Human-induced global warming: Why I am sceptical

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# Constant cyclical climate change

<table>
<thead>
<tr>
<th>Known Cycles</th>
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<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>tectonic, PDO</td>
</tr>
<tr>
<td><strong>143 million year</strong></td>
</tr>
<tr>
<td>galactic</td>
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<tr>
<td><strong>100,000 years</strong></td>
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<td><strong>41,000 years</strong></td>
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<td><strong>23,000 years</strong></td>
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<tr>
<td><strong>1,500 years</strong></td>
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<tr>
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<td><strong>210 years</strong></td>
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<td><strong>87 years</strong></td>
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<td><strong>22 years</strong></td>
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<tr>
<td><strong>18.7 years</strong></td>
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<tr>
<td>lunar</td>
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<tr>
<td><strong>11 years</strong></td>
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<tr>
<td>solar</td>
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</tbody>
</table>
Is the speed and degree of modern climate change unprecedented?
Sea levels

SL always changing (Neoproterozoic glaciation ±1500 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
Balding Bay, Great Barrier Reef coast

Holocene highstand oyster beds
Holocene highstand coral microatolls

Microatolls on dead reef flat
Orpheus Island, central GBR
Great Barrier Reef margin

Summary of Holocene local relative sea-level indicators

Subfossil Microatolls
High Islands, Central Great Barrier Reef
(After Chappell et al., 1988)
Holocene glacio-isostatic rebound

Uplift rate
4-20 m/ky

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 Mesozoic 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
Regional isostasy & local relative sea-level since 6 ka

Clark, J.A. & Lingle, C.S. 1979 Predicted relative sea-level changes (18,000 Years B.P. to present) caused by late-glacial retreat of the Antarctic ice sheet. Quaternary Research 11, 279-298.
ANTARCTIC EPICA-DOME-C ICE CORE ANALYSIS

Temperature Rise STARTS 650 years BEFORE CO2 Rise starts

Temperature Rise STOPS 1000 years BEFORE CO2 Rise stops

Temperature Rise STOPS 1100 years BEFORE CO2 Rise stops

Termination of Major Glaciation
Temperature Rise STARTS 1600 years BEFORE CO2 Rise starts

IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series # 2004-038.
NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.

IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series # 2004-055.
NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.

Graphic (c) 2005 Dr Guy LeBlanc Smith, MAIO, MAAPQ, (Rock Knowledge Services Pty Ltd, Australia).
Cooling with increasing CO2
Temperature

Location, location, location.....
Urban heat island effect

- Tucson U of Arizona (32.2N, 111.0W)

Graph showing annual mean temperature (°F) from 1880 to 2020.
What is really measured?

Temperature Trend per Decade 1940 - 1996 (°C)

Population of Country
Reliability of surface measurements

The Southern Hemisphere is the same temperature it was 28 years ago,
The Northern Hemisphere has warmed slightly.

The 28 years of high quality satellite data

Temperature Variation (°C)


Southern Hemisphere

Northern Hemisphere

Global
Models for atmospheric temperature

Zonally-averaged distributions of predicted temperature change in °K at CO₂ doubling (2xCO₂-control), as a function of latitude and pressure level, for four general-circulation models (Lee et al., 2007).
Radiosonde measurements

No “greenhouse warming” signature is observed in reality

Source: HadAT2 radiosonde observations, from CCSP (2006), p116, fig. 5.7E
Five years' global ocean cooling: reality yet again disobeys models
Smoothing of ice core CO$_2$ data - why pre-industrial choice of 280ppm?

1812-2004 Northern Hemisphere, Chemical Measurement
Doubling CO$_2$ at 388ppm has no effect

The warming effect of atmospheric carbon dioxide
Water: Main greenhouse gas & driver of CO$_2$
Greenland ice sheet

Greenland ice sheet change in cm/yr

*Derived from 11 years of ERS-1/ERS-2 satellite altimeter data, 1992-2003

10 per. Mov. Avg (d180 Site15 GISP2, Boltzman Strobel 1994)
Is global warming melting the ice caps and reducing sea ice? **NO!**

**Antarctic Sea Ice Trends**

... going up!

**Antarctic Land Ice Trends**

... going up over most of the continent!


*Source: National Snow and Ice data Centre*
Carbon reservoirs on Earth

The carbon in the Earth’s lithosphere and atmosphere has come from degassing of CO$_2$ from the Earth’s mantle. The amount of CO$_2$ in air is minute compared to the other reservoirs. Without sediments, the partial pressure of air CO$_2$ alone would be 40-60 atmospheres.

Figure from O’Nions (1984)
Atmospheric evolution

Evolution from reduced CO$_2$-rich (>5%) to oxygenated.

THE EARTH'S ATMOSPHERE BY MASS

- Nitrogen: 73.47%
- Oxygen: 22.53%
- Water: 2.7%
- CO$_2$: 0.05%
- Argon: 1.25%
If each of the 1511 active land-volcanoes on Earth emits 5,000 t C-equivalent of CO$_2$ each day

=> 7.5 Mt/day

If 4X more CO$_2$ is emitted from submarine volcanoes (30.0 Mt)

=> 37.5 Mt total

This is approximately double the amount of CO$_2$ derived from human burning of fossil fuels (<20 Mt/day).
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.

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).
Terrestrial felsic explosive volcanicity

Pathetic: Mt St Helens (1 km³)

Weather changing: (Krakatoa 1883, Tambora 1815, Thira 1470 BC)

Gases: H₂O, CO₂, CH₄, HCl, HF, SO₂, H₂S (e.g. White Island [NZ] 1150-4120 tpd CO₂, 320-1200 tpd SO₂)
Terrestrial felsic volcanicity

Structurally-controlled volcanicity, gas vents and epithermal systems (Andes, Chile)
Subglacial terrestrial volcanicity

Antarctica (felsic), Iceland (mafic)
Submarine basaltic volcanicity
Submarine basaltic volcanism
Acid oceans: When the planet runs out of rocks, the oceans become acid

\[
2\text{Ca}^{2+} + 2\text{HCO}_3^- + \text{KAl}_2\text{AlSi}_3\text{O}_{10}(\text{OH})_2 + 4\text{H}_2\text{O} = 3\text{Al}^{3+} + \text{K}^+ + 6\text{SiO}_2 + 12\text{H}_2\text{O}
\]

\[
2\text{KAlSi}_3\text{O}_8 + 2\text{H}^+ + \text{H}_2\text{O} = \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 2\text{K}^+ + 4\text{SiO}_2
\]

\[
2\text{NaAlSi}_3\text{O}_8 + 2\text{H}^+ + \text{H}_2\text{O} = \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 2\text{K}^+ + 4\text{SiO}_2
\]

\[
\text{CaAl}_2\text{Si}_2\text{O}_8 + 2\text{H}^+ + \text{H}_2\text{O} = \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + \text{Ca}^{2+}
\]

\[
\text{KAl}_2\text{AlSi}_3\text{O}_{10}(\text{OH})_2 + 3\text{Si(OH)}_4 + 10\text{H}^+ = 3\text{Al}^{3+} + \text{K}^+ + 6\text{SiO}_2 + 12\text{H}_2\text{O}
\]

\[
\text{CO}_2 + \text{CaSiO}_3 = \text{CaCO}_3 + \text{SiO}_2
\]

\[
\text{CO}_2 + \text{FeSiO}_3 = \text{FeCO}_3 + \text{SiO}_2
\]

\[
\text{CO}_2 + \text{MgSiO}_3 = \text{MgCO}_3 + \text{SiO}_2
\]

In the oceans, CO₂ exists as dissolved gas (1%), HCO₃⁻ (93%) and CO₃²⁻ (8%)

Ocean pH is 7.9 to 8.2

Rainwater pH is 5.6
Submarine basaltic volcanicity

Extension, continental fragmentation, basalts and degassing
Terrestrial felsic explosive volcanicicity

Gas-driven explosions
Terrestrial felsic explosive volcanicity

$\text{CO}_2$-driven explosions (Tahkt-e-Sulieman, Iran)
Terrestrial felsic explosive supervolcanoes

™ **Toba**: 74,000 bp (2,900 km³)

™ **Yellowstone**: 2.1, 1.3, 0.64 Ma (1,000-5,000 km³)

™ **Taupo**: Many recent (5,000-10,000 km³)
Terrestrial basalt supervolcanoes

- $10^6$ km$^3$ lava in <1 Ma

- Huge H$_2$S and SO$_2$ emissions, temporary surficial ocean acidity and life loss

- Roza Flow, Columbia River Basalt
  - >1000 km$^3$ lava
  - >10,000 Mt SO$_2$ aerosols
Terrestrial basalt supervolcanoes

Large provinces, sites of juvenile CO$_2$ degassing
Submarine basaltic supervolcanoes

- Not monitored, earthquake swarms and El Niño
- Particle and $^3$He plumes
- No aerosols
- $\text{CO}_2\ (\text{gas})$ and $\text{CO}_2\ (\text{liq})$ dissolves (cool high pressure bottom water)
Submarine basaltic volcanicity

Lava, hot springs, gas vents

64,000 km mid ocean ridges (10,000 km³ water for cooling per annum; buffers seawater)

Seamounts (>3,477,403* million > 0.1 km high), off axis volcanoes (cf 800 terrestrial felsic volcanoes)

Slow spreading (Gakkel Ridge basalts; >13.5% CO₂; explosive [1999])

No monitoring; gas measurements from 20 basaltic volcanoes, total emissions calculated at 0.08% of annual human emissions

Upwelling thousands of years later

*Hiller & Watts (2007)
Terrestrial CO$_2$-rich springs, sinters, vents
Terrestrial CO$_2$-rich springs, sinters, vents

Milos (Greece): CO$_2$ exhalations (2.5 x 10$^6$ tpa, $\delta^{13}$C = -1.0 to +1.0)
Terrestrial warm springs and travertine
Submarine basaltic volcanoes

Vent CO₂ (gas and liquid) exhalation
Hydrothermal fluids
Hot spring precipitates

Epithermal carbonate replacement and laminated crack-seal carbonate veins (Acupan, Philippines)
Continental evaporites?
Degassing

MOLTEN ROCKS (liquid, solid, gas): Degassing of molten rocks (2-15% gases in solution)
Carbonate lava
Basalt CO$_2$ degassing

MOLTEN ROCKS (liquid, solid, gas):
Extension settings such as rifts (basalts, twice temperature of felsic melts, higher gas solubility, main gas CO$_2$), mainly unseen)
Volcanicity, CO$_2$ and carbonate precipitation

Fig. 24. Changes in carbon dioxide concentration ($M_C$, $M_C'$) and the rate of formation of volcanic rocks ($V$) during the Phanerozoic

Fig. 14. Time changes in volcanogenic rock volumes ($V$), CO$_2$, buried in synchronous carbonate rocks ($J$) and the ratio (%) of the continental sea area to the total area of the continents ($J$).
Warm CO$_2$-bearing earthquake fluids

EARTHQUAKES
Warm water and gas CO$_2$, CH$_4$, He etc emissions

FRACTURES ASSOCIATED WITH AN EARTHQUAKE
AT DASHT-E BAÝAZ, IRAN
August 31 1968

INTERPRETATION

Modified from Tchalenko & Ambraseys 1970
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 CO₂ residence time

The effective lifetime for CO₂ in the atmosphere can be determined using radioactive, radiogenic and stable isotopes.

<table>
<thead>
<tr>
<th>Authors [publication year]</th>
<th>Residence time (years)</th>
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<tbody>
<tr>
<td>Based on natural carbon-14</td>
<td></td>
</tr>
<tr>
<td>Craig [1957]</td>
<td>7 +/- 3</td>
</tr>
<tr>
<td>Revelle &amp; Suess [1957]</td>
<td>7</td>
</tr>
<tr>
<td>Arnold &amp; Anderson [1957]</td>
<td>10</td>
</tr>
<tr>
<td>including living and dead biosphere (Siegenthaler, 1989)</td>
<td>4-9</td>
</tr>
<tr>
<td>Craig [1958]</td>
<td>7 +/- 5</td>
</tr>
<tr>
<td>Bolin &amp; Eriksson [1959]</td>
<td>5</td>
</tr>
<tr>
<td>Broecker [1963], recal. by Broecker &amp; Peng [1974]</td>
<td>8</td>
</tr>
<tr>
<td>Craig [1963]</td>
<td>5-15</td>
</tr>
<tr>
<td>Keeling [1973b]</td>
<td>7</td>
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<tr>
<td>Broecker [1974]</td>
<td>9.2</td>
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<tr>
<td>Oeschger et al. [1975]</td>
<td>6-9</td>
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<tr>
<td>Keeling [1979]</td>
<td>7.53</td>
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<tr>
<td>Peng et al. [1979]</td>
<td>7.6 (5.5-9.4)</td>
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<td>Siegenthaler et al. [1980]</td>
<td>7.5</td>
</tr>
<tr>
<td>Lal &amp; Suess [1983]</td>
<td>3-25</td>
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<tr>
<td>Siegenthaler [1983]</td>
<td>7.9-10.6</td>
</tr>
<tr>
<td>Kratz et al. [1983]</td>
<td>6.7</td>
</tr>
<tr>
<td>Based on Suess Effect</td>
<td></td>
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<tr>
<td>Ferguson [1958]</td>
<td>2 (1.8)</td>
</tr>
<tr>
<td>Bacastow &amp; Keeling [1973]</td>
<td>6.3-7.0</td>
</tr>
</tbody>
</table>

Based on bomb carbon-14

- Bien & Suess [1967]: >10
- Münnich & Roether [1967]: 5.4
- Nydal [1968]: 5-10
- Young & Fairhall [1968]: 4-6
- Rafter & O'Brian [1970]: 12
- Machta (1972): 2
- Broecker et al. [1980a]: 6.2-8.8
- Stuiver [1980]: 6.8
- Quay & Stuiver [1980]: 7.5
- Delibrias [1980]: 6.0
- Druffel & Suess [1983]: 12.5
- Siegenthaler [1983]: 6.99-7.54

Based on radon-222

- Broecker & Peng [1974]: 8
- Peng et al. [1979]: 7.8-13.2
- Peng et al. [1983]: 8.4

Based on solubility data

- Murray (1992): 5.4

Based on carbon-13/carbon-12 mass balance

- Segalstad (1992): 5.4

Estimates made using many different methods show effective lifetimes for atmospheric CO₂ of only c. 5 - 7 years.
Carbonaceous rocks

**CARBONACEOUS SEDIMENTS**: Natural sequestration
Carbonate sediments 2,750 Ma
1820 Ma
Corella Formation 1750 Ma
Esperanza Formation 1640 Ma
Cryogenian detritus
Flinders Ranges 800-600 Ma

If \([\text{CO}_2]\) high, then dolomite \(\text{CaMg(CO}_3\text{)}_2\)
Great Barrier Reef, 400 Ma Napier Range
Guilin 360 Ma
Southern Victoria 50Ma
Late Tertiary: Oxygen isotopes: ocean proxy for ocean surface temperature

Marine isotope Stages 1-11

The Principle of

Sea Level from Red Sea Analysis of Siddall et al.

Coral reefs

Shark Bay, WA

Soils

silicate + $\text{H}_2\text{O} + \text{CO}_2$

$= \text{hydrous silicate } + \text{carbonate}$
Where does CO$_2$ go to?

**OCEANS:** Especially polar and deep water

\[
\begin{align*}
\text{CO}_2 (\text{g}) & \iff \text{CO}_2 (\text{aq}) \\
\text{CO}_2 (\text{aq}) + \text{H}_2\text{O} & \iff \text{H}_2\text{CO}_3 (\text{aq}) \\
\text{H}_2\text{CO}_3 (\text{aq}) & \iff \text{H}^+ (\text{aq}) + \text{HCO}_3^- (\text{aq}) \\
\text{HCO}_3^- (\text{aq}) & \iff \text{H}^+ (\text{aq}) + \text{CO}_3^{2-} (\text{aq}) \\
\text{CO}_3^{2-} (\text{aq}) + \text{Ca}^{2+} (\text{aq}) & \iff \text{CaCO}_3 (\text{s})
\end{align*}
\]

**Net reaction:**
\[
\text{CO}_2 (\text{g}) + \text{H}_2\text{O} + \text{Ca}^{2+} (\text{aq}) \iff \text{CaCO}_3 (\text{s}) + 2 \text{H}^+ (\text{aq})
\]
280 ppm (or even 390 or 560 ppm) indicates CO$_2$ starvation compared with the geological past.
Temperature and time

Figure from Bryant (1997)
Is the magnitude of late 20th C temperature change unusual?

The last 6 million years – ODP Site 677, North Atlantic Ocean
Is the speed and degree of modern climate change unprecedented? (Vostok ice core; Salamatin et al. 1998; Petit et al. 2001)
Temperature proxy

$\text{H}_2\text{O}_{(vap)}$ buffer to maximum and minimum temperature

Temperature (°C)

Dust (ppm)

Thousands of Years Ago

Temperature proxy

CO$_2$ (ppmv)

280
260
240
220
200
In ice cores, changes in $T$ precede changes in $CO_2$ by ~800-2000 yrs.

$CO_2$ does NOT force temperature at the G/I scale

Monnin et al., Science Vol 291 5 January 2001
Is the 20th Century temperature outside natural variability?
Cold snaps, rates of climate change

The Younger Dryas in central Greenland

Source: Lamont-Doherty Earth Observatory at the Earth Institute of Columbia University and Abrupt Climate Change: Inevitable Surprises, National Academy of Sciences, Committee on Abrupt Climate Change, 2002
Is the **magnitude** of late 20th C temperature change unusual?

The last 5,000 years – Greenland Ice Core

What does the history of the planet tell us?

- Earth always changes
- Climate change is normal
- Climate change occurred well before humans were on Earth
- The rate of climate change today is no different from thousands, millions or billions of years ago
- >80% time, Earth has been warmer and wetter than at present
- Ice is rare
- Just because change occurs in our lifetime does not mean that we humans are driving the change
The gas of life

CO₂ gas of life, increase beneficial

Part of massive natural cycle (mantle-atmosphere-oceans-organisms-sediments)

Atmospheric CO₂ short temporary stock, marine reservoir 50x larger governs atmospheric CO₂

Heat stored in oceans and thermostat effect of clouds

Carbon isotopes show <4% atmospheric CO₂ anthropogenic, small effect compared to total

To argue that human emissions of CO₂ drive climate change is non-scientific political activism akin to creationism