

Interactive comment on “How to reconstruct diffuse radiation scenario for simulating GPP in land surface models?” by Yuan Zhang et al.

Anonymous Referee #2

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This manuscript presents a study on how the errors in the reconstructed fraction of diffuse radiation (F_{df}) would affect global GPP estimation using the ORCHIDEE_DF land surface model. The authors have investigated a few methods to reconstruct F_{df} under pre-industrial aerosol emission conditions and shown that different reconstruction method may result in diverse F_{df} and large biases in global GPP estimation. The study may be useful for the land surface modeling and global carbon cycling research community and thus worth publishing, however I have a few concerns that I feel have to be addressed.

First, the title is not accurate. Since clouds can be a major contributor to diffuse radiation, the paper is actually about aerosol-induced diffuse radiation scenario.

Second, the presentation quality of this paper needs to be improved. A lot of important

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details are missing. For example, L49: what are the time spans of ‘historical’ and ‘pre-industrial’? L106-112 is an extremely long sentence. Consider breaking it into shorter ones. The calculation of F_{df} is confusing. How did you make the ‘atmospheric radiative transfer calculations’? How do you make sure F_{df} is consistent with the CRUJRA data, while using aerosol data from other sources? For which years the reconstructing methods were applied? Which years were used for ORCHIDEE_DF runs? These all need to be stated in the methods section.

Third, which I think the most problematic, the reconstructing methods don’t remove the huge cloud impacts on F_{df}, thus implicitly apply the cloud conditions in the base years in 1901-1920 to other years. Therefore, if I understand it correctly, the work doesn’t actually study the aerosol-induced changes of F_{df}. In addition, as stated in L137, ‘Except the F_{df} field, all these simulations use the same climate and land use maps which vary throughout the simulations’. Usually the downward shortwave radiation covary with F_{df}; in other words, if F_{df} is changed (‘reconstructed’), the total downward radiation should also be changed accordingly – this is why a lot of empirical method can successfully estimate diffuse radiation from the total downward radiation with promising accuracy (e.g., see Berrizbeitia, S.E.; Jadrake Gago, E.; Muneer, T. Empirical Models for the Estimation of Solar Sky-Diffuse Radiation. A Review and Experimental Analysis. *Energies* 2020, 13, 701.). Actually these empirical methods are efficient options for estimate (or reconstruct) F_{df} with historical climate fields, although they are not able to distinguish the contribution of anthropogenic aerosols.

Overall, the authors needs to further justify their methods, otherwise the story of impacts on GPP really lacks a solid foundation.

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