

Interactive comment on “Validation of OCO-2 error analysis using simulated retrievals” by Susan S. Kulawik et al.

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The manuscript by Kulawik et al investigates possible error sources in OCO₂ L2 retrievals by the ACOS algorithm in an OSSE setting, with the caveat that not all the error sources in the real retrievals have been characterized. This is a careful study that merits publication in AMT, after the authors have responded to my (mostly minor) comments and suggestions. Overall, the manuscript would benefit from some copy editing; I've pointed out such errors where they confuse the message, but I cannot be certain that there are not more.

1. *Page 2, line 8*: Typo or possible missing words in “finds that non-linear retrievals this relatively simple simulation”.

2. *Page 2, line 21*: Vague antecedent in “these simulated results”, do “these” refer to Connor et al (2016) or the current work?
3. *Page 2, lines 26-27, and elsewhere*: Suggest making double quotes consistent throughout the document. Currently they’re a mixture of “quotes” (preferred), ”quotes” and "quotes".
4. *Page 3, line 7*: Typo, “retrievel”
5. *Page 3, line 30*: The claim that the performance of systems (3) and (4) were comparable is a strong one, since (4) includes a lot of complicating effects not in (3). It seems that the authors compared the two systems to arrive at this conclusion, the “preliminary studies” referred to here. I would like to see some sort of evidence from those studies, i.e., why do they think that the performances are comparable? This is not just idle curiosity; the authors themselves say that their error estimates are larger than earlier estimates by Hobbs et al (2017) using a surrogate model, which raises the question of whether choice (3) indeed is sufficient to capture most of the error sources.
6. *Page 4, line 35*: Typo, $S_{ainv} \rightarrow S_a^{-1}$
7. *Page 5, equation (5), and page 12, equation (8)*: Typo, $h_x CO_2^T \rightarrow h_{XCO_2}^T$ or something like that, right now it looks like CO_2 is the vector that’s being transposed
8. *Page 6, lines 26-30*: It was not clear to me whether the current work used the newer scheme (which picks the two most likely aerosol types per scene) or the older one.
9. *Page 7, lines 1-5*: The authors downsample from 24 soundings per second to 1 sounding per second. While I understand this choice from the point of computational convenience, this has the potential for changing inter-sounding corre-

- lations, and whether errors average down over multiple soundings (e.g., the top part of page 11). Can the authors comment? Would the conclusions in the top half of page 11 still hold for real OCO2 retrievals?
10. *Page 7, lines 16-17*: Why is a realistic cloud screener necessary for this work, given that coverage is not the focus of this investigation? Interfering errors from clouds are important, of course, but cloud screening to throw out soundings prior to retrieval should not affect the conclusions of this work, right?
 11. *Page 7, line 26*: Define “true” retrieval errors before this sentence. Currently it’s defined on line 33.
 12. *Page 8, lines 18-19*: Do the biases in table 5 average down with the number of soundings? Or are they true biases that are independent of the number of sounding used to calculate them (with variations due to finite sample size)?
 13. *Page 9*: Define the linear estimate and how it’s calculated before discussing it. For calculating the linear estimate from equation (1), are the Jacobians/averaging kernels evaluated at the prior state vector values or the posterior values from the nonlinear solution?
 14. *Page 9, line 9*: Are the 1.3 and 1.0 ppm figures biases or standard deviations (random errors)?
 15. *Page 11, line 27*: I’m surprised by the 0.0 ppm bias, is this because there are no clouds in the true state for this exercise?
 16. *Page 12, lines 1-4*: Seasonality of the effect of the averaging kernel is one reason for applying it to models, another is the possibility of spatial patterns. The data in this study do not span multiple seasons, but it does span multiple surface types, albedos, aerosol loading, etc., all of which influence the averaging kernel. Does the impact of applying the averaging kernel and prior have a spatial pattern?

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17. *Page 12, line 25*: What does it mean that there is no predicted relationship but a strong correlation? Does it mean that the correlation is arising because both variables are impacted by some common element in the state vector?
18. *Page 13, line 1*: Unresolved reference to “Eq xx”.
19. *Page 14, line 4*: “gradient”, not “curvature”
20. *Page 16, paragraph 2*: Here and elsewhere, it is not clear to me how a bias correction is done in this OSSE setup. For real OCO₂ retrievals, the retrieved XCO_2 are compared to any of a set of truth metrics, and linear relationships derived between the errors and co-retrieved parameters. In the OSSE, what supplies the truth metric? Just the “true” state that is already known (because this is an OSSE)? In that case, is the bias correction formula applied derived specifically for this OSSE, or is the formula for real v7 retrievals used? It would seem to be more appropriate to use the former, but lines 8-9 here suggest that the latter was used. Why is that valid?
21. *Page 16, lines 12-13*: I did not know that the ACOS algorithm kept the number of O_2 molecules fixed. How is this done, is it computed from the surface pressure and explicitly kept fixed? In that case, how does the surface pressure change during the retrieval? Purely due to water? And if so, is this change in water (which leads to $dP \neq 0$) consistent with the water column in the retrieval?

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