

The image shows a vast, flat landscape under a bright sun. The foreground is filled with a dense field of blue, rounded mounds, possibly representing a field of low-lying vegetation or a specific geological formation. The background is a flat, light-colored expanse that stretches to the horizon. The sky is a pale blue, and the sun is a bright, glowing orb in the upper center, casting a soft light over the scene.

# Earth and Space Science

## Structure of the Atmosphere

# Weather v Climate

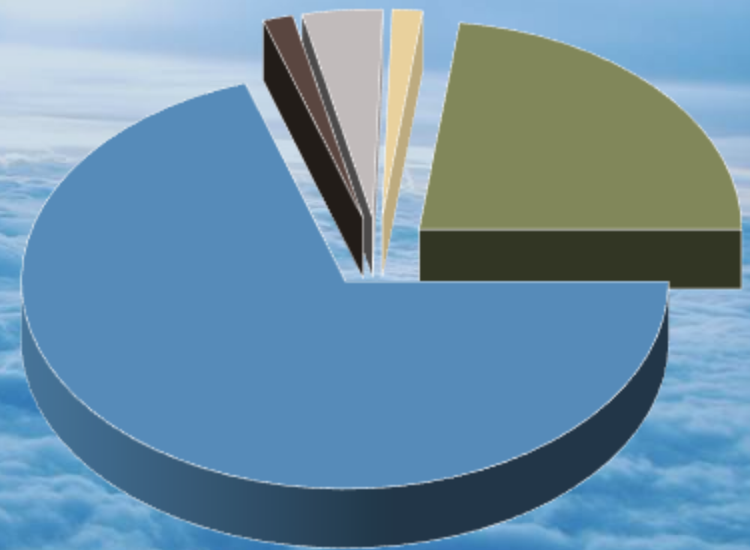
- Weather: the state of the atmosphere at a particular place for a short period of time.
- Climate: a generalization of the weather conditions over a long period of time.

# Elements

1. Air Temperature
2. Humidity
3. Type and amount of cloudiness
4. Type and amount of precipitation
5. Air pressure
6. The speed and direction of the wind

# Air

- Is a mixture of many different gasses
- 78% Nitrogen, 21% Oxygen, 0.93% Argon, 0.035% Carbon Dioxide, & 0.035% all other gasses



□ Nitrogen                      ■ Carbon Dioxide  
□ Argon                         ■ All Others  
□ Oxygen

# Water Vapor

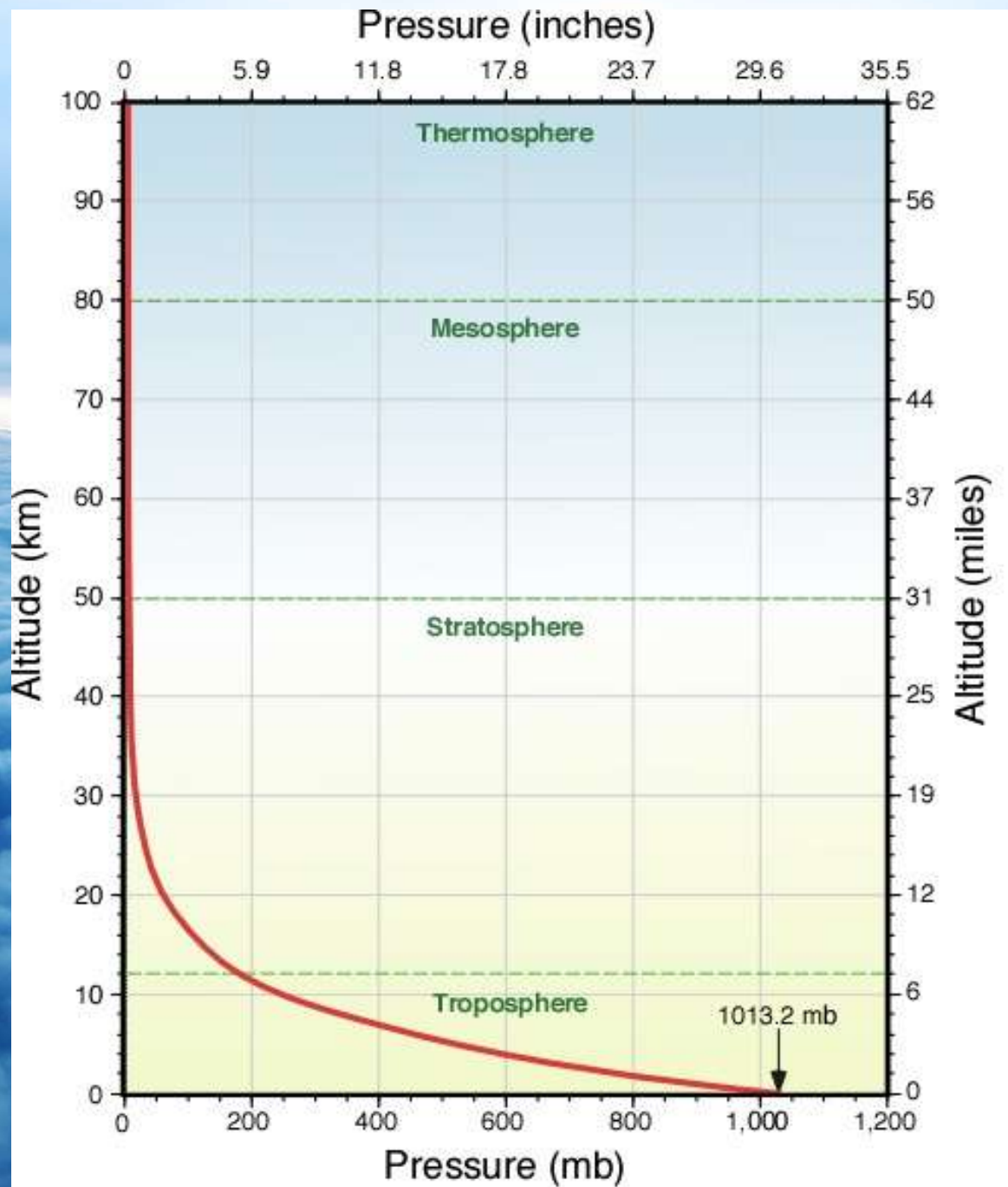
- Water in the air not only produces precipitation but as water changes from one state to another it absorbs or releases heat, called latent heat (e.g. “hidden”).
- This heat is transferred from one region to another by the water vapor and is the energy source that helps drive storms.

# Dust

- Dust in the air can be microscopic pieces of dirt, pollen, spores, and seeds.
- Dust can reflect or absorb sunlight causing changes to the Earth's surface temperature.
  - (i.e. dust in the air following a volcanic eruption, lowers the temperature by blocking sunlight)

# Ozone

- $O_3$  not  $O_2$
- Happens in the Stratosphere (between 10 and 50 kilometers, 6 and 31 miles from the surface)
- Requires enough UV light to split  $O_2$  into  $O$ , and also have enough  $O_2$  around for the  $O$  to collide into the  $O_2$  making  $O_3$
- The Ozone layer filters out most of the UV light.



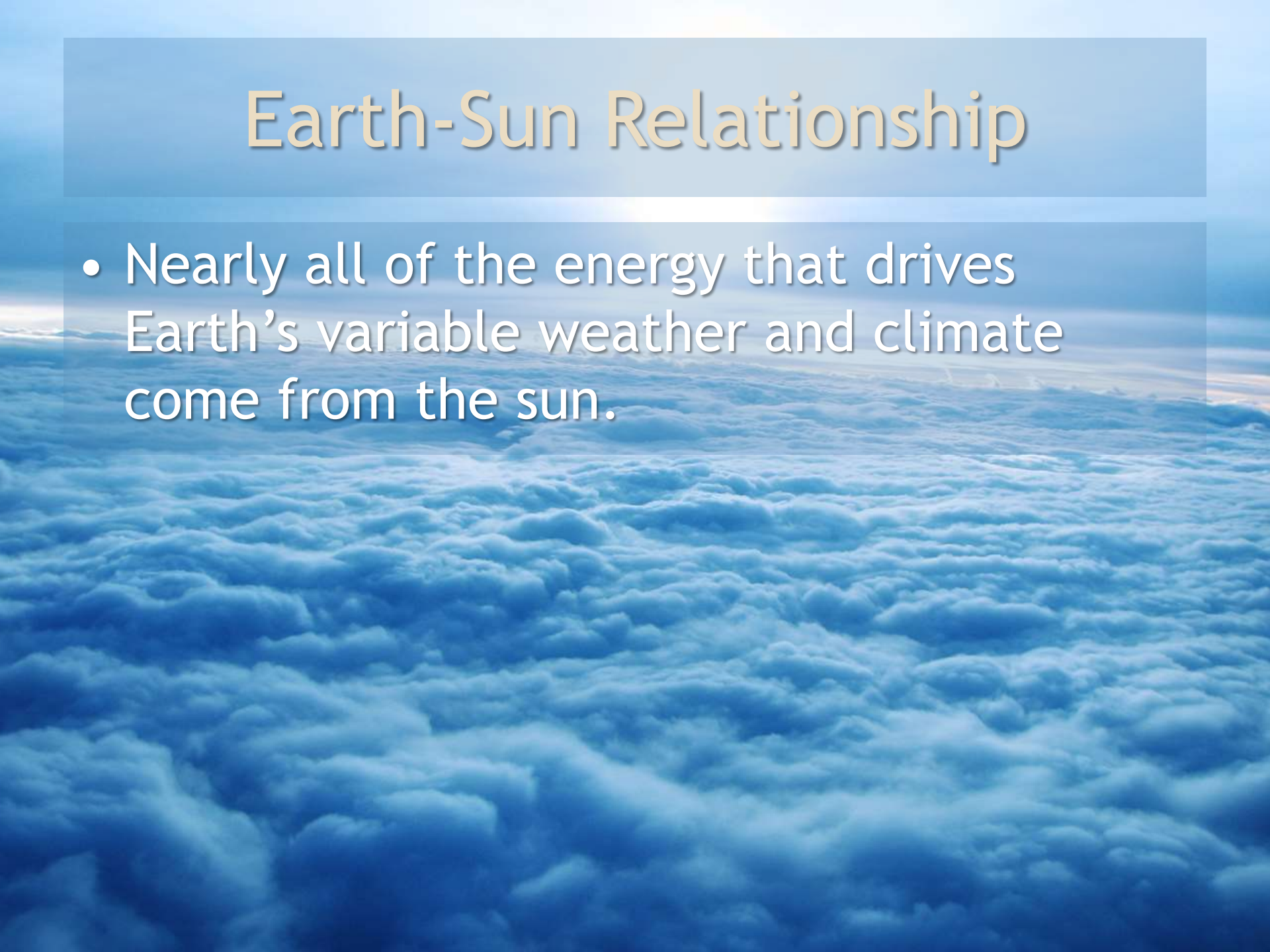


# Layers of the Atmosphere

- Troposphere - the regions where air “turns over” [0-12km]
- Stratosphere - where the majority of the ozone is located [12-47km]
- Mesosphere - around 80km temperature approaches  $-90^{\circ}\text{C}$  [47-80km]
- Thermosphere - extends past Mesosphere and has no well-defined upper limit; contains only a minute fraction of the atmosphere’s mass [80km+]

# Earth-Sun Relationship

- Nearly all of the energy that drives Earth's variable weather and climate come from the sun.

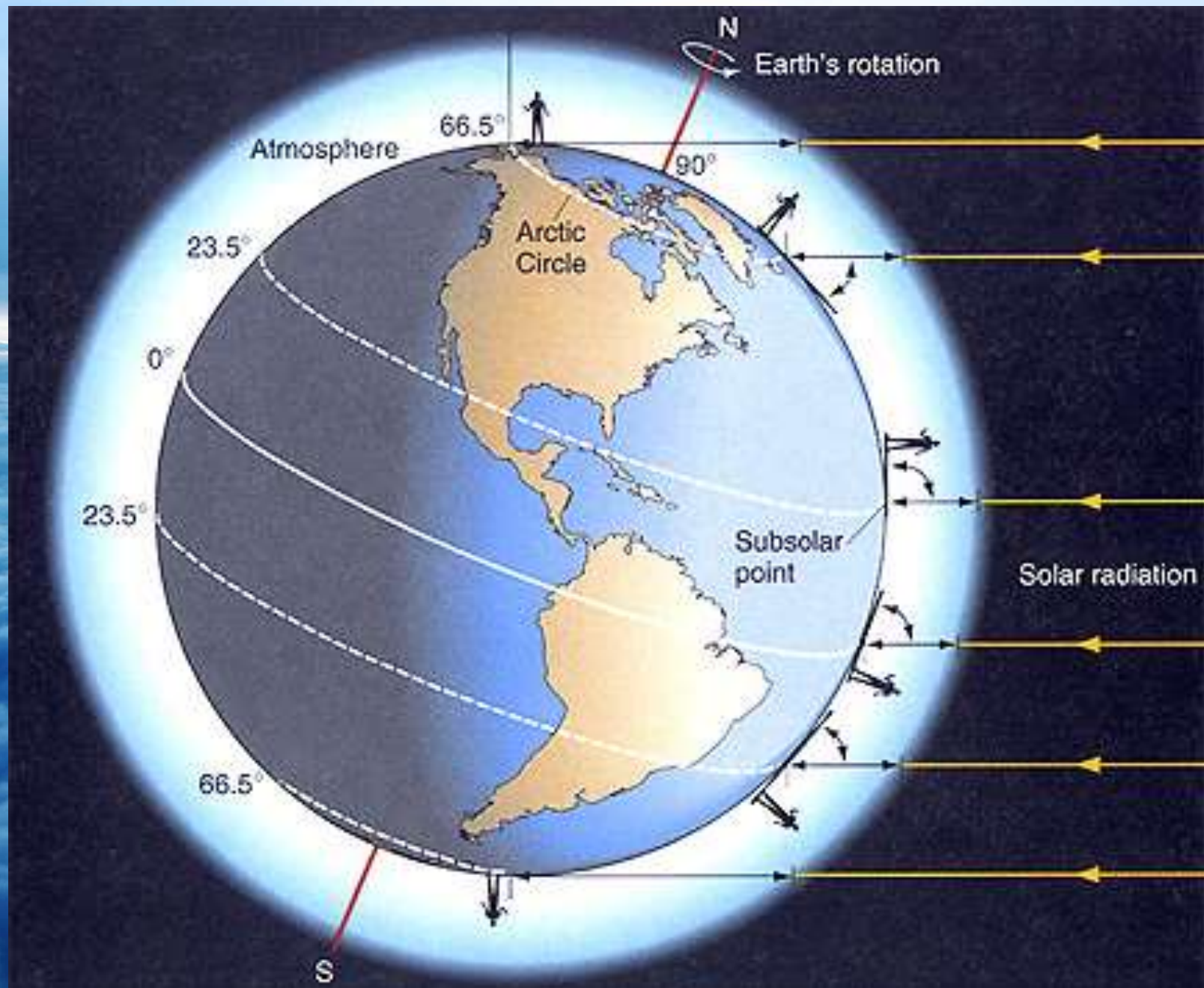


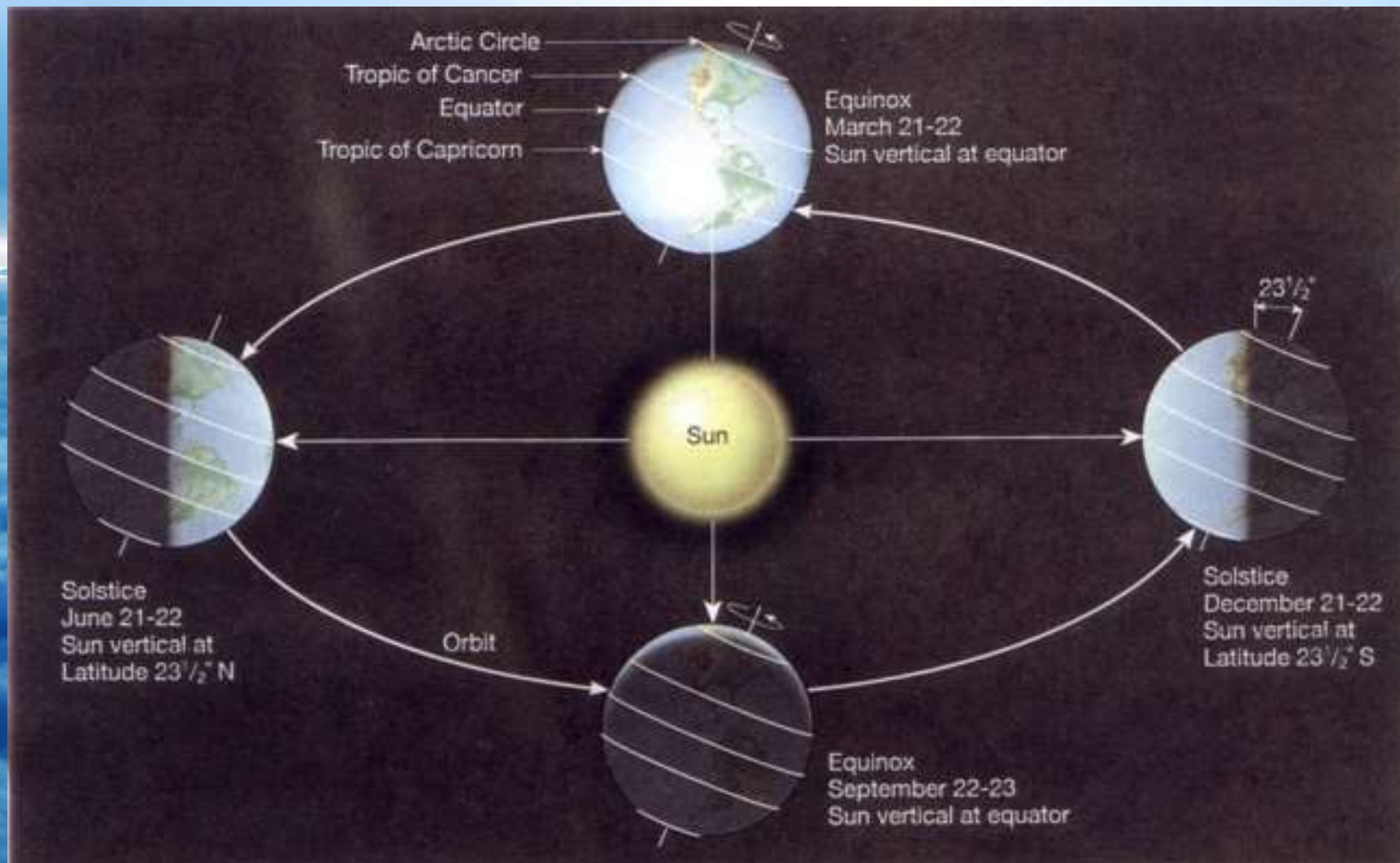
# Earth's Rotation and Revolution

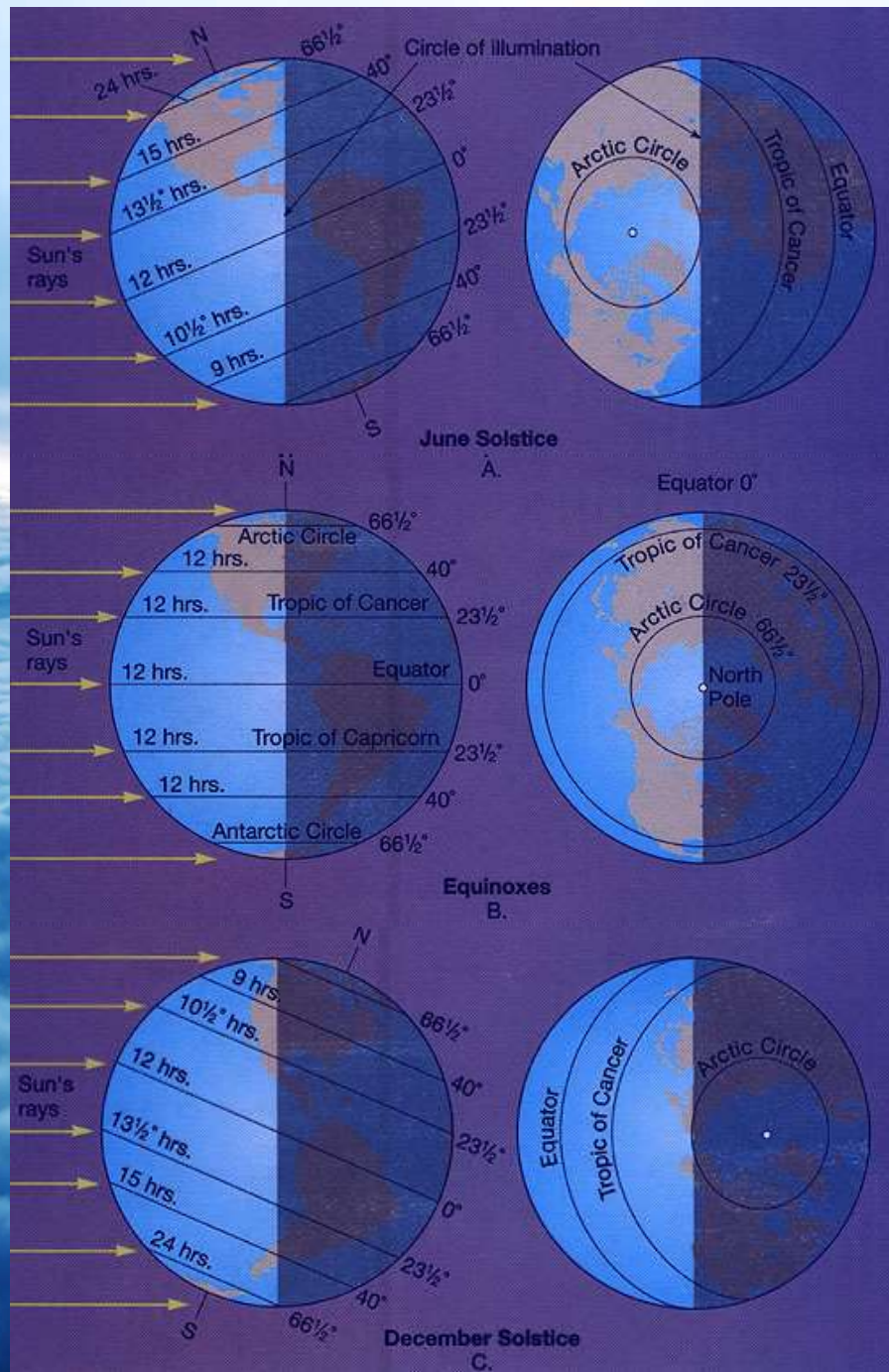
- Earth has two principle motions:
  - (1) Rotation - is the spinning of Earth about its axis
    - Rotates once every 24 hours
    - Circle of illumination - line separating the dark half from the light half
  - (2) Revolution - the movement of the Earth in its orbit around the sun.
    - Earth travels at more than 107,000 km/hr

# Seasons

- Two ways which the altitude of the sun in the sky affect the amount of energy received at Earth's surface:
  - (1) When the sun is high in the sky the sun's rays are more concentrated; conversely, the lower sun the more spread out the rays are.
  - (2) The angle of the sun determines the amount of atmospheres the sun rays travel through. (ex. Sun at noon vs. at sunset or sunrise)







# Heat Transfer

- In all situations, heat is transferred from warmer to cooler objects
- Three types of Heat Transfer:
  1. Conduction
  2. Convection
  3. Radiation



# Conduction

- The transfer of heat through matter by molecular activity.
- In other words, energy is transferred through collisions between molecules.

# Convection

- Is the transfer of heat by the movement of a mass or substance from one place to another.
- **CAN ONLY HAPPEN IN LIQUIDS AND GASSES**
- Advection is the term used for the horizontal convection motions such as winds (the movement from place to place of warmer and cooler fluids).

# Radiation

- The transfer of heat by electromagnetic waves.
- The only form of heat transfer that can be transmitted through the relative emptiness of space.

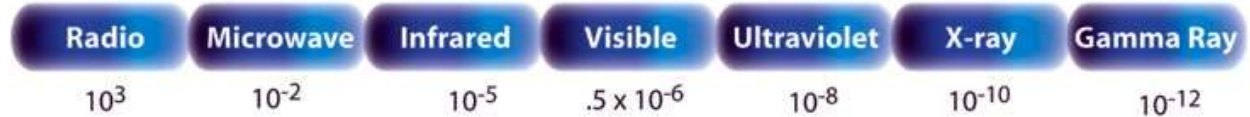
# Electromagnetic Spectrum

## THE ELECTROMAGNETIC SPECTRUM

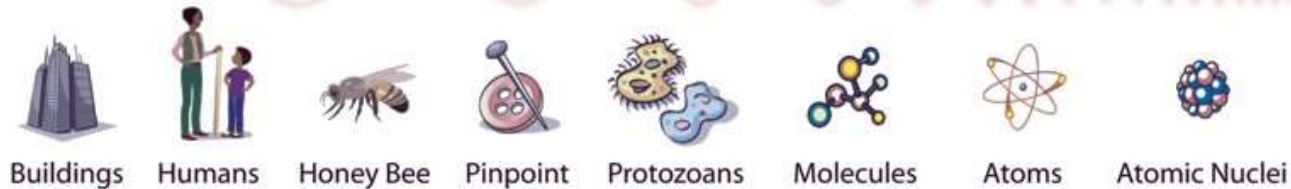
Penetrates Earth Atmosphere?



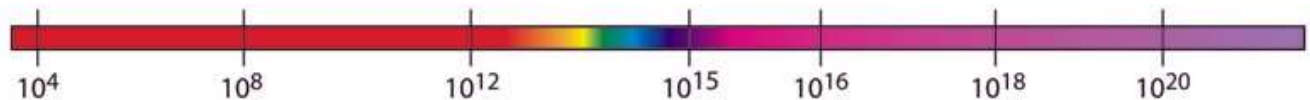
Wavelength (meters)



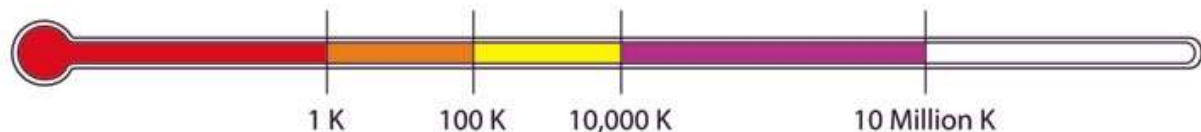
About the size of...



Frequency (Hz)



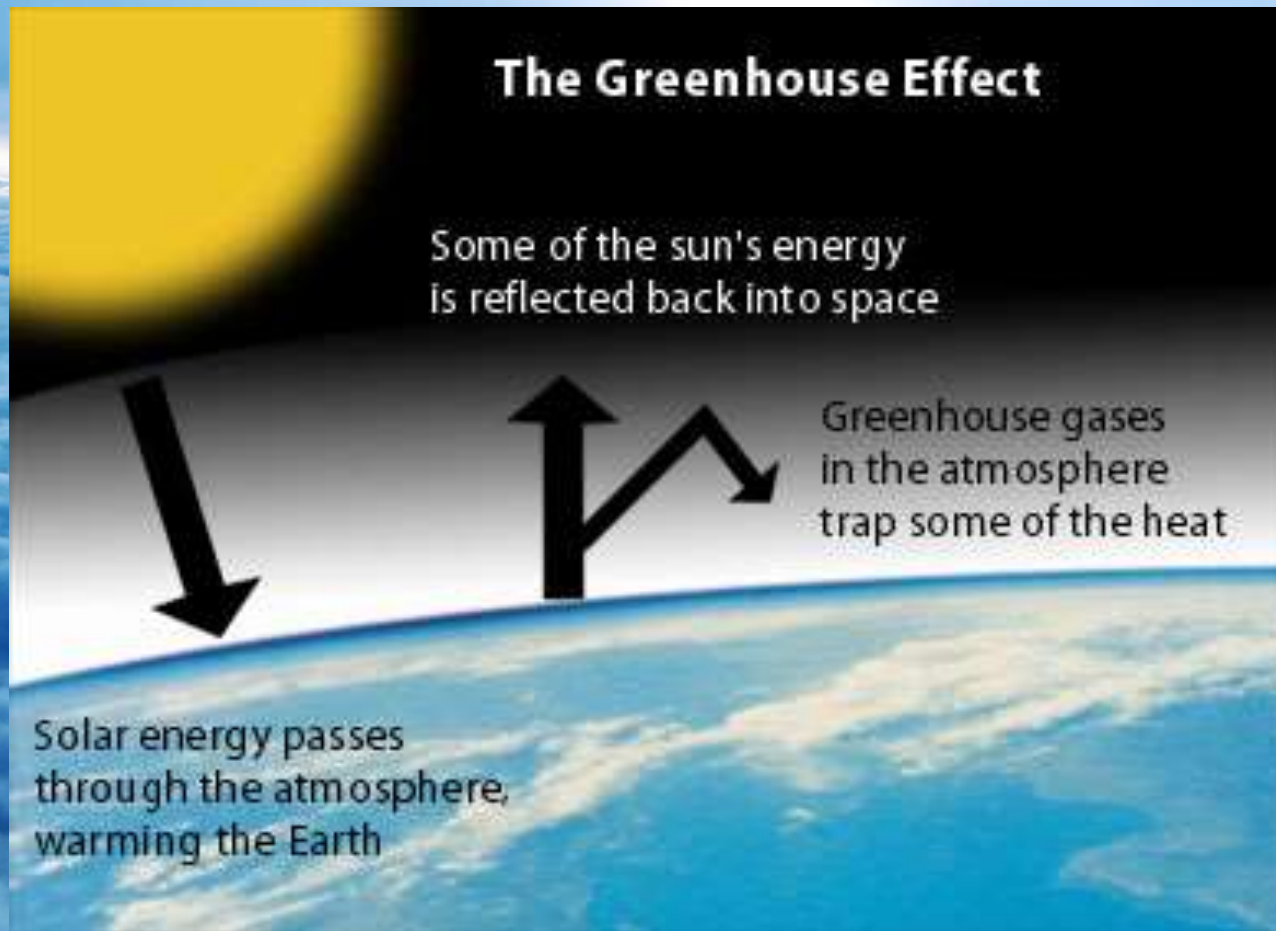
Temperature of bodies emitting the wavelength (K)



# Paths Taken by Incoming Solar Radiation

- Scattering
- Albedo - reflection of solar radiation back into space
- Absorption
- Atmosphere is mainly heated by energy that is first absorbed by Earth's surface and then reradiated to the sky.

# The Greenhouse Effect





# NWS Windchill Chart



Temperature (°F)

| Wind (mph) | Calm | 40 | 35 | 30 | 25 | 20 | 15  | 10  | 5   | 0   | -5  | -10 | -15 | -20 | -25 | -30 | -35 | -40 | -45 |
|------------|------|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 5          |      | 36 | 31 | 25 | 19 | 13 | 7   | 1   | -5  | -11 | -16 | -22 | -28 | -34 | -40 | -46 | -52 | -57 | -63 |
| 10         |      | 34 | 27 | 21 | 15 | 9  | 3   | -4  | -10 | -16 | -22 | -28 | -35 | -41 | -47 | -53 | -59 | -66 | -72 |
| 15         |      | 32 | 25 | 19 | 13 | 6  | 0   | -7  | -13 | -19 | -26 | -32 | -39 | -45 | -51 | -58 | -64 | -71 | -77 |
| 20         |      | 30 | 24 | 17 | 11 | 4  | -2  | -9  | -15 | -22 | -29 | -35 | -42 | -48 | -55 | -61 | -68 | -74 | -81 |
| 25         |      | 29 | 23 | 16 | 9  | 3  | -4  | -11 | -17 | -24 | -31 | -37 | -44 | -51 | -58 | -64 | -71 | -78 | -84 |
| 30         |      | 28 | 22 | 15 | 8  | 1  | -5  | -12 | -19 | -26 | -33 | -39 | -46 | -53 | -60 | -67 | -73 | -80 | -87 |
| 35         |      | 28 | 21 | 14 | 7  | 0  | -7  | -14 | -21 | -27 | -34 | -41 | -48 | -55 | -62 | -69 | -76 | -82 | -89 |
| 40         |      | 27 | 20 | 13 | 6  | -1 | -8  | -15 | -22 | -29 | -36 | -43 | -50 | -57 | -64 | -71 | -78 | -84 | -91 |
| 45         |      | 26 | 19 | 12 | 5  | -2 | -9  | -16 | -23 | -30 | -37 | -44 | -51 | -58 | -65 | -72 | -79 | -86 | -93 |
| 50         |      | 26 | 19 | 12 | 4  | -3 | -10 | -17 | -24 | -31 | -38 | -45 | -52 | -60 | -67 | -74 | -81 | -88 | -95 |
| 55         |      | 25 | 18 | 11 | 4  | -3 | -11 | -18 | -25 | -32 | -39 | -46 | -54 | -61 | -68 | -75 | -82 | -89 | -97 |
| 60         |      | 25 | 17 | 10 | 3  | -4 | -11 | -19 | -26 | -33 | -40 | -48 | -55 | -62 | -69 | -76 | -84 | -91 | -98 |

Frostbite Times

30 minutes

10 minutes

5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

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