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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A new scheme for sulphur dioxide retrieval from IASI measurements: application to the Eyjafjallajökull eruption of April and May 2010" *by* E. Carboni et al.

Anonymous Referee #1

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General comments:

This paper presents a retrieval scheme of atmospheric SO2 from measurements of the high resolution infrared sounder IASI. With respect to existing retrieval methodology, the approach has two novel aspects:

1. Use of a generalised error covariance which includes more than just the instrumental noise. It includes for instance the covariance due to modelling errors and due to interfering trace gases and clouds. In this way, these do not need to be retrieved or taken into account otherwise in the retrieval. The advantage is also that of a more accurate error budget at the end of the retrieval.

2. Explicit retrieval of altitude. Most other retrieval schemes that retrieve altitude information attempt to retrieve a profile. This often leads to plumes with an unrealistic broad profile. In this paper, SO2 is explicitly confined to a layer of certain width and this implies that the plume has been injected at a certain altitude (ie is of volcanic origin). This approach obviously has certain advantages.

I think the retrieval algorithm is scientifically sound, important and interesting. However, as outlined below, the presentation of this paper leaves much to be desired, and needs a thorough revision prior to publication.

Comments related to the presentation:

- Spelling and grammar. It is surprising to read so many grammar and spelling mistakes, especially as many of the authors are native speakers. Given this fact, it does not show a lot of respect to leave it to the referees or copyeditor to correct them. Just some examples:

1. verbs: P 11863, l21 “have make possible”; 11866, l7 “the model simulate the IASI signal”; l16 “the so2 coefficient are”, l19 “RRTOV consider an atmosphere”, P 11878 l 9 “this produce and overestimation” P1180 l12, “Figure 9 show” etc. The manuscript is riddled with these.

2. Section 5.1 is arguably the worst in this respect. Example sentence: “From the other side the presence of cloud in a pixel can not be discernible troughs the cost function values” instead of eg “On the other hand, the presence of clouds is not discernible through the cost function”

3. So again, the whole manuscript needs to be revised very carefully for spelling and grammar mistakes.

- Figures:

Figure 1: the axis labels (especially of the colour bars) need to be much larger. The caption mentions “waiting functions”?

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Figure 3: this is very hard to read. The first row should be removed I think, as it is confusing. The first row essentially shows the colour bar. The use of so many different colours makes it hard to deduce anything quantitative from the other rows (and this and next figures are not quantitatively described in the text either). What would really help is to convert the S02 absolute errors in relative errors (in %). Using a smaller number of colours should also make it easier to read (eg. in 5 bins <1% <5% <25% <100% and >100%). For the altitude, I suggest converting the pressure altitudes in height differences (km). For the error of the surface temperature and DF I suggest using a smaller colour scale (eg 0 to 2 and 1 to 4 respectively).

Figure 4: same comments as figure 3. Rather than the retrieved values, it would be much better to plot either the relative or absolute differences (relative difference for SO2, absolute for the other two). This would also make direct comparison with the other rows of figure 3 much easier. It would be good to also here, convert the pressure altitudes to heights (differences).

Figure 5: same comments, please convert everything to differences (absolute or relative). What are the numbers inside the plot of the cost?

Figures 6-8: I could not see any value over 10 DU. The figures would look better with a reduced colour bar 0-10 DU (or even smaller).

Specific comments:

- Page 11862, line 5: nu1 is at 8.7 and nu3 at 7.3

- Page 11862, line 22: 0.02 Tg instead of 0.2 Tg

- Page 11864, line 13: I wouldn't use the word affected here, since it is a good thing; more radiation is more signal and therefore higher sensitivity.

- Page 11864, line 20 and line 24 nu1 and nu3 should be swapped around.

- Introduction: here other SO2 retrieval algorithms from high resolution infrared

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sounders should be reviewed (from IASI but also AIRS and TES).

- Page 11865, section 2: some of the IASI specifications are inaccurate, such as the swath, footprint, 50x50 'square', radiometric noise (please specify the spectral region here).

- Page 11866, line 11: this is unclear, please revise

- Page 11872-3: please specify the precise spectral retrieval range.

- Page 11874: Line 5: what do you mean with "we do not subtract the bias?"

- Page 11874, section 5: the presented analysis is only representative for real situations when also Se errors are added to the simulated spectra. It was not clear to me if this has been done or not. If not, I suggest redoing the analysis, but this time adding noise generated randomly from the Gaussian distribution specified by the covariance matrix Se and its corresponding mean. A function for drawing randomly from a distribution like this is available in most statistical software packages.

- Page 11874, section 5: One type of error not covered in this analysis is the effect of errors of the temperature profiles on the retrieved SO2 parameters. While errors of the temperature profile that propagated to e.g. water vapour line strengths are accounted for by using the generalized Se, they are not taken into account when it comes to the line strengths of SO2. This could be checked separately by adding synthetic noise to the temperature profile prior to the retrieval. This effect should perhaps be mentioned in the text.

- Page 11875-6. Although the description of Figure 3 and Figure 4 is quite long, some accompanying typical numbers and ballpark ranges would be really helpful, especially for SO2 and the altitude. E.g, for plumes above 3 km and below 7 km, we expect an error between .. and .., E.g. for plumes between 1 and 10 DU we expect an altitude error between .. and .. km. etc.. When the figures are remade following the suggestions above, it should also be easier for the reader to figure this out by

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him/herself.

- Page 11877, section 5.1: at what wavenumber is the aerosol optical depth reported? Which refractive indices were used?

- Page 11877, section 5.1: there is a large difference between the effects of water and ash clouds. In both cases, can you show a spectrum with a large AOD to demonstrate these differences? From the errors in the SO2 retrievals, it is hard to believe that the ash simulation is realistic (see also next point). Also, something should be said with respect to the chosen spectral retrieval range (nu1 should be more sensitive to ash than nu3).

- Figure 5: it appears that ash above the SO2 layer has no impact on the retrieved loading. This is not logical and not clear from text. Thick ash clouds will completely wipe out the SO2 signal (even in the nu3 band) and obviously lead to errors in the retrieval. Could you investigate or clarify?

- Page 11877, section 5.1: the whole section really needs a rewrite, as it could be formulated much clearer.

- Page 11879, line 15: please give a reference for these numbers.

- Page 11880: line 17: this is an unusual way of calculating the total mass, which will lead to large errors. At nadir, IASI has a circular footprint of 12 km diameter and therefore the total mass of a pixel at nadir will be overestimated by a factor of five. At the swath's maximum, when the footprint is elliptical (20x39), the mass will be underestimated. Also, IASI has gaps between the different scan lines and arrays of 4 pixels. Just summing up the surface of the footprints will lead to large underestimates. At high latitudes on the other hand, IASI orbits overlap and by summing up the different footprints, the same so2 will be counted multiple times leading to so2 overestimates. An approach to calculate the total mass which doesn't have all these disadvantages (albeit also not perfect) is to interpolate the IASI data onto a regular latitude/longitude

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grid.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 11861, 2012.