Guide for uploading to the DeepMIP database

You should have received an invitation to access the system, from the bristol-based system (the "RDSF"). If not, please contact Dan (d.j.lunt@bristol.ac.uk). This includes the technical instructions for uploading (you can do it via sftp or via mapping a drive ("webdav")). The invitation email includes instructions, but they are also available here:
https://data.bris.ac.uk/sharing/collaboration/information-for-collaborators
https://data.bris.ac.uk/sharing/collaboration/information-for-collaborators-webdav

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We already created individual directories and an example template README file for each model on the FTP server. An example of the documentation, for HadCM3, is given at the end of this document.

The README documentation uses plain text Markdown files (*.md) (https://www.markdownguide.org/getting-started/) that you can edit with any text editor. Each group should state which experiments and variables are currently available. Example data for HadCM3 is already uploaded and the README documentation is attached to this document reference. Proposed file structure and list of variables should be self-explanatory from this file, but we want to briefly highlight the most important points:

- The output variable list includes two sections:
  - The core output variables are very similar to the appendix of the 2017 GMD experimental design paper (https://www.geosci-model-dev.net/10/889/2017/) . Each group should aim to upload these basic fields.
  - The second part includes "additional output variables" that are required for the analyses for planned DeepMIP papers (https://www.deepmip.org/publications/). You will need to upload these variables (or equivalents from your specific model) if you want your model to be included in the respective papers. The list of additional variables may also grow in the future.

- We propose to upload three main types of fields as separate files:
  - monthly mean climatologies over last 100 years
  - monthly mean standard deviation over last 100 years
  - monthly mean time series of last 100 years for surface temperatures and TOA radiation

- We encourage all groups to use the file structure and variable naming specified in the README files. This will greatly facilitate data analysis and potential future collaboration with the wider community. The variable names follow the CMIP standards (wherever possible) so any existing post-processing scripts for this task can be used. Variable names can also easily be changed via CDO (https://code.mpimet.mpg.de/projects/cdo/). For simplicity you don't need to change any dimension naming, netcdf attributes, etc!

HadCM3 DeepMIP documentation

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Model description

The HadCM3 simulations are carried out with the HadCM3B-M2.1aN (HadCM3BL_M2.1aN) version of the model, as described in detail in Valdes et al. (2017). Equations are solved on a Cartesian grid with horizontal resolutions of 3.75˚×2.5˚ in the atmosphere and 1.25˚×1.25˚ (3.75˚×2.5˚ for HadCM3BL_M2.1aN) in the ocean with 19 and 20 vertical levels, respectively. We make a few changes to the version described in Valdes et al. (2017) to make it suitable for deep-time paleoclimate modelling: (a) We apply a salinity flux correction to the global ocean in order to conserve salinity. (b) We turn off the various modern-specific parameterisations in the ocean model, such as associated with Mediterranean and Hudson Bay outflow, and North Atlantic mixing. (c) We use a prognostic 1D ozone scheme instead of a fixed vertical profile of ozone. The standard configuration uses a prescribed ozone climatology which is a function of latitude, height, and month of the year that does not change with climate and can become numerically unstable at high CO_2 levels. The prognostic ozone scheme uses the diagnosed model tropopause height to assign three distinct ozone concentrations for the troposphere, tropopause, and stratosphere ($2.0\text{x}10^{-8}$, $2.0\text{x}10^{-7}$ and $1.5\text{x}10^{-6}$ in mmr, respectively). This allows for a dynamic update of the 1D ozone field in response to the thermally driven vertical expansion of the troposphere. Absolute values for the three levels are chosen to minimise the effects on global mean and overall tropospheric temperature changes compared to the standard 2D climatology. Concentrations at the uppermost model level are fixed to the higher stratospheric value to constrain the lower bound of total stratospheric ozone. Significant differences to the standard configuration are limited to the stratospheric meridional temperature gradient and zonal winds and are related to the missing latitudinal variations in the 1D field. Although HadCM3 has been used previously to simulate the Pliocene (e.g. Lunt et al., 2008, Lunt et al., 2010), the presented simulations represent the first published application of HadCM3 to pre-Pliocene boundary conditions. However, the lower resolution HadCM3L model has been previously used to simulate a range of pre-Quaternary climates (e.g. Lunt et al., 2016; Farnsworth et al., 2019).

Model simulations

The HadCM3 simulations are carried out at $\times 1$, $\times 2$, and $\times 3$ CO_2 concentrations. Several ocean gateways were artificially widened to allow unrestricted throughflow and maximum water depths in parts of the Arctic Ocean were reduced. The ocean temperatures were initialised from the final state of Eocene model simulations using HadCM3L. The HadCM3L simulations were set up identically to the corresponding HadCM3 simulations, but with lower ocean resolution (3.75˚×2.5˚ as opposed to 1.25˚×1.25˚). The HadCM3L simulations were initialised from a similar idealised temperature and salinity state as described in Lunt et al. (2017), but with a function that scales with $cos^2(lat)$ rather than $cos(lat)$ and overall reduced initial temperatures to ensure numerical stability in tropical regions. Ocean temperatures below 600 m were set to constant values of 4, 8 and 10 ˚C (at $\times 1$, $\times 2$, and $\times 3$ CO_2 respectively) based on results from previous Ypresian simulations. The HadCM3 simulations were branched off from the respective HadCM3L

integrations after 4400 to 4900 years of spin up and run for a further 2900 years. Output data is averaged over years 2800-2899. The initial 50 years of all HadCM3 runs used the simplified vertical diffusion scheme from HadCM3L (Valdes et al., 2017) to reduce numerical problems caused by the changed horizontal ocean resolution. The remaining years of the runs use the standard HadCM3 diffusion scheme (Valdes et al., 2017).

Output file structure

The file structure follows the proposed DeeMIP convention, i.e.:

```
/{Model_Family}/{Model}/{Experiment}/{Verison}/{Model}-{Experiment}-{Variable}-{Version}.{Statistic}.nc
```

{*Model_Family*}:

- **HadCM3** (Valdes et al., 2017)

{*Model*}:

- **HadCM3B_M2.1aN** : default
- **HadCM3BL_M2.1aN** : lower horizontal ocean resolution (3.75˚×2.5˚ compared to 1.25˚×1.25˚)

{*Experiment*}:

Experiment names follow Lunt et al. (2017). Currently available for HadCM3 are:

- **piControl**
- **deepmip_sens_1xCO2**
- **deepmip_sens_2xCO2**
- **deepmip_stand_3xCO2**

{*Variable*}:

Output variable naming follows the proposed DeeMIP convention (see below).

{*Version*}:

- **v0.9** : [19/02/2020] Initial upload demonstrating the specified database structure and naming convention. Only the uppermost level is available for ocean variables. An updated version (v1.0) with enhanced model output will be uploaded in the future.

{*Statistic*}:

- **mean:** monthly mean climatology for last 100 model years
- **sd:** monthly mean standard deviation for last 100 model years
- **time_series:** monthly fields for last 100 model years

Example:

The mean climatologies of near-surface air temperatures for the four HadCM3B-M2.1aN experiments can be found at:

```
/HadCM3/HadCM3B_M2.1aN/piControl/v0.9/HadCM3B_M2.1aN-piControl-tas-v0.9.mean.nc
/HadCM3/HadCM3B_M2.1aN/deepmip_sens_1xCO2/v0.9/HadCM3B_M2.1aN-deepmip_sens_1xCO2-tas-v0.9.mean.nc
/HadCM3/HadCM3B_M2.1aN/deepmip_sens_2xCO2/v0.9/HadCM3B_M2.1aN-deepmip_sens_2xCO2-tas-v0.9.mean.nc
/HadCM3/HadCM3B_M2.1aN/deepmip_stand_3xCO2/v0.9/HadCM3B_M2.1aN-deepmip_stand_3xCO2-tas-v0.9.mean.nc
```

Available data:

Experiment	HadCM3B_M2.1aN (years)	HadCM3BL_M2.1aN (years)
piControl	v0.9 (2800-2899)	v0.9 (7400-7499)
deepmip_sens_1xCO2	v0.9 (2800-2899)	v0.9 (7400-7499)
deepmip_sens_2xCO2	v0.9 (2800-2899)	v0.9 (7400-7499)
deepmip_stand_3xCO2	v0.9 (2800-2899)	v0.9 (7400-7499)

Table 1: *Available experiments and associated model years for HadCM3 models*

Grid dimensions:

Dimension	HadCM3B_M2.1aN	HadCM3BL_M2.1aN
ocean grid (latitude x longitude)	144 x 288	73 x 96
vertical ocean levels	20	20
atmosphere grid (latitude x longitude)	73 x 96	73 x 96
atmospheric model levels	19	19
atmospheric pressure levels	17	17
temporal resolution	12 (statistic = mean, sd) 1200 (statistic = time_series)	12 (statistic = mean, sd) 1200 (statistic = time_series)

Table 2: Dimensions of output fields.

DeepMIP core output variables

Tables 3-5 specify the set of core DeepMIP output variables following Lunt et al. (2017). All groups should aim to produce these fields.

The section “Additional output variables” lists variables that are necessary to carry out the anlayses for planned DeepMIP papers (see https://www.deepmip.org/publications/). You need to upload these variables (or equivalents from your specific model) if you want your model to be included in the respective papers.

Atmosphere

Description	Name	Units	mean available	sd available	time_series available	Comments
Near-surface (1.5 m) air temperature	tas	K	[x]	[x]	[x]	
Surface skin temperature	ts	K	[x]	[x]	[ ]	
Precipitation	pr	$kgm^{-2}s^{-1}$	[x]	[x]	[x]	
Total evaporation	evspsbl	$kgm^{-2}s^{-1}$	[x]	[x]	[ ]	
Total cloud cover	clt	[0,1]	[x]	[x]	[ ]	
Surface downwelling longwave radiation	rlds	Wm^{-2}	[x]	[x]	[ ]	
Surface upwelling longwave radiation	rlus	Wm^{-2}	[x]	[x]	[ ]	
Surface downwelling shortwave radiation	rsds	Wm^{-2}	[x]	[x]	[ ]	
Surface upwelling shortwave radiation	rsus	Wm^{-2}	[x]	[x]	[ ]	
TOA incident shortwave radiation	rsdt	Wm^{-2}	[x]	[x]	[x]	
TOA outgoing shortwave radiation	rsut	Wm^{-2}	[x]	[x]	[x]	

TOA outgoing longwave radiation	rlut	Wm^{-2}	[x]	[x]	[x]	
Sensible heat flux (upward)	hfss	Wm^{-2}	[x]	[x]	[ ]	
Latent heat flux (upward)	hfls	Wm^{-2}	[x]	[x]	[ ]	
Near-surface eastward wind	uas	ms^{-1}	[x]	[x]	[ ]	
Near-surface northward wind	vas	ms^{-1}	[x]	[x]	[ ]	
Surface eastward wind stress	tauu	Nm^{-2}	[x]	[x]	[ ]	
Surface northward wind stress	tauv	Nm^{-2}	[x]	[x]	[ ]	
Mean sea-level pressure	psl	Pa	[x]	[x]	[ ]	
Surface pressure	ps	Pa	[x]	[x]	[ ]	
Eastward wind on model levels	ua	ms^{-1}	[ ]	[ ]	[ ]	
Northward wind on model levels	va	ms^{-1}	[ ]	[ ]	[ ]	
Vertical wind on model levels	wa	ms^{-1}	[ ]	[ ]	[ ]	
Eastward wind on pressure levels	uap	ms^{-1}	[x]	[x]	[ ]	
Northward wind on pressure levels	vap	ms^{-1}	[x]	[x]	[ ]	
Vertical wind on pressure levels	wap	Pas^{-1}	[x]	[x]	[ ]	
Geopotential height on pressure levels	zg	m	[x]	[x]	[ ]	

Temperature on pressure levels	ta	K	[x]	[x]	[ ]	
Specific humidity on pressure levels	hus	$kgkg^{-1}$	[x]	[x]	[ ]	

Table 3: *DeepMIP core atmospheric variables and availability for HadCM3 models*

Ocean

Description	Name	Units	mean available	sd available	time_series available	Comments
Sea-surface temperature	tos	$^{\circ}C$	[x]	[x]	[x]	
Sea-ice fraction	siconc	[0,1]	[x]	[x]	[x]	
Eastward velocity on model levels	uo	cms^{-1}	[x]	[x]	[ ]	
Northward velocity on model levels	vo	cms^{-1}	[x]	[x]	[ ]	
Vertical velocity on model levels	wo	cms^{-1}	[x]	[x]	[ ]	
Potential temperature on model levels	thetao	$^{\circ}$C	[x]	[x]	[ ]	
Salinity on model levels	so	psu	[x]	[x]	[ ]	
Mixed-layer depth	mlotst	m	[x]	[x]	[ ]	
Barotropic streamfunction	sftbarot	Sv	[x]	[x]	[ ]	
Global overturning streamfunction	sftmyz	Sv	[ ]	[ ]	[ ]	

Table 4: *DeepMIP core ocean variables and availability for HadCM3 models*

Boundary conditions

Description	Name	Units	Available for HadCM3	Comments
Land-sea mask	sftlf	[0,1]	[x]	on atmospheric grid
Topography	orog	m	[x]	
Bathymetry	deptho	m	[x]	

Table 5: *DeepMIP core boundary conditions and availability for HadCM3 models*

Additional output variables

The following tables list variables needed for the analyses for planned DeepMIP papers (see https://www.deepmip.org/publications/). You need to upload these variables (or equivalents from your specific model) if you want your model to be included in the respective papers.

Ocean circulation

Description	Name	Units	mean available	sd available	time_series available	Comments
Surface eastward wind stress (on ocean grid)	tauuo	Nm^{-2}	[ ]	[ ]	[ ]	
Surface northward wind stress (on ocean grid)	tauvo	Nm^{-2}	[ ]	[ ]	[ ]	
Net surface heat flux (on ocean grid)	hfno	Wm^{-2}	[ ]	[ ]	[ ]	
Net surface freshwater flux (on ocean grid)	wfno	kgm^2s^{-1}	[ ]	[ ]	[ ]	
Sea surface height	zos	m	[ ]	[ ]	[ ]	
Vertical ocean tracer diffusivity	difvto	m^2/s	[ ]	[ ]	[ ]	
Vertical ocean momentum diffusivity	difvmo	m^2/s	[ ]	[ ]	[ ]	
Vertical ocean background diffusivity (Kv)	difvbo	m^2/s	[ ]	[ ]	[ ]	time invariant

Table 6: *Additional ocean circulation variables and availability for HadCM3 models*

Clouds and energy balance

Description	Name	Units	mean available	sd available	time_series available	Comments
Surface downwelling longwave radiation (clear sky)	rldscs	Wm^{-2}	[ ]	[ ]	[ ]	
Surface downwelling shortwave radiation (clear sky)	rsdscs	Wm^{-2}	[ ]	[ ]	[ ]	
Surface upwelling shortwave radiation (clear sky)	rsuscs	Wm^{-2}	[ ]	[ ]	[ ]	
TOA outgoing shortwave radiation (clear sky)	rsutcs	Wm^{-2}	[ ]	[ ]	[ ]	
TOA outgoing longwave radiation (clear sky)	rlutcs	Wm^{-2}	[ ]	[ ]	[ ]	
Cloud cover on pressure levels (or low/medium/high amount)	cl	[0,1]	[ ]	[ ]	[ ]	
Surface snow cover	snc	[0,1]	[ ]	[ ]	[ ]	
Leaf area index	lai	1	[ ]	[ ]	[ ]	

Table 7: *Additional radiation variables and availability for HadCM3 models*

Comments

- v0.9 is an initial upload demonstrating the specified database structure and naming convention. Only the uppermost level is available for all ocean variables. An updated version (v1.0) with enhanced model output will be uploaded in the future.