CHAPTER 2

Energy from the Sun

E7T2M8

The Earth on which we live is full of diversity. We read in the previous classes about some aspects of this diversity – oceans, continents, mountains, plateaus and plains on the continents, and regions of high and scanty rainfall. In this chapter, 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 the other months. This is known as variation of temperature in one place. Temperature also varies from one place to another on the Earth. Some regions are warm while some regions are so cold as they are covered with ice throughout the year. You have read about the Equatorial regions where it is warm throughout the year and later on, you will also 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 the temperature difference between places.

Temperature and rainfall affect life in very critical ways. Plants and animals depend upon heat and water: only some 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 variations in temperature in different parts of the world.

- Have you been to places that have a 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

Greenhouses

Interestingly, human societies have tried to grow crops everywhere by creating artificial environment for plants. Thus, we grow vegetables and fruits in very cold regions by building greenhouses. These buildings are made with transparent roofs and walls which allow heat to come in but not escape. We create marshy environments for crops like paddy by irrigating the fields.

Fig 2.1: Artificial environment for plants

energy which is constantly emitted by the sun is known as solar radiations. 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. We can see and feel some aspects of this energy such as like light and heat. However, we also receive many other forms of energy like ultra violet (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.

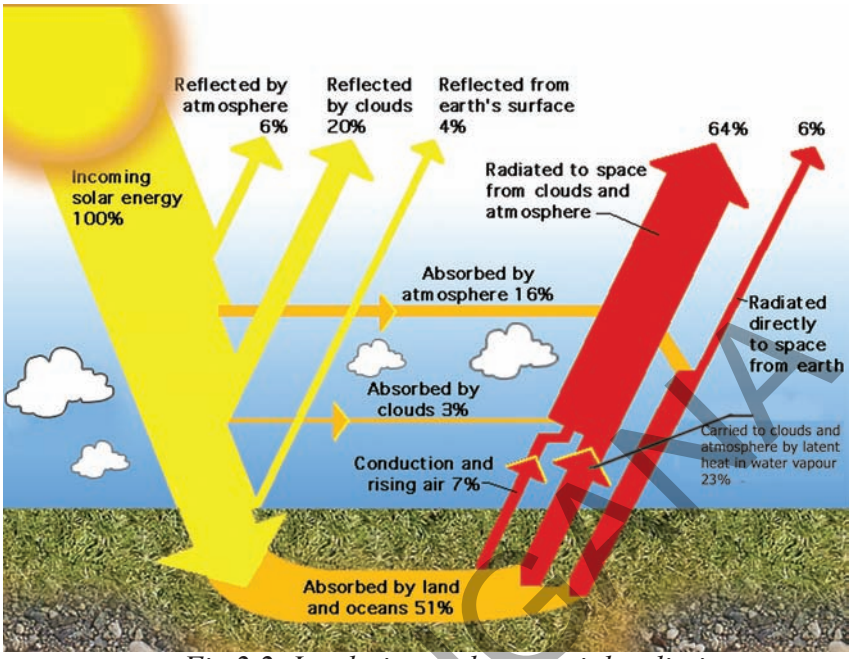


Fig 2.2: Insolation and terrestrial radiation

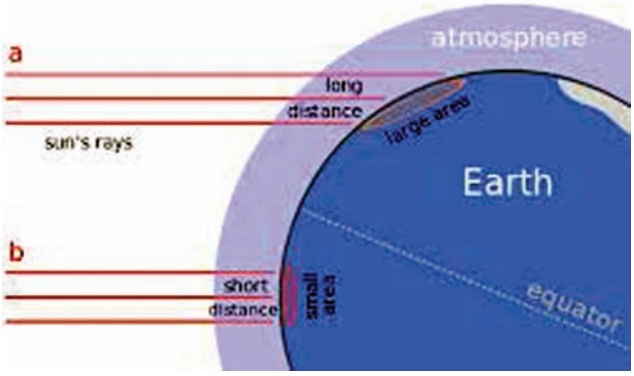
You can see from the pictures that due to the curvature of Earth's surface, the same amount of solar energy falls on a smaller area on the Equator and on a larger area as we move north or south of it. Thus it will get warmer on the Equator than near the Poles.

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 at which the rays fall on the earth's 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 45^0	(Northern Japan)	75 units are received
At $66\frac{1}{2}^0$	(Polar Circle)	50 units are received
At 90^0	(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 Telangana or Rajasthan?
- If the Earth was flat and not curved, then which place would get more heat -Japan or the Equator, or both equally?
- Look at the globe and find out which countries will be hotter and which will be cooler?

Fig 2.3: Angle of Incidence



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 chapter.

Land and Water Contrasts

The temperature distribution over land and oceans are quite different and varying. This will be very clear if we measure (record) the temperature of different places over different continents and oceans. Land is considered as a 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 actually 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 places of higher altitudes of the atmosphere.

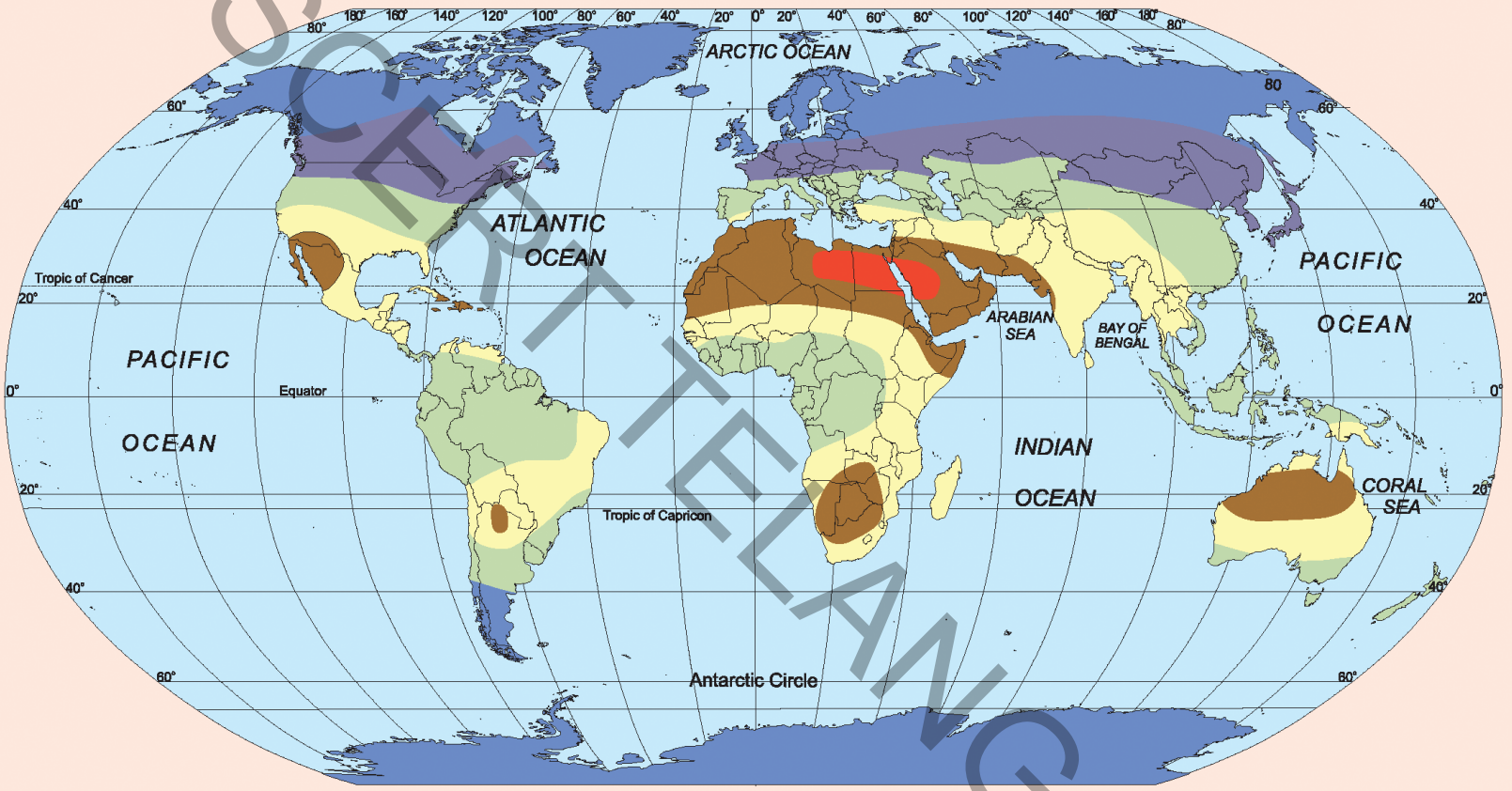
Heat Balance

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 surface of the Earth 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.

Have you observed 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 this happen more on flat land or sloping land? Will the two sides of a mountain front receive the same amount of sun rays? What could be the reasons for this?

Some gases like carbon dioxide prevent radiation of heat from the earth. Carbon dioxide in the atmosphere increases due to the increasing 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'.

WORLD MEAN ANNUAL TEMPERATURE



2.5 3.8 5.1 6.3 7.6 8.8

Celsius Per Minute Per Square Meter

0 1,500 3,000 Miles

0 1,500 3,000 Kilometers

ROBINSON PROJECTION

Designed and Complied By Kaarto India, Hyderabad

FOOT NOTE:- The details shown in this map are based on Survey of India & AP state Maps. All administrative boundaries are only informative, unauthorised and approximate. The responsibility of the details in the map is with the publisher only.

Note: The above can be expalained as "1 Sq.Meter of space in that region receives 2.5 celsius heat on an average per minute through out the year."

The Temperature of Atmosphere

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

- 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.

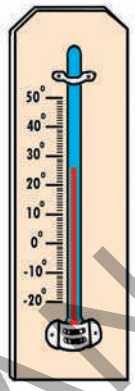
Thing	*Temperature, °C*	
	Guess	*Measurement*
Water in bucket		
Ice		
Glass of cold water		
Warm bath water		

- 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 one week, measure the air temperature every 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.

Thermometer



Place _____

Time _____

Month _____

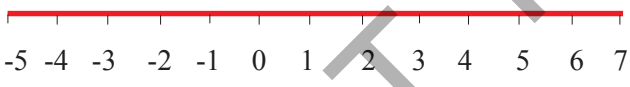
Date	*Air Temperature, °C*	
	Guess	*Measurement*

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

High and Low Temperatures

Scientists have recorded the highest and the 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 Celsius! Likewise, in a place called 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 lowest minimum temperature 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 higher: 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 the hottest?
- At which of the above temperatures will we feel the coldest?

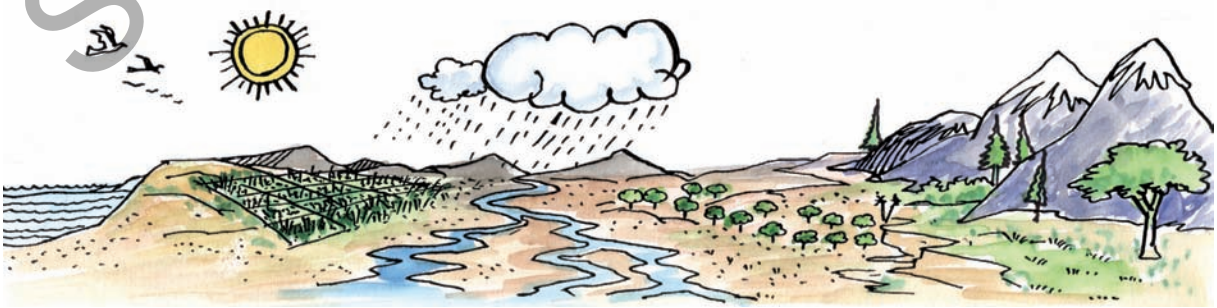


Fig 2.4: Factors influencing temperature

Recording temperatures

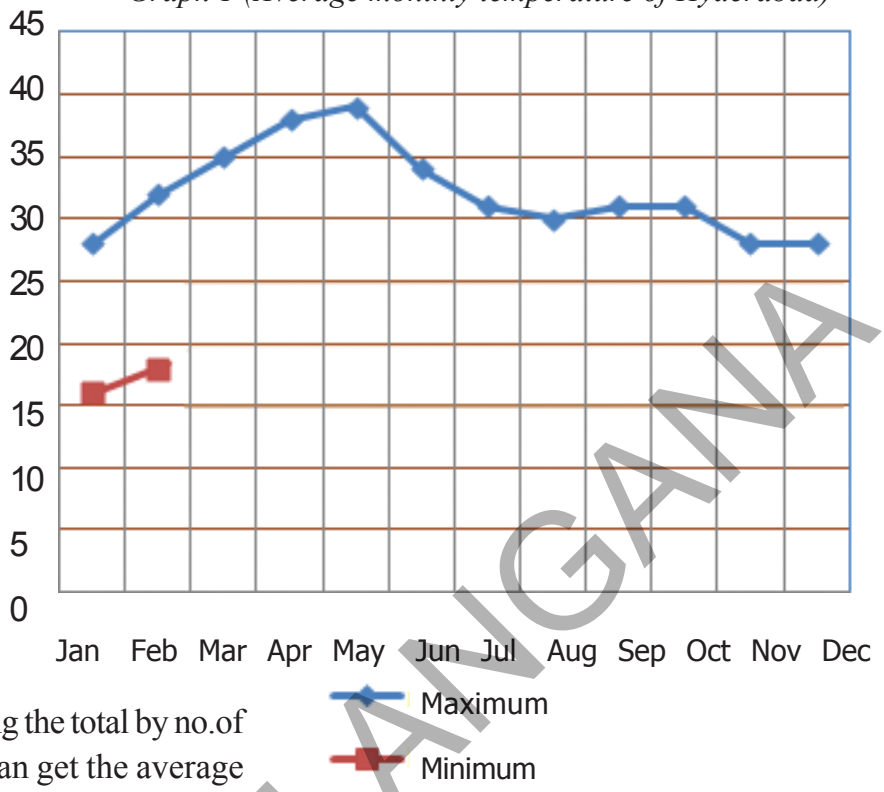
Note down the highest and the lowest temperatures of the day by using six maximum-minimum thermometer. At the end of the month, note down all the maximum temperatures and calculate the average maximum temperature for the place (by adding up all the maximum temperatures and dividing the total by no.of 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

Graph 1 (Average monthly temperature of Hyderabad)



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.

Maritime and Continental Climate

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 in Goa.

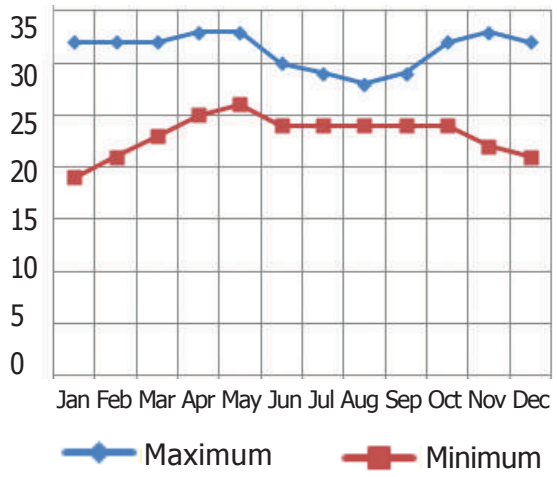
Table 2: (Average monthly temp. of Panaji)

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?

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 surface of 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 up 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).

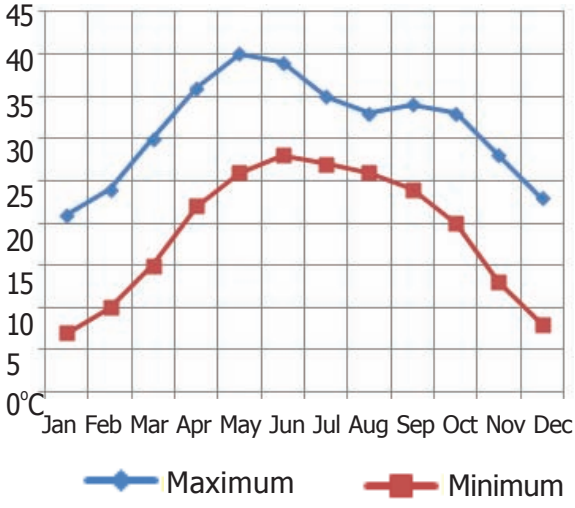
Height and Temperature

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).

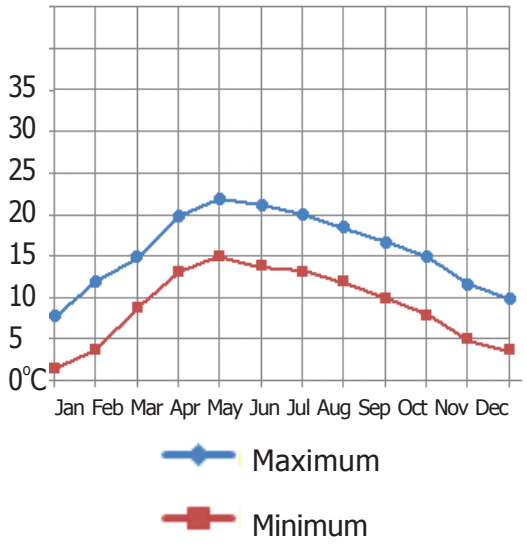
Look at the graphs showing the average monthly temperatures of Delhi and Shimla. You can see quite clearly that in each month of the year, the temperature of Shimla is far lower than that of Delhi.

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 6.4°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.

- 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 the temperature?
- 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?

Inversion

Sometimes, especially in mornings during winters, lower 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 kind of temperature?
- What will happen if the inversion occurs?

Temperatures in Places Near and Far from the Equator

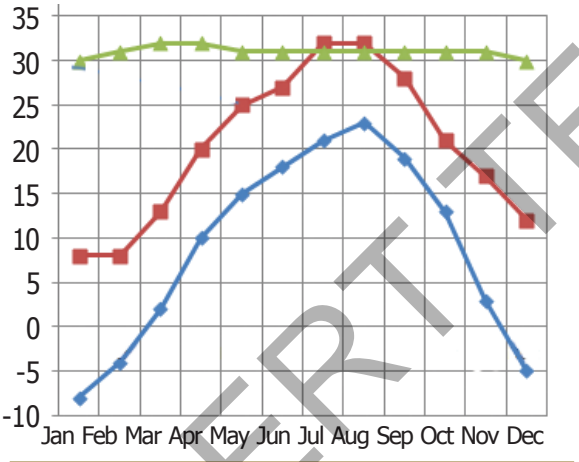
In Class VII, we studied about Nigeria, which is situated on the Equator. We also studied about France which is more to the north. This year, we will study about Arctic tundra, which is even farther north. We know that equatorial regions like Indonesia are quite hot throughout the year and they have 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 of the globe.

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 it 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 an average, warmer than Shanghai?"

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

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



KEY	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 nearest 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?
- Which 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 cooler, we can use a temperature map.

Look at 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, T.S.		17°N between 20°C 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 about the parts of India that 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 the time of sunrise and sunset in different cities in India on 10th January. Answer the questions below:

Place	*Sunrise*	*Sunset*
Hyderabad, T.S.	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 why the north of India remains cooler than the south in winter?

Keywords

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

X6A2P7

1. Correct the false statements –

a) If a place is closer to the 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 is 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? 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. Locate 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? Explain the similarity between these two places.

9. Look at the graph of Minimum-Maximum temperature on the right and answer the questions below:

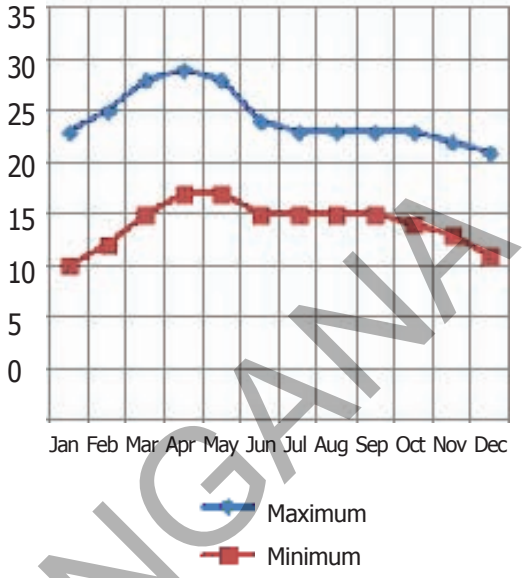
a) What is the average highest temperature in July?

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 temperature in May or in August?

e) When is summer?



Graph showing Temperature of Bangalore

10. How is solar energy better than thermal power?

11. Read the para under the title "Height and Temperature" of page 27 and comment on it.

Discussion:

The sun is the primary source of energy. The trees are the factories which produce food from sunlight. Are we growing or cutting down such trees? Discuss the advantages of trees and our responsibility in growing them.

Project:

Visit some families in your village/locality and fill up the following table.

Sl. No.	Name of the Family head	No. of electricity bulbs used	Type			Electricity Bill (in rupees)
			Bulb	Tube	CFL/LED	

Educate the families about the energy saving measures and then conduct the same survey again after three month and compare the difference.