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Atmospheric Measurement Techniques Discussions

Interactive comment on "Correlated observation error models for assimilating all-sky infrared radiances" *by* Alan J. Geer

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General comment: This paper introduced an observation error model for correlated all-sky hyperspectral infrared sounders based on eigenvectors and corresponding eigenvalues, and presented methods to handle the problematic trailing eigenvalues that can cause unrealistic increments in the analysis when used as is. After reducing the sensitivity to the trailing eigenjacobians, the new error covariance matrix gives good results in all-sky infrared assimilation. This research is important as more potentially correlated observations are assimilated. The manuscript is well written and can be published after some minor modifications.

Thanks for these helpful and positive comments.

3.1 *Specific comments: Eigen value decomposition mathematically finds the directions of largest variances within a dataset. While the leading eigenvalues and eigenvectors rep- resents the majority of variance related to strong physical constrains and can be stable, the trailing ones may be sensitive to the training dataset used. The value of the trailing eigenvalues may be small, but it does not necessarily mean the error in the channel combinations represented by the trailing eigenvectors are small. Firstly, eigenvalue de- composition is a linear operation but radiative transfer under all-sky condition is highly non-linear. Secondly, the eigenvalue decomposition is optimized for the entire training dataset, but the Jacobians used in data assimilation is respect to the current model state. Since the leading eigenvalues are orders of magnitude larger than the trailing eigenvalues, any error 'leaks' from the leading 'eigenchannels' during data assimilation due to the aforementioned reasons can overwhelm the trailing eigenvalues. As such, the trailing eigenvalues should be trust less and should not be used directly. Maybe that's why these trailing eigenvalues should be inflated.*

This point is well made and it is also supported in the comments by Wei Gu. Figure 3 does show that the detailed structure of the trailing eigenvectors, particularly for eigenchannel 6, does depend on the training dataset. It is hard to quantify the effect of these variations without an experiment like the one suggested by Wei Gu, which would re-run one of the existing experiments, but using error covariances from the 45r1 samples, to demonstrate the impact. I will definitely try this experiment but I would not like to commit to including the results in a revised manuscript due to the very long time it might take to complete.

Manuscript change: The stability of the trailing eigenvectors and values may be overstated in my manuscript, and without the proposed experiment it is hard to quantify anyway. Hence the assertions of stability will be toned down in sections 3.2 and 4.1 in the revised manuscript. Also in the conclusion the possibility needs to be left open that trailing eigenvectors are not stable enough to justify putting high weights on them, and that this is also a possible explanation for the importance of inflating the trailing

eigenvalues, and that further work would be needed to investigate.

3.2 *The author may overstate the value of the trailing eigenvalues too much in the conclusion section (e.g., Page 41, Line 5-7)*

Manuscript change: certainly the difference between the 0.37 and 1.0 eigenvalue adjustments is small, and this can be toned down on P41 L5-7 as suggested.

3.3 *and suggest modifications to address the possible uncertainties when using the trailing eigenvalues.*

This is already addressed in the response to point 3.1 above.

3.4 *Minor correction: Page 39, line 11: an extra 'because'*

Manuscript change: This typo will be corrected.

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