**Response to Reviewer #2's comments**

(*Italic* indicates the manuscript text, red indicates revisions)

**Comments 1:**

Accurately establishing the relationship between Net Primary Productivity (NPP) and forest age is a crucial prerequisite for precisely simulating ecosystem carbon sequestration capacity. This study presents the first attempt to establish this relationship at the species scale, with a specific focus on improving NPP prediction accuracy for mature forests. Validation demonstrated that the NPP-age relationship based on the species scale effectively enhanced the accuracy of aboveground biomass (AGB) estimates simulated by the ecological model. This research holds significant scientific merit. The paper addresses an appropriate topic, features a rigorous experimental design, provides thorough argumentation, and maintains a well-structured presentation. It is recommended for acceptance after minor revisions.

**Response:**

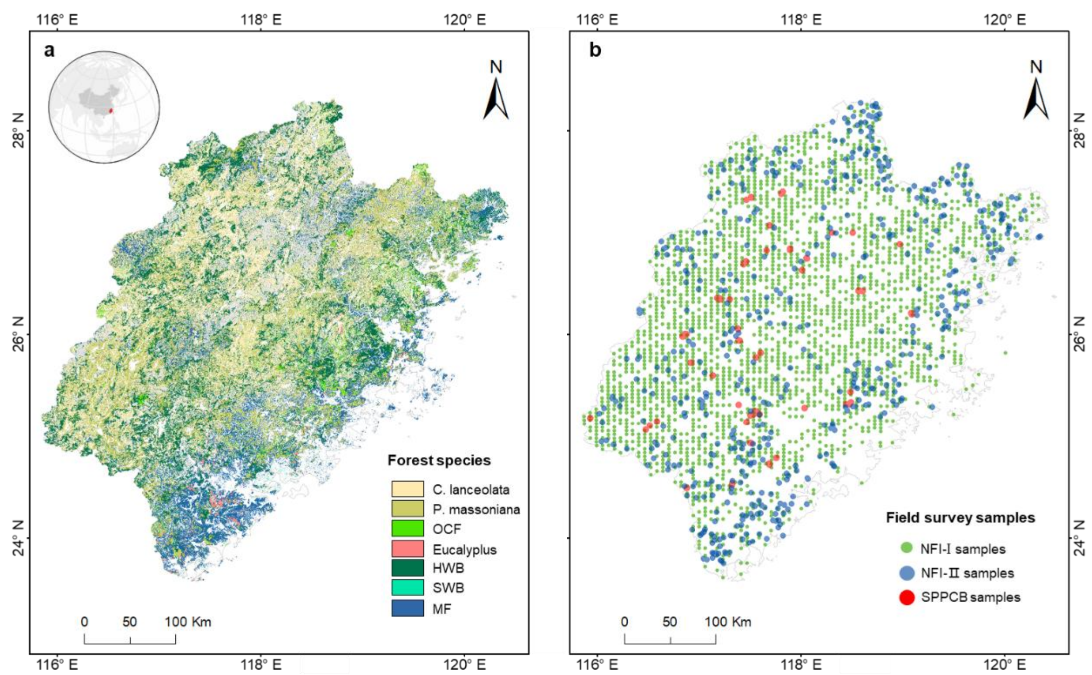
Thanks for your positive feedback.

**Comments 2:**

Figure 1a: Since the variable represented is categorical, the use of a color gradient is not recommended.

**Response:**

Thanks for your valuable comments. It was revised.



***"Figure 1: The distribution of forest species in Fujian Province (a) and the distribution of NFI-I, NFI-II, and SPPCB field survey samples (b).*** *Different colours indicate different forest species, and the grey colour is for bamboo. P. massoniana: Pinus massoniana, C. lanceolata: Cunninghamia lanceolata, Eucalyptus: Eucalyptus robusta smith, HWB: Hardwood Broadleaf excluding Eucalyptus, SWB: Softwood Broadleaf, OCF: Other Coniferous Forests excluding P. massoniana and C. lanceolata, MF: Mixed Forests."*

**Comments 3:**

AGB Validation Data: The specifics of the AGB data used for validation need further clarification. This includes details on how the data was acquired and its spatial scale. Furthermore, regarding the InTEC model simulation, the grid size employed must be explicitly stated. This is particularly important given the vastly differing spatial resolutions of the model input data (Table 3). Clarify how these data were harmonized to a common scale for simulation. Additionally, address whether scale discrepancies exist between the model-simulated AGB and the ground-collected AGB, and if so, how these were reconciled.

**Response:**

Thanks for your valuable comments. Additional descriptions regarding the AGB validation, the resolution harmonization of model inputs, and the scale discrepancies between the simulated AGB and the ground AGB were added in sections 2.2 and 2.3.2.

A discussion on the varying spatial resolutions of model inputs was also included.

*"**2.2. Data***

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*The SPPCB field survey samples have previously been effectively used for constructing ten forest NPP–age relationships across China (Li et al., 2024a; Shang et al., 2023) and we only selected the 128 samples located in Fujian for the analysis. It records the sample location, survey time (from 2009 to 2013), forest cover type, age, forest aboveground and underground biomass (Li et al., 2024a). The ground survey size for each SPPCB sample was 1000 m$^2$ (600 m$^2$ for some plantations), closely approximating a 30-m resolution (Lin et al., 2023). NFI-I samples were obtained from China's 8th (2009-2013) and 9th (2014-2018) National Forest Inventories. Each NFI-I sample records various attributes, including survey time and location, dominant tree species, forest height, diameter at breast height (DBH), forest stock volume, average forest age, and so on. The ground survey size for each NFI-I sample is typically 667 m$^2$ (1 mu, a square of 25.82 m × 25.82 m), closely approximating a 30-m resolution. After screening for different forest species, a total of 2,746 samples were retained for each period.*

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*"**2.3.2. Forest carbon modeling using the newly built NPP–age relationships***

*The NPP–age relationships constructed for different forest species were integrated into the Integrated Terrestrial Ecosystem Carbon Cycle (InTEC) model for forest carbon modeling. To evaluate whether the forest species-specific NPP–age relationships can improve forest carbon modeling, the forest carbon modeling using the newly built NPP–age relationships was compared with that of using the China-wide NPP–age relationships (Shang et al., 2023; Li et al., 2024a). The InTEC model integrates multiple processes, including leaf photosynthesis (using the Farquhar biochemical model), soil carbon and nitrogen cycling, net nitrogen mineralization, and NPP–age relationships (Chen et al., 2000a, b). This model estimates forest carbon balance by accounting for atmospheric, climatic, and biological changes since the pre-industrial era. The impact of climate change on photosynthesis is modeled through changes in the growing season length and photosynthetic rate, while elevated* $CO_2$ *concentrations and leaf nitrogen content positively affect photosynthesis. Model inputs include spatially distributed data on climate, soil texture, nitrogen deposition, and vegetation parameters derived from remote sensing (Table 3). Climate, atmospheric composition, and soil data with resolutions coarser than 30 m were resampled to 30 m using nearest-neighbor resampling. Given the coarse resolution of the climate data, the empirical formulas embedded in the BEPS-TerrainLab model (Xie et al., 2023; Govind et al., 2009) were applied to adjust the resampled climate data using elevation, slope, aspect, and solar position, thereby mitigating the impacts of both resolution and topography. The 30 m NPP generated by the Biosphere-atmosphere Exchange Process Simulator (BEPS) model for 2015, incorporating topographic effects (Cao et al., 2025), served as the reference NPP. The annual maximum LAI, originally from the 500-m GLOBMAP LAI V3 product, was downscaled to 30 m using the Reduced Simple Ratio (RSR) derived from Landsat data—an index used for LAI retrieval (Liu et al., 2012).*

$$LAI_{30} = RSR_{30}/RSR_{500} \times LAI_{500} \quad (5)$$

$$RSR = \rho_{NIR}/(\rho_{NIR} + \rho_{SWIR1}) \quad (6)$$

*where* $LAI_{30}$ *and* $LAI_{500}$ *are the annual maximum LAI at 30 m and 500 m resolution, respectively;* $RSR_{30}$ *and* $RSR_{500}$ *are the corresponding RSR at 30 m and 500 m resolution;* $\rho_{NIR}$ *and* $\rho_{SWIR1}$ *are Landsat surface reflectance in the near-infrared and short-wave infrared 1 bands.*

*Forest carbon modeling was conducted from 1986 to 2023 at a 30 m resolution. The period from 1901 to 1985 was used to spin up the soil carbon pools, reducing uncertainties in subsequent simulations. Specifically, the InTEC model assumes that the forest carbon cycle was in equilibrium before the Industrial Revolution, with NPP equaling heterotrophic respiration (Chen et al., 2000a, b). The model iterates using historical climate and atmospheric composition data, allowing the soil carbon pools to gradually adjust to a realistic and stable state, thereby reflecting long-term ecological dynamics prior to the study period (Chen et al., 2000a, b). Initializing the soil carbon pools in this way reduces the model's sensitivity to arbitrary initial conditions, yielding more robust and reliable transient simulation results.*

*The performance of forest carbon modeling was indirectly validated by comparing the modeled aboveground biomass (AGB) with the calculated AGB from forest field surveys or inventory data, since carbon flux measurements were not available in Fujian province. For each forest species, 20% of samples were randomly selected for validation. Both the SPPCB and NFI-I samples have a survey size closely approximating a 30 m resolution (Lin et al., 2023), while the NFI-I samples, though potentially larger than 30 m, were strictly screened and constrained to be located at the center of homogeneous forest polygons. Given the potential for significant AGB differences across different age groups, a stratified random sampling strategy was employed to select the validation samples. Specifically, validation samples were randomly selected within each 10-year age group to ensure adequate representation across all age groups. This approach ensured that the validation process was robust and representative of the full range of forest ages, thereby providing a comprehensive assessment of model performance across the entire age spectrum of the forest stands."*

*"**4. Discussions***

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*Last, the varying spatial resolutions of model inputs may affect the accuracy of model simulations. Downscaling LAI from 500 m to 30 m resolution using the RSR derived from Landsat data helps mitigate some scale-related impacts. However, in complex mountainous terrain, retrieving 30 m LAI may require consideration of additional factors, such as topography. Future research could focus on directly retrieving 30 m LAI based on Landsat data and Global Ecosystem Dynamics Investigation (GEDI) lidar data (Liang et al., 2025), thereby improving model accuracy. Besides, the empirical formulas embedded in the BEPS-TerrainLab V2.0 model (Xie et al., 2023; Govind et al., 2009) were also used to reduce the impacts of coarse resolution climate data. As higher-resolution remote sensing products and more ground climate data become available, it will be possible to integrate higher-resolution climate data to further enhance the performance and reliability of the InTEC forest carbon modeling."*

**Comments 4:**

Lines 174-177: The content in these lines would be more suitably placed within the figure caption.

**Response:**

Thanks for your valuable comments. It was revised.

*"**Figure 3: NPP–age curves fitted by the SEM function for different forest species with and without using NFI-II samples.** The green and red lines depict the forest NPP–age curves with and without using NFI-II samples, respectively. Solid lines indicate the forest age ranges where field data are available, while dashed lines represent extrapolated curves beyond the field sample age range. The red and blue circles, with associated grey error bars,*

*represent the average NPP values and their one standard deviation. The green and red lines depict the built forest NPP–age curves with and without using NFI-II samples. Solid lines indicate the forest age ranges where field data are available, while dashed lines represent extrapolated curves beyond the maximum age of the field samples. P. massoniana: Pinus massoniana, C. lanceolata: Cunninghamia lanceolata, Eucalyptus: Eucalyptus robusta smith, HWB: Hardwood Broadleaf excluding Eucalyptus, SWB: Softwood Broadleaf, OCF: Other Coniferous Forests except for P. massoniana and C. lanceolata, MF: Mixed Forest."*

**Comments 5:**

Lines 225-230: Several citations must be supplemented in this section.

**Response:**

Thanks for your valuable comments. They were added.

*"This can be explained by the fact that hardwood species maintain stronger carbon absorption during later growth stages due to their higher wood density and longer lifespans (Luyssaert et al., 2008; Mun et al., 2020). In contrast, softwood species excel in rapid carbon sequestration during early stages but experience earlier and more significant productivity declines (Stephenson et al., 2014). Compared to C. lanceolate, P. massoniana shows a later peak NPP age and higher stabilized-to-peak NPP ratio, as P. massoniana supports prolonged carbon sequestration (Justine et al., 2017; Bai and Ding, 2024), while C. lanceolata prioritizes rapid early growth (Zhou et al., 2016)."*

**Comments 6:**

Line 247 ("three previously built NPP–age curves for entire China"): Clarify the meaning of "three NPP-age curves". If this refers to curves for different forest cover types mentioned later, note that more than three types appear to exist. Additionally, it is recommended that the Methods section briefly describe how these prior China-wide NPP-age curves were constructed and explain the methodology used for their effective comparison with the relationship proposed in this study.

**Response:**

Thanks for your valuable comments and suggestions. They were added and revised.

*"**2.3.3. Comparison between the species-specific and China-wide NPP–age relationships***

*The NPP–age relationships for seven forest species (referred to as species-specific curves) in Fujian province were compared with the built NPP–age relationships for entire China (shortened to as China-wide curves) (Li et al., 2024a). Previously, ten China-wide NPP–age curves were built by separating the southern and northern regions and five forest cover types (Li et al., 2024a): evergreen broad-leaved forests (EBF), evergreen needle-leaved forests (ENF), deciduous broad-*

*leaved forests (DBF), deciduous needle-leaved forests (DNF), and mixed forests (MF). Only the southern-region ENF, EBF and MF curves were relevant to Fujian province, so the species-specific curves for C. lanceolata, P. massoniana and OCF were compared against the southern ENF curve, those for Eucalyptus, HWB and SWB against the southern EBF curve, and the MF curve against the southern MF curve. The intrinsic features of the species-specific and China-wide NPP–age curves and their performances within the InTEC carbon modeling were systematically compared."*

*"**3.3. Comparison to the forest NPP–age curves built previously***

*The normalized seven species-specific NPP–age curves were compared with three previously built China-wide curves (Fig. 6). The species-specific curves for C. lanceolata, P. massoniana and OCF were compared against the southern ENF curve, those for Eucalyptus, HWB and SWB against the southern EBF curve, and the MF curve against the southern MF curve. In general, the species-specific NPP–age curves constructed exhibit earlier peak ages and faster decline in old ages, particularly for Eucalyptus, C. lanceolate, OCF, and SWB."*