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Interactive comment on "Biases in the albedo sensitivity to deforestation in CMIP5 models and their impacts on the associated historical Radiative Forcing" *by* Quentin Lejeune et al.

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We thank the reviewer for taking the time to go through the manuscript and submitting detailed comments. We are providing answers to these below, by referring to the individual comments through mentions of the same line numbers given by the reviewer. We also attach a point-by-point response including the reviewer's comments, which may facilitate the second round of reviews.

-L158: We have extensively worked on improving the methodology description. Including a figure was indeed a good idea to facilitate its understanding by the reader, and we have followed this piece of advice from the reviewer. The new Figure 1 (see below) should clarify non-common technical terms like "big box", the used reconstruction methods and some methodological steps we apply to increase their reliability.

-L235: All reviewers have suggested to use a different kernel to convert the reconstructed historical albedo changes due to conversions between trees and crops/grasses into RF estimates. Following Ryan Bright's comment, we have decided to use the version 1.0 of the CERES-based albedo change kernel (CACK) from Bright and O'Halloran (2019) for the Radiative Forcing calculations. This kernel is based on a novel, simplified parameterisation of shortwave radiative transfer and driven with downwelling shortwave radiation values at the surface and the top of the atmosphere obtained from the Clouds and the Earth's Radiant Energy System (CERES) Energy Balance and Filled (EBAF) 1°-resolution products. CACK was evaluated by Bright and O'Halloran (2019): While being more easily understandable and easier to apply than kernels derived from climate models, it is able to mimick them more faithfully than five previously employed analytical, semi-empirical and empirical kernels.

-L284: The reviewer is right that the surface albedo in both observational data and climate models is influenced by both the vegetation canopy and the soil reflectance. We have now clarified this at the beginning of Section 2.1.1. For the sake of simplicity, we however use the formulation "albedo of a specific land cover class" when referring to this mixed contribution of the soil and canopy to the surface albedo. This has also made clear in Section 2.1.1.

We would like to stress that the present-day albedo of trees and crops/grasses is only reconstructed following the method described in Section 2.3.1 in order to be evaluated against satellite-derived data, as discussed in Section 4 and illustrated in Figures 5-10. In contrast, the historical albedo changes associated with transitions between trees and crops/grasses between the pre-industrial and 1981-2000 periods are reconstructed following the method described in Section 2.3.2, so that the associated global RF can be derived and discussed in Section 5 (based on Figures 11 and 12) in light of the model biases identified using the first reconstruction method. We acknowledge that this may have been ambiguous in the submitted manuscript, and intend to make it clearer in the revised version. That being said, changes in surface albedo over vegetated surfaces between the pre-industrial and present-day periods are mainly influenced by changes in albedo of the vegetation canopy, in the fraction of ground (soil or snow) that is shed from sunlight by the vegetation canopy, and in the albedo of the ground. The first two contributions are mostly influenced by LCC and in particular transitions between trees and crops/grasses. They are therefore included in the term $\delta 1$ of Equation (9). The latter contribution is mostly influenced by other climate forcings such as greenhouse gases, whose influence has a larger spatial extent which is thus assumed to be constant across a big box and included in the term $\delta 0$. For the models for which factorial experiments (with LCC only or with all forcings except LCC) are available, we were able to directly extract the simulated change in surface albedo due to LCC. The similarities between these direct estimates and the results from the reconstructed method (compare the columns on the left and right sides of Figures S6, S7, S11 and S13) confirm the ability to properly separate surface albedo changes due to LCC from those due to changes in snow accumulation and melt. Some differences are found for the GFDL-ESM2 model but both estimates remain compatible given the uncertainty ranges of each method (see Figure S21).

-L311: the present-day albedo of trees and crops/grasses that is reconstructed in the CMIP5 simulations using the methodology described in Section 2.3.1 is not used later on in the RF calculations, but simply to be evaluated against reference satellite-derived data. This evaluation effort reveals that, in some of the analysed CMIP5 models, the reconstructed albedo changes associated with transitions from trees to crops/grasses can differ from the reference values from Duveiller et al. (2018) by $\sim$0.05 (respectively, $\sim$0.4) over snow-free (respectively, snow-covered) areas (see Figures 9 and 10). These differences being substantially higher than the RMSE of the reconstruction (which amounts to $\sim$0.019 over snow-free and $\sim$0.051 over snow-covered areas), we affirm that this RMSE is acceptable enough for the purpose of the conducted model evaluation.

-L321: Because our analysis focuses on the potential albedo change resulting from a land cover conversion between trees and crops/grasses rather than the mean surface albedo of each model grid cell, differences in the vegetation distributions of individual models should play a limited role in the biases identified in Figures 5-10. It is however true that if a model has a too low proportion of trees in a given region, for example, it can hinder the retrieval of the albedo of trees in this same region and therefore limits the scope of our analysis.

-L335: The papers by Thackeray et al. (2014, doi=10.1002/2014JD021858 and 2015, doi=10.1002/2015JD023325), as well as Wang et al. (2016, doi=10.1002/2015JD023824) brought to our attention by the reviewer are indeed very relevant for the interpretation of our results. They also point at model deficiencies which can be linked to some of the biases identified in our study, such as the too high albedo of trees in snow-covered areas in the MIROC5 model.

We will also take the minor comments concerning the language into account when proofreading the manuscript again.

Bright, R. M. and O'halloran, T. L. (2019) 'Developing a monthly radiative kernel for surface albedo change from satellite climatologies of Earth's shortwave radiation budget: CACK v1.0', Geosci. Model Dev, 12, pp. 3975–3990. doi: 10.5194/gmd-12-3975-2019.
Duveiller, G., Hooker, J. and Cescatti, A. (2018a) 'A dataset mapping the potential biophysical effects of vegetation cover change', Scientific Data. Nature Publishing Groups, 5. doi: 10.1038/sdata.2018.14.

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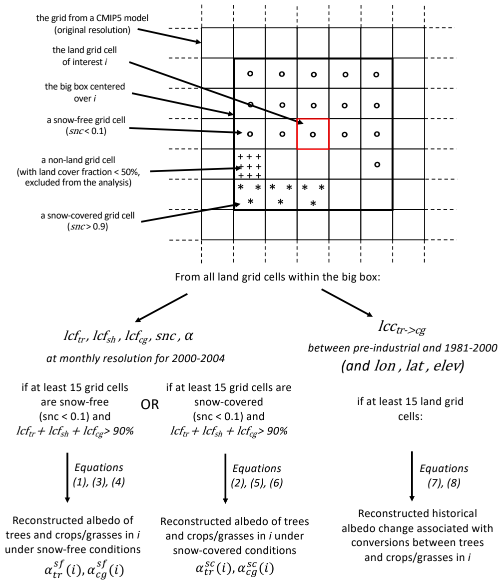

Figure 1: Description of the two employed reconstruction methodologies. *snc* stands for snow cover fraction, α for albedo, *lcf* for land cover fraction, *lcc* for land cover conversion, the suffixes *tr*, *sh* and *cg* for trees, shrubs and crops/grasses, respectively, *lon* for longitude, *lat* for latitude, and *elev* for elevation.

Fig. 1. Suggestion for a new Figure 1 describing the methodology.