

## ***Interactive comment on “Evaluation of leaf-level optical properties employed in land surface models – example with CLM 5.0” by Titta Majasalmi and Ryan M. Bright***

### **Anonymous Referee #2**

Received and published: 6 July 2019

Many land surface models require vegetation optical properties (leaf and stem reflectance and transmittance, leaf angle distribution), which are used to calculate the absorption and reflection of solar radiation by vegetation. These parameters are an important part of the model and its surface flux calculation, and are also important in determining changes in surface fluxes related to land cover change (e.g., through changes in surface albedo). The Community Land Model (CLM5) is one such model. Optical parameters in CLM5 trace their heritage to Dorman and Sellers (1989) - some 30 years ago, with minimal changes since then. The authors of the present study compare the CLM5 values with published measurements and show that the model parameters do not match observations in several notable discrepancies. This is a very

C1

nice study that reminds us that model decisions made many years ago (often for expediency) can be forgotten and perpetuated in subsequent model versions. As this paper shows, there is a need to continually recheck models for their fidelity to observations.

#### Major comments

1. An obvious question is whether the updated optical properties improve CLM simulation of surface albedo, or whether there are other factors in CLM that lessen the influence of the optical biases. Simulations with CLM would be quite helpful in this respect, but are not necessary for publication. What is necessary, however, is a discussion of this issue. My intuition is that it is quite likely the model has been tuned over its many versions to reduce the influence of albedo biases. Or if not explicitly tuned, there are likely compensating errors. A particular example is soil color, which is used to obtain soil albedo. No global soil color dataset was available during model development. Instead, soil color originally came from BATS (1986), which as with Dorman and Sellers is undocumented, but soil color was subsequently estimated by tuning the CLM simulated surface albedo to match MODIS (Lawrence and Chase, 2007; JGR, 112, G01023). In dense canopies with high LAI, this may not be too important but in sparse canopies (LAI < 2) soil albedo becomes more important. Also, CLM blends the optical properties of green leaves and wood (stems) to get effective parameters used in the two-stream radiative transfer (RT) model. This is a huge assumption, and is likely a large source of error. Other problems, as the authors have noted, relate to the simplified plane-parallel, homogenous turbid medium assumption used to model RT and the lack of foliage clumping. The authors have a discussion on page 16 about the need to update model parameters. I would like to see this discussion put in the context of other assumptions and simplifications used in the RT model so that readers can assess for themselves how important the new parameters are for improving CLM.

2. The manuscript evaluates the optical properties of grass and crop leaves, but not stems. This omission must be noted and discussed. The implication of the manuscript is that the updated parameter table is better. Modelers may adopt the new parameters,

C2

assume they are better, cite this manuscript as the source of the data, but forget that stem optical parameters were not updated for herbaceous plants.

3. The authors mention photon recollision probability ( $p$ ) in several places throughout the manuscript and make recommendations as to its importance (abstract; introduction; methods; discussion). This is used to upscale from an individual needle to a shoot with many needles – seen in the single scattering albedos (SSA) presented in Table 3 and calculated with eq. (1). The emphasis on  $p$  throughout the manuscript, and the recommendation to include it in models, distracts from the manuscript. The simple message of the study is that reflectance, transmittance, and leaf angle used in CLM can, in some cases, differ from measurements and should be improved. This, however, gets conflated with a second message that RT models are using the wrong optical properties and should use shoot values rather than needle values. The author's do not demonstrate that shoot values improve the model compared with needle values. A skeptic is likely to conclude that leaf optical properties in models are wrongly specified, but why fix them because the model should be using shoot values (though this is not proven). It is fine to maintain the distinction between needle and shoot SSA, but the importance of this has not been demonstrated.

#### Minor comments

page 1, lines 24-26: The authors refer to needle albedo. Is this single scattering albedo (SSA) or reflectance (R)? Presumably it is reflectance (because the comparison is with CLM) but the authors need to clarify because they distinguish between reflectance and SSA in the manuscript.

page 3, lines 8-10: Leaf angle (LIA) is used more fundamentally to obtain the direct beam extinction coefficient, not just to obtain sunlit/shaded leaf area or for RT model inversion.

page 4, line 6: clarify that leaf and shoot albedo refers to single scattering albedo

#### C3

page 4, lines 20-21: This paragraph is a correct history of how the optical parameters used in CLM were obtained. The sentence "Based on CLM grass and crop ..." is correct, but should be rewritten more strongly by deleting "it seems". Change to: "SiB-table class 7, groundcover, was used ..."

page 5, caption to Table 1: What is meant by "user-friendly version"? Table 1 is the same as in the CLM5 technical description, but collapsed to eliminate equivalent data entries. I believe this is what the authors mean by user-friendly, but that expression is likely to confuse readers.

page 10, line 21: Clarify that 0.07 and 0.05 are from CLM. Compare this sentence with the next sentence, in which the distinction between CLM and observations is clear.

page 11, line 1: Only panel c of Fig. 3 is cited. Panels a, b, and d should be cited when discussing the appropriate PFTs.

page 11, Figure 2: I did not find this figure to be too helpful. There is too much information (too many symbols, too many different PFTs in a panel, both VIS and NIR, both observations and CLM). Perhaps more panels (one for each PFT or for similar PFTs) would be helpful.

page 13, second line from bottom: Change Fig. 2b to Fig. 4b

page 15, lines 2-11: Clarify that this text is for leaves only (not for stems)

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Interactive comment on Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2019-59>, 2019.

#### C4