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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Characterisation of a stratospheric sulphate plume from the Nabro volcano using a combination of passive satellite measurements in nadir and limb geometry" *by* M. J. M. Penning de Vries et al.

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The paper presents previously unreported observational evidence for the evolution of the aerosol plume released by the Nabro volcano in Eritrea in June 2011. Particularly noteworthy is the demonstration that, besides gaseous sulfur dioxide, substantial amounts of sulfate aerosol are present immediately following the eruption. To demonstrate this and to investigate the transport of the plume during the first few days after the eruption, a comprehensive multi-sensor approach is taken, and by and large, the

results and conclusions are fully supported by the evidence presented. Only with respect to the plume's vertical extent, the wording is sometimes ambiguous, and the vertical resolution of 3 km together with statements about an underestimation of the plume top altitude (that is never exactly quantified) make this analysis less quantitative than analyses based on CALIOP data presented in earlier publications (Clarisse et al., 2014; Fairlie et al., 2013).

The work represents a significant contribution to the analysis of the stratospheric sulfur injection from Nabro in particular and to the space-borne analysis of volcanic aerosols in general. It should be considered for publication in Atmos. Chem. Phys. subject to the specific comments and a few technical corrections listed below.

Specific comments:

Page 7741, lines 18 – 20: "..., we find that the initial volcanic plume (...) crossed the tropopause and was located at an altitude of at least 18–19 km within hours of the eruption." If it is truly a "we find", then the statement belongs to the results section, backed by observational or other evidence. With respect to the literature cited in the following sentence to back this statement, I think it is formulated somewhat ambiguous, because the wording implies a plume of small vertical extent situated entirely above the tropopause. This is clearly not the picture presented in the referenced literature: Clarisse et al. (2014) state that "with respect to the Nabro eruption, we have presented evidence that the initial plume was injected at altitudes between 15 and 17 km. A smaller part was injected higher up reaching 18.5 km according to CALIOP measurements". The trajectory analysis presented by Fairlie et al. (2013) clearly relates Sede Boker Lidar detections of aerosol between 13 and 17 km to the fist Nabro eruption.
I suggest rephrasing this to make clear that material from the first eruption was injected into the stratosphere, but not exclusively. The wording in Section 3 (page 7748, lines 13 – 16) is better in this respect.

Page 7747, lines 23 – 25: please explain briefly how this “geometrical airmass factor works”, or at least give a reference (and I would write “air mass”, i.e. two words).

Sections 4.1 and 5.1: you should briefly discuss the implication of the large areas of deep blue color in Figures 1 and 2 (the panels showing UVAI) in Section 4.1. Can this be clear sky, or do the high positive values denote a significant load of absorbing aerosol? If the latter, can you explain it? In Section 5.1 (page 7756, lines 18 – 20), you state that these positive UVAI values “could, in principle, be caused by volcanic ash”. In the following sentence (page 7756, lines 20 – 22), you also offer elevated dust as an explanation. But I don’t really see this in Fig. 1, panels g and h. Please explain how one can identify “elevated dust” in the MODIS images provided.

Page 7751, line 13: different people will interpret “high altitude” in different ways. For example, if you discuss whether the plume reached the stratosphere or not, then 11 km is not high altitude! I suggest rewording to “the volcanic plume must be above 11 km” (an exact, quantitative statement), or, even better, to “the bulk of the volcanic plume must be situated above 11 km” (I don’t think that you can completely and quantitatively rule out any presence of volcanic aerosol below 11 km).

Page 7753, lines 14 – 16: this seems a reasonable explanation, but another explanation for the extinction increasing towards the surface (i.e. to the lowest TA, correct?) could be that there is more aerosol at the lower boundary of your vertical measurement range than above. Or can you rule that possibility out based on your observations?

Page 7754, lines 26 – 27: I suggest replacing “are underestimated” by “might be underestimated”. To be absolutely sure of a factual underestimation (that is significant in the light of the 3 km vertical resolution) would require a more quantitative analysis of this particular profile.

Page 7758, lines 7 – 9: the AOT of 0.17 seen by the ground based lidar seems rather high. Please provide a reference for this number.

Technical corrections:

In all multi-panel figures, you use capital letters in the panels and captions as panel identifiers, while in the text, you always refer to the panels using small letters. Please use either small or capital letters consistently!

Page 7741, line 13: should be Theys et al., 2013 (not 2012)

Page 7746, line 9: insert a comma before “in which”

Page 7751, line 28: replace “found” by “shown”

Figure 5: use x-axis units consistently, either km^{-1} or 10^{-3} km^{-1}. And as you use two different ranges for the two SCIAMACHY states anyway, you may use 2.5 x 10^{-3} as the x-axis maximum in panel B (and in all the panels in Figure 9).

Figure 8: Please extend the latitude range in this Figure to 10 °N or even the equator! This will not cost you anything in terms of resolution, but show the volcano and probably the plumes from later eruptions, for which you make claims for overlap/no overlap with the first plume at several places in the text.

Figure 9, panel F: should be June 17, not June 15

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 7739, 2014.