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Response to reviewers and changes in the revised manuscript

Dear topic editor and reviewers:

Please find below the remarks from the reviewers (in black), followed by our responses (in blue) and the revised portion of the manuscript (in purple).

Apart from correcting according to the comments of reviewer 2, we also corrected a technical error (Line 441: LTSIF_c* -> LT_SIFc*) and added acknowledgments for help with data sources in the Acknowledgments.

Thanks a lot for your careful review.

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Response to Reviewer 2 Comments:

I really appreciate the authors' very detailed responses to my previous comments. I have some follow-up comments that the authors may find helpful:

Thank you for all the suggestions, they are indeed improving this manuscript. Please find our point-to-point reply below.

Line 20: I understand that "weather conditions" refers to cloud conditions and atmospheric scattering, not just PAR. I'd suggest specifying them here, otherwise readers may consider some other meteorological variables (e.g., temperature, humidity).

Response: Thanks, we have specified that as below:

Besides, a photosynthetically active radiation (PAR)-based upscaling model was employed to upscale the instantaneous clear-sky observations to monthly average values to compensate for the changes in **cloud conditions and atmospheric scattering**.

Data availability: while the authors added the download links for a number of SIF datasets, the access links for other datasets are still missing (e.g., GOME-2A/2C radiance and MERRA-2/MODIS datasets). I think such information is critical especially for a dataset paper. Maybe consider adding a summary in the "Data availability" section or a table in the supplementary materials.

Response: Thanks. We have added a table showing all the datasets in the supplementary material as below.

Appendix A. Supplementary material

Table S1. Access to the dataset used to generate and compare TCSIF products.

Dataset Name	Description	Access
GOME-2A/C Radiance	Level-1B product of GOME-2A and GOME-2C.	https://data.eumetsat.int/data/map/EO:EUM:DAT:METOP:GOMEL1
Merra-2 PAR	Merra-2 meteorological assimilation reanalysis data (photosynthetically active radiation).	https://goldsmr4.gesdisc.eosdis.nasa.gov/data/MERRA2/M2T1NXRAD.5.12.4/
MODIS MOD13C1	MODIS Vegetation Indices 16-Day (Version 6.1).	https://lpdaac.usgs.gov/products/mod13c1v061/
MODIS MOD43C4	The MODIS Version 6.1 Nadir Bidirectional reflectance distribution Adjusted Reflectance (NBAR) product.	https://lpdaac.usgs.gov/products/mcd43c4v006/
LT_SIFc*	Temporally corrected, global 0.05° monthly SIF product.	https://doi.org/10.6084/m9.figshare.21546066.v1

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SIFTER	Level-2 daily GOME-2A SIF product accounts for temporal degradation.	https://www.temis.nl/surface/sif.php
NASA SIF	Level-2 daily SIF (at 740 nm) dataset from GOME-2A.	https://daac.ornl.gov/SIF-ESDR/guides/MetOpA_GOME2_SIF
GOSIF	Global 0.05° monthly product of SIF derived from OCO-2, MODIS, and reanalysis data.	https://globalecology.unh.edu/data/GOSIF.html
OCO-2 SIF	Level-2 daily SIF (at 740 nm) dataset from OCO-2.	https://disc.gsfc.nasa.gov/datasets/OCO2_L2_Lite_SIF_10r/summary
TROPOMI SIF	Level-2 daily SIF (at 740 nm) dataset from TROPOMI.	ftp://fluo.gps.caltech.edu/data/tropomi/
Trendy GPP	Global 0.5°monthly GPP based on the Dynamic Global Vegetation Model.	https://blogs.exeter.ac.uk/trendy/
Pmodel GPP	Global 0.5° daily GPP based on a LUE model (P-model).	https://zenodo.org/records/1423484
MODIS GPP	8-day composite, 500 m GPP product product based on the radiation use efficiency concept.	https://lpdaac.usgs.gov/products/mod17a2hv061/

Line 97-98: This sentence should be revised accordingly, regarding the addition of GOME-2C radiance. Maybe consider introducing a bit more about the two-step framework (one for radiance, one for SIF).

Response: Thanks. We have modified the description as below:

The dataset was verified through a two-step verification, i.e., the verification of the corrected radiance (compared to radiance measurements in the absence of sensor degradation) and SIF retrievals (compared to other long-term products).

Fig 3b: I appreciate the authors' explanation about the "normalized coefficients". However, what is its difference with Dfactor? If they're the same, I'd suggest using the same term across the manuscript (e.g., also in text and Fig. 13a) to avoid confusion.

Response: Thanks for the advice. In the last version of this manuscript, we defined the original data in Fig. 3b as "normalized coefficient", and the quadratic function used for temporal correction as "Dfactor". But their physical meanings are indeed the same. The term was changed to "Degradation Factor (Dfactor)" in the figures and text in the revised manuscript.

Line 264: GOME-C -> GOME-2C

Response: Thanks. It has been corrected.

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Line 349: relative -> related?

Response: Thanks, that was a mistake and has been corrected.

Line 361: it is interesting that the authors chose to plot the bar as "twice the yearly standard deviation". I am curious why the authors chose twice the standard deviation instead of one (which seems more commonly used?).

Response: Thanks. The bar chart shows the average ± one standard deviation, so the length of the bar here becomes twice the standard deviation. We have made it more cleaer in the revised version as below:

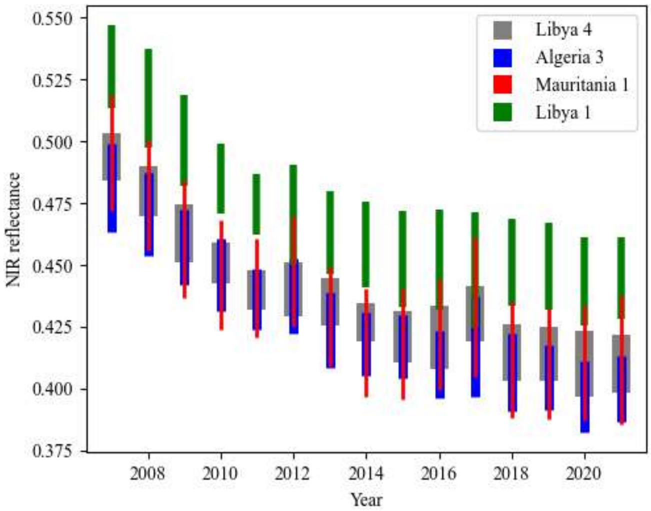

Figure 12. Instrument degradation at four different calibration sites. **Each bar shows the yearly average ± standard deviation.**

Line 364: I am confused (1) What information does Fig. 13b convey? (2) Why can we draw a similar conclusion from Fig. 13a and Fig. 13b?

Response: Thanks. As you mentioned in the last round of comments, the decay factor can change with both time and wavelength. A similar conclusion that can be drawn from both subfigures is that the degradation trend does not vary greatly with wavelength (less than 1%). Unlike Figure 13a, Figure 13b shows how temporal decay varies at different wavelengths. Without the affect of wavelength, the spectra in different year should be overlapped after normalization.However, Figure 13b illustrates that inconsistency mainly occurs at the Fraunhofer line. We then explained that for this reason, we cannot do wavelength-based correction at the expense of incorrectly correcting the Fraunhofer lines, as this would have a large impact on SIF retrieval. We have changed the clarification as below to make it clear:

In addition, the degradation at different wavelengths may also differ. Degradation functions fitted by different wavelengths in the 735–758 nm are compared. A difference of less than 1% was found in the degradation from 2007 to 2021 fitted at different wavelengths (**Figure 13a and Figure 13b**). **Figure 13b shows the**

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variation of temporal decay at different wavelengths, indicating that inconsistency mainly occurs at the Fraunhofer line, which is inherently unstable in time. On the other hand, SIF retrieval relies on the filling of absorption lines. Extremely high fitting accuracy must be ensured if wavelengths are considered an influencing factor of the degradation function. Otherwise, the accuracy of SIF retrieval will be greatly affected. Therefore, in this study, the wavelength dependence of the degradation within the 735–758 nm window is ignored.

Line 375-376: While the authors stated “the degradation may differ across different radiance levels”, I think a plot showing how the correction performs for different radiance levels would be helpful to gauge the correction uncertainty. Fig. 14 only showing the radiance range is probably not sufficient to demonstrate the validity of this framework across different radiance levels.

Response: Thanks for this comment, we have added correction uncertainty analysis for different radiance levels as below:

Line 381:

The relative residuals of the corrected GOME-2A NIR radiance on vegetated targets under different radiance levels were analyzed. As shown in Figure 15, the relative residuals are less than 20% when the NIR radiation is greater than 25 mW m^{-2} sr^{-1} nm^{-1}, and the averages of the relative residuals are less than 7%. The results indicate that the correction is basically accurate at different radiance levels. However, when the radiance is lower than 25 mW m^{-2} sr^{-1} nm^{-1}, the relative residual error reaches 40%. One reason for the result is that low radiance signals are greatly affected by random noise, resulting in poor comparability of GOME-2A and GOME-2C. Besides, the extremely low radiance level cannot be estimated by the correction based on desert pixels. Therefore, the correction results can be inaccurate at pixels with low vegetation coverage or stressed vegetation.

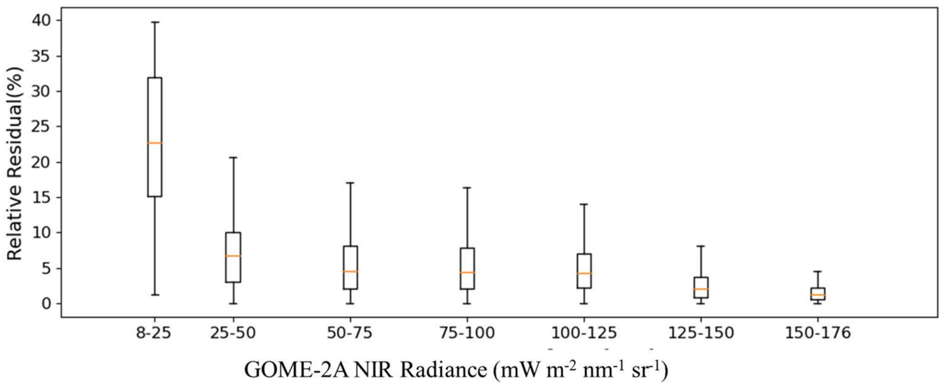

Figure 15. Relative residual of NIR radiance (calculated as the absolute difference between GOME-2A and GOME-2C NIR radiance at the co-located points) at different radiance levels. Global vegetation targets with SIF signals greater than 0.1 mW m^{-2} sr^{-1} nm^{-1} on July 1, 2019 were selected.

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Line 392: fluctuation->degradation?

Response: Here by "fluctuation", we mean the variation within every single year. In Figure 3, we found the yearly variation slightly increased with time since 2011, which may be caused by other effects of GOME-2A's contamination. In the revised manuscript, we distinguished the "intra-annual variation" and "inter-annual variation" to avoid confusion.

Line 401:

Besides, the contamination of the lens may not be the only reason for GOME-2A's degradation. As shown in Figure 3, the **intra-annual variation** in NIR reflectance does not decrease as the **inter-annual average** does. Instead, the **intra-annual variation** is growing with time. A similar phenomenon was found in the chlorine dioxide products (Pinardi et al., 2022) that GOME-2A results are noisier than those of GOME-2B, especially after 2011.