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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Probing the sensitivity of polarimetric O_2 A-band measurements to clouds with emphasis on potential OCO-2 and GOSAT retrievals" *by* S. Sanghavi et al.

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The authors thank the reviewer for their insightful comments and suggestions. In the following, we respond to them in a step-by-step fashion.

1. The manuscript contains some interesting insights and it covers the topics appropriate for Atmospheric Measurement Techniques. The authors discuss sensitivity of the cloud parameters using measurement of the reflected radiance at the top of atmosphere. They have demonstrated a possibility to evaluate important cloud

properties such as the cloud optical thickness and effective radius, the cloud layer geometry (height and thickness). The authors conclusion are based on result of numerical simulation and simple analytical models.
AUTHORS: We thank the reviewer for their positive summary of our manuscript

2. The manuscript is well structured but written with negligence; the abstract clearly summarizes the main results. The authors use 34 figures, the usefulness of most of them are quite questionable. I recommend to delay the manuscript publication until a significant revision of the manuscript text and figures made to achieve a clear and precise presentation of the authors ideas and results.
AUTHORS: The text has been revised and the number of figures have been reduced to the ones required for the points raised in the manuscript. The main changes can be summarized as follows:

    (a) The original Fig. 1 and Fig. 4 have been removed. The original Fig. 2 (now Fig. 1) has been modified so that both y-axes refer to the same plot.
    (b) Spectra have been recomputed at a resolution of 0.005 nm followed by convolution with a Gaussian slit function of FWHM 0.04 nm to be comparable to GOSAT and OCO-2 measurements.
    (c) The spectral plots (the new Figures 5, 6 and 7) are now based on simulated measurements of I and Q rather than I and $p = |Q|/I$. The discussion of Section 4 has been modified accordingly.
    (d) All spectral plots now include the pure Rayleigh case and the case of reflection by a white Lambertian plate (WLP, introduced in Section 2) as reference.
    (e) The new Fig. 8 (originally Fig. 17) has been modified to include the response of Q to changes in cloud geometrical thickness.
    (f) All other Figures (spectral plots) dealing with sensitivity to cloud geometric thickness Δz have been removed.

AMTD
7, C5331–C5335, 2015

(g) Angular dependences on size of I, Q and the corresponding p have now been condensed into one figure each for optically thin and thick cloud (Figures 10 and 11). The pure Rayleigh case has been included as reference.

(h) All 2D plots comparing the I, Q and $I \pm Q$ response to pairs of cloud parameters τ_{cloud}, z_{top} and r_0 have been eliminated. Instead, a simple table comparing the characteristic responses of I and Q to each parameter has been introduced to motivate the possibility of identifying the three parameters simultaneously using methods like optimal estimation in Section 5.

3. Major comments:
First and foremost drawback of the manuscript that it lacks of reality. Without stating the instrument characteristics (signal to noise ratio, spectral resolution) the author findings and conclusion are hardly useful since an ideal instrument can measure anything.
AUTHORS: Our attempt here has been to present a general overview of the response of the O_2 A-band to cloud characteristics, without tying these results down to any specific instrument. The instrumental effects will be dealt with in depth in follow-up studies, which would also deal with cloud retrievals from these instruments.

4. The other drawback is that most figures show how a given characteristic (intensity or polarization component, or their combinations) depends on the cloud parameters (optical thickness and effective radius, cloud top height etc) which do a poor job to present the authors points.
AUTHORS: We have reduced the number of figures, retaining only those that clearly show the results discussed in the text

5. page 9606. “GOSAT measures both orthogonal components $I_h = 1/2(I+Q)$ and $I_v = 1/2(I?Q)$." This is completely wrong. Please check any GOSAT L1B file the GOSAT measures $I_h = 1/2(siI + sqQ + suU)$, where (si, sq, su) are the Stokes

AMTD
7, C5331–C5335, 2015

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coefficients while si 1, sq and su can be quite different from 1 and 0, correspondingly.
AUTHORS: We stand absolutely corrected here. The text now reads: “Polarization is included in both instruments, albeit only in the form of $I_\mathrm{v} = \frac{1}{2}(I+Q)$ in the case of OCO-2, while GOSAT measures two orthogonal components I_P and I_S, each being a view geometry dependent linear combination of the elements of the Stokes vector of the measured signal (O'Brien et al., 2013)."

6. page 9610. It has to be mentioned that the cloud properties is evaluated at wavelength 765 nm.
AUTHORS: We assume this is already clear in the context of the O_2 A-band.

7. page 9614. “whereas the degree of polarization is reduced to levels close to $p = 0$" It is not true if the “rainbow" scattering angles are under observation. The degree of polarization at 142 is used to identify a cloud pixel for the POLDER product.
AUTHORS: Yes, we have considered here a nadir view with the Sun at SZA=$60°$. We have made explicit mention of this. The rainbow region is dealt with in detail in Section 4.3.1

8. page 9618. “GOSAT could also be potentially combined with its more comprehensive polarimetric coverage (measuring both $1/2(I?Q)$ and $1/2(I+Q)$) to obtain information on cloud droplet size." See comment to page 9606 regarding GOSAT measurement.
AUTHORS: Corrected as in previous instance

9. page 9628. “Cloud height has practically no influence on the intensity of reflected light for a non-absorbing atmosphere in the spectral range of the O_2 A-band". The authors have to write their ideas more carefully. Everyone knows that the oxygen A-band is used to measure the cloud top height among other parameters.
AUTHORS: Please note that we mention “for a non-absorbing atmosphere".

Our statement is validated both for atmospheres devoid of O_2 as well as non-absorbing wavelengths within/without the O_2 A-band.

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7, C5331–C5335, 2015

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