Impact of IASI thermal infrared measurements on global ozone reanalyses. Reply to referee # 2

Emanuele Emili[1] and Mohammad El Aabaribaoune[1]

[1]CECI, Université de Toulouse, Cerfacs, CNRS, Toulouse, France

Correspondence: Emili (emili@cerfacs.fr)

1 Reply to specific comments

We thank the anonymous reviewer for his comments, which helped to improve significantly the manuscript. Detailed replies to his comments follow:

1. *page 2 lines 15-20: the uninterrupted nature of IASI measurements versus the interrupted nature of TES measurements is a key motivation for the paper. However because the reader is not told what measurements Inness et al. (2019) use, this motivation is not so clear.*

   Answer: The fact that IASI measurements were not assimilated in Inness et al. (2019) was written at page 2 line 11-12. However, for better clarity we also modified the last sentence of the paragraph as follows:

   Although IASI O_3 observations might be very valuable for long reanalyses, they have not yet been assimilated within any of the currently available chemical reanalysis.

2. *page 6 line 18: it would be beneficial to quantify 'very small', even just a headline number to give the reader a feel for the significance of changing from 4D- to 3D-Var*

   Answer: The information has been added to the text as follows:

   However, assimilation experiments conducted with MLS observations revealed that O_3 differences between a 3D and 4D-Var algorithm are very small within the adopted model configuration (less than 1% difference on global averages, not shown).

3. *page 6 line 19: as pointed out by the authors the radiative transfer model changes between IASI-a and IASI-r, but there is no comment on the effect this has on resulting O3 fields. The reader would appreciate the distinction between the effect of changing IASI product level and the effect of changing radiative transfer model.*

   Answer: We agree with the reviewer about the fact that the impact of every single incremental change in the analysis system should be quantified and analysed. However, this is not always possible due to the significant time needed to compute and analyse satellite retrievals and data assimilation experiments. The changes between L2 and L1 assimilation using the same version of the RTM (RTTOV v11) has been thoroughly discussed in Emili et al. (2019) and the reference given in the introduction (page 2 lines 29-30). The impact of only changing the RTM version demands to recompute the L2 retrievals and re-assimilate them. This is unfortunately not possible in the framework of this study since the L2 O_3 retrievals are produced by an external entity and require significant computational and human resources. We already mentioned in the conclusions the potential interest of recomputing the IASI-a analysis based on a new version of the SOFRID L2 algorithm (Barret et al., 2020), to check wether the most recent version of L2 products might give similar results to IASI-r (page 12 lines 9-10). However, this is out of scope for the present manuscript, whose main purpose is to evaluate the overall impact of all the modifications introduced within the assimilation scheme since the publication of IASI-a (page 3 lines 8-10).

4. *page 7 line 3: could the reason for using a dynamical filter to reject pixels that differ from the model by more than 12% be given?*

Answer: The dynamical filter constitutes the last resort to discard observations that were initially considered for assimilation but differ substantially from the model counterpart. This step is needed because a careful selection of observations based only on cloud/dust contamination and surface emissivity is not always sufficient to exclude some satellite pixels that can still degrade the analysis. This can happen for example due to miss-predicted snow surfaces, undetected clouds/aerosols, poor representativity due to the model-satellite resolution mismatch. The threshold of 12% has been tuned based on observations minus background histograms computed for some days of assimilation. The purpose was to exclude the observations that fall outside the 2σ confidence interval. We report in Fig. 1 the geographical distribution of the background minus observation values and the effect of the emissivity and dynamical filters during the first 5 days of the IASI-r analysis, for a subset of assimilated channels. We can remark that all spectral channels show similar behaviour, with a standard deviation ranging from about 4% to 7% of observed radiances (histograms in Fig. 1). Also highest discrepancies are generally observed over land (top maps in Fig. 1), where surface emissivity values are lower and more uncertain. As a consequence of our filtering strategy, most of the rejected observations (brown pixels in the bottom plot) are located over land. The total number of rejected observations is about 12% of the initially retained ones for this 5 days period. We cannot display separately the effects of surface emissivity and dynamical filters here because we did not store the results of the action of each single filter in our DA system. Emili et al. (2019) used the same threshold of 12% for the dynamical filter and observed a ratio of about 3% of rejection due to this filter alone in July 2010 (no surface emissivity filter was needed in their study).

The following sentence has been included in the manuscript to resume this discussion:

Finally, a dynamical filter is used to reject pixels that differ from modelled radiances by more than 12%. This is done to avoid assimilating observations that, for some undetected reason (e.g. erroneous surface properties or poor model representativity), differ significantly from the model counterparts. The value of the threshold is about twice the standard deviation of the observation minus background values and allows to reject a relatively small number of potential outliers ($< 5\%$, see also Emili et al. (2019)) that might have passed the previous filters.

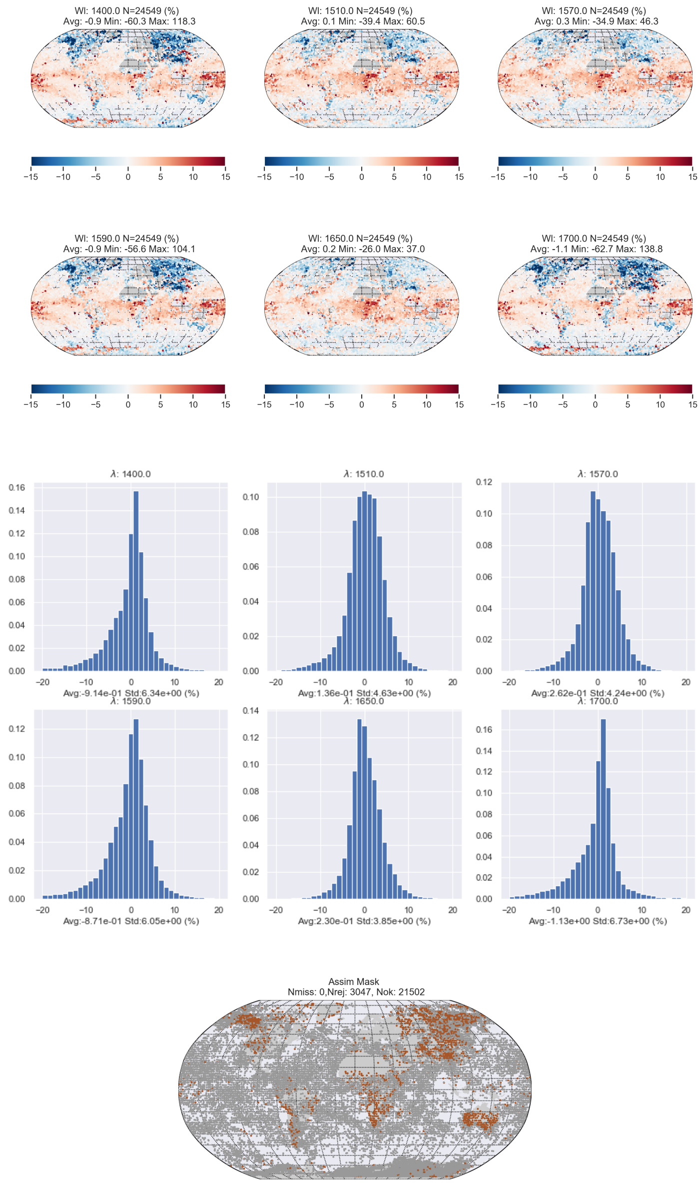

Figure 1. Background minus observations values (as % of observed values) for 6 IASI channels within the O_3 band cumulated during the first 5 days of IASI-r. On top: maps of all individual satellite pixels before the application of the surface emissivity and dynamical filters. In the middle: frequency histograms corresponding to the pixels above. Each map / histogram corresponds to a single IASI channel, whose number is indicated on top of the plot. On the bottom: map of selected (grey) and rejected (brown) pixels after the joint application of the surface emissivity and dynamic filters.

2 Reply to technical comments

Answer:

All technical comments have been integrated in the revised manuscript.

References

Barret, B., Emili, E., and Le Flochmoen, E.: A tropopause-based a priori for IASI-SOFRID Ozone retrievals: improvements and validation, Atmospheric Measurement Techniques Discussions, 2020, 1–35, https://doi.org/10.5194/amt-2020-5, https://amt.copernicus.org/preprints/amt-2020-5/, 2020.

Emili, E., Barret, B., Le Flochmoën, E., and Cariolle, D.: Comparison between the assimilation of IASI Level 2 ozone retrievals and Level 1 radiances in a chemical transport model, Atmospheric Measurement Techniques, 12, 3963–3984, https://doi.org/10.5194/amt-12-3963-2019, https://www.atmos-meas-tech.net/12/3963/2019/, 2019.