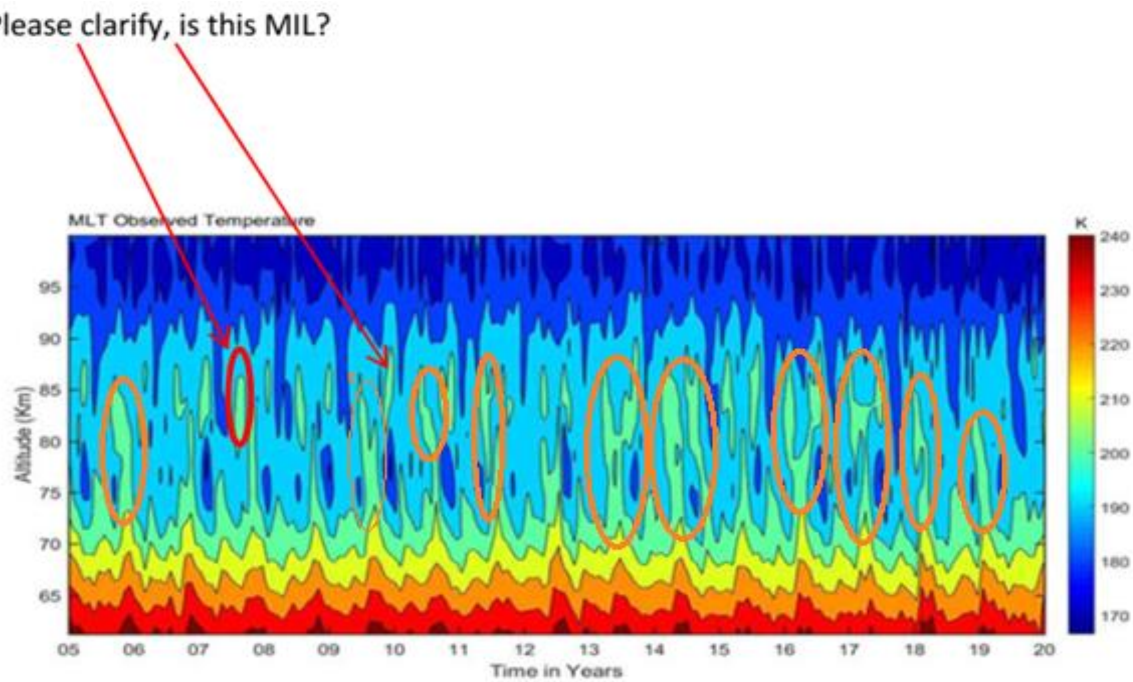
We would like to express our gratitude for the valuable feedback from the referee. We appreciate your tireless efforts in reviewing our manuscript, which has allowed us to improve the quality of our article.

**Referee # 1**

1.




Response: Thank you. As indicated in the figure, the inversions are described in lines 100-107 of the manuscripts as follows.

"We utilized SABER vertical temperature profiles taken within the 60–100 km altitude range. These profiles cover the period from 2005 to 2020, spanning latitudes from 3°N to 15°N and longitudes from 33°E to 48°E. Figure 1 shows the monthly mean of SABER temperature data for the mesosphere and lower thermosphere. The data aim to illustrate the MLT temperature variability, which helps us identify the inversion layers (MIL). The monthly mean temperatures in the MLT region show a maximum of 200-240 K at altitudes of 60-70 km. Then it decreases to around 160-180 K at 95-100 km throughout the entire period. While the temperature patterns in the 70-90 km altitude range suggest an inversion, these inversions are not visible."

2. I already recommended making Figure 3 clear and understandable. How should I understand it? Everything is in black lines and motley spots. How to evaluate the heights that you give in the description? How to understand where there is a temperature inversion day and where there is not? Please remove the black outline and leave just the fill.

Response: We thank you for your comment and suggestion. We acknowledge that it is challenging to precisely identify the inversions in Figure 3. However, we can infer the maximum inversion day temperatures of 220 K and 225 K from the bars in Figures 3(b) and 3(d) for the upper and lower MLT regions, respectively, relative to the observed temperatures in Figures 3(a) and 3(c) based on the bars in the contour plot. The left vertical panel of Figures 3(a) and 3(b) represents the observed and inversion day temperatures for the upper-MLT regions, while the right vertical panel of Figures 3(c) and 3(d) shows the observed and inversion day temperatures for the lower-MLT regions. We attempted various approaches to modify the plot, but it still does not display any other new results.

3. You are considering MIL over 3-15$^0$ N latitude and 33-48$^0$ E longitude regions. Why did you choose this region? Write a few words about this. It's better to put the coordinates of the area in the title, otherwise, it seems that you are doing research overall at low latitudes. As a last resort, add it to the abstract on line 17.

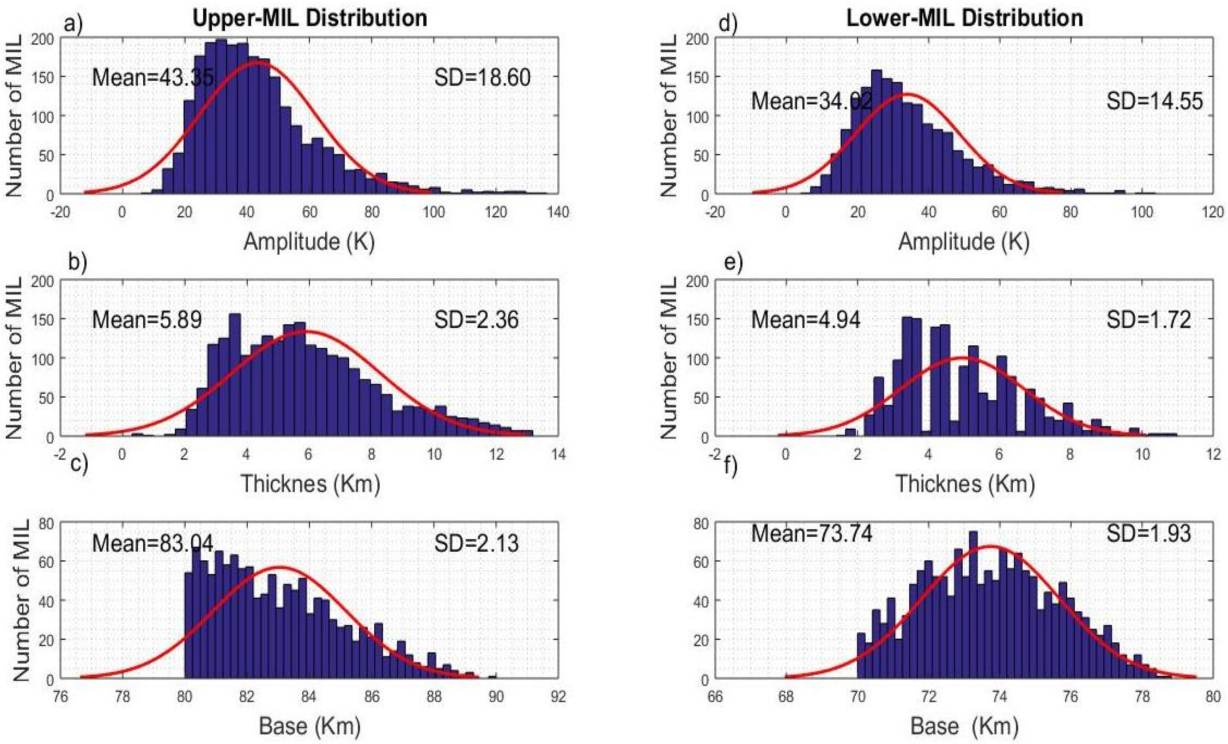
   Response: Thank you for your comments. The selected latitude and longitude range covers diverse climatic zones and geographical features, making it relevant for studying gravity waves due to the region's topography and atmospheric conditions. Gravity waves can be generated by features such as mountains and coastlines, which are prominent in this area. The varied topography and weather patterns create ideal conditions for examining atmospheric instability and potential energy, which are crucial for understanding weather extremes and improving prediction models.

4. I didn't understand your idea, what does «….seasonal variations of MIL in the planetary waves as a causative over low-latitudes using the SABER observations» mean? And there is a typo "causative".

   Response: Thank you. The manuscript has been corrected by removing the sentences.

5. And now in Figures 5(c) and 5(f) the averages are on top of the bars. Please, correct it.

   Response: Thank you. It is the corrected figure based on your recommendation.




6. The last conclusion sounds strange and vague - « In general, we concluded that the processes in the atmosphere vary from region to region. As a result, the atmospheric state varies significantly with altitude as well as from place to place and time to time»; I guess that this conclusion should be removed.

   Response: Thank you. I removed that one sentence based on the recommendations

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**Referee #2**

2B). There are various sources proposed as the causative mechanism of the lower and upper MILs. For example, the planetary waves are believed to be the causative mechanism of lower MILs similarly, gravity waves, tidal interactions, and chemical heating are proposed as a cause of upper MILs. These points are not considered and there is no reason why the authors only focus on the GWs. It is well understood that in most cases the GWs breaking in the mesosphere can cause only very few Kelvin temperature changes (>10K). If this is the scenario it cannot explain the higher amplitude MILs. Comment on it.

Response: The focus on gravity waves (GWs) in the study of mesosphere inversion layers (MILs) can be attributed to several reasons:

1. Gravity waves are ubiquitous in the atmosphere and play a significant role in the dynamics of the mesosphere. They are generated by various sources, such as topography, convection, and weather systems, and can propagate vertically, transporting energy and momentum from the lower to the upper atmosphere.
2. Gravity waves interact with the mesosphere more directly and frequently than other atmospheric waves. Their breaking and dissipation in the mesosphere can lead to temperature changes and influence the formation of inversion layers.
3. Gravity waves are relatively well-characterized in atmospheric models and simulations. Their effects can be parameterized with reasonable accuracy, allowing researchers to predict their impact on temperature and wind patterns in the mesosphere.
4. There is a substantial amount of observational data and research focusing on the impact of gravity waves on the mesosphere. This extensive body of work provides a solid foundation for understanding their role in atmospheric processes, making them a natural focus for studies on MILs.
5. While gravity waves generally cause temperature changes of a few Kelvin, they are more frequent and widespread compared to planetary waves and tidal interactions. This makes them a significant factor in the overall temperature variability in the mesosphere. However, it is important to note that focusing solely on gravity waves may overlook other important mechanisms, such as planetary waves, tidal interactions, and chemical heating, which also

contribute to the formation and variability of MILs. A comprehensive approach that includes all potential factors provides a more complete understanding of the complex dynamics in the mesosphere. Hence, we will consider it in future work.

3. As mentioned in comment 1, the authors should provide longitudinal information, because this has an important role if they try to understand the role of GWs which are highly localized in nature. It is not clear how the 1hr cutoff frequency applies to the data, if the authors used a particular region then in a day maximum of two to three satellite passes can be observed based on the area, with this limited data set how effective or logical is the 1hr band pass filter?

Response: Thank you for your recommendation. The latitudinal and longitudinal information is mentioned throughout the manuscripts, as I mentioned before. Using a 1-hour interval of high pass band filter on the data from SABER observations is possible. Hence, TIMED/SABER observations can access 1440 data points per day. It is not necessary to have two or more satellites to use the 1-hour interval band-pass filter.

11. How the GW 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. We have detailed their connections in the introduction and result section, specifically in lines 49–61, and 363-373 respectively as follows:

"Gravity waves and mesospheric inversion layers (MILs) are interconnected phenomena within the Earth's atmosphere, particularly in the mesosphere and lower thermosphere. MILs are layers within the mesosphere where the temperature profile shows an inversion. This means the temperature increases with altitude, contrary to the typical decrease. These inversion layers often form due to dynamic processes, including the breaking and dissipation of gravity waves. As gravity waves propagate upwards, they can grow in amplitude because the atmospheric density decreases with altitude. When these waves reach a critical amplitude, they become unstable and break. This breaking process releases energy and momentum into the surrounding air, causing localized heating. The energy dissipation from breaking gravity waves causes localized heating. This heating can create or enhance mesospheric inversion layers by increasing the temperature at certain altitudes. The breaking of gravity waves can also generate turbulence, which further influences the structure and stability of inversion layers. This process also contributes to momentum and energy deposition."

"Gravity wave breaking in the upper atmosphere usually leads to more turbulence and mixing. As gravity waves rise and break, they transform their potential and kinetic energy into turbulent energy. This process increases vertical mixing and transports momentum. This energy transfer can change thermal patterns and affect the overall dynamics of the upper atmosphere. Interestingly, the dissipation of gravity waves can lead to localized warming or the formation of mesospheric inversion layers (MILs). This is especially important in the upper mesosphere and lower thermosphere, where wave breaking can significantly impact the thermal structure. Gravity wave propagation and dissipation are major forces in the MLT region (Lindzen, 1981; Holton, 1983), influencing middle and upper atmospheric inversion. In a nutshell, gravity wave breaking and the dissipation of energy and momentum are key players in both the upper and lower atmospheres, affecting turbulence, circulation patterns, temperature, density, and weather systems."

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**Referee# 3**

**Q1) Points 1 and 2. Please include the manuscript the explanations of Figures 1 and 2 according to their responses:**

Response: Thank you. Based on the recommendation for the response of questions 1 and 2 with modifications are presented by yellow shadow on the manuscript in lines (100-107) for figure 1 and in lines (191-215) for figure 3 respectively as follows.

1. For example, Figure 1 shows the variability of the temperature in the mesosphere and lower thermosphere (MLT), what is the objective of it? Is it possible to see MILs, where? If not, why is it not possible to see? In summary, how can Figure 1 help the authors?

   Response: Thank you. We can see on the manuscripts from lines 100-107.

   "We utilized SABER vertical temperature profiles taken within the 60–100 km altitude range. These profiles cover the period from 2005 to 2020, spanning latitudes from 3°N to 15°N and longitudes from 33°E to 48°E. Figure 1 shows the monthly mean of SABER temperature data for the mesosphere and lower thermosphere. The data aim to illustrate the MLT temperature variability, which helps us identify the inversion layers (MIL). The monthly mean temperatures in the MLT region show a maximum of 200-240 K at altitudes of 60-70 km. Then it decreases to around 160-180 K at 95-100 km throughout the entire period. While the temperature patterns in the 70-90 km altitude range suggest an inversion, these inversions are not visible."

2. Figure 3 shows upper (left) and lower (right) MILs, to be sincere, I did not understand the bottom panels. May the authors explain them better? I also suggest enlarging captions and the size of the panels.

   Response: Thank you. I have corrected all in lines (187-211).

   Daily SABER temperature profiles, covering altitudes of 60–100 km from 2005 to 2020, are shown in the contour plots of Figure 3. Figures 3 (a and b) depict the upper mesosphere, while Figures 3 (c and d) show the lower mesosphere. The horizontal panels of Figures 3 (a) and 3 (c) show observed temperatures ranging from approximately 180–220 K, before accounting for inversion layers. The horizontal panels of Figures 3 (b) and 3 (d) show inversion day temperatures, ranging from 180–225 K. These inversion day temperatures are higher than those shown in Figures 3 (a) and 3 (c). This indicates that maximum temperatures occur on inversion days in both the upper and lower MLT regions.

"The upper left panel of Figure 3(a) shows the observed temperature in the upper mesosphere. It ranges from approximately 180–205 K at altitudes of around 80–90 km. The upper right panel of Figure 3(c) shows the lower mesosphere, with temperatures ranging from about 180–220 K at altitudes of approximately 70–80 km. In contrast, the lower left panel of Figure 3(b) shows an upper-mesosphere inversion day temperature. It ranges from 180–220 K at an altitude of approximately 80–90 km. The lower right panel of Figure 3(d) shows a lower-mesosphere inversion day temperature. It ranges from 180–225 K at an altitude of approximately 70–80 km. These inversion day temperatures in Figures 3(b) and 3(d) suggest a temperature gradient shifting from negative to positive. This could be due to factors such as atmospheric gravity waves, chemical reactions, or solar radiation. Our temperature observations for the lower MLT region on an inversion day, within the altitudinal range of 70–80 km, align with those reported by Sivakumar et al. (2001). They identified inversion day temperature variability in the altitudinal range of 73–79 km. Additionally, Sivakandan et al. (2014) examined mesospheric inversions in the 60–105 km altitude range over low-latitude regions. Their findings closely match our results."

**Q2) <u>Please revise point 7 again. Pay attention to the main concern that I have pointed out.</u>**

7. Section 3.4: The authors wrote that they used a low pass filter to exclude the effects of tidal and planetary waves in the residual signal. If I understood the process, I guess they could use high-frequency filters to maintain low periods. Indeed, the blue lines in Figure 10 show a smoothed signal that excludes short-time variations. If I am correct, Figures 11 and 12 could be revised and the interpretations as well.

Response: Thank you for the correction. We employed a 1-hour interval high-pass band filter, as depicted in Figure 10, to remove low-frequency signals by eliminating peaks. This method was applied to perturbed temperature data profiles, effectively filtering out variations longer than 1 hour. The results discussed in Figures 11 and 12 have been revised accordingly.