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RAPID TRANSMITTANCE STUDIES AT NOAA

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1. INTRODUCTION

The use of satellite measurements in numerical models requires the use of rapid methods for calculating atmospheric transmittances. One of the methods that has been developed and is in use is OPTRAN(McMillin et al. 1995a & 1995b) which , along with a number of similar approaches, shares a common heritage with (McMillin and Fleming 1976 and Fleming and McMillin 1977). These approaches gain their speed by fitting transmittances for a single channel that have been generated by a much more general but slower (Line-By-Line) LBL program. In the past, evaluations of some of the factors involved in these rapid approaches has been prohibitive because of the resources required to generate multiple versions of the input data. Computers have reached the point where some of these comparisons are now feasible. We have determined the effects of several of these factors.

2.DATA SETS

Several sets of profiles have been used as training data for these models. They have come to be associated with different groups running different fast models and even become associated with different LBL models, so comparisons of models has been complicated by the associated difference in profile data sets. In particular, most data created with LBLRTM have used the set of 32 profiles used in McMillin and Fleming's (***) original paper. More recent work at UMBC (Strowe et al. 1998) has been based on a set of 48 profiles. We used kCARTA (Strowe et al. 1998) to generate radiances for both sets of profiles and fit both with the same version of OPTRAN. We also used each to generate coefficients which were each then used on the other as an independent set. We found the set of 48 profiles harder to fit for several reasons. One is that the set of 32 profiles is actually based on only 6 ozone profiles. Another is that both sets are based on calculating transmittances for "fixed" gases (whose concentrations don't change), water vapor, and ozone. It was discovered that , for several reasons including changes made deep in the LBL programs, that the "fixed" gases were not all fixed. Running these combinations has allowed some the differences to be isolated.

3. EFFECTIVE TRANSMITTANCES

In the past it has been the practice to define an effective transmittance to account for the effects of mixed gases. This is done by dividing the layer transmittance for an LBL calculation for the combination of two gases by the LBL transmittance of one of the gases. This ratio is then defined as the effective transmittance for the other gas. The extension from 2 gases and 1 gas to 3 and 2 gases is obvious. A problem occurs when the denominator goes to zero. The best way to solve this is to use the most transparent gas in the denominator. The disadvantage of this is that it requires running the LBL calculations for all the gas combinations. For 2 gases the number is 7 and it rapidly increases if more gases are added. In addition, this approach has required a considerable amount of attention to avoid numerical difficulties. This can be resolved by using the concept of a correction factor that can use the same form as the effective transmittance or as an additive term. The first form has the advantage of requiring little or no change to existing software and the results are bout equal, so it was selected. Coefficients are generated by calculating the LBL transmittances for each gas individually. Then one additional calculation is made using all gases. The correction is the ratio of the layer transmittance for all gases divided by the product of the layer transmittances for the individual gases. For many wavelength regions, the required correction is small. When numerical difficulties are encountered, the correction ratio is set to one. When the transmittance is near zero, a correction that is small fraction of the value just doesn't matter.

4. OZONE

Ozone was a particularly difficult gas to fit. One problem is the vertical distribution. The other gases have their maximum concentrations near the surface, but ozone is concentrated in the upper atmosphere. The other coefficients were generated on a spacing that was appropriate for these gases. However, for ozone, these either gave too coarse a spacing in the upper atmosphere where it is needed or too dense a spacing in the lower atmosphere where resources are required to store unneeded coefficients and do unneeded calculations. The solution was develop a unique vertical spacing to be used for ozone that has the vertical resolution at the levels where ozone absorption is large. In addition, additional predictors were added just for ozone. The combination of the change in absorber space for ozone and the use of $P^{1/2}$ and $P^{1/4}$ reduced the error for this channel to under 0.1K.

5. FIXED GASES

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Examination of the other gases reveled that the variation of the “fixed” gases produces large errors in channels 11, 13, and 14. Finally, a polynomial expansion in the vertical reduced the number of coefficients and made the vertical spacing arbitrary. The combination of these factors is being used to produce an improved

5. RESULTS

These studies have produced several improvements to the rapid transmittance calculations. The use of the correction factor produces results that are equivalent to the effective gas approach. The other changes produced accuracy improvements. The effects of all the changes are summarized in Fig. 1. The errors of all channels are reduced to below 0.1 K.

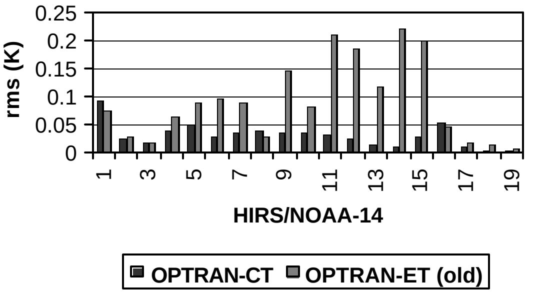

Figure 1 Comparison of the standard deviations of the fitting errors for the improved version of OPTRAN relative to the older version based on a dependent set of 32 profiles and six viewing angles.

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