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Development of stochastically perturbed parameterization scheme for the Noah Land Surface Model with the optimized random forcing parameters using the micro-genetic algorithm

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The ensemble data assimilation system is beneficial to represent the initial uncertainties and flow-dependent background error covariance (BEC). In particular, the inevitable model uncertainties can be expressed by ensemble spread, that is the standard deviation of ensemble BEC. However, the ensemble spread generally suffers from under-estimated problems. To alleviate this problem, recent studies employed stochastic perturbation schemes to increases the ensemble spreads by adding the random forcing in the model tendencies (i.e., physical or dynamical tendencies) or parameterization schemes (i.e., PBL, convective scheme, etc.). In this study, we focus on the near-surface uncertainties which are affected by the interactions between the land and atmosphere process. The land surface model (LSM) provides various fluxes as the lower boundary condition to the atmosphere, influencing the accuracy of hourly-to-seasonal scale weather forecasting, but the surface uncertainties were not much addressed yet. In this study, we developed the stochastically perturbed parameterization (SPP) scheme for the Noah LSM. The Weather Research and Forecasting (WRF) ensemble system is used for regional weather forecasting over East Asia, especially over the Korean Peninsula. As a testbed experiment with the newly-developed Noah LSM-SPP system, we first perturbed the soil temperature — a crucial variable for the near-surface forecasts by affecting sensible heat fluxes, land surface skin temperature and surface air temperature, and hence lower-tropospheric temperature. Here, the random forcing used in perturbation is made by the tuning parameters for amplitude, length scale, and time scales: they are commonly determined empirically by trial and error. In order to find optimal tuning parameter values, we applied a global optimization algorithm — the micro-genetic algorithm (micro-GA) — to achieve the smallest root-mean-squared errors. Our results indicate that optimization of the random forcing parameters contributes to an increase in the ensemble spread and a decrease in the ensemble mean errors in the near-surface and lower-troposphere uncertainties. Further experiments will be conducted by including soil moisture in the testbed.