NATS 101
Section 13: Lecture 7

The Seasons

The Importance of Seasons

The seasons govern both natural and human patterns of behavior. Some big and small examples:

Planting and harvesting of crops

Migratory patterns of animals

Deciduous trees

Types of sports

What kinds of clothes you wear

Where you go on vacation

Stonehenge, on the Salisbury Plain in southern England, is essentially an astronomical observatory, build thousands of years ago to detect the first day of summer. We'll see how it works a bit later…

Three orbital parameters of the Earth

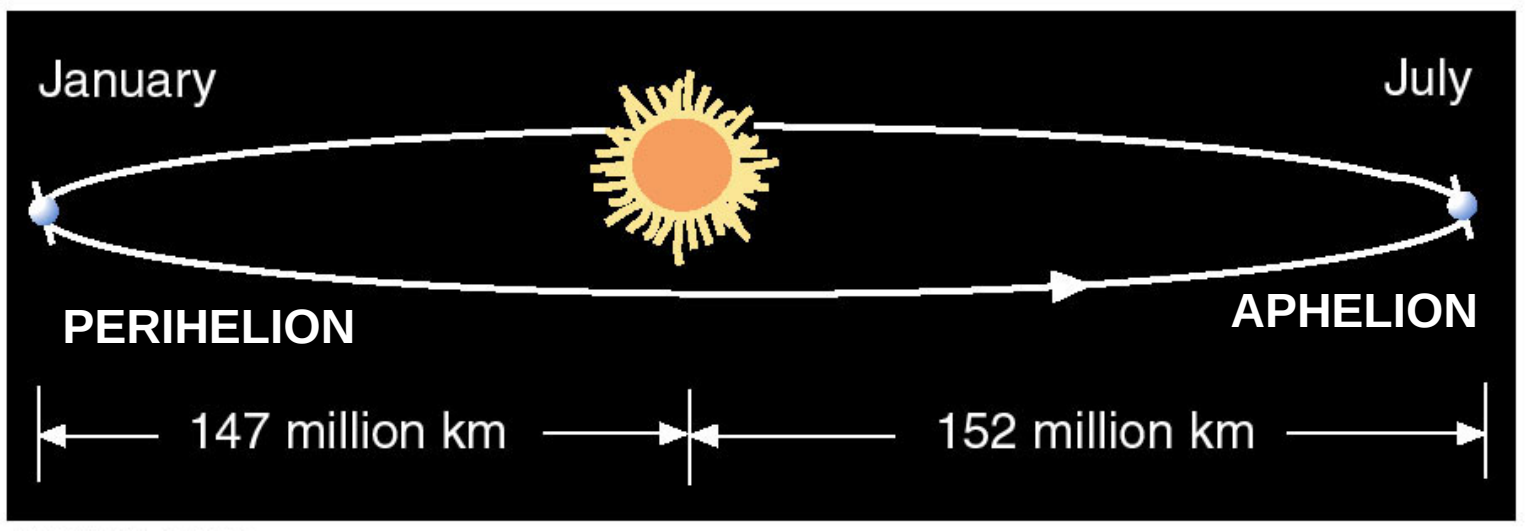
Eccentricity

Precession

Obliquity

Which one is responsible for the occurrence of the seasons?

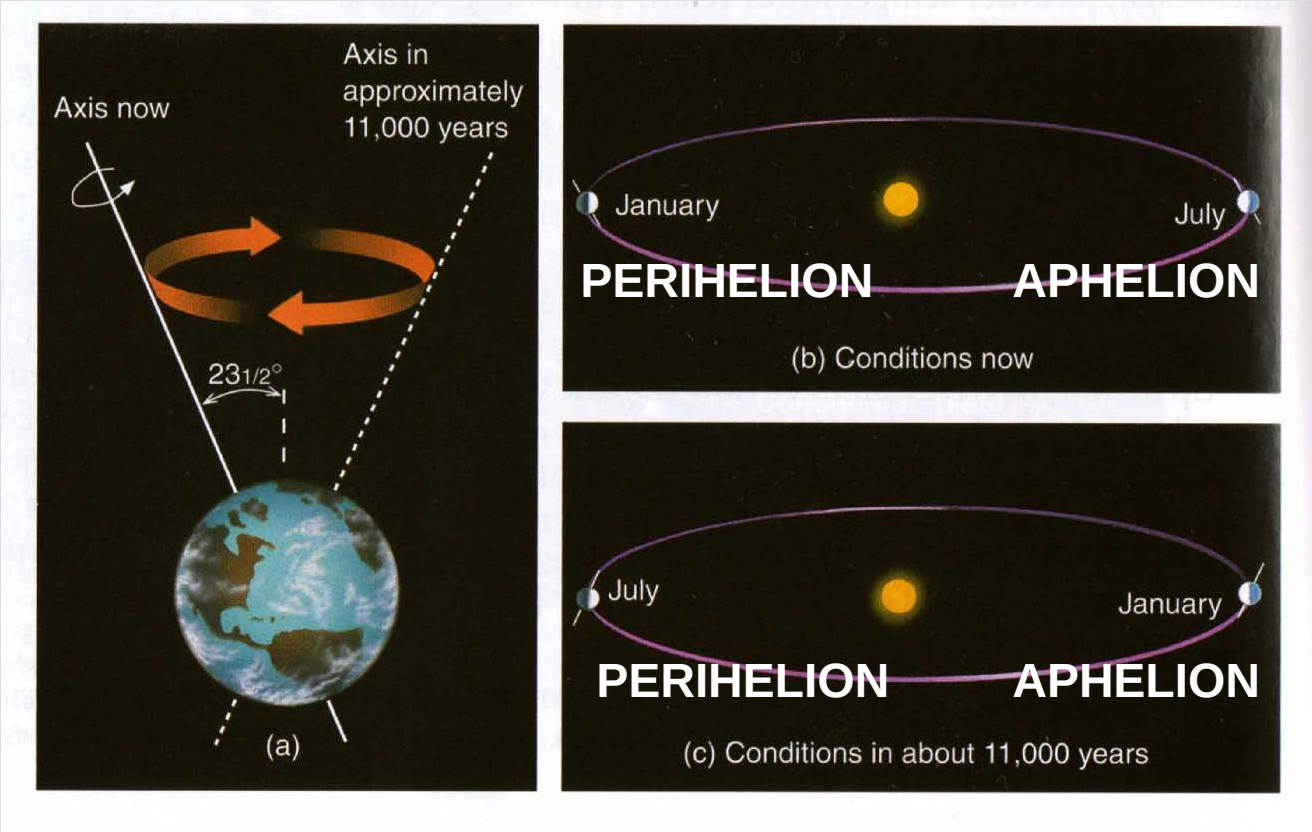
Eccentricity: Elliptical character of orbit



The Earth has an elliptical orbit around the Sun (<u>not</u> circular)

Earth actually gets 7% MORE solar radiation in January than July! So this cannot possibly explain why July could be warmer (at least in our part of the world)….

Precession: Change in Time of Perihelion and Aphelion

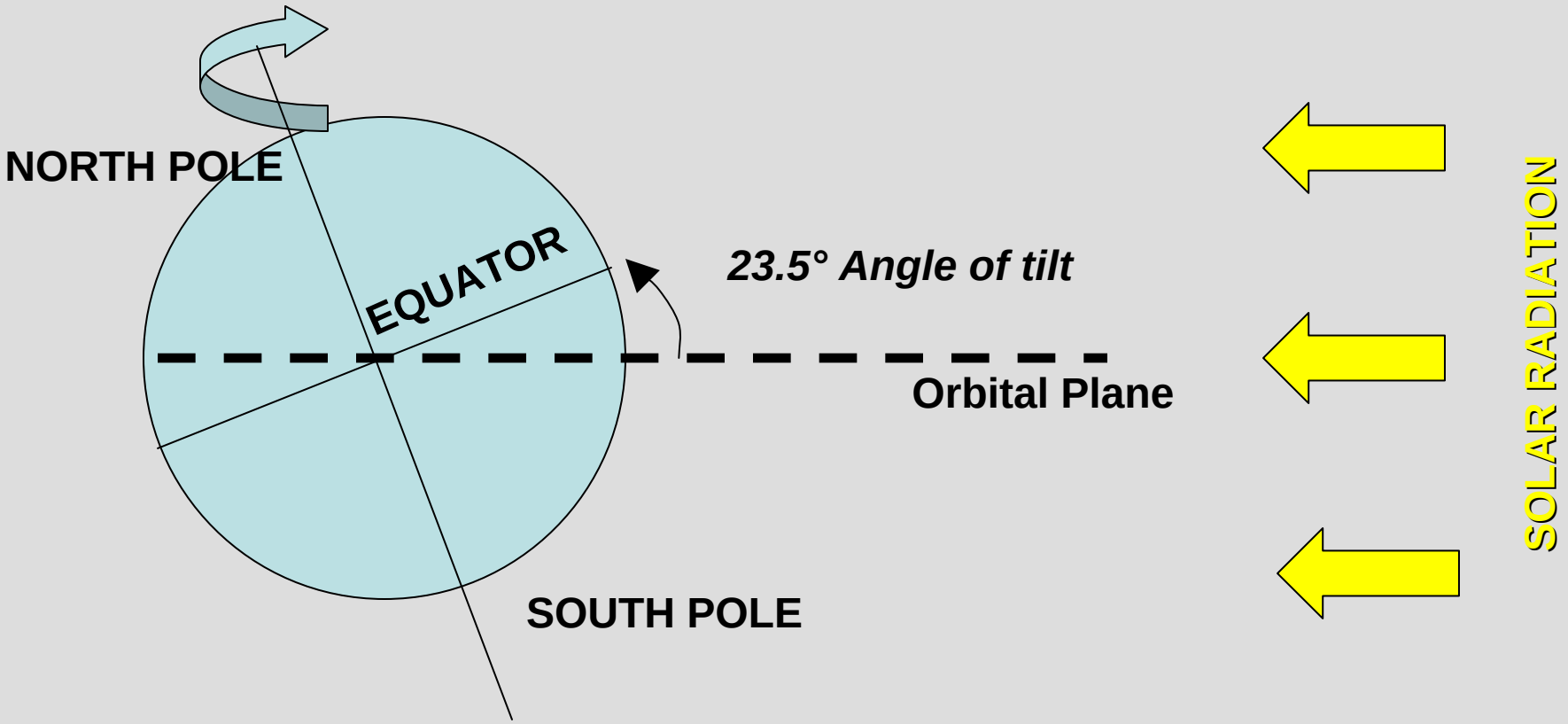


PRESENT DAY

ABOUT 11,000 YEARS IN THE FUTURE

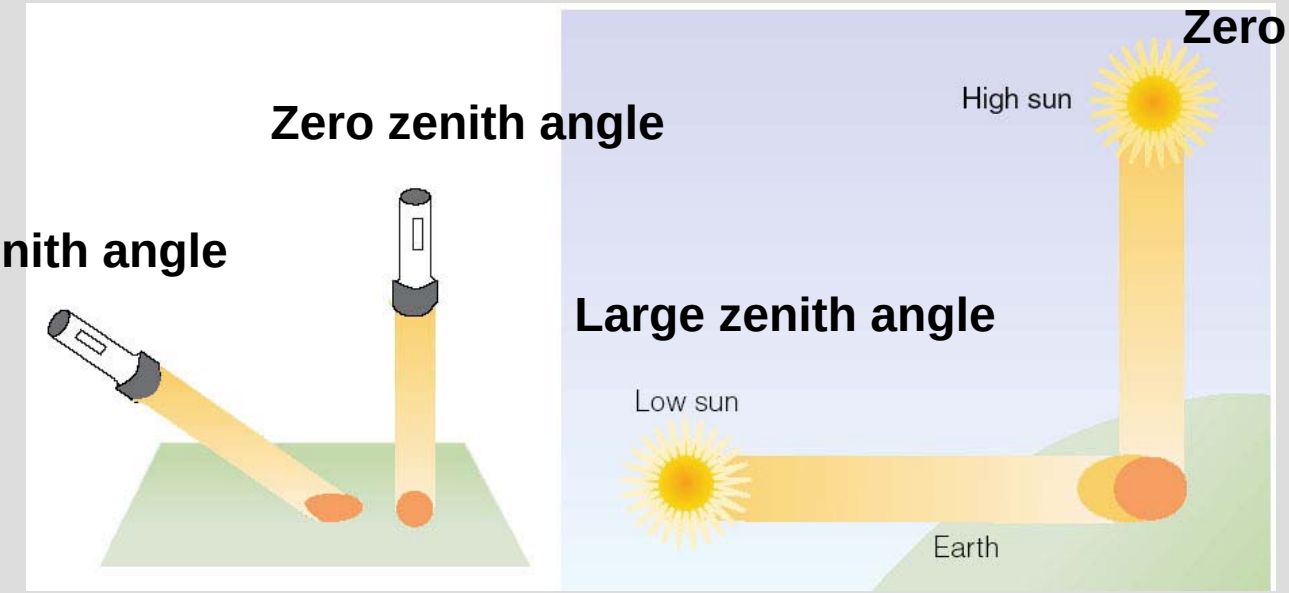
Position of perihelion and aphelion reverse

Obliquity: Tilt of the Earth with respect to its orbital plane



As the Earth rotates around the sun, it's axis of rotation is tilted at an angle of 23.5°.

The Zenith Angle



Intensity of solar energy depends the angle it strikes the earth. This is called the zenith angle.

Solar beam perpendicular = Zenith angle is zero
Solar energy most intense

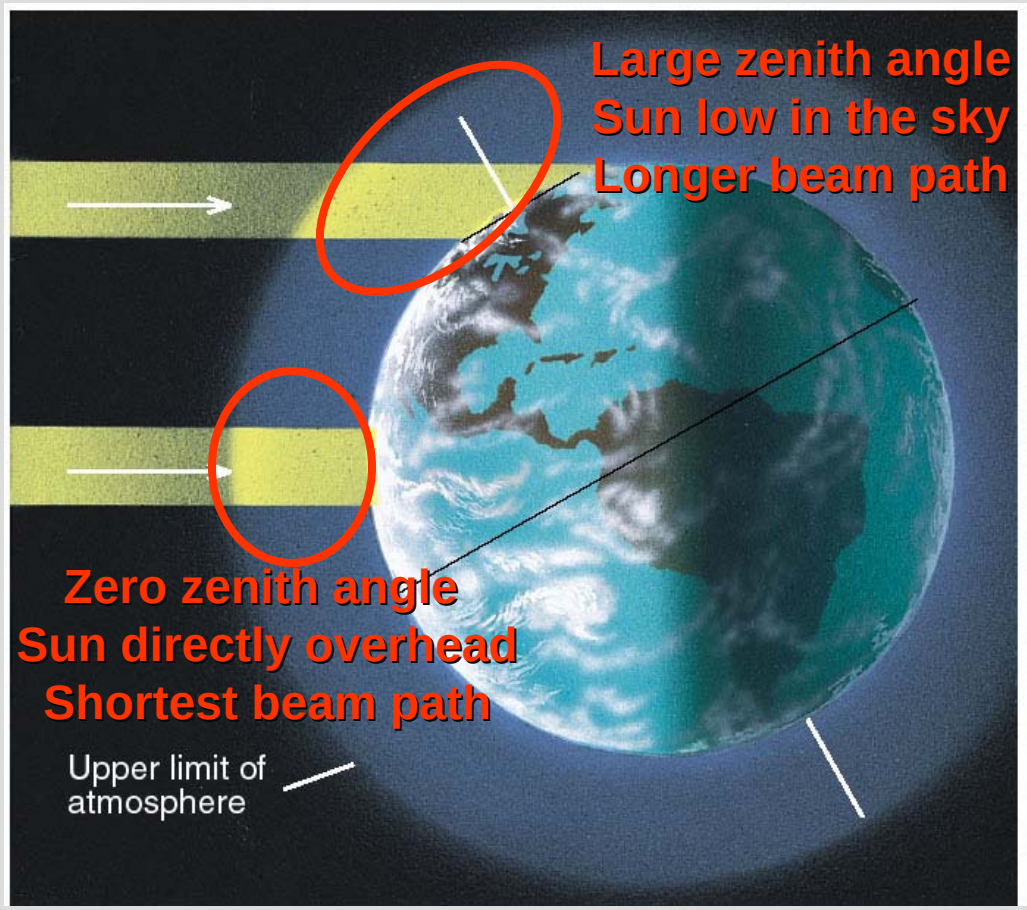
Solar beam tilted = Large zenith angle
Solar energy weaker

Zenith angle and atmospheric attenuation of solar energy

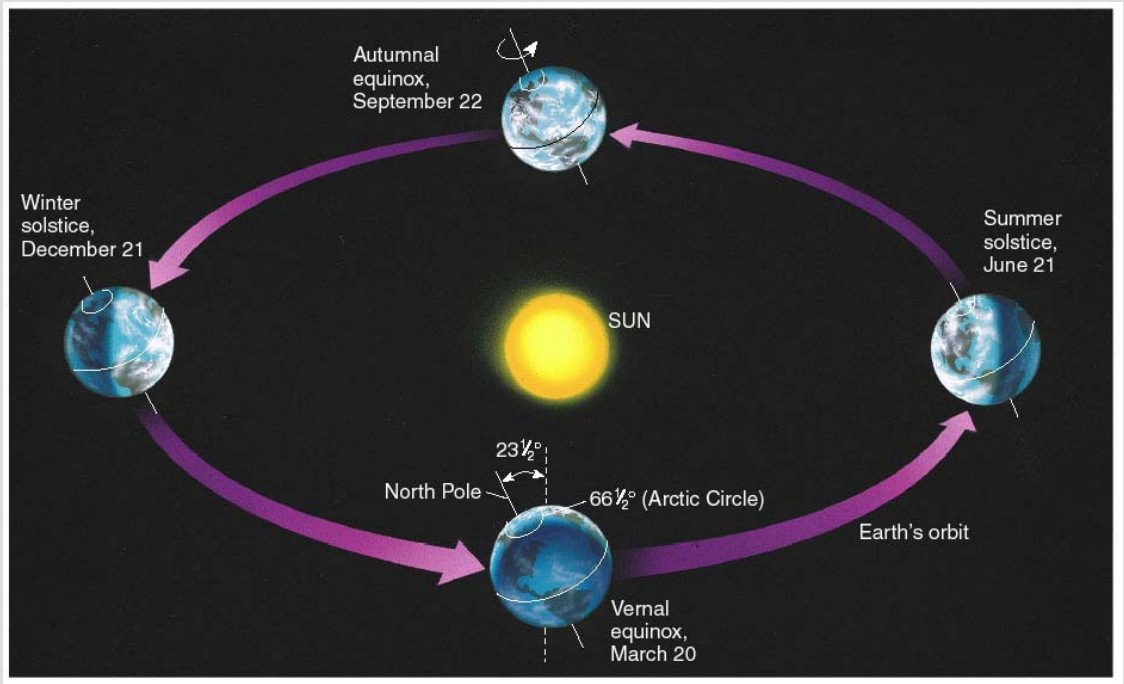
The presence of the Earth's atmosphere also weakens the amount of incoming solar radiation.

If the zenith angle is large, the solar beam has to pass through more atmosphere to reach the surface

So more absorption and scattering of solar radiation.



Obliquity and Seasonal Cycle

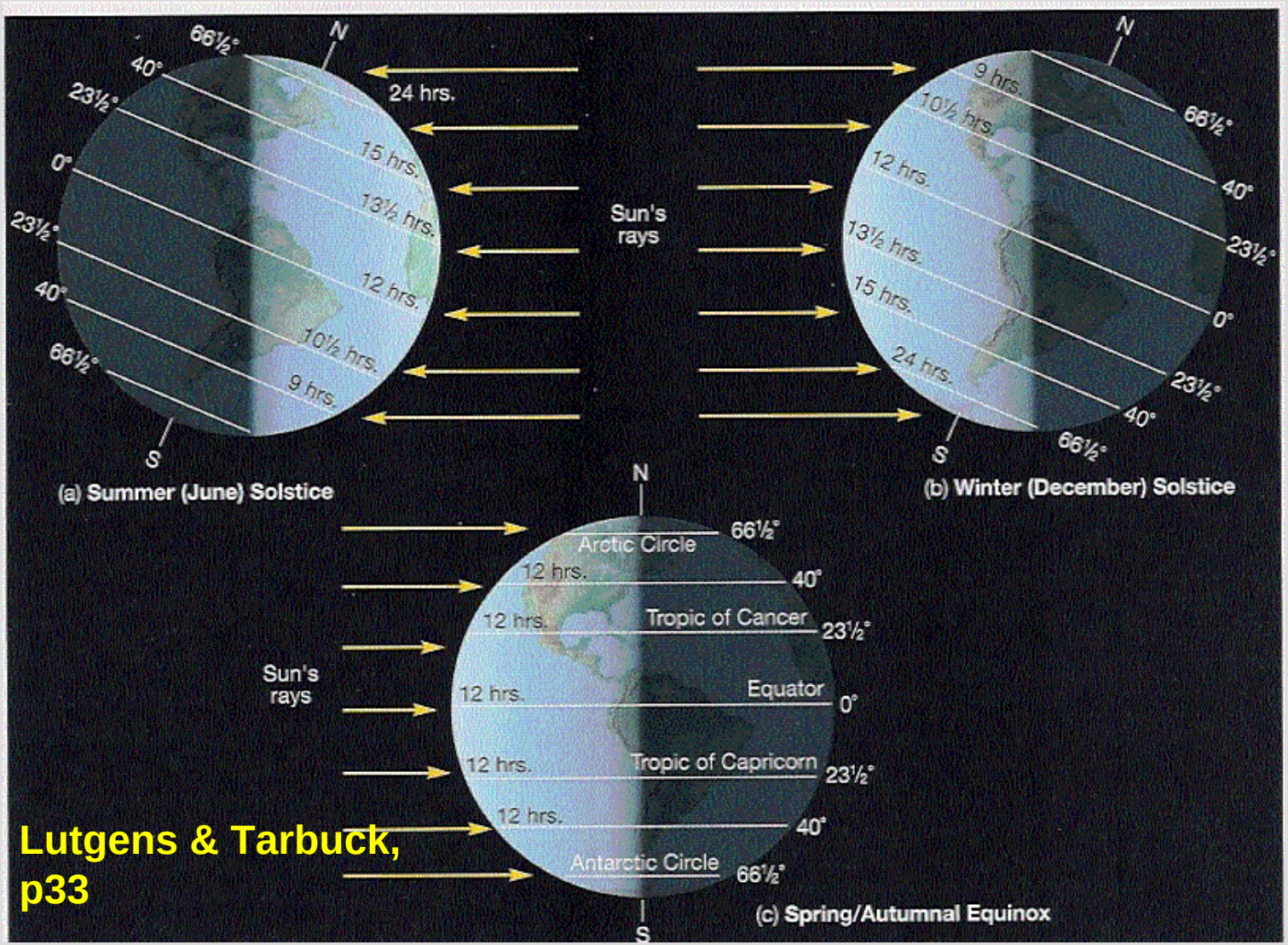


The variation in the amount of solar radiation through the year due to the obliquity of the Earth is what causes the seasons. Two ways this occurs:

1. _____

2. _____

Seasonal Change in Day Length

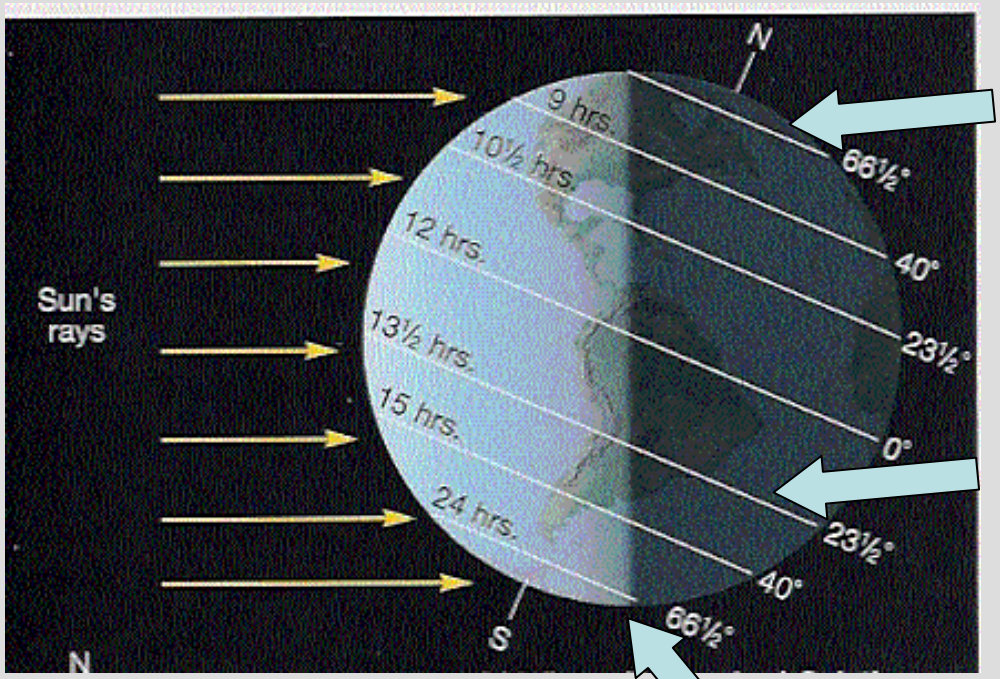


Lutgens & Tarbuck, p33

Winter solstice
Northern Hemisphere

What date?

Summer solstice
Southern Hemisphere



ARCTIC CIRCLE: 66.5°N
Limit of permanent darkness

TROPIC OF CAPRICORN: 23.5°S
Sun directly over head

ANTARCTIC CIRCLE: 66.5°S
Limit of permanent sunlight

Summer Solstice
Northern Hemisphere

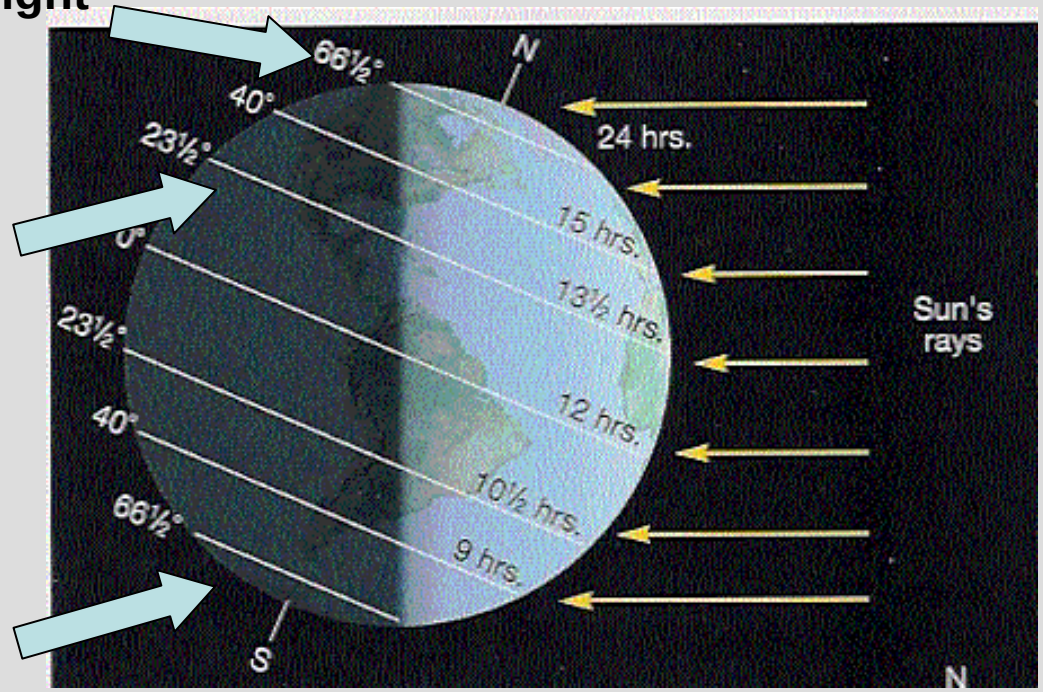
What date?

Winter Solstice
Southern Hemisphere

ARCTIC CIRCLE: 66.5°N
Limit of permanent sunlight

TROPIC OF CANCER: 23.5°N
Sun directly over head

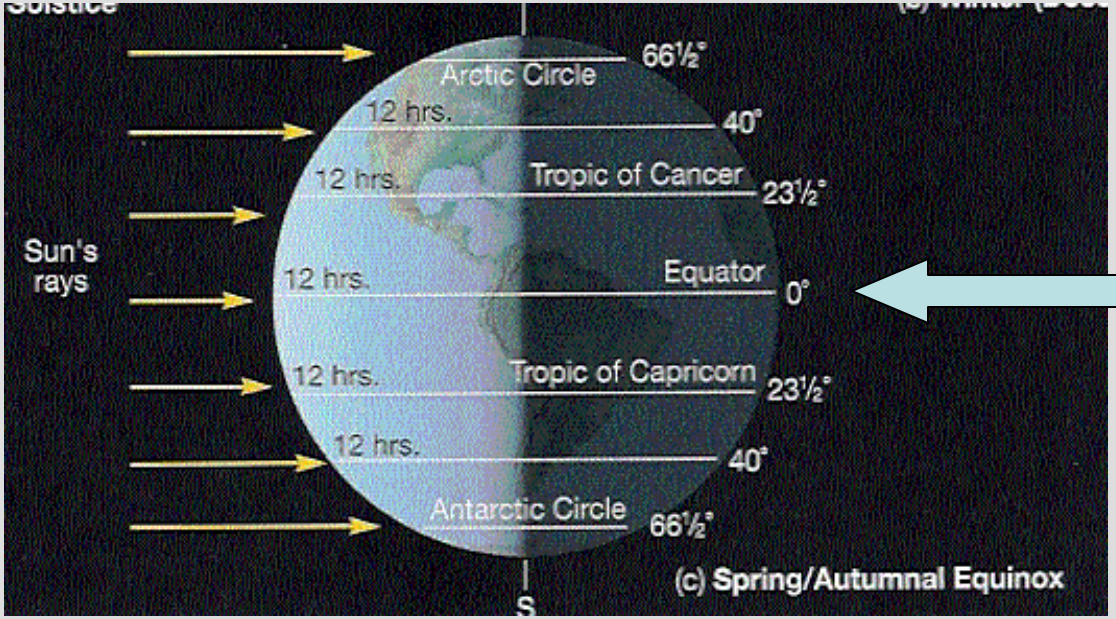
ANTARCTIC CIRCLE: 66.5°S
Limit of permanent darkness



Alaska: Land of the Midnight Sun

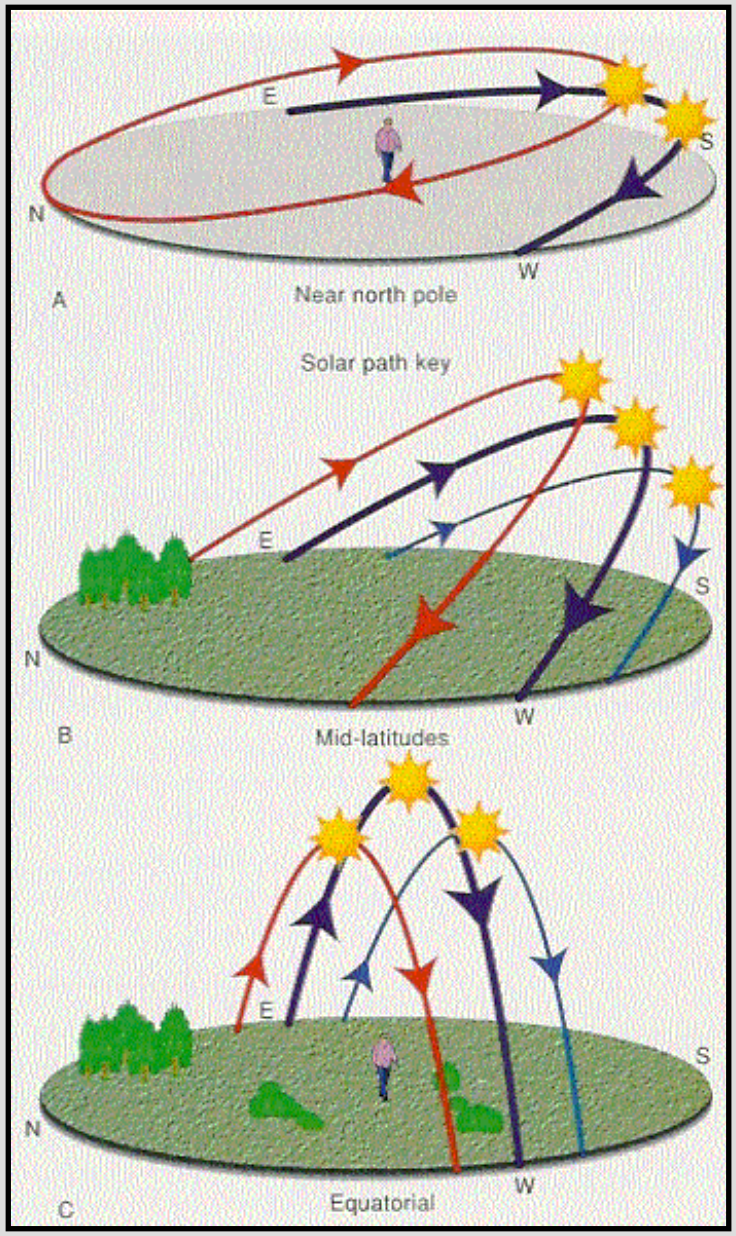
Equinox
Autumn: Summer to Winter
Spring: Winter to Summer

Dates of the equinoxes?



EQUATOR: 0°
Sun directly over head

Day and night are each equal to 12 hours at every point on Earth.



Danielson et al., p75

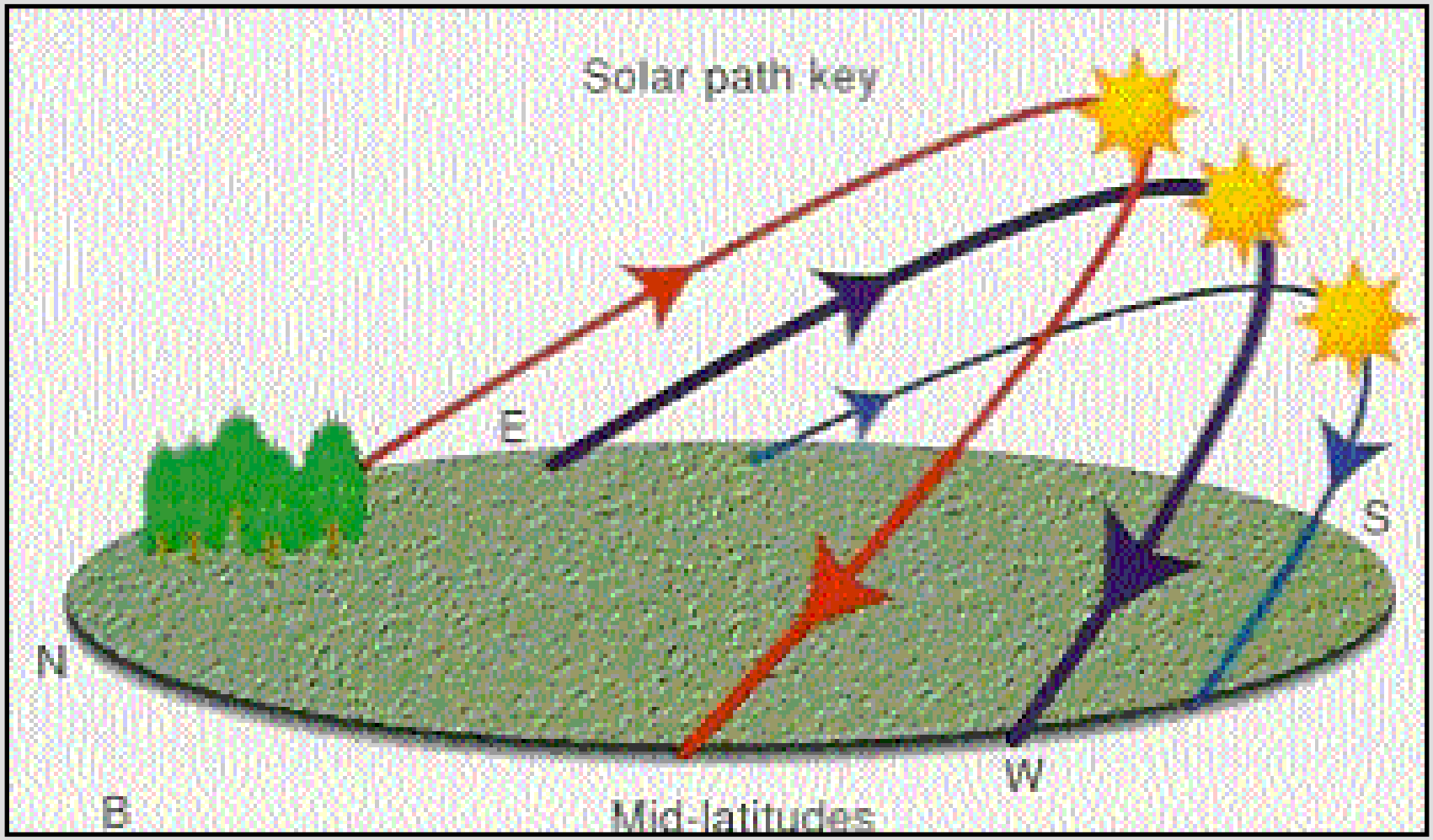
The farther you are away from the tropics (23.5°S to 23.5°N), the lower in the sky the Sun will be.

The figure here is for the Northern hemisphere. Flip the image and you'll get what happens in the Southern Hemisphere.

<u>For Tucson (~32° N):</u>

Summer solstice:
Day length: 14 hours
Zenith angle: 8°
Winter solstice:
Day length: 10 hours
Zenith angle: 55°

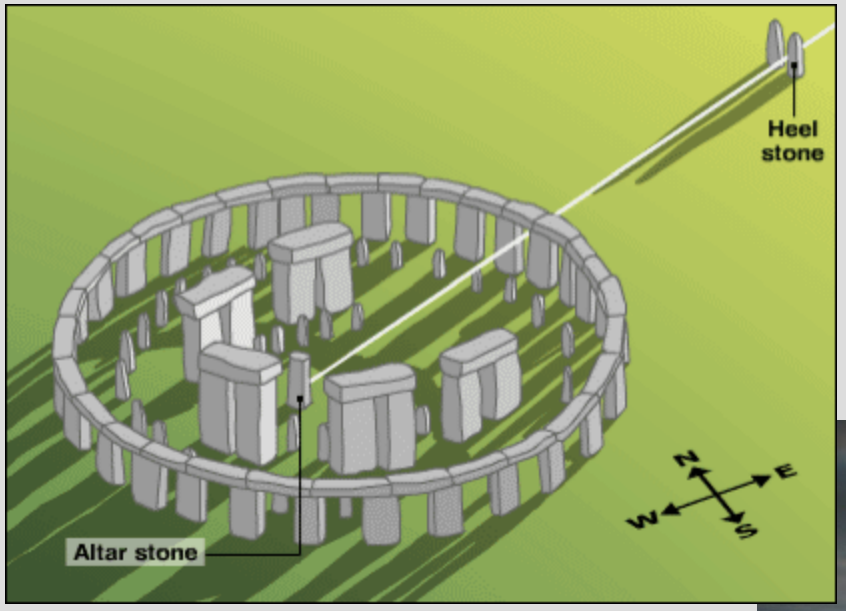
Identify the seasons in relation to solar path in the sky



SUN ALWAYS TO THE SOUTH AT SOLAR NOON ALL YEAR

Now let’s see how Stonehenge is actually an ancient astronomical observatory…

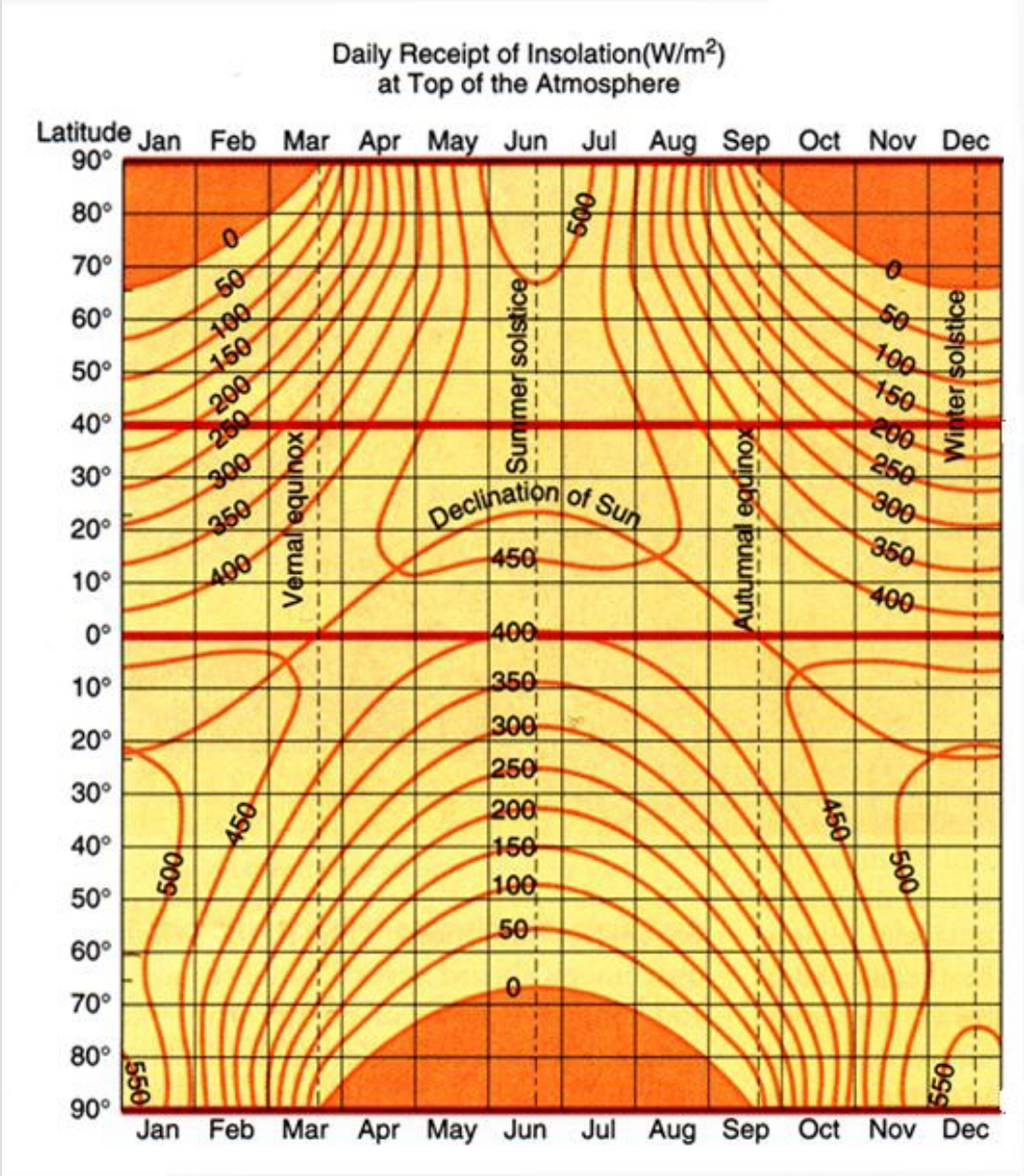
Stonehenge and the summer solstice



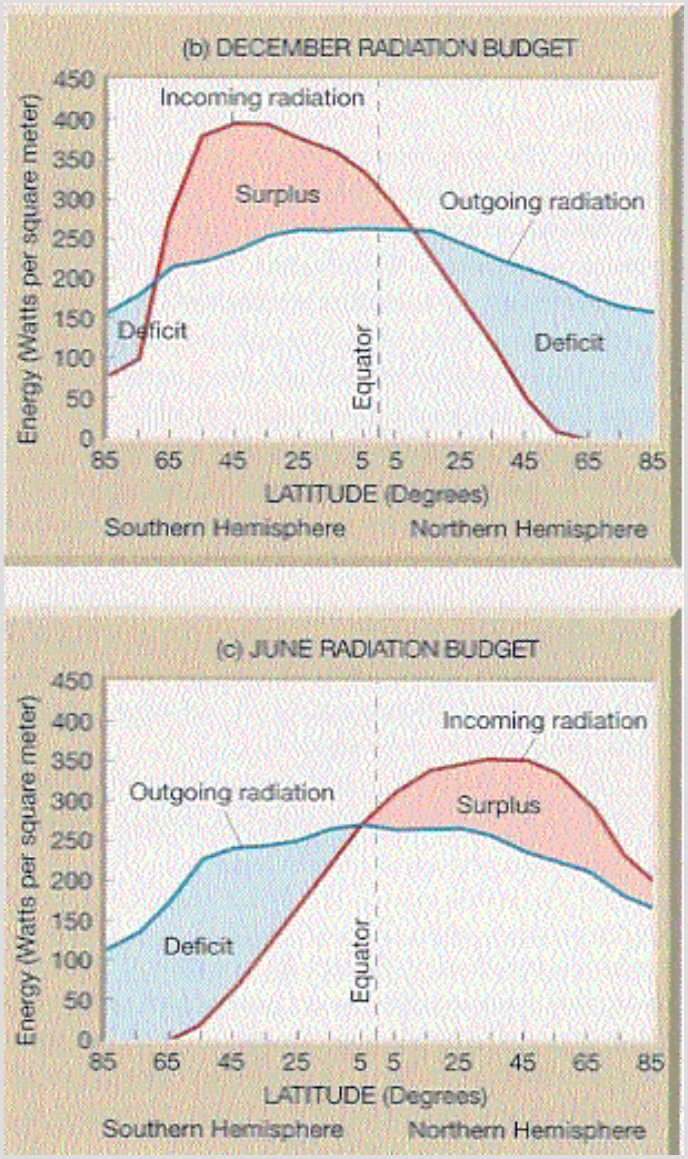
BBC image

Stonehenge Aoteoroa in New Zealand on Dec. 21
http://www.southernskyphoto.com/planet_earth
Photo by C.J. Picking

Considering all the concepts we've discussed today, let's get a brief preview of how this understanding helps us to understand weather and climate.



Because of the variation in zenith angle through the year and with latitude, amount of solar energy absorbed at the top of the atmosphere varies….



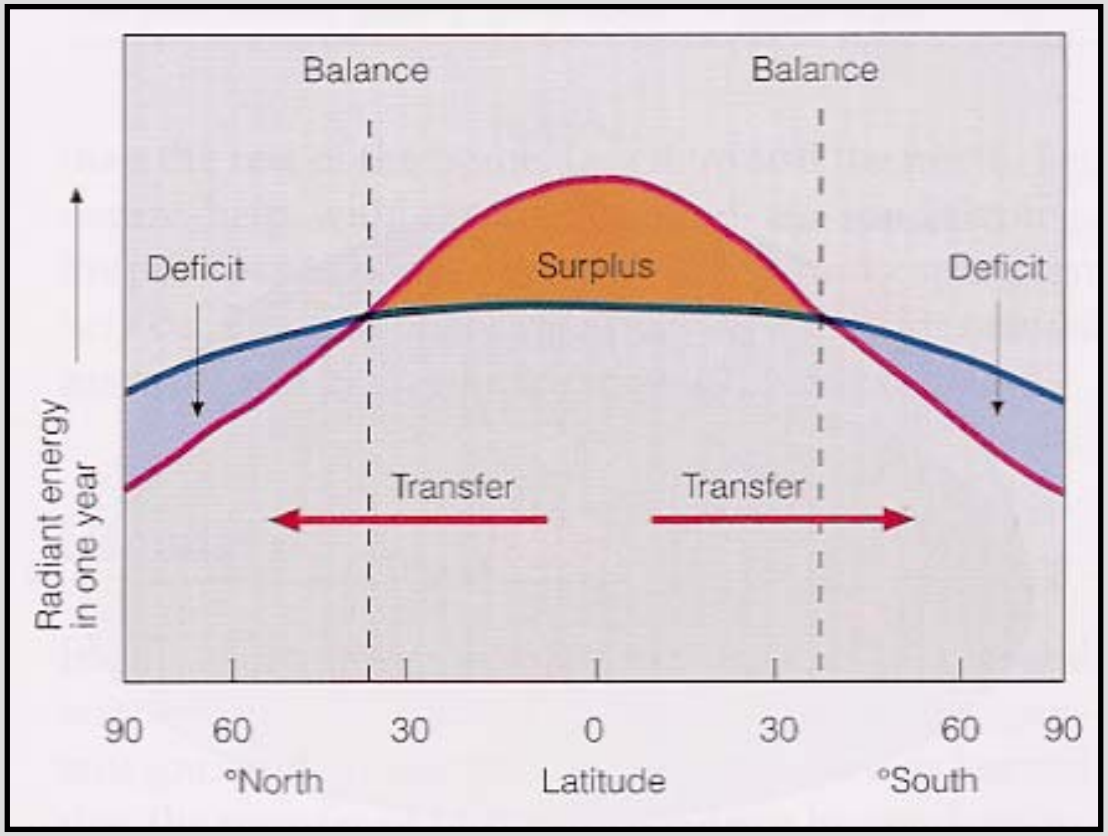
Lutgens & Tarbuck, p51

This means there is an imbalance of incoming vs. outgoing radiation.

Summer hemisphere has a net surplus of radiation

Winter hemisphere has a net deficit of radiation.

Earth's Net Radiation Balance



The equator doesn't keep getting warmer and warmer.

The high latitudes don't keeping getting colder and colder.

Therefore there must be ways that heat is transferred from equator to pole.

Summary of Lecture 7

The three orbital parameters of the Earth are the *eccentricity*, *precession*, and *obliquity*. Most relevant to the discussion of the seasons is the *obliquity*, or tilt of the Earth with respect to its orbital plane (at 23.5°).

The intensity of solar energy depends on the *zenith angle*. If the sun is directly overhead the *zenith angle* is equal to zero and the solar energy is most intense.

Solar energy is further attenuated at high zenith angles due to the fact that the solar bean has more atmosphere to pass through.

Earth's *obliquity* causes variation in solar radiation by changes in the zenith angle and length of day through the year—and thus is the cause of the seasons.

Special latitudes are associated with the *solstices* and *equinoxes*. Know what these special latitudes are and what they physically mean. Know dates when the *solstices* and *equinoxes* occur.

Reading Assignment and Review Questions

Ahrens, Chapter 3, pp. 63-82 (8th ed.)

pp. 65-84 (9th ed.)