

during the days and is associated with minimum amount of cloudiness.

- Rains in the doldrums are of convectional nature and are also called the 4 O' clock showers.

B. Orographic Precipitation

- It occurs when warm and humid air strikes landform barriers such as mountain ranges and is forced to rise.
- The windward side of the mountain range gets more precipitation than the leeward side (rain-shadow area) because the air descends down the slope and gets warmed up.

C. Cyclonic Precipitation is associated with a cyclonic circulation.

El Nino

- At interval of some 3 to 8 years there occurs a remarkable disturbance of ocean and atmosphere.
- It begins in the eastern Pacific Ocean and spreads its effects widely over the globe for more than a year's time.
- It bring with it unseasonal weather patterns with abnormalities in the form of droughts. Heavy rain falls, severe spells of heat and cold, or a high incidence of cyclonic storms.
- This occurrence is referred to as EL NINO, meaning the 'Christ Child' in Spanish since this phenomenon occurs each year around Christmas time.
- Normally, the cool Humboldt (Peru) current flows northward off the South American coast.
- Near the equator, it turns westward across the Pacific as the South Equatorial current.
- The Humboldt Current is characterized by upwelling of cold deep water, which carries nutrients that serve as food for planktons.
- Fish feed on these high concentrations of plankton.
- The anchoveta, a small fish commercially used to produce fishmeal for animal feed, thrives in great numbers.
- With the onset of El Nino, upwelling ceases, the cool water is replaced by warm water from the west, and the plankton and their anchoveta predators disappear.
- Vast numbers of birds that feed on the anchoveta die of starvation.

- The El Nino (EN) condition influences climates on the two sides of the tropical Pacific Ocean.
- Gilbert Walker, a British mathematician, observed an occasional strange reversal in the barometric pressure system.
- In some years, the Indonesian/Australian low pressure region was replaced by high pressure while low pressure deepened over the eastern Pacific portion of equatorial trough.
- Walker called this phenomenon the Southern Oscillation (SO).
- He observed that the onset of high pressure brought drought to the western regions while the eastern Pacific region experienced abnormally high rainfall.
- Another most significant development has been the recognition of a distinctive set of contrasting or complementary conditions that prevail between El Nino events.
- Known as LA NINA (the girl), it is a period during which sea-surface temperatures in the central and eastern Pacific Ocean fall to lower levels.
- The south Pacific subtropical high becomes very strongly developed during the high-sun season of that hemisphere and causes abnormally strong southeast trade winds.
- The force of these winds drag warm surface water westward, exposing cooler water at the surface.
- Lal Nina conditions were recognized during 1988 and were suspected of having been casually related to a severe drought experienced over North America in the summer of 1988.
- The La Nina gives rise to the onset of following El Nino, which in turn gives rise to next La Nina, perpetuating an unending succession of these events.

Global Warming & Climate

Global warming refers to an average increase in the Earth's temperature, which in turn, causes changes in climate. A warmer Earth may lead to changes in rainfall patterns, a rise in sea level, and a wide range of impacts on plants, wildlife, and humans. When scientists talk about the issue of climate change, their concern is about global warming caused by human activities.

Average global temperature have risen (0.6 0.2°C) since the late 19th century. The scientific consensus is that a significant proportion of this

past rise, particularly in the last 25-50 years, is due to humanity's emission of greenhouse gases such as carbon dioxide (CO₂).

The Impact of Climate Change

- It has been conclusively proved that climate change is attributable to human intervention. Carbon dioxide, emitted mainly by the burning of fossil fuels, and the emission of methane, nitrous oxide, CFC's and other greenhouse gases thickens the blanket of greenhouse gases over the earth's atmosphere, upsetting the natural flow of energy from the sun.
- Deforestation accelerates global warming by reducing the absorption of carbon dioxide in the atmosphere.
- Based on current emission levels, it is estimated that the global temperature will rise by between 1°C and 3.5°C by the year 2100; that even after emission levels are stabilized, climate change will continue to occur for hundreds of years.
- The mean sea level may rise upto 100cm by the year 2100, causing flooding and submergence of many islands and coastal cities.

Greenhouse Effect

- The Greenhouse Effect is the result of the atmosphere's absorption of long-wave radiation emitted by Earth.
- Among the atmospheric constituents, carbon dioxide absorbs the largest proportion of that radiation.
- Thus, when the carbon dioxide content of air changes, a corresponding increase or decrease in the greenhouse effect occurs.
- The natural supply of carbon dioxide has probably varied little over the past several million years, but over the past 200 years human beings have increasingly acquired the capacity to alter this balance.

Ozone Depletion

- The ozone layer is found in the atmosphere between 20-50 Km from the Earth's surface.
- The ozone layer is a region of concentration of the allotrope of an oxygen molecule known as ozone (O₃), which is produced by the action of solar radiation on ordinary oxygen atoms.
- It filters sunlight and prevents the harmful ultraviolet radiation from reaching the Earth's surface by absorbing most of the ultraviolet radiation.

- If these ultraviolet rays were to reach the Earth's surface in full intensity, all exposed bacteria would be destroyed and animal tissues damaged severely.

Acid Rain

- It is the precipitation charged with an excessive amount of acid droplets formed when oxides of Sulphur and Nitrogen, released by the burning of hydrocarbons, are converted to acids in the atmosphere.
- Acid rain leaches crucial minerals like calcium and magnesium, which are essential for plant growth, from the soils. A related problem is the continued leaching of heavy metals and other substances, providing a persistent source of toxicity to surrounding vegetation and aquatic life.
- It is now emerging as a major problem in the developing world where energy use has surged and the use of sulphur-containing coal and oil, the primary sources of acid emissions, is very high.
- Although there has been progress in controlling acid-forming emissions in some countries, the global threat from acid rain is far from over yet.
- Damage could be largely avoided if modern pollution control technologies are widely adopted and low-sulphur fuel substituted, where possible. But perhaps the most cost-effective option for controlling acid rain will be to adopt energy-efficiency measures that cut overall energy use and thus reduce emissions.
- In this protective role, the presence of the ozone layer is an essential factor in the life environment.
- There are certain household and industrial chemicals, having widespread application in refrigeration, air conditioning, fire extinguishing and dry cleaning, that are known to deplete this life-saving layer.
- These chemicals are called Ozone Depleting Substances and include primarily the Chlorofluorocarbons (CFCs), Carbon Tetrachloride (CCl₄) and Hydro Chlorofluorocarbons (HCFCs).
- Molecules of these substances drift upward through the troposphere and eventually reach the stratosphere.

- As these compounds absorb ultraviolet radiation, they are decomposed and chlorine is released.
- The chlorine in turn attacks molecules of ozone, converting them in large numbers into ordinary oxygen molecules.
- In this way, the ozone concentration within the stratospheric ozone layer can be reduced.
- With less ozone in the atmosphere, more ultraviolet radiation reaches the Earth, leading to a higher incidence of skin cancer (or melanoma), cataracts, destruction of certain forms of aquatic life, reduction in crop yields and damage to the immune system.

Changes in the atmosphere

Carbon dioxide, methane, and nitrous oxide are all long-lived greenhouse gases.

- Carbon dioxide, methane, and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values.
- The amount of carbon dioxide in the atmosphere in 2005 (379 ppm) exceeds by far the natural range of the last 650,000 years (180 to 300 ppm).
- The amount of methane in the atmosphere in 2005 (1774 ppb) exceeds by far the natural range of the last 650,000 years (320 to 790 ppb).
- The primary source of the increase in carbon dioxide is fossil fuel use, but land-use changes also make a contribution.
- The primary source of the increase in methane is very likely to be a combination of human agricultural activities and fossil fuel use. How much each contributes is not well determined.
- Nitrous oxide concentrations have risen from a pre-industrial value of 270 ppb to 2005 value of 319 ppb. More than a third of this rise is due to human activity, primarily agriculture.

IPCC Report

The IPCC report, released on 2 February 2007 in Paris, said man-made emissions of greenhouse gases can already be blamed for fewer cold days, hotter nights, killer heat waves, floods and heavy rains, devastating droughts and an increase in hurricane and tropical storm strength- particularly in the Atlantic Ocean.

The report is:

- Warming of the climate system unequivocal
- Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely (greater than 90% likely) due to the observed increase in anthropogenic (human) greenhouse gas concentrations.
- Hotter temperatures and rises in sea level "would continue for centuries" no matter how much humans control their pollution, although the likely amount of temperature and sea level rise varies greatly depending on the fossil intensity of human activity during the next century.
- The probability that this is caused by natural climatic processes alone is less than 5%.
- World temperatures could rise from anywhere between 1.1 and 6.4°C during the 21st century and that sea levels will probably rise by 18 to 59cm.
- It is more than 90% certain that there will be frequent warm spells, heat waves and heavy rainfall.
- It is more than 66% certain that there will be an increase in droughts, tropical cyclones and extreme high tides.
- Both past and future anthropogenic carbon dioxide emissions will continue to contribute to warming and sea level rise for more than a millennium.

Chlorofluorocarbons

Chlorofluorocarbons (CFCs) are a class of chemicals that contain only atoms of carbon, chlorine, and fluorine. As a group, they are unreactive, stable, and poorly soluble in water. Commercially, the most important CFCs were derivatives of methane and ethane. These included trichlorofluoromethane (CFC-11), dichlorodifluoro-difluoromethane (CFC-12), 1,1,2-trifluoroethane (CFC-113) and 1,2-dichloro-1,2,2-tetrafluoroethane (CFC-114). CFCs were introduced in the 1930s as safe replacements for refrigerants such as sulfur dioxide, ammonia, chloroform, and carbon tetrachloride. During World War II they were used to produce aerosols of insecticides. During the next fifty years the applications

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expanded to include foam blowing, precision cleaning, air conditioning, refrigeration, and propellants for medicinal, cosmetic, food, and general-purpose aerosols. These uses eventually resulted in large emissions of CFC s into the atmosphere. Because of their low chemical reactivity, CFCs typically have long atmospheric residence times, and as a consequence are distributed globally.

Isopleths		Instruments	
<i>Type</i>	<i>Connects points of equal</i>	<i>Instruments</i>	<i>Elements</i>
<i>Isallobar</i>	Change in atmospheric pressure	<i>Raingauge</i>	Precipitation
<i>Isobath</i>	Depth below the surface of an ocean	<i>Barometer</i>	Pressure
<i>Isobathytherm</i>	Temperature at a given depth	<i>Hygrometer</i>	Relative Humidity
<i>Isobar</i>	Atmospheric pressure	<i>Wind Vane</i>	Wind Direction
<i>Isothere</i>	Mean summer temperature	<i>Anemometer</i>	Wind Speed
<i>Isocheim</i>	Mean winter temperature	<i>Altimeter</i>	Altitude
<i>Isogeotherm</i>	Temperature in the earth's interior	<i>Evaporimeter</i>	Rate of Evaporation
<i>Isotach</i>	Wind speed	<i>Hydrometer</i>	Specific gravity of liquids
<i>Isohel</i>	Sunshine duration	<i>Hypsometer</i>	Absolute height above sea level
<i>Isohyet</i>	Rainfall amount	<i>Solarimeter</i>	Intensity of solar radiation
<i>Isohypse</i>	Height above sea level	<i>Barograph</i>	Continuous recording of atmospheric pressure
<i>Isoneph</i>	Degree of cloudiness	<i>Cathetometer</i>	Height
<i>Isonif</i>	Amount of snowfall	<i>Pyrometer</i>	Very high temperature
<i>Isoryme</i>	Frost intensity	<i>Cryometer</i>	Very low temperature
<i>Isohaline</i>	Salinity	<i>Fathometer</i>	Ocean depth
<i>Isotherm</i>	Temperature	<i>Manometer</i>	Pressure of gases
<i>Isoseismal Line</i>	Intensity of shock from an earthquake	<i>Photometer</i>	Luminous intensity of the source of light
<i>Isothermobath</i>	Sea water temperature at a given depth	<i>Radio micrometer</i>	Heat radiation
<i>Isobront</i>	Thunderstorm at the same time	<i>Salinometer</i>	Salinity of solutions
<i>Homoseismal Line</i>	Affected at the same time by an earthquake shock	<i>Actinometer</i>	Solar radiation
		<i>Atmometer</i>	Rate of evaporation
		<i>Nephoscope</i>	Height, movement and velocity of clouds
		<i>Lysimeter</i>	Actual evapotranspiration
		<i>Psychrometer</i>	Relative humidity
		<i>Pyranometer</i>	Scattered radiation on a surface
		<i>Wet and Dry Bulb</i>	Relative humidity
		<i>Thermometer</i>	
		<i>Thermostat</i>	Regulates temperature to a particular point

Air Borne!!Air Borne!!

- The Sky, as seen from Earth, appears blue because of the scattering of sunlight by the Earth's atmosphere. Sunlight consists of light waves of varying wavelengths. When sunlight reaches the Earth's atmosphere, it hits suspended molecules of air and dust and gets scattered in all directions. The size of the scattering molecules decides which colour is scattered most. Gas molecules in the atmosphere scatter blue colour the most. During the day the sky appears blue because more blue light is deflected towards the Earth. However, on the Moon, since there is no atmosphere, scattering of sunlight is negligible. So the sky appears black from the Moon. At sunrise and sunset, the oblique solar rays have to pass through the longest path of atmosphere, hence all the colour spectrums except the red (which has the shortest wavelength) and orange are scattered. This accounts for the reddish hue of the sky during the twilight.
- A rainbow is one of the most beautiful sights in nature, and man has long wondered what makes it happen. It is simply a great curved spectrum, or band of colours, caused by the breaking-up of light which has passed through raindrops which act as prisms. When sunlight enters a droplet of water, it is broken up just as if it had entered a glass prism. The light comes back out of the droplet in different directions, depending on the colour. And when one looks at these colours in a rainbow, one can see them arranged with red at the top and violet at the bottom (VIBGYOR). A rainbow is seen only during showers, when rain is falling and sun is shining at the same time, and only in the early mornings or late afternoons. Superstitious people used to believe that souls went to heaven on the bridge of a rainbow, and when a rainbow appeared it meant someone was going to die!
- Environmental Lapse Rate. Normally, temperature decreases with height at the rate of 10C of every 165 meters of height above sea level. The higher layers of the atmosphere contain smaller quantities of water vapour and carbon dioxide and hence their capacity to absorb heat energy is much less than that of the lower layers. Therefore, hill stations like Nainital and Darjeeling are cooler than Delhi.
- Temperature inversions. Under usual conditions, tropospheric temperature decreases with height as ground-warmed air rises, expands and cools. Thus, any pollutants contained in that surface layer of air would disperse along with it. At times, however, this vertical 'cleanup' mechanism does not operate due to an increase in temperature with height. It is called temperature inversion because it inverts what we, on the surface, believe to be the 'normal' behavior of temperature change with altitude. Due to the nightly cooling of the earth's surface and the atmosphere near the ground, it is common for temperature inversions to develop in early morning above both the city and the countryside. Air pollution is trapped and intensifies beneath the inversion layer that can pose a hazard in the cities.
- Though the Sun is overhead at around 12 noon, maximum temperature is recorded at about 3 P.M. because of the time lag involved in heating of the atmosphere from below by the heated earth's surface.
- Lightning occurs when a massive electrical discharge takes place between two oppositely charged clouds or between a charged cloud and the ground. Charges develop in thunder clouds due to friction as the water are tossed up and down with the rising and descending air currents within a cloud. During a bolt of lightning, thousands of amperes of electricity flows through air in a fraction of a second. This rapidly heats up the air producing shock waves, which we hear as thunder. Although the lightning and thunder are produced at the same instant, we hear the thunder later because light travels faster than sound.
- Ozone Hole over Antarctic. In 1982 a British

environment research team in Antarctic made a startling discovery: its instruments could not detect the ozone layer in the stratosphere overhead. Atmospheric scientists had never encountered this phenomenon before, but artificial satellites and high flying aircrafts by 1985 confirmed that a large “ozone hole” existed over most of this southern polar continent. Investigations found that this was a seasonal occurrence that peaked in the spring (the ozone hole has been observed each year since 1985). It must be mentioned that a corresponding hole has been observed over the Arctic Ocean since 1986. Although scientists attribute the seasonal thinning to the presence of chlorofluorocarbons (CFCs), the mechanisms by which they are made so effective at the poles have been strongly debated.

- **Terminal Velocity.** A large quantity of water remains suspended in a cloud. The water, however, is in the form of fine droplets that remain floating. These droplets do fall at a very slow rate but continue to be airborne so long as their fall speed or terminal velocity is less than the magnitude of the upward motion in the atmosphere. The larger the size of the droplet, the higher is the terminal velocity. Hence, for a droplet to fall and reach the ground as precipitation, it has to grow to a sufficiently large size in order to acquire terminal velocities sufficient to overcome the up current.
- **ANC.** No, it is not the African National Congress that we are talking about! This useful mnemonic indicates the direction of cyclones and anti-cyclones in the northern and southern hemispheres. It works like this- Anti-cyclones in Northern hemisphere have a Clockwise direction (when read from left to right) and Cyclones in Northern hemisphere have an Anti-clockwise direction (when read from right to left). The direction of cyclones and anti-cyclones gets reversed in the southern hemisphere.
- **Argon,** one of the inert gases found in the atmosphere, does not play a major role in

the workings of environmental systems. But, it is frequently used inside the ‘neon’ lights.

- **A Wet Day** is a period of 24 hours during which a least 1 mm of rainfall is recorded. While a **Rainy Day** is a period of 24 hours, during which at least 0.25 mm of rainfall is recorded.
- **Tornado** is derived from the Spanish word ‘tronada’, which means ‘to thunder’. It is the strongest known atmospheric disturbance with the wind velocity exceeding 300 km/hr. The most frequented tracks of tornadoes are in the Mississippi valley in the US. They are also called ‘Twisters’ because they twist whatever that comes in their way and bring large- scale devastation.
- **Most Tornadoes by Area.** The United Kingdom has the highest frequency of tornadoes by area, with an average of one tornado per 7397 sq. km recorded every year.
- **Fastest Tornado.** The highest speed measured to date in a tornado is 450 km/hr at Wichita Falls, Texas, USA on April 2, 1958.
- **Hottest Place.** Temperatures of over 49°C were recorded in Death Valley, California, USA on 43 consecutive days in July and August 1917.
- **Highest Shade Temperature.** A shade temperature of 58°C was recorded at Al’Aziziyah, Libya, on September 13, 1922.
- **Coldest Places.** Polus Nedostupnosti (Pole of Inaccessibility), Antarctic, has an extrapolated annual mean temperature of -58°C.
- **The coldest measured annual mean temperature** is - 57°C, recorded at Plateau Station. Antarctic, The coldest permanently inhabited place in the world is the village of Oymyakon in Siberia, Russia.

Go With the Wind

- Most destructive of weather disturbances Tornado
- Climatic type with minimum annual temperature range Hot, Wet Equatorial
- A 'wet day' is when then amount of rainfall is at least 1 mm
- If $x^{\circ}\text{C} = x^{\circ}\text{F}$: $x +$ $-40^{\circ}\text{C}/5=\text{F}-32/9$
- The average albedo of the Earth 35%
- Winter concentration of rainfall characteristic of Mediterranean climate
- Roaring Forties, Furious Fifties and Shrieking are westerlies of Southern hemisphere
- A wind which blows down valleys at night Katabatic wind
- Gale, Storm, Breeze, Hurricane arranged in decreasing order of wind velocities $\text{H}>\text{S}>\text{G}>\text{B}$
- Atmosphere layer that selectively absorbs ultraviolet radiation Ionosphere
- About 50% of the atmosphere lies below an altitude of 5.6 km
- Varied colours of red and orange at sunrise and at sunset are due to *Scattering of light by dust particles*
- Inversion of temperature represents Temperature increase with altitude
- Immediate cause of wind is Pressure difference
- Horse latitude lie within Subtropical high
- A pressure system with higher pressure at the centre Anticyclone
- The rain shadow effect is related to Orographic precipitation
- The type of rainfall occuring in the equatorial region is Convictional
- Extra-tropical cyclones have Fronts
- The central low pressure core of a tropical cyclone Eye
- In a tropical cyclone the pattern of isobars is Circular
- Sunspots are Huge magnetic storms on the solar surface
- Thunder clouds are technically known as Cumulonimbus
- A very short lived fast wind Squall
- Stevenson Screen is a Meteorological shelter
- Frozen raindrops are called Sltte
- Solar constant is equal to $1.94/\text{sq cm/minute}$
- Weather cock is used for ascertaining Wind direction
- The unit of relative humidity It is a ratio hence has no unit
- Condensation at dew point below 0°C produces Frost
- Line joining places with the highest mean temperature Thermal equator
- Normal lapse rate = 1°C decrease for every 165m ascent
- Scattering of light by dust particles is known as Tyndal effect