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RC1: This article is investigating the role of snow on treeline response to climatic warming by including snow (in addition to other abiotic and biotic variables) module in the vegetation model LAVESI. I like the idea with the model LAVESI. Results showed site specific response of treeline shifts and highlighted the role of snow in treeline dynamics. The approach including additional variable in vegetation model is interesting. The data are enough and relevant to test the authors' hypothesis. I recommend a minor revision.

AC: We sincerely appreciate your valuable feedback and constructive comments during the first review of our preprint. Your comments will significantly enhance our manuscript. We will carefully address all referees' suggestions to further improve the quality of our study and ensure it meets the high standards of Biogeosciences.

RC1: I like your introduction, but it is a bit too long, it would very nice if you are able to make it more concise by reducing it by 10-20 % pages.

AC: We will shorten the introduction while preserving all essential content.

RC1: Recently several studies reported role of biotic interactions on treeline dynamics. Please see Bader et al. 2021, Ecography, Liang et al. 2016, PNAS, Sigdel et al. 2024, Nature Plants.

AC: Thank you for the additional literature suggestions. We will consider to include them where fitting in the text.

RC1: Overall, the discussion is general and comprehensive for me and mostly authors focused on those influences and processes that have been investigated. It has been neglected role of snow duration, i.e., the period when snow covers the treeline, determines processes of tree regeneration and establishment.

AC: The snow module accounts for snow duration, i.e., the period during which snow covers the treeline area:

Building on the approach of Sato et al. (2007), the processes of snow accumulation and snowmelt were incorporated into the LAVESI model (see lines 231-232). As a result, the duration of snow cover is influenced by snow depth, which is affected by both snow accumulation and snowmelt. All subsequent influences on tree growth and treeline migration, which are dependent on snow depth, are consequently impacted throughout the duration of the snow cover. The effects of varying snow depths were implemented in the model in the following abstracted manner:

If the height of the tree is higher than the current snow depth, the mortality rate of the tree increases by 50%. This penalty decreases linearly with increasing tree height and is eliminated once the tree reaches a height of 5 m.

When seeds are covered by snow, their germination is enhanced, exhibiting a linear increase in germination rates with greater snow depth. Specifically, this relationship begins at zero and reaches a 30% increase in germination at a snow depth of 1 m.

If seedlings and saplings are covered by snow, their growth is enhanced by 30%. The germination process is influenced linearly, either positively or negatively, based on whether the snow melts before or after the 110th day of the year.

The actual day of snowmelt is divided by 110, and the deviation from 1.0 is added to the germination probability (see lines 237-243).

In general, the growing season length and its influence on seedling germination and tree growth are already incorporated into the vegetation model (see lines 187-189).

We will provide a clearer explanation of these connections especially of the snow period length in the updated version of the manuscript.

RC1: Related to this, snow fungi might also explain part of the spatio-temporal pattern.

AC: The influence of snow fungi was indirectly incorporated into the snow module, as prolonged high snow load or a shortened growing season negatively affects tree growth. In the discussion, we will highlight that snow fungi may also contribute to the observed spatio-temporal pattern.

RC1: Also snow movements and avalanches may affect the observed species differently.

AC: The snow module includes snow load and avalanche occurrence. However, we did not vary these effects by tree species, as the simulation areas in our study – as well as the North American and Siberian treeline ecotones in general – are predominantly dominated by spruce in Northwest Canada and Alaska, and by larch in Siberia.

We will include species-dependent differences in treeline migration in the discussion to provide further insights for studies focusing on species-specific responses.

RC1: Additionally, even though, different plant traits and interactions are included in the model, their influence on treeline sensitivity and migration is missing.

AC: Species-dependent plant traits are incorporated into the vegetation model. Since the simulation areas are dominated by spruce or larch, we consider the influence of other tree species on the sensitivity analysis as negligible.

RC1: It is not clear why site-specific specifics sensitivities are observed? What are the mechanisms behind such discrepancies? It needs to be justified based on site specific evidences. Authors discussed different factors (environmental and traits) but fail to link site specific variability. Thus, it needs to synthesize the results rather than presenting results directly.

AC: We acknowledge the need for a more integrated discussion of site-specific sensitivities. Rather than treating the study sites separately, we will synthesize the results to highlight overarching patterns and mechanisms driving the observed differences. By linking environmental factors and species traits more explicitly, we aim to provide a clearer, more comprehensive understanding of the site-specific variability in treeline dynamics.

RC1: Generally, authors just compare their results with other similar studies. To make it convincing, it needs deeper discussion with key scientific evidence and how it helps to advance our understanding on treeline ecology under changing climate.

AC: In the discussion, we will highlight the implications of our results for the future of North America's treelines in the context of global warming.

RC1: Also, ecological implications of the modified model should be highlighted.

AC: In the discussion, we will also further elaborate on the ecological implications for North American forests, including biodiversity, the albedo effect, and their role as a carbon sink.

RC1: L13-14: As site wise results are presented, it is better to mention the areas/sites considered in analysis.

AC: We will mention the study sites at this point in the abstract.

RC1: L64-66: Please see recent treeline studies used individual-based model to simulate plot-based data including both biotic and abiotic variables (Zheng et al. 2024, Eco Lett).

AC: Thank you for the literature suggestion. We will carefully review the methods and findings of this study.

RC1: L184: Please mention the sites considered in this study before this sentence.

AC: We will introduce the study sites earlier in the manuscript.

RC1: L307-308: Even though the trees traits data were adopted from previous publications, better to elaborate how these data were retrieved and sources.

AC: We will compile a complete table of species traits and model variable values in LAVESI and include it in the manuscript appendix.

RC1: Table 3 caption: impact factors could be replaced by predicting variables.

AC: We will change this term according to your suggestion.

RC1: No any parameter is significance from Road to central Alaska. What is mean? Is this model not well able to predict the sensitivity of Alaskan treelines?

AC: At the Road to Central, Alaska site, no single factor was found to be statistically significant. This may be due to stronger interactions between multiple factors, which could obscure the effects of individual parameters. Another possible explanation is that this site is more influenced by stochastic processes.

RC1: L392-395: It seems to methodology rather than results.

AC: We will relocate this section to the Methods section as suggested.

RC1: L464-469: Just speculations, no evidence supports the findings.

AC: As mentioned above, we will provide a more detailed explanation of the site-specific differences in the sensitivity analysis results, thereby clarifying or reassessing the significance of this section.

RC1: L532: either data or reference should be presented.

AC: We will insert a reference to 'Table 1: Characteristics of the study sites.' at this point.

RC1: L550: How did species-specific stand structures varies across the sites. It should be site and species specific. How population structure varied across the study sites? and so on.

AC: Since spruce or larch clearly dominates at all three study sites, we have not yet conducted a detailed comparison of species composition. However, we will include a general comparison of the stand structure of the study sites in the manuscript.