SOAR

Lifelong Learning in the North Country

Potsdam

THE STATE UNIVERSITY OF NEW YORK

SOAR: The Sky in Motion

Life on the Tilted Teacup Ride

Celestial Coordinates and the Day

Aileen A. O'Donoghue

Henry Priest Professor of Physics

ST. LAWRENCE UNIVERSITY

The Tilted Teacup Ride

- ☆ Coordinates and the Day: 9/11/25
  - Celestial Navigation
- ☆ The Year: 9/18/25
  - The Age of Aquarius
- ☆ The Month and Moon Phases: 9/25/25
  - The Harvest Moon
- ☆ The Day in All its Glory: 10/2/25
  - The Analemma

Photo by Marc Staves 2011

The Tilted Teacup Ride

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  - The Analemma

Photo by Marc Staves 2011

Where on Earth?

- ☆ Reference Points
  - Poles
  - Equator
  - Prime Meridian
    - ☽ Greenwich, England
- ☆ Coordinates
  - Latitude
  - Longitude

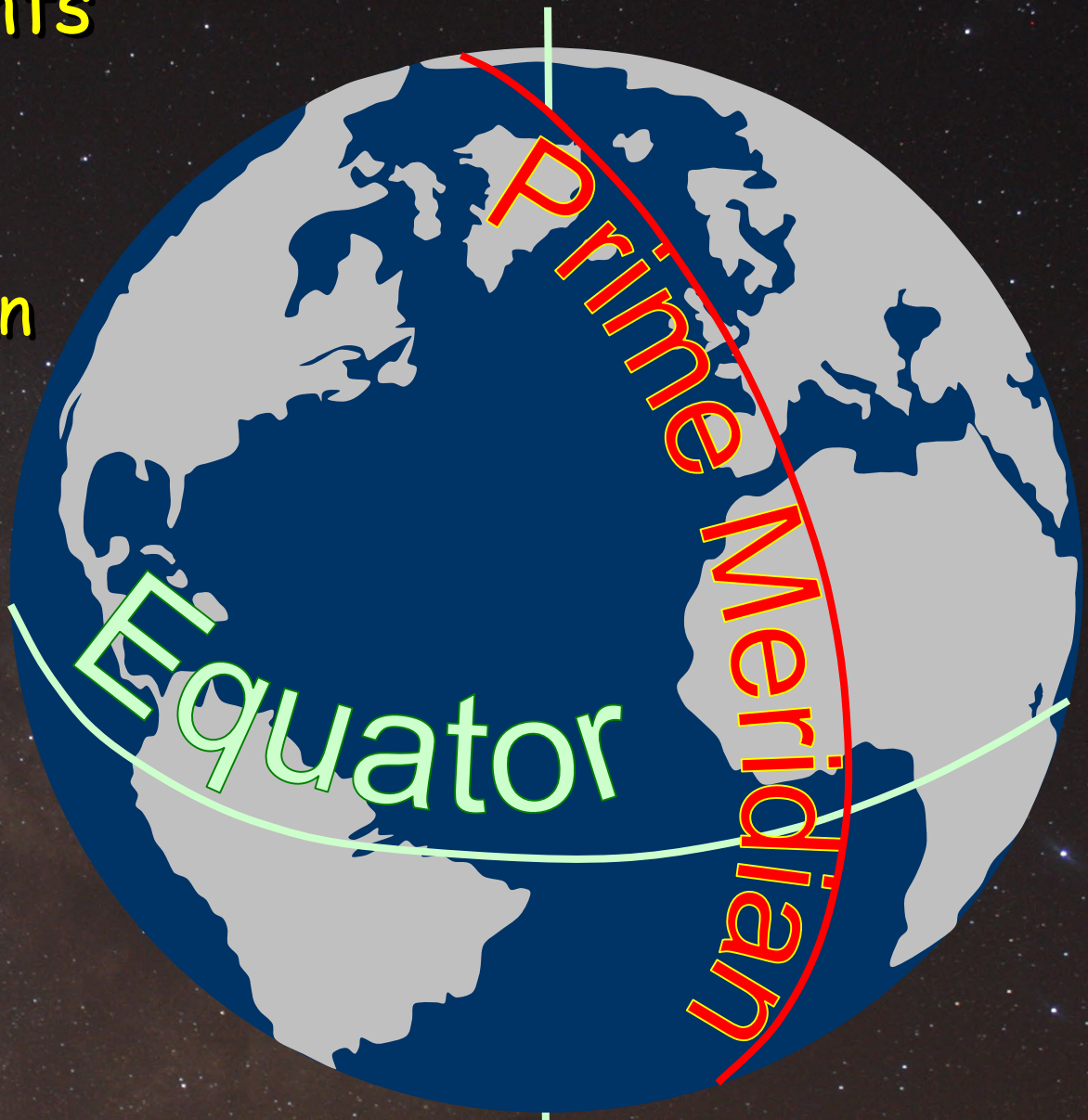


Photo by Marc Staves 2011

Where on Earth?

- ☆ Coordinates
  - Latitude
    - Measured N & S
    - From Equator to Poles
    - 0° to 90° N & S
  - Longitude
    - Measure E & W
    - From Prime Meridian (0°) to 180° E & W

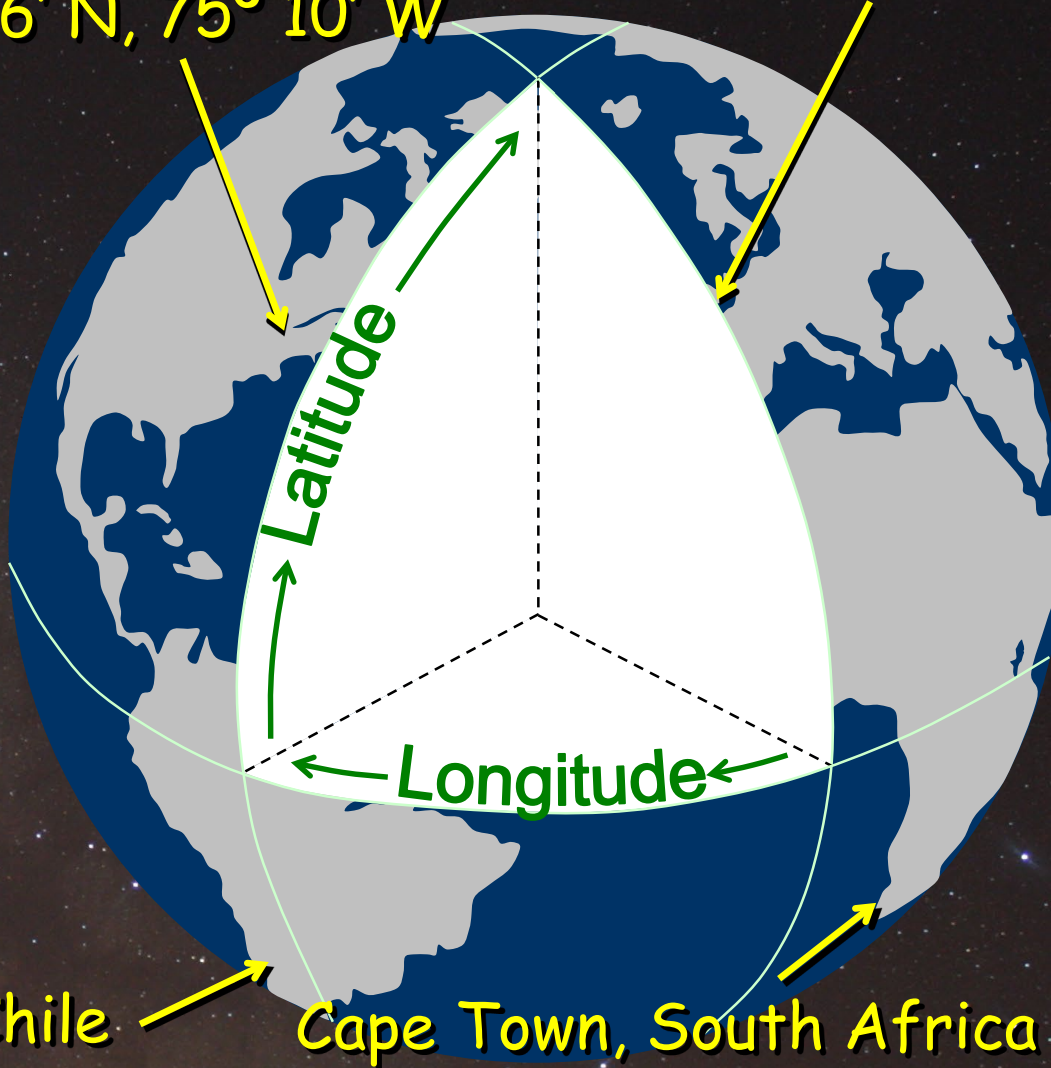


Photo by Marc Staves 2011

The Celestial Sphere

The view from a small planet on the edge of the Orion arm of the Milky Way galaxy …

Photo by Marc Staves 2011

Reference Points

- ☆ Celestial Equator
  - Projection of Earth's equator
- ☆ Celestial Poles
  - Projections of Earth's poles
- ☆ Point of Aries
  - Vernal Equinox
  - Defines prime meridian (Celestial Greenwich)

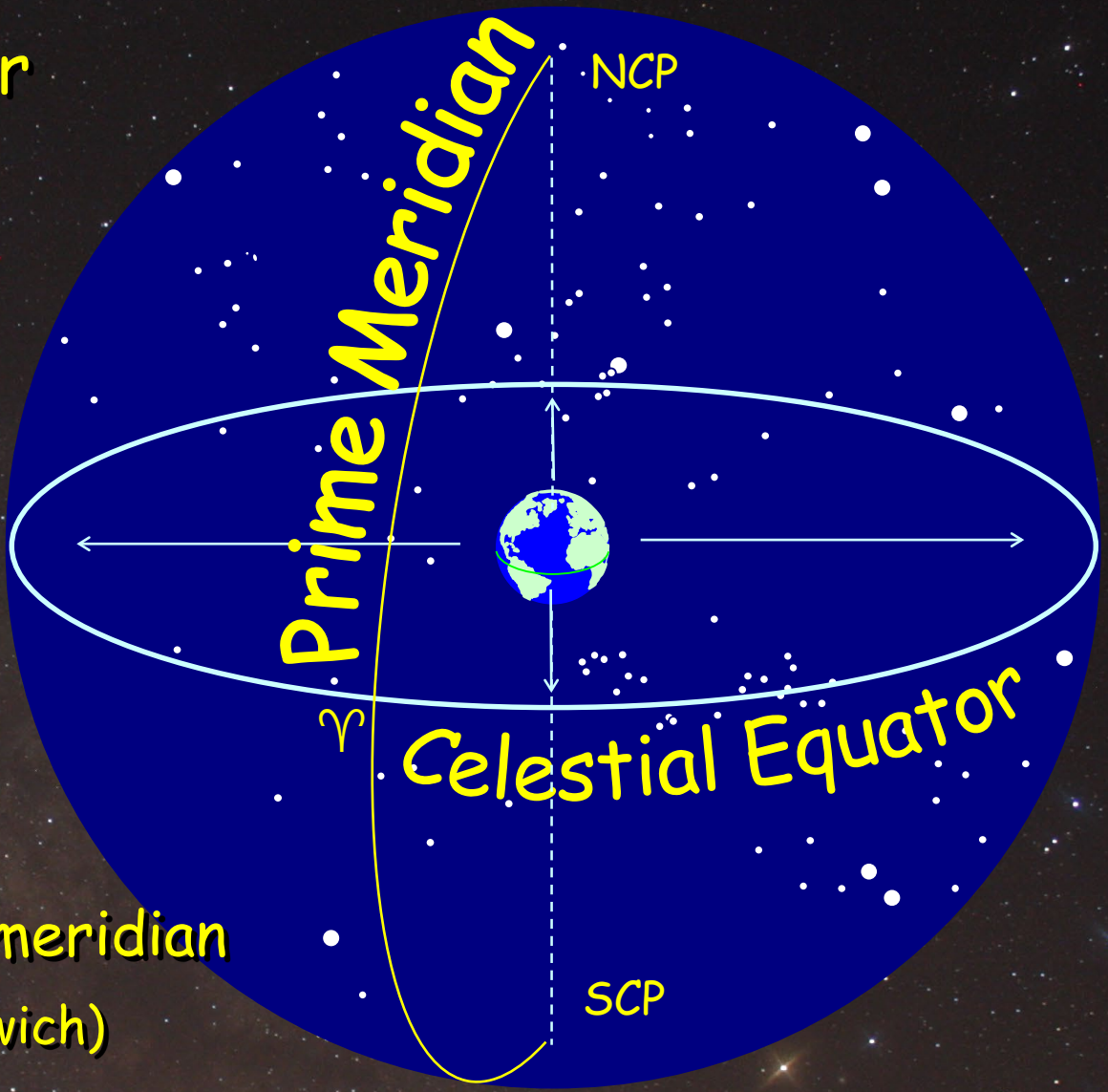


Photo by Marc Staves 2011

Celestial Coordinates

☆Right Ascension

- RA or α
- From prime meridian (0^h) to $23^h59^m59^s$ Eastward

☆Declination

- Dec or δ
- From celestial equator (0°) to poles N & S 90°

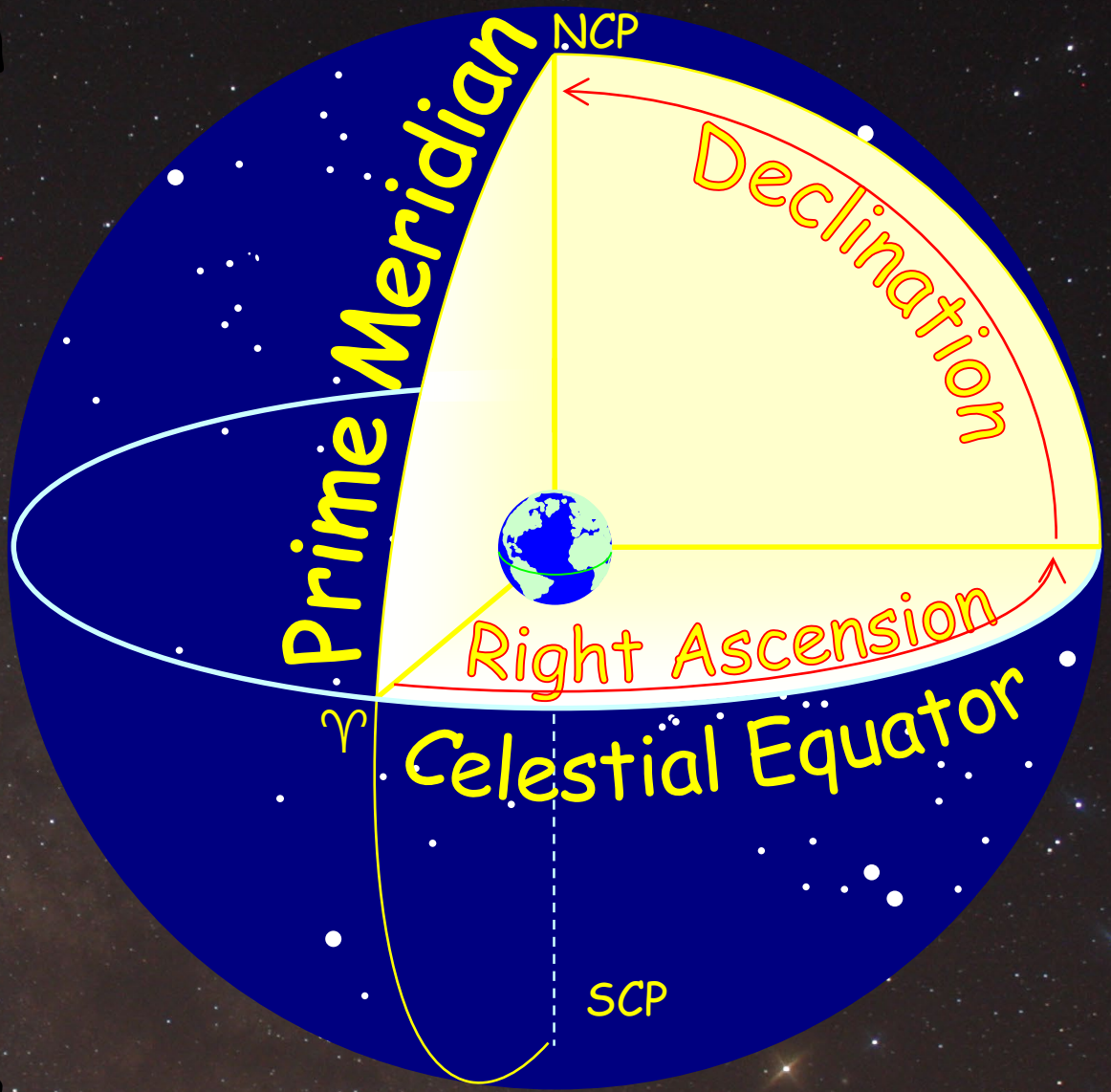


Photo by Marc Staves 2011

Celestial Coordinates

- ☆ Right Ascension
  - Celestial Longitude
- ☆ Declination
  - Celestial Latitude

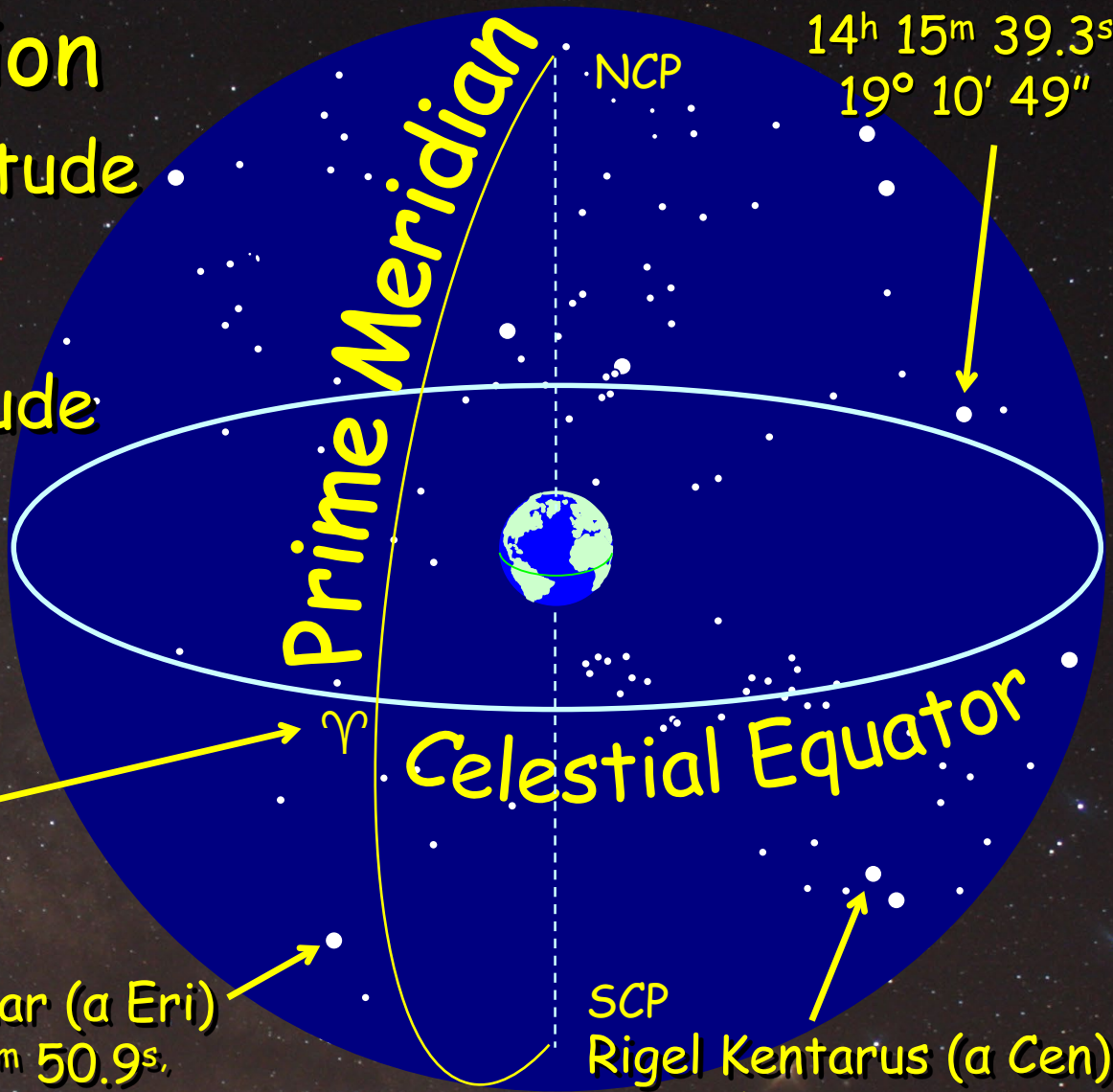


Photo by Marc Staves 2011

Celestial Coordinates

☆ Chet Raymo: 365 Starry Nights: October

Earth observer in North America looking up at Great Square of Pegasus (an asterism)

Degrees of Declination:
Positive (N) 0° to +90°
Negative (S) 0° to -90°

Hours of Right Ascension
0^h to 24^h

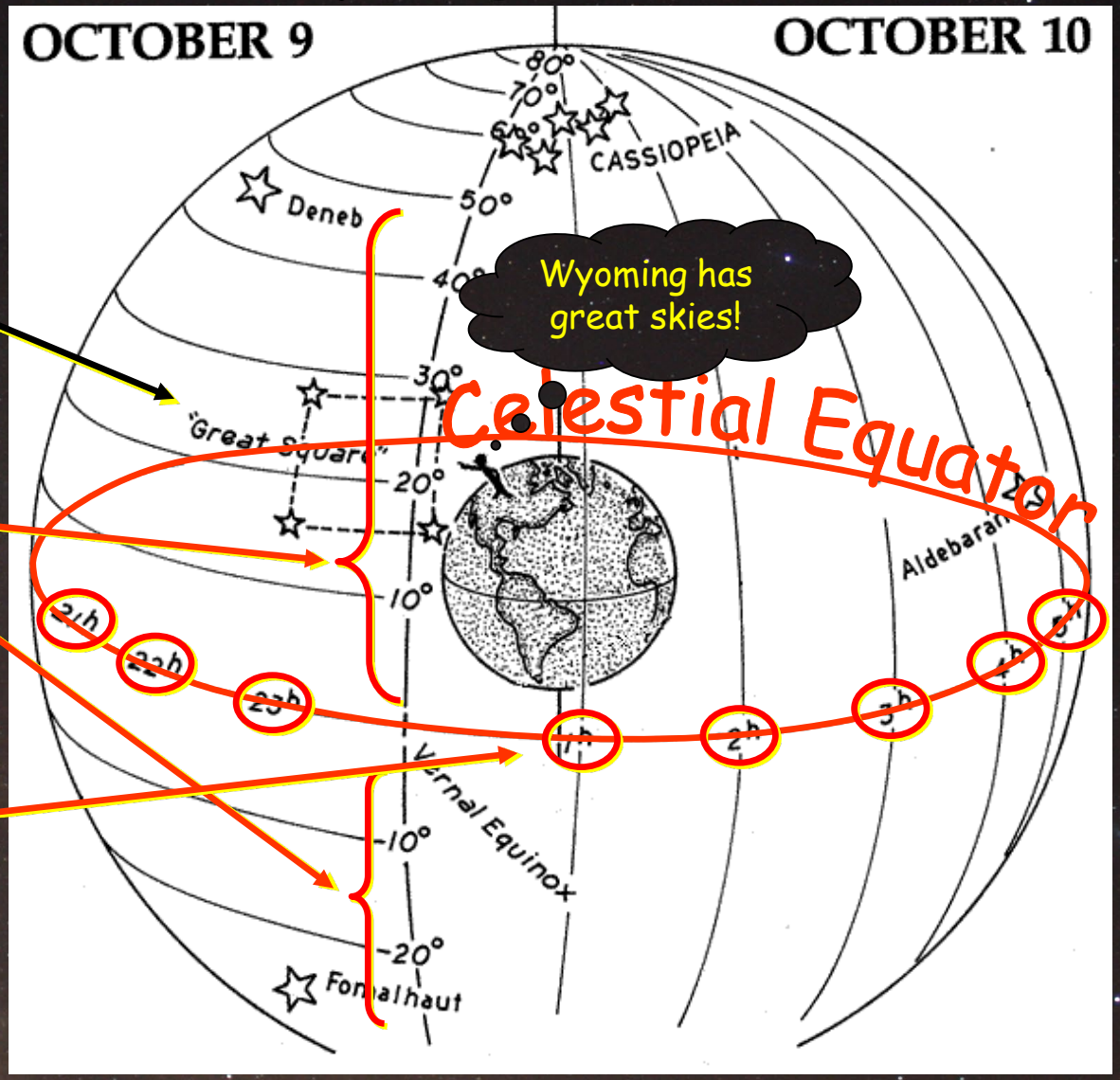


Photo by Marc Staves 2011

Observers On Earth

☆ See different sky depending on Latitude

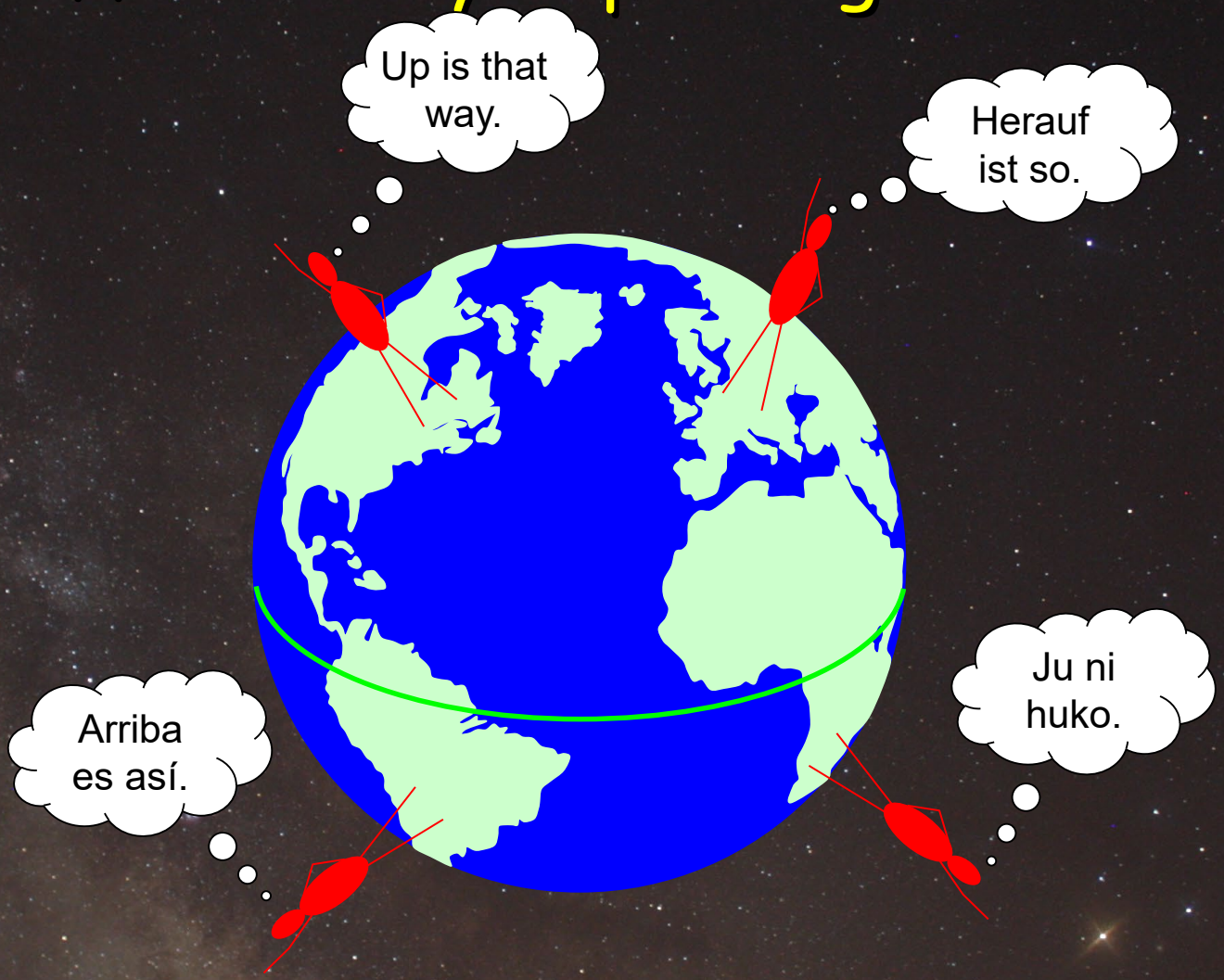


Photo by Marc Staves 2011

Tilted Sky

☆ Observers see sky "tilted" due to latitude

We see ourselves "on top" of the Earth, beneath the sky.

So we see sky motions tilted

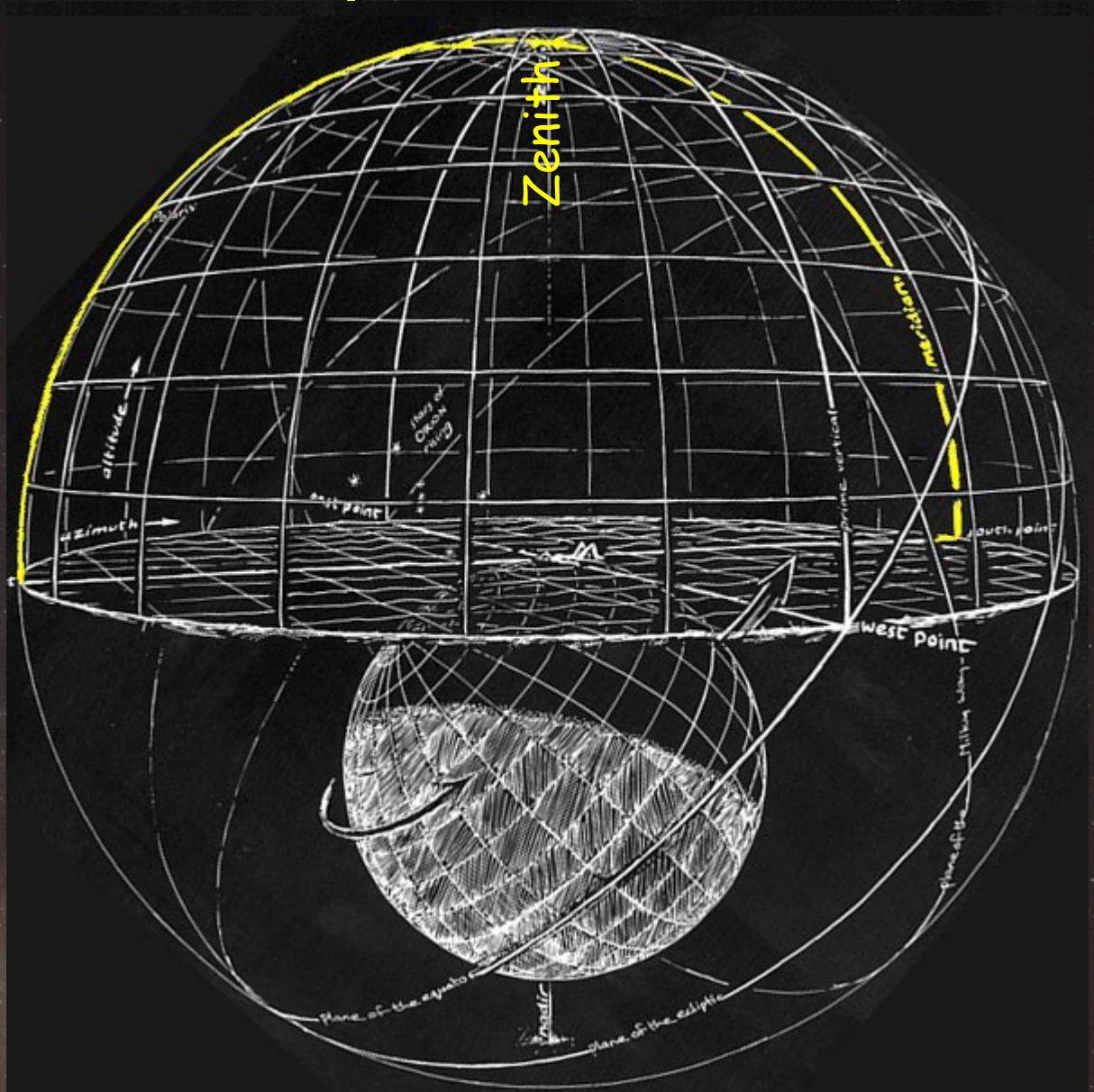


Photo by Marc Staves 2011

Tilted Sky

☆ Fun with your mind …

Try to see yourself held to the bottom of Earth by gravity looking "down" at the sky!

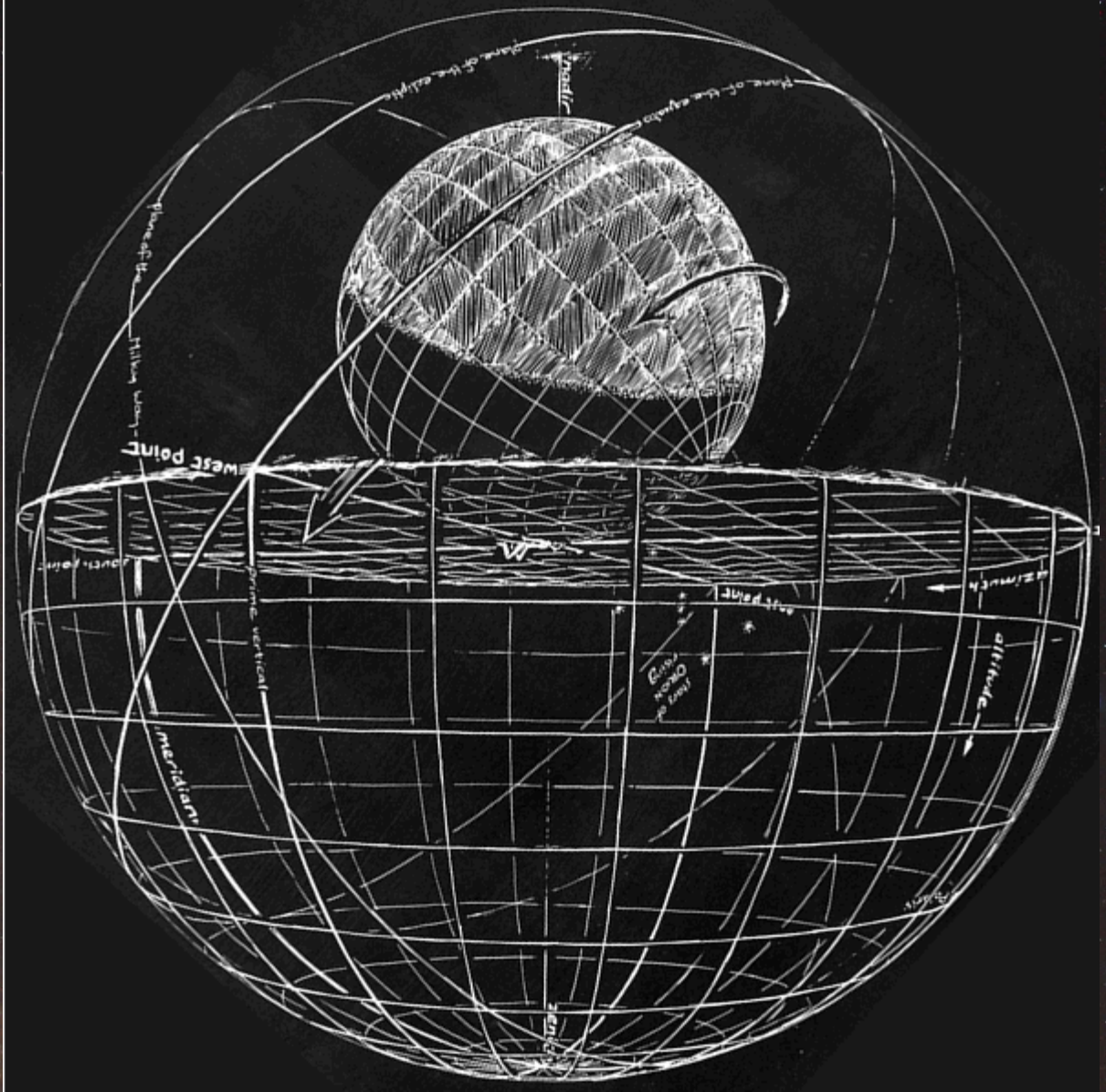


Photo by Marc Staves 2011

Viewing the Sky

☆ Observers see celestial reference points at angles related to their latitude

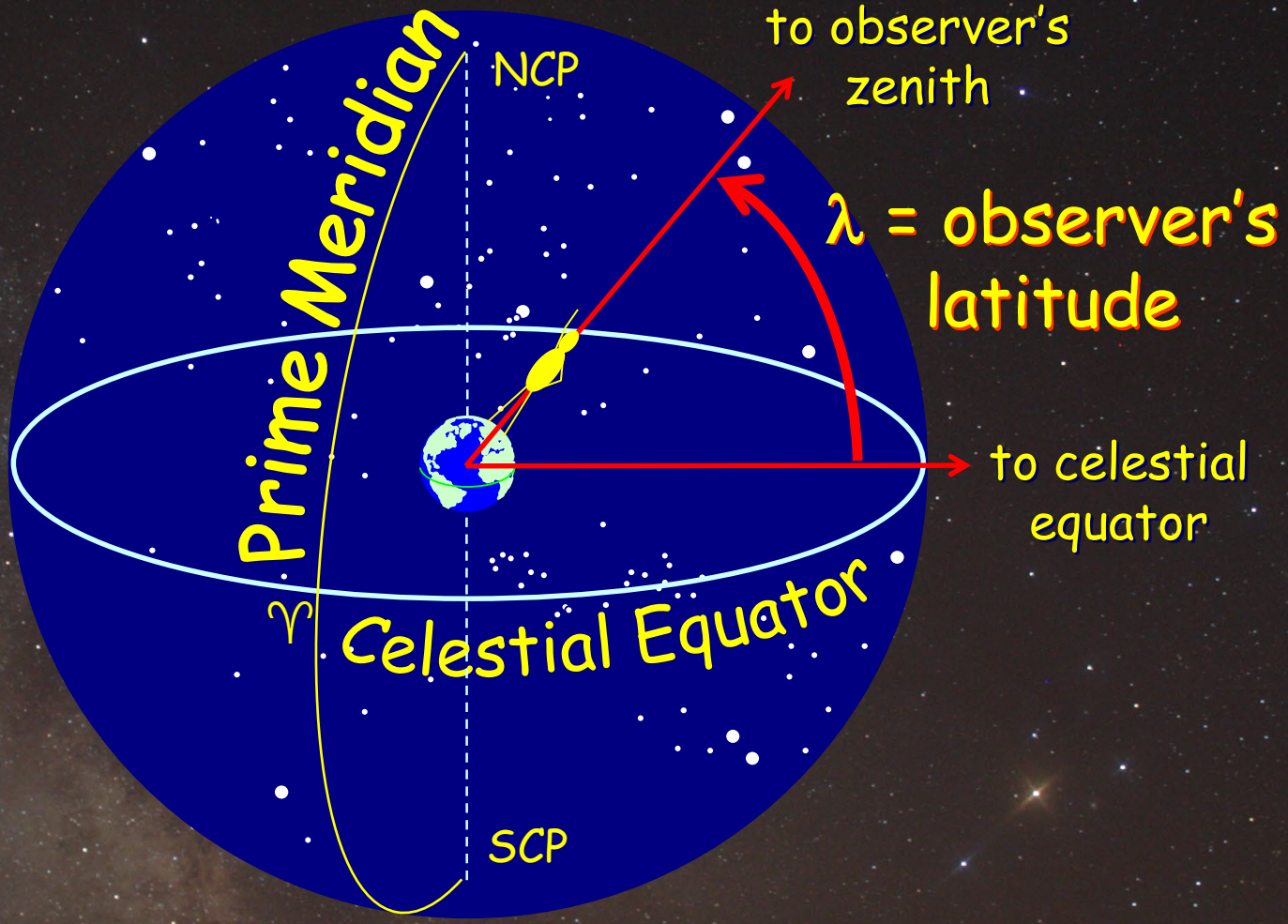
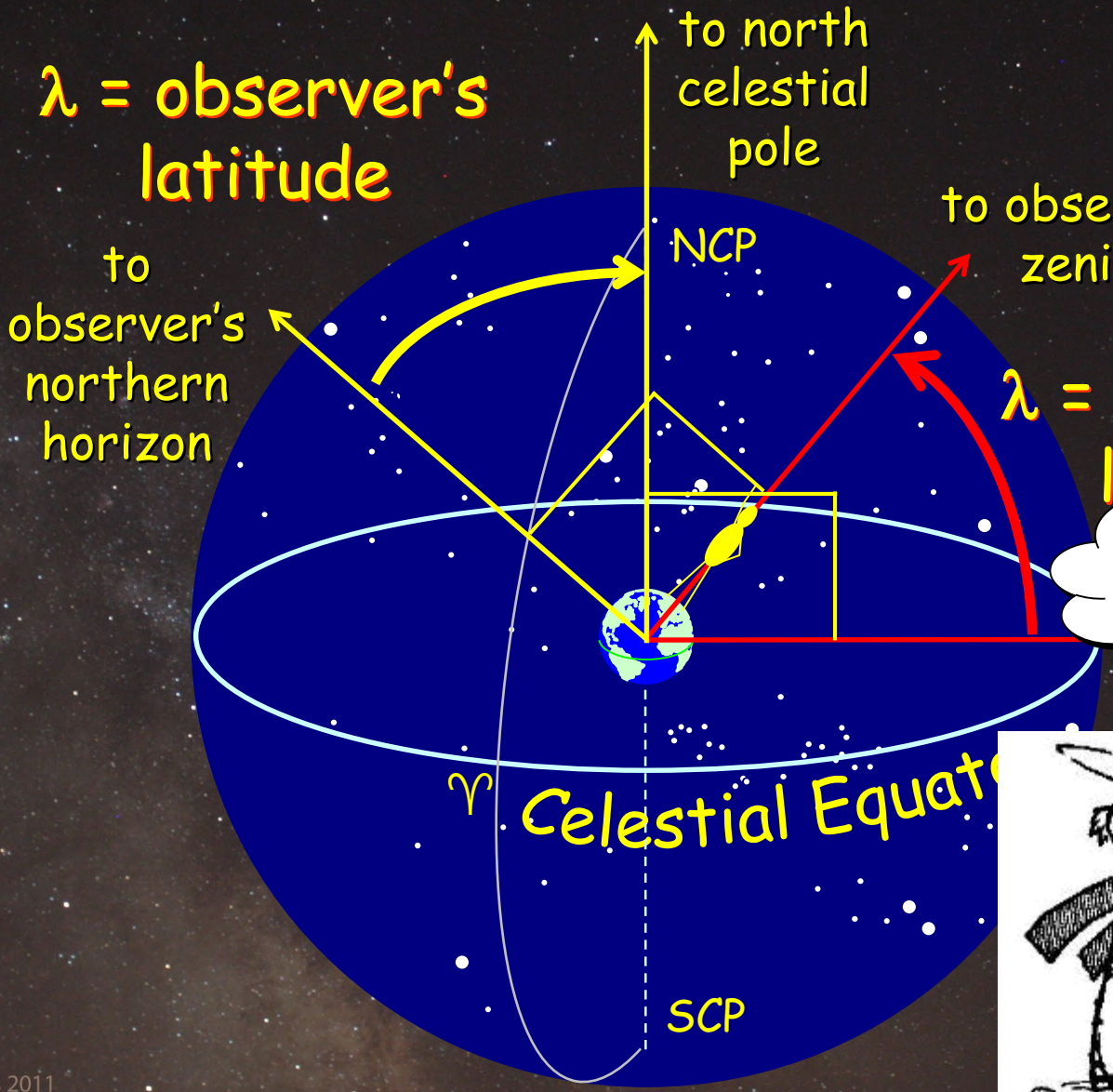


Photo by Marc Staves 2011

Sky Angles



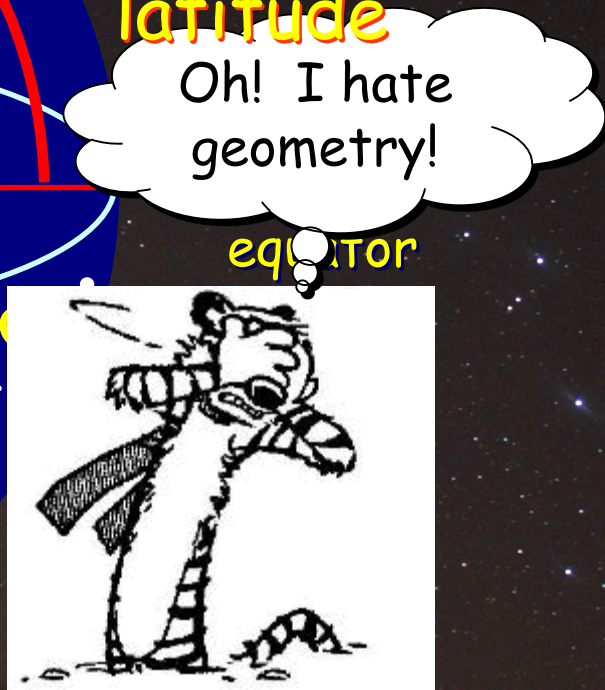


Photo by Marc Staves 2011

Earth Observer's View

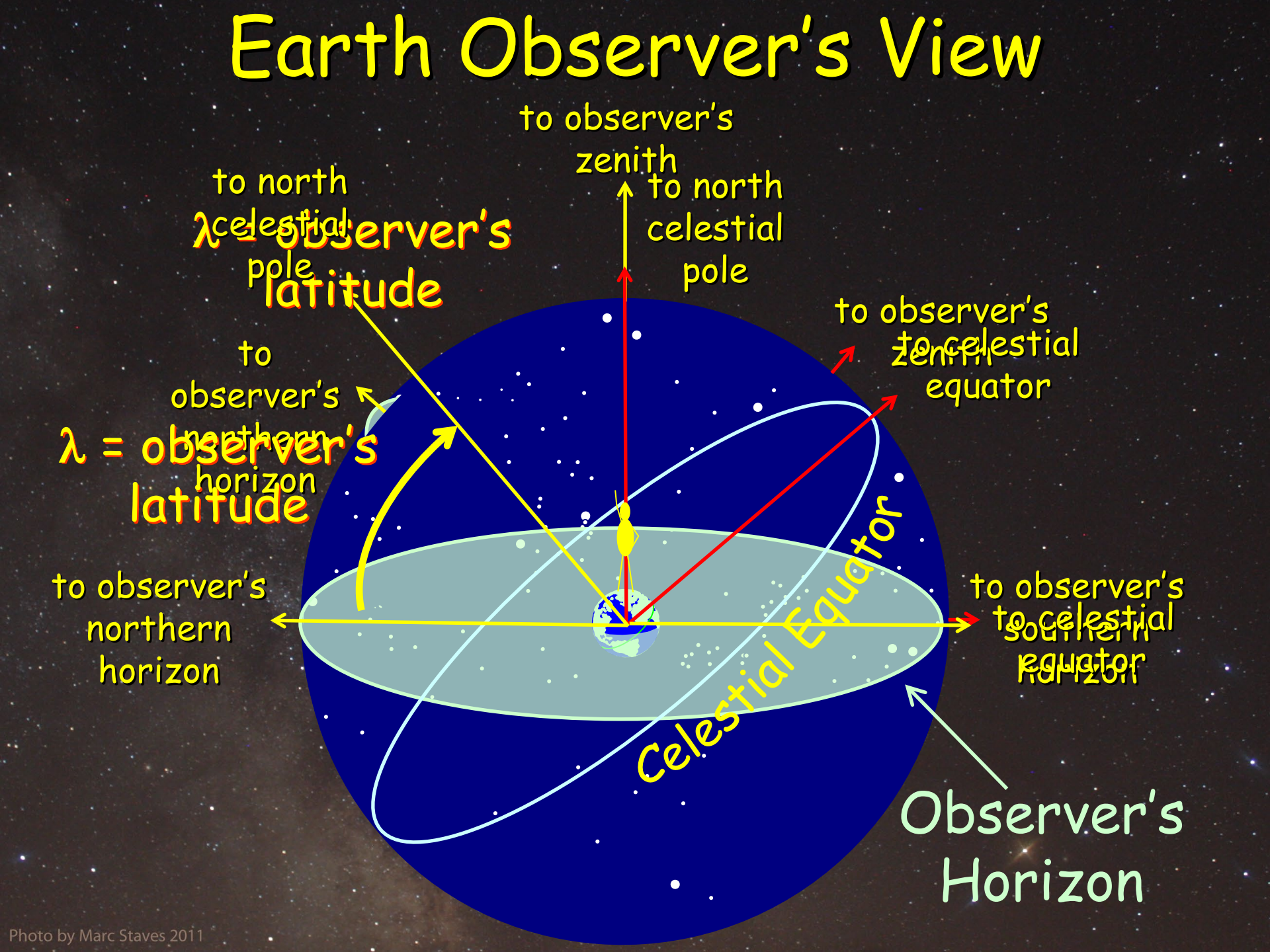


Photo by Marc Staves 2011

Altitude & Azimuth

- Position of an object in the sky
  - Azimuth = Angle from north through east
  - Altitude = Angle from horizon to object

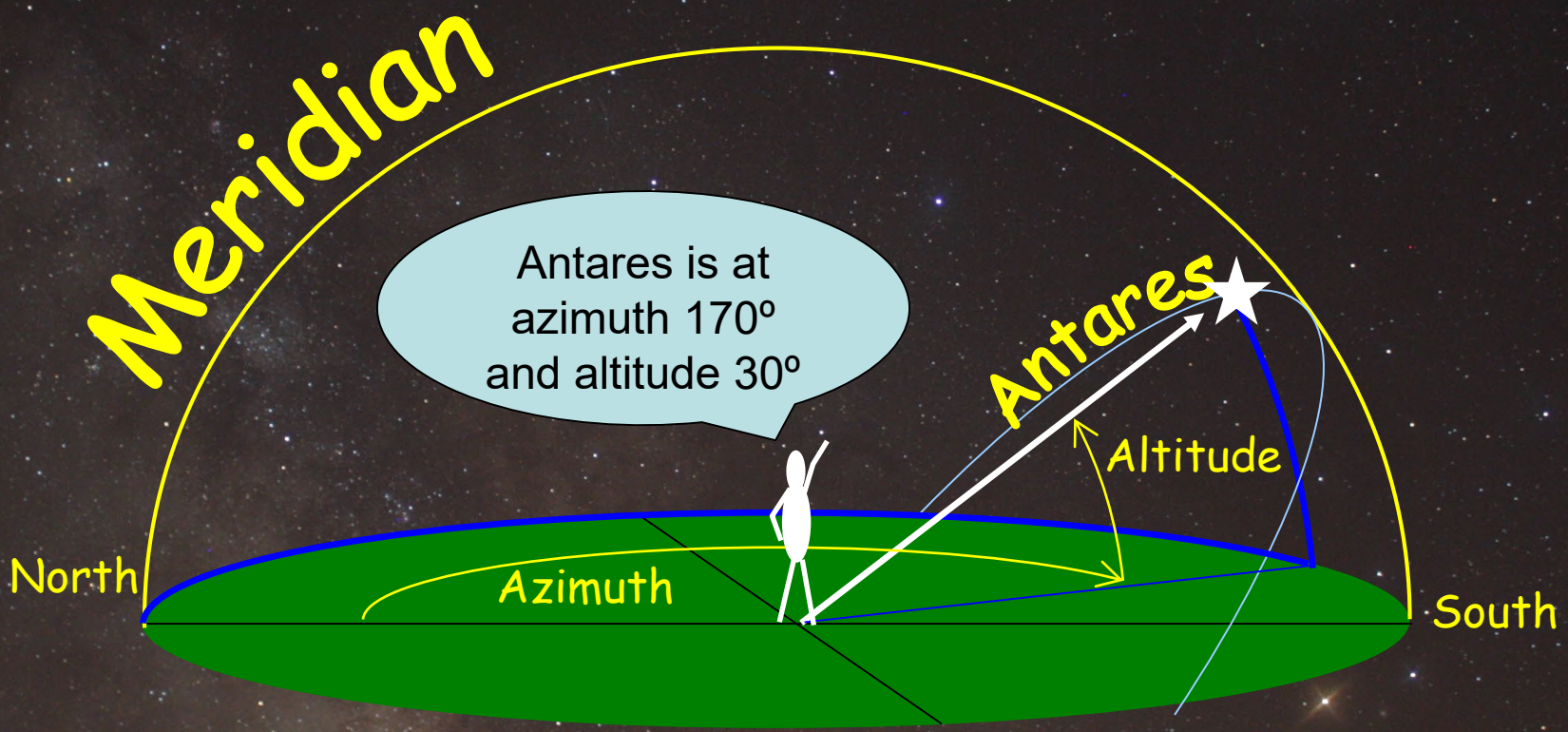


Photo by Marc Staves 2011

Azimuth

☆ Angle from North through East

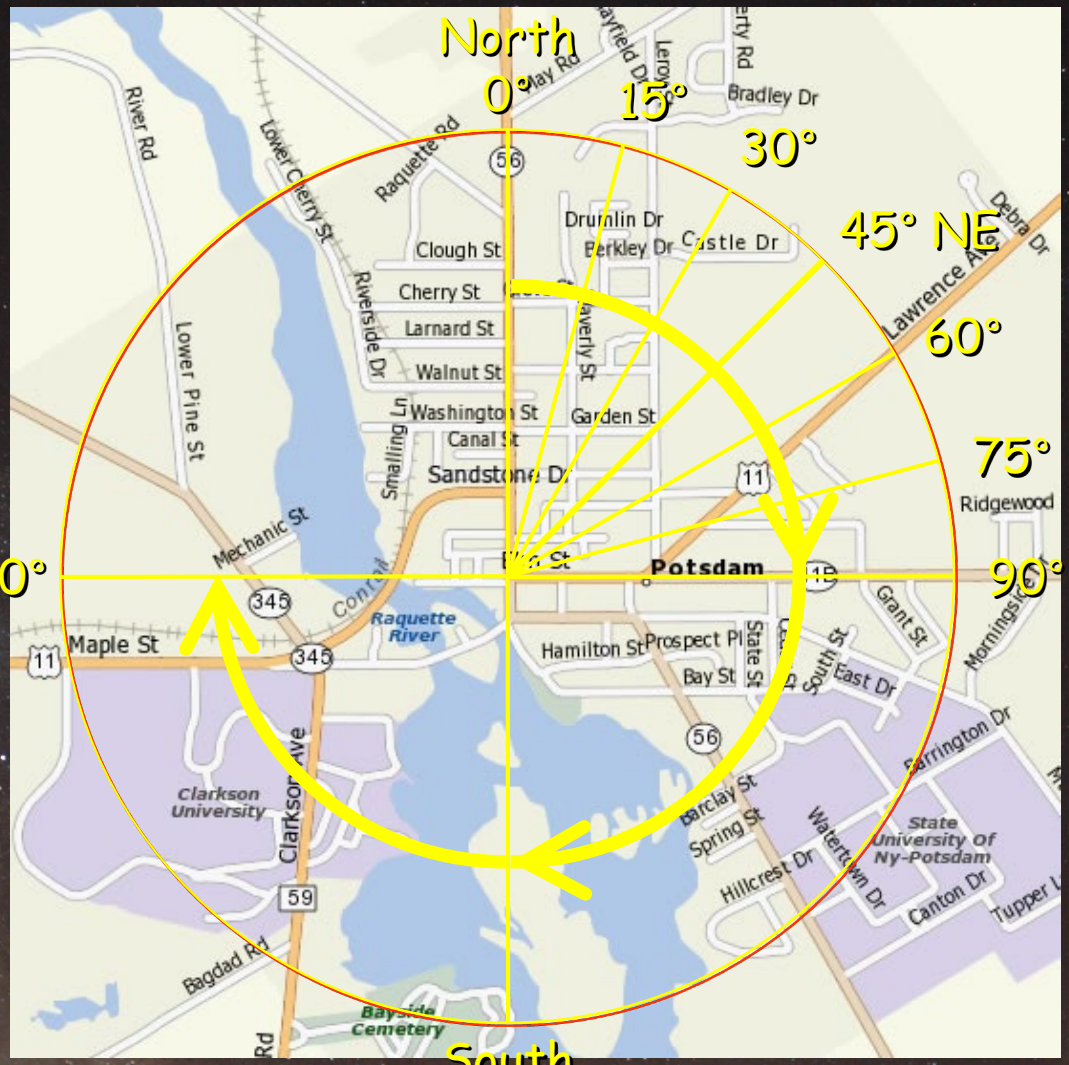
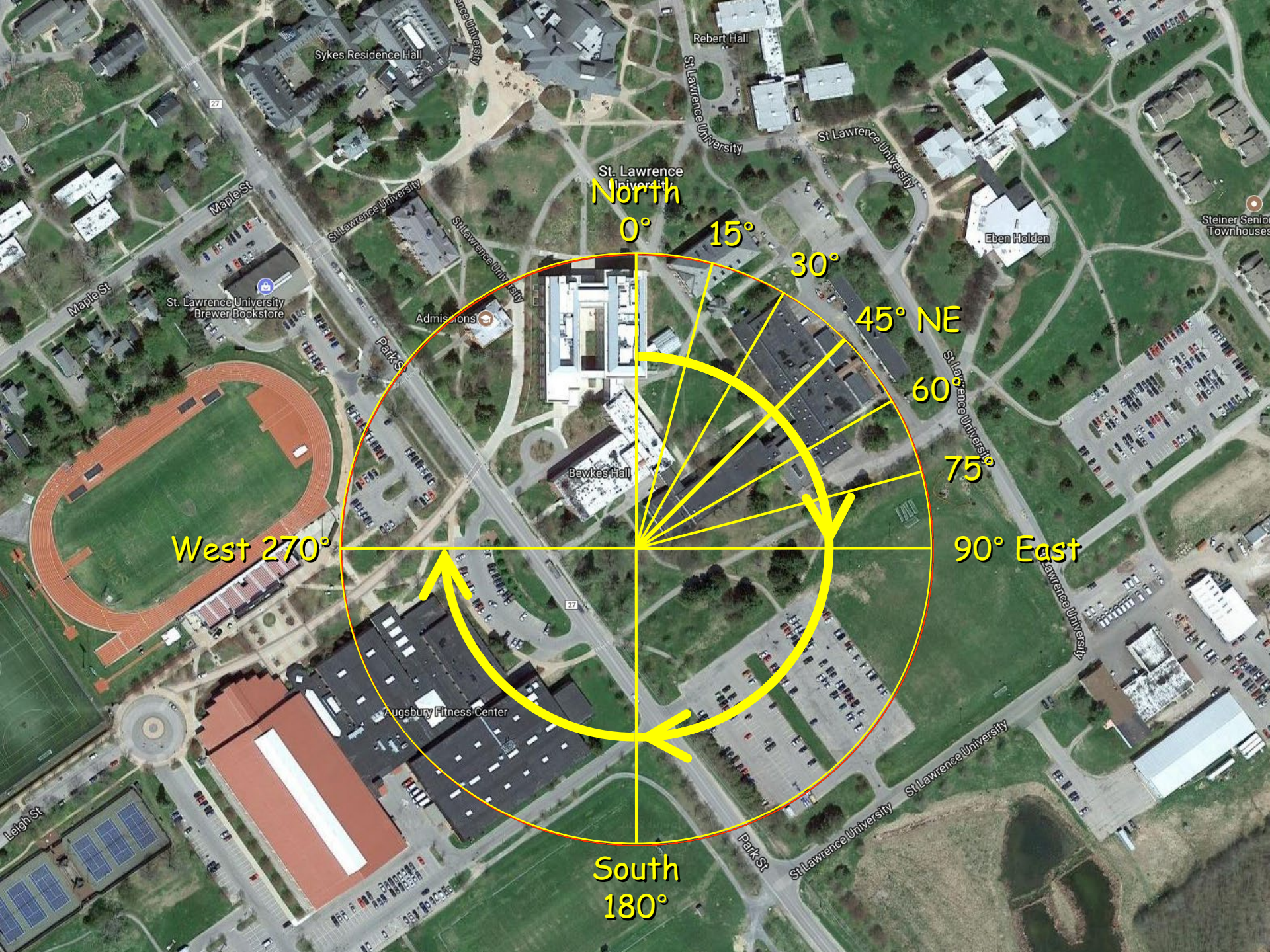
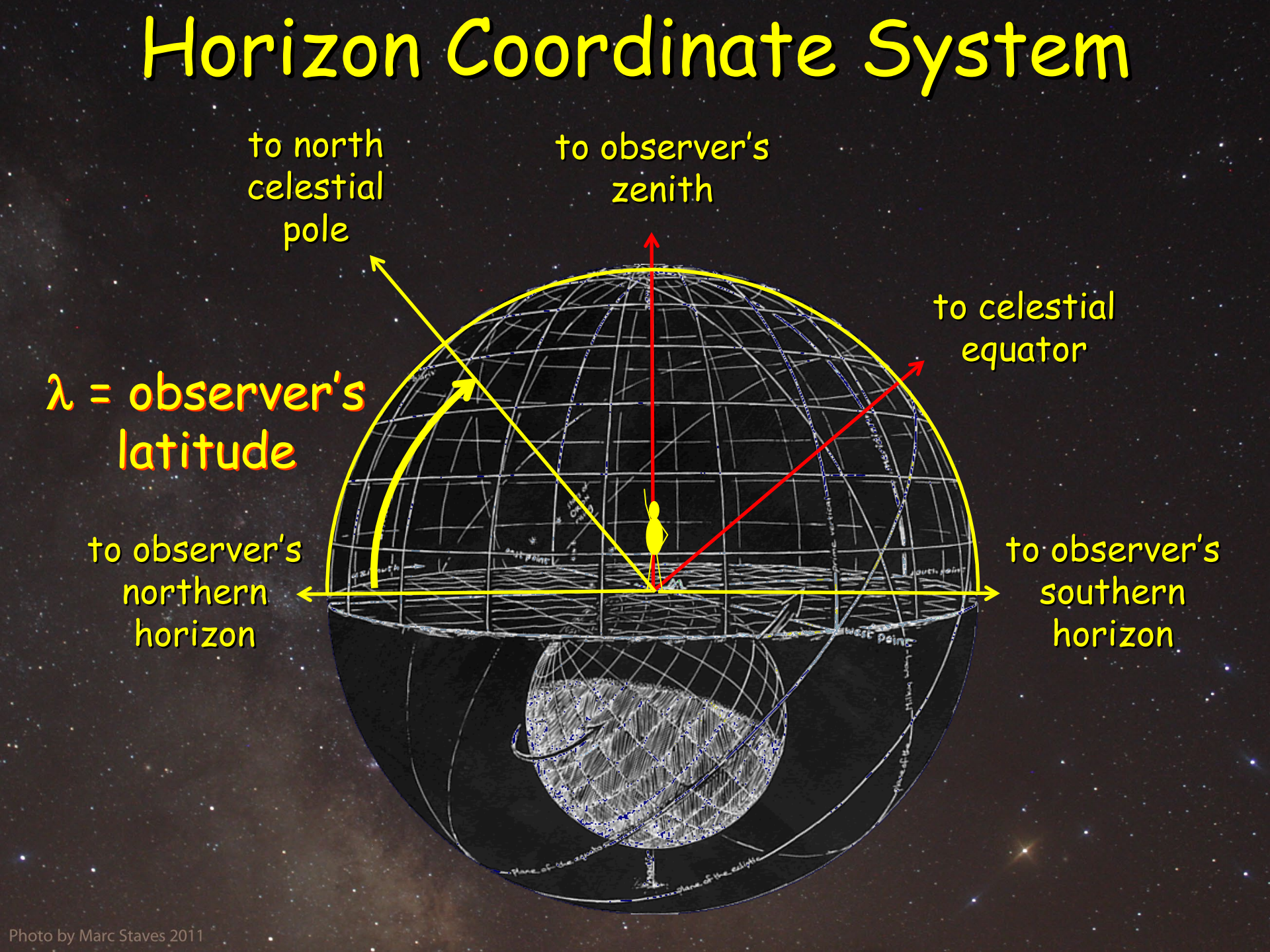


Photo by Marc Staves 2011


North
0°
15°
30°
45° NE
60°
75°
90° East
South
180°
West 270°
Sykes Residence Hall
Rebert Hall
St Lawrence University
Eben Holden
Steiner Senior Townhouses
Maple St
St. Lawrence University Brewer Bookstore
Admissions
Park St
Bewkes Hall
Augsbury Fitness Center
Leigh St
27

Horizon Coordinate System



Horizon Coordinate System

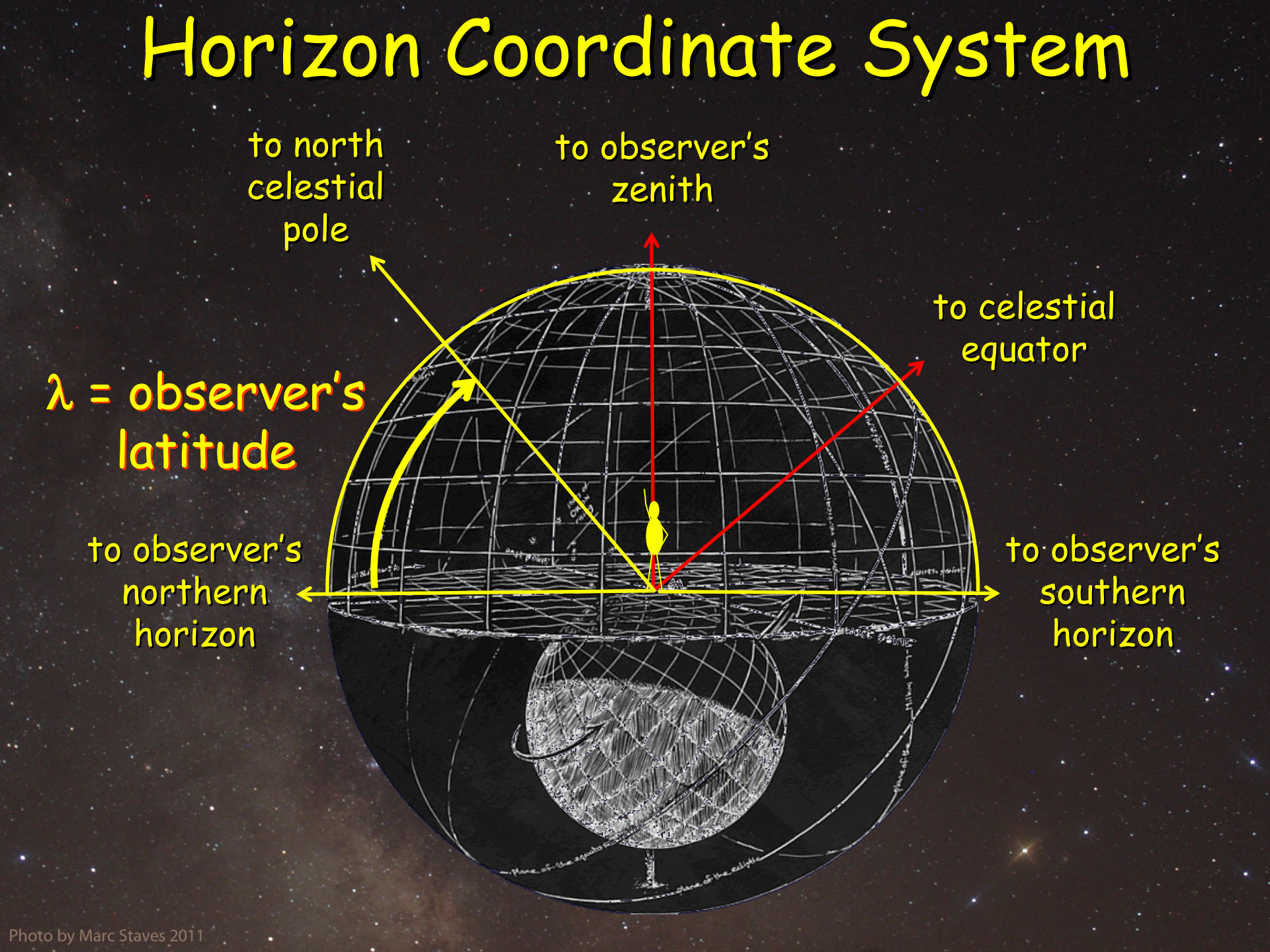
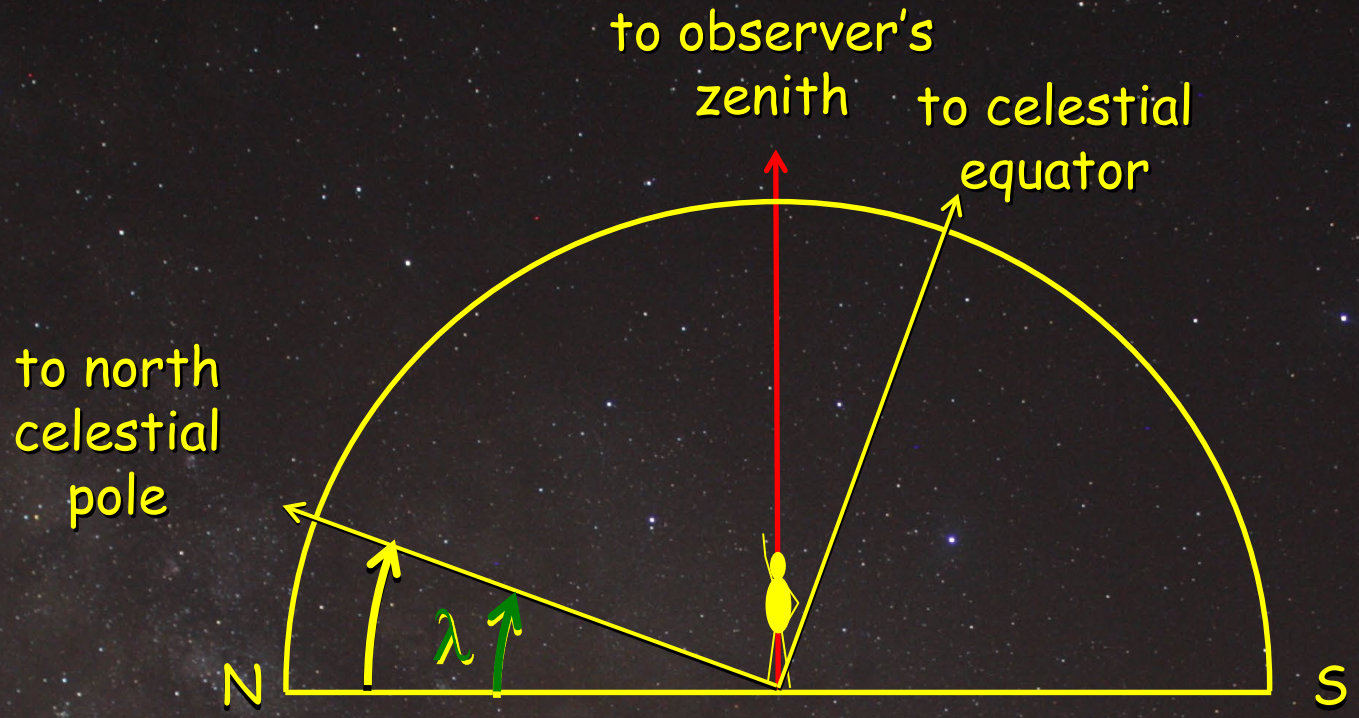


Photo by Marc Staves 2011

Question

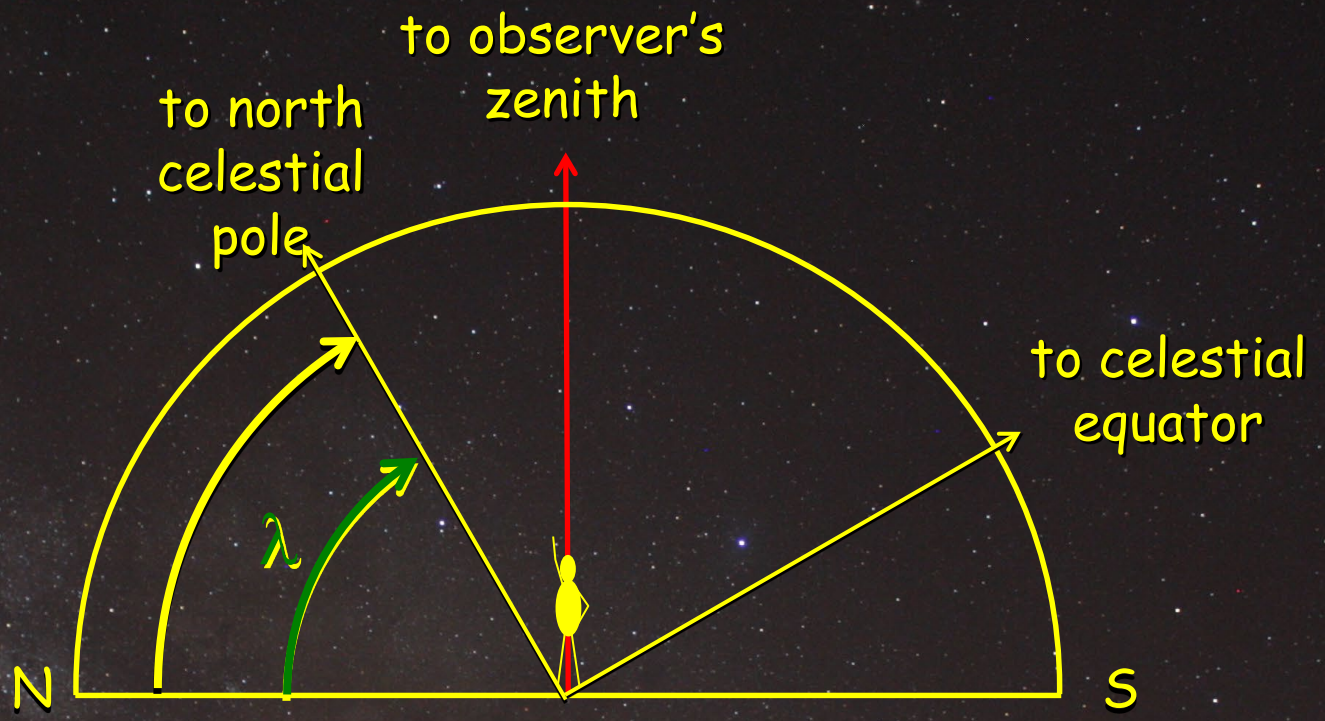


What's the observer's latitude?

a) 70° N **b) 20° N**

Photo by Marc Staves 2011

Question



What's the observer's latitude?

a) 60° N b) 30° N

Photo by Marc Staves 2011

Diurnal Circles

- ☆ Each celestial object circles the observer each day
- ☆ Observer sees part of each circle

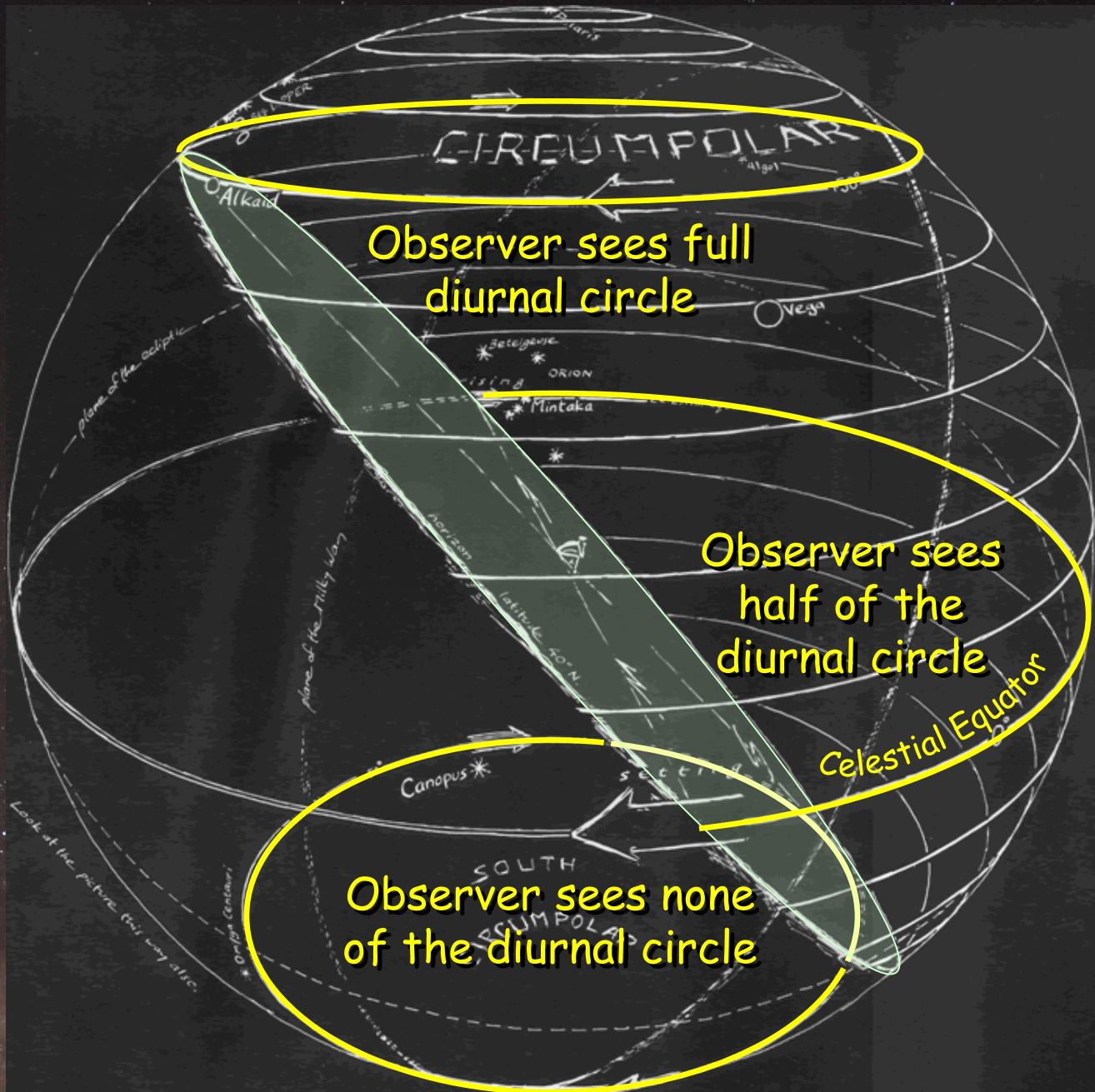
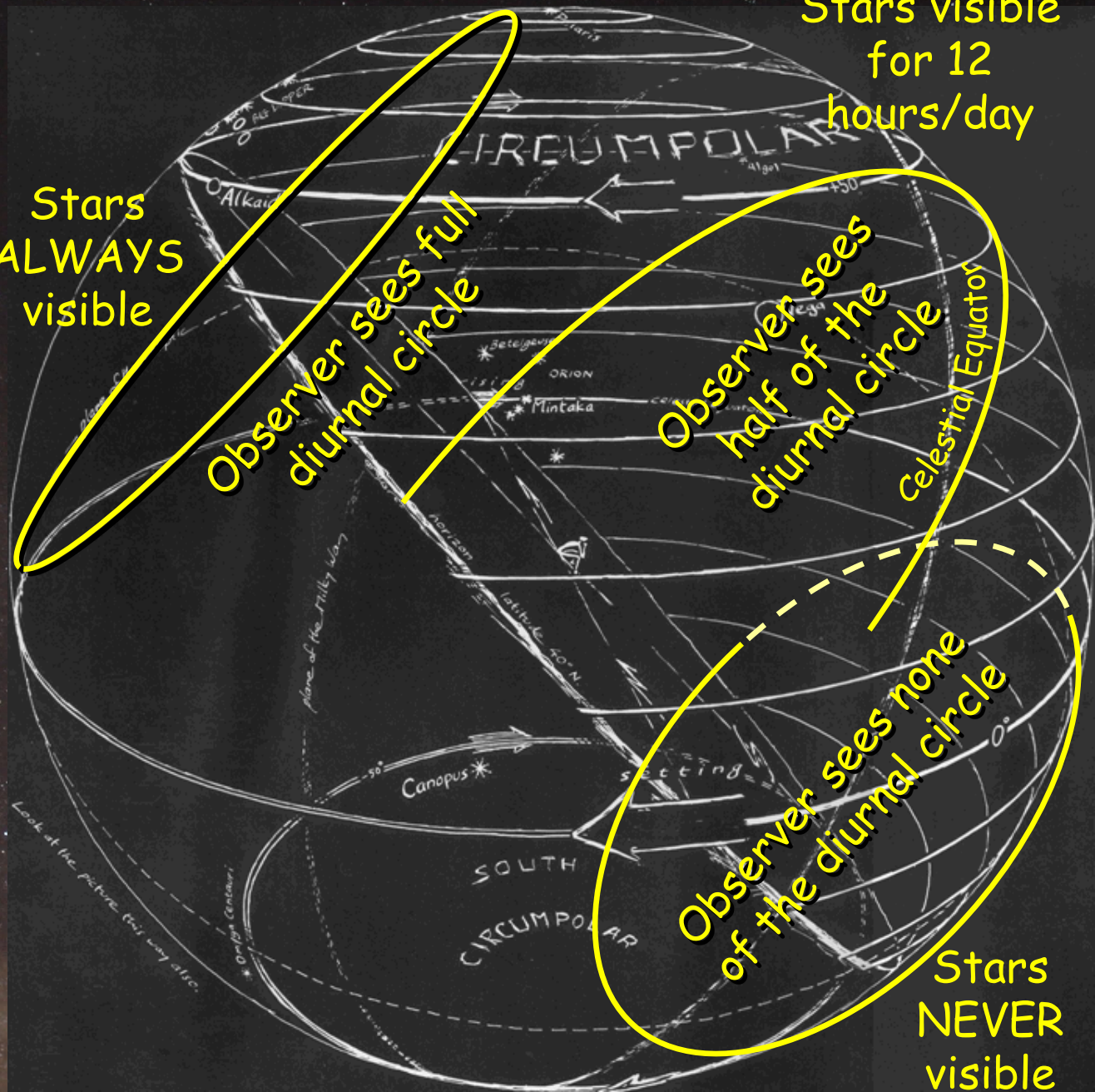


Photo by Marc Staves 2011

View of Observer



Rotate into the observer's frame of reference

Photo by Marc Staves 2011

View of Observers

- ☆ Diurnal circles are parallel to CE
  - 🌎 Stars rise and set at CE's angle from horizon

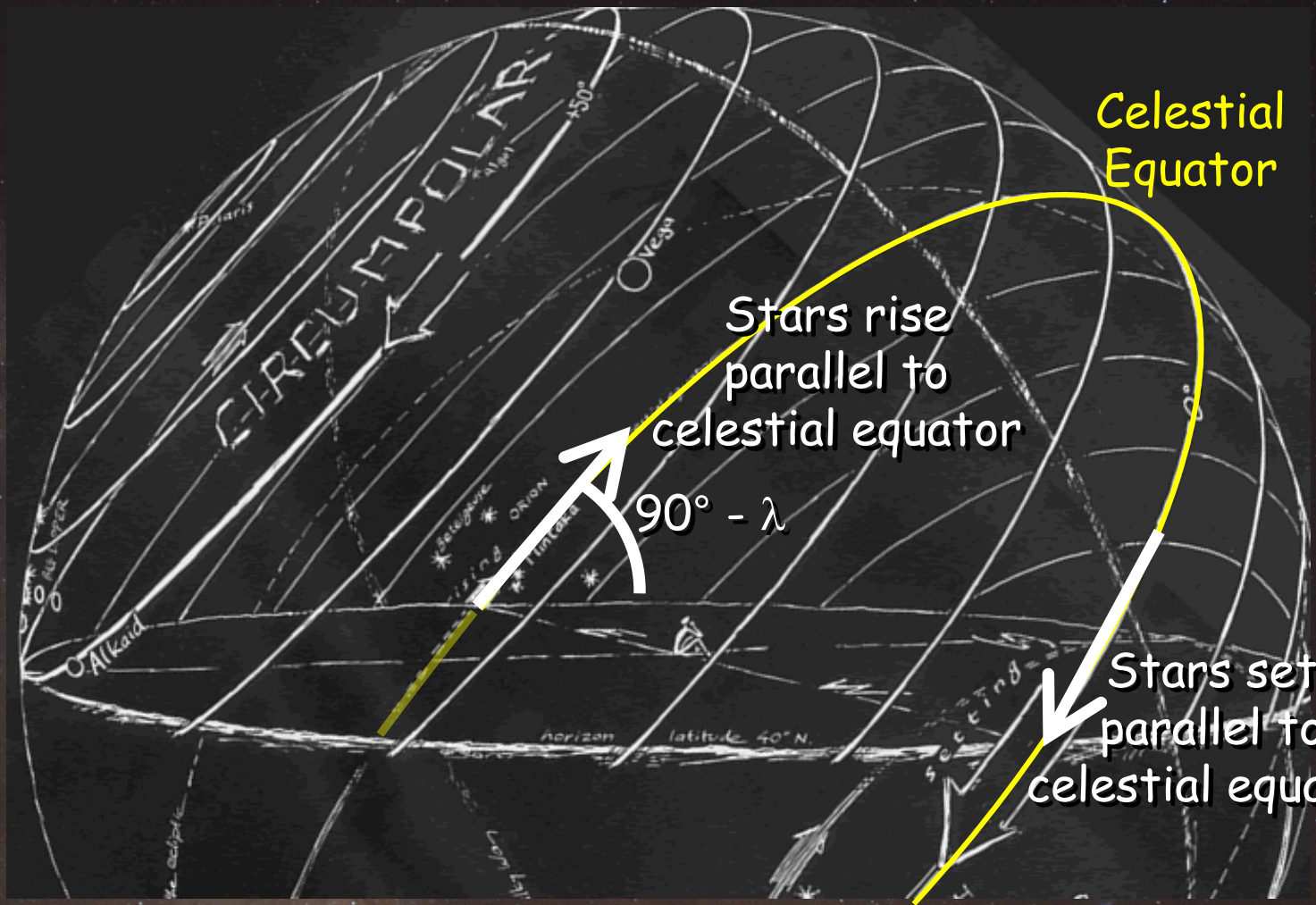


Photo by Marc Staves 2011

Star Paths

- Each travels a diurnal circle
  - Portion of diurnal circle above horizon determines time object is "up"

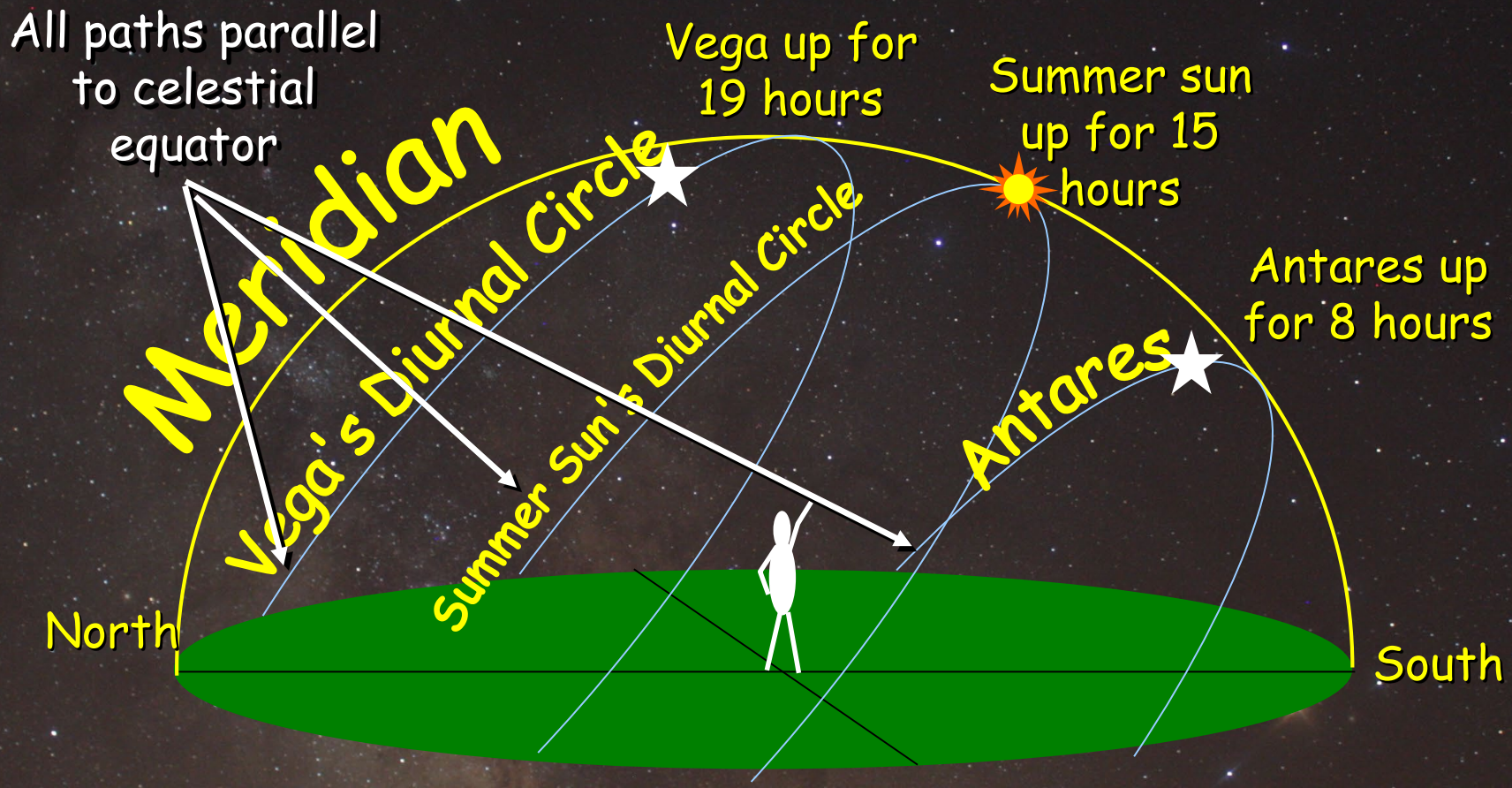


Photo by Marc Staves 2011

Question

Which observer(s) would see the star travel on the diurnal circle shown?

a)

b)

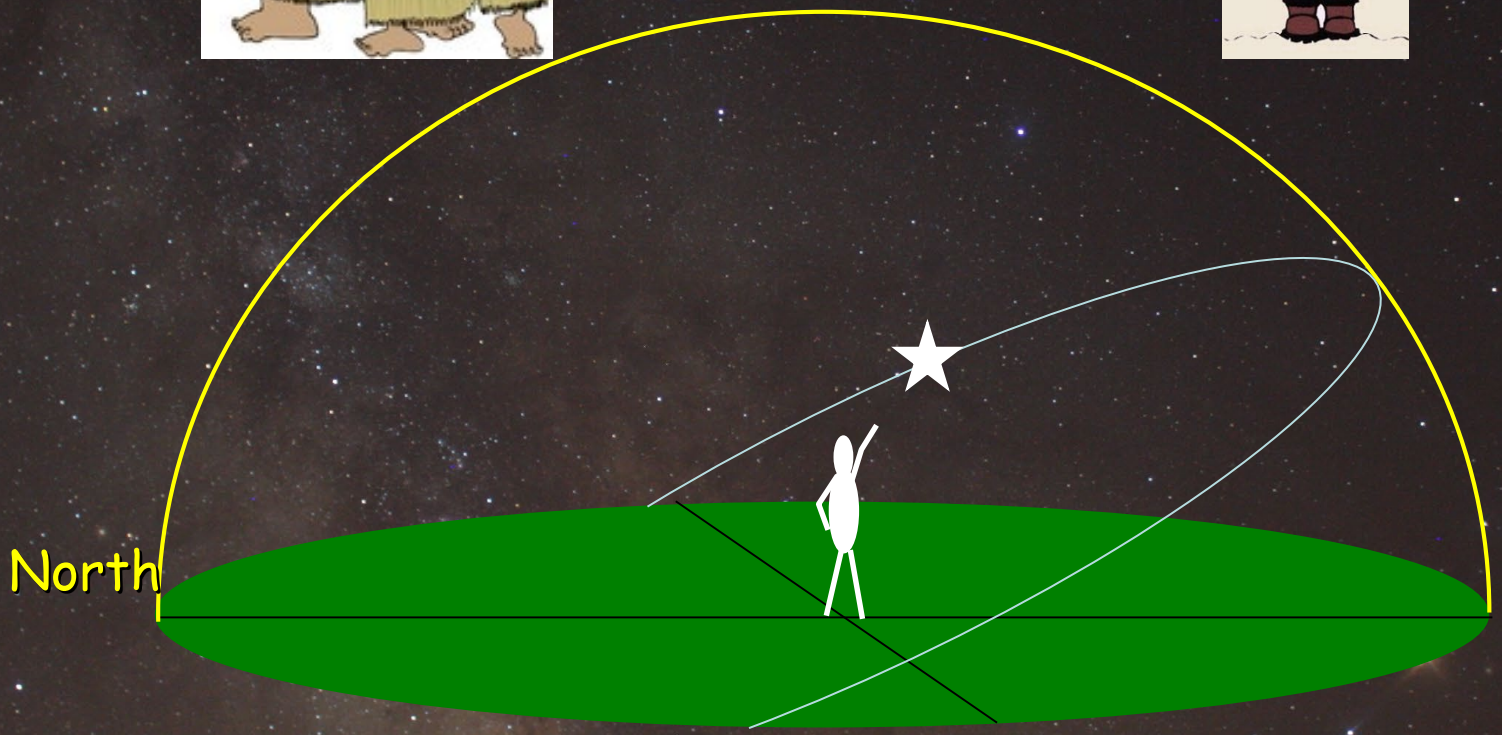


Photo by Marc Staves 2011

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a)

b)

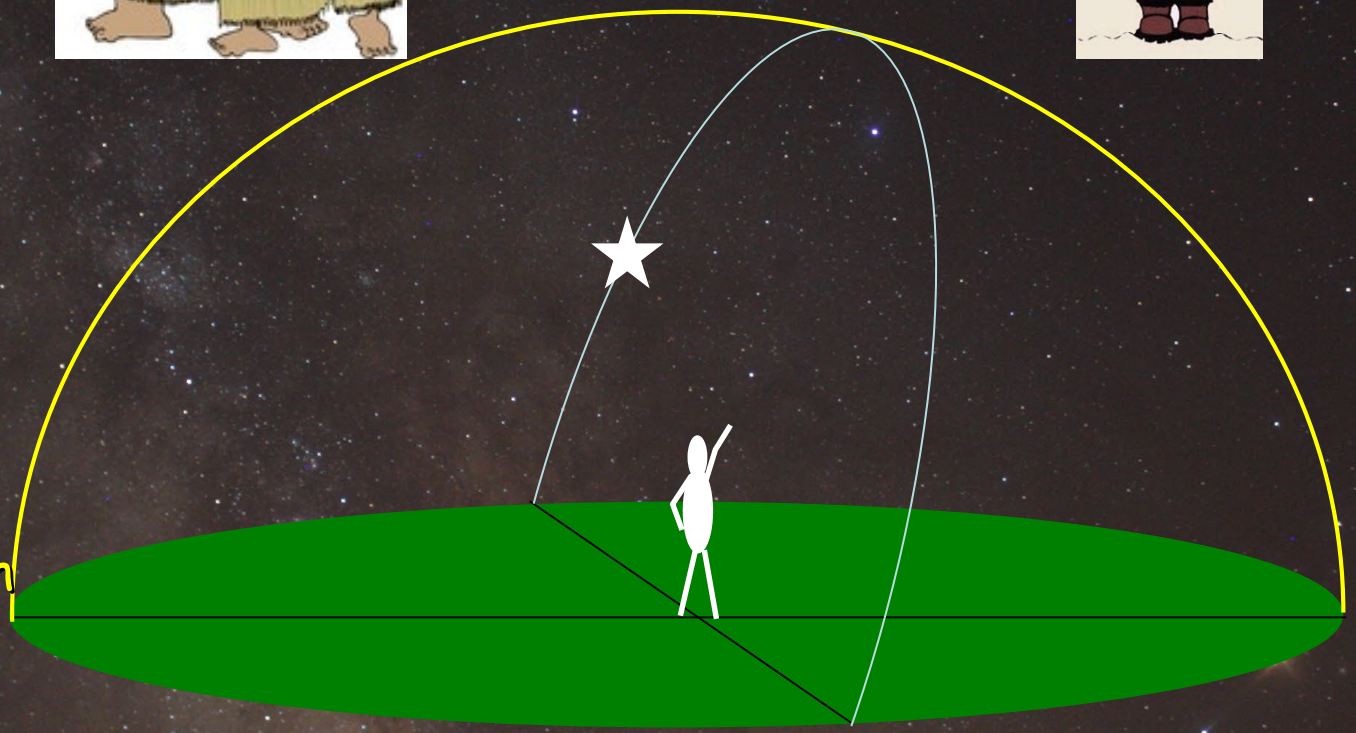
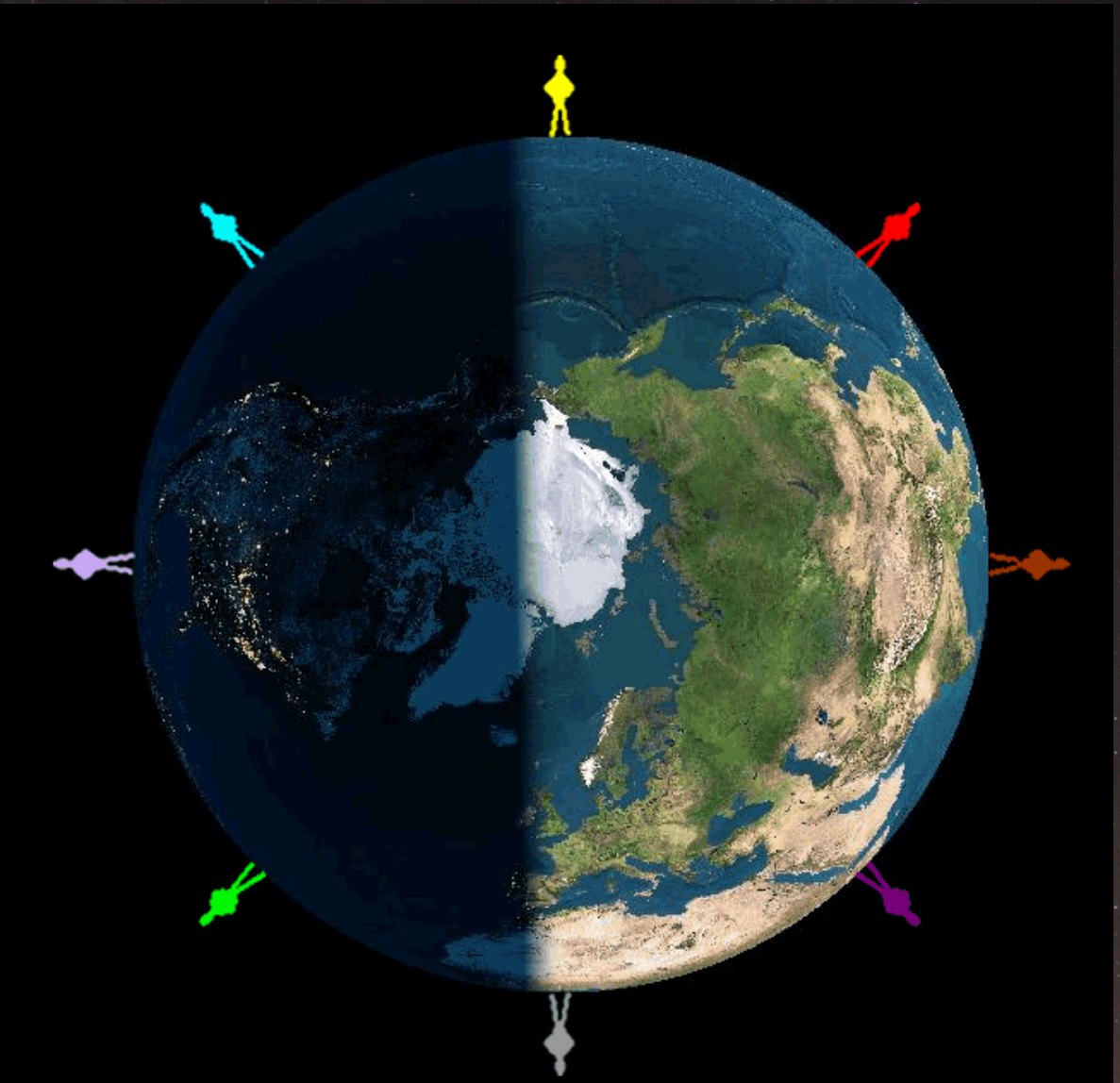


Photo by Marc Staves 2011

Time of day

☆ Earth Rotates Once Each Day



- 360° with respect to Earth-Sun line
- All Earthlings ride along

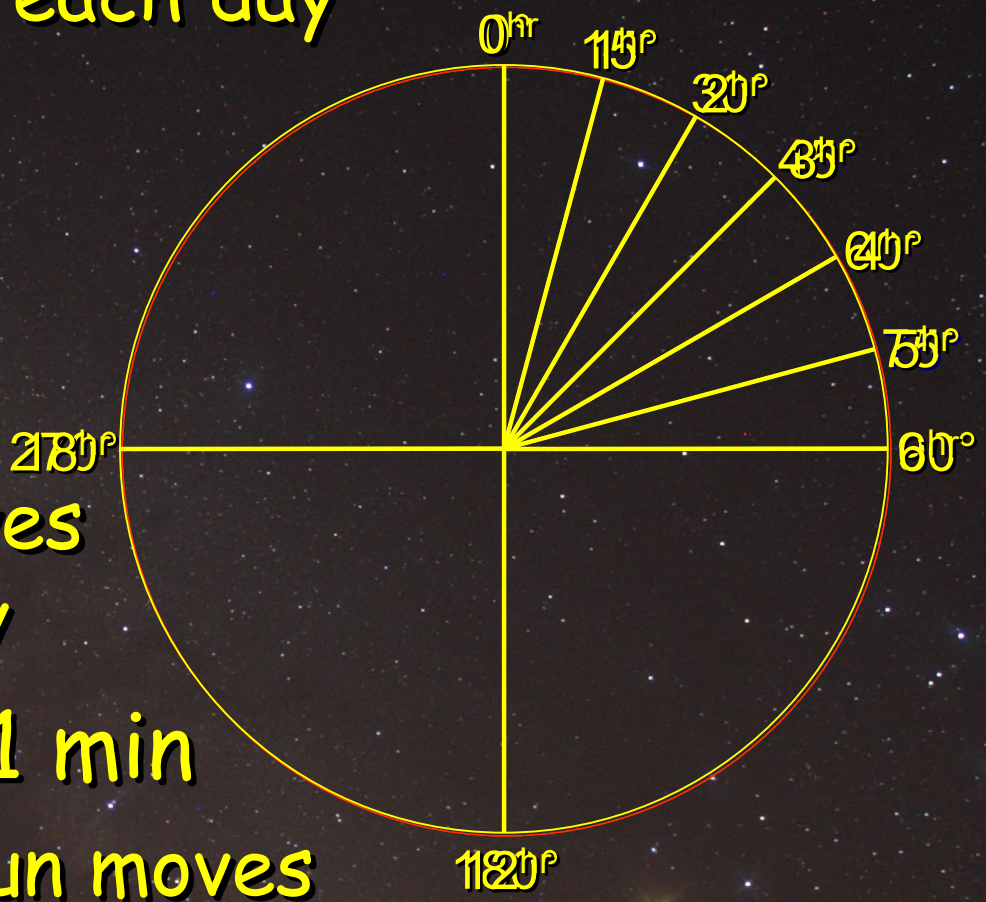
→ To Sol

Sunrise, Sunset …

☆ Everything in the sky (sun, moon, stars, etc.)

- Rises in the east
- Sets in the west

each day



Measuring Circles:

360° = 24 hr

15° = 1 hr

Each hour, the sun moves 15 degrees in the sky

1° = 4 min or 15′ = 1 min

Every 4 minutes, the sun moves 1 degree = 60′ in the sky

Photo by Marc Staves 2011

Observer's View of the Day

- ☆ Sun rises in east,
  moves 15°/hour from East to West
  transits at noon
  sets in west

Photo by Marc Staves 2011

Standard Clock Time

☆ Every Longitude at a different time

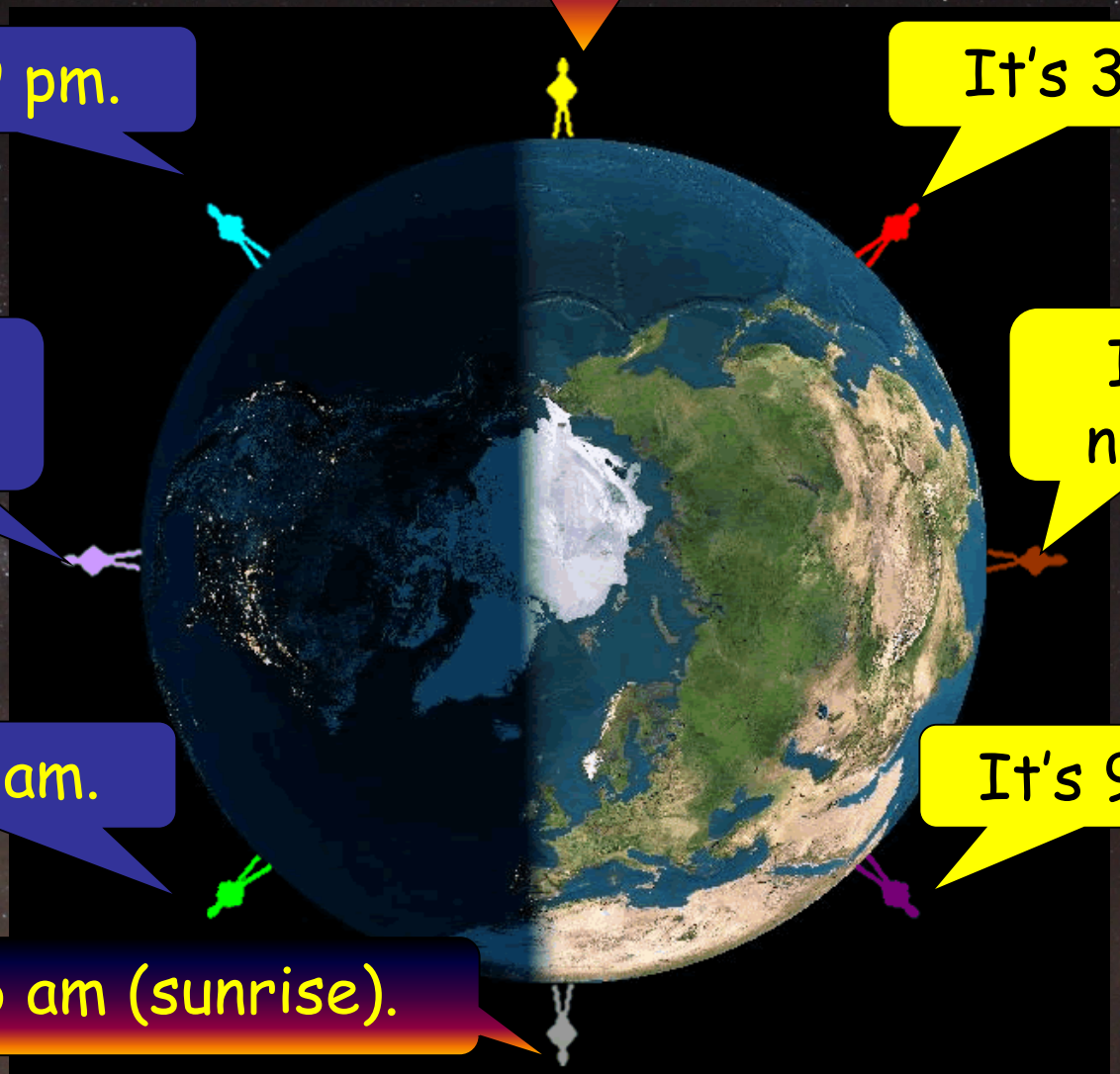


Photo by Marc Staves 2011

Clock Time = Position of Sol

☆ Observers move through times

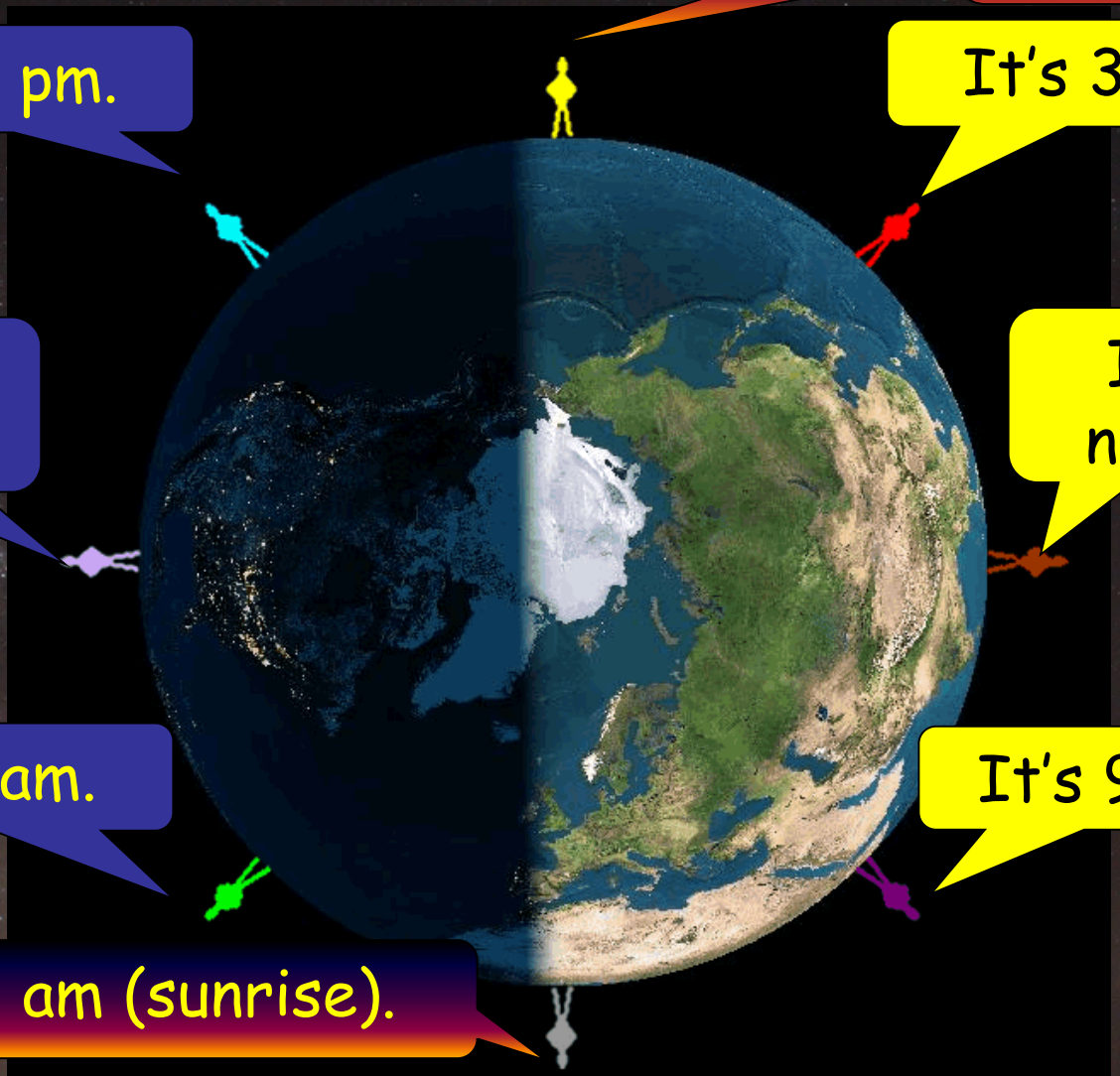


Photo by Marc Staves 2011

Daylight Saving Time

☆ Shifts times one h (USNO Explanation)

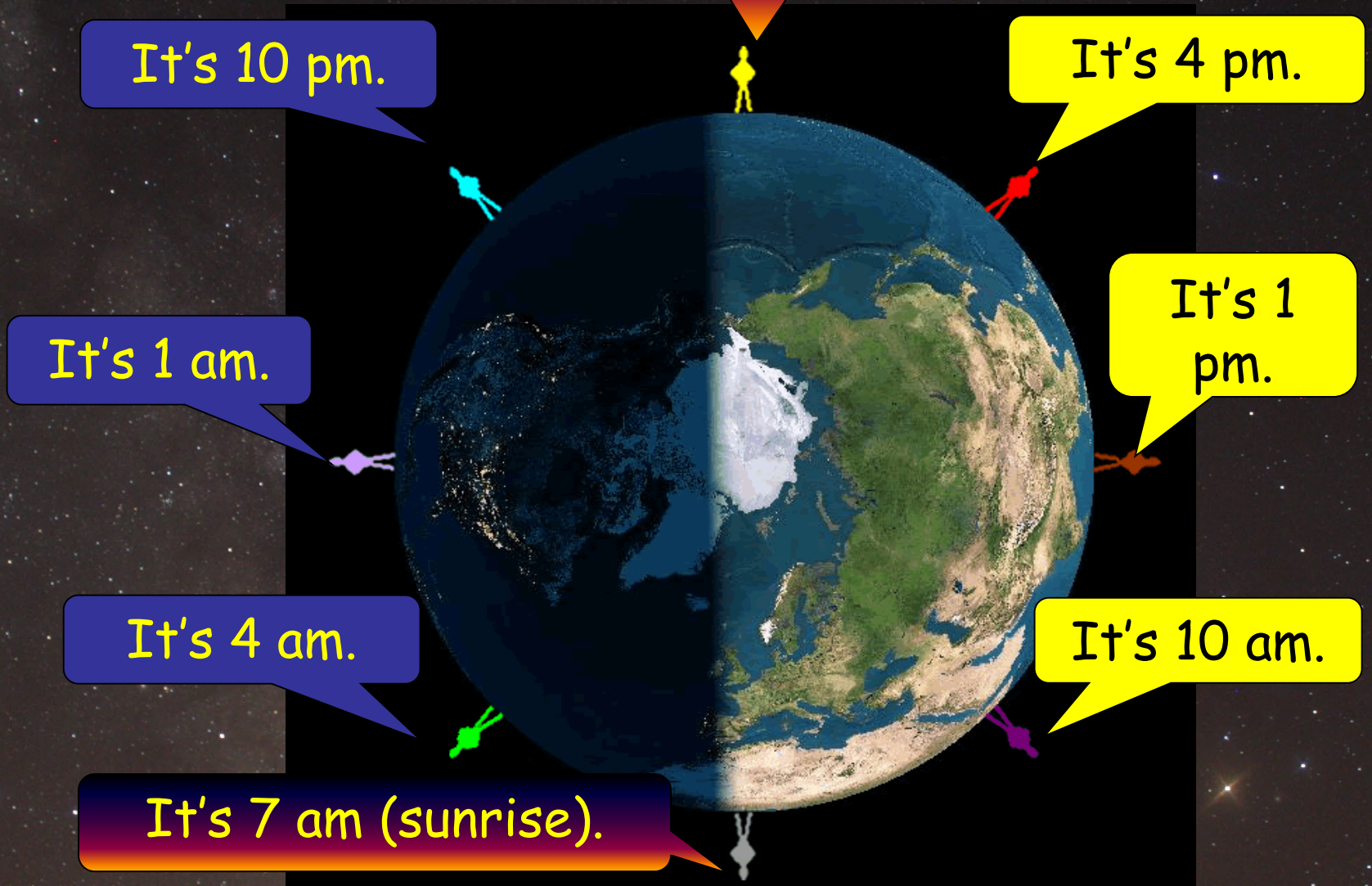


Photo by Marc Staves 2011

Clock Time

Time Zones:
24, roughly
15° apart

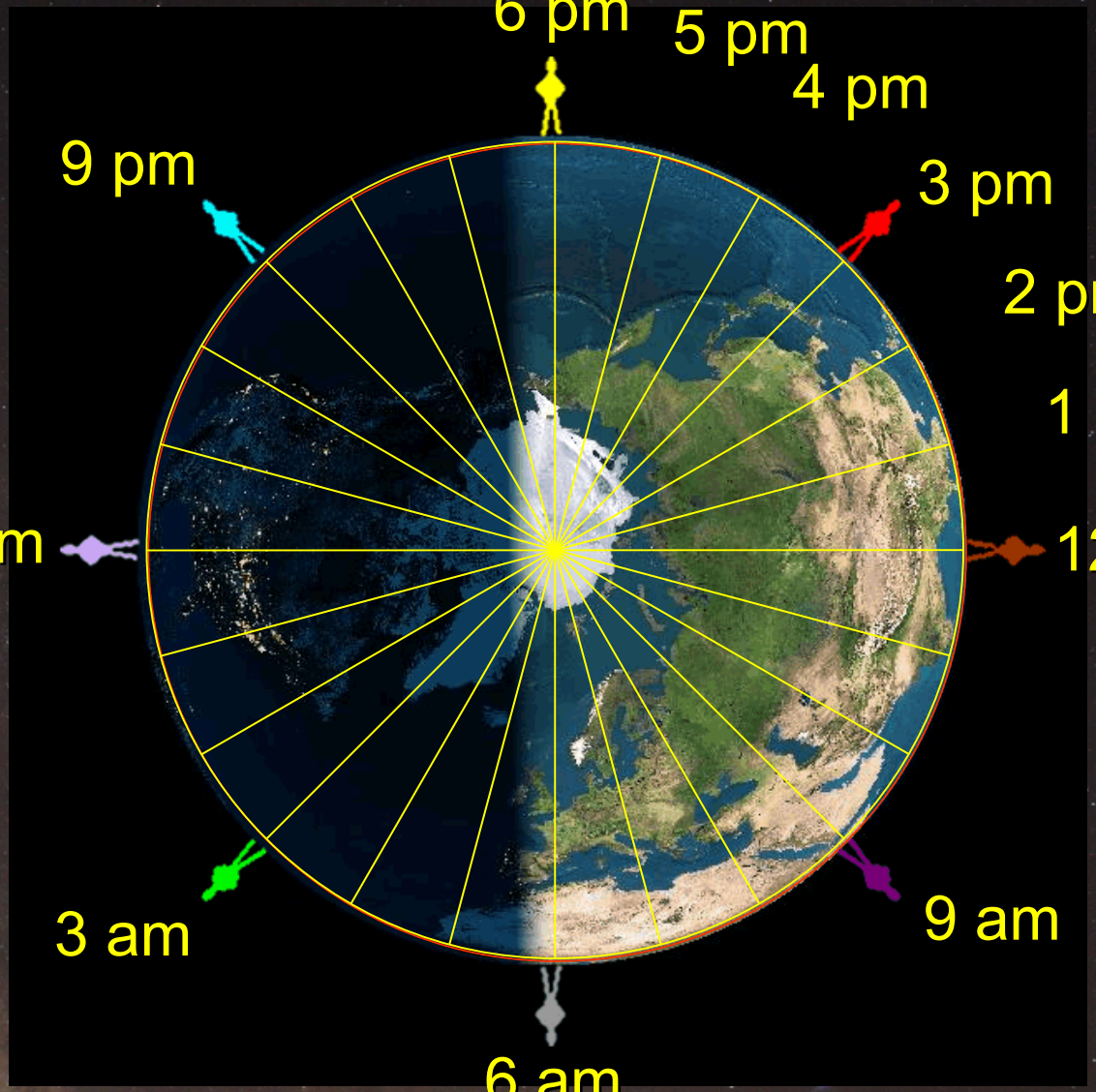
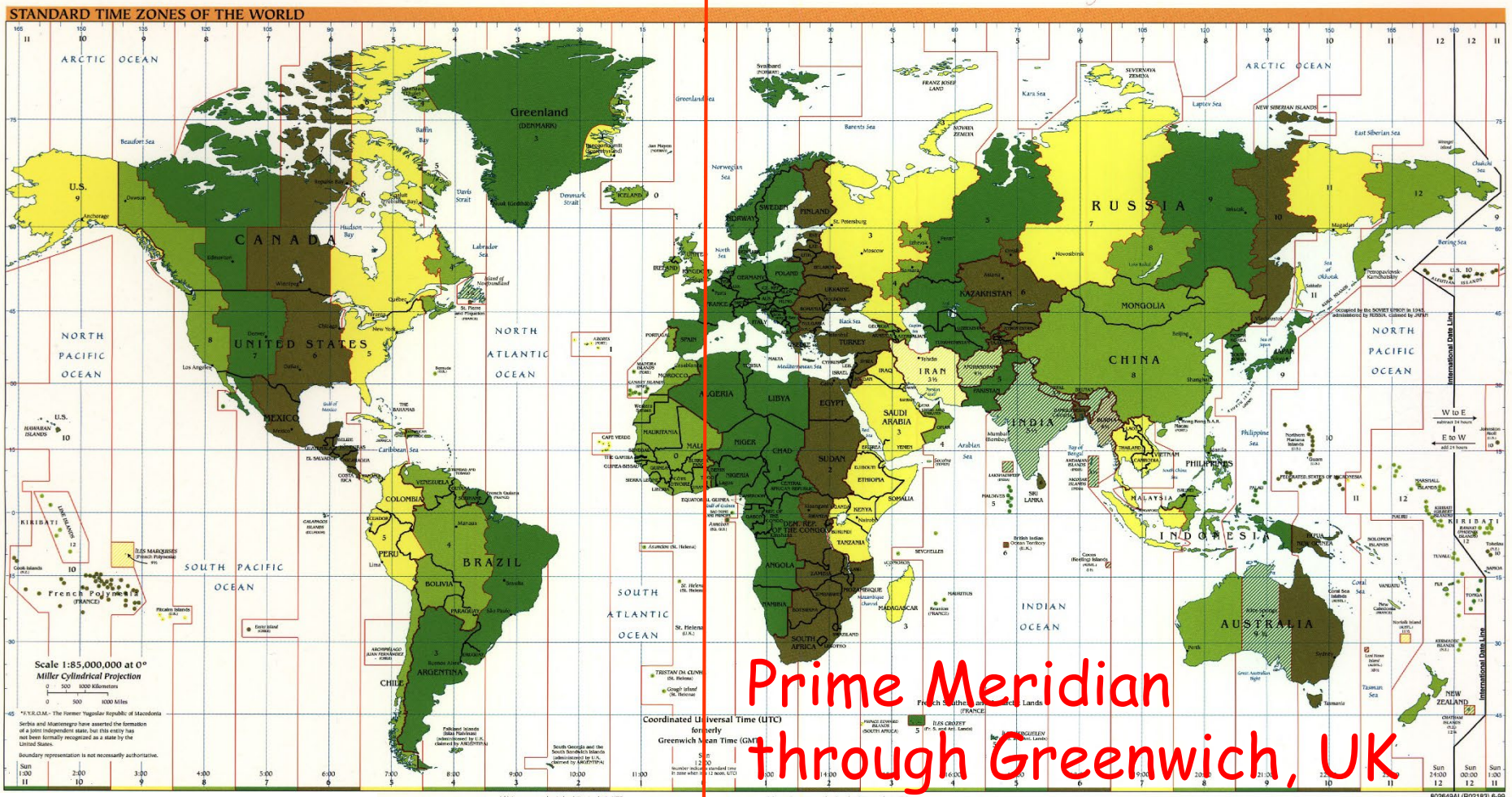


Photo by Marc Staves 2011

Time Zones

☆ Politics complicates things …



LIBRARY OF CONGRESS

https://www.loc.gov/item/00552771/

Time Zones

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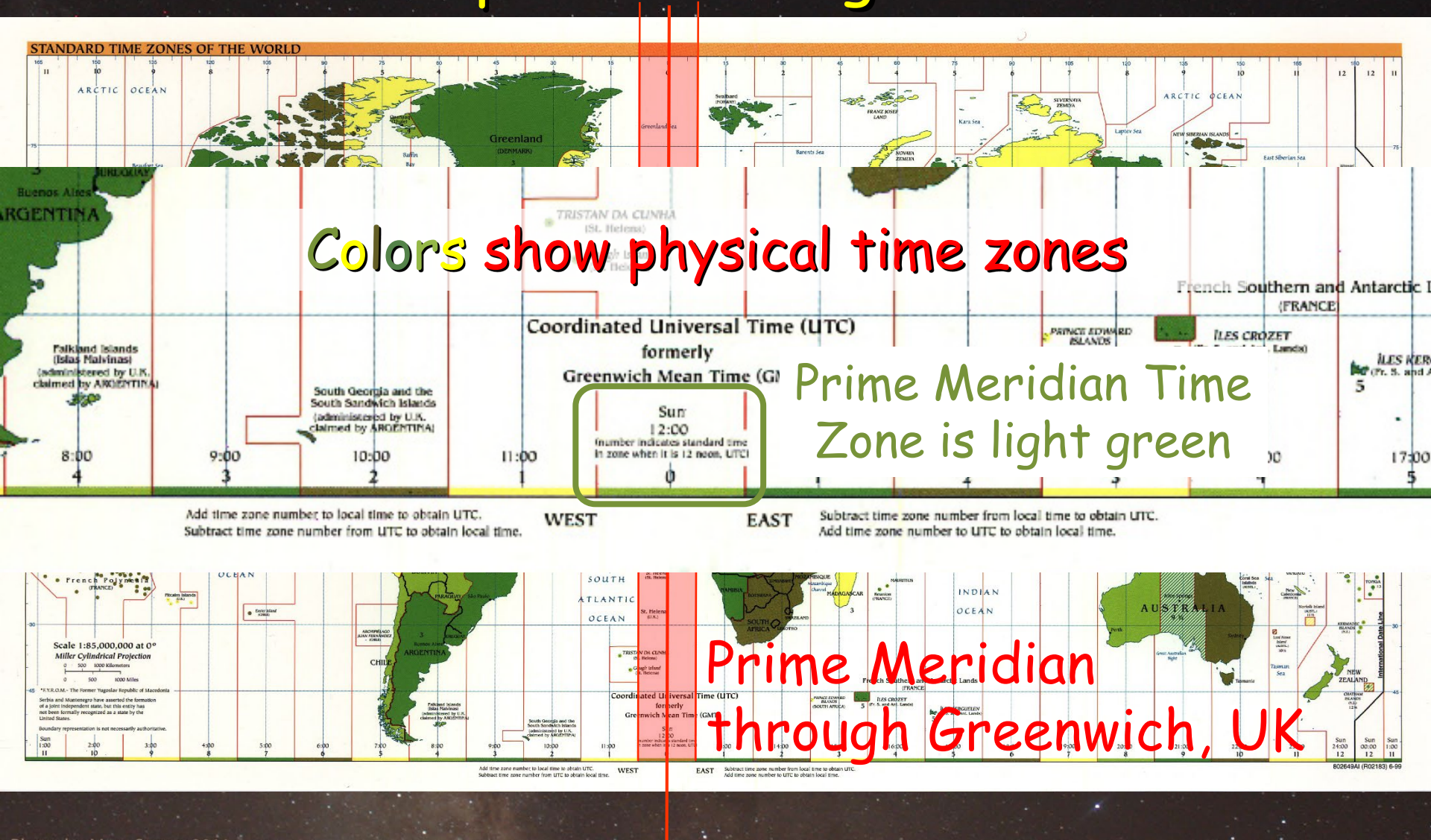
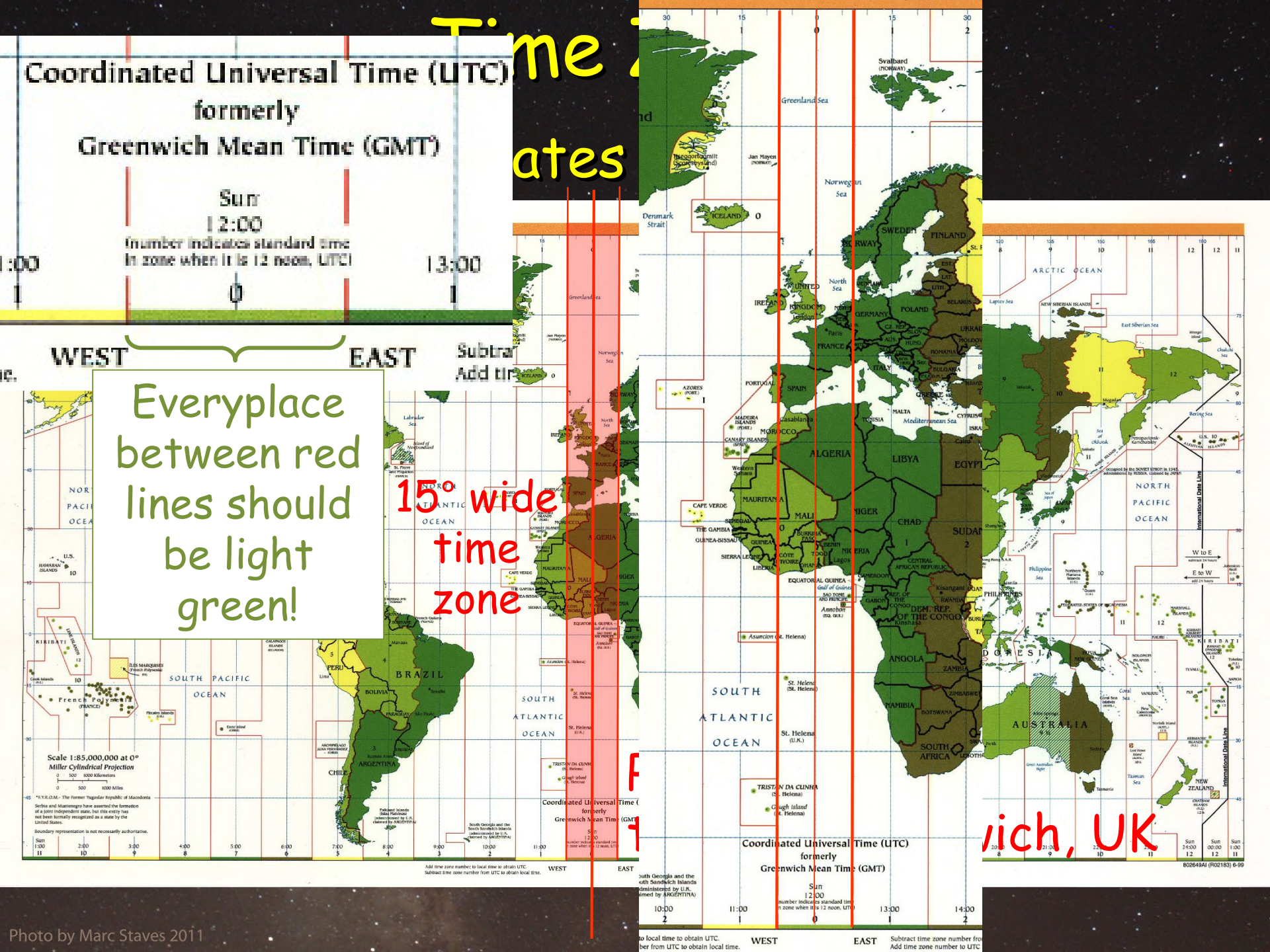


Photo by Marc Staves 2011


Coordinated Universal Time (UTC)
formerly
Greenwich Mean Time (GMT)
Sun
12:00
(number indicates standard time
in zone when it is 12 noon, UTC)
13:00
WEST
EAST
Everyplace between red lines should be light green!
15° wide time zone
Coordinated Universal Time (UTC)
formerly
Greenwich Mean Time (GMT)
Photo by Marc Staves 2011

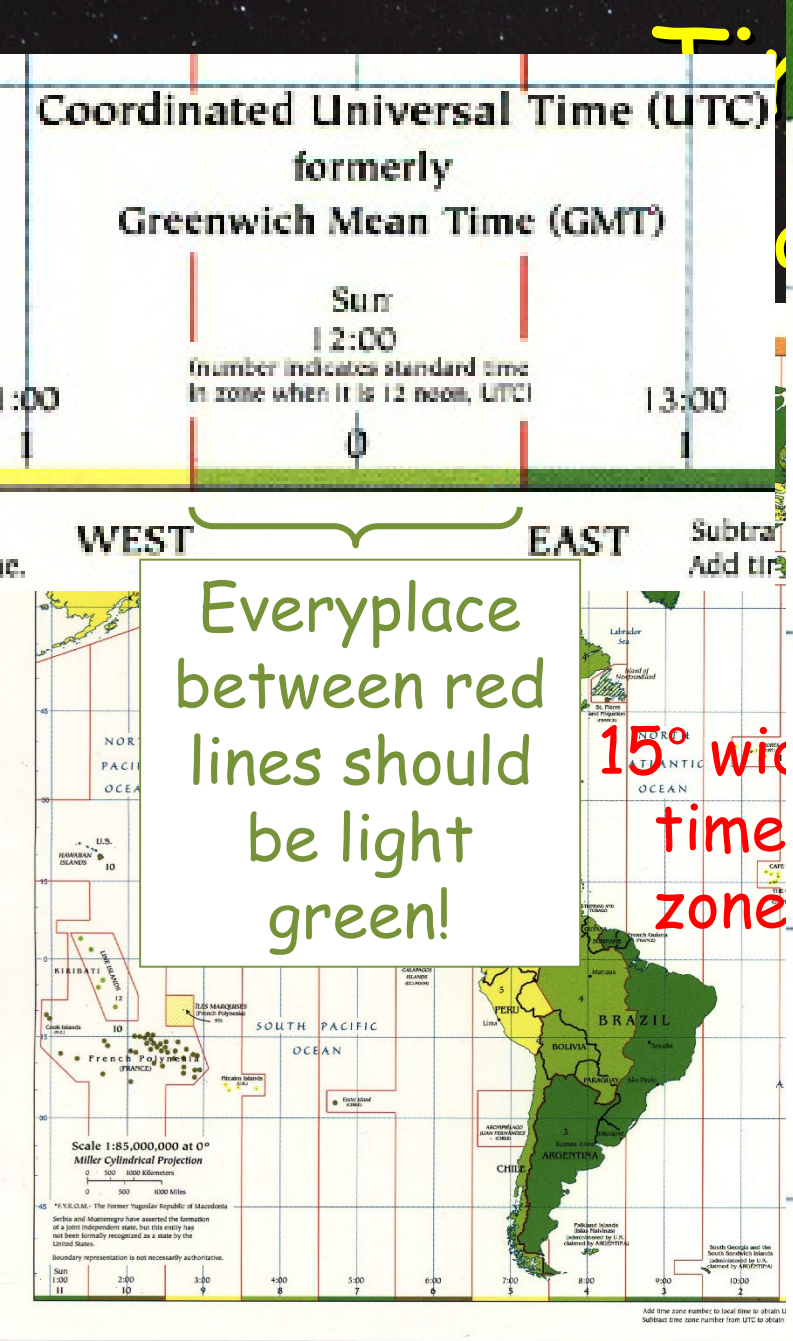
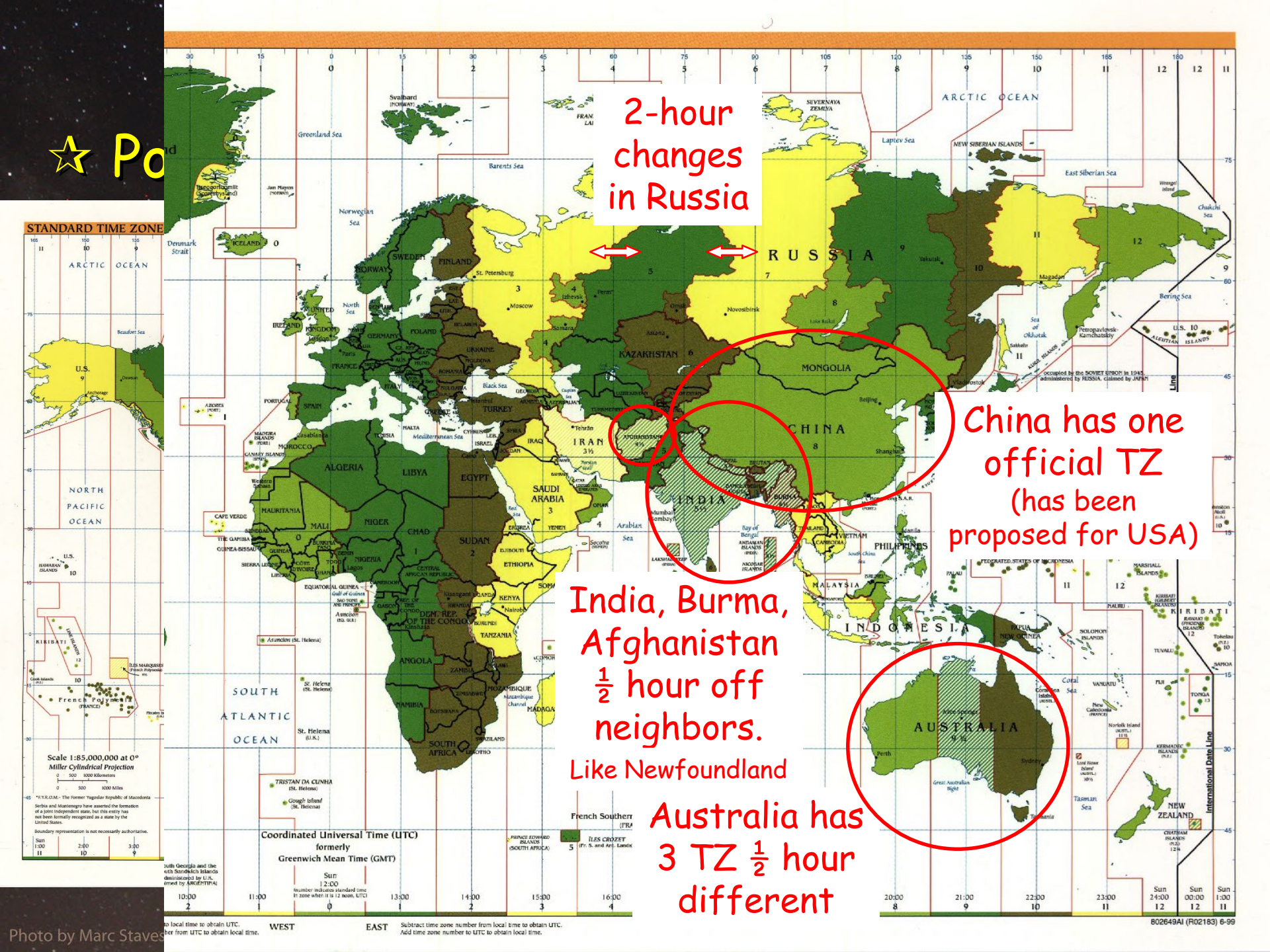
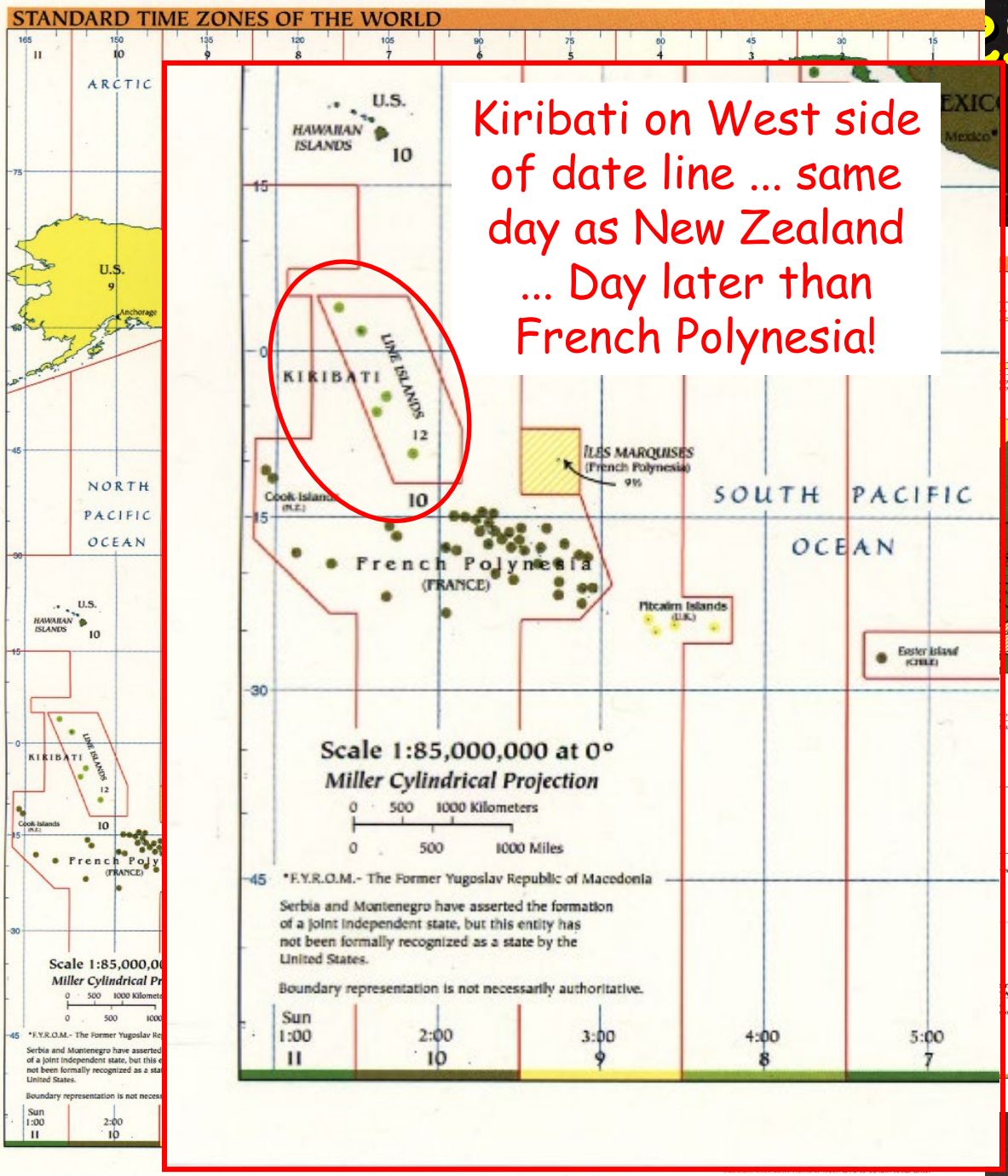


Photo by Marc Staves 2011

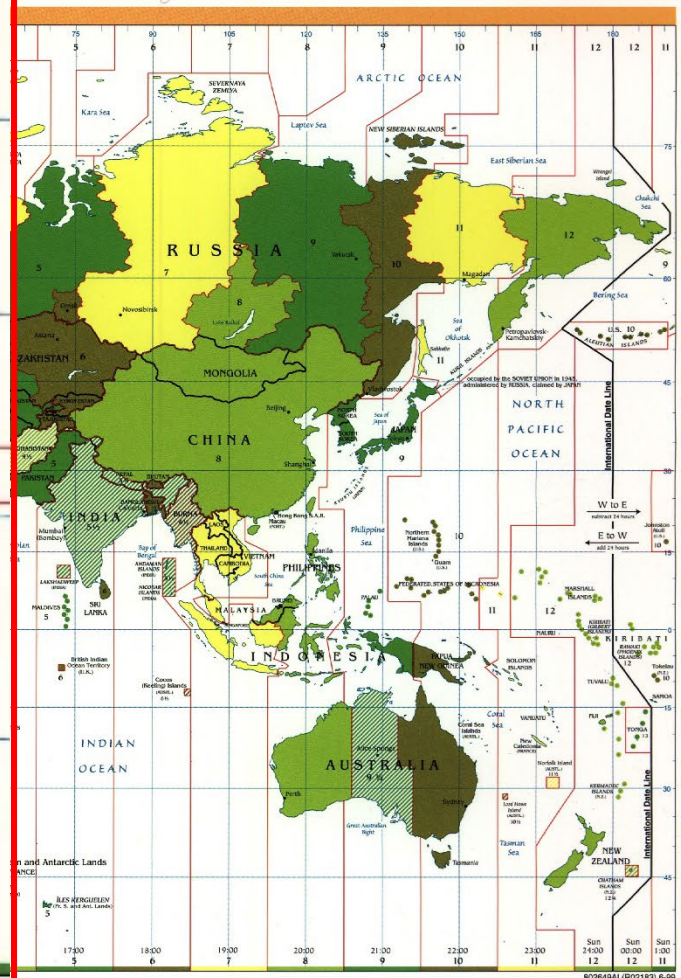
Iceland, Madeira & Canary Islands in UK TZ 1 hour west of Greenwich

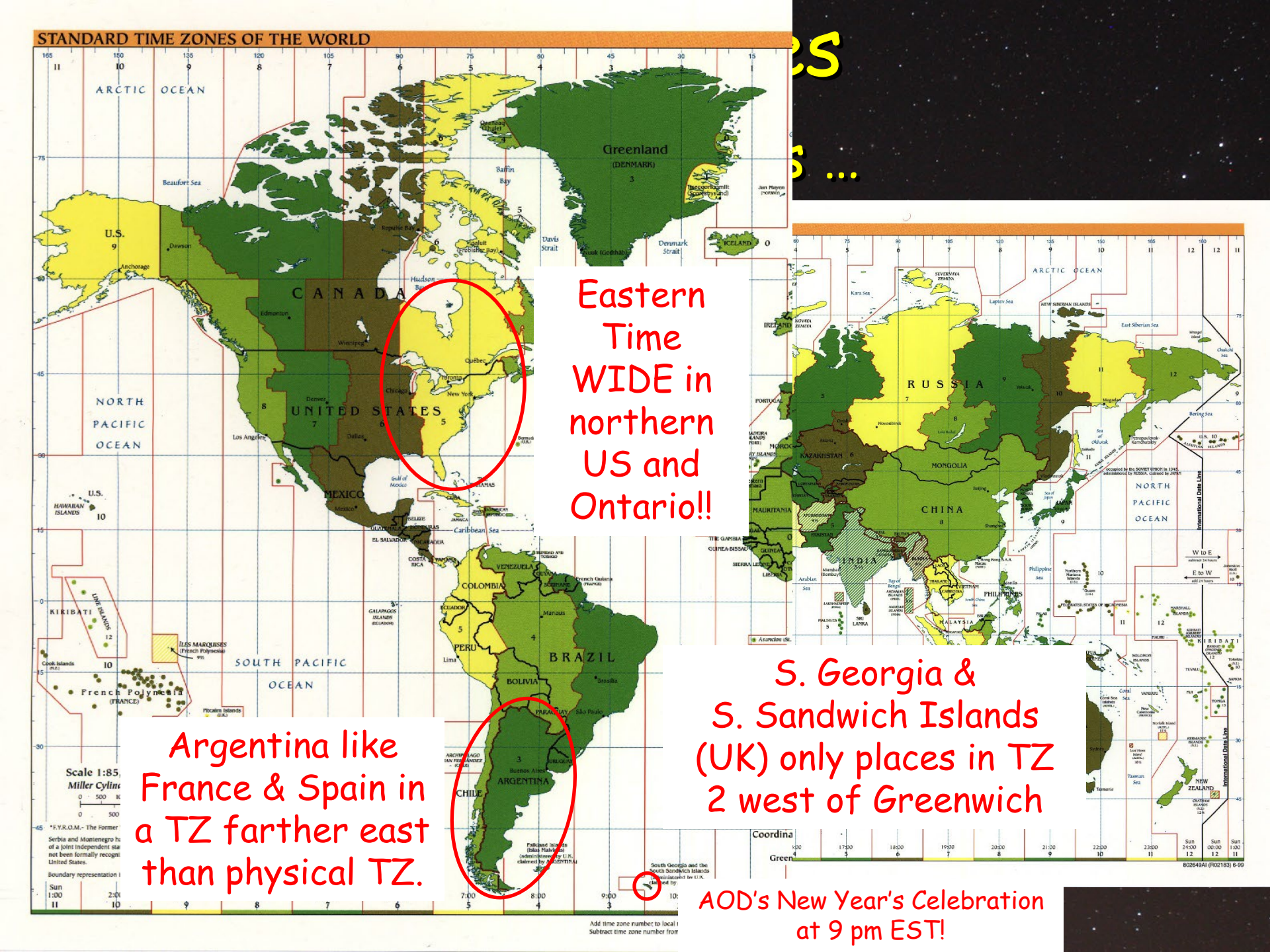
Spain, France Algeria, Niger, Nigeria & Benin in European TZ 1 hour east of Greenwich


☆ Po
STANDARD TIME ZONE
2-hour changes in Russia
China has one official TZ (has been proposed for USA)
India, Burma, Afghanistan ½ hour off neighbors.
Like Newfoundland
Australia has 3 TZ ½ hour different
Coordinated Universal Time (UTC) formerly Greenwich Mean Time (GMT)
WEST
EAST
Photo by Marc Staves



Kiribati on West side of date line … same day as New Zealand … Day later than French Polynesia!





Eastern Time WIDE in northern US and Ontario!!

Argentina like France & Spain in a TZ farther east than physical TZ.

S. Georgia & S. Sandwich Islands (UK) only places in TZ 2 west of Greenwich

AOD's New Year's Celebration at 9 pm EST!

Time Zo

☆ Politics complicates th

New Year arrival Times in EST:

7 pm London

8 pm E. Greenland, Azores, Cape Verde

9 pm S. Ga. & Sandwich Is.

10 pm E. Brazil, Argentina, W. Greenland

10:30 pm Newfoundland

11 pm Labrador, P.R., E. Brazil, Chile, et

AOD's New Year's Celebration at 9 pm EST!

Photo by Marc Staves 2011

Time Zones

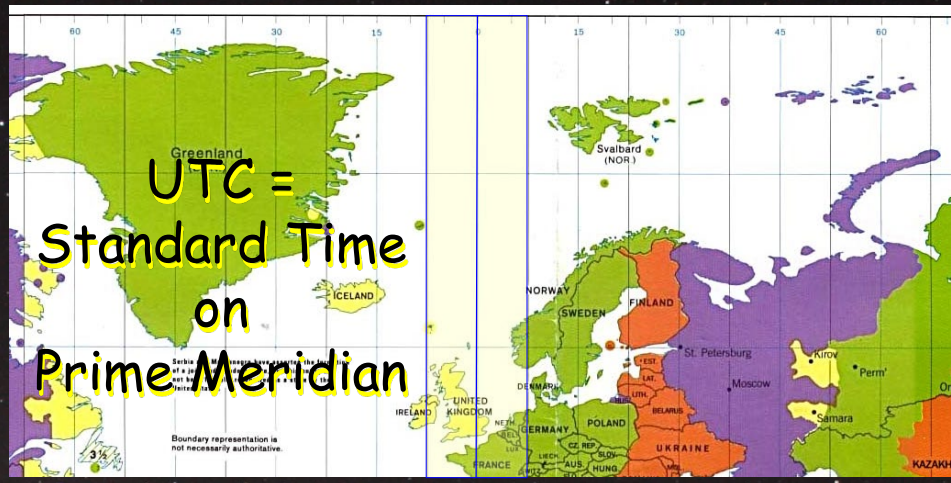
☆ Politics complicates things …

https://en.wikipedia.org/wiki/List_of_UTC_offsets#UTC%E2%88%9201:00,_N

Photo by Marc Staves 2011

Coordinated Universal Time

- ☆ UTC (UT or Zulu)
  - Time at Greenwich
    - no Daylight saving
- ☆ Conversion
  - EST (Eastern Standard Time) = UTC – 5hr
    - eg. 2pm (14:00) EST = 19:00 UT
  - EDT (Eastern Daylight Time) = UTC – 4hr
    - eg. 2pm (14:00) EDT = 18:00 UT

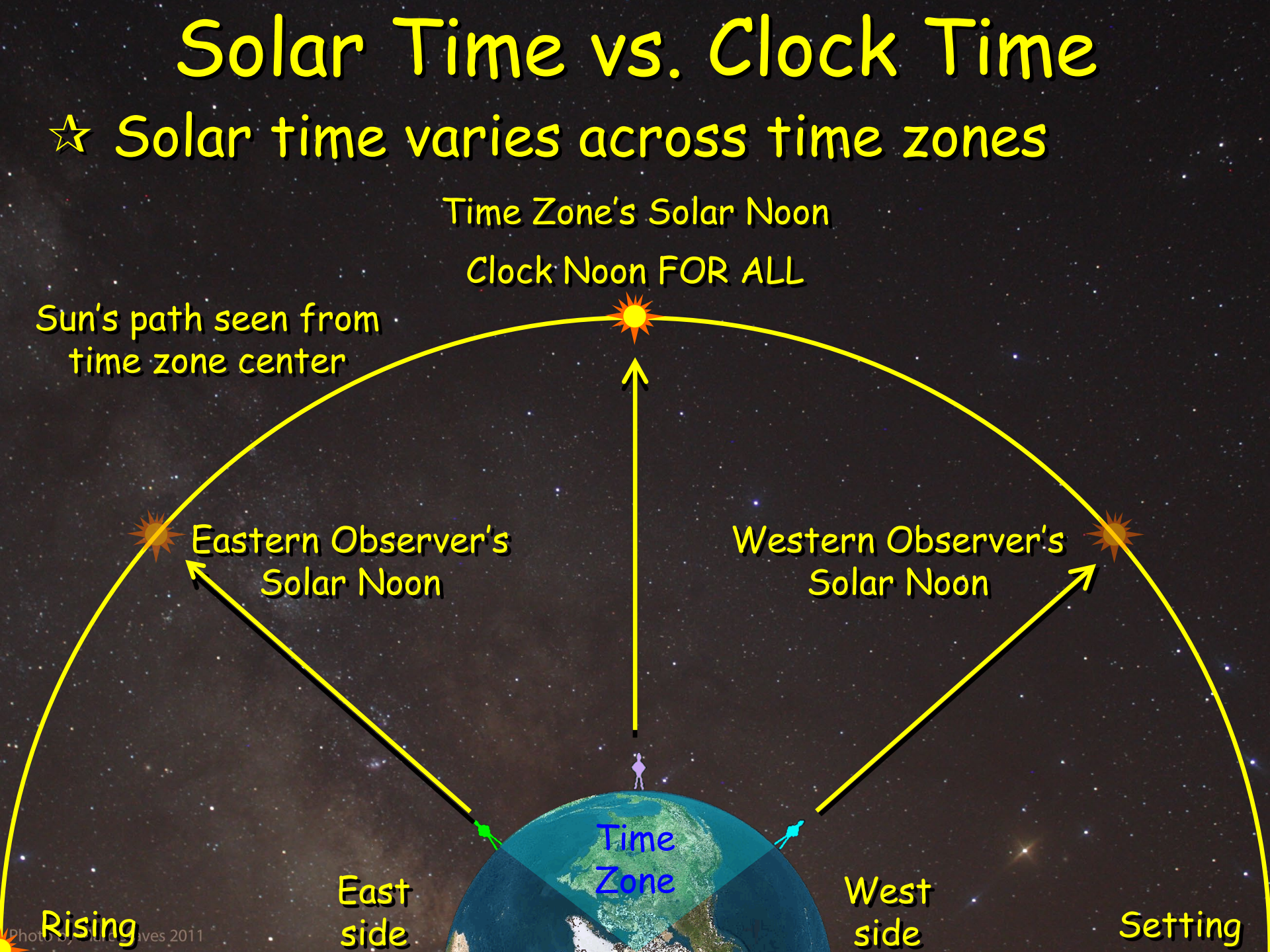


U.S. Naval Observatory

Photo by Marc Staves 2011

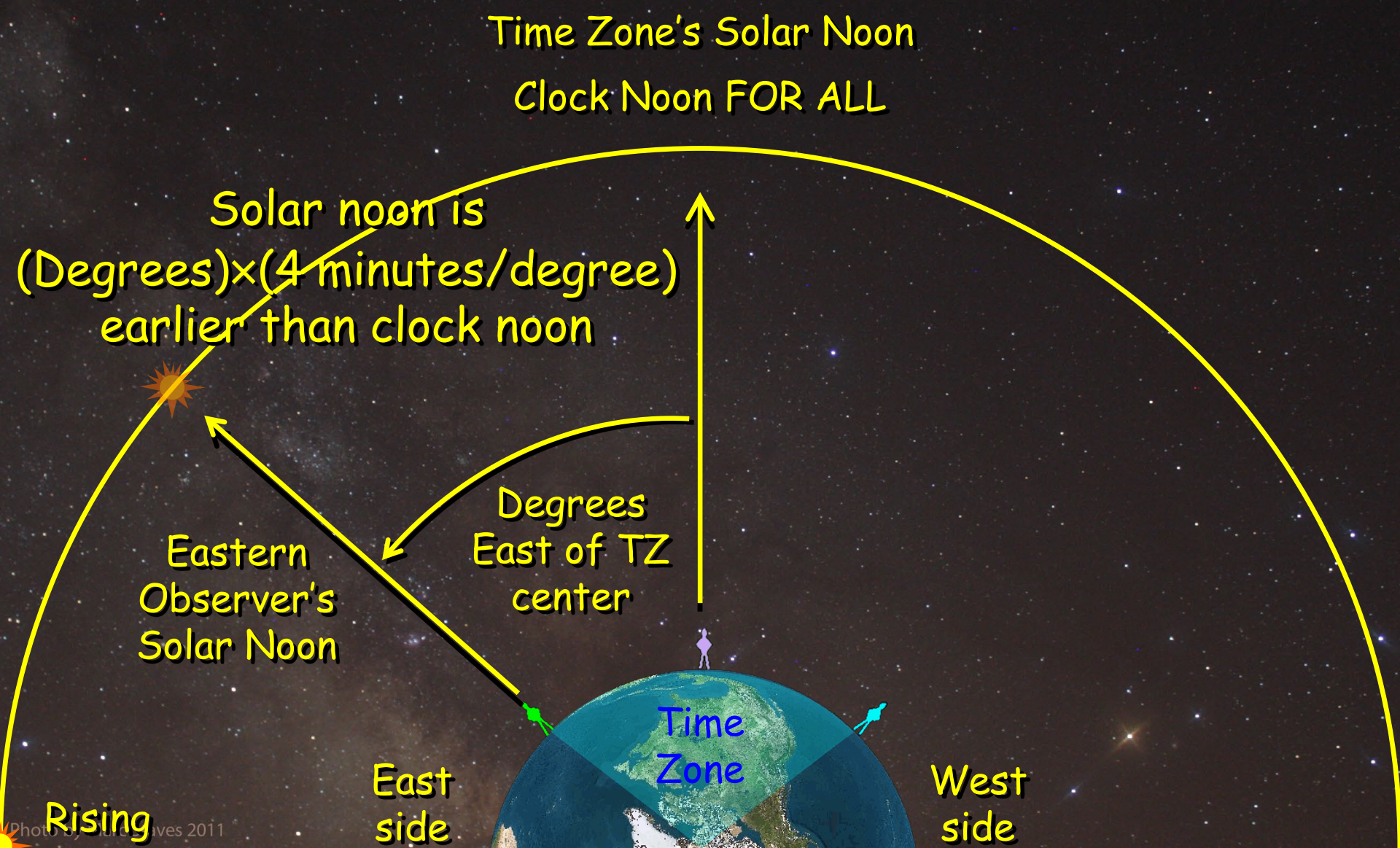
Solar Time vs. Clock Time

☆ Solar time varies across time zones



Solar Time vs. Clock Time

☆ Solar time varies across time zones



Question

Portland, Maine, 70° W is in the Eastern Time Zone (center: 75° W). Solar noon occurs at

(Degrees)x(4 minutes/degree) = (5) x (4) = 20 minutes early

Solar noon in Portland at 11:40 am

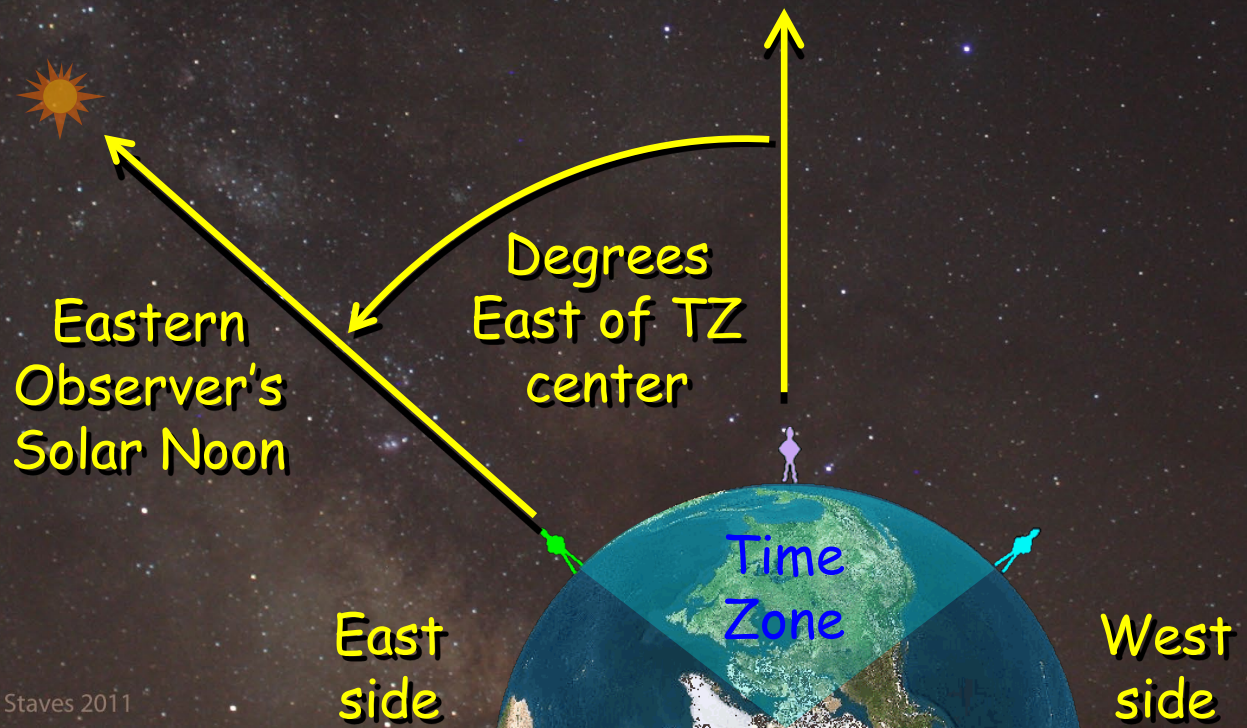
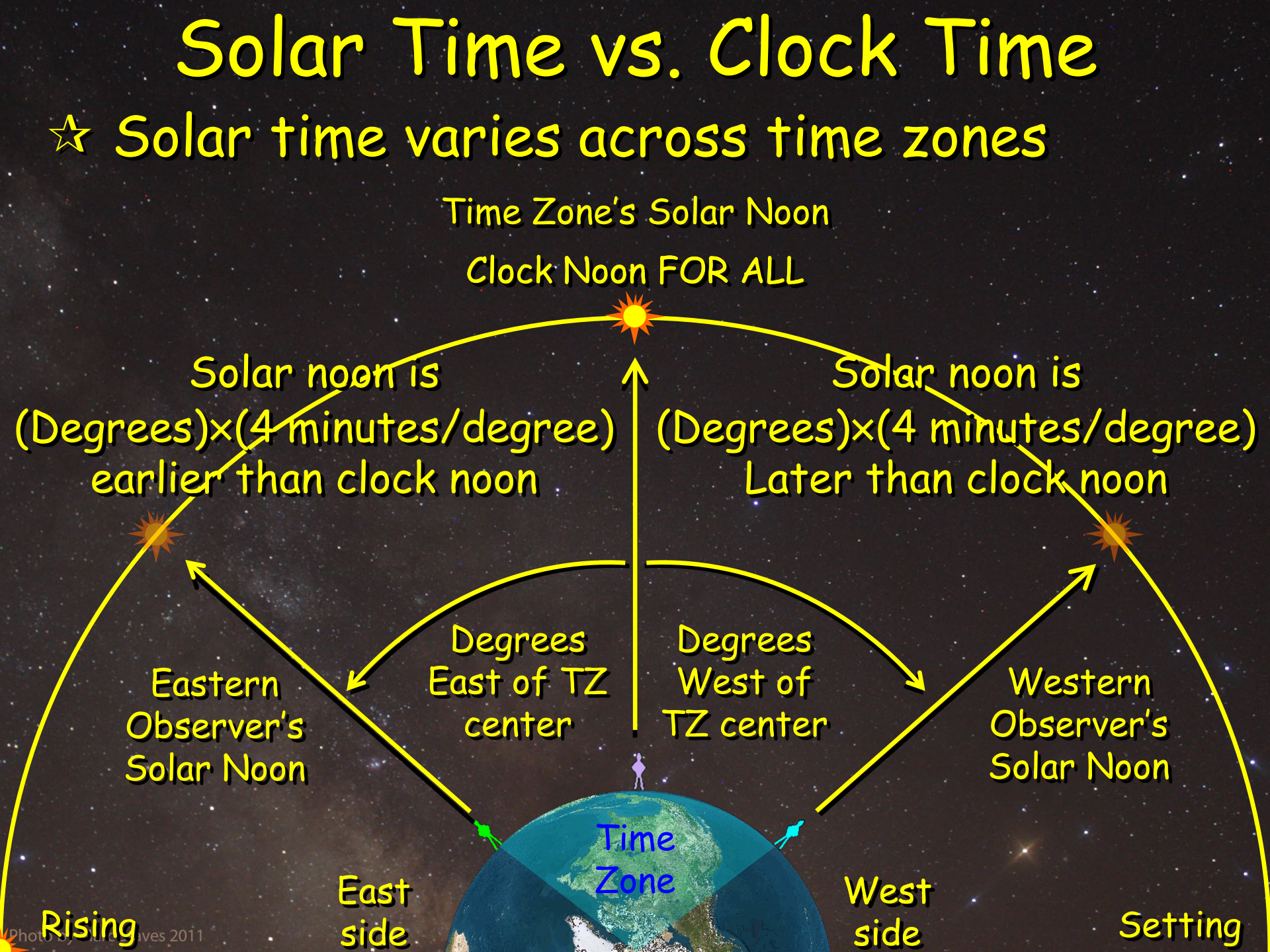


Photo by Marc Staves 2011

Solar Time vs. Clock Time

☆ Solar time varies across time zones



Question

Yuma, AZ, 115° W is in the Mountain Time Zone (center: 105° W). Solar noon occurs at

a) 11:20 am, b) 11:40 am, c) 12:20 pm, d) 12:40 pm

(Degrees)x(4 minutes/degree) = (10) x (4) = 40 minutes late

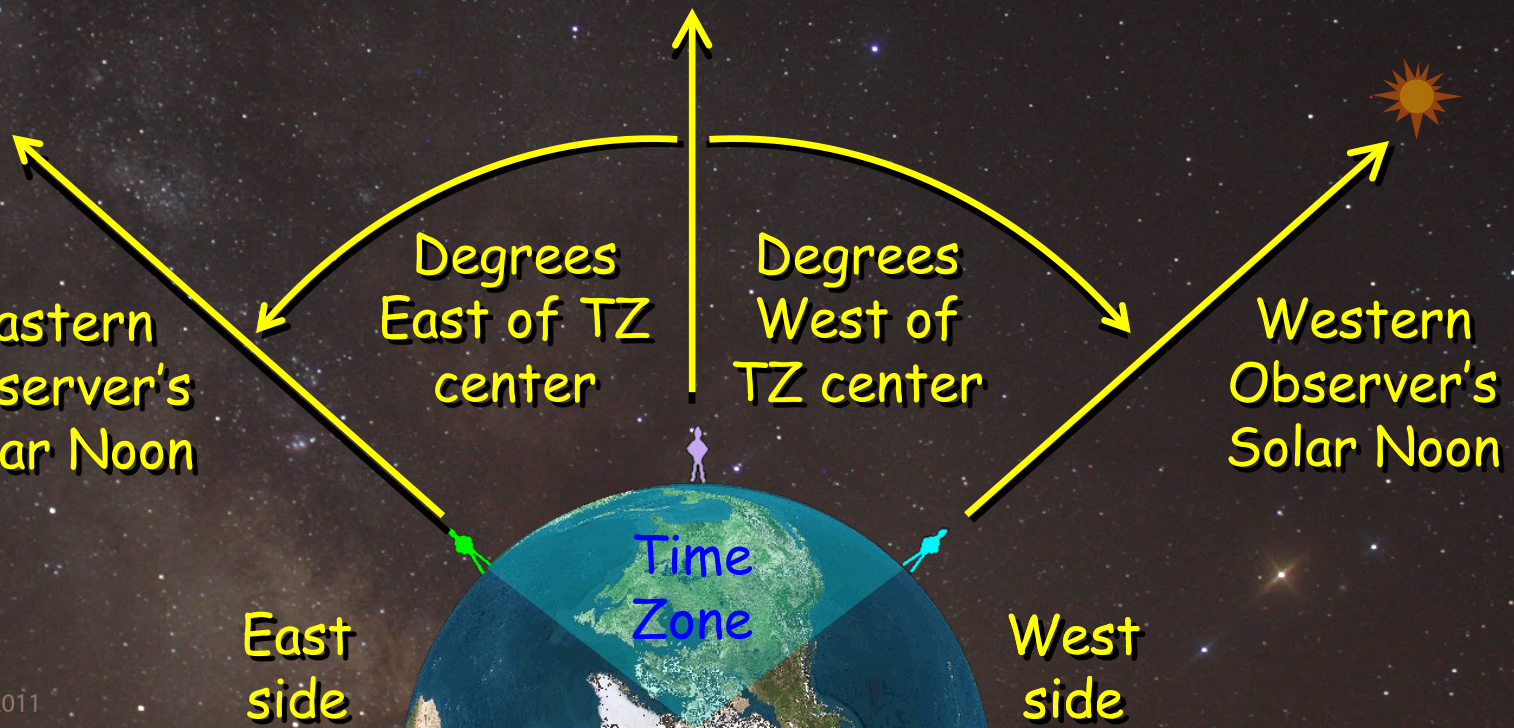
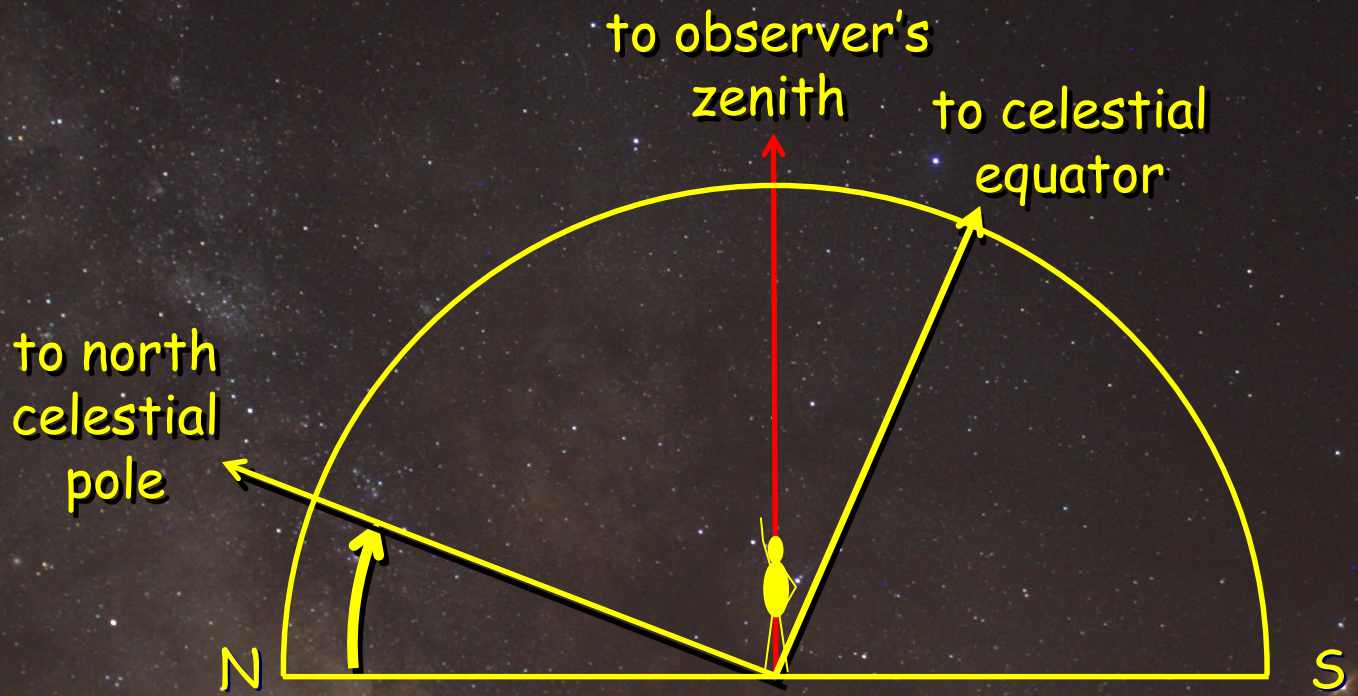


Photo by Marc Staves 2011

Celestial Navigation

- ☆ Finding Latitude & Longitude from
  - Altitude of Polaris (NCP)
  - Transit time of star
    - ☽ Looked up in an ephemeris (eg. Field Guide)



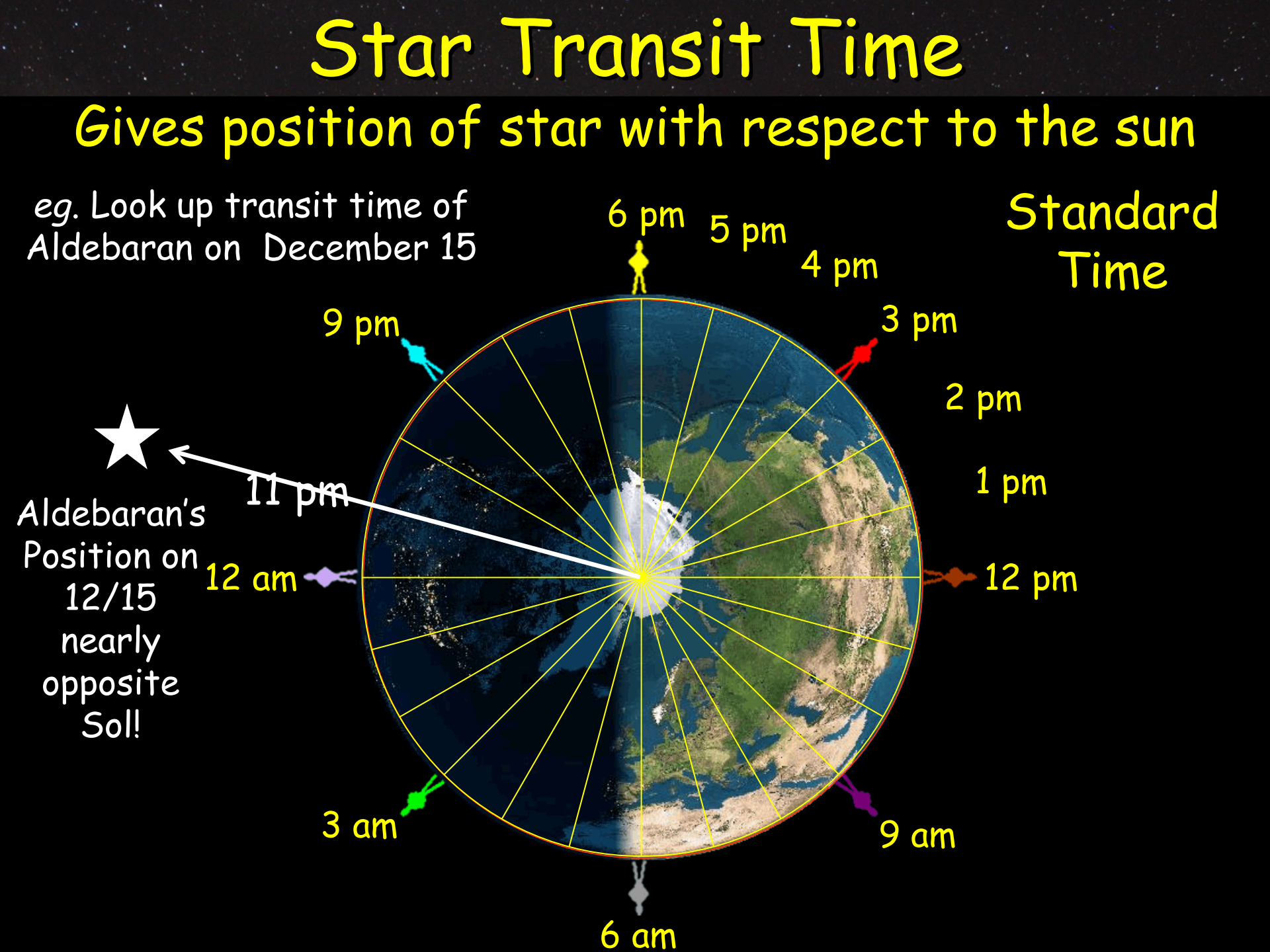
Observer at 20° N

Photo by Marc Staves 2011

Star Transit Time

Gives position of star with respect to the sun

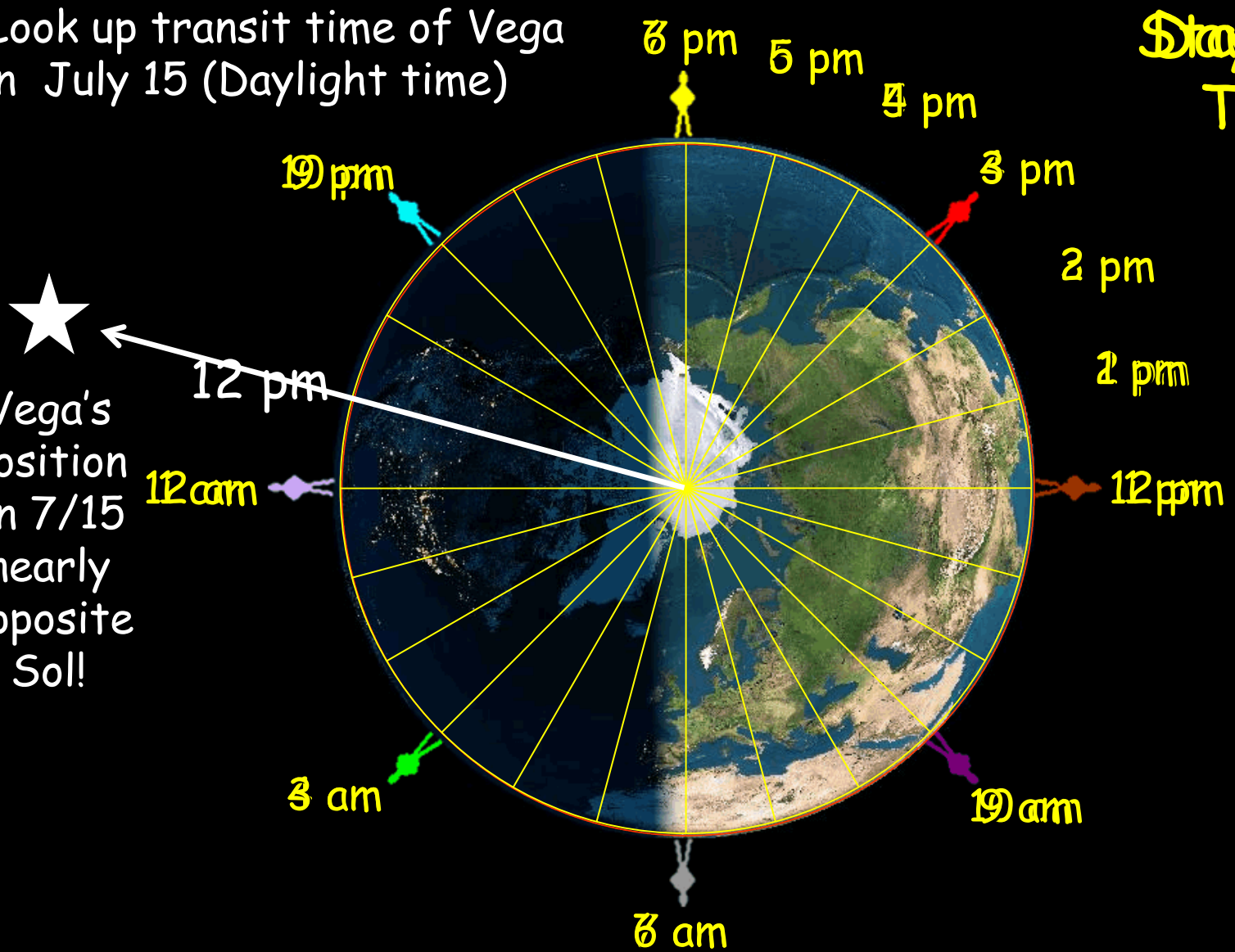
eg. Look up transit time of Aldebaran on December 15



Star Transit Time

Gives position of star with respect to the sun

eg. Look up transit time of Vega on July 15 (Daylight time)



Celestial Navigation

☆ Difference between observed and expected transit times gives longitude

Observer watches star transit.

Clock is set to some time zone.

Observed transit time disagrees with ephemeris.

Star's Transit

Clock's Time Zone Longitude

Degrees East of TZ center

Longitude difference from clock's time zone center = (Time difference)×(15°/hour)

Celestial Navigation

☆ Example: Transit of Deneb on August 1

Colorado Day!

Observer sees Deneb transit at 11 pm EDT

At 1 am Deneb will transit TZ center at 75° W

Looks up transit time in FG

On 8/1 Deneb transits at 1 am

Early ⇒ East of TZ center

Longitude difference from clock's time zone center = (2 hours)×(15°/hour) = 30° East

Observer's Longitude = TZ center – Latitude difference = 75° W - 30° = 45 ° W

Navigation Challenge

- ☆ Try it on your own with handout
- ☆ See you next week!
- ☆ Slides will be available at

  http://myslu.stlawu.edu/~aodo/SLU/SOAR/index.htm

Photo by Marc Staves 2011