ARM Modeling Nugget 1

Development of the means for climate and cloud resolving models to simulate the conditions at all ARM sites

A challenge for ARM has been relating data taken at a few points to global climate model simulations. The program has taken the lead in the development of "forcing" datasets that permit single-column versions of the climate models (Figure 1) and cloud resolving models (Figure 2) to simulate the weather that occurs at the ARM sites and thus permit direct comparison of model simulations to observations. A "forcing" dataset quantifies the impact of the regions adjacent to the ARM site on conditions at the ARM site.

Previous work had produced "forcing datasets" only for Intensive Observing Periods at the SGP site. These IOPs were costly due to the requirement of frequent measurements from an array of sounding stations that enclose the ARM site. A recent development has been the creation of forcing datasets for the SGP that do not require Intensive Observing Periods *[Xie et al. 2004a]*. Three years of data has been created that permit the evaluation of single-column and cloud resolving models in a statistical way against ARM data. A statistical evaluation is necessary because ARM instruments typically measure only a small fraction of the area of a grid box at a single time *[Jakob et al. 2004]*. A second recent development has been the creation of the first forcing datasets for sites other than SGP. In particular, a dataset for the North Slope of Alaska site for the ARM Mixed-Phase Arctic Cloud Experiment (M-PACE) has been created *[Xie et al. 2006]*. Additionally a forcing dataset is currently being developed for the TWP Darwin site for the recently completed TWP-ICE experiment.

While single-column models are useful to evaluate new cloud parameterizations developed in the ARM program, it is necessary to understand the interactions of new parameterizations with atmospheric dynamics. This can only be done in the context of global integrations of a climate model. As a result, ARM (together with the DOE CCPP) created the CAPT program *[Phillips et al. 2004]* – a program that pioneered the use of climate models as weather prediction models. The CAPT program performs weather forecasts by integrating the climate models of NCAR and GFDL after they have been initialized with analyses from weather prediction centers such as NCEP, ECMWF, or the Goddard DAO. As an example, Figure 3 shows the vertical profile of clouds for the ARM NSA site during M-PACE as observed by the ARM remote sensors ("ARSCL") and that as simulated by the NCAR and GFDL climate models. The CAPT program provides a direct way for scientists to use ARM data to test new parameterizations *[Xie et al. 2004b]*.

References

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Figure 1. Illustration of a Single Column Model (SCM). An SCM represents the evolution of the atmosphere in a single grid box of a Global Climate Model (GCM). To run an SCM, you give the SCM the horizontal flow of mass, water, and energy in and out of the single point and the physical parameterizations of the GCM computes the evolution of clouds and other properties. When the horizontal flow is specified from observations, the SCM can be directly compared to the observations from a fixed point. This matches the observing strategy of ARM which takes intense observations from a few fixed sites. (Figure courtesy of Sam Iacobellis)

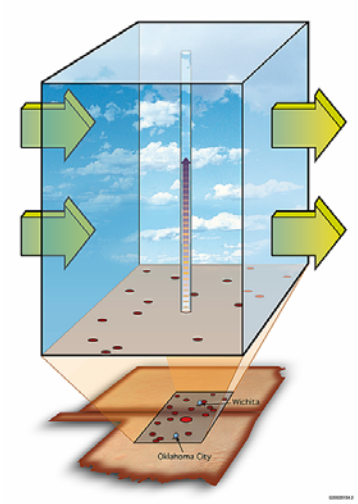

Figure 2. Illustration of a cloud field from a Cloud Resolving Model (CRM). A CRM is a limited area model which typically has horizontal resolutions of one kilometer. The figure shows the distribution of cloud condensate in green, and the strong radiative heating and cooling rates in red and blue, respectively, that occur because of the presence of the anvil cloud that is generated by deep convection. When a CRM is driven with the same observed horizontal flow as is used to drive SCMs, the output of the two models may be directly compared to each other and ARM data. While CRMs still contain parameterizations of great uncertainty (e.g. cloud microphysics and small-scale turbulence) and therefore should not be thought of as "ground-truth", they may carefully be used in some circumstances to diagnose errors in GCM parameterizations.

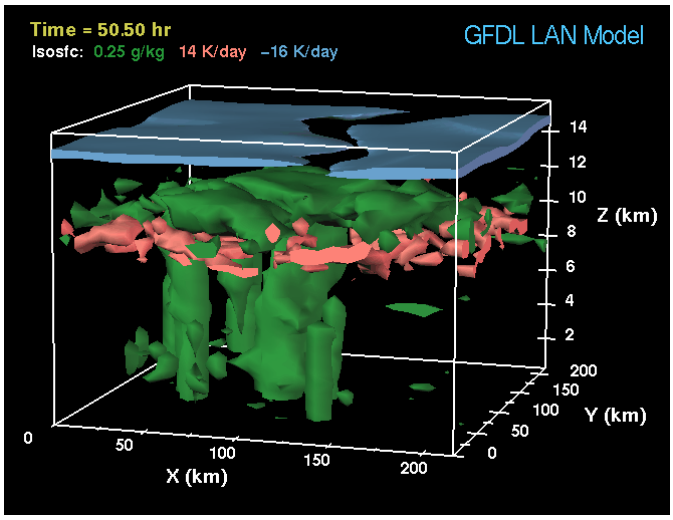
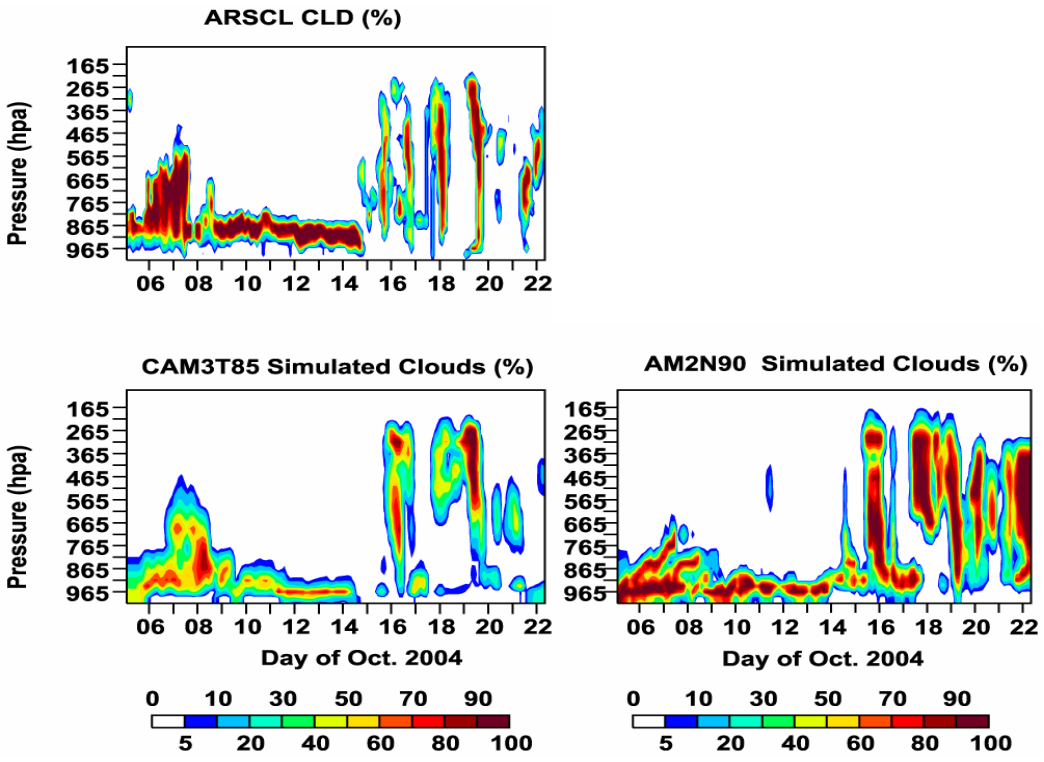
Figure 3. Illustration of the CAPT approach. CAPT facilitates the use of ARM data by the climate modeling community by integrating the climate models in weather prediction mode. This figure shows the time-height plots of cloud fraction from ARM observations (ARSCL CLD) and CAPT forecasts of the climate models of NCAR (CAM3T85) and GFDL (AM2N90) for October 2004 at ARM's Barrow, Alaska site. During this period, the ARM Mixed-Phase Arctic Cloud Experiment occurred. Note that the model output is plotted as a concatenated time series of data from hours 12 to 36 of forecasts that begin every day. (Figure courtesy of Shaocheng Xie)