

Interactive comment on “Building the COLlaborative Carbon Column Observing Network (COCCON): Long term stability and ensemble performance of the EM27/SUN Fourier transform spectrometer” by Matthias Frey et al.

Anonymous Referee #2

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Overall comments:

This paper analyzes multi-year analysis of EM27/SUN results compared to TCCON. The long-term performance and stability of the EM27/SUN systems is important to use EM27/SUN results for science analysis and satellite validation. The EM27/SUN systems have potential as lower cost stationary instruments, and for use in shorter term field campaigns since EM27/SUN are easier to move.

I agree with reviewer 1 that column averaging kernels should be shown and compared

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to TCCON and LR TCCON.

The assessment of EM27/SUN results relies on comparisons to a specially processed, modified TCCON dataset, called LR TCCON. LR TCCON is reduced resolution TCCON, with a differently derived ILS, and processed with the PROFFIT software. However, LR TCCON has not itself been validated.

Significant differences are seen between EM27/SUN and the full resolution TCCON (shown in Figures 4 and 6) for XCO₂ and XCH₄. These errors should be quantified in the paper. The errors are seasonally dependent and look to have peak-to-peak seasonal errors of about 1 ppm for XCO₂ and 20 ppb for XCH₄, larger than the TCCON errors compared to aircraft validation (0.4 ppm for XCO₂ and 5 ppb for XCO₂ for GGG2014 (Wunch, 2015)). Comparisons of EM27/SUN results to LR TCCON are very good. However, LR TCCON has NOT been validated and comparisons of EM27/SUN versus LR TCCON is NOT validation of the EM27/SUN results and does NOT tie EM27/SUN to WMO.

In summary, if LR TCCON can be validated versus aircraft/AirCore with similar errors as the standard TCCON, then this paper will set useful limits on EM27/SUN errors. As the paper stands, validation that must be considered is versus the standard TCCON product, which is marginal for satellite validation and on the high side for other uses.

Specific comments

Introduction:

The COCCON project should be introduced in the introduction, with the objectives of the COCCON, and who is participating in COCCON, the length of the project (for example).

In the introduction, add in the importance of TCCON for OCO-2 and GOSAT validation, adding a sentence after line 23 something like: "TCCON stations are also the primary validation for OCO-2 (cite [C2](https://oco.jpl.nasa.gov/files/ocov2/OCO-</p></div><div data-bbox=)

2_SciValPlan_111005_ver1_0_revA_final_signed1.pdf) and validating the satellite observations at different locations is critical for the validation effort (Wunch et al., 2017)."

A figure showing the TCCON (original and degraded resolution) and EM27 spectral range and radiance would be helpful for the reader, or a reference to a previous paper showing this.

The spectral ranges and approximate resolution should be given in wavelength in addition to wavenumber. Some scientists are used to wavelength and the translation is not immediately obvious.

Section 2.2 The description of the HR125 low resolution data set should include the software used to analyze it. I infer it is PROFFIT, but should be stated.

Page 5, line 15. Define ILS, modulation efficiency, phase error.

Page 5, line 22. How is the phase error calculated— describe or cite a reference. Why is phase error important? What does it affect?

The statement on line 7, page 7, "The remaining difference can be attributed to the different measurement heights of the HR125 (112 m) and EM27/SUN (133 m)." This needs to be further explained and quantified. Is it the total column? It would be useful to the reader to have a calculation accounting for the offset.

Table 2, it would be useful to show the effect on XCO₂, etc, which is the key result. The reader looks between columns and thinks it will probably cancel for XCO₂ but is not sure.

Page 8, line 11, "From this higher variability it can be concluded that the air mass dependency in the official TCCON O₂ retrieval is higher than for the PROFFIT retrieval, a finding also observed by Gisi et al. (2012)." This statement needs to be modified for clarity to "...higher than for the PROFFIT retrieval on reduced resolution TCCON measurements."

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Page 8, line 25. "There are no obvious steps between the EM27/SUN and the HR125 LR data sets so that it can be concluded that the EM27/SUN is stable." The offset versus time needs to be quantified as well. Step functions and slower drift are both important to quantify.

Page 9 line 7. The green line on Fig. 4 shows significant differences between TCCON and EM27, on the order of 1 ppm it looks like. This seasonal cycle amplitude difference should be quantified. The pink difference (comparison to LR TCCON to EM27) looks very good. As stated in the overall comments, if the difference of EM27/SUN vs. TCCON is larger than the reported TCCON error, then it is important to determine the cause of this difference. PROFFIT should be applied to the full resolution TCCON data, OR GFIT should be applied to the low resolution TCCON data to separate out the PROFFIT/GFIT differences vs. ILS/truncation differences to determine the source of the difference between full-resolution TCCON and LR TCCON.

LR TCCON needs to be validated versus aircraft/AirCore before it can be used to validate EM27/SUN.

Similar comment for XCH₄. In Fig. 6, differences for XCH₄ between EM27 and full resolution TCCON look to have seasonal differences of about 20 ppb, which is higher than the TCCON estimated XCH₄ error of 5 ppb.

Wording/formatting suggestions:

Line 11, suggestion: change "as demanded by" to "as specified by"

Line 16, word suggestion: "Nonetheless" change to "However" Line 20: "However, recently OCO-2 data was used for estimating the source strength of power plants (Nassar et al., 2017)", would reword to emphasize coverage issues, "Recently OCO-2 data was used for estimating the source strength of power plants (Nassar et al., 2017). However, this can only be done for power plants that lie directly under the OCO-2 overpass locations."

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Make the dots bigger on the Fig 2-7 legends. It is very hard to tell which dot is blue and which is black in the legend.

Page 7 line 11, "Before, a sensitivity study is provided demonstrating the effect of changes in the ILS on the gas retrieval." I think change "Before" to "First".

I see reviewer 1 suggests deleting Fig. 10. However I think Fig. 10 is useful to show the size of the instrument. Perhaps make this figure small.

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