Large-scale features and evaluation of the PMIP4 midHolocene simulations

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Abstract will written at the end (so in Dec)

1 Introduction

Para.1: An gentle introduction of the idea of using past simulations to evaluate future ones.

Para.2: A description/layout of paper. Summarise past work, describe expt/methods, present simulations, compare to previous simulations, present data compilations, evaluate against these data compilations, discuss findings and potential for future analyses.

1.1 Literature Review

Para.3: Explanation of the mid-Holocene as a climate period, in context of deglacation, Holocene and Anthropocene.

Para.4: PMIP as part of CMIP. The midHolocene in previous PMIP efforts

Para.5: model-only findings from previous PMIP midHolocene papers

Para.6: data-model comparison findings from previous PMIP midHolocene papers

2 Methods

Para.7: Bland introduction of methods

2.1 Experimental Setup

Para.8: Overview of midHolocene orbital conditions

Para.9: Discussion of GHG concentrations and aerosols. Changes from PMIP3

Para.10: Discussion of land cover specifications. State variety of ways to encode into GCMs. Role of dynamic veg (relate back to piControl specifications and DECK).

2.2 Models

Para.11: Introduce CMIP6 and DECK. Data available for download on ESGF. PMIP4 simulations are open to non-CMIP6 models, process for securing data not as obvious.

Para.12: Describe some basic ensemble features of PMIP4. Refer to Table 1. Specify inclusion criteria.

Para.13: Brief discussion of PMIP3 - stress no individual models identified here, so reference previous papers for that info

2.3 Calendar adjustments

Para.14: explain issue with calendar changes. Stress often not adjusted for in previous studies.

Para.15: introduce PaleoCalAdjust software.

Para.16: describe treatment of calendar adjustments in this paper, and highlight potential implications.

2.4 Analysis techniques

Para.17: Introduce CVDP. Highlight settings. Note all output data available to researchers, but only smattering shown in this papers. Rest for subsequent papers.

		Data				Used in plotting		
		piControl		midHolocene				
model name	group name	have or not	length (yrs)	have or not	length (yrs)	cal-adj	NO cal-adj	refs.
AWI-CM-1-1-MR	PMIP4							
CESM2	PMIP4							
EC-EARTH3.3	PMIP4							
FGOALS-f3-L	PMIP4							
FGOALS-g3	PMIP4							
GISS-E2-1-G	PMIP4							
HadGEM3-GC31	PMIP4							
IPSL-CM6A-LR	PMIP4							
MIROC-ES2L	PMIP4							
MPI-ESM1-2-LR	PMIP4							
MRI-ESM2-0	PMIP4							
NESM3	PMIP4							
NorESM1-F	PMIP4							
UofT-CCSM4	PMIP4							
COSMOS-ASO	PMIP3							
BCC-CSM1-1	PMIP3							
CNRM-CM5	PMIP3							
CSIRO-Mk3-6-0	PMIP3							
EC-Earth2-2	PMIP3							
IPSL-CM5A-LR	PMIP3							
KCM1-2-2	PMIP3							
FGOALS-g2	PMIP3							
FGOALS-s2	PMIP3							
MIROC-ESM	PMIP3							
HadGEM2-CC	PMIP3							
HadGEM2-ES	PMIP3							
MPI-ESM-P	PMIP3							
MRI-CGCM3	PMIP3							
GISS-E2-R	PMIP3							
CCSM4	PMIP3							
CSIRO-Mk3L-1-2	PMIP3							
HadCM3	PMIP3							
		yes						
		no						

Figure 1. PMIP3 vs PMIP4. The table lists the model included in this paper, the simulations we've got and whether they've been used in plotting.

Para.18: Monsoon domian definition. How treating calendar adjustment in this component. highlight differences to standard defintion, to better fit paleoruns/variability. Code available…

Para.19: How calculate variables for data-model comparison - MTCO, MTWA, but mainly pseudocorals.

3 Simulation Results

Para.20: Bland introductory paragraph saying what is to come in this section, and that it is important.

3.1 Temperature Response

Para.21: Describe large-scale features - interhemispheric gradient etc from Fig. 2. Compare to expected result from insolation forcings

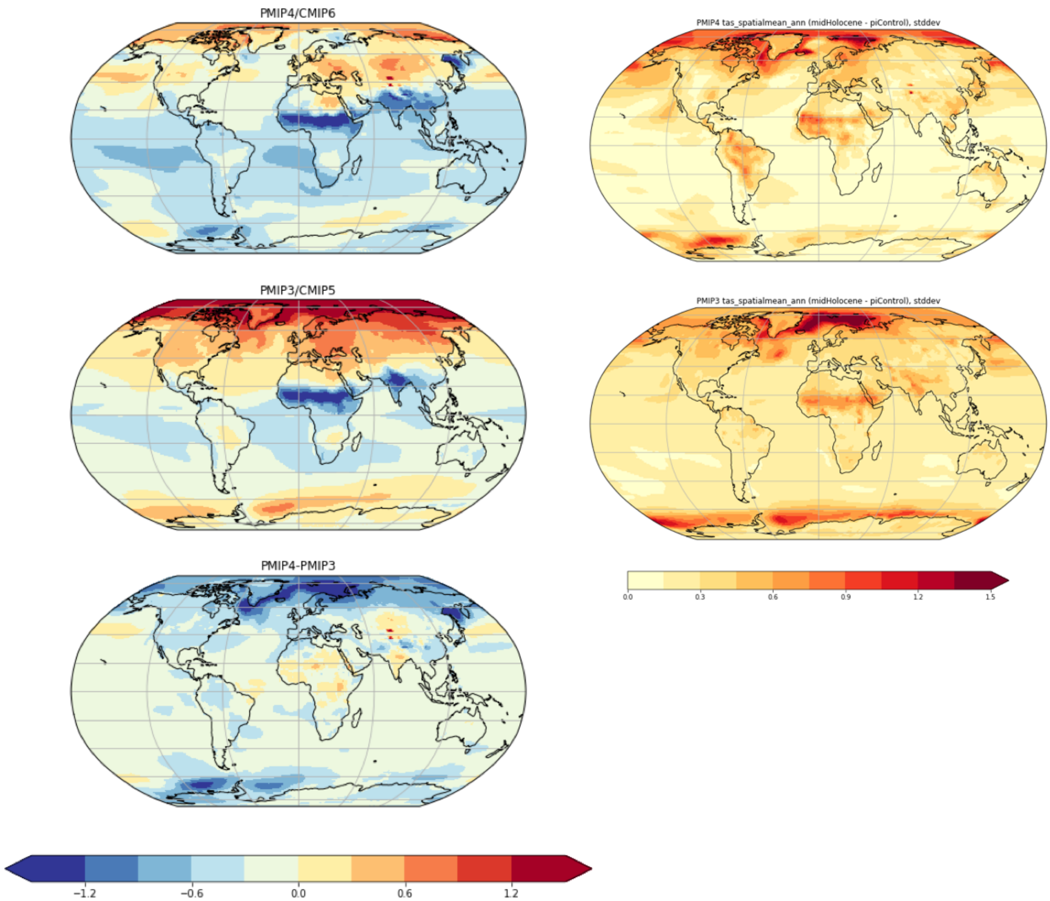

Figure 2. Annual mean temperature: ensemble average and uncertainty, PMIP3 vs PMIP4. Left (average): Top two figures show the ensemble mean of changes (midHolocene-cal-adj minus piControl) in annual mean temperature in PMIP4 and PMIP3. The bottom one is the changes since PMIP3, it shows the difference between the top two figures.**Right (uncertainty)**:ensemble mean of standard deviation of changes in annual mean temperature in PMIP4 and PMIP3.

Para.22: Describe dominant seasonality changes from Fig. 2.

Para.23: Discuss ensemble consistency. Look at spread between GCMs. Say where high and low.

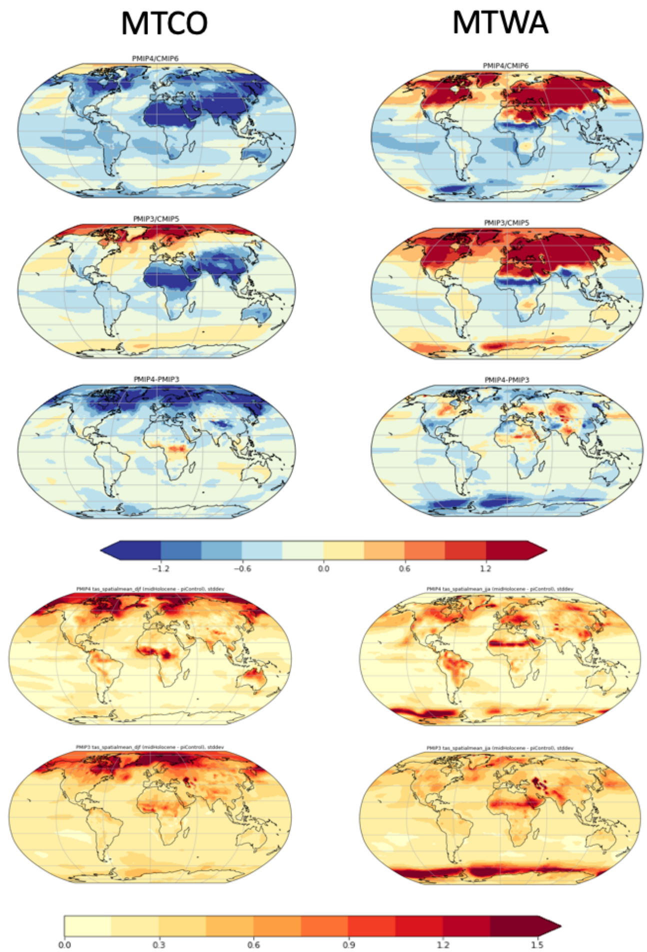

Figure 3. Changes in seasonal cycle of surface temp: ensemble average and uncertainty, PMIP3 vs PMIP4. Left (DJF): Top three figures show the ensemble mean of changes (midHolocene-cal-adj minus piControl) in DJF mean temperature in PMIP4, PMIP3 and the difference between them. Bottom two show the ensemble mean of standard deviation of changes in DJF mean temperature in PMIP4 and PMIP. **Right (JJA)**: Same as left but for JJA mean temperature.

3.1.1 Changes since PMIP3

Para.24: describe the differences between the PMIP generations by looking at the Fig. 2

Para.25: Significance - we don't plan to calculate this statistically (not sure of robust stats methid with these small, non-normal ensembles), but by comparing images we should speculate of the importance of any differences.

3.2 Hydrological Response

Para.26: Describe large-scale features - ITCZ shift etc from Fig. 4. Compare to expected result from insolation forcings

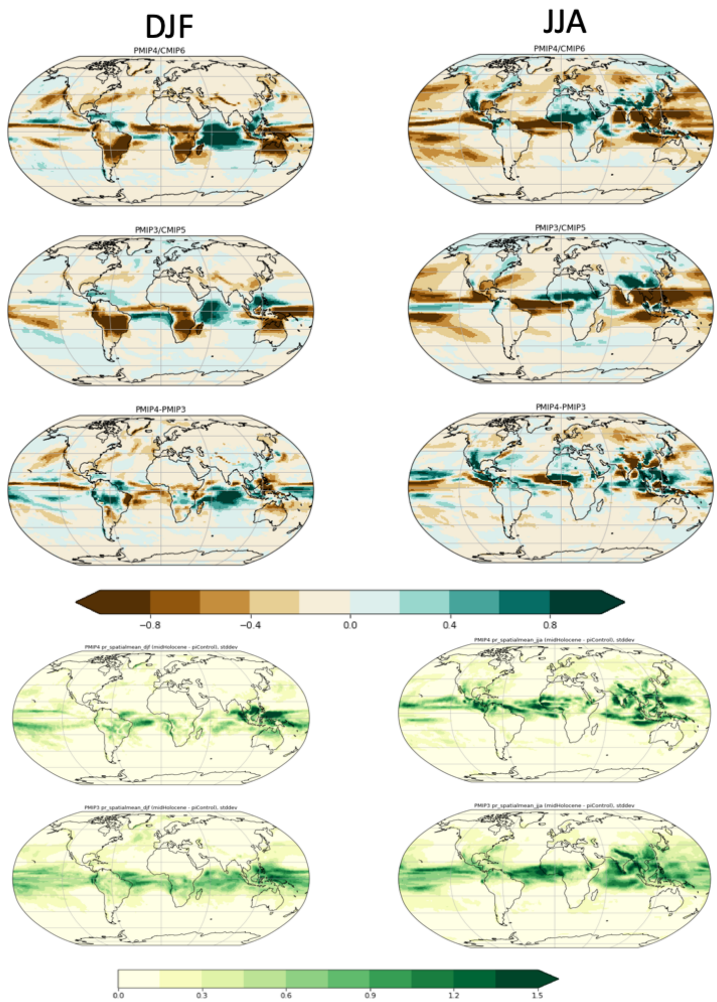

Figure 4. Changes in hydrological cycle: ensemble average and uncertaintyLeft (DJF average precipitation): Top three figures show the ensemble mean of changes (midHolocene-cal-adj minus piControl) in DJF mean precipitation rate in PMIP4, PMIP3 and the difference between them. Bottom two show the ensemble mean of standard deviation of changes in DJF mean precipitation in PMIP4 and PMIP3. **Right (JJA average precipitation)**: Same as left but for JJA mean precipitation.

Para.27: Describe dominant seasonality changes from Fig. 4.

Para.28: Discuss ensemble consistency. Look at spread between GCMs. Say where high and low.

3.2.1 Changes since PMIP3

Para.29: describe the differences between the PMIP generations by looking at the Fig.from Fig. 4

Para.30: Significance - we don't plan to calculate this statistically (not sure of robust stats methid with these small, non-normal ensembles), but by comparing images we should speculate of the importance of any differences.

3.3 Monsoons

Para.31: Description of what the global monsoon domain actually is

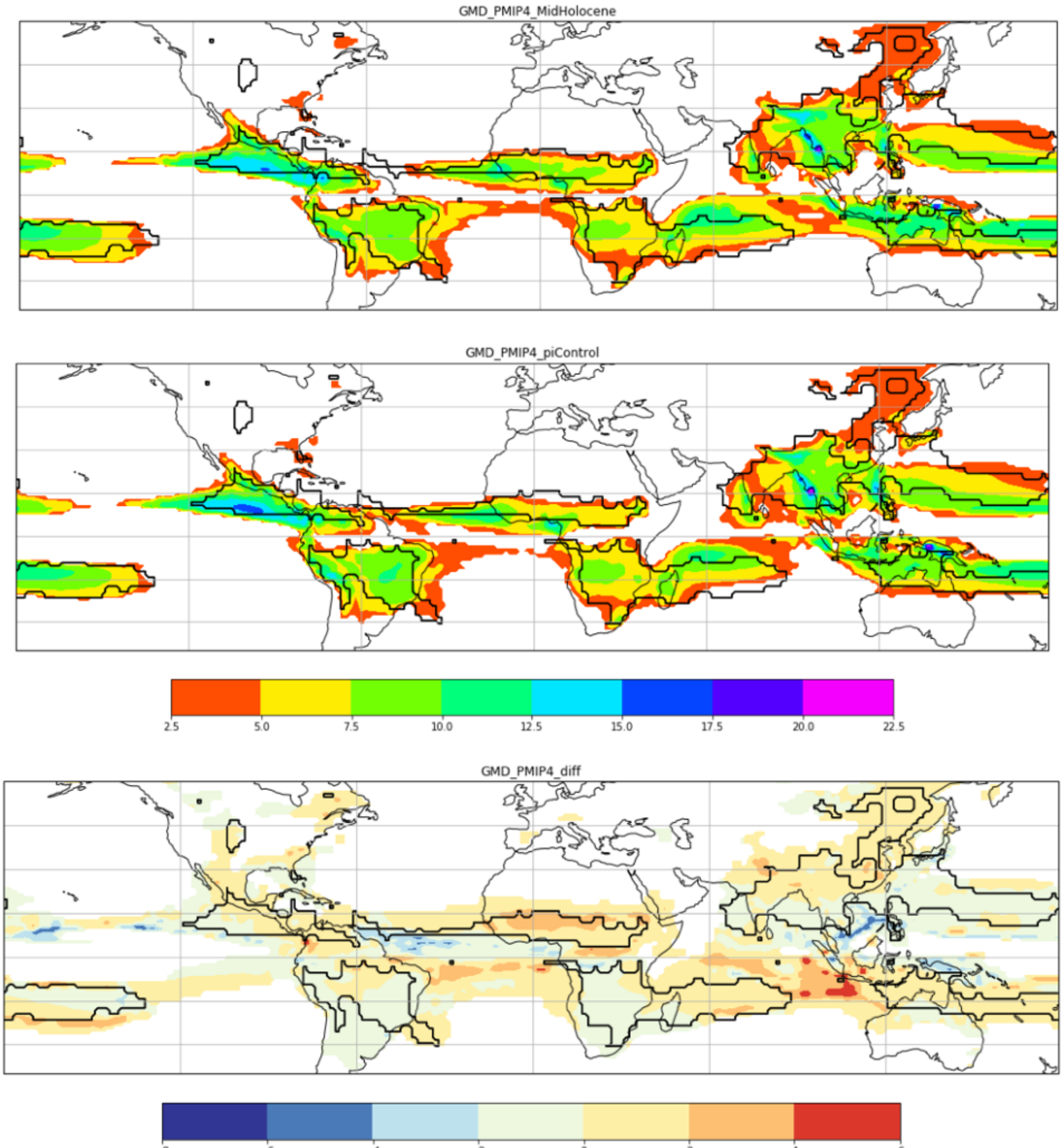

Figure 5. Ensemble mean change in global monsoon domain (Ensemble mean of PMIP4 simulated global mean domain for midHolocene (Top), piControl (middle) and changes between them (bottom). Domain regions are marked as values > 2.5 mm/day. Thick contour (black) shows the boundary of observed domain at present)

Para.32: What do the models suggest for midHolocene changes in the global monsoon domain (Fig. 5)?

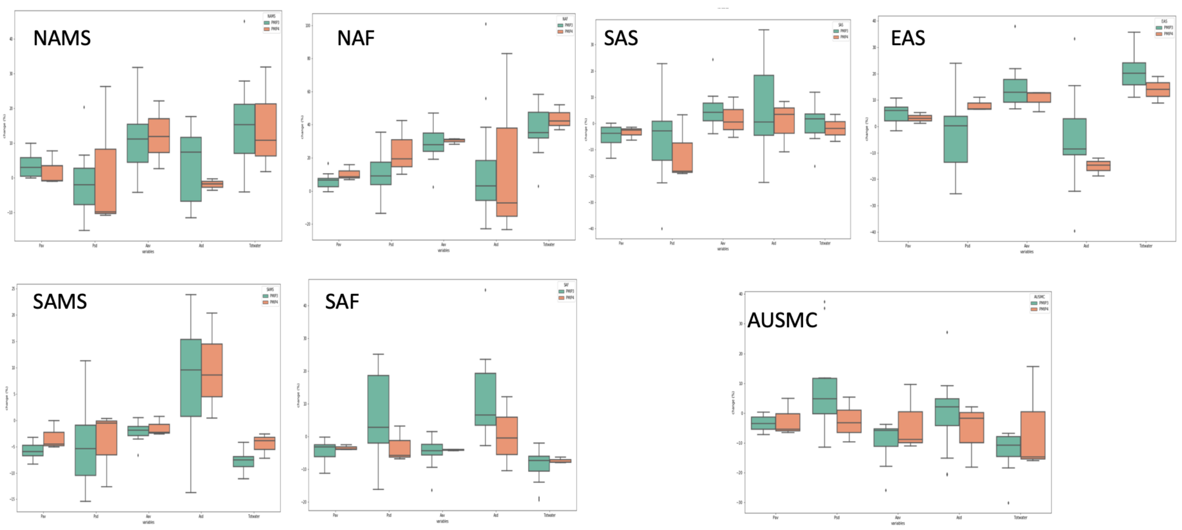

Figure 6. Relative changes (midHolocene - piControl) in monsoon over North America Monsoon System (NAMS), North Afraca (NAF), Southern Asia (SAS) and East Asia summer (EAS) in the Northern Hemisphere and South America Monsoon System (SAMS), South Africa (SAF) and Australian-Maritime Continent (AUSMC) in the Southern Hemisphere, in averaged precipitation (Pav), standard deviation of averaged precipitation (Psv), averaged area of monsoon domain (Aav), standard deviation of averaged Area (Asv) and total annual precipitaion (totwater)

Para.33: Describe changes in North African monsoon domain. Explain different metrics - expansion of area, average pr rate (Fig. 6)?

Para.34: Describe changes in Asian monsoon domains. Compare PMIP4 to PMIP3

Para.35: Describe changes other monsoons (S. Amer, N. Amer, AUSMC, S. African). Compare PMIP4 to PMIP3

3.4 Ocean Circulation

Para.36: Brief description of (reconstructed) ocean changes at midHolocene: small variations in sea level, SSTs follow SAT (so already discussed), thoughts about AMOC reconstruction.

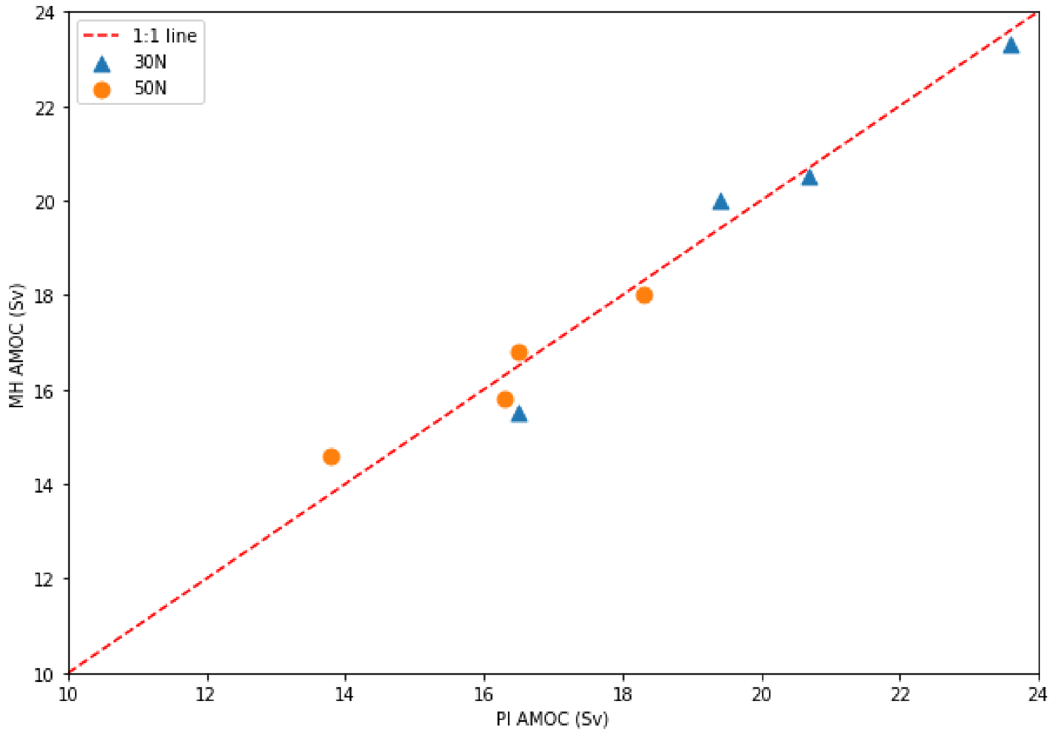

Figure 7. Changes in AMOC Max. below 500m at 30 and 50 degN. 4 included so far are 'CCSM4','FGOALS-G2','MPI-ESM-P','MRI-CGCM3'.

Para.37: Description of changes in AMOC using Fig. 7. They seem fairly non-existent so far)

3.5 Simulation Results Summary

Para.38: Sum up the results from the PMIP4 simulations. Mainly just repeat whats above.

Para.39: Provide an overview of PMIP4 vs PMIP3. Conclude by commenting on whether we can treat both as a combined ensemble, or if fundamentally different.

4 Data Model Comparison

Para.40: Intro paragraph outlining benefits of DMC, and its potential uses. Shout back to previous efforts.

4.1 Multi-proxy temperature reconstruction

Para.41: Describe the various mechanisms by which temperature can be reconstructed. Describe new data compilation coordinated by N. Arizona.

Para.42: Compare the latitudinal reconstructed temperatures to simulated changes. Resulting in something looking like Fig. 8.

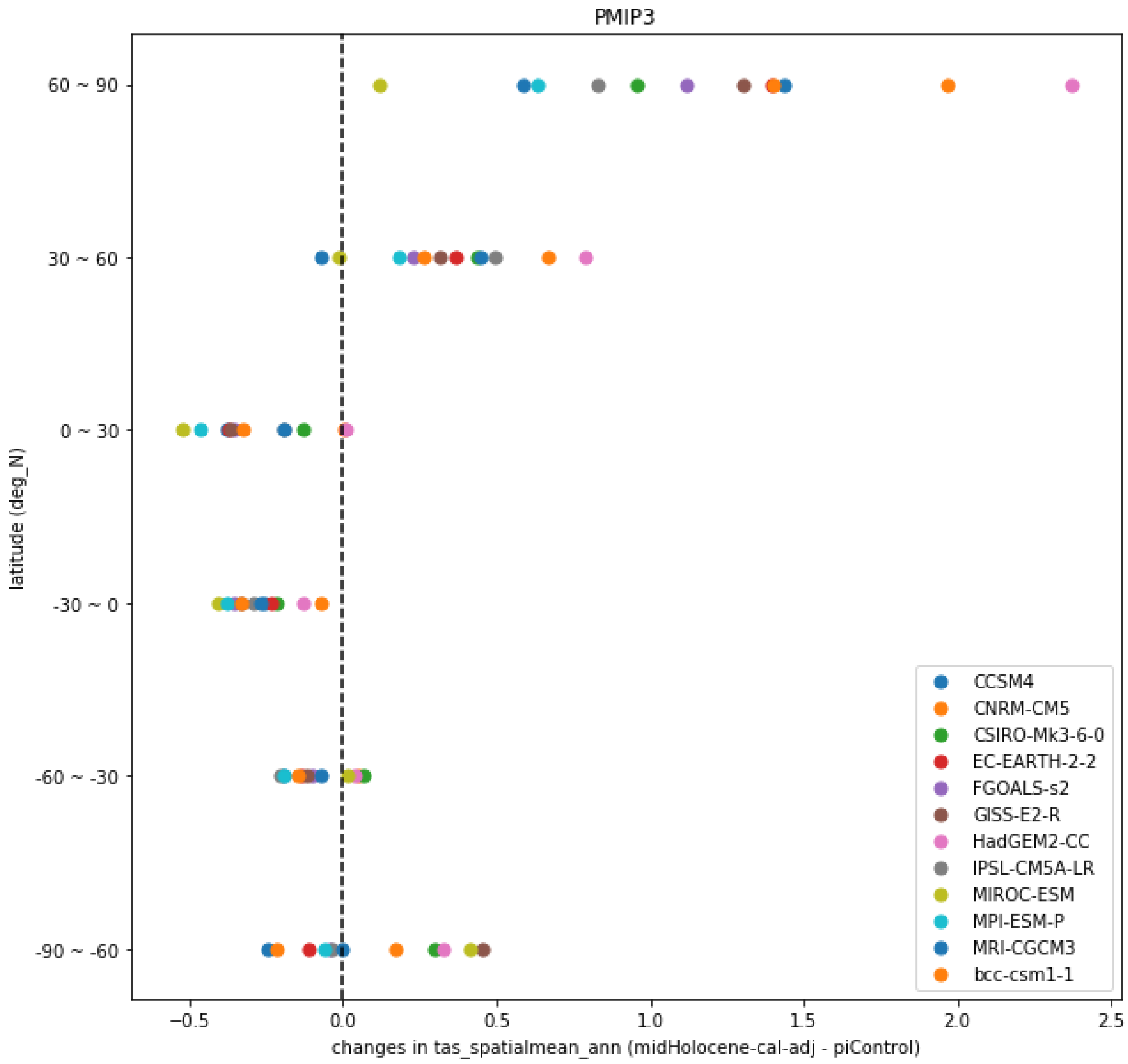

Figure 8. Example for changes in latitudinal gradients vs data. We will update the plot once we've got enough PMIP4 data. Reconstruction data will be added as boxplot or dots with errorbars

4.2 Multivariate terrestrial reconstructions

Para.43: Introduce pollen reconstructions of climate. Stress how can be used for multiple variables, adn mainstay of DMC in PMIP.

Para.44: Describe new Cleator et al reconstruction and data assimilation procedure. State how it compares to Bartlein et al. reconstruction (like in Fig. 9).

Para.45: Compare Cleator et al reconstruction to PMIP simulations via Taylor diagram. Show invidual models, for different variables. Will look something like Fig. 10.

Para.46: Culminate this DMC section by making a "carpet plot" (e.g. Fig. 11). Describe the method. And then a good few sentences unpicking its meaning.

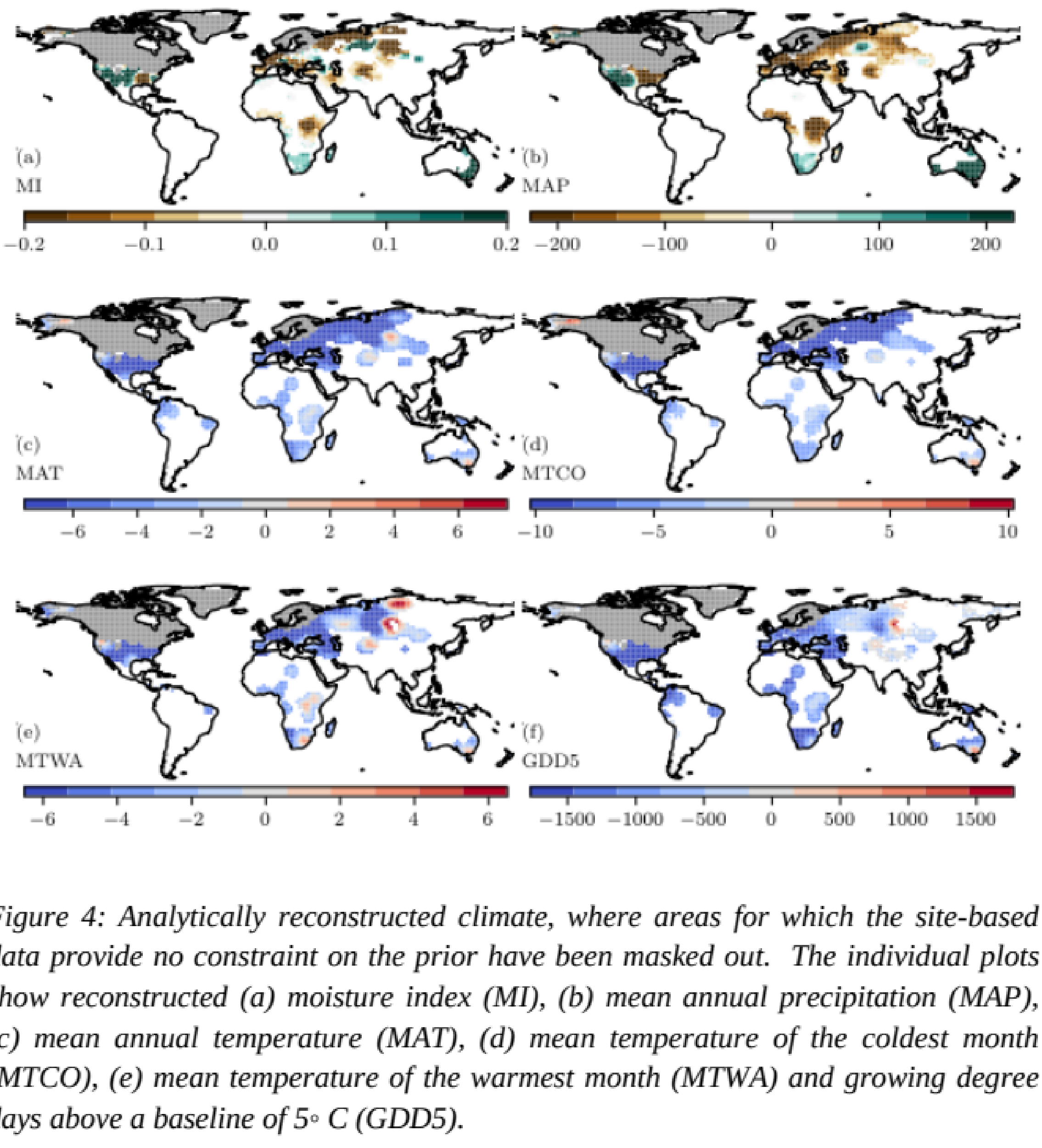

Figure 9. Example of comparing Bartlein vs Cleator data sets. In this case, looking at the LGM.

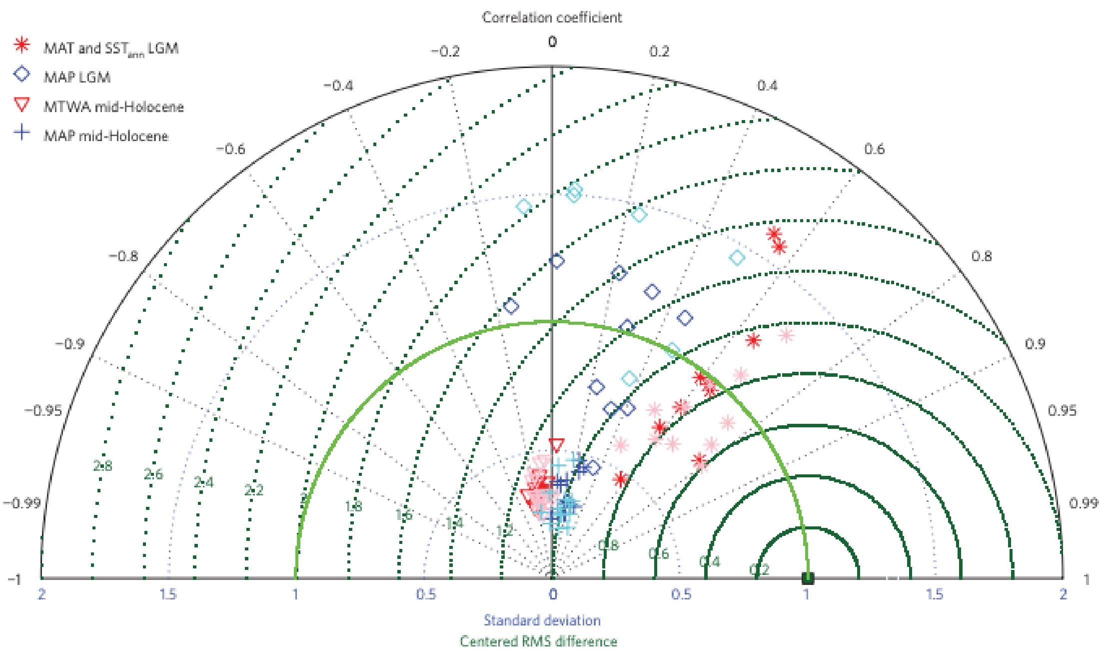

Figure 3 | Taylor diagram[90] for the LGM and mid-Holocene precipitation and temperature anomalies. The distance of any model point from the origin indicates standard deviation of field, the distance of any model point from the green reference point indicates the centred root mean square (RMS) difference between model and data. Pattern correlation between model and observations is given by the azimuthal coordinate. Temperature is represented by MAT over land and SST_{ann} at the LGM, and by MTWA for the mid-Holocene where the change in forcing is seasonal. Precipitation is always represented by MAP. Model statistics are corrected to account for observational uncertainties, by subtracting the estimated contributions made by observational errors as in ref. 62. Models from the CMIP5 ensemble are in red (temperature) and blue (precipitation), whereas models from the PMIP2 ensemble are in pink and pale blue, respectively.

Figure 10. An example of DMC using a Taylor Diagram (taken from Harrison et al, (2015; Nature Climate Change).

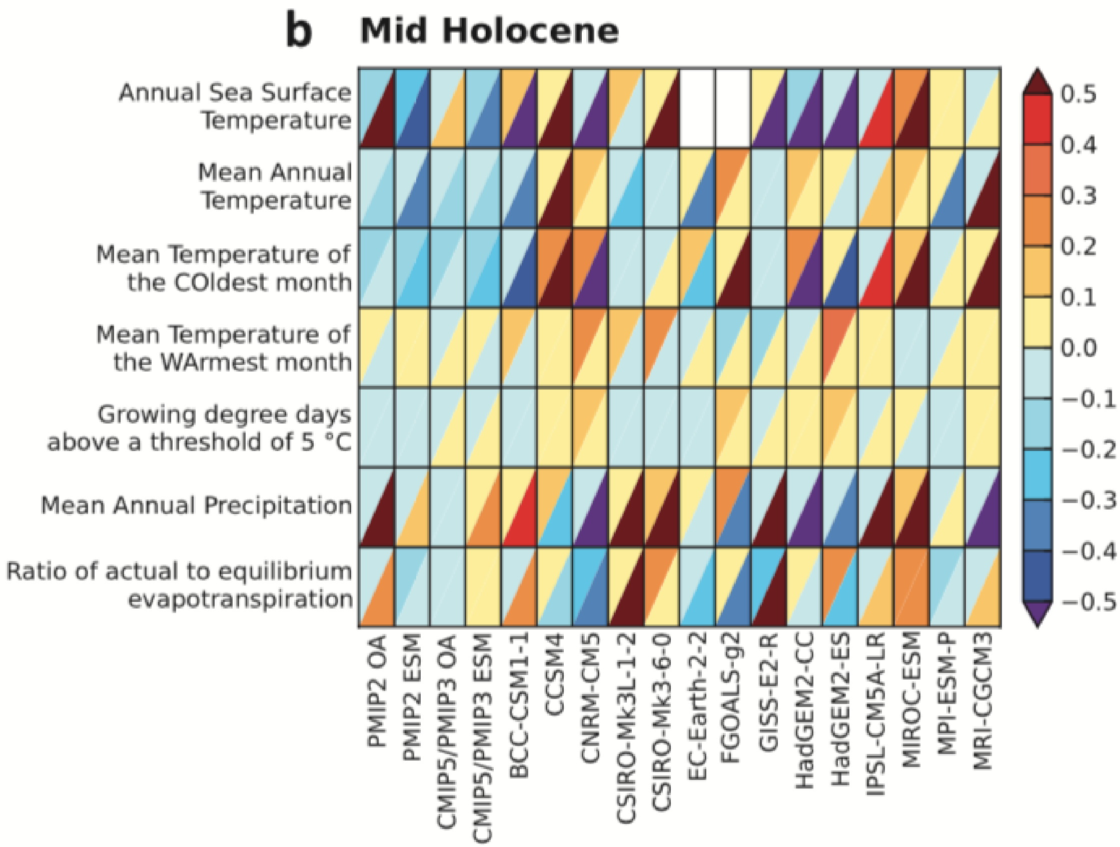

Figure 11. Example for benchmarking (IPCC,AR5,Chp9,P777) Same format, but we will have 4 variables instead (MAT,MAP,MTCO,MTWA)

4.3 El Niño–Southern Oscillation

Para.47: Describe how we think ENSO was different during the midHolocene. Reference some papers. Introduce Emile-Geay et al (2015, Nature Geoscience) paper as the authorative compilation of paleoENSO

Para.48: Describe pseudocoral method and advantagaes of using 'forward model' for DMC

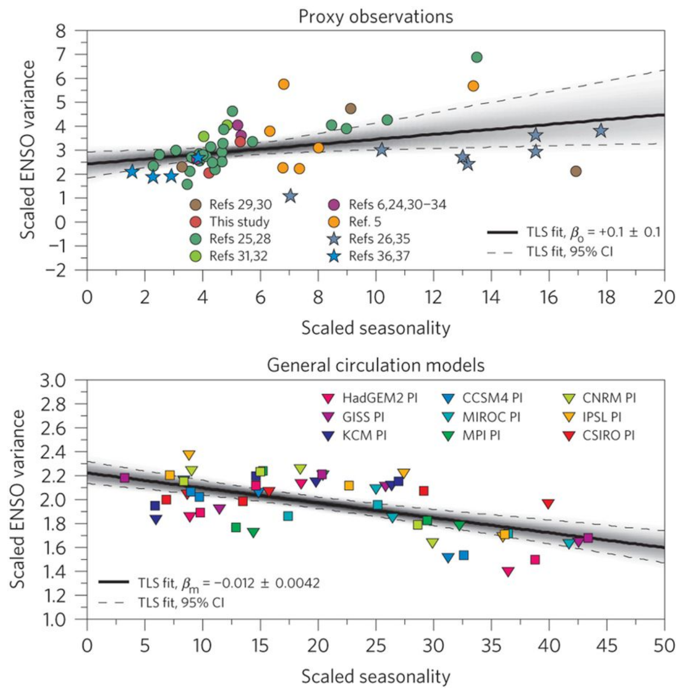

Figure 12. Example for Changes in annual cycle and interannual variability in preudocorals in Tropical Pacific (Emile-Geay et al., 2015; doi:10.1038/ngeo2608). We will calculate d18O from models, and then fwd data to Julien to update the figure.

Para.49: Present and discuss comparison between PMIP4 ENSO, data and PMIP3. Will need a figure, perhaps something like Fig. 12

4.4 Combined evaluation

Para.50: Provide and overarching summary of the data-model comparison. Provide preliminary answer as to whether PMIP4 is better that PMIP3. (I suspect it will be "In some cases, yes. In some places longstanding biases still exist though").

Para.51: Make some recommendations about what datasets may be more informative in future. Basically just make a shout-out for upcoming data compilations. Comment on role of isotope enabled models (some here are, but we're not using that capacity) and forward proxy models.

5 Conclusions

Para.52: Explain again what PMIP4 and its midHolocene simulation are

Para.53: Summarise the model results shown in this paper. A sentence each on the various sections: temperatures, rainfall, monsoons, AMOC.

Para.54: Summarise the data model comparison results. Say we have evaluated the models. Highlight possibility of formally bringing that evaluation through to projections with some past2future emergent constraint applications.