We sincerely thank the reviewer for their valuable comments and suggestions. Please find our response below in blue. The proposed revisions of the manuscript are quoted in *red italics*, with their corresponding sections and line numbers in the original manuscript marked in **bold red**.

[RC2-1] This manuscript examines the potential of Solar-Induced Fluorescence (SIF) in detecting fast changes in vegetation function and structure in dryland ecosystems. The authors use the Horn of Africa as an example to compare the performance of different satellite SIF data products in representing the fasting-changing intra-seasonal vegetation dynamics in an abnormally wet year. First, the authors cross-compared the satellite SIF products against tower-based SIF. They found that native satellite SIF data matches tower-based SIF best. The reconstructed SIF products do not show intra-seasonal changes observed from the tower. Then, the authors use climate data and field images to explain the observed inter-seasonal changes. The results show that the native satellite SIF data is mechanistically linked to the vegetation function, which makes this data a good candidate for future real-monitoring vegetation dynamics. The manuscript is overall well written. Here are some major comments I have:

[AR2-1] We thank the reviewer for appreciating our work and providing constructive comments that helped to improve this manuscript. Please find below our point-by-point response and revisions.

[RC2-2] I think the manuscript is missing some detailed explanation of the choice of temporal scaling, especially since the temporal resolution is a key component in this manuscript. All results are presented as 8-day averages. However, the manuscript does not explain why 8-day is picked given other options are available. This may not be intuitive for readers who are not familiar with TROPOMI.

[AR2-2] Thank you for this valuable suggestion. We fully agree that temporal resolution is a key component in this work. In this work, we selected the 8-day resolution for the intra-seasonal analysis at both site and regional scales (Sect. 3.2 and 3.3). The 8-day resolution balances the tradeoff between reducing the measurement noise of TROPOMI SIF and in situ SIF and still preserving the fast-changing intra-seasonal dynamics, the major focus of this study. In addition, the 8-day resolution also matches the temporal resolution of the reconstructed SIF (GOSIF and RTSIF).

To address this comment, we propose to add a dedicated section **Sect. 2.5 Spatial and temporal matching criteria** to justify our rationale and to detail the approaches we used for spatial and temporal matching (this information was in Supplementary Materials in the original submission).

2.5 Spatial and temporal matching criteria

We employed multiple spatial and temporal matching criteria for the intercomparison among different SIF datasets (Sect. 3.1) and for the analysis of intra-seasonal vegetation dynamics (Sect. 3.2 and 3.3). The principle is as follows: for the SIF intercomparison against in situ SIF, we aimed to ensure the best spatial/temporal consistency between in situ SIF and each satellite SIF dataset to be evaluated; for the intra-seasonal analysis, we attempted to ensure the spatial/temporal consistency among all the datasets (including SIF and other ancillary variables) so that all the variables refer to the same spatial domains and time intervals.

2.5.1 Spatial and temporal matching criteria for SIF intercomparison

Spatial matching: *for comparison with in situ SIF measurements, TROPOMI was regridded to 0.15° pixel (as explained in Sect. 2.3) centered at the tower location. For the reconstructed SIF products, we extracted the value of the 0.05° pixel where the tower is located to minimize the difference in spatial scales.*

Temporal matching: *For the paired comparison between in situ SIF and TROPOMI, we selected the quality-filtered in situ SIF observations (Sect. 2.2) collected within a time window of ±30 minutes with respect to the overpass time of each TROPOMI observation. The selected measurements were averaged after applying the daily-correction factor based on the SZA, which was also applied to the TROPOMI SIF. The TROPOMI observations for which no in situ SIF observations were available in the ±30 minutes time window were discarded. In total, 64 data pairs were used for comparison.*

For the paired comparison between in situ SIF and the reconstructed SIF products, we extracted the quality-filtered in-situ SIF within a ±30 minutes time window centered at the OCO-2 and TROPOMI nominal overpass time at the equator (i.e., 13:30 local solar time), applied the daily correction factor and then averaged the measurements across 4-, 8- or 16-day periods to match with the temporal resolution of the reconstructed products. In total, 67, 84, 40 and 55 data pairs were used for comparison for CSIF, GOSIF, SIF_oco2_005 and RTSIF, respectively.

2.5.2 Spatial and temporal matching criteria for intra-seasonal analysis

To ensure consistency among all datasets, we aggregated or resampled all datasets (e.g., in-situ SIF, TROPOMI SIF, MODIS NIRv, and climate variables) to the same 0.15° and 8-day resolutions. The 0.15° pixels were set so that the boundary of the 0.15° pixel around the tower was aligned with the 3 × 3 0.05° pixels of GOSIF and RTSIF closest to the tower. Therefore, this is slightly different from the 0.15° pixel for TROPOMI SIF described in Sect. 2.5.1. The 8-day resolution was selected, (1) to reduce the measurement noise of TROPOMI SIF and in situ SIF while preserving the fine-scale intra-seasonal temporal variations, and (2) to match the coarser temporal resolution of GOSIF and RTSIF. For the analysis of intra-seasonal dynamics at Kapiti (Sect. 3.1), we selected the quality-filtered in situ SIF observations (Sect. 2.2) collected within a time window of ±30 minutes with respect to the overpass time of TROPOMI and applied a daily-correction factor based on the SZA to convert them into daily values. The daily values were then aggregated to the same 8-day intervals.

The descriptions about the selection of 8-day resolution are quoted here:

"The 8-day resolution was selected, (1) to reduce the measurement noise of TROPOMI SIF and in situ SIF while preserving the fine-scale intra-seasonal temporal variations, and (2) to match the coarser temporal resolution of GOSIF and RTSIF."

[RC2-3] The manuscript did not present how SIF from different spatial resolutions and footprints are cross-compared, nearest pixel?

[AR2-3] Please see our response above. The spatial matching criteria were described in Supplementary Materials in the original submission and now have been moved to a dedicated section (**Sect. 2.5**) in the main manuscript. We employed different strategies of spatial matching for the analysis of SIF intercomparison (Sect. 3.1) and the analysis of intra-seasonal vegetation dynamics (Sect. 3.2 and 3.3). Our principle is: *"for the SIF intercomparison against in situ SIF, we aimed to ensure the best spatial/temporal consistency between in situ SIF and each satellite SIF dataset to be evaluated; for the intra-seasonal analysis, we attempted to ensure the spatial/temporal consistency among all the datasets (including SIF and other ancillary variables) so that all the variables refer to the same spatial domains and time intervals."*

Specifically, for SIF intercomparison, *"for comparison with in situ SIF measurements, TROPOMI was regridded to 0.15° pixel (as explained in Sect. 2.3) centered at the tower location. For the reconstructed SIF products, we extracted the value of the 0.05° pixel where the tower is located to minimize the difference in spatial scales. "* And in Sect. 2.3, we described our rationale of re-gridding TROPOMI SIF to 0.15°: *"0.15° was selected to include enough soundings for spatial aggregation to reduce measurement noise while maintaining overall representativeness of the area around the tower (Fig. S1)."* (**Line 172-174**)

For intra-seasonal analysis, "*To ensure consistency among all datasets, we aggregated or resampled all datasets (e.g., in-situ SIF, TROPOMI SIF, MODIS NIRv, and climate variables) to the same 0.15° and 8-day resolutions. The 0.15° pixels were set so that the boundary of the 0.15° pixel around the tower was aligned with the 3 × 3 0.05° pixels of GOSIF and RTSIF closest to the tower. Therefore, this is slightly different from the 0.15° pixel for TROPOMI SIF described in Sect. 2.5.1."*

[RC2-4] I think authors should cite papers to support their explanations for physiological changes, e.g., lines 270-271. In some locations, it would be better to include drylands/Africa-related references in addition to global-scale references, e.g., line 50.

[AR2-4] Thanks for these great suggestions.

For references to support our explanations for physiological changes in the result section, we propose to revise our descriptions and add relevant references in **Line 270**: *"The grass progressed to the reproductive stage during early and mid December (Fig., S5b, Cheng et al., 2020; Zhang et al., 2023), resulting in a gradual decrease in the photosynthetic activity, possibly because of nutrient remobilization and carbohydrate sink limitation (Tejera-Nieves et al., 2023)."*

Cheng, Y., Vrieling, A., Fava, F., Meroni, M., Marshall, M., and Gachoki, S.: Phenology of short vegetation cycles in a Kenyan rangeland from PlanetScope and Sentinel-2, Remote Sens Environ, 248, 112004, https://doi.org/10.1016/j.rse.2020.112004, 2020.

Zhang, Z., Zhang, Z., Hautier, Y., Qing, H., Yang, J., Bao, T., Hajek, O. L., and Knapp, A. K.: Effects of intra-annual precipitation patterns on grassland productivity moderated by the dominant species phenology, Front Plant Sci, 14, 1142786, https://doi.org/10.3389/FPLS.2023.1142786/BIBTEX, 2023.

Tejera-Nieves, M., Abraha, M., Chen, J., Hamilton, S. K., Robertson, G. P., and Walker James, B.: Seasonal decline in leaf photosynthesis in perennial switchgrass explained by sink limitations and water deficit, Front Plant Sci, 13, 1023571, https://doi.org/10.3389/FPLS.2022.1023571/BIBTEX, 2023.

For references related to Africa or drylands in the introduction, we have to argue that, in the original submission, we had several references related to:

- east Africa (e.g., Williams et al., 2012; Lyon and Dewitt, 2012; Funk et al., 2015; Ngoma et al., 2021; Matanó et al., 2022; Pricope et al. 2013; Beal et al. 2023);
- drylands (e.g., Prăvălie 2016; Poulter et al. 2014; Ahlström et al. 2015; Piao et al. 2020; Yao et al. 2020; Lian et al., 2021; Huang et al., 2015, Huang et al. 2017; Smith et al., 2019; Zhang et al. 2020a, 2022; Wang et al., 2022a; Adams et al., 2021; Smith et al., 2018; Robinson et al., 2019; Mengistu et al. 2021, Constenla-Villoslada et al., 2022).

Some of them are specifically focused on African drylands (e.g., Robinson et al., 2019; Mengistu et al. 2021, Constenla-Villoslada et al., 2022).

In the revision, we propose to include more references about SIF applications in inferring dryland vegetation dynamics in **Line 68**: *"For example, SIF has demonstrated a superior capability in accurately depicting dryland ecosystem phenology (Wang et al., 2019) as well as capturing seasonal variations (Wang et al., 2022c) and interannual variations (Smith et al., 2018) of in situ gross primary production (GPP)."*

Wang, C., Beringer, J., Hutley, L. B., Cleverly, J., Li, J., Liu, Q., and Sun, Y.: Phenology Dynamics of Dryland Ecosystems Along the North Australian Tropical Transect Revealed by Satellite Solar-Induced Chlorophyll Fluorescence, Geophys Res Lett, 46, 5294–5302, https://doi.org/10.1029/2019GL082716, 2019.

Wang, X., Biederman, J. A., Knowles, J. F., Scott, R. L., Turner, A. J., Dannenberg, M. P., Köhler, P., Frankenberg, C., Litvak, M. E., Flerchinger, G. N., Law, B. E., Kwon, H., Reed, S. C., Parton, W. J., Barron-Gafford, G. A., and Smith, W. K.: Satellite solar-induced chlorophyll fluorescence and near-infrared reflectance capture complementary aspects of dryland vegetation productivity dynamics, Remote Sens Environ, 270, https://doi.org/10.1016/j.rse.2021.112858, 2022c.

[RC2-5] The definition of vegetation function can be ambiguous. In line 57, Li et al., 2024 used “vegetation function” to include both physiology and structure. In this manuscript, vegetation function seems to only refer to physiology.

[AR2-5] Thanks for pointing this out. Indeed, in this manuscript, vegetation function refers to plant physiology (e.g., photosystem redox states, nonphotochemical quenching, electron transport rate, etc., all of which affect the efficiency of light use) and does not include leaf/canopy structure (e.g., leaf area, leaf angle, or pigment content, all of which affect light absorption and scattering). This terminology follows our previous review papers for SIF (Sun et al., 2023a, 2023b) along with other publications (e.g., Baldocchi et al., 2020; Dechant et al., 2020).

Baldocchi, D. D., Ryu, Y., Dechant, B., Eichelmann, E., Hemes, K., Ma, S., Sanchez, C. R., Shortt, R., Szutu, D., Valach, A., Verfaillie, J., Badgley, G., Zeng, Y., and Berry, J. A.: Outgoing Near-Infrared Radiation From Vegetation Scales With Canopy Photosynthesis Across a Spectrum of Function, Structure, Physiological Capacity, and Weather, J Geophys Res Biogeosci, 125, e2019JG005534, https://doi.org/10.1029/2019JG005534, 2020.

We propose to clarify this in Line 57: *“First, the former characterizes variations that are mainly driven by changes in vegetation function (i.e., leaf physiology, such as photosystem redox states, nonphotochemical quenching, electron transport rate, etc., all of which affect the efficiency of light use) (Gu et al., 2019; Han et al., 2022; Sun et al., 2023a), while the latter characterizes variations that are largely driven by changes in vegetation structure (e.g., leaf area, leaf angle, or pigment content, all of which affect light absorption and scattering) (Li et al., 2024).”*

[RC2-6] The manuscript introduces new terminology in results and discussion, such as NIRvP and SIFyield. They need to be better introduced before the results.

[AR2-6] Thanks for this great comment. In the revision, we propose to introduce NIRvP in the introduction by adding *“For example, NIRvP, the product of NIRv and photosynthetically active radiation (PAR), was found to be a robust structural proxy for photosynthesis (Dechant et al., 2022).”* in **Line 63**.

We plan to introduce SIF yield in **Sect. 2.3**:

*“**SIF yield:** SIF yield carries information on plant physiological/functional variations in response to environmental changes (Sun et al., 2015; Yoshida et al. 2015; Yang et al., 2015; Miao et al., 2018; Magney et al., 2019; Sun et al., 2023a). In this study, to tease out the plant functional variations from structural variations contained in the remotely sensed SIF signal, we derived SIF yield = SIF / PAR / NIRv, following Dechant et al., 2020.”*

Yang, X., Tang, J., Mustard, J. F., Lee, J.-E., Rossini, M., Joiner, J., Munger, J. W., Kornfeld, A., and Richardson, A. D.: Solar-induced chlorophyll fluorescence that correlates with canopy photosynthesis on diurnal and seasonal scales in a temperate deciduous forest, Geophys Res Lett, 42, 2977–2987, https://doi.org/10.1002/2015GL063201, 2015.

Miao, G., Guan, K., Yang, X., Bernacchi, C. J., Berry, J. A., DeLucia, E. H., Wu, J., Moore, C. E., Meacham, K., and Cai, Y.: Sun-Induced Chlorophyll Fluorescence, Photosynthesis, and Light Use Efficiency of a Soybean Field from Seasonally Continuous Measurements, J Geophys Res Biogeosci, 123, 610–623, 2018.

Magney, T. S., Bowling, D. R., Logan, B. A., Grossmann, K., Stutz, J., Blanken, P. D., Burns, S. P., Cheng, R., Garcia, M. A., Köhler, P., Lopez, S., Parazoo, N. C., Raczka, B., Schimel, D., and Frankenberg, C.: Mechanistic evidence for tracking the seasonality of photosynthesis with solar-induced fluorescence, Proceedings of the National Academy of Sciences, https://doi.org/10.1073/pnas.1900278116, 2019.

Sun, Y., Fu, R., Dickinson, R., Joiner, J., Frankenberg, C., Gu, L., Xia, Y., and Fernando, N.: Drought onset mechanisms revealed by satellite solar-induced chlorophyll fluorescence: Insights from two contrasting extreme events, J Geophys Res Biogeosci, 120, 2427–2440, https://doi.org/10.1002/2015JG003150, 2015.

Yoshida, Y., Joiner, J., Tucker, C., Berry, J., Lee, J. E., Walker, G., Reichle, R., Koster, R., Lyapustin, A., and Wang, Y.: The 2010 Russian drought impact on satellite measurements of solar-induced chlorophyll fluorescence: Insights from modeling and comparisons with parameters derived from satellite reflectances, Remote Sens Environ, 166, 163–177, https://doi.org/10.1016/j.rse.2015.06.008, 2015.

Some typographical suggestions:

[RC2-7] Lines 215-216 are not clear and seem to miss a word.

[AR2-7] We plan to rephrase the sentence to improve its clarity: *“In situ SIF showed strong inter-annual variability, with a much stronger signal in the first year compared to the second year, driven by the difference in precipitation between the two years (Fig. 1h). It also exhibited pronounced intra-annual variations such as growth peaks during SR seasons (e.g., November 2019 - January 2020, December 2020), LR seasons (e.g., May 2020, June 2021), and a dry season with intermittent precipitation (February - March 2021, Fig. 1h) (Fig. 2a).”* in **Line 212-216**.

[RC2-8] Line 221 “...variation in SIF…”, do you mean reconstructed SIF?

[AR2-8] Thanks for pointing this out. Yes, we were referring to the reconstructed SIF. We propose to clarify this in **Line 221** *“The reconstructed SIF products showed less frequent intra-seasonal variations, and their magnitudes of variations are sometimes inaccurate...”*

[RC2-9] Line 243, this line needs elaborations on why anomalous vegetation dynamics are challenging to measure. Is the anomaly or vegetation dynamics in general making it challenging?

[AR2-9] We will revise the sentence to avoid confusion: *“This period was chosen because excessive precipitation occurred during this SR season (i.e., 799 mm relative to the 2011-2020 average 343 ± 170 mm, Fig. 1h), leading to complex vegetation dynamics that can be challenging to be accurately characterized by satellite measurements. These challenges arise mainly from limited temporal frequency and/or spatial resolution of satellite data that can easily miss fast-changing vegetation functions. Therefore, our chosen period is unique in evaluating the efficacy of satellite measurements in capturing such complex dynamics. ”*

[RC2-10] Therefore, I recommend a major revision of this manuscript before it can be accepted for publication.

[AR2-10] We sincerely appreciate your constructive comments. We hope the proposed revisions have effectively addressed your concerns and improved the quality of the manuscript.