

Since posting our initial response, a sharp-eyed internal reviewer has advised us that the last two sentences in our revisions for section 2.2.1 do not accurately describe the error-handling procedures implemented in the CALIOP version 4 extinction retrieval code. Consequently, we have further modified the text, both here in our updated response and in the revised manuscript.

The revised paragraph from our previous response is shown below. The **text in orange** was inserted as part of our initial response to the comments from referee #3. The text rendered in ~~gray strike through~~ was also included as part of this initial response, but has now been removed and replaced by the **text in blue**.

Constrained retrievals use measurements of the effective two-way layer transmittance and its uncertainty that are determined by comparing signals from above and below the layer. **The determination of the layer boundaries is detailed in Vaughan et al. (2005 and 2009). Briefly, the initial determination of cloud base is determined as that range at which the attenuated scattering ratio (the ratio of the normalized, range-corrected backscatter signal to a molecular backscatter model) drops below a range-dependent threshold that is determined largely by SNR and signal attenuation by the overlying atmosphere. This initial estimate of cloud base is further refined by continuing to search below this altitude for a region where the attenuated scattering ratio ceases to be a decreasing function of range. Depending on the SNR in the region below the cloud, this refinement sets cloud base below any readily detectable “leakage” of the signal into the assumed clear region caused by, for example, the transient recovery time of the detectors or by multiple scattering from small particles in dense clouds. Note that this multiple scattering leakage is not pulse stretching (Miller and Stephens, 1999), but instead occurs for instance because the forward scattering angle from the small ice crystals in cold cirrus can be wider than the CALIOP receiver field of view (Reverdy et al., 2015), so that the multiple scattering factor can be slightly larger below the ice clouds than in cloud (Winker et al, 2003). Once all features have been detected in a column, so called “clear air” regions above and below each feature are identified. To initiate a constrained retrieval, the V4 CALIOP extinction algorithm requires a minimum feature-free vertical extent of 2.48 km both above and below a candidate feature. The required effective layer two-way transmittance is then calculated as the ratio of the mean attenuated scattering ratios computed over these below-cloud and above-cloud clear air regions. The fidelity of these estimates relies on the supposition that the backscatter signals in the clear air regions are due solely to air molecules. If this condition is not met (and this is impossible to confirm with absolute certainty), then unless the mean particulate scattering ratios in the two clear air regions are identical, the transmittance measurements will be in error, no matter how small the reported uncertainty, and the constrained retrieval will also be in error. These are bias errors, not random errors, as discussed in Sect. 3b2 of Young et al. (2013), and by del Guasta (1998). Undetected particulate layers above the layer being analyzed can also affect the calculated lidar ratio. Extreme errors can cause the derived lidar ratios to approach and sometimes even exceed the physically acceptable limits of 0.05 sr to 250 sr imposed by the V4 retrieval scheme. Any constrained retrieval (bit 0 set to 1 in the extinction QC flag – See Sect. 2.2.6) in which the derived lidar ratio is equal to either of these limits is to be treated as suspect. ~~In these cases, the lidar ratio is set to the limit and an unconstrained retrieval is performed using this value. Such cases are indicated by the setting of bit 8 to 1 in the extinction QC flag (see Sect. 2.2.6 and Table 2), giving a total value of 257.~~ **When serious errors are encountered in the solution of constrained retrievals, bit 8 is also set, giving an extinction QC flag value of 257.****