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NEIGHBORHOOD-SCALE TEMPERATURE VARIATION RELATED TO CANOPY COVER DIFFERENCES IN SOUTHERN CALIFORNIA

D.G. Levitt[1], J.R. Simpson[1], C.S. Grimmond[2], E.G. McPherson[1], and R. Rowntree[1].

[1]USDA Forest Service, Davis, California
[2]Indiana University, Bloomington, Indiana

1. INTRODUCTION

The effects of vegetative cover on neighborhood-scale climate in southern California are being studied as part of a larger project in urban forest climate research. A comparison of microclimate between two similar urban neighborhoods in Los Angeles county, with different vegetation densities is presented. Previous studies indicate temperature reductions of 1 to 2 °C can be expected for an increase in vegetation of 10% (Huang et al., 1987). Preliminary tree cover differences between the two areas of this study are approximately 18 percent (Simpson et al., 1994). The higher-cover area is in Arcadia and Pasadena, CA, and the lower-cover area is in San Gabriel and Alhambra, CA. Measurements were taken in each of the areas using fixed weather stations, augmented with mobile transects. Measurements taken at the fixed weather stations are described in a companion paper (Simpson et al., 1994). The mobile transect, car-mounted sampling approach has been used in a number of studies as an inexpensive and reliable land-climate sampling strategy (Brazel and Johnson, 1980; Duckworth and Sandberg, 1954). Measurements were made using the mobile transect strategy as an independent verification of the results presented by Simpson et al., 1994. The objective of this paper is to present the results found during the mobile transects and compare them to the results found at the fixed stations.

2. METHODS

2.1 *Fixed Weather station Measurements*

Eight fixed weather stations were placed in the backyards of participating homeowners. Four stations were placed in both the high and low-cover areas in December of 1992. The criteria for placement of the primary eight weather stations was based on detailed cover analysis (Simpson et al., 1994), and permission from the homeowners in the respective areas.

Fixed weather station measurements include: wind speed and wind direction at 3 m; aspirated air temperature and relative humidity at 2 m; net and total solar radiation at 2.5 m and 3 m, respectively; soil temperature and soil heat flux; surface wetness; and precipitation. Data are sampled every 15 s, and averaged at 30-min intervals.

2.2 *Mobile Transect Measurements*

Mobile transects, made with automobile-mounted sensors that measured air temperature, solar radiation, and wind speed, were conducted on July 14, and August 5, 1993. The transects were made with two vehicles, one in each area, at the same times of day. Transects consisted of generally circular routes though the low and high-cover neighborhoods, with each route running approximately 8 km and lasting approximately 15 minutes. Start and end locations were at the same place. Transects were conducted at 0815, 1200, 1600, and 2000 on July 14, and at 0900, 1200, 1500, and 1900 on August 5. Air temperature measurements were made with two 25 μm very fine wire thermocouples (one as a back-up) mounted 2 m above the ground. Solar radiation measurements were made with LI-COR pyranometers that were attached to the roof of each car, in order to determine when the cars were shaded. Wind speed measurements were made with R.M. Young Wind Sentry anemometers that were mounted 0.5 m below the thermocouples. All sensors were wired into a datalogger (Campbell Scientific Inc.; model CR10) located in the front seat of each car. Initial estimates of the resolution of air temperature measurements at fixed stations based on weather station calibrations was approximately 0.1 °C.

During the transects, each driver manually entered different flags into the datalogger which provided the dual function of identification of various geographic locators along the transects, and identification of when the cars were stopped. If a car

Corresponding author address: Daniel G. Levitt, Reynolds Electrical & Engineering Co., Inc., M/S 966, P.O. Box 98521, Las Vegas, NV 89193.

was moving less than 4 m/s, then the air temperature measurements were considered to be non-aspirated, and that data were not used in the analysis. Dataloggers sampled and collected data every 1 s.

An instrument check was conducted between two of the transect runs on July 14. This consisted of driving one car approximately 20 m ahead of another car through one of the transect routes, then reversing the position of the cars for another transect, then comparing the data measured from each car. Initial estimates of the resolution of mobile air temperature measurements was approximately 0.1 °C, which indicates similar agreement in instrument resolution with the fixed stations.

2.3 *Data Analysis*

Neighborhood mean air temperature at a particular time is defined as the average of these 30 minute data, one data point per station, over the 4 stations in a neighborhood. Mean transect temperature was computed by averaging edited data for a particular transect, i.e. approximately 15 minutes of 1-second data. The edited transect air temperature measurements were analyzed by several methods. In one method, mean transect temperatures were compared to neighborhood mean temperatures at the times closest to those of the transects. In another method, air temperatures were averaged using moving averages with various group lengths of data.

3. RESULTS AND DISCUSSION

3.1 *Fixed Weather station Measurements*

Preliminary results provided by the fixed weather stations indicate that the low-cover area was consistently warmer than the high-cover area, with an overall temperature difference between the two areas of approximately 0.5 °C for all data from December 1992 to September 1993. For example, for 28 of 31 days in July, 1993, the high-cover area was cooler than the low cover (Figure 1). Plotted points represent averages of 1400 h temperatures for each neighborhood (4 values).

In addition, the magnitude of the difference in air temperature between the high and low-cover areas appears to be temperature-dependent, with the magnitude of that temperature difference being inversely proportional to air temperature at a reference site. This inverse relationship between temperature difference and reference temperature is clearly visible in data from July, 1993, and illustrated in Figure 2, where the reference site used was a high-cover site.

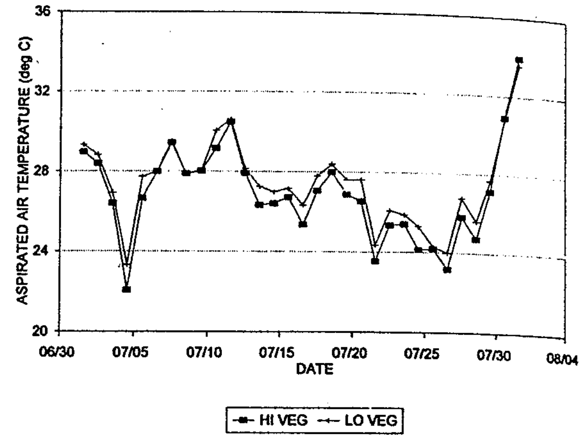

Figure 1. 30-min. average air temperatures of the high and low-vegetated areas measured at 1400 hours in July, 1993.

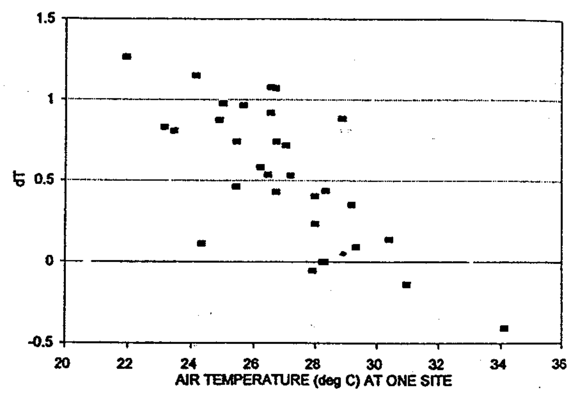

Figure 2. Aspirated air temperature at a reference site (H1) versus 30-min. average temperature difference between high and low-cover areas for data at 1400 hours in July, 1993.

3.2 *Mobile Transect Measurements*

Raw data sets of air temperature measured with thermocouples during mobile transect runs typically were rather erratic, due to the sensitivity of the thermocouples, and the heterogeneity of the transect run. A typical plot of air temperature measured during a transect run through the high-cover area is illustrated in Figure 3, which contains over 600 data points. Various types of moving averages were applied to each transect dataset in order to smooth the data. For example, a moving average with a group length of 48 data points (48 second moving average) was applied to the data shown in Fig. 3., which resulted in considerable smoothing (Figure 4). A 48-point moving average was also applied to the data from the simultaneous transect run through the low-cover area, which is also plotted in Figure 4. The peaks and valleys in this figure correspond fairly closely to various geographical landmarkings, such as large street intersections, and east-west versus north-south street alignments.

Initial indications are that mean transect air temperatures for the high-cover neighborhood were slightly greater than those for the low-cover for simultaneous runs (Figures 5 and 6). Individual differences ranged from -0.2 to 0.7 °C; average difference between means for all transects on both days was 0.2°C, with the low-cover area being cooler. While the high cover area was generally cooler based on the fixed measurements, transect results appear to be consistent with the pattern of temperature differences between high and low cover neighborhoods described earlier for hotter days (Figure 2). Air temperature at 1400 h on July 14 and August 5 were about 27 and 32 °C, respectively.

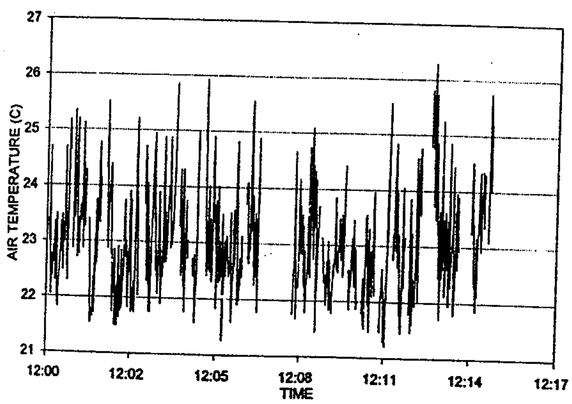

Figure 3. Air temperature measured using a fine wire thermocouple, during one transect at 1200 on July 14, 1993, in the high-cover area.

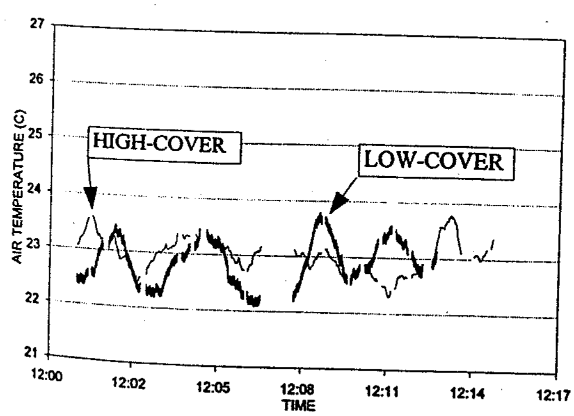

Figure 4. Results of using a 48 group length moving average on high and low-cover data.

Transect measurements may have been affected by external factors such as differences in pavement reflectance or differences in atmospheric mixing due to dissimilar surface morphologies. Additional analysis will treat these and related issues, and better integrate results from fixed and mobile platforms.

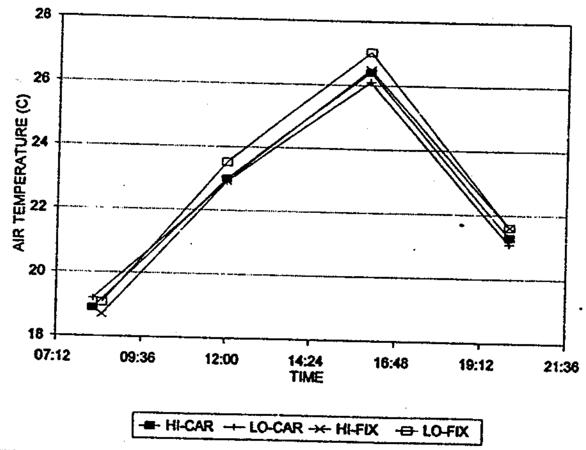

Figure 5. Air temperatures measured at fixed stations and during mobile transects on July 14, 1993.

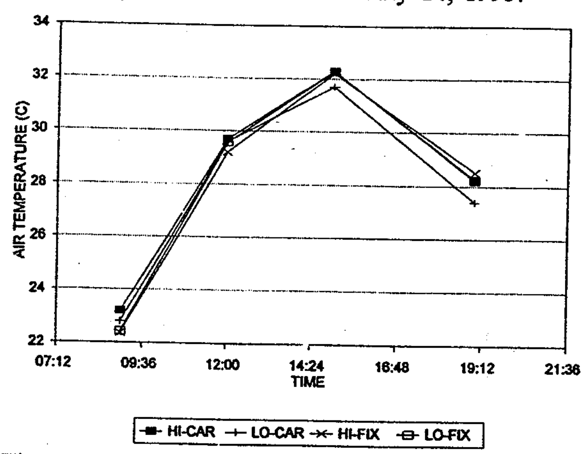

Figure 6. Air temperatures measured at fixed stations and during mobile transects on August 5, 1993.

4. ACKNOWLEDGEMENTS

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