

Essential Space Weather Information for Emergency Management





SWPC: "Safeguarding Society with Actionable Space Weather Information"



NORR TO MUSE

What is Space Weather?

Space weather refers to the variable conditions on the Sun and in space that can influence performance and reliability of space and ground-based technological systems, and endanger life or health.

> Coronal Mass Ejection

lonosphere

Various emissions from the Sun affect Earth 93 Million Miles from Sun to Earth Magnetosphere



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

Space Weather Importance Recognized by the Federal Government





NOAA

NATIONAL SPACE WEATHER STRATEGY AND ACTION PLAN

Product of the SPACE WEATHER OPERATIONS, RESEARCH, and MITIGATION WORKING GROUP SPACE WEATHER, SECURITY, and HAZARDS SUBCOMMITTEE COMMITTEE ON HOMELAND and NATIONAL SECURITY

> of the NATIONAL SCIENCE & TECHNOLOGY COUNCIL

One Hundred Sixteenth Congress of the United States of America

AT THE SECOND SESSION

Begun and held at the City of Washington on Friday, the third day of January, two thousand and twenty

An Act

To improve understanding and forecasting of space weather events, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, SECTION 1. SHORT TITLE.

This Act may be cited as the "Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow Act" or the "PROSWIFT Act".

SEC. 2. SPACE WEATHER

(a) POLICY.—It shall be the policy of the United States to prepare and protect against the social and economic impacts of space weather phenomena by supporting actions to improve space weather forecasts and predictions including: sustaining and enhancing critical observations, identifying research needs and pro-



Section 1. Purpose. Commonsense approaches and investments by State and local governments across American infrastructure will enhance national security and create a more resilient Nation. Federal policy must rightly recognize that preparedness is most effectively owned and managed at the State, local, and even individual levels, supported by a competent, accessible, and efficient Federal Government. Citizens are the immediate beneficiaries of sound local decisions and investments designed to address risks, including cyber attacks, wildfires, hurricanes, and space weather When States are empowered to make smart infrastructure choices, taxpayers benefit.

PLANNING THE FUTURE SPACE WEATHER OPERATIONS AND RESEARCH INFRASTRUCTURE



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



EXECUTIVE ORDERS

Executive Order on Coordinating National Resilience to Electromagnetic Pulses

INFRASTRUCTURE & TECHNOLOGY Issued on: March 26, 2019

Whitehouse gov

'Sec:.
'Sofol1. Space weather,
'Sofol3. Sustaining and advancing critical space weather observations.
''Gofol3. Search activities.
''Gofol5. Space weather data.
''Gofol6. Space weather knowledge transfer and information exchange.
''Gofol6. Space weather noblaining commercial sector space weather data.
''Gofol8. Space weather benchmarks.

(b) AMENDMENT TO TITLE 51, UNITED STATES CODE.—Subtitle VI of 51, United States Code, is amended by adding after chapter 605 the following:

"CHAPTER 606—SPACE WEATHER

Space Weather Plans for by EM at City, County, and State Levels is Increasing



Space Weather and Beyond: The

NOAA

State of North Dakota became the first state in the nation to prepare a robust evaluation of the risk and vulnerability to its electrical power infrastructure from an emergency management perspective. The Electrical System Resiliency Annex to the State of North Dakota Enhanced Mitigation Mission Area Operations Plan evaluated the risk and vulnerability to its electrical power infrastructure from the emergency management perspective. Hazards and threats range from the more prevalent natural hazards (i.e., flood, severe winter weather, severe summer weather) to geomagnetic disturbances (GMD) associated with space weather (caused by heightened activity like coronal mass ejections [CME] from the sun), and include the threat associated with man-made electromagnetic pulses (EMP) generated by nuclear weapons that have exploded in the atmosphere.



.....

4.9.1.1 Description

Space weather is defined by the American Meteoreliagical Society as, "dynamic conditions on the Sun and in the space environment," is particular, in the rear-Earth environment," (American Meteorological Society, 2013).

Figure 4:0-1 is the Sun on May 10, 2014, as shown by the NOAh Space Weather Prediction Center (SWPC), which monitors all space weather, harmful or not. The NOAA SWPC losues forecests, wetches, warrings, and alerts.

to keep us informed of the threat the Sun's weather can deliver to Earth. According to the NCAA SWIPC (2024), the image of the Sun includes dark spots, or coronal holes, where relatively cooler plasma exists, and where solar radiation storms and solar flants are more likely to emerge. It can be noted that there is a fuzzy hase around the round sun. This is due to solar winds that create geomagnetic storms.

Figure 4.9-2 shows several phenomena covered by space weather, some of which are defined below:

2024



The gubance you provided to the opace version Committee, the virtual space versities training you provided to our local, tribal, and state level Emergency Management professionals as part of our Plan Developers. Series; and the many resources, references, and contacts you provided to our plan writers and editors helped us to achieve the most comprehensive Space Weather Hazard section the FEMA Region VIII plan review staff had ever seen. We've even been contacted by the Tennessee Emergency Management Agency asking about our Space Weather Hazard section, as they consider adding this to their plan!

Eric Upton, Planning Section Chief North Dakota Department of Emergency Services

https://www.des.nd.gov/sites/www/files/documents/reports-plans/2024-29 EnhancedMitigation MAOP.pdf

00839-34 IBAH Dampanite 195 Keepinama 2004-07-11-06-83-1

Source: MOAA Space Weather Prediction Center, JSD



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".







Forecast Focus Areas

(3 main activity types SWPC forecasts for your needs/awareness)





a de la companya de l

Solar Flares R-scale



R3 Locati flare Earth disk do ma

Oct 3rd: X9 (R3) flare from the southern hemisphere of the Sun. Largest flare of 2024 in Solar Cycle 25

Their X-ray energy strength correlates to the likelihood of certain types of HF radio interference or signal absorption on the sunlit side of Earth; and relates to geographic area of impact. Impact on Earth's sunlit ionosphere is immediate.

A concern for Ham radio users and other types of HF communications (usually voice modulation and skywave); mainly 3 – 30 Mhz



When Extreme Space Weather and Catastrophic Terrestrial Weather come together



SPACE SCIENCE & SPACE PHYSICS 🕮 Scientific Press Release (y)-(f)-(8+)-(<)-Solar Flares Disrupted Radio During 2017 Hurricane Irma On 6 September 2017, as Category 5 Hurricane Irma hit the Caribbean's by AGU Leeward Islands, and Tropical Storm Jose hovered in the wings, another storm 30 Julv erupted on the Sun



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.







late afternoon of 21 Feb through the overnight hours into early 22 Feb. Levels reached were R3 (Strong) as seen in these images from GOES-16.

EFFECTS:

While solar flares can affect communication systems, radar, and the Global Positioning System, based on the intensity of these eruptions and associated phenomena, it is unlikely that these flares contributed to the widely reported cellular network outage.

Universal Time

 GOES-18 Short — GOES–18 Long ES-16 Short

Space Weather Prediction Center

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



Feb 22nd

TIMING:

The events peaked at 6:07 p.m.

EST on Feb 21st and the second

peak was at 1:32 a.m. EST on

NOAF



So, this would have lessened their impact in duration as well.

All three flares

were quite

impulsive (quick

to rise and

decrease).



Frequency (Radio) Bursts

Updated

2023 Dec 14 1900 EST





Strongest Solar Flare of this Solar Cycle

WHAT: Multiple Aviation Communication Impacts Associated with this Event

Amazing Event - likely one of the largest solar radio events ever recorded

Radio communication impacts between approximately 1200 - 1400 EST Thu

CWSUs report degraded communications across Nation

- ZKC, ZMP, ZAU, ZNY, ZOB
- "... Never seen anything like this..." ZOB

Possible Earth-directed Coronal Mass Ejection (CME) being analyzed

Dec 14th





If longer, this likely would have led to shutdown of Airspace.





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Can make radio communication difficult or unclear on Additional Air Traffic Control (ATC) bands impacted dra bands over U.S. - problem on 14 Dec! Could also be issue for urban environment

communication repeater systems. Also, concern for military assets and interests.





Solar Radiation Storms S-scale





EFFECTS:

Solar radiation storms of this magnitude can often result in degradation or loss of HF communications in the polar regions. Updated 2024-06-10 14:00 UT Space launch operations at risk; also slight risk to satellites.



Safeguarding Society with Actionable Space Weather Information



Can adversely affect aviation – increased radiation exposure risk to astronauts and perhaps aircrews at high altitudes near polar regions; relates to long HF communication outages extending from polar regions; can delay space launch and cause increased risk of anomalies or damage to satellites

Boulder, CC

Space Weather Prediction Center



Coronal Mass Ejections (CME)



Filament Prominence **Eruptions:** Sort of like the space weather version of a tremendous "tornado" carrying solar debris and a strong magnetic field along with it!

While these events can be impressive in nature, they usually are not as strong as space weather storms/events associated with energetic solar flares.



PTMENT OF

Coronal Mass Ejections (CME)





SP 7 2 6 3 7 8 7



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Geomagnetic Storms G-scale



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





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:



Forecast probabilities and intensities out 3 days

*Kp Index (0-9) is a common index used to determine strength of overall global geomagnetic disturbances. SWPC estimates the value of the Kp Index in real-time based on 8 magnetometer stations around the globe. When levels reach Kp 5, that warrants NOAA Space Weather Scale levels

> 0-2 = Quiet 3 = Unsettled 4 = Active

Estimated in real-time; with a final value attributed at the end of each 3-hour period. This can cause confusion, because we may not reach expected levels every 3 hours. Think of it like a rain gauge being emptied every 3 hours – but the heavy rain event continues, with varying amounts of precipitation rates



Based on Estimated Planetary K-index (8 magnetometer stations). Kp5 = G1 Kp6 = G2 Kp7 = G3 Kp8-K9m = G4 Kp9z = G5

*each Kp level divided into three levels: m (-); z (0); and p (+)



Typical Actions related to just the Power Grid regarding Geomagnetic Storms







Phone call to Wisconsin Electric Control Area and the New York ISO



Phone call to Wisconsin Electric Control and the New York ISO (NY only for G2 Watch)



NERC Hotline Call and Wisconsin Electric Control Area (G3 Watch – call NY only)



NERC Hotline Call and Wisconsin Electric Control; FEMA notified; possibly the NSC/WHSR



NERC Hotline Call and Wisconsin Electric Control; FEMA notified; NSC/WHSR informed

Communicating Space Weather





Geoelectric Field Model



"nowcast" model projection with calculated voltage per kilometer approaching 1V/km are noteworthy; 12V/km could be impactful

Usually measured in millvolts or 1/1000th of a Volt (mV)

Geoelectric fields are the electric potential on the earth's surface and is directly related to rate of change in magnetic fields. They have amplitude and direction, and act as a voltage source that can cause GICs to flow along conductors – like transmission lines



Measure of the induction hazard to artificial conductors, such as power lines. Used to estimate induced geomagnetic current (GIC) integration along conducting pathways.

HQ system knocked offline in just 90 seconds – for 9 hours. NE U.S. – transformer damage. Most power issues concentrated in areas of high surface impedance and geoelectric field amplitudes; especially near large cities.



Normal Sequence of Events





ALERT Sent at R2 or greater

Probabilities predicted in 3-day forecast; a flare occurs (speed of light), effect already taking place in outer atmosphere



WARNING Sent for S1 or greater ALERT Sent for each S1-S5 level

Probabilities predicted in 3-day forecast; Can be nearly speed of light, but warnings possible



WATCHES Sent for G1-G4 or greater WARNING Sent for Kp4-7+ (G1-G3+) ALERT Sent for each level through Kp 9z (G1-G5)

Geomagnetic Storms can be predicted out to 3 days; so watches and warnings possible. Science limits threshold capabilities however



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

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











Notable Space Weather Events



Carrington Event, 1-2 September 1859: Aurora may have been seen from Hawaii and Cuba 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.









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

s: Analysis likely reveal an arrival < 24 hours

hrs: Collaboration with other space weather centers for consensus of arrival date/timing

CME +10hrs: G3/G4 Watch issued

+10-12hrs: IDSS & Messaging accomplished

nrs: 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?



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 (effecting 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.



Solar Activity: May 6th – 8th

Massive sunspot groups present on the Sun. The northern cluster was responsible for numerous R2-R3 level events, but no CMEs of note. The southern region, however, became very magnetically complex r events as it rotated westward.



e southern spot cluster, RGN 3664, from an number of days. Notice the shifting complexity nges that took place. Magnetic maps confirmed the very complex and unstable nature of this active region



h May 12th



TC-day **G3**

d 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 infrequent, but not uncommon.

The CMEs are anticipated to merge and arrive at Earth late 10 to early 11 May EFFECTS:

general public should keep informed visiting our webpage for any forecast changes and updates. The aurora may ome visible over many of the northern tes and some of the lower Midwest to Oregon.

rmotion	Space Weather Prediction Center;
mauon	Boulder, CO

TIMING:

analyzed and at least 5 were determined to have Earthdirected components. G3 Watch issued over 36 hours in advance.

Multiple CMEs

uced numerous flares at the R2-R3 began flaring and provided plenty of

CMEs: to Arrive May 10-11^{th:} G4 Storm Likely

ic Storm WATCH for May 11, 2024

As will guite likely reach Earth and lead to highly elevated geomagnetic activity

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:

northern California.



Confidence increased and G3 was upgraded to the very rare G4 or Greater Watch 24 hours in advance.

EVENT:

2024-05-09





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. A G3 (Strong) Watch was issued 36 hours in advance of the CME arrivals. This was eventually upgraded to a G4 Watch 24 hours prior to CME arrivals.



having at least a day of

advanced warning (thank vou!).

y'all should be thanked and congratulated for your

effective efforts! Thank vou!"

First G4 or Greater 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 unusua event
 - Several strong flares have been observed over the past few days and were associated with a large and magnetically complex sunsp 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 G (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

CVBF

Space Weather Prediction Center

Boulder CO

& INFA

CISA

URITY AGEN

Prompted immediate action to provide decision support services to technology and infrastructure operators, including electric power grid operators, satellite partners, aviation, and other sectors.



"The Biden Administration is monitoring the situation"

Situation Room











Impact-based Decision Support



 SWPC activated the North American **Electric Reliability Corporation (NERC)** hotline to discuss the G4 or Greater Watch.

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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.

EVENTS of May 8th through May 12th

Ř

Updated

0830 EST

2024-May-11

G5 Conditions Reached Yet Again!

WHAT: Significant Geomagentic Storming to Persist this Weekend

KEY MESSAGES

Extreme (G5) conditions were observed again at 1128 UTC (0728 EDT), and storming of varying intensity will persist through at least Sunday.

The threat of additional strong flares and CMEs will remain until the large and magnetically complex sunspot cluster (NOAA region 3664) rotates out of view over the next several days.

There have been reports of power grid irregularities and degradation to high-frequency communications and GPS.

Overnight, aurora were visible across much of the United States. Weather permitting, they may be visible again tonight.

National Oceanic and Atmospheric Administration Safe



tion Safeguarding Society with Actionable Space Weather Information

Space Weather Prediction Center; Boulder, CO

Advance warning successfully mitigated many impacts

"SWPC was indispensable to NERC...grid operators across North America took significant steps to prepare before the storm."

Post-Event NERC 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!"

A MAJOR SATELLITE OPERATOR

Thank you for the updates and keeping us in the loop in real time. We are taking protective measures to minimize the impact on our satellite operations and overall network health.

The Weather Company

"This was the first space weather event that we were able to actively take preparedness actions for, and that was definitely due to having at least a day of advanced warning (thank you!)."

Numerous amounts of information flow, briefings, decision-support, products, messaging, and updates to a number of sectors and the general public throughout the event. From the real-world updates at the TTX in D.C. and FEMA Region VIII HQ in Denver for an Extreme space weather storm scenario being in progress at the time of the G4 Watch posting - to continuing warnings and situational awareness updates.

Geomagnetic Storm: 10-12 May 2024 **G5**

Energy Sector

- US and Canada grid operators took numerous actions to mitigate impacts
- High voltage lines tripped in northern Europe
- **UK transformers** overheated/alarmed
- New Zealand took actions to protect 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



Image: Ken Trombatore

NAWAS?

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



The New Hork Times May 13, 2024 Solar Storm Crashes GPS Systems Used by Some Farmers, Stalling Planting

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**





May 10th-12th: One of the Strongest Solar Storms, but G5 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	ОСТ 2003	MAR 1989	MAY 1921	SEP 1859
Disturbance Storm Index (nT)	-412	-383	-589	~ -907	~-1200
A _p -Index	271	204	246	NA	NA

Disturbance Storm Index (Dst): 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_p -Index: The average from eight daily values gives the A_p -index of a certain day (every 3-hour K-value - or measure of geomagnetic activity - is converted into a linear scale). Days with higher geomagnetic activity have a higher daily A_p -value.

Nati Atm

National Oceanic and Atmospheric Administration Sa 15 Department of Communice

Safeguarding Society with Actionable Space





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 lowestlatitude aurora sightings on record over the past 500 years, though scientists are still assessing this ranking.



Spectacular won over Consequential





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 accomlished, 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





SWPC PSS for direct emails of many various products and WWA *NWS INWS for direct text messages and/or emails of primary WA *experimental service intended only for NWS core partners, EMs, and other government agencies





Product: 3-Day Forecast Issued: 2024 Oct 05 0030 UTC * Prepared by the US Dept. of Commerce, NOAA, Space Weather Prediction Center * Product description and SWPC contact on the Web * http://www.swpc.noaa.gov/wwire.html

3-Day Forecast

A. NOAA Geomagnetic Activity Observation and Forecast

The greatest observed 3 hr Kp over the past 24 hours was 3 (below NOAA Scale levels).

The greatest expected 3 hr Kp for Oct 05-Oct 07 2024 is 7.00 (NOAA Scale 53).

NOAA Kp index breakdown Oct 05-Oct 07 2024

	Oct 05	Oct 06	Oct 07
90-03UT	5.00 (G1)	7.00 (G3)	3.67
93-06UT	5.00 (G1)	6.67 (G3)	3.00
96-09UT	3.67	6.00 (G2)	3.33
99-12UT	4.00	5.00 (G1)	4.67 (G1)
12-15UT	4.67 (G1)	4.00	5.00 (G1)
15-18UT	6.33 (G2)	4.67 (G1)	3.33
18-21UT	6.67 (G3)	5.00 (G1)	4.00
21-00UT	7.00 (G3)	5.33 (G1)	4.67 (G1)

Rationale: G3 (Strong) geomagnetic storming is likely on 05-06 Oct due to the aforementioned CME effects. A chance for isolated periods of G4 (Severe) storming is possible if the arrival of these CMEs coincide with one another, and are not separated by an appreciable amount of time as WSA-Enlil output suggests. However, confidence in this outcome is low. G1 (Minor) geomagnetic storming is likely on 07 Oct with any glancing influence from the CME that left the Sun early on 04 Oct coupled with positive polarity CH HSS onset.

B. NOAA Solar Radiation Activity Observation and Forecast

Solar radiation, as observed by NOAA GOES-18 over the past 24 hours, was below S-scale storm level thresholds.

Solar Radiation Storm Forecast for Oct 05-Oct 07 2024

0ct 05 0ct 06 0ct 07 S1 or greater 35% 35% 35%

Rationale: There is a chance for the greater than 10 MeV proton flux reaching the S1 (Minor) threshold on 05-07 Oct due to the enhanced flare potential from multiple, magnetically complex regions nearing the western limb of the solar disk.

C. NOAA Radio Blackout Activity and Forecast

Radio blackouts reaching the R1 levels were observed over the past 24 hours. The largest was at Oct 04 2024 1103 UTC.

Radio Blackout Forecast for Oct 05-Oct 07 2024

	Oct 05	Oct 06	Oct 07
R1-R2	75%	75%	75%
R3 or greater	35%	35%	35%

Rationale: R1-R2 (Minor-Moderate) radio blackouts are expected, with a chance for isolated R3 (Strong or greater) radio blackouts on 05-07 Oct.

3-Day Forecast

Issued twice daily: 0030 & 1230 UTC

Primarily for NOAA-scale {R, S, G} level events



SPACE WEATHER PREDICTION CENTER
MITIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

 Wednesday, June 05, 2024 15.05.13 UTC

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The Future of Decision-Support





Space Weather Effects Outlook for EM Apr 1-3

Additional Information Available at spaceweather.gov

Key Messages

Comm systems that use HF (i.e. Ham radio) may experience occasional, short duration (minutes to tens of minutes) disruptions during daylight.

Additional, longer duration degradation to HF comm systems near polar regions may be impacted regardless of daylight or night hours.

Space Weather Related Concerns		Cur 1 /	rent Apr	24hr Forecast 2 Apr		48hr Forecast 3 Apr
Communications Degradation		HF only		HF only		HF only
GPS Errors						
Power Grid Disruption						
Low Risk <10%	Slight Risk	<20%	Moderate	e Risk >50%		High Risk >70%

Apr 1, 2025 10:00 AM MDT

Discussion Points

There have been R1-R2 events in the past 24 hours that was restricted to short-duration, limited HF communication degradation over the sunlit side of Earth.

An S1 storm began 31 Mar and remains in progress, however, effects are limited to near the polar regions for HF comm systems.

There were no recent G-scale events and expectations are currently very low for any G1 or greater activity.

Space Weather Activity	Past 24 Hours
Communications Degradation	HF only
GPS Errors	
Power Grid Disruption	

National Oceanic and Atmospheric Administration Safequa

U.S. Department of Commerce

Safeguarding Society with Actionable Space Weather Information

Space Weather Prediction Center; Boulder, CO Our goal is to make our support products more tailored for sector-specificity and actionable.

Also, we are working towards fusing this space weather effects information with terrestrial weather information – a one-stop shop effects product.

Space Weather Preparedness





Space weather can have an impact on our advanced technologies, which have a direct impact on our daily lives. To begin preparing for the potential loss of electrical power in an **extreme** geomagnetic storm case, you should <u>;build an emergency kil</u> and make a <u>;family communications plan</u>. Other steps you should take to prepare for an emergency:

- Fill plastic containers with water and place them in the refrigerator and freezer if there's room. Leave about an inch of space inside each one because water expands as it freezes. This chilled or frozen water will help keep food cold during a temporary power outage.
- Most medication that requires refrigeration can be kept in a closed refrigerator for several hours without a problem. If unsure, check with your physician
 or pharmacist.
- · Keep your car tank at least half full because gas stations rely on electricity to power their pumps.

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- If you have a garage, find out where the manual release lever of your electric garage door opener is located and how to operate it. Garage doors can be heavy, so know that you may need help to lift it.
- Keep a key to your house with you if you regularly use the garage as the primary means of entering your home, in case the garage door will not open.
- Keep extra batteries for your phone in a safe place or purchase a solar-powered or hand crank charger. These chargers are good emergency tools to
 keep your laptop and other small electronics working in the event of a power outage. If you own a car, purchase a car phone charger because you can
 charge your phone if you lose power at your home.
- If you have a traditional landline (non-broadband or VOIP) phone, keep at least one non-cordless receiver in your home because it will work even if you lose power.
- Prepare a family contact sheet. This should include at least one out-of-town contact that may be better able to reach family members in an emergency.
- Make back-up copies of important digital data and information, automatically if possible, or at least weekly.

The vast majority of NOAA Geomagnetic Scale 5 level storms (G5) will not cause catastrophic damage to the electric grid. On average, the Earth is impacted by such storms about four times during every 11-year solar cycle, so many large storms have impacted the planet since the Carrington Storm with much less signification impact.

After an Extreme Space Weather Event

Weather.gov > Safety > After an Extreme Space Weather Event

Space Weather	Watches and Warnings	Before a Solar Event	During a Solar Event	After a Solar Event
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Powerlines can be o	effected by solar eru	uptions: NOAA	M	2 WY

Listen to Local Officials

• Follow any emergency plans that have been established in your area by your <u>state and local government</u>. In any emergency, always listen to the instructions given by local emergency management officials.

- Monitor emergency broadcast radios for EAS updates.
- Inventory supplies, medications, water levels, etc. Replenish (if needed) to prepare for future use.

NWS Space Weather Safety

Thank You!

POC for your questions or concerns

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https://www.swpc.noaa.gov/content/educationand-outreach





https://emilms.fema.gov/is_0066/



Federal Operating Concept for Impending Space Weather Events

May 2019



https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_space-weather.pdf



"Safeguarding Society with Actionable Space Weather Information"

