

# Great American Eclipse 2024

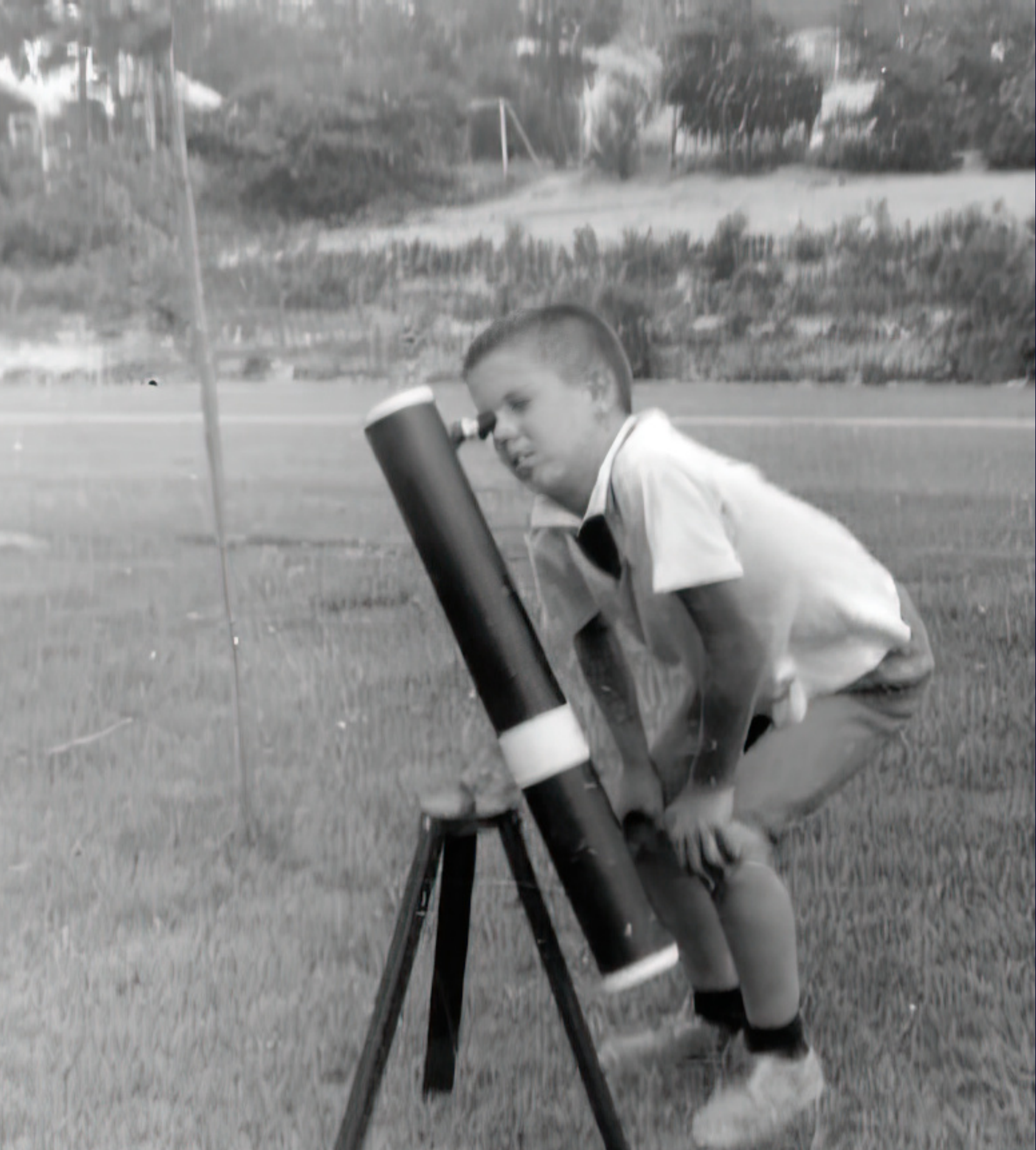
High Noon Talk, Bullock Texas State History Museum

April 3, 2024

**Rob Pettengill, Ph.D.**

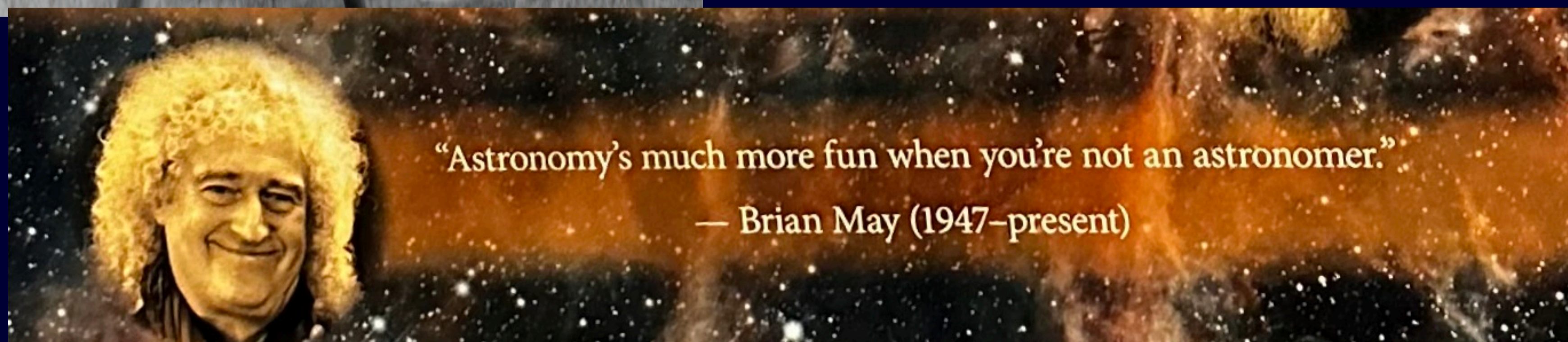
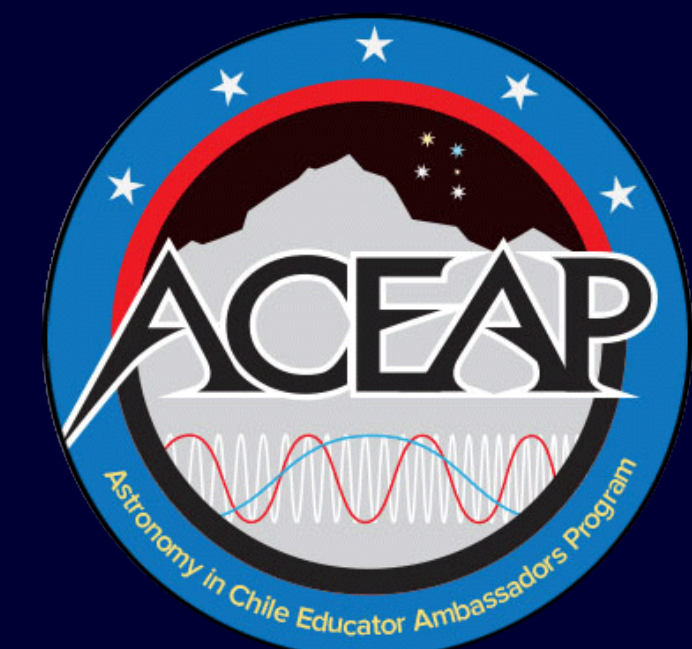
NASA/JPL Solar System Ambassador,

AUI/AURA/NSF Astronomy in Chile Educator Ambassador



# Why me

- Lifelong enthusiast
- Failed astronomer, seduced by small is beautiful, career in microelectronics and software
- Astrophotographer
- Educator
  - [BadAstroPhotos.com](http://BadAstroPhotos.com)
  - NASA JPL Solar System Ambassador
  - Astronomy in Chile Educator Ambassador



“Astronomy’s much more fun when you’re not an astronomer.”

— Brian May (1947–present)

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Our voyage today

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**Why do we have eclipses, as often as we do?**

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**Kinds of eclipses and their properties**

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**What to notice during a total solar eclipse**

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**Where to view the eclipse**

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**EZ eclipse photography**

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# Eclipse - the cast

- Illuminator
- Obstructor
- Shadow
- Target, interacts with Shadow
- Observer

# Eclipse - the plot

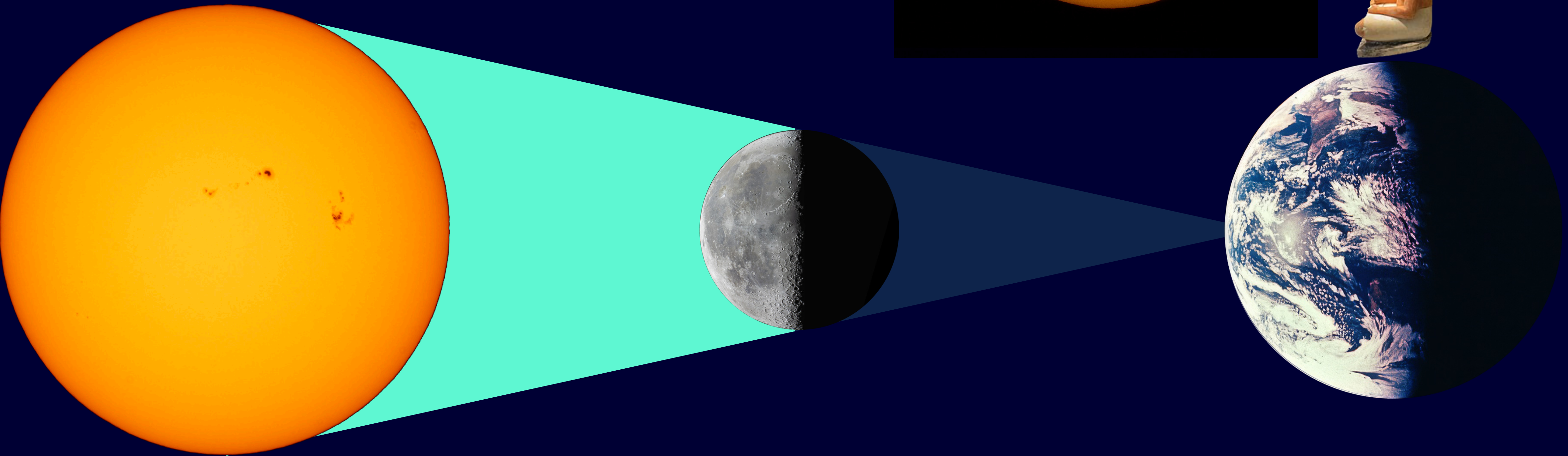
- Order and timing of events
- Frame of reference and POV

# When we see the universe in action...

- Sense our place in the universe
- Share a common experience across time and borders
- Deduce how the universe works

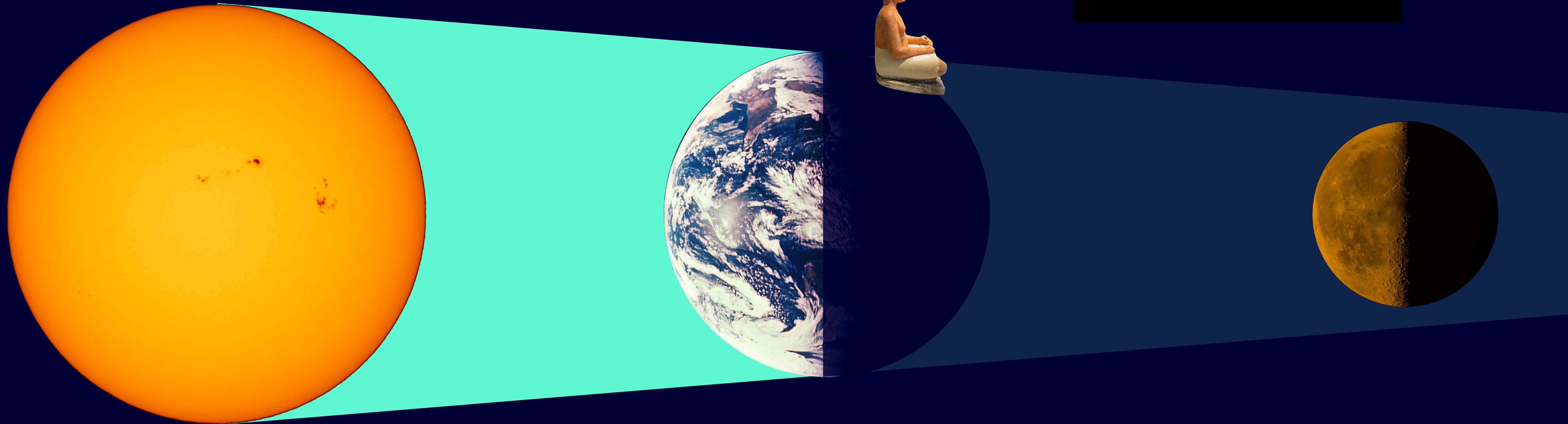


# Solar Eclipse



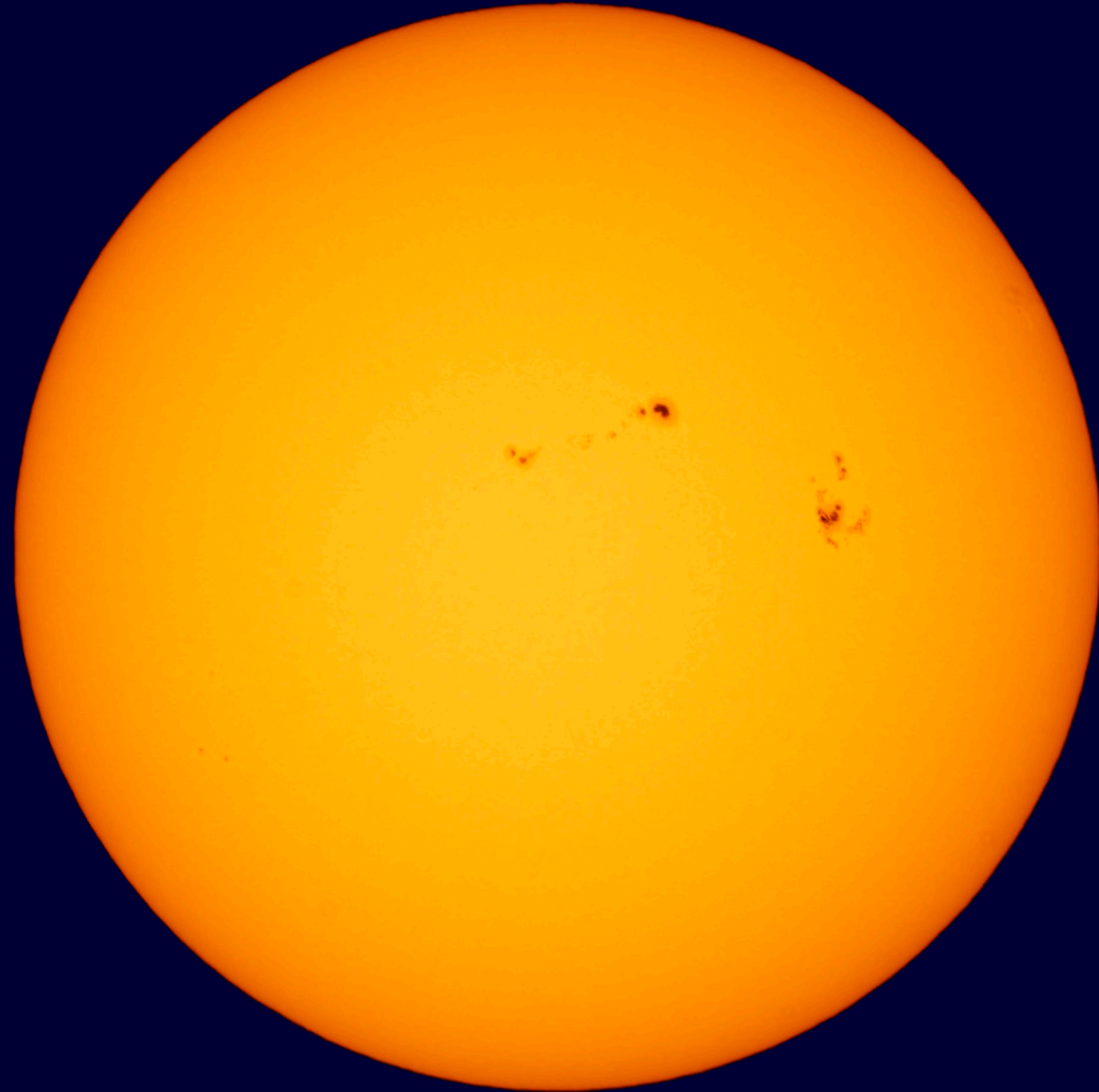
Sun - Moon - Earth

# Lunar Eclipse



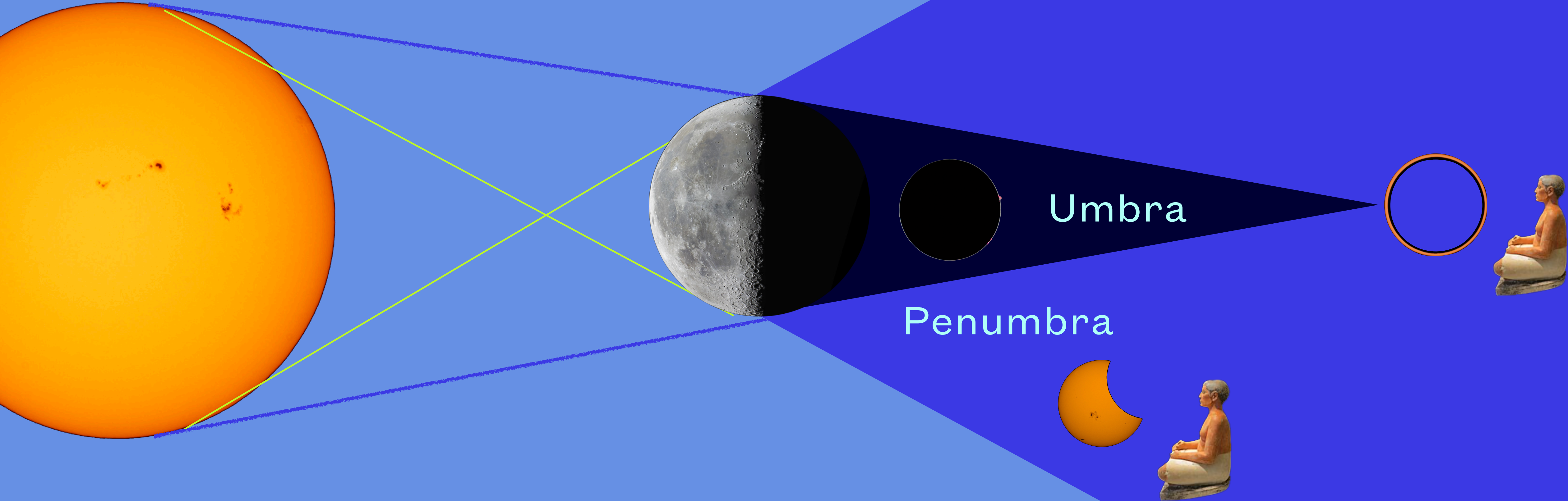
Sun - Earth - Moon

# Apocalypse



Not going to happen

# Shadows deep and partial





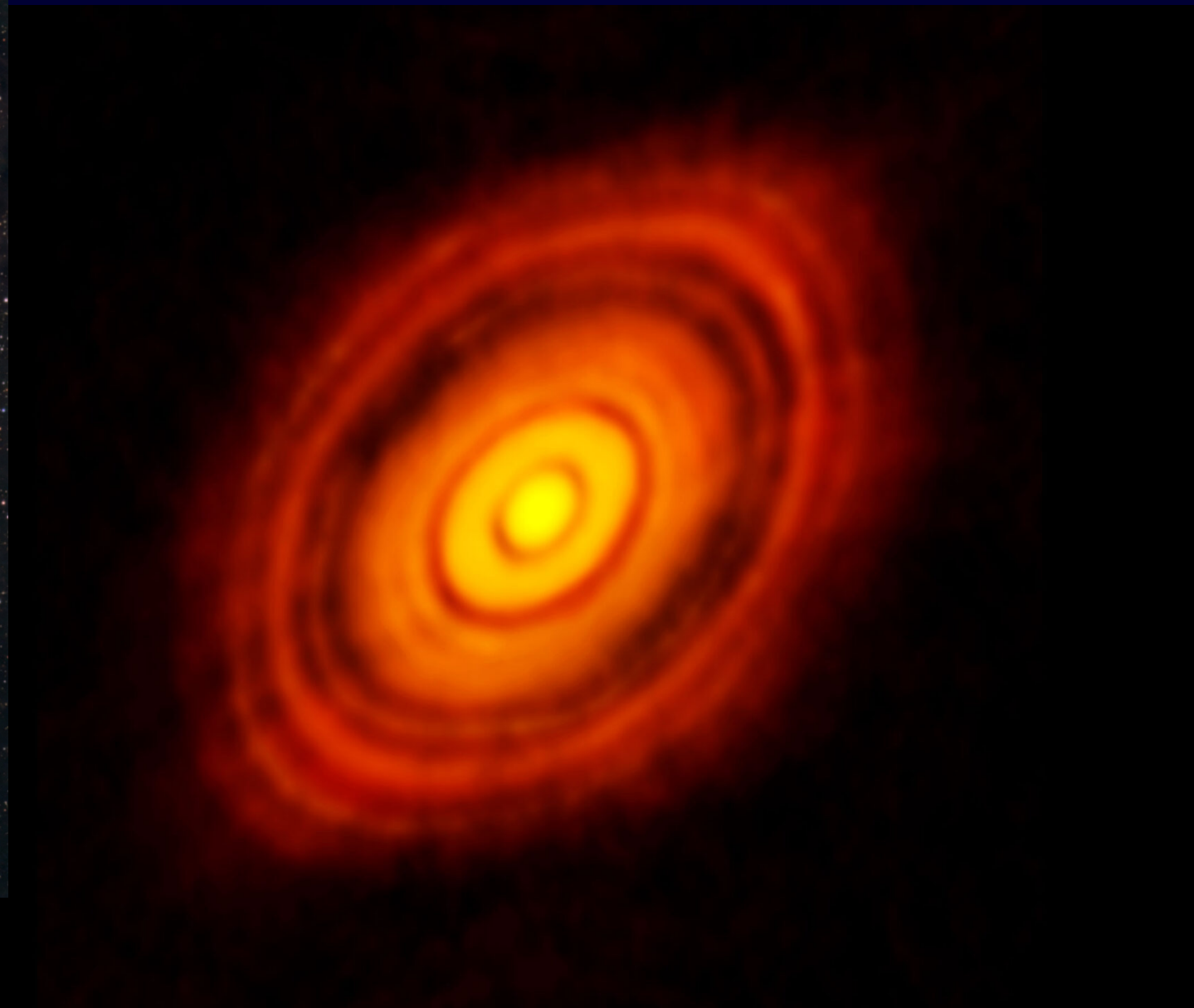
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# Why are eclipses not rare?

Blobs of gas become disks under influence of gravity and angular momentum

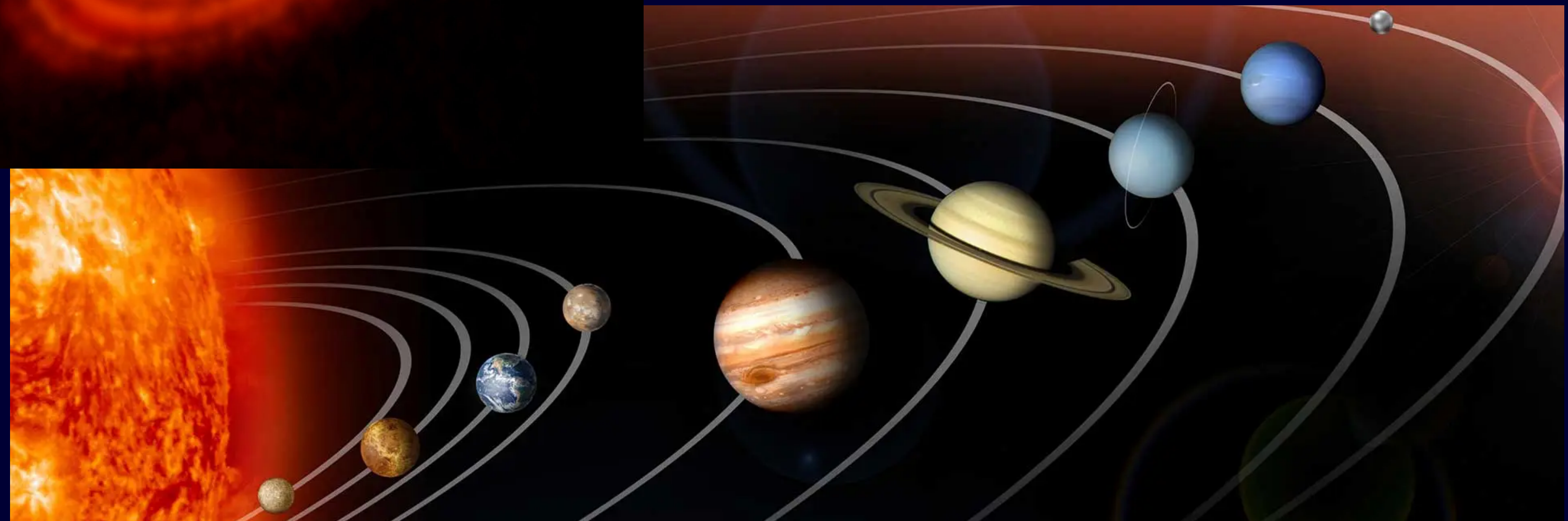


ALMA



NASA

Planetary and moon systems  
become disk shaped





2016-02-04 6:35 Austin, Texas  
Rob Pettengill @ BadAstroPhotos.com

Venus  
Mercury

Moon

Saturn

Antares

Mars

Spica

Jupiter

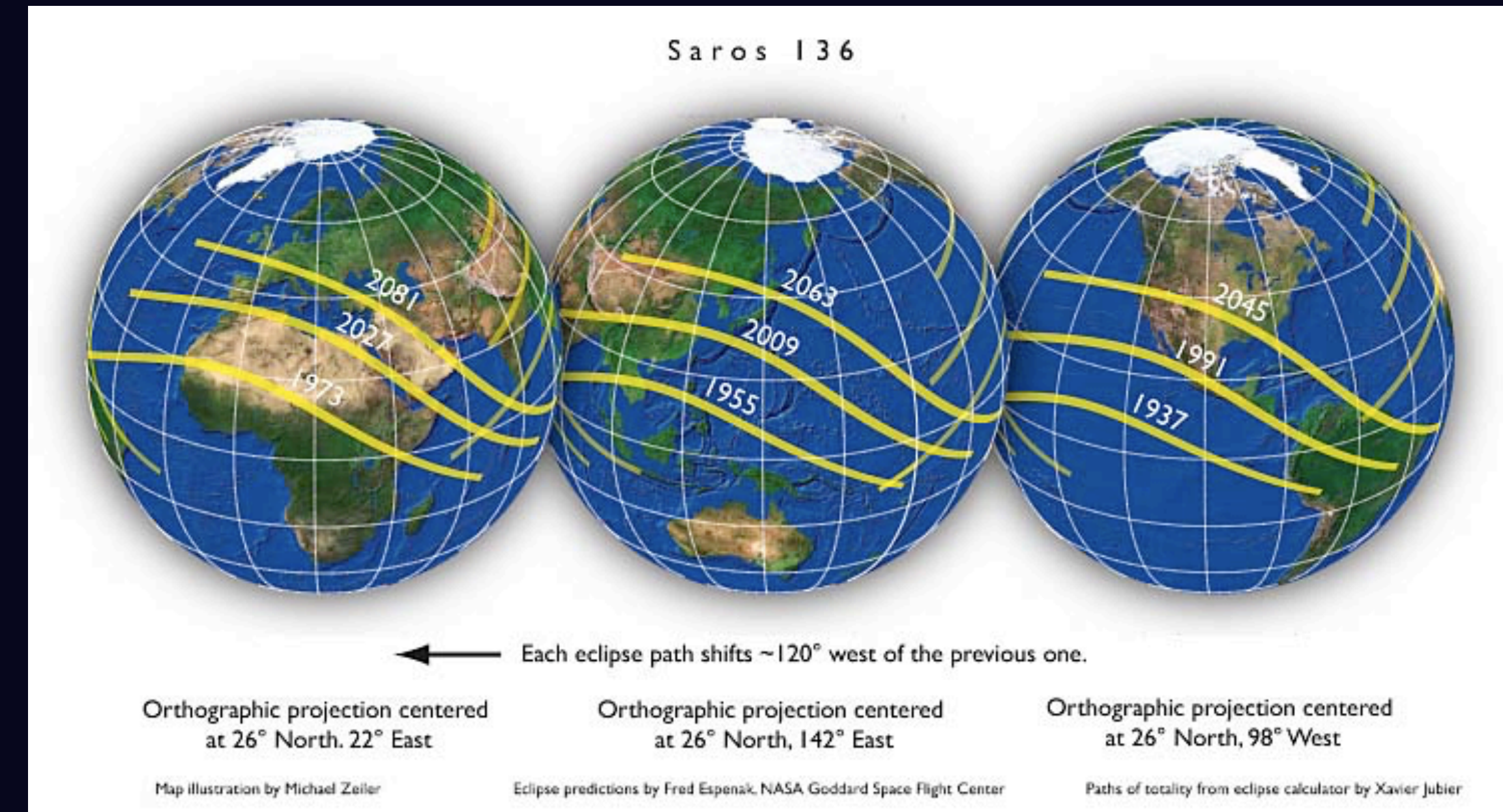
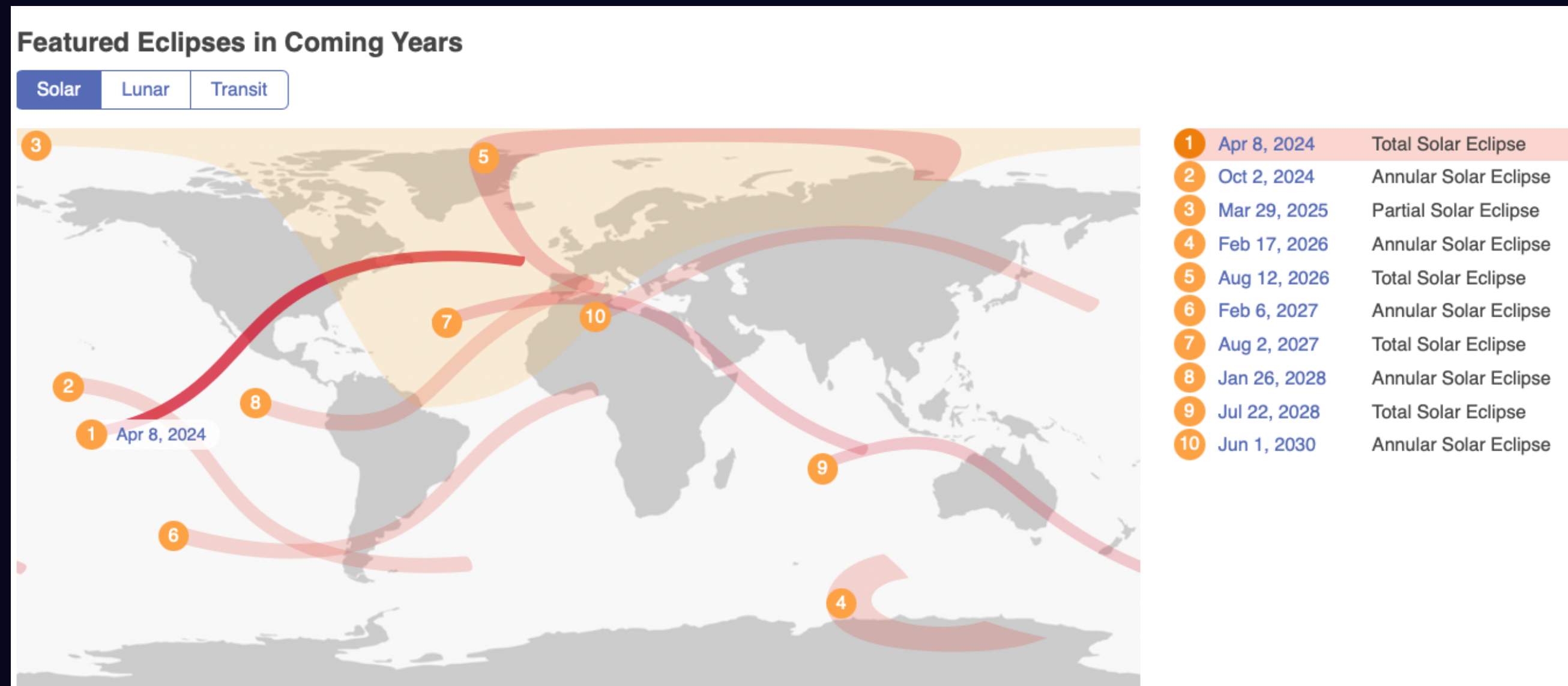
Our own solar system, a real example



2016-02-04 6:35 Austin, Texas  
Rob Pettengill @ BadAstroPhotos.com

Venus  
Mercury Moon Saturn Antares Mars Spica Jupiter

# Why don't solar/lunar eclipses occur every new/full moon?

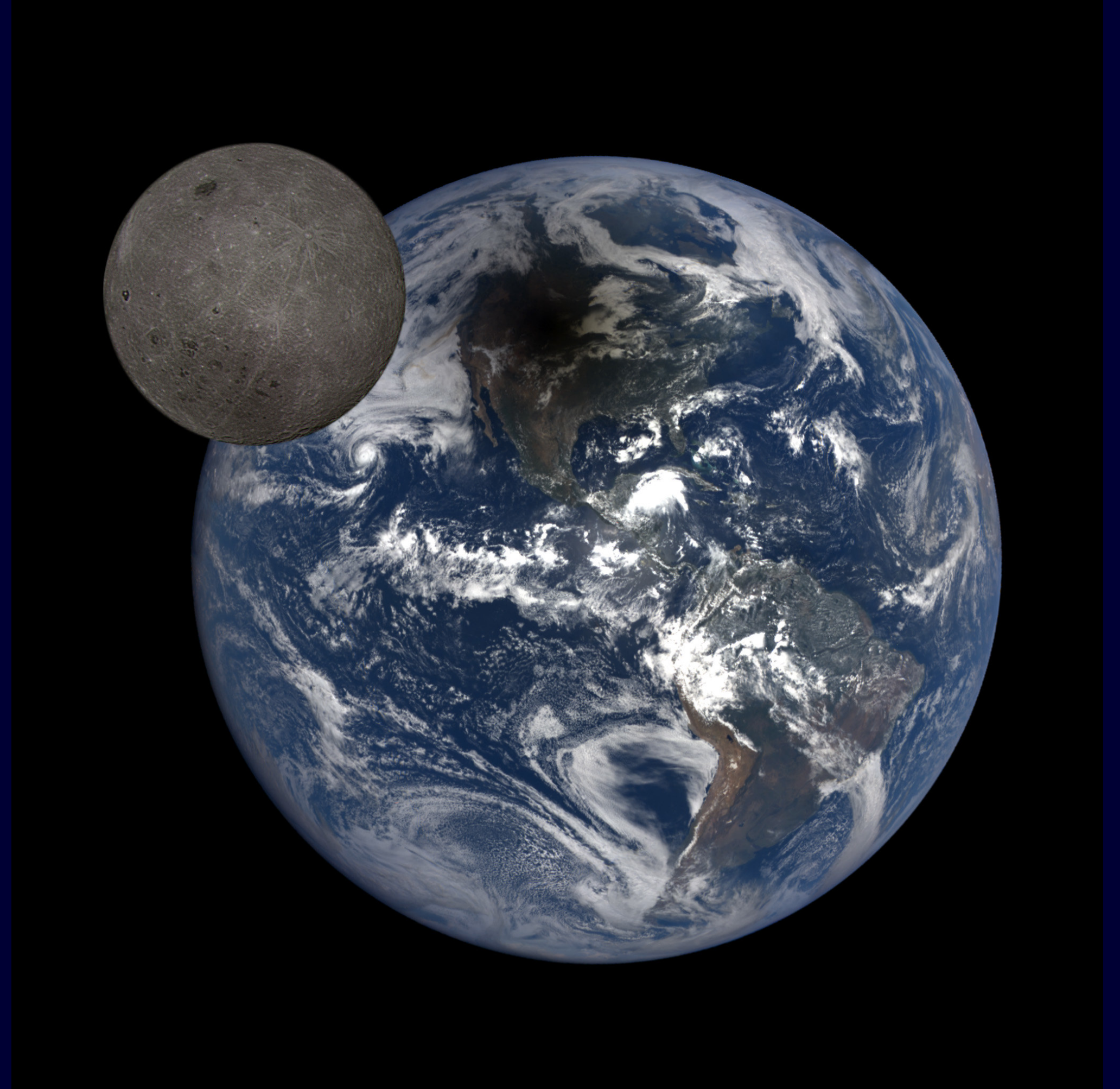


Tilted orbits line up 2x a revolution (year)

Earth's year, and lunar month harmonically combine to repeat eclipses in the 18yr Saros Cycle

# Eclipses and relatives

- Eclipse - object hidden by one of similar apparent size



NASA DSCOVR with moon moved into FOV

# Eclipses and relatives

- Transit - small in front of large



Mercury from Lomita, Tx



ISS from Briggs



Io & shadow transit of Jupiter

# Eclipses and relatives

- Ocultaion - large in front of small

Mars occulted by Moon from Elgin



# Eclipses and relatives

- Conjunction - a near miss, eclipse not

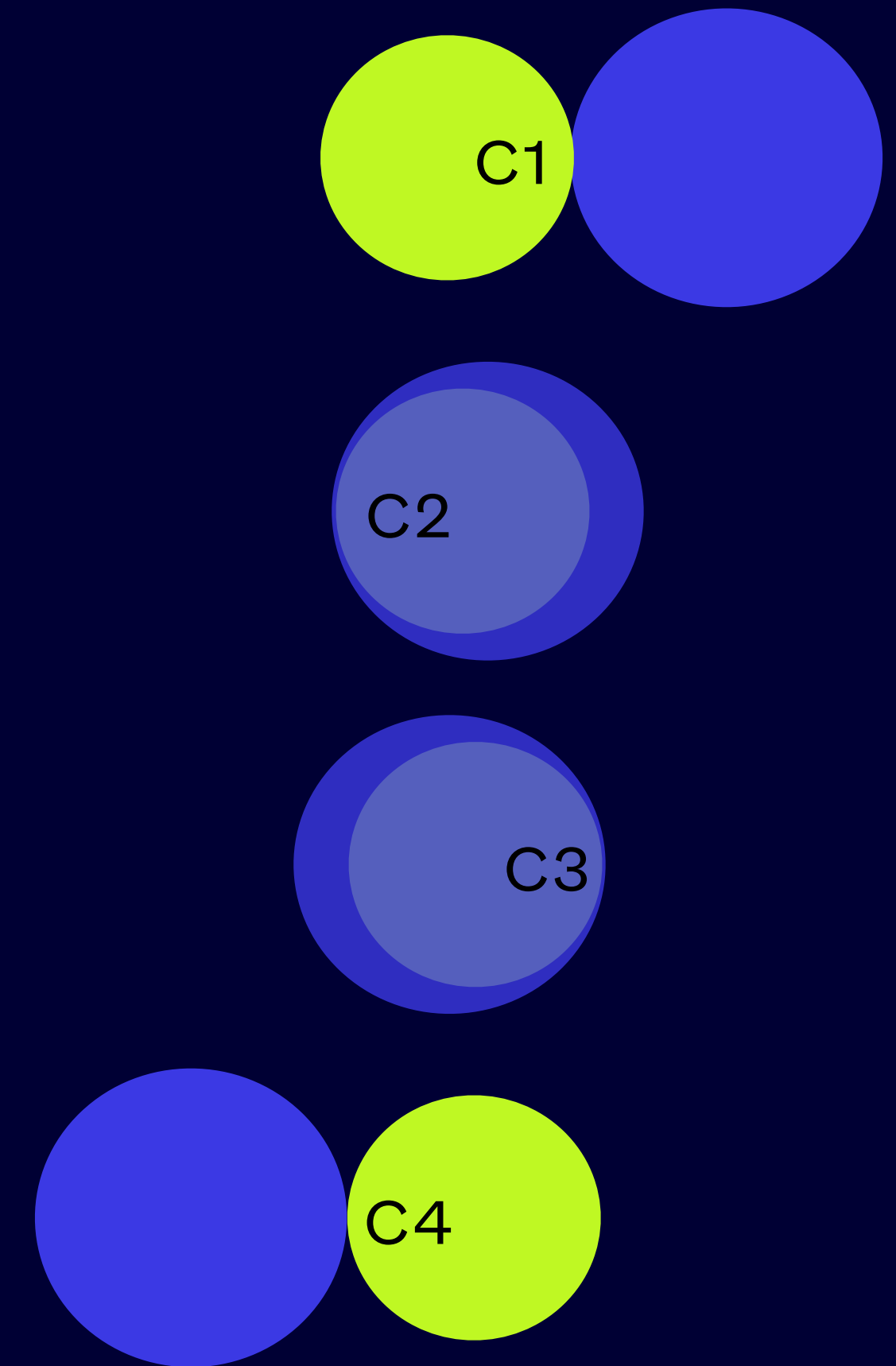


Jupiter & Saturn Mudville



# Events of an eclipse

- Pre
- C1, first contact, partial eclipse starts
- C2, second contact, total eclipse starts
- Maximum eclipse
- C3, third contact, total eclipse ends
- C4, fourth contact, partial eclipse ends
- Post
- Penumbra = P1 - P4
- Umbra = U1 - U4



# Eclipse - what to notice

<http://www.mreclipse.com/Totality2017/Totality2017-Ch01.html>



- C1 - can you catch the first bite out of the sun taken by the moon
- During partial eclipse notice the shape of the sun - different from crescent moon shapes.
- Notice your environment, temperature, wind, animal behavior, sound
- C2 - things happen fast
  - Remove your eclipse glasses/filters a few seconds before the last sliver of sun disappears, regular binoculars are great now
  - Look for Baley's beads and the diamond ring and watch how they change
- Totality, you have only a couple of minutes
  - With binoculars look for solar provinces rising past the edge of the moon, look carefully for signs of earthshine on the moons face
  - Observe the shape, color, and size of the solar corona
  - Look for stars and planets
  - Notice the color of the sky and 360 twilight
  - Listen to those around you and look at their expressions
- C3 - replace your filters and switch back to eclipse glasses



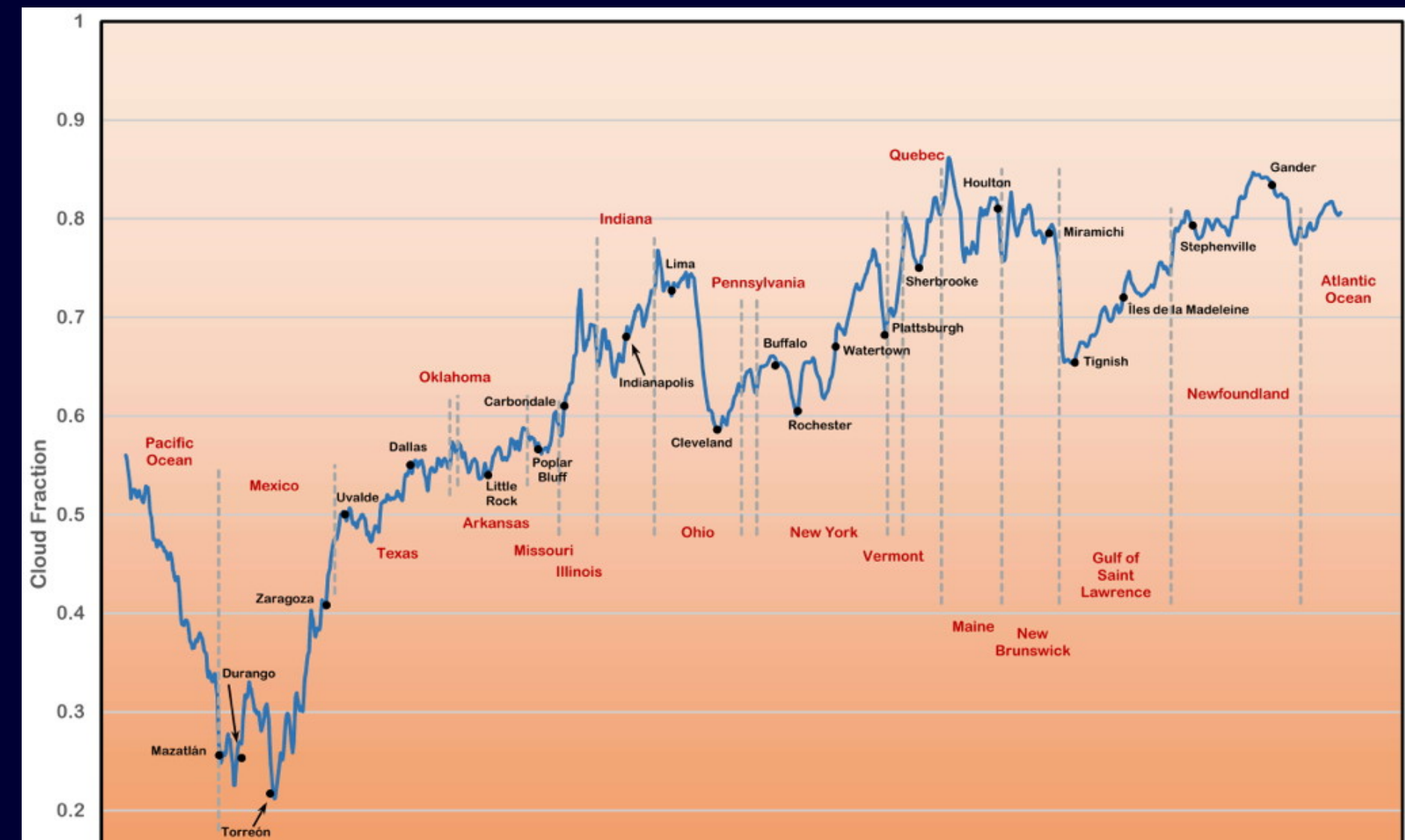
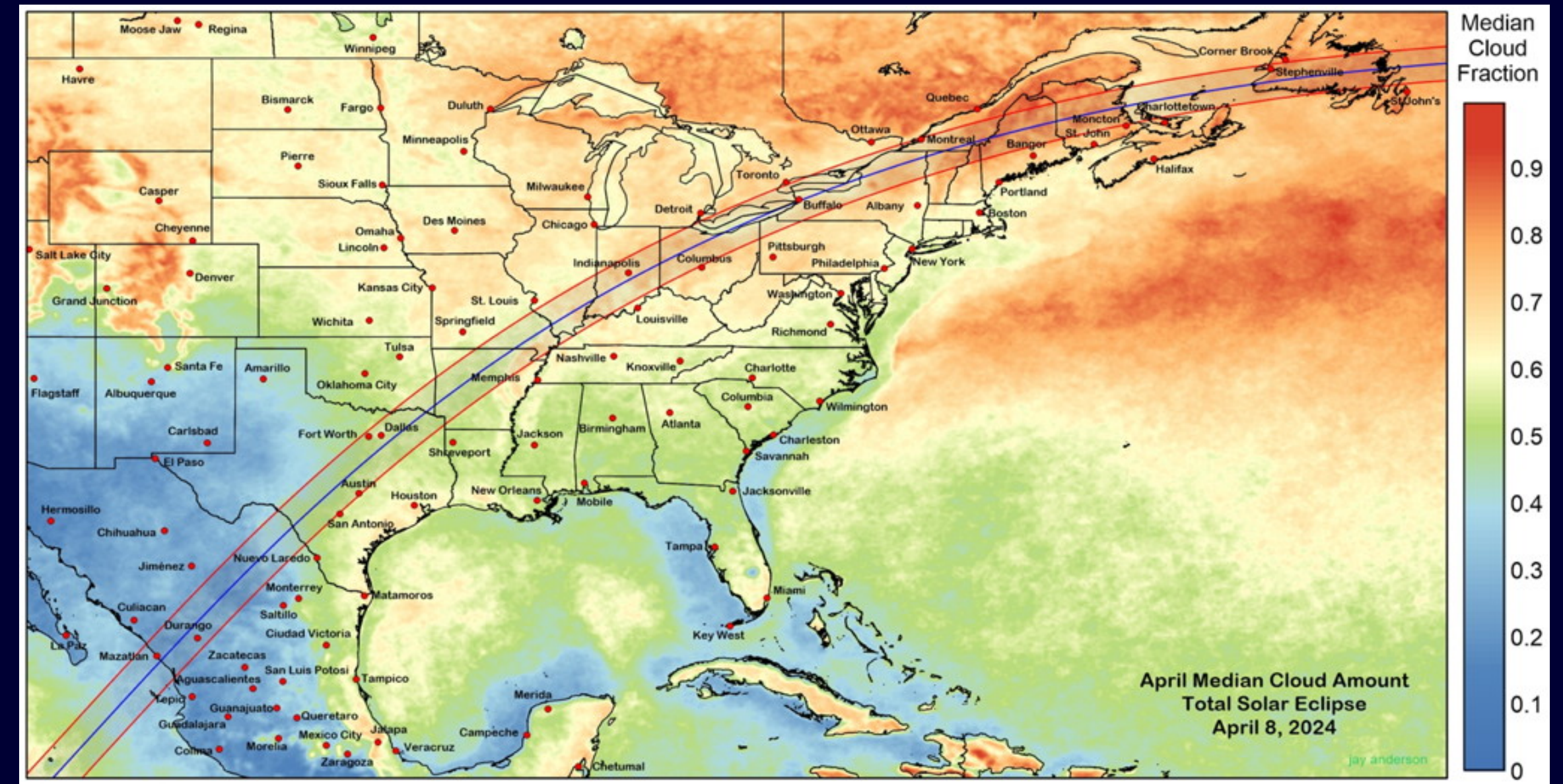
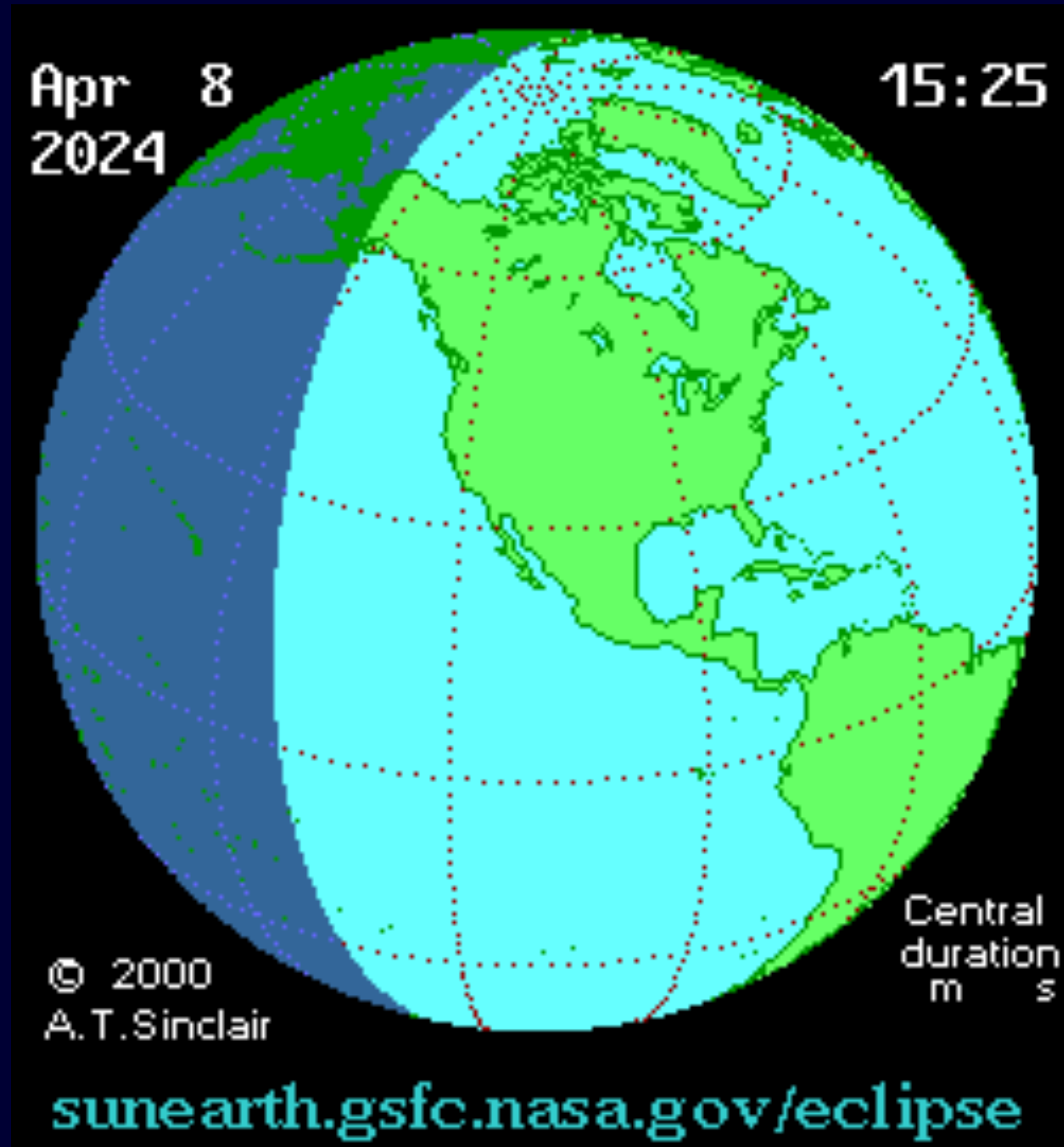
# Eclipse time lapse

2 hrs 49 min

to 30 sec

# Seeing eclipse = location + weather

Jay Anderson



# NASA Eclipse Bulletins

Fred Espanek, astronomer, <http://www.MrEclipse.com/>

Jay Anderson, meteorologist, <http://eclipsophile.com/>

<https://eclipse.gsfc.nasa.gov>

## Total Solar Eclipse of 2024 Apr 08

Geocentric Conjunction = 18:36:02.5 UT J.D. = 2460409.275029

Greatest Eclipse = 18:17:13.1 UT J.D. = 2460409.261957

Eclipse Magnitude = 1.0565 Gamma = 0.3432

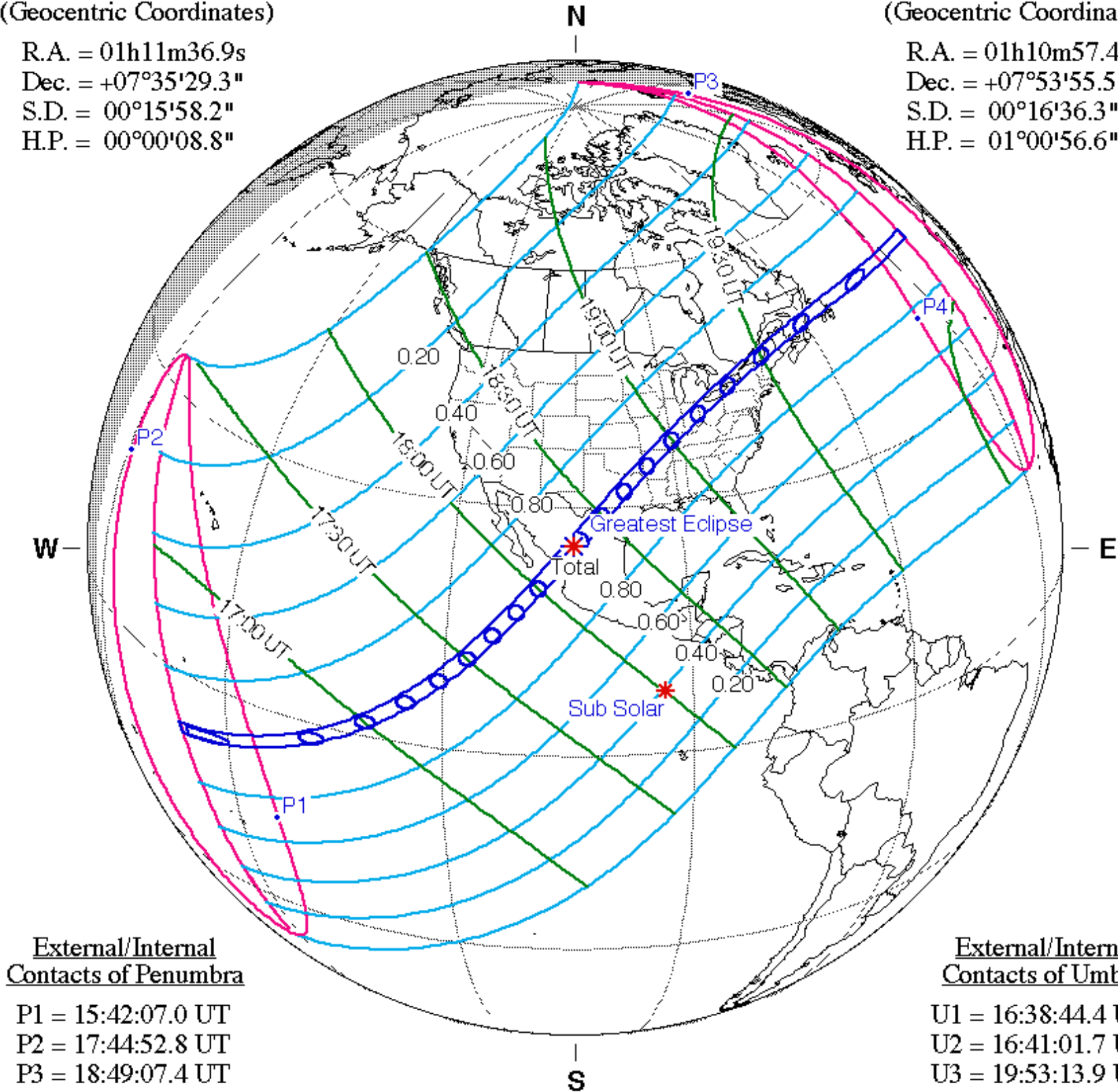
Saros Series = 139 Member = 30 of 71

Sun at Greatest Eclipse  
(Geocentric Coordinates)

R.A. = 01h11m36.9s  
Dec. = +07°35'29.3"  
S.D. = 00°15'58.2"  
H.P. = 00°00'08.8"

Moon at Greatest Eclipse  
(Geocentric Coordinates)

R.A. = 01h10m57.4s  
Dec. = +07°53'55.5"  
S.D. = 00°16'36.3"  
H.P. = 01°00'56.6"



External/Internal  
Contacts of Penumbra

P1 = 15:42:07.0 UT  
P2 = 17:44:52.8 UT  
P3 = 18:49:07.4 UT  
P4 = 20:52:13.8 UT

External/Internal  
Contacts of Umbra

U1 = 16:38:44.4 UT  
U2 = 16:41:01.7 UT  
U3 = 19:53:13.9 UT  
U4 = 19:55:29.1 UT

Ephemeris & Constants

Eph. = Newcomb/ILE  
 $\Delta T = 81.2$  s  
k1 = 0.2724880  
k2 = 0.2722810  
 $\Delta b = 0.0''$   $\Delta l = 0.0''$

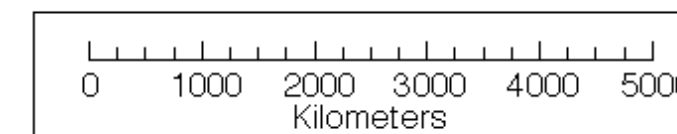
Local Circumstances at Greatest Eclipse

Lat. = 25°17.5'N Sun Alt. = 69.8°  
Long. = 104°07.2'W Sun Azm. = 149.4°  
Path Width = 197.5 km Duration = 04m28.1s

Geocentric Libration  
(Optical + Physical)

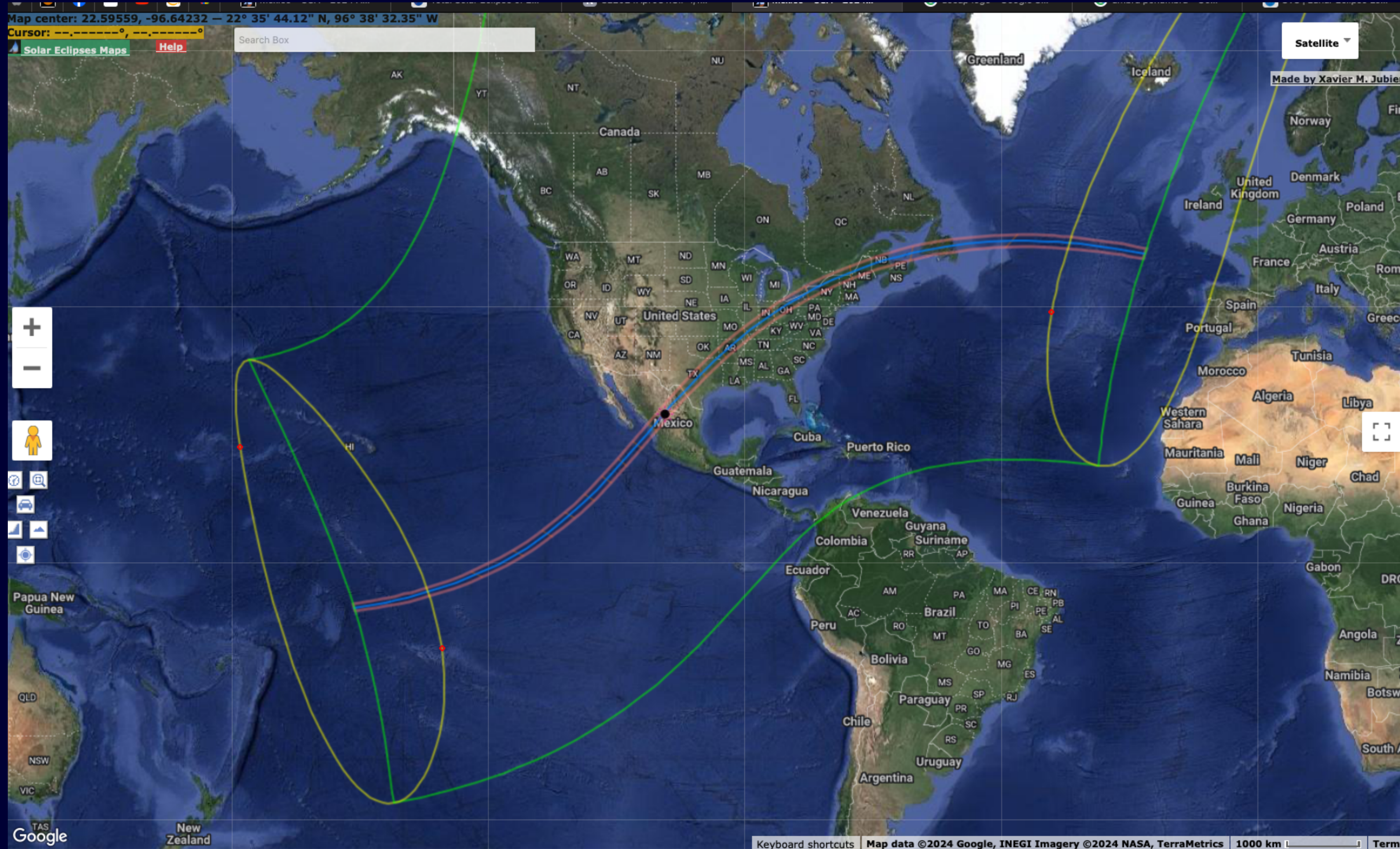
l = 2.00°  
b = -0.46°  
c = -20.75°

Brown Lun. No. = 1253



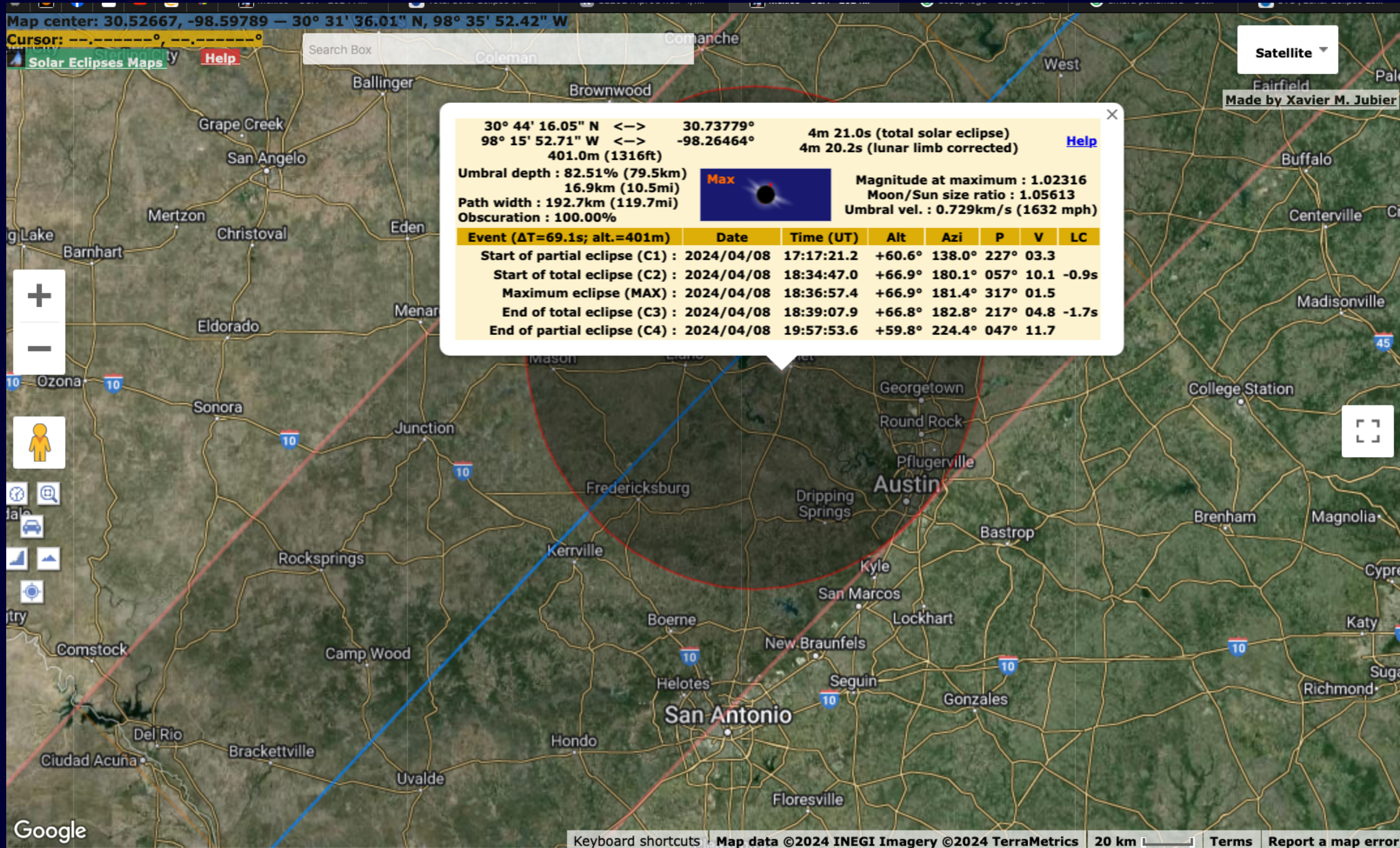
F. Espanek, NASA's GSFC - Fri, Jul 2,  
[sunearth.gsfc.nasa.gov/eclipse/eclipse.html](http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html)

# Interactive Map Xavier Jubier



[http://xjubier.free.fr/en/site\\_pages/solar\\_eclipses/TSE\\_2024\\_GoogleMapFull.html](http://xjubier.free.fr/en/site_pages/solar_eclipses/TSE_2024_GoogleMapFull.html)

# Interactive Map Xavier Jubier



[http://xjubier.free.fr/en/site\\_pages/solar\\_eclipses/TSE\\_2024\\_GoogleMapFull.html](http://xjubier.free.fr/en/site_pages/solar_eclipses/TSE_2024_GoogleMapFull.html)

# Interactive Map Xavier Jubier

Map center: 30.28221, -97.73921 — 30° 16' 55.96" N, 97° 44' 21.16" W  
 Cursor: ---°---'---" ---°---'---" W

Solar Eclipses Maps Help

Search Box

Satellite

Made by Xavier M. Jubier

30° 16' 49.23" N <--> 30.28034°  
 97° 44' 20.74" W <--> -97.73910°  
 166.0m (545ft)

1m 45.5s (total solar eclipse)  
 1m 52.6s (lunar limb corrected) [Help](#)

Umbral depth : 8.20% (7.9km)  
 88.2km (54.8mi)

Path width : 192.2km (119.4mi)  
 Obscuration : 100.00%

Max

Magnitude at maximum : 1.00230  
 Moon/Sun size ratio : 1.05619  
 Umbral vel. : 0.730km/s (1632 mph)

Event ( $\Delta T=69.1s$ ; alt.=166m)	Date	Time (UT)	Alt	Azi	P	V	LC
Start of partial eclipse (C1)	2024/04/08	17:17:15.6	+61.2°	138.3°	228°	03.1	
Start of total eclipse (C2)	2024/04/08	18:36:11.5	+67.3°	182.3°	113°	08.3	-8.5s
Maximum eclipse (MAX)	2024/04/08	18:37:04.2	+67.3°	182.9°	317°	01.5	
End of total eclipse (C3)	2024/04/08	18:37:56.9	+67.3°	183.4°	160°	06.8	-1.4s
End of partial eclipse (C4)	2024/04/08	19:58:09.0	+59.7°	225.9°	046°	11.7	

Map data ©2024 Google Imagery ©2024 Airbus, CAPCOG, CNES / Airbus, Maxar Technologies, U.S. Geological Survey, USDA/FPAC/GEO 200 m Terms Report a map error

[http://xjubier.free.fr/en/site\\_pages/solar\\_eclipses/TSE\\_2024\\_GoogleMapFull.html](http://xjubier.free.fr/en/site_pages/solar_eclipses/TSE_2024_GoogleMapFull.html)



# Weather

Sky Cover %

<https://digital.weather.gov/>

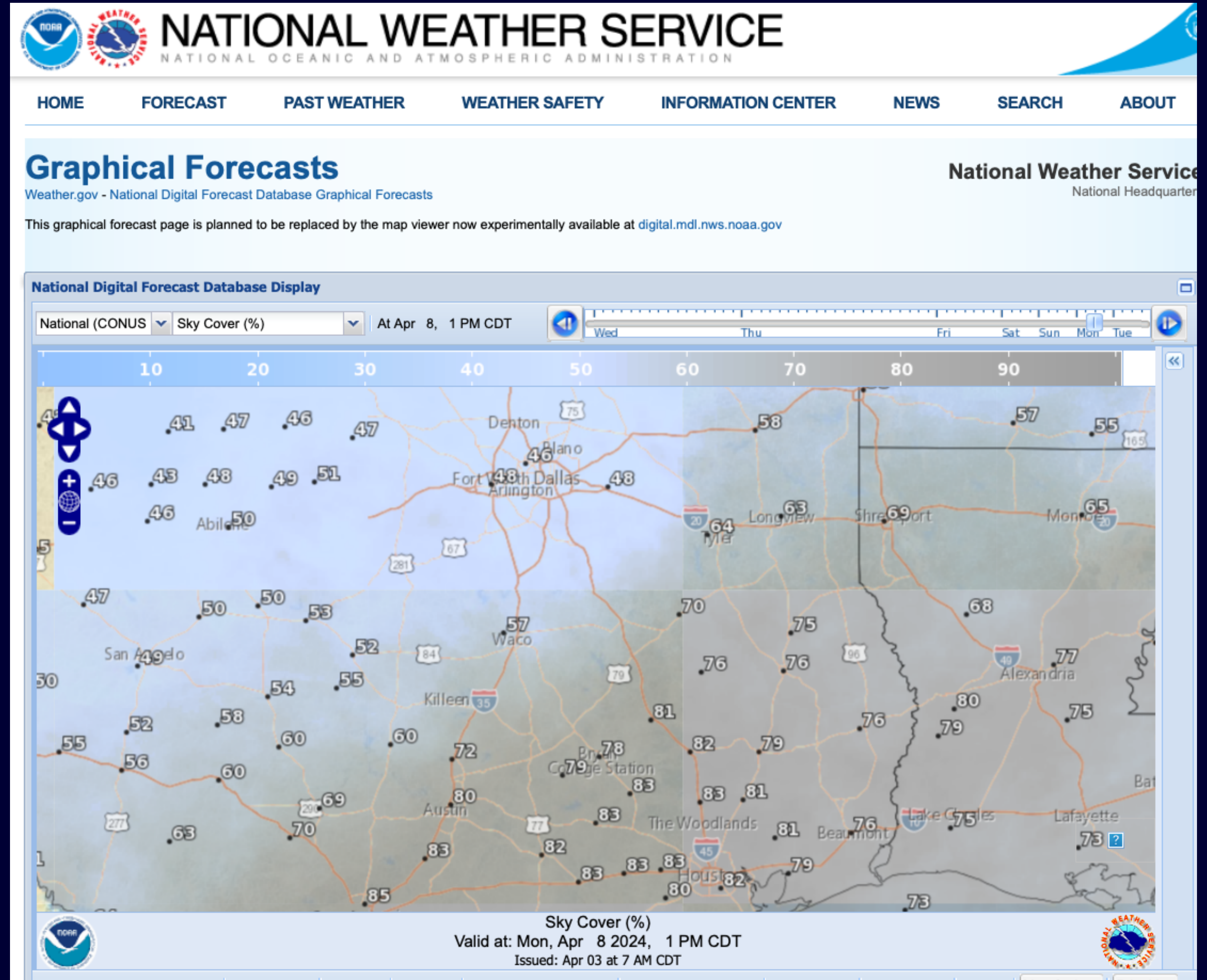
Astro weather

<https://www.astrospheric.com/>

Eclipse Cloud Watch

<https://www.pivotalweather.com/eclipse2024/>

Days	%
1	95
2	90
3	80
5	70
7	50



# Weather - ensemble models

### April 8, 2024 Total Solar Eclipse Cloud Watch

1. Choose a computer model:  
**Canadian Ensemble** **American Ensemble** **European Ensemble** **NWS Blend**

The Canadian ensemble (CMCE) runs twice daily, with new maps typically available by 4:00 AM and PM EDT (1:00 PDT). Its forecasts for cloud cover are the most nuanced and realistic available on this page.

2. Choose a forecast type:  
**Cloud Cover** **Probability of Precipitation**

This map shows the cloud cover (0-100%) averaged across dozens of weather model simulations within the ensemble at 1:00 PM CDT on April 8, near the time of totality. Brighter blue indicates greater cloud cover (worse visibility) in the simulations. The more cloud cover occurs around a location the afternoon of April 8, the less likely the eclipse will be directly visible. However, if clouds are thin or relatively high in the sky, a spectacular show is still possible — see [Space.com article](#).

3. Choose a map region:  
**Continental U.S.** **S Texas** **N Texas** **Arkansas** **Missouri** **Illinois-Indiana** **Ohio** **New York** **New England**

Optional: view this model's previous forecasts with slider 4/2

**Map based on model simulations that used weather observations as recent as: Apr 02, 2024 7:00 PM CDT 7pm**

**Cloud Cover, Total %, mean of last 4 runs** Eclipse totality and centerline Init: Wed 2024-04-03 00z CMCE

F138 Valid: Mon 2024-04-08 18z

www.pivotalweather.com

### Astrospheric

**Cloud Ensemble** Ensemble Cloud (Pro)

**RDPS** When all models agree then the clouds will appear white or transparent.

**WAM GFS**

Sat 6, 1:00 pm  
(Central Daylight Time)

# Eclipse Photography

- Keep it simple so that your attention is on the eclipse
- What story will you tell
- Earth or sky
- Sky tracking
  - Stars
  - Sun
  - Moon
- Which actor will hold your POV
  - Earth, fixed mount wide FOV
  - Sun/Moon, tracking mount, narrow FOV
- Practice, practice, practice



# Eclipse - time lapse composite



# When clouds are your friend

iPhone images



Mary Pettengill

Eldorado, Tx



Dublin, Ireland



# Filters are essential and easy to add to any camera

Small aperture cameras are not immune from damage, focal ratio determines brightness not aperture size



# Look around and down, not just up

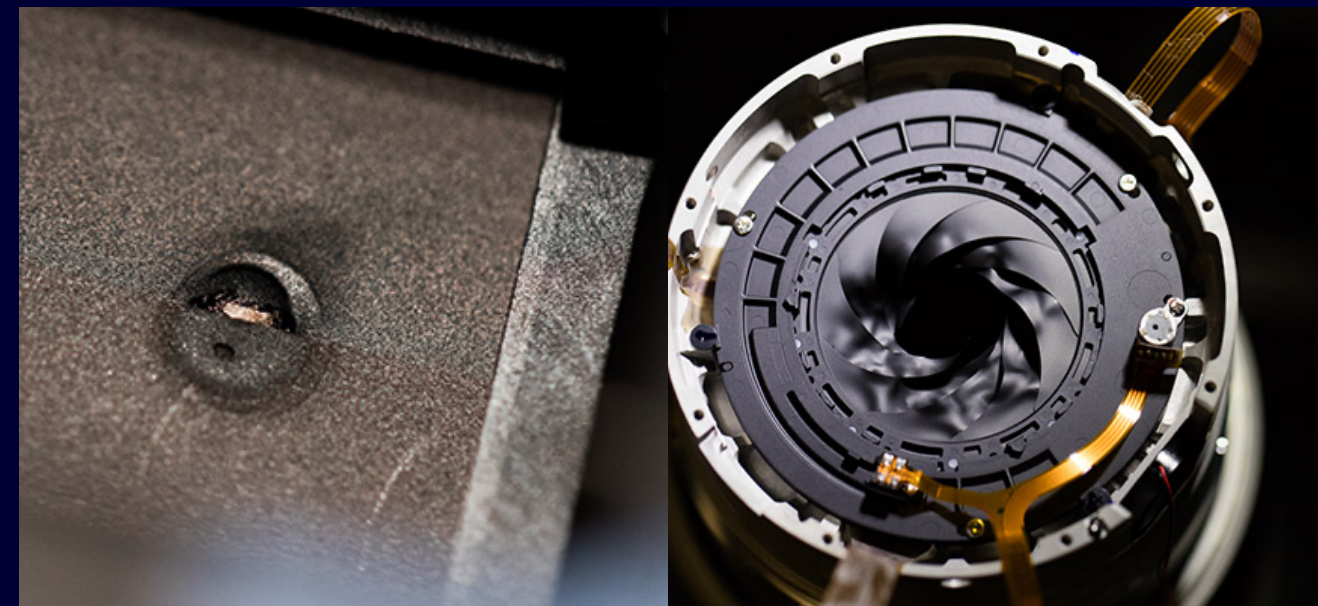


# Filters and eye protection

- Safe solar filters (ND5) transmit 0.001%
- Super dark sunglasses transmit 20%

20,000 x less light than dark sunglasses

ISO 12312-2:2015 or  
CE #0086 HP2 4SQ



[lensrentals.com](http://lensrentals.com)





# Serious Photographers

- Partial phases - filter on
  - Exposure times are short and a tracking mount is not needed even with telephoto
- Totality - filter off 15 sec before / after
  - Longer exposures require tracking mount or care in exposures
  - Rule of 500 applies for untracked tripod
- Screw on filters take longer to remove than slip on
- Auto exposure bracketing around C2 & C3

## Solar Eclipse Exposure Guide

ISO	f/Number									
	1.4	2	2.8	4	5.6	8	11	16	22	32
25										
50	2	2.8	4	5.6	8	11	16	22	32	44
100	2.8	4	5.6	8	11	16	22	32	44	64
200	4	5.6	8	11	16	22	32	44	64	88
400	5.6	8	11	16	22	32	44	64	88	128
800	8	11	16	22	32	44	64	88	128	176
1600	11	16	22	32	44	64	88	128	176	

Eclipse Feature	Q	Shutter Speed									
Partial <sup>1</sup> - 4.0 ND	11	–	–	–	1/4000	1/2000	1/1000	1/500	1/250	1/125	
Partial <sup>1</sup> - 5.0 ND	8	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	
Baily's Beads <sup>2</sup>	11	–	–	–	1/4000	1/2000	1/1000	1/500	1/250	1/125	
Chromosphere	10	–	–	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	
Prominences	9	–	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	
Corona - 0.1 Rs	7	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	
Corona - 0.2 Rs <sup>3</sup>	5	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2	
Corona - 0.5 Rs	3	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1 sec	2 sec	
Corona - 1.0 Rs	1	1/30	1/15	1/8	1/4	1/2	1 sec	2 sec	4 sec	8 sec	
Corona - 2.0 Rs	0	1/15	1/8	1/4	1/2	1 sec	2 sec	4 sec	8 sec	15 sec	
Corona - 4.0 Rs	-1	1/8	1/4	1/2	1 sec	2 sec	4 sec	8 sec	15 sec	30 sec	
Corona - 8.0 Rs	-3	1/2	1 sec	2 sec	4 sec	8 sec	15 sec	30 sec	1 min	2 min	

### Instructions

Choose the ISO speed in the upper left column. Next, select the f/number of the lens or telescope (on same line as ISO). Finally, drop straight down to the bottom table to get the correct exposure for each feature of the solar eclipse.

Note that the brightness of the corona varies dramatically with distance from the Sun's edge. All exposure values in this guide are estimates. For best results, use them only as a guide and bracket your exposures.

Exposure Formula:  $t = f^2 / (I \times 2^Q)$  where:  $t =$  exposure time (sec)  
 $f =$  f/number or focal ratio  
 $I =$  ISO film speed  
 $Q =$  brightness exponent

Abbreviations: ND = Neutral Density Filter.  
 Rs = Solar Radii.

Notes: <sup>1</sup> Exposures for partial phases are also good for annular eclipses.  
<sup>2</sup> Baily's Beads are extremely bright and change rapidly.  
<sup>3</sup> This exposure also recommended for the *Diamond Ring* effect.

# links for more

- Curated Google Search for events and info  
<http://BadAstroPhotos.com/eclipseSearch.html>
- Xavier Jubier, Eclipse timing  
[http://xjubier.free.fr/en/site\\_pages/solar\\_eclipses/TSE\\_2024\\_GoogleMapFull.html](http://xjubier.free.fr/en/site_pages/solar_eclipses/TSE_2024_GoogleMapFull.html)
- Last week sky cover from NWS  
<https://graphical.weather.gov/sectors/southplains.php>
- Eclipse Cloud Watch  
<https://www.pivotalweather.com/eclipse2024/>
- Last 48 hours cloud cover  
<https://www.astrospheric.com/?Latitude=30.3&Longitude=-97.8>
- Fred Espanek, observation and photography <http://www.mreclipse.com/>
- Jay Anderson, eclipse weather, <https://eclipsophile.com/>
- NASA Eclipse Web Site, <https://eclipse.gsfc.nasa.gov/eclipse.html>