Parameterization of Cirrus Microphysical and Radiative Properties in Larger-Scale Models

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This study exploits measurements in clouds sampled during several field programs, including the Atmospheric Radiation Measurement (ARM) Program, to develop and validate parameterizations that represent the physical and radiative properties of convectively generated cirrus clouds in intermediate and large-scale models (including cumulus ensemble models and general circulation models). We focus on cirrus anvils because they occur frequently, cover large areas, and play a large role in the radiation budget. Because of a lack of knowledge about how anvils develop, age, and decay, preliminary work focuses on understanding the physical (microphysical, radiative, and dynamical) processes that occur in these clouds. Our approach is discussed below.

We have constructed a detailed microphysical package that can be inserted into existing Eulerian cloud-scale models. This microphysical package is based on the Lagrangian ice crystal trajectory-growth model developed by Heymsfield (1986) and considers the growth of the following hydrometeor types: water drops, needles, plates, dendrites, columns, bullet rosettes, aggregates, graupel, and hail. Particle growth processes include diffusional and accretional growth, aggregation, sedimentation, and melting. In light of the new demands by radiative transfer schemes, this package includes and tracks these particle habits. Parameterized ("Kessler-type") microphysical schemes commonly used in cloud-scale models are not appropriate for predicting cloud radiative properties, which require more detailed knowledge about particle size distributions and shape.

This microphysical package is being implemented in a simple dynamical model that tracks the evolution and dispersion of hydrometeors in a stratiform anvil cloud. Given the momentum, vapor, and ice fluxes into the stratiform region and the temperature and humidity structure in the anvil's environment, this model will suggest anvil properties and structure. We will be using microphysical measurements from Kwajalein and the Tropical Ocean Global Atmosphere (TOGA) Coupled Ocean Atmosphere Response Experiment (COARE) and, as measurements become available, Central Equatorial Pacific Experiment (CEPEX) and ARM, to evaluate and improve our approach.

The nonhydrostatic, anelastic cloud model described by Clark (1977) and Clark and Hall (1991) will be used to model anvil production and investigate the influence of large-scale effects on the sustenance of anvil clouds.

References

Clark, T. L. 1977. A small-scale dynamic model using a terrain-following coordinate transformation. *J. Comp. Phys.* **24**:186-215.

Clark, T. L., and W. D. Hall. 1991. Multi-domain simulations of the time dependent Navier-Stokes equations: Benchmark error analyses of some nesting procedures. *J. Comp. Phys.* **92**:456-481.

Heymsfield, A. J. 1986. Ice particle evolution in the anvil of a severe thunderstorm during CCOPE. *J. Atmos. Sci.* **43**:2463-2478.