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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Physical and optical properties of 2010 Eyjafjallajökull volcanic eruption aerosol: ground-based, LIDAR and airborne measurements in France" *by* M. Hervo et al.

Anonymous Referee #1

Received and published: 10 October 2011

General comments:

Hervo et al. describe a method where ground-based in-situ measurements are used to characterize volcanic ash aerosols at Puy de Dome ($\approx$1.5km a.s.l., France). Using these measurements, the mass extinction ratio and the lidar ratio of the aerosol is calculated. In the next step, these parameters are used to calculate the mass concentration profile from measurements of a nearby backscatter lidar. The vertical and temporal development of the ash layers and their mass concentrations are intercompared in two case studies, whereby the lidar profiles, ground-based in-situ measurements, aircraft

in-situ measurements, and FLEXPART simulations are considered.

The manuscript contains interesting and original work. However, the description of the instruments and the methods is often too superficial, the uncertainties of the measured parameters are not properly accounted for and discussed, and the calculation of the lidar ratio seems to be flawed (see below). Therefore, I recommend to publish the manuscript in ACP only after substantial revisions.

Specific comments:

[page/line]

24632/18: "dominance" might be replaced by "presence": If the supermicronic particles were dominant with respect to Angstrom, the Angstrom would close to zero.

24632/24: Are the uncertainties of your method really this low? If you write the uncertainty in the abstract, please specify clearly what it covers. Otherwise such low uncertainties are misleading.

24636/3,4: Please add details about the "TEOM-FDMS 8500C", for example cutoff diameter, measurement principle, etc... I think it is a very important instrument in your study.

Section 2.1: In addition, the description of relevant details of the other instruments would also be very helpful.

24636/10: Please call this parameter "Angstrom exponent for scattering" or "scattering Angstrom exponent" throughout the manuscript because the default meaning for Angstrom exponent is for extinction.

24636/15: An Angstrom of 1 means that large and small particles are mixed and that they are almost equally relevant for the extinction (if 2 is assumed for small and 0 for large particles). Nevertheless, large particles might be dominant with respect to particle volume if the Angstrom is around 1. If "dominated" is meant with respect to particle volume, this should be mentioned here.

24637/3,4: "... Angstrom exponent is equal to unity (i.e. the absorption is independent from wavelength variation... ": This is wrong. The Angstrom exponent is zero for wavelength independent properties.

24637/8: How do you calculate the mass extinction factor at λ=355nm? Do you use Angstrom assumption? Do you assume wavelength-independent properties?

24637/5-9: Do the instruments measure "dry" or "wet" aerosol properties?

24638/14-21: It is well-known that the particle shape is highly relevant for the backscattering by aerosol particles (e.g. Mishchenko et al., 1997, doi:10.1029/96JD02110) and consequently also for the lidar ratio. As you mention, volcanic ash particles are non-spherical, thus I'm surprised that you use Mie theory for calculating the lidar ratio.

24638/20: How do you account for the difference in wavelength (lidar 355nm vs. maap 637nm)?

24638/20-21: Please explain in more detail how the refractive index is inverted. Is the measured size distribution also "dry"?

24642/2,3: Why is the asymmetry factor lower in case of volcanic ash aerosols (large particles) than for other aerosols (small particles)? Above, you mentioned that the asymmetry parameter is mainly a function of the size distribution. But then, your results are in contradiction with Andrews et al. (2006), who showed that the asymmetry parameter increases with increasing particle size.

24642/22: What is the "1.8μm particle concentration measurement channel"?

24645/3-4: The real part of 1.65 is a bit high for volcanic ash. A comment on this refractive index would be useful.

24645/4: Using spherical particles and a refractive index of 1.65+0.005i, it is hardly possible to get a lidar ratio of 52sr at λ=355nm. Mie shows that the lidar ratio of any

single particle in the range from about 0.4μm to 4μm diameter is lower than 50sr. For 0.6μm to 2μm particles, the lidar ratio is on average lower than 5sr. Their backscattering is on average more than 10 times stronger than for particles with lidar ratio 52sr! Only particles around 0.3μm diameter (or larger than 10μm) have a lidar ratio substantially larger than 52sr. The 0.3μm particles must be at least a order of magnitude more relevant for the extinction at λ=355nm than the larger particles in order to explain a ensemble-average lidar ratio of 52sr at λ=355nm. Please check whether the 0.3μm particles are really that dominating or whether your Mie calculations are flawed.

24645/4: If it turns out that 0.3μm particles are really dominating, the applicability of your mass extinction factor is questionable because the factor then critially depends on the presence of these 0.3μm particles. Are they really present in the layer at 3000m a.s.l. where the conversion factor is applied?

24645/4: How is the uncertainty of the lidar ratio derived?

24645/8: How is the uncertainty of the extinction derived?

24645/9: 461*1.42=655 not 700

24645/9: Would it be possible to estimate the uncertainty of the mass extinction factor and to consider it for the mass concentration? If you can not estimate the uncertainty of the mass extinction factor, this should be mentioned and discussed.

24645/9-11: A "consistency" check of the extensive properties (extinction, mass concentration) with results for a ash plume at a large spatial and temporal distance (over one month!) might be a bit far-fetched.

24645/14-15: How was the mass extinction factor derived here? It is lower than used at 3000m a.s.l. On what information is the height dependence of the mass extinction factor based? This should be explained.

24645/15: Why is the relative uncertainty of the mass concentration higher than for the extinction, while it was about the same for mass and extinction in line 8-9?

24645/15-24646/3: In Section "instrumentation and modelling" it was not clearly described what aerosol parameters were measured or modeled as "dry" or "wet". This should be elaborated in more detail. Otherwise the results and discussions are not easy to follow.

24650/23-26: Miffre et al. assumed a diameter of 10μm, which is 5 times larger than the 2μm found in your study. This difference in particle size would result in about 5 times higher mass concentrations in Miffre et al. than in your study (if all other parameters are the same). Thus, the diameter of 10μm from Miffre et al. does not explain the differences, rather it makes the difference of mass retrievals less understandable. Please try to explain the difference more consistently.

Fig. 4: There is a sharp decrease of the volume distribution between 2.5μm and 3.5μm. Is this realistic or an instrument effect?

Technical corrections:

24632/20-21: "... aerosol density, which was found ..." might be split into "... aerosol density. The mass-to-extinction ratio was found ...".

24633/24,25: add comma after closing brackets

24634/20: "Another high-altitude stations ..."

24636/2: add "particles" at the end of this line

24636/25: you may replace "=" by "$\approx$"

24637/7: "γ" should be replaced by "λ"

24638/9: "strong laser depolarization" may be replaced by something like "strong depolarization of the backscattered laser light"

24640/7: you may write "in heights of about 3000 m to 5000 m a.s.l. above ..."

24640/17: The symbol δ, introduced in Section 2, should be used here.

24642/5: replace "Diameter" by "diameter"

24642/25,26: "number size distribution ... centered at 2 micrometer": Probably "volume size distribution" is meant. You may also write "centered at 2-3 micrometer".

24645/10: replace "400-600 Mm^{-1}" by "400-750 Mm^{-1}"

24650/21: Minus to exponent.

Fig. 1: The UTC time in the upper panel and the caption do not agree

Fig. 2a: Is this the depolarization ratio of the volume or the depolarization ratio of particles only?

Fig. 2: Please improve the labels of the axis (e.g. time=UTC?, altitude=a.s.l.?)

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