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Atmospheric Measurement Techniques Discussions

Interactive comment on "Sulphur mass balance and radiative forcing estimation for a moderate volcanic eruption using new sulphate aerosols retrievals based on IASI observations" *by* H. Guermazi et al.

Anonymous Referee #2

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The paper introduces a new retrieval scheme for quantifying sulphate aerosol mass and height from IR nadir measurements with IASI. The new retrieval is demonstrated in a case study of a single paroxysmal episode of Mt Etna. The sulphate aerosol mass retrieval is used together with an independent IASI SO_2 retrieval to estimate the gas/particle phase partitioning of SO_2 24 h after the eruption. Further, for this plume the shortwave radiative forcing was calculated.

While the title implies that the manuscript mainly focuses on sulphur mass balance and radiative forcing the paper itself is mainly on the retrieval. In my opinion the new quan-

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titative retrieval of sulphate aerosol from IR nadir merits publication in AMT. However, for none of the three aspects the methods and inputs are described sufficiently and the interpretation and discussions of the results are incomprehensible. Further, I think that the motivation that heads towards lower troposphere reaching degassing events does not match with the rather high-troposphere reaching eruption that is presented as a case study.

Since I really like the idea of retrieving sulphate aerosol from IR nadir measurements, I'd like to suggest to revise the manuscript considering the comments below.

General comments:

To me it is not clear which altitude range you want to address with the new sulphate aerosol retrieval. From the introduction I had the impression that you will focus on the lower parts of the troposphere (because you speak about volcanic effluents and "passive degassing activities"), but the retrieval and case study rather focus on the upper troposphere/lower stratosphere (6-21 km). Please be more specific and consistent with respect to the altitude range you want to address. For the introduction I'd like to suggest that you focus more on the benefits of the high horizontal resolution that IASI provides.

The main scope of the paper is the introduction of an altitude-resolving retrieval of sulphate aerosol from IASI. However, it is not clear in how far the retrieval agrees with or differs from the AEROIASI retrieval and plenty of characterising information is missing. Please provide more information on the retrieval and work-flow. Did you use any pre-filter to identify SA-containing spectra, e.g. Clarisse et al. 2013, or did you retrieve SA in all spectra and then filtered out clouds? Will other aerosol types (e.g. wild fire, mineral dust) be filtered out, or retrieved as SA? To which altitude range are you sensitive to? What is the vertical resolution/altitude uncertainty? What are the lower AOD and extinction detection limits? Please show kernel functions and averaging

kernel.

Why did you choose one of the strongest in terms of SO_2 injection and highest reaching Etna eruptions during the IASI measurements period to demonstrate the IASI sulphate aerosol retrievals can provide global measurement information in the troposphere, especially for effluents and passive degassing events? Either reconsider your motivation or provide an additional example for a low altitude eruption event.

Concerning the methods and the used inputs a lot of information is missing. You are presenting a quantitative sulphate aerosol retrieval from IR nadir measurements, but basic characterisations are missing (please see detailed comments below). The information provided for all three topics of the paper (sulphate aerosol retrieval, Etna case study, direct radiative effect) is not sufficient to allow for reproduction.

Please also add a section on code and data availability for AEROIASI, AEROIASI-Sulphate, KOPRA, LibRadtran and IASI, AVHRR, IASI SO_2 retrieval, respectively.

Specific comments:

l 2/3: “vertically-resolved” ... “profiles” Remove one, since this is a tautology.

l 4 and throughout the manuscript: “medium-sized”: Please specify what you mean by “medium-sized”. Medium sized eruption in terms of injection altitude, SO_2 mass, ash mass, eruption duration, damage?

l 16: “highly reflective”: Sulphate aerosol is highly reflective in UV/VIS, but highly absorbing in mid-IR. Please be more precise here.

l 17: “Moderate to strong”: See comment to line 4. Specify and quantify what you mean with moderate to strong. Are these stratosphere reaching eruptions?

l 19: “... important radiative imbalance ... significant ...”: Please specify what you mean

by important radiative imbalance and significant perturbations.

l 20: “smaller tropospheric eruptions”: Do you mean with smaller only troposphere reaching eruptions? See comments above. Please clarify.

l 26-28: Which altitude range do you mean? “Effluents” I would expect in the boundary layer and lowermost troposphere. Concerning injections this is not true. The whole suite of limb satellites provides information on stratospheric sulphate aerosol and some (e.g. SAGE II, OSIRIS, MIPAS) even extend into the upper troposphere. Further CALIOP provides information on tropospheric sulphate aerosol in the entire troposphere. If you mean only nadir satellite instruments and/or measurements in the (lower) troposphere, please state so here.

l 28: “... partial characterisation ...”: Please specify what you mean by partial. I assume, you mean partial characterisation in terms of altitude (stratosphere and upper troposphere)? Or do you mean partial with respect to the horizontal extent? Or something else?

l 29: What is “relatively high altitude”? 5, 10, 15, 20 km?

l 32: Which “process studies”?

l 33: “... limb observations are not effective in the troposphere ...”: This is not true for the upper troposphere. Please see comment above and state more precise.

l 54-60; Section 2.1: The IASI instrument is described here, but not the data. Please state which data you used (level 1, level 2?) and where the data is available.

l 62-97; Section 2.2: To me it did not become clear in how far AEROIASI and AEROIASI-Sulphur agree or differ. Please clarify, which are AEROIASI characteristics and what was modified for AEROIASI-sulphates.

l 81 & Table 1: Please provide window boundary wavenumbers instead of window central wavenumbers for reproducibility.

l 81/82 & Table 1: The numbers indicating the spectral range in the text do not agree with the numbers given in Table 1. Please fix.

l 86: Please provide a reference that 57 % sulphuric acid solution is characteristic for "tropospheric volcanic SA". I'd assume it mainly depends on temperature.

l 87-88: Do you really mean the mean radius of the log-normal distribution? I'd rather consider this value the median radius. Please provide the formula you are using for the log-normal distribution.

l 91-92: What is the vertical range and vertical resolution of your output vector? Do you restrict the retrieval to 6-21 km as indicated in Table 1? Why? Don't you aim at effluents and passive degassing events?

l 93: Which quality tests? What do they test? Please clarify.

l 99-106: Is this detailed description of the Etna eruption your own observation? Please state so, or provide references.

l 108-110: In my opinion the introduction and description of the IASI SO_2 retrieval should have an own (short) subsection.

l 110-122: The CHIMERE model and simulation data should be in a separate subsection and should provide additional information on the following questions: Which region is covered by the simulation domain? Which external data drives the transport, reanalyses or global model, something else? How long did the eruption last and to which altitudes did it reach? Please show the altitude time series of the SO_2 injection.

l 117-122: This part leaves me puzzled. From this I don't understand how you derived the mass flux. Did you use camera or, satellite data, or both for the case study? Please state what you used and provide a reference.

l 126: "higher AOD": enhanced AOD

Figure 1: Ackerman (1997) found that AOD has to exceed 0.01 in order to result in

a signal that exceeds clear air variability (at 11μm). In Fig. 1a) the background AOD is 0.05. Does this mean that the AOD is enhanced over the entire domain? What is your lower detection limit? Which AOD threshold did you choose to show the plume altitude?

l 138-140: For the plume south of Crete I do agree that there is co-location with the SO_2 retrieval and the CHIMERE model simulation. However, for the plume at about 34-36N and 17-18E there is not agreement with the model and only for 3 out of 13 IASI footprints there is agreement with the IASI SO_2 retrieval. Please clarify. Did you notice that at the locations where your retrieval shows the highest AODs, the SO_2 concentration is at the lowest limit? Was there maybe some cloud/aerosol filtering before the SO_2 retrieval?

l 145-147: Was the *low plume* before or after the paroxysmal phase? It cannot be both. Please clarify.

l 152-157: It appears likely that the two aerosol plumes close to Taranto and Thessaloniki are related to pollution. Here it is necessary to know from which altitudes the IASI signal comes from (sensitivity kernel from surface to 21 km). See comment on model description.

l 173-180: Is it correct that the FLAME SO_2 emission rates count everything from ground to plume top? What is the FLAME estimation error? For which altitude range is the IASI SO_2 retrieval valid, $>$6 km? What is the IASI SO_2 error? For which region did you estimate the SO_2 mass from your retrieval? From the whole domain shown in Fig. 1 or only the two plumes you attributed to the eruption before? Please explain the "instantaneous particulate/gaseous sulphur mass ratio". What is the meaning of it? Doesn't the ratio sulphate aerosol/SO_2 depend on time and OH availability? With respect to an SO_2 lifetime of 14 h I don't consider particle/gas SO_2 ratios measured after 24 h at several 100 km distance comparable to a fresh plume measured directly in the crater.

l 182-185: Please think a bit more about the uncertainties. Maybe 0.3 kT are already within the error bars of FLAME observations and the IASI retrievals? Also, the IASI sulphate retrieval only considers aerosol mass above 6 km. It is unclear for which altitude range the IASI SO_2-retrieval accounts for.

l 186-189: Please describe the LibRadtran, the method, and chosen input parameters shortly in the methods section and explain what the f-ratio is for.

l 191: This part is confusing. In the sentence before you state, that you derived the extinction at 10 μm. But sulphate aerosol has not a single scattering albedo of 0.99 in the IR. It is rather 0.01. Also, at 10 μm sulphate aerosol is mainly absorbing. If you refer to the UV/VIS range, please state so.

l 193: Having a fixed particle size and width, why don't you use Mie theory to scale from 10 μm to UV/VIS?

l 195: Which "standard mid-latitude atmosphere" did you use? US-Standard? Please be more specific.

l 196-201: I don't consider the DRE of a sulphate aerosol plume comparable to to the DRE of an ash plume. The difference is already quite obvious, when comparing the surface and TOA values. For the sulphate plume both DREs are very close, whereas for the ash plume there is a factor of 1.3. How did you scale the from sulphate aerosol DRE with AOD of one to a DRE with AOD of 1.0? Did you consider that the scaling factor from 10 μm to UV/VIS is significantly different for sulphate aerosol and ash?

l 203-206: Which region did you consider for the averaged DRE? Please indicate in Fig 1 and state in km^2.

l 206-208: I don't understand the sense of comparing the DRE of a very localised plume 24 h after the eruption with a 30 days old plume averaged over the entire northern hemisphere. Please clarify.

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