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Atmospheric Measurement Techniques Discussions

Interactive comment on "Validation of three different scientific ozone products retrieved from IASI spectra using ozonesondes" *by* G. Dufour et al.

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The authors thank the referees for their interest in the article and their suggestions for improvements. The comments made are addressed below.

Reply to Referee #1:

General Comments "The paper is a description of the error characteristics and vertical resolution of three different ozone retrieval approaches that use IASI radiances to estimate ozone profiles. The paper is appropriate for AMT but needs some revisions to the language as well as a better description of the error sources, mainly that the

geophysical parameters that also affect the measured radiance such as temperature, water, and surface properties."

Reply to the general comment We explicitly wrote in the paper which error sources were considered in the study (see page 5431 – equations 5 and 6 and the discussion page 5438 lines 23-27). Only the measurement noise error and the smoothing error are considered. We mentioned previous studies that show the contribution of other sources is smaller (Coheur et al., 2005; Boynard et al., 2009). However, we did some error calculations including different error sources like temperature uncertainties or interference with water vapor (error sources included in Boxe et al., 2010 for instance). The calculations show that these error sources contribute for less than 0.1 DU ($\sim \leq$ 2%) to the total error for each partial column considered in the study. We then decided not to include them – it would not change significantly the error values reported in the tables. We have added the following sentence p5438 line 27: "We checked that the contribution of other sources of error (temperature, interference with water vapor) contributed for less than 0.1 DU ($\leq$ 2%) for each partial column considered in this study and can then be neglected." , and this other sentence before equations 5 and 6 "Several studies show that the smoothing error largely dominates the error, followed by the measurement noise errors (Coheur et al., 2005, Boynard et al., 2009)."

Comment #1 "Page 5428 – line1: This sentence is vague, what does sophisticated mathematical and numerical methods mean?"

Reply #1 We have followed the reviewer's suggestion and the sentence has been changed to "Ozone concentrations from satellite measurements are typically inferred from measured radiances using a non-linear least squares approach that involves minimizing a cost function depending on the radiance and a forward model of the geophysical parameters (including ozone concentrations) that affect the radiance. If a profile of ozone is estimated from the radiance then the problem is ill-posed and the cost function needs to be augmented by an additional term that, either describes the a priori statistics of the atmosphere or corresponds to a mathematical constraint."

Comment #2 “Page 5428 – line 8: Reference Boxe et al., 2010 ACP “Validation of TES...””

Reply #2 The reference has been added.

Comment #3 “Page 5428 – line 9: you say variations AND variability.. only need to say this once”

Reply #3 This has been corrected.

Comment #4 “Page 5428 – line 12: remove (temporal and spatial variations)... or alternatively explain what you mean.”

Reply #4 “(temporal and spatial variations)” has been removed

Comment #5 “Page 5428 – line 26: What does mature mean? I think you mean well characterized, that is, the expected and actual errors agree and the biases are quantified using validation measurements. Please explain or remove this sentence”

Reply #5 The sentence has been modified as follow “These three products are based on radiative transfer models and retrieval strategies that were already validated (Keim et al., 2009; Barret et al., 2011; Boynard et al., 2009) and used to conduct analyses on the atmospheric composition and the transport (e.g. troposphere/stratosphere exchanges, air quality monitoring, etc).” A similar sentence was written in the abstract “The three products are mature enough to be used for detailed analyses of atmospheric chemistry and transport in the troposphere.”. The sentence has been removed from the abstract.

Comment #6 “Page 5432: Line 25 The discussion on even and odd pixels is highly confusing to someone not familiar with the IASI instrument”

Reply #6 We have clarified the description of the L2 temperature and water vapour profiles used for the RT calculations : “The temperature and water vapour atmospheric profiles required for the radiative transfer computations are EUMETSAT operational

IASI level 2 products. IASI Elementary Field Of View (EFOV) corresponds to 4 pixels for which the measurements are acquired simultaneously. Until March 2010, IASI L2 products from EUMETSAT are only provided for pixels 1 and 3 of the EFOV. Therefore we have used the same temperature and water vapour profiles for pixel 2 (resp. 4) than for pixel 1 (resp. 3).”

Comment #7 “Page 5433:How are the cloud properties retrieved if the cloud fraction is 25%? Also, remove the sentence about Nehalem quad-core cpu. . . It is not informative”

Reply#7 The retrievals are “clear sky” retrievals and we do not introduce or retrieve any cloud properties. The threshold of 25% has been chosen based on sensitivity tests. We have complemented the sentence about the 25% threshold with “are treated as cloud free pixels” to makes thing clear. The sentence about “Nehalem quad-core cpu” has been removed.

Comment #8 “Page 5435: Line 40 Add Reference: Kulawik, S.S; OSterman, G.; Jones, D.B.A; Bowman, K.W.; Calculation of Altitude-Dependent Tikhonov Constraints for TES Nadir Retrievals, IEEE Trans. Geosci. Remote Sensing, 44, 1334- 1342, May 2006”

Reply #8 The reference has been added.

Comment #9 “Page 5444. Note that TES ozone retrievals are also biased in the UTLS region (H. Worden et al., 2007; Nassar et al., and Boxe et al., 2010). While we thought that the cold-space calibration could be the reason, we found that the TES calibration error could not explain the ozone bias. Our current explanation is that the upper tropospheric bias is also due to spectroscopy.”

Reply #9 We have added the following sentence at the end of the discussion about the possible explanation of the UTLS bias: “Note that ozone retrievals from other infrared nadir sounders like TES are also biased high in the UTLS region (Worden et al., 2007; Nassar et al., 2008; Boxe et al., 2010).”

Comment #10 Page 5445-5446 Table 6:8 These tables are rather confusing. The error

profiles shown in Figure 3 pretty much show the same content. What I would like to see is a comparison of the actual random error (RMS of IASI-Smoothed Sonde) versus the calculated random error (measurement plus interfering species, temperature emissivity, clouds etc). This information is all in the various tables bu is spread out in a manner that is inconvenient to the reader. Can you put on the top row the different products and in the left column the different partial columns and then put actual and calculated errors in each entry of the table? Alternatively, just show the errors as a function of altitude as in Figure 3 and the correlations in a table. Finally, as noted in general comments, are the interference errors included in the random error?"

Reply #10 In the corrected version of the manuscript, we have merged Table 6 and Table 7 in one table, and Table 6 and Table 8 in one other table in order to facilitate the comparison of the actual and theoretical errors to the reader.

Comment #11 "Page 5450: The discussion of the "S-shape" is highly confusing. For one, is figure 13 just the retrieval itself or a comparison of the retrieval to a sonde? It is not clear from either the discussion of the Figure caption. Is the claim that the "S-shape" is a retrieval artifact of some kind? This would be confusing because one might expect a "natural" S-Shape in the true tropical ozone distribution due to convective lofting of ozone poor air into the UTLS region and due to lightning in the middle troposphere (Jourdain et al., Worden et al., Liu et al., Li et al. papers on TES website). Please clarify in both the discussion and in the figure caption.

Reply #11 The discussion paragraph now reads as: "The second reason rises in the particular shape of the ozone profile in the tropics, an "s-shape" profile that can lead to misbehavior during the retrieval or the smoothing processes. Indeed, the "s-shape" of the profile can be artificially accentuated either in the retrieved ozone profile or in the sonde profile smoothed with the averaging kernels. Figure 13 illustrates this effect in the two cases. The 1σ standard deviation of the mean profiles is significantly larger towards the low values in the upper troposphere when the standard deviation of the mean retrieved profile for one ozonesonde station is compared to those of the

corresponding raw sonde profile (right in Fig. 13) or when the standard deviation of the mean smoothed profile is compared to those of the corresponding raw sonde profile (left in Fig. 13). The most affected part of the profile is the upper troposphere, where the values of ozone, either retrieved or smoothed, are systematically underestimated and can become unrealistically low for some individual pixels. However, the resulting profiles remain reasonable when we consider the average over all the pixels from the current validation exercise." The figure caption has been changed to: "Effect of the unrealistic accentuation of the "s-shape" of the tropical ozone profile during the smoothing (left) and the retrieval (right) processes. This effect is visible when comparing the 1ïAş error bars."

Reply to Referee #2:

Specific Comment "Page 5441 – the authors have selected 7 hours as a coincidence criteria. This is a rather long time, given the variability of ozone. It would be beneficial to see a histrogram of the times difference between the IASI and the ozonesondes, so we know how the time difference might influence the results."

Reply to the specific comment The coincidence criteria used for this study are in agreement with the range of coincidence criteria found in the literature: Worden et al., 2007 used a +/- 48H criterion for TES validation, Nassar et al., 2008 a +/-9H criterion still for TES validation, Boxe et al., 2010 +/- 3H criterion still for TES validation, Keim et al. 2009 and Boynard et al., 2009 same day of observations for IASI validation. Plotting the histogram asked by the referee shows the time difference is rather well distributed between 0 and 7 hours. Note that the time difference for one station does not vary a lot from one measurement to another (within one or two hours). For example the mean time difference is about 4H30 for the Hohenpeissenberg station, about 6H for the Edmonton station and less than 1H for the Madrid station. We checked that the bias observed for each station was not correlated to the time difference. In consequence, we have added one sentence in section 4.2 to mention it "We checked a posteriori that the biases between the ozonesonde measurements and the IASI observations are not

correlated with the time difference between the sonde and IASI measurements." We do not add any figure because we think it is not very informative for the reader as no correlation was revealed.

Technical comments The authors thank the referee for all the improvements that he/she proposed. All of them have been included in the revised version of the manuscript.

Reply to T. August Comment:

We thank T. august for his precisions about the L2 products from EUMETSAT. We have addressed his comment in the reply to comment #6 concerning the same subject.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 5425, 2011.