Climate change: The past is the key to the present

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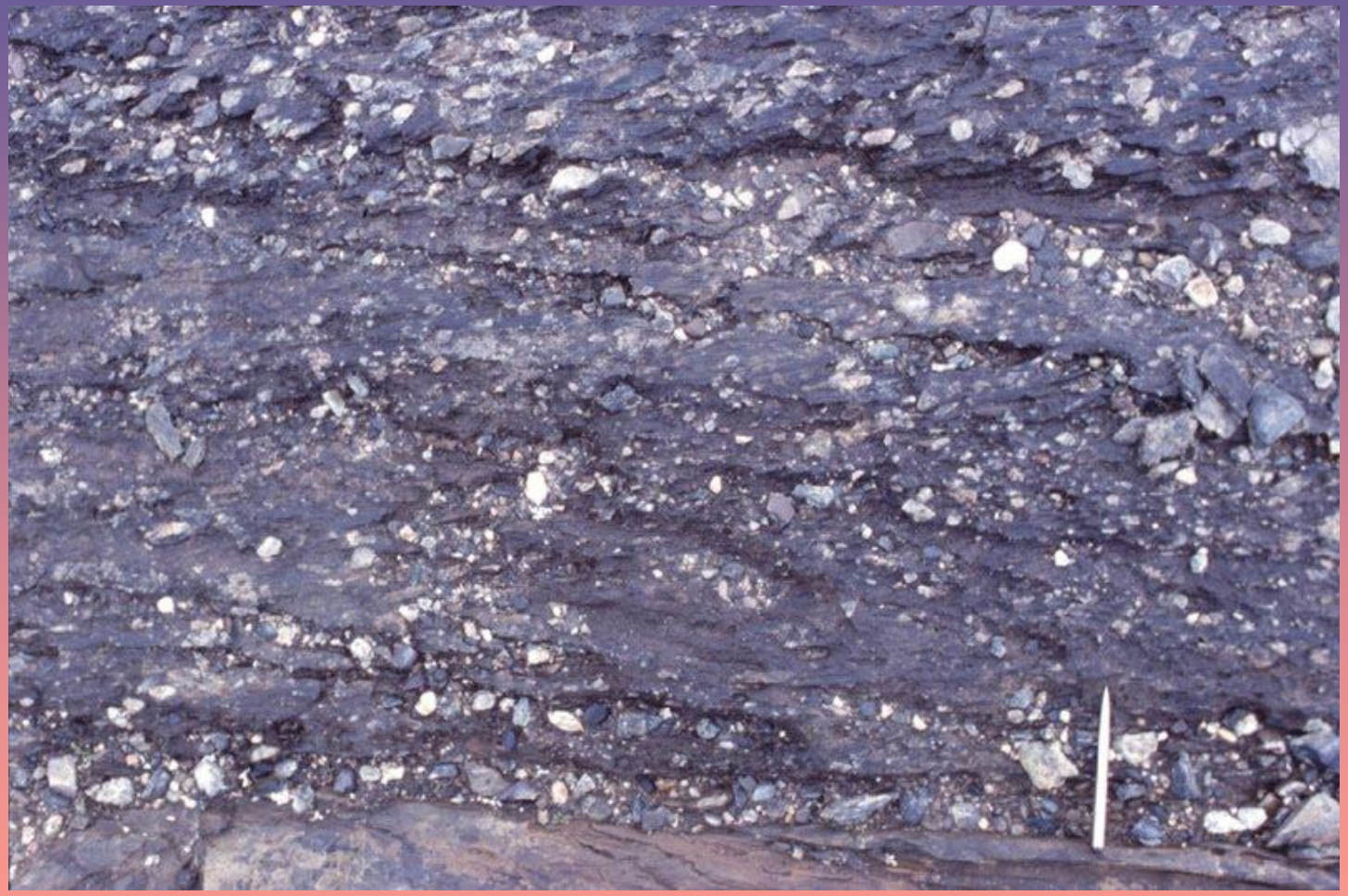
Human emissions of carbon dioxide (CO_2) global warming

- It has never been shown that the human emissions of CO_2 drive global warming
- Before possible human influences on climate can be evaluated, complex natural climate change and carbon cycles must be understood
- A focus on human CO_2 emissions ignores the main drivers of climate (Earth's orbit, Sun, extraterrestrial radiation, volcanoes etc) and ignores ocean and planet degassing
- We ignore the past at our peril

- **Big events (first running water; 3600 Ma; cooled planet, evolving oxygen-poor atmosphere; first life)**



- **Big events (microbialites; reefs; 3430 Ma; oxygen)**

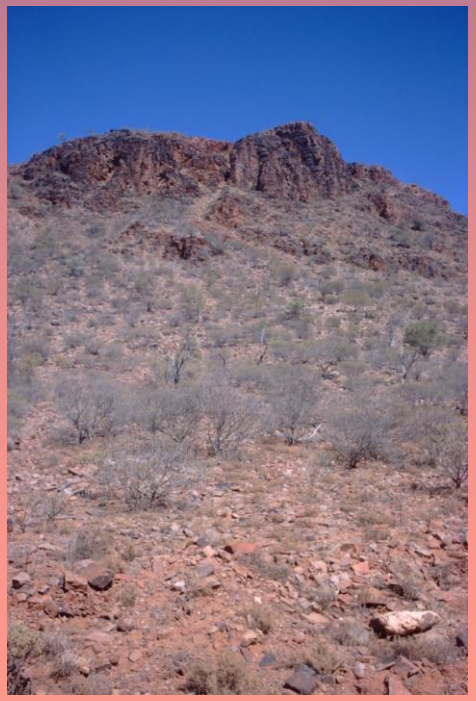
- **Big events (first ice age [Pongolian; 2,900 Ma; mid latitude])**

- **Big events (stromatolite reefs; 2724 Ma; photosynthesis; continents)**

- **Big events (second ice age with 4 glaciations; [Huronian]; 2450-2220 Ma; equatorial; oxygenation event; extinction; supercontinent breakup and stitching back together; bacteria; Cu mineral deposits when high atmospheric O_2 and Pb-Zn mineral deposits when low atmospheric O_2)**

- Big events (third ice age; 4 glaciations; [Sturtian; 720-660 Ma; equatorial; cap carbonate; dolomite and CO_2)

- **Big events (complex life; Arkaroola Reef; 650 Ma; equatorial; high CO_2)**



- **Big events (third ice age; 2 glaciations; [Marinoan]; 650-635 Ma; equatorial; cap carbonate)**

- **Big events (Ediacaran fauna; 635-542 Ma; extinction; high CO_2, no following glaciation, multicellular life established)**

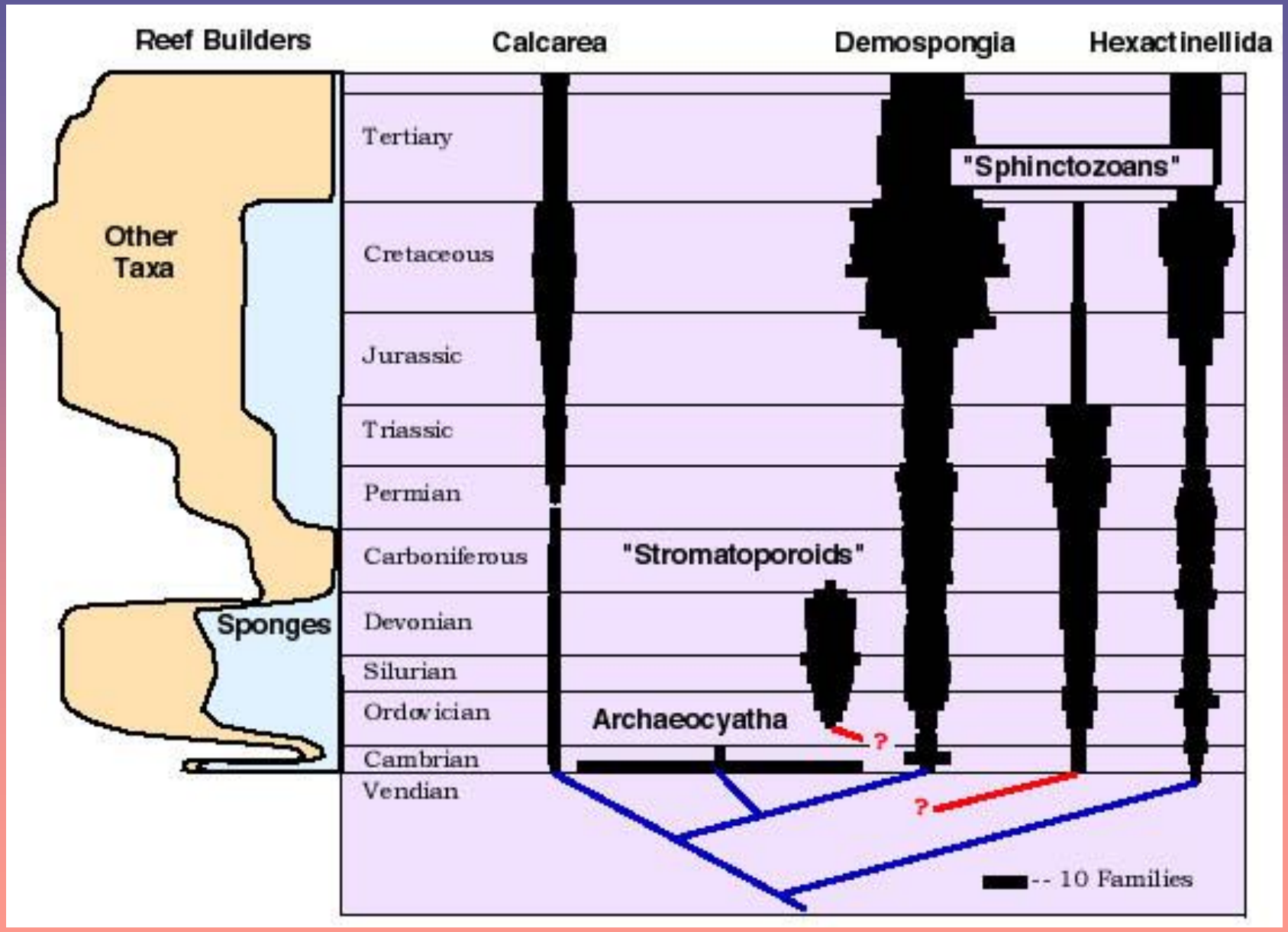
Spiral galactic arm encounters

Pongolian	?
Huronian (? Snowball Earth)	Sagittarius-Carina Arm
Neoproterozoic (Snowball Earth)	Sagittarius-Carina Arm
Ordovician-Silurian	Perseus Arm
Carboniferous-Permian	Norma Arm
Jurassic-Cretaceous	Scutum-Crux Arm
Miocene	Sagittarius-Carina Arm
Quaternary	Orion Arm

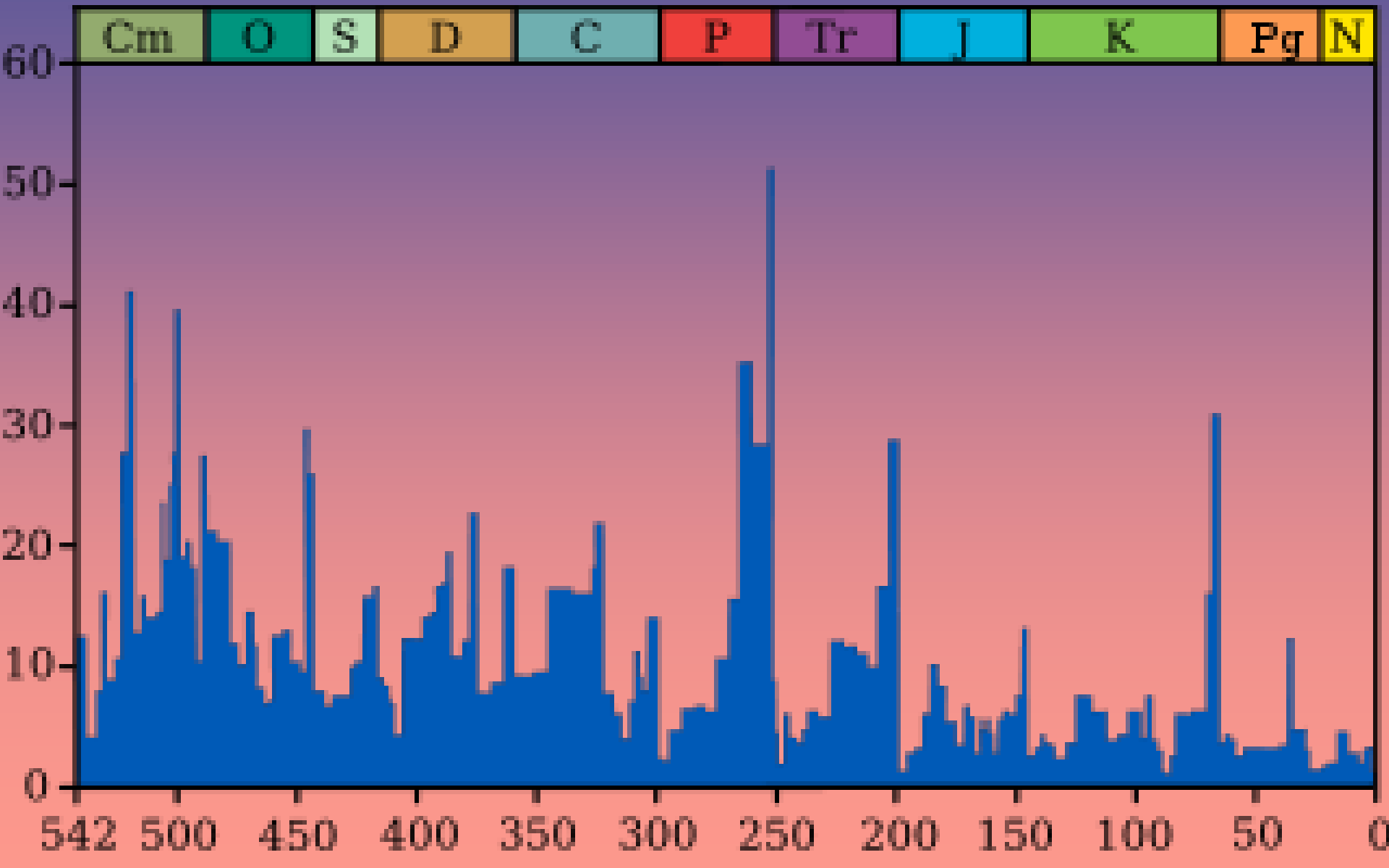
Increased dust and cosmic radiation giving low level clouds

- **Big events (Cambrian 'explosion of life' [explosion of predation, building of protective scaffolding]; 542-488 Ma; lasted 25 million years; most phyla; followed by diversification; Archaeocyathid reefs; high CO_2)**

- **Big events (Diversification; high CO_2)**



- **Big events (mass extinction of families of multicellular life; high CO_2)**



✦ Big events (mass extinctions; last 20% of time)

END ORDOVICIAN 450-440 Ma 27% families; 57% genera; 70% species

LATE DEVONIAN 375-360 Ma 19% families; 50% genera; 70% species

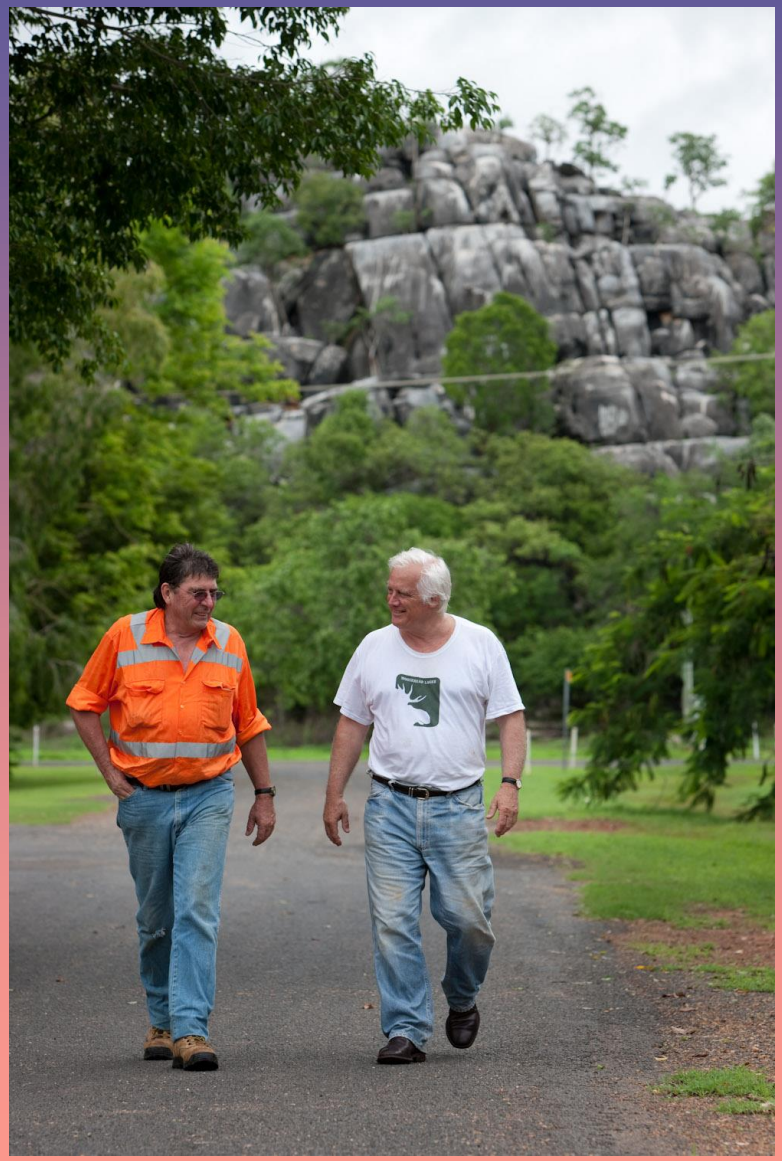
END PERMIAN 252 Ma 57% families; 83% genera; 96% species

END TRIASSIC 201.3 Ma 23% families; 48% genera; 75% species

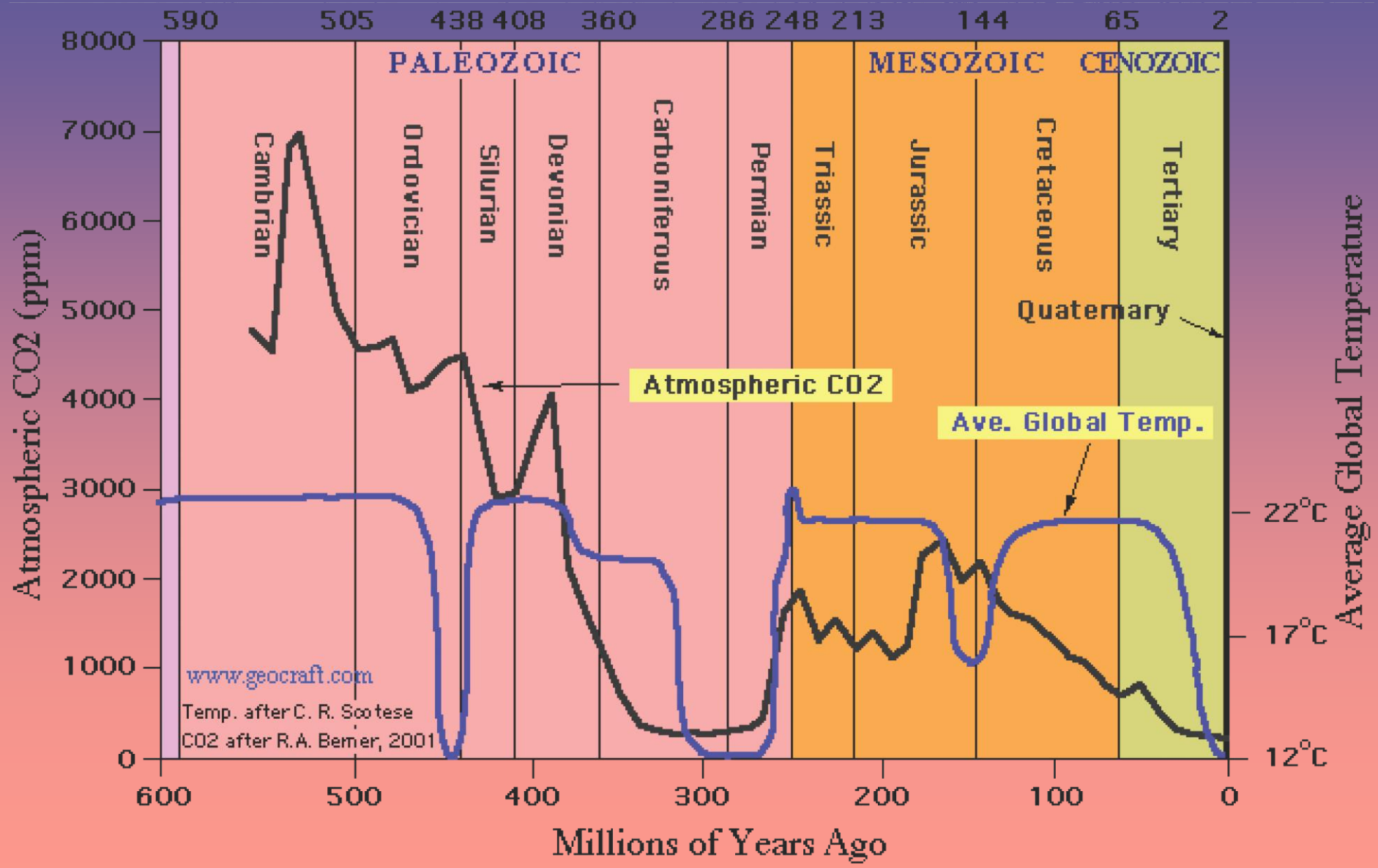
END CRETACEOUS 65 Ma 17% families; 50% genera; 50% species

NOW No 6^{th} mass extinction, increase in species, normal species turnover

✦ Big events (Silurian-Devonian “Great Barrier Reefs”)



- **Planetary evolution (CO_2 drawdown; T change)**

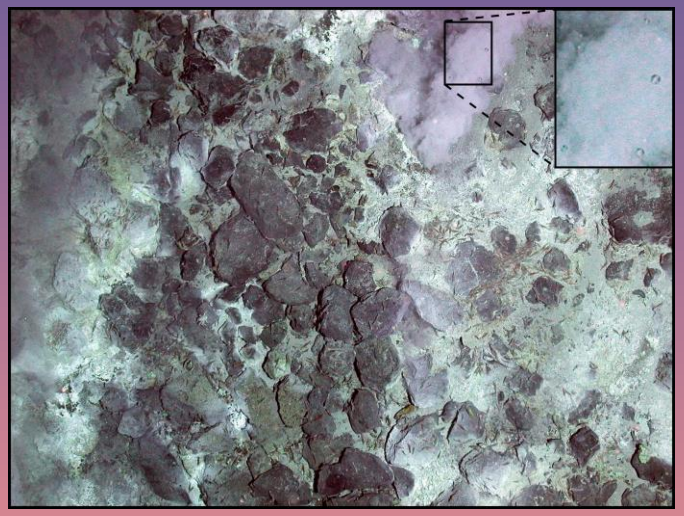


Submarine basaltic volcanicity

- Lava, hot springs, gas vents; heat huge volumes of ocean water (Hunga, Tonga; Dec 2014-Jan 2015)
- 64,000 km mid ocean ridges (10,000 km^3 water for cooling per annum; buffers seawater)
- Seamounts (>3,477,403 million > 0.1 km high), off axis volcanoes (cf 1,800 terrestrial felsic volcanoes) (Hiller & Watts 2007)
- Slow spreading (Gakkel Ridge basalts; >13.5% CO_2; explosive [1999])
- No monitoring; gas measurements from 20 basaltic volcanoes
- Upwelling thousands of years later

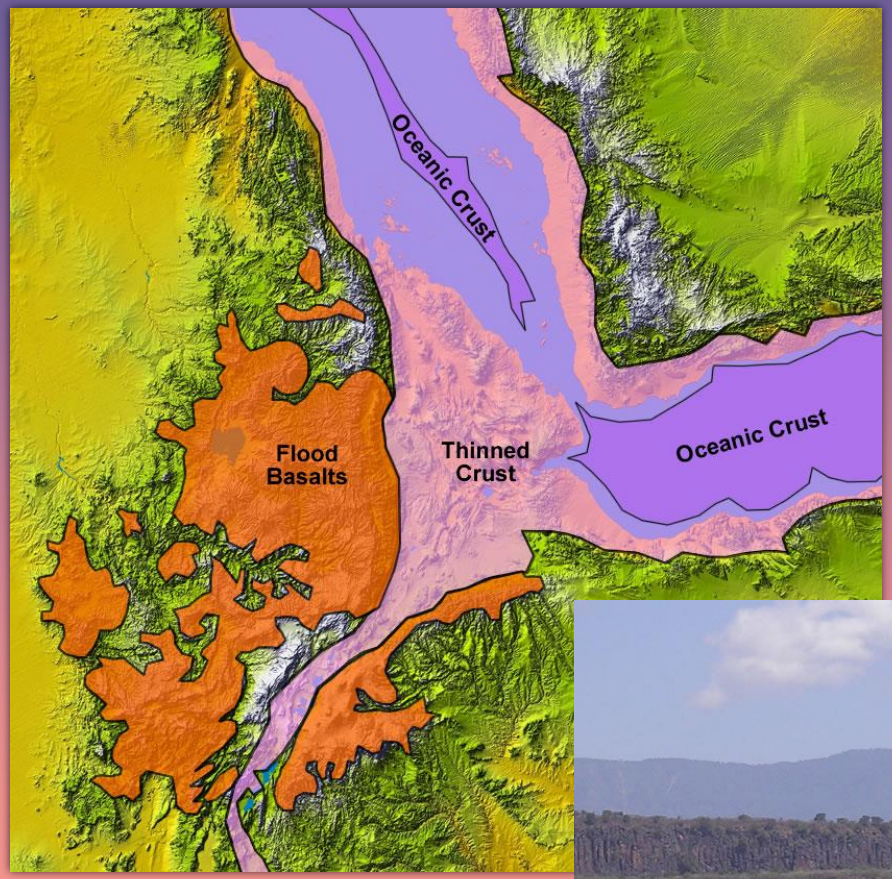
Submarine basaltic volcanoes

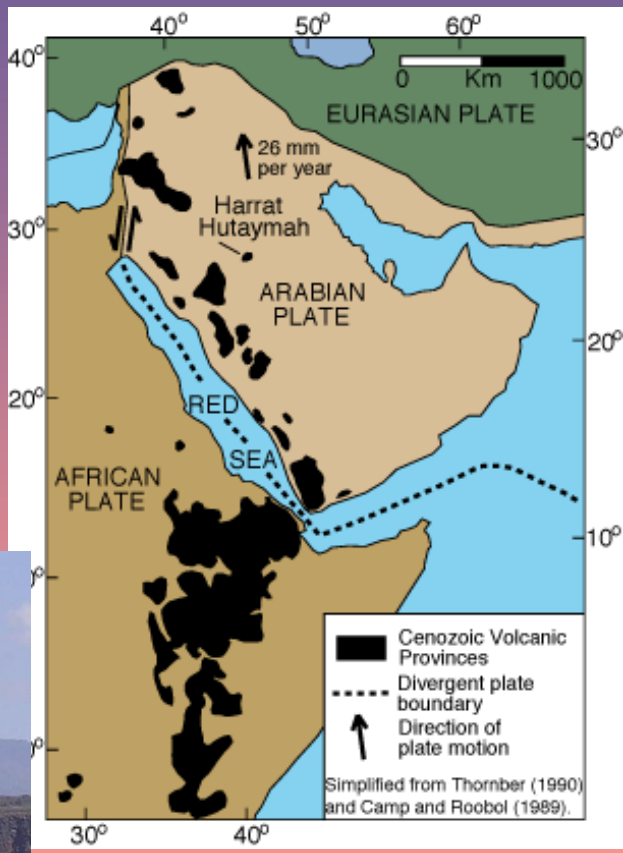
Vent CO_2 (gas and liquid) exhalation

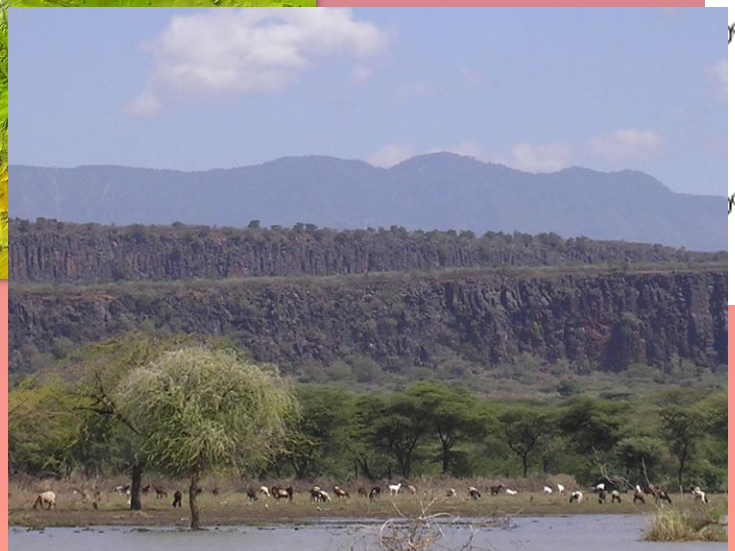


Terrestrial basalt supervolcanoes

- Large provinces, sites of juvenile CO_2 degassing







Terrestrial basalt supervolcanoes

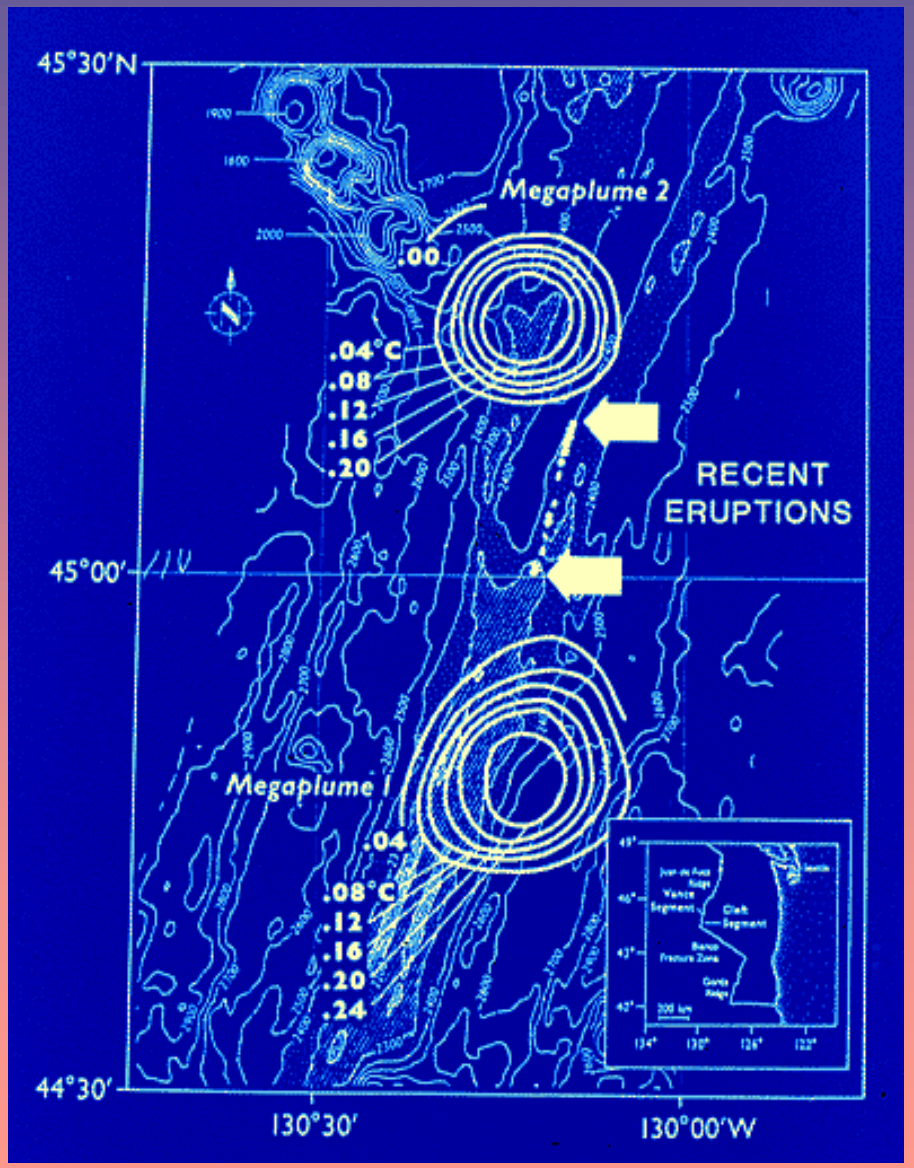
- 10 million cubic kilometres of lava in less than 1 million years
- Huge sulphur gas emissions, temporary surficial ocean acidity and life loss
- Roza Flow, Columbia River Basalt

>1,000 km^3 lava

>10,000 Mt SO_2 aerosols

Submarine basaltic supervolcanoes

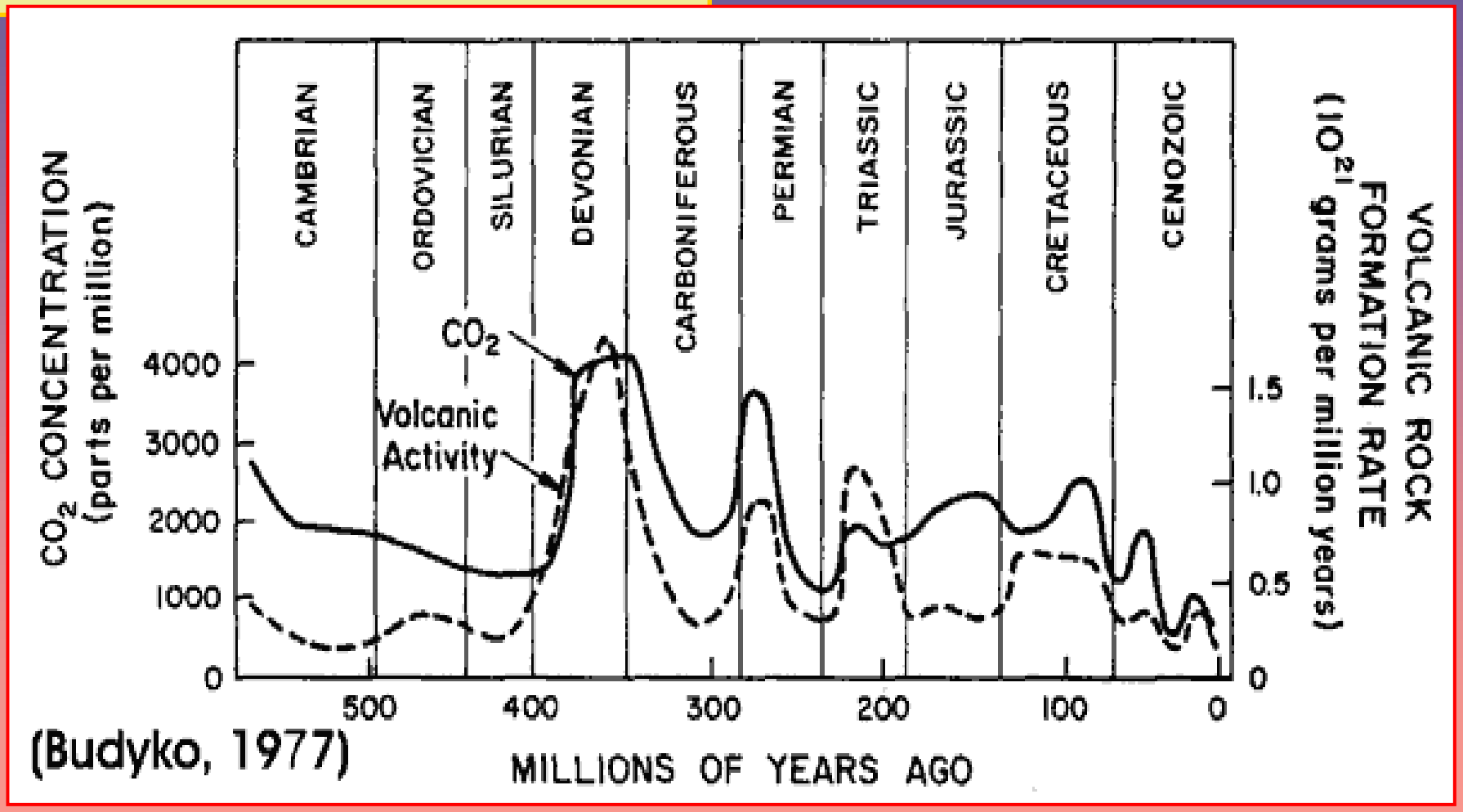
- Not monitored, earthquake swarms and El Niño
- Particle and helium plumes
- No aerosols
- $CO_{2\ (gas)}$ and $CO_{2(liq)}$ dissolves (cool high pressure bottom water)



A mantle melt may have up to 8 wt.% CO_2 at ~125 km depth. Surface lava can only hold 0.01-0.001 wt.% CO_2 dissolved.

The difference is degassed to the atmosphere.

CO_2 and volcanism



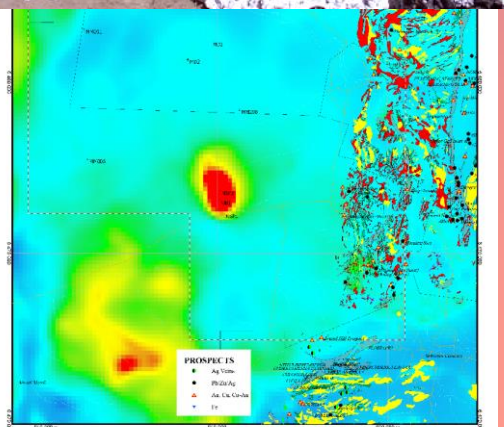
A strong correlation exists between emissions of CO_2 at times of extensive volcanism and deposition of limestones during the last ~600 million years (Mikhail Budyko).

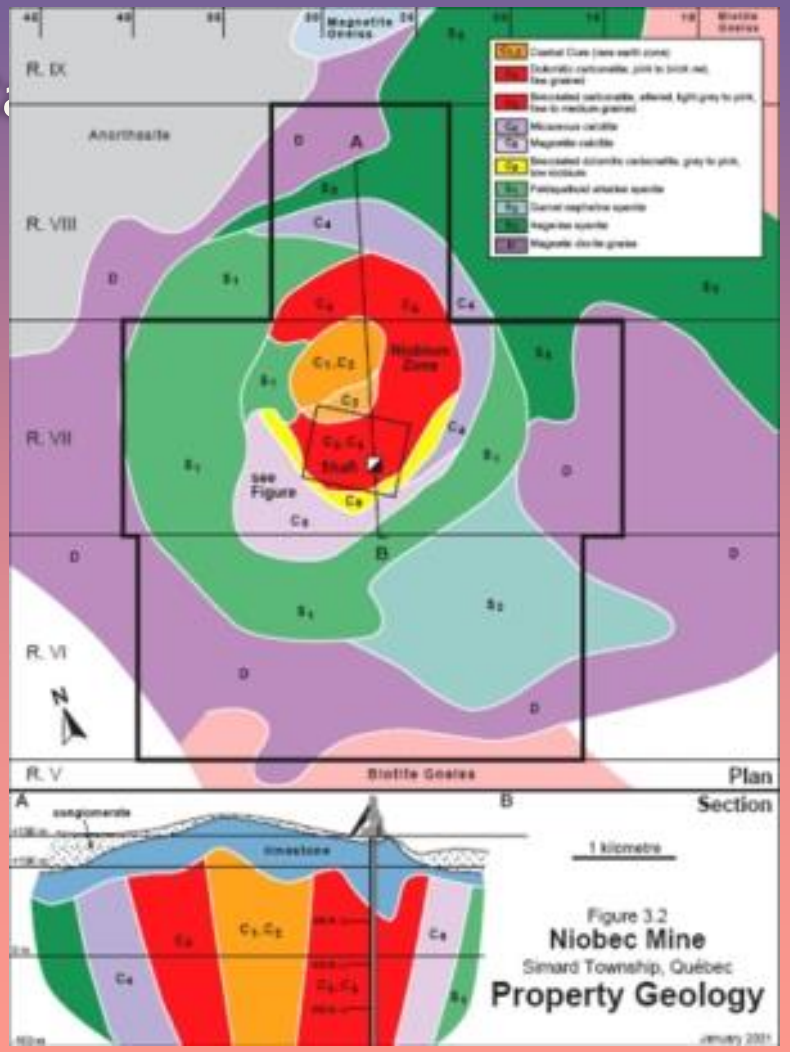
Slide after Tom Segalstad, Oslo

Degassing

MOLTEN ROCKS (liquid, solid, gas): Degassing of molten rocks (2-15% gases in solution)

Carbonate lava





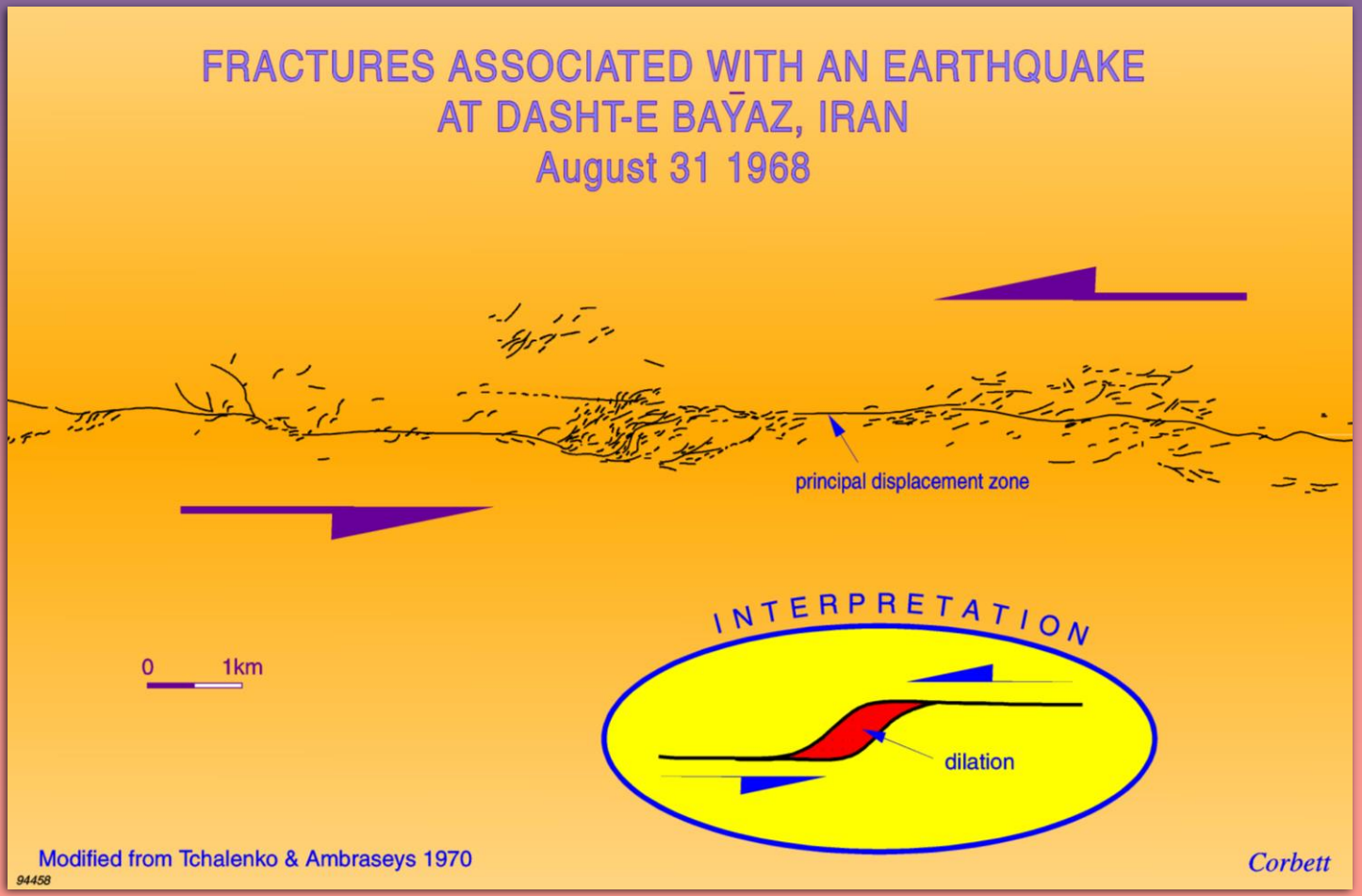
Terrestrial felsic explosive volcanicity

CO_2-driven explosions (Tahkt-e-Sulieman, Iran)

Warm CO_2-bearing earthquake fluids

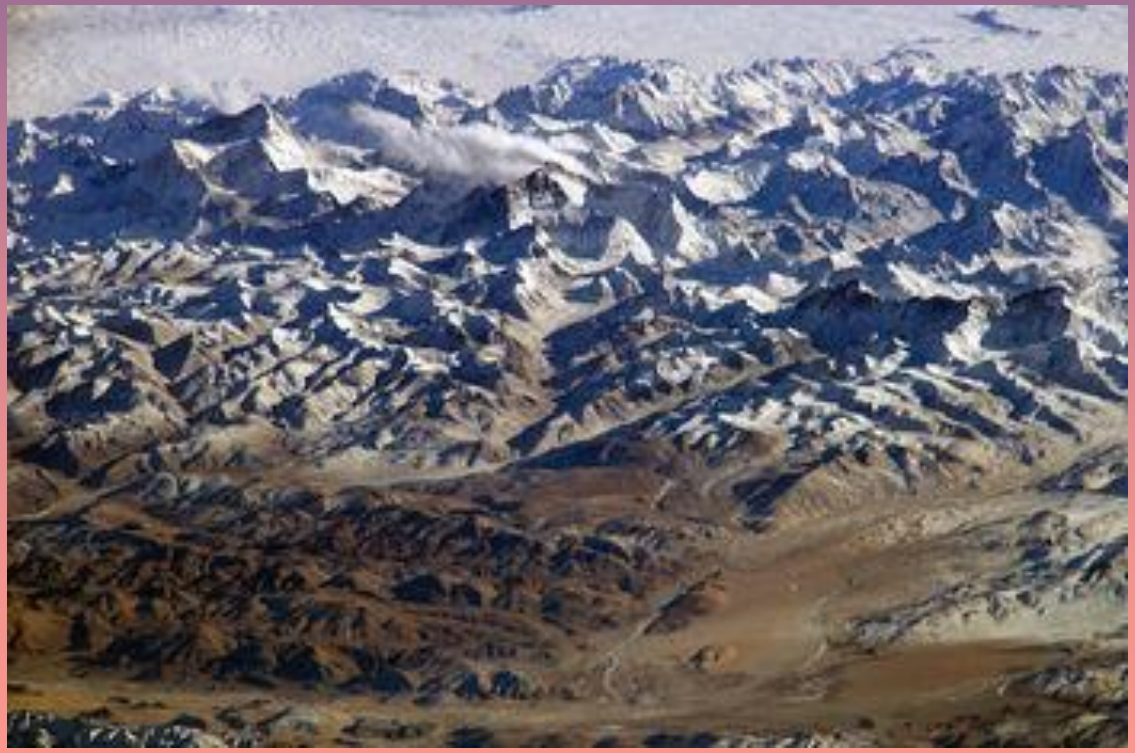
EARTHQUAKES

Warm water and gas CO_2, CH_4, He etc emissions)



CO_2-bearing springs

MOUNTAIN BUILDING: Thermal springs (bicarbonate), gas vents (CO_2)



Decarbonation from mountain building

MOUNTAIN BUILDING: Dewatering, degassing, precipitation of carbonate, CO_2- and bicarbonate-bearing springs

Atmospheric CO_2 residence time

- 5 to 7 years

Then sequestered into:

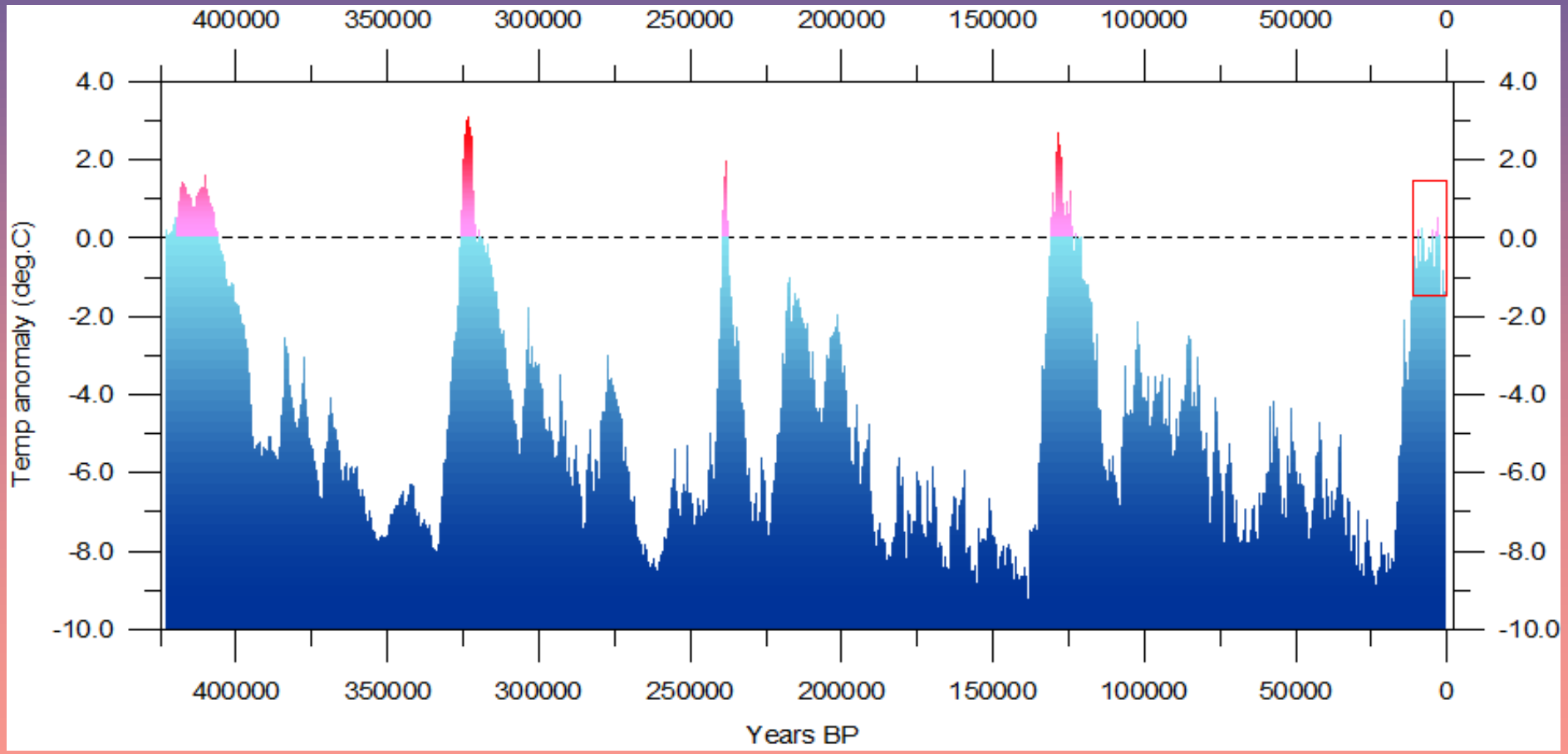
- Oceans (kept alkaline by buffering)
- Plant food
- Soils
- Rocks

Constant cyclical climate change

Known cycles	
400 million year	tectonic
143 million year	galactic
100,000 years	orbital
41,000 years	orbital
23,000 years	orbital
1,500 years (10,000?)	solar
210 years	solar
87 years	solar
60 years	ocean
22 years	solar
18.6 years	lunar

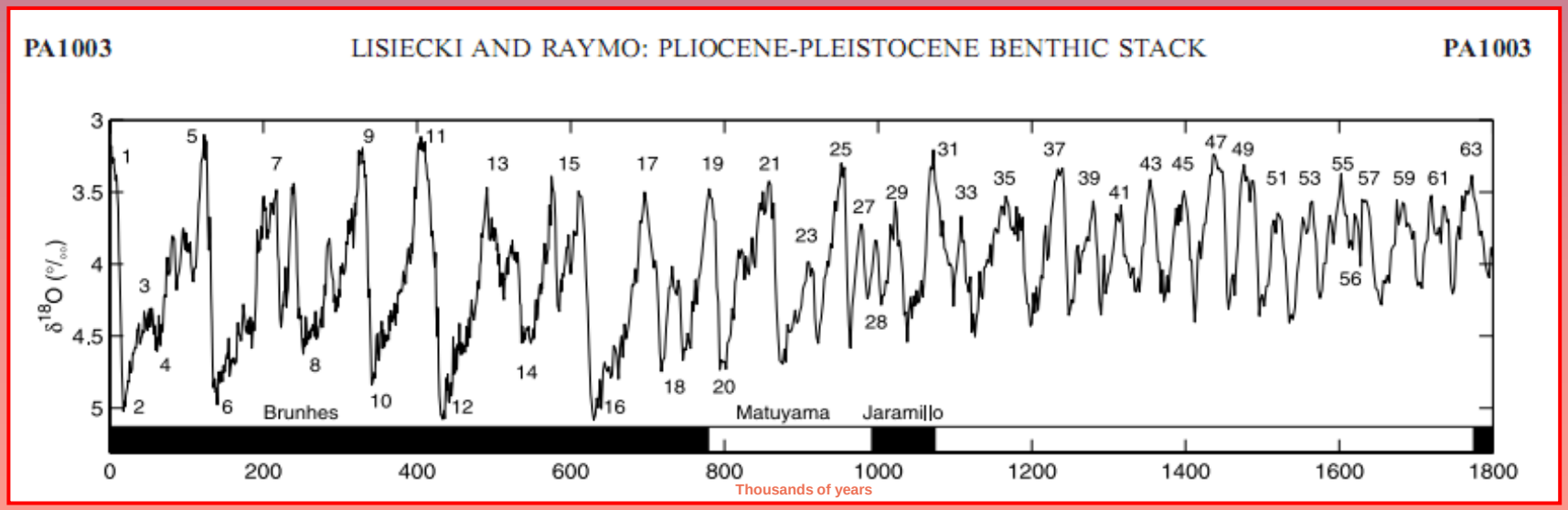
Is the speed and degree of modern climate change unprecedented?

(Vostok ice core; Salamatin *et al*. 1998; Petit *et al*. 2001)



Ocean warmings and coolings

- Were past warmings due to humans?
- Normal for oceans to cool and warm
- Ocean temperature not static

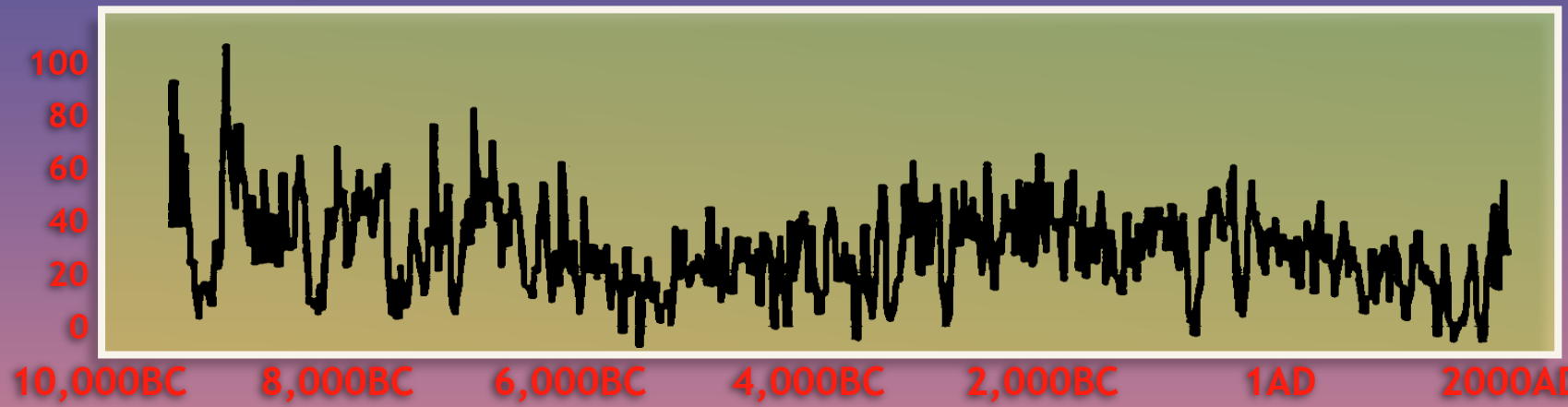


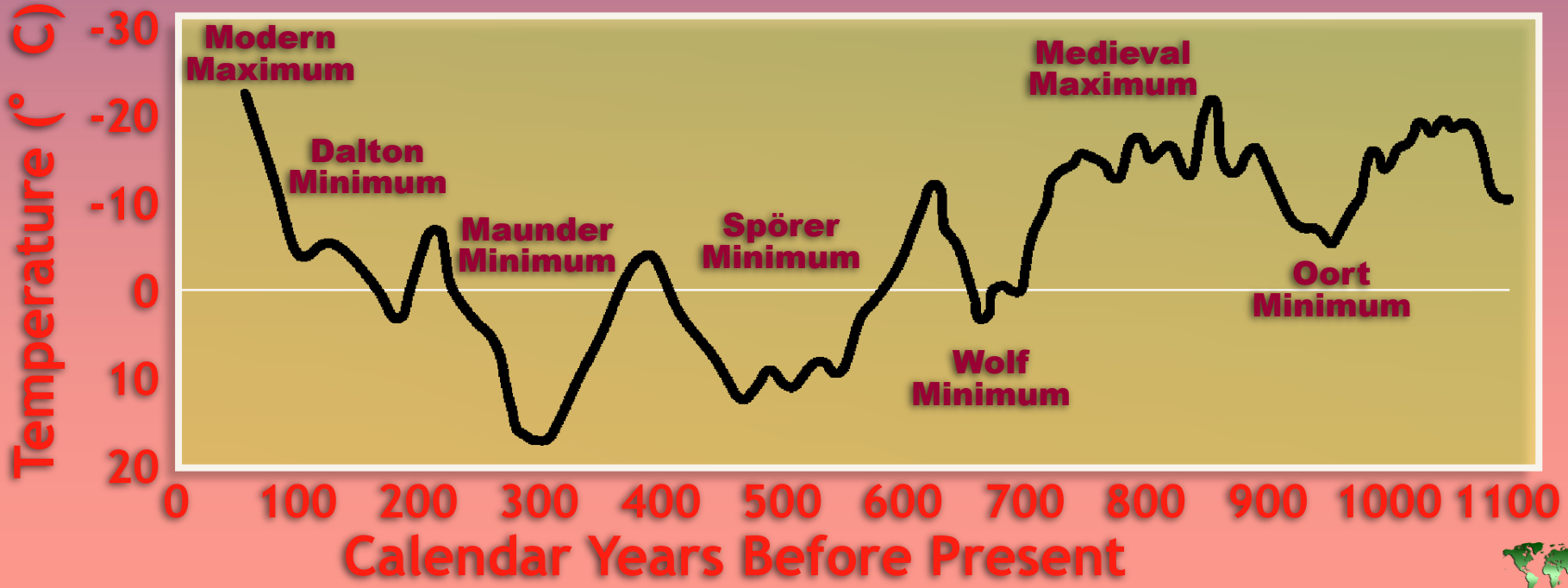
The next climate change: The future is written in the past

Pleistocene glaciation	110,000 to 14,700 years ago
Bölling	14,700 to 13,900 years ago
Older Dryas	13,900 to 13,600 years ago
Allerød	13,600 to 12,900 years ago
Younger Dryas	12,900 to 11,600 years ago
Holocene warming	11,600 to 8,500 years ago
Egyptian cooling	8,500 to 8,000 years ago
Holocene Warming	8,000 to 5,600 years ago
Akkadian cooling	5,600 to 3,500 years ago
Minoan Warming	3,500 to 3,200 years ago
Bronze Age Cooling	3,200 to 2,500 years ago
Roman Warming	500 BC to 535 AD
Dark Ages	535 AD to 900 AD
Medieval Warming	900 AD to 1300 AD
Little Ice Age	1300 AD to 1850 AD
Modern Warming	1850 AD to ….

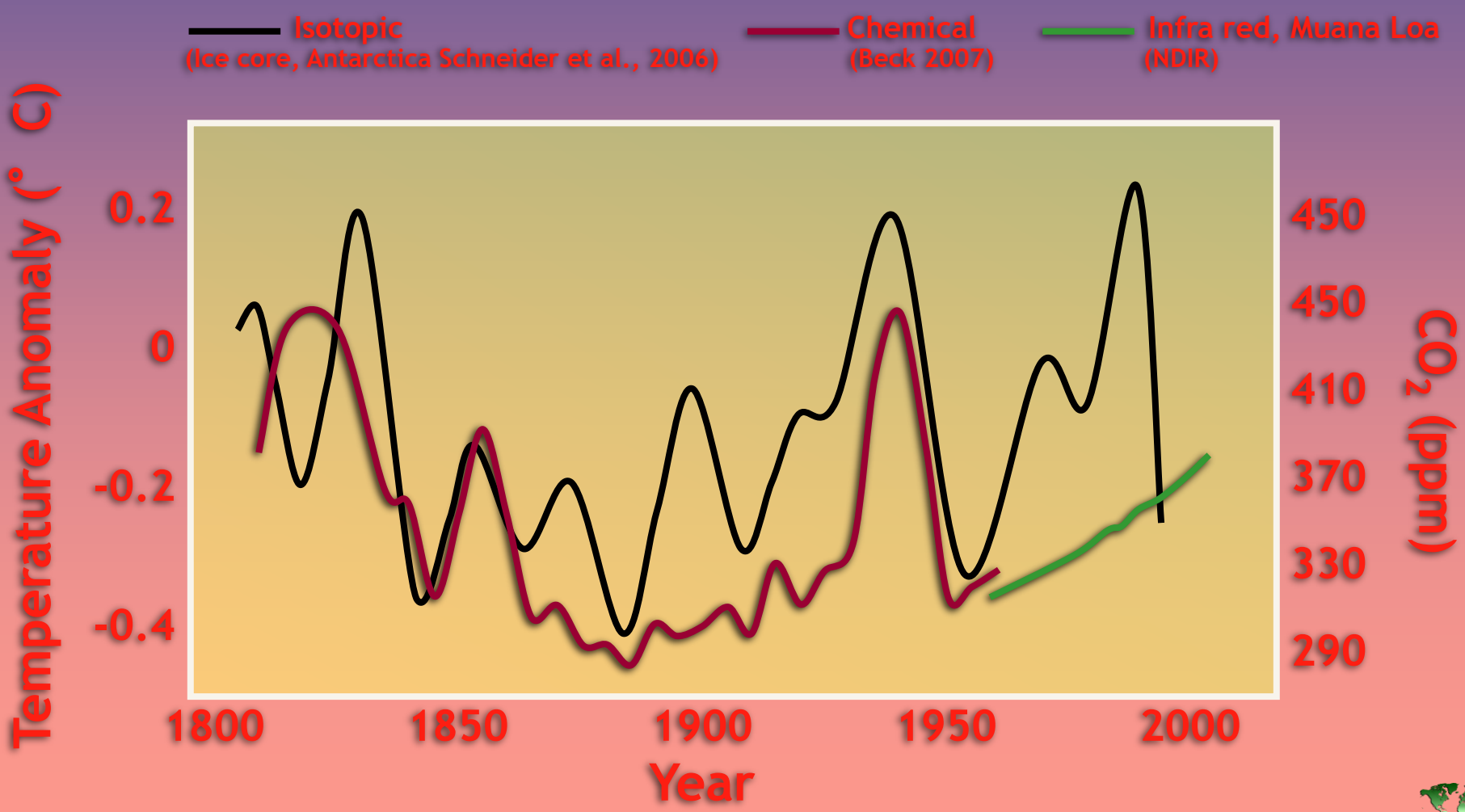
Temperature proxy

Cosmogenic isotopes ($C^{14;}$ also Be^{10}, Al^{26}, Cl^{36}, Ca^{41}, Ti^{44}, I^{129})

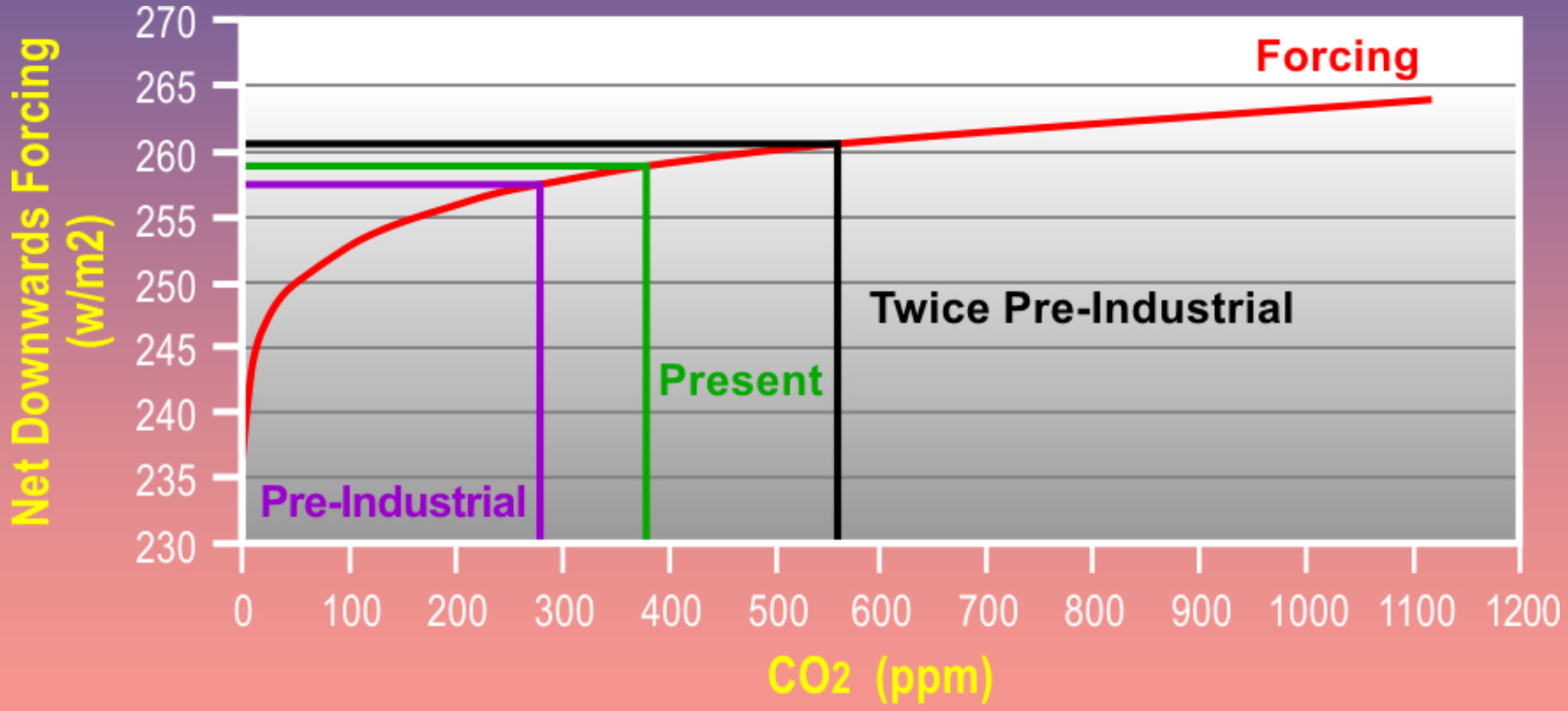




CO_2 measurements



Further CO_2 increase has tiny effect



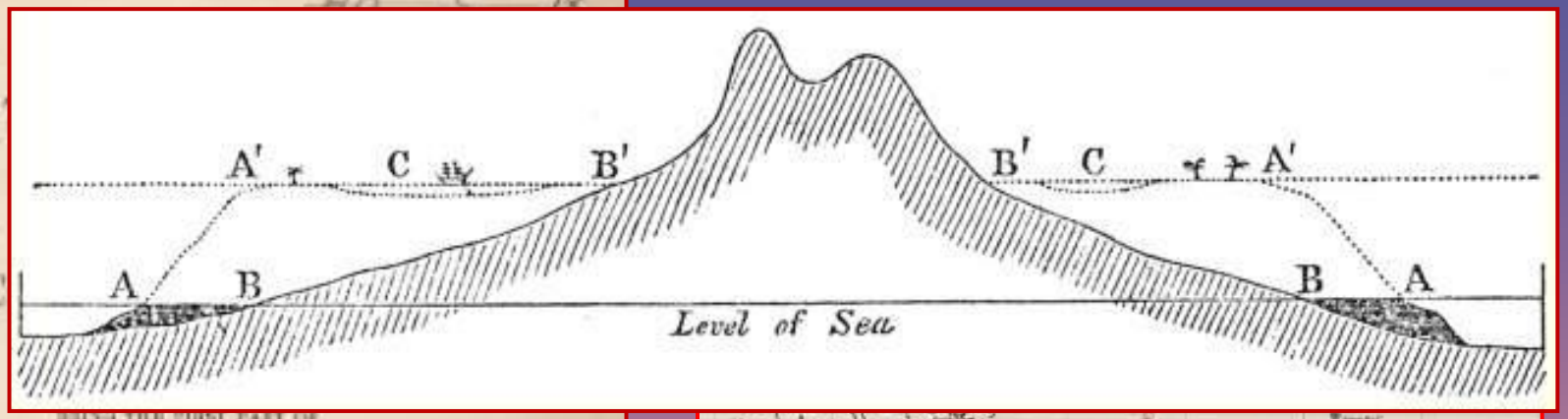
Sea levels

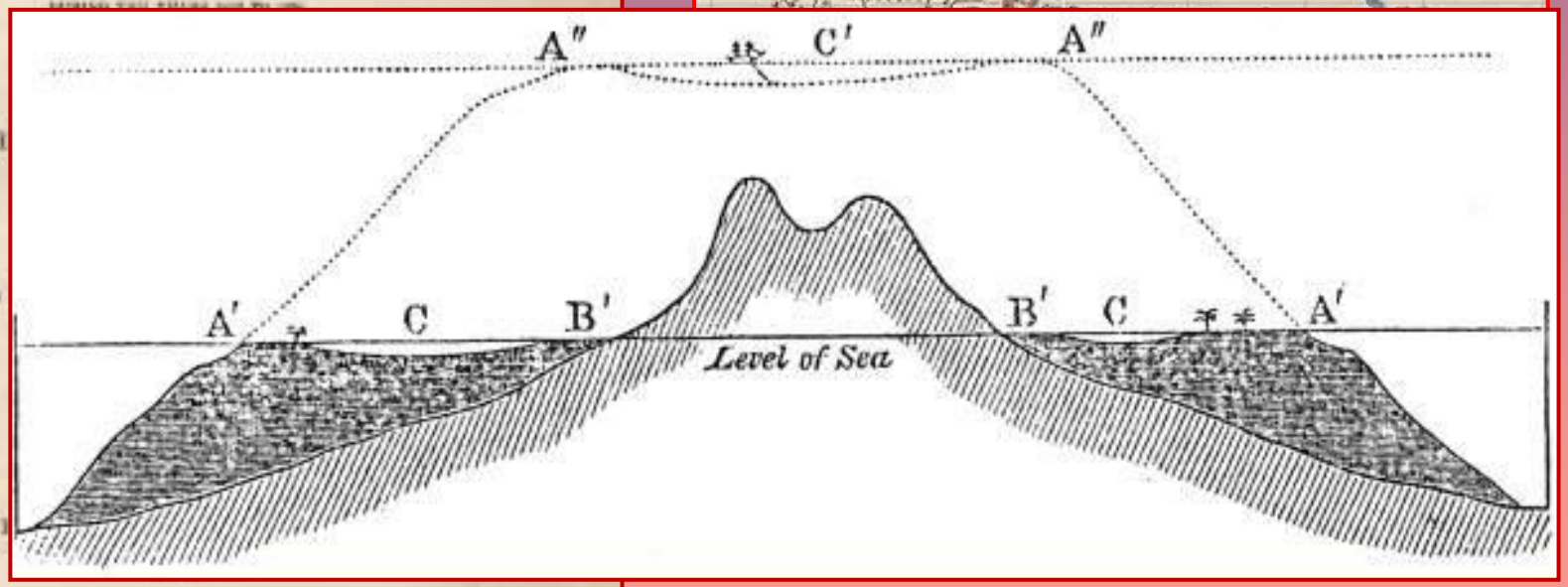
- SL always changing (Neoproterozoic glaciation ±600 m, Quaternary glaciation ±130 m)
- 116,000-128,000 years bp SL +7m
- 6,000 years bp SL in Indian/Pacific Oceans +2m
- Atolls rise as SL rises
- Many reasons for SL change

Sea levels

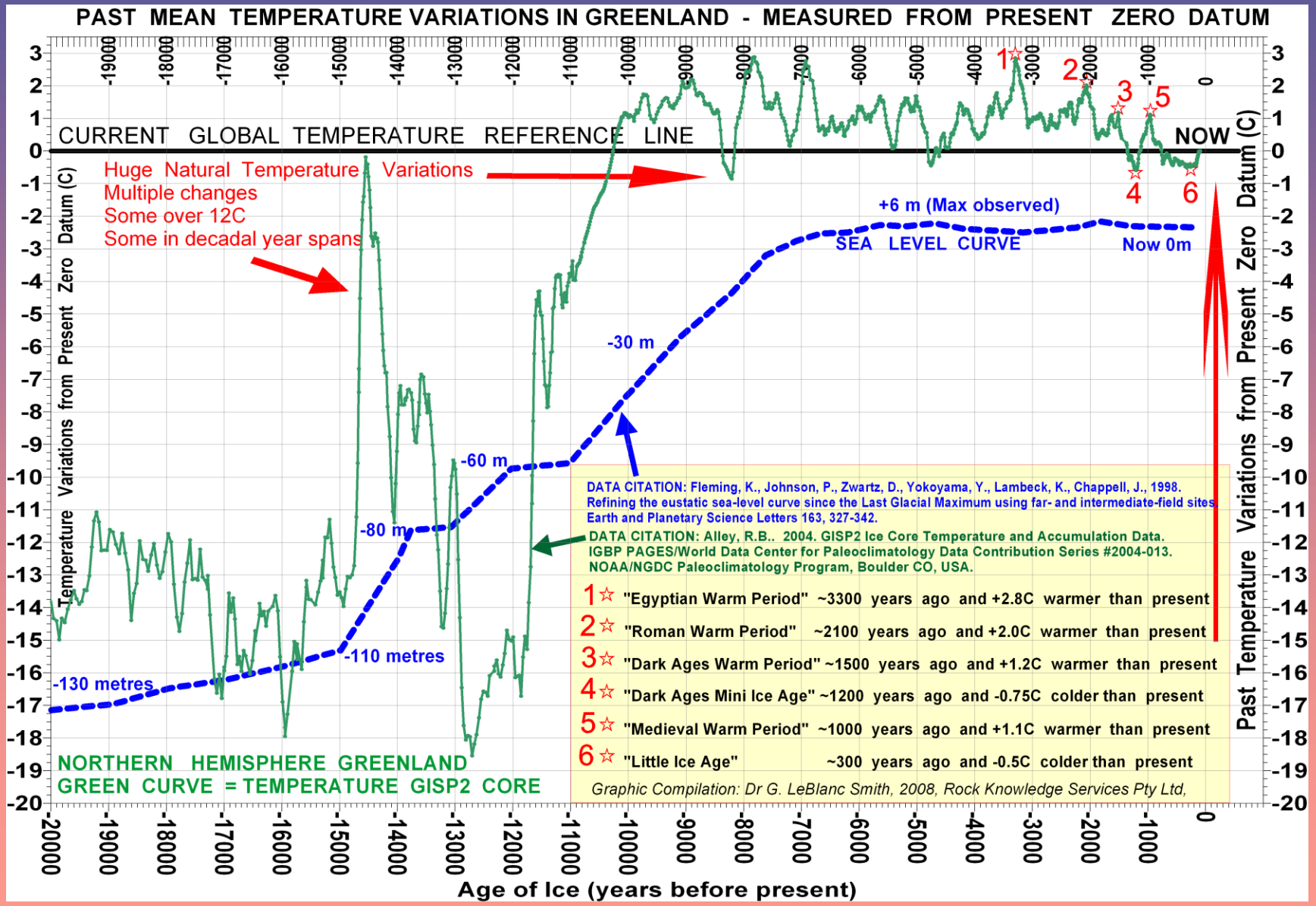

a
N
200 m
b
N
100 m
c
N
100 m
d
N
100 m
e
N
100 m
Date
1971
1984
2006
2014

Fringing reefs & atolls





Greenland sea level rise



Holocene glacio-isostatic rebound

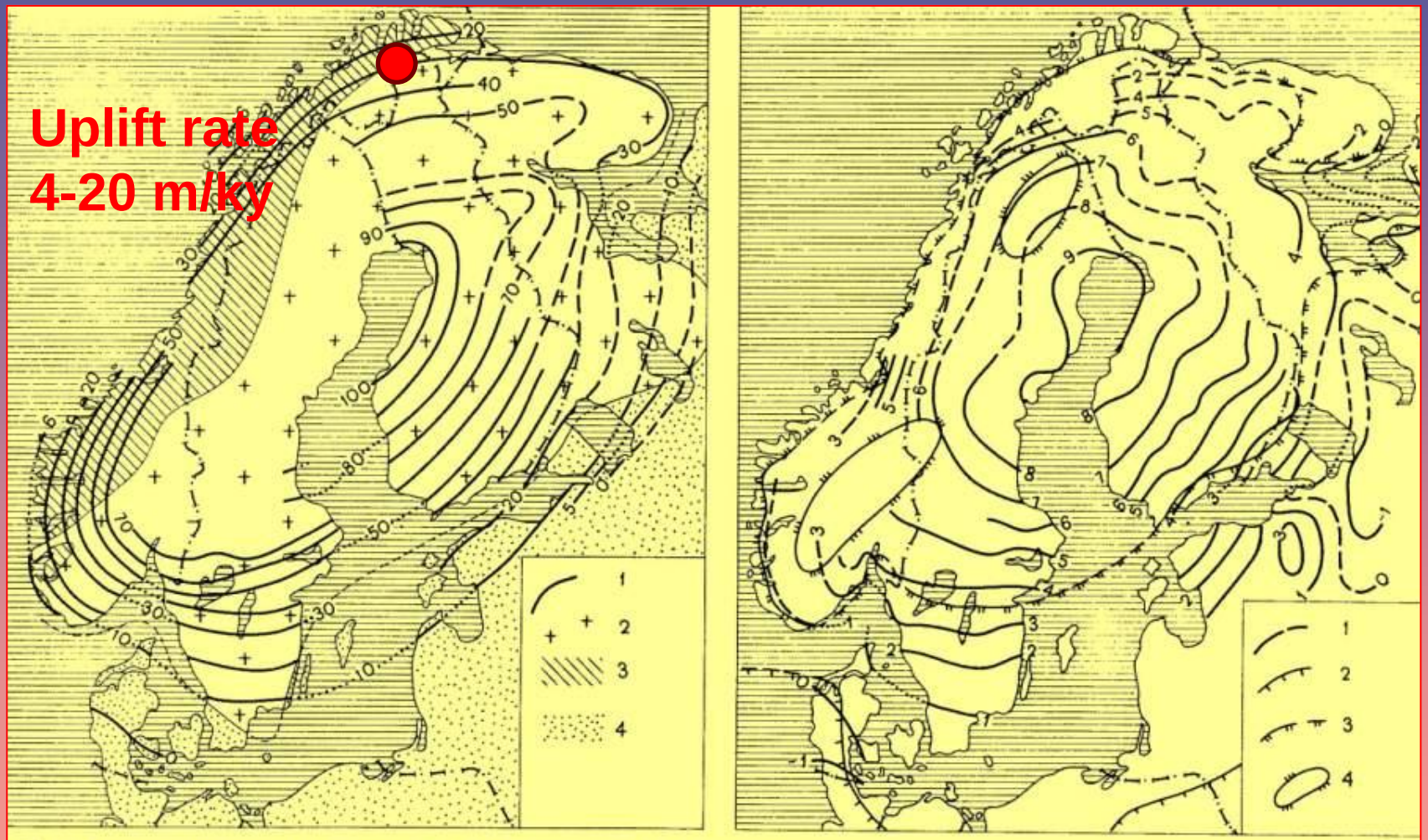


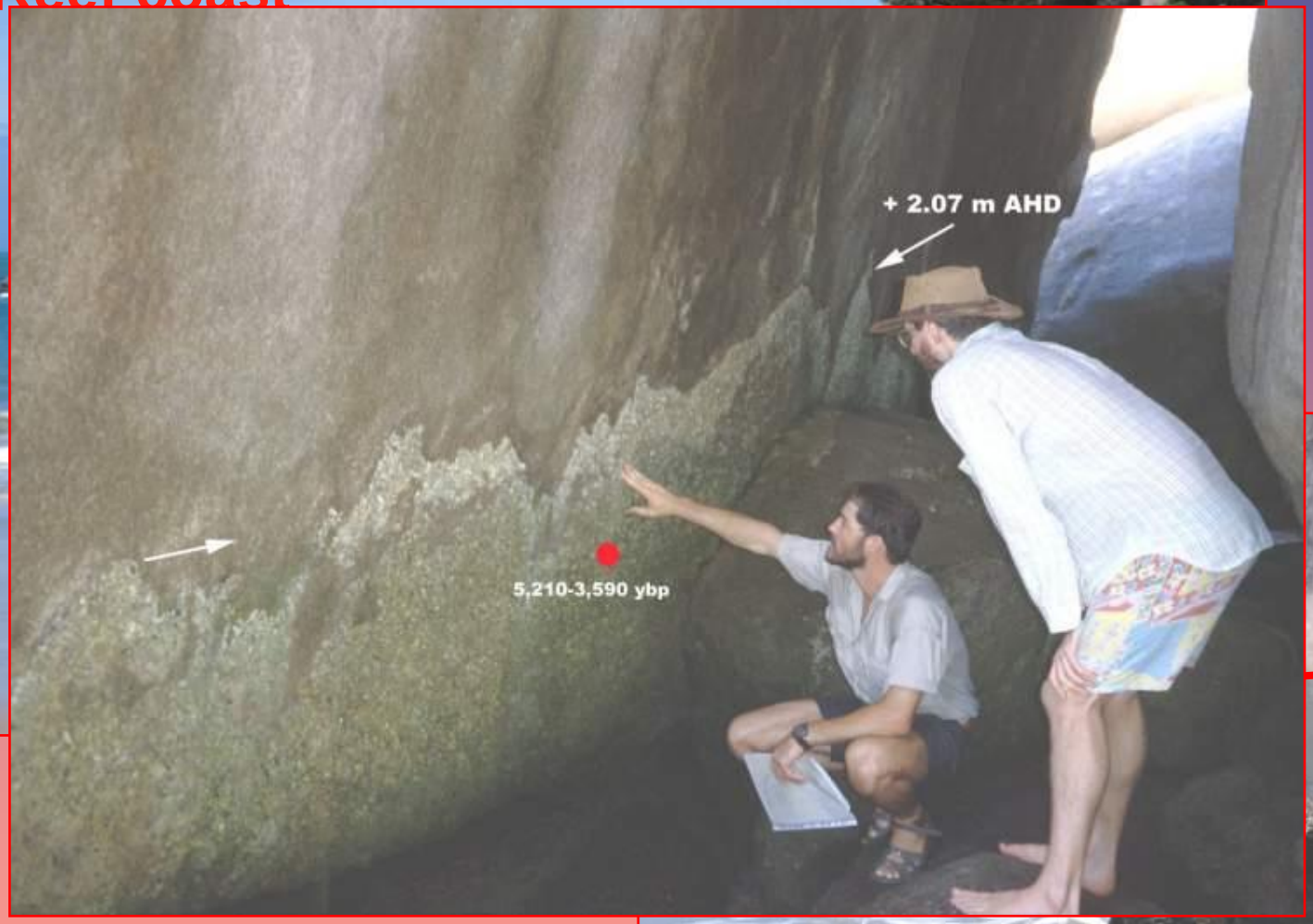
Fig. 1. Schemes of Holocene (A) and recent (B) crustal movements in Fennoscandia

A. 1, isolines of uplift since Middle Holocene (about 6000 yr), in metres; 2, crystalline rocks of the PreCambrian within the Baltic shield; 3, Caledonides; 4, Paleozoic and Mezozoic strata on the platform

B. 1, isolines of rate of recent movements, in mm/yr; 2, boundary line of the Würm (Valdaj) ice sheet; 3, limit of the ice sheet about 10,000 yr BP; 4, ice sheet remnants about 8000 yr BP

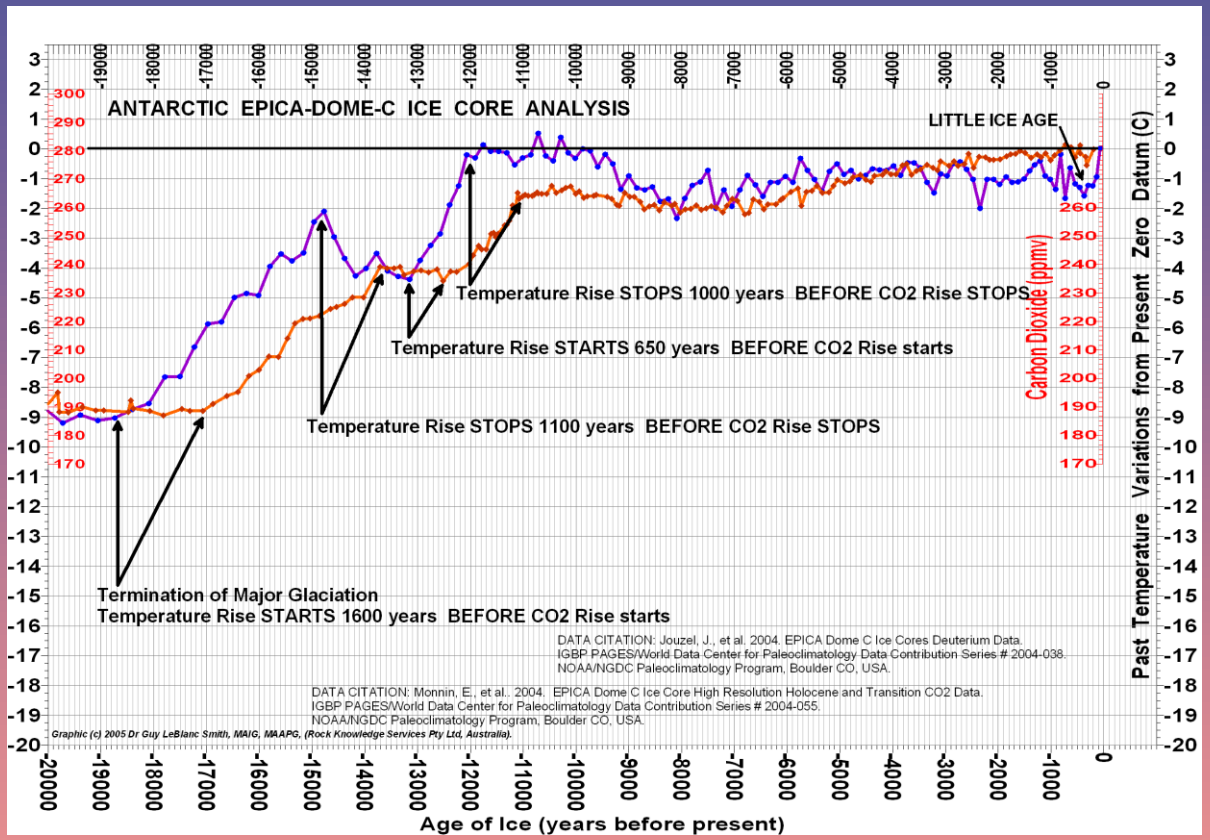
Balding Bay, Great Barrier Reef coast

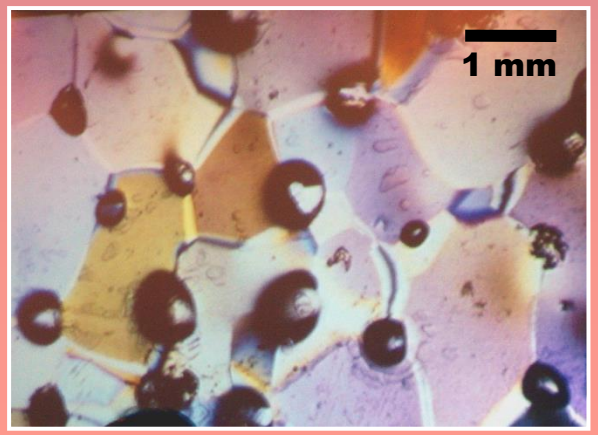
Holocene highstand oyster beds

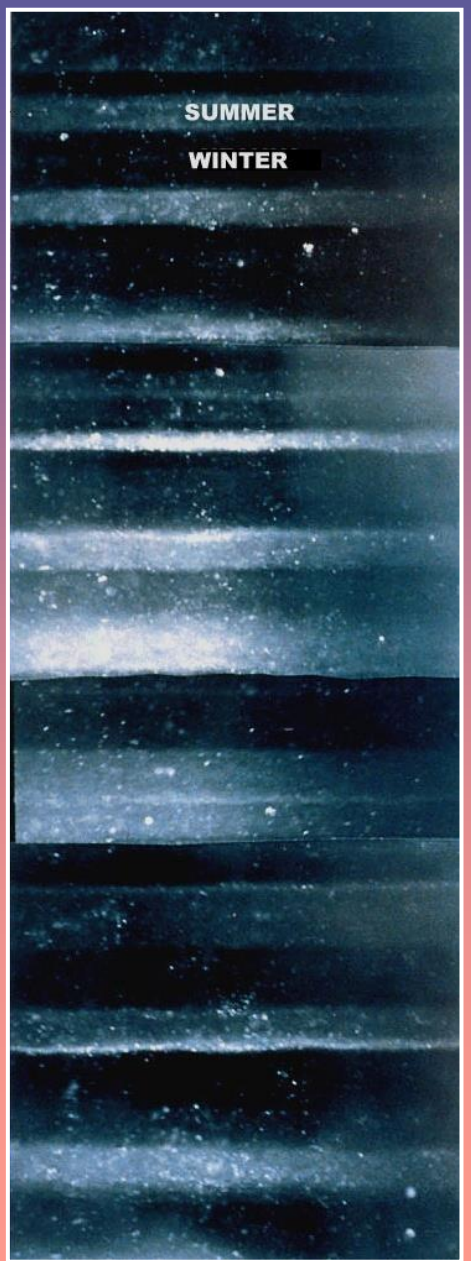


Holocene highstand coral microatolls

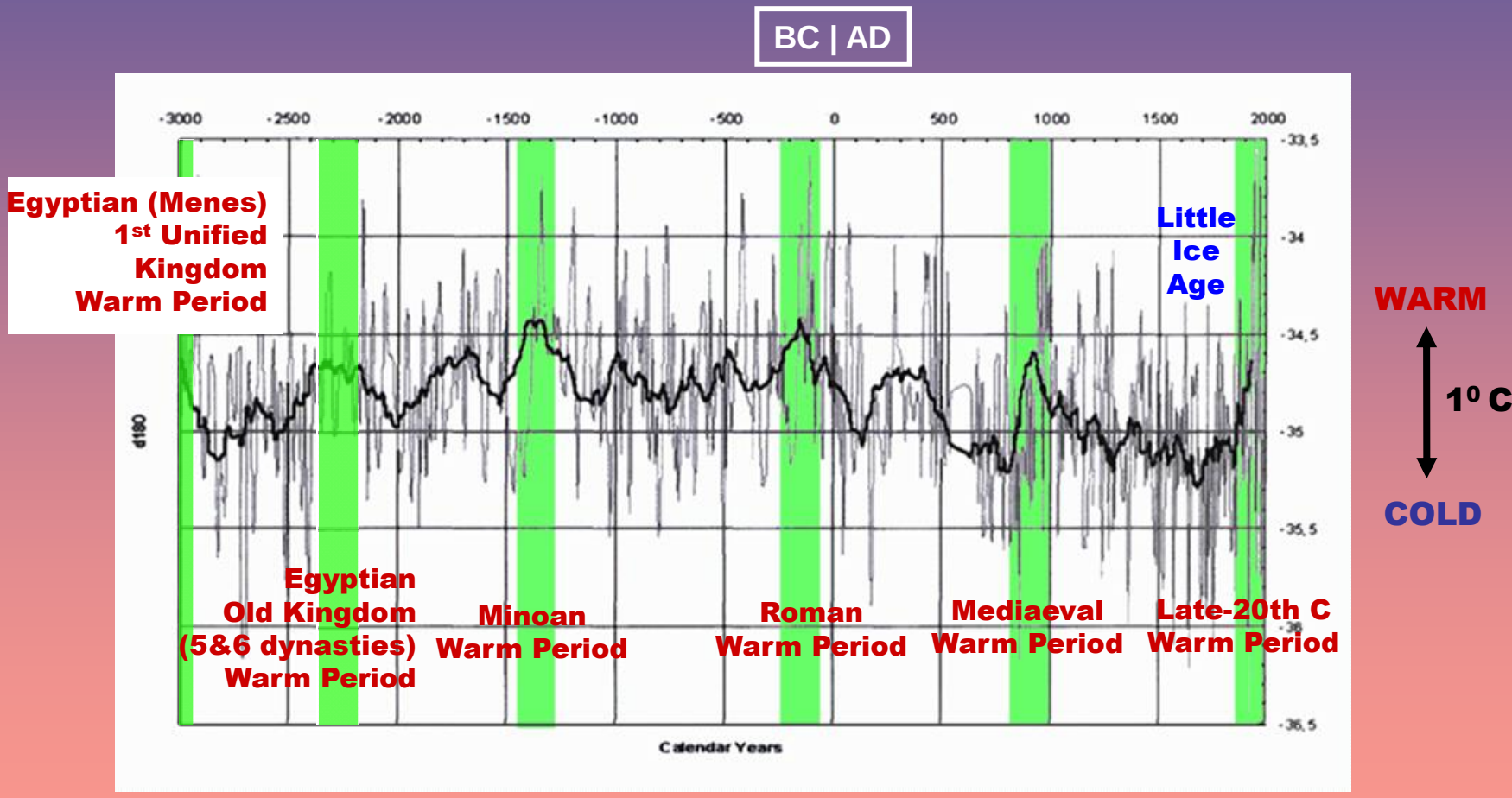
CO_2 rise follows temperature rise







Is the magnitude of late 20thC temperature change unusual? (Greenland ice core)

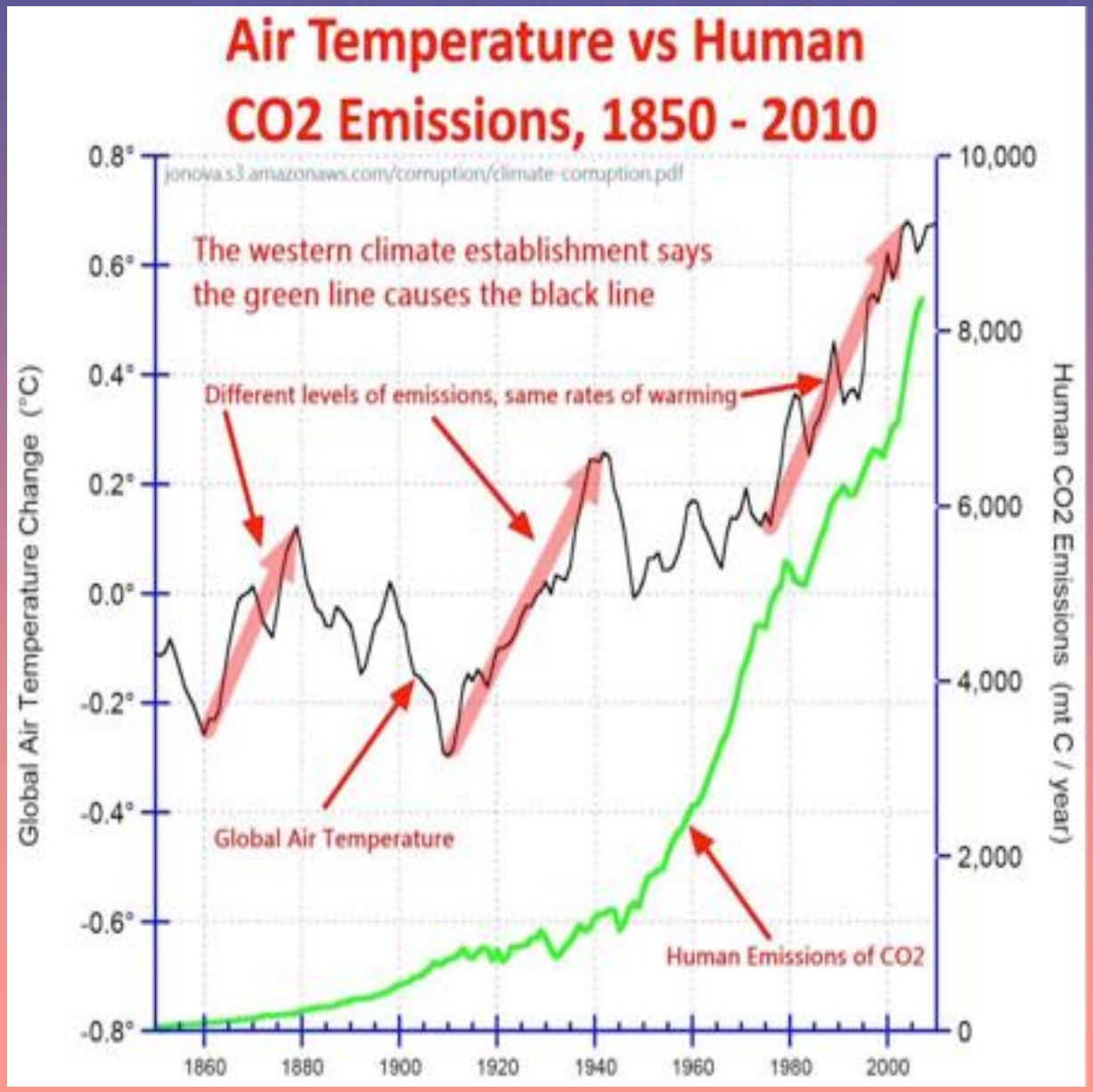


Grootes, P.M., Stuiver, M., White, J.W.C., Johnsen, S.J., Jouzel J., Comparison of oxygen isotope records from the GISP and GRIP Greenland ice cores. Nature 366, 1993, pp. 552-554.

Slide after A. Illarionov, Powerpoint presentation, December 2004.

Rates of change and CO_2

(no correlation hence no causation)



What does the past tell us?

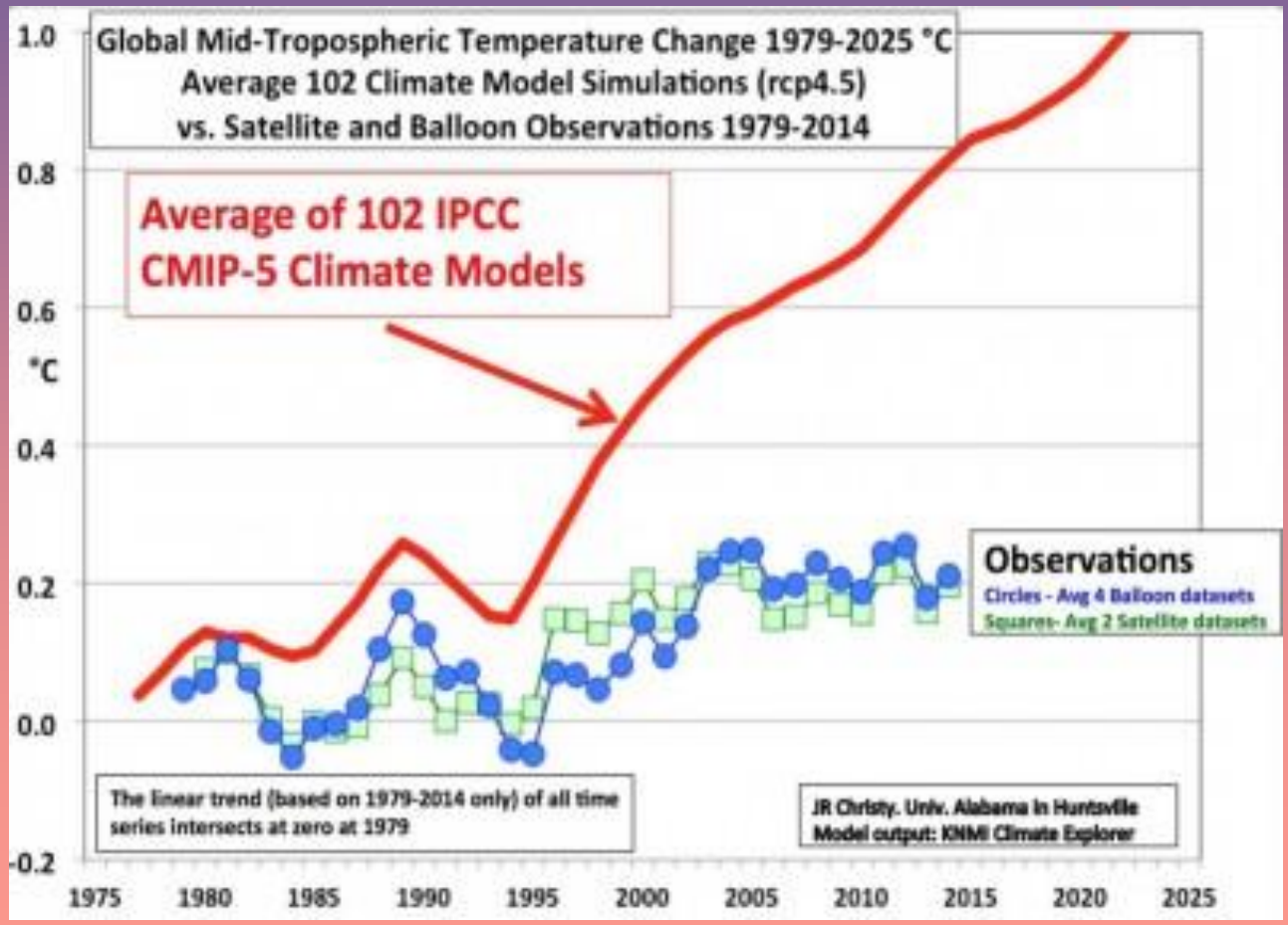
- Climate is part of planetary evolution (water, air, rocks, life)
- Change is normal (life, landscapes, sea level, climate) and the rate of change today is not exceptional
- Climate has changed for the last 4,567 million years
- For >80% of time, the planet has been warmer and wetter
- There have been 6 major ice ages, we currently live in an interglacial of an ice age that is 34 million years old
- Each ice age started when there was far more CO_2 in the atmosphere than now
- CO_2 is the gas of life (i.e. plant food) and not a pollutant

The scientific method

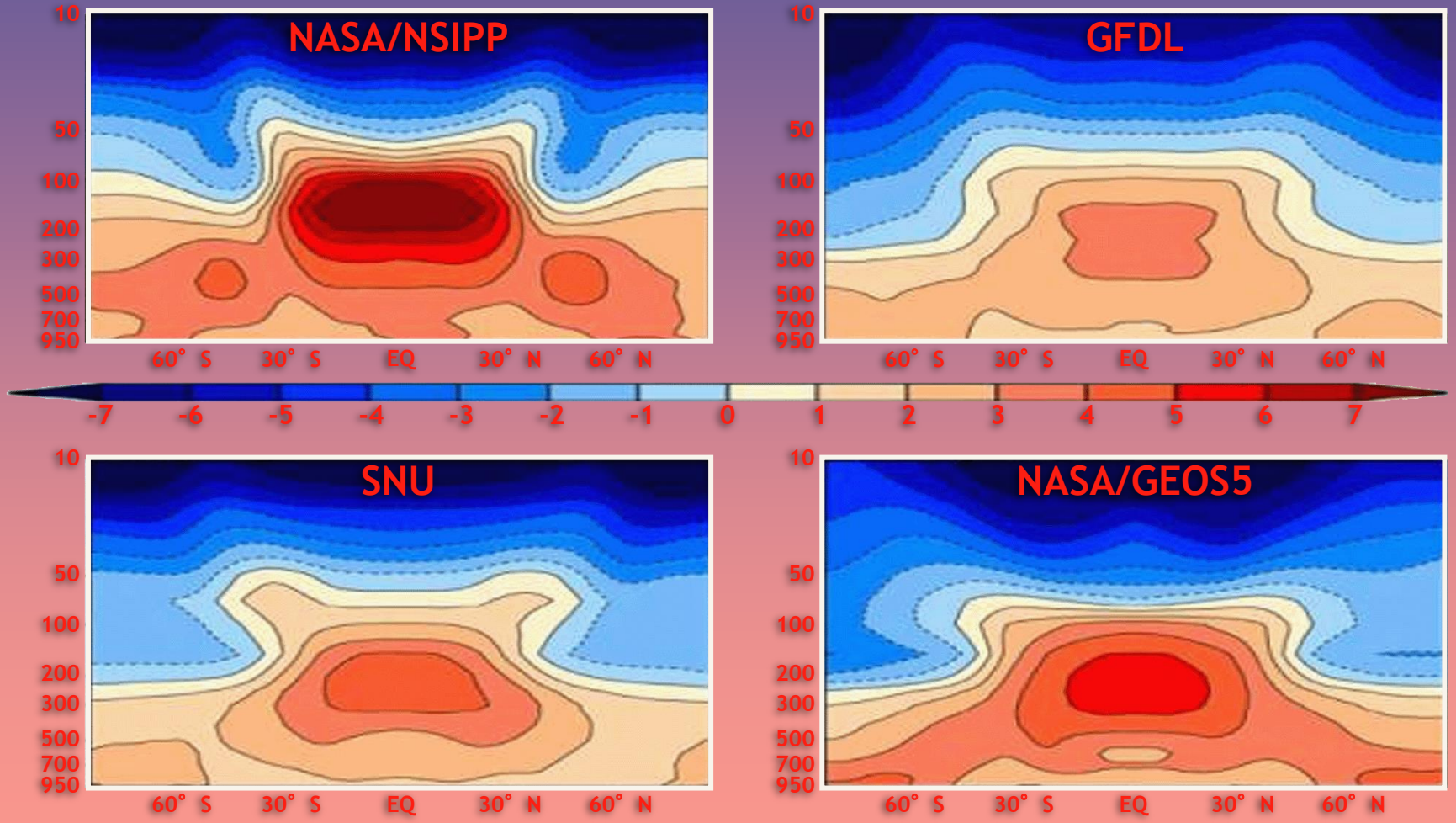
- How were T and CO_2 measured? By whom? When? Where?
- What is the order of accuracy of measurements?
- What re the measurement errors? What data has been rejected (e.g. Antarctic subglacial volcanicity)?
- What statistical and data reduction processes have been used? (e.g. 97% scientists)
- Is validated data from past climate changes ignored?
- Why are models used rather than measurements?
- Integration of science with history (e.g. Roman Warming, Medieval Warming)

Why are there differences between scientists?

- Mathematical models of the atmosphere compared to measurements



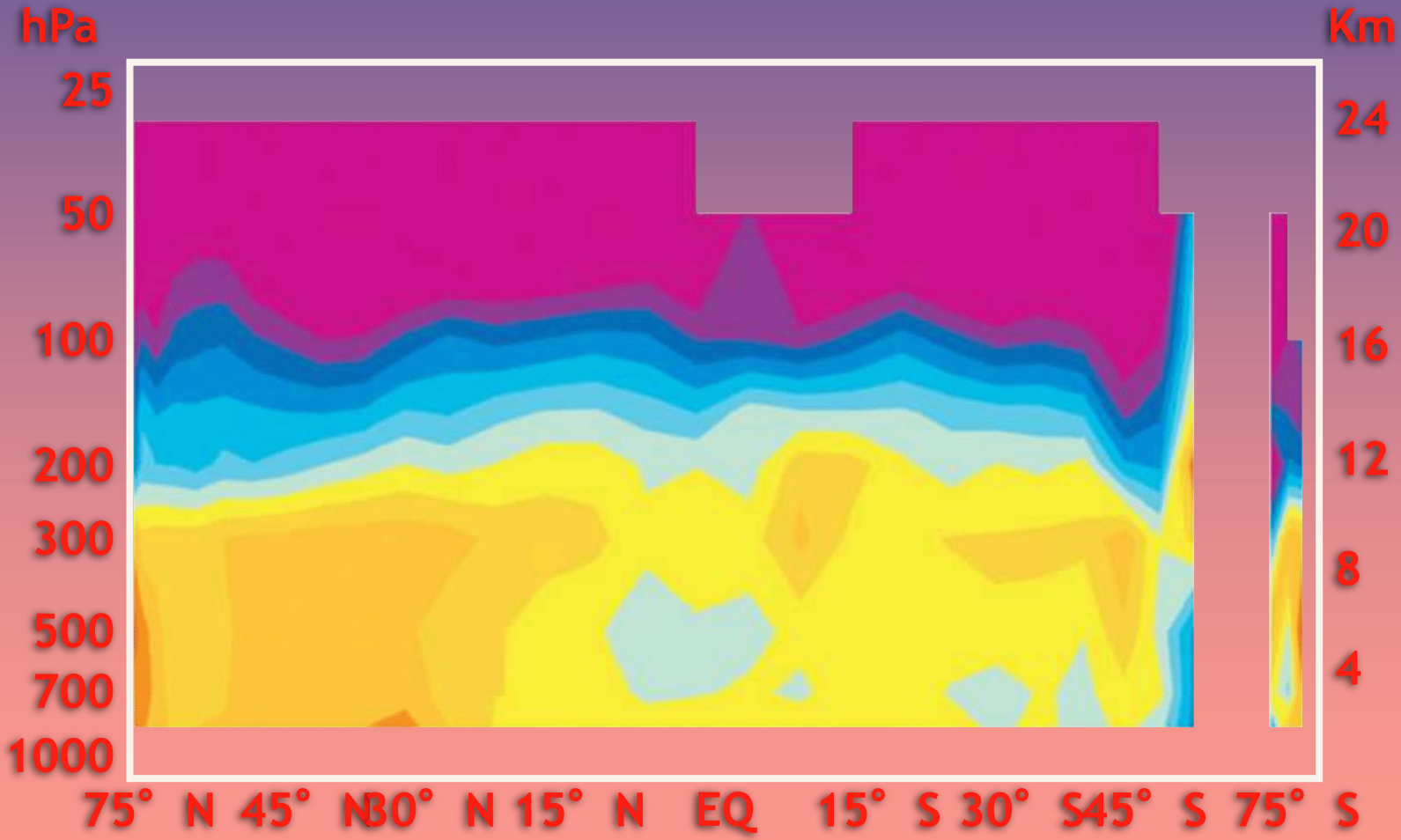
Models: Atmospheric temperature change by doubling [CO_2]



Zonally-averaged distributions of predicted temperature change in ° K at CO_2 doubling ($2xCO_2$-control), as a function of latitude and pressure level, for four general-circulation models (Lee et al., 2007)

Empirical measurements: Radiosonde

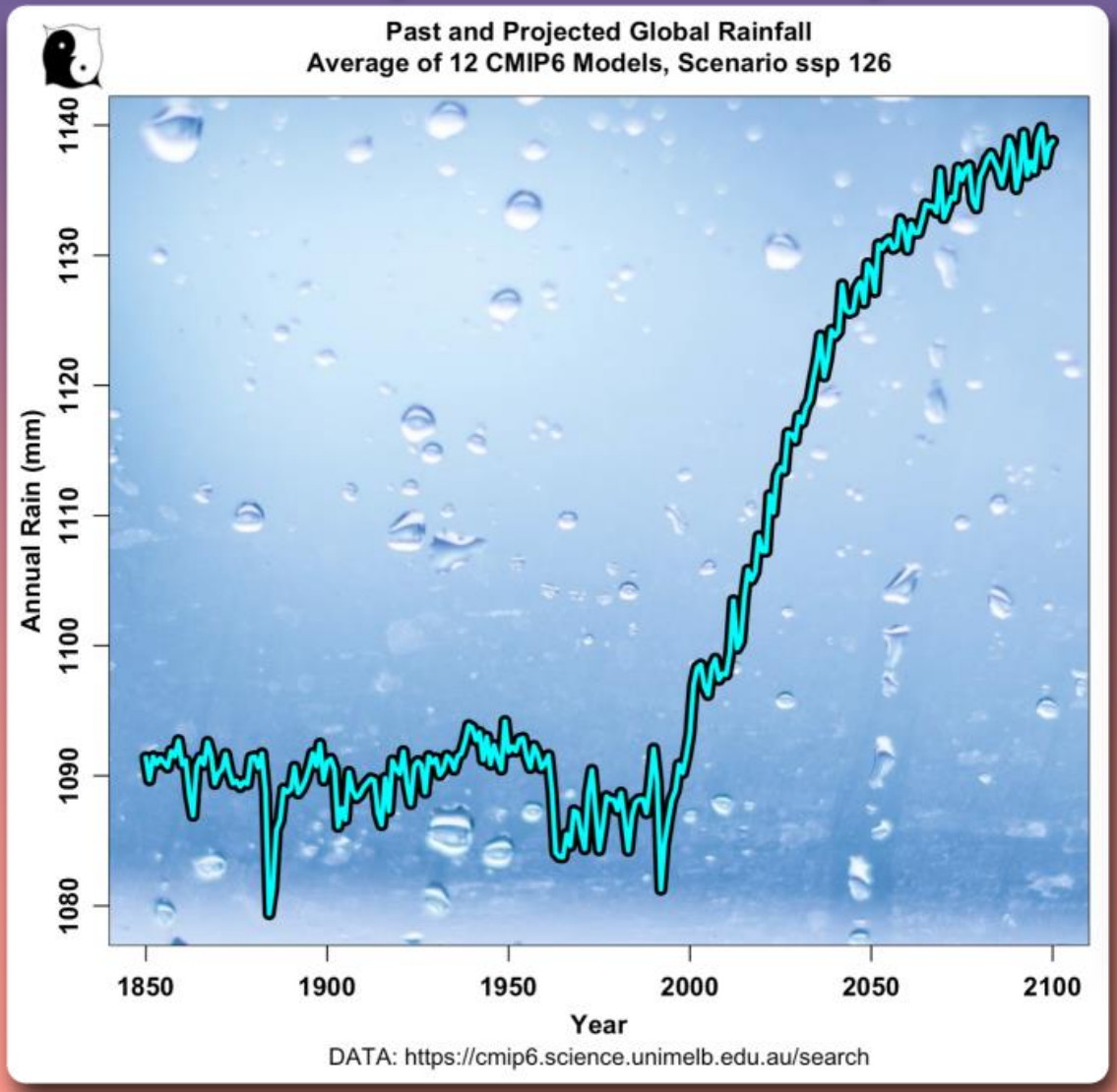
No "greenhouse warming" signature is observed in reality



Source: HadAT2 radiosonde observations, from CCSP (2006), p116, fig. 5.7E

Average global annual precipitation models as shown by 12 CMIP computer models

Unrelated to reality at the time of publication



The past shows:

- Measured changes of T, CO_2, sea level, species turnover, warming events, extreme weather etc today are within long-term variability and are cyclical.
- A large body of validated integrated interdisciplinary earth science is contrary to climate catastrophe projections and conclusions and is ignored.
- Energy policy is based on incomplete data, models, political activism and misleading and deceptive conduct unrelated to science.
- It has never been shown that human emissions of CO_2 drive global warming.
- We will pay dearly for following fools, fashions, fads and frauds.