Module 3: How does the Sun affect the Earth?

Activity C: Solar Research in Action! - Make a Magnetometer

Overview

The solar wind is a constant stream of particles (mainly electrons and protons) that travel from the Sun, past Earth, to the edge of the solar system at incredible speeds of up to 3,000,000 km/h (over 2,000,000 miles/h)! Solar wind is caused by the expansion of the Sun's extremely hot corona, which is made of plasma. The solar wind contains solar storms, also called magnetic storms, which are caused by solar activity. Scientists can determine the strength of solar storms by measuring changes in the Earth's magnetic field using a magnetometer. A magnetometer works like a sensitive compass that picks up slight changes in the magnetic field at Earth's surface. Changes in the magnetic field are signs of space weather that have impacted our planet.

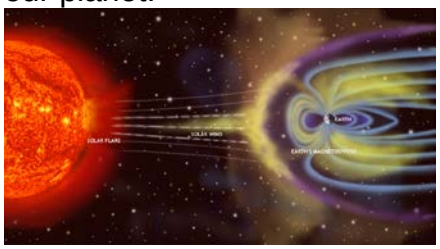


Image: NASA

Earth has a magnetic field with north and south poles. Earth's invisible magnetic field reaches 36,000 miles into space, in a region called the magnetosphere. The magnetosphere prevents most of the solar wind's particles from hitting the Earth. If solar storms are strong enough, some particles from the solar wind can enter the magnetosphere. Beautiful auroras, seen most often in Polar Regions, are natural signs of solar storms passing by Earth. Negative effects of space weather include communication and navigation disruptions, electrical current surges in power lines, increased rates of corrosion in oil pipelines, changes in satellite orbits, and radiation hazards to orbiting astronauts and spacecraft.

Teacher Overview

The focus of Module 3C is to provide an opportunity for students to build a magnetometer to monitor real-time changes in Earth's magnetic field caused by passing solar storms.

The solar wind is a constant stream of particles (mainly electrons and protons) that travel from the Sun to the edge of the solar system at incredible speeds ranging from 18000 km/h (over 11,000 miles/h) to more than 3,000,000 km/h (over 2,000,000 miles/h)! The solar wind contains solar storms, also called magnetic storms, which are caused by solar activity. Scientists use magnetometers to measure the strength of solar storms that affect Earth's magnetic fields. A magnetometer operates like a sensitive compass that records slight changes in the magnetic field at Earth's surface, which are evidence that space weather has impacted our planet. Earth's invisible magnetic field reaches 36,000 miles into space, in a region called the magnetosphere. The magnetosphere protects the Earth from most of the solar wind's particles hitting our planet. If solar storms are strong enough, some particles from the solar wind can enter and disrupt Earth's magnetosphere, which can result in natural events like amazing Aurorae but also affect human technology systems (satellites, etc.).

Objectives

Students will be able to:

- Create and use a magnetometer to detect and visualize changes in Earth's magnetic field to monitor solar storm impacts on Earth.

Team Goal

Your goal is to make and use a magnetometer to measure changes in Earth's magnetic field caused by solar storms from the Sun for 7-10 days.

Materials

- "Make a Magnetometer" lab sheets
- One quart size jar OR one 2-liter plastic soda bottle with cap
- About ½ pound (500g) of sand
- Thread (50cm)
- 1 Bar magnet (200mm x 7mm)
- One 3"x5" index card
- 1 small craft mirror or large sequin
- 1 Laser Pointer OR adjustable gooseneck desk lamp with clear bulb
- Scissors
- Meter stick
- Super Glue
- Clear packing tape
- Plastic soda straw,
- Large sheet of white paper
- Ruler
- Pencil
- Nail & hammer

Essential Vocabulary

- Magnetometer
- Magnetosphere
- Magnetic Field
- Magnetic Storm
- Corona
- Solar Wind

Module Lesson

Time: 1 block period/2 class periods to make magnetometer plus 7-10 days of measurements (2-3 measurements/day)

Materials: per team

- One quart size jar OR one 2-liter plastic soda bottle with cap
- About ½ pound (500g) of sand
- Thread (50cm)
- 1 Bar magnet (approx. 2.5cm x 0.7cm; available from www.magnetsource.com)
- One 3"x5" index card
- 1 small craft mirror or large sequin
- 1 Laser Pointer OR adjustable gooseneck desk lamp with clear bulb
- Scissors
- Meter stick
- Super Glue
- Clear packing tape
- Plastic soda straw,
- Large sheet of white paper
- Ruler
- Pencil
- Nail & hammer

Teacher Prep: Prepare a sample magnetometer

- Make copies of "Make a Magnetometer" lab sheets
- Prepare remaining materials

Engage & Explore!

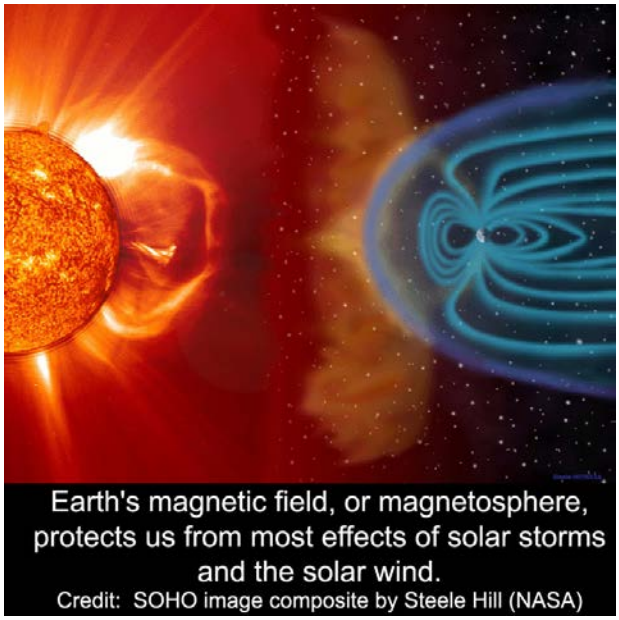
1. BUILD Knowledge:

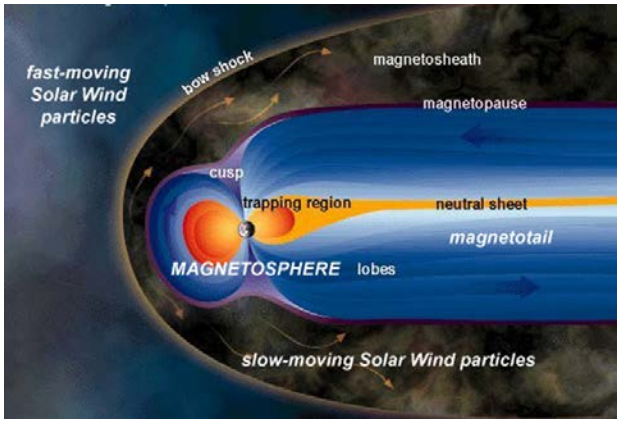
Earth's Magnetosphere

Learn about the magnetic field that surrounds Earth, the magnetosphere, which protects our planet from the Sun's solar winds and activity that cause space weather. Click on the NOVA Sun Lab and NASA video links to learn more:

Earth's Magnetic Shield Video
NASA Space Weather Media Viewer: Videos "Magnetosphere #1-6"
NASA Space Weather Media Viewer: Illustrations "The Magnetosphere"

Images: NASA





Student Engage/Explore Activity

1. BUILD Knowledge:

Earth's Magnetosphere

Student teams will watch the following NOVA Sun Lab video to learn about the magnetosphere, the magnetic field that surrounds Earth, which protects the planet from solar winds and space weather.

Earth's Magnetic Shield Video

NASA Space Weather Media Viewer: Videos "Magnetosphere #1-6"

NASA Space Weather Media Viewer: Illustrations "The Magnetosphere"

2. CREATE Resources & CONNECT to the Real World:

Make a Magnetometer

Following the "Make a Magnetometer" lab sheets, your team will make a magnetometer and record real-time changes in Earth's protective magnetosphere. Your team will be able to identify the presence of passing solar magnetic storms from the Sun that are affecting Earth's magnetic field. Your magnetometer, data table, and graph will serve as artifacts for your team's SDO Module 4 SDO Exploration Museum 3-D Solar Exhibit.

Make a Magnetometer Lab Sheet (see attached file)

Student Engage/Explore Activity

2. CREATE Resources & CONNECT to the Real World:

Make a Magnetometer

Distribute instructions and materials for the "Make a Magnetometer" activity to each group. The jar or soda bottle magnetometer is one type of simple magnetometer design that students can build to directly measure the changes in Earth's magnetic field. When magnetic solar storms impact Earth, teams will observe that the direction their magnetometer's magnet points changes by several degrees within a few hours, and then returns back to its normal orientation pointing towards the magnetic north pole. Student teams should plan to take 2-3 magnetometer measurements per day over a period of 7-10 days. The magnetometer and lab data sheets will be included in each team's Module 4 SDO Exploration Museum 3-D Solar Exhibit.

SDO Project Suite Student Guide

Names:_____ Date: _____

Module 3C: Make a Magnetometer Lab Sheet

Overview

Solar activity can affect the Earth's magnetic field causing small changes in its direction at Earth's surface, which are called magnetic storms. A magnetometer operates like a sensitive compass and can sense slight changes in the magnetic field that surrounds our planet. Your team will build a simple magnetometer to measure changes in Earth's magnetosphere (magnetic field) over a 7-10 day period of time by following the directions below.

This activity is adapted from: National Geographic Education Build a Magnetometer
http://education.nationalgeographic.com/education/activity/build-a-magnetometer/?ar_a=1

IMPORTANT SAFETY TIP: DO NOT point the laser pointer at other students or at your own eyes. Lasers can cause permanent damage to the retina of the eye.

Materials:

- Quart size jar OR 2L plastic bottle
- Sand (about ½ pound/500g)
- Index card (3"x5")
- Scissors
- Bar magnet (about 200mm x 7mm)
- Small craft mirror or large sequin
- Straw
- Low-melt glue or Super Glue
- Thread
- Clear packing tape
- Meter stick
- Metric ruler
- Laser pointer OR adjustable gooseneck desk lamp with clear bulb
- Nail & hammer
- Large sheet white paper
- Pencil

Procedure:

1. Refer to the magnetometer model and illustrated instructions when building your magnetometer.
2. Remove labels, clean, and dry a quart size jar or 2L plastic bottle. If using a 2L bottle, use scissors to carefully cut around the circumference of the bottle about ¼ of the distance below the bend in the neck of the bottle.
3. Review Diagram A "Magnetometer" details. Fill the bottom of the jar or bottle with enough sand to cover and stabilize it.

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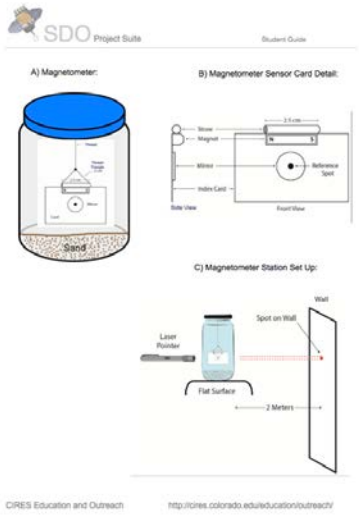

SDO Project Suite Student Guide

A) Magnetometer:

B) Magnetometer Sensor Card Detail:

C) Magnetometer Station Set Up:

CIRES Education and Outreach http://cires.colorado.edu/education/outreach/

Marvelous, your team members are Magnetic Masters!

Differentiation/Extension

- Teams film a space weather prediction news segment explaining how a magnetometer functions and incorporate the results of their magnetometer data table and graph.
- Students draw a 2-D or build a 3-D model of Earth's magnetosphere to illustrate how solar magnetic storms cause changes in Earth's magnetic field (magnetosphere).
- Teams conduct research to correlate their magnetometer data with concurrent SDO/space weather reports of solar storms. Results are presented in a compare-contrast or summary format of the team's choice.

Internet Resources

NASA Magnetic Fields of the Earth and Sun
LASP Magnetometer Activity
Soda Bottle Magnetometer and D-Component
A Simple Magnetometer
Exploring Magnetism