Response to reviewer

Reviewer # Questions and our responses

We extend our deep appreciation to Reviewer for the constructive comments and suggestions toward improving our paper.

Reviewer:

The authors decided not to move journals, which is fine. They have made significant improvements in terms of explaining how water stress theoretically affects allocation, as well as tying their results back to this theory. However, I still have some significant questions about the methodology and confusion about the interpretation of results. As such, I again suggest this manuscript be ***reconsidered after major revisions***.

Response: We greatly appreciate the reviewer's detailed and insightful comments which helped us to clarify the logic and presentation of the manuscript. According to suggestions, we have added more detailed description about methods and results in the revised manuscript.

Point-to-point responses to all the comments are given below.

1. Methods: Hydrological regions

The aridity zones were determined based on a 115-year average, but it's possible that they could see long-term trends. For example, a gridcell classified as "semi-arid" on average might have been arid at the beginning of the simulation and sub-humid at the end. This is potentially a very important confounding factor, and might explain the sometimes-large variation around Δ=0 and the resulting weak trends in Figs. 9–10. If a lot of gridcells see shifts like this, it might be necessary to restrict analysis to grid cells that didn't change in terms of aridity, or didn't change much.

Another option might be to let gridcells shift their classification over time. This would require the classification to be based on a rolling mean of the previous, say, 15 or 30 years of climate. So, e.g., a bin in Figs. 9–10 would be "[mean 2015 L/WVBC value for all cells that were in this bin in 2015; i.e., whose 2001–2014 climate fit into this bin] minus [mean 1916 L/WVBC value for all cells that were in this bin in 1916; i.e., whose 1901–1914 climate fit into this bin]." Fig. 11 would show, at each year Y in each subfigure F, "mean Y L/W ratio for all cells that were in class F in Y; i.e., that qualify as class F based on climate in years Y–15 to Y–1." This would be necessary in order to avoid spurious interannual switches in classification, as well as to minimize the effects of a lag in vegetation community response to changing conditions.

Response: Thanks for the detailed and constructive suggestion. We agree with the review that the property of some grid cells was shifted from arid at the beginning of the simulation to sub-humid at the end of the simulation. Based on precipitation and potential evapotranspiration data, we calculated the multiyear average aridity indices at the 1916-1945 period and at the 1986-2015 period, and analyzed the transformation of hydrological conditions from the period of 1916-1945 to the period of 1986-2015 (Figure A4). We added more explanation and figure in the revision as below:

"Under the influences of climate change, the hydrological condition was changed in some grid cells (Figure A4). For example, the grid classified as sub-humid zone in the period of 1916-1945 was redefined as semi-arid zone in the period of 1986-2015." (see Revision, Page 12, Lines 308-310)

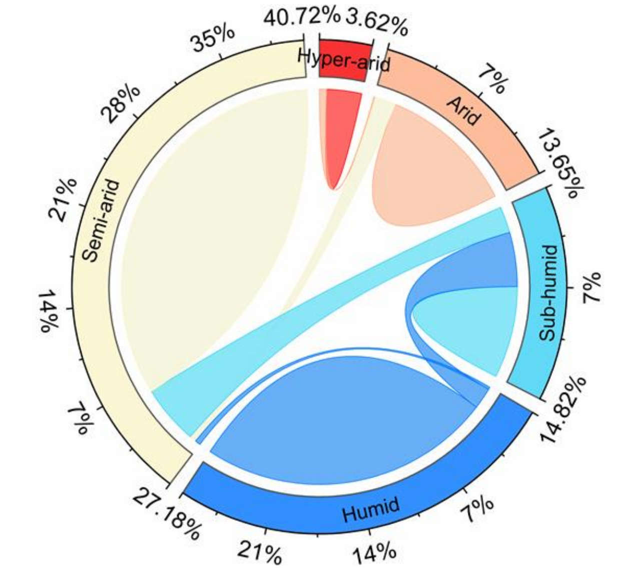

Figure A4. The shift of hydrological regions defined by the multiyear average AI index from the period of 1916-1945 to the period of 1986-2015. The outermost number represent the percentage of hydrological regions in 1916-1945.

(see Revision, Page 33)

Following your suggestion, we selected grid cells with consistent hydrological conditions in study period to investigate the effects of water availability on carbon storage potential. We recalculated the trend of carbon stocks in hydrological regions and redrawn the figures in the revision as below:

"In this study, gird cells with consistent hydrological condition between the period of 1916-1945 and the period of 1986-2015 were selected and classified (Figure 1)." (see Revision, Page 12, Lines 310-312)

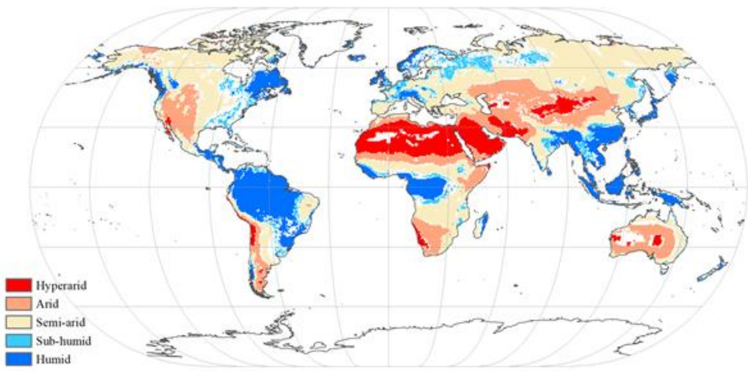

Figure 1. Global spatial patterns of water availability. Spatial variations in water availability were categorized based on the multiyear average aridity index (AI),

defined as the ratio of the multiyear mean precipitation to the potential evapotranspiration. Categories include: hyper-arid (AI ≤ 0.05), arid (0.05 < AI ≤ 0.2), semi-arid (0.2 < AI ≤ 0.5), sub-humid (0.5 < AI ≤ 0.65), and humid (AI > 0.65).

(see Revision, Page 12)

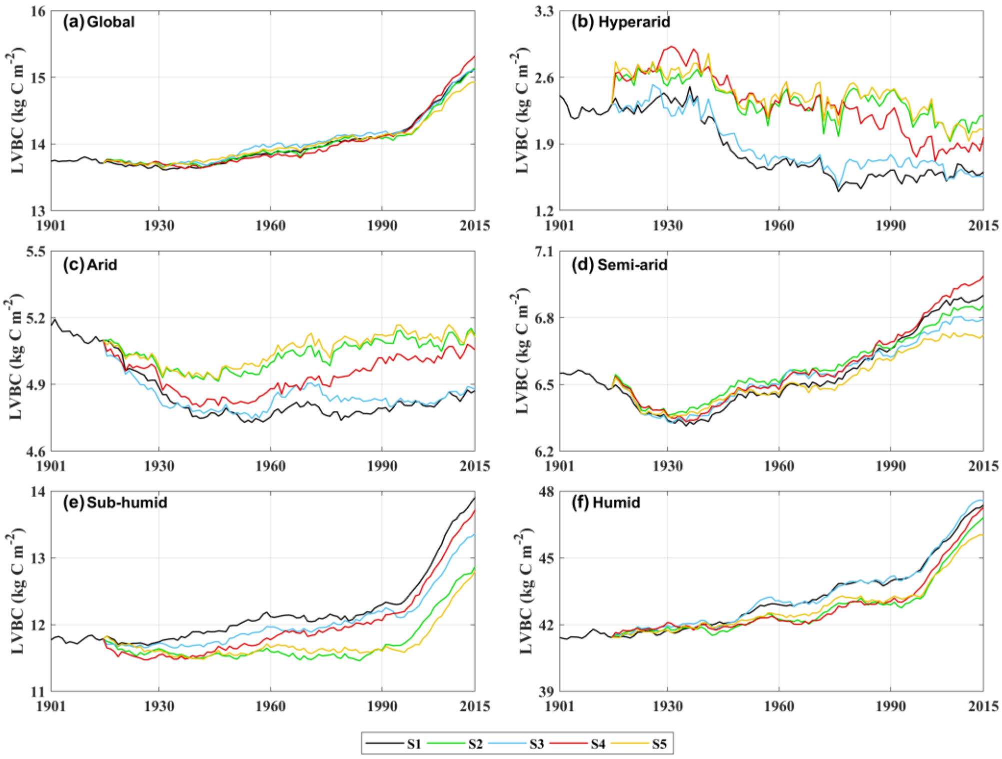

Figure A7. Trends in average density of potential LVBC. (a) Modelled trend of annual averaged LVBC globally. Modelled trends in annual averaged LVBC in hyper-arid zone (b), arid zone (c), semi-arid zone (d), sub-humid zone (e), and humid zone (f).

(see Revision, Page 35)

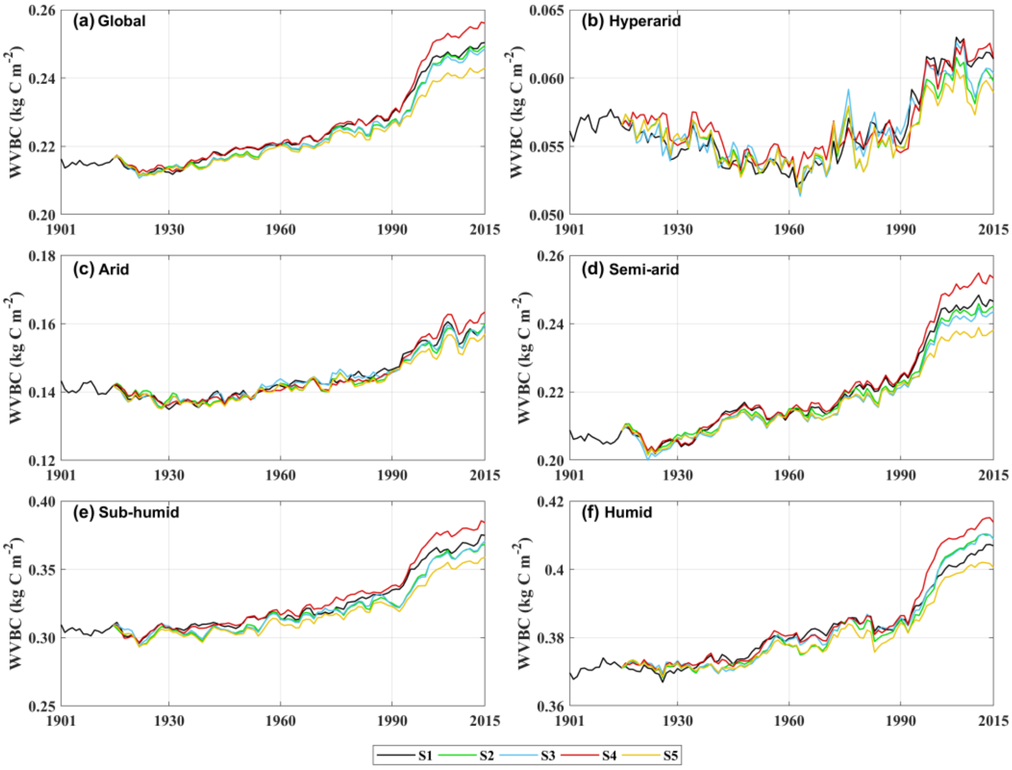

Figure A8. Trends in average density of potential WVBC. (a) Modelled trend of annual averaged WVBC globally. Modelled trends in annual averaged WVBC in hyper-arid zone (b), arid zone (c), semi-arid zone (d), sub-humid zone (e), and humid zone (f).

(see Revision, Page 36)

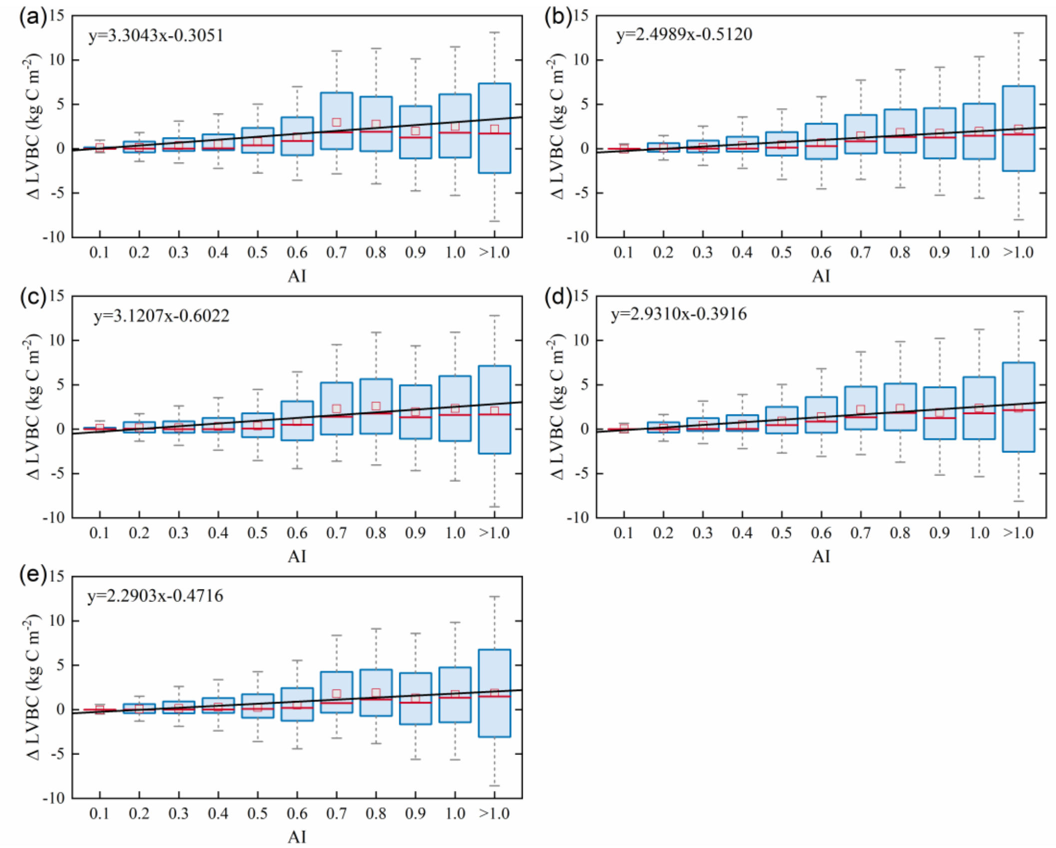

Figure 9. Relationships in the incremental change between AI and LVBC over the hydrological grid cells (Figure 1). Magnitude of change in LVBC in the historical scenario S1 (a), CO_2 in scenario S2 (b), CO_2 + precipitation in scenario S3 (c), CO_2 + temperature in scenario S4 (d), and CO_2 + radiation in scenario S5 (e). Range of the box is 25%-75% of values; range of the whiskers is 10%-90% of values; the small red square is average value; the red line is the median line; and the black line is the fitted curve. Positive value of the Y axis represents the magnitude of increased LVBC from 1916 to 2015 under water-limitations conditions, and vice versa. AI of grid cells is calculated by multiyear average precipitation and multiyear average potential evapotranspiration in the period of 1916-2015. Categories of hydrological zones include: hyper-arid (AI $\leqslant$ 0.05), arid (0.05 < AI $\leqslant$ 0.2), semi-arid (0.2 < AI $\leqslant$ 0.5), sub-humid (0.5 < AI $\leqslant$ 0.65), and humid (AI > 0.65).

(see Revision, Pages 22-23)

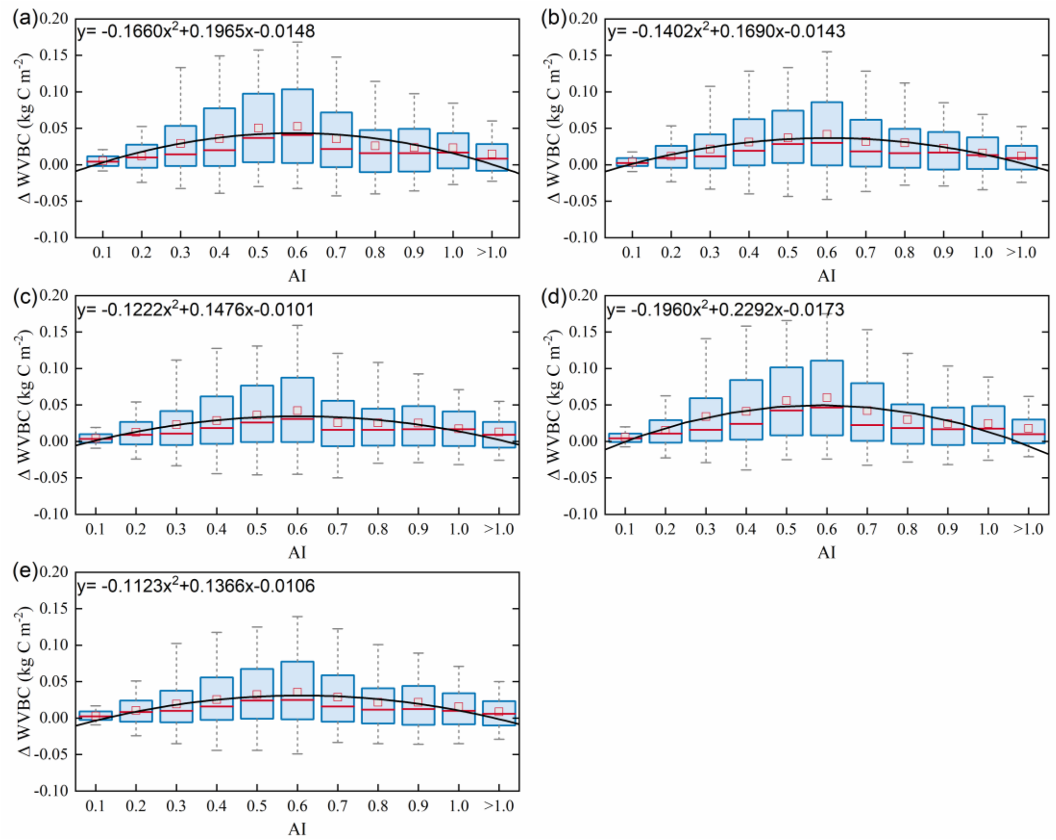

Figure 10. Relationships in the incremental change in AI and WVBC over the hydrological grid cells (Figure 1). Magnitude of change in WVBC in the historical scenario S1 (a), CO_2 in scenario S2 (b), CO_2 + precipitation in scenario S3 (c), CO_2 + temperature in scenario S4 (d), and CO_2 + radiation in scenario S5 (e). Range of the box is 25%-75% of values; range of the whiskers is 10%-90% of values; the small red square is average value; the red line is the median line, and the black line is the fitted curve. Positive value of the Y axis represents the magnitude of increased WVBC from 1916 to 2015 under water-limitations conditions, and vice versa. AI of grid cells is calculated by multiyear average precipitation and multiyear average potential evapotranspiration in the period of 1916-2015. Categories of hydrological zones include: hyper-arid (AI ≤ 0.05), arid (0.05 < AI ≤ 0.2), semi-arid (0.2 < AI ≤ 0.5), sub-humid (0.5 < AI ≤ 0.65), and humid (AI > 0.65).

(see Revision, Page 24)

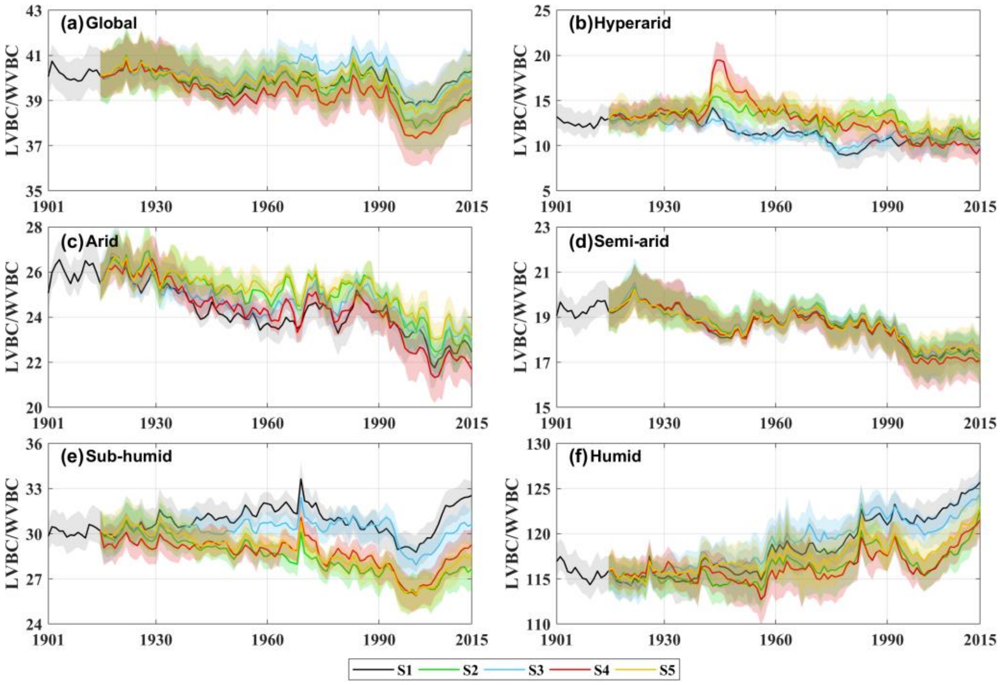

Figure 11. Temporal fluctuations in carbon stock dynamics in vegetation biomass in different factorial simulations. Black indicates historical factorial simulation from 1901-2015, green indicates the CO_2-driven factorial simulation, blue indicates the precipitation-driven factorial simulation, red indicates the temperature-driving factorial simulation and yellow indicates radiation driven factorial simulation. Uncertainty bounds are provided as shaded areas reflect the intra-annual fluctuation (± 1 s.d.) (a) Modelled trend of LVBC/WVBC ratio in Global area. (b-f) Modelled trend of the LVBC/WVBC ratio in different hydrological regions (Figure 1).

(see Revision, Page 26)

2. Pasture exclusion

I appreciate the authors having made this change to their analyses, as I suggested. However, I'm a bit unclear as to how they actually did it. L338-42 are confusing, but I interpret them as saying: "To minimize confounding effects of livestock grazing, we excluded grassland grid cells with pasture fraction greater than 1%."

If my interpretation is correct, it's hypothetically possible for a "forest" gridcell that's 51% forest and 49% grassland, with LUH2 saying "49% of the area in this gridcell is pasture," and it wouldn't be excluded. This doesn't seem right. Instead, the authors should exclude any gridcell with a significant pasture fraction, whether it's classified as "grassland" or not. 1% might be too strict, though—maybe something like 10% instead.

Also, make it clear that this exclusion only applies for the NPP comparison.

Response: Thanks for your constructive suggestion. Following your suggestion, we redefined the gird cells affected by livestock grazing where the fraction of managed pasture is greater than 10%. We added more detailed explanation as below:

"When the fraction of managed pasture is over 10%, the grid was considered to be affected by the managed pasture. To reduce the interference effects of livestock grazing, we first removed the grids affected by managed pasture. Then, we map the distribution of natural vegetation zones without anthropogenic disturbance (Figure A6). We declare that this exclusion method is only used for potential NPP comparison." (see Revision, Page 14, Lines 343-347)

3. Unimodal pattern in Fig. 10

In my initial review, I raised the question of why ΔWVBC decreases along the aridity axis from semi-arid to humid regions. The authors have not actually addressed this, despite an attempt at L556-9. "Drought mitigation promotes the growth of WVBC"—okay, sure, that explains why it initially increases from left to right. "humid region with high light competition limits root growth"—but this figure is about WVBC, not LVBC. Why would high light competition in humid regions lead to decreased ΔWVBC relative to semi-arid regions? (My thinking is it's because vegetation in these regions is light-limited: They're not seeing any alleviation of that limitation with climate change.)

Response: Thanks for your constructive comment. Yes, light resources are limited in each grid cell. Humid regions are covered by vegetation with higher plant height. Plants usually face intensified light-competition in humid regions, so plants must invest and allocate as much non-structural carbon as possible into leaf and trunk. This allocation scheme leads to the decreased investment of ΔWVBC in wet regions. We added more detailed illustration of the unimodal pattern in the revised manuscript.

"Drought mitigation promotes the growth of WVBC. In sub-humid and humid regions, plants face intensified light-competition and have to invest as much non-structural carbon as possible into leaf and trunk. This allocation scheme leads to the decreased investment of ΔWVBC in wet regions." (see Revision, Page 28, Lines 578-581)

4. Other issues with interpretation: Results

Some of these suggestions might seem like they're better suited for a Discussion section than a Results section, but I think it would not be good writing to simply list a set of observations with no context, then explain them somewhere later in the paper. The current Discussion section is well structured in the sense that it provides a general overview of the results and then compares to previous literature.

L461-2: It's not that plants stop growing; they're still alive! It's that they don't end up increasing their carbon stocks—i.e., it's so dry that they can't take advantage of higher CO2.

Response: Thanks for your encouraging comments and constructive suggestion. We modified this sentence as below:

"In extreme water stress, the increase of LVBC tends to zero and plants stop increasing their carbon storage." (see Revision, Page 23, Lines 468-469)

5. L462-3: What does it *mean* that there's no obvious difference among the slopes?

Response: Thanks for your detailed comment. We have clarified this in the revised manuscript added more detailed explanations in order to help readers understand better as below:

“There is no obvious difference in the slopes of fitting curves between factorial simulations, which shows the robustness in the response of LVBC to the change of water stress.” (see Revision, Page 23, Lines 469-471)

6. L472-483: What do all these factorial results mean? It is not sufficient to just saying how big the difference is between the minimum and maximum experiment. What do they imply regarding the drivers of partitioning according to your hypotheses? You approach this for LVBC at L475-7, but you don’t actually connect the results back to the hypotheses. (And you don’t do this at all for WVBC.) Guide the reader!

L472-4: I’m not sure where these numbers come from.

L473: “changed” should be “ranged”, I think. You’re not comparing a change, you’re comparing across a range of aridity classes. Unless I’m misunderstanding—as I said, I don’t know where the numbers came from.

Response: Thanks for your constructive comment. We are sorry for these confusions. We have re-written this sentence.

“Figure A7b shows that the maximum change magnitude of LVBC density across all factorial simulation is 1.202 kg C m^{-2} in the hyper-arid regions for the 1916-2015 period. As shown in Figure A7f, the maximum change magnitude of LVBC density in humid regions is 6.068 kg C m^{-2} during the same period. In Figure A8b, the maximum change magnitude of WVBC density across all factorial simulation is 0.011 kg C m^{-2} in the hyper-arid regions during the time of 1916-2015. In Figure A8f, the maximum change magnitude of WVBC density is 0.046 kg C m^{-2} in humid regions during the same period. Compared with plants lived in aridity regions, plants in humid regions show more dramatic responses to the stimulation from drivers’ change. With a lessening of water stress (from hyper-arid to humid region), the response magnitudes of the carbon stock to the changes of climate and CO_2 gradually become more noticeable. The robust pattern in the zonal average density of the carbon stock shows that terrestrial water limitations strongly regulate the enhanced magnitude of the carbon stock.” (see Revision, Pages 23-24, Lines 480-490)

7. Fig. 11 (L484-97)

Again, guide the reader. Here you've done a good job of phrasing the results in a way that connects back to hypotheses ("Under the synergistic effect of drivers and water stress, … there is a larger proportion of biomass allocated to, and stored in, light-gathering vegetation organs."), but it's unclear how that is evident from the figure. Is it because the blue line is so much higher than the other lines? But why only in sub-humid and humid zones? And there, what does it mean that the ratio goes back down when additional factors are added after S3?

Response: Thanks for your encouraging comments and constructive suggestion. Figure 6 shows that LVBC and WVBC significantly increased in the past hundred years, while the increasing rates of LVBC and WVBC are obviously different (Figures 7d and 11a). Based on the simulated results, we found that LVBC increased faster than WVBC because more non-structural carbon was allocated to leaf and trunk in sub humid and humid zones under the synergistic effect of drivers and water stress. S4 and S5 represent the effect of CO_2 + temperature and the effect of CO_2 + radiation on carbon stocks, separately. Compared with S3, the ratio goes back down in S4 and S5, which indicates that precipitation is the main contributing factors to the change of LVBC/WVBC ratio. We added more detailed explanations in revised manuscript as below:

"Under the synergistic effect of drivers and water stress, the trends of light- and water-gathering vegetation carbon stock are upward in the past hundred years (Figure 6). However, there is a difference in the increasing rate between LVBC and WVBC, resulting in a dramatic and complicated fluctuation in global LVBC/WVBC ratio (Figure 11a). The density of LVBC decreases and that of WVBC increases in hyper-arid and arid zones for all factorial simulations (Figures A7 and A8). So, the ratio of LVBC and WVBC shows a downward trend in these zones. LVBC in semi-arid regions shows upward tendency in the past years (Figure A7d) because of the aridity mitigation. There is an upward trend in WVBC in semi-arid (Figure A8d). Plants in semi-arid still utilize a tolerance strategy and allocates more non-structural carbon to water-gathering vegetation organ to resist water stress, resulting in the decline of LVBC/WVBC ratio. In humid zones, light- and water-gathering biomass carbon stocks both increased in all factorial simulations (Figures A7 and A8). The proportion of LVBC increases more than that of WVBC for capturing more resources like CO_2 and radiation energy, leading to an increase in the LVBC/WVBC ratio. The value of LVBC/WVBC in S3 is higher than that in S4 and S5, which represents that precipitation makes more contributions to the change of LVBC/WVBC ratio among meteorological factors." (see Revision, Page 25, Lines 500-515)

8. L488: What does "variation range of ratio between LVBC and WVBC" mean? Interannual variation? Variation among factorial experiments? Neither seems to match the trend mentioned.

Response: Thanks for the detailed comments. "the variation range of ratio between LVBC and WVBC" was changed to "the fluctuation range of LVBC/WVBC ratio", which represents the response magnitude of LVBC/WVBC ratio to changes in climate and CO_2. We have re-written this sentence to help readers understand better.

"From hyper-arid zones to humid zones, the fluctuation range (the difference between maximum value and the minimum value in each factorial simulation) of LVBC/WVBC ratio significantly changes. The fluctuation magnitudes of LVBC/WVBC in humid and hyper-arid zones are greater than that in other hydrological zones. Compared with plants in hyper-arid zones, plants in humid zones exhibit more significant responses to changes in climate and CO_2." (see Revision, Pages 24-25, Lines 494-499)

9. Other issues with interpretation: Discussion

L503-29: LVBC and WVBC trends overall

This is very confusing and disjointed. L514-7 and L527-9 make it seem like plants are tending to shift their allocation from WVBC to LVBC, but then L519-20 ("LVBC…

dominates the long-term trends") and L525-7 seem to suggest the opposite. What's correct? Here's a hint-focus on the ratio. The absolute numbers I think are not very informative about allocation changes, because wood biomass is always so much higher than fine root biomass.

Response: Thanks for your detailed comments. In this study, we found that LVBC significantly increased 116.18 ± 2.34 Pg C, accounting for 97.42% of the total carbon stock increase. WVBC increased 3.08 ± 0.14 Pg C. So, we suggested that the LVBC predominates the spatio-temporal pattern of total carbon storage potential and dominates the long-term trends of vegetation carbon stock at the global scale. Meanwhile, Figure 7d showed that there was a slight upward trend in the ratio of LVBC/WVBC, because LVBC increased more dramatically than WVBC in the past decades. We suggest that plants change the allocation scheme and store more non-structure carbon into LVBC. We have re-written sentences as below:

"LVBC increases 116.18 ± 2.34 Pg C from 1916 to 2015, accounting for 97.42% of the total carbon stock increase (119.26 ± 2.44 Pg C). The long-term trends and spatial pattern of vegetation carbon stock are predominated the variability characteristic of LVBC." (see Revision, Page 27, Lines 537-539)

"During the past hundred years, the ratio of LVBC/WVBC showed a slight upward trend since LVBC increased more dramatically than WVBC." (see Revision, Page 27, Lines 546-547)

10. What does "Compared with WVBC" mean here? Does it mean "116.18 ±2.34 Pg C" is ΔLVBC minus ΔWVBC?

Response: Thanks for your detailed comments. We removed the sentence "Compared with WVBC" in the revision. The "116.18 ± 2.34 Pg C" is the increasing value of LVBC from 1916 to 2015. We added more detailed illustration about "116.18 ±2.34 Pg C" as below:

“LVBC increases 116.18 ± 2.34 Pg C from 1916 to 2015, accounting for 97.42% of the total carbon stock increase (119.26 ± 2.44 Pg C).” (see Revision, Page 27, Lines 537-538)

11. L520-2: Yes, but then why is increasing ΔWVBC concentrated in high latitudes? The difference here might be something that partitioning theory could explain, or maybe not—maybe it’s just a relaxation of climate limitations in the high latitudes that low latitudes never experienced (as possibly suggested at L545-7).

Response: Thanks for your detailed suggestion. Yes, we agree that climate limitations may be able to explain the spatio-temporal patterns of WVBC. We added explanations about the variant patterns of WVBC as below:

“Under the influences of environmental stressors, WVBC increases significantly in boreal latitudes” (see Revision, Page 27, Lines 541-542)

12. L531-47: Factorial experiments

This needs to be cleaned up a lot. For one thing, just listing these numbers feels much more like something for the Results rather than the Discussion. Here, you should be focusing on the implications of your results for scientific understanding, and comparing your results to previous literature. For another, the presentation of results is really confusing. For example, radiation doesn't “dominate” the trend at any latitude band. It explains 20.67% of the global variation, though. Explain where these numbers are coming from (Fig. 8b/d, adding the (–) and (+) numbers at the bottom of each). But then maybe I have it wrong—it doesn' t make any sense for any of these "fraction of variation explained" numbers to be negative, as they are for, e.g., precip → WVBC (–2.76%). Do you mean instead that the net influence of precip on WVBC is negative?

Response: Thanks for your detailed comment. In this study, we reveal the effects of drivers’ changes on carbon stocks from global and grid cell perspectives, respectively.

We listed some results from Figure 8 to better reveal the discrepancy from two perspectives in the Discussion. The number “-2.76%” represents the negative effects of precipitation on the changes of WVBC from 1916-2015 at the global scale. We added more detailed illustration in revision as below:

“Figure 8c shows there are negative effects and contributions of precipitation on the change in WVBC at the global level (–2.76%, –0.013 g m^{-2} yr^{-1}).” (see Revision, Page 21, Lines 443-444)

We used the method from Piao et al. (2006, Geophysical Research Letters, 33(23), L23402) to identify the dominated factors of each grid and quantify its contribution, which is shown in Figure 8 b/d. We added more detailed illustration about results to help readers understand better. The Figure 8 in the revised manuscript have been improved.

“While the increase or decrease in the carbon stock may be attributed to more than one driving factor, within any specified grid, the one with the highest positive or negative contribution is the dominated driver that consistently resulted in the highest increase or decrease in the carbon stock for that grid.” (see Revision, Page 20, Lines 426-429)

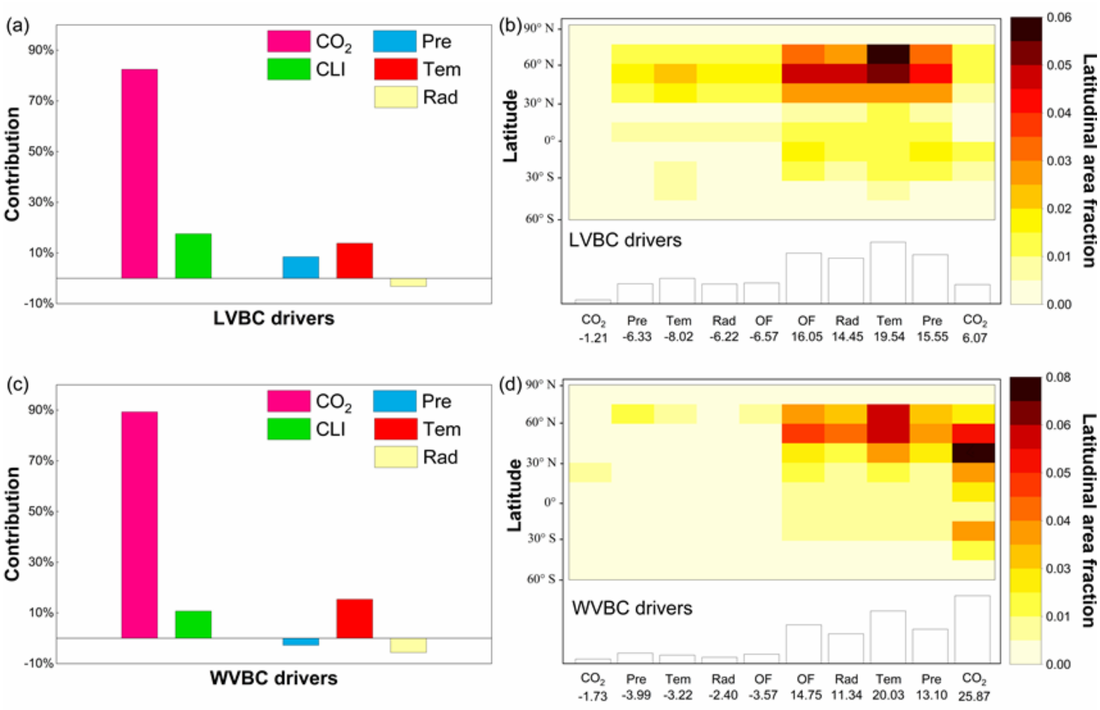

Figure 8. The proportion of change in the vegetation biomass carbon stocks attributed to driving factors. Ratios of the driving factors of CO_2 fertilization effects (CO_2), climate change effects (CLI), precipitation (Pre), temperature (Tem), radiation (Rad) for LVBC (a) and WVBC (c) under the five scenarios using the Mann-Kendall and Sen's slope estimator statistical tests. Attribution of LVBC (b) and WVBC (d) dynamics to driving factors calculated as averages along 15° latitude bands. At local scales, the driving factors include CO_2, Pre, Tem, Rad, and other climate factors (OF). The fraction of global area (%) that is predominantly influenced by the driving factors is showed at the bottom of the bar. The '-' symbol before fraction indicates a negative effect of the driving factor on carbon stock, and vice versa.

(see Revision, Pages 20-21)

We have re-written this sentence in Discussion.

"At the grid cell scale, shown in Figure 8b and 8d, radiation and precipitation dominate the long-term trend of carbon stocks over one third of global grid cells. At the global scale, radiation and precipitation explain approximately 10% of long-term trend in LVBC and WVBC (Figure 8a and 8c). LVBC and WVBC variations driven by precipitation and radiation are ultimately offset by spatially compensatory effects, which dampens the response of the carbon stock to these factors at global scale (Jung et al., 2017). This spatially compensatory effect of climate changes is consistent with previous analyses (Zhu et al., 2016) that climate changes explain 8% of the increasing carbon storage of global foliage, while climate changes dominate the greening trend over 28.4% of the global land." (see Revision, Page 28, Lines 557-564)

13. L531-2: Is this conclusion drawn from Fig. 8? If so, I would rephrase to talk about the amount of variation explained, rather than the amount of increase. Always mention what figure(s) your assertions come from.

Response: Thanks for your detailed comment. Following your suggestion, we reworded the sentence in the revision as below:

“Based on our factorial simulations (Figure 8), the influences of CO_2 fertilization induce the most significant variation of the vegetation carbon stock. In addition, the responses of carbon stocks to the changes of climatic factors are obvious, particularly at the zonal scale.” (see Revision, Pages 27-28, Lines 552-554)

14. L535-540: Still need to do a better job of tying these results back to the hypotheses and/or to other explanations. The sentence at L539-40 might be directly relevant to optimal partitioning theory, depending on what it ends up saying after the authors clean up the section.

Response: Thanks for your constructive comment. We added more detailed explanation about this citation to compare our findings with previous explanations.

“This spatially compensatory effect of climate changes is consistent with previous analyses (Zhu et al. 2016) that climate changes explain 8% of the increasing carbon storage of global foliage, while climate changes dominate the greening trend over 28.4% of the global land.” (see Revision, Page 28, Lines 562-564)

15. L578-90: Caveats

L587-90: This sentence could be interpreted as “We didn’t vary N deposition over the experiment,” when in reality no N deposition was included at all. This means that the simulated ecosystems would have an incorrectly low amount of N input, leading to incorrectly high amounts of N limitation, leading to an underestimate of CO2 fertilization (because if they’re N-limited, they can’t take advantage of higher CO2 levels). This is the opposite of what the authors seem to conclude.

Response: Thanks for your constructive comment. We changed the sentence to “which leads to a slight underestimate of the contributions of CO_2 fertilization on biomass production.” (see Revision, Page 30, Lines 616-617)

16. To avoid confusion (such as I exhibited in my first review), aridity index axes on all figures with them should include (something like) “drier” at 0 and (something like) “wetter” at 1. Or at least an explanation of this should be in the caption. The axes should also include labels indicating what the ranges are for the different classifications (humid, semi-arid, etc.).

Response: Thanks for your constructive suggestion. Following your suggestion, we added more explanations about the aridity index and hydrological zones in the caption of Figures 9 and 10.

“Categories of hydrological zones include: hyper-arid ($AI \leq 0.05$), arid ($0.05 < AI \leq 0.2$), semi-arid ($0.2 < AI \leq 0.5$), sub-humid ($0.5 < AI \leq 0.65$), and humid ($AI > 0.65$).” (see Revision, Pages 22-23)

“Categories of hydrological zones include: hyper-arid ($AI \leq 0.05$), arid ($0.05 < AI \leq 0.2$), semi-arid ($0.2 < AI \leq 0.5$), sub-humid ($0.5 < AI \leq 0.65$), and humid ($AI > 0.65$).” (see Revision, Page 24)

17. L50: “are” should be “is”

Response: Corrected. (see Revision, Page 2, Line 50)

18. L56-8: Citation?

Response: Thanks. We added the citation. (see Revision, Page 2, Line 58)

19. L76: “region” should be “regions”

Response: Corrected. (see Revision, Page 3, Line 76)

20. L82-83: The two parts of this sentence seem to contradict each other.

Response: Thanks for your detailed comment. We added more detailed illustration about this example in order to help readers understand better as below:

"For example, global warming positively stimulates plant productivity (Keenan et al. 2017), while Madani et al. (2020) found that plant productively with water stress show a negative response to temperature rise in tropical zones." (see Revision, Page 3, Lines 82-84)

21. L84: "predictable" should be "predicted"

Response: Corrected. (see Revision, Page 3, Line 85)

22. L104-6: It's not really a proxy; this is just how you define it. (Which is fine, of course!)

Response: Thanks. "a proxy" was changed to "an indicator". (see Revision, Page 4, Line 107)

23. Good clarification of model timesteps

Response: Thanks for your encouraging comment.

24. L175-6: "doesn't include" should be "isn't included"

Response: Corrected. (see Revision, Page 7, Lines 176-177)

25. L207: Define "soffit" (or, ideally, use a simpler word, like "layer").

Response: Thanks, "soffit" was changed to "layer". (see Revision, Page 8, Line 208)

26. L220-1: Not a complete sentence. Suggest changing the period to a comma and deleting "This".

Response: Corrected. (see Revision, Page 8, Lines 221-222)

27. L221: "NSC" not previously defined (should happen at L187).

Response: Thanks. "NSC" was changed to "non-structural carbon" in the revision. (see Revision, Page 8, Line 222)

28. L221-2: Clarify that these organs are not explicitly simulated (unless they are!), and instead are represented as a flux to litter.

Response: Thanks for your constructive suggestion. We added explanation as below:

"These organs are not explicitly modelled in SEIB-DGVM." (see Revision, Page 8, Lines 223-224)

29. L254: Delete "in PFTs", maybe? What does it mean?

Response: Thanks. We deleted "in PFTs". (see Revision, Page 9, Line 256)

30. L257-8: GVBC should be LVBC.

Response: Corrected. (see Revision, Page 10, Line 260)

31. L259-63: "wood" should be "woody vegetation".

Response: Corrected. (see Revision, Page 10, Lines 261-262)

32. L257-263: $Wmass$ should be renamed, e.g. to $Tmass$ (T for "tree" [or "trees and shrubs"] instead of W for "woody vegetation"), to avoid confusion with other use of W for "water gathering".

Response: Corrected. (see Revision, Pages 9-10, Lines 259-266)

33. L274-7: The "remarkable effects" comment about wind and relative humidity is a result; don't include it in Methods. Deleting that comment will allow wind and RH to replace "other factors" in the previous sentence.

Response: Thanks. Following your suggestion, we have re-written this sentence as below:

"In order to further quantify the relative contributions of varying atmospheric CO_2 concentrations, precipitation, temperature, radiation, and other factors (wind velocity and relative humidity), we performed six factorial simulations." (see Revision, Pages 10-11, Lines 276-278)

34. L294: "A2, 3" should be "A2–3" or "A2 and A3"

Response: Corrected. (see Revision, Page 11, Line 295)

35. Figs. A2–3: Caption should include experiment labels S2 etc.

Response: Thanks. We rewrote the caption of Figures A2 and A3 as below:

"Figure A2. Potential LVBC trend maps during the period of 1916 to 2015 under different factorial simulations. (a) CO_2 driving factorial simulation (S2); (b) CO_2+precipitation driving factorial simulation (S3); (c) CO_2+temperature driving factorial simulation (S4); and (d) CO_2+radiation driving factorial simulation (S5)." (see Revision, Page 32)

“Figure A3. Potential WVBC trend maps during the period of 1916 to 2015 under different factorial simulations. (a) CO_2 driving factorial simulation (S2); (b) CO_2+precipitation driving factorial simulation (S3); (c) CO_2+temperature driving factorial simulation (S4); and (d) CO_2+radiation driving factorial simulation (S5).” (see Revision, Page 33)

36. L328-9: “It was defined as vegetation grid that the land cover type of this grid is” should be “We defined vegetated grid cells as those whose largest component was”. This grammatical correction turns out to also be a simplification, as it then allows the deletion of the sentences at L332-4.

Response: Thanks. We changed this sentence in original manuscript L328-9 and removed the sentences in original manuscript L332-4.

“We defined vegetation grid cells as those whose largest component was evergreen needleleaf forest, evergreen broadleaf forest, deciduous needleleaf forest, deciduous broadleaf forest, mixed forest, closed shrublands, open shrublands, woody savannas, savannas or grasslands.” (see Revision, Pages 13-14, Lines 332-335)

37. L331-2: Replace this with a simpler sentence along the lines of “Other grid cells were excluded from our analysis.”

Response: Corrected. (see Revision, Page 14, Lines 335-336)

38. L334: Start a new paragraph here, as you’re talking about something new.

Response: Corrected. (see Revision, Page 14, Line 338)

39. Fig. A4: There should be a clear break in the color bar at whatever threshold you end up using (currently 1%). Also, red-green axes should be avoided, because red-green colorblindness is relatively common

Response: Thanks for your constructive comment. Following your suggestion, we remap the distribution of managed pasture.

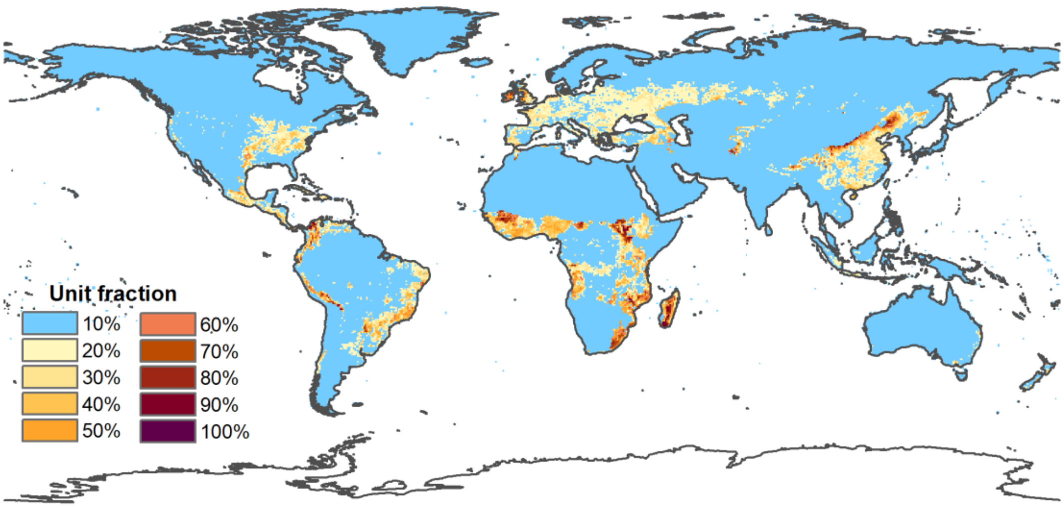

Figure A5. Spatial distribution of multi-year average fraction of managed pasture from 2001-2015 at 0.5 × 0.5 arc-degree resolution.

(see Revision, Page 34)

40. Fig. A5: “NNG (no natural vegetation)” should more accurately be something like “NI (not included)”. END” should be “ENF”.

Response: Thanks. We corrected the legend in Figure A6 (Fig. A5 in original manuscript) as below:

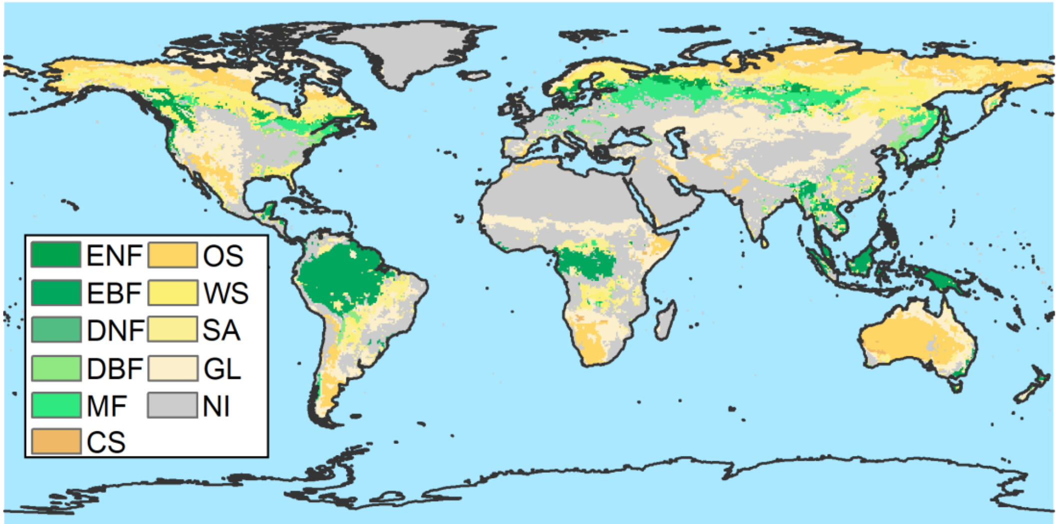

Figure A6. Map of land vegetation without anthropogenic disturbance from MCD12C1 and LUH2. ENF: Evergreen needleleaf forest, EBF: Evergreen broadleaf forest, DNF: Deciduous needleleaf forest, DBF: Deciduous broadleaf forest, MF: Mixed forest, CS: Closed shrublands, OS: Open shrublands, WS: Woody savannas, SA: Savannas, GL: Grasslands, NI: Not included, which means the zone is not covered by vegetation without anthropogenic disturbance.

(see Revision, Page 34)

41. Fig. 4: Pixels that were excluded based on land cover should be colored gray, to distinguish from included pixels with low correlation.

Response: Corrected.

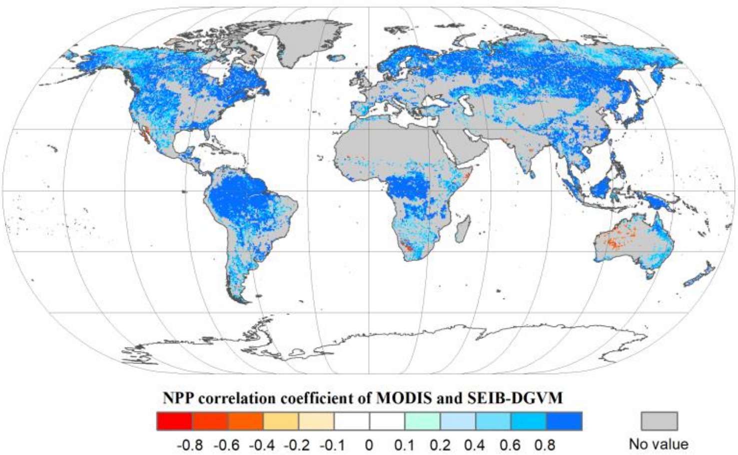

Figure 4. Spatial patterns in the potential NPP correlation coefficients (P<0.05) between SEIB-DGVM and MODIS between 2001–2015. These data were used to

validate SEIB-DGVM.

(see Revision, Page 15)

42. Fig. 5: This is much better than the previous bar graph version. My only suggestion is to delete “Dynamic of” from the Y-axis label.

Response: Corrected.

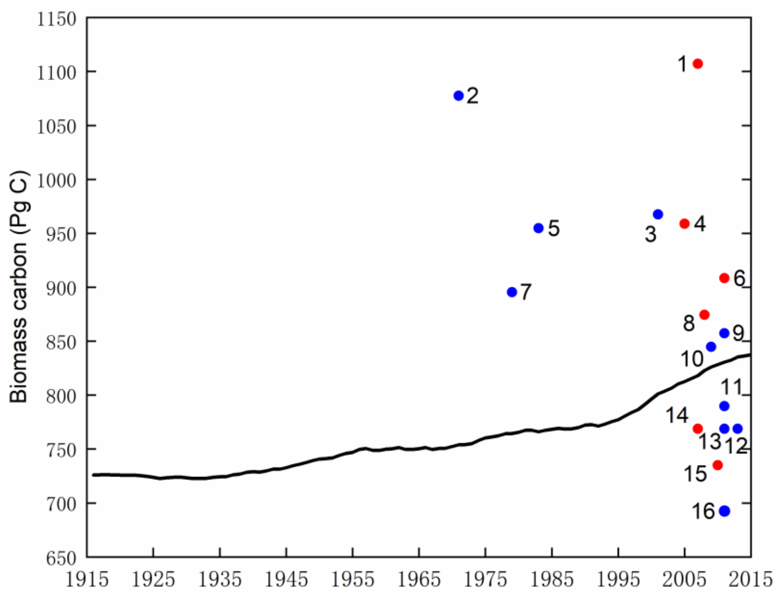

Figure 5. Estimates of the potential vegetation biomass carbon stock from the literature (blue plot), state-of-the-art datasets (red plot) and this study (black line). Datasets are from the following studies: (1)(Erb et al., 2018; Erb et al., 2007), (2)(Bazilevich et al., 1971), (3)(Saugier et al., 2001), (4)(Erb et al., 2018; Bartholome and Belward, 2005), (5)(Olson et al., 1983), (6)(Erb et al., 2018; Pan et al., 2011), (7)(Ajtay et al., 1979), (8)Erb et al., 2018; Ruesch and Gibbs, 2008), (9)(Kaplan et al., 2011), (10)(Shevliakova et al., 2009), (11)(Kaplan et al., 2011), (12)(Pan et al., 2013), (13)(Prentice et al., 2011), (14)(Erb et al., 2018; Erb et al., 2007), (15)(Erb et al., 2018; West et al., 2010), (16)(Hurtt et al., 2011).

(see Revision, Page 16)

43. Fig. 6: (a): Delete “Dynamic of” from right Y-axis label.

Response: Corrected.

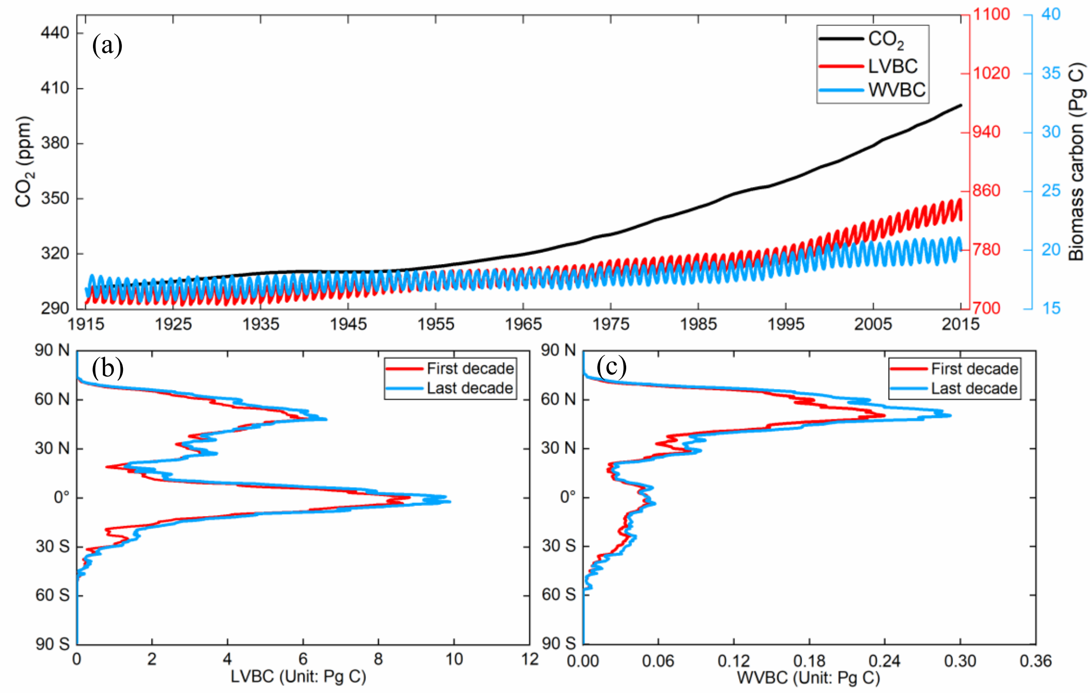

Figure 6. Global potential biomass carbon stocks of vegetation during the past 100 years. (a) The evolution of global potential biomass stocks (LVBC+WVBC), along with changes in biomass stocks that can be attributed to the variability and trend of LVBC and WVBC through the twentieth century. The red line represents the monthly value of LVBC, the blue line represents the monthly value of WVBC, and the black line represents the annual value of CO_2 concentration. (b, c) Zonal averaged sums of the annual LVBC and WVBC for latitudinal bands during the first decade (1916–1925, red line) and the last decade (2006–2015, blue line) shows the increased carbon stock capacity.

(see Revision, Page 17)

44. Could also refer to Fig. 7 for extra support in this section.

Response: Thanks. We added the citation of Figure 7 in section 3.2 as below:

"The latitudinal bands of increasing annual LVBC are mainly distributed in the tropical and boreal latitudes, which is consistent with Figure 7b." (see Revision, Page 17, Lines 381-382)

"There is a single peak in the spatial variation of annual WVBC (Figure 6c and Figure 7c)." (see Revision, Page 18, Line 386)

45. L385: "while they declined"

Response: Corrected. (see Revision, Page 18, Line 390)

46. L387: "decrease" should be "decreasing"

Response: Corrected. (see Revision, Page 18, Line 392)

47. Figs. 9-10: Are Y-axis units per year? It would be easier to relate to other figures if they were total over the simulation.

Response: Thanks. Y-axis units represents the accumulated change value of LVBC or WVBC from 1916 to 2015. We added explanation in the revision.

"As shown in Figures 9 and 10, with the accumulated change of LVBC or WVBC in the period of 1916 to 2015 across the aridity index (i.e., an increase in available water)" (see Revision, Page 23, Lines 464-466)

48. L460: "enhance" should be "increase".

Response: Corrected. (see Revision, Page 23, Line 467)

49. L460-1: That's not really from the factorial simulations; it's obvious from the historical simulation.

Response: Thanks for your constructive suggestion. We added more detailed explanation as below:

"Based on the results of historical simulation (Figure 9), we find a positive relationship between LVBC and aridity index." (see Revision, Page 23, Lines 467-468)

50. L461: "water pressure" should be "aridity".

Response: Corrected. (see Revision, Page 23, Line 468)

51. L462: "different" should be "difference"

Response: Corrected. (see Revision, Page 23, Line 469)

52. L476: Should be "matches", not "matchs"

Response: Thanks. We are very sorry for our incorrect writing and removed it in revised manuscript.

53. L490: "Positive influence" is unclear, and "allocate" should be "allocation"

Response: Corrected.

"Meanwhile, the long-term effects of driver changes have a remarkable influence on this carbon allocation pattern at global level. (Figure 7d)" (see Revision, Page 25, Lines 499-500)

54. L503-29: LVBC and WVBC trends overall. L520: For clarity, say "annual **change in** LVBC"

Response: Corrected. (see Revision, Page 27, Lines 539-540)

55. Great improvements here with regard to comparison to other literature and tying back to theory.

Response: Thanks for your encouraging comment.

56. L552: “region” should be “regions”

Response: Corrected. (see Revision, Page 28, Line 574)

57. L550-2: Refer to figures supporting this (presumably Figs. 9 and 10).

Response: Thanks. We added the citation of Figures 9 and 10 as below:

“These results indicate that vegetation in humid regions is responsible for most of the trend in global LVBC, while plants in semi-arid regions play a dominate global role in controlling the long-term trend in WVBC (Figures 9 and 10).” (see Revision, Page 28, Lines 572-575)

58. L565: Start a new paragraph here, since you’re switching from analyzing your results to comparing them with previous literature.

Response: Corrected. (see Revision, Page 29, Line 591)

59. L567-8: Description of Madani et al. (2020) is too vague. “Variable”? In what way, and how does it compare to your results?

Response: Thanks for your detailed comment. We added more explanations and compared my results with previous conclusion, and suggested that terrestrial hydrological conditions significantly affect the carbon cycle process of terrestrial ecosystem.

“Madani et al. (2020) found that changes in water constraints significantly affect the response patterns of ecosystem productivity and net carbon exchange. Humphrey et al. (2021) found that increasing water stress limits the response magnitude of carbon uptake rates through a down-regulation of stomatal conductance and suggested that land carbon uptake is driven by temperature and vapour pressure deficit effects that are controlled by terrestrial water availability. Ma et al. (2021) found that plants increase investment into building roots in arid region because the extent of water limitation there is exacerbated by global warming. Terrestrial hydrological conditions significantly affect the carbon cycle process of terrestrial ecosystem, including carbon uptake, allocation, and stock.” (see Revision, Page 29, Lines 592-600)

60. L578-90: Caveats. L584: I would say “apparent underestimate,” as the numbers from SEIB-DGVM aren’t wrong—they’re measuring something different.

Response: Corrected. (see Revision, Page 29, Line 611)

61. L592-601: Conclusion. L594: “to” should be “vs.” or “and”

Response: Corrected. (see Revision, Page 30, Line 621)

Thanks again for your time and efforts put on this manuscript.