

## ***Interactive comment on “Construction of non-diagonal background error covariance matrices for global chemical data assimilation” by K. Singh et al.***

### **Anonymous Referee #2**

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#### 0.1 Overview

The work develops an efficient numerical framework for inclusion of non-diagonal error covariance matrices within 3D and 4D variational data assimilation systems. The method is applied to assimilation of satellite observations of ozone from the TES instrument. The overall approach is well developed, and the application verified through comparison of the assimilation results to independent observations. Overall, this work is well written, scientifically sound and quite useful to the community. I have a few comments and a short list of corrections below.

C628

#### 0.2 General comments

1. It is curious that this work focuses on horizontal correlations rather than vertical correlations for assimilating TES O<sub>3</sub> observations. There is systematic lack of information in the TES instrument near the surface, which is where much of the interest in O<sub>3</sub> lies from an air quality perspective. Thus, it would be most beneficial to correlate changes in state variables at higher altitudes, where the information content of the observations are greater, to lower altitudes. However, that the methods described here are easily extendible to an additional vertical dimension is well noted.
2. Use of the off-diagonal error covariance matrix improves the performance of both the 3D and 4D assimilations – when the correlation length scales are optimally chosen. Hence, I believe some of the wording in the abstract, discussion and conclusion (e.g., “inclusion of spatial correlations leads consistently to improved analysis”) should be adjusted to reflect the importance of proper length scales for the success of this approach.

#### 0.3 minor corrections

1. 1784.17: “observations of reality” → “observations”
2. 1784.18: “ improved estimate ” → “ optimally estimated ”
3. 1785: I believe the first variational chemical data assimilation study was Fisher and Lary, 1995, QRJ M. Soc., with a Lagrangian model. The first with an Eulerian CTM was Elbern and Schmidt 1999. Khattatov 2000 used sequential data assimilation techniques, and is thus does not fit in the list of early works in variational methods.

C629

4. throughout: watch for use of parenthetical references when referring directly to a specific work, such as the reference to Chai 2009 on 1785.17 or to Bey 2001 on 1792.6.
5. 1790: “gradient requires to computation ” → “gradient requires computation ”
6. 1792: the url for GEOS-Chem is simply geos-chem.org.
7. 1792: “is being widely used” → “is widely used”
8. 1793, 1808.25: In these locations, the impact of a non-diagonal error covariance matrix is described as spreading information from the location of the observations to state variables in other locations. More precisely, this description should only be applied to 3D-VAR; in 4D-VAR, most of this spreading is accomplished via transport of sensitivities within the adjoint.
9. 1793.1-15: This material could be merged into the introduction, removing redundant content.
10. 1808.4: “are spread are less aggressive” → ??
11. 1808.16: “correlations leads” → “correlations can lead to”

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Interactive comment on Geosci. Model Dev. Discuss., 3, 1783, 2010.