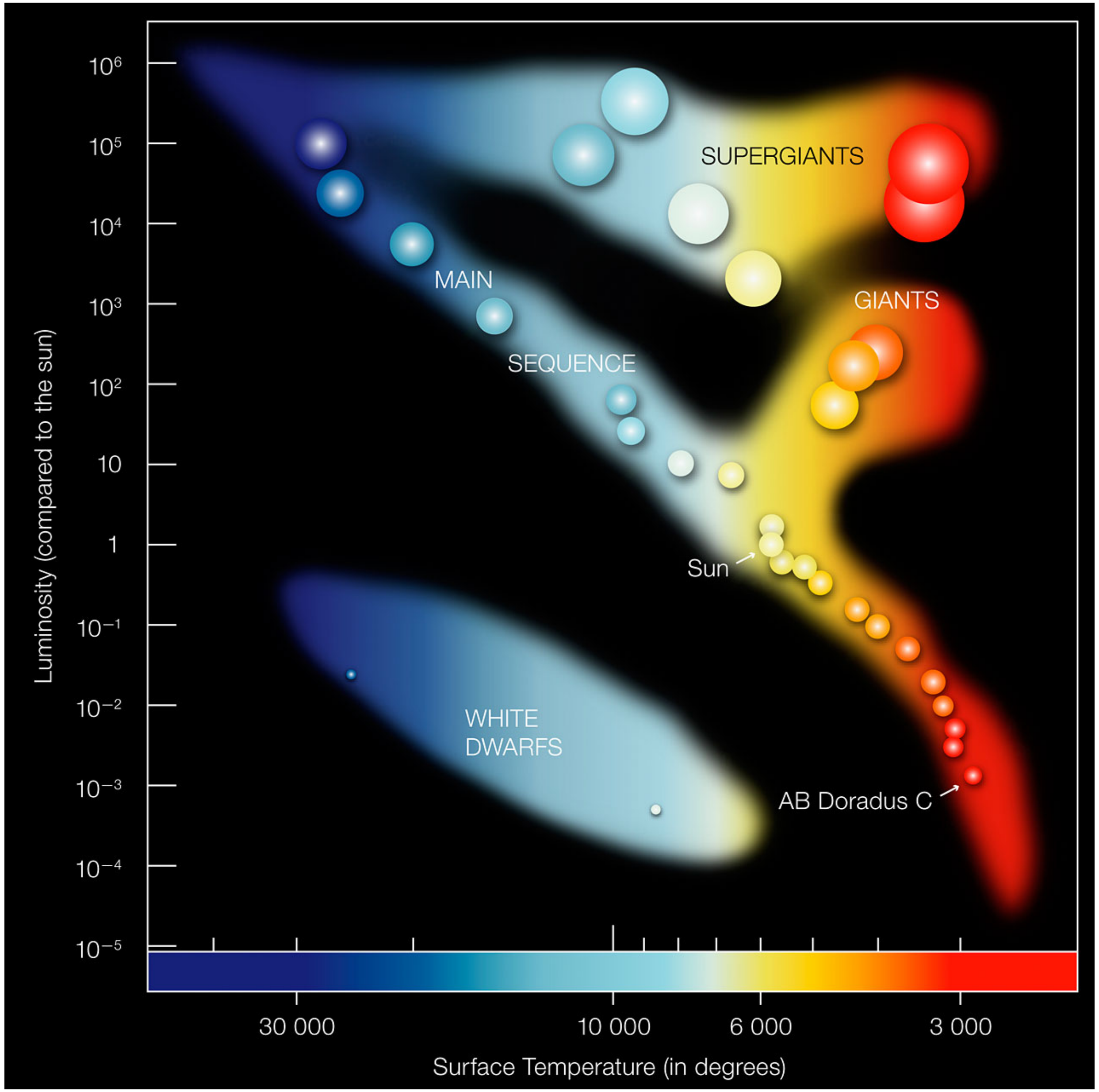
Global Warming
Lecture 3.2
Sunlight & Seasons

Sun*

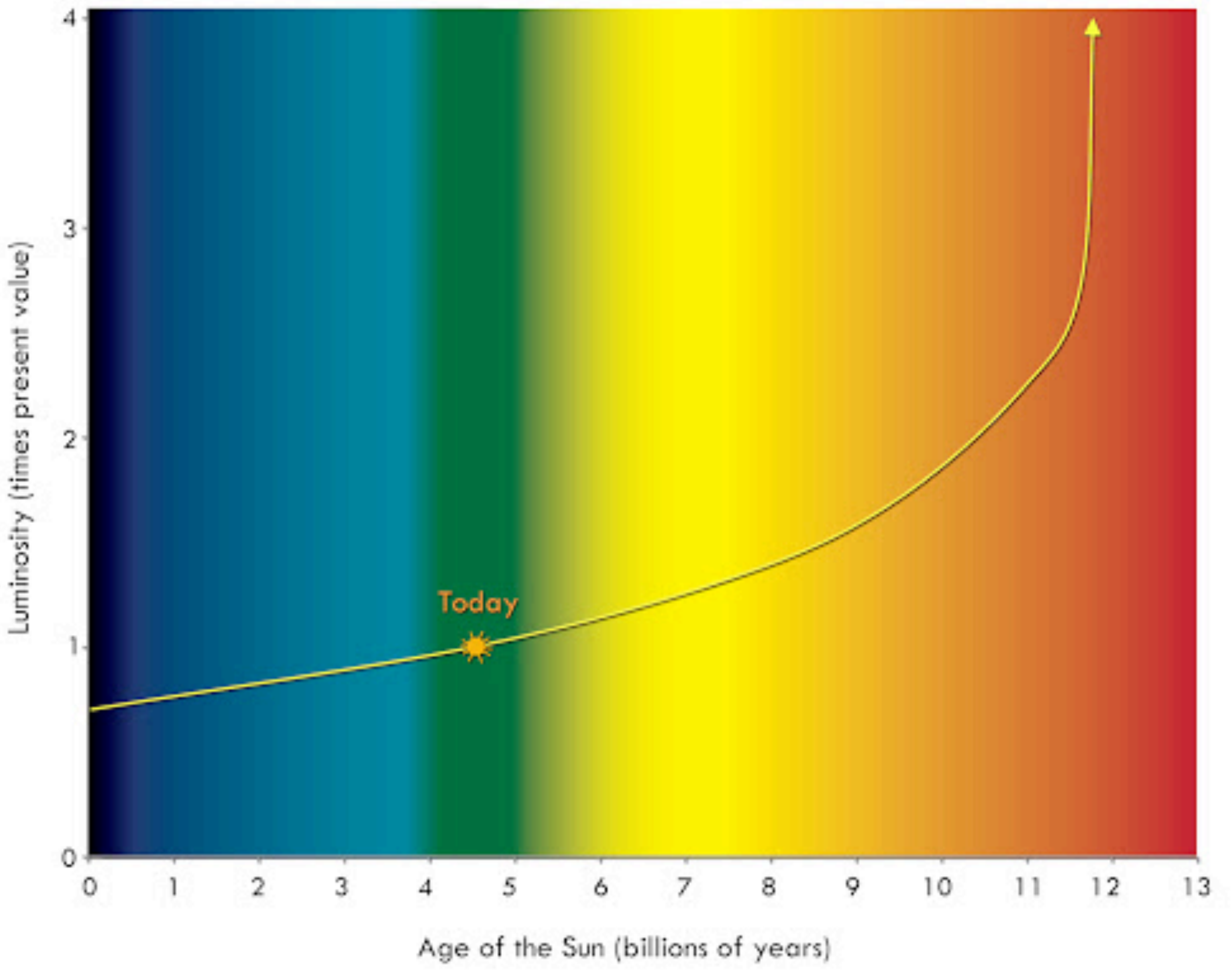
- **Sun:** Main Sequence star for 4.6B years.

Hertzsprung-Russell diagram



Sun’s Luminosity

- **Sun:** Main Sequence star for 4.6B years. Over that time, **its luminosity increased by 50%**.
- On the **timescales of human civilization**, the Sun’s luminosity hasn’t varied by much - it **cannot explain** the increase in temperature that we’ve observed over the past few hundred years.



Insolation

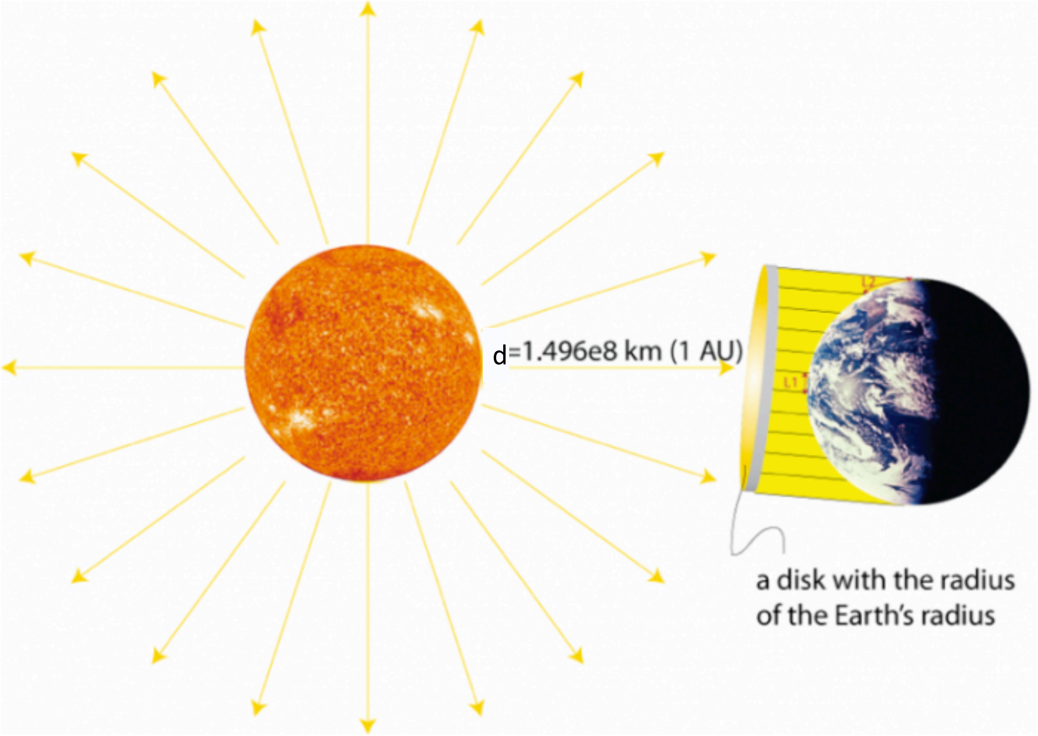
- The **insolation** is the amount of solar energy that reaches a position in space per unit area per unit time.

Sun's luminosity [W]

$$S_0 = \frac{L}{4\pi d^2}$$

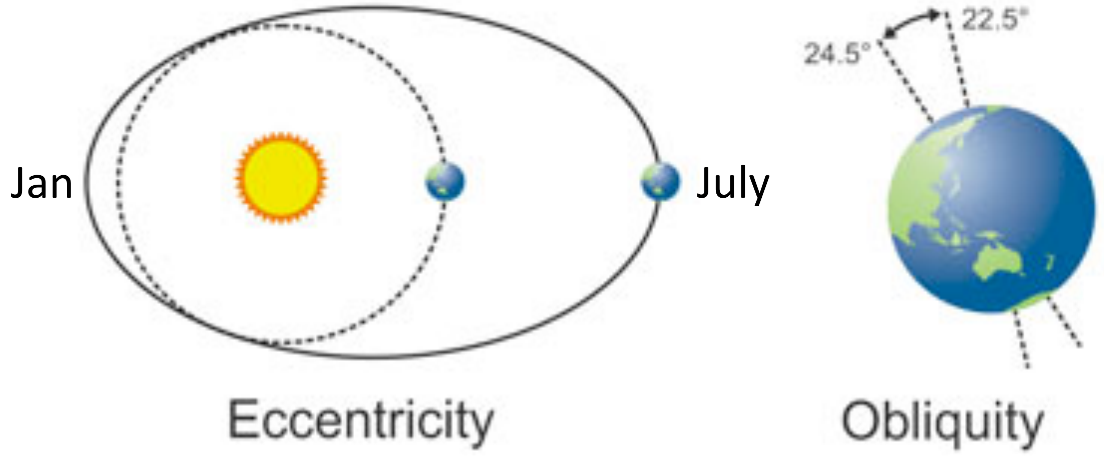
Isolation [W/m2]
(Solar constant)

Distance to the Sun [m]



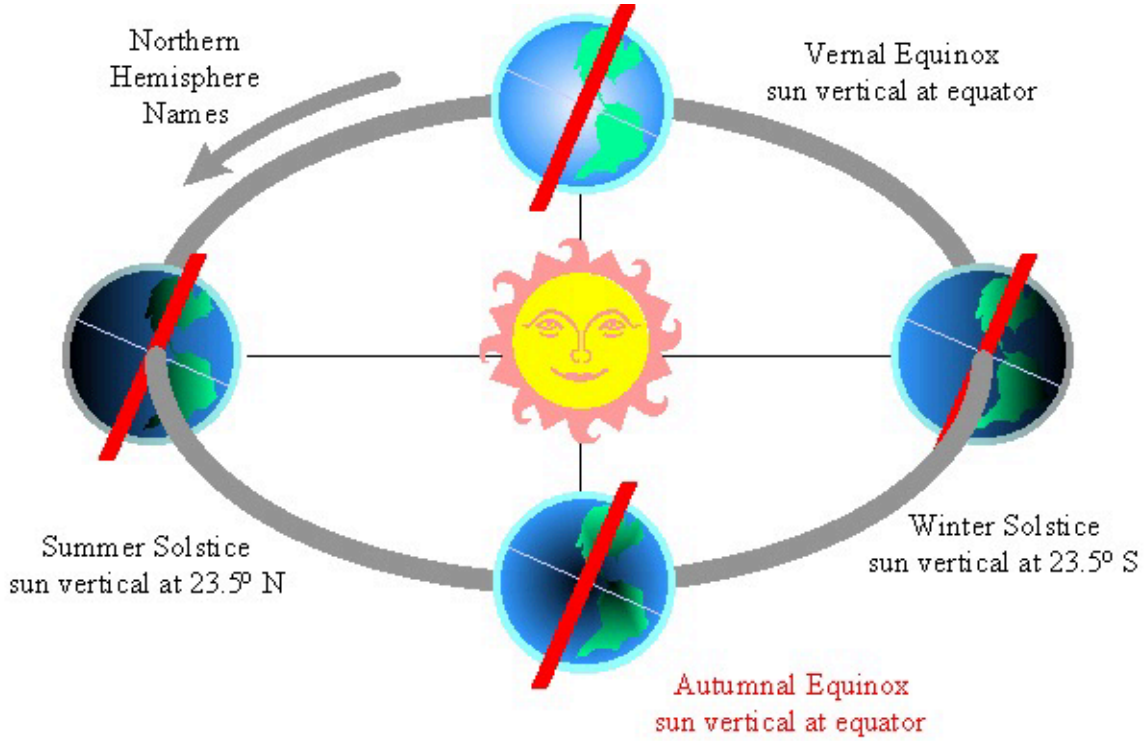
Sun-Earth distance: 1 AU (astronomical unit) = 1.5×10^{11} m

Eccentricity & Obliquity



- **Eccentricity:** Ovalness of a planet's orbit:
  - Earth's current eccentricity = 0.0167. This leads the insolation to be about 7% larger when Earth is closest to the Sun (**January**) than when it is farthest from the Sun (**July**).

- **Obliquity:** Axial tilt
  - Summer happens in the hemisphere that is tilted toward the Sun during Earth's orbit, and winter happens in the hemisphere that is tilted away from the Sun.

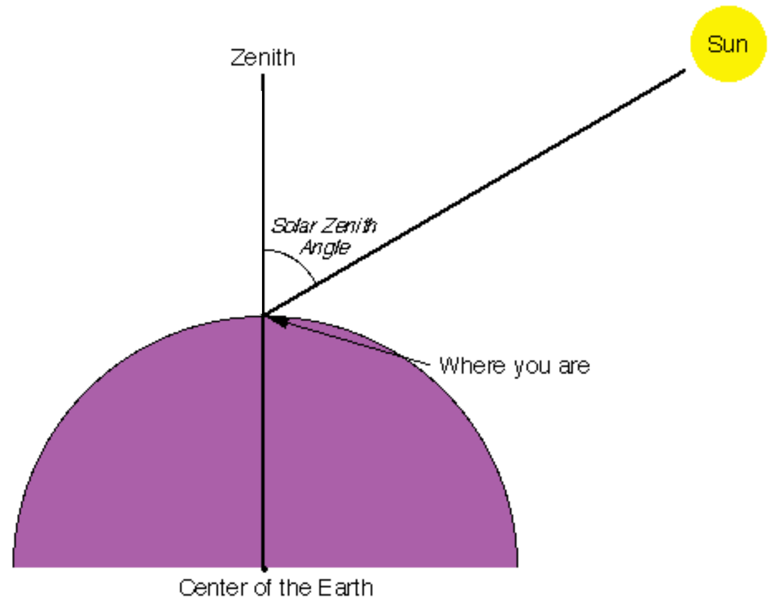


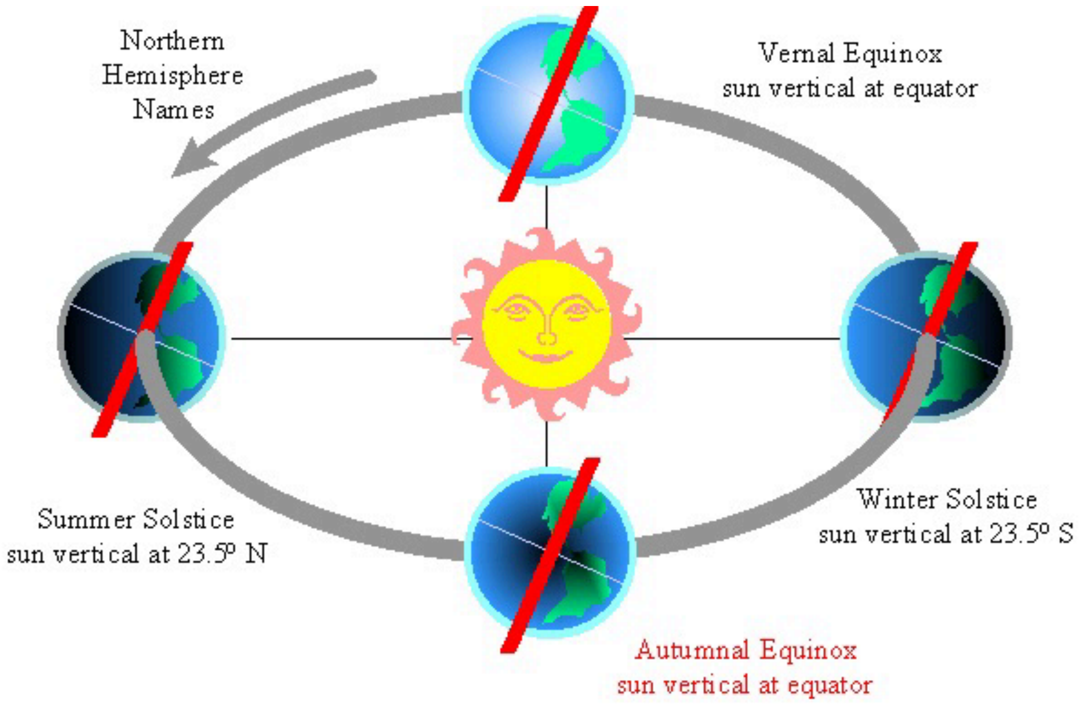
Solar Zenith Angle

- The solar zenith angle (θ_z) is the angle between the Sun and the vertical

$$S = S_0 \cos\theta_z$$

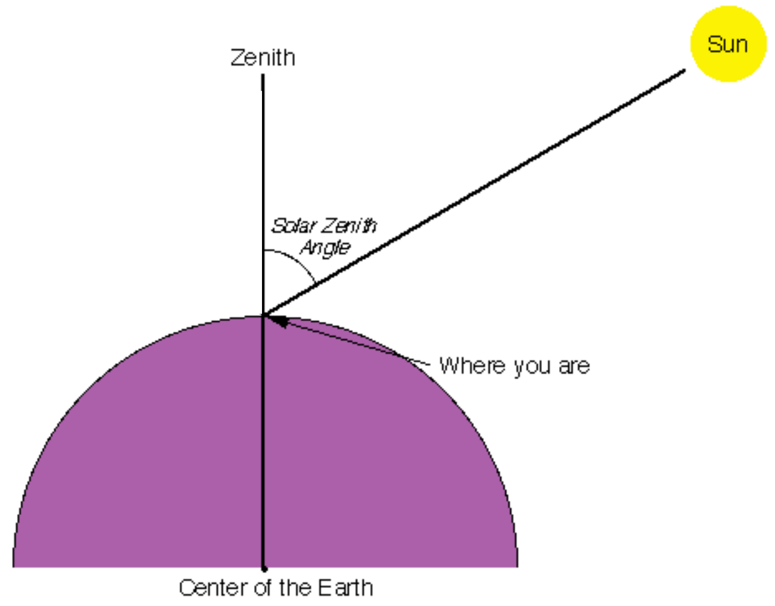
- This is the reason that **<u>it's warmer in the summer hemisphere</u>**: the solar zenith angle in that hemisphere is smaller, so sunlight hits its surface more directly and the local insolation is higher.

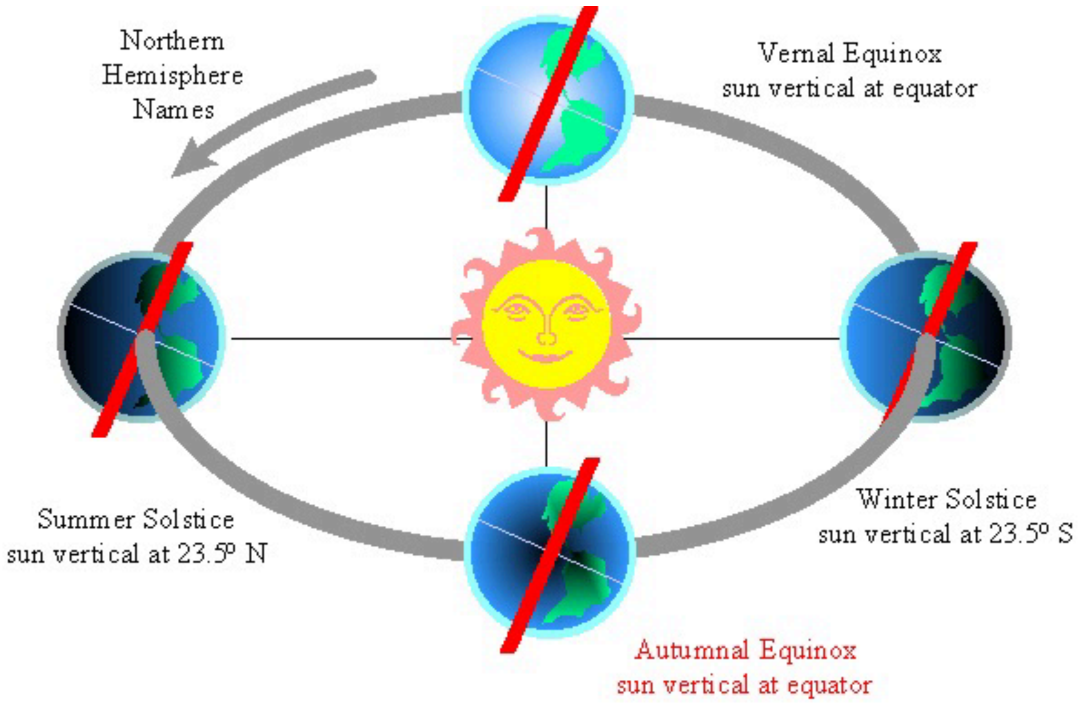




Solar Zenith Angle Calculation

- **At noon:**
- Summer solstice: $\theta_z = \text{Latitude} - 23.5°$
- Winter solstice: $\theta_z = \text{Latitude} + 23.5°$
- Equinox: $\theta_z = \text{Latitude}$





Some video

The Arctic circle:
https://www.youtube.com/watch?v=XzTWkgKqs_Q