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Atmospheric Measurement Techniques Discussions

Interactive comment on "Aerosol information content analysis of multi-angle high spectral resolution measurements and its benefit for high accuracy greenhouse gas retrievals" *by* C. Frankenberg et al.

Anonymous Referee #3

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General comment

This is a clearly written, well-focused paper on an important topic, namely the potential of detailed aerosol retrieval to support accurate CO2 and CH4 retrievals from NIR-SWIR spectrometry. Although earlier sensitivity studies have been published on aerosol retrievals from the O2 A-band, this study demonstrates the advantage of multi-directional sensors for both aerosol and CO2-CH4 retrievals as compared to single-view sensors. Also the study of the DOF dependence on FWHM and SNR is very

useful (Figs. 5-6). The study is relevant for future GHG missions like OCO-2, but also for aerosol missions like 3MI.

At some places in the paper (like Sect. 3.2) a more physical explanation of the sensitivities found would be in place. Why are certain aerosol microphysical parameters better retrievable with multiple directions than other parameters? This must be due to the phase function effect. But this should hold also for particle size. Furthermore, some of the results shown in Fig. 2 seem counter-intuitive (see below).

Specific comments

The comments below are mainly aimed at clarification, referencing, and improvement of presentation. When these comments are taken into account, the paper can be accepted.

Abstract:

p. 2858, l. 11: here - and in the Introduction - POLDER should be mentioned first, since POLDER was earlier than MISR in aerosol remote sensing with multiple viewing directions; and POLDER has more aerosol retrieval capabilities than MISR: more viewing angles, O2 A-band channel, and polarization capability.

Introduction:

- Missing reference on aerosol retrieval from the O2 A-band and sensitivity studies relevant to CO2: Boesche et al.: Aerosol influence on polarization and intensity in near-infrared O2 and CO2 absorption bands observed from space, J. Quant. Spectrosc. Rad. Transfer, 110, 223–239, doi:10.1016/j.jqsrt.2008.09.019, 2009.

- Missing reference on the importance of multi-directionality for cloud geometric thickness retrieval from the O2 A-band: Ferlay, et al. 2010: Toward New Inferences about Cloud Structures from Multidirectional Measurements in the Oxygen A Band: Middle-of-Cloud Pressure and Cloud Geometrical Thickness from POLDER-3/PARASOL. J. Appl. Meteor. Climatol., 49, 2492–2507. doi:

http://dx.doi.org/10.1175/2010JAMC2550.1

- It should be noted that inclusion of polarization in the multidirectional measurements could also lead to more information on the aerosols, especially on the particle size. Please give a reference of a POLDER paper using this information.

- How many viewing directions will OCO-2 have ? (p. 2860, l. 4-5). Are the three viewing direction of Fig. 1 typical for OCO-2 ? Does the information content increase linearly with the number of viewing directions? This point occurs also later in the paper (in Sect. 2 an "arbitrary number" of viewing directions is mentioned).

Sect. 2

p. 2861, l. 14: its > their, wavelengths > wavelength

p. 2862, l. 15: reflectance > surface reflectance
Eq. 7: what kind of surface is represented by this equation?
Eq. 7: please explain the symbols representing angular quantities; show these quantities also in Fig. 1 and Table 2.
l. 21: 1995).
l. 24: Lambertian

p. 2863, l. 15: are the aerosol refractive indices at the 3 or 2 bands allowed to vary independently from each other? Or is there some spectral relationship imposed on the refractive indices at the different spectral bands? Please note the large spectral distance of the 3 bands, which would make an assumption on a spectral relationship problematic.
l. 15: real-and > real- and
l. 17: column > column density
l. 26: what kind of surface does Lamont have? What is the typical albedo?

p. 2864, l.2: Please mention that since the three viewing directions were chosen in the principal plane (0 – 180 deg relative azimuth) the information content of the three

different viewing directions is maximized. In general, the information content of three viewing directions outside the principle plane will be less.
l. 3: scattering angles > solar and viewing geometries. The scattering angle is a specific angle, namely the angle between the direction of incident sunlight and the direction of scattered light towards the sensor. This should also be corrected in Table 2. Please clearly introduce angles in Fig. 1.

Sect. 3

p. 2866, l. 7: aerosols > aerosol

p. 2867, l. 11: introduce here the abbreviation DOF
l. 19: line-shapes

p. 2868, l. 15: and/or

Sect. 4

p. 2870, l. 8: a priori > a priori value
l. 9: N should be in italics
l. 15: satellite > satellites

Tables and figures

Table 1: header: a prior > a priori

1-sigma: looks like a subtraction: 1 – sigma. Please adapt, e.g. 1sigma; same holds for text and captions.

Please specify together with the aerosol column density also the relevant aerosol optical thickness (AOT), since that is a more commonly used quantity for aerosol amount.

What type of surface is represented by these surface parameters?

Table 2: Please specify all relevant angles: solar zenith angle, viewing zenith angle,

relative azimuth angle, and scattering angle. Now the term scattering angle is incorrectly used for viewing zenith angle. For satellite observations, scattering angles are mostly > 90 deg. Show the relevant angles also in Fig. 1.

Fig. 1: show all angle definitions here. Here “viewing angle” should be corrected into “viewing zenith angle”. What does the white-blue box mean? What does “scan” mean?

Fig. 2: Why is the sensitivity (Jacobian) of the O2 A-band to aerosol height so small? The values are around 10^{-7}. This looks very unrealistic. How can it be that the CO2 band Jacobian for aerosol height is even larger than the O2 A-band Jacobian ?

Please explain the quantity along the y-axis. What is the unit? Or is it a normalized radiance? Is it a reflectance?

Fig. 2: how do the Jacobians look like for the SZA=20 deg case? Please add that figure, since the other figures are shown for both the large and small SZA cases.

In order to avoid confusion with the terms “high sun” and “low sun”, please change in the figure captions and text: high solar zenith angle > large solar zenith angle low solar zenith angle > small solar zenith angle

Fig. 3: what is the a priori value of AOT at 760 nm?

Figs. 5-6: please give the SZA in the caption.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 2857, 2012.