

Interactive comment on “The arctic seasonal cycle of total column CO₂ and CH₄ from ground-based solar and lunar FTIR absorption spectrometry” by Matthias Buschmann et al.

Anonymous Referee #1

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The manuscript under consideration discusses measurements of column-averaged amounts of carbon dioxide and methane by applying near-infrared ground based lunar absorption spectroscopy. The suggested approach might be regarded as a useful addition to solar measurements especially at high latitude sites, because then the sun is inaccessible during longer periods in wintertime. However, in my feeling, more emphasis should be laid on potential systematic biases of lunar measurements (the abstract only provides an estimate for the precision!). Moreover, a crucial question is left untreated: which quality (precision and accuracy) is required for such observations in order to justify the associated effort and to improve our knowledge of the atmospheric state? The de-trended wintertime year-to-year variability of the MACC data would al-

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low estimating figures. One potential source of systematic bias is due to the fact that the solar spectrum observed on the moon is a solar disc-averaged spectrum, while TCCON observes disc-centered spectra (and this is assumed in the GFIT analysis also, therefore the lunar spectra need to be processed with different settings). A discussion of the two crucial items (accuracy budget and of the target accuracy and precision) should be discussed in the final version of the paper. My detailed technical comments are given below.

Abstract: also provide an estimate for the accuracy (bias with respect to solar TCCON measurements) of the lunar measurements.

Page 2, line 28: “The extension of the bandgap . . . reduces the quantum efficiency” – is this true?

Figure 1: It would be instructive to show a lamp spectrum recorded with the standard TCCON detector element also (and to provide some information concerning the noise level achieved with the selected lunar InGaAs diode (cooled and uncooled) and with the standard extended TCCON detector element for the same input signal level, e.g. for the 6000 . . . 6400 cm⁻¹ region, where the CH₄ and CO₂ bands reside).

Page 4, line 10 ff: not a sentence.

Section 3.2: The fact that the noise level is too high in the lunar observations for using the spectroscopically observed oxygen column should be regarded as a severe drawback of the suggested approach.

Page 5, line 11: “. . . for the analysis in section 4.” It would be instructive to explain here to the reader which topic is covered in Section 4.

Page 7, line 10 ff: “. . . one option to decrease measurement time . . . is to increase the velocity . . .”. No, this is not the case in the context of optimizing the spectral signal-to-noise-ratio (SNR). Here, only the spectral resolution and the throughput matter.

I would have expected (for a given allowed integration time) to see a more pronounced

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reduction of error bars on the retrieved columns until a further reduction of resolution starts to decrease the contrast between the lines and the adjacent continuum. Has the spectral SNR been adjusted as function of resolution in this manner (assumption of a certain amount of available integration time)? When comparing different resolutions, one might also take into account that a larger fieldstop can be applied when resolution is reduced (increasing the signal level, favoring shorter scans even more).

Page 8, line 4: “. . .white noise were added.”. How has this operation been performed technically? In the interferogram domain before the FFT? Note that this section does not specify (nor treats) the choice of the numerical apodization function, which seems a further important choice in addition to the scan length if reaching the best possible precision of the retrieved column is so crucial.

Page 12, line 10: “air-glow emissions”. This study would be especially interesting if lunar spectra taken during twilight would be treated separately (spelling: airglow).

Figure 12: Despite the fact that no biases were discovered in the September 2013 measurements, one is left with the impression that the lunar CH₄ measurements in 2015 are biased high in comparison to the solar observations.

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