Are we ready for Global Cooling?

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Dows Lake Toastmasters Presentation
14 March 2006

from "Climate Change: What Makes Sense?: A critical review of the challenges and options for the future" June 2004 (never completed, published)

Starter questions: **(true or false and why)**

What do you think is the "current, prevailing" opinion in Canada?

1. If not for mankind, temperatures and greenhouse gases (GHGs) would stabilize to their "natural" levels.

2. Temperatures today are about as high as they ever have been since life began Earth, and higher than they have been since civilization began.

3. What is, BY FAR, the most important GHG?

4. Industrialization has driven greenhouse gases (GHGs) to levels higher than they have ever been.

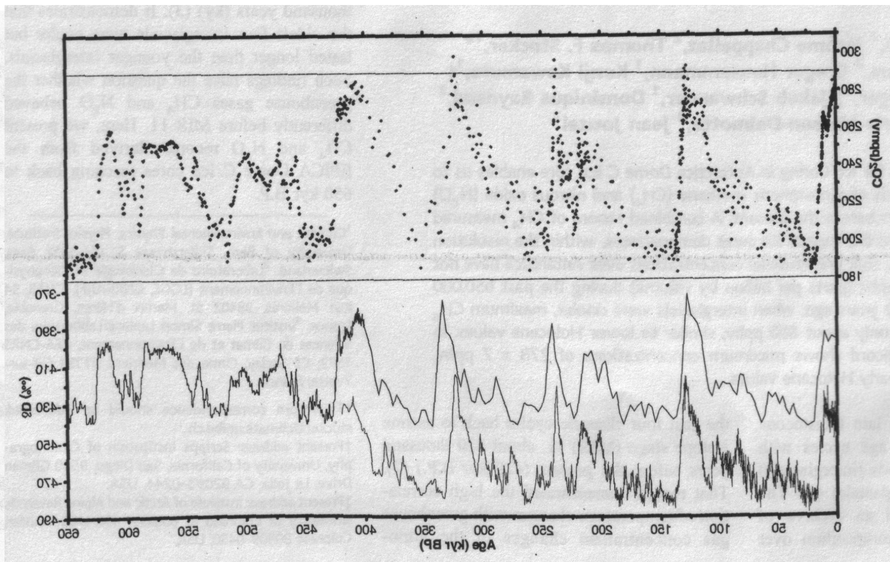
Some popular misconceptions (contentious)	
climate is "naturally stable"	climate always has changed, it is changing, and it always will change,...irrespective of anthropogenic effects
recent temperature changes are large	recent and projected T changes due to anthropogenic effects are modest in scale and rapidity compared to "natural" changes across all timescales
CO2 is the most important GHG	Water vapour is, by far. (plus ice, cloud) CO2 concentrations have >10 times higher during our Phanerozoic (last 570 My).
CO2 correlates with temperature since ~1850	Other than a general rise in both variables, CO2 does NOT correlate very well with T (solar irradiance does)!!!
CO2 drives temperature	**Temperature drives CO2!!!** but perhaps there is a "minor extra delta-T" in the last 20 or 30 years?
the "precautionary principle" demands radical action to combat global warming	Adaptation continues to be the key response by mankind – as it always has been! **Probability of radical cooling compared to warming!?!**

Glacial Period

EPICA ice cores, Antarctica - Temperature, CO2

(graph flipped to show time increasing to the right)

Fig. 4. A composite CO_2 record over six and a half ice age cycles, back to 650,000 years B.P. The record results from the combination of CO_2 data from three Antarctic ice cores: Dome C (black), 0 to 22 kyr B.P. (*9*, *11*) and 390 to 650 kyr B.P. [this work including data from 31 depth intervals over termination V of (*1*)]; Vostok (blue), 0 to 420 kyr B.P. (*5*, *7*), and Taylor Dome (light green), 20 to 62 yr B.P. (*8*). Black line indicates δD from Dome C, 0 to 400 kyr B.P. (*1*) and 400 to 650 kyr B.P. (*18*). Blue line indicates δD from Vostok, 0 to 420 kyr B.P. (*7*).



Temperatures- the last 1,000 years

J. Veizer "Celestial climate driver: a perspective from four billion years of the carbon cycle" Geoscience Canada, vol 32, no 1, pp13-27, 2005. CAVEAT: gas diffusion effects in glaciers
(a) solar cycle length (b) cosmic ray flux © solar irradiance (e) atmospheric [CO2]

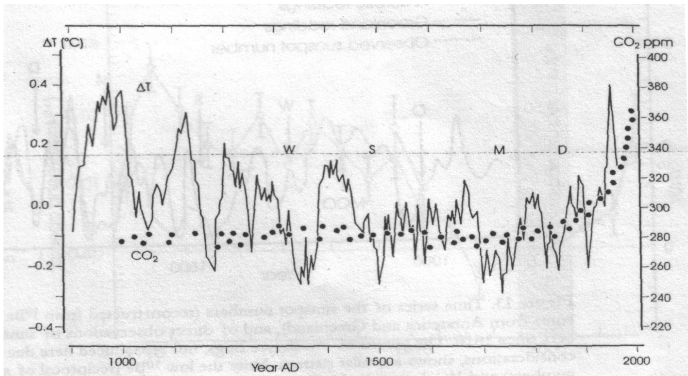
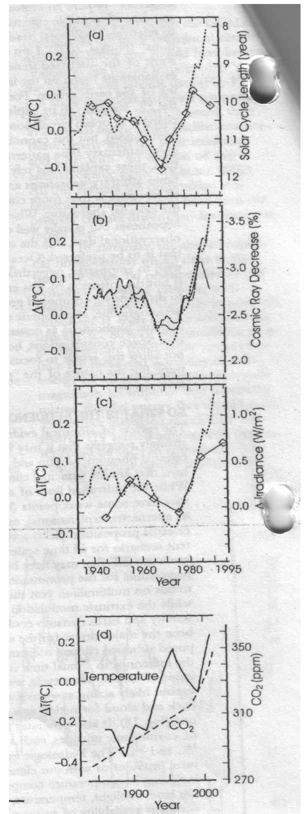


Figure 12. The temperature change (ΔT) and CO_2 records of the last millennium from a Greenland ice core (GISP2). Temperature was calculated from the 50 year smoothed record as T(°C) = 0.6906 δ^{18}O–13.68. The δ^{18}O database is available at ftp://ftp.ngdc.noaa.gov/paleo/icecore/greenland/summit/gisp2/isotopes/d18o1yr.txt. The detailed structure showing the coincidence of cold intervals with sun activity minima (W to D; Wolf, Spörer, Maunder, Dalton) may or may not be statistically valid because of the noisy nature of the proxy signals, but the overall trend is confirmed also by the borehole temperature profiles (Dahl-Jensen et al., 1998). Adapted from Berner and Streif (2000).



Solar irradiance – last 400 years

K. Tapping, D. Boteler, P. Charbonneau, A. Church, A. Manson, H. Paquette "Modelling solar magnetic activity and irradiance variability from the Maunder minimum to the present", unpublished draft presentation ?Jan06?

(Slide deleted - might not be published yet)

Back to Cooling?

- Chances are, the temperature will go down in fits and starts into the next ice age.
- During ~Richard Nixon's Presidential era, global cooling was a concern (there was a cooling trend from ~1940-1975, even while CO_2 emissions were rapidly rising).
- While perceptions over the last 15 years have emphasized global warming (highest solar irradiance in 7 ky?), many scientists are revisiting the global cooling threat.
- Apparently a Russian scientist predicts we'll enter a Maunder-like minimum, starting in 7-10 years, which might take ~30 to 50 years to develop.

Influenza pandemics and solar activity

K. Tapping, unplublished

(Slide deleted - might not be published yet)

Influenza pandemics & solar phase

K.F. Tapping, R.G. Mathias, D.L. Surkan, Canadian J. Infectious Diseases, vol 12, no 1, pp 61-62, Jan-Feb 2001

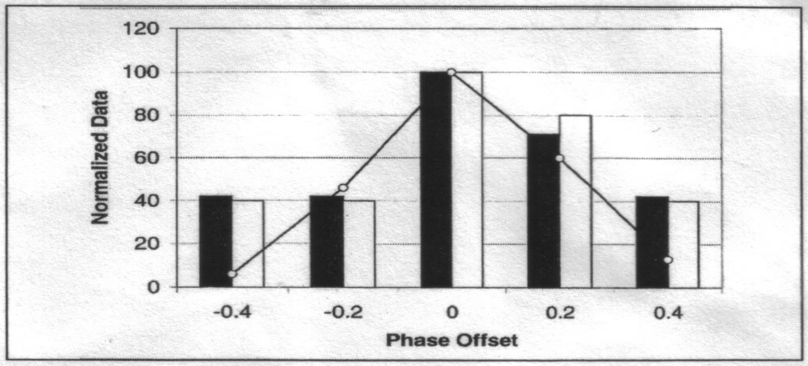


Figure 1) *The two distributions of pandemic count versus phase offset scaled to a peak value of 100. Pandemics listed by Garrett (4) and Potter (5) are shown, respectively, in solid black and white. The circles connected by solid lines show an average solar activity cycle, also scaled to have a peak value of 100*

Consequences of Global Cooling

- Agricultural productivity – down in a big way?
  land area, [CO_2], temperature
- Influenza – possibility of severe pandemics
- Plagues (bubonic, smallpox, cholera) – may be associated with solar minima?
- Similar questions as for global warming?
- Energy consumption – big increase in heating for temperate climates (but less A/C)
- History shows these events aren't kind, unlike warming.

Addenda

Timescales for global mean temperatures

Phanerozoic Era (last 570 My)	?Astronomy – passage through the spirals of the galaxy' Geology – mountain formation Botany – gynosperms to angiosperms 130 to 80 my ago Extremely high [CO2] levels OK – 25 times present day
Rise of C4 plants (last 8 My)	Botany – C4 grasslands/ steppes, preconcentrate CO2 ?what happened to marine biology?
Glacial record (last 400 ky)	Astronomy - insolation and orbital precession –> effect of Jupiter, Saturn, Venus
Agricultural Age (last 8 ky)	Agriculture – clearance of forests
From the ?Renaissanc (last 700 y)	Astronomy - sunspot cycles, Maunder minimum volcanic eruptions, pandemics, ?massive wars?
Modern Industrial Era (last 150 y)	Anthropogenic – industrial emissions of CO2 Agriculture, Urbanization – land coverage/ use
Seasonal (last year!)	temperature swings >60 Celcius in Canada

Plant mediation of [CO2]?

T.E. Cerling, J.R. Ehleringer, J.M. Harris "Carbon dioxide starvation, the development of C4 ecosystems, and mammalian evolution" Phil TransRSocLondB vol 353, pp159-171, 1998

C4 grasses expanded over last 6 to 8 Million years

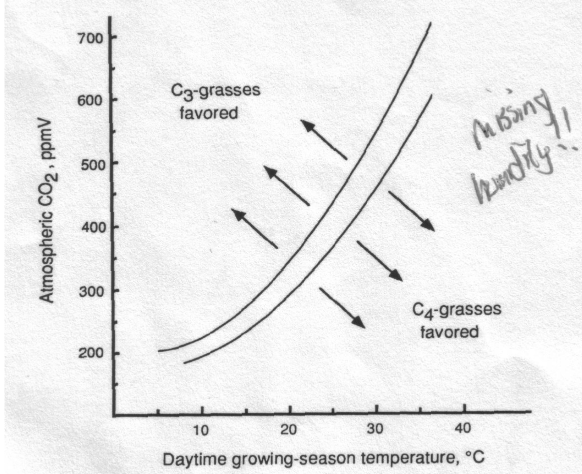


Figure 2. Crossover model of C_3/C_4 photosynthesis based on quantum yield of C_3 and C_4 plants. Modified from Cerling *et al.* (1997) and Ehleringer *et al.* (1997).

Solar Variability since 1500

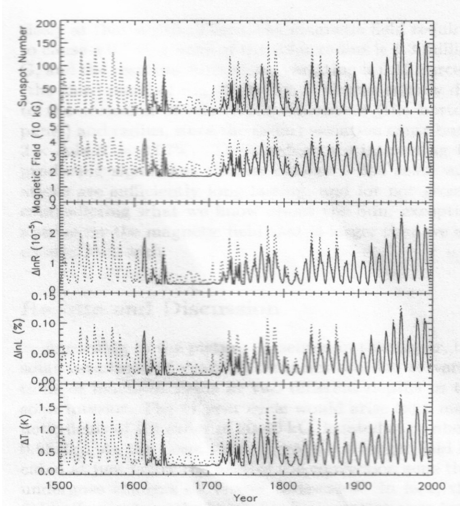


Figure 3. Solar variability in the past five centuries (dotted curve corresponds to the Zürich sunspot number R_Z) and in the past four centuries (solid curve conrresponds to the group sunspot number R_G). kG stands for kilo-Gauss, L for total solar luminosity, T for solar effective temperature, R for solar radius.

Sunspots – last 120 years

Sunspots: An overview 157

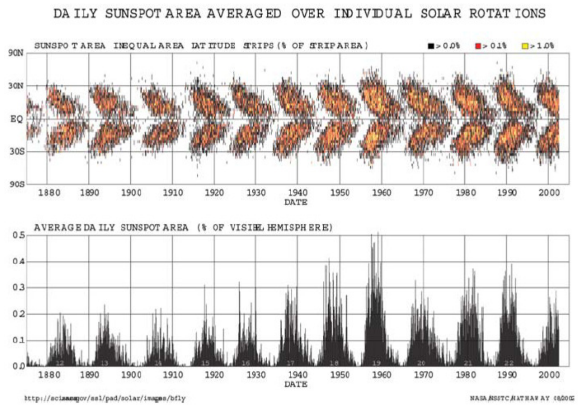


Fig. 2.1. Butterfly diagram (*upper panel*) and record of relative solar surface area covered by sunspots (*lower panel*). *Upper panel*: the vertical axis indicates solar latitude, the horizontal axis time. If a sunspot or a group of sunspots is present within a certain latitude band and a given time interval, then this portion of the diagram is shaded, with the colour of the shading indicating the area covered by the sunspots. (Figure courtesy of D. Hathaway, http://science.nasa.gov/ssl/pad/solar/sunspots.htm).

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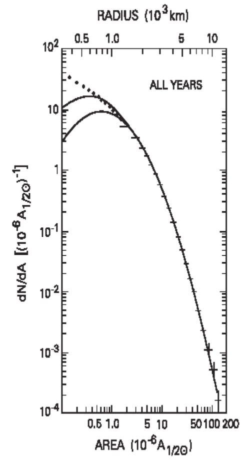
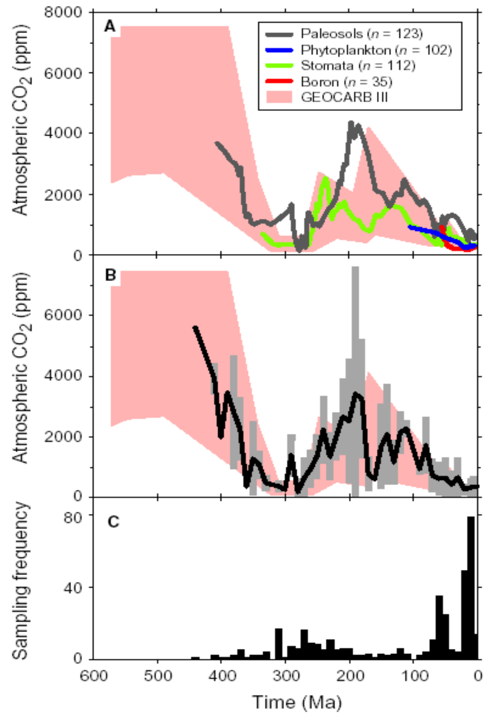


Fig. 2.2. Overall size spectrum for the Mt. Wilson data set of 24615 sunspots (*crosses*). Unreliable smaller sizes are denoted by filled circles. Upper and lower lognormal fits to the crosses have also been sketched (adapted from Bogdan et al. 1988, by permission).

sami k. solanki 'sunspots; and overview' ***The Astron Astrophys Rev (2003) 11: 153–286***

Abstract. ***Sunspots are the most readily visible manifestations of solar magnetic field concentrations and of their interaction with the Sun's plasma. Although sunspots have been extensively studied for almost 400 years and their magnetic nature has been known since 1908, our understanding of a number of their basic properties is still evolving, with the last decades producing considerable advances. In the present review I outline our current empirical knowledge and physical understanding of these fascinating structures. I concentrate on the internal structure of sunspots, in particular their magnetic and thermal properties and on some of their dynamical aspects.***



Phanerozoic CO2

Royer et al – critique of Veizer&Shaviv

note;
Current [co2]=250-350 PPM i.e. 1/25 of past levels
the previous low is due to what at 350 My
authors do not explain t cycles

Figure 1. Details of CO_2 proxy data set used in this study. **A:** Five-point running averages of individual proxies (see footnote 1). Range in error of GEOCARB III model also shown for comparison. **B:** Combined atmospheric CO_2 concentration record as determined from multiple proxies in (A). Black curve represents average values in 10 m.y. time-steps. Gray boxes are standard deviations (± 1σ) for each time-step. **C:** Frequency distribution of CO_2 data set, expressed in 10 m.y. time-steps. All data are calibrated to the timescale of Harland et al. (1990).

d.l. royer, r.a. berner, i.p. montanez, n.j. tabor, d.j. beerling 'co2 as a primary driver of climate' ***GSA Today; v. 14; no. 3, march 2004***

ABSTRACT ***Recent studies have purported to show a closer correspondence between reconstructed Phanerozoic records of cosmic ray flux and temperature than between CO2 and temperature. The role of the greenhouse gas CO2 in controlling global temperatures has therefore been questioned. Here we review the geologic records of CO2 and glaciations and find that CO2 was low (<500 ppm) during periods of long-lived and widespread continental glaciations and high (>1000 ppm) during other, warmer periods. The CO2 record is likely robust because independent proxy records are highly correlated with CO2 predictions from geochemical models. The Phanerozoic sea surface temperature record as inferred from shallow marine carbonate δ18O values has been used to quantitatively test the importance of potential climate forcings, but it fails several first-order tests relative to more well-established paleoclimatic indicators: both the early Paleozoic and Mesozoic are calculated to have been too cold for too long. We explore the possible influence of seawater pH on the δ18O record and find that a pH-corrected record matches the glacial record much better. Periodic fluctuations in the cosmic ray flux may be of some climatic significance, but are likely of secondorder importance on a multimillionyear timescale.***

Geocarb Model

194 *R.A. Berner and Z. Kothavala—GEOCARB III:*

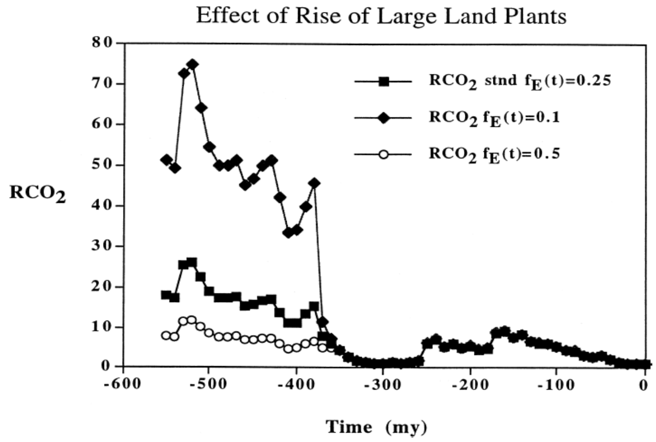


Fig. 5. Effect on RCO_2 of variation of the quantitative effect of the Devonian rise of large vascular land plants on continental weathering. The standard value for the early Paleozoic of the plant weathering factor $f_E(t)$ = 0.25 is based on the field results of Moulton, West, and Berner (2000). Note enlarged vertical scale compared to other figures.

r.a. berner, z. kothavala 'geocarb iii; a revised model of atmospheric co2 over phanerozoic time' american journal of science, vol 301, february 2001, p 182-204

'the long-term carbon cycle - on a multimillion year time scale the major processes affecting atmospheric co2 is exchange between the atmospher and carbon stored in rocks.' --- geocarb model plus/minus 10 mega-year resolution

gymnosperms before 130 my ago, angiosperm-dominated since 80 my ago

ABSTRACT. Revision of the GEOCARB model (Berner, 1991, 1994) for paleolevels of atmospheric CO_2, has been made with emphasis on factors affecting CO_2 uptake by continental weathering. This includes: (1) new GCM (general circulation model) results for the dependence of global mean surface temperature and runoff on CO_2, for both glaciated and non-glaciated periods, coupled with new results for the temperature response to changes in solar radiation; (2) demonstration that values for the weathering-uplift factor $f_R(t)$ based on Sr isotopes as was done in GEOCARB II are in general agreement with independent values calculated from the abundance of terrigenous sediments as a measure of global physical erosion rate over Phanerozoic time; (3) more accurate estimates of the timing and the quantitative effects on Ca-Mg silicate weathering of the rise of large vascular plants on the continents during the Devonian; (4) inclusion of the effects of changes in paleogeography alone (constant CO_2 and solar radiation) on global mean land surface temperature as it affects the rate of weathering; (5) consideration of the effects of volcanic weathering, both in subduction zones and on the seafloor; (6) use of new data on the d13C values for Phanerozoic limestones and organic matter; (7) consideration of the relative weathering enhancement by gymnosperms versus angiosperms; (8) revision of paleo land area based on more recent data and use of this data, along with GCM-based paleo-runoff results, to calculate global water discharge from the continents over time. Results show a similar overall pattern to those for GEOCARB II: very high CO_2 values during the early Paleozoic, a large drop during the Devonian and Carboniferous, high values during the early Mesozoic, and a gradual decrease from about 170 Ma to low values during the Cenozoic. However, the new results exhibit considerably higher CO_2 values during the Mesozoic, and their downward trend with time agrees with the independent estimates of Ekart and others (1999). Sensitivity analysis shows that results for paleo-CO_2 are especially sensitive to: the effects of CO_2 fertilization and temperature on the acceleration of plant-mediated chemical weathering; the quantitative effects of plants on mineral dissolution rate for constant temperature and CO_2; the relative roles of angiosperms

Agricultural Effects?

THE ANTHROPOGENIC GREENHOUSE ERA BEGAN THOUSANDS OF YEARS AGO 263

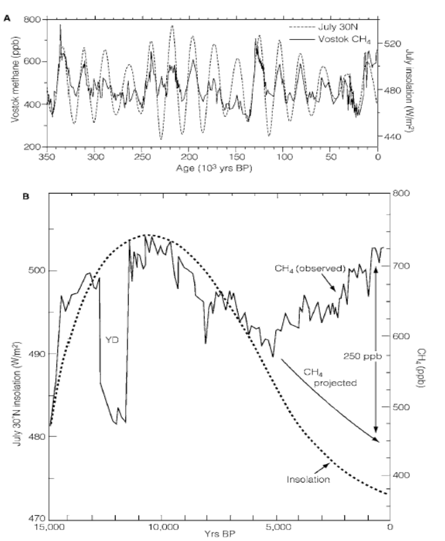


Figure 1. Comparison of July insolation values from Berger and Loutre (1996) with ice-core concentrations of atmospheric CH_4. (a) Long-term Vostok CH_4 record of Petit et al. (1999), using time scale of Ruddiman and Raymo (2003). (b) GRIP CH_4 record from Blunier et al. (1995), dated by counting annual layers. Early Holocene CH_4 trend projected in late Holocene to values reached during previous early-interglacial CH_4 minima.

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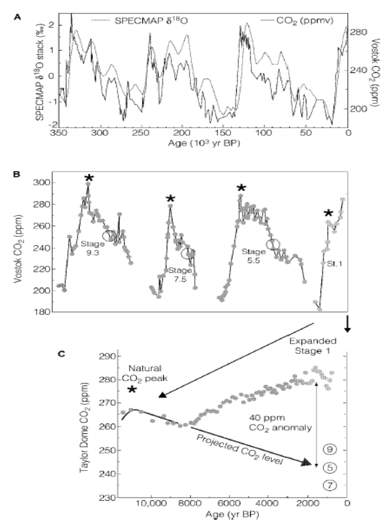

Figure 2. Concentrations of atmospheric CO_2 in Antarctic ice cores. (a) CO_2 trends from Vostok ice record of Petit et al. (1999) using time scale of Ruddiman and Raymo (2003). Marine $\delta^{18}O$ signal from SPECMAP (Imbrie et al., 1984). (b) CO_2 trends during 4 deglacial-interglacial intervals. Asterisks mark late-deglacial CO_2 maxima; circles show positions of early-interglacial CH_4 minima that follow 11,000 years later during insolation minima similar to today. (c) High-resolution CO_2 record from Taylor Dome of Indermuhle et al. (1999). Early-Holocene CO_2 trend projected during late Holocene toward circled values reached during previous interglaciations.

w.f. ruddiman 'the anthropogenic greenhouse era began thousands of years ago'
climate change 61; 261-293, 2003

Abstract. The anthropogenic era is generally thought to have begun 150 to 200 years ago, when the industrial revolution began producing CO2 and CH4 at rates sufficient to alter their compositions in the atmosphere. A different hypothesis is posed here: anthropogenic emissions of these gases first altered atmospheric concentrations thousands of years ago. This hypothesis is based on three arguments. (1) Cyclic variations in CO2 and CH4 driven by Earth-orbital changes during the last 350,000 years predict decreases throughout the Holocene, but the CO2 trend began an anomalous increase 8000 years ago, and the CH4 trend did so 5000 years ago. (2) Published explanations for these mid- to late-Holocene gas increases based on natural forcing can be rejected based on paleoclimatic evidence. (3) A wide array of archeological, cultural, historical and geologic evidence points to viable explanations tied to anthropogenic changes resulting from early agriculture in Eurasia, including the start of forest clearance by 8000 years ago and of rice irrigation by 5000 years ago. In recent millennia, the estimated warming caused by these early gas emissions reached a global-mean value of ~0.8 .C and roughly 2 .C at high latitudes, large enough to have stopped a glaciation of northeastern Canada predicted by two kinds of climatic models. CO2 oscillations of ~10 ppm in the last 1000 years are too large to be explained by external (solar-volcanic) forcing, but they can be explained by outbreaks of bubonic plague that caused historically documented farm abandonment in western Eurasia. Forest regrowth on abandoned farms sequestered enough carbon to account for the observed CO2 decreases. Plague-driven CO2 changes were also a significant causal factor in temperature changes during the Little Ice Age (1300–1900 AD).