We are grateful to the referees for their time and energy in providing helpful comments and guidance that have improved the manuscript. In this document, we describe how we have addressed the reviewer's comments. Referee comments are shown in black italics and author responses are shown in blue regular text.

Referee 1

This vegetation model-based quantification of various components, including rising CO2, O3 pollution, and warming, influencing carbon sequestration across terrestrial ecosystems in China is not less than being complete. Moreover, there are many places that are quite interesting to me and would appeal to the broad communities around ACP. For example, to supplement with diffuse radiation the CMIP5 data the authors compiled empirical relationships between total and diffuse radiation and identified the best one therein to derive the diffuse radiation. What's also interesting is that the authors drew a conclusion that the allowable carbon budget is higher than expected to achieve the 1.5 deg C goal under a stabilized pathway.

➔ Thank you for your positive evaluations.

However, one major concern among other smaller ones is about land use change, which throughout the simulations with two different pathways the land cover is assumed fixed. The impacts of land cover change on the land carbon sink are undoubtedly tremendous. I argue it is more persuasive to include this in the quantification, especially considering the effort by the authors trying to offer numbers on allowable carbon budget.

➔ We agree that land cover change (LCC) can induce different responses in regional carbon budget for different emission pathways. However, "For this study, we fix the land cover to isolate impacts of CO_2 and climatic changes." The effect of LCC can be quantitatively evaluated using TRENDY data shown as below:

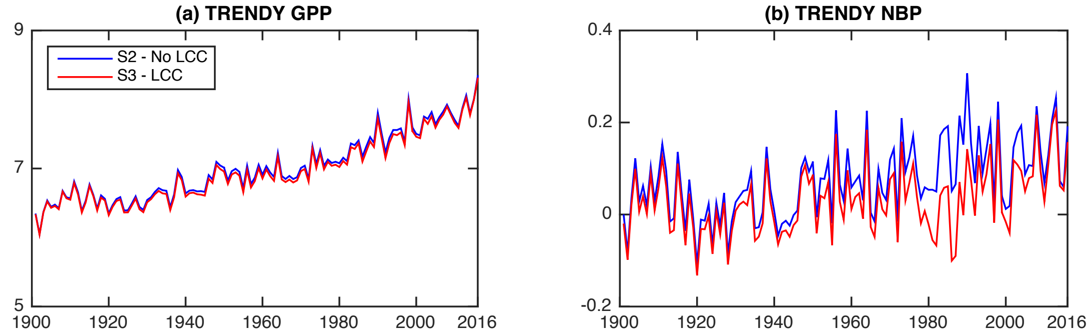

Fig. R1 Multi-model ensemble mean (a) GPP and (b) NBP from TRENDY for S2 (fixed land cover, blue) and S3 (with LCC, red) simulations. Units: Pg C yr^{-1}.

In the above figure, we compare multi-model ensemble mean GPP and NBP with and without LCC in China. As it shows, the differences are only 0.6±0.2% for GPP between simulations with (S3) and without (S2) LCC during 1901-2016 (Fig. R1a). The TRENDY dataset does not provide NEE for all models. Instead, it has net biospheric production (NBP = – NEE – LCC). For NBP, we can see some differences between the two simulations (Fig. R1b), especially over the 1980s when S3 is less positive than that of S2. This change means that land carbon sink is weakened (or more land carbon emissions) due to LCC in the 1980s. However, this change is not caused through the perturbations in ecosystem but by anthropogenic activities, because GPP with LCC shows little changes (Fig. R1a). From this aspect, the LCC acts as an additional anthropogenic emission, instead of ecosystem responses.

Furthermore, the LCC changes in China are very uncertain (or unrealistic). From TRENDY simulations, we can see that NBP is lower in S3 than S2 during 2000-2016, indicating that LCC weakens land carbon sink. However, satellite observations suggest that afforestation significantly contributes to the greening in China over the recent decades (Chen et al., 2019), indicating that LCC actually strengthens regional carbon sink. For the future projections, LCC is even more uncertain because it is related to many policy-related and economic factors (Stehfest et al., 2019) that are not associated with CO_2 emissions. Such uncertainties will undermine the main findings of this work.

In the method section, we added following statement to explain why LCC is not included: "The main focus of this study is to quantify how the differences of anthropogenic emissions, including both CO_2 and air pollution which are usually associated, will cause different responses in land carbon budget to the same global warming target. Especially, the role of air pollution on land carbon cycle has always been ignored. The assumptions of land use can be quite uncertain among future pathways (Stehfest et al., 2019), and these assumptions are not necessarily associated with CO_2 and air pollution emissions. As a result, for this study, we consider fixed land cover in all simulations." (Lines 244-250)

CORRECTION: In the paper, we use –NBP from TRENDY to represent NEE (Fig. 4b). We noticed that we incorrectly use S3 instead of S2 for comparison in the original paper. In the revised paper, we use output of S2 (no LCC) for the evaluation of YIBs simulations and discuss the results accordingly.

Another concern is about scaling up leaf-scale co2 fixation to the canopy. How have the authors accounted for canopy layers and diffuse radiation produced within the canopy?

➔ We use the multi-layer canopy radiative transfer scheme proposed by Spitters (1986) to separate diffuse and direct radiation for sunlit and shaded leaves. The canopy is divided into an adaptive number of layers (typically 2-16) for light stratification. The sunlit leaves can receive both direct and diffuse radiation, while the shading leaves receive only diffuse radiation. The details of this scheme have been well documented in Yue and Unger (2017) and fully evaluated in Yue and Unger (2018). For this study, we refer readers to these references as follows: "Leaf-level photosynthesis is calculated hourly using the well-established Farquhar et al. (1980) scheme and is upscaled to canopy level by the separation of sunlit and shading leaves (Spitters, 1986). Sunlit leaves can receive both direct and diffuse radiation, while shading leaves receive only the diffuse component (Yue and Unger, 2017)." (Lines 180-184) "Simulated GPP responses to direct and diffuse radiation show good agreement with observations at 24 global flux tower sites from FLUXNET network (Yue and Unger, 2018). In general, diffuse radiation is more efficient to enhance canopy photosynthesis compared to the same level of direct radiation." (Lines 210-213)

Also, the authors compiled experimental studies on ozone impacts on plants in China, based on which sensitivity of differing PFTs are assigned and a high and low sensitivity scheme is implemented. The variability of plant-ozone sensitivity is undeniable, which can go all the way down to the species level, evidenced by experimental studies across the globe. I am wondering what magnitude of uncertainty would such a PFT scheme bring to the quantification of GPP dampening by ozone.

➔ The uncertainties of ozone vegetation damaging are quantified using a low-to-high range of sensitivities for each individual PFT. Such range has been evaluated against available observations as shown in Fig. S4. In the revised text, we quantified and showed the uncertainties of ozone effects due to different damaging sensitivities: "In the present day, O_3 decreases GPP by 6.7±2.6% (uncertainties ranging from low to high damaging sensitivities) in China (Fig. 7d), because of the direct inhibition of photosynthesis by 6±2.4% (Fig. 7a) and the consequent reduction of 1.8±0.8% in leaf area index (LAI, Fig. 7g). For 1.5°C global warming, this weakening effect shows opposite tendencies in the two RCP scenarios, with a reduced GPP loss of 4.7±2.0% in RCP2.6 (Fig. 7e) but an increased loss of 7.9±3.0% in RCP8.5 (Fig. 7f). … Consequently, changes in O_3 help increase GPP by 0.1±0.03 Pg C yr^{-1} in RCP2.6 but decrease GPP by 0.14±0.04 Pg C yr^{-1} in RCP8.5 for the same 1.5°C warming. Following the benefits to GPP, the lower O_3 decreases NEE (strengthens the sink) by 0.06±0.02 Pg C yr^{-1} in RCP2.6, offsetting more than half of the negative effect (weakens the sink) from CO_2 (Fig. 6b)". (Lines 367-380)

Finally, a couple of spots of language errors are obvious: L64: changing 'in differing pathways' to 'of differing pathways' would be better. L164: 'respectively' should be added.

➔ Corrected as suggested.

Reference

Chen, C., Park, T., Wang, X., Piao, S., Xu, B., Chaturvedi, R. K., Fuchs, R., Brovkin, V., Ciais, P., Fensholt, R., Tømmervik, H., Bala, G., Zhu, Z., Nemani, R. R., and Myneni, R. B.: China and India lead in greening of the world through land-use management, Nature Sustainability, 2, 122-129, 2019.

Farquhar, G. D., Caemmerer, S. V., and Berry, J. A.: A Biochemical-Model of Photosynthetic Co2 Assimilation in Leaves of C-3 Species, Planta, 149, 78-90, 10.1007/Bf00386231, 1980.

Spitters, C. J. T.: Separating the Diffuse and Direct Component of Global Radiation and Its Implications for Modeling Canopy Photosynthesis .2. Calculation of Canopy Photosynthesis, Agr Forest Meteorol, 38, 231-242, 10.1016/0168-1923(86)90061-4, 1986.

Stehfest, E., van Zeist, W. J., Valin, H., Havlik, P., Popp, A., Kyle, P., Tabeau, A., Mason-D'Croz, D., Hasegawa, T., Bodirsky, B. L., Calvin, K., Doelman, J. C., Fujimori, S., Humpenoder, F., Lotze-Campen, H., van Meijl, H., and Wiebe, K.: Key determinants of global land-use projections, Nat Commun, 10, 2166, 10.1038/s41467-019-09945-w, 2019.

Yue, X., and Unger, N.: Aerosol optical depth thresholds as a tool to assess diffuse radiation fertilization of the land carbon uptake in China, Atmospheric Chemistry and Physics, 17, 1329-1342, 10.5194/acp-17-1329-2017, 2017.

Yue, X., and Unger, N.: Fire air pollution reduces global terrestrial productivity, Nat Commun, 9, 5413, 10.1038/s41467-018-07921-4, 2018.