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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

**H. E. Thomas and A. J. Prata**

hethomas@mtu.edu

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Anonymous Referee #1 Received and published: 6 May 2011 Main Comments: The paper does not go deeply to the various differences of the measurement techniques, but simply studies the differences by comparing visually the estimated plumes. A deeper analysis on the differences between the measurement techniques would make the paper stronger. Now it speculates that IASI and AIRS are not sensitive to the SO2 at lower layers. Would it be possible eg to compare GOME-2 and IASI SO2 quantitatively by showing the differences or some measures of differences (see also below last comment)? Also, I think that it would be useful to include a bit more discussion about the general accuracy of the SO2 and ash satellite measurements. Also the effect of clouds vs SO2/ash plume could be discussed. The results and observed differences could be also compared to the expected accuracy.

A more in depth discussion of the different techniques is now included in the manuscript. However, we feel that a detailed inter-sensor comparison is beyond the remit of this paper, whose aim is to document the differential transportation of ash and SO2. We refer to Prata et al., (2003) and Thomas et al., (in press) for further discussion of these points.

Minor comments: P-7762 L-8: unclear what the saturation means here and how it affects the measurements.

The retrieval band becomes saturated due high concentrations of absorbing species which reduces the sensitivity of the band to changes in SO2 concentration. This is outlined in detail in Prata and Bernardo, (2007) which is cited in the manuscript.

Section 2.1. Ash retrievals: Is there some information about the accuracy of the SEVIRI instrument and reference?

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).

Section 2.2 SO2 retrievals: Is there some information about the accuracy of the IASI, OMI, GOME-2 SO2 measurements and references? How do eg clouds affect the measurements.

Clerbaux et al., (2009) estimate a sensitivity for the IASI retrieval down to 2 DU, but so far a thorough validation, error analysis and inter comparison of retrievals has not been undertaken.

For OMI, error in estimates of the a priori cloud altitude can result in errors of up to 20 % or 15 % respectively, depending on whether the altitude is over-or underestimated (Yang et al., 2007). Further error due to the nonlinear effect can result in underestimation of total SO2 column by 20 % (for a 100 DU column) up to 70 % where SO2 loadings are high (400 DU) (Yang et al., 2007). For GOME-2, Heue et al., (2011) estimate retrieval of SO2 vertical column density accuracy at approximately 1.3 DU for Eyjafjallajökull measurements which provides a minimum error of around 25 % for the data presented here. Although the UV retrievals include terms to account for thin or broken clouds, molecular scattering, gas absorption, aerosols and Rotational Raman Scattering although presence of dense meteorological cloud or significant aerosol can mask the volcanic signal (Yang et al., 2007; 2009).

P-7764 L-27: Last sentence is a strong point and it is strongly related to the sensitivity and accuracy of the satellite measurements. It also emphasizes the need of careful validation of the satellite measurements to conïňĄrm that when the satellites do not see anything it also means that the values are below the ïňĆight safety ash concentration thresholds. These points could be discussed more.

P-7764 L-21. Could you, please, clarify if (and what?) data was included in the VAAC model?

Satellite observations are compared to the prediction issued by the London VAAC using the operational dispersion model, NAME III (Numerical Atmospheric – dispersion Modelling Environment) (Jones et al., 2007). The model is a Lagrangian dispersal model, uses inputs of meteorology from either the Met Office Numerical Weather Prediction (NWP) Unified Model (UM) or ECMWF (Jones et al., 2007). During the eruption, particle size was predefined with a six-bin distribution (0.1 – 100 $\mu$m; peak at 10 - 30 $\mu$m), ash density fixed at 2300 g m-3, a constant ash eruption rate of 1 x 109 g s-1 and plume height based on three hourly observations provided by the Icelandic Met Office were used (Mylne, 2010). The model allows for gravitational settling and wet and dry deposition processes, although no attempt is made to model the volcano or plume rise dynamics (Mylne, 2010). Predictions were released on a six-hourly basis for the north Atlantic region and are available online from http://www.metoffice.gov.uk/aviation/vaac/.



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Figure 5: Since the OMI data is missing (row anomaly) below the track of the CALIOP at the orbit 14:34 it might be more informative to use OMI data from the previous orbit (about 100 min earlier). Also, the lower row of CALIOP measurements need more clariïňĄcation.

The OMI overpass at around 12 noon has been added to the figure. However, there is still a data gap within the region of the pink circle as this is outside the swath edge of this orbit. The later orbit is also shown on the figure as this is the one which actually coincides best temporally with the CALIOP data. Additional annotation has been added to this figure.

Figures in general: The labels should be larger in all ïňĄgures.

All labels have now been made larger in the figures.

It would be good to analyze also the differences between the measurements more quantitatively (GOME-2 and IASI, AIRS and OMI). This might not be totally straightforward but it would be very useful. However, some indicators like size of the spatial distribution, maximum values, distribution of values etc could be analyzed and compared. Again, this is outside the remit of this article and could be investigated in another study.

Prata, A. J., and Bernardo, C., 2007, Retrieval of volcanic SO2 column abundance from Atmospheric Infrared Sounder data, Journal of Geophysical Research, 112, D20204, 10.1029/2006jd007955, 2007.

Prata, F., and Prata, A., 2010. Eyjafjallajokull volcanic ash concentrations determined from CALIOP and SEVIRI measurements (Invited), AGU Fall Meeting Abstracts. Prata, A. J., Rose, W. I., Self, S., and D. M. O'Brien, Global, long-term sulphur dioxide measurements from TOVS data: A new tool for studying explosive volcanism and climate, In Volcanism and the Earth's Atmosphere (ed. Robock and Oppenheimer), Geophysical Monograph. 139, 75-92, 2003.

Thomas, H. E., Watson, I. M., Carn, S. A., Prata, A. J., and Realmuto, V. J.: A compari-



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son of AIRS, MODIS and OMI sulphur dioxide retrievals in volcanic clouds, Geomatics, Natural Hazards and Risk, in press.

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Interactive comment on Atmos. Chem. Phys. Discuss., 11, 7757, 2011.

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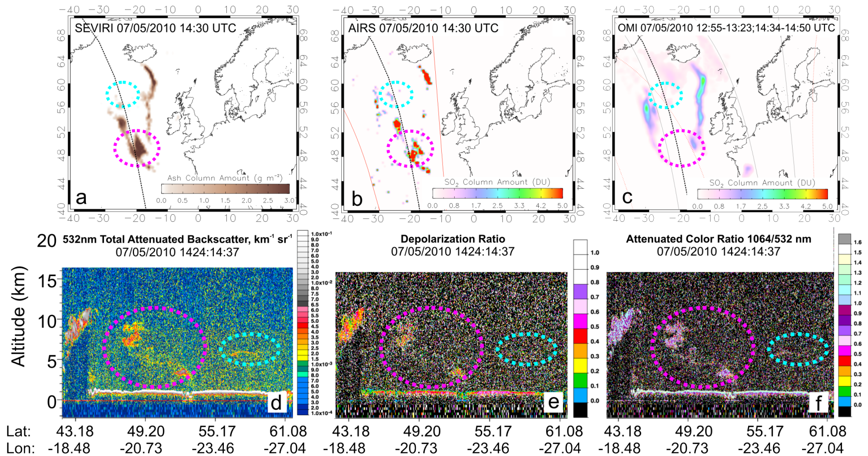


Figure 5: Retrievals of ash and $SO_2$ for May 7 from SEVIRI, AIRS and OMI (a-c) as well as the coincident data from the CALIOP spaceborne lidar (d-f). The pink and turquoise circles indicate where the lidar track crosses the cloud and the associated features visible in the lidar imagery. The dashed black line defines the ground track of the lidar. As before the red dashed lines indicate the swath edge of the polar orbiting instruments and the grey lines delimit the OMI row anomaly, between which no useable data are acquired.

**Fig. 1.** Figure 5



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