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Model error estimation and correction by solving a inverse problem

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Nowadays, the weather forecasts and climate predictions are increasingly relied on numerical models. Yet, errors inevitably exist in model due to the imperfect numeric and parameterizations. From the practical point of view, model correction is an efficient strategy. Despite of the different complexity of forecast error correction algorithms, the general idea is to estimate the forecast errors by considering the NWP as a direct problem. Chou (1974) suggested an alternative view by considering the NWP as an inverse problem. The model error tendency term (ME) due to the model deficiency is assumed as an unknown term in NWP model, which can be discretized into short intervals (for example 6 hour) and considered as a constant or linear form in each interval. Given the past re-analyses and NWP model, the discretized MEs in the past intervals can be solved iteratively as a constant or linear-increased tendency term in each interval. These MEs can be further used as the online corrections. In this study, an iterative method for obtaining the MEs in past intervals was presented, and its convergence had been confirmed with sets of experiments in the global forecast system of the Global and Regional Assimilation and Prediction System (GRAPES-GFS) for July-August (JA) 2009 and January-February (JF) 2010. Then these MEs were used to get online model corretions based of systematic errors of GRAPES-GFS for July 2009 and January 2010. The data sets associated with initial condition and sea surface temperature (SST) used in this study are both based on NCEP final (FNL) data.
According to the iterative numerical experiments, the following key conclusions can be drawn:(1) Batches of iteration test results indicated that the hour 6 forecast errors were reduced to 10% of their original value after 20 steps of iteration.(2) By offlinely comparing the error corrections estimated by MEs to the mean forecast errors, the patterns of estimated errors were considered to agree well with those of the forecasts.
According to the two-month (January 2010 and July 2009) online correction experiments, the conclusions can be summarized as follows: (1) According to zonally averaged latitude–height cross sections of geopotential height and zonal wind errors, the systematically underestimated equator-to-pole geopotential gradient over the Northern Hemisphere is sharply enhanced due to the online correction. Sequentially, the negative westerly wind bias is reduced as well.(2) According to zonally averaged latitude–height cross sections of temperature and zonal wind errors,the temperature bias over the tropics is also reduced by the LDW correction, as well as the convergence and divergence wind biases associated with an unrealistic heating source and sink.(3) The online correction leads to better mean forecast scores: the RMSE and bias are reduced for short-term forecasts (first 5 days of forecasts), and the ACC is increased for all the 8-day forecasts.