4. Stratospheric ozone depletion

The thickness of the ozone layer above Europe has decreased significantly since the beginning of the 1980s, and is declining at a rate of 4–5 % per decade.

The gradual fall in the concentration of chlorine-containing ozone-depleting substances in the troposphere (on their way to the stratosphere) shows that international policies to control emissions of ozone-depleting substances are succeeding.

Production, sales and consumption of ozone-depleting substances in European countries have fallen significantly since 1989. However, the long life of these substances in the atmosphere means that the ozone layer may not recover fully until after 2050.

The remaining policy challenges for European countries are to tighten control measures, reduce the production and use of hydrochlorofluorocarbons and methyl bromide, to manage the remaining stocks of ozone-depleting substances, and to support developing countries in their efforts to reduce their production, use and emissions of ozone-depleting substances.

4.1. Introduction

4.1.1. The issue

The ozone layer in the stratosphere, albeit very dilute, is an essential component of the Earth's atmosphere. It protects humans, animals and plants from damaging short-wave ultraviolet (UV) radiation. Ozone is also a greenhouse gas, but most of the warming effect comes from the ozone in the troposphere.

Ozone is produced in the upper stratosphere by the interaction of short-wave solar UV radiation with oxygen. It is destroyed (dissociated) by reactions with certain compounds (ozone-depleting substances) in the presence of somewhat longer wavelength UV radiation. The dynamic balance between production and destruction determines the concentration and total amount of ozone in the stratosphere, or the 'thickness' of the ozone layer. Anthropogenic emissions of ozone-depleting substances that contain chlorine and bromine disturb this balance. A single chlorine or bromine atom can destroy thousands of ozone molecules before being removed from the atmosphere.

The dramatic depletion of stratospheric ozone which is observed in polar regions is caused by a combination of anthropogenic emissions of ozone-depleting substances, stable circulation patterns, extremely low temperatures and solar radiation.

Compounds that cause significant ozone depletion include chlorofluorocarbons (CFCs), carbon tetrachloride, methyl chloroform, halons, hydrochlorofluorocarbons (HCFCs), hydrobromofluorocarbons (HBFCs) and methyl bromide. They are used as solvents, refrigerants, foam-blowing agents, degreasing agents, aerosol propellants, fire extinguishers (halons) and agricultural pesticides (methyl bromide). The extent to which an ozone-depleting substance affects the ozone layer (its 'ozone-depleting potential' or ODP) depends on its chemical characteristics. Other factors which affect the ozone layer include natural emissions, large volcanic eruptions, climate change, and the greenhouse gases methane and nitrous oxide.

The ozone column (a measure of the thickness of the ozone layer) above Europe has decreased significantly since the beginning of the 1980s. The average ozone column over Europe in March for 1997–2001 was about 7 % lower than that for 1979–81 (Figure 4.1). This decrease is larger that the global average decrease (about 4 %) at northern mid-latitudes for winter-spring (WMO, 2003).

International measures to protect the ozone layer were triggered by the dramatic discovery of a hole in the layer above the Antarctic. The effect of these measures, introduced in the Montreal protocol (1987) and subsequent actions to reduce emissions of ozone-depleting substances, is observed first in the lower part of the Earth's atmosphere. The total potential chlorine concentration in the troposphere has fallen since 1994 mainly because of a large decrease in the concentration of methyl chloroform. The concentration of some CFCs is decreasing, while the increase in the concentration of other CFCs is levelling off.

However, concentrations of HCFCs (used as an alternative to CFCs) are increasing. The changes in concentrations of ozone-depleting substances in the stratosphere follow the changes of concentrations in the troposphere with a delay of three to five years.

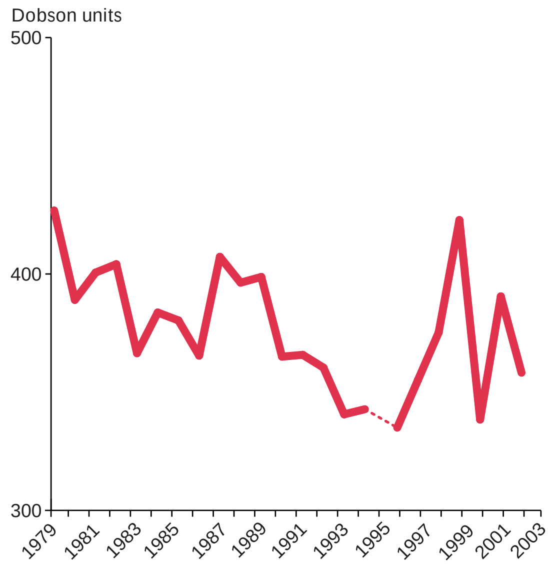
As for the concentration of hydrogen chloride in the stratosphere, which is a measure of the total amount of chlorine in the stratosphere, the annual increase has been substantially less since 1997 than before that year (WMO, 2003). Contrary to earlier expectations, the total potential bromine concentration in the troposphere is still rising as a result of increased concentrations of halons.

> The thickness of the ozone layer over Europe in March has decreased significantly since the beginning of the 1980s by 4–5 % per decade.

Because ozone-depleting substances have a very long lifetime in the stratosphere, detectable recovery of the ozone layer is not expected before 2020 as a result of the Montreal protocol. Complete recovery is not expected until after 2050 (WMO, 1999). Over the polar regions, extensive ozone depletion will continue to be observed in spring for many decades.

Ground-based measuring stations have recorded increases in the amount of UV radiation in recent years. Satellite-derived UV data and ground measurements generally agree. Increased UV radiation will continue until ozone recovery is complete, but the damaging effects of UV on human health and ecosystems are likely to persist even longer. Ecosystems in mountain regions, which have high natural background levels of UV radiation, are particularly vulnerable to increases. Skin cancers only appear many years after exposure to UV (see Chapter 12). However, if the current control measures are implemented, the increase in future skin cancer incidence caused by ozone depletion will be very limited (with the maximum impact expected around 2050 (see also EEA, 1999)). Changes in lifestyle, involving more exposure to the sun, may have a much larger effect.

Average ozone column over Europe in March, 1997–2002 — Figure 4.1.



Notes: 1 Dobson unit = 0.01 mm ozone column thickness at standard temperature and pressure. Monthly average ozone data derived from satellite instruments, averaged from 35 ºN to 70 ºN and from 11.2 ºW to 21.2 ºE.

Source: EEA (calculations from published data)

4.1.2 Policies

The Montreal protocol of 1987 (and subsequent amendments and adjustments) aims to eliminate the production and use of ozone-depleting substances (ODS) worldwide. Council Regulation 2037/2000 is the European Union's (EU) current legislative instrument for phasing out ODS in line with the requirements of the Montreal protocol. The regulation includes controls on the production, import, export, supply, use, leakage and recovery of controlled substances. It also establishes a licensing procedure for all imports of ODS.

Current policy challenges include:

- ensuring full compliance by all countries, notably developing countries and economies in transition;
- reducing the remaining production of ODS for essential uses and for supply to countries which have an authorization in accordance with the protocol;
- stopping 'dumping' in developing countries and countries with economies in transition of second-hand equipment which uses CFCs;
- taking action against smuggling of CFCs and halons;
- reducing emissions of halons and CFCs from existing equipment, especially in developed countries;
- discouraging the use of HCFCs as replacements for CFCs;
- preventing the increased use of methyl bromide in developing countries;

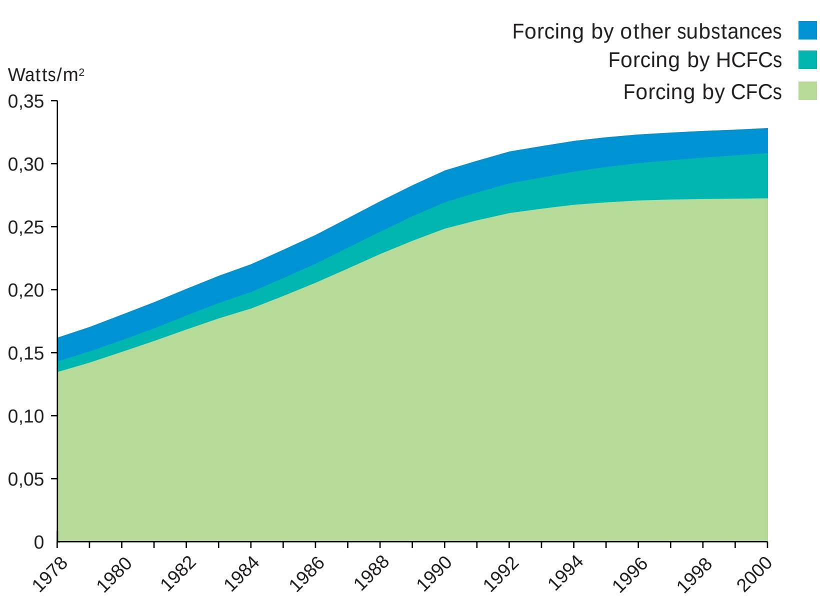
- preventing the production and marketing of new ozone-depleting substances.

Europe's successes and the recovery of the ozone layer will be jeopardised unless developing countries also meet their commitments under the Montreal protocol. These came into effect in 1999.

In 1990, the Parties to the Montreal protocol established a multilateral fund to help developing countries implement the protocol. Developed countries contribute to this fund, while developing countries can apply for financial assistance for particular projects.

Western European countries contributed about USD 560 million to the multilateral fund between 1991 and 2000. This amount is about 48 % of total global payments to the fund. The total amount spent so far by the fund (USD 936 million) is expected to result in the phasing out of the use of 122 million ODP kg (more than twice the 1997 production in western Europe) and the phasing out of the production of about 42 million ODP kg of ozone-depleting substances. European countries operating under Article 5 of the Montreal protocol are Albania, Bosnia-Herzegovina, Croatia, Cyprus, the Former Yugoslav Republic of Macedonia, Georgia, Malta, Republic of Moldova, Romania, Turkey and Serbia and Montenegro.

Figure 4.2. **Radiative forcing of ozone-depleting substances at the global level**



Source: RIVM

4.1.3. The interaction between climate change and ozone depletion

Ozone is itself a greenhouse gas, but most of its warming effect comes from tropospheric ozone. Some ozone-depleting substances e.g. CFCs and HCFCs are also potent greenhouse gases. Stratospheric ozone depletion and climate change therefore have some common sources. CFCs, HCFCs and related compounds contribute about 13 % to total radiative forcing (the net extra radiation giving rise to global warming) from all greenhouse gases (Figure 4.2). However, their emissions are not regulated under the Kyoto protocol (see Chapter 3, Section 3.6) but under the Montreal protocol. Hydrofluorocarbons (HFCs), which are increasingly used as substitutes for ozone-depleting substances, are also potent greenhouse gases. HFCs are covered by the Kyoto protocol. One of the current policy challenges is to find ways to use HFCs, which can be applied to substitute Montreal protocol gases, in a way that would minimise their contribution to global warming.

The radiative forcing of ozone-depleting substances is still increasing but less than in the 1980s. There are a number of reasons for this. The phasing out of methyl chloroform under the Montreal protocol is largely responsible for the decrease in total potential chlorine. However, methyl chloroform contributes less to radiative forcing than CFCs and HCFCs. In addition, the contribution from CFCs is levelling off as a direct result of the Montreal protocol, and the radiative forcing of HCFCs is increasing as their concentrations in the troposphere increase.

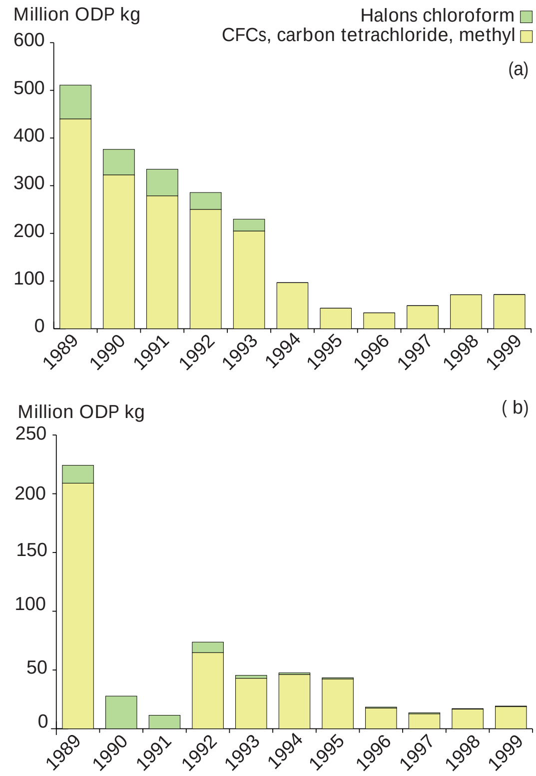
In addition to the radiative effects of ozone-depleting substances, there are further interactions between climate change and ozone depletion through atmospheric chemistry, possible changes in troposphere-stratosphere exchange, emissions of the greenhouse gases nitrous oxide and methane, etc.

The interaction between climate change and ozone depletion could be especially important for the polar regions. The depth,

The radiative forcing of ozone-depleting substances is still increasing. This is because the radiative forcing of HCFCs is increasing, while that of CFCs is levelling off.

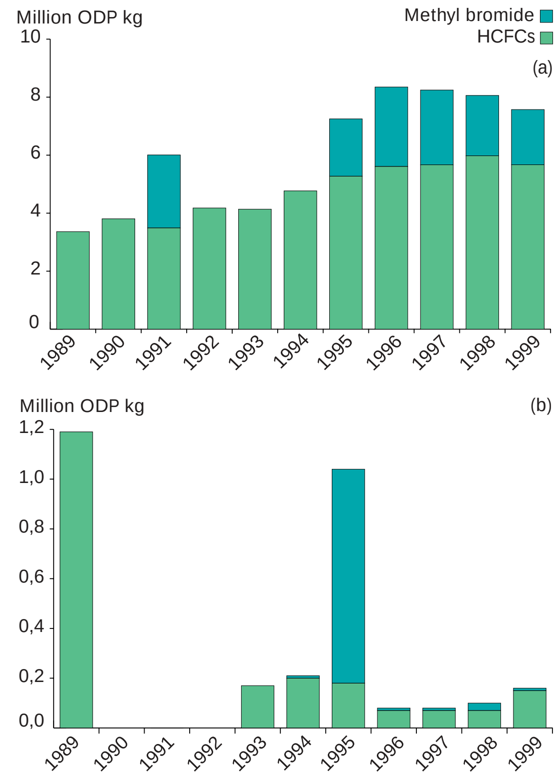
Production of ozone-depleting CFCs, carbo tetrachloride, methyl chloroform and halons in western Europe (a) and in EECCA countries (b)

Figure 4.3.



Production of HCFCs and methyl bromide in western Europe (a) and in central and eastern European and EECCA countries (b)

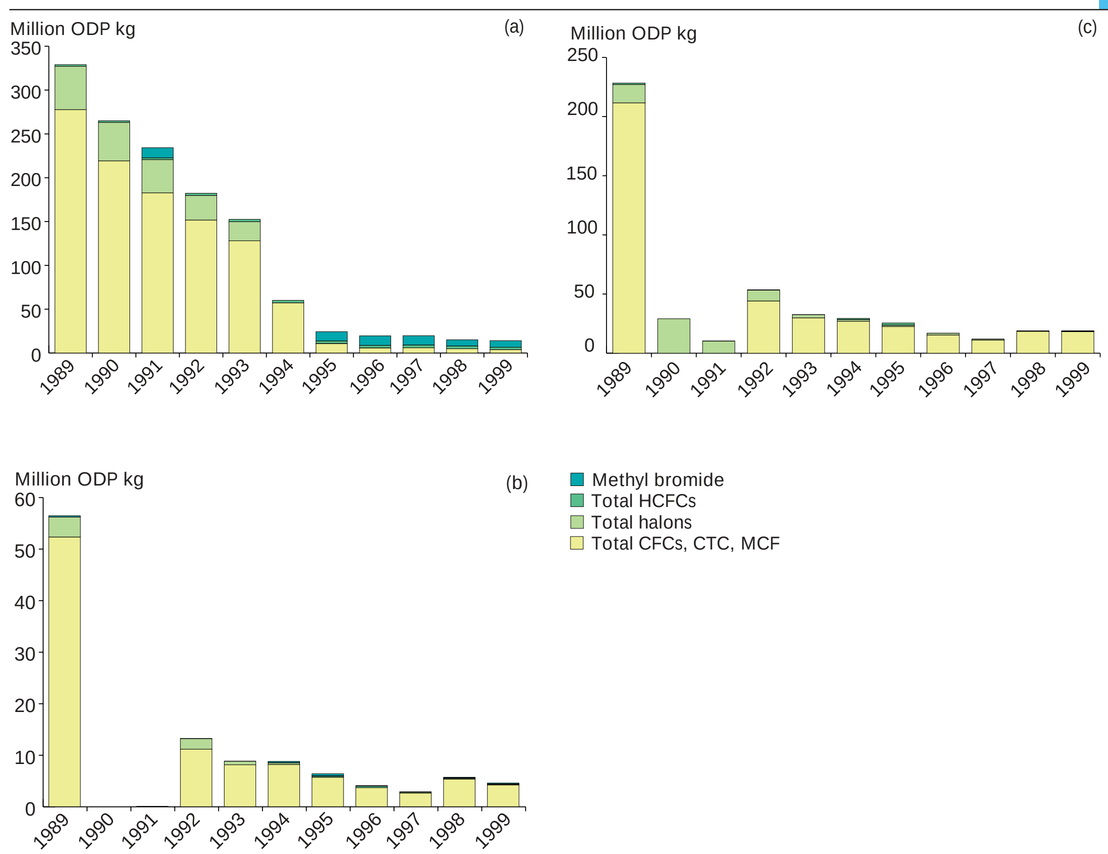
Figure 4.4.



Notes: Production is defined as actual manufacture in the EU for dispersive uses, but excluding: imports, production for use as a raw material for the production of other chemicals, and used material recovered, recycled or reclaimed. Production data are weighted according to ozone-depleting potential (ODP). Production data are weighted according to ozone-depleting potential (ODP). Some data gaps as countries were only required to report data on HCFCs and methyl bromide in certain years.
Source: European Commission, 1999; UNEP, 1998

Sales of ozone-depleting substances in western Europe (a) and consumption in central and eastern European (b) and EECCA countries (c)

Figure 4.5.



Notes: The EU reports sales data while UNEP reports consumption data. They are considered equivalent here. Data are weighted according to ozone-depleting potential (ODP). There are some data gaps because countries were only required to report data on HCFCs and methyl bromide in certain years.

Source: European Commission, 1999; UNEP, 1998 duration and extent of the ozone holes at the north and south poles could increase as a result of lower stratospheric temperatures associated with climate change.

UNFCCC has requested the Intergovernmental Panel on Climate Change (IPCC) and the Technological and Economic Assessment Panel of the Montreal protocol to develop a special report on options to limit the contribution of HFCs to climate change.

4.2. European production, sale and consumption of ozone-depleting substances

The production of CFCs, carbon tetrachloride, methyl chloroform and halons in Europe fell substantially between 1989 and 1999, while production of HCFCs increased (Figures 4.2 and 4.3). The sale and consumption of all ODS shows a similar pattern (Figure 4.4). This overall decline in the production and sale of ODS is a direct result of the Montreal protocol and EU and national regulations. Halon production has been banned in the EU since 1994 and production of CFCs, carbon tetrachloride and methyl chloroform since 1995. Limited production and use of certain compounds (mainly CFCs) is still allowed for designated essential uses (e.g. metered dose inhalers for medical purposes) and to meet the basic needs of developing countries. Production for sale to developing countries accounts for the increase in 1997. HCFCs and methyl bromide may still be produced and sold in the EU subject to mandatory limits.

The production of ODS in western Europe (WE) varied between 20 % and 30 % of global production in the years 1996–99. In all countries in WE, the use of ODS has fallen faster than required under the Montreal protocol.

Global production and emissions of ODS have also decreased significantly. However, existing equipment and products still contain large amounts of CFCs and halons, generating emissions when these are released. Emissions of ODS can occur within a few months of production, e.g. during the manufacture of open-cell foams or after several years. e.g. from refrigerators, closed-cell foams and fire extinguishers.

Illegal production and smuggling of ODS is estimated at 10 % of 1995 global production. These illegal activities will delay the recovery of the ozone layer by several years.

 Production of ozone-depleting substances in western Europe has decreased by almost 90 %. However, production of hydrofluorocarbons — with low ozone-depleting potential but high global warming potential — is increasing.

4.3. References

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