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Technique for comparison of backscatter coefficients derived from in situ cloud probe measurements with concurrent airborne lidar

Shawn Wendell Wagner and David James Delene

Correspondence to: Shawn Wendell Wagner (shawn.wagner.atmos@gmail.com)

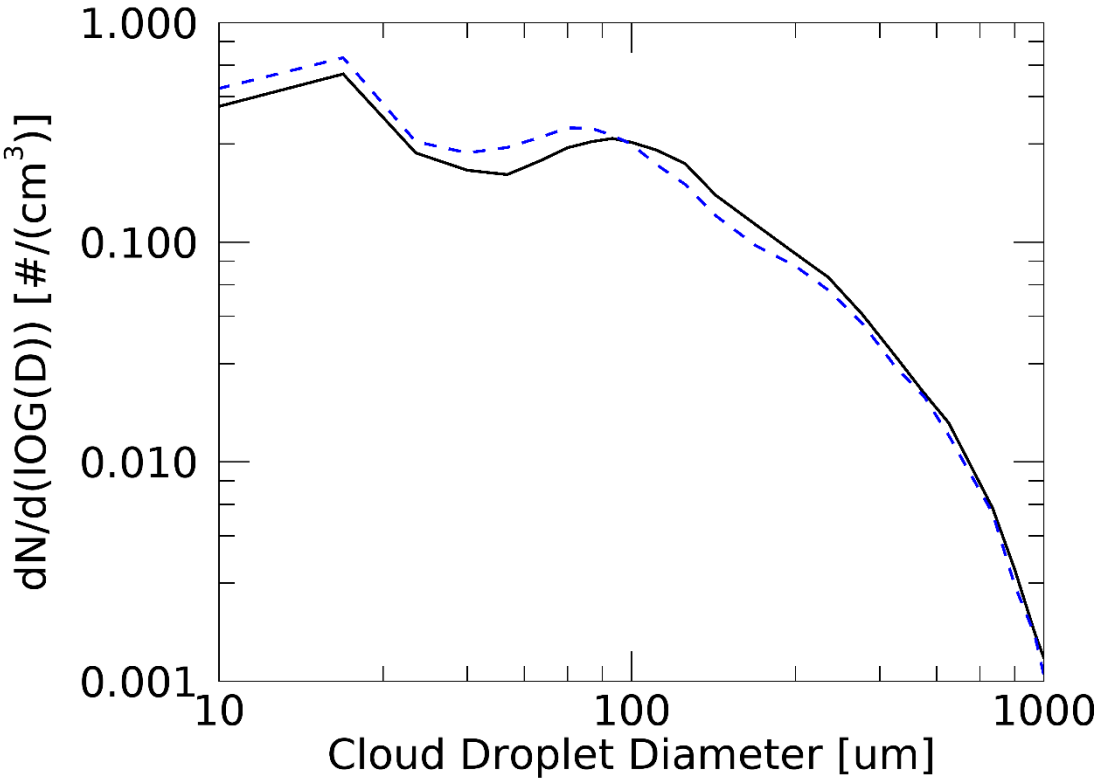


Figure S1: Plot comparing the 2D-S size spectrum from the horizontally (solid, black line) and vertically (dashed, blue line) oriented arms (relative to the earth's surface) for the -46 °C case (see Table 2 for details). The area-equivalent method is used for image data processing.

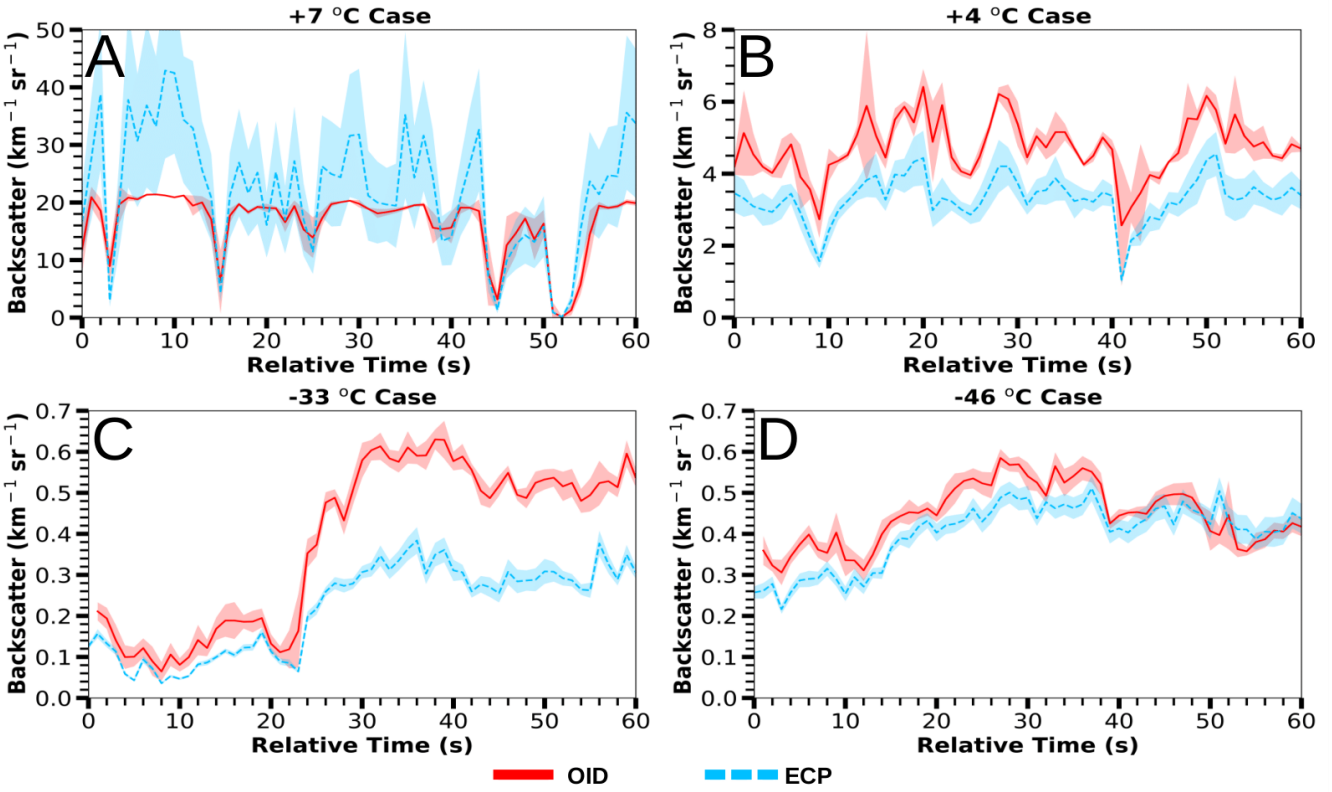


Figure S2: Plots showing 1 Hz time series in seconds of backscatter coefficients with a shadowed range for the four case study segments (see Table 2 for details). Note the differing backscatter coefficient scales for the warm cloud cases. The external cloud probes (ECP) shadowed range represents 1 standard deviation. The Optical Ice Detector (OID) shadowed range is 1 Hz data representing one standard deviation of the 5 Hz measurements. The ECP backscatter coefficient is obtained using the fast-circle method for image data processing.

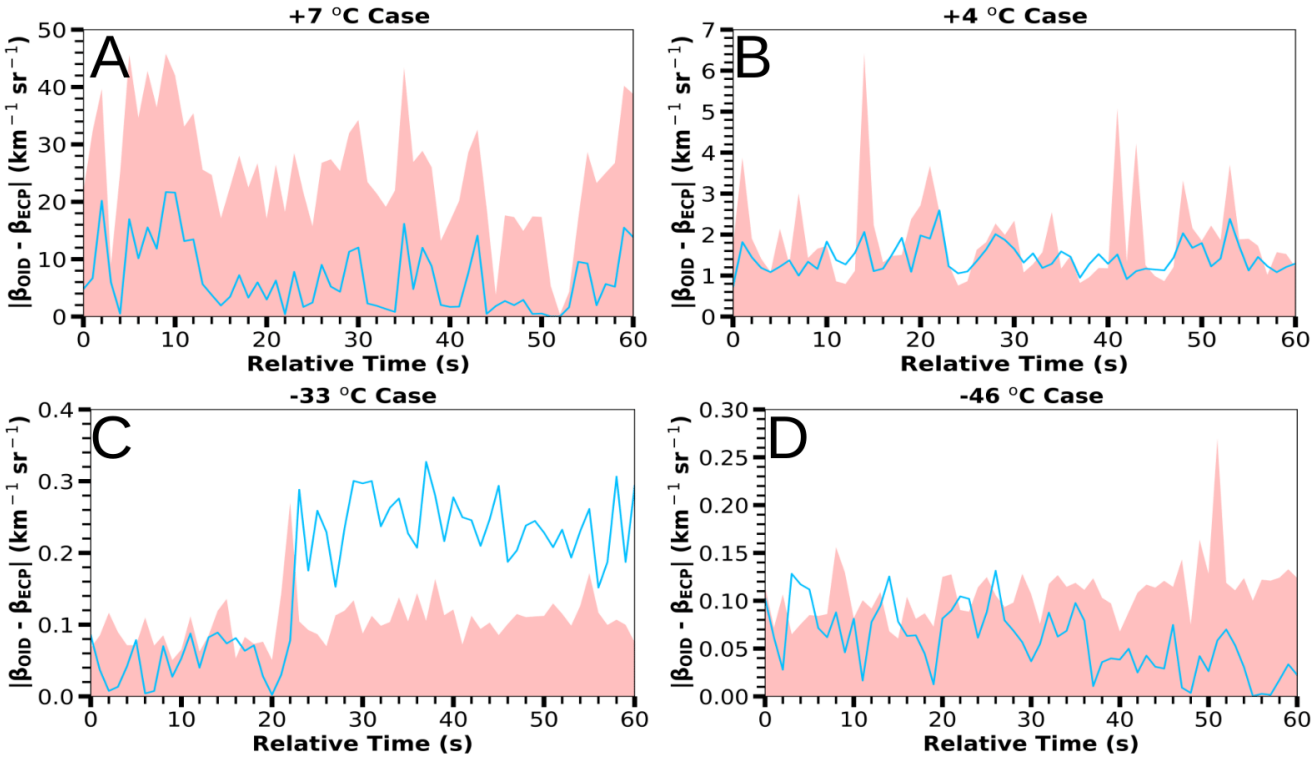


Figure S3: Plots showing 1 Hz time series of the absolute difference (blue line) between the Optical Ice Detector (OID) and external cloud probes (ECP) backscatter coefficients for the four case study segments (see Table 2 for details). The shadowed region top represents 3 standard deviations of OID and ECP backscatter coefficients. The ECP backscatter coefficient is obtained using the fast-circle method for image data processing.

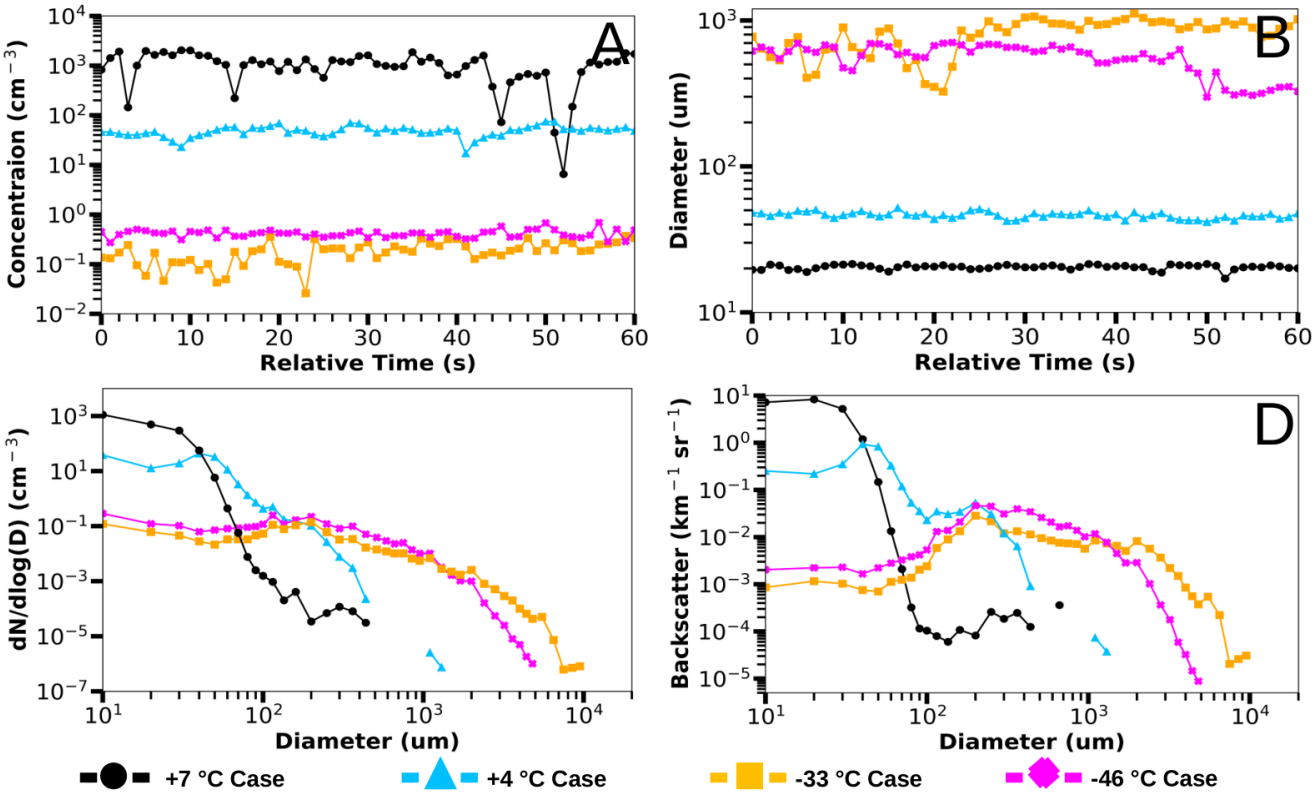
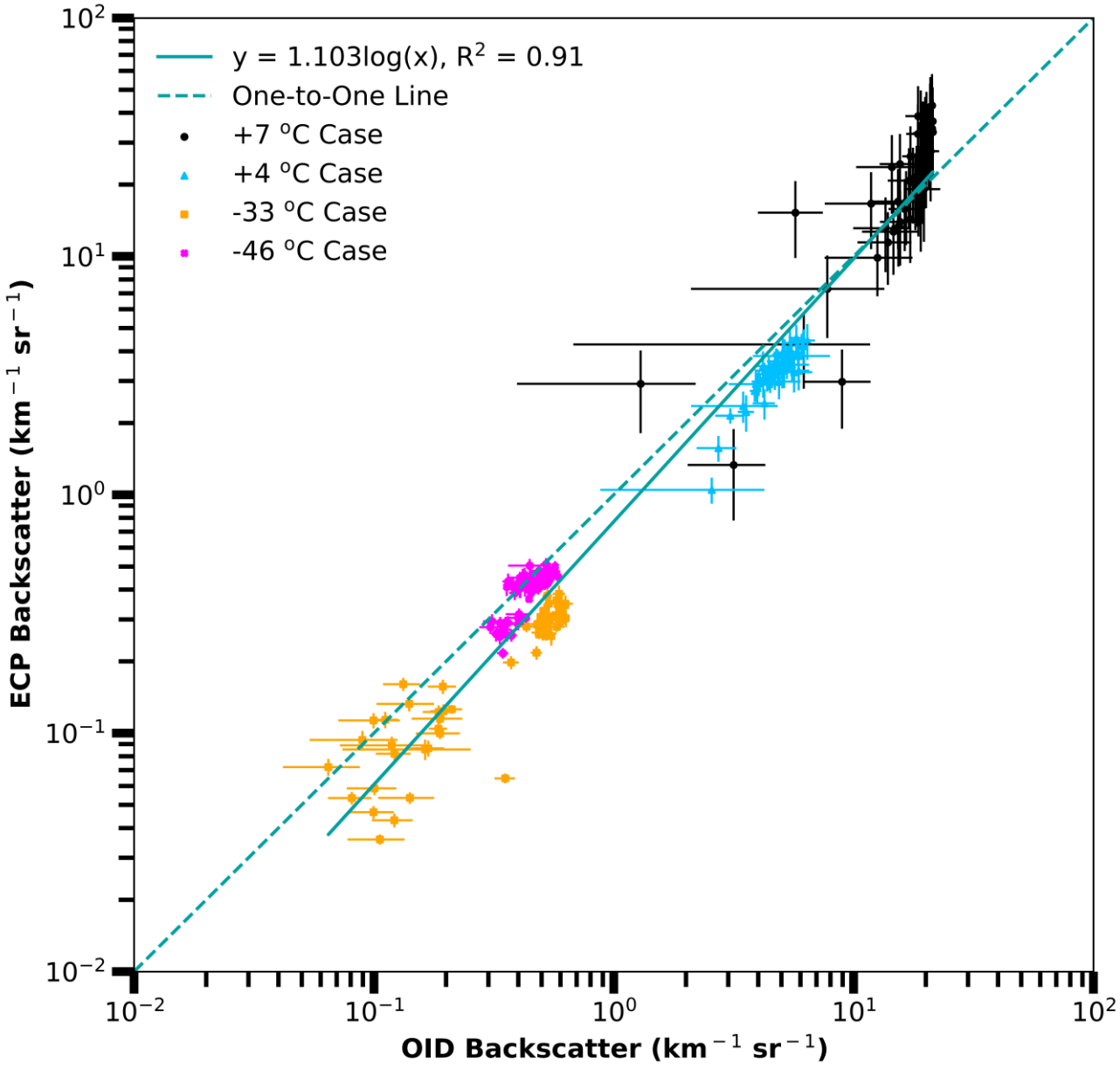


Figure S4: Plots showing measurements within the 60 s segments of four analyzed cases. The upper left plot (A) is total number concentration measured by the external cloud probes (ECP), specifically the Two-Dimensional Stereo (2D-S) and High-Volume Precipitation Spectrometer Version Three (HVPS3) probes. The upper right plot (B) is mean particle diameter measured by the ECP. The lower left plot (C) is a log-log plot of number density function vs. diameter measured by the ECP. The lower right plot (D) shows ECP backscatter coefficient versus the particle diameter. The y-axis of plot D is not normalized by size channel width; however, neighboring channels typically have simple widths (see Table 1 for details). The ECP backscatter coefficient is obtained using the fast-circle method for image data processing.



25 **Figure S5: The Optical Ice Detector (OID) versus external cloud probes (ECP) backscatter coefficients for four analyzed cases. Each point is colored by case (see legend) and represents 1 s of data with bars indicating uncertainty. The least square fit is given by the solid line. The dashed line is a one-to-one correspondence for the ECP and OID data. The ECP backscatter coefficient is obtained using the fast-circle method for image data processing.**

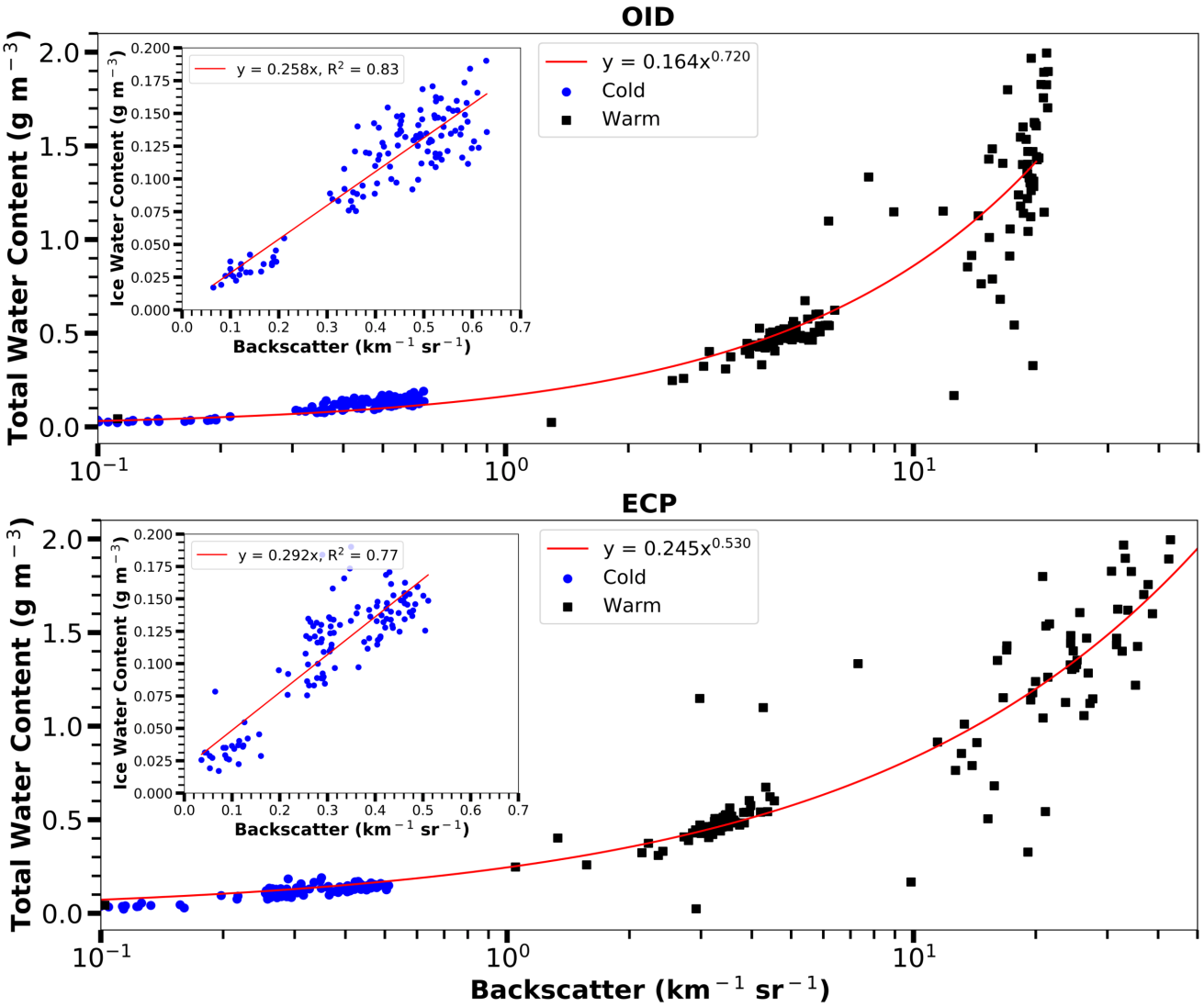


Figure S6: Plots showing Nevzorov probe total water content (TWC) versus Optical Ice Detector (OID) backscatter coefficients (top) and external cloud probes (ECP) backscatter coefficients (bottom) with a logarithmic x-axis. Backscatter coefficients are separated by warm (+7 °C and +4 °C) cases (square, black) and cold (-33 °C and -46 °C) cases (round, blue). Insets in the top-left corners show further detail of Nevzorov probe TWC versus respective backscatter coefficients for the -33 °C and -46 °C cases. Each point represents 1 s of Nevzorov, OID, and ECP data. The ECP backscatter coefficient is obtained using the fast-circle method for image data processing.

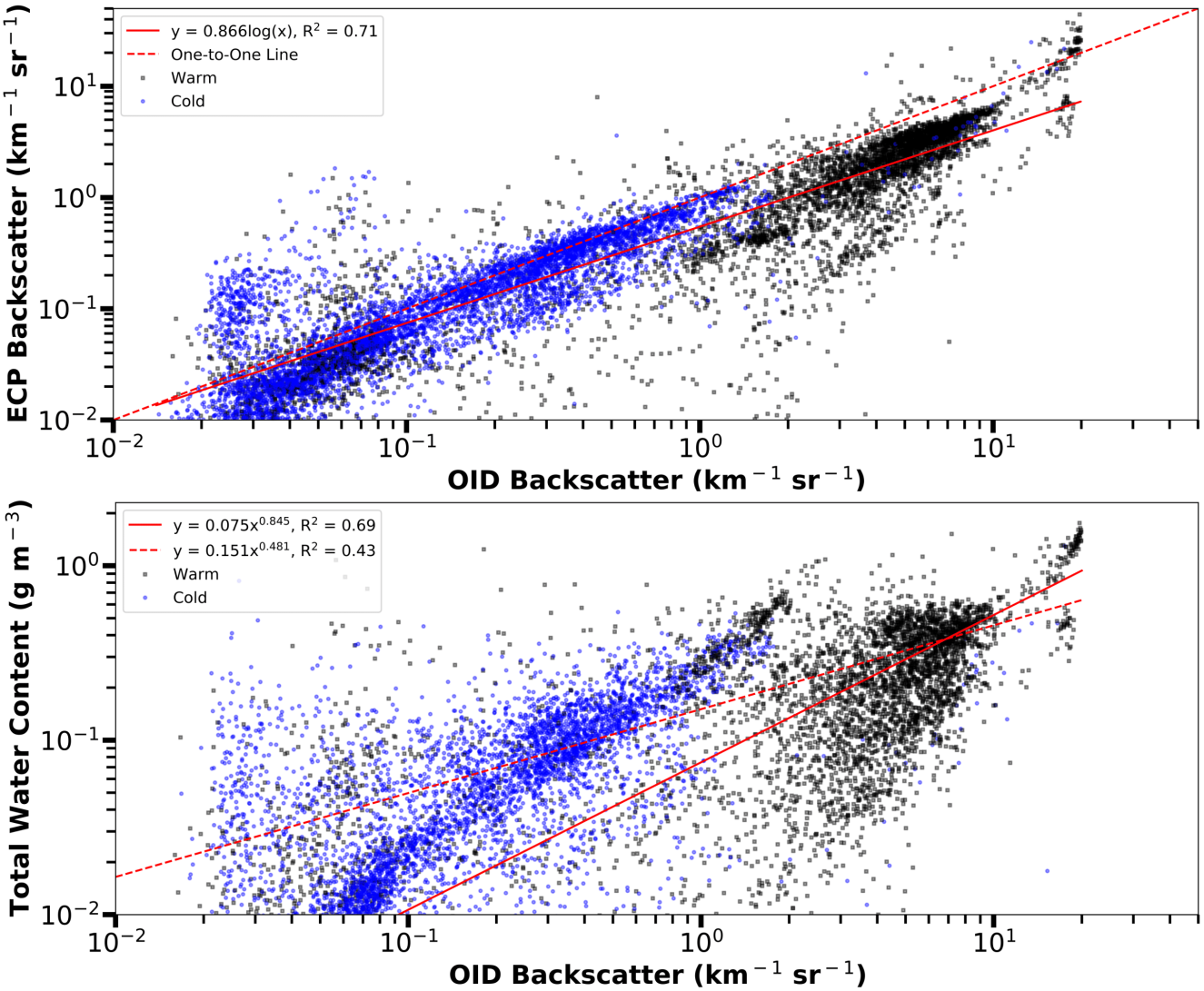


Figure S7: The external cloud probes (ECP) backscatter coefficients versus Optical Ice Detector (OID) backscatter coefficients (top) and Nevzorov probe total water contents (TWC) versus OID backscatter coefficients (bottom) for all times within the four flights that contain the four temperature cases. The 1 Hz data is grouped by cold (round, blue) and warm (square, black) environments. Data are excluded when temperatures are between 0 °C and –20 °C. Liquid scattering efficiencies are used for temperatures greater than 0 °C and ice scattering efficiencies used for temperatures below –20 °C. OID data has a 20 $km^{-1}sr^{-1}$ limit to avoid times where observations are above the OID's detection limit. The lower plot's solid red line indicates the fit equation for the warm data, while the dashed red line indicates the fit equation for the cold data. The ECP backscatter coefficient is obtained using image data processed with the fast-circle method for all cases.

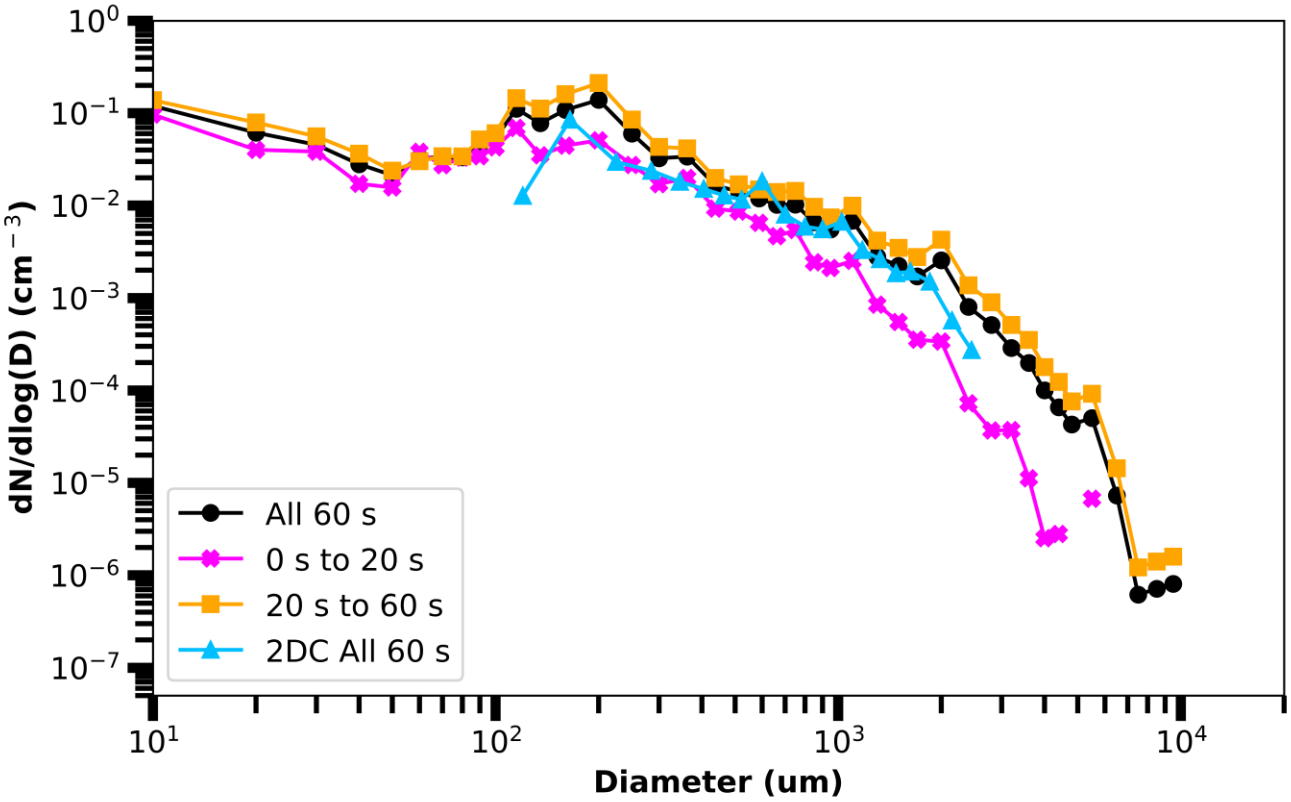


Figure S8: The size spectrum normalized by bin width measured by the external cloud probes (ECP) for the -33 °C case. The spectrum of the entire 60 s case (round, black) has been separated according to times of more (cross, magenta) and less (square, orange) agreement between ECP and Optical Ice Detector (OID) backscatter coefficients. The ECP (2D-S/HVPS3) backscatter coefficient is obtained using the fast-circle method for image data processing. Also given is the 2D-C spectrum (triangle, blue) obtained using fast-circle and full particle reconstruction processing methods.

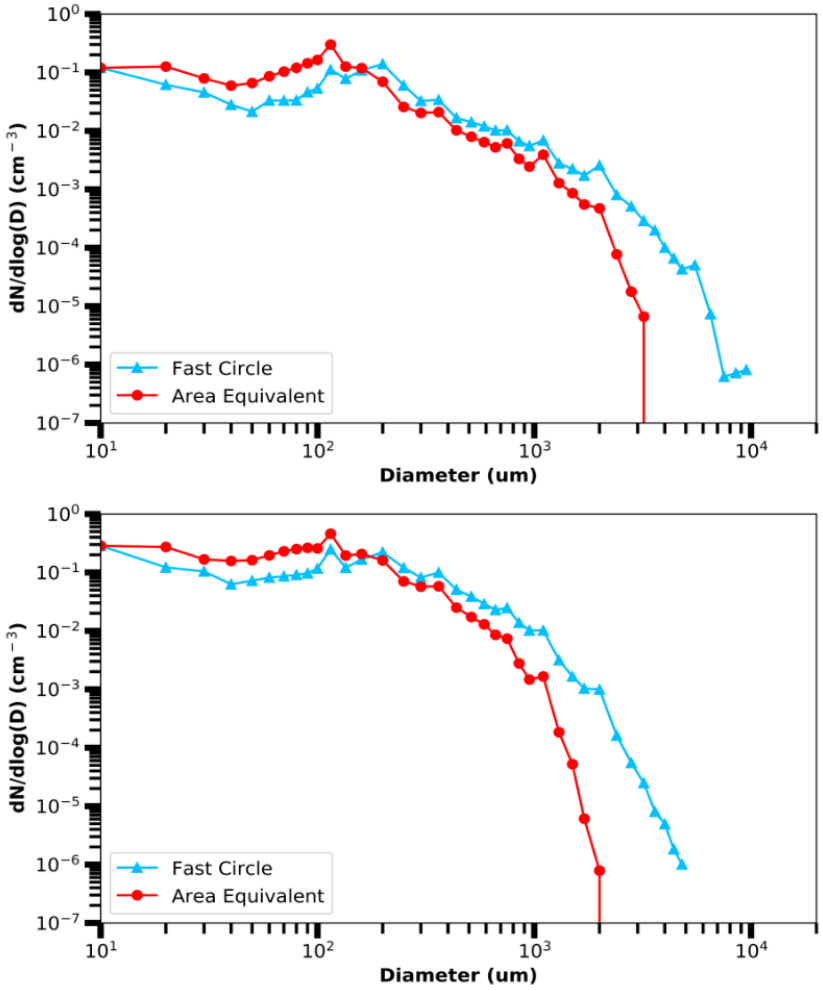


Figure S9: Plot showing the 2D-S size spectrums obtained using the fast-circle (triangle, blue) and area-equivalent (round, red) methods for the -33 °C case (top) and the -46 °C case (bottom).