# Ozone Destruction Worsens

Don't look up now, but new satellite data show that the ozone shield over the United States is eroding twice as fast as had been assumed. Indeed, the ozone layer is disappearing so quickly that it now looks as if current plans to reduce the losses may be too little, too late. "I find it very disturbing that the ozone layer is peeling away this quickly," says atmospheric chemist Michael Oppenheimer of the Environmental Defense Fund in New York. "Now it looks like the strong measures we're about to take won't be enough."

Those measures are embodied in the Montreal Protocol, which aims to eliminate the release of the manmade chlorofluorocarbon chemicals (CFCs) thought to underlie stratospheric ozone losses. When first signed back in 1987, with the newly recognized Antarctic ozone hole—the first tipoff to a deteriorating ozone layer—hanging over the negotiators, the protocol mandated a 50% reduction of CFC production by the year 1998. The fear was that stratospheric ozone depletion, if it continued, would allow increased amounts of ultraviolet radiation to strike Earth, increasing the rate of human skin cancer and also harming plants and animals.

The original provisions for controlling CFCs looked strong enough to buy plenty of time for ozone scientists to study the problem further—or so the treaty negotiators hoped. Then the Antarctic hole deepened, evidence mounted for similar ozone destruction over the Arctic, and signs appeared of possible ozone destruction over the mid-latitudes of the Northern Hemisphere (*Science*, 12 August 1988, p. 785). In response to these ominous developments, the Protocol was revised last June to phase out CFC production by 2000. Now, even that may fall short of what's necessary to hold ozone depletion to tolerable levels.

The latest ominous development comes from NASA's satellite-borne Total Ozone Mapping Spectrometer (TOMS). Three years ago, the international Ozone Trends Panel (*Science*, 25 March 1988, p. 1489) analyzed 17 years of ground-based ozone measurements and concluded that the northern mid-latitudes (roughly between Seattle and New Orleans) were losing ozone at a rate of about 1% to 3% per decade. But the new TOMS results, which were released on 4 April by William Reilly, who heads the Environmental Protection Agency (EPA), indicate ozone losses there of 4% to 5% per decade. During the winter months, the rate goes as high as 8% per decade. And the enhanced losses are now dragging into April and May, when both plants and people are more exposed—and therefore more vulnerable—to ultraviolet radiation. Globally, ozone is decreasing 2.3% per decade. The EPA estimates that in the United States alone such ozone depletion may cause 200,000 additional deaths from skin cancer over the next 50 years.

Although Reilly called the new depletion rates "stunning," the difference between the loss rate found by TOMS and that estimated 3 years ago by the Ozone Trends Panel may not be as great as it appears, says Richard Stolarski of NASA's Goddard Space Flight Center in Greenbelt, Maryland, who analyzed the TOMS data with his Goddard colleagues. The panel analyzed data only through 1986, while the new satellite analysis includes the years since then, when ozone losses were, if anything, greater than those in the early 1980s, Stolarski says. And the satellite analysis did not have data from the 1970s, when there was little or no downward trend in ozone.

But even if the new satellite data were overdramatized a bit, they confirm that the downward trend has continued since 1986. And that's having a sobering effect in the scientific community. Few researchers are arguing very strenuously anymore that the trend might be a natural one; the assumption is that CFCs are behind the decline. And even under the revised protocol provisions, atmospheric chlorine is expected to reach 25% to 30% above present values.

Researchers are now assuming that the mid-latitude ozone losses originate at least in part in CFC-induced chemical reactions far to the north. The Arctic has its own version of the Antarctic ozone hole contained within a wintertime vortex of swirling stratospheric winds. Here the ozone-destroying chlorine of CFCs is released through reactions on icy cloud particles unique to the polar regions. But the chlorine needn't stay penned within the vortex. It and any air already depleted of ozone can escape to lower latitudes to make mischief there, too. Great streamers of air can peel off the vortex, the vortex itself can break up (as it always does by March), and chemically altered air might simply leak out the bottom of the vortex.

In addition to the ozone losses imported from the Arctic, some ozone destruction may occur locally in the mid-latitudes. Lab experiments have shown that some of the ice-mediated reactions of the Antarctic ozone hole can also occur on sulfuric acid droplets, which pervade the stratosphere at all latitudes.

The higher quoted rates of ozone loss come as scientists are preparing for another reassessment of ozone trends under the auspices of the Montreal Protocol, which is due by the end of the year. That leaves time for more bad news, perhaps from a 6-month-long airborne expedition into the Arctic to be mounted this fall from Bangor, Maine. After all, in the ozone business, bad news seems to be the only news. ■ RICHARD A. KERR

# Greenhouse Policy: A Bargain?

Ever since people began to take the greenhouse effect seriously, it has been widely assumed that it would be horrendously costly to make a significant dent in the amount of carbon dioxide and other greenhouse gases that industrial society pours into the atmosphere each year. Both the Reagan and Bush Administrations seem to have accepted that notion in declining, so far, to join several other countries in pledging to control $CO_2$ emissions (*Science*, 22 February, p. 868). A committee of the National Academies of Science and Engineering and the Institute of Medicine politely, but firmly, disagrees with this conventional wisdom, however.

In a report* published this week, the Committee on Science, Engineering, and Public Policy concludes that the United States could cut emissions of greenhouse gases by 10% to 40% for little or no cost. "Some reductions may even be at a net savings if the proper policies are implemented," says the panel, which was chaired by former U.S. senator and civil engineer Daniel Evans, a Republican from Washington state. The committee urges the Administration and Congress to start now in cutting greenhouse gases "as insurance protection against the great uncertainties and the possibility of dramatic surprises" inherent in global warming. "Insurance," it says, "is cheap."

The Administration may not regard some of the panel's recommendations as "proper policies," however. In essence, the panel calls for an energy program that relies on a combination of regulations and price incentives (including taxes) to encourage conservation and efficiency, stepped-up efforts to reduce deforestation, and—of course—more research on energy technologies, climate modeling, and the ecological and economic effects of global warming. In contrast, the Administration recently sent Congress a package of legislation for an energy strategy that studiously avoids addi-

**Policy Implications of Greenhouse Warming*, National Academy Press, 1991.

tional regulation and taxes to spur conservation, concentrating instead on encouraging energy production.

The report, which was requested by Congress, notes that if current trends continue, the concentration of greenhouse gases in the atmosphere would climb to roughly double the pre-Industrial Revolution level by the middle of the next century. The result, says the report, would be somewhere between a modest 1°C increase in global temperatures and a catastrophic 5°C jump—a broader range than many other scientific analyses, which generally predict a rise of 2°C to 5°C. The committee adds that it cannot rule out nasty surprises, such as a sudden increase in atmospheric methane caused by the melting of high-altitude tundra, or significant melting of the West Antarctic ice sheet, resulting in a sea level "several meters higher than it is today."

In the short term, the panel points out that the biggest reduction in greenhouse gas emissions will come from phasing out chlorofluorocarbons (CFCs), which currently account for about 10% of global greenhouse gas emissions. Fortunately, the United States, along with most other major CFC users, agreed last year to stop using these compounds by 2000 in an effort to arrest erosion of the ozone layer (see page 204).

Carbon dioxide, which accounts for two-thirds of greenhouse gas emissions (methane and CFCs account for most of the rest), is a tougher problem. The trick in setting public policy will be to encourage individuals and businesses to do what is in their own long-term economic interest: conserve fossil fuels by making investments in technologies that eventually pay for themselves in lower energy costs. "The efficiency of practically every end use of energy can be improved relatively inexpensively," the report notes. But it may require higher energy prices, low-cost loans, and regulations to convince consumers and businesses of the wisdom of switching to more efficient lighting, heating, and cooling, and making vehicles that get more miles to the gallon. The federal government should also "sharply increase the emphasis on energy efficiency in the energy research and development budget," and put more emphasis on alternatives to fossil fuels, including R&D on solar energy and safer nuclear plants, the panel says.

Sound familiar? Perhaps that is because many of these ideas first circulated in the late 1970s and early 1980s in response to rapidly increasing oil prices. They went out of vogue in the laissez faire economic climate of the Reagan years. But now concern over greenhouse warming, rather than fears of OPEC, have brought them back to center stage. ■ COLIN NORMAN

# Microbes and "The Trabi Problem"

One of the most popular films now showing in Germany (both east and west) is a comedy called *Go Trabi Go*. The plot has an east German family celebrating post-unification freedom to travel by piling into the family sedan and heading for Italy. One of the running gags is their vehicle: the Trabant ("Trabi" for short), a smoke-belching product of socialist engineering with a two-stroke engine and a plastic body. Along the way to the Mediterranean, the family car suffers many indignities, including being mistaken for junk at an auto graveyard.

And that's where, like all comedies, this one cuts close to a home truth: The Trabi is on its way to the junkyard. Last year Volkswagen signed a deal to begin building cars at sites where the boxlike sedan has been produced; the plan was to phase out the Trabant by 1993. But that will present an enormous waste-disposal problem. It seems that, while the Trabi's two-stroke engine was famous for breaking down, its plastic shell is all but indestructible. The reason is that the shell is made of cellulose filling covered by phenol formaldehyde resins that make up a "duroplastic" which, unlike ordinary thermoplastics, cannot be melted down.

That is what some German officials—all joking aside—refer to as "The Trabant Problem." In addition to the Trabis already moldering in auto graveyards, there are still 2 million of them on the road. Each time a proud new east German capitalist replaces his Trabi with a shiny new VW or BMW, more than 1400 pounds of unrecyclable plastic heads for the scrap heap. At the moment, the only way to get rid of all those Trabi bodies is to burn them (giving off toxic gases that only add to east Germany's foul air) or dump them into overcrowded landfills.

Patrick Piel/Gamma Liaison

**On the junkheap of history.** *Trabant bodies in eastern Germany.*

Which is where science comes in. During the past few months, an east Berlin biotech company has been looking into the possibility of a biological solution to the Trabant problem—microorganisms capable of biodegrading Trabi resins. A team of microbiologists at IFZ Biotechnology Research and Development Company (a former east German state enterprise with a staff of about 100) has identified several species of bacteria and fungi that might be up to the tough job of having a Trabi body for dinner.

Those strains, which the German newspaper *Das Bild* has lumped together under the fanciful name *Trabicilli*, are found naturally in the environment—mainly in the area around production plants where resins are synthesized, as well as in landfills where plastic products have been dumped. The microbiologists at IFZ are still working out the details of how the bugs metabolize the resins. If the process turns out to be practical on a large scale, the plastic from the Trabant would have to be broken down into particles of about 2 square millimeters. They would be introduced into a reactor, yielding biological residues, carbon dioxide, and water. The residues would be converted to nontoxic gas in a separate chamber.

Promising as the *Trabicillus* approach may be, it isn't right around the corner. Franz Weissbach, the chemist leading the company's project, acknowledges that he doesn't yet know "whether our process will be practical or economical. We hope that within the next 2 years we will have an answer to that." Nevertheless, the group has already come up with a process based on fungi from the genus *Penicillium* for degrading the cellulose part of the Trabant body.

And in a clear sign that the capitalist ethos is taking root, and that socialism is going the way of the Trabi, Weissbach declines to identify the precise microorganisms involved. "It's a trade secret," he says slyly. ■ MICHAEL BALTER

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