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Interactive Comment

Interactive comment on "Global carbon monoxide products from combined AIRS, TES and MLS measurements on A-train satellites" *by* J. X. Warner et al.

Anonymous Referee #2

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General Comments

The manuscript present a data fusion methodology applied to combining AIRS, TES, and MLS CO retrievals. The methodology is similar in form as the Kalman filter. The analysis is then compared to independent CO profiles from 2 field campaigns (INTEX-B and HIPPO). Results show improved analysis and highlight the complementarity of these retrievals. This improved analysis is potentially useful for studies of CO, in particular, and atmospheric chemistry in general.

However, I have several concerns with regards to the technical details of the method-

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ology. I find the manuscript to lack the necessary details on the observation operator, H in the Kalman filter equation. I also find the manuscript to lack some discussion on the validity of several assumptions critical for an effective data fusion, and useful for easy interpretation of the analysis. In particular, Id like the authors to elaborate on the following issues:

1) Collocation. I understand that the retrievals are 15-30 minutes apart. Is the variability in CO small enough at this spatio-temporal time scale? If not, how is the difference in location and time between retrievals handled in the filter? Are the spatial error correlations between observations (between 2 TES retrievals for example) handled as well?

2) Observation error covariance, R.

a) In Line 1 p 15416, it is assumed that R is diagonal. I assume that R is a retrieval error covariance matrix of TES or MLS in this case. And the elements of this matrix is the error covariance of a retrieval at a certain vertical level of the retrieval grid with the retrieval at a different vertical level. As I understand it, R in TES and MLS is not strictly diagonal (in fact the errors are particularly correlated in the vertical). And so, what justifies the diagonal assumption?

b) In Line 15 p 15417. What is the rationale behind using one global set of error profiles? Should the errors be scene-dependent?

3) Retrieval bias. In Line 26-27 p 15415, it is also assumed that the retrievals are unbiased. I believe this is not the case for both TES and MLS and AIRS CO. What justifies this unbiased assumption? This especially has an impact if both retrievals are biased on the same direction.

4) Background error covariance, Pb.

a) In line 9-11 p 15416, it states:

“The background error covariance Pb, consists of not only the correlation information between any two variables (at different locations) in the background state vector, but

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also the covariance matrices of the AIRS retrievals."

Pb = sqrt(D) x C x sqrt(D)

where C is the matrix containing the correlations and D is the matrix containing the variances of the analyzed species (El Amraoui et al., 2004). Here C stands for the covariance between two grid points. We model the terms of C with the quantity Ci,j $=\sigma i \sigma j$hv, where σi and σi are the standard deviations of background error at location i and j respectively, h is the horizontal correlation model, and v is the vertical correlation model.

Please rephrase since Pb is in fact a function of the correlation matrix and the variances. Is the error covariance matrix of the AIRS retrievals equal to Pb?

If not, why is it not used in Pb? How is it incorporated in the filter?

b) What exactly is C? is C the error correlation matrix? If yes, the definition of Ci,j is erroneous (it should be Pb(i,j) since ph*pv is C and si and sj are the diagonal elements of D.

It appears from the definition of C(i,j) that the vertical and horizontal error correlation is assumed to be uncoupled. What justifies this assumption? Also, what is the rationale behind choosing a power law function for ph? Errors in CO are in fact anisotropic.

5) Observation (or forward) operator, H. Characterization of this matrix is critical in 'transferring' information in any data fusion. Please discuss how H is constructed. Are the associated retrieval averaging kernels and priors incorporated in H? If not, why aren't they? I believe this is an important information to know from the users perspective in order to help the users of this analysis to better interpret and better understand how to properly use it for their purposes. Does H include mapping to AIRS grid as well? How is this done for TES and MLS?

6) Analysis diagnostics. It would be very informative if the averaging kernels of the analysis are shown – since this is the crux of the data fusion. This will greatly support

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and better elucidate the comparison with independent data.

Specific Comments

1) Line 17-18 p 15411. The improvements shown in the Abstract are not explicitly stated in the text.

2) Line 17-27 p 15413, Line 1-17 p 15414. It would be informative if the associated biases of these retrievals (if there are) are explicitly stated as well.

3) Line 8-9 p 15415. 'The population of the profiles on the horizontal plane is determined primarily by the observed variances'. Please elaborate or rephrase.

4) Line 14-15 p 15415. '...but rather uses AIRS continuous measurements...' Please elaborate on the use of the word 'continuous'.

5) Line 24 p 15415. 'i.e. the current size of the AIRS vector' Is this vector the state vector in AIRS CO retrieval? Please specify. Also, does the AIRS CO state vector include non-CO state variables like emissivity and surface pressure, etc? If yes, is this part of the state vector as well? How do you handle this in H?

6) Line 24 p 15418. 'Observation Minus Forecast (OMF)'. I suggest modifying this terminology to an appropriate term to fit the data fusion approach of this study.

7) Figure 1. Equ?

8) Figure 5. Please increase font size and specify units in the caption

9) Figure 6&7&8 Please specify the units.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 15409, 2013.

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