

Interactive comment on “FLiES-SIF ver. 1.0: Three-dimensional radiative transfer model for estimating solar induced fluorescence” by Yuma Sakai et al.

Anonymous Referee #1

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General comments This manuscript by Sakai et al. presents a new 3D canopy radiative transfer model for chlorophyll fluorescence (SIF). Considering the rapid advances of remote sensing of SIF during the last several years, especially on the impacts of canopy structure on SIF, the 3D SIF model FLiES-SIF developed is therefore relevant and it will be of interest for the scientific community working on modeling of SIF and also for the user community. The manuscript is a nice addition to the current body of literature and I think it is worth publishing. However, a few comments may be taken into account to improve the manuscript.

My first concern is the comparison of the new FLiES-SIF 3D model to some field data,

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at least to some other model simulations, such as DART. I knew some groups are doing bi-directional SIF measurements in the field. These data may be used to validate the new model to some extent. Also, the comparison to DART would also give some hints on the performances of FLiES-SIF.

Meanwhile, in the section of Introduction, it seems that there are missing in some new advances and recent publications on how canopy structure impacts the top-of-canopy SIF during the last two years. The authors may consider including them.

Several points:

1. L58: The expression of “At present, the Discrete... is the only available 3D model” is not clear. Is the DART model the only available 3D model to simulate SIF or other processes? As far as I know, there are other models that can simulate SIF, such as FluorFLIM (Zarco-Tejada et al, 2013), FluorFLIGHT (Hernández-Clemente et al., 2017). Are these not 3D models?

References: Hernández-Clemente R, North P R J, Hornero A and Zarco-Tejada P J. 2017. Assessing the effects of forest health on sun-induced chlorophyll fluorescence using the FluorFLIGHT 3-D radiative transfer model to account for forest structure. *Remote Sensing of Environment* 193: 165-179.[doi:10.1016/j.rse.2017.02.012]. Zarco-Tejada, P., Suárez, L., & Gonzalez-dugo, V. (2013). Spatial Resolution Effects on Chlorophyll Fluorescence Retrieval in a Heterogeneous Canopy Using Hyperspectral Imagery and Radiative Transfer Simulation. *IEEE Geoscience and Remote Sensing Letters*, 10, 937-941. doi:10.1109/LGRS.2013.2252877

2. It is not clear how to calculate APARC in Eq. (2)? Please add some information of the method.

3. According to the phase function for SIF emissions in Eq. (12), SIF emissions are calculated from the adaxial and abaxial sides of a leaf separately, which indicates hemisphere integration. But in Eq. (4), the normalization factor is 4π . Should it be 4π or

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2π ?

4. Eq. (10) demonstrated the leaf-level SIF emission. Since you have already used a leaf level SIF model (FluoMODleaf) to derive the fraction of SIF emission from adaxial and abaxial side of leaves, I am curious why don't you use this model to simulate SIF emissions at leaf level?

5. To reduce time, the simulation of SIF direct emission (Eq. (5)) and APARL (Eq. (11)) both follow the Beer-law instead of using the backward ray tracing method. Regarding to the simulations, are there a large differences between the two methods? The assumption of a homogeneous layer should be made to apply the Beer-law attenuation. Does that indicate the model is not a real "3D" model in the conventional sense?

6. How do you calculate the scattering parameter $w_{i,j}$ in Eq. (14)?

7. Please add the description of the parameter GS in Eq. (16).

8. The authors have simulated the broadband SIF and considered the multi-scattering effect in the near-infrared spectral domain. Have you considered the re-absorption effect of SIF in the red spectral range?

9. Figure 3: The arrows in Fig 3. did not point the voxels clearly.

10. To exhibit the variation of SIF with wavelengths clearly, it would be good for the Fig 8. and Fig 9. to be transformed into three-dimensional images.

11. L178: replace "The SIF radiance emitted..." by "The scattered SIF radiance emitted...".

12. L315: replace "contribute" by "contributes".

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