



Chasing Aurora During Solar Maximum & Beyond

*Melissa F. Kaelin,
Founder of the Michigan Aurora Chasers*

Photo by Shannon Kivi



About Melissa

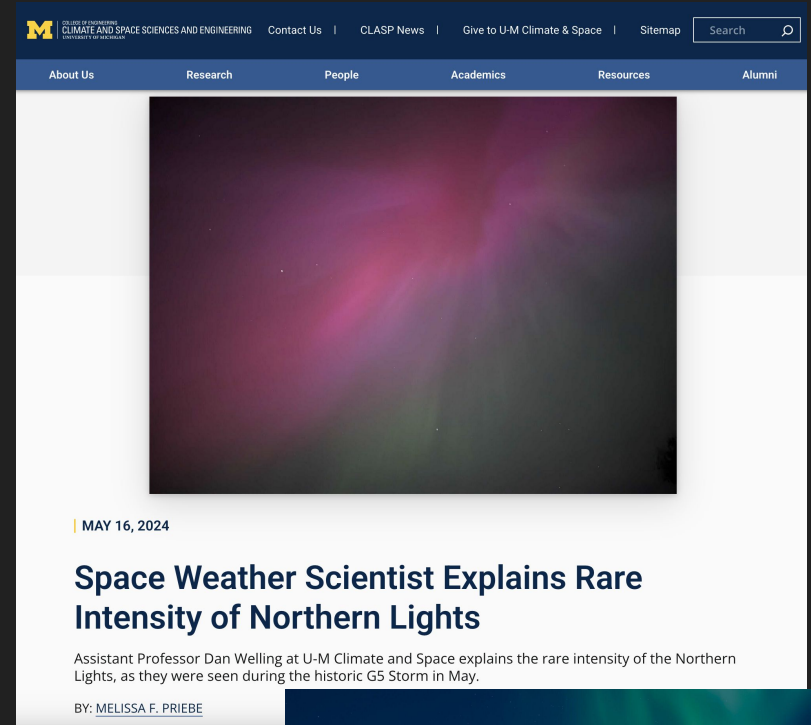
- Caught her first Aurora on Oct. 1-2, 2013
- Co-Founder of Aurora Summit
- Founder of Michigan Aurora Chasers
- A writer at heart; Published The 45th Parallel Series guidebooks, poetry, novels & short stories
- Interviewed for Thrillist, USA Today, NPR's all things Considered, iHeartRadio
- Served as a NASA Social Media Ambassador for the launch of the Solar Orbiter



... and Science Communicator!

In the office, Melissa works as Manager of Marketing & Communications for the **University of Michigan Department of Climate and Space Sciences**.

- Interviews researchers in fields of space weather & climate change
- Leads communications for the University of Michigan Space Institute
- Manages websites, social media, marketing and press at the Space Physics Research Laboratory



"The better we understand how the atmosphere reacts to this energy input, the more precisely we can specify the probability of collision between objects."

Aaron Ridley
Professor, Michigan Engineering
Featured on mlive.com



Human to @ElioTheSunDog

Caught his 1st Aurora, STEVE, Corona, Totality



Chasing the Aurora

MINNESOTA

WISCONSIN

MICHIGAN

ALASKA

ICELAND

THE NIGHT AURORA CHASED ME

Driving home from the Inaugural
Upper Peninsula Dark Sky Festival
along Lake Superior's Shore
in the Upper Peninsula of Michigan,
April 23-24, 2023.

Photo by Jessica Ellis Rorman



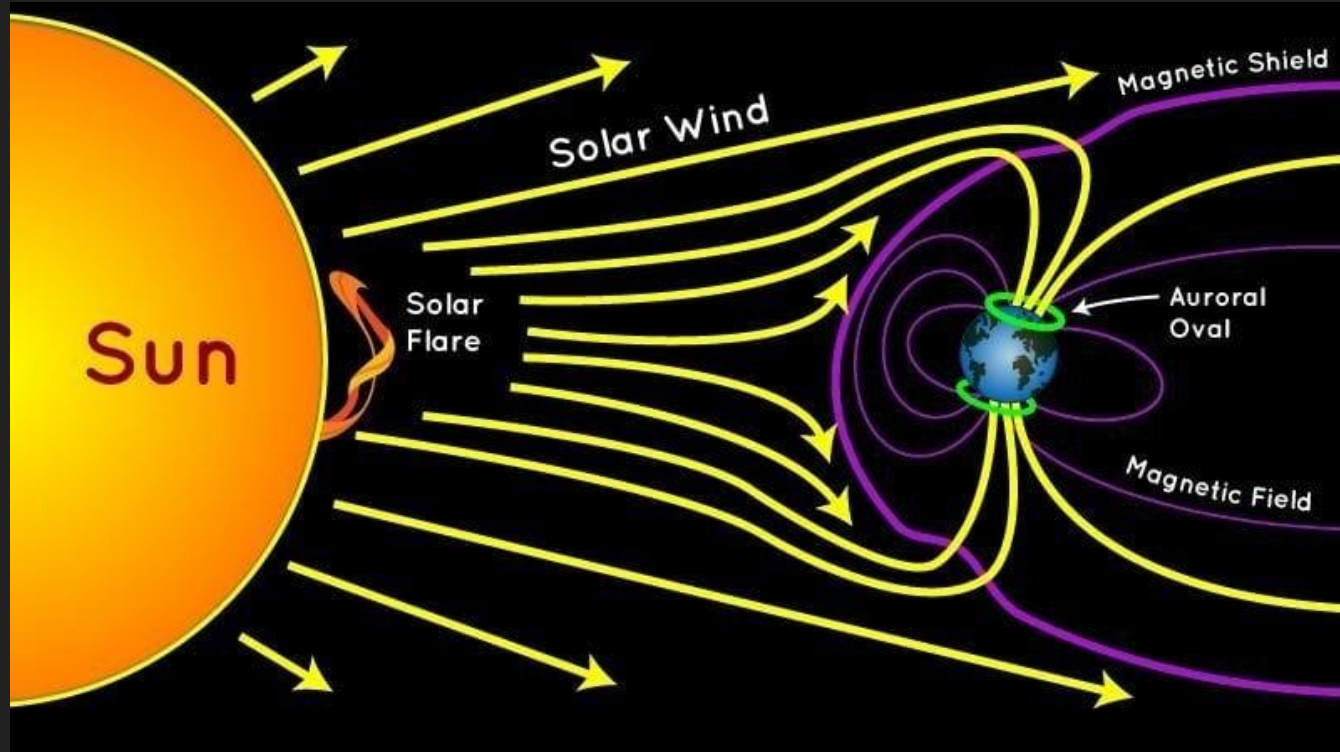
SCIENCE

Originating on the Surface of the Sun

Now we know Aurora is solar matter or plasma that originates from sun spots, solar flares, filaments and coronal holes on the sun's surface.

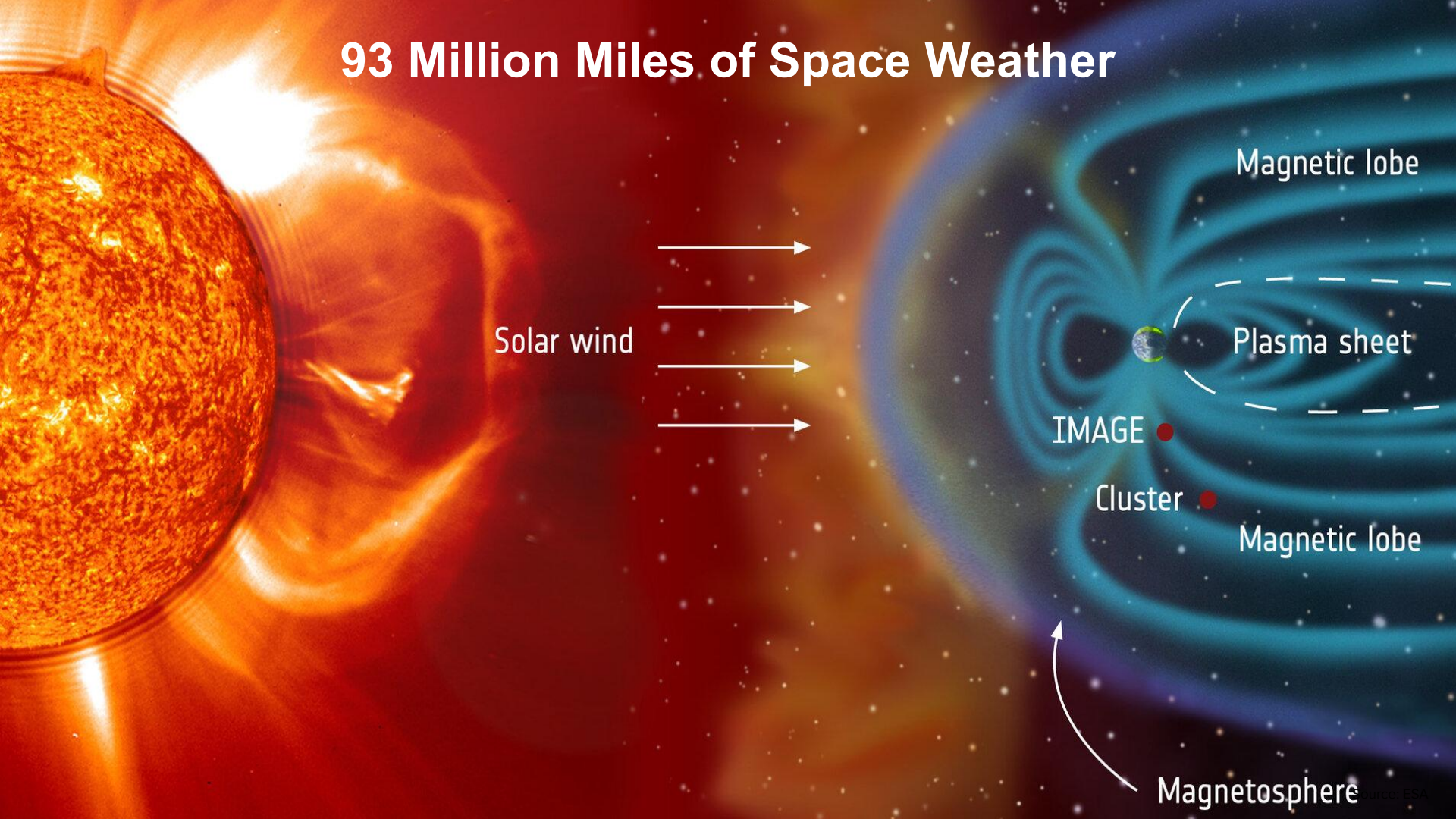


Understanding the Cause of Aurora: Solar Wind

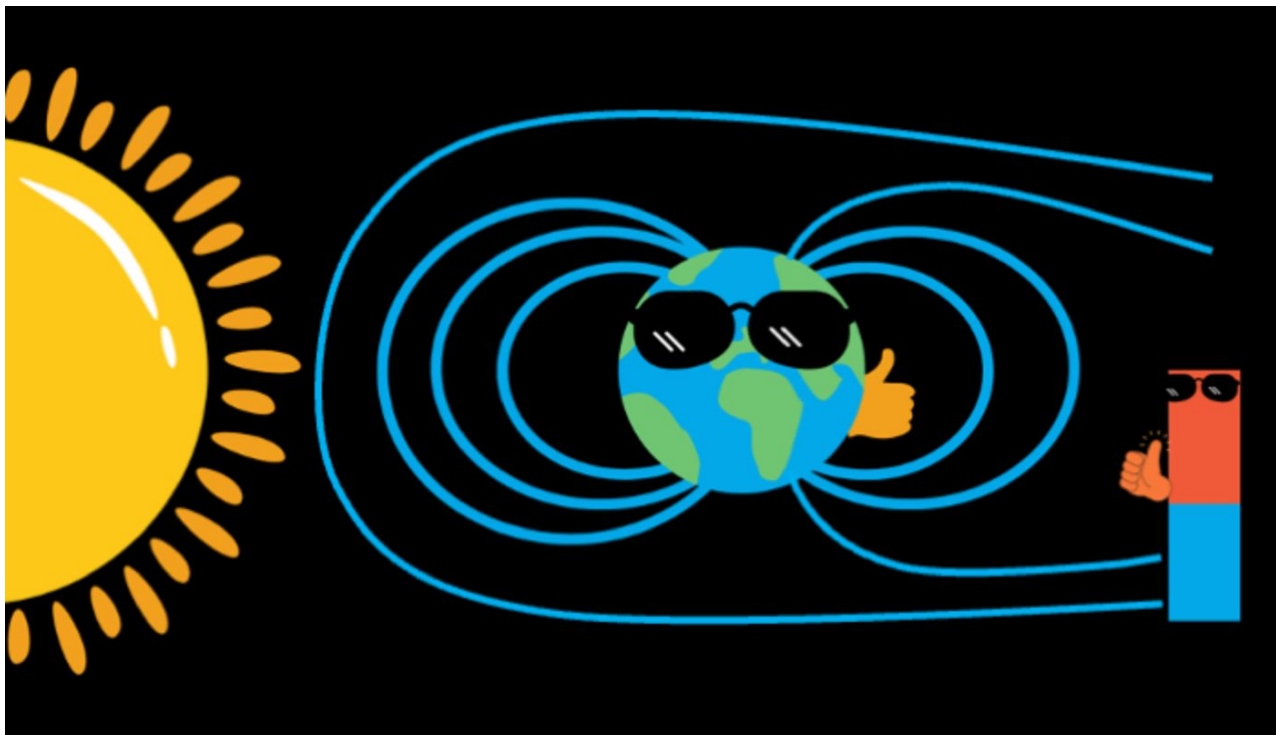


- Solar Flares
- Eruptions
- CMEs
- CH HSS: Coronal Hole High Speed Stream
- Filaments
- Co-rotating Interactive Regions
- The Ever Present Solar Wind

93 Million Miles of Space Weather

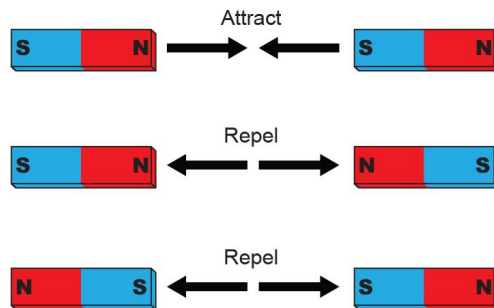


What is the “Bz”? Meet the “Gatekeeper”



- Southward Bz
- More Negative
- Oscillate back and forth
- Like an open door

#ThatPeskyBz



Particles Collide with Air Molecules to Emit Light

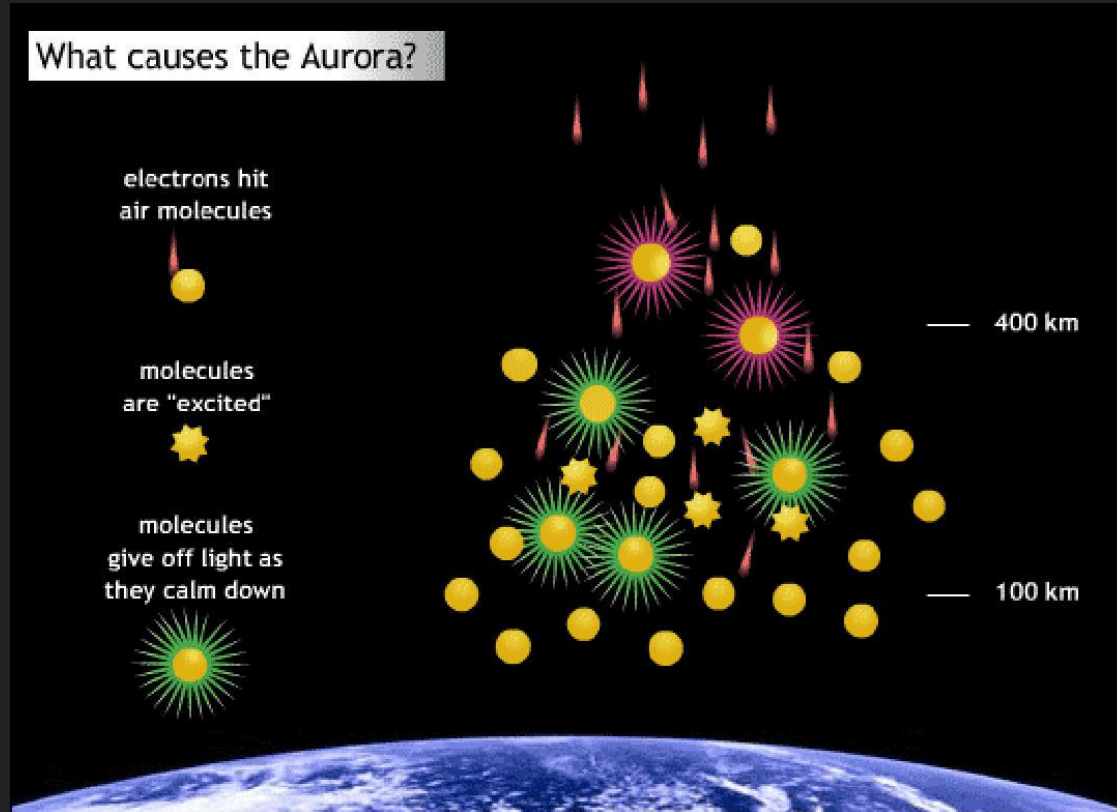
Colors are created when excited particles entering Earth's atmosphere interact with molecules like oxygen, hydrogen and nitrogen to emit light.

Oxygen - High Altitude: Red

Hydrogen, Helium: Purple, Pink

Oxygen - Low Altitude: Green

Nitrogen: Blue



Many Methods for Predicting Aurora

Beginner

Apps, Kp Alerts, Webcams

Beginner

K-Index, Predictions, Ovation Model, HPI

Intermediate

Space Weather Live, Real Time Solar Wind

Intermediate

Coronagraphs, SolarHam, Ap-Index

Advanced

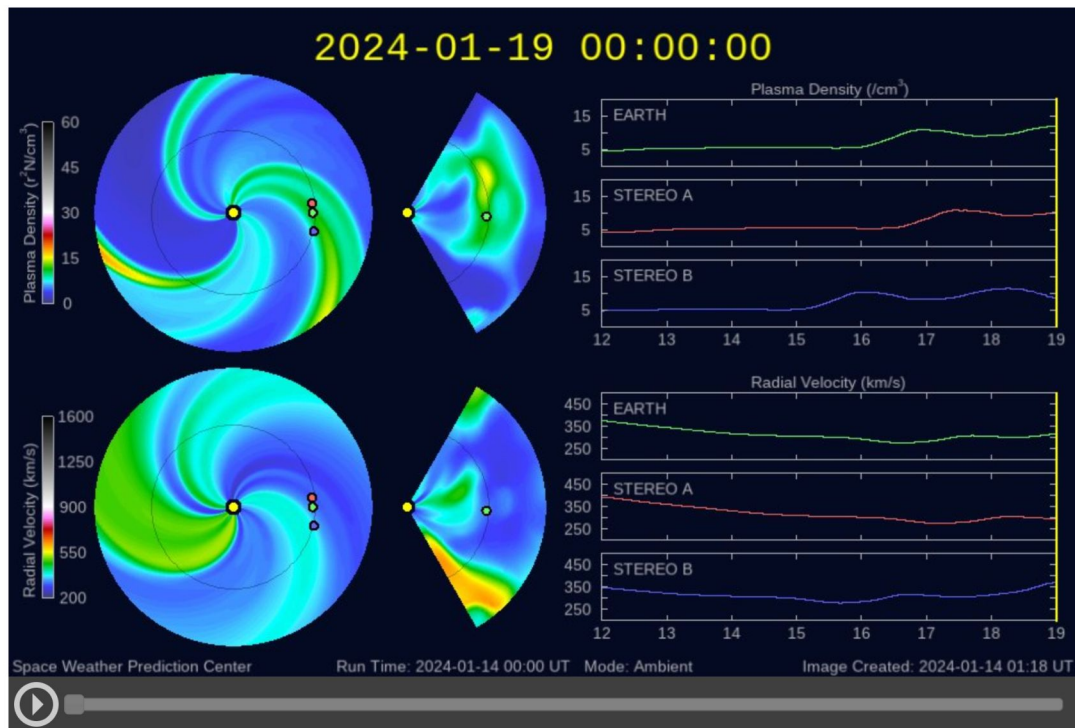
WSA-Enlil, CME Scoreboard, Magnetometer Plots

Advanced

Analyzing CMEs, Understanding Flux Ropes

WSA-ENLIL Solar Wind Prediction Model

WSA-ENLIL SOLAR WIND PREDICTION



K-Index & Geomagnetic Storm Scales

The K-Index measures geomagnetic activity on a scale of 0-9.

	Kp 9 • G5 Storm	Extreme Geomagnetic Storm
	Kp 8 • G4 Storm	Severe Geomagnetic Storm
	Kp 7 • G3 Storm	Strong Geomagnetic Storm
	Kp 6 • G2 Storm	Moderate Geomagnetic Storm
	Kp 5 • G1 Storm	Minor Geomagnetic Storm
	Kp 4 or Less	Below Storm Levels

Geomagnetic Storm Impact Scale



G1

Minor

Weak power grid fluctuations and minor impacts on satellites are possible.

Migratory animals are affected at this and higher levels.

Aurora is commonly visible at high latitudes.

G2

Moderate

Transformer damage is possible with long duration storms.

Corrective actions to spacecraft orientation may be required; may affect orbit predictions.

Aurora may be seen as low as New York and Idaho.

G3

Strong

Power system voltage corrections may be required.

Satellite and LF radio navigation problems may occur. HF radio may be interrupted.

Aurora may be seen as low as Illinois & Oregon.

G4

Severe

Possible widespread voltage control problems on the power grid.

HF radio sporadic, satellite navigation degraded for hours, LF radio navigation issues.

Aurora may be seen as low as Alabama and northern California.

G5

Extreme

Blackouts or complete collapse of power grids possible.

Navigation systems may be out for hours or days.

Aurora may be seen as low as Florida and southern Texas.

The Limitations of the K-Index: Be Weary of Kp

The K-Index actually describes the strength of geomagnetic activity associated with Aurora. When referred to as a “planetary average,” this is called Kp. Kp is not a perfect tool.



Aurora Chasing

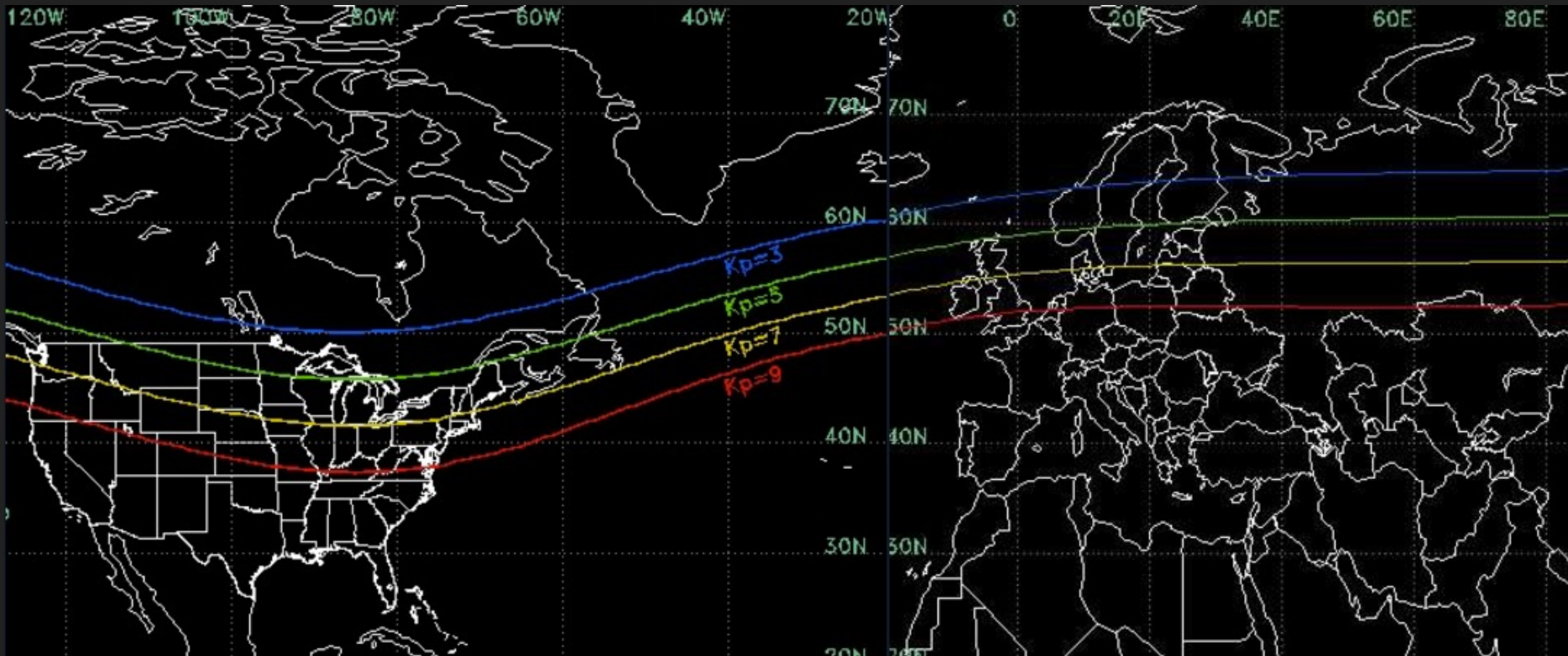
The Pros and Cons of Relying on Kp

When you're trying to catch the Northern Lights for the first time, it's natural to wonder when you can see them and where. The answer to these questions, it turns out, is not so easy.

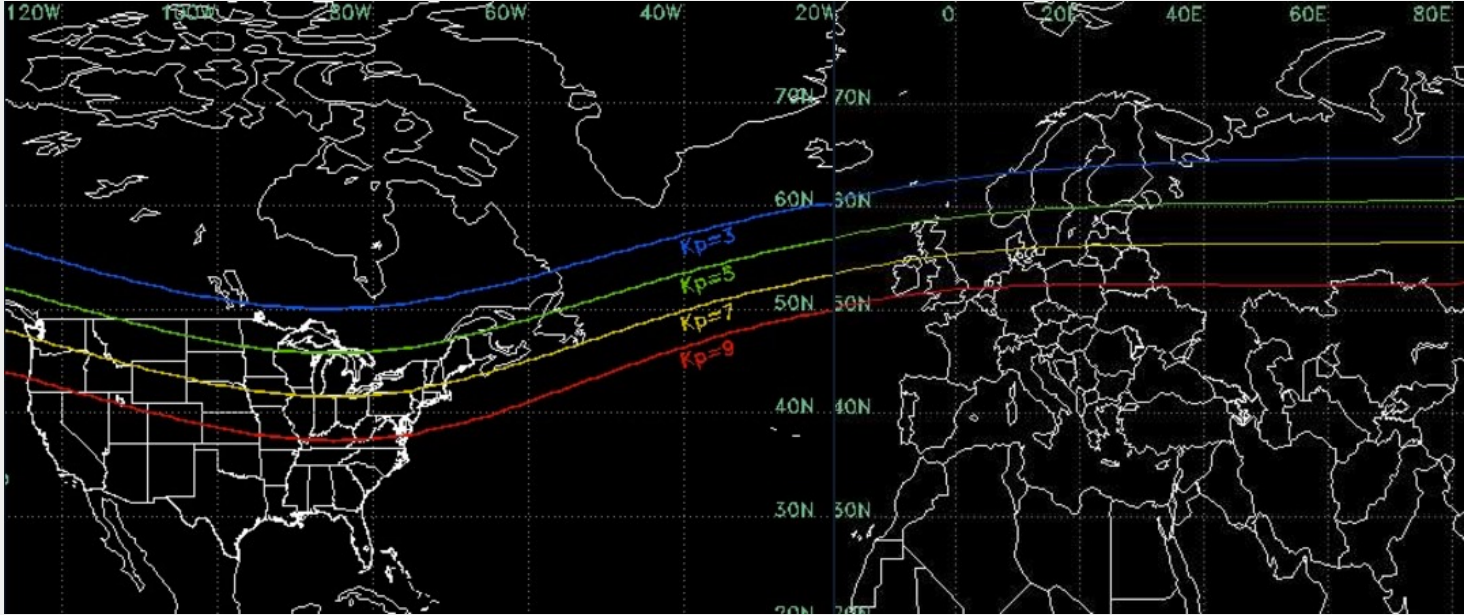
- The national forecasting standard
- A forecasting tool, not a good real-time tool
- Data from magnetometers across the world
- An average over 3 hours
- Often refers to the past
- Available on many apps, which may lag
- Not an exact science
- Other data becomes more important

The K-Index

Evaluating average planetary geomagnetic activity and G-Storms by latitude



Forecasting by Latitude: Kp & K-Index



The K-Index can be used to understand how far south Aurora may appear based on predicted conditions. It also works well to compare displays in history.

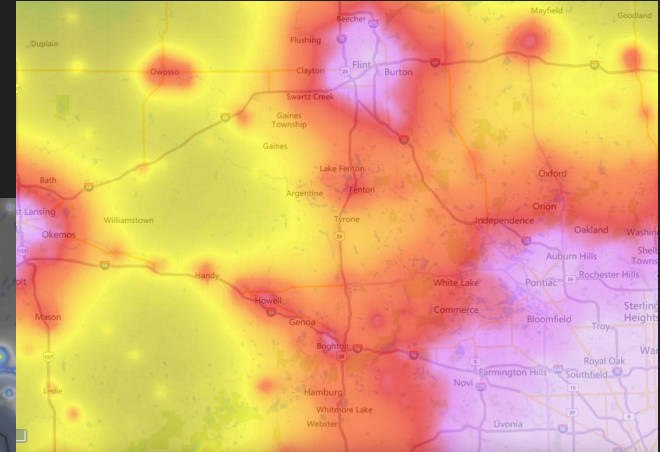
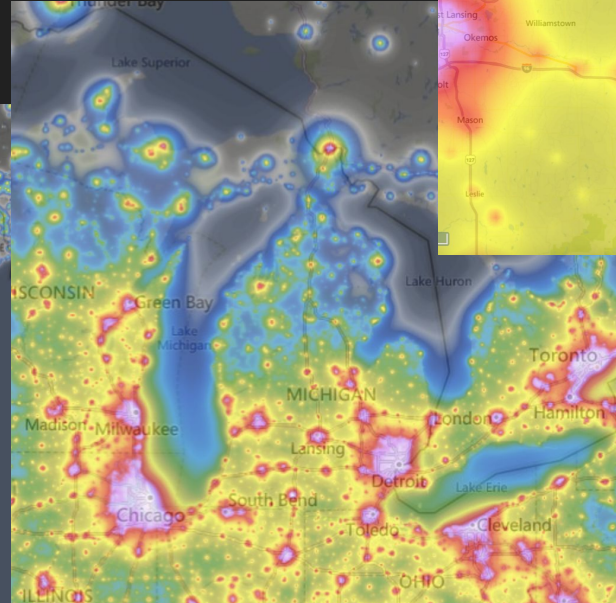
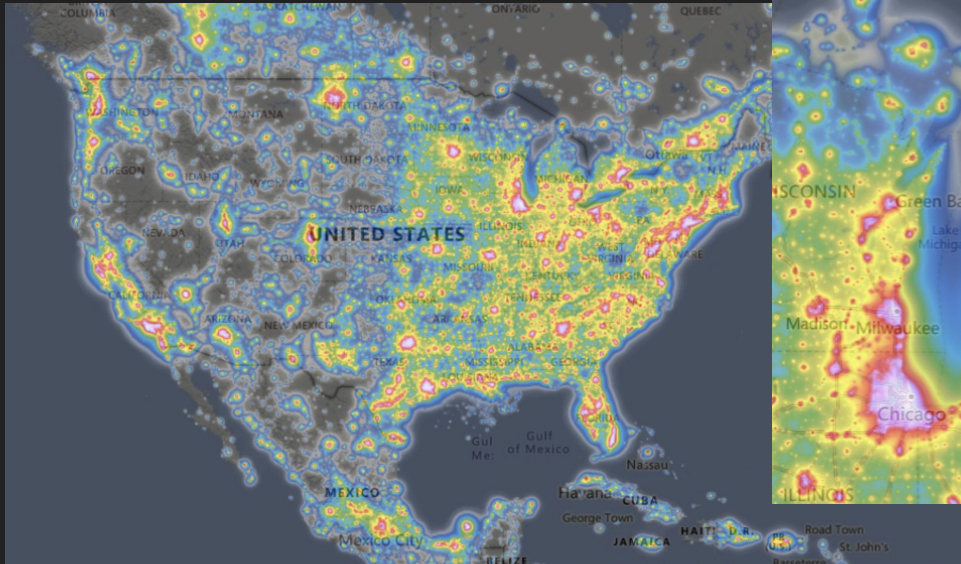
In real time, Kp is not a good indicator of Aurora activity.

Overcoming Light Pollution to View the Aurora

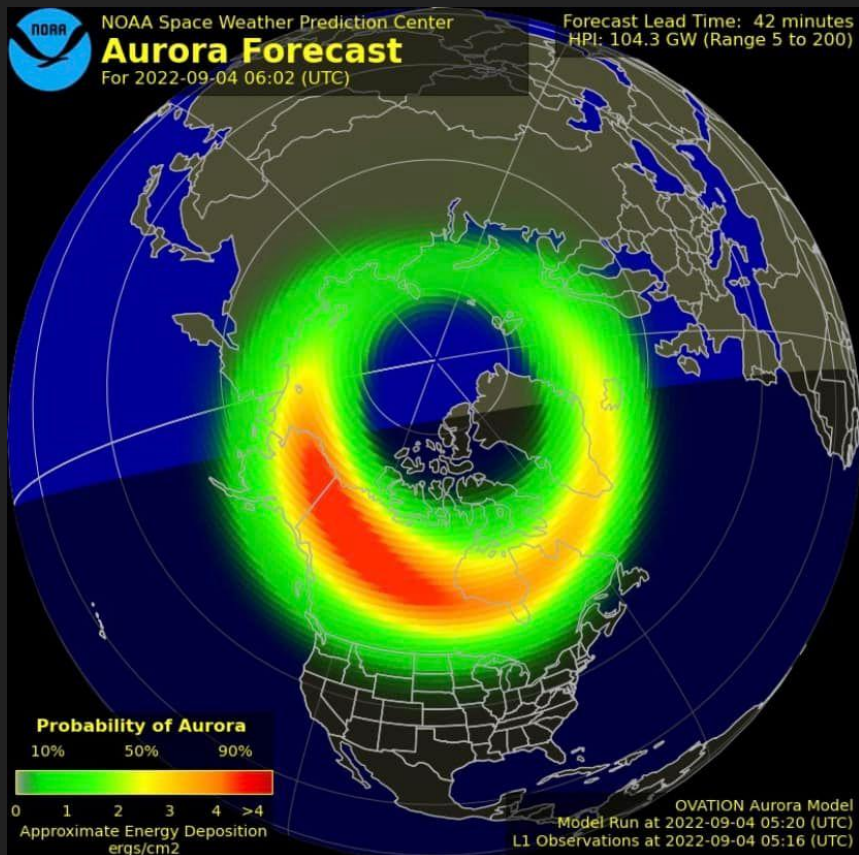
Light pollution by Location

Search your area at

www.LightPollutionMap.info



Ovation Model



Source: Space Weather Prediction Center

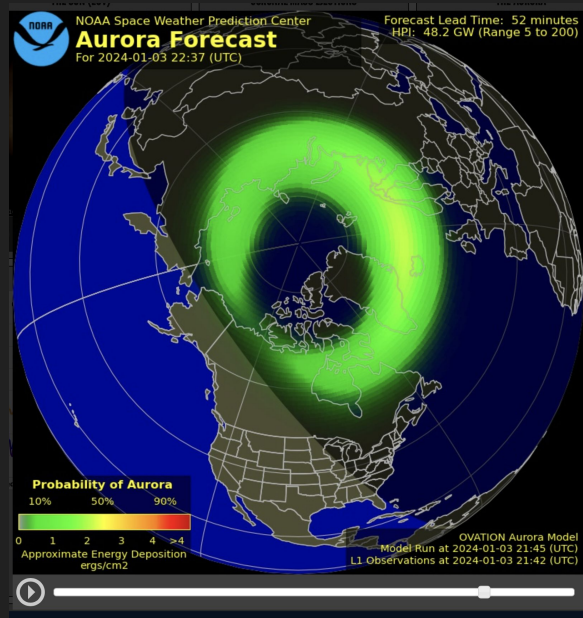
Components of the Ovation

The model uses the solar wind velocity and interplanetary magnetic field measured at the L1 orbit position, located one million miles from Earth, to calculate three types of electron precipitation and proton precipitation which strongly correlate with the aurora. (SWPC)

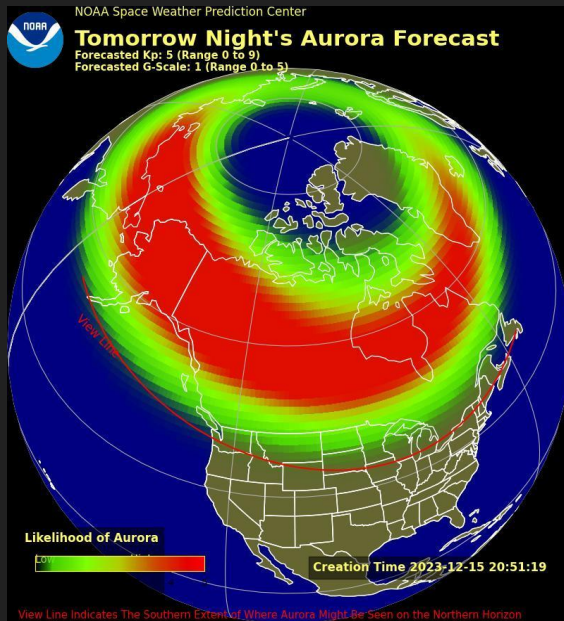
- Simpler than it looks, beginning with labels & dates
- Top left: Agency name, Forecast, Date of Forecast
- Top right: Covers important aurora strength details
- HPI (Hemispheric Power Index) — Hemispheric Power is another measure of aurora strength.
- Lead Time
- Bottom right: Times of the last model run and actual observations
- Bottom left: Legend with colors showing the probability
- Energy Deposition: Measures the energy flux or amount of energy Aurora is putting into the atmosphere

Variations of Ovation

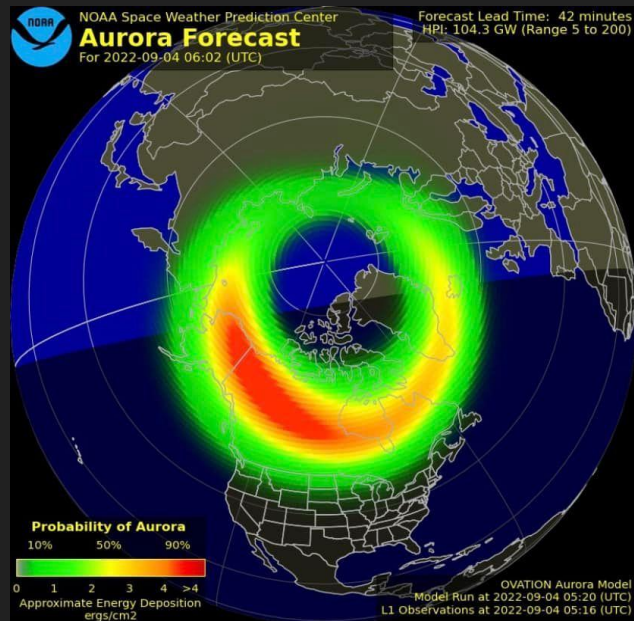
Many sources give you the Ovation Model in a video loop, but only the last second or so refers to the forecast. The new “Aurora Forecast” version is overstated. The still image forecast model is more reliable.



Video



Tomorrow Night's Forecast Version



30-Minute to Real-Time Model

Source: Space Weather Prediction Center

What it takes to see Aurora

Many factors have to align
to create the Northern Lights,
on Earth and in Outer Space!

The Right Conditions in Space

- Solar activity
- Direction of the solar wind
- Solar wind composition: Speed, Density, B_t , B_z
- A favorable B_z : This is essentially the gatekeeper
- Conditions can change instantly

The Right Conditions on Earth

- Starry nights
- Dark skies
- Moon phase & obstacles
- Northern location
- Eyesight visibility



Things to Consider

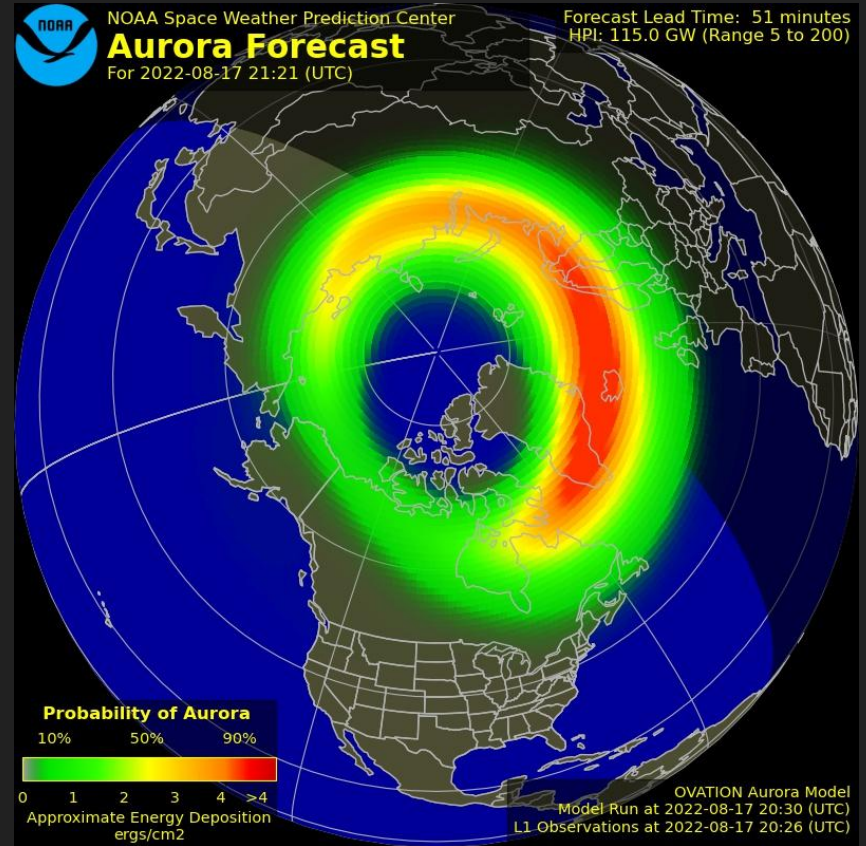
- Scout Out a Location
- Light Pollution or Dark Sky Maps
- Cloud Cover & Weather
- Sunset, Twilight & Moonrise
- Reliability of the Forecasts
- Patterns of the Northern Lights
- Safety, Sleep & Sanity

Number #1 Tip: Plan something exciting in case you get aced!

Chasing at the Peak

- Hours: Two hours before and after local magnetic midnight
- Season: September to April
- Years: Solar Maximum is a time at the height of the 11-year solar cycle*

* In the 11-year solar cycle, activity on the sun's surface gradually increases over time, reaching a peak during 1-2 years, then a gradual decline. It's part of a 22-year cycle, where the poles on the sun reverse.



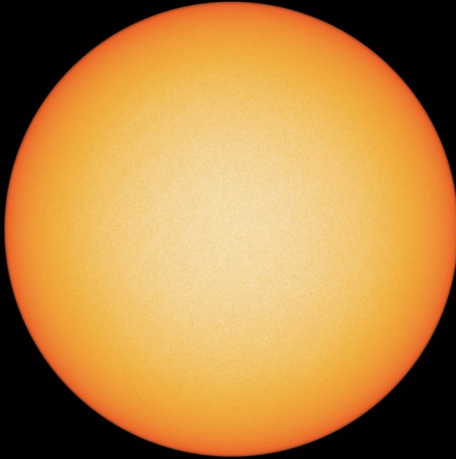
Chasing during Solar Maximum



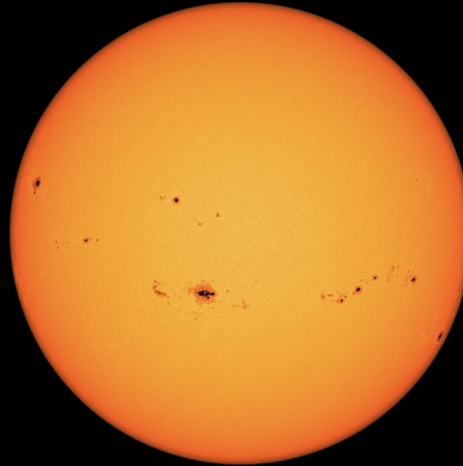
Solar flare erupting from the surface of the sun. (Science Photo Library via Getty Images)

Official News on October 15, 2024

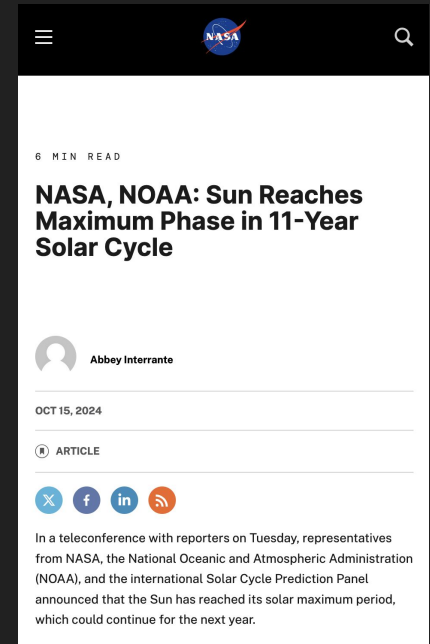
SOLAR MINIMUM



SOLAR MAXIMUM

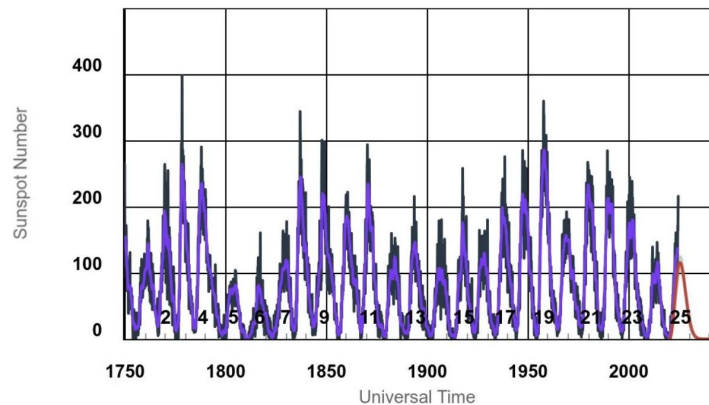


- Peak of the 11-year solar cycle of our sun
- Every 11 years, the sun's magnetic poles flip
- A period of time — not a day, week or month



Monitoring Sunspots

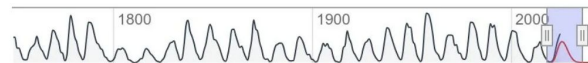
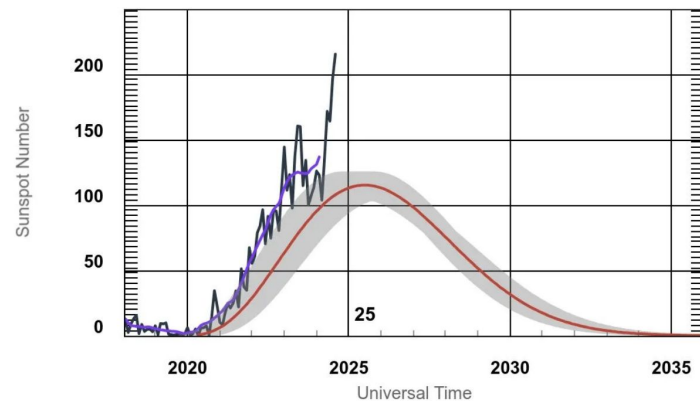
ISES Solar Cycle Sunspot Number Progression



◆ Monthly Values ◆ Smoothed Monthly Values ◆ Predicted Values
■ Predicted Range

Space Weather Prediction Center

ISES Solar Cycle Sunspot Number Progression



◆ Monthly Values ◆ Smoothed Monthly Values ◆ Predicted Values
■ Predicted Range

Space Weather Prediction Center

Explosive Aurora Events in 2024

- Catch the Aurora on May 10, 2024?!
Did you also know it was visible at low latitudes for three nights in a row:
 - May 10
 - May 11
 - May 12
- June 10-11, 2024
- August 11-12, 2024
- October 7-8, 2024
- October 10-11, 2024



Implications for Infrastructure

The strong geomagnetic storms that produce stunning Aurora events can cause havoc in our infrastructure and space operations.

SPACE.com

[Home](#) [Space Exploration](#) [The Universe](#) [Stargazing](#) [Launches & Spacecraft](#)

TRENDING [Voyager 1 phones home!](#) ['Halloween Comet' burns up](#) [Bes](#)

[Space Exploration](#) > [Satellites](#)

SpaceX says a geomagnetic storm just doomed 40 Starlink internet satellites

News By [Tariq Malik](#) published February 8, 2022

The satellites launched on Feb. 3, only to be hit by the storm a day later.

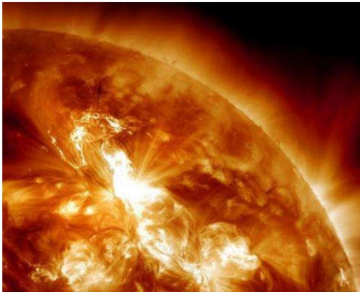
PHYS ORG

[Nanotechnology](#) [Physics](#) [Earth](#) [Astronomy & Space](#) [Chemistry](#) [Biology](#) [Other Sciences](#) [X Medicine](#) [Technology](#)

[Home](#) / [Astronomy & Space](#) / [Space Exploration](#)

[JANUARY 25, 2012](#)

Flights rerouted as massive solar storm slams Earth



This January 23, 2012 image provided by NASA, captured by the Solar Dynamics Observatory, shows a solar fl...

Solar radiation from a massive sun storm -- the largest in nearly a decade -- collided with the Earth's atmosphere, prompting an airline to reroute flights and skywatchers to seek out spectacular light displays.

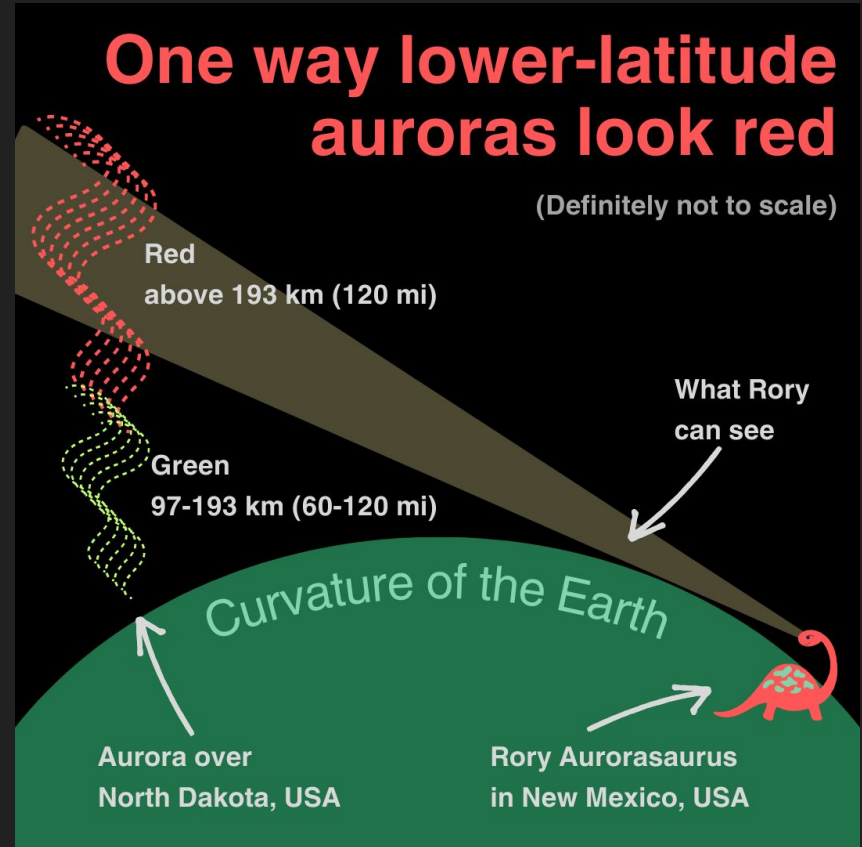
Game Changers after 1999

Never before could we instantly see Aurora sightings anywhere.

Never before could we use pocket cameras to detect color at night.

Never before could we capture such high altitudes and far distances on camera.

Never before could we use scientific models to predict Aurora.

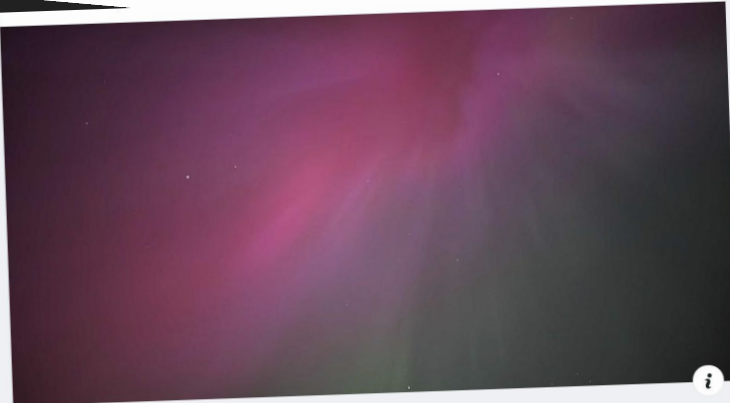


Historic G5 Storm

The New York Times

Northern Lights Set to Return During Extreme Solar Storm's 2nd Night

Electrical utilities said they weathered earlier conditions as persistent geomagnetic storms were expected to cause another light show in evening skies.



CLASP.ENGIN.UMICH.EDU

Space Weather Scientist Explains Rare Intensity of Northern Lights - Climate and Space Sciences and Engineering

1 comment 1 share
Dixie J. Burbank, Samuel Warfel and 9 others



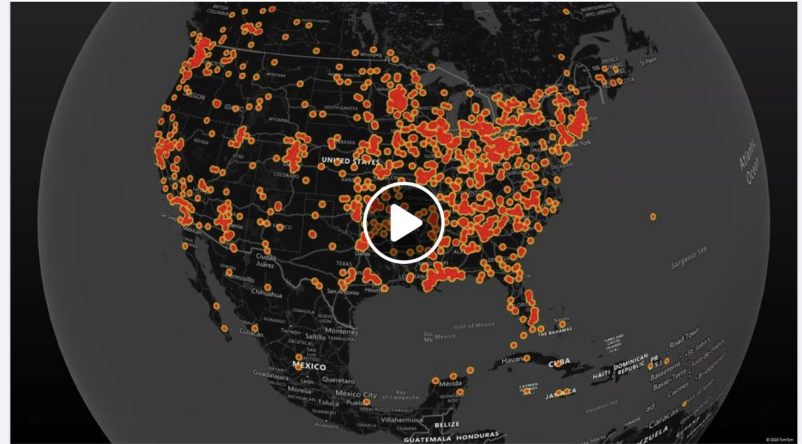
Chris Wicklund

July 31 at 2:52 PM · 🌐

Thanks to my friend [Vincent Ledvina](#) I have discovered a new way to plot the historic G5 aurora event seen across the globe. Look at all those points! I have even submitted my preliminary dataset to a scientific research site where it has obtained a DOI and can be open sourced and used in scientific research. I have been working on this with a small team since the magnificent event in may and have supplied a couple agencies with it. Feel free to share this across platforms.

Fun times! [#aurora](#)

The live map to view is also here: <https://www.google.com/maps/d/edit...>

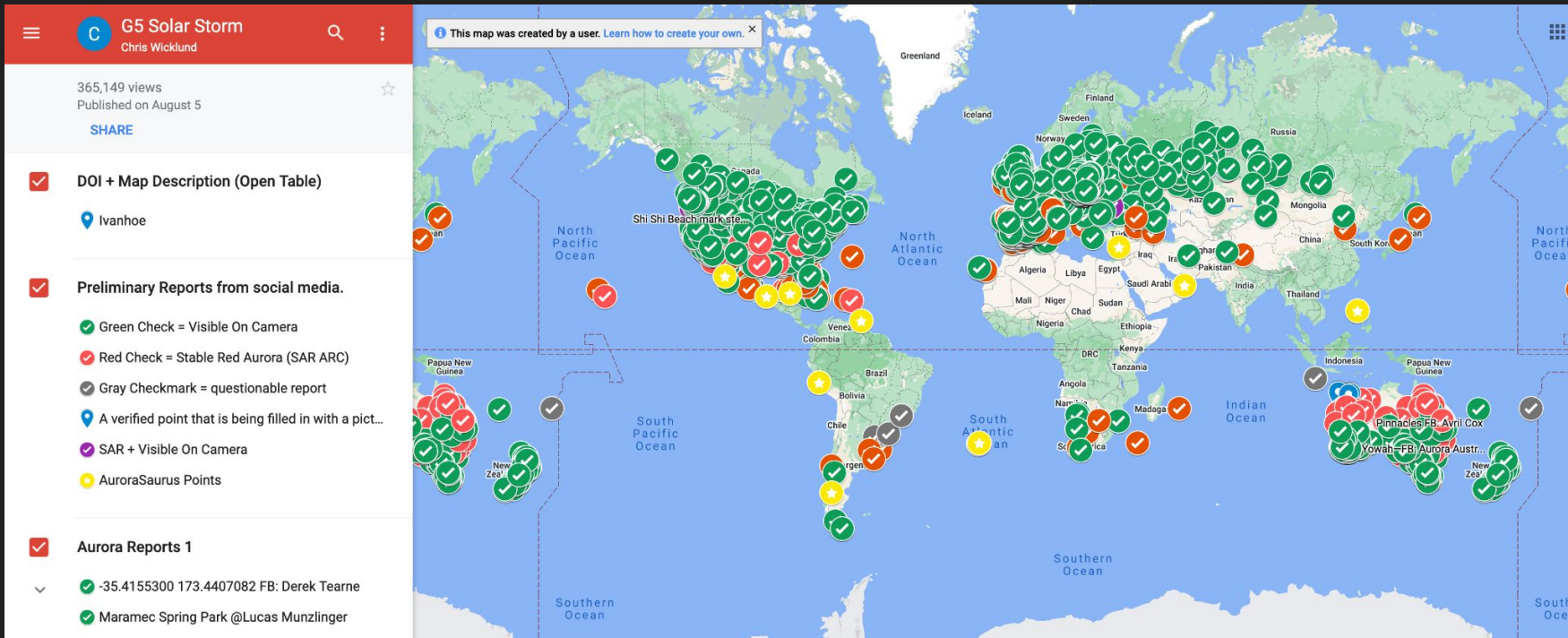


16

14 comments 13 shares

Mapping the Historic G5 Storm

Aurora Chaser Chris Wicklund worked with enthusiasts around the world to map every location where Aurora was seen on May 10, 2024. It was spotted in every U.S. state including Hawaii and many unusual parts of the globe.

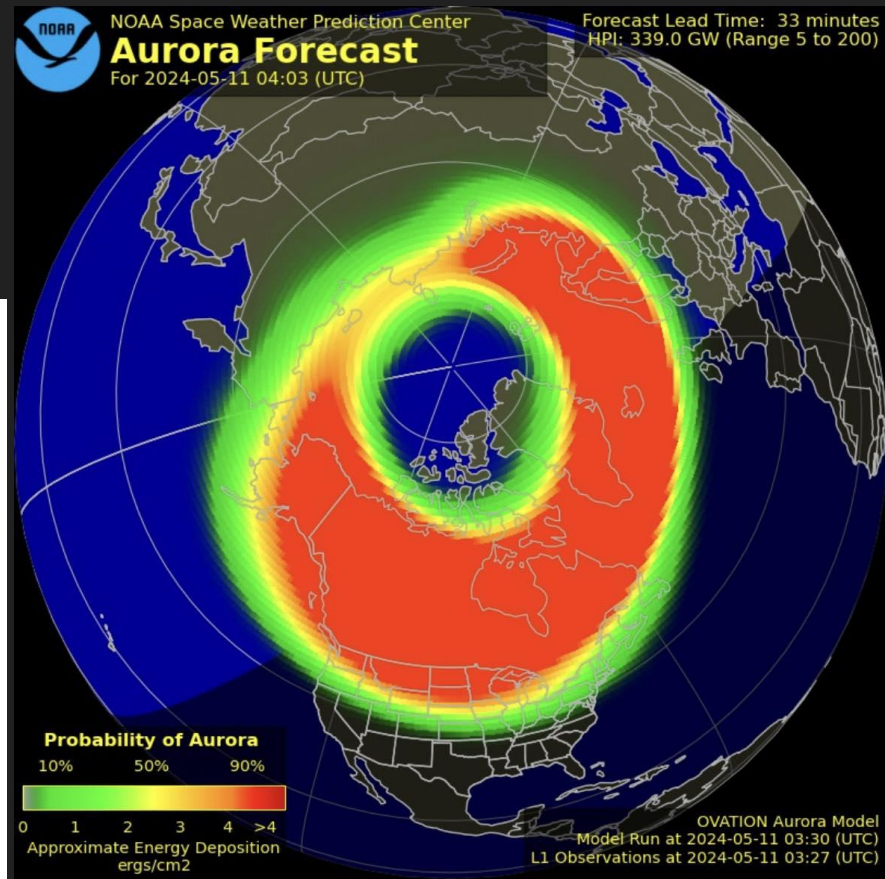


What did the Ovation Model Look Like on May 10, 2024?



USATODAY.COM

One week ago, the northern lights stunned America. When will it happen again?



#LiveChase

Led a Live Chase on May 10, 2024, during historic G5 Storm. We celebrated 100K with a Statewide Live Chase, June 10, 2024!



Photo by Patricia Parker



Photo by Lauren Kovich



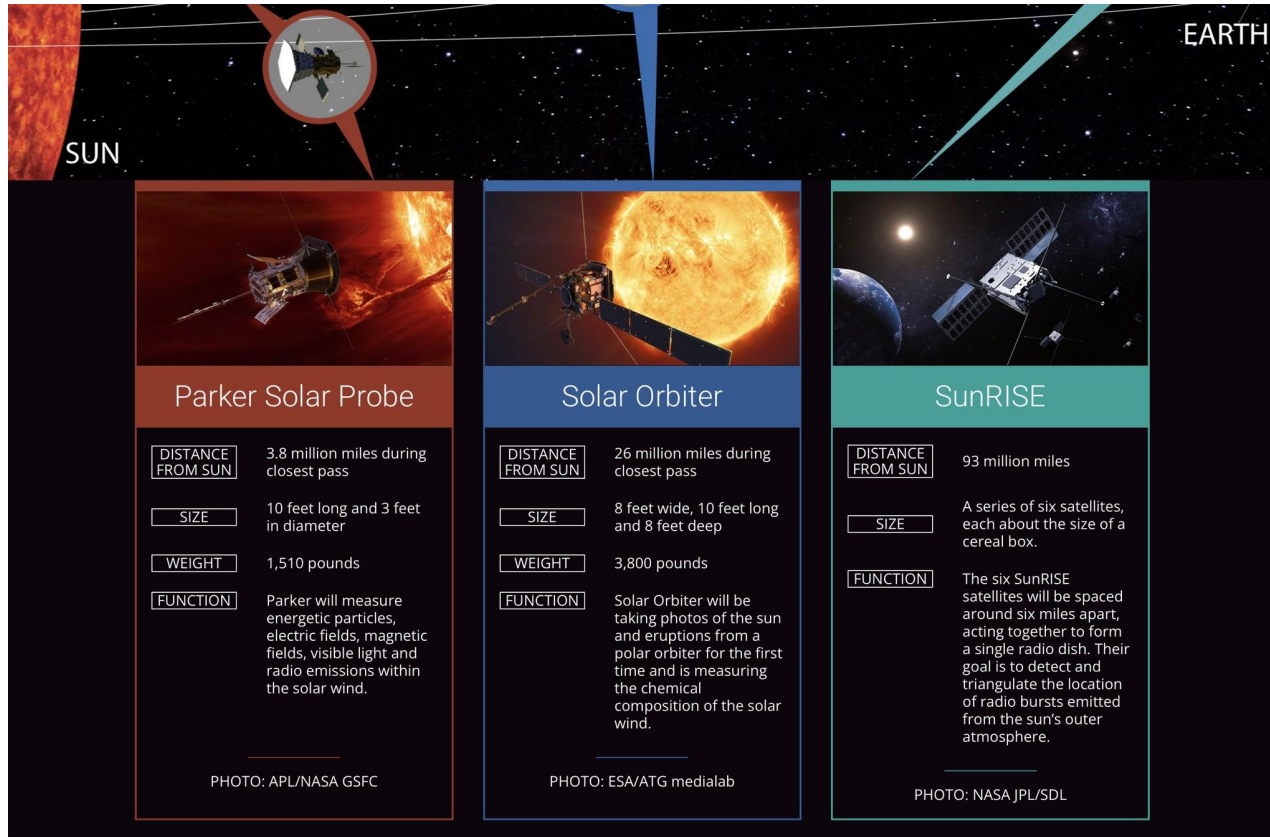
Photo by Karen Serwatowski

At the Cutting Edge of Emerging Science

Our Work at University of Michigan Climate & Space

M | CLIMATE AND SPACE SCIENCES AND ENGINEERING

Missions at University of Michigan



The infographic is set against a dark space background with stars. At the top left is a red sun labeled 'SUN'. At the top right is a blue and white Earth labeled 'EARTH'. A small circular inset at the top center shows a satellite. The three mission panels are arranged horizontally below. Each panel has a header image, a title, and a list of specifications. The Parker Solar Probe panel has a red header, the Solar Orbiter panel has a blue header, and the SunRISE panel has a teal header.

Mission	Distance from Sun	Size	Weight	Function	Photo Credit
Parker Solar Probe	3.8 million miles during closest pass	10 feet long and 3 feet in diameter	1,510 pounds	Parker will measure energetic particles, electric fields, magnetic fields, visible light and radio emissions within the solar wind.	PHOTO: APL/NASA GSFC
Solar Orbiter	26 million miles during closest pass	8 feet wide, 10 feet long and 8 feet deep	3,800 pounds	Solar Orbiter will be taking photos of the sun and eruptions from a polar orbiter for the first time and is measuring the chemical composition of the solar wind.	PHOTO: ESA/ATG medialab
SunRISE	93 million miles	A series of six satellites, each about the size of a cereal box.	The six SunRISE satellites will be spaced around six miles apart, acting together to form a single radio dish. Their goal is to detect and triangulate the location of radio bursts emitted from the sun's outer atmosphere.	PHOTO: NASA JPL/SDL	

University of Michigan Space Institute

Founded in 2019, the hub of space-related research at the University of Michigan:

- Conducting research from space
- Designing systems to operate in space
- Allowing humans to live in space

space.umich.edu



WHO WE ARE

The Space Institute is the central focal point of space-related research across the University of Michigan, where colleagues from a broad range of backgrounds collaborate.



OUR MISSION

The Space Institute empowers the University of Michigan to advance its world leadership in space.

OUR FOCUS IS THREE-FOLD

1. Conduct research from space
2. Design systems to operate in space
3. Allow humans to live in space



SPACE.UMICH.EDU

GET INVOLVED!

- Subscribe to our newsletter
- Apply for funding
- Donate to the Space Institute
- Partner with us!



SCAN TO LEARN MORE!

Space Physics Research Laboratory

Extreme Labs for testing
space-flight ready
instruments and electronics.

During recent years, SPRL
faculty and engineers have
built more than 30 space
instruments, instrumented
numerous sounding rockets,
balloons and aircraft, and
developed ground-based
instruments.

sprl.umich.edu



Space Weather Modeling Framework & Centers

- SWMF invites the ideas of scientists, developers, and scholars around the world. The versatile tool can be used to study the Sun, the heliosphere, and planetary environments.
- Space Weather Centers of Excellence including the CLEAR Center at U-M Climate & Space



Updates & News: linktr.ee/UMclasp

Michigan Space Grant Consortium

The mission of the MSGC is to create, develop, and promote programs that reflect NASA strategic interests and support cooperation between academia, industry, state and local government in science and technology in Michigan. Various opportunities for educational and research funding are available.

www.mispacegrant.org



NASA Missions

- CYGNSS Mission, 2015
- Parker Solar Probe, 2018
- SunRISE & Ground Radio Lab, 2025
- Geospace Dynamics Constellation, 2027
- MAAX Aurora Imaging Mission Concept
- Instrumentation such as SPICES spectrometer



SunRISE Mission: 2024

- NASA's Sun Radio Interferometer Space Experiment (SunRISE)
- SunRISE Ground Radio Lab
- "NASA's 6-pack of Satellites Ready for their Moment in the Sun"



WHAT IS SUNRISE GROUND RADIO LAB?

High schools across the United States are invited to participate in a radio science campaign: They can team up with a NASA mission, the Sun Radio Interferometer Space Experiment (SunRISE), and its science team led by University of Michigan. The mission will be ready to launch in 2024. Building upon the Radio JOVE Project, the SunRISE Ground Radio Lab engages citizen science using a multi-frequency radio telescope to observe radio emissions from the Sun, Jupiter, and the Milky Way Galaxy.

The SunRISE Ground Radio Lab aims to complement SunRISE's measurements in space, and to engage the public and educate the next generations of Science, Technology, Engineering, Arts, and Math (STEAM) scholars through hands-on citizen science campaigns.

GET INVOLVED:

Are you involved in an organization or high school that is interested in participating in the SunRISE Ground Radio Lab?

Visit: <https://sunrise.umich.edu/contact/>

SUNRISE.UMICH.EDU



MORE

The Aurora Summit

- Founded in 2017 by a team of three: Dixie J. Burbank, Melissa F. Kaelin & Dr. Mike Shaw
- Celebrating the Art, Culture, Science & Photography of the Aurora
- Registration launches in June each year
- Open to the public

Join the Adventure:
TheAuroraSummit.com



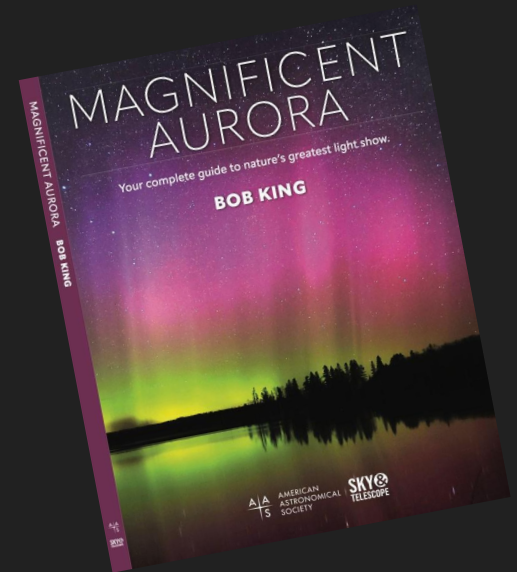
Aurora Summit 25

Featuring Dan Zafra, Capture the Atlas
November 7-9, 2025 | Northern Wisconsin

Michigan Aurora Chasers

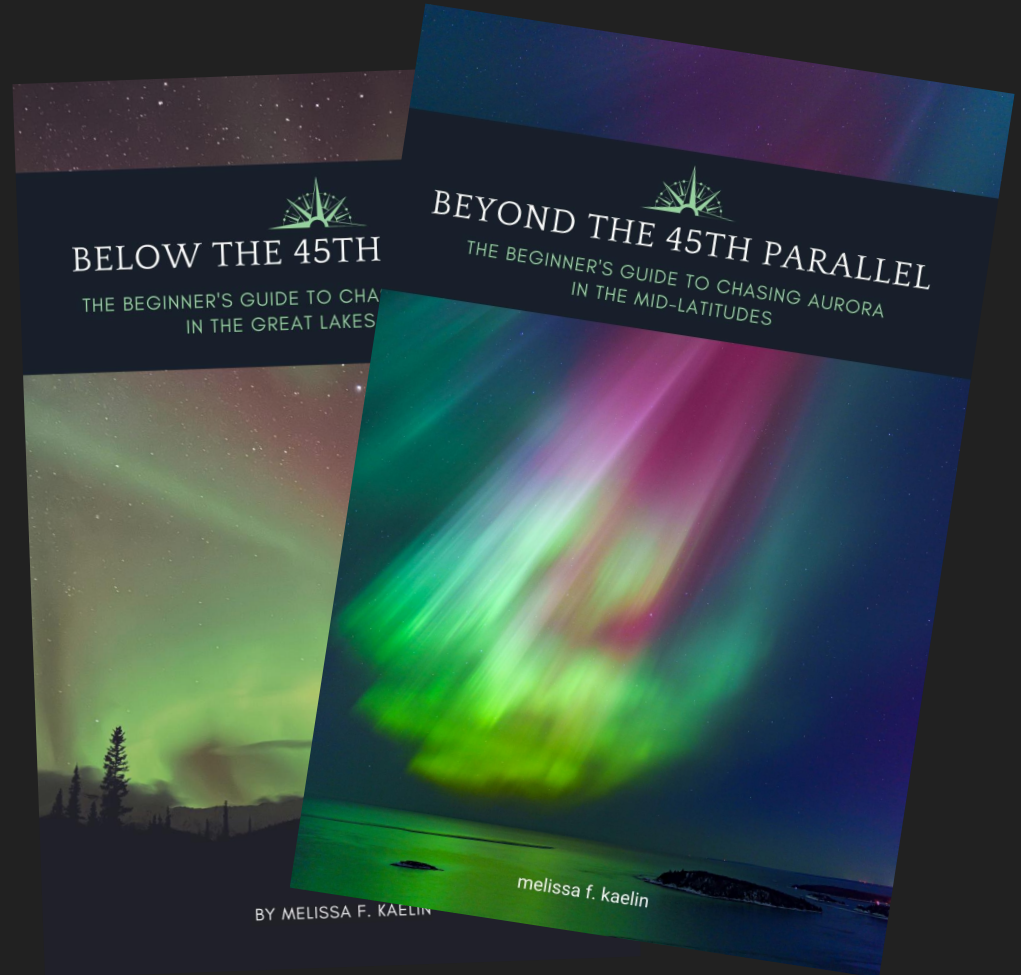
- Founded January 20, 2021
- Over 127,000 members
- Featured in the new book by Bob King:
“Magnificent Aurora: A comprehensive guide to nature’s greatest light show”
- Logo created by Admin Patrick Grubba
- Home of the #LiveChase
- Supporting International Dark Sky Parks

Get Our Guides:
MichiganAuroraChasers.com



The 45th Parallel Series

- Aurora Chasing Guidebooks expanded from Great Lakes to anywhere in the Mid-latitudes
- Cover Photos feature Shannon Kivi of 906 Images, and Michele Aucello in a professional collab
- Seven new chapters
- Available on B&N and Amazon



iPhone Photos I've Taken



Northwestern Michigan and Northeastern Michigan 2024

Iceland Aurora

February 13, 2024, Budir and Langaholt, Iceland,
Photos by Jim Klingshirn.



Michigan's New International Dark Sky Sanctuary



Aurora, the Milky Way
and Light Pollution,
Photo by Justin Miller,
JM Naturescapes,
Beaver Island, Michigan.

Auroral Arc with Pillars

Lower latitudes can offer a wider spectrum of color due to the atmospheric chemical gradient as seen from the side, not from below. Photo by Tim Wenzel.



Aurora Rays, Veils, Overhead



Photo by DJ Studios Photography, Marquette, MI



Photo by Jenn Boss Mainka, Northern Michigan

“STEVE,” the Sub-Thermal Emission Velocity Enhancement



Photo by Justin Miller, JM Naturescapes, Beaver Island, MI, Sept. 19, 2023, Silver Lake Dunes

STEVE with “Picket Fence”

STEVE, although not an aurora, appears along with picket fences at more southerly locations. Midland, Michigan. Photos by Tim Wenzel



STEVE with the “Picket Fence”



Photo by Clayton Adams, Upper Peninsula, MI



Photo by Pamela Hofacker Teachout, MI

“SAR,” the Stable Aurora Red arc



Photo by Joanne Furton, Colorado, May 10, 2024

Aurora Pillars/Rays

The entire sky was lit up. Munising, Michigan, iPhone 13 with a 30 second exposure on September 17, 2024, at 5:30am. Photo by Mary K Prager-Wolfgang



Aurora



August 12, 2024, Forester, Michigan, Photo by Enrique Garcia

Aurora Rays & Meteor

August 12, 2024,
Secret Sky Barn,
Kinde, Michigan,
Photo by Patrick Russell



Aurora

Wetzel Lake,
Mancelona,
M.A.K Photography
October 10, 2024,
Photo by
Mary Ann Kennedy



Copyright M.A.K Photography

Aurora

Photo by Rachel
VanFossen



Aurora Pillars

Sept. 17, 2024,
Around 6am

Photo by
Christina Cantu
Sharp, Mackinac
City, MI



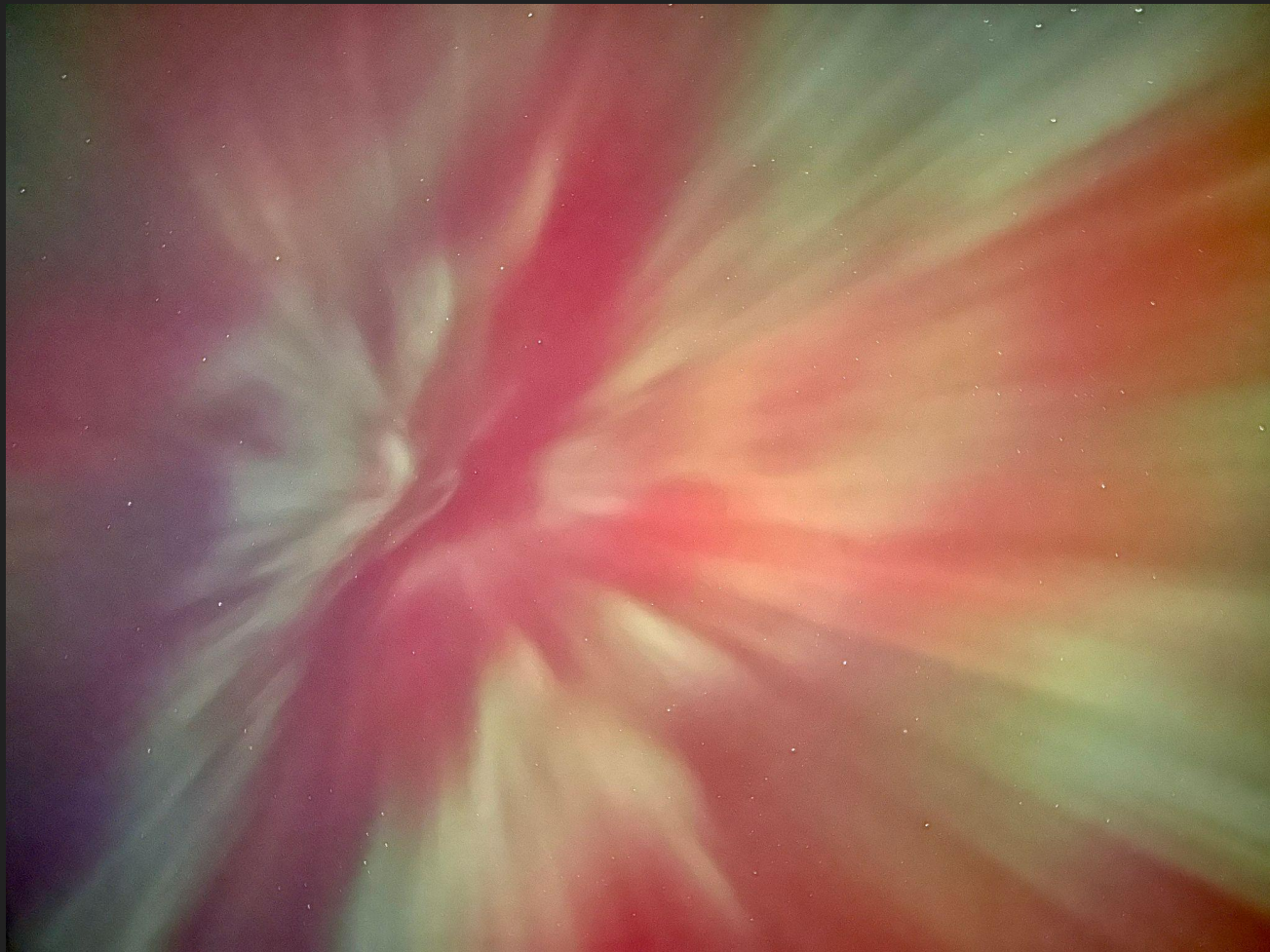
Corona

Photo by
Robert
Freeman



Corona

Photo by
Penny Wall



Corona

Photo by
Lisa Marks
Mahon



Corona

Photo by Justin Bradley.



Get Guides to Learn the Chase

Visit our free website for a wealth of advice, guides and tools:

- Camera settings and gear
- Aurora forecasting tools
- Viewing locations
- Upcoming events
- Video tutorials

MichiganAuroraChasers.com



Guides to the Night & Etiquette

- An Empowered Guide to Viewing Locations
- MI Aurora Resource List
- Advice Blog: Aurora Chasing in the U.S.
- YouTube: Aurora Chasing in Your Backyard



Using The Ovation Model
Aurora Chasing with Melissa F. Kaden

Aurora Chasing in Your Backyard

Melissa, The Aurora Chaser

Public ▾

6 videos 169 views Last updated on Nov 10,...

Find out what it takes to catch the Northern Lights in your backyard! Get Aurora Chasing tips, ...More

▶ Play all

↻ Shuffle



Aurora Chasing

Seven Ways to Find an Aurora Viewing Location

So, you want to see the Aurora! Here are seven ways to find a great Aurora Viewing Location, which are included in my new Empowered Guide.



Aurora Chasing

Five Simple Steps for Tracking Solar Flares

As Aurora Chasers, we love hearing about new solar flares. But many things have to happen for a solar flare to have any visible impact on our night skies.



Aurora Chasing

Make or Break Your Shot: The Beauty of Night Sky Etiquette

Take a few easy steps to ensure everyone around you can enjoy the night sky.



Aurora Chasing

Ask How, Not Where to View Aurora

Often, people who chase the Northern Lights can become too focused on WHERE

Blog > Book > YouTube

Aurora Chasing in the U.S.

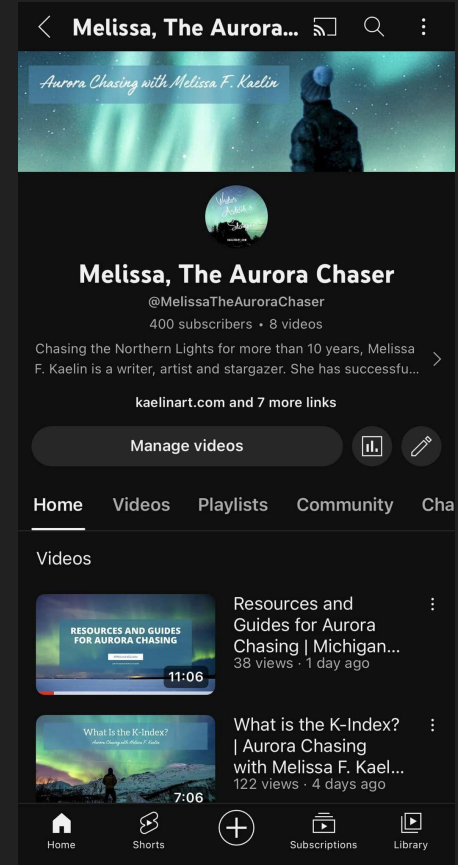


Chase the Northern Lights, and find out what it takes to catch a view in your own backyard.

An avid Aurora Chaser, I'm excited to share my advice on capturing the Northern Lights in the lower 48 states. Get tips for beginners and overcome the many obstacles to catch an amazing display. If you enjoy the content, subscribe below.



Explore: KaelinArt.com/Aurora



< **Melissa, The Aurora...**   

Aurora Chasing with Melissa F. Kaelin



Melissa, The Aurora Chaser

@MelissaTheAuroraChaser

400 subscribers • 8 videos

Chasing the Northern Lights for more than 10 years. Melissa

< **Melissa, The Aurora...**   

Home Videos Playlists Community Cha

Videos

-  What is the K-Index? | Aurora Chasing with Melissa F. Kaelin...
37 views · 6 hours ago 7:06
-  How to Read the SWPC Forecast | Aurora Chasing with Melissa F. Kaelin...
363 views · 2 days ago 10:29
-  Find a Viewing Location with Dark Sky & Light Pollution Maps | Aurora Chasing with Melissa F. Kaelin...
507 views · 2 days ago 13:55
-  Using the Ovation Model | Aurora Chasing with Melissa F. Kaelin...
264 views · 3 days ago 11:42
-  How to Find the Featured Section | Michigan Aurora Chasing with Melissa F. Kaelin...
713 views · 3 days ago 2:52

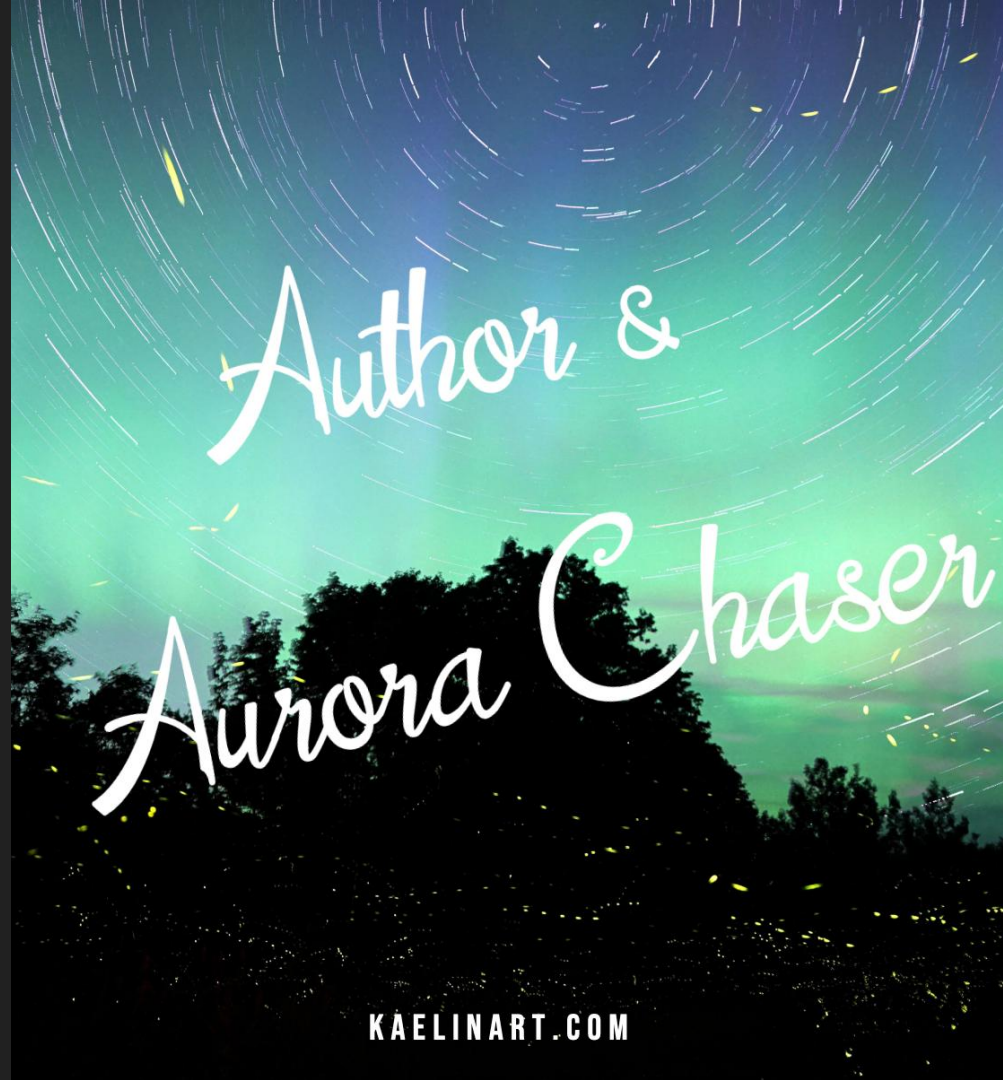
    

Home Shorts Subscriptions Library

Making the Dream a Reality

Find upcoming events,
advice, tools, techniques,
videos, books and more!

Visit: KaelinArt.com



Author &
Aurora Chaser

KAELINART.COM