Response to RC2

This manuscript presents a comprehensive and methodologically innovative study that systematically explores the potential of data-driven vegetation indices (VIs) to estimate key forest properties (biomass, LAI, GPP, and NPP). By coupling an individual-based forest dynamics model (FORMIND) with a multilayer radiative transfer model (mSCOPE) and applying a Monte Carlo sampling strategy, the authors generate an exceptionally large and well-structured synthetic dataset. The analysis of all possible two-wavelength combinations across the 400–2400 nm range, combined with an explicit treatment of multiple uncertainty sources, represents a substantial advance over existing studies.

Overall, the manuscript is scientifically sound, clearly written, and highly relevant to the remote sensing and forest ecology communities, particularly in the context of emerging hyperspectral satellite missions such as EnMAP. The study offers valuable conceptual insights into wavelength selection, index design, and uncertainty robustness. I think the manuscript suitable for publication after some revisions, mainly aimed at clarifying applicability and ensuring reproducibility.

- Thank you for your time and effort in reviewing our manuscript and all your helpful comments! We respond to your individual comments below and make suggestions to improve the manuscript.

Major comments

1. The introduction could be strengthened by improving accessibility for a broad audience. A greater emphasis on the ecological motivation would be beneficial. The authors could clarify why forest parameters such as forest biomass, LAI, GPP, and NPP are critical variables and why their large-scale estimation remains challenging.

- Thank you. Your comment is in line with the other reviewer's comment, and we will address this in our revision. Specifically, we will rewrite the introduction's story line, putting a strong emphasis on the motivating underlying problem of estimating forest properties from remote sensing data. To that end, we will also touch at more of the existing literature in this area (e.g. Xiao et al., 2019). To make space for the additional text, we will reduce the background on methods and move it to the methods section where applicable.

2. While the comprehensive coupling of forest model and radiative transfer model is impressive, the manuscript would be more convincing if the authors could demonstrate that FORMIND reasonably represents real forest conditions. For example, how do the observation-based estimates of forest properties at sites such as "Hohes Holze" (i.e.,

biomass, LAI, GPP, NPP) compare with the simulated ranges generated by FORMIND? Are all observed values captured within the model's simulated distributions?

- Thank you for these questions. We have validated FORMIND at the "Hohes Holz" site by initializing it with forest inventory data and comparing the model predictions with values for GPP, NEP, and respiration derived from eddy covariance data at the site (Pohl et al., 2023). The validation results are presented in our supplement (S5.3). Further validation results on a daily time scale (but an earlier version of the parameterization) can be found at Holtmann et al. (2021). We will make these results more accessible by referring to them in the main text (line 97).

Minor comments:

Line 5: "two wavelengths (400 nm-2400 nm)"à"two wavelength (within 400 nm -2400 nm), to avoid the confusion.

- Will be fixed.

Line 116: You may specify the meaning of the ODM and the correct unit for different variables.

- We will do that.

Lines 117-118: Consider briefly explaining the interpretation of DBH entropy values—for example, does a more negative value indicate lower heterogeneity?

- We will do that. Yes, a lower value indicates lower heterogeneity and / or stronger dominance of a single individual.

For Table 1: It would be helpful to add references or explanations regarding the rationale for selecting the wavelengths used in classical indices.

- We chose wavelengths compatible with existing satellite missions (e.g. MODIS, Landsat), which typically cover larger bands rather than individual wavelengths. As such, the potential wavelengths are not unique. We will clarify in the text.

Lines 179-180: what are the criteria to select the "separating thresholds" for biomass and DBH entropy?

- We chose them so that the dataset would be split somewhat evenly (we chose rounded values for easier presentation). We will clarify this in the text

Lines 341-342: The study would be further strengthened if the developed hybrid model could be validated against sites with hyperspectral observations and observation-based estimates of forest properties in future work.

- We fully agree. Though outside the scope of this study, we will add more detailed recommendations for testing and developing new vegetation indices. This will

facilitate follow-up studies. Please see also our response to the corresponding point of reviewer 1.

References

The references can be found in the reviewed main text. The only new reference used in our response is the following:

Holtmann, A., Huth, A., Pohl, F., Rebmann, C., & Fischer, R. (2021). Carbon Sequestration in Mixed Deciduous Forests: The Influence of Tree Size and Species Composition Derived from Model Experiments. Forests, 12(6), 726. https://doi.org/10.3390/f12060726