Aerosol and Meteorological Influences on Boundary Clouds at High Latitudes: Results from MARCUS and COMBLE

Category

High-latitude clouds and aerosols

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Description

Controls on cloud and aerosol properties are investigated using data acquired by DOE ARM’s Mobile Facility on the R/V Aurora Australis during MARCUS in conjunction with model simulations and 72-hour back trajectories with the HYSPLIT model. To investigate the impacts of horizontal transport, wind speed and precipitation scavenging on aerosols and cloud condensation nuclei (CCN), a novel machine-learning algorithm was implemented to remove time periods of ship stack contamination. Aerosols in the accumulation mode with diameters between 0.5 and 1.0 micrometer were weakly correlated with wind speed, but meteorological influences had a bigger impact on aerosol and CCN concentration. Remote sensing retrievals show low-level boundary layer (BL) clouds are ubiquitous over the Southern Ocean even south of the oceanic polar front where there is significantly less precipitable water. Large variations in liquid water amount and retrieved cloud droplet number concentration occur even when excluding the influence of cyclonic cloud systems by restricting to data 500 km or greater from the nearest cyclone center. Some variations in cloud properties and their relation to aerosol properties are dependent upon the nature of cloud-BL coupling. Three types of coupling were noted: 1) coupled cloud-BL in presence of weak surface positive flux; 2) decoupled cloud-BL in presence of surface negative flux with very shallow surface-based BL; and 3) decoupled cloud-BL in presence of higher clouds and stronger surface flux, with thicker surface-based BL. The performance of different numerical planetary BL schemes in the Weather Research and Forecasting (WRF) model was assessed by comparing simulated and observed properties for a case study for each of the three conditions, in order to identify processes that control cloud properties.
Findings on the controls of cloud properties over the Southern Ocean are contrasted against those over the North Atlantic Ocean by examining data collected during COMBLE. COMBLE data were classified according to whether single-layer or multi-

layer clouds occurred and whether there was no drizzle, virga, or rain conditions. Cloud microphysical and macrophysical properties were compared according to whether measurements were or were not made in a cold air outbreak period for each class. Combined, the MARCUS and COMBLE data and numerical simulations are offering important clues on the aerosol and meteorological controls of cloud properties.