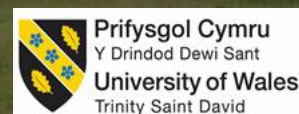


# Watching the Sky

Dr Bernadette Brady  
University of Wales Trinity Saint David  
Feb 2019



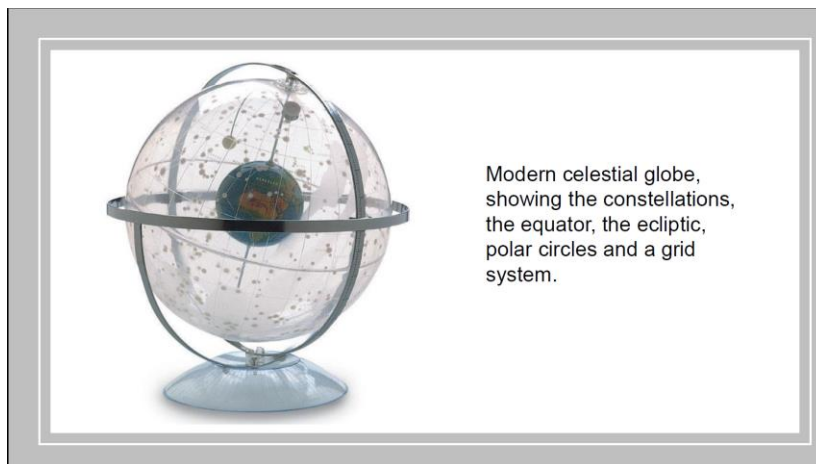
1

The sky is a moving canvas set against a fixed local landscape.  
How do you describe the movement of the sky?  
How do you record the location of an object in the heavens?  
How do you ascertain the relationship a place or structure has to the sky?

The answer to these questions is strongly influenced by the culture of the observer.

2

## Our cultural 'lens' is the celestial sphere



It is most important to recognise that your way of seeing is coloured by your culture

3

**A "handy" way to measure the sky**

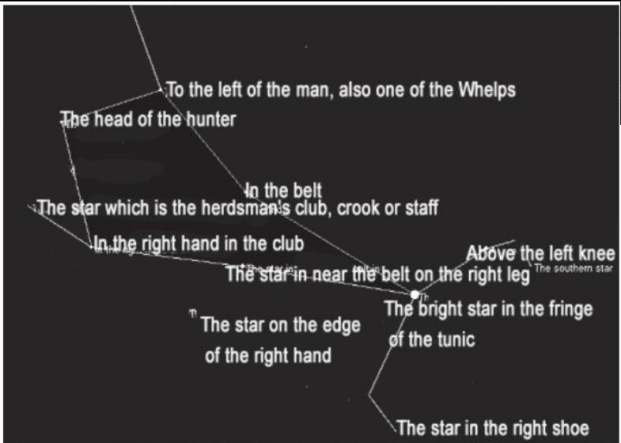
The first way and most organic way to measure the sky.

4

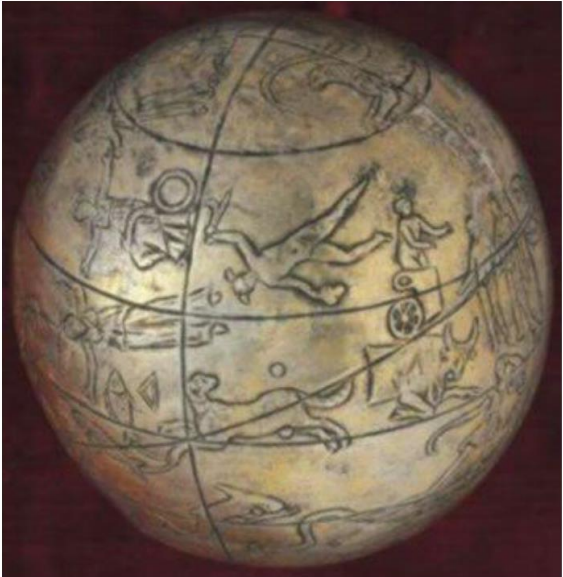


By the time of Ptolemy, in the first century CE, planets were measured against the back drop of the stars while the stars were measured in their constellations.

This removed the earth from the sky and opened the way for drawing grids over the heavens and placing all the object on a sphere.



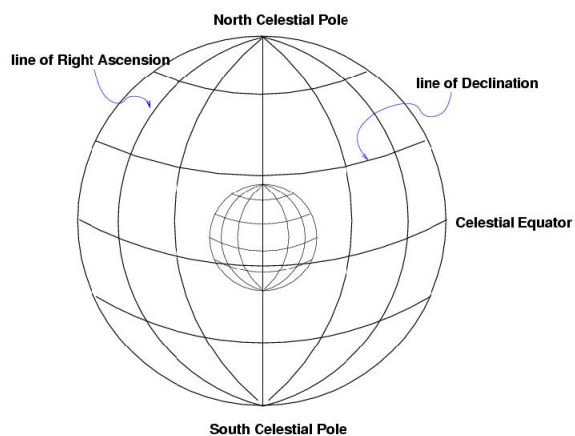
5



The Kugel globe shows the polar circles, the tropic of Capricorn and Cancer, the equator, the ecliptic and the prime vertical and prime median.

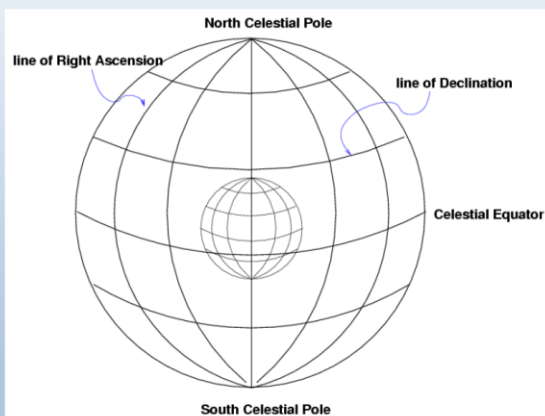
The Kugel Globe  
a miniature globe which is dated circa 300-100 BCE

6



7

## Basic numbers you need to understand



## The Fixed Address System

Just as cities have a longitude and latitude sky objects have a Right Ascension and Declination

**Declination is *like* latitude and RA is *like* longitude (time based)**

The Fixed Address of the star Sirius the star:

RA: 06:45:38

Dec:  $-16^{\circ}44'$

Sirius will pass directly overhead once a day if you are located at a latitude  $16^{\circ}44'$  South,

8

RA is a time based measurement and can be used to find the time difference between two stars culminating.

Just like the longitude of cities can be used to find their local time differences.

For example the RA of:

Arcturus, in Bootes is: 14h 16' 08"

Spica, in Virgo is 13h 25' 45"

Time difference between their two culminations is: 0h 50' 13"

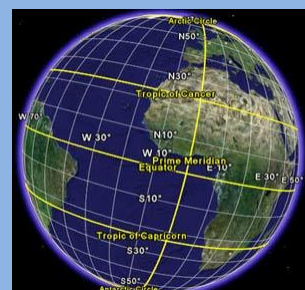
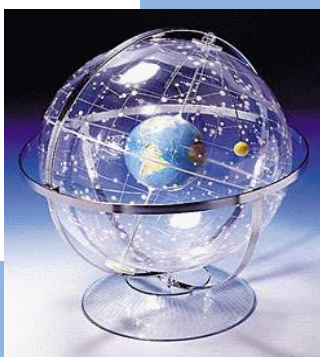
New York has a longitude of  $74^{\circ} 00' 23''$  West.

Dublin has a longitude of  $00^{\circ} 10'$  West

Longitude difference is  $73^{\circ} 50' 23''$

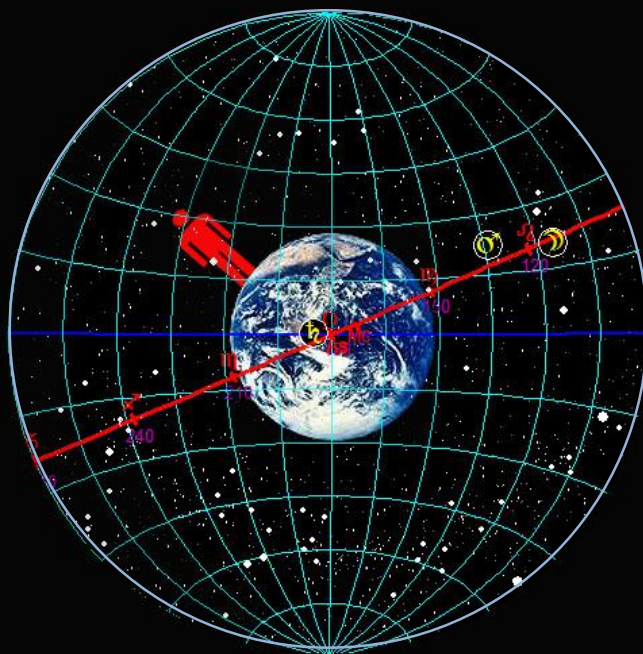
This is converted to time by every 1 degree of longitude being equal to 4 minutes of time.

Time difference is 4 hours 55 minutes.



9

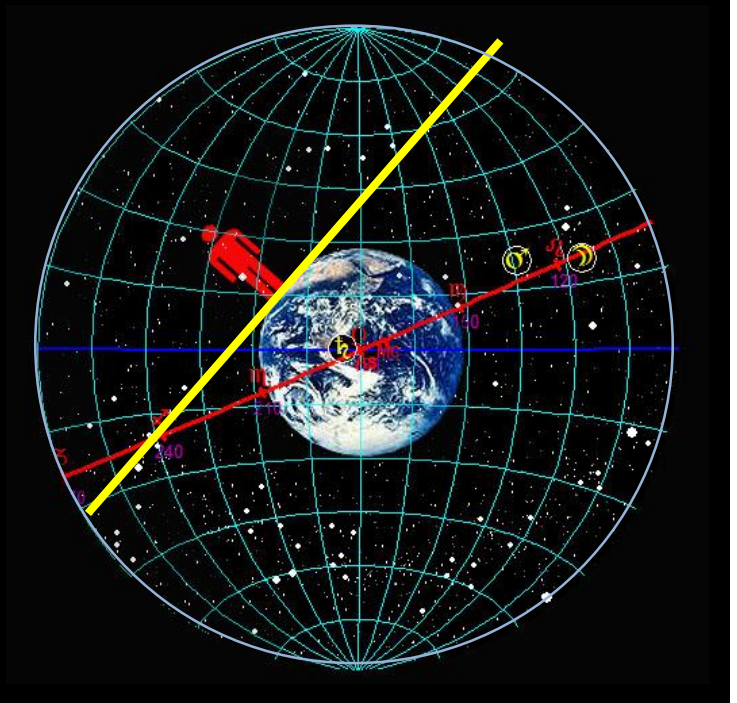
We see the sky from our own perspective so we need a system of measurement that reflects our personal spatial and temporal view.



10

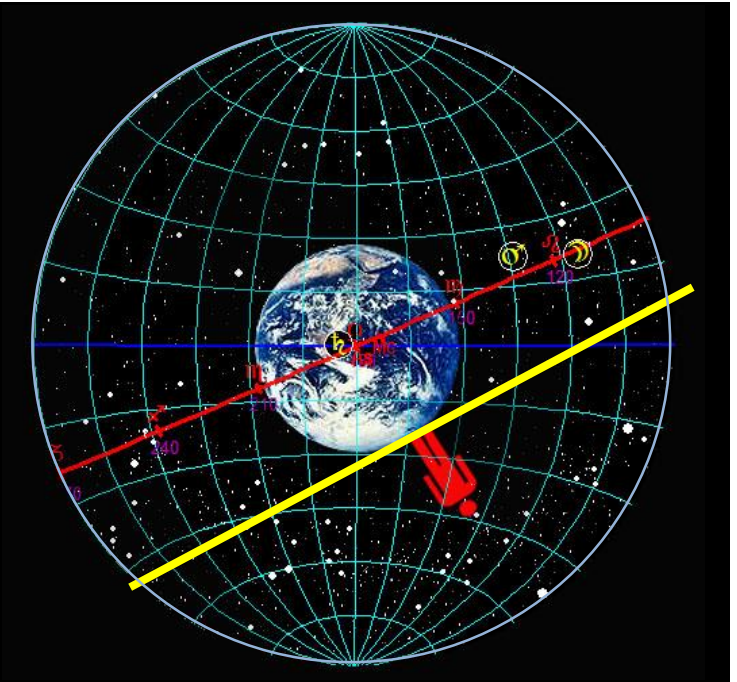
Part of our view is the horizon which is ALWAYS  $90^\circ$  from our upright position.

From this position we see the sky moving as it rotates around the pole.



11

No matter where we are standing!

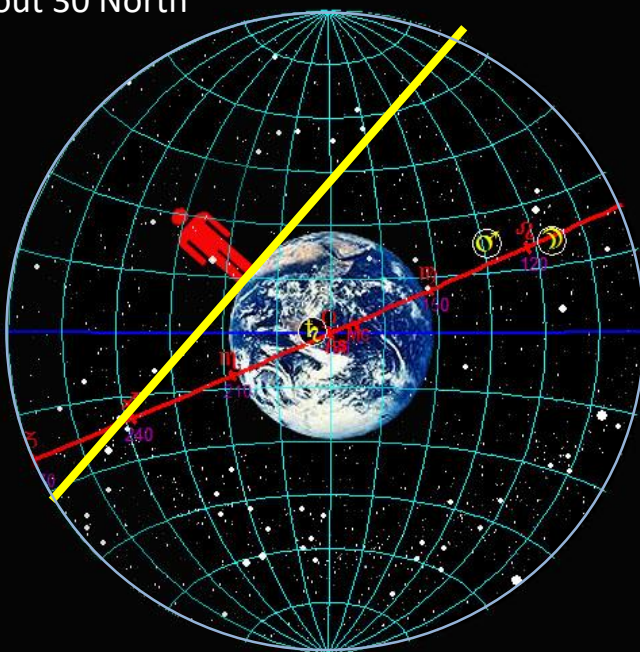


12

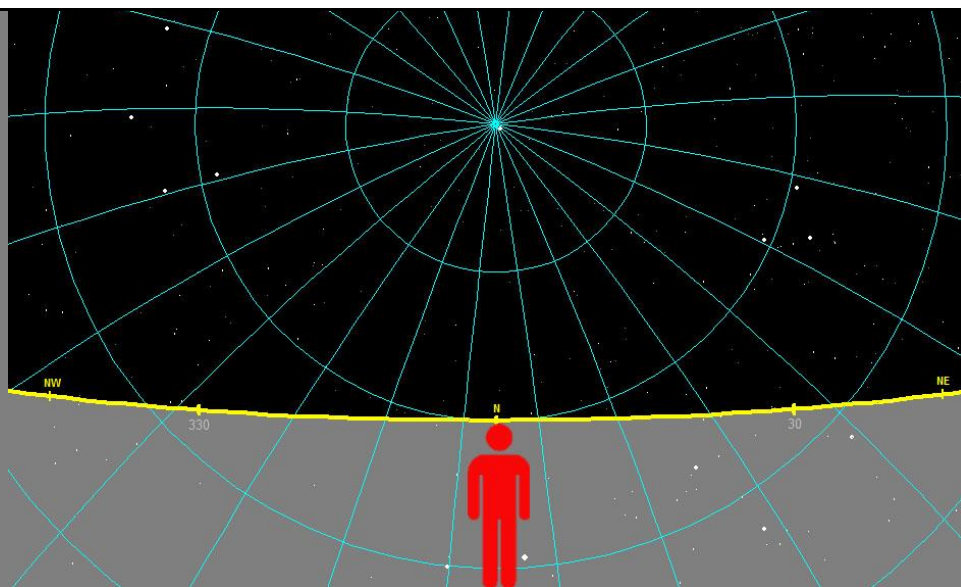
At about 30 North

The pole for this person is elevated  $30^\circ$  above their horizon.

The latitude of the observer defines the elevation of the pole for that location.



13



Looking at the Pole when you are at 30 North

14



The moon can be located on the grid based on the equator and the pole and thus it will have a particular declination and RA. Any heavenly body on a set declination line will rise and set in the same place on the horizon. The moon, in this image is at dec  $-10.53^\circ$ , RA  $14^h 36' 10''$ .

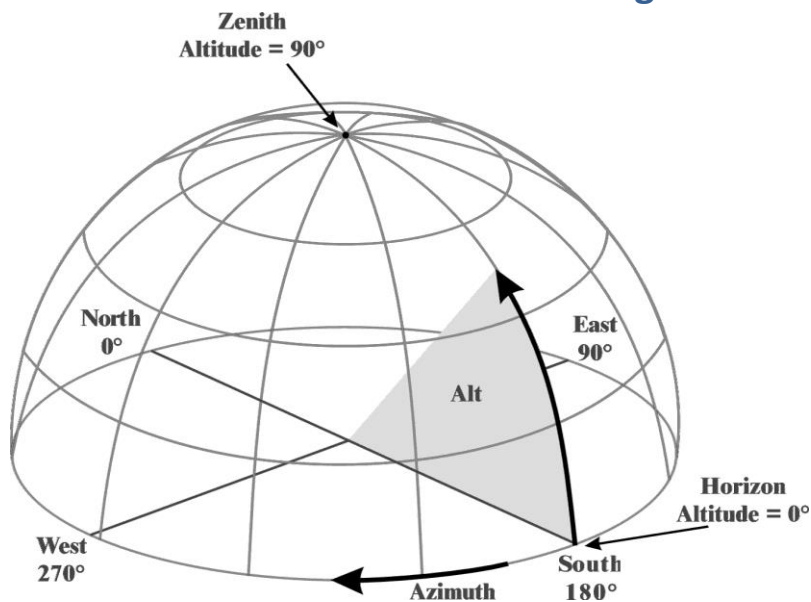
15



But the measurement of Declination and Right Ascension does not help us describe the moon's relationship to the horizon. For this we need to build a grid based on the horizon and elevation above (or below) the horizon. This is known as azimuth and altitude.

16

## The “Moving” Addresses

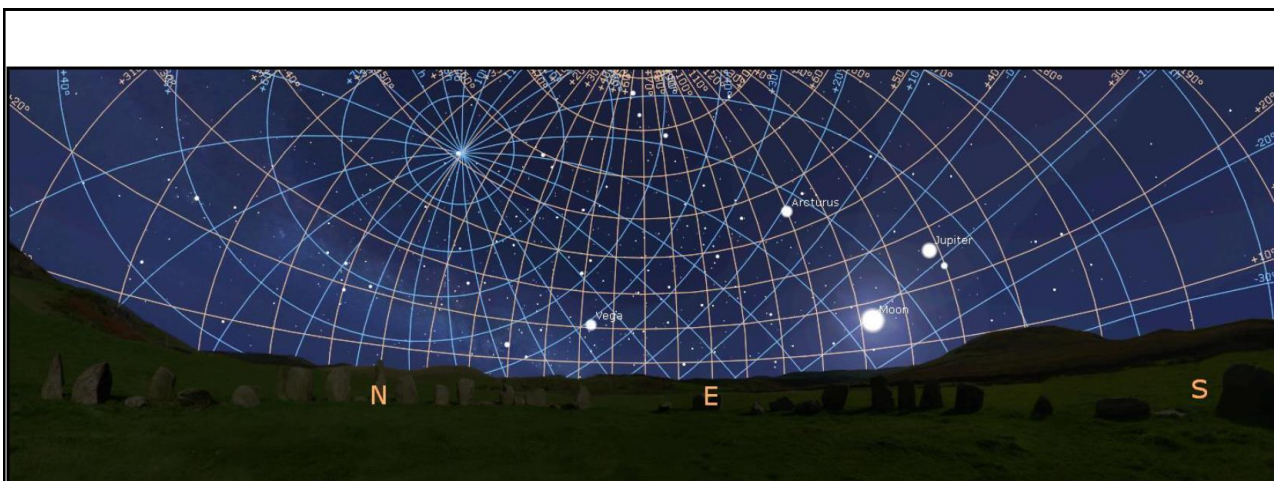


### Azimuth and Altitude

Fixed by the local horizon and the heavenly bodies move against this ‘net’

This is the ‘net’ that we are able to measure when looking at an horizon.

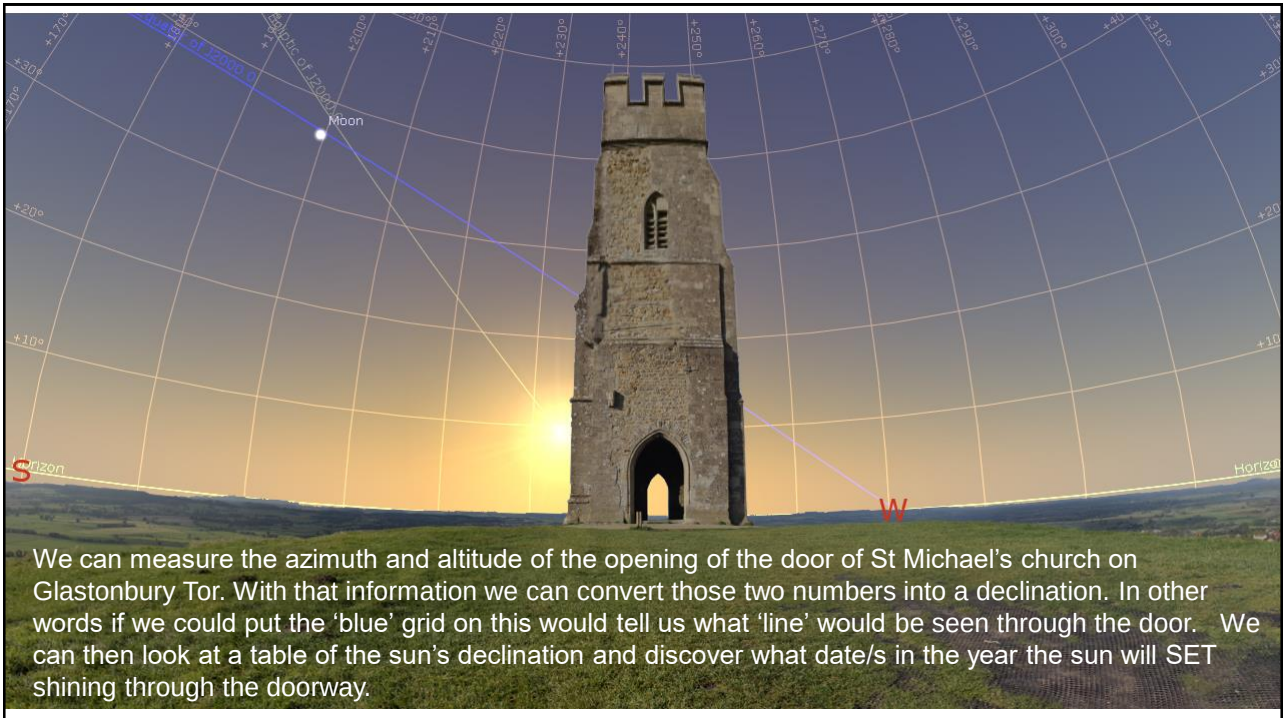
17



The Two Grids. The brown grid is the azimuth/RA grid, the one that we can measure with instruments. With these measurements you will learn how to convert these to the blue grid of Declination and RA.

WHY – consider the following example

18



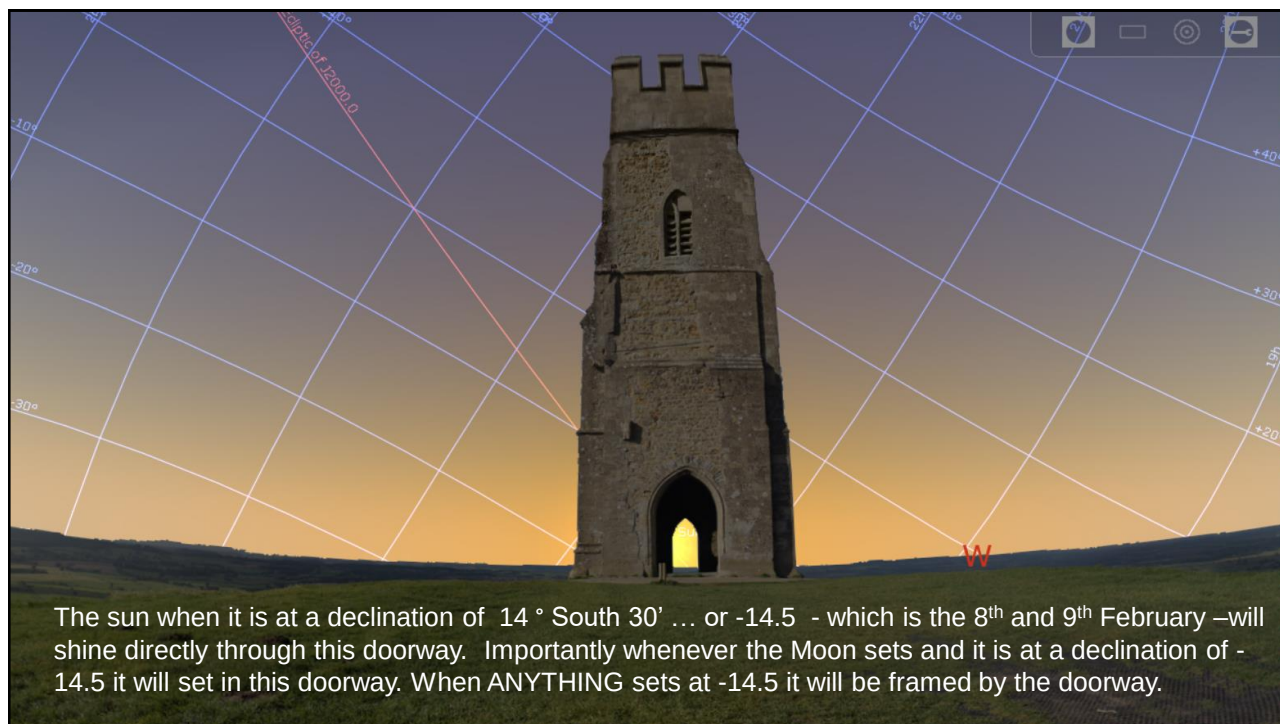
19

A particular declination will have a fixed relationship to a local horizon.

Table of the Declination of the Sun  
Mean Value for the Four Years of a Leap-Year Cycle  
Positive signs (+) Sun north of Celestial Equator; negative signs (-) Sun south of Celestial Equator.

| Day | JAN     | FEB     | MAR    | APR     | MAY     | JUN     | JUL     | AUG     | SEP    | OCT     | NOV     | DEC     |
|-----|---------|---------|--------|---------|---------|---------|---------|---------|--------|---------|---------|---------|
| 1   | -23°04' | -17°20' | -7°49' | +4°18'  | +14°54' | +21°58' | +23°09' | +18°10' | +8°30' | -2°57'  | -14°14' | -21°43' |
| 2   | -22°59' | -17°03' | -7°26' | +4°42'  | +15°12' | +22°06' | +23°05' | +17°55' | +8°09' | -3°20'  | -14°24' | -21°52' |
| 3   | -22°54' | -16°46' | -7°03' | +5°05'  | +15°30' | +22°14' | +23°01' | +17°40' | +7°47' | -3°44'  | -14°53' | -22°01' |
| 4   | -22°48' | -16°28' | -6°40' | +5°28'  | +15°47' | +22°22' | +22°56' | +17°24' | +7°25' | -4°07'  | -15°11' | -22°10' |
| 5   | -22°42' | -16°10' | -6°17' | +5°51'  | +16°05' | +22°29' | +22°51' | +17°08' | +7°03' | -4°30'  | -15°30' | -22°18' |
| 6   | -22°36' | -15°52' | -5°54' | +6°13'  | +16°22' | +22°35' | +22°45' | +16°52' | +6°40' | -4°53'  | -15°48' | -22°25' |
| 7   | -22°28' | -15°34' | -5°30' | +6°36'  | +16°39' | +22°42' | +22°39' | +16°36' | +6°18' | -5°16'  | -16°06' | -22°32' |
| 8   | -22°21' | -15°15' | -5°07' | +6°59'  | +16°55' | +22°47' | +22°33' | +16°19' | +5°56' | -5°39'  | -16°24' | -22°39' |
| 9   | -22°13' | -14°56' | -4°44' | +7°21'  | +17°12' | +22°53' | +22°26' | +16°02' | +5°33' | -6°02'  | -16°41' | -22°46' |
| 10  | -22°05' | -14°37' | -4°20' | +7°43'  | +17°27' | +22°58' | +22°19' | +15°45' | +5°10' | -6°25'  | -16°58' | -22°52' |
| 11  | -21°56' | -14°18' | -3°57' | +8°07'  | +17°43' | +23°02' | +22°11' | +15°27' | +4°48' | -6°48'  | -17°15' | -22°57' |
| 12  | -21°47' | -13°58' | -3°33' | +8°28'  | +17°59' | +23°07' | +22°04' | +15°10' | +4°25' | -7°10'  | -17°32' | -23°02' |
| 13  | -21°37' | -13°38' | -3°10' | +8°50'  | +18°14' | +23°11' | +21°55' | +14°52' | +4°02' | -7°32'  | -17°48' | -23°07' |
| 14  | -21°27' | -13°18' | -2°46' | +9°11'  | +18°29' | +23°14' | +21°46' | +14°33' | +3°39' | -7°55'  | -18°04' | -23°11' |
| 15  | -21°16' | -12°58' | -2°22' | +9°33'  | +18°43' | +23°17' | +21°37' | +14°15' | +3°16' | -8°18'  | -18°20' | -23°14' |
| 16  | -21°06' | -12°37' | -1°59' | +9°54'  | +18°58' | +23°20' | +21°28' | +13°56' | +2°53' | -8°40'  | -18°35' | -23°17' |
| 17  | -20°54' | -12°16' | -1°35' | +10°16' | +19°11' | +23°22' | +21°18' | +13°37' | +2°30' | -9°02'  | -18°50' | -23°20' |
| 18  | -20°42' | -11°55' | -1°11' | +10°37' | +19°25' | +23°24' | +21°08' | +13°18' | +2°06' | -9°24'  | -19°05' | -23°22' |
| 19  | -20°30' | -11°34' | -0°48' | +10°58' | +19°38' | +23°25' | +20°58' | +12°59' | +1°43' | -9°45'  | -19°19' | -23°24' |
| 20  | -20°18' | -11°13' | -0°24' | +11°19' | +19°51' | +23°26' | +20°47' | +12°39' | +1°20' | -10°07' | -19°33' | -23°25' |
| 21  | -20°05' | -10°52' | 0°00'  | +11°39' | +20°04' | +23°26' | +20°36' | +12°19' | +0°57' | -10°29' | -19°47' | -23°26' |
| 22  | -19°52' | -10°30' | +0°24' | +12°00' | +20°16' | +23°26' | +20°24' | +11°59' | +0°33' | -10°50' | -20°00' | -23°26' |
| 23  | -19°38' | -10°08' | +0°47' | +12°20' | +20°28' | +23°26' | +20°12' | +11°39' | +0°10' | -11°12' | -20°13' | -23°26' |
| 24  | -19°24' | -9°46'  | +1°11' | +12°40' | +20°39' | +23°25' | +20°00' | +11°19' | -0°14' | -11°33' | -20°26' | -23°26' |
| 25  | -19°10' | -9°24'  | +1°35' | +13°00' | +20°50' | +23°24' | +19°47' | +10°58' | -0°37' | -11°54' | -20°38' | -23°25' |
| 26  | -18°55' | -9°02'  | +1°58' | +13°19' | +21°01' | +23°23' | +19°34' | +10°38' | -1°00' | -12°14' | -20°50' | -23°23' |
| 27  | -18°40' | -8°39'  | +2°22' | +13°38' | +21°12' | +23°21' | +19°21' | +10°17' | -1°24' | -12°35' | -21°01' | -23°21' |
| 28  | -18°25' | -8°17'  | +2°45' | +13°58' | +21°22' | +23°19' | +19°08' | +9°56'  | -1°47' | -12°55' | -21°12' | -23°19' |
| 29  | -18°09' | -7°53'  | +3°09' | +14°16' | +21°31' | +23°16' | +18°54' | +9°35'  | -2°10' | -13°15' | -21°23' | -23°16' |
| 30  | -17°53' | -7°29'  | +3°32' | +14°35' | +21°41' | +23°13' | +18°40' | +9°13'  | -2°34' | -13°35' | -21°33' | -23°12' |
| 31  | -17°37' | -7°05'  | +3°55' | +14°50' | +21°50' | +23°10' | +18°25' | +8°52'  | -2°57' | -13°55' | -21°43' | -23°08' |

20



21

Stars also have declination and RA. Thus knowing the declination of the doorway means we can simply look up what stars have that same declination to find which stars will set at that particular azimuth.

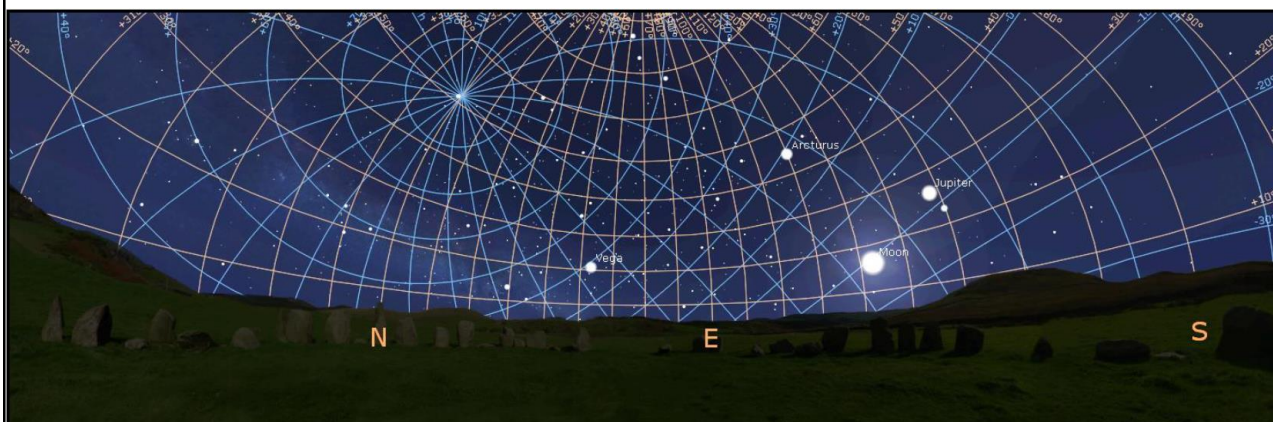
|                     |                |                |
|---------------------|----------------|----------------|
| <b>Altair</b>       | <b>297°55'</b> | <b>+08°55'</b> |
| <b>Ankaa</b>        | <b>006°47'</b> | <b>-42°13'</b> |
| <b>Antares</b>      | <b>247°37'</b> | <b>-26°28'</b> |
| <b>Arcturus</b>     | <b>214°07'</b> | <b>+19°05'</b> |
| <b>Bellatrix</b>    | <b>081°32'</b> | <b>+06°22'</b> |
| <b>Betelgeuse</b>   | <b>089°02'</b> | <b>+07°24'</b> |
| <b>Canopus</b>      | <b>096°06'</b> | <b>-52°43'</b> |
| <b>Capella</b>      | <b>079°30'</b> | <b>+46°01'</b> |
| <b>Capulus</b>      | <b>035°04'</b> | <b>+57°14'</b> |
| <b>Castor</b>       | <b>113°56'</b> | <b>+31°51'</b> |
| <b>Deneb Adige</b>  | <b>310°30'</b> | <b>+45°21'</b> |
| <b>Deneb Algedi</b> | <b>327°00'</b> | <b>-16°03'</b> |
| <b>Denebola</b>     | <b>177°30'</b> | <b>+14°28'</b> |
| <b>Diadem</b>       | <b>197°43'</b> | <b>+17°26'</b> |
| <b>Dubhe</b>        | <b>166°13'</b> | <b>+61°39'</b> |
| <b>El Nath</b>      | <b>081°52'</b> | <b>+28°37'</b> |
| <b>Facies</b>       | <b>279°22'</b> | <b>-23°53'</b> |

22



23

So we measure the BROWN grid – the local **Azimuth** and **Altitude** and use those numbers to convert to the non-location based measurement of **declination**



### Two points:

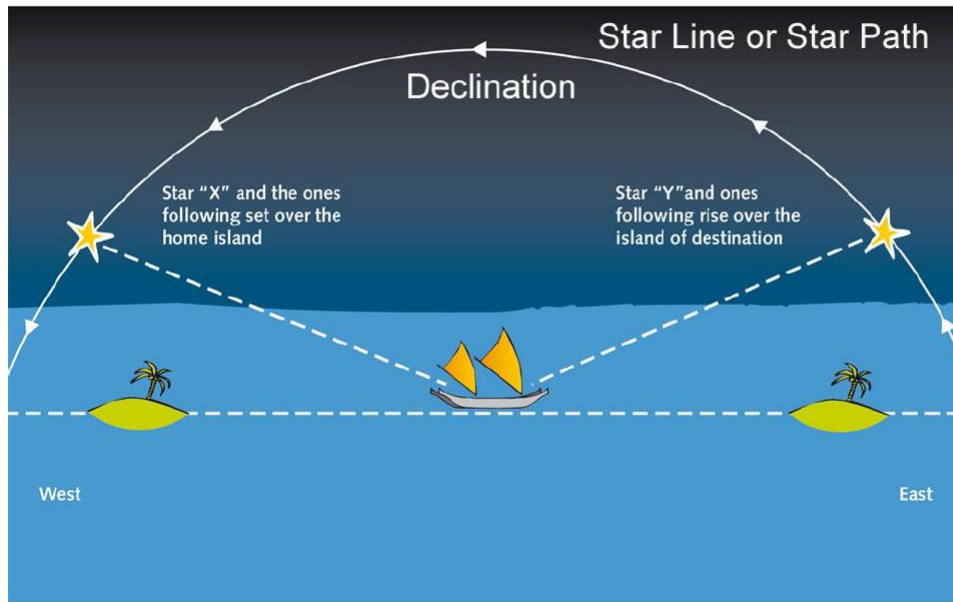
Once we know the declination of a landscape feature we can tell **WHERE** in a **particular** landscape the stars or other bodies will 'touch' it by rising or setting.

Once we know the declination of a heavenly body we can tell **WHERE** in any landscape that particular body will touch the earth, or if it can touch the earth.

24

## STARPATH NAVIGATION

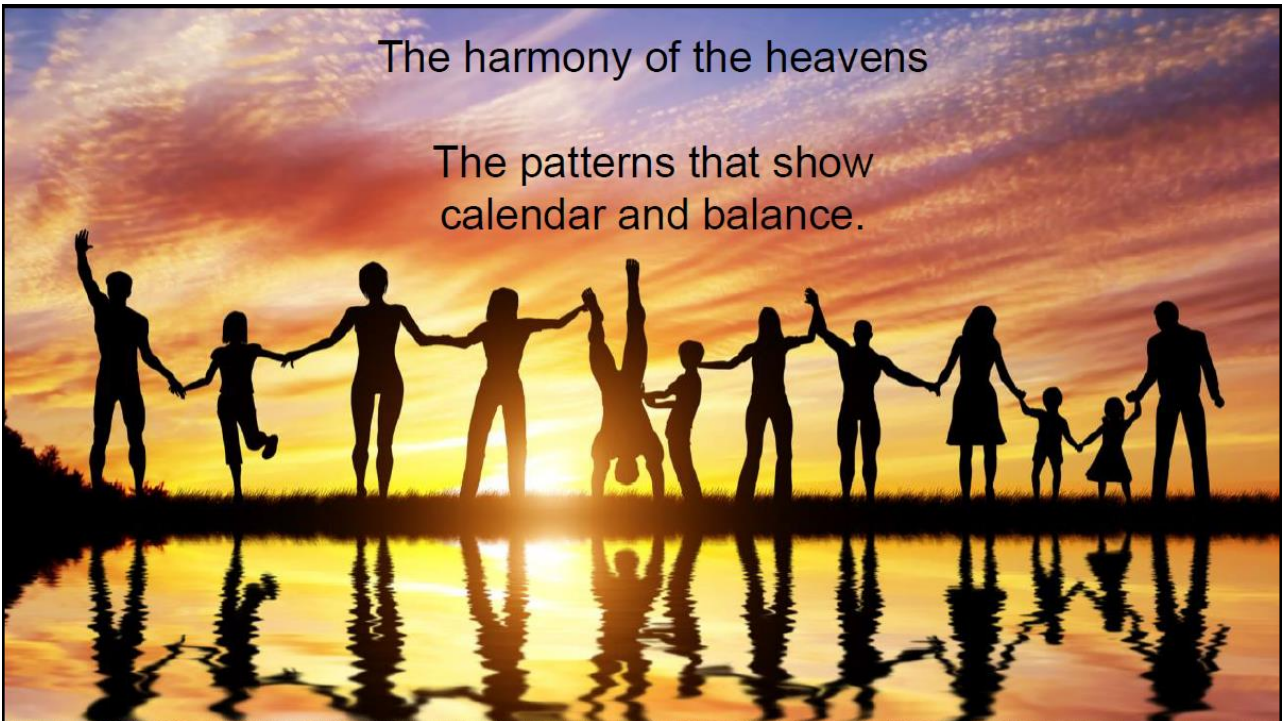
By sea or by land



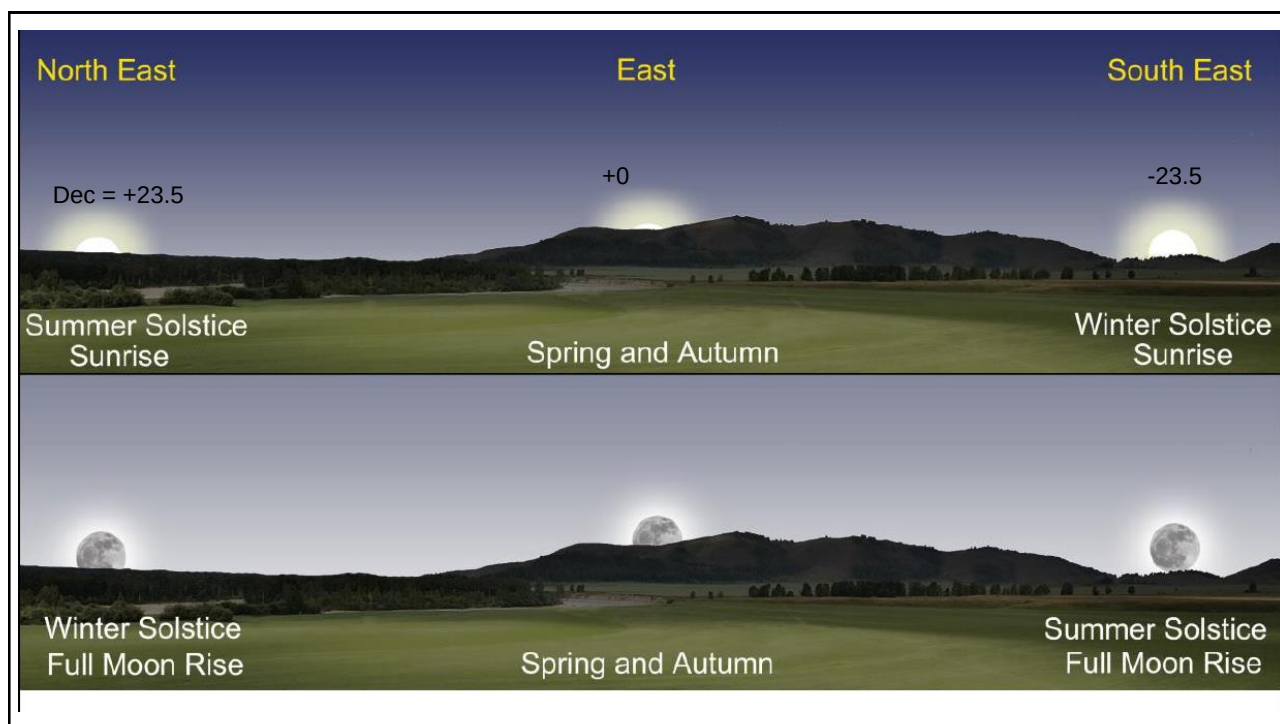
25

The harmony of the heavens

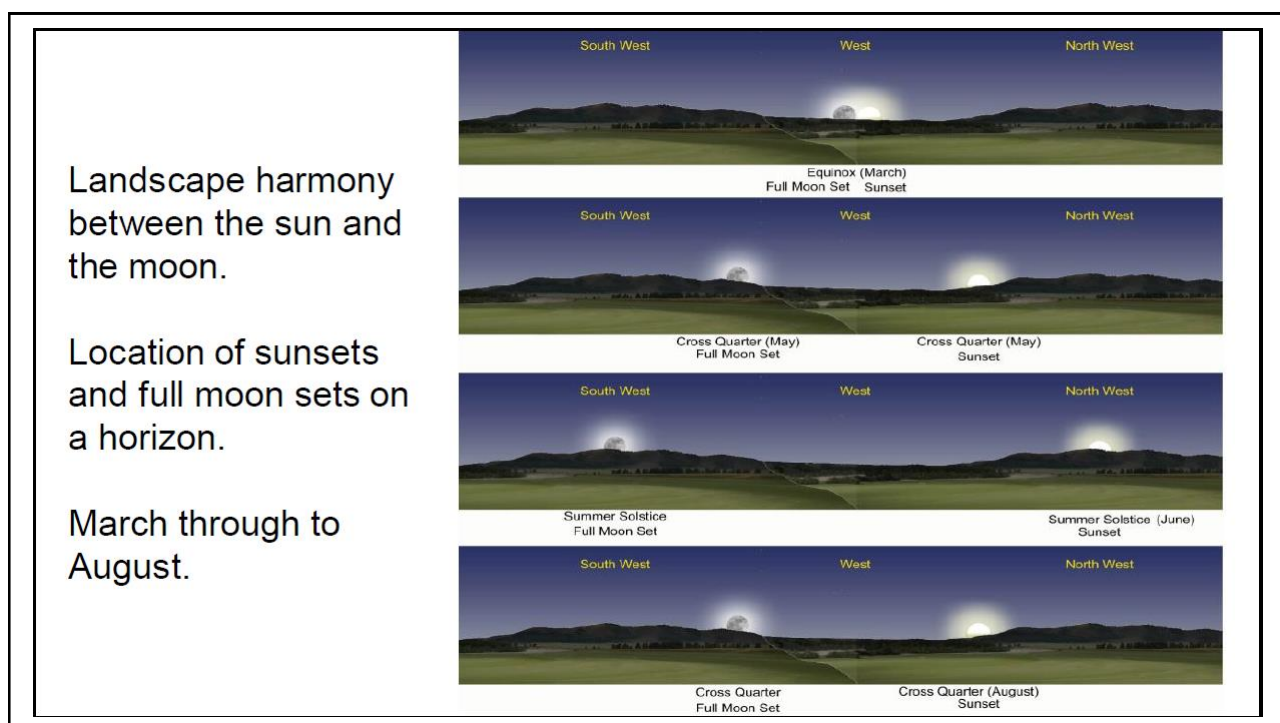
The patterns that show  
calendar and balance.



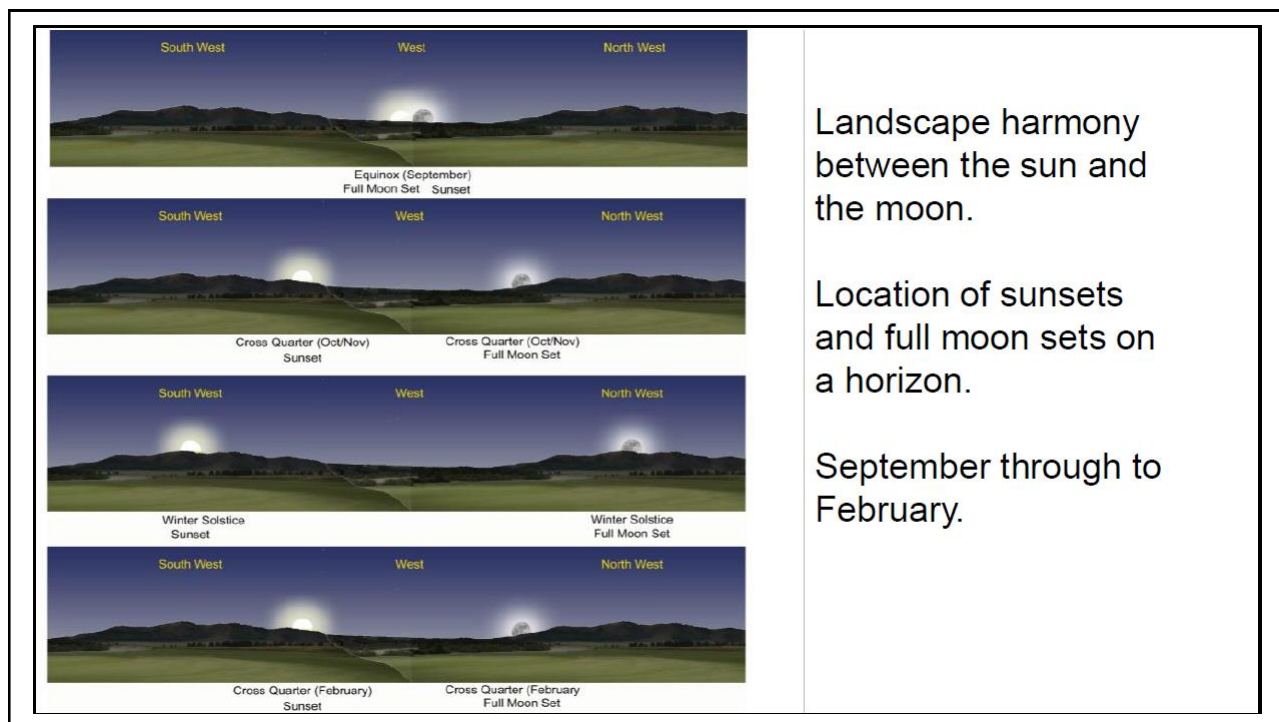
26



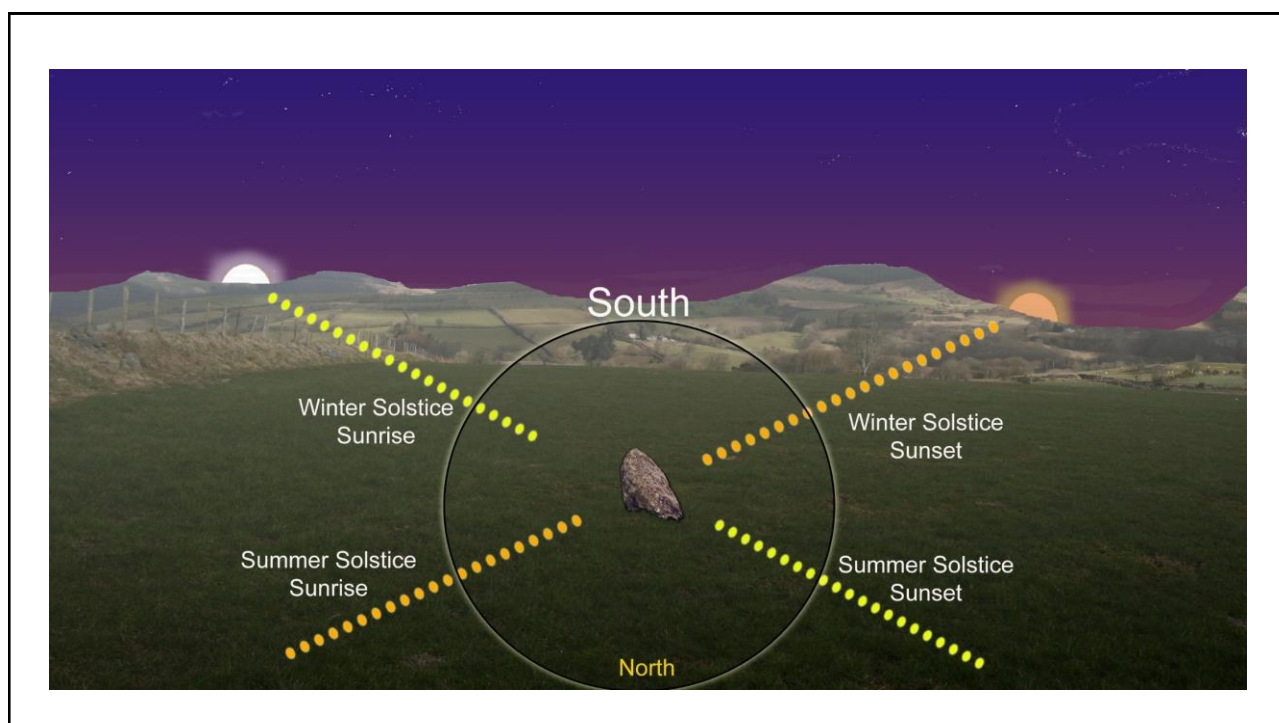
27



28



29

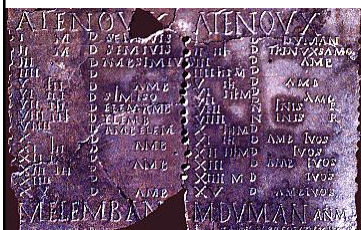


30

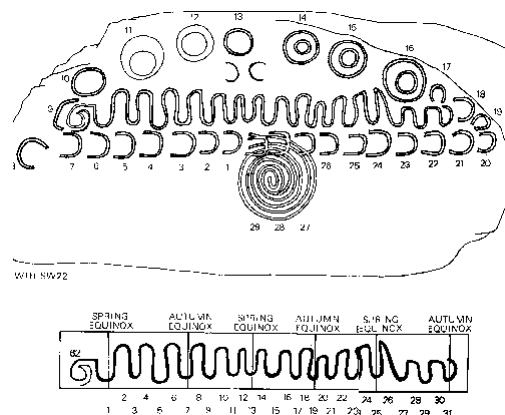
## Calendars in the Landscape

Sun  
Moon  
Lunar-Solar  
Lunar- Stellar  
Lunar-Solar-Stellar

Coligny Calendar 1<sup>st</sup> Century BCE?



Newgrange – a possible lunar calendar



31

To get a feel for the way the sky moves  
download the free planetarium software.

Stellarium - <http://www.stellarium.org/>

32

## References

Aratus, *Phaenomena*. trans. Aaron Poochigian (Baltimore, USA: John Hopkins University Press, 2010)

Brady, Bernadette. "Star-Paths, Stones and Horizon Astronomy." In *Stars and Stones*, edited by F.Pimenta, N. Ribeiro, F.Silva, N.Campion, A.Joaquinito and L.Tirapicos, : SEAC 2011

Kaler, James B., *The Ever-Changing Sky : A Guide to the Celestial Sphere* (Cambridge: Cambridge University Press, 1996).

Sadler, Philip M, Haller, Doug, and Garfield, Eliza, 'Observational Journals:An Aid to Sky Watching', *JCST*, February (2000), 245 - 254.

Schaaf, Fred, *The Starry Room : Naked Eye Astronomy in the Intimate Universe* (Mineola, N.Y.: Dover Publications ; Newton Abbot : David & Charles, 2002).

Zhitomirsky, S. "Aratus' "Phaenomena": Dating and Analysing Its Primary Source." *Astronomical & Astrophysical Transactions* 17 (1999): 483-500. p.492.

.