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

Anonymous Referee #1

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The paper by Kulawik and colleagues "Validation of OCO-2 error analysis using simulated retrievals" is a thorough piece of work which advances the state of the art. AMT is the ideal journal for this study. I recommend publication after fixing a number of mostly minor issues. I have spotted only one major issue (see below). At many instances there seem to be formatting errors, just as if LaTex maths commands were used outside the maths environment or in a non-LateX document, or similar. This makes reading unnecessarily difficult and causes the impression that the paper has been finished in a hurry. Given the inherent scientific quality of the paper, it deserves a more careful presentation.

Major issue:

p6 l5, Eq 6: This is not the χ^2 of an optimal estimate because the constraint term is missing. Without the additional term $(\hat{x} - x_a)^T S_a^{-1} (\hat{x} - x_a)$ I think the expectation value will not be the number of degrees of freedom of the retrieval system (See Rodgers book Eq. 2.43).

Minor and technical issues:

p1 l14: what about adding "... larger than predicted *by linear error estimation,*..."

p1 l25: shouldn't it read "was launched"

p2 l1: either "analysis follows"" or "analyses follow"

p3 l16: "...linearity of the retrieval system *in the vicinity of the result*..." Actually it is not assumed that the retrieval system is linear but that it is only moderately nonlinear (in Rodgers' language). That is to say, that the system behaves approximately linear in $\pm 1\sigma$ around the result.

p3 l18: I thought you talk about error estimation but here you talk about the retrieval. Please clarify. Perhaps "Error estimation based on retrievals using a..."?

p4 l10 "...the a priori *covariance matrix for* CO_2 *has the dimension*..."

p4 l12 I might have missed something but it is not clear to me what 'aircraft variability'

is. I am not sure if the term 'error' is adequate in the context of a priori uncertainty.

p4 l14 I suggest to add the term 'assumed' somewhere. Either "The assumed a priori errors" or "are all assumed uncorrelated".

p4 l35 "Sainv" have you pasted a LaTeX macro into a word document here?

p5 l 33 and throughout: I suggest to avoid these technical abbreviations like "CO2_grad_delta" in the text as far as possible and to use common language instead. If you do not want to use common language for these terms, then please replace the variable name of the computer code by a variable in mathematical notation.

p6 l1 this should read χ^2; there are numerous errors of this type. I do not mention each single one.

p6 l5 try to avoid computer language type variable names, replace by mathematical notation.

p7 l20 'errors due to physics that is perfectly described by the retrieval forward model' not quite clear what is meant. Please reword.

p11 l17. I do not think that the smoothing error describes the error introduced by the 'imperfect sensitivity'. Imperfect sensitivity will cause retrieval noise. The cause of the smoothing error is that $x_{true} \neq x_a$.

p8 l19 should this read "second moment"?

Subsection headers 4.1 and 4.2: please avoid variable names in the subsection headers.

p14 l13: Not sure if abbreviation 'LMT' has been defined. I might have missed the definition but please check.

p15 l9: There is something wrong after '...contribute.'

p15 l22: I thought that the reduced χ^2 means χ^2 divided by the degrees of freedom. Isn't normalization with the related inverse covariance matrix inherent in the χ^2 by definition?