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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Forcing Mechanisms of the Terdiurnal Tide" *by* Friederike Lilienthal et al.

Anonymous Referee #1

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General Comment

The paper "Forcing Mechanisms of the Terdiurnal Tide" by Lilienthal et al. investigates the forcing of the migrating terdiurnal tide (TDT), a tidal mode that is still not well understood. Several model simulations with the nonlinear Middle and Upper Atmosphere Model (MUAM) are carried out to isolate the effect of different forcing mechanisms: absorption of solar radiation, nonlinear tidal interactions, and the interaction between gravity waves and tides. It is found that direct solar forcing is the dominant process, but also the other processes contribute. Interestingly, the nonlinear forcings can counteract the direct forcing and lead to reduced tidal amplitudes.

Overall, the paper is well written, and it provides very interesting results. Therefore, publication in ACP is recommended after addressing my minor comments.

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Discussion paper

My main comment is:

From the manuscript, it was not completely clear to me whether removing of forcings would alter the atmospheric background and whether an altered background could have some effect on the TDT in addition to changes in the forcing.

Please find more detailed specific and technical comments below.

Specific Comments

1. p.2, l.7/8:
   Miyahara and Forbes (1991) used a modified Lindzen parameterization to investigate the interaction between gravity waves and tides. In this approach gravity wave physics was very simplified. It should be mentioned that more recent simulations show that details of gravity-wave tidal interactions can change if more comprehensive physics is included (for example, Ribstein and Achatz, 2016).

   Ribstein, B., and U. Achatz (2016), The interaction between gravity waves and solar tides in a linear tidal model with a 4-D ray-tracing gravity-wave parameterization, J. Geophys. Res. Space Physics, 121, 8936-8950, doi:10.1002/2016JA022478.

2. p.3, l.9/10: Please explain in more detail:
   Why do you want to avoid the coupling between stationary planetary waves and tides?

3. p.3, l.11:
   Which gravity wave parameterization is used in your simulations?

4. p.3, l.27:
   The statement "The last source might be gravity waves" sounds too weak!

There is evidence for the interaction between gravity waves and tides. For example, on p.3, l.28, it could be mentioned that, indeed, a longitudinal variation of gravity wave activity in the tropical MLT region has been observed that may be caused by an interaction between tides and gravity waves (Trinh et al., 2018, their Fig.4).

Citation: Trinh, Q. T., Ern, M., Doornbos, E., Preusse, P., and Riese, M.: Satellite observations of middle atmosphere–thermosphere vertical coupling by gravity waves, Ann. Geophys., 36, 425-444, https://doi.org/10.5194/angeo-36-425-2018, 2018.

5. p.3, l.34:
   Latent heat release in the troposphere has a zonal wavenumber 3 structure. Do you think that this latent heat release could contribute to the forcing of the migrating TDT as was speculated by Pancheva et al. (2013)?

6. p.4, l.2: Please clarify!
   I think that eliminating each forcing separately is a good approach! However, does eliminating of forcings alter the atmospheric background state? If it does: How do you avoid that changes in the background state cause some variations in the TDT that are then attributed to changes in the forcing mechanisms? Or are variations of the background state negligible compared to the effect of variations in the TDT forcing?

7. p.5, l.19/20:
   Please clarify whether the forcing at all zonal wavenumbers is “switched off” for the CTRL run.

8. p.6 about Figs. 2 and 3:
   Please explain: why are values scaled with the density factor? I think that unscaled values would be more intuitively related to TDT amplitudes in K or m/s.

9. p.9, l.28/29:
   Here you write that “The structure of this remaining tide is not completely irregular indicating that it is possibly not owing to noise.”

   Still, noise could be the driver of this tidal structure. Please note that even the numerical noise of a GCM dynamical core can cause “regular oscillations”. For example, it has been noted by Rind et al. (2014) that numerical noise can cause QBO-like oscillations in a model.

   Rind, D., J. Jonas, N. K. Balachandran, G. A. Schmidt, and J. Lean (2014), The QBO in two GISS global climate models: 1. Generation of the QBO, J. Geophys. Res. Atmos., 119, 8798-8824, doi:10.1002/2014JD021678.

Technical Comments

- p.1, l.17: suggestion for clarification:
  higher wavenumbers → higher wavenumbers / higher frequencies
- p.2, l.19: have been → were
- p.3, l.33: owing to → excited by
- p.5, l.14:
  attributes the thermosphere → takes effect in the thermosphere
- p.5, l.25: ensembles = years ?
- p.7, l.23: is smaller. → is lower.

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