PROTECT THE OZONE LAYER AND THE CLIMATE

KEMENTERIAN
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ACKNOWLEDGEMENT

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First English Version Publication:
July 2021, Bangkok

PREFACE

The stratospheric ozone layer is vital for life on Earth. Stratospheric ozone is considered good for humans and other life forms because it absorbs ultraviolet (UV) radiation from the Sun, preventing it from reaching the planet's surface. If not absorbed, high energy UV radiation, UV-B, would reach Earth's surface in amounts that are harmful to a variety of life forms. By shielding us from harmful UV-B radiation, it guards us against health risks ranging from skin cancer to cataracts to immune deficiency disorders. The ozone layer also protects the health of animals and ecosystems, both critical pillars of nature that are vital for humanity's well-being.

When reactive halogen gases come into contact with ozone in the stratosphere, they destroy ozone molecules. It is estimated that one chlorine atom can destroy over 100,000 ozone molecules through catalytic reactions before it is removed from the stratosphere. During this process, ozone can be destroyed more quickly than it is naturally created and lead to depletion. Some compounds containing chlorine or bromine atoms release reactive chlorine or bromine gases or atoms when they are exposed to intense UV light and other chemical reactions specific in the stratosphere. These halogen source gases contribute to ozone depletion and are called ozone-depleting substances (ODS). The emissions of manmade ODSs, including chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), is the main cause of damage to the ozone layer. Since 1987, the global community has been working diligently to phase out these harmful substances under the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer. This collective effort has resulted in one of the greatest environmental success stories of our times: scientific evidence now shows that the ozone layer is on track for recovery by the middle of this century. Recently, the Kigali Amendment added climate protection objectives to the Montreal Protocol through the phase down of hydrofluorocarbons (HFCs), which are alternatives to ODS that have significant global warming potential.

Countries in the Asia and the Pacific region continue to be exemplary in these efforts and have already successfully eliminated a wide range of ODSs in many applications. They are on track to completely phase out HCFCs by 2030, control measure set in the Montreal Protocol, and many have begun to take steps to control and phase down HFCs in accordance with the Kigali Amendment.

A key element of their success has been effective outreach and communication of the issue by National Ozone Units to the general public, business community and specific stakeholder groups in their countries involved in Montreal Protocol implementation. This communication effort has not only conveyed the need for action but has also demonstrated that practical and cost-effective solutions are available. Since the Montreal Protocol's work is far from finished, and significant climate protection action is now a priority, these communication efforts must be continued and intensified to ensure that both the existing and emerging challenges will be met.

This booklet was originally developed by the National Ozone Unit in the Directorate General of Climate Change at the Ministry of Environment and Forestry of Indonesia. With the support of the OzonAction Compliance Assistance Programme of the United Nations Environment Programme, and with resources from the Montreal Protocol's Multilateral Fund, this publication has been translated and updated with a view toward making it useful for other countries in the Asia and Pacific region.

Protecting the stratospheric ozone layer is in everybody's interest. Through collaboration, cooperation, and communication, we can ensure that it happens.

June 2021

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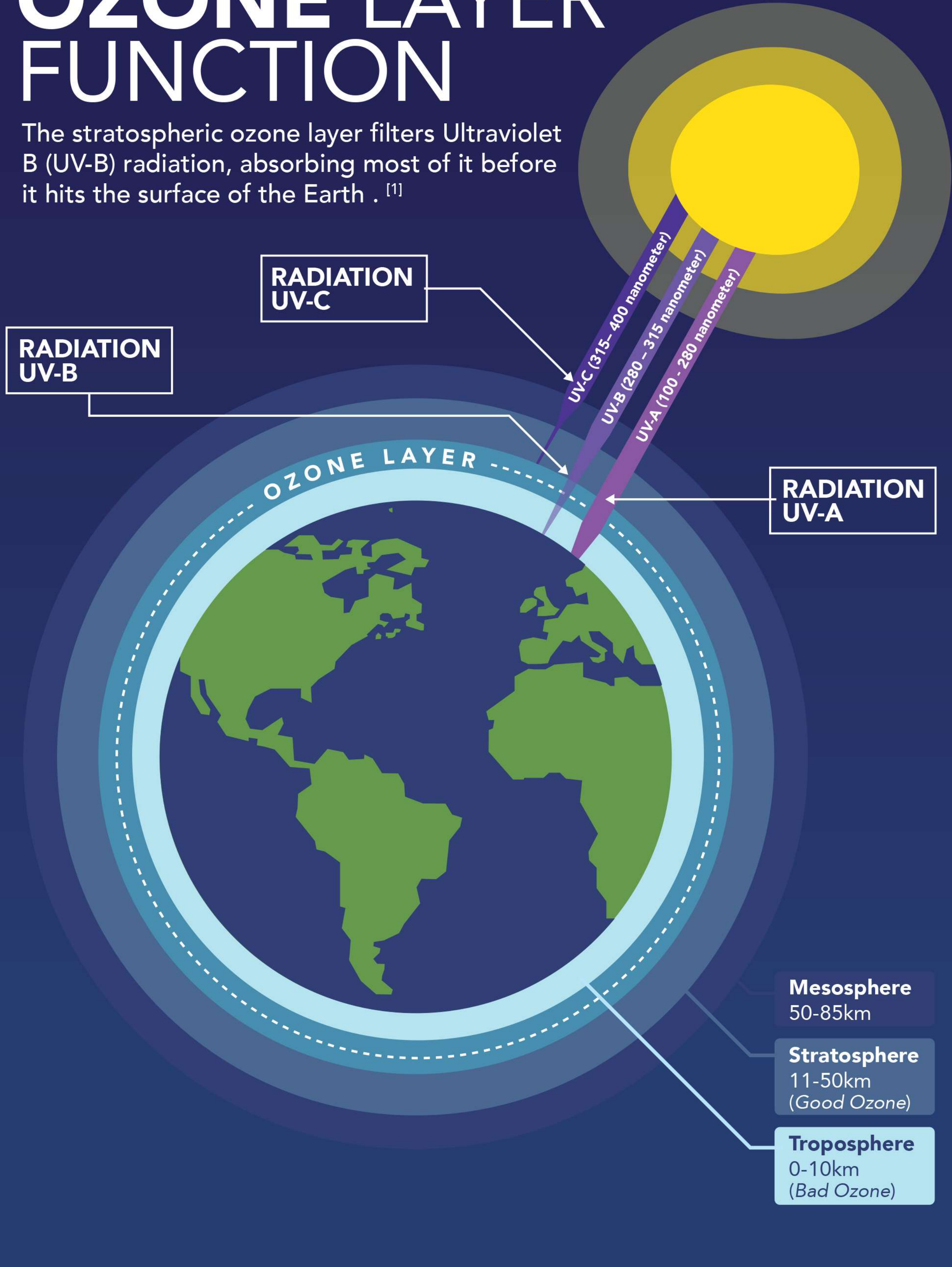
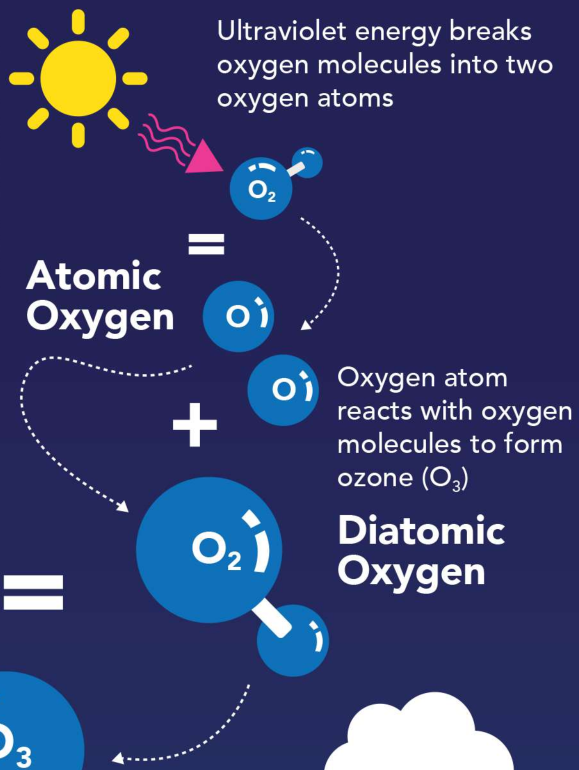
STRATOSPHERIC OZONE LAYER FUNCTION

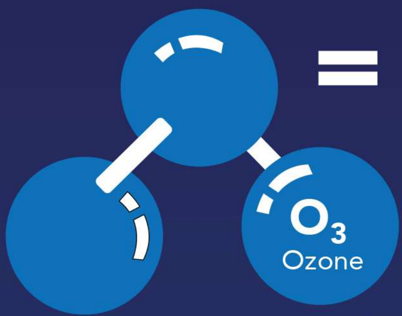
The stratospheric ozone layer filters Ultraviolet B (UV-B) radiation, absorbing most of it before it hits the surface of the Earth . [1]



WHAT IS **OZONE**? [1]

Ozone is a molecule of gas consisting of 3 (three) oxygen atoms.





3 out of 10 million

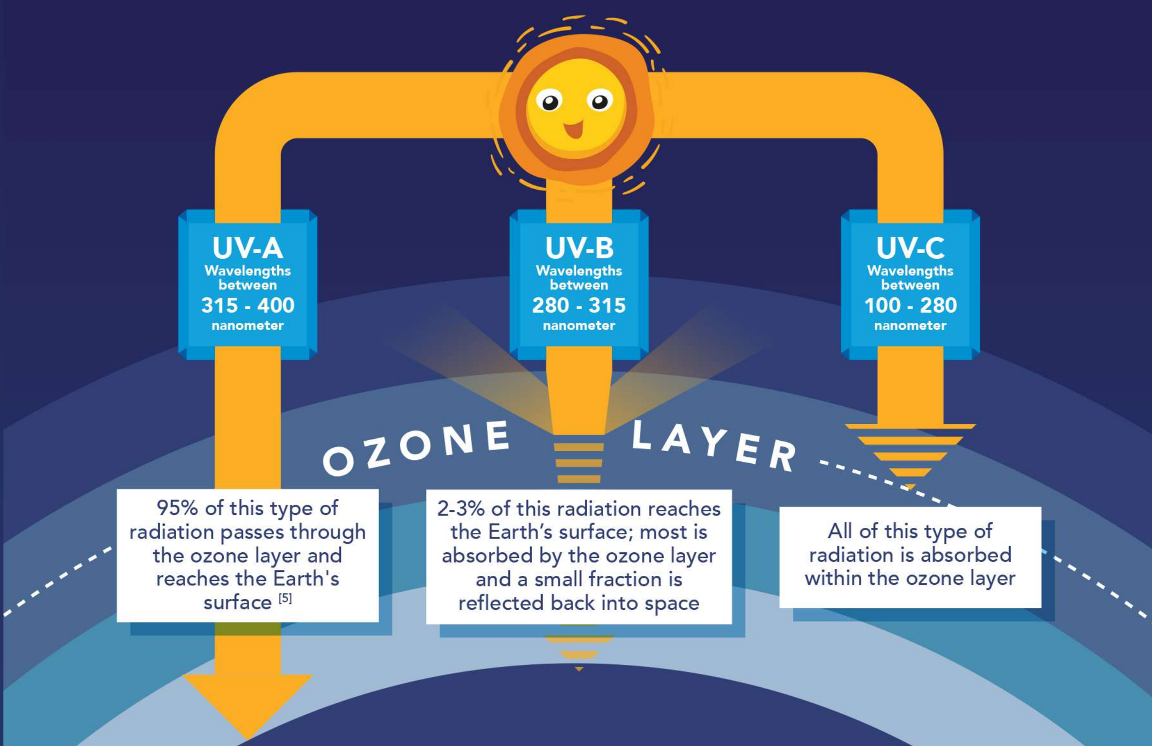
Only 3 out of every 10 million molecules in the Earth's atmosphere are ozone, so these molecules are very rare. [2]

WHERE **ARE OZONE MOLECULES** FOUND?

Up to 90% of ozone molecules are found in the stratosphere and considered as "good ozone", whose function is to protect the Earth from ultraviolet radiation. Meanwhile, 10% of ozone molecules are located in the troposphere (ground level ozone) and considered as "bad ozone", which is formed due to air pollution. [1]

ULTRAVIOLET RADIATION [3]

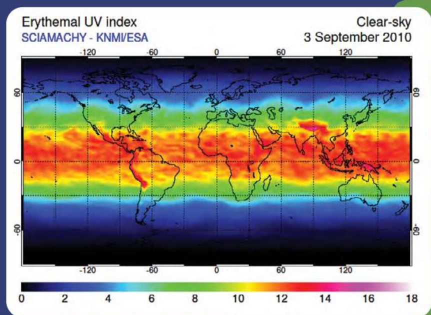
Ultraviolet (UV) radiation is a form of radiant energy emitted by the sun.



Exposure to UV radiation on the Earth's surface can be measured by the UV index. This scale measures UV radiation levels from 0 (low) to 11+ (extreme). [3], [4], [5]

UV INDEX	COLOR CODE	CRITERIA (if without protection)	PROTECTION
0-2	Green	Low	Wear sunglasses and sunblock for sensitive skin
3-5	Yellow	Medium	Wear sunglasses, sunblock, hat/cap, clothes to cover the body
6-7	Orange	High	Wear sunglasses and sunblock SPF 15 or or higher, and clothes to cover the body
8-10	Red	Very high	Same as above, and do not stay outside too long
11 >	Blue	Extremely high	Wear as much protection as possible and avoid exposure from 2 hours before and 3 hours after the sun reaches its zenith

UV index level



UV exposure on Earth

PROTECT YOURSELF
FROM UV RADIATION [6]

Prevent Skin Cancer by Protecting Yourself from Ultraviolet Radiation Rays

Wear A Hat

A hat with at least a 5-8 cm wide brim is ideal for protecting the eyes, ears, forehead, nose, and scalp from UV radiation. A shade cap, with a drape along its sides and back, can protect the ears and neck.

Wear Sunglasses that Block UV

Sunglasses that are equipped with UV protection will filter out the UV light that enters the eye. Research has shown that long hours under the sun without protecting the eyes can increase the risk of certain eye diseases.

Use Sunblock

Use sunblock with an adequate Sun Protection Factor (SPF) relative to your skin type, intensity of sunlight exposure and amount of sunscreen used. Sunblock does not prevent UV exposure entirely. Even though you have used sunblock, UV rays can still penetrate the skin, so you should combine sunblock with other skin protection.

Reduce outdoor activities, especially from 10:00 a.m. to 3.00 p.m. when the sun is high in the sky.

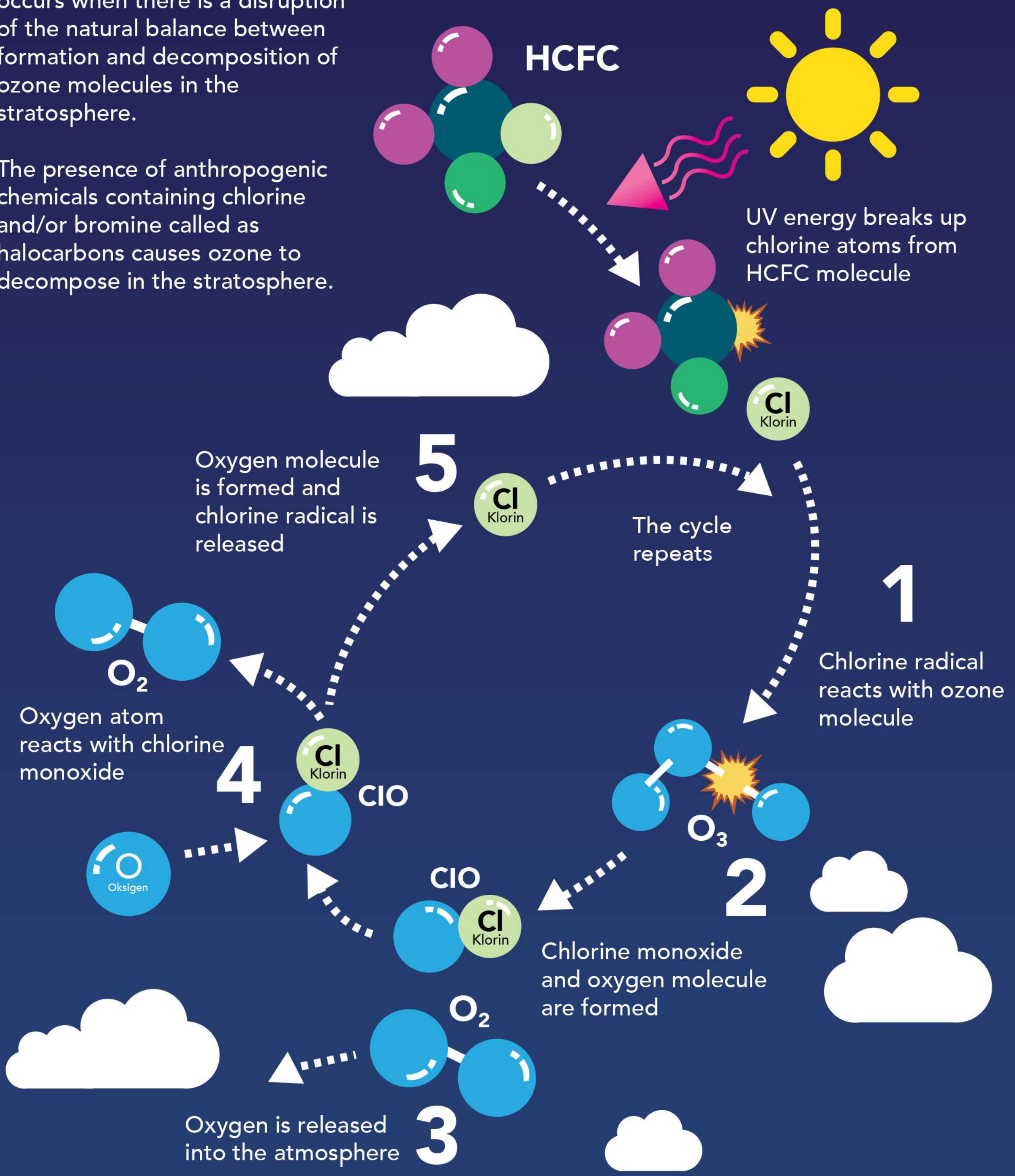
Protect Your Skin with Clothes

When you are outdoors, cover as much of your skin as possible. Long-sleeved clothes, long pants, or long skirts that cover most of the skin are best.

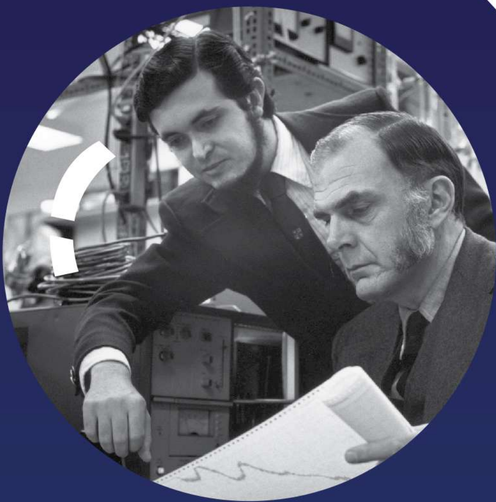
HOW DOES **OZONE DEPLETION** OCCUR? [7]

Depletion of the ozone layer occurs when there is a disruption of the natural balance between formation and decomposition of ozone molecules in the stratosphere.

The presence of anthropogenic chemicals containing chlorine and/or bromine called as halocarbons causes ozone to decompose in the stratosphere.



THE DISCOVERY OF OZONE LAYER DEPLETION [8]



1974

Two scientists from the University of California – Irvine in the United States of America, published the results of laboratory studies showing that chlorofluorocarbon (CFC) compounds could threaten the ozone layer in the presence of UV radiation.

Professor F. Sherwood Rowland

Dr. Mario Molina

1995

Scientists Paul Crutzen, Mario Molina and Sherwood Rowland receive the Nobel Prize in Chemistry for their contribution to explaining how ozone is formed and decomposed through chemical processes in the atmosphere.

HOW IS **OZONE CONCENTRATION MEASURED** IN THE STRATOSPHERE? [9]

Most ozone is found in the stratosphere, which begins about 10 –15 kilometers (km) above Earth's surface and extends up to about 50 km altitude. The total ozone column at any location on the globe is defined as the sum of all the ozone in the atmosphere directly above that location.

The unit used to measure ozone concentration in the stratosphere is the Dobson Unit (DU). One Dobson Unit is the number of molecules of ozone that would be required to create a layer of pure ozone 0.01 millimeters thick at a temperature of 0 degrees Celsius and a pressure of 1 atmosphere.

An ozone hole occurs when ozone concentration is below 220 DU

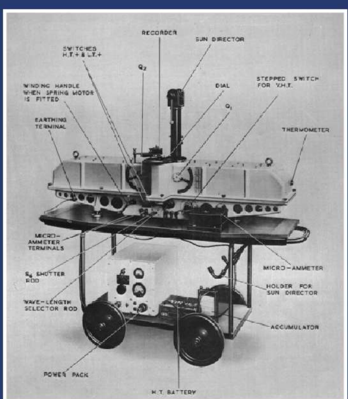
Illustration of Ozone Layer Thickness (on average)

300 DU = 3 mm

3 mm thick ozone layer is comparison of when we bring all the ozone molecules at the 1 atmosphere pressure (at the Earth's surface) and 0 Celsius degree temperature.

100 DU = 1 mm

Illustration of Ozone Depletion Concentration

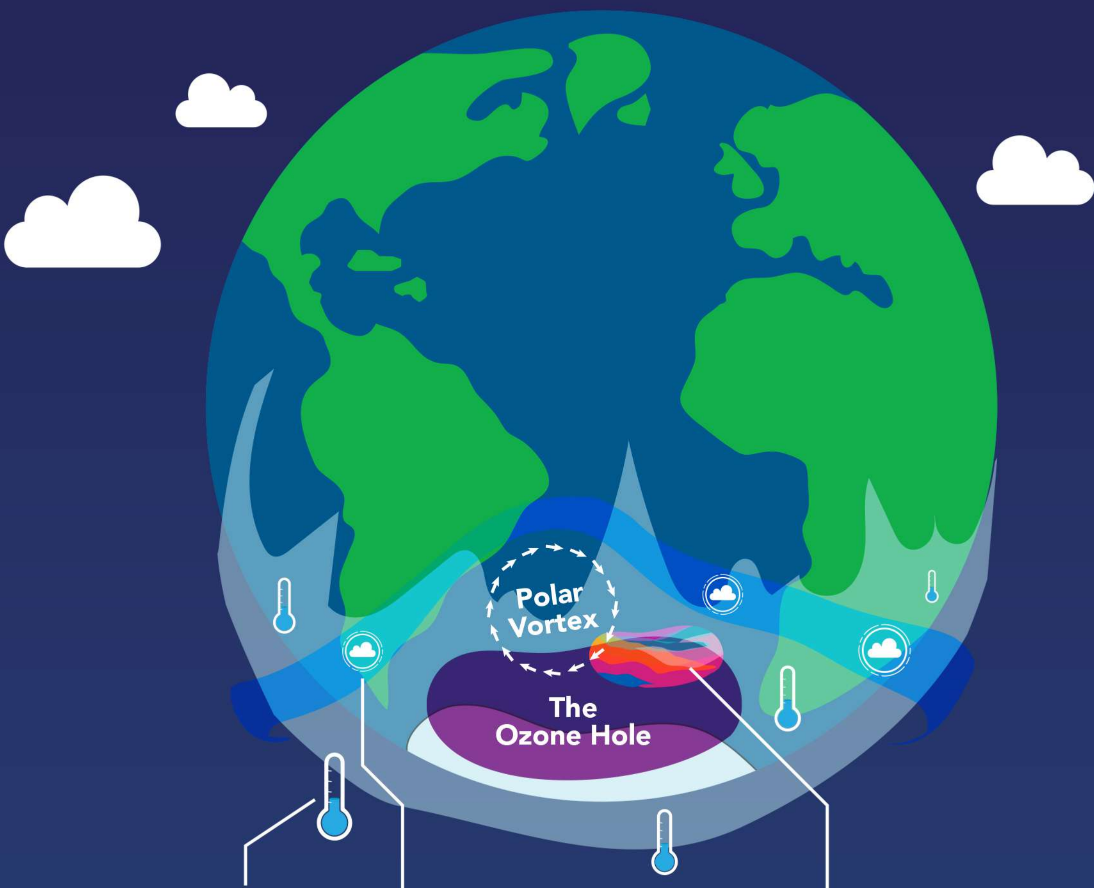


The amount of ozone in the atmosphere is measured by an instrument operated on land or carried by a balloon, airplane or satellite. One of these is called a Dobson spectrophotometer, after its inventor Sir G.M.B. Dobson. A Dobson spectrophotometer has been located at the South Pole since 1931 to monitor ozone concentration by measuring how much UV radiation is reaching the Earth's surface.

Source of photo:
Belgian Institute for Space Aeronomy website, the Dobson instrument
(http://ozonehistory.aeronomie.be/thedobsoninstrument.html)

WHY IS OZONE HOLE FOUND AT THE **SOUTH POLE?** [1]

An ozone hole was first detected at the South Pole in late winter and early spring due to seasonal atmospheric conditions and the unique chemical composition in the atmosphere of the region. The very low temperatures during the south pole winter enable the formation of polar stratospheric clouds (PSCs). These ice clouds combined with isolated air in the polar vortex, ultraviolet radiation and halogen source gases create more favourable conditions for chemical reactions that deplete the ozone than in other places.



Very low temperature. This condition causes the formation of PSCs, and chemical reactions on the surfaces of these clouds initiate a remarkable increase in the most reactive chlorine gas, chlorine monoxide (ClO).

Isolated Conditions. The Southern Hemisphere polar vortex circulation tends to be stronger than that in the Northern Hemisphere. Once temperatures drop low enough, PSCs form within the polar vortex and induce chemical changes such as an increase in the abundance of ClO that are preserved for many weeks to months due to the isolation of polar air.

Polar Stratospheric Clouds. The reaction between the liquid and solid surfaces of these clouds can increase the formation of reactive chlorine gas, causing chemical reactions that break down ozone bonds.

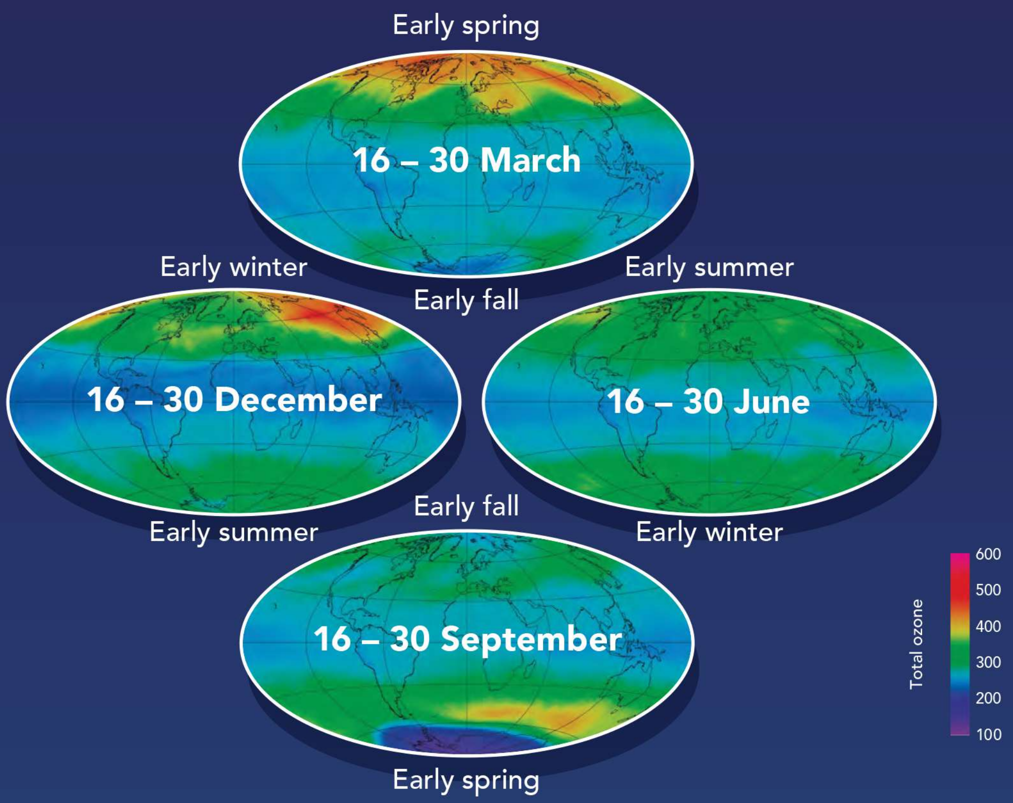
THE OZONE LAYER **IN THE TROPICS**

Ozone is formed in the tropical region because of the presence of strong UV light from the sun throughout the year. But more ozone is found outside the tropics, at higher latitudes, as a result of the large-scale circulation of air in the stratosphere, that transports ozone from the tropics to the middle and polar latitudes. This slow circulation is known as Brewer-Dobson circulation.

The average amount of ozone around the equator is less than 300 DU throughout the year.

That is why it is necessary to always protect yourself from overexposure to UV-B radiation in this region.

Global Satellite Maps of Total Ozone in 2009



Brewer-Dobson Circulation [10]

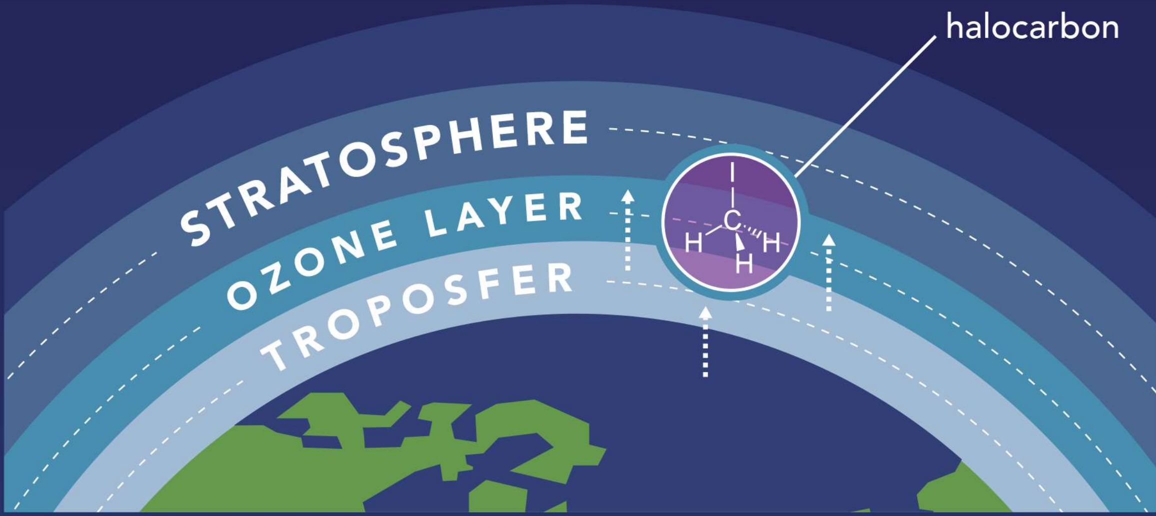
Alan Brewer and Gordon Dobson explained how stratospheric ozone is distributed around the globe with their circulation model.

Global distribution of the ozone layer is the result of the large-scale circulation of air in the stratosphere that slowly transports ozone from the tropics, where ozone production from solar ultraviolet radiation is highest, toward the poles. Ozone accumulates at middle and high latitudes, increasing the vertical extent of the ozone layer and, at the same time, total ozone. This poleward ozone transport is much weaker during the summer and early autumn periods and is weaker overall in the Southern Hemisphere.

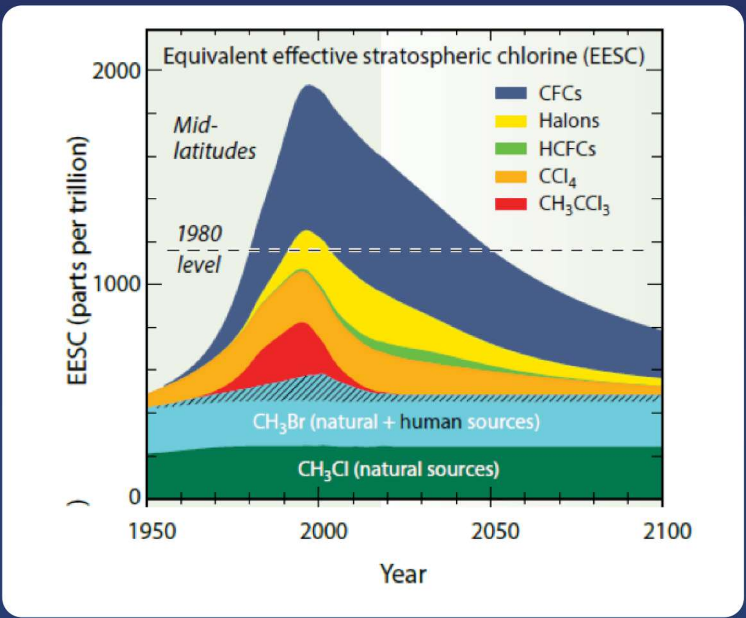
OZONE-DEPLETING SUBSTANCE **(ODS)**

Ozone-depleting substances (ODS) are chemical compounds that consist of carbon, hydrogen, chlorine and/or bromine. They are known as halocarbons.

Halocarbon compounds are very stable, and do not break down in the lower atmosphere (troposphere). This allows the compounds to reach the stratosphere and remain there for up to 120 years.



Past and Projected Atmospheric Abundances of Halogen Source Gases.

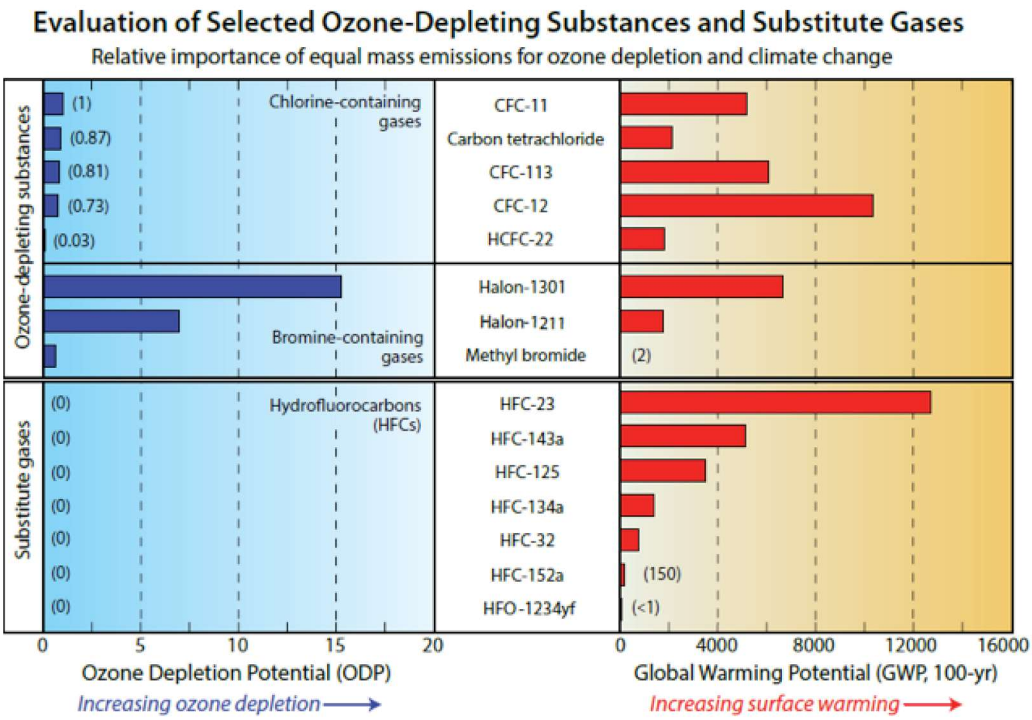


Note:
Equivalent effective stratospheric chlorine is a measure of the total amount of reactive chlorine and bromine gases in the stratosphere that is available to deplete stratospheric ozone.

Source: Twenty Questions and Answers About the Ozone Layer: 2018 Update, Scientific Assessment of Ozone Depletion: 2018, November 2019, pp.55 (http://ozone.unep.org/science/assessment/sap) [11]

OZONE DEPLETION POTENTIAL **(ODP)**

Ozone depletion potential (ODP) is a term to describe the potential of chemicals to damage the ozone layer. Each ozone depleting substance has a different ODP value, which is a measure of how much damage it can cause to the ozone layer relative to CFC-11/CFC-12.



Source: Twenty Questions and Answers About the Ozone Layer: 2018 Update, Scientific Assessment of Ozone Depletion: 2018, November 2019, pp 64. (http://ozone.unep.org/science/assessment/sap) [11]

ODS	ODP VALUE*	LIFETIME, YEARS **
CFC 11	1.0	52
CFC 12	1.0	102
Halon 1301	10.0	72
Halon 1211	3.0	16
HCFC 22	0.055	12
HCFC 123	0.02	1.3
HCFC 141b	0.11	9.4
Carbon tetrachloride	1.1	32
Methyl bromide	0.6	0.8
Methyl chloroform	0.1	5

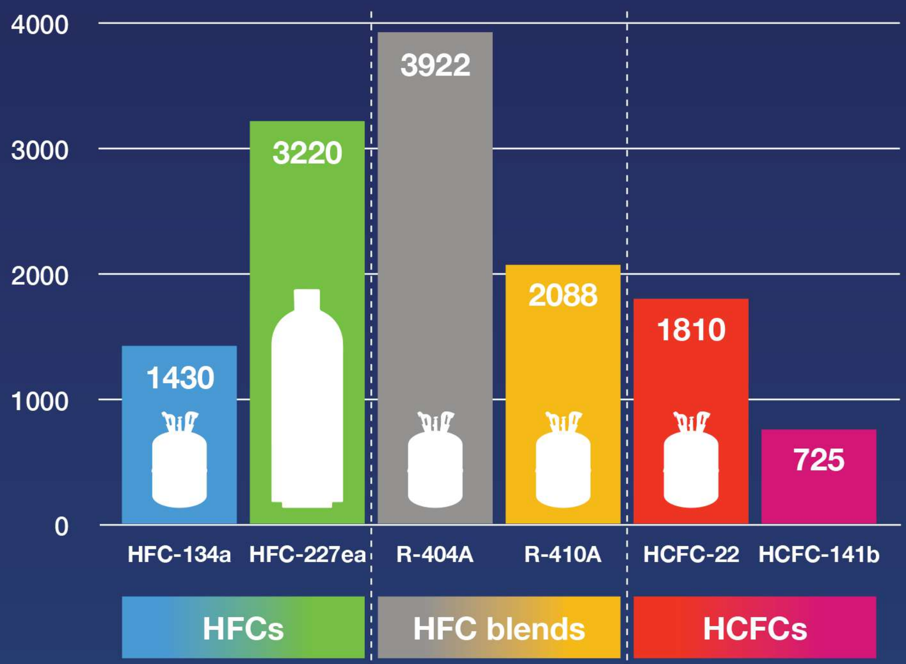
Source:
1) *ODP Value from Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer. fourteenth edition, UNEP Ozone Secretariat, 2020, pp.31-34 [12]
2) **Atmospheric lifetime, years from, Scientific Assessment of Ozone Depletion: 2018, Global Ozone Research and Monitoring Project–Report No. 58, WMO (World Meteorological Organization), 2018. pp.452 [13]

GLOBAL WARMING POTENTIAL AND OZONE PROTECTION [14]

Greenhouse gases include carbon dioxide, methane, nitrous oxide and many others. Synthetic chemicals, such as CFCs, HCFCs and HFCs are also greenhouse gases. Some GHGs trap more heat than others. This is called their global warming potential (GWP).

As the world worked to heal the ozone layer, many of the chemicals that replaced ozone-depleting substances were powerful greenhouse gases with high GWP. Some of these replacements had a GWP tens of thousands of times that of carbon dioxide, the most common greenhouse gas.

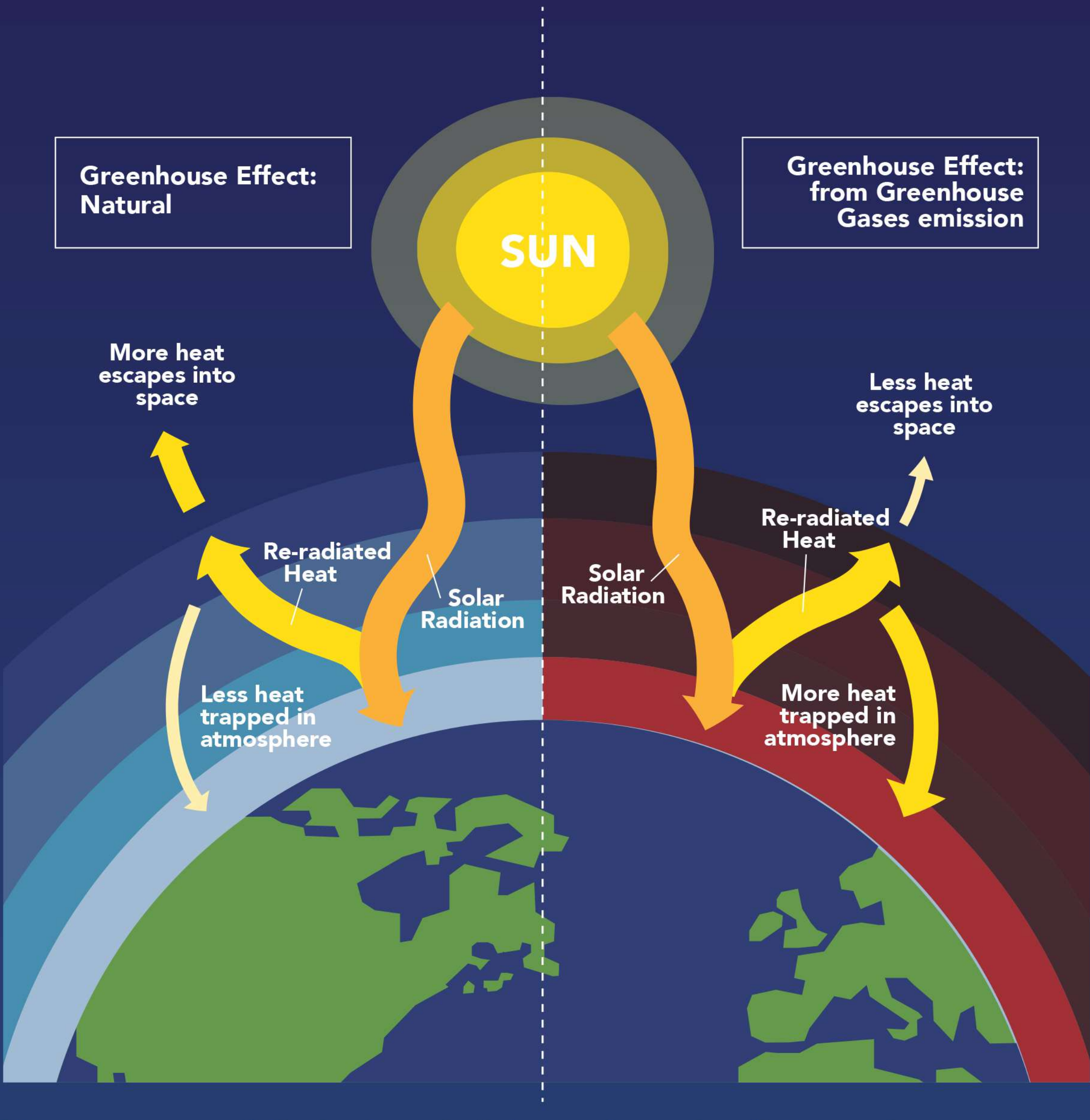
Example of Substances with High GWP [15]



For more detailed substances, please visit **WhatGas?** in the OzonAction website or download the smartphone application use the QR code.

WHAT IS CLIMATE CHANGE? [16]

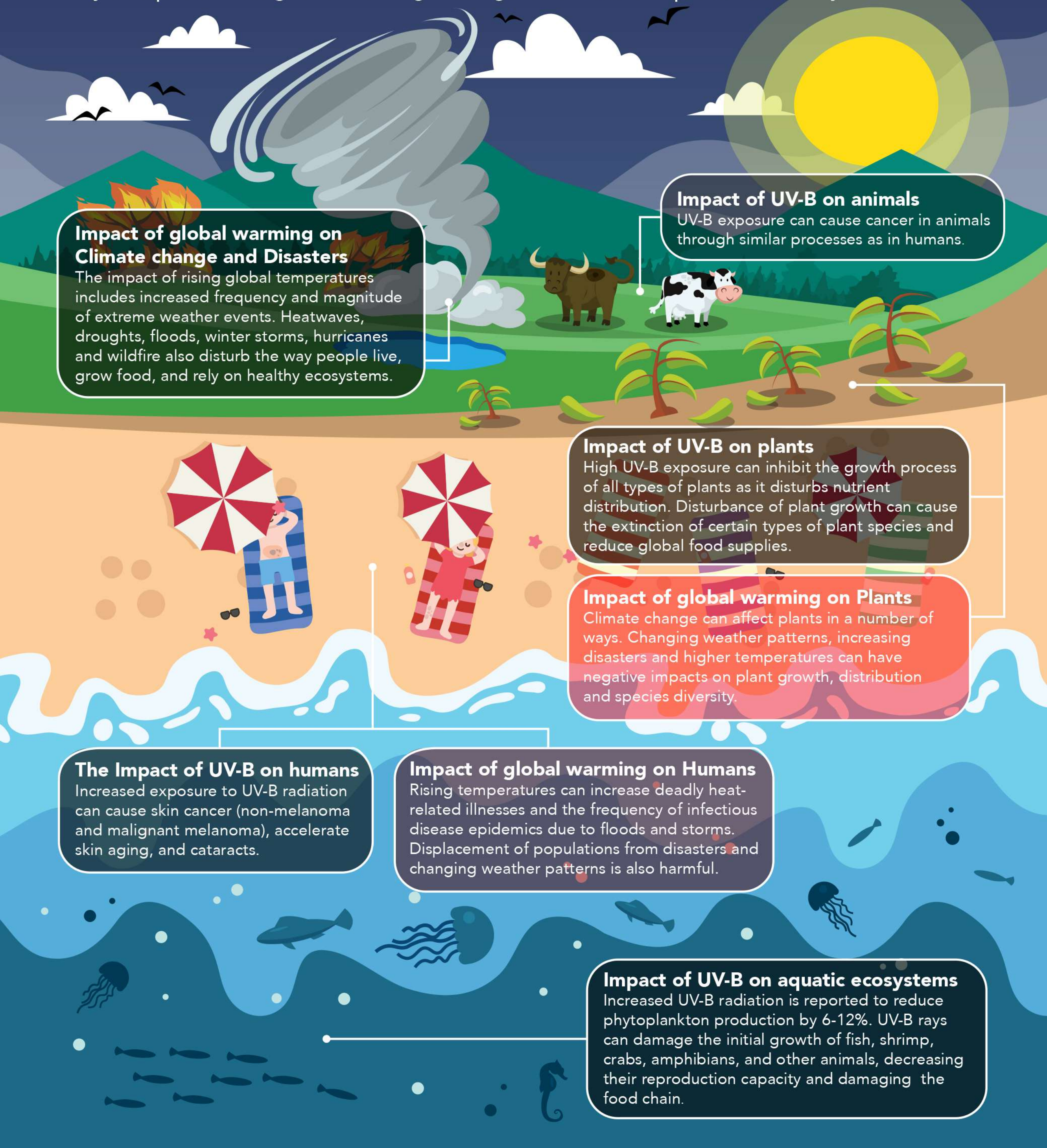
Greenhouse gases (GHGs) in the atmosphere prevent some of the sun's heat from leaving Earth and help provide the conditions for a habitable planet. But GHG concentrations have risen steeply due to human activity from the time of the Industrial Revolution. Emissions from carbon-heavy landuse and agriculture, transport, buildings, industrial processes and polluting energy sources are contributing to GHG levels that are now artificially altering the global climate.



The consequences of climate change include more frequent and intense extreme weather and disasters, such as droughts, floods, storms, and wildfires. Along with temperature and sea level rise, climate change is altering ecosystems, disrupting food production and water supply, and damaging infrastructure. It is also negatively affecting human health and well-being.

THE IMPACTS OF OZONE LAYER DEPLETION AND CLIMATE CHANGE [17], [18], [19]

Ozone layer depletion causes levels of UV-B radiation to increase on the Earth's surface while global warming caused by greenhouse gases is heating the temperature of Earth. Both ozone layer depletion and global warming endanger the health of species and ecosystems.



INTERNATIONAL AGREEMENTS

1985 | Vienna Convention

The international community agreed to establish a framework to protect the ozone layer through the 1985 Vienna Convention. The Vienna Convention showed the commitment of the signatories to protect human health and the environment from the effects of ozone depletion through research, observation and exchange of information.
(https://ozone.unep.org/treaties/vienna-convention).

1987 | Montreal Protocol

The Montreal Protocol, enacted in 1987, mandated that parties take action to limit the production and consumption of ozone-depleting substances (ODS). Initially, the Montreal Protocol regulated only certain types of ODS, which consisted of five types of chlorofluorocarbons (CFCs) and three types of halon gases. With new technologies new research, the number of controlled substances increased through several amendments.
(https://ozone.unep.org/treaties/montreal-protocol).

1	London Amendment (1990)	- Scheduled a complete phase out of *CFCs*, *halons*, and *carbon tetrachloride* by 2000 in developed countries, and by 2010 in developing countries. - *Methyl chloroform* was listed of controlled ODSs, with phaseout in developed countries targeted in 2005, and in 2015 for developing countries - Financial support system of the Multilateral Fund for implementation of Montreal Protocol agreed
2	Copenhagen Amendment (1992)	- *CFC* and *halon* controls strengthened. - Controls on the use of *HCFCs* (CFC replacement chemicals) *HBFCs*, and *Methyl Bromide*
3	Montreal Amendment (1997)	- Application of a licensing system to control and monitor ODS trading
4	Beijing Amendment (1999)	- Control on the use of *Bromochloromethane* - Tighten control of production and trade of HCFC
5	Kigali Amendment (Year 2016)	The control and reduction in consumption (phase-down) of some *hydrofluorocarbons* (HFC) which were initially introduced as an alternative to ODS, considering their high global warming potential

Note:
1) 'Phase-out' refers to the principle to avoid as far as possible the sale or the use of a (chemical) product, considered to pose a risk to humans or the environment. Ideally, they can be replaced by products that are assumed to be less hazardous.
2) 'Phase-down' refers to the principle to reduce the amount of the sale or the use of a (chemical) product by phases.

ON OZONE LAYER PROTECTION [20], [21]

Key Institutions Under the Montreal Protocol

- ***Meeting of the Parties*** **is the governance body of the Protocol** **(https://ozone.unep.org/treaties/montreal-protocol/decisions/by-meeting)**

- ***Open-ended Working Group*** **is the technical support body of the Protocol** **(https://ozone.unep.org/treaties/open-ended-working-group)**

- **Assessment Panels include:** **(https://ozone.unep.org/science/overview)**
  - ***Technology and Economic Assessment Panel (TEAP):*** established in 1990 as the technology and economics advisory body to the Montreal Protocol Parties
  - ***Scientific Assessment Panel (SAP):*** consists of hundreds of top scientists from around the world to assess the status of the depletion of the ozone layer and relevant atmospheric science issues and prepare the report pursuant to the Protocol
  - ***Environmental Effects Assessment Panel (EEAP):*** consists of scientists working in photobiology and photochemistry, from universities and research institutes to assess the various effects of ozone layer depletion and provide the report
- **Ozone Research Managers (ORM)** was established as a scientific forum comprised of government atmospheric research managers and scientists who specialize in research related to ozone modifications meeting every three years.
- ***Financial Mechanism*:**
  - ***Multilateral Fund for the Implementation of the Montreal Protocol:*** established in 1991 under Article 10 of the treaty to provide financial and technical assistance to developing country parties to the Montreal Protocol whose annual per capita consumption and production of ODS is less than 0.3 kg to comply with the control measures of the Protocol **(http://www.multilateralfund.org/Our%20Work/policy/default.aspx)**
  - ***Executive Committee:*** The Fund is managed by an executive committee with equal membership from developed and developing countries **(http://www.multilateralfund.org/aboutMLF/executivecommittee/default.aspx)**
  - ***Implementing Agencies:*** Financial and technical assistance as well as transfer of technology are provided to Article 5 parties through four Implementing Agencies (UNDP, UNEP, UNIDO and World Bank).
- ***Implementation Committee:*** is the compliance mechanism for the Montreal Protocol. It functions to receive, consider and report on any submission by parties or observations/information forwarded by the Ozone Secretariat related to non-compliance with the Montreal Protocol.

For more information please see the Ozone Secretariat's website on Institutions. **(https://ozone.unep.org/institutions)**

KIGALI AMENDMENT

HFCs have been widely used as alternatives for ozone-depleting substances, but they also have a high GWP. The Parties to the Montreal Protocol agreed on 15 October 2016 in Kigali, Rwanda to control the use of HFCs. While not ozone depleting substances themselves, HFCs are greenhouse gases which can have high or very high global warming potentials (GWPs), ranging from about 121 to 14,800. This successful agreement continues the historic legacy of the Montreal Protocol in protecting our planet.

TIMELINE OF HFC REDUCTION IN DEVELOPING COUNTRIES [22]

HFCs are man-made chemicals widely used as substitutes for ozone-depleting substances in air conditioning, refrigeration, foam, fire extinguishers, solvents, and aerosols.

Group	Baseline Formula for Production & Consumption	Compliance Targets: Years and % Consumption/Production Limit				
Group 1 (Most developing countries).	HFC (Average 2020-2022) + 65% of HCFC baseline*	**2024**	**2029**	**2035**	**2040**	**2045**
		100%	90%	70%	50%	20%
Group 2 (Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, United Arab Emirates)	HFC (Average 2024-2026) + 65% of HCFC baseline	**2028**	**2032**	**2037**	**2042**	**2047**
		100%	90%	80%	70%	15%

Phases of HFC reduction in developing countries

Group 1

Group 2

Reference:
'Kigali Amendment FAQ' - Briefing Notes on Frequently asked questions relating to the Kigali Amendment to the Montreal Protocol, 17 February 2017.
(https://ozone.unep.org/resources?term_node_tid_depth%5B866%5D=866)

TYPES OF **OZONE-DEPLETING SUBSTANCE** (ODS) [21]

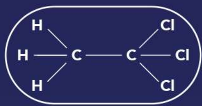
Chemical compounds considered as ODS are:

Halons

Halons contain carbon, fluorine, bromine and chlorine in their structure and are up to 10 times more damaging to ozone than CFCs. Halons are very effective as fire extinguishers because they leave no residue. Some types of halons are Halon 1211, Halon 1301 and Halon 2402.
(phased out since 2010)

Methyl chloroform

Methyl chloroform consists of carbon, hydrogen and chlorine. This compound is widely used as a metal cleaner and solvent.
(phased out since 2015)

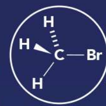


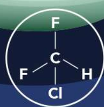
Bromochloromethane

Bromochloromethane consists of chlorine, bromine, carbon and hydrogen. This compound is also known as Halon 1011, or chlorobromomethane.
(phased out since 2010)

Methyl bromide

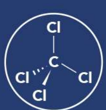
Methyl bromide consists of bromine, hydrogen and carbon. This substance is used to control pests in agriculture and warehouses, quarantine applications and pre-shipment of export-import commodities.
(phased out since 2015)





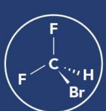
Carbon tetrachloride

Carbon tetrachloride consists of one carbon atom and four chlorine atoms. This compound is widely used as raw material for producing CFCs, and as solvents.
(phased out since 2010).



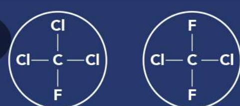
Hydrobromofluorocarbon

HBFC consists of one, two or three carbon atoms and at least one atom of hydrogen, bromine and fluorine. This compound is widely used as a solvent, cleaning agent, fire extinguisher and cooling agent.
(phased out since 1996).



Hydrochlorofluorocarbon

HCFCs consist of one, two or three carbon atoms and at least one atom of hydrogen, chlorine and fluorine. The element of hydrogen in HCFC causes the compound to be less stable, which means HCFCs are not as damaging to ozone as CFCs. HCFCs are used as a substitute for CFCs. Most commonly used HCFCs are HCFC-22, HCFC-141b and HCFC-123.
(currently being phased out).



Chlorofluorocarbon

CFCs consist of one, two or three carbon atoms and at least one chlorine and fluorine atom. CFCs were developed in the 1920s to replace toxic gases used as a cooling gas. CFCs are non-toxic, non-flammable, stable and have the ability to absorb heat effectively. There are several types of CFCs: CFC-11, CFC-12, CFC-113, CFC-114, CFC-115.
(phased out since 2010)

RELEASE OF ODS INTO ATMOSPHERE [23]

ODS are released into the atmosphere in various ways:

1. Production processes in the air conditioning manufacturing industry, and production of refrigeration and foam products. Release might occur during refrigerant charging or during the mixing process of foam production.
2. Improper refrigeration and air conditioning servicing and maintenance practice, e.g. using vacuum pumps to take refrigerant out of the system without proper equipment.
3. Leaks in systems or equipment that use ODS.
4. Use of halon as a fire extinguisher.
5. Release of methyl bromide from fumigation activities.

ODS AND HFCs
COMMONLY USED IN ASIA-PACIFIC COUNTRIES

Refrigeration and Air Conditioning (AC)

Used as a refrigerant.

ODS type: CFC-11, CFC-12 and HCFC-22, HCFC-123, HCFC-124

HFC type: HFC-32, HFC-134a, R-404A, R-407C, R-410A, R-507A

Foam

Used as a blowing agent in foam-making.

ODS type: CFC-11, CFC-12, HCFC-141b

HFC type: HFC-245fa, HFC-365mfc in combination with HFC-227ea

Aerosol

Used as propelling agent for sprays.

ODS type: CFC-11, CFC-12

HFC type: HFC134a

Fire Extinguisher

Used in fire extinguishers.

ODS type: Halon (Halon 1301, Halon1211), HCFC-123

HFC type: HFC-125, HFC-227ea

Fumigation

Used as a fumigant to control pests in agricultural activities, warehouses, quarantine, and shipping.

ODS type: Methyl bromide

Solvent

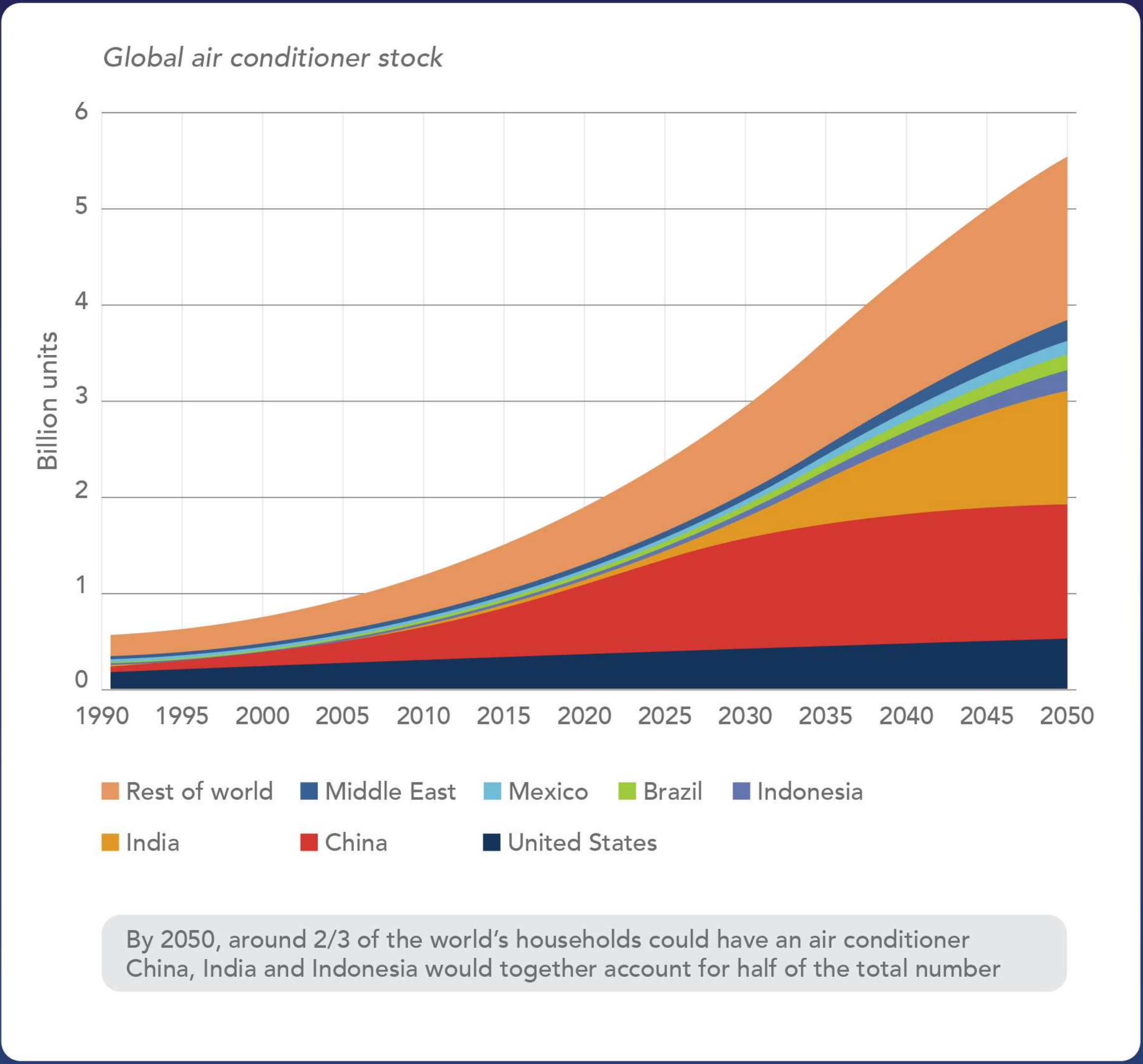
Used as a cleaning agent in the electronics industry, laboratory analysis, and the dry cleaning process.

ODS type: CFC-113, HCFC-225, HCFC-141b, carbon tetrachloride and methyl chloroform

HFC type: R-43-10mee

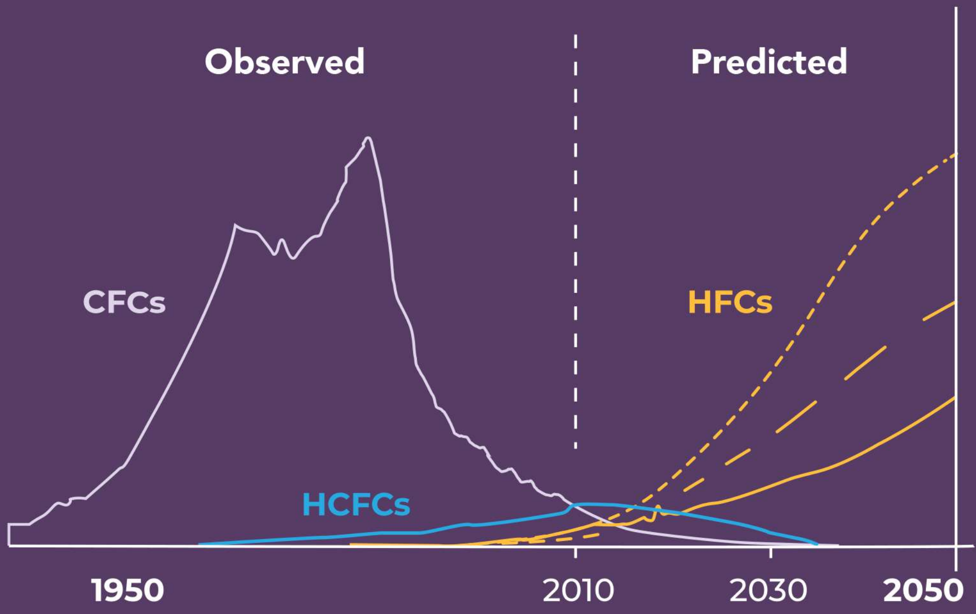
AIR CONDITIONING (AC) AND REFRIGERATION **GROWTH PROJECTION**

Increasing demand for air conditioning and refrigeration is being triggered by the rising temperatures of global warming and increasing incomes around the world. [24]



Source: IEA 2018, The Future of Cooling
https://www.iea.org/reports/the-future-of-cooling

The use of HFC refrigerants is growing rapidly. HFCs are being widely used as a substitute for ODS like chlorofulocarbons (CFCs) and hydrochlorofluocarbons (HCFCs), which are being phased out under the Montreal Protocol.



HFC consumption in various sectors

About **1% of global warming can be directly attributed to HFCs**. But the production and consumption of HFCs, which includes emissions from production plants, contributes up to 8% per year to global warming.

47%	24%	8%	11%	5%	5%
Refrigeration and air conditioning for residential, commercial and industrial use	Vehicle Air Conditioning	Unitary AC (ducted split)	Foam Agents	Aerosol	Fire extinguisher and solvents

Source: CCAC https://ccacoalition.org/fr/slcps/hydrofluorocarbons-hfc

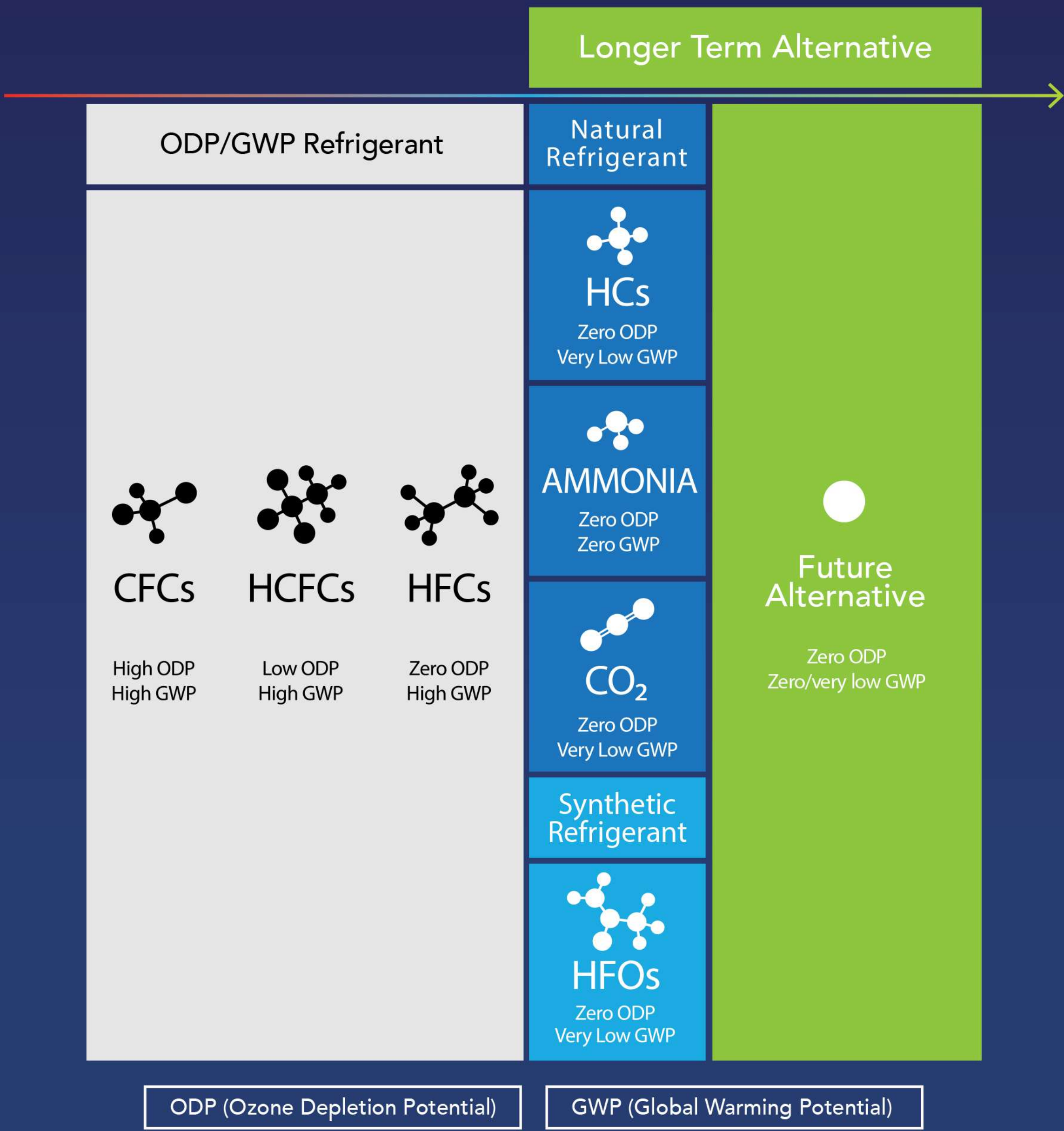
ALTERNATIVE **MATERIAL SUBSTITUTES** FOR ODS AND HFC

	APPLICATION	ODS	HFC	Longer term alternative
	Refrigeration and Air Conditioning (AC)	CFC & HCFC	*Hydro-fluorocarbon* (HFC)	*Hydrocarbon,* Ammonia, CO_2, HFO
	Foam	CFC & HCFC	HFC	HFO, *Hydrocarbon,* CO_2, Methyl formate
	Aerosol	CFC	HFC	*Hydrocarbon* aerosol propellent (HAP), HFO
	Fire Extinguisher	Halon & HCFC	HFC	*Dry chemical, Inert Gas,* CO_2
	Fumigation	Methyl bromide	no HFC used	*Phospine,* CO_2, 1,3-Dichloropropene, Sulfuryl Fluoride, Chloropicrin
	Solvent	CFC and Carbon tetrachloride, Methyl chloroform	HFC	*Hydrocarbon, Hydroflouro-ethers* (HFEs), *Methyl alcohol, Trichloro-ethylene*

ALTERNATIVES TO HCFCs and HFCs IN VARIOUS SECTORS

HCFCs → HFCs → ???

Preferable alternatives to replace HCFCs are those compounds that have no Ozone Depletion Potential (ODP) value, and with low Global Warming Potential (GWP).



ALTERNATIVES

WINDOW/ SPLIT AC

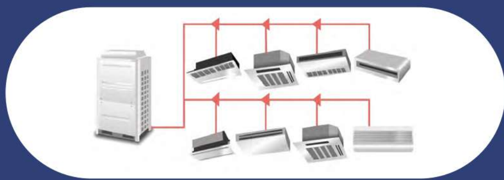
AC Window

AC Split

AC Portable

R-410A (2100) R-407C (1700)	HFC-32 (675) R-290 (3) Blends of HFC/HFO R-452B (680) R444B (300)

VRF



Variable Refrigerant Flow System

R-410A (2100)	Continue to be R-410A

SCREW CHILLER

Air Cooled

Water Cooled

HFC-134a (1430)	HFO-1234yf (<1) HFO-1234ze (<1) R-513A (600)

Note: GWP value in parenthesis

Ducted & Packaged AC

Ducted Indoor | Ducted Outdoor | Packaged AC

R-410A (2100)
R-407C (1700)

→

HFC-32 (675)
R-452B (680)
R-444B (300)

Mobile AIR CONDITIONING

Compressor | Condenser | Indoor

HFC-134a (1430)

→

HFO-1234yf (5)

SCROLL CHILLER

Air Cooled | Water Cooled

R-410A (2100)
R-407C (1700)

→

HFC-32 (675)
R-452B (680)

FOOD RETAIL

Sealed Integral
0.1 to 0.5 kg

Condensing Unit
1 to 10 kg

Large Centralised Pack
20 to 200 kg

R-404A (3922)
HFC-134a (1430)

→

HFO-1234yf (5)
R-290, propane (3)
R-744, CO_2 (1)

HFO-1234yf (5)
R-454C, R-455A (146)
R-744, CO_2 (1)
transcritical or cascade
R-290 (3) integrals,
water cooled

R-454C, R-455A (146)

CENTRIFUGAL CHILLER

Water Cooled | Cooling Tower

HFC-134a (1430)

→

HFO-1233zd (1)
HFO-1336mzz (2)
HFO-1234yf (<1)
HFO-1234ze (<1)

FOOD AND DRINK
Manufacture And Cold Storage

Large Pumped System
50 to 5000 kg

Small / Medium DX
10 to 100 kg

Chiller + Secondary Fluid
100 to 2000 kg

R-404A (3922)
HFC-134a (1430)

→

R-744, CO_2 (1)
R-717; Ammonia (0)

R-450A, R-513A (600)
R-454C, R-455A (146)
R-744, CO_2 (1)
HFO-1234yf (5)

R-514A (9)
HFO-1234ze (7)
HFO-1233zd (4)
R-717; Ammonia (0)

Note: GWP value in parenthesis

PU FOAM



Rigid Foam	Integral Skin	Thermoware
Panel, Freezer	Saddle, Chair, Interior	Cooler Box, Thermos

R-404A (3922)
HFC-134a (1430)

→

HFO-1233zd (1)
HFO-1336mzz (2)

Handheld FIRE EXTINGUISHER



Fire Extinguisher

HFC-236fa

→

ABC and BC Powder
Foam
Water
CO_2

FOOD SERVICE



Sealed Integral	Condensing Unit
0.1 to 0.5 kg	1 to 10 kg

R-404A (3922)
HFC-134a (1430)

→

HFO-1234yf (5)
R-290; Propane (3)
R-744; CO_2 (1)

R-450A, R-513A (600)
R-454C, R-455A (146)
HFO-1234yf (5)
R-744, CO_2 (1)

Fixed Fire EXTINGUISHING SYSTEM


Fire Hydrant

HFC-227ea (3220)
HFC-125 (3500)

→

NOVEC 1230
NO_2
Argon
CO_2
Water Mist
Foam
Water Sprinkler

FOOD TRANSPORT



Road Vehicles	Intermodal Container
1 to 8 kg	4 to 8 kg

R-404A (3922)
HFC-134a (1430)

→

R-744 (1)
CO_2 (1)
R-454C (146)
R-455A (146)

SOLVENTS



Coating	Metal Cleaner/Polish	Rust Remover

HFC-245fa (1030)
HFC-365mfc (794)

→

HFO-1233zd (1)
HFO-1336mzz (2)

Note: GWP value in parenthesis

HCFC PHASE-OUT & HFC PHASE-DOWN
IN THE AIR CONDITIONING AND REFRIGERATION SERVICING SECTOR

The majority of refrigerant emissions can be attributed to lack of maintenance and inappropriate servicing. During the product's lifetime, refrigerant leakage can occur during manufacture, installation, operation, servicing and even when the equipment is not being used.

Refrigerant deficit due to leakage is often resolved by frequent refrigerant recharge (top-up), without fixing the leakage source. This is a typical example of poor servicing practice.

Improving the competencies of refrigeration and air conditioning servicing technicians in refrigerant handling and equipment servicing will benefit the protection of the ozone layer and the mitigation of climate change. This often requires supporting technician trainings through educational and/or vocational institutions and promoting good practices to minimize leakage and safely adopt alternatives.

"By selecting qualified technician, everyone is playing a role in reducing ODS and greenhouse gas emissions, and in maintaining optimal energy efficiency of our appliances thus reducing energy consumption."

CHEMICAL NAME

HCFC-141b, HFC-245FA/HFC-365MFC combined with HFC-227EA

FOAM BLOWING AGENT FOR SANDWICH PANEL APPLICATIONS, INSULATION FOR REFRIGERATORS, FURNITURE, AND CAR INTERIORS

ALTERNATIVE

FOAM PRODUCTS

- CARBON DIOXIDE
- METHYL FORMATE/METHYLAL
- CYCLOPENTANE

WHAT CAN YOU DO TO C

TO THE OZON PROTECTION CLIMATE CHA MITIGATION?

- Choose environmentally friendly refrigerators and air conditioning appliances that do not rely on ODS or high-GWP refrigerants, if in doubt ask your trusted retailer.
- Carry out periodical maintenance to clean the systems.

CHEMICAL NAME

HALON, HCFC-123 & HFC-227ea

LIGHT FIRE EXTINGUISHERS,
FIRE EXTINGUISHER IN AIRCRAFT

ALTERNATIVE

FIRE EXTINGUISHERS

• DRY CHEMICAL • AQUEOUS FILM-FORMING FOAM
• WATER-BASED • CARBON DIOXIDE • DRY POWDER

CHEMICAL NAME

R-12 & R-22

REFRIGERANT/COOLING MATERIALS
IN AC UNITS AND REFRIGERATORS

ALTERNATIVE

AC UNITS AND REFRIGERATION

Interim alternative (subject to HFC phase-down)
• HFC-134a • HFC-32 •R-410A • HC-290 (PROPANE),
R-744 (CO_2), HFO-1234yf • R-717 • HC-600a

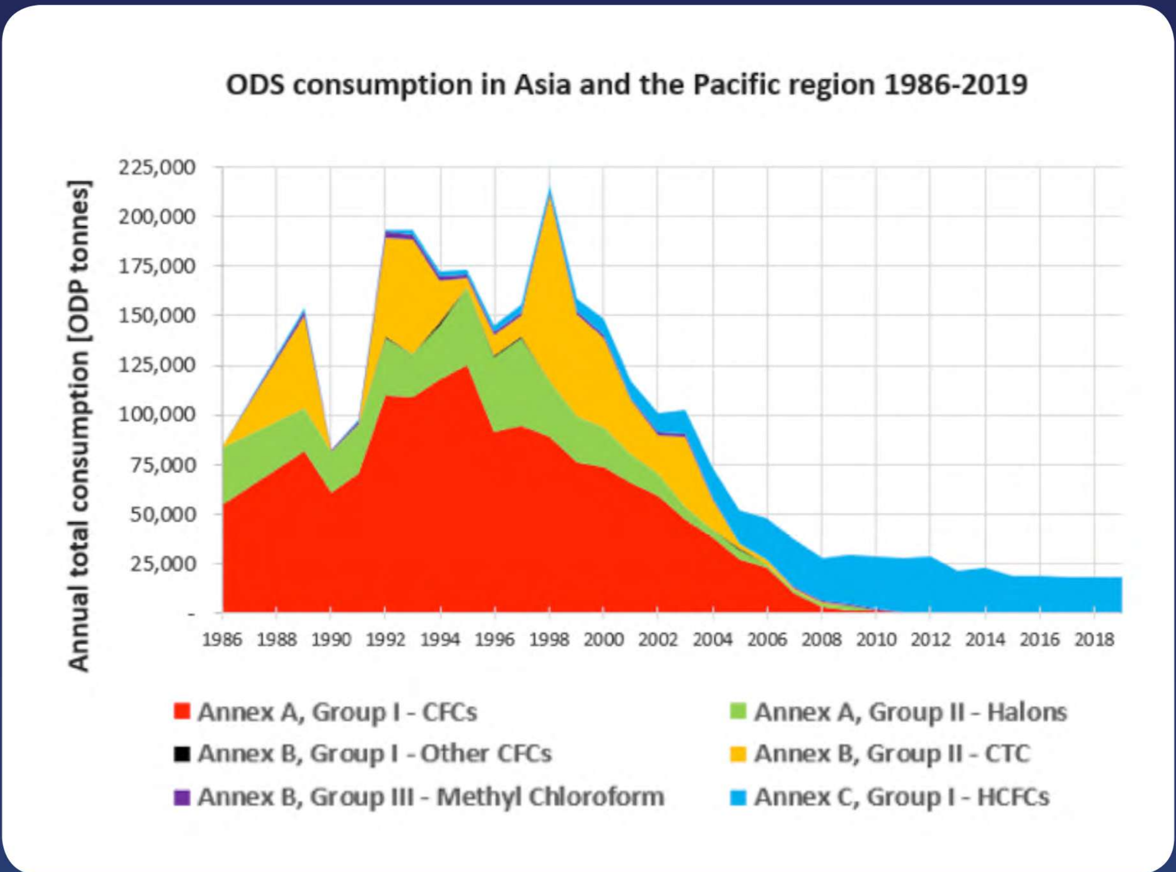
CONTRIBUTE

E LAYER
OR
ANGE

• Choose appliances with high energy efficiency (in some countries you can rely on the energy labels to understand efficiency), if in doubt ask your trusted retailer.

• Rely only on properly certified/trained servicing technicians (in some countries certification schemes are enforced)

MAJOR **ACHIEVEMENTS OF REGIONAL** OZONE PROTECTION AND CLIMATE CHANGE MITIGATION UNDER THE MONTREAL PROTOCOL



Source: UNEP ROAP CAP (2020), created based on Ozone Depleting Substances consumption data from UNEP Ozone Secretariat website, United Nations Environment Programme, Regional Office for Asia and the Pacific, Compliance Assistance Programme

Since 1987, countries in Asia and the Pacific have made concrete efforts to introduce and implement ODS phase-out policies.

Asia and the Pacific region has achieved the complete phase out of the majority of ODSs including CFCs, Halons, Carbon tetrachloride, Methyl chloroform within the prescribed time schedule. The annual consumption peak level of more than 200,000 ODP tonnes for the whole Asia and the Pacific region, reached in the 90s, has been successfully reduced in the last 2 decades. Although having rising trend of HCFC consumption as alternatives to CFC prior to 2010, Asia and the Pacific region is reducing its HCFC consumption and continuing this success journey of protecting the ozone layer by committing to reduce HCFC consumption in a stepwise manner until complete phase out in 2030.

An increasing number of Asia-Pacific countries are continuing their successful participation in the Montreal Protocol by ratifying the Kigali Amendment to the Montreal Protocol, an international agreement to reduce the consumption of hydrofluorocarbons (HFCs) with significant Global Warming Potential. The Kigali Amendment was agreed in 2016 and entered into force on 1 January 2019. Many Pacific Island Countries proceeded with an early ratification of the Kigali Amendment in 2017. By ratifying the Kigali Amendment, countries are committing to phase down the consumption of HFCs by more than 80 per cent (measured in CO2-equivalent tonnes) over the next 30 years and avoid a temperature rise of up to 0.4°C by the end of the century as well as increasing the energy efficiency of cooling equipment, significantly reducing energy costs to consumers and businesses at the same time.

Resources for more information

- OzonAction factsheet on Kigali Amendment
  https://www.unep.org/ozonaction/resources/factsheet/ozonaction-series-fact-sheets-relevant-kigali-amendment-quick-links
- Other OzonAction factsheets
  https://www.unep.org/ozonaction/resources?type=231&topic=All&keys=
- Twenty questions and answers about the ozone layer 2018 update
  https://ozone.unep.org/sites/default/files/2019-11/twentyquestions.pdf
- Ozone Secretariat
  https://ozone.unep.org/
- OzonAction
  https://www.unep.org/ozonaction/
- In-depth Scientific Information:
  Technology and Economic Assessment Panel (TEAP) report
  https://ozone.unep.org/science/assessment/teap;
  Scientific Assessment Panel (SAP) report
  https://ozone.unep.org/science/assessment/sap;
  Environmental Effects Assessment Panel (EEAP) report
  https://ozone.unep.org/science/assessment/eeap
- Information on Ozone Depleting Substances regulations, policy, control measures and Montreal Protocol implementation activities in your country, please contact your local National Ozone Unit.
- OzonAction Education Pack for Primary Schools
  https://wedocs.unep.org/bitstream/handle/20.500.11822/9820/-OzonAction%20Education%20Pack_%20Guide%20for%20Primary%20School%20Teachers-2006727.pdf?sequence=2&isAllowed=y
- High Sky. OzonAction Education Pack for Secondary Schools.Teacher´s Guide.
- OzonAction Scoop Caring for all life under the Sun, 2017.
  https://wedocs.unep.org/bitstream/handle/20.500.11822/26734/7920Ozone_Scoop1.pdf?sequence=1&isAllowed=y

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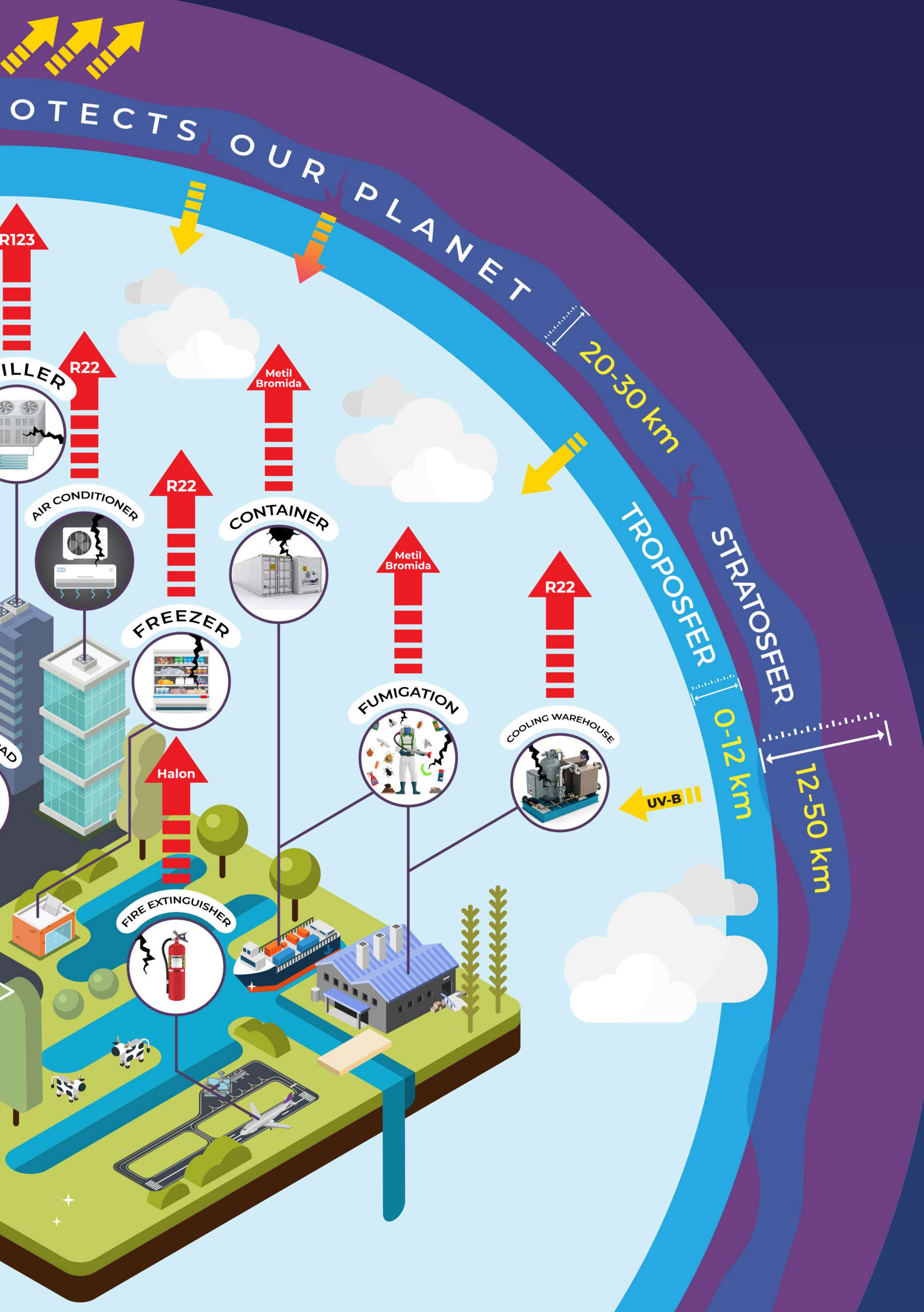
UV-B
UV-B
UV-B
THE OZONE LAYER PR
UV-B
141b
141b
141b
FOAM MAT
SEAT CUSHION
CH
PANEL PARTITION
R123
141b
FIRE EXTINGUISHER
CHAIR FOAM P
R225
COATING
REFRIGERATOR



OTECTS OUR PLANET
R123
ILLER
R22
AIR CONDITIONER
R22
FREEZER
Metil Bromida
CONTAINER
Metil Bromida
FUMIGATION
R22
COOLING WAREHOUSE
Halon
FIRE EXTINGUISHER
UV-B
20-30 km
TROPOSFER
0-12 km
STRATOSFER
12-50 km

SAVE OZONE LAYER

In collaboration with :

DIRECTORATE GENERAL OF CLIMATE CHANGE
MINISTRY OF ENVIRONMENT AND FORESTRY
THE REPUBLIC OF INDONESIA

UN environment programme

OzonAction
COMPLIANCE ASSISTANCE PROGRAMME