ABSTRACT

Investigations of the Microphysical, Radiative, and Dynamical Properties of Mixed-Phase Clouds

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The U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Program has recognized the need for observational studies to improve our understanding of mixed-phase cloud properties, processes, and lifecycles. Uncertainties regarding the balance and interaction of phases in mixed-phase clouds, and the sensitivity of cloud radiative properties to the phase balance, make the parameterization of mixed-phase clouds in climate models a challenge. ARM has also expressed interest in bridging the considerable gaps that exist between cloud observations and modeling. The research described in this renewal proposal speaks to these important issues regarding mixed-phase clouds by addressing the basic question: *What are the cloud and environmental properties that lead to the formation, phase balance, and persistence of mixed-phase clouds?* The answers to this question will be explored through a combination of method development, observational studies, and model simulations using data obtained from the ARM North Slope of Alaska (NSA) and Southern Great Plains (SGP) sites. The first objective of the research is to further develop methods for identifying and characterizing mixed-phase clouds using multiple ground-based sensors with a particular focus on gleaning more information from cloud radar Doppler spectra. Method development will result in an all times/all heights cloud properties data set for multiple years at the NSA and SGP sites that will be of great use for establishing a cloud properties climatology, for evaluating models, and in the broader context of ARM's efforts toward computing accurate atmospheric heating rate profiles. Using new and existing retrieval methods for deriving microphysical and dynamical properties, focused cloud process studies will target an understanding of the specific processes that are involved in the mixed-phase cloud lifecycle. In particular, the seasonal variation of cloud formation mechanisms in response to environmental conditions such as surface turbulent heat fluxes, thermodynamic state, and atmospheric radiation, will be explored.
These studies will coordinate with three ARM aircraft observation campaigns (M-PACE, ISDAC, and RISCAM) in order to leverage additional information from aircraft. Lastly, cloud processes will be evaluated within the context of mesoscale model simulations using the Weather Research and Forecasting (WRF) model that includes a new double-moment cloud microphysics scheme. This model perspective will provide further insight into cloud formation mechanisms and the relationship between cloud microphysics and dynamics, while also placing the measurements from the individual ARM sites within a regional perspective. The combination of observations and model simulations used in these process studies will provide support for improved mixed-phase cloud parameterizations in numerical models.