

Geosci. Model Dev. Discuss., referee comment RC2
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Comment on gmd-2020-444

Anonymous Referee #2

Referee comment on "A new exponentially decaying error correlation model for assimilating OCO-2 column-average CO₂ data using a length scale computed from airborne lidar measurements" by David F. Baker et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2020-444-RC2>, 2021

General comments.

Authors propose an innovative approach to the construction of the error covariance matrixes for XCO₂ observations by OCO-2 satellite. The method relies on comparison of OCO-2 retrievals to the collocated XCO₂ observations by an airborne lidar made along ground tracks of several tenth of km in length, and thus avoids use of model simulations for estimating the amplitude and spatial statistics of the OCO-2 retrieval errors, which constitutes a major innovation presented in this work. Authors derive spatial error correlation lengths in the range of 10 to 20 km, which is a new result, based solely on observations. Authors consider 2 variants of the spatial error correlation models that are used to evaluate the errors and errors correlations for target 10 second averages derived from intermediate 2-second mean data, and propose ways to overcome related technical difficulties. The paper is well written and can be accepted after minor revisions.

Detailed comments

Although the problems and remaining deficiencies are extensively discussed in the Summary and conclusions, it is worth revisiting a couple of topics below:

- The paper would benefit from deeper look at the problem with negative covariance elements, addressed in Sect. 3.2. Similar problem with spatial correlations would appear with covariance matrixes for surface fluxes errors in the same inverse problem for which the data uncertainty matrix is constructed. But the problem of negative

elements for surface fluxes is not widely known, thus there is a possibility that the problem here is caused by an unrealistic design of the covariance matrix, but not by statistical properties of the data in hand.

- Unfortunately authors do not provide information on the amplitude of the correlating component – what is a fraction of the (OCO-2 – lidar) difference that is correlated at 10 km or less scale. If that is only a fraction of the 1.5-2 ppm of error as found by comparison with TCCON, then the origin and spatial scales of remaining is unknown, thus it can be treated as random and uncorrelated. Bell et al (2020) notice that the correlations at local scale are pretty low, they write: “We conclude from these low correlations that for an average scene with no strong variability in the XCO₂ field, OCO-2 and the MFL do not typically “see” the same small-scale features”. In practice, the adopted level of correlation coefficients as shown on Eq. 15 do not appear justified by the comparison with MFL and may possibly come from a separate source.

Minor comments, technical corrections:

L9 ‘Errors in the CO₂ retrieval method have long been thought to be correlated at these fine scales’ – It would be more accurate/safe to say that data are correlated, rather than the errors.

L44 Alternatively, one can call this ‘summary value’ an ‘average value’

L48 Authors imply the errors here correspond to model-observation difference, and contributed by model errors related to smoothing due to coarse model resolution. Its better to define somewhere above this point what is implied by ‘errors’.

L86 Adding some MIP paper reference should be useful here (eg Crowell et al. 2019).

L167 Any rationale for detrending Y rather than X itself?

L203 As the MFLL data are first aggregated to 7-9 km blocks, it appears that one needs to clarify here on how the analysis would become useful for finer scales.

L221 Although temporally uncorrelated errors are convenient for Kalman filters, it does seem to be excessive requirement, need to add a reference to appropriate text, if exists.

L627 Mistype: correct 'Zendolo' to 'Zenodo'

L660 For web document, need to give url.