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Atmospheric Measurement Techniques Discussions



# *Interactive comment on* "Sensitivity of remotely-sensed trace gas concentrations to polarisation" *by* D. M. O'Brien et al.

**Anonymous Referee #1**

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The paper by O'Brien et al. investigates the impact of polarization effects on the performance of carbon dioxide, methane, and carbon monoxide retrievals from the proposed geoCARB satellite measuring solar backscatter spectra in the shortwave infrared spectral range. The paper provides a theoretical – and actually quite tutorial - assessment of how to describe and to calibrate the instrument's polarization characteristics. Then, retrieval simulations quantify polarization-induced retrieval errors given a few cases of assumed knowledge of instrument characteristics. Thereby, the authors avoid circularity of the simulation-retrieval process by using different forward models for simulating measurements and performing retrievals.

The paper is of interest to the readers of Atmospheric Measurement Techniques. The employed methods and techniques appear robust and scientifically sound. The paper



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is well written. Discussion of the results could benefit from some more detail as outlined below. Overall, I recommend publication in AMT after considering my minor comments.

Section 2: Would it be worth mentioning that quantities are wavelength dependent?

Section 3: The calibration procedure puts the scan mirrors in their exact nadir position. Would it not be necessary to separately calibrate radiometric response and polarization properties for the relevant range of off-nadir angles?

P8795: It would be good to elaborate a bit more on the radiative transfer algorithm used (or to provide the relevant references).

P8795: Section 6 describes the differences between simulated measurement and retrieval algorithm which are in particular the (polarization relevant) surface reflection and particle scattering properties. Bullet 1 at P8795,L21 seems to indicate that absorption coefficients are also different between simulation and retrieval. Is this true? This would induce errors that could mask the polarization effects to be isolated here.

P8795: I agree that noisy simulations could dilute conclusions on polarization-induced errors. Therefore, the authors choose to run noiseless simulations. In principle, linear retrieval theory could be used to a posteriori subtract the noise error using the contribution function matrix and the actual noise realization in the spectra (known for simulations), see e.g. Butz et al., Remote Sensing of Environment, 2012. Subtracting noise errors a posteriori would have the advantage that the retrieval faces the real challenge. Noiseless simulations could, for example, result in overly optimistic convergence behavior. This is, however, a minor point and does not need to be evaluated for the current simulations.

Section 7: While the histograms clearly illustrate that, statistically, polarization effects have a small impact on geoCARB's retrieval performance, it could be worthwhile to investigate whether badly performing cases correlate with viewing and solar angles or polarization/scattering/reflection properties of the atmosphere and surface.



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P8799,L24: Why are XCH4 and XCO less reliant on the O2A-band than XCO2?

Figures 4 and 6: At first glance, it is somewhat misleading that the upper panels show spectral ranges beyond the ones in use while the lower panels focus on the actually used ones.

Figure 5: Define relation between datasets and right-hand/left-hand axes.

Figure 9: It could be interesting to also show the degree of polarization for the bands other than the O2A-band. Could it be true that polarization effects are smaller in the 2.3 micron CH4, CO window than in the CO2 windows and therefore, XCH4 and XCO are less affected by polarization effects?

Figure 10: I presume that the column-average mole fractions are calculated by dividing the retrieved total column CO2, CH4, and CO concentrations by the retrieved (surface pressure derived) O2 column. So, XCO2, XCH4, XCO errors include both sources, erroneous total column retrievals of the actual species and erroneous surface pressure retrievals. What are the individual contributions?

Figure 11: Should albedo slope have units of 1/wavelength? Does the cloud of lower-than-true albedo slope (right panel) correlate with geophysical parameters?

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Interactive comment on Atmos. Meas. Tech. Discuss., 8, 8779, 2015.