The impact of stratosphere to troposphere: raising model top from 5hPa to 0.1hPa of GRAPES_GFS (weather model)

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Over the past 15 or so years, there has been an increasing recognition of the role of the stratosphere in modulating tropospheric processes, especially for the winter hemisphere. Forecast centers such as ECMWF, Met Office have moved their model tops to the middle mesosphere, 80km or 0.01hPa, the GEM of ECCC also move their model top to 0.1hPa.

The Global Regional Assimilation and PrEdiction System, Global Forecast System, GRAPES_GFS, independently developed by the Numerical Weather Prediction Center of China Meteorological Administration, main task is the operational application of 0 to 10 day weather forecast. At present, the horizontal resolution is 0.25 degree, in vertical direction, height based terrain following coordinate is adopted, 60 layers, the model top is about 5hpa, located in the middle of stratosphere.

For the GRAPES_GFS, the model top is to low compare to other centers. The problem is that, on the one hand, the weather model generally adopts rigid boundary conditions, the distribution of the real atmosphere cannot be correctly simulated near the model top, so the low model top will cause the prediction deviation of the troposphere to increase gradually in the long-term cycle integration; On the other hand, raising the model top can make more satellite data into the data assimilation system, and this can directly improve the prediction effect of the stratosphere.

Based on the experience of IFS and GEM, we increase the vertical level of GRAPES_GFS from 60 to 87, and the model top is increased from 5hpa to 0.1hpa. We redesigned the sponge layer of the model, mainly including the Rayleigh Friction scheme which is close to the monthly average state, the W implicit damping scheme which changes with the altitude and latitude; In the physical process, we introduced the New non orographic gravity wave scheme, debugged the orographic gravity wave drag scheme, and adjusted the equation of saturation specific humidity at low temperatures.

Through the 4Dvar cycle forecast, we tested the prediction ability of the new high top system, with more reasonable simulation of the stratosphere and mesosphere, the prediction ability in troposphere is improved.

Keywords: GRAPES GFS, Stratosphere, Troposphere, Model top, Sponge layer

