Dear Reviewer

We sincerely thank you for your valuable comments, which greatly improved the quality of this manuscript. We highly appreciate the time and effort they devoted to reviewing our work.

Our responses to each comment are provided below in **blue**.

Reviewer #2's comments:

This paper discusses a method for evaluating calibration constant (gain ratios) with higher precision by removing the contribution of scattering from atmospheric molecules, as an improvement upon the existing method (OTIC calibration technique) that uses sunlight scattered by optically thick ice clouds to perform polarization calibration of space-borne polarization lidar. The paper also demonstrates the effectiveness of this method using actual satellite observation data (CALIOP); it also discusses the applicability of this method to other satellite lidars (ADCL, ATLID). The description is clear, and the paper contains all the information necessary for understanding it, with neither excess nor deficiency. Considering the novelty and applicability of the method proposed in this paper, as well as the quality of its description, it is recommended that this paper be published in AMT.

It does not appear that a major revision is necessary. Several minor points are listed below.

Response: We sincerely appreciate the time and effort you devoted to reviewing our manuscript. We also thank you for your positive and constructive comments. Our responses to each of your comments are provided below.

L61: λ-4 => λ^4?

Response: It should be λ^{-4}, thank you for capturing this. We also noted that λ^4 had to be replaced with λ^{-4} in L155 of the submitted manuscript.

L114-L127: In this part, it would be less confusing if you first explained that there are two methods for calculating PGR: one based on received photons (Eq. A5) and one using RMS (Eq. A8). It would then be easier to understand if you explained that CALIOP adopted Eq. A8 due to system constraints.

Response: Good point, thank you. We have added a short paragraph to the manuscript: "In Appendix A we present mathematical derivations of two different approaches that can be used to calibrate the PGR. The first uses the ratio of the directly measured mean background signals (e.g., as in Liu et al., 2004) while the second uses the ratio of the root-mean-squares (RMS) of the background signals. Because identical results are obtained using either method, data availability will dictate the choice of technique to apply. The following discussions leverage the mathematical derivations given in Appendix A to further explore both approaches.

Replacing the expression for digitizer counts measured in the perpendicular and parallel channels of the lidar receiver (i.e., $N_{dc,\perp}$ and $N_{dc,\parallel}$ in Eq. (A5)) with $BKG_{\perp}$ and $BKG_{\parallel}$, the equation for deriving PGR from OTIC background measurements at long wavelengths becomes"

L133, Eq. 6: What does the "c" in RMS_c stand for?

Response: This is a very good question. The "c" originally stands for cirrus clouds. However, since the method is not limited to cirrus clouds, we have replaced it with OTIC (optically thick ice cloud) in the revised manuscript to avoid confusion.

L133, Eq. 6: BDDR => BDR?

Response: thank you for carefully checking equations. We changed BDDR to BDR.

L128-L155: The sudden introduction of "BDR" in the text is somewhat confusing. If additional explanation were provided—including the relationship between Equation (7) and Equation (2)—the connection between the first half of Section 2 and this part would become clearer, which would likely deepen the reader's understanding.

Response: This is a very good suggestion. To improve clarity, we have added additional explanation of the bidirectional reflectance (BDR) and its role in the molecular scattering correction. Specifically, we added the following text:

"where BDR is the bidirectional reflectance, which describes how the atmosphere–surface system reflects incoming light as a function of both the illumination and viewing geometries. In the molecular scattering correction presented here, only the contribution from atmospheric molecular scattering is considered. The quantities BDR_I and BDR_Q are derived from the Stokes parameters (I) and (Q), which represent the intensity and linear polarization components of the scattered light, respectively. These Stokes parameters are calculated for molecular scattering using a polarization-sensitive vector radiative transfer model (VRTM, Zhai et al., 2009 We note that, whereas Eq. (2) describes the scattering of incident light by a single particle, the BDR terms used in Eq. (7) characterize the emergent radiation field of the atmosphere–surface system after radiative transfer, in which extinction, multiple scattering, and polarization are taken into account. Consequently, the bidirectional reflectance varies with both the solar illumination and sensor viewing geometries. "

We also changed the word "intensity" to "power" on Line 68 and clarified that the equations apply for "single" cloud droplets. In addition, we replaced (I) with (P) in Eqs. (1) and (2) to differentiate power from intensity.

L292: “The method can also be applied to ADCL/DQ-1 to calibrate its HSRL 532 nm polarization measurements.”

In L253–L257, it appears that the application of OTIC is described as “challenging”—doesn’t this contradict the description here?

Response: We have revised this sentence as follows: “The method can also theoretically be applied to ACDL/DQ-1 to calibrate its HSRL 532 nm polarization measurements. The main challenges are the limited sampling height (40.4 km) and photon folding for the second shot of each laser pulse pair.”

Fig.2 & Fig. 5: The image looks a little blurry. Is it a resolution issue?

Response: We have revised both plots.

Fig.3: Around ±80 degrees, the RMS ratio values appear to be widely scattered. Is this normal? It also appears that the latitudes at which the values are scattered differ somewhat from those in Fig. 2(d).

Response: Large variations at high latitudes are expected because the solar elevation angle is low, resulting in weaker solar background signals and lower signal-to-noise ratios (SNRs).