STATISTICS OF DEPOLARIZATION RATIO FROM AN AIRBORNE BACKSCATTER LIDAR

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ABSTRACT

Ice and water clouds significantly influence both longwave and shortwave radiative forcing [7]. The accuracy of cloud radiative forcing estimations depends highly on the determination of cloud properties from instruments such as atmospheric backscatter lidars. These lidar instruments measure depolarization ratio which contains information about particle morphology and cloud type. However, depolarization ratio may be a function of temperature, geographic location and/or cloud generation mechanism, resulting in disagreement of typical values for ice clouds [4,6,8]. In this study, we will examine airborne lidar data from the Cloud Physics Lidar (CPL) to quantify trends in depolarization ratio as a function of temperature and geographic location, and compare depolarization ratio statistics with previous results.

The CPL is a backscatter lidar system operating at three wavelengths; 1064 nm, 532 nm, and 355 nm. It measures depolarization using the 1064 nm channel and obtains cloud optical properties using the backscattered signal at all three channels [1]. Over the past decade, the CPL has retrieved high resolution profiles of cloud properties at an altitude of about 20 km during a multitude of field campaigns. In this study, The layer integrated depolarization ratio was calculated using the ratio of perpendicular polarized 1064 nm layer integrated backscatter to parallel polarized 1064 nm layer integrated backscatter [2] from CPL data for five projects between 2003 and 2007, chosen to provide a wide range of geographic locations throughout North America.

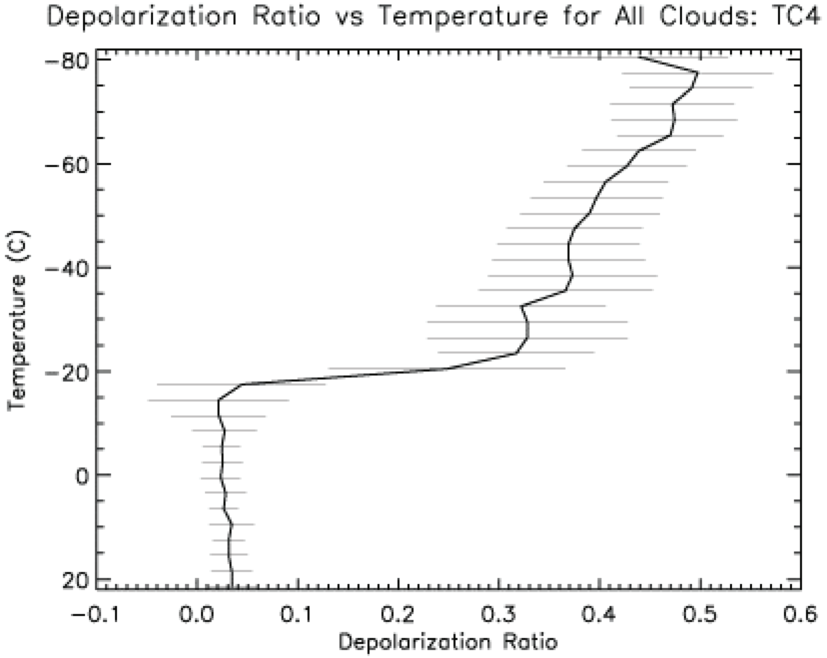

FIG. 1. Depolarization ratio values are plotted as a function of temperature (C), using the median depolarization ratio of temperature bins of 3 C for all cloud types during TC4. The error bars represent +/- one standard deviation of the data contained in the respective bin.

Particle depolarization measurements can be extremely helpful when examining cirrus microphysical properties [5]. Therefore, values and trends of depolarization ratio as a function of temperature were evaluated by retrieving the median depolarization ratio for temperature bins of 3 C, as demonstrated in Figure 1 for the TC4 project. Between temperatures of 20 and -15 C, the depolarization ratio remained relatively constant, dominated by water particles. This was expected since most liquid water particles are consistently “perfect” spheres. A transition from water particles to ice crystals was observed between -15 and -25 C, in which mixed clouds were detected. For temperatures less than -25 C and depolarization ratios greater than 0.27, ice cloud observations dominated the curve. Also observed in this ice clouds data was a trend of increasing depolarization ratio with decreasing temperatures, very consistent throughout all geographic locations. On average, the depolarization ratio increased roughly 0.15 from -20 to -70 C. This known dependence of depolarization ratio on temperature agrees with the findings of previous studies [3,4,6]. The temperature thresholds determined from Figure 1 can be used as a proxy for lidar cloud discrimination algorithms in the absence of depolarization ratio. Furthermore, values of depolarization ratio ranged from about 0.30 to 0.60 for ice clouds, 0.03 to

0.07 for water clouds and 0.17 to 0.27 for mixed phase clouds. Discrepancies are observed in depolarization ratio for ice clouds reported in this study for different geographic locations, specifically the values and magnitude of trends. These differences likely resulted from local cloud microphysics that could affect the shapes of ice crystals.

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