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Interactive comment on "Disturbance legacies have a stronger effect on future carbon exchange than climate in a temperate forest landscape" *by* Dominik Thom et al.

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Anonymous Referee #3

REFEREE #3: General comments : The research article named 'Disturbance legacies have a stronger effect on future carbon exchange than climate in a temperate forest landscape,' try to explore the effect of disturbance legacies and climate change in the projection of the forest carbon sequestration. In order to do that, they reconstruct a well documented historical scenario of an Austrian forest landscape with two disturbance events and one forest management shift. At the end of the paper, they encourage the scientific community to take into account the forest history when initializing the

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forest state before running projections of the forest dynamic. This is a nice attempt to promote the integration of disturbances and abrupt mortality in model development. I really appreciate the quality of the work done by the simulation experiment and the past reconstruction forest state with the new method of spin-up. I am convinced that this paper can be published without deep changes in the structure and the content.

AUTHORS: We are grateful for the positive evaluation of our study.

REFEREE #3: However, five points need to be clarified: 1) The results of the simulation experiment show that past forest management (absence or presence) is the main factor to explain the divergence between simulations. But this finding is not central to the paper! Instead of that, the authors define forest management as a human disturbance (that is perfectly true) and merged natural and human disturbances in one general disturbance term. This merging leads to a misinterpretation of the title and the conclusion because, for most of the ecologist and the forest manager, disturbance legacies always refer to an extreme event legacy like storms, beetles outbreaks, fires or droughts. My advice is to explicitly divide interpretation of the result into the natural and the human disturbance. For example, the title will become: "Human disturbance/forest management/human activity legacies have a stronger effect on future carbon exchange than climate in a temperate forest landscape."

AUTHORS: We thank the reviewer for this important comment, and for the recommendations on how to improve our work further. This comment is congruent with one of the comments provided by Referee #2. As mentioned in the response to Referee #2, our attempt was to combine natural and human disturbances first in order to quantify the overall disturbance effect on carbon storage, and subsequently to disentangle the partial effects of natural and human disturbances. However, we understand the potential confusion this has been causing. In the revision we will clearly distinguish between management and natural disturbances throughout the study. We will also rephrase the title of the study into “Legacies of forest management have a stronger effect on future carbon exchange than climate and natural disturbances in a temperate forest

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landscape".

REFEREE #3: 2) the authors need to be careful with the last statement of the title: "than climate in a temperate forest landscape" because the authors only realized simulations with a medium climate change scenario (A1B). The strongest climate change scenario like the RCP 8.5 is most likely to happen, and it will have a stronger impact. In addition, the authors forget to take into account the indirect effect of CC on forest growth via the increase of the frequencies and the intensities of the extreme events. This partly due to the setup of the simulation experiment where disturbances are forced and disconnected to the mortality module of iland. But this interaction can be simulated in iland because the authors already developed abrupt mortality module into this model.

AUTHORS: We agree with the referee that a more severe climate change scenario will likely alter the effect of climate change in our study. The exclusion of high intensity disturbance events after 2013 was necessary to exclude confounding effects from disturbance interactions with past disturbance events (i.e., spatio-temporal autocorrelation) in order to disentangle the partial effects of past disturbance and future climate change. In the revision, we will add this aspect explicitly to the discussion, highlighting possible impacts of a more severe climate change scenario on NEE. We will also mention the necessity to exclude high intensity disturbances in the methods section.

REFEREE #3: 3) The way the authors display the results of the simulation experiment is very confusing. The figure 5 for example which display the difference between reference NEE and alternative NEE, starts to diverge from 2013 and not from 1905. The simulations without management should not be far from other simulation in 2013?

AUTHORS: In order to derive the effect of management and natural disturbance legacies on the future trajectories of NEE we have defined the start point of the analysis after the second disturbance episode, i.e. in 2013. The figure thus presents the cumulative differences in carbon uptake or release resulting from this legacy effect of disturbance (comparing disturbed and undisturbed scenarios) as well as climate change

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(comparing climate change and baseline climate) on the future NEE. The differences in total ecosystem carbon storage starting from year 1905 have been presented in Table 1. Based also on the comments of referee #2, we will omit Fig. 6 and combine Fig. 5 and Fig. S14. To avoid confusion, we will extend the figure caption, explaining more specifically how to interpret the newly added figure.

REFEREE #3: 4) In table 1, we can see a difference of about 40 tC ha between managed and unmanaged simulations. The strangest thing here is that in 2099 this difference disappears (compensation process?). This is interesting but the authors don't mention that in the discussion. Why? and why the figure 5 doesn't display that?

AUTHORS: As the referee points out correctly, Table 1 indicates that the differences in total ecosystem carbon storage between formerly disturbed and undisturbed scenarios become negligible by the year 2099. In other words, this shows that the legacy effect of past disturbances does not influence carbon storage beyond 2099. Fig. 5 corresponds to the output presented in Table 1 by showing that the cumulative carbon uptake levels off over time. Consequently, the differences in cumulative NEE in Fig. 5 at year 2099 correspond approximately to the differences in total ecosystem carbon storage in year 2013 between disturbed and undisturbed scenarios in Table 1 ($\sim$40 tC ha-1). The underlying reason for this compensatory effect is an increased growth (increased carbon uptake) by forests after disturbance. We will amend the discussion regarding the duration of the legacy effect of natural and human disturbances as well as the cause of the compensatory effect on NEE in the revised version of the manuscript.

REFEREE #3: 5) Did the two imposed disturbances have a different impact on the forest across simulations? If not, it means that the authors can't observe the legacy effect of one disturbance to another future one. It is maybe the reason why they don't observe a strong effect of natural disturbances. Due to this lake of interaction, the interesting questions like: - Can this forest have the capacity to absorb extreme events well enough to keep the same level of NEE if the intensity and the frequencies of natural disturbances will increase? Or - Are the forest management made between 1905 and

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1997 is able to change disturbance impact on NEE in the future? cannot be tackled. It is a pity because it will strengthen the purpose of this paper.

AUTHORS: While we could not use the dynamic disturbance modules to mimic the first disturbance episode as we did not know its characteristics reasonably well to represent it in our process-based disturbance module (e.g., wind speed, wind direction), the second disturbance episode was in fact simulated dynamically, i.e., the simulation model produced different disturbance impacts on forests and carbon storage depending on the inclusion or exclusion of the first disturbance episode and forest management. The simulation design is explained to the reader in detail in l. 328 – 331: "From 1905 to 1923 management and natural disturbances were implemented in the simulation as recorded in the stand-level archival sources. After 1923, natural disturbances were simulated dynamically using the respective iLand disturbance modules." However, the aim of our study has not been to assess the effects of past natural and human disturbance on future disturbances. Instead, we excluded high mortality disturbance events in order to not confound the investigation of the legacy effects from past disturbances on NEE. Also in response to comments of other referees, we will provide a new analysis to investigate the contribution of the first disturbance episode and forest management on the second disturbance episode. In this way, we will derive some further insight into the legacy effects of natural and human disturbance on subsequent disturbance events.

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