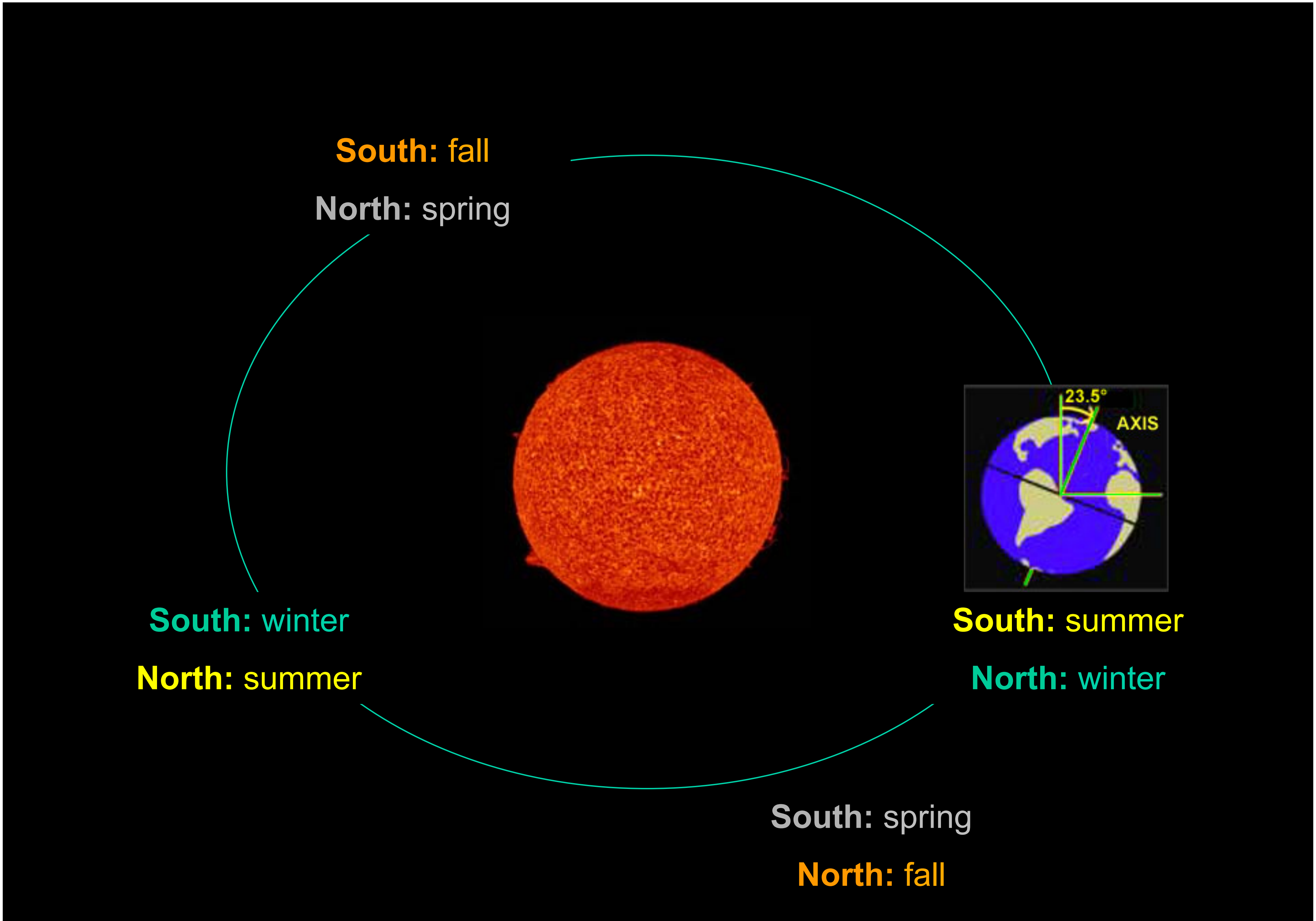
Seasonality

- What ***does not*** cause seasons
- What ***does*** cause seasons
- Seasonal effects

http://www.net-art.it/

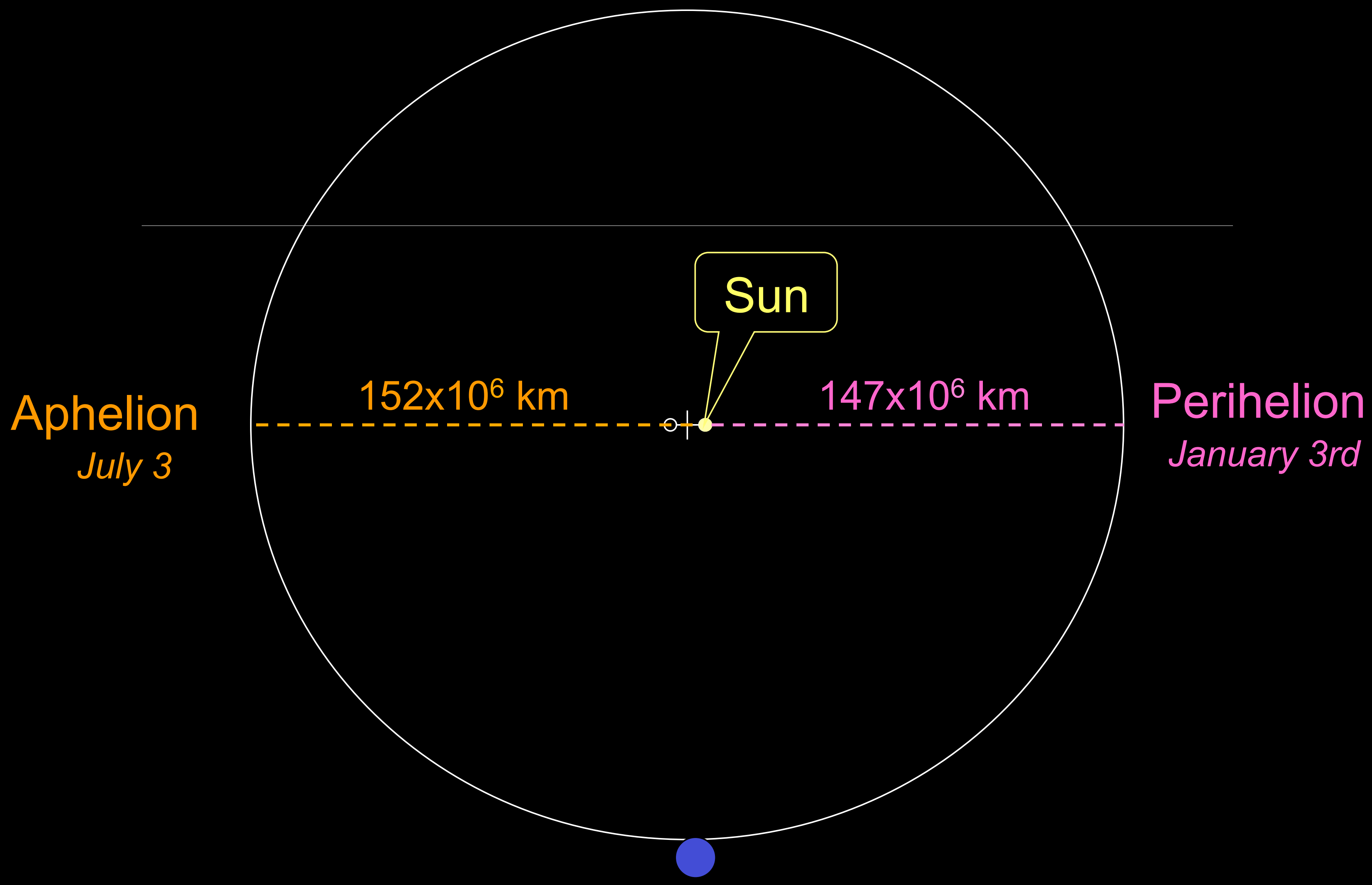


http://www.boechat.com/tele/base/2001_11.html

http://www.bbc.co.uk/science/space/solarsystem/earth/solsticescience.shtml

Shape of the Earth's Orbit

What's the difference between the amount of solar energy at the extremes?



Shape of the Earth's Orbit

What's the difference between the amount of solar energy at the extremes?

$$\frac{E_a = E_0(4\pi d_a^2)/(2\pi r_{earth}^2)}{E_p = E_0(4\pi d_p^2)/(2\pi r_{earth}^2)}$$

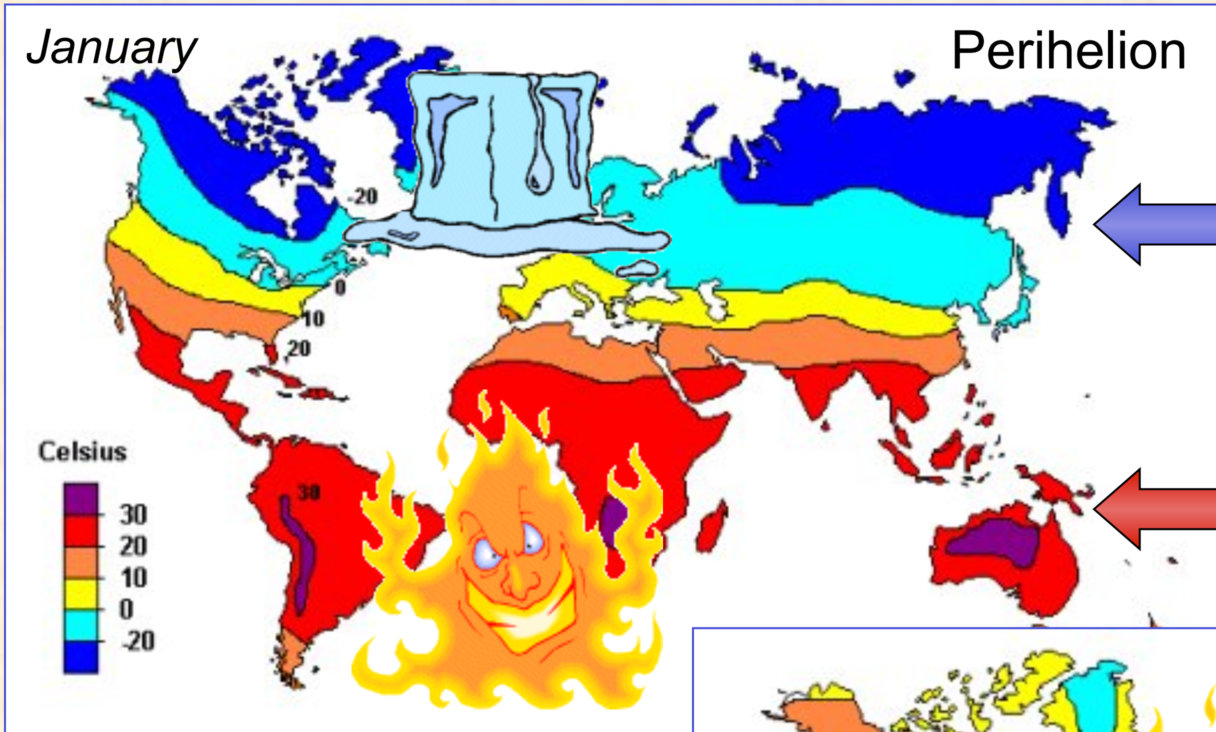
$$\frac{E_a = d_a^2}{E_p = d_p^2}$$

$$E_a / E_p = d_a^2 / d_p^2$$

$$E_a / E_p = 0.065 = 6.5\%$$

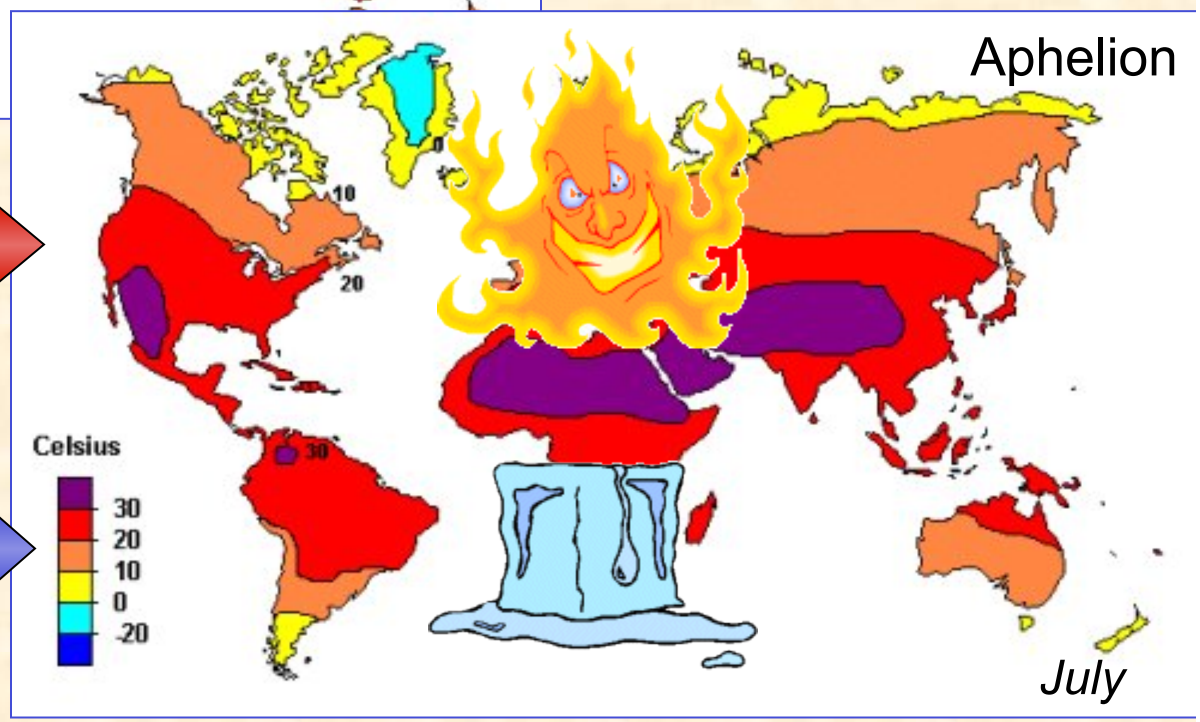
Compared to other factors, this is a completely negligible amount!

Temperature



winter in northern hemisphere

summer in southern hemisphere



summer in northern hemisphere

winter in southern hemisphere

http://www.doc.mmu.ac.uk/aric/eae/english.html

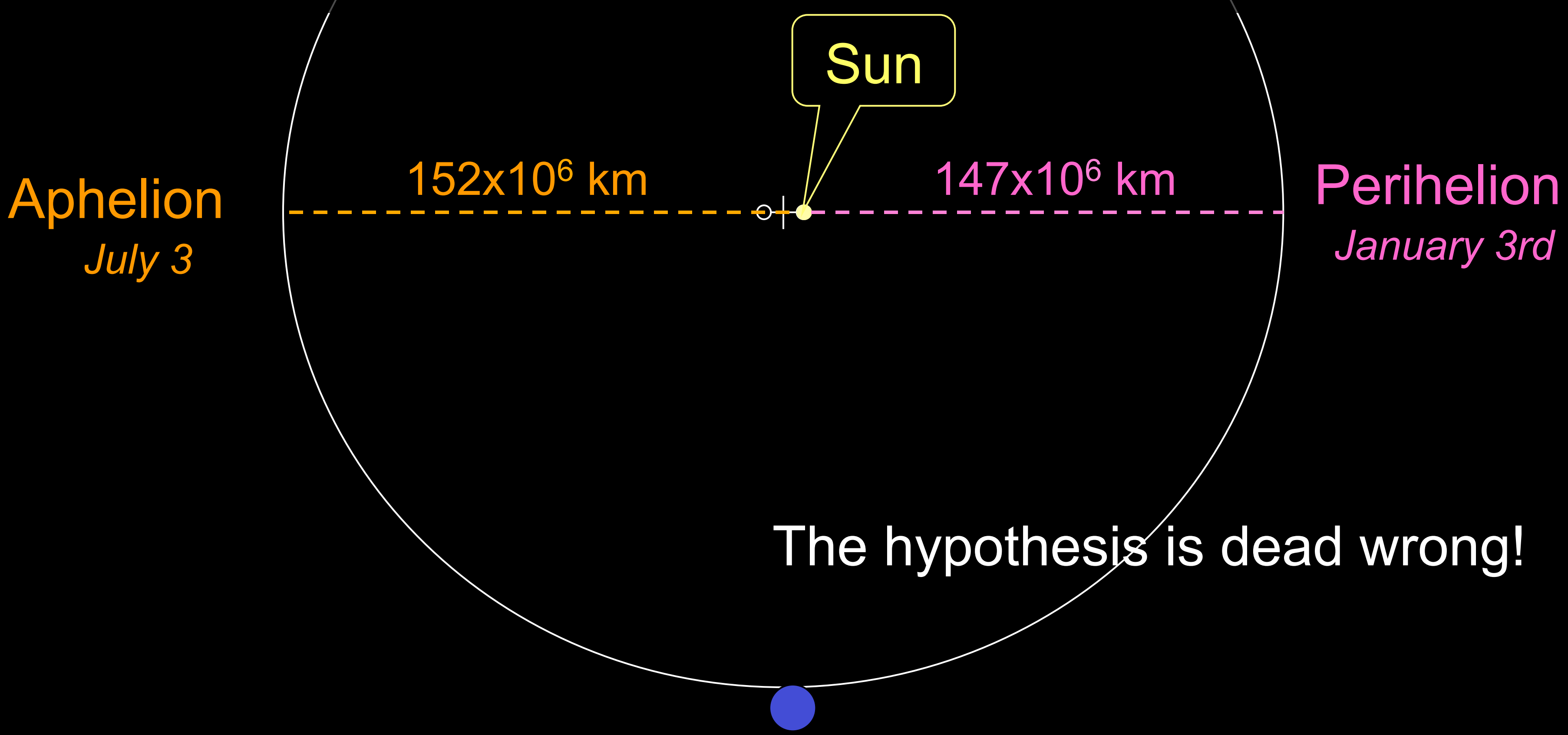
Shape of the Earth's Orbit

Other fatal problems with the hypothesis that the changing distance from the Sun to the Earth causes seasonality:

The dates fall during the wrong times of the year

It is winter in the Northern Hemisphere at perihelion

It is summer in the Northern hemisphere at aphelion



The hypothesis is dead wrong!

So what DOES cause the changes in season?

Our new hypothesis *must* explain the following observations:

- The seasons change in a regular cycle on a yearly basis
- It is **winter** in the Northern Hemisphere when it is **summer** in the Southern Hemisphere and *vice versa*

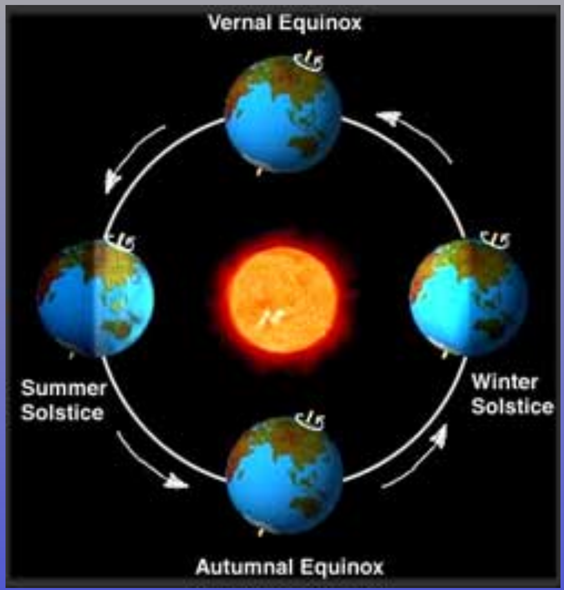
Janet Stahle-Fraser, Canadian woodcut artist *http://www.worldprintmakers.com/*

New Hypothesis

Seasonality is caused by the tilt of the Earth relative to its orbital plane around the Sun. This causes both:

- The strength of sunlight reaching the surface, and
- The length of the day

to vary on a regular, yearly cycle.



Observations we expect to make:

- Temperature is positively correlated with the strength of sunlight reaching the surface.
- Temperature is positively correlated with day length

http://www.doc.mmu.ac.uk/aric/eae/english.html

THE EFFECT OF CHANGES IN THE SUN'S ANGLE ON INTENSITY OF SOLAR RADIATION

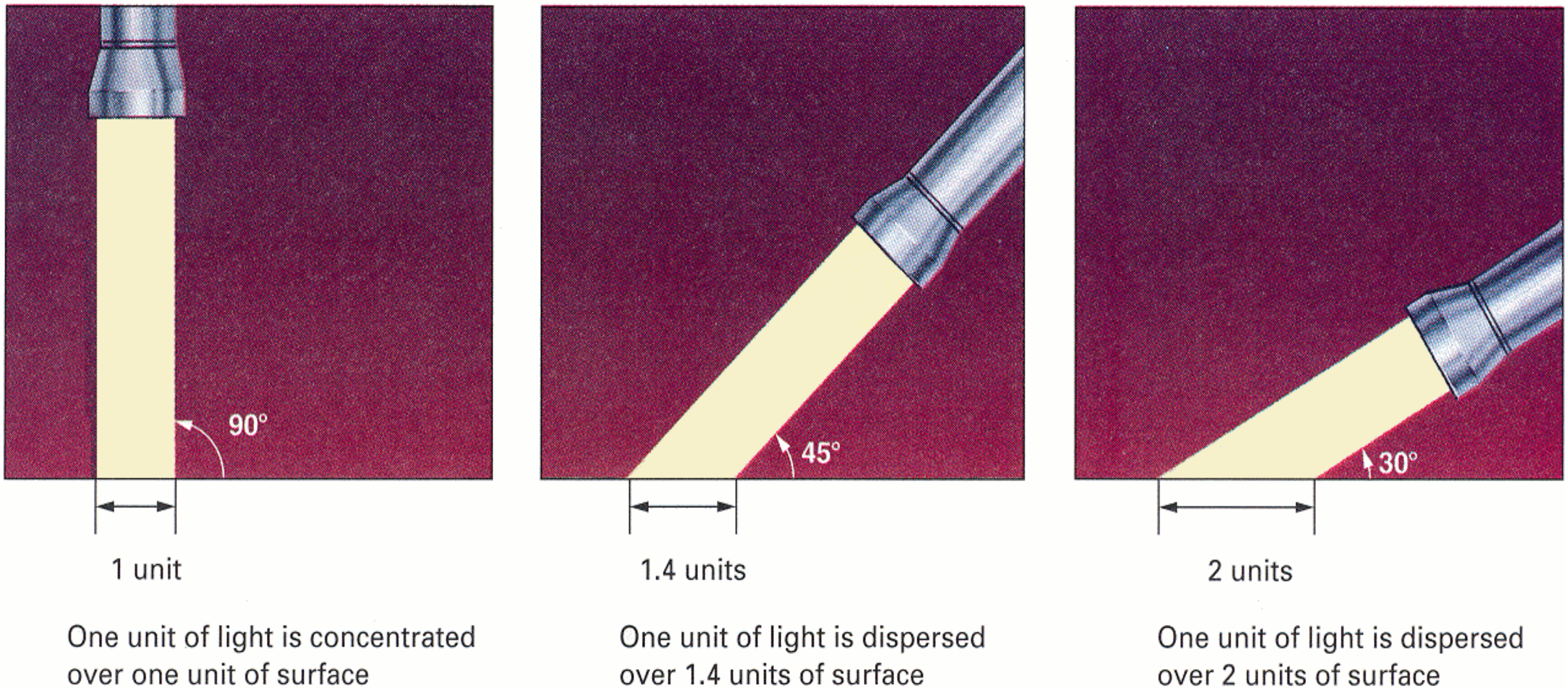
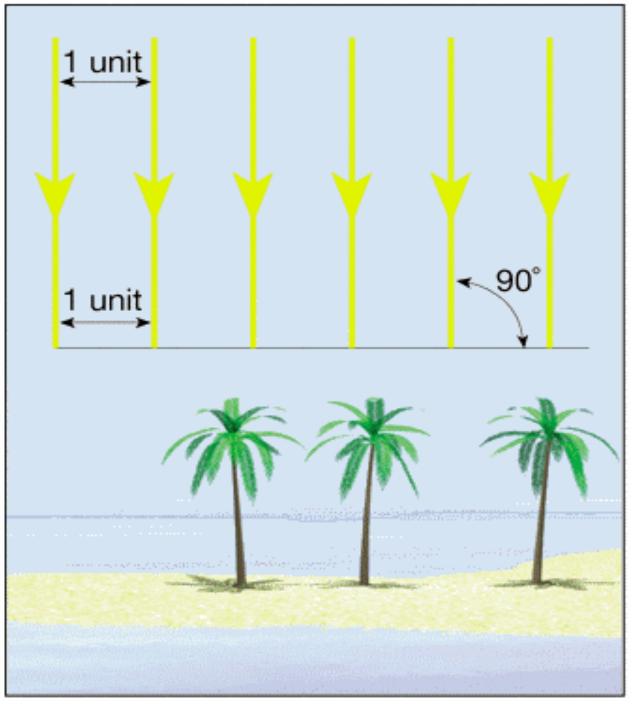


Figure 15–15 If a light shines from directly overhead, the radiation is concentrated on a small area. However, if the light shines at an angle, or if the surface is tilted, the radiant energy is dispersed over a larger area.

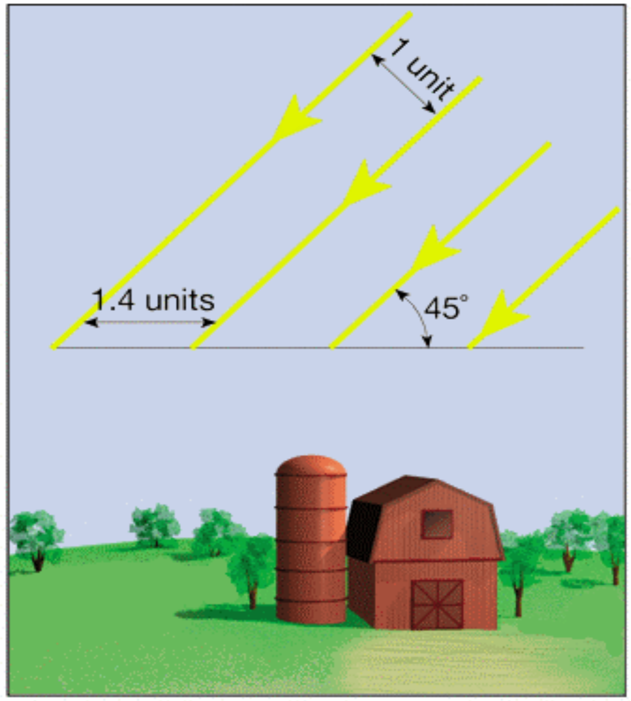
(Thompson and Turk, 1999, Earth Science and the Environment, 2 nd Ed.)

THE EFFECT OF CHANGES IN THE SUN'S ANGLE ON INTENSITY OF SOLAR RADIATION



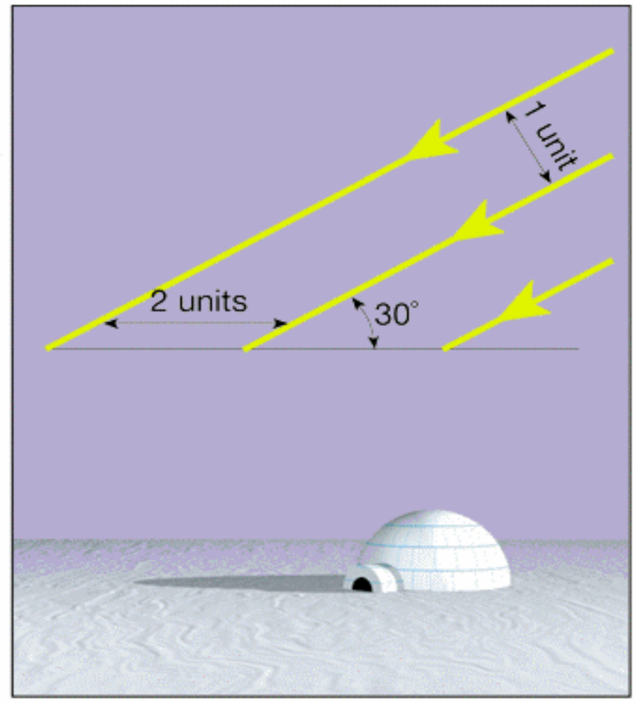
A.

One unit of light is concentrated over one unit of surface



B.

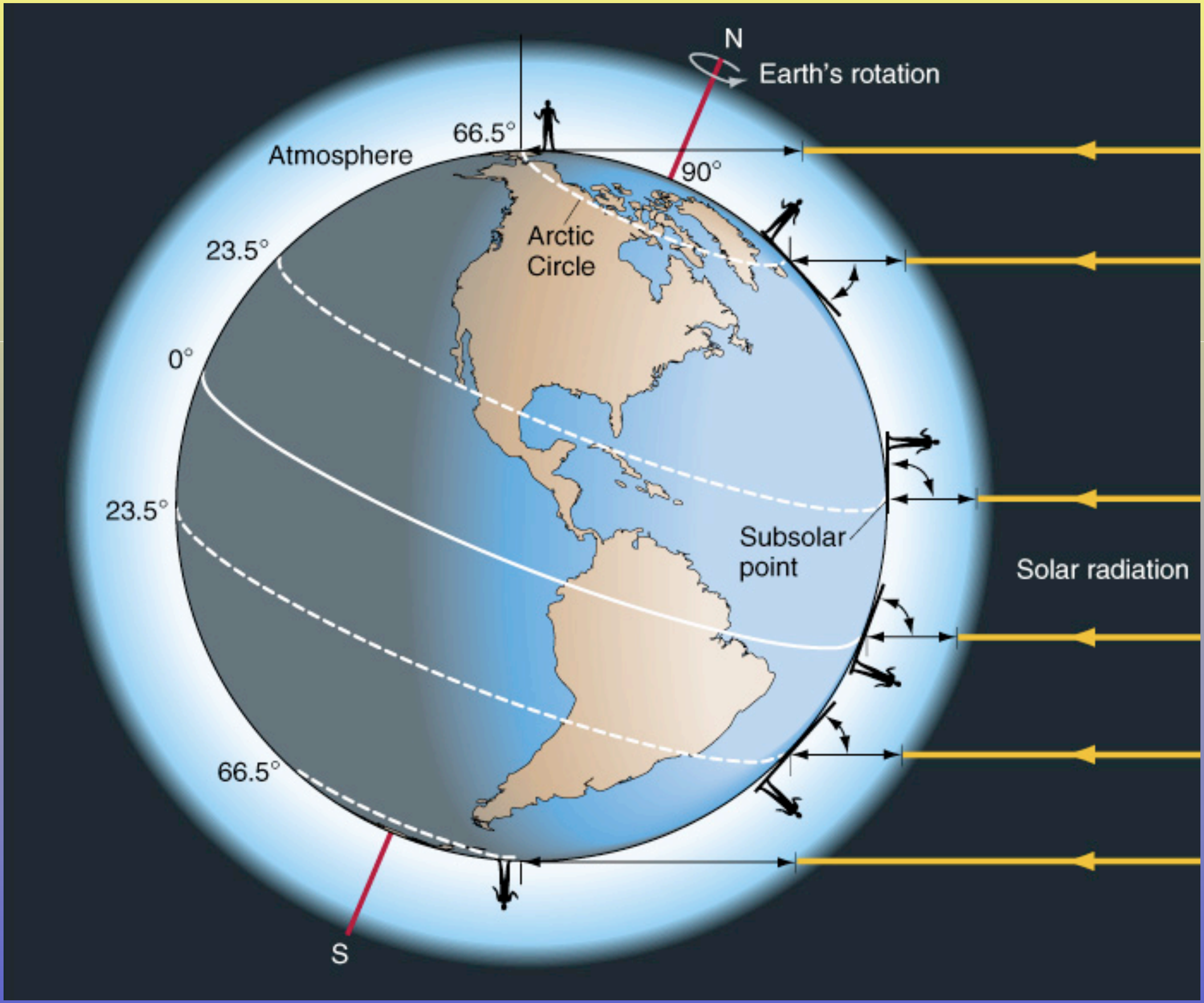
One unit of light is dispersed over 1.4 units of surface



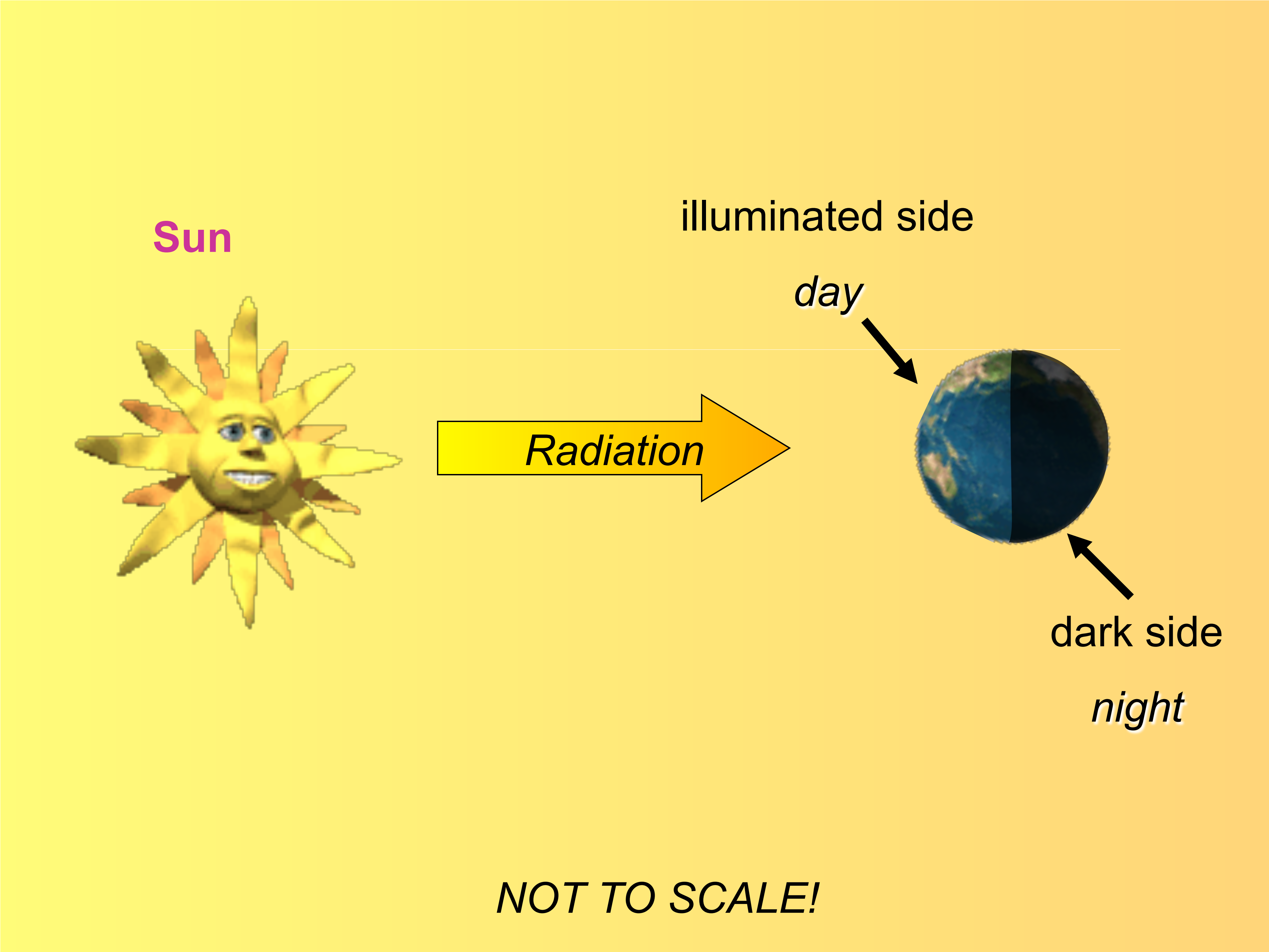
C.

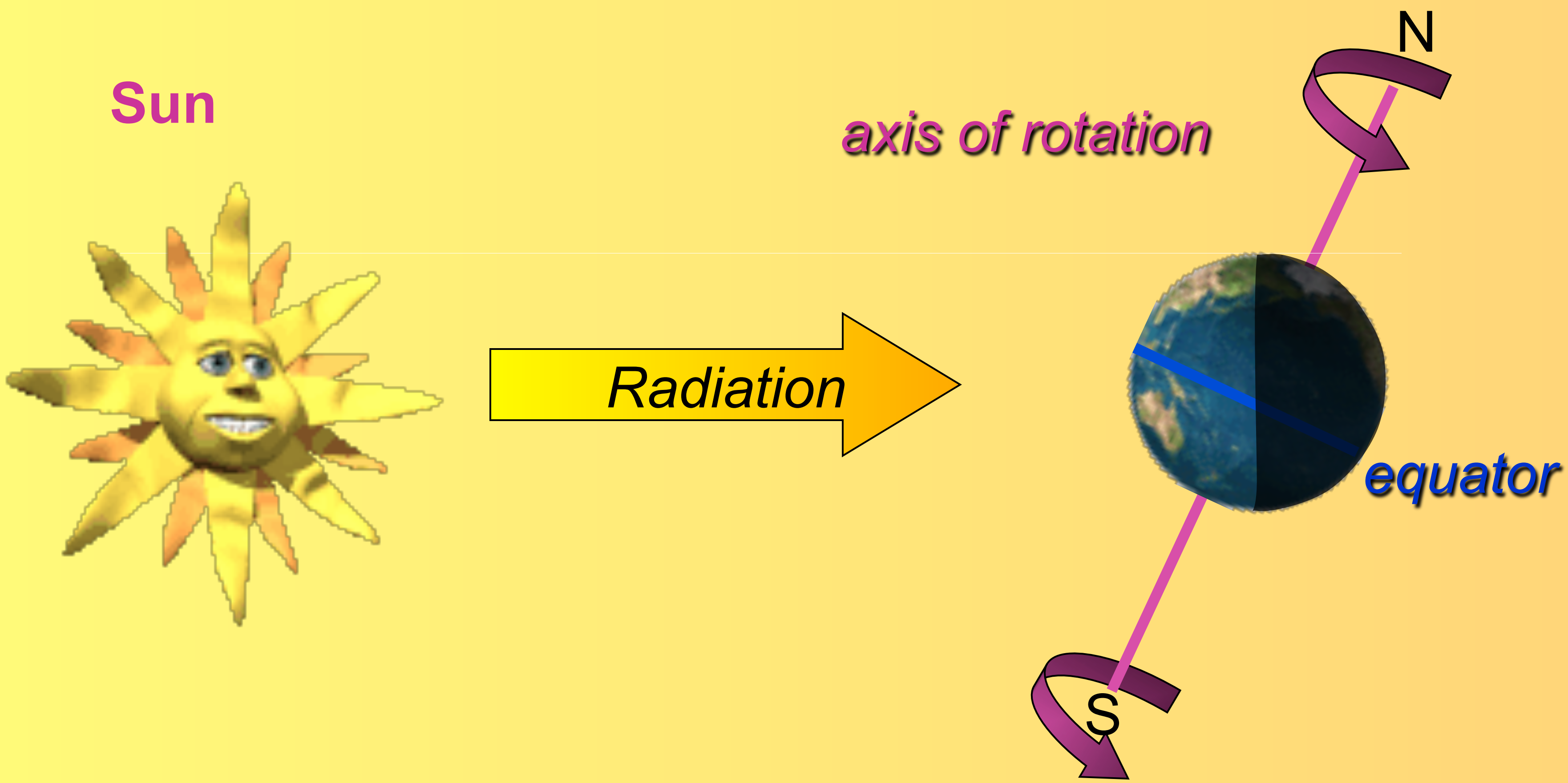
One unit of light is dispersed over 2 units of surface

(Lutgens and Tarbuck, 2003, Fundamentals of Earth Science, 3rd Ed.)

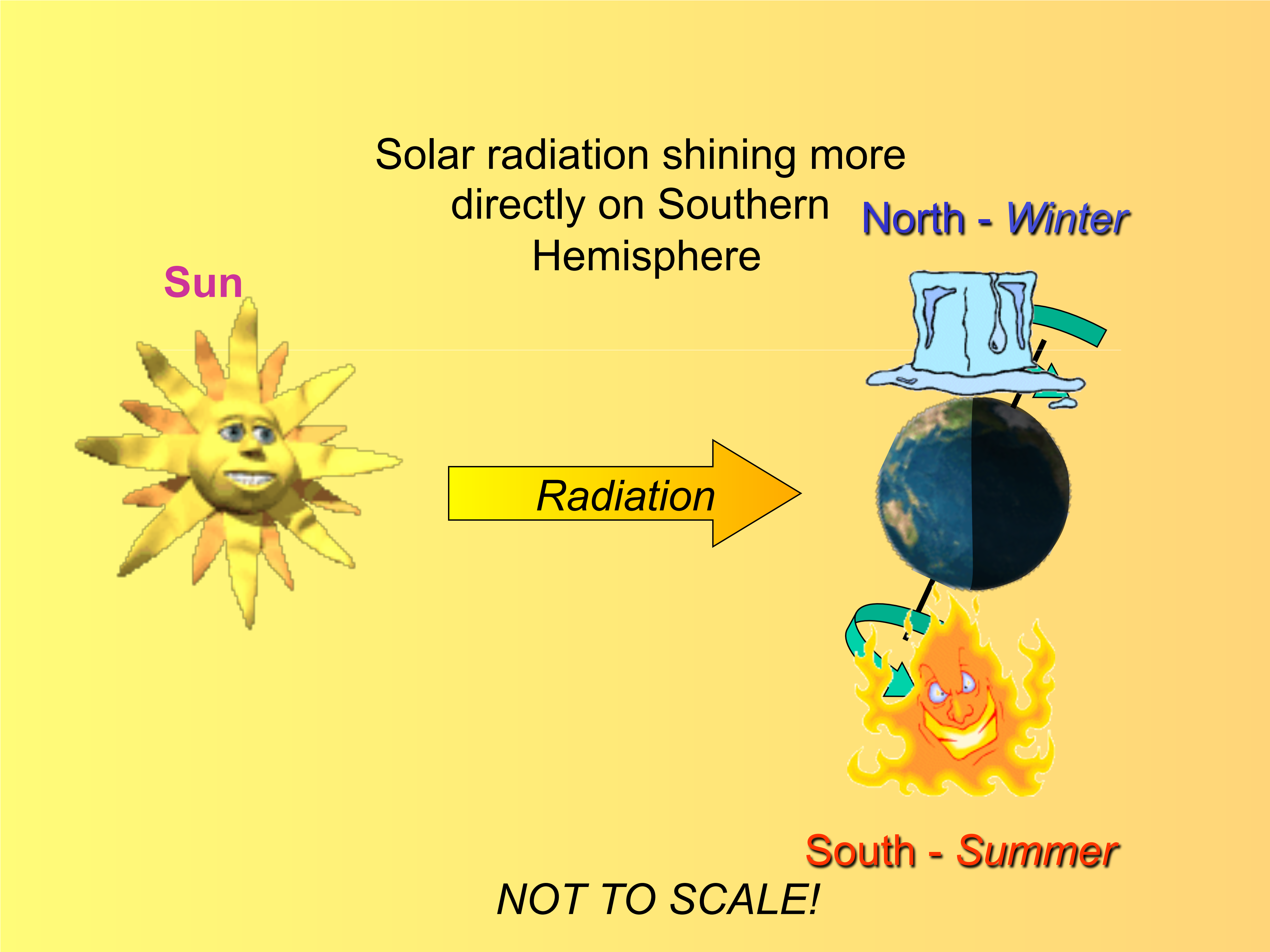


http://www.u.arizona.edu/~korine/230/chap2_figs.htm

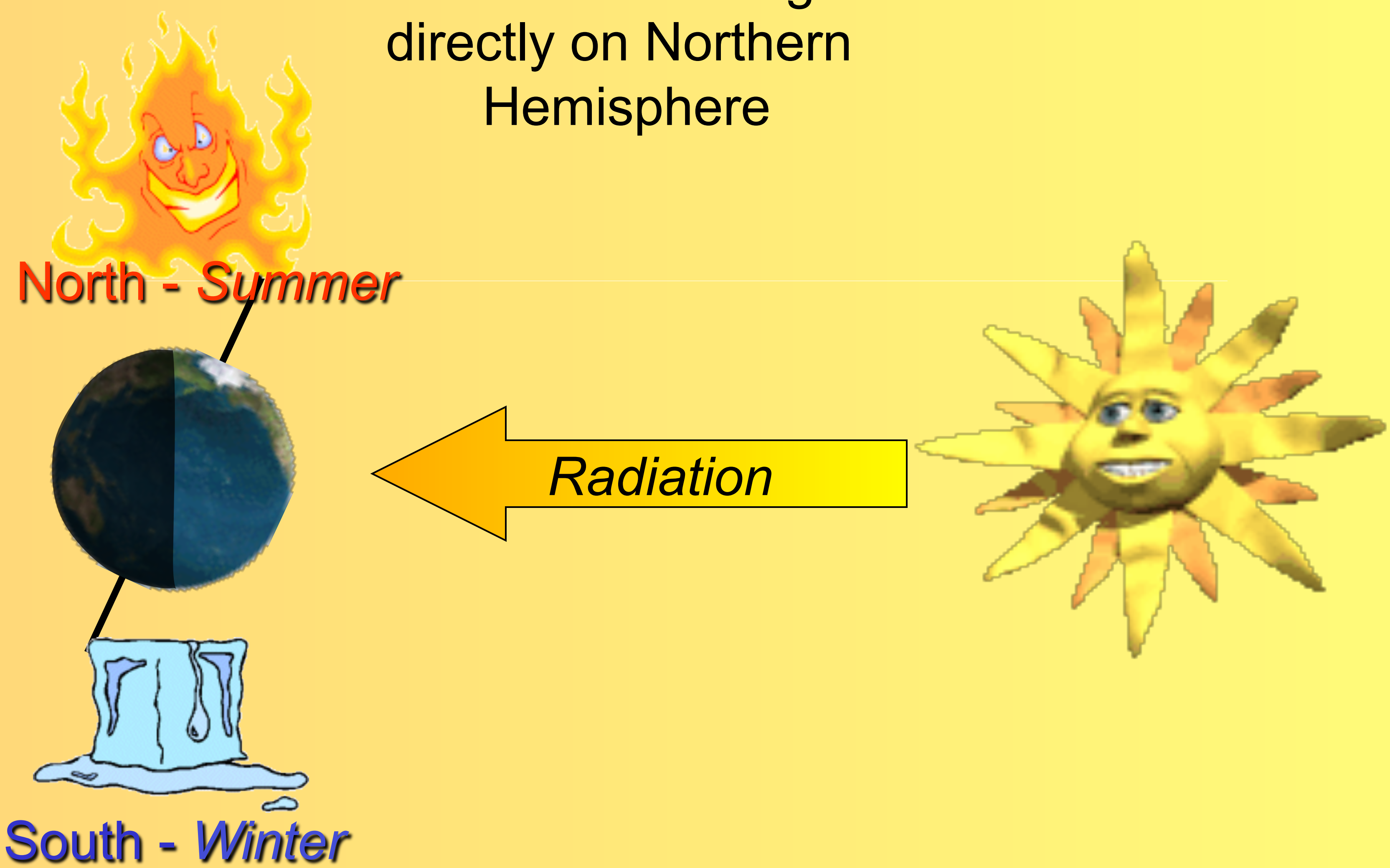

Sun
illuminated side
day
Radiation
dark side
night
NOT TO SCALE!



NOT TO SCALE!


Solar radiation shining more directly on Southern Hemisphere
Sun
North - Winter
Radiation
South - Summer
NOT TO SCALE!

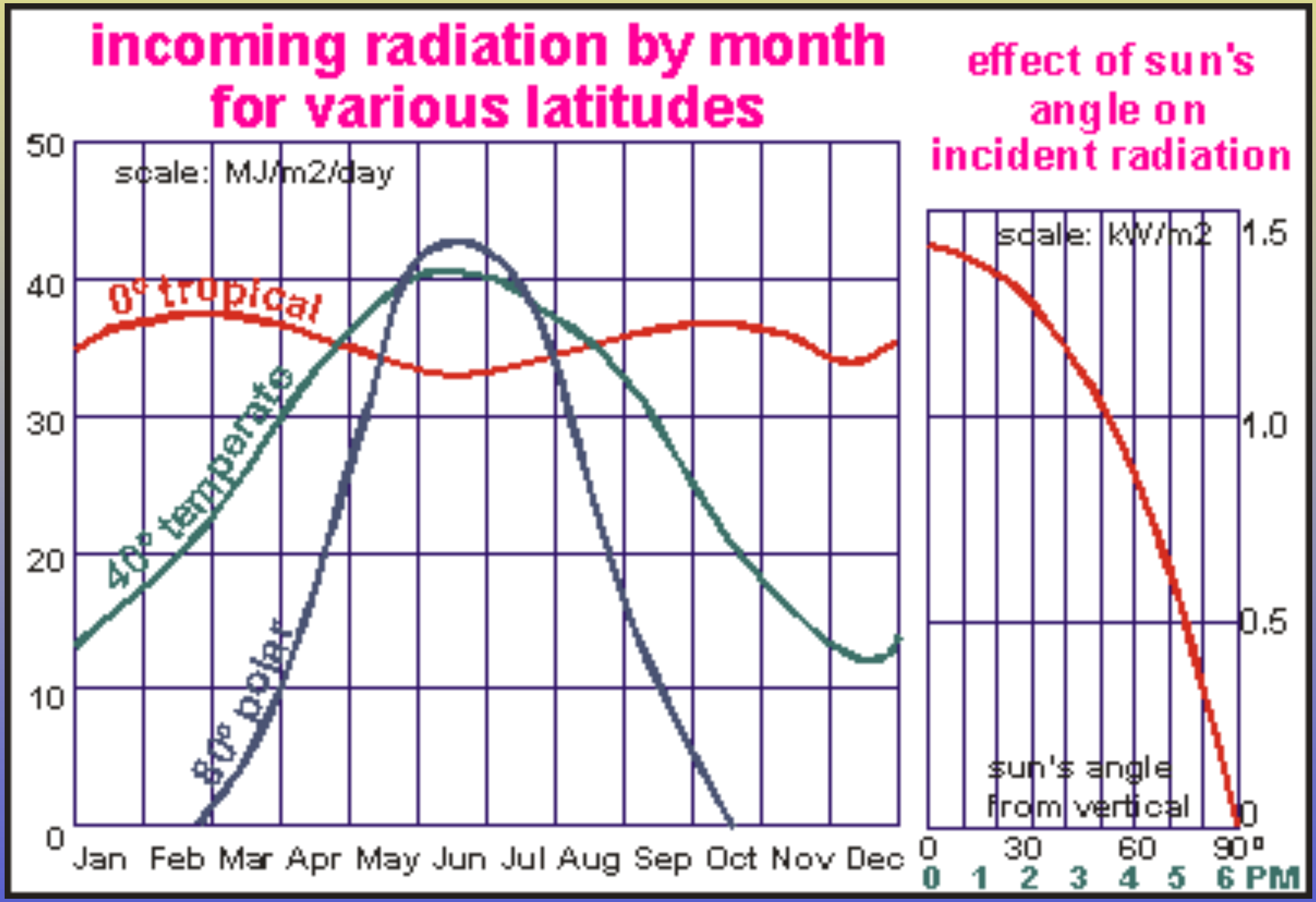
Solar radiation shining more directly on Northern Hemisphere



NOT TO SCALE!

http://www.secussa.nafsa.org/

The changing angle at which sunlight strikes the Earth at different latitudes and during different times of the year has a significant, measurable effect on the amount of energy that reaches the surface.



http://www.seafriends.org.nz/oceano/currents.htm

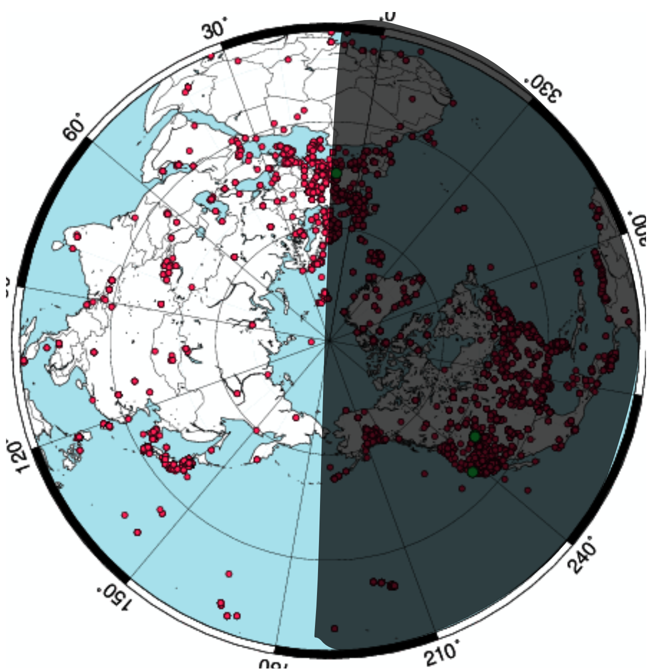
Equinoxes – Two specific points in the Earth's orbit when each hemisphere gets 12 hours of sunlight. Spring equinox in the Northern Hemisphere is Fall Equinox in the Southern Hemisphere.

Equinox dates – September 22, March 22

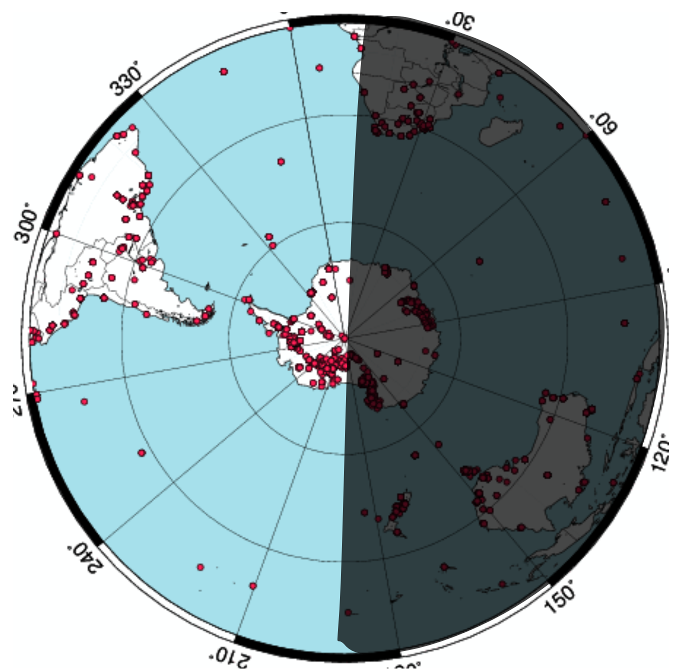
Solstice dates – December 22, June 21

Solstices – Two specific points in the Earth's orbit when the amount of day length in one hemisphere has reached a maximum, and in the other has reached a minimum. Winter solstice in the Northern Hemisphere is Summer solstice in the Southern Hemisphere.

Equinoxes – Two specific points in the Earth's orbit when each hemisphere gets 12 hours of sunlight.



North Pole on March 22

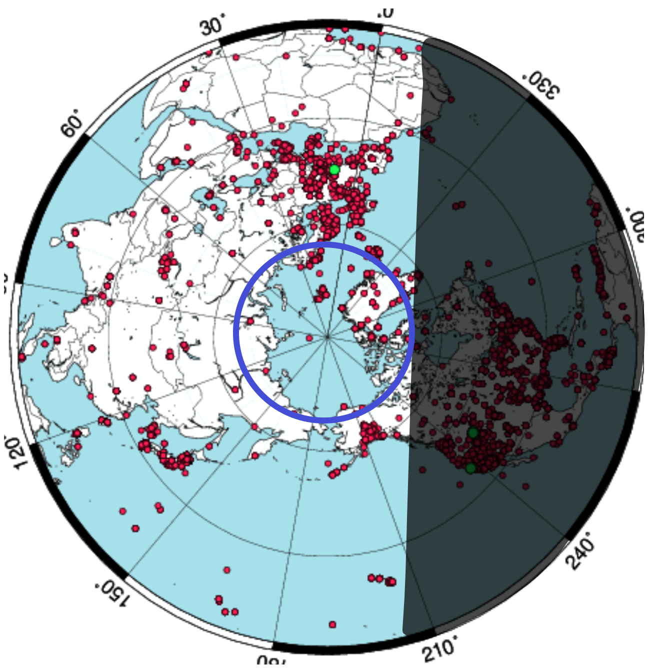


South Pole on March 22

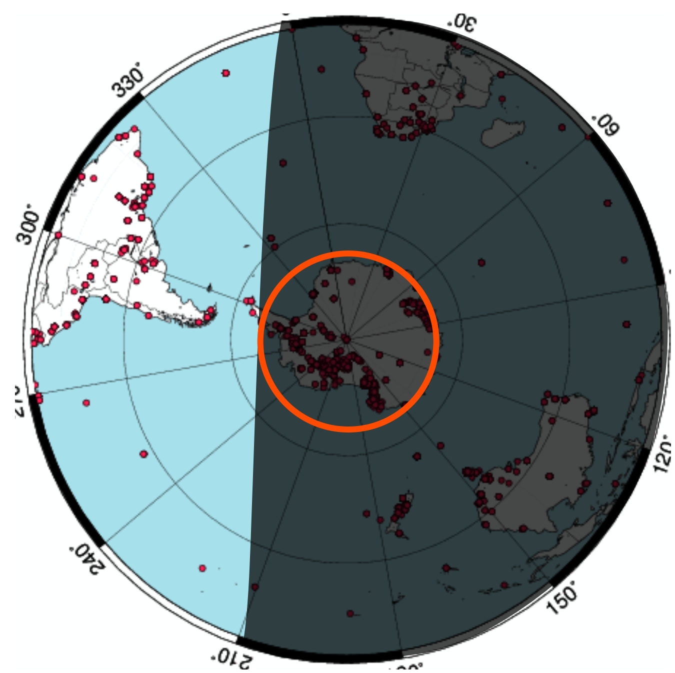
Twice a year (September 22nd, March 22nd) every latitude on Earth gets exactly 12 hours of sunlight. These are the equinoxes.

http://milhouse.jpl.nasa.gov/

Solstices – Two specific points in the Earth's orbit when the day length in one hemisphere has reached a maximum and in the other has reached a minimum.



North Pole June 21

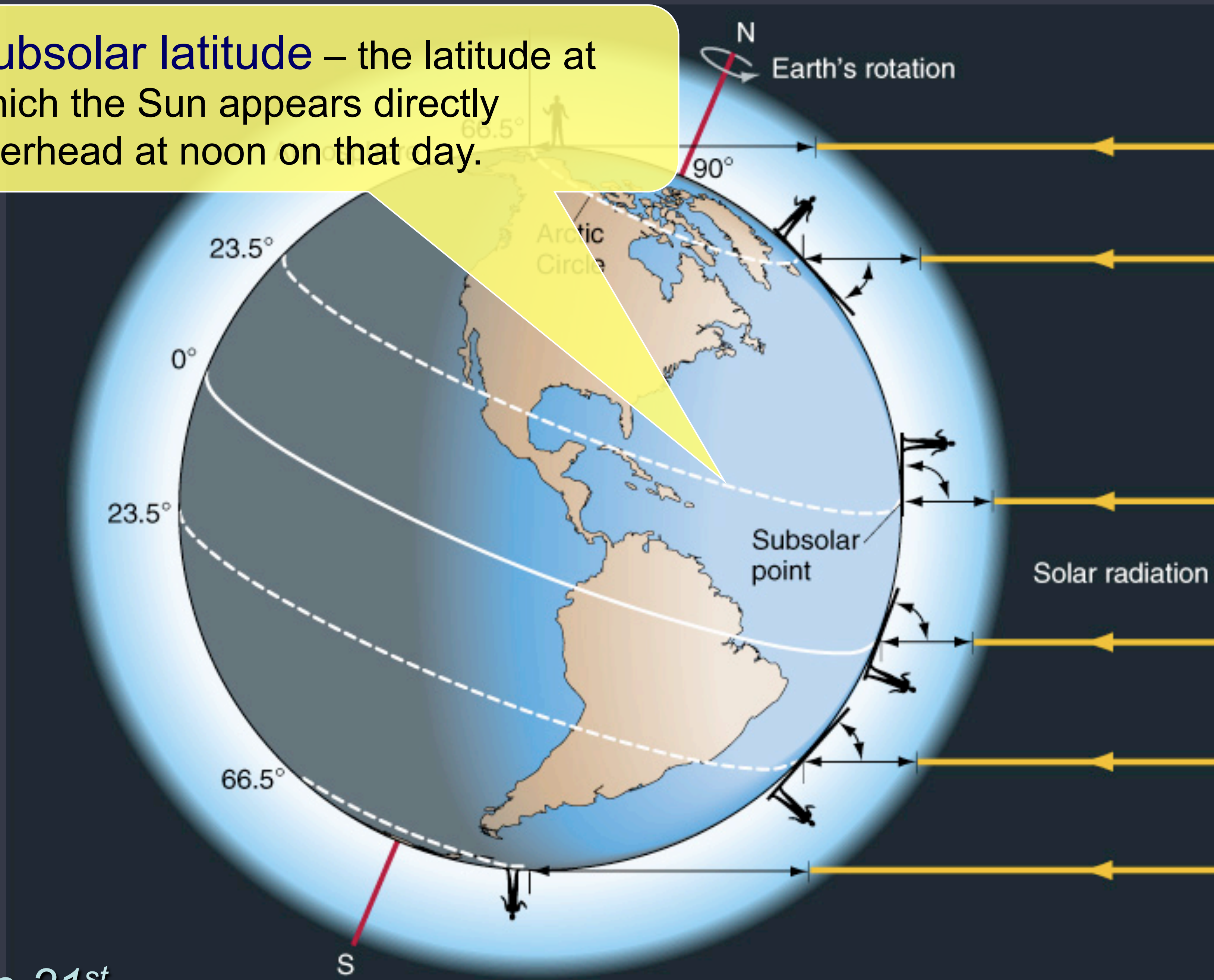


South Pole on June 21

On the longest day of the year in the Northern Hemisphere (June 21st), the Sun never sets on any latitude above the **Arctic Circle** (blue) and latitudes below the **Antarctic Circle** (red) get no sunlight at all.

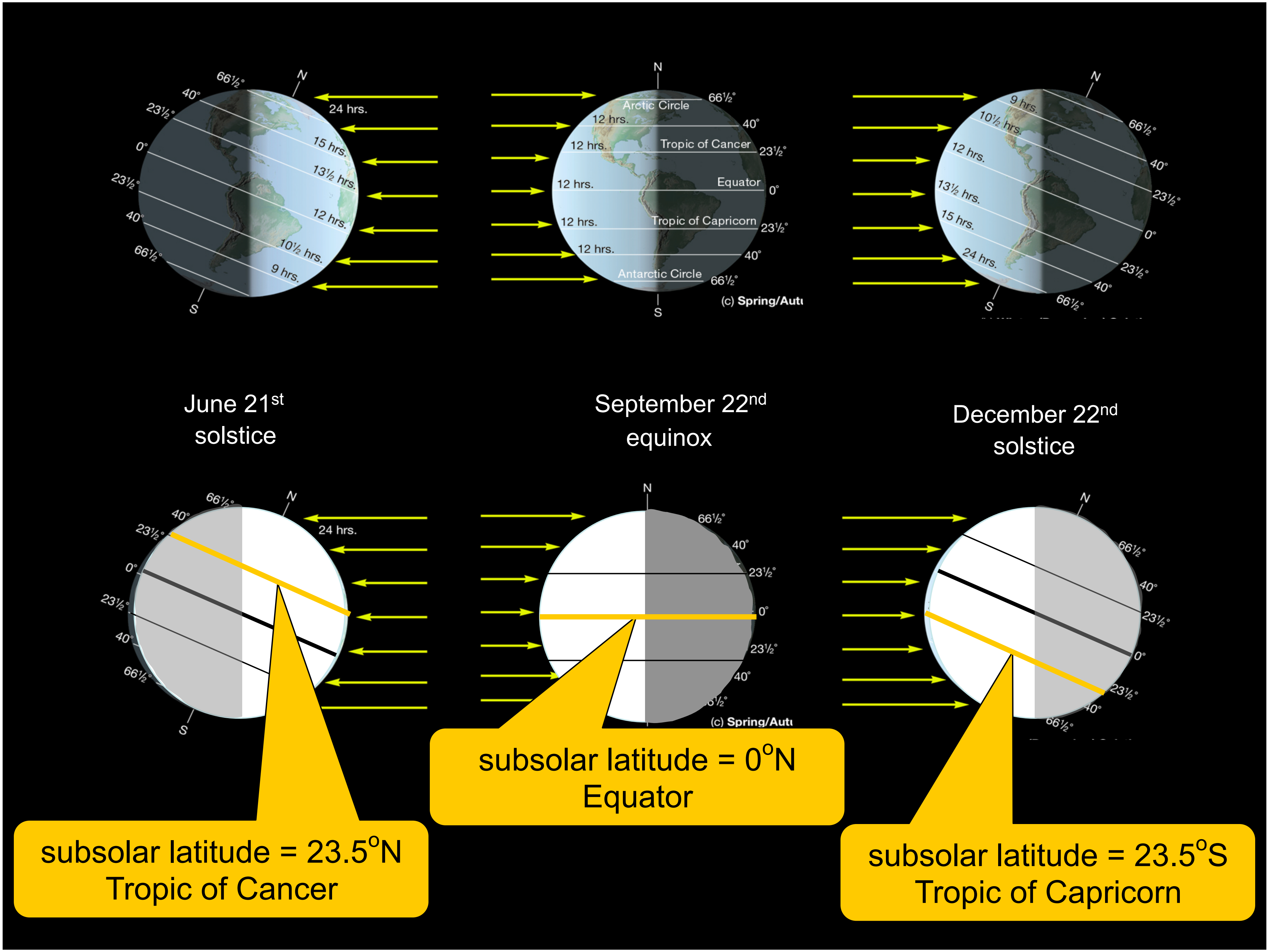
http://milhouse.jpl.nasa.gov/

Subsolar latitude – the latitude at which the Sun appears directly overhead at noon on that day.

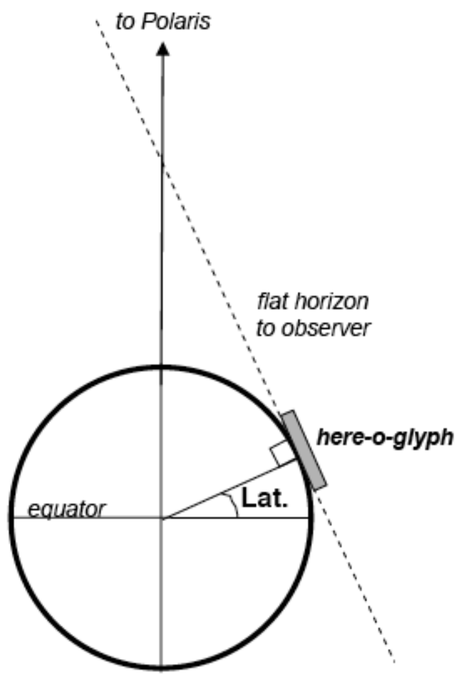


June 21st

http://www.u.arizona.edu/~korine/230/chap2_figs.htm



N
S
24 hrs.
15 hrs.
13½ hrs.
12 hrs.
10½ hrs.
9 hrs.
66½°
40°
23½°
0°
Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle
(c) Spring/Autu
June 21st
solstice
September 22nd
equinox
December 22nd
solstice
subsolar latitude = 23.5°N
Tropic of Cancer
subsolar latitude = 0°N
Equator
subsolar latitude = 23.5°S
Tropic of Capricorn

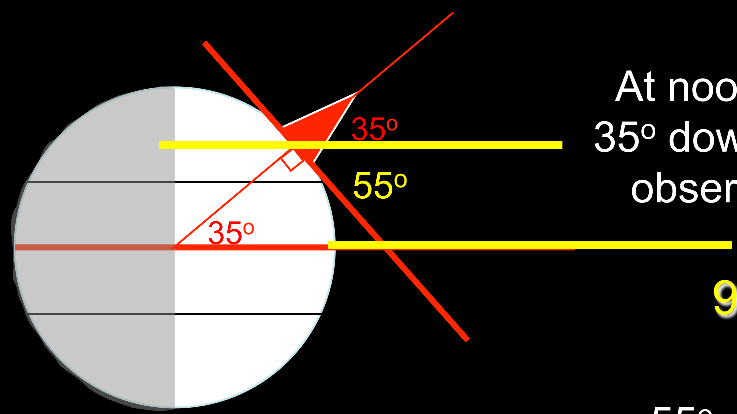


Polaris appears
<your latitude>
above your horizon

Rock Hill Latitude= 35^{o}N
Polaris appears 35^o
above horizon to
observers in Rock Hill

September 22nd

Sun directly overhead at the equator

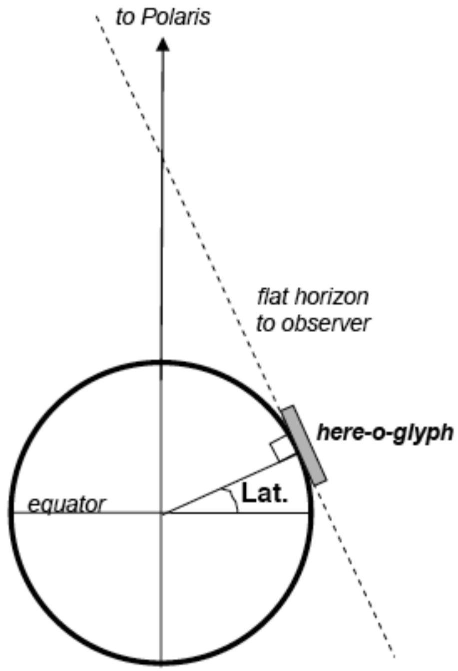


At noon, the Sun appears 35^o down from vertical to an observer in Rock Hill, or:

$90^o - 35^o = 55^o$

55^o above the horizon.

Rock Hill Latitude= 35^{o}N

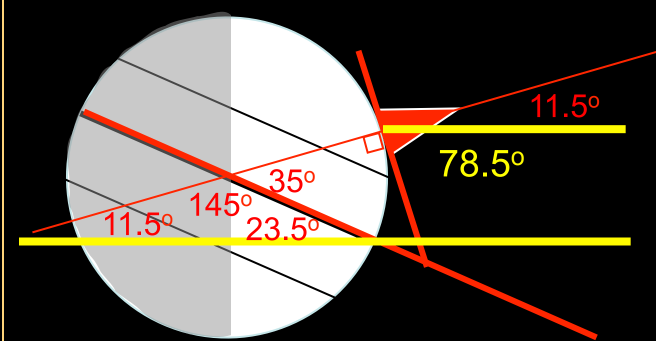


Polaris appears
<*your latitude*>
above your horizon

Rock Hill Latitude= 35^{o}N
Polaris appears 35^{o}
above horizon to
observers in Rock Hill

June 21^{st}

Sun directly overhead at 23.5^{o} N



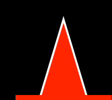
At noon, the Sun appears:

$180^{o}-145^{o}-23.5^{o} = 11.5^{o}$

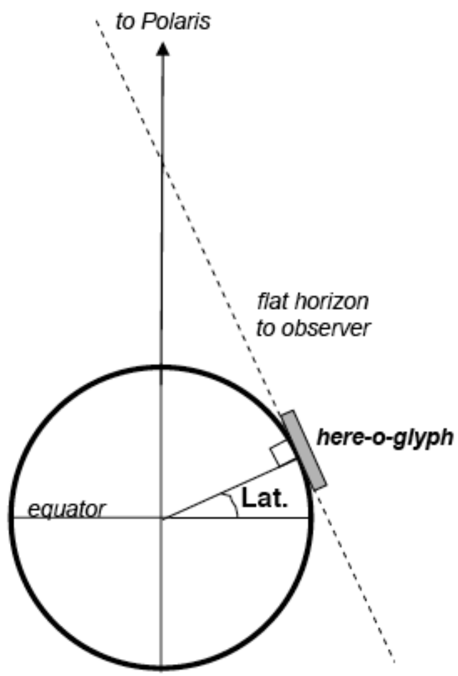
down from vertical to an observer in Rock Hill, or:

$90^{o} - 11.5^{o} = 78.5^{o}$

78.5^{o} above the horizon.



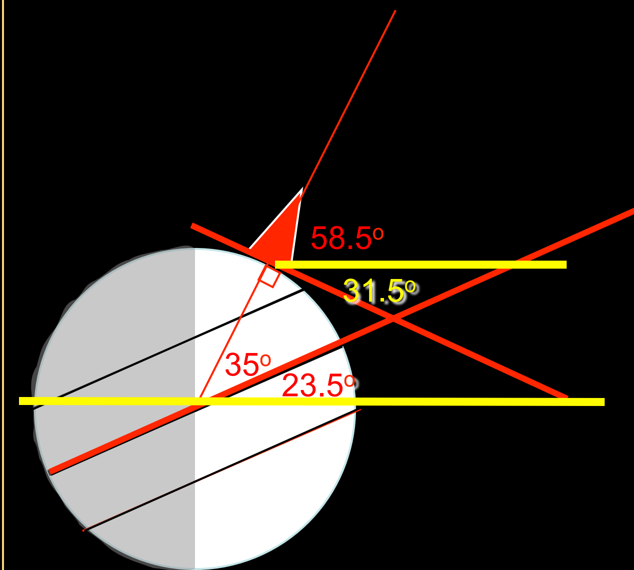
Rock Hill Latitude= 35^{o}N



Polaris appears
<your latitude>
above your horizon

Rock Hill Latitude= 35°N

Polaris appears 35°
above horizon to
observers in Rock Hill



December 22st

Sun directly overhead at 23.5° S

At noon, the Sun appears:

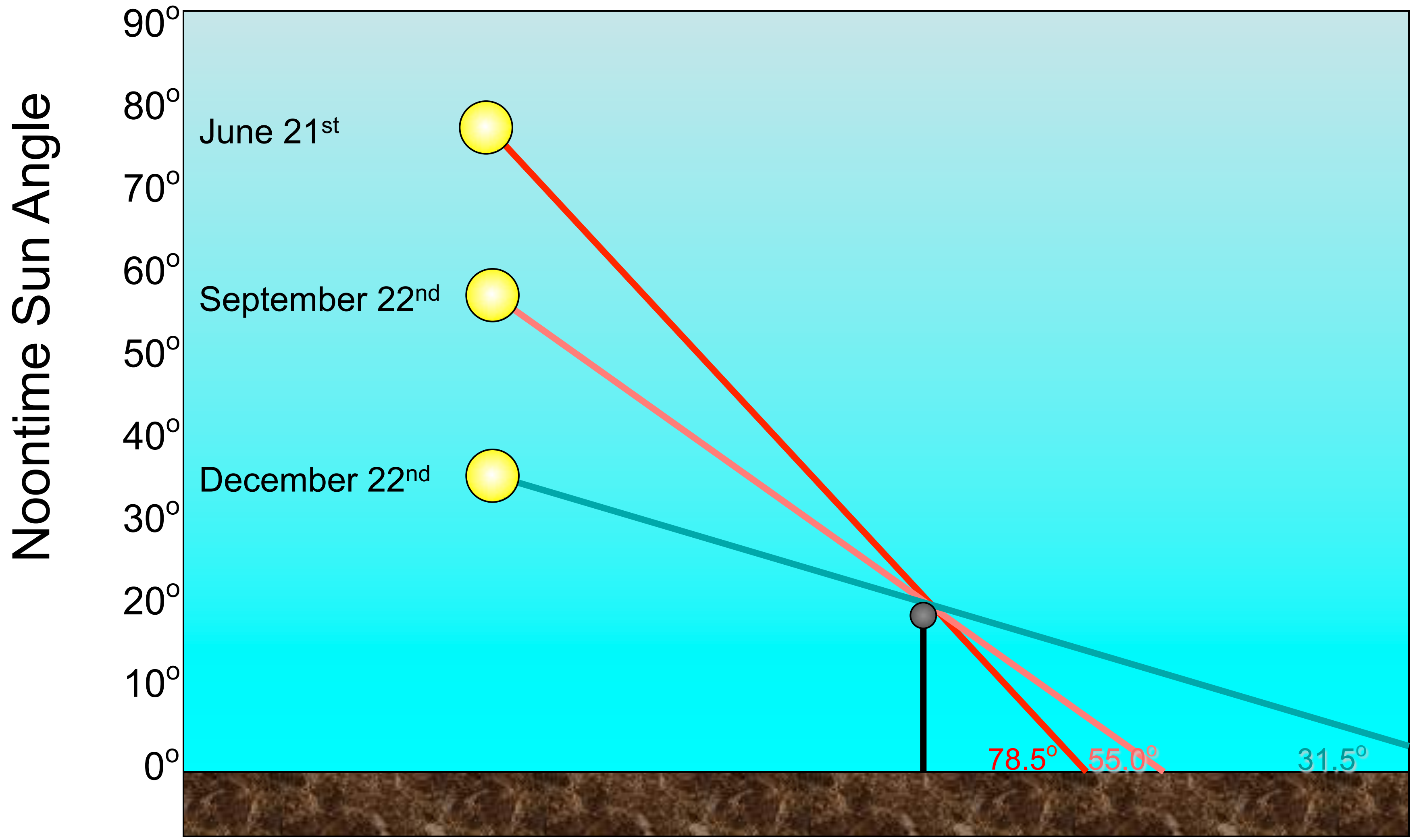
35° + 23.5° = 58.5°

down from vertical to an observer in Rock Hill, or:

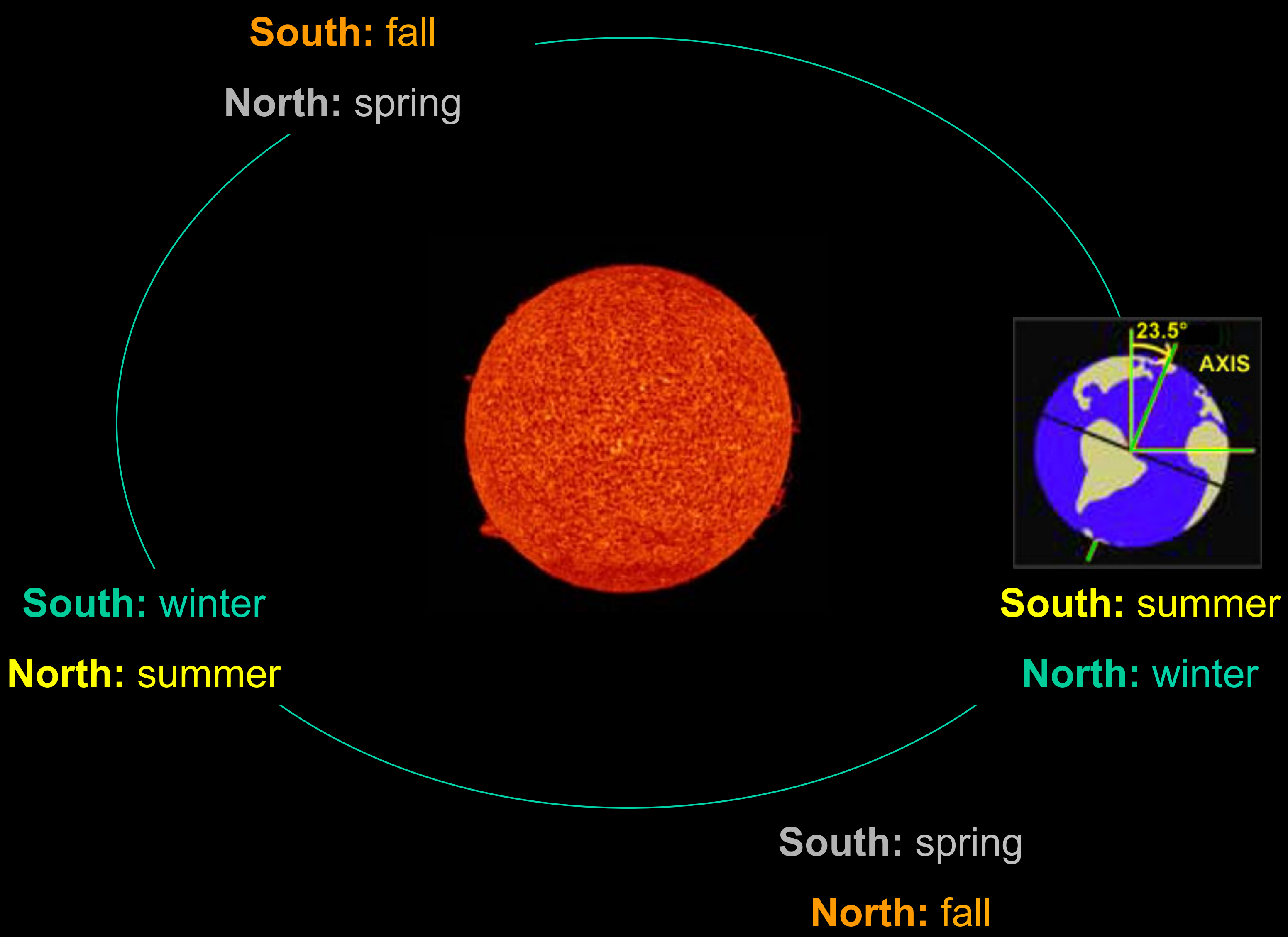
90° - 58.5° = 31.5°

31.5° above the horizon.

Rock Hill Latitude= 35°N

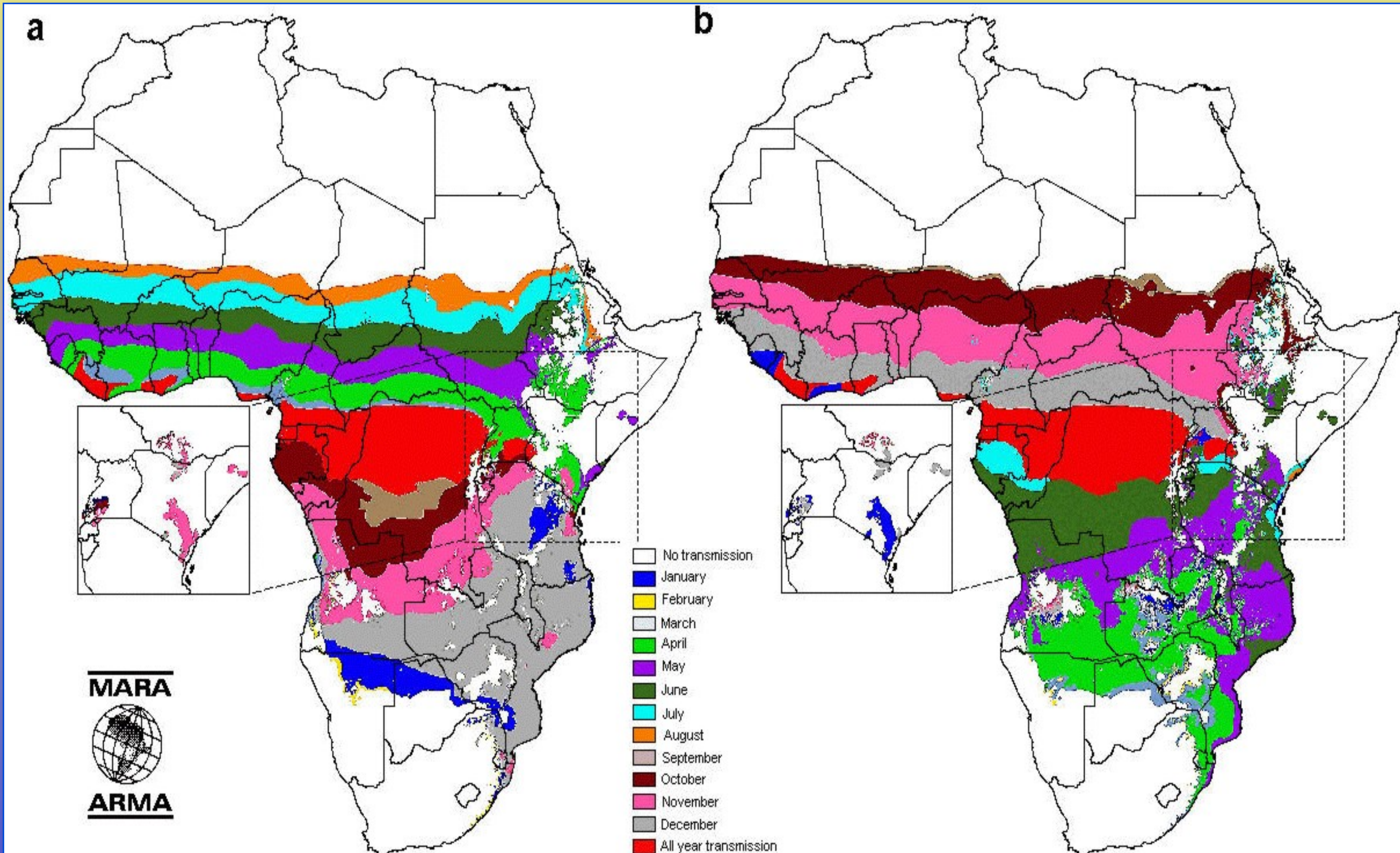


Noontime Sun Angle
90°
80°
70°
60°
50°
40°
30°
20°
10°
0°
June 21st
September 22nd
December 22nd
78.5°
55.0°
31.5°



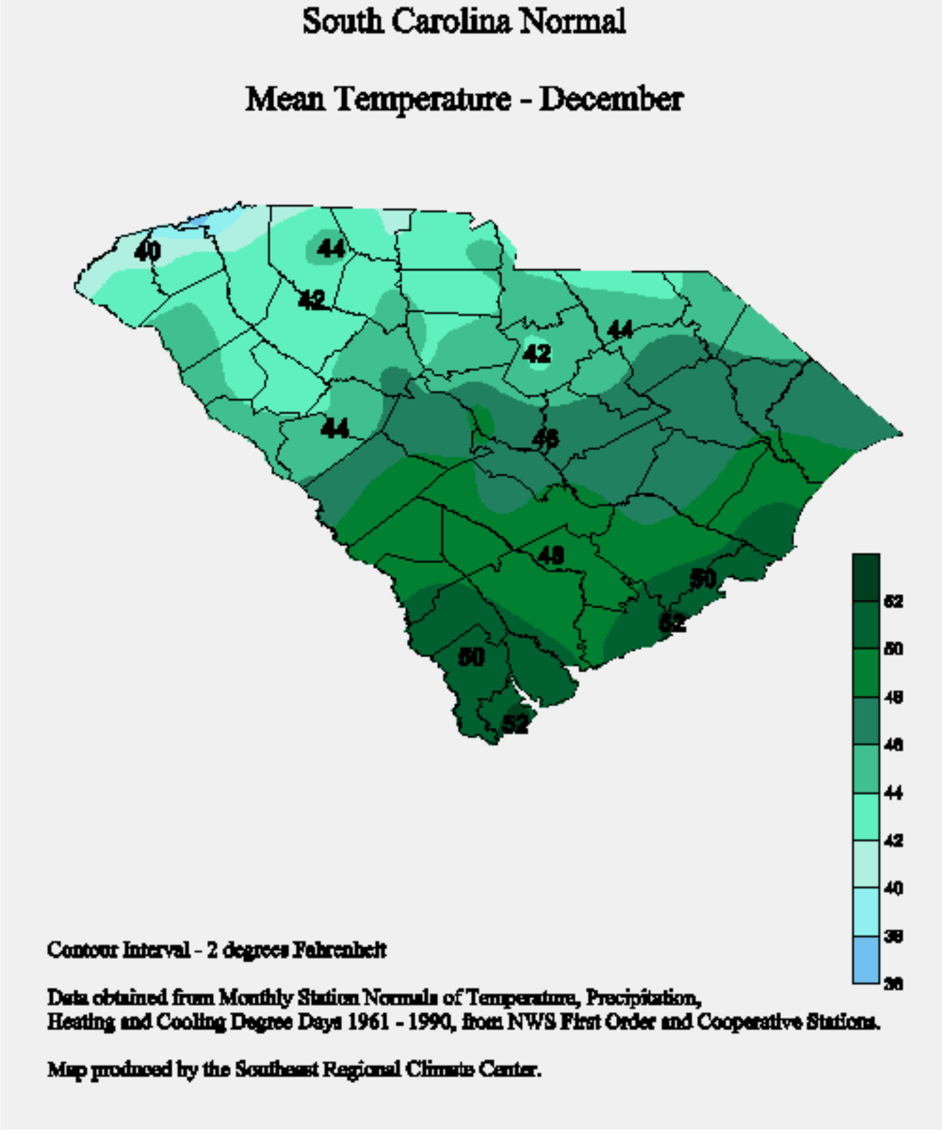
http://www.boechat.com/tele/base/2001_11.html http://www.bbc.co.uk/science/space/solarsystem/earth/solsticescience.shtml

Effect of Seasonality on Malaria Season

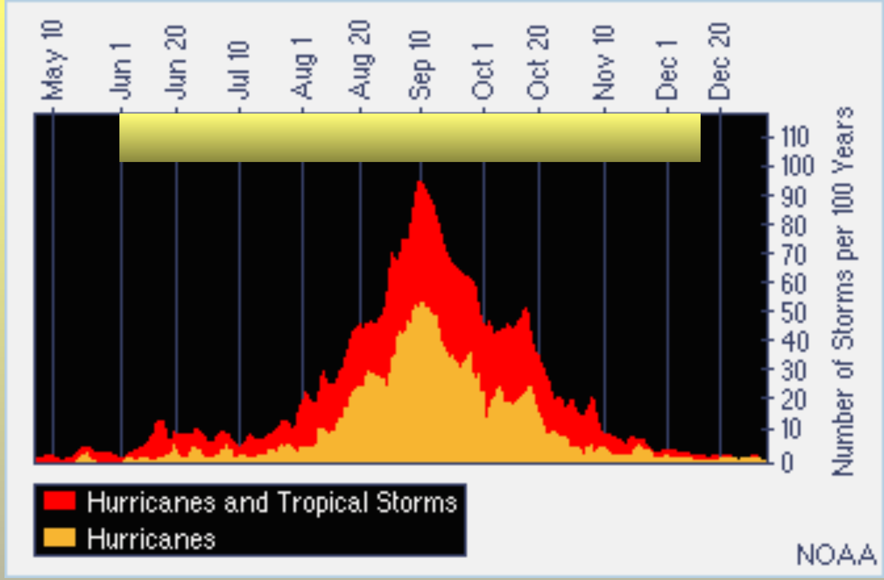


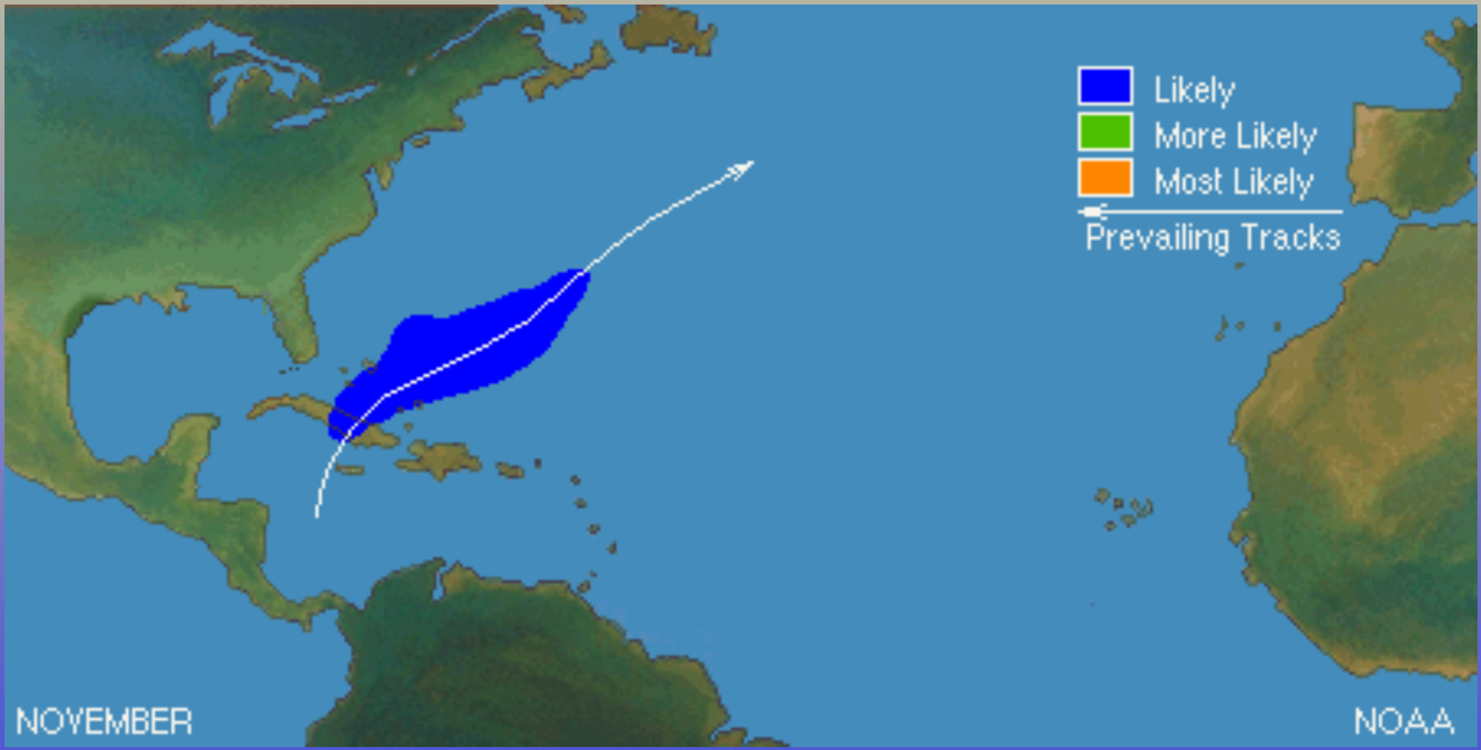
http://www.angelfire.com/sc2/frankt/start_and_end_malaria.htm

South Carolina Seasonality



http://www.dnr.state.sc.us





http://hurricanes.noaa.gov/prepare/season.htm