

# Solar radiation storms

The impact of solar radiation storms (consisting primarily of protons) is to cause sudden lack of signal in high frequency (HF) and very high frequency (VHF) comms in the polar regions. This is called polar cap absorption.

| Category                      |                 | UK Effect  | US and Global Effect  | Physical measure                                     | Average Frequency (1 cycle = 11 years)                                    |
|-------------------------------|-----------------|--|---|--|---|
| Scale                         | Descriptor      | Duration of event will influence severity of effects   |   |  |   |
| <b>Solar radiation storms</b> |                 |  |   | <b>Flux level of &gt;= 10 MeV particles (ions) *</b> | <b>Number of events when flux level was met (number of storm days **)</b> |
| <b>S5</b>                     | <b>Extreme</b>  | <p><b>Biological:</b> Passengers and crew in aircraft on certain routes may be exposed to increased radiation levels. The increase depends on flight path and the detailed storm characteristics.***</p> <p><b>Spacecraft operations:</b> Some satellites may suffer temporary outages due to memory impacts which can cause loss of control, serious noise in image data or orientation problems and permanent damage to solar panels.</p> <p><b>Aircraft operations:</b> Some aircraft electronic systems may experience single event effects (SEE) which can cause upsets or unexpected behaviour. The rate of SEE depends on flight path and the detailed storm characteristics.***</p>                      | <p><b>Biological:</b> unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.***</p> <p><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.</p> <p><b>Aircraft operations:</b> pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.)**</p> | 10 <sup>5</sup>                                      | Fewer than 1 per cycle  |
| <b>S4</b>                     | <b>Severe</b>   | <p><b>Biological:</b> Passengers and crew in aircraft on certain routes may be exposed to increased radiation levels. The increase depends on flight path and the detailed storm characteristics.***</p> <p><b>Satellite operations:</b> Some satellites may suffer temporary outages due to single event effects on electronics which can cause unexpected behaviours, noise in image data or orientation problems and permanent damage to solar panels.***</p> <p><b>Aircraft operations:</b> Some aircraft electronic systems may experience single event effects (SEE) which can cause upsets or unexpected behaviour. The rate of SEE depends on flight path and the detailed storm characteristics.***</p> | <p><b>Biological:</b> unavoidable radiation hazard to astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.***</p> <p><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.</p> <p><b>Aircraft operations:</b> blackout of HF radio communications through the polar regions and increased navigation errors over several days are likely.</p>  | 10 <sup>4</sup>                                      | 3 per cycle   |
| <b>S3</b>                     | <b>Strong</b>   | <p><b>Biological:</b> Passengers and crew in aircraft on certain routes may be exposed to increased radiation levels. The increase depends on flight path and the detailed storm characteristics.***</p> <p><b>Satellite operations:</b> A small number of satellites may experience outages due to single event effects, which can cause unexpected behaviours, noise on imaging systems and orientation problems.</p> <p><b>Aircraft operations:</b> Some aircraft electronic systems may experience single event effects (SEE) which can cause upsets or unexpected behaviour. The rate of SEE depends on flight path and the detailed storm characteristics.***</p>  | <p><b>Biological:</b> radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.***</p> <p><b>Satellite operations:</b> single-event upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely.</p> <p><b>Aircraft operations:</b> degraded HF radio propagation through the polar regions and navigation position errors likely.</p>   | 10 <sup>3</sup>                                      | 10 per cycle  |
| <b>S2</b>                     | <b>Moderate</b> | <p><b>Biological:</b> No additional risk.</p> <p><b>Satellite operations:</b> Infrequent single-event upsets possible.</p> <p><b>Aircraft operations:</b> Unlikely to have significant effect.***</p>  | <p><b>Biological:</b> passengers and crew in high-flying aircraft at high latitudes may be exposed to elevated radiation risk.***</p> <p><b>Satellite operations:</b> infrequent single-event upsets possible.</p> <p><b>Aircraft operations:</b> small effects on HF propagation through the polar regions and navigation at polar cap locations possibly affected.</p>  | 10 <sup>2</sup>                                      | 25 per cycle  |
| <b>S1</b>                     | <b>Minor</b>    | <p><b>Biological:</b> none.</p> <p><b>Satellite operations:</b> none.</p> <p><b>Aircraft operations:</b> Unlikely to have an effect***</p>   | <p><b>Biological:</b> none.</p> <p><b>Satellite operations:</b> none.</p> <p><b>Aircraft operations:</b> minor impacts on HF radio in the polar regions.</p>  | 10   | 50 per cycle  |

\* Flux levels are 5 minute averages. Flux in particles-s-1-ster-1-cm-2. Based on this measure, but other physical measures are also considered.

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

\*\*\* High energy particle measurements (>400 MeV) are a better indicator of radiation risk to aircraft avionics, passengers and crews. Pregnant women are particularly susceptible.