Response to Editor – revision 5

Dear Editor,

Thank you for your comments (which are reproduced in black). We reply to each of them in *blue and italics*.

One substantive comment.

p12 "No additional interactive component should be included in the model unless it is already included in the DECK version. Such changes would affect the global energetics (Braconnot and Kageyama, 2015) and therefore prevent rigorous analyses integrating across multiple time periods or between MIPs (section 3).

Because of this, even though environmental records show that natural vegetation patterns during each of the PMIP4-CMIP6 periods were different from today, the PMIP4-CMIP6 palaeoclimate simulations should use the same model configuration to the DECK and historical simulations. If the DECK and historical simulations use dynamic vegetation, then the PMIP4-CMIP6 palaeoclimate simulations should do so too. If the DECK and historical simulations use prescribed vegetation, then the same vegetation should be prescribed in the PMIP4- CMIP6 palaeoclimate simulations."

Please rephrase this to be consistent with what is written in the other PMIP4 papers. To start with I suggest removing, "Such changes would affect the global energetics (Braconnot and Kageyama, 2015) and therefore prevent rigorous analyses integrating across multiple time periods or between MIPs (section 3). Because of this."

A main focus of this manuscript is the promotion of PMIP as a series of experiments, the output from which may be compared with real data. If you knowingly implement your protocols to have very incorrect vegetation then these arguments are rendered much less convincing. It is not at all clear here why dynamic vegetation should be permitted but different fixed-vegetation not permitted, especially when many other boundary conditions are changed for the experiments. I went back to the LGM paper, and there it is simply stated that present day vegetation should be used without a reason being given. However, in that paper, modellers are also encouraged to run sensitivity experiments with altered vegetation, as well as the default protocol. This makes sense to me in the following way: the response to vegetation is so variable between models that we want all those who alter their paleo fixed-vegetation to first do the run with present day fixed-vegetation - otherwise we have no hope of understanding the response of the models. Not sure if that is your intended meaning, but rather than attempt to add further explanation, which is not anyway included in the LGM paper, I suggest that here you again encourage modellers to perform the vegetation sensitivity tests. (That these sensitivity tests may be not strictly CMIP6 runs is unimportant - this manuscript has to make sense scientifically!)

This comment covers different points of the experimental set-up.

One first point is that we want to ensure the same model is used for PMIP4-CMIP6 experiments, the DECK experiments, and if possible the other CMIP6 experiments. For instance, if a group chooses to

use interactive vegetation or aerosols for the lgm *experiment but not for the* piControl *experiment, we will actually end studying two different models. There is nothing that will warrant that these models have the same climate sensitivity, and the same responses to external forcings and even the same* piControl *characteristics. We want to avoid this situation. Groups might want to represent interactive vegetation or dust to get more realistic experiments, but they have to also perform the DECK experiments. This was the main message of the first paragraph of section 4.1. We do not want to discourage modelling groups from running experiments which are the most realistic as possible, but we want to ensure consistency of the model version used for the DECK and PMIP4-CMIP6 experiments.*

We have therefore modified the end of this paragraph, hoping that the message is now clearer:

"Such changes would prevent rigorous analyses of the responses to forcings across multiple time periods or between MIPs (section 3) because the differences between the experiments could then arise from both the models' characteristics and the response to changes in external forcings. Adding an interactive component usually affects the piControl simulation as well as simulations of past climates (Braconnot et al., 2007) so it is very important that experiments for PMIP4-CMIP6 and the DECK are run with exactly the same model version."

This point is common to all PMIP4-CMIP6 simulations, it is very important, we have therefore written it in the overview. It is not new compared to the companion papers. Actually it is stated in the first paragraph of section 3.1 of the LGM paper.

The second point is about using more realistic vegetation. It is clearly stated in the companion paper on interglacials that the data coverage is not sufficient to produce global vegetation maps for these periods, which would be used in order to prescribe realistic vegetation. It is the same situation for the lgm experiment, even though it is not written in the corresponding paper as clearly as in the interglacial one. If a model does not include dynamic vegetation, then a first simulation has to be run with present day vegetation. The resulting climate can then be used to compute an LGM vegetation map. This vegetation can then be used for a second lgm simulation, which will therefore be a sensitivity experiment to the vegetation. This is what the Editor suggests and apart from directly using a dynamic vegetation model within the Earth System Model, there is no other way of taking the LGM vegetation changes into account. We have therefore added one sentence to encourage the groups to run sensitivity experiments to vegetation, as suggested by the Editor. This is at the end of the second paragraph of Section 4.1.

Apart from that, it will helpful to fix the following.

p3 l22 "feedbackfeedbacks" → corrected!

p4 l23 "between climate-ice sheet system"
Missing "the"

l29-31
Can't understand this sentence:

" Finally, PMIP is also relevant to the third CMIP6 question "How can we assess future climate changes given climate variability, predictability and uncertainties in scenarios?" through examination of these questions for documented past climate states and via the use of the last millennium simulations as a reference state for natural variability."

We modified this sentence to make it clearer:" Finally, PMIP is also relevant to the third CMIP6 question "How can we assess future climate changes given climate variability, predictability and uncertainties in scenarios?" because the simulation of the last millennium climate includes more processes (e.g. volcanic and solar forcings) to describe natural climate variability than the piControl experiment."

p6 l22 "Mediaeval Climate Anomaly"
Google Trends for the United Kingdom show no hits at all for this phrase, and far, far fewer hits for "Mediaeval" vs. "Medieval". I think, therefore, it makes no sense to use your alternative spelling.
(The split for paleoclimate and palaeoclimate is much more even!)
(Don't even think of trying "musaeum".)

The Oxford disctionary gives both writings (I actually checked). I put it back to the previous spelling.

p7 l6-8 "The PMIP4-CMIP6 past1000 protocol will use a new, more comprehensive reconstruction of volcanic forcing (Sigl et al., 2015) and ensures a more continuous transition from the pre-industrial past to the future."

"ensures" -> "ensure"
or
"will use" -> "uses"

…depending on which tense you want to use. First option sounds a bit better than the second, to me.

Well, I chose the second. Now that the protocols are published, there is no reason to employ the future tense.

l8-9 "The final choices resulted from strong interactions with the groups producing the different forcing fields for the historical simulations (Jungclaus et al, 2017)."

"choices" here is ambiguous. Are you talking about choices you made (perhaps "decisions"?) to produce the forcings for a single protocol, or are you alluding a the range of possible forcings that people running the experiments may choose from?

"Decisions" is indeed more appropriate.

p8 12-14 "However, as is the case for the Last Interglacial, the PlioMIP simulations were not always derived from the same models as for the CMIP5 future projections."

perhaps,
"..the PlioMIP simulations were not always performed using the same models that were used for the

CMIP5 experiments."

Apart from awkward syntax, surely PlioMIP models were also different from those used in CMIP5-PMIP3 (e.g. the PMIP3 LGM).

Yes, this is true. The sentence was modified according to the Editor's suggestion.

l16-18
"The PMIP4-CMIP6 midPliocene-eoi400 experiment (Haywood et al., 2016) is designed to elucidate the long- term response of the climate system to a near modern concentration of atmospheric CO2 (long term climate sensitivity or Earth system sensitivity)."

I have seen "modern" used in the paleoclimate literature to have a rather vague meaning, sometimes closer to pre-industrial. Here I think you specifically mean close to 400ppm, so it might be clearer to say this…? After all, people may read this paper in 20 years time when CO2 is 500ppm… !

Yes. I have modified the sentence to: "The PMIP4-CMIP6 midPliocene-eoi400 experiment (Haywood et al., 2016) is designed to elucidate the long-term response of the climate system to a concentration of atmospheric CO_2 close to the present one: 400 ppm"

p9 l22 "also run historical experiment, in addition to the piControl one. "

Missing "the"

OK!