Authors' response
Reviewer #2

RC1: The increase of the seasonal-cycle amplitude (SCA) of CO2 has been long researched. This study utilized the inversions and LSM simulations to research the main drivers of the enhanced SCA, and pointed out that the effects of CO2 fertilization and warming on SCA have the contrasting effects. However, I have a big concern that whether the GLM can give us the reliable result. It can be a good prediction model but not for causal analysis, especially the predictors here you used (eg. Temperature and CO2) have the high correlations. So (a) I think you should show a figure that makes a direct comparison between the statistical decomposition (CO2, Tgs, ..) and factorial simulations (S1,S2-S2, S3-S2) upon TRENDY S3 NBP, not in the form of your Figure S6 (slope).

AR1: We agree with the reviewer that attribution simply based on the statistical GLM fit would be insufficient for causal analysis. The rationale for combining the attribution by LSMs with that of the GLM is the following:
Trends in SCA can be quantified from observation-based datasets (here the inversions) or from simulations of net land-atmosphere fluxes by LSMs. As they are based on multiple in-situ measurements, the former should provide a reference (and respective uncertainty) for evaluating the LSMs results. The only option to identify drivers of SCA from inversions is statistical attribution. LSMs, on the other hand, allow separating the contribution of each term through the different factorial simulations. However, the attribution by LSMs cannot be easily validated, which is especially problematic given that LSMs underestimate the trends in SCA at latitudinal scale, and show regional mis-matches with inversions. Thus, we compare: (i) the process attribution by LSMs (S1, S2 and S3), (ii) the statistical attribution based on inversion fluxes, (iii) the statistical attribution based on LSMs fluxes from S3 (directly comparable to the inversion results) and (iv) the statistical attribution based on the differences between factorial simulations (cross-evaluation of (i) and (iii)). We believe this is a robust way to evaluate attribution from both inversions and LSMs, and it has not been done in other studies (which have relied mainly on factorial simulations and did not compare with observation-based data). We agree with the referee that it is more meaningful to show the direct decomposition, rather than the sensitivities. We have therefore updated Figure S6, as shown in Figure R1. The discussion around Fig. S6 has accordingly been changed.

RC2: (b) In your Figure S6b, we can focus on the green bar which represents the climate effect only. But after your MLRM fit, we can find that the WH and CO2 also have the significant effect.

AR2: In the revised version of Fig. S6, the climate effect is only significant for Tgs and HW, but very small for the latter. On the other hand, the positive CO_2 fertilization effect is clearly dominant and found in S1. We acknowledge that the discussion of Fig. S6 should be improved, and have addressed this issue in the answer to the previous comment.

RC3: (c) We can see the climate effect is positive in model experiments in Figure 2c, but temperature effect is negative in statistical analysis in Figure 3a. So what's the matter? These phenomena show that the explanations should be cautious.

AR3: The climate effect in Figure 2c encompasses changes in all the relevant variables for ecosystem productivity (temperature, radiation, precipitation, wind) throughout the year, while Figure 3a shows only the effect of growing-season temperature (i.e. Tgs). Therefore, it is possible for the effect of the combined climate changes to be positive, but for the effect of

Tgs to be negative. This is the reason why we compare the statistical attribution from inversions to that of LSMs.

RC4: Details: (1) Abstract Line 4: 'from and 11 state-of-the-art' remove the and
AR4: Corrected.

RC5: (2) In introduction, the last two paragraphs can be place into Section Data
AR5: The information in these two paragraphs was redundant. We merged the key points with the Methods sections and removed the parts that were repeated elsewhere.

RC6: (3) Page 7 line 4 'The coefficients from the GLM fit for each datasets are shown in Figure S' maybe Figure S5;The last sentence in next paragraph should be 'Figure S6'
AR6: Both references to the figures have been corrected.

RC7: (4) Page 7, line 14. 'strong decreasing trends for mid-latitudes'-only CAMS shows
AR7: We have reformulated the sentence:

"[…] even though CAMS shows heterogeneous patterns in North America with strong decreasing trends for mid-latitudes (Figure 1a, S1)."

RC8: (5) Page 9, line 12-13 'In boreal North America, LSMs estimate SCAnbp trends very close to CarboScope estimates, mainly attributed to climate' not only to climate, CO2 effect even stronger.
AR8: Thank you for noting the error. We have corrected the sentence to:

"[…] mainly attributed to CO_2 followed by climate […]"

RC9: (6) Page 11, line 23 '(i) indirect negative effects of T on decomposition during the "release period"' why negative effects? It seems a positive effect, because warmer temperature can result in more release of C by respiration, which can enlarge the SCA.
AR9: Indeed, higher temperatures are expected to increase respiration both during the "net uptake period" and the "net release period". However, the effects of temperature are seasonally-dependent as exemplified below. In the left panel of figure R2, increasing T might increase GPP during the uptake period (having a positive effect on SCA), but at the same time increase maintenance respiration and decomposition in the uptake period, and leading to an increase in C available for decomposition during the release period. The latter effect would decrease SCA during the growing season, and increase SCA in the release period. On the other hand (middle panel), T might increase water-stress and contribute to decrease growing-season GPP (decreasing SCA). Consequently, maintenance respiration could be decreased in the growing-season (offsetting part of the GPP decrease effect), but also in the release-period (contributing to decrease SCA). Finally, in snow-covered regions, warming might contribute to reduce the snow-cover, which in turn might imply more TER during the growing-season but also increased GPP (left panel), but also have delayed effects during the release period, by reducing the insulation cover and inhibiting TER during the release period, which would contribute to a decrease in SCA (right panel). This figure and corresponding discussion have been added to the Supplementary Material.

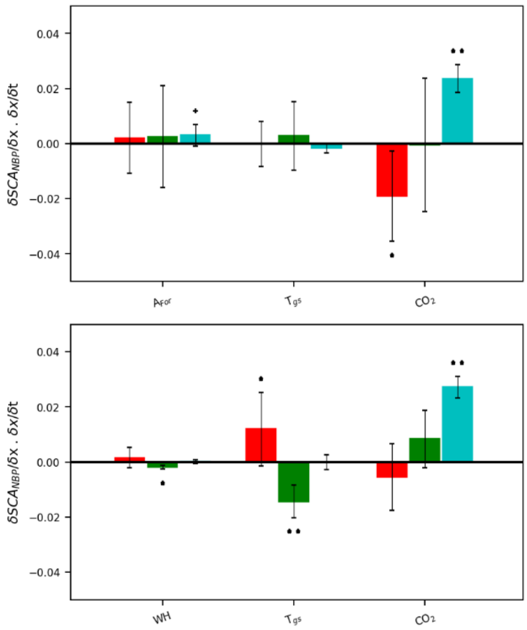

Figure R1 (new Figure S6): Factorial verification of the drivers in TRENDY S3 for (a) >40°N and (b) 25-40°N. The MLRM fit to the partial fluxes for the effects of LULCC (S3-S2, red), climate (S2-S1, green), and CO_2 fertilisation (S1, cyan). Results should be compared to those in Figure 3. The significant predictors in the GLM fit to the LSMs in S3 should be detected in the corresponding factorial simulations. It should however be noted that management and fertilization are already included in S1 and S2 for some models. The difference between S3 and S2 (LULCC effects) mainly suggest LULCC processes and does not identify the effect of CO_2, except if there are interactions between the CO_2 fertilization effect and LULCC emissions (e.g. higher emissions from deforestation because of higher C-stocks). The effect of CO_2 is identified mainly by the difference in S1-S0 and S2-S1, possibly due to synergies between CO_2 fertilisation and climate change. The effect of temperature should be evident in the difference between S2 and S1 (effects of climate), consistently found in $L_{25\text{-}40N}$.

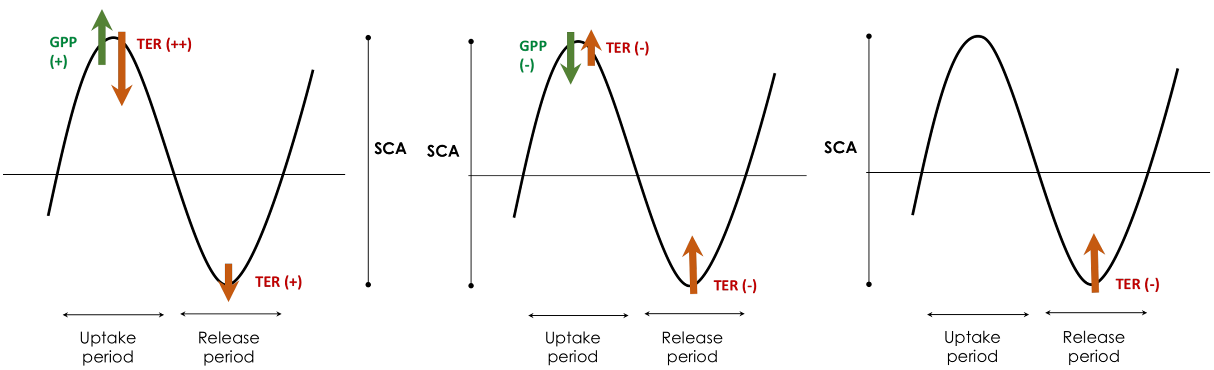

Figure R2: Conceptual scheme of the impacts of warming in SCA.