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Ensemble forecast of typhoon generated by orthogonal conditional nonlinear optimal perturbations

Zhenhua Huo (1,2), Wansuo Duan (1), and Feifan Zhou (3)

(1) LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China, (2) University of Chinese Academy of Sciences, Beijing, China, (3) LACS, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China

Orthogonal conditional nonlinear optimal perturbations (CNOPs) are the initial perturbations that have the largest impact on the forecast results in orthogonal subspaces of the initial perturbation space. Previous studies demonstrate the successful application of orthogonal CNOPs in ensemble forecasting. And further analysis indicates that orthogonal CNOPs may be more adapt to the prediction of strong events, among which typhoon events occur in the tropical or subtropical areas where the diabatic physical processes is very important and has strong nonlinear behavior. For these reasons, this paper focuses on the application of orthogonal CNOPs in ensemble forecast of typhoon.

In this study, orthogonal CNOPs, orthogonal singular vectors (SVs), bred vectors (BVs) and random perturbations (RPs) are applied for typhoon ensemble forecasts using MM5 model. The results show that, for typhoons Matsa in 2005 and Sepat in 2007, ensemble forecasts generated by orthogonal CNOPs greatly improve the control forecast, successfully predicts the landing location of Matsa, and gives the warning information of the landing of Sepat. In detail, for the ensemble mean associated with orthogonal CNOPs, the averaging track forecast error over 5 days is decreased by 45.58 km for Matsa and 87.8 km for Sepat, compared with control forecast. However, ensemble forecasts generated by other three methods could not successfully predict the landing location of Matsa and give the warning information of the landing of Sepat. Compared with orthogonal SVs, BVs and RPs, ensemble forecasts generated by orthogonal CNOPs corresponds to the largest ensemble spread, improves the control forecast at the largest extent, and best samples the distribution of initial analysis errors. All these results show that orthogonal CNOPs may provide another useful technique for ensemble forecast of typhoon.