Reply to Referee 1 (in blue)

This is the review of the paper by C. Scannell et al. titled "A review of the ozone hole from 2008 to 2010 as observed by IASI". The paper addresses relevant scientific questions about relevancy of the satellite ozone observations for the detection of ozone recovery. Authors compare the ability of measurements taken in the Infra-Red or UV-Vis part of the Solar spectrum to capture the spatial and seasonal development of the Polar ozone hole. The IR measurements have the advantage of taking observations during the Polar night conditions, which are unattainable for the UB-Vis instrumentation, and during both sunlight and night time during ozone hole development. While the sounding provides the most accurate and vertically resolved sensing of ozone vertical distribution, they are launched only once a week, while satellites take daily scans of the spatial and vertical ozone distributions. The agreement with the GOME and ozonesonds is found to be within 30 %. The Antarctic ozone is exhibiting signs of the recovery and it is of great importance to monitor these changes. The Antarctic ozone hole is meticulously observed by ground-based, the in-situ , and satellite remote sensing systems. All instruments are frequently compared to assure the long term changes are not affected by instrumental changes, calibration artifacts, and the differences are well understood. Therefore, this paper is very important as it described validation of IASI ozone column and profile data. It is aimed to answer the questions of the IASI ozone measurement limitations and retrieval uncertainties. This paper is recommended for publication after minor revisions.

We are very grateful to Referee 1 for the constructive comments. We took all the recommendations into account, thank you for helping us to improve our manuscript.

General comments:

This paper presents the new FORLI-O3 retrieval, and discusses it's accuracy relative to other correlative measurements. It would be good to know the range of the measurement and smoothing errors of the retrieval. These can be estimated using Rodgers (2000) equations (2.19 and 2.17 respectively). It would be also good to know the changes in the vertical resolution of the retrieved ozone profile (possibly looking for the shift in the maximum sensitivity of the retrieved layers) as function of surface brightness (Figure 4).

Since our publication was accepted in AMTD, a detailed paper (Hurtmans et al., 2011) that provides more information on the FORLI-O3 code, including on errors, biais, etc., has been submitted to JQSRT. A reference to that paper is now added.

The fact that IASI could not capture the reduction of ozone over the land at the altitudes between ~20 and 25 km is clear from the AK plots shown in Figure 4 (b), where the AK plotted at 25 km does not exhibit sensitivity to ozone variability in that altitude range.

The information content at 20- 25 km should be good as it is where IASI has most of its sensitivity. The averaging kernel at ~25 km does not show a lot of information (over the land) probably mostly because the O3 levels are too low at this period of the year are it corresponds to a sounding inside the ozone hole.

And from the sounding flown at the South Pole (http://www.esrl.noaa.gov/gmd/ozwv/ozsondes/spo.html) it is clear that the main depletion occurs between 14 and 24 km altitude. Therefore, the IASI retrieval would rely on the a priori information to feel in the gaps…

True.

It would be useful to include the plot showing the AK over the snow, which is more appropriate for the discussion.

The avgk of Fig4 land is over the snow.

IT is also of interest to plot the contribution function Dy (Rodgers, 2000), which clarifies how the difference between measured radiance (brightness) and the calculated from the a priori ozone profile converts to the difference between measured and a priori ozone profile.

This was not done as we were not sure how to answer this request.

Since the IASI total ozone column is compared to the GOME, it would be most useful to present the AK for the TO rather than ozone profile. It would clarify how vertical profile contributes to the total ozone column (plotting Jacobian for change in the total column due to change in layer ozone).

TO avgk were plotted in a first version of the paper but we felt that the discussion was easier on the avgk profiles, that better show the limits of the sensitivity of IASI in terms of vertical sounding, in particular at the altitudes where the ozone concentrations are low.

One concern is about the trend ability of the data set: would the change of the surface brightness (climate related changes in the snow coverage) create any artificial trend in the retrieved ozone column or profile record?

The IASI radiances measured above cold surfaces are such that the signal-to-noise is lessened, and consequently also the amount of information on the vertical ozone profile. However, this decrease is essentially in the troposphere. As the DOFS remains larger than 2, with sensitivity mainly in the UTLS, we are don't think that the long-term IASI record of ozone over the Antarctic would be affected by variations in the surface brightness.

Here are detailed comments:

1) P.4721, line 18 – there seems to be missing part of the sentence: "pla x 2 pixels" probably means "platform that records the surface image as the set of 2x2 circular pixels". I would change the "on board" to "onboard". Also should mention that the nadir measurements are taken every 50 km (before the swath width information).
Part of the sentence was indeed missing (was lost in the ACPD editing step…). It is now corrected to "orbiting MetOp-A satellite platform on the 19th October 2006. The IASI field of view is composed of 2x2 circular pixels »
"Onboard" is corrected and information on horizontal resolution added as recommended
2) P. 4722, line19: could be changed to "in the 960–1075 cm−1 spectral window"
Text rephrased
3) P. 4722, line 20: replace to "between observed and fitted spectrum. The level of the IASI instrumental noise (dashed line) is also provided for comparisons".
Done
4) P, 4722, line28 "global, near real time"
Comma inserted
5) P. 4723, line 1: "per day, which are"
Comma inserted
6) P. 4723, line1 : please provide a reference for the Eumetcast antenna system.
A reference to an Eumetsat technical document was added as suggested
7) P. 4723, line 5, replace "below" to "less than" – otherwise it is confusing, and "was" to "were".
OK, done
8) P. 4723, line 7. "This while IASI was providing a good global overview of the ozone distributions and concentrations of ozone, the above discussed issues made it difficult "
Changes done as suggested
9) P.4723, line 9 . Make a break in the long sentence. "as the Antarctica. This is the area where as not only there are were there large gaps … , but there are also data gaps…"

Changes done as suggested

10) P.4723m line 21, " where the left panel shows results retrieved from the NN scheme and the right panel show data derived by the FORLI-O3 scheme."

Indicated in text which figure panel was for FORLI and which was for NN

11) P. 4723, line 23-26. "The FORLI scheme, unlike the initially developed NN scheme, has no limit on scan angle width, and can adjust the surface temperature, and thus processes all the data resulting in a much greater spatial coverage"

Done

12) P.4724, line 7: "depending on the which version of FORLI which is used (Wan, 2008).

Done

13) P. 4724. Line 11: "for based on a given a measurement *y*, (the IASI radiance spectra), which accuracy is defined by with an error covariance matrix"

Done

14) P. 4724, line 15, change "which" to "that"

"which" changed to "that"

15) P. 4724, line 16 – use comma after "Therefore"

OK, corrected

16) P. 4724, line 17 "results with some a priori information, by choosing the …"

Inserted "by choosing"

17) P.4724, line 27 "infra-red. Here In the FORLI-O3 retrieval"

Changes done

18) P. 4725, line 25-26 " Over the ocean the retrieved spectrum shows significant strength in the ozone absorption band in of the thermal infrared spectrum with significant strength. However, on the contrary , although over the ice caps even the ozone band is still observed in the spectrum taken over the ice caps, …" absorption and emission by ozone? Not clear.

and 19) P. 4725, line 25 "Because of the weaker weakening of the ozone spectral signal over the ice, part of the vertical information is lost.

Replaced by:

Over the ocean the retrieved spectrum shows significant strength in the ozone absorption band in the thermal infrared. However, on the contrary, over the ice caps, although the ozone band is still observed, it is weaker and the absorption lines seem to disappear as part of the vertical information is lost because of the low ozone content.

20) P. 4726, line 20, "appeared to level out off, but have also slowed down the ozone loss rates"

Done

21) P.4726, line 22 – what does the "typical ozone maps" mean in the context. Are these retrieved using FORLI-O3 retrieval? According to Figure 5 caption it should be, but what version (several versions are available, but not indicated in the plot).

yes it means derived from FORLI, we have removed "typical" from the text at it is indeed confusing

22) P. 4726, line 27 change "of" to "or".

This sentence now reads: ". Such distribution maps show that the size, shape and evolution of the ozone hole can be clearly monitored. "

23) P. 4727, line 2, Figure 6 indicates periods of different versions of FORLI-O3 used for IASI retrieval. How do these versions compare? Is there a period of time in IASI measurement when several versions are compared?

Ozone is processed in near real time, and the retrieval is quite consuming in terms of computing power. So each time a new version of the algorithm is implemented, simultaneously to the near-real time processing, a back-processing also starts on the "oldest" (in terms of algorithm) data… until an improved version appears again. At the time of this study a consistent (=processed with the same version of the algo) dataset was not available (and it is still not available). We checked that the changes were minor and did not impact our findings. A sentence was added in the text to clarify this.

24) P. 4727, lines 7-16, provide references to the historic publications and the latest WMO Ozone Assessment report.

and 25) P. 4727, lines 18-19 – provide reference to other papers that discussed 2009 ozone hole shape.
Several publications were added to the list
26) P. 4730, line 2 "7 – 8 %"?
7 – 8%, corrected
27) P.4730, line 4 instead of "such a bias" use "similar bias"
"such a" replaced with "a similar"
28) P.4730, line 5, "and (space) maybe"
OK
29) P. 4730, line 8 Overestimated by how much?
By 2-8%. It is now added in the text
30) P. 4730, line 29 "Though, as already discussed above, there is …"
Done
31) P. 4731, line 6-7 The statement needs to be changed to clarify that IASI has limited sensitivity to ozone profile variability in the upper troposphere and lower stratosphere over the land, and particularly over the snow, and thus relies on the a priori climatology.
As suggested, the following sentence was added: "It is worth noting that IASI relies on the a priori climatology when low levels of ozone occur, eg inside the ozone hole.
32) P. 4731, line 22 change: "to IASI" to "from IASI"
Done
33) P. 4731, line 26 – would the difference of 0.5 degrees from the coastal station location result in the use of the IASI retrievals over the ocean? How many of the analyzed IASI profiles are derived from the spectrum over the ocean and over the land? If you separate these two groups, how would the comparisons change? Have you compared IASI against South Pole station ozone sonde record?
For the stations located in the Antarctic only IASI profiles over land were considered. The latitudes and longitudes of each profile were checked prior to inclusion in this study. For the South Pole station, there were no sonde/IASI colocations for the period of time that was investigated.
34) P. 4732, line 24 – please collaborate more information on the meaning of "well defined: AK. Does it mean that you chose only profiles where AKs were equally distributed vertically for better vertical coverage?
Yes it means that only profiles where AKs were equally distributed vertically for better vertical coverage were chosen. This is now clarified in the text.
35) P. 4732, line 27 separate words "profiles measured"
Corrected, thanks for noticing it.
36) P.4733, line 4 – in Figure 12 and 13, it would be of interests to add the high resolution profiles measured by ozone sonde (prior to the AK smoothing). It is of concern that the highly stratified vertical ozone profile would not compare well with the IASI. I would also object to plot high resolution IASI profiles – IASI retrieval has no information about high vertical resolution. So, it is better to compare ozone sonde profile integrated in the thick layer for comparisons with IASI, where the thickness of the layer is defined by the IASI AK resolution.
Figure 12 and 13 have been modified to include the high resolution profiles measured by the sondes (see grey profiles). The plots were split in two subpanels for a sake of clarity.
We decided to keep the full profiles instead of comparing with partial columns, which, we believe, allows for an adequate comparison and is the most frequent way of presenting the results.
Figure captions

Fig 1: The grey line in the bottom panel represents the residual of the fit, which is comparable to the IASI instrument noise level (dashed line).

The figure caption was corrected as recommended.