Annex II: Paleoclimate

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AII.1 Introduction to the Paleo Data Annex

This Annex is a compilation of key references that report paleoclimate and long-term forcing datasets used by Working Group I in the Sixth Assessment Report. It provides a traceable account of the studies and data that form the basis of the confidence-likelihood statements associated with the assessments of paleoclimate, or that were used by WG 1 authors to calculate new values in this report. The table lists variables that measure changes in the atmosphere, hydrosphere, ocean, cryosphere and biosphere. The entries are grouped by paleo 'reference periods,' which are used in multiple chapters of AR6 and are summarized in Cross-Chapter Box 2.1. These periods have received considerable research attention as examples of distinct states of the climate system. They are used as targets for climate modelling experiments (Kageyama et al., 2018). Generally, observational evidence for these reference periods is based on geochemical and paleontological analysis of sediments and materials from other natural archives. They pre-date instrumental-based observations.

The list is divided into two parts: (1) Deep past (Cenozoic Era) and (2) post glacial (past 8000 years). Within each part, the list is organized into major Earth-system components (e.g., atmosphere, ocean/hydrosphere, etc.). Within each sphere, the list progresses from oldest to youngest reference period.

Deep past (Cenozoic Era)
PETM — Palaeocene-Eocene thermal maximum (55.9-55.7 Ma)
EECO — Early Eocene climate optimum (53-49 Ma)
MPWP — mid-Pliocene warm period (3.3-3.0 Ma) as known as mid-Piacenzian warm period
LIG — last interglacial (129-116 ka or 127 ka peak)
LGM — last glacial maximum (21-19 ka)
LDT — last deglacial transition (18-11 ka)

Post-glacial (past 8000 years)
MH — mid-Holocene (5.5-6.5 ka)
MWP — Medieval Warm Period (950-1250) also known as Medieval Climate Anomaly
LIA — Little Ice Age (1450-1850)
PI — approximation for pre-industrial (1850-1900; Cross-Chapter Box 1.2)
P — present (1995-2014; Cross-Chapter Box 1.2)

[SOD note: This version is incomplete and preliminary. It currently reflects datasets featured in Chapter 2 only. Input is requested from reviewers and other chapter authors. Some bibliographic citations and data citations are missing in this version.]

Period	Spatial scale	Climate variable	Bibliographic reference and data citation	Notes	Section or Figure #
Deep past (Cenozoic Era) - Atmosphere					
PETM	global	CO2 concentration	(Gutjahr et al., 2017)		Fig. 2.3; Table 2.2
PETM	global	temperature, annual	(Hollis et al., 2019; Inglis et al., submitted; Zhu et al., 2019)		
EECO	global	CO2 concentration	(Anagnostou et al., 2016, submitted; Witkowski et al., 2018)		Fig. 2.3; Table 2.2
EECO	global	temperature, annual	(Inglis et al., submitted; Caballero and Huber, 2013; Hollis et al., 2019)		
MPWP	global	CO2 concentration	(Martínez-Botí et al., 2015; Haywood et al., 2016)		Fig. 2.3; Table 2.2
MPWP	global	temperature, annual	(Martínez-Botí et al., 2015; Foley and Dowsett, 2019; McClymont et al., 2020)	Fischer et al., 2018 scaler: SST x 1.6 = GMST	
LIG	global	CO2 concentration	(Bereiter et al., 2015) Petit et al., 1999; Schneider et al., 2013; Otto-Bliesner et al., 2017; Chalk et al., 2017; Hoenisch et al. 2009; Raitzch et al., 2018		Fig. 2.4; Table 2.2
LIG	global	CH4 concentration	(Loulergue et al., 2008)	116-128.5 ka	Fig. 2.4
LIG	global	N2O concentration	(Flückiger et al., 2004; Schilt et al., 2010, 2014)	116-128.5 ka	Fig. 2.4
LIG	global	temperature, annual	(Turney et al., in reveiw; Snyder, 2016; Fischer et al., 2018; Friedrich and Timmermann, 2020)	Fischer et al., 2018 scaler: SST x 1.6 = GMST	
LGM	global	CO2 concentration	(Bereiter et al., 2015) Marcott et al., 2014; Ahn et al., 2008; Lourantou et al., 2010; Monin et al., 2001, 2004; Kageyama et al., 2007; Chalk et al., 2017; Hoenisch et al., 2009 Raitzch et al., 2018		Fig. 2.4, Table 2.2
LGM	global	CH4 concentration	(Mitchell et al., 2011; Rhodes et al., 2013; Marcott et al., 2014; WAIS Divide Project Members, 2015)		Fig. 2.4
LGM	global	N2O concentration	(Flückiger et al., 2004; Schilt et al., 2010, 2014)		Fig. 2.4
LGM	global	temperature, annual	(Harrison et al., 2015; Snyder, 2016; Friedrich and Timmermann, 2020; Tierney et al., submitted)	Scaled SST to GMST based on various assumptions	
LGM	land	temperature, annual	(Harrison et al., 2015)		
LDT	global	CO2 concentration	(Marcott et al., 2014)		Fig. 2.4
LDT	global	CH4 concentration	(Rhodes et al., 2015)		Fig. 2.4
Deep past (Cenozoic Era) – Ocean and hydrosphere					
EECO	global	GMSL	(Fischer et al., 2018)	assumes total ice loss and 7 ± 1 m for steric	
MPWP	subtropics and mid latitude	E-P	(Burls and Fedorov, 2017)		
MPWP	global - land	monsoon	(Pound et al., 2014; Yang et al., 2018)	N Africa, Asia, N Australia, Central America, and E SAm	
MPWP	global	GMSL	(Dutton et al., 2015; Dumitru et al., 2019)		
MPWP	sea surface	pH	(Sosdian et al., 2018)		Fig. 2.35
LIG	global	GMSL	(Dutton et al., 2015)		

LGM	global - land	monsoon	(Jiang et al., 2015; Fornace et al., 2016; Chevalier et al., 2017; Novello et al., 2017)	uncertainty in S SAm and S Africa	
LGM	mid latitude land	P, humidity, soil moisture	(Scheff et al., 2017)		
LGM	global	GMSL	(Lambeck et al., 2014; Nakada et al., 2015; Yokoyama et al., 2018)		
LDT	global	GMSL	(Peltier, 2004; Lambeck et al., 2014; Liu et al., 2015; Yokoyama et al., 2018)		
Deep past (Cenozoic Era) – Biosphere					
EECO	NH	northern treeline	[Need citation]		
MPWP	NH	northern treeline	(Salzmann et al., 2008, 2013)		
LIG	NH	northern treeline	(CAPE Last Interglacial Project Members, 2006)		
LGM	NH	northern treeline	(Williams et al., 2011; Binney et al., 2017)		
LDT	Europe	forest turnover	(Seddon et al., 2015)		
LDT	E NAm	forest turnover	(Williams et al., 2004; Shuman, 2012)		
Post-glacial period - Forcing					
MH	global	total solar irradiance	(Jungclaus et al., 2017; Wu et al., 2018)	6.1-5.9 ka	Fig. 2.2
MH, MWP, LIA	Europe	open (non-forest) land cover	(Marquer et al., 2017)		
MWP, LIA, PI	global	total solar irradiance	(Jungclaus et al., 2017; Matthes et al., 2017; Wu et al., 2018)		Fig. 2.2
MWP, LIA, PI	global	stratospheric aerosol optical depth	(Toohey and Sigl, 2017; Luo, 2018)		Fig. 2.2
Post-glacial period - Atmosphere					
Holoce ne	Antarctica and NH	temperature	(Lovejoy et al., 2013)	time-scale at which 20C temperature exceed the amplitude of long-term fluctuations	
MH	N Africa / N Atlantic	dust emissions	(McGee et al., 2013; Williams et al., 2016; Hayes et al., 2017; Middleton et al., 2018)	based on ensemble of marine sediment records	
MH	global	dust emissions	(Albani et al., 2015)	based on one model tuned to global dataset	
MH	global	CH4 concentration	(Mitchell et al., 2011; Rhodes et al., 2013; Marcott et al., 2014; WAIS Divide Project Members, 2015)		
MH	global	temperature, annual	(Marcott et al., 2013; Kaufman et al., submitted, a; Kaufman et al., submitted, b)(Marcott et al., 2013; Kaufman, D., McKay, N., Routson, C., Erb, M., Dätwyler, C., Sommer, P., Heiri, O., Davis, submitted)(Marcott et al., 2013; Kaufman, D., McKay, N., Routson, C., Erb, M., Dätwyler, C., Sommer, P., Heiri, O., Davis, submitted)(Kaufman, D., McKay, N., Routson, C., Erb, M., Dätwyler, C., Sommer, P., Heiri, O., Davis; Marcott et al., 2013)(Kaufman, D., McKay, N., Routson, C., Erb, M., Dätwyler, C., Sommer, P., Heiri, O., Davis; Marcott et al., 2013) (data at: www.ncdc.noaa.gov/paleo/study/27330)		
MH	sea surface	temperature, annual	(Harrison et al., 2015)	area-weighted	

	and land				
MH, MWP, LIA, PI	global	CO2 concentration	(Bereiter et al., 2015) Ahn et al., 2012, 2019; Bauska et al., 2014, Rubino et al., 2019, Siegenthaler et al., 2005		Fig. 2.4; Table 2.2
MWP, LIA	global	CH4 concentration	(Mitchell et al., 2013)		Fig. 2.4
MWP, LIA	global	temperature, annual	(PAGES 2k Consortium et al., 2017; Neukom et al., 2019; PAGES 2k Consortium, 2019) (data at: www.ncdc.noaa.gov/paleo/study/21171		Fig. 2.11
LIA, PI	land	temperature profiles inverted	(Cuesta-Valero et al., submitted)		
PI	global	CO2 concentration	(Meinshausen et al., 2017)		Fig. 2.4; Table 2.2
PI	global	CH4, N2O concentration	(Meinshausen et al., 2017)		Fig. 2.4
Post-glacial period – Ocean and hydrosphere					
MH	mid latitude land	E-P	(Shuman and Marsicek, 2016; Routson et al., 2019)		
MH	global	GMSL	(Lambeck et al., 2014)	does not include thermal expansion	
MH, MWP, LIA	Pac 0-700 m	heat content	(Rosenthal et al., 2013)		
MWP, LIA	Caribbean	Atlantic hurricanes	(Burn and Palmer, 2015)		
MWP, LIA, PI	global	GMSL	(Kopp et al., 2016; Kemp et al., 2018)		Fig. 2.33
MWP, PI to 2015	Pac 0-700 m	temperature	(Rosenthal et al., 2013)		
P	global	GMSL	(WCRP Global Sea Level Budget Group, 2018; Dangendorf et al., submitted)		Fig. 2.32
Post-glacial period - Biosphere					
MH, MWP, LIA	NH	northern treeline	(MacDonald et al., 2008; Binney et al., 2017)		
Holocene/MH	Europe	forest turnover	(Seddon et al., 2015)		
Holocene/MH	E NAm	forest turnover	(Williams et al., 2004; Shuman, 2012)		
PI	Europe	forest turnover	(Seddon et al., 2015)		
PI	E NAm	forest turnover	(Williams et al., 2004; Shuman, 2012)		
PI	Eurasia	northern treeline	(Binney et al., 2009)		
Post-glacial period - Cryosphere					
MH	global mountains	glacier	(Solomina et al., 2015)		
Post-glacial period – Modes of variability					
MWP, LIA	N Atlantic	North Atlantic Oscillation	(Ortega et al., 2015)		

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