Interactions Between the Daytime Mixed Layer and the Surface: Oklahoma Mesonet and EBBR Heat Fluxes

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Introduction

Surface layer estimates of surface sensible heat flux have been made at 10 - 14 locations within the Central Facility (CF) of the Southern Great Plains (SGP) Atmospheric Radiation Measurement (ARM) Program site by using energy balance Bowen ratio (EBBR) stations located mostly in uncultivated areas. The advent of the Oklahoma Mesonet (OKM) with approximately 50 stations within the boundaries of the Cloud and Radiation Testbed (CART) site that measure a variety of meteorological parameters leads to the possibility of using the OKM to provide additional estimates of surface energy budget to augment those made with the ARM EBBRs.

Analysis Technique

A bulk aerodynamic method for estimating surface sensible and latent heat fluxes during periods when the Bowen ratio technique fails (primarily during transition periods) has been used with the EBBR stations since 1995 with good success. This same approach has now been taken with the OKM data, at least for sensible heat flux at locations that measure wind speed and temperature at two different heights, to provide temperature differences that are directly related to vertical heat transfer and solar radiation. The OKM data differ from the available meteorological data at the EBBR sites in that there is generally no measurement of net radiation. Thus, the net radiation is parameterized as a function of the measured solar radiation when available. Five-minute-averaged values from all available OKM stations within the CART site are used to make estimates that are averaged to 30 minutes to match EBBR heat flux estimates.

Results

One-to-one comparisons of measurements of heat flux at sites that are separated by tens of kilometers are very difficult to make and even more difficult to interpret because of considerable differences in site land use and controlling conditions. Thus, we consider here mainly sitewide averages of heat flux between 0800 and 1600 Local Standard Time. Figure 1 shows that the time variations of sensible heat flux measured with the two systems agree well in the yearly and periodic fluctuations. That is, the two systems apparently respond to the same controlling influences (frontal passages, seasonal changes, precipitation) in similar ways although significant differences occur on individual days. In fact, the data have a correlation coefficient of 0.81 with a slope of 0.85. Figure 2 shows considerably better agreement between sitewide average temperatures, as is expected. One interesting feature of these comparisons is a distinct yearly pattern in the differences between estimates of both temperature and heat flux (Figure 3). The OKM measurements of mean temperature and EBBR estimates of heat flux are noticeably larger during mid-summer and generally smaller during early spring. This reflects the fact that the EBBR sites are mainly located on non-crop land; thus, the rapid growth and transpiration of winter wheat in early spring leads to decreased values of heat flux; the situation is reversed during and immediately after winter wheat harvest.

Variations of heat fluxes across the CART site are reflected in Figures 4 - 6. The increased number of useful OKM sites is also evident in 1999 and 2000. Larger heat flux values in the west are a feature of both OKM and EBBR evaluations. A well-defined minimum in the OKM estimates that appears in the southeastern region of the CART site is not evident in the EBBR evaluations, because no EBBR sites are located in this region, which is characterized by forest and more heavily treed rangeland. The recent addition of a forest site to the ARM extended facilities will address this shortcoming. The resultant smaller heat fluxes are reflected in the land use pattern in Figure 6.

The combination of data from the EBBR and OKM sites results in increased spatial definition of both meteorological and surface energy budgets across the ARM SGP CART site. Although latent heat fluxes are not yet directly useful from the OKM sites because multiple measurements of water vapor are not generally available, some limited estimate should be available through balancing of the surface energy budget.

Acknowledgement

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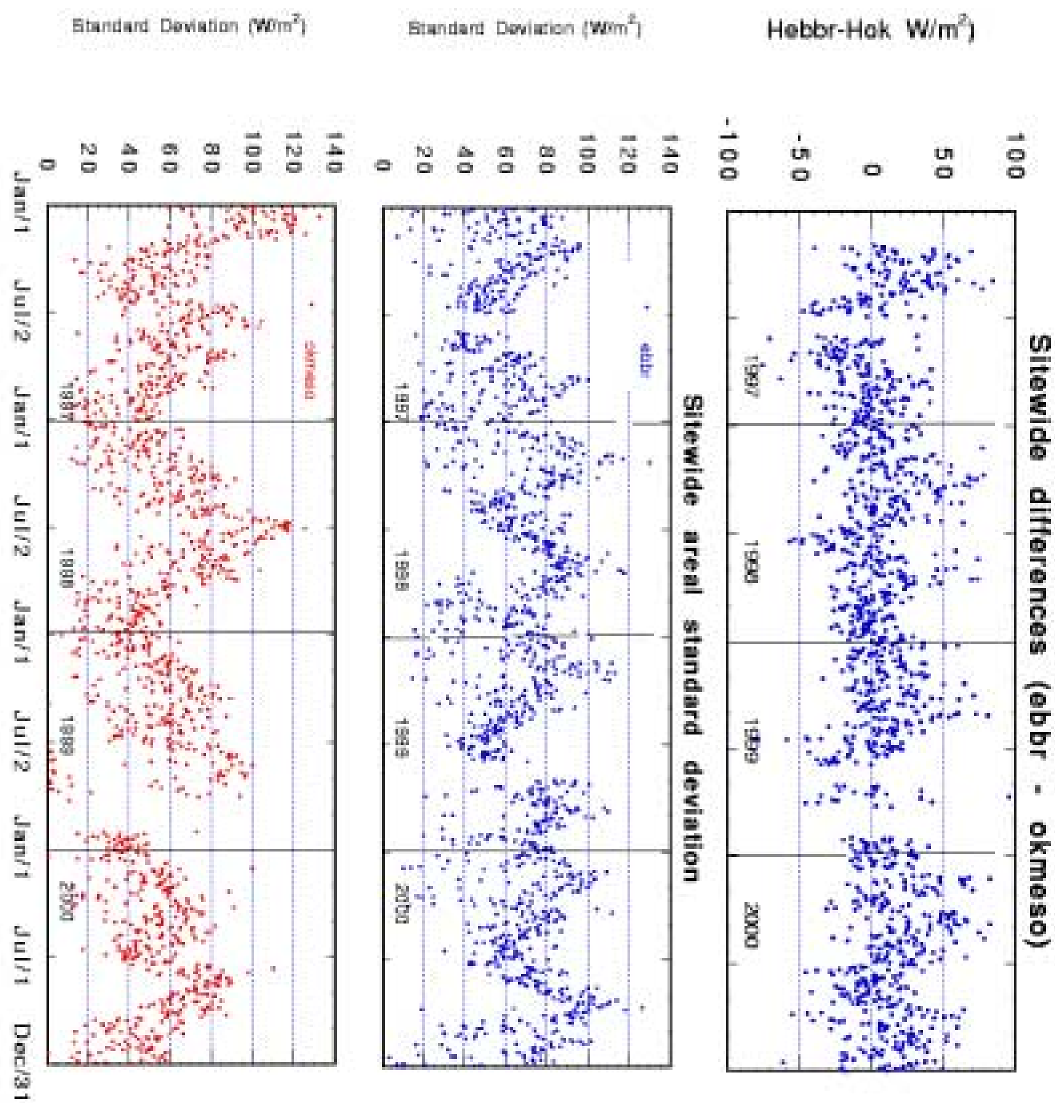

Figure 1. EBBR and OKM calculations of daily averaged heat flux averaged across the SGP CART site. With the exception of the first 60 days of 1997, agreement is generally good, particularly during summer months.

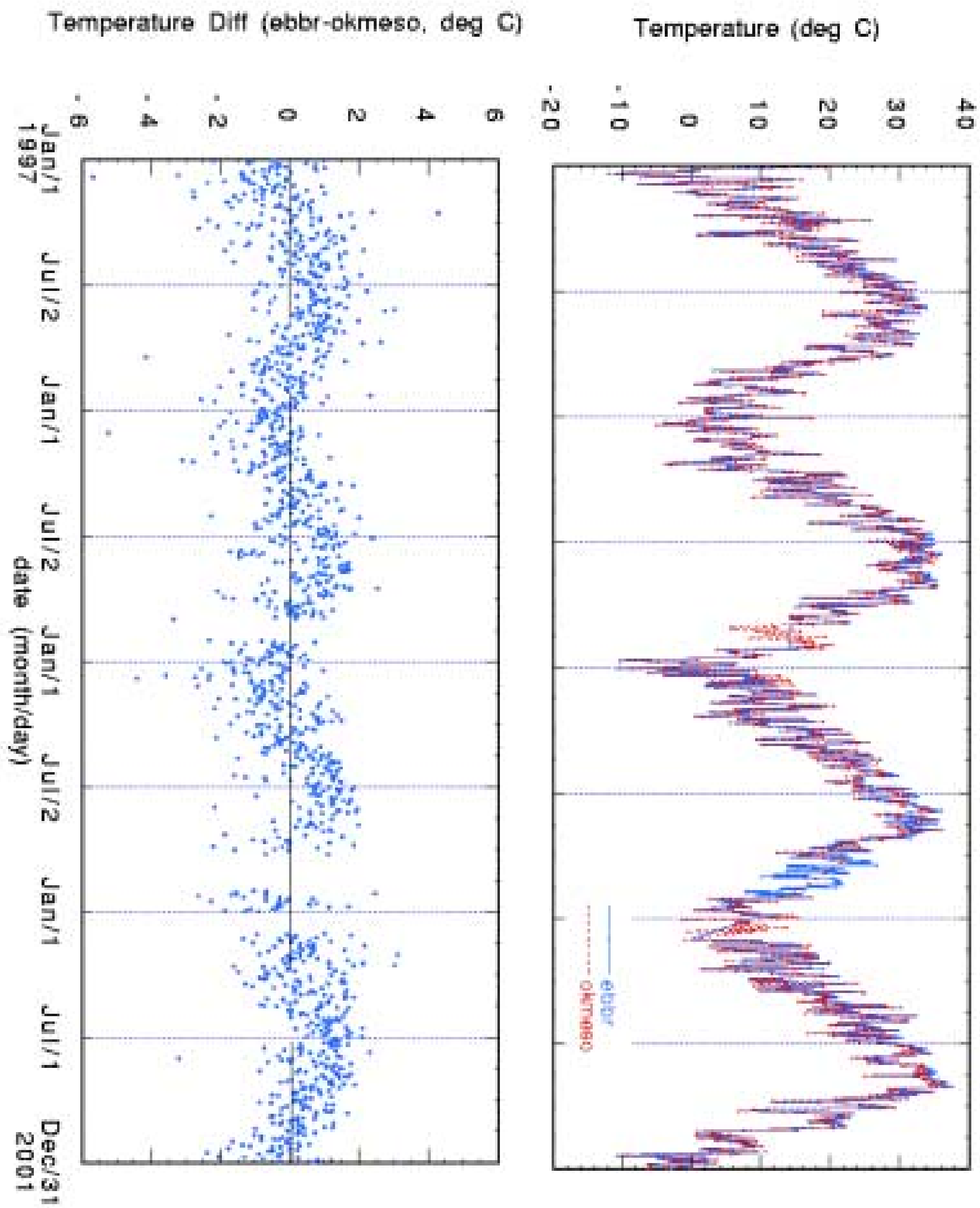

Figure 2. EBBR and OKM temperatures averaged across the CART site for 1997-2000. When the differences are plotted, a pattern of higher measured temperatures with the EBBR is evident during summer.

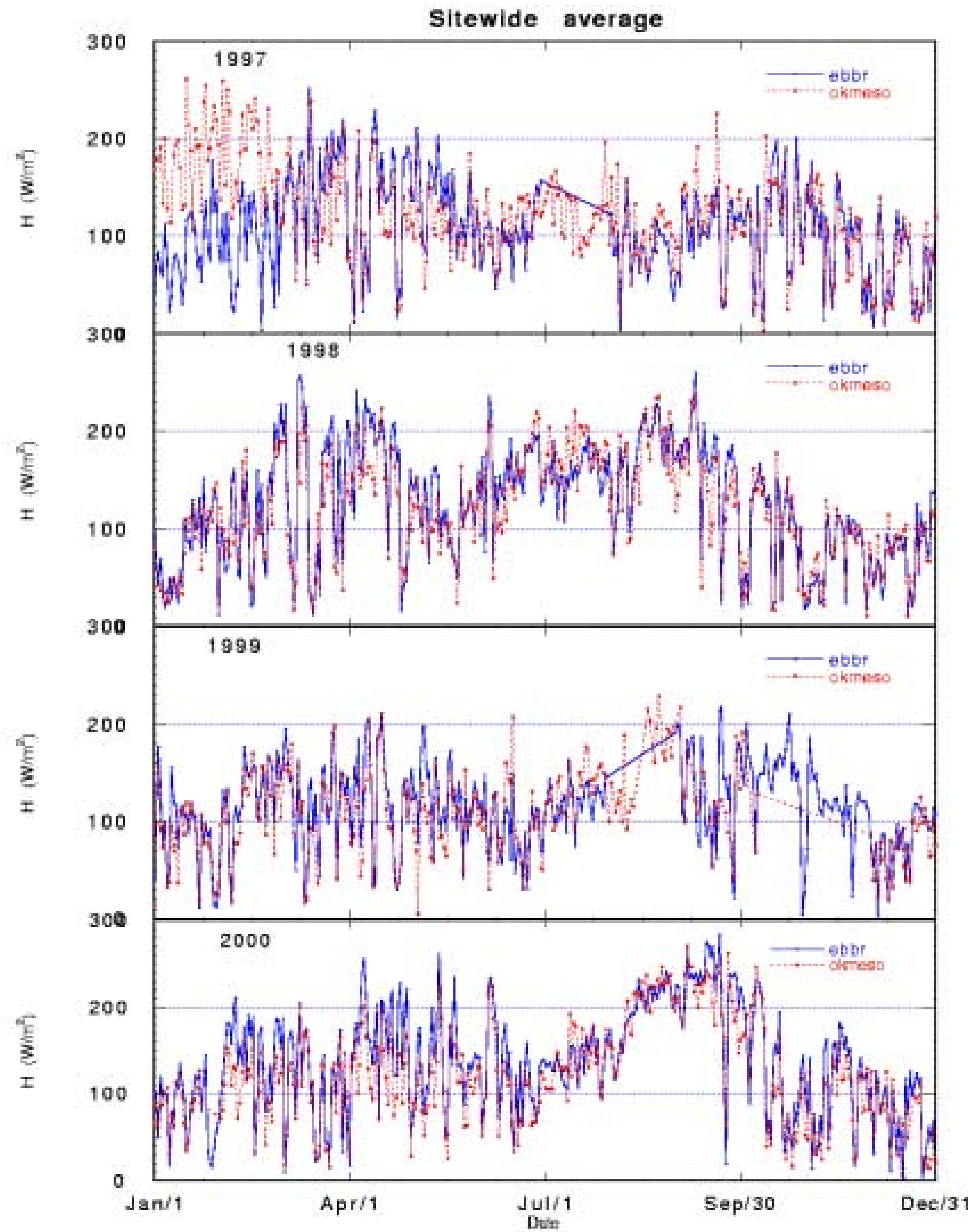

Figure 3. Differences in average heat flux measured by the two methods over the 4-year period. Note the larger values of EBBR values during early spring (winter wheat growth). Plots of areal standard deviation show peaks at different times of the year because of different exposure to land use patterns.

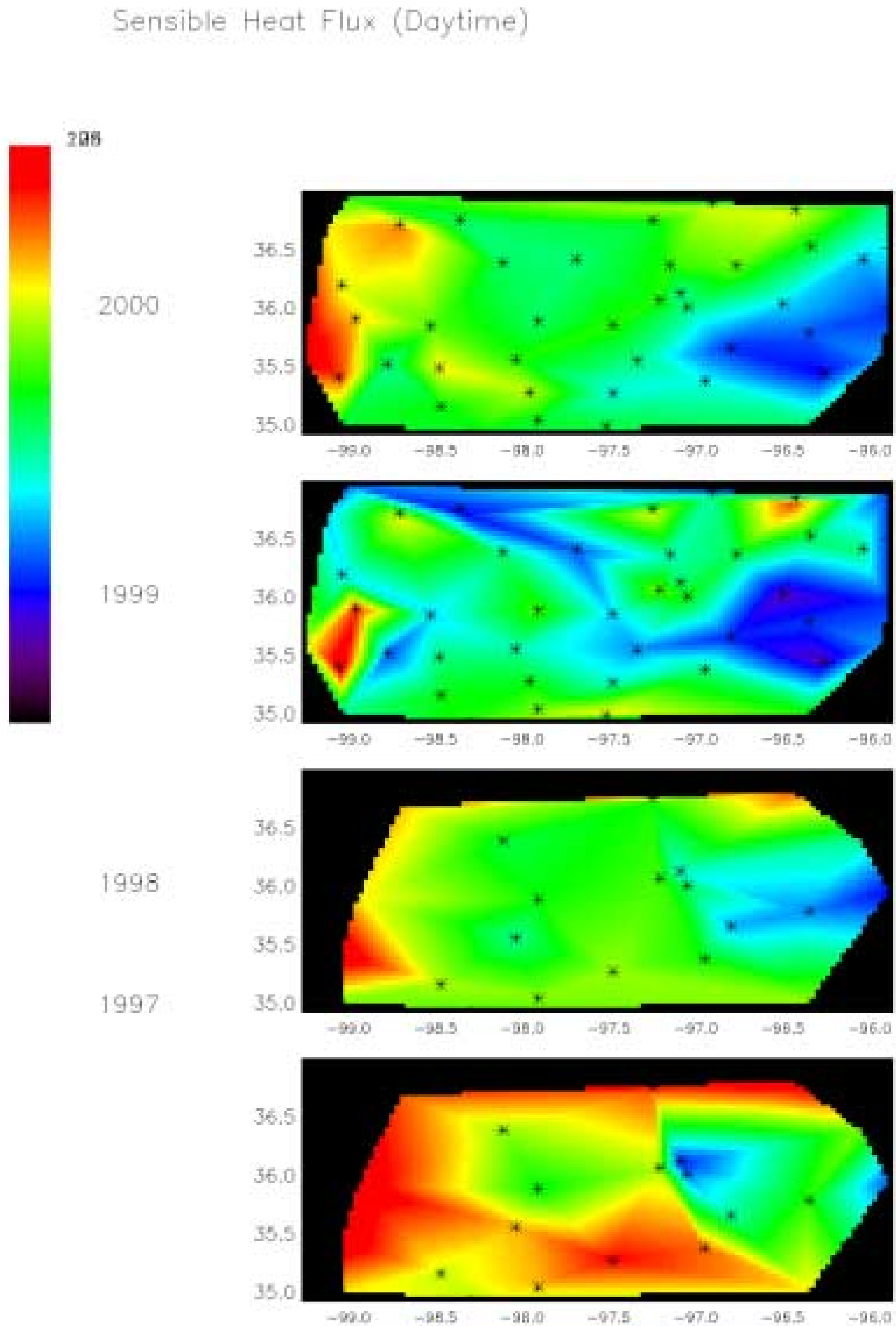

Figure 4. Variation of average daily heat flux across the CART site combined over yearly periods. Note the increasing number of OKM sites with time and the well-defined minimum in the southeastern part of the site.

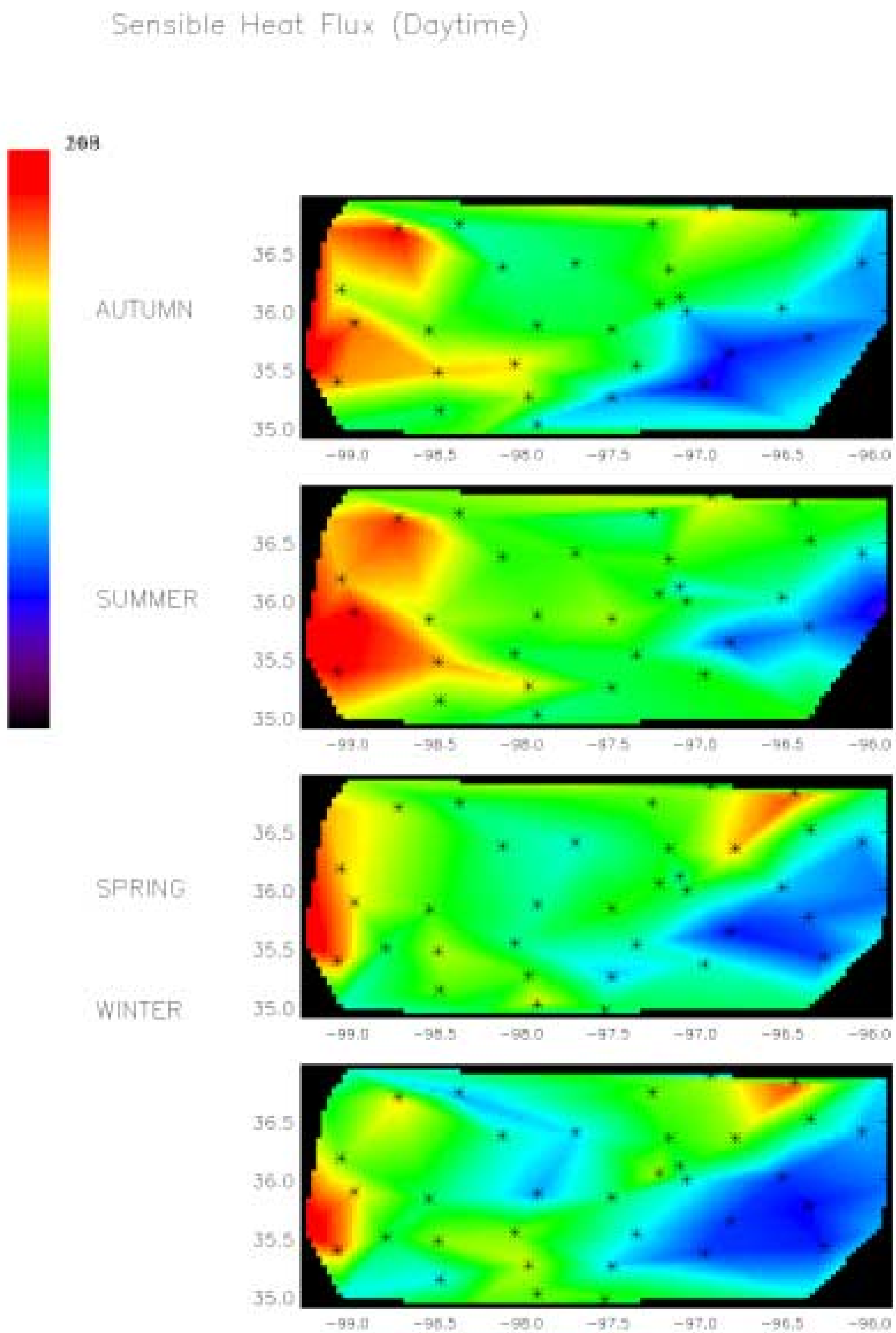

Figure 5. Seasonal variation of heat fluxes across the CART site during 2000. The minimum in the southeastern region is evident throughout the year, as is the region of higher values in the drier western part.

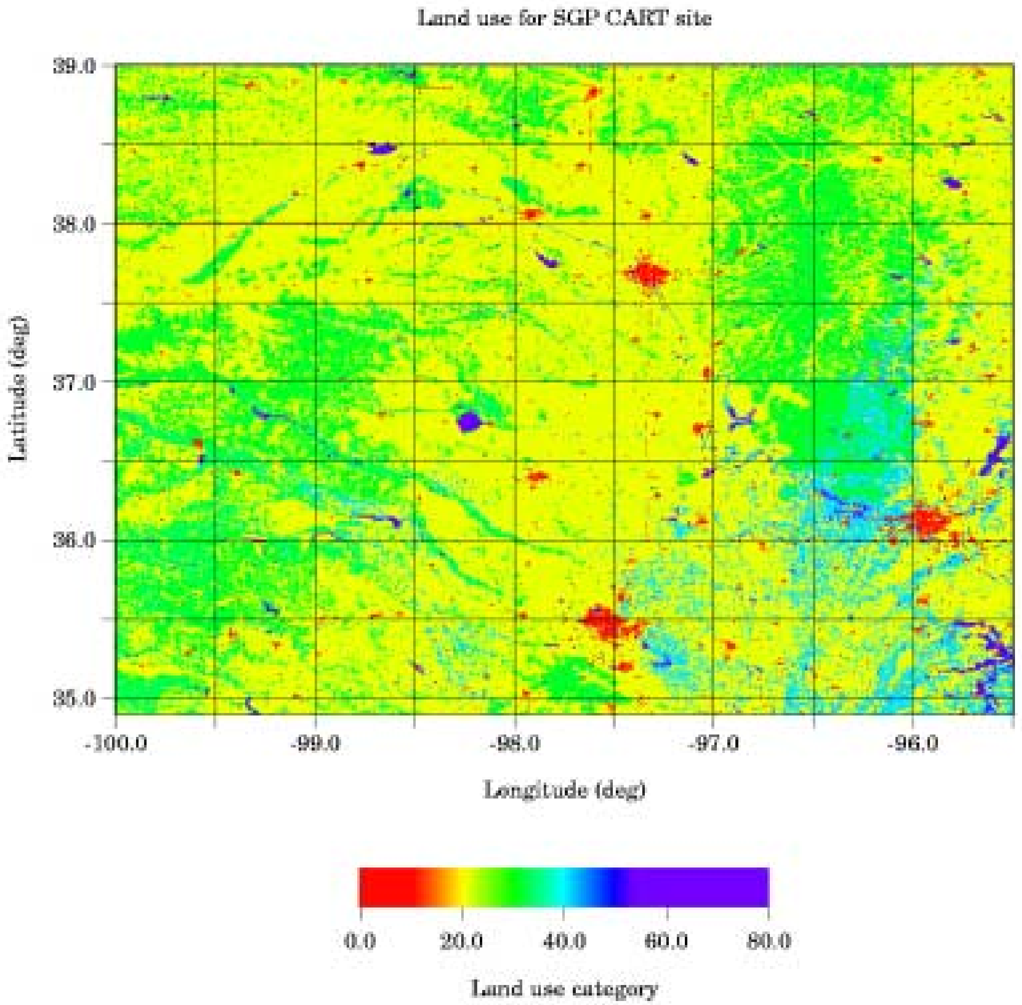

Figure 6. Land use patterns across the SGP CART site (200-m resolution). Land use is limited to five categories: (1) water (dark blue), (2) rangeland (dark green), (3) cultivated farmland (light green), (4) forested (light blue), and (5) urban (red).