Mitigation Strategy for the Impact of Low Energy Laser Pulses in CALIOP Calibration and Level 2 retrievals

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Since mid-2016, the frequency of low energy laser pulses emitted by the CALIPSO lidar has been slowly increasing due to pressure losses in the canister housing the laser. While originally confined primarily to the South Atlantic Anomaly (SAA) region, these low energy pulses now occur intermittently around the globe. In 2021, an average of 0.8% of profiles had low energy outside the SAA and 36% within. Low energy pulses cause calibration biases in the 532 nm daytime and 1064 nm channels and degrade the science quality of level 2 retrievals by decreasing the SNR, and thereby inhibiting accurate feature detection.

This presentation will describe a new low energy mitigation (LEM) algorithm that will be implemented in CALIOP data processing to ameliorate these effects. The task of LEM is to identify the profiles affected by low energy pulses and to remove them during the calibration (level 1) and feature detection (level 2) processes. Identifying profiles affected by low energy is not straightforward because of the altitude-dependent averaging performed onboard the satellite prior to downlink. In addition, the level 2 retrieval algorithms further average the level 1 attenuated backscatter to improve SNR and identify optically thin features. Taken together, this means that the ill effects of low energy pulses can degrade the science quality of neighboring profiles, even those with nominal energies, in complicated ways. The LEM algorithm accounts for this by applying data rejection to small, targeted segments to maintain acceptable SNR for level 2 retrievals.

We will show that by rejecting profiles affected by low energy during the calibration process, the LEM algorithm significantly reduces calibration biases. These LEM-based corrections are implemented in the 2022 release of the version 4.5 level 1 data product. We will also demonstrate how level 2 retrievals are improved and how the LEM algorithm minimizes the amount of level 2 data lost since low energy pulses began (< 0.7% outside the SAA, estimated). The LEM algorithm is a top-priority initiative for the CALIPSO mission and will be implemented in level 2 processing in the next major release after version 4.5.