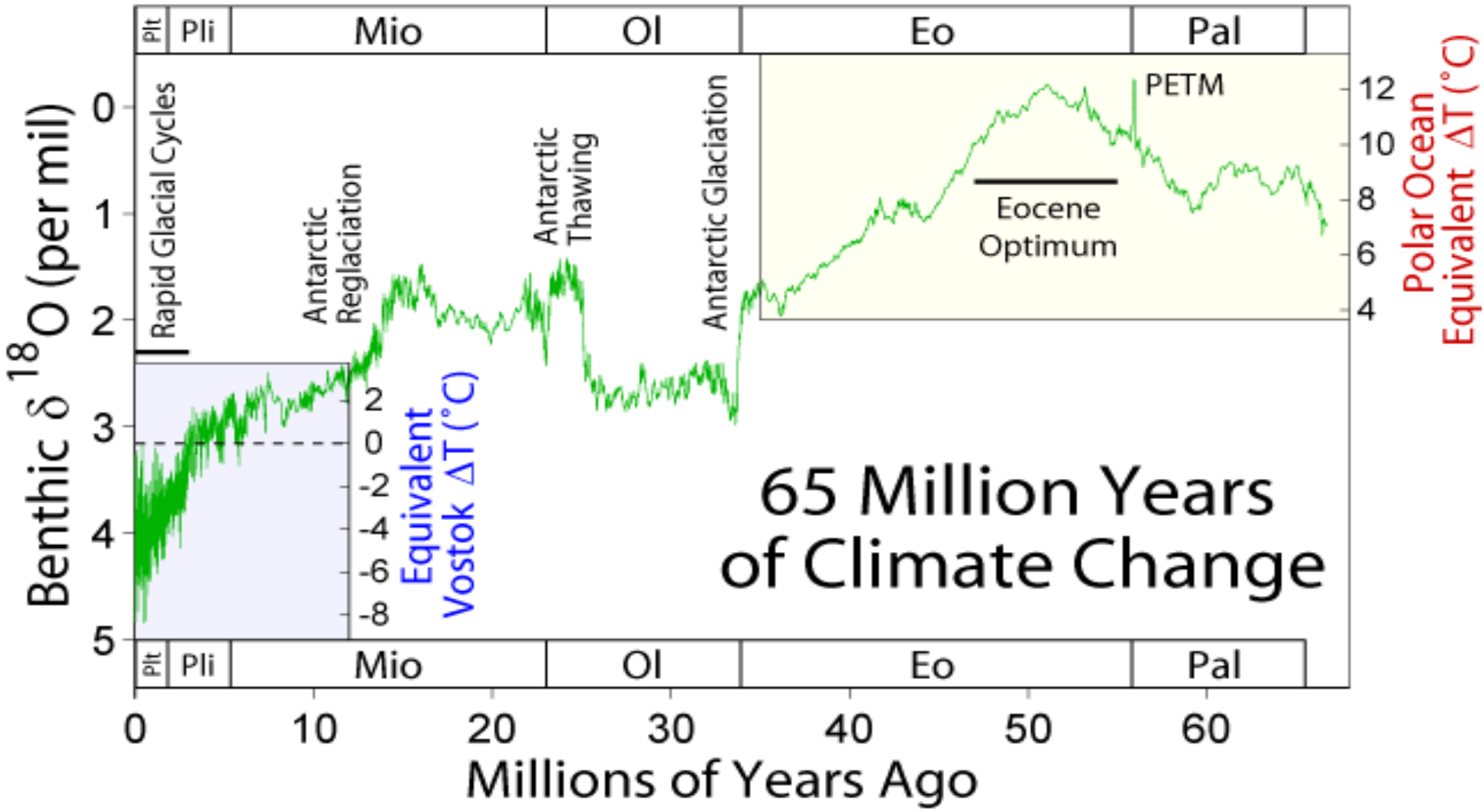
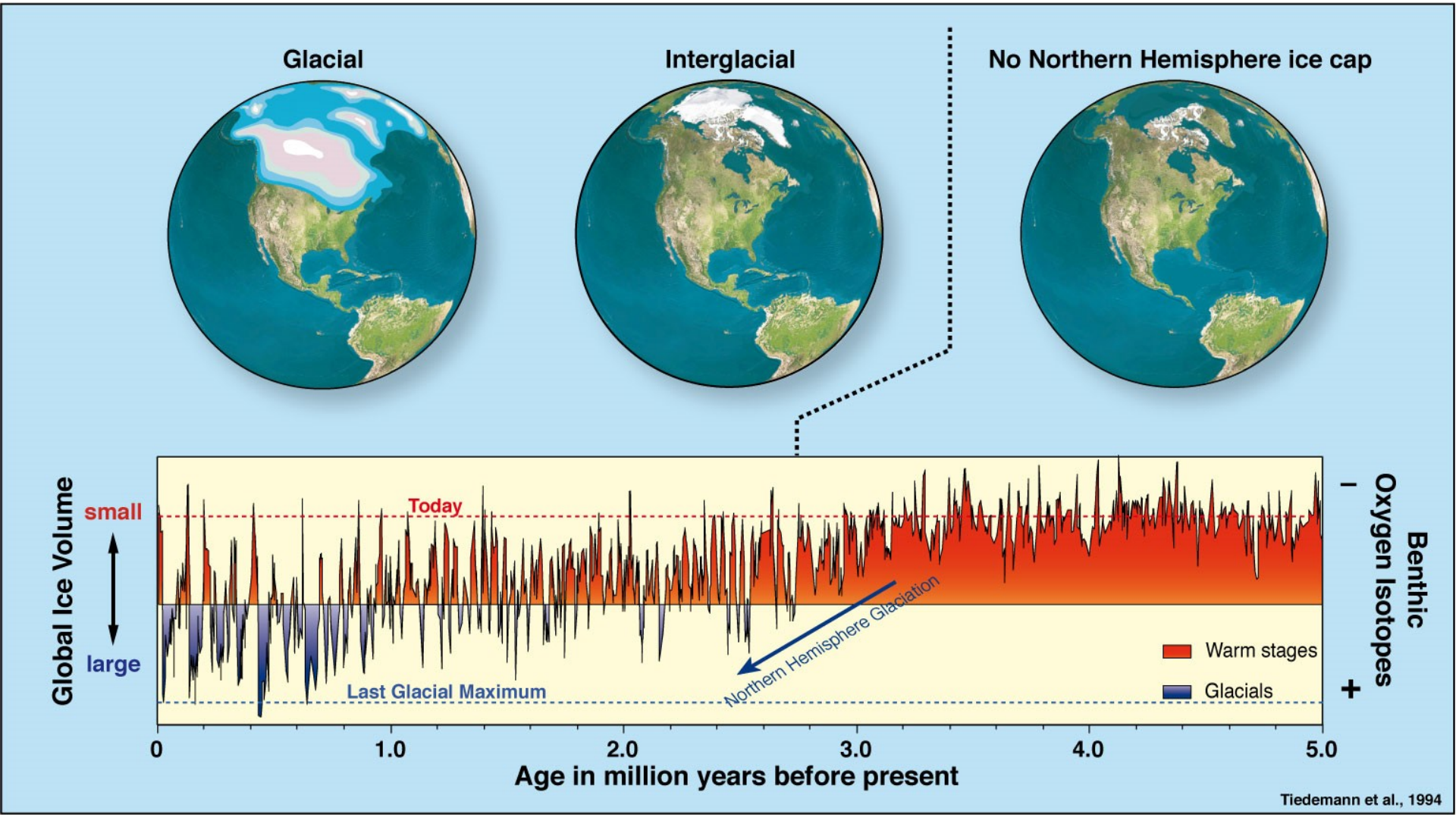
Early man and a changing climate

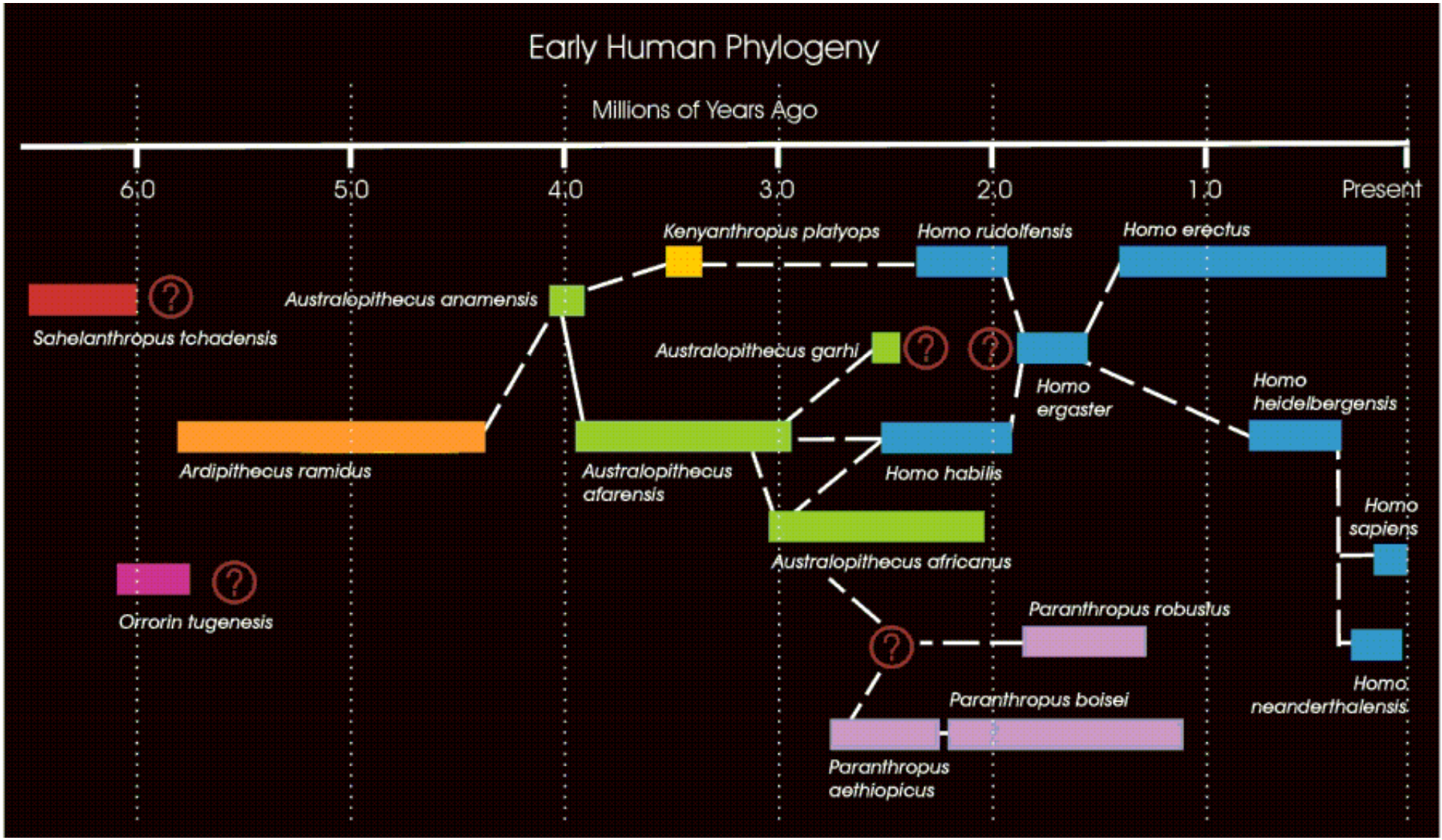

Plt
Pli
Mio
Ol
Eo
Pal
Rapid Glacial Cycles
Antarctic Reglaciation
Antarctic Thawing
Antarctic Glaciation
PETM
Eocene Optimum
Benthic δ18O (per mil)
Equivalent Vostok ΔT (°C)
Polar Ocean Equivalent ΔT (°C)
65 Million Years of Climate Change
Millions of Years Ago

Pliocene and Pleistocene temperatures

(based on $\delta^{18}O$ from Cibicidoides in ocean core)



Tiedemann, Ralf; Sarnthein, Michael; Shackleton, Nicholas J (1994): Astronomic timescale for the Pliocene Atlantic d18O and dust flux records of Ocean Drilling Program site 659. *Paleoceanography*, **9(4)**, 619-638



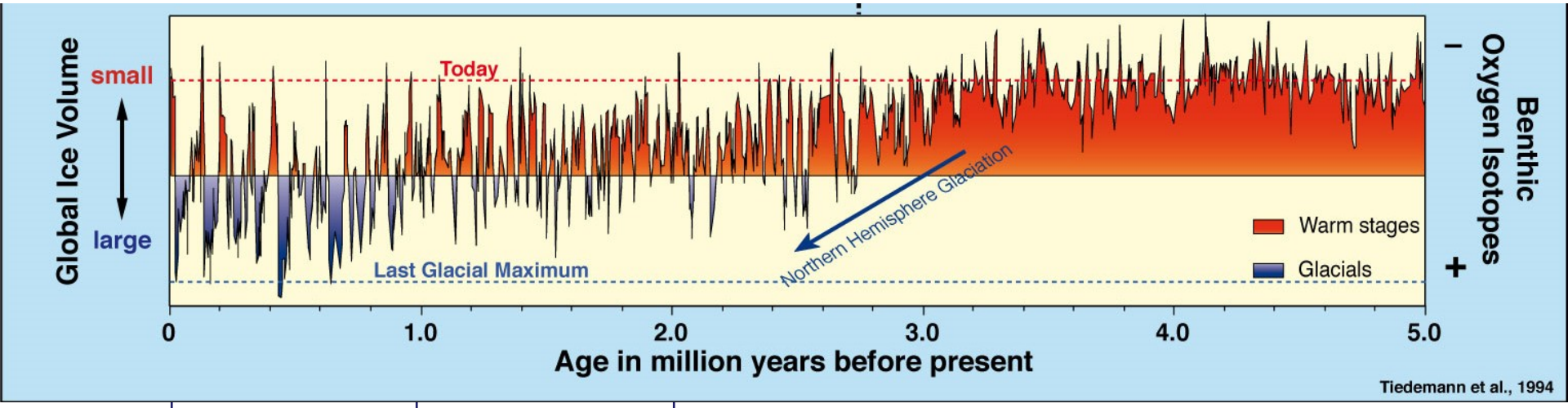
Smithsonian Institute - http://humanorigins.si.edu/ha/a_tree.html

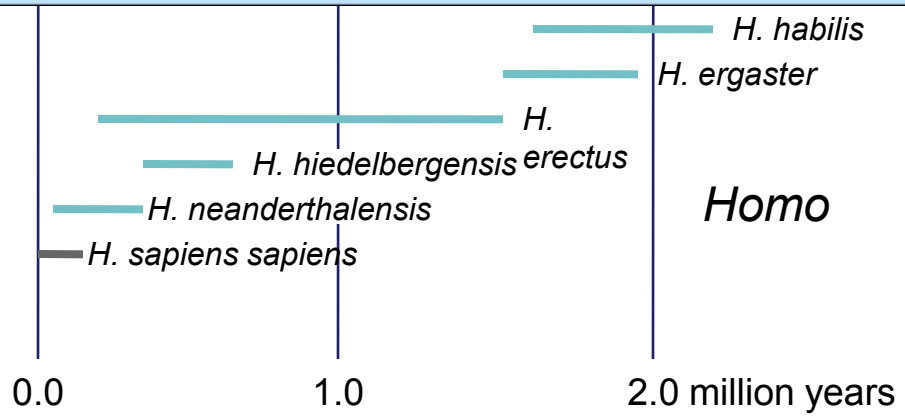
Important members of the genus *Homo*

Homo Species	Lived when (y)	Lived where	Adult height	Adult mass	Brain volume (cm^3)
H. habilis	2,200,000-1,600,000	Africa	1.0–1.5 m	33–55 kg	660
H. erectus	1,400,000-200,000	Africa, Eurasia	1.8 m	60 kg	850 (early) – 1,100 (late)
H. ergaster	1,900,000-1,400,000	Eastern and Southern Africa	1.9 m		700–850
H. heidelbergensis	600,000-350,000	Europe, Africa, China	1.8 m	60 kg	**1,100–1,400**
H. neanderthalensis	350,000-30,000	Europe, Western Asia	1.6 m	55–70 kg (heavily built)	**1,200–1,900**
H. sapiens sapiens	200,000-0	Worldwide (but remained in Africa until 50 ka)	1.4–1.9 m	50–100	**1,000–1,850**

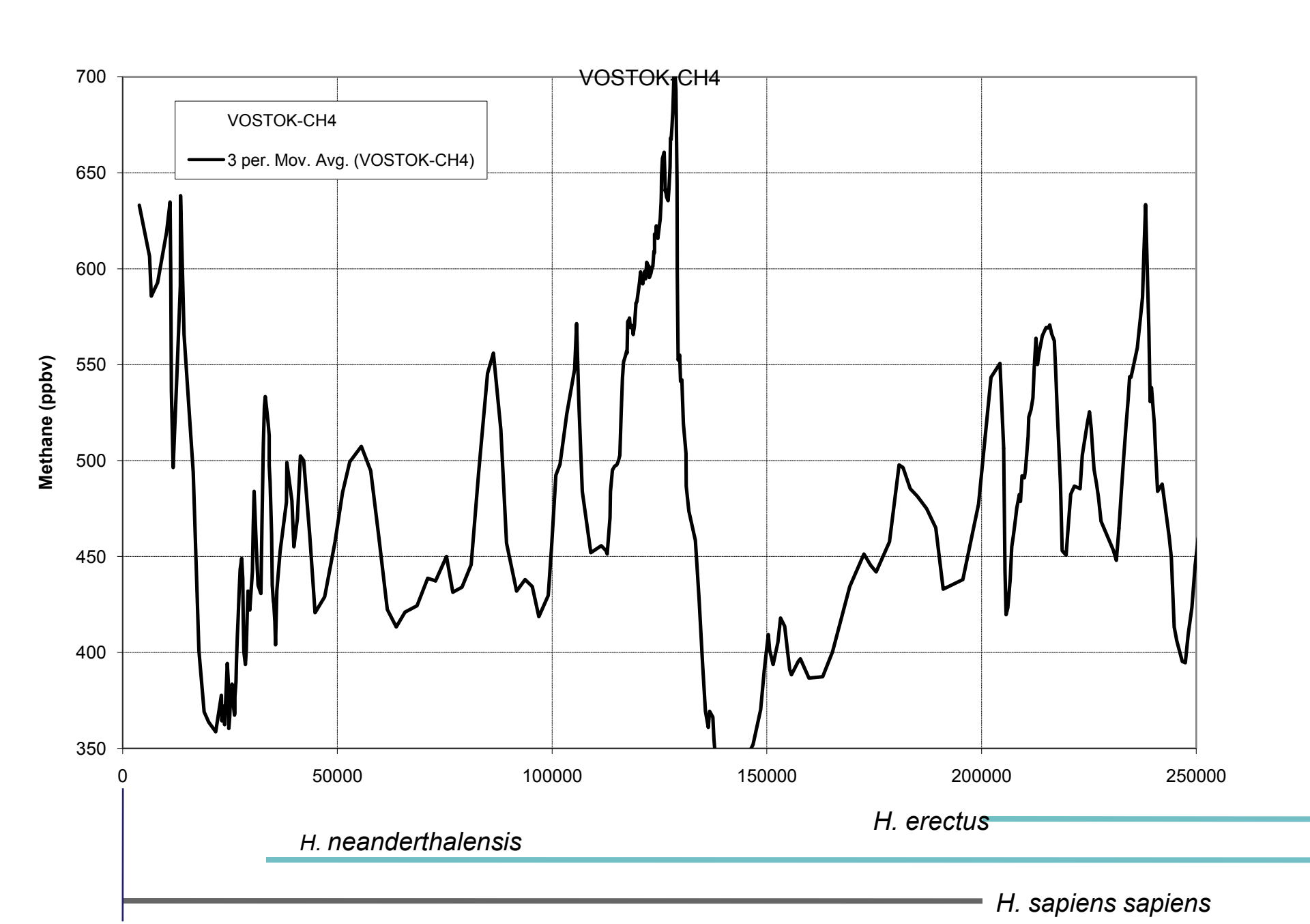
Pliocene and Pleistocene temperatures

(based on $\delta^{18}O$ from Cibicidoides in ocean core)



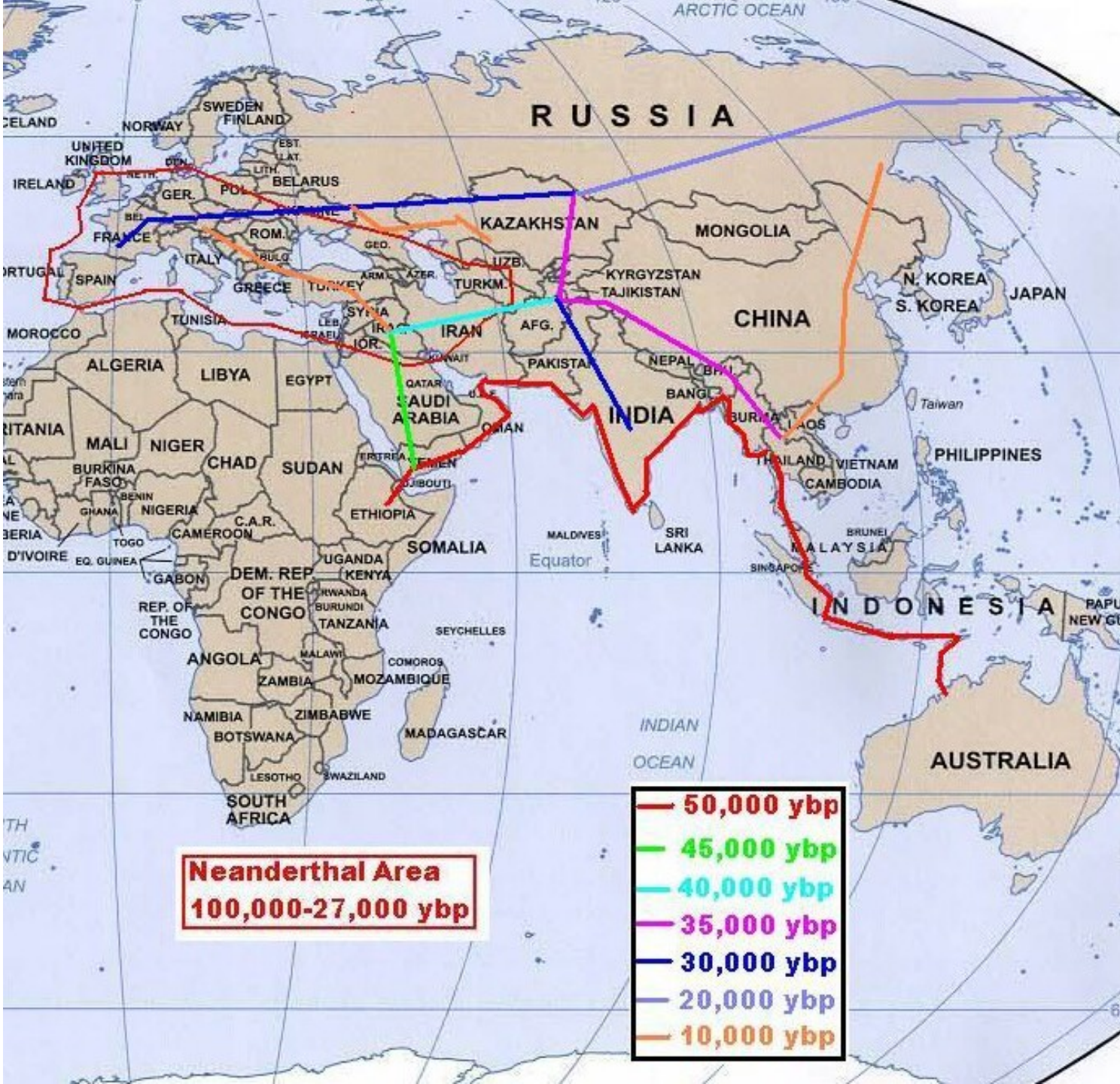


Tiedemann, R; Sarnthein, M; Shackleton, N (1994): Astronomic timescale for the Pliocene Atlantic d18O and dust flux records of Ocean Drilling Program site 659. *Paleoceanography*, **9(4)**, 619-638

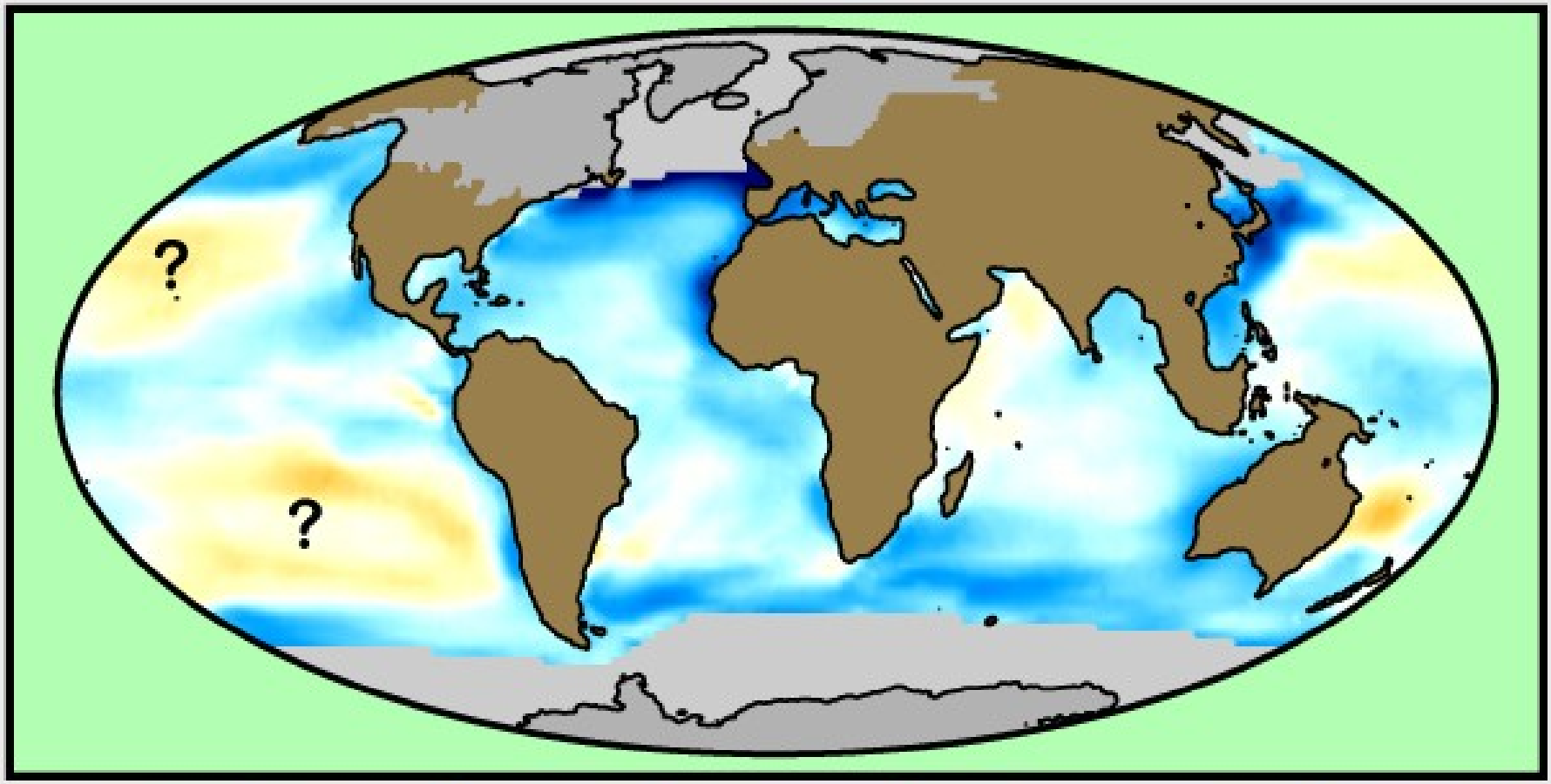

VOSTOK-CH4
VOSTOK-CH4
3 per. Mov. Avg. (VOSTOK-CH4)
Methane (ppbv)
700
650
600
550
500
450
400
350
0
50000
100000
150000
200000
250000
H. erectus
H. neanderthalensis
H. sapiens sapiens

Migrations of Homo sapiens

(from L. David Roper, U. Of Vermont)



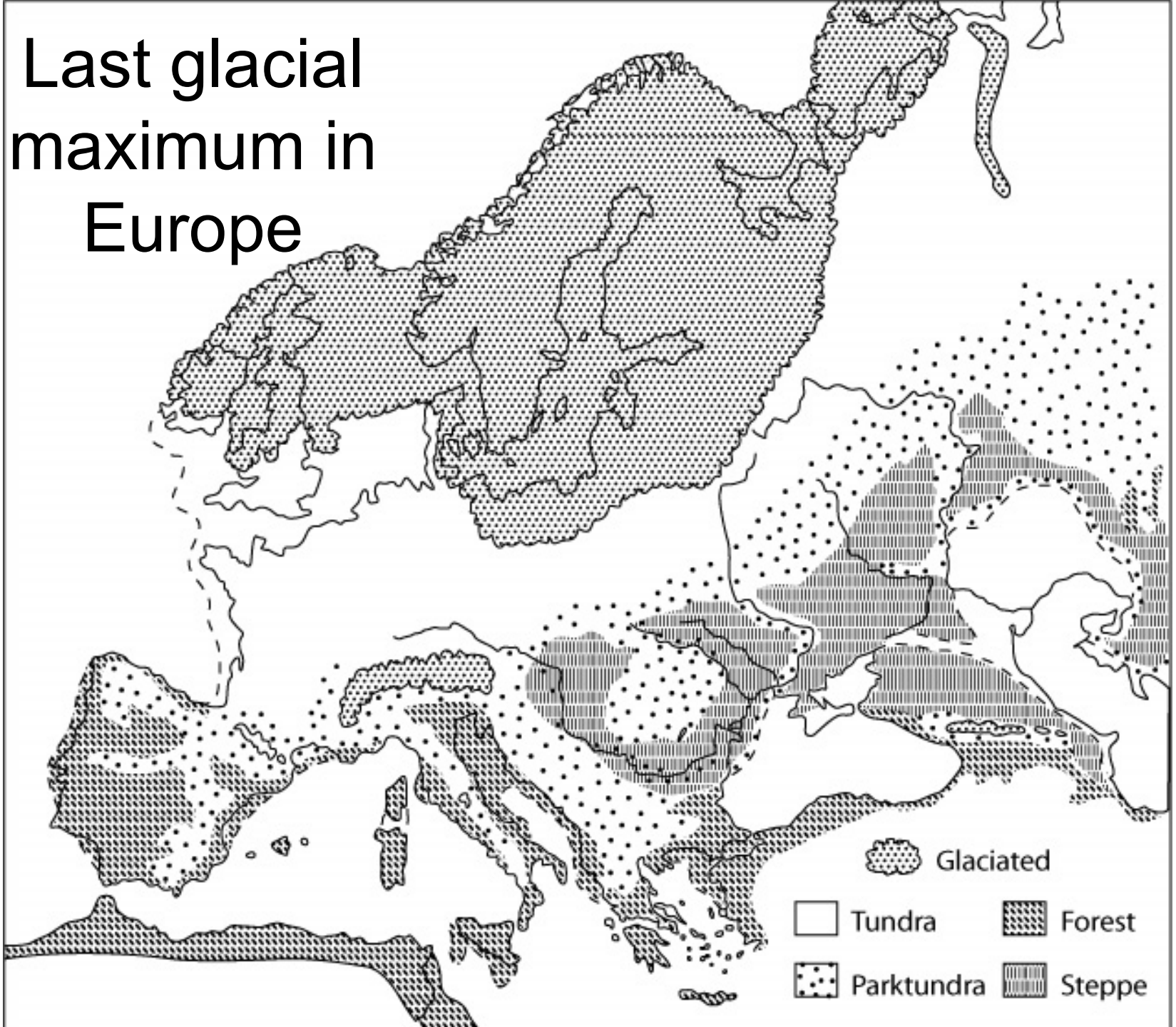
CLIMAP: The Last Glacial Maximum



-10 -8 -6 -4 -2 0 2 4

Temperature Difference (˚C)

Last glacial maximum in Europe



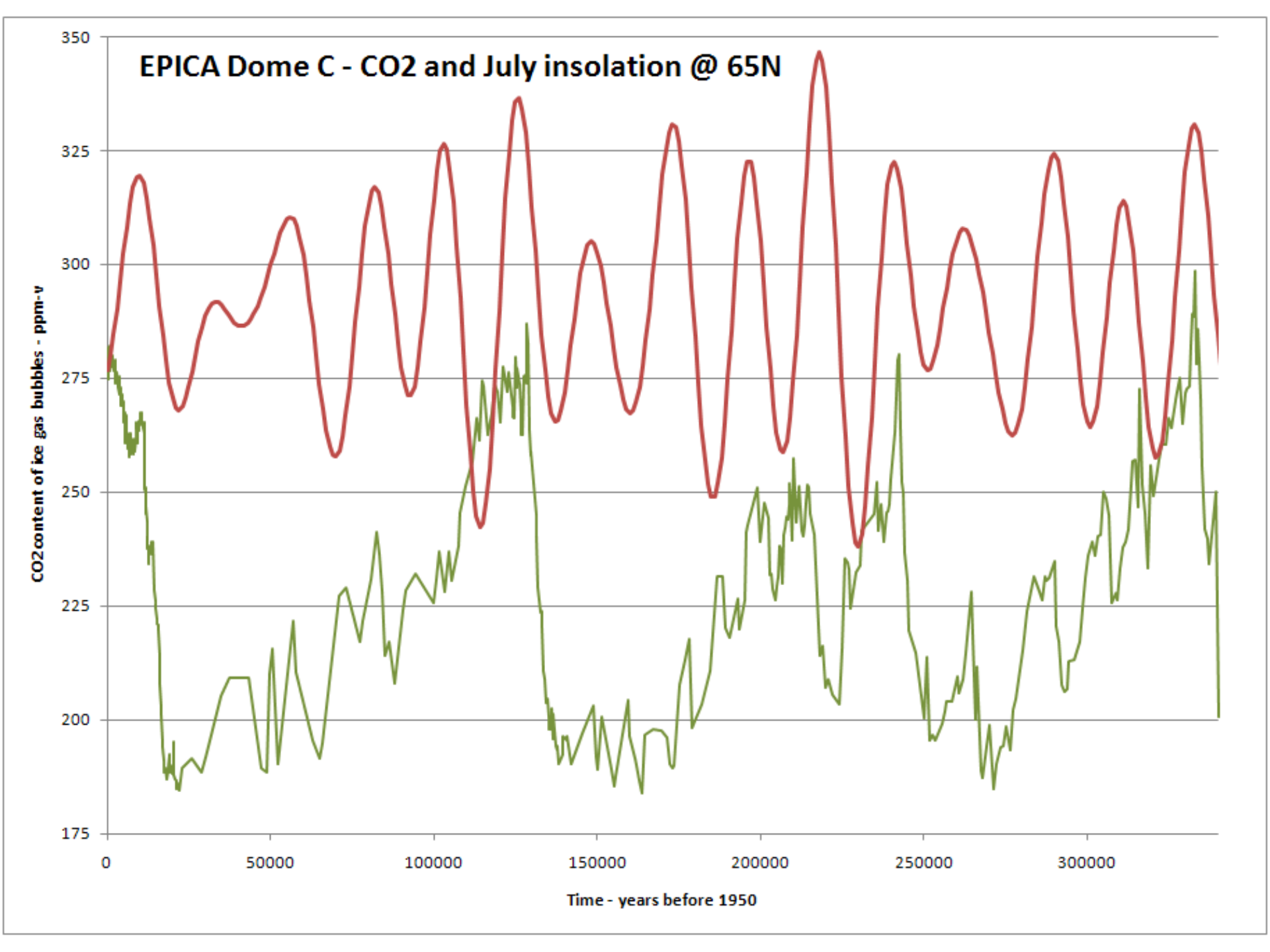
Human Activities and Climate Change

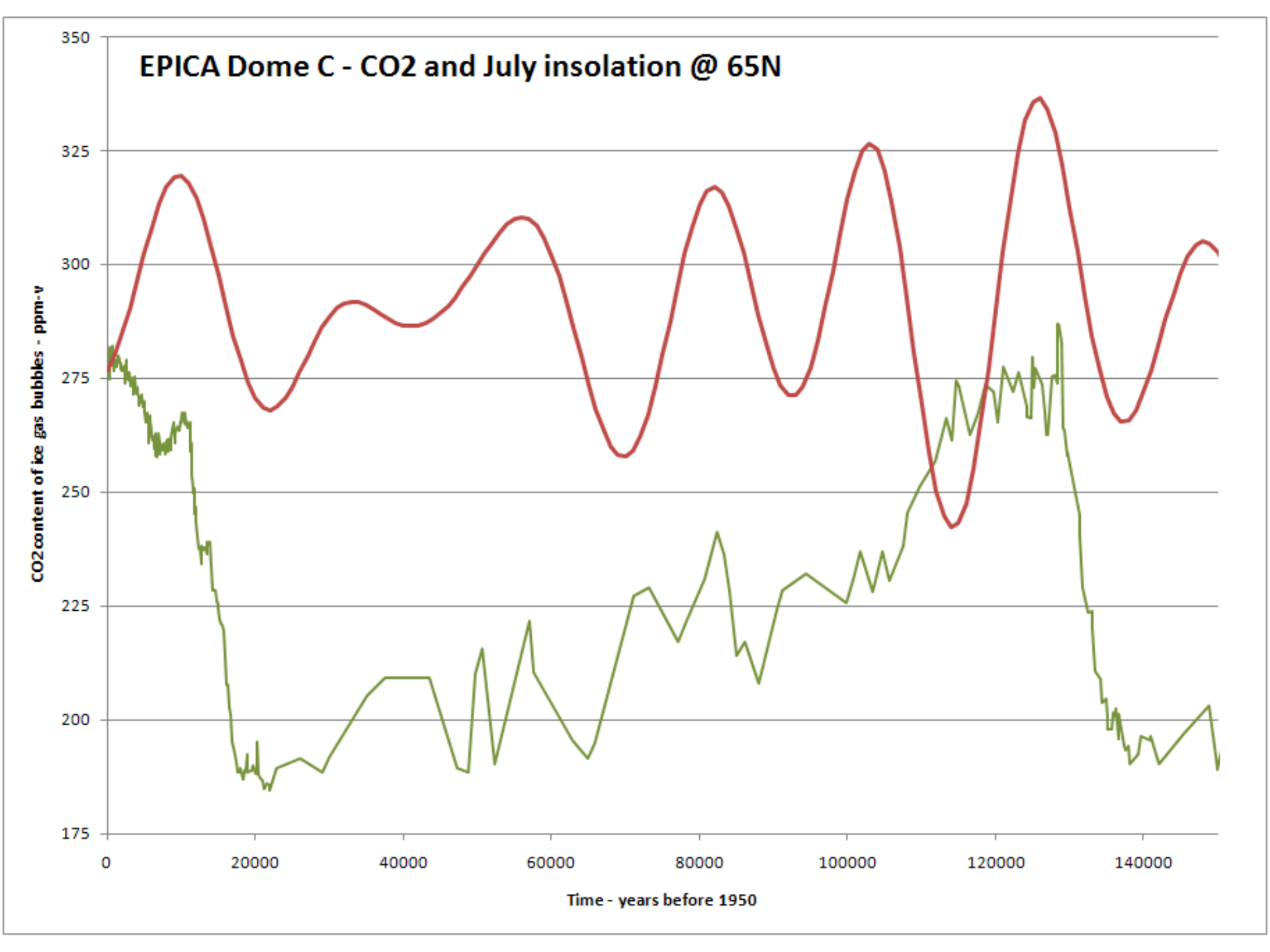
HOW DID HUMANS FIRST ALTER GLOBAL CLIMATE?

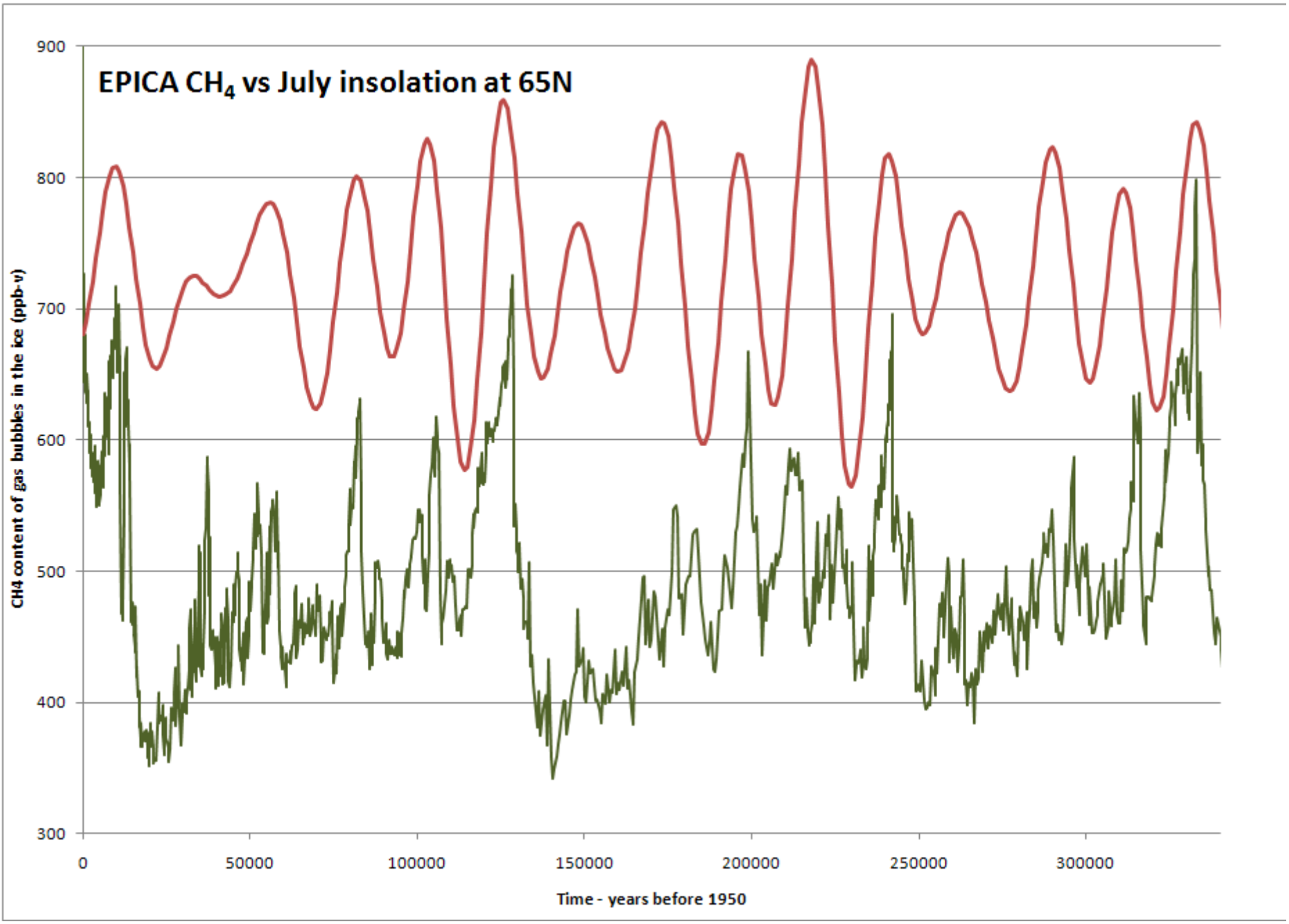
A bold new hypothesis suggests that our ancestors' farming practices kicked off global warming thousands of years before we started burning coal and driving cars

By William F. Ruddiman

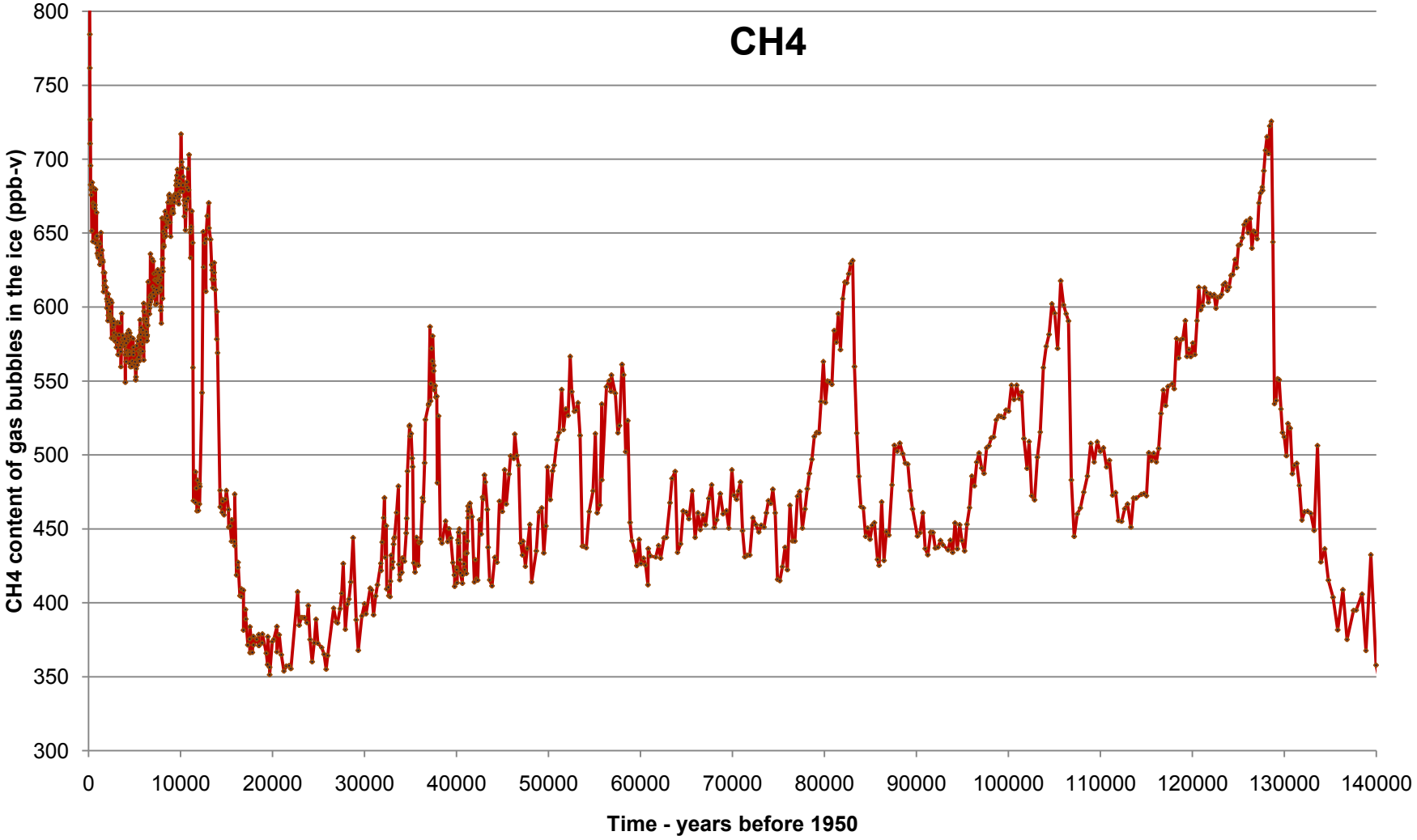
Scientific American, March 2005


EPICA Dome C - CO2 and July insolation @ 65N
CO2 content of ice gas bubbles - ppm-v
350
325
300
275
250
225
200
175
0
50000
100000
150000
200000
250000
300000
Time - years before 1950

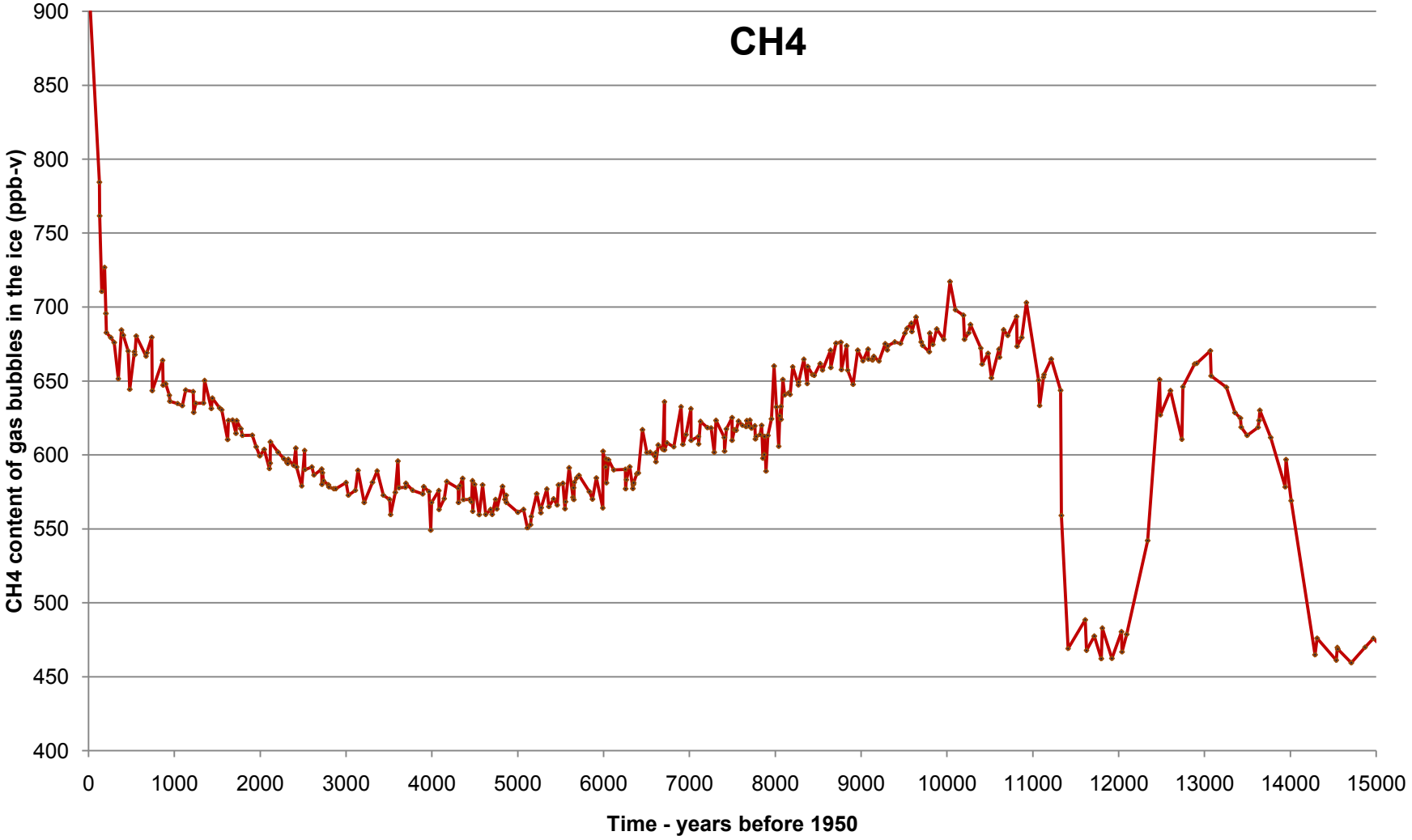

EPICA Dome C - CO2 and July insolation @ 65N
CO2 content of ice gas bubbles - ppm-v
350
325
300
275
250
225
200
175
0
20000
40000
60000
80000
100000
120000
140000
Time - years before 1950


EPICA CH4 vs July insolation at 65N
CH4 content of gas bubbles in the ice (ppb-v)
900
800
700
600
500
400
300
0
50000
100000
150000
200000
250000
300000
Time - years before 1950

EPICA CH_4


CH4
CH4 content of gas bubbles in the ice (ppb-v)
800
750
700
650
600
550
500
450
400
350
300
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
130000
140000
Time - years before 1950

EPICA CH_4


CH4
CH4 content of gas bubbles in the ice (ppb-v)
900
850
800
750
700
650
600
550
500
450
400
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
Time - years before 1950

Human Activities and Greenhouse Gases

11,000 years ago: Early peoples invent agriculture in Mesopotamia and China

Paleolithic sickle blade

Carbonized wheat

8,000 years ago: Late Stone Age Europeans begin clearing forests to grow wheat, barley, peas and other nonindigenous crop plants

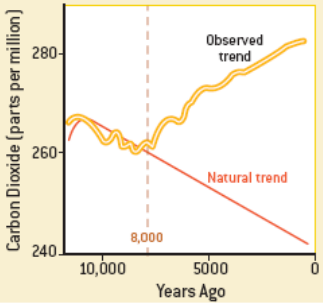
5,000 years ago: Farmers in the south of China begin flooding lowlands near rivers to grow rice

2,000 years ago: Europe, India, Southeast Asia and China have cleared much of their natural forest cover to grow crops such as wheat

200 years ago: Combustion of fossil fuels and accelerating deforestation result in unprecedented releases of greenhouse gases

Otto engine

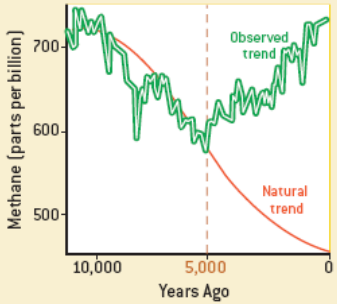
10,000 YEARS AGO | **8,000 YEARS AGO** | **6,000 YEARS AGO** | **4,000 YEARS AGO** | **2,000 YEARS AGO** | **PRESENT**



8,000 years ago: CO_2 trend, which has been falling for 2,500 years, bottoms out and suddenly reverses direction

7,500 years ago: Humans adapt wild rice for cultivation

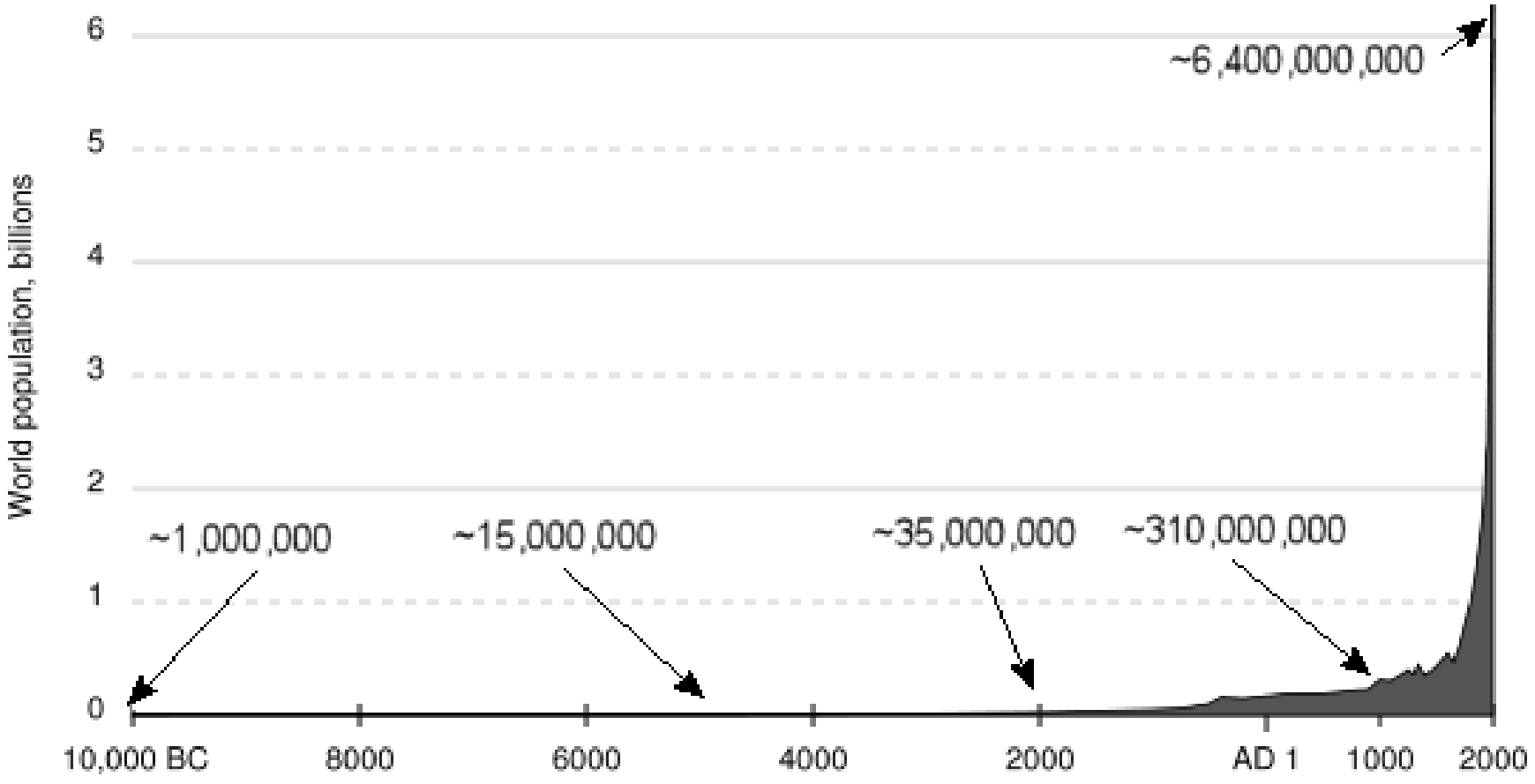
5,000 years ago: Methane trend, which has been falling for 6,000 years, suddenly reverses direction



2,000 years ago: Farmers in Southeast Asia begin to construct terraced rice paddies on steep hillsides

Global population – 10 ka

7,000,000,000
by late 2012



Human Activities and Greenhouse Gases

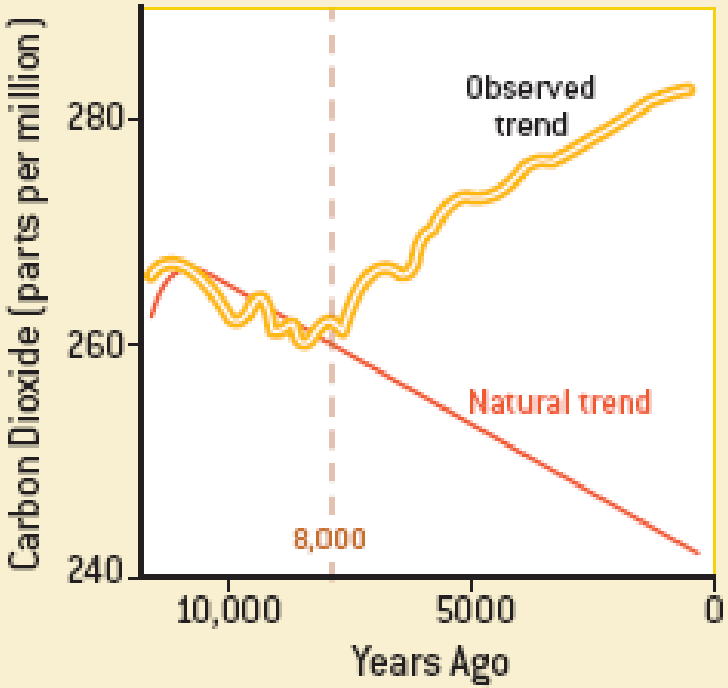
11,000 years ago: Early peoples invent agriculture in Mesopotamia and China

Paleolithic sickle blade

Carbonized wheat

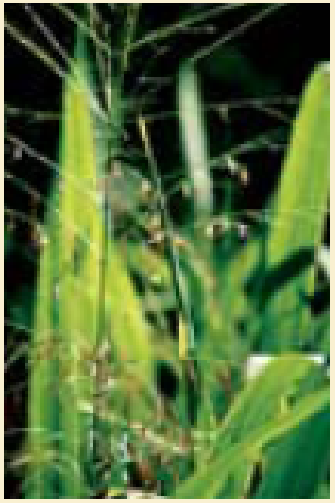
8,000 years ago: Late Stone Age Europeans begin clearing forests to grow wheat, barley, peas and other nonindigenous crop plants

10,000 YEARS AGO — **8,000 YEARS AGO**



8,000 years ago: CO_2 trend, which has been falling for 2,500 years, bottoms out and suddenly reverses direction

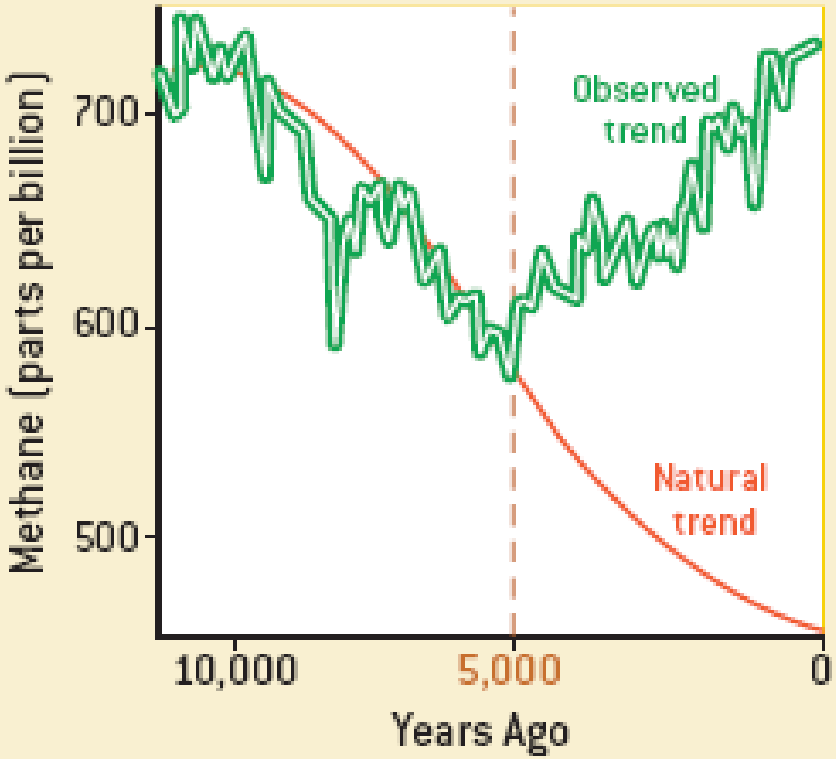
7,500 years ago: Humans adapt wild rice for cultivation

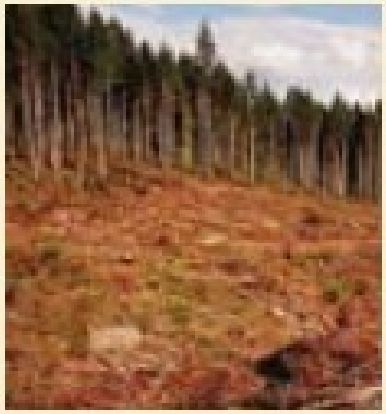


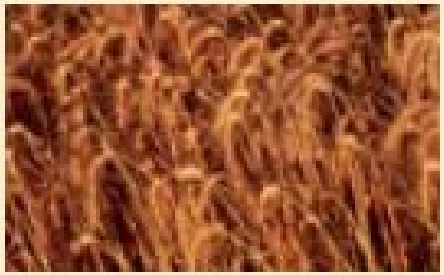
5,000 years ago: Farmers in the south of China begin flooding lowlands near rivers to grow rice

6,000 YEARS AGO | **4,000 YEARS AGO**

5,000 years ago: Methane trend, which has been falling for 6,000 years, suddenly reverses direction







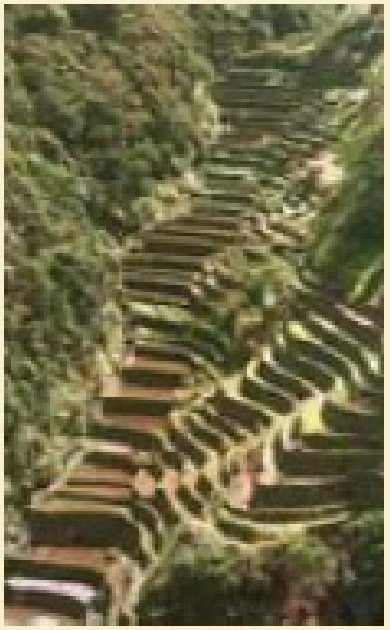
2,000 years ago: Europe, India, Southeast Asia and China have cleared much of their natural forest cover to grow crops such as wheat

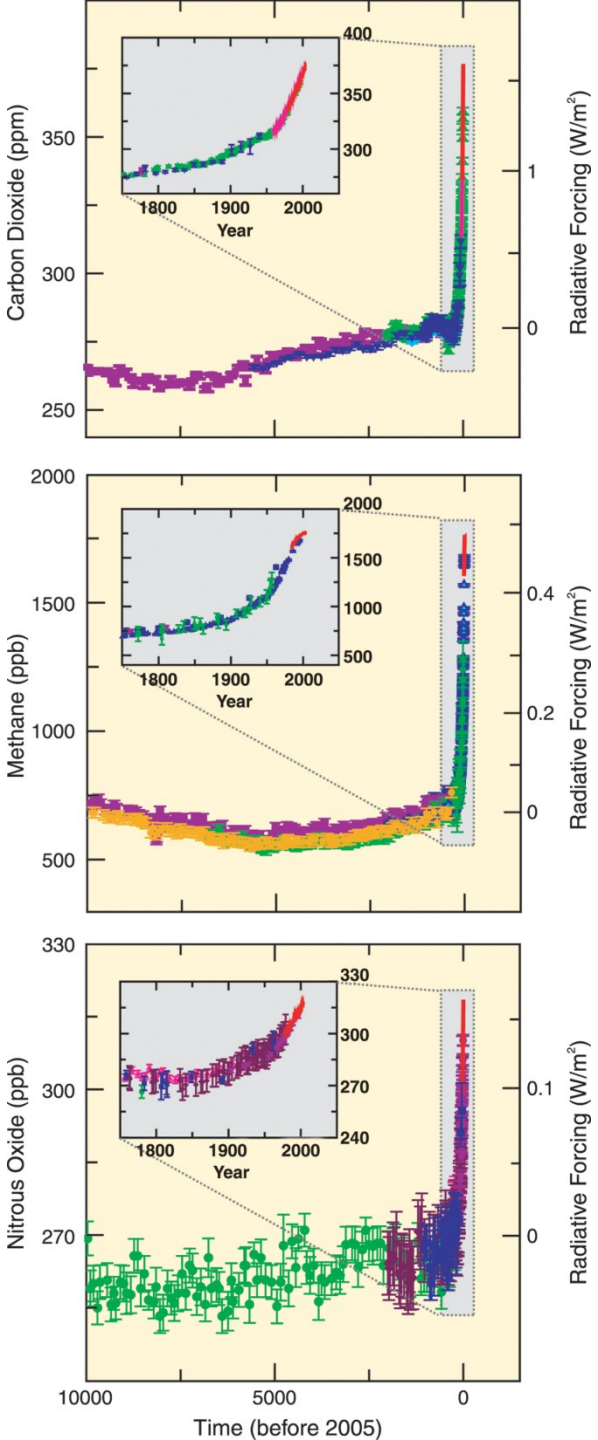
200 years ago: Combustion of fossil fuels and accelerating deforestation result in unprecedented releases of greenhouse gases

Otto engine

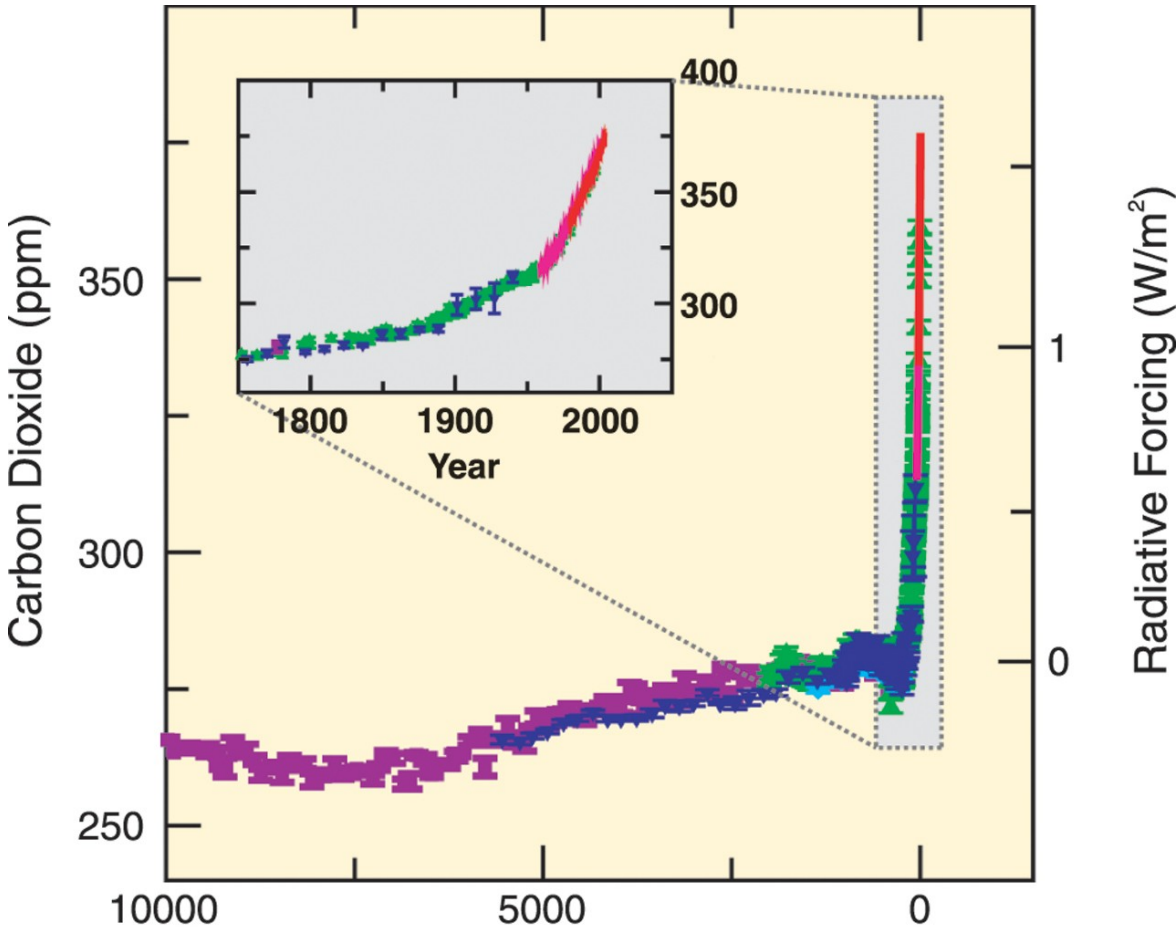
2,000 YEARS AGO — **PRESENT**

2,000 years ago: Farmers in Southeast Asia begin to construct terraced rice paddies on steep hillsides

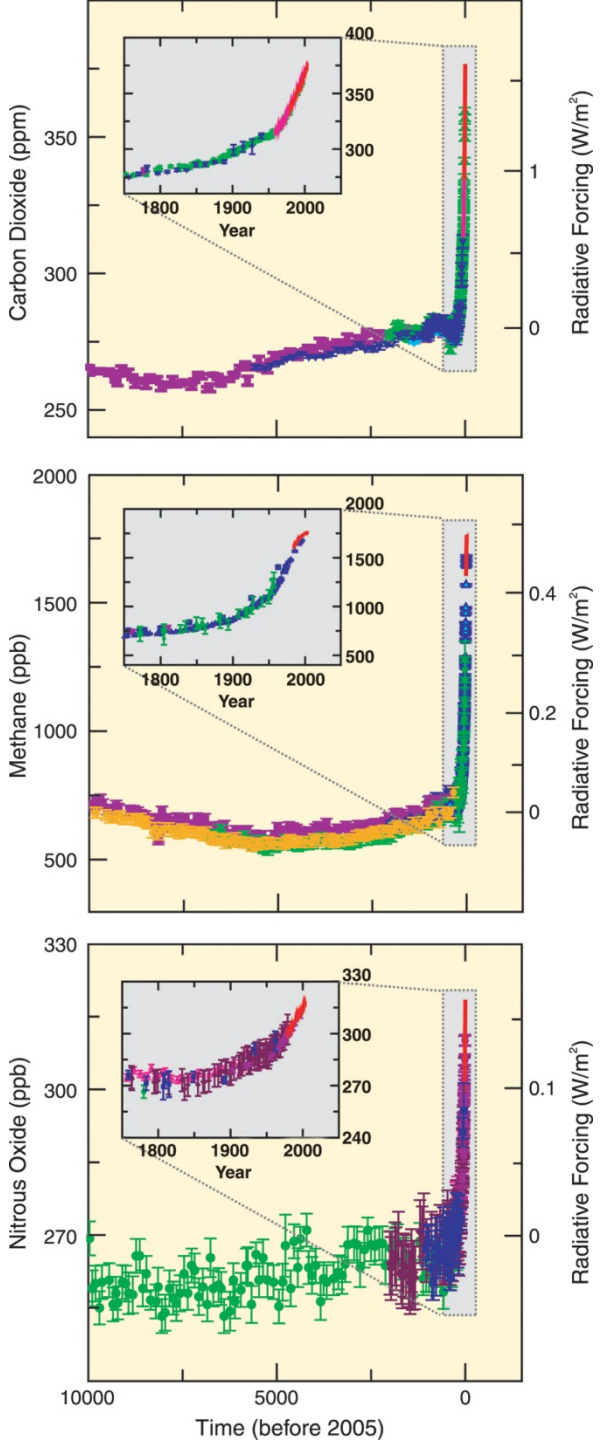




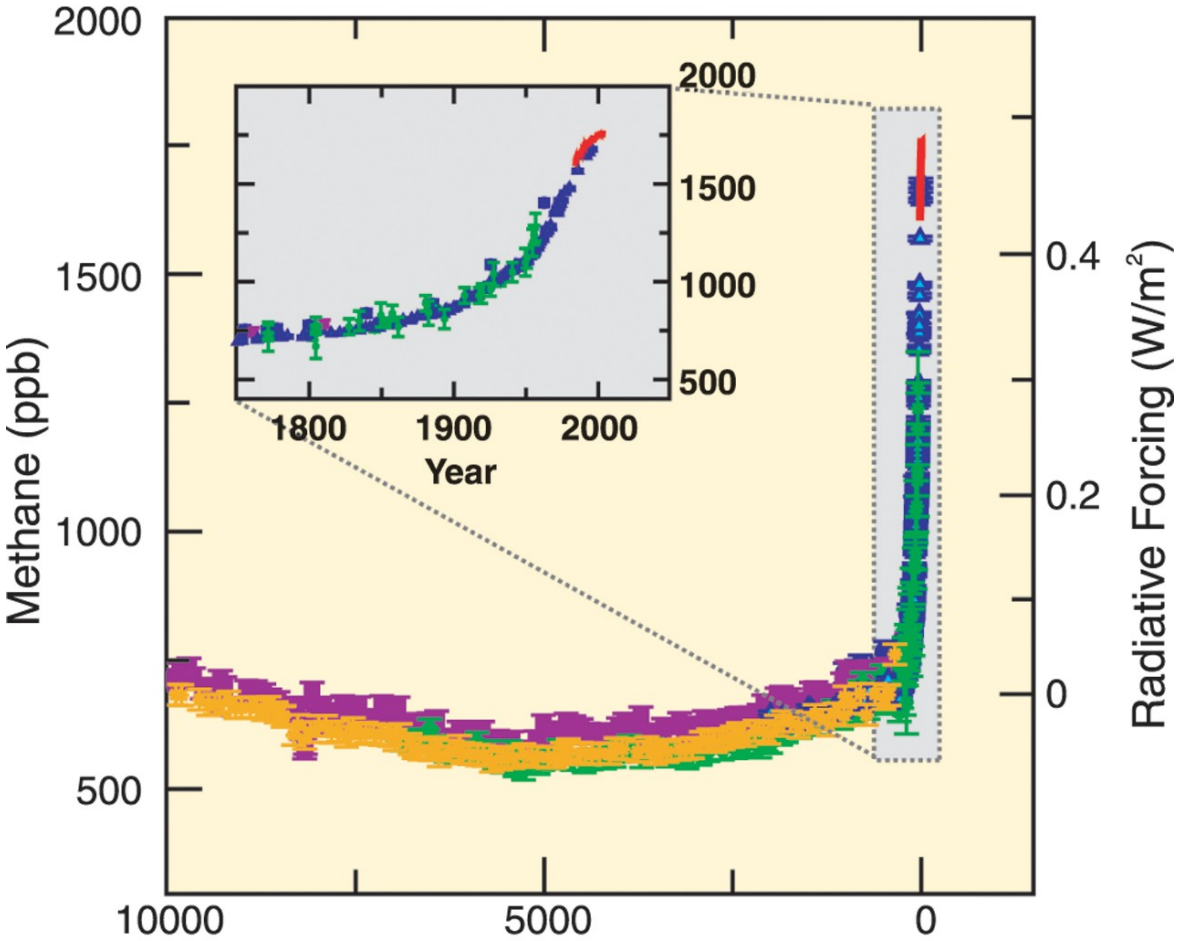
CO_2



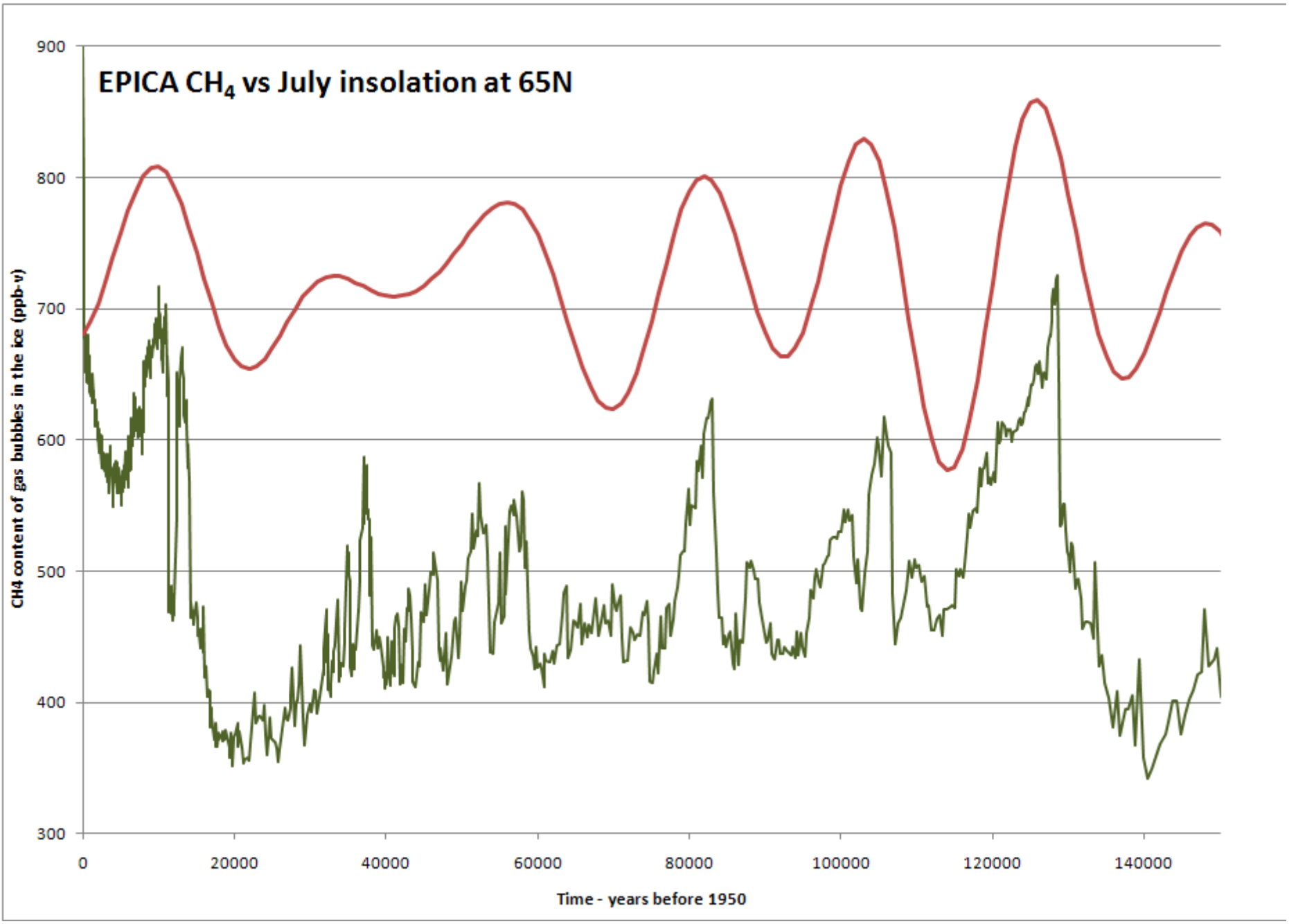
IPCC 2007



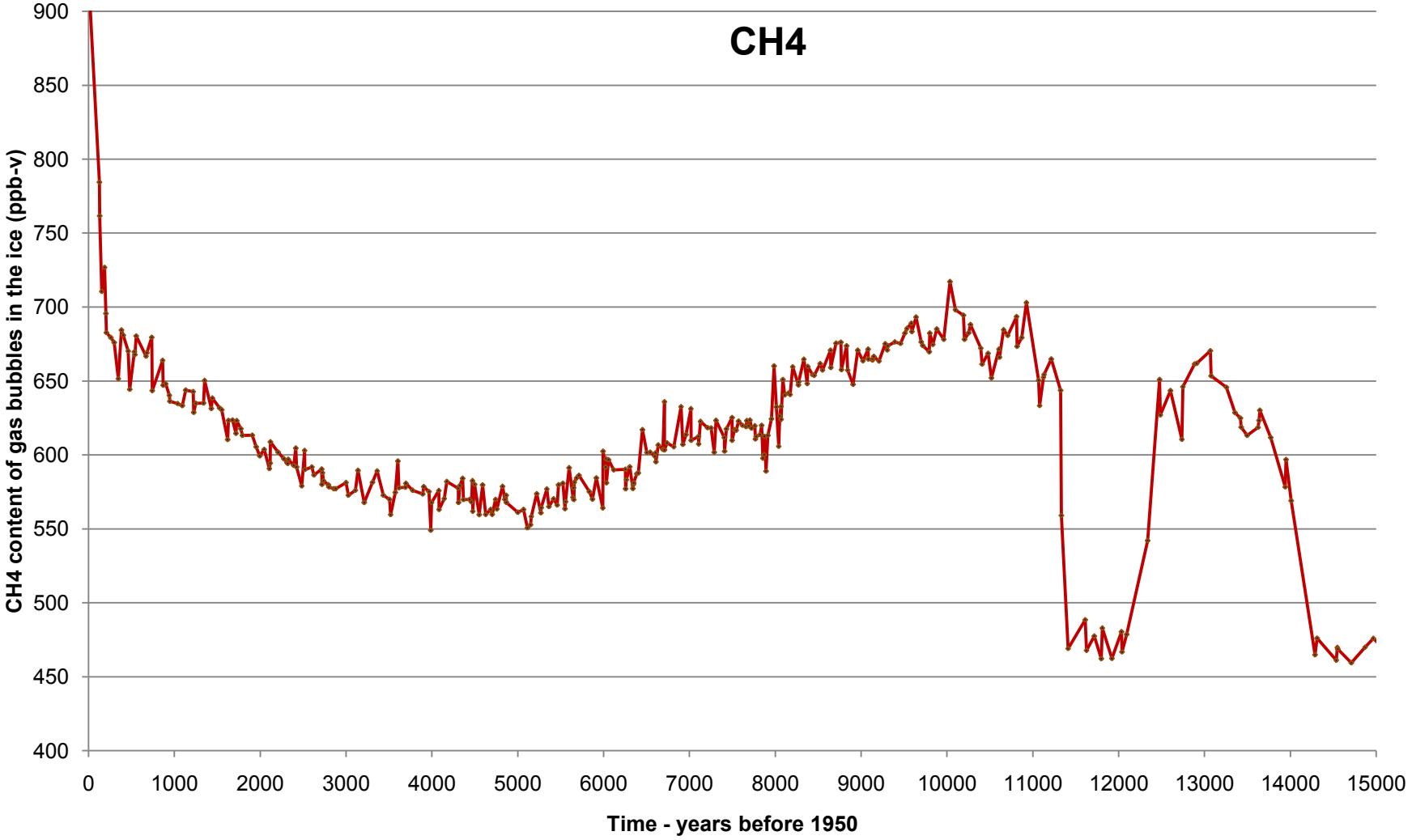
CH_4



IPCC 2007


EPICA CH_4 vs July insolation at 65N
CH4 content of gas bubbles in the ice (ppb-v)
900
800
700
600
500
400
300
0
20000
40000
60000
80000
100000
120000
140000
Time - years before 1950

EPICA CH_4


CH4
CH4 content of gas bubbles in the ice (ppb-v)
900
850
800
750
700
650
600
550
500
450
400
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
Time - years before 1950