Response to Reviewer:

(Retype your comments in *italic font* and then present our responses to the comments)

This manuscript introduces the newly generated global High-Quality LAI (HiQ-LAI) Product at 500 m/5 km and 8 days resolution from 2000 to 2022. This product was generated on the GEE platform using a well-validated Spatio-Temporal Information Composition Algorithm (STICA). The HiQ-LAI can be considered as a reprocessed and value-add version of the raw official MODIS LAI products. Evaluation results demonstrate a significant improvement compared to raw MODIS LAI in terms of RMSE and Bias, enhanced temporal stability, and superior continuity especially in equatorial regions where optical remote sensing typically struggle to achieve good performance. HiQ-LAI keeps the same data format and similar quality control information with MODIS LAI, which is very convenient for data users. For me, this paper is well organized and the new product should be useful to the community of Climate Data Record (CDR). This new version of global LAI has the potential to better replace the MODIS raw product (MOD15A2) for most applications and thus desires to be published. However, there are still some minor points that need to be modified to improve the paper. Please improve these issues as follows:

Response：Thank you so much for providing positive feedback and detailed suggestions to improve our paper. We have thoroughly revised our manuscript and addressed all the questions and concerns raised. Our responses are given below.

1. Authors are encouraged to employ precise terminology when addressing uncertainty and accuracy in the manuscript. According to GCOS/CEOS, accuracy is defined as the proximity between the product and the reference values (doi: 10.1016/j.envsci.2015.03.018).

Response：Thanks for your comments. We had checked our manuscript and revised.

" It reduces apparent error of the raw LAI retrievals and generates smoother time series LAI profiles that align better with expected phenological patterns."

2. As the manuscript said, most existing filtering methods could artificially remove land surface real disturbances (e.g., forest fire, land cover change). In such cases, how does HiQ-LAI perform?

Response：While most existing filtering methods effectively utilize temporal and QC layers information, they often overlook spatial correlation information. Consequently, although the LAI profile may appear smoother, genuine land surface LAI anomalies may be artificially removed. Therefore, we fully utilized the quality, spatiotemporal information, and relative original observation records, and these pieces of information are weighted and averaged according to our fusion strategy. More robust results are obtained by considering multiple dimensions of information to compensate for the limitations of using a single information source and by preserving as real LAI anomalies as possible.

3. In the abstract "However, MODIS LAI retrievals are calculated independently for each pixel and a specific day, resulting in high noise levels in the time series and limiting its applications." Can the expression here be more precise, for example, in the regions of XXX.

Response: Thanks for your suggestions, and we had overwritten this sentence.

"However, MODIS LAI retrievals are calculated independently for each pixel and a specific day, resulting in high noise levels in the time series and limiting its applications in the regions of optical remote sensing is severely limited."

4. Page 2, Lines 50-55: “The long time series MODIS LAI dataset has made significant contributions to landmark studies on "Greening the Earth" phenomena”, suggest replace ‘long time series’ to ‘long-time series’, ‘on "Greening the Earth" phenomena’ to ‘on the "Greening the Earth" phenomena’.

Response：Thanks for your suggestion. We have overwritten this sentence.

“The long-time series MODIS LAI dataset has made significant contributions to landmark studies on the "Greening the Earth" phenomena, the possible causes of large-scale vegetation dynamics, and the relationship between vegetation dynamics and global climate change or human activities.”

5. Page 4, Figure 1: suggest adding a schematic representation of the study area's location of Section 5.3 on this global map.

Response：Thank you for your comments and have been modified the Figure 1 according to your suggestions.

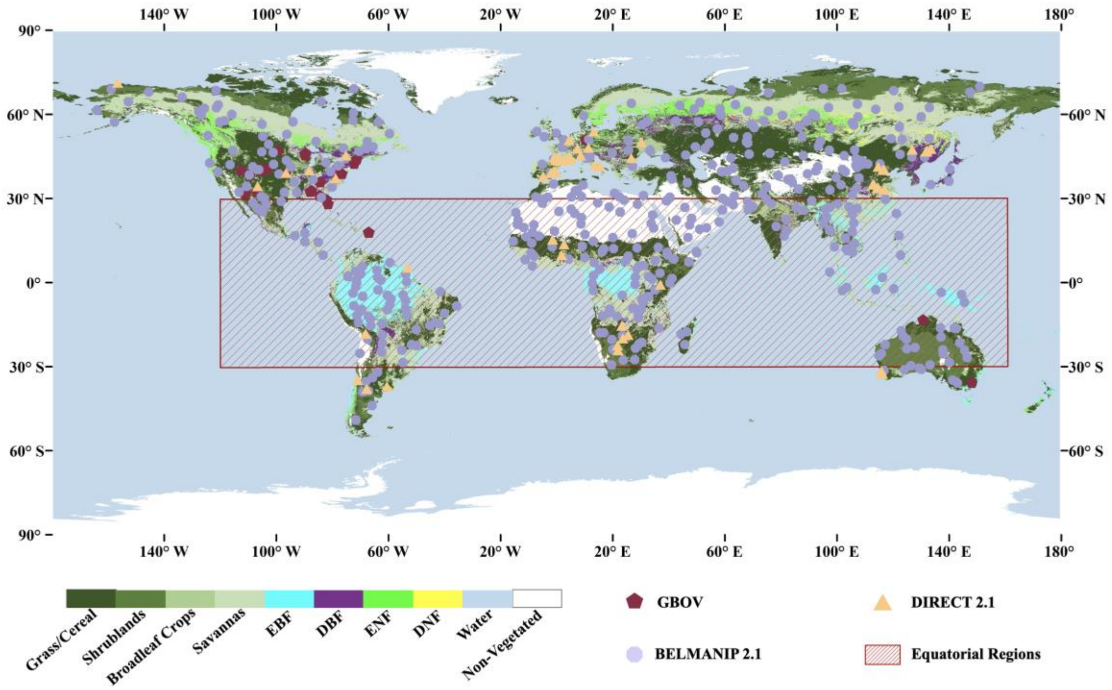

Figure 1. Geographical distribution of the selected sites. The background color indicates the biome types of the 2021 MCD12Q1 classification scheme. The red hexagon, yellow triangle, pink dots, and red frame represent the GBOV sites, DIRECT 2.1 sites, BELMANIP 2.1 sites, and Equatorial Regions, respectively.

6. Page 7, Lines 190-195: “we utilized the GBOV LAI measurements from a total of 29 sites spanning from 2013 to 2021 as our ground reference LAI.”, add reference here.

Response：Thanks for your comments and we added the references as suggested.

“In this study, we utilized the GBOV LAI measurements from a total of 29 sites spanning from 2013 to 2021 as our ground reference LAI (Bai et al., 2019; Brown et al., 2020).”

7. Page 7, Lines 195-205: “Furthermore, we compared MODIS LAI and HiQ-LAI in 2021 using the BELMANIP V2.1 sites (445 in total).”, “Additionally, we used DIRECT V2.1 ground measurements in this research.” Please add reference here too.

Response：Thanks for your comments and we added the references as suggested.

“Furthermore, we compared MODIS LAI and HiQ-LAI in 2021 using the BELMANIP V2.1 sites (445 in total) (Baret et al., 2006).”

“Additionally, we used DIRECT V2.1 ground measurements in this research (Morisette et al., 2006; Garrigues et al., 2008).”

8. Page11, Table 1: the decimal places are not consistent, suggest changing them and unifying them. Besides, if there is insufficient data to compute RMSE and R2 for a particular site, it is recommended to fill the table with ‘—’ rather than ‘0.00’.

Response：Thanks for your suggestions, we had unified the decimal places and used ‘---’ instead of ‘0.00’. Besides, we added information about the biome type of site, the Relative RMSE (RRMSE), and Bias in Table 1.

Table 1. Comparison of MODIS LAI and HiQ-LAI over GBOV sites

Biome Type	Site	M_RMSE	H_RMSE	M_R^2	H_R^2	M_RRMSE (%)	H_RRMSE (%)	M_Bias	H_Bias
Grasslands	CPER	0.44	0.40	0.21	0.22	75.90	69.32	-0.39	-0.37
	KONA	1.26	1.19	0.47	0.68	102.32	96.31	-1.20	-1.16
	MOAB	---	---	---	---	---	---	---	---
	ONAQ	0.31	0.29	0.06	0.04	95.57	90.81	-0.20	-0.19
	SRER	0.21	0.21	0.84	0.86	45.16	44.94	-0.11	-0.05
	STER	---	---	---	---	---	---	---	---
	WOOD	1.29	1.19	0.55	0.66	110.19	102.07	-1.24	-1.15
Forests	HARV	0.82	0.53	0.72	0.83	19.37	12.41	-0.24	-0.15
	TALL	1.29	1.14	0.77	0.81	38.72	34.10	-1.08	-0.96
	TUMB	1.33	1.31	0.94	0.95	77.58	76.23	-1.19	-1.19
Grasses & Shrubs	JORN	0.06	0.16	1.00	1.00	14.95	35.91	-0.03	0.01
	VASN	---	---	---	---	---	---	---	---
Crops & Savannas	BLAN	0.53	0.34	0.41	0.71	36.72	23.76	-0.44	-0.31
	LAJA	0.32	0.17	0.99	0.20	25.31	13.42	-0.24	-0.13
Grasses & Savannas	GUAN	0.72	0.49	0.36	0.43	22.23	15.13	-0.59	-0.33
	JERC	0.72	0.80	0.70	0.81	24.69	27.42	0.61	0.76
	LITC	0.85	0.68	0.58	0.66	149.71	120.21	-0.83	-0.66
	NIWO	0.49	0.31	0.68	0.64	66.89	42.19	-0.47	-0.30
Savannas & Forests	BART	0.75	0.46	0.80	0.89	19.60	11.87	-0.14	0.06
	DELA	1.16	1.10	0.05	0.03	26.67	25.17	0.42	0.91

DSNY	0.76	0.89	0.75	0.86	30.34	35.54	0.75	0.89
HAIN	1.11	0.45	0.50	0.88	24.83	10.16	0.16	0.21
ORNL	0.73	0.68	0.44	0.55	18.50	17.05	-0.02	0.39
OSBS	0.45	0.42	0.85	0.74	18.44	17.24	0.20	0.30
SCBI	1.05	0.81	0.52	0.78	23.00	17.67	0.41	0.54
SERC	0.84	1.38	0.83	0.80	18.85	30.92	0.75	1.31
STEI	0.75	0.65	0.54	0.67	18.17	15.81	-0.20	0.42
UNDE	0.42	0.28	0.03	0.47	9.50	6.40	0.07	0.14
WOMB	---	---	---	---	---	---	---	---

9. Page13, Lines 260-265: "the R2 for other pure vegetation types exceeds 0.88, and B1 and B3 surpassed 0.95. The consistency of mixed pixels is also relatively high, as indicated by an RMSE of 0.42 and an R2 of 0.86. However, B5 exhibits a significant disparity, with an R2 value of 0.15." please modify these 'R2' to 'R^2'.

Response: Thank you for pointing this out and we apologize for this point. We checked all mathematical symbols and corrected the incorrect ones.

"The result demonstrates that, except for B5, the R^2 for other pure vegetation types exceeds 0.88, and B1 and B3 surpassed 0.95. The consistency of mixed pixels is also relatively high, as indicated by an RMSE of 0.42 and an R^2 of 0.86. However, B5 exhibits a significant disparity, with an R^2 value of 0.15."

"In the Poor-Quality level, HiQ-LAI exhibited a 17.81% increase in R^2 and an 18.99% reduction in RMSE compared to MODIS LAI."

10. Page15, Lines 285-290: the usage procedures for Theil–Sen's slope (TS) method and the Mann-Kendall (MK) test are not sufficiently clear, please provide a more detailed description and relevant mathematical formulas for Theil–Sen's slope (TS) method and the Mann-Kendall (MK) test in Section of the methodology.

Response: Considering the Reviewer's suggestion, we added the detailed description and relevant mathematical formulas for Theil–Sen's slope (TS) method and the Mann-Kendall (MK) test in Section 3.1.

"In this study, the Theil-Sen's slope (TS) method and Mann-Kendall (MK) test (Suhartati, 2013; Theil, 1992) were employed to extract LAI trends from the two products. The TS method computes pairwise slopes across the study period, with the median slope representing the sign and magnitude of the long-term trend. Unlike ordinary least-square linear regression, the TS trend is less susceptible to the influence of outliers. Meanwhile, the MK test is utilized to determine the significance of the trend (Kendall, 1948). The combination of TS and MK forms a robust approach for identifying trends in long-term sequential data. TS and MK are calculated as follows:

$$TS = median\left(\frac{X_j - X_i}{j - i}\right), \qquad 2000 \leq i < j \leq 2022 \tag{1}$$

where X_j and X_i represent the LAI value of year j and year i, respectively. If $TS > 0$ indicates an increasing trend, while indicates a decreasing trend. Following this, the MK test was applied to assess the annual mean trends for MODIS LAI and HiQ-LAI from 2000 to 2022, ensuring the statistical significance of the identified trends.

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn(x_j - x_i) \tag{2}$$

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t_i(t_i - 1)(2t_i + 5)}{18} \tag{3}$$

$$Z_s = \begin{cases} \frac{S-1}{\sqrt{Var(S)}}, & \text{if } S > 0 \\ 0, & \text{if } S = 0 \\ \frac{S+1}{\sqrt{Var(S)}}, & \text{if } S < 0 \end{cases} \tag{4}$$

where S represents the sum of step function values obtained from the differences between any two distinct points within the time series, n signifies the total number of data points, m indicates the count of continuous groups in the data (duplicate data set), and t_i refers to the associated count (the number of repetitions in the ith range). Ultimately, we calculate the test statistic Z_s, when $|Z_s| > Z_{1-\alpha/2}$ means reject the null hypothesis (i.e., the absence of a trend), with α representing the significance level. In our analysis, we set $\alpha = 0.05$, with $Z_{1-\alpha/2} = 1.96$ (indicating significance at 90% and 95% confidence levels when equal to 1.65 or 1.96, respectively)."

References:

[1]. Bai, G., Dash, J., Brown, L., Meier, C., Lerebourg, C., Ronco, E., Lamquin, N., Bruniquel, V., Clerici, M., and Gobron, N.: GBOV (Ground-Based Observation for Validation): A Copernicus Service for Validation of Vegetation Land Products, Int. Geosci. Remote Sens. Symp., 4592–4594, https://doi.org/10.1109/IGARSS.2019.8898634, 2019.

[2]. Baret, F., Morissette, J. T., Fernandes, R. A., Champeaux, J. L., Myneni, R. B., Chen, J., Plummer, S., Weiss, M., Bacour, C., Garrigues, S., and Nickeson, J. E.: Evaluation of the representativeness of networks of sites for the global validation and intercomparison of land biophysical products: Proposition of the CEOS-BELMANIP, IEEE Trans. Geosci. Remote Sens., 44, 1794–1802, https://doi.org/10.1109/TGRS.2006.876030, 2006.

[3]. Brown, L. A., Meier, C., Morris, H., Pastor-Guzman, J., Bai, G., Lerebourg, C., Gobron, N., Lanconelli, C., Clerici, M., and Dash, J.: Evaluation of global leaf area index and fraction of absorbed photosynthetically active radiation products over North America using Copernicus Ground Based Observations for Validation data, Remote Sens. Environ., 247, 111935, https://doi.org/10.1016/j.rse.2020.111935, 2020.

[4]. Garrigues, S., Lacaze, R., Baret, F., Morisette, J. T., Weiss, M., Nickeson, J. E., Fernandes, R., Plummer, S., Shabanov, N. V., Myneni, R. B., Knyazikhin, Y., and Yang, W.: Validation and intercomparison of global Leaf Area Index products derived from remote sensing data, J. Geophys. Res. Biogeosciences, 113, https://doi.org/10.1029/2007JG000635, 2008.

[5]. Kendall, M. G.: Rank correlation methods., 1948.

[6]. Morisette, J. T., Baret, F., Privette, J. L., Myneni, R. B., Nickeson, J. E., Garrigues, S., Shabanov, N. V., Weiss, M., Fernandes, R. A., Leblanc, S. G., Kalacska, M., Sánchez-Azofeifa, G. A., Chubey, M., Rivard, B., Stenberg, P., Rautiainen, M., Voipio, P., Manninen, T., Pilant, A. N., Lewis, T. E., Iiames, J. S., Colombo, R., Meroni, M., Busetto, L., Cohen, W. B., Turner, D. P., Warner, E. D., Petersen, G. W., Seufert, G., and Cook, R.: Validation of global moderate-resolution LAI products: A framework proposed within the CEOS land product validation subgroup, IEEE Trans. Geosci. Remote Sens., 44, 1804–1814, https://doi.org/10.1109/TGRS.2006.872529, 2006.

[7]. Suhartati, T.: Estimates of the Regression Coefficient Based on Kendall's Tau, J. Am. Stat. Assoc., 63, 106, 2013.

[8]. Theil, H.: A Rank-Invariant Method of Linear and Polynomial Regression Analysis. In: Raj, B., Koerts, J. (eds) Henri Theil's Contributions to Economics and Econometrics., Adv. Stud. Theor. Appl. Econom., 23, 1397–1412, 1992.