Atmos. Chem. Phys. Discuss., 7, S1678–S1682, 2007
www.atmos-chem-phys-discuss.net/7/S1678/2007/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Long range transport and fate of a stratospheric volcanic cloud from Soufriere Hills volcano, Montserrat" *by* A. J. Prata et al.

A. J. Prata et al.

Received and published: 9 May 2007

Response to Reviewer

We are somewhat perplexed by the Reviewer's comments and surprised by them. Here is our rebuttal:

1. The movie files (there are 3) were generated from FLEXPART, a highly complex particle dispersion model, and from satellite data. Movies were made because they convey temporal information in a much better way than either words or a series of line graphs or contour plots could. Advanced media of this kind requires

sophisticated tools and we believe this is both an informative and appropriate method of presenting data. The comment about the movie files being “pretty pictures" is gratuitous and requires no rebuttal.

2. The use of SEVIRI data is not premature. SEVIRI has been in orbit for more than 2 years and the data have been calibrated. Validation of the SO_2 algorithm is problematic–there are simply not enough independent data on SO_2 to do this well. Prata and Kerkmann (2007) describe the algorithm used to determine SO_2 from SEVIRI. We will add this reference to our paper.

3. The Reviewer states this is a small, localised eruption. It spread 18,000 km and was detectable for more than 3 weeks, and was the largest injection of S into the stratosphere during 2006. It was not local. The Reviewer is incorrect in this observation.

4. AOD is a measure of the “clarity” of the atmosphere due to all types of atmospheric pollutants. SO_2 converts to H_2SO_4 which is responsible for the radiative effects on climate (SO_2 itself has some radiative impacts), thus we think if SO_2 can be used directly in models that would be better. A first step is surely to use SO_2 to determine the AOD and then feed that into models. A paper by Ammann (2003) uses the total sulphate burden as volcanic forcing in GCM simulations (rather than AOD). Total sulphate burden is the primary factor controlling the radiative perturbation (Stothers, 2001).

5. The Reviewer’s comments about Crutzen and Wigley’s work should be addressed to those authors. We take no position on the value of such a geo-engineering approach to combat climate change, and leave the judgement of whether this concept is flawed or not to others. However, we firmly believe that such a judgement needs to be based on actual observations. If we want to avoid a possibly dangerous and pre-mature interference with the Earth system, for these observations we need to rely on natural events. SO_2 injections by volcanoes are the best

ACPD

7, S1678–S1682, 2007

analogue we have and, thus, by quantifying the stratospheric sulphur content following such events, we are informing the debate.

Specific comments

1. (4660/22) We are not sure what kind of large particles the Reviewer is referring to. It is generally observed that the brightness temperature difference (BTD) is largest for ice and smallest for large water droplets (e.g. Inoue, 1985; Wu, 1987; Parol *et al.*, 1991). For supercooled water droplets and ice particles, the larger the size, the smaller the BTD. This is a consequence of increasing opacity with particle size and depends on the ratio of the absorption coefficients at the two wavelengths used. To get large temperature differences (we observe BTDs of 12-15 K) the cloud must be semi-transparent and contain ice. The whiteness therefore is most likely due to ice.

2. (4661/10 and Fig 2.) The algorithms and techniques are described in Prata and Kerkmann (2007).

3. (4661/12) The Reviewer is incorrect. Large particles do not produce large brightness temperature differences.

4. (4661/15) The consensus of opinion of experts working in this field is that ice is a ubiquitous component of volcanic clouds, especially at tropical latitudes. Our data supports that notion–regardless of the origin of the water forming the ice.

5. (4661/10) Please see Prata and Kerkmann (2007) for details of the SEVIRI algorithm. Errors: The error quoted is an assessment of the precision based on the NEΔT of the sensors' channels and the error associated with assumptions

ACPD

7, S1678–S1682, 2007

Interactive Comment

and approximations used in the algorithm. The 30% figure quoted is a conservative accuracy estimate based on potential confounding effects (e.g. clouds, water vapour). While we believe the algorithm is reasonably precise we are less confident about its accuracy. It is reassuring to note that the 3 (independent) sensors measured similar SO_2 amounts in this cloud. As described in our paper the peak values were: 0.177 Tg (SEVIRI), 0.178 Tg (AIRS) and 0.22 Tg (OMI).

6. (4663) One possible reason why the HCl and SO_2 were not observed to be co-incident is due to the spatial sampling of the MLS. The MLS HCl measurements are made at a much coarser scale and with poorer spatial sampling than that for OMI. Thus it is entirely possible that parts of the HCl concentration cloud were not captured by MLS.

Technical

1. (4658/3) Great heights in this context refer to stratospheric heights, or altitudes where the SO_2 has penetrated the tropopause.
2. (4658/21) We are happy to re-word this sentence.
3. (4661/14) It is accepted usage that ash is pollution. We follow common usage. The Reviewer is referred to the following resources for information (from 3 different "English speaking" countries):

   http://volcanoes.usgs.gov/Hazards/What/VolGas/VolGasPollution.html
   http://www.york.ac.uk/depts/eeem/gsp/esm/issues/volcanic.htm
   http://www.cru.uea.ac.uk/cru/info/causecc/
   http://geography.otago.ac.nz/Courses/283_389/Resources/palaeo/Volcanoes.html

4. (4670/Fig. 1) We agree that the reproduction of the Figures was less than ideal, but this was beyond our control. We are happy to scale-up the Figures for clarity.

ACPD
7, S1678–S1682, 2007

References

Ammann, C. M., G. A. Meehl, and W. W. Washington (2003), A monthly and latitudinally varying forcing data set in simulations of the 20th century climate, *Geophys. Res. Lett.*, **30**(12), 1657, doi:10.1029/2003GL016875.

Inoue, T. (1985) On the transparent and effective emissivity determination of semitransparent clouds by bispectral measurements in the 10 μm region, *J. Meteorol. Soc. Jpn.*, **63**, 88-98.

Parol, F., J. C. Buriez, G. Brogniez, and Y. Fouquart (1991) Information content of AVHRR channels 4 and 5 with respect to the effective radius of cirrus cloud particles, *J. Appl. Meteorol.*, **30**, 973-984.

Prata, A. J., and J. Kerkmann (2007) Simultaneous retrieval of volcanic ash and SO_2 using MSG-SEVIRI measurements, *Geophys. Res. Lett.*, **34**, L05813, doi:10.1029/2006GL028691.

Stothers, R. B., (2001) Major optical depth perturbations to the stratosphere from volcanic eruptions: Stellar extinction period, 1961$-$1978, *J. Geophys. Res.*, **106**(D3), 2993-3003.

Wu, M-L. (1987) A method for remote sensing the emissivity, fractional cloud cover and cloud top temperature of high-level, thin cirrus, *J. Clim. Appl. Meteorol.*, **26**(2), 225-233.

ACPD

7, S1678–S1682, 2007