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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Assessment of errors and biases in retrievals of X_{CO2}, X_{CH4}, X_{CO}, and X_{N2O} from a 0.5 cm^{-1} resolution solar viewing spectrometer" *by* J. K. Hedelius et al.

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General comments:

This manuscript presents a study of several portable low resolution (0.5 cm-1) solar viewing FTIR spectrometers. These spectrometers are used to measure column averaged dry air mole fractions of greenhouse gases (GHGs) from ground based stations. Four such spectrometers from three research laboratories (Caltech, LANL and Harvard) are used in this study; with several results described for the Caltech EM27/SUN spectrometer. The Caltech spectrometer used in this study is a Bruker EM27/SUN spectrometer in a modified form using an extended InGaAs detector covering a spectral range of 4000 – 11000 cm-1 at first and later in its standard configuration with the

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standard InGaAs detector covering a spectral range of 5500 – 12000 cm-1. The other EM27/SUN spectrometers have used a standard InGaAs detector which can measure CO2, CH4, O2 and H2O. The additional spectral range from the extended detector made the retrieval of CO and N2O possible. This is one of the key aspects of the manuscript. Furthermore, the measurements are performed right next to a high resolution solar viewing spectrometer from the Total Carbon Column Observing Network (TCCON). The EM27/SUN data is compared with respect to the TCCON data. The manuscript gives an overview of the assessment of errors and biases in the retrieval of XCO2, XCH4, XCO and XN2O. It identifies very nicely the non-linearity behavior of the extended InGaAs detector while the detector has been used in combination with a low resolution spectrometer. It gives a clear message that using the extended InGaAs detector with its full spectral range is not recommended for low-resolution spectrometers. It also identifies the effect of mirror degradation on the retrieval of the GHGs when the mirrors are exposed outside for long period of time. It also describes in detail the different steps of the data processing chain. The retrieval software suite EGI, which has been used in this study, is offered for open use to any potential user. Finally the manuscript proposes a list of tests to be performed for assessing biases and sensitivities of solar viewing remote sensing instruments. The paper gives added value to the currently existing know-how of the ground based solar absorption spectrometer community. The community will benefit from the lessons learned while using the extended InGaAs detector and its non-linearity issues in relation to the low resolution spectrometers. Therefore I recommend it for the AMT publication with some minor additions as outlined below in the specific and technical comments.

Specific comments:

I would appreciate if you could specify the conditions of your quality control filters which are used for the selection of ifms used for this study.

The long term stability of the Caltech EM27/SUN spectrometer was tested with the extended InGaAs detector which has non-linear characteristics. The data show a strong

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drift in the XCO2 and XCH4 retrievals which is not so evident in the XCO and XN2O due to frequency and signal strength dependent non-linearity effects. I suppose with a proper characterization of the detector non-linearity it may be possible to understand the drift. Furthermore, I would like to mention that this does not prove that the EM27/SUN in its standard configuration (with InGaAs detector in the spectral range 5500 – 12000 cm-1) may also show long term drifts in the retrieved values of GHGs.

The author claims that it is a first time presentation of the retrieval results for XCO and XN2O. While this is true for XN2O, I would like to point out here that there has already been a publication on XCO observations using EM27/SUN by F. Hase et al. (doi:10.5194/amt-2015-403, 2016). The author should acknowledge this work and include it as a reference in this paper.

Figure 1 shows the selection of the spectral windows used for the retrieval. However, the reader has no feeling of the spectral fits for the respective gases in different microwindows. Therefore, I would include the residual of the spectral fits for the retrieved gases for a better understanding.

Both TCCON and EM27/SUN spectrometers at Caltech use protected gold coated mirrors. However, only the latter shows a strong degradation of the mirror quality for the measurement time period. Can you please comment on the cause?

Page 18 Line 6: it says that “The non-linearity of the detector has a less pronounced effect on XCO and XN2O retrievals . . .” – Can you please spare some words on why (may be include a figure)?

Page 21 Line 18: “Our experience also suggests that the extended InGaAs detector is incompatible with precise XCO2 and XCH4 retrievals”. This is a very general statement which is not necessarily true always. The author himself points out earlier that the use of a band-pass filter will be needed to operate the extended InGaAs detector in the linearity range and provide high quality measurements of CO, CO2 and CH4. The non-precise XCO2 and XCH4 retrieval was as a result of the configuration used for this

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study. I would reformulate this sentence accordingly.

Figure 3: How is the ifm maximum calculated? Do you do any zero-filling? What is the reason for the intermediate increase in the ifm value (e.g. for abscissa values in-between the start and 07-14)

Technical comments:

Page 2 Line 19: I would include the formula for Xgas here.

Page3 Line 22: I would restructure the sentence as . . . The main goal of this work is to quantitatively evaluate the robustness of EM27/SUN retrievals over a long period of time.

Page 4 Line 3: . . . and data acquisition technique (or process)

Page 4 Line 4: . . . we describe the inherent properties

Page 4 Line 10: 2.1. TCCON IFS 125HR spectrometer Please replace 125 HR to IFS 125HR in the whole manuscript

Page 4 Line 13: InGaAs (Indium Gallium Arsenide)

Page 4 Line 16: I would modify “individual gases retrieved are highlighted”

Page 4 Line 18: I would include here the definition of the factor 0.2095

Page 5 Line 5: I would replace “Most use” by “The standard EM27/SUN spectrometer uses”

Page 5 Line 9: All EM27/SUN spectrometers use here . . . please give details here

Page 5 Line 22: using a medium Norton-Beer apodization with those using no special apodization.

Page 7 Line 3: the retrieval algorithm used by the TCCON

Page 18 Line 15: I would remove $\sim$ from “to EM27/SUN ($\sim$0.5”

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