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Optimized Stochastically Perturbed Parameterization Scheme for the Soil Temperature and Moisture within an Ensemble Data Assimilation System

Sujeong Lim[1,2], Seon Ki Park[1,2,3], and Claudio Cassardo[4]
[1]Center for Climate/Environment Change Prediction Research (CCCPR), Ewha Womans University, Seoul, Republic of Korea
[2]Severe Storm Research Center, Ewha Womans University, Seoul, Republic of Korea
[3]Department of Climate and Energy System Engineering, Ewha Womans University, Seoul, Republic of Korea (spark@ewha.ac.kr)
[4]Department of Physics and NatRisk Centre, University of Torino, Torino, Italy

The ensemble data assimilation (EDA) system contains uncertainties both in initial conditions and model forecast. In general, the uncertainties are represented by the ensemble spread that is a standard deviation of background error covariance (BEC). However, this ensemble spread is usually underestimated due to insufficient ensemble size, sampling errors, and imperfect models: it often causes a filter divergence problem as the analysis ignores the observation due to insufficient model uncertainty. This phenomenon is also found in the coupled land-atmospheric modeling system, especially near the surface where the heat flux exchanges are crucial as the lower boundary conditions. Therefore, we have developed the stochastically perturbed parameterization (SPP) scheme for the Noah Land Surface Model (hereafter, SPP-Noah LSM) using the soil temperature and moisture within the coupled WRF-Noah LSM system to represent the near-surface uncertainty. It perturbs the soil variables by adding the random forcing to inflate the ensemble spread. In particular, the random forcing used in perturbation is controlled by the tuning parameters such as amplitude, time scale, and length scale, which vary depending on the target variables. To obtain the optimal random forcing parameters to the soil variables, we employed a global optimization algorithm --- the micro-genetic algorithm, which is based on the natural selection or survival of fitness to evolve the best potential solution. The optimization is conducted in each daytime and nighttime to consider the diurnal variations of soil variables. As a result, the soil temperature and moisture perturbations using the SPP-Noah LSM can indirectly inflate the ensemble BECs of temperature and water vapor mixing ratio through the heat flux changes, respectively, in the planetary boundary layer (PBL) of the EDA system. The SPP-Noah LSM with diurnal variations depicts reasonable ensemble spreads for soil variables, but the ensemble spreads for atmospheric variables from the propagation of the soil variable perturbations are less effective. Our results indicate that the inflated ensemble spread helps to produce an adequate analysis increment reducing the background error in the PBL.