Climate model simulations from the Last Glacial Maximum to today

Steven J. Phipps[1,2], Duncan Ackerley[3] and Maisa Rojas[4,5]

[1]Climate Change Research Centre, University of New South Wales, Sydney, Australia [2]ARC Centre of Excellence for Climate System Science, University of New South Wales, Sydney, Australia
[3]Monash Weather and Climate, Monash University, Melbourne, Australia [4]Department of Geophysics, University of Chile, Santiago, Chile [5]Millennium Nucleus on Paleoclimate of the Southern Hemisphere

1. Introduction

The SHAPE project aims to reconstruct and understand past changes in the atmospheric and oceanic circulation of the Southern Hemisphere (SH). Within this context, climate modelling plays a critical role in testing the interpretation of the proxy data and exploring the underlying dynamical mechanisms. This poster summarises the diverse range of climate model simulations that are available to members of the SHAPE project, and highlights some of their key features.

2. The Palaeoclimate Modelling Intercomparison Project

SHAPE will utilise the simulations generated using state-of-the-art climate system models by the third phase of the Palaeoclimate Modelling Intercomparison Project (PMIP3; Braconnot et al., 2012). There are four core PMIP3 experiments:

- a pre-industrial control simulation (0 ka)
- the mid-Holocene (6 ka)
- the Last Glacial Maximum (21 ka)
- the last millennium (850–1850 CE)

However, PMIP3 is also performing additional experiments, including transient simulations of the Holocene (8–0 ka) and the Last Interglacial (130–115 ka). Twenty-one modelling groups have completed some or all of the PMIP3 experiments (Table 1). This data is freely available to the research community via the Earth System Grid (e.g. http://pcmdi9.llnl.gov/esgf-web-fe/).

List of PMIP3/CMIP5 participants *Information as of May 20th 2014*
Up to date PMIP3 info: https://pmip3.lsce.ipsl.fr/wiki/doku.php/pmip3:database:status
Some ESGF access nodes: PCMDI IPSL DKRZ BADC
Node information: http://esgf-node.ipsl.fr/esgf-desktop
CMIP5 Errata: http://pcmdi-cmip.llnl.gov/cmip5/errata/cmip5errata.html
PMIP3 Errata: https://wiki.lsce.ipsl.fr/pmip3/doku.php/pmip3:database:errors
Models' documentation: http://q.cmip5.ceda.ac.uk/cmip5/publisheddocs/

	Institute	Country	0k *piControl*	6k *midHolocene*	21k *lgm*	LM *past1000* (1000 years)	1 % CO_2 *1pctCO2* (140 years)	CMIP5	PlioMIP	Last Interglacial	Holocene	Carbon cycle	Atm	Ocn	Model id	Term of Use	Data Node	Extra Doc Errata etc...
1	**AWI**	Germany	Completed	Completed	Completed			No	Yes	Yes	No	Yes	96×48 x L19	120×101 x L40	*COSMOS-aso ?*	?	*DKRZ*	
2	**BCC**	China	CMIP5 (500)	CMIP5 (100)		CMIP5	CMIP5	Yes	No	No	No	Yes	128×64 x L26	360x232 x L40	bcc-csm1-1	Unrestricted	BCC	
3	**BCCR**	Norway	Completed	Running Summer 2013	Completed	Running Summer 2013	Running Summer 2013	No	Yes	Yes	No	Yes	96×48 x L26	100×116 x L32	NorESM1-L	Unrestricted	*DKRZ ?*	
4	**CAU-GEOMAR**	Germany	PMIP3	PMIP3	Starting		PMIP3	No	Yes	Yes	Yes	No	96x48 x L19	182x149 x L31	KCM1-2-2	Non-commercial only	DKRZ	
5	**CNRM-CERFACS**	France	CMIP5 (850)	CMIP5 (200)	CMIP5 (200)		CMIP5	Yes	No	No	No	No	256x128 x L31	362x292 x L42	CNRM-CM5	Unrestricted	CNRM	Doc
6	**FUB**	Germany	PMIP3 (400)		PMIP3 (600)			No	No	No	No	Yes	96×48 x L19	120×101 x L40	COSMOS-ASO	Unrestricted	*IPSL (DKRZ later?)*	
7	***NOAA-GFDL***	*USA*	***CMIP5*** *(470)*		***Not Successful***		***CMIP5***	Yes	*No*	*No*	*No*	*Yes*	*144x90 x L24*	*360x200 x L50 360x210 x L64*	*GFDL-ESM2M GFDL-ESM2G*	*Unrestricted*	*GFDL*	
8	**NASA-GISS**	USA	CMIP5 (7 x)	CMIP5 (100)	CMIP5 (2 x 100)	CMIP5 (8 x 1000)	CMIP5 (151)	Yes	Yes	?	Yes	No	144x90 x L40	288x180 x L32	GISS-E2-R	Unrestricted	NCCS	Doc
9	**IPSL**	France	CMIP5 (1000)	CMIP5 (500)	CMIP5 (200)	CMIP5	CMIP5	Yes	Yes	Yes	Yes	Yes	96x95 x L39	182x149 x L31	IPSL-CM5A-LR	Unrestricted	IPSL	Doc
10	**ICHEC (KNMI)**	Netherlands	PMIP3 (40)	PMIP3 (40)				No	Yes	No	No	No	320×160 x L62	362x292 x L42	EC-Earth-2-2	Unrestricted	ICHEC	
11a	**LASG-CESS**	China	CMIP5 (900)	CMIP5 (100)	CMIP5 (100)		CMIP5	Yes	Yes	No	No	No	128x60 x L26	360x180 x L30	FGOALS-g2	Unrestricted	LASG	
11b	**LASG-IAP**		CMIP5 (501)	CMIP5 (100)		CMIP5	CMIP5		No	No	No		128x108 x L26		FGOALS-s2	Unrestricted	LASG	
11c			Completed			CMIP5				No	No		72x45 x L26		FGOALS-gl	Unrestricted	LASG	Doc
12	**LOVECLIM**	Belgium France Netherlands	Completed	Completed	Completed	Completed		No	No	Yes	Yes	No	32x64 x L3	122x65 x L20	LOVECLIM1-2	Unrestricted	IPSL	
13	**MIROC**	Japan	CMIP5 (531)	CMIP5 (100)	CMIP5 (100)	CMIP5	CMIP5	Yes	Yes	?	?	Yes	128x64 x L80	256x192 x L44	MIROC-ESM	Non-commercial only	DIAS	
14	**MPI-M**	Germany	CMIP5 (1156)	CMIP5 (2x100)	CMIP5 (2 x 100)	CMIP5	CMIP5	Yes	No	No	No	No	196x98 x L47	256x220 x L40	MPI-ESM-P	Unrestricted	DKRZ	
15	**MRI**	Japan	CMIP5 (500)	CMIP5 (100)	CMIP5 (100)	CMIP5	CMIP5	Yes	Yes	No	No	No	320x160 x L48	364x368 x L51	MRI-CGCM3	Non-commercial only	DIAS	
16	**NCAR**	USA	CMIP5 (501)	CMIP5 (1x301 + 1x30)	CMIP5 (1x101 + 1x31)	CMIP5	CMIP5	Yes	Yes	No	No	No	288x192 x L26	320x384 x L60	CCSM4	Unrestricted	NCAR	
17	**OSUVic**	USA	Completed	Completed (400)	Completed		Completed	No	No	No	No	No	128x64 x L10	100 x 100 x L19	OSUVic-0-3	Unrestricted	?	
18	**CSIRO-QCCCE**	Australia	CMIP5 (500)	CMIP5 (100)			CMIP5	Yes	No	No	No	No	192x96 x L18	192x192 x L31	CSIRO-Mk3-6-0	Non-commercial only	NCI	
19a	**MOHC** (UK groups)	UK	CMIP5 (497)	CMIP5 (102)	Starting	Running Spring 2013	CMIP5	Yes	Yes	Yes	Yes	Yes	192x144 x L38	360x216 x L40	HadGEM2-ES	Unrestricted	BADC	Doc
19b			CMIP5 (240)	CMIP5 (35)				Yes	No	No	No	Yes	192x144 x L60	360x216 x L40	HadGEM2-CC	Unrestricted	BADC	
19c	**UOED**		PMIP3 (1200)			PMIP3	CMIP3	Yes	Yes	Yes	Yes	No	96x73 x L19	288x144 x L20	HadCM3	Unrestricted	BADC	
20	**UNSW**	Australia	PMIP3 (1000)	PMIP3 (500)	***Not Successful***	PMIP3	PMIP3	No	No	Yes	Yes	No	64x56 x L18	128x112 x L21	CSIRO-Mk3L-1-2	Non-commercial only	IPSL *(NCI later?)*	Doc
21	**UofT**	Canada	Completed	Completed	Completed	Completed	Completed	No	No	No	No	No	256x128 x L26	320x386 x L40	UofT-CCSM3	Unrestricted	?	
	Click for up-to-date exp check :		piControl ?	midHolocene ?	lgm ?	past1000 ?	1pctCO2 ?											

Legend: Status expected completion date — No / Yes; Available in CMIP5 DB (nb ens x nb years in CMIP5 DB); Available in PMIP3 DB (nb years in PMIP3 DB); Available in CMIP3 DB; *Not Successful*

PMIP3 + PlioMIP groups: Note that the models used for PlioMIP are often not (exactly) the same as the ones used for PMIP3/CMIP5
PlioMIP-only (not in the table): LPAP, UoM

Table 1. Status of the PMIP3 database as of 20 May 2014 (source: PMIP3 wiki).

The simulations of the Last Glacial Maximum (LGM) display some notable inter-model differences. Generally, the PMIP2 and PMIP3 models simulate a slight weakening of the SH westerly winds at the LGM, with little or no shift in the latitude (Figure 1). They also differ in the extent of Antarctic sea ice (Figure 2a), and the degree of coupling between temperature, sea ice extent and the SH westerly winds (Figure 2b–c).

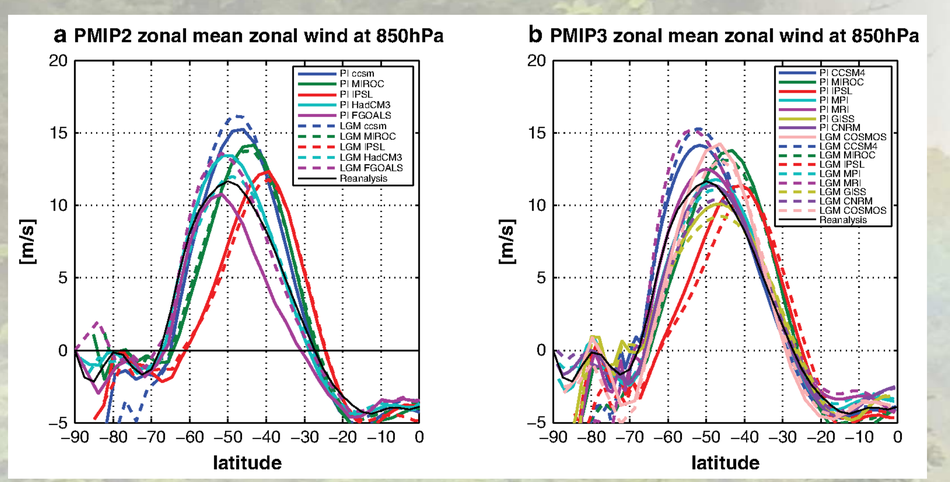

Figure 1. Annual-, zonal-mean zonal wind speed at 850 hPa in the pre-industrial (PI) and Last Glacial Maximum (LGM) experiments for (a) PMIP2, and (b) PMIP3 (Rojas, 2013).

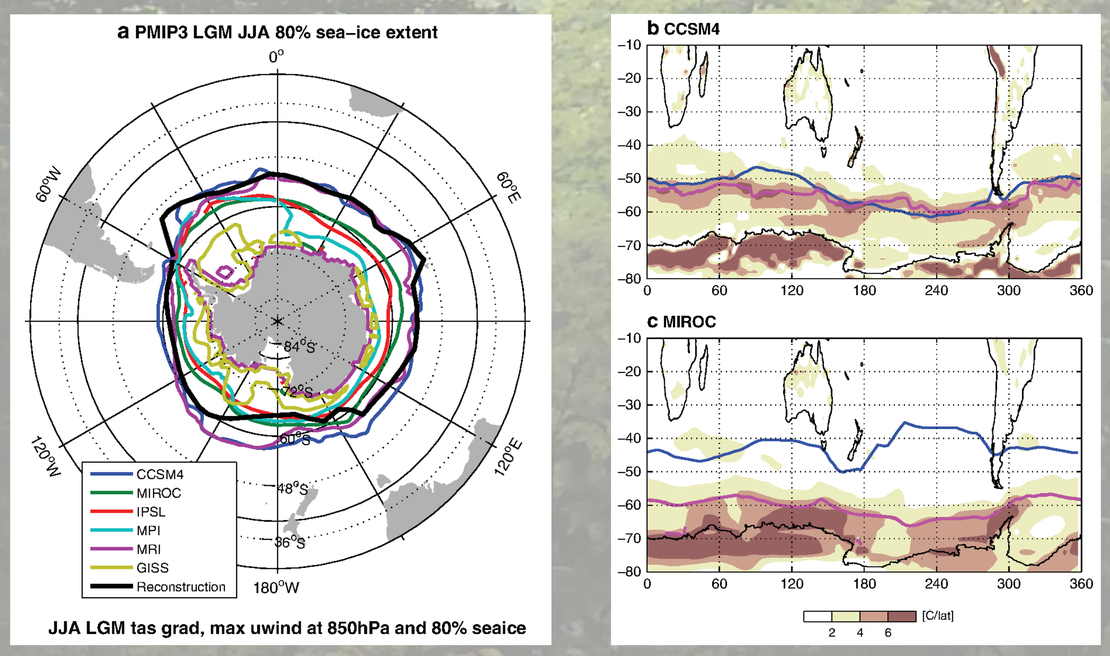

Figure 2. (a) PMIP3 winter sea ice extent, and (b)–(c) surface temperature gradient (shading), winter sea ice extent (purple line) and maximum zonal wind at 850 hPa (blue line) (Rojas, 2013).

The transient simulations of the Holocene and the Last Interglacial exhibit an intensification and poleward shift of the SH westerly winds, although the magnitudes of these trends are model-dependent (Figure 3).

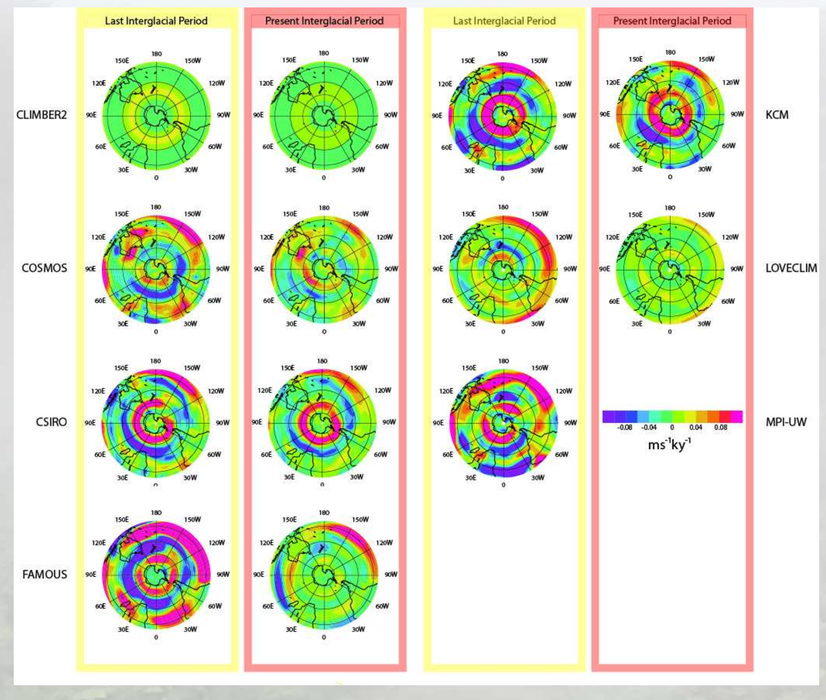

Figure 3. Simulated trends in the annual-mean zonal surface wind during the Last Interglacial (123.0–116.2 ka) and Present Interglacial (8.0–1.2 ka) periods (Bakker et al., in revision).

3. Other projects

Other initiatives have generated climate model simulations of direct relevance to SHAPE. In particular, the SynTraCE-21 project has produced a transient simulation spanning the full period from 21–0 ka (http://www.cgd.ucar.edu/ccr/TraCE/). This simulation is forced primarily by meltwater fluxes in the Northern and Southern Hemispheres. In the SH, the Antarctic Cold Reversal appears as a response to the Bølling-Allerød warming (~14.3 ka; Figure 4). During the LGM, the SH westerly winds are stronger, wider and shifted slightly poleward relative to the Holocene (Figure 5).

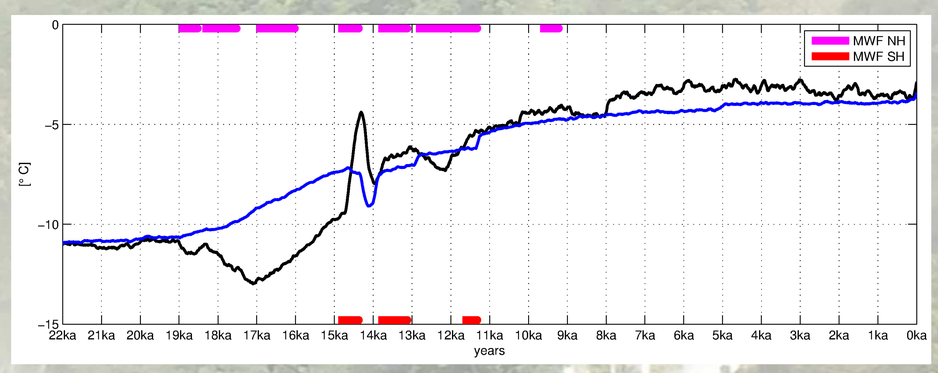

Figure 4. Northern Hemisphere (20–90°N; blue) and Southern Hemisphere (90–20°S; black) temperature in the SynTraCE-21 simulation (Rojas et al., in prep.).

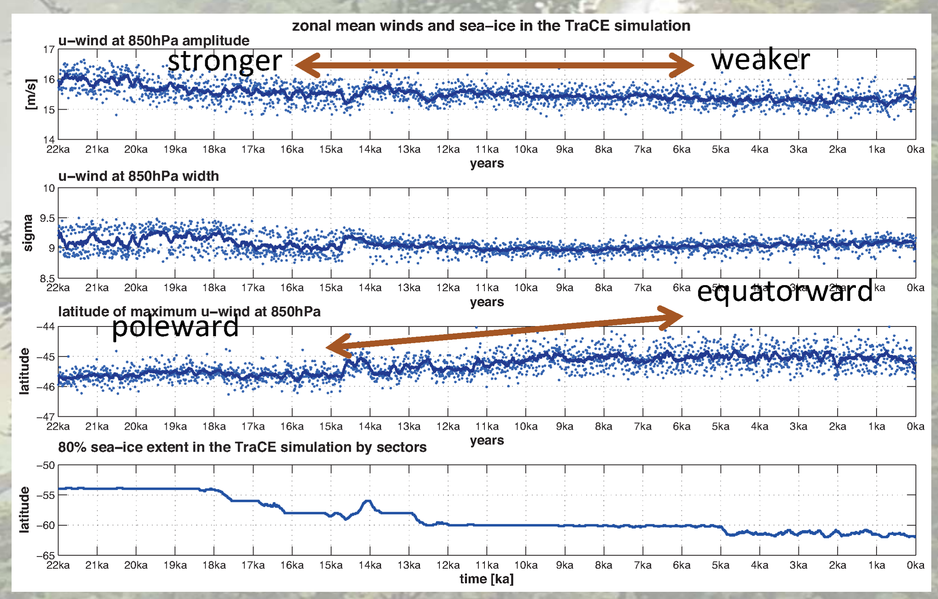

Figure 5. Amplitude, width and latitude of maximum zonal wind speed at 850 hPa, and sea ice extent, in the SynTraCE-21 simulation (Rojas et al., in prep.).

The CSIRO Mk3L climate system model has also been used to conduct multiple transient and time slice experiments spanning the Holocene (Phipps and Brown, 2010; Baker et al., 2013), while members of the PAGES 2k Network have simulated the response of the climate system to different natural and anthropogenic forcings over the past 2,000 years (PAGES 2k Consortium, 2013; Phipps et al., 2013).

4. Conclusions

A wide variety of climate model simulations are available that are of direct relevance to SHAPE researchers. In future, SHAPE will complete further simulations of its own in order to study key phenomena identified by the regional- and hemispheric-scale proxy syntheses. Suggestions from members of the proxy community are welcome!

References

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