REPLY TO REFEREE #2

Referee comments are in highlighted text

Author reply is in normal text

First, on behalf of all co-authors, the corresponding author would like to thank the referee for the valuable comments provided, that have been very useful to improve the quality of the manuscript.

The paper presents the comparison between observed (IASI) and calculated (σ-IASI-as) radiances during a dust event affecting Lampedusa Island. The novel σ-IASI-as radiative transfer model takes into account the effects of aerosols on extinction.

General comments:

1) First of all I would encourage the authors to explain better the differences between σ-IASI and σ-IASI-as models. If I have well understood the σ-IASI computes the atmosphere spectral radiance both for clear and cloudy sky and the σ-IASI-as model includes also the effects on spectral radiance due to atmospheric aerosols.

The differences between the two models have been more extensively explained in Sec. 1 (Introduction, Page 2, L13-19): "The capability of the model to deal with plenty of atmospheric aerosols, with arbitrary vertical profiles and dimensional distributions, is one of the main advancements with respect to the former σ-IASI model (Amato et al. , 2002), which was conceived to work only with simplified single-layer cloud models, in which the cloud was characterized by its own temperature and emissivity. The new version of the model, instead, works with the spectrally variable complex refractive index of aerosols and clouds (water/ice), performing ab-initio Mie calculations, and adopting robust and well-validated schemes for the fast parameterization of multiple scattering effects.". This may help to better introduce the specific explanation of the radiative transfer scheme, in the following Section.

The authors state that the effects of particles and clouds on extinction are based “on the same physics”. However, for example, multiple scattering has a major importance in clouds rather than in a dust layer.

The referee is right. Of course, the code considers this difference between clouds and aerosols computing the effect of multiple scattering, as extensively explained. However, in order to avoid any misunderstanding, the sentence has been suppressed.

Some of the equations reported in this manuscript (Liuzzi et al., AMTD) have been already discussed in Amato et al. (2002) however there are some differences which I do not understand. For example equation 1 in the present manuscript corresponds to equation 7 in Amato et al. (2002) but there are two differences in the third right term of the equation: τ_0 is τ^2_0 in Amato et al. (2002) and τ^f_* is $1/\tau$ in Amato et al. (2002). What are the reasons for these differences? The same in the equations 3 and 4 in Liuzzi et al. AMTD (corresponding to equations 12 and 13 in Amato et al. (2002)).

In the paper by Amato et al. (2002) the reflected term of the radiance was slightly handled (via Equation 5) in order to put in evidence the term τ^2_0, and that this part of the observed radiance is of second order with respect to the atmospheric and surface emitted term. However, the radiative transfer code does not compute the transmittances of the reflected term in the form used in Amato et al., but indeed works in the way explained in the present manuscript. This is the reason why we have used this new notation, which does not yield any substantial difference with respect to the Amato et al. paper. Also, the new notation is useful to better explain the difference between the τ^f_* term computed in the case of specular reflection or Lambertian diffusion.

Equation 2 in Liuzzi et al. AMTD is exactly the equation 8 in Amato et al. (2002) but a different nomenclature is used (R_C instead of R_0 and R_N instead of R_{cld}). Is there any reason for this? This is a bit confusing and the same nomenclature as in Amato et al. (2002) should be used in this manuscript, unless the terms included in the equations of Liuzzi et al., AMTD are different, but this is not clear.

Apart from the new physics introduced in the σ-IASI-as model as far as aerosols and clouds are concerned (see the first review point), the only reason for using R_C instead of R_0 is to avoid confusion between the "0" of τ_0 and the "0" of clear sky. Thus, we have replaced the subscript "N" with "cld" where needed, and left unchanged the "C" subscript for clear sky terms.

2) Is it possible to know ω(σ), b(σ) and g(σ) computed by the model and compare these intensive aerosol properties with their experimental determinations reported in literature for dust?

The way in which these intensive properties are computed is explicitly stated in the manuscript, sec. 2.2, and it is based on Mie routines: their calculation is straightforward, given the dimensional distributions and refractive indices. The radiative transfer code computes all these intensive properties, but we preferred not to report it, given the number of sets of refractive indices and dimensional distributions involved in the manuscript. Instead, we work directly with the observed and computed radiances.

3) Pag. 11, Lines 19-22. It is nice to see that the radiance computed with σ-IASI-as, which includes the impact of dust aerosols, reproduces quite well the observed IASI radiance compared to the simulated clear-sky radiance. However, the authors state that the slope due to the peak in the complex refractive index around 1000 cm-1 “is well manifested both in the computed and observed radiances”. However, I cannot clearly see the effect of dust absorption on the simulated radiance in Fig. 6 and 7 because of the absorption due to O_3 in the same spectral region.

The referee is right. The sentence has been modified writing “The attenuation due to the behaviour of complex refractive index at both sides of the O_3 band is well manifested both in the computed and observed radiances”.

Moreover, I do not see any effect of dust absorption at 1500 cm-1 in Figs. 6 and 7. Is this due the fact that the absorption by H_2O is dominant in this spectral region?

Correct. The water vapour absorption around 1500 cm^{-1} is strong enough to hide the effect of aerosol extinction in the cases we examine, in which the aerosol distribution extends up to an altitude of 5800 m (or lower). To better see this fact, the referee can look at Figure 1 on this report, which shows the derivative of the radiance with respect to desert dust concentration, computed by σ-IASI-as for the case of 22 June, and averaged on the spectral interval 1400-1600 cm^{-1}. In this plot, the derivative is rescaled with dust concentration, so it represents the extinction, in radiance units, due to desert dust in that spectral region, which in this case is negligible (the absolute value is of the order of 10^{-6} radiance units).

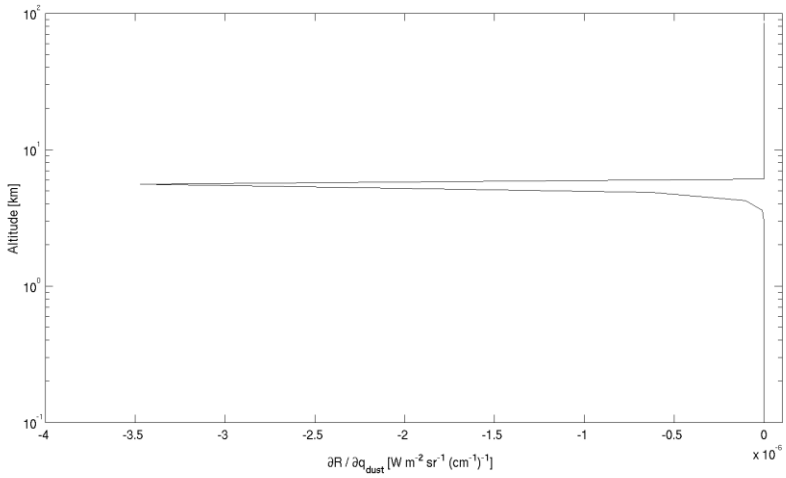

Figure 1.

4) Not sure if this was already discussed in Di Biagio et al. What is the reason for the lack of peak in the imaginary part of RI for Algeria dust around 1500 cm-1?

This aspect is briefly discussed in the paper by Di Biagio et al, sec. 5.3. The Algerian aerosol is poor in calcite compared to Tunisia and Morocco dust, hence the absorption feature centred at 7 μm, which is typical of calcite, is not present in the refractive index of Algerian dust.

5) The English must be improved.

We have revised the manuscript and rephrased/improved the language where needed.

6) Uncertainties of σ-IASI-as outputs should be discussed.

Here, 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). There it is shown that σ-IASI uses 60 atmospheric layers to describe the vertical distribution of every parameter (aerosols and clouds included), and that this number of layers produces outputs affected by errors <<0.1 K in the thermal infrared. This aspect has been commented at Page 5, L8-9, and page 9, L6-8. Such uncertainties are far lower than IASI radiometric noise. Moreover, the code reckons aerosol and clouds optical depth using exact Mie routines, and avoids any approximation for scattering effects. Indeed, the manuscript is not intended to pursue any comparison between a full treatment of aerosol extinction and our code. Instead, we have completed the analysis of IASI data sensitivity with respect to aerosol properties by adding a new section 4.3, in which we have better quantified the effect of dimensional distributions uncertainty on radiative transfer outputs. Finally, we have better commented the residuals presented in the manuscript at L2-5, page 13, in order to provide to the reader further elements to better discriminate between those residual features due to desert dust properties and other factors (such as gases or temperature vertical profiles).