

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

**Anonymous Referee #1**

Received and published: 15 December 2018

Overall this was an excellent paper, a joy to read, and of significant practical value as well to operational NWP centers. The concepts presented will be applicable to other sets of channels and other instruments as well.

One relevant issue that I would like to see discussed is that of the sample eigenvalue spectrum of the observation error covariance matrix vs. the true eigenvalue spectrum. The expectation value of the largest eigenvalue is always overestimated by the sample eigenvalue, and the smallest is always underestimated. This provides additional justification for raising the value of the smallest sample eigenvalues. (This issue is discussed on a paper you reference, Campbell et al. 2017, which references Ledoit & Wolf, 2004)

Instead of the Desroziers method, which estimates  $R$  as the outer product of the departures and the obs minus analysis, this paper uses the outer production of the de-

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partures with themselves, which yields  $HBH^T + R$ . Because  $HBH^T$  is small compared to  $R$ , especially in all-sky assimilation, this is justified; however, I would like to see a more quantitative estimate of the size of  $R$  relative to  $HBH^T$ . One advantage is that for monitored observations, some operational DA systems do not routinely produce obs minus analysis, which is an obstacle to the Desroziers calculation of  $R$ , but not to the calculation of  $HBH^T + R$ .

Some minor comments:

P14, L20: Campbell et al. 2017 has an extensive discussion of trailing eigenvalues and condition number, so would be appropriate to include as a reference. P27, L15 Please provide a reference for the background fit to observations diagnostic presented here, and comments on how it compares to traditional forecast scores. P29, L11-12 Clarify how the blue curve is better than the orange curve P30 L15. They did not have to increase all evals; they chose to.

The remainder of my comments relate exclusively to the figures:

Fig 3. As noted in the text, eigenvectors are only unique up to sign, so the ones in this figure with the opposite sense should be multiplied by -1 and plotted, so as not to falsely draw the eye to a difference that is not real. Also the subfigures should be laid out differently to allow for larger size. A zero line would also be helpful.

Figs. 5-9, 16, 17, 21 Could use thicker lines to help differentiate the line color

Fig. 10. White should not be used to correspond both to a zero value and to unassimilated. Use e.g. gray over the Antarctic, Sahara, etc.

Fig 11. Colorbar does not need to extend to -2; -1 looks sufficient.

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2018-379, 2018.

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