

# LONGMONT ASTRONOMICAL SOCIETY

NOVEMBER 2024

**COMET C/2023 A3 (TSUCHINSHAN-ATLAS)**  
**BY LEAH SHIPLEY**

**VOLUME 40, No 11, 2024**  
**ISSN 2641-8886 (WEB)**  
**ISSN 2641-8908 (PRINT)**

## Next LAS Meeting November 21 at 7 pm

### “Space weather: the history, status, and future prospects for understanding the space environment” by Dr. Tom Berger

#### Summary

While the term “space weather” is relatively new to the scientific vocabulary, attempts to understand associated phenomena such as the aurora go back centuries and as recently as the mid-20th century there were still significant gaps in our understanding of how the Sun causes phenomena at Earth such as geomagnetic storms. In this talk I’ll review the history of our understanding of how the Sun and the Earth interact to create space weather, the many phenomena associated with space weather and their impacts on critical technological infrastructure, and what we need to do to increase our understanding of, and ability to mitigate, space weather impacts as we venture back to the Moon and eventually to Mars and beyond.

#### Biography

Dr. Thomas (Tom) Berger is the director of the University of Colorado Boulder Space Weather Technology, Research, and Education Center (SWx TREC). Prior to this position, he was the director of NOAA’s Space Weather Prediction Center (SWPC) in Boulder. Tom recently became the Principal Investigator of the NASA Space Weather Operational Readiness Development (SWORD) center of excellence, working with the Universities of Michigan, Iowa, Alaska, and NCAR/High Altitude Observatory to advance predictive models of the geospace environment during space weather storms. Tom’s original research was in solar physics as a member of the Lockheed Martin Solar and Astrophysics Lab in Palo Alto following his Ph.D. from Stanford University. He is originally from the Bay Area of California and has an undergraduate degree in Engineering Physics from the University of California Berkeley.



The meeting will be at the First Evangelical Lutheran Church, 803 Third Avenue, Longmont, CO 80501. If you cannot attend the in-person meeting, it will be available on Zoom. Tom will present in person. Video of the meeting will be available on the LAS member portal website <https://members.longmontastro.org> a couple days after the presentation.

#### About LAS

The Longmont Astronomical Society Newsletter ISSN 2641-8886 (web) and ISSN 2641-8908 (print) is published monthly by the Longmont Astronomical Society, P. O. Box 806, Longmont, Colorado. Newsletter Editor is Vern Raben. Our website URL is <https://www.longmontastro.org> and the webmaster is Sarah Davis. The Longmont Astronomical Society is a 501 c(3), non-profit corporation which was established in 1987.



The Longmont Astronomical Society is affiliated with the Astronomical League (<https://www.astroleague.org>). The Astronomical League is an umbrella organization of amateur astronomy societies in the United States.



# Contents

<a href="#">Front Cover</a>	Comet C/2023 A3 (Tsuchinshan-ATLAS) by Leah Shipley
<a href="#">2</a>	LAS Meeting Nov 21 at 7 pm - "Space weather: the history, status, and future prospects for understanding the space environment" by Dr. Tom Berger
<a href="#">3</a>	Contents
<a href="#">4</a>	Planets and Lunar Phases in November
<a href="#">5</a>	Showpiece Object in November, Meteor Showers in November, LAS Execs
<a href="#">6</a>	Comet C/2023 A3 (Tsuchinshan-ATLAS) in November
<a href="#">7</a>	Navigating the November Night Sky by John Goss
<a href="#">8</a>	Venus low in the SW and Other Suns: Gamma Aretis by Astronomical League
<a href="#">10 - 23</a>	October 17 Meeting Notes by Eileen Hall-McKim
<a href="#">24</a>	Aurora and C/2023 A3 (Tsuchinshan-ATLAS) by Aref Nammari
<a href="#">25</a>	M33 by Aref Nammari
<a href="#">26</a>	Milky Way at Deadwood by Brian Kimball
<a href="#">27</a>	Comet C/2023 A3 (Tsuchinshan-ATLAS) and Sun in H-Alpha on Oct 6 by Brian Kimball
<a href="#">28</a>	Solar Active Regions on Oct. 5 by Brian Kimball; M27 by Allen Jeeter
<a href="#">29</a>	Sh 2-136 and Sh 2-200 by David Elmore
<a href="#">30</a>	C/2023 A3 (Tsuchinshan-ATLAS) by Jim Pollock
<a href="#">31</a>	NGC 7000 North America Nebula and Moon by Jim Pollock
<a href="#">32</a>	Aurora by Leah Shipley
<a href="#">33</a>	NGC 1333 and Erakis by Martin Butley
<a href="#">34</a>	NGC 7741 and Supernova Remnant G108-2-0.6 by M. J. Post
<a href="#">35</a>	Supernova Remnant in Cepheus G108.2-0.8 and Wizard Nebula by M. J. Post
<a href="#">36</a>	C/2023 A3 (Tsuchinshan-ATLAS) by Paul Robinson
<a href="#">37</a>	IC 1396 Elephant Trunk Nebula and NGC 7293 Helix Nebula by Rolando Garcia
<a href="#">38</a>	C/2023 A3 (Tsuchinshan-ATLAS) by Rolando Garcia; Aurora by Leah Shipley
<a href="#">39</a>	Sh 2-157 and Aurora in Iceland by Stephen Garretson
<a href="#">40</a>	Sh 2-88 by Stephen Garretson
<a href="#">41</a>	Aurora in Iceland by M. J. Post M31 by Rolando Garcia
<a href="#">42 - 43</a>	Newsletter Archives for November 1994, 2004, and 2014 by Eileen Hall-McKim
<a href="#">Back Cover</a>	Aurora by Leah Shipley

## Planets in November

### Mercury

Mercury is not visible naked eye this month.

### Venus

Venus is visible low in the southwest after sunset. It is about magnitude -0.4 in brightness and increases from 14 arc sec across to 18 arc sec during the month.

### Mars

Mars becomes visible in the evening sky in constellation Cancer after midnight this month. It increases in brightness from +0.1 to -0.5 magnitude. Its disk increases from 9.3 arc sec to 12 arc sec across.



Mars Oct. 26 by Vern Raben

- Nov 10 at 1:55 am alt 74°
- Nov 12 at 3:34 am alt 63°
- Nov 12 at 11:25 pm alt 57°
- Nov 14 at 5:12 am alt 43°
- Nov 15 at 1:03 am alt 72°
- Nov 15 at 8:54 pm alt 31°
- Nov 16 at 6:50 am alt 23°
- Nov 17 at 10:32 pm alt 52°
- Nov 19 at 4:19 am alt 49°
- Nov 20 at 12:10 am alt 69°
- Nov 20 at 8:01 pm alt 25°
- Nov 21 at 5:57 am alt 28°
- Nov 22 at 1:48 am alt 71°
- Nov 22 at 9:39 pm alt 46°
- Nov 24 at 3:26 am alt 54°
- Nov 24 at 11:17 pm alt 65°
- Nov 25 at 7:08 pm alt 20°
- Nov 26 at 5:04 am alt 34°
- Nov 27 at 12:55 am alt 73°
- Nov 27 at 8:46 pm alt 40°
- Nov 29 at 2:33 am alt 60°
- Nov 29 at 10:25 pm alt 60°

### Jupiter

Jupiter is high up in the southern sky in constellation Taurus in the early morning. It is about -2.8 magnitude in brightness and about 48 arc sec across. It is at opposition with Earth on Dec. 7th. The following is a list of visible transits above 20° altitude this month:

- Nov 2 at 6:19 am altitude 52°
- Nov 3 at 2:10 am alt 68°
- Nov 3 at 9:01 pm alt 23°
- Nov 5 at 2:48 am alt 73°
- Nov 5 at 10:39 pm alt 43°
- Nov 7 at 4:28 am alt 57°
- Nov 8 at 12:17 am alt 63°
- Nov 9 at 6:04 am alt 37°



### Saturn

Saturn is +0.9 magnitude in brightness and its disk is 18 arc sec across.

### Uranus

Uranus is 5.6 magnitude and 3.8 arc sec across.

### Neptune

Neptune is 7.8 magnitude and 2.3 arc sec across.

## Lunar Phases in November



**New Moon:**  
Nov 1 at 6:48 am

**First quarter:**  
Nov 8 at 10:57 pm

**Full Moon:**  
Nov 15 at 2:29 pm

**Third quarter:**  
Nov 22 at 11:23 pm

**New Moon:**  
Nov 30 at 11:23 pm

Images created with NASA Scientific Visual Studio's Moon Phase and Libration Tool.

See <https://svs.gsfc.nasa.gov/5187/>

## Showpiece Objects in November

- NGC 7000, North America Nebula in Cyg, mag 4
- M31, Andromeda Galaxy in And, mag 4.3
- NGC 7293, Helix Nebula in Aqr, mag 6.3
- NGC 6992, Veil Nebula (east) in Cyg, mag 7.0
- NGC 6960, Veil Nebula (west) in Cyg, mag 7.0
- NGC 281, Pacman Nebula in Cas, mag 7.4
- NGC 253, Sculptor Galaxy in Sct, mag 7.9
- IC 5070, Pelican Nebula in Cyg, mag 8.0
- NGC 6543, Cat's Eye Nebula in Dra, mag 8.3
- NGC 7662, Blue Snowball in And, mag 8.6
- NGC 6826, Blinking Planetary in Cyg, mag 8.8
- IC 5146, Cocoon Nebula in Cyg, mag 10.0
- NGC 6888, Crescent Nebula in Cyg, mag 10.0
- M76, Little Dumbbell Nebula in Per, mag 10.1
- NGC 40, Bowtie Nebula in Cep, mag 10.7
- NGC 7635, Bubble Nebula in Cas, mag 11
- NGC 7008, Fetus Nebula in Cyg, mag 12
- NGC 7026, Cheeseburger Nebula in Cyg, mag 12
- Hickson 92, Stephen's Quintet in Peg, mag 12
- NGC 7023, Iris Nebula in Cep
- Sh 2-155, Cave Nebula in Cep

## Meteor Showers in November

The Leonid Meteor shower is a type I (major) meteor shower which peaks on night of Nov 17/18. Only about 15 per hour is expected. The Moon is just past full and rises at 6:01 pm so it will interfere the entire night. The Leonid meteor shower peaks about every 33 years and can be spectacular but probably not this year. On Nov 12/13 in 1833 the estimated peak rate was 240,000 per hour. In 1999, 2000, and 2001 up to 3000 meteors per hour were recorded. The Leonid meteor shower is caused by debris from comet 55P/Tempel-Tuttle entering the Earth's atmosphere.



### LAS 2024 Execs

Vern Raben, President  
Hunter Morrison, Vice President  
Eileen Hall-McKim, Secretary  
Bruce Lamoreaux, Treasurer

### LAS 2024 Board Members

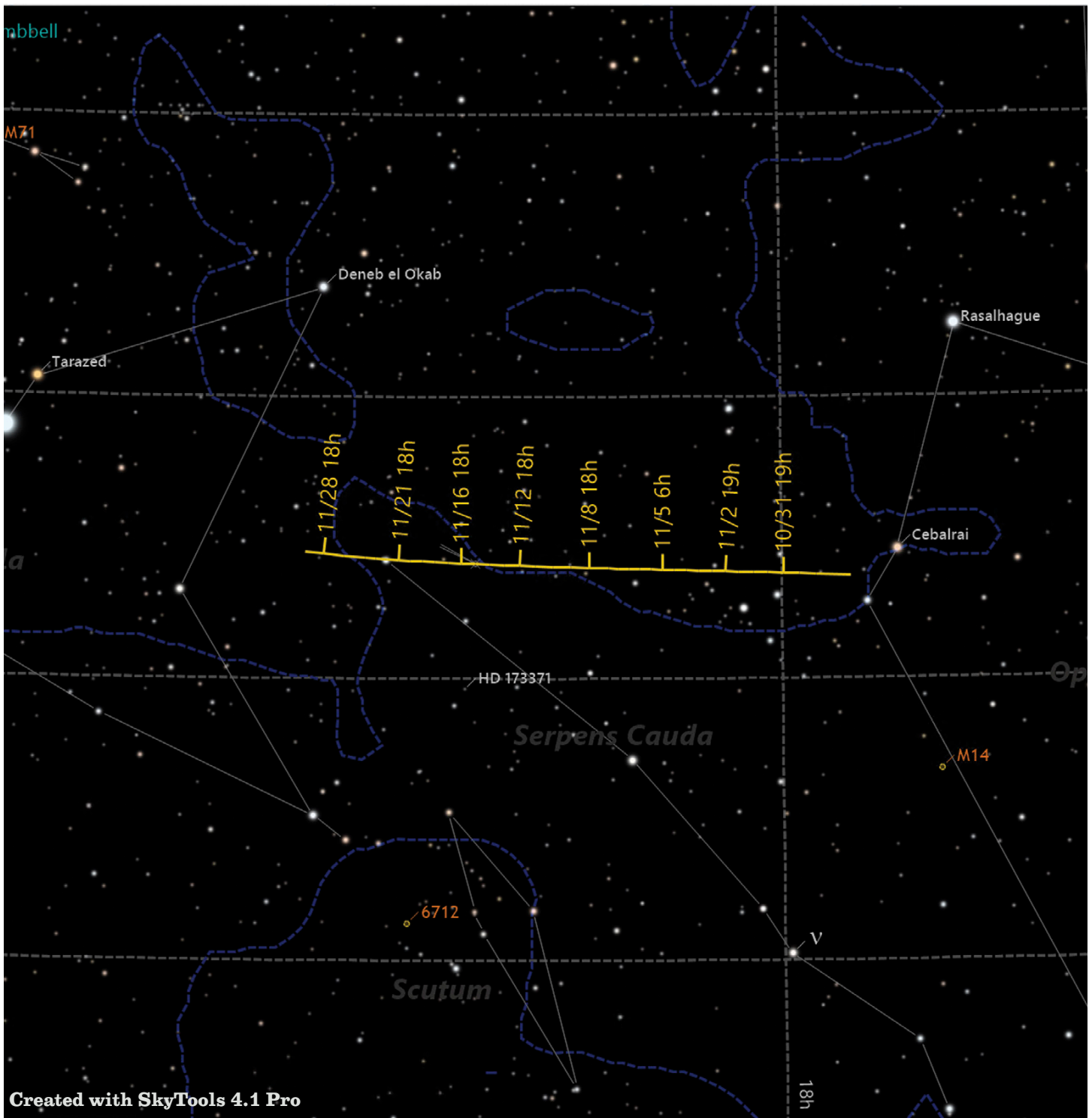
David Elmore, Gary Garzone,  
Mike Hotka, Brian Kimball, and Tally O'Donnell

### Appointed Positions 2024

Sarah Detty, Webmaster  
Bruce Lamoreaux, Library Telescope Coordinator  
Open Position, Public Outreach Coordinator

Vern Raben, Newsletter Editor  
Eileen Hall-McKim, Newsletter Archives

## Comet C/2023 A3 (Tsuchinshan - ATLAS) in November



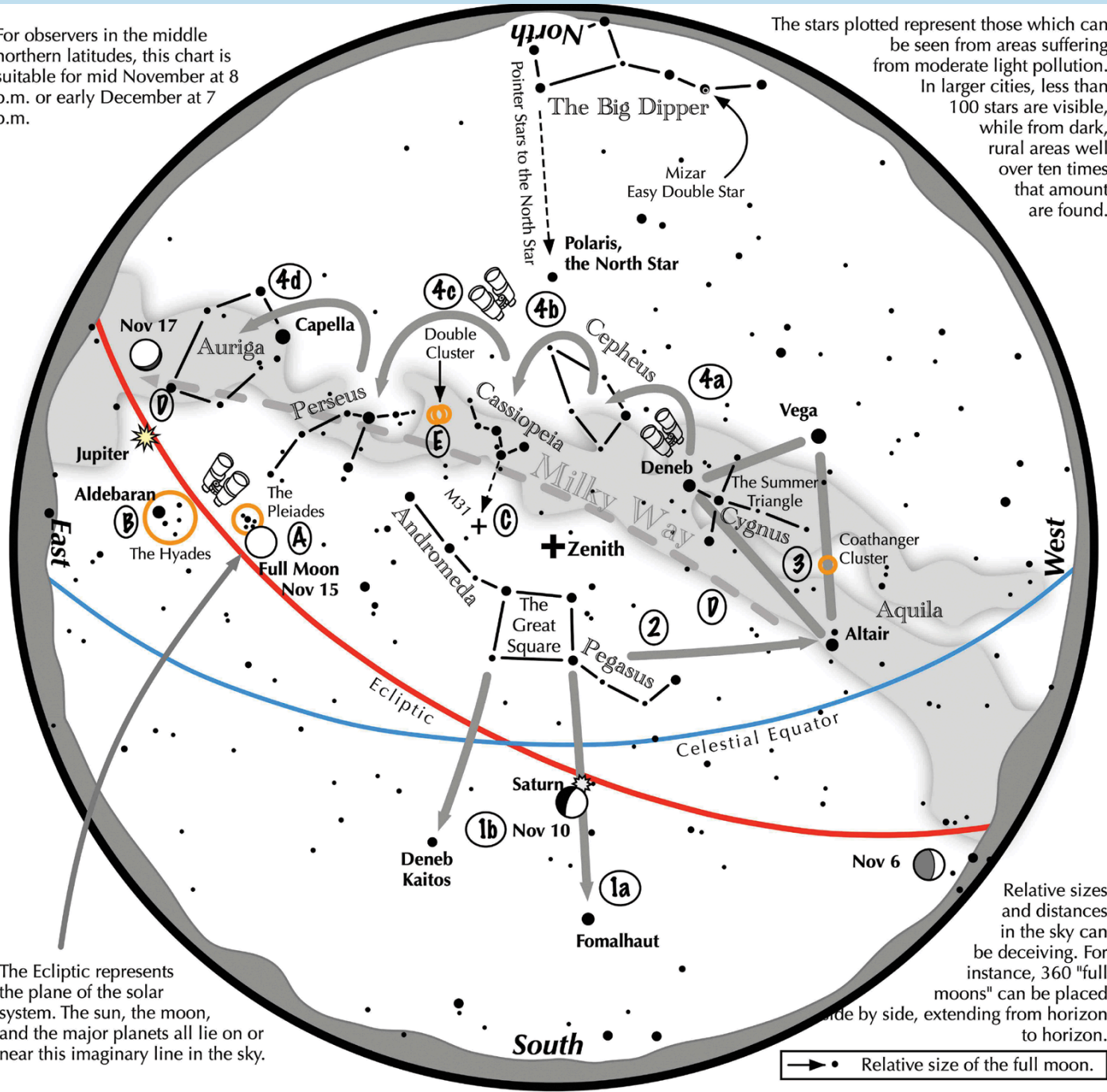
Created with SkyTools 4.1 Pro

Date	Optimal time	RA	Dec	Constellation	Magnitude	Size (arc min)
Nov 1	7:28 pm	18h05m19.1s	+03°45'57"	Ophiuchus	6.5	3.4
Nov 7	6:23 pm	18h25m49.8s	+03°55'39"	Ophiuchus	7.3	2.8
Nov 13	6:18 pm	18h40m38.8s	+04°02'59"	Serpens	8.0	2.4
Nov 19	6:14 pm	18h52m15.3s	+04°11'01"	Serpens	8.6	2.1
Nov 25	6:12 pm	19h01m55.1s	+04°21'06"	Aquila	9.1	1.9
Nov 30	6:09 pm	19h08m59.5s	+04°31'34"	Aquila	9.4	1

# Navigating the November Night Sky by John Goss

For observers in the middle northern latitudes, this chart is suitable for mid November at 8 p.m. or early December at 7 p.m.

The stars plotted represent those which can be seen from areas suffering from moderate light pollution. In larger cities, less than 100 stars are visible, while from dark, rural areas well over ten times that amount are found.



The Ecliptic represents the plane of the solar system. The sun, the moon, and the major planets all lie on or near this imaginary line in the sky.

Relative sizes and distances in the sky can be deceiving. For instance, 360 "full moons" can be placed side by side, extending from horizon to horizon.

## Navigating the November night sky: Simply start with what you know or with what you can easily find.

- 1 Face south. Almost overhead lies the "Great Square" with four stars about the same brightness as those of the Big Dipper. Extend a line southward following the Square's two westernmost stars. The line strikes Fomalhaut, the brightest star in the south. A line extending southward from the two easternmost stars, passes Deneb Kaitos, the second highest star in the south.
- 2 Draw a line westward following the southern edge of the Square until it strikes Altair, part of the "Summer Triangle."
- 3 Locate Vega and Deneb, the other two stars of the Summer Triangle. Vega is its brightest member, while Deneb sits in the middle of the Milky Way.
- 4 Jump along the Milky Way from Deneb to Cepheus, which resembles the outline of a house. Continue jumping to the "W" of Cassiopeia, then to Perseus, and finally to Auriga with its bright star Capella.

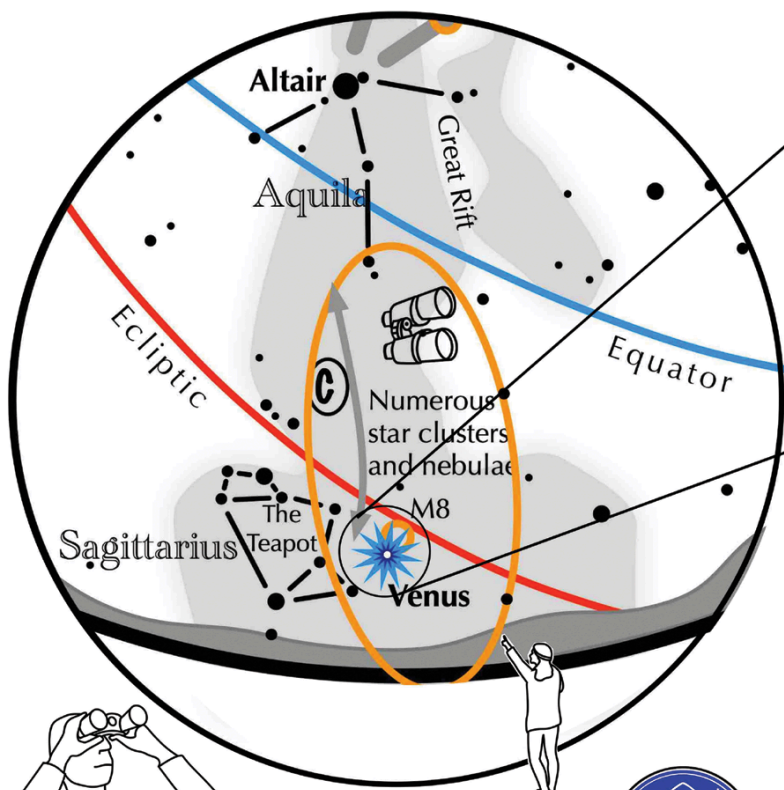
### Binocular Highlights

**A and B:** Examine the stars of the Pleiades and Hyades, two naked eye star clusters. **C:** The three westernmost stars of Cassiopeia's "W" point south to M31, the Andromeda Galaxy, a "fuzzy" oval. **D:** Sweep along the Milky Way from Altair, past Deneb, through Cepheus, Cassiopeia and Perseus, then to Auriga for many intriguing star clusters and nebulous areas. **E:** The Double Cluster.

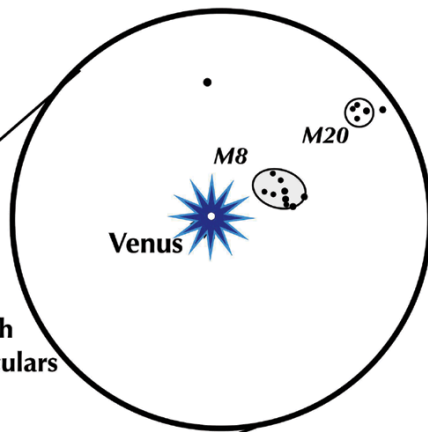


Astronomical League [www.astroleague.org/outreach](http://www.astroleague.org/outreach); duplication is allowed and encouraged for all free distribution.

If you can observe only one evening celestial event this month, consider this one:



View through 10x50 binoculars



### Venus reveals celestial treasures

Look to the south-southwest 75-90 minutes after sunset.

- On November 11 & 12, look for Venus low in the south-southwest. It will be the brightest object in the area.
- Use binoculars to view Venus. To its immediate upper right, subtly glows a nebulous star cluster, M8, nicknamed "the Lagoon Nebula" (4100 L-Y distant).
- To the upper right of M8 dimly glows another star forming nebula and cluster, M20, called "the Trifid Nebula" (5200 L-Y distant).

South-southwest  
75 minutes after sunset  
on Nov. 11 & 12.



## Other Suns: Gamma Arietis

### How to find Gamma Arietis on a November evening

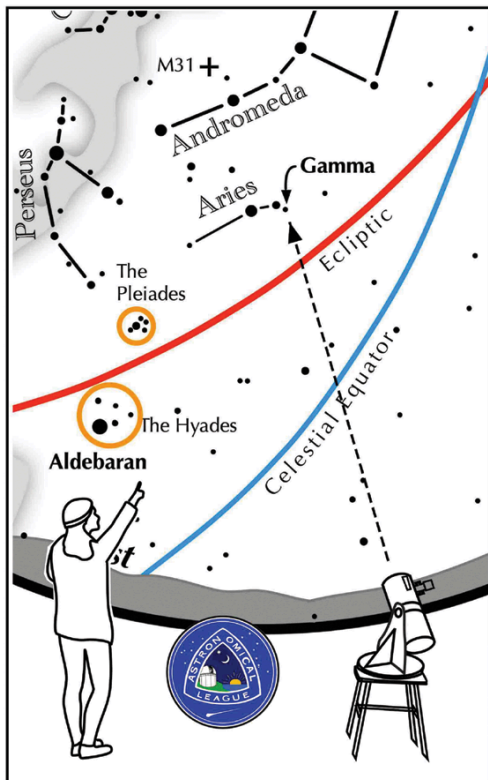
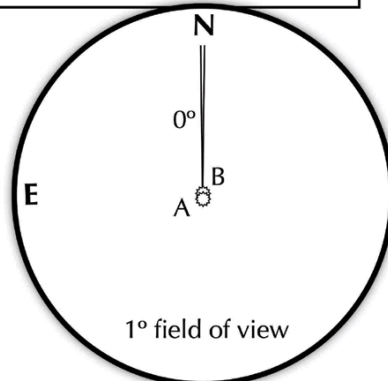
Face east. Locate the Pleiades. Aries lies to its upper right about the same distance that it is from the Hyades. Gamma is a dim star at the end of the string of stars that form Aries.

Suggested magnification: >50x  
Suggested aperture: >2 inches

#### Gamma Arietis

A-B separation: 7.5 sec  
A magnitude: 4.5  
B magnitude: 4.6  
Position Angle: 0°  
A & B colors:  
white, white

Also known as the  
"Ram's Eyes."





# October 17 LAS Meeting Notes by Eileen Hall-McKim

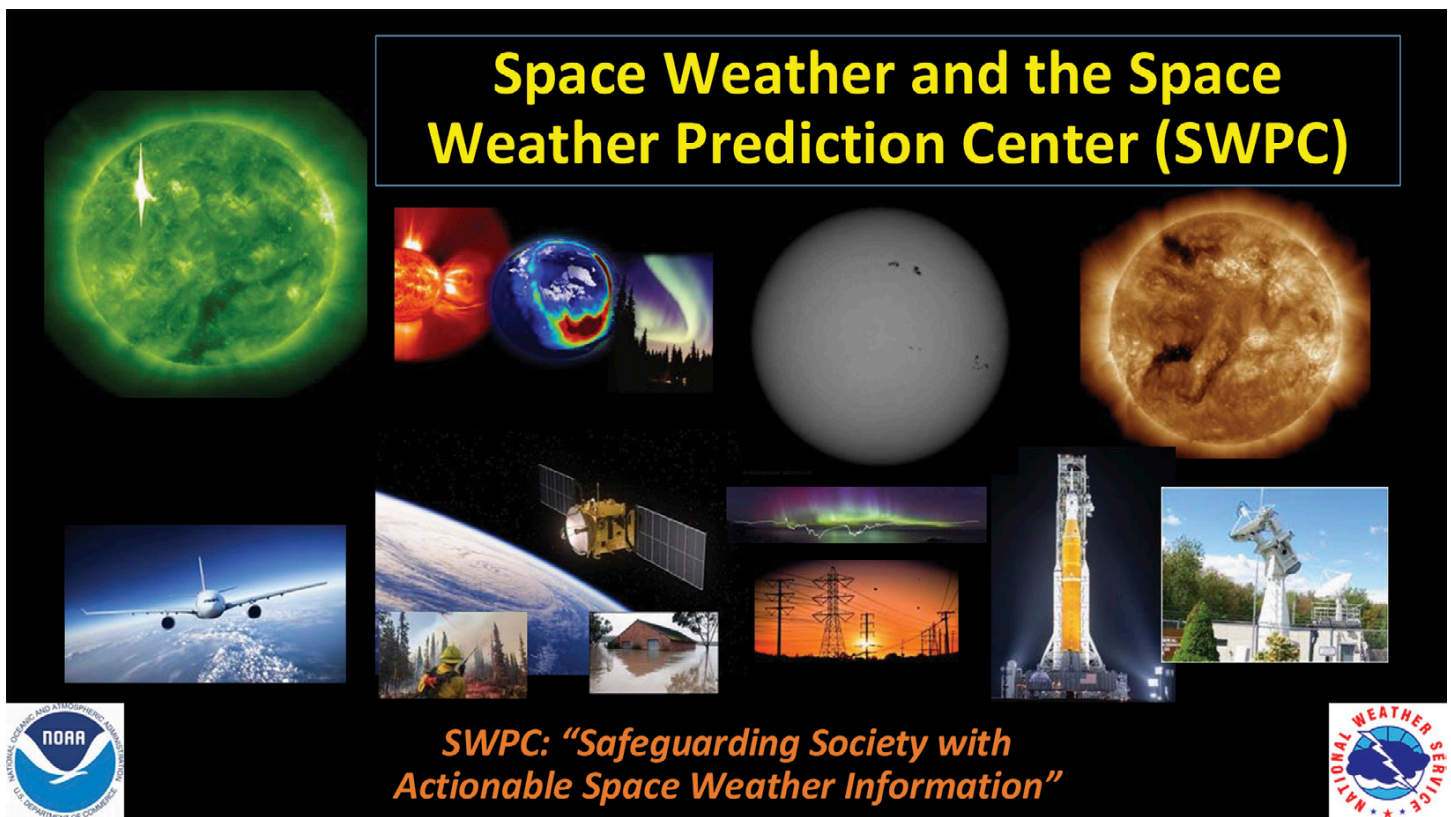
## I. Introduction

The October LAS monthly meeting was held in-person and by zoom on October 17th at the Longmont Lutheran Church, 803 Third Ave. President Vern Raben began the meeting with self-introduction of members attending in person and those online. Twelve members attended in person, 14 attended on-line.

## II. Main Presentation

Our guest speaker tonight is Mr. Shawn Dahl. Shawn is a U.S. Air Force (USAF) retiree (22 years) where he spent most of his career in the field of meteorology and space weather. He retired from active duty in 2007 and held several meteorological forecasting positions with the USAF and the NWS until 2015, when he was hired as a physical scientist and senior space weather forecaster by the Space Weather Prediction Center (SWPC). He was selected as SWPC's first Service Coordinator in August of 2023 and now leads Impact-based Decision Support Services (IDSS) issues, relations, and products. He also leads education/outreach initiatives and efforts, and conducts many customer and partner interactions on behalf of SWPC - to include working with the press/media, broadcast meteorologists, and the emergency management community.

### Active Solar Cycle 25: What You Want to Know By Shawn Dahl



**Space Weather and the Space Weather Prediction Center (SWPC)**

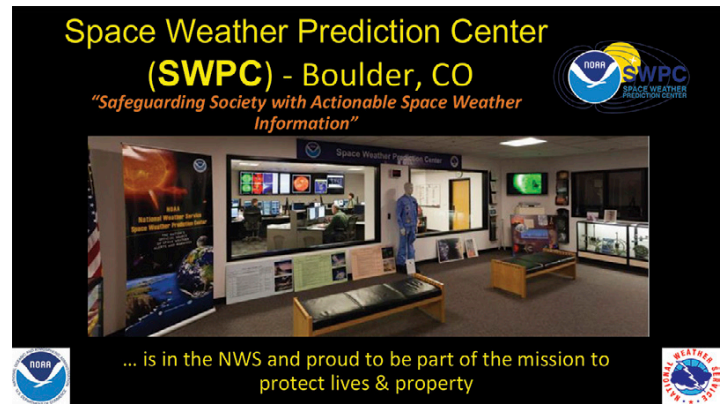
**SWPC: "Safeguarding Society with Actionable Space Weather Information"**

In this presentation we learn about space weather; the physical properties of sunspots, flares, and CMEs, hazards, potential risks and how these risks are determined, and steps being taken to mitigate potential impacts on Earth. Shawn discusses the current highly active Solar Cycle 25, how the cycle continues to be quite prolific and how primary solar storms of concern and potential impacts relates to our society and the technology we rely upon. Discussion

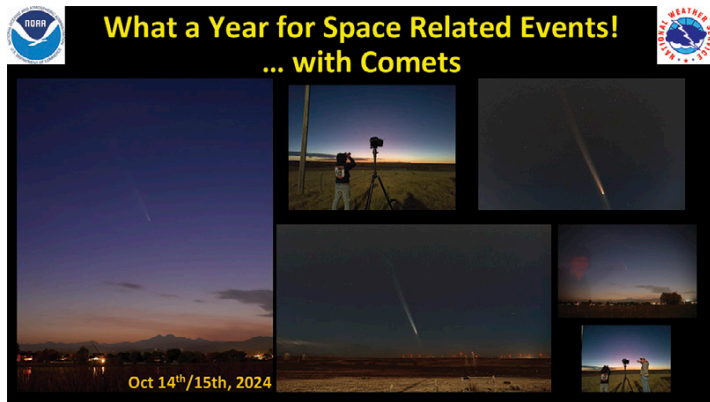
throughout focuses on space weather activity – impacts, mitigation, past storms of interest and how they are classified and associated with each other; also discuss the solar wind and other influencers and what that means for auroral viewing potential.

An understanding of potential effects of space weather is important to our way of life and our society today. The

U.S. Government has developed a Space Weather Prediction Center (SWPC), as part of the National Oceanic and Atmospheric Administration (NOAA) where scientists and technicians research and manage many aspects of the effects of space weather on Earth. A lot goes on at (SWPC), both behind the scenes and in the public sector, that we will learn about in this presentation.



What a Year for Space Related Events!



Images by Shawn Dahl, Wyoming, Twin Peaks Lake View and near residence in Berthoud, CO

... with Comets



...with a Total Solar Eclipse  
Eclipse views of August 8, 2017 and April 8, 2024

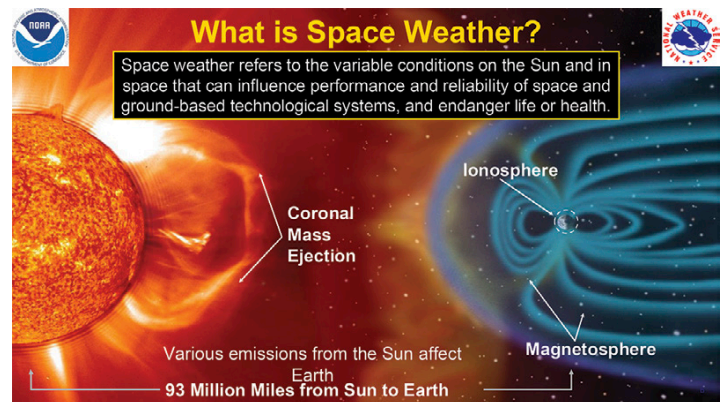


Images by Shawn Dahl in Berthoud, CO October 10th, 2024

...and a Spectacular Aurora

*"Safeguarding Society with Actionable Space Weather Information"*

SWPC is based in Boulder, Colorado and observes the Sun in real time from both ground-based observatories and satellites and is a 24/7 operation. Scientists can combine these observations with models and forecast space weather for the government, power companies, airlines, satellite communications and navigation providers and users from around the world. SWPC with 70+ personnel is in the National Weather Service and proud to be part of the mission to protect lives and property.



**What is space weather?**

Space weather refers to variable conditions in space primarily caused by solar activity that can influence performance and reliability of space and ground-based technological systems and endanger life or health. Though 93 million miles apart, various emissions from the Sun affect Earth.

# Space Weather Importance Recognized by the Federal Government

**Space Weather Importance Recognized by the Federal Government**

NATIONAL SPACE WEATHER STRATEGY AND ACTION PLAN

One Hundred Sixteenth Congress of the United States of America AT THE SECOND SESSION

PLANNING THE FUTURE SPACE WEATHER OPERATIONS AND RESEARCH INFRASTRUCTURE

Space Weather Advisory Group (SWAG) Meeting at the Department of Commerce

Executive Order on Coordinating National Resilience to Electromagnetic Pulses

The government cares about space weather; it understand the implications it can have.

**Space Weather Impacts are wide ranging**  
Infrastructure and Activities Vital to National Security and the Economy

Satellite Malfunctions; SATCOM Interference/Disruption; Satellite Drag; Pipeline Corrosion  
Radiation Exposure; Power Outages; HF Comm Dropouts; GNSS Degradations

Space weather-induced electricity blackout: Daily domestic economic loss in the U.S. = \$41.5 billion plus an additional \$7 billion loss through the international supply chain.  
"Quantifying the daily economic impact of extreme space weather due to failure in electricity transmission infrastructure," Centre for Risk Studies, University of Cambridge, Jan 2017

Regardless of political affiliation Space Weather continues to be something that is invested in and planned for to prepare ourselves for the event of a catastrophic event of major breakdown of the power grid.

- Space weather impacts are wide ranging with infrastructure and activities vital to National Security and the economy
- Satellite malfunction, SATCOM interference/disruption, satellite drag, pipeline corrosion, radiation exposure, power outages, HF radio dropouts, SCSS degradations
- Cost of space weather-induced electricity blackout: Daily domestic economic loss in U.S.= \$41.5 billion + \$7 billion loss of the international supply chain

**SWPC Forecast Operations (SWFO)**

Operations, systems & data monitoring, forecasting, watches/warnings & Alerts, IDSS, etc.

Staffed 24 hours 7 days a week – just like any NWS forecast office

Core partnerships with USAF, NASA, FEMA, NERC

Minor geomagnetic storm watch in effect: 31 January and 1 February, 2019  
Most likely area of Aurora Extent: to the vicinity of the green line (Kp=5)

- Operations, systems & data monitoring, forecasting, watches/warnings & alerts, IDSS
- Staffed 24 hours 7 days week- just like any National Weather Service forecast office; a vast room where scientists constantly scan the monitors and observe the Sun
- Core partnerships with USAF, NASA, FEMA, NERC (National Electrical Reliability Corporation) this is our electric grid - electric coordinators across the country
- Image sample of G1 Minor storm watch in effect: 31 January and 1 February, 2019

**Sunspots & Solar Cycle**

Previous Solar Cycle 24

Current Solar Cycle 25 In/around maximum

On average, every 11 years the Sun goes from quiet to active and back to more quiet. This is called the "Solar Cycle".

Experimental solar cycle 25 Prediction

International Sunspot Number  
Predicted Max: 127 - 146  
Avg: 100 - Jan 2025

10.7cm Radio Flux  
Predicted Max: 195 - 216  
Jan - Dec 2024

Experimental Solar Cycle 25 Prediction

Monthly observations  
Space Weather Prediction Model  
2019 NOAA/NWS/CIRES Panel Prediction changes

Essential Predictions  
25% quartile  
50% quartile  
75% quartile

## Sunspots & Solar Cycle

- On average, every 11 years the Sun goes from quiet to active and back to more quiet; this is called the "Solar Cycle"
- Last solar minimum peak 2019, not exactly sure when the maximum is reached until later in cycle when it has clearly started to decline in activity
- Previous Solar Cycle 24 2010-2020 – Current Solar Cycle 25 2021 – presently we are in/around maximum, but still to be determined; we have a few years yet to go we are in the solar maximum still for 2025 and into 2026
- 2025-2026 an important year because U.S. is returning to the Moon and we will be responsible for ensuring the safety of the astronauts
- The next solar minimum marks the start of the new solar cycle

**Focus areas**  
(3 primary activity types SWPC forecasts)

**Impacts & Phenomena Based Forecasts**

- Solar Radiation Storms (S-scale):** related to **Solar Proton Events**  
Solar Radiation Storm Warnings and Alerts
- HF Radio Blackouts (R-scale):** as related to **Solar Flares**  
Solar Flare Alerts
- Geomagnetic Storms (G-scale):** as related to origin source  
**Coronal Mass Ejection (CME), Coronal Hole (CH)**  
Geomagnetic Storm Watches, Warnings, and Alerts

Scale: Minor (S1, R1, G1), Moderate (S2, R2, G2), Strong (S3, R3, G3), Severe (S4, R4, G4), Extreme (S5, R5, G5)

- Location of a flare on the Earth-facing disk does not matter, as long as seen on sensor, we know it's on way to Earth, effect on Earth's sunlit side ionosphere is immediate
- Great, sudden bursts of electromagnetic energy that can immediately impact the sunlit side of Earth from minutes to hours. More intense flares can ionize the lower ionosphere (D-layer) and cause HF Radio Blackouts HF (3-30 MHz)

**SOLAR FLARE RADIO BLACKOUTS**

In regards to the M5 flares on Saturday, **May 20th**

From 1400-2000z, 18 messages timed out (7 ATC Clearance messages 11 ATC Requests and advisories)

Use of SatVoice communications was not widespread during the event and only used a handful of times. Prior to 15z, flights were being assigned higher than normal HF frequencies. After the earlier solar flare in the morning, which had no effect on ops, our NYC Radio Operators kept with the frequencies they were on. At 11am (15z), the second solar event occurred and had a major impact. The impact was mainly on the Caribbean HF groups.

On the whole, the ATC message timeouts were for assignment of transponder codes, a couple of requests air-to-air VHF relay and requests for overflight position reports, speed assignments, deviations around weather and a re-route for an aircraft.

Excerpt from the NYC Daily LOG:

1845	SOLAR ACTIVITY	We had an X-RAY event that exceeded a M5. Total of a M5-E between 144E & 154E. It did have a major impact on the operation. Operators were utilizing the highest freqs available on their respective HF groups. ATC clearances and other messages delivery times exceeded our FAA codtime metrics.
------	----------------	--

Impacts to HF for airline and ATC operations are real and can be impactful

### Focus Areas

Three primary activity types SWPC forecasts (impacts & phenomena based forecasts):

- Solar Radiation Storms (S-Scale): related to Solar Proton Events; Solar Radiation Storm Warnings and Alerts are issued
- HF Radio Blackouts (R-Scale): as related to Solar Flare Solar Flare Alerts are issued
- Geomagnetic Storms (G-Scale): as related to origin source Coronal Mass Ejection (CME), Coronal Hole (CH): Geomagnetic Storm Watches, Warnings, and Alerts are issued

Similar to the hurricane status, based on similar scale Scale of Minor, (1) Moderate (2), Strong (3), Severe (4), Extreme (5)

### Solar Flare Radio Blackouts

- M5 flares on Saturday, May 20th had major impacts on Air Traffic Control
- Especially important to the aviation sector for trans-oceanic flights across the Pacific – they use HF radio, to communicate with (ATC), very impactful throughout the industry; they have to have it operating
- Cannot predict when solar flare is imminent or give warning for them, can only predict the probability that they may happen and how strong they may get to
- Most are quite impulsive, just minutes to 10s of minutes, but sometimes a few hours

**Solar Flares**

**R3 Dec 31st: X5 flare from the east limb of the Sun - largest flare of SC25 to that point**

Location of a flare on the Earth-facing disk does not matter. The affect on Earth's sunlit side ionosphere is immediate.

Their strength is measure in X-ray energy from a space weather package on the GOES satellites and the strength relates to geographic area of impact to our ionosphere.

Great, sudden bursts of electromagnetic energy that can immediately impact the sunlit side of Earth from minutes to hours. More intense flares can ionize the lower ionosphere (D-layer) and cause **HF Radio Blackouts** HF (3-30 MHz)

Solar Flares – Giant blasts of energy across most of the electromagnetic spectrum

R3 Dec 31st 2023: X5 flare from the east limb of the Sun – largest flare of SC25 to that point

- Their strength is measured in X-ray energy from a space weather package on the GOES satellites and the strength relates to geographic area of impact to our ionosphere

**When Significant Space Weather and Catastrophic Terrestrial Weather come together – Sep 2017**

Solar Flares Disrupted Radio During 2017 Hurricane Irma

On 9 September 2017, an Category 5 Hurricane Irma hit the Caribbean's Lesser Antilles, and Tropical Storm Jose followed in the energy, another storm reported on the day.

Radio Blackout

Highest Frequency Affected by 1dB Absorption

0 5 10 15 20 25 30 35

Degraded Frequency (MHz)

Moderate X-ray flux Moderate Proton Flux NOAA/SWPC Boulder, CO

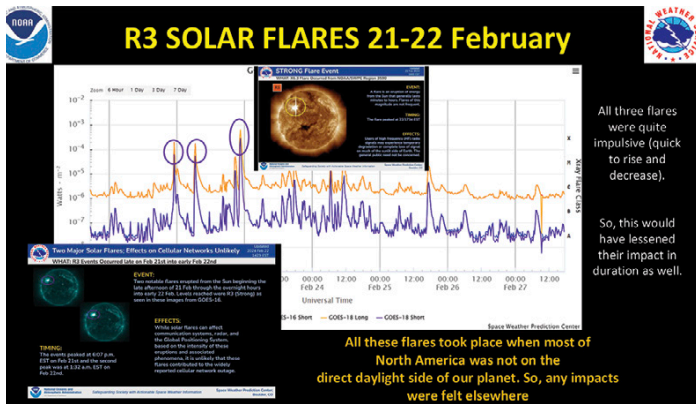
HF Radio Comm from the Caribbean Islands (Ham Radio in particular) was nearly impossible during the hurricane disasters & crisis response for several hours. Hurricane Watch Net & Aviation Communication notably impacted.

### When Significant Space Weather and Catastrophic Terrestrial Weather come together

- Sept 2017 – Solar flares disrupted radio during the 2017 Hurricane Irma
- HF Radio communication from the Caribbean Islands (Ham Radio in particular) was nearly impossible during

the hurricane disasters & crisis response for several hours; Hurricane Watch Net & Aviation Communication notably impacted

Top right (of last image on previous page) shows map of D-region Absorption product, showing location where a flare has had its impact, and HF radio will be difficult or impossible

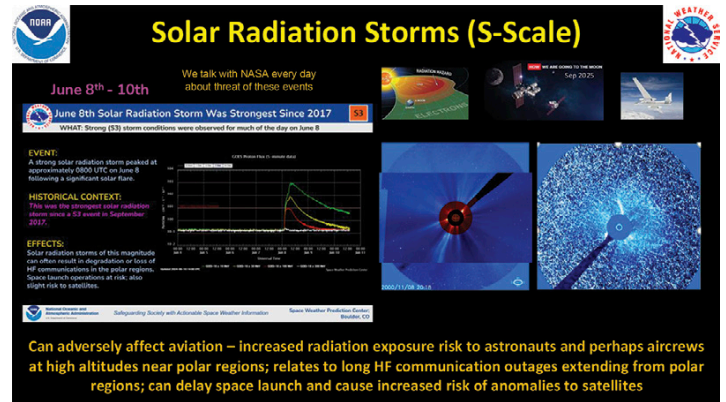


December 14, 2023 - Strongest flare of this solar cycle, this effected other frequencies than HF. It let loose over 10,000x the normal background level of the Sun, this one was dramatically impactful, with multiple aviation communication disruptions associated with this event. Can make radio communications difficult or unclear on frequencies other than HF bands. Additional (ATC) bands impacted dramatically on higher communication bands over U.S.

- Amazing event- likely one of the largest solar radio events ever recorded
- Radio communication impacts between approx. 1200-1400 EST Thu
- CWSUs report degraded communications across nation – never seen anything like this before; cyberattack?! system malfunctions?! If this went on a few minutes longer would likely have led to shutdown of airspace
- Possible Earth-directed Coronal Mass Ejection (CME) being analyzed
- May 9th, 2024 another even stronger radio burst, but mainly effected Europe

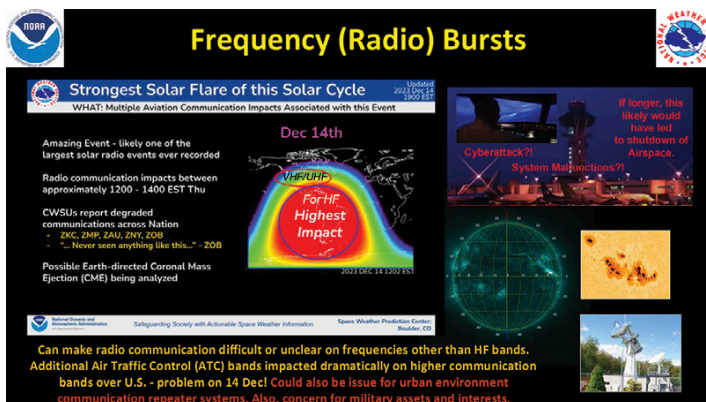
### R3 Solar Flares 21-22 February – Flares not responsible for all widespread outages

- R3 events occurred late on Feb 21st into early Feb 22nd effects on outage of Cellular Networks reported; while solar flares can affect communication systems, based on analysis of intensity and associated phenomena of these eruptions it was determined unlikely that these flares contributed to the widely reported outages
- All three flares were quite impulsive (quick to rise and decrease) so this would have lessened their impact in duration as well
- All these flares took place when most of North America was not on the direct daylight side of our planet; so, any impacts were felt elsewhere
- Within 24 hours shown not to be the cause; it was a software upgrade issue

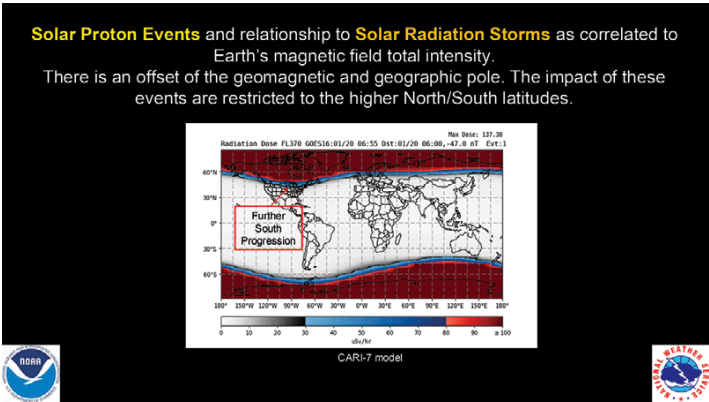


### Solar Radiation Storms (S-Scale)

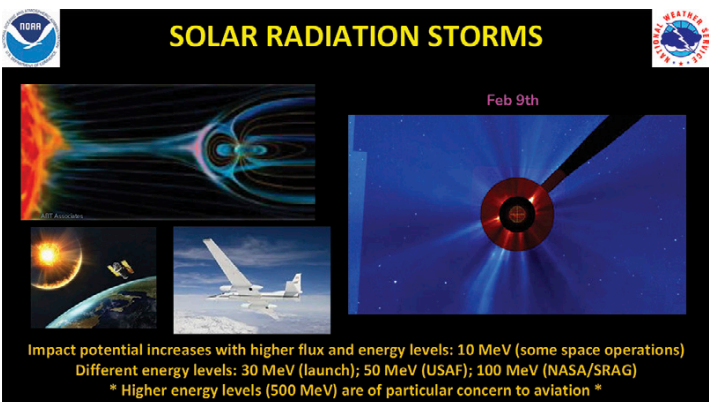
- June 8th-10th Strongest Solar Radiation Storm since S3 event in 2017
- If aligned favorably, can get here in strong events in 15 minutes
- SWPC talks to NASA everyday – increased radiation exposure risk to astronauts and perhaps aircrews at high altitudes near polar regions; solar radiation storms of this magnitude can result in degradation or loss of HF communications in the polar regions; space launch operations at risk; also increase risk of anomalies to satellites



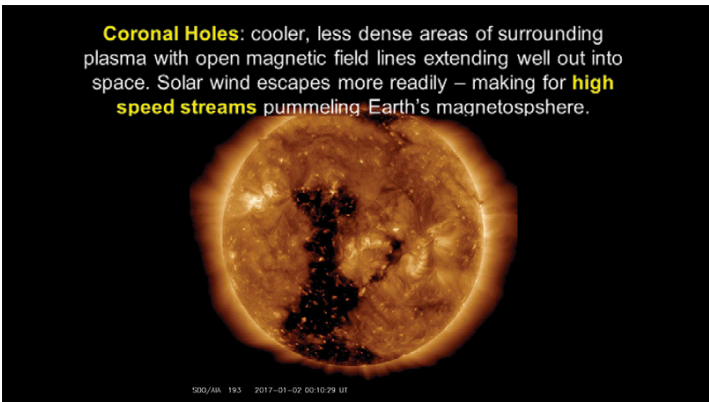
### Frequency (Radio) Bursts – A Blast of Radio Energy



**Solar Proton Events and relationship to Solar Radiation Storms** as correlated to Earth's magnetic field total intensity. There is a little dip, due to an offset of the geomagnetic and geographic pole, that means the effect of these events can be farther south over North America than elsewhere. The impact of these events are restricted to the higher North/South Latitudes

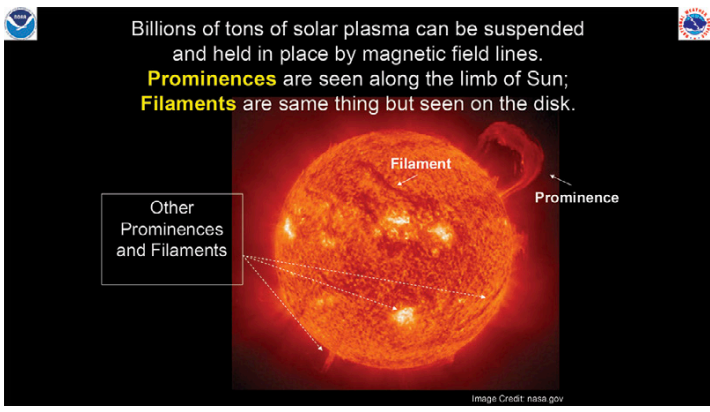


**Solar Radiation Storms** – measured in different energy levels. Impact potential increases with higher flux and energy levels: 10MeV (some space operations) Different energy levels: 30 MeV (launch); 50 MeV (USAF); 100 MeV (NASA/SRAG)  
 \*Higher energy levels (500 MeV) are of particular concern to aviation\*

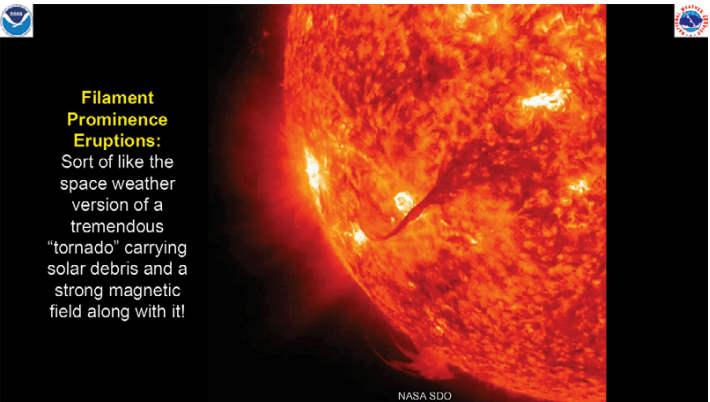


**Coronal Holes:** Cooler, less dense areas of surrounding plasma with open magnetic field lines extending well out into space. Solar wind escapes more readily – making for high

- speed streams pummeling Earth's magnetosphere.
- Starting to see some larger coronal holes now, not unusual during solar maximum
  - Animation is dramatic coronal hole, as we might see as we come down off maximum
  - These are much more predictable, and can allow some 27 days lead time as to when a good time to plan a trip ahead to see aurora in Iceland for example



**Prominences and Filaments**  
 Billions of tons of solar plasma can be suspended and held in place by magnetic field lines. Prominences are seen along the limb of the Sun: filaments are the same thing but seen on the disk.



**Filament Prominence Eruptions:** A filament turns into a prominence and blasts off the Sun; sort of like the space weather version of a tremendous "tornado" carrying solar debris and a strong magnetic field along with it!

**Coronal Mass Ejections (CME)**

Fastest Earth-directed CMEs can get here in 15 hours. Usually, they are slower and take 2 to 4 days.

Tremendous expulsions of solar and embedded magnetic fields. Their impact to our magnetosphere can cause major changes resulting in **Geomagnetic Storms**.

We analyze and parametrize any CME for model submission in order to determine possibility of any Earth directed component.

- field connects with Earth's
- Protection of the Power Grid (U.S. Map) – All these RCs are on NERC hotline call when we initiate the NERC hotline
- Can produce problematic induced currents on power grid and lead to upper atmospheric conditions that can cause variety of communication (SATCOM included) & navigation accuracy problems

**Real-Time Solar Wind**

1 Million Miles from Earth - L1

IMF Mag field strength in nT

Mag orientation (-) or (+)

Speed in km/s

Earth's field is pointed NORTH, so need SOUTH IMF for good connection.

**Real-Time Solar Wind**  
 ACE and DSCOVR – Satellites on board that measure the solar wind environment

Important measures are Magnetic Field and Speed  
 When magnetic field changes, it make a difference. Like try to put two magnets together, if 2 north ends, they repel, 1 north + 1 south they attract – if orientation changes they connect

- White line on top – interplanetary magnetic field strength
- Red line in top graph- orientation is it North or South?
- Bottom graph shows differences in orientation and strength of storms. As orientation changed went from G3-G5 and back

**Real-Time Solar Wind – Aug 8-14<sup>th</sup> w/ CME**

Notice how the orientation shifts between N/S, by comparison, this CME mag strength was 4x above background as compared to early May - which was 12x above background

By comparison, this CME was 1/2 the speed of the early May CME

Kp 4 - Kp5 (G1) w/ N-directed IMF; but Kp6-Kp8 (G2-G3) when IMF shifted S-directed. Rapidly decreased when IMF rotated Nward again.

- Real-Time Solar Wind – Aug 8-14<sup>th</sup> w/ CME**
- Notice how the orientation shifts between N/S, by comparison, the CME mag strength was 4x above background compared to May – which was 12x above background
  - Speed – by comparison, this CME was 1/2 the speed of

**Coronal Mass Ejection (CME)**

- Tremendous expulsions of solar and embedded magnetic fields. Their impact to our magnetosphere can cause major changes resulting in geomagnetic storms
- We analyze and parametrize any CME for model submission in order to determine possibility of any Earth directed component
- Fastest Earth-directed CMEs can get here in 15 hours; usually they are slower and take 2-4 days
- Only have 1 instrument in space we measure these with a million miles from Earth, the NASA SOHO Research Satellite with a chronograph on board
- New instrument - compact chronograph- that's on the GOES 19 Satellite – soon first public release of image or animation, will map and analyze closely to see if we are going to have a magnetic storm here on Earth = arrival of CME

**Geomagnetic Storms**

When a CME strikes and envelopes Earth's magnetic field, storms may begin. In particular, if the CME mag field connects with Earth's.

G3 and greater

Protection of the Power Grid

All these RC's are on NERC hotline call when we initiate the NERC hotline.

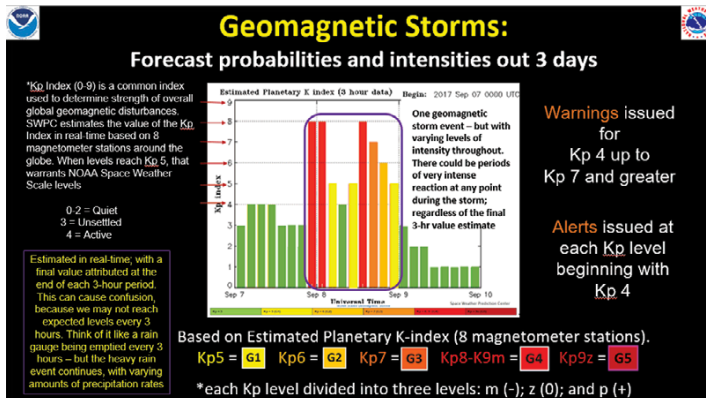
Can produce problematic induced currents on power grid and can lead to upper atmospheric conditions that can cause variety of communication (SATCOM included) & navigation accuracy problems

**Geomagnetic Storms**

- This is what happened in May, 2024, we got slammed by a train of CMEs; hit G4 very quickly; then G5 with G4-to G5 for 24hr, 36hr with G3 added in,; a wide global event
- Red line extending from Earth in image is Earth's magnetic barrier, our magnetosphere, comes out bottom and goes in top, orientated northward
- When a CME strikes and envelopes Earth's magnetic field, storms may begin, in particular, if the CME mag

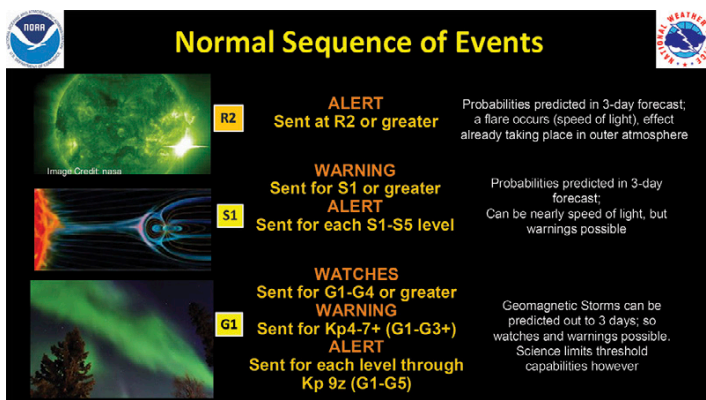
the early May CME

- Bottom: G1 with N-directed IMP but G2-G4 when IMF shifted S-directed, then rapidly decreased when IMF rotated N-ward again
- This is why we struggle with forecasts, depends on orientation with can change quickly
- We can put out a watch, but is just our best scientific guess; we have no idea what structure of CME is until its 1 million miles from Earth and we finally see it!



**Geomagnetic Storms: Forecast probabilities and intensities out 3 days**

- Estimated in real-time, with a final value attributed at the end of each 3-hour period
- This can cause confusion; we may not reach expected levels every 3 hours
- One geomagnetic storm event – but with varying levels of intensity throughout
- There could be periods of very intense reaction at any point during the storm; regardless of the final 3-hr values estimate

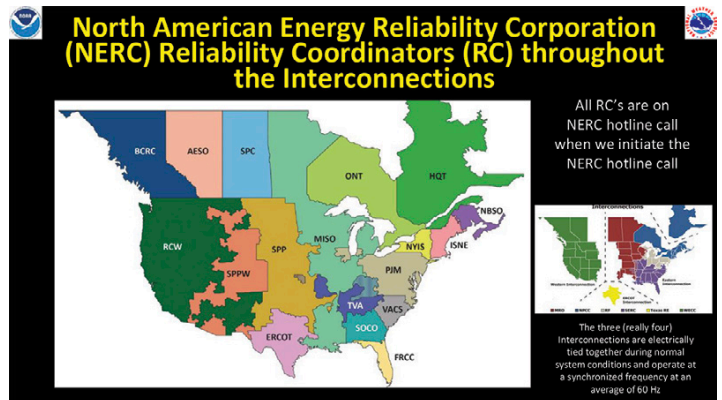


**Normal Sequence of Events**

- R2 – Detect massive flare on the Sun – we see it, put out alert- probabilities predicted in 3-day forecast; a flare occurs at speed of light, effect already taking place in outer atmosphere
- S1 – Talk about will there be a radiation storm – probabilities predicted in 3-day forecast; can be nearly speed of

light, but warnings possible

- G1 – Geomagnetic Storms can be predicted out to 3 days so watches and warnings possible; science limits threshold capabilities however



**North American Energy Reliability Corporation (NERC)**

- Map of divisions of the reliability community that gets the phone calls when we talk about G3 level activity, each has reliability coordinator
- Interconnected system, so one area of the country could be experiencing problems, this can stress out other areas if they are pulling power, using extra transformers
- The three (really four) interconnections are electrically tied together during normal system conditions and operate at a synchronized frequency at an average of 60 Hz



**Typical Actions related to just the Power Grid regarding Geomagnetic Storms**

- G1 Phone call to Wisconsin Elec. Control and the New York ISO
- G2 Phone call to Wisconsin Elec. Control and the New York ISO
- G3 NERC Hotline Call and Wisconsin Elec. Control Area
- G4 NERC Hotline Call; Wisconsin Elec. Control; FEMA notified; possibly National Security Council/ White House Situation Room
- G5 NERC Hotline Call; FEMA; Wisconsin Elec. Control; NSC/WHSR notified/informed



- High level of communications at this point, all on alert during storm in May

**Typical SWPC Actions for Space Weather Storms**

**USAF:** continual – for consistency in DoD concerns

**Space Launch:** ad hoc – concern for impacts to launch success

**NASA SRAG:** R2/S1/G2 – concern for Astronaut safety

**Transmission Operation Centers:** G1+ situational awareness and possible preparatory actions/procedures

**Air Traffic Control:** R2/S1/G3 – for aviation safety

**North American Power Grid:** G3 levels and above – for electrical reliability actions, procedures, planning, etc.

**FEMA/State Emergency Watch Centers:** S4/S5 & G4/S5 levels for situational awareness and potential preparations

**NSC/WHSR:** S5 & G5 levels – for situational awareness and any required actions

**Communicating Space Weather Information**

**Space Weather Event Risk & Notification - Emergency Response**

**SWPC Mission Goals**

**SWPC Products**

**SWPC Services**

### Typical SWPC Actions for Space Weather Storms

- USAF: continual – for consistency in DoD concerns
- Space Launch: ad hoc – concern for impact to launches
- NASA: Concern for astronaut safety
- Transmission Operations Center – for preparatory actions/procedures
- Air Traffic Control – for aviation safety
- North American Power Grid – reliability actions, procedures, planning, etc.
- FEMA/State Emergency Watch Centers – awareness and potential preparedness
- NSC/WHSR – for situational awareness and any required action
- This list continues to grow, all this was in effect during the May, 2024 event

**Notable Space Weather Events**

**Carrington Event, 1-2 September 1859:** Aurora may have been seen from Hawaii. Most significant event on record. Telegraph system world-wide impacted. Aurora visible in Central America.

**Hydro-Quebec Storm, 14 March 1989:** Power blackout in Montreal and entire province of Quebec. Severely damaged New Jersey transformers. Numerous U.S. grid anomalies.

**Operation Anaconda, Afghanistan, 4 March 2002:** Three U.S. soldiers killed – space weather disrupted satellite communications.

**Halloween Storms, October 2003:** Power grid outage in Malmo, Sweden; damage to South Africa grid; Japan loses satellite.

**Near Miss, 23 July 2012:** “Century class” event, but the eruption site was 90 deg ahead of Earth.

**SpaceX Starlink Loss, 3 February 2022:** Loss of 38 of 49 satellites due to a minor geomagnetic storm.

### Notable Space Weather Events

- Carrington Event, 1-2 September 1859 was most significant event on record. Telegraph system world-wide impacted; Aurora may have been seen from Hawaii
- Hydro-Quebec Storm, 14 March 1989: Power blackout in Montreal and entire province of Quebec; severely damaged New Jersey transformers, numerous U.S. grid anomalies
- Operation Anaconda, Afghanistan, 4 March 2002: Three U.S. soldiers killed – space weather disrupted satel-

lite communications

- Halloween Storms, October, 2003: Last time we reached G5, this led to actions now taken. Power grid outage in Malmo, Sweden; damage to South Africa grid; Japan loses satellite
- Near Miss, 23 July 2012: This was a “Century class” Carrington event, we got lucky the eruption site was 90° ahead of Earth!
- SpaceX Starlink Loss, 3 February 2022: Loss of 38 of 49 satellites due to a minor geomagnetic storm – low level event but satellites in too low of an orbit

**... and even more recently**

**Massive CME ripped from the Sun late on 12 March, 2023**  
Analysis from NASA Moon to Mars Space Weather Office measured the CME at 2,127 km/s (a rare event)

**CME was fortunately from the far-side of the Sun**  
Headed completely away from Earth; but still we were impacted by an S1 Event (Minor Solar Radiation Storm) – quite extraordinary for these energetic particles (protons) to reach Earth from this event  
- S1 Warning/Alert for 2 days  
- Moderate Polar Cap Absorption Advisory issued for Aviation

**Potentially, an Extreme event if aimed at Earth**  
Carrington CME event reached Earth in about 18 hours  
This could have reached Earth in a little over 24 hours  
- What would have happened here at Earth is unknown, but that is why planning is important

### ...and even more recently

- Massive CME on 12 March, 2023 analysis from NASA measured the CME at 2,127 km/s (a rare event)
- Fortunately the CME was from far side of Sun – headed completely away from Earth but still impacted by an S1 Event (minor solar radiation storm) – quite extraordinary for these energetic particles (protons) to reach Earth from this event
- Potentially, an extreme event if aimed at Earth, what would have happened here on Earth is unknown, that is why planning is important

**The “Carrington Event” of 1859**

Richard Carrington (1826-1875) meticulous solar observer:  
Discovered the Sun’s differential rotation

**\*Observed the great flare of 1859**  
A flare so bright, he saw it in white light (1 Sep)  
Great geomagnetic storm began only 18hrs later  
aurora seen over the Caribbean Sea  
telegraph systems failed; others threw sparks;  
some still worked with the power disconnected

### The “Carrington Event” of 1859

- Richard Carrington (1826-1875) meticulous solar observer: Discovered the Sun’s differential rotation.
- He happened to be doing a sunspot observation; observed the great flare of 1859 – a flare so bright, he saw it in white light (1 Sept) (Sketch of Carrington’s observa-

tion)

- Great geomagnetic storm began only 18 hrs later aurora seen over the Caribbean Sea; telegraphs systems failed; others threw sparks; some still worked with the power disconnected; batteries starting on fire

**What would a Carrington Level Event mean Today?**

**CME:** CME arrives at Earth; Immediate geomagnetic storm levels may begin (G1-G4/G5) to extreme conditions.

**CME:** Alerts issued with each G1-G5 level reached; repeats every 3 hours (00-03 UTC through 21-00 UTC); IDSS and collaboration, briefings, interviews, reports continue to all partners and required government levels.

**CME:** Emergency alert system (NAWAS/WAWAS) notifications taking place for G5 levels. Broadcast Media and the press will be making massive inquiries, especially if there are power grid disruptions.

**CME:** Induced current on the power grid reaches unmanageable levels and bulk transmission power failures occur (affecting up to millions of customers)

Map from the report showing likely induced voltages on the National Electric Power Grid for this level of storm.

**CME Arrival +15-36hrs:** Conditions improve and CME passage weakens. All clear notifications probably required. Recovery begins.

Map shows likely induced voltages on the National Electric Power Grid for this level of storm

**What would a Carrington Level Event mean Today?**

**CME +4hrs:** Massive and Fast CME detected headed directly towards Earth

**CME +8hrs:** Analysis likely reveal an arrival  $\leq$  24 hours

**CME +10hrs:** Collaboration with other space weather centers for consensus of arrival date/timing

**CME +10hrs:** G3/G4 Watch issued

**CME +10-12hrs:** IDSS & Messaging accomplished

**CME +12hrs:** Briefings, Interviews, etc. and additional personnel in place

**CME +15-24hrs:** CME arrives at L1 (1M miles from Earth); Warnings Issued & IDSS contacts made

### What would a Carrington Level Event mean Today?

- 15-18 arrival time from the time we notice the associated event on the Sun
- Have to make quick decisions; first wait for enough imagery to analysis situation
- Need to collaborate with international partners, embedded with others on this
- Run model runs one at one time, and decide which we will go with, have no ensemble capability at this time, but will in the future
- Get G4 or greater watch out now, but need the imagery
- Bottom line, may not be much warning time, but hopefully we do
- What does this mean for its arrival at Earth? – catastrophic for the power grid if we are not prepared and ready– these storms induce current on high voltage power lines that doesn't belong there, called geomagnetically induced current; induced current on the power grid can reach unmanageable levels pull down the grid

**Aurora is what the public wants...**

Sometimes a bit more color variation is visible

Can be just a glimpse of green along the northern horizon

Bigger storms, move further up the sky and can be quite spectacular – think G4-G5 for Washington state

**What's it take to see the aurora in Colorado; generally a G3 (high end) - but you never know!**

### Aurora is what the public wants...

What it takes to see the aurora in Colorado; generally a G3 (high end) – but you never know!

- Can be just a glimpse of green along the northern horizon; sometimes a bit more color variation is visible; bigger storms, move further up the sky and can be quite spectacular
- We are learning the model we have is not holding water anymore, people are using their phones to see more and see farther south that we thought they could; this is where these observations are helping with research and making adjustments

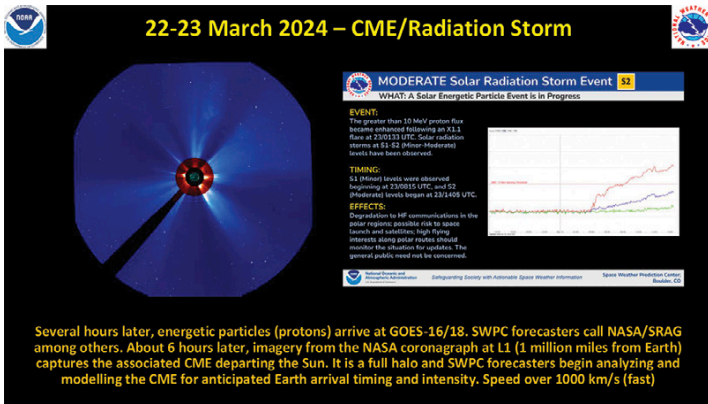
**While this is not a given, general expectations for geomagnetic storm intensity and possible equatorward extent of the aurora can roughly relate to Kp index**

**22 March 2024 – Sunspots/Flares**

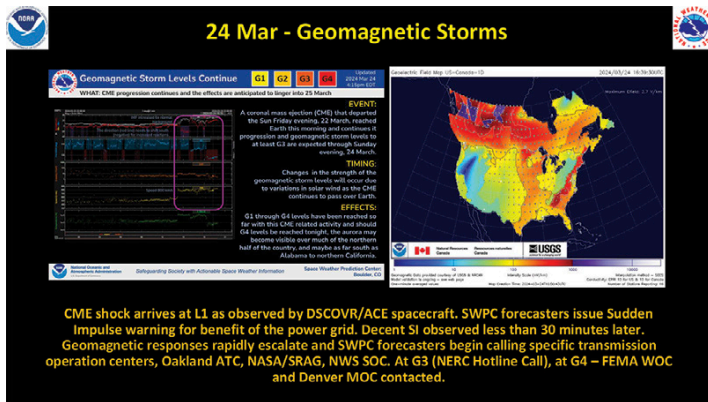
Massive and magnetically complex active region sunspot group to the south and a much smaller and moderately complex active region sunspot group to the north. The northern spot group erupted with an X1 (R3) long duration flare (few hours). The southern group also flared shortly afterwards. SWPC forecasters made calls to NASA and Oakland ATC when flare activity reached M5 (R2).

### March 22 2024 – Sunspots/Flares

Massive and magnetically complex active region sunspot group to the south and a much smaller and moderately complex active region sunspot group to the north.

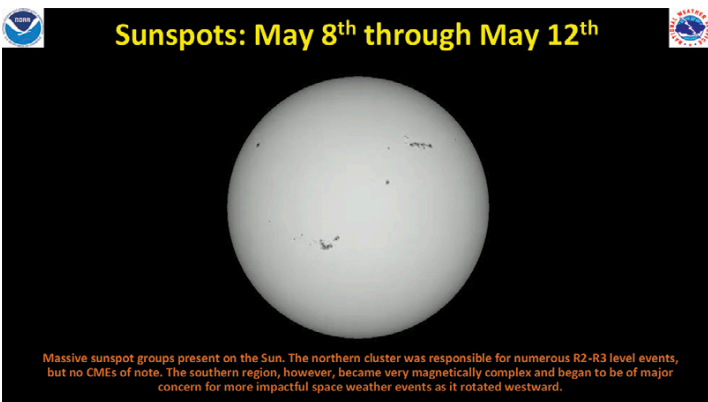


- The northern spot group erupted with a X1 (R3) long duration flare (few hours)
- The southern group also flared shortly afterwards
- SWPC forecasters call NASA and Oakland ATC when flare activity reached M5 (R2)



### March 24 – Geomagnetic Storms

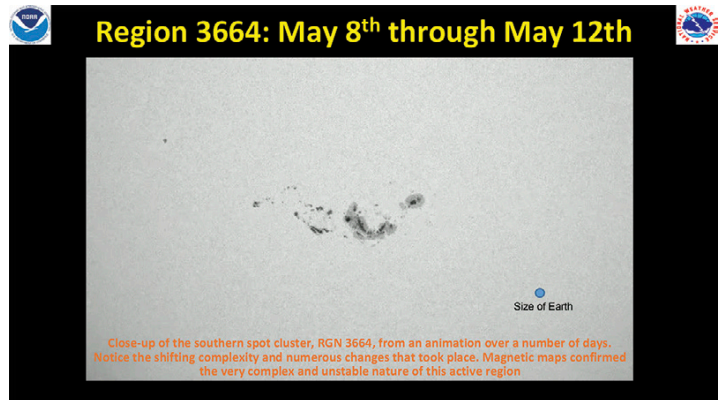
CME shock arrives at L1 as observed by DSCOVR/ACE spacecraft. SWPC forecasters issue Sudden Impulse warning for benefit of the power grid. Geomagnetic responses rapidly escalate and SWPC forecasters begin calling specific transmission operation centers. Soon rose quickly to G4 for a few hours, then things kind of turned off. So it was quick hit, fast event and that magnetic field made all the difference in the world!



### Sunspots: May 8th through May 12th

Massive sunspot groups present on the Sun. The northern cluster was responsible for numerous R2-R3 level flare

events but no CME's of note. The southern region, however, became very magnetically complex and began to be of major concern for more impactful space weather events as its rotated westward.



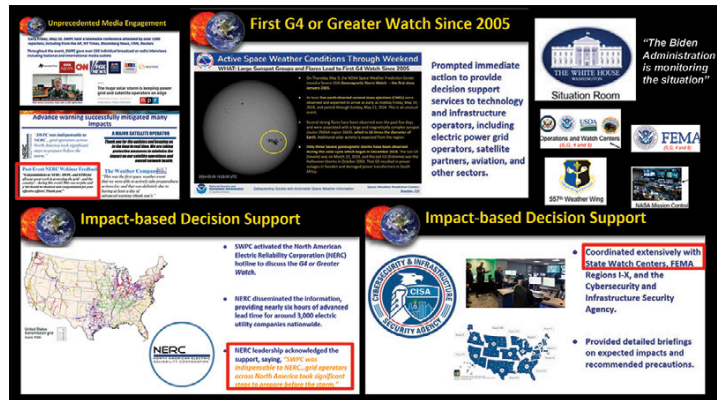
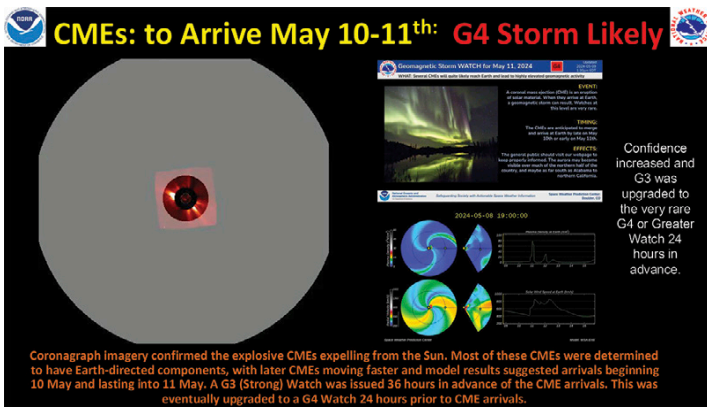
### Region 3664: May 8th through May 12th

Close-up of the southern spot cluster, RGN 3664, from an animation over a number of days, see comparative size to the Earth on far right. Notice the shifting complexity and numerous changes that took place. Magnetic maps confirmed the very complex and unstable nature of this active region.



### CMEs: to Arrive May 10-11th G4 Storm Likely

Coronagraph imagery confirmed the explosive CMEs expelling from the Sun. Most of these CMEs were determined to have Earth-directed components, with later CMEs moving faster and model results suggested arrivals beginning 10 May and lasting into 11 May. We now knew we were going to have a more serious situation on our hands of long duration. A G3 (Strong) Watch was issued 36 hours in advance of the CME arrivals. This was later upgraded to a G4 Watch 24 hours prior to CME arrivals, the first G4 Watch issued since 2005.



## First G4 or Greater Watch Since 2005

### Unprecedented media engagement

- Active Space Weather conditions through weekend: Large sunspot groups and flares lead to first G4 watch since 2005
- Prompted immediate action to provide decision support services to technology and infrastructure operators, including electric power grid operators, satellite partners, aviation, and other sectors
- Throughout the event, SWPC gave over 150 individual broadcast or radio interviews including national and international media outlets
- Advanced warning successfully mitigated many impacts

### Impact-based Decision Support

- SWPC activated the (NERC) hotline to discuss the G4 or Greater Watch
- NERC disseminated the information, providing nearly six hours of advanced lead time for around 3,000 electric utility companies nationwide
- NERC leadership acknowledged the support, saying “SWPC was indispensable to NERC; grid operators across North America took significant steps to prepare before the storm”
- Coordinated extensively with State Watch Centers, FEMA Regions 1-X, 557th Weather Wing, NASA Mission Controls, and the Cybersecurity and Infrastructure Security Agency
- From the Situation Room “The Biden Administration is monitoring the situation”
- Provided detailed briefings on expected impacts and recommended precautions
- What was accomplished by SWPCs advance alert and broadcasts made this extreme solar storm the most successfully mitigated in history

## G5 Geomagnetic Storm: 10-12 May 2024

Management successfully mitigating many impacts of the May 2024 Storm but not completely:

### Energy Sector:

- US and Canada grid operators took numerous actions to mitigate impacts
- High Voltage line tripped in northern Europe
- UK transformers overheated/alarmed
- New Zealand disconnected northern islands power
- Satellite Operations:
  - ~5000 Satellites experienced increased drag, necessitating more frequent station-keeping burns and collision avoidance maneuvers
  - Degraded Starlink and Iridium service
  - Global communications satellite lost sync lock
  - Some operations ceased due to increased radiation risk
  - Aviation
- Trans-oceanic flights rerouted due to High Frequency radio loss
- WAAS used for precision landing and performance based navigation unavailable for ~15hrs
- GPS Systems
  - Loss of lock on GPS signals
  - Range errors – supposed to be within few centimeters – off by 12 ft
  - Both civilian and defense
  - Idled Midwest planting – GPS dependent could not work fields
- Atomic Clock
- Surprising 0.1% variation in NIST Cesium clocks

## G5 Geomagnetic Storm: 10-12 May 2024

### Energy Sector

- US and Canada grid operators took numerous actions to mitigate impacts
- High voltage lines tripped in northern Europe
- UK transformers overheated/alarm
- New Zealand disconnected northern islands power

### Satellite Operations

- ~5000 Satellites experienced increased drag, necessitating more frequent station-keeping burns and collision avoidance maneuvers
- Degraded Starlink and Iridium service
- Global communications satellite lost sync lock
- Some operations ceased due to increased radiation risk

### Aviation

- Trans-oceanic flights rerouted due to High Frequency radio loss
- WAAS used for precision landing and performance based navigation unavailable for ~15 hrs
- NOTAM advising of comms/nav disruptions

### GPS Systems

- Loss of lock on GPS signals
- Range errors
- Both civilian and defense
- Idled Midwest planting

### Atomic Clock

- Surprising 0.1% variation in NIST Cesium clocks




Image: Ken Trombatore

### NAWAS?




Image: John Deere

### Eric's Herk Times

Solar Storm Causes GPS System Used by Some Farmers, Shaking Planting

## Spectacular won over Consequential

### The Popular Story

Aurora seen around the world...



### Authoritative Voice for Space Weather



- This event underscored the interconnectedness and vulnerability of modern infrastructure to space weather.
- SWPC's proactive measures and detailed briefings enabled industries to implement necessary precautions.
- Demonstrated the importance of preparedness and the effectiveness of coordinated responses to space weather threats.

In my opinion this was the most prepared for and successfully mitigated extreme space weather storms in history; thanks to all the government involvement and stress over the past 10 years, education and preparedness among the our technological infrastructure; and all the efforts at the Space Weather Prediction Center to warn, alert, and inform all sectors possible before and throughout the event. If this preparedness and actions were not in place, this storm could have been much more consequential than people realize. More work is to be done though, as this particular storm was about 3-4x less intense than the 1989 storm.

**May 10th-12th: One of the Strongest Solar Storms, but not the worst and not significantly impactful.** Storm in May historical but not the worst..how did the G5 geomagnetic storm compare to other events?

- By one measure of geomagnetic storm strength – called disturbance storm time index- this event was quite similar to historic storms in 1958 and 2003
- It may compete with some of the lowest-latitude aurora sightings on record over the past 500 years, though scientists are still assessing this ranking
- Because of precautions and mitigation being done, impacts were lessened


“In my opinion this was the most prepared for and successfully mitigated extreme space weather storms in history; thanks to all the government involvement and stress over the past 10 year, education and preparedness among the technological infrastructure; and all the efforts at the Space Weather Prediction Center to warn, alert and inform all sectors possible before and throughout the event. If this preparedness and actions were not in place, this storm would have been much more consequential than people realize. More work is to be done though, as this particular storm was about 3-4x less intense than the 1989 storm.”

## May 10<sup>th</sup>-12<sup>th</sup>: One of the Strongest Solar Storms, but not the worst and not significantly impactful

### Historical Comparison of May 2024 Solar Storms

WHAT: How did the G5 Geomagnetic Storm Compare to Other Major Events?

Index	MAY 2024	OCT 2003	MAR 1989	MAY 1921	SEP 1859
Disturbance Storm Index (d <sub>st</sub> )	-412	-363	-589	-807	-1200
A <sub>p</sub> -Index	271	204	246	NA	NA



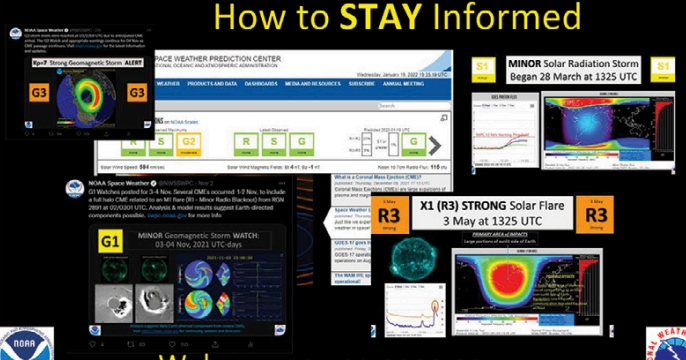
- By one measure of geomagnetic storm strength - called the **disturbance storm time index** - this event was quite similar to historic storms in 1958 and 2003.
- It may compete with some of the lowest-latitude aurora sightings on record over the past 500 years, though scientists are still assessing this ranking.

Disturbance Storm Index (d<sub>st</sub>): An index of magnetic activity derived from a network of near-equatorial geomagnetic observatories that measures the intensity in space of the ring of westward current around Earth (higher negative values generally correlate with stronger storms)

A<sub>p</sub>-Index: The average from eight daily values gives the A<sub>p</sub> index of a certain day (every 2-hour K-value - or measure of geomagnetic activity - is converted into a linear scale). Days with higher geomagnetic activity have a higher daily A<sub>p</sub> value.

Space Weather Prediction Center  
23 May 12:30 p.m. EDT

## How to STAY Informed



Webpage: [swpc.noaa.gov](http://swpc.noaa.gov)

**Spectacular won over Consequential In the May Storm!**

- The Popular Story...and...Authoritative Voice for Space Weather
- This event underscored the interconnectedness and vulnerability of modern infrastructure to space weather
- SWPC's proactive measures and detailed briefings enabled industries to implement necessary precautions
- Demonstrated the importance of preparedness and the effectiveness of coordinated responses to space weather threats.

**How to Get Informed:**

- Visit SWPC web page
  - Able to subscribe to different products:
- Main things to focus on:  
The three day forecast and forecast discussion  
Much more..

**Questions and comments from members:**

How hard is it to get funded? Are you having to fight for funding from the government for all this?  
Is it better to go to Iceland or Alaska to try to see the aurora?

### III. Business Meeting - Treasurer Report by Bruce Lamareuax



## Longmont Astronomical Society

P.O. Box 806  
Longmont, CO 80502-0806

### LAS Treasurer's Report - Bruce Lamoreaux

10/17/2024

#### Main Checking Account (xxx-1587)

Begin Balance:	\$ 8,010.00	9/4/2024
Deposits:	\$ 75.00	Membership
Expenses:	\$ (145.00)	Bank Charges, Web site Renew
<b>Current Balance:</b>	<b>\$ 7,940.00</b>	<b>10/3/2024</b>

#### 2-Year Savings Account (xxx-1478) (matures 10/23/23)

Past Balance:	\$ 8,230.00	6/28/2024
Interest:	\$ 15.00	
<b>Balance:</b>	<b>\$ 8,245.00</b>	<b>9/30/2024</b>

#### Telescope Fund (xxx-0165)

Past Balance:	\$ 1,100.00	8/29/2024
Deposits:	\$ -	
Expenses:	\$ -	
<b>Balance</b>	<b>\$ 1,100.00</b>	<b>9/27/2024</b>

#### Petty Cash

Past Balance:	\$ 50.00	
Deposits:	\$ -	
Expenses:	\$ -	
<b>Balance</b>	<b>\$ 50.00</b>	

**Total Assets** **\$ 17,335.00** \$ (67.53) Down from September

<b>Active Membership:</b>	<b>100</b>
<b>Student Membership:</b>	<b>1</b>
<b>Total</b>	<b>101</b>

## LAS 2025 Calendars Costs – Preliminary Cost Estimate

- Printing & shipping from Shweiki Media \$447.85 (Assuming we are printing 75)
- Price per calendar
  - Printing & shipping \$5.98
  - Envelope \$0.25
  - Donation \$2.00 (helps cover cost if not all calendars sold)
  - Base price each \$8.23
  - Price with transaction fee \$8.76
  - Add postage if having it mailed

If you are interested in submitting an image we need to have them in by midnight Nov.1, will probably have a review meeting on Nov. 2nd for selection of images for calendar, usually that meeting is only open to those who submitted images.

## HELP WANTED!

- Public outreach coordinator – coordinates with various cities, libraries, Boulder Parks, scheduled events though out the year, put out announcements about getting volunteers to attend and also attend star parties
- Webmaster – We need new webmaster, Sarah is moving on to other things

## 2025 OFFICERS & BOARD MEMBERS ELECTIONS

- All positions are open for election each year
- President, vice president, treasurer, secretary
- Board of Directors - usually 5 members on that group

LAS 40th ANNIVERSARY is coming up, so we need to start thinking about how we want to celebrate that. Will probably put a group of couple people to organize it Eileen has already expressed interest in helping out with that event so we need to decide what we want to do, have a banquet or whatever, need a couple people to organize that, find a location and negotiable how much it will cost per person.

## **IV. Upcoming Events**

- Rabbit Mountain November 1, starting 6:30 pm. New Moon Star Party for Boulder County Parks and Recreation at Ron Steward Preserve at Rabbit Mountain. All members are welcome to attend, please sign up on the website as a volunteer if bringing a telescope.
- Next LAS Monthly Meeting – Thursday, November 21st at 7pm, First Evangelical Lutheran Church Longmont, CO 80501



**Aurora at MacIntosh Lake, Long,ont on Oct 10 byAref Nammari**



**Aref Nammari**



**Comet C/2023 A3 Tsuchinshan-ATLAS on Oct 10 by Aref Nammari**





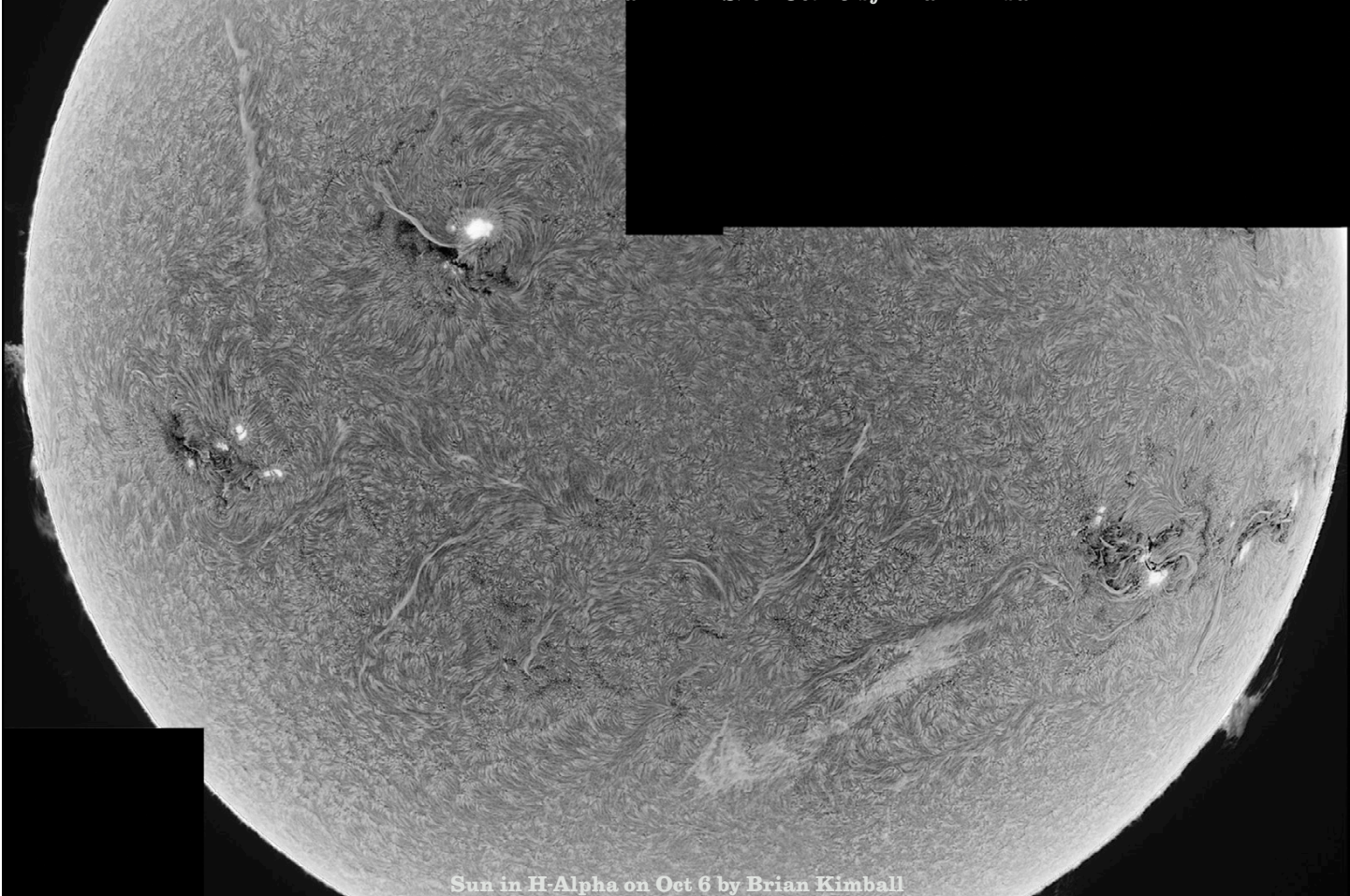
**M33 by Aref Nammari on Oct. 22**



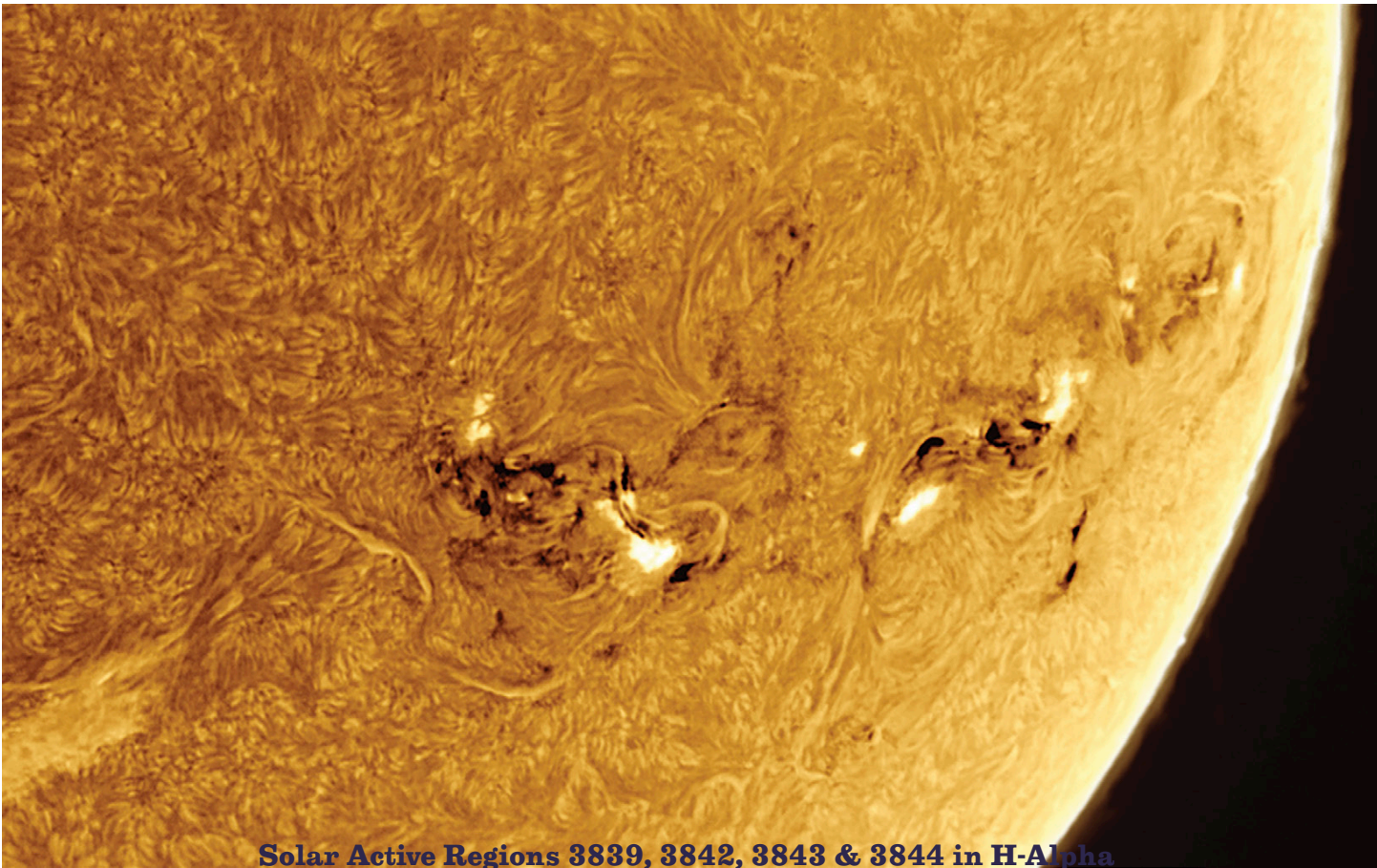
**Milky Way near Deadwood, SD on Oct 3 by Brian Kimball**



**Comet C/2023 A3 (Tsuchinshan-ATLAS) on Oct 15 by Brian Kimball**



**Sun in H-Alpha on Oct 6 by Brian Kimball**



**Solar Active Regions 3839, 3842, 3843 & 3844 in H-Alpha  
on Oct 5 by Brian Kimball**



**M27 Dumbbell Nebula by Allen Jepter on Oct 12**



**SH 2=136 by David Elmore on Oct 13\_2024-10-13**



**Sh2--200 Bear Claw by David Elmore on Oct 28**



**Comet C/2023 A3 (Tsuchinshan;an-AT:AS) Note anti-tail! by Jim Pollock on Oct. 14**



**C/2023 A3 (Tsuchinshan-ATLAS) by Jim Pollock on Oct. 14**



**NGC 7000 North America Nebula by Jim Pollock on Oct. 22**



**Moon by Jim Pollock on Oct. 18**



**Aurora by Leah Shipley on Oct. 11**



**Aurora by Leah Shipley on Oct. 11**





**NGC 1333 by Martin Butley on Oct 16**



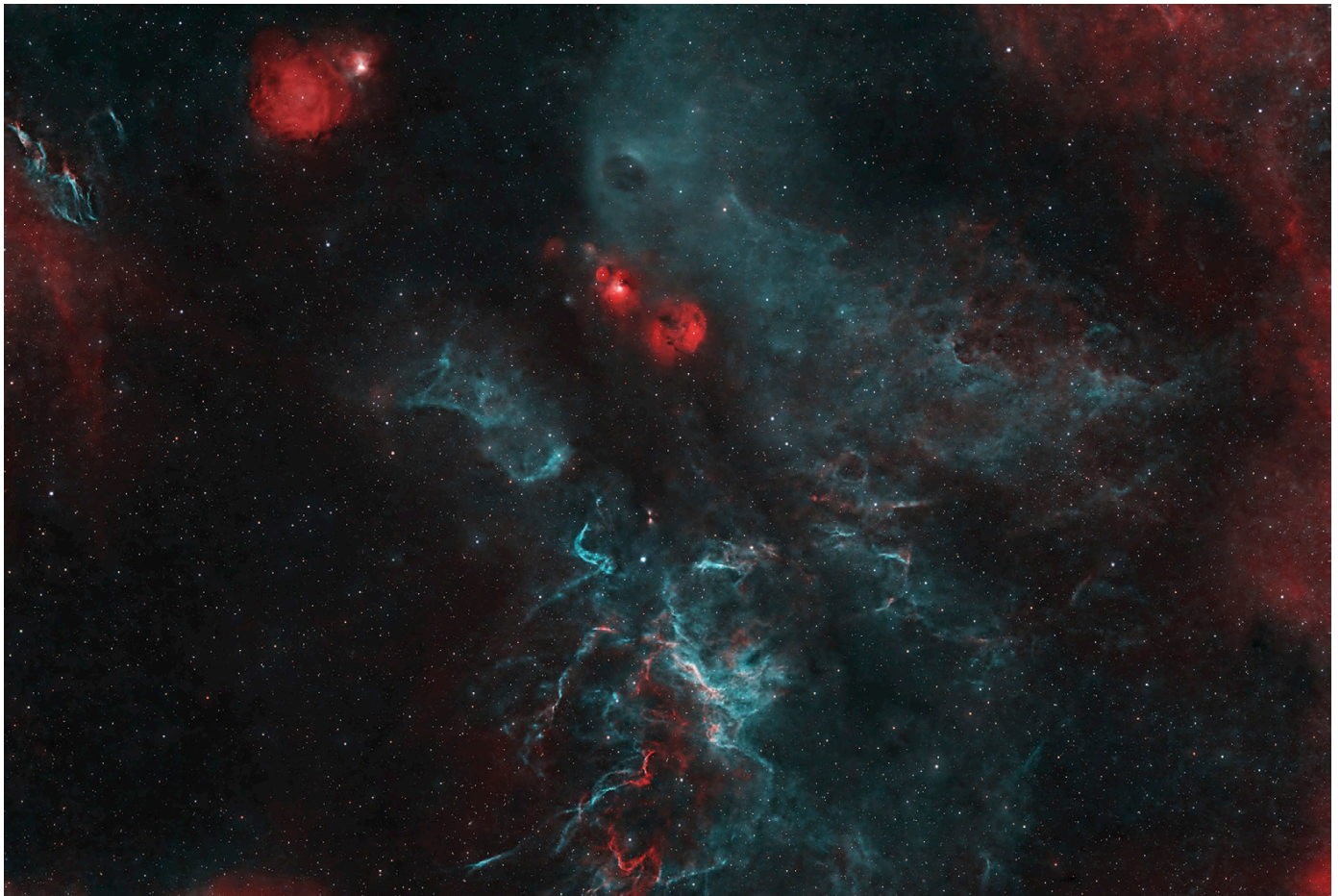
**Erakis by Martin Butley on Oct 16**



**NGC 7741 by MJ Post on Oct. 24**



**Supernova Remnant in Cepheus G108.2-0.6 with YSO by MJ Post on Oct. 2**



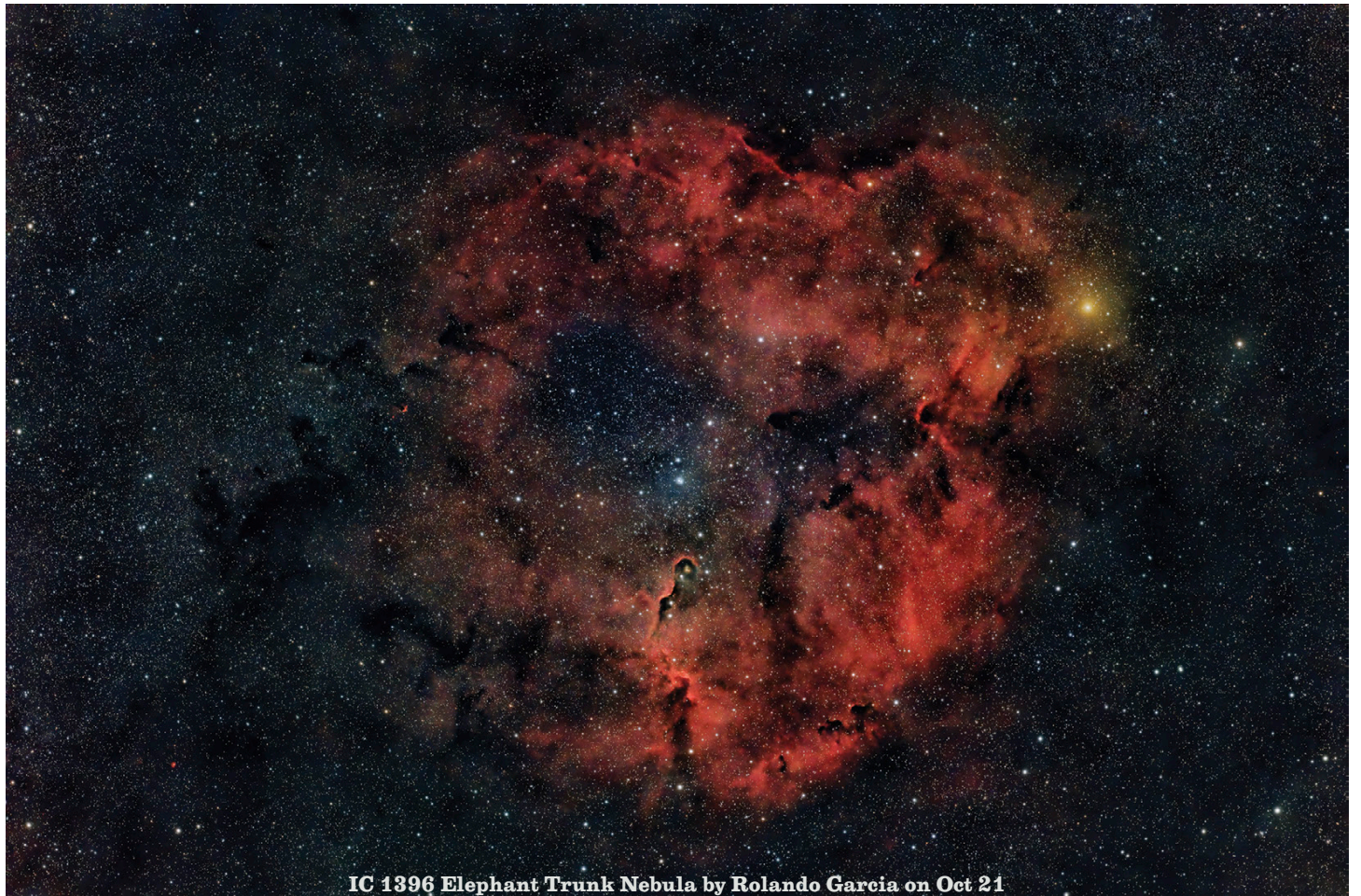
**Supernova Remnant in Cepheus G108.2-0.6 with HOO-RGB by MJ Post (zoomed in on young star object CPM 38)**



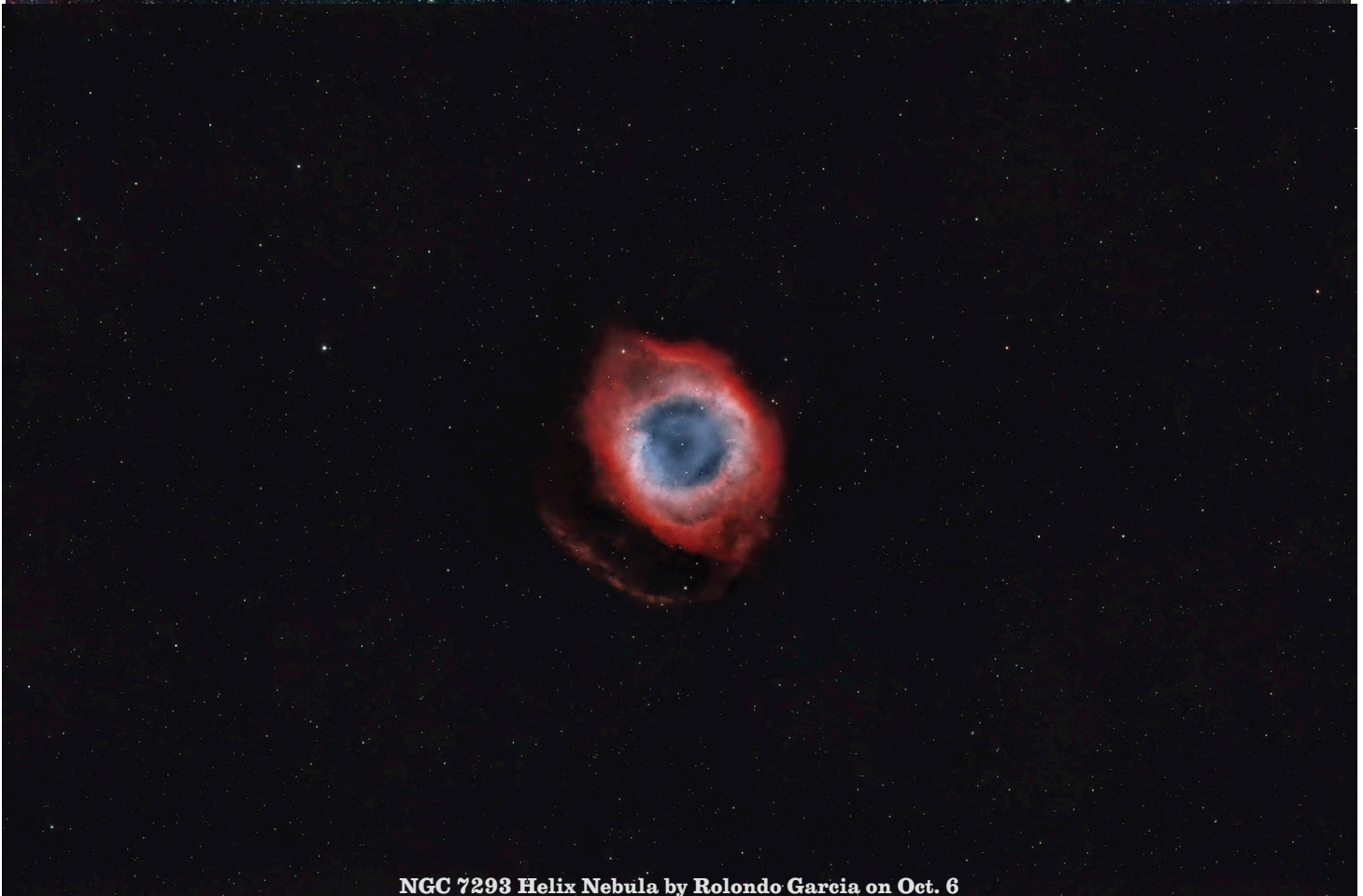
**Wizard Nebula by MJ Post on Oct. 28**



**C/2023 A3 (Tsuchinshan-ATLAS) on Oct 14 north of Cheyenne by Paul Robinson**



**IC 1396 Elephant Trunk Nebula by Rolando Garcia on Oct 21**



**NGC 7293 Helix Nebula by Rolando Garcia on Oct. 6**



**C/2023 A3 (Tsuchinshan-ATLAS) by Rolando Garcia on Oct 28**



**Aurora on Oct 10 by Sarah Detty**



**Sh 2-157 in HOS by Stephen Garretson on Oct. 18**



**Aurora from Hoffell 2b, Hornafjörður, Iceland by Stephen Garretson**



**Sh 2-88 Area by Stephen Garretson on Oct. 25.**





**Aurora in Iceland by MJ Post on Oct. 3**



**M 31 by Rolando Garcia on Oct. 28 Rolando Garcia**

# Newsletter Archives by Eileen Hall-McKim

## 30 Years Ago November 1994

The October meeting was started at 7:40 with general discussion by Jim Sharp, President. Jim discussed the excellent turnout by both the public and LAS members at the recent Astronomy day presentation at the Twin Peaks Mall. Jerry Wilkinson was presented with an achievement award for his dedication to the completion of the club 10' Dobsonian telescope. Great job Jerry! There was a reminder that officer nominations are in November with elections at the December meeting.

Bob Spohn is working on the club banquet for the December meeting, tentative plans include Dr. Robert Stencel of the University of Denver as the guest speaker on December 10th at the China Gardens. Firm plans will be mailed to the club membership as soon as they are resolved.

Club officers gave their brief reports. Bob Ross showed a video from his recent trip to the Ultimate Star Party at McDonald Observatory in Texas. Jerry Wilkinson gave an excellent presentation on mirror making and provided some helpful show-and-tell materials. Thank you Jerry.

Andrew Planck turned in his 110 Messier observations – CONGRATULATIONS!

## 20 Years Ago November 2004

No newsletter was published.

## 10 Years Ago October 2014

Twenty six people attended the October 16th meeting to hear Bill Possel's presentation, "MAVEN Arrives at Mars". Bill is an excellent presenter and his talks are always interesting and informative but this one was exceptional. MAVEN launched on November 18, 2013 at its first launch window. Had the mission been delayed it would not have arrived at Mars in time to take advantage of the literally once in million year opportunity to study a comet as passes very near to a planet. MAVEN's three instrument packages will provide the measurements essential to understanding the evolution of the Martian atmosphere. MAVEN will study the types and amounts of gas particles escaping, the processes that govern the escape, and perhaps learn how the processes have contributed to changes in the climate.

At the business meeting Michael Fellows presented the financial report LAS is doing well financially and we now have 70 members. He brought in the 2015 Deep Space Mysteries calendars for 2015.

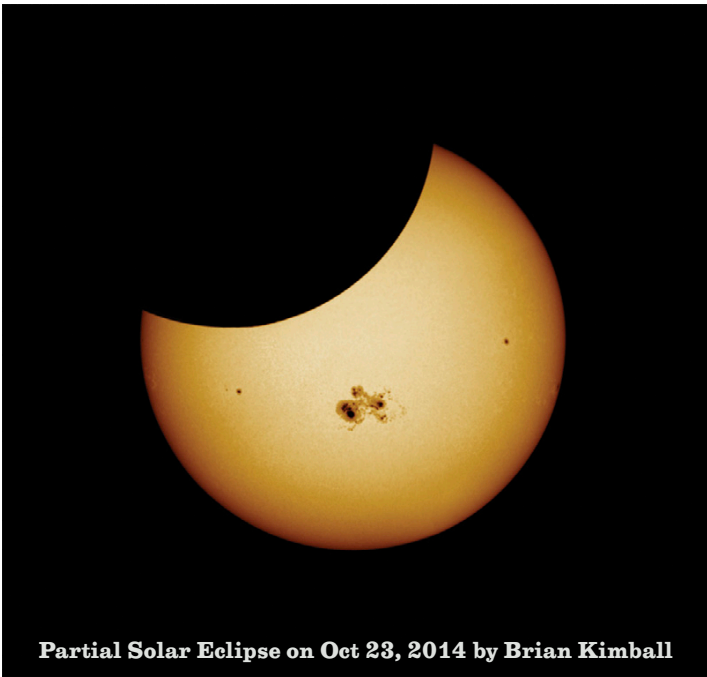
The presentation at the November 20th meeting will be "Visual Astronomy 101" by Mike Hotka. Mike's will share tips and discuss techniques he uses to decide what to observe, how to prepare for an observing outing, what to take with you when you go out, choosing where to go and what to do after returning home from the outing. The presentation will discuss many of the Astronomical League's Observing Programs that a beginning amateur can easily do as well as some of the more advanced programs.

Mike has been an amateur astronomer for many years and a member of LAS since 1995. During this time, Mike has earned many certificates completing Astronomical League Observing Programs. Following the Mike's presentation we'll have a short business meeting and then discuss member images and other current topics. Reminder, January elections are coming up, all positions are open.

### Upcoming Public Star Parties

Scopes and volunteers needed to support the following school events:

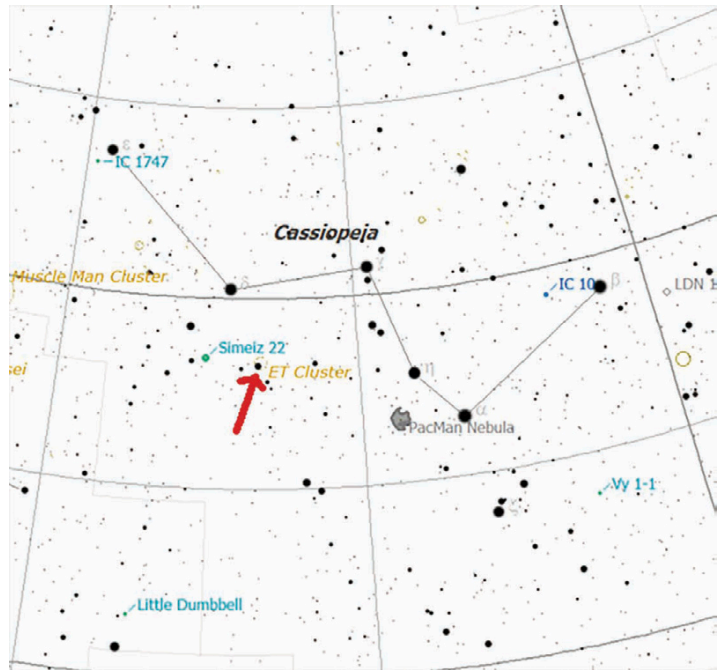
- Legacy Elementary, 7701 Eagle Rd. in Frederick, CO on November 13th at 6 pm
- Northridge Elementary, 1200 19th Ave. in Longmont, CO on December 8th at 7 pm



Partial Solar Eclipse on Oct 23, 2014 by Brian Kimball



NGC 457 ET Cluster by Gary Garzone Oct, 2014



Star chart to locate the ET Cluster



Our night sky in early November about 8 pm

Summer is gone. A chill now greets us when we go outside in the night air. A warm jacket and a comfortable hat are becoming required equipment. Looking east we recognize the constellation of Orion rising; the great square of Pegasus is high overhead; the stick house shape of Auriga is in the east. The vain queen of Greek mythology, Cassiopeia, is high overhead. Late fall in Colorado is great time to go observing with your telescope or maybe with just binoculars. The nights are generally clear and temperatures not so cold (though I recall some exceptions) as to preclude having a great time out in the dark.

#### Early evening dark sky objects for mid-November

- NGC 7293 Helix nebula in Aquarius
- NGC 7662 Blue Snowball in Andromeda
- M33 Pinwheel galaxy in Andromeda
- M110 Dwarf elliptical galaxy in Andromeda
- M32 Dwarf elliptical galaxy in Andromeda
- M31 Great Andromeda galaxy in Andromeda
- NGC 7789 (OCL 269) in Cassiopeia
- NGC 7635 Bubble Nebula in Cassiopeia
- NGC 281 (IC 1590) in Cassiopeia
- NGC 457 ET Cluster in Cassiopeia
- M52 NGC 7654 Cassiopeia
- M76 Little Dumbbell in Perseus
- M74 NGC 628 Pisces
- NGC 253 Sculptor Galaxy in Sculptor

**LONGMONT ASTRONOMICAL SOCIETY**  
**P. O. Box 806**  
**LONGMONT, CO 80506**



**AURORA ON OCTOBER 11 BY LEAH SHIPLEY**