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**Energy and Environment Division**

# Radiative and Passive Cooling

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RADIATIVE AND PASSIVE COOLING*

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## OBJECTIVE

The objective of this project, which was started in March of 1977, is to assess the infrared radiative cooling resource in order to determine the extent to which radiative cooling can supplement or replace refrigerative type systems for the space cooling of buildings. Convective and evaporative cooling techniques are also to be included, so that all aspects of passive cooling are covered.

## BACKGROUND

Radiative cooling is known to be quite effective in arid regions; the most promising areas for application are probably those in which large diurnal temperature fluctuations are observed. The extent to which a suitably designed radiator system could contribute to cooling a building in more humid areas has not yet been thoroughly investigated. Furthermore, the development of selective emitter surfaces,[1] which radiate preferentially in the 8 to 12 micron region of the spectrum in which the atmosphere is most transparent, presents the possibility of extending the use of this technique to climate regions in which it would not previously have appeared feasible.

## SUMMARY

The two primary accomplishments of the project to date are (1) the construction of a computer model to predict the infrared spectral radiance of the atmosphere under various meteorological conditions of temperature, water vapor profiles, and cloud cover; and (2) the design, testing, and installation of several spectral radiometers for the routine measurement of atmospheric infrared radiance. Emphasis has been placed on the study of the atmospheric radiance which would be absorbed by a thermal radiating surface exposed to the sky because the amount of radiation emitted from a given system can usually be calculated in a straightforward manner.

## TECHNICAL ACCOMPLISHMENTS

- An existing computer program (LOWTRAN),[2] which calculates the spectral transmissivity of the atmosphere under a variety of weather conditions, was modified to predict the infrared emittance from the atmosphere as observed at ground level. Input to this program includes temperature and water vapor profiles, aerosol content, cloud cover, and elevation above sea level. A sensitivity analysis was performed to assess the effects of changes in these parameters on the spectral radiance.[3] The spectral radiance of the atmosphere in the vertical direction is plotted in Fig. 1 under three conditions, to illustrate the effect of water content on the radiation emitted. The solid curve represents the radiance calculated for a **precipitable** water vapor column of 3 cm. The upper curve shows how the atmospheric radiance increases as the water vapor content is doubled, and the lower curve shows a decreased radiance corresponding to an atmosphere with half the original amount of vapor. Figure 2 shows four different spectral radiance calculations representing the infrared radiation received from the horizon, from the zenith direction, and from two intermediate angles.

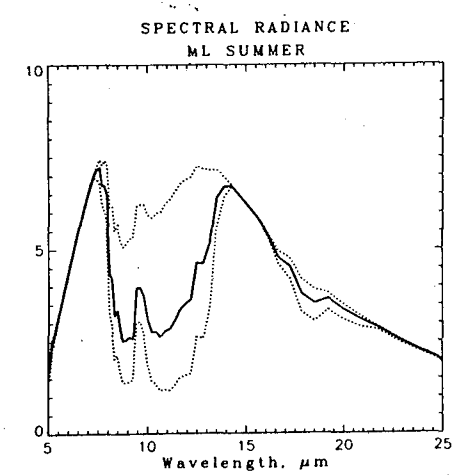


Fig. 1. The solid curve shows the atmospheric radiance from the zenith, (3 cm precipitable water vapor). The upper dotted curve shows the radiance when the water vapor is doubled (6 cm). For the lower curve the water vapor is halved (1.5 cm).



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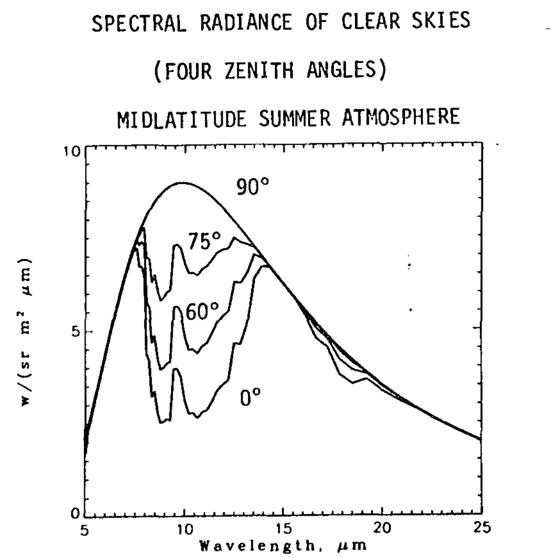


Fig. 2. Spectral radiance of a clear, midlatitude summer atmosphere. Zenith angles (from top to bottom) are: 90°, 75°, 60°, 0°.

- An infrared spectral radiometer was developed which is suitable for unattended field use.[4] Four such systems have been constructed. The design incorporates the Barnes model 12-880 radiometer equipped with an eight-position filter wheel and pyroelectric detector. The filters covering the spectral ranges of primary interest are centered at wavelengths of 8.8, 9.6, and 10.9 microns. The assembly includes a stepping mechanism to allow the filter wheel to be positioned automatically, and a rotating mirror assembly to direct the instrument's view alternately in the vertical direction and into a reference blackbody cavity. The entire instrument is under microprocessor control and is accessible to LBL through a MODEM telephone link. The signal received through each of the eight filters is stored every half hour and transmitted from the random access memory of the microcomputer to LBL at intervals of one to three days. Dry bulb and dew point temperature readings are recorded with each set of infrared measurements. A pyrgeometer records the total hemispheric infrared radiation.

- Two of four radiometer systems have been installed at Tucson and San Antonio, and are providing data on a routine basis. Data reduction routines and the establishment of a computer data base will be completed as soon as all four stations are in operation. No significant problems have yet been encountered with the field equipment.

- The final two radiometer systems are being readied for installation in St. Louis and near Washington, D.C.

## FUTURE ACTIVITIES

Infrared sky radiation measurements are to be continued throughout the winter in order to obtain data of relevance to solar collector heat loss and freeze problems, and for use in heat loss calculations for passive stuctures. The data analysis routines and data base will be developed, and a complete set of summertime infrared radiation measurements are to be taken at four sites during the summer of 1979. Measured data together with radiosonde readings will be used to validate the computer program (based on LOWTRAN) that has been assembled to perform the sensitivity analysis reported in the foregoing section. Measured data will also be correlated with the standard meteorological measurements of temperature, cloud cover, and dew point temperature to permit estimation of atmospheric radiance based on these quantities.

Passive cooling systems based on radiative cooling principles, separately or in conjunction with evaporative cooling techniques, are to be defined. The most promising configurations will be incorporated into a computer model to simulate passive building performance in the cooling mode.

## REFERENCES

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