Evaluation of the Offline-coupled GFSv15-FV3-CMAQv5.0.2 in Support of the Next-generation National Air Quality Forecast Capability over the Contiguous United States

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Abstract

The next-generation of the operational National Air Quality Forecast Capability (NAQFC) consists of the Finite Volume Cube-Sphere dynamic core (FV3)-based Global Forecast System (GFS) and the Community Multiscale Air Quality (CMAQ) modelling system. In this study, the forecast skill of an offline-coupled GFSv15-CMAQv5.0.2 is comprehensively evaluated for the year 2019. The forecast system shows good overall annual-mean performance but larger seasonal and monthly biases for temperature and relative humidity at 2-m and wind speed at 10-m, and moderate-to-large biases for hourly precipitation. It shows an overall good forecast skill in predicting annual and seasonal mean maximum daily average 8-h ozone (O_3), despite a significant overprediction near the Gulf Coast during O_3 season. While the forecast system performs well in forecasting fine particles ($PM_{2.5}$) for warm months (May-September), it significantly overpredicts for other months, particularly in the U.S. EPA designated regions 5 and 7 (mostly in the Midwest), and the states of Oregon and Washington, due mainly to the high predicted concentrations of fine fugitive, coarse-mode, and nitrate components. Underpredictions in the southeastern U.S. and California during summer are attributed to missing sources and mechanisms of secondary organic aerosol formation from biogenic volatile organic compounds (VOCs) and semi- or intermediate-VOCs. Categorical evaluation indicates that GFSv15-CMAQv5.0.2 can predict well the exceedance of "moderate" classification but not well for the "unhealthy for sensitive groups" in the U.S. air quality index system, due to the aforementioned $PM_{2.5}$ overprediction. The region-specific, time-specific, and categorical evaluations in this work can provide a scientific basis for the further development of NAQFC, in particular in improving the emissions and model chemical representations, as well as the development of the science-based bias correction method to improve forecasting skill for O_3 and $PM_{2.5}$.