28/10/2024

We would like to express our gratitude to our editor for giving valuable comments. We appreciate your tireless efforts in reviewing our manuscript, which has allowed us to improve the quality of our article.

Here we have revised the manuscript to correct wording, spelling, and such errors in addition to those of the requested inquiries from the editor.

1. **Editor**: Please, provide a proper revision to the comment of Referee #2, i.e.: "How the GWs potential energy is connected to the MILs? First establish the connection by showing a single case in which a physical connection should be clear and then go for the statistics."

Response: Thank you for your thoughtful question. We have addressed it in lines 350–370 as follows:

“In the MLT atmospheric region, gravity wave breaking typically dissipates their potential and kinetic energy, leading to increased turbulence and mixing. As illustrated, gravity wave propagation and dissipation are major forces in the MLT (Lindzen, 1981; Holton, 1983), influencing the middle and upper atmospheric regions. This has a substantial impact on the overall dynamics as well as the MLT's thermal structure, particularly the increase in temperature variability with elevation, known as inversion. Holton et al. (2003) and Holton and Hakim (2013) has demonstrated an interaction between the potential energy of gravity waves and inversions. This notable upper and lower inversion is observed in Figure 4 during the period 2005–2020 over the low-latitude regions. During this period, particularly for the upper-MLT region above 80 km altitude, high-resolution SABER satellite temperature data revealed the presence of a strong mesospheric inversion layer (MIL), with peak occurrence rates ranging between 60% and 78%, especially during 2010, 2014, 2016/17, and 2018/19, Figure 4a. Correspondingly, at the same time and in the same region (upper-MLT), at altitudes of 85 and 90 km, there is a noticeable increase in gravity wave potential energy (Ep), shown in Figure 11. The maximum potential energy (PE) for the upper-MLT region corresponds to the breaking or dissipation of gravity waves as they propagate upward. This spike in potential energy coincides with the occurrence of the inversion layer, suggesting that the breaking or dissipation of gravity waves releases energy into the atmosphere, contributing to localize heating in the mesosphere and leading to the formation of the inversion. The sudden transfer of momentum and energy from the breaking GWs to the surrounding atmosphere disrupts the thermal structure, causing the temperature inversion. In this case, the temporal and spatial coincidence between the peak in gravity wave potential energy and the formation of the inversion demonstrates a clear physical connection. The energy released from breaking GWs plays a direct role in the creation of the inversion layer, as shown in Figures 4 and 11. Similarly, the statistical distributions of upper-

MLT inversions in Figure 5(a) show maximum amplitudes, which correspond to the maximum potential energy of gravity waves in Figure 11(a & b). This provides a straightforward demonstration of how gravity wave dynamics-specifically, the dissipation of their potential energy-are linked to the formation of mesospheric inversion layers (MILs)."

2. **Editor:** Additionally, the concern of Referee #3 is that: the blue line in Figure 10 is not a high-pass filter, because the high frequencies have been suppressed.

Response: Thank you very much for your kind question. We are presented as follows in lines from 339-342;

"The blue curve data in Figure 10 (a to d) appears smoother after applying the high-pass filter to the perturbed temperature. However, the filter removes the peaks of low-frequency variations, resulting in retained perturbed temperature values that appear more uniform, creating a smooth plateau effect."