We thank the reviewer #1 for the constructive comments on our manuscript. Below, we answer to each of them. In black, are the reviewer comments and in red our responses and in italics, the additional text we propose to add in the revised manuscript.

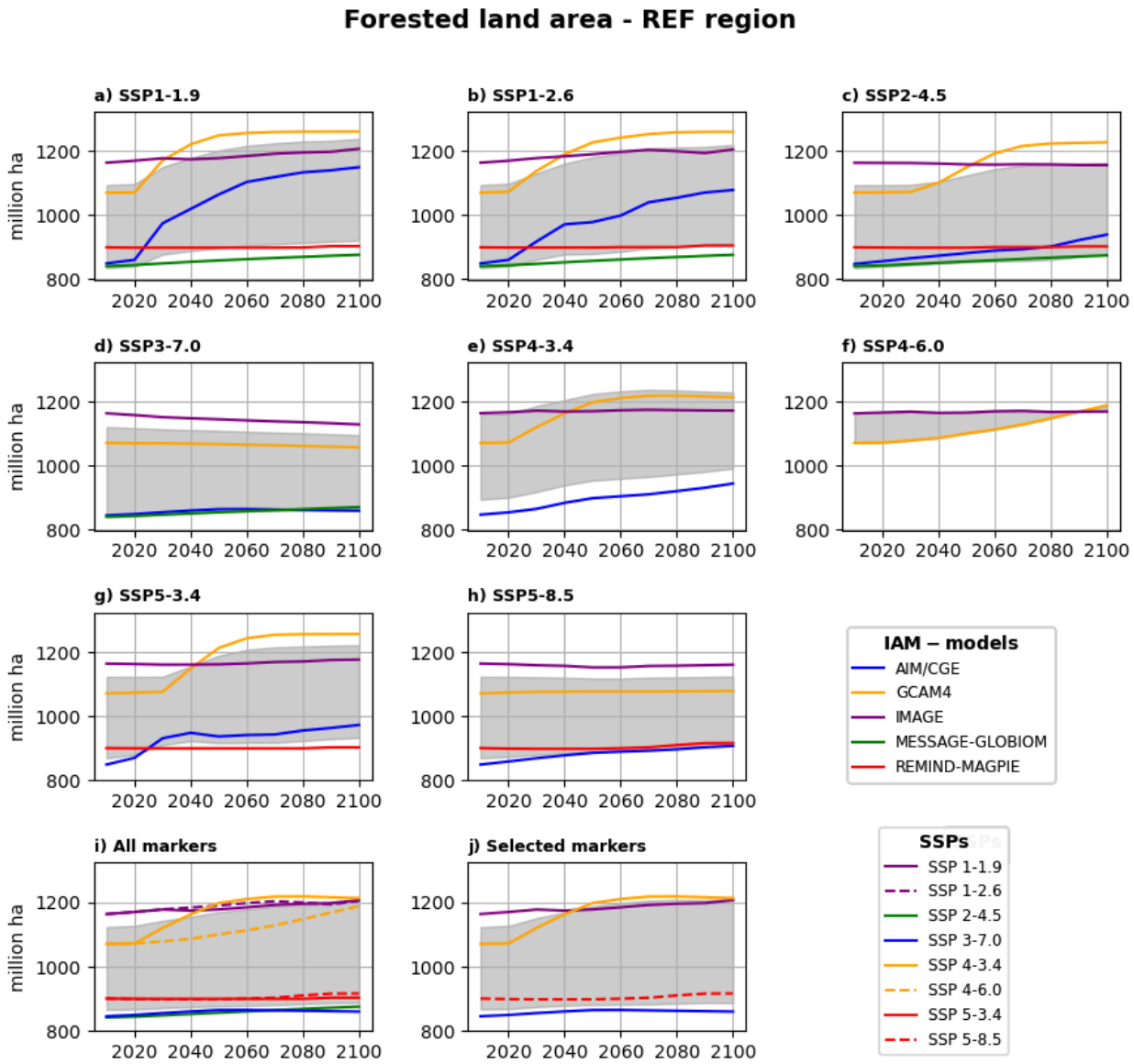
In the manuscript “Projected changes in land carbon store over the 21st century: what contributions from land-use change and atmospheric nitrogen deposition?”, the authors evaluated the changes of CLCS projections in SSPs, focusing the uncertainties from land use change and nitrogen deposition. The authors concluded that the projection spread contributed by land use change spread is larger than from CO2 spread, and the nitrogen deposition has relatively smaller contribution. This conclusion is important and has significant implications for understanding the projections of the Earth system models. However, I think the presentation of this manuscript need to be improved and a few concerns need to be addressed before publishing.

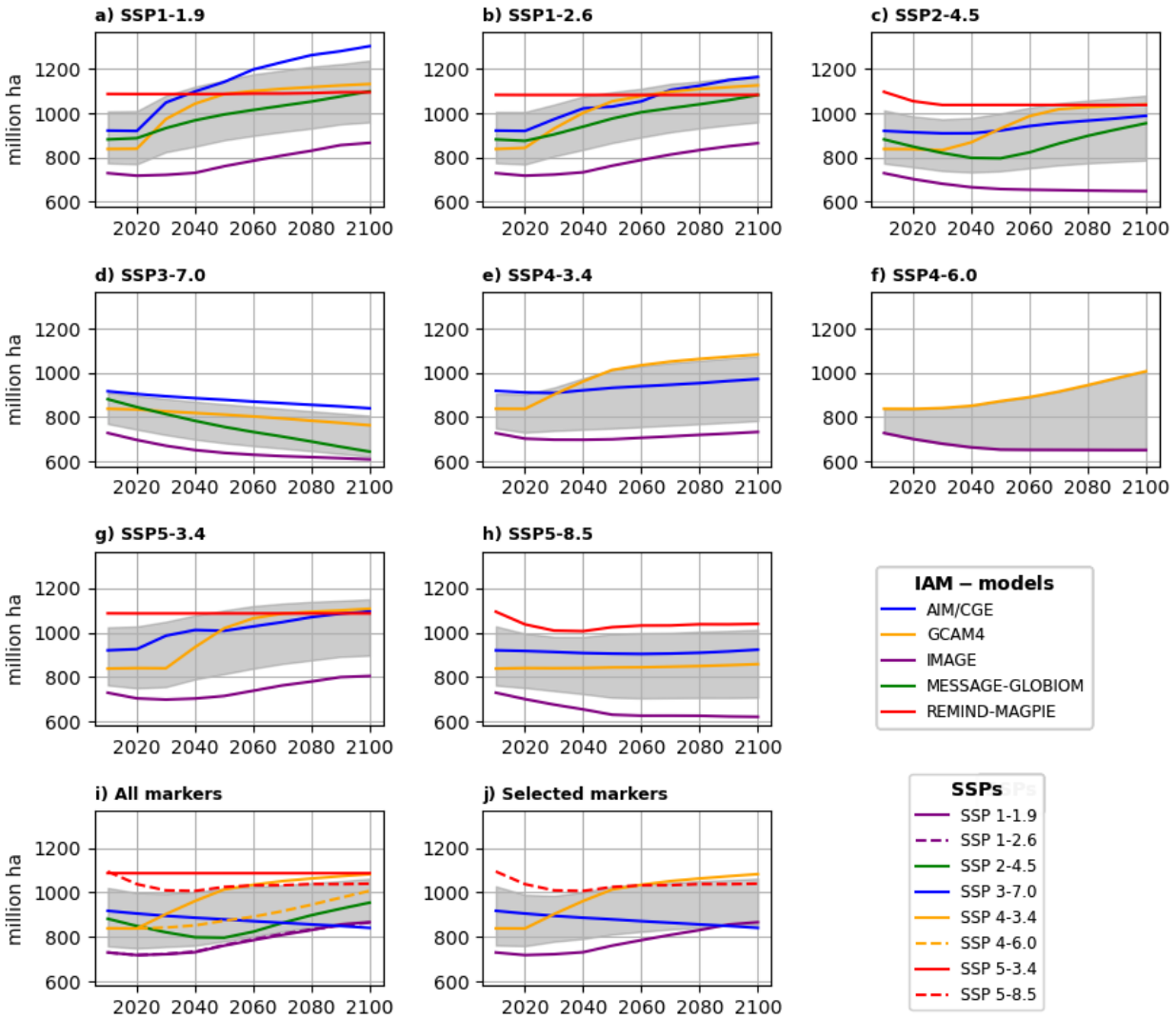
– The main concern I have is about the land use change and N deposition spread. The authors “used the selected SSP markers spread as a proxy for the inter-IAM spread”. Although the authors compared the two spreads, and showed them to have similar magnitude. There is still possibility that the differences of vegetation types are systematically different among SSP markers and IAMs. i.e. the SSP markers spread could come from the scenario differences while inter-IAM spread for the same scenario is from model differences. The same vegetation type distributed in different regions (e.g. tropical and boreal forests) may have different C source/sink. Therefore, besides the global analyses, it is necessary to check where the differences are in SSP markers spread and inter-IAM spread.

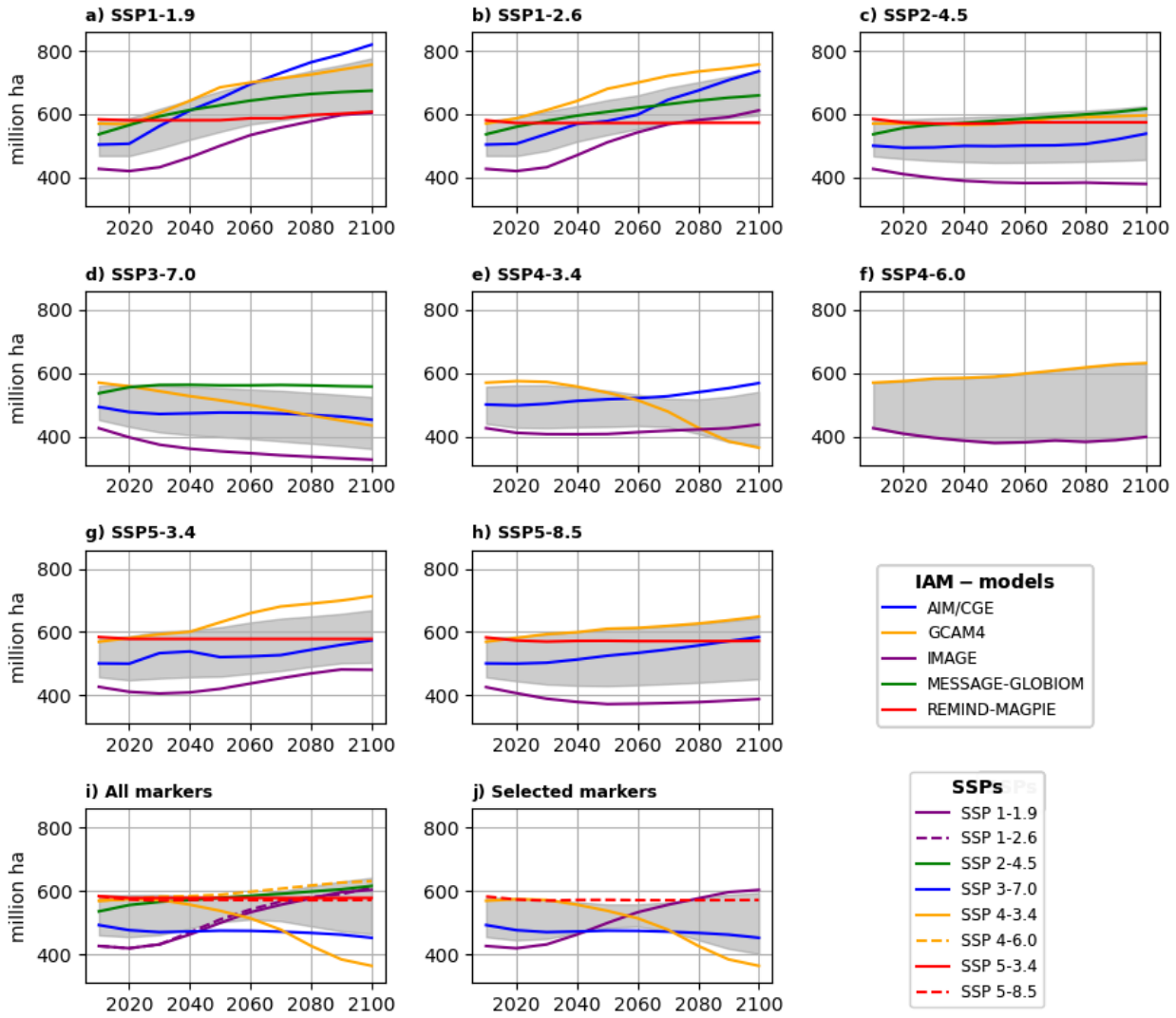
We thank the reviewer #1 for the suggestion of performing a regional analysis. Such regional analysis will help to ensure that the SSP markers spread is comparable to the inter-IAM spread not only at global scale but also at regional scale. The data we used for processing Figures 1, 2 but also A1, A2 and A3 is IAM output data produced for CMIP6, available on the SSP Database (https://tntcat.iiasa.ac.at/SspD). They are accessible at global scale but also for five aggregated geographical and/or economical regions. These five regions are “Asia” (ASIA), “Latin America” (LAM), “Reforming economies (REF), “Middle East and Africa” (MEA) and countries from the “Organisation for Economic Co-operation and Development” (OECD). We re-processed for the five aggregated regions (see Figures below) the Figure 1 which shows the time evolution (2015-2100) of the forested land area projected by different Integrated Assessment Models (IAM) for different Shared Socio-economic Pathways. The results of this regional analysis show that the inter-IAM spread is significant for any of the five regions and comparable to the selected SSP markers spread. As a consequence, the assumption of using the selected SSP markers spread as a proxy for the inter-IAM spread based on a global analysis remains valid at regional scale. We do not suggest to keep these extra figures as part of the manuscript nor in the Appendix. Nevertheless, we propose to add extra information in the manuscript reporting on this regional analysis at line 130:

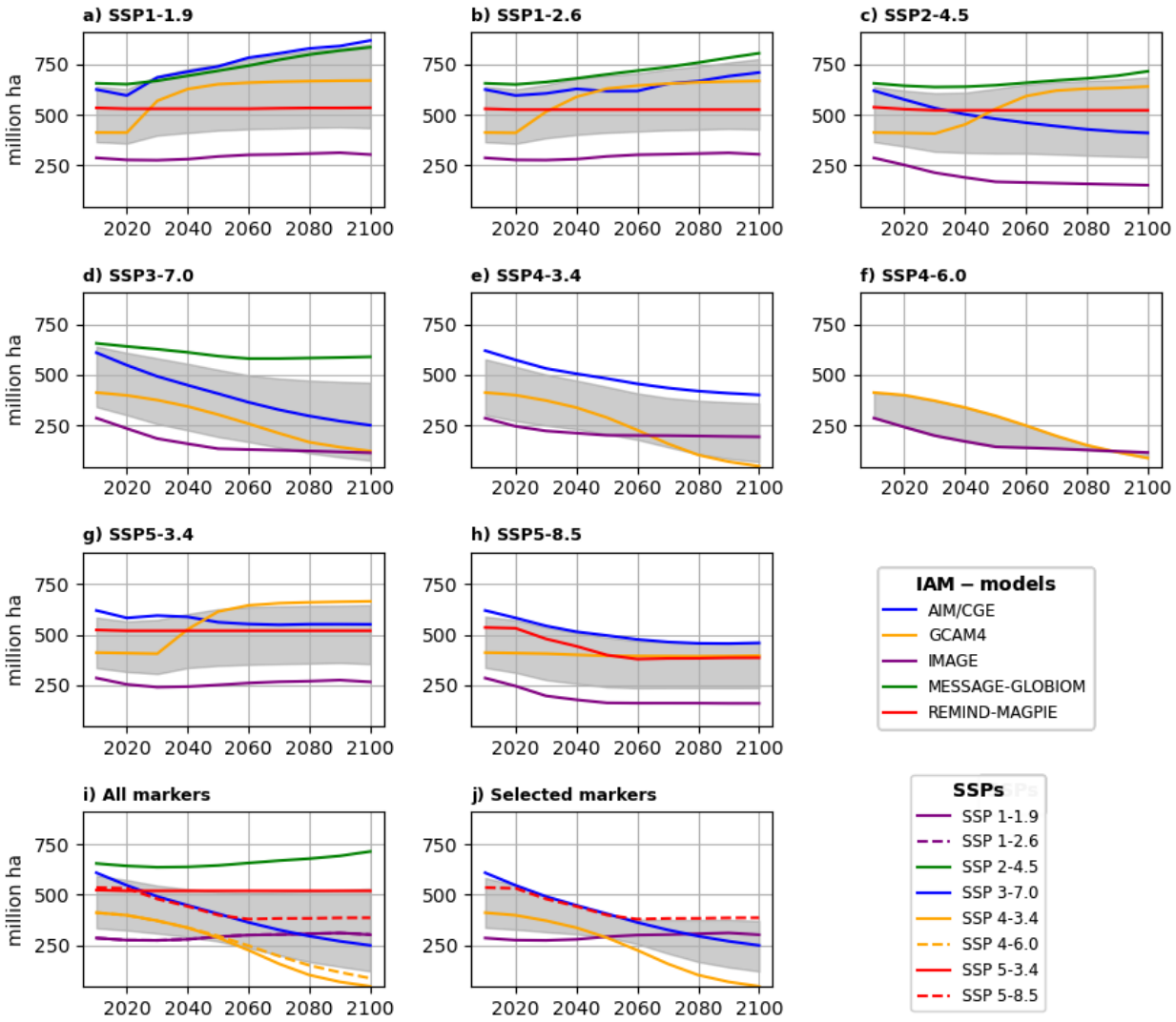
“The comparison between inter-SSP markers and inter-IAM trajectories for the different SSPs is presented at global scale, but the conclusion that the selected SSP markers

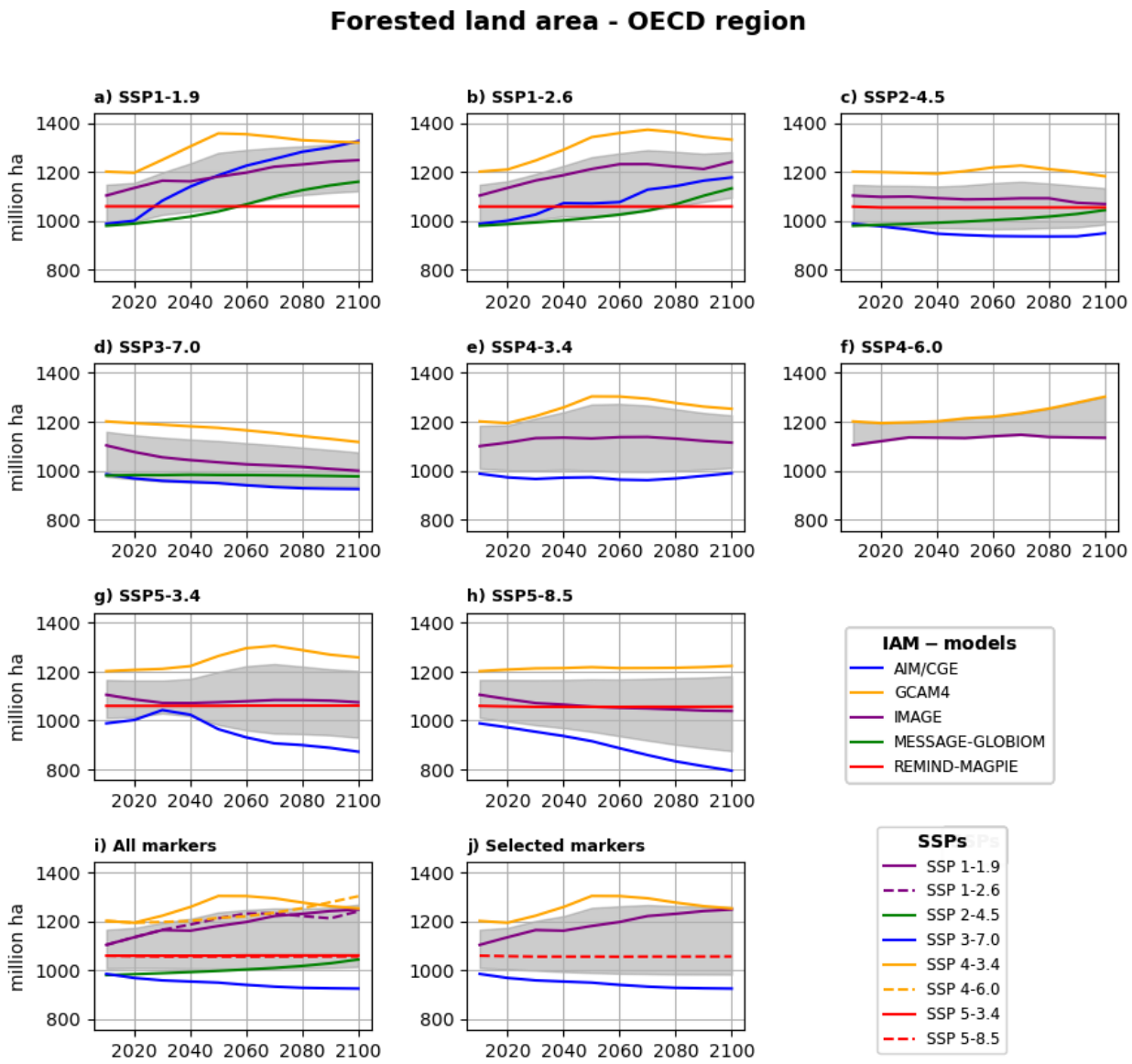
spread is comparable to the inter-IAM spread for the different SSPs remains valid at regional scale (based on the data available on the SSP Database for five aggregated regions (“Asia”, “Latin America”, “Reforming economies”, “Middle East and Africa” and countries from the “Organisation for Economic Co-operation and Development”*), not shown).*




Forested land area - LAM region
a) SSP1-1.9
b) SSP1-2.6
c) SSP2-4.5
d) SSP3-7.0
e) SSP4-3.4
f) SSP4-6.0
g) SSP5-3.4
h) SSP5-8.5
i) All markers
j) Selected markers
million ha
600
800
1000
1200
2020
2040
2060
2080
2100
IAM – models
AIM/CGE
GCAM4
IMAGE
MESSAGE-GLOBIOM
REMIND-MAGPIE
SSPs
SSP 1-1.9
SSP 1-2.6
SSP 2-4.5
SSP 3-7.0
SSP 4-3.4
SSP 4-6.0
SSP 5-3.4
SSP 5-8.5


Forested land area - ASIA region
a) SSP1-1.9
b) SSP1-2.6
c) SSP2-4.5
d) SSP3-7.0
e) SSP4-3.4
f) SSP4-6.0
g) SSP5-3.4
h) SSP5-8.5
i) All markers
j) Selected markers
million ha
800
600
400
2020
2040
2060
2080
2100
IAM – models
AIM/CGE
GCAM4
IMAGE
MESSAGE-GLOBIOM
REMIND-MAGPIE
SSPs
SSP 1-1.9
SSP 1-2.6
SSP 2-4.5
SSP 3-7.0
SSP 4-3.4
SSP 4-6.0
SSP 5-3.4
SSP 5-8.5


Forested land area - MAF region
a) SSP1-1.9
b) SSP1-2.6
c) SSP2-4.5
d) SSP3-7.0
e) SSP4-3.4
f) SSP4-6.0
g) SSP5-3.4
h) SSP5-8.5
i) All markers
j) Selected markers
million ha
750
500
250
2020
2040
2060
2080
2100
IAM – models
AIM/CGE
GCAM4
IMAGE
MESSAGE-GLOBIOM
REMIND-MAGPIE
SSPs
SSP 1-1.9
SSP 1-2.6
SSP 2-4.5
SSP 3-7.0
SSP 4-3.4
SSP 4-6.0
SSP 5-3.4
SSP 5-8.5



– Also, I think the authors need to carefully use the term “uncertainty”. In my opinion, the forcings are from different scenarios and the differences due to the forcings are thus not something “uncertain” but some “certain” signal. The use of “spread” is also somehow inaccurate as we usually use the term for “model spread”. I prefer to explain the results as scenario difference rather than “uncertainty”.

We agree that the use of the term “uncertainty” may not be always appropriated in the manuscript. Indeed, we used the term “uncertainty” when referring to uncertainty on land-use change or nitrogen deposition trajectories for instance because ultimately that is the uncertainty from the different IAMs we would like assess. Unfortunately, because these IAM trajectories for the different SSPs are not gridded and harmonized, we used the selected SSP markers spread as a proxy for the inter-IAM. You are right that the different SSP trajectories do not strictly reflect a model uncertainty but indeed more “differences” obtained from different assumption in terms of socio-economic development and mitigation target.

We thus propose to change a much as possible the word “uncertainty”, when it refers directly to various SSPs, to “differences”. As an example:
The Initial sentence in the abstract: “Through a set of land-only factorial simulations, we specifically aim at estimating the **CLCS uncertainties** associated with land-use change and nitrogen deposition trajectories. ”
New sentence: *”Through a set of land-only factorial simulations, we specifically aim at estimating the CLCS **differences** associated with **differences in** land-use change and nitrogen deposition trajectories.”*

With respect to differences induced by IAM model structure, we choose to keep in certain cases the term “model uncertainties” and to be more explicit with the terms “model spread” or “model differences”. Note that for the land surface model evaluation (TRENDY inter-comparison) the term model uncertainties is often used to qualify some outputs.

However, in some particular cases it is more appropriate to keep the word uncertainty, although it also partly refers to different assumptions. We thus also added the following sentence, line 115: *“Given that, ultimately, we would like to assess the uncertainty associated to land-use and nitrogen inputs from the different IAMs for any SSP, in the following we may use the term “uncertainty” when referring to the different inter-SSP markers trajectories although they correspond to more certain trajectories obtained for different assumptions in terms of socio-economic development and mitigation level.”*

Finally with respect to the term “spread” we do not agree with the reviewer as indeed it is often used as “model spread” but we believe it is more general and can thus be used in other context to refer to differences. We have however tried to restrict a bit its use throughout the revised manuscript.

– My second concern is that this study is based on a single model ORCHIDEE-v3. Given the large differences among land surface models, I wonder how robust the results are. I am not asking to add new simulations, but discussing this uncertainty is helpful. The authors may compare ORCHIDEE-v3 and other models’ performances in the TENDY land use change experiments to estimate the robustness of this study.

We fully agree with this comment. The end of the Discussion section is referring to this topic. In particular, line 284, there is the following sentence: “This limited set of studies thus highlights the need of performing the multi-sensitivity analysis we proposed in this paper with an extended ensemble of models, in order to evaluate how our conclusions can be shared across models with different representations of the key C-related ecosystem processes.”

As suggested by the reviewer, we propose to add some information about the ORCHIDEE-v3 model performances within the TRENDY ensemble. O’Sullivan et al. (2022) developed an extended multi-model analysis of the drivers of the land carbon sink and its sources of uncertainty based on the TRENDY models ensemble. Their figure 3 shows the multi-model ensemble of the time evolution over the last six decades of the change in carbon stored in the vegetation and in the soil pools due to change in CO2 and

Nitrogen deposition, climate, and land use change. The Figure 2 in the supplementary information of O'Sullivan et al. paper shows the same information for each of the eighteen models of the TRENDY ensemble, including ORCHIDEE-v3. This figure highlights the high inter-model dispersion for any of the six trajectories in terms of carbon changes (2 pools x 3 drivers). The comparison of the two figures shows that the changes in carbon stored in vegetation and soil due to the three main drivers as simulated by the ORCHIDEE-v3 model are very similar to those computed as the multi model ensemble mean. The only significant difference is obtained for the change in carbon stored in the soil pool due to land-use change: the multi-model ensemble mean estimates a loss of carbon in soil due to land-use changes of about 25 PgC between 1960 and 2020 while ORCHIDEE-v3 estimates there is no change by 2020. Note that this difference of ~25 PgC remains in the ±1sigma interval of the TREND models distribution (see Figure 3b of O'Sullivan et al., 2022).

We propose to rewrite and extend the sentence lines 284-286 ("This limited set of studies thus highlights the need of performing the multi-sensitivity analysis we proposed in this paper with an extended ensemble of models, in order to evaluate how our conclusions can be shared across models with different representations of the key C-related ecosystem processes.") as follows:

"The large inter-model spread regarding changes in land carbon store has also been reported in many studies such as the one of Liddicoat et al. (2021) based on the CMIP6 historical and SSPs experiments or the one of O'Sullivan et al. (2022) based on the TRENDY land models ensemble over the last six decades. In this latter study, eighteen land surface models were used to assess the changes in carbon stored in vegetation and soil due to change in CO2 and Nitrogen deposition, climate, and land use. ORCHIDEE-v3 was one of these models and showed results very similar to those obtained with the multi model ensemble means which gives confidence on how relevant are the results of the present study. Nevertheless, there is a need of performing the multi-sensitivity analysis we proposed in this paper with an extended ensemble of models, in order to evaluate how our conclusions can be shared across models with different representations of the key C-related ecosystem processes."

– Finally, I suggest the authors to divide Section 3 into subsections, so the readers can better follow and capture the key points.

Thank you for this suggestion. We propose the following subsection titles:

"*Change in land carbon store (CLCS) over the historical period and for the different SSPs experiments*": From line 173 to 197

"*Spatial and temporal analysis of the CLCS dispersion and its drivers*": From line 198 to 227

"*Change in carbon stored in vegetation and litter and soil pools*": From line 228 to 248

"*CLCS as a function of atmospheric CO2, Forested land area and atmospheric nitrogen deposition*": From line 249 to 269

"*Comparison with other studies and path for future research*": From line 270 to 286

– Line 57: non-makers -> non-markers

This will be corrected for in the revised manuscript