

Interactive comment on “Nonlinear forcing mechanisms of the terdiurnal solar tide and their impact on the zonal mean circulation” by Friederike Lilienthal and Christoph Jacobi

Friederike Lilienthal and Christoph Jacobi

friederike.lilienthal@uni-leipzig.de

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Dear anonymous reviewer,

thank you very much for your valuable comments to help improve our manuscript. Please find below our detailed response to each of your concerns:

"1. The model does not generate non-migrating tides in the current configuration as described in section 2. Please add “migrating” before “terdiurnal solar tide” in the title."

We adjusted the title, accordingly.

"2. “In order to reduce the time of computation for the simulations with enhanced

C1

forcing mechanisms, only the January runs are performed as an ensemble. The other months represent the conditions for the year 2000, only”. Please discuss the potential difference or evaluate the influence of these two kinds of preprocessing methods."

In the meantime, we can provide an update with ensemble means for the 5% enhanced simulations (GW5/NL5), too. This should be more consistent than using only one single year. Figure 4 will be updated in the revised version. Please note that Fig. 2 of the manuscript also includes a standard deviation with respect to the 11 ensemble members so that the reader may also get an idea of the year to year variability from these figures.

"3. Figure 1 and Page 5 Line 1: “This is due to the fact that MUAM tends to underestimate tides in general, which is frequently seen in other models, too”. Page 5 Line 14: There are differences in the seasonal variation of the TDT from different models. What’s the reason behind these phenomena? Besides, would you please demonstrate why you present the seasonal cycle of TDT at 109 km?"

There is no general agreement on the cause of tidal underestimation in models, but it has to be connected with strong damping in the mesosphere region, for example due to gravity waves. The Lindzen-type parameterization used in MUAM tends to damp tides relatively strongly, while other parameterizations can lead to slightly stronger tides (e.g. the one after Hines or Yigit). Nevertheless, as we mainly focus on relative amplitude changes, our results are not significantly influenced by this underestimation.

Please note that our statement about the different seasonal cycles (page 5 line 14) only refers to the pure nonlinear TDT, not to the total TDT (which could be compared to observations). The reason is most likely based on the different tidal forcing mechanisms, but also on different methods to determine the nonlinear TDT contribution. For example, Smith and Ortland (2001) used a model with explicit lower boundary forcing of the diurnal (DT) and semidiurnal tides (SDT), while all tides in MUAM are forced in-situ by absorption of solar radiation without lower boundary forcing. The latitudinal

C2

distribution of the tides by Smith and Ortland (2001) is therefore already prescribed to a certain degree and possible nonlinear interactions may appear at different latitudes and altitudes than in our model.

For Fig. 1, the altitude of 109km was chosen to be able to compare the REF results with satellite measurements which are not available further above. Below that altitude, MUAM produces relatively small amplitudes which might be connected with large uncertainties. Therefore, we think that 109km is the best choice as a compromise between large amplitudes and comparability. Note, however, that according to the suggestions of reviewer #1 we will not show this figure in the final revised version, as it shows similar results as already presented in Lilienthal et al. (2018).

"4. Figure 3 and Page 7 Line 4: ". . . in the forcing locally amounts to +500% . . . and to . . . +1800% . . .". The +500% and +1800% cannot be tell in Figure 3b and Figure 3h, although you have demonstrated the maximum and minimum values. You can add some red contours with the exact contour values in Figure 3 especially in Figure 3 (b, d, f, and h)."

Thank you for the suggestion, we will provide an updated version of the figure.

"5. You can simply illustrate the limit of the standard deviations. Only the interval of the standard deviations in Figures 1, 2, and 4 can not demonstrate the exact values."

In an updated version of the figures, we will also provide the maximum values of the standard deviations and amplitude differences (contour lines) in each figure panel.

"6. Page 7 Line 30: ". . .becomes instable for some months." The results of which months in Figure 6 are unstable?"

For the months June, July and August, Figure 6c and 6d do not show any data for an enhancement factor of 1.10. These are the simulations that became unstable. We will add a brief note in the revised version.

"Problems in figures and grammatical suggestions:

C3

Figure 3: Figure description and titles of the Figure 3 are inconsistent. For example: 1. "July" in the figure description; "Jan and Apr" for the titles of Figure 3 2. "Zonal drag" due to GW-tide interactions in the figure description, "Zon. Acc." in the titles of Figure 3 3. a-h is not noted in Figure 3. There are similar problems in Figures 4, 5, 6."

We double checked all figures for the correct descriptions and included the a,b,c,... labels.

"Figures 6 and 7: 1. What's the difference of the vertical mean and global mean? The results of which latitude are demonstrated in Figures 6 and 7."

Figure 6 shows the horizontal mean (over all latitudes/longitudes) vertical mean (80-160km) amplitudes of the TDT. Figure 7 presents the horizontal and vertical mean of zonal mean wind/temperature differences, respectively.

"2. You can add some descriptions about the "factor of fgw" in the manuscript."

We will add a more precise description of that in the revised manuscript.

"Page 1 Line 4: "Scondar y sources" -> "Scondary sources" Page 1 Line 15: "the internal gravity waves (GW)" -> "the internal gravity waves (GWs)" Page 1 Line 16: "orography"->"geography" Page 2 Line 15: "be subject of" -> "be subject to"? Page 3 Line 18: "as described above" -> "as described in section 1" Page 4 Line 25 "rREF" -> "REF"; "maximums" -> "maxima" Page 5 Line 6: You presented the results at 109 km which can not represent the whole middle atmosphere. Thus, "in the middle atmosphere" is not exact in this sentence. Page 5 Line 6: "So the midlatitude" -> "For example, the midlatitude" Page 7 Line 25: "the respective slopes are given in the legend." -> "the respective slopes (s) are given in the legend.""

Thank you very much for all these technical corrections to improve the language. They will be addressed in the revised manuscript version.

2019.

C5