Space Weather and Aviation Impacts

Char Dewey

NOAA/National Weather Service
Salt Lake City, UT
@DeweyWx
charlotte.dewey@noaa.gov

IWAWS 2020

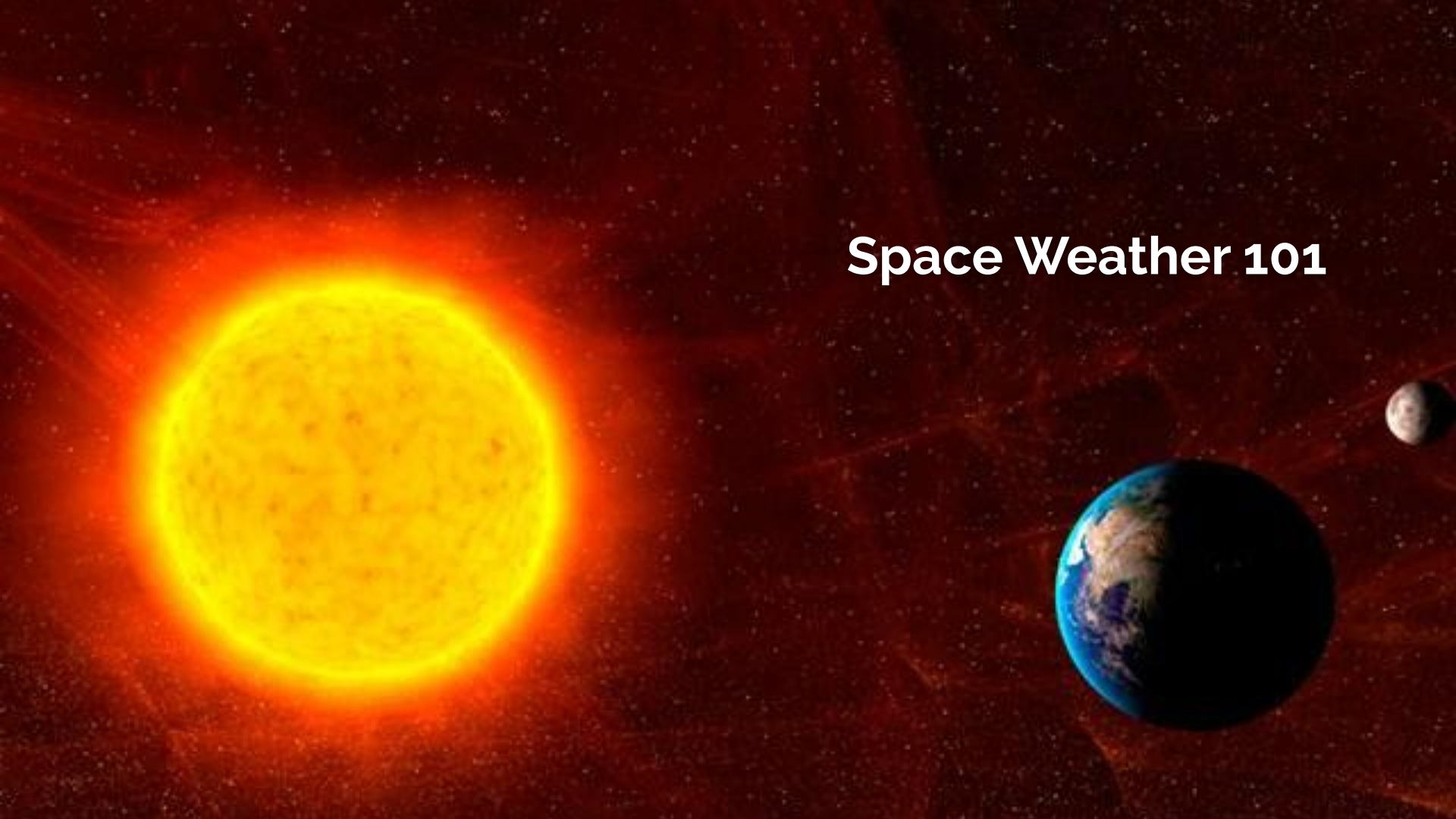
Space Weather and Aviation Impacts

What is space weather?

How space weather affects Earth and aviation; hazards and impacts

How to monitor conditions and be space weather-aware

Space Weather 101



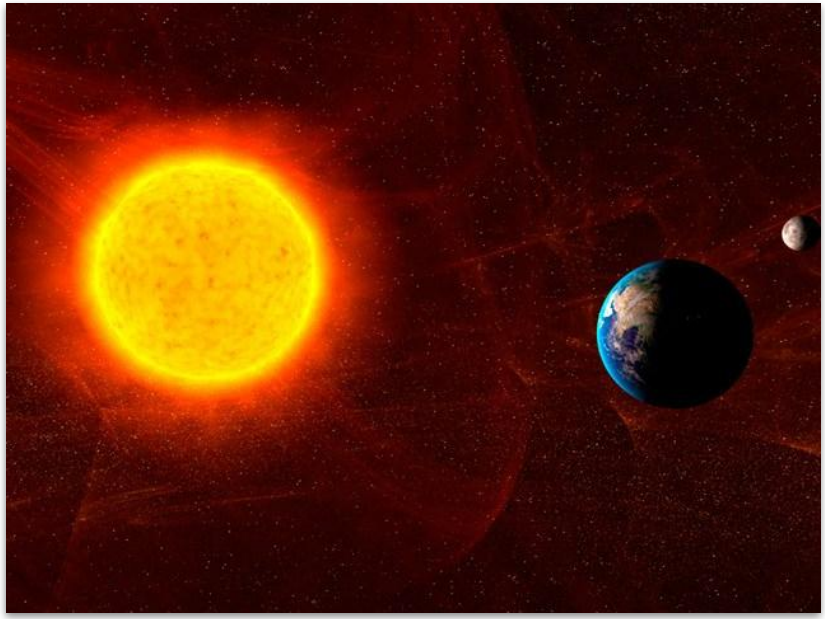
Space Weather 101

Weather originating from the Sun and traveling the **93 million miles** to reach Earth and our atmosphere, interacting with systems on and orbiting Earth.

Observations come from satellite sources with instruments that monitor space weather.

Model data (some now operational!) developing.

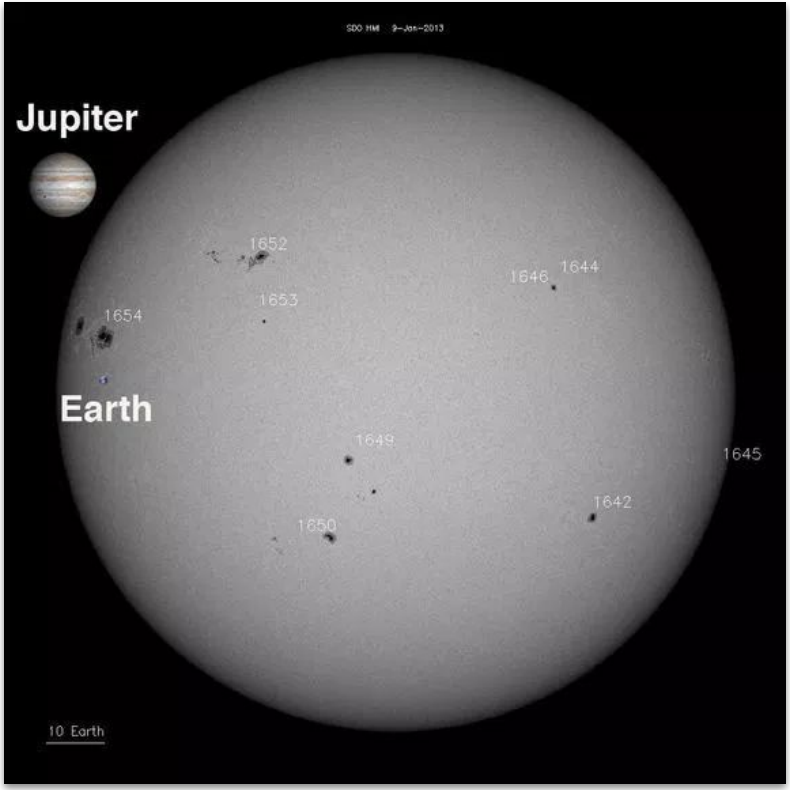
Coronal Mass Ejections (CME), Solar Energetic Particles (SEP), and Solar Flares.



Space Weather 101

Active regions on the sun are where solar activity begins; where sunspots are located on the solar disk.

Magnetic “instability” where solar storming forms.



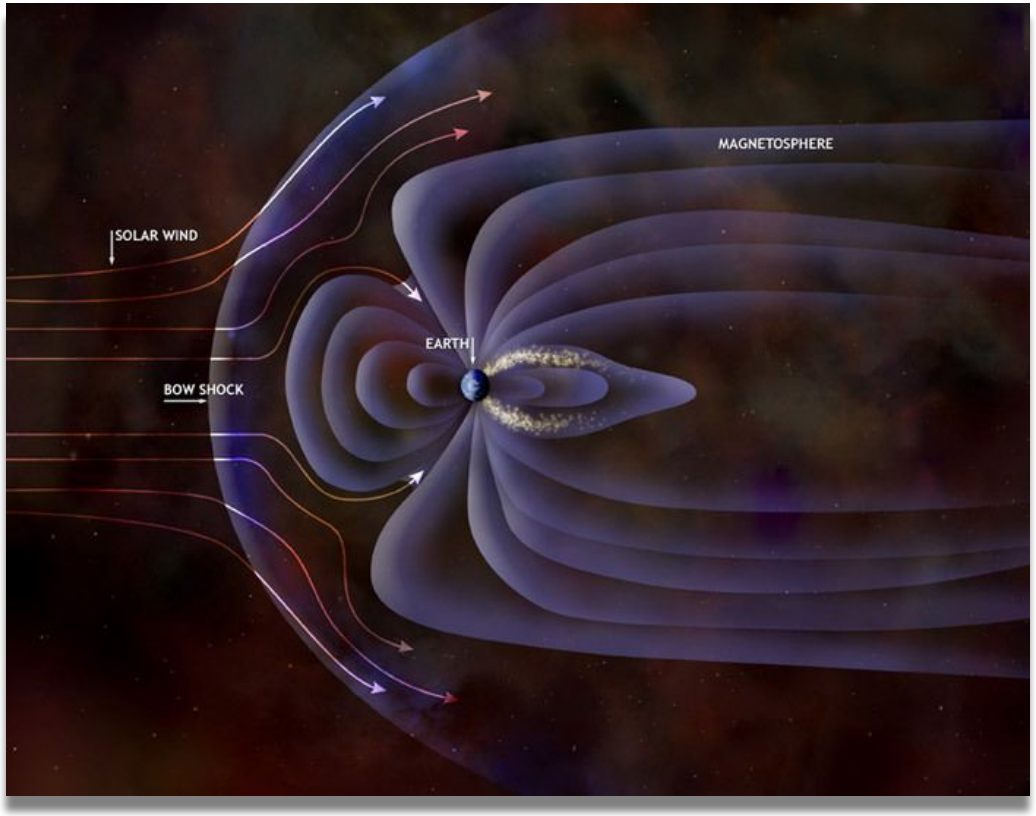
Space Weather 101

Coronal Mass Ejections (CME)

An eruption of plasma particles and electromagnetic radiation from the solar corona, often following solar flares.

Originate from active regions on the Sun's surface (sunspots).

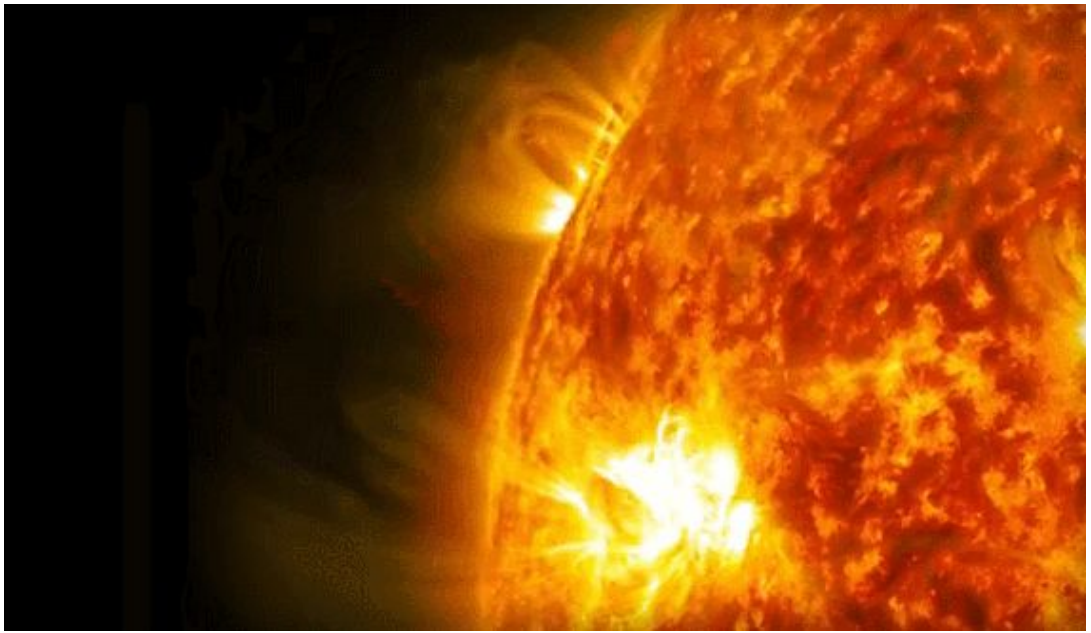
Very slow to reach the Earth from 12 hours to days or a week.



Space Weather Impacts

Coronal Mass Ejections (CME)

Impacts: Geomagnetic storming compresses Earth's magnetosphere on the day-side, extending night-side "tail" and reconnecting, focusing energy at the poles and resulting in Aurora. Increase electrons in the ionosphere at high-latitude regions, exposing to higher radiation values.



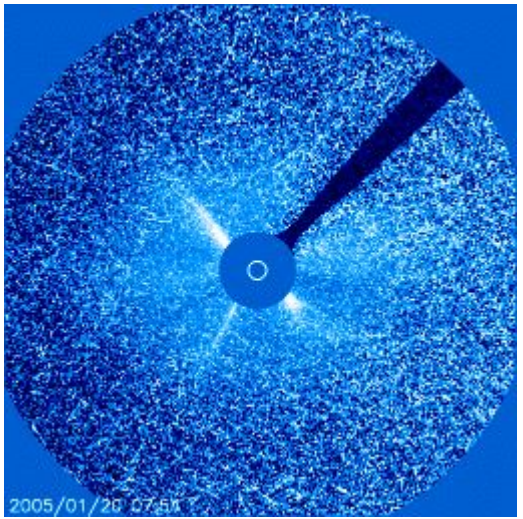
Space Weather 101

Solar Energetic Particles (SEP)

High-energy particles; protons, electrons

Originate from solar flare or shock wave (CME) reaching the Earth from 20 minutes to many hours, depending the location it leaves the solar disk.

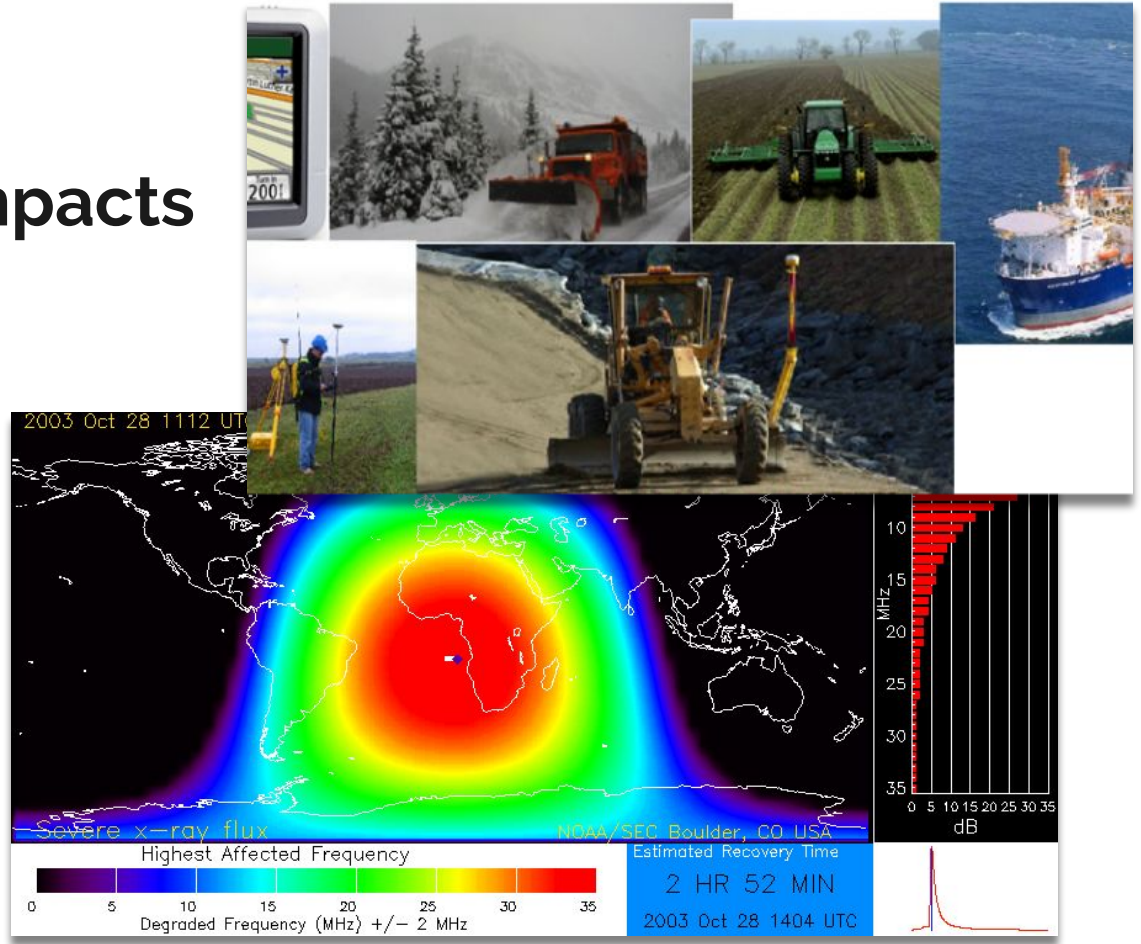
Proton detectors on the GOES geostationary and NOAA polar orbiting satellites.



Space Weather Impacts

Solar Energetic Particles (SEP)

Impacts: GPS receivers used by nearly every cell phone, automobile, onboard ships, high-precision positioning such as offshore drilling, surveying to name a few. Radio signals pass through ionosphere, which becomes bent and inaccurate.



Space Weather 101

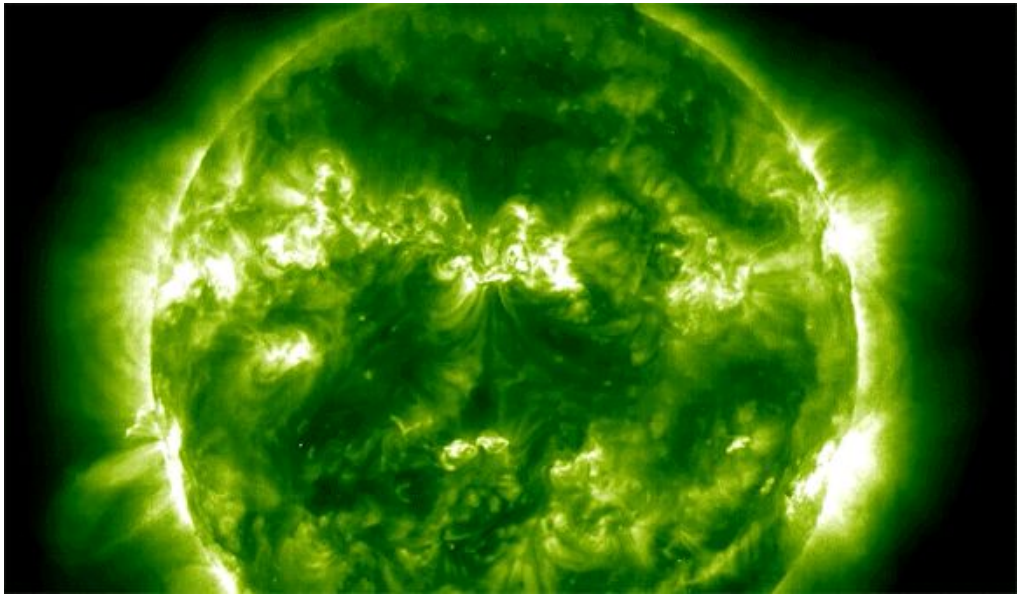
Solar Flare

Large solar flares can block HF radio transmissions on the sunlit side of Earth.

Associated with CMEs.

Cause satellite communication and radio navigation issues.

Duration of the entire solar flare impacts can be from seconds to an hour or so.



Space Weather Impacts

Solar Flare

Impacts: radio communications at high frequency (1-30 mega Hertz) on day side of Earth

Space Weather 101

Solar Cycle: 22-year cycle

Space Weather Scales (think hurricane and tornado intensity) from 1 (weakest) to 5 (strongest)

Radio Blackouts - R-scale (Solar flares)

Solar Radiation Storms - S-scale (particle events)

Geomagnetic Storms - G-scale (CME)

Radio Blackouts

Scale	Description	Effect	Physical measure	Average Frequency (1 cycle = 11 years)
R 5	Extreme	**HF Radio:** Complete HF (high frequency) radio blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no HF radio contact with mariners and en route aviators in this sector. **Navigation:** Low-frequency navigation signals used by maritime and general aviation systems experience outages on the sunlit side of the Earth for many hours, causing loss in positioning. Increased satellite navigation errors in positioning for several hours on the sunlit side of Earth, which may spread into the night side.	X20 (2×10^{-3})	Less than 1 per cycle
R 4	Severe	**HF Radio:** HF radio communication blackout on most of the sunlit side of Earth for one to two hours. HF radio contact lost during this time. **Navigation:** Outages of low-frequency navigation signals cause increased error in positioning for one to two hours. Minor disruptions of satellite navigation possible on the sunlit side of Earth.	X10 (10^{-3})	8 per cycle (8 days per cycle)
R 3	Strong	**HF Radio:** Wide area blackout of HF radio communication, loss of radio contact for about an hour on sunlit side of Earth. **Navigation:** Low-frequency navigation signals degraded for about an hour.	X1 (10^{-4})	175 per cycle (140 days per cycle)
R 2	Moderate	**HF Radio:** Limited blackout of HF radio communication on sunlit side, loss of radio contact for tens of minutes. **Navigation:** Degradation of low-frequency navigation signals for tens of minutes.	M5 (5×10^{-5})	350 per cycle (300 days per cycle)
R 1	Minor	**HF Radio:** Weak or minor degradation of HF radio communication on sunlit side, occasional loss of radio contact. **Navigation:** Low-frequency navigation signals degraded for brief intervals.	M1 (10^{-5})	2000 per cycle (950 days per cycle)

https://www.swpc.noaa.gov/noaa-scales-explanation

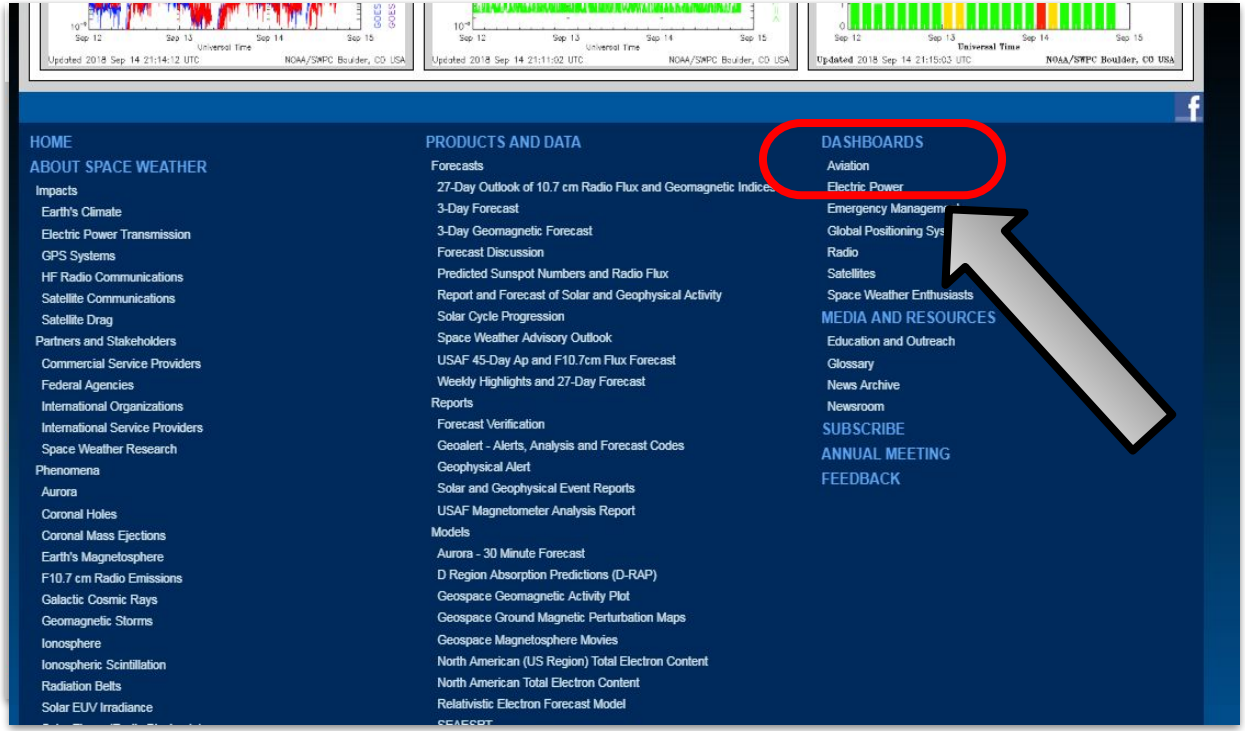

Hazards
Impacts
Solar Flares
Coronal Holes
Sunspots/Solar Cycle
F10.7 cm Radio Emissions
Solar EUV Irradiance
Coronal Mass Ejections
Solar Radiation Storm
Solar Wind
Magnetosphere
Geomagnetic Storms
Aurora
Ionosphere
Total Electron Content
Ionospheric Scintillation
Ground Induced Currents
Steele Hill/NASA

Space Weather Affects: Earth and Aviation

High latitude flights more susceptible to effects from Space Weather

Customers: Airlines, satellite operations, NASA, GPS applications, power utilities, oil pipelines, FEMA, Aurora viewing enthusiast, pigeon racers.

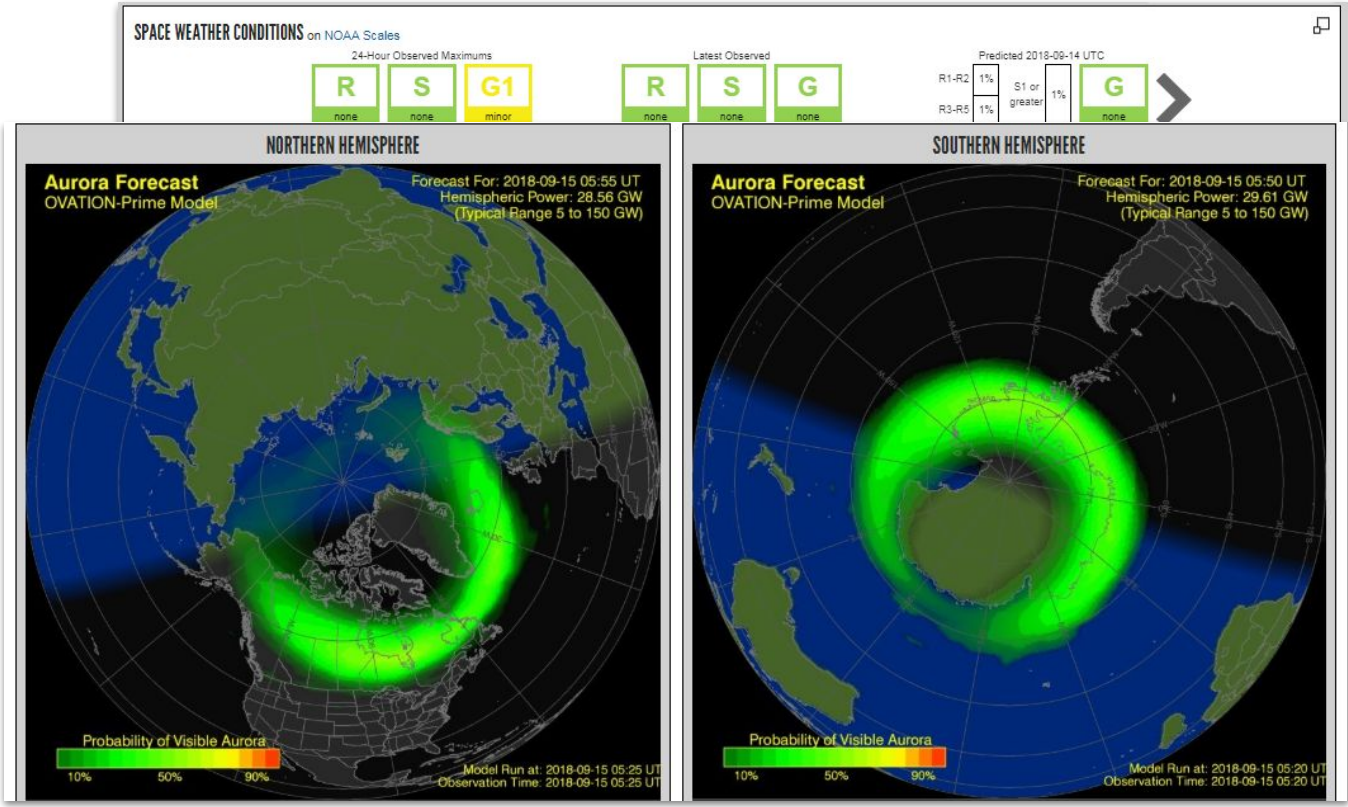
Space Weather Monitoring



https://www.swpc.noaa.gov/

Space Weather Monitoring

Tools to benefit aviation community for space weather



https://www.swpc.noaa.gov/communities/aviation-community-dashboard

Space Weather and Aviation Impacts

Charlotte Dewey
Forecaster, NOAA/NWS Salt Lake City, UT
charlotte.dewey@noaa.gov
@DeweyWx

https://www.swpc.noaa.gov/