

Review of Teixeira et al. "Direct Observational Evidence from Space of the Effect of CO₂ Increase on Longwave Spectral Radiances: The Unique Role of High Spectral Resolution Measurements"

This study used AIRS high spectral infrared radiance data to quantify the impact of increasing atmospheric CO₂ concentration on the absorption of 15-um CO₂ band after eliminating interference from water vapor and temperature changes. They found that the isolated signal from increased absorption by CO₂ from AIRS is consistent with RT model simulations. Overall, this letter was well written. The message the authors trying to deliver is clear. The results from this study based on data driven analysis are important to confirm our understanding of CO₂ greenhouse effect. However, given its short length, some important details are not there in the paper and therefore lead to confusions. I will list them below.

(1) Some parameters in Experiments A and B are not the same. For example, you analyzed 2005-2015 for A but 2003 to 2012 for B. Is there a reason that the two experiments need to start from different years? Also, you explain the adoption of 1.2k and 1.2g/kg in the appendix for A, but in B, you used 1.4k and 1.4 g/kg. You need to justify these numbers.

(2) In the experiments, you selected one set of profiles for A and 100 sets for B. It is not clear how the set of profiles were selected. How do you make sure they are representative of the temperature and h₂o vertical distributions on Earth? It would be better if you can show some of the profiles in the appendix as well.

(3) "In experiment B, a key assumption is that the annual mean spectral radiance differences corresponding to each reference state are (to first order) not sensitive to the reference state itself for these selected reference profiles."

You now have 100 sets of profiles and the corresponding spectral change. Can you use these results to justify your assumptions here? For example, are the temperature (or h₂o) variabilities correlated with the spectral radiance differences?

(4) In Figure 2, how large is the uncertainty for the observations? You have that for Figure 1 but not Figure 2. Also, the mismatch between observations and theoretical calculations are large over those CO₂ absorption line centers. The difference can be 0.04K for the lines on the left of 700 cm⁻¹, which is larger than the expected spectra noise. You attributed this difference to CO₂ uncertainty. Can you reconcile the two if you increase the CO₂ in your RT model? It seems your current calculations have less absorption over those lines.

Minor comments:

(1) Line 181-182, the absolute radiometric calibration accuracy is usually temperature dependence. For this 0.2K accuracy, is it relative to what temperature blackbody?

(2) Line 206-207, do you have figure or reference to justify that the temperature profiles in AIRS/AMSU and AMSU MW-only are similar?

(3) In Longueville et al. (2021), the authors showed Figure 2 to illustrate the increased CO₂ absorption in the IASI spectra from 2008 to 2017, though they did not isolate it from the joint effects of temperature and h₂o. This is a related reference for this study.

De Longueville, H., Clarisse, L., Whitburn, S., Franco, B., Bauduin, S., Clerbaux, C., et al. (2021). Identification of short and long-lived atmospheric trace gases from IASI space observations. *Geophysical Research Letters*, 48, e2020GL091742. <https://doi.org/10.1029/2020GL091742>