Report on Activities Testing the Super-parameterization in the CAPT* Framework

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*CCPP-ARM Parameterization Testbed

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One of the activities scheduled for FY2004 in the CAPT Project at PCMDI (Phillips et al. 2004) was to test the "superparameterization" methodology (Randall et al. 2003) in a forecast mode. As one of the first outside participants in the CAPT, Marat Khairoutdinov of CSU visited LLNL to implement an embedded cloud resolving model (CCRM) into the Community Atmosphere Model version 2 (CAM2) model running the testbed. The initialization procedure was modified to run with the embedded Cloud Resolving Model (CRM) to allow turbulent processes to take effect before starting a forecast. We experimented with 12 and 24 hour spin-up periods and eventually settled with 12 hours. We successfully completed a 5-day forecast for part of the April 1997 ARM Intensive Observation Period (IOP).

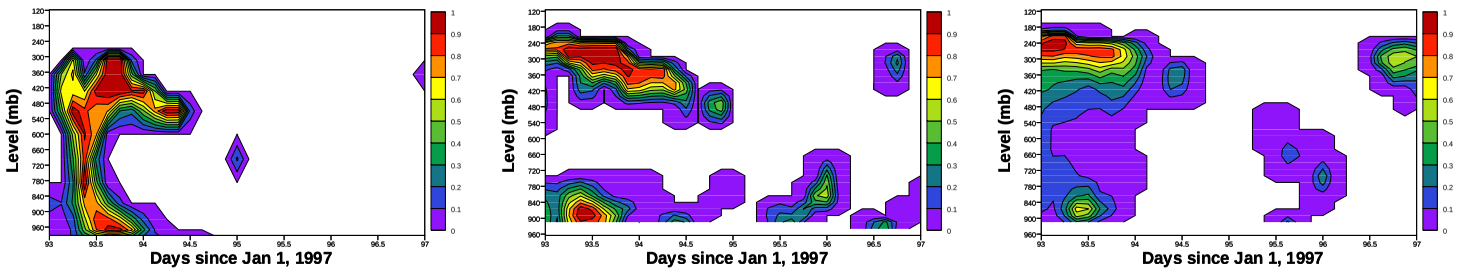
The CAM2 was first run in a forecast mode for a series of five day forecasts. Another simulation was carried out with the embedded CRM for one five-day forecast using initial conditions from early April 1997. Although the forecast was global we only examined one grid column to compare in detail with the ARM Southern Great Plains (SGP) site. For this preliminary report we examine the vertical structure of clouds at the SGP site for the five day forecast. The model in the second run calculates clouds in two ways. The first, involves sending the atmospheric state fields from the CRM to the original CAM2 cloud parameterization in which clouds are calculated in the traditional diagnostic manner. The second involves calculating the clouds directly in the CRM.

The results are still very preliminary. Figures 1a-1c all show the model produces too many high clouds and not enough middle clouds when compared to either the ERA-40 or the ARSCL (Figures 1d and 1e). The full super-parameteization (Figure 1c) suggests a structure more in line with other observations (eg. longwave radiation-not shown) taken during the April 1997 ARM IOP. Evaluating clouds in this way - having the diagnostic cloud parameterization operate on the CRM fields - allows separation of errors in cloud

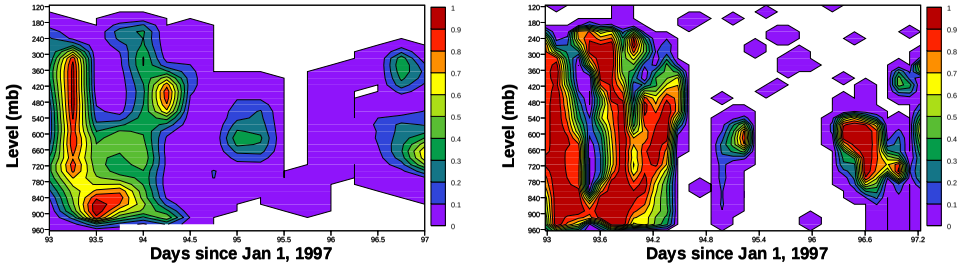
fraction parameterization from errors in other parameterization processes (e.g. turbulence and convection). In days 4-5 of the forecast period, the original CAM2 produces no clouds while the super-parameterization shows some low level cloud development similar to the ERA-40 and the ARSCL observations.

The comparison between the ERA-40 reanalysis cloud fraction profile in Figure 1d and the ARSCL cloud radar is very encouraging. For the most part, the ECMWF forecast model does an excellent job producing realistic clouds Mace et al. (1998). It is striking to note that nearly all of the individual cloud structures observed by the radar can be identified in the ERA-40.

In summary, this first forecast of the superparameterization using CAPT was successful in that clouds formed in much the same way as in the ERA-40. Each of the major events were captured by the model to some degree and even more subtile events later in the forecast can also be identified. In the future, we will examine various convective events during other IOPs in greater detail. Working closely with the developers at CSU will allow us to move foreward to continue using the superparamenterization for science issues.



(a) (b) (c)



(d) (e)

Figure 1: Cloud fraction by pressure level as originally calculated in the CAM2 for the forecast period 4-7 April 1997 (a), the profile that is diagnosed using the standard CAM algorithm using the T, qv, qc vertical profiles outputted from the CRM (b), and the cloud fraction profile computed directly from the CRM domain (c), Cloud fraction taken from the ERA-40 (d) and the observed cloud fraction from the ARSCL radar (e)

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References

Mace, G. G., C. Jacob, and K. P. Moran, 1998: Validation of hydrometeor occurrence predicted by the ecmwf model using millimeter wave radar data. *Geophys. Res. Lett.*, **25**, 1645–1648.

Phillips, T. J., G. Potter, D. L. Williamson, R. Cederwall, J. Boyle, M. Fiorino, J. Hnilo, J. Olson, J. J. Yio, and S. Xie, 2004: Evaluating parameterizations in general circulation models: Climate simulation meets weather prediction. *Bull. Amer. Meteor. Soc.*, **84**, in press.

Randall, D., M. Khairoutdinov, A. Arakawa, and W. Grabowski, 2003: Breaking the cloud parameterization deadlock. *Bull. Amer. Meteor. Soc.*, **84**, 1547–1564.