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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieval of near-surface sulfur dioxide (SO_2) concentrations at a global scale using IASI satellite observations" *by* S. Bauduin et al.

Anonymous Referee #1

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In the manuscript the authors present a study of 'near-surface SO2' based on the IASI measurements, using the IASI spectra around v3 absorption band. This is the first global map of low level SO2 from IASI and I suggest it for publication. The work is original, contain important addition to existing literature and is in general well written. Nerveless it will need some clarifications and additions as my following comments.

Main comments:

1) The use of only the v3 band to study close to the surface SO2 is not the best exploitation of IASI spectra. The present work is still valuable and I suggest it for publication but the presence of V1 band within IASI spectra have to be empathize more. I can

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accept there are practical reason for using only the v3 band, (as for example missing a good forward model, surface temperature/thermal contrast problem etc...). The v3 absorption band is within the water vapor absorption band, and it is in general not sensitive up to the surface and this should be mentioned (at the end of the introduction and in the conclusion). A work using both band v3 and v1 is desirable and it will carried more information on SO2 close to the surface that using only v3 band. The fact that they use only the v3 band should be mention in the abstract. I really don't won't that the reader to have the impression that IASI cannot measure SO2 close to the surface in condition with a lot of water vapour, this is a limitation of this retrieval not of the IASI measurement itself.

2) This work is missing the sensitivity of the linear detection HRI(h), how much SO2 do you need to 'detect' something between 0-4 km? How much if SO2 is between 0-4 and how much if SO2 is between 0-1 km? I'm not sure if they are using the HRI(h) to reject the pixels with h > 4 km or if they are using HRI(h) to select the pixels with h < 4 km, please clarify this somewhere in section 2.

3) The data cut implemented a posteriori really affect the global map presented and all the results are biased high, in particular they are averaging only values bigger than some 'value' and presumably are sensitive to only SO2 higher than some 'altitude' (I do think that the work is still valuable and that v3 band is sensitive below 4km, but not sure it is sensitive up to the surface). It will be a nice addition to estimate these 'value' and altitude for a specific atmosphere (standard atmosphere?).

4) You apply a posteriori cut for cloud cover and for SO2 errors. I agree with the cut for cloud fraction (e.g. if there is cloud IASI don't see the surface), but I think that the cut you are doing for error in SO2 load (< 25% and <10 DU) is introducing a sampling bias and really affect your global map. Values which are zero should still contribute to the calculation of global mean distribution (and cut values with error >25% is equivalent to cut low values). What happen if you cut only for <10 DU and accept any relative error? It will 'save' a lot of pixels with low amount of SO2 to go into the global distribution.

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I think that applying these cuts (= accepting only < 25% and <10DU) is equivalent to consider only SO2 in some defined range of amount and altitude. Apply a relative error cut means that only the retrieval above some absolute amount of SO2 (which depend on altitude) will contribute to the mean. To understand how the SO2 distribution if Fig.6 is limited by the actual presence of SO2 or by sensitivity of the algorithm, it will be informative to add a map illustrating the sensitivity, e.g. the mean absolute error or the percent of retrievals that have error <10DU. Why you don't you do an error-weighted average without any cut based on the error? Given that approach from Fig.6 is not possible to judge the significant of the blue values plotted especially without any indication of the percent of pixels that have gone into the "average" – the map looks reasonable but blue values could be generated by single retrievals randomly crossing the quality control thresholds.

Specific comments:

p 11032 l 28- p 11033 l 1: why you are not using v1 band? You should mention that v1 band is desirable for studying values close to the surface.

p 11035 l 8,9: '. . . calculating the function HRI(h) and finding the altitude of its maximum' to change into: '. . . calculating the function HRI(h) at predefined altitudes, and finding the altitude of its maximum'.

p 11036 l 8-11. It is not clear how they use the HRI(h): (a) to filter out the pixel that result with detection of SO2 > 4 km; or (b) they use only the pixels that result positive to a detection between 0-4 km?

p11040 l3-5 If the answer above is (2) then this sentence is not true and they have to check the detection limit of HRI(h), when the detection 0-4 is positive and when it is not?

p 11040 Error characterization: A big source of error is the SO2 profile assumed. IASI v3 band is not sensitive up to the surface even in dry conditions. IASI signal in v3 is

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affect by SO2 above some threshold altitude (∼1km?). So you are assuming the SO2 amount below that threshold altitude according to your profile. (I agree this threshold depend on water vapour but anyway it is not zero.) It is hard to estimate the error associate to the assumed profile, but it should be mentioned in the paper as source of error.

p11041 l5-7: which are the conditions that fulfil the surface sensitivity?

p 11044 l 21-24. If the majority of HRI is below 5, why your fig 2 and fig 5 have y-axe that go up to 1600 HRI?

p 11045 l 17-19. 'Sources in India and in South Eastern Asia are also not observed by IASI, likely because of large H2O amount in the atmosphere in the tropical region.' These source are not observable by IASI using the v3 band only, but it may be possible to observe them with the v1 band. You can mention here that the use of v1 band could help.

p 11046 l 23 'but the humidity is too high during the other months to allow IASI probing the surface.' to change into: 'but the humidity is too high during the other months to allow probing the surface using this IASI scheme.'

p 11047 l 14-15 I'm not sure I understand what is not covered in the LUT range, do you means that the thermal contrast was less than -30 (as you range of thermal contrast from table 1)? I'm not sure I understand the problem, why you don't extend the LUT range?

p 11048 l 7-8 Again why not simply increase the LUT range? Otherwise you should really document which conditions are outside your analysis, e.g. add a map illustrating the sensitivity as main comment (4).

p 11048 l 23-25 'the average are bias high'. This is true not only for the night measurements, it is true also the day and dry measurements, they will be biased high as well. It will be a different bias (a lower bias) but you are still overestimating the average. You

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are averaging the SO2 only when the IASI v3 is sensitive with little error, so it is bias high anyway. The map in fig 6 are not an 'average' they are a global distribution of detected signal, e.g. signal that overpass some amount.

p 11050 l 10-17 This paragraph is not 100% clear. I don't think that when there is discrepancies between iterative retrieval and the linear one it means that the linear one is correct. It simply means that when there is low signal the iterative and the linear give different results. Please delete the last sentence 'This result shows the strength of the LUT-approach for these low-signal cases.'

p 11052 l 6 '...the posterior selection of the retrieved SO2 columns for which IASI is sensitive enough.' This is really a key point and should be explained better, please document the minimum values of So2 amount and altitude that you retrieve. For example in a standard atmosphere conditions, applying cut of 25% and 10 DU errors in SO2 amount, which valued can you retrieve? I think this correspond at least in cutting all the data that have $\sim$<2 DU and with altitude $\sim$<1 km but it will be important to know the proper numbers for this scheme.

l 14: This is only a suggestion: the Taklamakan desert SO2 source can be a Potassium Chloride facility, as you can see in wikipidia (sorry I don't have better source): https://en.wikipedia.org/wiki/Lop_Nur

p 11053 l 4-5 Nothing in this manuscript demonstrate that the linear retrieval is better than the iterative one, please delete this sentence: 'It is also very sensitive and has shown interestingly better results for weak SO2 signals'.

l 8-12. I'm not sure I think that the difference in day/night can also come from the data cut applied.

l 14-15 'The use of the v1 band can also be envisaged to reduce the impact of humidity and increase the number of used data.' To change into: 'The use of the v1 band can also be envisaged to reduce the impact of humidity and increase the sensitivity close

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to the surface.'

Fig 1: how much is in DU the profile plotted here on the left?

fig 2: (a) is mainly all blue, please use a different colorscale. Maybe a logarithmic one? Why are the values going up to 1600 HRI? Maybe it can be a plot in smaller y-axe, and you can zoom more in the interesting part (the central one). Are these HRI, in the range -400 +1600, values that you find in the analysis?

fig 4: again a lot of blue here, what about a log scale colorbar? Or a non linear or different colorbar. Values between 0 and 3 DU are mainly indistinguishable.

fig 5: it is nearly all blue. Please use different colorscale (log one?). Plus do you really need this range or can you zoom it to something around -10 10 TC and -100 100 HRI? I will prefer this plot in absolute value (and not relative) to go together with fig 2. Maybe you can plot both the relative and the absolute errors?

Figure 6: these are average of the data that exceed some threshold values, e.g. the amount of SO2 that i needed to 'activate' the HRI(h) for 0-4 km, and have to be in favorable condition to pass the error thresholds. See my previous comment (4).

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 11029, 2015.