

Magnetic Connection



What's this Activity About?

Objectives:

- 1) Introduce the connection between the Sun's magnetic activity and Earth's magnetic field
- 2) How solar storms are generated from the Sun's magnetic activity
- 3) How solar storms interact with Earth's magnetic field to affect Earth's infrastructure

Presenters: A minimum of one person.

Visitors: Appropriate for families with older children, the general public, and school groups in fifth grade and up. Up to about 5 visitors at a time can participate comfortably.

Duration: From 10 minutes up to a half hour, depending on the number of topics covered.

Materials:

What materials do I need?

- Box with Velcro dots
- 1.5 - 2" (4 – 5 cm) rod magnet
- 4 compasses
- A shake flashlight
- Two cards, one with images of Earth's and Sun's magnetic fields, and one with aurora and a Presenter's Guide, included here
- "Solar Storm" plastic arc, see below
- 3 – 4 small, strong magnets
- Strong glue
- A permanent marker



Materials Assembly when Using for the First Time:

- Apply five Velcro dots to the top of the box. Notice that there is a soft loop side and a rougher hook side. Apply the softer loop dots to the top of the box – one in each corner about 2 in/5cm from the sides and one in the middle – just peel and stick. Now put the hook sides of the dots on the back of the four compasses and one on the rod magnet.
- Print the words "Solar Storm" on the top of the plastic arc. Glue the small magnets to the underside of the arc to create prop that mimics a wave of charged particles coming from the Sun, also called a Coronal Mass Ejection or CME. (See **Background Information** for an explanation of solar storms.)
- Print the 3 images included here in full color along with the presenter's guide.

Getting set up each time:

- Be sure that everything has been removed from the box and that all metal and magnets are at least a couple of feet away so they don't interfere with the compasses. This includes making sure the table you're using doesn't have metal supports right under your demonstration.
- Sometimes when a compass is exposed to a strong magnet it becomes demagnetized. Each time you present this demonstration, you'll want to make sure your compasses are all pointing in the same direction – North. If they're not, you can easily realign them by swiping the rod magnet over the surface using the following steps:

- First, select a compass that is working correctly
- Next, determine the north end of the rod magnet by holding it against the side of a *working* compass
- The north end of the magnet will attract the north arrow of the compass that is working correctly
- Now select the non-working compass and place the **north end** of the magnet against the **south mark** on the compass
- And slide it across the top of the compass toward the north compass mark



Where do I get additional materials?

- The images can all be found at the end of this document and online here:
 - http://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=493
- A small pizza box can be found at a pizza restaurant.
- Magnets can be found online. For the strong rod magnets in the center of the box, we used:
 - 3/16" Dia x 1/2" Long Rod Grade N40 Neodymium Rare Earth Magnet, item #R500A2 from Amazing Magnets: www.amazingmagnets.com
- Search the Web for "clear shake flashlight". At the time of printing, you can find them here: www.quakekare.com
- Inexpensive compasses can be found online by searching for "Magnetic Compass"

Optional Introduction to Magnetic Connection:

Have you ever heard of the northern lights? Also called aurora borealis or just the aurora for short. Where on Earth do people see those? Has anyone here ever seen them?

The aurora is a beautiful display of colored lights that dance across the sky. And they are usually seen very far north, in Alaska and Russia for example. But that's not always the case. Let me tell you about a very unusual case of aurora.

It was the evening of September 3, 1859. Before cell phones, or even regular landline telephones were invented. It was before people had TV, and even before radios. It was a dark time in many ways.

Auroras were particularly spectacular and bright that night, brighter than a full moon and filled with vibrant colors. In New York, it was reported that you could read a newspaper by the light of the aurora. Gold miners in Colorado got up in the middle of the night to fix breakfast, thinking dawn had arrived. Not to mention, these beautiful lights could be seen as far south as Florida! That's very far south for the "northern lights". But that wasn't all.

Another very strange thing happened that day. Remember there were no phones yet, but people could still send messages. They used machines called telegraphs that were connected by wires and worked by tapping out Morse code.

That night, telegraph systems all over North America and Europe stopped working. Operators couldn't send signals because the wires had gone crazy. Some even received electric shocks and the paper they were printing spontaneously caught fire. Even when the wires were disconnected, some systems continued sending signals. It was definitely not business as usual.

But there is one more piece to the puzzle. It so happened that just the day before, British astronomer Richard Carrington became the first person to see a huge bright flash on the Sun. He wasn't sure what it was he was seeing. This was the first time anyone had witnessed a solar flare!

And then the lights in peoples' heads started to go off. Maybe that huge solar flare had something to do with the beautiful lights and the strange telegraph disruption. When scientists started putting all of these pieces together, the study of solar storms began. **This was the first time that we realized that changes in the Sun could have dramatic consequences for us here on Earth.**

Let's take a look at what was happening that day when the telegraph went haywire. (*Introduce the Magnetic Connection demonstration*)

Magnetic Connection

Activity Script

Leader's Role

Participants' Role (Anticipated)

To say:

We're talking about the Sun today, and I have some compasses here. But what do compasses have to do with the Sun? Well, let's start by asking where do compasses point?

North pole

OK. Earth has fairly regular magnetic field lines that run north and south. The compasses follow those magnetic field lines.

To do:

Refer to image of Earth's magnetic field.

To say:

If we place a magnet into the middle of these compasses, will they change the direction they're pointing?

Maybe, yes, don't know.

To do:

Hand the bar magnet to a visitor.

To say:

Let's find out. Would you slowly lower this magnet onto the board? Whoa. What happened?

The compasses all changed direction.

Sure – the compasses are now following the North to South magnetic field lines around this magnet. Who would like to follow the magnetic lines down the other side?

I do!

To do:

Detach one of the compasses and follow the N->S lines on one side of the magnet.



To say:

OK, let's take this magnet out. Where will the compasses point after we take it out?

Back to Earth's magnetic field.

Well, we saw that Earth's magnetic field is fairly regular. But the Sun has more complicated magnetic fields.

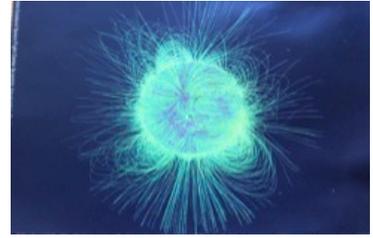
To do:

Show Sun's magnetic field image.

To say:

Would you be able to navigate on the Sun using a compass?

No!



From a distance, the Sun has roughly the same pole-to-pole field, but below the surface, the magnetic field lines are tangled and irregular. Sometimes, field lines will loop and pop through the surface of the Sun.

To do:

Use your hands and a visitor's arm to illustrate how a loop comes up through the surface, as shown in the pictures on the right. A video of this demonstration can also be found here:

http://www.astrosociety.org/samplers/Solar_Storm_Demo.mov

To say:

Put your arm straight out. Your arm will represent the surface of the Sun.

My arms represent a magnetic field line that gets twisted and pops through the surface.

Has anyone seen sunspots in the telescopes today? Sunspots occur here, where this loop emerges. They're the footprints of the magnetic field lines on the visible surface of the Sun!

These magnetic loops gather material from the Sun's atmosphere, and it spirals around the loops.

Sometimes the loops can reconnect, and like a short circuit, can generate a sudden release of energy. This can violently blow part of the atmosphere away from the Sun and eject it into space. We call that a solar storm.



To do:

Bring out the Solar Storm arc.

To say:

This represents a part of the solar storm.

The corona of the Sun is about a million degrees, so it's too hot for electrons to remain associated with the positively charged nucleus of the atoms in the corona. Thus, the solar storm is an enormous cloud filled with positively and negatively charged particles, represented by these magnets. It usually takes two or three days for this cloud to reach and wash over Earth. As we move the solar storm toward Earth what going to happen to the magnetic field? Let's watch.

**To do:**

Move solar storm across top of the box at a moderate rate, not too fast, about 1 inch/2cm above the compasses.

Watch the compasses go crazy.

To say:

The particles in the solar storm excite the atoms in Earth's magnetic field, causing it to shift around. Perhaps you know that moving magnetic fields can generate an electrical current.

Please take this flashlight and shake it vigorously for several seconds. The moving magnet in the flashlight generates a current that allows it to light up.

[Note: If you are outside in the Sun, you might have to put the flashlight into shadow or point it at a dark surface to see it light up.]

Shake and turn on flashlight.

This happens on a much larger scale on Earth. Those generated currents can enhance the beautiful aurorae by exciting the gases in our atmosphere, just like the gases in a neon sign.

To do:

Show aurora card.

To say:

They can also induce electrical fields at Earth's surface that can blast along our electrical grid, overloading the grid and blowing out transformers. This happened in Canada in 1989, causing a widespread blackout over eastern Canada and into the US. Fortunately, just as we now understand how earthquakes can shake buildings and build them to withstand the force, power companies have developed new ways to help protect our electrical grid from these electrical surges.

Who has a cell phone? Who has used a GPS device?

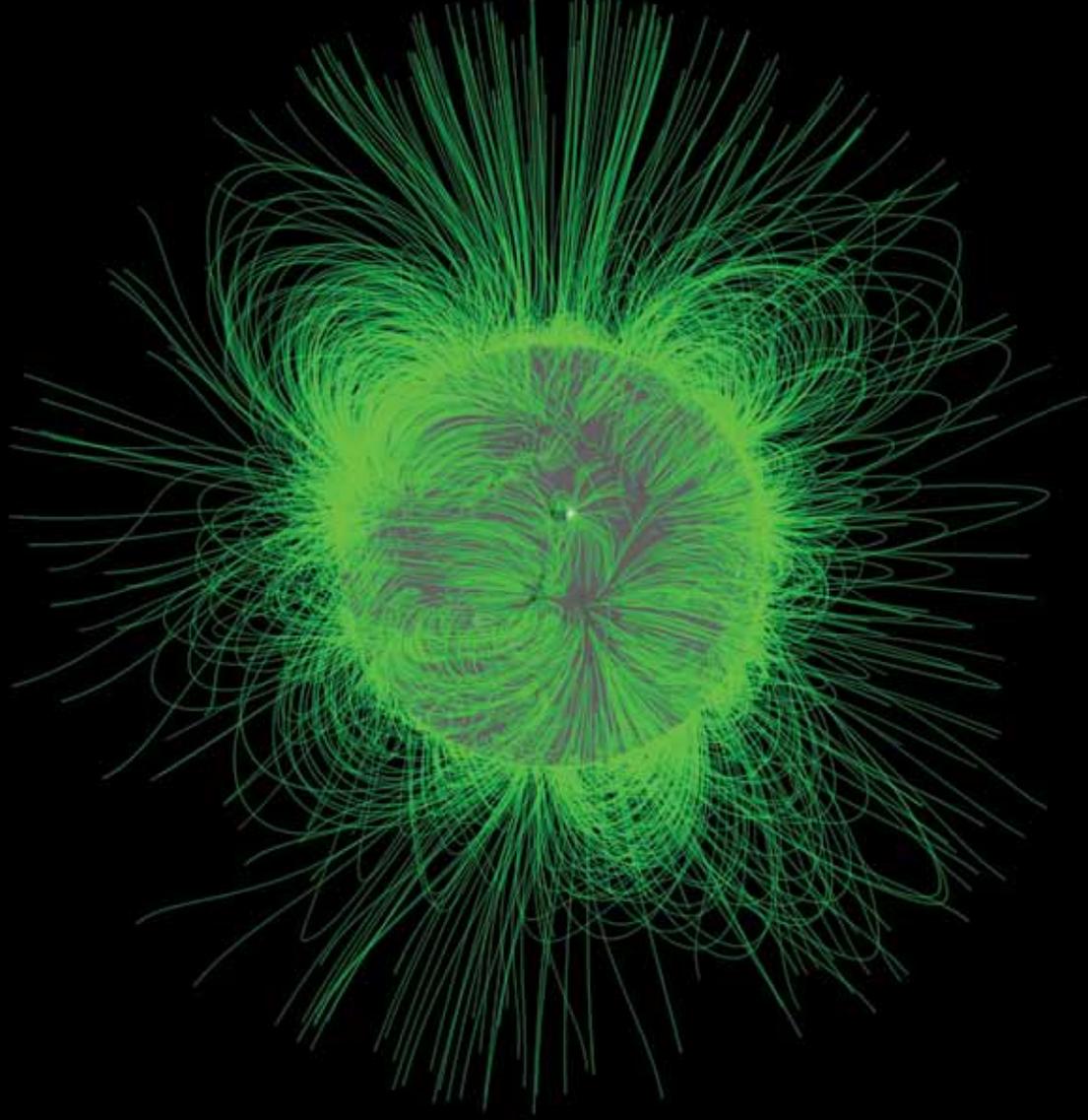
Raise hands.

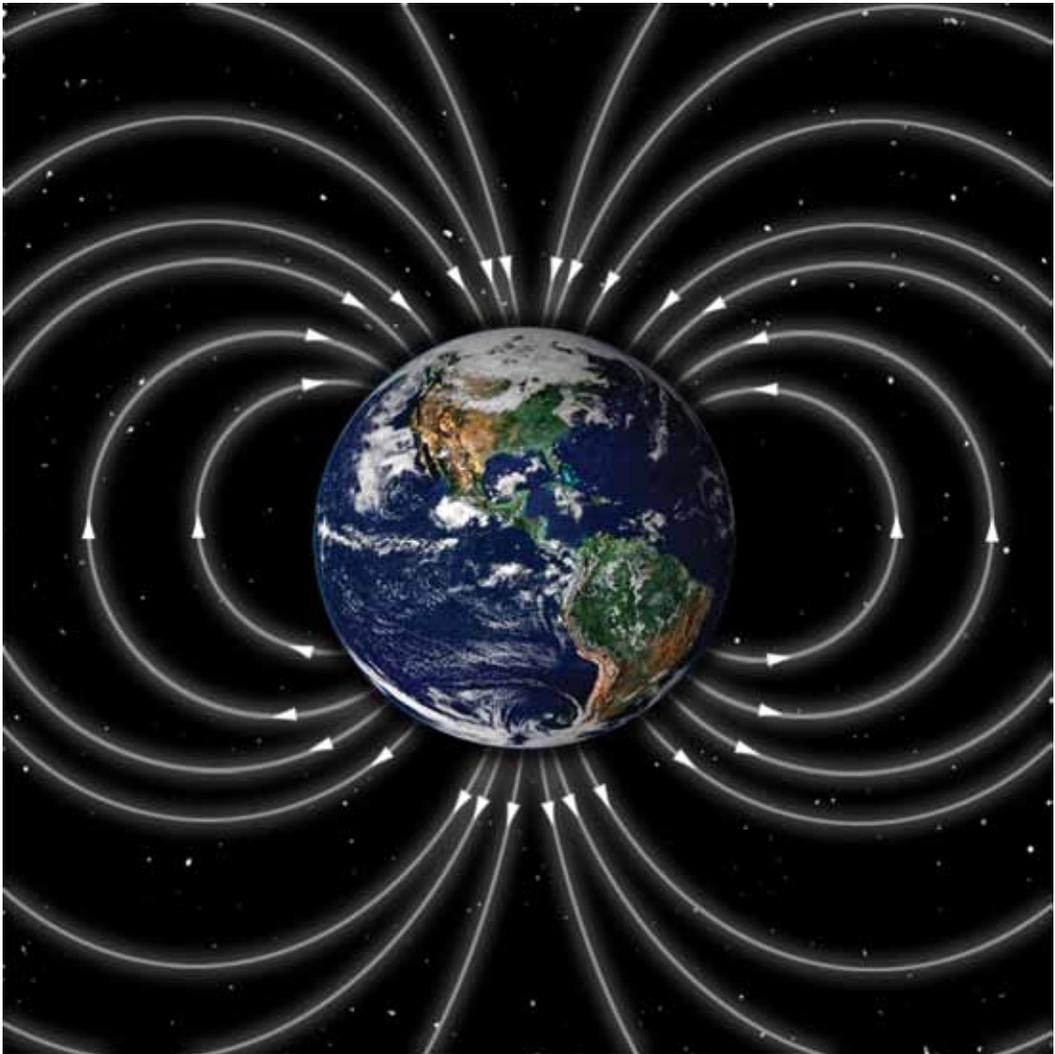
The solar storm can impact and short-circuit orbiting satellites, causing things like long-distance cell phone service to be interrupted. Changes in Earth's magnetic field can confuse navigational sensors on satellites, like those used for GPS. Satellites can be protected by proper shielding and, given enough notice, satellites can be powered down temporarily to protect their electronics. But communications that depended on those satellites would still be interrupted.

NASA and other international space agencies have placed numerous instruments on a variety of satellites that are keeping a close eye on the Sun, watching its every flicker.

Since many spacecraft are tracking activity on the Sun, we can see when a solar storm is ejected from the Sun. We have a couple of days to prepare before it arrives. If I throw a snowball at you (pick someone from the back), you can see the snowball in my hand, then you can react by putting your hands up before it reaches you.

By better understanding the Sun and how it works, we can better predict solar storms and provide earlier warnings to help protect our technologies from that weather out in space.







Presentation Basics

Grab their attention:

Have you ever used a compass?

Where do compasses point?

What do compasses have to do with the Sun?

Make a point:

Compasses follow magnetic fields

- Without a magnet nearby, compasses follow Earth's magnetic field (show picture)
- Place a magnet in center and follow the field lines
- Show picture of Sun's magnetic fields and ask, "Could you use a compass on the Sun?"

Use arms to show how sunspots emerge and how Solar Storms happen

Watch as a Solar Storm impacts Earth's magnetic field

Moving magnetic fields generate electric current - *use shake flashlight to illustrate*

Effects of Solar Storms:

- Brighter aurorae at lower latitudes
- In the past, electrical grids have overloaded
- Currently, can short-circuit satellites
- Satellites may be shut down, causing temporary outages in GPS and long distance cell phone use

Wrap Up:

The Sun's magnetism impacts our technologies

Let your audience explore the magnets and compasses and ask questions