We would like to thank the anonymous reviewers for their comprehensive comments. Below, we provide our responses in detail and describe the corresponding changes in the manuscript.

Referee #1

***RC1**: (1) The paper lacks a clear causal explanation of why the models vary so much in the change in the amplitude of soil temperature. The attempt to explain the variation relies of two factors: the annual amplitude of ground heat flux, and soil moisture. Soil moistures is a perfectly valid explanatory variable but ground heat flux is not. Temperature and ground heat flux are both thermodynamic quantities and thus are very closely linked. Without an internal heat source (such are waste heat from soil carbon decay) subsurface temperature is surface heat flux modified changes in thermal diffusivity and heat capacity. In models thermal diffusivity is likely only being changed by soil moisture and maybe soil carbon content. Thus, it is no surprise that temperature and heat flux correlate well, but also this does not constitute an explanation.*

Instead the focus should be on the differences in surface energy balance components (which are briefly examined) and the differences in model structure that may cause these differences. Key features to examine are: how snow is treated, how litter is treated (it is a good insulator), how forest canopies are treated and how root-depth is treated.

AC: We agree that we should examine in-depth the reasons behind the changes in soil heating with afforestation and consequently in annual amplitude of soil temperature across modelling systems. We have noted that the changes in the annual amplitude of soil temperature are due to the representation of summertime climate processes, thus we should focus on summer season. Specifically, we will examine the differences in surface energy balance components across models and regions. The physical processes which take place at land surface, such as the radiative and turbulent heat fluxes, are differently weighted in models depending on land-use characteristics, like surface roughness, LAI, surface albedo etc. Analyzing the changes in surface energy budget components with respect to inter-model differences in land-use parameters, we will potentially reveal a large spread in the magnitude of afforestation effect on radiative and non-radiative processes and consequently in soil heating across models. Since the analysis is going to be carried out for summer, the land-surface is assumed to be snow-free. Heat storage in biomass or litter above ground is not considered in our models.

Changes to manuscript: We will change the section 3.2 (Annual amplitude of GHF) with the section "Surface energy balance" where an analysis focused on the summer changes of surface energy balance components will be performed, taking into account inter-model differences in surface albedo, LAI, cloud fraction, roughness length, which directly affect the energy and heat fluxes at land surface. It is expected that many of changes in land-use parameters will finally explain a large part of inter-model variance in AAST.

***RC1**: (2) Despite being mentioned in the introduction soil profiles are never examined. Instead annual amplitudes of temperature at just one depth are examined. It would be useful to examine how temperature changed with depth in grassland and afforested conditions. Examining these profiles may also be helpful in finding a causal explanation for inter-model variance.*

AC: We had examined the soil temperature changes with depth, specifically we showed the simulated changes in soil temperature profile across seasons in Figures S9-S16 in the supplementary material. Although, you are right, we never mentioned any clear conclusion from these plots. Finally, the sign of temperature changes does not change with depth and only the magnitude of changes is affected.

Changes to manuscript: To better illustrate the changes in soil temperature with depth, we will add three additional figures, similar to Figure 2, where the AAST responses at 2 cm, 20 cm, 50 cm below the ground are to be shown (in addition to AAST response at 1 meter depth). Furthermore, we will include the soil temperature changes at the above-mentioned soil depths in our analysis on the mean monthly soil temperature changes due to afforestation over the regions of interest (Figure 3, Figure 4).

RC1 *:(3) How the models are being forced is unclear. The text implied that RCMs are being used with interactive atmospheres but the methods section seems to imply the reanalysis data is being used to force the models. The methods may be trying to say the reanalysis is being used at the RCM boundaries but this is not at all clear.*

AC: RCMs are forced by ERA-Interim reanalysis data at their lateral boundaries and at the lower boundary over sea.

Changes to manuscript: In line 115 we will add "..forced by ERA-Interim reanalysis data (Dee et al., 2011) at their lateral boundaries and at the lower boundary over sea".

RC1 *:(4) The manuscript has far to many abbreviations. As a rule of thumb, only define an abbreviation if you are going to use it 5 times or more.*

AC: Agreed

Changes to manuscript: We will reduce the abbreviations as much as possible.

RC1 *:(5) Citation parenthesis are used incorrectly. Citations are not placed in parenthesis if they need to be pronounced as part of a sentence. For example "(Davin and de Noblet-Ducoudre, 2010) analysed a GCM's sensitivity to idealized global deforestation ..." should be: "Davin and de Noblet-Ducoudre 2010, analysed a GCM's sensitivity to idealized global deforestation ..."*

AC: Agreed

Changes to manuscript: Citation parentheses will be used correctly

RC1 *:(6) Using Celsius instead of Kelvin would make the manuscript more readable.*

AC: Agreed

Changes to manuscript: Temperature unit will be converted to Celsius

RC1 *:(7) The paper is not self-contained and relies on Davin et al. 2020. Elements critical for understanding the experiments should be reproduced here.*

AC: Agreed

Changes to manuscript: Vegetation maps and the table about RCMs characteristics and settings will be added in supplementary material.

Specific Comments:

RC1: *Abstract: Make it clearer you are examining soils.*

AC*: Agreed*

Changes to manuscript*: The abstract will be edited accordingly.*

RC1: *Introduction: Briefly introduce the biogeochemical effects of deforestation and make clear that you are only examining the biophysical effects. Also need to explain what RCMs are and how they improve on global studies.*

AC*: Agreed.*

Changes to manuscript*: We will add the proposed changes in the introduction section.*

RC1: *Line 44: Many of the models that you are referring to are Earth system models.*

AC*: will be corrected*

Changes to manuscript*: GCM will change to ESM*

RC1: *Line 48: Cloud feedbacks?*

AC: *maybe it's needed to make this sentence more readable.*

Changes to manuscript: *Lines 46-50: "Davin and de Noblet-Ducoudre, 2010 analysed an ESM's sensitivity to idealized global deforestation, indicating that the net biophysical impact results from the balance between radiative and non-radiative processes. In the same study, deforestation induced a warming over the tropical zone owing to a reduction in evapotranspiration rate and surface roughness, whereas a deforestation-induced cooling simulated over the temperate and boreal zones, because an albedo increase provided the dominant influence in these regions. "*

RC1: *Line 48: "On contrary" is not grammatically correct. "However" would work.*

AC: Agreed

Changes to manuscript*: will be corrected*

RC1: *Line 50: Citation needed.*

AC*: maybe it's needed to make this sentence more readable.*

Changes to manuscript*: Lines 46-50: "Davin and de Noblet-Ducoudre, 2010 analysed an ESM's sensitivity to idealized global deforestation, indicating that the net biophysical impact results from the balance between radiative and non-radiative processes. In the same study, deforestation induced a warming over the tropical zone owing to a reduction in evapotranspiration rate and surface roughness, whereas a deforestation-induced cooling simulated over the temperate and boreal zones, because an albedo increase provided the dominant influence in these regions. "*

RC1: *Line 54: "Inter-comparison" should be "Intercomparison"*

AC: Agreed

Changes to manuscript*: will be corrected*

RC1: *Line 106: This table should be reproduced for this paper.*

AC: Agreed

Changes to manuscript*: will be added in supplementary material*

RC1: *Line 110, 112: Forest and Grass are not acronyms and thus do not need to be in all caps.*

AC*:* We would prefer to keep FOREST and GRASS in caps, as they are presented in previous studies of LUCAS FPS (Davin et al 2020, Breil et al 2020). They may not be acronyms, but they indicate the names of the experiments/scenarios under consideration. If they are written in lower case, there will be confusion between the names of the experiments and the general meaning of words "forest" and "grass".

Changes to manuscript: None

RC1: *Line 113: Show the maps.*

AC*: Agreed*

Changes to manuscript*:* Will be added in the supplementary material

RC1: *Line 117, 118: These abbreviations are barely used. They can easily be eliminated.*

AC*: Agreed*

Changes to manuscript*: will be removed*

RC1: *Figure 1: The map needs a North arrow, a scale, and inset showing the study domain, and higher resolution territorial boundaries. Using a different line style for national boarders and coastlines would also be helpful.*

AC*: Agreed*

Changes to manuscript*: The map will be refined.*

RC1: *Line 165-166: Rewrite sentence for clarity.*

AC*: Agreed*

Changes to manuscript*: In lines 165-166: "The theoretical maximum afforestation in RCMs has the potential to induce changes in large-scale atmospheric circulation, which can create teleconnections (Swann et al., 2012) that modify the regional cloud cover (Laguë and Swann, 2016) and thus the regional climate conditions. Such feedbacks are not realistic in observations, where most forest measurement locations are located in relatively small forest patches surrounded by open land and is almost unlikely to alter the climate conditions on regional scale."*

RC1: *178: 'assumed' is a poor choice of words. Models suggest.*

AC*: Agreed*

Changes to manuscript*: "assumed" will be changed to "suggested".*

RC1: *Line 207: Change 'involve' to 'include'*

AC*: Agreed*

Changes to manuscript*: "involve" will be changed to "include".*

RC1: *Line 213, 215: 'Obviously' and 'totally different' are informal constructions 'Clearly' and 'largely different' would be more consistent with formal English.*

AC*: Agreed*

RC1: *Figure 3,4: Use Celsius, also in caption give depth of temperature.*

AC*: Agreed*

RC1: *Figure 5: In caption explains which direction of heat flow is considered positive.*

AC*: Agreed*

RC1: *Figure 8: Net radiation and turbulent fluxes should have opposite signs, one is opposing the other. Is melt energy included in the latent heat flux?*

AC*: In this plot, we see the afforestation effect (FOREST minus GRASS) on radiative and heat fluxes at surface, thus positive (negative) values mean an increase (decrease) with afforestation.*

Changes to manuscript*: We will make it clear what the direction of changes mean.*

RC1: *Figure 11: Write out the region names.*

AC*: Agreed*

RC1: *Line 371: At what depth is the cooling?*

AC: In Table 2, we concentrated the characteristics of the sites selected from FLUXNET2015 dataset. More specifically, we provided the common measurement depth below the ground surface that is available for each pair site. The range of depths varies from 5 cm to 15 cm, with the most common depth being 10 cm for most pair sites. As already mentioned in section 2.3, soil temperature from models was linearly interpolated to the common measurement depth that is available for each pair site and averaged over the time period 2003-2014 which covers the observational time span.

Changes to manuscript: None

RC1: *Line 389: This section is the Discussion and Conclusions.*

AC*: it will be corrected*

RC1: *Line 439: 'Nowadays' is English slang, very informal.*

AC*: it will be corrected*

References:

Breil, M., Rechid, D., Davin, E. L., Noblet-Ducoudré, N. de, Katragkou, E., Cardoso, R. M., Hoffmann, P., Jach, L. L., Soares, P. M. M., Sofiadis, G., Strada, S., Strandberg, G., Tölle, M. H., and Warrach-Sagi, K.: The Opposing Effects of Reforestation and Afforestation on the Diurnal Temperature Cycle at the Surface and *in the Lowest Atmospheric Model Level in the European Summer, 33, 9159–9179, https://doi.org/10.1175/JCLI-D-19-0624.1, 2020.*

Davin, E. L., Rechid, Di., Breil, M., Cardoso, R. M., Coppola, E., Hoffmann, P., Jach, L. L., Katragkou, E., De Noblet-Ducoudré, N., Radtke, K., Raffa, M., Soares, P. M. M., Sofiadis, G., Strada, S., Strandberg, G., Tölle, M. H., Warrach-Sagi, K., and Wulfmeyer, V.: Biogeophysical impacts of forestation in Europe: First results from the LUCAS (Land Use and Climate across Scales) regional climate model intercomparison, https://doi.org/10.5194/esd-11-183-2020, 2020.

Laguë, M. M. and Swann, A. L. S.: Progressive Midlatitude Afforestation: Impacts on Clouds, Global Energy Transport, and Precipitation, 29, 5561–5573, https://doi.org/10.1175/JCLI-D-15-0748.1, 2016.

Swann, A. L. S., Fung, I. Y., and Chiang, J. C. H.: Mid-latitude afforestation shifts general circulation and tropical precipitation, Proceedings of the National Academy of Sciences, 109, 712–716, https://doi.org/10.1073/pnas.1116706108, 2012.