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Interactive comment on "Tropospheric carbon monoxide variability from AIRS and IASI under clear and cloudy conditions" *by* J. Warner et al.

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We appreciate very much the comments by reviewer #2. We have answered all questions; with each answer starting with "ANSWER:" We also appreciate this reviewer for praising this paper as "sound, innovative, and potentially very valuable."

—- Interactive comment on "Tropospheric carbon monoxide variability from AIRS and IASI under clear and cloudy conditions" by J. Warner et al. Anonymous Referee #2 Received and published: 16 August 2013

General Comments: This manuscript presents a combined analysis of AIRS and CO observations with several goals. An informative discussion of AIRS cloud clearing is presented in order to demonstrate the quality of the results. A new technique is in-

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troduced to separate background and recently emitted CO observations, potentially aiding in the development of new techniques for constraining emissions (though this is not done here). And third, a comparison between AIRS and IASI is presented to discuss the use of these datasets together for longer term trend analysis. Each of these topics could be the basis of a very rich and useful paper and at times, they seem a bit disjointed presented together here. They could also use a bit more discussion. In particular, the separation of recent emissions from background CO observations is very interesting and potentially very useful to other researchers seeking to estimate emissions, but not enough information is provided to allow others to apply these techniques. Also, discrepencies between AIRS and IASI require further discussion. I recommend publication because I think the analysis presented here is sound, innovative, and potentially very valuable, but more details need to be given so that researchers could duplicate this type of analysis.

ANSWER: We have made some general changes in the manuscript based the comments from both reviewers. 1) Following Reviewer #2's points that "Each of these topics could be the basis of a very rich and useful paper..." and that "discrepencies between AIRS and IASI require further discussion.", we have removed all discussions with IASI CO including the intercomparison with AIRS CO. We will develop the IASI CO related studies to a separate paper at a later time. 2) We have moved the PDF discussions from Sect. 3 that addresses clear vs cloud-cleared issues to Sect. 4 where we focus on the background CO vs fresh emissions. We use the CO averaged amounts, instead of the modes of the Gaussian fits, in Sect. 3 for the discussion of clear vs cloud-cleared ensembles. Likewise, we have limit our discussion on the trends only in Sect. 4 as suggested by Reviewer #1.

Specific Comments: P16337, Line 7 – I find the term 'new emissions' a bit confusing. Readers could interpret that to mean, recently emitted CO; a new source of emissions that didn't exist before (like a fire or new power plant), or a more up-to-date emissions inventory. I think 'recently emitted CO' is more clear for this work.

ANSWER: We agree! We have change the terms "new emissions" to "recently emitted CO" and/or CO from "fresh emissions".

P16338, Line 23 – Why not use the MODIS fire products? Is it because they are limited and cant observe all fires? Might point this out.

ANSWER: We added the following discover in the text to address this concern: "This study attempts to draw information on fresh emissions from satellite CO data only to benefit the ultimate goal of monitoring fire activities in near-real time using CO. AIRS CO based biomass burning detection will compliment the current real-time fire alarming system using MODIS thermal signals, because AIRS CO products are less constrained by smoke and heterogeneous clouds."

P16338, Lines 24-27 – Is there any long-term instrumental degradation expected in these records as is the case with MOPITT?

ANSWER: None found for AIRS.

P16340, Line 26 – What is the AIRS L2 clear indication based on? Why not use this instead of MODIS?

ANSWER: MODIS cloud masks are one of the most sophisticated and accurate cloud detection products, since the instrument was designed with this goal in mind. Our objective in this study is to establish a subset of AIRS measurements that are under clear conditions. Our goal is also to partly study the quality of AIRS L2 cloud coverage product. We updated the following content to the text to clearly state our findings: "AIRS clear coverage defined by the MODIS cloud mask for March 4 2006 is shown in blue in Fig. 2 top panel and the total clear sky pixel ratio is approximately 14.9%. If we choose to define a clear AIRS pixel when all MODIS pixel are flagged clear, there would be only 13.3% clear AIRS pixels per day. AIRS clear coverage is also defined by AIRS measured radiances, instead of by the MODIS cloud mask, as part of the L2 products. The blue pixels in Fig. 2 middle panel show AIRS L2 clear sky cases

(when CloudFraction=0 in the L2 product) and the total clear sky pixel ratio is ∼24.3%, which tends to overestimate the amount of clear coverage compared to Fig. 2 top panel using the MODIS cloud mask. AIRS L2 cloud ratio products can be compared to those defined by the MODIS cloud mask only under clear sky conditions because the MODIS sub-pixel (1x1 km2) cloudiness is unknown. The clear sky coverage differences between MODIS and AIRS L2 are shown in Fig. 2 bottom panel, where the blue pixels represent the cases when both MODIS and AIRS L2 detect clear sky (∼9.5% of total daily pixels). The green pixels are when MODIS detects clear sky, but AIRS L2 failed to identify clear sky cases (∼5.4%), whereas the magenta pixels are clear sky detected by AIRS L2, but not by MODIS (∼14.8%)."

Figure 5 – I have trouble distinguishing the clear and cloudy lines – can these be made thicker?

ANSWER: This has been corrected. We have also removed the background vs fresh emissions discussion, and used the averaged CO for the clear vs cloud-cleared discussions. Additionally, we added a difference curve between the clear and cloud-cleared discussions to make this discussion easier to understand.

P16343, Paragraph – I'm confused over how the background and recent emissions are separated. More details are needed here as this is fundamental to the analysis.

ANSWER: We have added more details to this discussion. We have changed the order of figures because the PDF discussion is now in Sect. 4 and the old Fig. 5 is now Fig. 6. We added "We note that the histograms for CO distributions are not generally Gaussian and often show two peaks (see Fig. 6 top right and bottom right panels) over a CO population. The peaks at lower CO values are generally associated with the background (BG) CO, whereas the peaks at the higher CO values are associated with fresh emissions (FE). We fit two Gaussian functions simultaneously for each histogram for clear (solid) or cloud-cleared (dashed) conditions. The left Gaussian fits (blue) in each panel represent a well-mixed background whereas the right Gaussian fits (red)

with higher CO values represent the fresh emissions."

Figure 6 – It strikes me that the 'new emissions' tend to follow the background which makes me wonder what the differentiation is. When does a 'new emission' mix/age enough to become the background? How do you separate them entirely?

ANSWER: It is difficult to separate the background and fresh emissions completely since the approach we take in this study is by statistical analysis. There is not a way to determine the age of the plumes using CO measurement alone, without using a model and other species, such as C_2H_2. The time it takes for a recently emitted CO plume to mix in to become part of the CO background will depend on the dynamic and transport conditions.

P16344, Line 25 – I think the 'new emission' term is particularly confusing here. It implies that emissions are being calculated from AIRS which is not the case. This is showing that a subset of AIRS CO observations captures the seasonal cycle of inventories well. Could the same be said of the total CO observations (not segregated into new emission and background)?

ANSWER: We have removed the discussion of background vs fresh emissions from this section Sect. 3) and used the total CO (not segregated) for the clear vs cloud-cleared discussion.

P16346, lines16-18 – See first comment. These are not emissions.

ANSWER: We have change the wording to "recently emitted CO".

Figure 11 – Why use AIRS only through 2011? Aren't AIRS CO data available for more recent periods to include in these comparisons? This would seem to be a priority given the discussion of trend analysis.

ANSWER: We have updated our figures to extend AIRS CO data to the end of 2012. From March 1 2013, AIRS products were switched to V6, so we can't extend the V5 data trends beyond that point.

P16348, Lines 16-17 – There seems to be a clear discrepancy between AIRS and IASI in NH trends during the period for which both datasets are shown in Figure 11. Why might this be? I understand that this may be beyond the scope of this paper, but I think some more discussion would be helpful as this is potentially very important.

ANSWER: We have moved the IASI related discussions to a future study so that we can include more detailed analysis.

P16348, Line 25 – I think the correlation coefficients need to be placed in context. What is the correlation between the total CO (segregated into new emission/background values)? What improvement in correlation coefficient does this technique give?

ANSWER: This is a great point! We have added the discussions for the short-term tends under clear and cloud-cleared conditions for the total CO (before the segregation of BG and FE), and added the coefficients in Table 1. For example, the trends for the cloud-clear total CO in the NH (land and ocean) is -1.16ppbv/year in comparison to the NH recently emitted CO at -1.71ppbv/year over land and -1.95ppbv/year over ocean. See more details in the final version of the paper. We have also added the correlation coefficients for AIRS CO to the inventories without separating the CO background and recently emitted CO, for comparison purposes.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 16337, 2013.

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