

***Interactive comment on* “Characterization of Tropospheric Emission Spectrometer (TES) CO₂ for carbon cycle science” by S. S. Kulawik et al.**

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Below contains parts of the review from Reviewer 1. Where a response is needed, a response statement is given with a description of the action taken. Thanks to this reviewer for their comments and suggestions.

When the comparisons are performed (P27425 and Figure 12), it is stated that the agreement is within 2 ppm for all datasets. However, for the Southern Hemisphere this value is of comparable magnitude to the seasonal cycle and in fact for Jul-Dec the TES results appear to be considerably different to the other measurements, enough so that they should be commented upon in more detail.

Response: We agree that the southern hemisphere should be discussed in figure 12.

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Additionally, along the same lines, the 1.3 ppm number in the abstract should be updated. We have calculated comparisons between TES and CONTRAIL+Samoa in the Southern Hemisphere with the standard deviation found to be 1.9 ppm versus CONTRAIL and 2.3 ppm versus Samoa, with, however, a bias in the second half of the year. We are now referring to the Rarotonga aircraft data in the text to understand the southern hemisphere comparisons better. The caption for figure 12 now reads: In the Southern hemisphere, TES shows ~ 2 ppm high values compared to Samoa and CONTRAIL in the second half of the year which is discussed in the text. Similarly, comparisons at SGP have a 2.3 ppm standard deviation and the abstract was updated to read: The estimated error is ~ 10 ppm for a single target and 1.3 - 2.3 ppm for monthly averages on spatial scales of $20^\circ \times 30^\circ$.

P27416 1-4: The authors state that the degrees of freedom available for CO₂ could be increased if more windows were included to independently determine temperature, h₂o, etc and that averaging to reduce measurement error could be performed but it is not clear whether this has been attempted and if not, the reasons for it. A brief comment to clarify this would prove useful.

Response: Since calibration and spectroscopy vary for TES for different filters and spectral regions, this approach has not yielded good results. A statement was added to this effect in the paper: However since calibration and spectroscopy vary for TES for different filters and spectral regions, a working strategy implementing this has not been developed.

P27420 9: Reference is made to the different versions of TES radiance data (v003 and v004) and that this affects the observed bias in the retrieval but the differences between these data versions is not mentioned apart from that v004 includes a frequency calibration update. A comment/reference regarding any additional differences and the reasons why these affect the bias should be included if possible.

Response: A better estimate of the frequency scale is the main difference between v3

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and v4 TES data. At the time this paper was written, v3 data was available up to August, 2008 and v4 data was available after August, 2008. However, now both v3 and v4 data are available for 2005-2008. A comparison was made and found only minor systematic differences between these so discussions of v3 and v4. This section was changed to read: The bias changes when spectral windows or constraints are changed. This bias, however, appears to be stable over the 3 years of uniformly processed data using TES v003 radiances.

Figure 2 Due to the large amount of information being conveyed, this figure would benefit from a key/legend in addition to the caption. The large black border outlining the image could be reduced in thickness.

Response: Labels were added to this figure and the border thickness was significantly reduced.

Figure 3 Rather than dRadiance, the units should be included on the y-axis. Response: Changed as suggested.

Figure 4 The colourbar on the right-hand plots partially obscure the y-axis (which I assume is altitude). This should be correct so that the y-axis is visible. Response: Changed as suggested.

Figure 5 The caption does not specify which geographical regions or time periods these averaging kernels are for or how many retrievals these have been averaged for. In addition, as thermal contrast is important over land, whether these are daytime or nighttime retrievals becomes important. Additional detail in the caption would be useful and some of these issues may need to be clarified in the text when commenting upon the sensitivity of the retrieval. The fact that the surface AKs actually peak at 500 hpa should also be commented upon.

Response: This figure caption text was changed to be more clear: Averaging kernel rows for an average of ocean (near Mauna Loa, left) and land (near the SGP site, right)

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targets over a 3-year period. The ocean targets show more sensitivity on average because the average tropical ocean temperature is 300K versus 290K for the land cases, leading to a higher thermal contrast. So although daytime, summer, land targets will have the greatest sensitivity, averaging over winter and night reduces land average sensitivity.

Figure 9 It is not clear from the caption what TES-swap refers to in the legend.

Response: We agree that this figure was confusing. TES-swap is the linear conversion of the a priori vector from 360 ppm to 380 ppm. However this figure was too confusing with TES-swap present, so we took TES-swap out of this figure. The figure and caption text were updated.

Figure 15 The size and layout of this figure requires some improvement with both the colourbar and the map plots themselves too small.

Response: This figure was simplified to better show the key points by removing the surface carbontracker results, enlarging the colorbar, reduced the border thickness, and improving the colorscale. The typesetting will set the final figure size but hopefully these changes will make the final figure and legend larger.

Thanks to reviewer 1 for the helpful suggestions.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 27401, 2009.

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