.S. Godfrey, G.A. Wick, J.B. Edson, and G.S.Young, 1996: Cool-skin and warm-layer effects of sea surface temperature, J. Geophys. Res.,101,1295-1308.

Fairall, C. W. , E.F.bradley, D.P. Rogers, J.B.Edson, G.S. Young, 1996: Bulk parameterization of air-sea fluxes for tropical ocean-global atmosphere coupled-ocean atmosphere response experiment, *J. Geophys. Res*., 101, 3747-3764.

Wick, G. A., W. J. Emrry, L..H. Kantha, and P. Schlussel, 1996: The behavior of the bulk-skin sea surface temperature difference under varying wind speed and heat flux, *J. Geophys. Res*., **26**, 1969-1988.