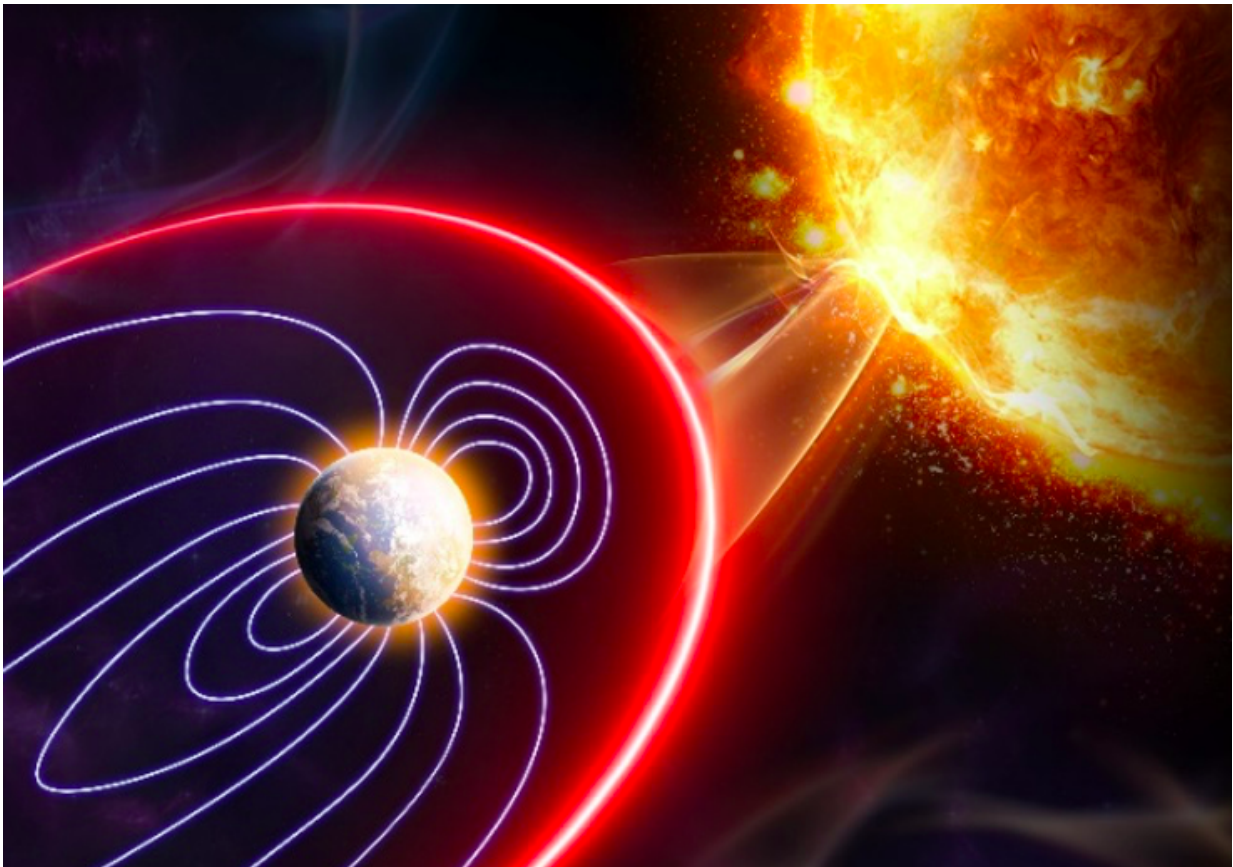


The effects of solar flares on Earth's magnetosphere

April 23 2021, by Ingrid Fadelli



An illustration of solar flare impacts on the whole geospace. Credit: Jing Liu.

Planet Earth is surrounded by a system of magnetic fields known as the magnetosphere. This vast, comet-shaped system deflects charged

particles coming from the sun, shielding our planet from harmful particle radiation and preventing solar wind (i.e., a stream of charged particles released from the sun's upper atmosphere) from eroding the atmosphere.

While past studies have gathered substantial evidence of the effects that solar wind can have on Earth's magnetosphere, the impact of [solar flares](#) (i.e., sudden eruptions of electromagnetic radiation on the sun) is poorly understood. Solar flares are highly explosive events that can last from a few minutes to hours and can be detected using X-rays or optical devices.

Researchers at Shandong University in China and the National Center for Atmospheric Research in the U.S. have recently carried out a study investigating the effects that solar flares can have on Earth's magnetosphere. Their paper, published in *Nature Physics*, offers new valuable insight that could pave the way towards a better understanding of geospace dynamics. Geospace, the portion of outer space that is closest to Earth, includes the upper atmosphere, ionosphere (i.e., the ionized part of the atmosphere) and magnetosphere.

"The magnetosphere is located in the region above the ionosphere and is the fully ionized space region above 1000 km from the ground," Professor Jing Liu, one of the researchers who carried out the study, told Phys.org. "The region is surrounded by the solar wind and is affected and controlled by the earth's magnetic field and the solar wind's magnetic field."

The magnetosphere is generally described as Earth's protective barrier against solar wind and other solar particles, as it prevents these particles from entering the planet's other protective layers. Nonetheless, past studies showed that when the direction of solar wind is opposite to the magnetosphere's magnetic field, magnetic lines from these two regions

can 'connect.'" This means that some solar [wind](#) particles can be directly transmitted to the space surrounding Earth.

"We asked ourselves: Can the flare process, which is characterized by enhanced radiation, not only directly affect the earth's ionosphere, but also cause disturbance in the magnetosphere like the [solar wind](#)?" Liu said. "To answer this question, we adopted a series of observational datasets, collected by global satellite navigation systems, the European incoherent scattering radar network, ionospheric satellites, lunar orbiting satellites, and more."

Liu and his colleagues analyzed data collected by different devices and satellites during a solar flare event that took place on 6 September 2017. To do this, they adopted a recently developed numerical geospace model developed at the National Center for Atmospheric Research. This model, called the high spatial-temporal resolution magnetosphere ionosphere thermosphere model (LTR), reproduces the changes triggered by solar flares in the magnetosphere-ionosphere coupling system.

Using the LTR model and previously collected data, the researchers were able to unveil solar flare effects on magnetospheric dynamics and on the electrodynamic coupling between the magnetosphere and the ionosphere. More specifically, they observed a rapid and large increase in flare-induced photoionization of the polar ionospheric E-region at altitudes between 90 and 150 km. The phenomenon observed by Liu and his colleagues appeared to have a number of effects on the geospace region, including a lower Joule heating of the Earth's upper atmosphere, a reconfiguration of the magnetosphere convection and changes in auroral precipitation.

"We demonstrated that solar [flare](#) effects extend throughout the geospace via electrodynamic coupling, and are not limited, as previously believed, to the atmospheric region where radiation energy is absorbed,"

Liu explained. "Due to the similar solar-magnetosphere-ionosphere coupling process in other earth-like planets, our study also provides new clues for exploring and understanding the effects of solar flares on other planets. In my future research, I plan to study the effects of flares on planets with the same [magnetosphere](#) (such as Jupiter, Venus and Saturn)."

More information: Jing Liu et al. Solar flare effects in the Earth's magnetosphere, *Nature Physics* (2021). [DOI: 10.1038/s41567-021-01203-5](#)

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