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Description of a Spectral Atmospheric Radiation Monitoring Network

Marlo Martin and Paul Berdahl

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Lawrence Berkeley Laboratory University of California/Berkeley

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DESCRIPTION OF A SPECTRAL ATMOSPHERIC RADIATION MONITORING NETWORK

Marlo Martin and Paul Berdahl

Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

1. INTRODUCTION

The spectral emission characteristics of the infrared atmospheric window in the 8 to 13 micron region are of interest in the development of passive cooling technologies for buildings. Although a number of empirical relationships exist by which the integrated net radiation can be estimated knowing the ambient air temperature and relative humidity (see for example, Bliss, 1961) little information is available regarding the spectral distribution of such radiation.

Although the existing integrated net radiation data is of importance, it is not sufficient to allow predictions of the thermal performance of "selective" radiating surfaces. An ideal selective radiator for use with a passive cooling system would be highly emissive within the atmospheric window and reflective outside that region of the spectrum. Experiments have been reported which indicate that lower temperatures can be attained using a suitable selective radiating surface than with a black body radiator (Catalanotti, 1975; Harrison, 1978). The amount of net heat radiated away from a surface depends on its temperature and emission characteristics, and on the amount of sky radiation incident on it. Many of the atmospheric molecular emission processes are understood theoretically and have been measured experimentally. In fact, much of the available spectral data exists in higher spectral precision than required for the present purpose. Unfortunately, no extended measurements of this type are available over a period of months or years, although several studies have reported such measurements at a given location for one night intervals (Bell, 1960). Thus, it is impossible to accurately determine the monthly averages of net radiation through the atmosphere within specific infrared wavelength bands.

This paper describes a modest network of four radiometers which will be used to make spectral infrared atmospheric emission measurements on a continuous basis starting in the summer of 1978.

2. DESCRIPTION OF THE FIELD INSTRUMENTS

A commercial infrared radiometer (Barnes model 12-880) forms the basis of the field instrument package. This radiometer is equipped with an eight position filter wheel, an external chopper, and a pyroelectric detector. The detector and filter wheel are located in a cavity behind a germanium lens, which has a 2° field of view, and the cavity is maintained at a reference temperature of 45°C. The instrument package is shown in Figure 1 with the weatherproof cover removed.

Since the instrument must operate unattended for extended periods of time it is provided with a stepping motor drive to turn the filter wheel through its eight positions. A front surface aluminum mirror is mounted at a 45° angle on the optical axis of the radiometer. This allows the observation of sky radiation incident from directly overhead while enabling the radiometer to be mounted horizontally. Horizontal mounting is desirable as a means of inhibiting the buildup of dust or moisture on the radiometer lens and chopper blades, and allows the instrument to be mounted inside the protective cover to eliminate the problems of rain damage.

The 45° mirror is mounted inside a rotating cylindrical housing with a circular viewing hole near the outer end which is visible in Figure 1. Between measurements this housing is rotated into the stow position in order to minimize intrusion of rain or dust. A rain sensor overrides the system control and does not permit the mirror to rotate into the upward facing position when rain is detected. Further protection is provided against rain and dust by an air blower which maintains a positive pressure inside the instrument case. In Figure 2 the air filter is visible in the left hand segment of the case, which also contains the blower.

Although the abovementioned precautions have been taken in order to minimize the intrusion of dust and rain, it is still necessary to provide a system checking capability for monitoring the overall performance of the instrument. The component most vulnerable to the adhesion of dust or water is the 45° mirror, and it is necessary to test the performance of this mirror as well as the remainder of the optical system. For this purpose, an external blackbody cavity is designed to be permanently mounted on the front of the instrument case. By causing the 45° mirror cylinder to rotate to an intermediate position, the radiation from this cavity can be measured between sky radiation measurements. Degradation of the mirror surface or problems arising within the radiometer or the associated electronics package are detected when the signal obtained from the instrument deviates from a known value while viewing this cavity. If and when this occurs remedial action must be taken by personnel on site. This consists primarily of cleaning the mirror surface or simply replacing it with a new mirror.

3. DATA ACQUISITION SYSTEM

A Monolithic Systems microcomputer is used on site with each of the four instruments, both to control the instrument and to store the data received. A random access memory of 20 kilobytes suffices to store data for more than two days of operation. Repeated measurements are made and the signals are averaged digitally until the signal to noise ratio exceeds an acceptable limit. At that time the averaged signal is stored in a random access memory location and the filter wheel is caused to index to the next position. When readings from all filter positions have been recorded in this manner the 45° mirror is rotated into the stow position. The temperature of the external blackbody cavity is monitored, as is the ambient air temperature and humidity, and the temperature inside the instrument housing.

A set of readings can be made at any desired interval; nominally every half hour. Once every day or two the microcomputer is accessed by telephone through a Modem link and the contents of the appropriate memory addresses are transferred to the Lawrence Berkeley Laboratory computer. Battery backup power is provided for the memory card of the microcomputer so that data is not lost in the event of a power failure. A set of current calibration constants is maintained in a computer data base, and they are used to convert the raw data received from the field instruments into spectral infrared radiation intensities. The data is permanently stored in a data base and will be tabulated following the summer operation period.

4. REFERENCES

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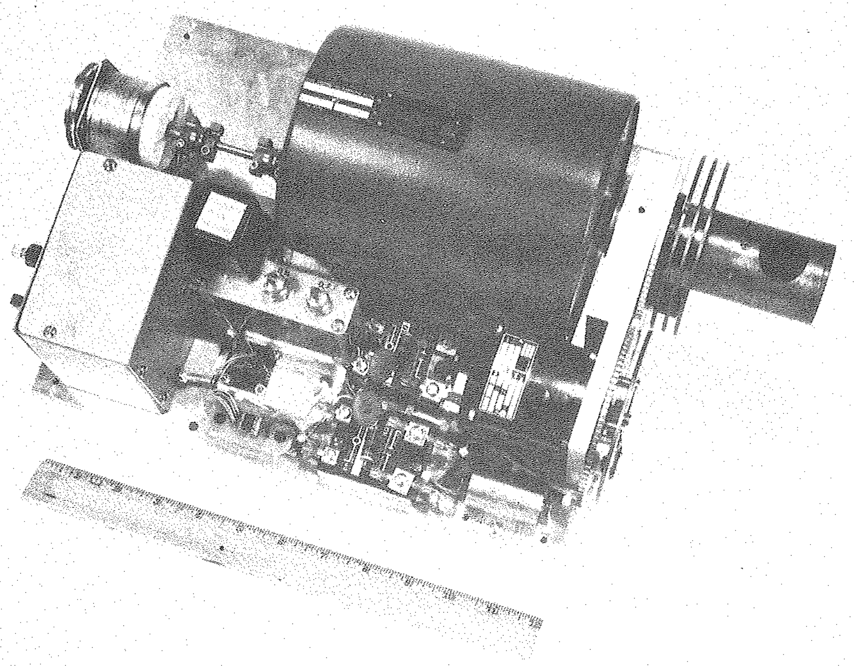

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Figure 1: Photograph of the instrument package for obtaining infrared spectral atmospheric radiation data. The large cylindrical object is the radiometer. When the protective housing is placed over the package only the cylindrical can containing a mirror, which extends along the optical axis from the radiometer, is visible. The remaining hardware is required to position the filter wheel and to rotate the mirror assembly.

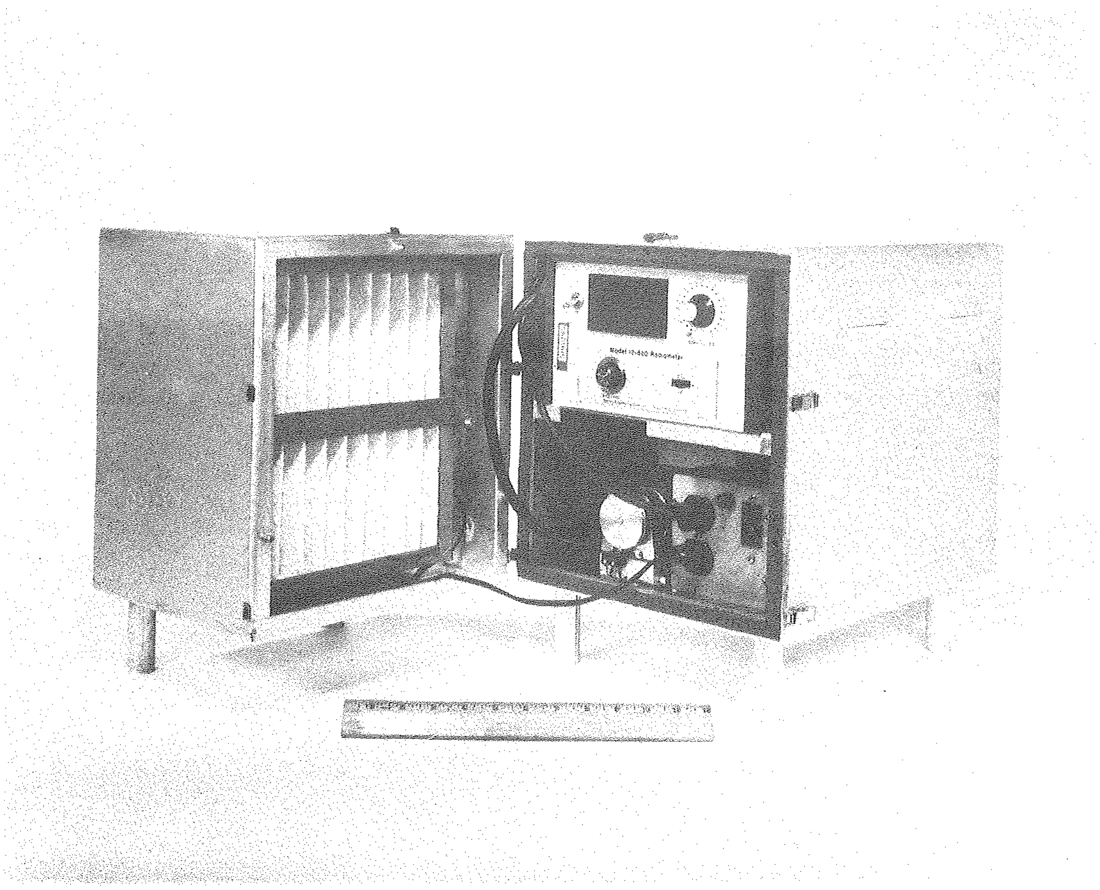

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Figure 2: Photograph showing the radiometer package assembled. The unit shown in Figure 1 is located in the lower right segment of the housing in this photograph. Above it is the electronics package for the Barnes radiometer. The left hand segment contains an air blower, which is located behind the air filter shown.

TECHNICAL INFORMATION DEPARTMENT
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720