RC4

The manuscript by Yang et al. (2025) addresses an important issue in carbon emission reporting, namely the comparison of six different bottom-up inventories using China as a case study. Accurate quantification of CO_2 emissions is critical for developing effective mitigation policies. The authors' approach of including three global inventories and three local inventories makes the comparison meaningful and comprehensive. The manuscript is clearly written and was enjoyable to read. I have the following specific comments that require clarification before the manuscript can be considered for publication

Specific Comments:

Introduction section

I found the introduction engaging, but a few aspects could be elaborated further:

1. Please clarify why China was selected as the case study. Is it solely because China is the world's second largest emitter of CO_2, or also because it provides a unique combination of global and local inventories suitable for comparison? Additionally, given that many similar studies have already been conducted for China, does this choice facilitate comparison with existing literature? Please specify.

Response: We thank the reviewer for this thoughtful question regarding the selection of China as our case study. China was chosen for both scientific and practical reasons. Scientifically, China accounts for approximately 80% of East Asia's anthropogenic CO_2 emissions (Xia et al., 2025) and about 32% of global emissions according to the Global Carbon Project (GCP, 2024; available at https://globalcarbonbudget.org/). Practically, China has pledged to peak its CO_2 emissions by 2030 or earlier and to reduce CO_2 intensity by 60–65% relative to 2005 levels (SCIO, The State Council Information Office of China; available at http://www.scio.gov.cn/). Accurate quantification of China's emissions is therefore critical for understanding its carbon budget and for supporting national mitigation policies.

Second, China was selected because its energy structure is undergoing an obvious transition to achieve the dual-carbon targets. This transformation is being driven by policies such as the renewable portfolio standards (RPS) and the clean air policy, which have promoted the adjustment of energy structure and industrial upgrades. The share of renewable energy in China's total power generation increased from 16.6% in 2000 to 28.2% in 2020, reflecting steady progress toward cleaner energy sources. However, fossil fuels still dominate the mix, and issues such as overcapacity in energy supply remain (Zhao et al., 2022). Therefore, assessing anthropogenic CO_2 emissions under this transitional energy structure is crucial for evaluating the effectiveness of China's mitigation efforts.

Furthermore, although many previous studies have analyzed China's CO_2 emissions, our work extends the temporal coverage (2000–2023) beyond earlier analyses (e.g., Han et al., 2000–2016;

Zheng et al., 2006–2021) by incorporating the latest versions of six major inventories. This design enables both temporal and methodological comparison with prior research, refining the understanding of inter-inventory discrepancies and uncertainties. For example, our analysis identifies three distinct emission phases, quantifies national and provincial uncertainties (1σ), and shows that EDGAR estimates the highest national emissions and MEIC the lowest, differing from the near-agreement reported by Han et al. (2020b). Collectively, these advances allow a more robust evaluation of how inventory methodologies and consistency have evolved over time.
We have revised the Introduction to emphasize the significance and rationale for studying China's emissions.

Revision:
Section 1, paragraph 1: *"China, which is responsible for about 80% of East Asia's anthropogenic CO_2 emissions (Xia et al., 2025) and about 32% of global CO_2 emissions according to the Global Carbon Project (GCP, 2024; available at: https://globalcarbonbudget.org/), has committed to reaching peak emissions by 2030 and carbon neutrality by 2060. Besides, China's energy structure is also undergoing an obvious transition driven by policies such as the renewable portfolio standards (RPS) and the clean air policy, which promote cleaner energy and industrial upgrades. The share of renewables in total power generation increased from 16.6% in 2000 to 28.2% in 2020, although fossil fuels still dominate and overcapacity issues remain (Zhao et al., 2022). Under this ongoing energy transition, accurate quantification of anthropogenic CO_2 emissions and understanding the uncertainties in emissions inventories are needed to guide emission reduction policies toward the dual-carbon goals (Li et al., 2017a). "*
References:
Li, M., Liu, H., Geng, G., Hong, C., Liu, F., Song, Y., Tong, D., Zheng, B., Cui, H., Man, H., Zhang, Q., and He, K.: Anthropogenic emission inventories in China: a review, National Science Review, 4, 834–866, https://doi.org/10.1093/nsr/nwx150, 2017.

Xia, L., Liu, R., Fan, W., and Ren, C.: Emerging carbon dioxide hotspots in East Asia identified by a top-down inventory, Commun Earth Environ, 6, 1–13, https://doi.org/10.1038/s43247-024-01991-7, 2025.

Zhao, F., Bai, F., Liu, X., and Liu, Z.: A Review on Renewable Energy Transition under China's Carbon Neutrality Target, Sustainability, 14, 15006, https://doi.org/10.3390/su142215006, 2022.

2. The authors have summarized previous studies from China that compared a few inventories. What is the novelty of the present work? Is the use of updated versions of inventories the only advancement, or are there other new aspects? Please state this explicitly.

Response: We thank the reviewer for this important question regarding the novelty of our study. Beyond the use of updated inventory versions, our work introduces several key advancements. Specifically, it (1) extends the temporal coverage to 2000–2023, identifying three distinct emission phases linked to China's evolving energy policy and industrial structure; (2) evaluates the internal consistency of CEADs data and recommends prioritizing CEADs (sectors) for provincial analyses;

(3) reveals notable sectoral spatial allocation discrepancies, particularly between EDGAR and MEIC in the transport sector; and (4) quantifies scale-dependent uncertainties, showing that provincial uncertainties are two to ten times higher than at national level. We have added a short paragraph in the Introduction and a more detailed paragraph in the Conclusion explicitly outlining the main advancements compared with previous studies.

Revision:

(1) ***Section 1, paragraph 5:*** *"To this aim, this study conducts a comprehensive analysis of the spatiotemporal variation of China's anthropogenic CO_2 emissions and investigates the differences among six widely used emission inventories at their latest versions: the global inventories ODIAC, EDGAR, MEIC, GEMS, CAMS, and the China-specific inventory CEADs. The data and methods are presented in Section 2. We report our results in Section 3 and conclude the paper in Section 4. Compared with previous studies (Han et al., 2020b; Zheng et al., 2025), we extend the temporal coverage to 2000-2023, enabling a more current and consistent assessment of recent emission trends, inter-inventory discrepancies, and scale-dependent uncertainties across China. "*

(2) ***Section 4, paragraph 5:*** *"In summary, this study extends previous work by identifying a three-phase trend in China's anthropogenic CO_2 emissions from 2000 to 2023 and quantifying the emission uncertainties (1σ) at both national and provincial levels. At the national level, CAMS shows the closest agreement with the government-reported NGHGI, while ODIAC aligns best with the multi-inventory mean over the study period. At the provincial level, the Chinese local inventories, CEADs and MEIC, provide the most consistent estimates for regional studies. Differences in spatial proxies significantly affect the spatial distribution of sectoral emissions, as shown by the contrasting transport emission patterns in EDGAR and MEIC. We also clarify the appropriate use of CEADs for provincial analyses. Our results further underscore the importance of improving the consistency of regional inventories to provide a stronger scientific basis for China's emission mitigation and carbon neutrality policies."*

Result Section

Section 3.1

The authors state that differences among the emission inventories become more pronounced after 2012 and continue to diverge in recent years. However, the manuscript does not provide an explanation for this trend. It would greatly benefit the reader if the authors elaborated on the possible reasons for this divergence—for example, changes in activity data sources, revisions in statistical reporting, or methodological updates within specific inventories. Such context is essential to help readers better understand the evolution of Chinese emissions estimates over time.

Response: We thank the reviewer for this constructive comment. As noted in Section 3.1, the post-2012 divergence among inventories is mainly driven by EDGAR reporting the highest emissions and MEIC the lowest. We further investigated the possible reasons for this behavior by comparing the versions used in our study (EDGAR 2024 and MEIC-Global-CO_2 v1.0) with those used by Han et al. (2020b) (EDGAR v4.3.2 and MEIC v1.3). Our analysis shows that EDGAR's national totals remain almost unchanged between the two versions, whereas MEIC-Global-CO_2 v1.0 reports significantly lower emissions than MEIC v1.3 (by about 1.43 Gt year^{-1} on average over 2008–2017). Consequently, the increased inter-inventory divergence after 2013 primarily originates from the downward revision in the latest MEIC dataset. Since the MEIC team does not provide detailed documentation on version-specific updates publicly, we can only infer that this reduction may reflect changes in energy statistics, emission factors, and data processing procedures introduced in the latest MEIC product. We have clarified this explanation in the revised manuscript to help readers better interpret the divergence among inventories after 2012.

Revision:

Section 4, paragraph 1: *"China's annual anthropogenic CO_2 total emission increases from 3.42 Gt in 2000 to 12.03 Gt in 2023. When compared with the officially reported NGHGI and the six-inventory mean, CAMS shows the smallest deviation from the NGHGI, while ODIAC agrees most closely with the multi-inventory mean. The six inventories display a broadly consistent emission trend, but their discrepancies among the inventories have widened from 0.41 Gt year^{-1} to 1.63 Gt year^{-1}, mainly due to the highest estimates reported from EDGAR and the lowest values estimated from MEIC, especially after 2012. Our results are consistent with Zheng et al. (2025) but opposite to Han et al. (2020b), demonstrating the differences in emission versions (Our study: EDGAR2024, MEIC-global-CO_2 v1.0; Zheng: EDGAR v7.0, MEIC-China-CO_2 v1.4; Han: EDGAR v4.3.2, MEIC-China-CO_2 v1.3). A comparison between these versions (Fig. S6) shows that the divergence mainly arises from a downward revision in the latest MEIC dataset, which reports about 1.43 Gt year^{-1} lower emissions on average over 2008–2017. In contrast, EDGAR's national totals remained nearly unchanged across versions, with differences within 0.001 Gt year^{-1} during 2000-2012. These results highlight the significant impact of inventory version updates on comparative emission analyses."*

Section 7, Figure S6:

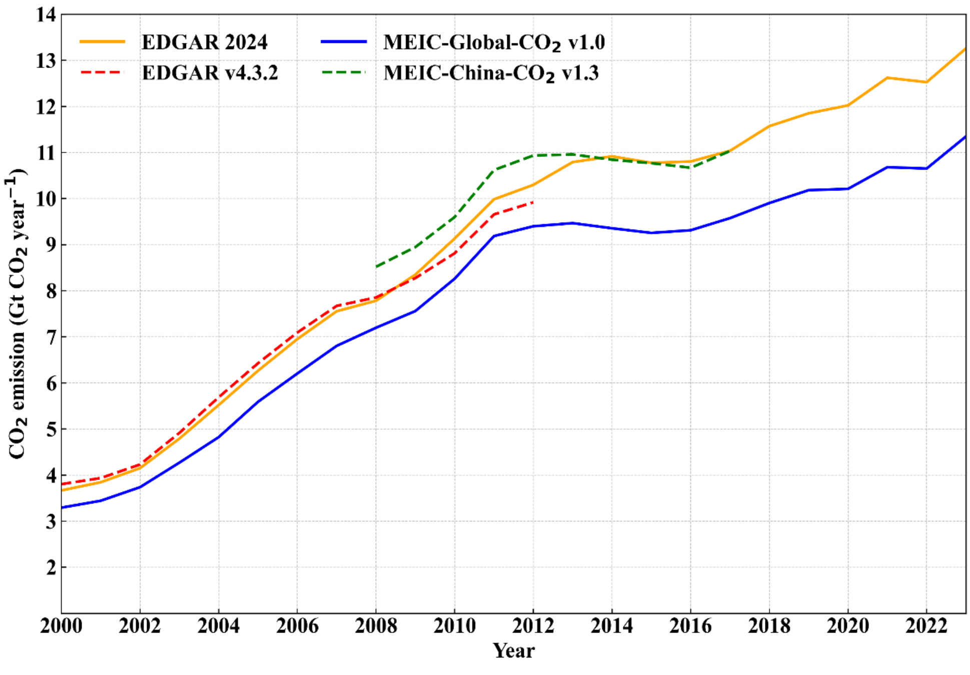

Figure S6. *Comparison of national CO_2 emissions from different versions of the EDGAR and MEIC inventories. The older versions (EDGAR v4.3.2 and MEIC-China-CO_2 v1.3) used in Han et al. (2020b) are compared with the updated versions (EDGAR 2024 and MEIC-Global-CO_2 v1.0) used in this study.*

Conclusion section

The conclusion could be strengthened by addressing the following points:

1. What is the main take-home message from this study?

Response: Thanks for the comment. The key findings can be summarized as follows: (1) China's anthropogenic CO_2 emissions from 2000–2023 exhibit three distinct growth phases driven by changes in energy policy and structure; (2) CEADs (sectors) provides more consistent estimates than CEADs (provinces) at both provincial level and national level; (3) large spatial discrepancies among inventories originate mainly from different downscaling proxies and spatial allocation approaches, as illustrated by the contrasting spatial pattern between EDGAR and MEIC, and the inter-inventory discrepancies at the provincial level; (4) provincial level uncertainties are substantially higher (2-10 times) than national ones (5) CEADs and MEIC yield consistent estimates across nine representative provinces. At the national scale, CAMS shows the smallest deviation from the National Greenhouse Gas Inventory (NGHGI), while ODIAC aligns most closely with the six-inventory mean during the study period. These clarifications have been added to Section 4 to summarize the new insights contributions.

Revision:
Section 4, paragraph 5: *"<u>In summary, this study extends previous work by identifying a three-phase trend in China's anthropogenic CO_2 emissions from 2000 to 2023 and quantifying the emission uncertainties (1σ) at both national and provincial levels. At the national level, CAMS shows the closest agreement with the government-reported NGHGI, while ODIAC aligns best with the multi-inventory mean over the study period. At the provincial level, the Chinese local inventories, CEADs and MEIC, provide the most consistent estimates for regional studies. Differences in spatial proxies significantly affect the spatial distribution of sectoral emissions, as shown by the contrasting transport emission patterns in EDGAR and MEIC. We also clarify the appropriate use of CEADs for provincial analyses. Our results further underscore the importance of improving the consistency of regional inventories to provide a stronger scientific basis for China's emission mitigation and carbon neutrality policies.</u>"*

2. Which inventory performs better overall for China?
3. Are certain inventories more reliable in high-emission regions versus low-emission regions?

Response to Comments 2 and 3: We thank the reviewer for these constructive questions regarding the relative reliability and regional performance of different inventories. Determining which inventory performs best requires evaluation against independent observation-based datasets (e.g., atmospheric CO_2 measurements and inversion results), which is beyond the scope of this study. Instead, our analysis focuses on assessing internal consistency among inventories and their deviations from available references.
To strengthen the conclusions, we have now included the National Greenhouse Gas Inventory

(NGHGI) submitted by the Chinese government to the UNFCCC as a national benchmark. Figure 1 has been updated accordingly. Consistency was assessed by calculating the mean absolute difference (MAD) of each inventory relative to both the NGHGI and the six-inventory mean. The results indicate that CAMS shows the best agreement with the NGHGI, while ODIAC aligns most closely with the six-inventory mean throughout 2000–2023.

At the provincial level, uncertainties are two to ten times larger than those at the national scale, making it difficult to identify a single "best" inventory. Nonetheless, our analysis (Section 3.2.2) shows that CEADs and MEIC exhibit strong agreement across nine representative provinces, particularly in Inner Mongolia, Shandong, Henan, Hubei, and Shanghai. These findings have been incorporated into Sections 3.1 and 4 to provide clearer, quantitative insights into inventory reliability across different spatial scales and emission intensities.

Revision:

(1) ***Section 3.1, paragraph 2:*** *"To further assess the consistency of the six inventories, we calculate the mean absolute difference (MAD), which is defined as the multi-year mean of annual absolute differences between each inventory and either the NGHGI or the six-inventory mean. Compared with NGHGI, the MADs range from 0.156 Gt year^{-1} (CAMS) to 0.835 Gt year^{-1} (MEIC). Against the six-inventory mean, the MADs range from 0.12 Gt year^{-1} (ODIAC) to 0.449 Gt year^{-1} (MEIC). EDGAR reports the highest emissions, which is about 0.370 Gt year^{-1} larger than the mean emission. MEIC shows the lowest emission levels, which is about 0.449 Gt year^{-1} less than the mean emission. Overall, CAMS exhibits the greatest consistency with the NGHGI, being at least 30% lower than that of the other inventories. In comparison, ODIAC agrees most closely with the six-inventory mean, with an MAD at least 58% lower than the others."*

(2) ***Section 4, paragraph 1:*** *"China's annual anthropogenic CO_2 total emission increases from 3.42 Gt in 2000 to 12.03 Gt in 2023. When compared with the officially reported NGHGI and the six-inventory mean, CAMS shows the smallest deviation from the NGHGI, while ODIAC agrees most closely with the multi-inventory mean. The six inventories display a broadly consistent emission trend, but their discrepancies among the inventories have widened from 0.41 Gt year^{-1} to 1.63 Gt year^{-1}, …"*

(3) ***Section 4, paragraph 4:*** *"…The pronouncedly higher emissions in the coastal megacities (e.g., Shanghai, Jiangsu, and Guangdong) by ODIAC and the abnormal increase in CAMS by 50-230% in Liaoning, Hubei, and Shanghai exacerbate this divergence. Despite these inconsistencies, CEADs and MEIC exhibit broadly consistent estimates across nine provinces, especially in Inner Mongolia, Shandong, Henan, Hubei, and Shanghai."*

(4) ***Section 4, paragraph 5:*** *"In summary, this study extends previous work by identifying a three-phase trend in China's anthropogenic CO_2 emissions from 2000 to 2023 and quantifying the emission uncertainties (1σ) at both national and provincial levels. At the national level, CAMS shows the closest agreement with the government-reported NGHGI, while ODIAC aligns best with the multi-inventory mean over the study period. At the provincial level, the Chinese local inventories, CEADs and MEIC, provide the most consistent estimates for regional studies. Differences in spatial proxies significantly affect the spatial distribution of sectoral emissions, as shown by the contrasting transport emission patterns in EDGAR and MEIC. We also clarify the appropriate use of CEADs for provincial analyses. Our results further underscore the importance of improving the consistency of regional inventories to provide a stronger scientific basis for China's emission mitigation and*

carbon neutrality policies."

Section 3.1, Figure 1:

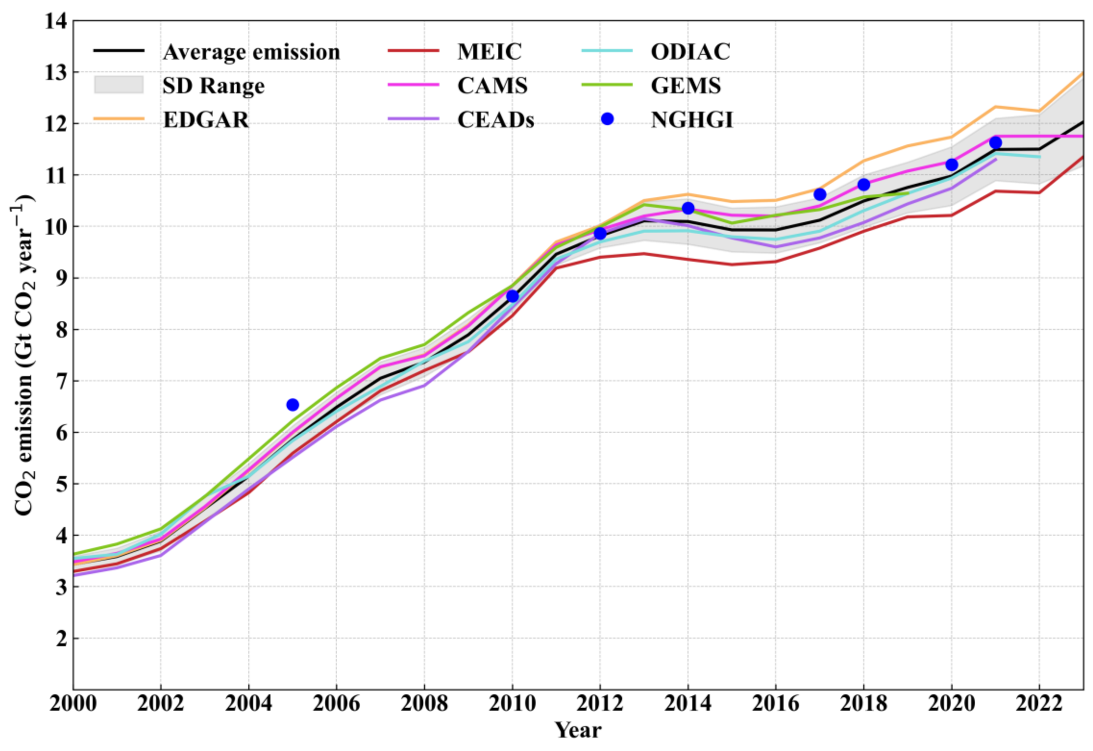

Figure 1. *Annual anthropogenic CO_2 emissions in mainland China from 2000 to 2023, as reported by six emission inventories: EDGAR, MEIC, CAMS, CEADs (up to 2021), ODIAC (up to 2022), and GEMS (up to 2019), and one government-reported data (NGHGI). Apart from ODIAC, all inventories provide national totals directly. We calculated China's emissions by summing the grid values within China for ODIAC. The shaded area indicates the standard deviation of the six inventories. It's noteworthy that the inter-inventory mean and SD were calculated from the above mentioned six inventories.*

Currently, these questions remain unanswered. I think including these aspects will be helpful for readers, providing them with clearer guidance and enhancing the practical value of the study.

Recommendation: This manuscript has the merit and it presents valuable data. However, it requires above minor revisions to be addressed before considered for the publication in Atmospheric Chemistry and Physics journal.