Comment on cp-2021-51

Anonymous Referee #2

Referee comment on "Holocene vegetation transitions and their climatic drivers in MPI-ESM1.2" by Anne Dallmeyer et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-51-RC2, 2021

This is a solid paper that presents a new set of transient climate simulations for the last 6,000 years, using a state-of-the-art Earth System Model. The paper presents an extensive series of model results and data-model comparisons. That said, it is not clear what new has been learned by this paper, nor how it advances on prior work. The paper's presentation in its current form is highly descriptive, with lengthy results sections (4-6) and really no discussion section to contextualize these new findings in light of the prior literature. Most of the work on biome comparisons and monsoon dynamics was well done, but it was hard to see what was new here relative to prior papers. I thought the analysis of linear and abrupt responses was perhaps the most interesting and novel part of this paper. Understood that bioclimatic thresholds as represented by this model may not be the true driver of abrupt vegetation change, but still this paper presents interesting hypotheses about where and when we would expect abrupt vegetation change given climatic drivers.

My comments are organized into Major Comments, Line-by-Line comments, and minor annotations on the PDF. The PDF annotations are just grammatical, not substantive.

Other major comments:

- The Introduction covers the right papers (mostly, see below), but comes across as an unfocused region-by-region review of the paleovegetation and paleoclimatic literature. The Introduction doesn't really set up the key topics that the Roadmap Paragraph (L130-142) establishes as paper foci: abrupt vegetation change; biome-scale vegetation changes; climate drivers. We get a sense that a lot of prior work has been done, but not where there are key knowledge gaps or unresolved questions that this paper will help address.
  - Also, the Roadmap Paragraph does a good job of telling me what analyses will be done, but doesn't really explain what questions will be asked and answered, nor what hypotheses will be tested. What are the overall goal(s) of this paper: Test MPI-ESM1.2 against proxy data? Gain a better understanding of climatic drivers of Holocene vegetation? Feedbacks? Causes of abrupt vegetation change?
- Similarly, clarify in Intro/Roadmap what is new about this study. The latest MPI-ESM1.2 paper is 2019, but the latest vegetation paper is 2013, so is the new contribution the simulation of a fully transient and coupled vegetation-climate model for the Holocene? Given that at least three other papers have been published by this team with this transient simulation (see L199-200), how does this paper advance beyond these prior works?
- The abrupt vegetation change analyses (Section 6, Figs. 12, 13) are to me the most interesting part of the paper. They essentially represent a model hypothesis that most abrupt climate change is forced by PFTs passing bioclimatic limits at the edge of their distribution. It would be interesting to compare this to the global rate of change vegetation analyses just published by (Mottl et al., 2021). (Note that this paper had a correction just published, so I recommend contacting the authors to confirm which version of the data to use.) These analyses also leverage the strength of this paper, which is its transient simulations for the last 6000 yrs. Appendix C needs more description; the figure looks interesting but the legend is short and cryptic.
- Section 5 is rather long and descriptive. Suggest shortening substantially.
- There's not really any Discussion section; i.e. the paper presents several lengthy Results sections (4-6) that mostly focus on describing results and do not put the results in context with the prior literature.
- The Conclusions are a good summary of the paper's findings. However, the last paragraph - L805-817 is an interesting paragraph arguing for the importance of the monsoons, but feels out of place here. One rule is that the Conclusions should introduce no new information; it should summarize what has come before. This paragraph reads as if it is breaking new ground rather than summarizing. Also, this is a place where better citation and discussion of the prior literature is absolutely critical. There is a *huge* literature on past monsoon dynamics, so e.g. L815-816 ("far greater importance… than previously assumed…" comes across as uninformed relative to prior work. As one example, see (Liu et al., 2004), who've previously argued for the effects of monsoonal dynamics on extra-tropical regions. So this paragraph could be a good focal topic for a discussion section.

Line-by-Line Comments:

L22: Here, elsewhere, capitalize Northern Hemisphere and Southern Hemisphere

L39: This focus on monsoons is appropriate, but I would argue that monsoons are only half the story. The other big change is the northern hemisphere tundra/treeline ecotone, which is probably more of a direct response to T and insolation, instead of monsoons. See e.g. L290-295

L45-54: This opening intro on orbital forcing should also mention changes in obliquity/tilt at least in passing.

L52: Here and elsewhere: spell out 'approx.' as approximately

L56: Yes to changes in annual mean signals, but the sentence implies that only mean annual signals were changed. Rephrase.

L56-57: warmer/colder than what? Be sure that all comparative statements like this have a clear referent.

L61-62: Over what time period is this weakening/strengthening?

L65: Here and elsewhere, check for verb tense consistency. This sentence is in past tense, while most of the prior paragraph was in present tense.

L85-87: This section understates the existing literature on Holocene land cover reconstructions. Other papers: (Williams, 2003) (Williams et al., 2011) (Pirzamanbein et al., 2018; Pirzamanbein et al., 2014) (Trondman et al., 2015) (Marquer et al., 2017)

L88-90: This sentence understates the availability of Holocene paleoclimatic proxies, which has improved greatly over the last several years. Papers include: (Kaufman et al., 2020) (Marsicek et al., 2018) and the authors should also do a search for 'The Holocene Conundrum' to find additional recent appers.

L98: I would argue that vegetation changes are complex everywhere, not just in North America, with all areas experiencing distinct PFT-level and taxa-level changes.

L101-102: Clarify that this forest expansion is during the mid to late Holocene and is in the eastern Great Plains.

L102-103: I think this sentence needs to be narrowed to South America, not all of the Americas, but check the original reference.

L107:

L120: It's not clear why this fairly lengthy review of the prior literature indicates we lack substantial understanding. I'd argue that we actually have a pretty good understanding of past vegetation changes. A better argument would be: 1) We have quite a detailed understanding of the patterns of Holocene vegetation dynamics, thanks to lots of regional to continental to hemispheric-scale syntheses. 2) We still lack a clear understanding of the climatic and other drivers (and feedbacks) associated with these vegetation changes. This shift from pattern to process would then help motivate the modeling study presented here.

L195: spin-up simulation? I haven't heard the 'spin-down' phrase before.

L199-200: Given all these recent papers using the same model and setup, what new is being contributed by this paper?

L233: exclude->minimize (there was some land use prior to 150BC), see e.g. (Stephens et al., 2019) (Mottl et al., 2021)

L233-239: This treatment of timescales is very confusing. Suggest ditching entirely the BC/BCE timescale and only using ka BP, using yr 2000 (b5k) as the datum. Most paleoclimatologists and paleoecologists use ka BP, not BCE.

L262-264: Add some of the other Holocene vegetation references noted above. Williams et al. 2011 provides a Northern Hemisphere reconstruction for the extratropics.

L269: Here and elsewhere: Delete sentences that solely exist to introduce a figure. Just describe a key result and put a figure pointer in parentheses at end of sentence (Fig. 1).

L273-275: 'On one hand… on other hand…' isn't appropriate here, because the two sentences aren't really opposed to each other.

L277: Not reflected in what way? Not shown at all?

L279: What is meant by a 'very distinct ecology?

L305-306: This description of c-means clustering is redundant with methods.

L310-311: rephrase to avoid double negative

L354: At some point, these RDA analyses could be compared to remote sensing analyses of climatic drivers, e.g. (Seddon et al., 2016) (Seddon et al., 2016)

Fig 1 legend: 'positive ecological development' and 'negative ecological development' is too vague and sounds normative. Simply use 'increase in openness' and 'decrease in openness'

Fig 4b could be deleted; I'm not sure how much information it adds to what's shown in Fig. 4a.

Fig 5: This figure legend is wordy. Keep the legend focused on figure orientation, and move other material as needed to the main text.

REFERENCES

Kaufman, D., McKay, N., Routson, C., Erb, M., Davis, B., Heiri, O., Jaccard, S., Tierney, J., Dätwyler, C., Axford, Y., Brussel, T., Cartapanis, O., Chase, B., Dawson, A., de Vernal, A., Engels, S., Jonkers, L., Marsicek, J., Moffa-Sánchez, P., Morrill, C., Orsi, A., Rehfeld, K., Saunders, K., Sommer, P.S., Thomas, E., Tonello, M., Tóth, M., Vachula, R., Andreev, A., Bertrand, S., Biskaborn, B., Bringué, M., Brooks, S., Caniupán, M., Chevalier, M., Cwynar, L., Emile-Geay, J., Fegyveresi, J., Feurdean, A., Finsinger, W., Fortin, M.-C., Foster, L., Fox, M., Gajewski, K., Grosjean, M., Hausmann, S., Heinrichs, M., Holmes, N., Ilyashuk, B., Ilyashuk, E., Juggins, S., Khider, D., Koinig, K., Langdon, P., Larocque-Tobler, I., Li, J., Lotter, A., Luoto, T., Mackay, A., Magyari, E., Malevich, S., Mark, B., Massaferro, J.,

Montade, V., Nazarova, L., Novenko, E., Paŝil, P., Pearson, E., Peros, M., Pienitz, R., PŁóciennik, M., Porinchu, D., Potito, A., Rees, A., Reinemann, S., Roberts, S., Rolland, N., Salonen, S., Self, A., Seppä, H., Shala, S., St-Jacques, J.-M., Stenni, B., Syrykh, L., Tarrats, P., Taylor, K., van den Bos, V., Velle, G., Wahl, E., Walker, I., Wilmshurst, J., Zhang, E., Zhilich, S., 2020. A global database of Holocene paleotemperature records. Scientific Data 7, 115.

Liu, Z., Harrison, S.P., Kutzbach, J., Otto-Bliesner, B., 2004. Global monsoons in the mid-Holocene and oceanic feedback. Clim. Dyn. 22, 157-182.

Marquer, L., Gaillard, M.-J., Sugita, S., Poska, A., Trondman, A.-K., Mazier, F., Nielsen, A.B., Fyfe, R.M., Jönsson, A.M., Smith, B., Kaplan, J.O., Alenius, T., Birks, H.J.B., Bjune, A.E., Christiansen, J., Dodson, J., Edwards, K.J., Giesecke, T., Herzschuh, U., Kangur, M., Koff, T., Lataŀowa, M., Lechterbeck, J., Olofsson, J., Seppä, H., 2017. Quantifying the effects of land use and climate on Holocene vegetation in Europe. Quaternary Science Reviews 171, 20-37.

Marsicek, J., Shuman, B.N., Bartlein, P.J., Shafer, S.L., Brewer, S., 2018. Reconciling divergent trends and millennial variations in Holocene temperatures. Nature 554, 92.

Mottl, O., Flantua, S.G.A., Bhatta, K.P., Felde, V.A., Giesecke, T., Goring, S., Grimm, E.C., Haberle, S., Hooghiemstra, H., Ivory, S., Kuneš, P., Wolters, S., Seddon, A.W.R., Williams, J.W., 2021. Global acceleration in rates of vegetation change over the last 18,000 years. Science 321, 860-864.

Pirzamanbein, B., Lindström, J., Poska, A., Gaillard, M.J., 2018. Modelling spatial compositional data: Reconstructions of past land cover and uncertainties. Spatial Statistics 24, 14-31.

Pirzamanbein, B., Lindström, J., Poska, A., Sugita, S., Trondman, A.-K., Fyfe, R., Mazier, F., Nielsen, A.B., Kaplan, J.O., Bjune, A.E., Birks, H.J.B., Giesecke, T., Kangur, M., Lataŀowa, M., Marquer, L., Smith, B., Gaillard, M.-J., 2014. Creating spatially continuous maps of past land cover from point estimates: A new statistical approach applied to pollen data. Ecological Complexity 20, 127-141.

Seddon, A.W.R., Macias-Fauria, M., Long, P.R., Benz, D., Willis, K.J., 2016. Sensitivity of global terrestrial ecosystems to climate variability. Nature 531, 229-232.

Stephens, L., Fuller, D., Boivin, N., Rick, T., Gauthier, N., Kay, A., Marwick, B., Armstrong, C.G., Barton, C.M., Denham, T., Douglass, K., Driver, J., Janz, L., Roberts, P.,

Rogers, J.D., Thakar, H., Altaweel, M., Johnson, A.L., Sampietro Vattuone, M.M., Aldenderfer, M., Archila, S., Artioli, G., Bale, M.T., Beach, T., Borrell, F., Braje, T., Buckland, P.I., Jiménez Cano, N.G., Capriles, J.M., Diez Castillo, A., Çilingiroğlu, Ç., Negus Cleary, M., Conolly, J., Coutros, P.R., Covey, R.A., Cremaschi, M., Crowther, A., Der, L., di Lernia, S., Doershuk, J.F., Doolittle, W.E., Edwards, K.J., Erlandson, J.M., Evans, D., Fairbairn, A., Faulkner, P., Feinman, G., Fernandes, R., Fitzpatrick, S.M., Fyfe, R., Garcea, E., Goldstein, S., Goodman, R.C., Dalpoim Guedes, J., Herrmann, J., Hiscock, P., Hommel, P., Horsburgh, K.A., Hritz, C., Ives, J.W., Junno, A., Kahn, J.G., Kaufman, B., Kearns, C., Kidder, T.R., Lanoë, F., Lawrence, D., Lee, G.-A., Levin, M.J., Lindskoug, H.B., López-Sáez, J.A., Macrae, S., Marchant, R., Marston, J.M., McClure, S., McCoy, M.D., Miller, A.V., Morrison, M., Motuzaite Matuzeviciute, G., Müller, J., Nayak, A., Noerwidi, S., Peres, T.M., Peterson, C.E., Proctor, L., Randall, A.R., Renette, S., Robbins Schug, G., Ryzewski, K., Saini, R., Scheinsohn, V., Schmidt, P., Sebillaud, P., Seitsonen, O., Simpson, I.A., Sołtysiak, A., Speakman, R.J., Spengler, R.N., Steffen, M.L., Storozum, M.J., Strickland, K.M., Thompson, J., Thurston, T.L., Ulm, S., Ustunkaya, M.C., Welker, M.H., West, C., Williams, P.R., Wright, D.K., Wright, N., Zahir, M., Zerboni, A., Beaudoin, E., Munevar Garcia, S., Powell, J., Thornton, A., Kaplan, J.O., Gaillard, M.-J., Klein Goldewijk, K., Ellis, E., 2019. Archaeological assessment reveals Earth's early transformation through land use. Science 365, 897-902.

Trondman, A.K., Gaillard, M.J., Mazier, F., Sugita, S., Fyfe, R., Nielsen, A.B., Twiddle, C., Barratt, P., Birks, H.J.B., Bjune, A.E., Björkman, L., Broström, A., Caseldine, C., David, R., Dodson, J., Dörfler, W., Fischer, E., van Geel, B., Giesecke, T., Hultberg, T., Kalnina, L., Kangur, M., van der Knaap, P., Koff, T., Kuneš, P., Lagerås, P., Latałowa, M., Lechterbeck, J., Leroyer, C., Leydet, M., Lindbladh, M., Marquer, L., Mitchell, F.J.G., Odgaard, B.V., Peglar, S.M., Persson, T., Poska, A., Rösch, M., Seppä, H., Veski, S., Wick, L., 2015. Pollen-based quantitative reconstructions of Holocene regional vegetation cover (plant-functional types and land-cover types) in Europe suitable for climate modelling. Global Change Biology 21, 676-697.

Williams, J.W., 2003. Variations in tree cover in North America since the Last Glacial Maximum. Global and Planetary Change 35, 1-23.

Williams, J.W., Tarasov, P.A., Brewer, S., Notaro, M., 2011. Late-Quaternary variations in tree cover at the northern forest-tundra ecotone. Journal of Geophysical Research - Biogeosciences 116, G01017, doi: 01010.01029/02010JG001458.

Please also note the supplement to this comment:
https://cp.copernicus.org/preprints/cp-2021-51/cp-2021-51-RC2-supplement.pdf