2. Insolation

1. Heat budget of the Earth.
2. Factors affecting horizontal distribution of temperature.
3. Inversion of temperature, lapse rateand its types.
4. Global warming.

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2. Insolation

Introduction:

The sun is the primary source of energy on the earth. This energy is radiated in all directions into space through short waves. This is known as solar radiation.

Only two billionths of the total solar radiation reaches the earth's surface. This small proportion of solar radiation is of great importance, as it major source of energy on the earth for most of the physical and biological phenomena.

Incoming solar radiation through short waves is termed as insolation. The amount of insolation received on the earth's surface is far less than that is radiated from the sun because of the small size of the earth and its distance from the sun.

(a) Factors influencing Insolation

The amount of insolation received on the earth's surface is not uniform everywhere. It varies from place to place and from time to time. The tropical zone receive the maximum annual insolation. It gradually decreases towards the poles. Insolation is more in summers and less in winters.

The following factors influence the amount of insolation received.

(i) The angle of incidence.

(ii) Duration of the day. (daily sunlight period)

(iii) Transparency of the atmosphere.

(i) The Angle of Incidence : Since the earth is round, the sun's rays strike the surface at different angles at different places. The angle formed by the sun's ray with the tangent of the earth's circle at a point is called angle of incidence. It influences the insolation in two ways. First, when the sun is almost overhead, the rays of the sun are vertical. The angle of incidence is large hence, they are concentrated in a smaller area, giving more amount of insolation at that place. If the sun's rays are oblique, angle of incidence is small and sun's rays have to heat up a greater area, resulting in less amount of insolation received there. Secondly, the sun's rays with small angle, traverse more of the atmosphere, than rays striking at a large angle. Longer the path of sun's rays, greater is the amount of reflection and absorption of heat by atmosphere. As a result the intensity of insolation at a place is less.

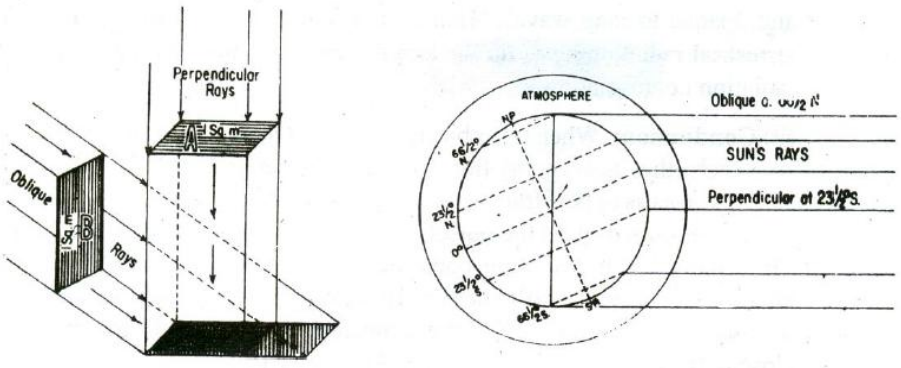


Fig. 10.1 : Effect of Angle of Incidence on Insolation

(ii) Duration of the day : Duration of the day varies from place to place and season to season. It decides the amount of insolation received on earth's surface. The longer the duration of the day, the greater is the amount of insolation received. Conversely shorter the duration of the day leads to receipt of less insolation.

(iii) Transparency of the atmosphere: Transparency of the atmosphere also determines the amount of insolation reaching the earth's surface. The transparency depends upon cloud cover, its thickness, dust particles and water vapour, as they reflect, absorb or transmit insolation. Thick clouds hinder the insolation to reach the earth while clear sky helps it to reach the surface. Water vapour absorb insolation, resulting in less amount of insolation reaching the surface.

Heating and cooling of the Atmosphere and various Process

Forms of Energy:

- **Energy** can be defined simply as the capacity to do work. Work is done whenever matter moves.

Energy is also placed into one of two major categories:

- kinetic energy and
- Potential energy.

- **Kinetic Energy:** Energy associated with an object by virtue of its motion is described as **kinetic energy.**
- **Potential Energy** As the term implies, **potential energy** has the capability to do work.

Temperature:

- **Temperature** is a measure of the average kinetic energy of the atoms or molecules in a substance.
- When a substance gains energy, its particles move faster and its temperature rises.

By contrast, when energy is lost, the atoms and molecules vibrate more slowly and its temperature drops

Heat:

- We define **heat** as energy transferred into or out of an object because of temperature differences between that object and its surroundings.
- Heat flows from a region of higher temperature to one of lower temperature. Once the temperatures become equal, heat flow stops.

Mechanisms of Heat Transfer:

There are four heating processes directly responsible for heating the atmosphere

- The flow of energy can occur in three ways:
  - Conduction,
  - Convection
  - Radiation
  - Advection

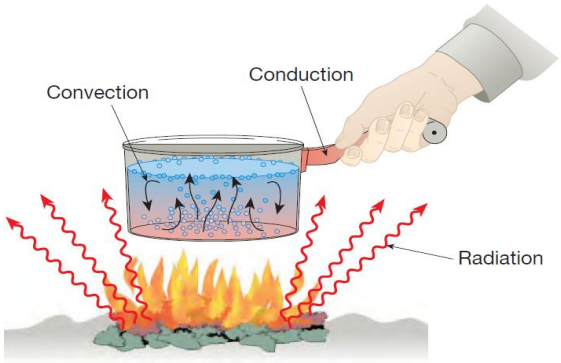
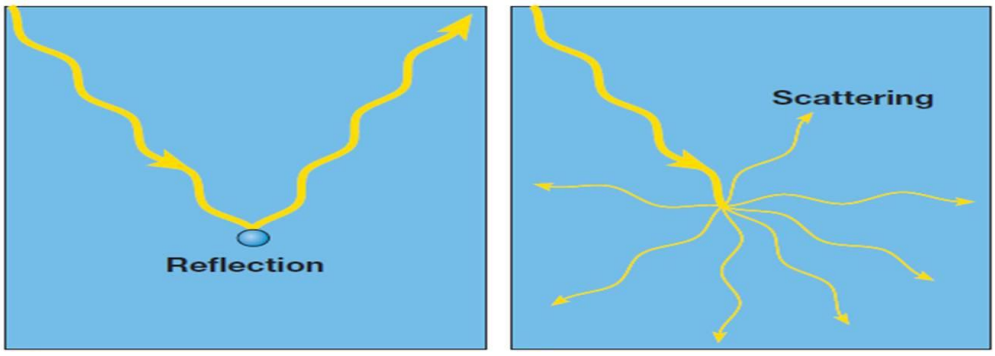


Figure 2–10 The three mechanisms of heat transfer: conduction, convection, and radiation.

(i) Radiation : Radiation is the process by which solar energy reaches the earth and the earth loses energy to outer space. When the source of heat transmits heat directly to an object through heat waves, it is known as radiation process.
(ii) Conduction: When two objects of unequal temperature come in contact with each other, heat energy flow from the warmer object to the cooler object and this process of heat transfer is known as conduction.
(iii) Convection: Transfer of heat by movement of a mass or substance from one place to another, generally vertical, is called convection. The air of the lower layers of the atmosphere get heated either by the earth's radiation or by conduction.
(iv) Advection: Winds carry the temperature of one place to another. The temperature of a place will rise if it lies on the path of winds coming from warmer regions. The temperature will fall if the place lies on the path of the winds blowing from cold regions. This process of horizontal transport of heat by winds is known as advection.

Reflection and Scattering

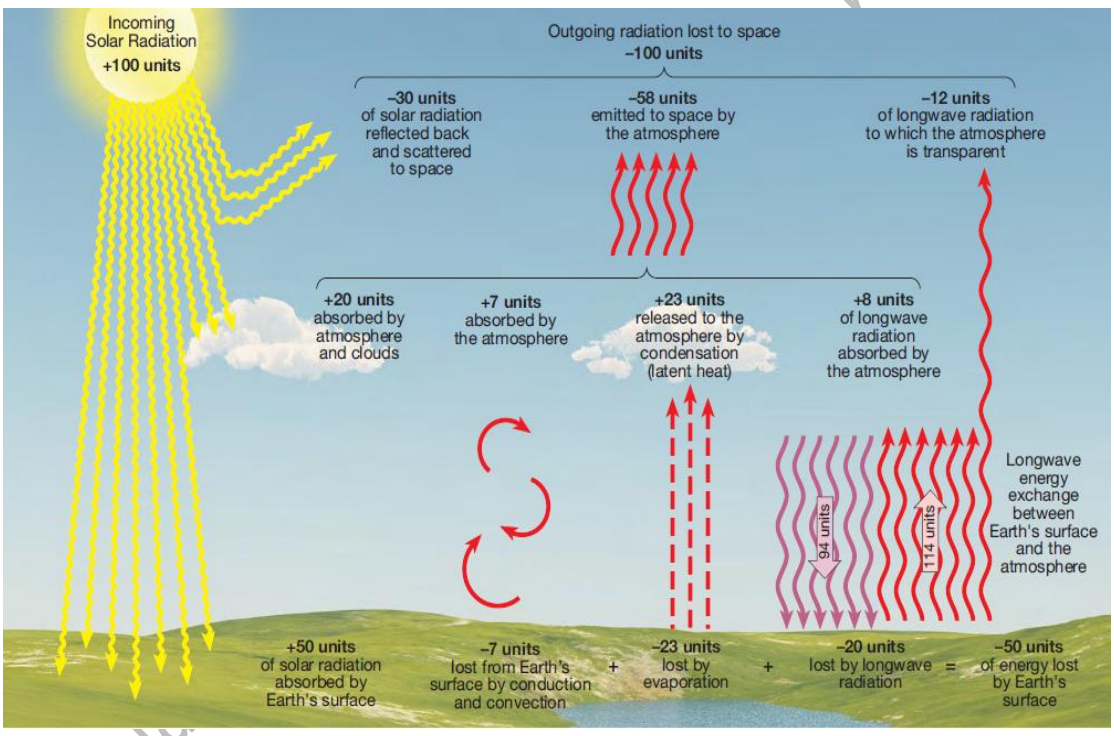
- **Reflection** is the process whereby light bounces back from an object at the same angle and intensity.
- **Scattering** produces a larger number of weaker rays, travelling in different directions. Scattering disperses light both forward and backward (**backscattering**)



2.1 Earth's Heat Budget:

Insolation is the amount of solar radiation that reaches the earth's surface through shortwaves. The earth also radiates heat energy like all other hot object. This is known as terrestrial radiation. The annual mean temperature on the surface of the earth is always constant. It has been possible because of the balance between insolation and terrestrial radiation. This balance is termed as a heat budget of the earth.

- Globally, Earth's average temperature remains relatively constant, despite seasonal cold spells and heat waves.
- This stability indicates that a balance exists between the amount of incoming solar radiation and the amount of radiation emitted back to space;
- Otherwise Earth would be getting progressively colder or progressively warmer.
- The annual balance of incoming and outgoing radiation is called Earth's **heat budget.**



Annual Energy Balance:

- Figure illustrates Earth's annual energy budget.
- For simplicity we will use 100 units to represent the solar radiation intercepted at the outer edge of the atmosphere.
- the total radiation that reaches Earth,
- Roughly 30 units (30%) are reflected and scattered back to space.
- The remaining 70 units are absorbed,
- 20 units within the atmosphere and
- 50 units by Earth's land–sea surface.

2.2 Temperature and its Distribution:

Temperature indicates the relative degree of heat of a substance. Heat is the energy which make things or objects hot, while temperature measures the intensity of heat. Temperature are closely related to gain or loss of heat to raise or lower the temperature. The Celsius scale, named after the Swedish astronomer. Anders Celsius, is accepted internationally by Scientists for reporting air temperature.

Distribution of temperature varies both horizontally and vertically. Let us study it under:

(a) The horizontal distribution of temperature

(a) Horizontal Distribution of Temperature

Distribution of temperature across the latitudes over the surface of the earth is called its horizontal distribution. On maps, the horizontal distribution of temperature is commonly shown by "Isotherms", lines connecting points that have equal temperatures. An isotherm is made of two words 'iso' and 'therm', 'Iso' means equal and 'therm' means" temperature. If you study an isotherm map you will find that the distribution of temperature is uneven. The factors responsible for the uneven distribution of temperature are as follows:

(i) Latitude

(ii) Land and Sea Contrast

(iii) Relief and Altitude

(iv) Ocean Currents

(v) Winds/ Prevailing Wind

(vi) Vegetation Cover

(vii) Nature of the soil

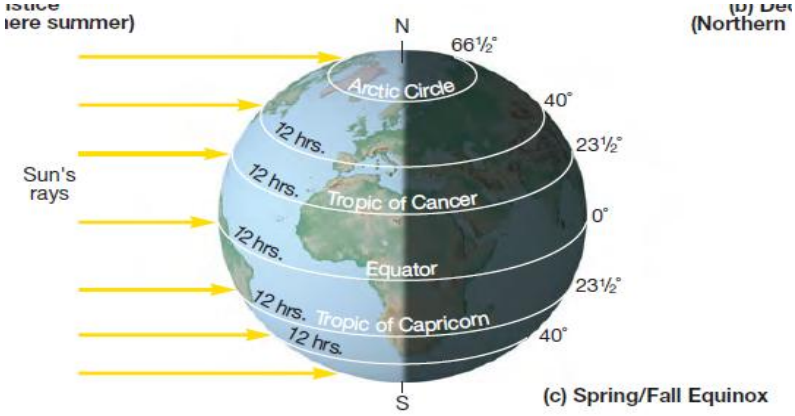
(viii) Slope and Aspect

(ix) Cloud Cover and Albedo

(x) Distance from the Coast

(i) Latitude :

You have already studied under'insolation' that the angle of incidence goes on decreasing from equator towards poles (fig. 10.1). Higher the angle of incidence, higher is the temperature. Lower angle of incidence leads to the lowering of temperature. It is because of this that higher temperatures are found in tropical regions and they generally decrease at a considerable rate towards the poles. Temperature is below freezing point near the poles almost throughout the year.



(ii) Land and Sea Contrast:

Land and sea contrast affects temperature to a great extent. Land gets heated more rapidly and to a greater degree than water during sunshine. It also cools down more rapidly than water during night. Hence, temperature is relatively higher on land during day time and it is higher in water during night. In the same way there are seasonal contrasts in temperature. During summer the air above land has higher temperature than the oceans. But the air above oceans gets higher temperature than landmasses in winter. A snow covered land as in polar areas warms very slowly because of the large amount of reflection of solar energy. A vegetation covered land does not get excessively heated because a great amount of insolation is used in evaporating water from the plants.

(iii) Relief and Altitude:

Relief:

Relief features such as mountains, plateaus and plains control the temperature by way of modifying its distribution. Mountains act as barriers against the movement of winds.

The Himalayan ranges prevent cold winds of Central Asia from entering India, during winter. Because of this Kolkata is not as cold as Guangzhou (Canton) in winter though both are situated almost on the same latitude.

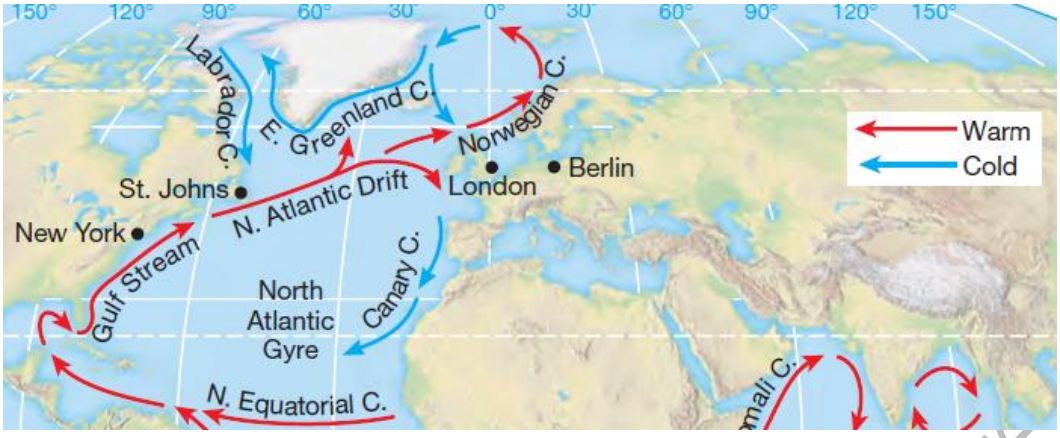
Altitude

As we move upwards from sea level, we experience gradual decrease in temperature. Temperature decreases at an average rate of 6.5^0C per 1000 m. altitude. It is known as normal lapse rate. The air at lower elevations is warmer than that of higher elevations because it is closest to the heated surface of the earth. As a result mountains are cooler thanthe plains even during summers.

(iv) Ocean Currents:

Ocean currents are of two types - warm and cold. Warm currents make the coasts along which they flow warmer, while cold currents reduce the tempeeture of the coasts along which they flow. The North-Western European Coasts do not freeze in winter due to the effect of North Atlantic Drift (a warm current), while the Quebec on the coast of Canada is frozen due to the Cold Labrador Current flowing along it, though the Quebec is situated in lower latitudes than the North-West European Coast Refer following Fig.

@ For only local circulation among the Geography (G2) student as learning material.



(iii) Winds:

Winds also affect temperature because they transport heat from one region to the other.

(vi) Vegetation Cover:

Soil devoid of vegetation cover receives heat more rapidly than the soil under vegetation cover. Because vegetation cover absorbs much of sun's heat and then prevents quick radiation from the earth whereas the former radiates it more rapidly. Hence the temperature variations in dense forested areas are lower than those in desert areas. For example annual range of temperature in equatorial regions is about 5°C while in hot deserts; it is as high as 38°C.

(vii) Nature of the Soil:

Colour, texture and structure of soils modify temperature to a great degree. Black, yellow and clayey soils absorb more heat than sandy soils. Likewise heat radiates more rapidly from sandy soils than from black, yellow and clayey soils. Hence temperature contrasts are relatively less in black soil areas than those of sandy soils.

(viii) Slope and Aspect:

Angle of the. slope and its direction control the receipt of insolation. The angle of incidence of sun's rays is greater along a gentler slope and smaller along a steeper slope. The ray in both the cases carry an equal amount of solar energy. Greater concentration of solar energy per unit area along gentler slope raises the temperature while its lesser concentration along steeper slopes lowers the temperature. For such reasons, the southern slopes of the Himalaya are warmer than the northern ones. At the same time the slopes, in terms of aspect, exposed to the sun receive more insolation and are warmer than those which are away from the direct rays of the sun.

(ix) Cloud Cover and Albedo:

The albedo of a surface is the ratio of radiation reflected from the surface to the incident radiation.

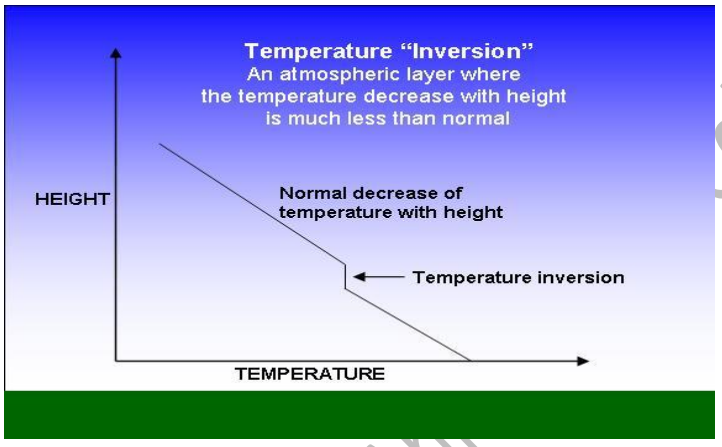
Clouds:

- Cloud albedo has substantial influence over atmospheric temperatures.
- Different types of clouds exhibit different reflectivity, theoretically ranging in albedo from a minimum of near 0 to a maximum approaching 0.8.
- "On any given day, about half of Earth is covered by clouds, which reflect more sunlight than land and water.

- Clouds keep Earth cool by reflecting sunlight, but they can also serve as blankets to trap warmth.

2.3. Inversion of temperature, lapse rate and its types.

In meteorology, an **inversion** is a deviation from the normal change of an atmospheric property with altitude. It almost always refers to a "**temperature inversion**", i.e. an increase in **temperature** with height, or to the layer ("**inversion** layer") within which such an increase occurs.



Lapse rates:

The **atmospheric lapse rate** ( ) refers to the change of an atmospheric variable with a change of altitude, the variable being temperature unless specified otherwise (such as pressure, density or humidity)

Types of lapse rates:

There are three types of lapse rates that are used to express the rate of temperature change with a change in altitude, namely…

1.the dry adiabatic lapse rate,
2.the wet adiabatic lapse rate and
3.the environmental lapse rate.

1.Dry adiabatic lapse rate

Since the atmospheric pressure decreases with altitude, the volume of an air parcel expands as it rises. Conversely, if a parcel of air sinks from a higher altitude to a lower altitude, its volume is compressed by the higher pressure at the lower altitude. An *adiabatic lapse rate* is the rate at which the temperature of an air parcel changes in response to the expansion or compression process associated with a change in altitude, under the assumption that the process is adiabatic (meaning that no heat is added or lost during the process).

The ***dry adiabatic lapse rate*** refers to the lapse rate of unsaturated air (i.e., air with a relative humidity of less than 100%). It is also often referred to as the *dry adiabat*, *DALR* or *unsaturated lapse rate*.

2.Wet adiabatic lapse rate

An unsaturated parcel of air will rise from Earth's surface and cool at the dry adiabatic rate of – 9.8 K / kilometre (5.4 °F /&tninsp;1000 ft) until it has cooled to the temperature, known as the *atmospheric dew point*, at which the water vapor it contains begins to condense (i.e., change phase from vapor to liquid) and release the latent heat of vaporization. At that dew point temperature, the air parcel is saturated and, because of the release of the heat of vaporization, the rate of cooling will decrease to what is known as the ***wet adiabatic lapse rate***.

3. Environmental lapse rate

The actual real-world profile of temperature versus altitude that exists at any given time and in any given geographical location is called the ***environmental lapse rate***, also often referred to as the *ELR*, *prevailing lapse rate* or *ambient lapse rate*.

2.4. Global warming.

Definition of Global Warming:

A gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, CFCs, and other pollutants.

Global warming is the observed and projected increases in the average temperature of Earth's atmosphere and oceans.

The Earth's average temperature rose about 0.6° Celsius (1.1° Fahrenheit) in the 20th century, see temperature graphs below.

Green House Effects: The greenhouse effect is the natural process by which the atmosphere traps some of the Sun's energy, warming the Earth enough to support life.

Green House Gasses: The primary greenhouse gases in Earth's atmosphere are…water vapor,
carbon dioxide, methane, nitrous oxide, and ozone.

Climate Change: *Changes in the earth's weather, including changes in temperature, wind patterns and rainfall, especially the increase in the temperature of earth's atmosphere that is caused by the increase of particular gases, especially carbon dioxide.*

Process of Global Warming:

Major sources and processes of global warming includes ozone depletion and greenhouses effects. Thus, it necessary to understand the mechanism of creation, destruction and maintenance of ozone layer and sources and processes of intensification of greenhouse effects by increasing emission of carbon dioxide and methane for evaluation of global warming.

Evidences of Global Warming:

The following evidences support the theory of gradual rise in air temperature and consequent global warming:

1. Temperature records,
2. Melting of mountain and continental glaciers,
3. Warming of ocean water at global level,
4. Rise in sea level,
5. Thawing of permafrost areas,
6. Upward shifting of snow lines of the tropical and subtropical mountains,

7. Spreading of tropical diseases towards temperature and Polar Regions.
8. Shifting of seasonal weather phenomena and changes in precipitation patterns etc.

Cusses of Global Warming:

1 Global warming is primarily a problem of too much carbon dioxide (CO2) in the atmosphere—which acts as a blanket, trapping heat and warming the planet. As we burn fossil fuels like coal, oil and natural gas for energy or cut down and burn forests to create pastures and plantations, carbon accumulates and overloads our atmosphere. Certain waste management and agricultural practices aggravate the problem by releasing other potent global warming gases, such as methane and nitrous oxide. See the pie chart for a breakdown of heat-trapping global warming emissions by economic sector.

2.Ozone Deplation: The stratospheric ozone layer mostly concentrated between the altitudes of 12km to 35km, is considered as a protective shield and earth's umbrella because it prevents ultraviolet solar radiation from reaching the earth's surface. Thus, the presence of ozone layer in the stratosphere is of vital significance for all biota including plants, animals and man in the biosphere.

Consequences/ Effects of Global Warming:

One of the most immediate and obvious effects of global warming is the increase in temperatures around the world. The average global temperature has increased by about 1.4 degrees Fahrenheit (0.8 degrees Celsius) over the past 100 years, according to the National Oceanic and Atmospheric Administration (NOAA).

Effects of Global Warming

Following are the effects of global warming:

1. More heat waves
2. Expansion of desert area
3. Natural fires in forest lands
4. More evaporation of water from oceans and water bodies
5. Melting of Ice caps in Arctic and Antarctic regions
6. More cloud formation in the atmosphere
7. Shorter and warmer winters coupled with longer and hotter summers
8. Changes in rainfall pattern
9. Rise in sea level
10. Flooding and submergence of low lying coastal areas
11. Disruption in farming
12. More drought
13. Impact on plants, animals and humans