

# Geomagnetic Storms and GPS

## What is a geomagnetic storm?

A geomagnetic storm is a temporary disturbance in Earth's magnetosphere. This type of disturbance is classified as "space weather" and can have adverse effects on communications, navigation systems, satellite hardware, geologic exploration, electric grids, and pipelines depending on the severity of the storm. Geomagnetic storms are also responsible for lower latitude viewing of auroras, commonly known in the U.S. as aurora borealis or "The Northern Lights".



## So what causes geomagnetic storms?

Several different events, such as solar flares and coronal mass ejections (CME's), can trigger these disturbances. A solar flare is a brief powerful eruption of particles and intense electromagnetic radiation from the sun's surface.<sup>1</sup> The energy of a solar flare, which consists primarily of charged particles and x-rays, is comparable to tens of millions of hydrogen bombs, but is less than one-tenth the total energy emitted by the Sun every second.<sup>2</sup> A coronal mass ejection is a large-scale solar event involving an ejection of hot plasma that may accelerate charged particles and travel as far as the Earth's orbit, preceded by a shock front that may create a magnetic storm on earth.<sup>3</sup> These storms cause the Earth's ionosphere to become unstable. The ionosphere is that part of the atmosphere ionized by solar radiation. The ionosphere influences radio wave propagation between space and earth, which is why communications, navigation systems, and satellite signals are affected. Typically, the ionosphere over the United States is fairly predictable due to slow changes. However, during a geomagnetic storm, rapid changes cause degradation in GPS measurements. In a very severe magnetic storm, GPS receivers could completely lose lock on multiple satellite signals, ultimately making the GPS incapable of providing a position.

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## How long before a solar flare or CME affects GPS?

Solar flares travel at the speed of light, but the effects of a solar flare on GPS receivers have been noted to begin approximately one hour later. CME's on the other hand, travel much slower and usually arrive at Earth one to five days after the eruption occurs. However, just because a solar flare or CME occurs doesn't mean that GPS will for sure be affected, it depends on the magnitude of the storm that is produced, the direction it is traveling, etc.

For more information about solar activity and space weather, visit [www.spaceweather.com](http://www.spaceweather.com). Spaceweather.com also provides an e-mail alert service to keep you informed of active solar flares and CME's. Also, visit the Space Weather Prediction Center at [www.swpc.noaa.gov](http://www.swpc.noaa.gov).

*Chris Gaylor  
Cleveland Utilities/City of Cleveland  
GIS Technician  
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