Review of MS. MS No.: EGUSPHERE-2025-6531

Title: Estimation of nocturnal boundary layer height in the central Amazon, supported by gas concentration profiles

Response (blue color) to anonymous **Referee #1** (black). The original manuscript was changed accordingly. Please note that all line numbers indicated in our responses refer to the tracked-changes version of the revised manuscript.

General comments

This manuscript addresses a timely and potentially interesting topic of the dynamics of the nocturnal boundary layer and the impact on the gas concentration profiles in a remote location of the Amazonia. The meteorological and atmospheric composition data is very comprehensive. However, the analysis and interpretation remain largely descriptive and do not sufficiently engage with the underlying physical mechanisms or relevant observational and theoretical studies. Substantial additional work would be required to strengthen the physical interpretation of the dynamics of the Amazonian Nocturnal Boundary Layer (ANBL) and fully exploit the observations. Given the extent of revisions needed, we recommend rejection at this stage, with the encouragement that the authors resubmit a thoroughly revised manuscript after deeper physical and observational analysis. In the following, we provide several points where the analysis could be further elaborated to establish clearer physical causality.

We thank Reviewer#1 for their constructive comments. We have carefully revised the manuscript (MS) and incorporated substantial additional analyses addressing the key points raised by the Reviewer. These include a more explicit treatment of the physical mechanisms controlling the nocturnal boundary layer, an extended climatological context, and a clearer quantification of the main drivers of ANBL variability. We believe that these additions significantly improve the robustness of the results and the physical interpretation, and that the actual revised manuscript addresses the concerns raised by the Reviewer. Below, we respond to each comment in detail and describe the corresponding changes implemented in the revised version of the MS. The line numbers referenced here are based on the revised version.

Specific comments

1. The study could benefit from an extended climatology of the stability of the ANBL. Based on only one La Nina year (2022) and one El Nino year (2023) it is hard to explain which part of the variability can be attributed to the ENSO and which part to the annual variability. With an elaborate description of the yearly variation, the ENSO effect could be clearly quantified.

We thank the Reviewer for their important comment. We agree that an extended climatology of ANBL stability is necessary to place the 2022 and 2023 results in the context of the background interannual variability. At the same time, we would like to clarify an observational limitation of the dataset. The full vertical profile of sonic anemometers up to 325 m at Amazon Tall Tower Observatory (ATTO) became operational only in August 2021. Therefore, reliable estimates of the nocturnal boundary-layer height (hn) are only available from 2022 onward. Although 2024 could provide an additional year of hn estimates, this year was also affected by the aftermath of the 2023 El Niño and cannot be treated as an independent climatological reference (Souza et al., 2024).

To address this limitation, we added an extended climatological analysis based on variables available over a longer period and directly linked to ANBL variability: nocturnal net radiation (Rn) and the atmospheric stability parameter (z/L). These variables provide important information about nocturnal radiative cooling and the atmospheric stability, both of which strongly influence ANBL behavior. This climatology was calculated for the 2016–2024 period using the same nighttime interval adopted throughout the manuscript (00:00–09:00 UTC).

Figure 1 (of this document) shows that the dry season is generally characterized by higher negative net radiation values, consistent with stronger nocturnal radiative cooling, and by larger z/L values, indicating more stable conditions. The year 2023 shows z/L values above the climatological mean during most months, particularly from May onward, whereas 2022 remains generally closer to, or below, the climatological mean during several months. This additional analysis supports the interpretation that the shallower ANBL observed in 2023 was associated with enhanced nocturnal stability.

We included this discussion in the revised manuscript to place the analyzed years within the observed ATTO climatology context. Since radiative cooling and stability are relevant controls on nocturnal turbulence and ANBL structure, these deviations from the climatology can be associated to the observed differences in hn between 2022 and 2023.

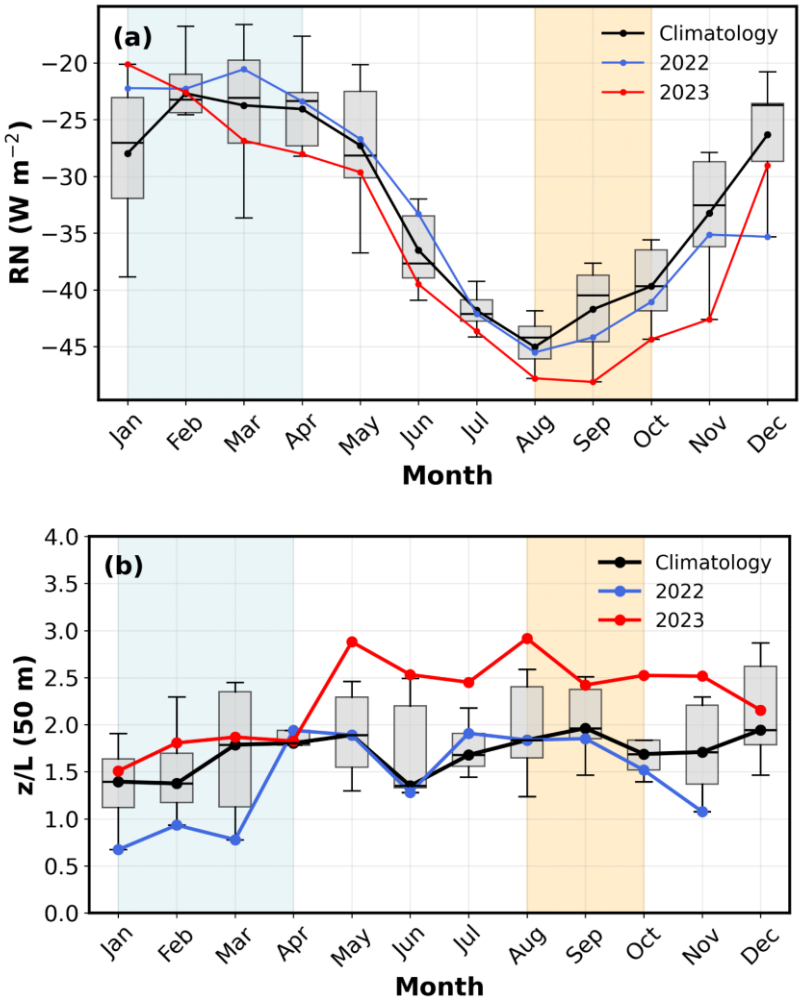

Figure 1 (Figure 3 in new version of the manuscript). Monthly mean of (a) net radiation (Rn) at 81 m and (b) stability parameter (z/L) at 50 m for the nighttime period (00:00–09:00 UTC). Grey boxplots represent the monthly climatological distribution for 2016—2024. Shaded blue and orange areas indicate the wet and dry seasons, respectively .

In the new version of the manuscript, it was added:

L 187- 195: To place the analyzed years in a broader climatological context, Figure 3 shows the monthly nocturnal climatology of Rn and z/L for the 2016–2024 period, using the same nighttime interval adopted in this study (00:00–09:00 UTC). The climatology highlights a clear seasonal cycle, with stronger nocturnal radiative cooling during the dry season associated with

higher z/L values and therefore more stable atmospheric conditions. In 2023, z/L values were higher than the climatological mean during most months, especially from May onward, whereas 2022 remained closer to, or below, the climatological mean values. These departures from the ATTO climatology indicate that the two analyzed years experienced distinct nocturnal radiative cooling and stability conditions. Since Rn and z/L are relevant controls on turbulence intensity and the vertical structure of the nocturnal boundary layer, these differences may be related to the contrasting hn behavior observed in 2022 and 2023 (discussed in section 3.2).

2. In relation to this a clearer identification and quantification of the main drivers would substantially strengthen the manuscript. For example, Figure 2 of this document presents longwave radiative cooling, but its role in enhancing nocturnal stratification is not sufficiently discussed. Further elaboration on how radiative cooling contributes to the stability of the nocturnal boundary layer would be valuable. Similarly, in lines 200–205, the manuscript discusses shear associated with changes in wind direction, which is a well-known mechanism for turbulence generation. Quantifying the magnitude of this shear using the available observations, and assessing its relative importance in sustaining turbulence and shaping the nocturnal boundary layer structure, would greatly improve the physical interpretation. We think here it can be convenient to connect and relate their findings with recent work of Mahrt and Acevedo (Boundary-layer Meteorology 187:141–161, 2023 and references therein).

We thank Reviewer #1 for this comment. To better quantify the main drivers of NBL evolution, we expanded the analysis of the two case-study nights showed in the previous version of the manuscript, including net radiation (Rn) at 81 m, cloud fraction (%), vertical profile of the potential temperature (θ), and vertical wind shear (dU/dz) for 18 and 25 August 2022 (Figure 2 of this document). To compute wind shear, third-order polynomial fits were applied to the wind speed profiles (U(z)), from which analytical vertical derivatives were calculated. Cloud cover was estimated from observations obtained by the Cloud Radar Profiler (METEK MIRA-35C) installed at the ATTO site. GOES-16 IR Channel 13 (10.3 μm) brightness temperature imagery was additionally used to illustrate cloud cover conditions during the two nights (Figures 3 and 4 of this document).

The night of 18 August 2022 represents a strongly stratified and more decoupled case compared to 25 August 2022. Strong radiative cooling (Fig. 2a), reduced cloud occurrence (Fig. 2c and Fig. 3), and a pronounced vertical potential temperature gradient (Fig. 2e), were associated with a shallow hn, mostly around 80–100 m. Despite the presence of wind shear at some levels, the strong thermal stratification suggests that mechanically generated turbulence aloft was not efficiently coupled downward to the layer near the canopy. This behavior is consistent with a layered nocturnal structure in which the shallow surface-based layer remains isolated from the air above, similar to the regime described by Mahrt and Acevedo (2023). In contrast, the night of 25 August 2022 showed larger cloud cover (Fig. 2d and Fig. 4), reduced radiative cooling during the early night (Fig. 2b), and weaker thermal stratification (Fig. 2f). Wind shear extended to higher levels (Fig. 2h), reaching approximately 150–170 m, close to h_N. This suggests that mechanical forcing contributed to sustaining turbulence over a deeper layer under weaker stratification. Therefore, the differences between those two nights are interpreted as the result of the balance between radiative cooling, which enhances thermal stratification and suppresses turbulence, and shear-generated mechanical turbulence, which can deepen or sustain the NBL when coupling is possible.

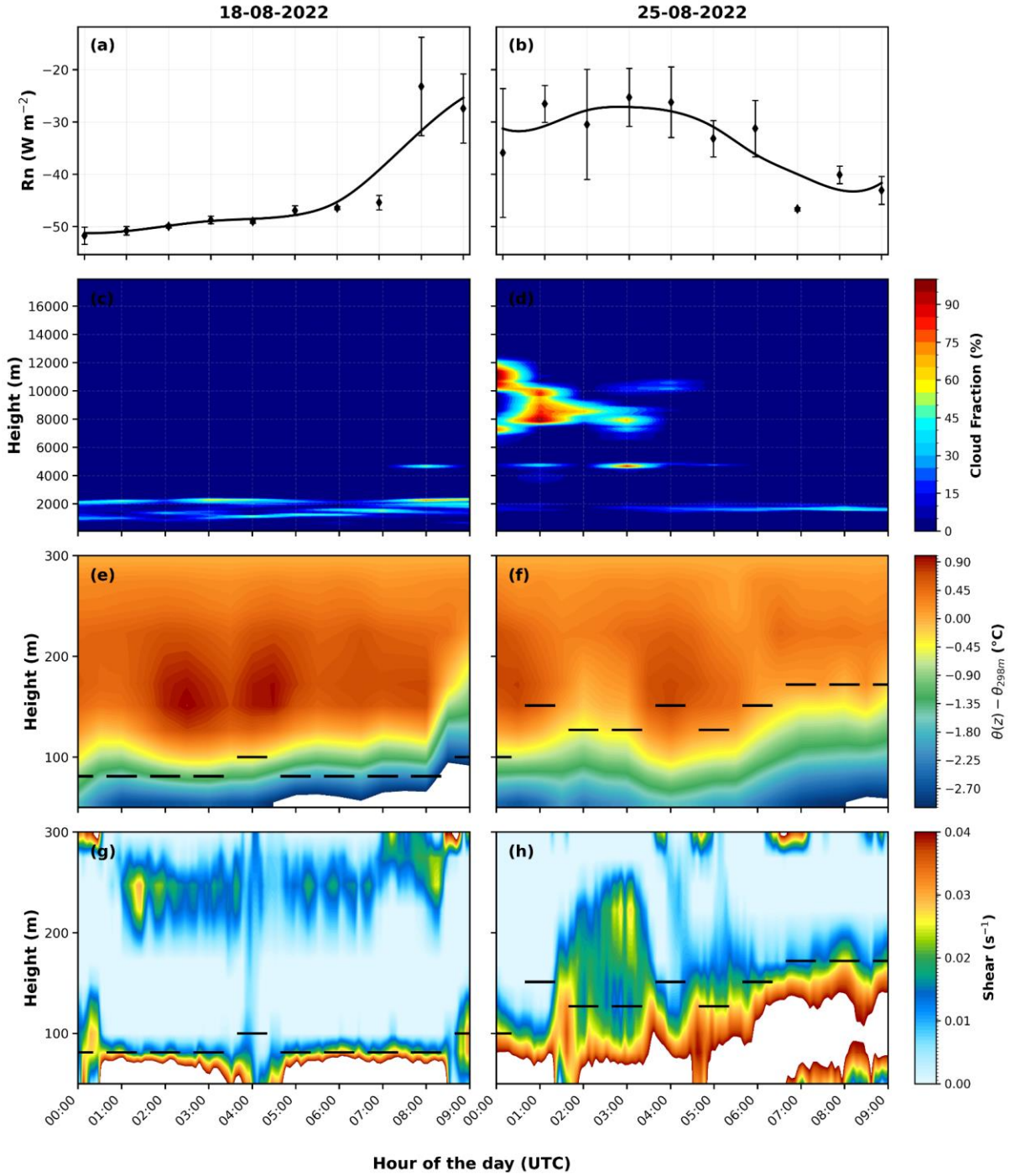

Figure 2 (Figure 9 in new version of the manuscript). Nocturnal evolution of (a, b) hourly mean net radiation (Rn) at 81 m (± standard deviation), (c, d) cloud fraction (%), (e, f) vertical potential temperature (θ) difference from the value observed at 298 m, and (g, h) vertical wind shear (dU/dz) during the case-study nights of 18 August 2022 (left panels) and 25 August 2022 (right panels). Black horizontal segments indicate the estimated nocturnal boundary layer height at each hour.

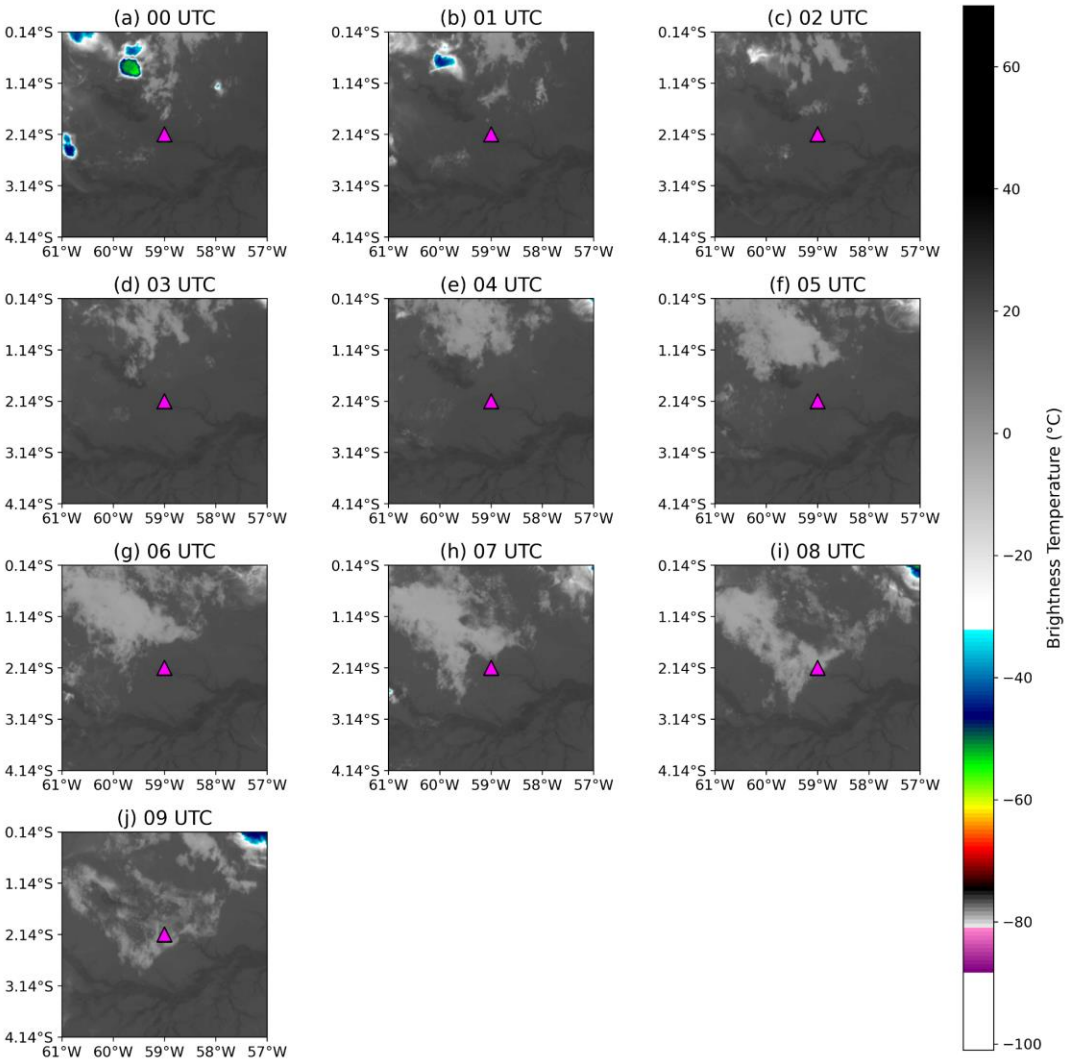

Figure 3 (Figure S2 in new version of the manuscript). GOES-16 IR Channel 13 (10.3 µm) brightness temperature over the ATTO site on 18 August 2022. Panels (a–j) show hourly images from 00 to 09 UTC. The magenta triangle marks the location of the ATTO tower.

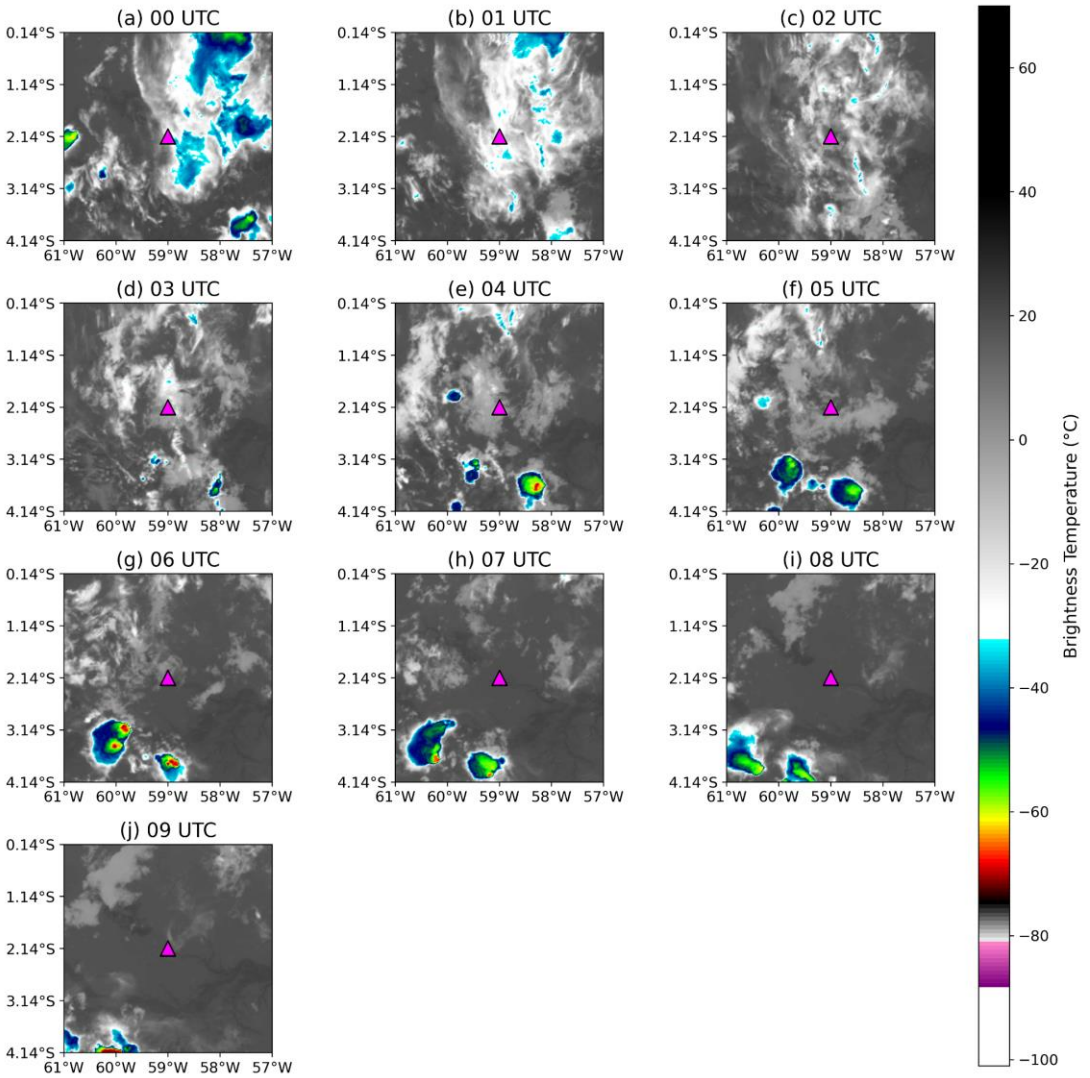

Figure 4 (Figure S3 in new version of the manuscript). GOES-16 IR Channel 13 (10.3 µm) brightness temperature over the ATTO site on 25 August 2022. Panels (a–j) show hourly images from 00 to 09 UTC. The magenta triangle marks the location of the ATTO tower.

We included this new analysis in Section 3.3 of the Results and in the new Discussion section of the revised manuscript.

In section 3.3

L239–253: To better identify the main drivers controlling the contrasting hn behavior during the two case-study nights, we further ana lyzed Rn at 81m, cloud cover,the vertical profile of θ and windshear (dU/dz) (Fig. 9). These variables provide complementary information on the local radiative forcing, cloud modulation of nocturnal cooling, thermal stratification, and mechanical turbulence generation. The night of 18 August 2022 was characterized by strong nocturnal radiative cooling (Fig. 9a), reduced cloud occurrence (Fig. 9c and Fig. S2), and a pronounced vertical potential temperature gradient (Figure 9e). These conditions indicate enhanced thermal stratification near the surface. Although wind shear was observed at some levels (Fig. 9g), the strong stratification suggests that mechanically generated turbulence aloft was not efficiently coupled downward toward the canopy. This supports the interpretation that the shallow hn observed on 18 August 2022 reflects not only strong thermal stratification, but also canopy-induced suppression of vertical mixing near the forest top. This configuration is consistent with a shallow surface-based nocturnal layer that remained partly decoupled from

the air above, similar to the layered nocturnal structure described by Mahrt and Acevedo (2023). In contrast, the night of 25 August 2022 showed larger cloud cover (Fig. 9d and Fig.S3), weaker radiative cooling during the early part of the night (Fig. 9b), and weaker thermal stratification (Fig. 9f). Wind shear extended to higher levels (Fig. 9h), reaching approximately 150–170 m, close to the observed hn. This suggests that, under weaker stratification, mechanically generated turbulence was more effectively coupled over a deeper layer, contributing to the larger and more variable hn observed during this night.

In section 4 - Discussion

L289-322: “The results presented here demonstrate that the nocturnal boundary-layer height (hn) above the central Amazon is strongly controlled by the interaction between nocturnal radiative cooling, atmospheric stability, cloud cover, and mechanically generated turbulence. Although previous Amazonian studies have primarily focused on the daytime evolution of the atmospheric boundary layer (Fisch et al., 2004; Carneiro and Fisch, 2020; Dias-Júnior et al., 2022), our results show that the nocturnal boundary layer also exhibits pronounced seasonal and interannual variability, with important implications for turbulence exchange and trace-gas transport above tropical forests.

One of the clearest patterns observed in this study is the systematic reduction of hn during the Dry season and during the El Niño year (2023). These periods were characterized by stronger nocturnal net radiative loss (Figure 2a) and enhanced atmospheric stability, reflected by larger z/L values (Figure 2b) and a stronger thermal gradient (Fig. S6b, d). Under these conditions, turbulent exchange becomes increasingly suppressed, limiting the upward transport of sensible heat and favoring the formation of shallower nocturnal layers (Figures 4d and 5b). In contrast, wetter conditions, particularly during the Wet season of 2022, were associated with weaker radiative cooling (Figure 2a), reduced stability (Figure 2b), Weak thermal gradient(Fig S6a, c), and deeper nocturnal layers (Figures 4a and 5a). These findings reinforce the strong coupling between cloud cover, nocturnal cooling, and turbulence generation over the Amazon rainforest.

The hourly evolution of hn also reveals the importance of the temporal evolution of thermal stratification during the night. In all analyzed periods, hn was generally larger at the beginning of the night and progressively decreased toward the early morning hours (Figure 5). This behavior is particularly evident during the Wet season of 2022, when the thermal gradient remained relatively weak during the first hours of the night (Figures 9e,f and S6a), allowing mechanically generated turbulence to sustain a deeper nocturnal boundary layer. As the night progressed, radiative cooling intensified the thermal gradients, suppressing turbulence and leading to a gradual collapse of hn. This progressive reduction of turbulent mixing throughout the night is consistent with the classical evolution of stable nocturnal boundary layers described in previous studies (Mahrt, 1999; Sun et al., 2002).

The results also demonstrate that the interaction between thermal stratification and mechanically generated turbulence is fundamental for understanding the nocturnal boundary-layer structure above the Amazon forest (Figure 9). The case studies revealed that low-level jets (LLJs) (Figure 7) and enhanced vertical wind shear (Figure 9 g,h) may sustain turbulence above the canopy, but the influence of this turbulence on the lower nocturnal boundary layer depends on the degree of vertical coupling between atmospheric layers. This interpretation is consistent with the conceptual framework proposed by Mahrt and Acevedo (2023), in which nocturnal boundary layers may deviate from a vertically monotonic structure and instead exhibit layered configurations composed of shallow surface-based layers, transition layers, and elevated turbulent regions.

Our observations suggest that the forest canopy plays a key role in reinforcing this layered structure. Under strongly stable conditions, the canopy acts as a roughness and drag layer that attenuates momentum transfer toward the surface. Consequently, turbulence generated

aloft by LLJs or strong wind shear may remain confined to elevated layers and may not efficiently penetrate downward through the canopy layer. This mechanism likely explains the shallow hn observed on 18 August 2022, when strong thermal stratification and weak vertical coupling produced a highly decoupled nocturnal structure. In contrast, on 25 August 2022, weaker thermal stratification allowed mechanically generated turbulence to penetrate deeper into the lower nocturnal boundary layer, resulting in larger and more vertically connected hn values.“

3. In the results, Figure 4, which presents the nocturnal boundary layer height under wet and dry conditions for 2022 and 2023, would benefit from further elaboration. While the results are interesting, the discussion remains largely descriptive. A deeper analysis is needed to explain the origin of the observed differences. In particular, it would be valuable to discuss which physical processes may drive these contrasts and whether they can be linked to other controlling variables. In particular the role of locally driven processes such as stability, turbulence, surface fluxes, or large-scale meteorological conditions, that influence the ANBL.

Our analyses indicate that the seasonal and interannual variability of the ANBL is strongly linked to the modulation of nocturnal radiative forcing by cloud cover. Wetter conditions, associated with increased cloudiness, reduce net longwave radiative loss at the surface, weakening near-surface cooling and limiting the development of strong thermal stratification. In contrast, clearer conditions during the dry season favor stronger radiative loss and a more stable nocturnal boundary layer.

These large-scale meteorological conditions directly influence the efficiency of local turbulent processes controlling hn. Under weaker stability, turbulence generated by wind shear can more effectively maintain vertical mixing and sustain a deeper nocturnal layer. Conversely, under strongly stable atmospheric conditions, turbulence is suppressed, vertical exchange becomes less efficient, and the ANBL remains shallower.

The case studies analyzed in response to Reviewer Comment (2) support this interpretation by showing that deeper hn values are associated with weaker stability and enhanced turbulent mixing, whereas shallower hn occurs during nights characterized by stronger thermal stratification. Based on these results, we interpret the deeper nocturnal layers observed during the wet season of 2022 as a consequence of reduced radiative cooling and weaker stability, while the shallower hn observed during the dry season of 2023 reflects enhanced radiative cooling and stronger suppression of turbulence. We revised the manuscript to make these physical links clearer in the Results and Discussion sections.

We have added a new discussion addressing this point in the revised version of the manuscript (lines 150–225 of this document).

4. In the same line, and perhaps to support their analysis, perhaps it is interesting to study if there are current formulations (representations) or other methods to estimate the NBL height that are able to reproduce the observational dynamic evolution.

We thank the reviewer for this suggestion. We now added a short discussion of this point in the manuscript.

Several methods can be used to estimate hn, including criteria based on potential temperature, CO2, wind speed, Richardson number, and TKE. A recent study at ATTO using field data collected during CloudRoots-Amazon22 (Vila-Guerau de Arellano et al., 2024) observations applied these five criteria and showed that they reproduce the hourly evolution of the nocturnal boundary-layer height, with values ranging from 114 to 241 m and mean estimates between 150 and 188 m (Figure 2 of the Huitema et al., 2026). The same study also

showed that hn was shallower under strongly stable conditions and deeper under weakly stable conditions, consistent with the expected stability-turbulence control.

In our study, we decided to use the sensible-heat-flux profile method because it is directly linked to the turbulent definition of the nocturnal boundary layer. This choice is also supported by Mendonça et al. (2025, 2026), who showed that vertical profiles of sensible heat flux can be used to estimate hn at ATTO. Therefore, although other diagnostic methods are available and can reproduce the dynamic evolution of the NBL, we retained the heat-flux-based method because it provides a direct turbulence-based estimate and is consistent with previous ATTO studies.

We added a new sentence in the manuscript as bellow:

L344-354: Compared to previous Amazonian studies, the turbulence-based methodology adopted in this work provides an important advantage because it estimates hn directly from the vertical decay of turbulent sensible heat fluxes. Most previous studies relied on indirect methods based on thermodynamic profiles, Richardson number, or remote sensing approaches (Santos et al., 2007; Dias-Júnior et al., 2022). More recently, Mendonça et al. (2025) used the same turbulence-based methodology and reported hn values ranging between approximately 81 and 223 m, demonstrating the importance of surface roughness and topography for nocturnal boundary-layer structure. However, their study did not focus on the hourly evolution of hn or on its relationship with trace-gas concentration profiles. In addition, Huitema et al. (2026), using CloudRoots-Amazon22 observations (Vila-Guerau de Arellano et al., 2024), showed that multiple criteria based on potential temperature, CO2, wind speed, Richardson number, and turbulent kinetic energy reproduce similar nocturnal boundary-layer dynamics, with estimated values between 114 and 241 m. The agreement between these independent approaches and the results presented here supports the robustness of the observed dynamic evolution of hn at the ATTO site.

5. In section 3.3 the role of the canopy deserves more explicit attention. Given the observational setup, the authors are in a unique position to assess how the forest canopy influences the structure and dynamics of the nocturnal boundary layer (see for instance line 179 and 225). Although the results (line 223-228) conclude that the canopy plays a role, this influence is not sufficiently specified or supported by analysis. A more detailed discussion, ideally supported by quantitative evidence, of the mechanisms through which the canopy affects nocturnal stratification, turbulence, or mixing would substantially strengthen the manuscript.

In the revised manuscript, we expanded Section 3.3 to better describe the physical mechanisms through which the Amazon forest canopy influences nocturnal stratification and turbulent mixing. The tall and dense canopy strongly modifies the exchange of momentum and heat enhancing the vertical coupling/decoupling between the surface layer and the atmosphere aloft under stable nighttime conditions.

Our analysis indicates that during nights with stronger radiative cooling and enhanced thermal stability, turbulence generated above the canopy was not efficiently transported downward through the canopy layer. Under these conditions, the canopy acts as a barrier to vertical mixing, favoring the formation of a shallow and strongly stratified nocturnal layer close to the forest top. This behavior was particularly evident on 18 August 2022, when strong thermal stratification and weak cloud cover were associated with shallow hn values around 80–100 m. In contrast, during nights with weaker stability and enhanced wind shear, mechanically generated turbulence was able to remain coupled across a deeper layer above the canopy. Under these conditions, the canopy-induced decoupling was weaker, allowing turbulence to extend to higher levels and contributing to deeper and more variable hn values, as observed on 25 August 2022.

To support this interpretation, we added new analyses of vertical profile of the potential temperature gradients, wind shear, cloud fraction, and radiative forcing (Figure 2). These additional results provide quantitative evidence that the canopy influence on hn emerges from its interaction with thermal stratification and mechanical turbulence generation, rather than from a purely local surface effect.

We added a new sentence in the revised version of the manuscript:

L316-323: “Our observations suggest that the forest canopy plays a key role in reinforcing this layered structure. Under strongly stable conditions, the canopy acts as a roughness and drag layer that attenuates momentum transfer toward the surface. Consequently, turbulence generated aloft by LLJs or strong wind shear may remain confined to elevated layers and may not efficiently penetrate downward through the canopy layer.”

6. Finally, additional background information would strengthen the results in Figure 8, which compared to two stability cases. More emphasis should be placed on the different background concentrations during the past days of the gases and their effect on the current nocturnal gas exchange. In addition, to truly understand the effect of stability on trace gas concentrations, it would be valuable to compare two nights with similar wind and background trace gas conditions. Especially, because previous papers highlight the complicated CH4 signal at ATTO with winds from the South-East (Botia et al., 2020).

We agree with the reviewer that it would be valuable to compare nights with similar wind and background trace gas conditions. However, due to the large natural variation of CO and CH4 concentrations, this is challenging. In the previous version of the manuscript, we included a multi-day figure showing the CO and CH4 concentrations before and during each case study (Figure S4) which indeed shows that the starting background conditions were not the same for the two case studies.

To improve this part of the manuscript, we first of all have expanded this aspect in the discussion of the revised manuscript. In the text, we now better acknowledge the complexity of CH4 and CO signals at ATTO as also highlighted by Botía et al. (2020). In addition, in the revised manuscript, we suggest to focus more on vertical gas concentration patterns (differences between upper and lower layers), rather than absolute concentration values. Lastly, we added two additional case studies to the supplement, namely the nights of 02 September 2022 and 28 August 2022.

The case studies were selected to provide an additional comparison of nights with different stability and hn behavior. On 02 September 2022, the nocturnal boundary layer remained shallow, mostly around 80-100 m, and the potential temperature gradient was stronger, reaching values close to -4 K near the canopy (Figure 6a). In this case study, the upper levels (273 and 321m) consistently showed an independent behaviour in comparison to the lower levels (Figure 5a and 5c), indicating that the shallow and stable layer acted as a barrier to vertical exchange (Figure 6).

In contrast, on 28 August 2022, the potential temperature gradient was weaker, approximately −2 K (Figure 6b) near the canopy top, hn was deeper and more variable, and decreasing during the night. This temporal behaviour is visible also in the gas concentrations, especially for CH4, where at 5:00 the hn separated the upper levels from the lower levels, after which the upper levels started to behave differently, and demonstrating the possible arrival of a new enriched air mass (Figure 7).

These two additional cases also exemplify the interaction between the hn and the initial or background concentrations prior to the evolution of the nocturnal event. In the first one

(02.09.2022) the initial concentrations are relatively high, since previous hours, at all levels (~290 ppb CO and ~2050 for CH_4) compared to the rest of the night. The weak decoupling (~40 ppb in both CH_4 and CO) between 273-321 m and the levels below, is due to the shallow hn (80-100 m) which disconnects the layers closer to the canopy, with low CH_4 and CO, and leading to a dilution of the initial mole fractions at the levels below 273 m. In contrast, the trace gases at 273-321 m remain with small variability relative to their initial state because the measurement height is above the hn.

In the new version of the manuscript we added the following sentence:

L328-343: The interpretation of these concentration patterns must also consider the background atmospheric composition during previous days. As discussed by Botía et al. (2020), the ATTO site frequently experiences nighttime CH4 accumulation associated with strong thermal stratification, suppressed turbulence, and horizontal transport from likely wetland source regions. In addition, CO concentrations are strongly influenced by regional biomass-burning plumes (Andreae et al., 2015; Van Asperen et al., 2024). For example, the elevated CO and CH4 concentrations observed on 25 August 2022 likely reflected the residual influence of previous plume events (Figure S5) combined with slower ventilation near the canopy. Therefore, rather than associating multi-day concentration variability directly with hn, our interpretation focuses on the short-term vertical concentration gradients and their relationship with nocturnal turbulent structure. The additional case studies presented in the Supplement further reinforce this interpretation (Fig. S7). Strongly stable nights with shallow hn (Fig. S8a) exhibited clear vertical separation between upper and lower layers (Fig. S7a,c), while less stable nights with deeper hn (Fig S8b) showed much more homogeneous concentration patterns throughout the tower profile (Fig. S7b, d). The supplementary cases also show the importance of the initial/background concentrations from the previous days in shaping the nocturnal CO and CH4 profiles (Fig. S9). As in the 18 and 25 August cases, the vertical gradients were influenced not only by the evolution of hn, but also by the concentration structure already present before the night. These consistent relationships between hn and the observed concentration gradients provide independent observational support for the turbulence-based estimates of nocturnal boundary-layer height presented here.

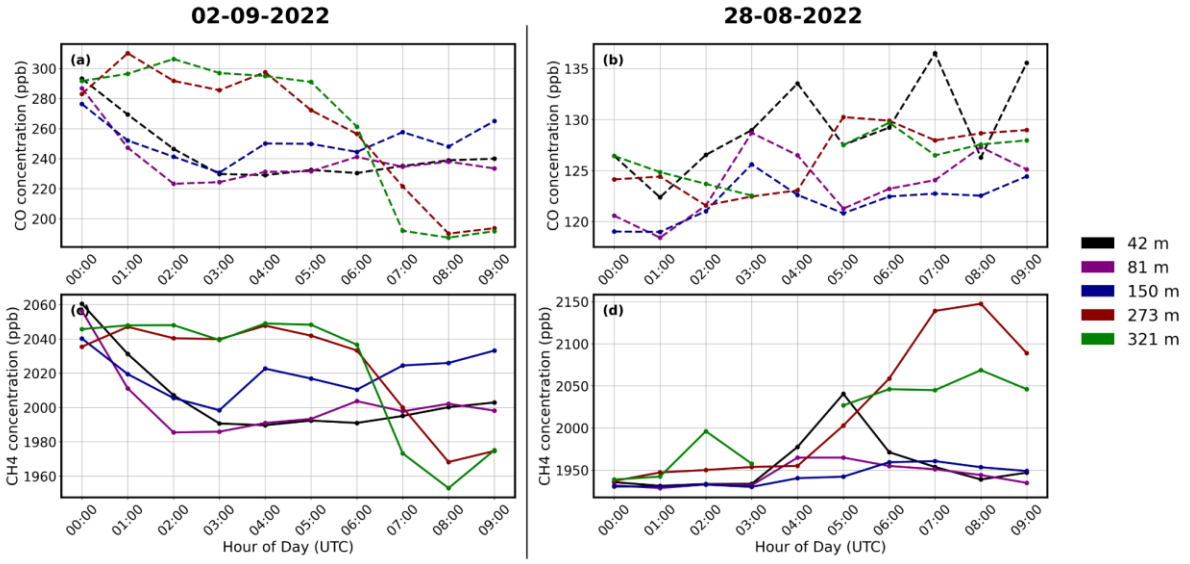

Figure 5 (Figure S7 in the new version of the manuscript).Hourly mean vertical profiles of CO and CH4 concentrations during two additional nocturnal case studies: 02 September 2022 and 28 August 2022. Panels (a) and (b) show CO and CH4, respectively, for 02 September 2022, while panels (c) and (d) show COand CH4, respectively, for 28 August 2022

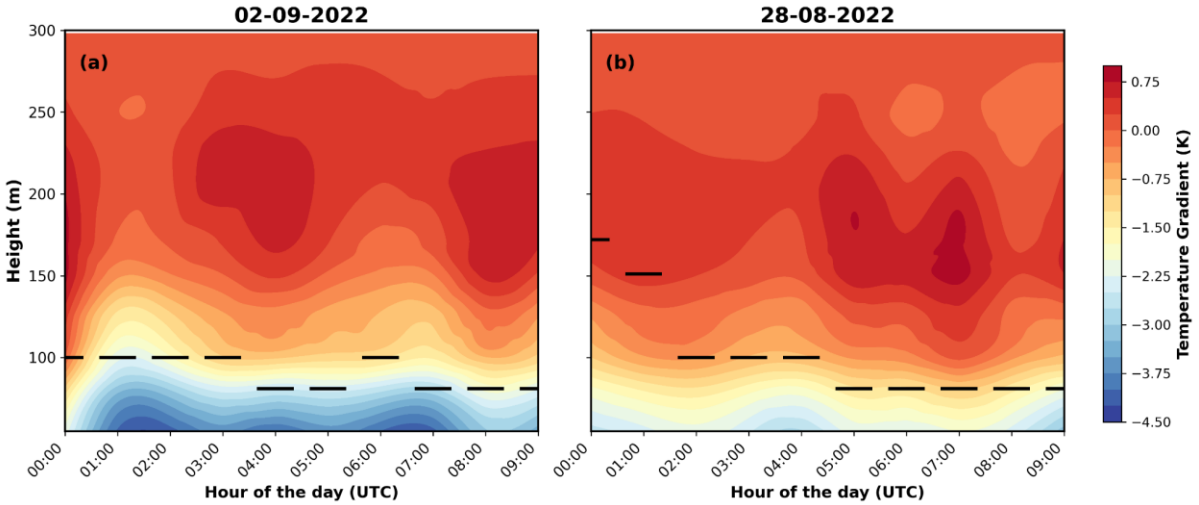

Figure 6 (Figure S8 in the new version of the manuscript. Time-height evolution of the vertical potential temperature gradient during the nights of 02 September 2022 and 28 August 2022. Panels (a) and (b) show the respective nights, with dashed black lines indicating the estimated nocturnal boundary-layer height hn

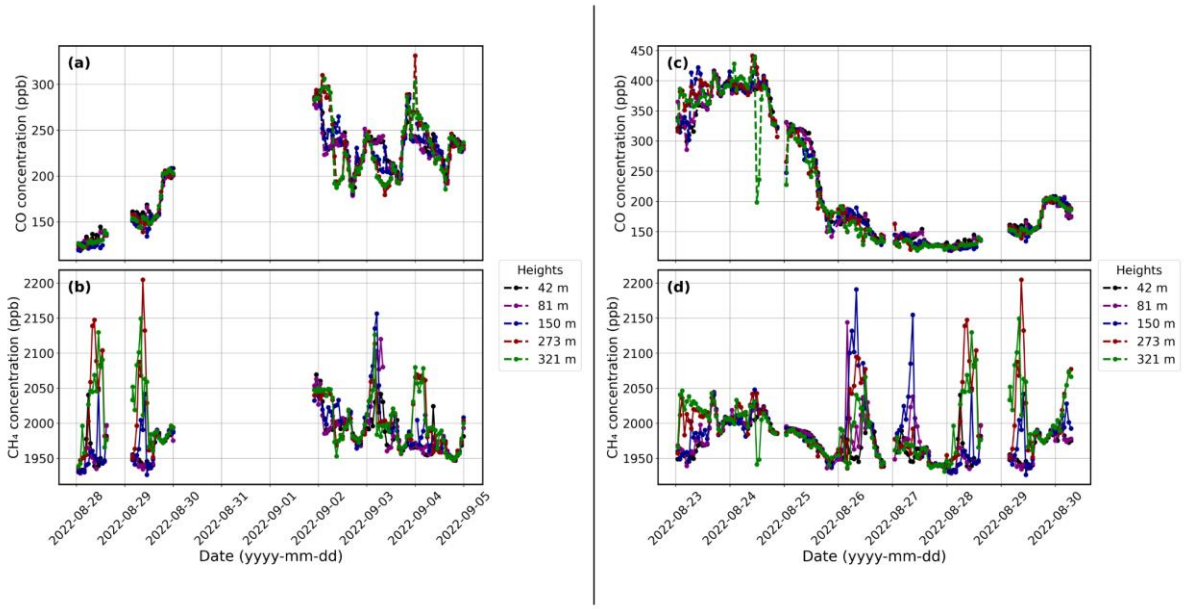

Figure 7 (Figure S9 in the new version of the manuscript). Multi-day evolution of CO and CH4 concentrations at different sampling heights before and during the selected nocturnal case studies. Panels (a) and (b) show CO and CH4, respectively, for the period including 02 September 2022, while panels (c) and (d) show COandCH4,respectively, for the period including 28 August 2022.

References:

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