Does Solar Activity Create Space Weather that Can Impact Earth?

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Science Type Project

Introduction:

Does the particles released by the Sun's activity have an impact on Earth?

- Space weather is a very new area of science and while much has been discovered, so much more is waiting for us to find it! While wind on Earth is caused by moving air, space wind involves both magnetic and electrical forces.
- Coronal Mass Ejections (CMEs) are a result of this combination of solar activity and they release tiny excited particles as a solar wind that heads out to the planets, Earth included. They travel at the speed of light and when they get here, all kinds of light happens!
- On Earth, when these particles hit our EM field, we experience amazing auroras of lights at both north and south poles.
- So, do these CMEs cause the auroras? This was the purpose of my research: to determine if space weather does impact Earth.

Introduction:

- Most of the literature reviewed seems to be more descriptive than causal, it tells what the colors mean and how high the light show is, rather than how or why it got here. There has been much discussion around finding proof that auroras are caused by space weather. The Carrington Effect, in 1856, was the first such storm that they could directly tie into the cause of the auroras. It was so strong that telegraph machines caught fire and even shocked their operators. Another incident was our grid failure in the States in recent years. It was also directly tied to a geomagnetic storm.
- The purpose of this research is to ascertain if solar storms coming from the Sun have an impact on the Earth, causing disruptions that can pass through Earth's magnetosphere.
- The research question is actually the title of this project: does solar activity create space weather that can impact earth?
- The hypothesis tested states that Solar activity will have an impact on Earth because the Sun releases CMEs (Coronal Mass Ejections) and energetic particles that create a geomagnetic storm which will hit Earth's magnetosphere.
- If solar weather affects Earth, then auroras will be visible at the planetary poles just after a geomagnetic storm happens on the Sun.

Methods:

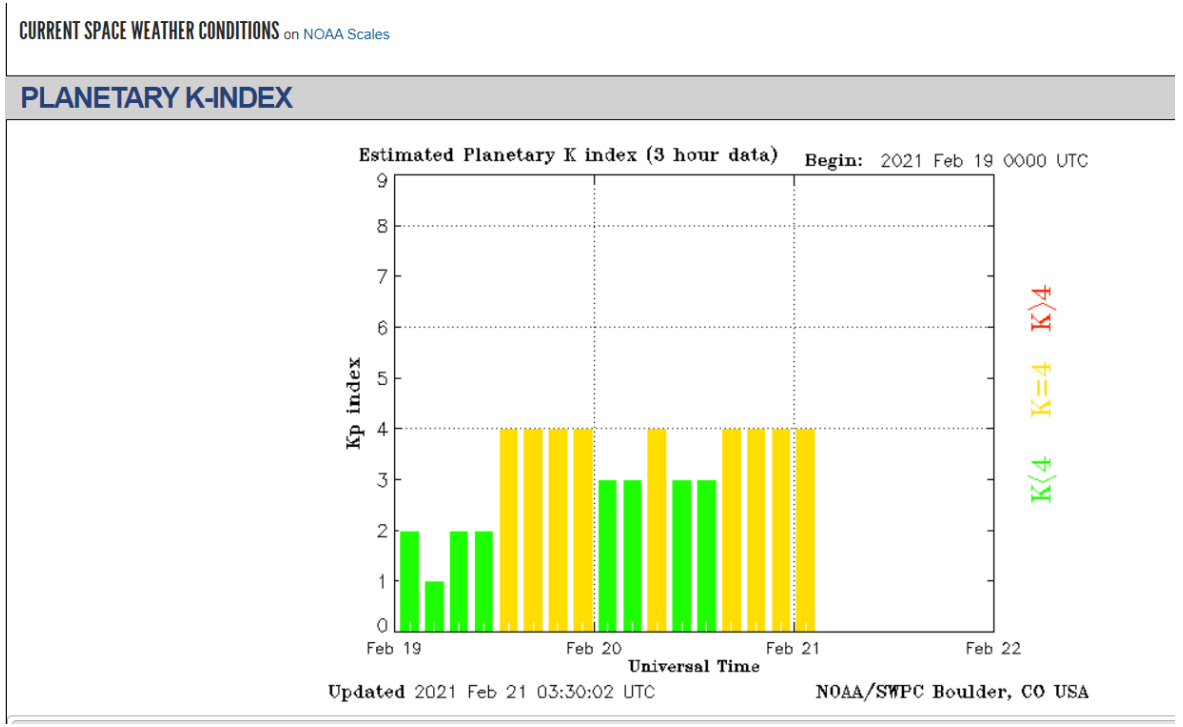
Experimental Design and Procedures

- Data was collected from both historical and current space weather reporting sites. Phone apps for aurora alerts were monitored for possible sightings and connected to onset of geomagnetic storm activity.
- Data was recorded daily and compared to actual aurora sightings and reports of CME activity. Sites such as www.aurorasauras.com, spaceweather.com, and especially the keagramist site (which records both solar wind and auroras daily) were consulted and data logged when proven accurate.
- Interviews were conducted with plasma physicists involved in studying space weather and auroras to gain understanding and direction of study.
- If there was a 50% or higher correlation between space weather and auroras, then the data was considered as supporting the hypotheses. Anything less would be disproving the stated hypothesis.

Results:

What did the data show?

- The data shows strong connections to geomagnetic storms impacting earth and causing auroras.
- It also shows strong interference in other vital systems such as GIS, electronics operation, and electrical interference from these magnetic storms colliding with Earth's EM field. (electro-magnetosphere).
- The stronger the planetary index kp shows, the greater the chances are for a storm and aurora.



Sample graph used with permission from NOAA

The space weather division of NOAA shows the kp is yellow Feb 20th, 21st and indeed a geomagnetic storm hit twice during those yellow times and auroras were present.

Results:

January

Date	Time	Geomagnetic storm (kp)	Aurora (Y/N)	Polar Air Temp C°
01/06	12:32 AM	K>4	Yes	-21.1
01/06	1:17 AM	K=4	Yes	-25.55
01/06	11:04 PM	K<4	Yes	-16.11
01/06	11:53 PM	K=4	Yes	-23.27

Date	Time	Geomagnetic storm (kp)	Aurora (Y/N)	Polar Air Temp C°
01/07	12:59 AM	K>4	Yes	-12.22
01/07	1:12 AM	K=4	Yes	-21.66

February

Date	Time	Geomagnetic storm (kp)	Aurora (Y/N)	Polar Air Temp C°
02/16	9:24 PM	K=4	YES	-11.11
02/16	11:26 PM	K>4	YES	-12.87
02/17	12:21 AM	K<4	YES	-15.55
02/17	12:30 AM	K=4	YES	-12.77
02/17	12:42 AM	K=4	YES	-16.59

Date	Time	Geomagnetic storm (kp)	Aurora (Y/N)	Polar Air Temp C°
02/17	8:27 AM	K=4	YES	-26.52
02/17	10:40 AM	K<4	YES	-15.55
02/17	5:37 PM	K=4	YES	-17.25
02/17	9:36 PM	K<4	YES	-20.00
02/18	12:53 AM	K=4	YES	-34.44

Date	Time	Geomagnetic storm (kp)	Aurora (Y/N)	Polar Air Temp C°
02/18	6:31 AM	K>4	YES	-34.44
02/19	11:44 PM	K=4	YES	-31.02
02/19	11:55 PM	K<4	YES	-35.55
02/20	6:39 AM	K>4	YES	-27.77
02/20	11:42 AM	K=4	YES	-25.55

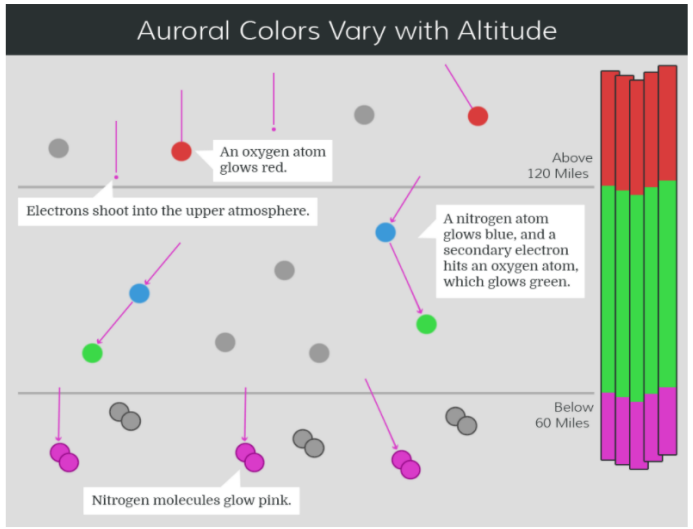
Each time a storm was detected, the planetary index was K4 or above and resulted in geomagnetic disturbances that caused auroras to appear at the magnetic poles on Earth.

Discussion:

How were these results interpreted

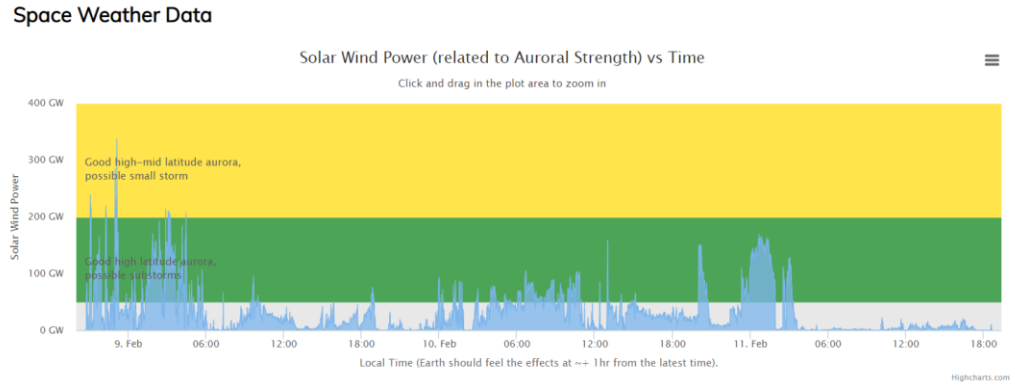
What Gives Auroras Different Colors?

An aurora can appear in a variety of colors, from an eerie green color, to a spectrum of blue and purple to pink and red. The light of the aurora is emitted from gases in the atmosphere when they are bombarded by particles from space.



The colors displayed are related to the type of gas being bombarded and the altitude.

If spaceweather.com indicated a solar storm was possible, then kp predictions were monitored for geomagnetic activity. It needed to be yellow or higher for an aurora to occur.



Both graphs used with permission from www.aurorasauras.com

These factors were consulted and utilized as determining factors for expecting an aurora to occur as a result of space weather. Each instance was then logged for analysis.

Discussion:

How were these results interpreted? What does the data mean?

- First, it should be noted that the sampling and length of time used is very small. In reality, the data is inconclusive, although the sample does appear to support the hypothesis. The sample should be much larger and extend over a longer period of time.
- It is interesting to note that there is much fear in the polar regions concerning the aurora. Legends include such things that children are stolen if you laugh at an aurora, mental issues can happen if the entities that cause the aurora think you disbelieve their existence. All such things can interfere with scientific study of this phenomenon.
- The data gathered did correspond with solar wind , CMEs, and solar particles that hit Earth's EM field. Auroras did occur when these events happened, which seems to suggest that the stated hypothesis is valid. Further study is imperative and I want to be part of it!

Discussion:

- There were unexpected anomalies when gathering the data. It was generally expected that CMEs on the Sun would occur before space wind set out toward the planets. However, there was one occasion this past month where a large solar storm occurred without a CME.
- These are formed from co-rotating interactive regions on the Sun’s surface and have been causing these same storms that impact earth. These are called CIRs.
- The auroras were viewed differently from various locations. They might be all green in one area, but register red and blue in another, yet still were the same aurora.
- One of the things that was unusual was that auroras only occur during the winter months. This was unexpected information.

Conclusions:

- The results obtained seem to follow the general direction of the rest of the available literature encompassing this very new science of space weather and auroras. Any magnetic activity from the Sun will cause solar wind that does impact Earth.
- There are negative aspects of geomagnetic storm activity upon humans and other living things. There is a reason that the International Space Station does NOT fly over the planetary poles! Radiation poisoning, scrambling of electronics, GIS systems no longer work, for example.
- Geomagnetic storms wreak havoc on electronics but those who operate ham radios benefit from this activity in the ionosphere. (They can talk all over the planet.)
- The research also raised many questions: can the radiation from these storms be harnessed for medical use? Can exciting these strong oxygen ions accelerate healing of brain dysfunction? It is evident that further research is necessary and I want to be part of it!

Conclusions:

- The research question was answered and many more questions were raised through the research and data gathered. One such question included: are there auroras on other planets? The answer is surprising as it involves whether or not the planet has a working EM field.
- Data analysis did support my hypothesis but more research needs to be done as samples were so small.
- Applications for this research are multiple. Anyone working with electronic equipment should be aware of possible affects from these auroras: GIS systems cannot work within these storms, guidance systems on planes and astronauts are negatively impacted. All entities using these systems should be aware of this research and its implications. As for this researcher, plans are made to experience an aurora in person and the prepare for university study in the plasma field!

References:

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- https://www.usgs.gov/faqs/what-are-hazards-magnetic-storms?qt-news_science_products=0#qt-news_science_products
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- Interview with Dr. Elizabeth MacDonald, plasma physicist from Aurorasauras (NASA)
- Interview with Laura Brandt from aurorasauras.com
- The Northern Lights - where, when and what. (uit.no)
- Planetary K-Index (planetary-k-index.org)