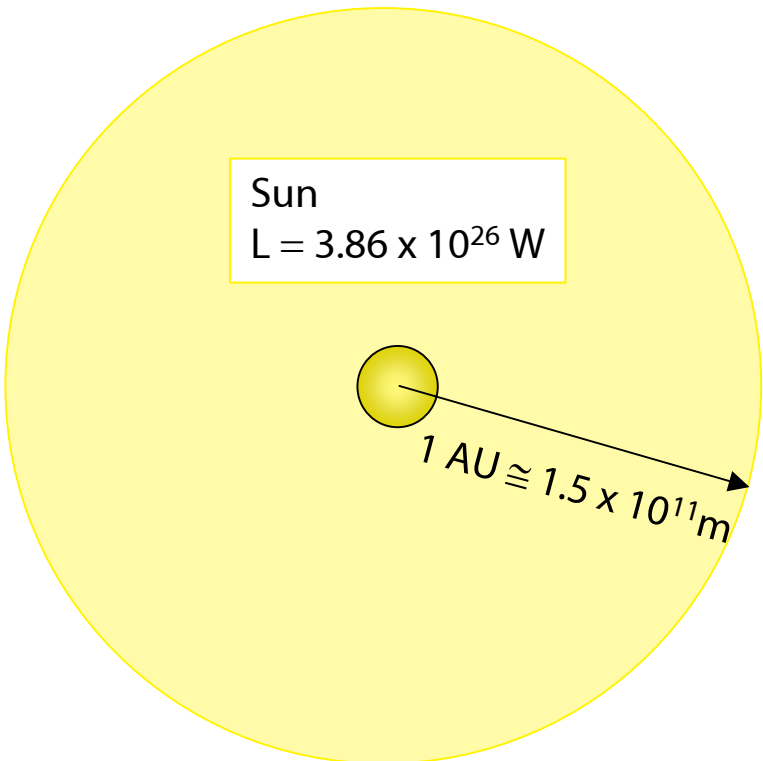
UNIT 2: Solar Geometry

- Solar constant
- Extraterrestrial radiation
- Sun-earth astronomy
- Examples

Solar Constant



Area of a sphere = $4\pi r^2$

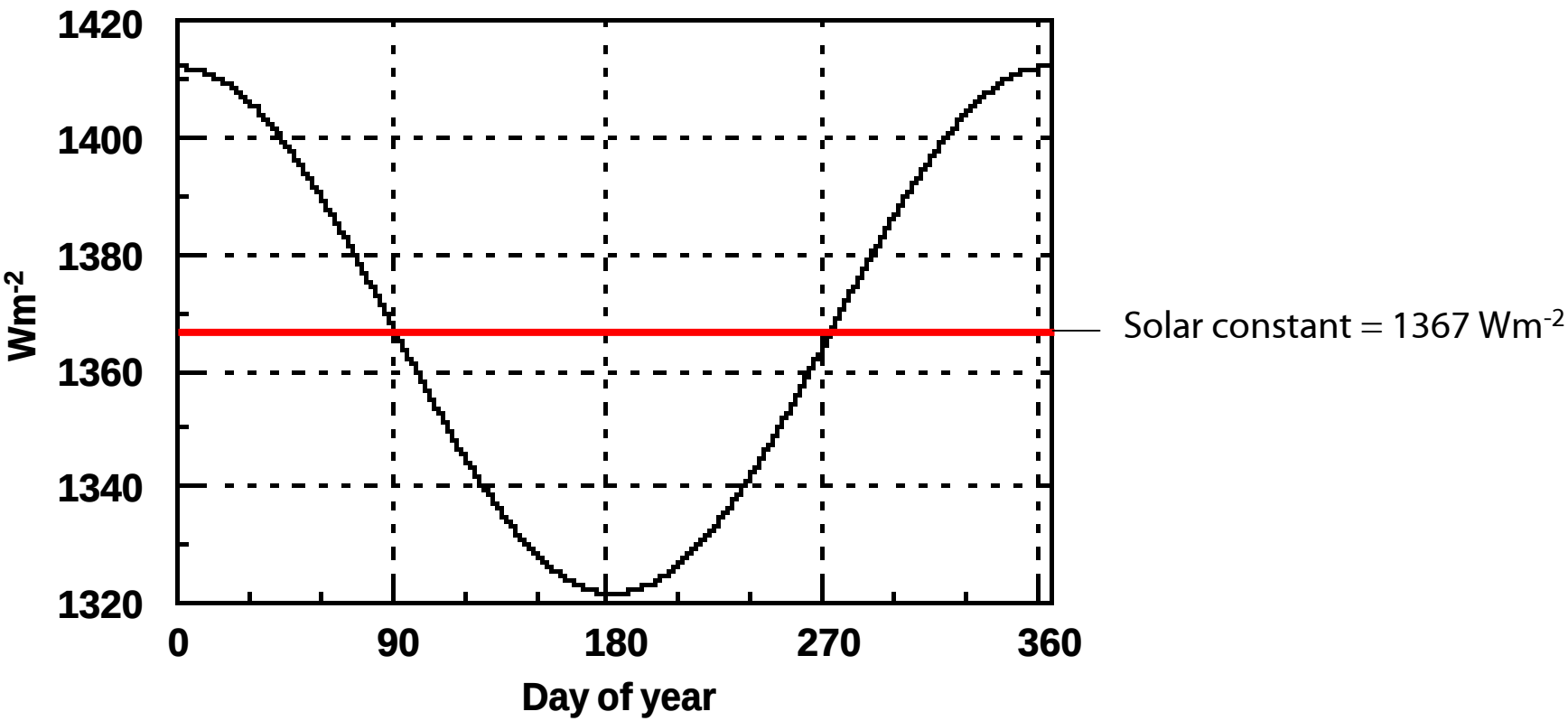
Conservation of energy requires that the total energy flux coming out of the sun must also pass through a sphere at 1 AU.

The energy flux density at 1 AU is

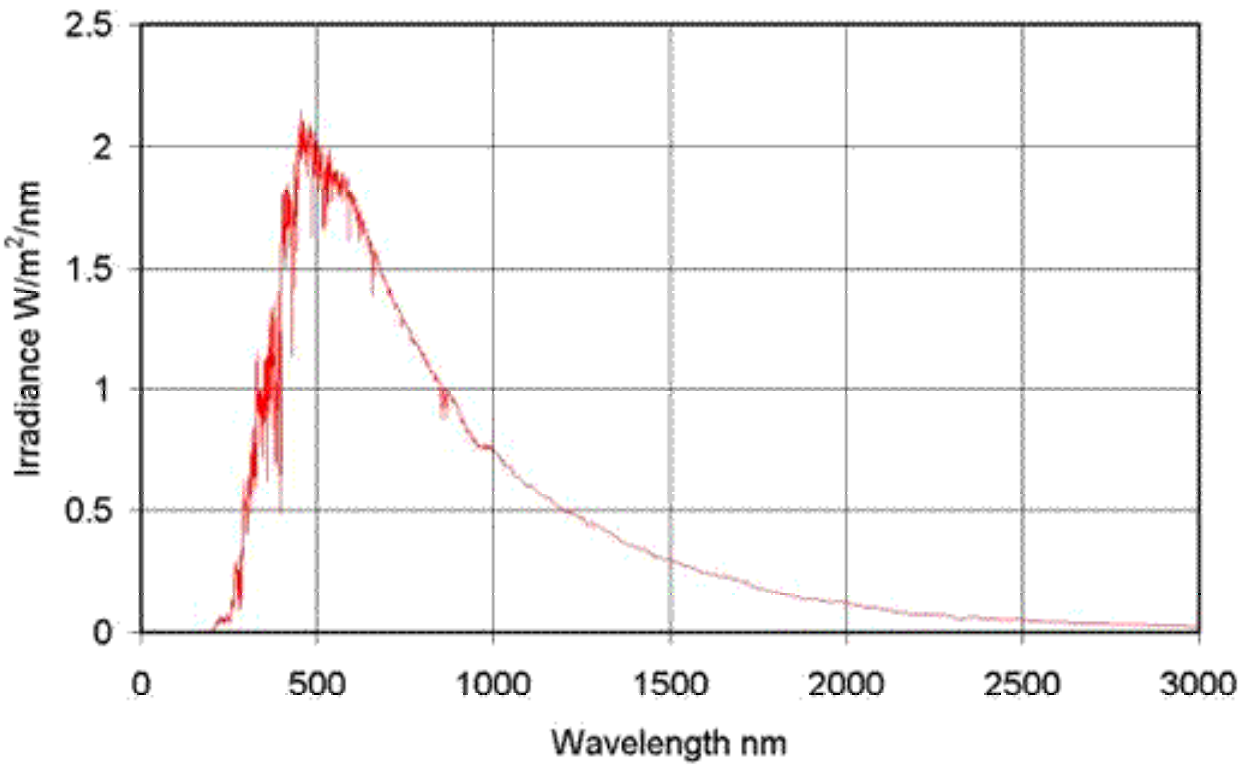
$$\frac{L}{4\pi r^2} = 1367 \text{ Wm}^{-2}.$$

This is the **Solar Constant**.

Extraterrestrial Radiation

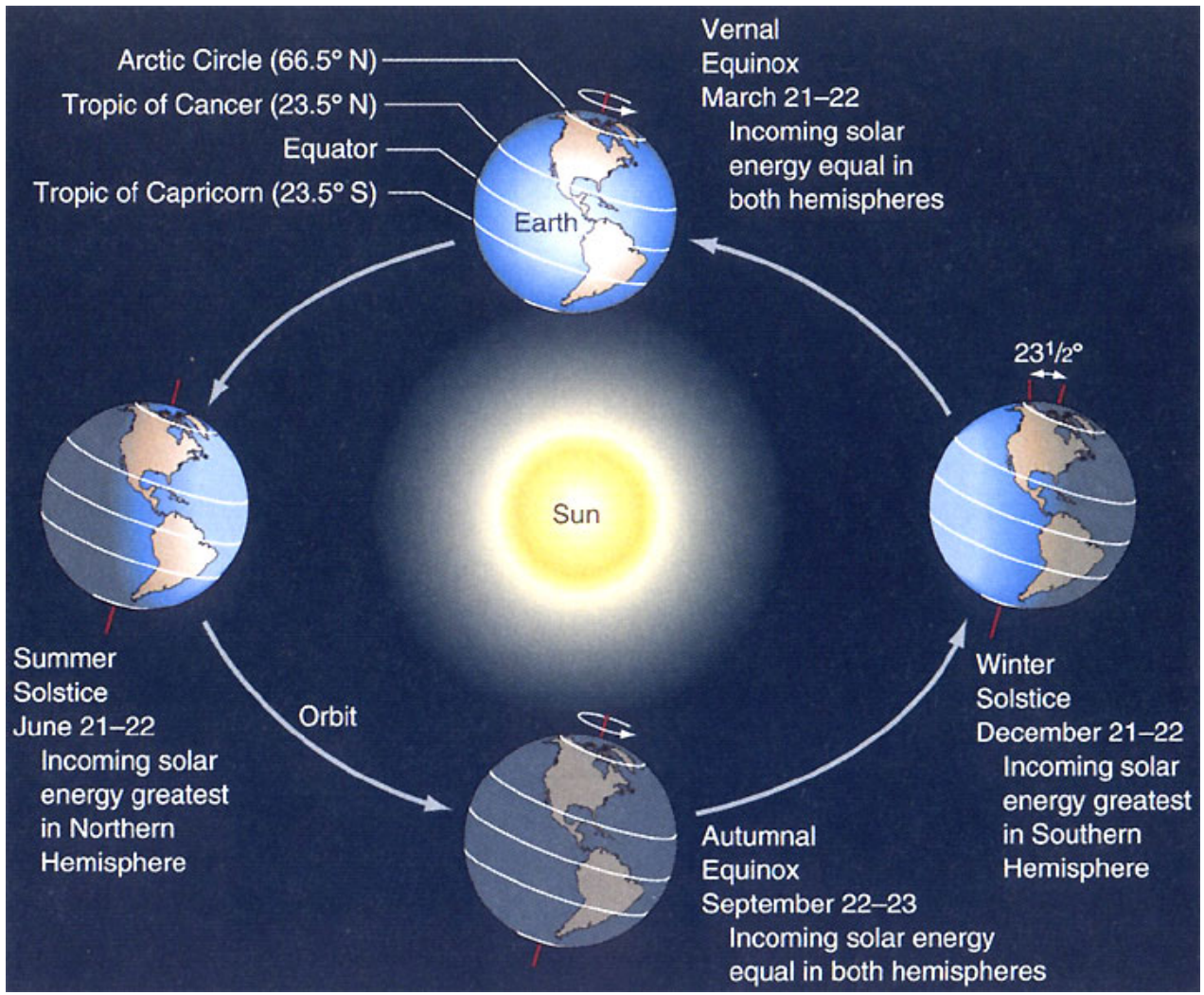


Extraterrestrial Solar Spectrum

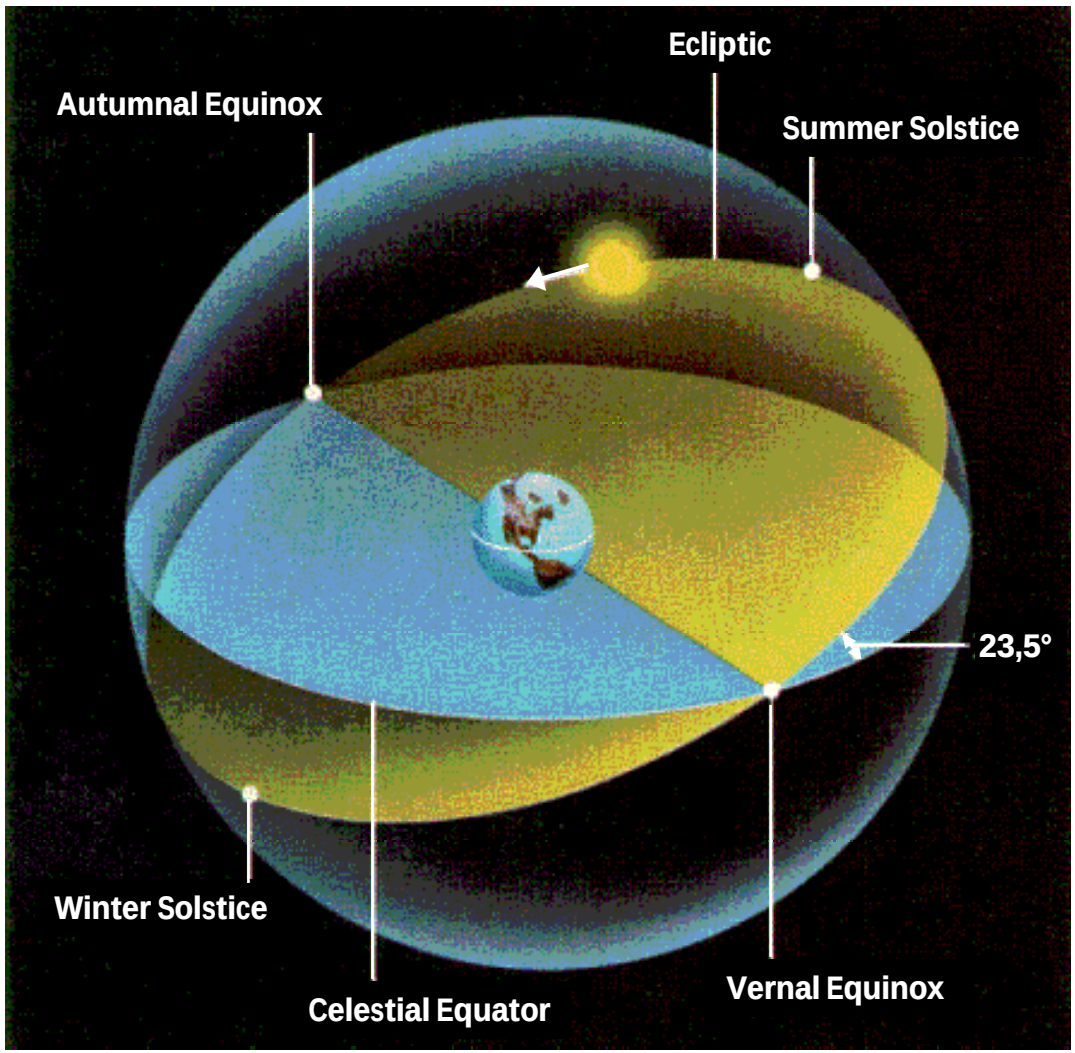


Source: C. Wehrli,1985

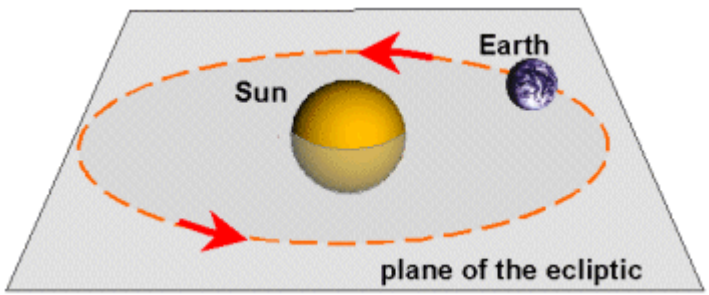
Ecliptic

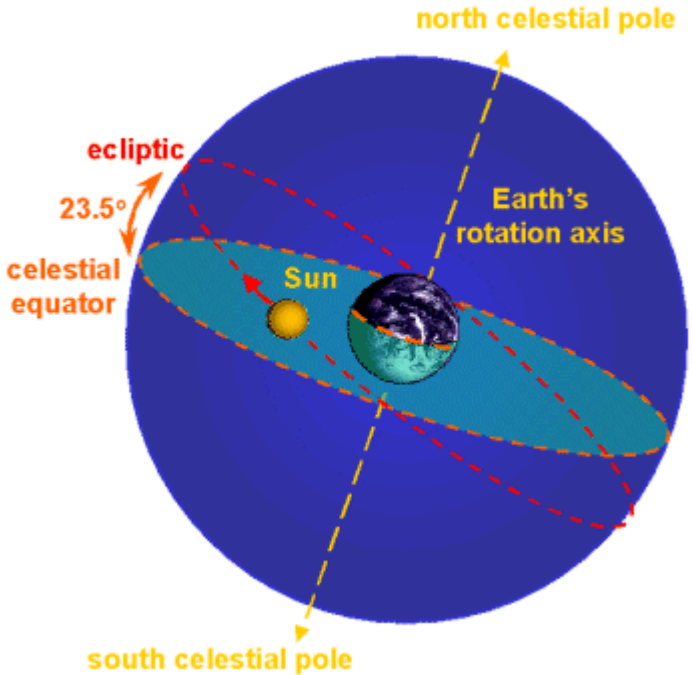

Arctic Circle (66.5° N)
Tropic of Cancer (23.5° N)
Equator
Tropic of Capricorn (23.5° S)
Earth
Vernal Equinox March 21–22
Incoming solar energy equal in both hemispheres
23½°
Sun
Summer Solstice June 21–22
Incoming solar energy greatest in Northern Hemisphere
Orbit
Winter Solstice December 21–22
Incoming solar energy greatest in Southern Hemisphere
Autumnal Equinox September 22–23
Incoming solar energy equal in both hemispheres

Ecliptic


Ecliptic
Autumnal Equinox
Summer Solstice
23,5°
Winter Solstice
Celestial Equator
Vernal Equinox

Ecliptic

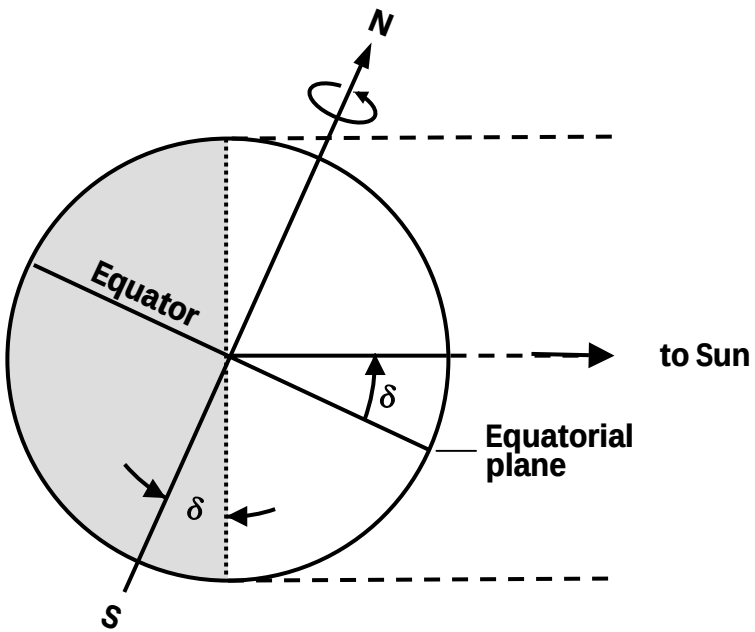


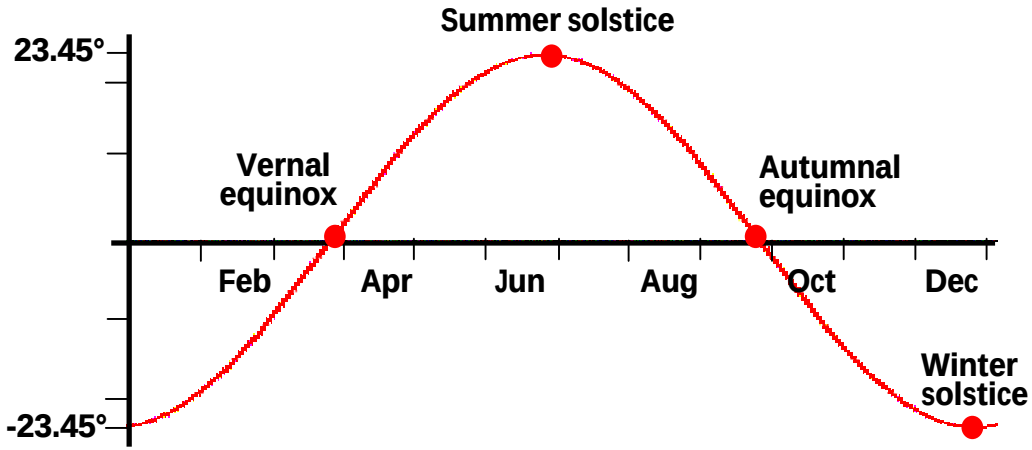


The ecliptic is the region of sky (region of the celestial sphere) through which the Sun appears to move over the course of a year. This apparent motion is caused by the Earth's orbit around the Sun, so the ecliptic corresponds to the projection of the Earth's orbital plane on the celestial sphere. For this reason, the Earth's orbital plane is sometimes called the plane of the ecliptic.

Due to the tilt of the Earth's rotation axis with respect to its orbital plane, there is an angle of 23.5° between the ecliptic and the celestial equator.

Solar Declination





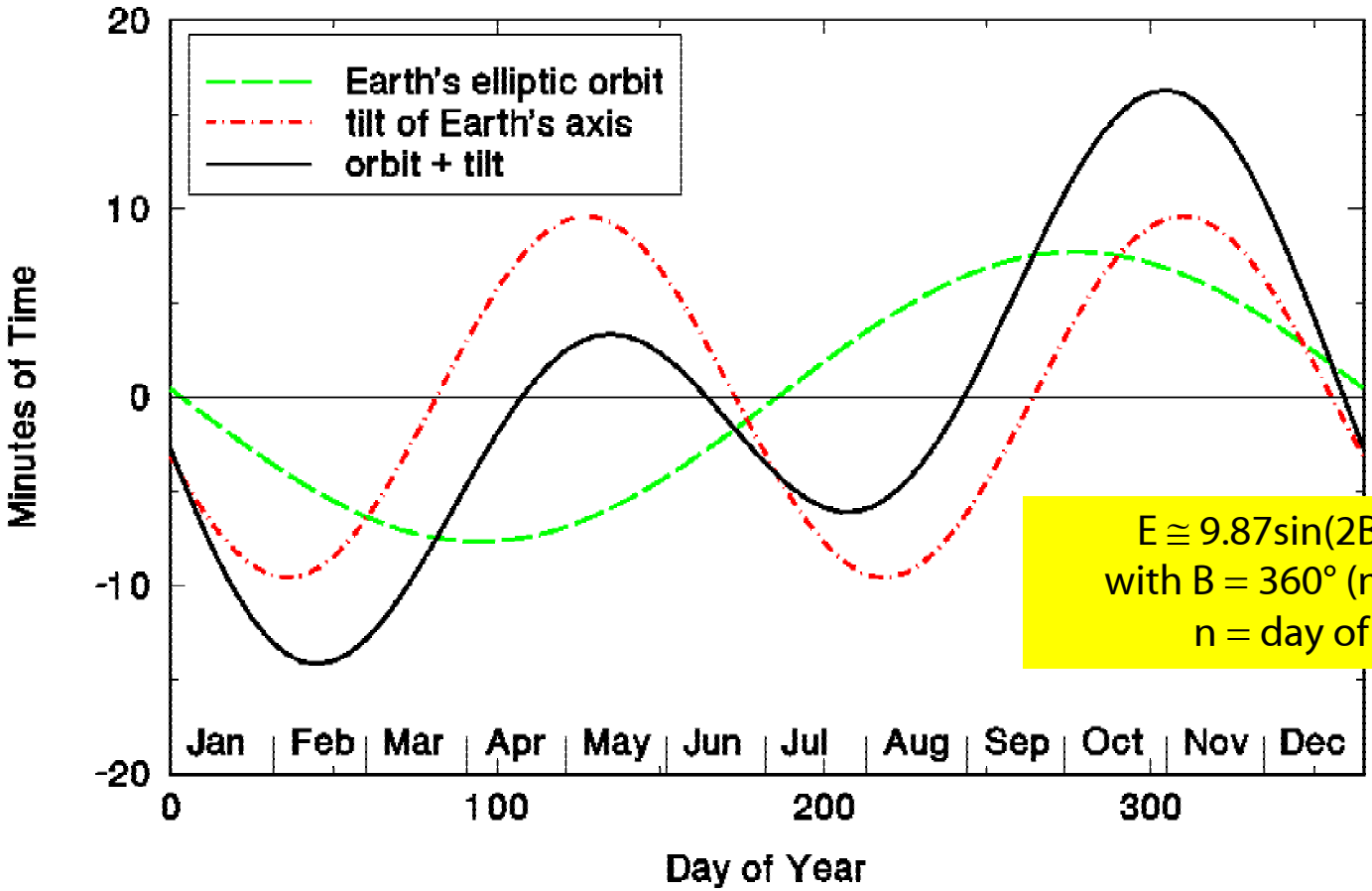
Declination angle $\delta = 23.45°$

Variation of the declination angle:

$\delta \cong 23.45 * \sin [360 / 365 * (284 + n)]$

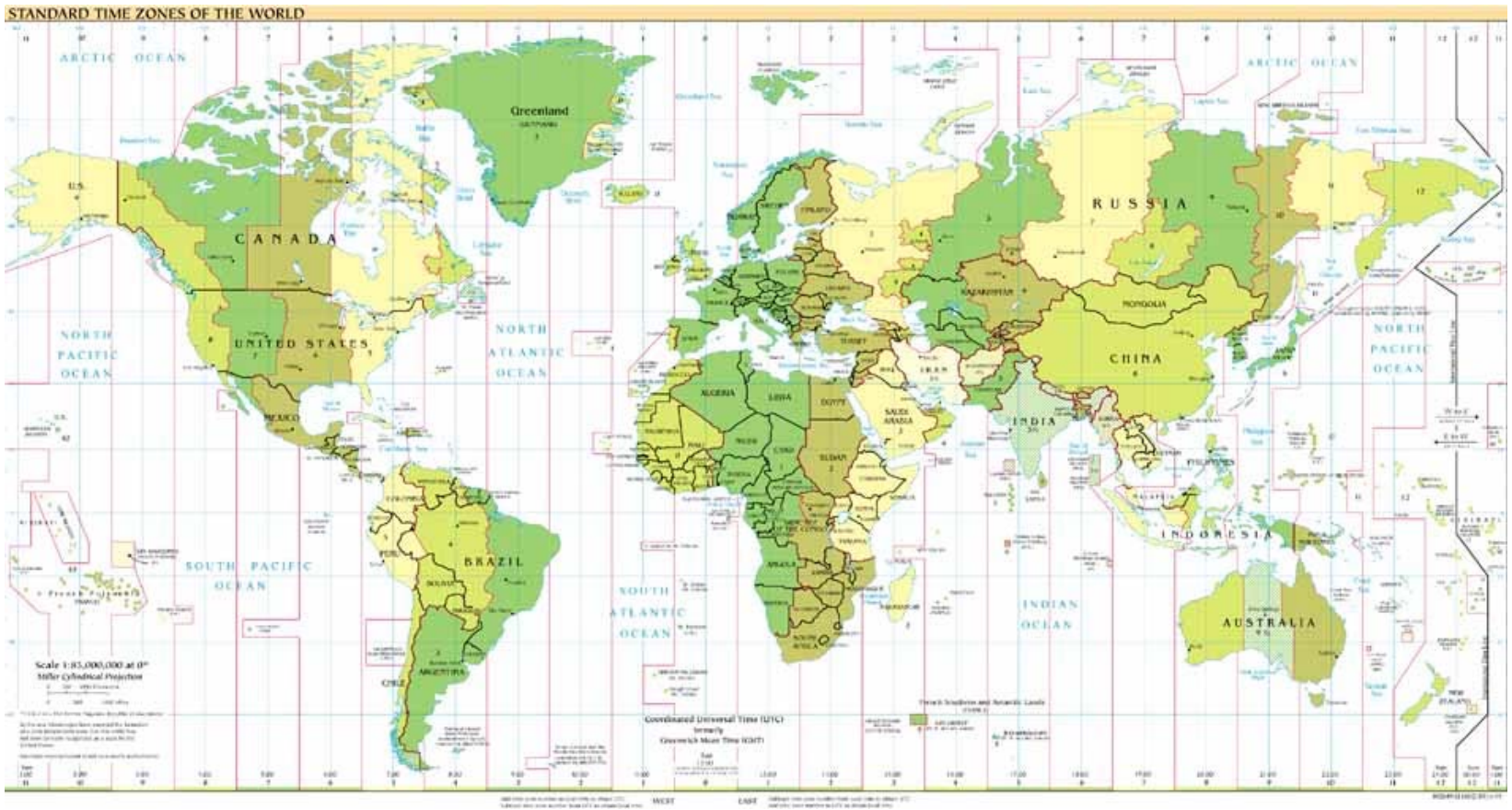
with n = day of the year

Equation of Time

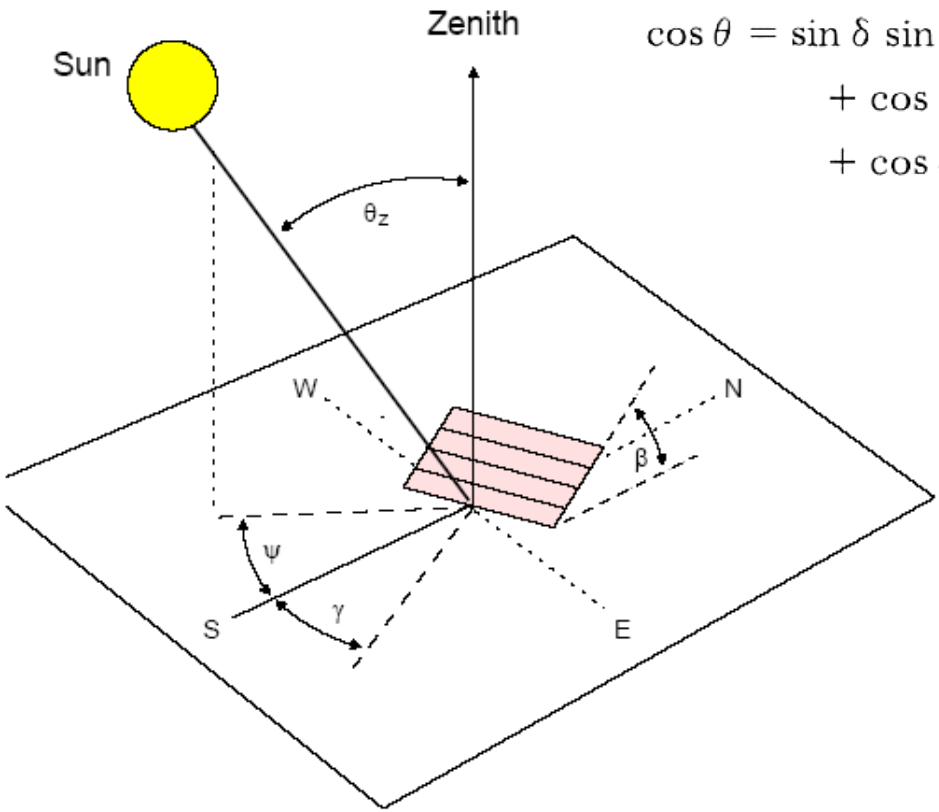


$E \cong 9.87\sin(2B) - 7.53\cos(B) - 1.5\sin(B)$
with $B = 360° (n - 81) / 364$ and
n = day of the year

Time Zones


STANDARD TIME ZONES OF THE WORLD
ARCTIC OCEAN
Greenland
CANADA
U.S.
UNITED STATES
RUSSIA
CHINA
INDIA
INDONESIA
AUSTRALIA
BRAZIL
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
Coordinated Universal Time (UTC)

Solar Geometry: Angle of incidence θ



$$\cos\theta = \sin\delta \sin\phi \cos s - \sin\delta \cos\theta \sin s \cos\gamma + \cos\delta \cos\phi \cos s \cos\omega + \cos\delta \sin\phi \sin s \cos\gamma \cos\omega + \cos\delta \sin s \sin\gamma \sin\omega$$

with:
latitude ϕ
solar declination δ
hour angle ω
slope s
surface azimuth γ