A New Technique to Retrieve Aerosol Vertical Profiles Using Micropulse Lidar and Ground-based Aerosol Measurements Supporting Information

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1 Processing Normalized Relative Backscatter from raw signal

MPL and MiniMPL receive raw a signal that is described as:

$$raw(R) = \frac{O_c(R)ECR^{-2}\beta(R)T(R)^2 + n_b + n_{\mathrm{ap}}(R)}{D[raw(R)]} \quad \text{(S1)}$$

R is the range of the lidar; O_c is the overlap contribution, which describes the compromised optical efficiency of the lidar at the near field due to the incomplete geometric overlap of the receiver field of view and the beam width; n_{b} represents the background contribution; n_{ap} represents the afterpulse contribution caused by the saturation of the detector diode due to internal scattering at the start of each scan; $D[raw(R)]$ is the "dead time" factor which is unique for each detector and is a function of the raw signal; *E* is the lidar laser energy output; *C* is the system calibration constant; β is the backscatter coefficient; $T(R)$ is the transmittance (Campbell et al., 2002). After applying corrections for the overlap, afterpulse, "dead time" factor, and the background signal, we get the classic lidar equation.

$$P(R) = \frac{\{raw(R) \times D[raw(R)]\} - n_{\mathrm{ap}}(R) - n_b}{O_c(R)} = ECR^{-2}\beta(R)T(R)^2 \quad \text{(S2)}$$

The range and energy normalized relative backscatter (also known as attenuated backscatter) is calculated as:

$$NRB(R) = \frac{P(R) \cdot R^2}{E} = C\beta(R)T(R)^2 \quad \text{(S3)}$$

By expanding Equation SI. 3 for a 2-component atmosphere, we get

$$NRB(R) = C[\beta_1(R) + \beta_2(R)]T_1^2(R)T_2^2(R) \quad \text{(S4)}$$

2 Numerical calculations of the Fernald inversion

The numerical form of Equation 2 for the backwards retrieval from a calibration range at far field is:

$$A(I, I+1) = (S_1 - S_2)[\beta_2(I) + \beta_2(I+1)]\Delta R$$

$$\beta_1(I-1) + \beta_2(I-1) = \frac{NRB(I-1) \cdot exp[+A(I-1, I)]}{\frac{NRB(I)}{\beta_1(I) + \beta_2(I)} + S_1\,\{NRB(I) + NRB(I-1) \cdot exp[+A(I-1, I)]\}\Delta R} \quad \text{(S5)}$$

Therefore, the total backscatter coefficient of each layer can be calculated with the total backscatter coefficient of the layer above. The total backscatter coefficient profile can thus be calculated iteratively once the total backscatter coefficient at calibration range is given. The ΔR matches the vertical resolution of lidar data and is 15 meters for ARM MPL and 30 meters for MiniMPL. A new calibration constant $\frac{NRB(I)}{\beta_1(I)+\beta_2(I)}$ at step *I*-1 is calculated using the backscatter coefficient at step *I* (Gimmestad and Roberts, 2023).

3 Depolarization Ratio and Cloud Masking

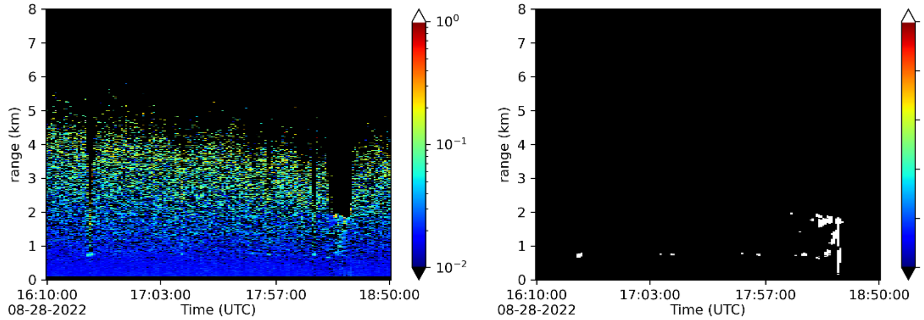

Figure S1 Depolarization ratio and cloud mask time series for 28 August 2022, with MiniMPL in Galveston, Texas

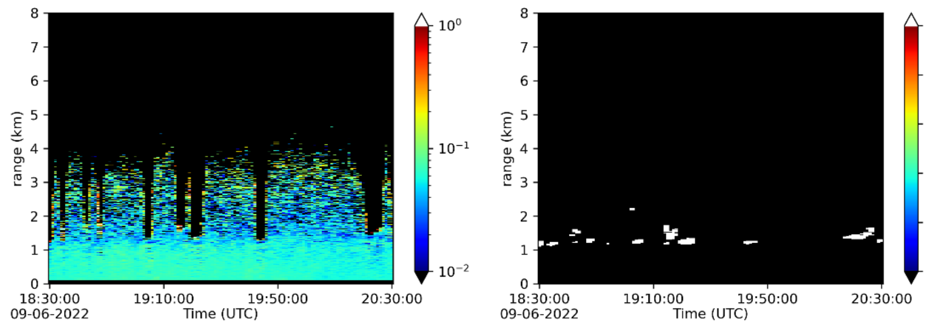

Figure S2 Depolarization ratio and cloud mask time series for 6 September 2022, with MiniMPL in Hockley, Texas

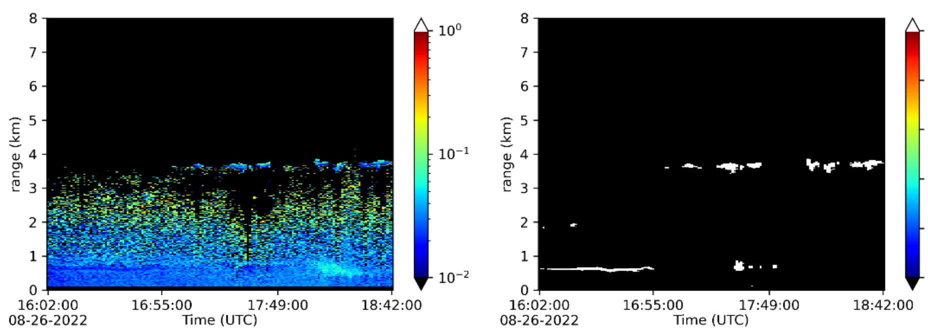

Figure S3 Depolarization ratio and cloud mask time series for 26 August 2022, with MiniMPL in Galveston, Texas

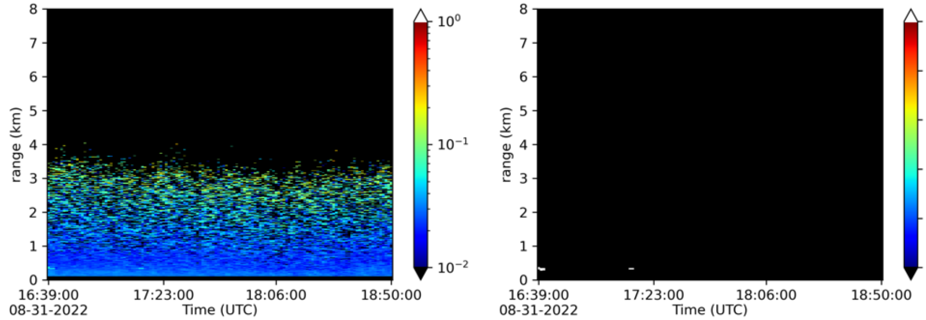

Figure S4 Depolarization ratio and cloud mask time series for 31 August 2022, with MiniMPL in Galveston, Texas

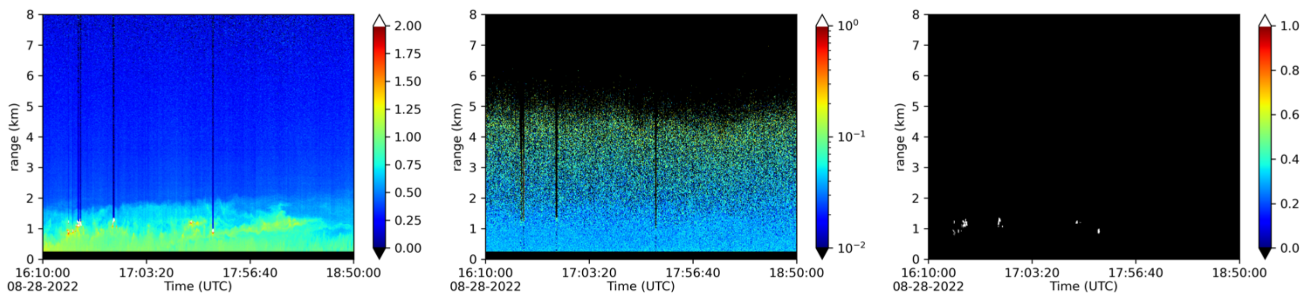

Figure S5 NRB, depolarization ratio, and cloud mask time series for 28 August 2022, with ARM AMF-1 MPL in LaPorte, Texas

4 Bibliography

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Gimmestad, G. G. and Roberts, D. W.: Lidar engineering: introduction to basic principles, Cambridge University Press2023.