Point-to-point response to Reviewer 2:

Thank you very much for your careful review comments and corrections! I performed a moderate revision.

Your points are in bold face, *our response is in italic font style*, the changed text is in a normal font style.

1) Line 43-48 - The manuscript refers to the (2,2) and (2,4) modes of the lunar tide, but these are not really defined for the reader. Since the later interpretation of the phase profiles also relies on this terminology, a brief explanation of what these mode labels mean and why they are relevant here would help the reader follow the later discussion.

I agree and I add an explanation of the tidal wave mode (m,n).

(2,2) refers to the tidal wave mode (m,n) where m is the zonal wave number and n is the meridional mode number. The latitude structure is described by the Hough function with n−m internal nodes where the tidal amplitude is zero. The (2,2) mode is symmetric with a maximum of the tidal amplitude at the equator and a decrease of the amplitude towards the poles. While the (2,2) mode propagates vertically with a long wavelength of about 300km, the (2,4) mode has a shorter vertical wavelength.

2) Line 90 - The most important issue in the paper is the explanation of how the semidiurnal lunar M2 tide appears as a semi-monthly signature in Aura/MLS because of the sun-synchronous sampling. This is central to the interpretation of the entire analysis but is currently explained mostly qualitatively. Since the analysis relies on the 14.7653-day signal as the observational signature of M2, it would improve the paper if the authors could include a clearer explanation, or a short mathematical derivation, of this sampling/aliasing framework.

I agree and I added a formula for the aliasing frequency in Figure 1.

The aliasing frequency f_{alias} is defined as $f_{alias} = f_{tidal\ bulge} - f_{Aura}$. In the Sun-fixed coordinate system of Figure 1 the green line of the Aura orbit is fixed (no azimuthal rotation) so that $f_{Aura} = 0$. The frequency of the tidal bulge $f_{tidal\ bulge}$ in the Sun-fixed coordinate system is 2/(lunar month). Thus, the aliasing frequency is equal to 2/(lunar month). The corresponding aliasing period of the lunar tide in the Aura dataset is T_{alias} = (lunar month)/2 = 14.7653 days.

3) Line 104-105 - The text states "the arithmetic mean of all observed atmospheric profiles is computed" each day, but Aura samples

each latitude twice per orbit at two fixed local solar times (01:45 and 13:45 LST at the equator). This daily mean combines sampled from both Aura local-time branches. Since the two overpasses are separated by about 12 hours, this works for the semidiurnal tide because the two samples are nearly in phase for a 12.42-hour oscillation. Could the authors state this explicitly in the methodology, since this seems important for justifying the daily averaging procedure used to construct the time series?

I agree and I add an explanation. It is important that the lunar tide has a zonal wavenumber 2, so that the daily average of the noon and midnight profiles contain the full tidal signal.

The local time of the atmospheric profiles is either around noon or midnight. Since the lunar tide has a zonal wavenumber 2, the tidal bulges will appear similarly in both, in the atmospheric profile at noon and at midnight. Thus, the lunar tide is fully contained in the daily means of the selected atmospheric profiles.

4) Line 137 - 148 - Line 137 - 148 The manuscript does show January-versus-July variability for Aura/MLS at 82 km in Figure 7. However, the vertical-profile comparison with Geller (1970) in Figures 4 and 5 seems to be compared with the full-record Aura/MLS amplitudes, whereas the values from Geller are for January and July. Since the Aura/MLS data also show a pronounced January-July difference in Figure 7, it would help if the authors could clarify how the full-record Aura/MLS amplitudes in Figures 4 and 5 should be compared with the January and July values from Geller (1970).

Yes, I should add a sentence which explains the imperfectness of the comparison.

I assumed here that the mean of the January and July value of the z amplitude from [1] can be roughly compared to the annual mean of the z amplitude from Aura/MLS.

5) Line 172-179 and 206-215 - Figures 8 and 9 show enhanced amplitudes at high latitudes in winter, and the discussion relates this to radar observations and possible SSW-related amplification. At the same time, the manuscript also states that contamination by planetary wave-like oscillations cannot be excluded. Could the authors comment on how much contamination from other variability is expected at high latitudes in winter, and whether the signal seen at high latitudes in Figure 9 can still be confidently interpreted as a lunar tide signature?

I have not the experience to make an estimate of the contamination in Figure 9 from various sources. Generally, it seems to be a problem to retrieve tidal parameters at high latitudes from satellite observations. I am critical about the high values of the lunar tide at northern polar latitudes in winter (Figure 9) since the annual mean of the lunar tide (Figure 8) only shows small values of about 15m for the lunar tide at northern polar latitudes. I will mention this uncertainty of Figure 9.

In addition, the annual mean of the lunar tide in Figure 8 is just around 15m at northern polar latitudes. This seems to be not consistent with the large tidal amplitude values (up to 148m) at northern polar latitudes in winter in Figure 9. The retrieval of the annual mean of the lunar tide is certainly more reliable than the retrieval of the monthly means of the lunar tide, since the lunar tide signal can be better separated from atmospheric noise in case of the FFT of the whole time series (Figure 8).

6) Line 74 - The authors mention the vertical range of the atmospheric profiles between 15 to 95 km and then note on line 86 that 'The temperature and geopotential height values beyond 90 km altitude are less reliable'. However, it is not explicitly whether the analysis will be limited below 90 km. The vertical profiles in Figures 4 and 6 appear to slightly extend over 90 km, and the text describes the upper limit for these figures at 90.4 km. A simple line stating the altitude or pressure range used in the analysis will improve the clarity for the reader.

Yes, I see this weakness in the vertical range description. I removed the sentence " .... beyond 90 km less reliable" since I have no indication for this statement.

7) Line 77 - Could the authors briefly explain how the interpolation errors would affect the analysis or results? i.e. would the method used here affect the retrieved amplitudes and phases?

I think an explanation is not necessary since the data were not interpolated to fixed height levels. Other studies show that such an interpolation is feasible, that means, the error is possibly small.

8) Line 177 - Please provide citations for the "numerous reports"

This result is in agreement with numerous reports on the lunar tide and the geomagnetic lunar tide which is stronger in January than in July [2, 3, 4, 5, 6, 7].

Thank you for your careful review which improved the manuscript (and also for detection of typos).

References

[1] Geller, M.A. An Investigation of the Lunar Semidiurnal Tide in the Atmosphere. *Journal of Atmospheric Sciences* **1970**, *27*, 202 – 218. https://doi.org/10.1175/1520-0469(1970)027<0202:AIOTLS>2.0.CO;2.

[2] Bartels, J.; Johnston, H.F. Geomagnetic tides in horizontal intensity at Huancayo. *Terrestrial Magnetism and Atmospheric Electricity* **1940**, *45*, 269–308. https://doi.org/10.1029/TE045i003p00269.

[3] Hocke, K.; Ma, G. Big L Days in GNSS TEC Data. *Atmosphere* **2025**, *16*. https://doi.org/10.3390/atmos16101191.

[4] Yamazaki, Y. Large lunar tidal effects in the equatorial electrojet during northern winter and its relation to stratospheric sudden warming events. *Journal of Geophysical Research: Space Physics* **2013**, *118*, 7268–7271, [https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2013JA019215]. https://doi.org/https://doi.org/10.1002/2013JA019215.

[5] Forbes, J.M.; Zhang, X. Lunar tide amplification during the January 2009 stratosphere warming event: Observations and theory. *Journal of Geophysical Research: Space Physics* **2012**, *117*. https://doi.org/10.1029/2012JA017963.

[6] Pedatella, N.M.; Richmond, A.D.; Maute, A.; Liu, H.L. Impact of semidiurnal tidal variability during SSWs on the mean state of the ionosphere and thermosphere. *Journal of Geophysical Research: Space Physics* **2016**, *121*, 8077–8088, [https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2016JA022910]. https://doi.org/https://doi.org/10.1002/2016JA022910.

[7] Conte, J.F.; Chau, J.L.; Peters, D.H.W. Middle- and High-Latitude Mesosphere and Lower Thermosphere Mean Winds and Tides in Response to Strong Polar-Night Jet Oscillations. *Journal of Geophysical Research: Atmospheres* **2019**, *124*, 9262–9276, [https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2019JD030828]. https://doi.org/https://doi.org/10.1029/2019JD030828.