Response to Comments from Reviewer 1

Principal criteria

Scientific significance is excellent

Scientific Quality is excellent

Presentation quality Good

The authors realize that Global observations of chlorophyll fluorescence (SIF) as first observed in ground reflected solar spectra measured by the Japanese GOSAT satellite can serve as a proxy for monitoring vegetation for photosynthetic activity as well as monitoring an significant part of the terrestrial carbon cycle.

The paper deals with modeling the measurement parameters in support of the development of a new satellite, TanSat-2, that permits to more accurately map chlorophyll fluorescence and thereby obtain a more accurate inventory of terrestrial vegetation and its effect on the Carbon cycle.

The paper is well organized.

Part 1 provides an introduction and background to the current status of realization in the subject field.

Part 2 Materials; provides the background to the work presented including the parameters of the planned TanSat-2 mission, simulation experiments and data, and an end to end orbit simulation dataset.

Part 4 Results; explains clearly that the analysis method is based on empirical data. It includes an independent validation with data not used in the modeling.

Part 5. Discussion.

Thanks a lot for your encouraging words and helpful comments. We have carefully revised the manuscript according to your comments and suggestions, especially on the discussion of the limitations of our simulation framework and the shortcomings of the elliptical orbit for TanSat-2. The responses are in blue font, and the relevant revised parts of the manuscript are attached in purple font.

Comments 1. The issue of cloud interference is of considerable importance. Especially over a wide swath as is planned for TanSat-2. The fraction of clear sky measurements gets to be quite small. Adding a cloud imaging camera could be beneficial to permit processing of identified cloud-free segments of each swath. The statement of not having incorporated rotational Raman scattering is probably not required since this occurs mainly at shorter wavelengths and is quite likely negligible in both regions of SIF. However, having made a statement about rotational Raman scattering, it is recommended that the authors make a cursory evaluation of its significance.

Thank you for your valuable comments. The issue of cloud interference is indeed of significant importance. Cloud presence can substantially affect radiative transfer processes and, consequently, SIF retrievals. The CAPHI instrument onboard TanSat-2 will provide AOD and cloud coverage information, which will enhance our understanding of atmospheric conditions and support future SIF retrievals with TanSat-2.

Regarding radiative transfer modeling limitations, our simulations explicitly exclude rotational Raman scattering (RRS) due to the coupled complexities arising from its interdependencies with Mie scattering and nonlinear interactions with other atmospheric parameters. This omission arises from algorithmic constraints in the MODTRAN-based radiative transfer framework, which struggles to resolve such multi-scale scattering synergies. The RRS effects will be relatively small in the spectral range of red and far-red bans (Vasilkov et al., 2013). In data-driven SIF retrieval frameworks, its influence can be modeled. Consequently, it is incorporated into the basis vectors (Joiner et al., 2016). This inherent limitation of our simulation framework was analyzed in the Section 5.1.

In Section 5.1:

It should be noted that our simulations did not account for radiative effects induced by RRS. The RRS intensity typically decreases with increasing wavelength (Vasilkov et al., 2013), and its spectral interference is statistically negligible within the red to far-red spectral bands. Moreover, the data-driven SIF retrieval framework inherently addresses potential RRS contamination through basis vector parameterization (Joiner et al., 2016). This approach enables the decoupling of RRS-induced spectral variations from SIF emission signals.

Comments 2. The first part of the paper deals with the derivation of a mathematical model that permits accurate computation of the intensity of fluorescence validated with a subset of available satellite data. The derivation follows well established mathematical methods such principal component analysis and is verified with additional satellite data. The model is used to guide the development of Tansat-2 including a planned elliptical orbit that, according to the authors, shall somewhat favor the more populated Northern hemisphere. This is a problematic part of the paper. The highly elliptical orbit suggested for Tansat-2A does not appear to me an optimal choice. Whereas it will limit the global coverage to favor the Northern Hemisphere, and be Sun-synchronized around mid-day, it will seriously affect the uniformity of ground coverage. Near the apogee of the orbit, the swath size will be ten times larger than at perigee and the orbital motion will be significantly slower than at perigee.

I feel that the sun-synchronous elliptical orbit with an apogee approximately 10x higher than the perigee is not efficient and may lead to field of view aberrations that could compromise the accuracy of measurements. As well the swath width at apogee is much wider than at perigee making its ground coverage incomplete and difficult to fill out. I recommend that the authors describe in more detail the observational consequences of their choice of orbit. It seems to me that a near circular sun-synchronous orbit is more advantageous despite the overpass of more territory that is of less interest.

Thank you for your valuable comments. We truly appreciate your thorough analysis and well-considered concerns regarding the use of an elliptical orbit for TanSat-2. Your insights are highly relevant, and we totally agree your comments on the elliptical orbit, and add a paragraph on its shortcomings in the Section 5.1. Furthermore, we would like to add some details to clarify the scientific rationale behind our orbital choice in the response letter.

TanSat-2 is designed to facilitate global carbon stocktaking. The choice of the inclined elliptical orbit is intended to ensure more frequent coverage of the densely populated Northern Hemisphere, particularly key regions such as Asia, North America, and Europe. These regions are of paramount scientific importance for global carbon inventory assessments, especially in the monitoring of atmospheric gases like carbon dioxide. The satellite's trajectory is optimized to ensure that the Northern Hemisphere benefits from more frequent and consistent data collection.

However, as you pointed out, the use of such an elliptical orbit may present challenges. The efficiency of the sun-synchronous elliptical orbit is relatively low, as the apogee is approximately 10 times higher than the perigee. Although the imaging setting only allows observation for orbital altitudes above ~2,350 km, significant altitude disparity still persists. This results in a swath width variation exceeding twofold, causing uneven ground coverage and reduced efficiency in achieving uniform global sampling—particularly pronounced in equatorial zones. Additionally, this orbit may lead to field of view aberrations, which can impact the accuracy of measurements. These shortcomings must be carefully considered during the orbit design and satellite system design phases.

In Section 5.1:

For the end-to-end orbit simulation, we modeled TanSat-2’s Earth observations based on its orbital parameters. Designed to facilitate global carbon stocktaking, the inclined elliptical orbit enhances observational frequency over the Northern Hemisphere’s densely populated regions (e.g., Asia, North America, and Europe), as evidenced by the increased observation density shown in Figures 11 and A1. Continuous observations over four- or eight-day cycles ensure near-global coverage. However, this orbital architecture introduces inherent challenges. The efficiency of the sun-synchronous elliptical orbit is relatively low, as its apogee is approximately ten times higher than its perigee. Although the imaging setting only allow observation for orbital altitudes above ~2,350 km, significant altitude disparity still persists. This results in a swath width variation exceeding twofold, leading to uneven ground coverage and spatial resolution, which in turn reduces the efficiency of achieving uniform global sampling—particularly in equatorial regions. Furthermore, the orbit may induce field of view aberrations that could compromise measurement accuracy. These limitations necessitate systematic mitigation strategies during satellite system design and orbital parameter optimization.