Activity - Coronal Mass Ejection Plotting

Adapted by NSO from the NASA IMAGE/POETRY Teacher and Student Consortium.
https://image.gsfc.nasa.gov/poetry/activities.html

Objective

In this activity, students map the paths of Coronal Mass Ejections (CMEs) by plotting their positions over the course of a few days.

Materials

- ◻ Student activity sheet
- ◻ Ruler
- ◻ Protractor
- ◻ Pen or pencil

Background

A Coronal Mass Ejection (CME) is a storm of particles ejected from the Sun. These particles can shoot out from any of the 360° around the Sun. Therefore, the probability of a CME being directed towards Earth is relatively small. Students will plot CME locations and map their paths in order to spot trends and draw conclusions on CME behavior. As students add more CMEs to their activity sheets, it becomes apparent that in order for a CME to hit Earth, it must be ejected from a specific region of the Sun facing Earth.

Assuming that every 12 hours or so, a CME with an initial width of 0.5 million kilometers, will:

- Travel a distance of approximately 20 million kilometers
- Move approximately 7° counter clockwise
- Spread over a width of approximately 6.5 million kilometers.

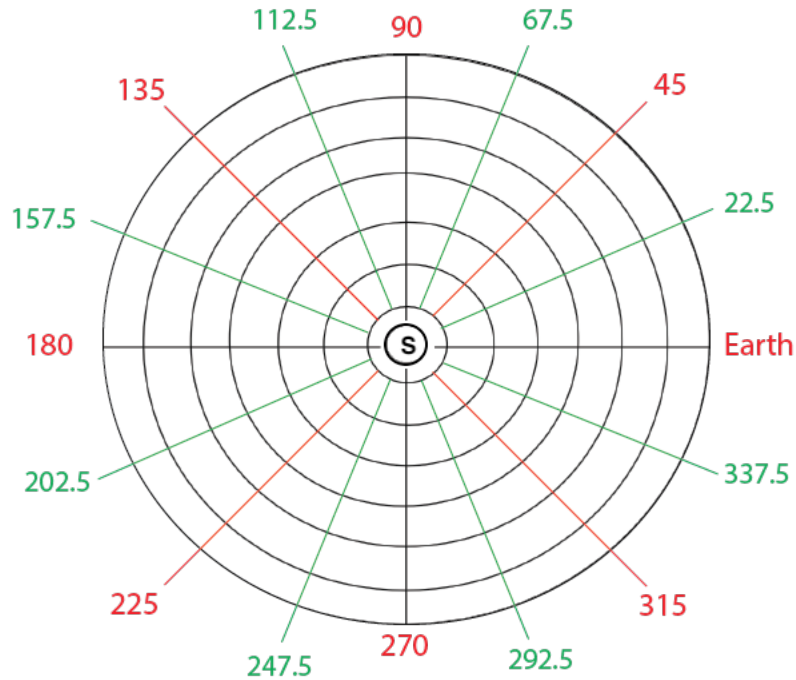
Students can generate and map other probable paths of CMEs ejected from the Sun at many different angles from 0° to 360°.

Note: Different CMEs travel at different speeds, which affect the distance that they travel over time, among other factors. The assumed values above are provided to simplify this activity for students.

Teacher Directions

1. Label each angle on the grid using degrees as your unit. Draw and label additional angle lines between each 90º interval for more precise plotting

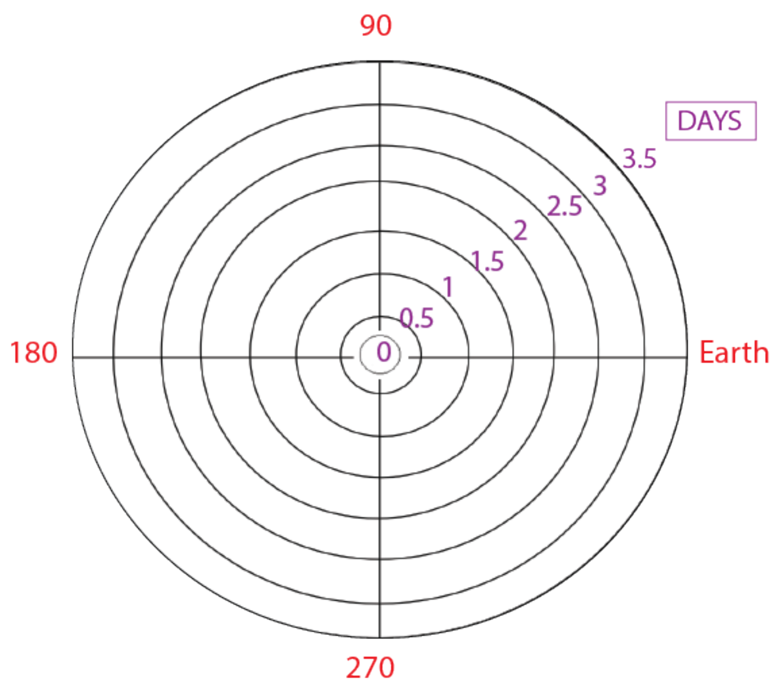
Example:



S = Sun

2. Because the provided CMEs' distances from the Sun increase linearly in approximate intervals of 20 million kilometers per 0.5 day, it is possible to label each circle as time in days, starting from Day 0 and increasing in 0.5 day intervals for each concentric circle.

Example:



Teacher Directions Cont...

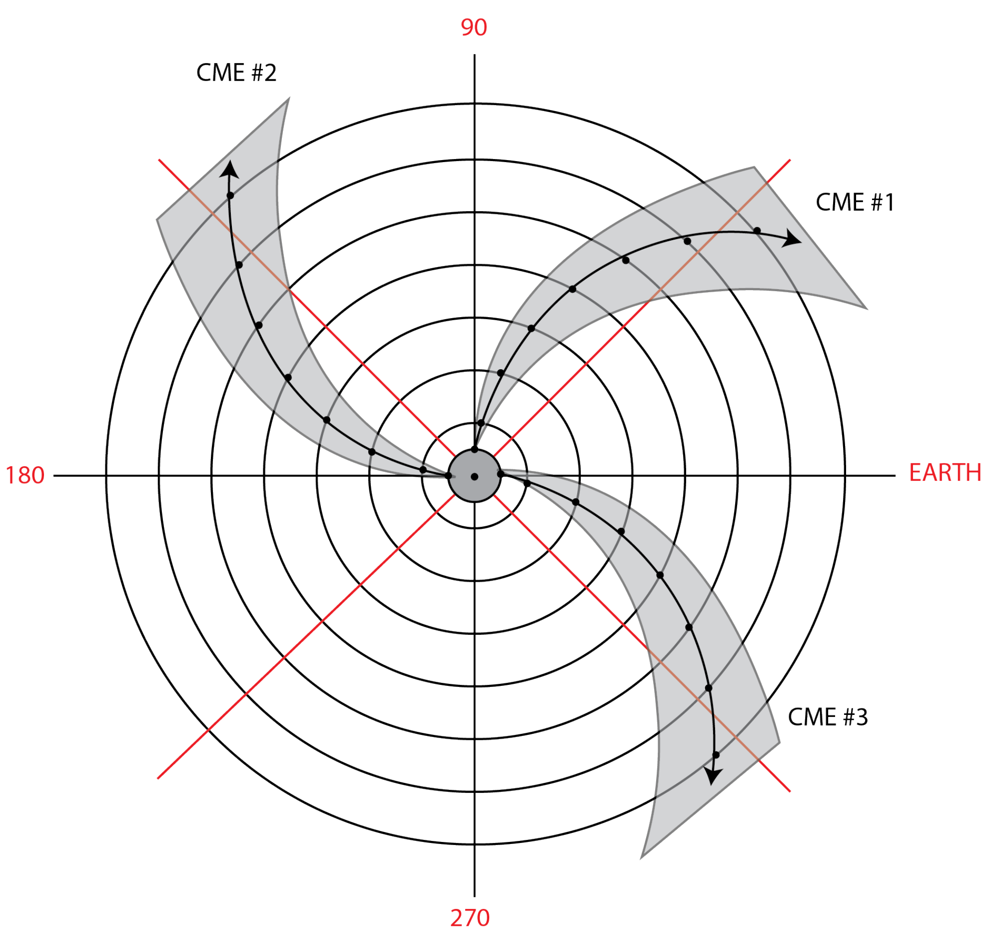
3. Now that the grid is ready, start plotting CME locations over time, using the data table provided. You will use the data in the "Day" and "Angle" columns to plot your points.

4. Once each location is plotted, draw to scale the width of the CME as indicated in the "Width" column of the data table. *Distances and widths are given in millions of kilometers. Students can calculate their own scale for drawing width measurements, or you can give them the conversion:

5. 20 million kilometers = 1 centimeter = 10 millimeters

6. Hand sketch the path of each CME and complete the shape by shading in between the width measurements.

Teacher Answer Key:



Key for Student Activity Sheet width scale

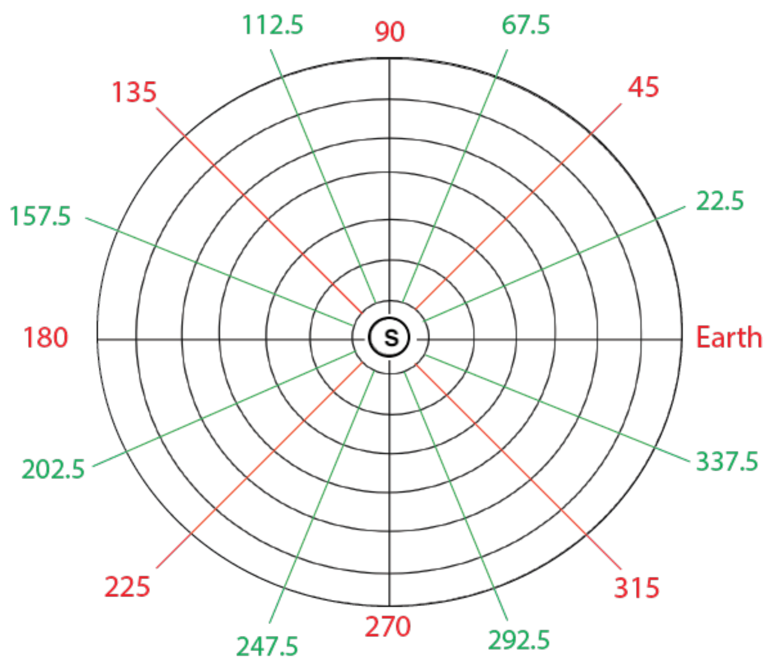
WIDTH (millions of kilometers)	WIDTH TO SCALE (MM)
0.5	0.25
7	3.5
13.5	6.75
20	10
26.5	13.25
33	16.5
39.5	19.75
46	23

CME Plotting - Student Activity Sheet

Directions

1. Label each angle on the grid using degrees as your unit. Draw and label additional angle lines between each 90º interval for more precise plotting.

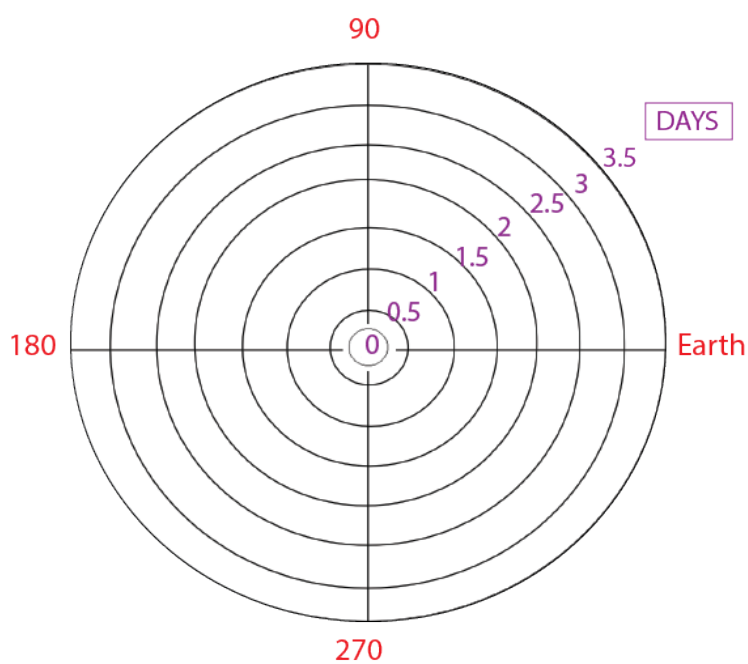
Example:



S = Sun

2. Because the provided CMEs' distances from the Sun increase linearly in approximate intervals of 20 million kilometers per 0.5 day, it is possible to label each circle as time in days, starting from Day 0 and increasing in 0.5 day intervals for each concentric circle.

Example:



CME Plotting - Student Activity Sheet

Directions Cont...

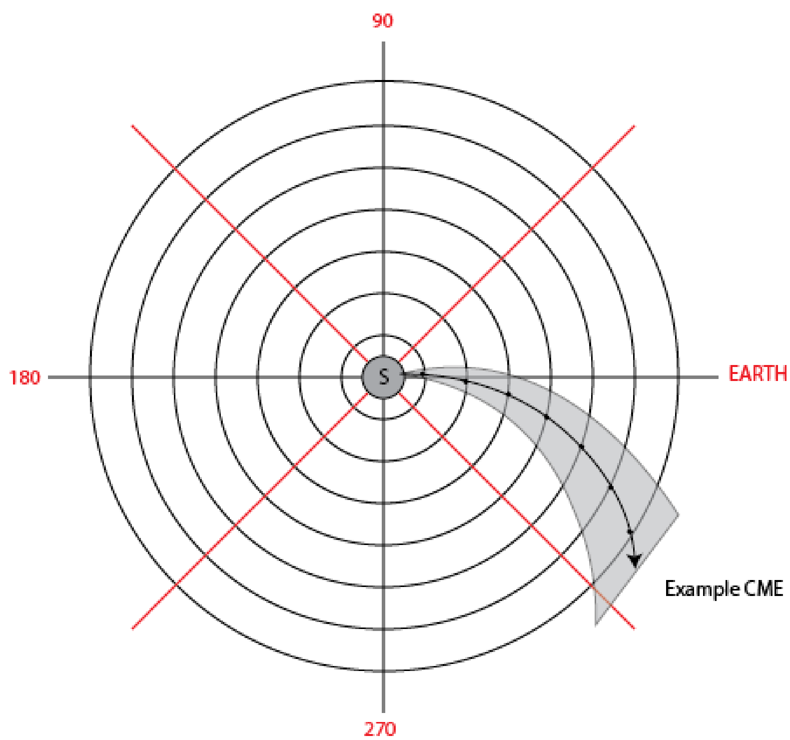
3. Calculate the scale width of each CME and record the values in the "WIDTH TO SCALE (mm)" column of each data table provided. Use the map grid provided to calibrate your measurements. Hint: the distance between concentric rings represent 20 million kilometers and measure 10 millimeters apart.

4. Using the data tables provided, plot the path of CME #1, CME #2, and CME #3 as they leave the Sun during their 3.5-day journey. You will use the data in the "DAY" and "ANGLE" columns to plot your points.

5. Using a ruler, draw to scale the width of each CME indicated in the "WIDTH TO SCALE (mm)" column.

6. Hand sketch the path of each CME by connecting your location points and drawing an arrow to indicate the direction that the CME is moving (away from the Sun). Complete the shape of the CME by shading in your width measurements.

Example:



7. Use the data provided for CMEs 1, 2, and 3, to determine at which angle a CME can emerge from the Sun and hit Earth. Then, fill in the "ANGLE" and "WIDTH TO SCALE (mm)" columns in the data table provided for "CME that hits Earth". Lastly, plot the path of this CME on your map grid and label it CME #4.

STUDENT ACTIVITY SHEET - DATA TABLES

CME #1

DAY	DISTANCE (millions of kilometers)	ANGLE (degrees)	WIDTH (millions of kilometers)	WIDTH TO SCALE (MM)
0	0	90	0.5	
0.5	20	83	7	
1	40	76	13.5	
1.5	60	69	20	
2	80	62	26.5	
2.5	100	55	33	
3	120	48	39.5	
3.5	140	41	46	

CME #2

DAY	DISTANCE (millions of kilometers)	ANGLE (degrees)	WIDTH (millions of kilometers)	WIDTH TO SCALE (MM)
0	0	180	0.5	
0.5	20	173	7	
1	40	166	13.5	
1.5	60	159	20	
2	80	152	26.5	
2.5	100	145	33	
3	120	138	39.5	
3.5	140	131	46	

CME #3

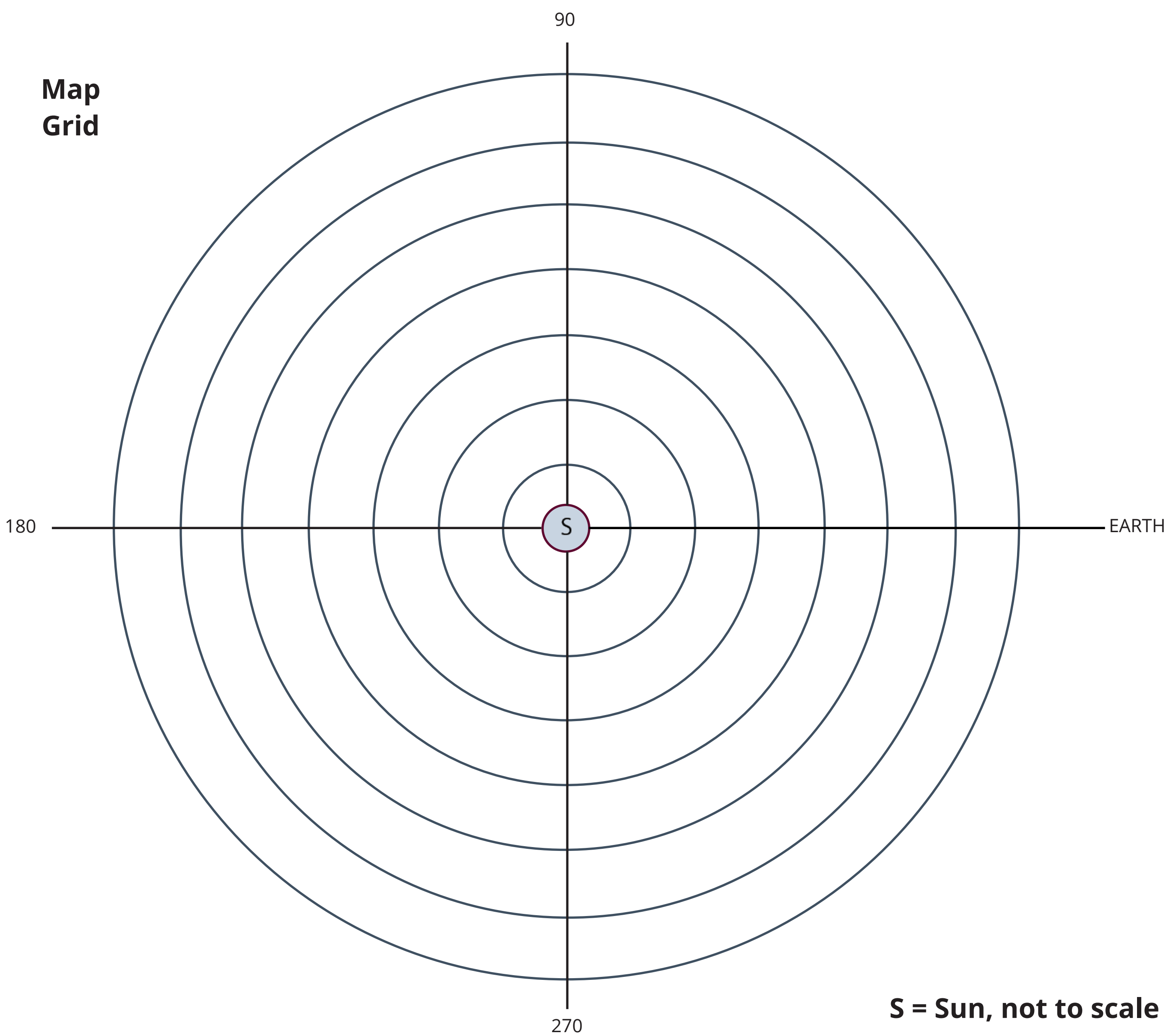
DAY	DISTANCE (millions of kilometers)	ANGLE (degrees)	WIDTH (millions of kilometers)	WIDTH TO SCALE (MM)
0	0	360	0.5	
0.5	20	353	7	
1	40	346	13.5	
1.5	60	339	20	
2	80	332	26.5	
2.5	100	325	33	
3	120	318	39.5	
3.5	140	311	46	

Student Activity Sheet - CME Plotting

CME that hits Earth:

DAY	DISTANCE (millions of kilometers)	ANGLE (degrees)	WIDTH (millions of kilometers)	WIDTH TO SCALE (MM)
0	0		0.5	
0.5	20		7	
1	40		13.5	
1.5	60		20	
2	80		26.5	
2.5	100		33	
3	120		39.5	
3.5	140		46	

Map Grid



S = Sun, not to scale

Conclusions

1. Based on your CME plot, do most Coronal Mass Ejections (CMEs) hit Earth? Why or why not?

2. The points in the tables were calculated for an assumed CME speed of 450 km/sec. How do you think CME paths or shapes might change if traveling at a speed twice as fast (900 km/sec.)? Challenge yourself by re-calculating the table entries for different speeds.

3. What are the limitations of this plotting activity? In other words, what other factors might be missing or not accounted for in this exercise. How might your results be different if you were tracking “real-life” CMEs? Explain.