

Interactive comment on “Observing atmospheric formaldehyde (HCHO) from space: validation and intercomparison of six retrievals from four satellites (OMI, GOME2A, GOME2B, OMPS) with SEAC⁴RS aircraft observations over the Southeast US” by L. Zhu et al.

Anonymous Referee #1

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This is a long over due paper concerning the validation of satellite HCHO columns, retrieved by various sensors/groups data against in-situ aircraft measurements. It addresses an important topic and should be published when the following issues have been addressed. The paper is generally well written with nice graphics (apart from fig 7).

Although the analysis is decent, and it gives the reader an impression of the quality of the satellite HCHO column data, I do, however, feel that a somewhat opportunity has

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been missed since the aircraft data could have been used to really pick the retrievals apart. Maybe this is planned for the future, one can only hope!

Specific Comments:

Page 2, Line 25 & subsequent paragraph: Please note that Barkley et al (2013) compared OMI data to GABRIEL aircraft HCHO measurements and found OMI was about 40% too low.

Table 1 – I would include much more information about the details of the retrieval and AMF algorithms, e.g., fitting windows, absorbers fitted, use of radiance references, CTM vertical and horizontal resolutions, profile (monthly vs daily), resolution of scattering weight grids, treatment of clouds, terrain corrections, treatment of aerosols etc. Also discuss explicitly exactly how the reference sector correction is done in each case – yes they all follow the same approach - but there are subtle differences. This is a validation paper after all, so the reader needs to be well informed about the retrieval differences.

Page 3, Line 21: You have gridded the data yourself, so why quote the error on the monthly means from De Smedt's 2008 paper? Surely you can compute this error for each retrieval.

Equation (1) - please state if σ_0 is a vertical (I assume it is) or a slant column background.

Reference sector correction – since the retrieval groups are authors on the paper, I would urge the satellite data producers to provided their uncorrected slant columns (i.e. the raw retrieved slant columns) so that a consistent a reference sector adjustment could be applied to all. This really would add substantial value to the paper. But I suspect that it will not be attempted, which is a shame.

Page 4, line 27: “diurnal variability in the HCHO column is expected to be small. . .” Please quantify small – is this statement based on measurements or model studies?

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Page 5: The normalisation process concerns me. I can sort of see why it was done but there are some opened questions. For example, what are the spatial gradients in mixing layer depths, how does this impact the HCHO column. It is stated that day to day variability is “fitted well” by $\exp[0.11T]$ – please quantify well? What is the uncertainty in the comparison procedure due to fitting this function? How does the satellite comparisons change say if an arbitrary function of $\exp(cT)$ is used instead, where ‘c’ is a different constant? Isoprene emissions, and thus HCHO columns, are very sensitive to temperature. What do you mean by ‘local surface air temperature’, where is this from (is it the GEOS-FP data) & how accurate is it? The conversion to a ‘mean HCHO columns’, using the mean vertical profile, again what is the error in this procedure and how does it impact the subsequent comparisons? What if you use a different assumed profile shape? Lastly, please discuss why it’s really needed at all? Surely, you could compute HCHO columns for each flight, corresponding to a specific day and underlying surface footprint, and compare this to the satellite observations that lie in the same footprint (in which case you don’t need to adjust for day-to-day variability)? I am, perhaps, being quite harsh but this step in the study is very important and yet it is given only a paragraph. Given the importance of the paper, I urge the authors to thoroughly discuss this key part of the analysis.

Section 4: Why don’t the retrievals apply the same GEOS-Chem model background correction, and probably better still, compute the AMFs using the GEOS-Chem model data? This would help isolate the columns differences due to the spectral fitting approaches. Yes, this would be some work but it would really add another dimension to the paper. You’re already half way there, using the mean CAMS profile anyway.

Page 8, lines 1-2: the AMFs are also sensitive to the respective cloud parameters for each retrieval (which instrument specific and subject to their own uncertainties), hence it is not just the scattering weights and angles.

Page 8, line 5 onwards: Again using the same surface reflectance data set in the AMF for all retrievals, would give some idea of its relative importance in this validation

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exercise. Ok, each retrieval 'should' use a reflectance data set consistent with the cloud algorithm but it would be an interesting experiment to carry out.

Page 8, line 15: Am I missing something here, but you've corrected the GEOS-Chem model using the CAMS data, which is adjusted for day-to-day variability, and yet this shows 'good agreement' with temporal dependence of isoprene emissions. Isn't this a somewhat circular comparison/argument? Please elaborate, and if not, then make sure you adjust the text to avoid leaving the reader with this impression.

Page 8, line 30: I would say spatial correlations are 'moderate to relatively high', rather than give the feeling that the retrievals are better than they really are.

Page 9, final paragraph: yes you are right in what you say! But couldn't the authors address some of these issues in the framework of this paper?

Figure 3: are the temperature and HCHO columns, both sampled according to OMI observations (i.e. under the same cloud conditions?)

Figure 5, the GEOS-Chem data is sampled along the 'OMI schedule' – according to which OMI retrieval? I suspect that each retrieval will have different quality flags for their measurements, so a 'good' measurement in one might be flagged as 'bad' in another. Are the actual same OMI pixels gridded between the retrievals? This also holds for the OMPS data as well. Maybe discuss this in the main text to clarify.

Figure 6: why not show the AMFs alongside????

I'm sorry but Figure 7 looks like coloured spaghetti. Maybe make it multi-panelled, with GEOS-Chem plus OMI data, then GEOS-Chem plus the OMPS data etc.

Table 1 please explicitly state how the detection limits are calculated for each retrieval.

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