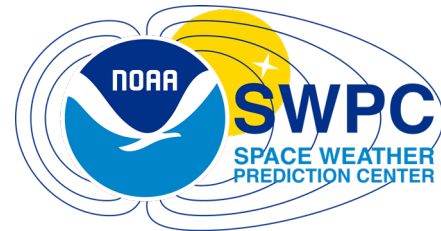




NATIONAL WEATHER SERVICE

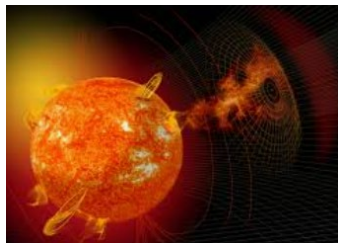
Building a Weather-Ready Nation

SWPC Decision Support for the Gannon Storm of May 10-12, 2024



Presenter: Shawn Dahl; SWPC Service Coordinator

January 14, 2025



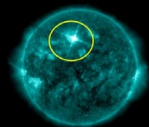
SPACE WEATHER SITUATION (CME-4: May 6)

SWPC increased messaging began even earlier than 6 May, but the amount of additional messaging (other than normal/routine products) really began to increase at this point, along with the increased activity and growing confidence in increasing risk of additional and stronger activity.

STRONG Flare Event

WHAT: X1.6/1b Flare Occurred from NOAA/SWPC Region 3663

R3



EVENT:

A flare is an eruption of energy from the Sun that generally lasts minutes to hours. Flares of this magnitude are not frequent.

TIMING:

The flare peaked at 03:02:22 UTC (03:22:22 EST)

EFFECTS:

Users of high frequency (HF) radio signals may experience temporary degradation or complete loss of signal on much of the sunlit side of Earth.

GOES-16 SSW Composite 133 Angstroms 2024-05-03 02:23:48
National Oceanic and Atmospheric Administration
Safeguarding Society with Actionable Space Weather Information
Space Weather Prediction Center
Boulder, CO

STRONG Flare Activity Observed - 05 May 2024

WHAT: Two X1 flares were observed from Region 3663

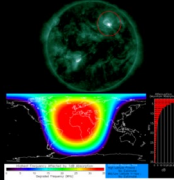
R3

EVENT:

Region 3663 produced an X1.3 flare at 05:06:01 UTC and an X1.2 flare at 05:11:54 UTC. There is a chance for additional X-class flare activity over 05-07 May due to the flare potential of Region 3663.

EFFECTS:

Users of high frequency (HF) radio signals may experience temporary degradation or complete loss of signal on the sunlit side of Earth.



National Oceanic and Atmospheric Administration
Safeguarding Society with Actionable Space Weather Information
Space Weather Prediction Center
Boulder, CO

Geomagnetic Storm WATCH for May 05-06 UTC-day

WHAT: A CME may arrive at Earth and lead to increased geomagnetic activity

G2

Updated 2024 May 05 22:03:07



EVENT:

A coronal mass ejection (CME) is an eruption of solar material. When they arrive at Earth, a geomagnetic storm can result. Watches of this level are not uncommon.

TIMING:

CME influence is anticipated on 05-06 May (UTC day). A G2 Watch is out for 05 May and a G2 Watch is out for 06 May.

EFFECTS:

The aurora may become visible over some northern and upper Midwest states from New York to Idaho. Those wishing to see the aurora should visit our webpage for updates

National Oceanic and Atmospheric Administration
Safeguarding Society with Actionable Space Weather Information
Space Weather Prediction Center
Boulder, CO



STRONG Flare Events 5-6 May

R3

Updated
2024 May 06
11:00am MST/MDT

WHAT: Multiple X-class Flares Occurred from NOAA/SWPC Region 3663

EVENTS:

Flares are eruptions of energy from the Sun that generally last minutes to hours. All X-class flares occurred from Region 3663

TIMING:

Multiple M-class flares also occurred, but beginning on 5 May, intensity of flares increased, with a peak energy of X4.5 (R3) reached on 6 May at 0635 UTC

EFFECTS:

Users of high frequency (HF) radio signals may experience temporary degradation or complete loss of signal on much of the sunlit side of with such flares.



2024-05-06T06:20:25-0600

National Oceanic and
Atmospheric Administration
NOAA Government of the United States

Safeguarding Society with Actionable Space Weather Information

Space Weather Prediction Center
Boulder, CO



NATIONAL WEATHER SERVICE

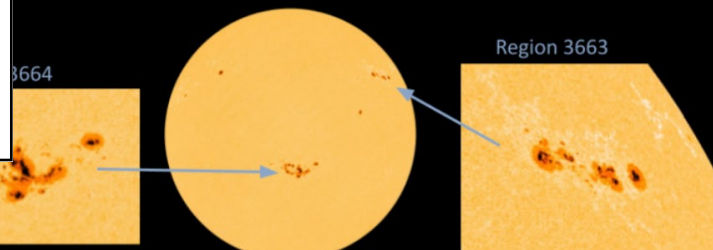
SPACE WEATHER (CME-3: May 7)

early stage decision support on 7 May about levels of confidence and concern over increasing a prolific space weather storm to develop and particular product caught the attention of many their space weather support raised accordingly

Complex & Complex Sunspot Groups on Solar Disk

Updated
7 May 2024
1000 MDT

The Sun has Two Large Active Regions of Increased Solar Flare Risk



Active Regions 3663 and 3664 Making for an Increased Solar Flare Risk Forecast

These two sunspot clusters are magnetically complex and much larger than Earth. Together, they have been the source of frequent M-class flares (R1-R2; Minor-Moderate). While RGN 3663 has been the source of the stronger activity thus far (R3; Strong events 5-6 May), RGN 3664 continues to grow and increase in magnetic complexity and has evolved into a higher threat of increased solar flare risk. Therefore, M-class flares are expected, with an increasing chance of X-class flares (R3) over the next several days. Continue to monitor the SWPC webpage for the latest information and forecasts.



National Oceanic and
Atmospheric Administration
U.S. Department of Commerce

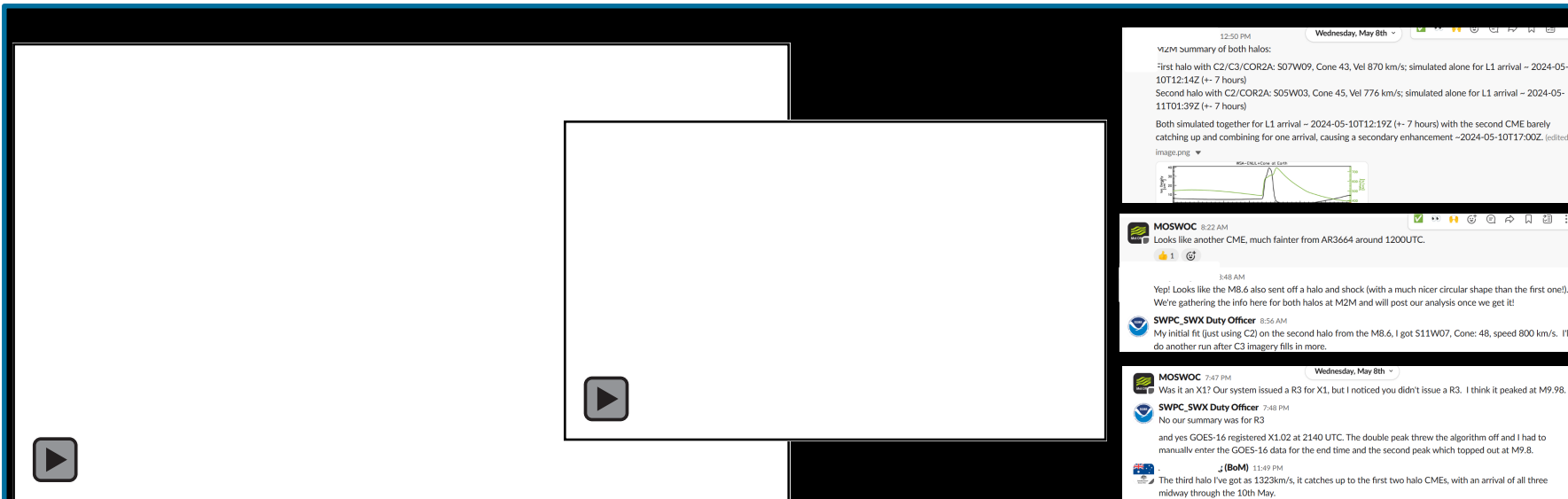
Safeguarding Society with Actionable Space Weather Information

Space Weather Prediction Center:
Boulder, CO



NATIONAL WEATHER SERVICE

SPACE WEATHER (CME-2: May 8)



12:50 PM Wednesday, May 8th

viz2M summary of both halos:

First halo with C2/C3/COR2A: S07W09, Cone 43, Vel 870 km/s; simulated alone for L1 arrival ~ 2024-05-10T12:14Z (+/- 7 hours)

Second halo with C2/COR2A: S05W03, Cone 45, Vel 776 km/s; simulated alone for L1 arrival ~ 2024-05-11T01:39Z (+/- 7 hours)

Both simulated together for L1 arrival ~ 2024-05-10T12:19Z (+/- 7 hours) with the second CME barely catching up and combining for one arrival, causing a secondary enhancement ~2024-05-10T17:00Z. (edited)

image.png

8:22 AM

MOSWOC

Looks like another CME, much fainter from AR3664 around 1200UTC.

3:48 AM

Yep! Looks like the M8.6 also sent off a halo and shock (with a much nicer circular shape than the first one!). We're gathering the info here for both halos at M2M and will post our analysis once we get it!

8:56 AM

SWPC_SWX Duty Officer

My initial fit (just using C2) on the second halo from the M8.6, I got S11W07, Cone: 48, speed 800 km/s. I'll do another run after C3 imagery fills in more.

7:47 PM Wednesday, May 8th

MOSWOC

Was it an X1? Our system issued a R3 for X1, but I noticed you didn't issue a R3. I think it peaked at M9.98.

7:48 PM

SWPC_SWX Duty Officer

No our summary was for R3

and yes GOES-16 registered X1.02 at 2140 UTC. The double peak threw the algorithm off and I had to manually enter the GOES-16 data for the end time and the second peak which topped out at M9.8.

11:49 PM

(BoM)

The third halo I've got as 1323km/s, it catches up to the first two halo CMEs, with an arrival of all three midway through the 10th May.

SWPC forecasters closely analyze the increasing number of flares and now, full halo CMEs expelling from the Sun. Collaboration with core partners (557th SpaceWOC, M2M, NASA-SRAG, UKMet Office, BoM-Australia) increases and forecasters begin comparing model runs, analyses, confidence levels, etc. to ensure international and national continuity of forecasts as concerns for severe to extreme geomagnetic storm levels now begin. SWPC messaging continues at an elevated pace and frequency due to frequency of strong flares and now, CME production.



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Department of Commerce // National Oceanic and Atmospheric Administration // 4

SPACE WEATHER (CME-1: 9 May)

SWPC issues an initial G3 Watch and upgrades to a G4 Watch (24 hours before CME arrival at Earth) due to increased confidence of a multiple train of CMEs directed towards Earth.

Collaboration and messaging continues at an elevated pace, but now FEMA is getting briefed directly on 9 May due to the ironic situation of National TableTop Exercise that involves Federal Department Agencies; along with FEMA Region VIII. Real-time space weather updates begin from SWPC and in-place at D.C. and Denver. The National Security Council and White House Situation Room began receiving updates.



Geomagnetic Storm WATCH for May 11, 2024

G4

Updated
2024-05-09
1:30pm EDT

WHAT: Several CMEs will quite likely reach Earth and lead to highly elevated geomagnetic activity

EVENT:

A coronal mass ejection (CME) is an eruption of solar material. When they arrive at Earth, a geomagnetic storm can result. Watches at this level are very rare.

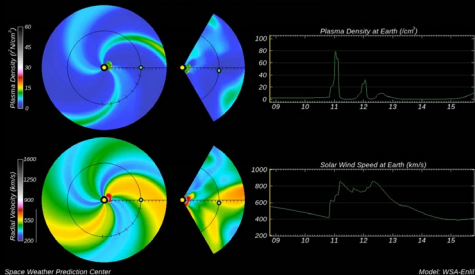
TIMING:

The CMEs are anticipated to merge and arrive at Earth by late on May 10th or early on May 11th.

EFFECTS:

The general public should visit our webpage to keep properly informed. The aurora may become visible over much of the northern half of the country, and maybe as far south as Alabama to northern California.

2024-05-08 19:00:00



Space Weather Prediction Center

Model: WSA-Enlil

National Oceanic and
Atmospheric Administration
U.S. Department of Commerce

Safeguarding Society with Actionable Space Weather Information

Space Weather Prediction Center;
Boulder, CO

SWPC ISSUES ITS FIRST G4 WATCH SINCE 2005



Active Space Weather Conditions Through Weekend

WHAT: Large Sunspot Groups and Flares Lead to First G4 Watch Since 2005

- On Thursday, May 9, the NOAA Space Weather Prediction Center issued a Severe (G4) Geomagnetic Storm Watch – the first since January 2005.
- At least five earth-directed coronal mass ejections (CMEs) were observed and expected to arrive as early as midday Friday, May 10, 2024, and persist through Sunday, May 12, 2024. This is an unusual event.
- Several strong flares have been observed over the past few days and were associated with a large and magnetically complex sunspot cluster (NOAA region 3664), which is 16 times the diameter of Earth. Additional solar activity is expected from the region.
- Only three Severe geomagnetic storms have been observed during this solar cycle which began in December 2019. The last G4 (Severe) was on March 23, 2024, and the last G5 (Extreme) was the Halloween Storms in October 2003. That G5 resulted in power outages in Sweden and damaged power transformers in South Africa.

2024-05-09 19:28:00 UTC

National Oceanic and
Atmospheric Administration
U.S. Department of Commerce

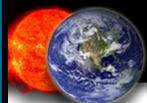
Safeguarding Society with Actionable Space Weather Information

Space Weather Prediction Center;
Boulder, CO

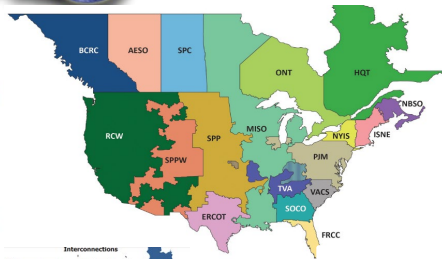


NATIONAL WEATHER SERVICE

SPACE WEATHER (CME-6hr through Arrival: 10 May)



Impact-based Decision Support

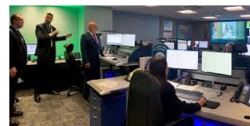


NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

- SWPC activated the North American Electric Reliability Corporation (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."*



Impact-based Decision Support



- Coordinated extensively with State Watch Centers, FEMA Regions I-X, and the Cybersecurity and Infrastructure Security Agency.
- Provided detailed briefings on expected impacts and recommended precautions.



Forward Thinking Decision Support Provided Through Event
G4 Watch NERC Hotline Call initiated -6hr prior to CME arrival
CISA Briefings and discussions
State Watch Centers and FEMA Region updates
Communications' Infrastructure Executives Update
Satellite Operators kept informed and questions addressed
National NWS and Regional Watch Centers advised
NASA & Space Launch Missions kept informed



NATIONAL WEATHER SERVICE

SPACE WEATHER SUPPORT Continued into May 12th

USAF: continual – concern for DoD assets and operations



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: S4/5 & G4/5 levels – for situational awareness and potential preparations



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



Unprecedented Media Engagement

Early Friday, May 10, SWPC held a telemedia conference attended by over 1300 reporters; including from the AP, NY Times, Bloomberg News, CNN, Reuters

Throughout the event, SWPC gave over 150 individual broadcast or radio interviews including National and International media outlets

AP Associated Press



SWPC Service Coordinator, Shawn Dahl, on NBC Nightly News

SPACE

The huge solar storm is keeping power grid and satellite operators on edge

UPDATED MAY 11, 2024 - 12:52 PM ET

HEARD ON ALL THINGS CONSIDERED



NATIONAL WEATHER SERVICE

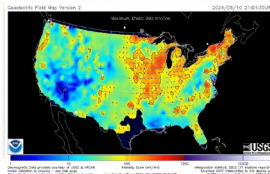
SWPC IDSS PROVED CRUCIAL to Decision Makers



Many Success Stories



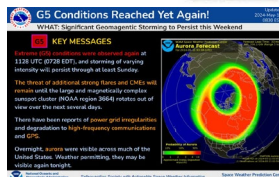
NERC leadership acknowledged said that *“SWPC was indispensable to NERC...grid operators across North America took significant steps to prepare before the storm.”*



Expected disruptions in high-frequency (HF) radio communications had significant implications for trans-oceanic aviation, which relies heavily on HF radio for communication over long distances.



SWPC provided frequent updates and detailed briefings on the expected impacts and recommended precautions with several partners and federal agencies.



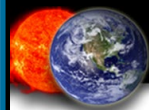
Several satellite operators were in direct communication with SWPC during the event, and stated that *“SWPC warnings on incoming space weather events were super useful!”*

Space Weather Warnings Protect Critical Infrastructure



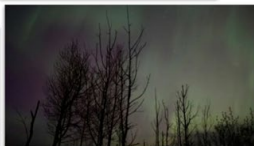
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SPECTACULAR Won over CONSEQUENTIAL



The Popular Story

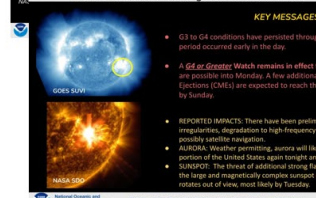
Aurora seen around the world...



Authoritative Voice for Space Weather



Historic Geomagnetic Storm Continues
WHAT: Most Extreme Geomagnetic Storm Since 2003



- 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.

NERC Post-Event Webinar Feedback

Congratulations to NERC, SWPC, and EPRI for all your great work in protecting the grid - and the country! - during this event! This was no joke and y'all should be thanked and congratulated for your effective efforts! Thank you!

In my opinion **this was the most prepared for and successfully mitigated extreme space weather storm in history**; thanks to all the government involvement and stress over the past 10-20 years, education and preparedness among the our technological infrastructure; and all the efforts of the Space Weather Prediction Center to inform all sectors possible before and throughout the event. If these actions were not accomplished, this storm would have been much more impactful. More work is to be done though, as this particular storm was less intense than the 1989 storm and likely 3-5x less strength of what we know is historically possible

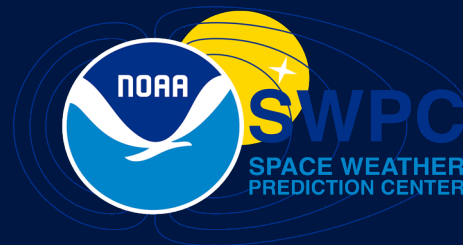


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Thank you!

Shawn Dahl – SWPC Service Coordinator

shawn.dahl@noaa.gov



“Safeguarding Society with Actionable Space Weather Information”



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