I got chatting to a self-proclaimed Anthropological Global Warming denier at a party last night. The evidence he referred to comprised Milankovitch Cycles and 600-year lag in the connection between atmospheric carbon concentrations and global average temperatures. His view was that reforestation was the simple answer to the problem.

The paradox relating to Milankovitch cycles is that some previous scientific research suggested that at some eras in the last 800,000 years, rapid increases in temperature preceded similar increases in CO2 concentrations. This research suggested that warming at that time might have been caused/triggered initially by the combined effects of Milankovitch Cycles, resulting in a greater warming effect from the sun and that this caused the initial rises in CO2 (released from the oceans) rather than the causality being the other way round. It was suggested that, although CO2 had a warming effect, there was a time-lag of several hundred years between the increased CO2 and the warming effect from it.

The following articles explain how recent scientific research suggests that the time-lag between CO2 concentrations and temperature rises might, in fact, be zero, and reaffirm the warming effect of increasing CO2 concentrations. I’ve highlighted the most significant findings in yellow.

**Synchronous Change of Atmospheric CO2 and Antarctic Temperature During the Last Deglacial Warming**

Byrd Polar Research Center, Ohio State University, Columbus, OH, USA. (March 2013)

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* [Abstract](http://www.sciencemag.org/content/339/6123/tab-abstract)

Understanding the role of atmospheric CO2 during past climate changes requires clear knowledge of how it varies in time relative to temperature. Antarctic ice cores preserve highly resolved records of atmospheric CO2 and Antarctic temperature for the past 800,000 years. Here we propose a revised relative age scale for the concentration of atmospheric CO2 and Antarctic temperature for the last deglacial warming, using data from five Antarctic ice cores. We infer the phasing between CO2 concentration and Antarctic temperature at four times when their trends change abruptly. We find no significant asynchrony between them, indicating that Antarctic temperature did not begin to rise hundreds of years before the concentration of atmospheric CO2, as has been suggested by earlier studies.**No Leader to Follow**

Changes in the concentration of atmospheric CO2 and surface air temperature are closely related. However, temperature can influence atmospheric CO2 as well as be influenced by it. Studies of polar ice cores have concluded that temperature increases during periods of rapid warming have preceded increases in CO2 by hundreds of years. **Parrenin *et al.*** (p. [1060](http://www.sciencemag.org/lookup/doi/10.1126/science.1226368); see the Perspective by [**Brook**](http://www.sciencemag.org/lookup/doi/10.1126/science.1234239)) present a revised age scale for the atmospheric component of Antarctic ice cores, based on the isotopic composition of the N2 that they contain, and suggest that temperature and CO2 changed synchronously over four intervals of rapid warming during the last deglaciation.

**Ice Bubbles May Solve Carbon-Temperature Paradox**

* *Published:* February 28th, 2013

By [Michael D. Lemonick](http://www.climatecentral.org/what-we-do/people/michael_lemonick)

Scientists may have resolved a long-standing puzzle in climate science by showing that ancient increases in atmospheric carbon dioxide came at the same time as rising temperatures, rather than hundreds of years afterward.

In a new analysis of bubbles trapped in Antarctic ice, published Thursday in *Science*, lead author Frederic Parrenin of the Laboratory of Glaciology and Geophysics of the Environment, in Grenoble, France, and his colleagues write that at the end of the last ice age, about 20,000 years ago, “. . . Antarctic temperature did not begin to rise hundreds of years before the concentration of CO2, as has been suggested in earlier studies.”

Figure 5 from [Shaken et al.](http://www.nature.com/nature/journal/v484/n7392/full/nature10915.html), 2012 illustrates the seeming disparity between temperature and CO2 changes.
**Click to enlarge.**Credit: [Shaken et al.](http://www.nature.com/nature/journal/v484/n7392/full/nature10915.html), 2012.

“Scientists had been saying the CO2 was an amplifier of global warming, but not the initial cause,” Parrenin said. “Now we’re saying it could be the cause.”

This doesn't mean CO2 isn’t an amplifier as well. If the oceans warm, basic chemistry says that some of the carbon dioxide dissolved in the water will emerge into the atmosphere. And if the permafrost that covers about a quarter of the Northern Hemisphere’s land surface melts, it will put enormous amounts of carbon dioxide (plus methane, an even more powerful greenhouse), into the atmosphere as well.

This new analysis only applies to the most recent period of natural warming, which brought the planet out of the last ice age starting about 20,000 years ago.

“I think they’ve taken a big step toward getting this right,” said Edward Brook, a paleo-climatologist at Oregon State University, in an interview. Brook also wrote a commentary on the research for *Science,* and he cautioned in that commentary that “We . . . do not know whether the results can be generalized to other time periods.”

Still, if there remained any doubt that CO2 itself could initiate global warming, this paper — along with a [2012 paper](http://www.clim-past.net/8/1213/2012/cp-8-1213-2012.html) that also showed no time lag — should go a long way toward putting that doubt to rest.

The time lag suggested by those earlier studies didn’t call into question the well-established relation between CO2 and warming, and did nothing to lessen scientists’ confidence — and fear — that without curbing human greenhouse-gas emissions, global temperatures will continue to rise dangerously through the rest of this century. Nevertheless, the new research emphasizes that the CO2-warming relationship could be somewhat more straightforward in some ways than previously thought.

The idea that warming came before CO2, rather than simultaneously, comes from ancient ice drilled from [Greenland](http://www.climatecentral.org/videos/web_features/neem_ice_cores_tell_of_climate_history) and Antarctica. The ice itself reveals what the temperature was at a given time (it has to do with the relative amounts of different types of oxygen atoms) and the [air bubbles trapped within the ice](http://www.climatecentral.org/news/frigid-bubbles-get-to-the-core-of-climate-change/) show how much CO2 was present in the atmosphere.

But the bubbles are actually younger than the ice that traps them. That’s because the bubbles start out as air spaces between snowflakes on the surface, and gradually become entombed as new layers of snow compress the old, eventually turning it to ice. That doesn’t happen, however, until the snow is between 200 and 300 feet deep, and until it does happen, air circulates within the snow. “We have an ice archive,” said Parrenin in an interview, “and we have a gas archive, and they don’t have the same age.”

Ice-core experts estimate and correct for the age difference, and the general consensus had been that temperature increases at the ends of ice ages stretching back at least 400,000 years preceded CO2 increases by about 800 years. Some triggering factor — a change to the angle of summer sunlight at the poles, for example, or a change in ocean currents, or [both](http://www.climatecentral.org/news/global-warming-egg-before-the-chicken/) — began warming the Earth, triggering the release of CO2 from the oceans, which warmed the planet further, in an upward spiral. Some sort of opposite spiral, went the argument, plunged us back into an ice age.

Still, there was plenty uncertainty in the timing, so Parrenin and his colleagues came up with a new way to estimate the age difference between ice and air: they looked at a heavy, naturally occurring form of nitrogen that sinks to the bottom of the air circulating within snow. Since this is where ice finally solidifies, the bubbles are always richer than average with this heavy nitrogen, and depending on how rich it is, the scientists were able to measure how thick the snow was — and thus how long the air had been circulating before being entombed.

When they used this new age-correction factor, Parrenin and his colleagues recalculated the lag between temperature and CO2, and it more or less vanished.

<http://www.climatecentral.org/news/antarctic-ice-bubbles-may-solve-carbon-temperature-paradox-15663>