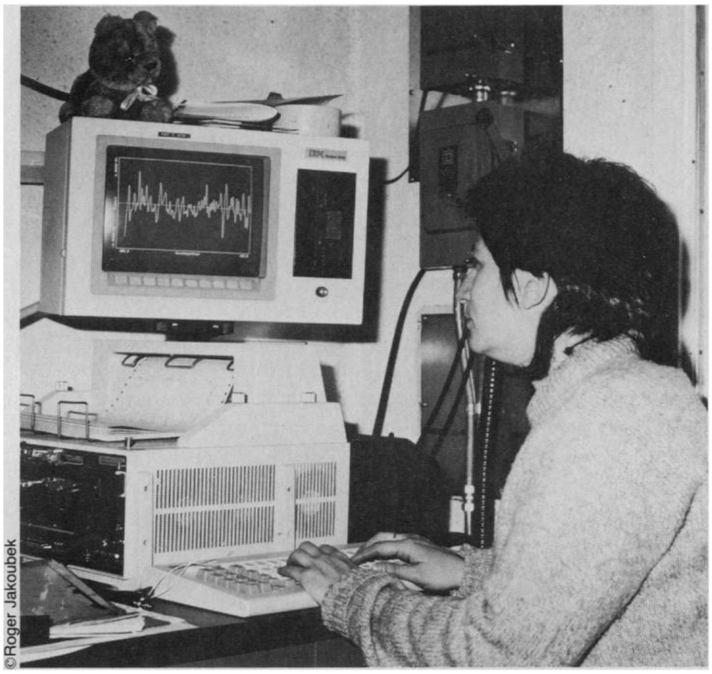
Research News

Evidence of Arctic Ozone Destruction

The same chlorine compound that first pointed to the destruction of ozone by chlorofluorocarbons in the Antarctic hole has now been found over the Arctic



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On the hunt in the far north. *NOAA group member Susan Solomon went to Thule, Greenland, in early February to look for signs of ozone-destroying chemicals. Here she is processing data in Thule.*

Snowmass Village, Colorado

MORE bad news for Earth's stratosphere. First, it was the catastrophic loss of ozone over the Antarctic during the austral spring and the proof that this annual "hole" is dug by man-made chlorofluorocarbons (CFCs). Then came the announcement that ozone is decreasing globally, especially during the winter and at higher latitudes.

Now comes the first evidence that ozone-destroying forms of chlorine also form over the Arctic during the winter. The significance of this first chemical clue, the presence of chlorine dioxide, was hotly debated when it was first found over the Antarctic, especially by meteorologists preferring purely wind-driven mechanisms for creating the hole. But the detection of chlorine dioxide turned out to be the first in a string of observations that ultimately implicated CFCs in the creation of the Antarctic ozone hole. With that experience behind them, atmospheric chemists are tentatively assuming that CFCs are destroying Arctic ozone, albeit at markedly slower rates. Signs of a springtime ozone loss in the Arctic, as seen in the Antarctic, are appearing, too.

The first detection of Arctic chlorine dioxide was reported on 12 May at the Polar Ozone Workshop held here. George Mount of the National Oceanic and Atmospheric Administration's Aeronomy Laboratory in Boulder, Ryan Sanders and Roger Jakoubek at the University of Colorado, and Arthur Schmeltekopf and Susan Solomon at the Aeronomy Laboratory had rushed their spectrographs to Thule, Greenland, in late February, just a few months after bringing them back from their second trip to Antarctica. To their good fortune, the Arctic weather cooperated magnificently. Not only was the sky clear so that they could record the ultraviolet and visible spectra of moonlight and scattered sunlight, but the polar vortex swirling in the lower stratosphere lingered near Thule at 77°N during the 2-week observing period.

The vortex provides the coldest temperatures in the stratosphere and thus the best hunting for signs of ozone-destroying chemicals. In Antarctica, their formation is mediated by stratospheric clouds that only form at temperatures colder than about −80°C. Once formed, reactions on the surface of the cloud particles, or heterogeneous reactions, can release ozone-destroying chlorine. Over Thule, stratospheric temperatures were running between −80°C and −85°C.

Mount and his colleagues detected chlorine dioxide in disconcertingly large amounts. There were $4.5 \pm 1.5 \times 10^{13}$ molecules in a square-centimeter column of atmosphere over Thule. The amount varied just as predicted when the sun came up and began destroying it and when the moon sank behind more of the atmosphere near moonset. The same group failed to detect it over Colorado, implying that the Thule values are at least five times those at midlatitudes. Chemical models that do not include the creation of reactive chlorine on polar stratospheric clouds predicted only a tenth of the observed chlorine dioxide. Over Antarctica in late winter there is two to five times as much as seen in the Arctic.

Just how chlorine dioxide participates in ozone destruction has been a matter of some debate. It is a by-product of a recycling of chlorine and bromine that destroys ozone. It may be a participant in another ozone-destroying catalytic cycle in which two chlorine monoxide molecules combine to form a dimer. Whatever its true role, elevated chlorine dioxide is now generally viewed as a reasonably good marker for chlorine monoxide, the active form of chlorine that actually destroys ozone.

The Thule team found another sign that Antarctic-type chemical reactions are occurring over the Arctic. It found nitrogen dioxide in amounts as low as 4×10^{14} molecules per square centimeter. That is about the amount seen over Antarctica in early spring when the extreme cold has stripped much of the nitrogen dioxide from the lower stratosphere to form cloud particles of nitric acid hydrate or water ice. The production of ozone-destroying chlorine compounds on cloud particles alone would not reduce ozone concentrations unless nitrogen is removed from the atmosphere because it can tie up chlorine as innocuous chlorine nitrate.

"All this implies that heterogeneous chemistry may be operative in the Arctic," said Mount, "but to a lesser degree than in the Antarctic." "It's clear there is more chlorine in the Arctic than expected," added Solomon. "Transport could be partly responsible, but in my opinion there is also heterogeneous chemistry. At a minimum, it is necessary to assume that nitrogen dioxide has been removed in the Arctic," which sets up the possibility of heterogeneous chemistry. With these and other studies, the global implications of heterogeneous chemistry, the subject of a subsequent story, are becoming clearer.

Another attempt to detect chemical perturbations of the Arctic stratosphere seems to have fallen short of the vortex, but in an interesting way. William Brune and his colleagues at Harvard University flew their resonance fluorescence analyzer north from San Francisco on the ER-2, the scientific version of the U-2 spy plane. The plane may have just made it into the vortex, but it encountered temperatures no colder than −67°C, too warm for polar stratospheric clouds. The analyzer did detect elevated levels of chlorine monoxide and ozone, but Brune is assuming that air is simply descending from higher altitudes where these compounds are enriched. Heterogeneous chemistry is probably not involved. However, the edge of the Arctic vortex over northern Canada does look familiar. "What we saw at 61°N is very similar to what we saw on the shoulders" of the Antarctic hole, said Brune.

As the chemistry of the Arctic begins to look familiar, springtime ozone losses are being suggested in the north as well. Richard Stolarski of Goddard Space Flight Center in Greenbelt, Maryland, presented ozone observations made by the satellite-borne Total Ozone Mapping Spectrometer (TOMS). Comparing 1986–1987 values with those of 1979–1980, Stolarski found "a reasonably large decrease coming out of polar winter," just as has happened in the south. The difference was about 6% above a latitude of 60°N. Neil Harris of the University of California at Irvine and his colleagues also reported winter-spring losses on the basis of long-term ground-based observations.

The next step will be to nail down the existence of heterogeneous chemistry in the Arctic vortex and any resulting ozone destruction. Michael Kurylo of the National Aeronautics and Space Administration announced that an airborne expedition like the one that settled the controversy about the Antarctic ozone hole will be launched from Stavanger, Norway, next January. Whether this effort will be as decisive as last fall's may depend on how cooperative the Arctic vortex proves to be. Meteorologists can direct research planes toward the vortex, as can the operators of TOMS, which sometimes sees reduced ozone in it. Unlike the Antarctic vortex, the Arctic version can break down and reform during the winter. It also slides around the polar region, which could easily place it out of range of the ER-2. Stratospheric clouds are probably spottier in the warmer Arctic as well. And next winter's vortex is expected to be less stable than usual. Arctic ozone hunters may need some luck to bag their quarry on the first try. ■

Richard A. Kerr

Change in Polio Strategy?

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The Institute of Medicine (IOM) is urging the government to consider the biggest change in polio vaccine policy since the 1962 switch from the killed Salk to the live Sabin vaccine. The new change, which IOM suggests in a report requested by the Public Health Service, is intended to reduce the five to ten cases of polio that result each year from immunization with the live vaccine.

This new switch would not occur for several years, however, when a new, souped-up version of the killed vaccine should be licensed in the United States. At that time IOM suggests changing to a combined schedule with several shots of the killed vaccine, followed by two doses of live vaccine. The souped-up killed vaccine, now being developed in Canada by Connaught Laboratories and sold in Europe by Merieux, is an enhanced Salk vaccine administered in combination with the diphtheria-pertussis-tetanus (DPT) vaccine. Until that vaccine is available here, IOM recommends staying with the status quo—which is a primary reliance on the orally administered Sabin vaccine, except in special circumstances.

As the wild polio virus has been nearly eliminated from the country, the biggest risk—and it is still small—of contracting the disease comes from the vaccine itself. The risk is estimated at one case of paralytic polio per 2.7 million doses of oral vaccine, or one case per 560,000 first doses. (The highest risk is associated with the first dose.)

Despite the small risk it carries, the Sabin vaccine has been the vaccine of choice since 1962 because it provides a stronger, longer lasting immunity than the killed version. Moreover, it also confers "herd immunity" on the unvaccinated population as well. For several weeks after immunization, the live vaccine replicates in the gut and can be passed on to other people the child comes in contact with, providing indirect immunization.

However, a new and enhanced inactivated vaccine (known as E-IPV for enhanced inactivated polio vaccine) now rivals the live version in effectiveness and, because it is inactivated, cannot cause polio. (Cases could conceivably arise if the virus were improperly killed.) The enhanced vaccine was recently licensed in the United States and is already in use in Europe. Thus the reason for considering a change in course.

The downside of the killed vaccine is that it provides less herd immunity—an important consideration, since in some disadvantaged areas of the country the immunization rate is as low as 50% in contrast to the nationwide average of 95%. Nor are its possible adverse effects known. Although it appears safe, it has not been used in countries where the populations are large enough to reveal a very rare effect.

For these and other reasons, the committee says, a complete switch to the killed vaccine would eliminate the vaccine-related cases but might increase the number of wild polio infections. Thus, they went for a compromise: the killed vaccine, administered at perhaps 2, 4, and 6 months, followed by the live vaccine at 18 months and upon entry to elementary school. This strategy should reduce—but not eliminate—the number of vaccine-related cases and provide the desired herd immunity. It would also ensure an adequate supply of the live vaccine, which is the vaccine of choice in an epidemic.

Even so, the change will bring only a marginal benefit to a remarkably successful program, says the committee. For that reason they recommend waiting until the enhanced killed vaccine is available in combined form, with DPT, which will be both cheaper and easier to administer. And if it becomes clear that the wild virus has been eliminated, then a complete switch to the killed vaccine would be in order. ■ **Leslie Roberts**