The Free Troposphere as a Source of Arctic Boundary Layer Aerosol

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Large-eddy simulations[1] of the summertime high Arctic boundary layer with mixed-phase stratus clouds have been performed based on observations taken during the ASCOS[2] campaign. The model includes a prognostic aerosol scheme where accumulation mode aerosol particles can be activated into cloud droplets, impaction scavenged, and regenerated upon cloud droplet evaporation or ice crystal sublimation. Three sets of simulations were performed. Each set consists of three simulations (for a total of nine simulations) in which the accumulation mode aerosol concentration is set to 15, 30, or 45 cm^{-3} in the boundary layer. Within each set, the gradient of the accumulation mode aerosol concentration in the free troposphere is set to 0.0, 0.6, or 1.2 cm^{-3} m^{-1}.

During the course of the simulations, there is a slow depletion of the boundary layer aerosol concentration. Cloud-processing (activation plus regeneration) and impaction scavenging both deplete aerosol at about the same rate, which is on the order of $1x10^5$ m^{-2} s^{-1}. When the elevated aerosol concentration in the free troposphere is included, there is a source of boundary layer aerosol also on the order of $1x10^5$ m^{-2} s^{-1}. In all but the cleanest simulation, the entrainment of new aerosol particles from the free troposphere is able to more than offset the loss of aerosol particles due to cloud processing and impaction scavenging. These results suggest that enhanced levels of accumulation mode particles, if located at the cloud top, may under certain conditions be an important source of accumulation mode particles in the Arctic boundary layer.

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