Classifying Cloud Phase

Contributors
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Research Highlight

Cloud phase identification is a necessary prerequisite to performing cloud property retrievals from remote sensor measurements. Most retrieval algorithms are specifically developed and tuned for clouds of a particular phase and type. Thus, a cloud phase classifier is a crucial component to any operational algorithm for deriving cloud properties above ground-based atmospheric observatories such as the ARM Climate Research Facility (ACRF) sites.

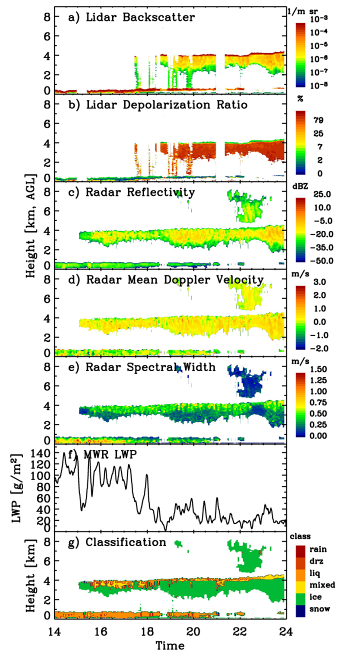
Using observations from the ACRF North Slope of Alaska (NSA) site in Barrow and the National Oceanic and Atmospheric Administration (NOAA) Study of Environmental Arctic Change (SEARCH) site in Eureka, Canada, a multisensor cloud classification algorithm has been developed and specifically tailored to Arctic conditions. The method exploits the complementary strengths of cloud radar, depolarization lidar, microwave radiometer, and temperature soundings to classify hydrometeors observed in the vertical column as ice, snow, mixed-phase, liquid, drizzle, rain, or aerosol. These phase classes are, by design, based on hydrometeor phase types instead of meteorological cloud types in order to facilitate subsequent cloud property retrievals. Moreover, a classification based directly on phase is most appropriate for evaluating model simulations.

An example classification is shown in the adjacent Figure which contains clouds at three levels. The boundary layer cloud (<1km) contains a positive liquid water path, with high lidar backscatter, low lidar depolarization ratio, and radar reflectivities that are less than -17 dBZ, all of which are consistent with liquid-only clouds containing a high concentration of small, spherical droplets. The mid-level cloud layer is a common Arctic stratiform mixed-phase cloud layer wherein ice particles form in, and fall from, a liquid water cloud layer. High lidar backscatter and low depolarization ratio near the top of this layer again indicate liquid water, while wide radar Doppler spectrum widths near cloud top suggest the presence of both liquid and ice together. Moving lower in this layer, high depolarization ratios, radar reflectivities, and radar mean Doppler velocities are consistent with large, non-spherical ice crystals. Finally, the upper cloud layer is composed of only ice particles since most of this cloud layer is colder than -40 C (not shown), and the radar moments are consistent with an ice-only cloud.

This rule-based cloud classifier can be applied operationally to the measurements obtained at Arctic observatories that contain the required instrumentation. Indeed, this classification is one component of a larger cloud retrieval framework that is currently being used to produce cloud microphysics properties at all times and heights above the NSA site.

Reference(s)

Shupe, MD. 2007. "A ground-based multisensory cloud phase classifier." Geophysical Research Letters 34, L22809, doi:10.1029/2007GL031008.



Observations of (a) lidar backscatter, (b) lidar depolarization ratio, (c) radar reflectivity, (d) radar mean Doppler velocity, (e) radar Doppler spectrum width, (f) microwave radiometer-derived liquid water path, and (g) the resulting multisensor cloud-phase classification mask.

Working Group(s)
Cloud Properties