

Trial of the Century: Co-Conspirators Convicted

People can be convicted of murder on the basis of overwhelming circumstantial evidence, as the public has been reminded recently. The same is true of three odious, though not odorous, ‘greenhouse gases’, who have been observed lurking in the Earth’s atmosphere.

The ring-leader, code-named “see-oh-two”, or CO₂ (carbon dioxide), is the boisterous one who demands attention, but two taciturn sidekicks, code-named CH₄ (methane) and N₂O (nitrous oxide), were also accused. Expert testimony revealed that the wispy CH₄ had been almost as brutal as rotund CO₂ in toying with planet Earth’s climate. Reliable intelligence revealed that the three defendants were conspiring for a spectacular final attack on planet Earth, with heat and pestilence, ferocious storms, and rising seas to overwhelm coastal areas.

Evidence was shown during the trial (Fig. 1) that the Earth’s temperature had tracked closely the presence of the accused for hundreds of thousands of years. Confronted with this circumstantial evidence, a composed CO₂ responded calmly “this evidence is misleading. It is the baryon planets, Jupiter and Saturn, who are to blame for tugging at Earth and changing its orbit.” He even accused saintly Venus of skirting close by Earth, like a siren, inducing the spinning Earth to tilt its axis.

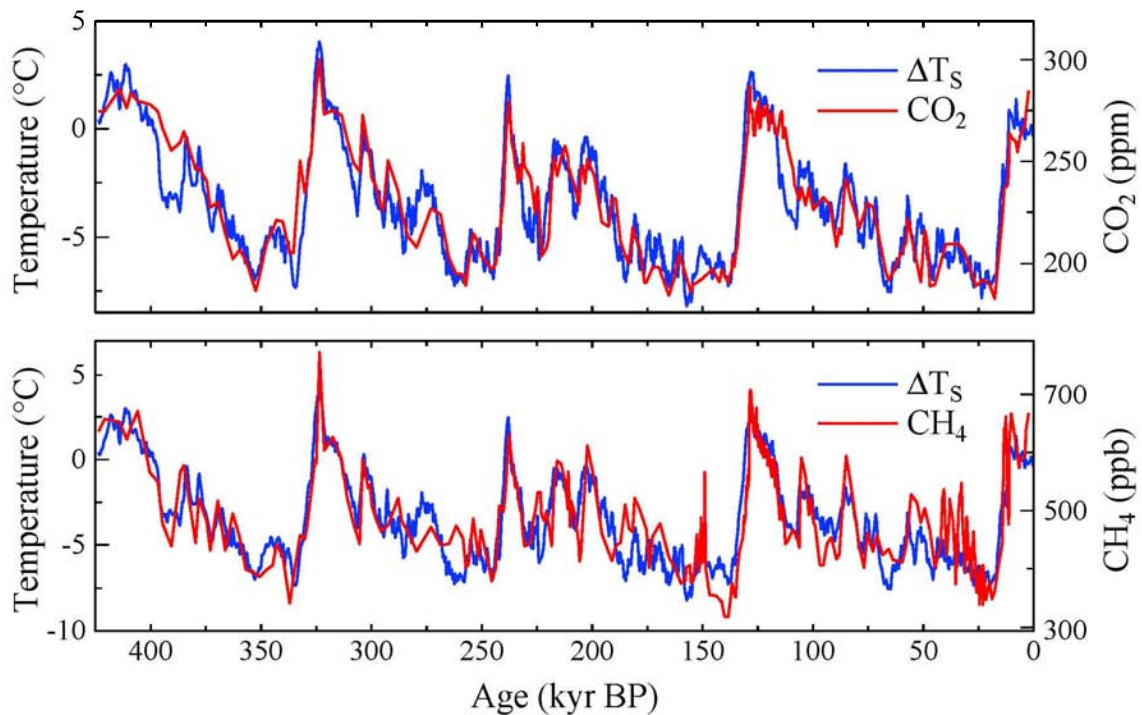


Fig. 1. Antarctic (Vostok) ice core records of temperature, CO₂ (upper) and CH₄ (lower) including time scale adjustment to account for the ice-gas age difference associated with the time for air bubbles to be sealed (Petit et al., *Nature* 399, 429, 1999) and corrected for variations of climate in the water vapor source regions (Vimeux et al., *Earth Planet. Sci. Lett.* 203, 829, 2002) as described in Supporting Text of Hansen and Sato (1).

However, the prosecution showed that the Earth's orbital twitches were only guiding pacemakers, their message carried by sunbeams to all regions of the Earth in different seasons. The three culprits had willingly followed the sunbeams' cue, sometimes seeping together from the soil and seas into the air, and other times diving back into subterranean lairs, almost always traveling together so as to wreak the greatest possible havoc upon the Earth's climate.

Hammered not only with this circumstantial evidence, but also with the common knowledge of their force in blocking heat radiation, CH₄ cracked. "Why blame us? H₂O is a bigger culprit in the long run, snowing and glaciating the way he does, ever so slowly making himself into huge ice sheets. H₂O is the problem! When we came out again, he started melting and dripping and sliding, and all of a sudden, boom, he collapsed! He caused the flooding!"

H₂O testified that it was true, but he was powerless to stop the effects of their heat on him. "And I have always tried hard to deliver clean fresh drinking water to everyone, and I want to do so in the future!"

CO₂, sensing empathy for H₂O, rose lawyer-like to object. "Let not chameleon H₂O fool you. Experts have shown that he, coating the ground with snow and ice, is the greater force in changing climate (Fig. 2)!"

The revered long-lived yodyte was called on. "Aye, in days of yore they worked in concert, CO₂ and CH₄ stealing away to withdraw their heat, H₂O falling as gentle snowflakes, building mile-thick ice sheets over millennia. As CO₂ and CH₄ returned, the ice was dripping, sliding, and boom, floods and warming climate, in the twinkling of a century or so!"

"And now?" "Now," the yodyte continued, "CO₂ and CH₄ from the dark side are joining their brethren. Their numbers, more than 375 for CO₂ and 1750 for CH₄ are off the scale of Fig. 1. Such heating has never been experienced in the age of humanoids."

"What does it mean?" The yodyte paused and bowed his head. "I feel a force, a long struggle. The feeble pull of the planets is now fruitless. Alien CO₂ and CH₄ are a much more dominant force. H₂O, as always, must follow. The future is murky, still in the making."

H₂O was acquitted. CO₂, CH₄, and N₂O were convicted. However, their devilish plot to terrorize the modern world, as they had the ancient worlds, was already far advanced. The planet was now populated by humanoids, a remarkably resourceful species – perhaps growing a bit flaccid as they indulged in the pleasures of their inventions – but they were basically peaceable, and trusting, perhaps even gullible!

A gleam entered the beady eyes of plump self-confident CO₂. Their conviction need not foil their plot if they were not bottled up in jail – perhaps the judge would parole them! CO₂ was articulate, trained in the sciences at MIT, he could debate with the best, and his message fell on welcoming ears. He knew that humanoid leaders would be reluctant to act on the scientific verdict. It was easier to deny it. Many leaders and their financial supporters had vested interests in the status quo. They could find a way for CO₂ to keep his freedom, at least for long enough to get that traitor H₂O sweating and weakened beyond recovery! Oh, what sweet revenge!

Hansen and Sato (1) dispassionately examined the status of this melodrama by going beyond the circumstantial data, finding a discouraging, but not hopeless situation. CO₂ has craftily avoided attempts to bottle it up. It has now reached a level of 378 ppm. More important, it has increased its underlying growth rate to 1.9 ppm per year. Given the inertia in the world's energy infrastructure and growing global economies, it now seems impractical to avoid reaching a level of at least 440 ppm.

The CO₂ amount of 440 ppm is a critical threshold. Other things being “normal”, it is the peak CO₂ amount in a scenario (1) that would keep additional global warming from exceeding 1°C (1.8°F). Based on the history of the Earth, it is estimated that warming greater than 1°C above today’s level would weaken the ice sheets that cover Greenland and Antarctica, causing eventual rise of sea level by several meters.

On the bright side, Hansen and Sato (1) showed that if CH₄ emissions decreased substantially, rather than continued to increase, it would allow the critical threshold of CO₂ to be higher. Some CH₄ emissions are easier to deal with than CO₂. A concentrated global effort to reduce CH₄ and other trace gas emissions may allow the CO₂ amount to be as great as 520 ppm without spelling doom for the ice sheets. Reducing N₂O emissions, for example via more carefully measured application of nitrogen fertilizers, would also help.

A program to reverse CH₄ growth would require global cooperation, but it could be a positive, enabling experience, analogous to the global program to control chlorofluorocarbons. However, the benefits from CH₄ reduction would be wiped out if at least the beginning steps to limit CO₂ were not initiated at the same time.

The possibility of finding a practical, beneficial way out of the Earth’s climate predicament, by dealing with the entire group of causative agents, is a hopeful vision. This climatic melodrama will be playing longer than any soap opera. Stay tuned for the next episode.

Reference

1. Hansen, J. and M. Sato, Greenhouse gas growth rates, *Proc. Natl. Acad. Sci.*, **101**, 16109-16114, 2004. <http://www.pnas.org/cgi/content/full/101/46/16109>

Ice Age Climate Forcings (W/m^2)

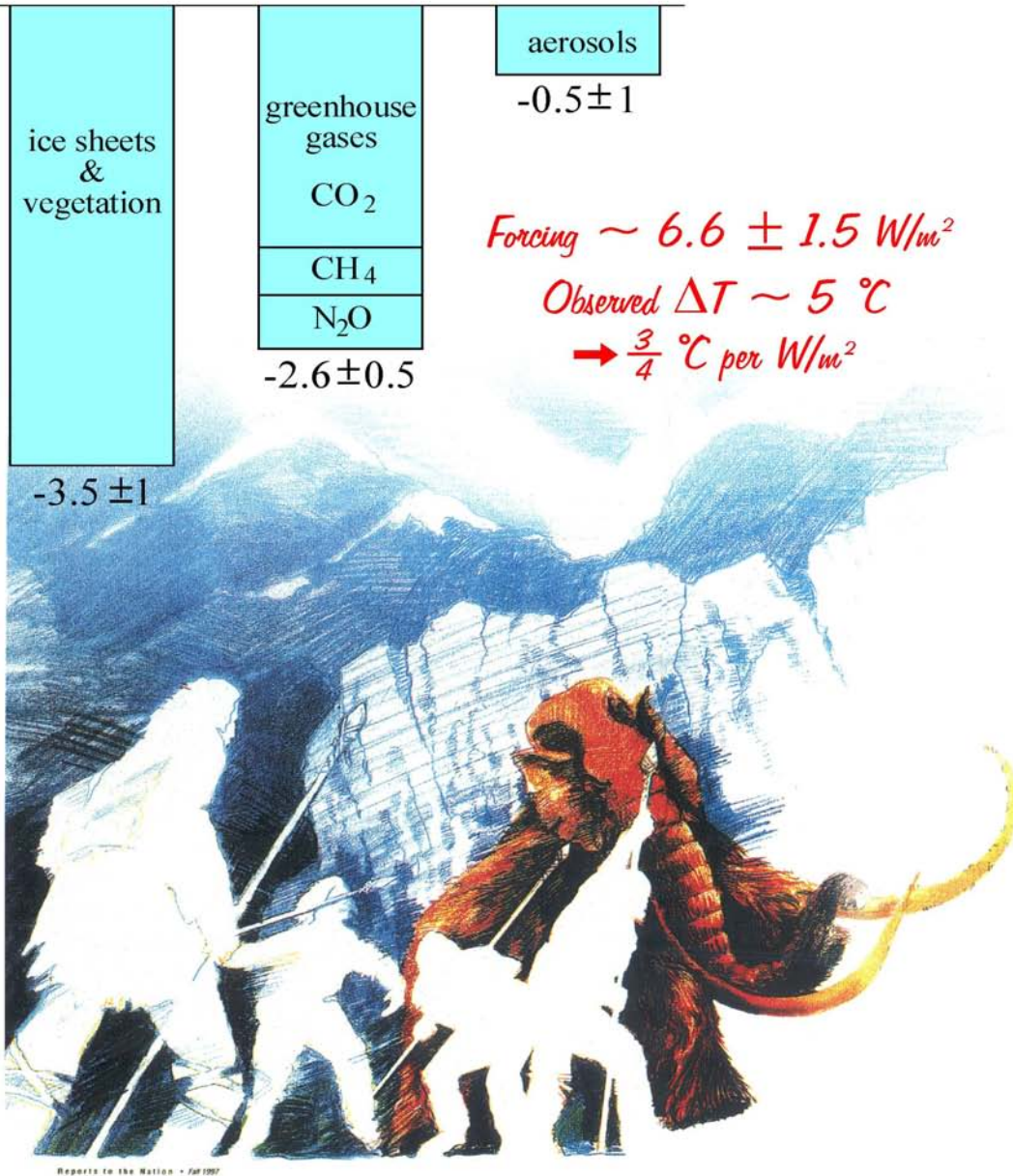


Fig. 2. The Earth must be in radiative (energy) balance within a very small fraction of 1 W/m^2 averaged over the current interglacial period as well as during the peak of the last ice age 20,000 years ago. The changes in atmospheric composition and surface properties, indicated here, which maintained a global temperature difference of $5 \pm 1^\circ\text{C}$ between the ice age and the interglacial period, are known accurately. They imply that climate sensitivity is $\frac{3}{4}^\circ\text{C}$ per W/m^2 , which corresponds to $3 \pm 1^\circ\text{C}$ for a doubled CO_2 forcing of 4 W/m^2 (Hansen, et al., *Natl. Geogr. Res. & Explor.* 9, 141-158, 1993).