Comparison of radiative transfer models for AIRS

by
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Abstract

Many of the results of this study are presented in the paper included in the ITSC-14 proceedings by Saunders *et. al. (2005)* and a paper by Saunders *et. al.* (2006) about to be published. This paper therefore only summarizes the final conclusions of the study.

1. Summary

The comparisons of AIRS radiative transfer (RT) models were undertaken in order to better understand the error characteristics of AIRS RT models important for data assimilation and retrieval applications. For the forward model comparisons when averaged over 49 diverse profiles all the models agreed within 0.06K and most models to within 0.02K of the RFM line by line model used as a reference. Exceptions to this are in regions affected by CFCs, water vapor continuum or CO_2 line mixing where larger differences were found. The differences between the line-by-line models are as large as between the fast models suggesting the dominant error sources are related to the spectroscopic assumptions and line parameters used rather than the errors in the fast model formulations. Other sources of error include the treatment of the surface reflection, Plank constants assumed, and treatment of layers in the integration of the radiative transfer equation. A summary of the differences seen for different spectroscopic regions is shown in Figure 1.

The mean biases shown by each model can be removed by a bias correction procedure as is standard practice in data assimilation applications. It is encouraging that the standard deviation of the differences between the models and RFM is for all models less than the AIRS instrument noise as shown in Figure 1. This suggests that the forward model error is not the dominant error source but instrument noise and errors of representativity are likely to be more important when comparing simulated with measured radiances.

The comparison of the model simulations against AIRS observations for a single profile shows bigger differences with mean brightness temperature differences at the 1K level. The SARTA model fits the AIRS observations best especially in the 2100-2200 cm^{-1} region but it has been tuned using data including this profile. Some of the differences with the AIRS observations are due to our inadequate representation of the atmospheric state for ozone and stratospheric variables in the forward model.

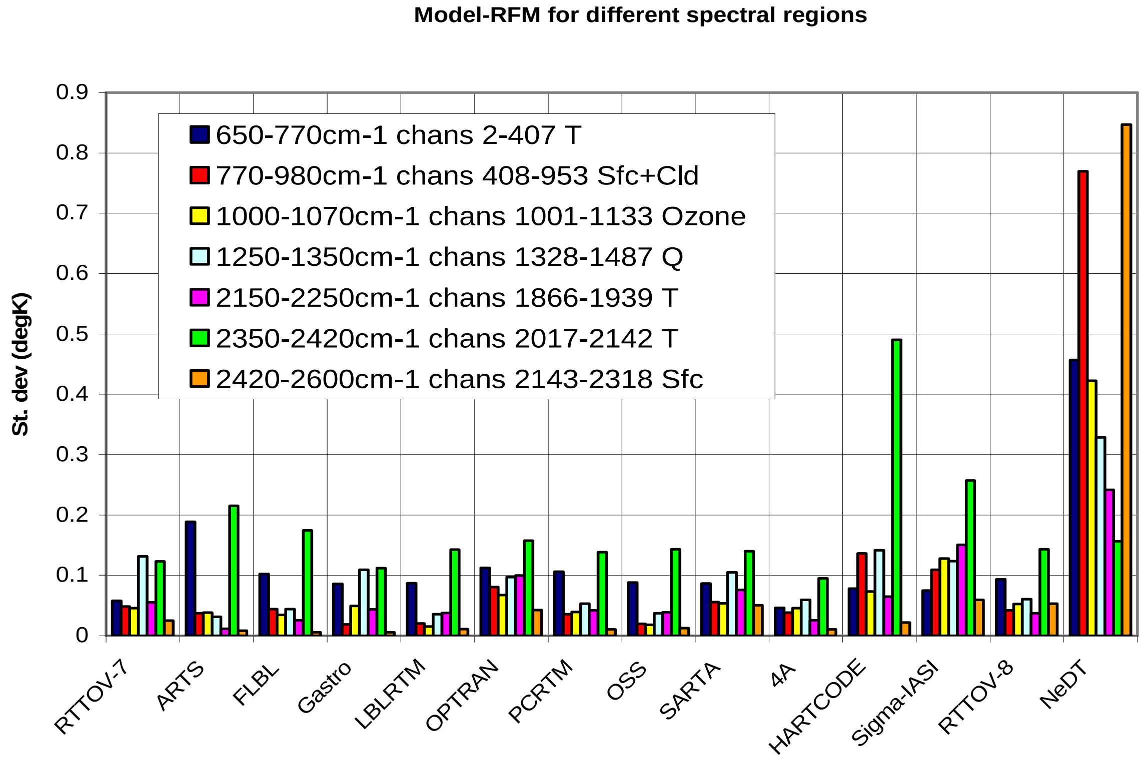

Figure 1: *A histogram of the RT model nadir view differences from RFM for different spectral regions. The columns on the far right give the AIRS instrument noise for a 250K brightness temperature scene*

In terms of transmittances the 4A model, and to a lesser extent RTTOV-8, are consistently different from RFM but this may just reflect the fact that these models have recently been updated and include more up to date spectroscopy than RFM.

The performance of the models in terms of accuracy of the Jacobians varies with most models having problems for some profiles. For temperature the box and whisker plots in Figure 2 summarize the results. The AIRS 787 (917 cm^{-1}) channel appears to be the most problematic channel for modeling Jacobians with 4 out of the 8 models diverging significantly from RFM. For water vapour RTTOV-8 is consistently different from the RFM response for most water vapour channels but this may be due to the new spectroscopy in the kCARTA dataset on which this version of RTTOV-8 was trained. The ozone Jacobians were in general more consistent between models. Further study is needed to assess the impact of model-specific Jacobian errors (e.g. erratic weak Jacobians, poorly modelled Jacobians in cold, dry atmospheres) and Jacobian errors associated with bias correction, on retrieval accuracy. Sherlock (2005) has started to address this with a study of the effect of fast model errors, including Jacobians, on AIRS retrieval accuracies.

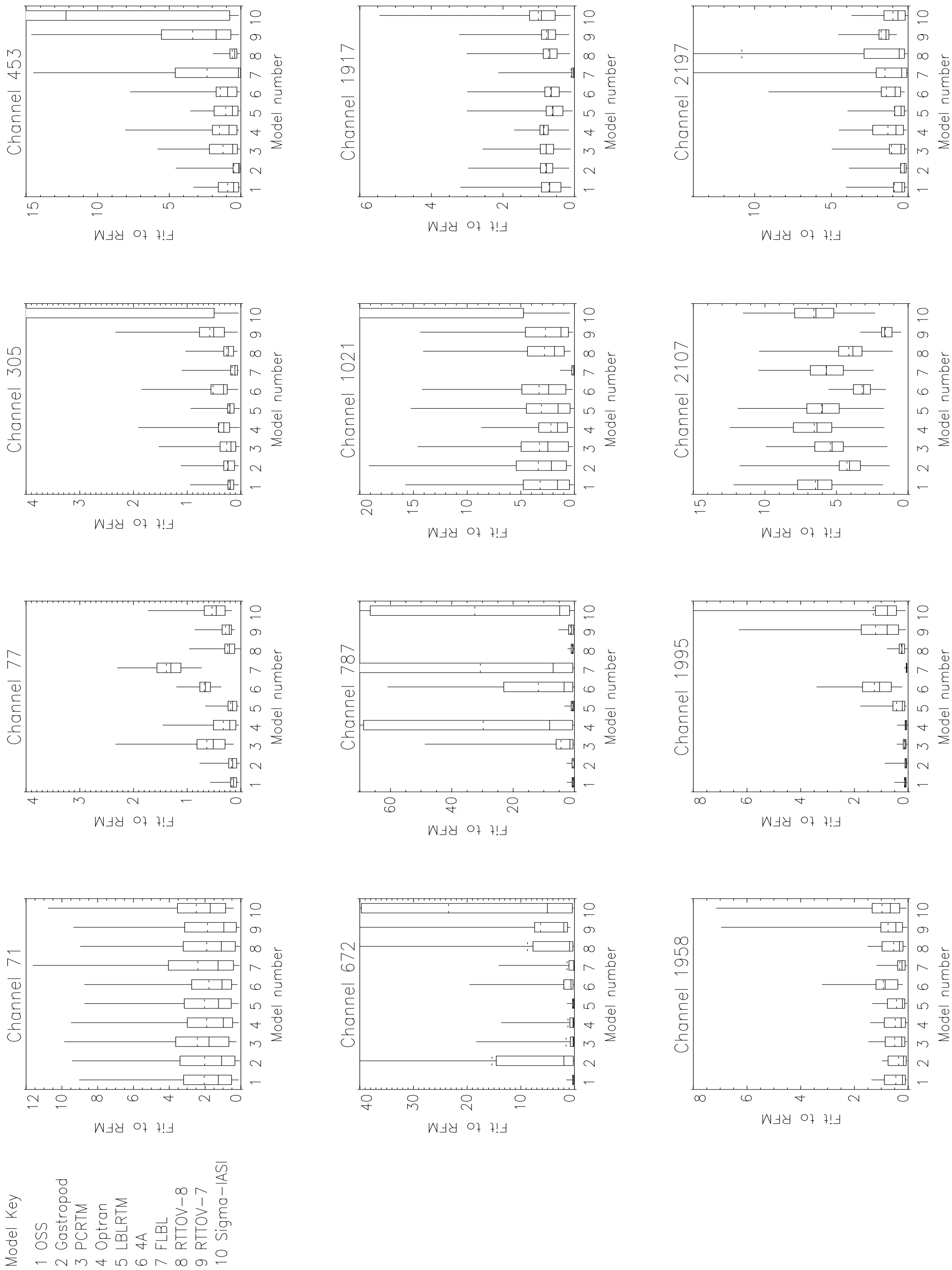

Figure 2: *Box and whisker plots which show the range of the fits to the RFM temperature Jacobians for each model. The box gives the bounds of the upper and lower quartiles, the solid line through the box is the median, the dashed line the average and the whiskers indicate the maxima and minima of the differences. The lower the number the closer the fit.*

To allow other modelers who did not participate in this comparison to compare their models with the datasets presented in this paper the International TOVS Working Group have set up a web site which includes the raw model output data that produced the results presented here. The link is at:
http://cimss.ssec.wisc.edu/itwg/groups/rtwg/rtairs.html

2. References

Saunders, R.W., P. Rayer, A. von Engeln, N. Bormann, S. Hannon, S. Heilliette, X. Liu, F. Miskolczi, Y. Han, G. Masiello, J-L Moncet, V. Sherlock, D.S. Turner, G. Uymin 2005 Results of a comparison of radiative transfer models for simulating AIRS radiances. *ITSC-14 Proc. Beijing 25-31 May 2005.*

Saunders, R.W. P. Rayer, A. von Engeln, N. Bormann, L. Strow and S. Hannon, S. Heilliette, Xu Liu, F. Miskolczi, Y. Han, G. Masiello, J-L Moncet, G. Uymin, V. Sherlock, D.S. Turner 2006 A comparison of radiative transfer models for simulating AIRS radiances. *J. Geophys. Res. – Atmopsheres (in press)*

Sherlock V. 2005 Extended studies with the IASI_1DVar code to characterize the impact of AIRS fast model errors on AIRS retrieval accuracy. *EUMETSAT NWP SAF Associate Scientist, Report available at:* *http://www.eumetsat.int/idcplg?IdcService=SS_GET_PAGE&nodeId=484&l=en*

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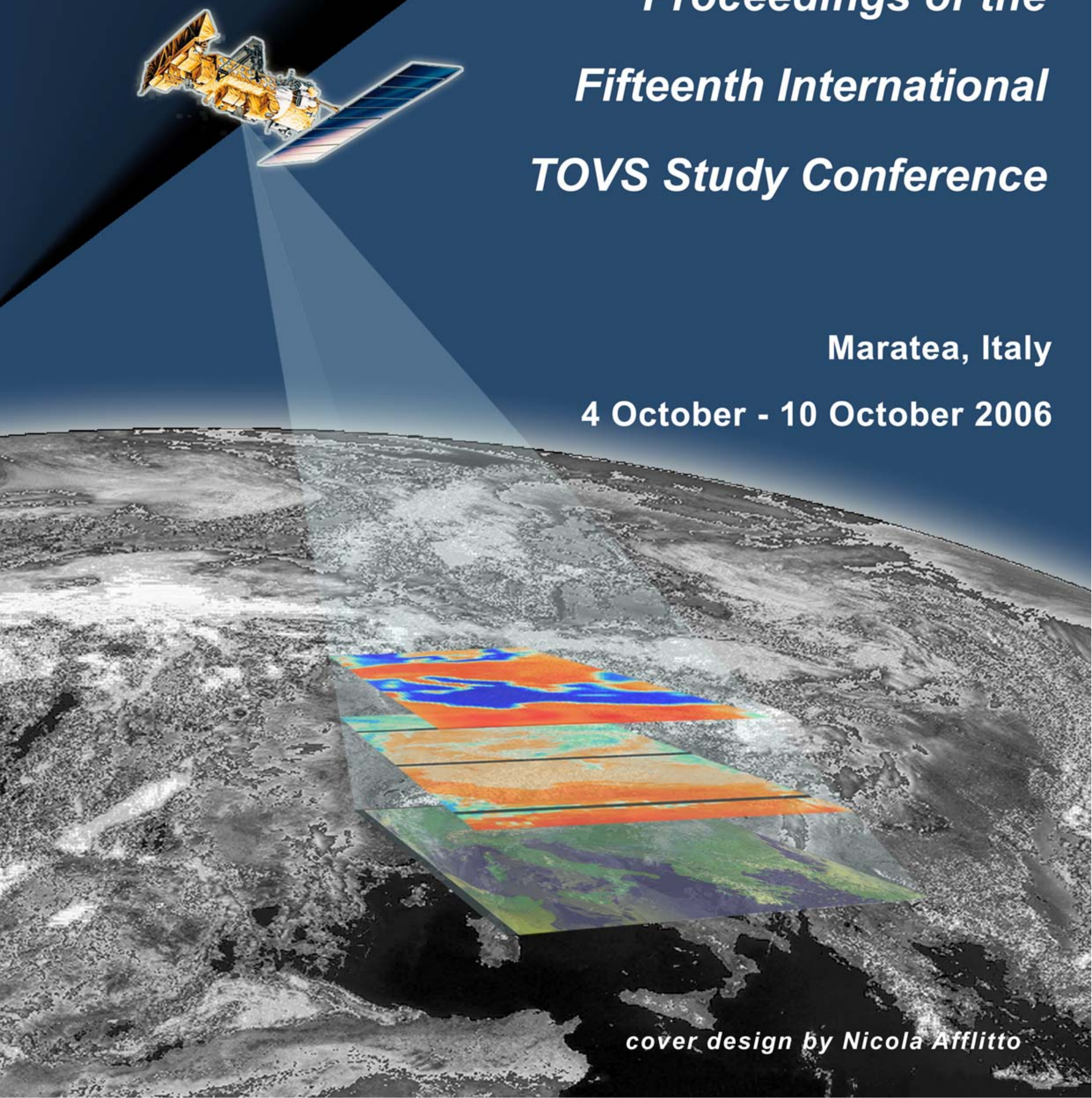

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