COMPARISON OF RADIATIVE TRANSFER CALCULATIONS USING THREE FAST TRANSMITTANCE ALGORITHMS

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1. INTRODUCTION

A significant source of error in atmospheric soundings can be attributed to errors in the forward calculation. Forward calculation errors are due to uncertainties in spectroscopy and deficiencies in the fast radiative transfer (RT) model. A fast RT model is a regression solution of the expected atmospheric transmittance from predictors such as temperature, water vapor, pressure, and absorber amount. The coefficients are derived from an ensemble of line-by-line atmospheric transmittances and the atmospheric state variables used in computing the line-by-line data. Fast RT models are needed because line-by-line data are too computationally intensive for real-time processing of radiances/retrievals.

This paper will compare three models - TRANH, OPTRAN, and RTTOV. TRANH (McMillin et al. 1976, 1979; Fleming et al. 1977) and OPTRAN (McMillin et al. 1995) are both used by NESDIS. RTTOV (Eyre, 1991) is used by a number of agencies, notably ECMWF, UK Met Office, MeteoFrance, and NCEP. OPTRAN has been found to be the most accurate for fitting line-by-line data. The focus here, however, is to compare the three models with real observations. This is accomplished by using a set of collocated radiosonde and NOAA-14 HIRS/MSU observations. Radiiances are computed using the three fast RT models and compared with the measured observations. The collocated HIRS and MSU radiances are treated as ground truth. There are of course difficulties in using collocated data to evaluate radiative transfer models. A large component of the standard deviation and bias of the difference between measured and computed radiances is due to non-simultaneity of the collocated data as well as fundamental differences in the resolution of the data. However in this test scenario all radiative transfer computations are derived from the same set of atmospheric conditions and compared to the same set of HIRS/MSU observations. There are two comparisons of RTTOV based on two different sets of fast RT coefficients. RTTOV coefficients were obtained from ECMWF and MeteoFrance. ECMWF coefficients are based on TRANH for the dry coefficients and HARTCODE/HITRAN-92 for the wet coefficients. MeteoFrance coefficients for both
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dry and wet are based on FASTCODE-3P/HITRAN-92. OPTRAN is based on HARTCODE/HITRAN-92 for all species. TRANH, the oldest of the fast RT models used HITRAN-77.

2. RESULTS

The collocated data is from the month of April 1996. Only nadir viewing oceanic observations were considered. Bias and standard deviation of computed minus observed are given in fig. 1.

![Computed minus Observed - Clear/Ocean](image)

**Computed minus Observed - Clear/Ocean**

**Bias / sample=377**

![Computed minus Observed - Clear/Ocean](image)

**Computed minus Observed - Clear/Ocean**

**Standard Deviation / sample=377**

Fig. 1 Bias and standard deviation of the difference between computed and observed for TRANH, OPTRAN, RTTOV/ECMWF and RTTOV/MeteoFrance.
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These results show that for the thermal channels (all but 10, 11 and 12) RTTOV/MeteoFrance errors are lower than RTTOV/ECMWF, suggesting that the improvement is solely due to the data used in generating the dry transmittance coefficients. As mentioned above, RTTOV/ECMWF used TRANH for generating the dry coefficients and as a result TRANH and RTTOV/ECMWF errors are virtually the same. OPTRAN and RTTOV/MeteoFrance errors are very similar. Note that the order of the bars and the legend in fig. 1 are the same.

For the water vapor channels (10, 11 and 12). RTTOV/MeteoFrance has the largest errors especially for channels 11 and 12. Scatter diagrams between OPTRAN channel 12 and RTTOV/ECMWF and between RTTOV/ECMWF channel 12 and RTTOVS/MeteoFrance are given in Fig 2.

![Scatter diagrams of OPTRAN vs. RTTOV/ECMWF and RTTOV/MeteoFrance vs. RTTOV/ECMWF for HIRS channel 12.](image)

At lower brightness temperatures the disagreement between the two RTTOVs increases. This is not the case for the comparison between OPTRAN with RTTOV/ECMWF.
TRANH has the smallest errors for channels 11 and 12, the bias is nearly zero. However further inspection of the weighting functions found that the peak contribution for TRANH was much lower in the atmosphere than for the other RT models. This is probably due to the older spectroscopic data in HITRAN-77. The reason for the smaller bias is still unknown. For channel 10, the lower weighting function peak results in a larger surface contribution. It can be observed in fig. 3 that the scatter between RTTOV/ECMWF channel 10 and total precipitable water (UTOT) closely resembles the scatter between observed channel 10 and UTOT. This is not true for TRANH at larger values of UTOT, which strongly suggests that its estimate of water vapor absorption is not as precise.
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3. CONCLUSIONS
Overall OPTRAN appears to provide the best agreement for most channels. However RTTOV/ECMWF should be able to yield similar results if the dry coefficients are recomputed from line-by-line data. Such coefficients are now available, but we were unable to evaluate them for this paper. Results indicate that the RTTOV/MeteoFrance wet coefficients should be reexamined.

4. REFERENCES


