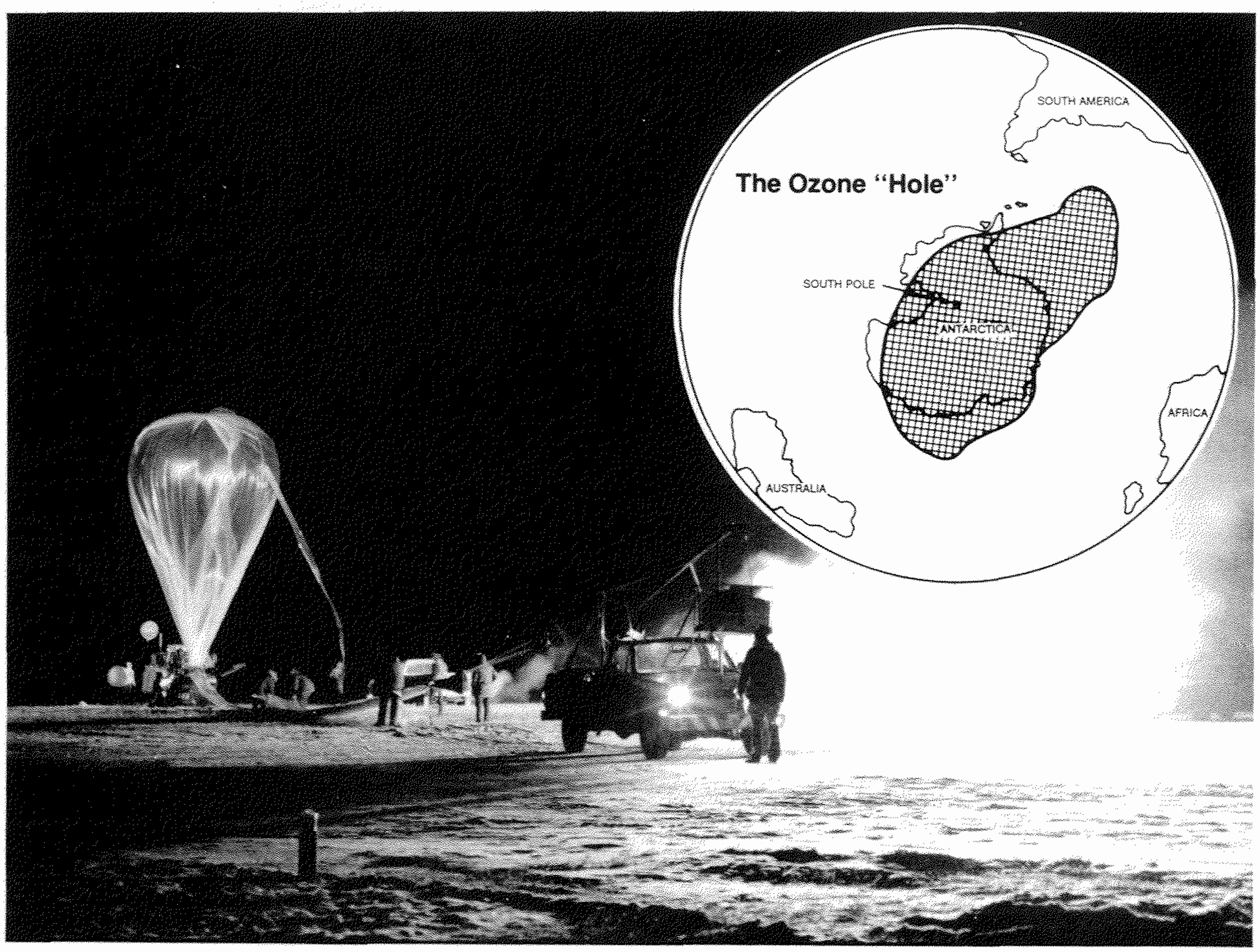
Fact Sheet

Environment Canada / Environnement Canada

Atmospheric Environment Service / Service de l'environnement atmosphérique

Atmospheric Environment Service

THE OZONE LAYER

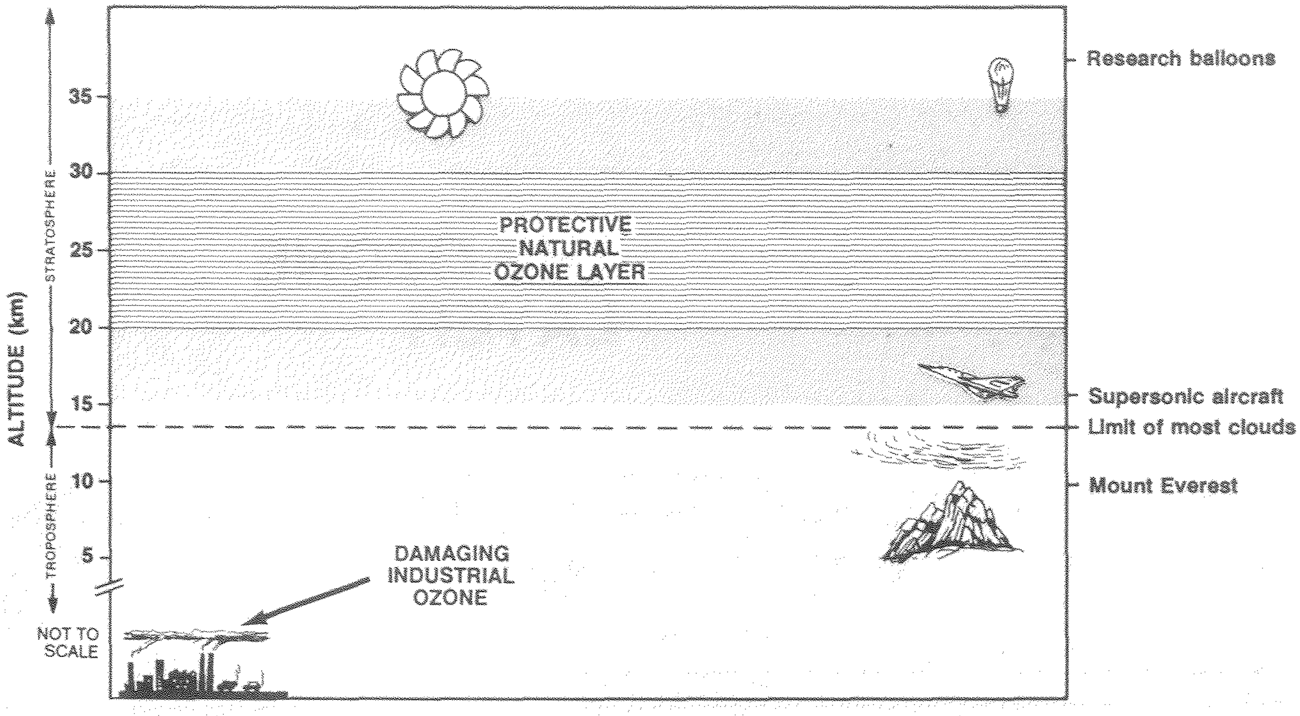


A "hole" in the ozone layer over Antarctica has alarmed scientists. Satellite photography captured the hole (shaded area) as it appeared in October, 1986. At the other end of the earth, Environment Canada launches a research balloon to study the Arctic ozone layer (photo).

Human activities have had such an impact on our planet that we are changing the composition of the earth's atmosphere. There is widespread concern that industrial chemicals have now reached even the upper layers of the earth's atmosphere and are threatening the planet's fragile ozone layer — a layer of gases that protects us from the damaging ultra-voilet rays of the sun. Exposure to ultra-violet can cause skin cancer, reduce crop yields and damage aquatic life. Indeed, serious depletion of the ozone layer could affect most life on earth.

In recent years, scientific attention has focused on ominous changes in the ozone layer. Over the past decade, the global ozone layer appears to have been

Ozone in the Atmosphere



In the upper atmosphere, a protective layer of ozone shields us from the sun's damaging rays, while at ground level this same gas is a serious air pollutant. (Most of the ozone in the upper atmosphere occurs between 15 and 35 km, with the heaviest concentration between 20 and 30 km.)

slowly depleting. Measurements taken over Toronto, for example, show a decrease of 4% since 1975. However, it was the discovery of a sudden unexplained "hole" in the ozone over Antarctica that galvanized scientific interest. Here the ozone layer has been observed to thin dramatically during the spring over an area the size of the continental United States. Environment Canada scientists are currently studying the Arctic to determine if a similar thinning may be developing there.

Scientists do not fully understand these changes in the ozone layer but they are concerned that they could indicate a serious weakening in the earth's protective shield. Although some changes in the ozone layer could be due to natural conditions, increasing evidence now points to chemical contamination from our industrialized society as the root cause.

What is Ozone?

Ozone (O_3) is a pungent-smelling slightly bluish gas, which is a close chemical cousin to oxygen (O_2). The ozone in our atmosphere is spread so thinly that its bluish color would never be noticed. However, one can occasionally catch a whiff of this gas after a thunderstorm. Lightning can literally split apart the air molecules, which re-combine to form a trail of ozone, leaving that sharp "clean" odour which soon dissipates after a storm.

About 90% of the earth's ozone occurs in a natural layer far above the surface of the globe, in a frigid region of the atmosphere known as the stratosphere. Some natural ozone can also be found near the earth's surface, however most ground-level ozone is formed as a result of human activities. Ironically, ozone near the ground is a serious pollutant, damaging human health and agricultural crops in, or near, large urban areas. Ground-level ozone is formed from air pollutants, primarily motor vehicle exhaust and gasoline vapours, which collect over cities on hot summer days. A thick blanket of smog — in which ozone is a key ingredient —can result.

High Altitude Ozone — The Protective Shield

The ozone layer in the earth's upper atmosphere acts as a natural filter, absorbing most of the sun's damaging ultra-violet rays. Excessive exposure to ultra-violet can cause serious damage to living tissue — these are the rays responsible for sun burn and some forms of skin cancer.

Even small changes in the ozone layer can have significant impacts. Studies show that a 1% depletion in ozone would result in about a 4% increase in non-melanoma skin cancer. Although this form of skin cancer is rarely life-threatening, it can be highly unsightly. Scientists strongly suspect that an increase would also occur in malignant melanoma — a rarer but often fatal form of skin cancer. Ultra-violet can also cause skin and eye aging and suppress the human immune system, leading to greater susceptibility to disease.

Many agricultural crops are particularly sensitive to ultra-violet, including most of the world's major food sources: wheat, rice, corn and soya beans. Although much research remains to be done, preliminary studies on soya beans indicate that a 1% depletion of ozone would result in a 1% reduction in crop yield.

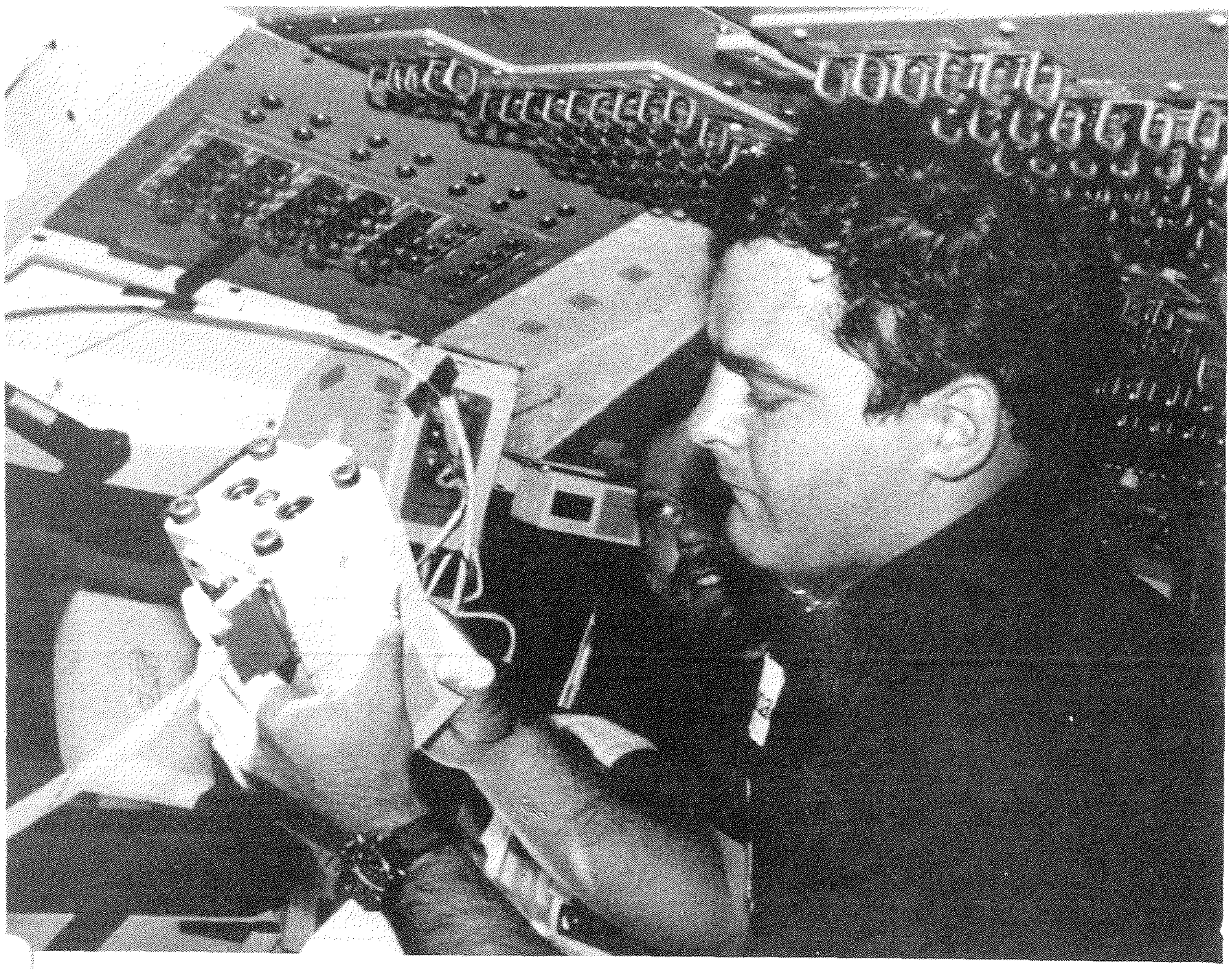
uatic life near the ocean's surface is also very susceptible to ultra-violet, and excessive exposure could disrupt fish production in the world's oceans. Even industrial materials, such as plastics and paints, have been shown to be affected, becoming yellow and brittle with lengthy exposure.

Threats to the Ozone Shield

Most of the ozone in the stratosphere is found in a layer about 20 km thick, lying between 15 km and 35 km above the earth's surface. Here, in these frigid heights, the ozone is spread so thinly that if it were compressed to ground-level pressure, it would form a layer only 3 mm thick. Ozone is a very unstable substance which can be readily destroyed by contact with certain industrial pollutants. Even the upper atmosphere isn't far enough away to escape the effects of human activities. Air pollutants reach the stratosphere by slowly moving up from the lower atmosphere, or by being injected directly from high altitude aircraft and space vehicles.

Concern about the ozone layer first surfaced in the early 1970s when high altitude aircraft were originally proposed. Fleets of supersonic planes were planned to fly at high speed through the stratosphere — far above the height of normal aircraft — leaving ozone-destroying exhaust fumes in their wake. However, the new jets proved to be uneconomical and were never widely used. Today the European "Concorde" is the only high altitude plane in regular service. (Other vehicles travelling through the stratosphere, such as space craft and new military aircraft, do not pose a problem at present, as they have not yet come into heavy use.)

In the mid-1970s, attention had switched from advanced high-tech aircraft to the ordinary aerosol spray can. By this time, spray cans had become a tremendously popular item — used by millions on a daily basis to dispense products such as hair sprays and deodorants. The products in these spray cans were mixed with propellants and stored under pressure. When the can was used, the propellant helped to force out the contents.



c Garneau, Canada's first astronaut, studies the ozone layer from outer space during his historic flight in the U.S. space shuttle. He is taking readings with a "sunphotometer", an instrument designed by Environment Canada.

Industrial chemicals, known as "CFCs" ("chlorofluorocarbons"*) were used as the propellant. CFCs are a stable non-toxic group of chemicals which were considered to be environmentally safe. Unfortunately, the effects of CFCs were considered only for the lower atmosphere.

During the 1970s, the use of spray cans released literally thousands of tons of CFCs directly into the lower atmosphere, where they began their slow movement up into the stratosphere. Although CFCs are very stable in the lower atmosphere, scientists are concerned that once they reach the upper stratosphere, these chemicals will be broken apart by the intense ultra-violet light above the ozone layer. One of the substances that is produced in this break down process is chlorine. Chlorine has a voracious appetite for ozone — a single molecule is capable of destroying thousands of molecules of ozone.

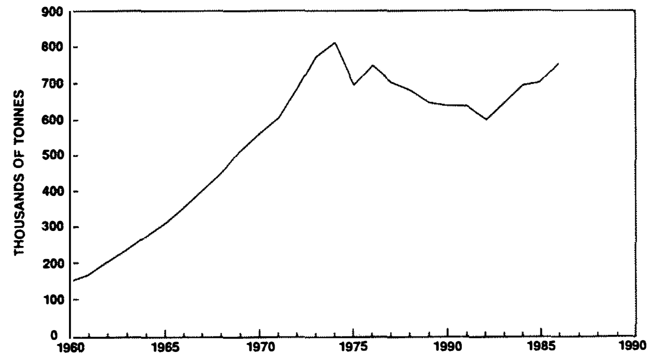
In the late seventies, steps were taken to reduce the use of CFCs in spray cans. In 1976, Canadian industry agreed to cut this use by half. In fact, this objective was surpassed, partly because of a widespread consumer boycott. In 1980, Canada banned the major propellant uses — in hair sprays, antiperspirants and deodorants. This action reduced the use of CFCs in spray cans by 86%, and resulted in an overall national reduction of 45%. Similar bans were undertaken in the U.S.A. and Nordic countries in the late 1970s and early 1980s. Europe followed suit with less restrictive regulations. These actions caused a sharp drop in the global release of CFCs.

However, this drop was quickly offset by increases in other industrial uses. CFCs had been found to be very useful in a wide variety of industrial processes, since they are non-toxic and non-flammable. In many cases, they replaced chemicals which were seen as being much more directly hazardous to human health. CFCs were now being used to manufacture foam insulation and padding, as coolants in refrigerators and air conditioners, and as solvents for cleaning microchips and other electronic equipment. By the mid 1980s, global levels of CFCs in the atmosphere were increasing at an alarming rate of 5-6% per year.

The problem was further compounded by the fact that, once released in the atmosphere, most CFCs remain there for 75 to 100 years. Thus virtually all of the CFCs that have ever been released are still in the atmosphere. During the early to mid 1980s, roughly 800,000 to one million tonnes of CFCs were added each year to this ever-increasing global pool of ozone-destroying chemicals in our atmosphere. Thus global action to control these chemicals had to be taken well in advance of any evidence of a major depletion of the ozone layer.

There is also concern that CFCs are contributing to another important environmental problem: global climate change. Through a process known as the greenhouse effect, world climate is expected to become warmer, with accompanying shifts in rainfall patterns and increases in sea level. CFCs and carbon dioxide are expected to be major contributors to this greenhouse effect. Although CFCs are far less abundant than carbon dioxide, their effect on climate, molecule for molecule, is about 10,000 times more powerful. At present, CFCs contribute over 15% of the current greenhouse effect.

Global Production of CFCs



The world production of CFCs, which threaten the ozone layer, is increasing again, after a sharp decrease in the early 1970s, when their use in spray cans was restricted.

A Hole in the Sky?

Scientists have discovered a disturbing thinning of the ozone layer over the Antarctic during the polar spring, in September and October. This "hole" appears to be spreading steadily, becoming wider and thinner over the past decade. In recent years, the ozone has thinned by about 50% over an area half the size of Canada. This "hole" lasts for about two months each year and then fills in.

There is now concern that a similar hole may be developing over the north pole. During the spring of 1986, Environment Canada scientists discovered a large thin area in the ozone over the Arctic which lasted for at least six weeks during March and April. Unlike the Antarctic hole, which remains relatively stationary, the Arctic hole was observed to shift about the north pole, being observed first over northern Europe and then moving over northern Canada, apparently following the movements of the cold polar air. The depleted area appears similar to the ozone hole over the Antarctic, but lesser in extent, being only about one third the size and one third the depth.

These ozone holes are of serious concern to scientists, as they were totally unexpected and remain unexplained. Although many theories have been proposed, increasing evidence is now pointing to CFCs as the cause of these depletions.

A Global Commitment

Rising concern over the ozone holes and the apparent steady loss of global ozone prompted the recent signing of an international accord to reduce the use of CFCs. In September 1987, 24 nations, including Canada, pledged to reduce the use of these chemicals by 50% by 1999. The agreement, known as the Montreal Protocol on Substances that Deplete the Ozone Layer, is the first accord of its kind and sets a global precedent for the safeguarding of both the environment and human health. The accord was developed under the United Nations Environment Programme and marks the

*also known by the commercial trade names "freon", "genetron" or "arcton" cumulation of over five years of intensive international negotiations, in which Canada played a key role.

The Montreal Protocol was signed as an addition to the 1985 Vienna Convention for the Protection of the Ozone Layer. The convention established a framework to protect the earth's upper atmosphere through cooperative international efforts. It also provides for international cooperation in scientific research and information exchange. Canada signed the convention in 1985 and was the first nation to formally ratify it in June 1986. To date, a total of 28 countries have signed this accord.

Strong trade sanctions against non-participating countries were included in the agreement. These will encourage other nations to sign both the protocol and the convention.

The Montreal Protocol also placed controls on the production of other ozone-destroying chemicals. These include halons, a group of chemicals used in fire extinguishers, which are up to ten times more destructive to ozone than CFCs.

Reducing the Use of CFCs

Industry is now developing substitute chemicals and processes to reduce their dependency on CFCs. In some cases, the use of CFCs can be eliminated entirely. Butane and other similar materials have proven to be effective substitutes as propellants in spray cans, while food containers can be made from paper products instead of plastic foam. A new type of refrigerator is being developed which uses helium instead of the standard CFC coolant. Other chemicals could be used as solvents to clean microchips and electronic equipment.

CFCs are widely used to manufacture foam products —both soft foam padding, and rigid foam used for packaging and home insulation. The manufacture of rigid foam insulation is growing rapidly, as this material is now commonly used to insulate homes and to produce foam food containers, including egg cartons, meat trays and fast food containers. Industry is now developing ways to manufacture these products without the use of CFCs.

Substitute chemicals have been developed for CFCs which present little or no threat to the ozone layer. These include fluorocarbons (CFC-like chemicals which contain no chlorine) and certain CFCs which are not as damaging to the ozone layer.

At present, the Montreal Protocol covers only those CFCs which are very stable and persist for long periods of time in the atmosphere. Other types of CFCs (known as HCFCs) break down rapidly in the lower atmosphere before they can reach the stratosphere. Since these do not pose as great a risk, they may be used on an interim basis as substitutes for the more damaging CFCs. Industry is now considering the use of a less damaging CFC in air conditioners and certain plastic foams.

While the protocol focuses on chemicals which threaten the ozone layer, there is also a sensitivity not to replace ozone-depleting CFCs with substances which will have a major impact as greenhouse gases.

Under the terms of the Montreal Protocol, industry must reduce the use of CFCs by 20% by 1994 and a further 30% by 1999. Will these actions fully protect the ozone layer? Unfortunately, scientists cannot yet answer this question. The earth's atmosphere is an extremely complex system which is not yet fully understood. For this reason, the protocol includes a provision to review scientific findings on the ozone layer every four years and to accelerate the reduction of ozone-destroying chemicals if necessary. The first review meeting is scheduled for 1990. Such flexibility is a very important feature of the protocol.

Keeping Watch on the Ozone Layer

The international scientific community is keeping close watch on our protective shield through a world-wide network of measuring stations, co-ordinated by the World Meteorological Organization. Environment Canada plays a leading role in this system by operating the World Ozone Data Centre. For over 20 years, this Canadian centre has collected data from the global network and distributed it to the world's scientists. Such information is essential for understanding long term change in the ozone layer.

Keeping tabs on a layer of invisible gases 25 km above the earth's surface is no easy task. Scientists at Environment Canada use a variety of techniques to study our protective shield. Huge helium-filled ballons —some as tall as 28 meters — carry measuring instruments to heights of up to 40 km. High altitude rockets are used as well. Measuring instruments have also been developed that are so sensitive they can take readings of the gases in the stratosphere from the surface of the earth, or from outer space.

Marc Garneau, Canada's first astronaut, studied the ozone layer from outer space during his historic flight on the U.S. space shuttle in 1984. He used a "sunphotometer" — a small compact instrument developed by Environment Canada to measure haze and gases in the atmosphere.

In recent years, satellite measurements have proved to be a most useful tool, by providing a comprehensive global overview of the ozone layer. Maps developed from satellite data clearly show fluctuations in the layer and could be a key factor in understanding the Antarctic ozone hole.

The global ozone measuring network relies mainly on ground-based instruments which measure the height and thickness of the ozone layer from the surface of the earth. As part of this network, Environment Canada operates stations at Toronto, Edmonton, Churchill, Goose Bay (Labrador) and Resolute (N.W.T.).

Environment Canada's Atmospheric Environment Service has perfected the design for a modern ground-based ozone measuring instrument — the Brewer Ozone Spectro-photometer. This is a unique, state-of-the-art instrument which is now being used to upgrade the global network of measuring stations. The new instrument has proved to be the world's most accurate ozone-measuring device, making measurements easier and more precise. In the future, this instrument is scheduled to fly on board the U.S. space shuttle, to measure the ozone layer from outer space.

Canada's Role

Canada has become a world leader in encouraging international protection of the atmosphere by playing a key role in the development of the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol.

Our nation was an active participant throughout the lengthy negotiations to develop both these agreements. During the development of the Montreal Protocol in 1986, a Canadian proposal broke a serious deadlock in the negotiations and paved the way for the development of the final accord. In recognition of our efforts the United Nations Environment Programme accepted Canada's offer to act as the host country for the final signing of the protocol.

The Montreal Protocol is a major environmental landmark. It sets out a formula whereby nations can work together to prevent an environmental problem, before it reaches the crisis stage. Using the protocol as a model, Canada is now encouraging further international efforts to more fully protect the atmosphere.

A Call for Further Action

In June 1988, Environment Canada organized a major global conference in Toronto on "The Changing Atmosphere: Implications for Global Security". The conference, attended by over 300 scientists and policy makers from around the world, was supported by the United Nations Environment Programme and the World Meteorological Organization.

Participants issued a strongly worded statement calling for immediate action to protect the atmosphere. They concluded that changes in the earth's atmosphere are a serious threat, second only to global nuclear war.

The provisions of the Montreal Protocol were re-examined in light of recent scientific findings. New evidence had made an even stronger case for the destructive effect of CFCs on the ozone layer. The Antarctic ozone hole was continuing to deplete. This promoted conference participants to call for a revision of the Montreal Protocol to ensure the virtual elimination of the most destructive CFCs by the year 2000. They also recommended that stronger measures be considered to limit other ozone-destroying substances, such as halons.

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Also available in French
Aussi disponible en français
September/88

Canada

Published by Authority of the Minister of the Environment

Catalogue No. En57-24/15-1987E
ISSN 0715-0040
ISBN 0-662-15436-3