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Climate of the Past Discussions

Interactive comment on "Impact of precession on the climate, vegetation and fire activity in southern Africa during MIS4" *by* M.-N. Woillez et al.

Anonymous Referee #2

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The manuscript "Impact of precession on the climate, vegetation and fire activity in southern Africa during MIS4" by Woillez et al. presents novel insights on the interactions between climate, vegetation, and fire disturbance in southern Africa during Marine Isotope Stage 4. By combining the general circulation model IPSL_CM5A with the dynamic global vegetation model LPJ-LMfire, the authors investigate how changes of the precession index over the course of MIS4 affected the African monsoon and precipitation patterns, and present the resulting effects on vegetation cover and fire activity. Their findings from this study emphasize that natural fire activity in southern Africa strongly depends on the prevailing vegetation type, which in turn is driven by precipitation patterns.

General comments:

The manuscript is well-written and meets the requirements for publication in Climate of the Past. The authors nicely combined two different models to address an interesting scientific question, and present their methodological approaches as well as their results in a mostly concise and transparent way. However, some open questions and points that would benefit from further clarification remain in this discussion version of the manuscript and are pointed out below under "Specific comments". In addition, a number of typos and language issues that need correction are listed in the "Technical comments" section. With respect to the figures presented in this manuscript, Fig. 4 is not very useful to evaluate the performance of LPJ-LMfire under present-day conditions as it is rather hard to compare the quantitative cover fractions in Fig. 4b to the qualitative biome categories in Fig. 4a. I therefore suggest to replace Fig. 4a with a map showing fractional tree cover based on remote sensing products, e.g. the Global Land Cover Facility (GLCF) tree cover data set (DeFries et al., 2000), and base the discussion of the model performance on that comparison.

Specific comments:

5393, line 1: "which would change the amount of fuel": please briefly mention that a shift in vegetation composition is likely not only going to affect the fuel quantity, but also the qualitative composition of the fuel, e.g., the ratio from coarse fuels to fine fuels and the flammability of fuel components, which in turn will affect fire intensity and frequency.

5392, line 11: "during Marine Isotopic Stage 4" - please define the duration of Marine Isotopic Stage 4 in years BP once in brackets, to make it easier to see right away what time frame you are talking about.

5394, line 17: "This interpretation has been confirmed by many numerical models for the Holocene": You are interested in the Pleistocene, not the Holocene. So does the same explanation also hold true for the Pleistocene? Are there any studies using numerical models that have focused on the Pleistocene with respect to the relationship between precession index, pressure, and monsoonal strength? If so, please cite, or

else indicate why it is a valid assumption that the situation during Pleistocene and Holocene are likely to be comparable.

5396, line 4/5: “the vegetation is prescribed and fixed”: on what basis? present-day climate?

5397, line 13: “The fractional coverage reflects both the productivity and individual density of the PFTs”: The fractional coverage of the PFTs is not necessarily reflecting the productivity of a PFT. A specific PFT can have a high fractional coverage albeit having low biomass values (i.e., low productivity) and a high individual density (small average individual, e.g. due to frequent disturbance which keeps tree PFTs from growing to tall trees). A better measure for the productivity of a specific PFT than its fractional coverage therefore would be its biomass. The fractional coverage is often a better indicator for the competitive balance between different PFTs present in the same grid cell.

5397, line 14: “The spatial resolution is the same as the climatic forcings...”: Please phrase this more clearly. Is this the 3.75° x 1.9° spatial resolution used for the atmosphere simulations in the GCM that you are using when running LPJ-LMfire?

5398, line 2: “to a spatial resolution of 0.16°”: is there a specific reason to chose exactly this resolution?

5398, line 14: “...thus keeping present-day interannual variability”: Do you have any information whether the interannual variability during your simulation time period (MIS4) would have been comparable to present-day interannual variability?

5400, line 8: “defined as cubic splines in our case”: on what did you base your decision to use cubic splines as the most suitable functions in this case?

5400, line 15: “... at a regular spatial resolution of 0.16°...”: I guess this is the reason why you chose the 0.16° spatial resolution as your high-resolution spatial scale? If so, please mention this on p. 5398, line 2, to justify why you chose exactly that spatial resolution.

5401, line 15: “If the predictors values [...] are outside the calibration range...” How often does this happen? I think this is important to know because it influences the uncertainty of the downscaling procedure.

Statistical downscaling method using GAM: What is the advantage of using this method of downscaling compared to other methods also including topographic effects (e.g., thin plate spline, Kriging...)?

Table 2, and explanation on page 5403: The % of variance explained for precipitation is rather low compared to the variance explained for the other three parameters. Why would that be so? Is it because the AOGCM does not do very well in simulating precipitation to start with, so that the derived predictor for precipitation is already not very good, or is it more likely due to the spatially highly variable nature of precipitation?

5402, line 10: “...100 % very remote from any ocean, corresponding to a purely continental air parcel.” At what distance from the ocean would DCO become 100 %?

5402, line 16: “Some of the MIS4 monthly temperature values . . . are lower than the calibration values...” Could you give a percentage value of how often it approx. happens that you are outside the calibration range? And does this happen scattered over the entire simulation area, or are there areas in particular where you tend to be outside the calibration range? Does it only happen for temperature that you are sometimes outside the calibration range, or also for the other parameters?

5404, line 4: “we compare qualitatively” - instead of comparing your simulation results to the biomes, why don’t you do a direct forest-grassland comparison based on remote sensing products, e.g., the Global Land Cover Facility(GLCF) tree cover data set (DeFries et al., 2000)

5405, line 18: “... the model simulates the potential vegetation, i.e. without any anthropogenic disturbance...” - This is very important to keep in mind, since especially in Africa people still heavily rely on the usage of fire for agricultural and non-agricultural

purposes and likely have influenced the natural vegetation over a long time. More detailed insights into the role of climate, humans and fire in southern Africa can for example be found in Archibald et al. (2008, GCB, doi: 10.1111/j.1365-2486.2008.01754.x), Archibald et al. (2012, PNAS, doi/10.1073/pnas.1118648109) and should be cited here for further information on the topic.

5407, l. 4-16: While interesting, this paragraph could be shortened given the fact that this study focuses on south Africa rather than north Africa, and the North African monsoon sensitivity could be/will be the subject of another study.

5407/5408, l. 25-l.1: So overall, precipitation is lowest during MIS4_min, and both MIS4_min and MIS4_max are lower than present-day if I understand this passage and Fig. 8 correctly. Please clearly state this once in a short sentence, because it will allow the reader to understand more quickly.

5409, l. 14/15: “The high tree percentages in that region seem to be more in qualitative agreement with pollen data from MIS4 than for present day.” This is an interesting observation that might indicate that for the present day mismatches between the vegetation model and actual observations are only to a certain degree due to performance issues of the DGVM, and the rest of the mismatch might indeed be attributed to the effects of humans and human land use.

5410, line 11/12: The decrease of 3 to 7 % for the woody PFTs due to the decrease in CO2 of 30 ppm is not totally surprising, given that LPJ is know to be a DGVM that reacts rather sensitively to CO2 concentrations.

5412, line 4/5: “... no clear relationship appears between the amplitude of the annual precipitation changes and the fire activity.” I guess that this might be due to the different reaction of east vs. central with respect to grass biomass. Overall, precipitation decreases almost everywhere between MIS4_min and MIS4_max, but in the East, albeit there being a decrease in precipitation, it is still wet enough to lead to an increase in grasses (and thereby easily incinerable light fuels) as you explain in the previous

section, thus leading to an increase in annual burned area fraction, whereas in the center the total amount of precipitation remaining after the precipitation decrease is so low that the grasses decline, therefore leading to smaller amounts of light fuel and less fire in this part.

Technical comments:

p. 5392, line 4: please replace “Mediterranean-like” with “Mediterranean-type”, also in subsequent occurrences throughout the manuscript

p. 5392, line 9: please replace “dynamical” with “dynamic”

5393, line 8: please replace “annual precipitations” with “annual precipitation amounts”

5393, line 18: please correct “developpement” to “development”

5393, line 23: please correct “analised” to “analyzed”

5394, line 4: “...lead to an decrease...” => “lead to a decrease”

5394, line 6: “... this study brings two interesting results” => “this study presents two interesting results”

5394, line 13: “precipitations”: change to “precipitation amounts”

5394, line 21: “...are specially rare”: please change to “...are particularly rare”

5395, line 24: “...96 x 95 points”: replace “points” with“grid pixels” . Do the indicated numbers of grid pixels for atmosphere and ocean refer to a global grid? Please clarify.

5397, line 9: “functionnal”: please correct typo

5397, line 13: “fractionnal”: please correct typo

p. 5399, line 22: replace “improve” with “increase”

5399, line 28:” ...preciptiations...”: change to singular (precipitation), also for further occurrences in the manuscript

5400, line 4: “... so these two variables were simply bi-linearly interpolated at the same spatial resolution.” - “interpolated to the desired 0.16 ° spatial resolution.”

5400, line 18: “precipitations have to be” - precipitation has to be

5402, line 24: “satisfactoring” - satisfactory

5403, line 26: “distinguishes” - distinguish

5404, line 11: ”The higher grass fractions...” - “Higher grass fractions...”

5404, line 13: “forests fractions” - forest fractions

5405, line 8: “specially” - especially

5406, line 25, p. 5407, line 3: “decrease” - decreases

5409, line 27, p.4210, line 4, line 28: “decrease” - decreases

5410, line 3: “Arfica” - Africa

5413, line 2: “analised” - analysed

5413, line 7: “a cooling over Africa” - a cooling over southern Africa

5413, line 24: “grasses fractions” - grass fractions

5413, line 26: “where trees are no longer sustainable”: please rephrase to “where tree cover declines”, after all the trees do not completely disappear.

p. 5413, line 28: “decrease (increase) on grid cells” - decreases (increases) on grid cells...

Interactive comment on Clim. Past Discuss., 9, 5391, 2013.