Boundary-Layer Observations Over the Southern Great Plains Cloud and Radiation Testbed Site During the November Flux-Profiler Test

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Introduction

In situ flux measurements were made to compare to the momentum flux profiler being designed by the National Center for Atmospheric Research (NCAR) as part of the Instrument Development Program for the Atmospheric Radiation Measurement (ARM) Program.

The NCAR King Air aircraft took about 10 hours of flux data during the period November 12-17, 1992, near the Southern Great Plains (SGP) Cloud and Radiation Testbed (CART) site central facility with the following characteristics:

- Flight legs were centered over the prototype profiler.
- Measurements of u', v', w', T', and q' were made to allow direct calculation of momentum and sensible and latent heat fluxes by eddy-correlation.
- Legs were 40 km long to obtain fluxes to 10%.
- Legs were at altitudes corresponding to profiler range gates and covering the bottom to the top of the planetary boundary layer (up to 1 km) to observe a large variation of fluxes.

The profiler was operated in Doppler beam swinging (DBS) mode while also processing the signal using interferometry.

Radiosondes were launched from both the central facility and the flux-profiler site to provide measurements of wind, temperature, and humidity above the boundary layer for input to a mesoscale model and to provide an additional comparison for measurements made in the boundary layer.

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Results

Figure 1 shows the raw data from two of the ten profile patterns flown during this experiment. Each aircraft profile consisted of a descent to the profiler site followed by 3-5 legs at increasing heights. Note that because of this flight pattern, the downward and upward profiles may differ due to temporal changes during the time of the pattern (about 50 minutes) and due to horizontal gradients.

The profiler was operated in DBS mode alternating between two sets of three beams. Thus, two sets of consensus-averaged winds were available. Finally, several radiosondes were launched during this experiment which may be compared, though they generally were not launched exactly when the aircraft was overhead for safety reasons.

The wind profiles agree reasonably well. In both profiles, the two 3-beam DBS estimates are similar, indicating that the air flow was reasonably homogeneous. The temperature and humidity profiles were measured primarily to determine the inversion (and thus boundary layer) height. The nearest radiosonde to the flight pattern starting at 20:18 was launched at 22:34 and shows a deeper, cooler, and drier boundary layer.

Figure 2 shows the fluxes which were computed from the aircraft flight legs using the covariance of horizontal velocity, potential temperature (to remove variations of the aircraft altitude), and humidity with the vertical velocity. The variation of the flux profiles with time may be seen from the two patterns shown. In both cases, the momentum flux profile decreases to nearly zero at the top of the boundary layer as expected. The sensible heat flux profile also shows a decrease with height in both cases. The 18:41 sensible heat flux profile shows a change in sign at the top of the boundary layer due to entrainment of warmer air as the

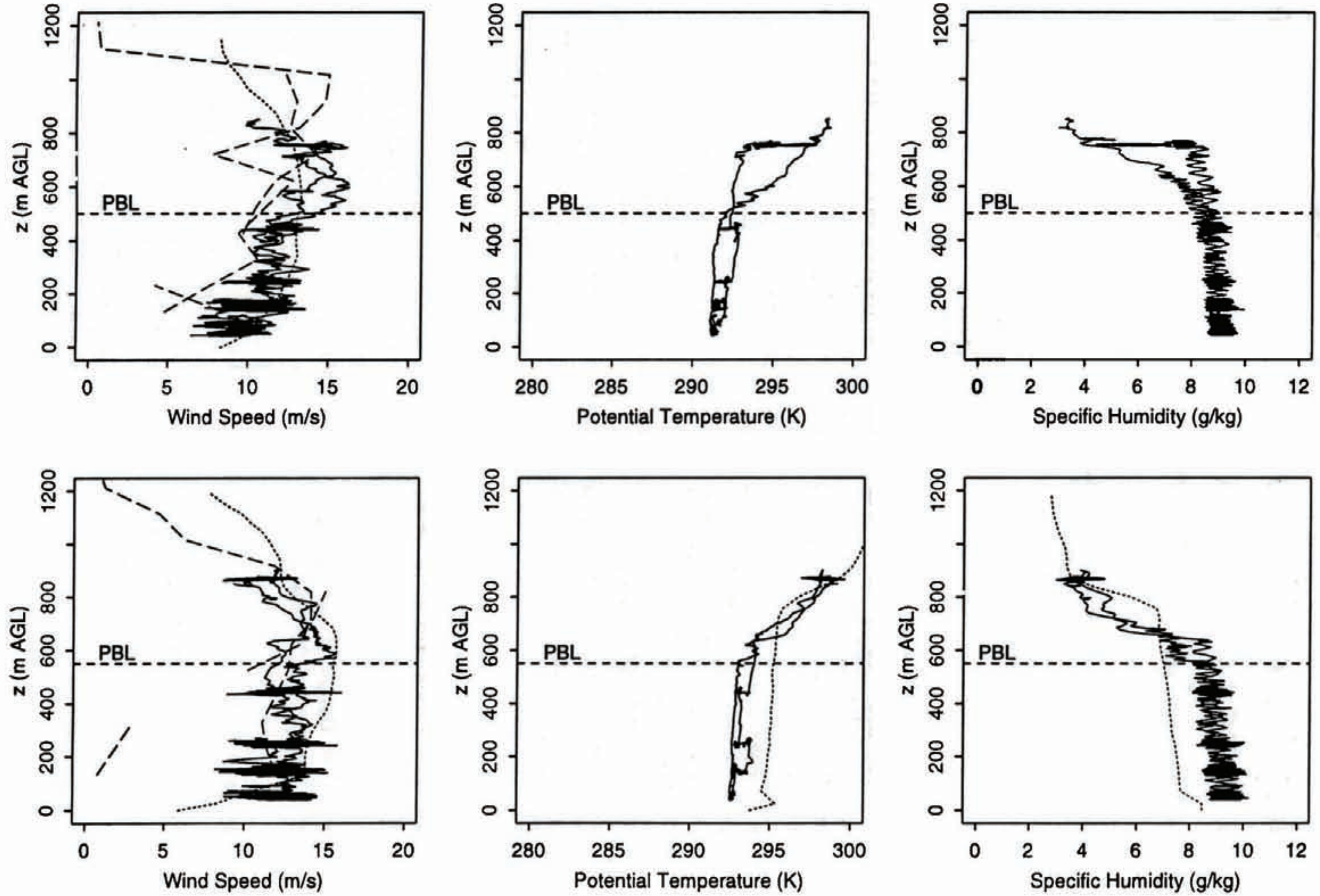

Figure 1. Measured profiles of wind speed, potential temperature, and specific humidity from the aircraft (solid line), radiosonde (dotted line), and the two 3-beam DBS measurements (dashed lines). Data are shown from Nov. 16, 1992 for patterns starting at 1241 CST (top) and 1418 CST (bottom).

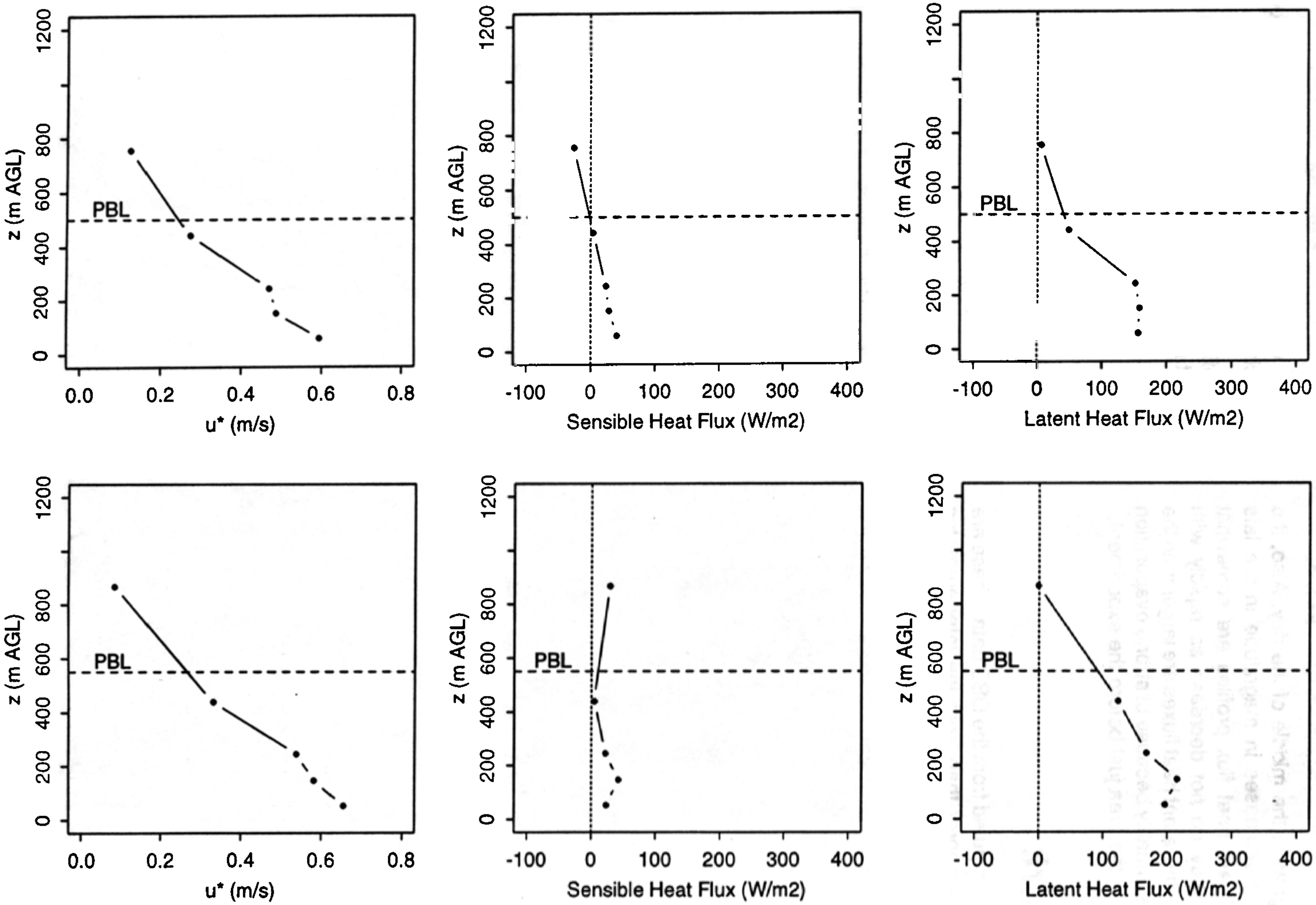

Figure 2. Measured profiles of u*, sensible heat flux, and latent heat flux from flight 6 for the patterns shown in Fig. 1.

boundary layer grew in the middle of the day. Also, the sensible heat flux decreases in magnitude in the late afternoon. The latent heat flux profiles are somewhat surprising since they do not decrease as rapidly with height. Notice that the latent heat fluxes are larger than the sensible heat, presumably because of strong evaporation after heavy rains in the area just before the experiment.

Future Work

Fluxes will be computed from the DBS data. These are expected to be poorer than from the interferometric results since horizontal homogeneity of the fluxes must be assumed for DBS.

- Fluxes will be computed from the interferometric data on each of the 5 beams.
- All profiler flux measurements will be compared with aircraft measurements.