

# Assimilation of mid to lower tropospheric $CO_2$ retrievals from the Atmospheric Infrared Sounder

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## Response to Reviewer 2

Major Comments:

Page 26687 lines 4-5. This statement has been removed.

Page 26688 line 24. The averaging kernels are calculated as the derivative of the brightness temperature to the  $CO_2$  concentration in each layer, thus is more of a sensitivity rather than a true averaging kernel. These are a by-product of the retrieval, and do not affect the retrievals directly. We have added details on this to the paper.

Page 26689 line 22. Superobbing is simply an averaging of the observations over the model grid box. This results in lower representation error in the observations, and ensures that the matrix solution to the assimilation equations is well conditioned. Details of superobbing have been added.

Page 26689 line 24. The retrieval method is based on a simple least-squares matrix inversion and it turns out to be a normalized weighed mean of the used channel Jacobians (the derivative of the Brightness temperature with respect to changes of the  $CO_2$  profile). We have added additional details on this to the paper. Please see Strow and Hannon (2008) for a complete explanation.

Page 26691. The background error covariance model is indeed a first cut, and needs to be improved upon. We are working on developing an error covariance model that includes seasonal and geographical variations (eg. land and ocean) using global in situ observation networks. We have added further clarification clarifying this in the text.

Page 26693. Further discussion and comparison with the Engelen and Chevalier work has been added. While we agree that this data set is limited in the improvements that can be made to the temporal variability of  $CO_2$ , this is primarily due to the limited clear sky observations available. We have shown that significant improvement can be made to mean  $CO_2$  values at all levels, without increase the error standard deviations. This is in contrast to the Engelen work in which surface level  $CO_2$  could not be improve, and random errors increased as a result of the assimilation.

Page 26698. Further discussion has been added to the paper. We recognize the need for multiple sources of observations, from both satellite and ground based measurement, along with the implementation of a forecast bias correction scheme to this system.

Page 26699. We have clarified this section, in regards to data density and it's impact on the assimilation. We agree that assimilating a sparse observation set like this will result in non-physical

fields, and cannot constrain CO<sub>2</sub> fields completely.

Minor Comments:

Abstract. line 14 Changed to "used channels".

Page 26688. line 21. Change has been made.

Page 26689. line 21. "screen" was changed to "screening".

Page 26692. Line 25. "comparisons" changed to "comparison"

Page 26693. Changes have been made to the paper.