Stratocumulus to Cumulus Transition Climate Process Team (CPT)

Ruiyu Sun representing CPT (Thanks to C. Bretherton, J. Teixeira, H. Pan, R. Mechoso, and S. Park and others)

The purpose of the CPT was to improve the representation of subtropical boundary-layer cloud processes in the NCEP GFS and CFS, as well as in the NCAR Community Earth System Model (CESM), with a focus on the subtropical stratocumulus to cumulus (Sc-Cu) transition. The strategy of the CPT is to find the weaknesses of each system by analyzing their simulation results and identify the relevant processes, then use benchmark LES and single-column model to test possible improvements to the parameterizations of the processes. The proposed improvements are ultimately tested in short global integrations either in free-run mode or with data assimilation.

For the NCEP GFS we performed a 50-year long GFS-MOM4 coupled integration and compared with a CESM simulation and climate observations. It was found (Xiao et al. 2013) that GFS simulations were of comparable quality to those with CESM. But the GFS had problems simulating the global shortwave and longwave cloud radiative effects and planetary energy budget. Much of this response was attributable to the inadequate cloud over most parts of the oceans, including the near-coastal part of the subtropical stratocumulus regions and tropical-subtropical shallow cumulus regions. Based on these findings we identified that adding the atmospheric heating due to dissipation of turbulent kinetic energy in the boundary layer led to an improved energy budget. Single column-GFS simulation of GCSS cases suggested several modifications to the shallow cumulus parameterization. These modifications significantly improved the distribution of total cloud cover, and cloud radiative forcing in two year-long GFS free-run integrations (Fletcher et al 2013). In our attempt to improve the cloud cover and cloud condensate predictions we unified the two different cloud cover calculations used in the microphysical process and the radiative transfer calculation. The new cloud cover applied in the macrophysical process increased cloud condensate and improved cloud radiative forcing. A data assimilation experiment showed the cloud cover and macrophysics modifications with other adjustments also improved the precipitation skill scores.

An Eddy-Diffusivity/Mass-Flux (EDMF) parameterization for dry convection was implemented in the single column version of GFS, and validated against a range of large-eddy simulations in several GCSS cases. Results showed that the EDMF parameterization is promising. The scheme is currently implemented into the NCEP GFS and tested in the data assimilation mode against the current operational PBL scheme.

The work performed with CAM5 aims to impose consistency between the cloud physics parameterizations. A PDF-based macrophysics scheme was implemented and tested. Over the course of this development a number of unexpected issues related to coupling between cloud physics processes were identified and resolved.

The institutions participating in the CPT are NCEP, NCAR, JPL, U. of Washington, U. of California Los Angeles, and LLNL.