Representing the stratosphere in low-topped NWP models

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The importance of stratospheric influences for medium range numerical weather prediction (NWP) of the troposphere has led to increases in the heights of global model domains at operational centers around the world. Grids now routinely extend to 0.1 hPa (approximately 65 km) in these systems, thereby covering the full depth of the stratosphere and the lower portion of the mesosphere. Increasing the vertical extent of higher resolution limited area models (LAMs) nested within the global forecasts is problematic because of the computational cost of additional levels and the possibility of inaccuracy or instability in the high-speed stratospheric jets. An upper boundary nesting (UBN) technique is developed that allows information from high-topped driving grids to influence the evolution of a lower-topped 10 hPa LAM integration in a manner analogous to the treatment of lateral boundary conditions.

A stratospheric vortex displacement event in winter 2007 is used to study the effectiveness of the UBN technique. Tropospheric blocking over Europe leads to the development of an amplifying planetary-scale wave in the lower stratosphere that culminates in an anticyclonic wave-break over Asia and a marked increase of wave-1 asymmetry. The rapid evolution of stratospheric potential vorticity (PV) is poorly represented in low-topped models, resulting in PV-induced forecast height errors throughout the depth of the troposphere on time scales as short as 2-5 days. Application of the UBN technique is shown to be an effective way for low-topped configurations to benefit from stratospheric predictability without the problems associated with the inclusion of the stratospheric flow in the higher resolution model domain. The robustness and relative ease of implementation of the UBN technique may make this computationally inexpensive strategy attractive for a wide range of NWP applications.