Solar weather has real, material effects on Earth

July 11 2019, by Michael Batu

Credit: Frank Cone from Pexels

On Sep. 1, 1859, solar astronomer Richard Carrington witnessed

sunspots that suddenly and briefly flashed brightly before they disappeared. Just before dawn the next day, auroras erupted over most of the Earth, reaching as far south as the Caribbean and Hawaii while southern lights were seen as far north as Chile. The event produced not only a visible light show in areas where they do not typically appear, but it also sent telegraph systems around the world haywire.

Given the state of technology during Carrington's time, the impact of a geomagnetic storm was limited to disruptions of telegraph service. If something similar happened today, the world's technological infrastructure could grind to a halt. Extreme space weather events such as geomagnetic storms are more disruptive now than in the past. This is because of our greater dependence on technical systems that can be affected by electric currents and energetic particles high in the Earth's atmosphere.

The space weather threat

We might think of space as a silent, empty void and the sun as only a distant source of light and heat. This is not necessarily true. The sun and the Earth are connected in more complex, intimate and sometimes dangerous ways.

Sunspots are temporary phenomena on the sun's photosphere that appear darker than the surrounding areas. Sunspots can change continuously and may last for only a few hours to days; or even months for the more intense groups. The total number of sunspots has long been known to vary with an approximately 11-year repetition known as the solar cycle. The peak of sunspot activity is known as solar maximum and the lull is known as solar minimum.

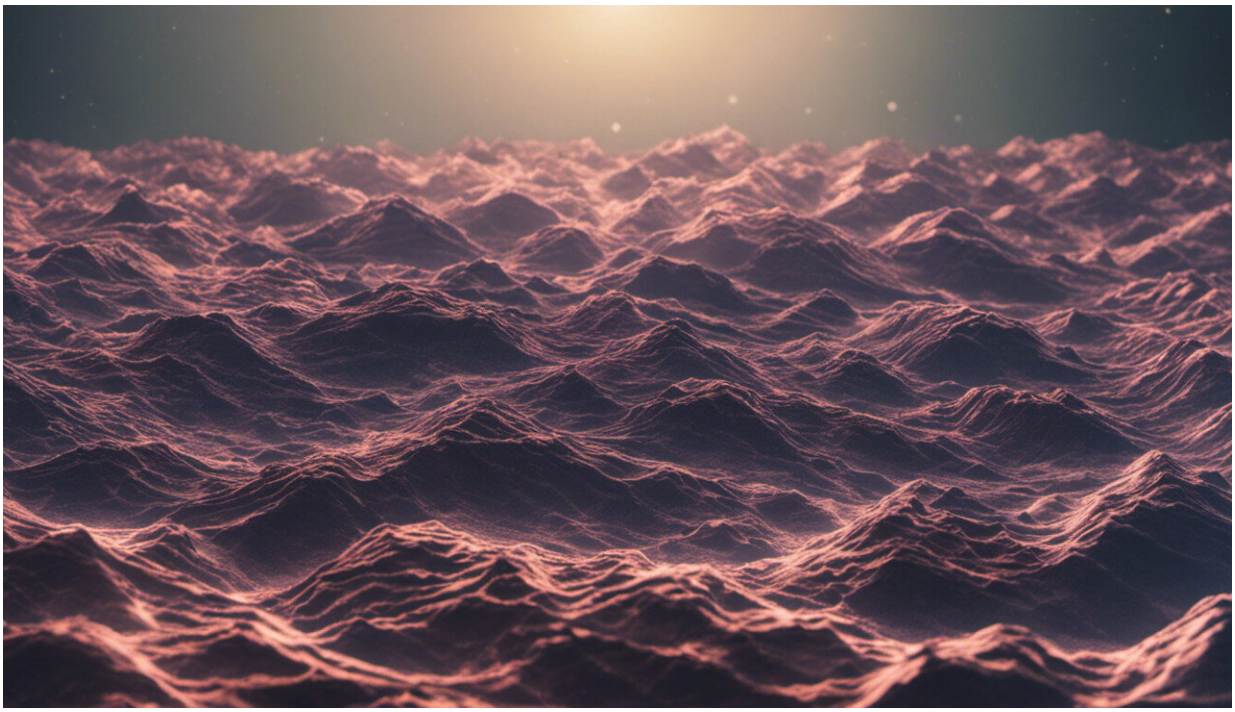
Indicating intense magnetic activity, sunspots accompany secondary phenomena such as bursts of electromagnetic radiation (flares) and

coronal mass ejections (CME) —which are sudden eruptions of material —accompanied by solar energetic particles (SEPs). A solar flare is a sudden release of energy from the sun, while a CME shoots hot plasma from the sun into space.

The precise mechanisms that trigger flares and CMEs are still being debated, but the bigger the group of sunspots, the more intense solar activity tends to be. The sun continually ejects high-energy electrons, protons and other nuclei that bombard the Earth. Solar flares and CMEs send enormous amounts of energy and charged particles hurtling into collision with the Earth's upper atmosphere, where they can cause geomagnetic storms.

Charged particles during geomagnetic storms cause disturbances in the Earth's magnetic field, generating effects on electrical systems. Geomagnetic storms produce numerous effects such as voltage disruptions leading to power outages; changes in soil voltage that enhance corrosion in oil pipelines; disruption in satellite, radio and cellular communications networks; exposure to elevated levels of radiation; and reductions in flights with polar routes.

For the most part, the Earth's magnetic field protects humans from the barrage of radiation which comes from the sun. However, the Earth's magnetic field is weaker at either pole and therefore some particles of enter the Earth's atmosphere through geomagnetic storms.



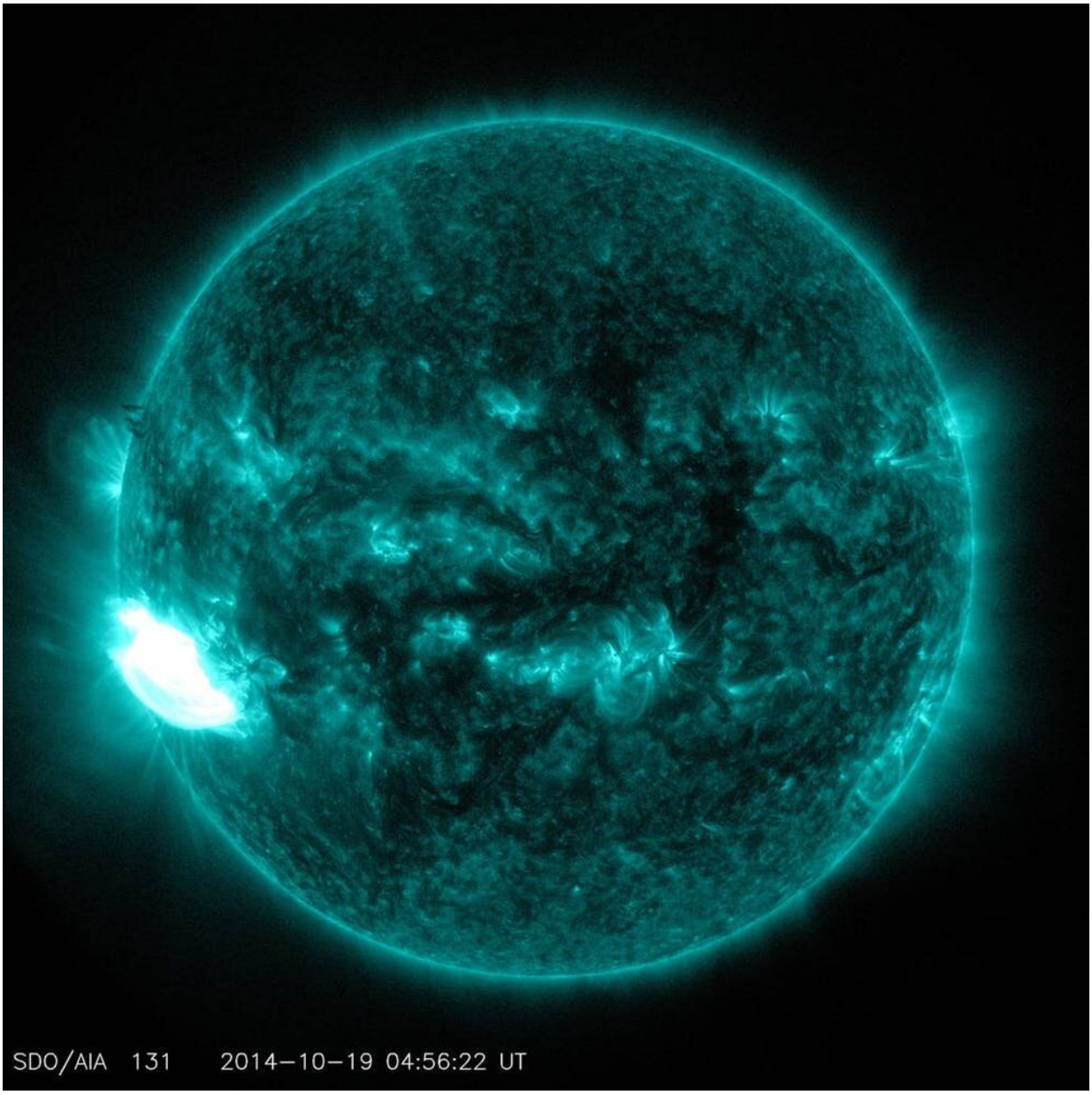
Credit: AI-generated image (disclaimer)

Solar weather effects

The adverse economic impacts of solar activity on the North American power grid have been well-documented. For instance, four percent of the power disturbances between 1992 and 2010 reported to the U.S. Department of Energy are attributable to strong geomagnetic activity.

I have been working on the economic effects of climate change for some time now and thought: "How about the sun?"

Interestingly, while the study of space weather is a rapidly growing field, academic work to assess its overall social and economic impacts appears to be in its infancy.



A solar flare surges off the lower left hand of the sun on Oct. 19, 2014. The image was captured in extreme ultraviolet wavelength of 131 Angstroms – a wavelength that can see the intense heat of a flare and that is typically represented in teal. Credit: NASA/SDO

I am currently working with one of my former graduate students, Zichun Zhao, on the economic impacts of space weather. Our proxy measure of solar activity is the number of sunspots produced by the sun at a given time and, luckily, this data is publicly available.

In our empirical analysis, we found that the Gross Domestic Products (GDP) of the 34-member countries of the Organization for Economic Co-operation and Development decreases as solar activity increases. On average, GDP decreases by at least 0.06 percent for every increase of one percent in solar activity.

We find that the negative economic effects of geomagnetic storms are more significant in northern latitudes. However, the effects of geomagnetic storms are not restricted to high latitudes and have been documented in the United Kingdom, Finland, Sweden, Spain, the U.S., Canada, South Africa, Japan, China and Brazil.

Our empirical results indicate that damages caused by geomagnetic storms are much greater in the information and communications sectors.

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