Review of
"Winds and Tides of the Extended Unified Model in the Mesosphere and Lower Thermosphere Validated with Meteor Radar Observations", Griffith et al.

The manuscript reports on a study of the atmospheric winds and tides with the Met Office's Extended Unified Model (ExUM), which extends from the lower atmosphere to the lower thermosphere. This model is based on a previous version of a Met Office model that has been recently extended to the mesosphere and lower thermosphere region. A comparison against meteor radar observation of winds and tides from 2006 between 80 and 100 km over two radar stations are performed. Specifically, the authors test the ability of the ExUM to model diurnal and semi-diurnal tides by comparing the model to observations of zonal and meridional winds made in the mesosphere and lower thermosphere. A standard least-square fitting method is used for tidal analysis.

The study shows that the ExUM model is capable of reproducing the overall structure of the atmospheric winds and tides, capturing many of the key characteristics seen in meteor radar observations, such as zonal and meridional wind maxima and minima, the increase in tidal amplitude with increasing height, and the decrease in tidal phase with increasing height. The model is still under development and further tests will certainly improve the GCM, which the authors correctly recognize.

I think, a development of an extended general circulation model is an important contribution to the field of atmospheric modeling and atmospheric coupling. Having more models connecting the lower atmosphere and the upper atmosphere will provide more opportunities for young researchers coming into the field of atmospheric vertical coupling. There is certainly room for further model development, however, model development is an iterative and long-term endeavor and the authors are in a good position to complete this. I would like to also mention that some important earlier contributions to the field of high-top GCMs and atmospheric wave coupling have not been included neither in the introduction nor in the discussion, so I encourage the authors to include in their discussion these contributions in the field of vertical coupling. For this, I have provided further details below. I suggest the manuscript to be published after the following comments are adequately addressed.

Comments:

1. In fact, high-top GCMs have been around for some time. Some earlier GCMs that extend from the lower atmosphere to the upper thermosphere have not been included in the high-top GCMs. Please add the following:

- The Coupled Middle Atmosphere Thermosphere-2 GCM extends from the lower atmosphere up to 300-500 km, depending on the solar activity. This GCM was first presented in the work by Yiğit et al. (2009) , which has utilized the nonlinear spectral GW parameterization of Yiğit et al. (2008) to study the propagation of a broad spectrum gravity waves from the lower atmosphere to the thermosphere. Note that this scheme is designed for the vertical evolution and dissipation of GWs. It is not a parameterization of GW sources. The most recent work with this

GCM is given in the work by Yiğit et al. (2021). The authors ought to include these studies in their introduction.

- The University of Leipzig Middle and Upper atmosphere model extends from the lower atmosphere up to 160 km. A recent study with this GCM on the interaction of GW and terdiurnal tides is given in the work by Lilienthal et al. (2021).
- The Kyushu GCM extending up to 450 km (S Miyahara et al., 1993; Miyoshi & Fujiwara, 2008; Miyoshi & Yiğit, 2019).

2. lines 116-118. The authors correctly acknowledge that modeling tides has been a challenging aspect of GCM studies. Without adequately modeling nonorographic GWs, tides cannot be properly simulated (S. Miyahara & Forbes, 1991). Please note here that the general circulation modeling study of Yiğit & Medvedev (2017) extensively discuss this aspect in the context of the coupling between the diurnal migrating tide and sub-grid-scale gravity waves. They show that GWs play an important role for the diurnal tide in the MLT region. They found that the GW effects on the thermal tide can be appropriately captured in a coarse-grid GCM provided that a GW parameterization (1) considers a broad spectrum of harmonics, (2) properly describes their propagation, and (3) correctly accounts for the physics of wave breaking/saturation.
3. Please discuss your results in the context of the recent publication of Miyoshi & Yiğit (2019) who have used the Kyushu GCM incorporating the nonlinear spectral GW scheme of Yiğit et al. (2008). They showed that the nonorographic subgrid-scale GWs attenuate the migrating semidiurnal solar-tide (SW2) amplitude in the lower thermosphere and modify the latitudinal structure of the SW2 above a 150 km height.
4. lines 159-161: What is the vertical extent of the damping coefficient? What kind of impact does it have on your results?
5. You may consider adding in the introduction the review paper by Yiğit et al. (2016), which discussed vertical coupling processes via internal waves, including, GWs and tides. This study has provided further motivation for the development of high-top models.
6. lines 206: What do you mean with year dependent forcing?
7. lines 206: Can you clarify whether you have used nudging above 90 km in this study or not. Why are the details postponed to another study? I think, they are relevant to this paper.
8. lines 534-538: I think, further details of the used GW parameterization should be provided in this study. A physics-based parameterization with an empirical GW source should include a broad spectrum of GWs and should be able to handle the MLT region without extensive tuning. Here are some helpful references that can guide your discussion: For example, the book chapter by Yiğit & Medvedev (2013) talks about the implementation methodology of an extended GW parameterization suitable for the middle and upper atmosphere. The work by Majdzadeh & Klaassen (2019) showed that the Warner-McIntyre scheme has in fact the ability to reproduce the observed spectral tail for the case of no background wind. However, it was also shown that the associated saturation threshold generally does not follow the observed spectral behavior at high vertical wavenumbers. Another insightful paper on GW dynamics in the middle atmosphere is the work by Geller et al. (2011). In a study of MLT tides, the GW aspects of the story should be carefully discussed.
9. As a follow-up to the discussion of GWs and possible missing physics: Have you included GW thermal effects? Previous studies, for example, by Hickey et al., (2011); Medvedev and Klaassen (2003); Yiğit & Medvedev (2009) have shown that GWs produce localized,

and occasionally very strong, heating and cooling, which certainly play an important role for the thermosphere and can also be important in the MLT region. Please discuss this aspect and consider including the cited contributions.

10. Please discuss your results in comparison with the GCM simulations of GW-tidal interactions performed by Yiğit and Medvedev (2017) for the GW-diurnal tides and Miyoshi and Yiğit (2019) for GW-semi-diurnal tide interactions. These studies have used the Yiğit et al. (2008) scheme, as noted above. Nonlinear interaction between GWs is an important process in the MLT region (Medvedev & Klaassen, 2000). Some of the biases in the simulations can be due to this missing process in ExUM. Please acknowledge these previous efforts adequately.
11. Yiğit et al. (2021) GCM showed that implementing a latitudinally variable GW spectrum in somewhat agreement with SABER observations can impact the middle atmosphere circulation significantly. This type of GW variability can have an important effect on the diurnal tides. This mechanism should be mentioned in the discussion.

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