

The Earth on which we live is full of diversity. We saw in the previous classes about some aspects of this diversity – oceans and continents, mountains, plateaus and plains on the continents, and regions of high and scanty rainfall. In this lesson we shall study about another important form of diversity – which we cannot see but only feel. This is diversity in temperature. You would have noticed that while it is cool in the morning it gets warmer during the day and gets cooler again in the night. Similarly, you may have noted that it is very hot in some months of the year and less hot in other months. This is variation of temperature in one place. Temperature also varies from place to place on the Earth. Some regions are warmer while some regions are so cold as they are covered by ice throughout the year. You have read about the Equatorial regions where it is warm throughout the year and later on you will read about Polar regions which are very cold.

Temperature difference between places also causes winds and rains. The amount of rain received at a place is to some extent determined by temperature differences between places.

Temperature and rainfall affect life in very critical ways. Plants and animals depend upon heat and water: only certain kinds of trees and plants will grow in hot

regions, and some other kinds will grow in cold regions. Nothing grows in very cold regions. Thus we have variation in vegetation and animal life. In this chapter we will study about variation in temperature in different parts of the world.

- Have you been to places that have different climate than where you live? Describe it in the class.
- You know that the Sun is the source of heat on the Earth. But why do you think the heat varies from morning to night or from season to season and from place to place? We are listing some variations here. Try to think a reason for it and discuss in the class before you proceed to read this chapter.

1. Cool in the early morning and warmer in the afternoon.
2. Warm in summer and cool in winter.
3. Cool on hill tops and warm in the plains.
4. Warm in Equatorial region and cold in Polar region.

Solar Energy and Sun's Rays

The Sun is the principal source of energy on the Earth's surface. It is like a powerhouse which generates and gives out energy in the form of light and heat. This

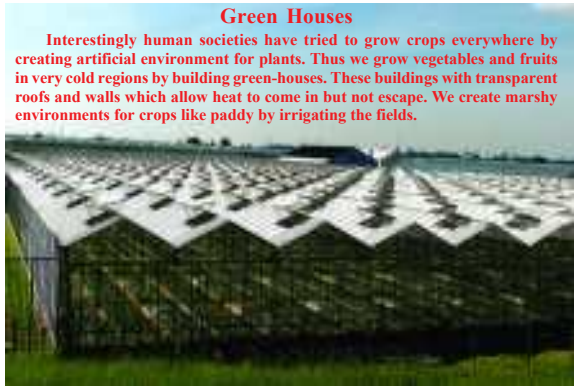


Fig 2.1: Artificial environment for plants

energy constantly emitted by the sun is known as solar radiation. When a body gives out energy it is called radiation. The energy produced by the Sun comes to us in the form of Sun's rays. Some aspects of this energy we can see and feel, like light and heat. However, we also receive many other forms of energy like UV rays, radio waves, x rays, from the sun which we can neither feel nor see.

The energy radiated by the Sun is more or less constant with very little variation throughout the year and year after year. Then what causes the change in temperature on the Earth?

The solar radiation received on the surface of the Earth is called 'insolation'. The actual amount of solar energy received on the ground level is only a small portion

of what reaches the Earth's atmosphere. This is because about one third of the solar energy is reflected back (like a mirror reflecting light) by the Earth's atmosphere. Further some portion of the energy is scattered and absorbed in the higher reaches of the atmosphere. In fact some of the harmful rays of Sun like the UV rays don't reach the ground and this has made life possible on the Earth. Some amount of solar rays are also absorbed or reflected away by clouds and smoke or dust in the atmosphere. You would have noticed that on cloudy days it does not get very hot.

- Can you point out the difference between insolation and radiation?
- What will happen if the atmosphere gets more polluted with smoke and dust?

Sun's Rays and Earth's Surface

Even the rays that reach the ground do not heat the Earth's surface uniformly. This is because of the curved nature of the Earth's surface. Compare the two pictures given here to understand this.

You can see from the above that due to the curvature of Earth's surface, the same amount of solar energy falls on a smaller area on the Equator and on a larger area as we move north or south of it. Thus it will get warmer on the Equator than near the Poles.

You can see that while the sun rays fall at about 90 degrees on the Equator, they fall slantingly towards the Poles. This is called the 'Angle of Incidence' or the angle

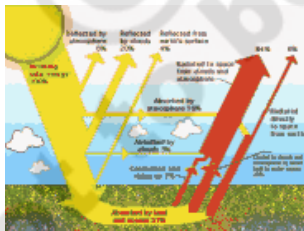


Fig 2.2: Insolation and terrestrial radiation

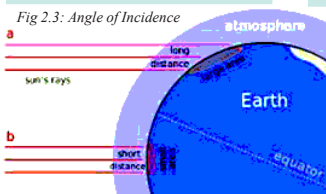
at which the rays fall on the earth surface. See the chart below to understand what difference the 'angle of incidence' makes for the amount of energy received on the surface.

If the insolation received at the Equator (0 degrees) is 100 units, then		
At 45°	(Northern Japan)	75 units are received
At 66 1/2°	(Polar Circle)	50 units are received
At 90°	(North and South Poles)	40 units are received

- Where will the rays fall more slanting – in Japan or North Pole?
- Where will Sun's rays fall more intensively, in Andhra Pradesh or Rajasthan?

- If the Earth were flat and not curved then which will get more heat - Japan or Equator, or both equally?
- Look at the globe and see which countries will be hotter and which will be cooler?

Even though more intense sun rays fall on Equatorial region, it is usually cloudy there after midday and less sun rays fall on the ground. Hence Equatorial regions are not as warm as the regions immediately north or south of them.



But this is not all. As the Earth goes around the Sun in the course of the year the angles of incidence constantly change. Thus the angle of incidence increases in the north during the months of November, December and decreases in the months of May, June. We will look at this in detail in the next lesson.

Land and Water Contrasts

The temperature distribution over land and oceans is much different and varying. This will be very clear if you measure (record) temperature of places over continents and oceans. Land is considered as good conductor of heat, whereas water bodies are different. While land gets heated and cooled quickly, oceans will take time to heat and cool.

- Can you tell why there is difference in heating of land and water?

In the map (p.22) the regions marked in brown receive maximum heat while the regions shaded with blue get the least.

Heating of the Atmosphere

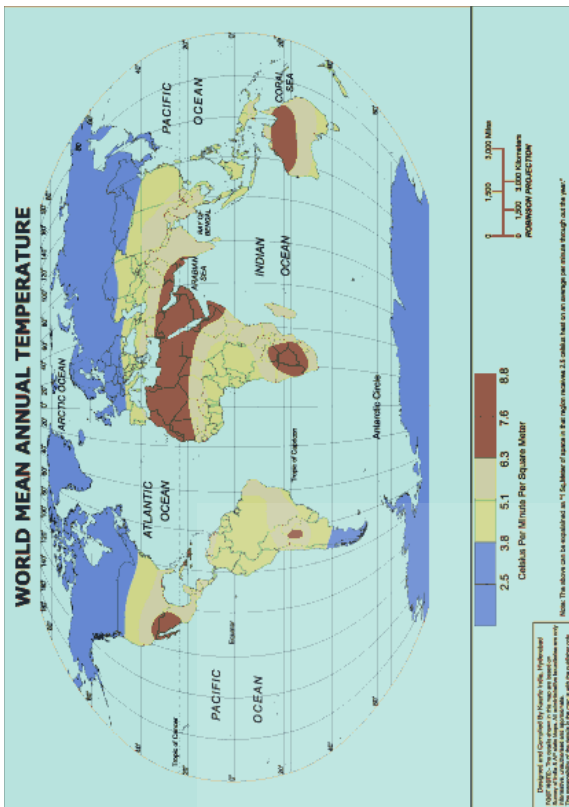
You may be surprised to know that the atmosphere or the air around us is not heated directly by the rays of the Sun. In fact it allows the rays to pass through without being heated by them. The Sun rays first heat the Earth's surface. This in turn begins to radiate heat which heats up the air around us. That is why it is warmer near the surface of the Earth compared to higher reaches of the atmosphere.

Heat Balance

The heat the earth receives from the Sun is radiated back by the earth in different ways. As we saw, about one third of it is immediately reflected back into the space. The rest heats up the earth surface which in turn heats the atmosphere and eventually is radiated into the space. This complete radiation of the heat received from the Sun is important. If the entire heat is not radiated back, then every day the amount of heat that remains will accumulate and it will become hotter and hotter. On the other hand if the earth received less heat than it gave out in radiation it would get cooler and cooler.

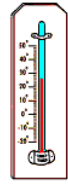
Did you observe absolutely flat land over a long stretch? Everywhere the land seems to be slightly undulating and sloping, resulting in variations in the amount of solar energy received on the land. Will it be more on flat land or sloping land? Will the two sides of a mountain front receive the same amount of sun rays? What may be the reasons?

Some gases like carbon dioxide prevent radiation of heat from the earth. Carbon dioxide in the atmosphere increases due to increased use of diesel and petrol, cutting down of forests etc. If the carbon dioxide proportion in the atmosphere increases then less heat will be radiated causing an increase in global temperatures. This results in what is called 'Global Warming'.



The Temperature of Atmosphere

Bring a Celsius thermometer to the classroom. Note the temperature that the thermometer shows. This is the present temperature of air in your class.



Thermometer

- To get an idea of other temperatures, measure and note the temperature of the following things. Before you start measuring, guess the temperature of each one.

Thing	Temperature, °C	
	Guess	Measurement
Water in bucket		
Ice		
Glass of cold water		
Warm bath water		

- It is safer and advisable to use thermometers that have a scale of -10°C to 110°C. Using such a thermometer, also measure and note the temperature of boiling water and hot tea.

Measure the temperature for a week in different months throughout the year. You will be able to see the temperature differences that occur between the summer, winter, monsoon, and other seasons.

- For the next week, measure the air temperature each day at the same time and place (Remember to choose

a place that is in the shade). Each day before you measure, write down your guess. Keep your record in a separate notebook.

Place _____
Time _____
Month _____

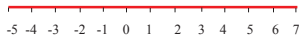
Date	Air Temperature, °C	
	Guess	Measurement

- Record the temperature every day for one week for few months.
- Calculate the weekly average temperatures.
- Discuss the variations between different weeks.

High and Low Temperatures

Scientists have recorded the highest and lowest temperatures reached on the earth. For example the highest temperature recorded is from a place called Azizia in Libya (Africa) where in July 1922 the temperature reached 57.8 degrees Centigrade! Likewise on a place, at Vostok Station in the Antarctica the temperature fell to -89.2 degrees Celsius in July 1983.

Do you know what it means for the temperature to be -5°C or -89°C? You already know that when water reaches a temperature around 100°C it starts boiling, and at about 0°C it freezes into ice. The minimum temperature below is -273.16°C. Temperature cannot go below this. When the temperature reaches below 0°C it is recorded in -x °C. Look at the number line below, you can see how + and - numbers are marked.



- Which temperature is greater: 5°C or -5°C?
- At which of these two temperatures will we feel colder?

- How many degrees difference is there between -5° and 5°?
- Write in short form each of the following temperatures:
88 degrees below zero, Celsius
38 degrees above freezing, Celsius
32 degrees below freezing, Celsius
- Did you note the temperature in your classroom today? 88 degrees below zero Celsius is how many degrees lower than the temperature you measured?
- The temperature of a normal human body is 37°C. How much hotter than normal body temperature is 50°C?
- How much colder than the normal body temperature is -5°C?
- Arrange the following temperatures from the highest to the lowest: 12°C, -16°C, 29°C, 0°C, -4°C.
- At which of the above temperatures will we feel hottest?
- At which of the above temperatures will we feel coldest?



Fig 2.4: Factors influencing temperature

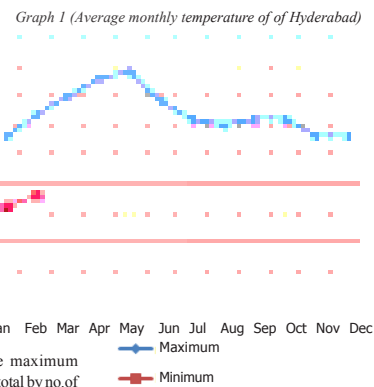
Recording temperatures

Note down the highest and the lowest temperatures of the day by using Six maximum-minimum thermometer. At the end of the month note down all the maximum temperatures and calculate the average maximum temperature for the place (by adding up all the maximum temperatures and dividing the total by no. of days). In this way we can get the average maximum temperature and average minimum temperature for the month.

See below the average monthly temperatures of each month for Hyderabad.

Table 1: (Average monthly temperature of Hyd.)

Month	Maximum, °C	Minimum, °C
Jan	28	16
Feb	32	18
Mar	35	21
Apr	38	24
May	39	26
Jun	34	24
Jul	31	23
Aug	30	22
Sep	31	22
Oct	31	21
Nov	28	17
Dec	28	15



Use the data in the Table 1 and plot the average minimum monthly temperatures for Hyderabad on the same graph paper in which the graph of maximum temperatures is drawn for your understanding. The first two months have already been done for you in the Graph 1.

Look at the data and the graph and answer the following questions about Hyderabad:

- How cold does it usually get in November in Hyderabad?
- Which month has the highest maximum temperature in Hyderabad?
- What is the difference between the highest maximum temperature and the lowest maximum temperature in the year?

- Which three months are the hottest in Hyderabad?
- Which three months are the coldest?
- What is the average maximum temperature in January in Hyderabad?
- From June through December, the average minimum monthly temperature keeps falling in Hyderabad. Does the average maximum monthly temperature also keep falling?
- What is the difference between the maximum and minimum temperature in May?
- What is the difference between the maximum and minimum temperature in August?
- Based on your answers to the above two questions, is there a larger difference between the maximum and minimum temperatures in the summer or in rainy season in Hyderabad?

Different Places have Different Temperatures

You know that different places have different temperatures. Do you know why they have different temperatures? There are many reasons. Now we'll take a look at some of the possible reasons.

Places that are near the sea and far away from the sea usually have different temperatures.

Temperatures differ on the top of a mountain and at its foot. And you already know that temperature changes as we go north or south from the Equator.

Places Near and Far from the Sea have Different Temperatures

We have already seen the average temperatures of Hyderabad. Hyderabad is far away from the sea. Now let's look at the temperatures of a city that lies next to the sea: Panaji.

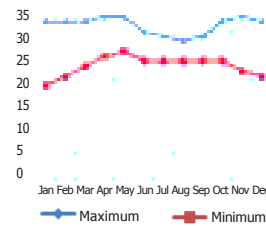
Table 2: (Average monthly temp. of Panaji)

Month	Maximum, °C	Minimum, °C
Jan	32	19
Feb	32	21
Mar	32	23
Apr	33	25
May	33	26
Jun	30	24
Jul	29	24
Aug	28	24
Sep	29	24
Oct	32	24
Nov	33	22
Dec	32	21

The average of maximum and minimum monthly temperatures are plotted on the Graph 2.

- Which month has the lowest minimum temperature in Panaji? How much is it?
- Which is the hottest month in Panaji? How much was the average maximum temperature for that month?

Graph 2 (Average monthly temperature of Panaji)



- Compare the temperatures of Hyderabad and Panaji to answer the following:
In January, which place is colder?
In June, which place is hotter?
In which place, Hyderabad or Panaji, does the temperature remain more or less the same throughout the year?

Moderate and Extreme Climates

Why does the temperature in Panaji not change much throughout the year? Because it is on the seashore! It's difficult for the sun to heat up or cool down the sea. Since the sea doesn't get too hot or cold, the air above the sea also doesn't get too hot or cold. Therefore places near the sea usually have temperatures that remain fairly constant throughout the year. They have what is known as a moderate climate.

In contrast to this, Hyderabad is far away from the sea. There is no moderating influence of the sea in Hyderabad. In the summers the ground temperature rises very

high and this heats up the air. In winters the ground temperature falls and the air is also cold. This is called an extreme climate (that is, one with great differences between maximum and minimum temperatures).

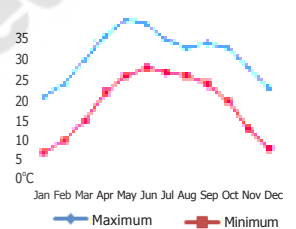
Height and Temperature

At the peak of summer some people go from the plains to hilly places such as Ooty or Shimla to avoid the heat. Even in the summer months the temperatures are low on high hills. The highest parts of a mountain generally have the lowest temperatures. Temperature decreases with elevation (height).

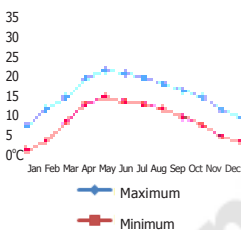
Look at the graphs showing the average monthly temperatures of Delhi and Shimla. You can see quite clearly that in each month of the year the temperature of Shimla is far lower than that of Delhi.

Delhi is at an elevation (height) of about 200 metres above sea level, while Shimla is at an elevation of about 2200 metres above sea level. Usually, for every 1000 meters increase in elevation, the temperature falls by about 6°C. Due to

Graph 3 (Average monthly temperature of Delhi)



Graph 4 (Average monthly temperature of Shimla)



cooler temperatures, different kinds of plants grow on high hills and mountains.

Inversion

Sometimes, especially in mornings of winters, cool temperatures are found near the ground. You can see dew drops on the grass due to condensation. The cooler temperatures near the ground level are due to less amount of insolation received due to the shorter days and excessive radiation due to the longer nights. This is known as inversion.

- Can you think of any other reason for this state of temperature?
- What will happen if the inversion occurs?
- How many meters higher than Delhi is Shimla?
- Based on the difference in elevation, calculate the likely difference in temperature between the two places.
- Which month has the highest maximum temperature in Shimla?

How much is it?

- Which month has the highest maximum temperature in Delhi? How much is it?
- In September the average maximum temperature in Shimla is _____°C while in Delhi it is _____°C.
- Which is colder: Delhi in January or Shimla in July?

Temperatures in Places Near and Far from the Equator

In Class VII we studied about Nigeria, which is situated on the Equator. We also studied about France which is more to the north. This year we will study about Arctic tundra, which is even farther north. We know that equatorial regions like Indonesia are quite hot throughout the year and they have no winter. As we go north or south from the equator it becomes colder, and there are separate summer and winter seasons. A look at the temperatures of places near and far from the equator will illustrate this clearly.

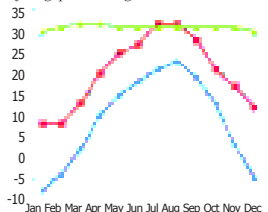


Find out the locations of Singapore, Shanghai and Vladivostok on the above picture

Graph 5 has the average maximum temperatures of three places: Singapore, Shanghai, and Vladivostok. In the last column of the Key, the average temperature for the whole year is shown. This is calculated by adding up all the maximum and minimum temperature readings for every month and then dividing by the total number of readings. Thus, we get to know the average temperature on an average day in the year. We might use this number to answer a question like, "Is Singapore, on average, warmer than Shanghai?"

Places near the Equator usually get more heat. Places farther away from the Equator often have lower average temperatures for the year.

Graph 5 Average maximum monthly temp. of Singapore, Shanghai, Vladivostok



City	Average Temp for the year
Vladivostok	3.9°C
Shanghai	15.3°C
Singapore	27.8°C

- Which of the three places shown in the graph is located near to the Equator?
- What is the average yearly temperature in that place?

- Does it usually get much warmer in the summer than in the winter there?
- Is summer in Vladivostok warmer than the winter in Singapore?
- Does it usually get warmer in July in Singapore or in Shanghai?
- Which of the three places on the graph has the most extreme climate?
- What is the warmest month in Shanghai?
- What is the average yearly temperature there?
- Which month has the lowest average maximum temperature in this place?

Temperature maps

India is a vast, sprawling country and the temperature varies in its different regions. If we want to find out which places are hotter and which are colder, we can use a temperature map.

Look in your Atlas to find the map of India that shows the average (mean) temperatures in January.

This average temperature is the average of the maximum and minimum temperatures for that month. In this map India has been divided into different sections, each marked with a different colour. By referring to the key you can find out the average temperature in January in each of these sections.

- Use the maps in your Atlas to find out the latitude and the average temperature in January of each of the following places: The first one has already been done for you.

Place	Lat.	Temp. in January
Hyderabad, A.P.	17°N	between 20 and 22.5°C
Agra, U.P.		
Madurai, T.N.		
Nagpur, MH		

According to this map, there is no place in India that has an average January temperature higher than 30°C. (Remember, this is the average. There may be some January days in some places that do get hotter than 30°C.)

Look at the map and find out which parts of India usually have the highest average temperature (in January).

If you look north from this place on the map, is the average January temperature higher or lower?

Why is the North Cooler in winter?

Look at the following table. It shows sunrise and sunset in different cities in India on 10th January. Answer the questions below:

Place	Sunrise	Sunset
Hyderabad, A.P.	6:49	5:58
Agra, U.P.	7:09	5:42
Madurai, T.N.	6:37	6:12
Nagpur, MH	6:53	5:48
Visakhapatnam, A.P.	6:29	5:38
Kohima, Nagaland	6:02	4:40

- In which of these six cities does the sun rise first?
- In which of these cities does the sun set last?
- How long is the daytime in each of the six cities? (The daytime is the number of hours between sunrise and sunset.)
- Do the cities that are farther north have longer or shorter daytimes than the cities to the south?
- Based on your answers to the above questions, can you think of one reason why the north of India remains cooler than the south in winter?

Key words

1. Atmosphere
2. Equatorial regions
3. Condensation
4. Solar Radiation
5. Insolation
6. Angle of Incidence
7. Heat Balance
8. Maximum Temperature
9. Minimum Temperature
10. Temperature Inversion
11. Global Warming

Improve your learning

1. Correct the false statements –
 - a) If a place is closer to sea, irrespective of its distance from equator, it will always be cooler.
 - b) As you go up higher from the earth, it becomes warmer because sun is closer to you.
 - c) Sun heats the air first and then the earth.
 - d) Global warming is related to oxygen.
2. What's the difference between the highest temperature in Table 2 and the lowest temperature in Table 1?
3. Suppose, the temperature in Moscow was –8°C at 10 AM on 6 December. Twenty-four hours later it was 12°C higher. What was the temperature at 10 AM on 7 December?
4. Delhi and Mumbai are both situated on plains and their height above sea level is less than 300 meters. Why is there so much difference in their monthly average temperatures? In which months are the average temperatures in these two cities most similar? Can you explain?
5. Given below are the average monthly minimum and maximum temperatures of Jodhpur. Make a line graph of them. Which are the hottest and coldest months of the year?

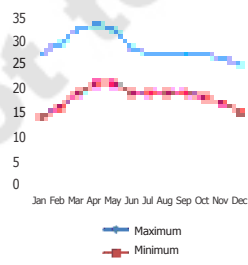
Table: Average Monthly Maximum Temperatures in Jodhpur, Rajasthan (°C)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	9	12	17	22	27	29	27	25	24	20	14	11
Maximum	25	28	33	38	42	40	36	33	35	36	31	27

6. Given here are the average maximum temperatures of three places: A, B, and C. Make graphs of them. What can you guess about each place by looking at the Table and graphs?

Place	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	23	26	33	38	41	39	34	33	33	33	29	25
B	-3	1	6	12	17	21	25	24	21	14	8	2
C	31	32	33	32	32	29	29	29	30	30	30	31

7. Give three possible explanations for the differences between the average temperatures in Thiruvananthapuram and Shimla in January (refer to your Atlas).
8. Between Bhopal, Delhi, Mumbai and Shimla, which two places show a similar temperature pattern? How can you explain the similarity between these two places?
9. Look at the graph of Minimum-Maximum temperature on the right and answer the questions below:
 - a) What is the average highest temperature in July?
 - b) How warm does it usually get in December?
 - c) How cool does it usually get in June?
 - d) Is there a bigger difference between night and day temp. in May or in August?
 - e) When is summer?
10. Nithin says thermal power is better to use, but Padmaja says that Solar Energy is better. Which of them do you support? Why?



Graph showing Temperature of Bangalore