

## ***Interactive comment on “Temporal variations of flux and altitude of sulfur dioxide emissions during volcanic eruptions: implications for long-range dispersal of volcanic clouds” by M. Boichu et al.***

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This paper describes an advanced method to estimate SO<sub>2</sub> emission during eruptions and to model the dispersion of SO<sub>2</sub> clouds using an inversion technique that optimizes the fit between the model and the observations. The study uses multiple sets of SO<sub>2</sub> measurements from the April 10–11, 2011 eruption of Etna volcano and shows that ground-based measurements of SO<sub>2</sub> underestimate SO<sub>2</sub> flux by up to an order of magnitude when the SO<sub>2</sub> cloud becomes optically thick or is partially obscured by

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ash. This conclusion reinforces earlier studies suggesting that SO<sub>2</sub> could be underestimated by UV cameras looking into optically thick clouds [e.g., Kern et al., 2012].

I'm not a specialist in remote sensing techniques and therefore can't comment on the details of the methodology. But overall the article is clear, meticulously written, the main conclusions appear to be well supported by the data presented in the article, and the conclusions are of enough significance and broad enough interest to merit publication. I have only a couple of suggestions concerning broad topics and several specific comments, mostly trivial, concerning fine points of English.

Points of slightly more than trivial importance: 1) I had some difficulty following the explanation on p. 5040 of how the altitude is independently determined from IASI observations. The main point of uncertainty concerns what terms are in the Jacobian, mentioned on lines 17 and 18. Since this technique is already described in Clarisse et al. (2014), hopefully the clarification can be just a matter of adding a sentence or so. 2) On page 5053, your discussion of Fig. 10 would be more quantitative if you gave the  $r^2$  value for the regression. Also, on lines 25–26, I was confused by the reference to a cloud image in Fig. 10, since Fig. 10 shows no cloud image.

Specific, mostly trivial points: Page 5033, Line 23: change “confronted” to “compared”

Page 5034,

– line 11: delete “which is still going on at the time of writing” (the Bardarbunga eruption is now over).

Page 5034,

–line 18, change “On its hand” to something like “additionally” (“On its hand” is not a normal English expression). And reword this sentence. It doesn't make a lot of sense as currently written.

Page 5037:

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–line 12: is CHIMERE Eulerian or Lagrangian?

–line 18: If you're referring to the NCEP/NCAR Reanalysis 1 data, the appropriate citation would be Kalnay et al. [1996].

Page 5039:

–line 11: is roughness the meta-parameter you refer to in line 10? Lower roughness means less smoothing?

Page 5040:

–lines 16-19: If you are developing a weighted projection of the observed spectrum onto different Jacobians, does that mean that you were looking at the partial derivative of each specific wavelength to see how much its amplitude changed for a given small perturbation in SO<sub>2</sub> at a given altitude? Are the partials in the amplitude of a given wavelength the response function you mention? Perhaps some rewording would clarify for non-specialists like me.

Page 5043:

–line 3: change “thiner” to “thinner”.

Page 5044:

–line 19: the wording in this sentence seems awkward and unclear. Perhaps replace “maps, which is” with “, “ to clarify?

–line 23: change “model” to “modeling”

Page 5045:

–line 16: what do you mean by “a stretch of the blue color of these radiances”?

–lines 19-26: The agreement between the hysplit trajectories and the visible plumes Fig. 5b is indeed very good. It seems surprising that you would have sources at two discrete heights; 4 and 7 km, rather than a continuous source that extends from the

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vent up to the maximum elevation. The lower one is the vent elevation and the upper one is the top of the plume?

Page 5047:

–line 7: change “others” to “other”.

–line 13: change “Lybia” to “Libya”.

Page 5050:

–line 3: change “associate to” to “associated with”. Same on line 10.

–line 19: change “consist in” to “consist of”

–line 20: change “have already settled” to “had already settled”

–lines 23-24: change “over night” to “at night”

Page 5051:

–line 2: change “like in Siberia” to “as in Siberia”

–line 8: is there a reference that can tell us what the “row anomaly” is for the OMI sensor?

Page 5052:

–line 2: change “relatively to SO<sub>2</sub>” to “relative to SO<sub>2</sub>”.

–line 26: change “instrument” to “instruments”

Page 5053:

–line 4: change “a an automatic” to “an automatic”

–lines 8-9: You say that there is good agreement between SO<sub>2</sub> cloud altitudes predicted by the inverse method and the altitudes derived by IASI observations, illustrated in Fig. 10, but You don't give the regression  $r^2$  or show the slope of the best-fit line in

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Fig. 10.

–line 16: change “difference” to “different”

–line 17: change “on altitude” to “in altitude”

–lines 25-26: “They match the forefront of the volcanic SO<sub>2</sub> cloud in the 11 April p.m. image (Fig. 10)”. I’m not sure what this sentence means. There is no image of the cloud in Fig. 10.

Page 5054:

–line 12: change “caveats” to “pitfalls”

–line 19: delete “an” before “information”

Page 5056:

–line 6: change “associated to” to “associated with”

–lines 22-23: “The altitude of SO<sub>2</sub> emissions retrieved by the inversion procedure are confronted to the forward trajectories of the HYSPLIT Lagrangian model”. I’m not sure what you mean by “is confronted to”. I think you mean that you used the altitudes as input to Hysplit trajectory runs? (Fig. 5)? Also, change “are” to “is” in this sentence (or change “altitude” to “altitudes”).

Page 5057:

–line 10: change “simultaneously to” to “simultaneously with”.

Figure 7 caption, second from last line: change “Lybia” to “Libya”

References:

Kalnay, E., et al. (1996), The NCEP/NCAR 40-Year Reanalysis Project, Bulletin of the American Meteorological Society, 77(3), 437-471, doi:10.1175/1520-0477(1996)077<0437:TNYRP>2.0.CO;2.

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Kern, C., T. Deutschmann, C. Werner, A. J. Sutton, T. Elias, and P. J. Kelly (2012), Improving the accuracy of SO<sub>2</sub> column densities and emission rates obtained from upward-looking UV-spectroscopic measurements of volcanic plumes by taking realistic radiative transfer into account, Journal of Geophysical Research: Atmospheres, 117(D20), n/a-n/a, doi:10.1029/2012jd017936.

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