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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Estimating the volcanic emission rate and atmospheric lifetime of SO_2 from space: a case study for Kīlauea volcano, Hawai'i" *by* S. Beirle et al.

Anonymous Referee #1

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Title: Estimating the volcanic emission rate and atmospheric lifetime of SO2 from space: A case study for Kilauea volcano, Hawai.

This paper provides a study on the SO2 emissions and lifetime for the persistent degassing volcano of Kilauea. I believe this paper should be published in ACP after the following points are addressed.

Main comments

1) I think the paper is weak in the references. This is especially true for the introduction section which does not give a good overview of past studies on the subject. Instead,

the authors put forward the "new potential" of satellite sensors for monitoring volcanic activity. Estimation of SO2 fluxes and lifetime from space have been reported in several papers, recently but also in early studies using TOMS data. Moreover, when referring to satellite measurements, the authors should also mention SCIAMACHY, OMI, GOME-2, IASI, AIRS (among others) in addition to the GOME-1 sensor. In the first two paragraphs of the introduction (on the role of SO2 on the atmosphere and its lifetime), it would be good to have references to key papers.

2) The paper is well written and the discussion section is valuable but the key message of this study is vague. Is it a paper on a technique or is it about the discrepancy between the ground- and space-based estimates of the emission rates? In the first case, the technique is not new (it is already described by the same first author in another paper) and is similar to other methods in the literature. If the focus is on the ground-based/satellite discrepancy, then the reason for it remains unexplained and the authors do not propose hints for further investigations. It is not clear if it could be that the ground-based instruments sample only part of the SO2 plumes emitted. Section 4 gives a description of the uncertainties of the emission rate and lifetime estimates but the latter uncertainties only relate to the method used and not to the SO2 column retrievals (see next point).

3)In view of the above, the description of the SO2 retrieval (section 2.1) is insufficient. For an SO2 plume at a presumable altitude of 1.5-2.5 km, many parameters can influence the retrieval which are not even discussed here. In reality, the results of the SO2 algorithm have not been validated and it is hard to know what it is the accuracy of the retrieved slant columns. The exact settings for the AMF calculation are not provided either. In the 312-324 nm range used, the wavelength dependence of the AMF is strong especially for a low plume (as it is the case here). The surface albedo used is not given, although it is arguably a large source of uncertainty on the SO2 column retrieval. GOME-2 is also known to suffer from several limitations at the edge of band 2 and this is not developed in the text. GOME-2 has undergone severe degradation since its launch and it is not clear whether the elevated background values of a few kT/day observed from 2009 onwards (Figure 7) are real or not. It is anyway in clear contradiction with the ground-based data. The authors shall expand the data description and include an error analysis to confirm (or not) if their space-based emission rates estimates are larger than the ground-based values.

Other comments

Section 1

- "..spatial fluctuations, and total emissions are still highly uncertain": please provide a reference.

- Please add information on the Kilauea volcano: lat,lon,elev.

Section 2.1

- All clear-sky pixels are used in the gridding procedure including the ones which contains no volcanic SO2. What is the impact of using a data filter (e.g. a cutoff value on the columns) on gridded data and hence on the lifetime and emissions rates estimates.

Section 2.2

- "..cloud altitudes derived from satellite observations have high uncertainties for low cloud fractions" : please provide a reference.

Section2.3

- The plume direction is determined by the slope of a weighted linear fit. What are the weights? In this procedure, all grid pixels are accounted for, including the ones over the island with high values (Fig 2). How can it affect the accuracy of the plume direction estimate. Only one ECMWF profile is used and the threshold of 3x10e16 cm-2 make pixels far away from the volcano included in the plume direction estimation. How can it affect the results?

- Using horizontal transport features to derive plume altitudes have already been used in other studies. Please refer to Bluth and Carn, IJRS, 2008 and Hugues et al., JGR, 2012.

Section 3

- The seasonal variation of the SO2 lifetime (Fig 5) is in contradiction with the findings of Lee et al. which show higher values in winter than in summer. The authors speculate on the role of clouds (blue crosses in Fig. 5) but they have no means really to confirm this hypothesis. The authors should test whether systematic features in their retrievals might be the cause for the observed seasonal variation.

Section 4

- An error on the plume height of 0.5km leads to 30 % errors on the emissions. Explain why 0.5km uncertainty is believed to be a reasonable estimate of the error on the height (and not a convenient value as it looks now).

- One option that has not been considered is a possible uplift of the SO2 plume after its emission. This could explain at least partly the differences between the satellite and the ground-based data.

- The point b in Section 4.1 simply points to choosing an appropriate lat-lon box for this study and does not bring a lot.

- ". . . to those reported previously at the ESA ATMOS conference (Beirle et al., 2012).." ->". . . to those reported previously (Beirle et al., 2012).."

- Page 8: (in a Lagrangian framework) please clarify.

Section 5

- Please refer also to OMI. Given the better spatial resolution and noise level of OMI compared to GOME-2, it would have been a more logical choice for studying the Kilauea degassing emissions.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 28695, 2013.