Correcting CALIOP Polarization Gain Ratios for Diurnal Variations

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The Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) flying aboard the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission measures 532 nm backscatter in polarization planes oriented parallel and perpendicular to the polarization plane of the transmitted laser light. The polarization gain ratio (PGR) quantifies the relative gain between the two receiver channels and is required for calculating both the 532 nm total attenuated backscatter, $\beta'_{532}(r)$, and the 532 nm volume depolarization ratios, $\delta_v(r)$. The magnitude of the PGR is assessed by periodically inserting a pseudo-depolarizer into the optical path of the receiver, thus ensuring that both the parallel and perpendicular channel detectors are illuminated by equal intensities of backscattered light.

For all CALIOP data releases through version 4.2 (V4.2), PGR measurements were made during nighttime orbit segments only and the relative gain of the two channels was assumed to remain diurnally invariant. However, several publications have reported unexpected day–night differences in $\delta_v(r)$, particularly for CALIOP measurements of cirrus clouds. To investigate these disparities, in November 2016 the CALIPSO mission began conducting occasional extended PGR measurements during which the pseudo-depolarizer remained inserted for continuous periods of 2 to 5 days. The very long dwell times were required to reduce the uncertainties in the daytime PGR estimates to levels commensurate with the existing nighttime record. These measurements show that the PGR systematically varies by ~6% from night to day, with daytime values being higher.

Because the extended PGR measurements were not available for the first 10+ years of the mission, an alternative calibration approach is required to characterize diurnal PGR changes. We do this using an approach pioneered by Liu et al. (2004) which derives PGR estimates from daytime background measurements acquired above strongly scattering cirrus clouds. In this work we describe the CALIOP implementation of the Liu method, present mission-long time series of day and night PGR values, and discuss changes that can be expected in the forthcoming CALIOP version 4.5 level 1 and level 2 data products as a result of implementing diurnally varying PGR estimates.

Reference

Liu et al., 2004: Validating lidar depolarization calibration using solar radiation scattered by ice clouds, *IEEE Geosci. Remote Sens. Lett.*, **1**, 157–161, https://doi.org/10.1109/LGRS.2004.829613.