

## ***Interactive comment on “Retrieval of the Eyjafjallajökull volcanic aerosol optical and microphysical properties from POLDER/PARASOL measurements” by F. Waquet et al.***

**Anonymous Referee #1**

Received and published: 6 April 2013

This is a good study, using both standard and research algorithms to derive volcanic plume properties from POLDER observations. The strengths of the combined multi-spectral, multi-angle polarization measurements are sensitivity to particle size and real refractive index, some constraints on particle shape, and the ability to retrieve AOT for plume over optically thick liquid water cloud, when  $AOT < 3$ . The paper is worthy of publication in ACP, though some clarifications and further consideration of a few points, summarized below, would significantly improve the paper in my opinion.

1. Introduction, P8665, line 24. Volcanoes are not the only, and often not even the primary source of natural sulfate aerosol. For example, over ocean, DMS emissions

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can be the main source.

2. Introduction, P8665, line 25. Although gravitational settling might be more rapid for volcanic ash than for sulfate aerosol, the relative impact of these species depends also on the relative optical depths, which vary from eruption to eruption, the particle absorption properties, and the likelihood of washout, which tends to affect sulfate more than dust.

3. Introduction, P8666, line 4. “. . .reach the free troposphere. . .”

4. Introduction, P8666, lines 19-20. In addition to the paper by Gasso (2008) that you reference, there are other papers, such as Scollo et al. (JGR 2012) and Kahn and Limbacher (ACP 2012), that use the visible part of the spectrum to characterize volcanic aerosol particle properties.

5. Section 2.1.1, P8668, line 1. The retrievals use total and polarized radiance at 0.67 and 0.87 micron, plus 0.49 for the research algorithm. As the information content depends heavily on the input data, it would help to know also what range of scattering angles was included.

6. Section 2.1.1, P8668, lines 6-7. Won't assuming that volcanic ash is non-absorbing in the visible cause the retrieved AOT to be underestimated? Ash absorption properties were reported from in situ measurements of these eruptions by Schumann et al. (ACP 2011). I see you discuss the real refractive index from Schumann et al. in Section 4.

7. Section 2.1.2, P8669, lines 17-18. What effect on the uncertainties in the results does assuming the indices of refraction are spectrally invariant and the same for the fine and coarse modes, when the fine mode is probably dominated by non-absorbing sulfate and the coarse mode is mostly ash that has spectrally varying absorption? 8. Section 2.1.2, P8669, line 26, Table 1. On what are the assumed a priori AOT and particles properties for the fine and coarse modes based?

9. Section 2.2, P8671, line 7. You might mention here that “AAC” means aerosol above

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cloud.

10. Section 3.1.1, P8672, lines 16-17. Are there MISR stereo heights for any part of the 16 April plume? If so, they might complement the CALIPSO heights, because they cover more extensive areas.

11. Section 3.1.2, P8674, lines 11-16. At least for the upwind case on 7 May, the plume itself is as narrow as 10 km. Given the 6 km pixel size for POLDER, could some of the observed variability be due to retrievals done on pixels partly filled by the plume?

12. Section 3.1.2, P8674, lines 16-27 and Figure 3. What are the uncertainties associated with the retrieved particle size distribution, fraction spherical, and SSA values? This information would provide important perspective on which details of the retrieved particle properties, and especially which differences between retrieval cases, should be considered significant.

13. Section 3.1.2, P8675, lines 1-3, Figure 4. This is confusing. At what latitudes is the plume being sampled in Figure 4? Based on Figure 2, it appears that -20° longitude would be near-source, and -15° would be downwind along the plume. Yet the AOT increases, and the Angstrom Exponent, single-scattering albedo, and fraction spherical all decrease going from -20° to -15°, which seems opposite what might be expected, and the subsequent discussion seems to indicate that -20° is actually farther away from the plume core. So I guess you are sampling at some fixed latitude across the plume rather than along the plume. As such, this must be showing plume vs. background particle properties rather than plume particle evolution downwind. Please clarify.

14. Section 3.1.2, P8676, lines 1-5. Could limitations in the assumed look-up-table particle properties, such as the particle shape model for volcanic ash, contribute to the surprising trends in the retrieved real refractive index and the fine-mode particle radius?

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15. Section 3.2.1, P8677, lines 14-16. The quality of Fig. 5b could be better, especially in the region where the plume crosses the cloud bow; it is very small, and difficult to see features. Much of the foreground, where the glint dominates, seems unneeded.

16. Section 3.2.1, P8677, line 23. It would be helpful to add the associated plot for typical cirrus to Figure 6a for comparison.

17. Section 3.2.2, P8680, lines 19-20. If you have a constraint on particle shape, in addition to particle size, this would strengthen the conclusion about whether the particles north east of the UK are volcanic ash.

18. Section 4, P8682, lines 6-11. Since Kahn and Limbacher (2012) analyzed the 7 May and I see also part of the downwind plume on 16 April, is there any point in making further comparisons between the results of the two studies.

19. Minor grammatical corrections scattered throughout: volcanic ash (not ashes), infrared radiation (not radiations), spectral behavior (not behaviors), particle absorption (not particles absorption), less than  $5 \times 10^{-4}$  (not inferior to  $5 \times 10^{-4}$ ), etc.

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Interactive comment on Atmos. Chem. Phys. Discuss., 13, 8663, 2013.

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