Chapter 18
The atmosphere

Layers of the atmosphere

1. The **troposphere** extends from the surface of the earth to a height of about 10 kilometers (slightly less at the poles and more at the equator). It is the turbulent layer of the atmosphere in which all aspects of weather are found. Clouds, rain, surface winds, hurricanes, and tornadoes are all found in the troposphere so it is the layer of the atmosphere that affects us on a daily basis. Air temperature and air pressure drop as we go up in altitude through the troposphere. At the top of the troposphere, known as the **tropopause**, the temperature drops to about -56° Celsius. When the tropopause is reached, the temperature gradually begins to rise due to the ozone in the next layer of the atmosphere.

2. Above the troposphere is the **stratosphere**, which extends from the tropopause to approximately 50 kilometers above the earth's surface. This layer lacks the turbulence of the troposphere due to its reduced density and weather conditions in this layer remain constant. Here, in the lower layer of the stratosphere, strong wind currents known as jet streams flow like fast moving rivers of air from west to east. For this reason, commercial airliners fly in the lower level of the stratosphere-which is clear, dry and no colder than the top of the troposphere. The thin rarified air creates very little drag on the airplanes and as long as they are flying east, pilots can use the jet streams to fly faster while saving fuel. The temperature in the stratosphere begins to rise due to the amount of ozone gas - which absorbs large amounts of incoming ultraviolet radiation from the sun. (The **ozone layer** protects humans and other life forms from harmful ultraviolet radiation). The temperature increases steadily until the top of the stratosphere, the **stratopause**, is reached.

3. The **mesosphere** is the third layer of the atmosphere and here temperatures drop again as ultraviolet radiation is allowed to pass through without being absorbed. Temperatures drop to -100° C. near the top of this layer. Meteors entering the earth's atmosphere burn up in this layer. By the time meteors reach the stratosphere most have burned up but a few will survive the fall through all four layers of the atmosphere and strike the earth's surface.

4. The thickest layer, the **thermosphere,** extends from about 90 to 500 km. above the earth's surface. Here temperatures rise again as the air molecules are few and far between, allowing the incoming solar radiation to rapidly heat the thin air. The temperature here depends entirely on solar activity (the sun's energy is not constant!) and has been estimated as high as 3000° C. Beyond 500 km. there are so few air molecules that is is nearly a vaccuum. This is the end of our atmosphere - the exosphere.

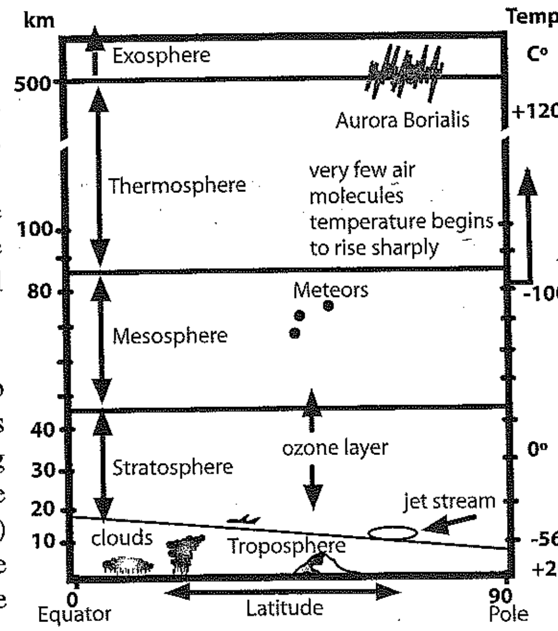

Figure 18.1 Layers of the atmosphere

Composition of the atmosphere

A mixture of gases make up earth's atmosphere. By far the most abundant gases are nitrogen (78%) and oxygen (21%) with a variety of other gases making up the remaining one percent. Argon makes up nearly the entire remaining 1% with very minute amounts of hydrogen, helium, ozone, carbon dioxide, water vapour and others gases added in.

Small amount but still very important

Carbon dioxide, ozone, and water vapour are gases that make up a very small amount of our atmosphere, but nevertheless, they play an important role in the big picture. **Carbon dioxide** is called a **greenhouse gas** because increasing CO_2 levels in the atmosphere will make average temperatures warmer, like in a greenhouse used to extend the growing season of flowers or vegetables. A rise in average world temperatures will result in the melting of glacial ice - which will make ocean levels rise, possibly by several meters. From 1993 to 2003, ocean levels have risen by 18 centimeters. Rising ocean levels are significant because much of the world's food is grown near fertile deltas at or near sea level.

Another greenhouse gas, **ozone**, is a form of oxygen gas, which forms when ultraviolet radiation acts upon oxygen molecules in the air. This change occurs mainly in the stratosphere layer of the atmosphere. Only a very small amount of ozone is present in the atmosphere, but it plays an important role. By absorbing incoming ultraviolet rays, ozone protects humans, as well as plant and animal life on earth from the harmful effects of ultraviolet radiation.

Water vapour enters the atmosphere through the process of **evaporation**. When water vapour condenses to form **clouds**, incoming solar radiation is blocked from reaching the earth, resulting in significantly cooler temperatures. At night, clouds hold the heat in by blocking outgoing radiation, resulting in much warmer temperatures than are experienced during cloudless nights.

The sun's rays warm the earth

About 2/3 of the solar radiation that reaches our planet is absorbed; 1/3 is reflected and has little effect on our temperatures. Of the incoming solar radiation, called **insolation**, the atmosphere absorbs 18% but reflects and scatters 26%. Of the remaining 56% that reaches the earth's surface, 50% is absorbed by the earth, while 6% is reflected.

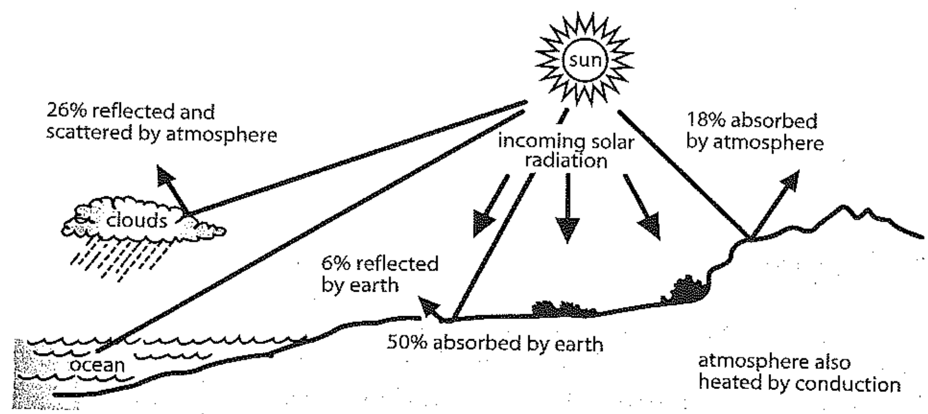

Figure 18.2 Incoming solar radiation from the sun

The fact that so much insolation is absorbed by the land, water, and vegetation that cover the earth's surface is one indication that the atmosphere is actually heated by the earth, not by the sun. The lower atmosphere is heated in 3 ways. First, some of the incoming solar radiation is absorbed by the atmosphere. Secondly, heat radiates from the earth and heats the air close to earth. And thirdly, air in contact with the warm ground is heated by **conduction**, a process in which heat is transferred from a warmer object (earth) to a cooler one (atmosphere). When the lower atmosphere heats, the air expands and rises. These **convection currents** are created by the transfer of heat from the earth into the atmosphere.

Remember that absorption of solar radiation is not constant around the earth. Areas of dark vegetation near the equator absorb the incoming radiation readily but polar regions covered with ice and snow reflect a large percentage of the insolation.