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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieval of SO_2 from thermal infrared satellite measurements: correction procedures for the effects of volcanic ash" *by* S. Corradini et al.

S. Corradini et al.

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Referee1 comments

General: The paper presents a method to correct for the influence of ash on retrievals of SO2 from mid-IR nadir sounding spectrometers. The manuscript is well structured and written. The results clearly demonstrate the necessity for such a correction, since otherwise the SO2 abundances would be largely overestimated. The method is demonstrated for the example of MODIS and SEVIRI observations of an eruption of Mt. Etna. My main comment concerns the explanation of the differing results obtained by the two instruments and the lack of discussion of further possible error sources.

Specific:

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Interactive Discussion

Discussion Paper

1. p.308, l.16: 'The effect of ash at 7.3 μm is much less important and the radiance percentage difference results are always less than 3% for all the simulations considered'. Can you explain why ash has so little effect at 7.3 μm compared to 8.7 μm? Do you consider the same altitude profile for SO2 as for ash (boxcar from 4-5km) or is SO2 also present at higher altitudes? Has ash a stronger absorption at 8.7 μm and how strong does this depend on the chosen composition of the ash?

2. p.309, l.16: Eq. (1) Why are the relative radiance differences (squared) minimized instead of the square of the absolute radiance differences? The reason might be the definition of the channel weight wj. Can you define this more clearly in the text?

3. p.311, l.5: Which width of the log-normal distribution has been used?

4. p.311, l.5: What was the reason to use andesite refractive index? How strong is the influence of the refractive index on the results for the example case?

5. p.316, l.7...: The passage should be re-worded to make clear that the water vapour influence is the major reason for the differences between both channels.

6. p.318, l.18: 'This can be explained considering that SEVIRI has a higher NEΔT (i.e. lower sensitivity), and smaller ground pixel resolution than the MODIS instrument'. The explanations given for the large differences between the two instruments do not convince me: I don't think that a higher spectral noise (NEΔT) can explain this: first, why should a higher noise lead to generally lower values for aerosol mass and SO2? I would anticipate a larger standard deviation in the results but not generally a systematic bias. Second, as stated by the authors earlier in the text, the noise of SEVIRI is even lower than that of MODIS in the 7.3 μm channel.

7. Thus, I think it would be necessary to perform a quantitative estimation of the error induced by the spectral noise on the SO2 retrieval.

8. The smaller ground pixel resolution of SEVIRI is given as another explanation. I don't understand why this should reduce the retrieved values, especially the mean value for

the whole plume. Could you explain this in more detail?

9. I think it is also necessary to discuss further possible reasons for the observed systematic differences. Therefore, at least in the conclusions further systematic possible error sources for the SO2 retrieval should be discussed.

Technical:

10. p.317, l.16, p.320, l.17 criteria -> criterion

11. Figs. 6 and 12 The colour scales for the aerosol optical thickness should be made equal.

Response to Referee1 comments

1. All the simulations have been made considering the same plume height and thickness (4000 m and 1000 m respectively). The ash absorption is generally stronger at 8.7 μm than at 7.3 μm. In the case of the andesite ash type considered in this work, the absorption coefficient results more than three times greater at 8.7 μm than at 7.3 μm. About three times is also the absorption difference between 8.7 μm and 7.3 μm obtained considering the Volz ash type [F. E. Volz, 'Infrared optical constants of ammonium sulfate, Sahara dust, volcanic pumice and fly ash', Appl. Optic. 12 564-568, 1973]. The other important reason of such a small ash radiance variation at 7.3 μm is the strong atmospheric water vapour absorption at this wavelength. For the tropospheric eruptions, the water vapour absorption can override both SO2 and ash signals.

2. The equation introduced is a typical χ^2 procedure. Anyway the use of the procedure indicated by the referee doesn't change the results.

3. The width of the log-normal distribution (σ) is 1.77 and the minimum and maximum radii corresponding to +/-3σ from the central wavelength.

4. The referee is right to say that the choice of the ash type is very critical. Because we don't know the ash characteristics of the Etna 24 November eruption, we decided

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to consider one of the most common ash, the andesite. In our recent paper [Corradini S., Spinetti C., Carboni E., Tirelli C., Buongiorno M. F., Pugnaghi S., Gangale G., 'Mt. Etna tropospheric ash retrieval and sensitivity analysis using Moderate Resolution Imaging Spectroradiometer measurements', Journal of Atmospheric Remote Sensing, Vol. 2, 023550, 2008.] we have estimated the ash retrievals errors due to the ash type uncertainty . The total ash mass retrieval error due to the ash type uncertainty result about the 20%.

5. The passage has been reworded as follows: 'The main reason of the SO2 differences between 8.7 μm and 7.3 μm retrievals is due to the atmospheric water vapour absorption that is much stronger around 7.3 μm. In case of tropospheric eruptions, at this wavelength, the water vapour tends to override the plume signal making the SO2 retrieval critical and meaningfully underestimated'.

6. In the text the comparison is concerning the MODIS and SEVIRI SO2 retrievals at 8.7 m. At this wavelength the SEVIRI NEΔT (0.11 K) is meaningfully greater than the MODIS NEΔT (0.05K). Great instrument NEΔT values means that low values of SO2 or ash, present in some pixels, cannot be retrieved because the plume signal is less than the noise signal. In the limit of a very high instrumental NEΔT no SO2 or ash pixels could be retrieved.

7. The referee is right to consider important the estimation of the error induced by the instrumental spectral noise. But such analysis (that needs a specific and deep examination) is out of the scope of this paper, focused on the discussion on the ash effect on SO2 retrieval and on the ash correction procedure development.

8. Two instruments with the same NEΔT and different pixel resolution give different retrievals for the same test case. At limit of a huge pixels the SO2 or ash signal could be so low to become not detectable by the instrument. This is particularly true for the edge pixels in which both plume and free atmosphere are present.

9. If accepted the answers above could be sufficient to justify the differences.

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Interactive Comment

Technical:

10. Corrected

11. Changed

Interactive comment on Atmos. Meas. Tech. Discuss., 2, 303, 2009.

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