Atmospheric
Chemistry
and Physics
Discussions

Open Access

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 #1

Received and published: 14 August 2013

Manuscript of Warner et al. "Global Carbon Monoxide Products from Combined AIRS, TES, and MLS Measurements on A-train Satellites" introduces a potential methodology to combine satellite datasets from nadir- and limb-viewing CO sensors that measure radiances in the thermal infrared and microwave spectral windows. Timeliness to create the unified global CO product in the troposphere and lower stratosphere is motivated by availability of six space-borne instruments that report CO products (MOPITT, AIRS, TES, IASI- TIR CO data; MOPITT – NIR CO data; ACE and MLS –CO profiles). The thermal infrared nadir sensors (MOPITT, AIRS, TES, and IASI) with DFS $\sim$ 0.5-1.5 provide information on the partial CO columns in the mid- and upper troposphere, while

the near-infrared channels of MOPITT and SCIMACHY report column-based CO with DFS $\sim$1. Information on CO profiles in the upper troposphere and lower stratosphere is presented by ACE and MLS CO limb retrievals. Indeed there is a tendency to perform the multi-sensor CO and ozone data fusion studies without help of assimilation of these data in the chemistry-transport or chemistry-climate models governed by meteorology of NWP systems. Study of Warner et al. represents this tendency, assuming that AIRS CO measurements can be considered as the background field, while TES and MLS CO retrievals can be analyzed as observations and improve the AIRS-CO background. Motivation for this "is simply combine a number of measurements taken within a short time period (15 - 30 min)" using framework of the optimal interpolation (OI) by weights expressed by errors of retrieved CO. This OI-technique is referred by authors as the Kalman Filter method (without 'transport by the model dynamics'). The 'transport by the model dynamics' is replaced by continuous high density AIRS CO retrievals that can constrain (resolve) only partial CO columns as shown by AIRS kernels.

Three main results of this data fusion study for AIRS-CO as a background state are: 1) "higher spectral resolution of TES" helps "to extend AIRS CO observational sensitivity to the lower troposphere"; 2) "combined CO measurements from AIRS and MLS provide enhanced information in the UTLS"; 3) combined CO "show improved sensitivities in the lower and upper troposphere (20-30% and above 20%, respectively) as compared with AIRS-only retrievals".

As a reviewer I have several questions and concerns on the method employed in this data fusion study with AIRS-TES and AIRS-MLS.

1. Methodology of data fusion using OI techniques without use of 'unified analysis space', such as CO forecast space, can be applied to the data with comparable vertical resolutions and persistent data-data differences should be identified before the multi-sensor data fusion. Authors mentioned only that 'we assumed that there is no global bias in CO between AIRS and TES." The use of AIRS-CO as 'unified' space with DFS < 1 (or vertical resolution that corresponds to column-based estimates) is a bit confusing.

All vertical structures of AIRS-CO should be represented at least by time-variable 3D a-priori to proceed towards data fusion with other CO products.

2. Resolutions and information contents of AIRS-CO (DFS <1) and MLS-CO (DFS ~10) are different. Analysis of MLS-CO with kernels is justified for constraining CO predictions by models in the UTLS. It is difficult to interpret what is MLS-CO constraining for CO-background represented by AIRS-CO retrievals with DFS <1.

3. In the nadir view TES and AIRS should have in general similar vertical resolution and sensitivity. I'm not aware about the limb CO measurements by TES. ("The Aura limb sounders (TES and MLS), on the other hand, possess the advantage of high vertical resolution in the UTLS region but lack horizontal coverage"). Before combining AIRS and TES CO-TIR data the instrument biases should be properly addressed (corrected) to avoid "biased" data fusion. The 'enhanced' sensitivity of TES in the lower troposphere is a surprising result for TIR-CO retrievals. It reminds the enhanced sensitivity of MOPITT-V3 CO retrievals with the dominant surface kernel. This feature was a bias of CO in MOPITT-V3 data. Bias was corrected in the next MOPITT versions (V4 and V5).

4.Technical comment: It is not clear how resolution (averaging) kernels of TES, MLS and AIRS and their a priori information were included in the 'sub-optimal' Kalman Filter analysis. Averaging kernels of MLS and TES data are parts of the observation operators H in (1)-(2). Discussions on error specifications by CO retrieval errors of AIRS, TES, and MLS and introduction of vertical correlations (0.17) provide a hint that CO retrievals are considered as conventional data without effects of kernels. There is no information/discussion on the vertical resolution of combined CO products in the text (except Figure 2b).

1) Scientific Significance

Idea to perform multi-sensor data fusion of CO observations and create unified CO data set on 1-deg. horizontal resolution is very important for evaluation of chemistry-

climate models, however the vertical resolution of combined CO product is not clarified and discussed.

2) Scientific Quality

Main questions to scientific approach and applied methods are listed above. Appropriate references are in the text. It would be useful to discuss what is a scientific quality of combined and 'individual' products of CO for model assessments?

3) Presentation Quality

Presentation and illustrations reflect major ideas, method and results. Several samples of sentences that need clarifications and corrections (typos) are below.

Page 6: "This system does not require a model to constrain the physics of the geophysical fields, but rather uses AIRS continuous measurements to constrain the spatial and temporal variability of the TES and MLS measurements."

Page 7: "Assimilating one set of observations into another presents an opportunity to gain some insight into satellite error correlations." Page 8: On error characterization "Figure 3 shows the prescribed error 1-sigma standard deviations (SDVs) for AIRS as the background error and for TES as the observational error. "

Style and typos:

Title: Global Carbon Monoxide Products from Combined AIRS TES and MLS (comma.. AIRS, TES...)

Abstract: "The combined retrievals from the data fusion technique ....." should be revised

Page 8, (Dee and da Silvar, 1999) => (Dee and da Silva, 1999) "The pixel sizes are not to scale for the AIRS Field Of Regard (FOR) of ...." needs revision

Page 9: "The distribution of the TES profiles in the horizontal plane is determined

primarily by the observed variances from AIRS" . . .. needs clarification

"The variations measured by AIRS represent the background CO distribution in this approach and TES retrieved CO is considered as the observations as described in Section 3." . . . needs revision