Evaluating Two Cumulus Parameterization Schemes in a Cycling Ensemble Data Assimilation System with GPS Radio Occultation Refractivity Profiles

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Abstract

The neutral atmosphere refractivity is a proxy of the air density and carries atmospheric thermodynamic information, with its vertical structure strongly affected by convection. The Global Positioning System (GPS) radio occultation (RO) refractivity profile observations, which are of high quality, high vertical resolution, and uniform global coverage, are of great value for evaluation of model physics. One of the most challenging model physics is the treatment of subgrid-scale convection, known as cumulus parameterization. The model precipitation, heat and moisture distribution, and cloud-radiation interaction are all strongly influenced by cumulus parameterization. Errors in cumulus parameterization can lead to large model systematic errors, affecting mesoscale and synoptic-scale circulations. The assimilation of atmospheric measurements can also be significantly influenced by cumulus parameterization, as model errors related to cumulus parameterization can persist in a data assimilation system. In this study, we assess the performance of the Tiedtke and the New Simplified Arakawa-Schubert (NSAS) cumulus scheme in a 40-member WRF-DART cycling ensemble data assimilation system, using the GPS RO refractivity profiles. The atmPrf refractivity profiles from the missions of COSMIC, SACC, GRACE, and TerraSAR-X are thinned to fixed geometric heights in 200 m interval for model verification. We found that the model-observation departure statistics are significantly different in the low- and middle-troposphere between the two single-physics ensemble data assimilation systems using the Tiedtke and the NSAS scheme, respectively. These results suggest that model errors can contribute substantially to the ‘perceived’ apparent RO bias in the lower troposphere, known as the ‘RO negative bias’, except for the large negative RO bias near surface which are most likely caused by real RO measurement errors. The short-range track and intensity forecasts of Typhoon Megi (2010) during the cycling period are strongly influenced by the choice of cumulus parameterization. It is interesting to note that the ensemble system that uses the combination of both cumulus schemes gives a superior performance to that using either scheme by itself.