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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Tracking and quantifying volcanic SO_2 with IASI, the September 2007 eruption at Jebel at Tair" *by* L. Clarisse et al.

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General comments:

Paper presents new method based on optimal estimation for deriving volcanic SO2 profile and column amount as well as aerosols using infrared (IR) IASI sensor on operational polar orbiting MetOp satellite and describes retrieval results for 2007 Jebel at Tair volcanic cloud. The IASI noise and other specifications are shown to be superb to any previously flown IR instrument (i.e. AIRS). This presents enhanced possibilities for further advancing volcanic plume monitoring. Estimating SO2 plume height is new feature, which is important enhancement compared to existing algorithms. Physical principals of SO2 retrievals are well described. Detecting volcanic aerosols and separating between ash and ice in volcanic plume is another important feature.

Specific comments:

1) Introduction should mention heritage IR and UV satellite techniques that have been highly complementary. Split window technique [Wen and Rose, 1994] has been applied to TIR channels of AVHRR and GOES instruments for detecting volcanic ash, while UV techniques were mostly utilized for detecting volcanic SO2 (TOMS, GOME, SCIAMACHY). Volcanic ash detection by UV Absorbing Aerosol Index technique has also been demonstrated with TOMS data and compared well with AVHRR IR technique [Krotkov et al 1999]:

Krotkov, N. A., O. Torres, C. Seftor, A. J. Krueger, A. Kostinski, W. I. Rose, G. J. S. Bluth, D. Schneider, and S. J. Schaefer (1999), Comparison of TOMS and AVHRR volcanic ash retrievals from the August 1992 eruption of Mt. Spurr, Geophys. Res. Lett., 26(4), 455–458.

2) Application of optimal Estimation method [Rogers 2000] to volcanic SO2 requires better justification, specifically 1) applicability of Gaussian a-priori covariance matrix to volcanic SO2; and 2) selecting diagonal values of the a-priori SO2 matrix based on IASI BT difference measurements (p. 16927) is not consistent with basic assumptions of the optimal estimation technique.

3) Change abbreviation for the "Degrees of Freedom for Signal" to commonly used DFS

4) Total SO2 mass calculation shows non-monotonic dependence in the first 2 days (figure 10), which suggests IASI underestimation for the fresh plume. Comparison with OMI SO2 mass calculation (p.16930) quotes Eckhardt et al. (2008) paper, which has incorrect OMI values as follows: "Eckhardt et al. (2008) estimate the total emitted mass to be of the order of 75 kt, based on measurements of the OMI satellite. ... The retrieved SO2 mass from OMI shows for instance an increase (from over 60 kt to over 100 kt) from 1 to 3 October "

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I have calculated OMI SO2 masses on first few days using low stratospheric SO2 data (assumed center of mass altitude ˜17km) and 0.6DU threshold and got monotonically decreasing values of 57kt , 43kt, 31kt and 24kt on October 1 through 4. These values agree well with IASI mass retrievals, except on October 1 (figure 10). The OMI SO2 masses and updated images will be posted on our web site in few days: http://so2/umbc.edu/omi. Therefore, I suggest replacing first paragraph on p.16930 with the following statement:

"OMI estimated total SO2 masses (assuming center of mass altitude ˜17km and 5km thickness and 0.6DU threshold) were 57kt , 43kt, 31kt and 24kt on October 1 through 4, respectively, which fits well with exponential decay rate ˜3.4 days: http://so2.umbc.edu/omi/pix/special/2007/redsea/altair07.php

Figure 10 shows that OMI tonnages agree well with IASI estimates on all days except October 1, when OMI mass was ˜25% higher (OMI overpass was before the beginning of the eruption on September 30). The reason for disagreement on October 1 needs further investigation."

Technical corrections:

p.16919, 13: remove "often"

19:"satellites can offer" - remove "can"; 20: change "obtained at best once a day"; to "obtained once a day at low latitudes and twice or more times a day at high latitudes"

24: correct: "Apart from SO2, IR sounders are" to "Apart from SO2, both IR and UV sounders are capable of detecting and quantifying volcanic aerosols [Krotkov et al 1999; Wen and Rose 1994] and ice [Rose, 2003] "

Krotkov, N. A., O. Torres, C. Seftor, A. J. Krueger, A. Kostinski, W. I. Rose, G. J. S. Bluth, D. Schneider, and S. J. Schaefer (1999), Comparison of TOMS and AVHRR volcanic ash retrievals from the August 1992 eruption of Mt. Spurr, Geophys. Res. Lett., 26(4), 455-458.

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Rose, W.I., et al. (2003) The February-March 2000 eruption of Hekla, Iceland from a satellite perspective. In: Volcanism and the Earth’s Atmosphere (eds. A. Robock and C. Oppenheimer), AGU Geophysical Monograph 139, pp. 107-132, 2003

P 16921, 8: replace "could be" with "was"

P 16923, 17: Correct "IASI is therefore in principle capable of sensing SO2 down to the ground," -> "IASI is therefore theoretically capable of sensing volcanic SO2 in the planetary boundary layer, "

p.16923, 20: Change: "observed [line?] intensities"

p.16923, 29: Change: "the ratio of [the BT spectra for] an atmosphere with and without SO2"

p. 16924, 16: replace "in function of" -> " as function of "

p.16925: 18 insert: "and its [measured] covariance Sa"

p.16926: 6 change to: "the weighting function is " p16926: change "DOFS"; -> DFS

p16926: 18 delete "of Eq.(4)"

p. 16926: Check equation (4): Unbalanced parenthesis; should the last term be: Saˆ-1(x_j -x_a)) ?

p.16927 4.2 Retrieval parameters: Specify explicitly the retrieved state vector, X. Provide more details on the choice of a-priori parameters.

20: "A priori values for all molecules were taken from either the tropical or midlatitude summer model," - What a-priori values were selected for SO2 molecule? The background SO2 a-priori is not appropriate for volcanic plume.

25: Justify the choice of a-priori covariance matrix, especially for SO2. Provide explicit Sa matrix at least for one sample retrieval.

16930: Remove reference to Eckhardt et al. (2008) with incorrect statements about

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OMI SO2 mass retrievals: "Eckhardt et al. (2008) estimate the total emitted mass to be of the order of 75 kt, based on measurements of the OMI satellite. A discrepancy of the vertical profile is probably responsible for this difference. Another difference with the retrievals from OMI, AIRS and SEVIRI presented in Eckhardt et al. (2008) is that the evolution of the retrieved mass in our retrieval is much smoother. The retrieved SO2 mass from OMI shows for instance an increase (from over 60 kt to over 100 kt) from 1 to 3 October "

I suggest replacing with the following statement: "OMI estimated total SO2 mass (assuming center of mass altitude ˜17km and 5km thickness) 57kt , 43kt, 31kt and 24kt on October 1 through 4, respectively, which fits well with exponential decay rate ˜3.4 days: http://so2.umbc.edu/omi/pix/special/2007/redsea/altair07.php

Figure 10 show that OMI tonnages agree well with IASI estimates on all days except October 1, when OMI mass was ˜25% higher (OMI overpass was before the beginning of the eruption on September 30). The reason for disagreement on October 1 needs further investigation. "

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 16917, 2008.