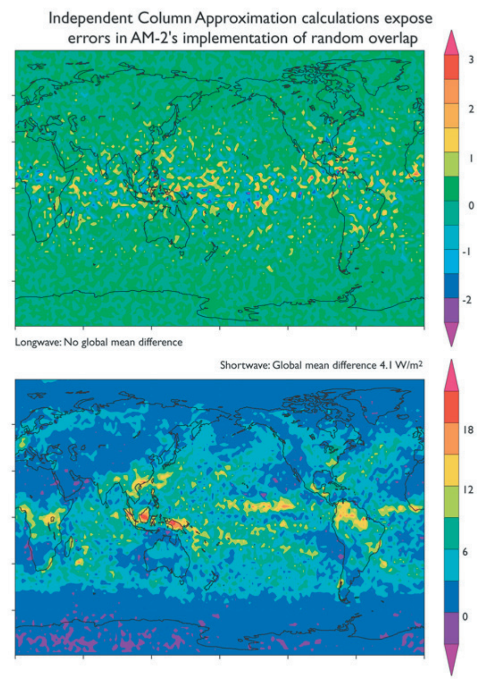
ARM

# Research Highlights

## Out with the Old, In with the New: McICA to Replace Traditional Cloud Overlap Assumptions

Because cloud-radiation interactions depend critically on the vertical structure of clouds, different assumptions about how this alignment occurs lead to differences in climate model results. As reported in the *Journal of Geophysical Research* in 2003, a team of international researchers led by the Atmospheric Radiation Measurement (ARM) Program developed the Monte Carlo Independent Column Approximation (McICA) to improve the treatment of cloud variability in climate models.

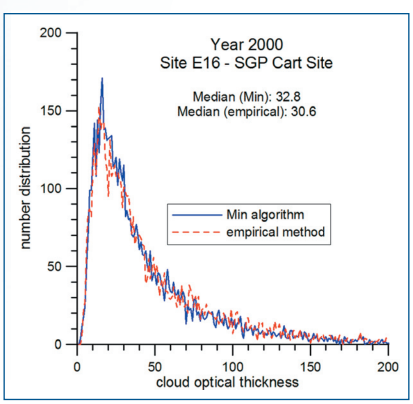
In collaboration with the National Oceanic and Aerospace Administration's Geophysical Fluid Dynamics Laboratory (GFDL), ARM researchers recently incorporated their new McICA scheme into the GFDL's atmospheric climate model (AM2) to gauge its effectiveness in improving the accuracy of cloud-radiation interactions. The McICA code demonstrated a significant improvement in solar radiation at the top of atmosphere of about 4 W/m2.




*As shown by the difference in top-of-atmosphere radiative flux, the upper panel (original AM2) is the longwave radiation and generally shows insignificant changes. The bottom panel (AM2 using McICA) is the net solar radiation and shows substantive changes.*

## For Estimates of Cloud Optical Thickness, Simple Equation is Good Enough

In contrast to complicated algorithms and extensive computer time required to obtain cloud optical thickness from surface measurements, researchers funded by the ARM Program developed a simple equation that does the job—as long as only reasonably close estimates are needed. Using data from several geographically diverse ARM sites, the researchers calculated cloud optical thickness from both their empirical method and a well documented transmission-based algorithm developed by Min and Harrison (1996). When compared, the median distributions were well within 10% of one another, and the shapes of the distributions were very similar. Because this new expression relies only on readily available solar flux measurements, it can be applied to a globally more extensive set of measurements and therefore provide cloud optical depth distributions across many more climatic regimes.




*Distributions of cloud optical thickness reveal that the empirical method (dashed line) closely replicates the Min algorithm (solid line), including the long tail that extends up to an optical thickness of 200. Both methods used observational data from the central facility at the ARM Program's Southern Great Plains site in 2000.*

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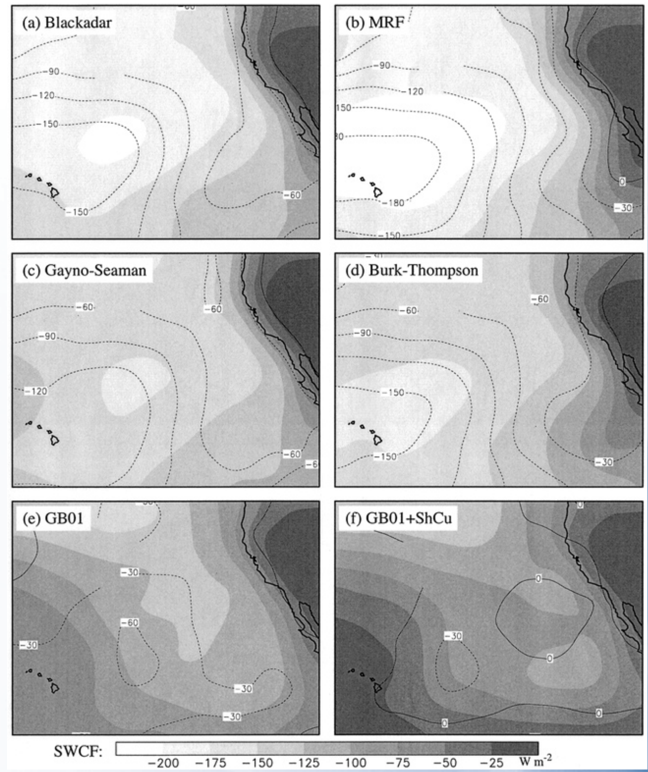
# A Deeper Look into Shallow Boundary Layer Clouds

Shallow cumulus and strato-cumulus clouds are the most abundant of all tropical and sub-tropical maritime clouds. They are among the most difficult clouds to simulate well in large-scale climate models, representing an important component of model uncertainty in simulations of future climate change. Scientists funded jointly by the ARM Program and the National Aeronautics and Space Administration developed a new parameterization of convection within shallow cumulus clouds that demonstrates improvement in the simulation of these clouds.

The new scheme is based on the fundamental physics of boundary layer cloud formation--it statistically parameterizes the rise of buoyant air parcels or plumes from the ocean surface. The researchers coupled this parameterization to an existing model describing turbulence and entrainment by a convective plume as it rises through the boundary layer. When subsequently implemented in a mesoscale model, the new scheme provided results closer to observed conditions than previous schemes.




*Mesoscale model calculations show the effect of clouds on the shortwave radiation budget at the top of the atmosphere (lighter colors indicate more reflective clouds) over the Western Pacific Ocean off the coast of California. The dotted lines indicate the difference from observations. Schemes (a) – (d) use existing cloud parameterizations; all significantly overestimate cloud reflectivity. A new mass flux parameterization (e) developed as part of this project produces substantial improvement by lowering model cloud reflectivity. Adding the new shallow cumulus parameterization (f) further decreases cloud reflectivity and produces the best agreement with observations. This research confirms the importance of proper treatment of shallow cumulus turbulence and mixing parameters in accurately modeling weather. Future research using millimeter-wavelength Doppler radar observations is expected to fine tune the parameterization and increase the accuracy of the results.*

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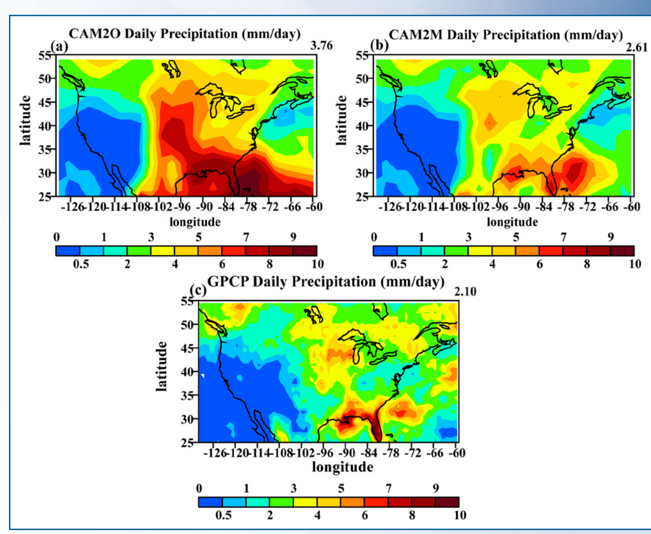
# Weather Prediction and Climate Simulation: A Meeting of the Models

Developed through a joint venture between the Climate Change Prediction Program (CCCP) and the ARM Program, the CCCP-ARM Parameterization Testbed, or CAPT, is a diagnostic tool for evaluating global climate models using weather prediction techniques. Two recently published articles report on research using the CAPT. The first, published in the *Bulletin of the American Meteorological Society*, describes the methodological approach to using numerical weather prediction techniques to evaluate cloud parameterization in climate models. The second article, in the *Journal of Geophysical Research*, describes in detail the comparison of a global climate model run in the CAPT with observations from satellite and the ARM Southern Great Plains site, as well as with analyses of temperature, wind, and humidity fields from the European Centre for Medium-Range Weather Forecasts model.

These articles demonstrate that the CAPT is a useful framework for identifying specific deficiencies in cloud parameterizations. The use of initial condition tests, similar to the way in which forecasting models are run, allows identification of parameterization errors before they are masked by departures of model dynamics from observed dynamics.




*Distribution of a 20-day mean precipitation forecast throughout the continental United States shows much better agreement from the original climate model (CAM2O) to the adjusted CAM2M model.*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