

Carbon Dioxide and Climate Change: A Review for the Coal and Mineral Industry

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Outline

- Introduction
- Is increasing CO₂ concentration in earth's atmosphere causing global warming?
- The unanswered questions about CO₂ being the real cause
- Other hypotheses behind climate change

Heated Debate

Human activities are the primary cause of global warming, especially the increasing **Carbon Dioxide (CO₂)** concentration. → The Intergovernmental Panel on Climate Change (**IPCC**)

Human contributions are minor. **Natural factors** are the main reason of global warming. → The Nongovernmental Panel on Climate Change (NIPCC)

Greenhouse Effect

- **Greenhouse Effect:** the greenhouse gases absorb **radiation** from the Sun and **keep energy** in the atmosphere

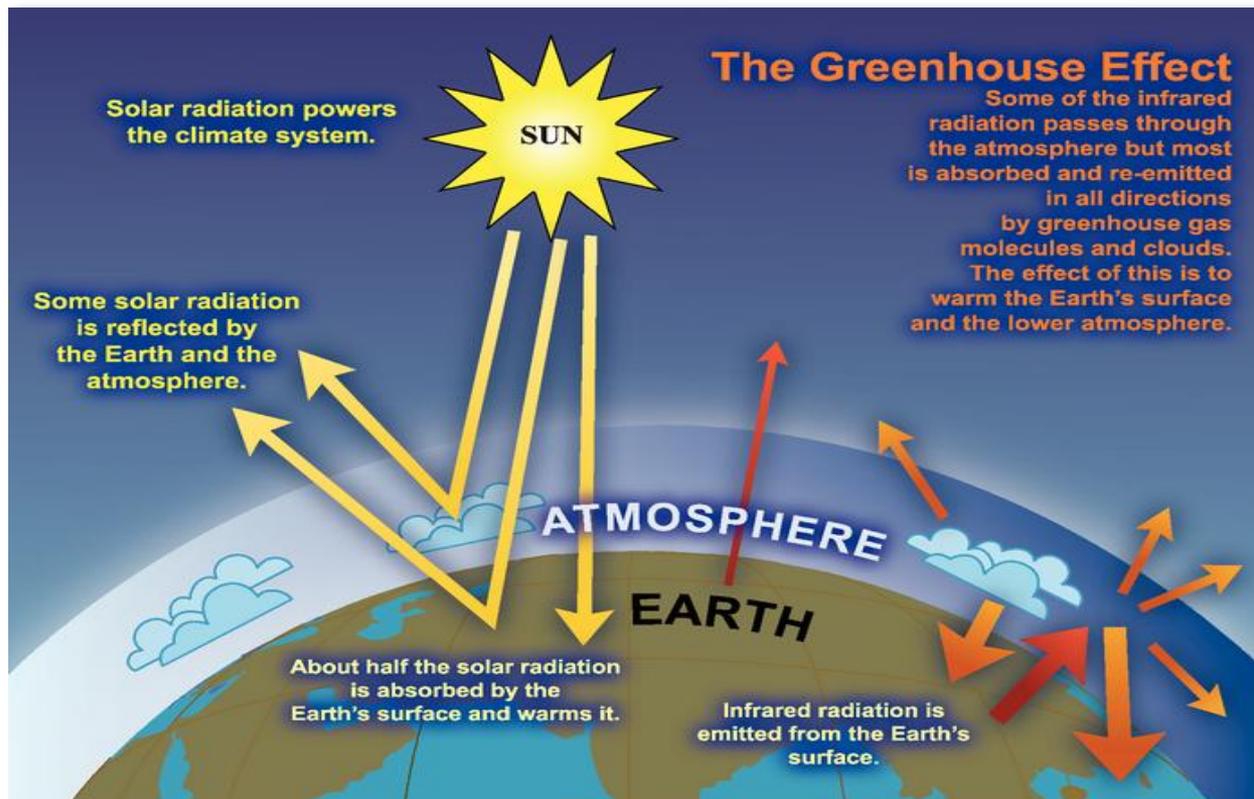
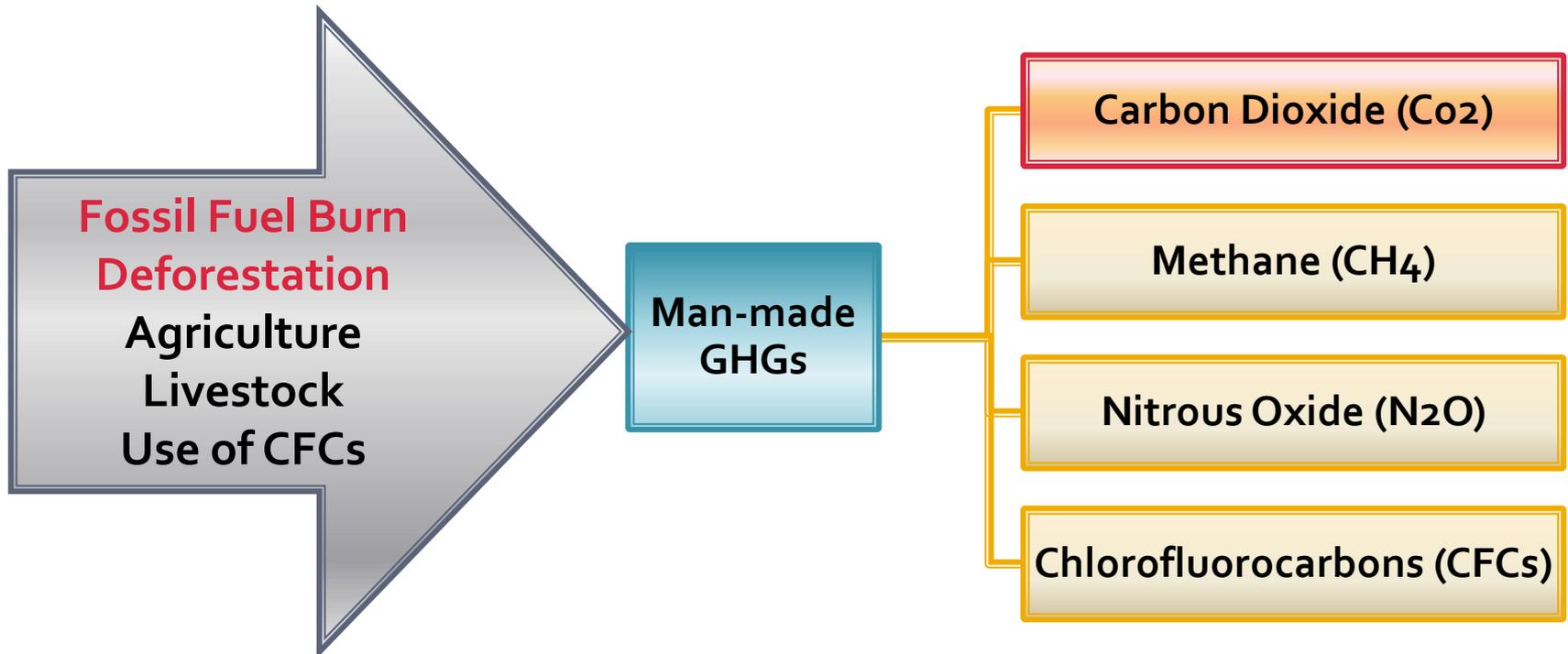


Figure source: The Fourth Assessment Report of the IPCC, 2007.

Green House Gases

- Water Vapor (H_2O)
- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)

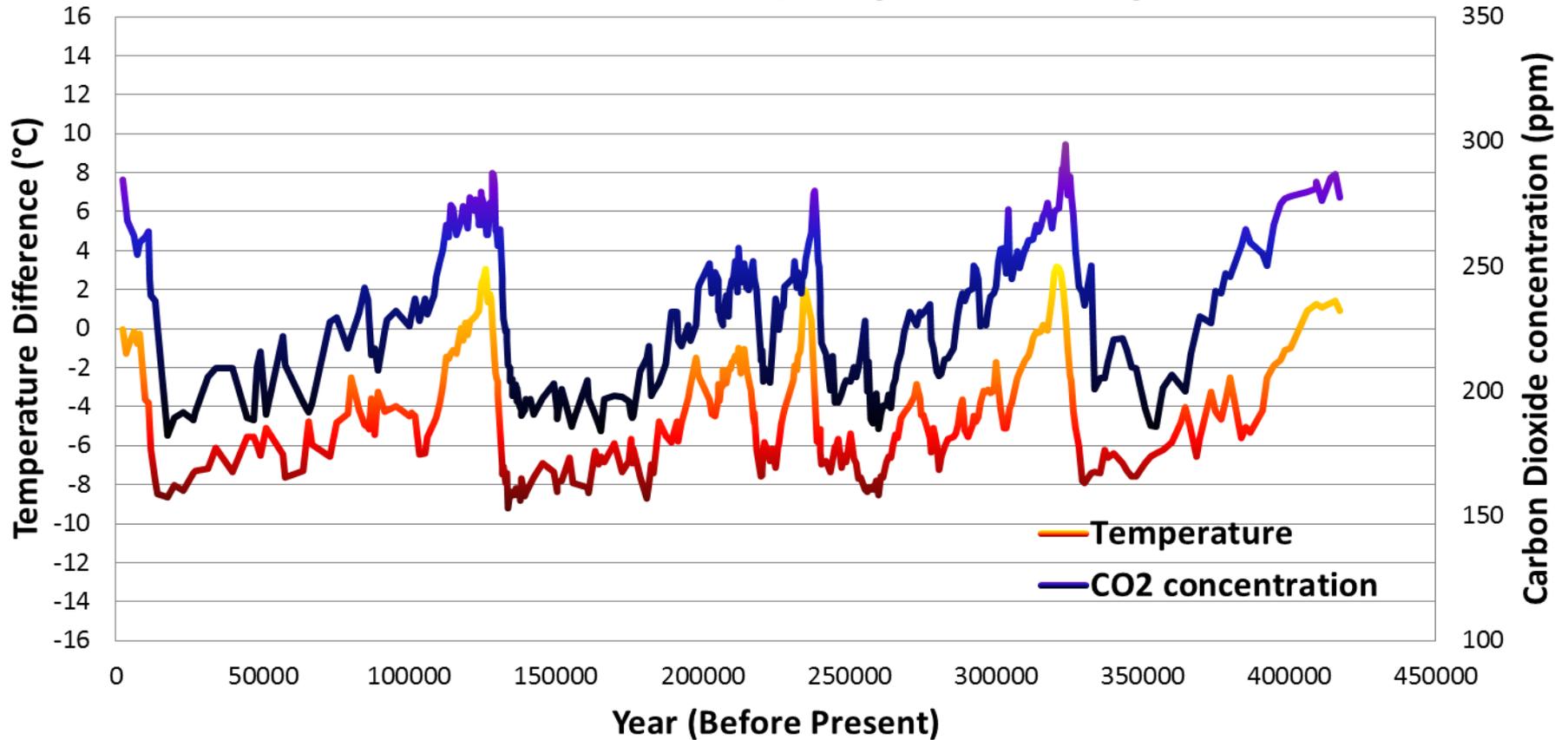
Man-made GHGs



- CFCs (Chlorofluorocarbons) are not ancient gases, they were caused by human activities, began to decline gradually after Kyoto Protocol.
- **Kyoto Protocol (1997-)**: reduce emission of GHGs
- 190 united nations signed and ratified, except U.S. and Canada

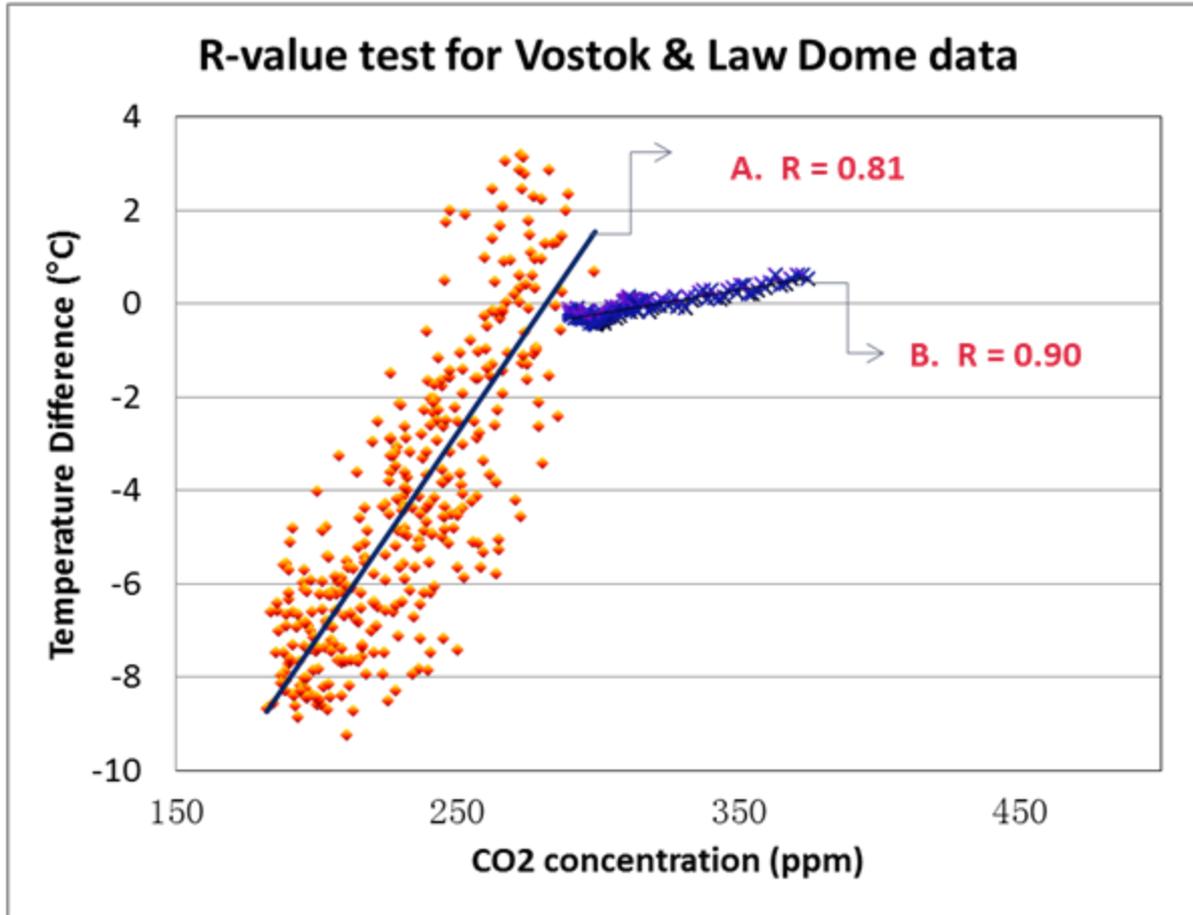
CO₂ Link

Vostok ice-core data (420,000 years before present)



- IPCC used similar type of picture with a period of 650,000 years before present.

Correlation between CO₂ and temperature



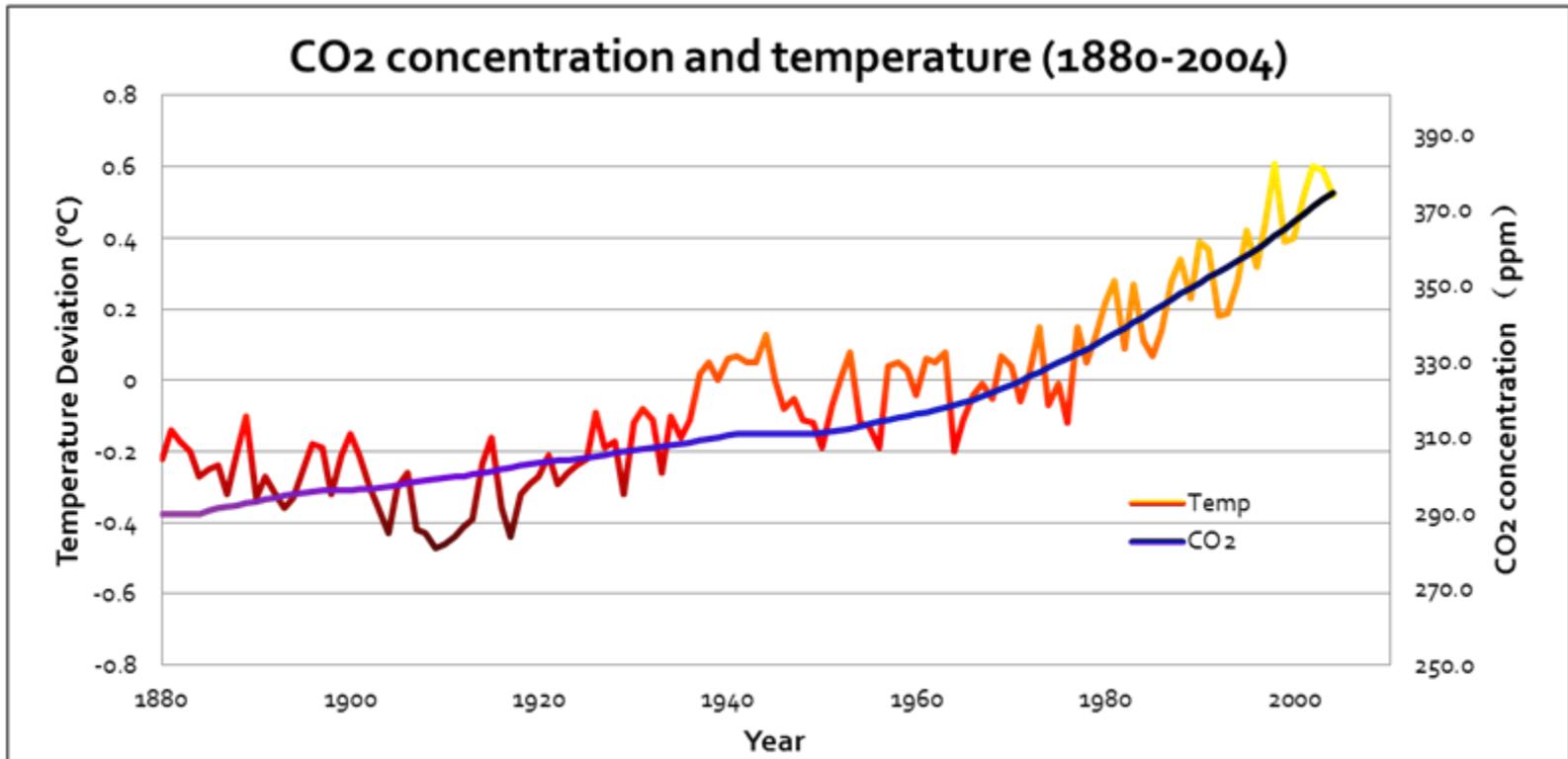
- **Data Source:**

A. Vostok ice core data for CO₂ and Temperature (420000 years before present)

B. Temp data — by NASA, CO₂ data — Law Dome (1880-2004)

- A similar analysis has been done by Georgios A. Florides and Paul Christodoulides in 2009

What causes What?



Data Source:

Temp: J.E. Hansen, R. Ruedy, M. Sato, and K. Lo, NASA Goddard Institute for Space Studies. Data collected from many national meteorology station. (1880-2004)
CO2: part of Law Dome ice core data (1880-2004)

Granger Causality Test

- **The Granger Causality Test** is an effective tool used in **time series** analysis to test the existence of causal relationships among variables.
- Using past data, if the present value of X can **help to predict** Y, then X is said to cause Y.
- In this analysis, only two variables are involved

Causality Test Result- Stata Software Output

- Sun L. and Wang M. did the Granger test in 1996, we also did the same test with the data below:

CO₂ — Law Dome ice core data (1880 – 2004);

Temperature — Meteorology station data from NASA (1880 – 2004)

Granger causality Wald tests

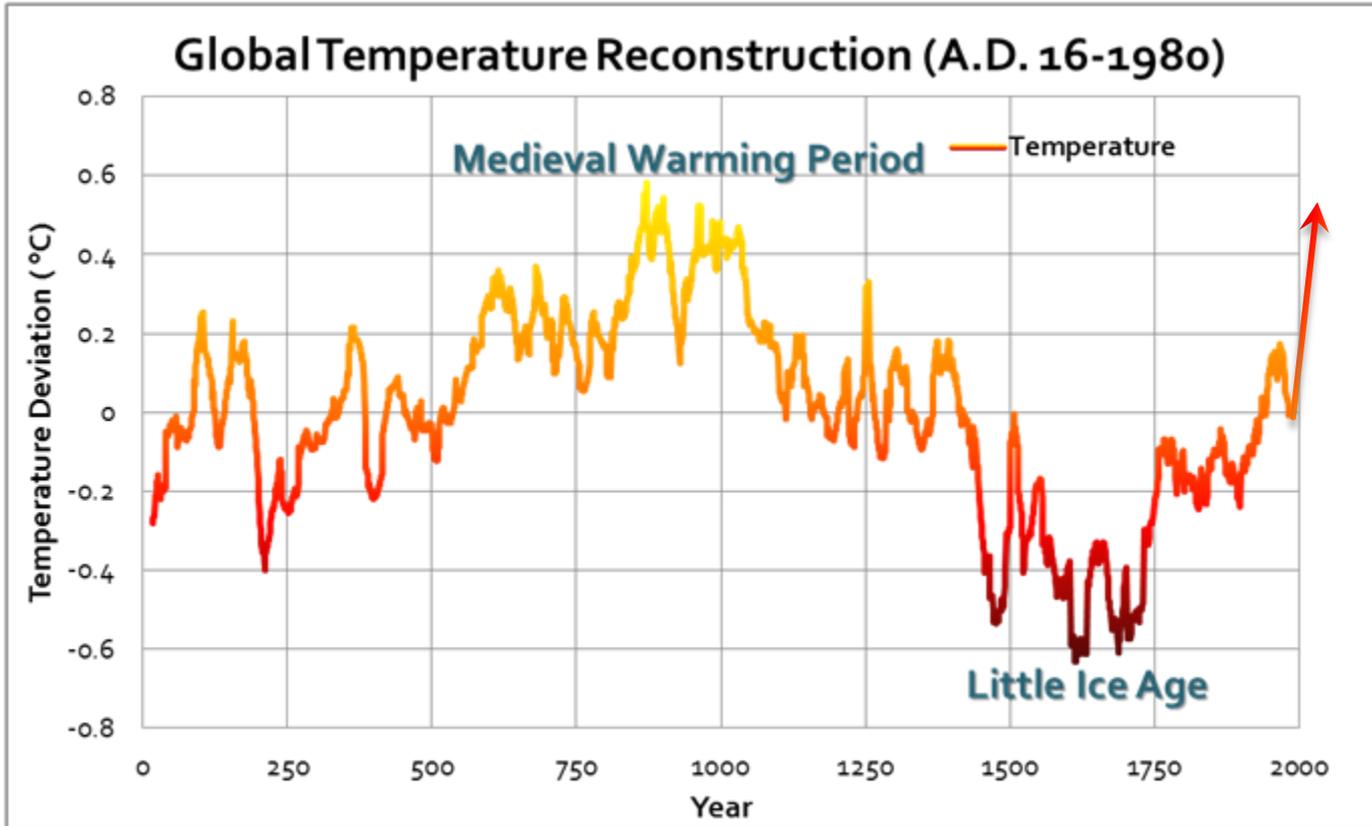
Equation	Excluded	chi2	df	Prob > chi2
co2	temp	1.7125	2	0.425
co2	ALL	1.7125	2	0.425
temp	co2	30.177	2	0.000
temp	ALL	30.177	2	0.000

- From P-value we can see that CO₂ concentration is significant to temperature, which means that **increasing CO₂ concentration causes earth's temperature rise.**

Potential Errors

- **Data accuracy**
Ice core data and ancient literature
- **Unevenly distributed temperature observation stations**
Example: in the early period, only few stations built in Southern Hemisphere; however mainly built in Europe and the US
- **The heat-island effect on temperature records**
Example: approximately 40% warming is contributed by urbanization in China

Unanswered Questions



Data Source:

Loehle, E&E (Nov. 2007),
National Council for Air
and Stream
Improvement, Inc.
(NCASI)

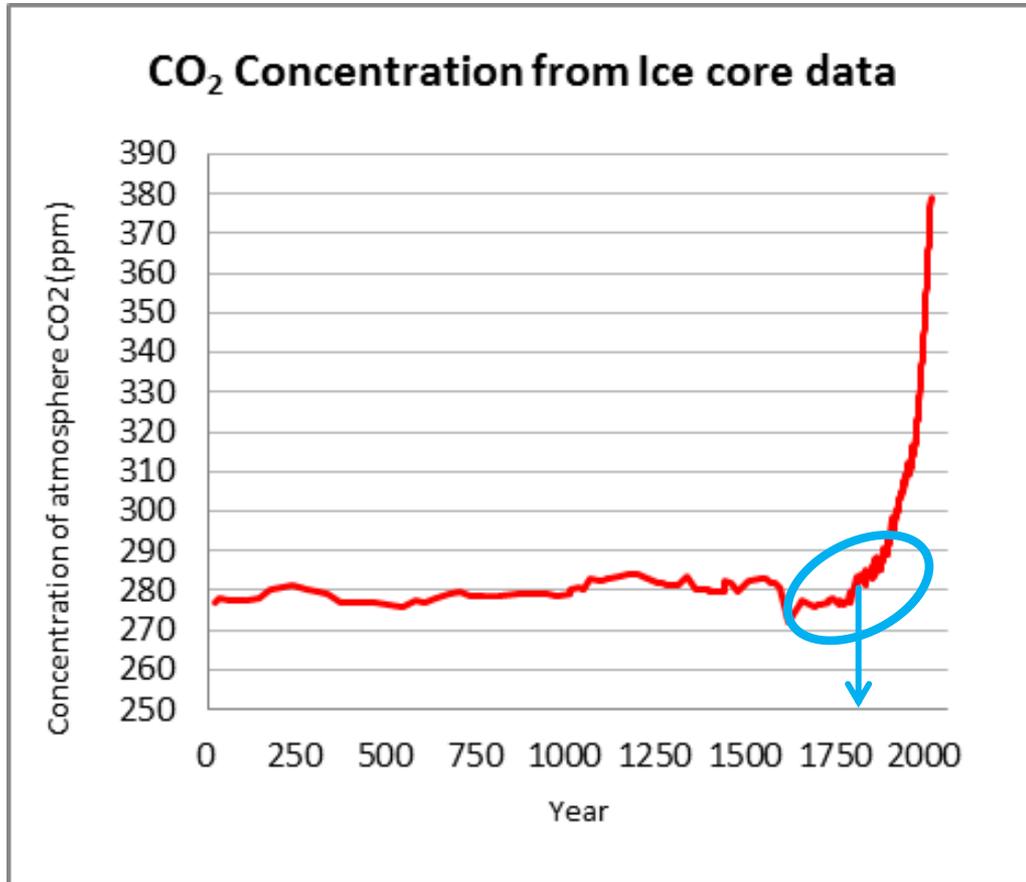
Other references:

Gerald R. North, etc., 2006,
The National Academy of
Sciences.
P.D. Jones, etc. al., 1998
M.E. Mann, etc. al., 1999
Crowley and Lowery, 2000
S. Huang, 2004
A. Moberg, etc. al., 2005

NOTE:

IPCC 2007 report: 0.74 ± 0.18 °C temperature increasing for 1906 – 2005.

Unanswered Questions (Continued)

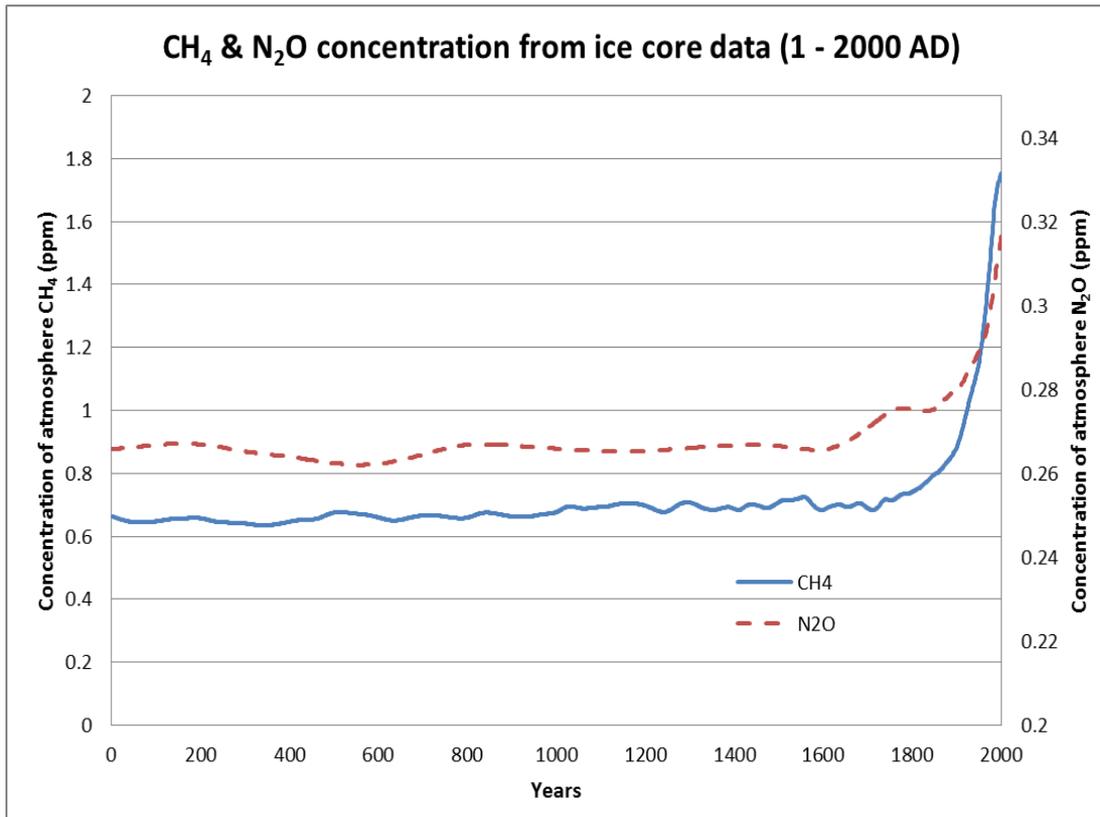


Data Source:

Law Dome ice core in Antarctica
Firn Air in Antarctica
Cape Grim instrumental station in Australia

- Industrial Revolution started from the period around 1760
- IPCC also has the similar type of plot showing that the CO₂ concentration increased rapidly from that point.

Unanswered Questions (Continued)



Data Source:

Law Dome ice core in Antarctica
Firn Air in Antarctica
Cape Grim instrumental station
in Australia

Other factors



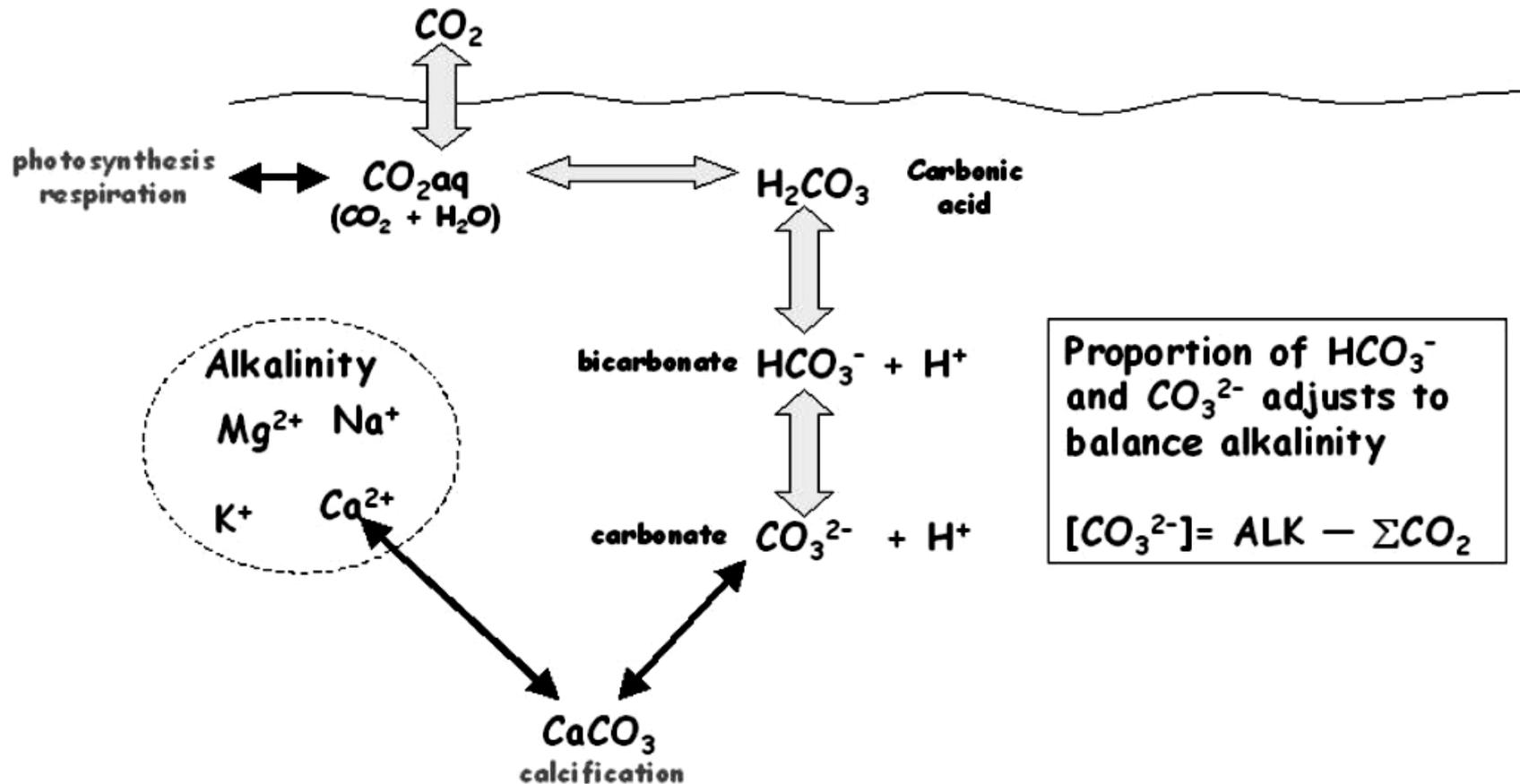
Other Hypotheses

- Ocean absorption
- Milankovitch cycles
- Solar Activity

Ocean Absorption

- Oceans can hold 50 times more CO₂ than earth's atmosphere.
- If ocean warms up, the solubility of CO₂ can decline and **the absorption of CO₂ released from the atmosphere in ocean will reduce; this could result in increasing CO₂ concentration in earth's atmosphere.**

The Carbonate System in Seawater



- Source: Joan Kleypas & Chris Langdon. Overview of CO_2 -induced Changes in Seawater Chemistry.

Milankovitch cycles

- **Milankovitch cycles** is a series of periodic changes in Earth's rotation and orbit around the Sun, which alters the way solar radiation is distributed over Earth's surface.

'T' denotes changes in the **Tilt** of the Earth's axis

'P' denotes **Precession**, that is, changes in the direction of the axis tilt

'E' denotes changes in the **Eccentricity** of the orbit

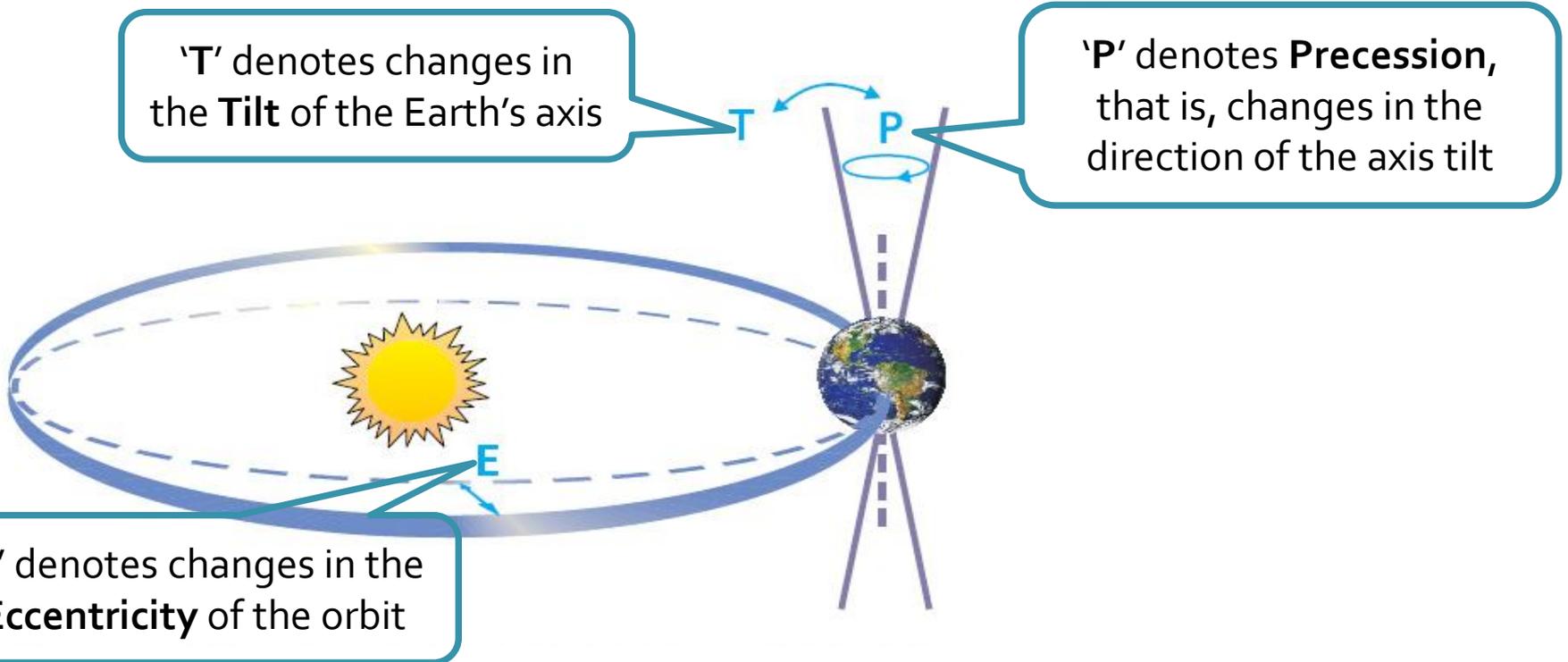


Figure source: The Fourth Assessment Report of the IPCC, 2007.

Solar Activity

- Solar radiation level and energy level fluctuate and this could lead to change in Earth's temperature.
- The sunspot number and the geomagnetic activity are some of the main measures of solar activities.

Summary

- A causality relationship between CO₂ Concentration Earth's temperature has been reported for the post-industrialized era (roughly for the last 150 years).
- However, the pattern of **temperature change showed no differences** between the pre and post industrial era of about 1800 years, while the concentration of all **GHGs remained nearly constant**.
- Alternative hypotheses need more investigation.
- However, considering the **catastrophic effect** of rising sea level, that could be caused by global warming, the **fossil fuel industry** world-wide must take all possible remedial actions.
- The USA, China and India must lead these efforts.

Thank you!

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