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Atmospheric Measurement Techniques Discussions

Interactive comment on "The application of mean averaging kernels to mean trace gas distributions" *by* Thomas von Clarmann and Norbert Glatthor

Anonymous Referee #1

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Referee comments on

The Application of mean averaging kernels to mean trace gas distributions. Clarmann & Glatthor Submitted to Atmos. Meas. Tech., 4 March 2019

Overview

The paper draws attention to a hitherto overlooked problem with the application of averaging kernel matrices, specifically that the AK matrix itself, A, has some dependence on the retrieved state, x. Hence, when using averaged data, <x> (e.g., a monthly mean), the appropriate averaging kernel <Ax> is not simply <A><x> constructed from an average AK matrix <A>.

Main Comments

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Discussion paper

The paper is concise, well-argued and includes a suitable illustrative example, although I have some suggestions below as to how it might be further clarified so as to reach a wider audience.

While the main recommendation of the paper is that the data providers should also provide a correction term for the mean averaging kernel, it does seem more practical if, instead, the data providers themselves use the guidance in this paper to produce a suitable averaging kernel to accompany the averaged products. We all know that it is a struggle to get data user to understand and apply an averaging kernel, so we should avoid making their task any more complicated.

I doubt if this paper will be the last word in the matter - there are a number of open issues which require a little more thought, such as logarithmic retrievals, retrievals of temperature/pointing/pressure, non-constant a priori data, averaging kernel matrices which are not square. However, this paper is a good starting point for the conversation.

Minor Comments

1) The authors frequently resort to Latin. Personally I find it a welcome change from the usual stock phrases, although I expect some readers may not be quite so appreciative.

2) Abstract (and elsewhere): reference to 'covariance profile' although the suggested correction is a matrix rather than a profile.

3) P1, L18: 'this is' does not make sense here.

4) P1, L20: I don't think the use of monthly means requires any references, although no doubt Hegglin and Tegtmeier will appreciate being selected for multiple citations from among many, many such users.

5) P1, L20: suggest 'their' rather than 'her'.

6) P2, L13: The casual reader may interpret this comment as suggesting none of this applies to non-linear, iterative retrievals, so I suggest rewording to emphasise that it

still does.

7) P2, Eq 2: It could be pointed out that the main dependence on x in the AK matrix comes from the Jacobian matrix, K (although possibly also from R if some form of adaptive regularization is used), so whether or not there is any dependence of A on x is usually a consequence of whether or not K depends on x.

8) P2, L25: An extra equation, y-F(x_a) = K (x - x_a) would help the reader get from eq (2) to eq (3).

9) P2, L28 onwards. This is confusing. Elsewhere averaging kernels are discussed as a characteristic of the lower-resolution (satellite) retrievals, but in this example (Eq 4) the averaging kernel seems to be on the grid of the higher resolution 'original' retrieval. Despite the similarity of Eq 4 and Eq 3, these seem to be two quite different things.

10) P3, Eq 6 and elsewhere: if this is prepared with LaTeX, I suggest using \langle and \rangle rather than < and > for the angle-brackets.

11) P3, Eq 7: it would be helpful to further simplify this here, giving cov(A,x) = < A x > - <A> <x> which makes Eq 6 clearer.

12) It does not help that many of these equations are split over two lines, but that may not be the choice of the authors.

13) P3, L22: There seems to be more to be said than this simple phrase 'an individual prior x_a'. For example, an individual but *almost* constant a priori could be used for each profile, in which case Eq (9) applies rather than Eq (11). The key is obviously what sort of 'individual prior' leads to the two covariances being approximately equal.

14) P4, Eq (11): In this case I think the extra equation confuses (especially when split over multiple lines) rather than clarifies. Perhaps better to refer back to Eq (6) and simply state the simplified result.

15) P4, L26: \bar r seems to be introduced in the wrong place in this sentence, pre-

sumably it should be after 'normalized covariance term'

16) P4, L14: I'm surprised that this produces stable results, eg for HCN at higher altitudes, where the <x> in the denominator would tend to zero. Covariance terms, as in the Pearson correlation, are usually scaled by the square root of the variance, so don't have this problem.

17) P5, L17: 'recommend' (spelling).

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