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IMPROVED PREDICTION OF ATMOSPHERIC HEATING AND COOLING RATES

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1. INTRODUCTION

The demands of accurate predictions of radiative transfer for climate applications are well-documented. While much effort is being devoted to evaluating the accuracy of the GCM radiative transfer schemes, the problem of developing accurate, computationally efficient schemes for climate models still remains. This paper discusses our efforts in developing accurate and fast computational methods for global and regional climate models.

2. RADIATIVE TRANSFER MODEL

We have used the two-stream model developed by Toon et al. (1989), that is computationally efficient and has been tested in a number of applications (e.g. Westphal, et al. 1992). The model assumes horizontally homogeneity and a number of vertically inhomogeneous layers. In the solar wavelengths the model uses the two-stream approximation in a generalized framework as described by Meador and Weaver (1980). In the infrared it performs a direct integration in the case of no scattering and uses a two-stream source function approximation technique to include scattering if needed.

The model is used to calculate the solar and infrared fluxes and heating rates in the earth's atmosphere. The absorption by gases is treated by an exponential sum technique with values taken from Pollack et al. (1975) for the solar spectrum and from Pollack and McKay, (1985) for the infrared spectrum. The treatment of the water vapor continuum is discussed below. The model has 26 solar wavelengths regions and 18 infrared wavelength regions, while the number of probability intervals (which represent the actual number of separate calculations needed) is 77 in the solar and 71 in the infrared.

The model is capable of treating aerosols and clouds in both the solar and the infrared. The properties of the aerosols and clouds are described by a particle size distribution and the Mie equations are integrated to evaluate the radiative properties.

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3. TREATMENT OF THE WATER VAPOR CONTINUUM

We have replaced the treatment of the water vapor continuum from that of Roberts et al. (1975) to that of Clough et al. (1989). A computer program supplied by Tony Clough of AER was used to generate the mean water vapor continuum coefficients for the 18 infrared regions. The continuum is described by both a self-broadening and foreign-broadening coefficients. The self-broadening dominates in the window region while the foreign-broadening is important in the other regions.

4. COMPARISON TO LINE BY LINE CALCULATIONS

We have compared the results of the model with the new continuum treatment to the results of line by line calculations provided by Tony Clough of AER. The results are shown in Figure 1.
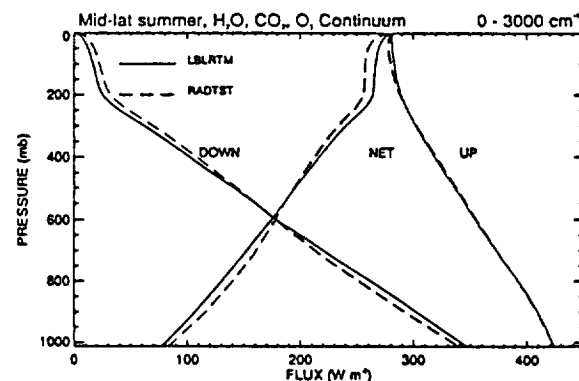

FIGURE 1: Comparison of the two-stream model (RADTST) and the line-by-line result (LBLRTM).

The results show that the two-stream method with 18 infrared bands can reproduce the fluxes relatively well. The predicted cooling rates show good agreement for the upper and lower atmosphere, but the two-stream model underpredicts the cooling rates near 500 mb. We are currently exploring the reasons for the underprediction.

5. FUTURE WORK

We are currently using the K- distribution method to produce a new set of gas absorption coefficients. The new HITRAN-92 data base is being used to derive the K-distributions and coefficients at specific temperatures and pressures for the major atmospheric trace gases. The problems include accounting for the overlap of different atmospheric gases; accounting for the line behavior in both high and low pressures, and choosing the appropriate spectral intervals. Our goal is to have a computationally efficient model that will be accurate from the surface up to 60 km.

We will present more detailed results at the meeting.

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