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Author(s): Lemonick, M.D.; Cray, D.

Abstract: Summarizes research by the National Aeronautics and Space Administration which used a modified spy plane and an orbiting satellite and found record-high concentrations of chlorine monoxide (ClO), implying that the ozone layer over some regions could be temporarily depleted by as much as 40 percent in early spring. Ozone hole over Antarctica; Regulating chlorofluorocarbon production; Effects of ultraviolet radiation; Loss at mid-latitudes. INSET: Hats On!

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COVER STORIES

THE OZONE VANISHES

> And not just over the South Pole. A hole in earth's protective shield could soon open above Russia, Scandinavia, Germany, Britain, Canada and northern New England.
>
> What does it mean to redefine one's relationship to the sky? What will it do to our children's outlook on life if we have to teach them to be afraid to look up?
>
> --Senator Al Gore, Earth in the Balance

The world now knows that danger is shining through the sky. The evidence is overwhelming that the earth's stratospheric ozone layer--our shield against the sun's hazardous ultraviolet rays--is being eaten away by man-made chemicals far faster than any scientist had predicted. No longer is the threat just to our future; the threat is here and now. Ground zero is not just the South Pole anymore, ozone holes could soon open over heavily populated regions in the northern hemisphere as well as the southern. This unprecedented assault on the planet's life-support system could have horrendous long-term effects on human health, animal life, the plants that support the food chain and just about every other strand that makes up the delicate web of nature. And it is too late to prevent the damage, which will worsen for years to come. The best the world can hope for is to stabilize ozone loss soon after the turn of the century.

If any doubters remain, their ranks dwindled last week. The National Aeronautics and Space Administration, along with scientists from several institutions, announced startling findings from atmospheric studies done by a modified spyplane and an orbiting satellite. As the two craft crossed the northern skies last month, they discovered record-high concentrations of chlorine monoxide (CIO), a chemical by-product of the chlorofluorocarbons (CFCS) known to be the chief agents of ozone destruction.

Although the results were preliminary, they were so disturbing that NASA went public a month earlier than planned, well before the investigation could be completed. Previous studies had already shown that ozone levels have declined 4% to 8% over the northern hemisphere in the past decade. But the latest data imply that the ozone layer over some regions, including the northernmost parts of the U.S., Canada, Europe and Russia, could be temporarily depleted in the late winter and early spring by as much as 40%. That would be almost as bad as the 50% ozone loss recorded over Antarctica. If a huge northern ozone hole does not in fact open up in 1992, it could easily do so a year or two later. Says Michael Kurylo, NASA's manager of upper-atmosphere research: "Everybody should be alarmed about this. It's far worse than we thought."

And not easy to fix because CFCS are ubiquitous in almost every society. They are used in refrigeration and air conditioning, as cleaning solvents in factories and as blowing agents to create certain kinds of plastic foam. In many countries CFCS are still spewed into the air as part of aerosol sprays.

Soon after the ozone hole over Antarctica was confirmed in 1985, many of the world's governments reached an unusually rapid consensus that action had to be taken. In 1987 they crafted the landmark Montreal Protocol, which called for a 50% reduction in CFC production by 1999. Three years later, as signs of ozone loss mounted, international delegates met again in London and agreed to a total phaseout of CFCS by the year 2000. That much time was considered necessary to give CFC manufacturers a chance to develop substitute chemicals that do not wipe out ozone.

But the schedule now seems far too leisurely. Last week's grim news spurred new public warnings and calls for faster action. In Denmark an Environment Ministry spokesman went on television to urge fellow Danes not to panic--but to use hats and sunscreen. German Environment Minister Klaus Topfer called on other countries to match Germany's pledge to stop CFC production by 1995. Greenpeace activists in Britain met with Prime Minister John Major and implored him to halt the manufacture of all CFCS immediately.

The U.S. Congress passed a law in 1990 that called for an accelerated phaseout of CFCS if new scientific evidence revealed a greater threat to ozone than expected. Last week the Senate, by a 96-0 vote, found the evidence alarming enough to justify a faster phaseout. "Now that there's the prospect of a hole over Kennebunkport, " Senator Al Gore said, "perhaps Bush will comply with the law." William Reilly, administrator of the Environmental Protection Agency, said that the U.S. might seek to end CFC production as early as 1996.

The vital gas being destroyed is a form of oxygen in which the molecules have three atoms instead of the normal two. That simple structure enables ozone to absorb ultraviolet radiation--a process that is crucial to human health. UV rays can make the lens of the eye cloud up with cataracts, which bring on blindness if untreated. The radiation can cause mutations in DNA, leading to skin cancers, including the often deadly melanoma. Estimates released last week by the United Nations Environment Program predict a 26% rise in the incidence of nonmelanoma skin cancers worldwide if overall ozone levels drop

10%.

Excess UV radiation may also affect the body's general ability to fight off disease. Says immunologist Margaret Kripke of the M.D. Anderson Cancer Center in Houston: "We already know that ultraviolet light can impair immunity to infectious diseases in animals. We know that there are immunological effects in humans, though we don't yet know their significance."

Just as worrisome is the threat to the world's food supply. High doses of UV radiation can reduce the yield of basic crops such as soybeans. UV-B, the most dangerous variety of ultraviolet, penetrates scores of meters below the surface of the oceans. There the radiation can kill phytoplankton (one-celled plants) and krill (tiny shrimplike animals), which are at the very bottom of the ocean food chain. Since these organisms, found in greatest concentrations in Antarctic waters, nourish larger fish, the ultimate consumers--humans--may face a maritime food shortage. Scientists believe the lower plants and animals can adapt to rising UV levels by developing UV-absorbing cell pigments. But that works only up to a point, and no one knows what that point is.

The impact of ozone loss will be felt first in Antartica, where levels of the gas have been severely depleted each spring for several years. Populations of marine organisms are not shrinking so far, but they have begun to produce UV-absorbing pigments. In Australia, scientists believe that crops of wheat, sorghum and peas have been affected, and health officials report a threefold rise in skin cancers. There are anecdotal reports of more cancer in Argentina too. While no increase in cancers or cataracts has shown up yet in Chile or New Zealand, experts note that these diseases can take years to develop.

Many people are reducing their risks. In Punta Arenas, Chile's southernmost city, some parents keep their children indoors between 10 a.m. and 3 p.m., and soccer practice has been moved from midafternoon to later in the day. The Australian government issues alerts when especially high UV levels are expected, and public service campaigns warn of the dangers of sunbathing, much as U.S. ads counsel people not to smoke. In New Zealand schoolchildren are urged to wear hats and eat their lunches in the shade of trees.

Scientists are also concerned about the potential effect of ozone depletion on the earth's climate systems. When stratospheric ozone intercepts UV light, heat is generated. That heat helps create stratospheric winds, the driving force behind weather patterns. Says Sherwood Rowland, a chemist at the University of California at Irvine, who first discovered the dangers of CFCS: " If you change the amount of ozone or even just change its distribution, you can change the temperature structure of the stratosphere. You're playing there with the whole scheme of how weather is created."

Weather patterns have already begun to change over Antarctica. Each sunless winter, steady winds blow in a circular pattern over the ocean that surrounds the continent, trapping a huge air mass inside for months at a time. As the sun rises in the spring, this mass, known as a polar vortex, warms and breaks up. But the lack of ozone causes the stratosphere to warm more slowly, and the vortex takes longer to dissipate. This leads to even more ozone destruction: the polar vortex acts as a sort of pressure cooker to intensify chlorine's assault on ozone molecules.

When Rowland and his colleague, Mario Molina, issued the first ozone alert back in 1974, they had no idea that depletion would be particularly severe in Antarctica or in any other part of the world. What they did predict was that CFCS would not disintegrate quickly in the lower regions of the atmosphere. Instead the hardy chemicals would rise into the stratosphere before dissociating to form CIO and other compounds. The highly reactive chlorine would then capture and break apart ozone molecules. Each atom of chlorine, it was later determined, could destroy up to 100,000 molecules of ozone--at a far faster rate than the gas is replenished naturally.

But Rowland and Molina had deduced only the broadest outlines of the process. The details had to wait until the mid-1980s, when atmospheric scientists realized belatedly that while worldwide ozone levels had declined somewhat, there was an enormous deficit in Antarctica every year. Determined to understand whether CFCS were the culprit, NASA mounted a series of flights from Punta Arenas into the Antarctic in 1987. They revealed unusually high concentrations--up to 1 part per billion--of CIO. They had found the smoking gun Rowland and Molina had predicted.

Rowland and others figured it was a combination of factors that made the ozone over Antarctica particularly vulnerable. First, the polar vortex collects CFCS that waft in from the industrialized world. Second, the superfrigid air of the Antarctic night causes clouds of tiny ice crystals to form high up in the stratosphere. When the CFCS break down, the resulting chemicals cling to the crystals, where they can decompose further into C1O, among other substances. And finally, when the sun rises after the long winter night, its light triggers a wholesale demolition of ozone by chlorine monoxide.

In Antarctica winds circulate unimpeded over the frozen landmass. In the north, though, the polar vortex is less well defined. Winds travel alternately over land and water, whose differing temperatures disrupt the smooth flow of air. The :vortex wobbles and sometimes breaks up entirely. Moreover, the Arctic stratosphere is not as cold as that over the Antarctic, and ice clouds are less likely to form. So while scientists knew that some ozone destruction should take place, they presumed it would not be nearly as severe as the southern hole. A reanalysis of 10 years' worth of ground-based and satellite data, completed last year, revealed a relatively mild but widespread depletion over the northern hemisphere, with losses of 4% to 8% over much of the continental U.S.

When NASA'S ex-spy plane, the ER-2, began a series of flights out of Bangor, Maine, in October, it quickly became clear that something strange was happening. For one thing, volcanic ash, lofted into the stratosphere from last year's Mount Pinatubo eruption, was evidently taking the place of ice crystals, giving CFC byproducts the platform they needed for their chemical reactions. Moreover, the scientists found that naturally occurring nitrogen oxides, compounds that tend to interfere with and slow down these reactions, were virtually gone from the atmosphere. Why? Besides enhancing the reactions that create ozone-destroying forms of chlorine, explains Susan Solomon, a chemist with the National Oceanic and Atmospheric Administration, "the volcanic aerosols provide a surface for chemical reactions that suppress nitrogen oxides."

Another flight that took off from Maine on Jan. 20 provided the clincher. The polar vortex had temporarily dipped as far south as Bangor--"It was almost as if we were deploy over the North Pole," says geophysic Darin Toohey of U.C.-Irvine--just in for the sensitive instruments on board detect CIO in a world-record concentration of 1.5 parts per billion. Data from the Upper Atmosphere Research Satellite had already found comparable levels of CIO over Northern Europe, and the evidence pointed to a potential ozone loss of 1% to 2% a day.

Even with all these factors in place, there is still one element necessary before a certified ozone hole can form: the sun. If the polar vortex breaks up before the sun rises after months of darkness to trigger the reaction, there will be no hole this year. If the vortex holds together until late February or early March, keeping its brew of dust particles and chemicals intact, ozone levels will almost certainly drop. Says Harvard chemist James Anderson: "We are now protected only by the hope of a rapid breakup of this vortex." But even if the hole does not appear this spring, says Anderson, it will almost certainly appear within the next few years.

When it does, the area of greatest ozone depletion and greatest danger will most likely be north of 50 degrees north latitude, a line that nearly coincides with the U.S.-Canada border and also takes in all the British Isles, Scandinavia, the Netherlands and much of Belgium, Germany and Russia. Regions farther to the south could be affected too, albeit not so severely. Life in the far north could come to resemble that in Australia, with ozone alerts and stern warnings to wear sunglasses and sunscreen.

Some scientists are equally concerned about the smaller but worsening ozone loss at mid-latitudes. The mechanism behind polar ozone holes was not predicted before its discovery. could there be an undiscovered reason for ozone to vanish over temperate zones as well? May be so. On Jan. 12 the ER-2 swooped south instead of north north. Says Anderson: "We discovered to our shock that there was CIO all the way down to the Caribbean." It was a very thin layer with concentrations of only 0.1 part per billion--but this was much higher than anyone had predicted.

No one is sure just such concentrations of the chemical got there or whether it is destroying ozone. It may be that some of the CIO-rich air from the polar vortex has split off and headed south on its own--a phenomenon that has been observed in the past. And while ozone depletion has not been directly observed, the chemistry over the Caribbean appears to be right. There is CIO; there are plenty of dust particles from Pinatubo; there is sunlight. NASA'S Kurylo thinks significant ozone loss is in fact happening in the tropics. Says Harvard's Anderson: "This is cause for extreme concern. It is the mechanism we most fear."

What also frightens scientists is the fact that CFCS remain in the atmosphere for decades after they are emitted. In their original research, Rowland and Molina estimated that CFCS can last 100 years or more. Even if CFC production stopped today, researchers believe that stratospheric levels of chlorine would continue to rise, peaking during the first decade of the next century and not returning to anything like natural levels for at least a century.

The ozone story is a tragic saga of doubt and delay. Rowland recalls that for several months after his original ozone paper was published in 1974, "the reaction was zilch." It was not until 1978 that the U.S., but not most other countries, banned the use of CFCS in hair sprays and other aerosols. Not until the Antarctic ozone hole was confirmed in 1985 did nations get serious about curbing all uses of CFCS. By now as many as 20 million tons of these potent chemicals have been pumped into the atmosphere.

World leaders should remember ozone when they think about other threats to the planet. If they always wait until there is undisputable evidence that serious damage is occurring, it may be much too late to halt the damage. Consider the widespread scientific predictions of global warming from the greenhouse effect. No one knows for sure that anything terrible will happen. But humanity has boosted the amount of carbon dioxide in the atmosphere by at least 25%. It is reckless to subject nature to such giant experiments when the outcome is unknown and the possible consequences are too frightening to contemplate.

At least nations now seem to agree on a crash effort to save the ozone. But the cure will not be instantaneous. The world may not know for decades how costly the years of recklessness will be. And whether children should be afraid to look.

THE POTENTIAL EFFECTS OF UV LIGHT

EYES

Cataracts can develop, causing the lens to cloud up.

Result: blurred vision and, without treatment, blindness.

SKIN

Exposure can lead to accelerated aging, wrinkling and various forms of skin cancer.

IMMUNE SYSTEM

A reduced immune response may make the body more susceptible to infectious diseases.

CROPS

Interfere with photosynthesis could result in lower crop yields.

MARINE LIFE

Radiation affects the growth of phytoplankton, the mainstay of the ocean food chain.

PHOTOS (COLOR): The red patch is a cloud of chlorine monoxide, as seen by NASA'S Upper Atmosphere Research Satellite last month. Ozone destruction is most likely to take place north of 50 degree latitude and could start as early as late February.

PHOTOS (COLOR): As the ozone gets thinner, people may have to cover up year-round to guard against the harmful radiation from the skies. The pale look could become sexier than a deep tan.

PHOTO (COLOR): Endangered Earth

DIAGRAMS: OZONE LAYER

1. A layer of ozone in the stratosphere protects the earth by blocking most of the sun's harmful ultraviolet light.

2. Ozone is a molecule made of three oxygen atoms.

3. Chlorine atoms from CFCS attack the ozone, taking one oxygen atom away and forming chlorine monoxide.

4. The chlorine monoxide then combines with another oxygen atom to form a new oxygen molecule and a chlorine atom.

The chlorine can go on to break apart thousands more ozone molecules.

5. The newly formed oxygen molecules do not block the ultraviolet light, allowing it to penetrate to the surface of the earth.

ILLUSTRATIONS

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By MICHAEL D. LEMONICK

Reported by Dan Cray/lrvine and Dick Thompson/Washington, with other bureaus

Inset Article

HATS ON!

Ozone depletion is cause for caution, but it's no reason to stay barricaded indoors or put on an astronaut suit before venturing outside. Excessive exposure to the sun's ultraviolet (UV) rays has always been dangerous; the ozone problem just adds to the risk. Says NASA'S Michael Kurylo: "We're not talking about a single exposure to a death ray. It takes repeated exposure over long periods of time."

Even if there were no atmospheric damage, an estimated one-sixth of all Americans would still develop skin cancer during their lifetime. Most cases are curable, if detected early. The 4% to 8% loss of ozone over the past decade could raise the risk at least 15%. A significant increase in cataracts, which now afflict 1 of every 10 Americans, could also occur.

As the ozone depletion gets worse, health risks will rise, but the odds of getting cancer or cataracts can be dramatically reduced by following guidelines that doctors recommended long before ozone depletion became a big issue. Their suggestions:

• When out in the sun for prolonged periods, wear protective clothing. That means choosing fabrics that have a tight weave and donning a wide-brimmed hat. A baseball cap is not adequate because it leaves the delicate rims of the ears exposed.

• In summer, when comfort calls for shorts and T shirts, use a broad-spectrum sunscreen with a sun protection factor of at least 15.

• Minimize the time spent in the sun between 10 a.m. and 3 p.m.

• Wear sunglasses when outdoors in bright sunlight. Ask for ones that are treated to absorb UV radiation or that meet the American National Standards Institute Guidelines for eye wear. Poorly designed sunglasses that do not block UV rays could do more harm than good. Under dark lenses, the pupils dilate, making it easier for UV light to damage the delicate membrane of the retina.

PHOTOS (COLOR): Hats

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