

# TOTAL SOLAR ECLIPSE – APRIL 8!

## USA, Mexico, Canada



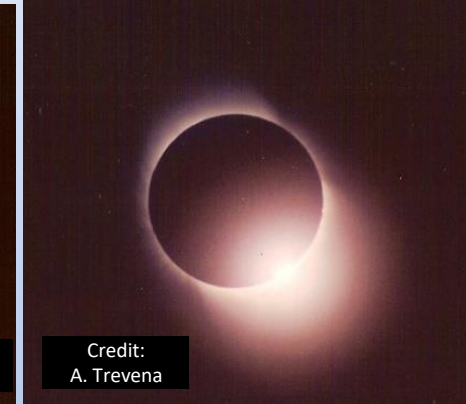
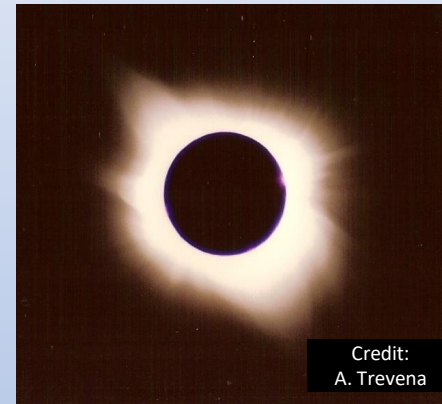
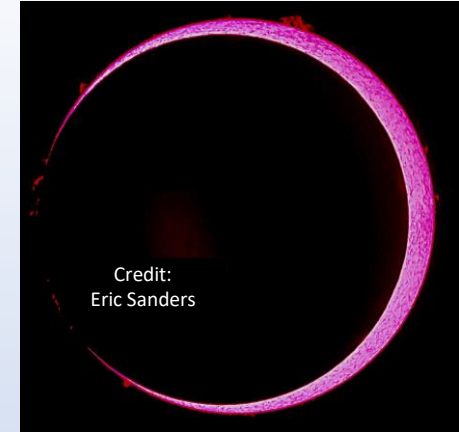
Art Trevena

## Objectives

- Understanding Solar Eclipses
- April 8, 2024 Total Solar Eclipse: Circumstances
- A Total Solar Eclipse: “...a vision magnificent beyond description” *General Albert J. Myer (co-founder, NWS)*

## Outline

- Geometry, Types & Phases of Solar Eclipses
- Eclipse Predictions
- Safe Solar Eclipse Viewing & Eclipse Phenomena
- Where & How to Experience: April 8, 2024 Solar Eclipse
- Post-2024 Total Solar Eclipses



21Aug2017, DSCOVR at L1. Credit: NASA/NOAA/USAF

## **A Source for Livestreams of the April 8, 2024 Total Solar Eclipse**

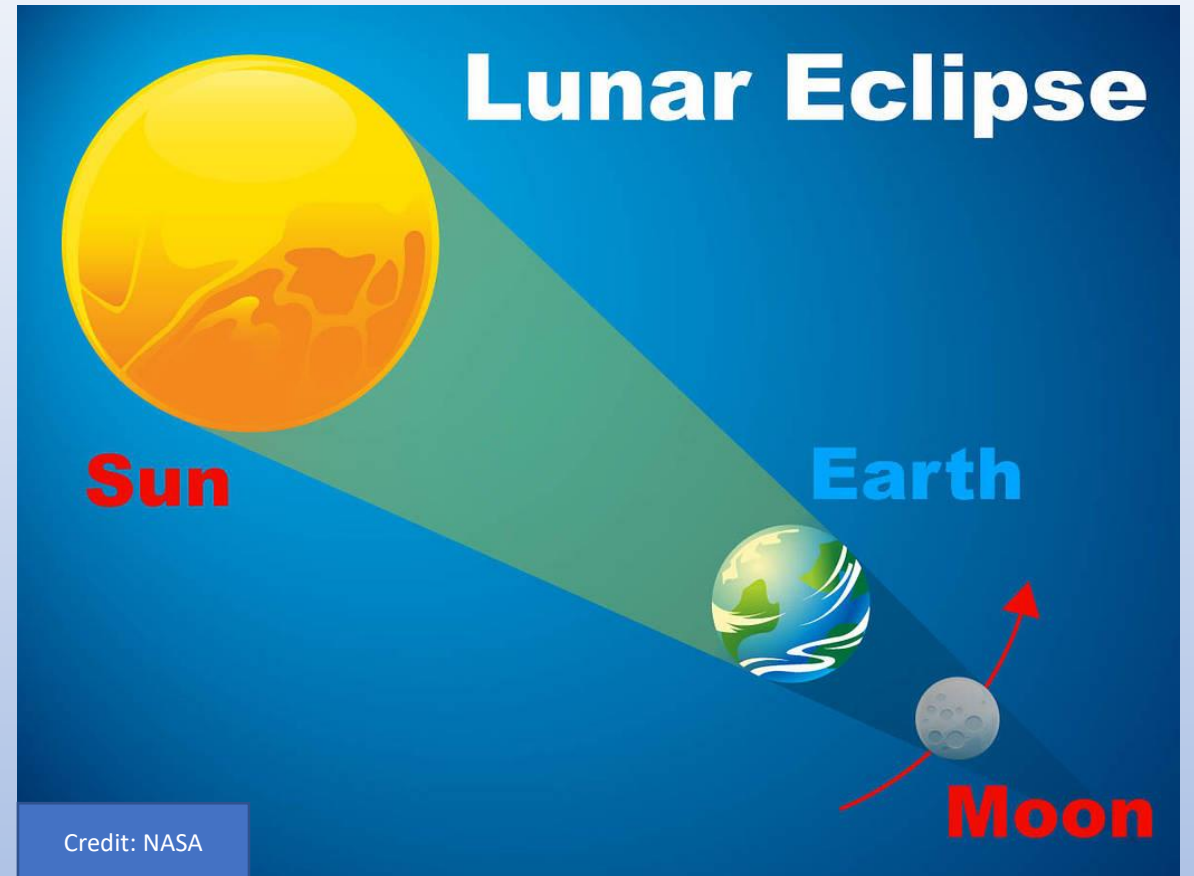
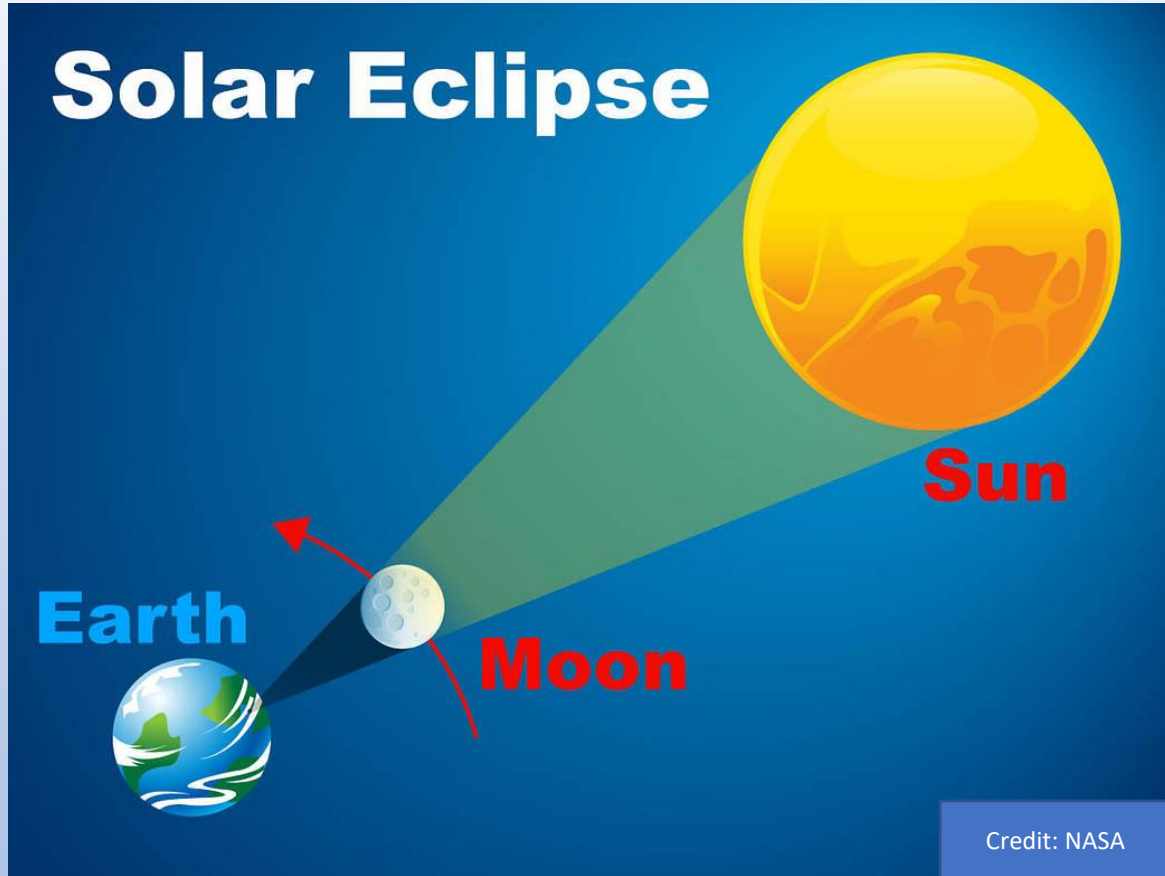
<https://eclipse.aas.org/resources/livestreams>

Courtesy of the American Astronomical Society

## **For more about the the April 8, 2024 Total Solar Eclipse...**

[TotalSolarEclipse8April2024BCASsite.pdf \(blackcanyonastronomy.com\)](#)

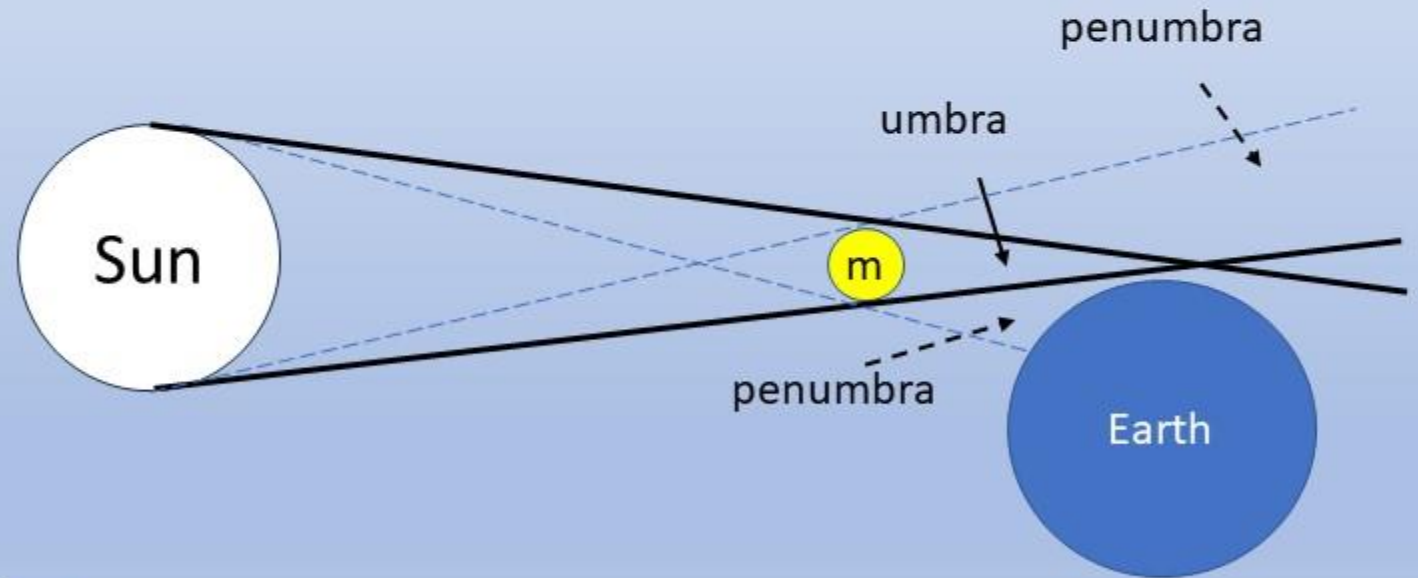
# What Causes Eclipses?



- **Solar eclipses**: the Moon moves in front of the Sun, casting its shadow on the Earth. This can happen only at New Moon.
- **Lunar eclipses**: the Moon moves through the Earth's shadow. This can happen only at Full Moon.

# Partial Only Solar Eclipse: Shadows & Geometries (not to scale)

Partial Only  
Eclipse



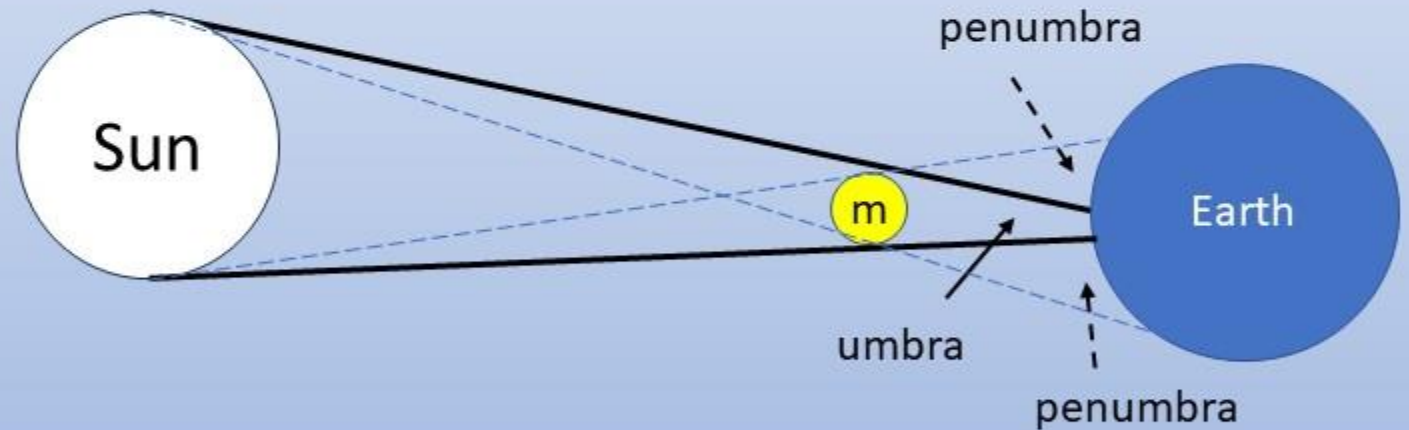
- A partial eclipses is visible from the penumbra
- The umbra (where a total eclipse is visible) passes above (or below) the Earth. There is no total eclipse



# Total Solar Eclipse: Shadows & Geometries

(not to scale)

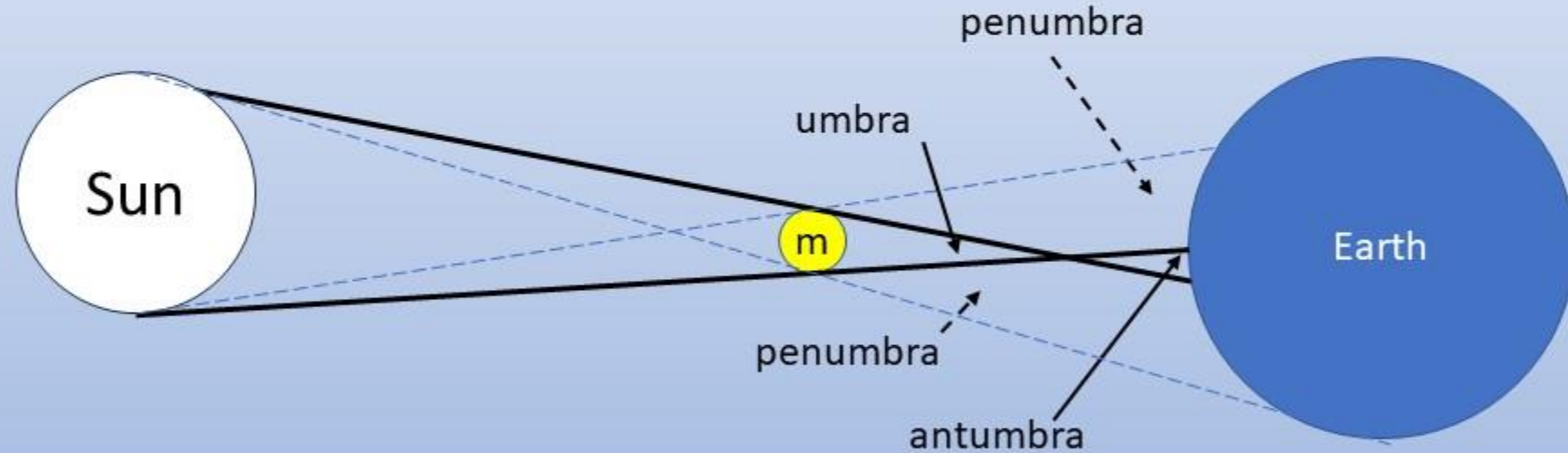
## Total Eclipse



- A partial eclipses is visible from the penumbra
- A total eclipse is visible from the umbra

# Annular Solar Eclipse: Shadows & Geometries (not to scale)

## Annular Eclipse



- A partial eclipses is visible from the penumbra
- An annular (“ring-of-fire”) eclipse is visible from the antumbra
- The umbra falls short of Earth, so no total eclipse occurs

# Surprising (?) Facts About Solar Eclipses

- Solar eclipses are **not rare** – there must be at least 2 each year somewhere on Earth.
- There can be as many as 5 solar eclipses in a year (e.g., 1935)!
- Partial solar eclipses are seen over large areas (8 visible from Montrose, 2000-2024!)
- Solar eclipses are (slightly) more frequent than lunar eclipses
- Annular eclipses are (slightly) more frequent than total solar eclipses
- Paths of totality (or annularity) are narrow (generally < 300 miles wide). But they can be many thousands of miles long
- Totality (or annularity) is short (< 7m:32 s for totality, < 12m:31s for annularity)
- Solar eclipse in 1919 provided first test of Einstein's General Relativity

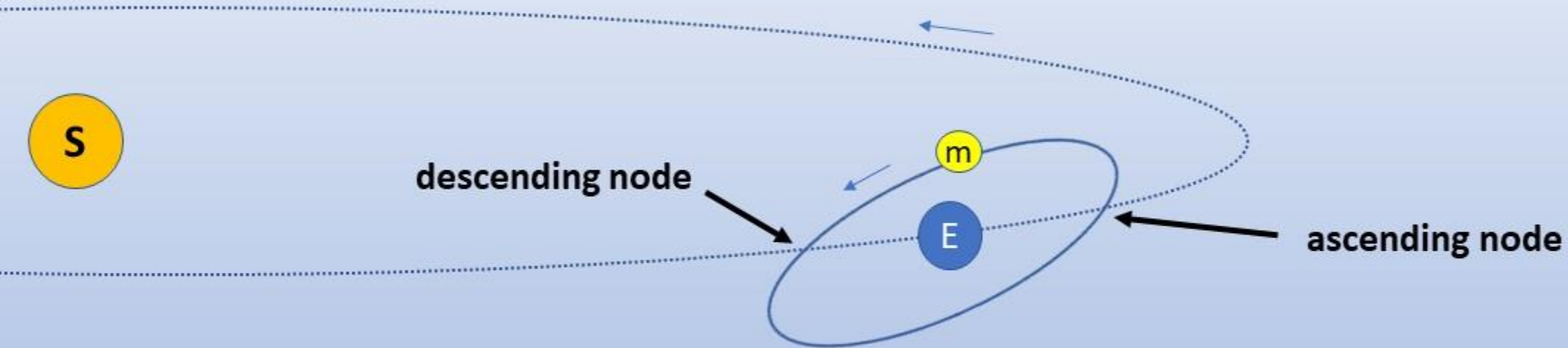
<u>20th Cent.</u>	<u>21st Cent.</u>	<u>Eclipse Type</u>
78	77	partial only
73	72	annular
71	68	total
6	7	annular-total hybrid
<b><u>228</u></b>	<b><u>224</u></b>	<b><u>Sum (No. of solar eclipses)</u></b>

Source: NASA Five Millenium Catalog of Solar Eclipses



# Solar Eclipse Periodicity:

## Why Don't Eclipses Happen at New Moon Each Lunar Month?



- The Moon's orbit is inclined 5 degrees from Earth' orbit about the Sun
- Those orbital planes intersect at “lunar nodes”
- Solar eclipses can occur only when new Moon occurs within about  $15^\circ$  of a node. Periods around nodal crossings at new Moon are called eclipse seasons. These are centered 173 days apart and last for +/- 15 to 18 days.



# Solar Eclipse Predictions

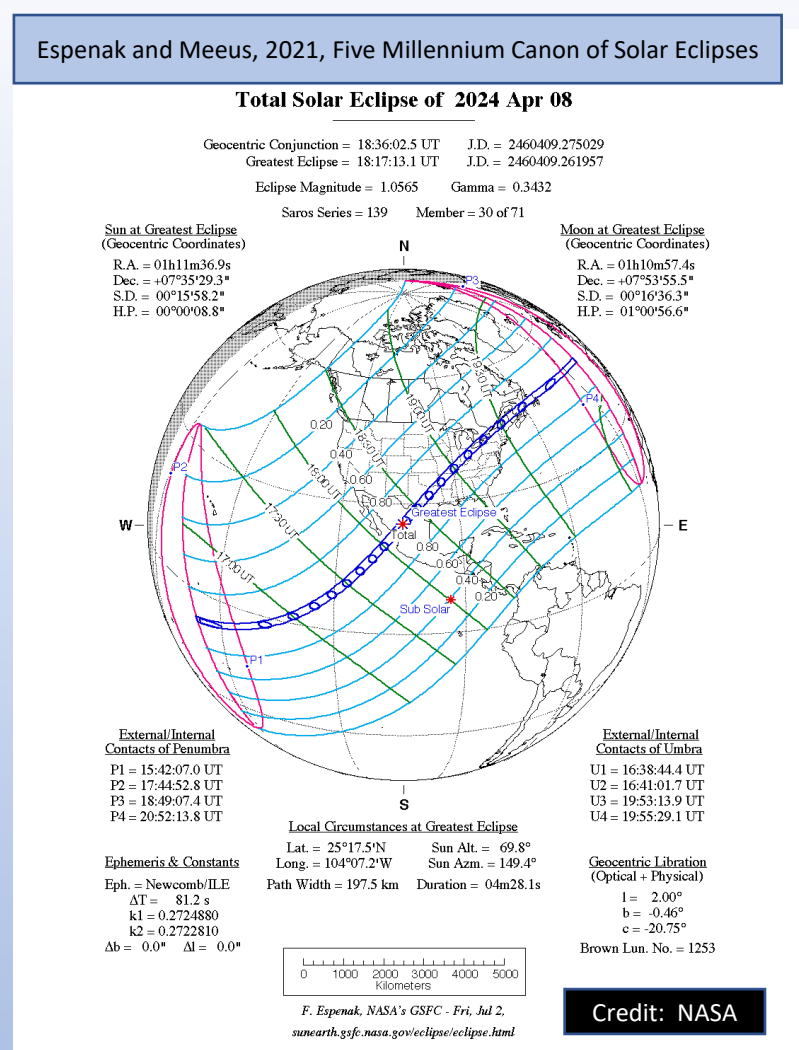
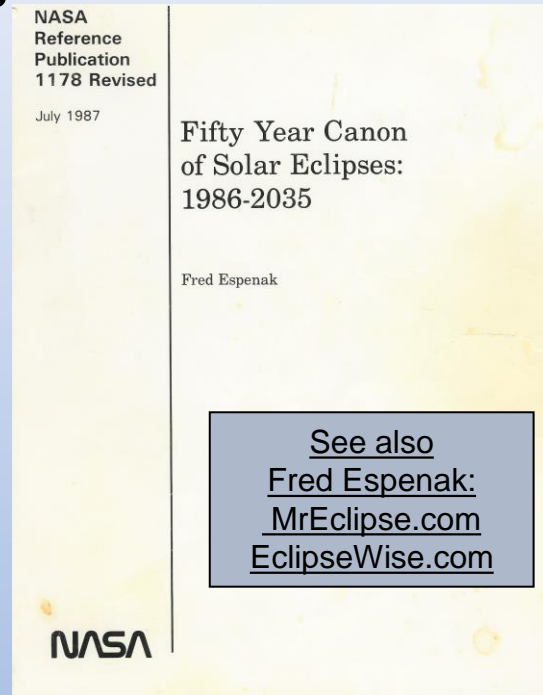
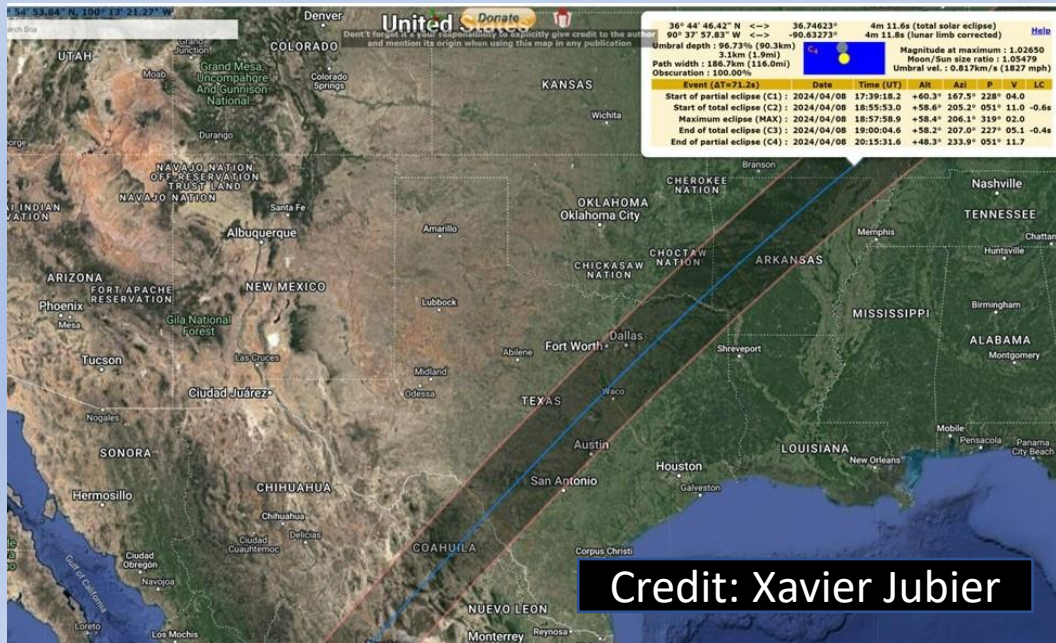
- Eclipse Seasons: Every 173 days (30 to 36 days long)
- Saros Cycle – 18 years + 11.32 days
- Modern eclipse predictions:

- Printed Canons & Other Publications →
- Sky & Telescope and Astronomy Magazines
- Websites –

<https://eclipse.gsfc.nasa.gov/SEcat5/SE2001-2100.html>

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

[http://xjubier.free.fr/en/site\\_pages/Solar\\_Eclipses.html](http://xjubier.free.fr/en/site_pages/Solar_Eclipses.html)





# Moon's Shadow from Space - 9Mar2016 Total Solar Eclipse

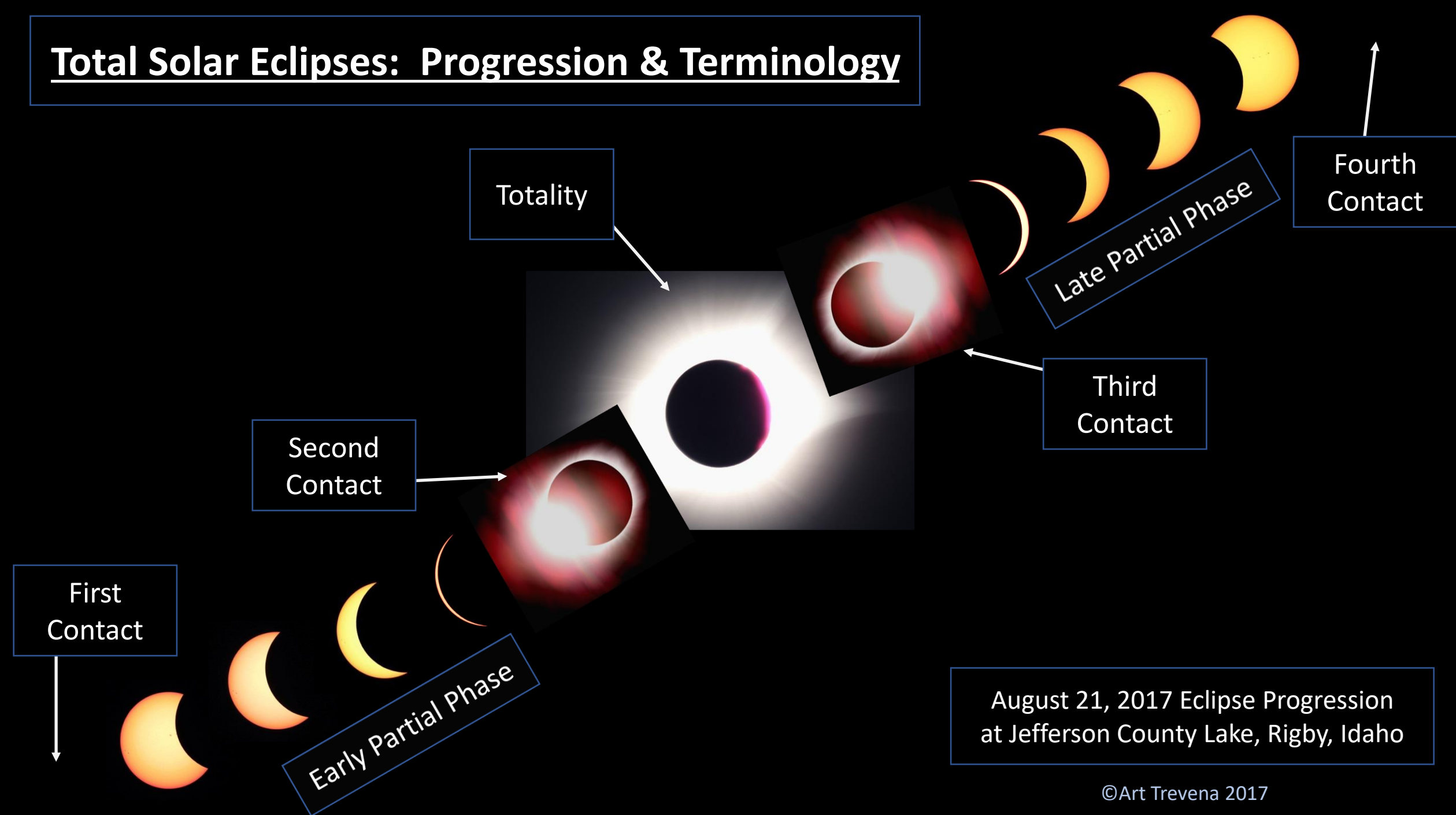
(from DSCOVR at L1 Lagrange Point)

9Mar2016  
Solar Eclipse



Credit:  
NASA/NOAA  
USAF

# Total Solar Eclipses: Progression & Terminology

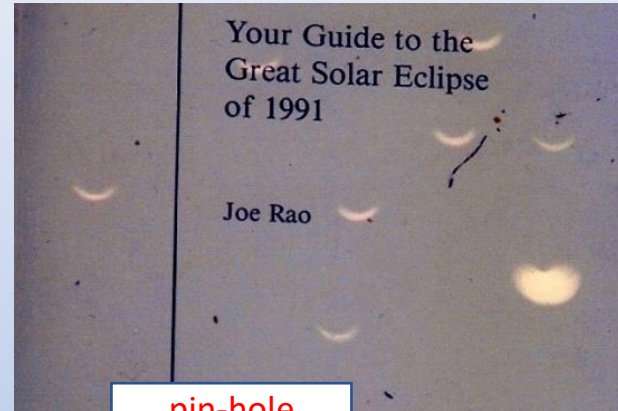




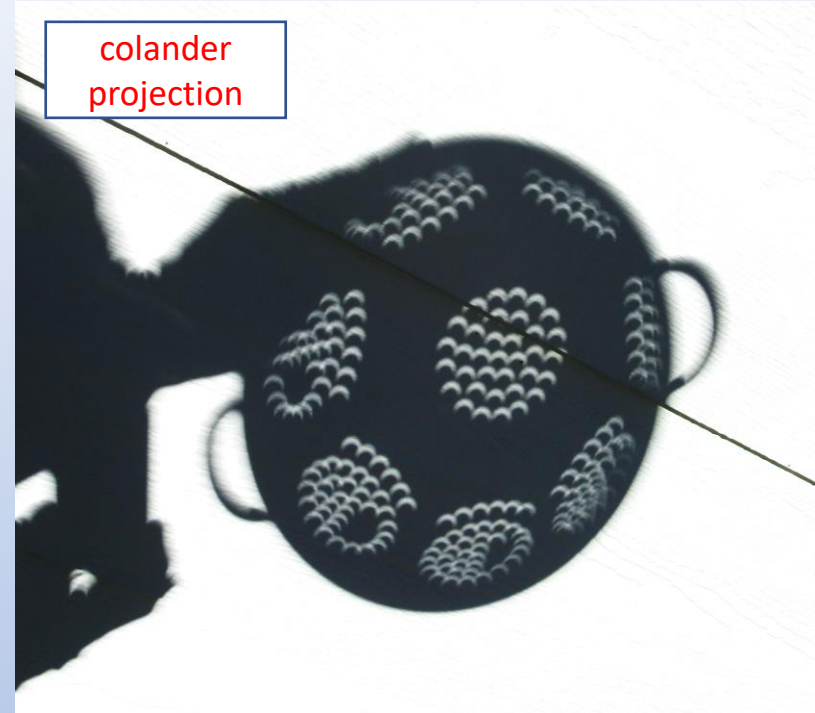
# Safe Viewing: Partial & Annular Phases of Solar Eclipses

Never View  
the Sun  
Directly!

melted  
cross-hairs!



pin-hole  
projection



colander  
projection

telescope  
projection

"Sunspotter"

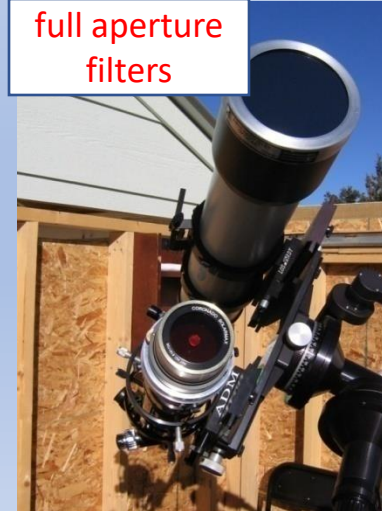
"eclipse glasses"

#14 welder's  
glass



aluminized  
glass or mylar

full aperture  
filters



EAA, Credit: Bryan Cashion



# Binoculars!

(with safe solar filters for partial phases)



“standard binoculars”  
with safe solar filters



“Mini-SUNoculars 6X30”  
with built-in, safe solar  
filters for partial phases,  
not useful for totality  
(marketed by Lunt Solar  
Systems)

## 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

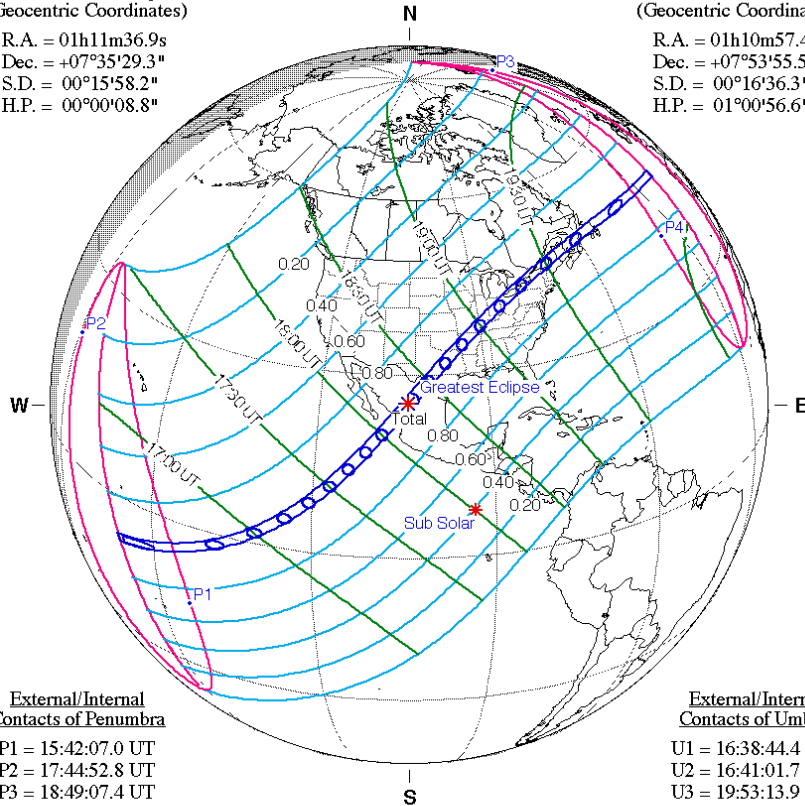
Saros Series = 139 Member = 30 of 71

### 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

### 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

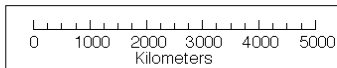
### Geocentric Libration (Optical + Physical)

l = 2.00°  
b = -0.46°  
c = -20.75°

Brown Lun. No. = 1253

### Ephemeris & Constants

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



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

# TOTAL SOLAR ECLIPSE!

## APRIL 8, 2024

### Partial Eclipse from Montrose, CO

11:23 AM MDT Start  
12:34 PM MDT Max  
1:48 PM MDT End

Maximum:  
69% (by diameter)  
62% (by area)

## Partial Eclipse



Photos by Art Trevena

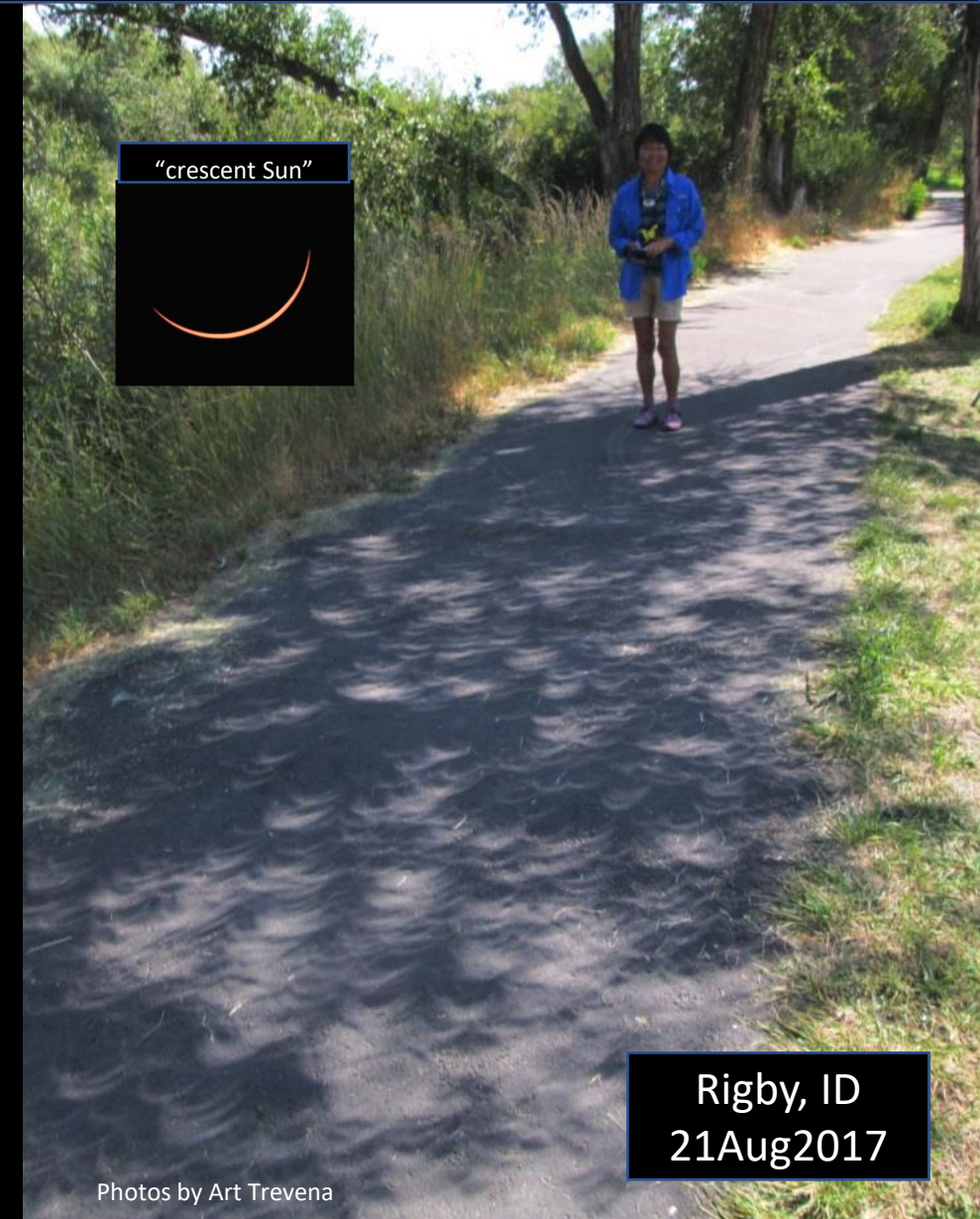
## Total Eclipse



<https://eclipse.aas.org/resources/livestreams>



# Partial Eclipse Phenomena: Fading light, sharp shadows, deep blue sky with “steely-gray metallic cast” to landscape, and “projected solar crescents”





# Total Solar Eclipse Viewing Options

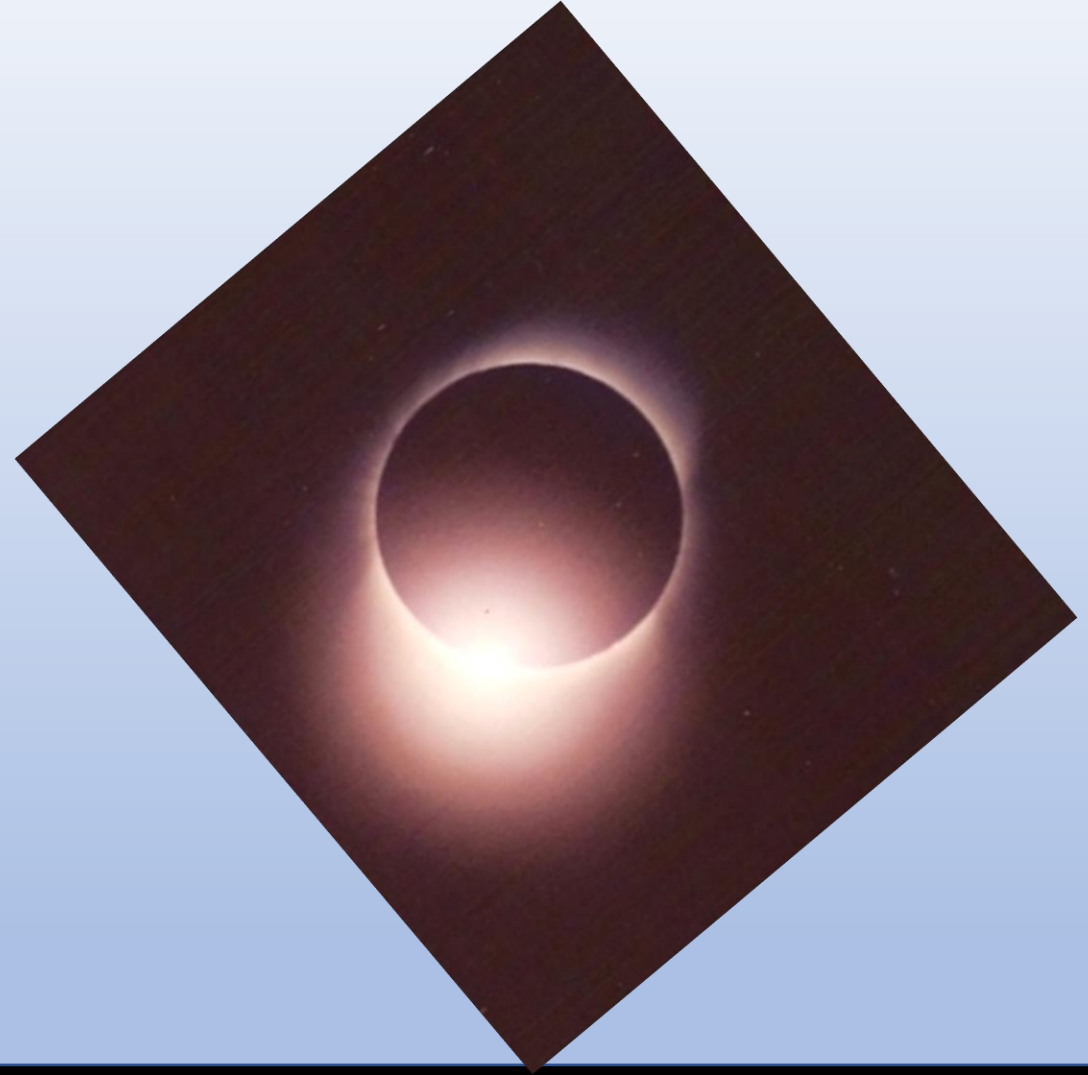




# Baily's Beads & Diamond Ring During Solar Eclipses



Baily's Beads at Second Contact of a Total Solar Eclipse  
August 21, 2017 from Madras, Oregon  
Credit: NASA/Aubrey Gemignani



Baily's Beads, November 1994 Total Eclipse  
Northern Chile  
Credit: Art Trevena

# Total Solar Eclipse Phenomena, No.1

Darkness in the west, like a silent storm,  
moving upward toward the Sun !

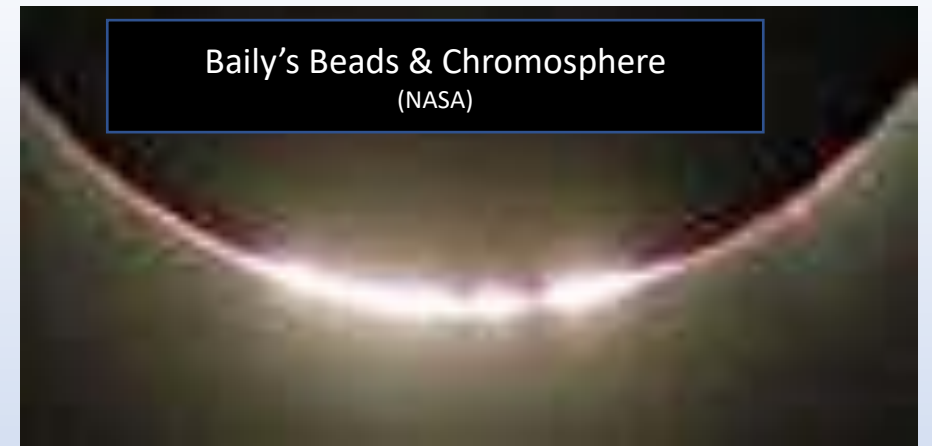
“...a palpable body  
of darkness, rising  
upward in a great  
wall...”  
*Mary R. Smith, 1878*



Shadow Bands  
M. Loomis Todd, 1870



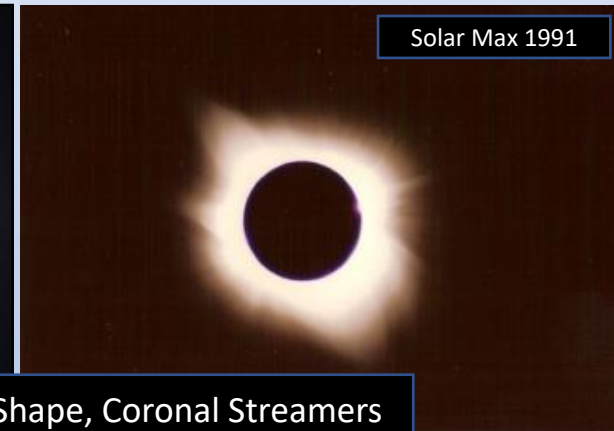
Credit: Joyce Tanihara, 2017



Baily's Beads & Chromosphere  
(NASA)

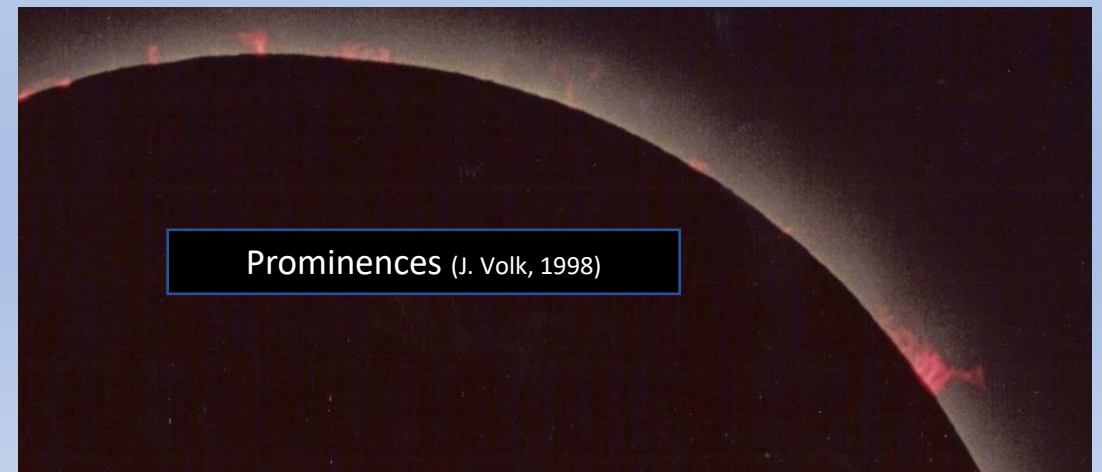


Quiet Sun 2017



Solar Max 1991

Corona Shape, Coronal Streamers



Prominences (J. Volk, 1998)

# Total Solar Eclipse Phenomena No. 2

photo by Bob "S"

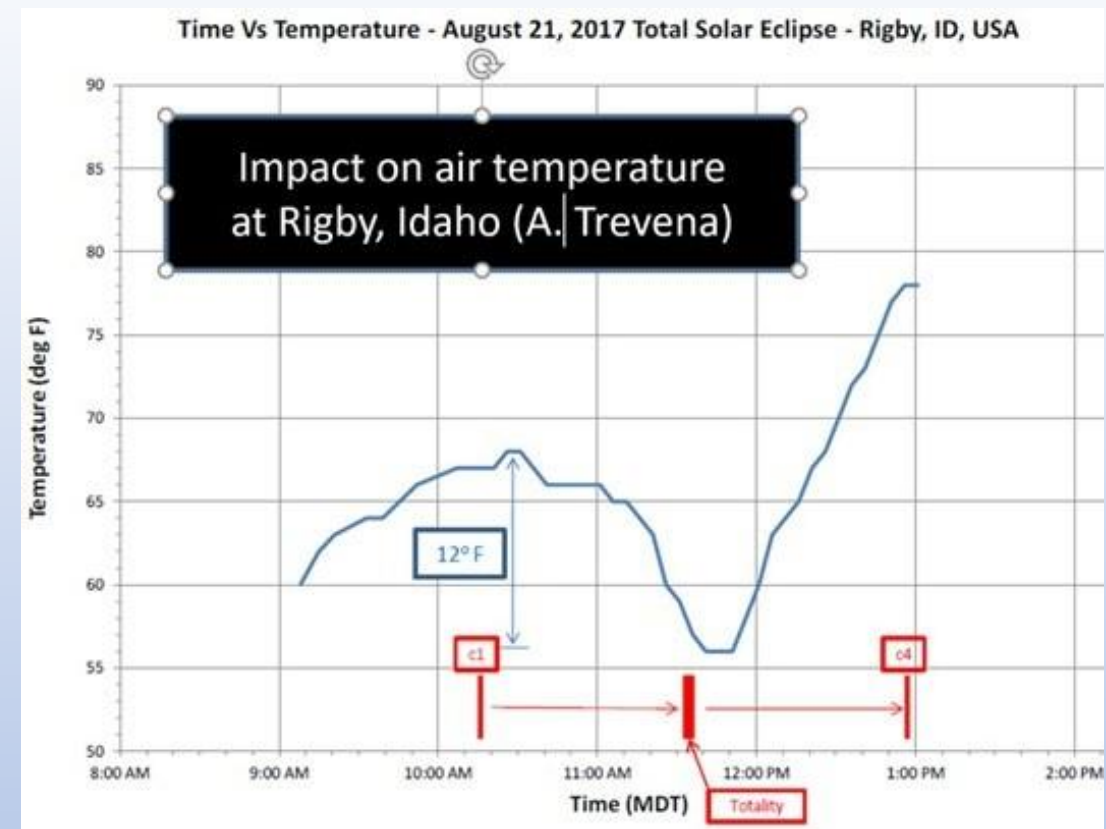
## Twilight at Mid-day!

looking southeast during totality  
11 July 1991, San Jose del Cabo

## 360° twilight!

Looking northwest, 11 July 1991.  
Street lights on during totality!

photo by Bob "S"



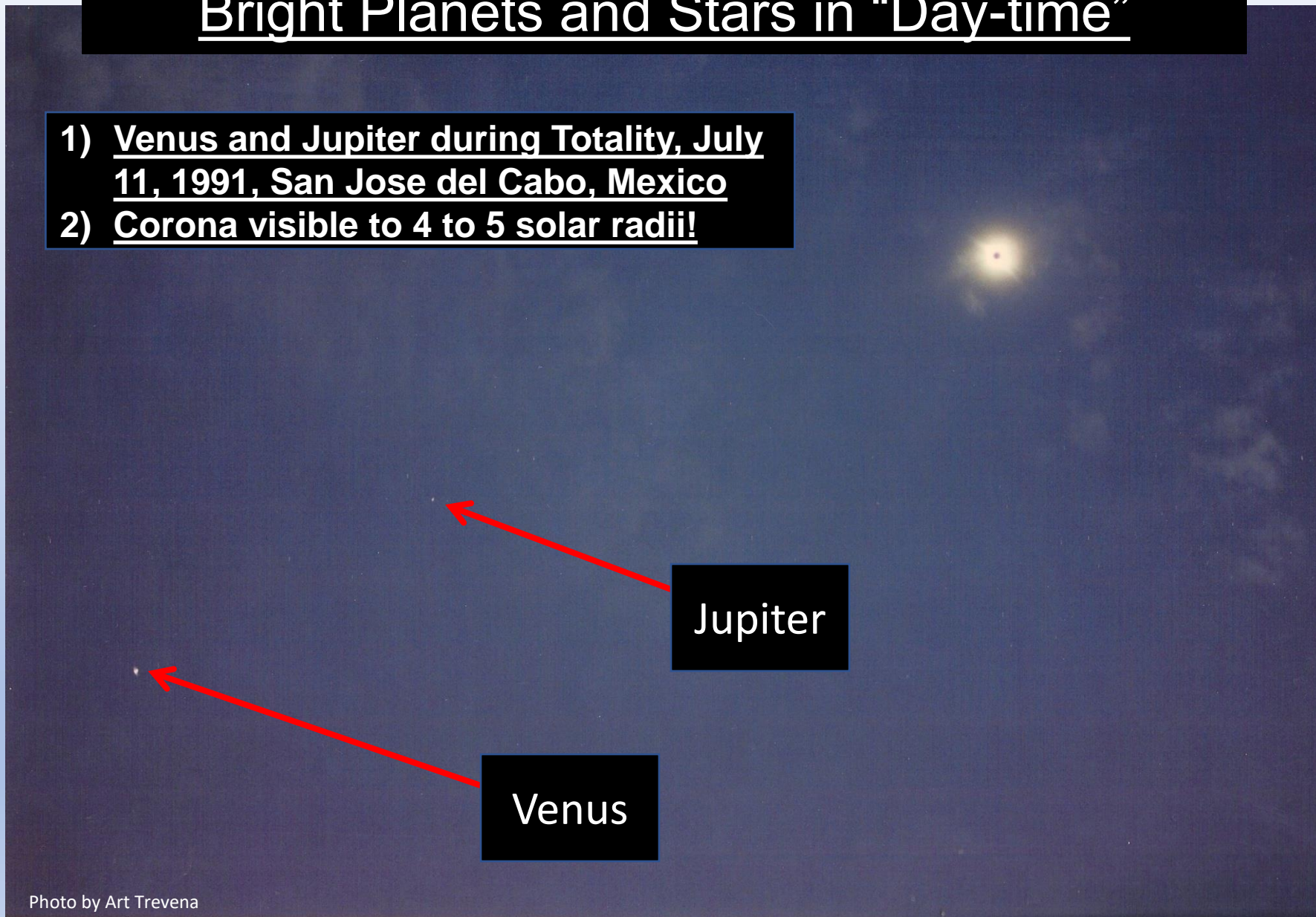
“When the shadow of the moon sweeps over us, we are brought into direct contact with a tangible presence from space, and we feel the immensity of forces over which we have no control. The effect is awe-inspiring in the extreme.”

Isabel Martin Lewis, 1924



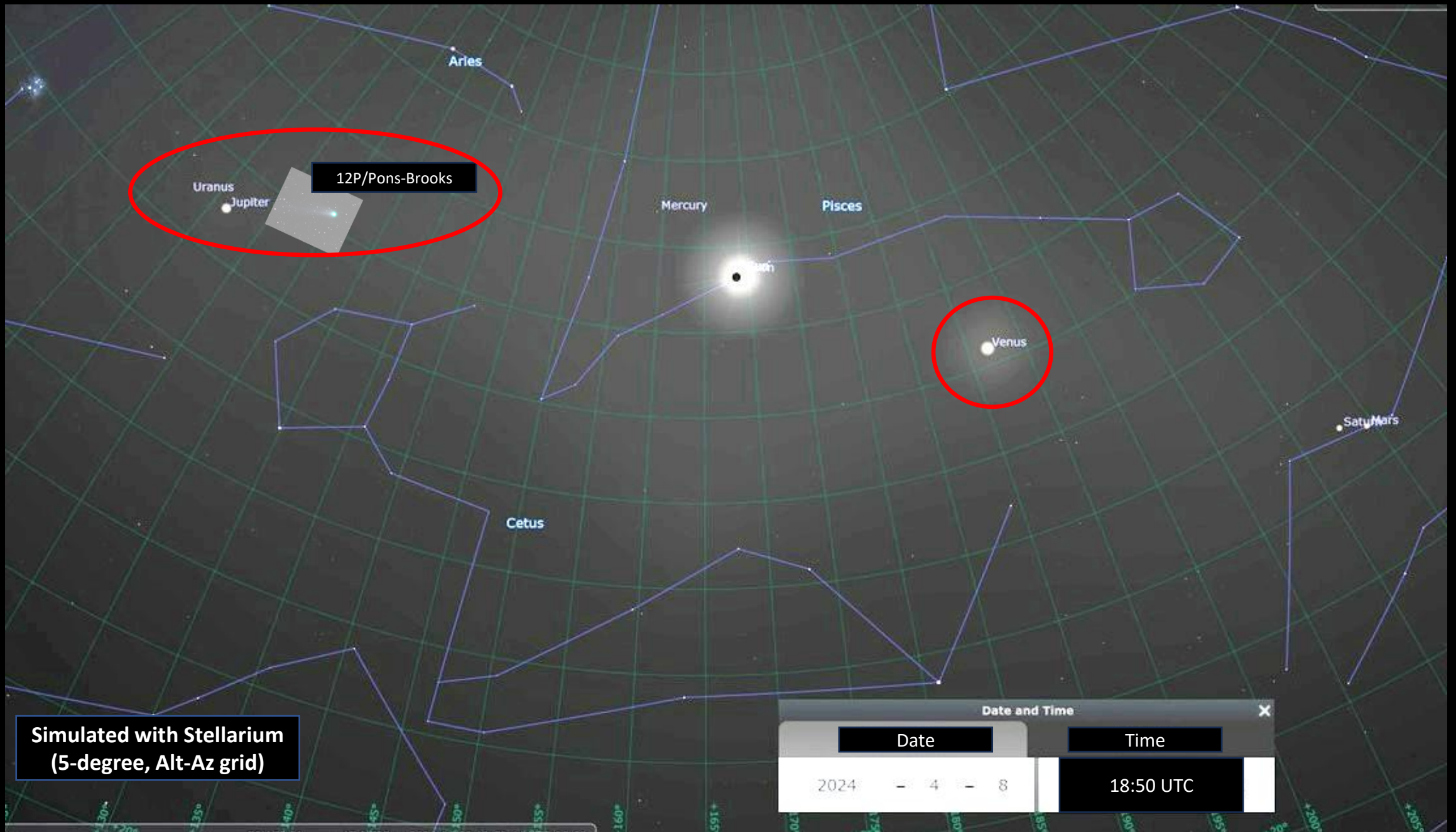
# Total Solar Eclipse Phenomena No. 3: Bright Planets and Stars in “Day-time”

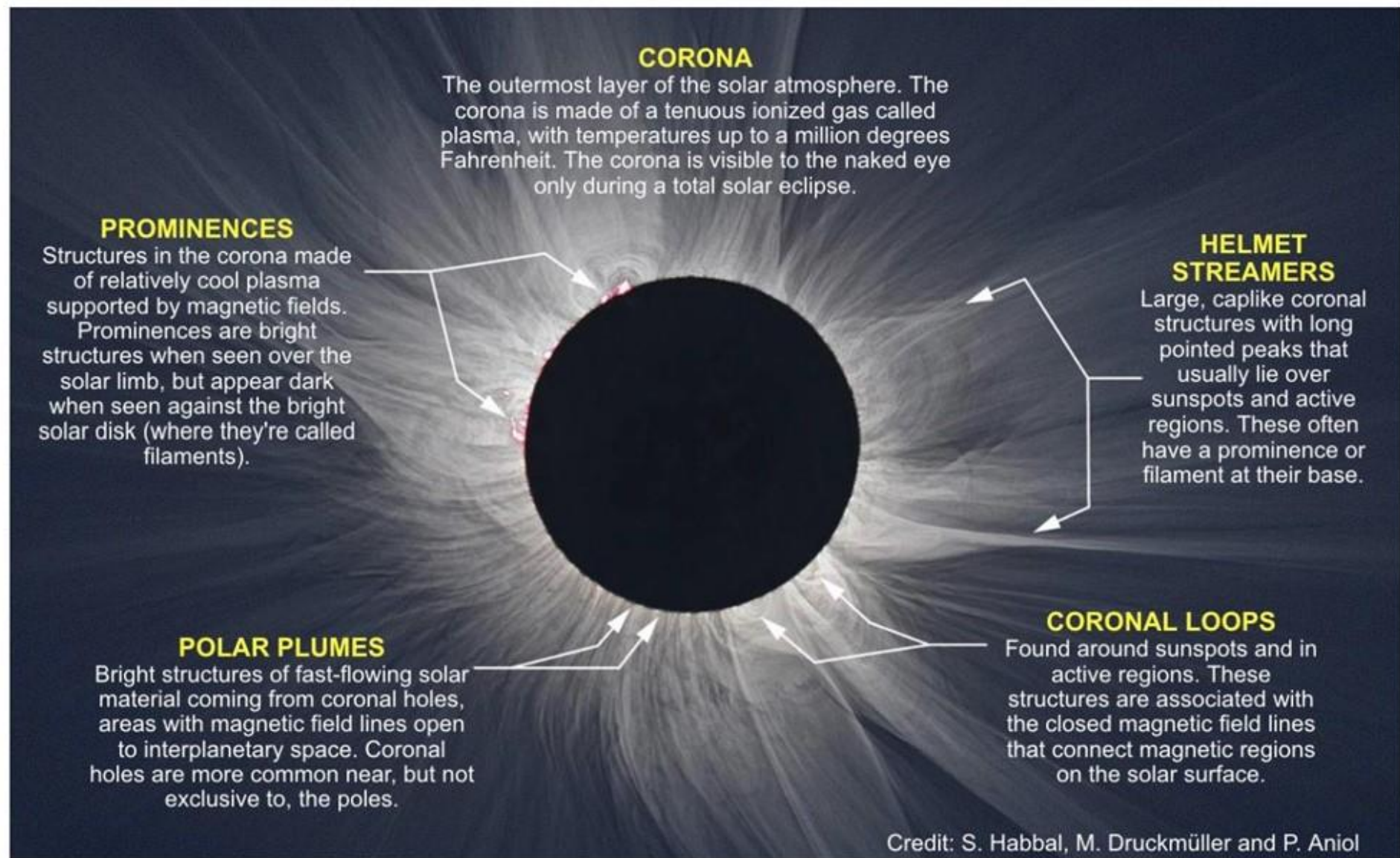
- 1) Venus and Jupiter during Totality, July 11, 1991, San Jose del Cabo, Mexico
- 2) Corona visible to 4 to 5 solar radii!





# Bright Planets (and a Comet?) at Mid Eclipse –April 8, 2024

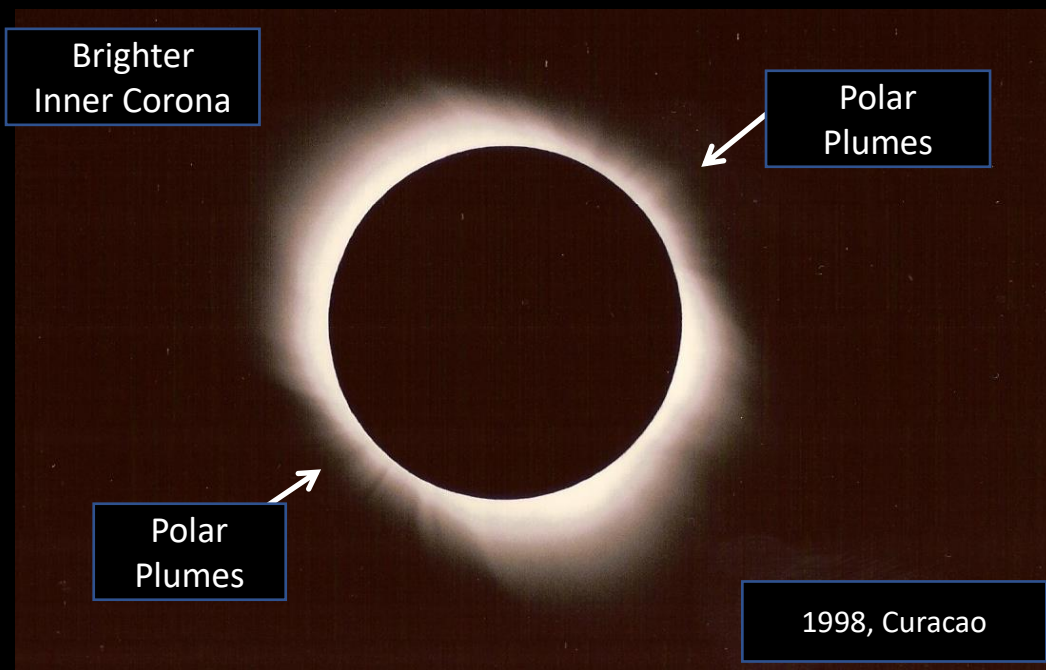




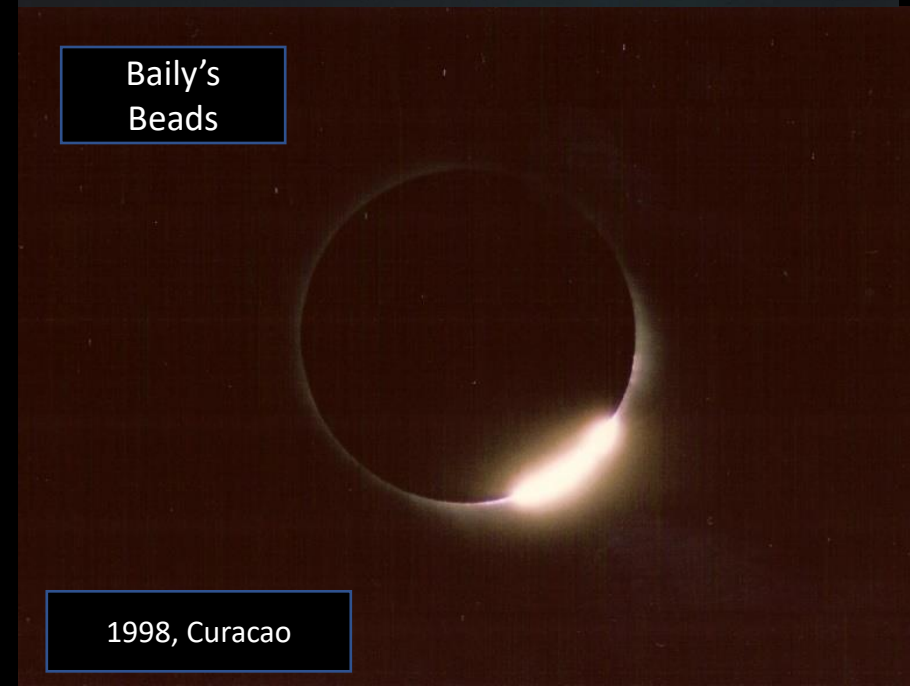
**Figure 1:** A highly processed NASA composite image showing some of the features of the Sun's corona. Credit: S. Habbal, M. Druckmüller, and P. Aniol



# Total Solar Eclipse Phenomena No. 4



At totality's end:  
Rapid transition  
from diamond ring  
to Baily's Beads

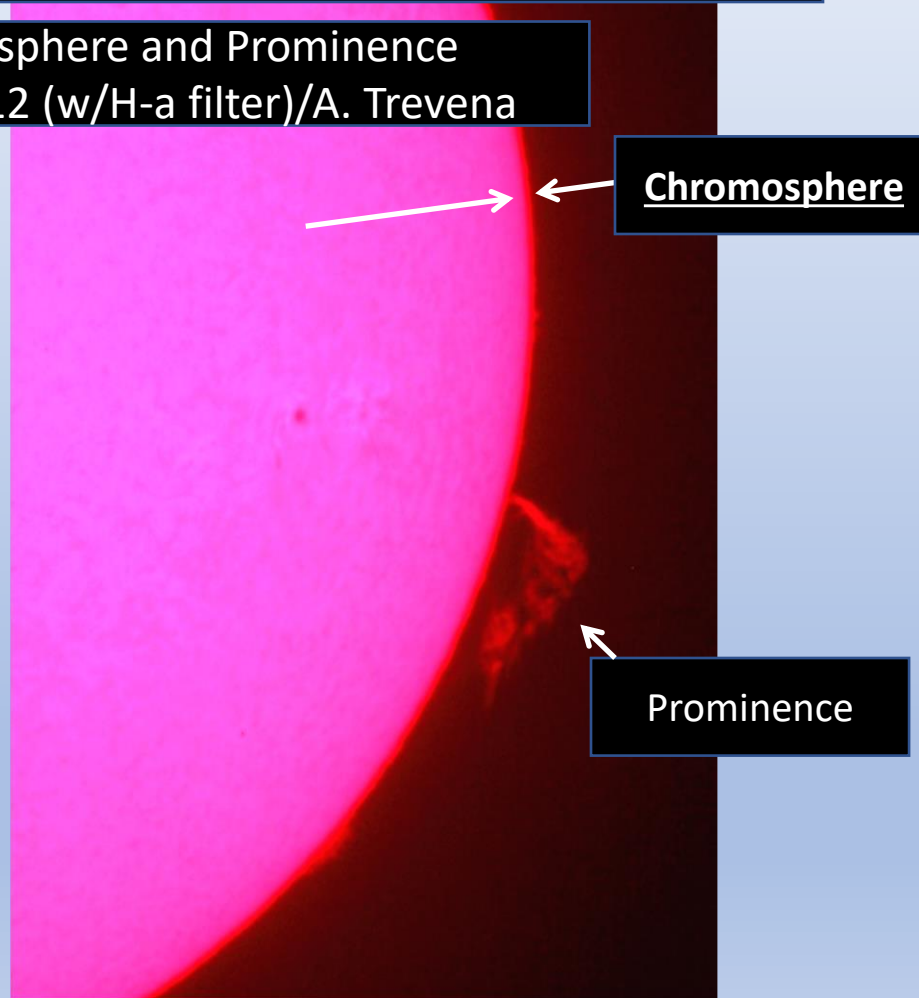


Beware Chromosphere Breakout  
during Late Totality!! Use eye  
protection NOW! - Total Eclipse is  
ENDING!

## Chromosphere & Emerging Photosphere

Photo Credit: NASA

The Chromosphere and Prominence  
on June 29, 2012 (w/H- $\alpha$  filter)/A. Trevena

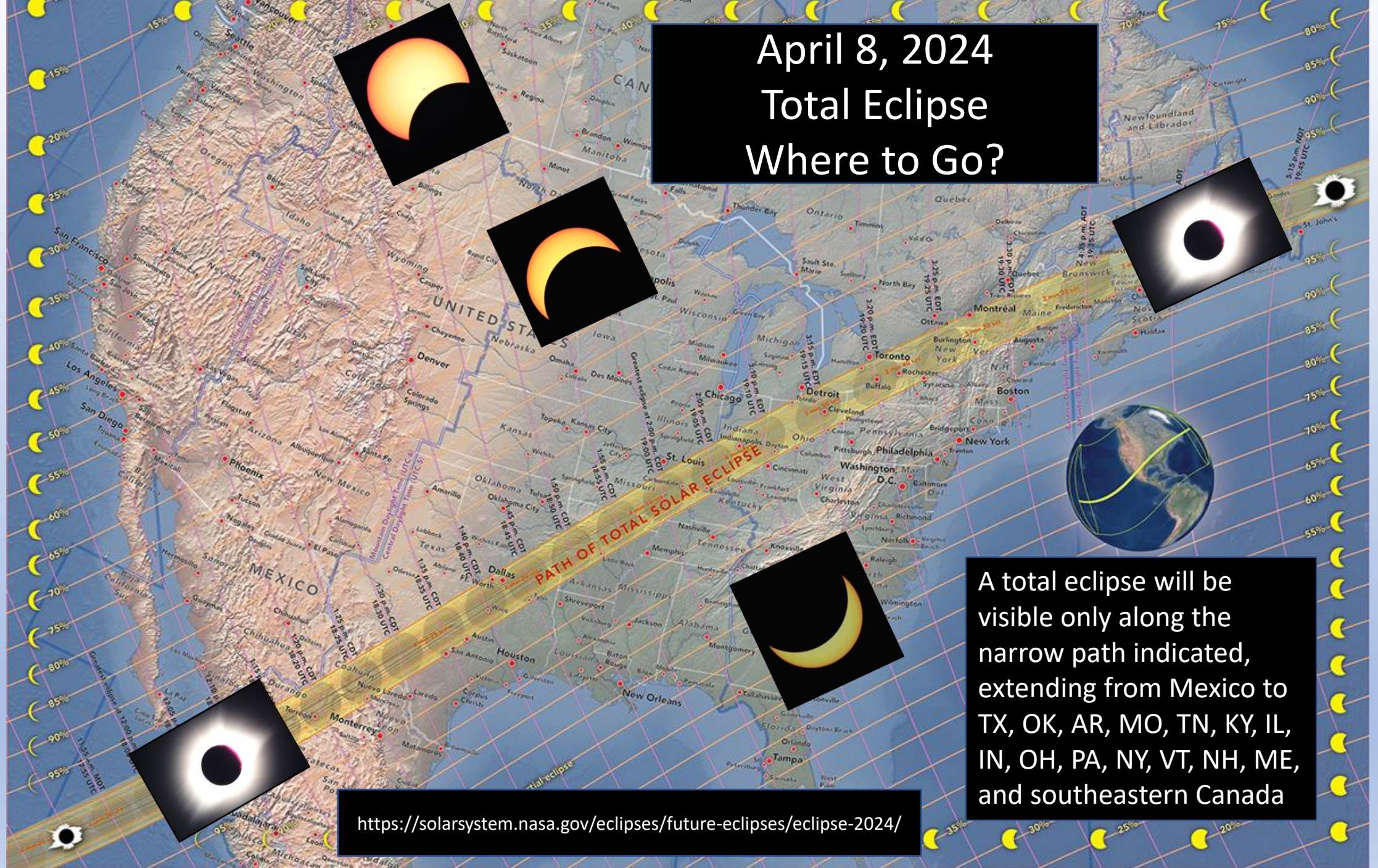




# April 8, 2024 Total Eclipse Where to Go?

A total eclipse will be visible only along the narrow path indicated, extending from Mexico to TX, OK, AR, MO, TN, KY, IL, IN, OH, PA, NY, VT, NH, ME, and southeastern Canada

<https://solarsystem.nasa.gov/eclipses/future-eclipses/eclipse-2024/>





Median April Cloud Fraction  
Terra Satellite, Years 2000-2018

**See Links, below...**

<https://eclipsophile.com/wp-content/uploads/2021/02/April-NoAm-cloud.png>

<https://skyandtelescope.org/astronomy-news/what-will-the-weather-be-on-the-day-of-the-total-solar-eclipse/>

Credit: Jay Anderson and Jennifer West  
eclipsophile.com

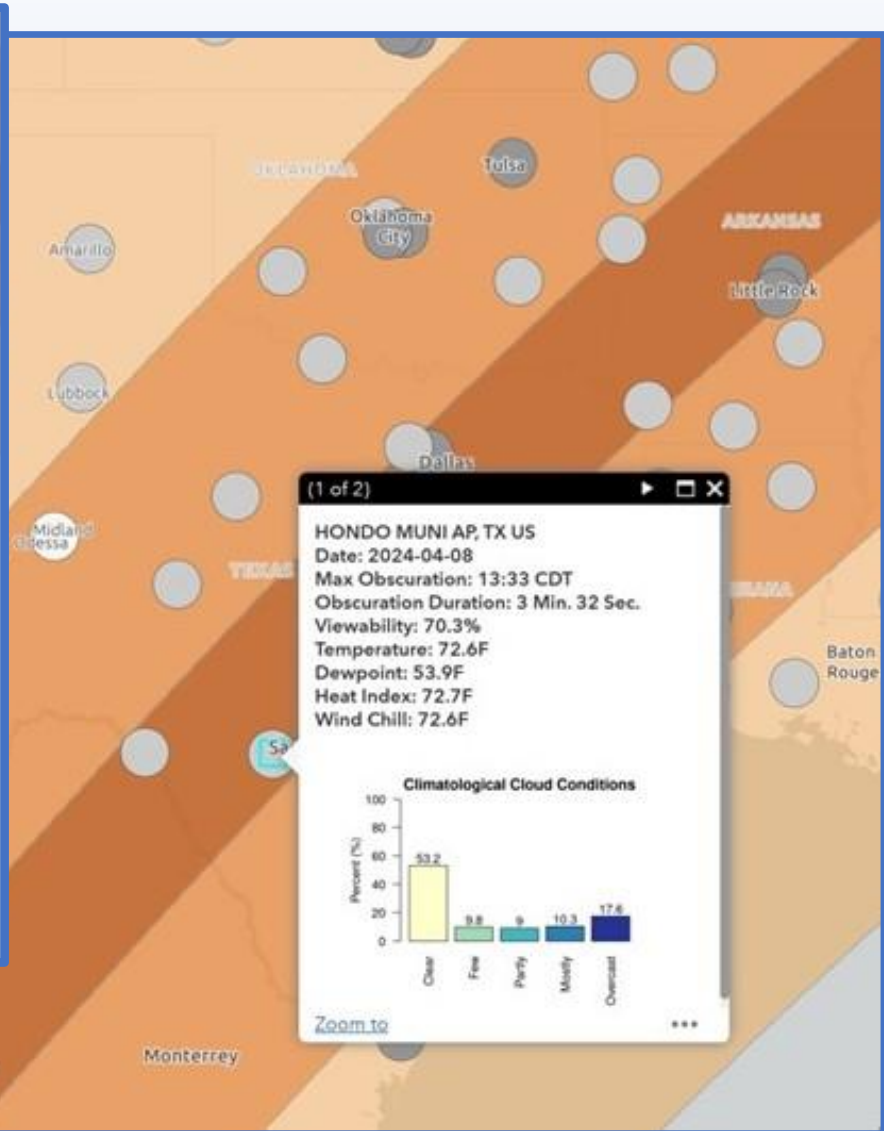
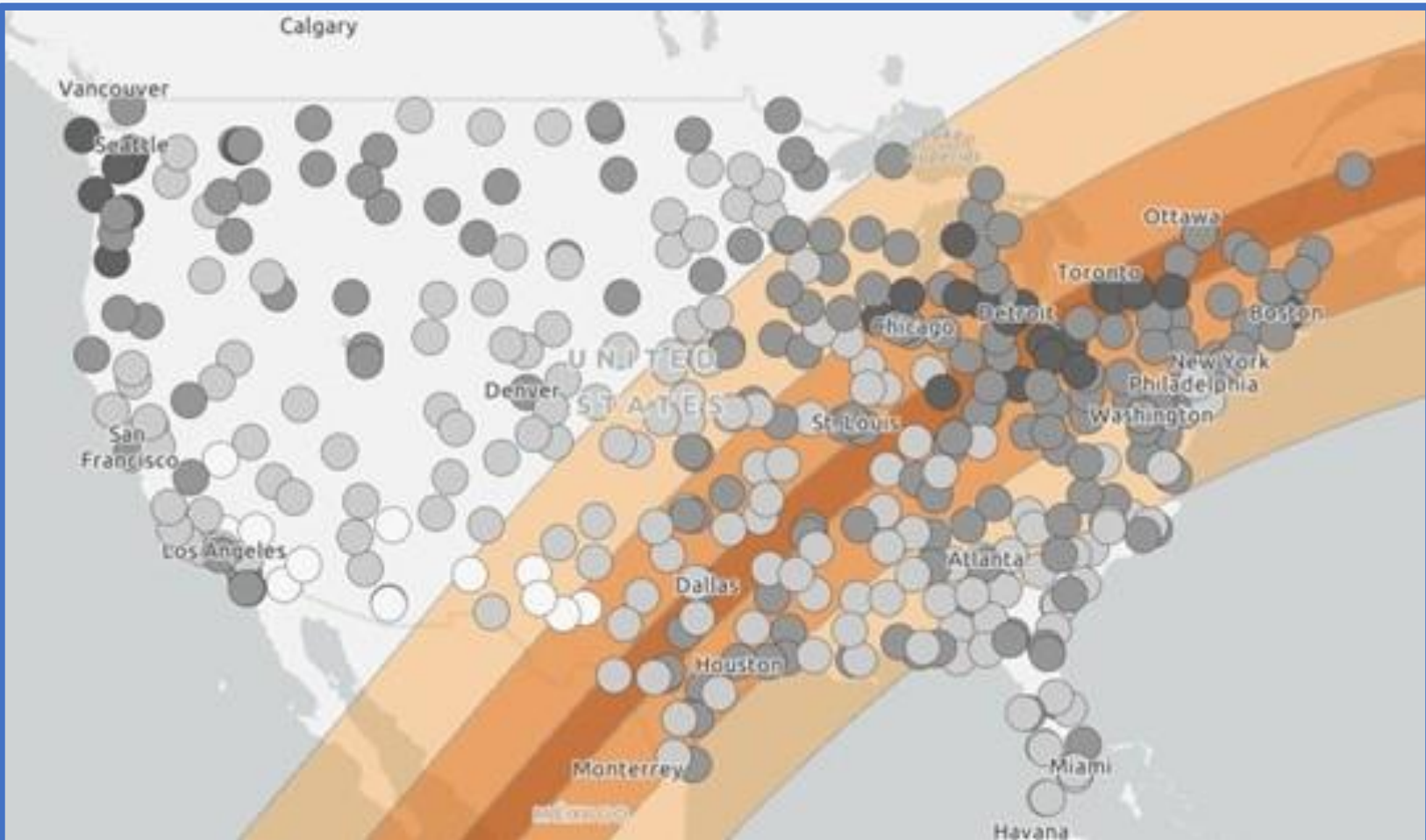
Mean April Cloud Fraction Along Center Line  
Terra Satellite, Years 2000-2018

**See Link, below...**

<https://eclipsophile.com/wp-content/uploads/2021/02/Noam-centre-cloud.png>

Credit: Jay Anderson and Jennifer West  
eclipsophile.com





# Average Weather Conditions & Eclipse Visibility Prognosis for April 8

NOAA Space Weather Prediction Center

<https://www.swpc.noaa.gov/news/are-you-ready-april-8-total-solar-eclipse>

## Percent of Possible Sunshine for April

See Link, below...

<https://eclipsophile.com/wp-content/uploads/2021/03/2024-sunshine.png>

Credit: Jay Anderson and Jennifer West  
eclipsophile.com



## El Nino Impact on April Cloud Cover (%) 1979-2023

**See Link, below...**

Credit: Jay Anderson

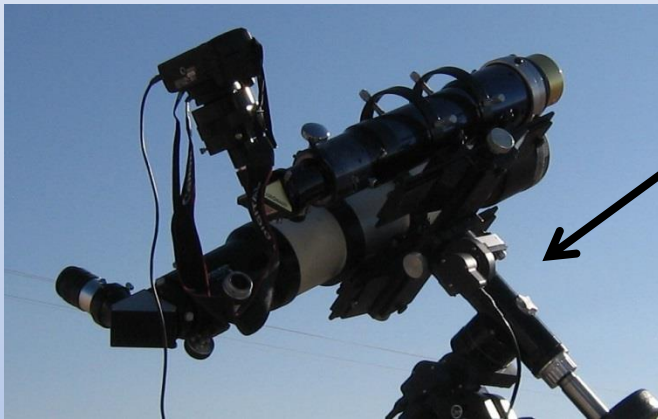
[El Niño and the 2024 Total Solar Eclipse - Sky & Telescope - Sky & Telescope \(skyandtelescope.org\)](https://skyandtelescope.org/education/el-nino-and-the-2024-total-solar-eclipse/)

# Solar Eclipse Photography

- Don't do it! ... Or, keep it simple!
- Allow time for viewing eclipse!!!
- Totality goes by **very quickly!!!**
- Solar filter for partial phases
- **DISABLE FLASH (cover with tape)!**
- Camera on tripod (or mount)
- Cable or wireless shutter control
- Camera w/ adjustable exposures
- Bracket your exposures
- Practice your plan before the eclipse!



Photo Credits:  
Art Trevena



See the “Exposure Guide” by Fred Espenak (Mr. Eclipse.com) at the following link:

<http://www.mreclipse.com/SEphoto/SEphoto.html>



# Why Travel to See a Total Solar Eclipse?

Some people see a partial eclipse and wonder why others talk so much about a total eclipse. Seeing a partial eclipse and saying that you have seen an eclipse is like standing outside an opera house and saying that you have seen the opera; in both cases, you have missed the main event.”

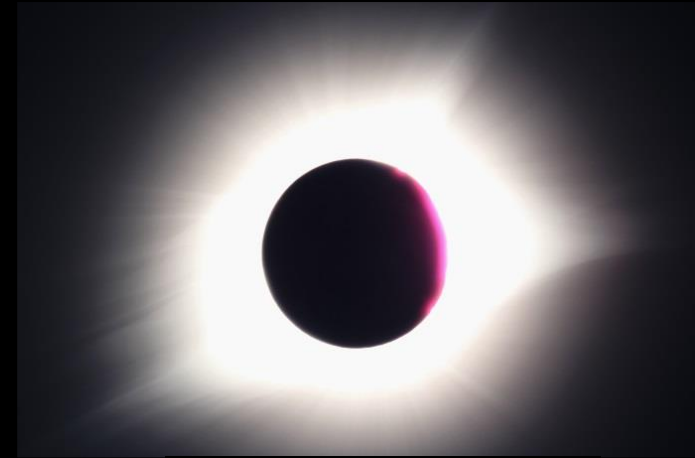
*Prof. Jay Pasachoff, 1983*

**“... a vision magnificent beyond description.”**

***General Albert J. Myer, 1869, co-founder, National Weather Service***



7/11/1991, Mexico



8/21/2017, Idaho, DSSN 63



2/26/1979, Montana, DSSN 153

DSSN = Daily Sunspot Number,  
Royal Observatory of Belgium



7/11/1991, Mexico, DSSN 235



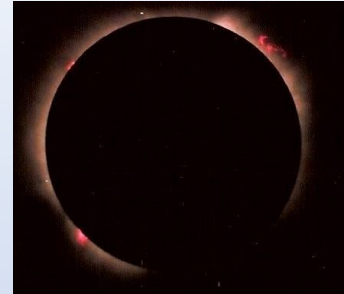
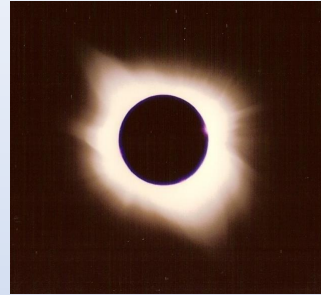
11/3/1994, Chile, DSSN 56



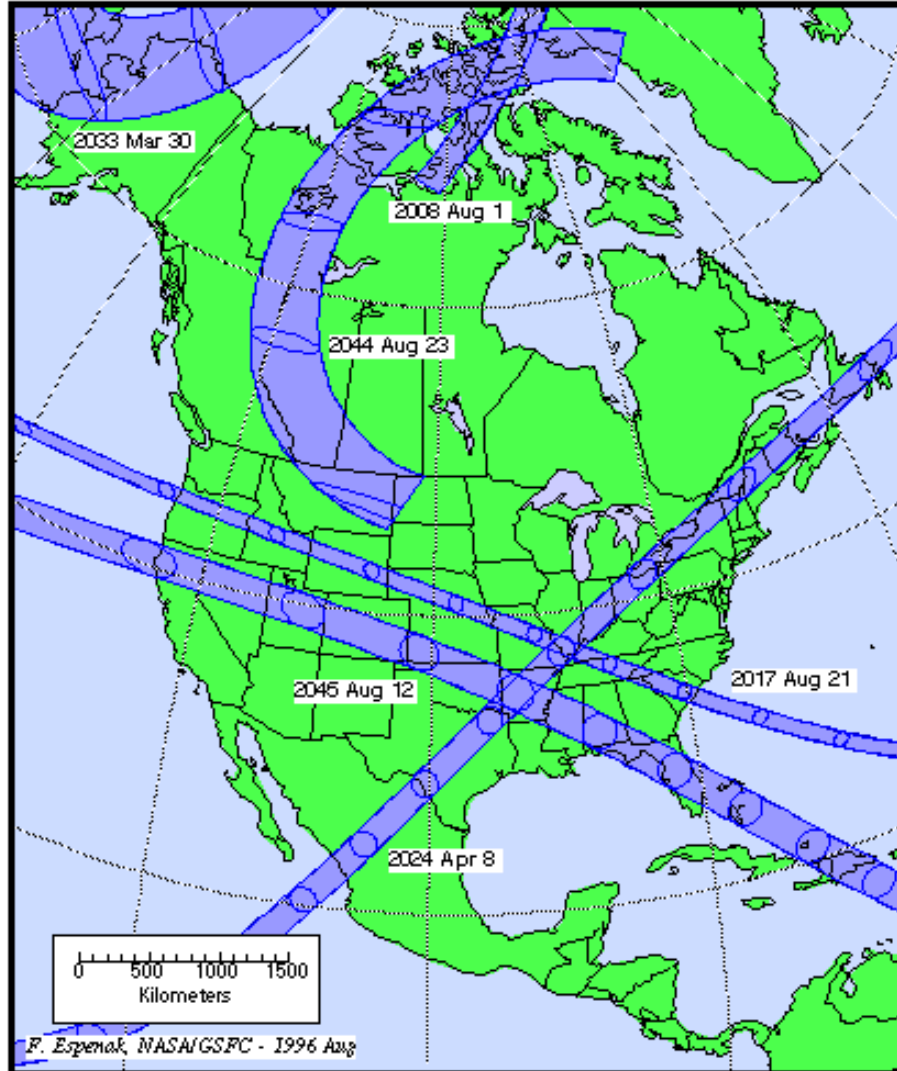
2/26/1998, Curacao, DSSN 56

# Future Total Solar Eclipses for North America

...or globally...  
if you just can't wait!



Total Solar Eclipses: 2001 - 2050



<u>Date</u>	<u>Location</u>
<b>8-Apr-2024</b>	<b>Mexico, USA (TX to ME), southeastern Canada</b>
12-Aug-2026	Arctic Ocean, Greenland, Iceland, Atlantic Ocean, Spain
<b>2-Aug-2027</b>	<b>Atlantic Ocean, Spain, N Africa, Arabia, Somalia, Indian Ocean</b>
22-Jul-2028	Indian Ocean, Australia, New Zealand
25-Nov-2030	Namibia, Botswana, S Africa, Indian Ocean, Australia
14-Nov-2031	central Pacific Ocean ( <u>hybrid eclipse</u> )
<b>30-Mar-2033</b>	<b>easternmost Siberia, W and N Alaska</b>
20-Mar-2034	Africa, Arabia, Iran, Pakistan, China
2-Sep-2035	China, N Korea, Japan, Pacific Ocean
<b>2036 to 2043</b>	<b>(6 total solar eclipses; but none in USA)</b>
<b>23-Aug-2044</b>	<b>Greenland, N &amp; W Canada, Montana, North Dakota</b>
<b>12-Aug-2045</b>	<b>USA (CA to CO to FL), Caribbean, N and E South America</b>



Thanks for your attention.  
Wishing you clear skies and good luck !

