Design for the Penultimate Deglaciation experiment

You will find on this page information about the experiment design for the PMIP4 Penultimate Deglaciation experiments.

This protocol is a product of the *PAGES-PMIP working group on Quaternary Interglacials* (QUIGS)

Please make sure to read the Associated publications before setting up your experiments or using the output data, and read any *how-to* sections associated with specific boundary conditions.

Get in touch with the following people if you have questions:

Laurie Menviel	Experimental design questions
Emilie Capron	Experimental design questions
Ruza Ivanovic	working group leader
Jean-Yves Peterschmitt	Technical questions or missing data

Associated publications

- **Penultimate Deglaciation experiment design, version 1:**

  The penultimate deglaciation: protocol for PMIP4 transient numerical simulations between 140 and 127 ka, version 1.0, Menviel et al, GMD, 2019, https://dx.doi.org/available_soon

Version 1 Specifications

For general advice on boundary condition implementation in palaeoclimate models, see Kageyama et al. (2016).

Penultimate Glacial Maximum spinup (140 ka)

If possible, this spinup simulation should start from the PMIP4-CMIP6 LGM (21 ka) experiment, as equilibrium would be reached more quickly.

	PMIP4 specifications
PMIP4 name	**PDGv1-PGMspin** (PDG ⇔ ***P****enultimate* ***D****e****G****laciation* - PGM ⇔ ***P****enultimate* ***G****lacial* ***M****aximum*)

	PMIP4 specifications
Astronomical parameters	**eccentricity** = 0.033 **obliquity** = 23.414° **perihelion-180°** = 73° **Date of vernal equinox** : Noon, 21st March
Solar constant	1361.0 ± 0.51365 W m^{-2}
Trace gases	**CO_2** = 191 ppm **CH_4** = 385 ppb **N_2O** = 201 ppb **CFC** = 0 **O_3** = Preindustrial (e.g. 10 DU)
Ice sheets, orography and coastlines	140 ka data from Combined ice-sheet reconstruction (IcIES-NH, GSM-G and GSM-A): [Access to data] (Abe-Ouchi et al 2013; Briggs et al 2014; Tarasov et al 2012)
Bathymetry	Keep consistent with the coastlines, using either: - Data associated with the ice sheet - Preindustrial bathymetry
Global ocean salinity	+ 0.85 psu, relative to preindustrial
All others	See manuscript section 6.1

Transient Penultimate Deglaciation (140-127 ka)

These are the specifications for the full transient run 140-127 ka.

	PMIP4 specifications
PMIP4 name	**PDGv1**
Initial conditions (140 ka)	Recommended: PDGv1-PGMspin See above for details. The method must be documented, including information on the state of spinup
Astronomical parameters	Transient, as per Berger (1978) [Access to data **&** README !]
Solar constant	1361.0 ± 0.51365 W m^{-2}
Trace gases	**CO_2** = Transient, as per the spline of Koehler et al. (2017): [Access to data] **CH_4** = Transient, as per the spline of Koehler et al. (2017): [Access to data] **N_2O** = Linear increase from 201 ppb at 140 ka to 218.74 ppb at 134.5 ka then transient, as per the spline of Koehler et al. (2017): [Access to data] **CFC** = 0 **O_3** = Preindustrial (e.g. 10 DU)
Ice sheet	Transient: Combined ice-sheet reconstruction (IcIES-NH, GSM-G and GSM-A) [Access to data] (Abe-Ouchi et al 2013; Briggs et al 2014; Tarasov et al 2012) How often to update the ice sheet is optional
Orography and coastlines	Transient. To be consistent with the choice of ice sheet. Orography is updated on the same timestep as the ice sheet. It is optional how often the land-sea mask is updated, but ensure consistency with the ice sheet reconstruction is maintained

	PMIP4 specifications
Bathymetry	Keep consistent with the coastlines, and otherwise use either: - Data associated with the ice sheet; it is optional how often the bathymetry is updated - Preindustrial bathymetry
River routing	Ensure that rivers reach the coastline It is recommended (optional) to use one of the following: - Self-consistent paleo-routing described in section 6.2.3 - Preindustrial configuration for the model - Manual/model calculation of river network to match topography
Freshwater fluxes	Recommended North Atlantic option is *fSL* and a constant 0.0135 Sv flux around the Antarctic coast between 140-130 ka [Access to data] - *fSL* : meltwater flux based on changes in sea-level - *fIRD* : meltwater flux based on Norwegian Sea and North Atlantic IRD - *fIC* : meltwater flux based on ice-sheet changes - *fSL2* : meltwater flux based on changes in sea-level and triangular input max. 0.15 Sv between 131-128 ka on the Antarctic coast - *fUN* : Globally uniform meltwater input based on sea-level changes
Vegetation & land cover Aerosols (dust)	Prescribed preindustrial cover or dynamic vegetation model Prescribed preindustrial distribution or prognostic aerosols

Focused simulations

- Empty
- Empty

Paleorecords to use for model-data comparisons

Overview

See Table 3 and Table 4 of the Penultimate Deglaciation GMD paper

Table 3 **Table 4**

Click on a table to get a bigger version,
or download the GMD paper

Tracer interpretation	Core	Coordinates and depth (m)	$\varphi1$ (ka)	$\varphi2$ (ka)	$\varphi3$ (ka)	$\varphi4$ (ka)	$\varphi5$ (ka)	References
Sea-level								
Sea-level	**Red Sea cores**	-	137.0±0.7 *increases*		133.4±0.7 *main increase*		130.2±1	Grant et al. (2012) This study
Benthic $\delta^{13}C$								
North Atlantic intermediate-depth	**ODP983**	60.40°N, 23.64°W 1984 m	136.1±1.2 *weaker ventil.*				128.1±0.9	Raymo et al. (2004) Barker et al. (2015)
ventilation	**ODP980**	55.80°N, 14.11°W 2180 m	137±1.9			128.6±1.8	127.6±1.3	Oppo et al. (2006)
North Atlantic deep-water	**MD95-2042**	37.80°N, 10.17°E 3146 m				131.0±1.4 *stronger ventil.* (T)		Shackleton et al. (2003)
ventilation	**Stack of U1308 CH69-K09 and ODP 1063**	49.88°N, 24.24°W, 3883 m 41.76°N, 47.35°W, 4100 m 33.69°N, 57.62°W, 4584 m	135.9±2.0			130.3±1.6	129.2±1.4	Hodell et al. (2008) Labeyrie et al. (1999) Deaney et al. (2017)
Southern Ocean deep-water ventilation	**MD02-2488**	46.48°S, 88.02°E 3420 m			131.9±2.1 *stronger ventil.* (U)	130.2±2.2 *weaker ventil.* (V)		Govin et al. (2009) Govin et al. (2012)
Planktic $\delta^{18}O$ and $\delta^{18}O_{sw}$								
North Atlantic surface $\delta^{18}O$	**ODP980**	55.80°N, 14.11°W 2180 m				130.0±1.3		Oppo et al. (2006)
salinity	**SU90-03**	40.51°N, 32.05°W				131.0±1.1		CS98
	MD95-2042 ODP 976	37.80°N, 10.17°E 36.20°N, 4.31°E			133.9±0.9	131.6±1.5 131.9±0.9		Shackleton et al. (2003) Martrat et al. (2014)
Speleothem $\delta^{18}O_c$								
North Atlantic surface $\delta^{18}O$	**Corchia Cave, Italy**	43.97°N, 13.0°E, 840 m a.s.l			133.9±1.2 *NA meltwater input* (I)	131.0±0.7 *NA meltwater paused* (J)		Drysdale et al. (2009) Tzedakis et al. (2018) Marino et al. (2015)
Mean ages for the beginning of $\varphi1$-$\varphi5$ from Tables 3 and 4								
Mean ages			136.4±1.7	133.9±0.8	133.3±1.1	130.4±1.3	128.5±1.3	

Table 3.

Tracer interpretation	Core, coordinates and depth/elevation	Chronology	$\varphi1$ (ka)	$\varphi2$ (ka)	$\varphi3$ (ka)	$\varphi4$ (ka)	$\varphi5$ (ka)	References
Atm. CO_2 concentration								
Atm. CO_2 concentration	**EDC** 75.05°S, 123.19°E, 3233 m asl	Ice core AICC2012 chrono.	137.8±2.7 *increases*				128.0±1.8	Bereiter et al. (2015)
SST								
North Atlantic *Summer* SST (FFA)	**ODP980** 55.80°N, 14.11°W, 2180 m depth	Alignment onto Corchia U-Th-based chrono.				129.7±1.3	128.7±1.3	Oppo et al. (2006)
North Altantic *Summer* SST (FFA)	**SU90-03** 40.51°N, 32.05°W, 2475 m depth	Alignment onto Corchia U-Th-based chrono.	136.9±1.6 *colder* [E]			131±1 *warmer* [F]		CS98 Cortijo et al. (1999)
W. Mediterr. Sea SST (Uk'37)	**ODP 976** 36.20°N, 4.31°E 1108 m depth	Alignment onto Corchia U-Th-based chrono.	135.9±1.1 *colder* [A]	134 ±1.1 [B]	133.3** ±0.9 [C]	131.4±0.9 *warmer* [D]		Martrat et al. (2014)
Southern Ocean *Summer* SST (FFA)	**MD02-2488** 46.48°S, 88.02°E, 3420 m depth	Alignment onto AICC2012				130±2.1** *max. warm* [R]		Govin et al. (2009) Govin et al. (2012)
Southern Ocean SST (Mg/Ca)	**MD97-2120** 45.54°S, 174.92°E, 1210 m depth	Alignment onto AICC2012				128.1±2.5** *max. warm* [S]		Pahnke et al. (2003)
Air temperature (SAT)								
Antarctic *Annual* SAT (Ice δD)	**EDC ice core** 75.1°S, 123.35°E, 3233 m a.s.l.	Ice core AICC2012 chrono.	135.6±2.5 *(warmer)* [W]			129.4±1.8** *max. warm* [X]		Jouzel et al. (2007)
SAT Southern Europe ([Mg])	**Corchia Cave, Italy** 43.97°N, 13.0°E, 840 m a.s.l	Alignment onto Corchia U-Th-based chrono.				131.0±0.7 *warmer* [K]	128.6±0.6 *warm plateau* [L]	(Drysdale et al., 2018)
Precipitation								
Vegetation/precipitation in Southern Europe	**Lago di Monticchio, Italy** 40.93°N, 15.58°E, 656 m a.s.l.	Independent absolute varve chronology					127.2±1.6 *max. warm/wet* [G]	Brauer et al. (2007)
(Temperate tree pollen)	**Ioannina terr. sequence, Greece** 39.65°N, 20.91°E, 470 m a.s.l.	Orbital tuning				132.7±2.3 *wetter* [H]		Tzedakis et al. (2003)
Intensity of Asian monsoon ($\delta^{18}O_c$)	**Chinese Caves** 25.28°N to 32.5°N 108.08-119.16°E 680 - 1900 m a.s.l.	Absolute U-Th-based chronology	135.6±0.5 *drier* [M]	133.7 ±0.5 [N]	133.3** ±0.5 [O]	128.9±0.1 *wetter* [P]		Cheng et al. (2016)
Intensity of East Asian monsoon (grain size)	**Chinese loess** 35.62-37.14°N 103.20 - 109.85°E	Alignment onto Hulu-Sanbao U-Th-based chrono.				130.2±0.4 o *wetter* [Q]		Yang and Ding (2014)
Mean ages for the beginning of $\varphi1$-$\varphi5$ from Tables 3 and 4								
Mean ages			136.4±1.7	133.9±0.8	133.3±1.1	130.4±1.3	128.5±1.3	

Table 4.

Data

You will find below the data mentioned in Table 3, Table 4, Figure 8 and Figure 9 of the GMD paper

The data files have a version string (`_vYYmmDD`) in their file name, indicating when they have been uploaded to this site (in case we have to update them later and use a more recent version/date).

CH69-K09 (txt)
MD95-2042 (txt)
ODP976 (txt)
ODP980 (txt)
ODP983 (txt)
ODP1063 (txt)
SU90-03 (txt)
SL_LIG_Dutton2017 (txt)
d13Cstack (txt) Stack of U1308, CH69-K09 and ODP1063
IRD-stack (txt)
Figure 9 data (xlsx)

References cited

- Ayako Abe-Ouchi, F. Saito, K. Kawamura, M. Raymo, J. Okuno, K. Takahashi, and H. Blatter: **Insolation-driven 100,000-year glacial cycles and hysteresis of ice-sheet volume**, Nature, 500, 190–193, 2013, doi:10.1038/nature12374
- Berger, A.: **Long-Term Variations of Daily Insolation and Quaternary Climatic Changes**, J. Atmospheric Sci., 35(12), 2362–2367, doi:10.1175/1520-0469(1978)035<2362:LTVODI>2.0.CO;2, 1978.
- Robert D. Briggs , David Pollard , Lev Tarasov, **A data-constrained large ensemble analysis of Antarctic evolution since the Eemian**, Quaternary Science Reviews, Volume 103, 1 November 2014, Pages 91–115, doi:10.1016/j.quascirev.2014.09.003
- Kageyama, M., Braconnot, P., Harrison, S. P., Haywood, A. M., Jungclaus, J., Otto-Bliesner, B. L., Peterschmitt, J.-Y., Abe-Ouchi, A., Albani, S., Bartlein, P. J., Brierley, C., Crucifix, M., Dolan, A., Fernandez-Donado, L., Fischer, H., Hopcroft, P. O., Ivanovic, R. F., Lambert, F., Lunt, D. J., Mahowald, N. M., Peltier, W. R., Phipps, S. J., Roche, D. M., Schmidt, G. A., Tarasov, L., Valdes, P. J., Zhang, Q. and Zhou, T.: **PMIP4-CMIP6: the contribution of the Paleoclimate Modelling Intercomparison Project to CMIP6**, Geosci. Model Dev. Discuss., 1–46, doi:10.5194/gmd-2016-106, 2016.
- P. Koehler and C. Nehrbass-Ahles and J. Schmitt and T.F. Stocker and H. Fischer: **A 156 kyr smoothed history of the atmospheric greenhouse gases CO_2, CH_4, and N_2O and their**

radiative forcing, Earth System Science Data, 9, 363–387, doi:10.5194/essd-9-363-2017, 2017.

- Lev Tarasov, Arthur S. Dyke, Radford M. Neal and W.R. Peltier, **A data-calibrated distribution of deglacial chronologies for the North American ice complex from glaciological modeling**, Earth and Planetary Science Letters, Volumes 315–316, 15 January 2012, Pages 30–40, doi:10.1016/j.epsl.2011.09.010
- Veres, D., Bazin, L., Landais, A., Toyé Mahamadou Kele, H., Lemieux-Dudon, B., Parrenin, F., Martinerie, P., Blayo, E., Blunier, T., Capron, E., Chappellaz, J., Rasmussen, S. O., Severi, M., Svensson, A., Vinther, B. and Wolff, E. W.: **The Antarctic ice core chronology (AICC2012): an optimized multi-parameter and multi-site dating approach for the last 120 thousand years**, Clim Past, 9(4), 1733–1748, doi:10.5194/cp-9-1733-2013, 2013.