Response to reviewer #1's comments

Comments 1:

Reliable NPP-age relationships are critical for carbon flux simulations and forest management. In this study, 10 NPP-age curves for different regions and forest types in China were derived based on field and satellite data. The authors also compared the performance of five different math models in deriving these relationships. The results were clearly described. The authors also compared their results to existing models in the same region and differences were interpreted. In my opinion, this study is unique in making use of the large amount of field data and satellite LAI time-series, and credible and up-to-date results provided. I found no major problems in this study. A list of minor comments is provided below for the authors' reference.

Response:

Thanks for your positive feedback.

Comments 2:

It is my interest to see a discussion on how the CO_2 fertilization could have affected in the collected datasets (i. e., biomass inventory and LAI), and correspondingly, how the trend changes in these datasets could be propagated into these derived curves. This is important because of the potentially uneven fertilization effects in different periods of time-series, compared to a scenario in the pre-industrial era. However, this might already be out of the scope of this study since a focus of this study is to compare different math models.

Response:

Thanks for your valuable comments and suggestions. We appreciate your insights on CO_2 fertilization's effect on biomass and LAI. The primary aim of this study was to establish forest growth curves useful for the entire landmass of China and to compare different models that would be applicable to China as well as other regions. However, the ground survey data we not designed in a way that is conducive to the study of the CO_2 fertilization effect (pairs of old and young stands at the same environmental conditions are needed to isolate the effect). We therefore could not achieve this objective in this study, although the CO_2 fertilization effect is embedded in the growth curves.

Comments 3:

L27: is not it GPP the largest flux (component)?

Response:

Thanks for your valuable comments. GPP is undoubtedly the primary component of ecosystem flux, but NPP represents the net production after deducting plant respiration from GPP. To avoid confusion, it was revised.

"Forest net primary productivity (NPP), which represents the net carbon gain from the atmosphere (Fang et al., 2001; Chapin et al., 2006), constitutes a key component of the terrestrial carbon cycle (Alexandrov et al., 1999; Hasenauer et al., 2004; Zha et al., 2013; Zhao and Zhou, 2005)."

Comments 4:

L29: a gradual decline is not always seen, especially for some mixed forests.

Response:

Thanks for your valuable comments. It was revised as "generally featured". Generally, forest NPP tends to decline in old ages. But there are also exceptions in mixed forests, due to their ecological diversity and complexity, the NPP of individual components changes at different rates with forest age, preventing a significant gradual decline in forest NPP in older ages.

"It varies significantly with forest age (Bond-Lamberty et al., 2004; Wang et al., 2007, 2011), generally featured by an initial increase at young ages, a maximum at a middle age, and then a gradual decline at old ages (Yu et al., 2017; He et al., 2012)."

Comments 5:

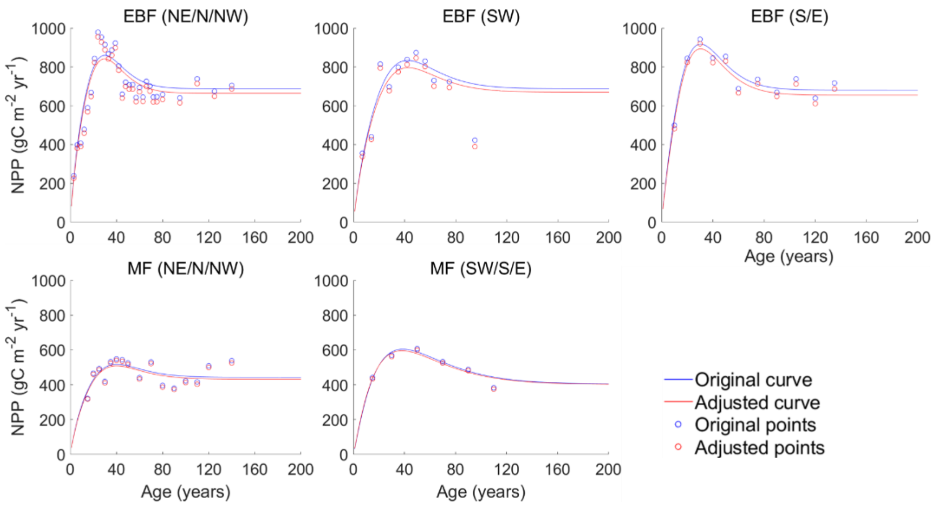
Table 1: turnover rate for EBF (evergreen) is "one", is it true?

Response:

Thanks for your valuable comments. Due to the lack of data in White et al., (2000), the turnover rate for EBF was previously set equal to that of DBF. After an extensive literature review, we found that the turnover rate for EBF is 0.86 (Lu et al., 2016).

As shown in Response Figure 1, we compared the built NPP-age curves of EBF and MF using the turnover rate of 1 and 0.86 for EBF. It shows that the peak NPP ages from the NPP-age curves remain unchanged for three curves, and only had a change of one year for two curves for EBF (SW, 43 vs. 42) and MF (SW/S/E, 38 vs. 39). In terms of the percentage of NPP duction at the age of 200 years, compared to the original curve, EBF(NE/N/NW) increased by 1.64%, EBF(SW) decreased by 1.63%, EBF(S/E) increased by 0.85%, MF(NE/N/NW) increased by 0.69%, and MF(SW/S/E) decreased by 0.69%.

The related figures (Figures 3-6), tables (Tables 1-2), and descriptions were revised. Despite these small changes, the main conclusion of this study does not change, and the SEM function was still the optimal model for building NPP-age curves in China.



Response Figure 1. Comparison of NPP-age curves fitted with different leaf turnover rates for EBF and MF. The blue colours indicate using a leaf turnover rate of 1, while the red colours indicate using a leaf turnover rate of 0.86. E: Northeast China; N: North China; NW: Northwest China; E: East China; S: South China; SW: Southwest China; EBF: Evergreen Broad-leaved Forests; MF: Mixed Forests.

Comments 6:

L99: LAI data in 1981-2022 were used – did you use the LAI in a specific year to calculate the corresponding L_l (age) in the NPP-age curve? LAI(age) may not be available for the earlier stage of old forest (42 yr+), did you use spatial surrogate? This could be clear in the revision.

Response:

Thanks for your valuable comments and suggestions. The annual maximum LAI for the survey year of the field sample was used to calculate the corresponding L_l (age) in the NPP-age curve. The field surveys were conducted from 2009 to 2013, and we only used the GLOBMAP Version 3 LAI product within the time period from 2009 to 2013. As we didn't build the relationships between LAI and forest age, the spatial surrogate was not used for old forests (42 yr+). The related descriptions in section 2.2 were revised to be clearer.

"This dataset records the site location, survey time (from 2009 to 2013), forest cover type, stand age, forest aboveground biomass, forest underground biomass, and so on. These attributes were first used to calculate the forest field NPP and then build the forest NPP-age curves."

"According to the site location and survey time, the annual maximum LAI within the survey year for the field survey sample was used to calculate the turnovers of foliage and turnovers of fine roots in the soil."

Comments 7:

L191: "consistent" - not sure for mixed forests

Response:

Thanks for your valuable comments. It was revised as "generally consistent". Generally, forest NPP tends to decline in old ages. But there are also exceptions in mixed forests, due to their ecological diversity and complexity, the NPP of individual components changes at different rates with forest age, preventing a significant gradual decline in forest NPP in older ages.

"Across various forest types, the annual increment of total living biomass rises in early forest development, peaks mid-term, and later declines, generally consistent with the trajectory of NPP with age."

Comments 8:

L208: "the rectangle in each line…" – no rectangles are seen.

Response:

Thanks for your valuable comments. The figures were updated from rectangle to triangle, but the revision was missed in the main text, and it was revised now.

"Figure 6. The normalized NPP-age curves built from the SEM function and the Γ function with the forest age extended to 300 years. The solid lines are for the age period with field data (the triangle in each line indicates the largest age with the field data), and the dashed lines are for the age period without field data. E: Northeast China; N: North China; NW: Northwest China; E: East China; S: South China; SW: Southwest China; EBF: Evergreen Broad-leaved Forests; ENF: Evergreen Needle-leaved Forests; DBF: Deciduous Broad-leaved Forests; DNF: Deciduous Needle-leaved Forests; MF: Mixed Forests."

Comments 9:

Figure 4, panel 8 (DNF …) – for Delta_Bc (biomass increment): any interpretation for the "increase" pattern in 120-180 yrs? Slightly increasing pattern is also observed for panel 1 (EBF).

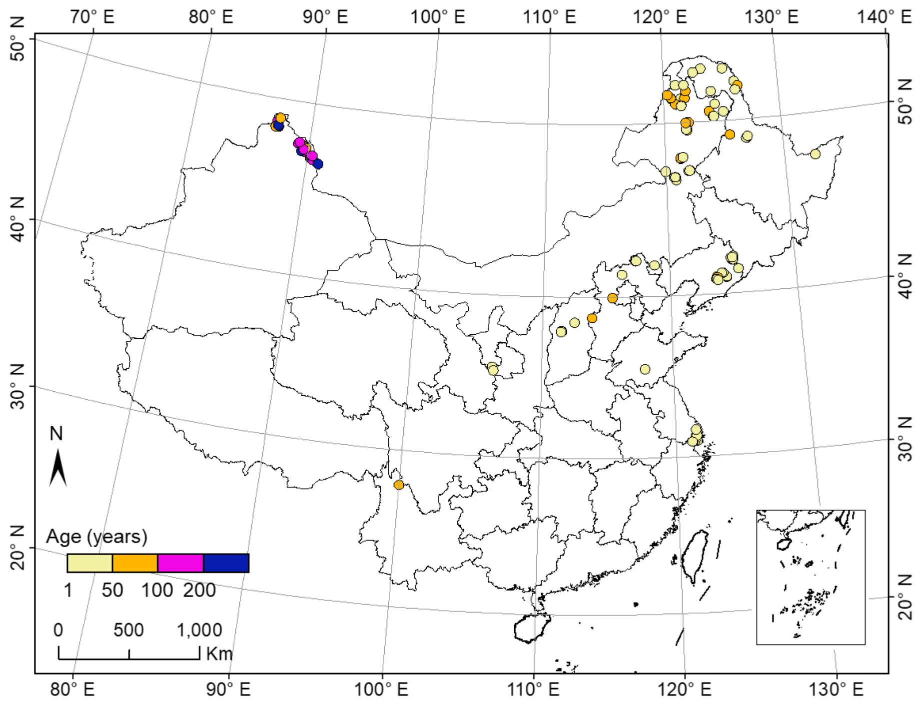
Response:

Thanks for your valuable comments. For DNF, the increase of Delta_Bc in 120-180 years may result from the blending of two different NPP-age curves. As shown in Response Figure 1, the DNF samples aged >100 years were all located in the northwest of China. But due to the limited samples across different age groups for DNF, we didn't build separate NPP-age curves in the northwest of China but used a single curve nationwide. For EBF (NE/N/NW), the slightly increasing trend of forest NPP in old ages is more likely influenced by noises, as the standard deviation of forest NPP in 100-140 years was much larger than the standard deviation of forest NPP in 40-90 years.

We revised and added the related descriptions, and recommended collecting more data in the future to discern NPP-age curves for different regions more precisely.

"4.1 Characterization of forest NPP-age curves

Figure 3 shows the comparison of the five models in building the NPP-age curves for various forest types and regions in China based on the averaged forest field NPP, and the three components of forest field NPP for each curve are shown in Fig. 4. The annual increment of total living biomass constitutes the predominant share of NPP, markedly surpassing the sum of other components in NPP. Despite their relatively minor proportions, the turnover rates of foliage and the fine roots in the soil are essential components of NPP (He et al., 2012). Across various forest types, the annual increment of total living biomass rises in early forest development, peaks mid-term, and later declines, generally consistent with the trajectory of NPP with age. There are also exceptions for some curves with slightly increasing trends of some NPP components in old ages. This might be explained by the following reasons: first, this study did not separate the overstory and understory LAI, and the presence and growth of understory LAI can influence the trends of the NPP components at old ages; second, due to the limited forest field survey samples, we merged samples over large regions to build the forest growth curves for some forest cover types in China, and this can also be a reason for not showing a declining trend. Lastly, in mixed forests, the growth of different forests is asynchronous, leading to the absence of a declining trend in old ages."



Response Figure 2. Distribution of deciduous needle-leaved forests (DNF) field survey sites and their age groups (different colour indicates different age groups).

Comments 10:

Figure 4 again: increase, stable, and decrease patterns of LAI (therefore for leave and fine-root biomass) are seen. It would be interesting to see the interpretation of these patterns (trends).

Response:

Thanks for your valuable comments. Indeed, Figure 4 illustrates both a declining trend in the forest LAI with age, as well as stable and increasing trends of forest LAI with age. This might be explained by the following three reasons: Firstly, the LAI used in this study did not differentiate between overstory and understory LAI. The presence and growth of understory LAI can influence the broader trend of the forest LAI's decline as the forest ages. Secondly, due to the limited forest field survey samples, we merged samples over large regions to build the forest growth curves for some forest cover types in China, and this can also be a reason why the LAI in older forests did not show a declining trend. Lastly, in mixed forests, the growth of different forests is asynchronous, which could also contribute to the absence of a declining trend in LAI among old forests. The above descriptions were also added to the manuscript.

"Across various forest types, the annual increment of total living biomass rises in early forest development, peaks mid-term, and later declines, generally consistent with the trajectory of NPP with age. There are also exceptions for some curves with slightly increasing trends of some NPP components in old ages. This might be explained by the following reasons: first, this study did not separate the overstory and understory LAI, and the presence and growth of understory LAI can influence the trends of the NPP components at old ages; second, due to the limited forest field survey samples, we merged samples over large regions to build the forest growth curves for some forest cover types in China, and this can also be a reason for not showing a declining trend. Lastly, in mixed forests, the growth of different forests is asynchronous, leading to the absence of a declining trend in old ages."

Comments 11:

Figure 5: this figure can be replaced by a Table, with max/min numbers bolded, but this is up to the authors. Unit for RMSE needs to be added.

Response:

Thanks for your valuable suggestions, but we think that figures allow readers to see the relative performance of different models at a glance. The unit for RMSE (gC m^{-1} yr^{-1}) was added in the revised Figure 5.

Comments 12:

Table 2: either coefficient “a” has a unit, or the unit of derived total NPP needs to be indicated.

Response:

Thanks for your valuable suggestions. The units were added in the revised Table 2.

Comments 13:

Table 3: for the “Source – This study”, are these peak-ages derived from NPP-age curves, or from measured data (Fig. 3)? It will be useful to show/interpret any differences (e.g. 39 yrs vs 50 ys for panel 10 – MF in Fig. 3?).

Response:

Thanks for your valuable comments. They were derived from the built NPP-age curves, and "*This study*" has been changed to "*Our NPP-age curves*".

To smooth out short-term fluctuations and better represent the overall trend over a period, we averaged the NPP values for specific age ranges. However, compared to the original dataset, this approach might shift the age at which the highest NPP is observed in the averaged dataset. If the peak is pronounced or lies close to the boundaries of the averaging interval, this process can broaden the peak. The discrepancy between 39 years and 50 years for panel 10 in Figure 3 arises because averaging the highest NPP values in the original dataset, which might be concentrated in a specific age range, while surrounding values can alter the age of the peak in the fitted curve. Upon analyzing the original NPP, we noted that higher NPP values were evenly distributed between ages 30-50. The fitted NPP curve, however, pinpointed a peak forest age of 39 years, which aligns more closely with the original NPPs.