National Parks as An Emerging Gateway for Space Weather: Sowing the Seeds for Current and Future Generations of Citizen Scientists, Researchers and Night Sky Enthusiasts



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Catherine joined the National Park Service at Glacier National Park in 2010. As a Wilderness Ranger at Rocky Mountain National Park from 2012 to 2018, she was exposed to the challenges of backcountry rescue highlighting gaps in technology, specifically shortwave radio. Her observation drove her to explore the "solar connection" leading her to study space weather at Millersville University.

Steve is a passionate Aurora chaser and photographer, whose interest in the Northern Lights and the science behind it led him to pursue space weather graduate work at Millersville University. He has captured and documented Aurora in its many forms in 10 different U.S. states and 3 countries, and counting. An international higher educator for over 20 years, Steve has transitioned into the realm of space weather science, communication and forecasting.

National Parks and Space Weather: A Natural Combination

These natural havens offer protection for wildlife and cultural resources while providing affordable public access and scientific research opportunities. National parks have also increasingly become a refuge for the preservation of dark sky environments, not only within their physical boundaries but also for adjacent gateway communities and other public lands.

Public interest in space weather and night sky phenomena has increased exponentially in recent years thanks to the proliferation of social media and affordable technology including mobile phones and digital cameras. Aurora chasing, eclipse viewing, meteor showers and deep space documentation have resultantly seen a similar explosion of interest.

With ever-increasing light pollution and the loss of dark sky environments, national parks provide havens for study, research, observation and general enjoyment to all who seek to learn about and understand space weather and night sky phenomena. Continued challenges with funding, staffing and keeping up with infrastructure present obstacles that may derail these opportunities.

Dark Sky Festival Events Draw Night Sky Enthusiasts

Various national parks around the world hold day or weekend-long gatherings to showcase the wonders of the night sky. One such annual event takes place at Death Valley National Park in California. The 2025 Dark Sky Festival, pictured below, drew nearly 7,000 people from far and wide, many who had never seen the wonders of the night sky before.

As the space weather profession grows and expands, national parks would seem to provide perfect places to harness increasing public interest, encourage citizens both young and old to consider entering the field, and offer ideal spaces for researchers and scientists to carry out individual and collaborative projects.

National Parks See Dramatically Increased Visitation

A look over the past 15 years shows the trend increasing annual recreation visits for a portion of the 63 US national parks. 2023 is the last year available. Anecdotal evidence would suggest visitation continues to grow. Data courtesy of National Park Service, U.S. Dept. of the Interior.

Name	2008	2013	2018	2023	Total
Great Smoky Mountains NP	9,044,010	9,354,695	11,421,200	13,297,647	**43,117,552**
Yellowstone NP	3,066,580	3,188,030	4,115,000	4,501,382	**14,870,992**
Rocky Mountain NP	2,757,390	2,991,141	4,590,493	4,115,837	**14,454,861**
Zion NP	2,690,154	2,807,387	4,320,033	4,623,238	**14,440,812**
Acadia NP	2,075,857	2,254,922	3,537,575	3,879,890	**11,748,244**
Glacier NP	1,808,027	2,190,374	2,965,309	2,933,616	**9,897,326**
Joshua Tree NP	1,392,446	1,383,340	2,942,382	3,270,404	**8,988,572**
Mount Rainier NP	1,163,227	1,148,552	1,518,491	1,674,294	**5,504,564**
Saguaro NP	699,137	678,261	957,405	1,010,906	**3,345,709**
Big Bend NP	362,512	316,953	440,091	509,129	**1,628,685**
Great Sand Dunes NP & PRES	273,903	242,841	442,905	512,219	**1,471,868**

Global Dark Sky-Designated National Parks

USA: Arches; Big Bend; Black Canyon; Bryce Canyon; Canyonlands; Death Valley; Grand Canyon; Great Basin; Joshua Tree; Mesa Verde; Voyageurs; Zion and 5 more
Canada: Waterton-Glacier International Peace Park; Parc National du Mont-Tremblant
United Kingdom: Brecon Beacons; Eryri/Snowdonia; Exmoor; North York Moors; Northumberland; Yorkshire Dales
Continental Europe: Eifel, Germany; Aenos, Greece; Bukk, Hungary; Lauwerschmeer, Netherlands; Ovre Pasvik, Norway;
Japan: Iriomote-Ishigaki

DarkSky International helps restore the nighttime environment. They also help certify and conserve starry sky parks and dark sky communities globally.

The Three E's of Collaboration – National Parks and the Space Weather Community

Education

Bridging the gap between space weather research and national park operations and vice versa is key for enhancing space weather education and improving visitor experiences. These educational programs could inspire a future scientist!

- Train at least one ranger or staff member in space weather phenomena
- Create interactive exhibits at visitor centers explaining the connection between space weather and Earth's atmosphere at each park
- Initiate citizen science projects for visitors to help document aurora and night sky changes

Experience

There are few other places like national parks to witness space weather events, often with pristine, dark skies that enhance visibility. National parks provide the perfect setting to connect with the dynamic forces of space weather.

- There are already a handful of Dark Sky Festivals, Astronomy Nights and "Park After Dark" programs around the world.
- The continued development of space weather-focused events featuring expert talks, night sky viewings, hands-on activities and ranger-led programs could help millions more globally who have never witnessed the amazing phenomena of the night sky.

Exchange of Information

Many parks lack infrastructure and expertise to interpret and communicate real-time space weather events effectively. While governmental scientific agencies and space weather research centers monitor and forecast solar activity, this information isn't always integrated into operations. A collaborative effort between national parks, space weather researchers, and government agencies could create a seamless exchange of information and resources, leading to a powerful educational outreach program helping millions of visitors better understand the forces behind space weather events..

A Night Under the Aurora in Glacier National Park

October 10, 2024 was a special night in this iconic park. With a widely publicized solar storm forecast to hit Earth, Glacier was a welcoming host to thousands of night sky enthusiasts who descended on the park to experience the magic of the Northern Lights. Photos by Steve Luther.




Potential Ramifications of US National Park Staffing Cuts

- Parks may close off areas to protect resources and discourage vandalism. This could severely limit space weather viewing areas and opportunities
- Less personnel available to protect fragile ecosystems and perform public outreach
- Already low funding will be stretched even thinner
- Many educational programs and research projects could get cancelled or curtailed
- Less interagency cooperation could result in less programs and opportunities, such as at Yellowstone where getting feedback on the monitoring-sharing operational data may cease

Yellowstone National Park's GPS Stations Played a Role in Monitoring the May 2024 Gannon Solar Storm

Courtesy of Yellowstone Caldera Chronicles, July 15, 2024, Yellowstone Volcano Observatory

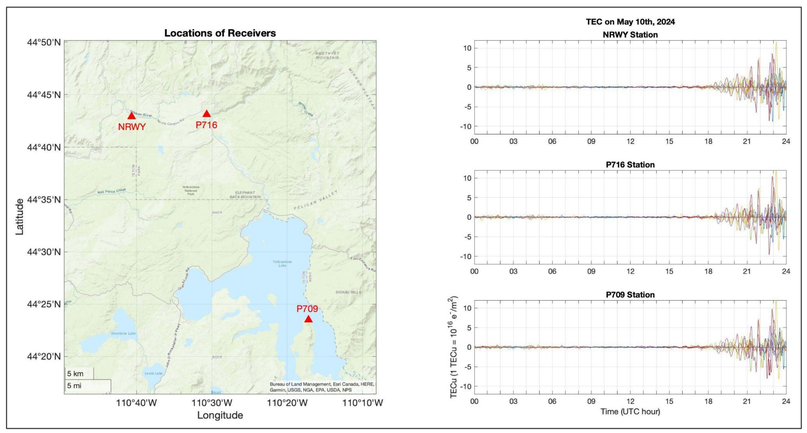
While it's not unheard of to have Aurora down to Yellowstone's latitude, it doesn't happen often. Some GPS stations in Yellowstone were among the tools used to monitor space weather like that solar storm.

GPS instruments on the Earth's surface, like those that monitor ground deformation in Yellowstone, can sense space weather events like coronal mass ejections (CMEs) and alert us as they develop. GPS stations receive signals from satellites that must first travel through the ionosphere. Part of the upper atmosphere, the ionosphere can be a source of error in GPS measurements, even without the presence of an incoming CME. GPS signals get refracted and reflected in the ionosphere, which causes a delay in the signal reaching the antenna on the ground.

Geomagnetic storms like the one on May 10 cause an increase in the number of electrons within the ionosphere, which in turn excites the gas atoms and molecules to produce aurora. But increasing the total electron content of the ionosphere causes more interference for GPS and other communications signals—an important hazard associated with space weather. This interference means that it is harder to pinpoint the location of a station, and applications that rely on high-precision GPS, like monitoring very subtle movement of Earth's surface, won't work quite as well. If the interference is sufficiently strong, it may become altogether impossible at that moment to determine a position.

So what does this have to do with volcano and earthquake science in Yellowstone? Geologists use GPS stations to track and detect ground deformation caused by the volcanic and tectonic activity, but the stations can also be used to help other scientists track space weather. Because space weather interferes with GPS signals, this interference can actually be used to measure the amount of ionospheric activity during events like the May 10 solar storm. This helps space weather scientists better characterize events of this type. One of the GPS stations in the park feeds data into the Space Weather Prediction Center's total electron content map.

While GPS stations in Yellowstone serve primarily to help scientists measure what's happening below the surface, they can also help track what's happening in the uppermost atmosphere. In both cases, the data can help us watch for hazards—and also better understand how these Earth systems work.



Total electron content (TEC) data—a measure of activity in the ionosphere—at three GPS stations in Yellowstone. Each line color is a measurement using a different satellite passing overhead. Note how the data are steady until the evening of May 10, 2024, when the signals start to fluctuate wildly due to the arrival of the Coronal Mass Ejection. A spectacular aurora was visible across large parts of the United States that evening, Charts by Pin-hsuan Cheng, University of Colorado - Boulder.

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See more of Steve's Aurora photography