Appendix: Specifications for archiving INTERDYNAMIC model output

Proxy data

- The focus is on climate indices and climate reconstructions, not the underlying raw data.
- The data provided must be sufficient to recalculate climate reconstructions based on indices.
  - For example:
    - in the ocean: $\delta^{18}O$, Uk'37 index and temperature reconstruction, but not just biomarker concentration
    - for tree rings: ring width, vessel area, runoff chronology
  - An age model and an age axis must be provided.
- Data will only be accepted if they satisfy the PANGAEA criteria.
  - It is recommended to provide an absolute climatologic value (for example, temperature in units of °C).
  - The geographic location must be included.

Model output

- All model output must be provided in netCDF.
- The convention for names and units must follow the IPCC standard, if applicable, otherwise it must comply with OCMIP or similar recommendations; in cases were no common standard is available, the particpating projects will make suggestions.
- NetCDF files must be compliant with simple viewers such as "Panoply" or "ncBrowse".
  - Latitude, longitude, depth must be provided on a regular grid (without grid rotation or shifted poles).
  - Land fields and land biogeochemistry fields will be archived on the same grid as the atmosphere.
  - Sea ice fields and ocean biogeochemistry fields will be archived on the same grid as ocean fields.

Required variables:

- Land:
  - Near-surface (2-m) air temperature
  - Sea-level pressure
  - Surface air pressure
  - Near-surface (10-m) wind
  - Precipitation
  - Evaporation
- Ocean:
  - Temperature (three-dimensional field with depths nearest to 7 standard levels: surface, 100 m, 500 m, 1000 m, 2000 m, 3000 m, 5000 m)
  - Sea-surface temperature
  - Sea-surface salinity
- Sea ice:
  - Concentration/fraction and thickness

- Marine biogeochemistry:
  - Oxygen, nitrate/ammonium/phosphate/silicate, primary productivity, $CaCO_3$/POC in sediment (including $\delta^{13}C$)
- Vegetation:
  - Growing degree-days on 0°C base
  - Tree/bare soil/natural grass/shrub/residual areal fractions, NPP

Required time averages:

- Long-term climatologic means for equilibrium runs:
  - Annual means
  - Monthly means
    - For the ocean: monthly means only for surface values
- Problem for Eemian, mid-Holocene: in some models, only present-day calendar monthly means are available (thismust be mentioned in the description of model output).
- For transient runs:
  - Provide 50-year means at 50-year intervals

Since daily mean fields are not required, but some models need measures of accumulating growing-season warmth as input, it is suggested to provide "growing degree days" on 0°C base as defined by Prentice et al. (1992): $GDD_0 = \int (T - T_0)\,dt$, where the integration is over the period with $T > T_0$, with T being the daily-mean near-surface (usually, 2 meter) air temperature and T_0 = 0°C being the minimum temperature for growth.

Table 1: Standard units and netCDF output variable names for climate models (based on recommendations for IPCC AR5 by Karl Taylor, www.mad.zmaw.de/uploads/media/Mail_Karl_Taylor.pdf and www.mad.zmaw.de/uploads/media/standard_output_05_03_09.xls)

Long name	Units	Comment	Output variable name
Atmospheric fields and some surface fields			
atmosphere grid-cell area	m²		`atmosphere_cell_area`
near-surface air temperature	K	near-surface (usually, 2 meter) air temperature.	`tas`
air pressure at sea level	Pa	not, in general, the same as surface pressure	`psl`
surface air pressure	Pa	not, in general, the same as mean sea-level pressure	`ps`

Long name	Units	Comment	Output variable name
near-surface eastward wind	$m\ s^{-1}$	near-surface (usually, 10 meters) eastward component of wind.	uas
near-surface northward wind	$m\ s^{-1}$	near-surface (usually, 10 meters) northward component of wind.	vas
precipitation flux	$kg\ m^{-2}\ s^{-1}$	at surface; includes both liquid and solid phases from all types of clouds (both large-scale and convective)	pr
water evaporation flux	$kg\ m^{-2}\ s^{-1}$	at surface; flux of water into the atmosphere due to conversion of both liquid and solid phases to vapor (from underlying surface and vegetation)	evspsbl
Ocean fields			
ocean grid-cell area	m^2		ocean_cell_area
sea water potential temperature	K		thetao
sea surface temperature	K	this may differ from "surface temperature" in regions of sea ice.	tos
sea surface salinity	psu		sos
Ocean cryosphere fields			
sea ice area fraction	%	fraction of grid cell covered by sea ice	sic
sea ice thickness	m	Compute the mean thickness of sea ice in the ocean portion of the grid cell (averaging over the entire ocean portion, including the ice-free	sit

Long name	Units	Comment	Output variable name
		fraction). Report as 0.0 in regions free of sea ice.	
Ocean biogeochemical fields			
oxygen	mol O_2 m^{-3}	dissolved oxygen gas concentration	o2
nitrate	mol N m-3	dissolved nitrate concentration	no3
ammonium	mol N m-3	dissolved ammonium concentration	nh4
phosphate	mol P m-3	dissolved phosphate concentration	po4
silicate	mol Si m-3	dissolved silicate concentration	si
primary production	mol C m^{-3} s^{-1}	total primary (organic carbon) production by phytoplankton	pp
calcite sediment fraction	% dry weight	calcite content in sediment	cal12_sedfrac
$\delta^{13}C$ of calcite in sediment	‰ PDB	$\delta^{13}C$ isotope ratio of calcite in sediment	cal13_sedfrac
POC sediment fraction	% dry weight	particulate organic carbon content in sediment	poc12_sedfrac
$\delta^{13}C$ of POC in sediment	‰ PDB	$\delta^{13}C$ isotope ratio of particulate organic carbon in sediment	poc13_sedfrac
Land vegetation fields			
growing degree days on 0°C base	°C	growing degree days with respect to a base temperature of 0°C	gdd0
tree cover fraction	%	fraction of entire grid cell that is covered by trees	tree_frac
bare soil fraction	%	fraction of entire grid cell that is	baresoil_frac

Long name	Units	Comment	Output variable name
		covered by bare soil.	
natural grass fraction	%	fraction of entire grid cell that is covered by natural grass.	`grass_frac`
shrub fraction	%	fraction of entire grid cell that is covered by shrub	`shrub_frac`
residual fraction	%	fraction of entire grid cell that is land and is covered by "non-vegetation" and "non-bare-soil" (e.g., urban, lakes, etc.)	`residual_frac`
net primary production	kg C m^{-2} s^{-1}		`npp`

Table 2: Additional units and netCDF output variable names for the social-technological GLUES model (subject to further validation):

Long name	Units	Comment	Output variable name
Social-technological fields			
	m^{-2}		`population_density`
			`subsistence_style`
			`technology_level`
			`economic_diversity`
	%	fraction of entire grid cell that is covered by crops	`crop_fraction`
	kg C m^{-2} s^{-1}		`carbon_emission`
	kg CH_4 m^{-2} s^{-1}		`methane_emission`

Links to useful software tools:

- http://www2-pcmdi.llnl.gov/cmor: CMOR - the Climate Model Output Rewriter can be used to produce CF-compliant netCDF files that fulfill the requirements of the IPCC scenario runs
- http://www.giss.nasa.gov/tools/panoply: Panoply - a Java application which runs on various platforms and plots geo-gridded arrays from netCDF datasets
- http://www.unidata.ucar.edu/software/idv: IDV - Integrated Data Viewer, a Java-based software framework for analyzing and visualizing geoscience data
- http://www.epic.noaa.gov/java/ncBrowse: ncBrowse - a graphical netCDF file browser, also a Java application that runs on various platforms