Case studies of the middle atmospheric response to gravity wave drag using NOGAPS-ALPHA at varying resolutions

David E. Siskind
Space Science Division,
Naval Research Laboratory, Washington DC

It is well understood that gravity waves play a dominant role in the momentum budget of the middle atmosphere. Because they usually are manifest on spatial scales smaller than typical theoretical model grid sizes, their effects in global models must be accounted for by parameterizations, rather than via explicit resolution. The recent implementation of a high altitude data assimilation system with NOGAPS-ALPHA (Eckermann et al., 2009; Hoppel et al., 2008) offers a new tool to evaluate the role of gravity waves in shaping the structure of the middle atmosphere and its response to perturbations. Specifically, we employ several short and medium term forecasts and use the divergence of the forecast model from the analysis as a measure of forecast skill and, by implication, the validity of our assumptions concerning gravity waves. We evaluate the ability of our model, at various spatial resolutions, to simulate gravity wave driven features of the middle atmosphere such as the warm winter stratopause and the cold summer mesopause. Also, we address the relative roles of gravity waves and planetary waves governing the response of the middle atmosphere to sudden stratospheric warmings. We focus in particular on recent extended warmings where the conventional stratopause at 50 km disappears and reforms above 80 km. We use wave forcing diagnostics from the Transformed Eulerian Mean formulation to quantify the effects of differing assumptions and compare forecast results at T79, T239 and T479 spectral truncations. While T79 is clearly too coarse, progressive improvements are seen at T239 and T479 truncation.

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