

REPLY TO REFEREE #1

Referee comments are in highlighted text

Author reply is in normal text

In this study, the authors make use of airborne measurements made over the Western Mediterranean during the ADRIMED campaign, as well as a dataset of complex dust aerosol refractive indices obtained in the lab to test the capability of the newly developed s-IASI-as radiative transfer code to mimic the IASI spectra in the presence of dust advected from Africa over the sea. The study makes use of 3 days of measurements of ADRIMED, which are not presented (they are extensively covered in Denjean et al. 2016), used to constrain the s-IASI-as algorithm. The strengths and limitations of the s-IASI-as algorithm are discussed on the basis of the comparison with real IASI spectra in the 700-2800 cm⁻¹ spectral range. Overall, this is an interesting study which deserves publication in AMT. The quality of the English could be improved. Also, some relevant references are missing which should be included. Finally, the authors should to a more thorough job at quantifying the errors and uncertainties in the different part of the spectrum. Also the impact of these errors and uncertainties on the aerosols microphysical properties (as presented in Section 2.2) derived from s-IASI-as.

We would like to thank the referee for the kind appreciation of the manuscript, whose importance in the context of the existing literature has been fully understood. Also, we thank the referee for the productive comments, which have been very useful to improve the overall quality of the manuscript. However, we point out that, apart from testing the code capabilities, the paper tries to pursue two further objectives: on the one hand, the σ -IASI-as code is fully presented and explained, in order to show the updates to the pre-existing work done in Amato et al. (2002). On the other hand, it has been shown that IASI data are sensitive to the aerosol optical properties, and consequently to their origin. We have somehow reinforced these concepts rephrasing a bit the abstract. As suggested, we have improved the quality of the English and the abundance of proper references.

As far as the last point is concerned, the referee should consider that the manuscript deals simply with radiative transfer simulations in presence of dust aerosol whose dimensional properties are measured, and optical behaviour discussed. We are not doing any retrieval of surface, atmospheric, or aerosol properties, and the uncertainties are those of radiative transfer, which are already discussed in the previous paper by Amato et al. (2002), where it is shown that σ -IASI outputs are affected by errors $\ll 0.1$ K in the thermal infrared. This is far lower than IASI radiometric noise. This aspect has been commented in the revised paper at page 5, L8-9 and page 9, L6-8. Another point is that, the code reckons aerosol and clouds optical depth using exact Mie routines, and avoids any parameterization. Single and multiple scattering effects are considered as well, even if in this case one does not expect that multiple scattering is dominant, which is instead the case, e. g., of dense clouds. Likewise, the manuscript is not intended to pursue any comparison between a full treatment of aerosol extinction and our code. Instead, to better discuss IASI data sensitivity with respect to aerosol properties, as requested, we added a new section 4.3, in which the effect of dimensional distributions uncertainty on radiative transfer outputs is discussed.

Based on the above, I recommended that the paper be published in AMT provide that the above mentioned comments as well as the ones below are taken into account.

Recommendation: minor revision

Abstract - Define ChArME_x - “a dust event which occurred”: based on the following, you have not looked at just a single dust event - there is no such thing as the southern med basin: here you are referring to the southern part of the Western Med basin - lines 5-9: the sentence is too long and conveys more than one idea, rephrase

We have rephrased the first sentence, rewriting "in presence of atmospheric desert dust, between June and July 2013 in the southern Mediterranean basin, in the air mass above Lampedusa island", in order to avoid confusion about the context of IASI observations. Lines 5-9 have been made more clear rephrasing in this way: "Simulations have been carried on using as input different sets of input complex refractive indices, which take into account the parent soils of the aerosols. Their accuracy also relies on the high-quality characterization of desert dust microphysical properties, achieved through direct measurements in the ChArMEx experiment. On the one hand, the fact that the model can ingest such a variable input proves its feasibility". Since (see previous comment) we have added also a new section in which we analyze the sensitivity of IASI radiances with respect to the effective radius of the particles, we have mentioned it in the revised abstract (L10-11): "and pursues an assessment of the sensitivity of IASI data with respect to the dimensional distribution of desert dust particles".

Introduction Page 1 - L15-16: there is also some work on the topic from Lars Kluser at DLR - L21-22: Note that profiling of dust was recently achieved over Eastern Asia by the group of Juan Cuesta in Creteil. Please cite:

J. Cuesta, M. Eremenko, C. Flamant, G. Dufour, B. Laurent, G. Bergametti, M. Höpfner, J. Orphal and D. Zhou, 2015: Satellite observation of the 3D distribution of dust plumes from IASI throughout a major desert dust outbreak across East Asia in March 2008, *J. Geophys. Res.*, 120, 7099-7127, doi:10.1002/2014JD022406.

We thank the referee for this comment. The following two works by L. Kluser have been cited at page 9, L17-19:

- Klüser, L., Kleiber, P., Holzer-Popp, T., and Grassian, V. H.: Desert dust observation from space - Application of measured mineral component infrared extinction spectra, *Atmospheric Environment*, 54, 419–427, doi:10.1016/j.atmosenv.2012.02.011, 2012.
- Klüser, L., Banks, J. R., Martynenko, D., Bergemann, C., Brindley, H. E., and Holzer-Popp, T.: Information content of spaceborne hyperspectral infrared observations with respect to mineral dust properties, *Remote Sensing of Environment*, 156, 294–309, doi:10.1016/j.rse.2014.09.036, 2015.

This has also helped to better present the way in which our manuscript contributes to provide an advancement to the existing research. Finally, the suggested reference by Cuesta et al. has been added at Page 1, L17.

Page 2 - L19: a high degree of generality - L20: the maximum fastness: lame, please rephrase

The referee is right. To avoid confusion, and since most of the significance of this lame sentences is better explained later in the manuscript, we have eliminated this sentences, and added a comment in L28-29: "Also, since the model ingests the optical properties of several aerosol and cloud types, it can be applied to simulate infrared observations including all the variability of such properties."

- L27-28: complicated sentence: just write that ADRIMED was a component of ChArMEx SOP1

- L29: is the ATR-42 an aircraft? Who is the operator, SAFIRE?? Please provide some details.

To answer to both the points, we have rephrased the whole paragraph between Line 32, Page 2, and L3, Page 3: "Thus, for this validation exercise, we have fruitfully employed the aerosol microphysical properties (i.e. dimensional distribution and concentration) derived during the Chemistry-Aerosol Mediterranean Experiment (ChArMEx) Special Observation Period SOP1a. One of the components of SOP1 was the Aerosol Direct Radiative Impact on the regional climate in the MEDiterranean region (ADRIMED) field campaign. Here, we exploit the measurements made on board the ATR-42 aircraft, operated by SAFIRE (Service des Avions Francais Instruments pour la Recherche en Environnement, <http://www.safire.fr/>) over Lampedusa, in four different days between June and July 2013."

- L33: later (p 10) you write that on 22 June some of the dust is coming from Southern Morocco, which is not the Sahara.. please correct.

To avoid misunderstandings, we have replaced "Saharan" with "North-western African".

Data and methods Page 9 - L14-15: could you specify the number of IASI pixels in the box? What is the time of the IASI overpasses on the 3 days? - L16: the 3 days are characterized by a decreasing atmospheric dust load: unclear, please rephrase.

To answer to both comments, and to better arrange this part of the manuscript, former L16 of the manuscript has been rewritten in this way: " These three days are characterized by different atmospheric desert dust loads and vertical profile shapes", while the former L14-15 have been rewritten at L6-8, Page 10, as follows: "This pre-filtering process yield to a total of 12 IASI IFOVs (out of 22 clear sky) actually used in this work, for the case of 22 June; 15 IFOVs (out of 23) for the 28 June case; finally, 18 IFOVs for the case of 3 July. The acquisition times for the three days are, respectively, 8h45m UTC, 8h21m UTC, and 8h17m UTC."

- L18: here and elsewhere: should this be IFOV?

It has been corrected to IFOV in the "Data and methods" section, since it is referred to the IASI instrument. Instead, in the previous section, we have used simply "FOV", since it is simply intended to be the Field of View of a generic instrument.

- L27: is this wind speed at 10 m above sea surface? How does 10-m wind speed relate to surface sea surface emissivity? In case of strong winds, whitecaps develop at the sea surface that will modify significantly the surface emissivity. It would be worth checking what the sea state and surface wind speeds are around Lampedusa during the 3 days selected.

As stated in the article, we use the Masuda model (Masuda et al., 1988) to describe sea surface emissivity. If the wind speed is in the interval 0-15 m/s, wherein the model holds, emissivity differences are as large as 0.004 in case the Viewing Zenith Angles is the maximum IASI VZA (~48 degrees), or lower for lower VZA values. As a consequence, we expect no significant bias in radiative transfer simulations in case wind speed is lower than 15 m/s. Indeed, we have verified (source: ECMWF reanalyses) that wind speed at 10 m (that to be considered in Masuda model) is 3 m/s, 8.5 m/s, and 4 m/s respectively in the three days we work with. Consequently, the sentence at Page 13, L1-2 has been eliminated, since it was clearly incorrect.

Conclusions P13 - L30: cases rather than scenarios

Corrected. Moreover, since a consistent part of the manuscript is dedicated to the characterization of dust refractive indices, we have mentioned it at L19, page 15.

P14 - L9-10: unclear sentence, please rephrase

We have rephrased as follows: " Overall, we find that the dimensional distributions derived from ChArMEx observations yield to a fair consistency between observations and calculations in the thermal infrared wave lengths. On the contrary, the discrepancies are significant in the short wave portion of the IASI spectrum where, anyway, also other major effects occur (e.g. non-LTE)."