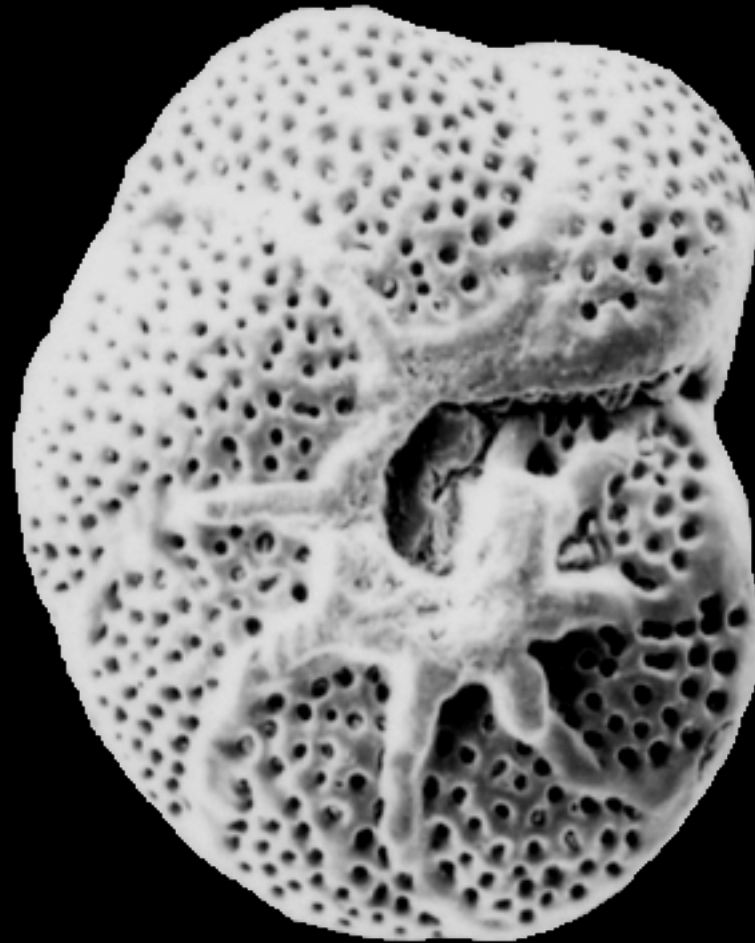


E. Brook

0.5cm



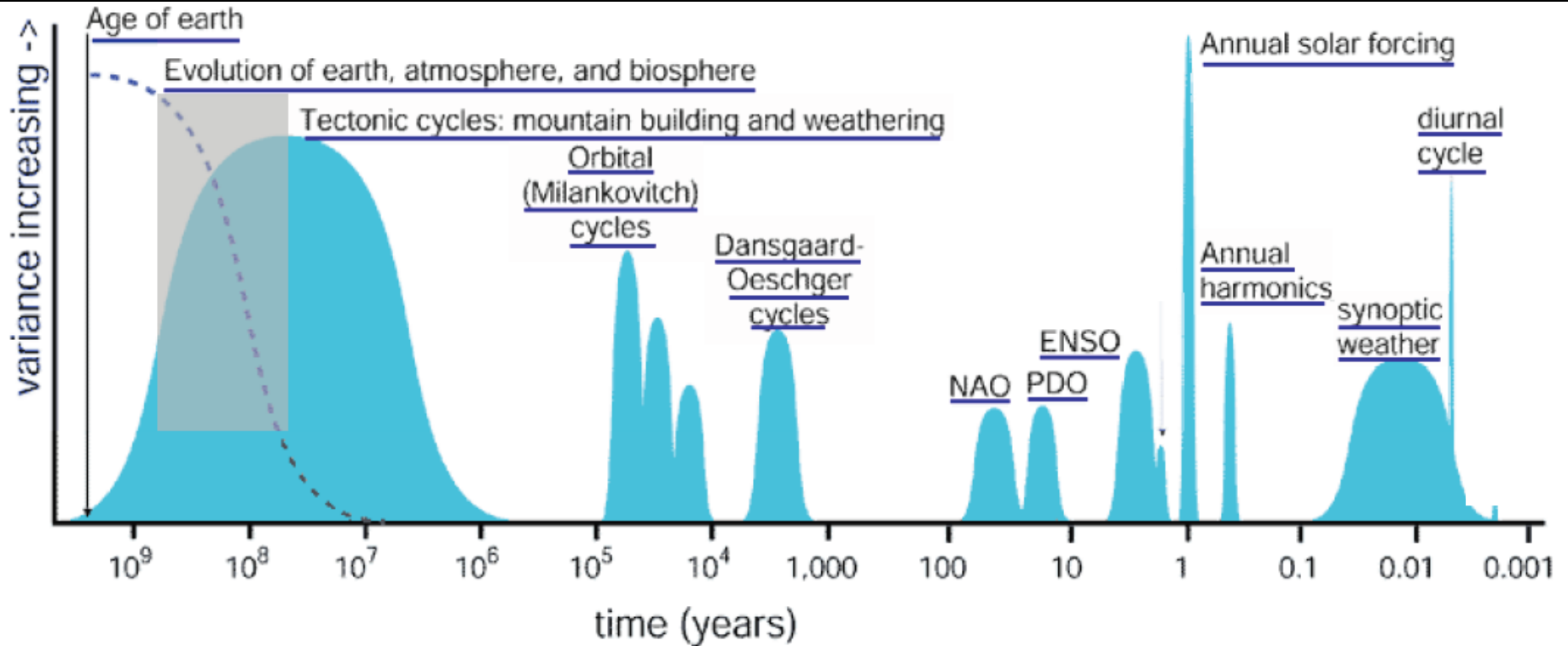


# Climate change over the last 65 million years

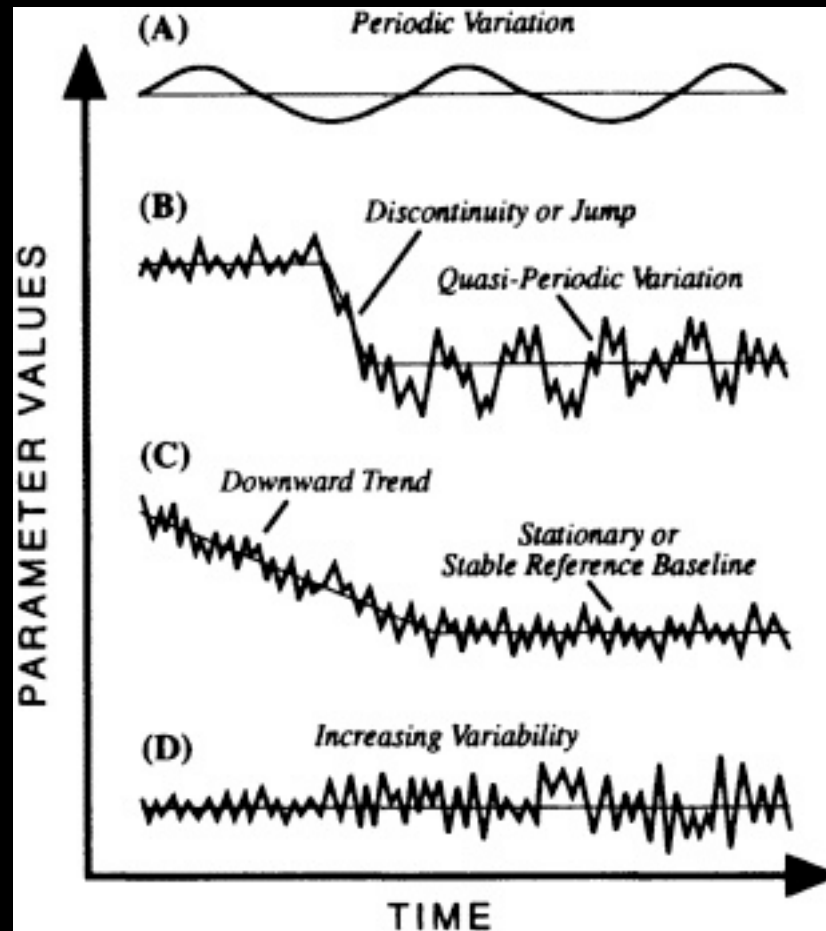




# Timescales of climate variability



# Types of climate variations



(From Marcus and Brazel, 1984; NAP, 1995)



# Climate archives: what information do we need?

Atmosphere



Cryosphere



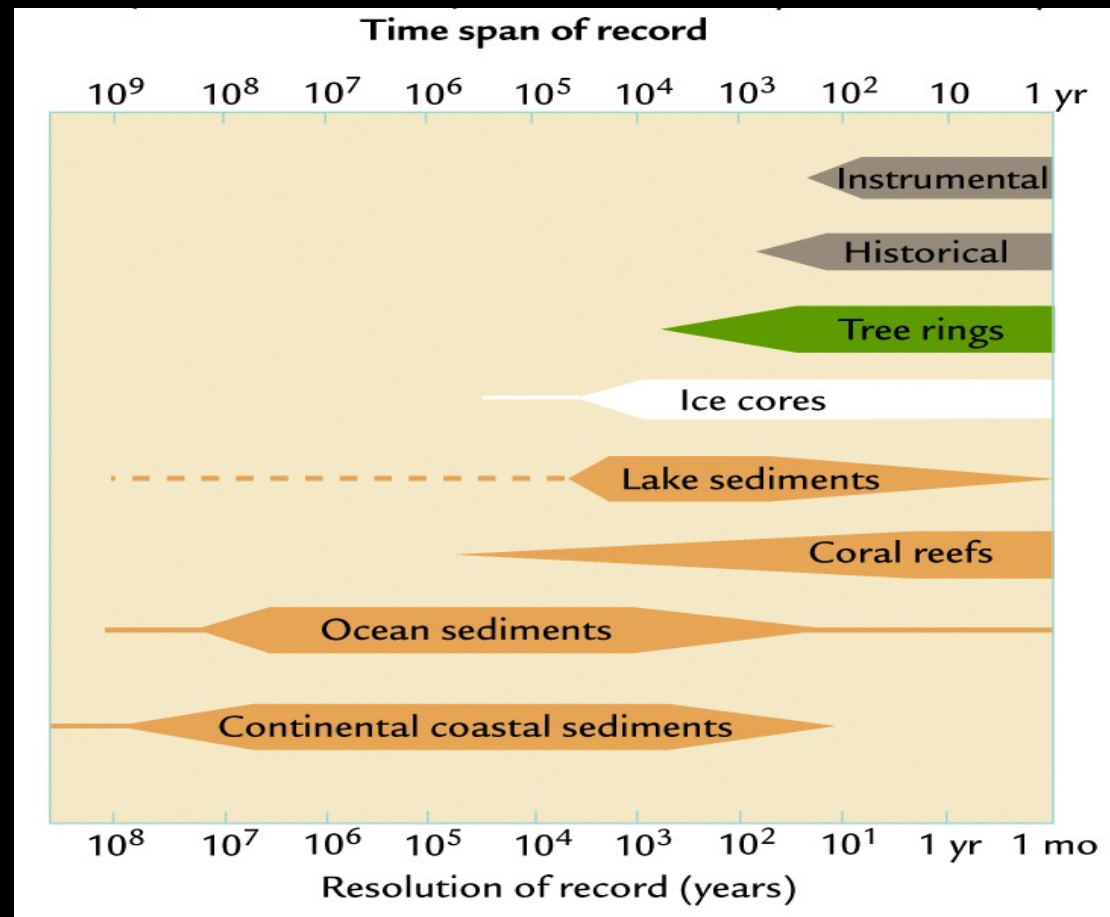
Hydrosphere/  
Aquatic Biosphere



Land/  
Terrestrial Biosphere



# Climate archives: what information do we have?



Ruddiman, W. F., 2008. Earth's Climate: past and future



# Climate data

NOAA Satellite and Information Service  
National Environmental Satellite, Data, and Information Service (NESDIS)

National Climatic Data Center  
U.S. Department of Commerce

DOC > NOAA > NESDIS > NCDC Search Field:  Search NCDC

**Data**

- [What's New](#)
- [Data Search](#)
- [Contribute Data](#)

**Paleo Perspectives**

- [Abrupt Change](#)
- [Drought](#)
- [Global Warming](#)
- [Colorado River Flow](#)

**Outreach**

- [About Paleo](#)
- [Site Map](#)

## NOAA Paleoclimatology

Model, Ice Core, Pale Fire, Borehole, Climate Reconstructions, Plant Macrofossils, Tree-ring, Paleocean, Coral, Climate Forcing, Lake, Pollen, Insect, Cave, Fauna, Historical, Loess

NOAA Paleoclimatology is a branch of NOAA's National Climatic Data Center. Paleo data come from natural sources such as tree rings, ice cores, corals, and ocean and lake sediments-- and extend the archive of weather and climate back hundreds to millions of years. NOAA Paleo provides data and information scientists need to understand natural climate variability and future climate change. We also operate the World Data Center for Paleoclimatology which distributes data contributed by scientists around the world.

<http://www.ncdc.noaa.gov/paleo/paleo.html>

# Trees that get really old....

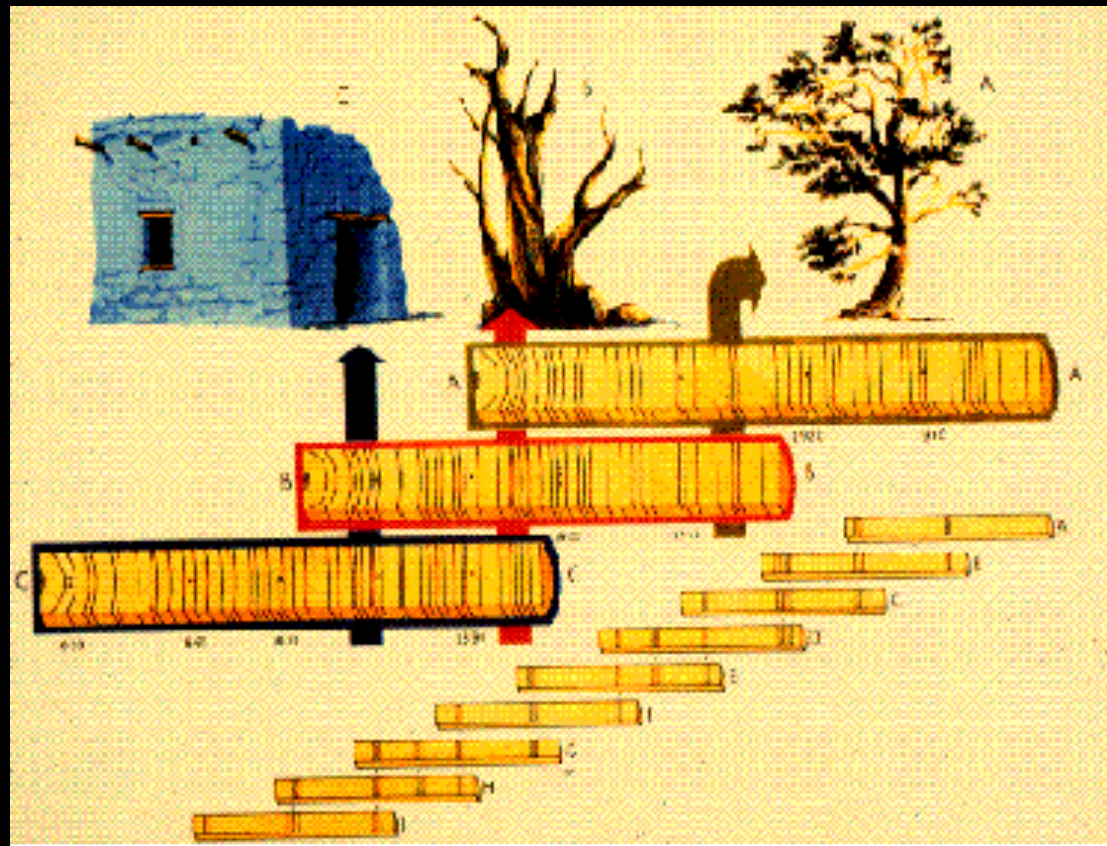
- Intermountain bristlecone pine **4,844 yrs**
- Alerce **3,620**
- Giant sequoia **3,300**
- Rocky Mountain bristlecone pine **2,425**
- Coast redwood **2,200**
- Foxtail pine **2,110**
- Rocky Mountain juniper **1,889**
- Limber pine **1,670**
- Alaska yellow-cedar **1,636**
- Baldcypress **1,622**
- Western juniper **1,288**
- Douglas-fir **1,275**
- Himalayan Hemlock **1,011**



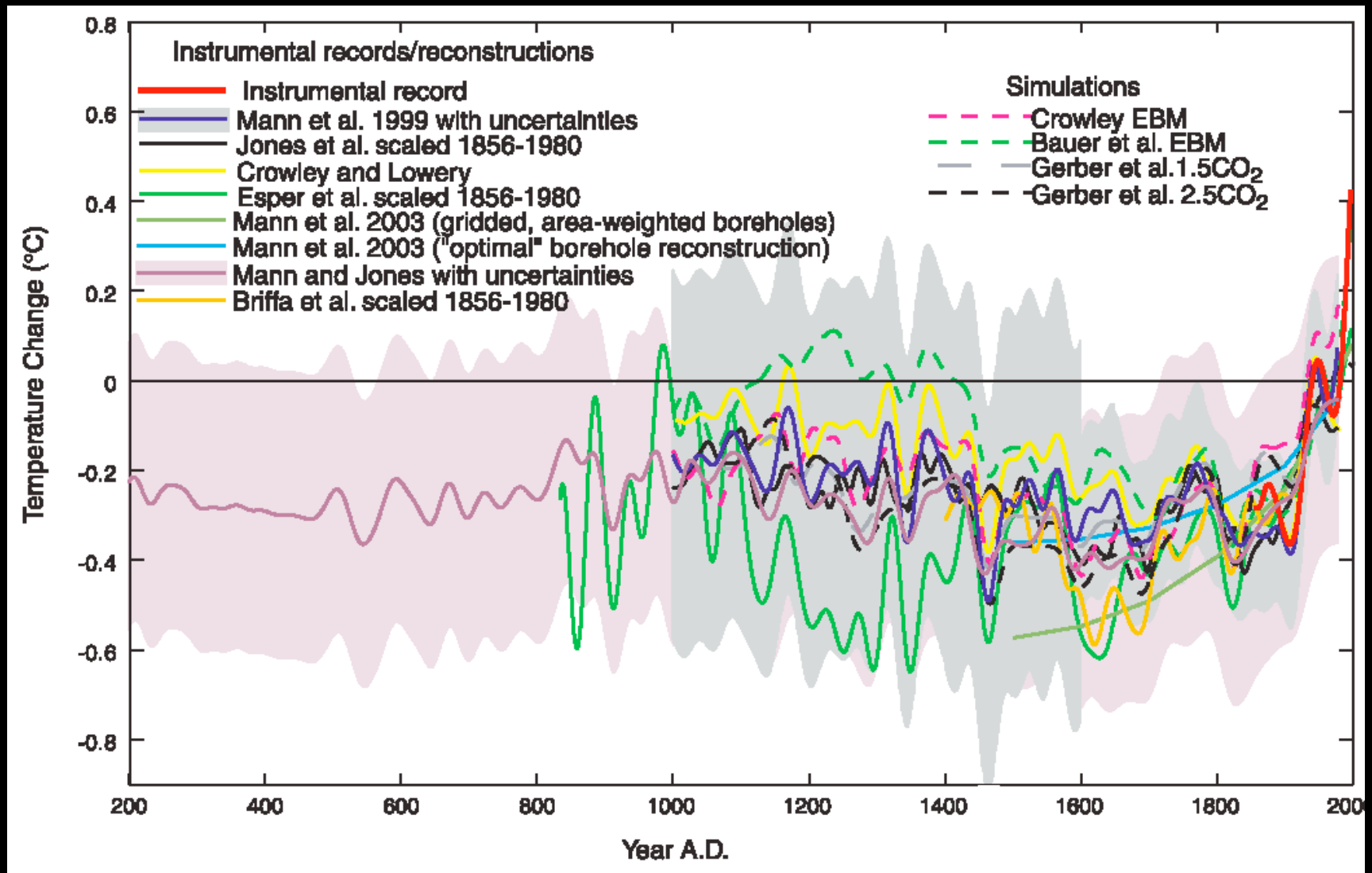


# How do we go older?

## Correlation and Crossdating



# Recent reconstructions....



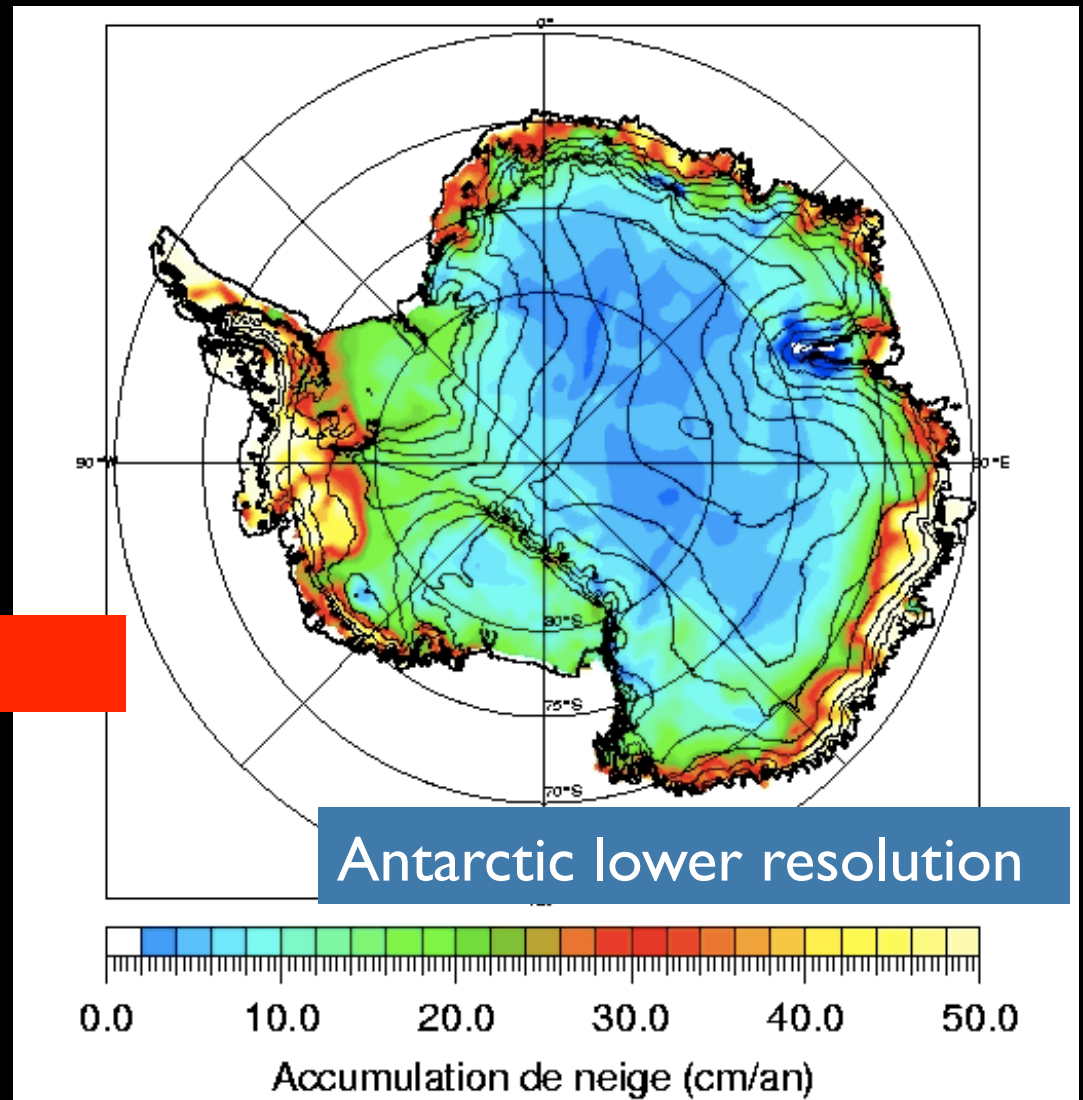
Mann et al, 2003, *Eos* (for discussion, see [www.RealClimate.org](http://www.RealClimate.org))

# Glacial climate in ice cores

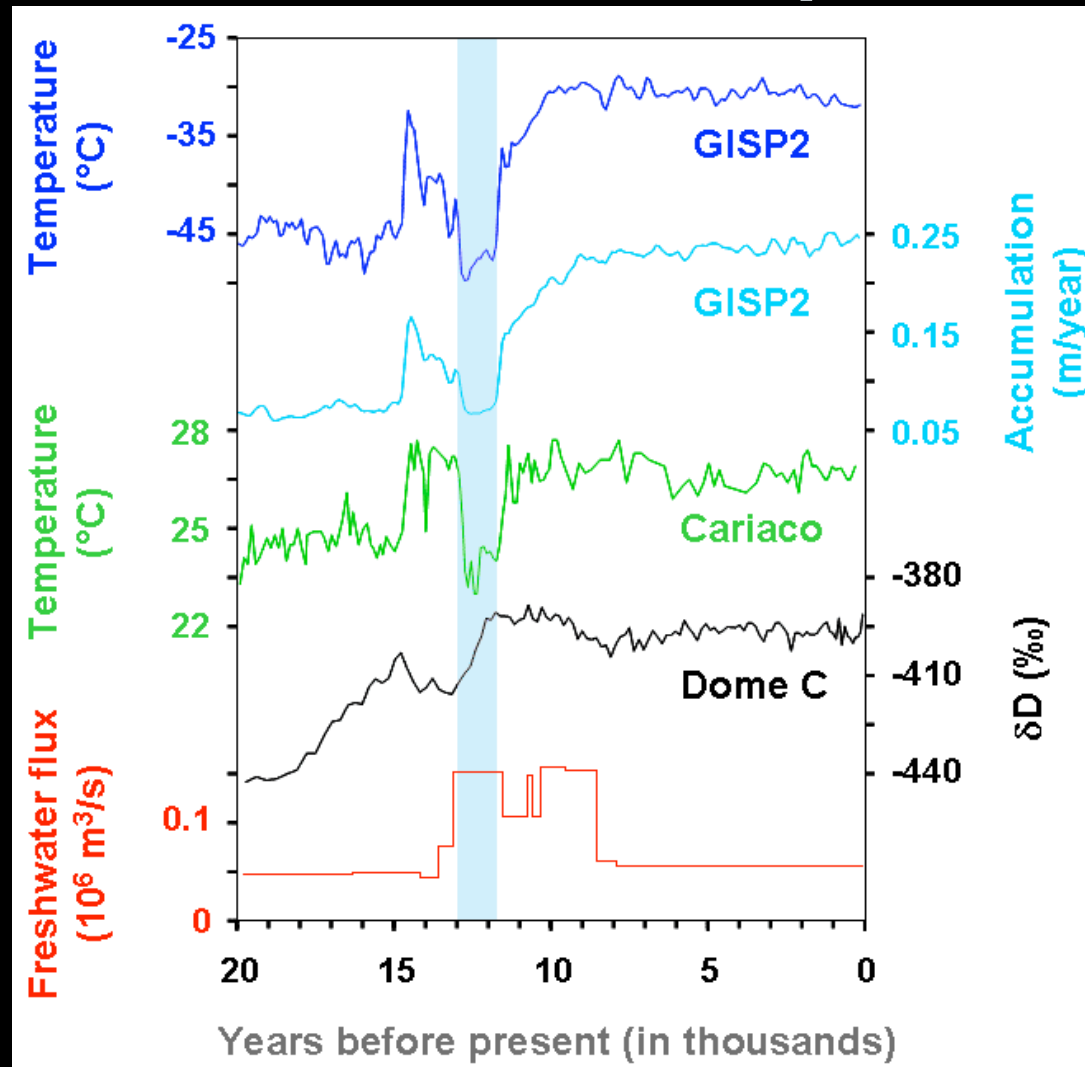




# Snow Accumulation Rates

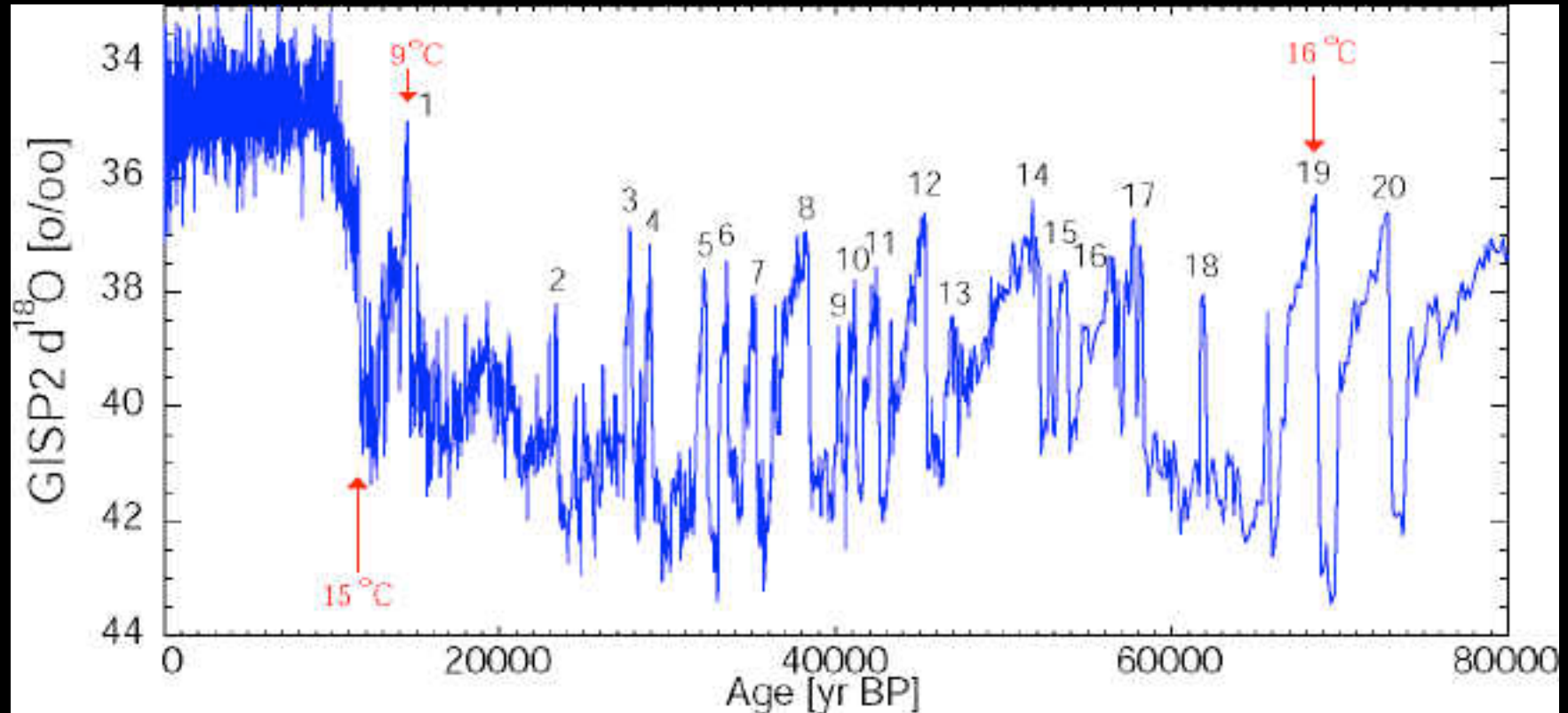


# The last 20,000 years



Alley (2000), Lea et al. (2003), EPICA (2004), Licciardi et al. (1999).

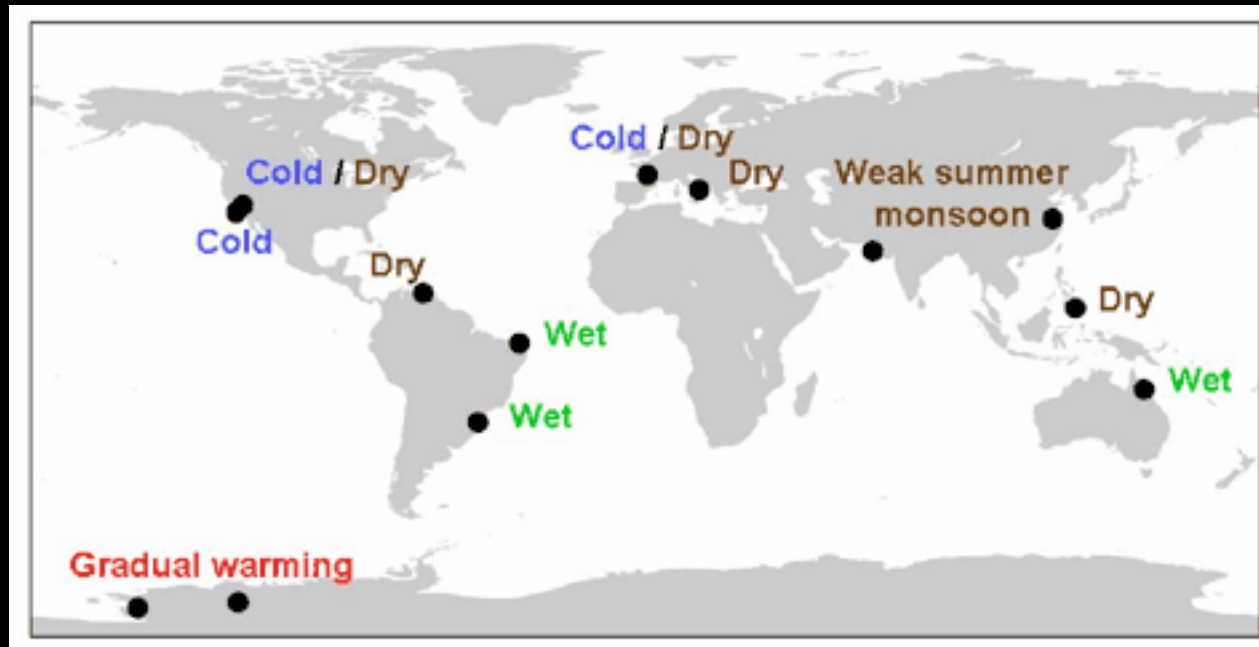
# The last 80,000 years



Grootes and Stuiver, 1997

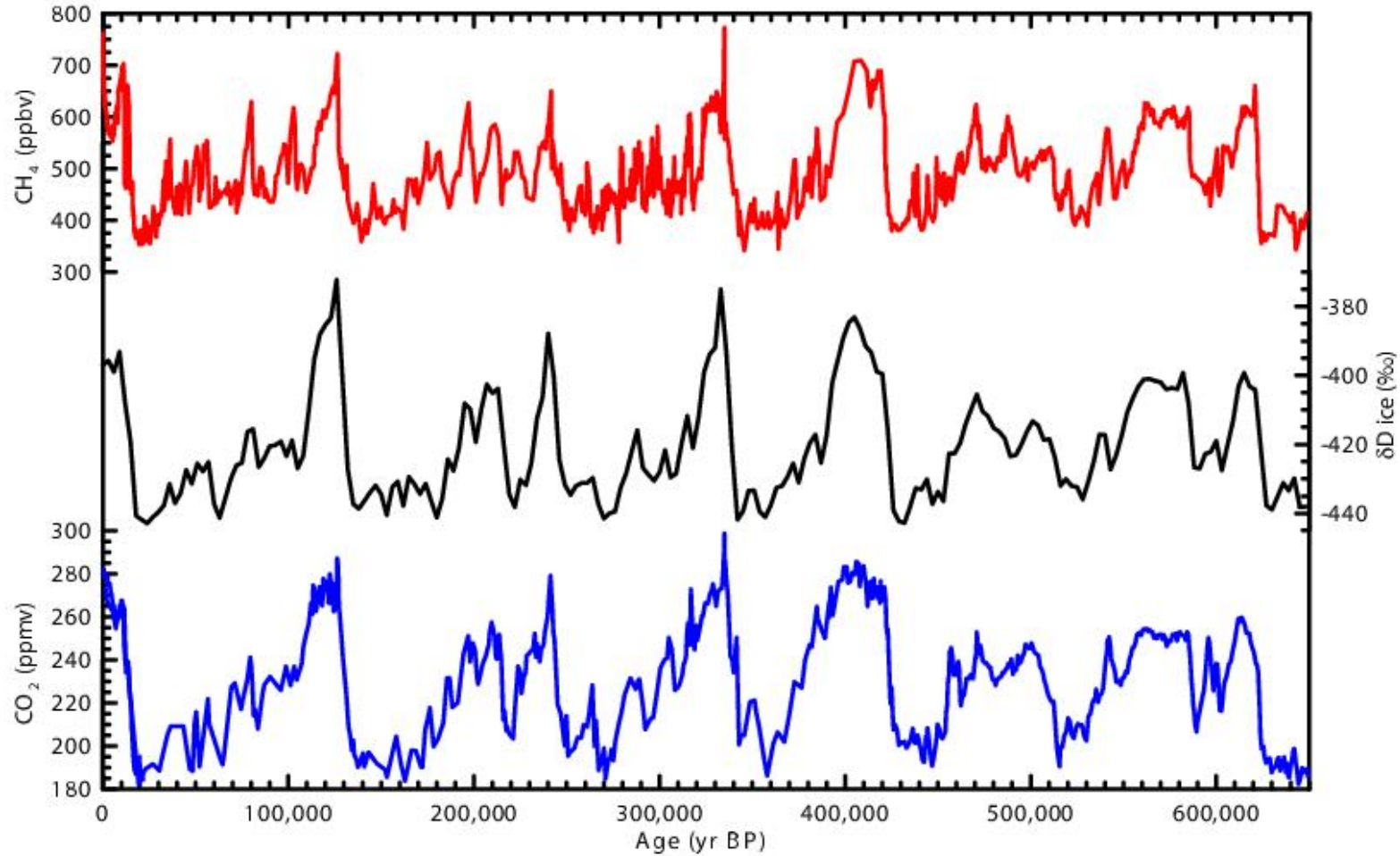


# Low resolution spatial records....



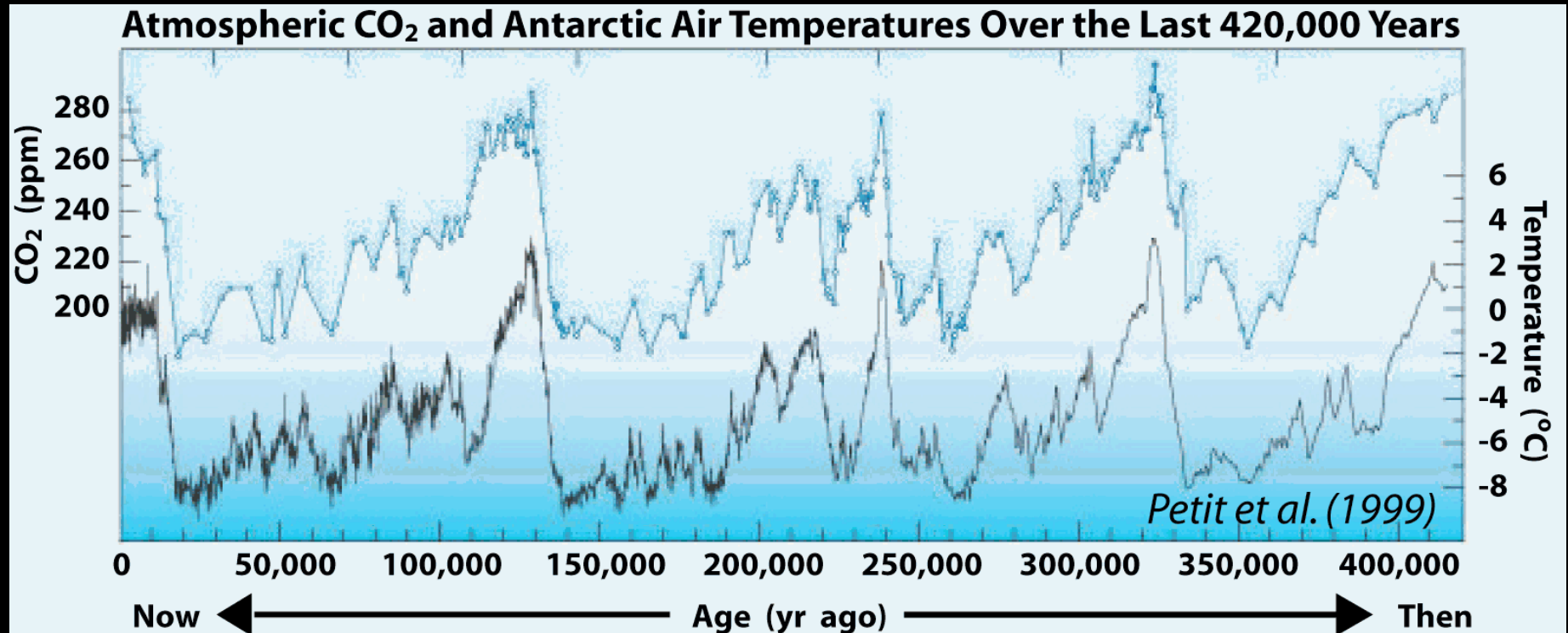
Overpeck, J.T. and Cole, J.E. 2006. Abrupt change in Earth's climate system. *Annual Review of Environment and Resources* 31: 1-31.

# Atmospheric gases...



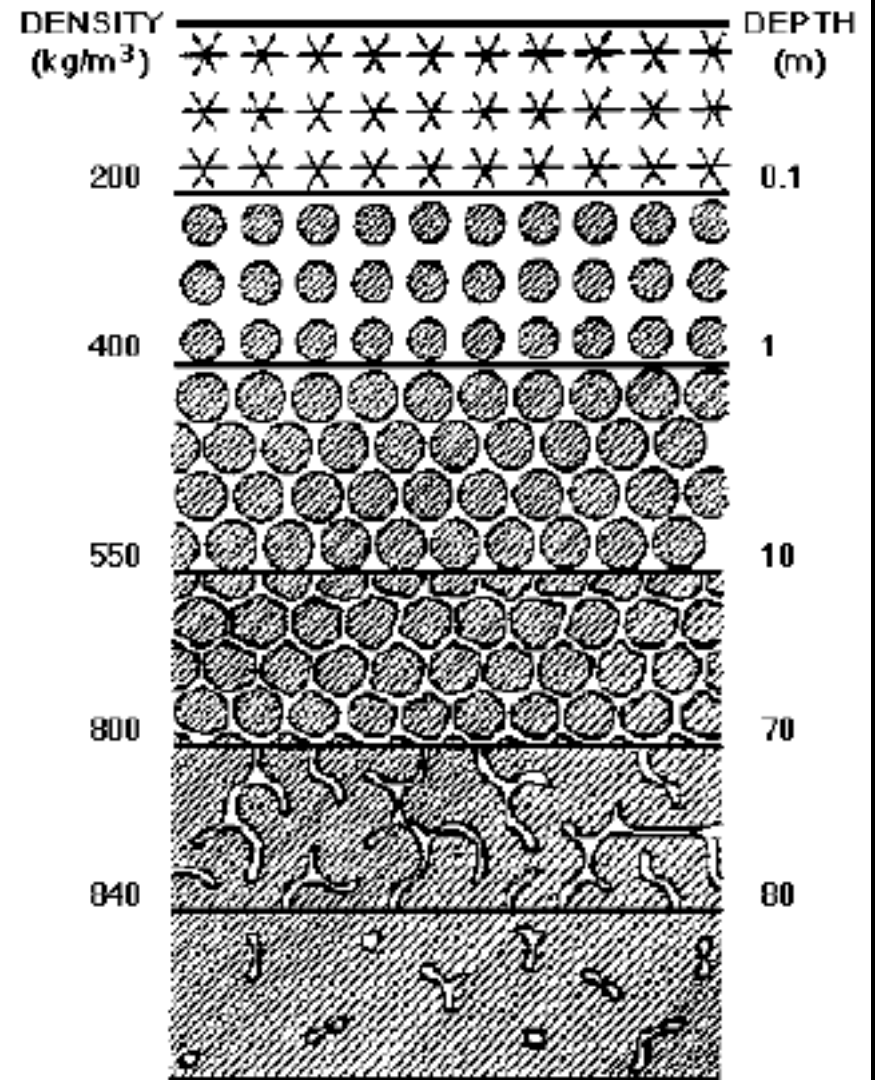
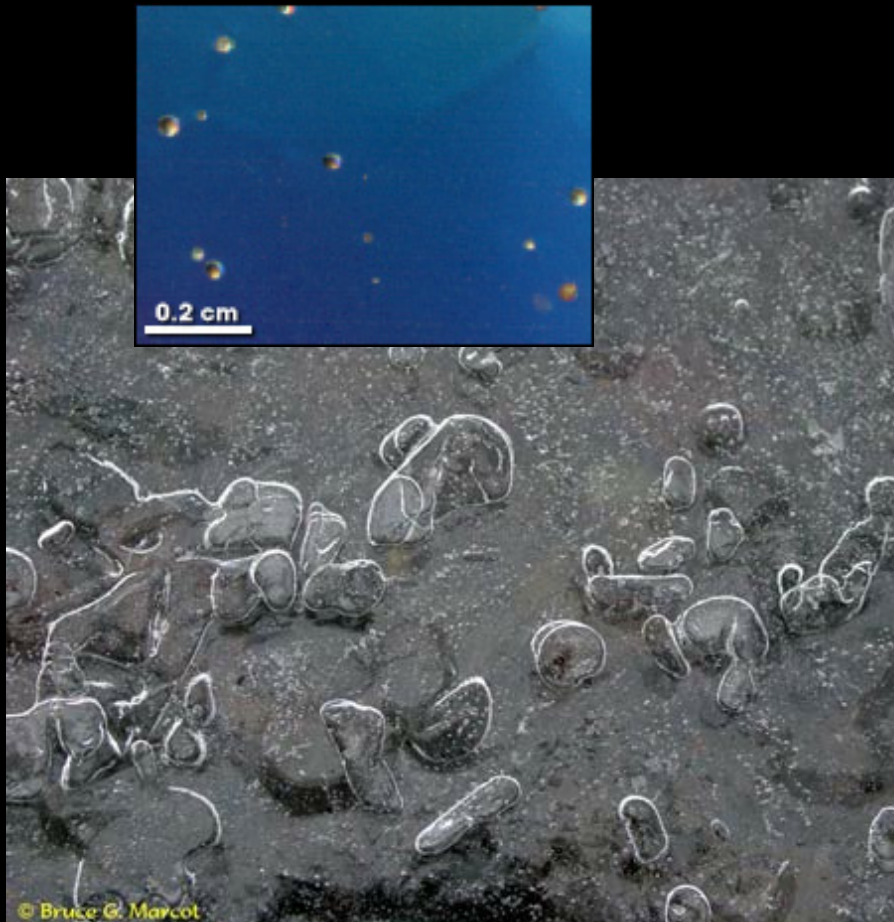
Epica group data

# Air temperature and CO<sub>2</sub>



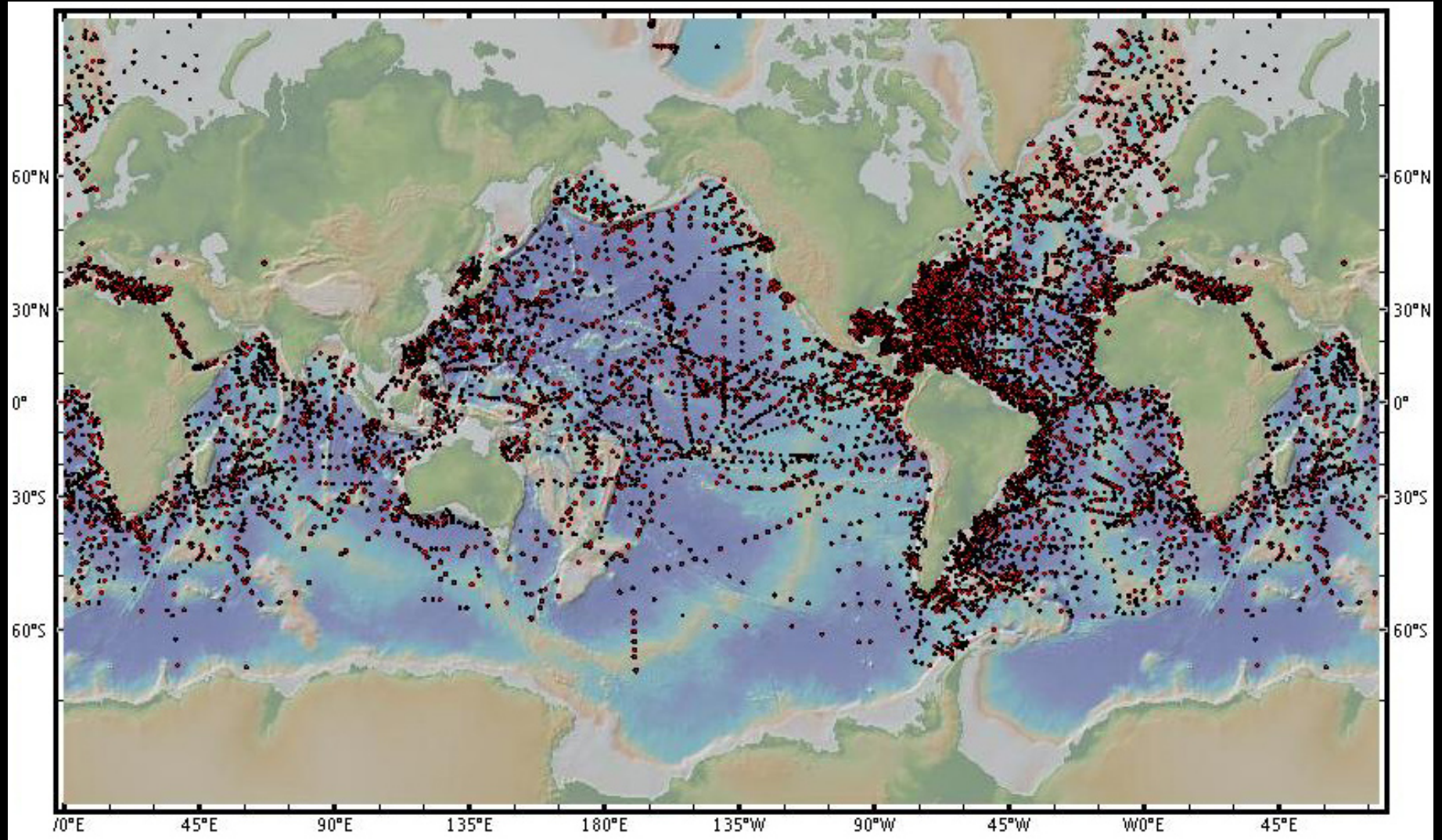


# Air trapped as bubbles...

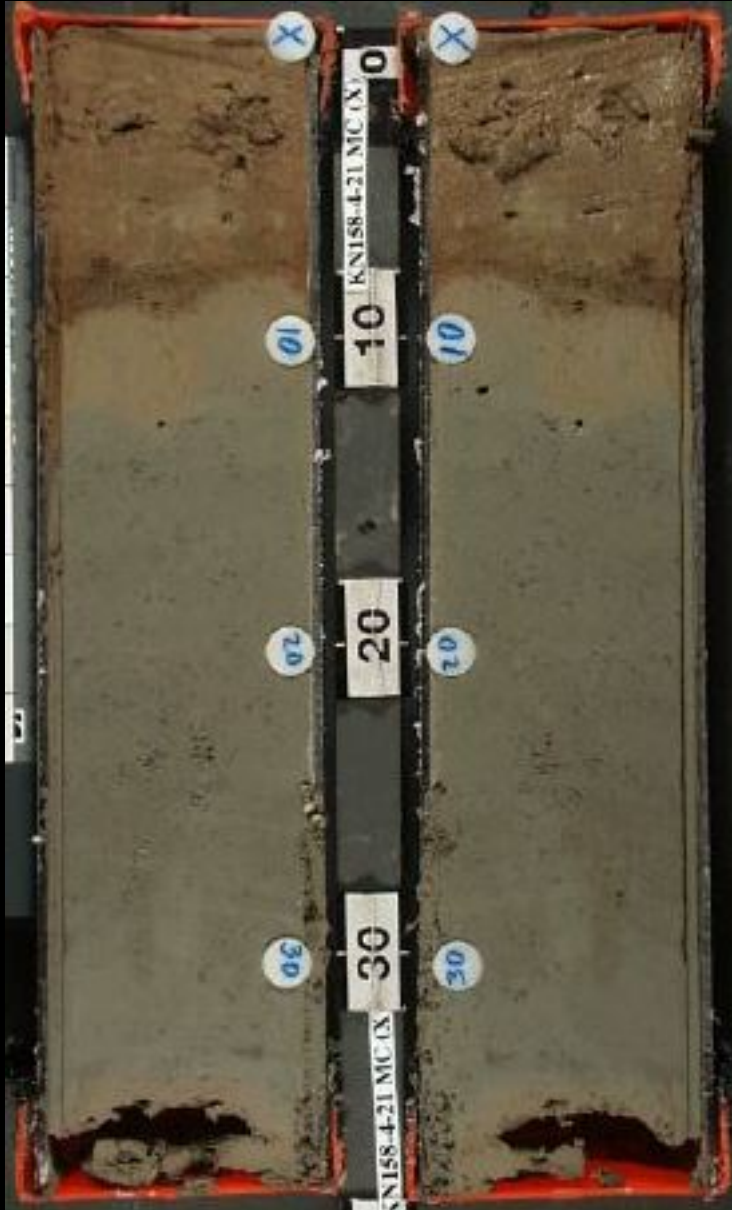




# Ocean sediment-core locations



# Deep sea cores



younger



older

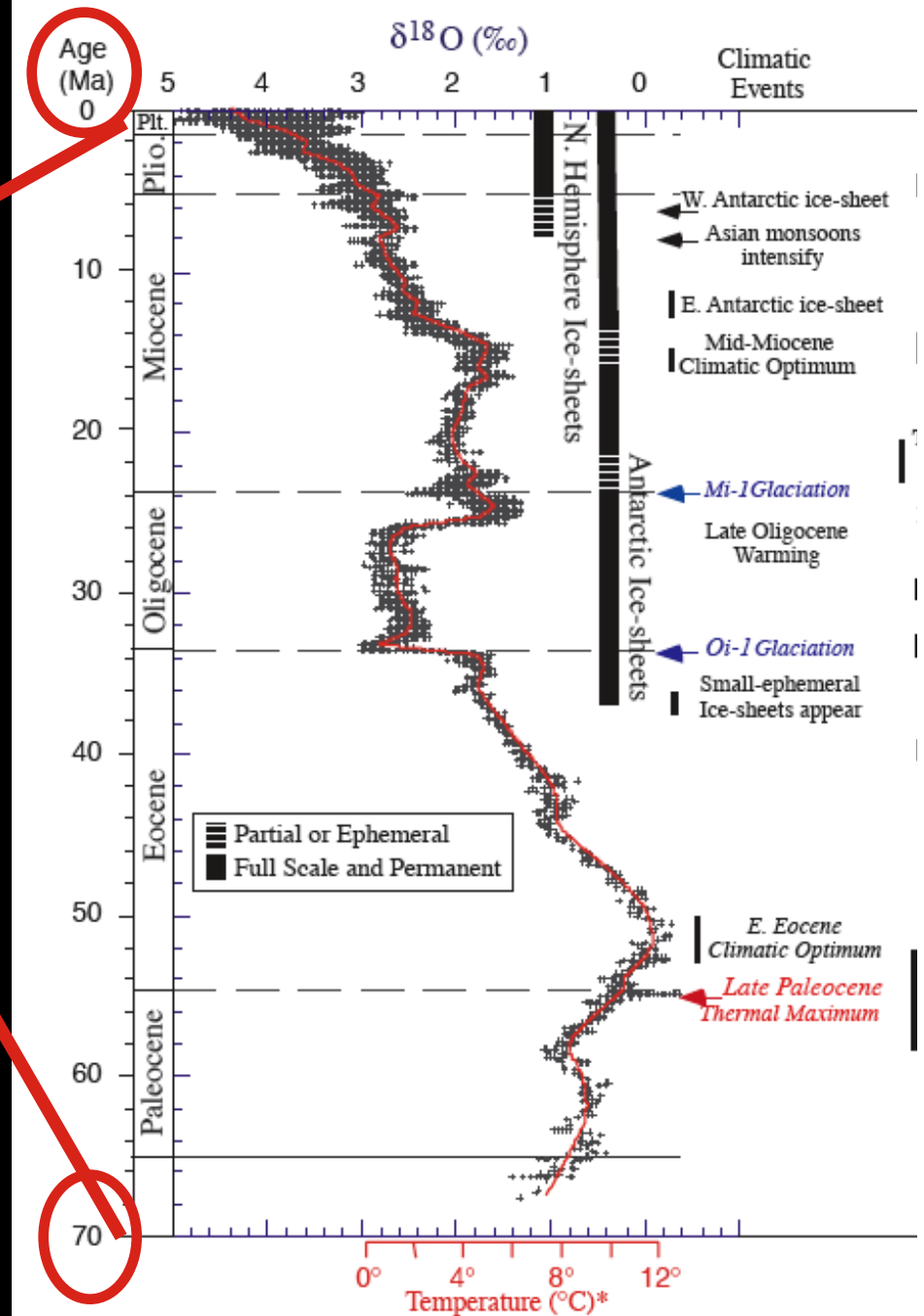


# Climate data

A 65 million year environmental record from deep sea sediments

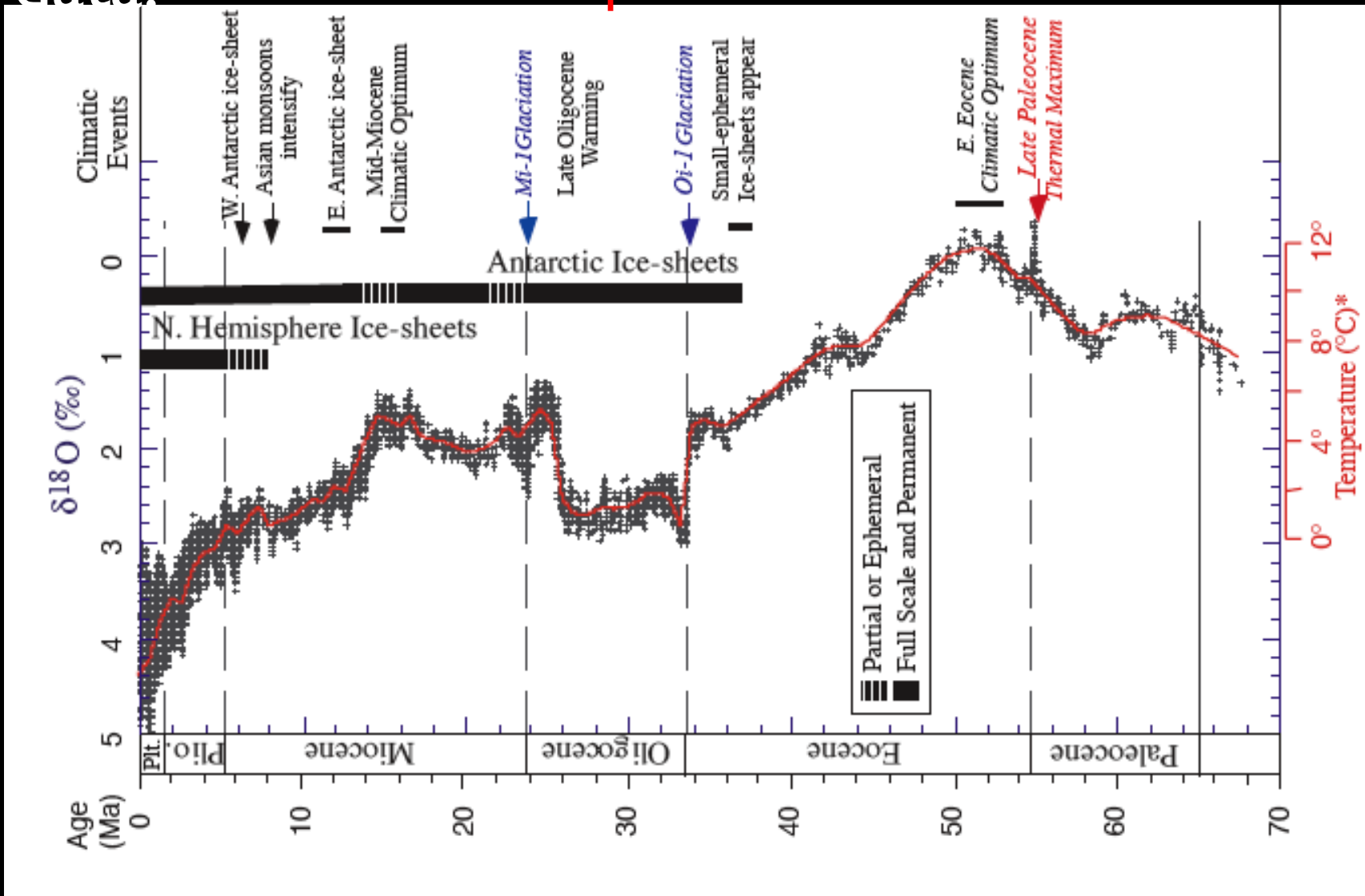
PHANEROZOIC	CENOZOIC	QUATERNARY		0	HOLOCENE	
		TERTIARY	NEOGENE		1.65	PLEISTOCENE
			PALEOGENE		23.8	PLIOCENE MIOCENE
	MESOZOIC	CRETACEOUS		65	OLIGOCENE	
		JURASSIC		144.8	EOCENE	
		TRIASSIC		200	PALEOCENE	
		PERMIAN		251		
		CARBONIFEROUS		300		
		DEVONIAN		355		
		SILURIAN		418		
ORDOVICIAN		441				
PALEOZOIC	CAMBRIAN		490			
	EDIIACARAN		544			
			570			
PRECAMBRIAN			4000+			

Millions of years ago (ma)



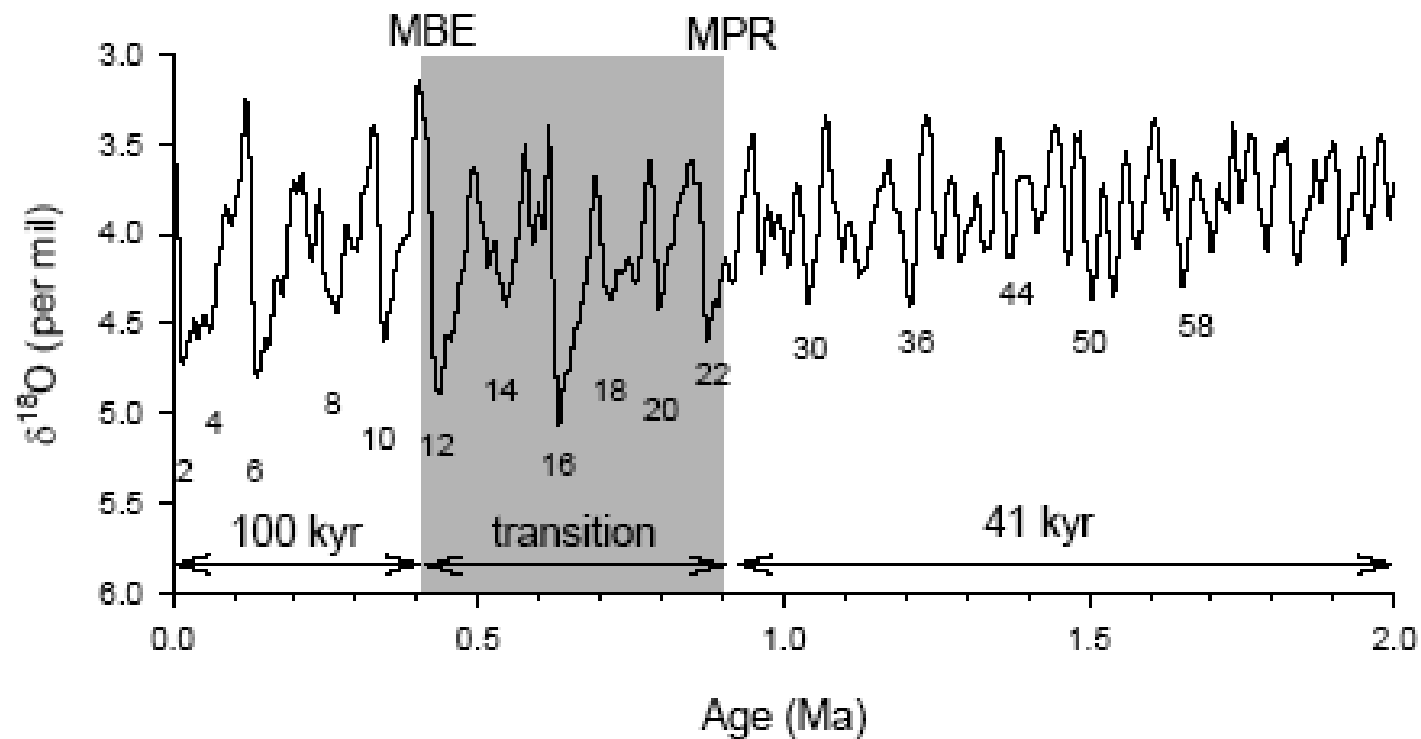
# Climate data:

A 65 million year environmental record from deep sea sediments



Zachos, 2001

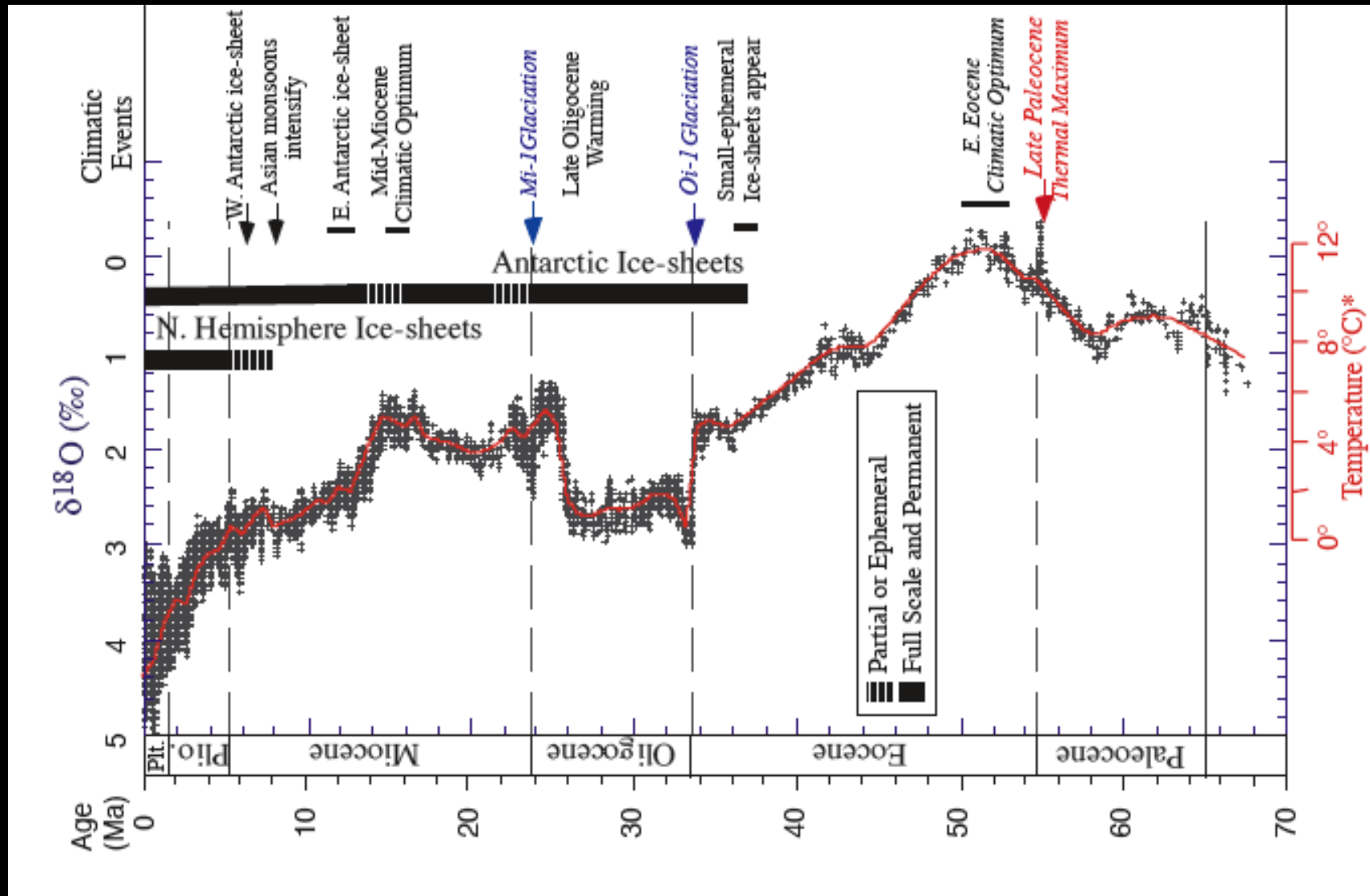
# Glacial-interglacial cycles





# Climate data:

A 65 million year environmental record from deep sea sediments



# Understanding the Dynamics of “Equable” climates

Latitude

Temperature (°C)

