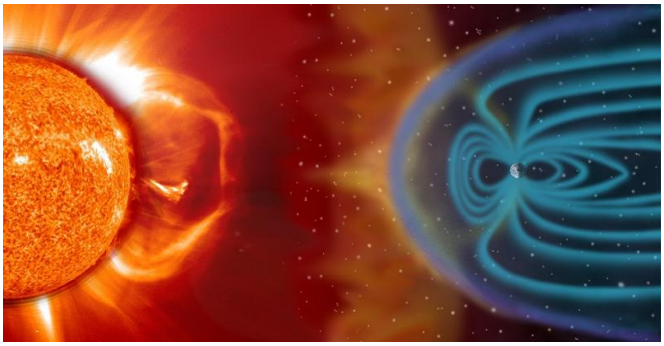
Why we should worry about powerful geomagnetic storms caused by solar activity

14 March 2016, by Tomasz Nowakowski, Astrowatch.net

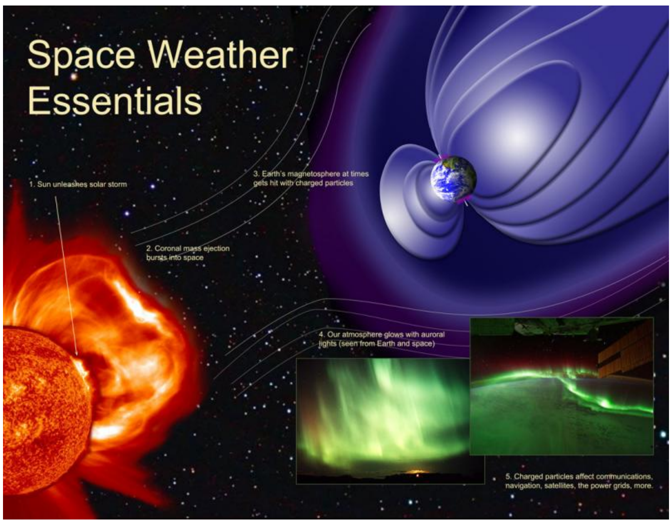


The sun's violent activity and many unexpected and unpredictable events taking place on its surface suggest that we should prepare for the worst. Huge explosions of magnetic field and plasma from the sun's corona, known as coronal mass ejections (CMEs), could one day produce extremely powerful geomagnetic storms striking Earth with enormous power, showing no mercy to our planet.

When a CME strikes Earth's atmosphere, it causes temporary disturbances of the planet's magnetic field, called geomagnetic storms. These storms could affect power grids, blacking out entire cities, impeding radio communications and GPS navigation. They could even disrupt satellites in orbit. So should we worry that an extreme CME could cause a very powerful geomagnetic storm, resulting in global catastrophe and endangering our lives?

"The short answer to this is absolutely. The possibility of an extreme CME causing a very powerful geomagnetic storm is real. There's considerable uncertainty to how frequent such storms are at the level where we worry about huge impacts on the power grid and the resulting impacts that a lack of electricity would have. Is it a one in 50, one in 100, or one in 1,000 year event? We just don't know," Doug Biesecker of the National Oceanic and Atmospheric Administration's (NOAA) Space Weather Prediction Center, told Astrowatch.net.

The largest recorded geomagnetic storm in history occurred in 1859 and is called the Carrington Event, or sometimes the 1859 Solar Superstorm. It disrupted telegraph systems throughout Europe and North America and auroras were seen in many parts of the world. The scientists predict that if a Carrington-sized event struck us now, it would devastate our technology, hitting almost every aspect of the modern world relying on electronic devices, internet and satellite navigation systems. It would wreak havoc on humans, damaging vital services such as transport, sanitation and medicine.



This illustration shows a coronal mass ejection (CME) blasting off the Sun's surface in the direction of Earth. Such storms can produce aurora and technological effects on Earth. Credit: NASA

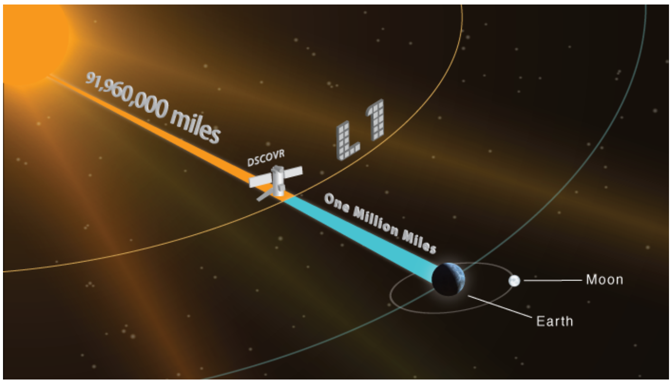
To confront these threats, the U.S. government published its National Space Weather Strategy and the National Space Weather Action Plan in October 2015, outlining activities to improve the understanding, monitoring, prediction, and mitigation of space weather hazards.

"There was a new National Space Weather Strategy published by the White House in October, 2015. This and an accompanying Action Plan specify what federal agencies and industry must do in the coming years to be prepared for not only forecasting an extreme event, but ensuring the nation is resilient to the impacts of such an extreme event," Biesecker noted.

These documents aim to enhance the preparedness for space weather events by interweaving and building upon existing policy efforts. They identify overarching goals that underpin and drive the activities necessary to improve the security and resilience of critical technologies and infrastructure. However, many of these activities will require long time horizons, necessitating sustained engagement among government agencies and the private sector.

Hopefully, our current deep-space observation fleet, designed to study the sun and solar activity events, proves helpful for prediction of space weather. Biesecker is convinced that spacecraft like NASA's Solar Dynamics Observatory and the Solar and Heliospheric Observatory (SOHO), built jointly by NASA and the European Space Agency (ESA), have revolutionized our understanding of solar activity and improved our space weather prediction models.

"SOHO was very much a game changer. In January 1997, the LASCO coronagraphs on SOHO observed what is now commonly referred to as a partial halo CME. Four days later, a geomagnetic storm occurred that was predicted based on the SOHO observations. This ushered in a revolution in forecasting, leading to more concrete knowledge of CMEs, the drivers of geomagnetic activity. Previously, one relied on proxies, such as erupting filaments or long duration solar flares, but these were at best about 70 percent reliable. Not only does a coronagraph tell us for sure that a coronal mass ejection erupted, but it tells us the direction, size, and speed. These have led to dramatic improvement in understanding the propagation of CMEs in the solar wind and in predicting geomagnetic storm occurrence and timing," Biesecker explained.



DSCOVR monitors space weather from the L1 point, a million miles from Earth. Credit: NOAA/NASA

"SDO is giving us a clearer picture of solar active regions and erupting filaments. The high cadence and high resolution of SDO give forecasters the clearest evidence of how sunspots and active regions are evolving and to then assess their potential to produce solar flares," he added.

Early prediction of a CME and the scale of the resulting geomagnetic storm could be crucial to advancing our forecasting and better preparing for the devastating effects of space weather. Although coronagraphs currently tell us whether Earth will be hit by an eruption and when, they don't provide the most important piece of information needed to determine the storm intensity.

Launched in February 2015, NOAA/NASA Deep Space Climate Observatory (DSCOVR) could be very helpful, serving as an "early warning" spacecraft. DSCOVR is operating at the Lagrange point 1 (or L1), between Earth and the sun,approximately 1 million miles from our planet, observing and providing advanced warning of particles and magnetic fields. Placing DSCOVR at L1 provides a vantage point for quality solar wind observations. The spacecraft can tell us in advance when a surge of particles and magnetic field from the sun will hit Earth and if they have characteristics that will cause a geomagnetic storm on our planet.

"That is why an L1 monitor such as DSCOVR is so important. The key to improving the long lead time forecasts is determining the strength and direction of the magnetic field that will interact with the Earth's magnetic field as early as possible," Biesecker said.

He also noted NOAA was also interested in the Sunjammer mission to fly some basic instruments closer to the sun with a solar sail (by a factor of two over the L1 distance). It was slated to launch along with DSCOVR, but unfortunately, the project was canceled in 2014. Sunjammer was expected to provide early warnings of potentially hazardous solar activity.

Many future projects are still awaiting implementation. There are groups trying various techniques to determine the magnetic field using such techniques aas Faraday rotation from radio observations, or using the Zeeman effect or Hanle effect from white light or infrared observations.

However, as Biesecker said, these are still in the speculative regime of science, with many of the efforts as yet unfunded, and much more that needs to be done, including finding techniques to quantify the magnetic field, before we can hope to use any of it for forecasting the influence on Earth.

In conclusion, is there still much to worry about when it comes to powerful solar events? It is important to note that we are currently past the maximum of the current solar cycle, which occurred in April, 2014, so will the influence of sun on Earth be less significant now?

"While solar activity such as solar flares and CMEs roughly correlate with the solar cycle, as we consider more extreme events, this correlation gets weaker. So, while we are headed toward fewer flares and CMEs on average, the likelihood of extreme events is always present. Even in the last solar cycle, the most extreme events in that cycle occurred two to four years after the maximum of the solar cycle," Biesecker concluded.

Source: Astrowatch.net