Responses to Editor and Reviewer's Comment on "Gross primary productivity of forest ecosystems in a subtropical city and its decadal climatic and environmental drivers" by Lam et al. (MS No.: egusphere-2025-4647), second iteration

We sincerely thank the editor and the reviewers again for the insightful and constructive comments, which have greatly improved the clarity and quality of our manuscript. Below, we would like to provide detailed responses to all points raised. The editor and reviewers' comments are in blue font, our replies are in black font, our text cited from the manuscript are italicized, and our modified text are both *italicized* and highlighted in **bold**.

Response to Editor

I suggest further major revisions. Please follow the reviewer's suggestions more strictly (from both revisions) and my suggestions below.

Thank you for your heartily suggestions. We have now followed all suggestions and revised the manuscript point-by-point, and we are happy to include further discussions when specified.

Please make sure to cite all used data sets properly. For instance, for the Merra-2 data set or the surface data map of CLM2 sources/citations are missing.

MERRA-2 meteorology, CLM2 surface data map, MODIS LAI and GPP data have now been cited. Please refer to the track-changes file.

I do not fully understand Fig. 6. You state that your IAV is the annual standard deviation. The latter means the standard deviation of your hourly data taken for each year? For a quantity of IAV, I usually expect just one value for the entire time period and not a time line as you show in Fig. 6. Do you mean that your lines show the interannual variability of the standard deviation? And why call it "IAV" where "Standard deviation" would also be fine?

We apologize for the confusion. IAV should indeed be a single value. We have redefined IAV at line 250-251:

*"Here we used **standard deviation** of the detrended **yearly** GPP to indicate the interannual variability (hereafter "IAV") of GPP."*

Values for IAV are included in lines 315-316.

The lines in Fig. 6 indeed illustrate the annual anomalies of GPP and environmental factors. IAVs are then calculated as the standard deviation of the GPP anomalies. The difference between "IAV" and "standard deviation" would be the elimination of seasonal variations, as we computed the anomalies using yearly mean. The figure caption has been written as:

*"Detrended **yearly anomalies** of gross primary production (GPP) influenced by environmental factors, as depicted by the solid lines. The corresponding normalized **yearly anomalies** of the environmental factors are depicted as dashed lines. Statistical metrics of Pearson correlation between the GPP **anomalies** and environmental factor **anomalies** are presented in the top-left corner of the plots. The Pearson correlation indicates the level of linearity between the environmental **anomalies** and the induced yearly **anomalies** of GPP. The magnitudes of influence are illustrated by the standard deviations of the **yearly anomalies** of GPP (solid lines), which are described in Section 3.4."*

Section 3.4 (line 313-332) has also been rewritten to distinguish clearly between "IAV" and "yearly anomalies". Please refer to the track-changes file.

In my opinion, the conclusions are too long and include parts about implications and limitations that should be moved to the Discussions (subchapter 3).

The manuscript has been restructured, and the "Limitations and implications" section has been moved to the "Discussions". Please refer to the track-changes file.

Further add a paragraph in the discussions about the usage of LAI as model input and the satellite-derived GPP for model validation, which is also highly dependent on LAI, since both reviewers pointed out that this is a drawback of the study.

We acknowledge this drawback and have added a paragraph for discussion in line 396-411:

"We ran the model with MODIS LAI and evaluated it with MODIS GPP. We are aware of the potential drawback that using MODIS data products in both model input and evaluation may appear self-fulfilling: The MODIS algorithm calculates GPP as a function of maximum light use efficiency (LUE), vapor pressure deficit, minimum air temperature, and fraction of incoming photosynthetically active radiation absorbed by canopy (FPAR) (Running et al., 1999), while FPAR is dependent on LAI within the retrieval algorithm (Knyazikhin et al., 1999). Yet, the calculations of GPP in an LUE model and a process-based model fundamentally differ. Using MODIS LAI as an input in a process-based model, the study from Chen et al. (2020) compared modelled GPP with MODIS GPP and with eddy covariance measurements; the results illustrated systematic discrepancies between simulated GPP and MODIS GPP. Due to the aforementioned constraints (Section 2.3.4), a direct flux measurement was not available in this study. Nonetheless, to minimize the coherence among remotely sensed data products, it is

recommended to evaluate process-based models that require remote-sensing data for parameters or inputs with eddy covariance measurements or SIF products. Here, our evaluation essentially highlights the similarities and differences in model physics for photosynthesis between LUE model for MODIS GPP and process-based ecophysiological model for TEMIR-HK, rather than being a full validation against independent observations of canopy structure and functions. To mitigate this limitation, *we* ***additionally*** *compared our model output against GOSIF GPP product as an order-of-magnitude check. Between 2012 and 2018, the aggregated GPP from TEMIR-HK is relatively close to the value produced by GOSIF GPP. Yearly total GPP time series for GOSIF, MODIS and TEMIR-HK are illustrated in Fig. S4.****"***

Please further add discussions about the missing consideration of nitrogen deposition in your study. Nitrogen deposition can also contribute to an increase in GPP. Also extend your discussion about forest management and human-induced features in the landscape and how it may be considered in future studies.

Discussion regarding nitrogen deposition has been added in line 447-453:
*"****We did not consider the fertilization effect of nitrogen on vegetation productivity in this study, despite the fact that nitrogen could be a key component for plant growth and productivity in nutrient-limited ecosystems (e.g. Reich et al., 1991; Wright et al., 2004; Dong et al., 2022). Recent site measurements indicate that the annual nitrogen deposition in Hong Kong was 39.2 ± 5.2 kgN ha^{-1} yr^{-1} in 2024 (Yu et al., 2026). Experimental evidence from a subtropical forest in China suggests that such a level of deposition may have already exceeded the saturation threshold (Tian et al., 2017). That said, it remains uncertain whether Hong Kong's forests are truly outside the nutrient-limited regime. Targeted research to unravel the current nitrogen status of Hong Kong's forest ecosystems and its corresponding effects on productivity is much warranted."***

Discussion on forest management and human-induced features has been extended in line 458-465:

"Land cover change is not comprehensively represented in this study. A more complete representation of land cover change should include changes in both LAI, which represents canopy structure, and PFT fraction, which represents vegetation distribution. A dynamic vegetation or land cover change map is currently unavailable in Hong Kong, thus a static land cover map was adopted instead. The high resolution 30-m FROM-GLC map is only available for 2015, and the effect of land cover change is only implicitly represented by the ***changes in LAI associated with deforestation and reforestation. Approximately 43% of land in Hong Kong is designated as protected areas, where the ecosystems are protected from urban development threats; some degraded ecosystems are also under rehabilitation. Restored and regenerated forests may offer a boost in total ecosystem productivity. On the other hand, privately owned lands that carry essential ecological values are not protected by conservation policies. Human activities such as unsustainable agricultural practices and the use of off-road vehicles may cause irreversible damage to terrestrial ecosystems. Future modeling studies in Hong Kong should represent the human-induced impacts on land cover change (and subsequently changes in PFT fractions) and the alteration in LAI.****"*

In the supplementary material, definitions of multiple variables and abbreviations are missing. Please add those descriptions.

Thank you pointing out the shortcomings. The description has been added. Please refer to the revised file.

Please recheck language and grammar, especially of the added parts.

Thank you for the note. We have checked our manuscript again and made necessary changes. Please refer to the track-changes file.

Response to Referee #1

We thank the referee for the invaluable comments and suggestions in the first iteration. We have made sure that the comments have been addressed and followed in our revised manuscript.

Response to Referee #2

I appreciate the authors' responses to my previous comments. Overall, I think the revised manuscript has addressed most of my concerns. I have only one minor remaining comment. The relationship between PFT fractions and PFT-specific LAI could be discussed more in the limitations section. The authors may consider using relatively pure pixels dominated by a single PFT to derive empirical PFT-specific LAI dynamics, which may help constrain LAI partitioning in mixed pixels.

Thank you for raising the concern regarding LAI partitioning. This shortcoming of the study has been added to the discussion section, line 421-429:

"LAI partitioning is required in this modeling study since each grid cell consists of a mosaic of PFTs. Hence, we adopted a base year PFT-specific LAI and used it to compute scaling factors for each grid cell and day, as described in Sect. 2.3.2. The phenological differences between competing PFTs are implicitly captured by the base year PFT-specific LAI, which is provided in daily resolution. This approach assumes the phenological differences is seasonally (and even daily) dynamic but interannually static. Yet in reality this relationship may be affected by climate and other environmental changes, given species-specific responses to elevated CO_2 level, temperature, nitrogen deposition, and other environmental conditions. Future model development should incorporate improvements to LAI partitioning. A straightforward approach would be to identify single-PFT grid cells and derive empirical PFT-specific LAI values. This allows dynamic ratios among PFTs in mixed-PFT grid cells, without requiring a base year PFT-specific LAI as a benchmark structural parameter."

Please also check the formatting of CO_2 throughout the manuscript and figures, and ensure that the number 2 is consistently shown as a subscript.

The simulation case <CO2_fixed> and <O3_fixed> was previously formatted in full character intentionally to indicate a computer code. The numbers for CO_2 and O_3 in the manuscript and figures are now modified and consistently shown as subscripts.