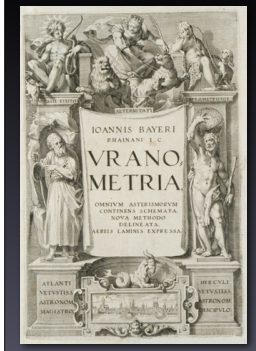
The sky in motion

Koupelis - sections 1.2, 1.3
OpenStax - sections 2.1, 4.1, 4.2

The sky in motion

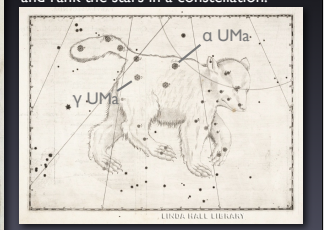
- Constellations
- Introduction to the night sky
- Measuring angles on the sky
- Motion of the celestial sky at different locations on Earth
- Coördinate systems
- Precession
- Motion of the Sun
- Timelapse movies (Stellarium demo)

Uranometria : the first atlas of the sky



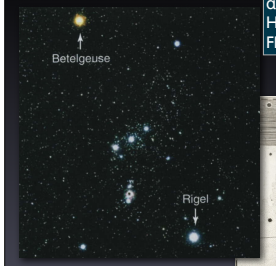
Johann Bayer
(1572 - 1645)

Introduced Greek letters to indicate and rank the stars in a constellation.



Accurate positions of the stars provided by Tycho Brahe.

Orion



Betelgeuse (Yad al-Jauzā)

α Ori , 58 Ori , HR 2061 , BD +7d1055 , HD 39801 , SAO 113271 , GC 7451 , FK5 224 , AAVSO 0549+07 , HIP 27989

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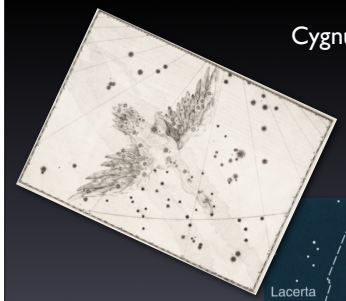
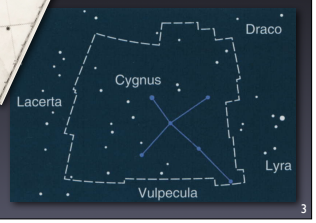
Cygnus - the Swan



Constellations have well-defined boundaries.



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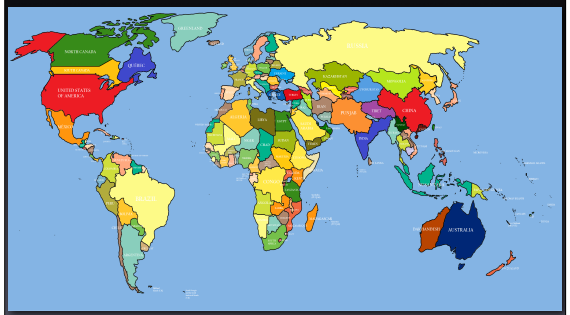
The sky is divided in 88 constellations.



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Definition of constellation boundaries

Established by Committee 3 (Astronomical Notations) of the International Astronomical Union (IAU).

Based on the article:

Délimitation Scientifique des Constellations,
by E. Delporte, 1930
Royal Observatory of Belgium

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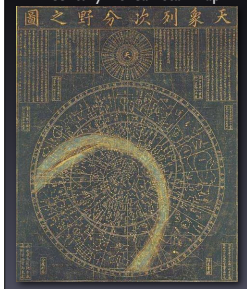
Non-western constellations

14th century Korean star map



Aboriginal constellation 'Emu in the Sky'

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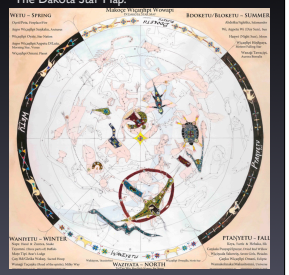
Native American sky maps

Ojibwe Giizhig Anung Masinaaigan
'The Ojibwe Sky Star Map.'

D(L)akota Makoće Wićaŋȟpi Wowapi
'The Dakota Star Map.'



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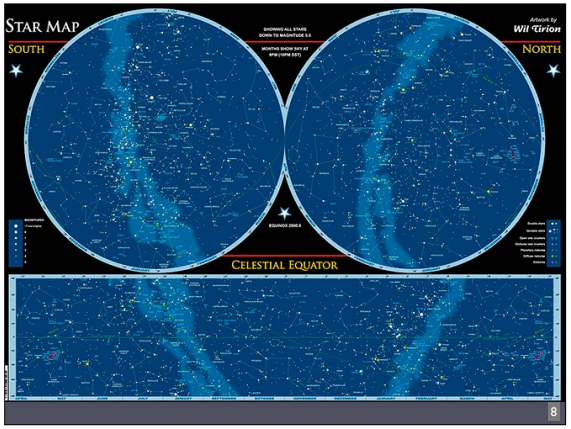

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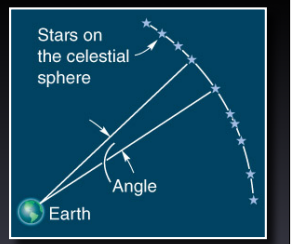
Measuring positions and angles on the sky.



- The angular distance between two objects on the sky is the angle between the two lines in the direction of these objects, as seen by the observer
- 1 *degree* is divided in 60 *arc-minutes* and 1 arc-minute is divided in 60 *arc-seconds*

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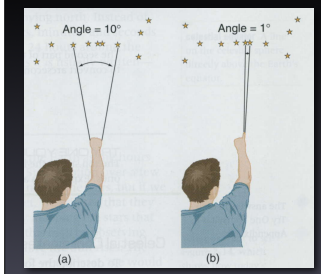
Rules of thumb



The width of a finger is ~1 degree.

Diameter of the Sun and Moon :

½ degree = 30 arc-minutes
=1800 arc-seconds

The unaided eye can separate 2 stars at an angular separation of ~1 arc-minute.

The Hubble Space Telescope can separate 2 stars that are 0.1 arc-second apart.

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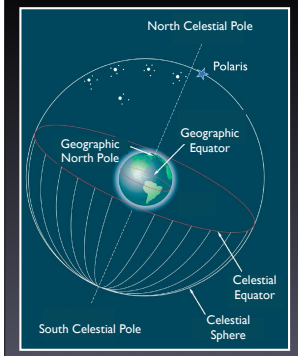
Positions on the sky



- The daily *rotation* of the Earth defines the celestial-equator and the northern and southern celestial poles.
- The polar star *Polaris* (α Ursa Minor) is located, accidentally, in the direction of the Earth rotational axis.
- The celestial equator is the equivalent of the geographic equator.

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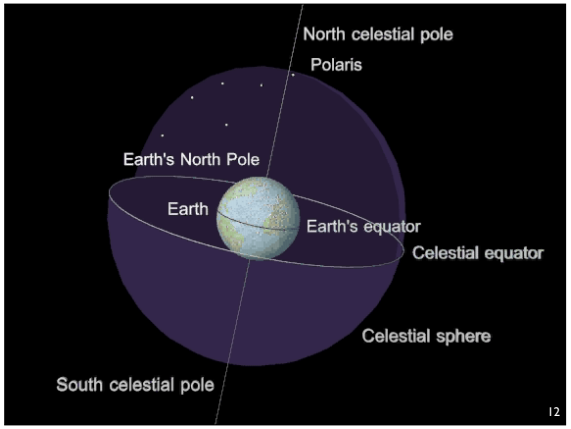

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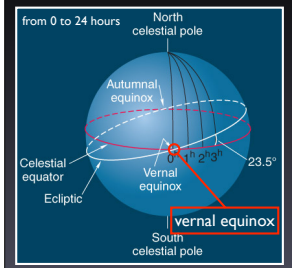
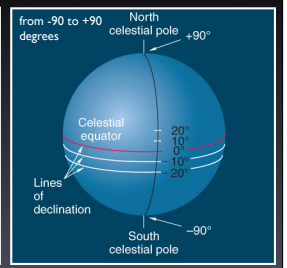
Sky locations are designated by equatorial coordinates.

Right Ascension (α)



Declination (δ)



Example: α Centauri is located at $\alpha = 14^h\,39^m\,36.^s2$, $\delta = -60°\,50'\,8''$

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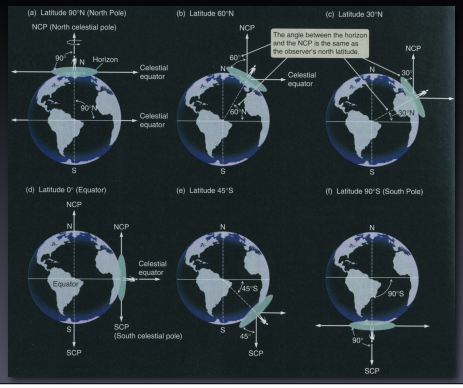
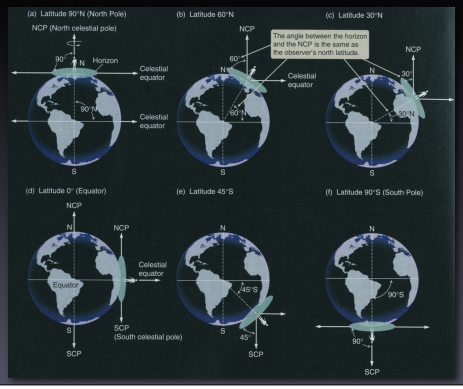
View of night sky depends on location on Earth



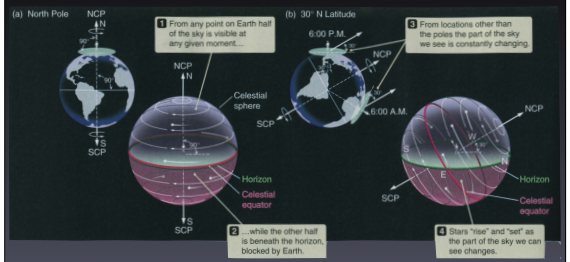
View of night sky depends on location on Earth



location & rotation

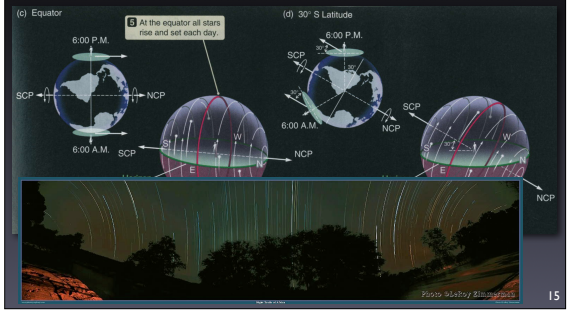
on the north pole

at 30° northern latitude



location & rotation

on the equator at 30° southern latitude



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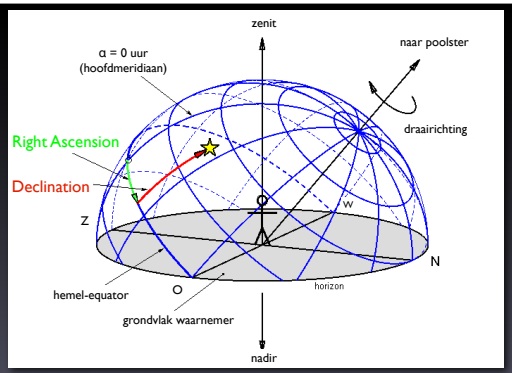

Right Ascension is measured along the celestial equator, increasing to east.
Declination is measured along a meridian, increasing towards north.

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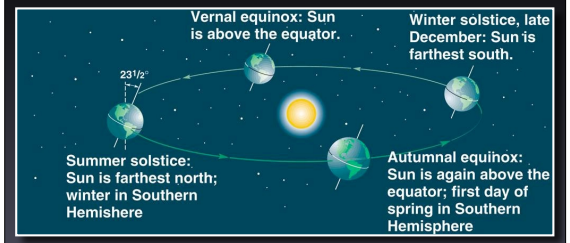
The rotating Earth moves around the Sun in 365,25… days in a nearly-circular orbit.

this orbital plane defines the ecliptic



The axis of rotation is *not* perpendicular to orbital plane!
→ the celestial equator and the ecliptic do *not* coincide…

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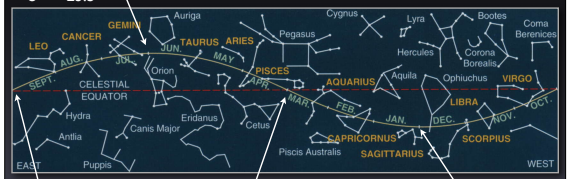
Constellations along the ecliptic (zodiac)

summer solstice
α = 6 uur
δ = +23.5°



autumnal equinox :
α = 12 uur
δ = 0°

vernal equinox : α = 0 uur
δ = 0°

winter solstice :
α = 18 uur
δ = -23.5°

The ecliptic crosses 13 instead of 12 constellations, including Ophiuchus.

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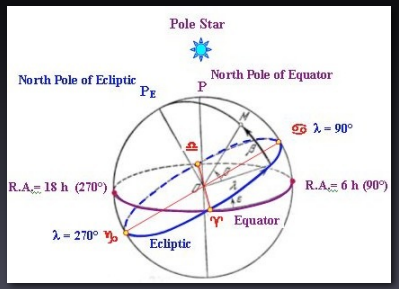
Ecliptic coordinate system



The ecliptic is the plane of reference

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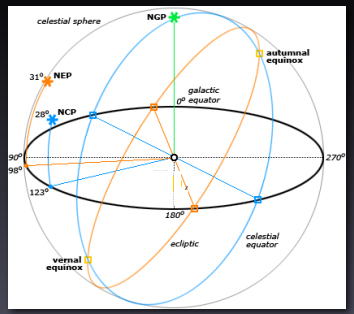
Galactic coordinates



The Milky Way is the plane of reference

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Common sky coordinates:

Name	symbols	reference (zero point)	range
Azimuthal	(Az , Alt)	horizon (north)	Az : 0 → 360 Alt : 0 → 90
Equatorial	(α , δ)	celestial-equator (vernal equinox)	α : 0 → 24 δ : -90 → +90
Ecliptic	(λ , β)	ecliptic (vernal equinox)	λ : 0 → 360 β : 0 → 90
Galactic	(l , b)	Milky Way (galactic center)	l : 0 → 360 b : -90 → +90
Supergalactic	(SGL , SGB)	supergalactic plane (l=137.37° , b=0°)	SGL : 0 → 360 SGB : -90 → +90

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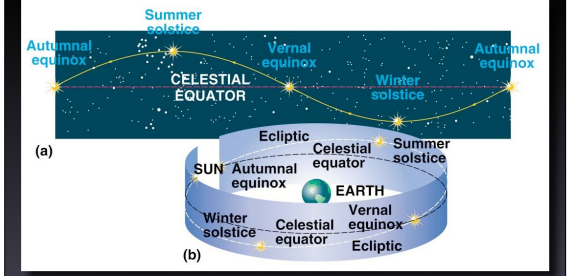

Seen from Earth, the Sun moves up and down in Declination between the stars, following the ecliptic.

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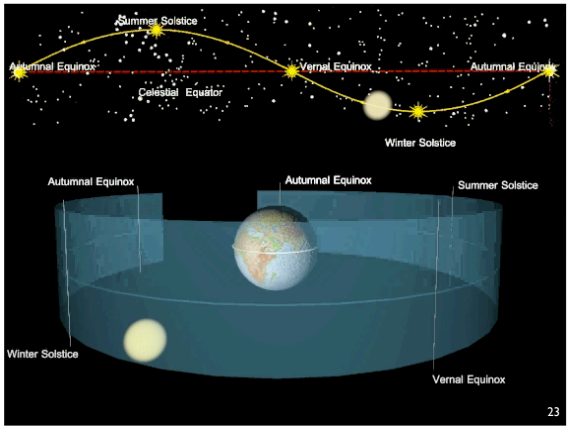

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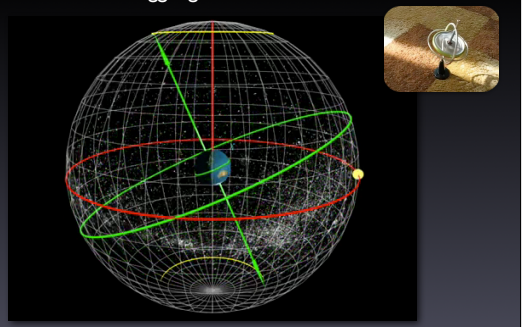
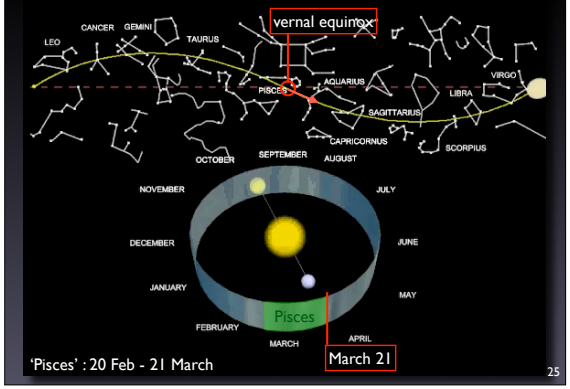
Precession : 'wiggling' of the Earth axis of rotation.



Every 26.000 years, the axis of rotation wiggles in a circle (yellow) around the ecliptic pole. Consequently, the celestial equator (green) 'wiggles' and shifts the vernal equinox along the ecliptic (red) through the various constellations. 24

The vernal equinox shifts along the ecliptic with astrological consequences…



'Pisces' : 20 Feb - 21 March

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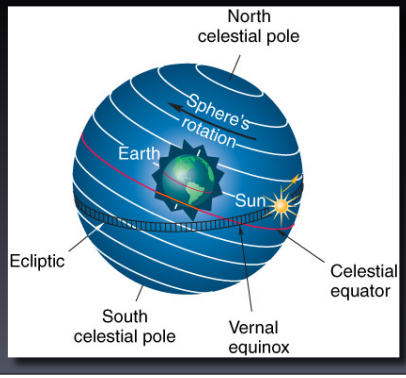
The Sun shifts along the ecliptic, 1 degree per day ...



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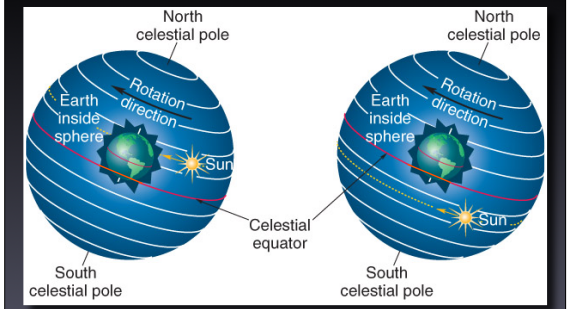
... while the Earth rotates around her axis.



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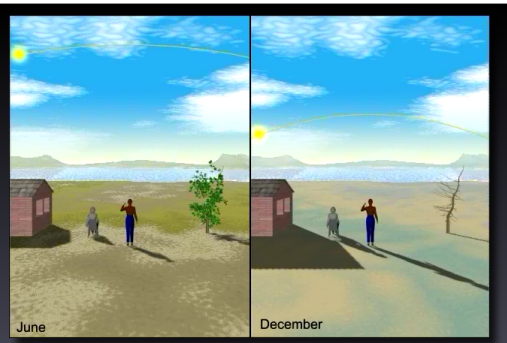

Consequently, the Sun is high up in the sky (high Declination) in summer and low in the sky (low Declination) in winter. This gives rise to the seasons!

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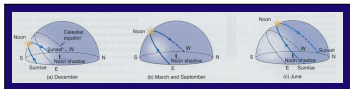
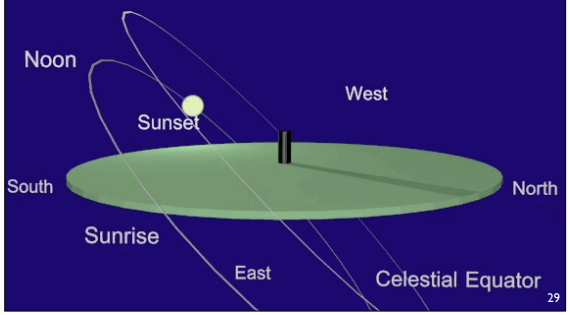


December



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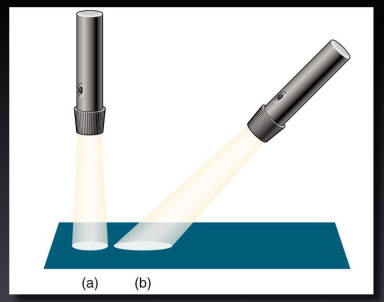

The heating of the surface of the Earth depends on the elevation of the Sun!

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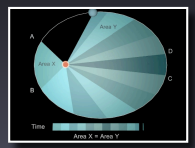
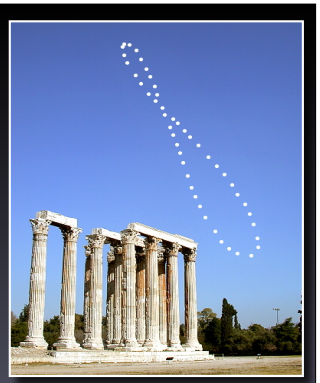
Take a picture at the same time every week in the same direction on the sky:

Analemma

A consequence of :
- obliquity of the Earth axis
- Kepler's second law.



The Sun does not move along the ecliptic with constant speed.



https://solar-center.stanford.edu/art/analemma.html

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circumpolar stars around the north celestial pole.

southern Alberta (+51°), autumn

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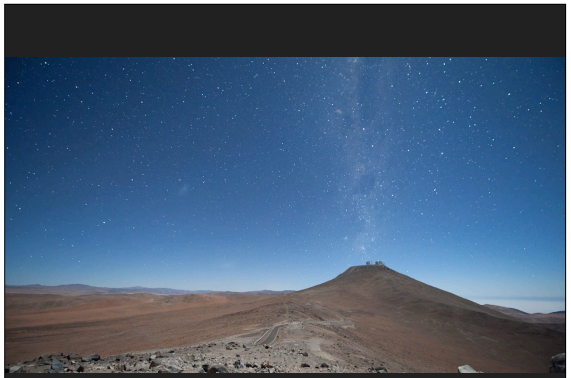

http://www.eso.org/public/videos/?search=timelapse+night+sky

http://www.dakotalapse.com/time-lapse-videos/

Install Stellarium **before** the first tutorial.
Bring your laptop computer to the tutorial.

www.stellarium.org

Check which group you are in/assigned to in brightspace.

&

Do not forget that tutorials are **mandatory**!

Next lecture

- Earth and Moon
- Solar and Lunar eclipses
- Calendars and time keeping