Improvement of cumulus convection and planetary boundary layer parameterizations in the NCEP GFS

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A new shallow cumulus convection scheme has been implemented into the NCEP Global Forecast System (GFS; 2010), which employs a mass flux parameterization replacing the old turbulent diffusion-based approach and helps not to destroy stratocumulus clouds off the West coasts of South America and Africa as the old scheme does. The deep cumulus convection scheme was revised to make cumulus convection stronger and deeper to deplete more instability in the atmospheric column and result in the suppression of the excessive grid-scale precipitation (2010). The planetary boundary layer (PBL) scheme was revised to enhance turbulence diffusion in stratocumulus regions (2010), which helps prevent too much low cloud from forming.

Recently, a hybrid eddy-diffusivity mass-flux (EDMF) PBL scheme with dissipative heating and modified stable PBL mixing has been implemented into the NCEP GFS (2015). With the EDMF PBL scheme, where the nonlocal transport by large turbulent eddies is represented by a mass-flux (MF) scheme and the local transport by small eddies is represented by an eddy-diffusivity (ED) scheme, the daytime PBL growth was improved. In order not to degrade the forecast skill in the tropical ocean where strongly unstable PBLs are rarely found, a hybrid EDMF PBL scheme has been adopted, where the EDMF scheme is applied only for the strongly unstable PBL, while the old GFS eddy-diffusivity counter-gradient (EDCG) scheme is used for the weakly unstable PBL. For the vertical momentum mixing, the MF scheme is modified to include the effect of the updraft-induced pressure gradient force. To enhance a too weak vertical turbulent mixing for weakly and moderately stable conditions, the current local scheme in the stable boundary layer is modified to use an ED profile method. On the other hand, the drag coefficient over sea was reduced in high wind speeds to increase hurricane intensity which is generally weaker than the observation in the GFS due to coarse resolution.