# 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* ***DeG****laciation* - PGM ⇔ ***P****enultimate* ***G****lacial* ***M****aximum*) |

| | **PMIP4 specifications** |
|---|---|
| Astronomical parameters | **eccentricity** = 0.033<br>**obliquity** = 23.414°<br>**perihelion-180°** = 73°<br>**Date of vernal equinox** : Noon, 21st March |
| Solar constant | 1361.0 ± 0.51365 W $m^{-2}$ |
| Trace gases | **$CO_2$** = 195 ppm<br>**$CH_4$** = 387 ppb<br>**$N_2O$** = 201 ppb<br>**CFC** = 0<br>**$O_3$** = 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 ] |
| Bathymetry | Keep consistent with the coastlines, using either:<br>- Data associated with the ice sheet<br>- 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<br>See above for details. The method must be documented, including information on the state of spinup |
| Astronomical parameters | Transient, as per Berger (1978)<br>[ 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 ]<br>**$CH_4$** = Transient, as per the spline of Koehler et al. (2017): [ Access to data ]<br>**$N_2O$** = 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 ]<br>**CFC** = 0<br>**$O_3$** = Preindustrial (e.g. 10 DU) |
| Ice sheet | Transient: Combined ice-sheet reconstruction (IcIES-NH, GSM-G and GSM-A) [ Access to data ]<br>How often to update the ice sheet is optional |
| Orography and coastlines | Transient. To be consistent with the choice of ice sheet.<br>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 |
| Bathymetry | Keep consistent with the coastlines, and otherwise use either:<br>- Data associated with the ice sheet; it is optional how often the bathymetry is updated<br>- Preindustrial bathymetry |

| | **PMIP4 specifications** |
|---|---|
| River routing | Ensure that rivers reach the coastline<br>It is recommended (optional) to use one of the following:<br>- Self-consistent paleo-routing described in section 6.2.3<br>- Preindustrial configuration for the model<br>- 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<br>[<br>Access to data<br>]<br>- *fSL* : meltwater flux based on changes in sea-level<br>- *fIRD* : meltwater flux based on Norwegian Sea and North Atlantic IRD<br>- *fIC* : meltwater flux based on ice-sheet changes<br>- *fSL2* : meltwater flux based on changes in sea-level and triangular input max. 0.15 Sv between 131-128 ka on the Antarctic coast<br>- *fUN* : Globally uniform meltwater input based on sea-level changes |
| Vegetation & land cover<br>Aerosols (dust) | Prescribed preindustrial cover or dynamic vegetation model<br>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**

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

| Tracer interpretation | Core | Coordinates and depth (m) | φ1 (ka) | φ2 (ka) | φ3 (ka) | φ4 (ka) | φ5 (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 ventilation | **ODP983** | 60.40°N, 23.64°W 1984 m | 136.1±1.2 *weaker venti.* | | | | 128.1±0.9 | Raymo et al. (2004) Barker et al. (2015) |
| | **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 ventilation | **MD95-2042** | 37.80°N, 10.17°E 3146 m | | | | 131.0±1.4 *stronger venti.* (T) | | Shackleton et al. (2003) |
| | **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 venti.* (U) | 130.2±2.2 *weaker venti.* (V) | | Govin et al. (2009) Govin et al. (2012) |
| **Planktic $\delta^{18}O$ and $\delta^{18}Osw$** | | | | | | | | |
| North Atlantic surface $\delta^{18}O$ *salinity* | **ODP980** | 55.80°N, 14.11°W 2180 m | | | | 130.0±1.3 | | Oppo et al. (2006) |
| | **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 $\delta^{18}Oc$** | | | | | | | | |
| 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 φ1-φ5 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.

**Table 4**

| Tracer interpretation | Core, coordinates and depth/elevation | Chronology | φ1 (ka) | φ2 (ka) | φ3 (ka) | φ4 (ka) | φ5 (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 Atlantic *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 ($U^k{}'_{37}$) | **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 $\delta D$) | **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 ($\delta^{18}Oc$) | **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 φ1-φ5 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<br>(txt) |
| MD95-2042<br>(txt) |
| ODP976<br>(txt) |
| ODP980<br>(txt) |
| ODP983<br>(txt) |
| ODP1063<br>(txt) |
| SU90-03<br>(txt) |
| SL_LIG_Dutton2017<br>(txt) |
| d13Cstack<br>(txt) Stack of U1308, CH69-K09 and ODP1063 |
| IRD-stack<br>(txt) |
| Figure 9 data<br>(xlsx) |

# References cited


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