International environmental agreements

- Enable countries to work together to address vital environmental issues that are transboundary or global in nature-----**air pollution, climate change, protection of the ozone layer, and ocean pollution.**

- Countries cannot achieve desired results by acting alone and have developed a wide range of international environmental agreements.

Historical context

- A few agreements until the second half of the 20th century.

- In 1972, the United Nations Conference on the Human Environment, held in Stockholm, marked the beginning of a comprehensive international effort to protect, preserve, and enhance the environment.

- Several important environmental agreements have been negotiated since then.

http://www.oag-bvg.gc.ca/internet/english/parl_cesd_200410_01_e_14914.html

Historical context.

- Over 500 international treaties and other agreements related to the environment in 2001
- ~60 percent post 1972

http://www.oag-bvg.gc.ca/internet/english/parl_cesd_200410_01_e_14914.html

Management challenges

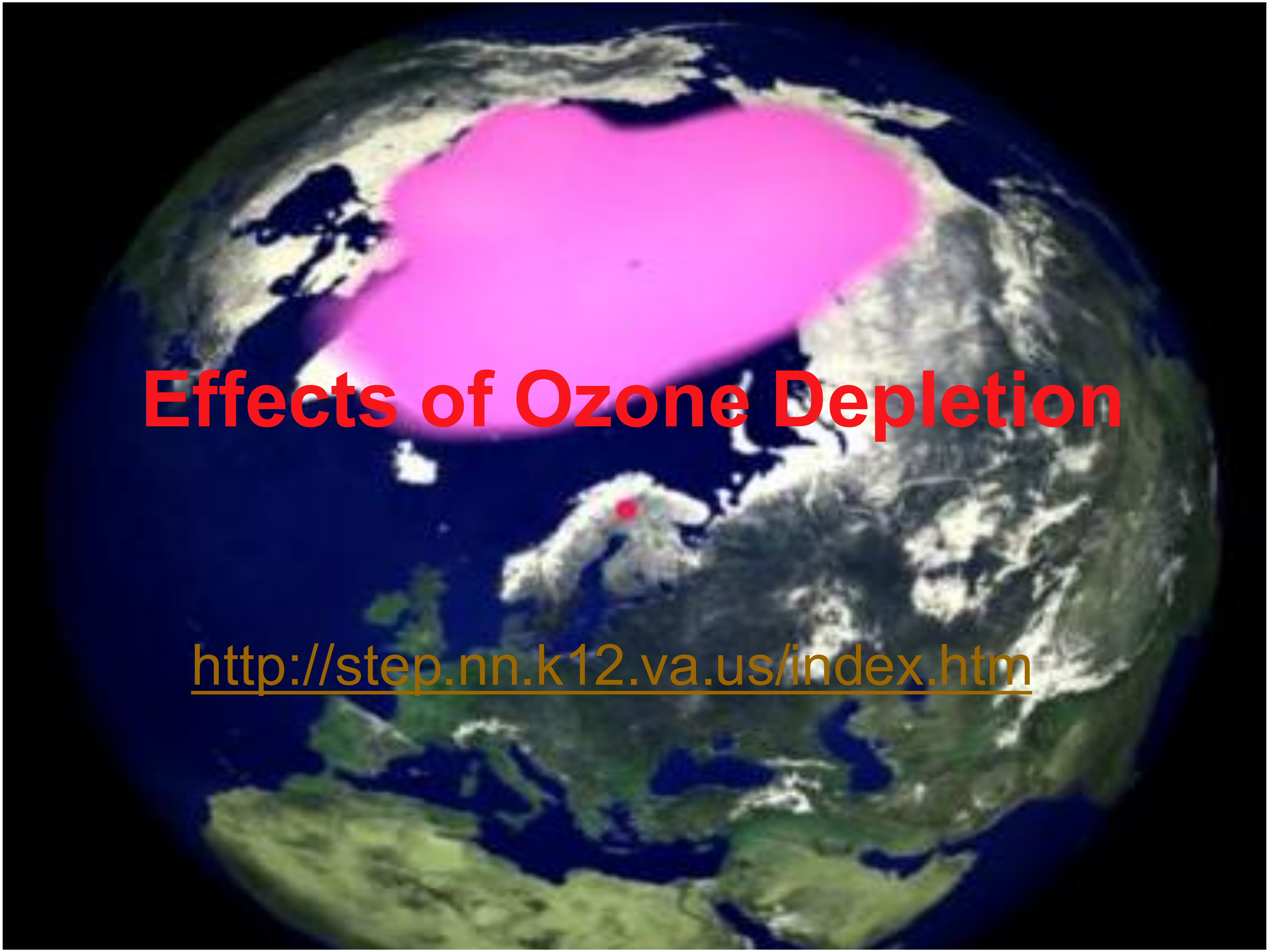
- Challenge of managing of increasingly complex international environmental agreements.
- The assessment of the implementation, compliance, and effectiveness of these agreements is complicated and often plagued by various problems.
- Different countries are not on the same page

http://www.oag-bvg.gc.ca/internet/english/parl_cesd_200410_01_e_14914.html

Montreal Protocol

on

Substances that Deplete the Ozone Layer


Effects of Ozone Depletion
http://step.nn.k12.va.us/index.htm

The Discovery

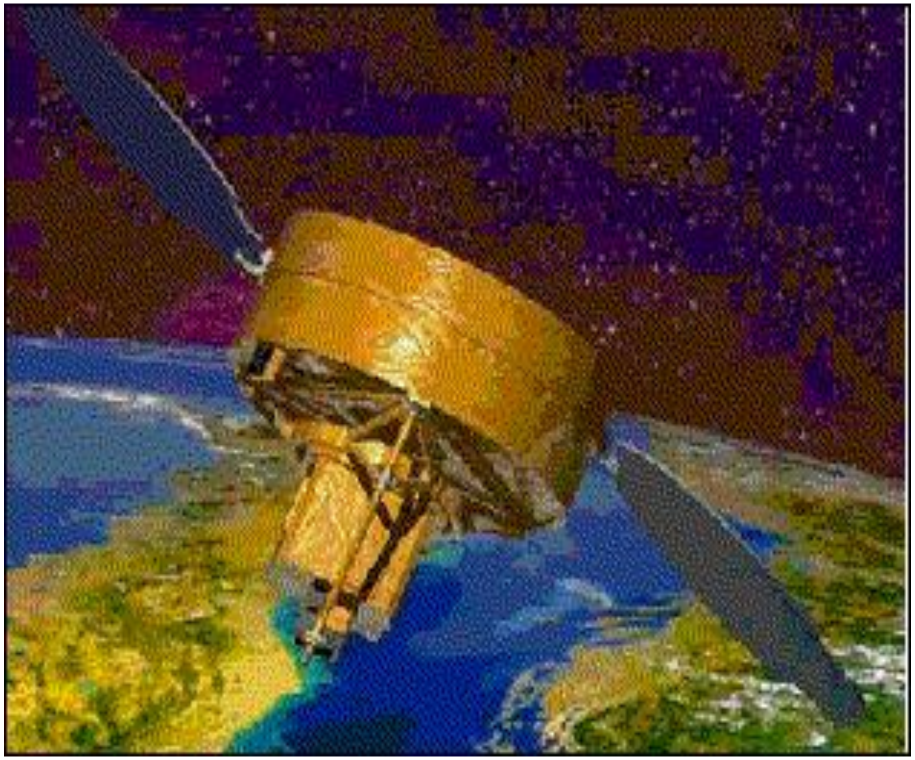
- **In 1985, using satellites, balloons, and surface stations, a team of researchers had discovered a balding patch of ozone in the upper stratosphere, the size of the United States, over Antarctica.**

Team who discovered the hole 1985.
From left: Joe Farman, Brian Gardiner, and Jonathan Shanklin

British Atlantic Survey Research station, Holly Bay, Antarctic coast

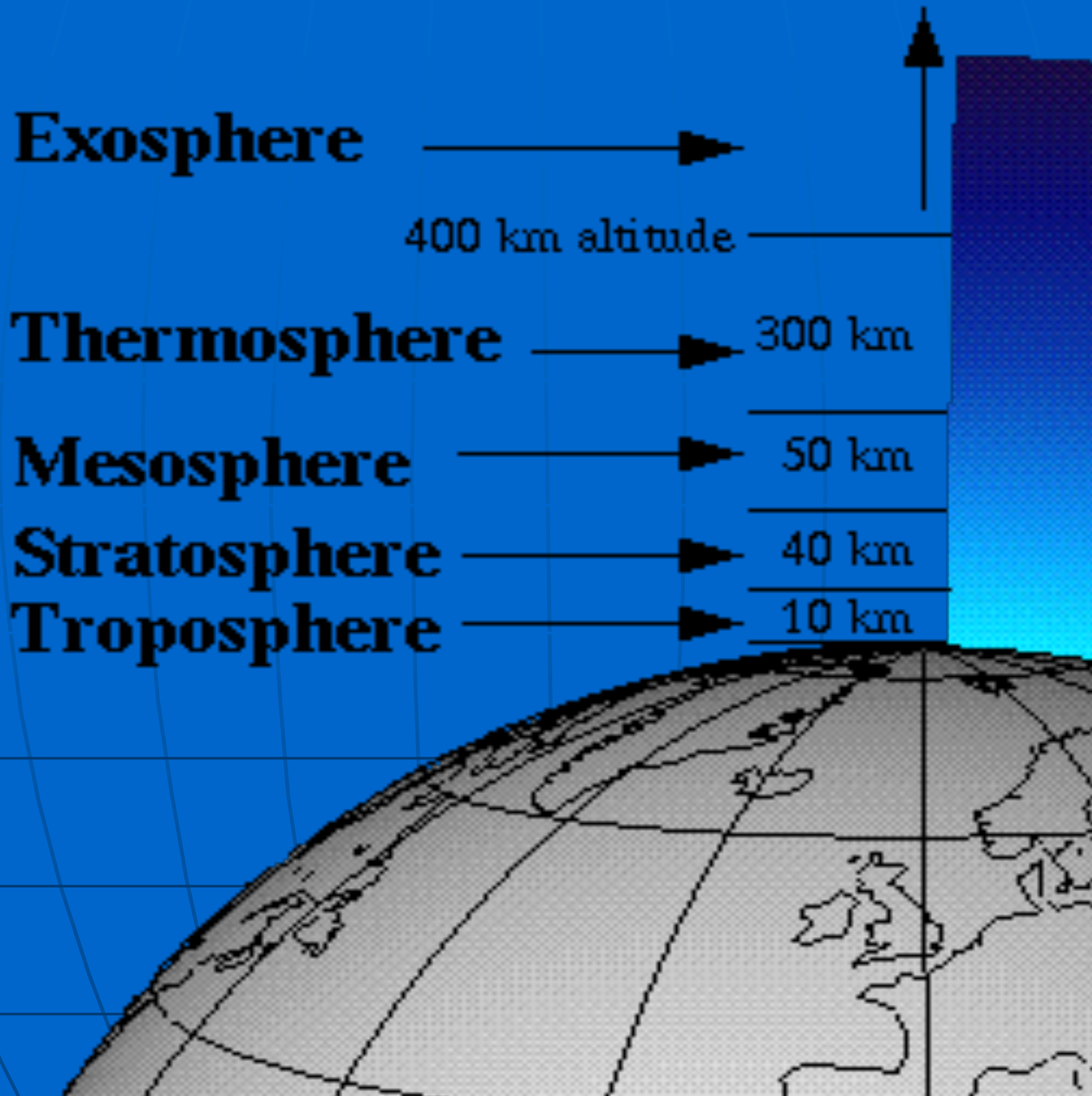
Total Ozone Mapping Spectrometer (TOMS)

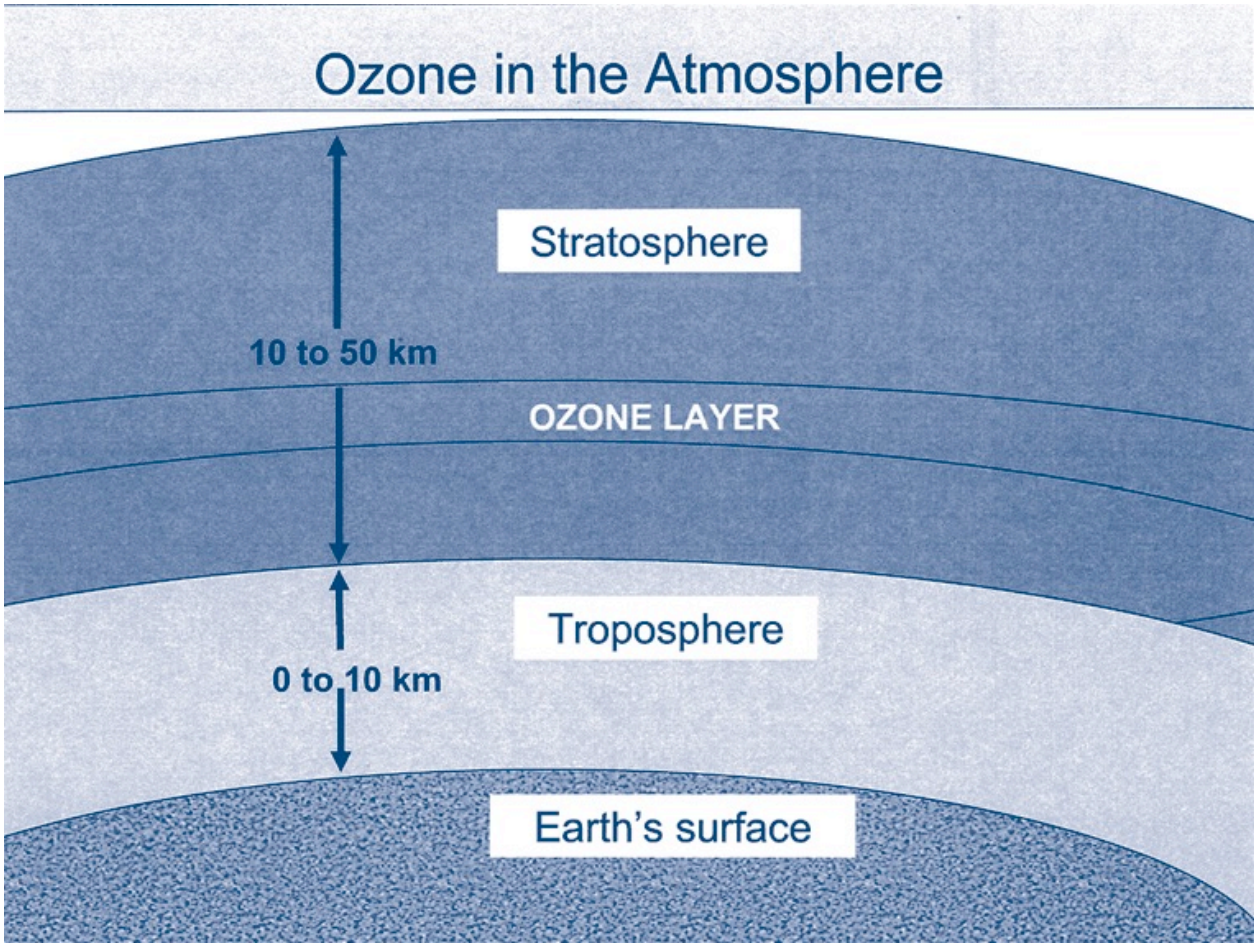
- Used by NASA to measure ozone concentrations
- TOMS – a satellite-borne instrument
- TOMS launched in 1996 – makes 35 measurements every 8 seconds
- Levels of ozone are measured in Dobson units (DU), where 100 DU is equivalent to a 1 millimeter thick layer of pure ozone



Artist's view of the QuikTOMS spacecraft (image credit: NASA)

Earth’s Atmosphere





Ozone concentrations: ~ 2-8ppm , 15-35 km above earth. Thickness varies seasonally and geographically.

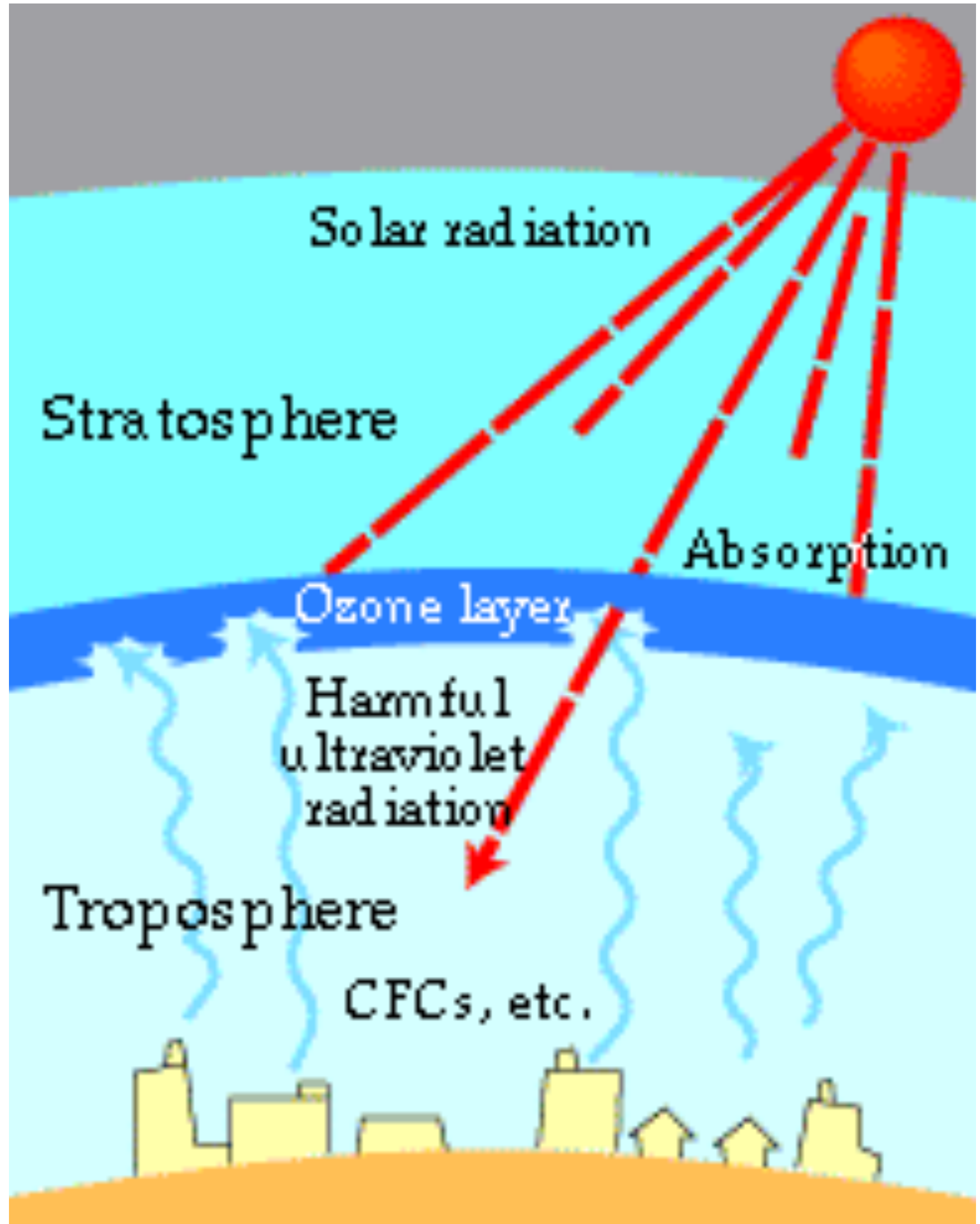
~90% of the ozone in our atmosphere is contained in the stratosphere

The ozone layer

•Ozone is a triatomic form of oxygen (O_3) found in Earth's upper and lower atmosphere.

•Ozone protects living organisms by absorbing harmful ultraviolet radiation from the sun.

•The ozone layer is being destroyed by CFCs and other substances.



www.epcc.pref.osaka.jp/apec/eng/earth/**ozone**_layer_depletion/susumu.html

Ozone cycle (Chapman Cycle)

- The stratosphere is in a constant cycle with oxygen molecules and their interaction with ultraviolet rays.
- This process is deemed a cycle because of its constant conversion between different molecules of oxygen. The ozone layer is created when ultraviolet rays react with oxygen molecules (O_2) to create ozone (O_3) and atomic oxygen (O). This process is called the Chapman Cycle.

1. An oxygen molecules is photolyzed by solar radiation, creating two oxygen radicals:

   $$hv + O_2 \rightarrow 2O\cdot$$

2. Oxygen radicals then react with molecular oxygen to produce ozone:

   O2 + O. → O3

3. Ozone then reacts with an additional oxygen radical to form molecular oxygen:

   $$O_3 + O\cdot \rightarrow 2O_2$$

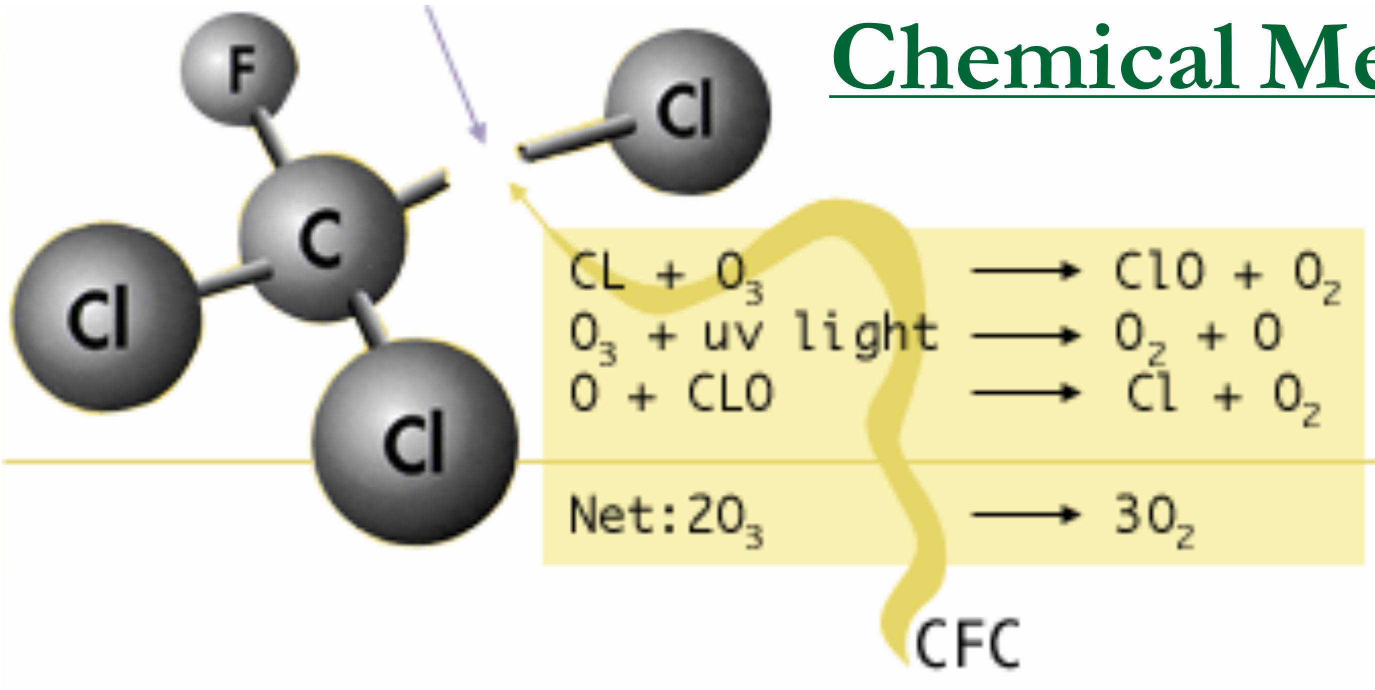
4. Ozone can also be recycled into molecular oxygen by reacting with a photon:

   $$O_3 + hv \rightarrow O2 + O\cdot$$

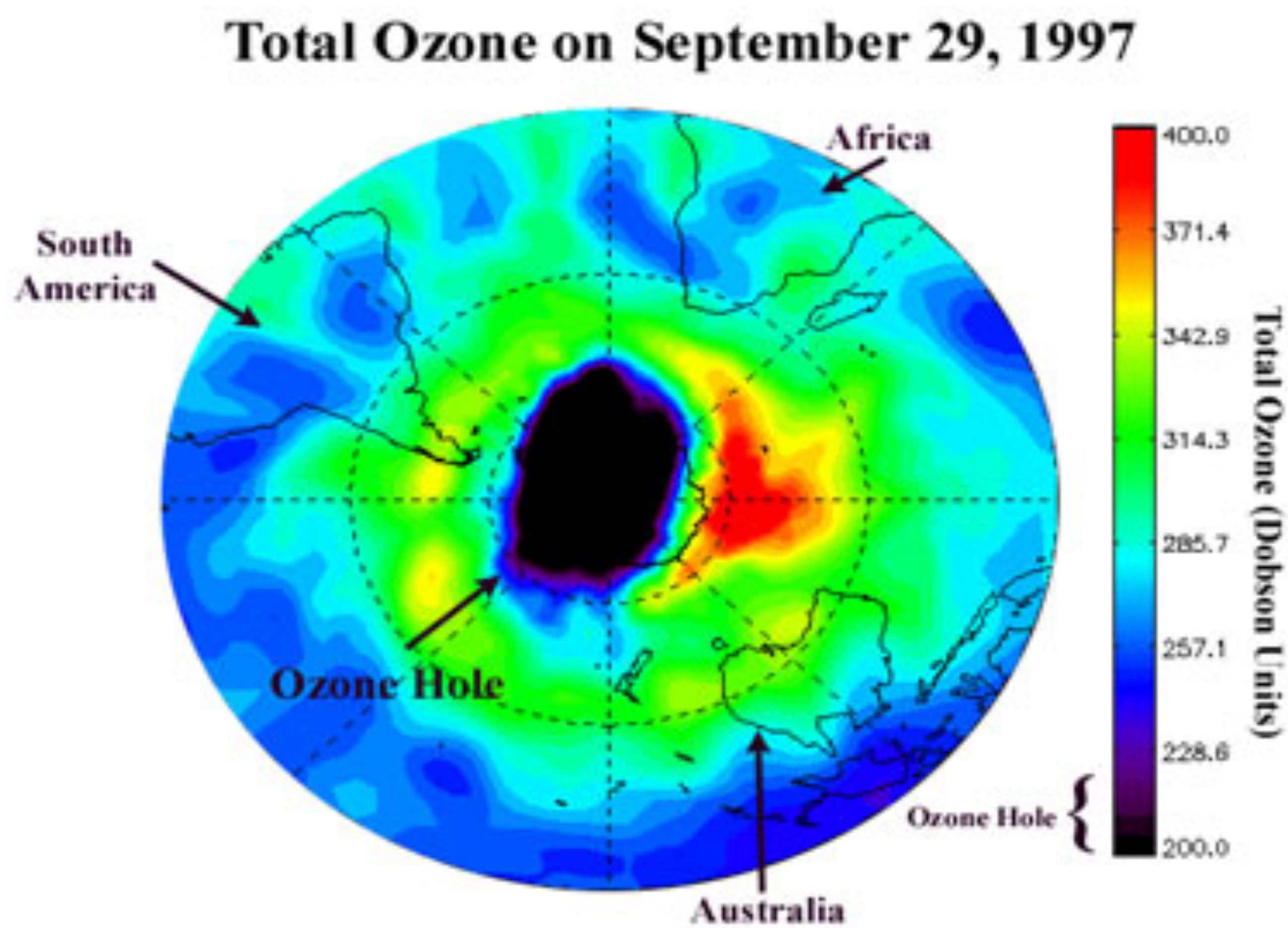
- Human activity has dramatically increased the levels of chlorine and bromine.
- These elements are found in certain stable organic compounds, especially chlorofluorocarbons (CFCs), which may find their way to the stratosphere without being destroyed in the troposphere due to their low reactivity.
- In the stratosphere, the Cl and Br atoms are liberated from the parent compounds by the action of ultraviolet light, e.g.

$CFCl_3$ + electromagnetic radiation → $CFCl_2$ + Cl

Chemical Mechanism



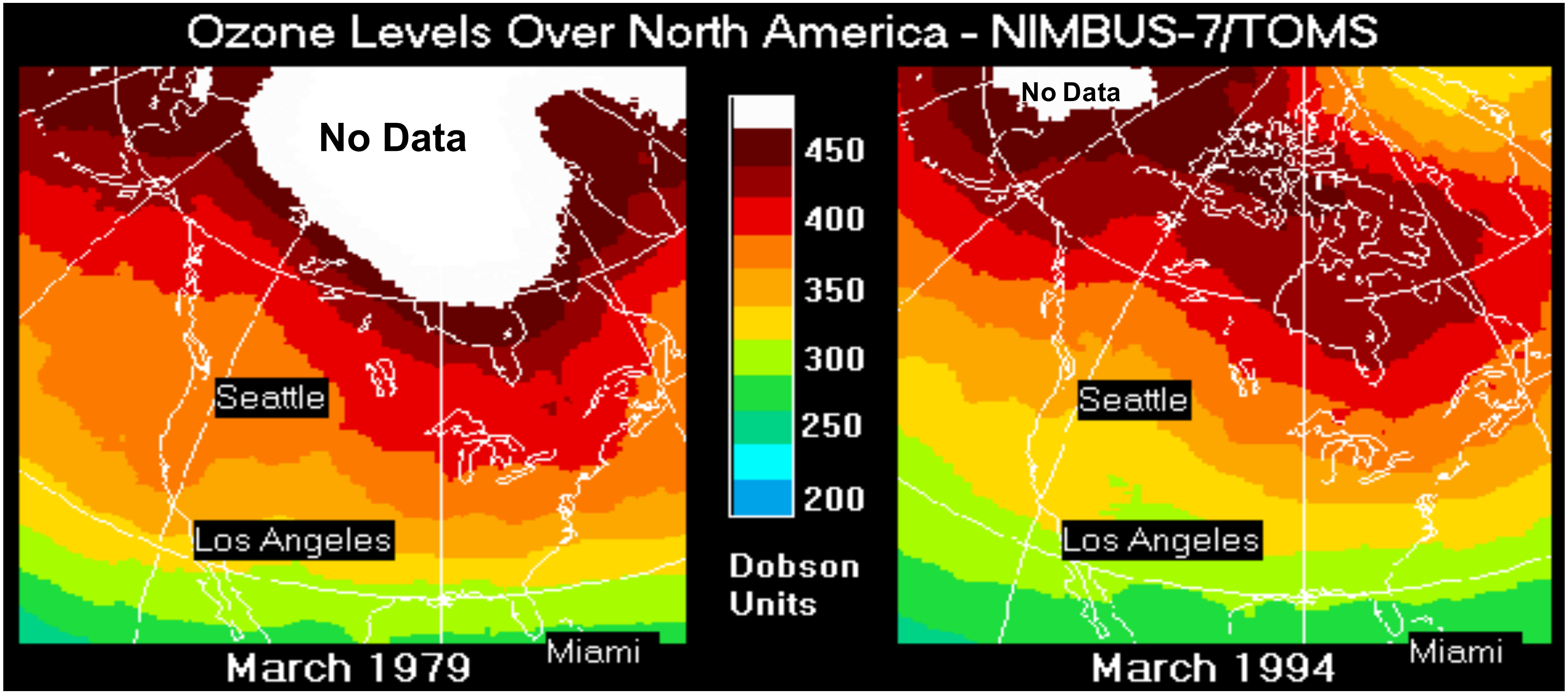
- Different chemicals are responsible for the destruction of the ozone layer
- Topping the list :
  - chlorofluorocarbons (CFC's)
  - man-made, non-toxic and inert in the troposphere
  - In the stratosphere are photolysed, releasing reactive chlorine atoms that catalytically destroy ozone



A combination of low temperatures and elevated chlorine and bromine concentrations are responsible for the destruction of ozone in the upper stratosphere thus forming a "hole". (Kerr, 1987)

www.met.sjsu.edu/~cordero/ education/education.h

Ozone levels over North America (USEPA, March 1994)



www.epa.gov/air/airtrends/ aqtrnd95/stratoz.html

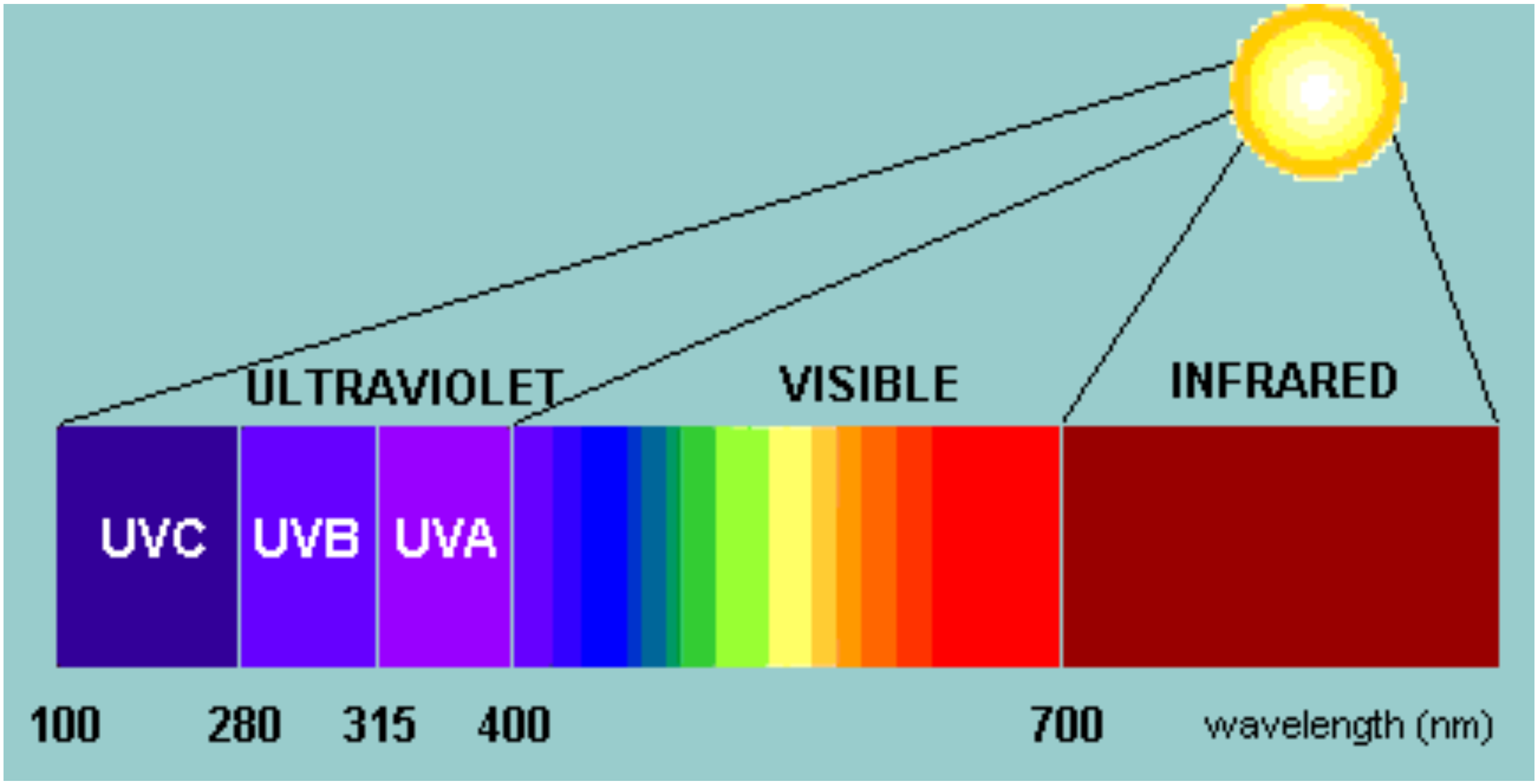
- Comparing the colors of the bands over a particular city, such as Seattle, shows lower ozone levels in 1994 than in 1979
- Over the U.S., stratospheric ozone levels are about 5 % below normal in the summer and 10 % below normal in the winter

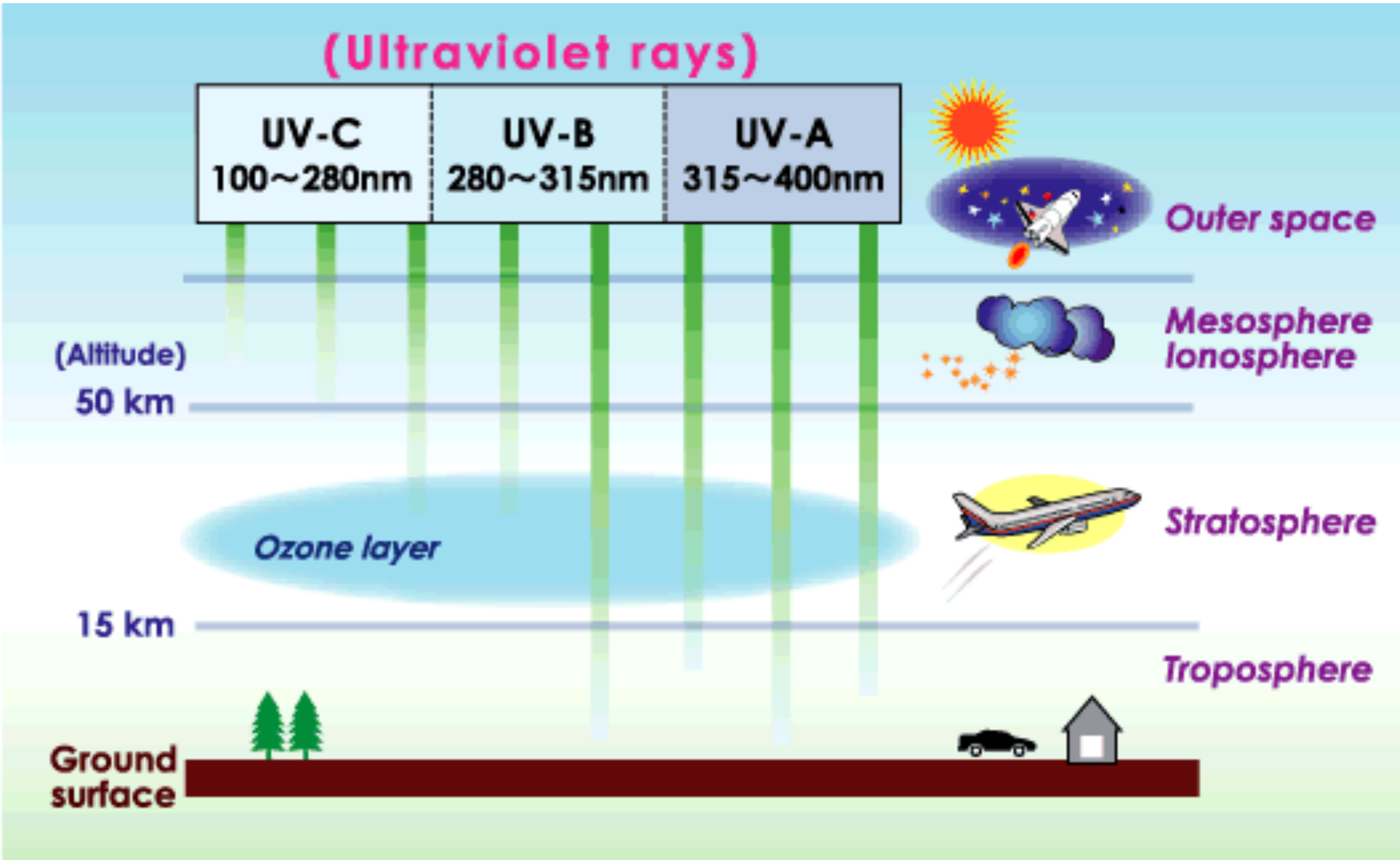
(U.S.E.P.A. 1994)

Stratospheric Ozone and Ultraviolet Radiation (UVR)

- **Ultra-violet radiation (UVR)** high energy electromagnetic wave emitted from the sun. It is made up of wavelengths ranging from 100nm to 400nm.

- **UV radiation includes** **UV-A**, the least dangerous form of UV radiation, with a wavelength range between 315nm to 400nm, **UV-B** with a wavelength range between 280nm to 315nm, and **UV-C** which is the most dangerous between 100nm to 280nm. UV-C is unable to reach Earth's surface due to stratospheric ozone's ability to absorb it.



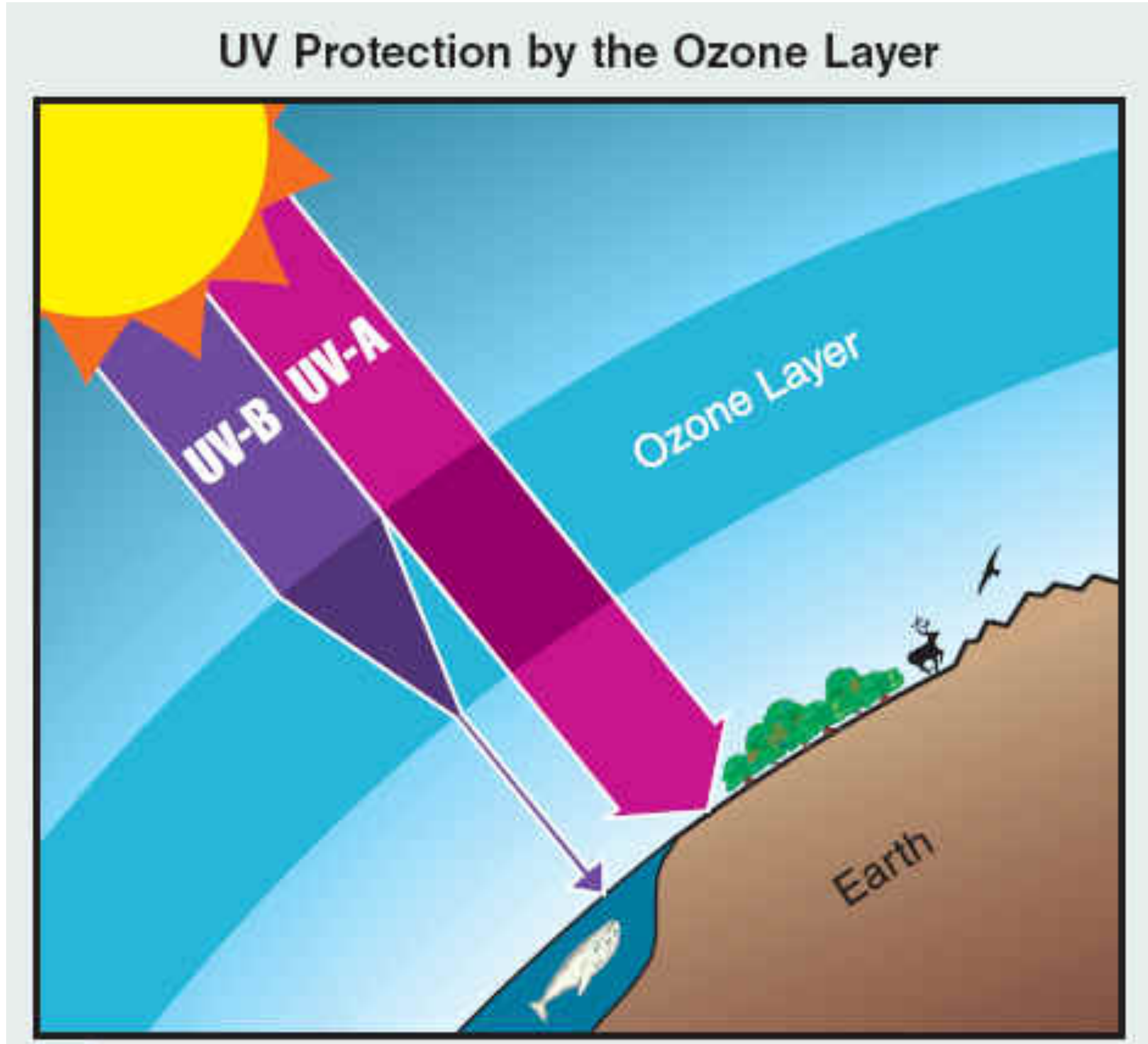

(Ultraviolet rays)
UV-C
100～280nm
UV-B
280～315nm
UV-A
315～400nm
Outer space
Mesosphere
Ionosphere
(Altitude)
50 km
Ozone layer
Stratosphere
15 km
Troposphere
Ground
surface

Stratospheric Ozone and Ultraviolet Radiation (UVR)

- Extremely short or vacuum UV (10–100 nm) is screened out by nitrogen.
- UV radiation capable of penetrating nitrogen is divided into three categories, based on its wavelength
  - UV-A (400–315 nm)
  - UV-B (315–280 nm)
  - UV-C (280–100 nm)
- UV-C, which would be very harmful to all living things, is entirely screened out by a combination of dioxygen (< 200 nm) and ozone (> about 200 nm) by around 35 kilometres (115,000 ft) altitude.
- UV-B radiation can be harmful to the skin and is the main cause of sunburn; excessive exposure can also cause genetic damage, resulting in problems such as skin cancer.
- The ozone layer (which absorbs from about 200 nm to 310 nm with a maximal absorption at about 250 nm) is very effective at screening out UV-B
- For radiation with a wavelength of 290 nm, the intensity at the top of the atmosphere is 350 million times stronger than at the Earth's surface.
- Nevertheless, some UV-B, particularly at its longest wavelengths, reaches the surface.

UV-B radiation (280- to 315-nanometer (nm) wavelength).

UV-A (315- to 400-nm wavelength)



Too much ultra-violet light can result in:

- Skin cancer
- Eye damage such as cataracts
- Immune system damage
- Reduction in phytoplankton
- Damage to the DNA in various life-forms
  - this has been as observed in Antarctic ice-fish that lack pigments to shield them from the ultra-violet light (they've never needed them before)
- Possibly other things too that we don't know about at the moment

Effects of UV radiation on biological organisms

- **DNA damage** …………………………. Maximum effect on small and single cell organisms
- **Impaired growth and photosynthesis** …poor crop yields
- **Phytoplankton**: ………………………..Reduced uptake of CO_2

………………………………………..mortality

………………………………………..Impaired reproductive capacity

- **Nitrogen-fixing soil bacteria**…………. Reduced, damaged
- **Human health effects**:

Suppressed immune system……………..Enhanced susceptibility to infection

………………………………………..Increase risk of Cancer

Dermatology (skin)……………………..Sunburn

………………………………………...Loss of skin elasticity (Premature aging)

……………………………………… Photosensitivity

Neoplasia (cancer)……………………...Melanocytic (malignant melanoma)

………………………………………....Squamous cell skin – cancer

………………………………………Basal skin – cancer

Still questionable if causes lip cancer or cancer of the salivary glands

Oculur (Eye)………………………......Cataract

……………………………………....Pterygium

(last, 1993)

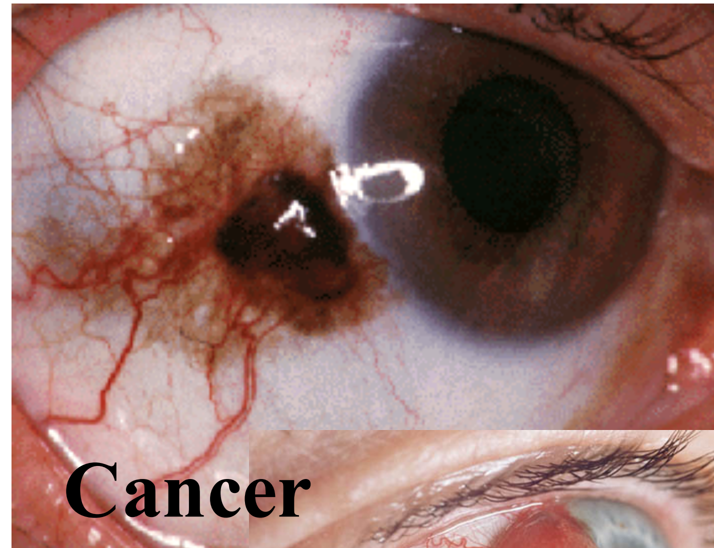
Effects on Human Health

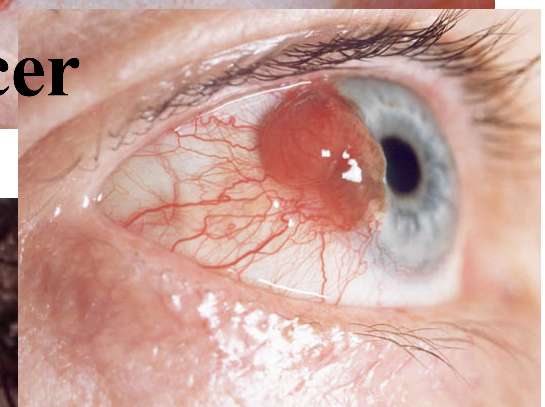
Over Exposure

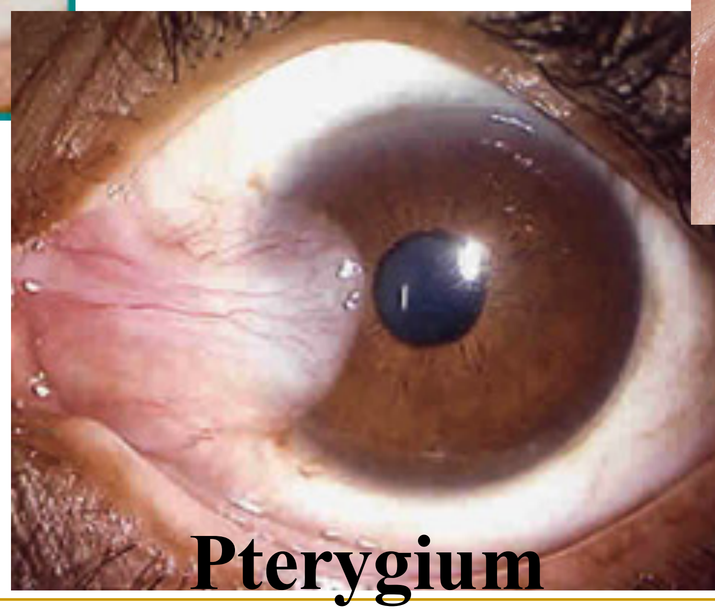
- Suppress immune system
- Accelerate aging of skin due high exposure
- Cause an outbreak of rash in fair skinned people due to photo allergy – can be severe

dermis.multimedica.de/…/en/13007/image.htm

Manifestations of…







brought on by over exposure to UV-B

What Is Being Done to Counter the Effects of Ozone Depletion?

Montreal Protocol

- The **Montreal Protocol on Substances that Deplete the Ozone Layer** (a protocol to the Vienna Convention for the Protection of the Ozone Layer) is an **international treaty** designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.

- Panel of experts was formed to investigate substances responsible for hole formation
  - Established policies that prevent future use of certain types of chemicals
  - Stipulated that the production and consumption of compounds contributing towards depletion of ozone in the stratosphere were to be phased out

What are Ozone depleting substances (ODS)

1. Chemicals that potentially deplete the ozone layer
2. Contain chlorine or bromine atoms
3. Have long atmospheric life

<u>Examples:</u>

Chlorofluorocarbons (CFCs) e.g. CFC-12 (aka R-12 or F-12)
Halons (Bromochlorofluorocarbons) e.g. Halon 1301
Carbon tetrachloride
Methyl chloroform
Hydrochlorofluorocarbons (HCFCs) e.g. HCFC-22 (aka R-22 or F-22)
Hydrobromofluorocarbons (HBFCs)
Bromochloromethane
Methyl bromide

Main uses of ODS

- Refrigerants (gases)
- Fire extinguishers
- Fumigants, pesticides
- Foam-blowing agents
- Cleaning solvents
- Aerosol propellants
- Air-conditioning systems (and components)

- Refrigerators/freezers
- Compressors
- Vehicles (mobile air-conditioning systems)
- Insulating boards/pipe covers
- Metered-dose inhalers (medical inhalers)

Common stratospheric ozone-depleting substances

Uses	Most common materials	Ozone depletion potential*	Global warming potential*	Production banned by 1/1/96	Likely substitute materials	Ozone depletion potential*	Global warming potential*
Industrial chillers	CFC-11†	1.0	1.0	yes	HFC-134a‡	0.0	0.25
	CFC-12	1.0	3.0	yes	HCFC-123§	0.02	0.02
Commercial refrigeration	CFC-12	1.0	3.0	yes	HFC-134a	0.0	0.25
	HCFC-22	0.055	0.36	no	HCFC-123	0.02	0.02
Car/truck A/C	CFC-12	1.0	3.0	yes	HFC-134a	0.0	0.25
Refrigerated transport	CFC-12	1.0	3.0	yes	HCFC-123	0.02	0.02
Computer/ Industrial cleaning	HCFC-113	0.8	1.0	yes	HCFC-225	0.033	0.04
Foam	HCFC-22	0.055	0.36	no			
Home refrigerators and A/C	HCFC-22	0.055	0.36	no			
Quarantine/ soil sterilization	methyl bromide	0.7	—	no			

*Ozone-depletion potential and global-warming potential are relative to those of CFC-11, the chemical found to be most destructive of ozone. These potentials are based upon calculations using laboratory measurements of the properties of each material.
†CFC chlorofluorocarbon
‡HFC hydrofluorocarbon
§HCFC hydrochlorofluorocarbon

Oozone depletion potential (ODP) of a chemical compound is the relative amount of degradation to the ozone layer it can cause, with trichlorofluoromethane (R-11 or CFC-11) being fixed at an ODP of 1.0

Montreal Protocol

- Vienna Convention in 1985
  - framework agreement
- Montreal Protocol in 1987
  - Phase-out schedules for CFCs and halons
- London Amendment in 1990
  - accelerated phase outs; additional CFC's, CCl_4, CH_3CCl_3
- Copenhagen Amendment in 1992
  - added methyl bromide, HBFCs, HCFCs
- Montreal Amendment in 1997
  - finalized phase-out schedules for methyl bromide

Phasing out ODS

Parties to the Montreal Protocol must freeze, reduce and phase out their production and consumption of ODS according to a specific step-wise schedule.

- Approaches:
  - Production Control
  - Consumption Control
  - Trade, Import, export and reimport control
  - Adaptation to Ozone Friendly technology
  - Training and Capacity Building

Phase-out Mandates of the Montreal Protocol

Ozone depleting Substance *Consumption = Imports + production – Exports*	Developed Country (*Article 2 Parties) (this schedule will be applicable for USA , Canada, EU*	Article 5 Parties developing Country (*India*, Mexico etc..)
CFCs	100% phase out Jan. 1st, 1996	Base level: 1995-97 Freeze in Consumption: Jan 1st, 1999 50% Cut:2005 85% Cut:2007 Phase out: Jan. 1st 2010
Halons	100% phase out Jan. 1st, 1994	Base level: 1995-97 Freeze in Consumption: Jan 1st, 1999 50% Cut: 2005 Phase out: Jan. 1st 2010
Methyl Bromide	Phase out 2005	Base level: 1995-98 Freeze in Consumption: Jan 1st, 2001 20% Cut: 2005 Phase out: Jan. 1st 2015

HCFC The schedule for Article 2, Developed countries is:

Schedule	Year
Base line	**1989**
Freeze	From beginning of 1996 Based on 1989 HCFC consumption with an extra allowance (ODP weighted) equal to 2.8% of 1989 CFC consumption.
35%	2004
75%	2010
90% by	2015
Phase out by	2020
Allowing 0.5% for servicing	**2020-2030** and thereafter, consumption restricted to the servicing of Refrigeration and Air-conditioning equipment existing at that date.

The HCFC schedule for Article 5 (developing) countries is:

Schedule	Year
Baseline	Average of 2009 and 2010
Freeze	2013
reduction of 10%	2015
reduction of 35%	2020
reduction of 67.5%	2025
Annual average of 0.5%	2030 to 2040
reduction of 100 %	2040

Others

ODS	Developed	Developing
Hydrobromofluorocarbons (HBFCs)	Phased out end of 1995	Phased out end of 1995
Bromochloromethane (CH_2BrCl)	Phase out by 2002	Phase out by 2002
Hydrobromofluorocarbons (HBFCs)	Phased out end of 1995	Phased out end of 1995

Monitoring

Monitoring the legal trade and preventing the illegal trade of ODS is crucial to achieving the gradual phase-out of ODS and conversion to non-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.

UNEP GRID ARENDAL

Measures - Import License System

An Import / Export Licensing System for ODS controlled by Montreal Protocol is necessary to:

- ✓ Facilitate control of ODS supply
- ✓ Increase the monitoring / collecting of information
- ✓ Identify end users
- ✓ Prevent illegal imports

Role of Customs & Border Control

Customs and other Border Control officials must be part of the monitoring process and enforcement of the measures instituted nationally including ensuring that import and export licenses are issued before ODS can be imported or exported

Trade names

The success of an import/export licensing system depends to a large extent on National Ozone Units (NOUs), Customs agencies and industries being able to distinguish between imported chemical products containing ODS and those that contain non ozone-depleting alternatives.

When information on trade names is available in the market, it is easier for these groups to track and combat illegal imports.

Customs officers can consult UNEP’s database of Trade Names of Chemicals containing ODS

http://www.unep.fr/ozonaction/information/tradenames/main.asp

Trade Names of Chemicals
containing *ozone depleting substances* and their *alternatives*

This service is designed to help customs officials and National Ozone Units control imports and exports of ozone depleting substances (ODS) and prevent their illegal trade. It is a worldwide database of the commercial trade names of chemical products containing ODS controlled under the Montreal Protocol and their alternatives. More...

Quick reports

- Products containing ODS
- Products not containing ODS
- Products listed by HS code
- Products listed by CAS number
- Companies listed in this database
- Montreal Protocol control measures

Search database

Help

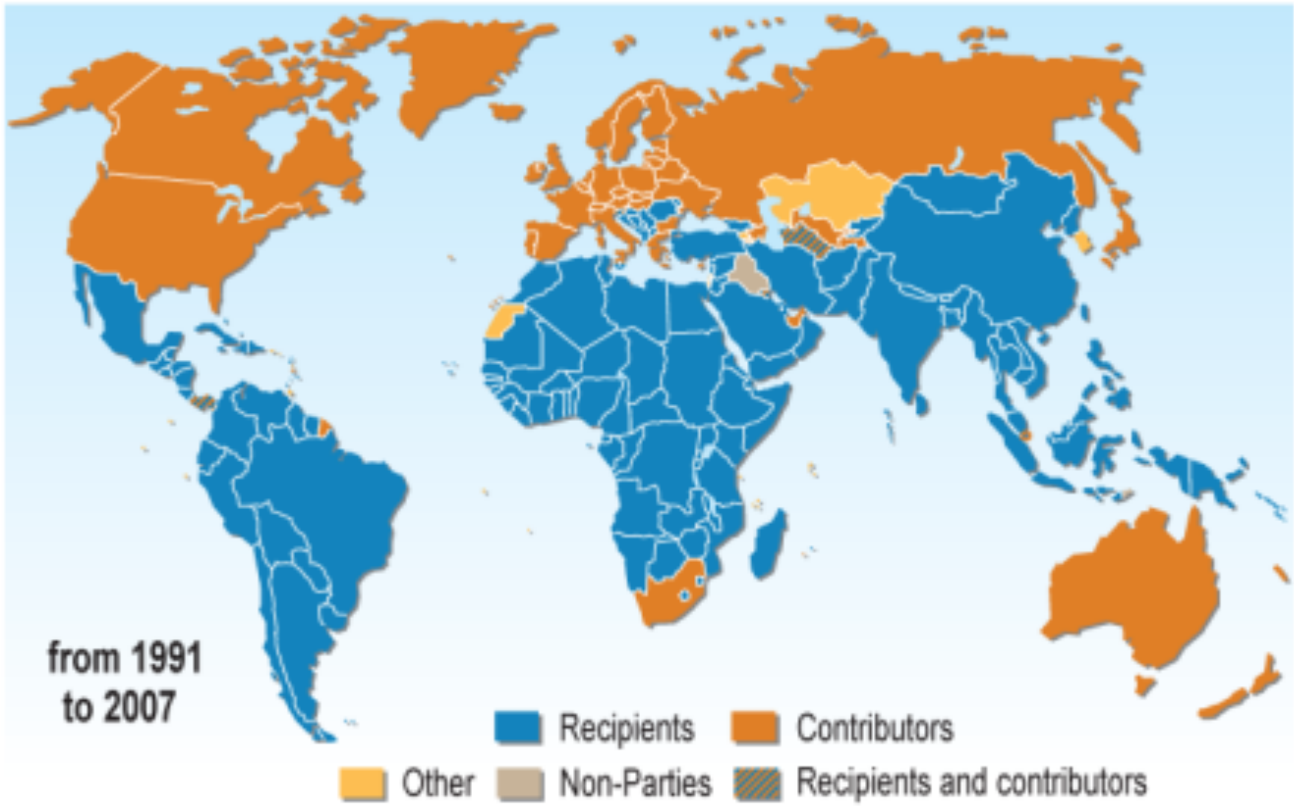
Contents:
- 886 products manufactured by 168 companies located in 30 countries
- 348 single-component ODS and 357 ODS blends
- 82 single-component and 97 blends of non-ODS alternatives

GreenCustoms

Multilateral Fund

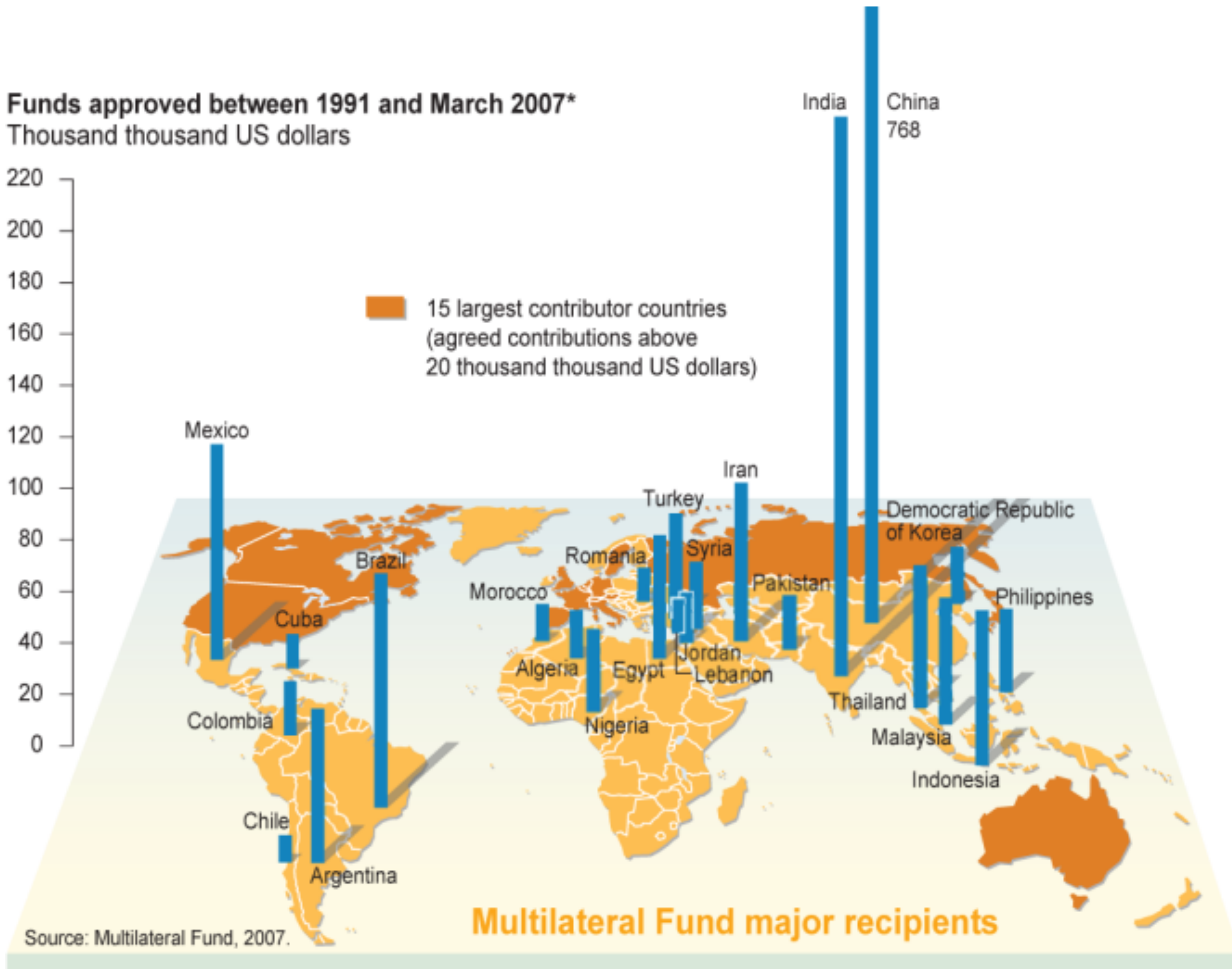
- Objective of the *Multilateral Fund for the Implementation of the Montreal Protocol* is to assist developing country parties whose annual consumption and production of ozone depleting substances (ODS) is less than 0.3 kg/capita to comply with the control measures of the Protocol.
- Currently, 147 of the 196 Parties to the Montreal Protocol meet these criteria (they are referred to as Article 5 countries).
- It embodies the **principle agreed at the United Nations Conference on Environment and Development in 1992 that countries have a common but differentiated responsibility to protect and manage the global commons**.
- The Fund is managed by an Executive Committee with an equal representation of seven industrialized and seven Article 5 countries, which are elected annually by a Meeting of the Parties.
- The fund is replenished on a three-year basis by the donors. Pledges amount to US$2.1 billion over the period 1991 to 2005. Funds are used, for example, to finance the conversion of existing manufacturing processes, train personnel, pay royalties and patent rights on new technologies, and establish national ozone offices.

All recipient and contributor countries of the Multilateral Fund

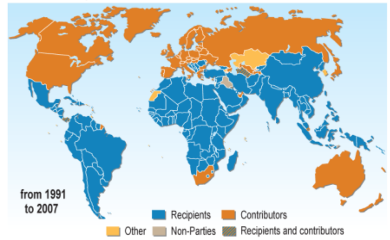


Countries receive funds according to their compliance needs. That is, they receive funds to phase-out specific amounts of ODS production and consumption (see table below for agreed production and consumption amounts). Hence,ODS producer countries and high consumers receive more funds since they have 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.

UNEP GRID ARENDAL


Funds approved between 1991 and March 2007*
Thousand thousand US dollars
220
200
180
160
140
120
100
80
60
40
20
0
15 largest contributor countries (agreed contributions above 20 thousand thousand US dollars)
India
China
768
Mexico
Iran
Turkey
Democratic Republic of Korea
Syria
Romania
Brazil
Pakistan
Morocco
Philippines
Cuba
Jordan
Algeria
Egypt
Lebanon
Thailand
Colombia
Nigeria
Malaysia
Indonesia
Chile
Argentina
Multilateral Fund major recipients
Source: Multilateral Fund, 2007.

All recipient and contributor countries of the Multilateral Fund



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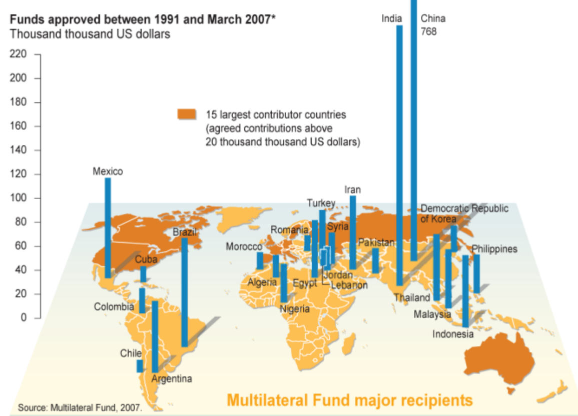
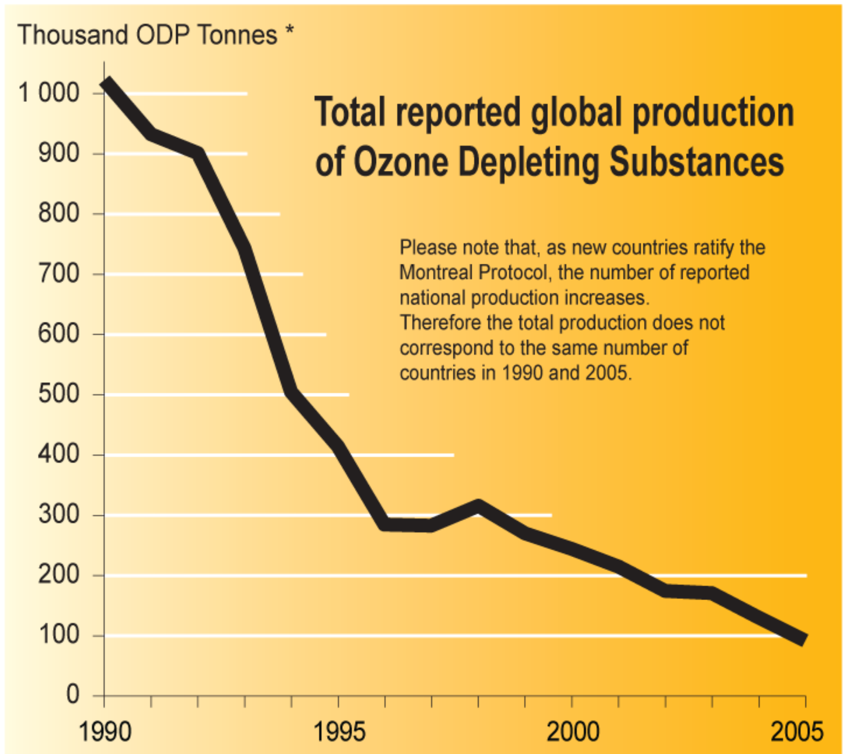


Source: Multilateral Fund, 2007.

Results to date

- The Montreal Protocol is working. There is clear evidence of a decrease in the atmospheric burden of ozone-depleting substances in the lower atmosphere and in the stratosphere

- Some early signs of the expected stratospheric ozone recovery are also evident

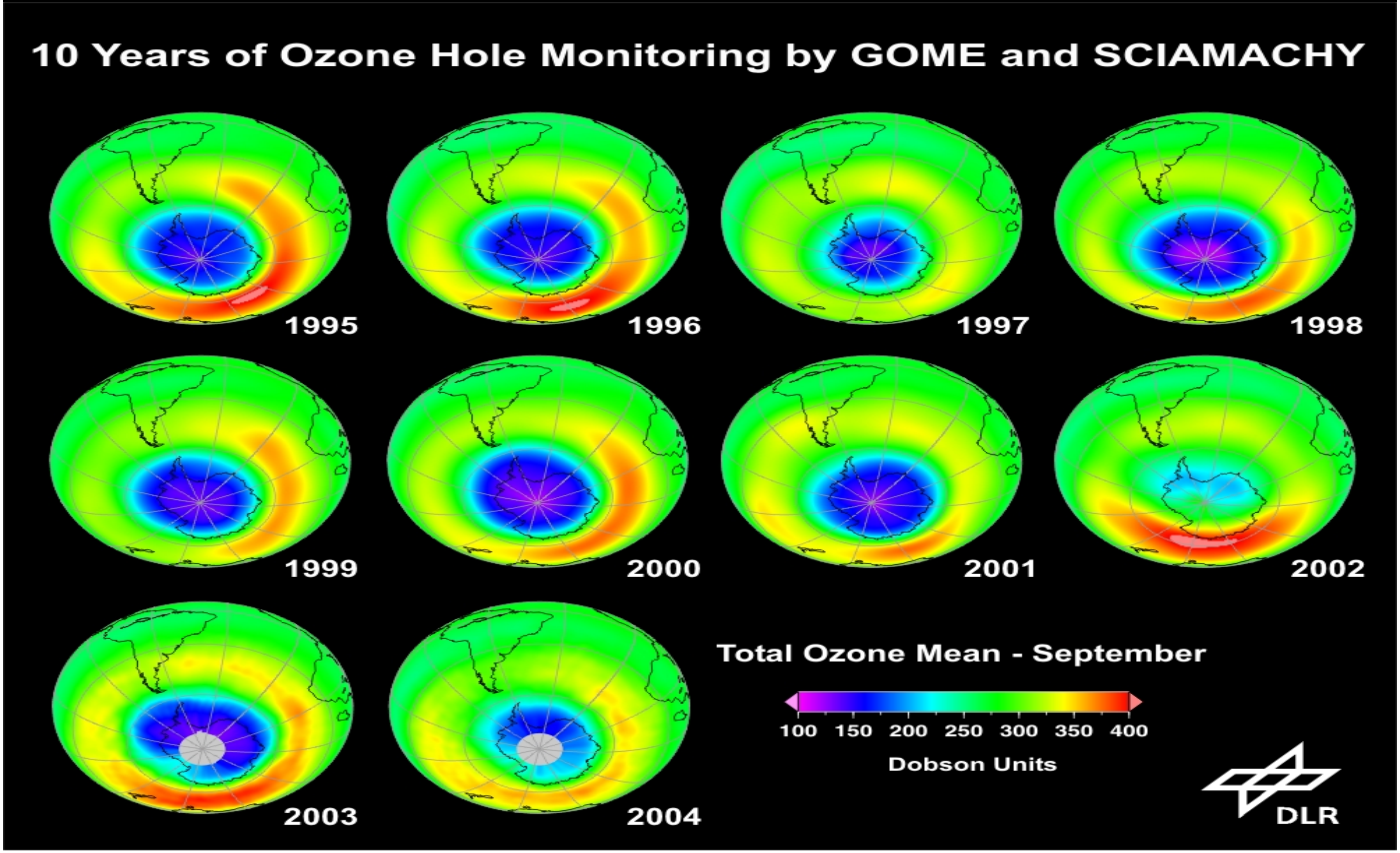


Total reported global production of Ozone Depleting Substances

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

Source: United Nations Environment Programme Ozone Secretariat, 2007.

Images of Antarctica Taken Indicate A Slow Recovery



Failure to Act

- Failure to continue to comply with the Montreal Protocol could delay or even prevent the recovery of the ozone layer.

- Multiple factors, including ozone-depleting substances and climate change, will affect the future state of the ozone layer.

- Every action counts

Without the Montreal Protocol by 2050

- Ozone depletion would have reached to at least 50 % in the northern hemisphere's mid latitudes
- 70% in the southern mid latitudes
- Doubling on the UV-B radiation reaching earth's surface
- Estimated increases of
  - 19 million more cases of non-melanoma cancer
  - 1.5 million more cases of melanoma cancer
  - 130 million more eye cataracts

Amendments to the Montreal Protocol (Source: USEPA)

- The Montreal Protocol has been repeatedly strengthened by both controlling additional ozone-depleting substances (ODS) as well as by moving up the date by which already controlled substances must be phased out.

- Under the original **Montreal Protocol** agreement (1987), CFCs were the only ODSs addressed.

- **The London Amendment** (1990) changed the ODS emission schedule by requiring the complete phaseout of CFCs, halons, and carbon tetrachloride by 2000 in developed countries, and by 2010 in developing countries.

- Methyl chloroform was also added to the list of controlled ODSs, with phaseout in developed countries targeted in 2005, and in 2015 for developing countries.

Amendments to the Montreal Protocol (Source: USEPA)

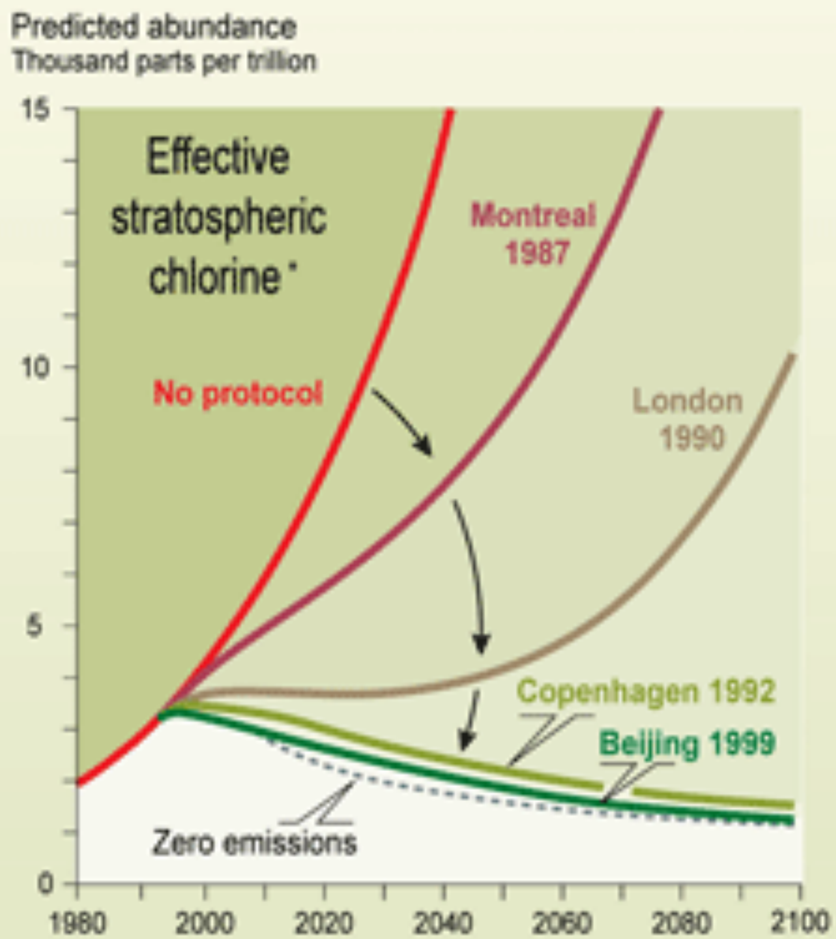
- **The Copenhagen Amendment** (1992) significantly accelerated the phase out of ODSs and incorporated an HCFC phaseout for developed countries, beginning in 2004.

- Under this agreement, CFCs, halons, carbon tetrachloride, and methyl chloroform were targeted for complete phaseout in 1996 in developed countries. In addition, methyl bromide consumption was capped at 1991 levels.

- **The Montreal Amendment** (1997) included the phaseout of HCFCs in developing countries, as well as the phaseout of methyl bromide in developed and developing countries in 2005 and 2015, respectively.

- **The Beijing Amendment** (1999) included tightened controls on the production and trade of HCFCs. Bromochloromethane was also added to the list of controlled substances with phaseout targeted for 2004.

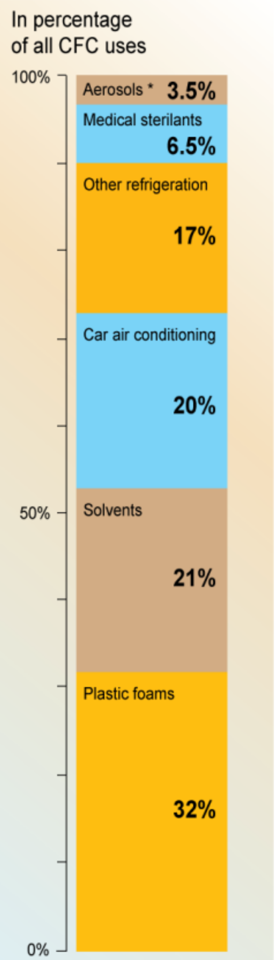
THE EFFECTS OF THE MONTREAL PROTOCOL AMENDMENTS AND THEIR PHASE-OUT SCHEDULES



* 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.

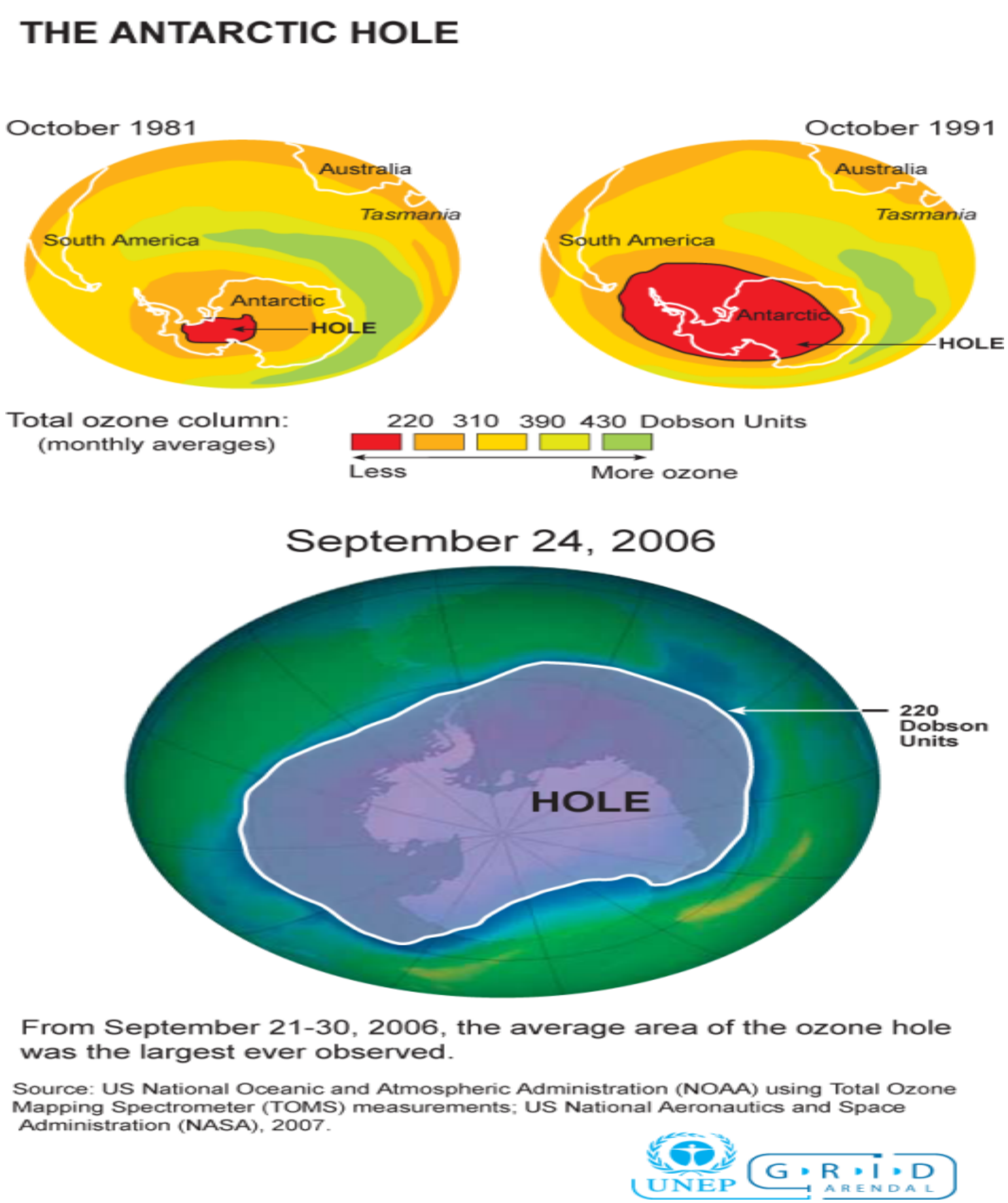
CFC END USES
IN THE US IN 1987



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

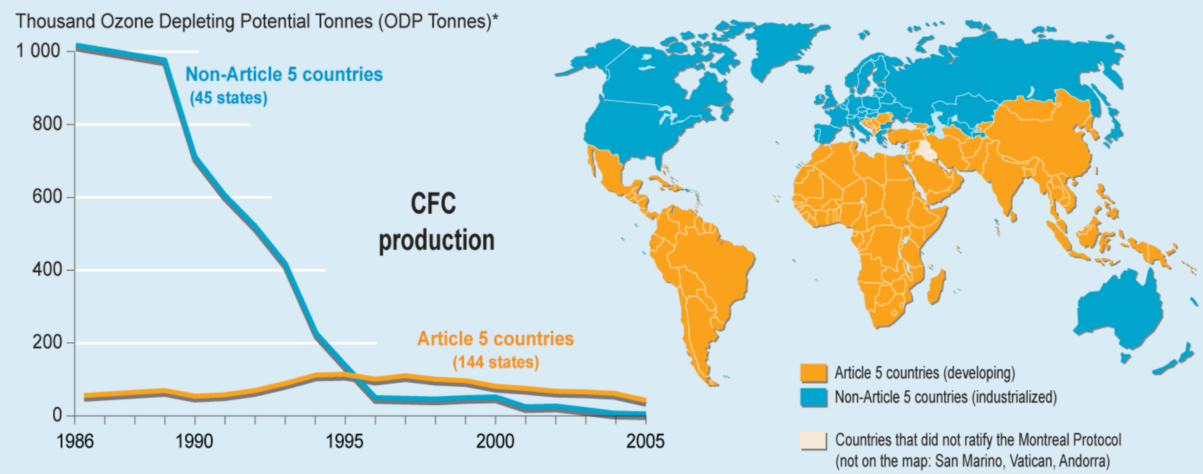
Source: US Environmental Protection Agency, 1992 (cited by WRI 1996).

UNEP GRID ARENDAL



2017 ozone hole smallest since 1988

COMMON BUT DIFFERENTIATED RESPONSIBILITIES

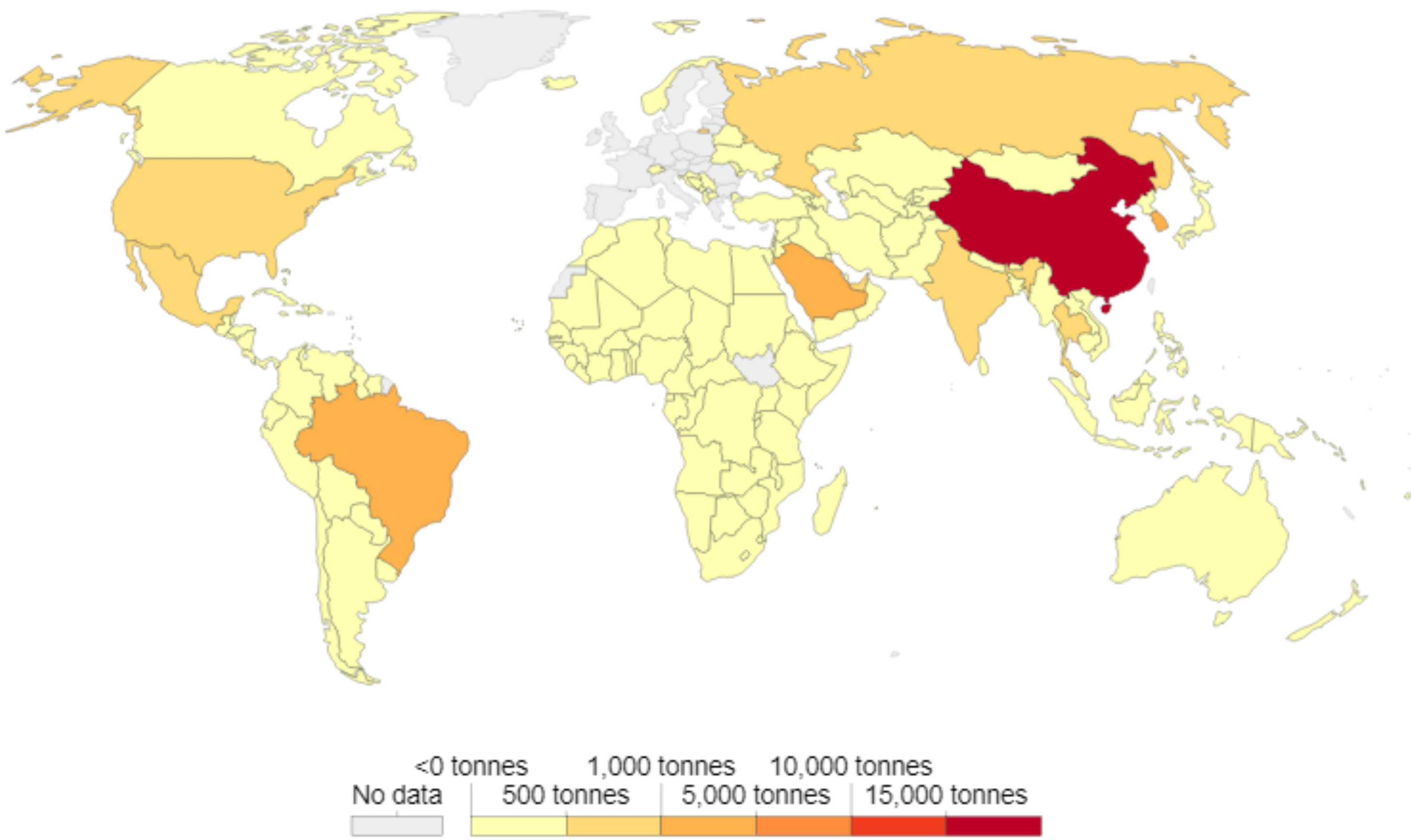


* Tonnes multiplied by the ozone depleting potential of the considered gas.

Source: United Nations Environment Programme Ozone Secretariat

Consumption of Ozone-Depleting Substances, 2014

Consumption of all ozone-depleting substances (ODS). ODS consumption is measured units of ODS tonnes, which is the amount of ODS consumed, multiplied by their respective ozone depleting potential value. Data for individual parties to the European Union (EU) are not shown since party obligations are collective.



Source: United Nations Environment Programme