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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Sulphur dioxide as a volcanic ash proxy during the April–May 2010 eruption of Eyjafjallajökull Volcano, Iceland" *by* H. E. Thomas and A. J. Prata

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This paper presents some interesting work that is of great relevance to the work of Volcanic Ash Advisory Centres (VAACs) who provide advisories on the presence of ash to the aviation industry. It discusses the major challenge of accurately observing ash. The paper uses the recent, high impact eruption of Eyjafjallajokull and is therefore of current interest. It's well written and presents ideas that are of current consideration to VAACs.

1. In the introduction please explain why "SO2 clouds may also be associated with very ïňĄne ash particles" or provide a reference.

Carn et al., 2009 give the example of an encounter with the Redoubt ash cloud in December 1989 where ash abrasion was reported on aircraft although no ash was detected in this aged volcanic cloud.

2. Under the heading "Ash retrievals" you write "the refractive indices of the ash are predetermined", please explain how these are predetermined. What composition is the ash? Is this known or is it an assumption that has a signiïňĄcant impact on results.

The refractive indices of andesitic ash particles, consistent with the findings of Sigmundsson et al.,(2010), were defined as a function of wavelength (Pollack et al., 1973) are interpolated and convolved with the SEVIRI response functions. Incorrect attribution of the refractive index will affect the accuracy of the retrieval but this is likely to be small (Wen and Rose, 1994). No other information on the sensitivity of the retrieval to refractive indices are provided in the literature.

3. In the same paragraph, please explain how and why the satellite data are "atmospherically corrected".

Atmospheric correction of satellite data prior to the retrieval of volcanic ash involves using infrared brightness temperatures in two infrared channels between 10 and 12.5 um to estimate the amount of BTD shift caused by lower tropospheric water vapour (Yu et al., 2002).

4. Under "SO2 retrievals" it would be useful to describe what information can be obtained from CALIPSO's lidar. This also applies to section 3.4 (7 May) when you write" this layer shows a low attenuated colour ratio (ACR) and also low depolarisation". These terms need explanation including how they infer information on ash / SO2.

CALIOP measures atmospheric backscatter profiles at 532 and 1064 nm up to 40 km altitude as well as a perpendicular backscatter component at 532 nm (Vaughan et al., 2004). Returned products available in the browse images include the total attenuated backscatter at 532 nm, the depolarization ratio and the attenuated colour ratio (1064

/ 534 nm). Small particles return lower values of attenuated colour ratio due to the lower amounts of backscatter at 1064 nm. The amount and ratio of backscatter from the lidar measurements can provide information in to the vertical extent and location of volcanic ash and sulphate aerosols (which are genernas well as providing some details regarding particle size and type (Thomason and Pitts, 2008).

5. In section 3.2 (15 and 16 April) you write "this conservative estimate of the cloud dispersion could have beneïňĄted from the additional information provided by the satellite data". You need to make it clear that the London VAAC did use satellite data to provide information on the cloud dispersion but that satellite observations have their limitations. The VAAC provides forecasts so the satellite data can only help with the present situation and forecasts can be adjusted from this point forward. It would be useful to provide some discussion on the detection limits of the satellite instruments. You have mentioned that infrared SO2 retrievals are limited to the upper troposphere and lower stratosphere due to water vapour, but not the limitations of the ash retrievals (e.g. particle size, thermal contrast, water/ice). Can low concentrations of ash be detected? There may be cases where the model predicts ash, but none is observed – can you be sure that no ash is present ? 6. In section 3.3 (4 May) you write "using SO2 retrievals to locate the cloud where ash retrievals may fail"; this illustrates my point above.

The detection limit of the SEVIRI ash retrieval has been determined as approximately 0.5 g m-2, with the accuracy of total mass loading accuracies being $\pm$50 % (Prata and Prata, 2010). The detection limit for the SO2 retrievals have been determined as around 2 DU for IASI (Clerbaux et al., 2009), 5 DU for AIRS (Thomas et al., in press) and 0.6 DU for both OMI (Brinksma et al., 2003) and GOME-2 (Rix et al., 2008).

A paragraph describing the detection limit and the limitations due to water vapour etc. of the ash retrieval has now been added to the manuscript.

7. In section 4 (Conclusion) you write that "We have shown that although for the majority of the eruption the gas and ash are collocated". I am not sure that you have shown

this, because you only illustrate a few cases. Perhaps you should write something along the lines of "We found in our studies that the majority of the eruption the gas and ash are collocated ..."

Agreed – this has been altered to Satellite data indicates that for majority of the eruption the gas and ash were collocated, although there are some instances where the two species do vary spatially.

8. Also in section 4 you refer to failure of the ash algorithm. This links to my earlier point that the limitations of ash detection need to be outlined. Why was ash not detected? Is it due to limitations of the method or is there little or no ash to detect?

This is difficult to address in the scope of this paper as there is no additional information on whether or not there was ash present in the cloud for this case. We can only speculate that there may have been ash there (as the MODIS image suggests), which may not be detected due to the meteorological water vapour.

9. In the final paragraph of the conclusion, you write that it is important to monitor both ash and SO2, do you suggest that VAACs should assume that fine ash may be present in a SO2 cloud even if no ash is detected? This is a very interesting problem. It is safest to say that ash may be present in SO2 plumes, but this may lead to an overestimation of the plume coverage.

One of the main issues in sensing volcanic clouds is that is is much more difficult to detect ash and when SO2 can be detected, it might be speculated that at least a small amount of ash might be present with it, until proven otherwise.

Technical corrections 1. I suggest that "constant" rather than "consistent" may be a better word to use in section 3.4 (7 May) in the sentence "These data demonstrate that although wind direction is fairly consistent ..."

This has been amended.

2. The caption for Fig 8 contradicts the text. I think that it should say "The windfield

data shows a stronger southerly component at higher altitude ..." Again, agreed, this has been amended.

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