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Ozone holes are the result of the freezing of atmospheric components.

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❖ *Abstract.*

The ozone hole found over the Earth's poles, for example in Antarctica, has no connection with the actual stratospheric ozone layer but is closely related to other atmospheric components (Aerosols, Gases, water vapour, SO2, NO2, OH, NH3, CH4, N2O, SO3, H2O, CO2, HOCl, etc.). Because they are primarily affected by temperature, as a result, the level of solar radiation increases for some time because these atmospheric components mainly absorb or interfere with ultraviolet radiation after oxygen and ozone layer. When the temperature becomes extremely low, the states of these atmospheric components changes and they reduce or stop affecting the radiation. And as soon as the polar vortex ends and the temperature there gradually increases, they again return to the gaseous states and start affecting the radiation. As a result, the amount of solar radiation reaching the surface decreases. Therefore, it is clear that atmospheric components are affected due to extremely low temperature, which increases the level of solar radiation, but this increased radiation has no direct connection with the ozone layer.

Because The measurement of Atmospheric constituents is mainly done in three ways, out of which the ground based instruments are Dobson Spectrometer, Ozone Sonde and satellite. The first instrument among these is Dobson Spectrometer which has been measuring the atmospheric constituents since 1920s. It measures the atmospheric constituents by measuring the difference between two wavelengths. The second Ozone Sonde is a balloon borne instrument which goes into the atmosphere and measures the atmospheric constituents by the vibrations of electrons received from the air and the satellite measures the atmospheric constituents by the light backscattered by the atmosphere and the basis of all these is Dobson Spectrometer which is the oldest instrument but the ozone layer absorbs light from 230 nm to 290 nm but its main absorption band is in 255 nm. Hence the light after 290 nm is absorbed or interference by other atmospheric components and not the ozone layer.

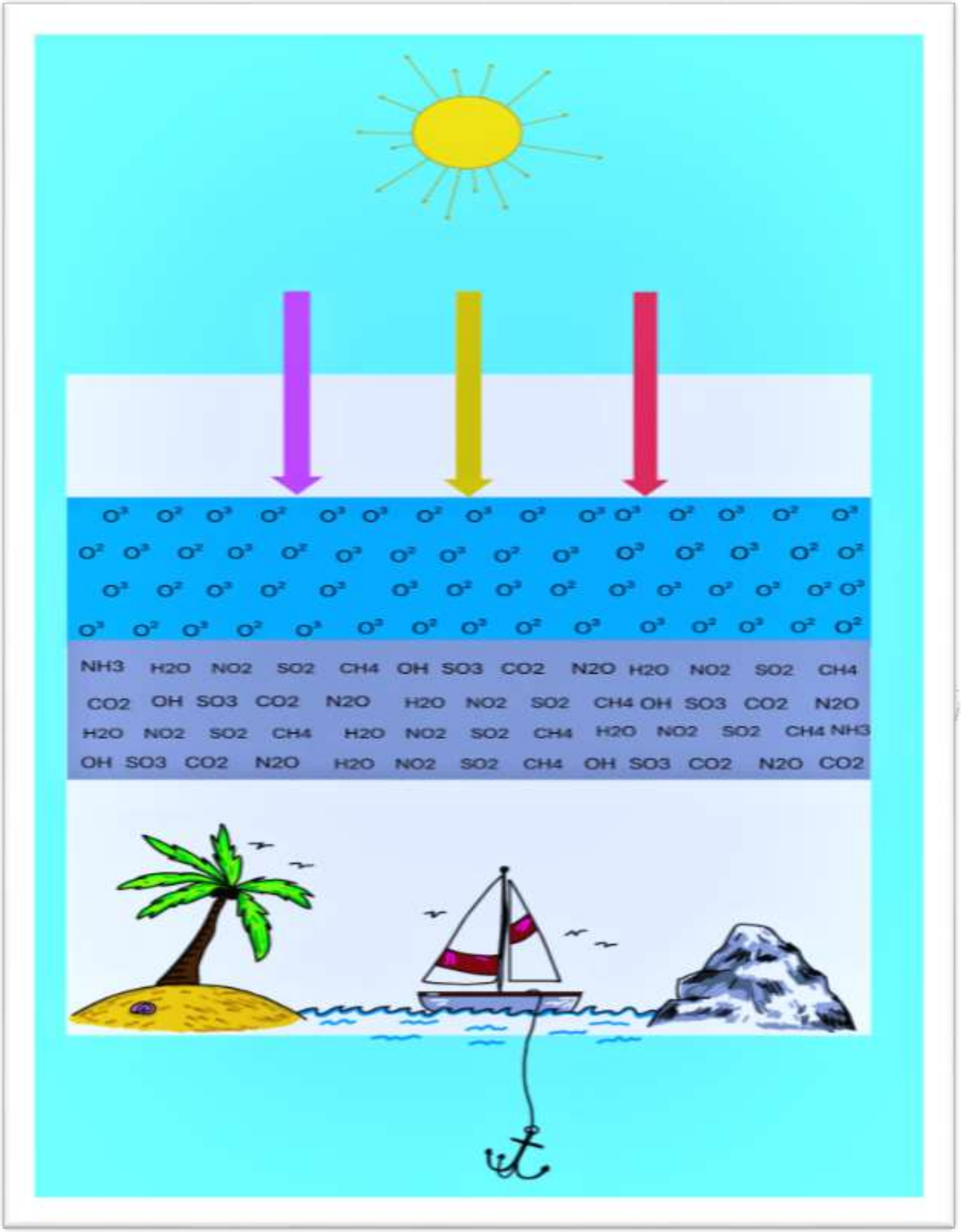
Therefore, by measuring the light after 290 nm, we can find out the concentration of other atmospheric components (aerosols, gases etc.) because Dobson Spectrometer works on a scale which measures light from A=(305 nm) to D=(317 nm) which tells the concentration of other atmospheric components instead of ozone.

And in Antarctica, when the temperature is low or these atmospheric components reach the freezing point, they freeze, due to which they cannot absorb sunlight, due to which the radiation increases there for some time, such a situation is seen in spring (September – October) when the temperature is lowest there. And it keeps changing its position continuously due to wind and as soon as the polar vortex ends and the temperature starts increasing slowly, these atmospheric components start absorbing or interference radiation again. On the other hand, the temperature in the northern hemisphere is higher than that In the southern hemisphere because that pole is located in the ocean due to which these atmospheric components do not freeze there and keep on absorbing radiation continuously. However, in Greenland and Alaska, the temperature decreases for some time and these atmospheric components can freeze and the radiation increases but this increased radiation does not cause harm, rather the light below 290 nm is harmful which luckily gets absorbed by the Oxygen and ozone layer. Also, the light from 290 nm to 315 nm is the main source of vitamin D i.e. even if this light reaches the earth, it is not harmful But excessive amounts can be harmful to human health. From the above topic, it is clear that ozone hole is the decrease in the concentration of atmospheric Components and not the concentration of the ozone layer.

In addition to ozone, other substances that absorb ultraviolet (UV) radiation include:-

• Water vapor: Along with ozone, water vapor absorbs most of the UV-B radiation and all of the UV-C radiation from sunlight as it passes through the atmosphere. Oxygen: Normal oxygen absorbs UV-C radiation. Carbon dioxide: Absorbs some UV-B radiation. Snow: Fresh snow can reflect up to 94% of incoming UV radiation, increasing UV-B radiation near the Earth's surface.

The ozone hole was discovered primarily by the Dobson spectrometer in 1985, but this instrument measures the intensity of light coming from the sun because the solar radiation coming from the sun reaches the earth's surface passing through the atmosphere in which it encounters innumerable gases (air).The remaining solar radiation reaches the surface after being affected by air. You can understand this by taking an example, if the Dobson Spectrometer is located in a polluted city or in a place where the sky is cloudy, then the level of direct solar radiation will be low there, but we cannot call it an increase in the concentration of the ozone layer, rather we have to pay attention to the situation there and we have to ignore such data. Similarly, due to low temperature in Antarctica, atmospheric pollution freezes, resulting in the formation of polar stratospheric clouds (PSCs). Carbon dioxide gas directly changes from gas to solid state at this temperature. The melting point of CO_2 is -78.5°C (-109.3°F). <u>However, under normal conditions, it does not exist as a liquid but rather sublimates directly from a gas to a solid.</u>



©apshuklaº2024 – Figure.1. Status of ozone layer and major components in the Earth's atmosphere.

Key Points on Polar Stratospheric Clouds (PSCs) Formation :-

Temperature: PSCs form at very low temperatures, typically below -78°C (-108°F). Such temperatures are most commonly found in the stratosphere over polar regions during winter.

SO2 + 2OH ~ H2SO4 (Sulfuric Acid)

NO2 + OH ~ HNO3 (Nitric Acid). * OH is a radical.

Atmospheric Gases	**Boiling Point**	**Melting/freezing Point**	**Concentrations**
Sulfuric acid (H_2SO_4)	337 °C (639 °F)	10.31 °C (50.56 °F).	-
Water (H_2O)	100 °C (212 °F)	0 °C (32 °F)	-
Bromine (Br_2)	58.8 °C(137.8 °F)	-7. 2 °C (19.0 °F)	1 ppt
Nitrogen dioxide(NO_2)	21.2 °C (70.2 °F)	-11.2 °C (11.8 °F)	0.1 to 0.5 ppb
Nitric acid (HNO_3)	83 °C (181 °F)	-42 °C (-44 °F)	1 ppb
Sulfur Dioxide (SO2)	-10 °C (14 °F)	-72.7°C (-98.9°F)	1ppb
Ammonia (NH_3)	-33.3 °C(-28 °F)	-77.7°C (-107.9°F)	1 to 10 ppb
Carbon dioxide (CO_2)	Δ	-78.5°C (-109.3°F)	420 ppm
Hydrogen Sulfide(H_2S)	-60.2°C(-76.4 °F)	-85.5°C (-121.9°F)	-
Nitrous Oxide (N_2O)	-88.5 °C(-127 °F)	-90.9°C (-131.6°F)	330 ppb
Chlorine (Cl_2)	-34.04°C (-29°F)	-101.5°C (-150.7°F)	-
Ozone (O_3)	-112 °C (-170 °F)	-192.5°C (-314.5°F)	10 to 40 ppb

- **Formation of polar stratospheric clouds (PSCs) :-** Polar Stratospheric Clouds (PSCs) form in the polar regions of the Earth's stratosphere during the winter months. The formation of these clouds is closely linked to the extremely low temperatures found in the stratosphere during this time.The formation of PSCs is influenced by the presence of a polar vortex, a large area of low pressure that forms over the poles during winter. The vortex traps cold air, allowing temperatures to drop low enough for PSCs to form.PSCs are often visible just before sunrise or just after sunset, as they are illuminated by sunlight from below the horizon. They appear as colorful, iridescent clouds, often referred to as "mother-of-pearl" clouds due to their appearance.

- **Reason behind the colorful appearance of clouds :-**
  The colorful appearance of clouds, particularly in certain types of clouds like polar stratospheric clouds (PSCs) and iridescent clouds, is due to the phenomenon of light diffraction and scattering. Due to this reflection, radiation may also increase there because clouds are made of solid crystals which act as prisms.

- **Major instruments for measuring solar radiation :-**
  Dobson Spectrometer :- The Dobson Spectrometer, also known as the Dobson Spectrophotometer, is a key instrument used for measuring the concentration of atmospheric components in the Earth's atmosphere. Developed by G.M.B. Dobson in the 1920s, it remains one of the most important tools for monitoring the atmospheric component

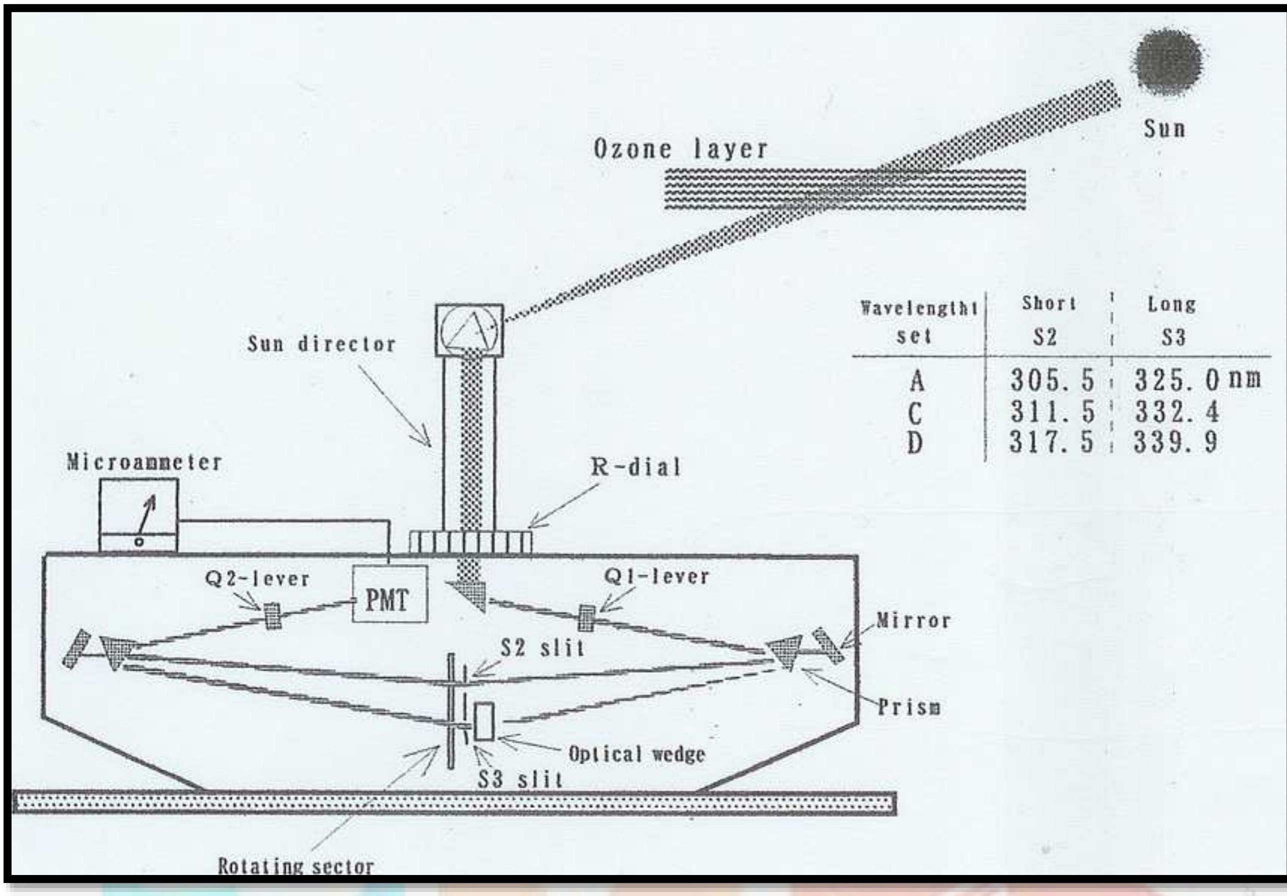
Key Features and Function :-

Purpose: The primary purpose of the Dobson Spectrometer is to measure the total column amount of atmospheric components in the atmosphere above a specific location.

Working Principle: The Dobson Spectrometer works by comparing the intensities of ultraviolet (UV) light at specific wavelengths that are absorbed by atmospheric components (around 300 nm) to those that are not significantly absorbed (around 330 nm).The difference in absorption at these wavelengths allows the instrument to calculate the amount of Atmospheric components in a vertical column of the atmosphere.

Measurement Process: The instrument takes measurements at different angles of the sun's elevation. By doing this, it corrects for the varying path length of sunlight through the atmosphere, which affects the absorption. It typically requires clear skies to obtain accurate measurements, as clouds and other atmospheric conditions can interfere with the data.

©WMO – Fig.2 -Table of mechanism and scale of Dobson spectrometer.



Satellite :- Satellites measure Atmospheric components in the Earth's atmosphere using a variety of sophisticated instruments and techniques. These measurements are crucial for monitoring the Atmospheric components, understanding its dynamics, and studying its role in climate and environmental processes. Here's how satellites measure Atmospheric components:

Key Satellite Instruments for Ozone Measurement :- Atmospheric components Sensors: Solar Backscatter Ultraviolet (SBUV)

Sensors: Measure the intensity of UV light scattered back to the satellite from the Earth's atmosphere. By analyzing the amount of UV light absorbed by Atmospheric components, these sensors determine the concentration of Atmospheric components. Total Ozone Mapping Spectrometer (TOMS): Measures the amount of ozone and Atmospheric components in the Earth's atmosphere by detecting UV radiation absorbed by ozone and Atmospheric components. TOMS has been used on several satellites, including the Nimbus-7 and Earth Probe missions. Ozone Monitoring Instrument (OMI) :- On the Aura satellite, OMI uses UV and visible light to measure ozone and atmospheric constituents.

Spectrometers: Michelson Interferometer for Passive Atmospheric Sounding (MIPAS): On the Envisat satellite, MIPAS measures the infrared radiation emitted by the Earth's atmosphere to determine atmospheric constituents and other atmospheric gases.

Atmospheric Chemistry Experiment (ACE): On the SCISAT satellite, ACE uses a high-resolution spectrometer to analyze the absorption of solar UV and infrared radiation by ozone and other trace gases.

Radiometers: Radiative Transfer Instruments: Measure the radiation emitted and scattered by the Earth's atmosphere and surface. These instruments analyze spectral data to infer ozone and atmospheric constituents concentrations.

Measurement Techniques: Solar Occultation: This technique involves measuring the sunlight that passes through the Earth's atmosphere when the satellite is in the Earth's shadow. The absorption of sunlight by ozone and atmospheric constituents is used to determine its concentration.

Limb Sounding: The satellite observes the Earth's limb (the edge of the atmosphere) to measure the amount of ozone and other gases in different layers of the atmosphere.

Earth Radiance Measurement: Measures the radiation emitted from the Earth's surface and atmosphere. By analyzing this radiation, the amount of ozone and other atmospheric components can be determined.

Ozone Sonde :- An ozone Sonde is a device used to measure the concentration of ozone and atmospheric constituents in the Earth's atmosphere, typically within the stratosphere. It is a key tool for studying the vertical distribution of ozone and other atmospheric constituents understanding its role in atmospheric chemistry and climate.

How an Ozone Sonde Works :-

Structure:

Ozone Sensor: Contains an electrochemical cell or other sensing technology that detects ozone and other atmospheric constituents levels. Common types include the Brewer-Mast Sonde, which uses electrochemical methods, and the ozonesonde, which often employs UV absorbance techniques.

Data Logger: Records the ozone and other atmospheric constituents concentration measurements.

Balloon: The Sonde is typically attached to a weather balloon, which carries it into the atmosphere.

Operation: Launch: The Sonde is carried aloft by a helium or hydrogen-filled balloon.

Transmission: Data is transmitted back to a ground station during the ascent.

Descent: After reaching the desired altitude or when the balloon bursts, the Sonde falls back to Earth.

- **<u>Some important facts related to the ozone layer.</u>**

  - British scientist Sydney Chapman first proposed the theory of ozone formation and destruction in 1930, according to which the main absorption band for oxygen is 130-180 nm and for ozone the main absorption band is 230 to 290 nm.

  - According to G.M.B. Dobson(1920), the inventor of Dobson Spectrometer, the absorption band for ozone is from 200nm to 330nm but the main absorption band is at 255nm and the last band is at 290nm.

- **<u>From the above topic we can understand that no instrument measures the actual ozone layer with 100% accuracy.</u>**

Dobson Spectrometer – This instrument measures the intensity of solar radiation coming from the sun which depends on atmospheric components (aerosols, gases, water vapour, etc.)

Ozone Sonde – This is a balloon-mounted instrument that goes into the upper atmosphere and takes electron pulses which can be affected by atmospheric components (aerosols, gases, water vapor, etc.)

Satellite – This instrument measures atmospheric components by comparing solar energy and backscattered energy. Backscattered radiation is the solar radiation scattered back towards the satellite by the particles present in the atmosphere. This is also affected by atmospheric components (aerosols, gases, water vapor, etc.).

Hence, no technique explains the ozone layer with 100%accuracy. And the ozone hole was discovered in 1985 by one of these techniques, Dobson Spectrometer. So the increased solar radiation in Antarctica depends on the specific conditions there (temperature, pressure, humidity etc.) and has no direct relation to the actual stratospheric ozone layer.

- **Major atmospheric air circulation :-** The major atmospheric air circulation patterns are essential for understanding global weather and climate. These patterns are driven by the uneven heating of the Earth's surface and the rotation of the Earth. The primary circulation cells and patterns include:

1. Hadley Cells: Location: Between the equator and approximately 30° latitude in both hemispheres. Mechanism: Warm air rises near the equator, creating low pressure. As it rises, it cools and moves poleward at high altitudes. Upon cooling, it descends around 30° latitude, creating high pressure and

resulting in the formation of the subtropical high-pressure zones. Characteristics: Drives the trade winds and influences the location of tropical rainforests.

2. Ferrel Cells: Location: Between 30° and 60° latitude in both hemispheres. Mechanism: Air flows poleward at the surface from the high-pressure zones around 30° latitude and moves equatorward at higher altitudes. Around 60° latitude, where air meets and rises, a zone of lower pressure is created. Characteristics: Responsible for the westerly's in the mid-latitudes and affects the weather patterns in these regions.

3. Polar Cells: Location: From about 60° latitude to the poles. Mechanism: Cold, dense air sinks at the poles, creating high-pressure areas. This air then flows equatorward at the surface and rises around 60° latitude, where it meets warmer air from the Ferrel Cell. Characteristics: Drives the polar easterlies and influences polar climates.

4. Polar Jet Stream: Location: Near the boundary between the polar and Ferrel cells, typically around 9 to 12 km (30,000 to 40,000 feet) above the Earth's surface. Mechanism: A fast-moving ribbon of air that forms at the intersection of cold polar air and warmer mid-latitude air. Characteristics: Influences weather systems and can impact storm tracks and temperature variations.

5. Subtropical Jet Stream: Location: Near the top of the Hadley Cell, around 10 to 14 km (30,000 to 45,000 feet) altitude. Mechanism: Forms due to the contrast between the warm, rising air in the Hadley Cell and the cooler, descending air in the Ferrel Cell. Characteristics: Affects weather patterns and the movement of weather systems in the mid-latitudes.

6. Trade Winds: Location: Found in the tropics, between the equator and 30° latitude in both hemispheres. Mechanism: Surface winds that blow from the high-pressure areas of the subtropical highs towards the equatorial low-pressure zone. Characteristics: Key drivers of tropical weather patterns and ocean currents. These circulation patterns are interconnected and influence each other, creating a complex system of global wind patterns and weather systems. Understanding these patterns helps in predicting weather and climate changes around the world.

- **Brewer-Dobson Circulation (BDC) :-** The Brewer-Dobson Circulation (BDC) is a large-scale atmospheric circulation pattern that describes the movement of air within the stratosphere and its interaction with the troposphere. It plays a critical role in the distribution of ozone and other trace gases in the stratosphere and influences the global climate system.

Key Features of Brewer-Dobson Circulation:-

Vertical Transport: The Brewer-Dobson Circulation involves the upward transport of air from the troposphere into the stratosphere near the tropics. Warm, moist air rises near the equator due to convection. This air then cools and moves poleward in the stratosphere.

Horizontal Transport: Once the air reaches the higher latitudes, it descends back toward the troposphere in the polar regions. This descent occurs in the mid-latitudes and polar regions, where the air cools and becomes denser.

Impact on Climate: The BDC plays a role in regulating the temperature and composition of the stratosphere. It influences the global distribution of water vapour and other atmospheric constituents, which impacts UV radiation levels and climate dynamics.

Interaction with Other Circulation Patterns: The Brewer-Dobson Circulation interacts with other atmospheric circulation patterns, such as the Hadley, Ferrel, and Polar Cells. These interactions can influence weather patterns and the distribution of pollutants and greenhouse gases.

Conclusions.

The ozone layer and other atmospheric constituents primarily absorbs three types of ultraviolet (UV) radiation from the sun:
When the Atmospheric components is thin or has holes in it, the amount of UV-B radiation increases, particularly between **280 and 315 nanometers**. This is the radiation that in large quantities harmful to human health and the environment. UV-C radiation (100 to 280 nm) is also absorbed by the Oxygen and ozone layer, but it usually does not reach the Earth because it is almost completely absorbed by the Oxygen and ozone layer. When the Atmospheric components is freezing or thinned, UV-B radiation with wavelengths of 280 to 315 nanometers (nm) reaches the Earth's surface in greater amounts. To a lesser extent, UV-A radiation with wavelengths of 315 to 400 nanometers also reaches the Earth's surface in greater amounts, but is less harmful.
However, UV-C radiation with wavelengths shorter than **280 nm** (100-280 nm) is almost completely absorbed by the oxygen and ozone layer, so this radiation does not reach the Earth.

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Special Thanks :- Heartily gratefully, we express our gratitude to the world's prestigious institutions that continuously collect Important data on issues like ozone layer and climate change and make it easily available. And our aim is to make the earth the Most beautiful planet, for this we are striving and in view of the global scientific concerns, we also focused our attention on the Subject of ozone layer and Ozone hole and studied it deeply and achieved this result. But these may be our personal views or suggestions. The author is not responsible directly or indirectly for any kind of loss. This is written only for knowledge acquisition. If you help and support us, we will be happy and excellent suggestions are cordially invited. Thank you[1].

TERMINOLOGY.

- UV-A – Ultraviolet radiation between wavelengths of 315 and 400 nm
- UV-B -Ultraviolet radiation between wavelengths of 280 and 315 nm
- UV-C - Ultraviolet radiation between wavelengths of 100 and 280 nm
- nm. – nanometer, one billionth of a meter (10–9 m)
- DU - Dobson unit, a measure of total column ozone; 1 DU = 2.687 ×1016 molecules/cm2
- CO – Carbon Monoxide
- CO2 – Carbon Dioxide
- H - Atomic Hydrogen
- H2O – Water and Water Vapour
- HNO3 – Nitric Acid
- H2SO4 – Sulfuric Acid
- N2 - Molecular Nitrogen
- N2O - Nitrous Oxide
- NOx - Nitrogen Oxides
- O - Atomic Oxygen
- O2 – Molecular Oxygen
- O3 - Ozone
- CH4 - Methane