EGUSPHERE-2025-157- Response Letter 1

Dear Editor and reviewers,

We would like to thank the reviewers and editor for their comments that have allowed us to further clarify some aspects of the manuscript in this revised version. Hereafter, we report reviewers' comments and our replies (*in italics*). For yours and reviewers' convenience we have put the corresponding major changes introduced in red color in the revised version of the manuscript.

Reviewer 1:

Profiling the atmospheric turbulence kinetic energy (TKE) is of great significance for improving our understanding of energy conversion, dissipation and material exchange in the atmospheric boundary layer, which is in turn able to affect the evolution of convection process. Due to limitations in previous detection methods, it has been challenging to visually observe the vertical structure of various budget terms of TKE, particularly the buoyancy generation term. This study provides a meaningful advancement by intuitively presenting the vertical characteristics of various TKE budget terms using high-resolution wind lidar data.

The manuscript offers a comprehensive and detailed analysis of the TKE budget in the Shenzhen area based on long-term observations from coherent wind lidar, which provides valuable insights into atmospheric boundary layer dynamics. One of the most notable and intriguing findings of this study is the discovery that the TKE tendency term transitions around 14:00 in all seasons, revealing critical insights into the diurnal variation of turbulence. The study presents important implications for atmospheric turbulence modeling and parameterization in climate models. Additionally, the analysis of seasonal variations in buoyancy and shear generation provides a more refined understanding of turbulence energy transfer processes at different altitudes.

The manuscript is well-structured, clearly written, and presents significant findings that contribute to improving our understanding of TKE budget dynamics. However, there are a few areas where minor revisions can further enhance the clarity and completeness of the study. Below are my suggested modifications:

1）The wind profile radar can also measure the dissipation rate in the TKE budget term. Add some literature on this topic in the second paragraph of the introduction. For example, Solanki, R., et al., Elucidating the atmospheric boundary layer turbulence by combining UHF radar wind profiler and radiosonde measurements over urban area of Beijing. Urban Climate, 2022. 43,

Response: *Thank you for the reviewer's thoughtful comments. We have carefully considered your suggestion and have incorporated the relevant literature (Solanki et al., 2022) into the introduction, as recommended. In particular, we have added a discussion on the role of wind profile radar in measuring turbulence and its limitations. The text now specifies that "**Although wind profile radar can provide valuable turbulence data, its spatial and temporal resolution might be insufficient, and its ability to monitor turbulence under clear sky conditions is limited (Solanki et al., 2022).**" (See lines 70 to 73)*

2）Line 144, The assumption that pressure transport (Tp) is negligible is common in turbulence studies, but it is important to provide a clear justification for this decision. While Tp is often small in comparison to other TKE budget terms, its significance can vary depending on meteorological conditions and observational techniques. Adding supporting references on why Tp can be safely ignored in this study would increase the scientific rigor of the methodology. This will also help readers unfamiliar with turbulence budget analysis better understand the reasoning behind this assumption.

Response: *Thanks for the reviewer's professional comments. We appreciate the importance of justifying the assumption that pressure transport (Tp) is negligible, as it plays a critical role in ensuring the transparency and rigor of the methodology. As the reviewer rightly points out, while Tp is often small compared to other TKE budget terms, its relevance can indeed depend on meteorological conditions and observational techniques. However, based on previous studies, it has been consistently observed that omitting the pressure transport term generally has minimal impact on the overall turbulence analysis, particularly in typical atmospheric conditions. For example, Kaimal and Finnigan (1994) and Wyngaard (2010) suggest that Tp's contribution is often negligible in turbulent boundary layer studies, especially in well-mixed conditions. Furthermore, Pozzobon et al. (2023) confirm that in many practical applications, the pressure transport term can be safely omitted without introducing significant errors into the turbulence budget. In light of these references, we have added appropriate citations to further support this assumption and clarify its validity. As the reviewer suggests, we have added citations (Kaimal and Finnigan, 1994; Wyngaard, 2010; Pozzobon et al., 2023) in revised version. (See lines 149 to 150)*

3）Line 323, Figure 18 provides a quantitative breakdown of the relative contributions of different TKE budget terms across various heights in the boundary layer. However, the manuscript does not clearly explain the computational method used to derive these contributions. Clarifying whether the values are obtained from normalized budget term magnitudes, fractional contributions, or other statistical methods would improve transparency.

Response: *Thanks for the reviewer's professional comments. We understand the importance of clearly explaining the computational method used to derive the relative contributions of different TKE budget terms, as this will enhance the transparency of our analysis. In the revised manuscript, we provide a more detailed explanation of our approach. Specifically, we first categorize the TKE budget terms into two groups based on their values: positive (or zero), which we refer to as "generation" terms, and negative terms, which we classify as "dissipation" terms. After this categorization, we calculate the contribution rate of each term within its respective category by determining its proportion relative to the total value of the terms within that category. This method ensures that the contributions of each term are quantitatively expressed in a clear and logical manner. We have updated the manuscript to include this explanation for greater clarity. The text now specifies that" **We first categorized the TKE budget terms into two groups according to positive (including zero) and negative values, which were designated as generation and dissipation terms, respectively. Subsequently, we calculated the contribution rate of each budget term within its corresponding category by determining its proportion.**" (See lines 335 to 340)*

4）The reduced number of available observational days in June and August raises questions about potential data collection biases (Table 2). Since the reliability of turbulence analysis is dependent on a continuous and representative dataset, it is crucial to clarify the cause of missing data. If the missing days are due to weather conditions (such as persistent cloud cover, heavy precipitation, or typhoon events), this should be explicitly stated.

Response: *Thanks for the reviewer's comment. We agree that the reduced number of available observational days in June and August could raise concerns about potential biases in the data collection process, and it is important to address this issue transparently. In the revised manuscript, we have clarified the reason for the missing data. Specifically, we explain that the missing observation days are not due to any issues with the data collection process itself, but rather the result of adverse weather conditions during those months. These conditions included persistent cloud cover and heavy precipitation, which significantly affected the ability to collect data. We have updated the manuscript to explicitly state this and improve transparency regarding the dataset. The text now specifies that* ***"Of note, the missing observation days in June and August are due to adverse weather***

conditions, including continuous cloud cover and heavy precipitation, rather than data collection issues. *" (See lines 131-134)*

5）Lines 216 and 242 respectively mention the buoyancy and shear generation terms as the reasons why TKE has the greatest impact height in autumn, but why are only buoyancy generation terms mentioned in the abstract and conclusion?

Response: *Thank you for the reviewer's constructive comment. You are correct that both the buoyancy and shear generation terms were mentioned in lines 216 and 242 as important factors contributing to the height at which TKE has the greatest impact in autumn. However, after further quantifying the contribution rates of both, we found that the buoyancy generation term has a much more pronounced influence than the shear generation term. As shown in Figure 18(c), the contribution from buoyancy generation reaches 60%, significantly higher than the 20% contribution from shear generation. This significant difference in contribution led us to emphasize buoyancy generation as the primary driver of the high-altitude impact of autumn TKE in both the abstract and the conclusion. We have updated the manuscript to reflect this reasoning more clearly. (See lines 335 to 348)*

6）What are the time resolution and spatial resolution of TKE budget terms? The manuscript should explicitly state the time and spatial resolution at which the TKE budget terms were derived. Resolution details are critical for interpreting turbulence measurements, as they influence how small-scale versus large-scale processes are captured. Given that the wind lidar operates at a temporal resolution of 5 seconds and a spatial resolution of 15 meters, it would be helpful to confirm whether the same resolution applies to all derived TKE terms or if additional temporal/spatial averaging was performed. Including this information in the methodology section would strengthen the manuscript's transparency and help readers better assess the scale of the analysis.

Response: *Thank you for the reviewer's constructive comment. We agree that providing explicit details about the time and spatial resolution of the TKE budget terms is crucial for understanding the scale at which turbulence measurements are captured and for ensuring the transparency of the analysis. As the reviewer pointed out, the wind lidar operates at a temporal resolution of 5 seconds and a spatial resolution of 15 meters, but it is important to clarify whether these same resolutions were applied to all the TKE budget terms or if additional temporal/spatial averaging was performed. In the revised manuscript, we have addressed this by specifying that the TKE budget terms were derived using a time resolution of 20 minutes and a spatial resolution of 30 meters, which represents the resolution applied during the analysis. The text now specifies that "****We obtained the horizontal wind speed (a), vertical wind speed (b), TKE (c), Et (d), Tt (e), D (f), S (g), and B (h) with a time resolution of 20 minutes and a spatial resolution of 30 m.****"(See lines 150 to 152)*

On behalf of all authors,
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