

## Space Weather

### NOAA Space Weather Scales

#### Solar Radiation Storms: Coronal Mass Ejections and Solar Proton Events

Category*	Descriptor	Effect	Frequency per Solar Maximum**
Protons >100,000 S 5	Extreme	<b>Biological:</b> Unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); high radiation exposure to passengers and crew in commercial jets at high latitudes (approximately 100 chest x-rays) is possible. <b>Satellite operations:</b> Satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage to solar panels possible. <b>Other systems:</b> Complete blackout of HF (high frequency) communications possible through the polar regions, and position errors make navigation operations extremely difficult.	Fewer than 1 per cycle
Protons >10,000 S 4	Severe	<b>Biological:</b> Unavoidable radiation hazard to astronauts on EVA; elevated radiation exposure to passengers and crew in commercial jets at high latitudes (approximately 10 chest x-rays) is possible. <b>Satellite operations:</b> May experience memory device problems and noise on imaging systems; star-tracker problems may cause orientation problems, and solar panel efficiency can be degraded. <b>Other systems:</b> Blackout of High Frequency radio communications through the polar regions and increased navigation errors over several days are likely.	3 per cycle
Protons >1,000 S 3	Strong	<b>Biological:</b> Radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in commercial jets at high latitudes may receive low-level radiation exposure (approximately 1 chest x-ray). <b>Satellite operations:</b> Single-event upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely. <b>Other systems:</b> Degraded High Frequency radio propagation through the polar regions and navigation position errors likely.	10 per cycle
Protons >100 S 2	Moderate	<b>Biological:</b> None. <b>Satellite operations:</b> Infrequent single-event upsets possible. <b>Other systems:</b> Small effects on High Frequency propagation through the polar regions and navigation at polar cap locations possibly affected.	25 per cycle
Protons >10 S 1	Minor	<b>Biological:</b> None. <b>Satellite operations:</b> None. <b>Other systems:</b> Minor impacts on High Frequency radio in the polar regions.	50 per cycle

\*Flux level of  $\geq 10$  MeV particles (ions). Flux levels are 5 minute averages. Flux in  $\text{particles} \cdot \text{s}^{-1} \cdot \text{ster}^{-1} \cdot \text{cm}^{-2}$ . Based on this measure, but other physical measures are also considered.

\*\* These events can last more than one day.

## Solar X-Ray Storms: High Frequency Radio

Category*	Descriptor	Effect	Frequency per Solar Maximum
X-Ray Measure (microwatts) >2000 R 5	Extreme	<b>High Frequency Radio:</b> Complete high frequency radio blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no high frequency radio contact with mariners and en route aviators in this sector. <b>Navigation:</b> 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.	Less than 1 per cycle
X-Ray Measure (microwatts) >1000 R 4	Severe	<b>High Frequency Radio:</b> HF radio communication** blackout on most of the sunlit side of Earth for one to two hours. HF radio contact lost during this time. <b>Navigation:</b> 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.	8 per cycle
X-Ray Measure (microwatts) >100 R 3	Strong	<b>High Frequency Radio:</b> Wide area blackout of HF radio communication, loss of radio contact for about an hour on sunlit side of Earth. <b>Navigation:</b> Low-frequency navigation signals degraded for about an hour.	175 per cycle
X-Ray Measure (microwatts) >50 R 2	Moderate	<b>High Frequency Radio:</b> Limited blackout of HF radio communication on sunlit side, loss of radio contact for tens of minutes. <b>Navigation:</b> Degradation of low-frequency navigation signals for tens of minutes.	350 per cycle
X-Ray Measure (microwatts) >10 R 1	Minor	<b>High Frequency Radio:</b> Weak or minor degradation of HF radio communication on sunlit side, occasional loss of radio contact. <b>Navigation:</b> Low-frequency navigation signals degraded for brief intervals.	2000 per cycle

\*GOES 8 X-ray peak brightness. Flux, measured in the 0.1-0.8 nm range, in  $\text{W}\cdot\text{m}^{-2}$ . Based on this measure, but other physical measures are also considered.

\*\* Other frequencies may also be affected by these conditions.