EGUSPHERE-2025-157- Response Letter 3

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:

The quantitative analysis of turbulent kinetic energy (TKE) budget is a crucial support for understanding the formation mechanism of turbulence. This paper, using coherent Doppler lidar observation data, visually presents the vertical structure and seasonal variation characteristics of TKE budget in the boundary layer of Shenzhen area. The research method of this paper has obvious innovation, and the conclusions obtained also have scientific significance. The study reveals the vertical distribution characteristics of TKE in different seasons in the coastal area of South China (for example, the TKE in the lower layer is the strongest in summer), and clarifies the relative contributions of buoyancy generation and shear generation. The features of the time evolution analysis (for example, the transformation of the trend term of TKE around 14:00) and the explanation of the mechanism (buoyancy generation dominates) are logically clear. This research provides new evidence for the formation mechanism of the boundary layer turbulence in subtropical coastal cities and theoretical support and data support for the parameterization scheme of the boundary layer turbulence process. Although this research is structurally rigorous and scientifically strong, some technical details and methodological explanations still need to be provided to enhance the completeness and universality of the paper.

(Line 140): The symbol θ is referenced in the TKE budget equation but lacks explicit definition. Given the critical role of thermal stratification in buoyancy-driven turbulence, the potential temperature (θ)should be explicitly defined to avoid ambiguity.

Response: *Thank you for the reviewer's valuable comment. We appreciate the importance of clearly defining all symbols used in the manuscript, especially for key variables like the potential temperature (θ). As suggested, we have updated the manuscript to explicitly define the symbol θ to avoid any ambiguity. Specifically, θm represents the mean potential temperature, while θ′ denotes the fluctuation in potential temperature. This clarification ensures that readers will have a clear understanding of the role of thermal stratification in buoyancy-driven turbulence. The revised text now reads: "**θm represents the mean potential temperature, and θ′ denotes the fluctuation of the potential temperature.**" (See lines 144 to 145)*

Vertical Coordinate Clarification (Line 138): The vertical coordinate z is ambiguously described as "height." Please specify whether z represents altitude above mean sea level (AMSL) or height above ground level (AGL) in the methodology section.

Response: *Thank you for the reviewer's helpful comment. We agree that providing a clear definition of the vertical coordinate is essential for avoiding any ambiguity. In the revised manuscript, we have clarified that the vertical coordinate z refers to the height above ground level (AGL), not altitude above mean sea level (AMSL). This distinction is important for ensuring that the methodology is clearly understood. The text now specifies that "where E represents the TKE (m^2/s^2), t is the time (s), and u′ (longitudinal direction), v′ (latitudinal direction),*

and w' (vertical direction) are the fluctuation values of the three-dimensional wind speed components u, v, and w, respectively, which vary ***with height above ground level z.*** *" (See lines 140 to 145)*

Pressure Transport Term (Line 144): The manuscript omits the pressure transport term (Tp) in the TKE budget analysis without theoretical or empirical justification. Cite peer-reviewed studies (e.g., Zhou et al., 1985; Nilsson et al., 2016a) that validate the negligible contribution of Tp in similar boundary layer regimes to strengthen methodological credibility.

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.*

Data Generalizability Limitations: the exclusion of complex weather conditions (e.g., precipitation, cloud cover) limits the applicability of findings to idealized scenarios. Explicitly acknowledge this limitation in the Conclusions section, emphasizing the need for future studies under diverse meteorological conditions.

Response: *As the reviewer suggests, we have modified the texts in revised version. The text now specifies that "****One limitation of the current study is that the analysis does not fully account for complex weather conditions, such as precipitation and extensive cloud cover. This aspect might limit the generalizability of our findings to idealized scenarios in which clear weather conditions prevail. Future studies should examine a broader range of meteorological conditions, including significant weather disturbances, to enhance the robustness and applicability of turbulence analyses across diverse atmospheric environments****."(See lines 382-387)*

Temporal Reference in Figures: Figures 3, 5, 7, 9, and 10 display diurnal cycles without specifying the time zone. Label all temporal axes as "Local Time (UTC+8)" to align with Shenzhen's geographic context to avoid misunderstanding.

Response: *Thank you for the reviewer's thoughtful comment. We agree that specifying the time zone is crucial for clarity, particularly when displaying diurnal cycles, to avoid any confusion. In the revised manuscript, we have addressed this by explicitly stating the time zone for all temporal references. Specifically, we have added that all times mentioned in this study are in local time (UTC+8), corresponding to Shenzhen's geographic context. The text now specifies that "Figure 4(b) shows mean TKE profiles at 13:00 for each season* ***(all times mentioned in this study are in local time****)."(See lines 173 to 174)*

On behalf of all authors,
Sincerely,
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