Comments on "Analysis of Migrating and Non-Migrating Tides of the Extended Unified Model in the Mesosphere and Lower Thermosphere" by Griffith and Mitchell (Manuscript # angeo-2021-21)

This modeling study analyzes and validates the amplitude of diurnal and semidiurnal atmospheric tidal perturbations in the Extended Unified Model (ExUM). The authors find that the temporal and spatial distribution of diurnal and semidiurnal migrating and non-migrating tidal amplitudes in the ExUM compare favorably to other whole atmosphere and upper atmosphere models, as well as satellite observations on seasonal time scales. This paper also examines day-to-day variations in tidal amplitudes and finds that they can be of the same magnitude as the seasonally-derived amplitudes. The manuscript is well-written, well-organized, and suitable for publication after some major revisions.

General Comment(s):

1.) While the model results presented in Figures 1, 2, 7, 8, 10, 12, 13, 14, 15 are important, they are extremely difficult to see and are too small. I would suggest the authors make the axis labels slightly bigger and in bold type font, while also making the plots larger. This would make them much easier to read.
2.) The word "tidal modes" or "modes" is used incorrectly throughout the manuscript. Typically, "tidal modes" or "modes" in this context refers to an individual tidal components "Hough mode" or latitudinal structure. Each "Hough mode" is represented by an accompanying latitudinal function, referred to as a Hough function, or the eigen functions of Laplace's tidal equation. The latitudinal structure of any individual tidal component (e.g., DW1, SW2, or DE3) is determined by the superposition of all the different Hough modes. I would strongly suggest changing "tidal modes" or "modes" to **tidal components** or **component(s)** throughout the entire manuscript. Please see a tidal review by Forbes [1995][1] for more details.
3.) There is very little discussion throughout the manuscript about the phases of the different tidal components produced in the model. The manuscript would be greatly enhanced if there were some phase comparisons between the tidal phases produced in ExUM and other models, as well as observations.
4.) While the authors discuss how one major source of tidal dissipation is handled (ion drag, which is not included since the model top is at 120 km), there is little to no discussion about how the other major tidal dissipation processes including eddy and molecular diffusion are handled in the model. Were these discussed in previous papers? If so, one or two sentences of how these types are handled would suffice. If not there needs to be some discussion about how these things are handled, parameterized, in the dynamical core in the ExUM. A follow onto this question would be how are the specific heats handled in ExUM? Are they height varying? Please elaborate on this as well.
5.) On L165-205 there is extensive discussion on how the background temperature profile is nudged towards climatology. How robust are the simulated tidal amplitudes

[1] Forbes, J.M. (1995). Tidal and Planetary Waves. In The Upper Mesosphere and Lower Thermosphere: A Review of Experiment and Theory (eds R.M. Johnson and T.L. Killeen). https://doi.org/10.1029/GM087p0067

and phases to this background temperature profile? For example, *Jones et al.* [2018][2] showed that tidal results in the NCAR TIME-GCM were very sensitive to changes in the how the model fields were constrained. The authors should comment on how tidal results shown in Section 3 and 4 might depend on this choice of background temperature profile?

6.) L240: States " we only show results from a single simulation …" What does this mean? The simulations performed as part of this study should be clearly outlined in this work, so that independent reproducibility of results presented herein would be possible.

7.) Daily tidal amplitudes simulated in ExUM could be validated against NAVGEM-HA and TIMED/TIDI calculated by Dhadly et al. [2018][3].

Minor Comment(s):

1.) Why was the month of January chosen for a number of the plots? This was not stated in the manuscript. I do not have any issue with it, just would like to know the authors' rationale behind this. The readers might be interested in this type of information.

2.) Several times throughout the manuscript the Global Scale Wave Model (GSWM) is incorrectly referred to as the Global Wave Scale Model (GWSM). Please correct this in all places throughout the manuscript.

3.) When referring to atmospheric tidal and ionospheric coupling, I believe the authors have neglected some pretty influential pieces of work. While, I understand, it is not necessary to cite every paper I would suggest the authors cite the following work by Immel et al. [2006].[4] There are number of other works that could be cited as well, but please cite at least Immet et al. [2006].

4.) L26: Strike *etc.*

5.) L27: Strike *and tides*.

6.) L63: Replace *have been suggested to result from* to **are in part driven by**.

7.) L77: Strike *the*.

8.) L81: *Nonmigrating* should be non-migrating.

9.) L124: Replace *ask* with **seek to answer**.

10.) L128: Replace *can be suggested to* **could**.

11.) L184: What altitude is this *z* referring to? Geopotential height, geometric height, etc. Please state what the variable z is.

12.) L194: Strike the first *mean* and replace it with **and**. (This occurs in other places in the manuscript when referring to *zonal mean monthly mean*. Please replace this throughout the manuscript.)

13.) L210: It is not clear why WACCM-X scale heights are used? What are the purpose of these? Is this self-consistent with the use of the CIRA climatological

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[2] Jones, M. Jr., Drob, D. P., Siskind, D. E., McCormack, J. P., Maute, A., McDonald, S. E., & Dymond, K. F. (2018). Evaluating different techniques for constraining lower atmospheric variability in an upper atmosphere general circulation model: A case study during the 2010 sudden stratospheric warming. *Journal of Advances in Modeling Earth Systems*, 10, 3076– 3102. https://doi.org/10.1029/2018MS001440

[3] Dhadly, M. S., Emmert, J. T., Drob, D. P., McCormack, J. P., & Niciejewski, R.(2018), Short-term and interannual variations of migrating diurnal and semidiurnal tides in the mesosphere and lower thermosphere. *Journal of Geophysical Research: Space Physics*, 123, 7106– 7123. https://doi.org/10.1029/2018JA025748

[4] Immel, T. J., Sagawa, E., England, S. L., Henderson, S. B., Hagan, M. E., Mende, S. B., Frey, H. U., Swenson, C. M., and Paxton, L. J. (2006), Control of equatorial ionospheric morphology by atmospheric tides, *Geophys. Res. Lett.*, 33, L15108, doi:10.1029/2006GL026161.

temperature model used for the background temperature? Please add additional details to address this.

14.) Sentence on L282-283: It is not clear the dominance of the different migrating tidal components with latitude. From a theorical and observation perspective, this is what one would expect, but it is hard to see this in Figure 7. I would suggest adding some additional details to describe this switch in the latitudinal structure.

15.) L355: Replace *non-migrating tidal components* with **tidal spectrum**.

16.) L414-415: Please provide any details as to why DE3, DE2, DE1, DO, and DW2 magnitudes are weak in ExUM at polar latitudes?

17.) L450: Strike *clear*.

18.) L456: Strike *The*.

19.) L472: Add **semidiurnal** between non-migrating and components.

20.) L528-529: It is stated that the short term variation in DE3 is 125%. Is this relative to the 30-day running average values? If so, please state that. Seeing that the DE3 peaks at 4 K, but the short term variation is up to 5 K is puzzling. (This occurs with other waves as well, i.e., the short term variation is greater than 100%. Make sure this is clear to the reader.)

21.) Strike *The* at the beginning of the sentences on L546 and L548.

22.) L600: Add **are** between there and a.

23.) L637: DE3 is a Kelvin wave (equatorially-trapped wave), please state this as the reason there is no meridional wind component.

24.) L690: Strike *the* between DE3. (This occurs below when referring to other tidal components. Please strike those leading *the*'s as well.

25.) L791: *Tides* should be **tide**.