# Action on Ozone

## 2000 Edition

UNEP
Ozone Secretariat
United Nations Environment Programme

UNEP

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ISBN: 92-807-1884-3

Published 2000

Produced by
The Secretariat for
The Vienna Convention for the Protection of the Ozone Layer &
The Montreal Protocol on Substances that Deplete the Ozone Layer

Printed and bound in Kenya by UNON. Printed on recycled paper.

Cover design by UNON Printshop (June 2000)

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# Foreword

Imagine a world without the treaties designed to protect the Earth's stratospheric ozone layer.

Production and consumption of industrial chemicals such as chlorofluorocarbons (CFCs) and halons would be climbing steadily, bringing products such as refrigerators, air conditioning, aerosol sprays, insulating and furniture foams into the homes and vehicles of hundreds of millions of families around the world.

Part of the attraction of these substances is their stability; they do not break down easily under heat, or pressure, or chemical reactions. But this very stability means that when they are released into the atmosphere, they survive to diffuse up into the stratosphere. In this world without the treaties, concentrations of these chemicals reach five times today's value and nine times the value now projected for 2050.

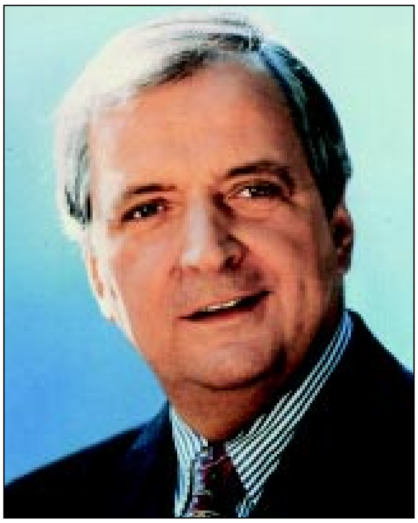
High in the atmosphere, these chemicals are finally broken apart by solar radiation and in turn react with and destroy the planet's protective layer of ozone. By 2000, ozone levels have fallen by 50% of pre-industrial levels north of the tropics, and by 70% southwards.

Without the stratospheric ozone layer to stop it, an ever-rising intensity of ultraviolet radiation penetrates to the planet's surface by 2050, double current levels in the north and quadruple in the south. Skin cancers, eye damage and immune system suppression are rife in those who expose their bodies to the sun. Walking in the open air cannot be risked without sunscreen and sunglasses; sunbathing is banned.

This is the world as it might have been, without the ozone treaties – the 1985 Vienna Convention for the Protection of the Ozone Layer and the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. The international regime created by these two agreements – revised, and made more effective, on no less than five occasions over the last decade – is saving the world from that alternative.

This is the fourth edition of *Action on Ozone* produced by UNEP. And although the depletion of the Earth's ozone layer has now reached record levels – thanks to the last seventy-five years of production and use of ozone-damaging chemicals – this is the first edition in which we can say it is now at its peak. The scientific evidence clearly shows the beginnings of a fall in the concentrations of the dangerous chemicals in the lower atmosphere – which is now being translated into a similar fall in the stratosphere, where the ozone is destroyed. The ozone layer is predicted to start to recover in the next one or two decades, and should be restored to full health by the middle of the new century.

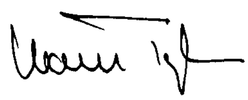
It is one of UNEP's proudest achievements to have led the international effort to protect the Earth's ozone layer. The Montreal Protocol, which was negotiated under our aegis, has, rightly, been regarded as a model for other international environmental agreements. It has proved a flexible and adaptable regime. It has helped to bring together scientists, industrialists and governments, with their different but essential viewpoints. It has dealt effectively with the different needs of industrialised and developing countries in meeting a common threat. There is much that can be learned from the story of the ozone regime of value to other areas of international environmental action, including biodiversity, desertification and climate change.



*UNEP*

We must remember, however, that although the fight is being won, there is still much to be done in the field of ozone protection. Although there is still some scope for tightening the control schedules for the remaining ozone-depleting substances, in order to hasten the recovery of the ozone layer, the ozone regime, as it continues to evolve, is facing new and different challenges. Implementation of the control measures in developing countries, who met their first targets under the Protocol just last year; cases of non-compliance; evasion of the controls through illegal trade: all pose new threats to the health of the ozone layer and to the planet beneath it.

We can be proud of our achievements. We can learn lessons, and continue to adapt and innovate. And we can continue to meet these challenges, so that we all may strive for a better life for the peoples of the world.



*Klaus Töpfer*
*Executive Director, UNEP*

1928: The first CFCs (CFC-11 and -12) are developed in the US, initially to be used as coolants for refrigeration. Beginning in the 1960s, consumption grows rapidly in developed countries, encouraged by the versatile and favourable properties of CFCs: stable, non-toxic, non-corrosive and non-flammable.

1970: A scientific paper points out the possibility that nitrogen-oxides from high-flying supersonic aircraft and from fertilizer applications might deplete the ozone layer.

# 1. The Shield in the Sky

All life on Earth depends on the existence of a thin shield of a poisonous gas high in the atmosphere: the ozone layer.

Ozone is a molecule made up of three oxygen atoms. It is an extremely rare component of the Earth's atmosphere; in every ten million molecules of air, only about three are ozone. Most of the ozone (90%) is found in the upper atmosphere (the stratosphere), between 10 and 50 kilometers (6–30 miles) above the Earth's surface. This 'ozone layer' absorbs all but a small fraction of the harmful ultraviolet radiation (UV-B) emanating from the sun. It therefore shields plant and animal life from UV-B, which in high doses can be particularly damaging.

## Ozone depletion

Any damage to the ozone layer therefore allows more UV-B radiation to reach the surface of the Earth. Throughout the 1970s and 1980s, scientists began first to suspect, and then to detect, a steady thinning of the layer. This was accompanied by increases in the amount of UV-B reaching the surface. In northern hemisphere mid-latitudes (25–60°, i.e. north of the tropics but south of the polar regions), UV-B levels are now about 7% higher than twenty years ago in the winter and spring, and about 4% higher in the summer and autumn. In southern hemisphere mid-latitudes, UV-B levels are about 6% higher all the year round. UV-B radiation has increased dramatically nearer the poles, particularly in the spring – 22% higher in the Arctic and 130% higher in the Antarctic relative to values in the 1970s. The next chapter explains why this damage to the ozone layer is occurring.

Moderate exposure to UV-B poses no dangers; indeed, in humans it is an essential part of the process that forms vitamin D in the skin. But higher levels of exposure have potentially harmful effects on human health, animals, plants, micro-organisms, materials and air quality.

In humans, long-term exposure to UV-B is associated with the risk of eye damage, including severe reactions such as 'snowblindness', cancer and cataracts; UV-B radiation can cause effects on the immune system, but may be both adverse and beneficial. Increases in UV-B are likely to accelerate the rate of photoaging, as well as increase the incidence (and associated mortality) of melanoma and non-melanoma skin cancer, basal cell and squamous cell carcinoma with risk increasing with fairness of the skin. The risk of the more serious melanoma may also increase with UV-B exposure, particularly during childhood; melanoma is now one of the most common cancers among white-skinned people.

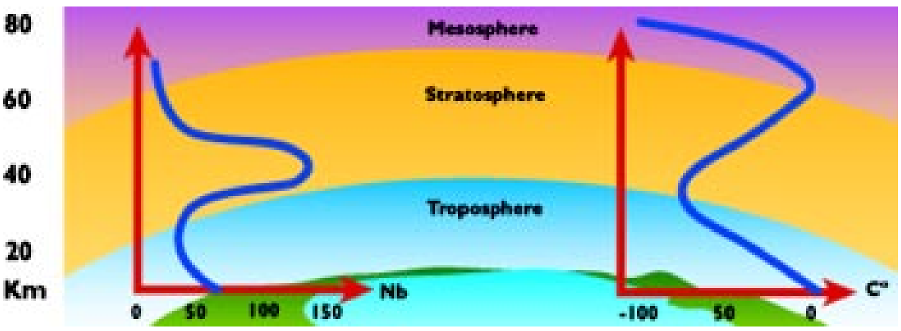



*Fig. 1.1 The thin layer of ozone in the stratophere is at its thickest between about 20-40 km up. It also accumulates near the ground in the troposphere, where it is a troublesome pollutant.*

1974: Two scientific papers suggest that CFCs emitted to the atmosphere will diffuse to the upper atmosphere and be broken down to release chlorine atoms, which will catalytically destroy ozone molecules. Nitrogen oxides emitted by high-flying supersonic aircraft are also suggested as a potential cause of ozone depletion.

1975: UNEP's Governing Council launches a programme of research on risks to the ozone layer; in the United States, a federal task force concludes that atmospheric release of CFCs is a 'legitimate cause for concern' and that uses of CFC-11 and -12 might have to be restricted. The National Academy of Sciences (NAS) launches an assessment of human impact on the stratosphere.

*Report of the UNEP Enviromental Effects Assessment Panel (1998) and Dr. Sasha Madronich*

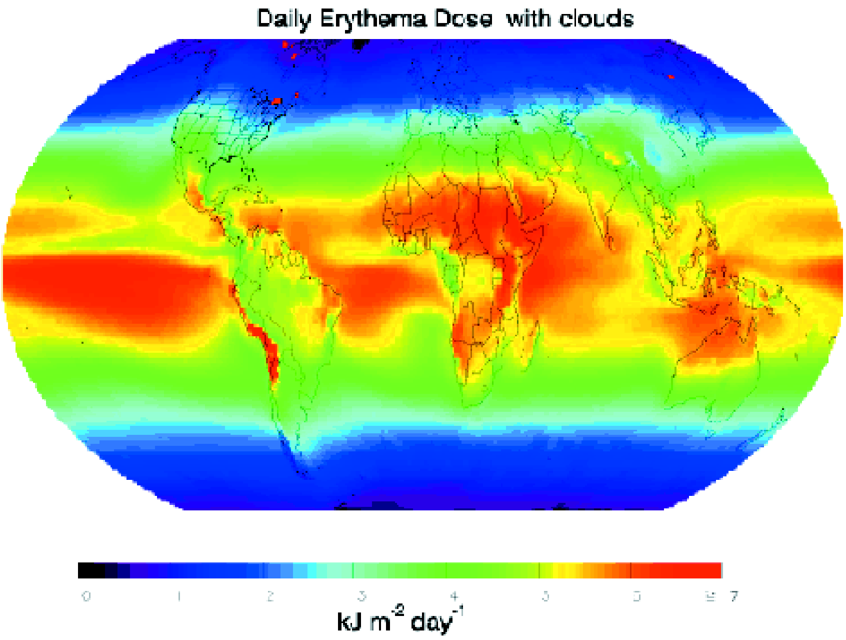



*Fig. 1.2 Daily erythemal (skin-reddening) UV radiation with clouds. Significant progress has been made in recent years in utilizing satellite-based measurements of cloud cover as well as atmospheric ozone, to derive estimates of surface UV radiation levels.*

Animals are subject to similar effects of increased UV-B levels. Squamous cell carcinoma associated with ambient solar exposure has been reported in cattle, horses, cats, sheep, goats and dogs. In addition, marine life is particularly vulnerable to UV-B, a matter of some concern as more than 30% of the world's animal protein for human consumption comes from the sea. Recent studies continue to demonstrate that solar UV-B and UV-A have adverse effects on the growth, photosynthesis, protein and pigment content and reproduction of phytoplankton, thus affecting the food chain. Plant growth may also be directly reduced by UV-B radiation (though responses vary a good deal depending on species), harming crop yields and quality, and various effects in forests. Effects of increased UV-B on emissions of carbon dioxide and carbon monoxide and on mineral nutrient cycling in the terrestrial biosphere have been confirmed.

*Dr. Donat Häder, member of the Enviromental Effects Assessment Panel*

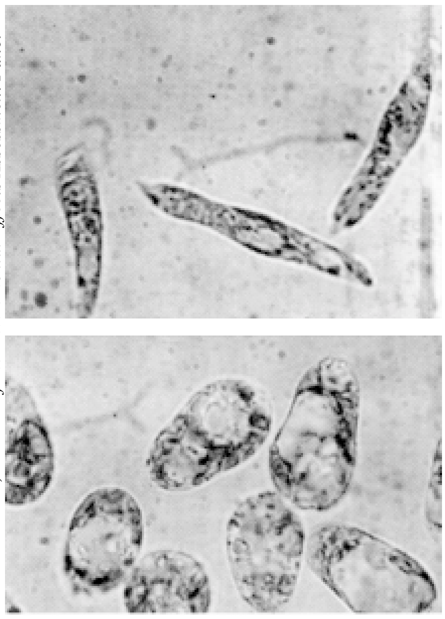


*Fig. 1.3 Euglena gracilis is a green flagellate organism which occurs in freshwater habitats and is common in lakes, ponds and rivers; Above: these organisms have a spindle form and swim in their elongated form. Below: After UV irradiation the cells twist and turn and then become rounded and cannot swim.*

Synthetic materials such as plastics and rubber, and naturally occurring materials such as wood, paper or cotton, are affected by UV-B; the damage caused ranges from discoloration to loss of mechanical strength. Increases in UV-B may limit the lifetimes of these materials and require more expensive production processes.

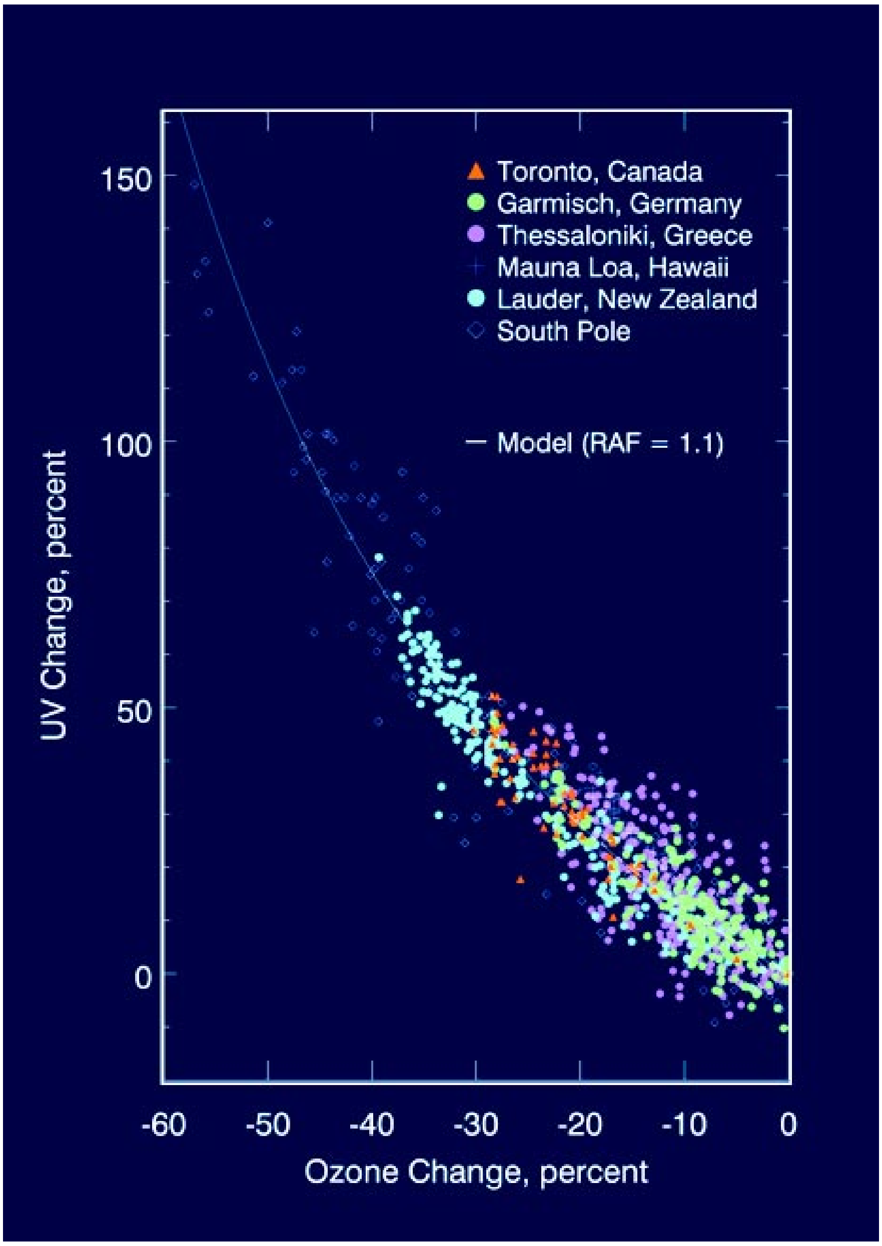
Finally, reductions in stratospheric ozone and the accompanying increases in UV-B radiation interact with other sources of pollution and environmental change. Increased levels of UV-B change the chemical activity of the troposphere, the lower region of the atmosphere. In

1977: 32 countries agree to a UNEP-brokered World Plan of Action on the Ozone Layer designed to stimulate research; UNEP establishes the Coordinating Committee on the Ozone Layer. The US Government requires warning labels on CFC-containing aerosols and announces its intention to phase out most CFC use as aerosol propellants. U.S.NAS estimates that continued release of CFCs to the atmosphere will deplete the ozone layer by 14%.

1978: Developed countries attend an international meeting on CFC regulation and recommend a significant reduction in CFC use in aerosols as a precautionary measure.

areas already suffering from pollution such as vehicle exhausts, concentrations of ozone (which at this level is a pollutant, causing irritation to eyes and lungs) tend to increase.

There are also complex interactions between ozone destruction and climate change. UV-B induced destruction of stratospheric ozone in recent years has led to a cooling of the lower stratosphere, masking to a certain extent the effects of the growing emissions of greenhouse gases. On the other hand, increases in tropospheric ozone contribute to global warming. In addition, the build-up of greenhouse gases in the atmosphere tends to reduce the frequency of sudden stratospheric warming in the northern hemisphere, adding to the severity of Arctic winters, which increase ozone loss (see next chapter).




Report of the UNEP Enviromental Effects Assessment Panel (1998)

*Fig. 1.4 UV change versus ozone change. Dependence of erythemal ultraviolet (UV) radiation at the Earth's surface on atmospheric ozone, measured on cloud-free days at various locations, at fixed solar zenith angles. Solid curve shows model prediction with a power rule using RAF=1.10.*

1979: A number of developed countries start to impose legal controls on CFC-11 and -12 production or use; in the United States, the NAS estimates eventual ozone depletion of 16.5%, or up to 30% if CFC production and release continues to grow, and calls on the US Government to lead a world effort to control CFCs.

# 2. The ‘Holes’ in the Layer

## Miracle substances

Concern began to be expressed in the early 1970s that the Earth’s ozone layer was vulnerable to damage by the release of chemicals known as halocarbons, compounds containing chlorine, fluorine, bromine, carbon and hydrogen. The most common ozone-depleting substances (ODS) were thought to be the family of chlorofluorocarbons, or CFCs, first produced in Belgium in 1892, and found, by General Motors chemists in the US in 1928, to be an effective refrigerating fluid. Stable and non-toxic, cheap to produce, easy to store and highly versatile, CFCs proved themselves an immensely valuable range of industrial chemicals. They came to be used as coolants for refrigeration and air conditioning, for blowing foams, as solvents, sterilants and aerosol propellants. Major new uses were found for CFCs each decade, and world production, concentrated largely in the USA and western Europe, doubled roughly every five years until 1970.

As scientific knowledge developed, other chemicals – halons, carbon tetrachloride, methyl chloroform and methyl bromide – also came to be identified as ozone-depleters. Some of the substitutes for CFCs that were eventually developed – such as hydrochlorofluorocarbons (HCFCs – CFCs with hydrogen atoms) also damage the ozone layer, but at much lower rates.

It is the high degree of stability of CFCs which causes their ozone-depleting properties. When released into the lower atmosphere, through the use of an aerosol spray, for example, or a cleaning solvent, or

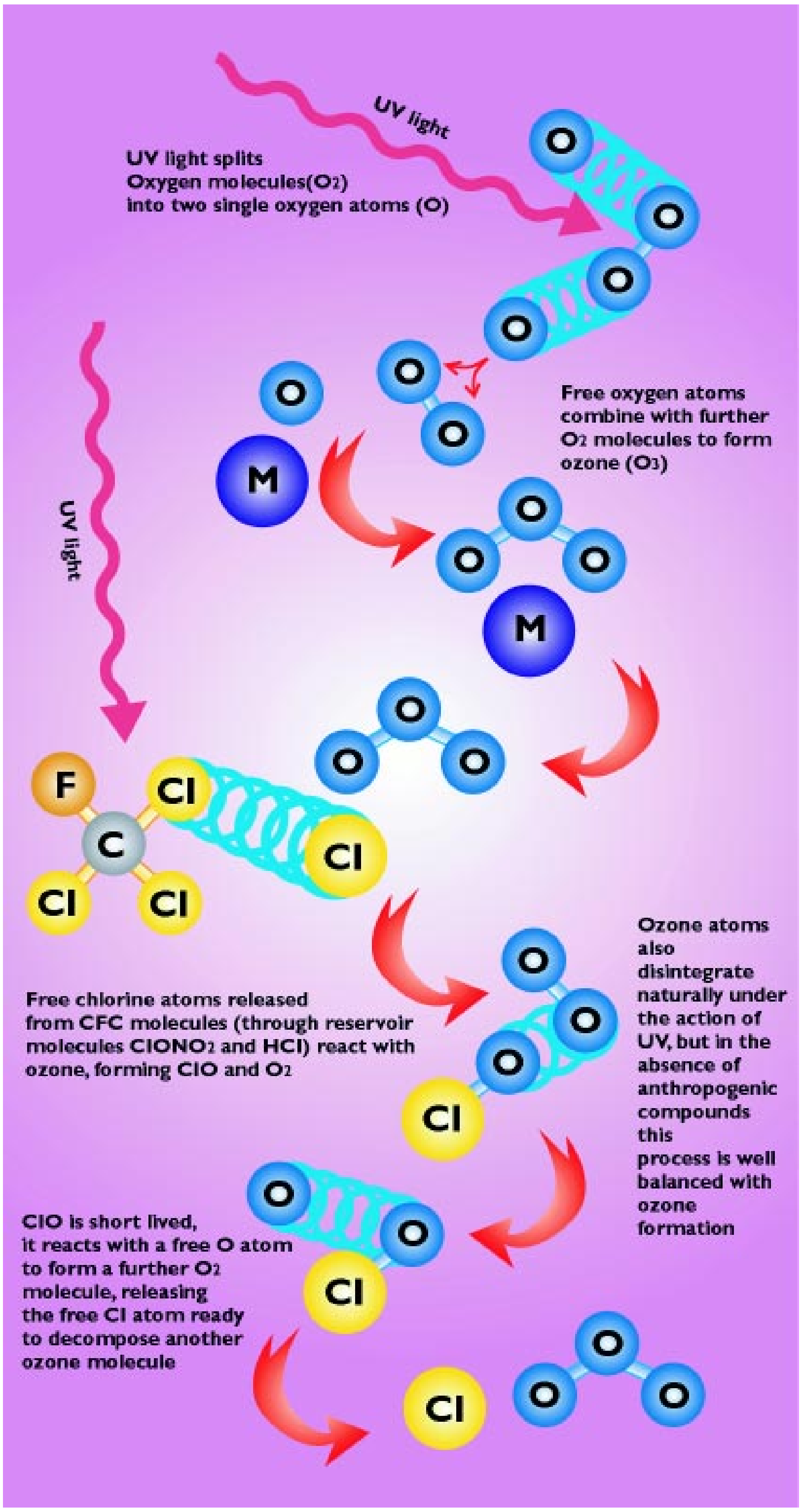
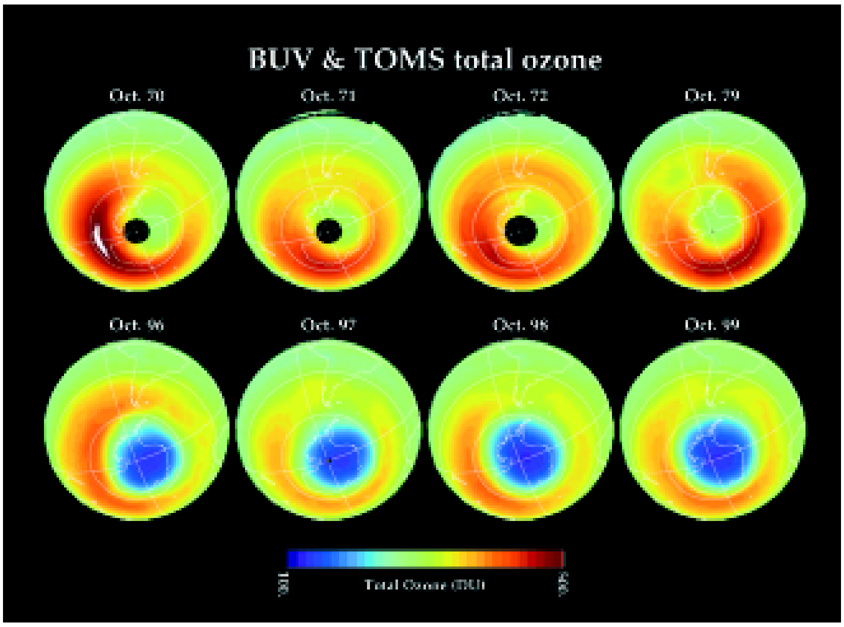



*Fig. 2.1 Schematic sequence of the destruction of ozone by active chlorine (Cl) released from a CFC-12 molecule.*

1980: Seven developed countries and the European Community call for an international convention to protect the ozone layer. The EC freezes production capacity and begins to limit use in aerosols. The US Environmental Protection Agency proposes the first legalcontrols on non-aerosol uses of CFCs. CFC manufacturers form the Alliance for Responsible CFC Policy, which argues that further regulation of CFCs would be premature in the absence of hard evidence of ozone depletion.




Dr. Paul Newman, NASA/GSFC/code 916

*Fig. 2.2 Monthly Antarctic (South Pole) ozone levels in October 1970, 1971, 1972, 1979 and 1996-1999. The Ozone measurements were taken by NOAA's and NASA's Backscatter Ultraviolet (BUV) and Total Ozone Mapping Spectrometer (TOMS), Goddard Space Flight Center (GSFC).*

*Fig. 2.3 The Antarctic ozone hole in October 1999.*

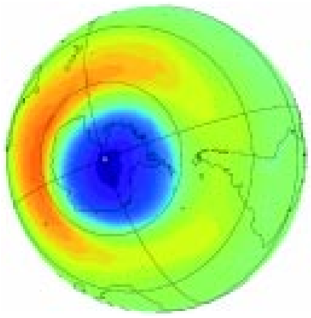
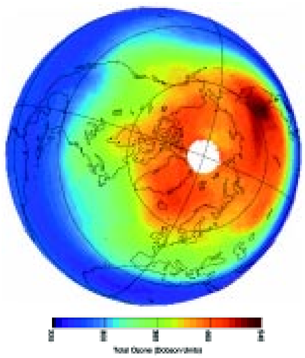


*Fig. 2.4 The monthly average total ozone in March 1999 for the Arctic (North Pole).*



Dr. Paul Newman, NASA/GSFC/code 916

through leakage of a refrigerant, CFCs persist long enough to diffuse up into the stratosphere, where they are broken apart by solar radiation to release chlorine atoms, which react strongly with ozone molecules. The chlorine oxide formed then undergoes further reactions which regenerate the original chlorine, allowing the process to be repeated many times; each chlorine atom can destroy an estimated 100,000 ozone molecules before it is removed from the stratosphere. Although UV radiation continually recreates ozone from oxygen, the presence of chlorine speeds up ozone destruction but not its creation, reducing the overall concentration of ozone. Similar reactions take place between bromine (found in the family of halons, used mainly as fire extinguishants and in methyl bromide) and ozone.

## The ozone 'holes'

These ozone-destroying reactions are particularly intense within the stratospheric clouds that form above Antarctica in the extremely cold night of the southern hemisphere winter. Reactions which occur on the surfaces of ice particles within the clouds release chlorine and bromine in active forms that accumulate through the winter. When the sun rises in the spring the clouds break up to release active chlorine and bromine which rapidly destroy ozone. The result is the 'ozone hole', an area of sharp decline in ozone concentrations over most of Antarctica for about two or three months during the southern hemisphere spring. Ozone depletion is accelerated by atmospheric circulation, which moves CFCs in the stratosphere away from the tropics towards both poles.

Currently the ozone layer above the whole of Antarctica thins between 40% and 55 % of its pre-1980 level with up to 70% deficiency in short time periods, and at some altitudes, ozone destruction is almost total. In September 1998, the Antarctic ozone hole reached a record size of 25 million km$^2$, or two and half times the size of Europe. Although the hole shrank to 13 million km$^2$ in November, this still marked the first time that the hole had measured more than 10 million km$^2$ for 100 days. The average ozone concentration for the whole of the area south of 65°S was the lowest ever recorded in November 1998. The Antarctic ozone hole of 1999 was the second largest and strongest ozone-hole phenomena ever.

1981: UNEP's Ninth Governing Council proposes to begin work on the elaboration of a legal framework convention for ozone layer protection and establishes an ad hoc working group of legal and technical exerts for this purpose.

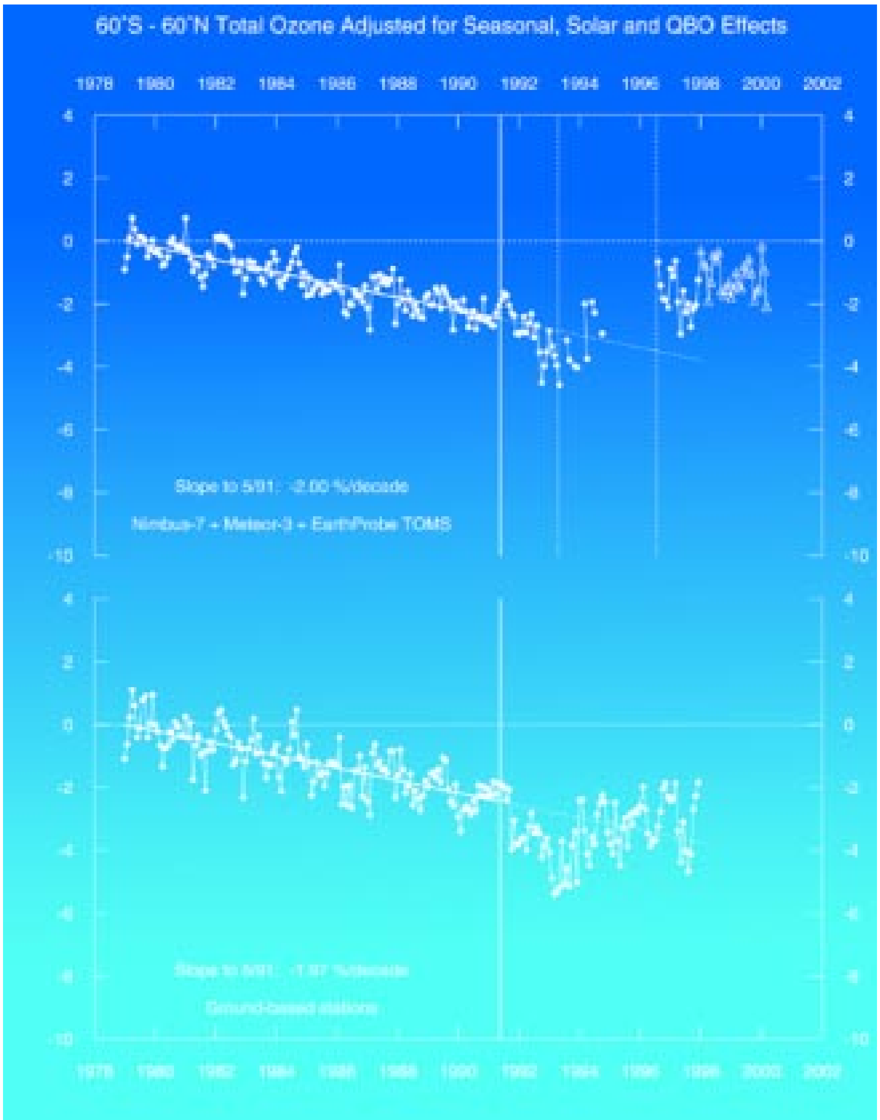
1982: The UNEP working group begins to elaborate a framework convention for the protection of the ozone layer, based on a draft proposal from Finland, Norway and Sweden. The US National Aeronautical and Space Administration (NASA) estimates that eventual ozone depletion due to CFC use will be lower than previously thought, between 5 and 9%.

Stratospheric air above the Arctic is generally warmer and less confined than over the Antarctic, and fewer clouds form there. Arctic ozone depletion is therefore less severe, though in recent years it has proved worse than anticipated, largely because of unusually cold winters, with ozone losses of up to 50% at some altitudes. The minimum Arctic temperatures are near the threshold for major chlorine activation, and therefore rates of ozone destruction can be highly variable year on year. During the 1999/2000 Arctic ozone deficiency the ozone deviations reached -20 to -30% poleward from 65°N. Ozone depletion at mid-latitudes (25° – 60°), between the poles and the tropics, is much less dramatic but is still observable. Between 1979 and 1991, ozone concentrations fell by about 4% per decade at mid-latitudes in both the northern and southern hemispheres, the losses being largest during the winter and spring. Particles formed from gases ejected into the atmosphere from the volcanic eruption at Mount Pinatubo in 1991 accelerated ozone destruction for two or three years, but the rate slowed down again thereafter, and total losses from 1979–97 reached about 5% per decade.

However, local losses can be more significant at certain times, particularly as the areas of ozone depletion around the poles rotate to cover different inhabited areas from year to year. In the spring of 1995, for example, after an unusually cold Arctic winter, stratospheric ozone concentrations over Europe were 10–12% lower than in the mid-1970s, and over North America 5–10% lower, although at times as much as 20% lower in some places. The winter of 1995–96 was even colder, and ozone concentrations over Britain fell by almost 50% in the first week in March, the lowest ever recorded over the UK. And in the spring of 2000 the ozone deviations were strongest (-20 to -30%), over Europe and the Canadian and Russian Arctic.

UV-B intensities have increased accordingly; 1992–93 saw the first reported examples of persistent increases over densely populated regions in the northern hemisphere. In 1992 southern South America experienced a doubling of UV-B radiation following a 50% fall in ozone. The highest UV occured whenever the ozone-hole region (220DU contour) elongated into an elliptical shape that rotated over South America and the cloud cover was minimal. See figure 3.2.

Increases in UV radiation in the Northern Hemisphere at high latitudes have been attributed to the low ozone amounts in the winter and spring of 1995, 1996, 1997 and 2000.




Report of the UNEP Scientific Assessment Panel (1998) and Dr. Lane Bishop

*Fig. 2.5 Global Ozone Trend. Deviations in total ozone, area weighted over 60°S-60°N.*

1983: UNEP's Coordinating Committee on the Ozone Layer again reduces estimated eventual ozone depletion from current emission rates of CFC-11 and -12 to between 3 and 5%. The EC decides against further restrictions on CFCs in the light of these estimates.

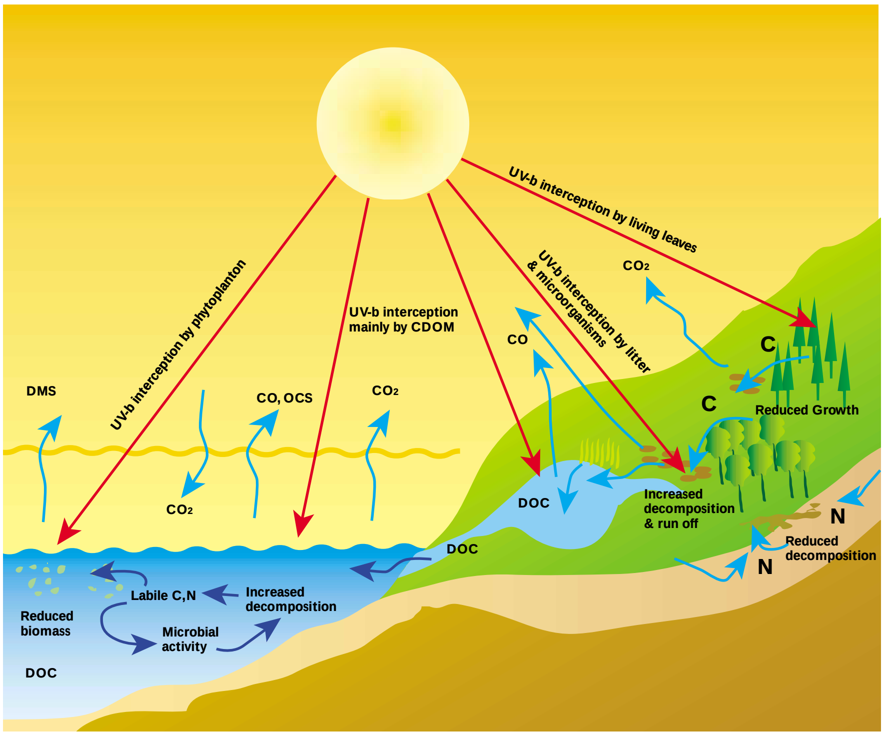
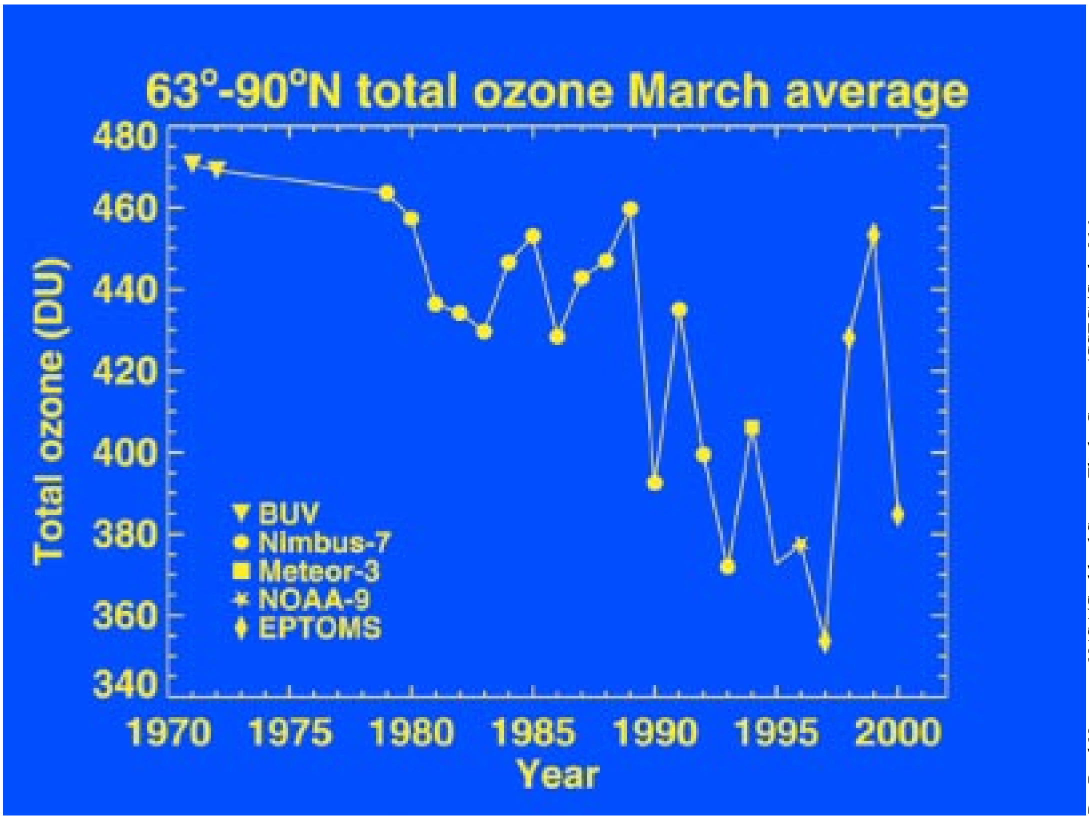



*Fig. 2.6 Conceptual model illustrating the potential effects of enhanced UV radiation on biogeochemical cycles in freshwater, marine and terrestrial ecosystems. The effects involving living organisms, e.g. reduced plant growth, are species and/or exposure dependent.*
*(CDOM — colored dissolved organic matter; DMS — dimethyl sulfide; DOC — dissolved organic matter)*

*Report of UNEP Enviromental Effects Assessment Panel (1998) and Dr. R.G. Zepp, T.V. Callaghan, D.J. Erickson.*




*Dr. Paul Newman, NASA/Goddard Space Flight Center (GSFC)/Code 916*

*Fig. 2.7 Monthly averages of total ozone for the Northern Hemisphere measured by satellites during March for the 1970-2000 period*

1985: The Vienna Convention for the Protection of the Ozone Layer is adopted by 28 countries. The Convention requires no restrictions on ozone-depleting substances, but allows for the future elaboration of specific controls; the resolution adopted along with the Convention lays the foundation for further work on a protocol on CFC control. Two months later Joe Farman, of the British Antarctic Survey, publishes a paper showing sharp seasonal depletion of the ozone layer over Antarctica - the 'Ozone hole'.

# 3. Saving the Ozone Layer

## Beginnings

Since its foundation, the United Nations Environment Programme (UNEP) has been concerned with the protection of the ozone layer. The UN Conference on the Human Environment in Stockholm in 1972, which gave birth to UNEP, addressed the topic of ozone depletion, though damage from supersonic aircraft exhausts was then thought to be the main threat.

The first major statement of scientific concern over ozone depletion from CFCs came in 1974, prompted by James Lovelock's discovery of the presence of CFCs in the atmosphere all around the world. Sherwood Rowland and Mario Molina's research (for which they were later to be awarded the Nobel Prize in chemistry) paved the way to the now thorough understanding of the processes by which CFCs diffuse up into the stratosphere, are broken apart and destroy ozone molecules.

Although the hypothesis was initially disputed, the extent and growth of CFC use worldwide was enough to trigger calls for urgent action. In March 1977, experts from 32 countries met in Washington DC to adopt the 'World Plan of Action on the Ozone Layer'. The Plan included research into the processes that control ozone concentrations in the stratosphere; the monitoring of ozone and solar radiation; the effect of ozone depletion on human health, ecosystems and the climate; and the development of ways to assess the costs and benefits of control measures. UNEP was the coordinating agency, assisted by the Coordinating Committee on the Ozone Layer, made up of experts from intergovernmental agencies, governments and industry.

In the US, the Washington meeting reinforced existing concerns over the impact of emissions from supersonic aircraft. An effective public campaign led to regulations prohibiting the use of CFCs as aerosol propellants in non-essential applications by 1978; Canada, Sweden and Norway soon followed. US production of CFC-11 and -12 fell from 46% of the world total in 1974 to 28% by 1985 as a result.

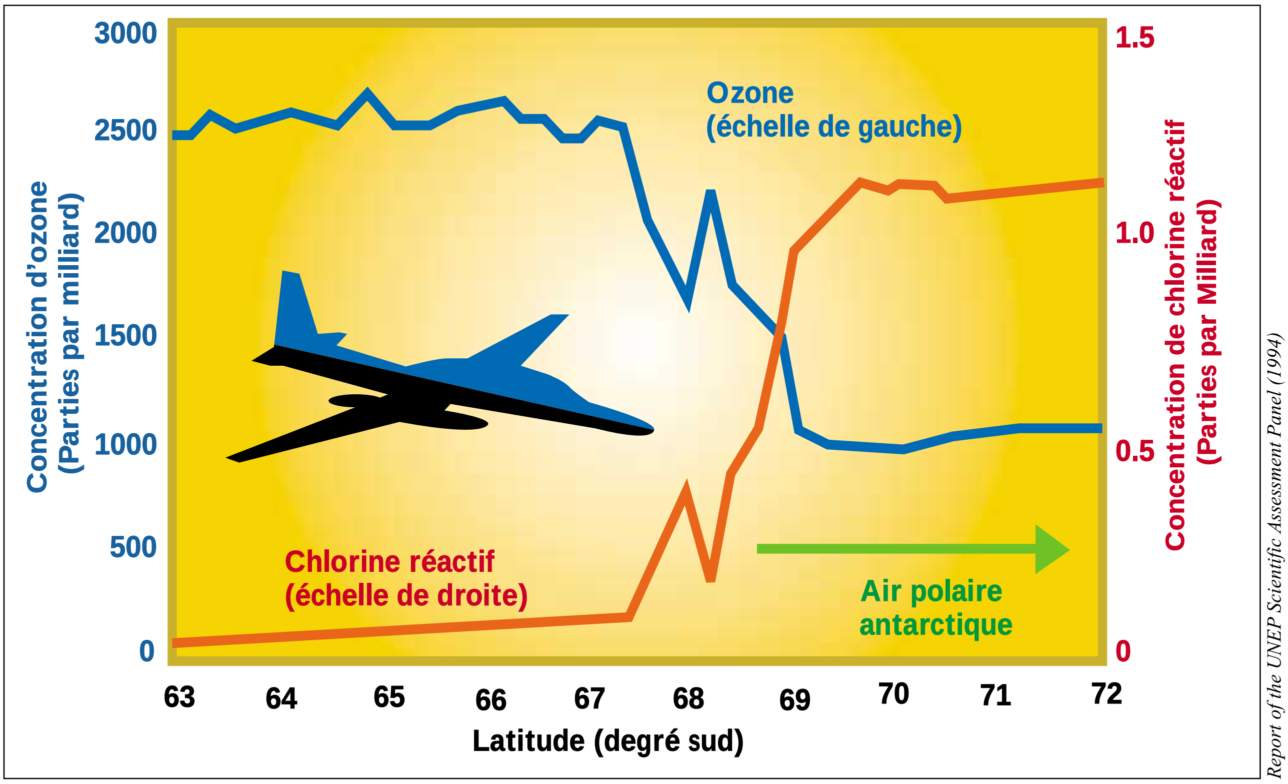



*Fig. 3.1 Measurements of ozone and reactive chlorine from a flight into the Antarctic Ozone hole*

1986: International negotiations continue on a protocol to the Vienna Convention to control CFCs. CFC-producing companies support a 'reasonable' limit on future growth in CFC production, and estimate that at least five years would be needed to develop substitutes for CFC-11 and -12.

Alternative, non-ozone-depleting, propellants were rapidly introduced and often proved more economic than the original CFCs. After 1982, however, CFC production in the US started to accelerate once more, as use increased sharply in vehicle air-conditioning and foam-blowing.

In 1980 the European Community agreed to reduce its CFC use in aerosols by at least 30% from 1976 levels by the end of 1981 and freeze its production capacity of CFC-11 and CFC -12. Since EC production capacity was at the time substantially above consumption levels, a capacity freeze hardly contributed much to the control of CFC emissions. The combined effect of the various measures taken, however, was enough to reduce public pressure for further controls. UNEP was left with the responsibility of keeping the issue of ozone depletion on the international agenda.

## The Vienna Convention for the Protection of the Ozone Layer

In 1981, UNEP's Governing Council established an Ad Hoc Working Group of Legal and Technical Experts for the Elaboration of a Global Framework for the Protection of the Ozone Layer. The Group's aim was to secure a general international treaty to tackle ozone depletion. The first step of a framework agreement was expected to be relatively easy to achieve, but differences between the proponents of control measures on the *use* of CFCs in various sectors (such as the US) and supporters of caps on existing *production capacity* (such as the EC) led to four years of hard work and negotiation.

The Vienna Convention for the Protection of the Ozone Layer was agreed by 28 countries in March 1985. It contained pledges to cooperate in research and monitoring, to share information on CFC production and emissions, and to pass control protocols if and when warranted. Although it contained no commitments to take any action to reduce CFC production or consumption, the Vienna Convention was nevertheless an important milestone. Nations agreed in principle to tackle a global environmental problem before its effects were clear, or its existence scientifically proven – probably the first example of the acceptance of the 'precautionary principle' in a major international negotiation.

## The Montreal Protocol on Substances that Deplete the Ozone Layer

The Vienna conference in 1985 also adopted a resolution empowering UNEP to convene negotiations for a protocol to the Convention, to include control measures for ozone-depleting substances and to be signed if possible in 1987. Progress in this second set of negotiations was given a boost by the publication, just two months after the Vienna conference, of the findings of members of the British Antarctic Survey led by Dr Joe Farman. This was the famous 'ozone hole' paper, which revealed for the first time the existence of the dramatic declines in ozone concentrations over the Antarctic in the spring. (In fact US satellite observations had already detected

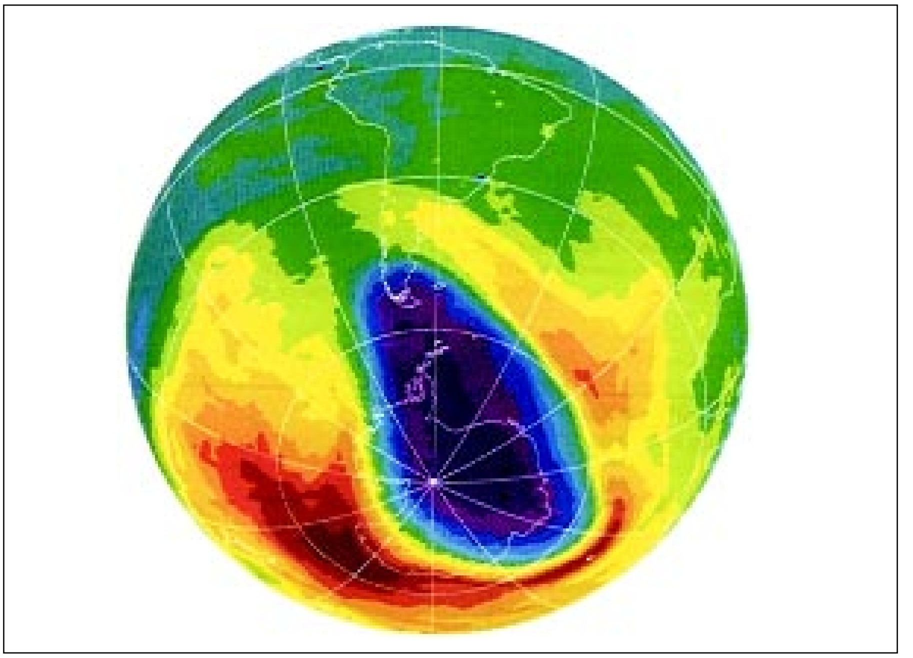


*Fig. 3.2. The Antarctic ozone hole of 17 October 1994, NASA's Total Ozone Mapping Spectrometer (TOMS), Goddard Space Flight Center (GSFC)/Code 916.*

1987: After several rounds of negotiations, 46 countries adopt the Montreal Protocol on Substances that Deplete the Ozone Layer. The Protocol requires an eventual 50% cut in consumption of five CFCs by the end of the century, and a freeze in the consumption of three halons, with a ten-year grace period for developing countries to enable them to meet their basic domestic needs; the controls are to be reassessed at least every four years. During the year, a number of European countries legislate to restrict the use of CFCs as aerosol propellants.

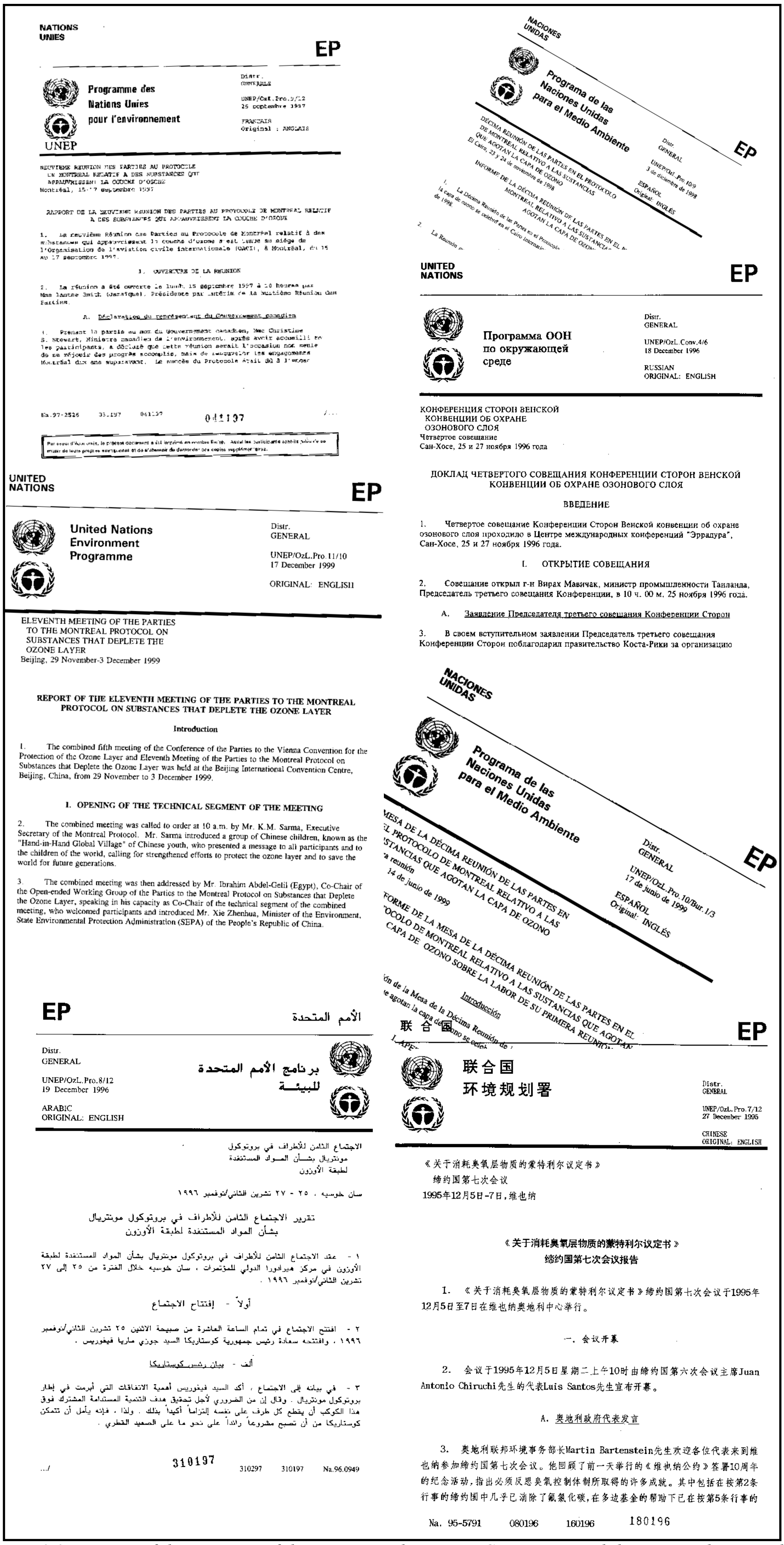


*Fig. 3.3. Reports of the meetings of the Parties to the Vienna Convention and the Montreal Protocol.*

this in the late 1970s, but the unexpected findings were discarded as suspected instrument error.) Although the cause was still then unknown, suspicion fell on CFCs.

By comparison with the protracted negotiations over the Vienna Convention, negotiations on the protocol proceeded remarkably quickly and achieved far more than was initially thought possible. On 16 September 1987, 46 countries signed the Montreal Protocol on Substances that Deplete the Ozone Layer. (In 1995, the UN General Assembly declared 16 September as the International Day for the Preservation of the Ozone Layer, and the signing of the Montreal Protocol has been commemorated in this way in each subsequent year.)

The Protocol required parties to make 50% cuts from 1986 levels in both the production and the consumption of the five main CFCs by 1999, with interim reductions. Production and consumption of the three main halons was frozen at 1986 levels from 1993.

Although these reductions could be attacked as either too little (if the ozone depletion hypothesis was believed) or too much (if it was not), the agreement marked an important political and psychological breakthrough. And once again science validated the negotiators' actions. March 1988 saw the release of the report of the Ozone Trends Panel, which reviewed evidence particularly from US Antarctic expeditions in 1986 and 1987, and provided, for the first time, convincing evidence of the linkage between ozone depletion and CFCs. Opposition to the principle of controls on ozone-depleting substances then largely collapsed, and industry started to concentrate resources on

1988: The scientific Ozone Trends Panel, sponsored by international agencies and US research bodies, concludes that CFCs are responsible for the Antarctic ozone hole. UNEP-administered international assessment panels are created under the Montreal Protocol to review the latest information on scientific, environmental, technical and economic aspects of ozone depletion. DuPont becomes the first CFC-producing company to announce that it will phase out CFC production; Northern Telecom, Seiko and Epson become the first multinational companies to announce phase-out goals for CFC consumption. Sweden decides to phase out CFCs by the end of 1994.

the development of non-ozone depleting alternatives to CFCs.

An important feature of the Montreal Protocol was the flexibility designed into it to allow for its further development in the light of evolving scientific knowledge and technological developments. Even before it entered into force on 1 January 1989, plans were being made to strengthen its provisions, advancing the phase-out schedules for the CFCs and halons it specified, and adding further ozone-depleting chemicals.

The Protocol has now been subject to five sets of *adjustments* to the control measures (agreed at the 1990, 1992, 1995, 1997 and 1999 Meetings of the Parties), accelerating the phase-out schedules for ozone-depleting substances. It has also been subject to four *amendments:*

- The London Amendment (1990) added methyl chloroform, carbon tetrachloride and a further range of CFCs to the phase-out schedules and established a mechanism for financial and technical assistance to developing country parties.
- The Copenhagen Amendment (1992) added hydrochlorofluorocarbons (HCFCs), hydrobromofluorocarbons (HBFCs), and methyl bromide to the phase-out schedules and formally created the Multilateral Fund as the route for financial and technology transfers to developing countries.
- The Montreal Amendment (1997) created a system of licenses for imports and exports of ODS, mainly in order to tackle the growing illegal trade in the substances.
- The Beijing Amendment (1999) added bromochloromethane to the phase-out schedules and the phase-out schedules and extended the controls on HCFCs to production in addition to the revised controls on consumption.

The main features of the regime established by the Montreal Protocol are examined in the next chapter, and their impact in Chapter Five.

*Fig. 3.4 Countries that have ratified the Montreal Protocol in green.*

1989: The Montreal Protocol enters into force. At their first meeting, parties agree to a non-binding statement calling for CFCs to be phased out as soon as feasible. Thirteen developed countries announce their intention to phase out the eight controlled substances by 1997. First synthesis of UNEP's Scientific, Environmental Effects, Technology and Economic Assessments.

# 4. The Montreal Protocol

## Control measures on ozone-depleting substances

At the heart of the Montreal Protocol lies the control measures it imposes on the production and consumption of ozone-depleting substances (ODS). Article 2 of the agreement defines phase-out schedules for the various categories of ODS. These have been progressively tightened with time through the agreements reached in London (1990), Copenhagen (1992), Vienna (1995), Montreal (1997) and Beijing (1999). In accordance with these schedules, the bulk of ODS – including all the substances specified in the original 1987 Protocol – were phased out completely in industrialised countries by the end of 1995. The remaining categories are scheduled for total phase-out by 2002 (bromochloromethane), 2005 (methyl bromide) and 2030 (HCFCs). (Developing countries have longer phase-out periods – see below.)

Production is defined as total production minus any amounts used as chemical feedstock or destroyed. Consumption is defined as production plus imports minus exports. Trade in recycled and used ODS is not included in the calculation of production, in order to encourage recovery, reclamation and recycling. 'Essential uses' for which no alternatives have yet been identified are exempt from the controls; the main exemption is currently for CFCs for use as propellants in metered dose inhalers for asthmatics.

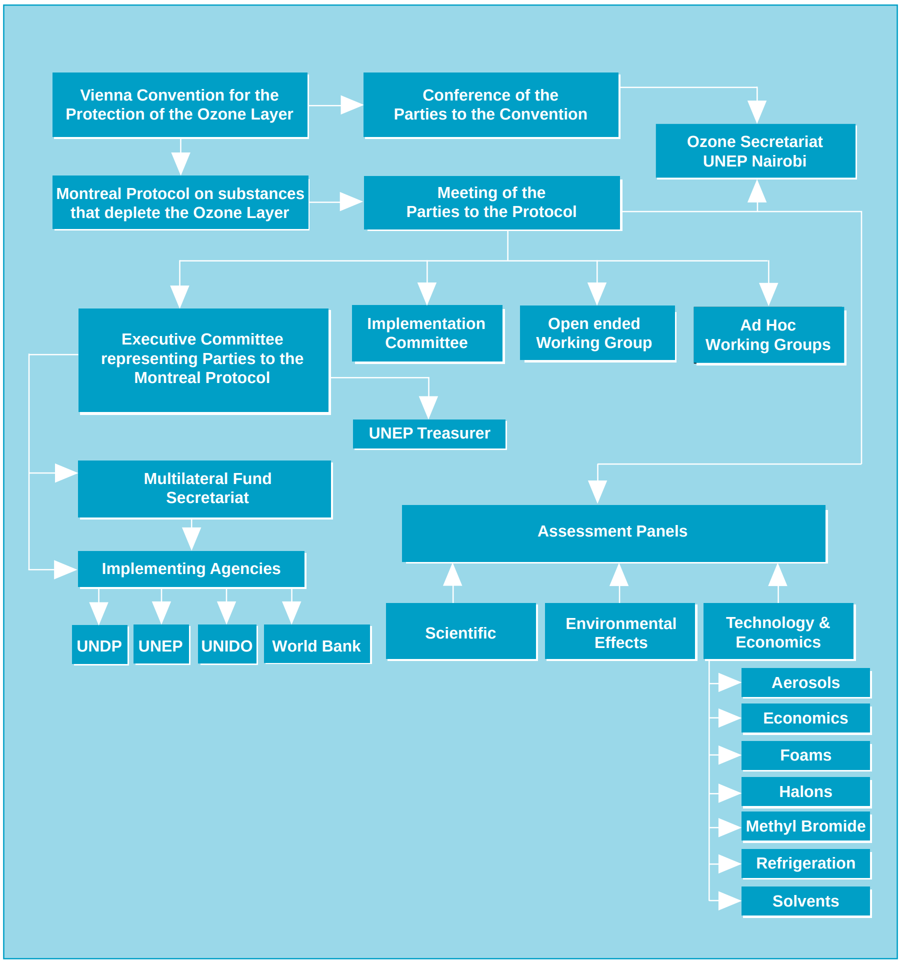



*Fig. 4.1 Organizational chart of the Montreal Protocol Implementation.*

1990: Meeting in London, parties agree to phase out CFCs and halons completely by the year 2000, and add phase-out dates for other CFCs, methyl chloroform and carbon tetrachloride. Parties agree to create a mechanism to provide financial and technical assistance to developing country parties, including a Multilateral Fund. Finland launches a fund for non-party countries.


*Fig. 4.2 At the Fifth Meeting of the Conference of the Parties to the Vienna Convention and the Eleventh Meeting of the Parties to the Montreal Protocol, Beijing, China, 29 November - 3 December 1999.*

*Fig. 4.3 Plenary of the Eleventh Meeting of the Parties to the Montreal Protocol.*

The Protocol includes restrictions on trade with non-parties to the treaty. These were included in order to encourage countries to join the treaty, and also to prevent the possibility of production of ODS migrating to non-parties to escape the controls. Parties were required to ban the import of Annex A ODS (CFCs and halons) from non-parties from 1990 (one year after the Protocol came into force); exports to non-parties were banned from 1993. Imports of goods containing CFCs (e.g. refrigerators) were also banned from 1993. As new substances have been added to the control schedules, the trade provisions have been gradually extended to cover them as well. The trade restrictions are not applicable, however, against a non-party which is nevertheless in compliance with the control schedules.

A requirement on parties to introduce a licensing system for imports and exports of all categories of ODS, including new, used, recycled and reclaimed substances, was introduced in the 1997 Montreal Amendment, and came into force in late 1999. The aim of the licensing system is to help tackle the growing illegal trade in ODS, stemming from some users' attempts to avoid the cost of replacing machinery requiring banned categories of chemicals.

## Institutions and procedures

The main decision-making body of the Montreal Protocol is the Meeting of the Parties, which can amend the Protocol's text and adjust its control schedules. Meeting

1991: An interim Multilateral Fund becomes operational with a three-year budget of $240 million – UNEP, UNDP and the World Bank are the initial implementing agencies, later joined by UNIDO. UNEP launches the OzonAction Programme. Assessment panels operating under the Protocol conclude that even more stringent controls than those agreed by parties in 1990 are needed, including restrictions on the use of HCFCs. The panels also conclude that technologies are available to replace virtually all uses of controlled substances, and that the phase-out process is less expensive than previously predicted.

annually, it reviews the control measures at least every four years on the basis of the available scientific, environmental, technical and economic information. The Open-Ended Working Group of the Parties meets between full sessions to develop and negotiate recommendations for the full Meeting.

The first Meeting established advisory panels bringing together experts from science, industry, governments and non-governmental organisations. These currently comprise:

- the Scientific Assessment Panel, responsible for reviewing scientific knowledge on ozone depletion;
- the Environmental Effects Assessment Panel, surveying information on the impact of ozone depletion and UV-B irradiation; and
- the Technology and Economic Assessment Panel, analysing the technical options for and the economic costs of controlling the use of ODS, including reviewing applications for essential use exemptions; the TEAP functions largely through subsidiary technical options committees, which currently cover refrigeration and air-conditioning, foams, solvents, aerosols, halons, methyl bromide, and economic options.

The reports the panels have produced for the key meetings of the parties have proved crucial in informing the decisions ultimately taken, including the adjustments to the control measures and the amendments to the Protocol.

The major findings and conclusions of the three Assessment Panels are contained in the Synthesis of the Reports, published in 1999.

The Implementation Committee of the Protocol consists of representatives of ten parties, two from each of the five UN regions. It reports cases of non-compliance to the full meeting and recommends courses of action; these can include providing technical or financial assistance from the Multilateral Fund and the Global Environment Facility (GEF), issuing cautions, or suspending the party from the Protocol.

The Ozone Secretariat, part of UNEP and based in Nairobi, provides support for all the activities of both the Montreal Protocol and the Vienna Convention. It publishes the *Handbook for the Ozone Treaties,* containing up-to-date texts of the Convention and Protocol, decisions of the meetings of the parties, and much other useful information.

## Developing countries and the Multilateral Fund

A key feature of the Montreal Protocol is its treatment of developing countries. Article 5 permits a developing country with consumption of ODS lower than a specified limit (an 'Article 5 country') to delay for ten years its compliance with the control measures set out in Article 2, 'in order to meet its basic domestic needs'. In 1995 the parties agreed precise control schedules for Article 5 parties, with most substances being scheduled for phase-out by 2010 (2015 for methyl chloroform and methyl bromide and 2040 for HCFCs).

Article 10 of the Protocol provides for a financial mechanism to meet the incremental costs of these countries in phasing out ODS. The Multilateral Fund was accordingly established, as an interim mechanism in 1990, and in its final form in 1992. Industrialised country parties contribute to the Fund according to the standard UN assessment scale. Funding was set at $240 million for 1991–93, $455million for 1994–96, $466 million for 1997–99 and $440 million for 2000–02 – a total of one and half billion dollars over twelve years. Over the first six years of the Fund, almost 90% of the promised funding was achieved, an excellent record for an international agreement (the main non-contributors were 'countries with economies in transition' in eastern Europe and the former Soviet Union).

The Fund has its own Secretariat (based in Montreal) and is directed by its Chief Officer who reports to the Executive Committee of the Fund, comprising representatives of seven Article 5 and seven non-Article 5 countries selected by the annual meeting of the parties to the Protocol. The Fund operates through four implementing agencies, each with slightly different roles:

- UNEP's Division of Technology, Industry and Economics provides clearing-house functions, which is a non-investment support (training, information exchange, etc), and helps prepare country programmes and refrigerant management plans for low-consuming developing countries;
- the UN Development Programme (UNDP) organises demonstration and investment

1992: Meeting in Copenhagen, parties to the Montreal Protocol agree to speed up phase-out schedules for already controlled substances and to control new substances for developed countries – HCFCs, HBFCs and methyl bromide. A number of developed countries adopt faster timetables for phase-out of controlled substances. Mexico (a developing country) announces that it is prepared in principle to phase out CFC use by 2000, the existing deadline for developed countries. The Multilateral Fund is officially established.

projects, technical assistance and feasibility studies;

- the UN Industrial Development Organization (UNIDO) prepares and appraises investment project proposals and implements phase-out schedules at plant level;

- the World Bank concentrates on large-scale phase-out and investment projects at plant and country levels.

Each Article 5 country, assisted by one of these agencies, prepares a country programme or an update, showing its present use of ODS and identifying opportunities for reduction. The 'incremental costs' which countries can claim may include the incremental capital operating costs of conversion to alternative technologies and ODS substitutes. Recycling controlled substances, modifying or replacing equipment and costs of patents/ royalties and training are examples of incremental capital costs. The Fund's Executive Committee has discretionary powers to include costs other than those listed. A recent important development has been the decision by the Executive Committee to help fund the phase-out of ODS production capacity in Article 5 countries; during 1999, China, India and Brazil announced target dates for the complete phase-out of CFC production capacity.

The Executive Committee approves both the country programmes (and their updates) and subsequent proposals for investment projects and institutional strengthening. By 31 March 2000, over US$ one billion has been allocated to eliminate the consumption and production of 131,000 ODP tonnes of ODS in 117 Article 5 countries.


*Fig. 4.4 Regional Workshop for the Central and Eastern European and Baltic States on Implementation Enforcement of National Licensing Systems in Hungary, supported by the Global Environment Facility.*

*Fig. 4.5 Training on methylbromide alternatives in Malawi, supported by the Multilateral Fund.*

1993: Parties to the Montreal Protocol agree not to allow any exemptions for the production of halons beyond the phase-out deadline agreed in Copenhagen, and approve a budget of $510 million for the Multilateral Fund for 1994–96.

1994: Total phase-out of halons in developed countries. Based on data submitted to the Ozone Secretariat in 1994, developed country parties' consumption of CFCs and halons dropped by about 50% between 1986 and 1992, while consumption rose for all controlled substances except halons.

# 5. The Impact of the Ozone Regime

## The record of the ozone regime

By May 2000, a total of 176 countries had ratified the 1985 Vienna Convention and 175 the 1987 Montreal Protocol; 139 had ratified the 1990 London Amendment, 106 the 1992 Copenhagen Amendment, 37 the 1997 Montreal Amendment and 1 the1999 Beijing Amendment. Production and consumption figures for the various controlled substances have changed dramatically. By the end of 1998 (the latest date for which full data is available), production of the original controlled CFCs had fallen by 95% in industrialised countries (the remaining production being devoted to essential use exemptions and exports to developing countries); and production of the original controlled halons had fallen by 99.8%. Although both production and consumption had increased in developing countries, as expected and allowed by the Protocol, overall world production had declined by about 88% (CFCs) and 84% (halons) from the base year, 1986.

The growth in concentrations of the major ozone-depleting chemicals in the atmosphere has clearly slowed. The total combined abundance of ozone-depleters in the lower atmosphere peaked in 1994 and is now slowly declining – though the fall in total chlorine is offset to an extent by a continued rise in total bromine.

Concentrations in the upper atmosphere, where the ozone layer is located, lag by up to six years, and it is believed that the total concentrations of chlorine and bromine in the stratosphere may have peaked before the year 2000 (full data is not yet available) – the growth rate of the concentrations of key chlorine compounds has certainly slowed. However, current average ozone losses (6% in northern mid-latitudes in winter/spring, 5% in southern mid-latitudes all year round, 50% in the Antarctic spring and 15% in the Arctic spring) and increases in UV-B irradiation (7%, 6%, 130% and 22% respectively) may increase further if the impact of climate change on ozone depletion gets worse.

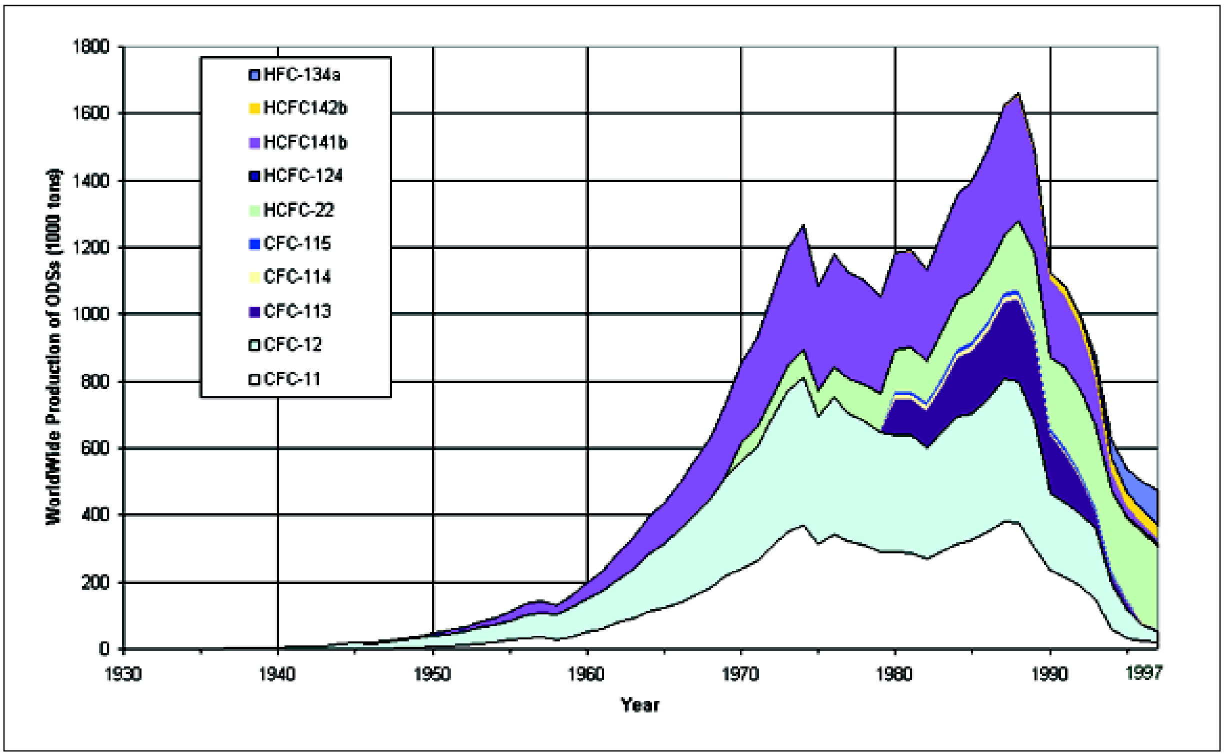



*Fig. 5. Worldwide production of Ozone Depleting Substances 1940 - 1997 (1000 metric tons).*

1995: Tenth anniversary of the Vienna Convention celebrated in Vienna. Montreal Protocol assessment panels report that phase-out is well advanced in most developed countries and that developing countries are also making progress, though consumption of controlled substances is increasing in some. Meeting in Vienna, the parties to the Protocol agree to tougher phase-out schedules for HCFCs and methyl bromide for developed countries, agree schedules for all substances for developing countries, and consider likely cases of non-compliance in some transition economies. European Union achieves total phase-out of CFCs.

The impact of the Protocol, and its adjustments and amendments, can be seen most clearly in the projected concentrations of ozone-depleting chemicals in its absence. Without the Protocol, the 'world that was avoided' would have experienced a concentration of the chemicals in the atmosphere of at least 17 parts per billion of equivalent effective chlorine by 2050 – five times today's value and nine times the value now projected for 2050. Ozone depletion would be at least 50% at northern, and 70% at southern, mid-latitudes, giving double and quadruple levels of surface UV-B. And all these figures would be growing.

The success of the Montreal Protocol has avoided the substantial impacts on human health and well-being that scenario would bring. Instead, assuming that the Protocol's control schedules continue to be adhered to, scientists expect a steady recovery of the ozone layer to its pre-industrial strength.The recovery will be much slower than the rate of damage, due to the slow rate at which natural processes remove the chemicals from the atmosphere – and it could be delayed by further volcanic eruptions, particularly cold Arctic winters or complex interactions with other sources of pollution. The next 10–20 years are therefore likely to see ozone levels remain at their lowest, but full recovery still seems likely to be about the middle of the century.

## Alternatives to ozone-depleting substances

This success story of international environmental diplomacy has proved possible because science and industry, stimulated by the clear objectives of the Montreal Protocol, have been able to develop and commercialise alternatives to ozone-depleting chemicals. These take the form not only of replacement *substances* but also of alternative, or 'not-in-kind', *technologies*.

In general, industrialised countries have found ending their use of CFCs much easier than was originally anticipated. Not-in-kind substitutes have proved particularly important in the electronics sector, where 'no-clean' techniques have often ended the use of CFCs as solvents. The foam-blowing sector has replaced CFCs with water, carbon dioxide and hydrocarbons, as well as HCFCs. The refrigeration and air-conditioning sector has largely used HCFCs as alternatives, but new equipment is increasingly using non-ozone depleting hydrofluorocarbons (HFCs- though these are poweful greenhouse gases, reinforcing the case for the ozone and climate change regimes to work closely together), ammonia (the chemical used in the very first refrigerators) or hydrocarbons. Stockpiling, or 'banking', in which CFCs have been produced before phase-out for use afterwards, has helped to extend development and testing periods of the substitutes.

Consuming industries have also used banking to provide extra time to develop substitutes for halons for fire-fighting. Other fire-extinguishing agents such as carbon dioxide, water, foam and dry powder are now widely used. Alternative approaches, such as good fire prevention practices, use of fire-resistant materials and appropriate designs for buildings have significantly reduced the need for halon systems, and total phase-out in industrialised countries was achieved smoothly by the end of 1993.

Phase-out efforts in industrialised countries are now concentrating on HCFCs and methyl bromide. Parties to the Montreal Protocol are encouraged to ensure that HCFCs are used only as direct replacements for other ODS where other more environmentally suitable alternatives are not available. HCFCs were critical in meeting the early CFC phase-out goals, but are generally considered much less important for new equipment available in the medium and long term.

The phase-out of methyl bromide has proved a more difficult issue. This is partly because it concerns a largely different set of producers and consumers to those involved in fluorocarbons, and also because alternatives are less easily available. Its major use is in agriculture, mainly for fumigation to control pests and weeds; such treatment is often required by importers. (Methyl bromide used for quarantine and pre-shipment (QPS) purposes is currently exempted from the controls.) In 1998, however, UNEP's Methyl Bromide Technical Options Committee identified technically feasible alternatives for more than 95% of non-QPS uses, and many countries have already subjected the chemical to controls in any case because of concerns about toxicity. In 1997 the parties agreed to bring forward the ultimate phase-out date for methyl bromide from 2010 to 2005 for industrialized countries while for developing countries the phase out date was set to 2015.

1996: Total phase-out of CFCs, carbon tetrachloride and methyl chloroform in developed countries, and of HBFCs in all countries. Parties to the Montreal Protocol agree the third replenishment of the Multilateral Fund at $540 million for 1997–99, and discuss the growing problem of illegal trade in CFCs.

1997: Tenth anniversary of the Montreal Protocol celebrated in Montreal. Meeting of the Parties to the Montreal Protocol brings forward controls on methyl bromide and adopts Montreal Amendment, introducing a system of licenses for imports and exports of all categories of ODS.

## New challenges

The ozone regime has grown and developed through different phases. Meetings of the Parties in the early years concentrated mainly on identifying ozone-depleting substances, agreeing on control measures and phasing out substances in industrialised countries. In recent years attention has been focused more on issues of *implementation,* particularly in developing countries and in countries with economies in transition (CEITs).

Since 1995, the ozone regime has faced a number of cases of non-compliance by several eastern European and former Soviet states, caused by the difficulties following the massive restructuring of their economies. These states are not eligible for assistance from the Multilateral Fund. This has been particularly true in Russia, the region's main consumer and producer. Resources are available for phase-out of ODS in these transition economies from the Global Environment Facility, which was created in 1991 to provide finance for environmentally sustainable development. The Facility has so far approved $148 million for projects and activities for phasing out ozone-depleting substances in 14 countries with economies in transition. The Protocol's Implementation Committee has worked with the parties in question, and with the GEF and the Implementing Agencies, to ensure that they improve their data reporting, draw up and implement new phase-out schedules and abide by specific trade restrictions. All the parties concerned have been or are being brought back into compliance, without the need for suspension from the Protocol (the ultimate sanction available) – a considerable achievement for an international environmental agreement. At the 1999 Meeting of the Parties, following a World Bank special funding initiative and the third tranche of GEF funding, Russia accepted a target date of June 2000 for the phase-out of production capacity.

The second new problem is the growth of illegal trade, which often follows any decision to ban the use of a particular substance. In areas where CFC replacements – or, more frequently, the new equipment that may be required to use them – have proved more expensive than the originals, a black market has developed. The problem has been most acute in the US, where the CFC excise tax introduced to encourage phase-out created additional incentives for illegal imports; in 1994–95 the money value of smuggled CFCs were estimated to be the second only to illicit drugs, smuggled mainly through Miami. The US authorities, however, responded vigorously to the problem and have arrested and sentenced many individuals on counts of smuggling CFCs and evading federal excise taxes. The steady replacement of the CFC-using machinery has also, of course, contributed to a fall in demand and therefore in trade. The European Union, and some other countries, have also experienced illegal imports of various categories of ODS, and have put in place regulations and systems to control this activity.

A different approach to stop illegal trade is to eliminate available stocks of new CFCs and halons, by closing down existing production facilities. The Government of the Russian Federation is working with the GEF and with donors to close its CFC production facilities and to phase out completely its consumption of CFCs by the year 2000. The GEF has contributed $60 million and 10 donor countries have together pledged additional $19 million to support this effort. China is now the world's largest producer of CFCs and halons. The Multilateral Fund has allocated $150 million to help close down production facilities for these chemicals over the next 10 years in China. The Fund has also agreed to allocate to India, the second largest developing country producer, $82 million for closing down production facilities in that country.

1998: Parties discuss ways of reducing various exemptions for ODS use, and spend increasing amounts of time on non-compliance matters.

1999 Assessment panels report that rate of ozone depletion is slowing down, and may peak before the year 2000 at a lower level than previously thought; clear evidence is available from atmospheric observations that the Montreal Protocol is proving successful. Virtually all developing countries meet their first

# 6. The Future of the Ozone Regime

The Montreal Protocol is widely regarded as one of the most effective international environmental treaties in existence. It has proved to be a flexible but robust regime, evolving over time in response to new developments in science and technology.

In the mid-1980s the international debate demonstrated considerable doubt over the extent and causes of ozone depletion and the feasibility of action. Just fifteen years later, the last Meeting of the Parties of the century, in Beijing in December 1999, agreed the fifth major set of revisions to the control schedules established in 1987. CFCs, whose production levels under the original agreement were still to have been 80% of 1986 levels, were phased out completely in industrialised countries at the end of 1995. Production of halons, which was simply to have been capped under the original agreement, ceased at the end of 1993. Other chemicals not even thought of as ozone-depleting substances two decades ago have been brought under the coverage of the agreements and their own control schedules progressively tightened. Developing countries, who were hardly present in Montreal in 1987, have joined the Protocol in large numbers and, in the middle of 1999, on the evidence available so far, virtually all of them met their first target under its control schedules.

The Protocol has been widely hailed as a model for future international environmental agreements – and, indeed, many of its features have been incorporated into, or adapted for, other treaties. The progress of the negotiations in many ways provides a model for international treaty negotiation, fully involving participants from all key groups: governments, industry, scientists and NGOs. The flexibility built into the Protocol in the form of its review process for targets and amendments has allowed a continuous evolution to respond to changes in both scientific evidence and technological developments. The limits on supply imposed by the control schedules have encouraged the rapid development of cost-effective alternatives, which in turn has helped to reduce demand.

Any effective international agreement in the modern world needs to recognise the special needs of developing countries. In the Montreal Protocol this has taken the form of the provision of financial assistance and technology transfer, the decision-making procedures which allot particular weights to Article 5 countries, and the grace period before implementation of the

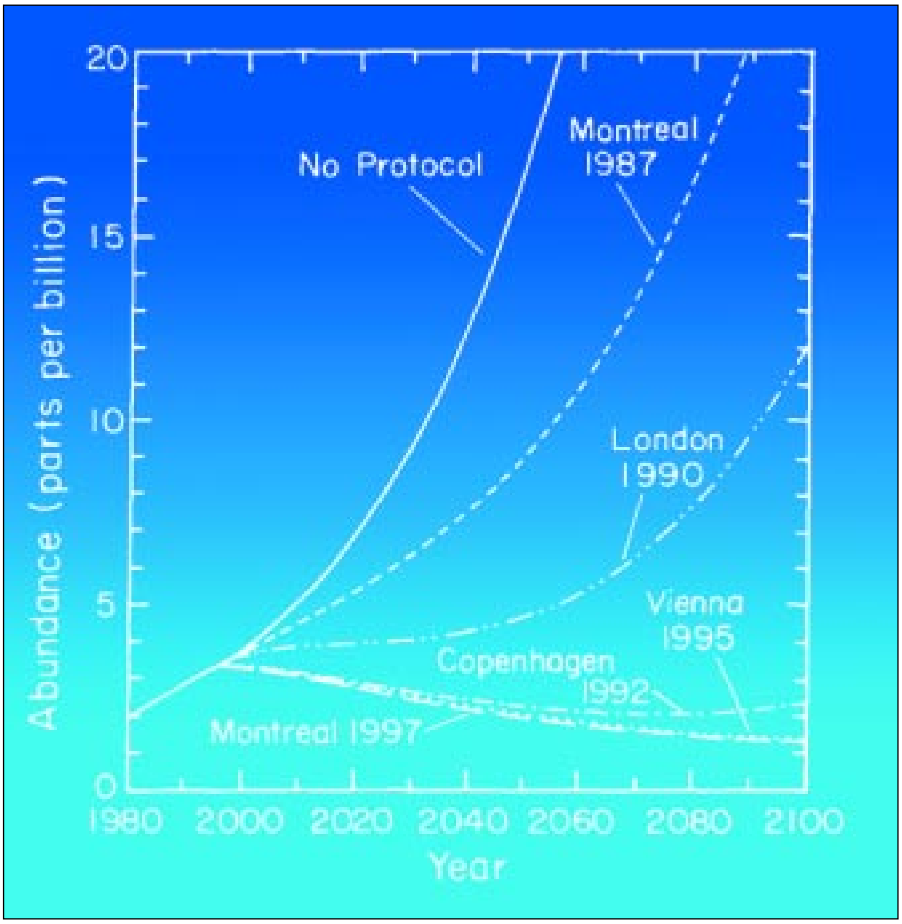



*Fig. 6.1 Effect of the international agreements on ozone-depleting-stratospheric chlorine/ bromine.*

target for CFC controls (freeze in production and consumption) in July. Meeting of the Parties in Beijing agrees fourth replenishment of the Multilateral Fund ($476 million for 2000–02), sets phase-out schedules for the production allowable in developed countries to meet developing countries' basic domestic needs, and agrees Beijing Amendment, adding one new substance (bromochloromethane) to the control schedules.


*Fig. 6.2 Ozone Publications*

phase-out schedules. The evolving phase-out schedules and the trade provisions have encouraged newly industrialising countries to move out of old technology and accelerate their own phase-outs even when not required to do so under the terms of the agreement.

Perhaps the most important feature of the ozone regime is the way in which it has brought together an array of different participants in pursuit of a common end. Scientists have provided the information, with steadily increasing degrees of precision, on the causes and effects of ozone depletion. Industry, responding to the stimulus provided by the control measures, has developed alternatives far more rapidly and more cheaply than initially thought possible, and has participated fully in the debates over further phase-out. NGOs and the media are the essential channels of communication, and education, with the peoples of the world in whose name the measures have been taken; in the early years in particular, they were instrumental in spurring decision-makers to take decisive action, and now still help to maintain pressure for further steps. Governments have worked well together in patiently negotiating agreements acceptable to a range of countries with widely varying circumstances, aims and resources – and showed courage and foresight in putting the precautionary principle into effect before the scientific evidence was entirely clear. And throughout its history, UNEP has provided both the catalyst for action and the means of agreeing and implementing it – the global

2000 Fifteenth anniversary of the signing of the Vienna Convention for the Protection of the Ozone Layer.
2002: Total phase-out of bromochloromethane in developed and developing countries.
2005: Total phase-out of methyl bromide in developed countries.
2010: Total phase-out of CFCs, halons and carbon tetrachloride in developing countries.
2015: Total phase-out of methyl chloroform and methyl bromide in developing countries.
2030: Total phase-out of HCFCs in developed countries.
2040: Total phase-out of HCFCs in developing countries.

institution that is required to meet a truly global problem.

The leadership and vision of the original negotiators in Vienna and Montreal resulted in a treaty that worked – that halted and turned back the progressive deterioration of the Earth's protective ozone layer. The same leadership and vision will still be needed in this new century, as the international community turns its attention to meeting the new challenges faced by the international ozone regime in restoring the stratospheric ozone layer once more to full health.

BEIJING DECLARATION ON RENEWED COMMITMENT TO THE PROTECTION OF THE OZONE LAYER

*We, the Ministers of the Environment and heads of delegations of the Parties to the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer*,

*Having participated*, at the invitation of the Government of the People's Republic of China, in the fifth meeting of the Parties to the Vienna Convention for the Protection of the Ozone Layer and the Eleventh Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, from 29 November to 3 December 1999, in Beijing, China,

*Having held* in-depth discussions on important issues relating to the protection of the ozone layer and the implementation of the Convention and the Protocol,

*Recalling* the achievements made to date in this field while earnestly seeking to address the challenges we will face in the future,

*Reaffirming*, at the threshold of a new millennium, our commitment to the protection of the ozone layer through a serious implementation of the Vienna Convention and the Montreal Protocol in order to achieve the phasing-out of ozone-depleting substances to protect the environmental security of present and future generations,

*Declare*:

1. That we are pleased to note that major progress has been achieved in the implementation of the Montreal Protocol in the past decade since the Helsinki Declaration was adopted, as testified by the fact that the Parties not operating under paragraph 1 of Article 5 ceased the production and consumption of CFCs from 1 January 1996, while the Parties operating under paragraph 1 of Article 5 committed themselves to freezing their production and consumption of CFCs at the average level of the period 1995-1997, from 1 July 1999;
2. That we are further pleased to note that the reduction and phase-out of other ozone-depleting substances are also proceeding in line with or in some cases faster than the control measures we have agreed upon in the past Meetings of the Parties and welcome the further progress agreed upon at this Meeting of the Parties;
3. That we take this opportunity to express our sincere appreciation for the efforts made towards this progress by Governments, international organizations, industry, experts and other relevant groups;
4. That we are fully aware, however, that we cannot afford to rest on our laurels, since scientists have informed us that the ozone hole has reached record proportions and the ozone layer recovery is a long way from being achieved;
5. That we are keenly aware that the Parties will have to face new challenges, as we have now entered a new period of substantive reduction of ozone-depleting substances from 1 July 1999 and, therefore, must ensure the continuation and development of our significant financial and technical cooperation under paragraph 1 of Article 10 of the Montreal Protocol, to enable all countries to take full advantage of benefits offered by the latest technological advances, including the continuation of the initiatives to ensure funding for the low-volume-consuming countries;
6. That we therefore appeal to all of the Parties to demonstrate a stronger political will and take more effective action to fulfil the obligations under the Vienna Convention and the Montreal Protocol, and to urge all States that have not yet done so to ratify, approve or accede to the Vienna Convention and the Montreal Protocol and its Amendments;
7. That we also appeal to the relevant Parties to take all appropriate measures to address illegal trade in ozone-depleting substances and to safeguard the achievements attained to date;
8. That we call upon the Parties not operating under paragraph 1 of Article 5 to continue to maintain adequate funding and to promote the expeditious transfer of environmentally sound technologies, under the Montreal Protocol, to the Parties operating under paragraph 1 of Article 5, to help them fulfil their obligations; and also call upon Parties operating under paragraph 1 of article 5 to take all appropriate measures necessary to secure the efficient use of the resources provided by the Parties not operating under paragraph 1 of Article 5;
9. That we further appeal to the international community to demonstrate more concern for the issues of ozone layer protection and for the protection of the global atmosphere in general, taking into account the need to promote social and economic development in all countries.

## Web links available through the site of the Ozone Secretariat (http://www.unep.org/ozone)

| | |
|---|---|
| **UNEP** | |
| The Ozone Secretariat - is the Secretariat for the Vienna Convention for the Protection of the Ozone Layer and for the Montreal Protocol on Substances that Deplete the Ozone Layer | http://www.unep.org/ozone<br>http://www.unep.ch/ozone |
| Multilateral Fund Secretariat for the Implementation of the *Montreal Protocol on Substances that Deplete the Ozone Layer* | http://www.unmfs.org/ |
| UNEP Technology, Industry and Economics, OzonAction Programme | http://www.uneptie.org/ozonaction.html |
| Technology and Economic Assessment Panel (TEAP): The TEAP site provides information about the work and reports of the Technology and Economic Assesment panel as well as about its seven Technical Options Committees (TOCs). You can download several reports from this site | http://www.teap.org/ |
| UNEP/TEAP Solvents Technical Options Committee | http://www.protonique.com/unepstoc/ |
| *Our Planet* - Issue Volume 9, Number 2 1997, which focuses on the Ozone Layer depletion | http://www.ourplanet.com/imgversn/92/contents.html |
| UNEP's GEF Financed Activities on the Stratospheric Ozone Layer | http://www.unep.org/gef/ozone.htm |
| **Other International Organisations** | |
| World Meteorological Organization (WMO) | http://www.wmo.ch/ |
| World Meteorological Organization (WMO) Ozone Mapping Centre Provides a list of daily ozone maps of the northern hemisphere taken daily between November 1- March 31 | http://www.wmo.ch/web/arep/nhoz.html |
| Global Environment Facility | http://www.gefweb.org/ |
| United Nations Development Programme (UNDP), Montreal Protocol Unit | http://www.undp.org/seed/eap/montreal/index.htm |
| United Nations Industrial and Development Organization (UNIDO), Montreal Protocol Branch | http://www.unido.org/ |
| The World Bank, Montreal Protocol Operations Unit | http://www-esd.worldbank.org/mp/ |
| **Environmental Convention Secretariats** | |
| Basel Convention on Transboundary Movement of Hazardous Waste | http://www.basel.int/ |
| Convention on Biological Diversity | http://www.biodiv.org/ |
| Convention on Climate Change | http://www.unfccc.de/ |
| Convention to Combat Desertification | http://www.unccd.ch/ |
| Convention on International Trade in Endangered Species (CITES) | http://www.wcmc.org.uk/CITES/ |
| Conservation of Migratory Species (The Bonn Convention) | http://www.wcmc.org.uk/cms/ |