



CME Plotting

Middle School Grades

Lesson Summary

Students plot the path of two coronal mass ejections

Prior Knowledge & Skills

Understanding of:

- Basic characteristics of solar storms

Ability to:

- Read and interpret data tables
- Measure simple angles
- Plot points in terms of distance and angle

AAAS Science Benchmarks

The Nature of Mathematics

Mathematics, Science, and Technology

The Physical Setting

The Universe

Energy Transformations

Motion

NSES Science Standards

Science as Inquiry

Understandings of Scientific Inquiry

Physical Science

Transfer of Energy

Earth and Space Science

Earth in the Solar System

History and Nature of Science

Science as a Human Endeavor

Nature of Science

NCTM Mathematics Standards

Problem Solving

Measurement

Geometry

Teaching Time: One 45-minute period

Materials per Student

- Student work page
- Calculator
- Colored Pencils
- ❖ *Pencil, standard*
- ❖ *Protractor*

Editor's recommendation

Advanced Planning

Preparation Time: 20 minutes

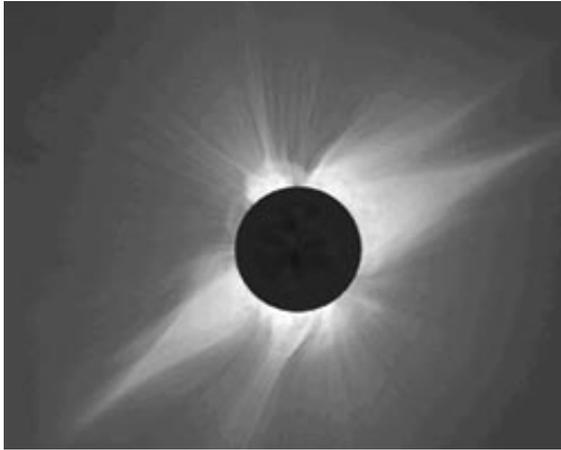
1. Review lesson plan
2. Gather materials
3. Copy student work page
4. Create overhead of student work page (optional)

Solar Storms and You! Exploring the Wind from the Sun, pp. 9-12, NASA

EG-2000-03-002-GSFC

<http://image.gsfc.nasa.gov/poetry/higley.html>

The Solar Wind



The outer layers of the Sun, called the **Corona**, are not stable but are constantly escaping into space. Although the magnetic field of the Sun 'bottles up' some of the hot gases near the solar surface to make spectacular prominences, in other regions the magnetic field opens into interplanetary space and allows the million-degree gases to escape as a **Solar Wind**.

Within the equatorial region of the Sun, the solar wind travels outwards in a pinwheel-shaped spiral pattern due to the combination of the outward gas motion, at over 400 kilometers/sec (1 million miles/hour), and the rotational motion of the Sun.

Although its normal density is less than 10 atoms per cubic centimeter, because the wind is spread out over such a vast volume of space, it amounts to over 50 billion tons of mass lost per day mostly in the form of high-speed electrons and protons - the components of the most abundant element in the Sun: hydrogen.

On occasion, and for reasons not fully understood by scientists, the magnetically



trapped gases in the Sun's corona can become unstable and get ejected into space as **Coronal Mass Ejections**, or **CMEs**. These clouds are carried by the solar wind. They are often as big as the Sun itself, and they contain upwards of one billion tons of matter in a single event which may last only a few hours. Traveling at speeds from 450 to 1000 kilometers/sec, the trip from the Sun to the Earth's orbit takes only a few days.

Most of these clouds dissipate quickly and merge into the solar wind while others can remain cohesive, though substantially diluted by the time they reach the Earth. Most of these CMEs never collide with the Earth, but those that do can cause satellite damage and brilliant auroral displays, so their effects are not inconsequential.

Like Stealth Bombers, it is not the ones we can detect on the limb of the Sun that pose a hazard to us here on Earth, it is the ones that are lost in the glare of the solar surface that can potentially reach Earth. NASA has stationed satellites in space between the Earth and the Sun to provide advanced warning for stealthy CME events, but even so, only about 1-2 hours of warning is possible from such distant outposts.

Introduction

Coronal Mass Ejections are major storms on the Sun which can hurl billions of tons of matter into space in a matter of a few hours. Traveling at millions of kilometers per hour, some of these clouds occasionally collide with the Earth and have produced power blackouts and satellite damage. CMEs can start out with a size of only a few 100,000 kilometers, but fan out to millions of kilometers by the time they reach Earth's orbit. Only the CMEs that emerge from near the Sun's eastern limb stand a chance of traveling all the way to Earth, so this is where astronomers look for early signs that one is on its way!

Objective

Students will construct a table of values and plot the points in order to make a prediction.

Procedure

- 1) Plot CME1 points from the appropriate tables and draw to scale the thickness of the CME indicated in the 'Width' column of the table.
- 2) Plot CME2 points from the appropriate tables and draw to scale the thickness of the CME indicated in the 'Width' column.
- 3) By hand, sketch the path of the CME that hits Earth and complete the shape of the CME using the width information from the table.
- 4) Identify the location on the Sun where the sketched CME in procedure #3 will emerge so that it hits the Earth. This point is about half way between the center of the Sun and the left (eastern) edge.

5) Show that most CMEs do not hit the Earth by choosing other CME locations on the Sun, and plotting the possible shape.

6) The points in the tables were calculated for an assumed CME speed of 450 kilometers/sec, however some CMEs can travel at a speed twice this fast. Challenge your students to re-calculate the table entries for a faster speed and repeat steps 1-4 in this procedure.

The students should see the shapes of the CME trajectories become flatter. The point where the Earth-hitting CME is ejected from the Sun will shift closer to the left (eastern) edge of the sun.

Materials

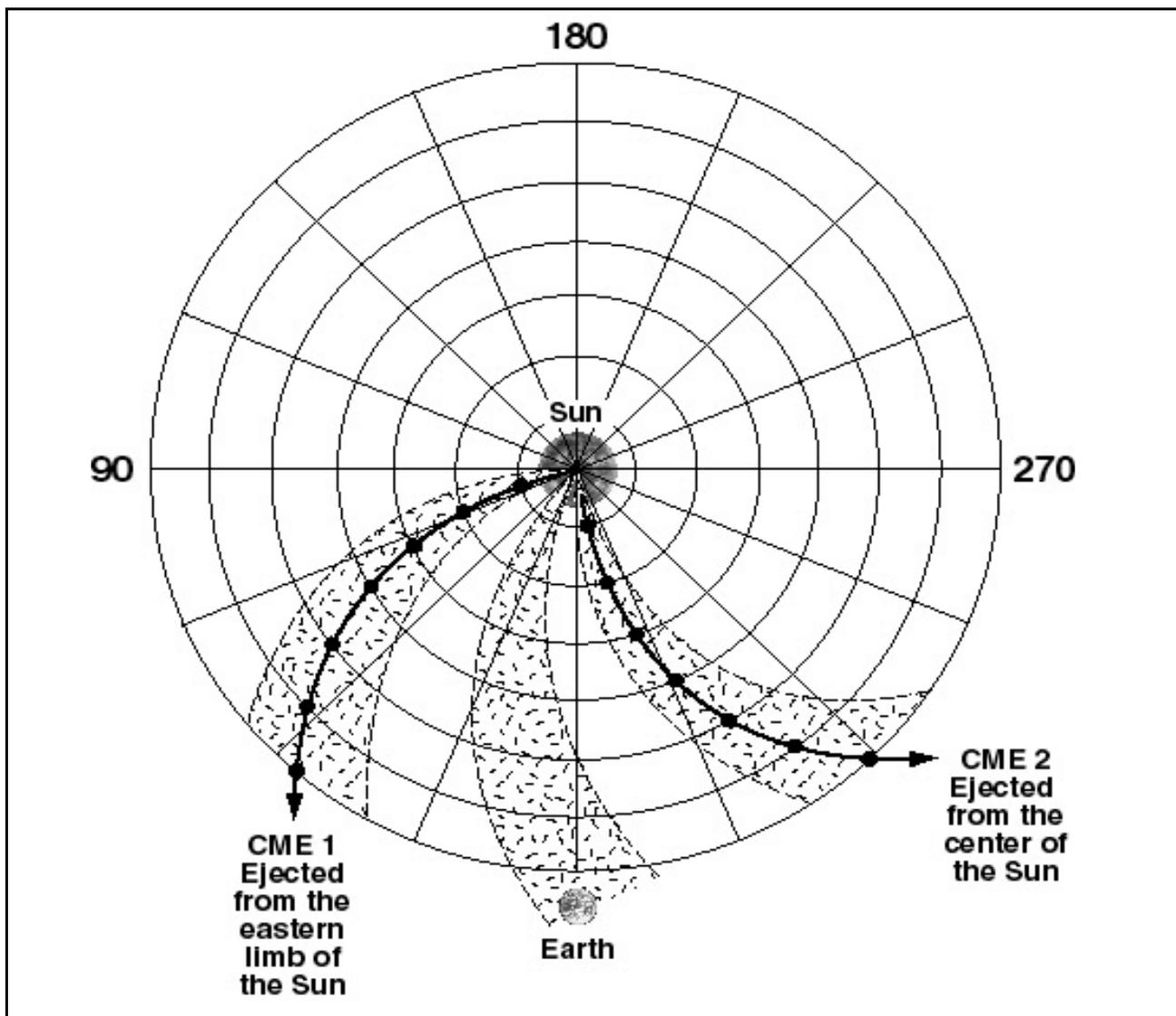
- Student work page
- Calculator
- Colored pencils

Teacher's Answer Key

| Day | CME #1 | | CME #2 | | Width |
|-----|----------|-------|----------|-------|-------|
| | Distance | Angle | Distance | Angle | |
| 0.0 | 0 | 90 | 0 | 360 | 0.5 |
| 0.5 | 20 | 83 | 20 | 353 | 7.0 |
| 1.0 | 40 | 76 | 40 | 346 | 13.5 |
| 1.5 | 60 | 69 | 60 | 339 | 20.0 |
| 2.0 | 80 | 62 | 80 | 332 | 26.5 |
| 2.5 | 100 | 55 | 100 | 325 | 33.0 |
| 3.0 | 120 | 48 | 120 | 318 | 39.5 |
| 3.5 | 140 | 41 | 140 | 311 | 46.0 |

From the table to the left, plot the path of two CMEs as they leave the Sun during its 3.5-day journey.

The distances and the widths of the CMEs are given in millions of kilometers.



Name _____

Date _____

| Day | CME #1 | | CME #2 | | Width |
|-----|----------|-------|----------|-------|-------|
| | Distance | Angle | Distance | Angle | |
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