**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "An assessment of the accuracy of the RTTOV fast radiative transfer model using IASI data" *by* M. Matricardi

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Comments on "An assessment of the accuracy of the RTTOV fast radiative transfer model using IASI data" by M. Matricardi:

General comments

This paper presents comparisons between IASI measurements and simulated radiances generated using the RTTOV fast radiative transfer model using ECMWF model forecast fields as input. Regression coefficients for the RTTOV fast model may be generated using different line-by-line algorithms. There are two main issues inherent to the discussion of the residuals in this paper: (1) Differences between different line-by-line models that may be used to generate regression coefficients for RTTOV and (2)

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How well the ECMWF model fields represent the true atmospheric state as observed by IASI. (A third issue, namely the differences between the fast RTTOV and the more accurate line-by-line models, has been discussed in a previous publication.) Within issue (1), there are a number of points to consider: (a) Differences in spectroscopic line parameter databases used as input to the line-by-line models (b) Differences in the continuum models used (c) Differences in the formulation of the line shape and the formulation of the line coupling for CO_2.

The use of the NWP system provides the opportunity to obtain a large number of clear-sky coincidences over a wide range of atmospheric and surface conditions. Both comparisons between the ECMWF and true atmospheric states and between the different line-by-line model set-ups should be of wide interest to the community and so the work in this paper is valuable, especially in the context of a NWP system. However, the nature of the performing such a large number of comparisons with its merits is limited in the amount of detailed information it can provide in terms of evaluating the sources of systematic errors (e.g. atmospheric state, spectroscopy, instrument). Several examples of this are pointed out in the comments below.

In general, the paper would benefit from making greater distinction between the issues listed above in the discussion of the IASI/RTTOV residuals. The author does state in the conclusions and to some extent throughout the paper that he is aware that both systematic profile errors and spectroscopic errors can affect the residuals. However, the distinction between the issues (1) and (2) is often somewhat blurred in the discussion. The paper could also benefit from some more specific attribution of differences in IASI/RTTOV residuals directly to specific aspects of the different line-by-line model set-ups used (for example the attribution of continuum differences between LBLRTM and kCARTA in Figure 7 and accompanying discussion.)

Specific comments: 1) Pg 9504, section "Results in the temperature sounding band". There is no mention of the slope of the residuals in the troposphere. Looking at the spectral envelope kCARTA and LBLRTM residuals in Fig 4,5, and 6 in the spectral

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region between ∼700-750 cm-1 indicates that the lapse rate of the input temperature profile in the troposphere is not correct. It is a little hard to determine exactly without a reference brightness temperature spectrum plot (not just residuals). For example, in Fig 4 the residuals are near zero around 700 cm-1, but with increasing wavenumbers (going down the temperature profile) the residuals increase with maximum differences of ∼0.5K near the surface. This general lapse issue can also be seen in the tropospheric sounding region of the NO2/CO2 v3 (∼2180-2250 cm-1). This is a very important point because any errors in the temperature field with propagate into residuals errors in other spectral regions (e.g. ozone, h2o, etc.). This should be noted in the paper.

2) Pg 9505 line 14: "However, the kCARTA spectrum is more irregular than the LBLRTM spectrum. This behaviour can be affected by factors that include the line mixing model, uncertainties in the temperature profile and errors in the strengths and widths of the weak water vapour lines originating from the edge of the water vapour pure rotational band. The errors in the line strengths and widths can either be due to uncertainties in the water vapour profile or due to spectroscopic errors (in addition to this kCARTA and LBLRTM use different water vapour molecular databases)."

There a few comments in regards to these lines:

(i) "...uncertainties in the temperature profile..." Uncertainties in the temperature profile will produce larger residuals between the observations and calculations, however, I believe the author is listing possible differences between kCARTA and LBLRTM. I am assuming the same ECMWF temperature profiles are being used in both models so this should not cause a difference between the two models (unless the temperature profile is being input differently in the two models for some reason). Please explain.

(ii) . There are some isolated residuals from water vapour lines in this region, but the general spectral signature of the residuals in this region follow the more dominant CO2 lines. Therefore, most of the residual differences are due to CO2 and not water vapor spectroscopy.

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(iii) What about just differences in the CO2 line shape between the two models, other that the effects due to line mixing (e.g. chi-factors)?

3) Pg 9505-9506 line 28: " A feature in common to the LBLRTM and GENLN2 spectra is the large bias (between 1.8K and 2 K) seen in correspondence to the CO 2 Q-branch at 667 cm -1 . Since GENLN2 and LBLRTM use line mixing coefficients based on a 1st order perturbation theory, it would appear that this is not adequate for the 667cm -1 Q-branch. " The residual in this region is an active area of research, and the exact cause for the 667 cm-1 residual is still under investigation. However, the statement by the author that it is due to 1st order perturbation approximation has recently been shown not to be the cause of 667 cm-1 residuals in LBLRTM (This will be included in the updates to Shephard et al., 2009, this issue - see attached plot). This does not rule out the fact that the differences to in the 667 cm-1 could be due to line coupling as kCARTA uses a formulation derived by L. Strow and LBLRTM uses a formulation derived by Niro et al. 4) Pg 9506 line 4: "Spectra in the ozone band are remarkably close. Biases observed in the ozone band are probably dominated by spectroscopic errors although the larger values (up to -1.6 K) observed in the Northern Hemisphere might reflect a poor performance of the ozone assimilation system." There is no evidence shown or referenced by the author to state that the ozone residuals are dominated by spectroscopy rather and the input profile. For example, the Shephard et al. 2009 paper (this issue) shows ozone brightness temperature residuals on the order of a few tenths of a degree, indicating that the spectroscopy is unlikely tobe the dominant source of the residuals. Without any additional evidence, the author cannot state that the residuals are probably dominated by spectroscopic errors.

5) Pg 9506 section "Results in the window regions". It is difficult to say much about the residuals in the window regions as most of the larger residuals are spectral signatures due to the apparent incorrect atmospheric amounts of minor species (e.g. HNO3).

6) Pg 9507 line 6: "However, since the SST is used as the skin temperature in the RT computations, the larger biases in the Northern Hemisphere cannot be explained in

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terms of SST alone since this feature should also be present in the high-wavenumber boundary of the window region." It should be pointed out that there is a ~0.2K residual difference in the window regions that is consistent across the baseline of the residuls. For example, if one picks out two regions that are not affect significantly by the water vapor continuum (e.g. 930 cm-1 and 2475 cm-1) they both have residuals of ~-0.2K. This would indicate that the input SST values are off by 0.2 on average, or the instrument calibration in the two bands is off by -0.2K.

7) Pg 9510 line 26: "Among the factors that can contribute to this result we can include the accuracy of the spectroscopic parameters and biases in the ECMWF stratospheric and mesospheric temperature profiles." What about the potential biases in the troposphere (see comment 1 above)?

8) Pg 9511 line 8: Author should point out the spectral region that is dominated by N2O absorption rather than CO2 v3. Even though the author does not explicitly mention any molecules, based on the previous first sentence in this section the reader may think that this region is all CO2 v3.

9) Pg 9511 line 27: This bandhead region is an area of active research. The Masiello et al., 2009 comment and reference likely does not apply due to recent updates in their revised their manuscript (see ACPD author comments for the Masiello et al. article).

10) Pg 9512, lines 20- 24: The author states that the Kcarta results suggest that the "modifications made to the continuum model have improved the accuracy of RT computations". While these UMBC H2O continuum modifications may reduce the magnitude of IASI/ECMWF residuals in the 2440-2624 cm-1 spectral region, the continuum plots in Figures 1 and 2 show that the UMBC modifications impose a shape to the water vapor continuum that is clearly unphysical. This would seem to suggest that the H2O continuum was being used to correct for an effect that is not, in fact, due to the water vapor absorption. Note that CO2 continuum absorption and nitrogen continuum absorption are also important in this spectral region. Both CO2 and N2 absorption are

correlated with temperature. Of course water vapor amounts are also correlated with temperature, which would help to account to the "success" of the UMBC modification if the model issues were actually due to CO2 or N2. These points should be addressed.
11) Pg 9513 line 25: Remove first order perturbation sentence (see comment 3 above).

Minor edits and comments:

1) Pg 9493, line 20: "Errors associated of" should be "Errors associated with"

2) Pg. 9496 line 18: Might want also reference work relating to new water vapor line strengths and positions from Coudert et al. (2008) with example in the IASI special issue (Shephard et al., 2009). Here it is shown that the new Coudert water vapor line strengths and positions change the residuals by ~0.5K.

Shephard M.W., S.A. Clough, V.H. Payne, W. L. Smith, S. Kireev, and K. E. Cady-Pereira, Performance of the line-by-line radiative transfer model (LBLRTM) for temperature and species retrievals: IASI case studies from JAIVEx, Atmos. Chem. Phys. Discuss., 9, 9313-9366, 2009.

2) Pg. 9497 line 22; Pg 9499 lines 21 and 26; The recommended MT_CKD and LBLRTM reference is Clough et al., 2005. For example, MT_CKD was developed after the Tobin et al., 1999. Also, the statements that "water vapour continuum is usually parameterized using. . . CKD" and that "This model has recently been revised. . ." are a little misleading. We might argue (1) that the MT_CKD continuum is in broad use and that (2) the MT_CKD continuum has been available to the community for a number of years now. These sentences should perhaps be rephrased.

Clough S.A, Shephard M.W, Mlawer E.J, Delamere J.S, Iacono M.J, Cady-Pereira K.E, Boukabara S, Brown P.D. Atmospheric Radiative Transfer Modeling: a Summary of the AER Codes. J Quant Spectrosc Radiat Transfer, 91, 233-244, 2005.

3) Pg 9498: Section 3.1: We suggest that references to "line mixing data" for GENLN2 be replaced with "line mixing coefficients"

4) Pg 9499, line 1: Strictly speaking, kCARTA is not a line-by-line algorithm. It used look-up tables from computations by a true line-by-line algorithm. Perhaps it would be more appropriate to refer to kCARTA as a pseudo LBL algorithm.

5) Pg 9499, lines 7 and 8; Pg 9501, lines 12-16; Pg 9501, Figures 1 and 2: There is an extra "K" in the continuum name: "MTK_CKD" should be "MT_CKD" is several places.

6) Pg 9499, lines 8 to 10. While the modifications made by the UMBC team to the MT_CKD_UMBC continuum are (sort of) shown in Figures 1 and 2, it would be helpful here to state the wavenumber regions in which the UMBC modifications (between MT_CKD_1.0 and MT_CKD_UMBC) were applied. Modifications were made only between around 2150 to 2650 cm-1, in the region surrounding the CO2 v3 region.

7) Page 9500, line 3; pg 9510, lines 25-26; pg 9511, lines 7 and 24: The "nu" symbols used here are not consistent with those used in other parts of the manuscript. 8) Page 9500, line 12: Shouldn't this be the start of a new section? The discussion before is specific to the LBLRTM, but the discussion after this point applies to all three LBL models.

9) Page 9500, lines 18-30: The spectral database used with LBLRTM v11.1 for these comparisons is described in some detail, which is helpful. However, note that when LBLRTM is downloaded from the AER website (rtweb.aer.com), it comes as a package with an "AER line file". In order to avoid any confusion of LBLRTM users, it would be helpful to state explicitly that the spectroscopic line file used for these comparisons is NOT the one supplied with the LBLRTM download package.

10) Pg. 9500 line 6: It would be helpful to reference Shephard et al., 2009 as it contains a description and figure of the CO2 continuum used in LBLRTM.

11) Pg 9502, lines 23-34: "The SST rms error relative to buoy observations is 0.36 K." Can something be said about a bias as opposed to an rms? Could such a bias help to explain the 0.2 K offset observed in the residuals for surface regions? (see general

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comments above, point (6).)

12) Pg 9503, lines 18-20: "several thousands spectra" should be "several thousands of spectra", "a few thousands" should be "a few thousand" and "at surface" should be "at the surface".

13) Pg 9504, line 18: Might want to more clear in that it is the "spectral residuals" and not the "spectrum" being plotted in Figures 4, 5, and 6. It would help identify the spectral regions of interest if one "representative" spectrum was plotted in an additional panel on top of the residual panels.

14) Pg 9504, line 24: "result" should be "results", "microns" should be "micron"

15) Pg 9505, line 4: "microns bands" should be "micron band"

16) Pg 9508, line 15: "wave numbers" should be "wavenumbers"

17) Pg 9508, lines 20-21: "Spectra obtained in the tropics are more articulate. . ." What does this statement mean?

18) Pg 9508, line 21: "larger then" should be "larger than"

19) Pg 9508, lines 24-25: " larger biases are seen in correspondence of" should be "larger biases correspond to"

20) Pg 9531, Fig, 11: The label in the top panel (a) should be kCARTA and kCARTA_LBL and not kCARTA and LBLRTM.

21) Table 1: "MTK_CKD_v1.1_UMBC": Shouldn't this be "MT_CKD_v1.0_UMBC", since the modifications made by UMBC were based around MT_CKD_v1.0? Also, "MTK_CKD_v2.2" should be "MT_CKD_v2.0" (v2.0 is stated in the text).

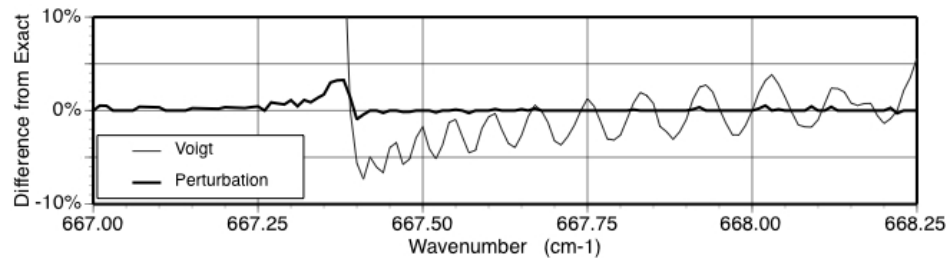Interactive comment on Atmos. Chem. Phys. Discuss., 9, 9491, 2009.

Fig. 1.

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