EGUSPHERE-2025-157- Response Letter 2

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:

Due to the lack of full boundary layer turbulence detection methods in the past, it was not possible to provide the continuous vertical distribution of turbulence within the boundary layer, resulting in a certain degree of insufficient understanding of turbulence generation, transport, and dissipation processes. This study, based on high temporal and spatial resolution data from wind lidar throughout the year, inverts the vertical profiles of TKE (Turbulent Kinetic Energy) budget terms (such as dissipation rate, shear/buoyancy generation terms, etc.), systematically revealing the diurnal and seasonal variation patterns of TKE and its budget terms, and deepening the understanding of the evolution of turbulence across the entire boundary layer. It clarifies unique phenomena in the Shenzhen area, such as the dominance of shear generation in summer and the significant buoyancy effect at high altitudes in autumn, which enhances the understanding of the boundary layer in coastal cities and provides observational evidence for climate model parameterization, offering practical application significance. The paper has a novel perspective, solid datasets, a reasonable structure, and detailed content, making it almost ready for publication. However, I believe there are still a few small issues that need attention:

The lidar-based dissipation rate inversion method mentioned in the reference (Xian et al., 2025) needs to be explained in detail (e.g., is it based on inertial subrange spectrum fitting?).

Response: *Thanks for the reviewer's professional comments. As the reviewer suggests, we have modified the texts in revised version. The text now specifies that "Based on our previous detection method, assuming T_P is ignored (Kaimal and Finnigan, 1994; Wyngaard, 2010; Pozzobon et al., 2023), and obtaining dissipation rate through turbulence inertial subrange spectrum fitting, 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 (Xian et al., 2025)，as shown in the various panels in Figure 2." (See lines 148 to 152)*

The temporal resolution of the wind lidar is 0.2 Hz/5s, but this does not necessarily mean that the turbulence kinetic energy and its budget terms have a time resolution of 5 seconds. Typically, a certain time period is required to compute the turbulence spectrum, which raises the question: is the turbulence assumed to be steady during this period? How is this ensured?

Response: *Thanks for the reviewer's professional comments. As the reviewer suggests, we have modified the texts in revised version. The text now specifies that "**Because the time resolution was 20 minutes, ensuring steady turbulence within this period was essential. Therefore, we strictly applied a stationarity test, wherein the average variance over the entire time period was required to be similar to the average variance over shorter time intervals (Xian et al., 2025).**" (See lines 152 to 155)*

The authors neglected the pressure transport term in the method. Is there any basis for neglecting this term? Please add relevant references.

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.*

The specific meanings of the three wind speed components in Equation 1 (u, v, w) should be provided (e.g., longitudinal direction, latitudinal direction, vertical direction).

Response: *Thank you for the reviewer's helpful suggestion. We agree that providing a clear explanation of the three wind speed components in Equation 1 is important for improving the readability and precision of the manuscript. As recommended, we have revised the text to specify the meanings of these components. 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 line 141)*

In the Introduction section, line 76-78, I agree that the author state the important of atmospheric turbulence and its impact on weather and climate change, please add relevant references. However, it is also crucial to air quality, please revise the sentence and add relevant reference (Retrieval of Boundary Layer Height and Its Influence on PM2.5 Concentration Based on Lidar Observation over Guangzhou. https://doi.org/10.46267/j.1006-8775.2021.027).

Response: *Thank you for the reviewer's insightful suggestion. We agree that in addition to its impact on weather and climate change, atmospheric turbulence plays a crucial role in air quality, particularly in relation to particulate matter (PM2.5) concentration. As recommended, we have revised the relevant sentence in the introduction to incorporate this aspect. We also added the suggested reference to strengthen the connection between turbulence and air quality. As the reviewer suggests, we have modified the introduction and added the relevant reference in revised version. (See lines 33 to 34)*

On behalf of all authors,
Sincerely,
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