Seasonal and Wavelength Dependence of Urban/Rural Radiance in Iowa

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ABSTRACT

LANDSAT measurements show that the radiance of urban areas is higher in the summer than that of rural areas and lower in the winter, aiding the heat budget of cities and tending to save energy. The radiance of both urban and rural areas increases with snow cover in winter, but cities have less radiance than the country. In the early summer the country has low radiance in the near infrared, and in the late summer it has low radiance in the visible region of the spectrum; the radiance of urban areas follows these trends in a very limited way.

1. Introduction

There has been extensive work worldwide on urban climate (Chandler, 1970) and some work on measurement of radiance on a larger than planetary scale (Nordberg *et al.*, 1962; Bray and Archer, 1966); however, recent work on the heat budget (Critchfield, 1974) of cities (Atwater, 1975) has used the same albedo value for rural, suburban and urban areas for summer and winter seasons. The present work was started because of the striking appearance of cities on LANDSAT imagery and the apparent reversal from summer to winter data shown in Fig. 1. Note in Fig. 1a that cities are lighter than the rural areas, while in Fig. 1b cities are darker. This reversal indicates a significant beneficial factor in urban heat budgets due to the variation of radiance between urban and rural areas.

2. Discussion

LANDSAT 1 and LANDSAT 2 are spacecraft designed to acquire multispectral images of the earth's surface. They pass each local area across most of the

earth at approximately 1000 local time every 18 days. The imagery used in this study was from the multispectral scanner. The scanner in the spacecraft is described in the *Data Users Manual* (1972).

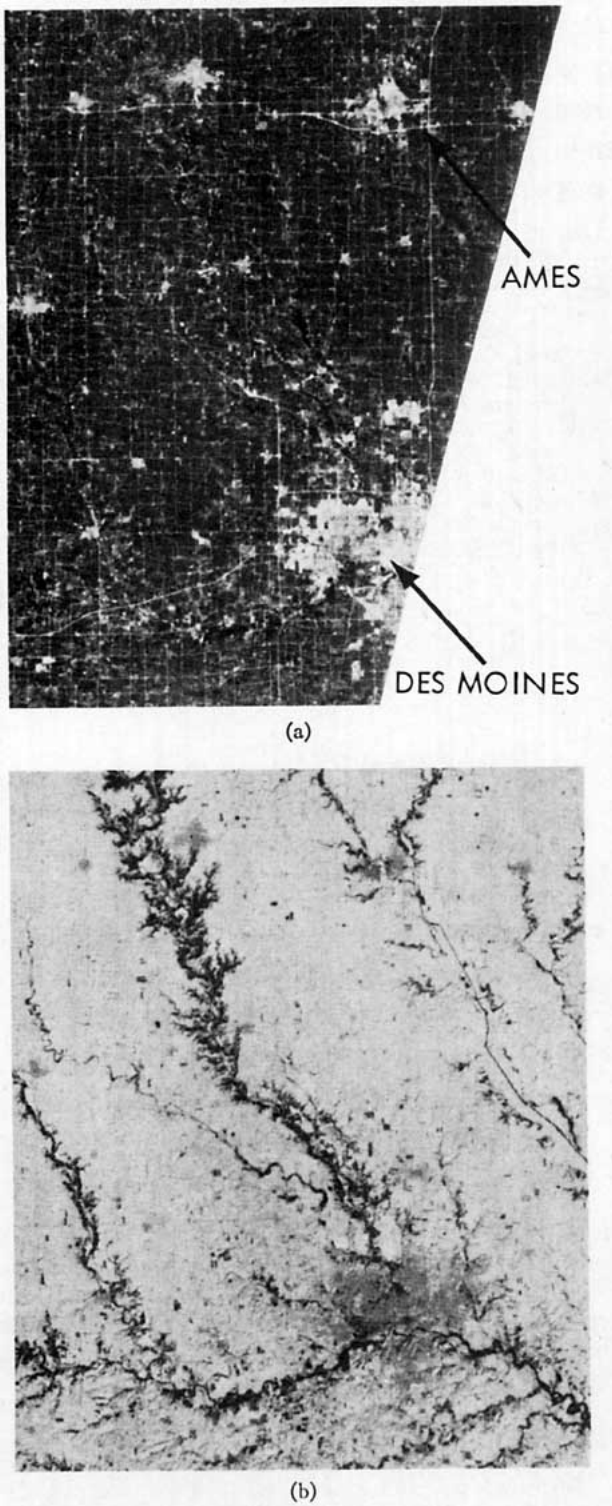

FIG. 1. Positive band 5 LANDSAT images of central Iowa on (a) 26 August 1973 and (b) 4 January 1973.

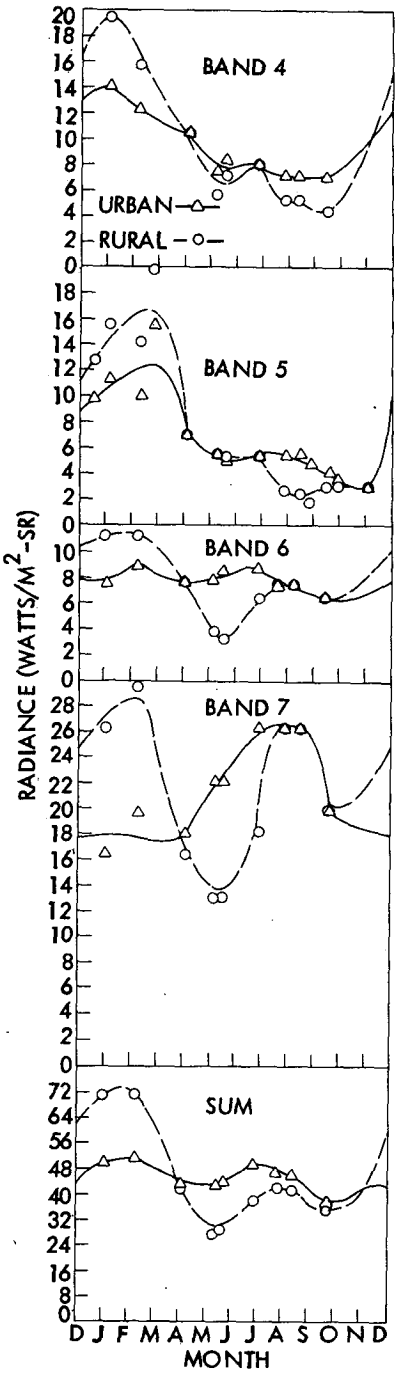

FIG. 2. Radiance variation during the year for urban and adjacent rural areas in Iowa.

Fig. 2 shows radiance values as measured from photographic images of the various scenes. The values for the urban areas are an average for the developed areas within two cities, Ames and Des Moines, Iowa. The values for the rural areas are an average for the nonurbanized area within a radius of 10 mi of the city, excluding river valleys. Only cloud-free images were used. The appropriate area of the image was

TABLE 1. Spectral sensitivities for multispectral sensor bands.

Band number	Spectral sensitivity (μm)
4	0.5–0.6
5	0.6–0.7
6	0.7–0.8
7	0.8–1.1

compared with the grey scale furnished with each image to ascertain which value of grey scale it matched. These values were converted to radiance using the information in the *Data Users Manual*. The band numbers in Fig. 2 refer to the various wavelength channels on the multispectral scanner. Table 1 shows the wavelengths to which the various bands are sensitive. The data in Fig. 2 are arranged by day and month of the year, without regard to calendar year.

Fig. 2 consists of plots of data for Ames plus that for 26 July 1972 for Des Moines. The sum of the energy detected by the multispectral scanner on LANDSAT from the urban areas under cloud-free conditions remains relatively constant throughout the year, with dips in the spring and fall when there is no active vegetation or snow. The radiation detected from the rural areas varies by nearly a factor of 3 throughout the year, from a high in the winter when the ground is covered with snow to a low in the late spring when the cultivated fields are bare of plant growth, with a low infrared radiance followed by a moderating region in late summer when the growing plants lower the visible radiance.

The data are plotted in Fig. 2 without regard to calendar year. There are fluctuations in the weather that will modify the graphs for any one year. There will be large fluctuations in the winter as new snowfalls raise the radiance of both the urban and rural areas; see, e.g., the data for 22 February. Even in this case, though, the difference between urban and rural radiance remained constant.

3. Conclusions

The radiance of urban areas in Iowa is significantly different from that of rural areas. The radiance from urban areas at 1000 local time averaged over weeks remains constant during the year to one part in seven. The radiance from rural areas fluctuates during the year, being greater than in the urban areas during the winter when there is snow cover, and less than in urban areas during the summer when there are bare fields and healthy plants in the rural landscape. The direction of the urban effect on the albedo is to help the urban energy budget, heating urban areas in winter and cooling them in summer.

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