Chapter Two

TEMPERATURE

Temperature is one of the most common weather variables announced on weather reports and forecasts. It can be defined as a measure of the average kinetic energy of individual atoms or molecules that compose a substance. Thus the faster the speed of motion of individual molecules the higher the temperature and the lower the speed the lower the temperature.

In ordinary terms, temperature is a measure of how hot or cold an area/substance is. The total energy emitted by these molecules is called heat.

Temperature as we shall later see plays an important role in influencing the weather of a place because it results into changes in air pressure (weight of air above a given surface) which triggers air movements, convergence, condensation and precipitation.

Temperature scale

There are 3 basic scales used in the measurement of temperature – the Celsius scale, the Fahrenheit scale and the Kelvin scale.

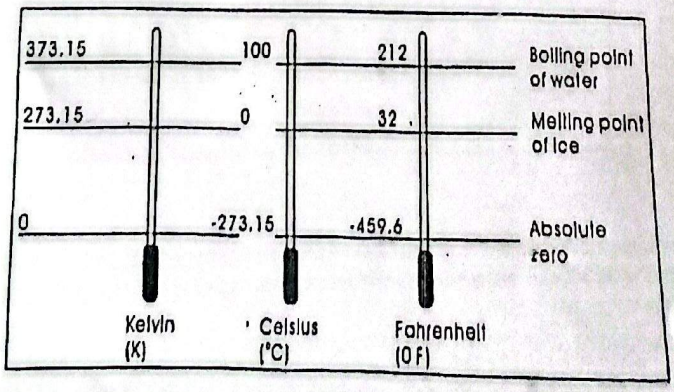
The Celsius scale was established by a Swedish astronomer called **Anders Celsius** in 1742. This temperature scale has got a numerical convenience of 100 degrees interval between the melting point of ice and the boiling point of pure water.

The Fahrenheit scale was introduced by German scientist called **Gabriel Fahrenheit.**

If a thermometer containing the 2 scales is immersed in freezing water the Fahrenheit scale will read 32° F while the Celsius scale will read 0°C. In boiling water at sea level, the readings will be 212°F and 100°C. Today this cumbersome temperature scale is highly used in USA.

The Kelvin scale is a more direct and clear way of showing temperature. On this scale, temperature is the number of degrees above absolute zero. Absolute zero is a point where there is no molecular motion and at that temperature, a substance does not emit any electro magnetic radiation.

The comparison of the 3 temperature scales.



Temperature measurement

The instrument used in the monitoring of temperature variation is called a thermometer.

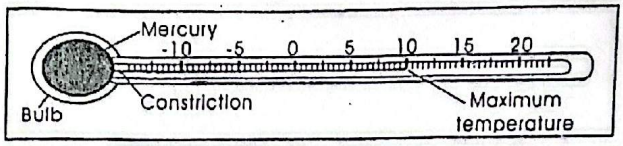
The most common thermometer was invented in the C17th and it consists of an in glass tube attached to a graduated scale. The liquid is either mercury, which freezes at –39°C or alcohol which freezes at –117°C. This liquid expands when temperature increases and contracts when temperature falls.

There are basically 3 types of thermometers; The maximum, the minimum and the sixth thermometers.

The maximum thermometer

This measures the highest temperature of the day. It has a small constriction in the tube just above the bulb. As temperature increases, the liquid usually mercury expands upwards and beyond the constriction. When temperature falls, the fluid threads break at the constriction such that the end of the mercury column is positioned at the highest (maximum) temperature. This is reset by whirling the mercury back into the bulb.

Maximum thermometer

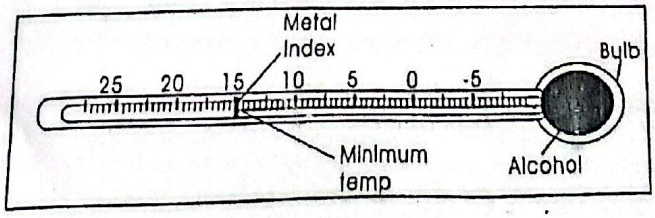


At constriction, the mercury thread break when temperature falls keeping mercury column at high temperature.

The minimum thermometer

In the minimum thermometer is a metal index ,which floats on the surface of a liquid column usually alcohol. As temperature falls, the index is drawn downwards. As temperature increases, alcohol expands and the index is left behind at the lowest point (minimum temperature). This thermometer is reset by tilting the bulb end upward. Usually these two thermometers are reset once every 24 hours.
Remember in the minmum thermometer, the liquid used is alcohol because its freezing point is lower than that of any other liquid.

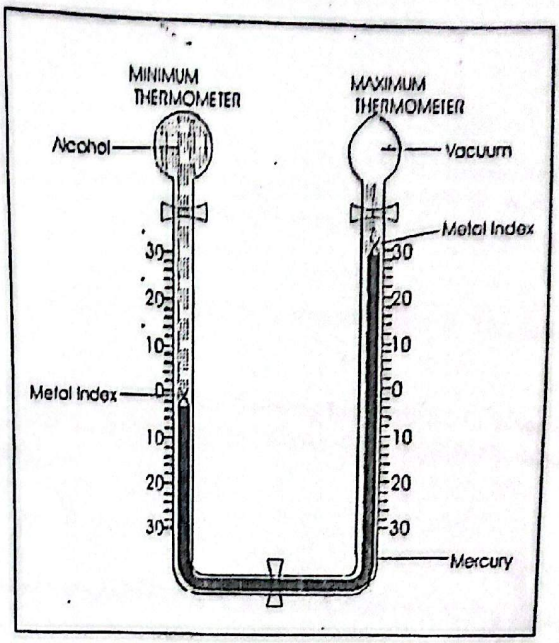
The minimum thermometer



The six thermometer

A six thermometer is a thermometer, which measures both maximum and minimum temperatures at the same time. It has got two thermometers one being a maximum thermometer and the other a minimum thermometer.

The six thermometer



How the thermometer works

There are two scales i.e. the minimum scale and the maximum scale. The maximum scale is progressive while the minimum scale is retrogressive (counts from big to small). When temperature increases alcohol and mercury expand towards the maximum side. Some of the alcohol in the maximum thermometer vapourises and occupies the empty space on top (vacuum). This flow pushes the index upwards up to the highest temperature.

When temperature reduces, there will be a reverse flow. The maximum index will stay still at the maximum temperature. This time, the vapour that was in the vacuum liquefies, the mercury and alcohol contract and this contraction forces the metal index in the minimum thermometer upwards. As it continues upwards, it reads lower and lower temperature on the scale until it stops on the lowest temperature of the day.

Transportation of heat.

Energy in form of temperature is transported in three major ways-conduction, convection and radiation

1. *Convection:* This is a mode of temperature transportation that works through convection currents. It works only in liquids and gases. In liquids, heat is transported as a result of the movement of the liquid itself. In the atmosphere convection occurs as a result of differences in air density. Warm air is always lighter than cold air. Hence as temperature rises, the air density reduces. Air from cool areas which is heavier undercuts this light air and forces it to rise and in the process it gets transported high up.

2. *Conduction*: This form of heat transfer occurs within substances which are in direct physical contact. In conduction the kinetic energy of atoms (heat energy) is transferred by collisions between neighbouring atoms. This is why a spoon heats up when put in a steaming cup of coffee. Conduction rates vary from substance to substance, as a rule, solids are better conductors than liquids and liquids are better conductors than gases.

9. *Distance from the sea: (continentality)*
There is always a very powerful interaction between land and sea. This interaction is either from the land to sea or from sea to land that involves the movement of air and the transfer of temperature. During the day, the land heats up more than sea. This causes a low pressure on land and high pressure on sea which results into the movement of cold air from sea to land and therefore the transfer of cold temperatures on land. The reverse flow occurs at night when cold temperature moves from the land to sea (this is what is refered to as sea and land breeze respectively). This temperature modification occurs near the coast hence areas far away from the coasts do not have such regulations in temperature.

10. *Ocean Currents*
Ocean currents are a stream of water moving from specific areas, in specific regions with specific temperatures. Ocean currents are of 2 types – warm and cold currents. Warm currents move from equator transferring warm temperature to areas they bathe. Cold currents move from polar regions and transfer cold temperatures to areas they bathe. Cold currents however result into drought and high temperatures due to their drying effects on prevailing winds which cross them while warm currents influence high rainfall, and thick cloud cover which reduce temperatures. Examples of cold currents include: Cool Benguela, cold Labrador, cold Canary , cold California, cold Hamboldt and cold Oyasio. Warm currents include; warm Mozambique, warm Guinea, the north Gulf stream and warm Kurasio currents.

11. *The work of man*
Man plays a great role in influencing the temperature of an area. In some places man has caused deforestation by for instance overgrazing by settlements, urbanisation and cultivation. This has increased the carbon concentration in the atmosphere which increases temperature of the affected areas.
Industrialisation and its consequent pollution also adds more carbon dioxide in the atmosphere, which also increases atmospheric temperature. In some areas however man has planted trees which absorb the carbon dioxide during photosynthesis. Vegetation acts as carbon sinks and this helps to keep the global temperatures low.

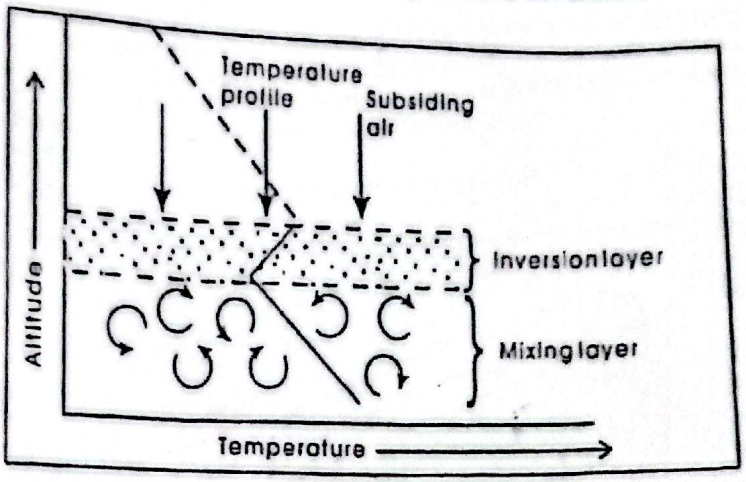
12. *Aspect:*
This refers to the degree to which an area is exposed to the sun. Some slopes are more exposed to the sun while others are shielded from the sun. Those areas which are more exposed to the sun will receive more temperature than those which are shielded. E.g the south facing slopes in the Northern hemisphere recieve more temperature than the north facing slopes in the temperate zones of the world.

Temperature inversion

Temperature inversion is an extremely stable air layer in which temperature increases with altitude. This is the inverse of the usual temperature profile in the atmosphere. Warm light air thus overlies cold dense air. Temperature inversion occurs under the following conditions.

1. Subsidence of Air
Subsidence of air results into a subsidence temperature inversion which covers a very wide area. It develops during a period of fair weather when hemispheric circulation patterns cause a warm anticyclone to develop. An anticyclone is characterised by air that subsides and is thereby warmed by adiabatic compression (warming of air as it descends towards the earth where high pressure compresses it and forces it to warm up).
Subsiding air is prevented from reaching the earth surface by the mixing layer (A layer towards the earth where air is thoroughly mixed by convection and therefore temperature tends to be low in this layer). Air temperature within the mixing layer decreases with altitude but air just above the mixing layer having been warmed by adiabatic compression is significantly warmer than air at the top of the mixing layer. Thus temperature inversion develops above the mixing layer.

Subsidence of air and temperature inversion



2. **Radiation cooling**

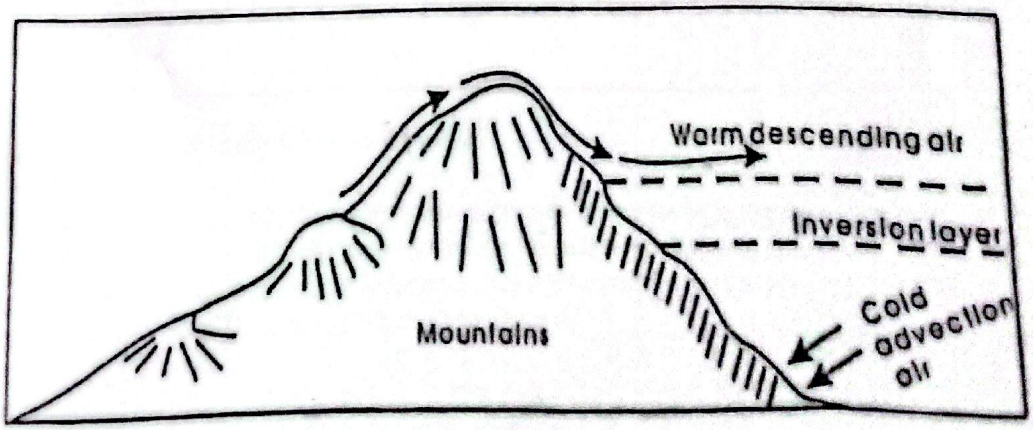
Inversion caused by radiation cooling is more common and more localised than subsidence temperature inversion. At night under clear skies, the earth's heat is rapidly lost to space. This is called nocturnal radiation cooling. The surface air layer is therefore chilled by contact with a colder ground. Because the air at the surface is coldest, a surface temperature inversion develops with temperature lowest on the surface and slightly high aloft. This is called nocturnal radiation temperature inversion. After sunrise, the ground absorbs heat and a normal lapse rate is restored

3. **Advection of air masses**

Advecting air masses can also give rise to temperature inversion. Air mass advection means a horizontal movement of air or air masses from one place to another. This type of inversion occurs at the base of the rocky mountains in America. A westerly air flow is compressionally warmed as it draws down the leeward slopes of the mountain ranges. Along the foot of the mountains however, surface winds advect cold air southwards. Hence a temperature inversion occurs aloft separating

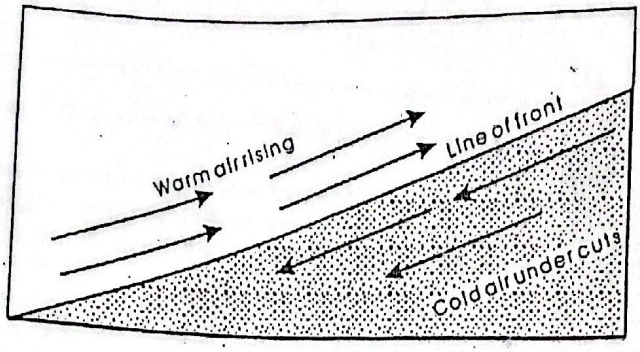
. ·m air above from the surface layer of cold air. Thus incase an air mass descending the leeward
slopes of a mountain and therefore adiabatically warmed is undercut by a cold air mass, a
temperature inversion will occur between these two air masses.

Air mass advection and temperature inversion



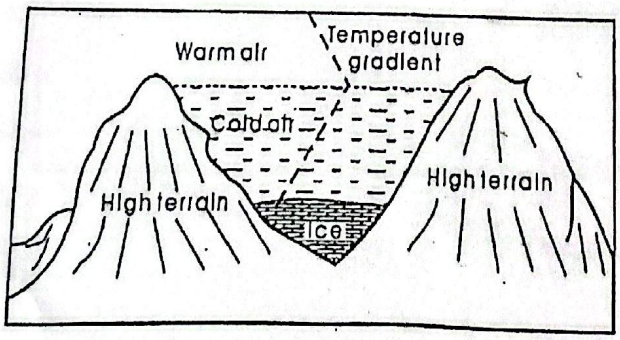
4. **Meeting of 2 Air masses**
This is called frontal temperature inversion. A front is a line of transition separating two air masses usually a warm air mass and cold air mass. When cold dry and dense air meets a warm, moist and light air, warm light air will be forced to rise on top of a cold dense air. A temporal temperature inversion will therefore occur above a frontal line.

Frontal temperature inversion



5. **High inversion**
This occurs in winter in areas where a fairly shallow layer (usually less than 600ft) of cold moist air is trapped in a low-lying area bordered by high lands. When this occurs. Air which is sitting on a cold surface (snow cupped) will lose temperature more rapidly through radiation cooling than air aloft. Thus air in contact with the surface will be colder than air aloft. Under such stable conditions and in such a situation where temperature increases away from the surface to aloft we say temperature inversion has occurred. This can also be experienced in the valleys of the East African glaciated regions.

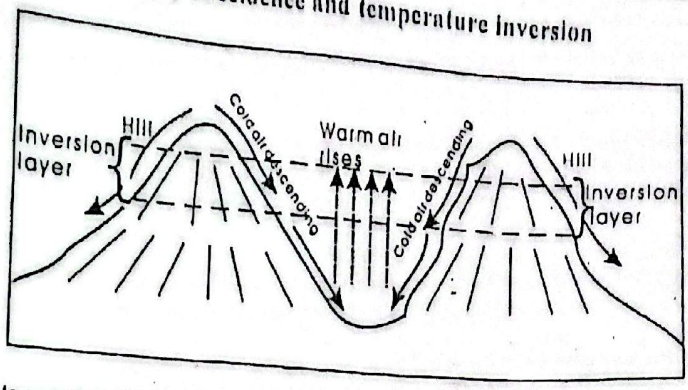
High Temperature Inversion



6. ***Subsidence of cold denser air down the valley:***

This is also common in areas, which are hilly or mountaineous. During the night, the slopes lose more temperature than the valley floor. The air in contact with the slopes therefore becomes heavier than the air in the valley. Under gravitational pull, the cold denser air descends (subsides) down the valley and displaces the warmer air in the valley. Thus warm air rises on top of cold air.

Valley subsidence and temperature inversion

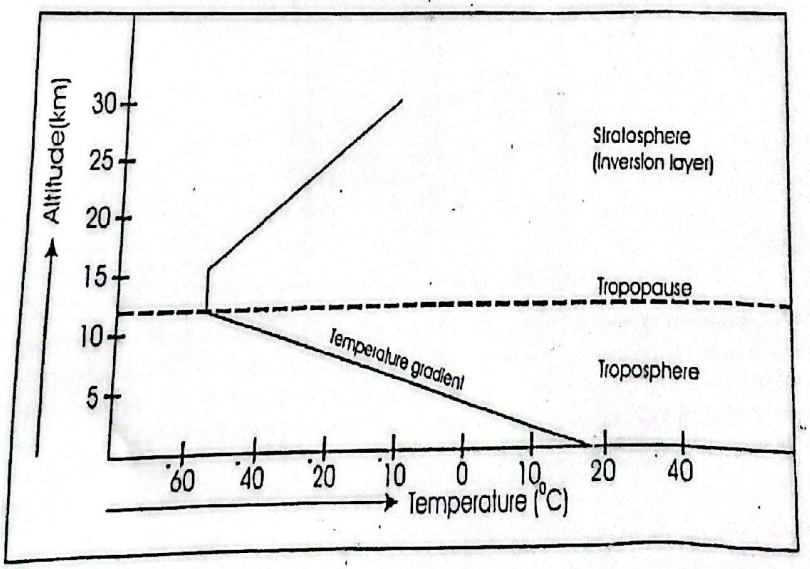


Such temperature inversion occurs in Kabale hills of Western Uganda.

7. **The movement of a warm airmass over a cold surface.**
If a mass of warm air passes over an area which is cold like an ice sheet, the temperature inversion will occur since the air in contact with a surface will be colder than the air above the surface.

8. **Increase in altitude:**
The normal lapse rate of increase in temperature with altitude, is a common phenomenon in the lowe layer of the atmosphere called troposphere. Above the tropopause (upper limit of troposphere), temperature will start to rise up again within the stratosphere (second layer of atmosphere). Hence inversion starts at the tropopause upwards and ends at the stratopause.

Change in altitude and temperature inversion



Effects of temperature inversion

1. It hinders convenctional currents in the atmosphere which results into low rainfall and dry conditio
2. Temperature inversion result into the formation of fog, which is a cloud, produced by condensati of moist air near the surface e.g. high inversion fog and at times mist.

3. Temperature inversion transport cold temperatures to the valley region especially during the nigh and early mornings.

4. Inversion in the atmosphere results into the air pollution especially in industrial nations. Hot exhaust gases from industries and vehicles rise faster above the cold air. This causes a condition of stability in atmosphere and as the concentration of these fumed gases increases, the air becomes polluted.

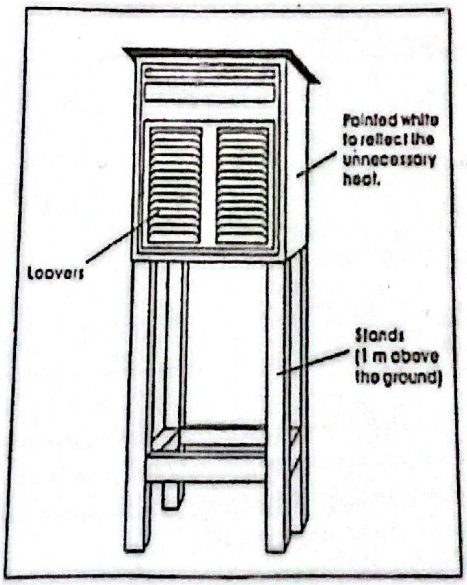
5. In temperate countrie, temperature inversion result into the development of frost in valley bottoms which consequently results into destruction of crops e.g. citrus, oranges and other fruits.

6. Cold temperatures associated with temperature inversion in valley areas discourages settlement in the valley bottoms. People have resorted to settlement in the upper slopes.

7. Fog and mist associated with temperature inversion reduce visibility.

8. Dry conditions which are influenced by temperature inversion are a hinderance to agricultural activity.

The stevenson screen



This is a wooded box whose major function is to keep instruments of weather particularly thermometers and at times hygrometer. This box is wooden in order that it only measure the temperature of surrounding air. Otherwise if it was a metallic box, the metal would warm up on being heated by the sun and hence would also rise the temperature in the box. This would result into the thermometers measuring wrong temperatures. I.e. the thermometers would measure temperature exaggerated by the heated metallic house, which is really higher than the temperature of the surroundings air.

How temperature is recorded

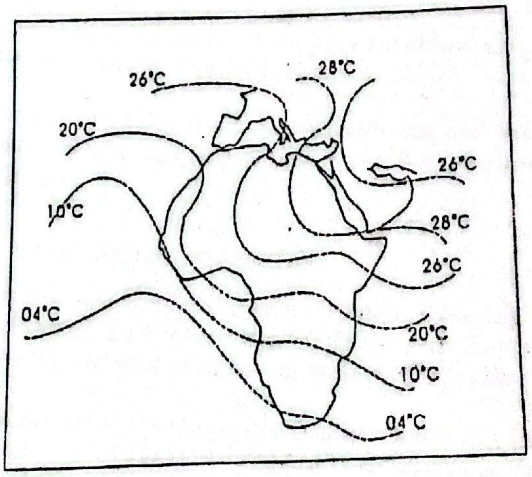
Meteorologists use various methods to record temperature. These include:

1. Use of Statistical tables e.g. temperature data from station A

Months	J	F	M	A	M	J	J	A	S	O	N	D
Temp °C	12	13	17	20	24	27	28	27	25	21	16	13
Temp °F	54	56	63	68	75	80	82	80	78	69	61	56

Altitude: 16m ASL Latitude: 30°N

2. By use of graphs: Temperature is usually recorded on line graphs. The data in the table shown above can be processed to produce a curve / line graph. From the graph one is able to know the temperature distribution in a year, the highest and lowest temperature.
3. Use of Isothermal maps: Maps with isothermal lines drawn on a map toform places of equal temperature are another way of recording temperature. These maps resemble topographic maps the difference being that they show isotherms rather than contours.
See example below: Distribution of temp on African continent - July.



4. Numerical records: Numerical records on specific date can be done e.g.
   i) Di-urnal range of temperature (Highest temperature - lowest temperature of the day)
   ii) Mean monthly temperature $\frac{\text{summation of daily temperature}}{\text{30 days (no of days in month)}}$
   iii) Mean annual temperature $\frac{\text{summation of monthly temperature}}{\text{12 months}}$
   iii) Annual temperature range (Highest mean monthly temp - lowest mean monthly temp)
   v) Monthly temperature range (Highest temp - lowest temp in a month)

Reasons why temperature reduces with an increase in altitude in the troposphere

1. *Effects of terrestrial radiation:* the Earth emits back part of the solar radiation into the atmosphere. The radiation definately reduces as the distance away from the ground increases.
2. *The effect of adiabatic compression:* Atmospheric pressure is highest on the surface and reduces away from the earth surface. The atmospheric pressure compresses air molecules and increase molecular activity with the result that air molecules in high pressure surface regions are compress more giving high temperature than those areas high in atmosphere.

3. The effect of ozone layer: The ozone is an oxygen layer positioned somewhere above the tropopause. This layer absorbs the ultra violet radiation rays whose burning effects would destroy life on Earth if allowed to reach the Earth. Its absorbing effects therefore reduce towards the earth resulting into more temperatures towards the Earth.
4. The role of man's activities e.g Idustrialisation, bush burning & use of automobiles which increases carbonic concentration in the lower layers of atmosphere and hence increases in temperature.

Sunshine

Though not commonly referred to in tropical countries as a very essential element of weather, in temperate countries, people & especially tourist resorts are very interested in knowing the number of hours of sunshine received.

Sunshine, temperature and solar radiation are highly related factors and that's why most people (geographers) don,t give sunshine a seperate treatment. The reason is that they are all about the warming of the earth and they all are directly produced by the sun.
Despite this relationship however, we look at sunshine in our study of meteorology from a different perspective i.e. the number of hours it has perfectly shined a day.

In the meteorological station, the duration of sunshine is recorded by a sun dial four inches in diameter and through which the rays of the sun are focused. These rays are then concentrated on a sensitized card that is graduated in hours.

Factors that affect the sunshine an area receives

1. *Seasonality:* Different seasons have varied amounts of sunshine received e.g. during the rainy season few hours of sunshine are expected than during the dry season. In temperate regions, more hours of sunshine are expected during summer than in any other season.

2. *Latitude:* Equatorial and tropical latitudes get more sunshine than temperate latitudes. At the extreme polarregions, there is total darkness during winter and total sunshine during summer.

3. *Climatic characteristics of an area:* We expect hot desert regions to have many more hours of sunshine than equatorial and savanna climates. this is because equatorial regions have high cloud density than desert regions and hence they receive lesshours of sunshine than deserts.

4. *Altitudinal effect:* Areas in the windward slopes tend to have limited sunshine because of having high humidities and cloud cover than areas in the leeward slopes which receive arid conditions.

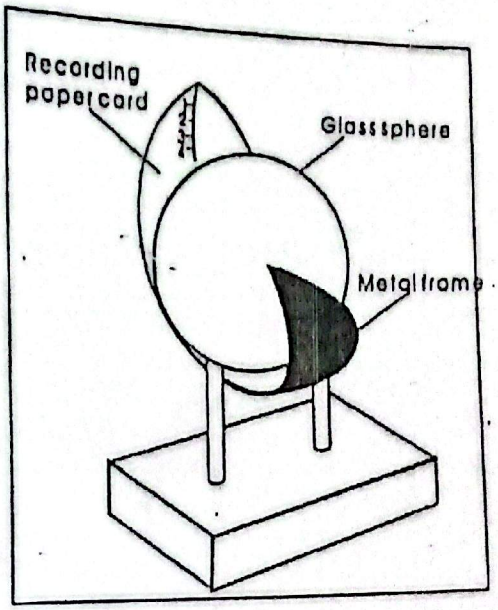
5. *Ocean currents:* Warm ocean currents trigger alot of evaporation, humidity and cloud cover which reduce hours of sunshine in the neighbouring areas. Cold currents on the other hand cause aridity and hence more hours of sunshine.

6. *The length of the day:* Equatorial and tropical regions receive more hours of sunshine than temperate regions due to longer hours of the day. On average tropical regions receive eight hours of sunshine while temperate regions receive four hours.

7. *Aspect:* Slopes which face in the directio of the sun are able to receive more hours of sunshine than those which are sheltered or facing in the lee side of the sun.

8. *The presence of vaporising surfaces:* Water bodies and forests will result into additional humidity into atmosphere. This will reducethe number of hours of sunshine compared to where such bodies are absent.

Campbell stokes sunshine recorder



The instrument above is for the campbell stokes sunshine recorder essentially made to record the number of hours it shines in a day.
The Instrument receives the sun energy through a glass sphere. The glass sphere conscetrates this energy into a pin point of heat which burns the carol below the shhere.
The card is calibrated in hours such that the burn tracing left on a paper card will directly show the number of hours it shined that day. Thus! The longer the tracing, the more the hours and vice versa.
It is the metal frame that reflects the pin point of heat to the recording paper card.
The paper card is always replaced per day.
Each day therefore starts with a fresh paper card.