

Response to Referee #3:

Thank you very much for your insightful comments, valuable suggestions, and thoughtful recommendations, all of which have greatly contributed to improving this paper. The response to all your comments are listed below. There was an extensive discussion among the authors regarding how to revise the content, and this paper is subjected to a major revision for addressing the concerns by all the referees. Thus, the response is delayed, and we are sorry for this.

The article "Quantifying transboundary transport flux of CO over the Tibetan Plateau: variabilities and drivers," addresses a critical topic with significant implications for atmospheric science and environmental policy. The study presents a comprehensive dataset and employs advanced methods like the closed-loop integral approach and regression modelling to analyse CO transport dynamics over the Tibetan Plateau. By exploring the seasonal characteristics, trends, and source attribution of CO transport, the study aims to contribute to a deeper understanding of the environmental processes shaping the Tibetan Plateau's atmospheric composition. However, there are notable shortcomings that diminish the overall impact and clarity of the research. Below are the key areas for improvement:

General comments:

The study heavily relies on TROPOMI, ERA5, and GEOS-CF datasets. While these are robust, the absence of cross-validation with ground-based measurements reduces the robustness of the conclusions.

Recommendation: It would be better to incorporate ground-based CO measurements or at least discuss the absence of such data as a limitation. Highlight any plans for future validation efforts.

Figures are referenced, but the level of detail provided about them in the main text is limited. For example, geographical disparities between the southwestern and northeastern segments are crucial but are not visually emphasized with appropriate maps or contrasting data visualizations.

Recommendation: Improve figure annotations and provide contrasting visualizations (e.g., heat maps or flow diagrams) to emphasize spatial and seasonal differences in CO flux.

Response: In the revised manuscript, we incorporated ground-based CO measurements from the CNEMC monitoring sites to enrich our understanding of surface CO variations on the Tibetan Plateau (Fig. S1), complementing the current analysis of CO in this study. However, due to the unique environmental conditions of the region and the limited ground-based measurement network, obtaining extensive ground data presents a significant challenge. We discuss this limitation in the revised manuscript and outline plans for future validation efforts. Additionally, we have included a bubble heat maps (Fig. 5) to enhance data visualization and highlight the spatial and seasonal variations in CO flux. Please refer to Sections 3.1, 3.3, and 5 for details.

Section specific comments:

Section 2.3: The closed loop integral method for CO flux calculation

While the closed-loop integral method and regression models are sophisticated, their explanation in the paper is overly technical and lacks sufficient simplification for accessibility. This hinders readers from other disciplines from comprehending the approach. A clearer visual explanation or step-by-step breakdown would enhance understanding.

Recommendation: Including a flowchart or stepwise illustration of the methodology could improve the understanding.

Response: In the revised manuscript, we have added a step-by-step flowchart (Fig. 5) to illustrate the closed-loop integral method and regression models, which has helped improve readers' understanding of these methods.

Section 3.1: Variability of CO total column

The findings highlight bimodal seasonal cycles and trends across the Plateau. However, these are repeated across sections without advancing the narrative or exploring less-obvious phenomena like anomalies or outliers.

Recommendation: Identify and explain unusual patterns or deviations from expected trends.

Response: In the revised manuscript, we have explored the unusual patterns and outliers, and analyzed the potential factors contributing to these phenomena. Please see section 3.1 for details.

Section 3.3: Uncertainty of CO flux calculation

The uncertainty analysis section provides quantitative insights yet inadequately connects to the study's primary findings. It would be better to explain how these uncertainties impact seasonal and regional trends.

Response: In the revised manuscript, we have expanded the uncertainty analysis to include a discussion on how these uncertainties impact seasonal and regional trends. Please see section 3.3 for details.

Section 4.1: Differences between Southwestern and northeastern segments

The paper mentions correlations between South Asia and the Tibetan Plateau, but it misses a deeper quantitative analysis of the mechanisms linking industrial or agricultural activities to observed flux trends. The analysis identifies South Asia as a key CO contributor but lacks granularity regarding specific industrial or agricultural hotspots. For example, no specific industrial hotspots are identified as primary sources, leaving the findings somewhat generic.

Recommendation: Use additional tools (e.g., emission inventories or regional modelling) to pinpoint primary CO sources. Link trends to specific regions or activities, such as urban centres or biomass-burning zones.

Response: We have accepted the reviewer's suggestion and incorporated the EDGAR emission inventory (Fig. S4) and MODIS fire data (Figs. S5 – S9) in the revised manuscript to further analyze emission hotspots and their potential contributions to CO fluxes. We have preliminarily identified industrial centers and urban hotspots to enhance the regional specificity of our results. Please see section 4.1 for details.