ATMOSPHERIC CHEMISTRY

Did Pinatubo Send Climate-Warming Gases Into a Dither?

The condition of Earth's troubled atmosphere has shown signs of stabilizing, even improving, if only temporarily, and now it's the atmospheric chemists who are troubled: They don't know where to place the credit. Beginning in 1991, the buildup of three greenhouse gases—carbon dioxide, methane, and nitrous oxide—sharply slowed or stopped, while the input of oxygen jumped. Now the behavior of a fifth gas, carbon monoxide, has put it on the list of improved vital signs—and deepened the mystery.

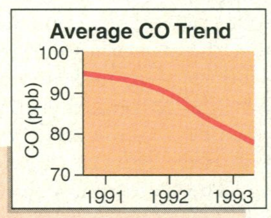
On page 1587, Paul Novelli and Ken A. Masarie of the University of Colorado and their colleagues at the National Oceanic and Atmospheric Administration's Climate Monitoring and Diagnostics Laboratory (CMDL) in Boulder report that the concentration of atmospheric carbon monoxide dropped 18% between June 1991 and June 1993. The gas's concentration had risen, atmospheric chemists believe, since the 1950s, because of the growth of fossil fuel combustion and increased burning in the tropics. With five gases now on the list, some researchers are considering the possibility of a common cause, says atmospheric chemist Paul Crutzen of the Max Planck Institute for Chemistry in Mainz. "At this time, it's all guessing, but it might be that things are related to each other."

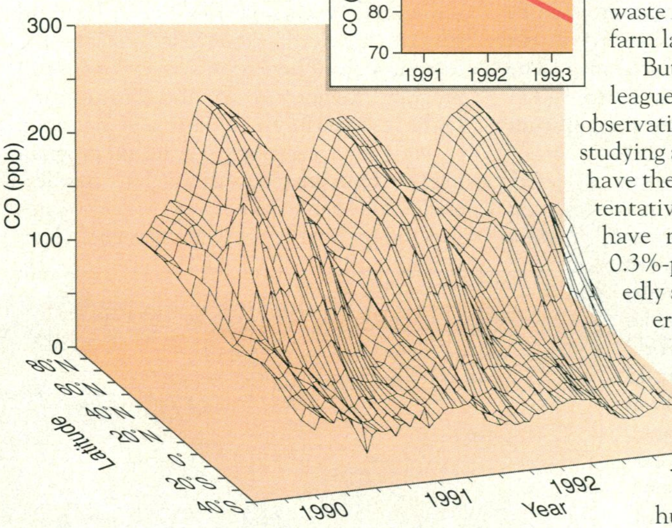
Given that the anomalies all began just after the June 1991 eruption of Mt. Pinatubo in the Philippines and at least those of the three greenhouse gases are now ending, the clearest candidate for a single driving force is the cloud of debris from the volcano. It cooled the globe by at least half a degree and accelerated the loss of stratospheric ozone. So far, however, atmospheric chemists have come up with a tangle of explanations, only some of which lead back to Pinatubo, and some atmospheric chemists doubt that a single, coherent explanation will ever emerge. "I don't think there will be a simple explanation for all" the gases, says Ralph Cicerone of the University of California, Irvine.

The first sign of the atmospheric disturbance came last summer, when Charles Keeling of Scripps Institution of Oceanography reported that measurements at Mauna Loa in Hawaii showed that the rise in carbon dioxide had begun to slow dramatically in July 1991 and didn't start returning to its normal pace until mid-1993. A CMDL group headed by Pieter Tans reported a similar trend. A hint of an explanation came when Ralph Keeling of Scripps (who is Charles Keeling's son) discovered signs that additional oxygen had been entering the atmosphere of the Northern Hemisphere since mid-1991. The rise in oxygen roughly mirrored the apparent drop in carbon dioxide input.

That correlation suggested the trends might have a common cause. Because oxygen release and carbon dioxide uptake by plants respond to global temperature changes such as El Niño events, says Charles Keeling, the Pinatubo cooling looks like a promising candidate. Within limits, he notes, cooler temperatures and the increased rainfall they often bring can boost photosynthesis. Cooling can also slow decomposition of soil organic matter, which releases carbon dioxide.

Only a coincidence? Carbon monoxide, which varies by season and latitude, began declining in 1991 *(inset)*.





SOURCE: NOVELLI, *ET AL.*

But the picture grew murkier in January, when Edward Dlugokencky of CMDL and his colleagues added a third gas to the list of anomalies. They reported that the rise in methane, which atmospheric scientists have monitored closely since 1978, began to slow in the second half of 1991 and had stopped altogether by mid-1992. Several methane sources, including biomass burning, rice paddies, and natural wetlands, might have slowed in a cooler climate. But Dlugokencky and his colleagues think those sources aren't likely to account for the entire slowdown; much of it, they suggest, could reflect the patching of leaks in the natural gas pipelines of the former Soviet Union (*Science*, 11 February, p. 751).

Whatever the causes of the methane slowdown turn out to be, they may also account for part of the drop in carbon monoxide, because some carbon monoxide is produced by the oxidation of methane in the atmosphere. But Novelli speculates that the full explanation may be a combination of mechanisms, at least one volcano-driven. In the high latitudes of the Northern Hemisphere, notes Novelli, the key may be the thinning of the stratosphere's ozone layer, which accelerated after Pinatubo's eruption. Thinner ozone would have let more ultraviolet light reach the lower atmosphere. There it could have produced more of the hydroxyl radical—the atmosphere's cleanser molecule—which destroys carbon monoxide.

In the tropics, however, volcanically driven ozone losses were small. The carbon monoxide drop there might be due to a dry spell, probably unrelated to the volcano, in the early 1990s. Dry weather, says Novelli, tends to reduce biomass burning—and hence carbon monoxide production—because it reduces the amount of agricultural waste and slows the expansion of farm lands through slash and burn.

But if Novelli and his colleagues have failed to link all their observations to Pinatubo, researchers studying a fifth gas, nitrous oxide, will have their hands full building even a tentative link. Although the data have not yet been released, the 0.3%-per-year rise in the gas reportedly slowed right after Pinatubo's eruption. But researchers aren't even sure what was causing the rise in the first place, because nitrous oxide has many sources in soil and water, and it is not known how human activity had been affecting them. The recent slowing simply adds a new dimension to the mystery.

"The scope of this [puzzle] is expanding willy-nilly," says Cicerone, and he's not optimistic about the ability of atmospheric chemists to catch up soon. "I'm afraid we're not going to resolve this quickly. We really don't have an integrating framework with which to view these things." At the moment, most researchers are still thinking about the one or two gases that they specialize in. If those narrow perspectives could be broadened, the episode could offer a unique opportunity to dissect links between climate and atmospheric composition that might amplify greenhouse warming in the future. If nothing else, though, trying to understand how a volcano might have had such a bracing influence on the atmosphere could force atmospheric chemists to consider their patient as a whole.

–Richard A. Kerr