Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2020-251-RC1, 2021

Geoscientific Model Development
Discussions

Interactive comment on "SCOPE 2.0: A model to simulate vegetated land surface fluxes and satellite signals" *by* Peiqi Yang et al.

Yelu Zeng (Referee)

yzeng@carnegiescience.edu

Received and published: 15 March 2021

Thanks for inviting me to review this manuscript. Earlier versions of SCOPE have been widely used in SIF, GPP, energy balance and thermal signal simulations. This paper mainly summarized the recent progress of the revised version, SCOPE 2.0, which includes (1) the consideration of multi-layer vertical variation of chlorophyll content and leaf angle distributions; (2) the adoption of the BSM soil reflectance model to account for the soil moisture; (3) the impact of the xanthophyll cycle on the leaf-canopy reflectance and (4) speed acceleration optimization. I believe these advances are of interest to the remote sensing and ecology modeling communities, and thus this paper matches the scope of the GMD journal very well. Overall, this paper is well written

and structured. I have a few comments from the perspective of a SCOPE user, and the authors may choose to consider or not according to the long-term plan of SCOPE improvements and the amount of effort needed.

1. P21, L390: Currently in SCOPE2.0, atmospheric properties are the input parameters that determine the proportion of the direct and diffuse solar radiation. As the authors mentioned in Line 390, for the simulation of a specific site (e.g., some Fluxnet and PhenoCam sites), PAR and diffuse PAR ratio are usually available instead of the atmospheric properties. This makes the simulation of SIF and photosynthesis to be difficult at the diurnal or seasonal cycle with different diffuse PAR ratio. It would be more convenient for users in ecology community, if PAR and diffuse PAR ratio could be used as input parameters in SIF and photosynthesis simulations.

2. Second is about the validation. As far as I know, there is rare literature about the validation of SCOPE over high productivity areas with GPP > 40 umol CO2 m-2 s-1. From my experience of using SCOPE to simulate GPP of soybean at the Corn Belt in the US and in summer, it is very difficult to be able to achieve the GPP simulations to be larger than 40 umol CO2 m-2 s-1 with the field PAR, temperature, chlorophyll content, etc measurements, unless we set the unmeasured Vcmax to be larger than 200 umol m-2 s-1. Of course, this is unreasonable. Validation of SCOPE simulated GPP over high productivity areas would give more confidence and guidance to the SCOPE users in ecology community.

3. P 15, Fig. 4: For the xanthophyll cycle, Vilfan et al (2018) only focused on the leaf scale. In fact, there are already many canopy-scale PRI field observations acquired during the plant stress in recent studies. Showing the capability (and good performance) of SCOPE2.0 with field data to capture the plant stress by quick response (and accurate simulation) of PRI (or CCI) would be more interesting and convincing than model comparisons if possible.

4. P17, L 345-350: Usually it is difficult to determine how many layers should be set

in SCOPE for a specific vegetation species, e.g., corn with narrow and long inclined leaves, or taro with big leaves but not many layers. In my understanding, the layers in SCOPE and the leaf layer in reality are different. For example, if there is only one flat big leaf over the ground, sensors can always observe the hot-spot effect in all viewing directions, while this kind of situations are difficult to consider in model settings. Of course, this is the gap between abstract models and nature in reality. The current model is correct under general assumptions of radiative transfer modelling, while caveats and more guidance may be still needed for users to correctly use the model and achieve accurate simulations.

5. P16, Fig. 5: Does SCOPE2.0 have the capability to simulate the scene with different leaf sizes at different layers? Even if the leaf size is the same for all layers, the hot spot factor or leaf specific dimension could vertically vary with different multi-layer leaf angle distributions (Kuusk 1991). Seems this issue was not considered and the hot-spot effect was not evaluated or discussed in mSCOPE and SCOPE2.0 manuscripts. Not quite sure how large are the uncertainties by this issue to the reflectance around the hot spot directions. If fixed as one value, I suppose the multi-layer hot spot factor could be closer to the hot spot factor of the upper layer instead of the vertically averaged value. Maybe uncertainties by this issue could be evaluated by 3D multi-layer simulations.

Kuusk, A. (1991). The hot spot effect in plant canopy reflectance. In Photon-Vegetation Interactions (pp. 139-159). Springer, Berlin, Heidelberg.

6. P12, L230: The BSM model which simulates the isotropic soil reflectance was adopted in this study. For sparse vegetation canopies such as shrubland with low fractional vegetation cover and considerable soil roughness, the soil anisotropy and hot-spot effects are also important to the canopy reflectance for the chlorophyll content and leaf area index retrievals. Hope in the future the soil anisotropic model, e.g., the Hapke model, could be incorporated in the SCOPE framework at least for the soil single scattering contribution.

7. A discussion paragraph or section maybe needed to show the future directions of SCOPE improvements. Recently the leaf specular reflection has been reported to considerably contribute to the canopy reflectance especially over needle leaf forest, while this effect seems was not well considered in the current version. Besides, the 3D complex forest structures which can cast crown-scale dark shadows may also be the challenge for the current 1D models.

8. Seems the canopy coverage Cv was considered in the code of SCOPE2.0, while was not mentioned in the current manuscript.

9. Congratulations to the authors for the several important advances of SCOPE2.0, and I can foresee that this paper as a milestone of SCOPE will have considerable impact on the remote sensing and SIF community. Not all my concerns need to be addressed this time according to the feasibility and available dataset, and some of them could be in the discussion. The accurate description and guidance of the model can better meet the users' needs and expectations. The well validation of the model by field observations can help to bridge the gap between abstract models (modeler community) and complex reality (user community with observations), and is also helpful for the future model improvements.

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-251, 2020.