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Revision of the Boundary Layer Mixing Scheme and Mass-Flux Parameterization of Shallow Cumulus Convection in the NCEP Global Forecast System

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To improve the non-local boundary layer vertical mixing scheme in the NCEP Global Forecast System (GFS), so called MRF (Medium-range Forecast model) PBL (Planetary Boundary Layer) scheme, the scheme has been significantly revised. In the revision, the entrainment flux for the convective boundary layer is explicitly determined as a function of surface buoyancy flux and friction velocity. A local closure scheme is used for the stable boundary layer and a non-local momentum mixing parameterization is included. A stratocumulus cloud driven vertical diffusion scheme simplified after Lock et al. (2000) is also incorporated into the revised model. In the simplification, the buoyancy reversal term due to evaporative cooling at the cloud top is neglected and only radiative cooling term is taken into account. For the cloudy region above stratocumulus layers, enhanced local diffusion is applied. Model forecast experiments with data assimilation indicate that the revised scheme significantly improve forecast skill in both 500 hPa height over globe and precipitation over US continent.

The current shallow cumulus convection scheme in the NCEP GFS uses a simple turbulent eddy diffusion approach with a specified eddy diffusivity profile for the transports of sensible heat and moisture within the cloud layer. While this scheme has been successful for destroying unrealistic moisture accumulation in the layer below the inversion by the additional diffusion of heat and moisture, it has been suffered from the systematic underestimation of the low clouds especially over the eastern Pacific and Atlantic Oceans. To improve the current shallow convection scheme, we develop a bulk mass-flux parameterization for shallow cumulus convection. While the scheme is

based on the Simplified Arakawa-Shubert (SAS) convection scheme, which has been developed for deep cumulus convection and is being used in the operational NCEP GFS, some aspects in the SAS scheme such as entrainment and detrainment specifications are modified suitable for shallow convection situation. The model forecast results with the new parameterization for shallow convection combined with the revised PBL scheme are presented.