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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Sensitivity of middle atmospheric temperature and circulation in the UIUC GCM to the treatment of subgrid-scale gravity-wave breaking" *by* F. Yang et al.

Anonymous Referee #2

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Review of ACPD manuscript "Sensitivity of middle atmospheric temperature and circulation in the UIC Ě" by Yan et al.

This study describes the implementation of a gravity wave scheme in the vertically extended UIUC General Circulation Model (GCM). The goal is to find the implementation of a scheme that produces the best mean climatology of the middle atmosphere. Since gravity waves are recognized as the major contributor to the momentum budget above the stratopause, the implementation of a gravity wave scheme is critical in order to carry out simulations of solar variability, and in general, of climate change in the middle atmosphere.

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The standard version of the UIUC/GCM implements a Rayleigh friction scheme which simply aims to slow down the upper level jets in order to maintain numerical stability and avoid spurious wave reflection from the model top. Although a Rayleigh friction scheme was first suggested as a way to close the momentum budget in the mesosphere, it was quickly recognized that it does not produce the observed climatology of winds and temperature. To this date, Rayleigh friction schemes have been used in models that do not reach high into the middle atmosphere (e.g. Boville, 1995), where the only desired outcome is manageability of the winds near the model top. Or, Rayleigh friction schemes are still used in mechanistic models where the goal is to experiment on the current climate state, rather than predict/interpret climate change in the middle atmosphere. More recently, the paper by Shepherd et al (1996) and the follow up by Shepherd and Shaw (2004; JAS) should have cleared out the field of any expectation or desire to implement a Rayleigh friction scheme in a full GCM of the middle atmosphere. Hence, I do not understand the effort that has been put in this study trying to justify/prove that the Rayleigh friction scheme results in an undesirable climatology. I take that as a fairly settled issue.

By and large, the manuscript is a tuning exercise in which a number of parameters are changed in the Alexander and Dunkerton (AD) gravity wave scheme. As one reads thru the manuscript, the study of McLandress and Scinocca (2005; JAS) is reminded to the reader. The McLandress and Scinocca study proves that trying to choose the best parameterization based on the different properties at the sink is not a very fruitful exercise, because all parameterizations are capable of producing indistinguishable results with the appropriate choice of tuning. The study under review here reinforces the McLandress and Scinocca conclusion, but it is not clear to me what it adds to that. One conclusion is that the largest uncertainties still remain on the source. The authors correctly point this out.

On the aspect of what is climatology, a description of the mean is not sufficient to infer conclusions. What about the variability? Is the different tuning of the AD scheme

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resulting in different interannual variations? There is no mention that Figs. 4 and 5 indicate substantial changes in the stratosphere following the different choices of parameters in the AD scheme: do these differences impact the resolved wave field? What are the implications, among other things, of Figs. 6 and 7 (the residual circulation) on constituent transport?

Regarding Fig. 3, are the accelerations shown from an instantaneous calculation? In other words, are the winds changed following the calculated tendencies? If what is shown is an instantaneous calculation, it is not clear to me what one has to infer from Fig. 3. It should be remembered that the resulting state is built-in in the gravity wave scheme (to the extent that gravity waves control the momentum budget of the middle atmosphere). Hence, an instantaneous tendency applied to a mean state (as in Fig. 3) does not tell anything about the equilibrated state that is implicit in the AD scheme.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 9085, 2006.