1.32 SIMULATIONS OF THE RADAR VARIABLES DURING VAPOR DEPOSITION AND RIMING IN ARCTIC MIXED-PHASE CLOUDS

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Arctic mixed-phase clouds develop and persist through complex interactions between radiative cooling, turbulence, surface energy fluxes, and ice microphysical processes. These systems may maintain themselves for several days and thus have important impacts on the radiative budget of the Arctic. In order to better understand ice particle growth in Arctic mixed-phase clouds, microphysical model simulations were performed for cases primarily of vapor depositional growth and riming, and the radar variables were simulated for each case and compared to the observations.

These simulations were performed using a microphysical model with adaptive habit microphysics, where the ice particle properties of maximum dimension, aspect ratio, and effective density evolve continuously based on the temperature, supersaturation, and liquid water content of the environment. In order to more realistically simulate the effective density evolution of branched planar crystals during vapor depositional growth, a parameterization for the density as a function of size was implemented in the adaptive habit model. This parametrization is based on the shapes of naturally observed branched planar crystals and therefore provides a more consistent representation of these particles in the model. The simulated ice particle properties were then used to calculate the radar variables with a forward model for the polarimetric radar variables that captures the scattering of realistic rimed and unrimed branched planar ice crystals.

The simulated radar variables for the vapor deposition case correspond well to the reflectivity (Z_H) and differential reflectivity (Z_{DR}) observations taken at the Atmospheric Radiation Measurement (ARM) site in Barrow, AK, United States by the X-band Scanning ARM Precipitation Radar (XSAPR). Both the model-simulated and observed radar variables show generally increasing Z_H and slightly decreasing Z_{DR} towards the ground. Based on the model-simulated ice particle properties, Z_{DR} was found to decrease during vapor depositional growth due to decreasing density of the branched planar crystals.

The simulated radar variables for the riming case are also relatively consistent with the XSAPR observations from Barrow, AK, United States, with Z_H increasing towards the ground and Z_{DR} decreasing towards the ground. Both Z_H and Z_{DR} changed more substantially in magnitude during the riming case than during the vapor deposition case. Additional simulations of light riming, where the liquid cloud drops were confined to a thinner layer in the model environment, produced similar radar signatures to those found for cases of vapor deposition. This similarity suggests that light riming of branched planar crystals may be difficult to distinguish from pure vapor depositional growth using polarimetric radar observations. In addition

to the thickness of the liquid layer, the simulated radar variables were also found to be sensitive to the slope of the effective density function and the assumed density of the mass added during riming. This sensitivity suggests that polarimetric radar variables may help constrain these variables, and thus reduce the uncertainty in the vapor deposition and riming processes occurring within Arctic mixed-phase clouds.