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Ice Formation and Growth in Orographically-Enhanced Mixed-Phase Clouds

Robert David (1), Douglas Lowenthal (1), A. Gannet Hallar (1,2), Ian McCubbin (1,2), Linnea Avallone (3), Gerald Mace (4), and Zhien Wang (5)

(1) Desert Research Institute, Reno, NV, United States, (2) DRI/ Storm Peak Laboratory, Steamboat Springs, CO, United States, (3) National Science Foundation, Arlington, VA, United States, (4) Univ Utah, Salt Lake City, UT, United States, (5) University of Wyoming, Laramie, WY, United States

The formation and evolution of ice in mixed-phase clouds continues to be an active area of research due to the complex interactions between vapor, liquid and ice. Orographically-enhanced clouds are commonly mixed-phase during winter. An airborne study, the Colorado Airborne Mixed-Phase Cloud Study (CAMPS), and a ground-based field campaign, the Storm Peak Lab (SPL) Cloud Property Validation Experiment (StormVEx) were conducted in the Park Range of the Colorado Rockies. The CAMPS study utilized the University of Wyoming King Air (UWKA) to provide airborne cloud microphysical and meteorological data on 29 flights totaling 98 flight hours over the Park Range from December 15, 2010 to February 28, 2011. The UWKA was equipped with instruments that measured both cloud droplet and ice crystal size distributions, liquid water content, total water content (vapor, liquid, and ice), and 3-dimensional wind speed and direction. The Wyoming Cloud Radar and Lidar were also deployed during the campaign. These measurements are used to characterize cloud structure upwind and above the Park Range. StormVEx measured temperature, and cloud droplet and ice crystal size distributions at SPL. The observations from SPL are used to determine mountain top cloud microphysical properties at elevations lower than the UWKA was able to sample in-situ. Comparisons showed that cloud microphysics aloft and at the surface were consistent with respect to snow growth processes. Small ice crystal concentrations were routinely higher at the surface and a relationship between small ice crystal concentrations, large cloud droplet concentrations and temperature was observed, suggesting liquid-dependent ice nucleation near cloud base. Terrain flow effects on cloud microphysics and structure are considered.