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Interactive comment on "Efficient modeling of sun/shade canopy radiation dynamics explicitly accounting for scattering" *by* P. Bodin and O. Franklin

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The comments made by the reviewer are very general and none of them relate to the actual modifications to the GOU model as suggested by us. Instead the reviewer seems to be of the opinion that there is little need for 1-D models and thus to any improvement to these models. Here we strongly disagree. There is always a need for simple models, and we believe that the modifications suggested by us to the widely used GOU model add both realism and flexibility to the model.

This paper's objective is to obtain a profile of scattered total solar radiation within

a canopy as an improvement over an expression developed by Goudriaan in 1982. Whether this is an improvement or not, not demonstrated, its usefulness is questionable and crop models that today use such an expression could easily be improved by attention to their objective, which I believe is photosynthesis.

We do not fully understand the reviewer's comment. Does the reviewer imply that simple radiation models such as the GOU model are not used today within the model community? This is not true as many LSMs do not even separate the canopy into sunlit and shaded leaves. Also, does he suggest that radiation models should be validated by the effect it has on how well models simulate GPP? We disagree since adding more processes to the model will only obscure the effect of the radiative transfer scheme. Still, we perform a test on the effect our suggested modifications have on GPP as suggested by reviewer 1.

First, the radiation needed is PAR, closely equivalent to visible. My guess is that 30 years ago, total radiation was highlighted as the only radiation quantity that could be measured. Because of the strong spectral dependence of leaf optical properties, any calculation of scattering using total radiation is likely to be highly inaccurate. Fortunately, the scattering in the visible is weak so that approximate treatments of that radiation are more likely to be successful.

The reason we used total radiation in this study is merely since we could not find any suitable profiles of PAR radiation in the scientific literature. The only difference between PAR and total radiation in the model is related to the parameterization of the model. If the reviewer is aware of any measured profiles of scattered radiation in the PAR spectra suitable for testing our model, we would be pleased to use these in the revised manuscript.

Second, what is needed is not a profile of scattered radiation but the PAR absorbed separately by sunlit and by shaded leaves. Since as Eq. (3) of the paper shows, there is a larger fraction of sunlit leaves higher in the canopy, where also diffuse radiation fluxes are higher. The diffuse radiation on the sunlight fraction is likely not to contribute much as these leaves are radiation saturated. Simple expressions for this absorption of PAR by shaded leaves and its contribution to photosynthesis are widely available in climate models, for example in CLM4 that can be downloaded from NCAR.

This is in line with the comments of Reviewer 1 and we intend to add a section about the difference in absorbed radiation by sunlit and shaded leaves. Indeed, the contribution on sunlit leaves is very small. The effect on GPP is heavily dependent on LAI and incoming irradiance, and for sparse canopy with low incoming global irradiance, the modifications made in the BF model compared to the GOU model can have substantial effect on simulated GPP (see response to reviewer 1).

Some other issues are the paper's lack of attention to the issue of leaf optical properties and leaf orientation. Leaves usually have very different transmission and reflection properties, and depending on sun angle, the upward and downward beams of scattered radiation consist of some combination of transmitted and reflected radiation.

In our study we assume a spherical leaf angle distribution, an assumption that is common when it comes to simulating the interception of radiation in canopies. This assumption is also used in the "benchmark" model used by Baldocchi et al. (1985). A G-function could be added to both the GOU and the BF model to modify the value of the beam extinction coefficient based on the variation of inclination angles in the canopy. However, when modeling radiation interception at larger spatial scales, information about leaf inclination angle distribution and radiation properties are rarely

available.

An other concern is the uncritical adoption of a 1-D plane parallel model for the radiation as 3-D effect can introduce large sun angle dependent differences in the profiles of absorbed PAR.

Again, we motivate why using a 1-D model is often necessary. We are perfectly aware of the large numbers of 3-D models and the advantages of these. However, 1-D representations still are commonly used in LSMs where models are used at a global scale, and where information about 3-D structures of canopies often is lacking. Also, in theoretical studies, for example in optimization studies, a 3-D representation is not an option, and there is thus a need for simpler 1-D representations. Our modifications, we believe, adds some realism to an existing, widely used 1-D model and should therefore be of interest to the wider modeling community.

Interactive comment on Geosci. Model Dev. Discuss., 4, 1793, 2011.