Look North:
Mid-Latitude Aurora Forecasting & Chasing for Beginners



By Jeremy Cruz

NASA

About Me

- From Pennsylvania
- Went to the University of Connecticut, work there currently with Athletics
- Hobbies are fishing, foraging, storm chasing, and aurora chasing (duh!)



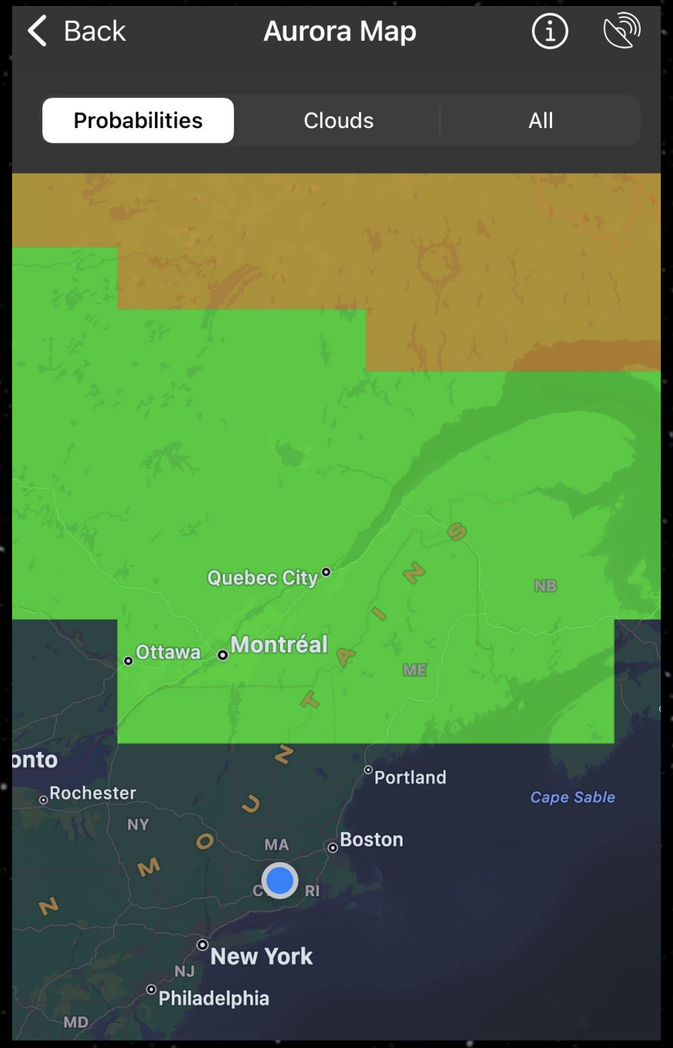
How It All Began

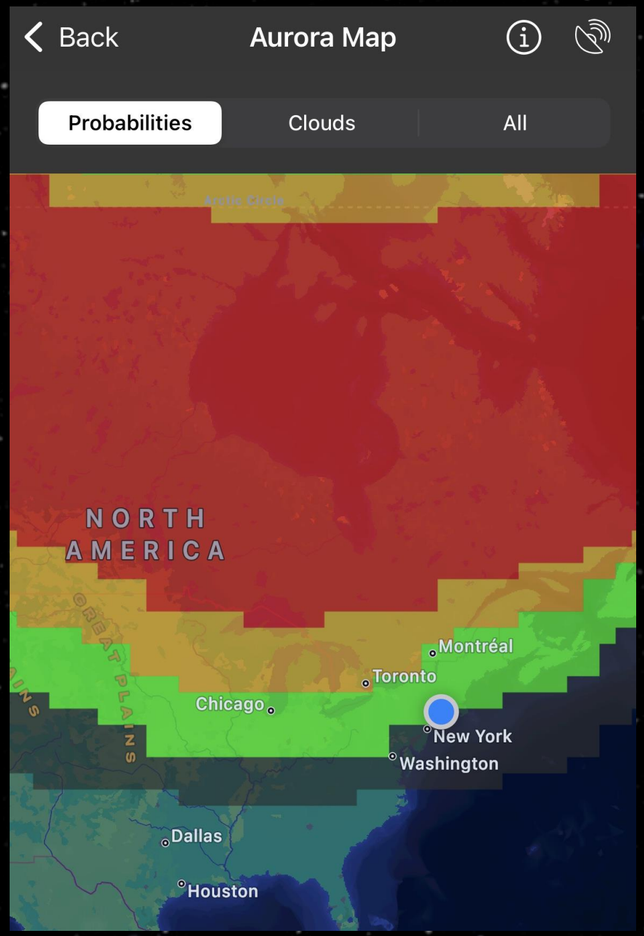
- Missed March 23rd, 2023 G4
- Ignorance & Inspiration
- Joined several Facebook groups
- Downloaded Aurora Apps



One Month Later

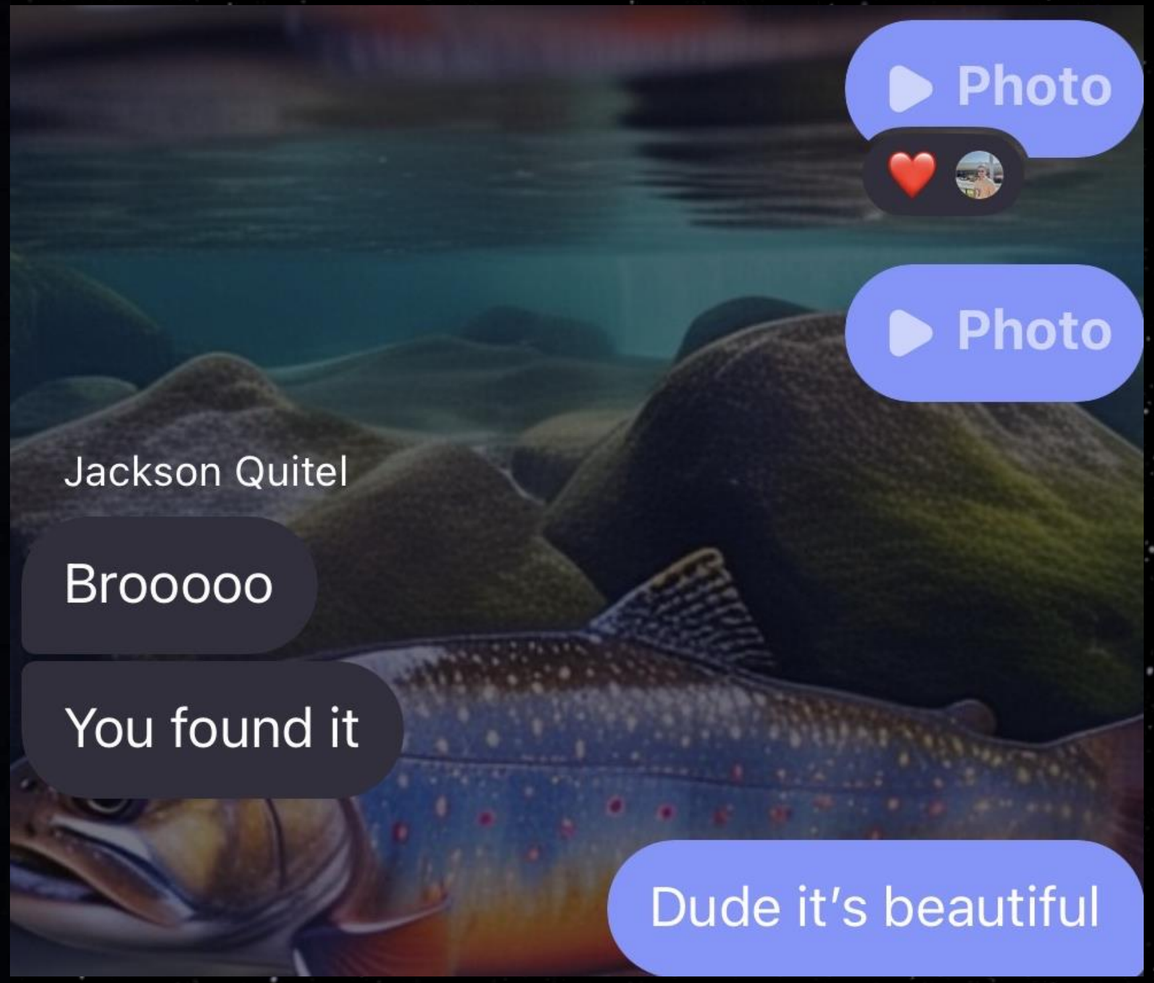
- April 23rd, 2023
- Had no idea CME had arrived
- Reliant on the app to send me notifications when things were happening
- Looked at cloud map and bolted west





The Rest is History





The Catch

- Did not see ANY naked eye aurora despite a G4 severe storm
- Didn’t know what substorms were
- Used autofocus ☹



Aftermath

- Obsessed
- Watched the probability map, KP index forecasts, % chance of seeing
- Decided to go out based on whenever I was in the map probability or got notifications
- May 5th, 2023



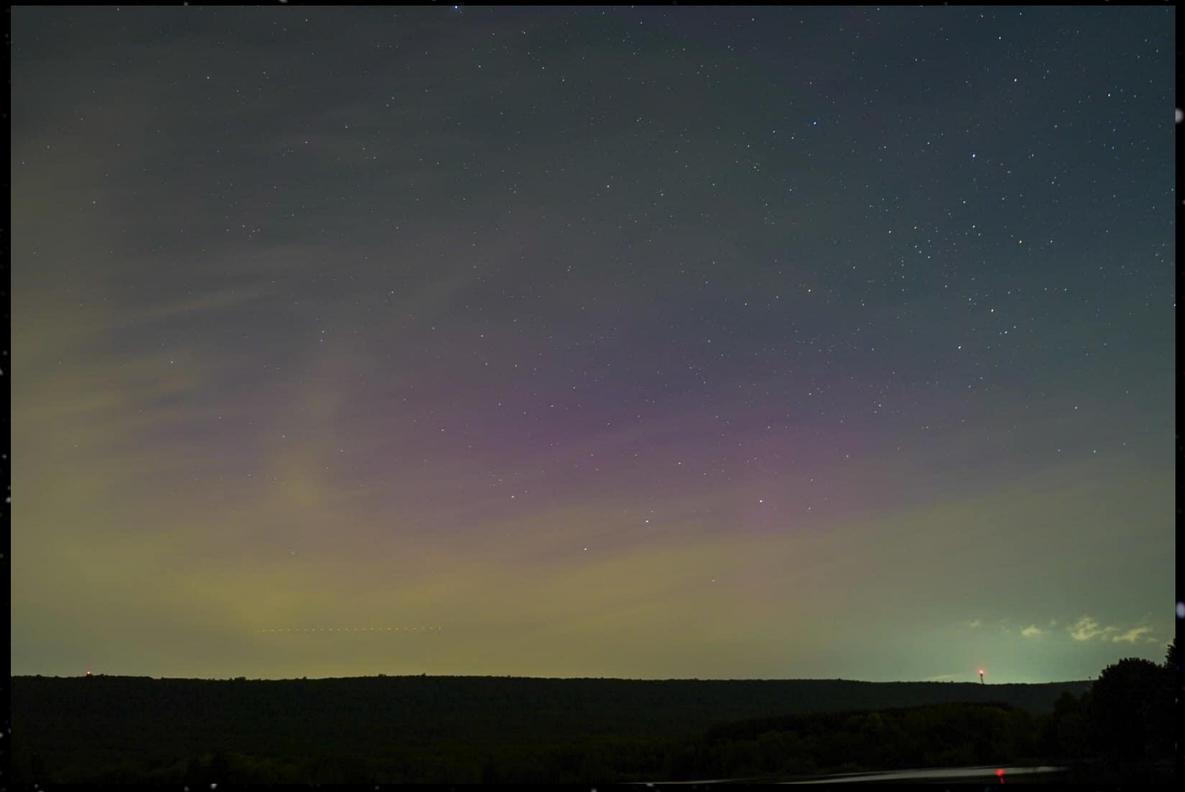
It Worked, So Why Change?

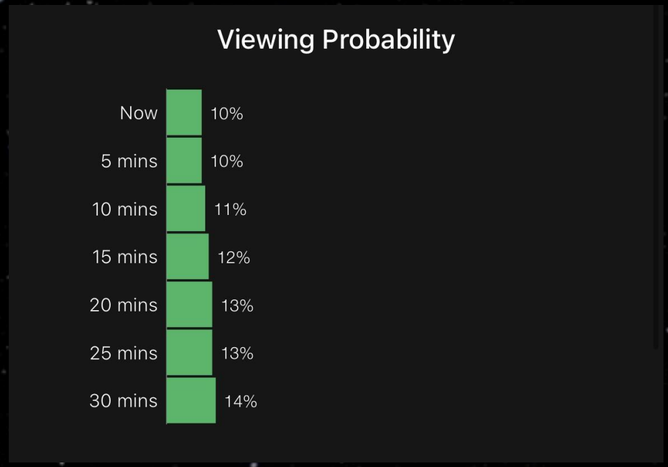




Reality

- Time and gas wasted
- Often got there just too late
- Spray and pray timelapses
- Missed naked eye aurora





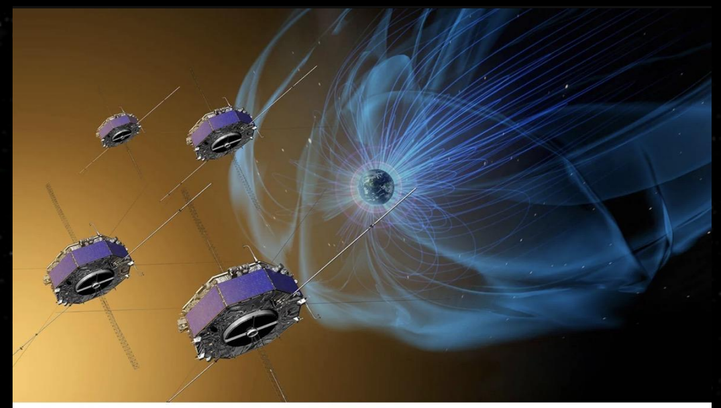
Finally

- September 24th, 2023
- Portage Lake, Maine



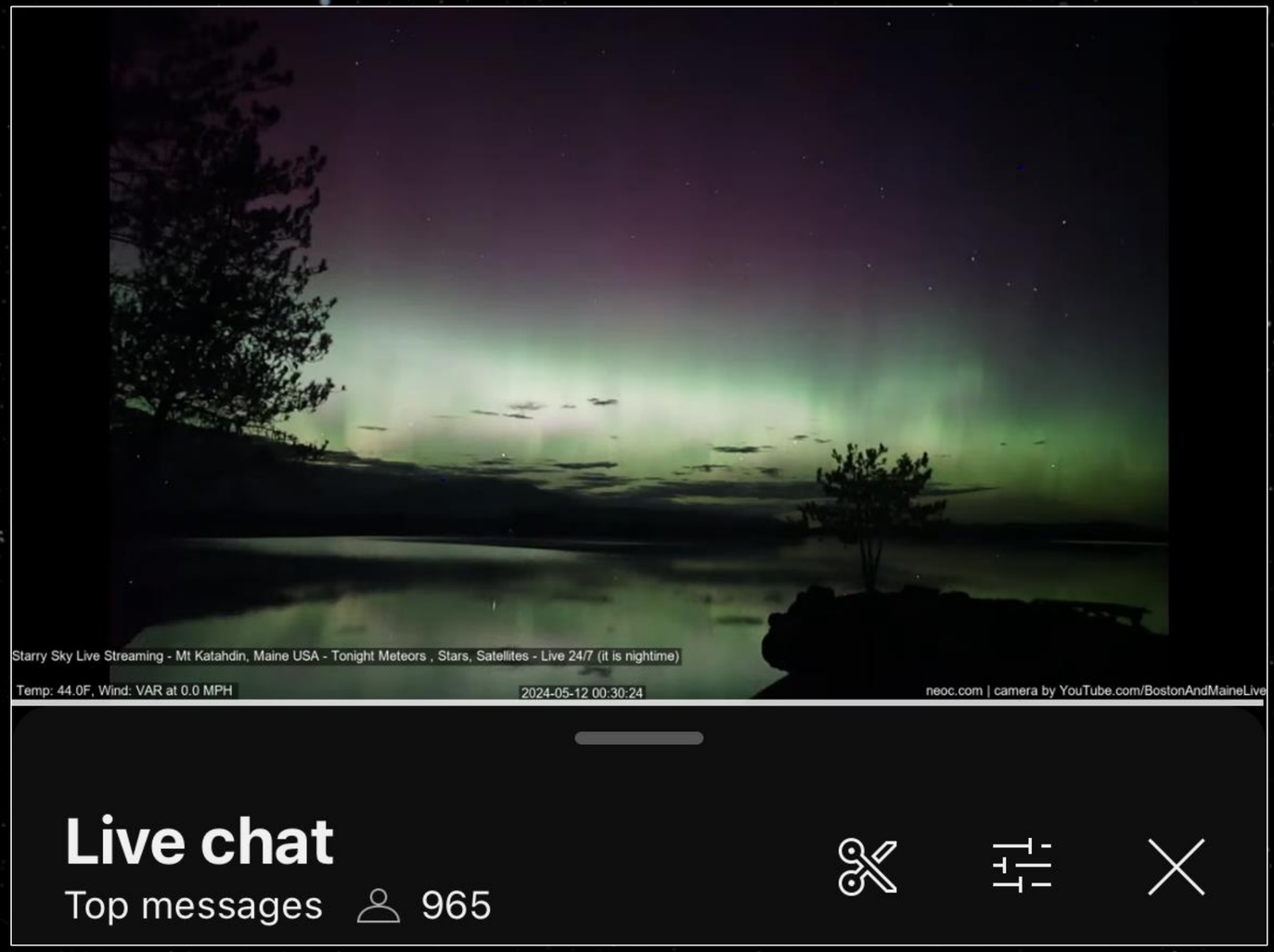
Path of Change

- First naked eye aurora spurred change
- Substorm discovery
- Looked into real time data
- Sought guidance from more experienced people



Discovery

- Introduced to GOES Magnetometer, Webcams



The Present

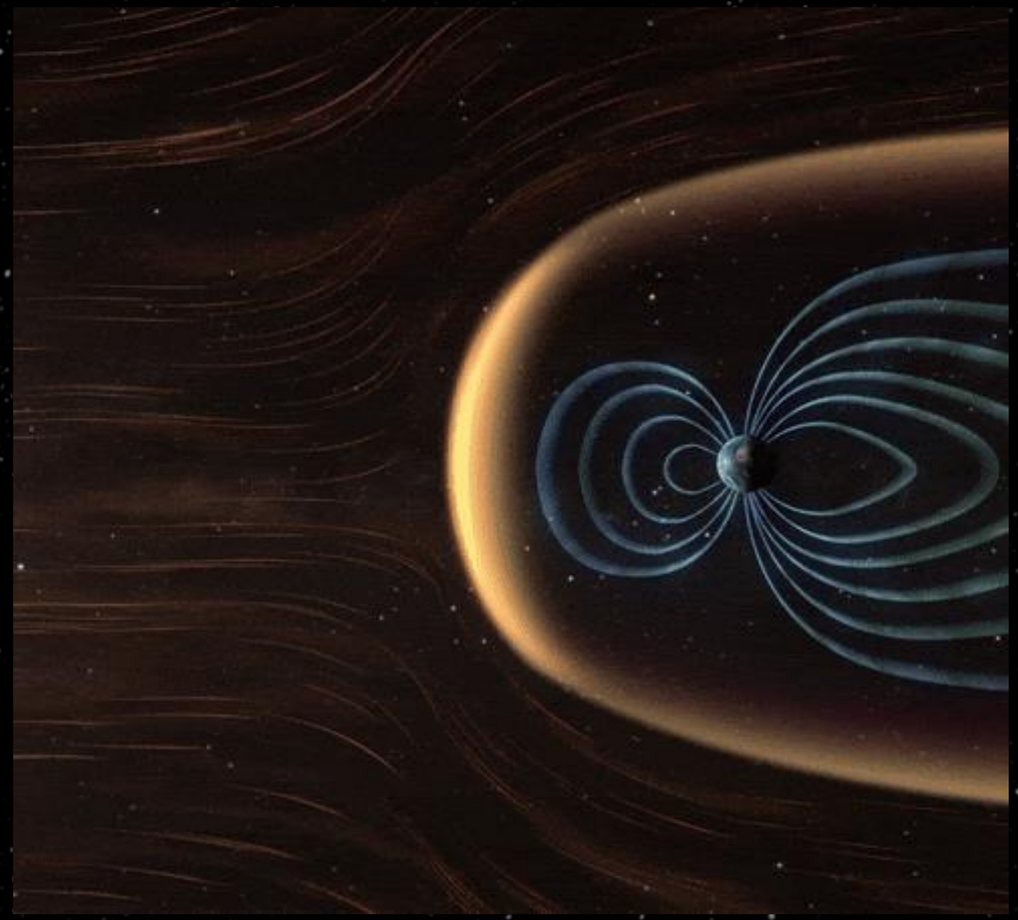
- 100+ mid-latitude aurora captures
- Active in aurora community
- Help run several aurora groups



How Did I Do It?

Start at the Sun

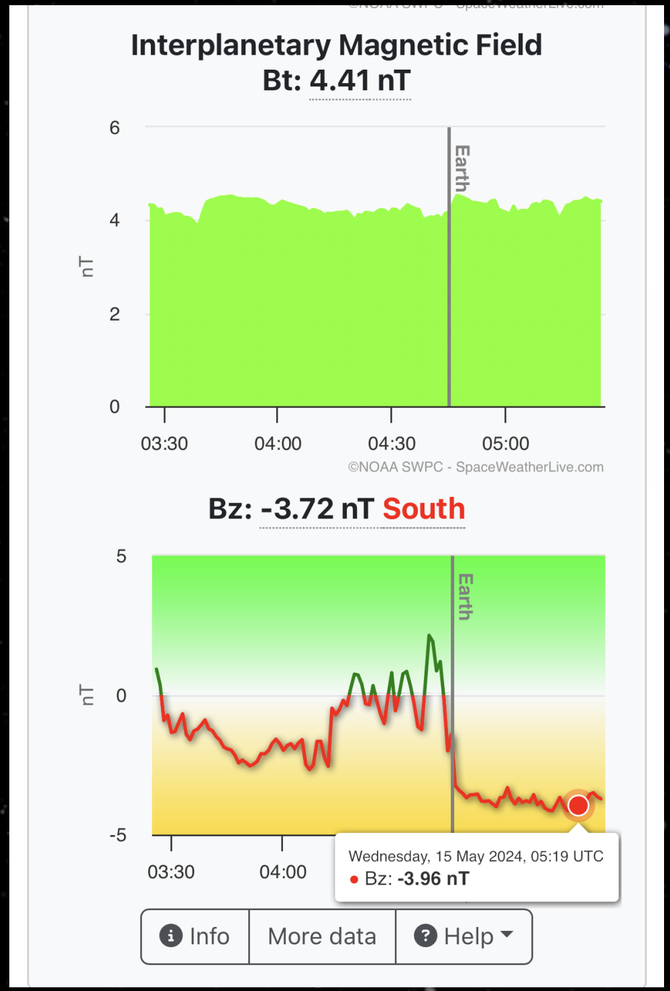
- Enormous ball of plasma.
- Full of charged electrons and protons.
- Magnetic activity helps send this electrically charged material into space.
- This continuous flow travels through our solar system at hundreds of miles per second in what we know as solar wind.



NASA's Conceptual Image Laboratory

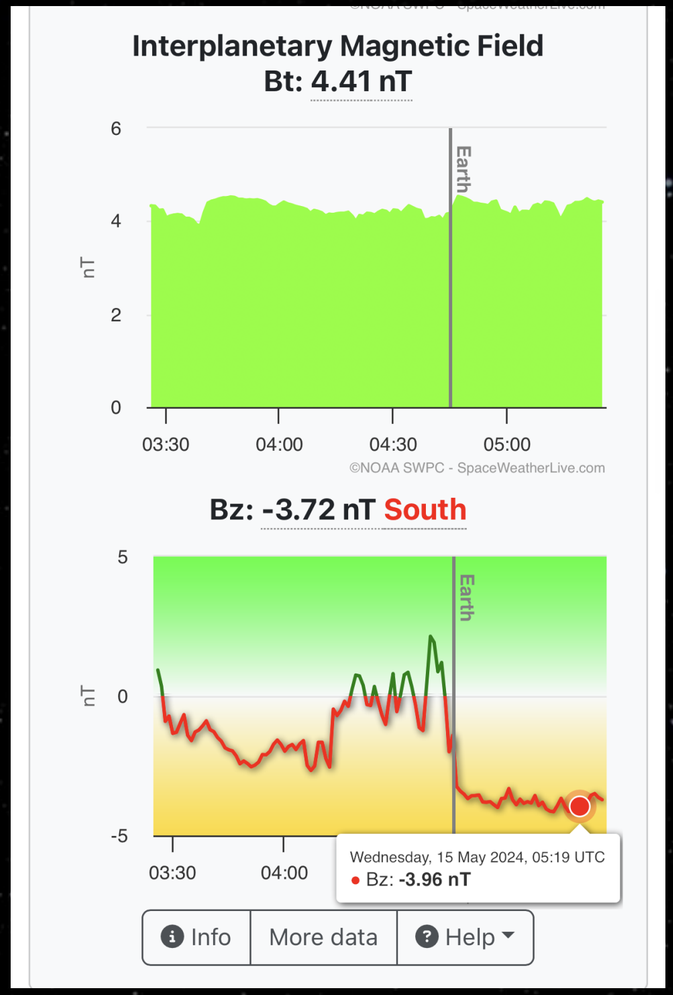
Solar Wind Vocabulary

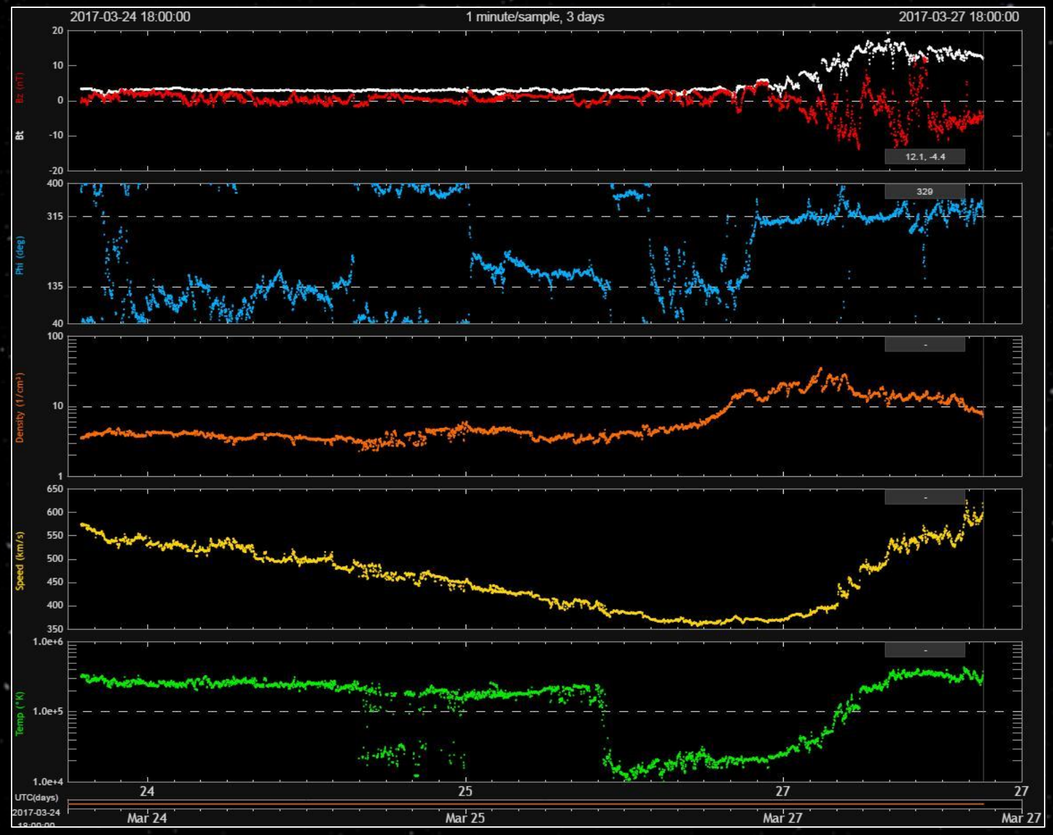
- Solar Wind Speed
- Bz
- Bt/Interplanetary Magnetic Field (IMF)
- Solar Wind Density
- nT:
  A unit used to measure magnetic field strength.



Solar Wind Monitoring

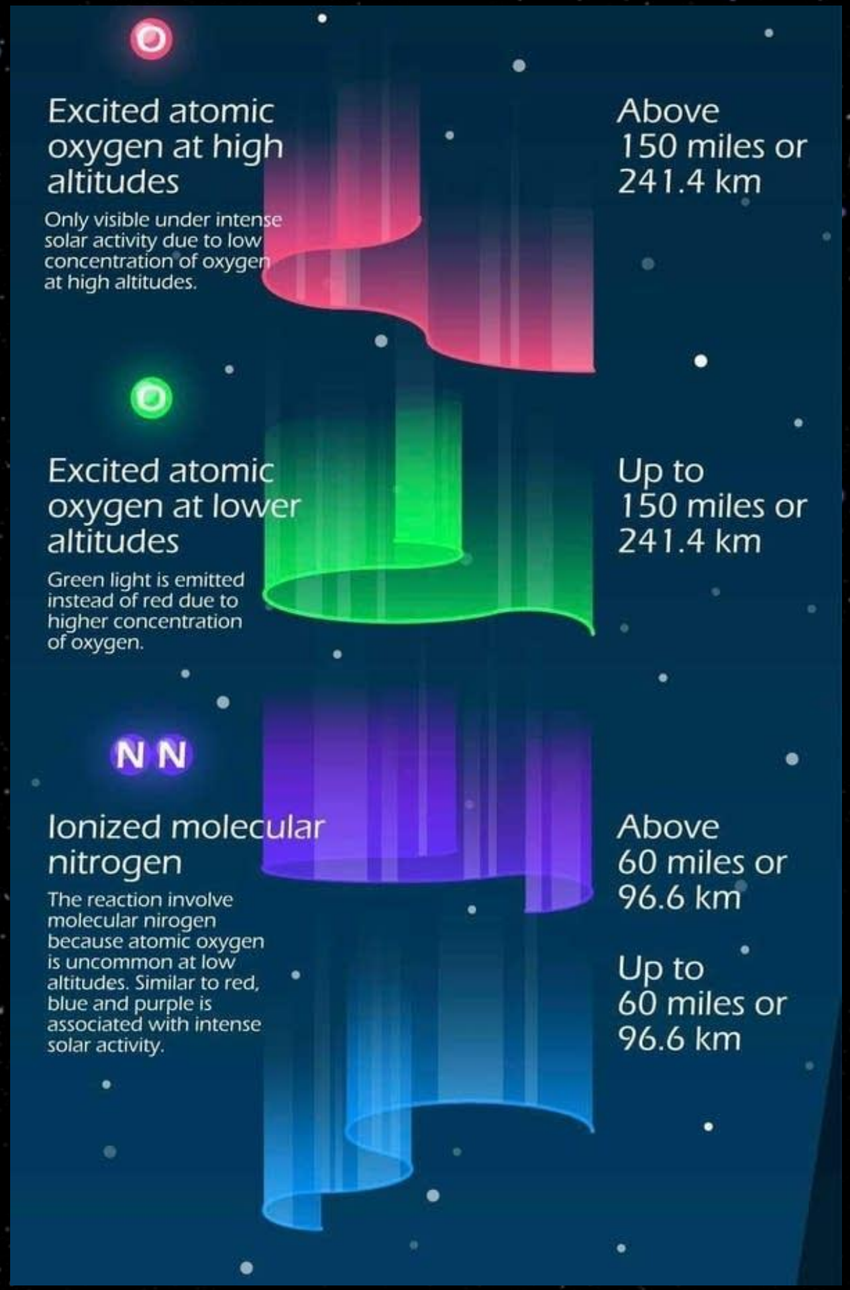
- ACE
- DSCOVR
- SOLAR-1
- IMAP





Solar Wind

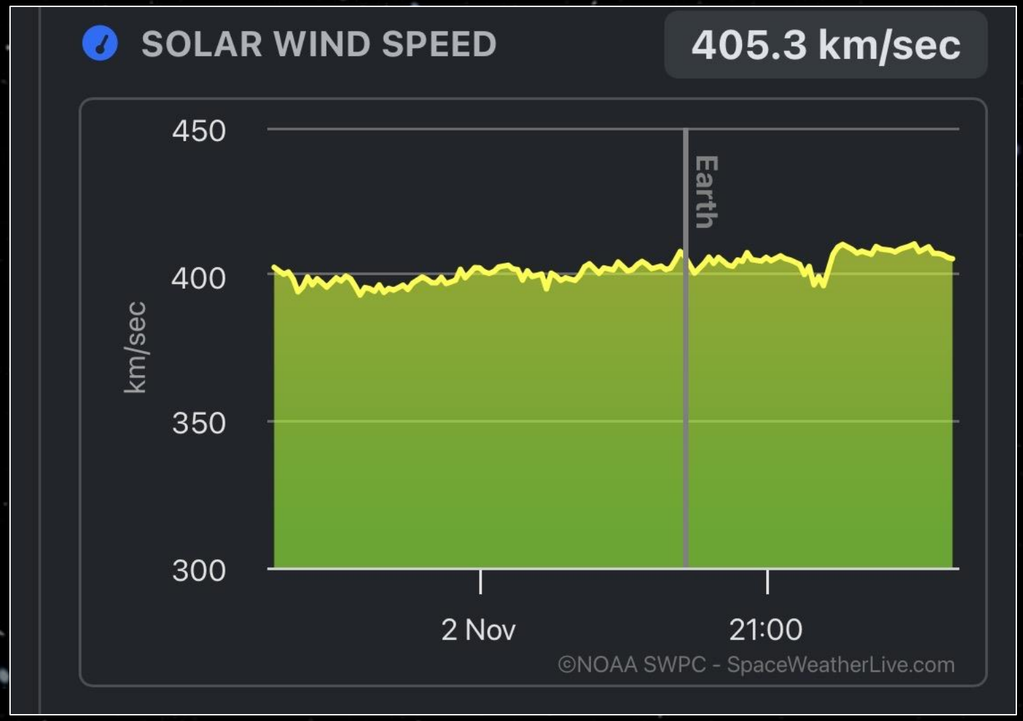
- When solar winds arrive at Earth, they interact with its magnetic field
- The magnetic field guides particles toward the poles.
- Some energized particles travel down Earth's magnetic field lines toward the upper atmosphere.
- The particles collide with oxygen and nitrogen high above the Earth.
- Lastly, the gases release light!



Aurora colors explained | National Weather Service

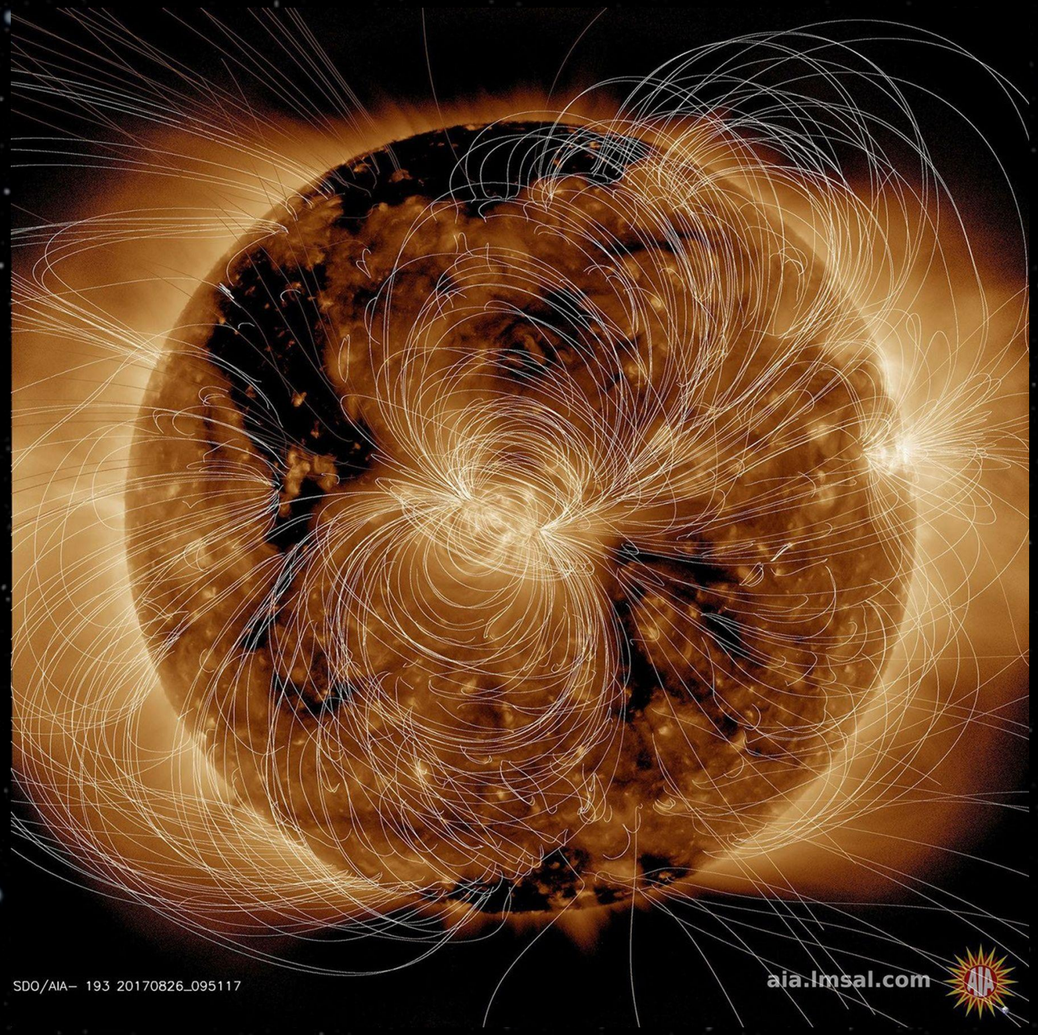
Ambient Solar Wind

- Background solar wind levels are only about:
  - Solar wind speed: 300-400 km/s
  - Magnetic field strength: 3-8 nT
  - Weak + or - Bz
- This is enough to power high-latitude auroras most nights, but not for mid-latitudes.
- So what do we need?



Shake It Up

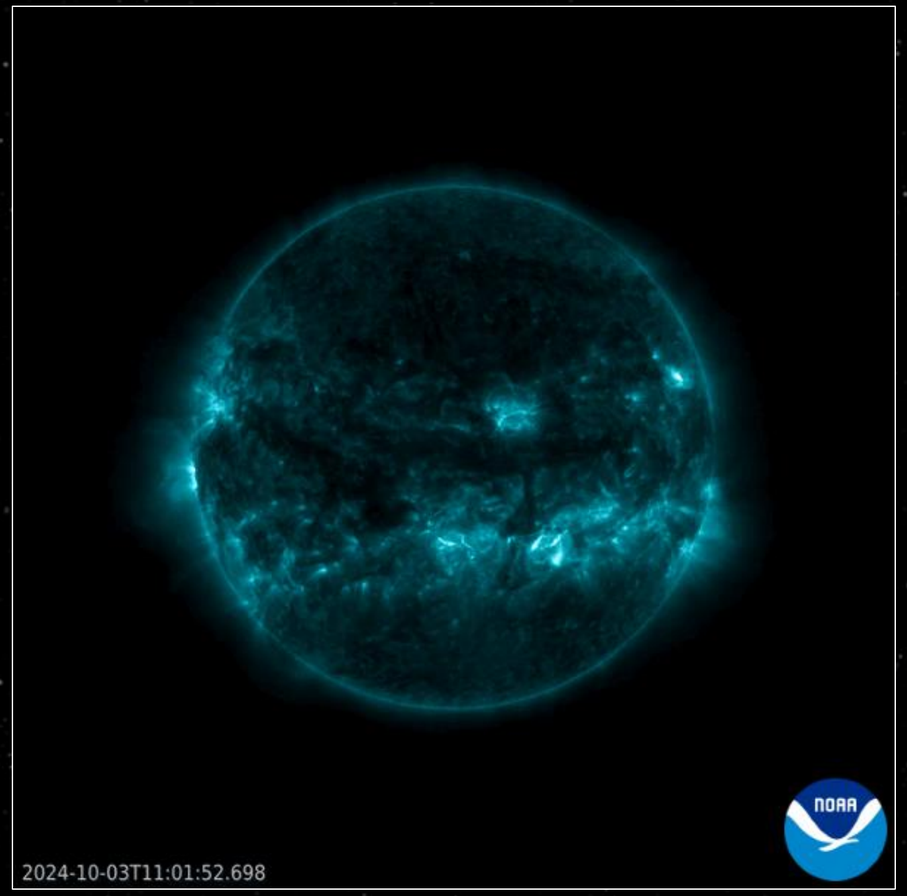
- Because the sun’s particles are electrically charged and moving around, they generate magnetic fields.
- Its plasma constantly moves and churns.
- This movement twists and stretches the Sun's magnetic field.



NASA/GSFC/Solar Dynamics Observatory

SNAP!

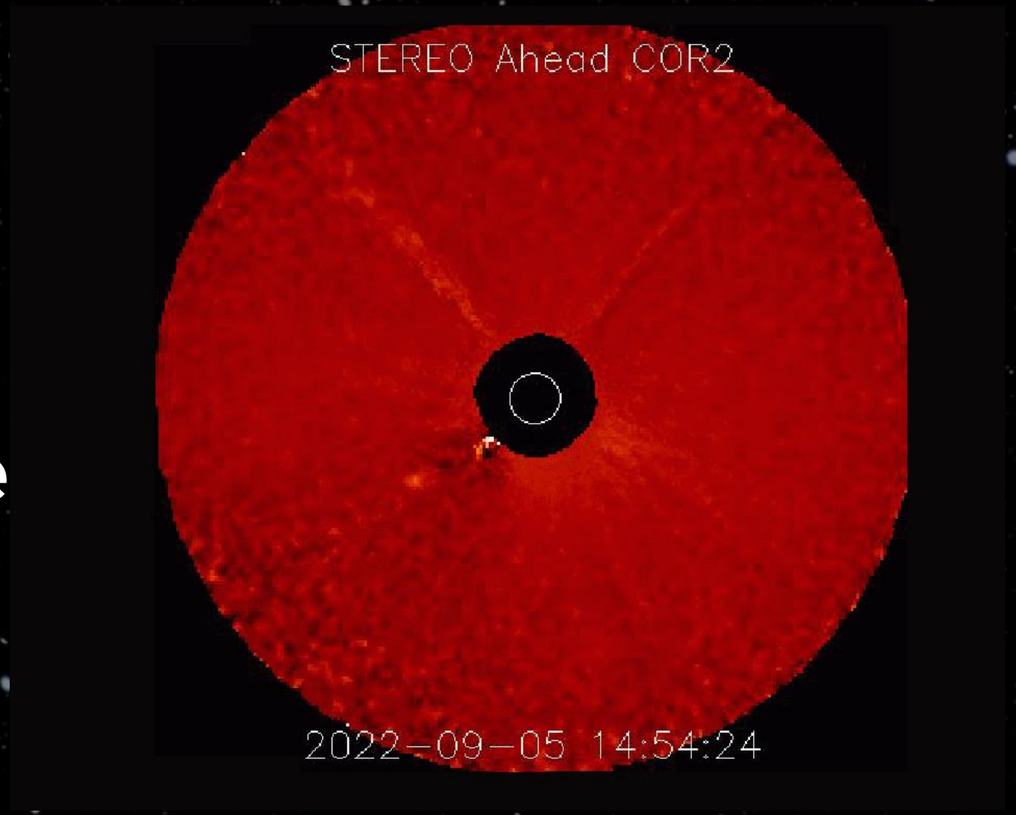
- Magnetic field lines become twisted and stressed.
- Different magnetic field lines can get pushed close together.
- Magnetic reconnection happens.
- Energy is released the form of a solar flare.



NOAA

Coronal Mass Ejections

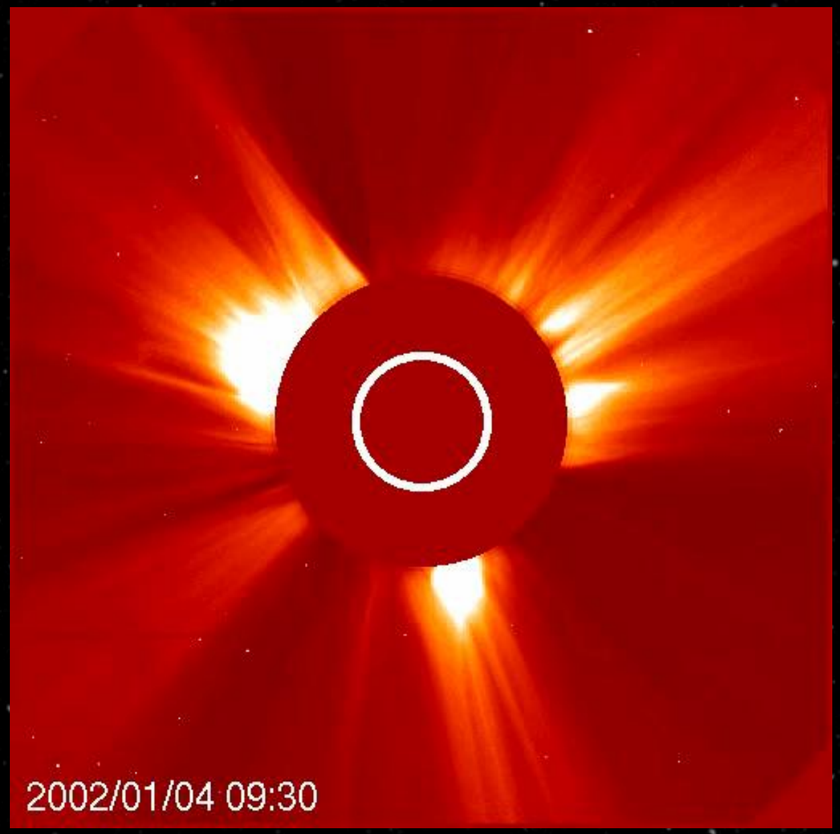
- Plasma release from the Sun
- Can be associated with solar flares or be separate
- Earth directed material can cause stronger aurora than ambient solar wind



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Solar Flare Classes

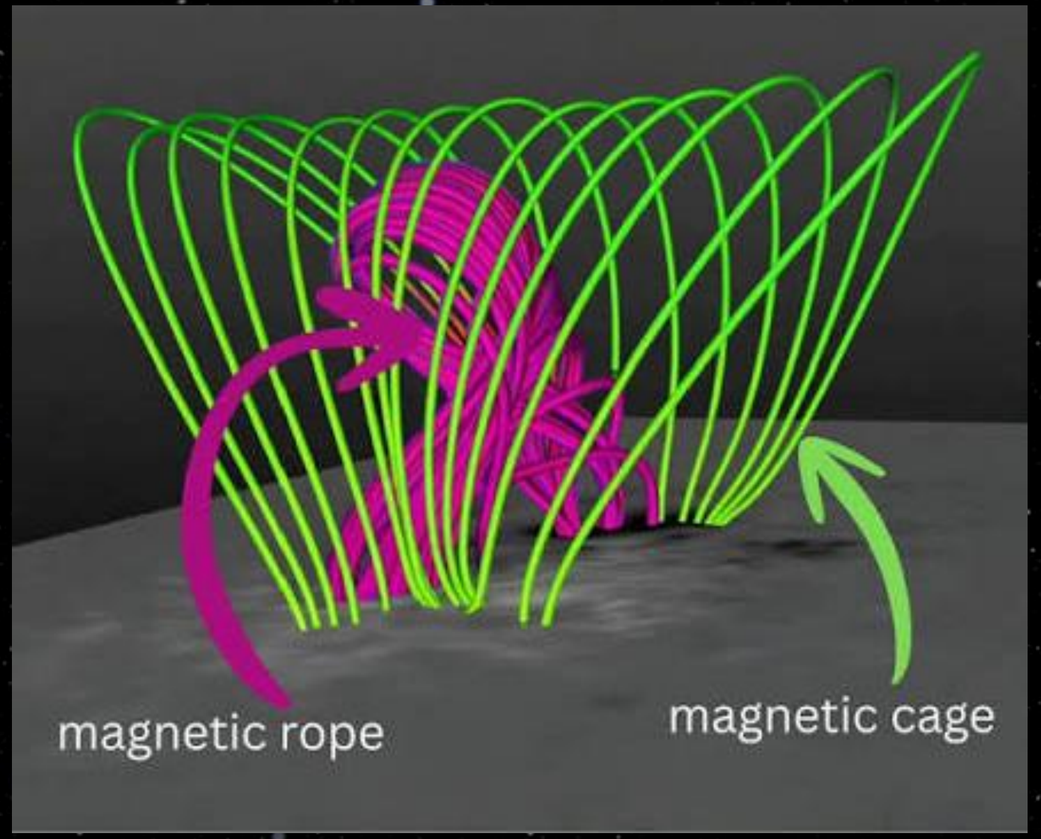
- Four main classes
- X, M, B, and A
- Strong solar flare ≠ strong CME
- C-flares can have more impactful CMEs than-X flares.



NASA

Solar Flares & CMEs

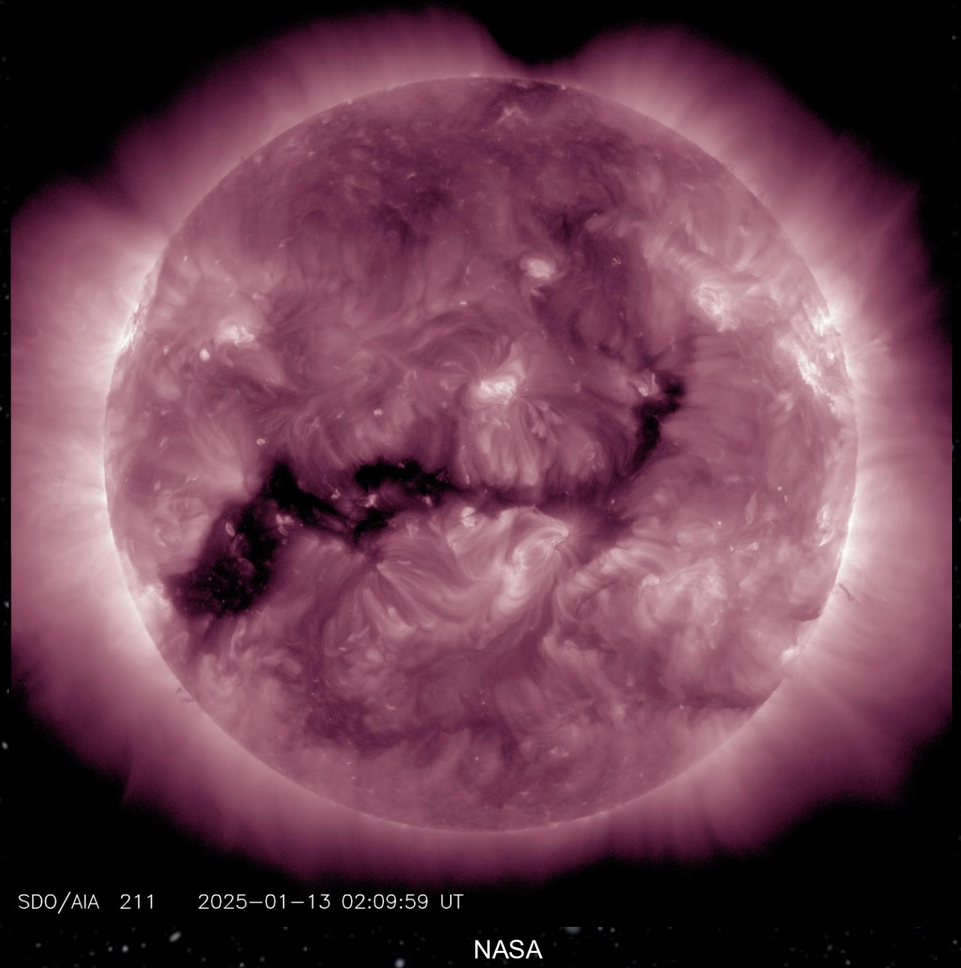
- Impulsive Flares
- Eruptive CMEs
- Magnetically Caged CMEs
- Filament Eruptions



@xpmelb

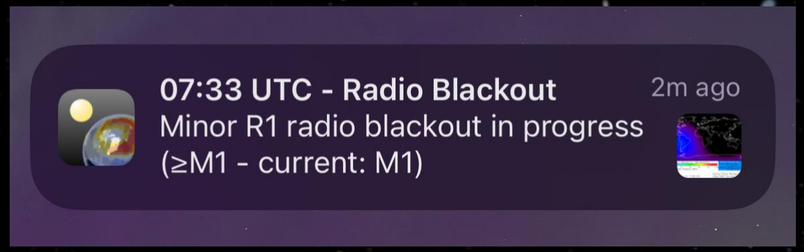
Coronal Holes

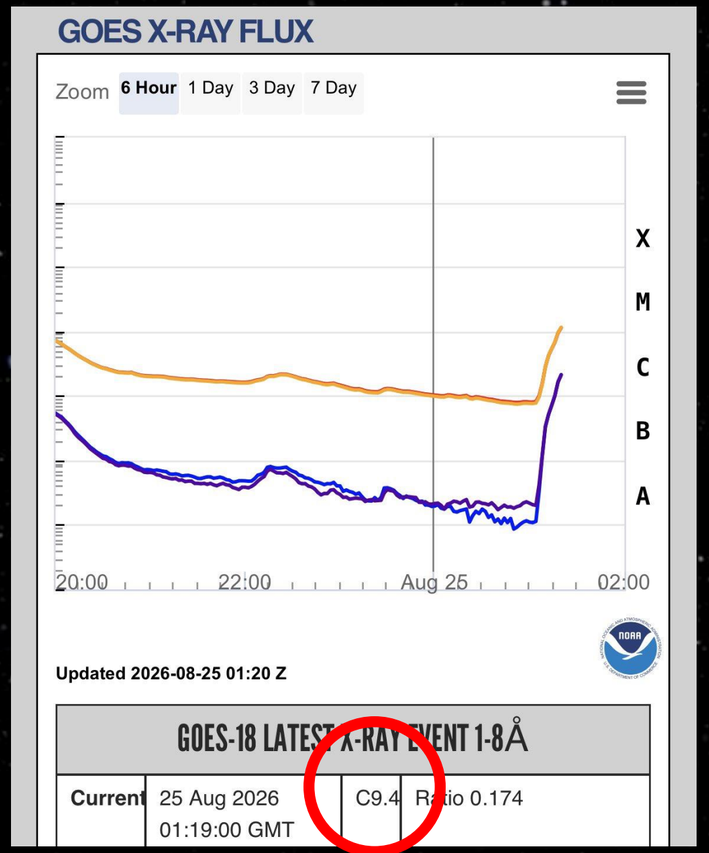
- Another way we can see aurora
- More reliable!
- Sometimes multi-day events
- 27 day rotation
- SDO/AIA 211

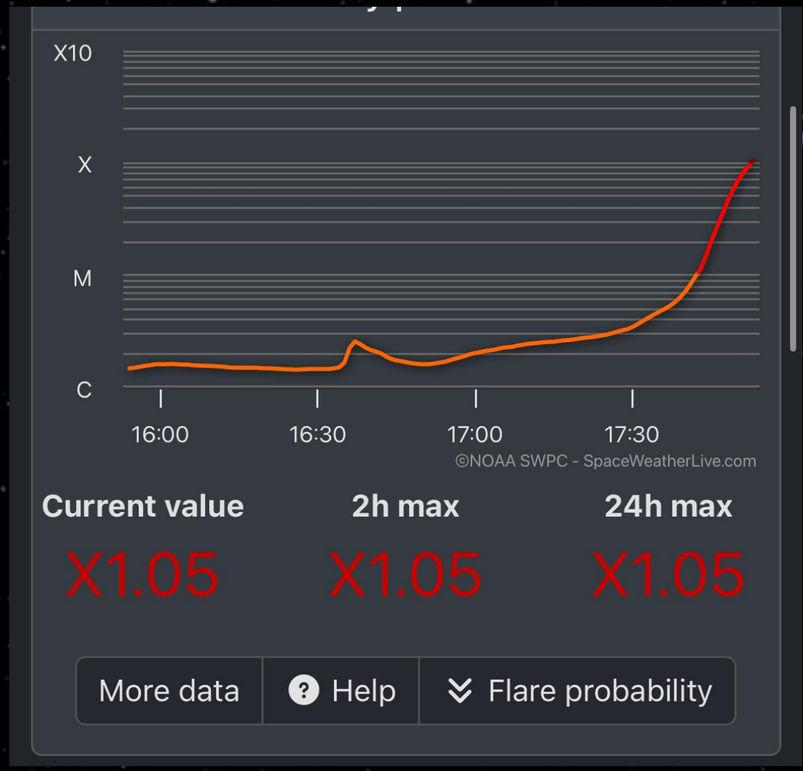


Solar Flare Tracking

- GOES X-Ray Flux
- SpaceWeatherLive

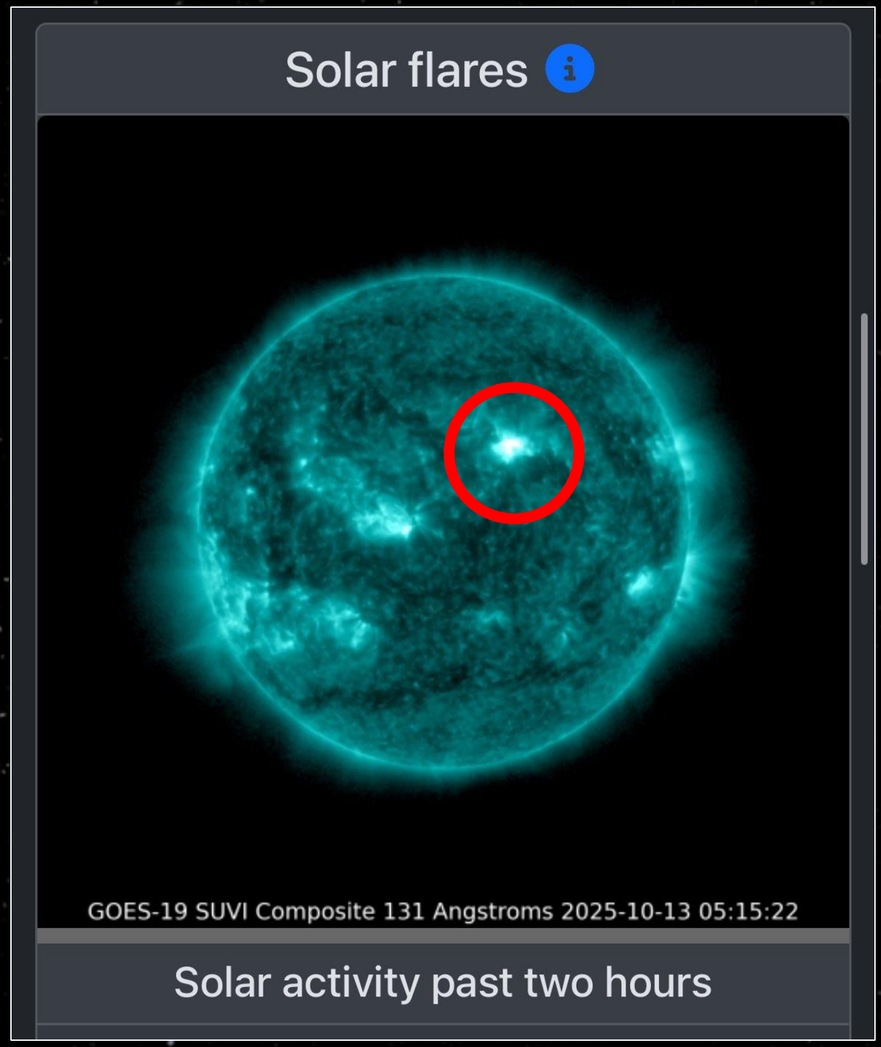






Solar Flare Tracking

- GOES-19 SUVI 131
- Helps determine active region



Coronal Dimming

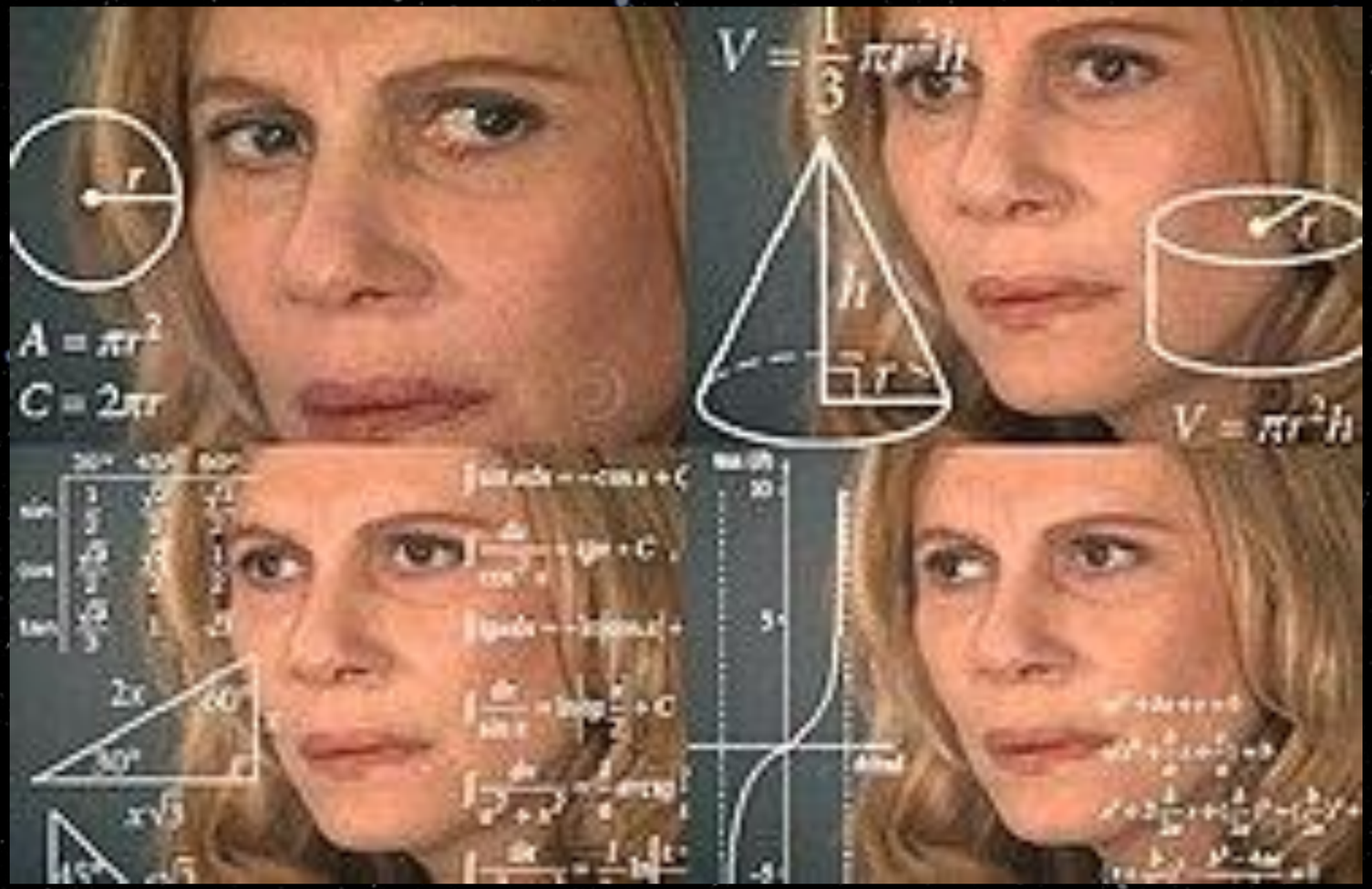
- After a CME happens, There is less plasma in that region to produce ultraviolet light, so it appears dark.

- Solar Demon



Time for the Experts

- Wait for models!



Forecast Vocabulary: Kp

- Kp stands for planetary K-index.
- 0 to 9
- Higher Kp generally means the auroral oval can expand farther toward the equator.
- NOT a direct measurement of aurora brightness and doesn't consider substorming.
- NOT REAL TIME!

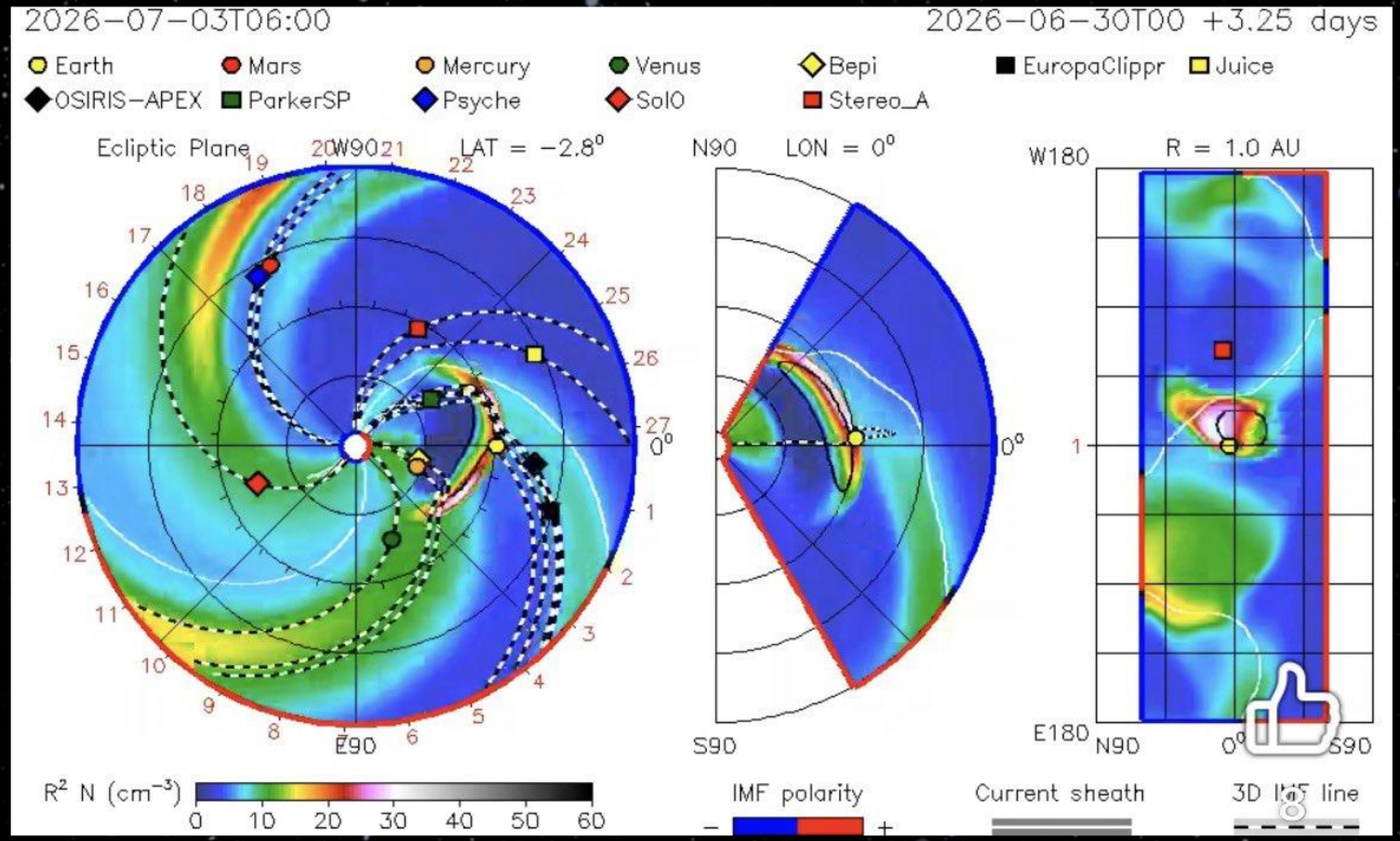


Forecast Vocabulary: G-scale

Rating	Storm Level	What It Means
G0 (KP0)	No storm	Geomagnetic conditions are below storm level.
G1 (KP5)	Minor	Increased aurora activity; auroras may become visible at higher mid-latitudes.
G2 (KP6)	Moderate	Greater aurora activity; auroras may be visible farther south.
G3 (KP7)	Strong	Stronger geomagnetic activity with potential for widespread aurora visibility.
G4 (KP8)	Severe	Significant geomagnetic storm; auroras may reach much lower latitudes.
G5 (KP9)	Extreme	Extremely powerful geomagnetic storm; auroras may be visible at unusually low latitudes.

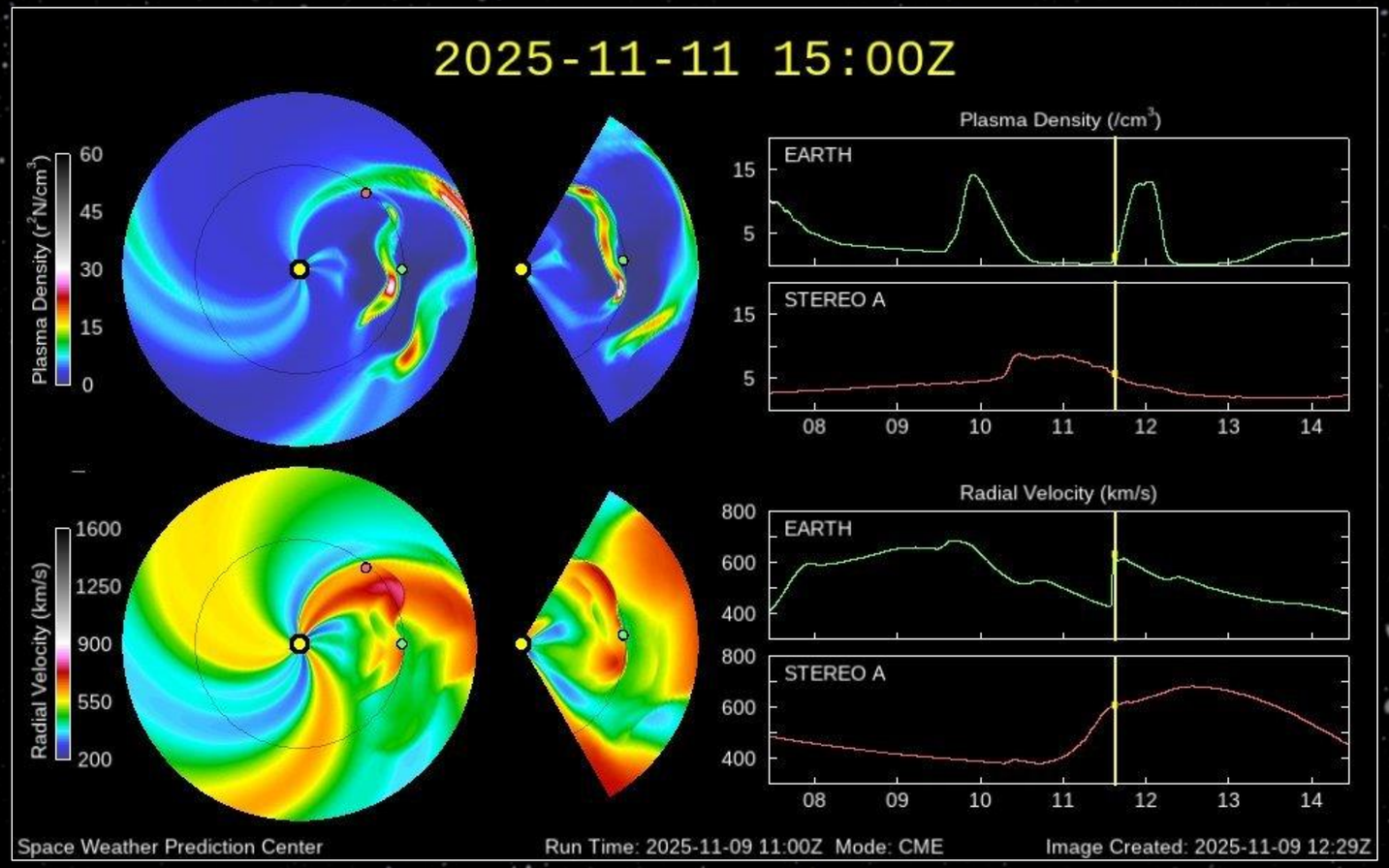
CME Scoreboard

- Arrival times
- KP Range
- Bulk and Impact models

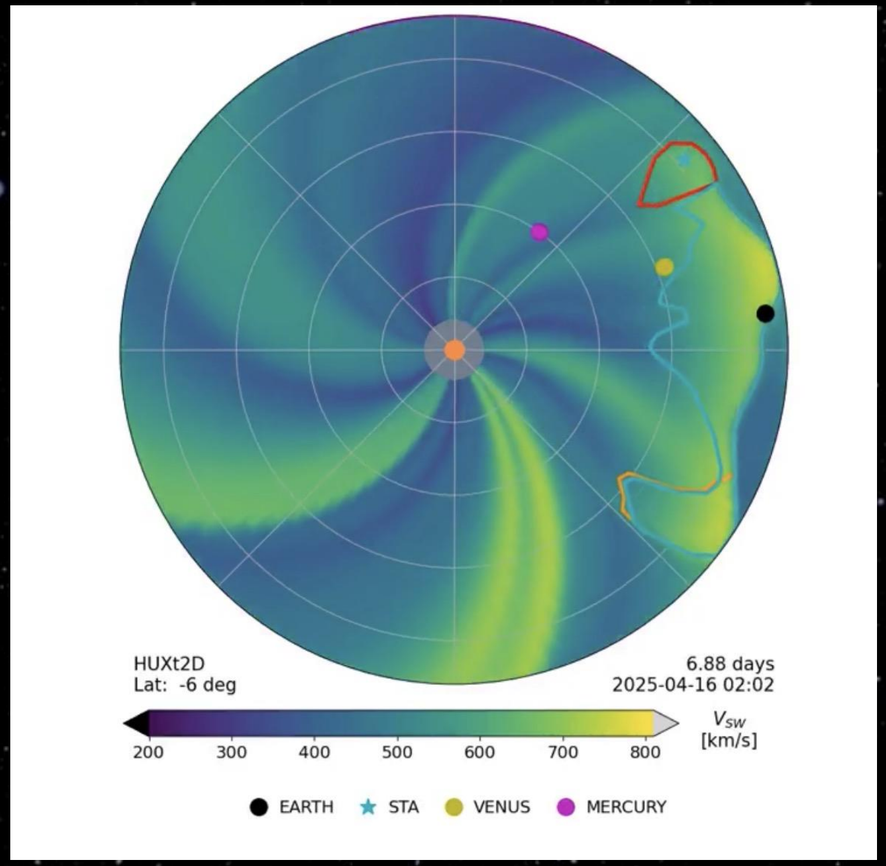


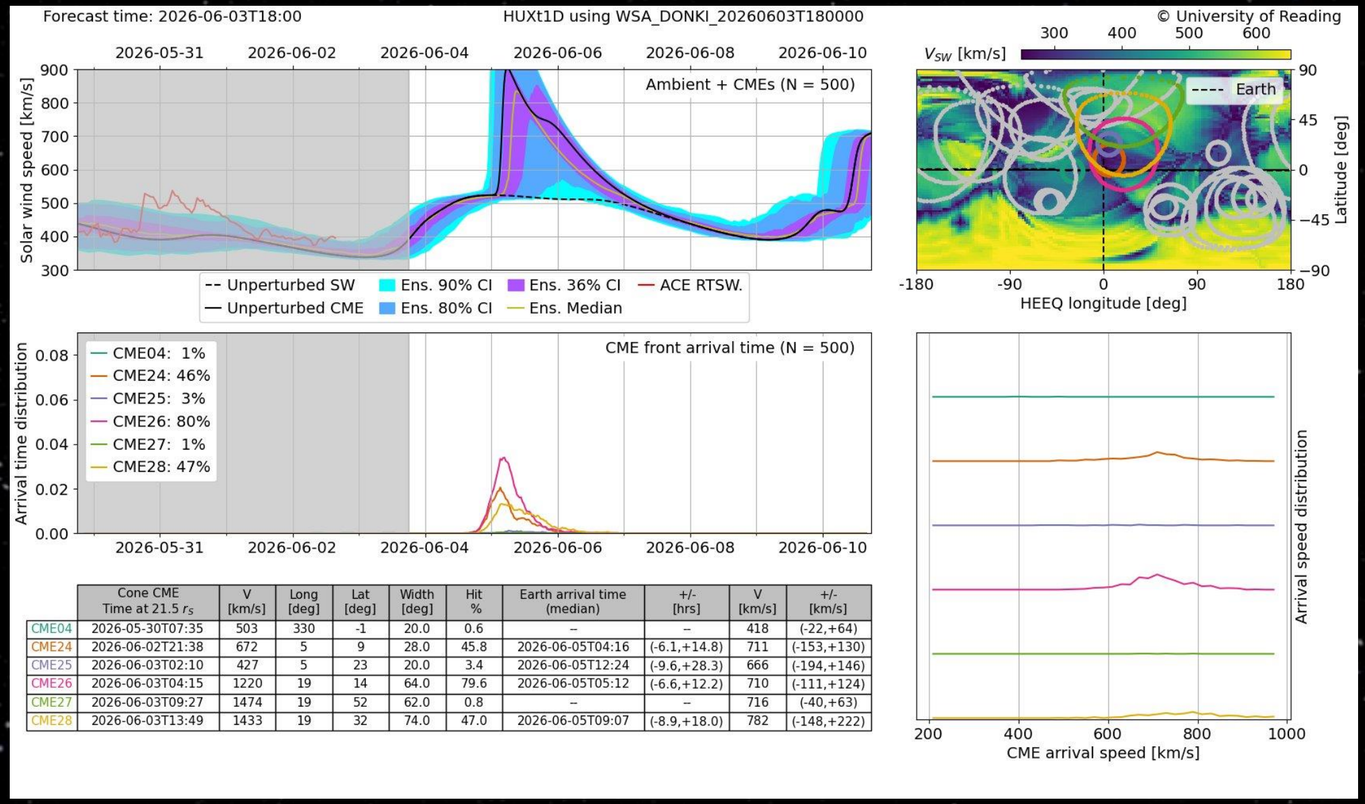
NASA WSA-ENLIL

Coronal holes too!



HUXt





	Cone CME Time at 21.5 r_S	V [km/s]	Long [deg]	Lat [deg]	Width [deg]	Hit %	Earth arrival time (median)	+/- [hrs]	V [km/s]	+/- [km/s]
CME04	2026-05-30T07:35	503	330	-1	20.0	0.6	--	--	418	(-22,+64)
CME24	2026-06-02T21:38	672	5	9	28.0	45.8	2026-06-05T04:16	(-6.1,+14.8)	711	(-153,+130)
CME25	2026-06-03T02:10	427	5	23	20.0	3.4	2026-06-05T12:24	(-9.6,+28.3)	666	(-194,+146)
CME26	2026-06-03T04:15	1220	19	14	64.0	79.6	2026-06-05T05:12	(-6.6,+12.2)	710	(-111,+124)
CME27	2026-06-03T09:27	1474	19	52	62.0	0.8	--	--	716	(-40,+63)
CME28	2026-06-03T13:49	1433	19	32	74.0	47.0	2026-06-05T09:07	(-8.9,+18.0)	782	(-148,+222)

NOAA 3-Day Forecast

Easiest way for beginners to track upcoming potential

Rationale: G1 (Minor) geomagnetic storm levels are expected on 01 Nov due to continued influence from a positive polarity CH HSS.

NOAA Kp index breakdown Nov 01–Nov 03 2026

	Nov 01	Nov 02	Nov 03
00-03UT	3.67	2.67	1.67
03-06UT	3.00	2.33	1.33
06-09UT	4.67 (G1)	2.33	1.33
09-12UT	2.67	2.33	1.33
12-15UT	3.67	2.33	1.33
15-18UT	3.33	2.00	1.67
18-21UT	3.00	2.33	1.67
21-00UT	3.33	2.67	1.33

UTC & Zulu Time

Converting from U.T.C. to...

Eastern Standard Time (EST)	UTC - 5 hours = EST
Central Standard Time (CST)	UTC - 6 hours = CST
Mountain Standard Time (MST)	UTC - 7 hours = MST
Pacific Standard Time (PST)	UTC - 8 hours = PST

When "Daylight Savings Time" is in affect, the conversion becomes...

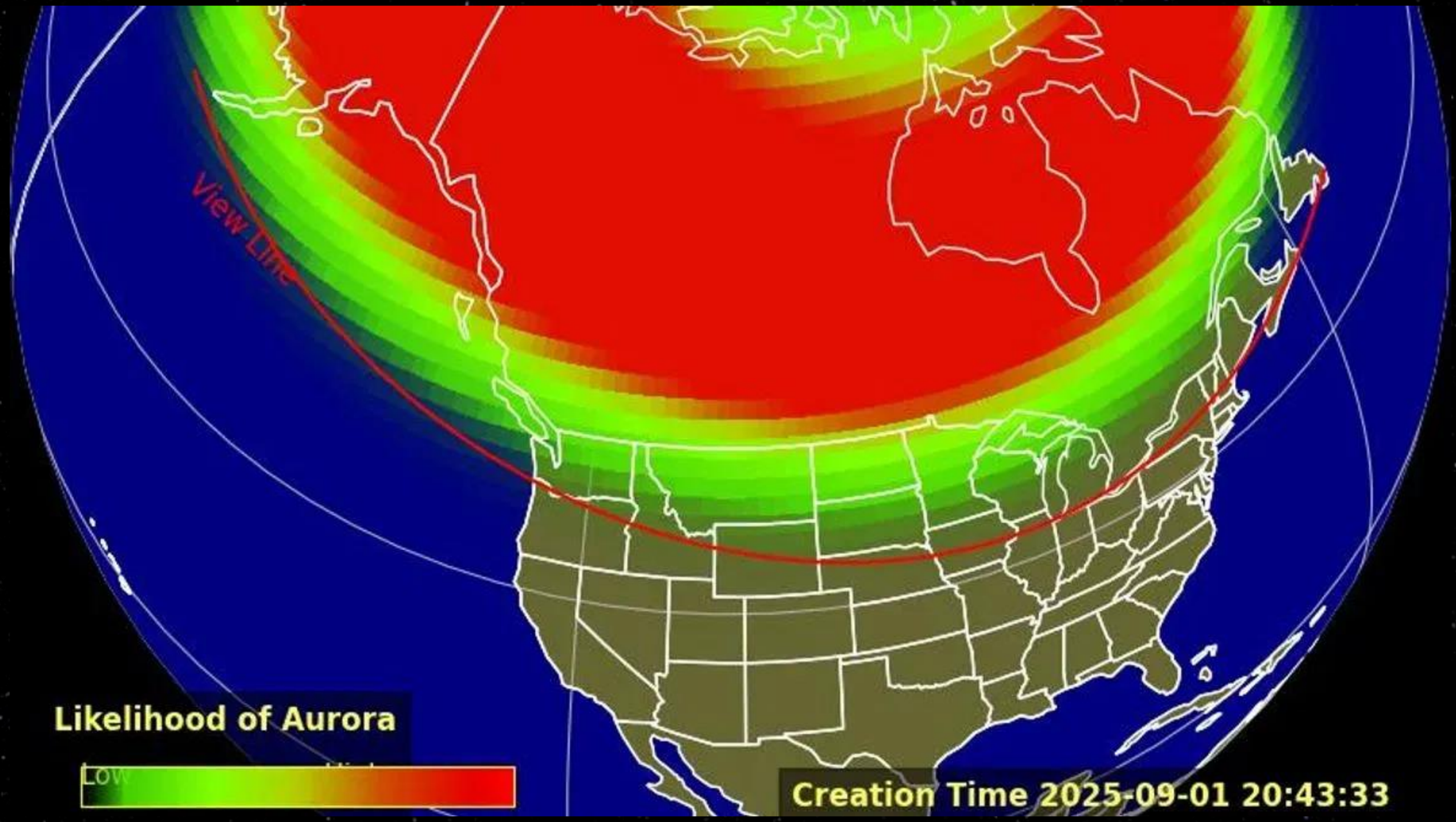
Eastern Daylight Time (EDT)	UTC - 4 hours = EDT
Central Daylight Time (CDT)	UTC - 5 hours = CDT
Mountain Daylight Time (MDT)	UTC - 6 hours = MDT
Pacific Daylight Time (PDT)	UTC - 7 hours = PDT

Department of Atmospheric Sciences
University of Illinois Urbana Champaign

Eastern Time Zone:

UTC (Coordinated Universal Time)	EDT (Eastern Daylight Time)	EST (Eastern Standard Time)
00:00	8:00 PM	7:00 PM
01:00	9:00 PM	8:00 PM
02:00	10:00 PM	9:00 PM
03:00	11:00 PM	10:00 PM
04:00	12:00 AM	11:00 PM
05:00	1:00 AM	12:00 AM
06:00	2:00 AM	1:00 AM
07:00	3:00 AM	2:00 AM
08:00	4:00 AM	3:00 AM
09:00	5:00 AM	4:00 AM
10:00	6:00 AM	5:00 AM
11:00	7:00 AM	6:00 AM
12:00	8:00 AM	7:00 AM
13:00	9:00 AM	8:00 AM
14:00	10:00 AM	9:00 AM
15:00	11:00 AM	10:00 AM
16:00	12:00 PM	11:00 AM
17:00	1:00 PM	12:00 PM
18:00	2:00 PM	1:00 PM
19:00	3:00 PM	2:00 PM
20:00	4:00 PM	3:00 PM
21:00	5:00 PM	4:00 PM
22:00	6:00 PM	5:00 PM
23:00	7:00 PM	6:00 PM

View Line Maps

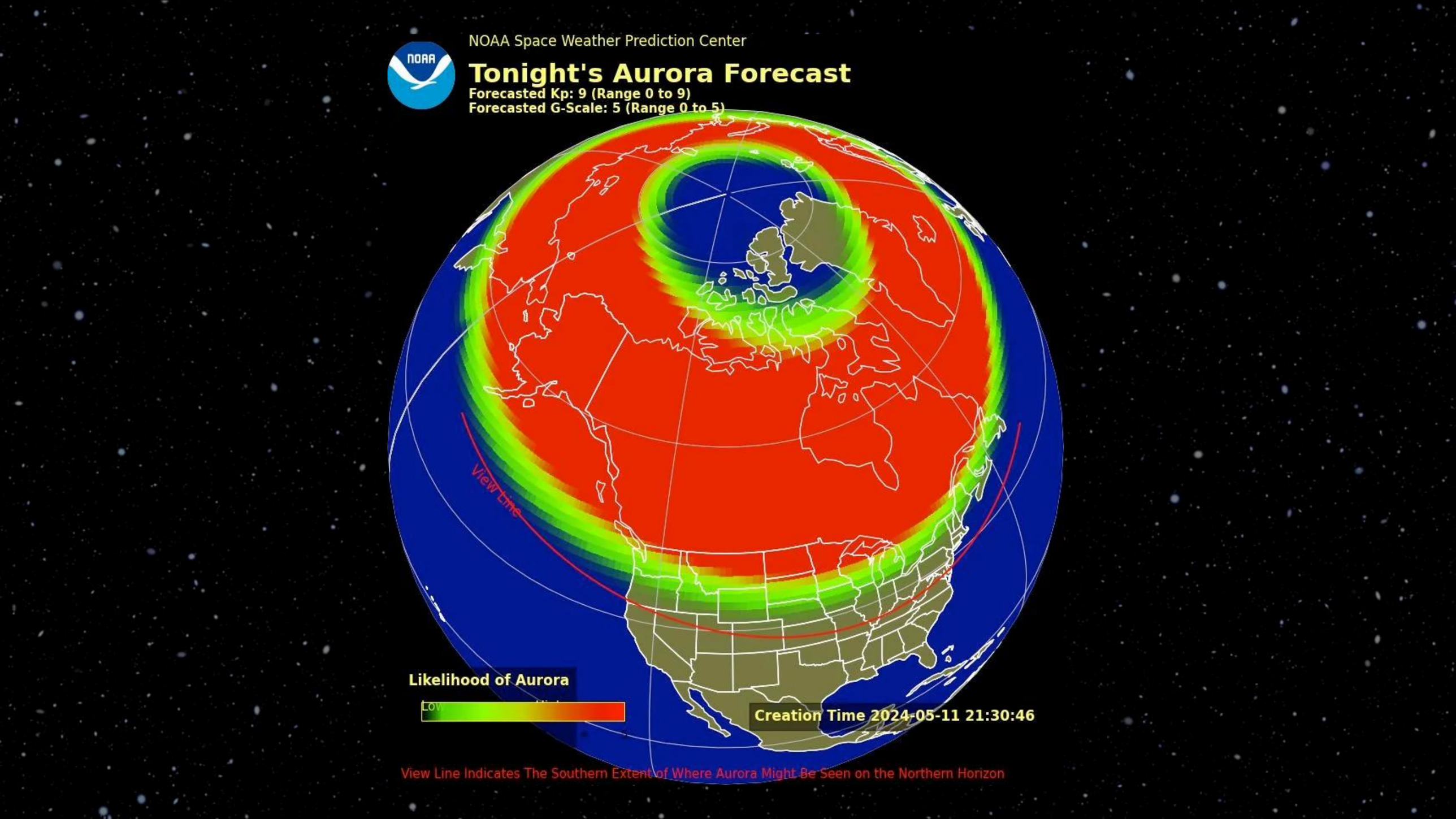


Don’t Miss Out!

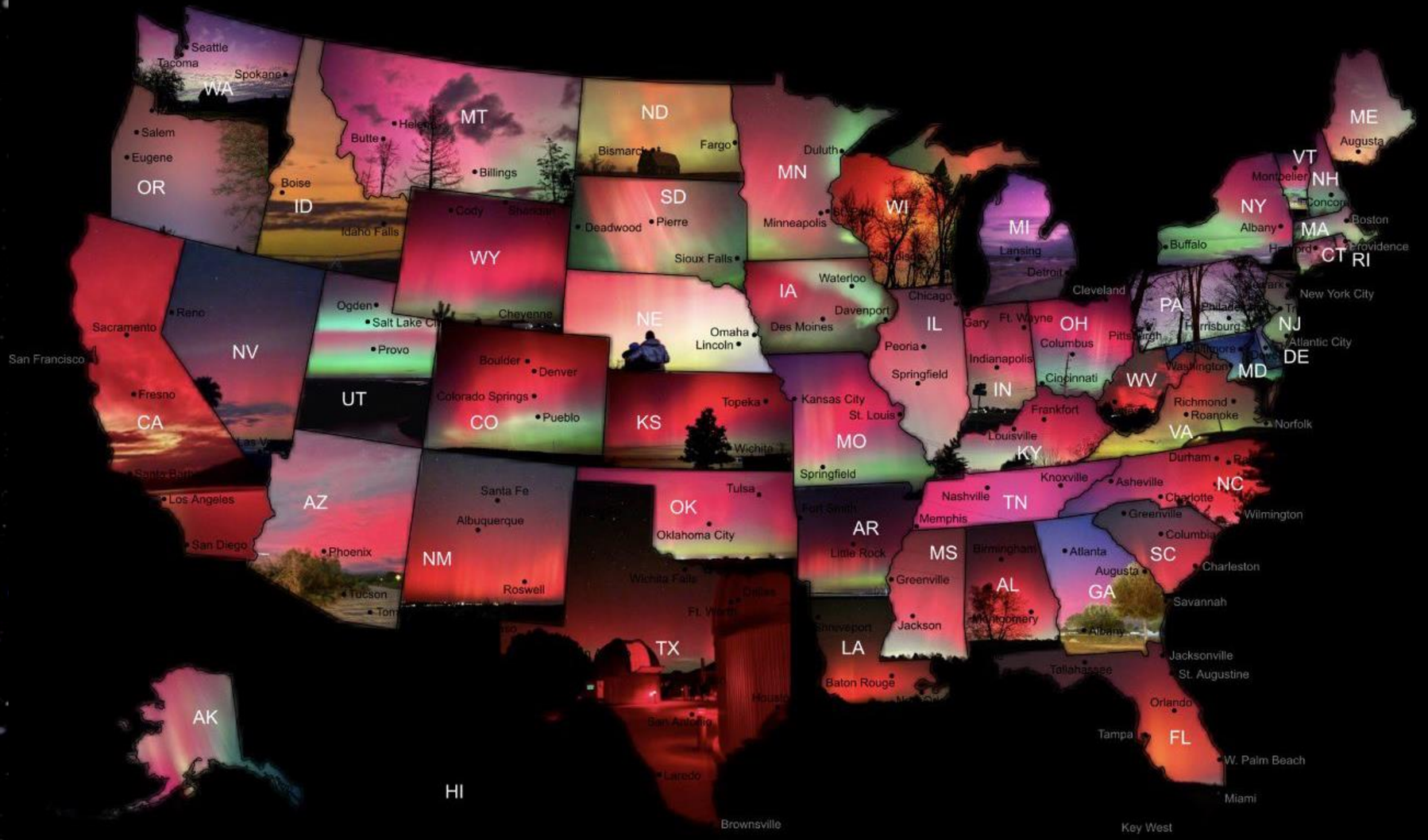
- Viewline maps help create the misconception that you need extremely strong storms to send aurora to southern states
- Tennessee has seen naked eye aurora during G2 storms
- Florida can capture G3’s



Isaiah Montgomery


NOAA Space Weather Prediction Center
Tonight's Aurora Forecast
Forecasted Kp: 9 (Range 0 to 9)
Forecasted G-Scale: 5 (Range 0 to 5)
View Line
Likelihood of Aurora
Creation Time 2024-05-11 21:30:46
View Line Indicates The Southern Extent of Where Aurora Might Be Seen on the Northern Horizon

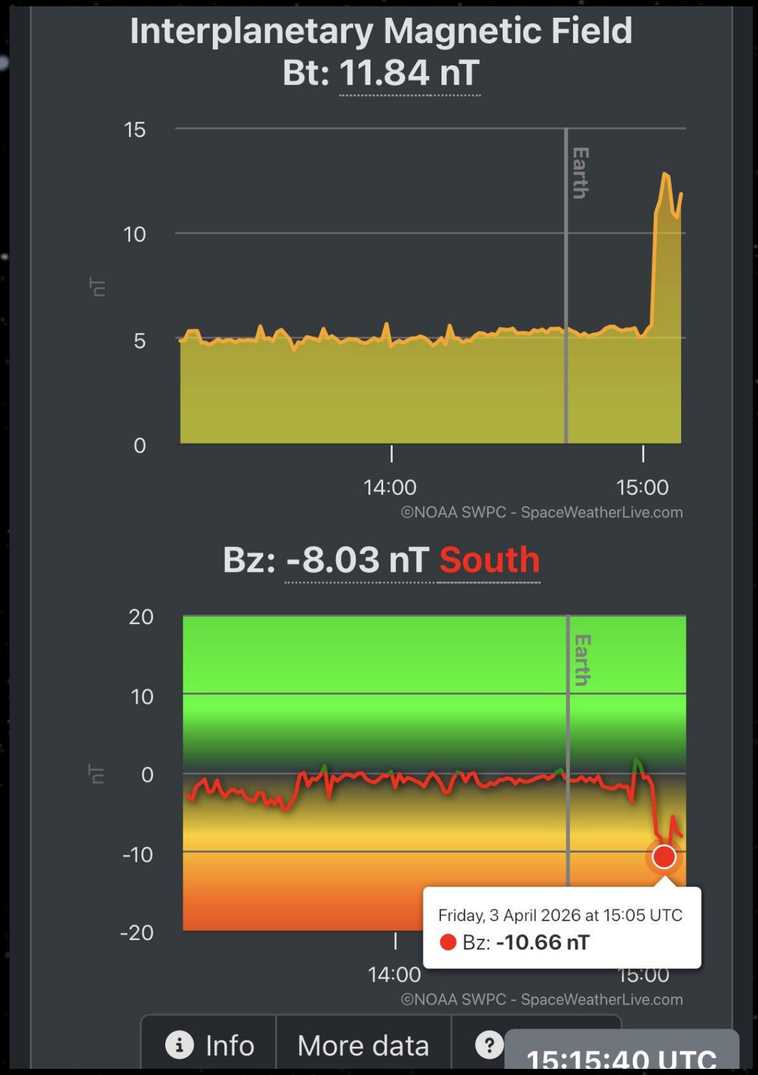
United States of Aurora



Chris Wicklund

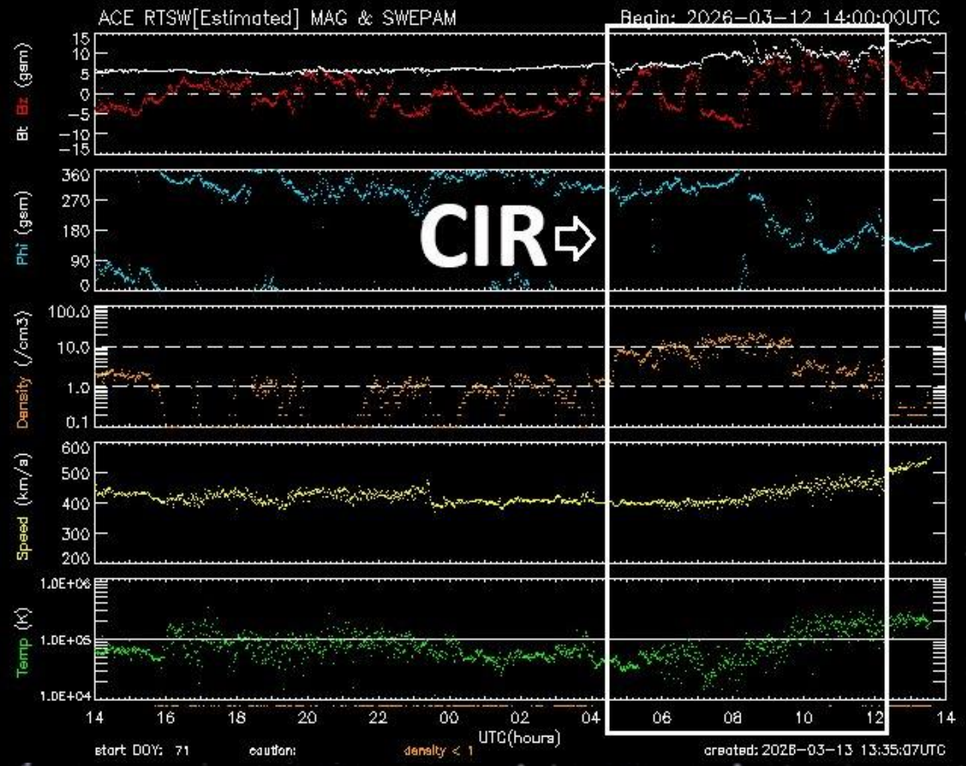
The Next Steps

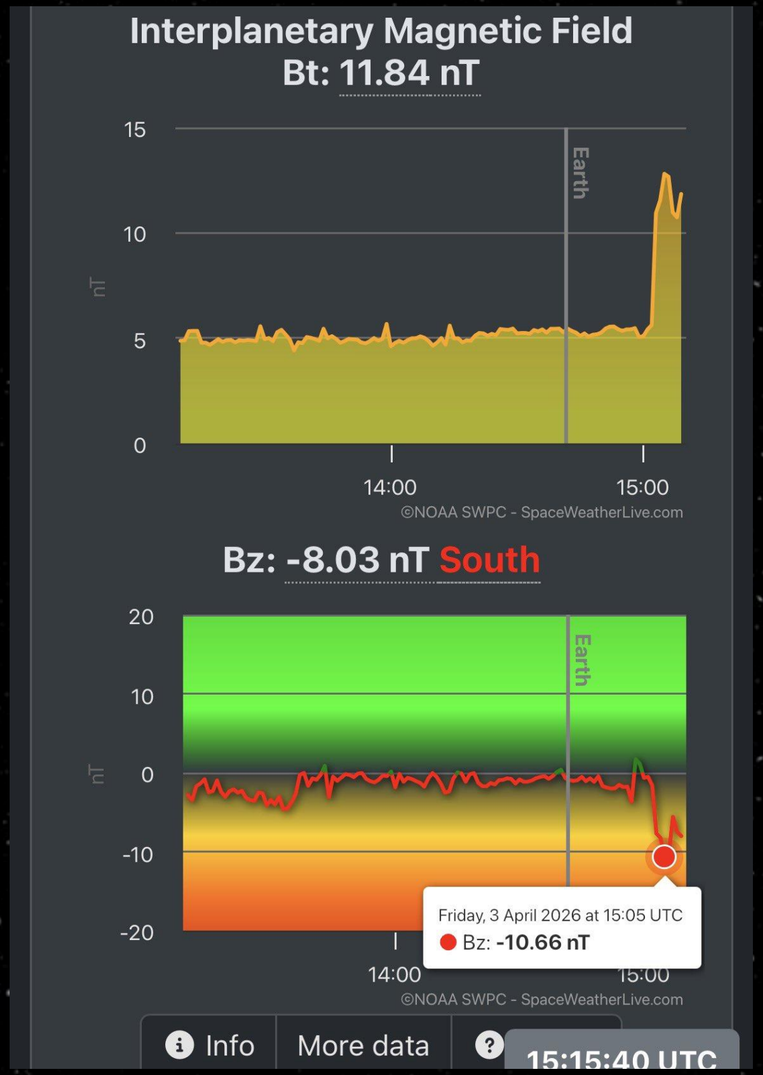
- Temper expectations
- Monitor impact signature
- Set impact notifications via SWL or Glendale
- Charge those camera batteries!



Impact Signatures

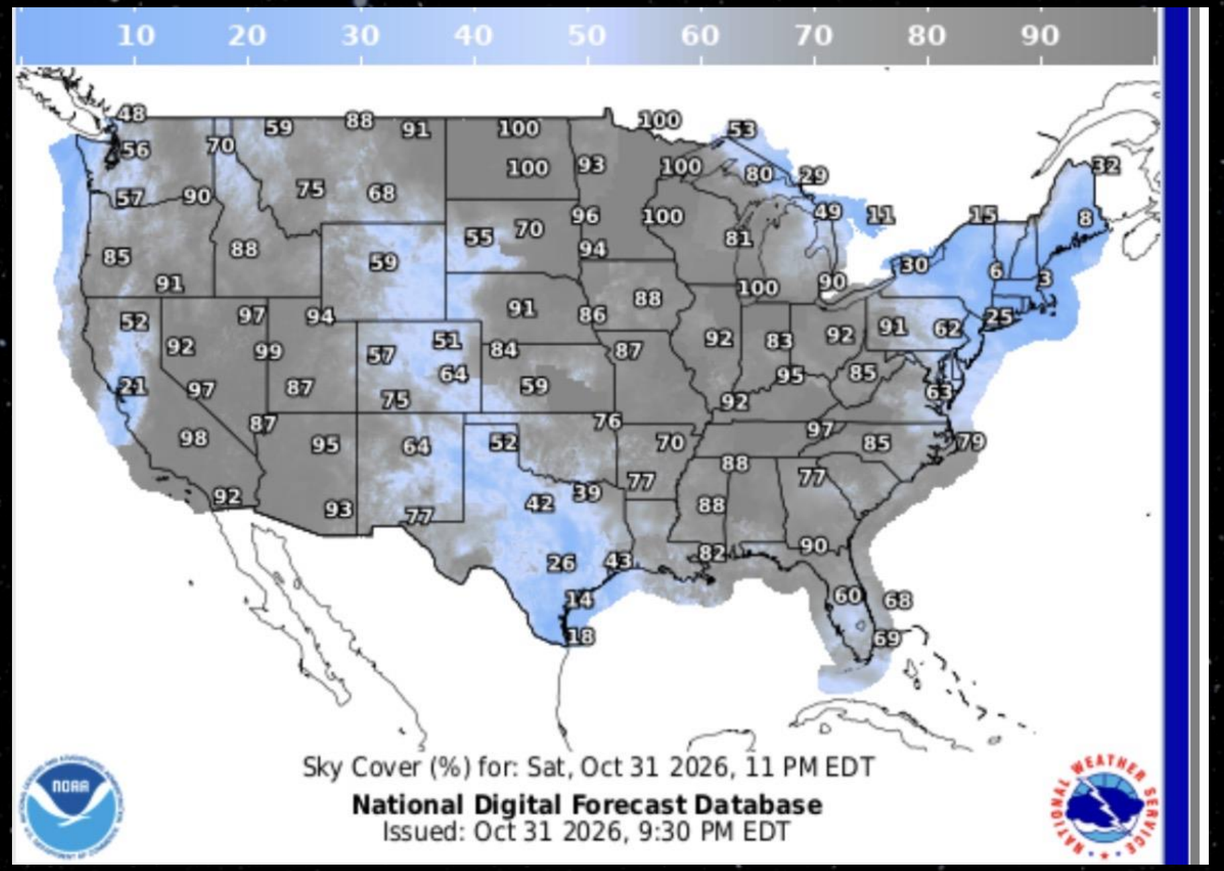
- CMEs: hard spikes or drops
- Coronal holes: gradual ramp up





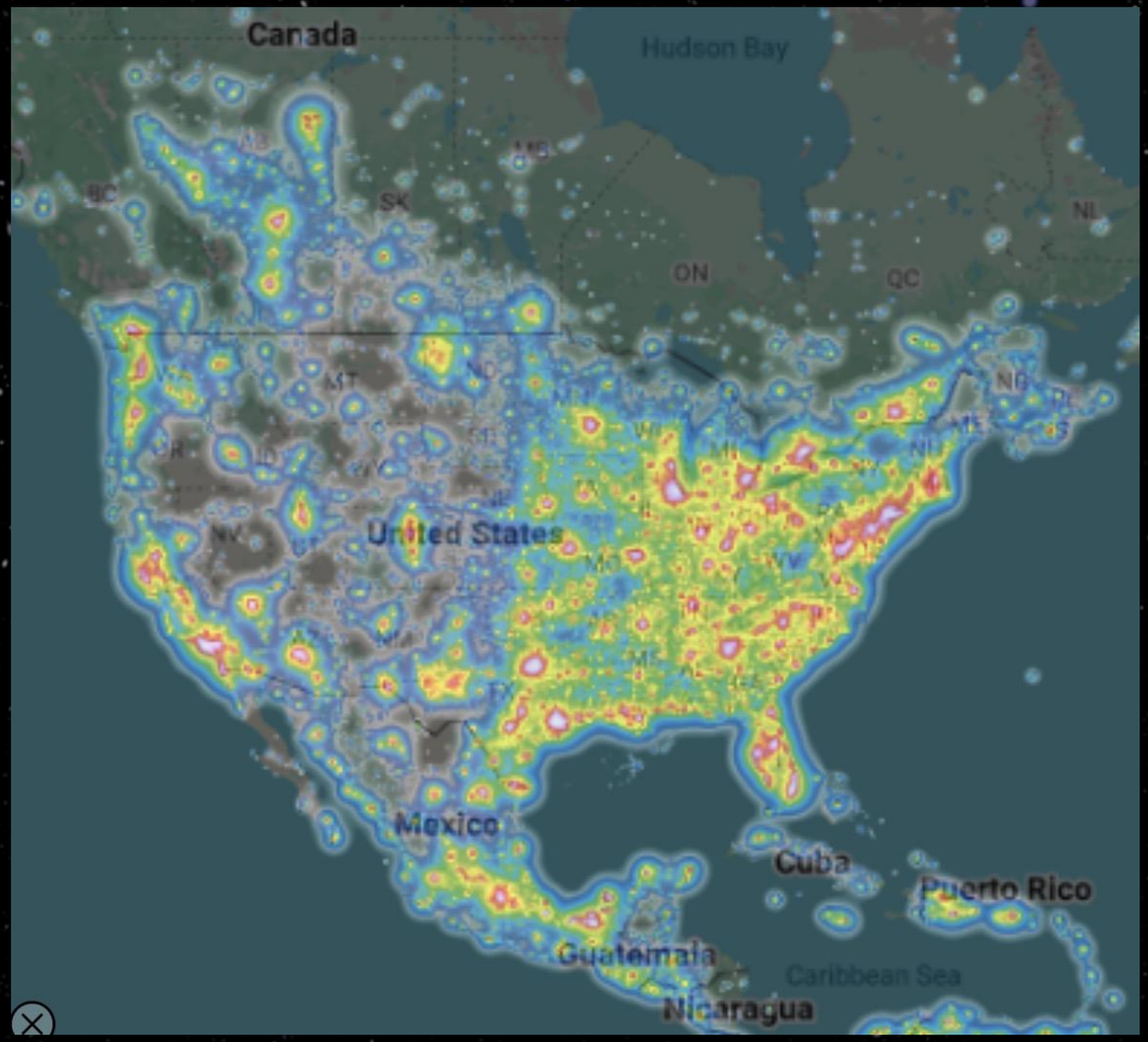
Check for Clouds!

- NOAA Graphical Forecast
- Pivotal Weather
  HRRR, RDPS, HRDPS
- GOES East
- SatSquatch
- Astropheric



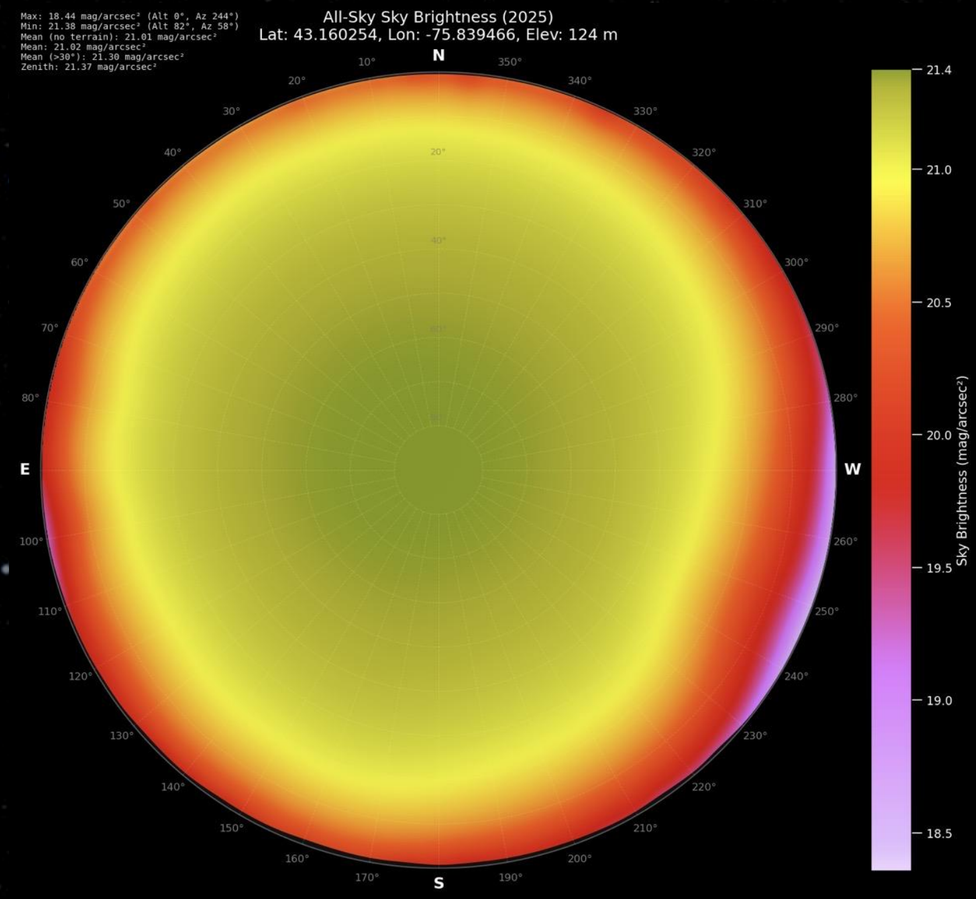
Light Pollution

- Aim for as dark of skies as possible
- Light pollution maps



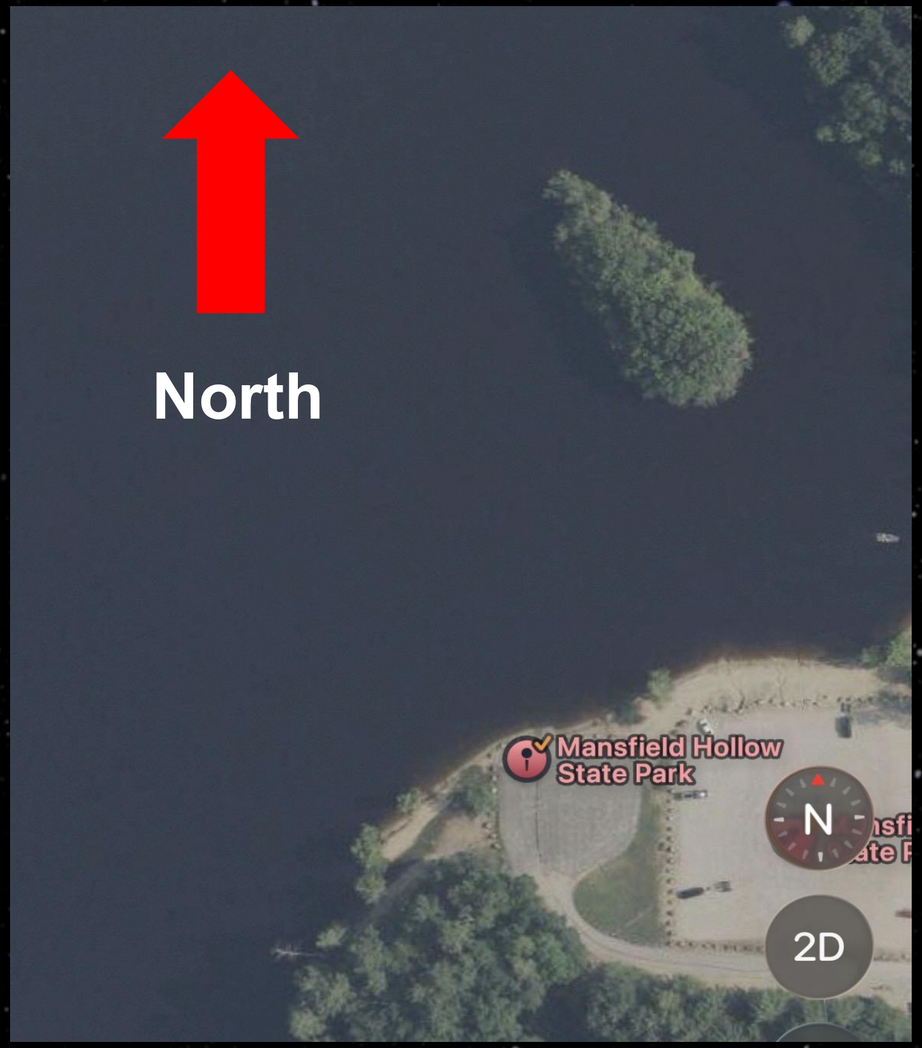
Light Pollution

- All-sky
- LightPollutionMap.info



Location Choice

- Clear, unobstructed view of the northern horizon
- Avoid bright streetlights or buildings
- Avoid shooting through trees
- NORTH FACING BOAT LAUNCHES!

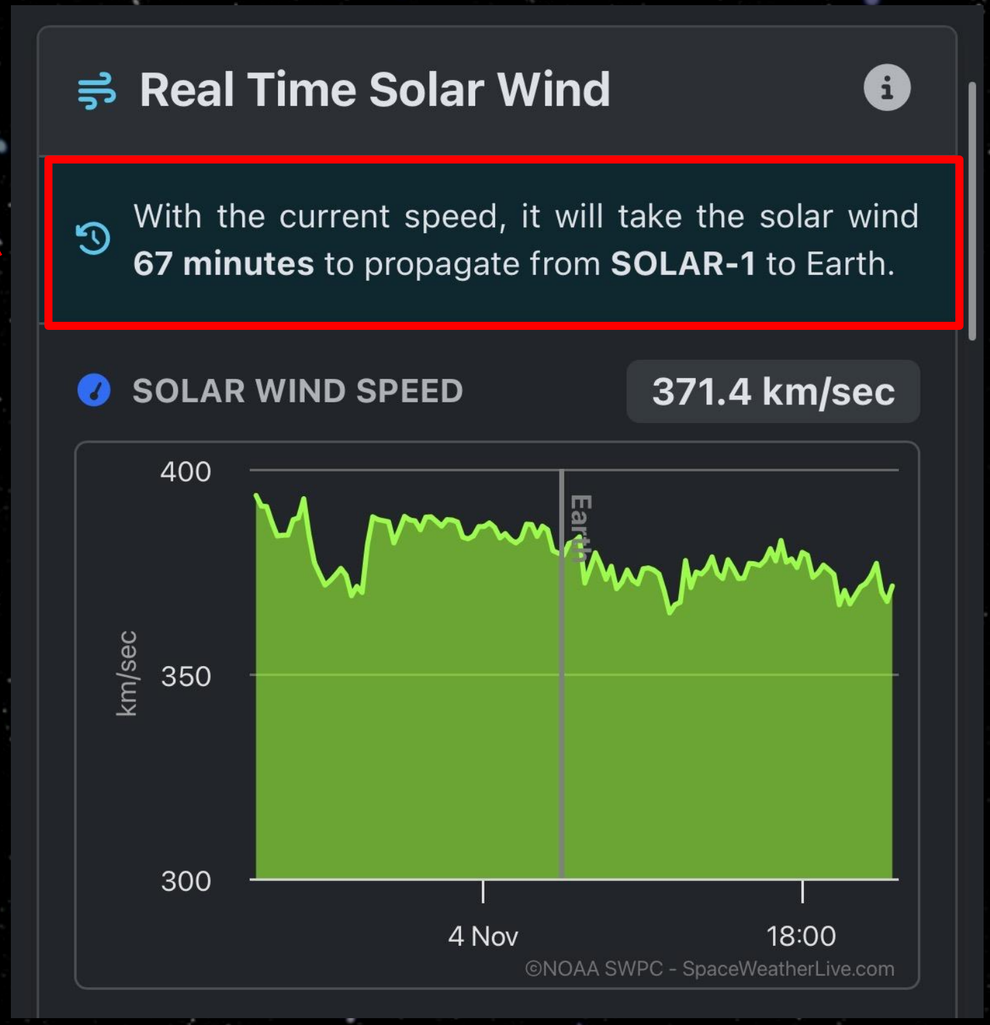


So Far, We've Learned!

- What causes aurora
- How to track solar flares, coronal mass ejections, and solar wind
- How to read aurora forecast models
- Cloud forecasting
- Location choice

IMPACT! What Now?

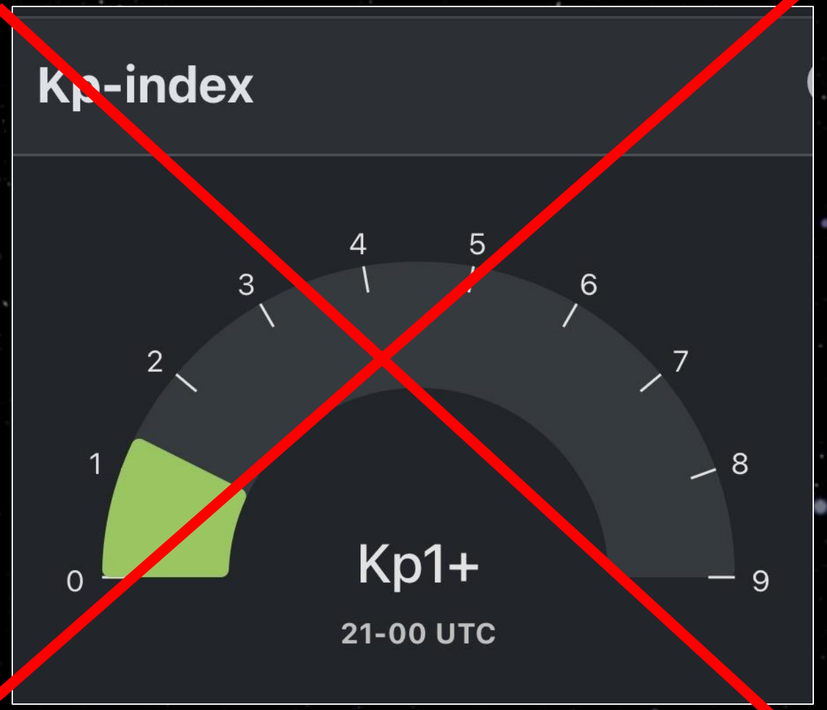
- A CME has arrived at L1
- Solar wind takes time!
- Pay close attention to real-time data
- Data can flip quickly



Don’t Do This:

- Use Kp, % chance, or aurora maps to <u>decide</u> whether to go out or not
- NOT REAL TIME

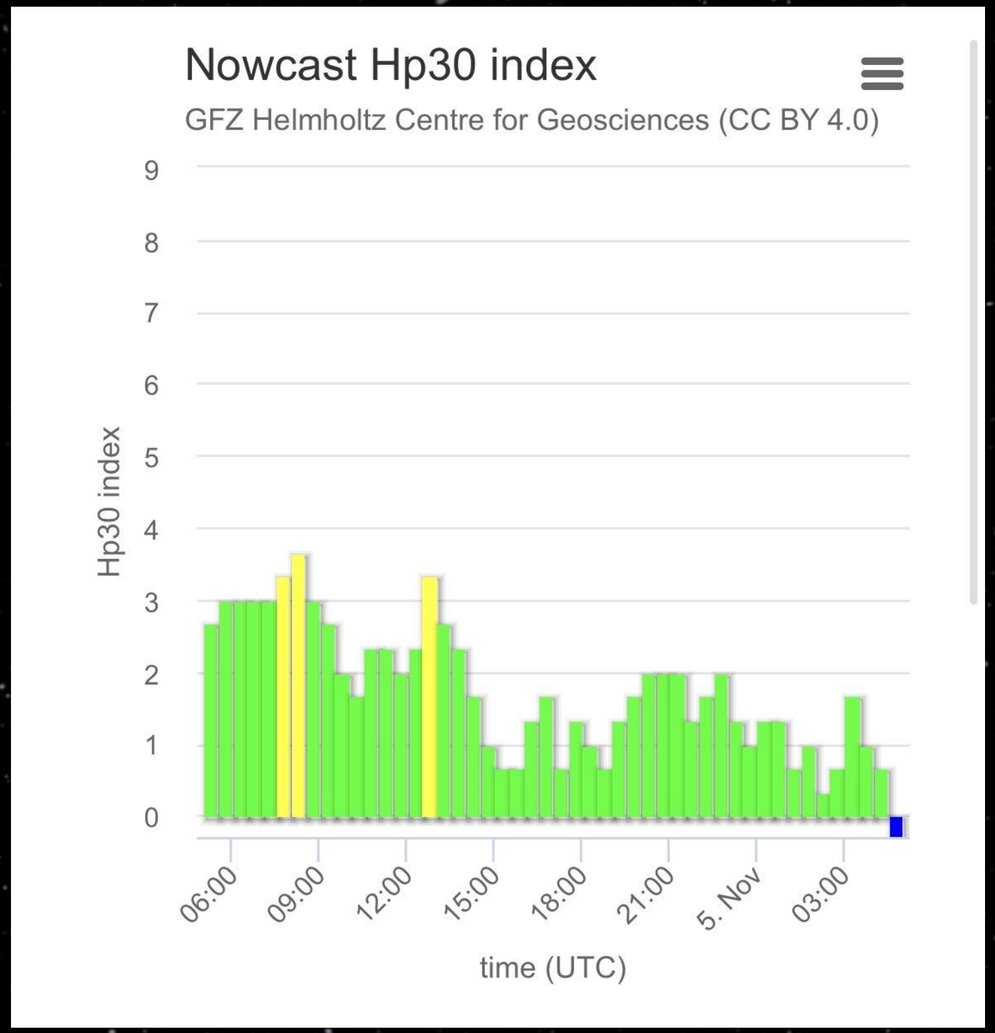






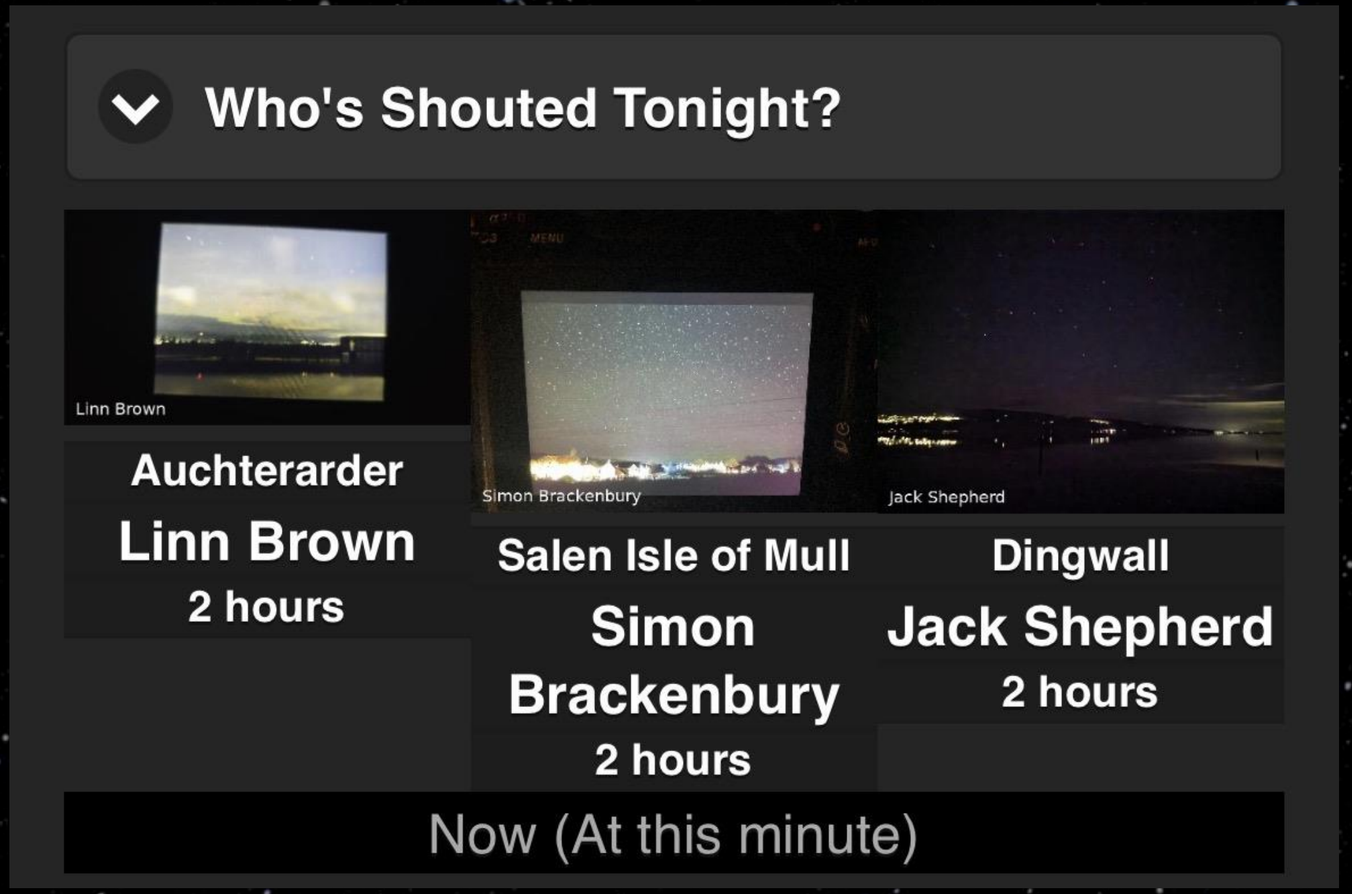
Substitute Kp with HP

- HP 30
- HP 60



Do This Instead:

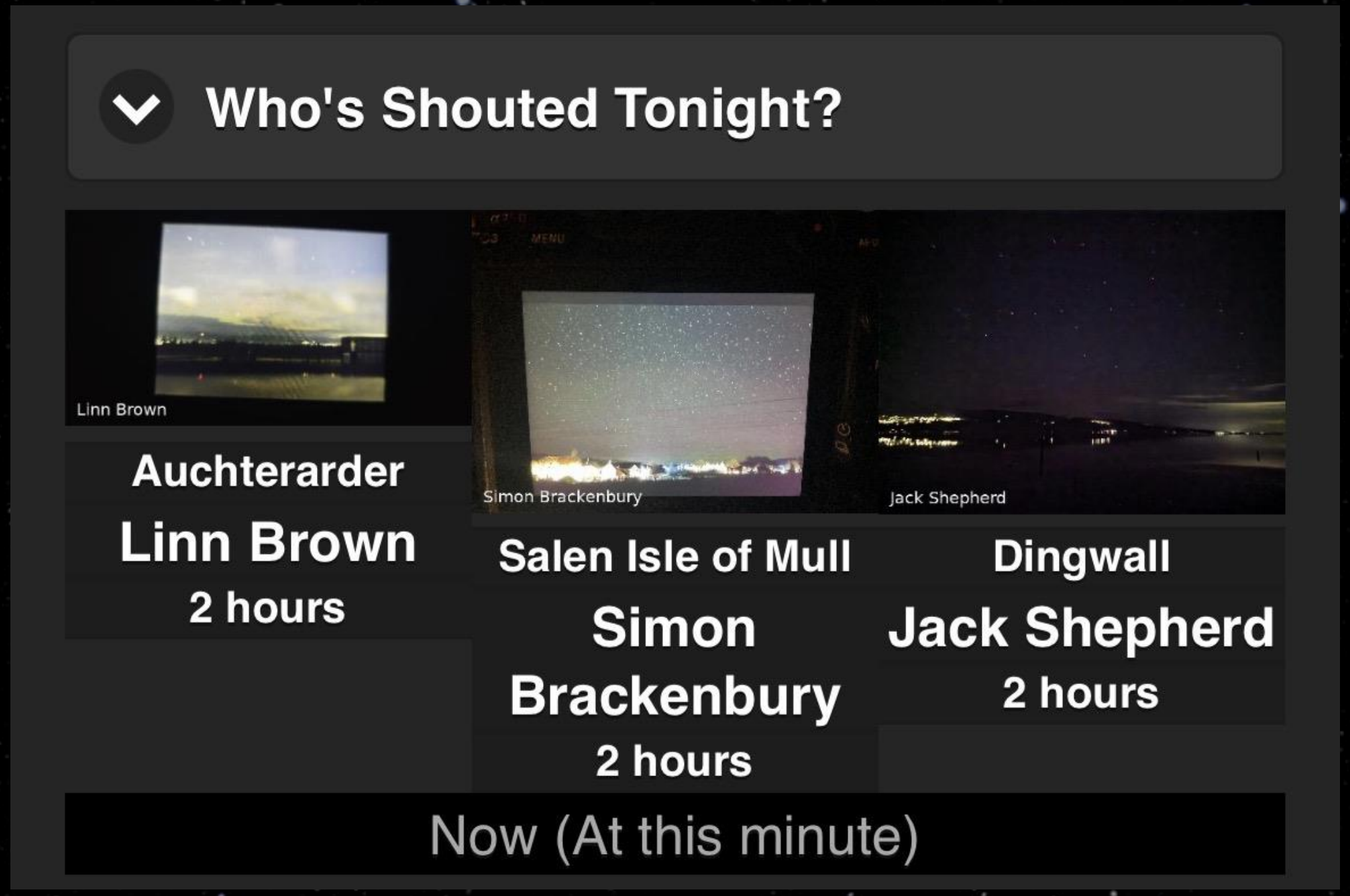
- Watch real-time data
- Track real-time reports
- Track substorms
- Watch webcams



Real Time Data

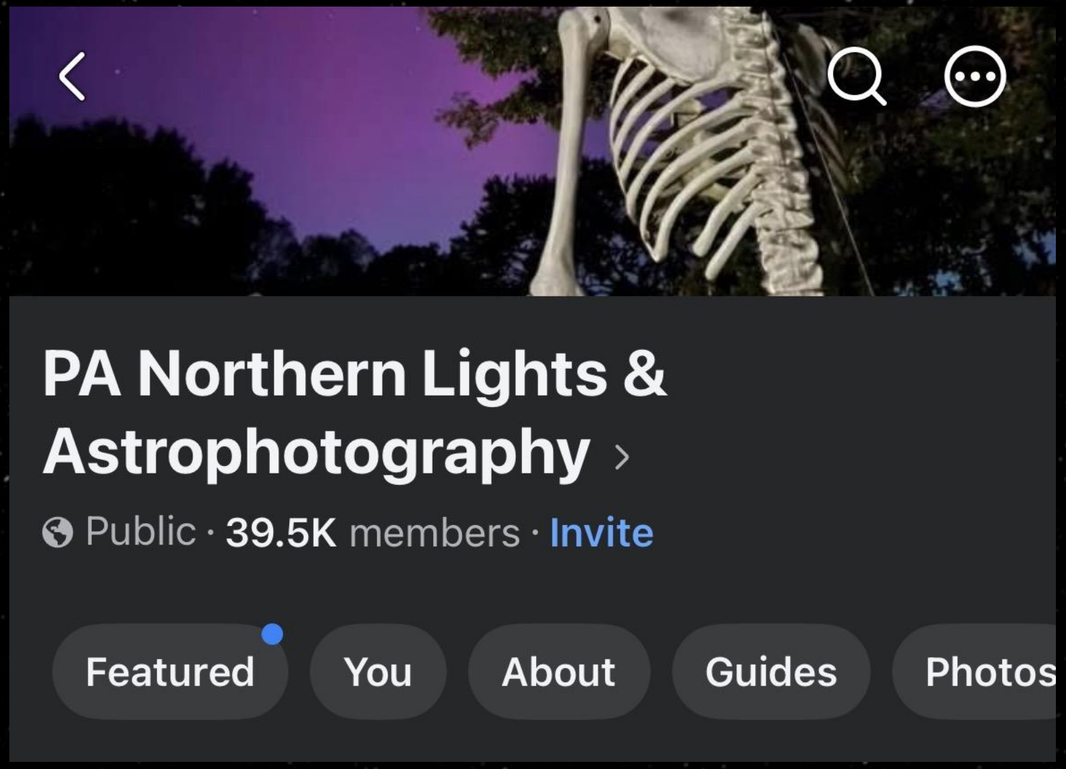
- Bz in a southward position < -10
- Solar winds > 450 km/s
- Bt > 10
- Density > 10

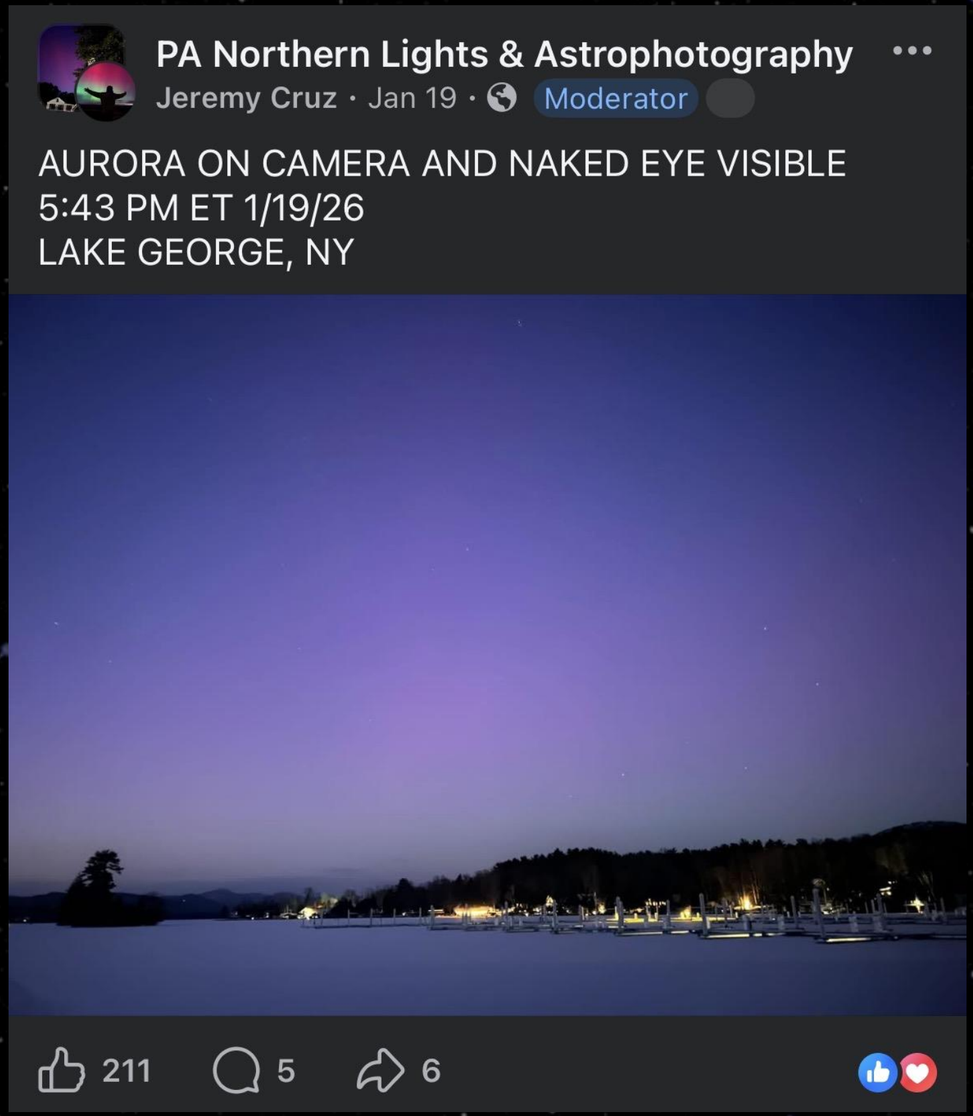
- Reality: data is complex
- Can never predict visibility 100%



Join Aurora Communities!

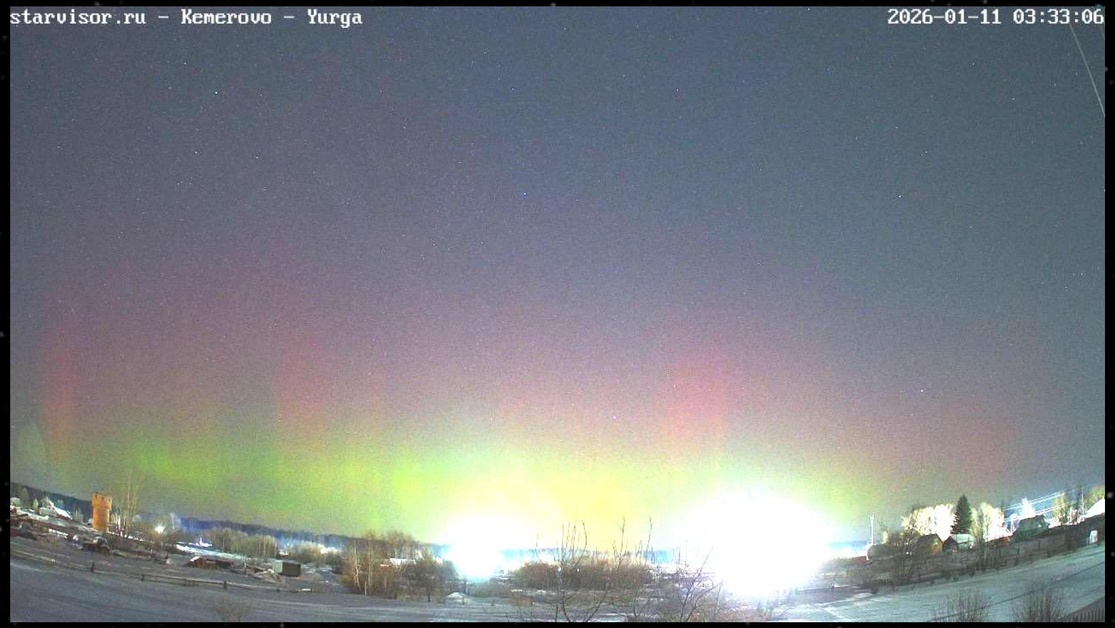
- Local
- International

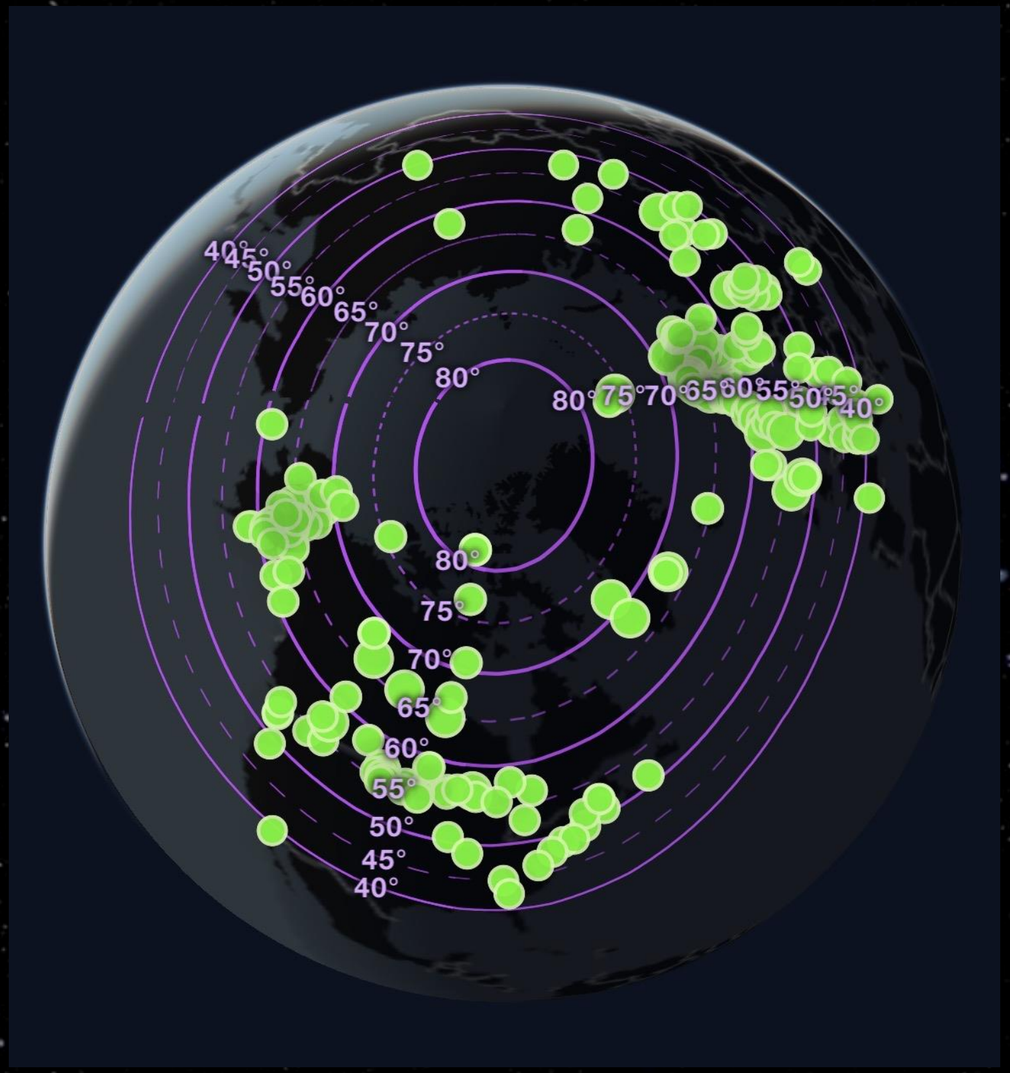




Follow Webcams!

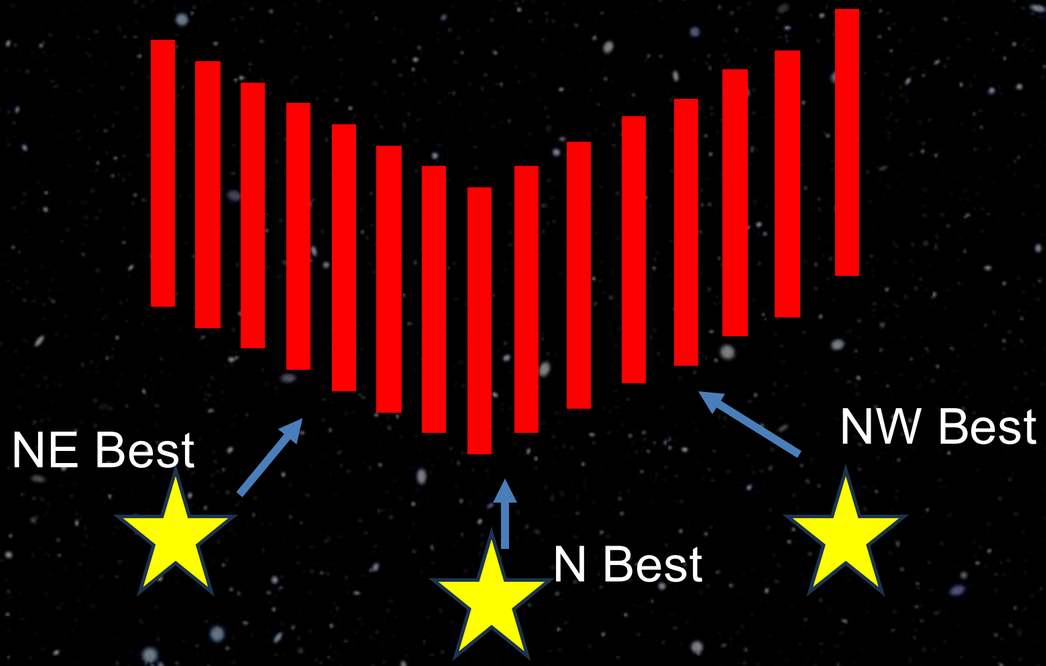
- #1 tool for aurora chasing!
- Tutorial

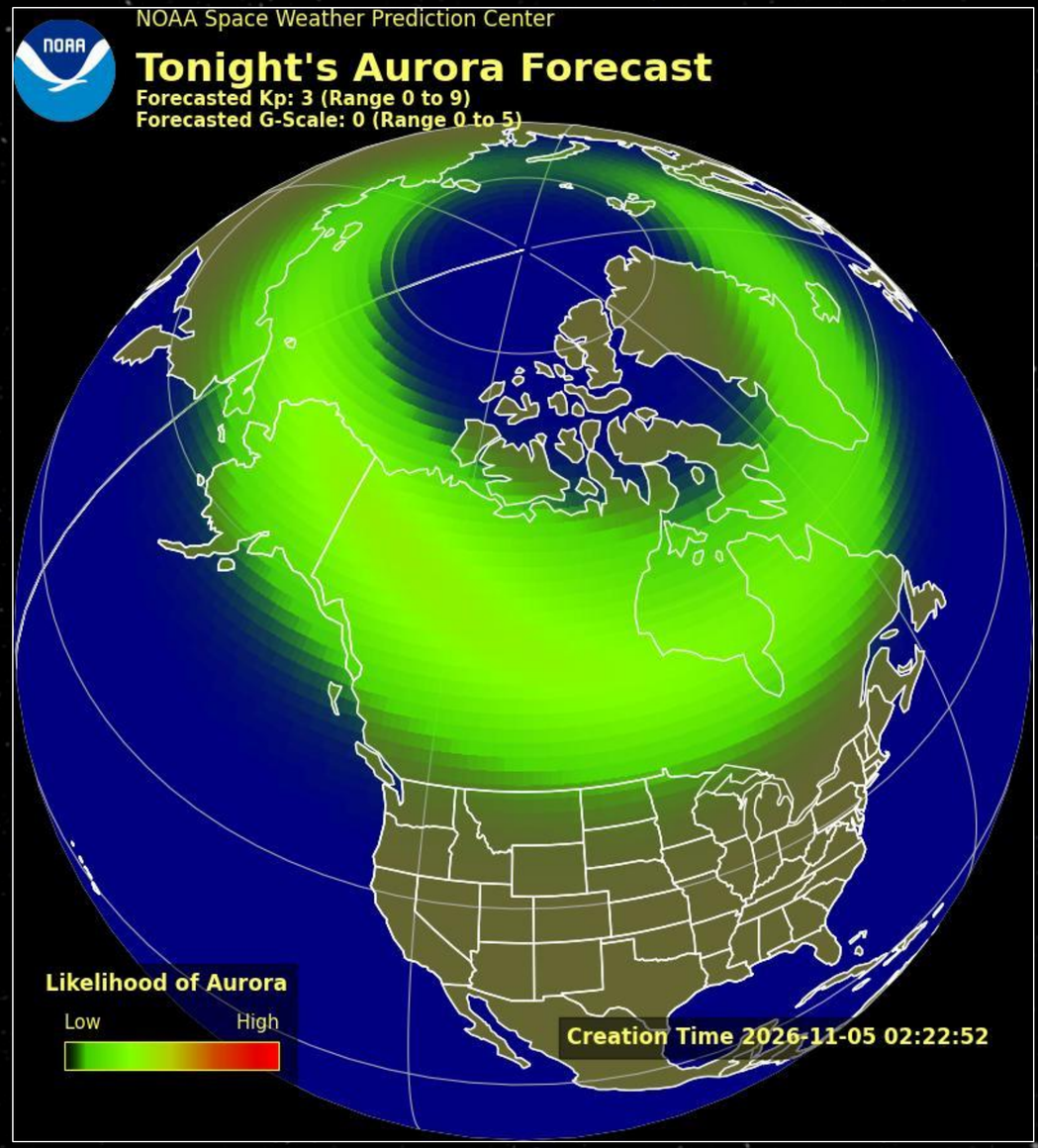




Geomagnetic Latitude

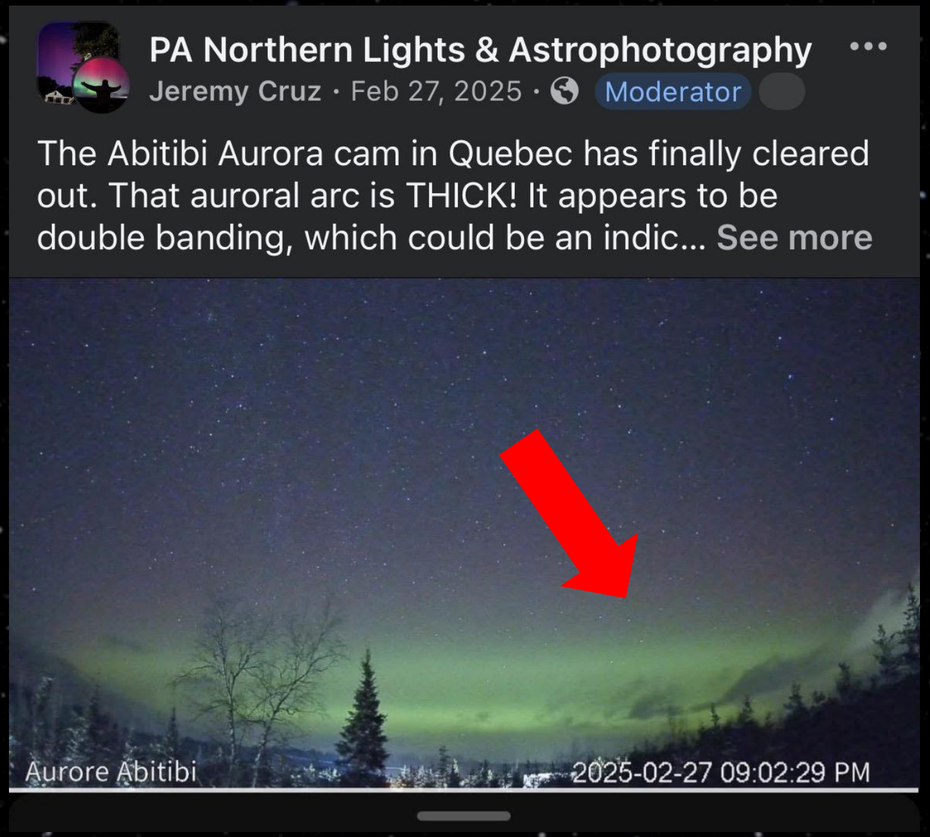
- Same latitude ≠ same aurora
- Aurora oval dips over central U.S.

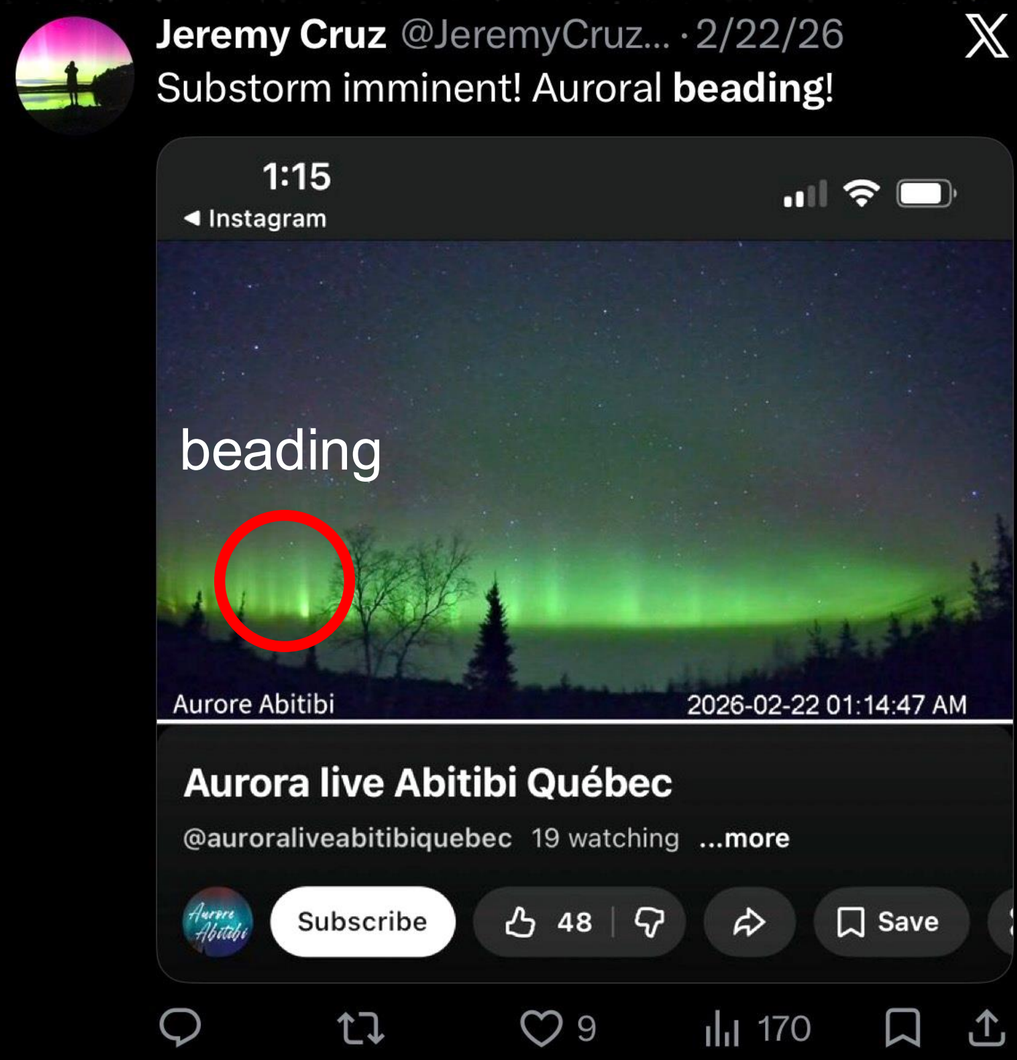




Follow Webcams!

- Identifying substorm indicators



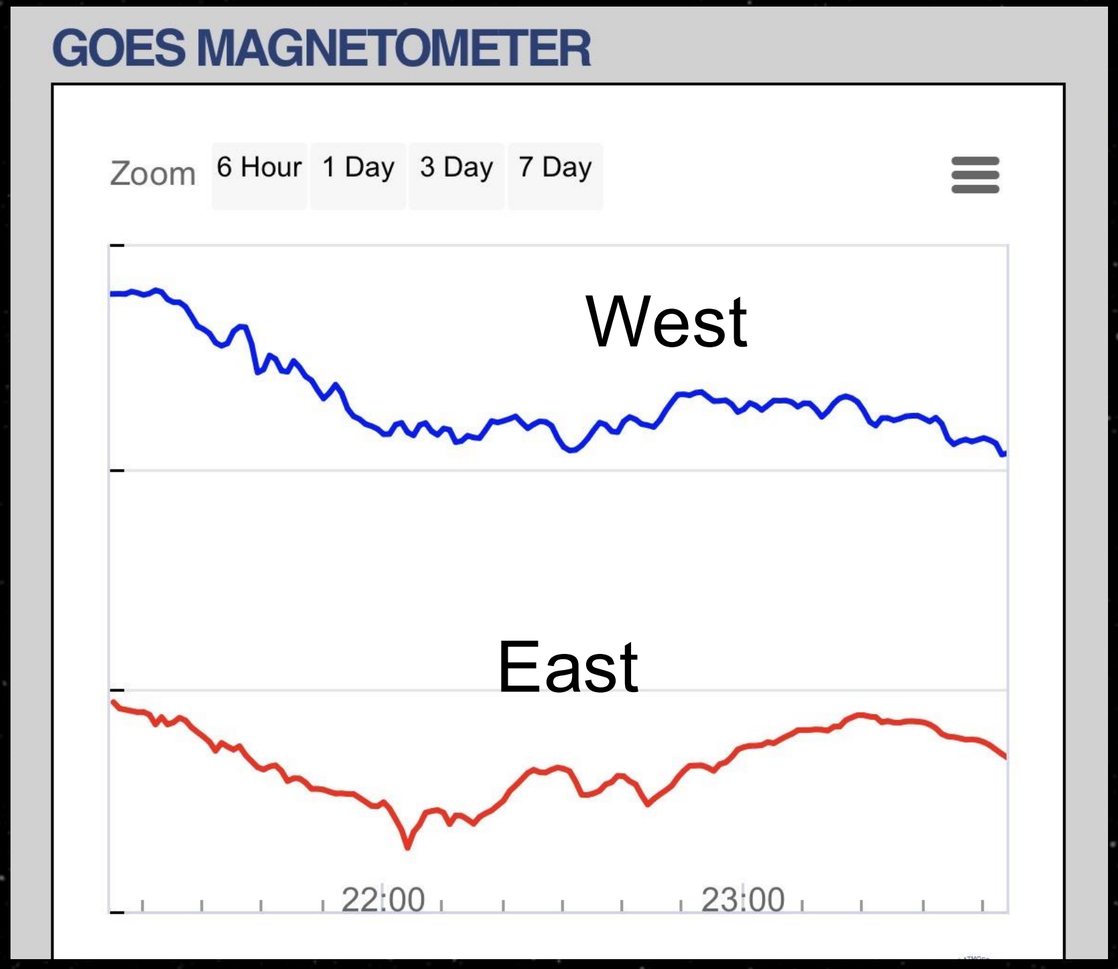


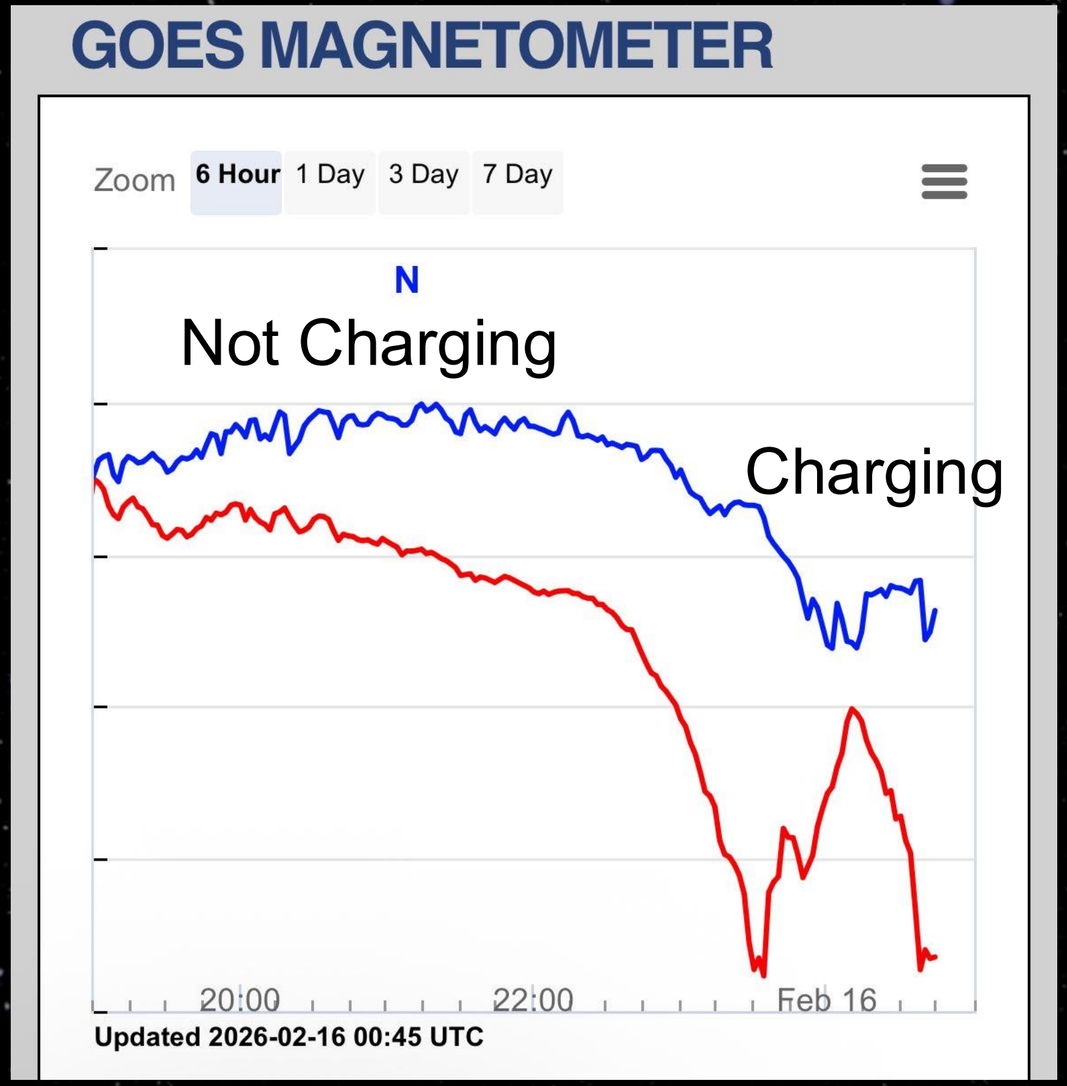
Substorms!

- Poleward expansion of aurora, aka expansion phase
- Rubber band/Water Balloon
- Sometimes +Bz is necessary!



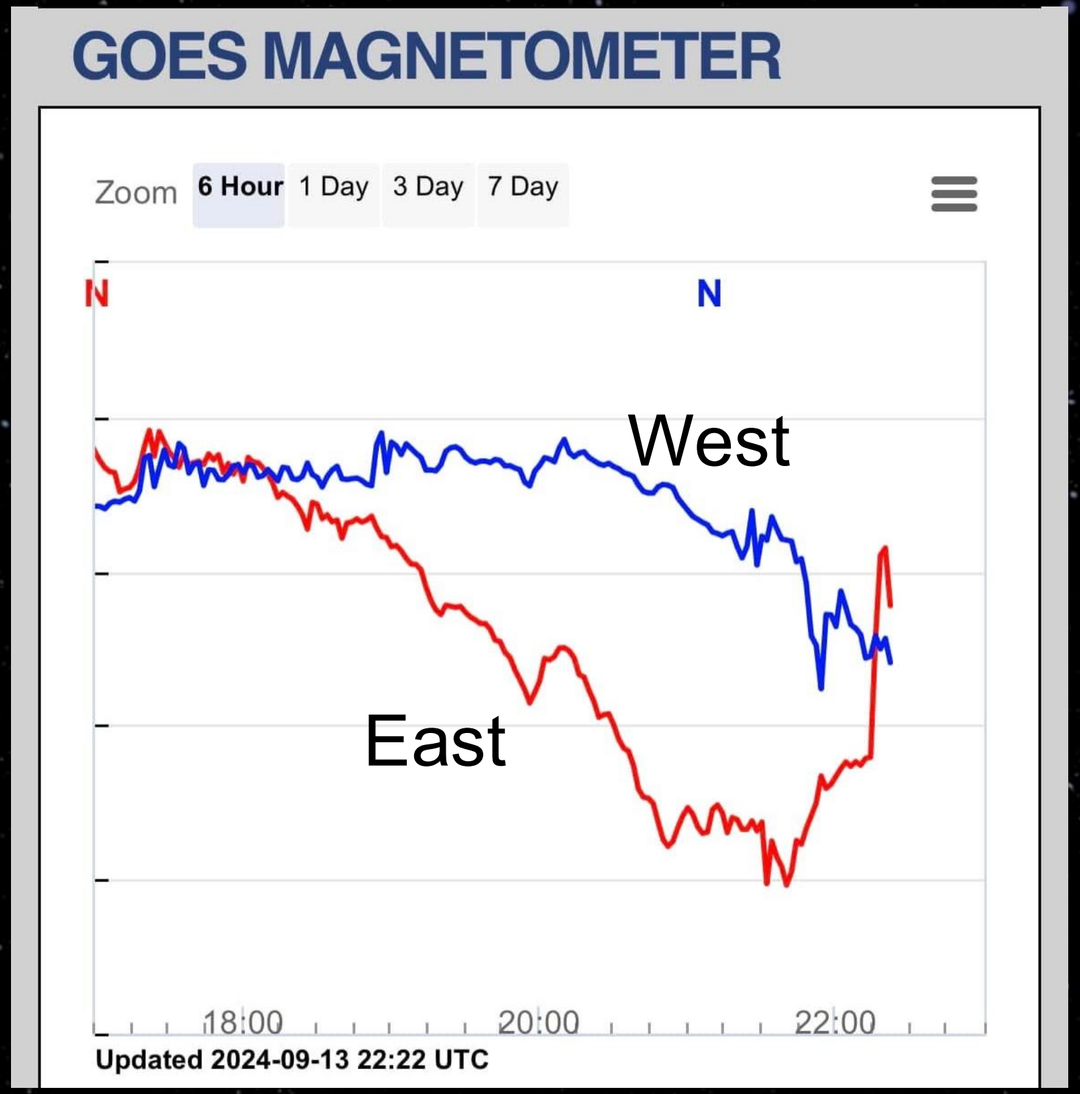
Monitor Substorms Via GOES



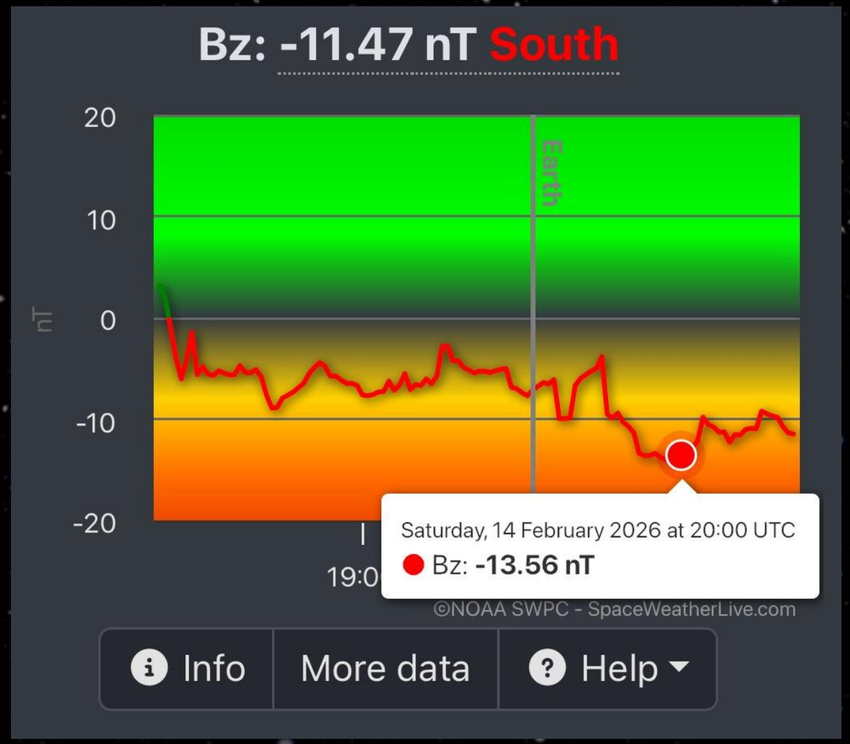


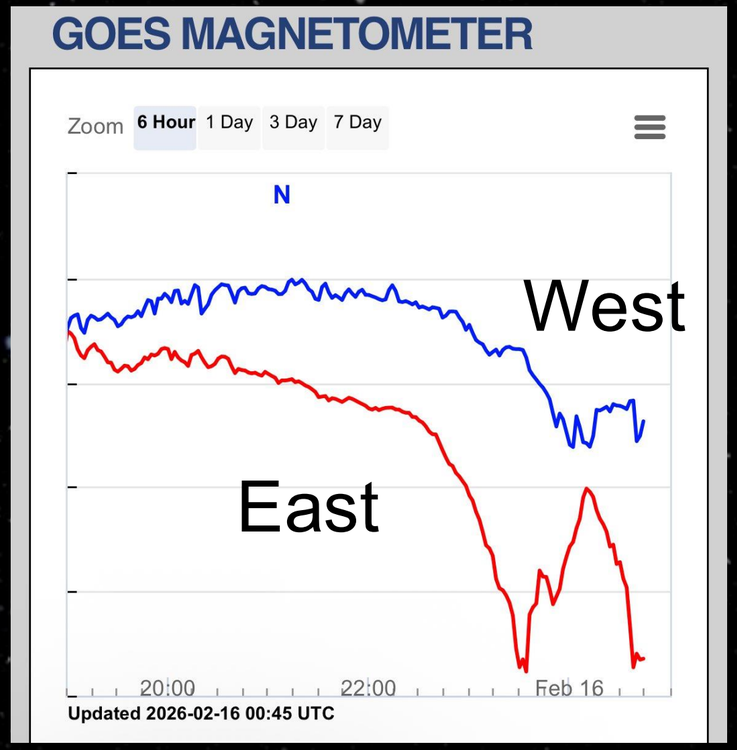
Substorm Propagation

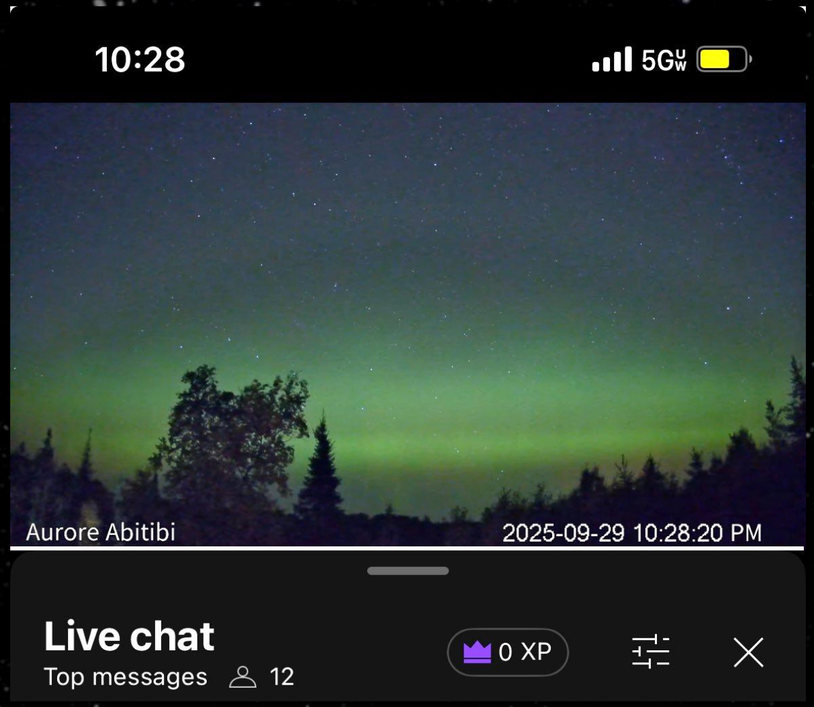
- Energy is not uniform!
- Auroral arc can be quiet on one side of the country and active on the other
- 8/11/2024
- This is why it’s important to use webcams closer to you if possible



Tools in Tandem

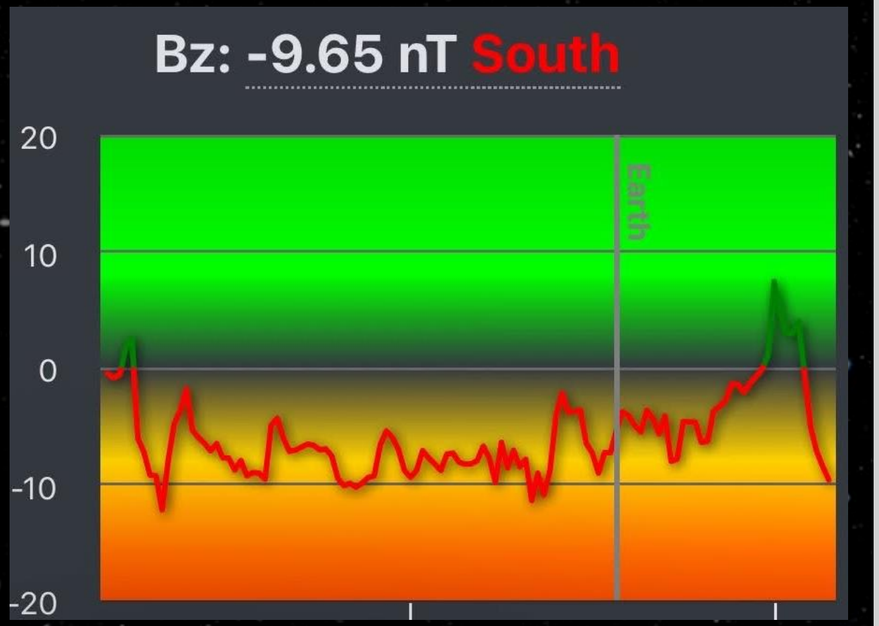


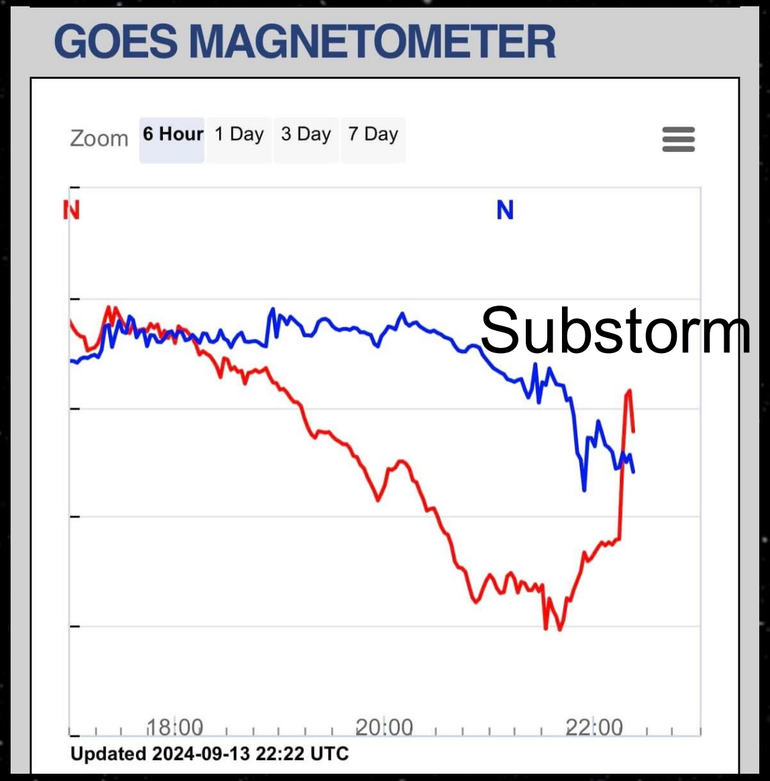


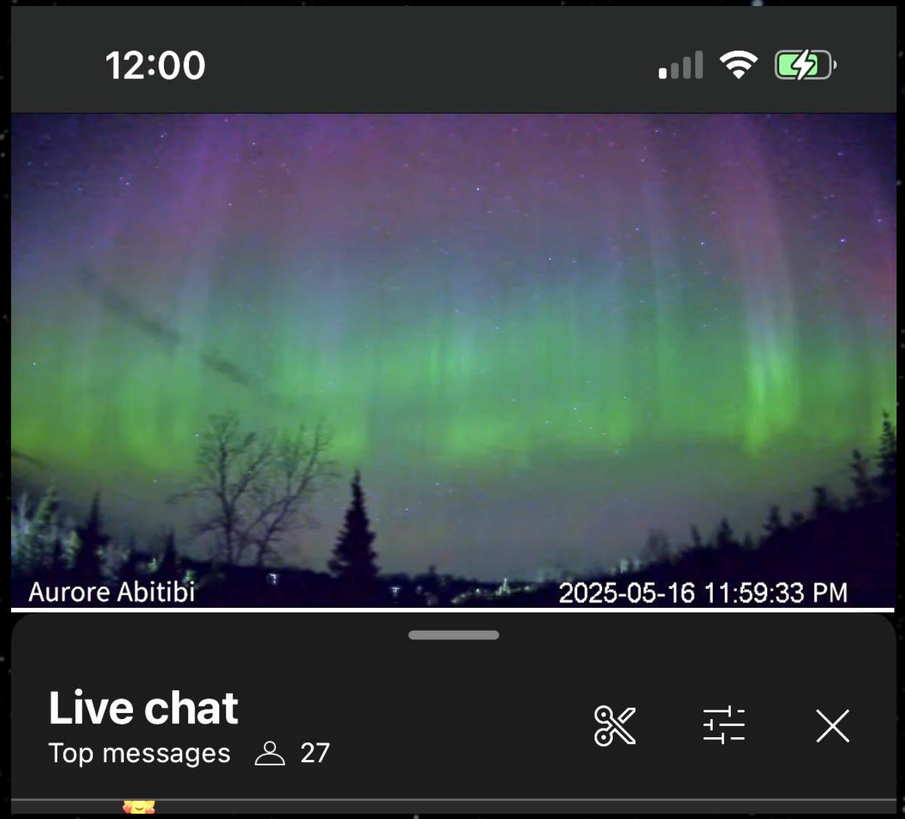


Aurora in growth phase

Tools in Tandem







Aurora in expansion phase

Identifying Aurora





Aurora!

Indentifying Aurora





Sensor noise!

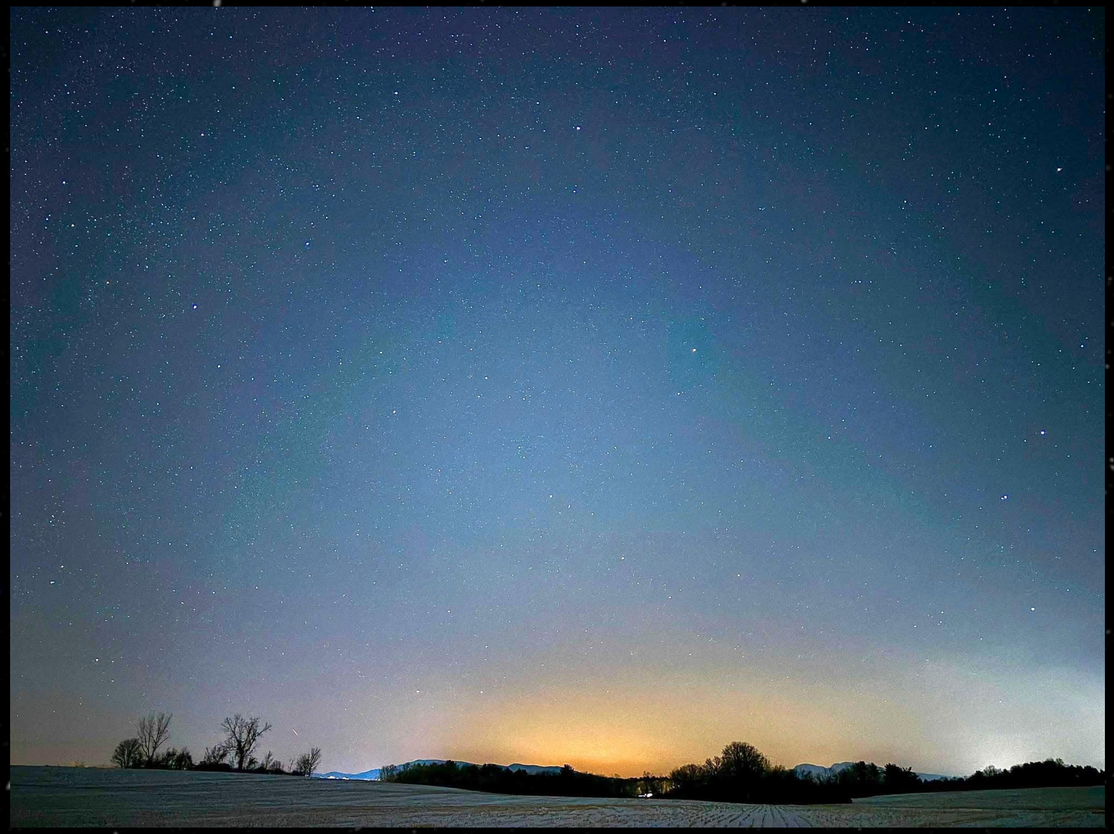
Identifying Aurora





Aurora!

Identifying Aurora





Sensor banding!

Identifying Aurora





Grow Lights!

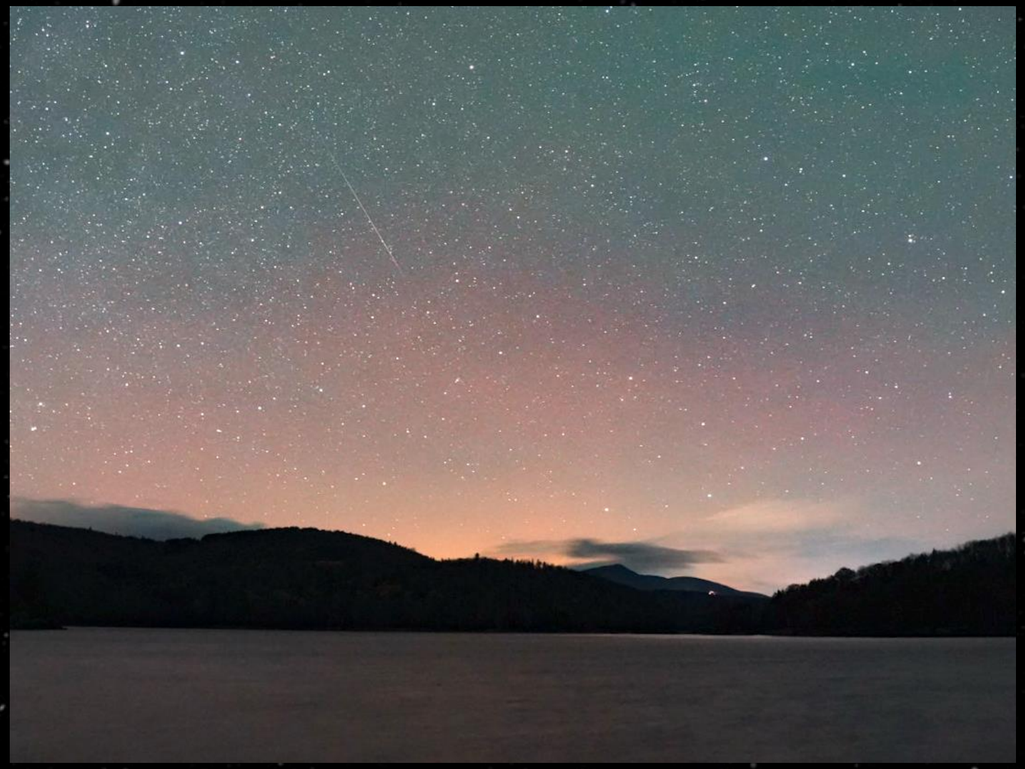
Identifying Aurora





Clouds!

Identifying Aurora

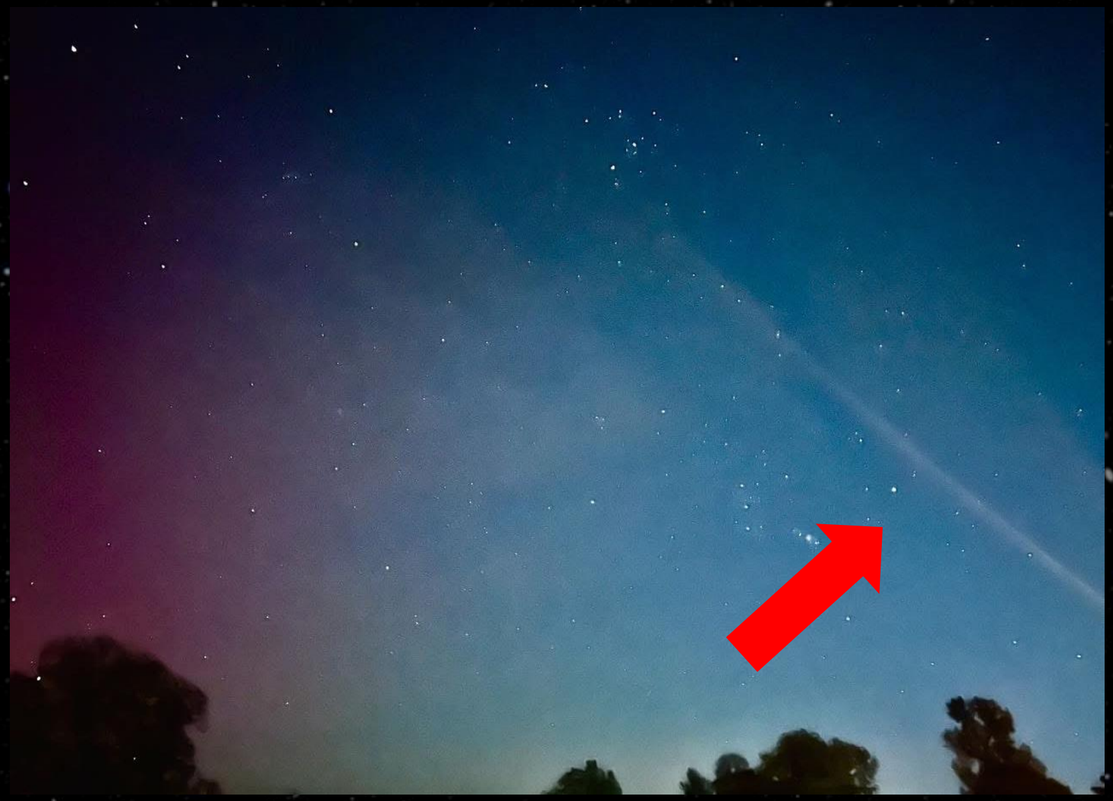




Aaron Watson

Air Glow!

Identifying Aurora





Lense Flare!

Avoiding Sensor Noise

- Use tripod & timer to avoid movement
- Expose correctly
- Avoid shooting through objects with cameras that have lower quality sensors
- Avoid light pollution



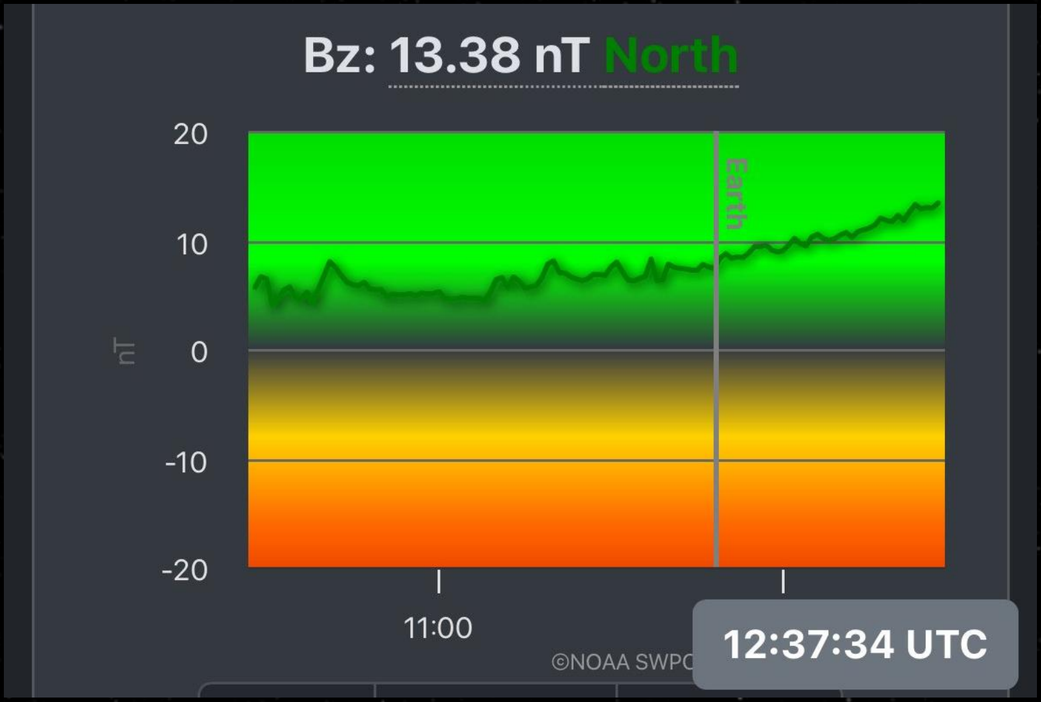
When in Doubt

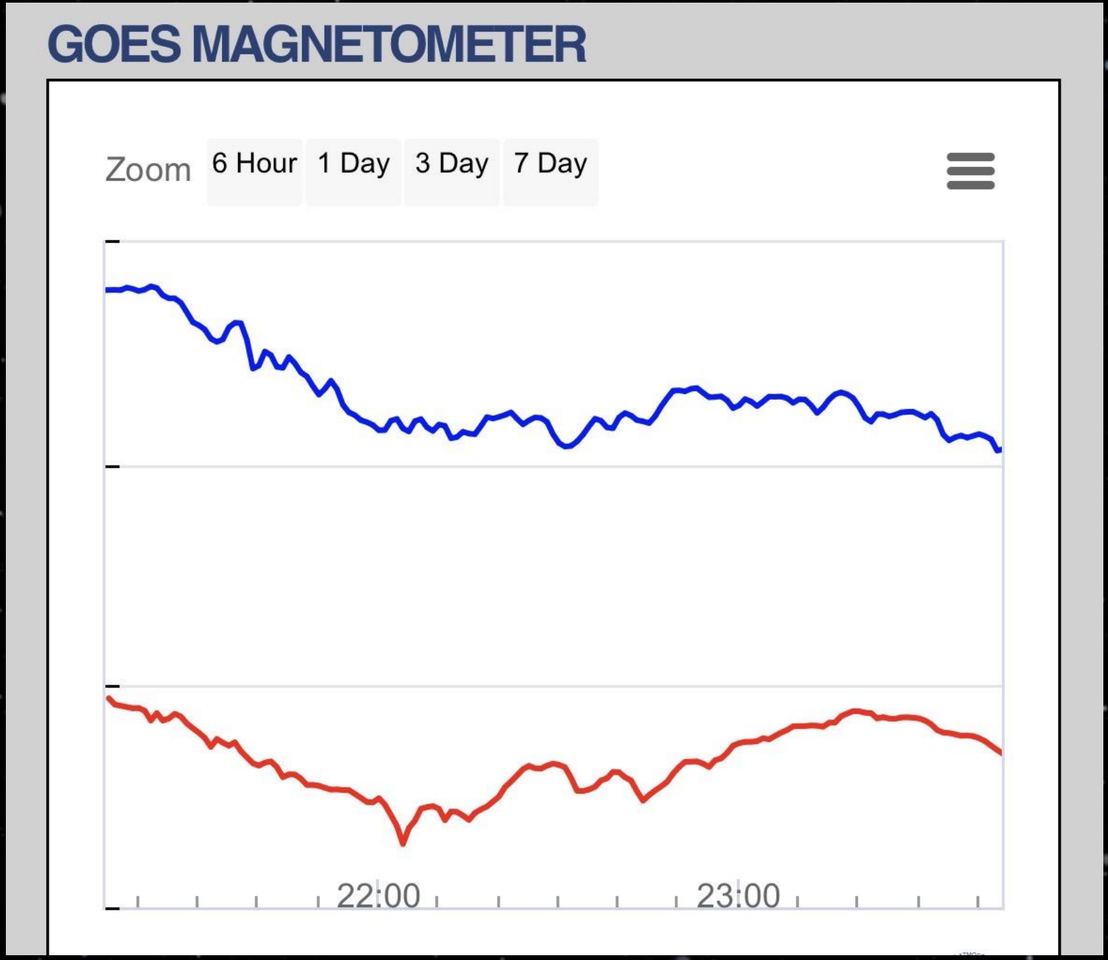
- Is there actually any auroral activity tonight?
- Am I near any greenhouses, concert venues, stadiums, etc that might be emitting colored light?
- Are my skies clouded out completely?
- Is it in a realistic part of the sky?
- Cross check with webcams and real time reports!



How to Know When to Leave?

- Flatlined GOES
- Pinned north BZ
- Weak Hemispheric Power





Conclusion

- Trial and Error
- Please don’t get impatient
- Have Fun



Questions?

Thank You!

Follow My Adventures:

@the_aurora_chaser

@JeremyCruzWX

@JeremyCruzWX



Resources

- SpaceWeatherLive: https://www.spaceweatherlive.com
- Glendale App: https://aurora-alerts.uk
- SWPC 3-Day Forecast: https://www.spaceweather.gov/products/3-day-forecast
- SWPC SW Enthusiasts Dashboard: https://www.spaceweather.gov/communities/space-weather-enthusiasts-dashboard
- SWPC Solar Wind: https://www.spaceweather.gov/products/solar-wind?layout=rtsw#start=2026-11-02T01:46:11&end=2026-11-04T11:35:10
- Light Pollution Map & All Sky: https://www.lightpollutionmap.info
- GOES X-ray Flux: https://www.spaceweather.gov/products/goes-x-ray-flux
- GOES Magnetometer: https://www.spaceweather.gov/products/goes-magnetometer
- NOAA Graphical Forecast: https://graphical.weather.gov
- Pivotal Weather: https://www.pivotalweather.com
- HRRR Cloud Cover: https://www.pivotalweather.com/model.php?m=hrrr&p=cloudcover_levels
- Aurora Guy Webcams: https://theauroraguy.com/pages/webcams?srsltid=AYCX9vLwZbOT1vR8cqVRH9P-Dsr2e5l1tPrAn82zTUK9RVKV9FxYZp41
- HP30&60: https://kp.gfz.de/en/hp30-hp60
- CME Scoreboard: https://ccmc.gsfc.nasa.gov/CMESB-Earth/
- NASA WSA-ENLIL: https://www.spaceweather.gov/products/wsa-enlil-solar-wind-prediction
- HUXt: https://swxforecastlab.org/forecasts.html