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Interactive comment on “Does GOSAT capture the true seasonal cycle of XCO₂?” by H. Lindqvist et al.

Anonymous Referee #2

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This paper explores whether GOSAT satellite observations capture the true seasonal cycle in XCO₂ in the Northern Hemisphere. GOSAT mean annual cycle amplitudes are evaluated against three versions of the “truth”: TCCON, the collective wisdom of several different algorithms used to retrieve XCO₂ from GOSAT, and data assimilation products that use surface CO₂ mole fractions as constraints. The authors conclude that GOSAT captures the true amplitude to within about 1 ppm across most latitude bands, but identify a systematic offset in the XCO₂ seasonal amplitude in Europe. This may be of special interest, since a few different data assimilation and inverse modeling efforts to infer fluxes from GOSAT data have inferred a large and potentially spurious sink in Europe.

The paper is clearly written and the analysis is thorough.

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The NOAA/Basu coincidence criteria seem to lead to huge footprints! Figure 2 shows the coincident observations for comparison with the Park Falls, WI TCCON site. This footprint would overlap the footprint of the TCCON site at Lamont, OK (since the latitude limit is 7.5 deg and these sites are separated by only 10 deg lat). These two sites have a seasonal that differ by several ppm, and there is a subset of ACOS data that is assumed to represent both sites. This is possibly justifiable, since transport in the free troposphere connects the two sites dynamically, but I think some justification of the criteria used, beyond a citation, is required.

The coincidence criteria are not plotted for any European TCCON sites, which are located quite close together. It seems that the autocorrelation between the GOSAT soundings used to compute the seasonal cycle for Bialystock, Bremen, Karlsruhe, Orleans, and Garmisch would be quite high. How does this affect the significance of the bias found by the authors with respect to the seasonal cycle?

When attempting to explain the discrepancy between TCCON and GOSAT, the authors use TCCON retrievals from both GGG2012 and GGG2014, and note that “The difference comes likely from the extended time series and the additional measurements present in the GGG2014 version”. Please clarify what is meant here. Are an additional 1-2 years worth of data going into the second data set? Are more TCCON data used to calculate its mean annual cycle since GGG2014 is better able to account for e.g., solar zenith angle bias so fewer observations are required to be excluded? It seems that for this comparison, the authors should take the average only of the same unique soundings.

Also on p 16476, the authors write that “a shallow-biased GOSAT seasonal cycle over Europe contradicts.. a stronger carbon sink over Europe”. This is not necessarily true, since the sink only depends on the imbalance between assimilation and respiration and does not require a strong seasonal difference between these two quantities. I don't think there is necessarily a contradiction to resolve, but I definitely don't understand the explanatory sentence that follows referencing Reuter.

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p 16479, If there are biases unique to individual retrieval algorithms that degrade the agreement with TCCON, is it really a good idea to brush these biases under the rug and attempt to use a composite dataset that contains a regionally inconsistent set of biases (EMMA)? I don't see the logical link that supports the use of the EMMA.

p 16483, The authors discuss the role of prior fluxes as driving differences in the GOSAT-to-model comparison, but should also include discussion of the differences in the transport models at the heart of each inversion.

Figures: Figure 4: This is the closest to raw data that we see for most of the sites, so I would like it if this figure were bigger so the reader could interpret it better. Maybe two columns, but the same height so that the tick marks could be better spaced and labeled?

Figure 8 and discussion in the text of longitude-dependence of seasonal cycle: It would be nice if there were a figure in the paper that showed the position of the continents and some indicator of the dominant tropospheric transport pattern to allow the reader to better interpret. For example, is the relatively higher amplitude between 120-60W due to the fact that those measurements are made over a continent? Or is it due to the fact that the jet is northwesterly at this location?

wording: Abstract: "The seasonal cycle ... represents an important variable to accurately measure from space", but we can't measure the seasonal cycle since the long-term upward trend necessitates pre-treatment of the measurements. Therefore, the wording might be better as "represents an important quantity to test the accuracy of measurements from space" or something like that.

"GOSAT agrees with the models". Why should the data have to agree with models? Perhaps better worded as "models are consistent with the GOSAT amplitude to within 1.4 ppm"

p 16465 "This finding not only suggests that regional XCO₂ can be indicative of local

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fluxes". I find this wording confusing.

p 16467 "GOSAT measures scattered solar". I think "reflected" sunlight is more accurate term.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 16461, 2015.

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