HORIZONTAL AND VERTICAL DISTRIBUTION OF TEMPERATURE

Dear students,

In the previous episode, we have discussed on the atmospheric temperature, Insolation and global energy budget.
This episode focuses on the Horizontal and Vertical distribution of temperature.

The present episode consists of the following modules:

1.1. Horizontal distribution of temperature:
1.2. Prominent controls of temperature
1.3. Seasonal distribution of temperature
1.4. Vertical distribution of temperature
1.5. Temperature Inversions.

In the previous episode we have discussed about the different processes of heating and cooling of the atmosphere. The temperature of a place depends on the amount of insolation received there which is determined by latitude. Besides latitude, there are other important geographical factors of the distribution of temperature. Isotherms are commonly used to show the horizontal distribution of temperature. We know that the temperature decreases with altitude at the rate of 6º C for every 1000 mts.

1.1. Horizontal distribution of temperature:

There are a number of factors that determine the horizontal distribution of temperature. There is a general decrease in temperature from the equator towards poles. The isotherms over certain part of the globe are closely spaced. While elsewhere they are widely spaced. There are other factors also affecting the distribution of the temperature like,

a) Differential heating of land and water b) Effect of ocean currents c) Mountain barriers.

The highest temperatures are found in the tropics and sub tropics which receive the largest amount of insolation all year round. On the contrary lowest average temperatures are recorded in the Polar regions.

Isotherms are the lines joining points of equal temperature. Global temperature patterns are shown with isothermal maps. Temperature maps are based on daily averages.

Isotherms while passing from the continents to oceans get distorted. The distortion is larger in the northern hemisphere due to the larger percentage of land surface. The coldest temperature in the winter and the highest temperature in the summer are found over continents. Since the temperature do not fluctuate as much over water as over land, the north south migration of isotherms is greater over continents than oceans, especially in the mid latitudes. The temperature gradient is very steep in the higher latitudes as well as along the eastern margins of the continents.

1.2. Prominent Controls of Temperature

Gross patterns of temperature are controlled largely by the following four factors: Temperature responds sharply to altitudinal changes. Isotherms on world temperature maps have conspicuous east-west trend. If the earth had a uniform surface and did not rotate, isotherms probably would coincide exactly with parallels.

The fundamental cause of temperature variation world over is insolation, which is governed primarily by latitude. Summer temperatures are higher over the continents than over the oceans; the isotherms over the continents bend poleward. Winter temperatures are lower over the continents than over the oceans; the isotherms over the continents bend equatorward. In both seasons isotherms make greater north-south shifts over land than over water. Regularity of isothermal pattern in the midlatitudes of the southern hemisphere is a manifestation of the fact that there is very little land. Isotherms in near-coastal areas of the oceans have prominent bends where warm or cool currents reinforce the land-water contrast. Cool currents deflect isotherms equator ward; warm currents deflect them pole ward. Cool currents produce the greatest isothermal bends in the warm season; warm currents in the cool season. Isotherms reflect the changing balance of insolation: moving northward from January to July and southward from July to January.

Isothermal shift is more pronounced in high latitudes than low latitudes and over continents than over the oceans. Temperature gradient is steeper in winter than in summer and over continents than oceans. The coldest places on Earth are over landmasses in high latitudes. For example Siberia, Canada, Greenland in January and Antarctica in July.

The highest temperatures are found over the continents in subtropical latitudes where descending air maintains clear skies, not in equatorial regions where frequent cloudiness prevent highest temperatures.

For example, Northern Africa and southwestern Asia and North America in July, Australia, southern Africa, South America in January.

Highest average annual temperatures are in equatorial regions because these regions experience so little winter cooling.

Average temperature range: difference between the average temperatures of the warmest and coldest months are usually, but not always in July and January.

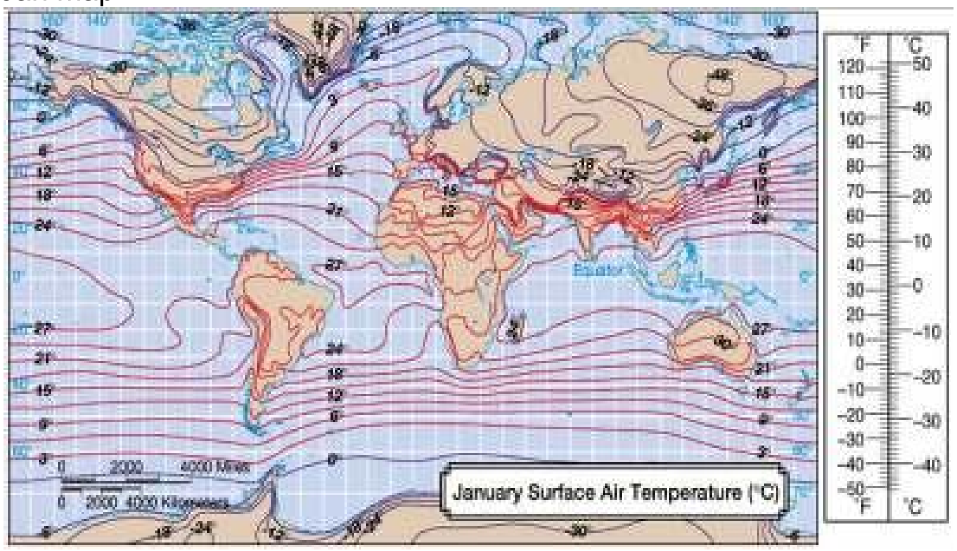
Largest annual temperature ranges occur in the interiors of high latitude continents. Annual temperature ranges in the tropics are very small

1.3. Seasonal distribution of temperature

Since January and July represent the seasonal extremes, the horizontal distribution of temperature in these two months only is described.

Distribution of temperature in January

Jan map



- Because of the presence of the more land surfaces in the Northern hemisphere the isotherms are more regularly and closely spaced.
- On the contrary, in the southern hemisphere (large water surface) the isotherms are relatively more symmetrical.
- The northern hemisphere has larger number of isothermal lines than in the southern hemisphere.

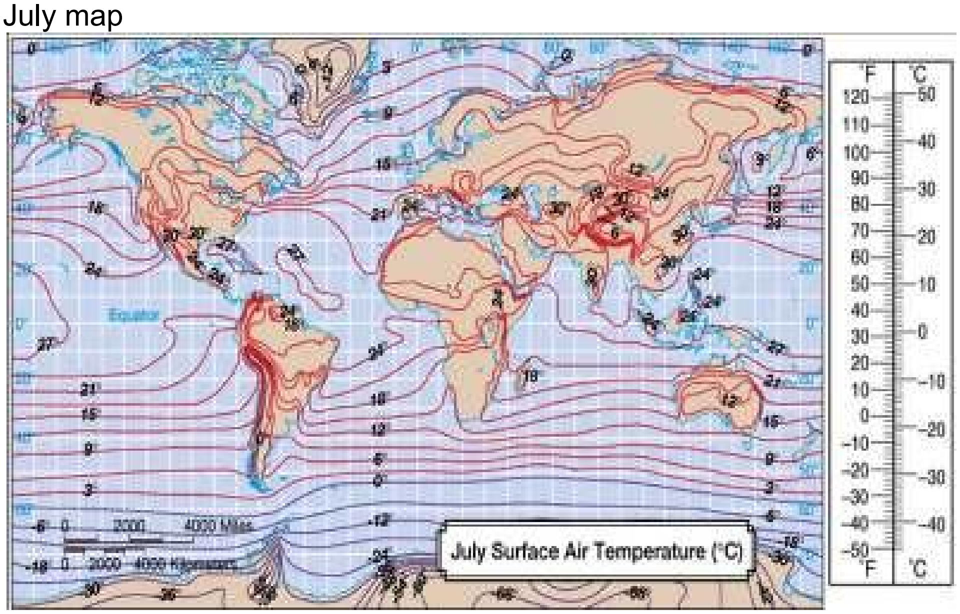
Isotherms bend sharply in January towards the equator.

- In January the coldest place on the earth is found in the north eastern Siberia, and another coldest region lies in Green land.
- In the mid latitude the western coastal regions of the continents are warmer because of the prevailing westerlies.
- In the Northern hemisphere the isotherms deflect more towards the pole, because of the warm current.

There will be a larger contrast in temperature over continents and oceans in the NH

Distribution of temperature in July;

July map



Isotherms in July in NH are most irregular and zig zag. On the contrary, the isotherms in the SH are more regular and straight.

High temperature is seen in N Africa through SW Asia to the North Western parts of US.

In northern Hemisphere, the continents are much warmer than oceans.(cooler) There are less number of isotherms and they are widely spread in NH

Isotherms over continents bend towards the North Pole and over oceans towards the equator.

Annual range of temperature

The difference between the warmest and the coldest monthly means is called the ATR.it varies from place to place. The following are the factors affect and control the range of temperature.

a) The latitudes
b) Height above the MSL
c) Ocean currents
d) Prevailing winds
e) Precipitation and cloudiness
f) Local relief
g) Distance from the sea.

a) Latitude: twice in an year the sun rays are vertical at the equator, thus the temperature is uniformly high in equatorial regions and annual range of temperature is negligible. But from the equator poleward there is a in temperature. It results in greater range of temperature. In Polar Regions the length of the day and night is 6 months, one should expect the highest range annual range of temperature. But due to the angle of incidence is low and most of the energy being reflected back, checks the rise in the temperature. But in mid latitudes where seasonal variation of temperature is greatest, the annual range of temperature is also greatest.

b) Height above the MSL: The annual range of temperature at a particular place is highly controlled by height. At high elevations the rarity of the air, large amount of precipitation and cloudiness combine together to lower down the average temperature. Thus, places situated at higher elevations have lower annual range of temperature.

c) Ocean currents: The warm ocean currents, prevailing winds help to raise the temperature of the adjoining regions. The effect of warm ocean currents is more pronounced in winter. Hence the annual range of temperature is relatively smaller.

d) Prevailing winds: Among all the factors that have controlling influence over the annual range of temperature the prevailing winds are the most important. Offshore winds

bring about an increase in annual range of temperature of the adjacent land. Besides, the effect of ocean currents is largely determined by the prevailing winds. Hence the annual range of temperature is relatively low.

e) Precipitation and cloudiness: In those regions where the rains are more and the skies are covered with clouds, the summer temperatures are not allowed to fall much. Thus, the annual range of temperature is relatively low.

f) Local relief: Slope is one of the factors which affect the temperature of a place. Slopes facing the sun have higher temperature during summer months, and the slopes protected by the sun have lower temperature during winter. Thus, the local factors are also affects annual range of temperature.

g) Distance from the sea: water is heated or cooled in a longer period of time than land. Because of this characteristic of water, the coastal areas enjoy a moderate climate and the variations in temperature between warmest and coldest months are not very large. Increasing distance from the sea- coast, there is a corresponding increase in the seasonal variation of temperatures. Hence the annual range of temperature is very negligible.

1.4. Vertical distribution of temperature

As one moves from equator to poles, there is a steady decrease in temperatures are observed. In the same way there is a steady decrease in temperature with increasing elevation in the atmosphere. This decrease in temperature with increasing altitude is called vertical temperature gradient.

Various factors affecting the vertical temperature gradient interact in a complex manner. Energy transfers involve the latent heat of condensation, cooling of air by the process of radiation and heat transfer from the ground. High pressure systems descending of air which lead to warming of extensive layers of air results in the decrease of vertical temperature gradient. On the other hand low temperature systems give rise to ascending air currents increases the vertical temperature gradient. Moisture is said to be the additional factor which creates lot of complications in the vertical distribution of temperature.

Lapse rate

The vertical decrease in temperature is called the “Lapse rate”. The lapse rate is not constant, but it varies with height , location and season. The vertical decrease in temperature continues to only up to the tropopause. Beyond which it stops. In tropical regions, where insolation is intense the lapse rate is generally high, up to 160 mts on most of the afternoons. The lapse rate may be steep or low depending upon the atmospheric conditions. Heating of the lower air is not due to the nearness of the earth surface, but at the lower level air is denser than the upper layer containing large quantity of water vapor and dust particles. On the contrary, the upper strata are dry fewer amounts of water vapor and CO_2 are present. Upper air is more transparent, temperature is relatively low. Hence the temperature is low as we go away from the earth surface. Actual lapse rate and normal lapse rate is always different. Continents and oceans not only influence on the horizontal distribution, but also on the vertical distribution.

Under normal conditions the temperature decreases with altitude. But sometimes the temperature increases with the altitude. This phenomenon is known as temperature inversion.

During winter in Polar Regions layers of air close to the surface become so cold that up to a certain height the temperature increases with elevation. Outside the polar region, the inversion of temperature over continents is of common occurrence. But on oceans inversion of temperature occur in summer.

Another important feature of laps rate is that in tropical regions the decrease in temperature with elevation continues up to a height of 16 to 18 kms in the troposphere. In this zone the temperature at the outer boundary of the troposphere is reduced to -80º C, but in the Polar Regions the laps rate continues up to 6 kms. Beyond latitude 60ºN and S the height of the troposphere is 10 kms in summer and 9 kms in winter. The height of the troposphere in higher latitudes is relatively less.

1.5. Temperature Inversion.

In the lower part of the atmosphere Up to the height of 8-10 kms from the earth surface the temperature normally decreases with increasing altitude (6.5ºC per km). But sometimes under special circumstances it is reversed and the temperature instead of decreasing is found to increase with elevation. In other ward the temperature gradient is inverted. It is called inversion of temperature.

Temperature Inversion near the surface may be produced under the following conditions

- When there is a long clear winter nights-clear sky with high clouds, dry and calm air, the inversion of temperature occurs.
- When there is little wind movement near the ground or wind movement is too slow-little mixing of air, inversion takes place.
- In higher latitudes- snow covered areas- where solar radiation is reflected-loss of heat-air near the surface goes rapid cooling- temperature inversion develops.
- In polar regions temperature inversion is common- all the year round
- Snow covered land surfaces in temperate regions- witness temperature inversion at night in winter.

Inversion layer in Polar Regions is thicker than middle latitudes.

- It is greater on the continent in winter- and on oceans in summer except in Arctic Ocean. During winter there is absence of temperature inversion.

Type of Inversion of temperature

Radiation Inversion
Subsidence
Inversions Trade
wind Inversion
Frontal Inversion

Radiation Inversion:

The surface inversion produced by radiational cooling of lower air is called radiation inversion. Inversion layer develops at an altitude of about 90 mts. Since the land surface radiates more heat than the air, ground is cooled more rapidly than the air at a great height during night time with the result, the coldest air lies at the ground and is overlaid by warm air. The layer of air in close proximity to the earth's surface is cooled by the process of radiation and condensation more quickly than the upper layer of the air. Thus, at a certain height (90mts) the temperature increases with altitude. It continues up to 300 mts.

Subsidence Inversions:

Subsidence Inversions take place in valleys and mountains. When the air blows over the hills, it is heated as it is compressed into the side of the hills when that warm air comes over the top; it is warmer than the cooler air of the valley. Also, increasing the inversion, as the air comes over the top of the hill, it causes the air in the valley to be compressed, heating the cooler, and valley air from the top down. It is known as Subsidence Inversions.

Trade-wind inversion:

The temperature inversion usually present in the trade-wind streams over the eastern portions of the tropical oceans. In the equatorial zone and over the western portions of the trade-wind belt, the inversion does not exist as a mean condition, although it appears in certain weather patterns. The strength of the inversion varies enormously, occasionally being more than 10°C over 1 km, but sometimes being absent altogether, especially in the Northern Hemisphere. The inversion is generally strongest when the height of its base is lowest, and vice versa. The thickness of the inversion layer varies from only a few meters to more than 1000 meters and an average thickness of about 400 m.

Frontal Inversions

Frontal Inversions are inversions caused by a shallow "cold front" blowing in under warmer air. In other words, sometimes a bunch of cold air, called an air mass, will get blown by the wind from one place to another, warmer place, and will get blown underneath the warm air, causing an inversion. This is known as frontal inversion.

Effects of Inversions

One of the most harmful effects of inversions is that they trap the pollution close to the ground, trapping the smog. In places like Los Angeles and Salt Lake City, this is a real problem because of all the emissions from vehicles, power plants, and other factories or heat sources add to the atmosphere. Besides, inversions also trap sound waves. Because of this, the loud sounds coming from airplanes while taking off will seem louder as the sound waves refract off the inversion layer and back down to the ground. But sound waves aren't the only thing that gets refracted by weather inversions, light can be bent by the inconsistency of the temperature.

Conclusion

During the revolution of the earth around the sun, the inclination of the axis remains the same. Therefore all its positions are parallel to each other. Sun is a primary source of heat but it is not the rays of the sun which directly heat the air. A considerable portion of heat and light is absorbed by atmosphere but the increase of temperature is small due to the great mass of air. The earth emits infra-red rays after receiving the heat energy from the sun. Consequently the air absorbs a larger proportion of heat radiated out from the earth. Normally the temperature goes on declining as we proceed higher up from the sea level. But under special circumstances, there is an increase in temperature with an increase in elevation. This state of affairs is known as temperature inversion. The isotherms near the Equator bend pole-wards over the land, equator-wards over the sea, towards the poles the bends are in the opposite direction. The horizontal distribution of temperature depends on insolation, seasonal changes, winds, currents and nature of the land. High pressure systems descending of air which lead to warming of extensive layers of air results in the decrease of vertical temperature gradient. On the other hand low temperature systems give rise to ascending air currents increases the vertical temperature gradient.

Apart from temperature air pressure and wind are also influence on the other elements of the weather which we will be discussing in our next module.