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Atmospheric Measurement Techniques Discussions

Interactive comment on "A Singular Value Decomposition framework for retrievals with vertical distribution information from greenhouse gas column absorption spectroscopy measurements" *by* Anand K. Ramanathan et al.

Anonymous Referee #2

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Review of "A Singular Value Decomposition framework for retrievals with vertical distribution information from greenhouse gas column absorption spectroscopy measurements" by Ramanathan et al.

Overall comments:

Development of a SVD approach for CO2 lidar instruments is useful and worth publishing. However there are some major issues in this paper that need to be addressed before it can be fully reviewed. Partitioning the profile into preset shapes is discussed

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in Tukiainen et al. (2016) for TCCON CH4, although the retrieved shapes were based on prior covariance. The error analysis in this paper should be compared to Tukiainen (2016).

One of the main ways this approach is validated is by comparisons to optimal estimation, however the optimal estimation retrievals do not look comparable to profile retrievals from OCO-2 available in the L2 standard products. For example Figure 6 shows 5 oscillations in the retrieval on the order of 50 ppm. OCO-2 retrieved profiles do not show these types of oscillations. It appears from p. 24 line 1-2 that the constraint used in OE is diagonal. The constraint used should match O'Dell, 2012 (Figure 2) which has strong off-diagonal correlations. Comparing the SVD retrievals to state of the art OE retrievals will be useful.

The second issue in this paper are the claims in the abstract that SVD results in unbiased results and is therefore better than OE. While it is true that the basis functions may not need to be constrained if truncated at whole degrees of freedom, and there may be no biases in the mapped space, the translation of the basis functions into a profile can result in biases and these should be quantified. The biases introduced by this approach should estimated by calculating the linear estimate for different true states, e.g. Tukiainen (2006) Fig. 3 shows the difference between AirCore and smoothed AirCore for methane and a similar SVD approach. The column difference between AirCore and smoothed AirCore (or some other set of trues) would give the bias and error resulting from the SVD mapping using Eq. 34 from this paper. Section 3.3 is also hard to follow.

The authors should clarify how many basis functions are selected. If there are 1.6 degrees of freedom, are 2 basis functions used? If 2, won't the retrieval need some constraint? If 1, won't that throw away information? Kulawik et al. (2017) used 1.6 degrees of freedom from GOSAT to get 2 parameters each with about 0.8 degrees of freedom (so some a priori component in the retrieved values). Would this approach be able to get any vertical information with 1.6 degrees of freedom?

I do not follow Figure 4. What are the units on the y-axis? Are the authors aware that OCO-2 has better precision and more degrees of freedom than GOSAT? This figure suggests the opposite.

I look forward to reviewing this paper when the authors improve the OE results and more carefully characterize the bias and errors compared to the current OE method.

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