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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ground-based and airborne in-situ measurements of the Eyjafjallajökull volcanic aerosol plume in Switzerland in spring 2010" *by* N. Bukowiecki et al.

Anonymous Referee #1

Received and published: 22 June 2011

General comments: The manuscript presents a unique dataset of observations of volcanic ash over Switzerland following the eruption of Eyjafjallajökull in April and May 2010. The measurements are analysed in great depth and allow for an assessment of the composition of the ash particles, the particle size distributions and an estimate of the mass concentration of volcanic ash over the measurement sites. The paper is clear and precise and provides valuable understanding of volcanic ash properties and transport processes. I highly recommend this paper to be published in ACP considering the minor comments listed below.

1. Does the paper address relevant scientific questions within the scope of ACP? yes

2. Does the paper present novel concepts, ideas, tools, or data? yes

3. Are substantial conclusions reached? yes

4. Are the scientific methods and assumptions valid and clearly outlined? yes

5. Are the results sufficient to support the interpretations and conclusions? yes

6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? yes

7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution? yes

8. Does the title clearly reflect the contents of the paper? yes

9. Does the abstract provide a concise and complete summary? yes

10. Is the overall presentation well structured and clear? yes

11. Is the language fluent and precise? yes

12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? yes

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? Yes, a few clarifications are needed. See specific comments.

14. Are the number and quality of references appropriate? yes

15. Is the amount and quality of supplementary material appropriate? yes

Specific comments: The specific comments are structured according to the sections of the paper, starting with a few general comments.

General:

It would be helpful to include an abbreviations list which would make it easier for the

reader to follow the manuscript. There are a lot of abbreviations and not always are they fully written out the first time they are mentioned. A check of abbreviations is needed where they are only written out once and after this an abbreviations list will help the reader. A clarification of the terminology is needed to distinguish between volcanic ash and volcanic aerosols (volcanic ash + sulphate). This is not used consistently in the current manuscript version.

Introduction:

P12952, L 13-14: VAAC is not located in London. Please change to e.g. " ..predictions by the London Volcanic Ash Advisory Centre (VAAC), which is part..."

P12953, L8: Please change "volcano plume" to "volcanic plume".

Methods:

P12954, L24-25: Why is there a considerable loss of particles with D>15 um in the sampling line?

P12954, L26: Please clarify what polystyrene latex spheres (PSL) means and that volcanic ash is a non-PSL aerosol. It is stated that non-PSL aerosols will result in a diameter shift due to different refractive indices. It would be helpful to shortly explain what refractive index means physically and how and why this is different for PSL aerosols and volcanic ash particles. Also later in the manuscript the refractive index term is used substantially, so a short explanation of the physical meaning of the term will help readers not so familiar with particle physics to more easily understand this.

P12955, L22: Section title "Analysis of air and snow samples by SEM, ICP-MS and IC" Please avoid abbreviations in section titles before they are explained.

P12957, L2: Please change "volcano eruption" to "initial volcanic eruption" or "during the first phase of the volcanic eruption".

P12957, L9: Is it necessary to include the abbreviation for visual flight rules, VFR,

which is not used further in the manuscript?

P12958, L6: Did you use ECMWF forecast fields for the simulations? The simulation was performed after the eruption as an analysis exercise and only the reanalysis data would be used.

P12958, L9-10: For the simulation only an ash mode particle of 3 um was used. Maybe it is helpful to mention that this is the peak in the measured volume size distributions at JFJ. This will further strengthen the choice of only using this mode for the simulations.

P12958, L10: Is this 4% of the mass estimated by Stohl et al 2011, or of the total erupted mass from the volcano? The mass estimated by Stohl et al is not the total mass emitted from the volcano, but fine ash in the size range 2.8-28 μm. How did you determine that 4% of the mass was in the 3 um mode?

Results and discussions:

P12959, L20-26: It is not very obvious that the first peak in SO2 and PM10 when there was a southerly wind direction and low RH (late on 17th April) is connected to the volcanic ash. There is a subsequent drop in SO2 which is mentioned but not elaborated further. This needs more discussion. How confident are you that this is volcanic ash even when SO2 values drop? Did the FLEXPART simulation show any ash cloud from south coming in over the station?

P12959, L26: Please discuss why there are two or three PM10 and SO2 peaks for the April event (one on 17th, 18th and 19th) while wind directions were rather constant. Could this reflect different emission pulses from the volcano?

P12959, L27: It is said that the plume was first detected at JFJ on 16 May. It is not obvious that these two small peaks in PM10 and SO2 are related to volcanic ash. The volume size distribution (Fig 1a) shows increased accumulation mode particles, which can suggest sulphate particles, but there is not a significant increase in the coarse mode particles for these two small peaks. Did your FLEXPART simulation show any

ash over the station on the 16 May that can support this? In the whole of this section it would be useful to try to distinguish between the increase in accumulation mode (suggesting sulphate particles?) and increase in coarse mode particles (suggesting volcanic ash?), and also to be clear in the terminology what you mean by volcanic aerosol plume/ volcanic influence. Are you talking about both sulphate and volcanic ash, or only the ash plume (on Figure 1 the events are marked as volcanic ash)? Please clarify.

P12960, L3-5: Again it is not obvious that this small PM10 peak late on the 19th May is related to volcanic ash. Is it possible to see from the FLEXPART simulation whether an ash plume was transported in from south over the station at this particular time? To me it seems that the two main peaks in April and May have a significant increase in both the accumulation mode and the coarse mode particles. The small peaks in April and May do not clearly show this, with only a significant increase in either the accumulation or the coarse mode. As mentioned, a discussion on sulphate versus volcanic ash aerosols and clearly define volcanic aerosol plume may help this interpretation.

P12959, L27: It is said that the plume was first detected again later on 19 May. I believe it is later on 18 May according to figure 1.

P12964, L7-8: "The imaginary part decreases indicating less absorbing (more transparent) particles", this is in contrary to P12963 L25-26 where you indicate presence of a significant portion of absorbing species within the volcanic ash coarse mode. Please clarify.

P12964, L8: The real part shows no significant change (figure 10). This is not so obvious from the figure. It seems to increase for the maximum volcanic aerosol influence? What does the real part of the refractive index tell us physically and what does it mean if it has no significant change or if it increases?

P12965, L 6-7: The observed number concentrations on 18April was lower than on the 17th for the aircraft measurements, which is opposite of the Jungfraujoch measure-

ments. What can the reasons be? Didn't the aircraft "hit" the ash plume, or only on the very edge of it? Figure 14 and 15 show that on 17 April the aircraft was more in the centre of the plume.

P12965, L14-16: The measured volume concentration on 18 May from DIMO was 5-10 times higher than the corresponding Jungfraujoch measurement (fig 12). What can be likely reasons for this? Was the aircraft closer to the centre of the volcanic plume (where is Biel and Emmental and how far is that from JFJ, from Figure 11 this is not seen)? Can you refer to the FLEXPART simulations to explain the difference in volume concentration from DIMO and JFJ to the locations of the measurements and whether they were taken more in the centre of the ash plume or at the edge (Figure 16 shows this)?

P12966, L10-11: Do you mean the contribution of volcanic ash or volcanic aerosol (ash + sulphate?)? Please define TiO2 and why this can be used as a tracer for volcanic aerosol.

P12966, L19: "A value also supported by FLEXPART". Is this shown on any figure?

P12967, L7-10: Even though the weather conditions at Jungfraujoch was fairly stable, there are local meteorological conditions in the mountain area of the Swiss alps which will lead to a heterogeneous plume, however these local effects are often not very well captured by the meteorological input data to the model, and thus increased uncertainty of the modelled plume is to be expected.

P12697, L13 and L24: Please change "the data" to "the model data".

Appendix A1:

P12970, L14-15: It would be helpful to shortly describe what the real and imaginary parts of the refractive index tell us about the particles. Also, why are you varying the index parts in this range (real 1.4-16., imaginary 0i-0.005i)?

P12970, L15, and P12971 L9: Can you say "the Mie wiggles", or better "the scattering

cross section wiggles"?

P12971, L19: "as shown in Figure 12", and discussed in which section?

Appendix A2:

P12971, L27: Is it necessary to refer to Fig. 21 at this stage without more explanation?

P12972, L28: Please revise the unclear sentence: ", because the large and correction factor.."

Figures:

Figure 3: On the b panel the left axis should be coloured according to the line (black).

Figure 4: Please specify all the chemical species shown in the figure.

Figure 11: It is not possible to see on a print version the labels of the marked cities. Can you also mark the location of Jungfraujoch? Either this figure needs to be revised with a larger right side panel, or the whole figure needs to be enlarged for the final version.

Figure 17: It is not clear from the figure what the effect of increasing imaginary part is as the line colors are the same for constant real part and changing imaginary part. Consider using the same line color and structure as in Figure 18. In the figure caption insert "Calculated Mie scattering.."

Figure 18: Change the caption to "The OPC diameter correction" instead of "The Figures shows OPC.." Also it is said that "..for a complex refractive index of 1.54 + 0.005i", but the imaginary part varies.

Figure 20: It is not possible to distinguish the blue lines with different symbols. Consider revising the figure with different line settings. Alternatively it could be stated that the differences are small and what the range is.
