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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Volcanic SO_2 fluxes derived from satellite data: a survey using OMI, GOME-2, IASI and MODIS" *by* N. Theys et al.

A. Durant (Referee)

adu@nilu.no

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General comments

The authors provide a comprehensive review of methodologies to calculate sulphur dioxide (SO2) fluxes from volcanic sources and compare satellite instruments operating in the ultraviolet-visible (UV-VIS) and thermal infrared (TIR). This is an important and timely study, and the paper is well-written with clear figures.

Specific comments

(1) 31352 L3 The definitions of "explosive" and "effusive" eruptive activity should be strengthened. These types of activity relate to the erupted materials. Broadly speaking, effusive activity erupts lavas (molten rock flows) and explosive activity erupts pyroclasts

(rock fragments). Also "Plinian" is out of context as there are many other categories in explosive eruption classification. The presence of SO2 in a volcanic plume/cloud cannot be taken as a proxy for volcanic ash. Fire fountaining is a form of explosive activity, and in reality, there is a continuous spectrum between "explosive" and "effusive" activity.

I suggest the following modification:

"Volcanism is the surface expression of internal processes, driven by heat generated in the Earth's interior. During eruptions, solid, liquid and gaseous products are generated. The main driving force behind eruptions is exsolution of gas from magma during decompression which drives ascent through the Earth's crust. Volcanic activity may be classified into two main types:

Explosive activity: Rapid exsolution of volcanic gases in the volcanic conduit (vent) generates an ensemble of particles (tephra) through fragmentation that is ejected explosively into the atmosphere forming a plume. Heat is derived from the erupted tephra and emitted gases, and atmospheric air is entrained which increases buoyancy. Additional latent heat may be released as water condenses and freezes in the plume. Volcanic plume heights may reach altitudes well into the stratosphere and the maximum height depends on the mass flux rate (amount of material released as a function of time), the size distribution of erupted particles, and the local wind field.

Effusive activity: Driven by gas exsolution, although at lower rates than during magma fragmentation, molten rock products (lava flows) are erupted at the surface. While this style of activity does not result in particle generation, magmatic gases released are hot and may still produce a significant plume. Thermal energy is also available from the lava, however, these plumes tend only to reach mid-tropospheric levels except in some exceptional cases."

(2) 31362 L7 Does temperature also play a role here? Furthermore, how about the effect of particle surface area in the cloud (e.g., ash surfaces) to catalyse heteroge-

neous chemistry? And how about “wet” deposition (i.e., hydrometeor formation) and sequestration of gases in water e.g., ice? See Rose et al. [1995] for a good example.

(3) 31376 L9-13 Going back to the definition of effusive versus explosive activity, the gas plume that reached the tropopause is plausible; the type of eruption is defined by the presence of erupted tephra, or the absence of it. Also, the definition of a “Plinian” eruption is not simply a function of the height of the column, it is related to the mass eruption rate of tephra, and also on the size characteristics of the erupted material. Please remove all reference to “Plinian” in the paper – it is not relevant to this study.

(4) Please add a systematic and objective comparison of the different satellite sensors. This could include plots that show percentage differences between the sensors, and/or a table could be included that gives quantitative information on the following: 1. spatial resolution; 2. temporal resolution; 3. sampling frequency; 4. height sensitivity of retrieval; 5. error estimate. This could also be an extension of Table 1.

Technical corrections

31350 L8 Please add a reference to “ultraviolet-visible (UV-VIS) and thermal infrared (TIR)” techniques in this sentence. Also please specify the names of the satellites and techniques that are discussed in the paper.

31352 L5-6 “The SO2 flux is often used as a proxy for the eruptive rate. . .” Better to write, “Changes in SO2 flux are often used as an eruption precursor . . .”. Also, an increase in SO2 flux may indicate that a shallow magma body has started to migrate upwards towards the surface. Please add this point.

31353 L12 “.. are widely carried out from ground since . . .” change to “out from the surface. . .”

31354 L1 “With measuremeants channels. . .” change to “The following instruments have measurement channels that correspond to the infrared and ultraviolet SO2 absorption bands:”

31354 L15 Change “e.g.” to “For example,”

31354 L19 This sentence is grammatically incorrect – please reword.

31354 L23 Change to “. . .flux calculations require . . .”

31355 L2 The use of “a fortiori” seems out of place. . . It is often used in the natural sciences to mean “even more likely”, for example.

31355 L15 VAST, SMASH and SACS-2 could also be mentioned.

31355 L16-17 Please correct grammar.

31356 L13 .”. . . performs regular measurements”

31357 L17 “. . . spectrograph that measures . . .”

31359 L6 Please change “Because of . . .” to “The vertical sensitivity of SO2 measurements is affected by water vapour interference below 3-5 km height . . .”

31360 L10 Please put the relevant citation after each satellite sensor mentioned.

31365 L1 “Satellite observations provide . . .”

31366 L9 “related to the plume height . . .”

31366 L12-22 This paragraph should come earlier, in the Introduction section.

31366 L15 “. . . injection altitude due to . . .”

31367 L20 Better to use “t” instead of “T”? The latter is usually used to denote temperature.

31374 L5-23 Please move to Methods Section 3. This is the results section.

31379 L15 “Accurate simulation of the transport of SO2 was challenging in the first 15 h.”

31381 L17 -31382 L28 This entire section should be moved to a new section: “Discus-

sion".

31383 L8-19 This is a review of methodology, and should be earlier in the methods section. It does not need to be repeated this late in the paper. Please move this to the relevant location. Also Section 4.3.3 should be moved to the new Discussion section as a subsection.

31385 L13 Grammar: ". . .in that a sequence . . ."

31385 L16 ". . . applicable to eruptions . . ."

31385 L23 Please remove references to "Plinian". . . this terminology has been confused.

31386 L16 "Flux estimates will also be improved and better constrained . . ."

Figures 2, 7 Please add error bars to all the retrieved values.

Figures 4, 8, 9, 11 Please add error bars to the flux estimates.

Figures 5, 6 (inset), 10, 12, 13, Please add geographic scale legend.

Figure 11 Text needs to be made larger; image quality poor.

Figure 14 Please increase text size

References

Rose, W. I., D. J. Delene, D. J. Schnelder, G. J. S. Bluth, A. J. Krueger, I. Sprod, C. McKee, H. L. Davies, and G. G. J. Ernst (1995), Ice in the 1994 Rabaul Eruption Cloud - Implications for Volcano Hazard and Atmospheric Effects, Nature, 375(6531), 477-479.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 31349, 2012.