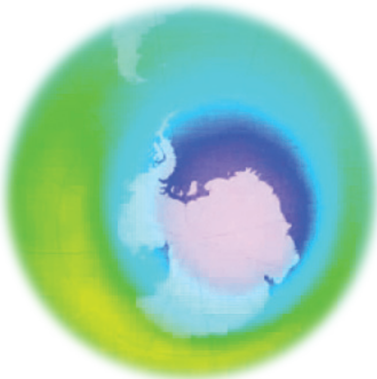
UNEP

ozone



vital ozone graphics 2.0 climate link

resource kit for journalists

UNEP DTIE OzonAction

vital ozone graphics 2.0 climate link

This is a joint publication of the Division of Technology, Industry and Economics (DTIE) OzonAction Branch, GRID-Arendal and Zoï Environment Network.

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The **UNEP DTIE OzonAction Branch** assists developing countries and countries with economies in transition (CEITs) to enable them to achieve and sustain compliance with the Montreal Protocol. The Branch supports UNEP's mandate as an implementing agency of the Multilateral Fund for the Implementation of the Montreal Protocol.
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UNEP/GRID-Arendal is an official UNEP centre located in Southern Norway. Grid-Arendal's mission is to provide environmental information, communications and capacity building services for information management and assessment. The centre's core focus is to facilitate the free access and exchange of information to support decision making to secure a sustainable future.
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Zoï Environment Network is a Geneva-based international non-profit organisation with a mission to reveal, explain and communicate the connections between the Environment and Society and to promote practical policy solutions to the complex international challenges.
www.zoinet.org

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foreword to the second edition

The efforts of the Parties to the Montreal Protocol have, over more than 20 years, translated scientific realities into political decisions leading to concrete action on the ground. The experience of this Protocol can act as both guide and inspiring example of the multilateral system at its best, and should help build confidence for future multilateral environmental agreements.

That confidence was given a boost when countries under the Montreal Protocol decided to take quick and early action down the path to ending HCFC consumption and production. These actions, however, must be taken in the spirit of a new era in which the world embraces the absolute need for 'green growth' – growth that casts off the 'business as usual' approach and accelerates us down the path to low-carbon, resource-efficient economies with an intelligent management of natural and nature-based assets. Indeed, the accelerated action on HCFCs will achieve maximum benefits in terms of ozone and climate if the phase-out is accompanied by improvements in areas such as energy efficiency and the adoption of alternate technologies. The world has an unparalleled opportunity to simultaneously eliminate ozone depleting substances, reap climate benefits, and improve energy efficiency and stimulate growth in green jobs.

This second, revised edition of "Vital Ozone Graphics" sheds a light onto the latest decisions taken by the Parties to the Montreal Protocol to accelerate the phase out of HCFCs and the implications this has on the use of replacement chemicals. It also focuses on the links to climate both physically up in the air and on the institutional ground of international treaty negotiations and discusses the remaining challenges posed by the large amounts of ozone killer banks still present in equipment in use and stocked away, only safe for the atmosphere once entirely destroyed.

10+ new maps and graphics accompany the entirely updated graphical material making it "Vital ozone graphics 2.0 – Climate link."

a note for journalists

Vital Ozone Graphics is designed to be a practical tool for journalists who are interested in developing stories related to ozone depletion and the Montreal Protocol. Besides providing a basic introduction to the subject, this publication is meant to encourage journalists to seek further information from expert sources and to provide ready-made visual explantions that can be incorporated into an article.

All of the graphics are available online free of charge at www.vitalgraphics.net/ozone. The graphics can be downloaded in different formats and resolutions, and are designed in such a way that they can easily be translated into local languages. The on-line version also features additional materials such as story ideas, contacts, a comprehensive glossary and more links to information related to the ozone hole.

UNEP DTIE OzonAction, UNEP/GRID-Arendal and Zoï Environment Network would appreciate receiving a copy of any material using these graphics. Please send an e-mail to ozonaction@unep.fr, ozone@grida.no and enzoi@zoinet.org.

foreword

On 16 September 1987, the treaty known as the Montreal Protocol on Substances that Deplete the Ozone Layer was signed into existence by a group of concerned countries that felt compelled to take action to solve an alarming international environmental crisis: the depletion of the Earth's protective ozone layer. Since that humble beginning two decades ago, this treaty has taken root, grown and finally blossomed into what has been described as "Perhaps the single most successful international environmental agreement to date". It has become an outstanding example of developing and developed country partnership, a clear demonstration of how global environmental problems can be managed when all countries make determined efforts to implement internationally-agreed frameworks. But why has it worked so well, how has it impacted our lives, what work lies before us, and what lessons we can learn from it?

The story of the Montreal Protocol is really a collective of hundreds of compelling and newsworthy individual stories which are waiting for the right voice. There are cautionary tales of the need to avoid environmental problems at the start. There are inspiring stories of partnership, innovation and countries working together for the common good. There are stories of hope, of humanity being able to successfully reverse a seemingly insurmountable environmental problem while balancing economic and societal needs. Beyond numbers and statistics, the Montreal Protocol is above all a story with a human face, showing how the consequences of a global environmental issue can affect us as individuals – our health, our families our occupations, our communities – and how we as individuals can be part of the solution.

This year, the 20th anniversary of this landmark agreement, affords us all the opportunity to investigate these stories. Each country and region, their institutions and individuals, have all made major contributions to the protection of the ozone layer, and their stories must be told. We want to enlist the help of journalists in telling this story, and through this publication, we are trying to assist in these broad communications efforts.

This , the youngest product in a series of Vital Graphics on environmental issues, provides journalists with the essential visuals, facts, figures and contacts they need to start developing their own ozone story ideas. The graphics and figures can be used in articles ready-made. We want the information in this publication and the associated web site to inform and inspire journalists to go out and investigate this story and to tell the ozone tale – the good and the bad – to readers, viewers or listeners.

was produced jointly by the OzonAction Branch of UNEP's Division on Technology, Industry and Economics (DTIE) and UNEP/GRID-Arendal, as part of an initiative to engage journalists on the ozone story, with support provided by the Multilateral Fund for the Implementation of the Montreal Protocol.

While specifically targeted at members of the media, we believe that anyone interested in learning about the Montreal Protocol and ozone layer depletion will find this publication to be an interesting and insightful reference.

I hope the reading of the coming pages is not only enjoyable, but will stimulate the creative juices of the media and trigger broader coverage of the ozone protection efforts in newspapers and on radio, TV and the Internet across around globe.

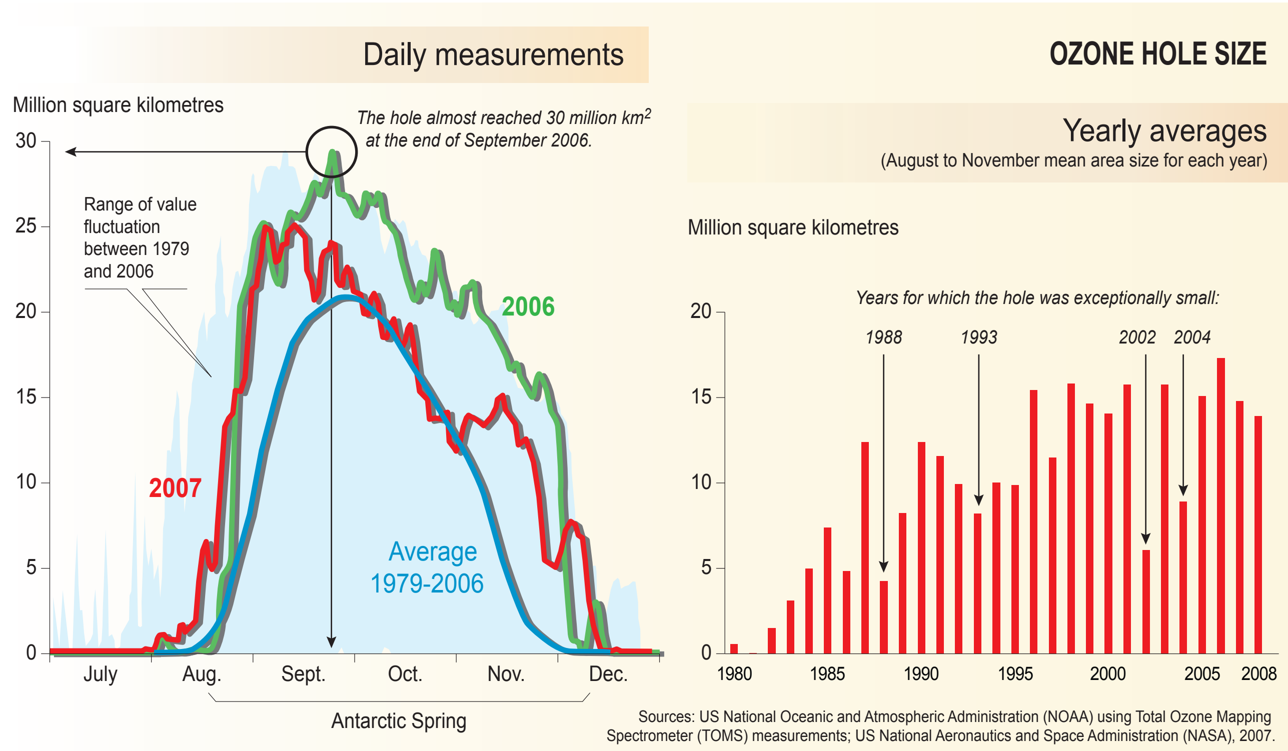
Achim Steiner,
United Nations Under-Secretary General
Executive Director, United Nations Environment Programme

01 the hole
a damaged uv shield

Hovering some 10 to 16 kilometres above the planet's surface, the ozone layer filters out dangerous ultraviolet (UV) radiation from the sun, thus protecting life on Earth. Scientists believe that the ozone layer was formed about 400 million years ago, essentially remaining undisturbed for most of that time. In 1974, two chemists from the University of California startled the world community with the discovery that emissions of man-made chlorofluorocarbons (CFCs), a widely used group of industrial chemicals, might be threatening the ozone layer.

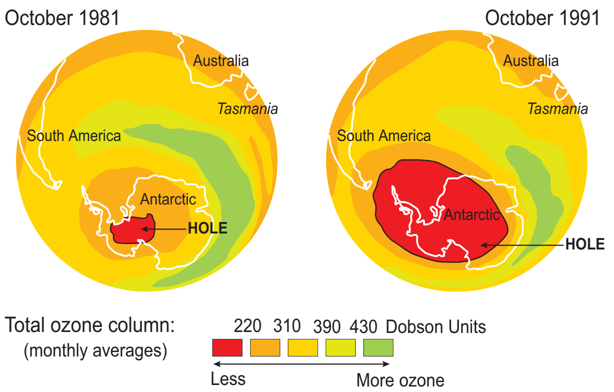
The scientists, Sherwood Rowland and Mario Molina, postulated that when CFCs reach the stratosphere, UV radiation from the sun causes these chemically-stable substances to decompose, leading to the release of chlorine atoms. Once freed from their bonds, the chlorine atoms initiate a chain reaction that destroys substantial amounts of ozone in the stratosphere. The scientists estimated that a single chlorine atom could destroy as many as 100,000 ozone molecules. The theory of ozone depletion was confirmed by many scientists over the years. In 1985 ground-based measurements by the British Antarctic Survey recorded massive ozone loss (commonly known as the "ozone hole") over the Antarctic, providing further confirmation of the discovery. These results were later confirmed by satellite measurements.

The discovery of the "ozone hole" alarmed the general public and governments and paved the way for the adoption in 1987 of the treaty now known as the Montreal Protocol on Substances that Deplete the Ozone Layer. Thanks to the Protocol's rapid progress in phasing out the most dangerous ozone-depleting substances, the ozone layer is expected to return to its pre-1980s state by 2060–75, more than 70 years after the international community agreed to take action. The Montreal Protocol has been cited as "perhaps the single most successful international environmental agreement to date" and an example of how the international community can successfully cooperate to solve seemingly intractable global environmental challenges.

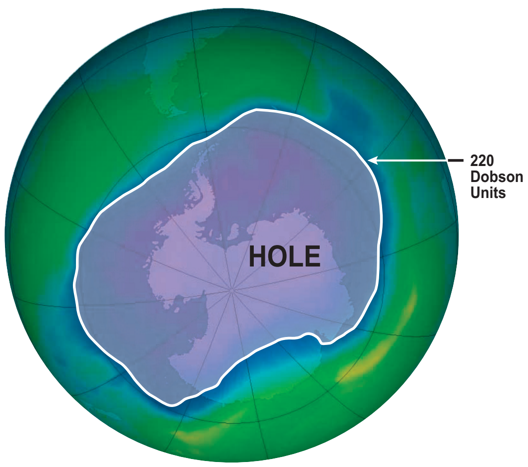


The extent of ozone depletion for any given period depends on complex interaction between chemical and climatic factors such as temperature and wind. The unusually high levels of depletion in 1988, 1993 and 2002 were due to early warming of the polar stratosphere caused by air disturbances originating in mid-latitudes, rather than by major changes in the amount of reactive chlorine and bromine in the Antarctic stratosphere.

THE ANTARCTIC HOLE



September 24, 2006

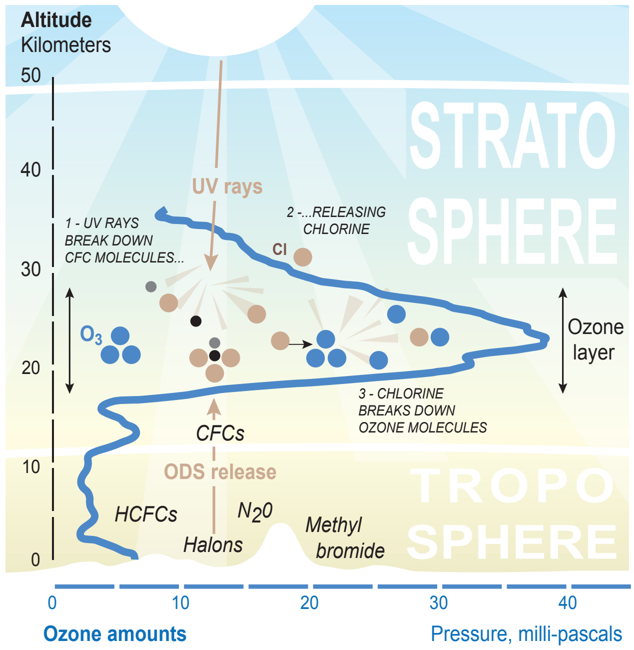


From September 21-30, 2006, the average area of the ozone hole was the largest ever observed.

Source: US National Oceanic and Atmospheric Administration (NOAA) using Total Ozone Mapping Spectrometer (TOMS) measurements; US National Aeronautics and Space Administration (NASA), 2007.

The ozone layer over the Antarctic has been thinning steadily since the ozone loss predicted in the 1970s was first observed in 1985. The area of land below the ozone-depleted atmosphere increased steadily to encompass more than 20 million square kilometres in the early 1990s, and has varied between 20 and 29 million square kilometres since then. Despite progress achieved under the Montreal Protocol, the ozone "hole" over the Antarctic was larger than ever in September 2006. This was due to particularly cold temperatures in the stratosphere, but also to the chemical stability of ozone-depleting substances – it takes about 40 years for them to break down. While the problem is worst in the polar areas, particularly over the South Pole because of the extremely low atmospheric temperature and the presence of stratospheric clouds, the ozone layer is thinning all over the world outside of the tropics. During the Arctic spring the ozone layer over the North Pole has thinned by as much as 30 per cent. Depletion over Europe and other high latitudes has varied from 5 to 30 per cent.

CHEMICAL OZONE DESTRUCTION PROCESS IN THE STRATOSPHERE



stratospheric ozone, tropospheric ozone and the ozone "hole"

Ozone forms a layer in the stratosphere, thinnest in the tropics and denser towards the poles. Ozone is created when ultraviolet radiation (sunlight) strikes the stratosphere, dissociating (or "splitting") oxygen molecules (O_2) into atomic oxygen (O). The atomic oxygen quickly combines with oxygen molecules to form ozone (O_3). The amount of ozone above a point on the earth's surface is measured in Dobson units (DU) – it is typically ~260 DU near the tropics and higher elsewhere, though there are large seasonal fluctuations.

The ozone hole is defined as the surface of the Earth covered by the area in which the ozone concentration is less than 220 DU. The largest area observed in recent years covered 25 million square kilometres, which is nearly twice the area of the Antarctic. The lowest average values for the total amount of ozone inside the hole in late September dropped below 100 DU.

At ground level, ozone is a health hazard – it is a major constituent of photochemical smog. Motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents as well as natural sources emit NO_x and volatile organic compounds (VOCs) that help form ozone. Ground-level ozone is the primary constituent of smog. Sunlight and hot weather cause ground-level ozone to form in harmful concentrations in the air.

02 the culprits

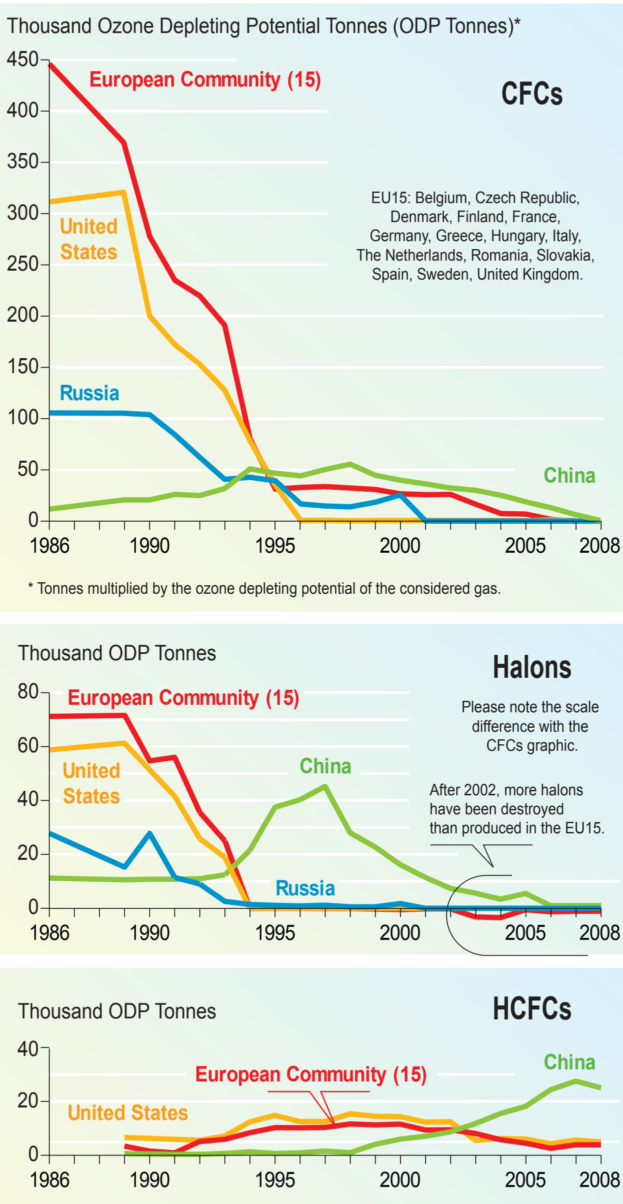
ozone depleting substances

When they were discovered in the 1920s, CFCs and other ozone depleting substances (ODS) were "wonder" chemicals. They were neither flammable nor toxic, were stable for long periods and ideally suited for countless applications. By 1974, when scientists discovered that CFCs could destroy ozone molecules and damage the shield protecting our atmosphere, they had become an integral part of modern life.

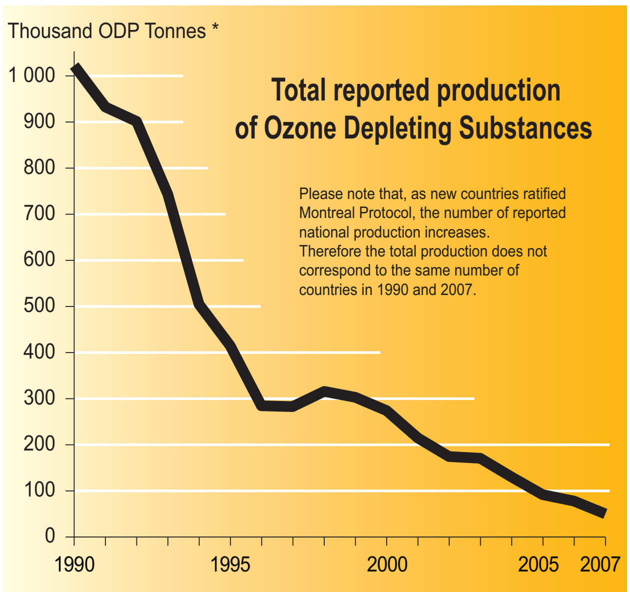
We would get up in the morning from a mattress containing CFCs and turn on a CFC-cooled air conditioner. The hot water in the bathroom was supplied by a heater insulated with CFC-containing foam, and the aerosol cans containing deodorant and hair spray used CFC propellants. Feeling hungry we would open the fridge, also chilled with CFCs. Methyl bromide had been used to grow those tempting strawberries, not to mention many other foodstuffs consumed every day. Nor would there be any escape in the car, with CFCs nesting in the safety foam in the dashboard and steering wheel. At work it was much the same, with halons used extensively for fire protection in offices and business premises, as well as in data centres and power stations. Ozone depleting solvents were used in dry cleaning, and to clean metal parts in almost all electronic devices, refrigerating equipment and cars. They also played a part in tasks such as laminating wood for desks, bookshelves and cupboards.

Since the discovery of their destructive nature, other substances have gradually replaced ODS. In some cases it is difficult to find and costly to produce replacements, which may have undesirable side-effects or may not be applicable for every use. Experts and the public need to remain vigilant to ensure replacements do not cause adverse health effects, safety concerns, or other environmental damage (for example global warming). As is often the case, the last mile on the road to complete elimination is the most difficult one.

PRODUCTION OF MAIN ODS GASES



Source: United Nations Environment Programme Ozone Secretariat, 2009.



* Tonnes multiplied by the ozone depleting potential of the considered gas.
Source: United Nations Environment Programme Ozone Secretariat, 2009.

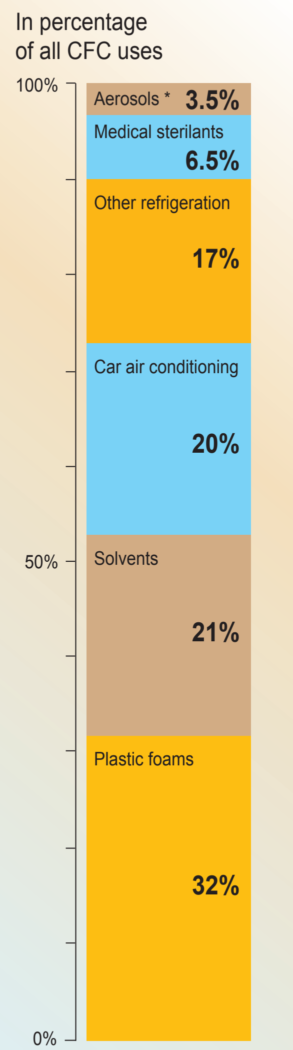
ODS can escape during use (for example when used in aerosol sprays), or are released at the end of the lifetime of a equipment if proper care is not taken during its disposal. They can be captured, recycled and re-used if proper procedures are followed by servicing technicians and equipment owners. Disposing of ODS is possible, though it is relatively costly and laborious. These chemicals must be destroyed using one of the destruction processes approved by the Parties to the Montreal Protocol.

Most commonly used ozone depleting substances and their replacements

Use	ODS	Characteristics	Alternatives
Refrigeration and air conditioning	CFC 11, 12, 113, 114, 115	Long-lived, non-toxic, non-corrosive, and non-flammable. They are also versatile. Depending on the type of CFC, they remain in the atmosphere from between 50 to 1700 years	HFCs, hydrocarbons, ammonia, water Alternative technologies: gas-fired air conditioning, adsorption chillers
	HCFC 22, 123, 124	Deplete the ozone layer, but to a much lesser extent. They are being phased out as well.	HFCs, hydrocarbons, ammonia, water Alternative technologies: gas-fired air conditioning, adsorption chillers
Aerosols	CFC 11, 12, 114	*see above*	Alternative technologies: gas-fired air conditioning, adsorption chillers
Foam blowing/rigid insulation foams	CFC 11, 12, 113 HCFC 22, 141b, 142b	*see above*	Non-foam insulation, HFCs, hydrocarbons, CO_2, 2-chloropropane
Fire extinction	Halons (e.g. halon-1301, halon-1211)	Atmospheric lifetime of 65 years	Water, CO_2, inert gases, foam, HFCs, fluorinated ketone
Pest control/soil fumigation	Methyl bromide	Fumigant used to kill soil-borne pests and diseases in crops prior to planting and as disinfectants in commodities such as stored grains or agricultural commodities awaiting export. Takes about 0.7 years to break down.	No single alternative Integrated pest management systems Artificial substrates Crop rotation Phosphine, Chloropicrin, 1,3-dichloropropene, Heat, Cold, CO_2, Steam treatments and Combined/Controlled atmospheres
Solvents (used for cleaning precision parts)	CFC 113, HCFC 141b, 225 1,1,1 trichloroethane	*see above for CFC, HCFC*	Change to maintenance-free or dry processes, no-clean flux, aqueous and semi-aqueous systems Hydrocarbons Hydrofluoroethers (HFEs) Chlorinated solvents (e.g. trichloroethylene) Volatile flammable solvents (e.g.methyl alcohol)
	Carbontetrachloride	Close to zero flammability Toxic ODP 1.1 Low dissolving power Forms poisonous phosgene under high temperatures in air. As its use as a feedstock results in the chemical being destroyed and not emitted, this use is not controlled by the Montreal Protocol	*see above*

Sources: US EPA 2006, www.Wikipedia.org, European Commission 2009.

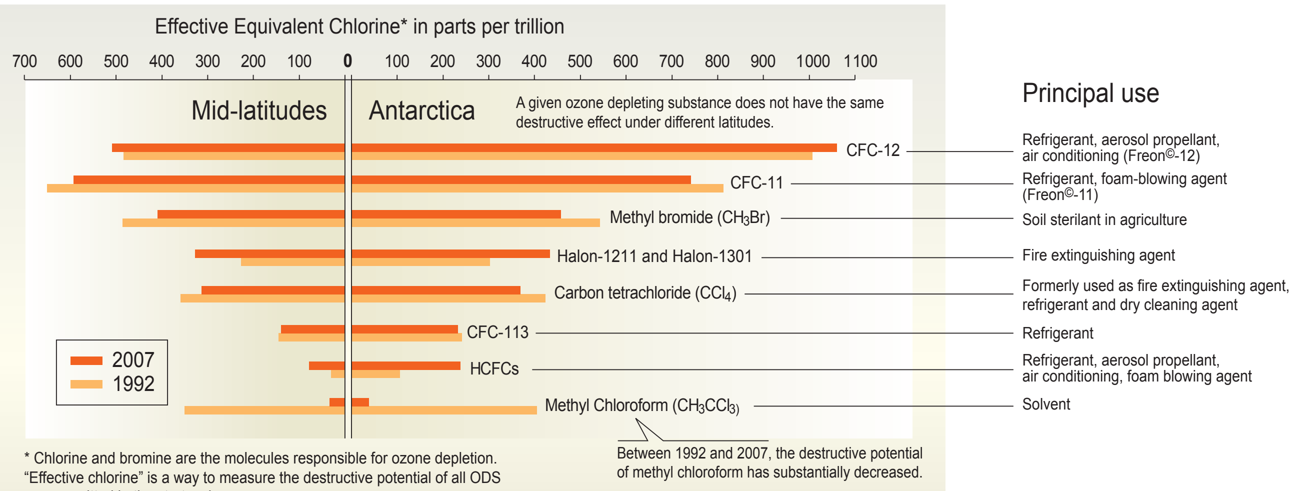
CFC END USES IN THE US IN 1987



* Note that CFCs in aerosols were banned in the US in 1978.

Source: US Environmental Protection Agency, 1992 (cited by WRI 1996).

DESTRUCTIVE POTENTIAL OF OZONE DEPLETING SUBSTANCES



* Chlorine and bromine are the molecules responsible for ozone depletion. "Effective chlorine" is a way to measure the destructive potential of all ODS gases emitted in the stratosphere.

Source: Stephen A. Montzka, David J. Hofmann, *The NOAA Ozone Depleting Gas Index: Guiding Recovery of the Ozone Layer*, 2008. (www.esrl.noaa.gov/gmd/odgi)

cooling equipment

Demand for refrigerators and air-conditioning systems is soaring. This is partly due to rising living standards spreading across the globe, partly to changing habits and standards of comfort. Furthermore, with a warmer climate the number of the world's refrigerators (estimated at 1.5 to 1.8 thousand million) and its domestic and mobile (car) air-conditioners (respectively 1.1 thousand million and 400 million) is expected to rise dramatically as developing nations such as China and India modernize.

This trend is causing two forms of collateral damage.

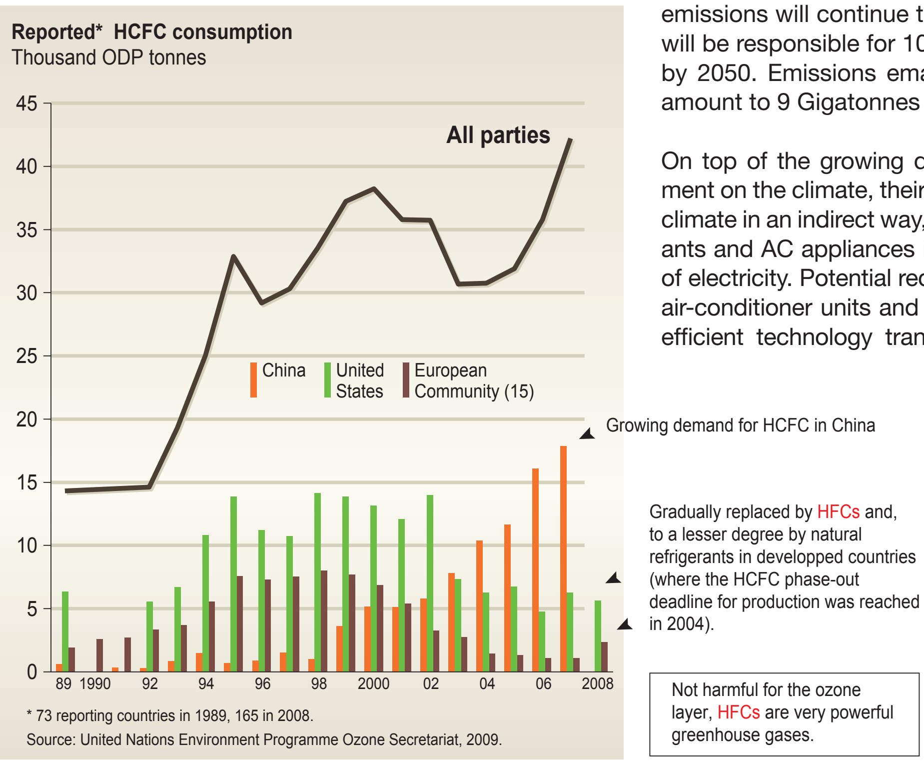
Cooling equipment needs refrigerants. Commonly used cooling agents, when released into the air, either destroy ozone molecules, contribute to warming the atmosphere, or both. With the Montreal Protocol the global community now virtually eliminated CFCs, the chemicals doing the most damage to the ozone layer. Their most common replacements, HCFCs, also destroy the ozone layer, although to a far lesser extent. But even if the danger of a given amount of an HCFC gas is less than for the same amount of a CFC, the rise in the total amount in use worldwide has resulted in a stock of HCFCs that poses a comparable threat to the ozone layer and the climate. According to the 2006 UNEP refrigeration assessment report the CFC bank consists of approximately 450,000 tonnes, 70 per cent of which is located in Article-5 countries. HCFCs, which form the dominant refrigerant bank in terms of quantity, are estimated at more than 1,500,000 tonnes, representing 60 per cent of the total amount of refrigerants in use (see feature on ODS banks).

Ironically the success of the Montreal Protocol is causing environmental negotiators an additional headache. In the initial phase of the treaty's implementation, shifting to chemicals with a lower ozone destruction potential was actively encouraged and even financially supported, because they allowed a faster phase out of CFCs. The powerful warming potential of these new substances was not a major issue at the time.

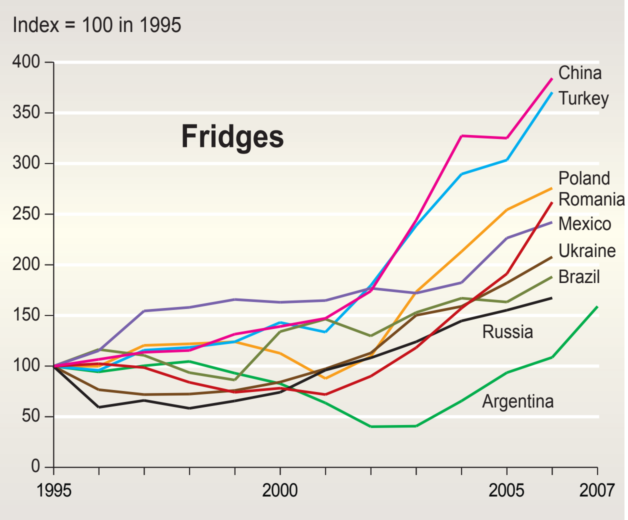
In 2007 growing awareness of the dual threat from HCFCs prompted the parties to decide to speed up the phasing out of HCFCs. Factories that shifted to HCFC production from CFC will need to either close or continue production for non-controlled uses such as feedstock. If a "business as usual" approach is taken, this will certainly lead to a surge in the use of HFCs. HFCs, however, are greenhouse gases thousands of times stronger than CO_2. Unless measures are taken to control HFCs specifically, the well-meant decision will have a huge negative effect on the climate. A recent scientific study estimates that assuming that CO_2 emissions will continue to grow at their current rate, HFCs will be responsible for 10 to 20 per cent of global warming by 2050. Emissions emanating from HFC releases could amount to 9 Gigatonnes of CO_2-equivalent.

On top of the growing direct effect of refrigeration equipment on the climate, their expansion increasingly affects the climate in an indirect way, as the growing number of refrigerants and AC appliances increases the overall consumption of electricity. Potential reductions in power requirements for air-conditioner units and refrigerators derived from energy-efficient technology transferred to developping countries

HCFC: A TRANSITIONAL SUBSTITUTE FOR CFC IN THE REFRIGERATION SECTOR

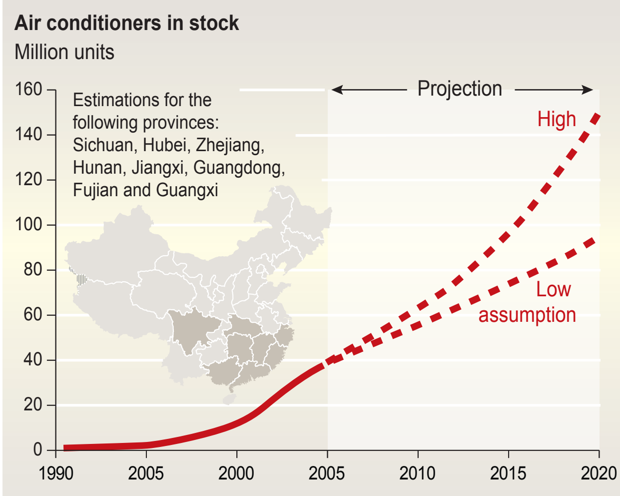


GROWTH OF REFRIGERATION



Source: Industrial Commodity Statistics Database, United Nations Statistics Division 2009.

AIR CONDITIONING IN SOUTHERN CHINA



Source: International Energy Agency, *Energy efficiency of air conditioners in developing countries and the role of CDM*, 2007.

would therefore have significant benefit. For example, based on calculations from Chinese warm provinces these could result in a reduction in total power generation of between 15 and 38 per cent in the next 15 years in China, that is of up to 260 TWh – equivalent to the output from about 50 power plants with corresponding reductions in CO_2 emissions.

Less emissions despite higher consumption?

Whatever the refrigerant used, there are many ways of limiting emissions, even with existing equipment. The first step is to reduce leakage. Besides harming the ozone layer, leaking substances can harm the environment and our health. Refrigerant leakage could be reduced by 30 per cent by 2020 by optimizing the seal on containers (refrigerant containment), particularly in mobile air-conditioners and commercial refrigeration, but also by reducing the charge of refrigerants (optimization of indirect refrigeration systems, micro-channel heat exchangers, etc.). Proper maintenance and servicing of refrigerating plants (regular checks, systematic recovery, recycling, regeneration or destruction of refrigerants) also helps. Lastly refrigeration professionals should be appropriately trained and possibly certified.

Natural refrigerants

In the search for alternatives to HFCs a great deal of attention has focused on naturally occurring refrigerants such as ammonia, hydrocarbons (HCs) and carbon dioxide (CO_2). Their use is already quite common for selected applications (e.g. HCs in domestic refrigeration) and is growing for others (e.g. CO_2 in automobile or aeronautics applications). Barriers to the spread of natural refrigerants are the lack of international standards regulating their use, the need for training of servicing technicians and, in some cases, the need for updating safety standards. Typically a limit is placed on the maximum amount of refrigerant that the thermodynamic cycle may use. This implies that for applications with a high cooling demand the cycles have to be split up into several smaller ones, demanding more equipment. Natural refrigerants are competitive in most cases, even if technology still needs to be developed for certain uses.

New synthetic refrigerants are also on the horizon, such as HFO-1234yf, which should be available in 2011 for air-conditioning applications. Completely new technologies are also being assessed, such as magnetic or solar refrigeration. The latter compensates the often higher energy demand for natural refrigerants by powering it with solar energy.

HCFCs and HFCs

Major application sectors using ODS and their HFC/PFC substitutes include refrigeration, air-conditioning, foams, aerosols, fire protection, cleaning agents and solvents. Emissions from these substances originate in manufacture and unintended releases, applications where emissions occur intentionally (like sprays), evaporation and leakage from banks (see page 32) contained in equipment and products during use, testing and maintenance, and when products are discarded after use without proper handling.

The total positive direct radiative forcing due to increases in industrially produced ODS and non-ODS halocarbons from 1750 to 2000 is estimated to represent about 13 per cent of total GHG increases over that period. Most halocarbon increases have occurred in recent decades. Atmospheric concentrations of CFCs were stable or decreasing in 2001–03 (0 to –3% a year, depending on the specific gas) whereas halons and their substitues, HCFCs and HFCs increased (Halons 1 to 3 per cent, HCFCs 3 to 7 per cent and HFCs 13 to 17 per cent per year).

What are non-HFC replacements of HCFCs?

Alternatives to HFCs are available across a wide variety of sectors, especially domestic refrigeration, commercial stand-alone refrigeration, large industrial refrigeration and polyurethane foams. When evaluating a potential alternative to HCFCs it is necessary to consider the overall environmental and health impact of the product, including energy consumption and efficiency. Ammonia and the hydrocarbons (HCs) substitutes have atmospheric life-times ranging from days to months, and the direct and indirect radiative forcings associated with their use as substitutes have a negligible effect on global climate. They do, however, have health and safety issues that must be addressed.

the culprits

methyl bromide

Methyl bromide, a substance used in agriculture, and also in food processing, accounts currently for about 10 per cent of ozone depletion. As a pesticide it is widely used to control insect pests, weeds and rodents. It is used as a soil and structural fumigant too, and for commodity and quarantine treatment. Methyl bromide is manufactured from natural bromide salts, either found in underground brine deposits or in high concentrations above ground in sources such as the Dead Sea.

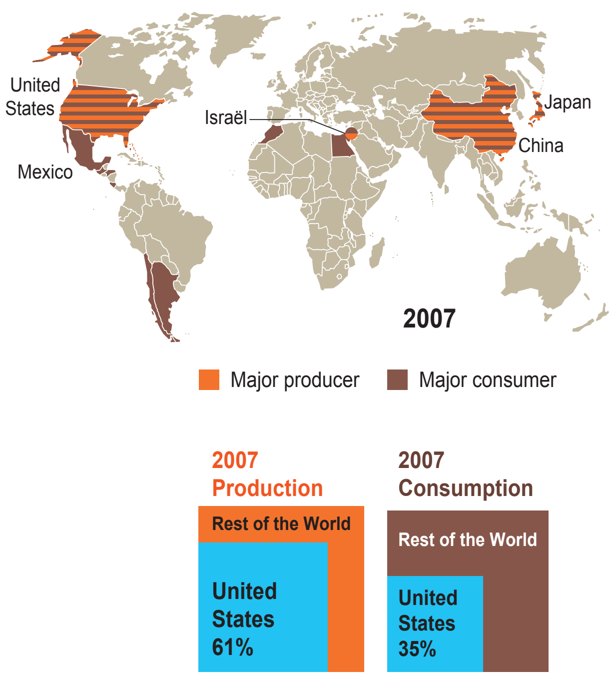
When used as a soil fumigant, methyl bromide gas is usually injected into the soil to a depth of 30 to 35 cm before planting. This effectively sterilizes the soil, killing the vast majority of organisms there. Strawberry and tomato crops use the most methyl bromide. Other crops for which this pesticide is used as a soil fumigant include peppers, grapes, and nut and vine crops. When used to treat commodities, gas is injected into a chamber containing the goods, typically cut flowers, vegetables, fruit, pasta or rice. Methyl bromide is also used by bakeries, flour mills and cheese warehouses. Imported goods may be treated as part of the quarantine or phytosanitary measures in destination countries (referred to as “quarantine and preshipment” applications). In any application, about 50 to 95 per cent of the gas ultimately enters the atmosphere.

Methyl bromide is toxic. Exposure to this chemical will affect not only the target pests, but also other organisms. Because methyl bromide dissipates so rapidly to the atmosphere, it is most dangerous at the fumigation site itself. Human exposure to high concentrations of methyl bromide can result in failure of the respiratory and central nervous systems, as well causing specific, severe damage to the lungs, eyes and skin.

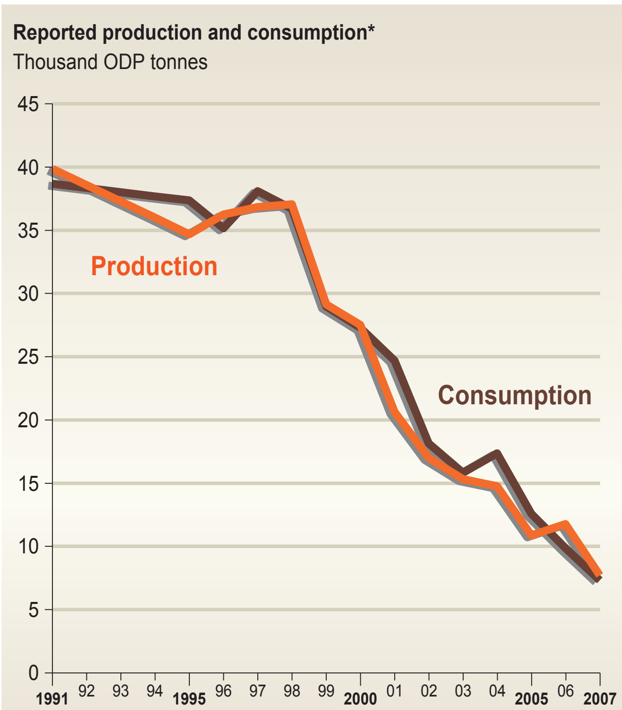
As the Montreal Protocol controls methyl bromide, emissions have declined significantly over the past decade. In non-Article 5 countries, the phase-out date was 2005, while Article-5 countries are allowed to continue production and consumption till 2015. The challenge is to eliminate its use by gradually phasing out the amounts still allocated to a small number of non article-5 countries for critical uses.

Both chemical and non-chemical alternatives to methyl bromide exist, and several tools can manage the pests currently controlled with methyl bromide. Research on alternatives continues, it being necessary to demonstrate the long-term performance of alternatives and satisfy risk concerns. As with CFC alternatives, researchers must show that alternative substances do not harm the ozone layer or heat up the atmosphere. This is the case for sulfuryl fluoride (SF), a key alternative to methyl bromide for the treatment of many dry goods (in flour mills, food processing facilities and for household termite control). Recent publications indicate that SF has a global warming potential of about 4,800, a value similar to that of CFC-11. Its concentration in the atmosphere is increasing rapidly.

METHYL BROMIDE TRENDS



Source: United Nations Environment Programme Ozone Secretariat, 2009.

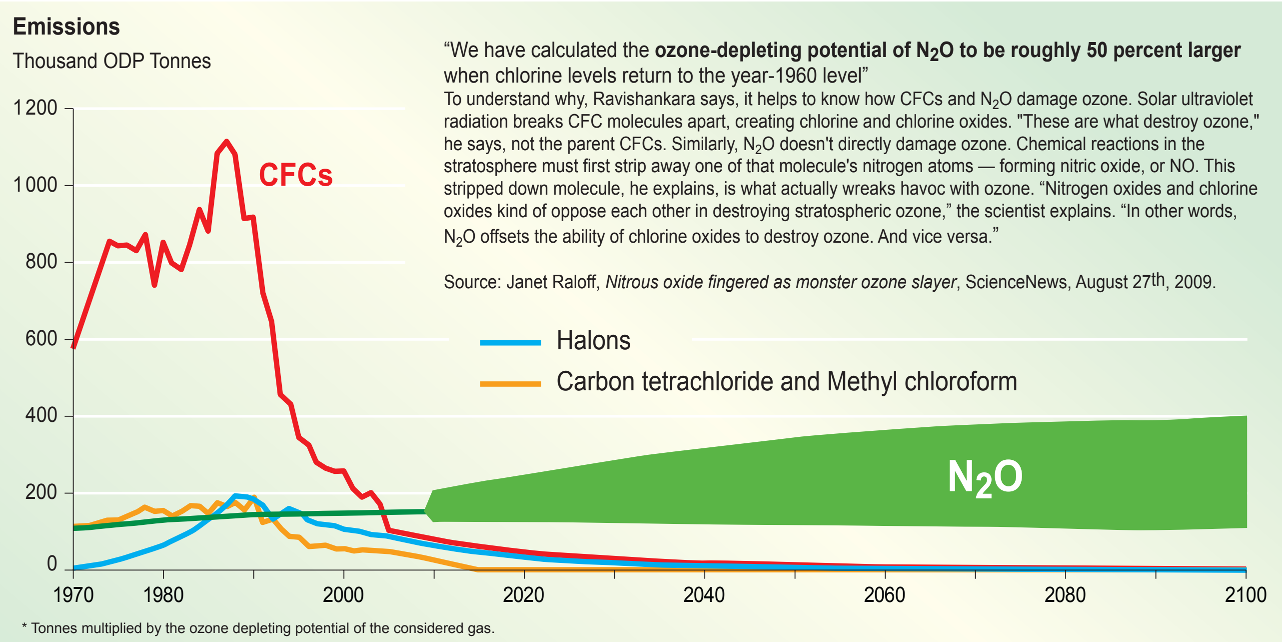


* Consumption: 170 reporting countries; production: 6 (on average).

nitrous oxide

Most people know nitrous oxide as laughing gas that dentists use as an anaesthetic. But this is only a minor source of emissions. Deforestation, animal waste and bacterial decomposition of plant material in soils and streams emit up to two-thirds of atmospheric N_2O. Unlike natural sources, emissions from human-related processes are steadily increasing, currently boosting the atmospheric concentration of N_2O by roughly one percent every four years.

NITROUS OXIDE: A MAJOR CULPRIT AFTER 2010



Source: A. R. Ravishankara, John S. Daniel, Robert W. Portmann, *Nitrous oxide (N_2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century*, Science, August 2009.

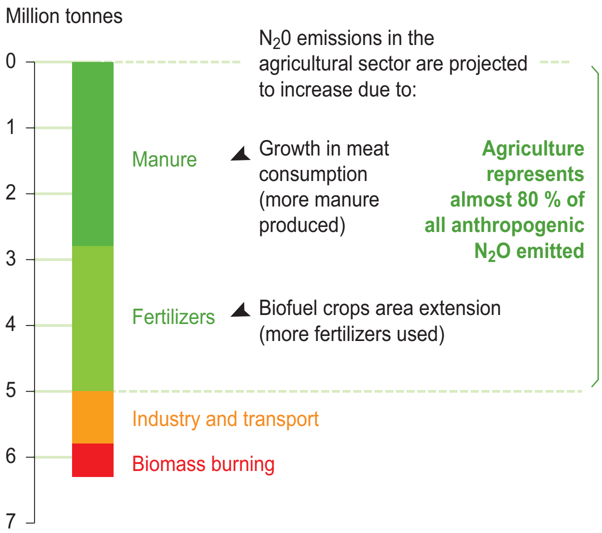
Annual global emissions are estimated at about 2 000 million tonnes of CO_2-equivalent. Now the main threat to the ozone layer, nitrous oxide is also a greenhouse gas. Limiting its emissions yields a double benefit. With a global warming potential (GWP) of about 300, N_2O accounts for almost eight per cent of GHG emissions. Nitrous oxide is not regulated by the Montreal Protocol, but falls under the Kyoto Protocol. An unwanted side effect of the Montreal Protocol in stalling CFC emissions is that N_2O can now develop its ozone destructive potential more effectively. (See explanation in the graph). Together with the rising concentrations this could slow the ozone layer's recovery.

options for control

Because many N_2O releases are diffuse, limiting them will be much more challenging than simply controlling industrial processes. Farming is a growing source of N_2O emissions. Widespread and often poorly controlled use of animal waste as a fertilizer also causes substantial emissions. Applying fertilizer dosages in line with demand and what the soil can absorb significantly reduces N_2O emissions and at the same time addresses high nitrate levels in drinking water supplies and eutrophication in estuaries. Information campaigns for farmers should focus on the optimal form and timing of fertilizer application.

... MOSTLY RELEASED BY AGRICULTURE

Nitrous oxide anthropogenic emissions



Source: Eric A. Davidson, *The contribution of manure and fertilizer nitrogen to atmospheric nitrous oxide since 1860*, Nature Geoscience, August 2009.

interlinked destruction

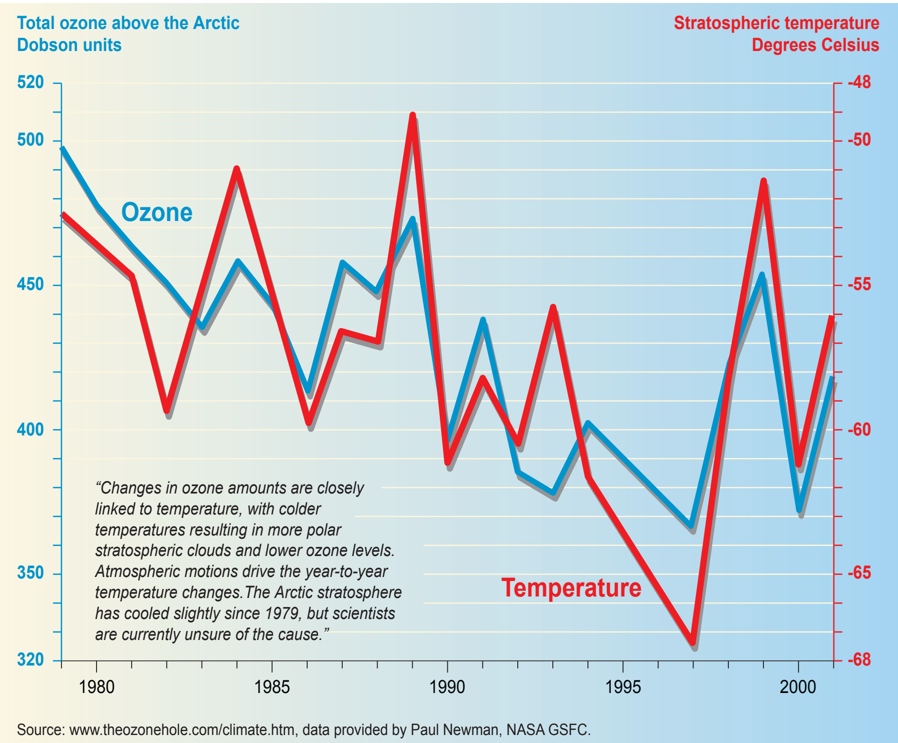
higher temperatures, polar stratospheric clouds and a changing climate

The causes and effects of the depletion of the ozone layer and climate change are seen by scientists, policy makers and the private sector as being inextricably linked in complex ways. Changes in temperature and other natural and human-induced climatic factors such as cloud cover, winds and precipitation impact directly and indirectly on the scale of the chemical reactions that fuel destruction of the ozone in the stratosphere.

The fact that ozone absorbs solar radiation qualifies it, on the other hand, as a greenhouse gas (GHG), much as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Stratospheric ozone depletion and increases in ozone near the Earth's surface (tropospheric ozone) in recent decades contribute to climate change. Similarly the build-up of anthropogenic GHGs, including ozone-depleting substances (ODS) and their replacements (in particular HFCs), enhances warming of the lower atmosphere, or troposphere (where weather systems occur), and is also expected, on balance, to lead to cooling of the stratosphere.

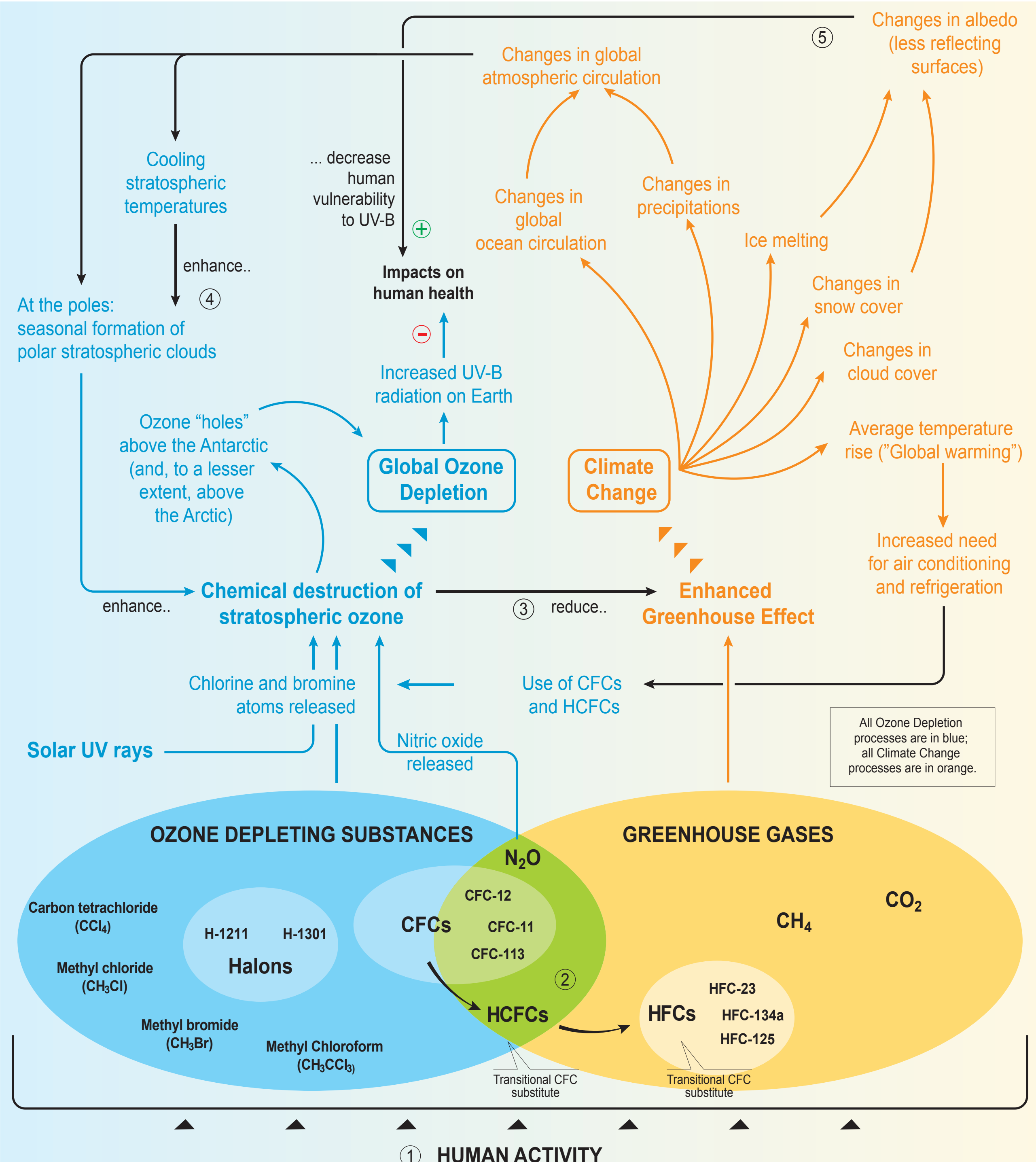
Stratospheric cooling creates a more favourable environment for the formation of polar stratospheric clouds, which are a key factor in the development of polar ozone holes. Cooling of the stratosphere due to the build-up of GHGs and associated climate change is therefore likely to exacerbate destruction of the ozone layer. The troposphere and stratosphere are not independent of one another. Changes in the circulation and chemistry of one can affect the other. Changes in the troposphere associated with climate change may affect functions in the stratosphere. Similarly changes in the stratosphere due to ozone depletion can affect functions in the troposphere in intricate ways that make it difficult to predict the cumulative effects.

ARCTIC OZONE DEPLETION AND STRATOSPHERIC TEMPERATURE



Total ozone and stratospheric temperatures over the Arctic since 1979.

OZONE DEPLETION AND CLIMATE CHANGE

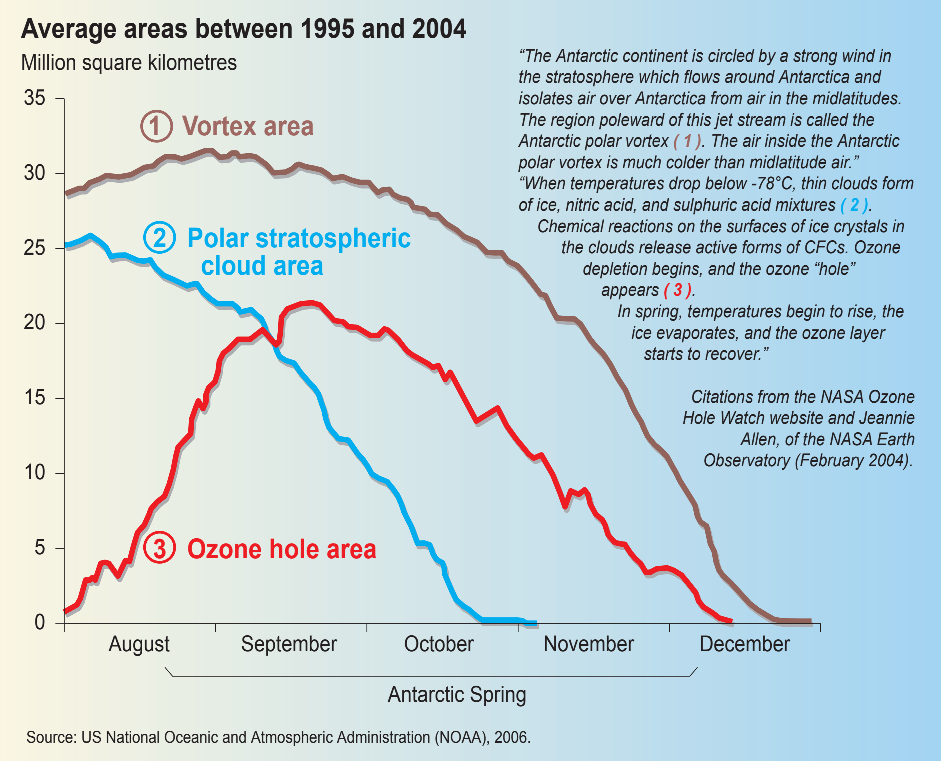


Source: Emmanuelle Bournay, UNEP/GRID-Arendal.

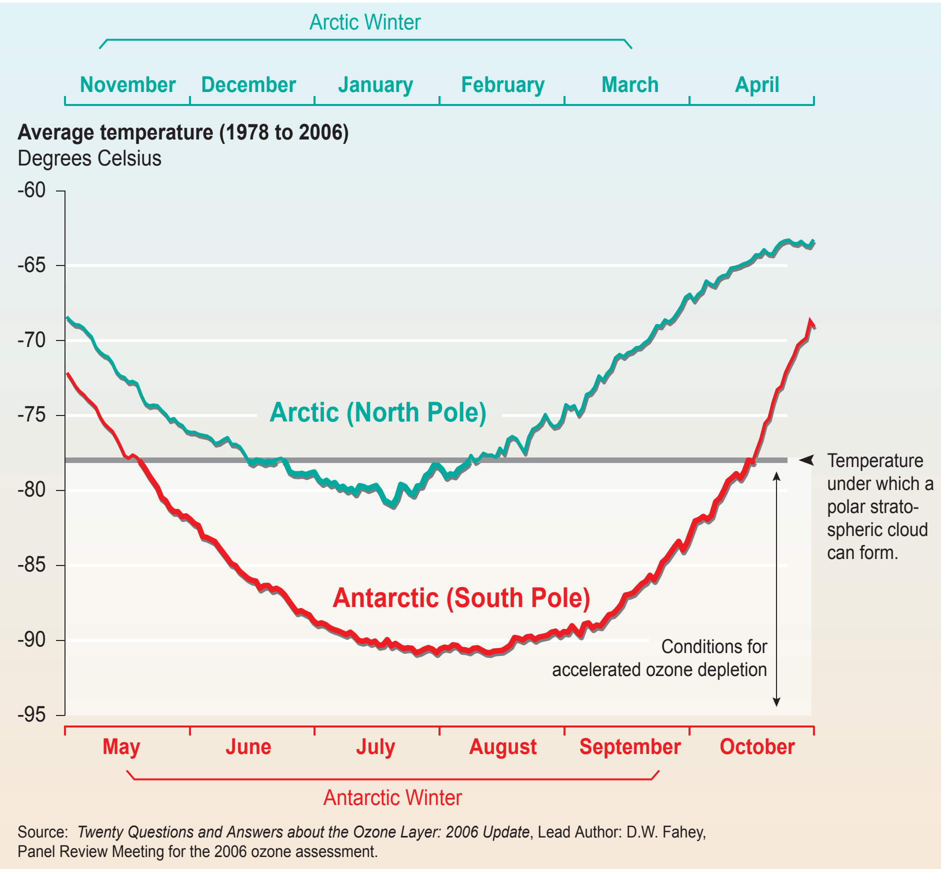
Ozone depletion and climate change are two distinct problems but as they both modify global Earth cycles, they cannot be totally separated. There are still many uncertainties concerning the relations between the two processes.
Several links have been identified, in particular:

1. Both processes are primarily due to human-induced emissions.
2. Many ozone depleting substances are also greenhouse gases, notably CFCs and HCFCs. HFCs, promoted to substitute CFCs, are sometimes stronger greenhouse gases than the CFCs they are replacing. This fact is taken into account in the negociations and decisions in both the Montreal and the Kyoto Protocol.
3. Ozone itself is a greenhouse gas. Therefore, its destruction in the stratosphere indirectly helps to cool the climate, but only to a small extent.
4. The global change in atmospheric circulation could be the cause of the recently observed cooling of stratospheric temperature. These low temperatures drive the formation of polar stratospheric clouds above the poles in the winter, greatly enhancing chemical ozone destruction and the formation of the "hole".
5. Human vulnerability to UV-B radiation is related in part to the albedo.The global warming context reduces white surfaces that are more likely to harm us.

THE "HOLE": A RESULT OF SPECIAL WEATHER CONDITIONS OVER THE POLE REPEATED EVERY SPRING



THE COLDER ANTARCTIC WINTER DRIVES FORMATION OF THE HOLE IN THE SOUTH



consequences and effects 1

uv radiation and ecosystems

We are particularly concerned by the potential impact of increased UV radiation on plants and animals, simply because they form the basis of our food supply. Significant changes in the health or growth of plants and animals may reduce the amount of available food.

Whereas scientists seem to agree that for any individual species, changes may be observed in an organism's growth capacity, it is much trickier to make observations and forecasts for an entire ecosystem. The task is complicated by the fact that we cannot single out UV radiation and separate it from other changes in atmospheric conditions, such as higher temperatures and CO_2 concentrations, or water availability.

UV radiation might affect certain species but also insects and pests, thus counter-balancing the direct negative effects of increased UV radiation. Similarly it might change their ability to compete with other species. In the long term UV-resistant plants may prevail over more vulnerable ones.

Excessive exposure to UV radiation can cause cancers in mammals, much as humans, and damage their eyesight. Fur protects most animals from over-exposure to harmful rays. But radiation may nevertheless damage their nose, paws and skin around the muzzle.

Experiments on food crops have shown lower yields for several key crops such as rice, soy beans and sorghum. The plants minimize their exposure to UV by limiting the surface area of foliage, which in turn impairs growth. However the observed drop in yield does not seem serious enough for scientists to sound the alarm.

aquatic wildlife is particularly vulnerable

Phytoplankton are at the start of the aquatic food chain, which account for 30 per cent of the world's intake of animal protein. Phytoplankton productivity is restricted to the upper layer of the water where sufficient light is available. However, even at current levels, solar UV-B radiation limits reproduction and growth. A small increase in UV-B exposure could significantly reduce the size of plankton populations, which affects the environment in two ways. Less plankton means less food for the animals that prey on them and a reduction in fish stocks, already depleted by overfishing. Furthermore, with less organic matter in the upper layers of the water, UV radiation can penetrate deeper into the water and affect more complex plants and animals living there. Solar UV radiation directly damages fish, shrimp, crab, amphibians and other animals during their early development. Pollution of the water by toxic substances may heighten the adverse effects of UV radiation, working its way up the food chain.

EFFECTS OF ENHANCED UV-B RADIATIONS ON CROPS

Possible changes in plant characteristics	Consequences	Selected sensitive crops
■ Reduced **photosynthesis** ■ Reduced **water-use efficiency** ■ Enhanced **drought stress sensitivity** ■ Reduced **leaf area** ■ Reduced **leaf conductance** ■ Modified **flowering** (either inhibited or stimulated) ■ Reduced **dry matter production**	Enhanced plant fragility Growth limitation Yield reduction	Rice Oats Sorghum Soybeans Beans

NB: Summary conclusions from artificial exposure studies.

Source: modified from Krupa and Kickert (1989) by Runeckles and Krupa (1994) in: Fakhri Bazzaz, Wim Sombroek, *Global Climate Change and Agricultural Production*, FAO, Rome,1996.

consequences and effects 2

uv radiation and human health

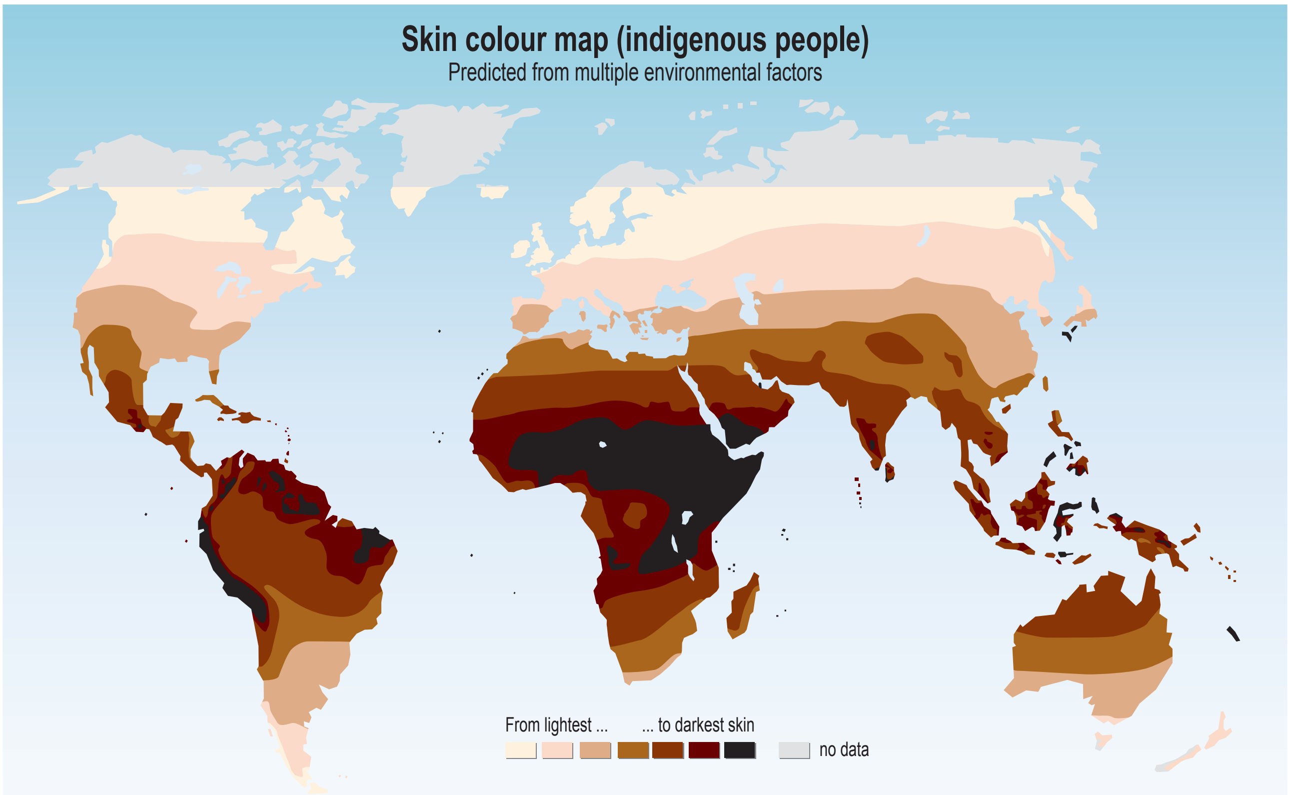
We need the sun: psychologically, because sunlight warms our hearts; physically, because our body needs it to produce vitamin D, essential to the healthy development of our bones. Yet increased doses of ultraviolet rays penetrating the ozone layer and reaching the surface of the Earth can do a lot of harm to plants, animals and humans.

Over thousands of years humans have adapted to varying intensities of sunlight by developing different skin colours. The twin role played by the skin – protection from excessive UV radiation and absorption of enough sunlight to trigger the production of vitamin D – means that people living in the lower latitudes, close to the Equator, with intense UV radiation, have developed darker skin to protect them from the damaging effects of UV radiation. In contrast, those living in the higher latitudes, closer to the poles, have developed fair skin to maximize vitamin D production.

who is most at risk?

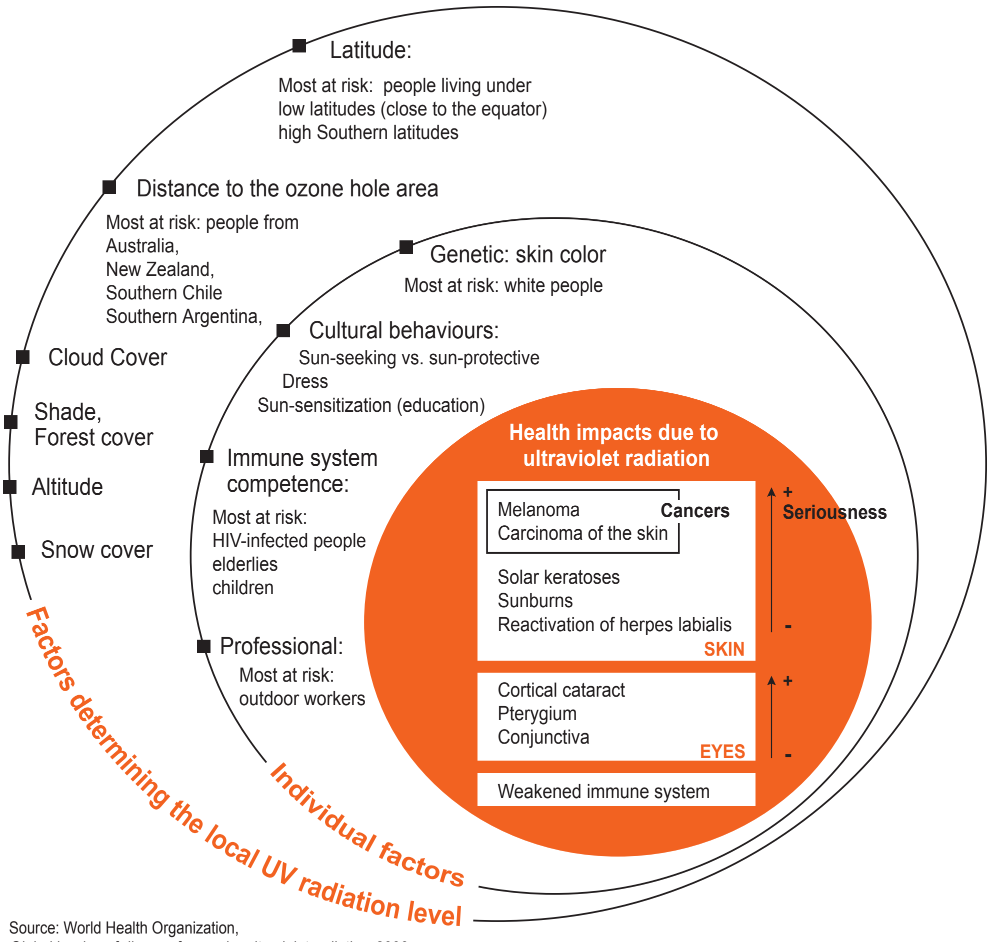
In the last few hundred years however, there has been rapid human migration out of the areas in which we evolved. Our skin colour is no longer necessarily suited to the environment in which we live. Fair skinned populations who have migrated to the tropics have suffered a rapid rise in the incidence of skin cancers.

Behavioural and cultural changes in the 20th century have meant that many of us are now exposed to more UV ra-



Source: Chaplin G.©, *Geographic Distribution of Environmental Factors Influencing Human Skin Coloration*, American Journal of Physical Anthropology 125:292–302, 2004; map updated in 2007.

VULNERABILITIES



Source: World Health Organization,
Global burden of disease from solar ultraviolet radiation, 2006.

diation than ever before. But it may also result in inadequate exposure to the sun which damages our health in other ways.

Many people from the higher latitudes grill their skin intensely in the sun during their short summer holidays, but only get minimal exposure to the sun for the rest of the year. Such intermittent exposure to sunlight seems to be a risk factor. On the other hand populations with darker skin pigmentation regularly exposed to similar or even higher UV rays are less prone to skin damage.

what damage is done?

The most widely recognised damage occurs to the skin. The direct effects are sun burn, chronic skin damage (photo-aging) and an increased risk of developing various types of skin cancer. Models predict that a 10 per cent decrease in the ozone in the stratosphere could cause an additional 300,000 non-melanoma and 4,500 (more dangerous) melanoma skin cancers worldwide annually.

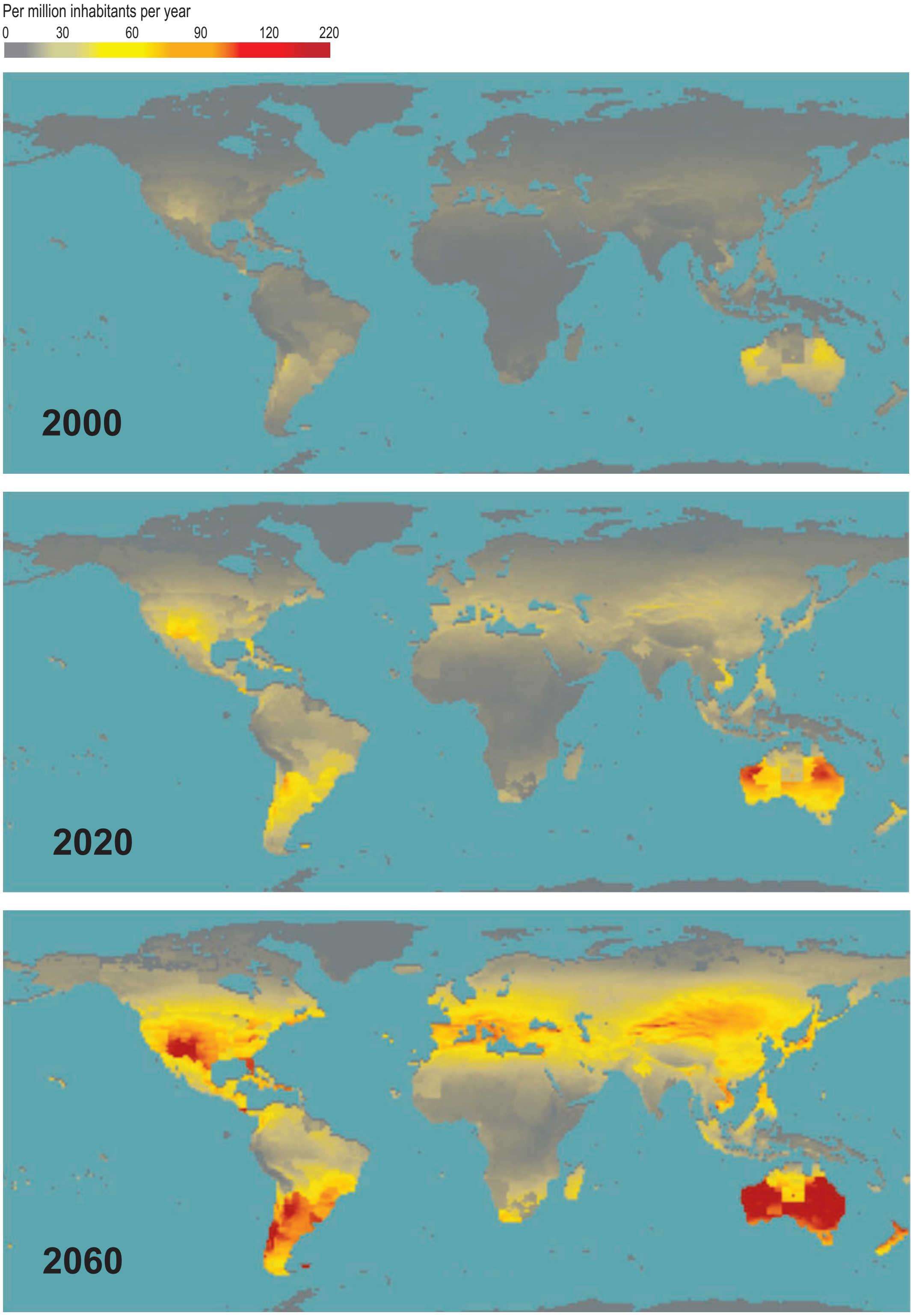
At an indirect level UV-B radiation damages certain cells that act as a shield protecting us from intruding carriers of disease. In other words it weakens our immune system. For people whose immune system has already been weakened, in particular by HIV-Aids, the effect is aggravated, with more acute infections and a higher risk of dormant viruses (such as cold sores) erupting again.

UV radiation penetrates furthest into our bodies through our eyes, which are particularly vulnerable. Conditions such as snow blindness and cataracts, which blur the lens and lead to blindness, may cause long-term damage to our eyesight. Every year some 16 million people in the world suffer from blindness due to a loss of transparency in the lens. The World Health Organisation (WHO) estimates that up to 20 per cent of cataracts may be caused by overexposure to UV radiation and could therefore be avoided. The risk of UV radiation-related damage to the eye and immune system is independent of skin type.

no reason for reduced attention

Simple counter-measures (see chapter 5) can control the direct negative effects of UV radiation on our health. But that is no reason to reduce our efforts to reverse destruction of the ozone layer. It is difficult to foresee the indirect effects such profound changes in the atmosphere may have on our living conditions. Changes to plants or animals might affect mankind through the food chain, and the influence of ozone depleting substances on climate change might indirectly affect our ability to secure food production.

Number of extra skin cancer cases related to UV radiation



Source: Dutch National Institute for Public Health and the Environment (RIVM), Laboratory for Radiation Research (www.rivm.nl/m ilieuStoffen/straling/zomerthema_uv/), 2007.

mobilization 1

sun protection and sensitization projects

These days most children know they have to protect their skin from damage by the sun. This is the result of successful communication and information campaigns in schools and the media all over the world.

The increased UV radiation reaching our planet through the diminishing ozone layer can have a widespread, dramatic effect on our health. But the remedy is comparatively easy, using sun screen or proper clothing to protect our skin, and sunglasses for our eyes. It is consequently all the more important to educate people widely so that they adopt these simple measures.

Sun-safe programmes have been introduced in virtually every country where the risk to the population has increased.

Particular credit is due to the UV index (UVI), an international public awareness initiative led by the World Health Organization (WHO) that encourages consistent reporting on news and weather bulletins about the levels of UV radiation received at the local level. Newspapers in many countries now publish a UVI forecast using a standard graphic format.

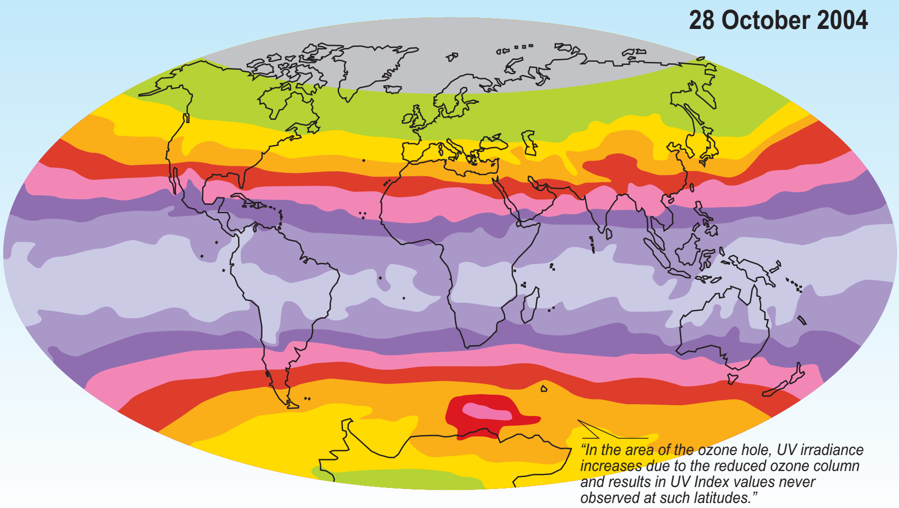
Awareness campaigns accompanying the index provide people with a clear indication of the necessary protective measures. Initiatives may take various forms: the Australian authorities, for instance, issue awards to local authorities providing the most shade for their citizens. Successful campaigns clearly distinguish between different target audiences, such as schoolchildren, farmers and outdoor workers.

To raise the awareness of children from an early age regarding the potentially damaging effects of the sun's rays and appropriate protective measures, educational media use cartoon characters such as Ozzy Ozone (UNEP/Barbados), Sid Seagull (Australia) and Top, l'Imprudente (Switzerland).

Another important reason why people began to pay attention to skin protection is because awareness of the dangerous consequences of not covering up, i.e., skin cancer, grew steadily. The media readily broadcasted the alarming study results the reported fast rising incidence of melanoma and other types of skin cancer.

And why have governments made such widespread efforts to raise public awareness of the dangers associated with excessive exposure to UV radiation? Apart from their sincere concern for public health, there is a clear financial incentive. For example, skin cancer costs the Australian health service about US$ 245 million a year, the largest amount for any cancer. The risk of Australians suffering from melanoma is four times higher than for their US, Canadian or UK counterparts. Based on the observed increased incidence in skin cancers and models taking into account projections of further ozone loss in the future, the government calculated that savings on medical spending would likely far exceed the cost of an awareness-building campaign.

THE GLOBAL SOLAR UV INDEX



"The Global Solar UV Index (UVI) is a simple measurement of the UV radiation level at the Earth's surface. It has been designed to indicate the potential for adverse health effects and to encourage people to protect themselves. The higher the Index value, the greater the potential for damage to the skin and eye, and the less time it takes for harm to occur.

In countries close to the equator, the UVI can be as much as 20. Summertime values in northern latitudes rarely exceed 8."

Daily maximum of the UV index by clear sky

0,5 2,5 4,5 6,5 8,5 10,5 12,5 14,5

Low · Moderate · High · Very high · Extreme

Source: GMES, 2006; INTERSUN, 2007.
INTERSUN, the Global UV project, is a collaborative project between WHO, UNEP, WMO, the International Agency on Cancer Research (IARC) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

mobilization 2

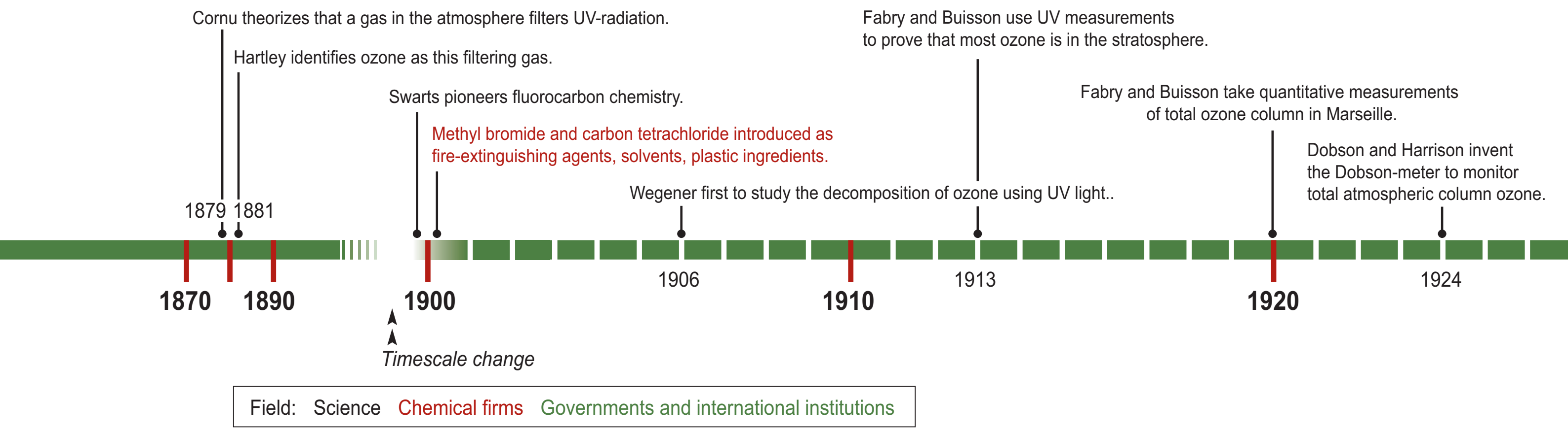
successful environmental diplomacy

The Montreal Protocol on Substances that Deplete the Ozone Layer ranks as one of the great success stories of international environmental diplomacy, and a story that is still unfolding. The protocol, along with its processor the Vienna Convention, is the international response to the problem of ozone depletion agreed in September 1987 following intergovernmental negotiations stretching back to 1981. Following the confirmation of the ozone destruction theory with the discovery of the Antarctic ozone hole in late 1985, Governments recognised the need for stronger measures to reduce consumption and production of various CFCs and halons. The Montreal Protocol came into force on 1 January 1989 and reached universal ratification in September 2009.

It is widely believed that without the Protocol, ozone depletion would have risen to around 50 per cent in the northern hemisphere and 70 per cent in the southern mid-latitudes by 2050. This would have resulted in twice as much UV-B reaching the Earth in the northern mid-latitudes and four times as much in the south. The implications of this would have been horrendous: 19 million more cases of non melanoma cancer, 1.5 million cases of melanoma cancer, and 130 million more cases of eye cataracts.

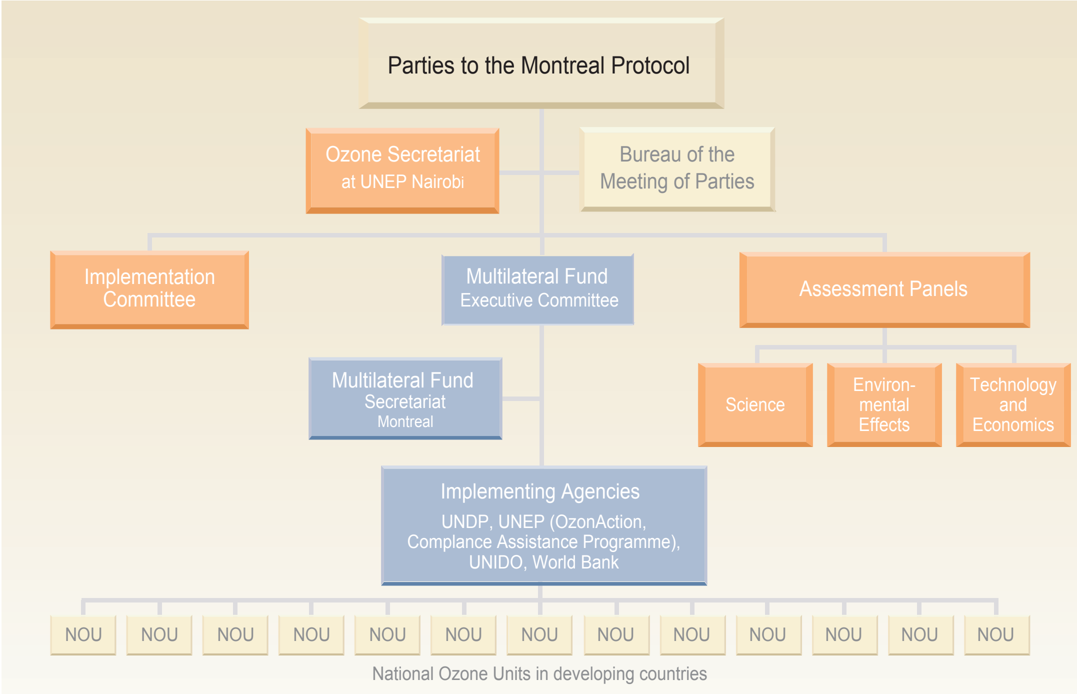
Instead, atmospheric and stratospheric levels of key ozone depleting substances are going down, and it is believed that with full implementation of all of the provisions of the Protocol, the ozone layer should return to pre-1986 levels by 2065.

THE OZONE INTERNATIONAL AWAKENING



Source: Stephen O Andersen, K Madhava Sarma, Protecting the Ozone Layer, the United Nations History, UNEP, Earthscan Publishing, 2002; US Environmental protection Agency, Achievements in Stratospheric Ozone Prote

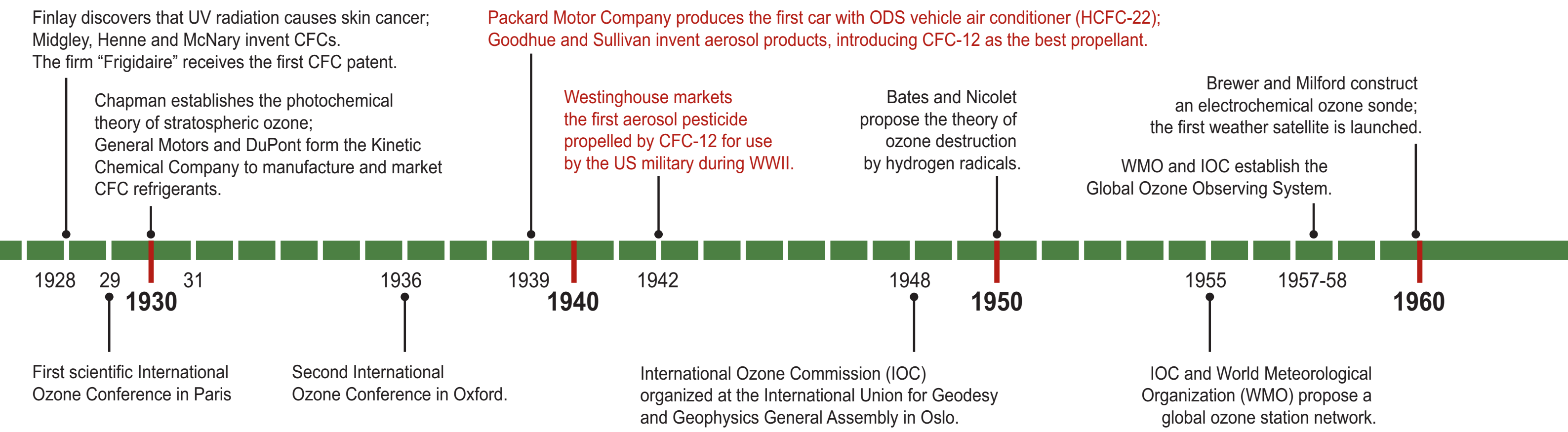
THE OZONE PROTECTION LANDSCAPE



Sources: Ozone Secretariat; Fund Secretariat; OzonAction, 2009.

The Protocol can be summarized in seven key features:

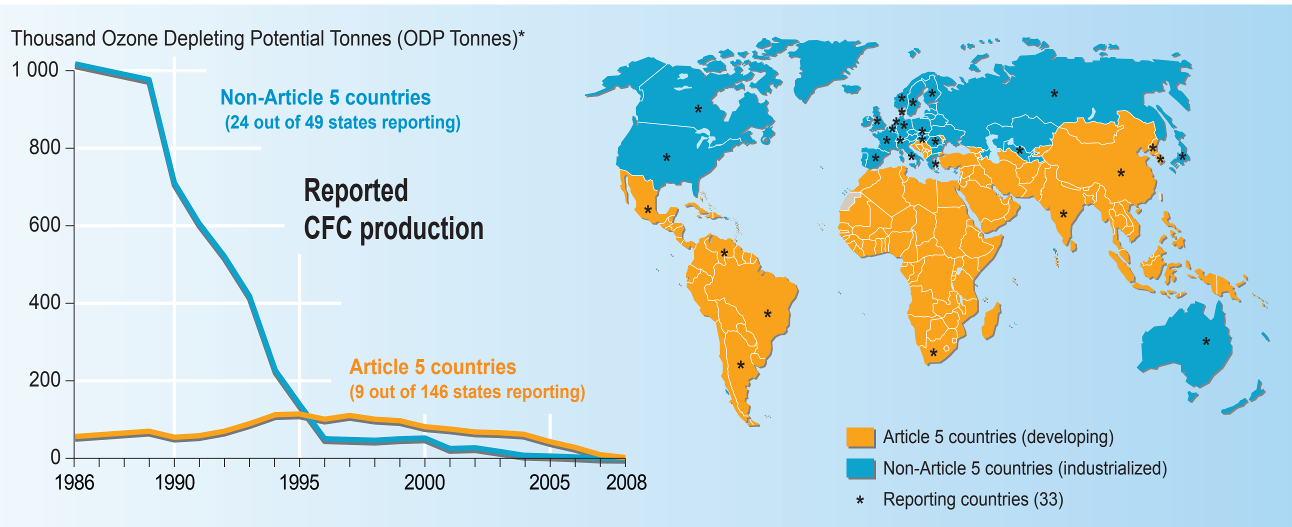
1. It requires each of the 196 countries and the European Union that ratified the protocol (called "Parties") and its amendments to almost completely eliminate production and consumption of nearly 100 chemicals that have ozone depleting properties, in accordance with agreed timelines;
2. The protocol requires each of the Parties to report annually on their production, imports and exports of each of the chemicals they have undertaken to phase out;
3. An Implementation Committee made up of ten Parties from different geographical regions reviews data reports submitted by Parties, assesses their compliance status, and makes recommendations to the meeting of the Parties regarding countries in non-compliance;
4. The protocol includes trade provisions that prevent Parties from trading in ODS and some products containing ODS with non-Parties, and also provisions for trade between Parties;
5. The protocol includes an adjustment provision that enables Parties to respond to developing science and accelerate the phase-out of agreed ODS without going through the lengthy formal process of national ratification. It has been adjusted five times to accelerate the phase-out schedule, which is in itself a remarkable achievement;
6. Developing countries are allowed a "grace period" of 10 to 16 years beyond the dates established for industrialized countries to comply with the control provisions of the Protocol;
7. In 1990 the Parties established the Multilateral Fund for the Implementation of the Montreal Protocol to help developing countries meet their compliance obligations under the treaty (see following chapter).



ction, Progress report, April 2007; Sharon L. Roan, Ozone crisis, 1989.

mobilization 2
successful environmental diplomacy

DIFFERENTIATED RESPONSIBILITIES



* Tonnes multiplied by the ozone depleting potential of the considered gas.

Source: United Nations Environment Programme Ozone Secretariat.

1963–65: Dobson publishes a paper indicating the anomalous Antarctic ozone behaviour.

1970: Nimbus 4 satellite begins ozone observation.

1970–74: The US Inadvertent Modification of the Stratosphere task force recommends that CFC propellants be banned by January 1978.

71: Crutzen and Johnston describe nitrogen-related ozone destruction.

72: Cline describes the chlorine-related ozone destruction.

73: Molina and Sherwood Rowland publish the CFC ozone-depletion hypothesis in Nature and present it at the American Chemical Society; McCarthy (DuPont) declares "If credible, scientific data (...) show that any CFCs cannot be used without a threat to health, DuPont will stop production of these compounds".

Lovelock measures CFCs in the atmosphere.

77: Sweden bans the use of CFC aerosol products.

77: UNEP sponsors the first international conference on CFCs in Washington DC and establishes the Coordination Committee on the Ozone Layer.

78: US bans the use of most CFC aerosol products and halts manufacturing with CFC propellants.

1981: British Antarctic Survey at Halley Bay records low ozone levels.

1985: 20 countries sign the **Vienna Convention** for the Protection of the Ozone Layer, which establishes a framework for negotiating international regulations on ozone-depleting substances; British scientists led by Joseph Farman announce 30-40% depletion of Antarctic ozone since 1977.

86: Sherwood Rowland coins the "Ozone Hole" term; 79 NGOs urge the total phase-out of CFCs.

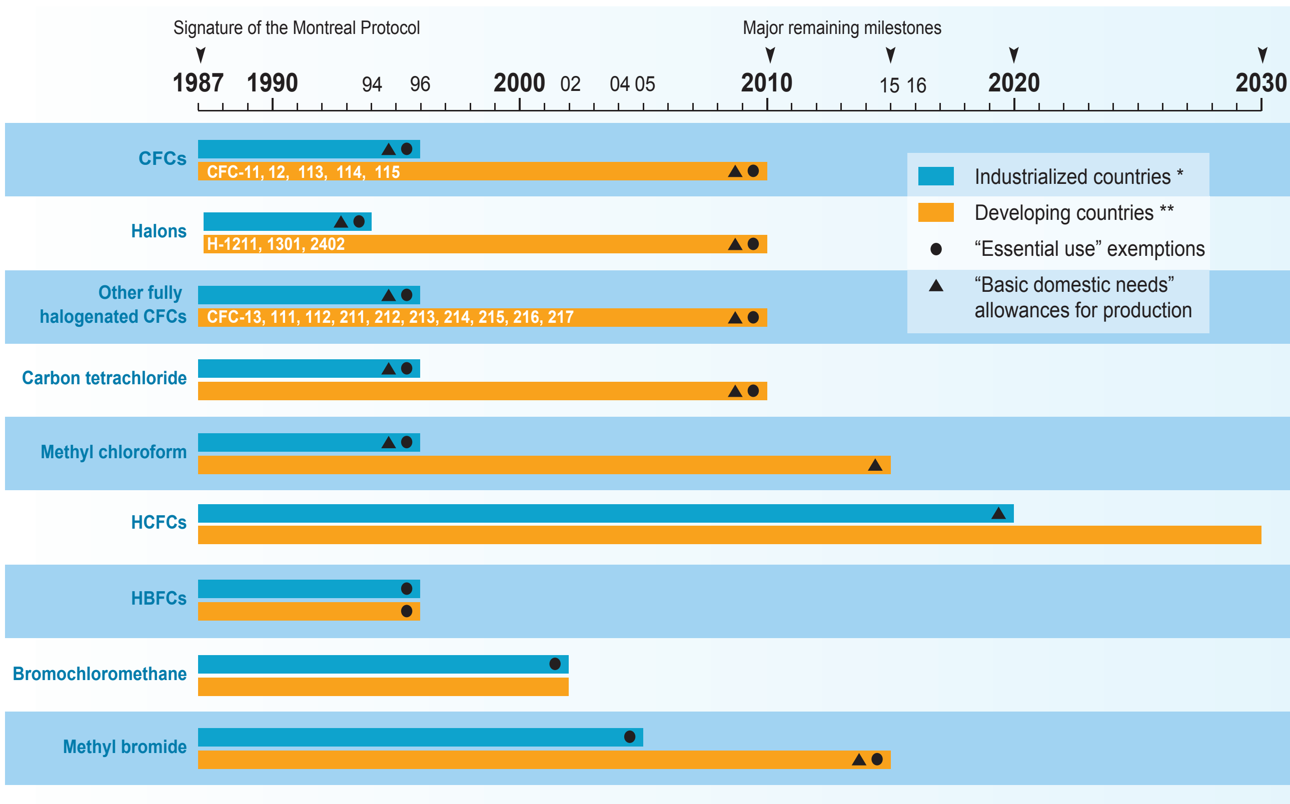
87: Signature of the **Montreal Protocol** on Substances that deplete the ozone layer.

1989: Vienna Convention and Montreal Protocol enter into force; first meeting of the Parties in May.

1990

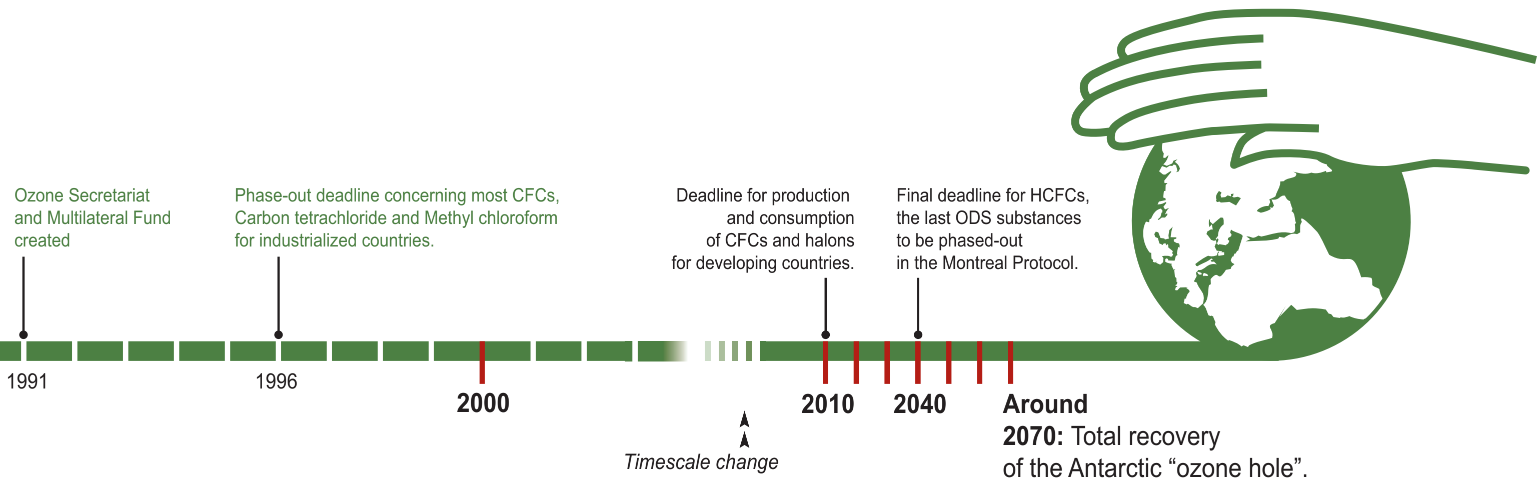
DEADLINES FOR PRODUCTION AND CONSUMPTION OF OZONE DEPLETING SUBSTANCES

defined in the Montreal Protocol phase-outs



* Non-Article 5 countries; ** Article 5 countries .

Source: UNEP Ozone Secretariat, 2009.



mobilization 3

pledging funds for patching the hole

The international consensus on the need to preserve the ozone layer is reflected in the establishment of a Multilateral Fund (MLF) to support projects to eliminate ozone depleting substances. Between 1991 and 2009 the MLF received contributions of US$ 2,563 million from 50 developed countries.

To date expenditures of US$ 2,471 million have been approved to support over 6000 projects in 148 “Article 5” countries, out of the 196 Parties to the Protocol. National Ozone Units (NOUs) have been established in 143 countries as government focal points for implementation of this multilateral environmental agreement. As of end December 2008 projects approved by the Executive Committee have resulted in the phase-out of 238,619 ODP tonnes of consumption and 176,464 ODP tonnes of production.

Financial and technical assistance is provided in the form of grants or concessional loans and delivered through four implementing agencies: United Nation Environment Programme (UNEP), United Nations Development Programme (UNDP), United Nations Industrial Development Organization (UNIDO) and The World Bank. Up to 20 per cent of the contributions can be delivered through the Parties' bilateral agencies in the form of eligible projects and activities. Funds are used for activities including the closure of ODS production plants and industrial conversion, technical assistance, information dissemination, training and capacity building of personnel aimed at phasing out the ODS used in a broad range of industrial sectors. The MLF Secretariat is based in Montreal, Canada.

challenges ahead

1. **The last mile**
   Although the Montreal Protocol has made considerable progress in the global drive to protect the ozone layer, there are still several issues that parties to the protocol need to address before we can be sure the ozone layer is safe for present and future generations. Momentum towards achieving a total phase-out must be sustained. All scientific analysis predicting the healing of the ozone layer is based on the assumption of full compliance with the agreed phase-out. Continued monitoring of the ozone layer needs to be ensured to observe the healing process.

2. **Precautionary principle and collateral damage**
   Effective control mechanisms for new chemicals threatening the ozone layer are essential. This means controlling other undesired environmental effects such as enhanced climate change caused by replacing ODS substances with high global warming potential, particularly the case for HFCs. Current initiatives by several parties aim to control HFCs, a non-ODS, under the Montreal Protocol. This would enable a binding phase-out schedule to be defined.

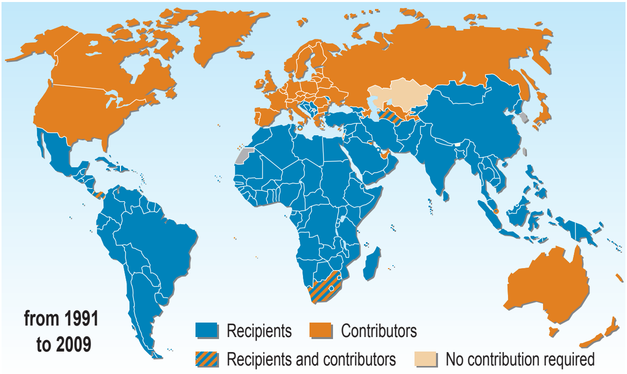
3. The increasing relative importance of remaining difficult to replace applications of some ODS, such as methyl bromide for high moisture dates.

4. **Controlling exemptions for “essential uses”, “critical uses” and “basic domestic needs”**
   If not properly controlled, these exemptions may become a loophole for countries to avoid the phase-out of ODS, in so far as such exemptions may ultimately have an impact on the recovery of the hole.

5. **Active promotion of non-HFC alternatives to HCFCs**
   Effective guidance in selecting and adopting new technologies to industry in Article 5 countries is essential in order to limit greenhouse gas emissions from the sectors concerned.

6. Illegal trade continues and needs to be dealt with to ensure that continued legal ODS uses are not diverted to illegal uses.

Recipients and contributors countries of the Multilateral Fund

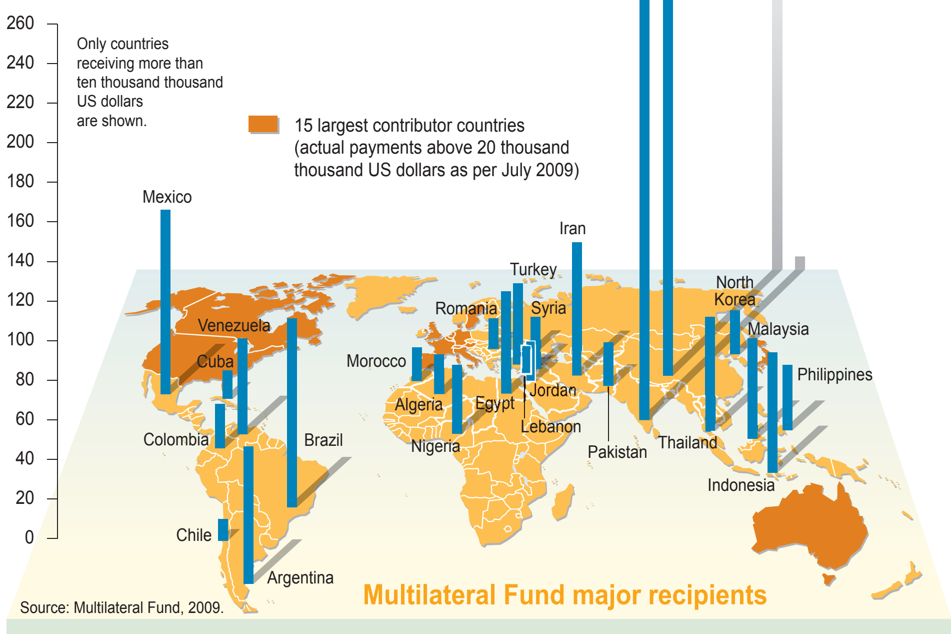


Countries receive funds according to their compliance needs. That is, they receive funds to phase-out specific amounts of ODS production and consumption. Hence,ODS producer countries and high consumers receive more funds since they have greater needs. However all developing countries who are Parties to the Montreal Protocol have received assistance. Naturally, larger countries with higher population will also have a greater need for ODS, and therefore will also have a bigger share of phase-out to tackle.

	ODP-tonnes approved for phase-out		
Country *	Consumption	Production	**Total**
China	113 324	142 565	**255 889**
India	25 756	31 004	**56 760**
Mexico	4 763	12 355	**17 118**
Brazil	13 403	0	**13 403**
Indonesia	11 211	0	**11 211**
Thailand	7 775	0	**7 775**
Argentina	4 365	2 746	**7 111**
Iran	6 956	0	**6 956**
Venezuela	2 492	4 418	**6 910**
Malaysia	6 446	0	**6 446**
Nigeria	5 810	0	**5 810**
Korea, DPR	3 349	1 750	**5 099**
Turkey	4 495	0	**4 495**
Egypt	4 253	0	**4 253**
Syria	3 796	0	**3 796**
Philippines	3 335	0	**3 335**
Algeria	2 558	0	**2 558**
Pakistan	2 435	0	**2 435**
Jordan	2 223	0	**2 223**
Colombia	1 869	0	**1 869**
Romania	1 579	175	**1 754**
Lebanon	1 616	0	**1 616**
Morocco	1 324	0	**1 324**
Chile	1 228	0	**1 228**
Cuba	588	0	**588**

* Only countries receiving more than ten million dollars are shown.

Funds approved between 1991 and July 2009
Million US dollars



Source: Multilateral Fund, 2009.

learning from montreal 1

the secret to success

What was the secret to success of the Montreal Protocol? What were the key drivers that made it possible to convince the companies producing ODS to look for alternatives? How did their business develop? Can we draw parallels to the processes in industry and the international community in facing the challenges of CO_2 reduction in the 21st century?

In March 1988, DuPont, the world's largest CFC producer, with 25 percent of the market share, made a startling announcement: it would stop manufacturing CFCs. Although the company took only a modest financial risk – less than 2 percent of its annual earnings came from these products – the decision had profound repercussions in the chemical and CFC-producing industry.

At the time, the Montreal Protocol had been signed by 46 countries but had not yet entered into force. That same month, however, the ozone trends panel published the first report demonstrating that the predictions made by scientists had been substantially accurate, and that there was a measurable decrease in thickness of the ozone layer throughout the atmosphere.

DuPont, long a fierce opponent of the ozone depletion theory, had begun its turnaround two years earlier, in 1986, when it and the Alliance for Responsible CFC Policy, a key industry group, announced their agreement to support global limits on CFC production. DuPont's dramatic decision to halt CFC production signalled that the beginning of the end had truly arrived.

The DuPont story illustrates the success of the Montreal Protocol process. A number of key ingredients have contributed to this success.

Strong science framed the ozone issue from the start and has been a key pillar of the Protocol's continuing success. The Protocol called for a review of best available science, environmental, technical and economic information every four years. To aid their decision-making, the Parties established a number of formal expert assessment panels.

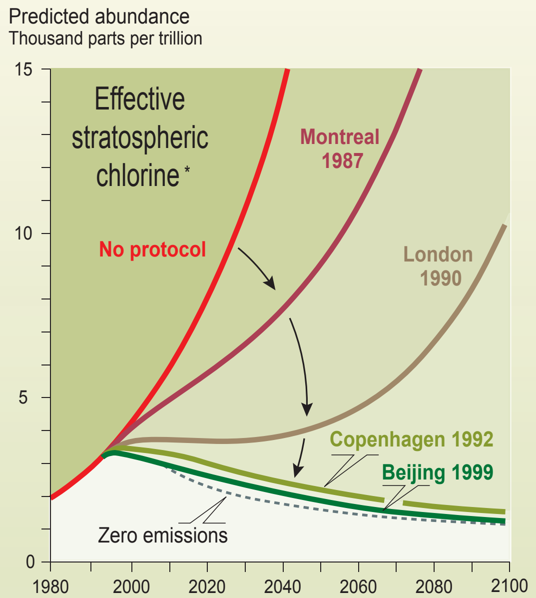
Political consensus was pursued and achieved. The largest developed nations, such as the U.S. and members of the European Community, were in accord about the need to commit to addressing ozone depletion in a multi-lateral framework. Industry was assured that a reasonable timeframe for effecting a transition would be granted. Provisions in the Protocol restricting trade with non-Parties contributed to the Protocol's near universal participation.

At the same time, the Protocol had important elements of flexibility. The concept of differentiated responsibilities between Parties made achievement of the Protocol's goals more reachable. While the countries agreed to meet specific numerical reduction targets in agreed timeframes, the Protocol is silent on the manner in which those reductions are to be met. This has allowed Parties to meet targets through the implementation approaches that best suited their capacities. Similarly, an "adjustment" provision enables the Parties to use new science to adjust controls on previously agreed ozone depleting substances without waiting for multi-year national ratification process.

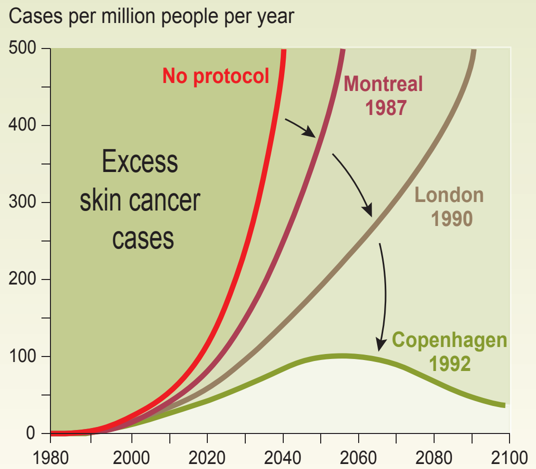
In cases of non-compliance a regionally balanced Implementation Committee has evolved an extremely successful system for equitable treatment of all Parties. Most important to developing countries was the notion that costs should be borne principally by the developed countries that had caused most of the problem. This was addressed by the 1990 London Amendment to the Protocol, which included provisions establishing a Multilateral Fund. The Parties were provided with undiluted control over the Fund's policies. The balanced membership of developed and developing countries on the Executive Committee signaled a large departure from the historic donor-driven nature of funding entities and carried forward the Protocol's spirit of equality. The Fund evolved into a key driver of success, as the Parties allocated vast sums to ensure compliance.

Important lessons have been learned along the way. The extent of reductions necessary to protect the ozone layer were originally underestimated, requiring further adjustments subsequently. Also underestimated was the ability of industry, faced with the prospect of prohibition, to adapt to change and convert to non-ozone depleting substances. Prognoses were systematically more pessimistic, the costs for industry estimated much higher than they turned out in reality. For example, in 1987, halons were consid-

EFFECTS OF THE MONTREAL PROTOCOL AMENDMENT AND THEIR PHASE-OUT SCHEDULES



* Chlorine and bromine are the molecules responsible for ozone depletion. "Effective chlorine" is a way to measure the destructive potential of all ODS gases emitted in the stratosphere.



Source: *Twenty Questions and Answers about the Ozone Layer: 2006 Update*, Lead Author: D.W. Fahey, Panel Review Meeting for the 2006 ozone assessment.

ered so indispensable that the Parties could only agree to freeze their production and consumption at historic levels. Only five years later, however, the Parties agreed to phase them out completely in developed countries by 1994, because industry stepped up to meet the challenges presented by the phaseout.

The successes and lessons of the Montreal Protocol are instructive in the context of global climate change discussions. A clear lesson is that a multilateral agreement with strong, science-based and legally binding limits is essential. Faced with bright-line goals governments and industries can adapt, and, history shows, far more readily than might be initially anticipated or argued. Equally important are provisions that create incentives for compliance, funding for less developed countries and a sense of common commitment and equity.

protocol achievements

The Montreal Protocol has achieved universal participation by all states in the world, the number of participating states is 196, an achievement unprecedented by any other treaty. Without the Protocol, it is estimated that by the year 2050 ozone depletion would have risen to at least 50% in the northern hemisphere's mid latitudes and 70% in the southern mid latitudes, about 10 times worse than current levels.

Global observations have verified that levels of key ozone depleting substances in the atmosphere are going down and it is believed that if Protocol's provisions continue to be implemented the ozone layer should return to pre-1980 levels by 2050 to 2075.

The Montreal Protocol is estimated to have prevented:

- 19 million cases of non-melanoma cancer
- 1.5 million cases of melanoma cancer
- 130 million cases of eye cataracts

The United States alone estimates that efforts to protect the ozone layer will produce an estimated US$ 4 200 million million (trillion) health benefit for 1990–2165.

Ninety-seven per cent of all (around 100) ozone depleting substances controlled have been phased out collectively, and what remains is still a challenge to eliminate; the phase out in developed countries (non-Article 5) was 99.2% and 80% in developing countries (Article 5) in 2005. During the phase-out process many countries have met their phase-out targets well before the allotted deadline.

Global observations have verified that levels of key ozone depleting substances in the atmosphere are going down and it is believed that if Protocol's provisions continue to be implemented the ozone layer should return to pre-1980 levels by 2050 to 2075;

- The remaining phase out is 88,000 ODP tonnes of annual consumption of which 76,000 ODP tonnes is in Article 5 countries.
- The remaining phase out of ODS in non-Article 5 countries is mostly HCFCs and methyl bromide.

With the assistance of the Multilateral Fund, developing countries have phased out about 238,619 ODP tonnes of consumption and 176,464 of production of ozone depleting substances from projects approved as of December 2008. The majority of developing countries are well-positioned to achieve the 1 January 2010 phase-out target for CFCs and halons.

The Protocol has also yielded substantial climate benefits. Because many ozone destroyers also contribute to global warming, cutbacks have resulted in a reduction in global warming gases of more than 20 thousand million tonnes of CO_2 equivalents compared to business as usual. These reductions make the Montreal Protocol one of the world's prime contributors to the fight against global warming.

learning from montreal 2

how does phasing out ozone depleters hit the temperature brake?

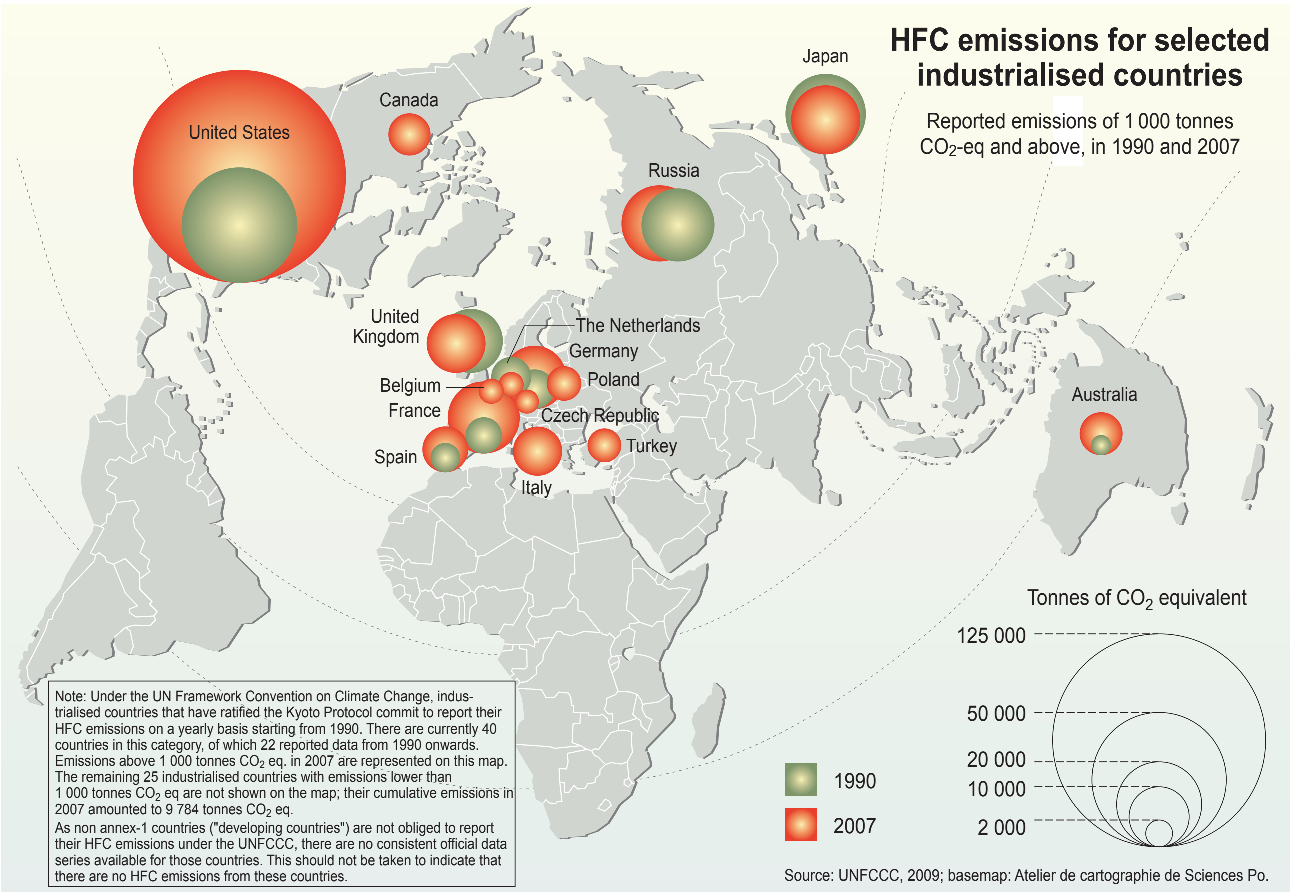
In 2007 a scientific paper confirmed that thanks to the ozone treaty greenhouse gas emissions amounting to as much as the equivalent of 135 thousand million (billion) tonnes of CO_2 had been avoided since 1990. This corresponds to a delay in global warming of seven to 12 years.

In a different calculation the US Environmental Protection Agency showed that phasing out substances harmful to the ozone layer has already avoided greenhouse gas (GHG) emissions equivalent to the CO_2 emissions associated with the following three scenarios lumped together: generating enough electricity to power every US home for more than 13 years; saving forests covering an area more than twice the size of Florida from deforestation; and saving more than 4 500 million million (trillion) litres of petrol – enough to make 4.8 thousand million (billion) round trips from New York to Los Angeles by car.

The reason for this surprisingly large "side effect" is that many of the man-made ozone-depleting substances (CFCs, HCFCs,) and their replacements are potent GHGs with a global warming potential (GWP) a thousand times that of CO_2. There are also indirect climate change contributions through the use of electricity to power appliances that use ODS.

HFC emissions for selected industrialised countries

Reported emissions of 1 000 tonnes CO_2-eq and above, in 1990 and 2007

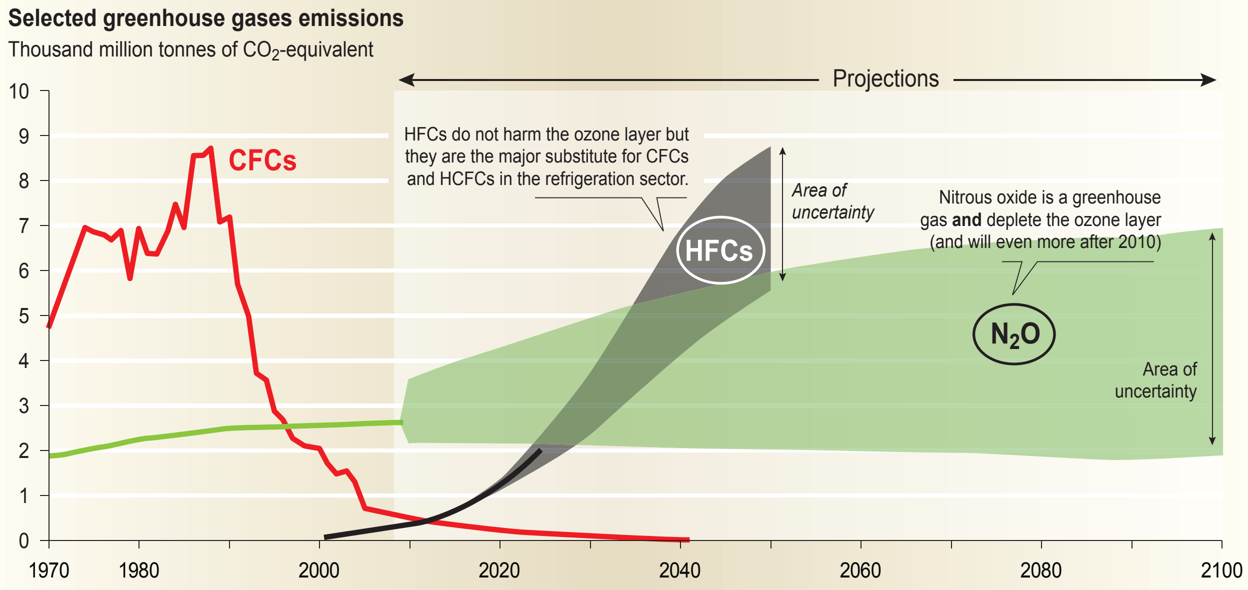


Note: Under the UN Framework Convention on Climate Change, industrialised countries that have ratified the Kyoto Protocol commit to report their HFC emissions on a yearly basis starting from 1990. There are currently 40 countries in this category, of which 22 reported data from 1990 onwards. Emissions above 1 000 tonnes CO_2 eq. in 2007 are represented on this map. The remaining 25 industrialised countries with emissions lower than 1 000 tonnes CO_2 eq are not shown on the map; their cumulative emissions in 2007 amounted to 9 784 tonnes CO_2 eq.

As non annex-1 countries ("developing countries") are not obliged to report their HFC emissions under the UNFCCC, there are no consistent official data series available for those countries. This should not be taken to indicate that there are no HFC emissions from these countries.

Source: UNFCCC, 2009; basemap: Atelier de cartographie de Sciences Po.

HFC AND N_2O: TWO CLIMATE ENEMIES RELATED TO THE OZONE LAYER



Source: A. R. Ravishankara, John S. Daniel, Robert W. Portmann, *Nitrous oxide (N_2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century*, Science, August 2009.

Although evidence suggests that intense cooperation is needed between parties to the Montreal and Kyoto protocols for both of these international agreements to succeed, the legal agreements treated ozone depletion and climate change as separate problems for a long time.

The decision taken by the parties to the Montreal Protocol in 2007 to accelerate the phase-out of HCFCs implies intensified collaboration between the two treaties: the likelihood of their increased replacement entails faster growth in the consumption of HFCs if not regulated. These chemicals have no effect on the ozone layer but some of them have huge GWP, with an effect on the climate up to 12 000 times that of the same amount of CO_2.

While the Kyoto agreement is restricted to targets on emission quantities, without prescribing how to reduce emissions at a national level, the Montreal Protocol controls the production and consumption of the substances it regulates, using a "push-pull" approach to convince producers and consumers to switch to alternatives.

Countries can claim climate credits for phasing out ODS under the Montreal Protocol. But this practice is disputed by climate activists who claim that ODS destruction is too cheap and will keep the price of CO_2-eq too low, thus slowing down innovation and emission reduction efforts in other sectors where avoiding emissions is more complicated and costly. They argue that the highest benefit for both the climate and the ozone layer would come from ODS destruction regulated through the Montreal Protocol. This would allow financing of destruction in Article 5-countries through the Multilateral Fund.

Should HFCs be regulated under the Montreal Protocol?

A similar debate centres on HFCs: in terms of emissions HFCs represent now about 1 per cent of the total long-lived GHGs, as stated in the IPCC's Fourth Assessment Report. According to Velders et al (2009) they could attain 9 to 19 per cent of total long-lived GHGs by 2050 assuming that no reductions in other GHGs are achieved, and 28 to 45 per cent in a scenario where global emissions are stabilized but HFCs continue to grow in an unregulated manner.

One approach to control HFC emissions could be through a phase out and ban under the Montreal Protocol. Although HFCs are not ozone depleters, the latest Montreal provisions to accelerate the HCFC phase-out mandate parties to act to protect the climate while choosing alternatives to ODS. Environmentalists argue that if HFCs are included under Montreal, that is, production frozen at a certain date and then gradually phased out, up to 30 per cent of GHG emissions could be avoided in one go. This puts the burden on the parties to seek HFCs with a low GWP or non-HFC alternatives. But it is also a new opportunity for environmental authorities and NGOs to cooperate on both ozone layer and climate protection.

Economists argue that if HFCs are withdrawn from the Kyoto Protocol's GHG basket and treated by the Montreal Protocol, this would reduce the attractiveness of the cap-and-trade system because it would deprive them of one item providing easy removal opportunities. That would raise the price of CO_2-eq in the carbon market and therefore stir resistance in economic and industry circles. In other words, keeping them in the market allows for greater economic efficiency by permitting the trading of one gas against another.

For example a utility company or cement manufacturer on the hook to reduce CO_2 emissions under a national climate law could opt to find sources of HFCs and have them destroyed instead. Small amounts of HFCs could substitute for large amounts of CO_2 emissions and offer a cheaper alternative to emissions reductions. It also means CO_2 emissions would ratchet down more slowly.

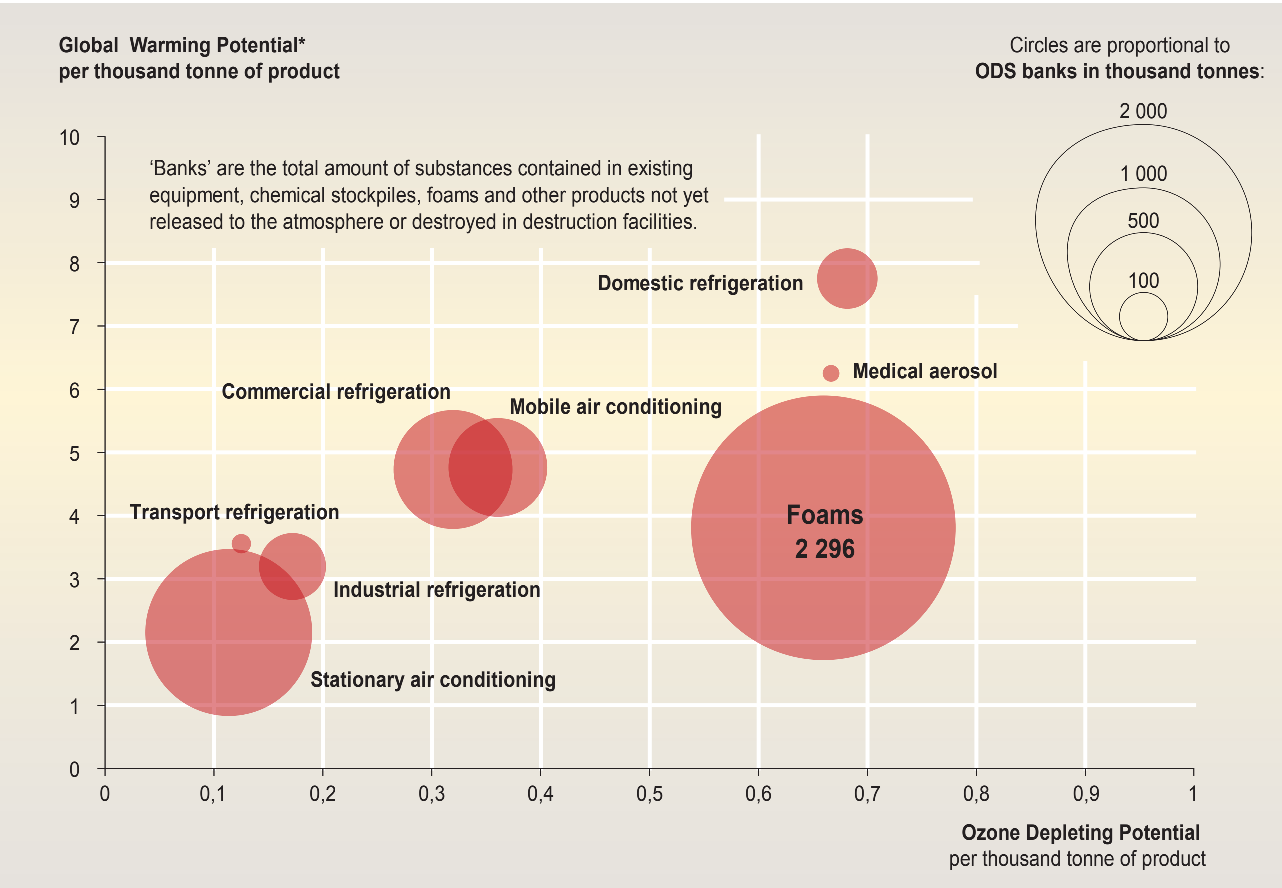
the legacy
ODS banks

Ozone depleting substances have been used for over 70 years. Assuming that all production will stop at a given date for each product, they will persist in many places such as insulating and other foams, in refrigerators and air-conditioners, but also in stocks of recovered and contaminated ODS. The jargon refers to these gases still in circulation in different equipment as "ODS banks".

The relevance of these banks for the protection of both the climate and the ozone layer becomes evident with the following numbers: overall, the Intergovernmental Panel on Climate Change (IPCC) and the Technology and Economic Assessment Panel of the Montreal Protocol (TEAP) estimate that ODS banks contain approximately 400 000 or more tonnes of ozone depleting potential and 16–17 Gigatonnes of CO_2 equivalents, of which 12 Gt in CFCs and 4–5 Gt in the form of HCFCs. As refrigerators are decommissioned and air-conditioners replaced, the gases contained in the old equipment will, unless properly handled, eventually be released into the atmosphere. In the meantime, equipment continuously leaks, contributing to avoidable emissions. Preventing the emissions of all ODS banks in 2004–25 would have avoided approximately 3 to 4 per cent of the total radiative forcing from all anthropogenic GHG emissions over the same period. By 2015, unless action is taken to avoid the loss, annual emissions will reach 2.3 Gt CO_2-eq. This amount is equivalent to the amounts reduced through the measures of the Kyoto Protocol.

In 2009, the Montreal Protocol, which focuses only on production and consumption, started to discuss regulating the management and destruction of ODS banks. That is why the Protocol has so far not provided financial incentives to destroy ODS banks. Yet, action to recover and destroy

WORLD ODS BANKS BY SECTOR



* 100-year time horizon

Source: IPCC /TEAP, *Safeguarding the ozone layer and the global climate system*, 2005 (data for 2002).

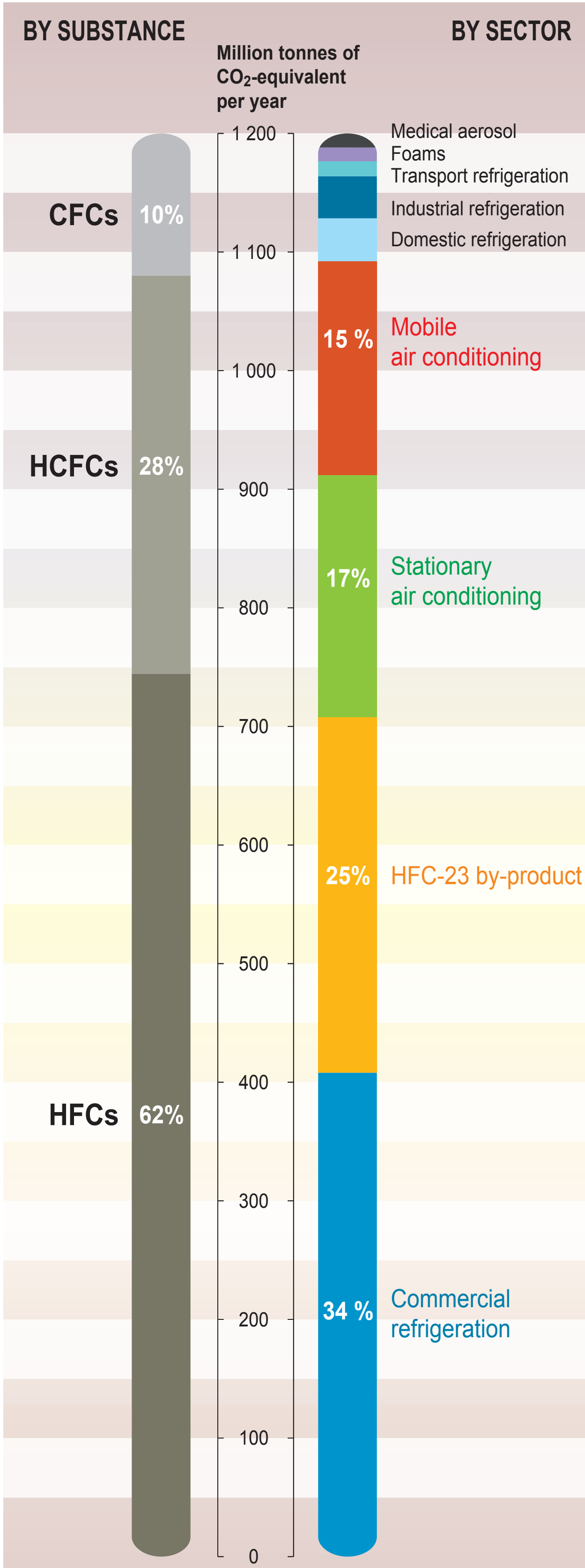
CFC and HCFC banks in refrigeration and air-conditioning represent a cost-effective means of protecting the ozone layer and climate system, because the technology is available and the chemicals are reachable (with the exception of insulation foams where destruction is more complicated). Simply destroying the most cost-effective banks in refrigeration and air-conditioning units at end-of-life, starting in 2008, could have accelerated the return of the ozone layer by up to two years.

According to the graph below, the costs of avoiding a given amount of GHG emissions by destroying ODS are lower than the average price of the same amount on the official carbon market. It is therefore cheaper to destroy ODS than to take other measures to avoid GHG emissions.

Advocates of controlled destruction point out the unique opportunity to hit a double target and call for the allocation of funding to support developing (Article-5) countries in managing and destroying their ODS banks. Quick action is needed because the longer we wait, the more ODS will escape uncontrolled into the air and reduce the potential benefits.

Another measure providing quick results is to improve the efficiency of the equipment in place and avoid leakages. Commercial refrigeration systems are characterized by significant leakage (15–30% of annual charge).

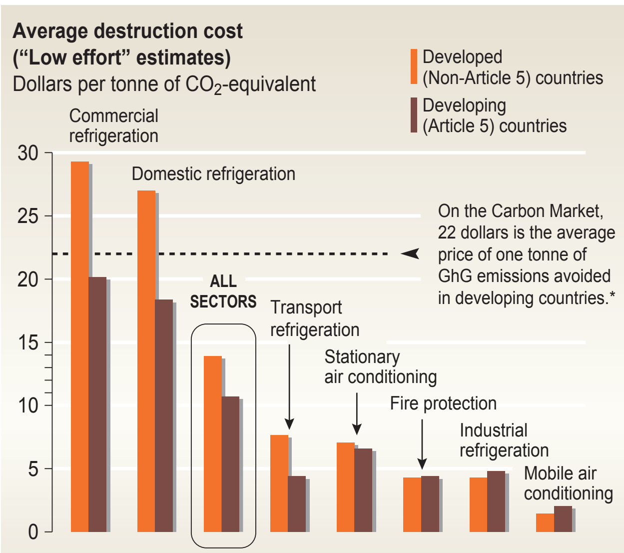
ODS BANKS REDUCTION POTENTIAL BY 2015



If no reduction measures were taken, 2009-2015 emissions from ODS banks could exceed all reductions achieved in 4 years under the Kyoto Protocol (2008-2012).

Sources: IPCC/TEAP Special Report, "Safeguarding the ozone layer and the global climate system", 2005 ; Environmental Investigation Agency, *Recovery and destruction of ODS banks: Immediate action for Global climate protection*, July 2009.

DESTROYING ODS BANKS: A CHEAP WAY TO MITIGATE CLIMATE CHANGE



* Under Kyoto's Clean Development Mechanism, average for 2005-2008 in CO_2-equivalent.

Source: Institute for Governance & Sustainable Development, *Frequently asked questions about destroying ozone-depleting substance banks under the Montreal Protocol, 2009.*

12 side effects

illegal trade in ozone depleting substances

The final phase-out date for CFCs is upon us, and the deadlines for other substances that harm the ozone layer are approaching – but smuggling operations threaten the continued recovery of the Earth's atmosphere. When worldwide trade restrictions or bans are placed on any commodity – drugs, guns, endangered species or whatever – a black market soon emerges. ODS are no exception.

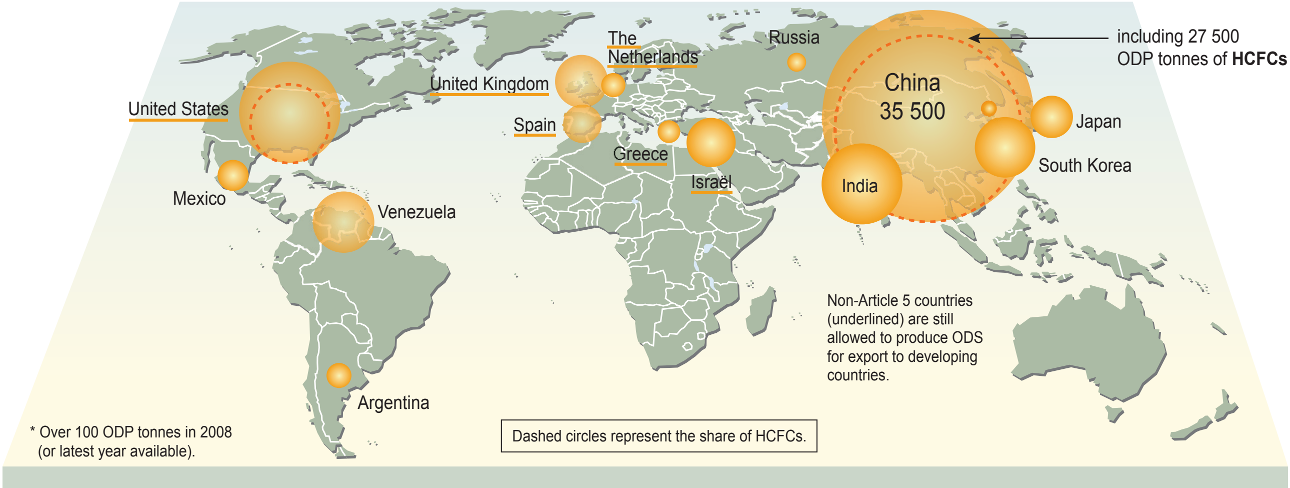
In the mid-1990s, when CFCs were phased-out in industrialized countries (non-Article 5 countries), illegal trade in those chemicals emerged. By 1996 this trade had reached alarming proportions, accounting for as much as 12–20% of global trade in ODS. It was once quoted in the US as being second in value only to cocaine. A 2006 estimate indicated that CFCs alone accounted for 7,000 to 14,000 tonnes of this trade, valued at US$ 25 to US$ 60 million. Alternatives can often be no more expensive than ODS, but the problem arises because equipment must often be retrofitted, sometimes even completely replaced, to use the new chemicals. This maintains the incentive for illegal trade, and it will most likely remain attractive until all ODS-using equipment is finally replaced with newer technology that works with ODS alternatives.

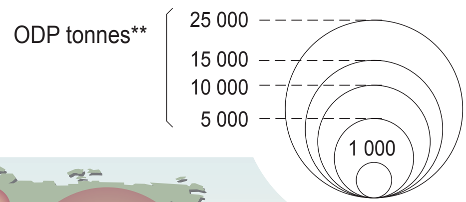
EXAMPLES OF ODS SMUGGLING PATTERNS IN ASIA AND THE PACIFIC

Source: UNEP ROAP, *Illegal trade in ODS in Asia and the Pacific*, September 2006.

Production of ozone depleting substances *

as reported to the Ozone Secretariat by Parties of the Montreal Protocol.





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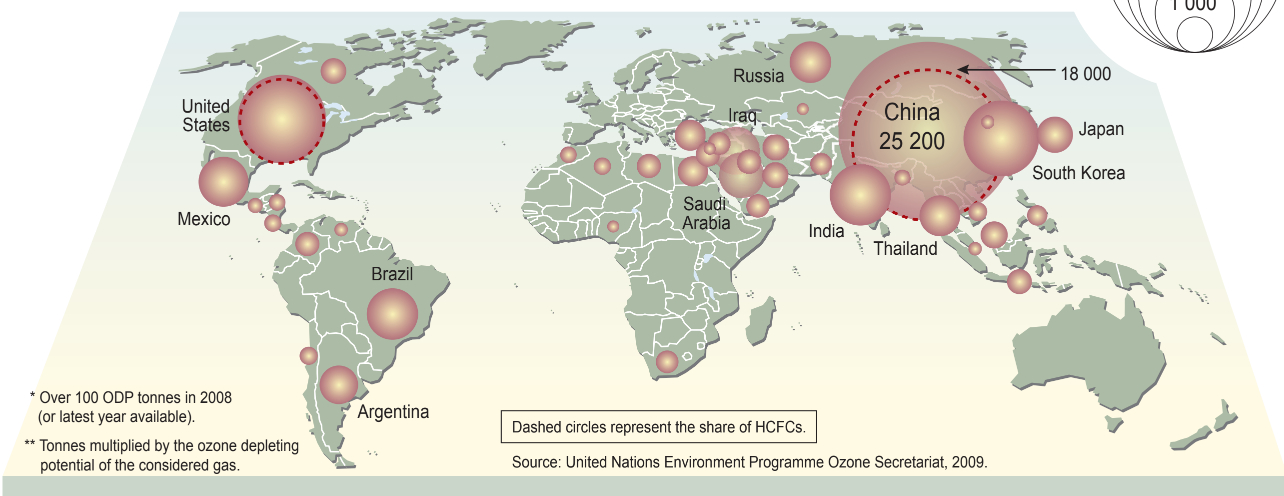

green customs initiative

Much effort has been devoted to training custom officers. The complexities surrounding the movement of illegal imports, as well as the scientific nature of ODS chemicals make it all the easier to deceive ill informed customs officers or Ozone Officers. At room temperature, most ODS are colourless, odourless gases, so chemical analysis is needed to determine precisely what substances are present. Smugglers have taken advantage of this fact and devised highly effective schemes, involving false labels on containers and misdeclarations on documents, diverting ODS to other countries, concealing illegal canisters behind legal ones and disguising virgin ODS to appear recycled.

The importance of skilled customs officers has become apparent not just for the Montreal Protocol, but also in the context of other Multilateral Environmental Agreements such as the Basel Convention (hazardous waste) and CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora).

protocol patching needed?

By the early 1990s it was clear that businesses and consumers would have to replace or adapt millions of appliances and pieces of equipment. Many measures could, at least in theory, have reduced the likelihood of illegal trade. Though unintentional, some aspects of the Montreal Protocol contribute to illegal trade. One obvious point is that the Protocol does not require all countries to follow the same phase-out schedule. The Montreal Protocol allows continued production of CFCs in developing countries for up to 10 years after production ceased in developed countries. This creates considerable potential for illegal trade. Demand for CFCs for continued in developed countries after the phase-out in 1995 due to the need to service existing CFC-based equipment.

Critics have also claimed that the Protocol was slow to respond when the problem of illegal trade became apparent, and that the actions taken were insufficient to fully address the problem.

Illegal imports to developing countries continue to be a problem. The phase-out of ODS is about to become more crucial for developing countries as the date they have pledged for completion in 2010 approaches. Illegal trade in CFCs and other ODS is expected to grow as a complete ban approaches.

By mapping the holes in the Montreal Protocol, we may learn lessons on how to deal with this and other environmental challenges.

the ozone stories – relevant questions, no ready answers

01 the hole

- Scientists have been conducting research in Antarctica for years. Have any studied the effects that the "ozone hole" has had/is having on the ecology of Antarctica?
- Arctic warming is being described as attributable to climate change. To what extent is ozone depletion a contributing factor? What impacts do scientists working in the Arctic think that ozone depletion in the Arctic may be having on Arctic biodiversity? Or on residents of, e.g., Greenland?

02 the culprits: ozone depleting substances

- To what extent are ODSs still prevalent throughout the world? How long will it take after the final phase-out before there are no CFC-containing products? What are the biggest challenges to reaching this point, keeping in mind that CFCs can remain in the stratosphere for decades if not hundreds of years even after they have been removed from the use entirely? What does it mean for ozone depletion, climate change?
- How long it will take the world to eliminate a very hazardous and destructive group of substances, even when best efforts are being made and success is being achieved?
- Where are most of the world's ODSs coming from – who is producing them, who is consuming them and who is being affected – in other words, exploring possible global inequities along the lines of climate change imbalance (US and Europe producing 40% of CO_2?).
- Similarly, are new threats emerging from accelerated economic growth in the BRIC (Brasil, Russia, India, China) countries?
- Methyl bromide is still in use for crops: one banned substance that is still harming the environment and harming consumers.
- To what extent have alternative refrigeration systems (solar chill) been applied to disaster recover areas around the world?
- Climate change impact: Increased warming in certain parts of the world threatens to increase demand for refrigerants, which would further deplete the ozone layer and further accelerate climate change.

03 interlinked destruction

- Climate change story: Just as we appear to be making progress turning back ozone depletion, scientists believe increasingly that climate change is itself a driver of ozone depletion and in fact may surpass CFCs as the leading cause of ozone depletion by 2030.

04 consequences and effects: UV radiation and ecosystems

- Case studies/science linking UV/ozone depletion to declines in fisheries or plants on which specific local communities or regions depend, stories could focus on the impacts of UV on local livelihoods (fisheries, farming), food security, etc.
- Impact of ozone depletion on phytoplankton and the fate of fisheries, which are already in profound decline.

05 consequences and effects: UV radiation and human health

- Look at specific health issues, e.g., eyes.
- Look at health threats from ozone from an environmental justice perspective in, say, Africa. Africa produces no ODSs, consumes few and bears disproportionate health risks as a high percentage of its populations are trying to cope with HIV.

06 mobilization 1: sun protection campaigns

- As stories increasingly focus on the negative impacts of climate change that are anticipated, the ozone story shows that environmental degradation on a global scale can have long-lasting consequences that are difficult to slow. Despite progress in reducing ozone depletion, higher UV radiation is a major cause of a dramatic upswing in skin cancers in recent decades.
- Ozone education as a fore-runner to the growth of environmental education worldwide, how children are agents of change in the family, and how behaviour changes as a result – more skin cream, more recycling, etc.
- What are the keys to success for UV protection programmes?
- What are the reasons for such intensive coverage of UV protection programmes in many countries?

07 and 08 mobilization 1 and 2: successful environmental diplomacy

- In the midst of pessimistic reports about climate change, the fight to decrease ozone depletion over the past 20 years has quietly yielded important progress not only with respect to ozone depletion but in reducing as much greenhouse gas emissions as would be caused by nearly five thousand million round trips from New York to Los Angeles by car.
- The political dynamics behind the success of the Montreal Protocol. Key issues: Faced with the threat, the countries came together and positive changes began to occur.
- Geographical focus: How did different countries respond. What did, e.g., Saudi Arabia do in response to the Protocol and what happened as a result in the country, against the backdrop of the global progress that has occurred.

09 learning from the Montreal Protocol 1: the secret to success

- How has implementation of this treaty impacted on small & medium sized enterprises?
- Have jobs been created or lost as a result of the phase out?
- How has ozone protection affected businesses bottom line?
- How has ozone protection affected consumers' pocketbook?
- What companies have benefited from the technology change, which ones have lost?

10 learning from the Montreal Protocol 2: how does phasing out ozone depleters hit the temperature brake

- What is the contribution of the Montreal Protocol to curb climate change? How is this figure estimated?
- Why, if this contribution is so important, hasn't this been highlighted more prominently in teh climate change debate?

11 the legacy: ODS banks

- Where are the main stocks of ODS located?
- How is the destruction of ODS practically organised?

12 illegal trade in ozone depleting substances

- Climate criminals. Black market trading in ODSs.
- Who are the local authorities responsible for interdicting international shipments of ODSs, and how do they do their business? Similarly, who are the dealers and buyers? Good opportunities for local angles interviews.

glossary

1,1,1 trichloroethane
This partially halogenated ODS contains chlorine and is controlled in Group III of Annex B of the Montreal Protocol. It is primarily used as a solvent for cleaning metals. It has an ODP of approximately 0.11. It is also known as methyl chloroform.

Aerosol
A suspension of very fine solid or liquid particles in a gas. Aerosol is also used as a common name for spray (or "aerosol") can, in which a container is filled with a product and a propellant, and pressurized so as to release the product in a fine spray.

Adjustments
Adjustments are changes to the Protocol with regard to the phase-out timetable for existing controlled substances as well as ODP values of controlled substances based on new research results. They are automatically binding for all countries, which have ratified the Protocol, or the relevant amendment, which introduced the controlled substance. Adjustments can change the text of the Protocol. In addition, the Parties can also take Decisions, which do not change the text but interpret the text.

Albedo
Surface reflectivity of solar radiation. It is quantified as the proportion, or percentage of solar radiation of all wavelengths reflected by a body or surface to the amount shed upon it. An ideal white body has an albedo of 100% and an ideal black body, 0%.

Amendments
Amendments are other more significant changes to the Protocol, such as adding new substances to the list of controlled substances, or new obligations. Parties are not bound by these changes to the Protocol unless and until they ratify the Amendment. Countries, which have not ratified a certain amendment, will be considered as a non-Party with regard to new substances or obligations introduced by that amendment.

Ammonia
A climate-friendly refrigerant used in some commercial refrigeration systems. Ammonia is hazardous at high concentrations.

Annex A substances
A specific group of ozone depleting substances controlled by the Montreal Protocol that appear in an annex to the treaty. This annex contains two groups of controlled substances, five CFCs (Group I) and three halons (Group II).

Annex B substances
Annex B contains three groups of controlled substances, 10 other CFCs (Group I), carbon tetrachloride (Group II) and methyl chloroform (Group III).

Annex C substances
Annex C contains three groups of controlled substances, 34 HCFCs (Group I), 34 HBFCs (Group II) and Bromochloromethane (Group III).

Annex E substance
Annex E contains methyl bromide (Group I).

Anthropogenic
Caused by human as distinct from natural activities.

Article 5 countries
Developing countries that are Party to the Montreal Protocol whose annual calculated level of consumption is less than 0.3 kg per capita of the controlled substances in Annex A, and less than 0.2 kg per capita of the controlled substances in Annex B, on the date of the entry into force of the Montreal Protocol, or any time thereafter. These countries are permitted a ten year "grace period" compared to the phase out schedule in the Montreal Protocol for developed countries.

Atmospheric lifetime
A measure of the average time that a molecule remains intact in the atmosphere.

Bilateral agencies
Non-Article 5 Parties are permitted to allocate up to 20% of their contributions due to the Multilateral Fund as bilateral projects in Article 5 Parties. Such bilateral projects must be approved by the Fund's Executive Committee. Australia, France, Germany, Sweden, UK and USA are examples of countries with such bilateral ozone programmes.

Blends
In refrigeration and air conditioning applications, a blend is a mixture of two or more pure fluids. Given the right composition, blends can achieve properties to fit almost any refrigeration purpose. For example, a mixture of flammable and non flammable components can result in a non flammable blend.

Blowing agent
A gas, a volatile liquid, or a chemical that during the foaming process generates gas. The gas creates bubbles or cells in the plastic structure of a foam.

Bulk chemicals/substances
Only a controlled substance or a mixture of controlled substances that is not part of a use system (a product that is applied directly to realise its intended use; e.g. a refrigerator or a fire extinguisher) is controlled under the Montreal Protocol. A substance that is contained in a manufacturing product other than a container used for storage or transport of the substance is not considered bulk controlled substance.

Compliance Assistance Programme (CAP)
The UNEP programme under the Multilateral Fund that helps Article 5 countries to support and sustain their compliance with the Montreal Protocol. The majority of the CAP staff are based in UNEP's Regional Offices, where they closely interact with the countries they are assisting. The CAP provides Regional Networks of Ozone Officers that promote the exchange of information, experience and know-how required to meet the Montreal Protocol commitments, report data, set and enforce policies and adopt technologies. An Information Clearinghouse supports the development and implementation of regional and national information, education and communication strategies; capacity building activities help developing countries build national capacity; and sector-specific direct assistance related to policy, enforcement and customs, and management of refrigerants, halon and methyl bromide.

Carbon tetrachloride
A chlorocarbon solvent (CCl 4) with an ODP of approximately 1.1 that is controlled under the Montreal Protocol. This controlled substance containing chlorine is included in Group II of Annex B of the Montreal Protocol. It is used as a feedstock in the production of CFCs and other chemicals and as a solvent.

Cataract
Cataract is a disease of the eye and, according to the World Health Organization, the leading cause of blindness in the world. Between 12 and 15 million people become blind from eye cataracts. Cataract causes a partial or total opacity of the lens of the eye. Exposure to UV radiation increases the risk of eye cataracts.

Climate-friendly refrigerants
Term used to refer to a group of naturally occurring substances, such as ammonia, CO_2 and hydrocarbons, which are also known as natural refrigerants. They are used as alternatives to synthetic refrigerants such as HFCs, and CFCs. also referred to as Natural refrigerants.

Chlorofluorocarbons (CFCs)
These ODS contain fluorine and chlorine, usually characterized by high stability contributing to a high ODP. The five main CFCs are controlled as Annex A substances (Group I) by the Montreal Protocol. Ten other, less common fully halogenated CFCs are controlled in Annex B (Group I). CFCs are entirely man-made in origin and are primarily used as aerosols, refrigerants, solvents and for foam blowing.

CO_2 – carbon dioxide
A greenhouse gas used as the base measurement to compare the impact of other gases in terms of their global warming potential. It is also a climate-friendly alternative to HFCs when used as a refrigerant, foam blowing or fire fighting agent.

CO_2 equivalence
A way of measuring the climate impact of all greenhouse gases in a standard form. Because they vary in their ability to trap heat in the atmosphere, and in the length of time they remain in the atmosphere, the effect of each gas is expressed in terms of an equivalent amount of carbon dioxide. Abbreviation: CO_2-eq.

Consumption
Under the Montreal Protocol definition, consumption refers to a country's ozone depleting substance production plus imports minus exports. Most Article 5 countries are importing all ODS which is used in the country.

Containment
The application of service techniques or special equipment designed to avoid or reduce loss of refrigerant from equipment during installation, operation, servicing and/or disposal of refrigeration and air conditioning equipment. Recycling and recovery equipment are typical examples of containment equipment.

Controlled substances
All ozone depleting substances listed in Annexes A, B, C, and E to the Montreal Protocol, whether existing as pure substances or as mixtures, are referred to as controlled substances.

Countries with Economies in Transition (CEITs)
States of the former Soviet Union, and Central and Eastern Europe that have been undergoing a process of major structural, economic and social change, which has resulted in severe financial and administrative difficulties for both government and industry. These changes have affected implementation of international agreements such as the phase out of ODS in accordance with the Montreal Protocol. CEITs include both Article 5 and non-Article 5 countries.

Country Programme (CP)
The Country Programme is the basis for the Multilateral Fund to finance projects and activities in countries. The Country Programme is also the first activity that the Multilateral Fund finances in an Article 5 country. It maps out the strategy and the action plan that the country would follow to eliminate the ODS consumption and production according to the Montreal Protocol schedules.

Customs codes
Traded goods are generally assigned specific numbers serving as customs codes. Custom authorities in most countries use the Harmonized System of customs codes to assist in the easy identification of traded goods. Knowledge about the relevant customs codes can be helpful for collecting import and export data of controlled substances.

Decommissioning
Decommissioning is the physical process of removing a halon system from service. This must be done to recover the halon so that it can be made available for other uses.

Destruction process/technology
Controlled substances can be destroyed using an approved destruction process that results in the permanent transformation or decomposition of all or a significant portion of these substances.

Drop-in replacement
The procedure when replacing CFC refrigerants with non-CFC refrigerants in existing refrigerating, air conditioning and heat pump plants without doing any plant modifications. Drop-ins are normally referred to as retrofitting because minor modifications are needed, such as change of lubricant, replacement of expansion device and desiccant material.

Dry powder inhaler (DPI)
An alternate technology to metered dose inhalers that can be used if the medication being dispensed can be satisfactorily formulated as microfine powder, thus eliminating the use of a chemical propellant such as CFCs.

Essential use
An exemption from the total phase-out of controlled substances can be granted for certain essential uses upon application, if approved by the Meeting of the Parties on a case-by-case basis. This requires that the ODS is either necessary for health, safety or for the functioning of society and no acceptable alternative is available. A global exemption has been granted for laboratory and analytical uses. For the essential use process see the Handbook on Essential Use Nominations.

F-gases
Three of the six GHGs limited under the Kyoto Protocol: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Feedstock
Controlled substances that are used in the manufacture of other chemicals and are completely transformed in the process. For example, carbon tetrachloride is commonly used in the production of CFCs. Amounts used as feedstock are exempted from controls but need to be reported.

Gigatonne (Gt)
A thousand million tonnes = 109 tonnes

Global Environment Facility (GEF)
The GEF, established in 1991, helps developing countries fund projects and programmes that protect the global environment. GEF grants support projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. In the ozone layer focal area, the GEF funds projects that enable Countries with Economies in Transition (CEIT) including the Russian Federation and nations in eastern Europe and central Asia to phase out their use of ozone destroying chemicals.

Global warming
Global warming is caused by the emission of greenhouse gases that trap the outgoing heat from the Earth causing the atmosphere to become warmer. Greenhouse gases include carbon dioxide, methane, CFCs, HCFCs and halons.

Global Warming Potential (GWP)
The relative contribution of greenhouse gases to the global warming effect when the substances are released to the atmosphere by combustion of oil, gas and coal (CO_2), direct emission, leakage from refrigerating plants etc. The standard measure of GWP is relative to carbon dioxide (GWP=1.0). The GWP can refer to a time span of 20, 100 or 500 years. There is not a complete agreement within the scientific community on what is the proper time horizon, but 100 years is most commonly used.

Greenhouse gas
A gas, such as water vapour, carbon dioxide, methane, CFCs, HCFCs and HFCs, that absorbs and re-emits infrared radiation, warming the earth's surface and contributing to global warming.

Halons
These ODS contain fluorine, bromine and, possibly, chlorine. Halons are primarily used in fire extinguishers and explosion suppression.

Halon bank
The total quantity of halon existing at a given moment in a facility, organization, country, or region. The halon bank includes the halon in fire protection systems, in portable fire extinguishers, in mobile fire extinguishers and the halon in storage (containers).

Halon bank management
A method of managing a supply of banked halon. Bank management consists of keeping track of halon quantities at each stage: initial filling, installation, "recycling", and storage. A major goal of a halon bank is to avoid demand for new (virgin) halons by redeploying halons from decommissioned systems or non-essential applications to essential uses. Halon banks are usually managed by a clearinghouse, i.e. an office that facilitates contact between halon owners and halon buyers.

Harmonised System (HS)
In most countries imports and exports are registered using the internationally Harmonised System (HS) of custom codes maintained by the World Customs Organization.

Hydrobromofluorocarbons (HBFCs)
These ODS contain fluorine and bromine and are controlled in Group II of Annex C of the Montreal Protocol. There is no known production or consumption of HBFCs.

Hydrocarbon (HC)
A chemical compound consisting of one or more carbon atoms surrounded only by hydrogen atoms. Examples of hydrocarbons are propane (C_3H_8, HC 290), propylene (C_3H_6, HC 1270) and butane (C_4H_{10}, HC 600). HCs are commonly used as a substitute for CFCs in aerosol propellants and refrigerant blends. The hydrocarbons have an ODP of zero. Hydrocarbons are volatile organic compounds (VOCs), and their use may be restricted or prohibited in some areas. Although they are used as refrigerants, their highly flammable properties normally restrict their use as low concentration components in refrigerant blends.

Hydrochlorofluorocarbons (HCFCs)
These are partially halogenated ODS with chlorine and fluorine and controlled in Group I of Annex C of the Montreal Protocol. HCFCs are substitutes for CFCs, but because they have an ODP, HCFCs are transitional substances that are scheduled to be phased out under the Montreal Protocol. HCFCs (e.g. HCFC-22) are mainly used in air-conditioning and refrigeration applications. HCFC-141b/142b is widely used as a foaming agent and a solvent. HCFC-123, HCFC-124 and others are used as refrigerants, solvents and fire suppressants.

Hydrofluorocarbons (HFCs)
A family of chemicals related to CFCs which contains one or more carbon atoms surrounded by fluorine and hydrogen atoms. Since no chlorine or bromine is present, HFCs do not deplete the ozone layer, but they are global warming gases with GWPs. HFCs are widely used as refrigerants, e.g. HFC-134a (CF_3CH_2F) and HFC-152a (CHF_2CH_3).

Immune system
The immune system is the natural capacity of our body to fight diseases – viruses for example – and to recover from them when we are sick. Exposure to UV radiation can affect our immune system.

Implementation Committee
The Implementation Committee under the Non-Compliance Procedure for the Montreal Protocol consists of five representatives of Article 5 Parties and five representatives of Non-Article 5 Parties. The Implementation Committee can make recommendations to the Meeting of the Parties to improve the implementation of the Protocol and on actions in case of non-compliance.

Implementing Agencies
Phase-out activities in Article 5 Parties supported by the Multilateral Fund are implemented through so-called Implementing Agencies. United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), United Nations Industrial Development Organisation (UNIDO) and the World Bank serve as the Fund's Implementing Agencies.

Incremental costs
With respect to assistance provided to Article 5 Parties, the additional cost that the Multilateral Fund finances. These are the additional costs incurred in converting to ozone-friendly technologies. An indicative list of the categories of incremental costs has been decided by the Meeting of the Parties.

Laboratory and analytical uses
Production, import and export of phased-out controlled substances are allowed under a global essential use exemption for specified laboratory and analytical uses. The Meeting of the Parties is to decide each year on any ODS use which should no longer be eligible under the exemption for laboratory and analytical uses, and from which date. The Ozone Secretariat makes available a consolidated list of uses that are no longer eligible.

Licensing system
In accordance with the Montreal Amendment of the Montreal Protocol, each Party to the Montreal Protocol that has ratified that Amendment has to adopt an import/export licensing system for monitoring the trade in controlled substances. Such a licensing system is used to collect data needed for reporting to the Ozone Secretariat and Fund Secretariat.

Low-Volume Consuming Countries (LVCs)
Article 5 countries consuming less than 360 tonnes of CFCs annually. The Executive Committee makes special provisions for facilitating phase out in these countries.

Melanin
Melanin is a black, dark-brown or reddish pigment present in the hair, skin and eyes. When exposed to the sun, our skin naturally produces melanin to protect itself from UV radiation. Everybody's skin contains melanin, but not the same amount: dark-skin contains more melanin than light skin. However, melanin does not protect efficiently against UV rays and everybody, regardless of skin types, needs additional protection.

Meeting of the Parties (MOP)
All the Parties to the Montreal Protocol meet once in a year at a ministerial/high level and take decisions on many issues including non-compliance, replenishment of the Fund etc.

Metered-Dose Inhaler (MDI)
Metered-dose inhalers contain an active drug dissolved or suspended in a propelled canister for patients with respiratory problems. Some MDIs contain CFCs.

Methyl bromide
This partially halogenated ODS (also known as bromomethane) contains bromine and is controlled in Group I of Annex E of the Montreal Protocol. It is primarily used as a fumigant on soils, commodities and in quarantine and preshipment applications. Methyl bromide has an ODP of approximately 0.6.

Mixtures of ODS
Chemicals which contain two or more controlled substances or one or more controlled substances mixed with other non-ozone depleting chemicals are defined as mixtures of ODS

National Ozone Unit (NOU)
The government unit in an Article 5 country that is responsible for managing the national ODS phase-out strategy as specified in the Country Programme.

Natural refrigerants
Naturally-existing substances that are already circulating in the biosphere, which can be used as refrigerants. Examples of natural refrigerants are ammonia (NH_3), hydrocarbons (e.g. propane), carbon dioxide (CO_2), air and water.

Non-Article 5 countries
Developed countries that are Party to the Montreal Protocol. The Parties in this category are also sometimes unofficially known as "countries operating under Article 2 of the Protocol" or simply "developed countries".

Ozone
A reactive gas consisting of three oxygen atoms (O_3), formed naturally in the atmosphere by the association of molecular oxygen (O_2) and atomic oxygen (O). It has the property of blocking the passage of dangerous wavelengths of ultraviolet radiation in the upper atmosphere. Whereas it is a desirable gas in the stratosphere, it is toxic to living organisms in the troposphere.

Ozone depleting substances (ODS)
All substances having an ODP above zero are, in principle, ODS. These are generally chemicals containing chlorine or/and bromine. The most important ODS are controlled substances under the Montreal Protocol. A smaller number of ODS are not (yet) controlled under the Protocol because they have not been produced or consumed in significant quantities. The term ODS in most cases refers to controlled substances.

Ozone depletion
Accelerated chemical destruction of the stratospheric ozone layer by the presence of substances produced, for the most part, by human activities.

Ozone depletion potential (ODP)
Each controlled substance is assigned a value indicating its impact on the stratospheric ozone layer per unit mass of a gas, as compared to the same mass of CFC 11. These ODP values for each of the controlled substances are given in the Annexes of the Montreal Protocol.

ODP tonnes
ODP-weighted data are generated when an amount of a controlled substance is multiplied by its ODP value. By this procedure, metric tonnes are converted into ODP tonnes which indicate the relative environmental damage rather than the physical quantity.

Open-Ended Working Group (OEWG)
All of the Parties to the Montreal Protocol meet once in a year at official level to discuss all the issues to be considered by the MOP and make recommendations.

Ozone layer
An area of the stratosphere, approximately 15 to 60 kilometers above the Earth, where ozone is found as a trace gas, i.e. at higher concentrations than other parts of the atmosphere. The ozone layer acts as a filter against the ultraviolet radiation (UV-B) coming from the sun and protects life on Earth from the damaging effect of increased UV-B exposure.

Ozone Secretariat
The Ozone Secretariat is the Secretariat for the Vienna Convention for the Protection of the Ozone Layer of 1985 and the Montreal Protocol on Substances that Deplete the Ozone Layer of 1987. It is based at UNEP headquarters in Nairobi, Kenya.

Perfluorocarbons (PFCs)
A group of synthetically-produced compounds that are characterized by extreme stability, non flammability, low toxicity, zero ozone depleting potential, and high global warming potential.

Phase out
The ending of all production and consumption of an ozone depleting substance controlled under the Montreal Protocol.

Polar vortex
A semi-isolated area of cyclonic circulation formed each winter in the polar stratosphere. The southern polar vortex is stronger than the northern one. The vortex increases ozone depletion by trapping very cold air containing aerosols on which ozone-depleting reactions can take place.

Pre-shipment applications
Amounts of methyl bromide applied directly preceding and in relation to export of a product to meet phytosanitary or sanitary requirements of the exporting or importing country are exempted from control.

Process agent
Some amounts of controlled substances are used in the production of other chemicals (e.g. as a catalyst or an inhibitor of a chemical reaction) without being consumed as feedstock.

Production
Under the Montreal Protocol, production of controlled substances by a country is calculated as total production minus amounts destroyed minus amounts used as feedstock. Controls do not apply for production for exempted categories.

Propellant
The component of an aerosol spray that acts as a forcing agent to expel the product from the aerosol canister. CFCs have been used as aerosol propellants.

Quarantine applications
Amounts of methyl bromide used to prevent the introduction, establishment and/or spread of quarantine pests (including diseases) and/or to ensure their official control are exempted from control.

Radiative forcing
The change (relative to 1750, taken as the start of the industrial era) in the difference between the amount of heat entering the atmosphere and that leaving it. A positive forcing tends to warm the Earth, a negative one to cool it.

Recovery
The collection and storage of controlled substances (e.g. refrigerants, halons) from machinery, equipment, containment vessels, etc., during servicing or prior to disposal without necessarily testing or processing it in any way.

Recycling
Re-use of a recovered controlled substance (e.g. refrigerants, halons) following a basic cleaning process such as filtering and drying. For refrigerants, recycling normally involves recharge back into equipment, and it often occurs "on site".

Refrigerant
A heat transfer agent, usually a liquid, used in equipment such as refrigerators, freezers and air conditioners.

Refrigerant Management Plan (RMP)
The objective of a RMP at country level is to design and implement an integrated and overall strategy for cost-effective phaseout of ODS refrigerants, which considers and evaluates all alternative technical and policy options. RMPs are designed primarily to assist countries with low levels of CFC consumption and with small manufacturing sectors, to meet their CFC compliance objectives through reduction in the consumption of CFCs in the refrigeration servicing sector. RMPs typically involve both investment activities (provision of recycling machines) and training of technicians and customs officers.

Retrofit
The upgrading or adjustment of equipment so that it can be used under altered conditions. For example, some refrigeration equipment can be retrofitted to be able to use a non-ozone depleting refrigerant in place of a CFC. This procedure usually requires modifications such as change of lubricant, replacement of expansion device or compressor.

Solvent
Any product (aqueous or organic) designed to clean a component or assembly by dissolving the contaminants present on its surface.

Stockpile
A controlled substance can be stored or accumulated for use in the future.

Stratosphere
The part of the earth's atmosphere above the troposphere, at about 15 to 60 kilometers. The stratosphere contains the ozone layer.

Technology and Economic Assessment Panel (TEAP)
The TEAP is a standing subsidiary body of the Parties to the Montreal Protocol, comprising hundreds of experts from around the world and coordinated by UNEP. It is responsible for reviewing and reporting to the Parties about: (a) the state of art of production and use technology, options to phase out the use of ODS, recycling, reuse and destruction techniques (b) economic effects of ozone layer modification, economic aspects of technology.

Total Equivalent Warming Impact (TEWI)
Combines the global warming effect associated with energy consumption, i.e. emission of CO_2 in power generation (indirect GWP) and the greenhouse effect due to the refrigerant emission (direct GWP). The TEWI depends on how the power is generated, system design, lifetime of the system, refrigerant leakages etc., hence it is not possible to list the TEWI for each refrigerant. Improved energy efficiency for a system has a great influence on the TEWI, compared to the new refrigerants with limited direct GWP and less leakage. The indirect GWP has a great impact for units with long lifetime, but is less important for units with short lifetime and higher leakage.

Terminal Phase out Management Plan (TPMP)
The Multilateral Fund supports the development of national ODS phase-out plans that map out a detailed plan of action to eliminate the entire remaining consumption of the most common ODS in Article 5 countries. These plans are a combination of investment and non-investment projects. Each multi-year plan is governed by an agreement between the Executive Committee and the government concerned.

Trade names
Pure controlled substances as well as mixtures of ODS are produced by a number of companies which give their products commercial trade names, rather than the name of the ODS. These trade names are indicated on the product packaging and transaction/manifest papers. An inventory of trade names is available from UNEP DTIE OzonAction Branch.

Transitional substances
Under the Montreal Protocol, a chemical whose use is permitted as a replacement for ozone-depleting substances, but only temporarily due to the substance's ODP or toxicity. For example, HCFCs are transitional substances.

Troposphere
The lower part of the earth's atmosphere, below 15 kilometers (9 miles). The troposphere is below the stratosphere.

Ultraviolet radiation (UV)
Ultraviolet radiation is a harmful component of sunlight that we cannot see or feel. Ultraviolet radiation is dangerous for us because it damages our health by penetrating deep into our skin and eyes, and by weakening our immune system.

UV-A
UV-A rays represent approximately 90% of UV radiation reaching the Earth's surface because the ozone layer lets them through. They are the least strong UV rays, so they may be the least dangerous.

UV-B
UV-B rays represent approximately 10% of UV radiation reaching the Earth's surface. UV-B causes the most damage to human health. Ozone layer depletion causes a significant increase of UV-B radiation reaching the Earth, which is dangerous for us, but also for plants and animals.

UV-C
UV-C rays are all blocked by the ozone layer. UV-C rays are extremely strong and dangerous.

UV index
The UV Index describes the level of solar UV radiation at the Earth's surface. It is aimed at alerting people about the need to adopt sun protective measures. The UV Index uses a range of values from zero upward. The higher the value, the greater the amount of dangerous UV rays and the potential for damage to our health.

Venting
A servicing practice where the refrigerant vapor is intentionally allowed to escape into the atmosphere after the refrigerant liquid has been recovered. This practice is no longer acceptable.

Vienna Convention
The international agreement made in 1985 to set a framework for global action to protect the stratospheric ozone layer. This convention is implemented through its Montreal Protocol.

acronyms and abbreviations

CAP	UNEP Compliance Assistance Programme
CEIT	Country with economy in transition
CFC	Chlorofluorocarbon
COP	Conference of the Parties
CTC	Carbon tetrachloride
DPI	Dry powder inhaler
DTIE	UNEP Division of Technology, Industry and Economics
EXCOM	Executive Committee
FAO	Food and Agriculture Organisation of the United Nations
GEF	Global Environment Facility
GWP	Global warming potential
HAP	Hydrocarbon aerosol propellant
HBFCs	Hydrobromofluorocarbons
HC	Hydrocarbon
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HS	Harmonised Commodity Description and Coding System (for customs)
IMO	International Maritime Organisation
LVC	Low-volume ODS-consuming country
MAC	Mobile air-conditioning
MCF	Methyl chloroform (1,1,1 trichloroethane)
MDI	Metered dose inhaler
MOP	Meeting of the Parties of the Montreal Protocol
NOU	National Ozone Unit
NGO	Non governmental organization
ODP	Ozone depletion potential
ODS	Ozone depleting substance
OEWG	Open-Ended Working Group Meeting
PFC	Perfluorocarbon
RMP	Refrigerant management plan
TCA	Trichloroethane (1,1,1 trichloroethane)
TEAP	Technology and Economic Assessment Panel
TEWI	Total equivalent warming impact
TOC	Technical Options Committee of the TEAP
TPMP	Terminal Phase out Management Plan
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UV	Ultraviolet radiation
WCO	World Customs Organization
WHO	World Health Organization
WMO	World Meteorological Organization

references

01 the hole

UNEP/DTIE (2007). Brief primer on the Montreal Protocol: The treaty, chemicals controlled, achievements to date, and continuing challenges

D.W. Fahey (2006). Twenty questions and answers about the ozone layer: 2006 Update 2006, NASA 2006, WMO/UNEP

UNEP (2005). Basic Facts and Data on the Science and Politics of Ozone Protection. Backgrounder for journalists: http://www.atm.ch.cam.ac.uk/tour/part1.html (Last accessed 9th October 2009)

02 the culprits: ozone depleting substances (ODS)

US Environmental Protection Agency, Office of Air and Radiation (2007). Achievements in Stratospheric Ozone Protection. Progress Report. Washington

UNEP/DTIE (2007). Brief primer on the Montreal Protocol: The treaty, chemicals controlled, achievements to date, and continuing challenges

refrigeration and air conditioning

Technical Options Committee (2006). Report Of The Refrigeration, Air Conditioning And Heat Pumps: http://ozone.unep.org/teap/Reports/RTOC/rtoc_assessment_report06.pdf

International Energy Agency, Satoru Koizumi (2007). Air Conditioners In Developing Countries And The Role Of Cdm

Technology and Economic Assessment Panel (2009): "Assessment of the alternatives to HCFCs and HFCs and update of the TEAP Supplement Report data"

Technology and Economic Assessment Panel (May 2009): Report Of The Technology And Economic Assessment Panel,volume 1, Progress Report: http://www.pnas.org/content/106/27/10949.full.pdf

Greenpeace International (2008). Cool Technologies: Working Without Hfcs. Examples of HFC-Free Cooling Technologies in Various Industrial Sectors

nitrous oxide and methyl bromide

David Sassoon, may 4th, 2009. Administration rift over handling super-ghgs continues: http://solveclimate.com/blog/20090504/administration-rift-over-handling-super-ghgs-continues

UNEP (2001). Handbook on Essential Use Nominations: http://www.unep.org/OZONE/pdfs/TEAP-Essential-Use-HB-2001-final.pdf

Eric A. Davidson (2009).The contribution of manure and fertilizer nitrogen to atmospheric nitrous oxide since 1860. In: Nature and geoscience online edition, August 2009.

Janet Raloff : Nitrous oxide fingered as monster ozone slayer. In: Science News web edition (August 2009) http://www.sciencenews.org/view/generic/id/46776/title/Nitrous_oxide_fingered_as_monster_ozone_slayer

Methyl bromide alternatives: TEAP Progress Report May 2009

Sierra club, http://www.sierraclub.ca/national/postings/montreal-protocol.html

03 interlinked destruction: temperatures, polar stratospheric clouds and a changing climate

Environmental Investigation Agency (2006). Turning up the heat: Linkages between ozone layer depletion and climate change: The urgent case of HCFCs and HFCs

04 consequences and effects 1: UV radiation and ecosystems

Bazzaz F., W. Sombroek (1996). Global Climate Change and Agricultural Production. FAO, Rome, and John Wiley & Sons, Chichester

Blaustein Andrew R. (not dated). Amphibian Population Declines. In http://www.waterencyclopedia.com/A-Bi/Amphibian-Population-Declines.html

Ilyas, Mohammad (ed.) (1991). Ozone Depletion. Implications for the Tropics. University of Science Malaysia and UNEP, Nairobi

Milchunas Daniel, King J., Mosier A., Moore J., et al. UV Radiation Effects on Plant Growth and Forage Quality in a Shortgrass Steppe Ecosystem. In Photochemistry and Photobiology(2004). (http://www.findarticles.com/p/articles/mi_qa3931/is_200405/ai_n9446040)

UNEP Division on Economy, Trade and Environment (2000): Methyl Bromide Alternatives for North African and Southern European Countries. Paris

Zepp R., D. Erickson, N. Paul, B.Sulzberger (2007). Interactive effects of solar UV radiation and climate change on biogeochemical cycling. In Photochemical and Photobiological Sciences. 2007 Mar;6(3):286-300

05 consequences and effects 1: UV radiation and human health

Dutch National Institute for Public Health and the Environment (RIVM), Laboratory for Radiation Research 2007. (www.rivm.nl/milieuStoffen/straling/zomerthema_uv) redirects to http://www.rivm.nl/milieuportaal

Australian Institute of Health and Welfare (AIHW) & Australasian Association of Cancer Registries (AACR)(2004). Cancer in Australia 2001. Cancer Series Number 28. Canberra: AIHW.

Australian Institute of Health and Welfare (2005). GRIM (General Record of Incidence of Mortality) Books. Canberra: AIHW. (http://www.sunsmart.com.au/browse.asp?ContainerID=1752)

Jones R. R., Wigley T. (eds.) (1989). Ozone Depletion. Health and Environmental Consequences. Wiley Science Editors, New York, Chichester, Brisbane Toronto, Singapore

Lucas R., T. McMichael, W. Smith, B. Armstrong (2006). Solar Ultraviolet Radiation. Global burden of disease from solar ultraviolet radiation. Environmental Burden of Disease Series, No. 13. World Health Organization, Geneva

Prüss-Üstün A. and C. Corvalán (2006). Preventing Disease Through Healthy Environments - Towards an estimate of the environmental burden of disease. WHO, Geneva

06 mobilization 1: sun protection and sensitization projects

World Health Organization, World Meteorological Organization, United Nations Environment Programme, International Commission on Non-Ionizing Radiation Protection (2002). Global Solar UV Index. A Practical Guide. WHO Geneva http://www.who.int/uv/publications/en/GlobalUVI.pdf

07 mobilization 2: environmental diplomacy – the Montreal Protocol

Stephen O Andersen, K Madhava Sarma (2002). Protecting the Ozone Layer, the United Nations History, UNEP, Earthscan Publishing

US Environmental Protection Agency, Achievements in Stratospheric Ozone Protection, Progress report, April 2007

Sharon L. Roan (1989). The 15 year evolution of a sudden global emergency. Ozone crisis, Wiley Science Editors, New York, Chichester, Brisbane Toronto, Singapore.

Benedick, Richard E (1999). The Indispensable element in the Montreal Ozone Protocol. IN EARTHmatters ~ Science & Environmental Negotiations THE COLUMBIA EARTH INSTITUTE. Fall 1999

Fahey DW (2006). Twenty questions and answers about the ozone layer: 2006 Update.

UNEP/DTIE (2007). Brief primer on the Montreal Protocol: the treaty, chemicals controlled, achievements to date, and continuing challenges (unpublished draft)

UNEP/DTIE (2007). The Montreal Protocol in 2007 – 20 Years of progress - A success in the making. (unpublished draft)

Velders G. J. M., S. O. Andersen, J.S. Daniel, D. W. Fahey, M. McFarland (2007). The importance of the Montreal Protocol in protecting the climate

UNEP (September 2009). Ozone Treaty Anniversary Gifts Big Birthday Present to Human Health and Combating of Climate Change. Press release.

UNEP, Montreal Protocol (2009). Report of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol on the progress made in reducing emissions of controlled substances from process-agent uses for the period 2007–2008

08 mobilization 3: pledging funds for patching the hole

Multilateral Fund for the Implementation of the Montreal Protocol (2005). Creating a real change for the environment. Brochure

09 learning from Montreal: the secret to success

Cook, Elisabeth (ed.) (1996). Ozone Protection in the United States. Elements of Success. World Resources Institute, Washington DC.

Roan, Sharon L. (1989). Ozone Crisis. The 15 Year Evolution of Sudden Global Emergency. Wiley Science Editors, New York, Chichester, Brisbane Toronto, Singapore.

Simonis Udo E. Kyoto I + Montreal = Kyoto II ? Wer zu spät kommt, den bestraft das Klima. In Freitag 49, 2005.

UNEP/DTIE, INWENT, CNP+L (2006). Environmental Agreements and Cleaner Production. Questions and answers.

UNEP/DTIE, UNIDO (2002). Changing Production Patterns: Learning from the Experience of National Cleaner Production Centres.

UNEP/DTIE (2004). The Cleaner Production Companion.

Reiner Grundmann (2006). Ozone and Climate Scientific Consensus and Leadership. In: Science, Technology, &Human Values, Volume 31 Number 1

10 learning from the MP how does phasing out ozone depleters hit the temperature brake

Environmental Investigation Agency (2006). Turning Up the Heat. Linkages between ozone layer depletion and climate change: The urgent case of HCFCs and HFCs

IPCC/TEAP, Bert Metz, Lambert Kuijpers, et.al. (Eds) 2005. Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons Cambridge University Press, UK

Guus J. M. Velders et al. (July 2009): The large contribution of projected HFC emissions to future climate forcing

OzonAction Special Issue (September 2008): HCFC Phase out: Convenient Opportunity to Safeguard the Ozone Layer and Climate: http://www.refrigerantsnaturally.com/assets/files/download/pdf/reports/UNEP_Ozone_action_%20report_2008.pdf

http://www.ipcc.ch/

UNEP Climate Assistance Programme (2009) Fact Sheet Applications of HCFCs and blends containing HCFCs

Institute for Governance & Sustainable Development (July 2009): Frequently asked questions about destroying ozone-depleting substance banks under the Montreal Protocol,

www.igsd.org/documents/IGSDHFCFAQGenevaJuly2009-1.pdf

11 the legacy: ODS banks

Environmental Investigation Agency (2009). Recovery and destruction of ods banks: Immediate action for Global climate protection. http://www.eia-international.org/

12 side effects: illegal trade

Environmental Investigation Agency (2005). Controlling the ODS Trade; The need to strengthen licensing systems.

Environmental Investigation Agency (2003). Lost in Transit; Global CFC Smuggling Trends and the Need for a Faster Phase out.

Environmental Investigation Agency (2001). Under the Counter; China's Booming Illegal Trade in Ozone Depleting Substances.

OzoneAction Newsletter Special Supplement Number 6 (2001). Illegal Trade in Ozone Depleting Substances – is there a hole in the Montreal Protocol?

UNEP/DTIE, Multilateral Fund for the Implementation of the Montreal Protocol, Environment Canada, MOFA Finland, WCO and Current Technologies Corporation (2001). Training Manual for Customs Officers; Saving the Ozone Layer: Phasing out ODS in Developing Countries.

UNEP ROAP (2006). Illegal trade in ODS in Asia and the Pacific.

Environmental Investigation Agency (2001). Unfinished business: The Continued Illegal Trade in Ozone Depleting Substances and the Threat Posed to the Montreal Protocol.

Ozone Secretariat (2002). Study on Monitoring of International Trade and Prevention of Illegal Trade in ODS, Mixtures and Products Containing ODS (Decision XIII/12), http://ozone.unep.org/Meeting_Documents/oewg/22oewg/22oewg-4.e.pdf (Last accessed 9th October 2009)

Charles W. Schmidt. Environmental Crimes: Profiting at the earth's expense. In Environmental Health Perspectives, Volume 112, Number 2, February 2004

recommended websites

general

The ozone hole tour (educational website by the University of Cambridge): www.atm.ch.cam.ac.uk/tour/index.html

Ozone protection website of the European Commission: http://ec.europa.eu/environment/ozone

U.S. Environment Protection Agency's Ozone website: www.epa.gov/ozone

Ozone information by a private NGO: www.theozonehole.com

01 the hole

Earth System Research Laboratory of NOAA: Ozone measurements: www.esrl.noaa.gov/gmd/about/ozone.html

Near real-time ozone column predictions and measurements (European Space Agency): www.temis.nl/protocols/O3total.html

British Antarctic Survey Ozone Bulletin: www.antarctica.ac.uk/met/jds/ozone

http://www.iifiir.org

http://www.atm.ch.cam.ac.uk/tour/part1.html

US National Oceanic and Atmospheric Administration (NOAA) Stratospheric ozone webpage: www.ozonelayer.noaa.gov

US National Aeronautics and Space Administration (NASA), Ozone Hole Watch: http://ozonewatch.gsfc.nasa.gov/facts/hole.html

US National Aeronautics and Space Administration (NASA), Earth Observatory (data and images): http://earthobservatory.nasa.gov/Observatory/Datasets/ozone.toms.html

02 the culprits: ozone depleting substances

UNEP/DTIE, Trade names of chemical products containing ozone depleting substances and their alternatives database: www.uneptie.org/ozonaction/information/tradenames/main.asp

UNEP/DTIE, Montreal Protocol Control Measures by Substance (phase-out schedules): www.uneptie.org/ozonaction/information/tradenames/trade_schedule_main.asp

03 interlinked destruction: temperatures, polar stratospheric clouds and a changing climate

US National Oceanic and Atmospheric Administration (NOAA) Polar Stratosphere and Ozone Depletion page: www.cpc.ncep.noaa.gov/products/stratosphere/polar/polar.shtml

05 consequences and effects 2: UV radiation and human health

Question and answers on effects of UV radiation on human health: www.who.int/uv/faq/uvhealtfac/en/index.html

International Agency for Research on Cancer (databases): http://www-dep.iarc.fr

International Agency for Research on Cancer (IARC), CANCER-Mondial databases: www-dep.iarc.fr

06 mobilization 1: sun protection campaigns

World Health Organization Intersun programme: www.who.int/uv/intersunprogramme/en

Australia's UV protection site: www.sunsmart.com.au

07 and 08 the Montreal Protocol and the Multilateral Fund

Ozone Secretariat (the secretariat coordinating the implementation of the Vienna Convention and Montreal Protocol) www.unep.org/ozone

Assessment Panels providing scientific background for the Montreal Protocol: http://ozone.unep.org/Assessment_Panels

Frequently Asked Questions about the Montreal Protocol: http://ozone.unep.org/Frequently_Asked_Questions

OzonAction Branch; www.uneptie.org/ozonaction

The Multilateral Fund (Funding mechanism to ensure compliance with MP): www.multilateralfund.org

United Nations Development Programme (UNDP) ozone –related activities: www.undp.org/chemicals/montrealprotocol.htm

World Bank ODS phase out projects: http://go.worldbank.org/K5RY1P1670

09 learning from Montreal 1: the secret to success

HCFC national regulations: http://www.arap.org/regs/

12 side effects: illegal trade

Environmental Investigation Agency (NGO specialised in detecting environment-related crime): www.eia-international.org and www.eia-international.org/campaigns/global_environment

Green Customs: www.greencustoms.org

Interpol: www.interpol.int

Workshop of Experts from Parties on Illegal Trade in ODS: http://ozone.unep.org/Meeting_Documents/illegal-trade/index.asp

Basel Convention (Hazardous waste convention): www.basel.int

The efforts of the Parties to the Montreal Protocol have, over more than 20 years, translated scientific realities into political decisions leading to concrete action on the ground. The experience of this Protocol can act as both guide and inspiring example of the multilateral system at its best, and should help build confidence for future multilateral environmental agreements.

This second, revised edition of "Vital Ozone Graphics" sheds a light onto the latest decisions taken by the Parties to the Montreal Protocol to accelerate the phase out of HCFCs and the implications this has on the use of replacement chemicals. It also focuses on the links to climate both physically up in the air and on the institutional ground of international treaty negotiations and discusses the remaining challenges posed by the large amounts of ozone killer banks still present in equipment in use and stocked away, only safe for the atmosphere once entirely destroyed.