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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Influences of the 2010 Eyjafjallajökull volcanic plume on air quality in the northern Alpine region" *by* K. Schäfer et al.

K. Schäfer et al.

klaus.schaefer@imk.fzk.de

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We thank the referee no. 1 for the constructive comments to our paper. We answer during the interactive discussion with the following and repeat the referee statements first.

"Chapter 2: You have only one site in Austria (Innsbruck), but in addition there are regional sites like Sonnblick, Illmitz and St. Koloman that could have complimentary measurements? Switzerland is not included in the study, but there are a lot of advanced measurements at Jungfraujoch that should be of interest. At least if there are similar studies with observed increase in the SO2 and PM levels that should be some referred to. Jungfraujoch is mentioned in chapter 4.1, but no reference." A comprehensive analysis of the spatio-temporal evolution of the volcanic ash cloud across Austria is

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beyond the geographical scope of this paper (Bavarian alpine forelands and adjacent areas). We therefore excluded the eastern Austrian regions, thereby did not consider the sites you suggest. Based on preliminary analysis, however, Innsbruck was found demonstrating the basic characteristics of the event after crossing the Northern alpine ridges. This is also important in context of synoptic analysis and to relate this paper to Emeis et al. (2011) in this issue. Addressing your comment nevertheless, we will present an extended analysis demonstrating the representativeness of Innsbruck for the Northern Alps. To avoid overloading the text, this may come as a supplement. The manuscript text is updated accordingly. The station Jungfraujoch (JFJ) is, as mentioned by the reviewer, outside the core study area as well. We therefore do not mention these results (of SO2 and PM10) which are however comparable to our own observations. A first increase of SO2 and PM10 concentrations was recorded at JFJ during late night of 17 April while the maximum concentrations were seen in the early afternoon on 18 April. A second maximum was observed on 19 April around noon. PM10 values peaked around 40 μg m-3 while SO2 concentrations were almost 4 μg m-3 or around 1.5 ppb (both on 18 April), being quantitatively in line with the results from HPB and ZSF. The JFJ results were presented by U. Baltensperger (PSI, Switzerland) during the AERONET III workshop held at Brussels in June/July 2010 (AERONET III – Workshop Volcanic Ash Impact to Aviation "The Eyjafjallajökull Incident. The European Air Traffic System Reaction to a Sudden, Uncontrollable and Paralysing Event", Brussels, 30th June – 1st July 2010). To our knowledge there is currently no reviewed paper available discussing these measurements.

“Chapter 3.2.: The SEVERI images can distinguish between ice and ash/dust, but how to be sure you distinguish between regular dust (wind blown mineral dust in particular) and volcanic ash? It is not clear from the text whether the SO2 product from SEVIRI has been combined or used together with the ash and dust product to identify what is really from the ash cloud and not from dust. Have you looked at any CALIPSO data to see if it is possible to identify any vertical profile of the ash cloud, or was it no overpass in the particular period? Ch 3.4 and Fig 1. It

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would help the reader if the same abbreviations used in 3.4 and later in the text and in figure 9 is identified in Figure 1 as well." We added an explaining paragraph about dust recognition and SO2 from SEVIRI and application of additional satellite data to Chap. 4.1 and Chap. 3.2, respectively. CALIOP/CALIPSO 532 nm backscatter lidar on polar orbit was however not crossing the area of interest in time and during cloudless conditions (e.g. at 17 April, 2:47 and 12:41: http://www-calipso.larc.nasa.gov/products/lidar/browse_images/show_date.php?s=production&v=V3-01&browse_date=2010-04-17). We used the same abbreviations of the stations as in the manuscript (Chap. 3.3 and later in the text) in the captions of Figs. 1, 8 and 9.

"Chapter 4.2, line 16-30: Not sure if the paragraph is complete or at least it may be misunderstood. In line 26 it seems you miss the word primary, i.e. "urban primary anthropogenic emissions"? You describe formation of UFP from secondary aerosol from anthropogenic sources only using SO2 as an example ? NOx is much more important, especially in urban environment, and VOC. NH3 from agricultural sources could be mentioned as well if you want to describe a more complete picture." In this chapter we discuss the formation of UFP only at the two monitoring sites already described by Flentje et al. (2010): ZSF and HPB. Especially at ZSF no anthropogenic influence is expected. Moreover, no increase of other gaseous precursors for UFP (NOx, VOC, NH3) is observed at those locations and we did not expect an important contribution of enhanced VOC oxidation so that we concentrate our discussion on SO2. On the other hand, the correlation between SO2 and UFP at both measurements sites is high in the period under observation. In addition, this is the case also for SSL, another site without anthropogenic influence (see Figs. 1, 2 and 3). Therefore, we assume that the increase of UFP could be mainly caused by the formation of H2SO4 from oxidation of SO2 to SO3, at least at all monitoring sites without anthropogenic background. Only in Augsburg (AUHS, urban background) no correlation between SO2 and UFP was observed and the identification of an UFP peak originated from the volcanic plume is not possible. We made it now more clearly for the reader (chapter 4.2, page 9096, line 20, until page 9097, line 16).

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"Chapter 4.3: It is a bit strange division of chapter into who is operation the sites rather than the topic. Therefore the title of the chapter is a somewhat uninformative for the reader. Rather redefine the title of this chapter to measurements of trace elements to estimate PM10 mass enhancement caused by the plume or something similar. It is a nice chapter utilizing the tool of trace element enrichment. Maybe it would be good to add a few sentences of what type of enrichment we would expect from other sources (relevant industry, traffic –tyre brakes etc) to indicate potential uncertainties in the methods and the fact that some elements are more suitable for the purpose than others. Schauinsland (SSL) also has measurements of trace elements in PM10 (UBA Germany). If possible this data should also be included. The PM10 results, are this daily (24h) averages? And at these particular days do the sites exceed the daily limit value of 50ug/m3? If so is it due to the volcano or would it been above anyway? You write in the conclusion that the volcanic ash caused PM10 threshold exceedances in the region. Is that really proved?" We improved the title and the content as proposed. SSL and ZSF PM10 samples could not be analyzed in the same way as the LÜB data because different filters were used in those samplers (glas fibre filters instead of quartz fibre filters in the LÜB). The PM10 results are daily averages. At some of the investigated sites (MÜLA, AUBÜ) and several other sites in Bavaria the PM10 daily limit of 50 μg/m^3 was exceeded due to the volcano ash impact. This is proved by elemental analysis of PM10 samples described in this paper. These exceedances were reported to the European Commission to be caused by natural sources (volcano ash).

"Chapter 4.4.3 and 4.4.4: It is a bit contradiction comparing the two nearby sites where one observes a reduction of SO2 at HPB during precipitation event but not the same at ZSF You could also use precipitation data from Schauinsland (SSL) for comparison to get a more complete picture on the effect of wet scavenging." Chapter 4.4.3: The differences in the temporal variation of SO2 concentrations at HPB and ZSF due to precipitation are caused by the differences in the precipitation amount: very low amount at ZSF (0.04 - 0.07 mm on 18 April from 11:00 to 13:00). The SO2 concentration levels at ZSF were not subject to reduction by precipitation. Chapter 4.4.4: The precipitation

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analyses data from SSL are unfortunately not yet available for a comparison with the analyses results from HPB.

Additionally, the Figures 5, 6, 7 and 11, which are of low quality, have been exchanged.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 9083, 2011.