Comments to the Editor

Associate Editor Decision: Publish subject to technical corrections (15 Jul 2020) by Thomas Wagner

Establishment of AIRS Climate-Level Radiometric Stability using Radiance Anomaly Retrievals of Minor Gases and SST

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Reviewer #1 Comments

1. Line 30: 'major limitation is that is ...' change 'is' to 'it'
2. Citation format error in Line 31, 619, 674, 676, and 677. (Line number in 'response to reviewer').
3. If possible, consider directly showing trends that pass the statistical significance test, including in Fig.3, Fig.19 + Fig.20, mainly to condense the context you aim to deliver.
4. Can you add an additional panel/curve in Fig.18 to contrast the BT anomaly contribution by retrieved quantities and BT anomalous residual (similar to Fig. 21)?

Author Replies

Request 1.

Done

Request 2.

I do not see any problems with these citations. Hopefully the copy editor might see what I am missing?

Request 3.

Figure 3

I am very reluctant to highlight this issue because (a) our observation subset is a highly spatially non-uniform set of clear scenes that make general geophysical insights difficult, and (b) we have already shown that our anomaly retrievals are extremely accurate for the minor gas forcings and agree reasonably well with ERA-I for temperature trends (see Appendix). In this work we rely on 95% (2-σ) uncertainties (often corrected for serial correlation in time series).

The following sentence has been added to partially respond to the Reviewer's suggestion for Fig. 3.

"Spectral regions in Fig. 3 that exhibit trends smaller than the 2-σ uncertainty are often channels where the BT trends that are due to increasing CO_2, CH_4, and N_2O are counter-balanced by changes of the opposite sign due to trends in either the atmospheric or surface temperature. These counter-balanced trends are all properly accounted for in the anomaly retrievals given the good agreement between the observed and in-situ minor gas trends."

Figures 19 and 20

Figure 19 shows the the mean BT anomalies for the 16-year period broken out by the geophysical contributions to these anomalies derived from our retrievals, as requested by Reviewer #1. In this paper, the CO_2 retrieval was the main in-situ data record used to determine the AIRS stability. The statistical uncertainties in these CO_2 anomaly retrievals are best determined by comparing to the truth data, which is done in Fig. 10 showing the AIRS-ESRL CO_2 anomaly differences, which are discussed in detail in the text.

As I understand it, the reviewer is asking for statistical uncertainties in retrieved parameters as derived from the optimal estimation (OE) process, which is very tricky and not all that relevant to this paper. Since we used a diagonal measurement uncertainty covariance estimate, any parameter retrieval uncertainty estimates will likely be unrealistically small, since the AIRS radiance (noise) can have significant correlations. However, none of the major (NASA and NOAA) systems that do AIRS retrievals include non-diagonal noise covariance. We also expect that the forward model (Jacobian) uncertainties have off-diagonal components as well, which are not included. Therefore we think it best to not estimate something that will likely be incorrect.

Request 4

Our answer here is similar to that for Request 3, Figure 3. However, we have added the following sentences in Section 6.1 to help remind the reader that the anomaly residual errors are far below the observed anomalies shown in Fig. 19.

"The uncertainties in the mean spectral BT anomalies shown in in Fig. 19 can be estimated from the mean differences between the observed and computed BT anomalies shown in Fig. 8. An average over all fitted channels gives a mean residual of -0.0021K ± 0.03K. This excellent fit, combined with the good agreement between the observed and in-situ truth data for the CO_2, CH_4, and N_2O anomalies indicates that the anomalies shown in the top panel of Fig. 19 are likely accurate to the anomaly fit 2-σ uncertainty of level 0.03K."

Similarly to Request 3, the reviewer is essentially asking us to break out the anomaly fit residuals versus time for each fitted variable and estimate their uncertainties. We could do that, but the point of this paper is to compare to "truth" data, ie CO_2, from which we obtain our stability estimate for AIRS. To do this we would take the uncertainties for each fitted variable returned by the OE retrieval, and then multiply that uncertainty by the Jacobian of the geophysical variable. We would prefer to not do that, since we have not really probed the accuracy of our OE uncertainty estimates, which are very sensitive to correlations in the measurement error covariances. Estimating off-diagonal measurement error covariances is very difficult, so for this work we used a diagonal measurement error covariance matrix, which will result in unrealistically low parameter error estimates. We believe the true CO_2 measurement uncertainties are best derived by comparing our retrievals to the ESRL CO_2 in-situ truth data. This is a common problem in OE retrievals, and we would rather not address it here since it does not impact the main conclusions of the paper, which are retrieval comparisons to truth.

Also, a few, mostly numerical changes, were made in the text regarding the newly inserted Figs. 19 and 20, which can be seen in lines 700-701 and lines 709-710 in the diff.pdf file. We inadvertently used slightly incorrect versions (scaling errors) of these two figures when summarizing them in text, requiring small changes to the discussion from lines 705-710. These changes only impact the descriptive summarizes of the mean anomalies.