Response to the reviewers (#ESSD-2023-143)

Thanks for the positive comments from the Reviewers. The reviewers' requests are repeated below, in italics, and with our responses written below each suggestion. We have responded in full to each request.

Reviewer #1 (Remarks to the Author):

Thanks a lot for your compliments on our paper. We are grateful for your insightful comments and constructive suggestions, which are very helpful for us to improve this manuscript.

Major shortcomings

[*Reviewer #1* Comment 1] *The authos claim having produced six annual tree cover maps from 2016 to 2021 based on a random set of 1515 reference samples (visually interpreted) that remain fixed over the 6-year period. However, no example maps are shown that would allow the reader to assess the stability of the derived tree cover over time at the pixel level. The stability of the derived forets cover (at 5m resolution) is also not summarized into statistical numbers - we have to assume that such statistics would show a very large number of implausible forest/non-forest trajectories.*

[Response] Thanks a lot for your valuable comments!

In this study, we have generated six annual tree cover maps during 2016-2021 based on the developed machine learning method on the Google Earth Engine platform (Yang et al., 2023). Then, we have made 1515 labels each year to investigate the accuracy of the time series tree cover map product and we find that our product achieves high accuracy, with an overall accuracy of ≥0.867±0.017 and a mean F1 score of 0.921, respectively. Thus, we have successfully generated the first accurate and high-resolution time-series tree cover map product for Southeast Asia by combining optical and SAR satellite observations.

We have added two example time series tree cover maps for the mainland and maritime

Southeast Asia locations from 2016 to 2019, respectively (Figs. R1 and R2), to allow the reader to visually assess our tree cover map product. Note that we have not shown the years 2020 and 2021 due to inconvenient visualization for monthly resolution Planet-NICFI imagery collected from QGIS. Compared to the original Planet-NICFI imagery, our mapped tree cover map products exhibit better accuracy.

In addition, we have counted the time series of the area of tree cover maps during 2016-2021 (Fig. R3) and we showed a slight increase trend for the area of tree cover from 2016 to 2021.

We have added some descriptions in the revised manuscript, "We further visually compared our time-series tree cover map product with the original Planet-NICFI imagery during 2016-2019 (Figures 4-5). Note that we have not shown the years 2020 and 2021 due to inconvenient visualization for monthly resolution Planet-NICFI imagery collected from QGIS. In comparison, our tree cover map product showed better consistencies with Planet-NICFI imagery, such as roads, the spatial distribution pattern of tree cover, and non-tree cover. However, our tree cover product potentially exhibited salt and pepper salt and pepper phenomenon in some years (i.e., 2017 and 2018) due to the employment of the RF approach. In practical applications, we need to pay attention to this phenomenon. In addition, we counted the time series of the area estimates of tree cover maps during 2016-2021 and showed a slight increase trend from 2016 to 2021, which is in line with the area estimates of ESA tree cover for the years 2020 and 2021. This may be due to forest restoration after the 2015 El Niño phenomenon (Wigneron et al., 2020), as well as the impact of expanded plantations (Xu et al., 2020)." (P13L288-P14L298 in the track version of the revised manuscript).

Reference:

Yang, Feng, Xin Jiang, Alan D. Ziegler, Lyndon D. Estes, Jin Wu, Anping Chen, Philippe Ciais, Jie Wu, and Zhenzhong Zeng. Improved fine-scale tropical forest cover mapping for Southeast Asia using Planet-NICFI and Sentinel-1 imagery. Journal of Remote

Sensing (2023).

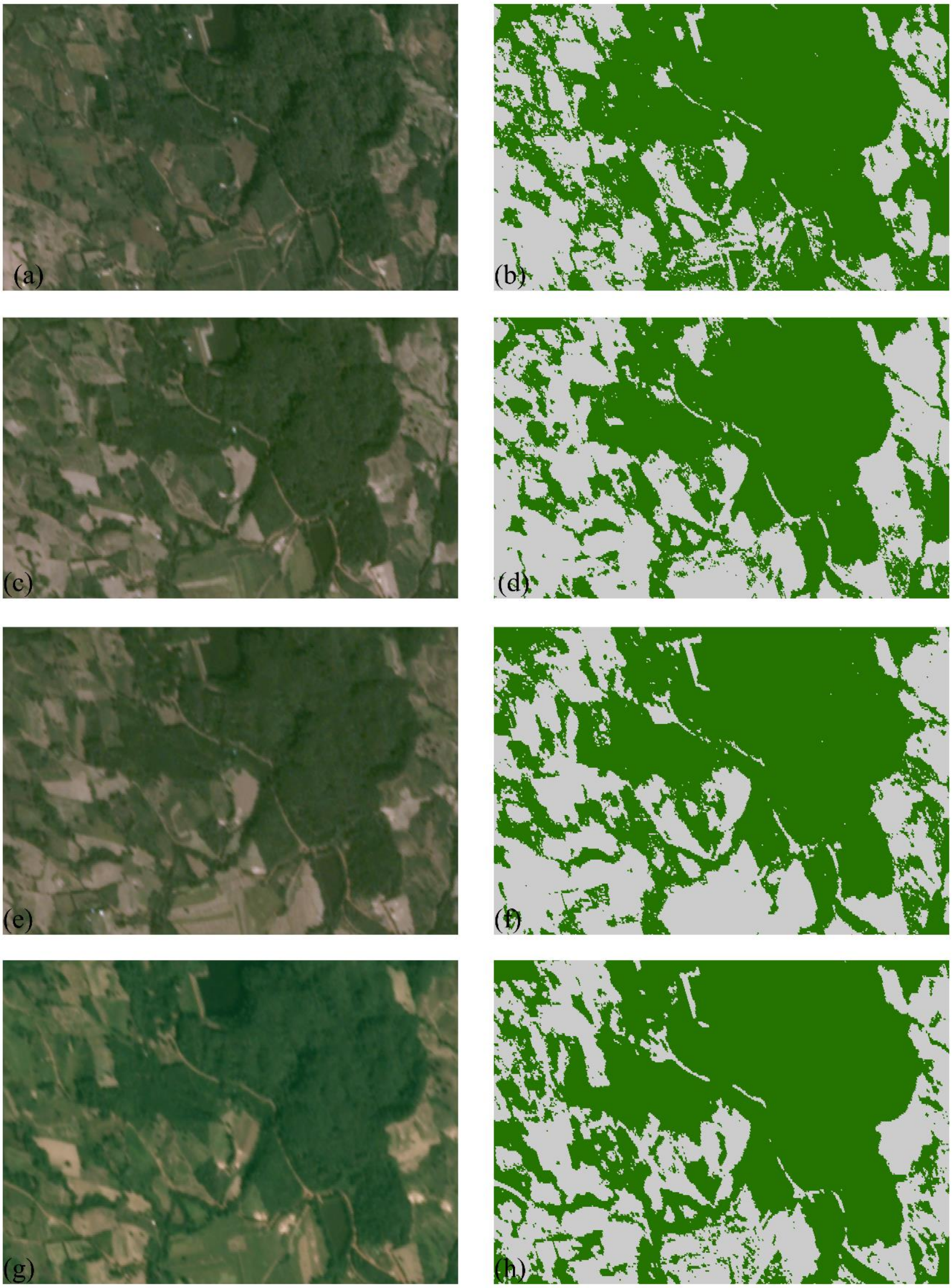

Fig. R1 Time series of the derived tree cover maps for the selected mainland Southeast Asia area (100.301°-100.322°E, 18.400°-18.409°N). (a) and (b), (c) and (d), (e) and (f), and (g) and (h) indicate 2019, 2018, 2017 and 2017, respectively.

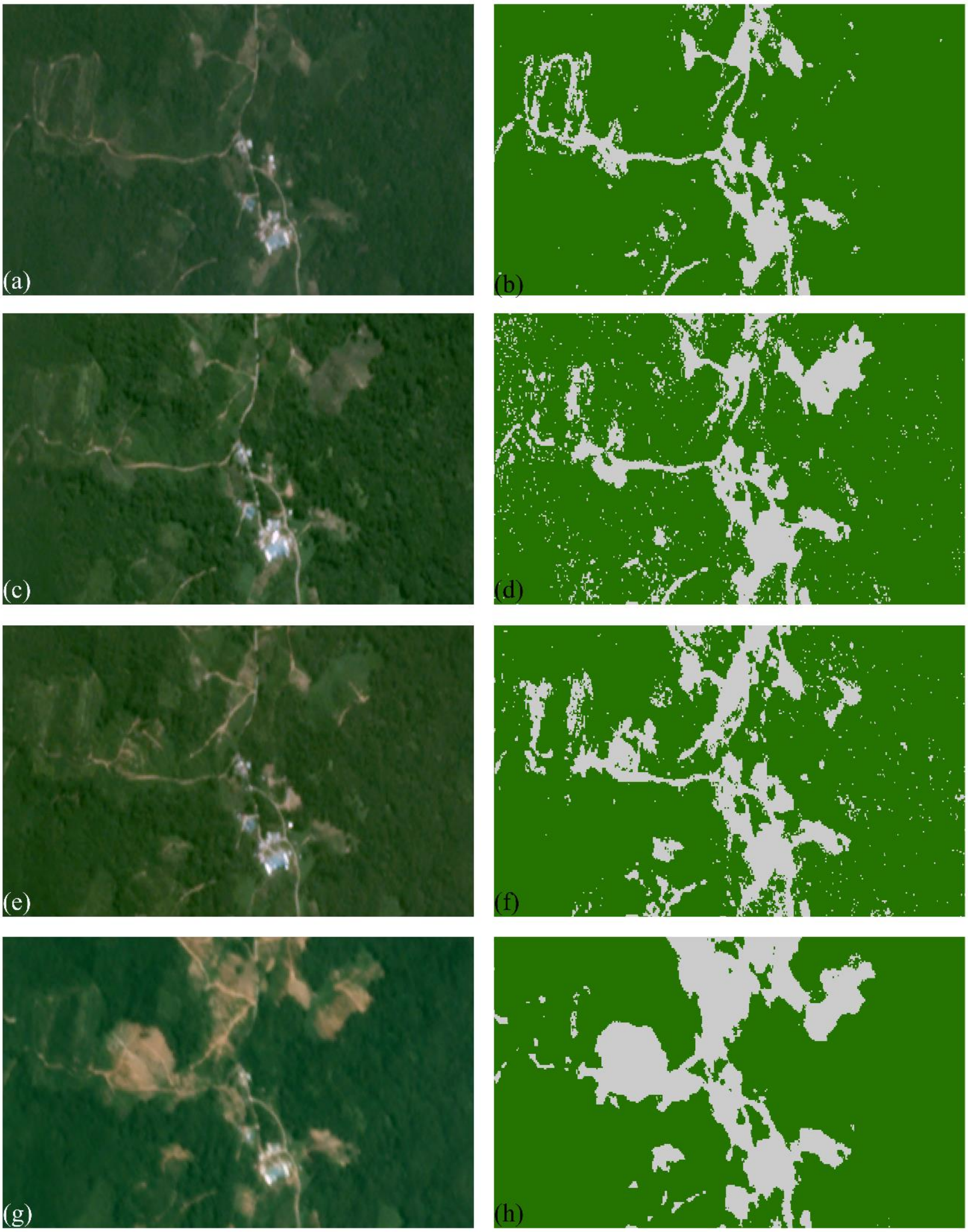

Fig. R2 Time series of the derived tree cover maps for the selected maritime Southeast Asia area (111.789°-111.806°E, 2.032°-2.040°N). (a) and (b), (c) and (d), (e) and (f), and (g) and (h) indicate 2019, 2018, 2017 and 2017, respectively.

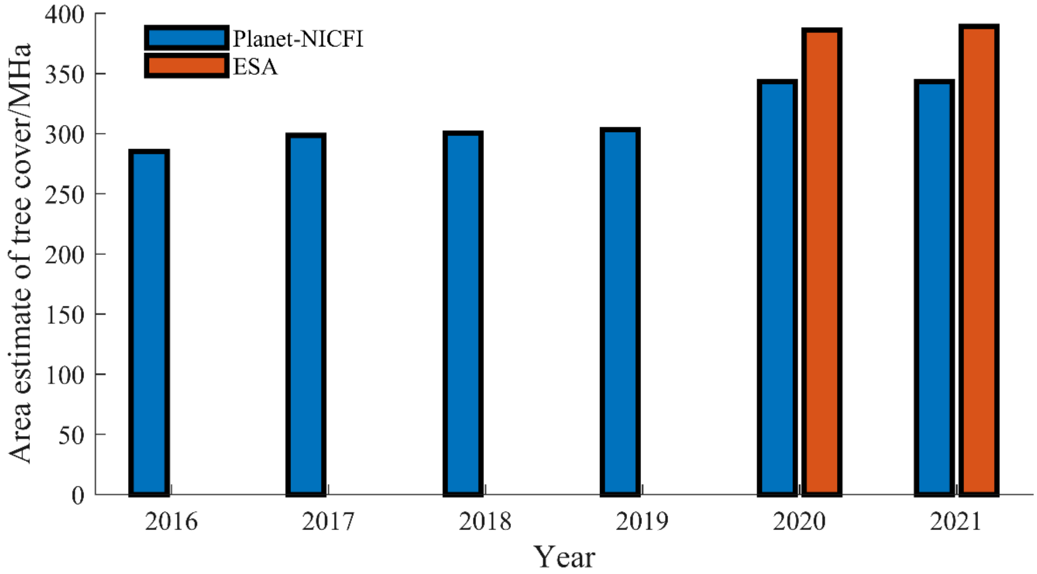

Fig. R3 Area dynamics change of tree cover maps for Planet-NICFI and ESA from 2016 to 2021.

[*Reviewer #1* Comment 2] *The quality of the reference data itself remains unclear and doubtful. In particular, the fixed set of (1515) reference samples shows inter-annual variations that are far from plausible (Tab.1). For example (Tab.1), the samples indicate a 13% tree cover loss between the two consecutive years 2017-2018 followed by a 12% gain the next year (2018 to 2019). The authors do not even mention/discuss this issue - they also fail to indicate possible spill-over effects on the maps produced with this reference data of questionable quality (see above comment).*

[Response] Thanks a lot for pointing this out.

We in this study aim to generate a 4.77 m resolution tree cover map product for Southeast Asia during 2016-2021. However, we cannot investigate the accuracy of the time series tree cover map product because the LCLUC community still lacks high-resolution publicly available tree cover/non-tree cover labels. Thus, we conduct strict standards to make the validation labels. Firstly, when the tree height (Lang et al., 2022) is higher than 5 m, we visually identify the tree cover cells in the true color composite of Planet-NICFI imagery. Then, we assess our samples in Google Earth and revised them.

We also have carefully checked the number of tree cover/non-tree cover labels. We find that we miscalculated the numbers for tree cover and non-tree cover labels in 2017 and we have corrected them in Table 1. Please note that this doesn't impact our results. We are very sorry for the misunderstanding caused to your reading due to our carelessness. In addition, a 12% gain from 2018 and 2020 may be reasonable, because our tree cover map product shows a slight increase trend for the area of tree cover from 2016 to 2021, particularly for years 2020 and 2021. Additionally, Planet-NICFI imagery at the monthly resolution collected from QGIS introduces a certain uncertainty in making the tree cover/non-tree cover labels for 2020 and 2021.

We have revised the text in Section 2.2, i.e., "(Yang et al., 2023). However, despite the advancements in the Land Cover Land Use Change (LCLUC) community, a notable gap remains the absence of publicly available high-resolution (e.g., ≤10 m) tree cover/non-tree cover labels. The existing coarse-resolution labels for tree cover/non-tree cover can introduce considerable uncertainties when evaluating high-resolution tree cover maps. As a result, our ability to delve deeper into the accuracy of time-series tree cover map datasets was hindered.

Following the methodology established by Yang et al. (2023), we undertook a rigorous process to generate a robust validation dataset for our study. Firstly, we randomly generated 1,515 points to ensure a representative sample of collected visual data, as illustrated in Fig. 1. Next, to classify these points as trees or non-trees, we enlisted four human interpreters and employed Planet Explorer within QGIS. Our approach involved visually identifying tree cover/non-tree cover pixels in the true color composite of Planet-NICFI imagery where the points were located. To ensure accuracy, we superimposed the 10 m tree height data, previously developed by Lang et al. (2022), onto the Planet-NICFI imagery. This step ensured that the labels adhered to the specified tree height criteria (i.e., ≥5 m). Subsequently, we thoroughly evaluated and refined the labels using Google Earth. To make time series tree cover/non-tree cover labels, we maintained the geographic location of the 1,515 points and changed the year of the Planet-NICFI imagery. The resulting labels encompassed data from the years 2016, 2017, 2018, 2020, and 2021. Comprehensive information about the validation dataset can be found in Table 1." (P6L116-P7L146 in the track version of the revised manuscript).

Reference:

Lang, Nico, Walter Jetz, Konrad Schindler, and Jan Dirk Wegner. A high-resolution canopy height model of the Earth. arXiv preprint arXiv:2204.08322 (2022).

[*Reviewer #1* Comment 3] *The authors claim having combined Planet multi-spectral imagery and S1 (two polarisation) to produce the annual tree cover maps. However, we learn nothing about the respective contribution of the two sensor modalities.*

[Response] The points are well taken!

We have given the explanations in the algorithms article (Yang et al., 2023). These mainly include the importance analysis (Fig. R4), as well as the comparison analysis of tree cover maps using Planet/Sentinel-1/Planet only imagery (Fig. R5).

Specifically, the importance analysis shows larger importance values except for the NDVI band, while the comparison analysis finds that introducing additional vegetation structure information can help improve the accuracy of the tree cover map, not mitigate rounding errors. Because we selected the SAR data to address potential overestimation resulting from confusion with herbaceous vegetation, as well as potential underestimation due to optical satellite observations omitting deciduous or semi-deciduous characteristics (Shimada et al., 2014).

Reference:

Shimada, M., Itoh, T., Motooka, T., Watanabe, M., Shiraishi, T., Thapa, R., Lucas, R. New global forest/non-forest maps from ALOS PALSAR data (2007–2010). Remote Sens. Environ., 2014: 155, 13-31.

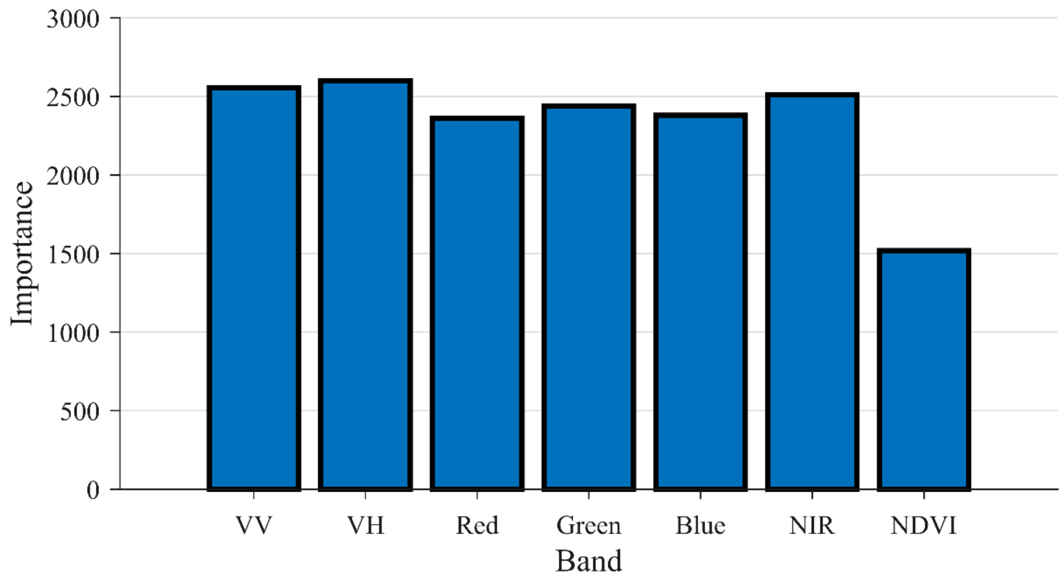

Fig. R4 The importance of the individual band input during the tree cover mapping.

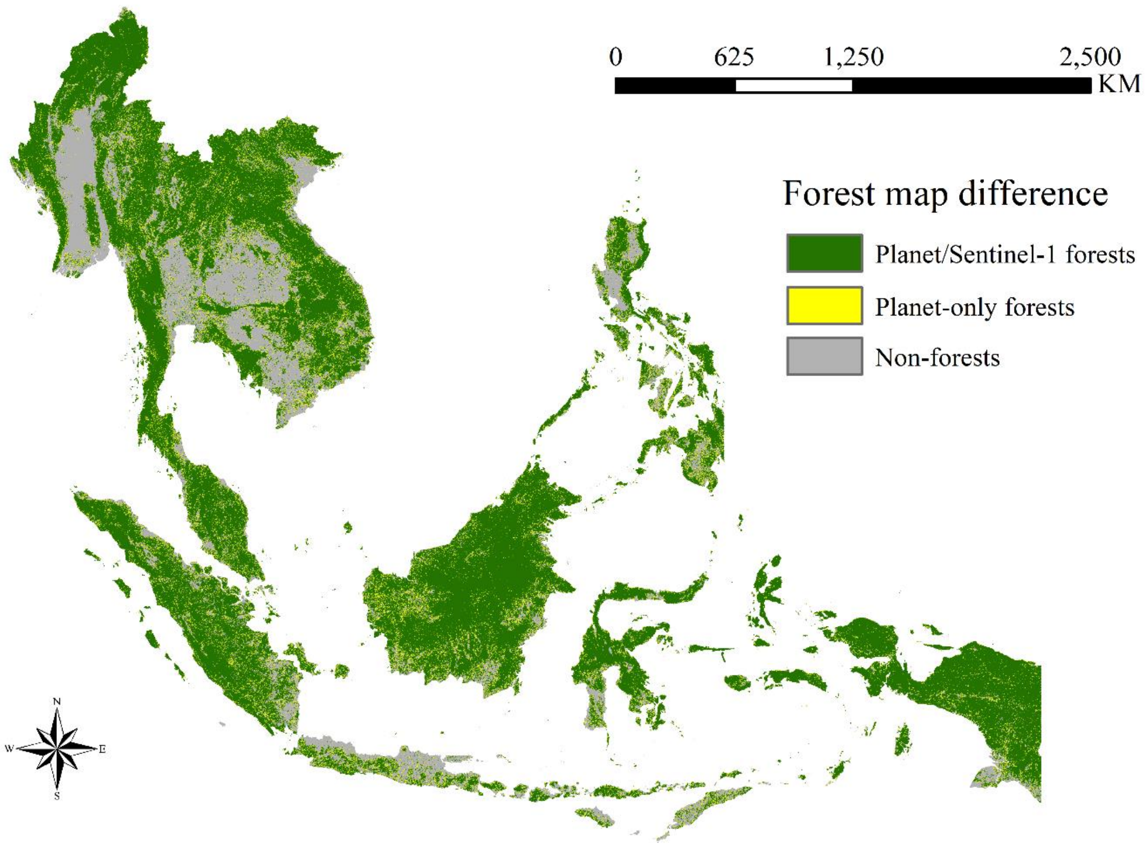

Fig. R5 Comparing tree cover maps generated using Planet-only and Planet/Sentinel-1 imagery.

Minor comments

[*Reviewer #1* Specific Comment 1] *What is labeled as "validation" data in Fig.2 is indeed "training" data.*

[Response] No, it is the "validation" data because we in this study aim to generate six annual tree cover maps during 2016-2021 based on the developed machine learning method on the Google Earth Engine platform (Yang et al., 2023), and then investigate the accuracy of the time series tree cover map products by making the tree cover/non-tree cover labels in this study.

[*Reviewer #1* Specific Comment 2] *The authors elaborate on the fact that different forest definitions exist (e.g., FAO) but fail to tell the reader which definition was finally adopted. We also learn only in the "Discussion" section, that plantations were excluded from the class "forest" during manual labeling.*

[Response] Thanks. We aim to utilize Planet-NICFI imagery to generate a prototype map with a resolution of 4.77 m. Then, our tree cover map products serve as baseline data for forest cover analysis. Upon further development of the map to include trees higher than 5/2-5 m, it can be utilized for deriving forest maps for various functions, such as those provided by FAO and UNFCCC.

[*Reviewer #1* Specific Comment 3] *The authors propose a "stability index" (year-to-year change in overall accuracies) "to evaluate tree cover accuracy". Unfortunately, tracking year to year changes in statistical measures will not tell us much about the tree cover accuracy. A good/better plausibility check would have been to compare (pixel-by-pixel) the forest/non-forest trajectories between 2016 and 2021 ... and to analyse if they are at least plausible.*

[Response] Thanks. Following Tsendbazar et al. (2021), we mainly leverage the stability index based on the user's and producer's accuracy to investigate the time-series accuracy consistency of the tree cover map products.

In addition, we have added two example time series tree cover maps for the mainland

and maritime Southeast Asia locations from 2016 to 2019, respectively (Figs. R1 and R2), to allow the reader to visually assess our tree cover map product.

Reference:

Tsendbazar, N., Herold, M., Li, L., et al.: Towards operational validation of annual global land cover maps, Remote Sens. Environ., 266, 112686 (2021).

[*Reviewer #1* Specific Comment 4] *Not clear how accuracies are assessed - I guess the authors use the OOB error provided by the RF algorithm?*

[Response] Thanks for pointing this out. No, we don't use the OOB error.

We use typical accuracy assessment metrics in the LCLUC community. Specifically, the generated tree cover map products are compared pixel by pixel with the labels. Then, a confusion matrix can be obtained, including true tree cover (TP), true non-tree cover (TN), false tree cover (FP), and false non-tree cover (FN). These four values were used to calculate the accuracy assessment metrics of the draft (Table R1).

Table R1 Product evaluation metrics and corresponding equations.

Metric	Equation
User's accuracy (UA)	$\frac{TP}{TP+FP}$
Producer's accuracy (PA)	$\frac{TP}{TP+FN}$
F1-score	$\frac{2 \times UA \times RPA}{UA+PA}$
Overall accuracy	$\frac{TP+TN}{TP+TN+FP+FN}$

We have also added the text in the revised manuscript, which are "product. The generated tree cover map product is compared pixel by pixel with the tree cover/non-tree cover labels. We then obtained a confusion matrix, including true tree cover (TP), true non-tree cover (TN), false tree cover (FP), and false non-tree cover (FN). These four values are used …… based on Eqs. (1)-(4), respectively.

$$\text{User's accuracy (UA)} = \frac{TP}{TP + FP} \tag{1}$$

$$\text{Producer's accuracy (PA)} = \frac{TP}{TP + FN} \tag{2}$$

$$\text{Overall accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \tag{3}$$

$$\text{F1 score} = \frac{2 \times UA \times PA}{UA + PA} \tag{4}$$

” (P10L226-P11L242 in the track version of the revised manuscript).