Responses to the reviewers

Title: Future response of ecosystem water use efficiency to CO2 effects in the Yellow River Basin, China

Authors: Siwei Chen, Yuxue Guo, Yue-Ping Xu, and Lu Wang

We thank the referees for your kind evaluation of our manuscript and for your insightful comments, which will be a great help in improving the quality of our paper. We will carefully revise the manuscripts according to your comments and suggestions.

RC1:

The authors developed a new land-atmosphere attribution framework to quantify the impacts of climate and underlying surface changes on WUE. This paper gives a rigorous mathematical proof and physically meaningful explanation for this framework and applies it to the Yellow River Basin (YRB), China. The results explained the future WUE trends and attribution outcomes in the YRB. In addition, the paper found an interesting two-stage response pattern of WUE to drought as well as future changes in the pattern. The findings of this study can be very helpful for ecosystem monitoring and health management.

The paper is well written and of high interest to the HESS readership. Overall, I think it has the potential to become a very interesting contribution, and I believe that it deserves to be published after some minor corrections. Below I list some comments that hopefully help to strengthen the paper.

Answer: Thank you very much for reviewing our manuscript and for your valuable insights. We have carefully considered each of your suggestions and have made corresponding revisions to the manuscript.

General comments

1. Introduction: Why was TWSA-DSI chosen as a drought indicator? Does it have any advantages over other drought indicators? I suggest the authors to explain accordingly in the introduction section.

Answer: Thanks to your suggestion. We have explained the advantages of TWSA-DSI in Section 1 *Introduction*.

L67:

This index effectively monitors regional drought characteristics and development paths (Yin et al., 2022). Compared to other traditional drought indicators such as Palmer drought severity index (PDSI), soil moisture drought index (SMI), standardized precipitation index (SPI), standardized runoff index (SRI), etc., TWSA-DSI is better able to detect overall regional drought conditions and to explore the effects of drought on hydrological systems and vegetation growth (A et al., 2017; Du et al., 2019; Zhao et al., 2017). This study chooses to use TWSA-DSI to identify regional drought events, allowing for a more nuanced understanding of how WUE may adapt or respond to these conditions in various ecosystems.

A, Geruo., Velicogna, I., Kimball, J. S., Du, J., Kim, Y., Colliander, A., and Njoku, E.: Satellite-observed changes in vegetation sensitivities to surface soil moisture and total water storage variations since the 2011 Texas drought, Environ. Res. Lett., 12, 054006, https://doi.org/10.1088/1748-9326/aa6965, 2017.

Du, J., Kimball, J. S., Velicogna, I., Zhao, M., Jones, L. A., Watts, J. D., and Kim, Y.: Multicomponent Satellite Assessment of Drought Severity in the Contiguous United States From 2002 to 2017 Using AMSR-E and AMSR2, Water Resources Research, 55, 5394–5412, https://doi.org/10.1029/2018WR024633, 2019.

Zhao, M., A, G., Velicogna, I., and Kimball, J. S.: Satellite Observations of Regional Drought Severity in the Continental United States Using GRACE-Based Terrestrial Water Storage Changes, Journal of Climate, 30, 6297–6308, https://doi.org/10.1175/JCLI-D-16-0458.1, 2017.

2. Introduction: I suggest the authors add a paragraph introducing the structure of this paper.

Answer: Thanks to your suggestion. We have added chapter introductions at the end of Section 1.

L78:

The reminder of this paper is organized as follows. Section 2 describes the study area and the data used. Section 3 defines the methodology. Section 4 and Section 5 gives the results and discussion of the study, respectively. Finally, Section 6 concludes the paper.

3. In L22-23 you defined the WUE as the ratio of GPP and ET. I suggest authors write the defining mathematical expression for WUE.

Answer: Thanks to your suggestion. We have labeled the formulas in the appropriate places to make it easier for the reader to understand them.

L22:

Ecosystem water use efficiency (WUE) is commonly defined as the ratio of the ecosystem's gross primary productivity (GPP) to water evapotranspiration (ET), i.e.,

$WUE = GPP/ET$, which reflects the carbon gain per unit of water lost (Keenan et al., 2013; Li et al., 2023; Naeem et al., 2023).

4. Section 3.1: Since trend-preserving bias correction is not well-known to readers, please add more details about trend-preserving bias correction.

Answer: Thanks for your suggestion. In order to balance the brevity and clarity of the language of the article, we have added the formula in the appropriate places to explain the core idea of this method. We also provide further clarification on the use of this method.

L154:

Step 3. Adjust the distribution of x_{fut}^{Dsim} based on x_{fut}^{Dobs} by quantile mapping. The formula is as follows:

$$x_{fut}^{\text{Dobs}} = x_{his}^{\text{Dobs}} + (x_{fut}^{\text{Dsim}} - x_{fut}^{\text{Dsim}})$$

Step 4. Add the results from *Step 3* to the trend values previously subtracted to get the corrected results.

This study took into account the variations in the frequency distribution functions of TWSA across different periods, thereby implementing corrections for individual months separately. The results indicate that this month-specific correction approach yields better outcomes than a correction approach that does not differentiate by month.

5. L13: 'be-comes' should be 'becomes'.

Answer: Thanks for the heads up. We have corrected it.

6. L55: 'there has been' should be 'there have been'.

Answer: Thanks for that. We have corrected it.

7. In L96 'complementary relationship' appears only once in the text, and I recommend that there is no need to write out its abbreviation 'CR'.

Answer: Thanks for that. We have deleted the abbreviation 'CR' in L96.

8. L100: 'The GPP dataset were …' should be 'The GPP dataset was …'.

Answer: Thanks. We have corrected it.

9. L123-124: I would like to see these variables abbreviated in CMIP6 to make it

easier for readers to search to get this data.

Answer: Thanks to your suggestion. We have added the variables abbreviated in CMIP6.

L123:

In this study, we utilized simulated monthly data for GPP (gpp), evapotranspiration (evspsbl), precipitation (pr), and terrestrial water storage (mrtws), where the terms in parentheses represent the variable names within CMIP6.

10. The Equation 2 is very basic for the following derivation. However, it popped up without enough details, and should be derived step by step.

Answer: Actually, the linear formula was proposed by previous study (Cheng et al., 2011; Fang et al., 2020). We apologize for any confusion caused by unclear expressions, leading to misunderstandings among the readers. We have revised the original text to present the formula in a more logical and clear manner.

L164:

In this study, we analyzed the relationship between hydrological elements and vegetation structure. After a selection process, we employed the linear Budyko function structure for WUE as proposed in previous studies (Cheng et al., 2011; Fang et al., 2020). The formula is expressed as follows:

11. Section 4.4: The article chooses the same time span for calculating future drought response, but in theory does not eliminate the effect of long-term trends on WUE and TWSA. If the authors have done other measures to avoid the effect of the long-term trend, they should make a statement here.

Answer: Thank you for your insightful comment regarding the potential influence of long-term trends on WUE and TWSA calculations in Section 4.4. In response to your concern, we would like to clarify the approach taken to mitigate these effects.

To address the impact of long-term trends on the analysis, we have adopted a method where the mean and standard deviation of WUE and TWSA are calculated for different time periods separately. This approach allows us to derive anomaly values of WUE and the standardized TWSA value (TWSA-DSI), effectively normalizing the data to remove the influence of long-term trends. By calculating anomalies relative to the respective time periods, we ensure that the analysis focuses on variability and anomalies within those periods, rather than being skewed by broader temporal trends.

This method provides a more accurate reflection of the specific conditions and variations within each studied period, allowing for a robust comparison across different time frames and scenarios without the confounding effects of overarching trends. We have amended the statement in the original text accordingly.

L382:

In order to investigate how WUE responds to different levels of drought under various scenarios, we calculated the anomaly of WUE at each pixel under different drought levels and averaged the anomaly results across different GCMs. In the analysis of future drought responses, particular attention was given to the potential influence of long-term trends on the calculated values of WUE and TWSA. To mitigate this effect, we calculated the mean and standard deviation of WUE and TWSA for the same time spans separately to get WUE anomaly and TWSA-DSI, which ensures that our analysis focuses on the specific variations and conditions within each period. As shown in Figure 8…

12. Section 5.3: The authors explain how the 'two-stage response pattern' will change in the future through stomatal conductance. In fact, the data comes from models in CMIP6, and I suggest that the authors explain what effect CO_2 will have on stomatal conductance through the parameter settings of the model.

Answer: Thank you for your insightful comment. In response, we have clarified the mechanisms through which CO_2 influences stomatal conductance in the CMIP6 models used in our analysis, particularly focusing on the different parameter settings of each model's land surface model. We also drew Table 3 for this purpose and made some revisions in Section 5.3.

L495:

As mentioned before, the increase in atmospheric CO_2 concentration directly leads to a reduction in plant leaf stomatal conductance. In Table 3, it is evident that although different GCMs employ various models for stomatal conductance, the physical implications across these models consistently align with this principle.

Table 3

Model parameter settings for simulating stomatal conductance in the GCMs.

GCM	Land surface model	Stomatal conductance	REF.
CanESM5	CLASS-CTEM	$g_s = g_0 + \frac{g_1 A}{(1 + D/D_0)(c_s - \tau)}$	Leuning, 1995
CESM2	CLM5	$g_s = g_0 + \frac{1 + g_1\sqrt{D}}{c_a} A$	Lawrence et al., 2019

CMCC-ESM2	CLM4.5	$g_s = m\frac{A h_r}{c_s/P_{atm}} + \beta g_0$	Oleson et al., 2013
CNRM-ESM2-1	SURFEXv8.0	$g_s = \frac{1.6A}{c_s - c_i}$	Jacobs et al., 1996; Séférian et al., 2019
IPSL-CM6A-LR	ORCHIDEE	$g_s = n\frac{A h_r}{c_a} + b$	Krinner et al., 2005
NorESM2-LM	CLM5	$g_s = g_0 + \frac{1 + g_1\sqrt{D}}{c_a}A$	Lawrence et al., 2019

Notes: CLASS-CETM: coupled Canadian Land Surface Scheme and the Canadian Terrestrial Ecosystem Model. CLM5: Community Land Model version 5. CLM4.5: Community Land Model version 4.5. SURFEXv8.0: Surface Externalisée version 8.0. ORCHIDEE: Organizing Carbon and Hydrology in Dynamic Ecosystems Land Surface Model. g_s is the stomatal conductance; g_0 is the minimum stomatal conductance as assimilation rate reaches zero; g_1, D_0, b, m, n and β are empirical coefficients; A is the net photosynthesis rate; D is the humidity deficit; c_s is the CO_2 concentration at the leaf surface; τ is the CO_2 compensation point; c_a is atmospheric CO_2 concentration; h_r is the relative air humidity; P_{atm} is the atmospheric pressure; c_i is the CO_2 concentration in the intercellular spaces

Jacobs, C. M. J., van den Hurk, B. M. M., and de Bruin, H. A. R.: Stomatal behaviour and photosynthetic rate of unstressed grapevines in semi-arid conditions, Agricultural and Forest Meteorology, 80, 111–134, 1996.

Krinner, G., Viovy, N., De Noblet-Ducoudré, N., Ogée, J., Polcher, J., Friedlingstein, P., Ciais, P., Sitch, S., and Prentice, I. C.: A dynamic global vegetation model for studies of the coupled atmosphere-biosphere system, Global Biogeochem. Cycles, 19, 2003GB002199, https://doi.org/10.1029/2003GB002199, 2005.

Lawrence, D. M., Fisher, R. A., Koven, C. D., Oleson, K. W., Swenson, S. C., Bonan, G., Collier, N., Ghimire, B., Van Kampenhout, L., Kennedy, D., Kluzek, E., Lawrence, P. J., Li, F., Li, H., Lombardozzi, D., Riley, W. J., Sacks, W. J., Shi, M., Vertenstein, M., Wieder, W. R., Xu, C., Ali, A. A., Badger, A. M., Bisht, G., Van Den Broeke, M., Brunke, M. A., Burns, S. P., Buzan, J., Clark, M., Craig, A., Dahlin, K., Drewniak, B., Fisher, J. B., Flanner, M., Fox, A. M., Gentine, P., Hoffman, F., Keppel-Aleks, G., Knox, R., Kumar, S., Lenaerts, J., Leung, L. R., Lipscomb, W. H., Lu, Y., Pandey, A., Pelletier, J. D., Perket, J., Randerson, J. T., Ricciuto, D. M., Sanderson, B. M., Slater, A., Subin, Z.

Leuning, R.: A critical appraisal of a combined stomatal-photosynthesis model for C $_3$ plants, Plant, Cell & Environment, 18, 339–355, https://doi.org/10.1111/j.1365-3040.1995.tb00370.x, 1995.

Oleson, K.W., D.M. Lawrence, G.B. Bonan, B. Drewniak, M. Huang, C.D. Koven, S. Levis, F. Li, W.J. Riley, Z.M. Subin, S.C. Swenson, P.E. Thornton, A. Bozbiyik, R. Fisher, E. Kluzek, J.-F. Lamarque, P.J. Lawrence, L.R. Leung, W. Lipscomb, S. Muszala, D.M. Ricciuto, W. Sacks, Y. Sun, J. Tang, Z.-L. Yang, 2013: Technical Description of version 4.5 of the Community Land Model (CLM). Ncar Technical Note NCAR/TN-503+STR, National Center for Atmospheric Research, Boulder, CO, 422 pp, DOI: 10.5065/D6RR1W7M.

Séférian, R., Nabat, P., Michou, M., Saint-Martin, D., Voldoire, A., Colin, J., Decharme, B., Delire, C., Berthet, S., Chevallier, M., Sénési, S., Franchisteguy, L., Vial, J., Mallet, M., Joetzjer, E., Geoffroy, O., Guérémy, J.-F., Moine, M.-P., Msadek, R., Ribes, A., Rocher, M., Roehrig, R., Salas-y-Mélia, D., Sanchez, E., Terray, L., Valcke, S., Waldman, R., Aumont, O., Bopp, L., Deshayes, J., Éthé, C., and Madec, G.: Evaluation of CNRM Earth System Model, CNRM-ESM2-1: Role of Earth System Processes in Present-Day and Future Climate, J. Adv. Model. Earth Syst., 11, 4182–4227, https://doi.org/10.1029/2019MS001791, 2019.

13. L134: 'Series' should be 'series'.

Answer: Thank you. We have corrected it.

14. L169: Is 'Equation (3)' a clerical error? In the context of what follows, it should be 'Equation (2)'.

Answer: Yes, we made a mistake. We have corrected it.

15. L175: As in the previous entry, here should be 'Equation (2)' instead of 'Equation (3)'.

Answer: Thanks for that. It's a mistake and we have corrected it.

16. L212: 'Equation (4) and (8)' should be 'Equation (3) and (7)'.

Answer: Thank you. We have corrected it.

17. L217: 'From Equation (14-16)' should be 'From Equation (13-15)'.

Answer: That's right. We have amended it.

18. L219: ‘Section 0’ should be ‘Section 2.2.4’.

Answer: There were some errors in the cross-reference process. Thanks for your reminding.

19. L251: ‘Section 0’ should be ‘Section 3.1’.

Answer: We have corrected it.

20. L288: Why is there a right bracket after ‘SSPs’?

Answer: It was a clerical error. We have deleted it.

21. L291: ‘appear’ should be ‘appeared’.

Answer: Thanks. We have changed the expression.

22. L354: ‘slight’ should be ‘slightly’.

Answer: Thank you. We have altered the wording.

23. L368: ‘act’ should be ‘acted’.

Answer: Thanks for that. We have changed the tenses.

24. L403: ‘decrease’ should be ‘decreased’.

Answer: Thanks for that. We have changed the tenses according your suggestion.

25. L414: ‘Section 0’ should be ‘Section 4.2’.

Answer: We have corrected it like the comment 17&18.

26. L448: ‘Equation (3)’ should be ‘Equation (2)’.

Answer: Yes. We have corrected it.

27. L474: ‘Zhao, Wu, et al., 2022’ should be ‘Zhao et al., 2022’

Answer: Thanks a lot. We corrected and checked the citations were correct again.

28. L502: ‘ecosystems’ should be ‘ecosystem’.a

Answer: Thanks. We have corrected it.

29. L515: ‘forecasts’ should be ‘forecast’

Answer: Thank you. We have amended it.

30. L543: ‘The NDVI date …’ should be ‘The NDVI data …’

Answer: Thank you. We have corrected it.

RC2:

This is a very interesting piece of work in which the authors explore what factors will drive and change one important eco-hydrological index --- water use efficiency, under future climate change. The land-atmosphere attribution framework proposed in the article is quite novel and has been well validated in the Yellow River Basin in China. I think this piece of work answers some of the much-asked questions about eco-hydrological processes and gives quite interesting results. The proposed method can also be used in other similar river basins with deteriorating ecosystem.

In general, this article not only presents an interesting approach but also provides very useful conclusions. Therefore, I recommend publication of this work after moderate revision.

Here are some of my specific comments that I hope will help improve the quality and validity of the article:

Answer: Thank you very much for your review and the insightful suggestions provided. We have made revisions in accordance with each of your suggestions.

1. The authors should check again the labelling in their papers when quoting from the article's own sections, e.g., 'Section 0' in L219 and L326. These are just a few examples I found, and there may be other lapses of the same kind in the manuscript. Please check all through the manuscript.

Answer: Thank you for your suggestions. Upon review, we discovered that errors occurred during cross-referencing. We have corrected these issues accordingly. The specific revisions are as follows:

L219: Section 0 → Section 2.2.4

L251: Section 0 → Section 3.1

L326: Section 0 → Section 3.2

L414: Section0 → Section 4.2

2. The authors used GPP data based on NIRv in their study. Why use NIRv? GPP data often have large uncertainty. If possible, add some discussion on this aspect.

Answer: Thank you for your suggestions. We chose the NIRv data because it is an advanced global GPP dataset that meets the needs of our analysis. Compared to other datasets like GMMIS, FLUXCOM, LUE, etc., the NIRv dataset offers advantages in terms of data precision and accuracy. In light of your advice, we have added discussion on GPP datasets in Section 5.1. The modifications in the paper are as follows:

L428:

…and ET in the YRB for both historical and future periods. GPP, as a key variablein calculating WUE, exhibits significant differences among various GPP datasets, such as NIRv, GMMIS, FLUXCOM (based on upscaled eddy covariance flux tower measurements), LUE (based on light-use-efficiency model), and TRENDY (a recent model intercomparison project) (Wang et al., 2021). Compared to NIRv GPP data, GMMIS ignores the impact of CO_2 on LUE (De Kauwe et al., 2016), and FLUXCOM GPP lacks consideration of the CO_2 fertilization effect (Anav et al., 2015), thus underestimating the interannual sensitivity of GPP to climate change. A recent study has improved the traditional LUE method which produced a revised global GPP product (EC-LUE GPP) (Zheng et al., 2019). However, the satellite-based APAR （absorbed photosynthetic radiation） data used may lead to inaccuracies in some regions due to saturation (Zhang et al., 2020). Furthermore, the GPP trends in TRENDY vary significantly between different models and offer lower spatial resolution (Zheng et al., 2019). Considering all these factors, we opted for the advanced GPP dataset based on NIRv with high temporal and spatial resolution. Our results also indicate that this data is reasonable and accurate. During the historical period…

Anav, A., Friedlingstein, P., Beer, C., Ciais, P., Harper, A., Jones, C., Murray-Tortarolo, G., Papale, D., Parazoo, N. C., Peylin, P., Piao, S., Sitch, S., Viovy, N., Wiltshire, A., and Zhao, M.: Spatiotemporal patterns of terrestrial gross primary production: A review, Reviews of Geophysics, 53, 785–818, https://doi.org/10.1002/2015RG000483, 2015.

De Kauwe, M. G., Keenan, T. F., Medlyn, B. E., Prentice, I. C., and Terrer, C.: Satellite based estimates underestimate the effect of CO2 fertilization on net primary productivity, Nature Clim Change, 6, 892–893, https://doi.org/10.1038/nclimate3105, 2016.

Wang, S., Zhang, Y., Ju, W., Qiu, B., and Zhang, Z.: Tracking the seasonal and inter-annual variations of global gross primary production during last four decades using satellite near-infrared reflectance data, Science of The Total Environment, 755, 142569, https://doi.org/10.1016/j.scitotenv.2020.142569, 2021.

Zhang, Z., Zhang, Y., Zhang, Y., Gobron, N., Frankenberg, C., Wang, S., and Li, Z.: The potential of satellite FPAR product for GPP estimation: An indirect evaluation using solar-induced chlorophyll fluorescence, Remote Sensing of Environment, 240, 111686, https://doi.org/10.1016/j.rse.2020.111686, 2020.

Zheng, Y., Shen, R., Wang, Y., Li, X., Liu, S., Liang, S., Chen, J. M., Ju, W., Zhang, L., and Yuan, W.: Improved estimate of global gross primary production for reproducing its long-term variation, 1982–2017, https://doi.org/10.5194/essd-2019-126, 7 August 2019.

3. L104: Has any previous study done a similar restriction to 'GPP > 10 gC·m-2 and ET > 10 mm'? If so, I suggest the authors make a citation.

Answer: Yes, our approach followed the method used by Naeem et al. (2023). To facilitate reference for readers, we have appropriately cited this in our manuscript. The revision can be found in the revised manuscript:

L103:

To avoid uncertainties introduced by extremely small values, this study calculated only grid-point monthly WUE with GPP > 10 gC·m^{-2} and ET > 10 mm, following the approach used by Naeem et al. (2023).

Naeem, S., Zhang, Y., Zhang, X., Rehman, A. U., Tang, Z., Xu, Z., Li, C., and Azeem, T.: Recent change in ecosystem water use efficiency in China mainly dominated by vegetation greening and increased CO2, Remote Sensing of Environment, 298, 113811, https://doi.org/10.1016/j.rse.2023.113811, 2023.

4. L113: Why did the authors choose the TWSA dataset only from 1997-2006? I think the length of time is somewhat inadequate.

Answer: We apologize for the typographical error. In fact, the TWSA dataset we used in this study covers the period from 1997-2016, spanning twenty years. We believe this duration is sufficient to reflect the trends and various conditions.

L113:

… TWSA datasets from 1997-2016 were…

5. L138: Since the author mentions the Penman–Monteith equation, I think it would be helpful to add specific expressions after this paragraph for easy access by the reader.

Answer: Thank you for your suggestion. We have added the expression of Penman–Monteith equation and the variable explanation in the corresponding position.

L138:

…to calculate potential evapotranspiration with the Penman–Monteith equation (Equation 1), which is the only standard method proposed by the Food and Agriculture Organization of the United Nations (FAO) (Allan et al., 1998). All GCM outputs were bilinearly interpolated to a common spatial resolution of 0.25°×0.25°.

$$PET = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}\mu_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34\mu_2)} \quad (1)$$

where PET is the potential evapotranspiration (mm), Δ is the slope of the saturation vapor pressure curve at T (kPa °C^{-1}), R_n is net surface radiation (MJ m^{-2}), G is the soil heat flux (MJ m^{-2}), γ is the psychrometric constant (kPa °C^{-1}), T is the near-surface air temperature (°C), u_2 is the near-surface wind speed (m s^{-1}), $(e_s - e_a)$ is the vapor pressure deficit (kPa).

6. L196: What's the meaning of 'R' here? Is what the author is trying to say actually O?

Answer: Sorry, it was a clerical error. It should be the residual term O. We have corrected it.

7. L275: 'SSP470' should be 'SSP370'.

Answer: Thank you for your reminding. We have corrected it.

8. L385: It is obvious from Figure 8 'the most region of YRB' show a two-stage character, but I personally think that the authors could have calculated the proportion of regions to quantify the 'the most region'.

Answer: Thanks for your insightful suggestion. We acknowledge that our initial analysis lacked a quantitative assessment to specify the applicability of the two-stage response model across the basin. Following your suggestion, we have calculated and quantified the proportion of regions that exhibit this two-stage character and have updated the manuscript accordingly to include these results.

L385:

…in the most region of YRB, the response of WUE to drought can be divided into two stages…The area percentages of the two-stage model in different periods and scenarios are 98.0% in Historical, 96.8% in SSP126, 97.6% in SSP245, 97.0% in SSP370 and 99.2% in SSP585, respectively.

9. L417: Δμ is not defined before.

Answer: Thank you for your observation regarding the undefined term on Line 417. The symbol $\Delta\mu$ is defined to denote the difference in the mean (μ) values between different drought severity levels within the same period. We have now included this definition clearly in the manuscript to ensure proper understanding of the context and to avoid any potential confusion. We apologize for the oversight and appreciate your attention.

L416:

The differences in μ ($\Delta\mu$) represent the difference in the mean values of WUE across varying intensities of drought within the same period. This measure, utilized to analyze the differential impacts of drought levels, also became larger (from SSP126 to SSP585, $\Delta\mu$ is 0.01, 0.01, 0.02, and 0.12 respectively).

10. Figure 7a: What do the numbers (0.30, 0.54, 0.75,0.34) mean? Can you clarify them in Figure subtitle? What are 101.4%, 14.9% etc.? Please make them more clearly defined in this figure. Figures are self-independent.

Answer: Thank you for your queries regarding Figure 7a. This figure consists of two parts: the stacked chart represents the relative contribution rates of climate change and underlying change to WUE variations under different scenarios, with the percentages on either side indicating the specific values of these contributions. The line graph depicts the average WUE changes across the basin under various scenarios, where the numbers 0.30, 0.54, 0.75, and 0.84 represent the changes in average WUE under respective scenarios. To avoid confusion and enhance clarity, we have unified the colors of the line and the right axis. Additionally, we have included detailed explanations in the figure subtitle to further clarify these elements.

Revisions:

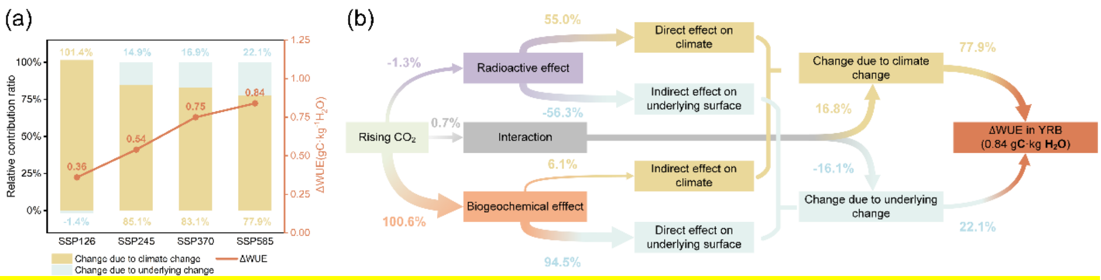

Figure 7. Attribution results for WUE changes. (a) Changes in WUE in the YRB under different SSPs, along with the relative contributions of climate factors and underlying surface factors. The stacked chart represents the relative contribution

rates of climate change and underlying change to WUE variations under different scenarios. The line graph depicts the average WUE changes (between 1985-2014 and 2070-2099) across the basin under various scenarios. (b) Land-atmosphere decoupling attribution results based on SSP585 and CO_2 experiments. The percentage represents the relative contribution rates.

11. Figure 8: Why did the authors only consider moderate-severe drought and extreme-exceptional drought? Please explain more clearly in the text.

Answer: Thank you for your suggestion regarding our focus on specific drought categories in Figure 8. We primarily followed Yin et. al (2022)'s classification method which resampled the WUE responses under more severe drought events to identify universally applicable patterns. In fact, we excluded drought levels with a TWSA-DSI less than -0.8 with consideration that such mild droughts are unlikely to have a significant impact on the ecosystem's WUE. We consolidated drought categories D1-D4 (Table 2) into two levels to ensure a sufficient sample of events to support our conclusions. This approach has resulted in clearer and more persuasive findings, highlighting the eco-hydrological processes under drought levels that require more urgent attention.

We have also provided more explanations in the corresponding section of the paper:

L383:

…across different GCMs. To obtain a sufficient number of event samples at the grid scale and derive more universally applicable conclusions, we focused only on the moderate-severe drought category ($-1.6 < \text{TWSA-DSI} \leq -0.8$) and extreme-exceptional ($\text{TWSA-DSI} \leq -1.6$), by treating all other conditions as non-drought situations ($\text{TWSA-DSI} > -0.8$) (Yin et. al 2022).

Yin, J., Guo, S., Yang, Y., Chen, J., Gu, L., Wang, J., He, S., Wu, B., and Xiong, J.: Projection of droughts and their socioeconomic exposures based on terrestrial water storage anomaly over China, Science China Earth Sciences, 65, 1772–1787, https://doi.org/10.1007/s11430-021-9927-x, 2022.