#15 NCEP Cloud-Climate Process Team (CPT2)

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The CPT2 aims to improve the global representation of cloud, especially low-lying cloud, in GFS, so as to produce a better free-running climate simulation and better operational weather forecasts. The CPT2 (2014-2016) is a successor to the Sc-Cu Transition CPT (CPT1, 2010-2013), involving partially overlapping personnel. A primary CPT1 goal was to improve the representation of subtropical boundary layer cloud processes in the NCEP GFS and CFS, with a focus on the subtropical stratocumulus to cumulus (Sc-Cu) transition. CPT1 also involved NCAR's CAM5 climate model, and applied a suite of CAM5 climate model metrics to coupled integrations with GFS. The strategy of both our CPTs is to find the weaknesses of the system by analyzing its 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 also tested in short global integrations either in free-run mode or with data assimilation.

We performed a 50-year long GFS-MOM4 coupled integration. It was found (Xiao et al. 2014) that the GFS (July 2011 version) 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. 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 2014). 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 forcings. On the other hand, an unexplained atmospheric energy loss of 4-5 W m^{-2} was found in the GFS coupled run. Inclusion of dissipative heating of turbulent kinetic energy (TKE) led to a greatly improved energy balance.

A hybrid 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. In the hybrid EDMF scheme, the EDMF scheme is applied only for the strongly unstable PBL, while the current operational GFS PBL scheme is used for the weakly unstable PBL. Results showed that the hybrid EDMF parameterization is promising. The hybrid EDMF scheme and the dissipative heating of TKE are implemented into the NCEP parallel GFS and are currently being tested in real time forecasts.

Based on the findings and improvements from the CPT1, we propose in the CPT2 to implement a moist EDMF scheme within GFS that improves its boundary-layer cloud climatology and operational weather and coupled climate metrics. We also propose to improve global cloud and precipitation climatology of GFS+MOM through using better new cloud microphysical and macrophysics schemes. We especially need to develop a cloud macrophysical scheme suitable to the new microphysical schemes, where partial cloudiness is taken into account. We will compare the clouds produced by the GFS with those produced by the GFDL climate models in the weather forecast mode.