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AMTD

5, C2667–C2674, 2012

Interactive Comment

Interactive comment on "Validation of IASI FORLI carbon monoxide retrievals using FTIR data from NDACC" *by* T. Kerzenmacher et al.

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We thank the referee for his positive and constructive comments. The main issues that he raises concern the IASI CO retrieval methodology, in particular with regard to the input parameters used for FORLI (the fast radiative transfer model used for near-real-time retrievals of the CO profiles), such as temperature profiles or emissivity, and to the quality of the spectral fitting as a function of these. These are indeed relevant comments. We agree that maybe part of the variability observed in the IASI CO data could be related to these but, as explained below, the current diagnostics do not really suggest a strong impact. Furthermore, the purpose of the present validation paper is more on the statistical analysis of the IASI data (this is required for estimating biases etc.), rather than on a close examination of the IASI retrievals on a pixel basis.

Most of the questions in relation to FORLI find answers in the recent paper by Hurtmans et al. "FORLI radiative transfer and retrieval code for IASI, Journal of Quantitative Spectroscopy and Radiative Transfer, Volume 113, Issue 11, July 2012, Pages 1391-1408", as further discussed below. The details provided in that paper is the reason why we felt unnecessary to repeat all the technical aspects of the IASI processing here. However, especially in section 2, we gave some more details refering to the paper by Hurtmans for more details.

The comments have been addressed point by point first repeating the comment of the reviewer followed by our answer:

1. The authors say that the comparison of IASI CO to that provided by ground based FTIR is not biased, although the variability of the IASI estimation is larger than expected. The present study does not hint to possible sources of this high variability, which is a weak point for the paper itself. It is not clear what the authors did to prepare the atmospheric state (of which mostly important is the temperature profile) needed for the final retrieval of IASI CO. This is only briefly summarized for ground based instrumentation, page 3979, after line 20), but no information is given for IASI. Well, they have to check that the atmospheric state is not adding spurious variability.

As said above, the present study aims at performing a statistical analysis of the IASI CO columns in comparison with the ground-based FTIR measurements. Although definitively of interest, we feel that it is outside the scope of the present paper to analyze in details the variability in the retrieved IASI CO profiles.

Regarding the specific comments: In FORLI, the temperature and humidity profiles are those from the the Eumetsat Level2 processor (see also the response to minor comment 1 below). Also the cloud fraction disseminated by EUMETSAT is used, and only those pixels in which the cloud fraction is below 25% are processed. Hence,

AMTD

5, C2667–C2674, 2012

each observation has a different and already optimized set of meteorological profiles associated. One should further note that the water amount is systematically adjusted (as a total column), strongly minimizing the impact of the latter on the total retrieval error. (Parts of these sentences have also been added to section 2).

Finally it is worth noticing here that for a long period, FORLI processing was achieved at LATMOS using in parallel the EUMETSAT Level2 in one processing chain and the ECMWF temperatures in another. The differences were shown to be small (smaller than the retrieval errors), suggesting a weak impact of the temperature profiles on the CO variability observed.

2. To this end, as suggested by Antonelli et al, DOI:10.1002/qj.909 a good test is to compute the standard deviation of the IASI spectral residual for the spectral region used for the retrieval analysis. In case all the important variability has been extracted from radiances, the spectral residual has to closely follow the IASI radiometric noise. 3. In this respect I think that its mandatory that authors show examples of IASI spectral residuals, in order to understand whether or not the method is at least internally consistent.In addition, the analysis of spectral residuals can give insight into understanding additional sources of their unexpected variability. Is it atmosphere? Or not.

Spectral residuals and biases are important indicators of the quality of the spectral fits. They are of course checked and a posterior quality filtering is achieved to remove the poorer fits. More explicitly all spectral fits with spectral biases lower/higher than -0.15/0.25 $10^{-9} \mathrm{W/cm^2 srcm^{-1}}$ and RMS larger than 2.7 $10^{-9} \mathrm{W/cm^2 srcm{-}1}$ have been removed from the dataset compared to the FTIR data.

For information, the two Figures below are extracted from Hurtmans 2012; they show respectively (right plot on the first Figure) an example of spectral fit in the region used for the CO retrievals, and diagnostics for a full day of CO processing. It is clear from there that on one hand the spectral fits are good, with values closely matching the

IASI spectral noise in the region of the CO 1-0 band (estimated at between 1 and 2 $10^{-9}\mathrm{W/cm^2 srcm^{-1}}$), and on the other hand that the variability in the RMS and biases are small within a narrow geographical region (they can be substantial when looked at over the globe).

The answer to the comment number 3 is also partly addressed with these Figures. Indeed, the variability observed in the CO columns is larger than the total retrieval error, which following the optimal estimation includes the quality of the spectral fits and the error on the water profile (the error on the temperature profile is not included in the budget but the latter is usually considered to be minimal as long as the atmospheric state is sufficient close to reality). The total error is also pretty uniform at a given location, which does not suggest that the variability in the atmospheric state impacts on the retrieval. We are confident, therefore, that the variability in the retrieved CO column above the different sites is for a large part the true spatial variability of CO around the NDACC stations.

Minor points. 1. On page 3976 line 10, I think that here a proper reference to Hilton et al, 2009 (doi:10.1175/BAMS-D-11-00027.1) should be much more appropriate, the same on page 3977, line 25.

Thanks, we added the Hilton reference.

2. On page 3977 section 2. Please in this section add information about the atmospheric state used for IASI, has surface emissivity been taken in any account? In this section, please also exactly show the IASI spectral range used for the retrieval.

See above for temperature and humidity. More specifically, in Hurtmans et al., the following is described:

“For the atmospheric state parameters FORLI uses level 2 temperature and pressure

AMTD

5, C2667–C2674, 2012

profiles retrieved fromIASI by the operational processor [15], and disseminated in near-real-time through the EUMETCast system. Also ground temperature and relative humidity profiles from the operational processor are included but, contrary to the former parameters, they are adjusted (for RH either as a profile or a total column),for each IAS IFOV"

For the emissivity, FORLI uses above continental surfaces the Zhou et al., climatology whenever possible (large majority of cases). More details are given in Hurtmans et al., page 1395:

"An additional critical input parameter to describe the surface is the wavenumber-dependent surface emissivity ϕ above continental surfaces(for ocean a single standard emissivity is considered). FORLI relies for these on the climatology built by Zhou using several years of IASI data (June2007 – May2010), and which was initially provided to us as monthly emissivity values on a 0.5×0.5 latitude/Longitude grid, for every 8461 IASI spectral channels. [...] In the few cases there are missing values in Zhou et al. climatology, [...]".

The spectral range for the retrievals is 2143-2181.25 cm^{-1}.

(These details also been added to section 2).

3. On page 3978, line 20, "cloud cover less than 12%". In which way cloud cover has been determined within each IASI field of view. AVHRR? Please, expand a bit. Clouds could also be another source of unknown variability.

The cloud fraction from the EUMETSAT level2 processor is used here. It is extracted from a combination of instruments onboard MetOp, following specific methods, detailed in "August et al., IASI on Metop-A: Operational Level 2 retrievals after five years in orbit, Journal of Quantitative Spectroscopy and Radiative Transfer, Volume 113, Issue 11,

AMTD
5, C2667–C2674, 2012

Interactive Comment

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Interactive Discussion
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July 2012, Pages 1340-1371" (This has also been added to section 2 of the paper).

Regarding variability: FORLI retrieves CO profiles only when the cloud fraction in the FOV is below 25%. In addition, for the present analyses only those retrievals for which the cloud fraction is below 12% have been kept. This threshold was chosen after careful tests, precisely to avoid spurious variability in the CO retrievals. It is therefore very unlikely that the impact of clouds in the range 0-12% of cloud fraction is significant.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 3973, 2012.

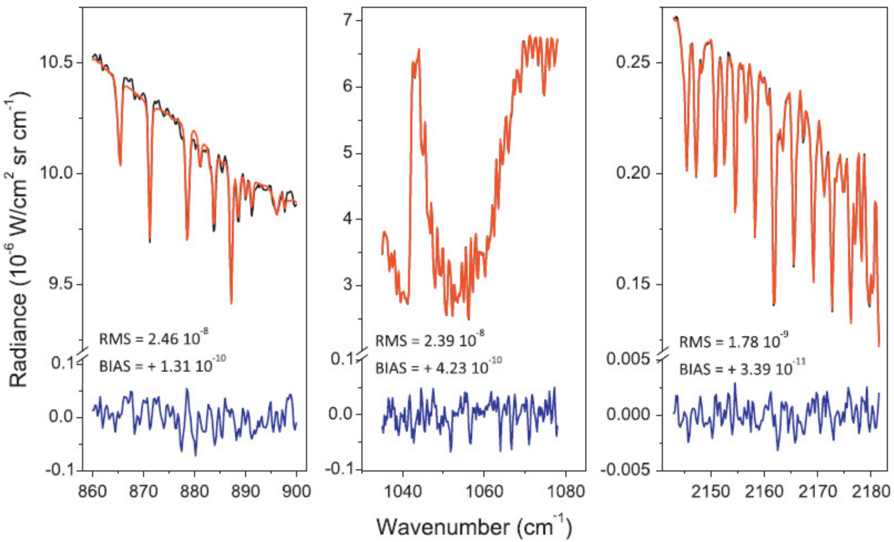

Fig. 5. Example FORLI spectral fits for, from left to right, HNO_3, O_3 and CO. The black and red curves are respectively the observed and fitted spectra; the blue curve is the spectral residual. The example is for a tropical scene, with strong water vapor interferences. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fig. 1.

AMTD
5, C2667–C2674, 2012

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Interactive Discussion
Discussion Paper

AMTD

5, C2667–C2674, 2012

Interactive Comment

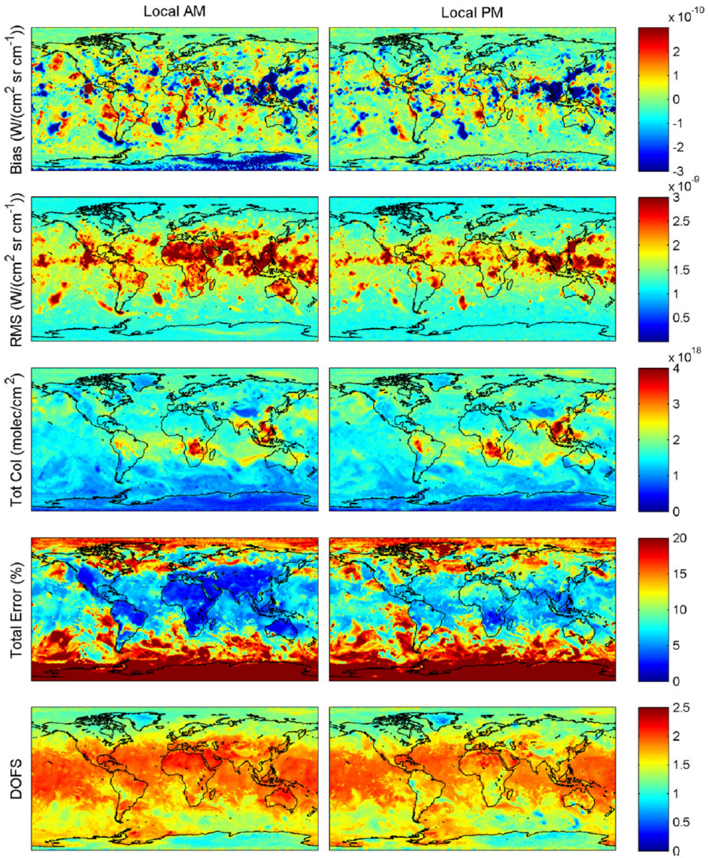

Fig. 9. Same as Fig. 6 for FORLI-CO. For the total column, error and DOFS, data for which bias values lower/higher than $-0.15/0.25 \times 10^{-9}$ W/(cm^2 cm^{-1} sr) and RMS larger than 2.7×10^{-9} W/(cm^2 cm^{-1} sr) were removed.

Fig. 2.

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Interactive Discussion

Discussion Paper