Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-61-AC1, 2019

Atmospheric Measurement Techniques Discussions
Open Access

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

Thomas von Clarmann and Norbert Glatthor

thomas.clarmann@kit.edu

Received and published: 27 May 2019

The authors thank the reviewer for the helpful suggestions which will add clarity to the paper.

Comment: *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>.

Printer-friendly version

Discussion paper

Main Comments:

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...

Reply: We thank the reviewer for the appreciation of our work.

Comment: *... 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.*

Reply: The adequacy of the correction vector can be deduced with mathematical rigour. Since the correction vector is additive while a modified averaging kernel would modify the mean profile in a multiplicative manner, we doubt that it is possible to find a modified averaging kernel which does in effect the same as our suggested additive correction. We think that work with scientific data is best done in cooperation with the data providers, who will then help the data users to apply the averaging kernel and the correction term correctly.

Comment: *...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.*

Reply: We do agree that this paper can only be a first step.

Comment: *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.

Reply: We have gone through the manuscript and checked where it seemed appropriate to replace the latin terms by English ones.
a priori (various places): This is so common that it is not even printed in italic font in Copernicus journals; thus we have decided not to change it.
viz. (p1 l18): can be easily replaced by 'namely' without adding much length to the paper.
mutatis mutandis (p3 l11): although we found it also in an English dictionary, this term might indeed not be widely known. Can be replaced with 'in an analogue way'.
cum grano salis (p3 l17): We will replace this with "with some qualification..."
a fortiori (p8 l3): this is not so easy to replace so we consider to leave it unchanged.

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

Reply: Here we respectfully disagree. The correction is a column vector. It results from a product of an $n \times n$ square matrix with a profile (see, e.g., Eq. 7).

Comment: *3) P1, L17: 'this is' does not make sense here.*

Reply: Will be replaced with 'that is to say'

Comment: *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.*

Reply: To our knowledge, the SPARC data initiative was the first large-scale international activity where the work was entirely monthly zonal means. And, beyond this, it was during the SPARC Data Initiave discussions where the title paper of the problem emerged. We agree that the original manuscript includes an over-exaggerated number of related references, and we will reduce the number of references to a single one (but we would, of course, not fight for leaving this reference included).

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

Reply: agreed.

Comment: *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.*

Reply: We agree. We will figure out some clearer wording here.

Comment: *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.*

Reply: Agreed. We will add such a statement after Eq (2) and modify the following statement because otherwise it might no longer be clear what 'this' refers to.

Comment: *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).*

Reply: Since $F(x)$ might be nonlinear, this extra equation does not necessarily hold in a general sense, although we see its didactic value. We consider to write something like "Within linear theory we have $y - F(x\_a) = K(x - x\_a)$ ..."

Comment: *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.*

Reply: We assume that the averaging kernel of the coarser resolved data set has been evaluated on a grid fine enough to do this transformation. For example, MIPAS averaging kernels are evaluated on a 1-km altitude grid although the MIPAS altitude resolution is typically only about 3 km. This allows application of Eq. 4 to, e.g., model data sampled on a 1-km grid. We realize that our terminology in the paper might lead the reader astray: Our $x_{original}$ is any high-resolved profile to be degraded. It is

NOT our original retrieval. We will change the terminology and use something like "high-resolution" to avoid this kind of misunderstanding. In the application described above, $x_{original}$ was meant to be the high-resolution model data to be degraded.

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

Reply: ok, thanks!

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

Reply: Agreed, we will add this.

Comment: *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.*

Reply: This indeed looks odd in the one-column format of the discussion paper. But the final paper will be formatted in two columns, and to avoid errors in the equation when the manuscript will be transformed from a one-column format to a two-column format, where many of these equations have to be split over two lines, we have chosen a format for the equations which will be compatible also with the two-column style file.

Comment: *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.

Reply: We had two different applications in mind:

1. The retrieval scientist might use climatologies as a priori. This is often done, and Rodgers' account of the smoothing error seems to suggest that this kind of priori information can be used. In this case Eq(9) applies.
2. In some other cases, the best available prior information for each individual retrieval can be used. For example, for MIPAS we use meteorological analyses as a priori for temperature retrievals (we constrain only the shape, not the values, but that is another story...). Eq (10) has been tailored for this kind of applications.

We agree that the entire 'grey scale' between these extremes deserves some discussion. We will expand on this in the text.

Comment: *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.*

Reply: The purpose of Eq (11) is to make clear which of the terms cancel out with the given assumptions in force. This is not easily seen in Eq (6).

Comment: *15) P4, L26: nbar r seems to be introduced in the wrong place in this sentence, presumably it should be after 'normalized covariance term'*

Reply: yes, indeed, thanks for spotting.

Comment: *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.*

Reply: well, rather by the product of both standard deviations involved rather than the variance, but we see your point. Our normalized covariance can be interpreted as a relative error. It is admittedly unstable, similarly as relative or percentage errors in the case of small measured values (and in this case nobody complains). A normalized quantity calculated along the idea of Pearson's correlation coefficient would be more stable but it would require an entirely different interpretation. We will test your suggestion and, if successful, will use it either instead or in addition to our normalized covariance.

Comment: *17) P5, L17: 'recommend' (spelling).-*

Reply: Thanks for spotting.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-61, 2019.