Lecture 3
Tropical Climate

The geometrical relationship between the earth and sun is responsible for the earth's climates

Climate of the earth is based on:
- Temperature (solar radiation)
- Winds and pressure
- Daylength
- Altitude

Factors Determining the Distribution of Energy

1. The intensity of solar radiation is a function of the angle at which sunlight reaches a portion of the earth's surface. The angle is due to the curvature of the earth.
2. Duration of solar energy is determined by the length of day and night.

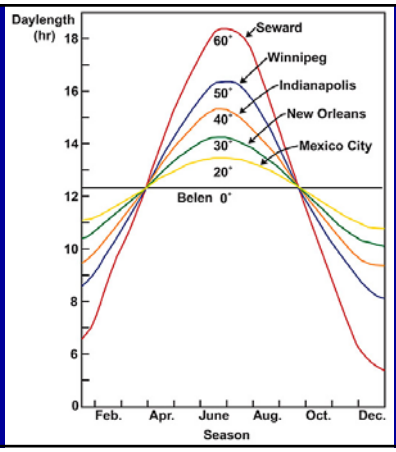
Daylength

	Latitude	Shortest day	Longest day
Tropics	0	12:07	12:07
	10	11:32	12:42
	20	10:56	13:20
Temperate	30	10:14	14:04
	40	9:20	15:00
	50	8:05	16:21
	60	5:54	18:49
Polar	70	0:00	24:00
	80	0:00	24:00
	90	0:00	24:00

Length of Day in Various Northern Latitudes*

Month	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
Jan.	12:07	11:35	11:02	10:24	9:37	8:30	6:38	0:00	0:00	0:00
Feb.	12:07	11:49	11:21	11:10	10:42	10:07	9:11	7:20	0:00	0:00
Mar.	12:07	12:04	12:00	11:57	11:53	11:48	11:41	11:28	10:52	0:00
Apr.	12:07	12:21	12:36	12:53	13:14	13:44	14:31	16:06	24:00	24:00
May	12:07	12:34	13:04	13:38	14:22	15:22	17:04	22:13	24:00	24:00
June	12:07	12:42	13:20	14:04	15:00	16:21	18:49	24:00	24:00	24:00
July	12:07	12:40	13:16	13:56	14:49	15:38	17:31	24:00	24:00	24:00
Aug.	12:07	12:28	12:50	13:16	13:48	14:33	15:46	18:26	24:00	24:00
Sept.	12:07	12:12	12:17	12:23	12:31	12:42	13:00	13:34	15:16	24:00
Oct.	12:07	11:55	11:42	11:28	11:10	10:47	10:11	9:03	5:10	0:00
Nov.	12:07	11:40	11:12	10:40	10:01	9:06	7:37	3:06	0:00	0:00
Dec.	12:07	11:32	10:56	10:14	9:20	8:05	5:54	0:00	0:00	0:00

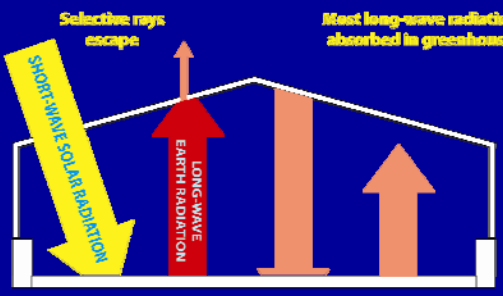
* In hours and minutes on the 15th of each month



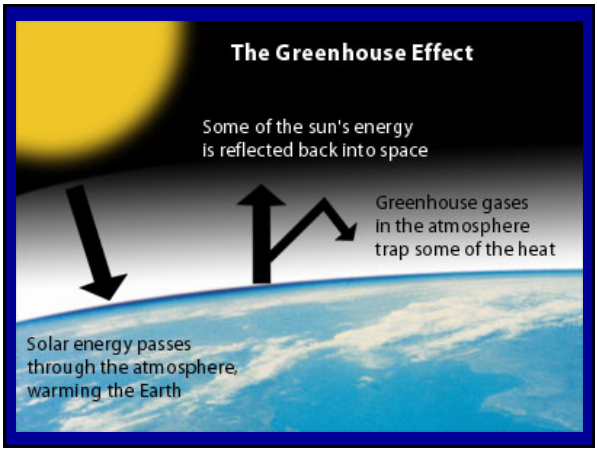
Energy of the Atmosphere

- Radiant energy from the sun provides 99.97% of total energy of the atmosphere.
- Sun's temperature = 12,000°F (6,000°K)
  - Earth intercepts 1/5 billionth of this energy
- Solar energy is the engine which drives the earth's atmosphere and oceanic circulation.
- Radiant energy travels through space as electric magnetic waves traveling at 186,000 miles per second.

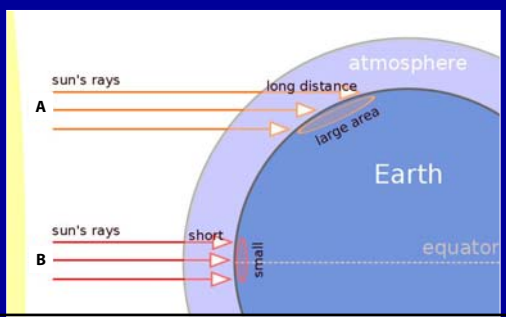
Illustrating the "greenhouse effect" of earth's atmosphere



The glass in the roof and sides of the greenhouse, like the atmosphere, is relatively transparent to short-wave solar energy, but relatively opaque to long-wave earth radiation.



Oblique solar rays (A) deliver less energy at the earth's surface than vertical rays (B), because their energy is spread over a larger surface (top), and because they pass through a thicker layer of reflecting and absorbing atmosphere.



When the sun is overhead at the equator (March 21 and September 23) the amount of atmospheric ray penetration varies with location:

1	atmosphere at equator
1.56	atmospheres at 40° N&S
45	atmospheres at poles

Oblique rays deliver less energy because

1. **Their energy is spread over a large surface.**
2. **They pass through a thicker layer of absorbing atmosphere.**

Note: Distance of earth to sun is a trivial factor in the amount of energy received, but does change in orbit. The earth is actually closer to the sun in December than in June.

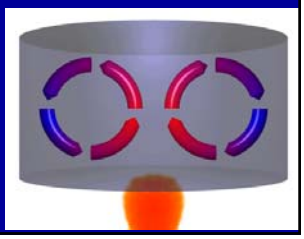
Effect of Altitude

Temperature declines 2.6°F (2.0°C) for every 1000 ft.
This is because atmospheric thermal energy is obtained from the earth's surface and only indirectly from the sun.
Air at lower altitudes has more water vapor and dust and is a more efficient absorber of terrestrial radiation.

Air Circulation

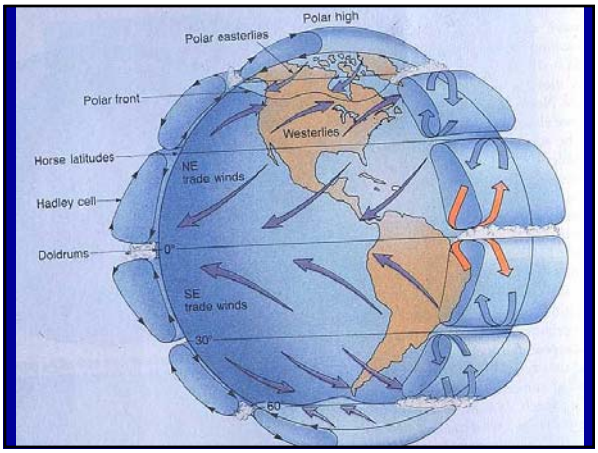
- Energy of air comes from reradiation of the earth's surface
- Warm air is light & rises = low pressure = associated with "hot & rainy" conditions
- Cool air is heavy and sinks = high pressure = dry (cooler) conditions

Circulation of air is similar to circulation of water in a pan of water heated by a Bunsen burner



Circulation of the Atmosphere: Winds

- Winds refer to the movement of the atmosphere felt on the earth's surface.
- Wind tend to move from high pressure to low pressure but the actual movement of winds is very complicated.
- Winds are named for the direction from which the come from.
- Winds coming from the east and moving to the west are known as Easterlies.

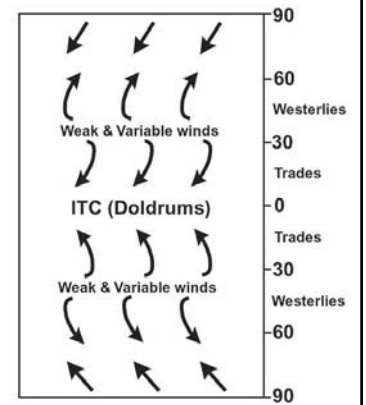


Pressure Zones in the Tropics and Subtropics

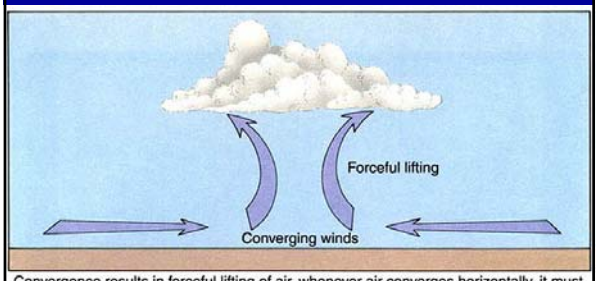
Low Pressure Zone

Inter-tropical Convergence zone (ITC)
- **Also known as Equatorial Trough**
- **10–12° band straddling the equator**
- **Moves with the sun**
- **This is an area of low pressure because of the intensity of solar radiation which heats the air**

Idealized Representation of Earth's Surface Winds



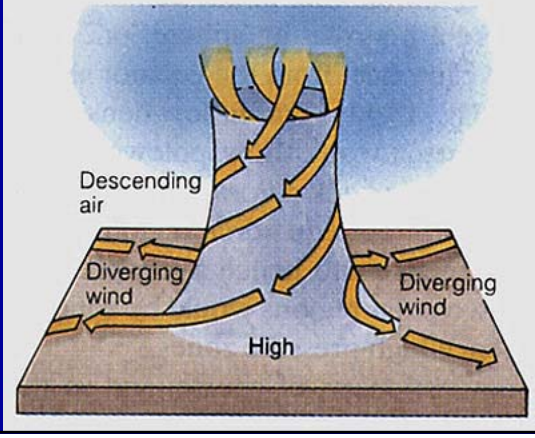
Convergence



Convergence results in forceful lifting of air. whenever air converges horizontally, it must increase in height to allow for the decreased area it occupies.

High Pressure Zone

- A band about 30° north and south.
- This area is known as the Horse Latitudes, characterized by calms and unstable, unsteady winds.
- In the days of sailing ships, horses got sick at this point and were often thrown overboard.



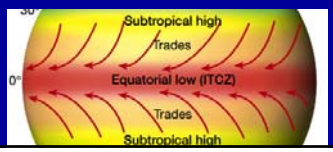
Tropical Winds

Doldrums

- In ITC winds are weak.
- It refers to the lack of progress of sailors in this area of the ocean due to calms, squalls, and light, baffling winds.
- However, there is a massive upward movement of air, but this is not apparent on the surface.
  - A sailor would say there is no air movement.
  - A balloonist would think the opposite.

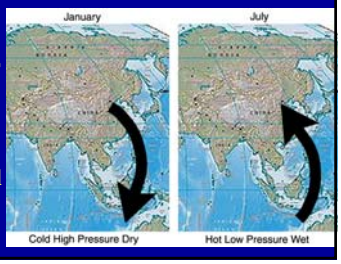
Trade Winds

- Dependable winds moving from high pressure zone of horse latitudes to the edge of the ITC.
- They veer to the west because of the rotation of the earth, thus are easterly winds.
- The trade winds dominate the tropics.
- Winds flow 10–15 miles per hours, fairly steady 10 to 12° to 25° N&S.
- NE winds north of the equator; SE winds south of the equator.

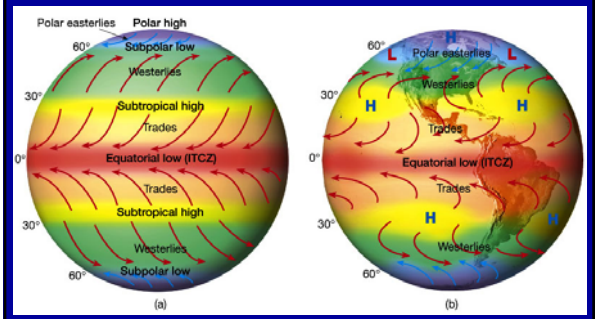


Monsoon Winds

- Monsoon is an Arabic word meaning season.
- Monsoon winds reverse themselves seasonally.
- Best developed in Western parts of oceans or eastern parts of continents, particularly Asia.
- Monsoon is based on differential thermal heating and cooling of land areas creating zones of high and low pressure over land in different seasons.
- Monsoons represent a great break in general circulation of the atmosphere.



Pressure Zones and Air Circulation



Idealized | Actual due to land masses

Temperature in the Tropics

- Isotherms (lines of equal temperature) are used to delineate climate
- Any location with coldest month averaging < 18°C (64.4°F) is not considered tropical
- Temperature based on total annual solar radiation. This is affected by cloud cover and daylength

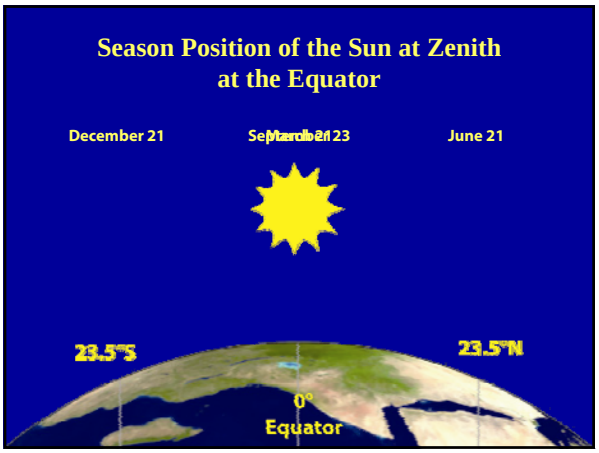
Total Annual Solar Radiation

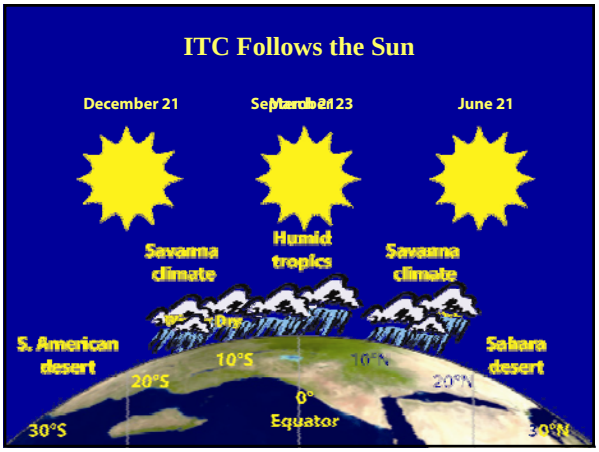
Latitude	Thermal days
0	365.2
10	360.2
20	345.2
30	321.0
40	288.5
50	249.7
60	207.8
70	173.0
80	156.6
90	151.6

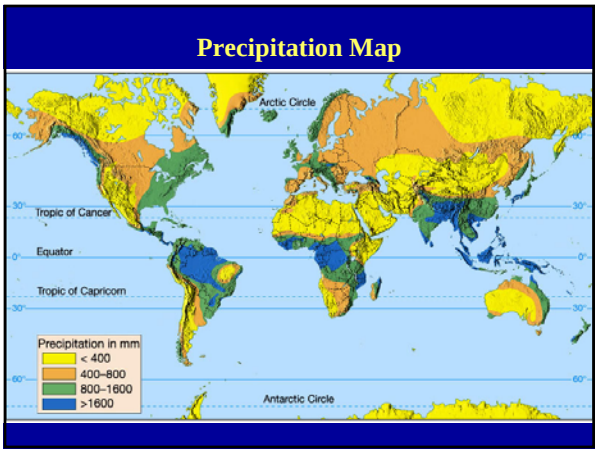
Thermal days = avg. total daily solar energy at equator

Precipitation in the Tropics

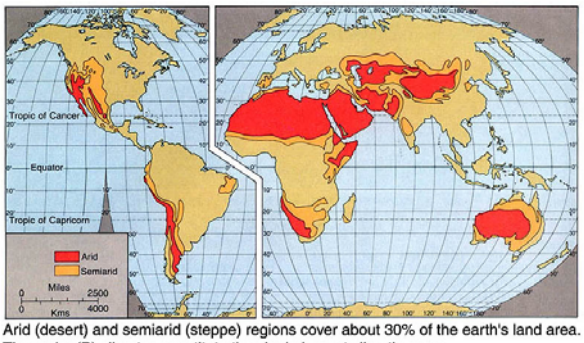
- In equatorial areas (ITC), rainfall is high and steady; the hot air rises and cools, condensing into rain.
- A month with less than 2.4 inches (60 mm) is considered a dry month in the tropics.


Season Position of the Sun at Zenith
at the Equator
December 21
June 21
23.5°S
23.5°N
0°
Equator


ITC Follows the Sun
December 21
June 21
Savanna climate
Humid tropics
Savanna climate
S. American desert
Sahara desert
10°S
20°S
10°N
20°N
0°
Equator
30°S
30°N


Precipitation Map
Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle
Precipitation in mm
< 400
400–800
800–1600
>1600

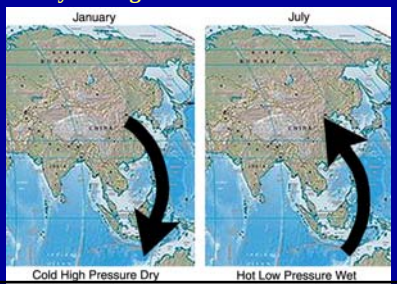
Arid Areas of Earth

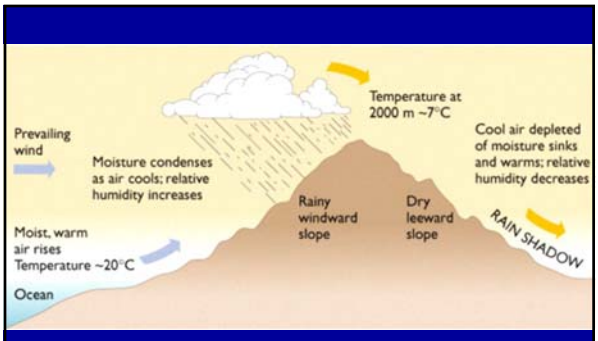


Arid (desert) and semiarid (steppe) regions cover about 30% of the earth's land area. These dry (B) climates constitute the single largest climatic group.

There are Other Patterns of Rainfall

Monsoon (Malabar coast of India, SW Coast of Burma and Thailand): In monsoon area, total rainfall may surpass equatorial rainfall. In India 50–60 inches in 2 months of July & August.





Orographic Precipitation: This is due to mountain lifting of trades. Always get high precipitation where mountain ranges are transverse to trade winds.

Kauai

Patterns of Temperature and Precipitation in Tropical Climates

Af	Am	Aw
Tropical Rainy	Tropical Monsoon	Tropical Savanna