

ACTIVITY - CALLING ALL HAWAI‘I SOLAR SCIENTISTS

Adapted by NSO from: NASA. 2003. Living with a Star-GEMS Teacher's Guide for Grades 6-8. University of California, Berkley, CA.

OBJECTIVE

In this activity, students investigate a series of mysterious events on Earth, and build a hypothesis to explain what happened. This activity is based on real events with fictionalized emergencies.

MATERIALS

- Student activity sheets
- Pen or pencil

BACKGROUND

Solar events such as coronal mass ejections and solar flares, also known as space weather, can cause technological disruptions and mishaps when they hit Earth. In this lesson, students are the solar scientists who determine the solar causes of mysterious events that have the potential to affect thousands of people. Similar real-life events like the ones described in this activity have occurred and impacted the lives of many.

In our present day society, we are heavily dependent on modern technologies such as radio wave communications, satellites, global positioning systems, and electrical power grids. In the event that a solar storm powerful enough to cause large-scale damage to these systems occurs, early prediction and preparedness will make all the difference in how society's technologies will recover.

CALLING ALL HAWAI‘I SOLAR SCIENTISTS!

STUDENT ACTIVITY SHEET

THERE HAVE BEEN A SERIES OF MYSTERIOUS EVENTS HERE ON EARTH. FIGURE OUT WHAT’S CAUSED THESE EVENTS AND USE YOUR KNOWLEDGE TO KEEP THE PUBLIC SAFE IN THE FUTURE.

MYSTERIOUS EVENTS

September 6

Rescue services lost communication fishermen out of Kahului port when their radios stopped working at 12:01pm.

September 8

Night time security guards recorded red and green lights on the horizon around 11:50pm.

September 8

A sudden impulse was observed at several of Earth’s magnetic field instruments (magnetometers) at 3:48am.

September 6

NASA’s SoHO satellite suffered radiation damage at 12:00pm.

September 8

10:30pm: UHMC students out stargazing in Waihee reported unusual clouds and colors in the sky in the north and northeast directions.

September 6

12:01pm: Astronauts on the International Space Station detected a sudden increase in X-rays and Gamma-rays and were directed to take cover immediately.

September 8

Voltage irregularities registered across Hawai‘i electrical grid through the day.

September 6

The number of dropped cell phone calls increased drastically throughout the day.

MYSTERIOUS EVENTS CONTINUED

September 7

Television broadcasts interrupted temporarily across the USA. Effect most noticeable with satellite television channels.

September 7

Department of Defense issued a memo regarding poor GPS reliability for drone operators for the next 24-36 hours.

September 6

Federal Aviation Authority has announced delays in flights from Hawai'i to Europe. Airlines are forbidden from flying over the north or south poles due to concern about radio communication stability until further notice.

September 8

Scientists at Antarctica's Amundsen-Scott South Pole Station noted irregularities in the location of the magnetic south pole today.

September 5

The National Solar Observatory observe highly complex sunspots near the center of the Sun.

September 9

Verizon, AT&T and T-Mobile have announced that cell phone services have returned to normal as of noon today.

September 6

The National Weather Service have issued a warning to electricity companies regarding possible nationwide outages for the next 24-36 hours.

September 9

Scientists at Antarctica's Amundsen-Scott South Pole Station report that magnetic south has returned to its normal position.

September 6

11:59pm: Astronauts report X-ray and Gamma-ray radiation levels returned to normal.

September 9

Federal Aviation Authority has declared flights from Hawai'i to Europe may resume flightpaths over the poles.

DIRECTIONS

1. Catalogue the mysterious events using the calendar below.
2. Use the calendar of events, along with the artifacts below to find evidence for what may have caused the mysterious events. Use the hints provided to guide you along the way.

September 6	September 7
September 8	September 9

ARTIFACTS

Artifact #1: "Internet Research"

You've done some research and have come across the following chart:

Coronal Mass Ejections	Solar Flares
Release explosions of magnetic field, protons and electrons (matter)	Release electromagnetic radiation
Particles take 2-3 days to reach Earth	Travels at the speed of light; takes 8 minutes to reach Earth
Carries a magnetic field that can interact with Earth's magnetic field.	Increase in EM radiation can cause disruptions in radio communications and GPS

Evidence :

Hint: How long does it take CME particles and Solar Flare energy to reach Earth?

Artifact #2: "Military Satellite Report"

Sept. 5 - Normal

Sept 6 - Alert

12:01pm - Increase in X-ray and gamma ray levels detected. Defense system on alert: Def Con 3.

12:11pm - Increased X-rays and gamma rays identified as not coming from Earth. Defense system taken off alert.

12:34pm - Communications with all other nuclear powers confirm that no detonation of nuclear weapons occurred.

11:59pm X-ray and Gamma-ray levels returned to normal

Sept. 7 - Normal

Sept. 8 - Normal

Evidence :

Hint: On what day and times did the alert occur? When was the increase in rays detected?

Artifact #3: "Hourly Record of Sept 6th Solar Flares and CMEs"

S = small

M = Medium

L = Large

Time	Solar Flares			Coronal Mass Ejection		
	S	M	L	S	M	L
00:00 - 00:59	1					
01:00 - 01:59		1			1	
02:00 - 02:59						
03:00 - 03:59		1				
04:00 - 04:59		1			1	
05:00 - 05:59						
06:00 - 06:59						
07:00 - 07:59	1					
08:00 - 08:59						
09:00 - 09:59		1				
10:00 - 10:59	1					
11:00 - 11:59			1			1
12:00 - 12:59	1					
13:00 - 13:59	1					
14:00 - 14:59						
15:00 - 15:59						
16:00 - 16:59	1			1		
17:00 - 17:59	1	1			1	
18:00 - 18:59						
19:00 - 19:59						
20:00 - 20:59	1					
21:00 - 21:59						
22:00 - 22:59						
23:00 - 23:59						

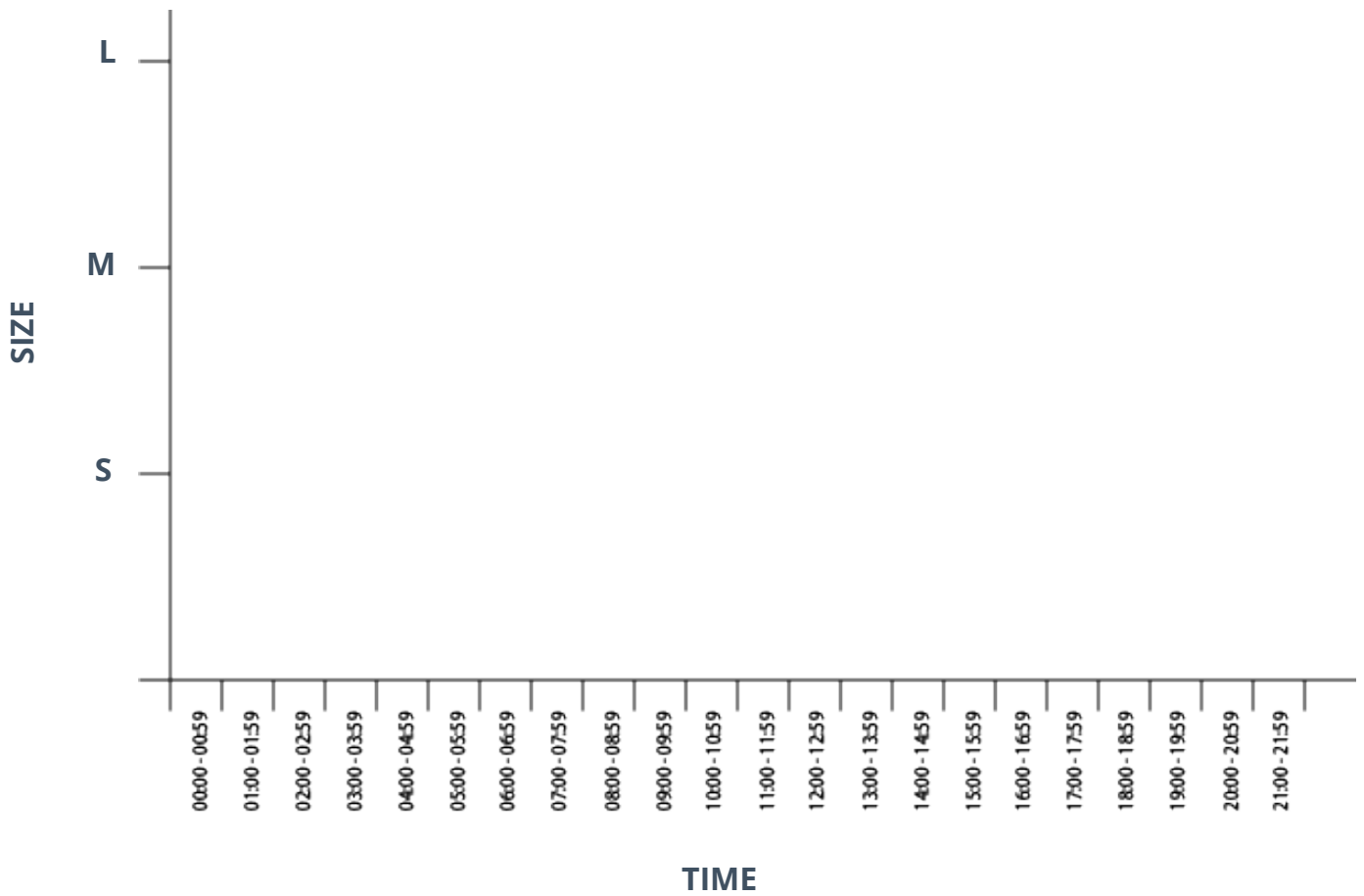
Flare Data from www.solarmonitor.org/?date=20170906

Evidence :

Hint: At what time did the largest CME and Solar Flare occur?

GRAPH THE DATA FROM ARTIFACT #3

Graph Title _____



- = Solar Flare
- = Coronal Mass Ejection

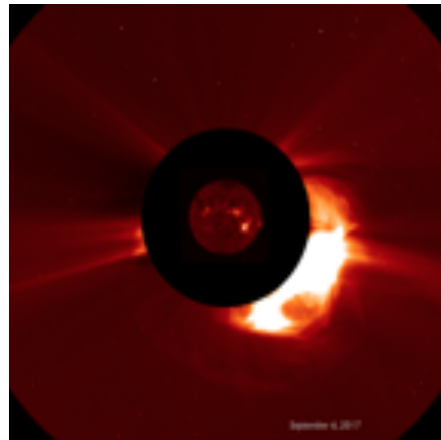
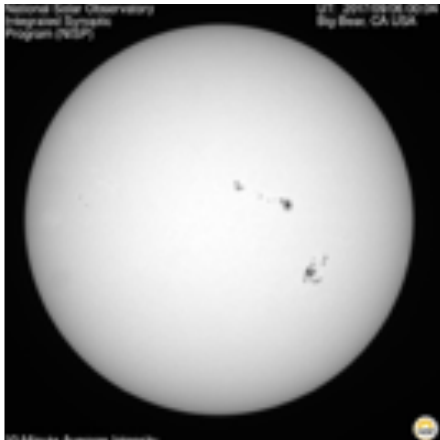
Artifact #4: Sunspot and CME observations

Date

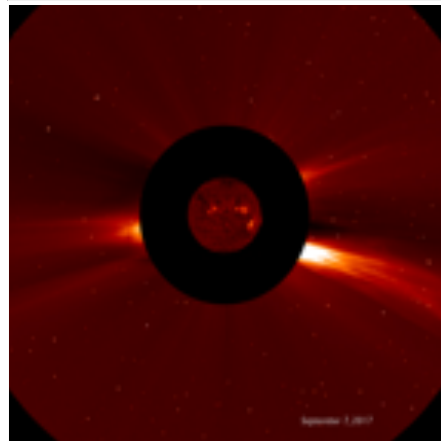
Sunspot activity

CME activity

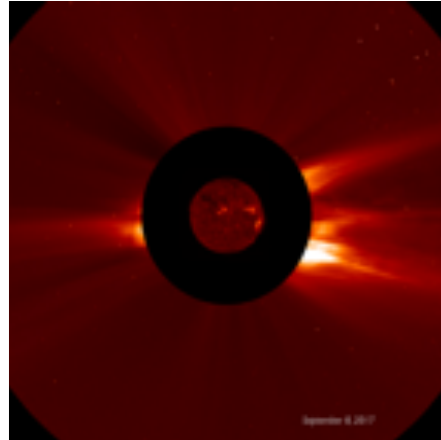
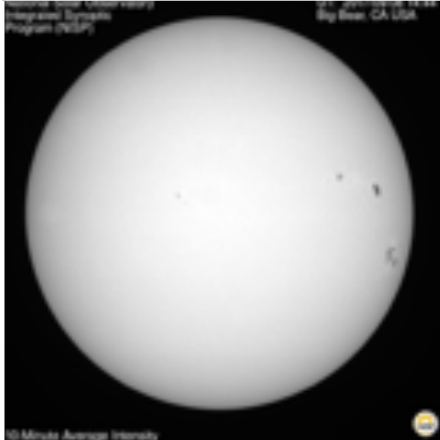
Sept. 6



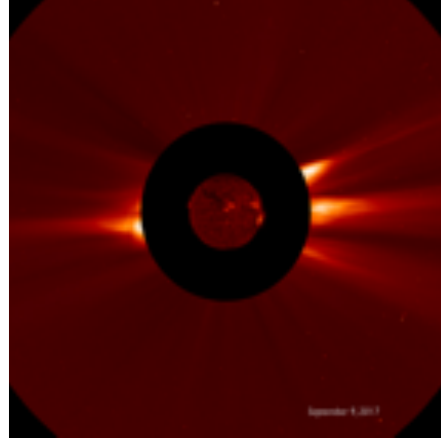
Sept. 7



Sept. 8



Sept. 9



Evidence :

Hint: On what day does the CME activity look different?

CONCLUSIONS

Questions:

1. What was the cause of all of these disruptions?

2. The largest solar flare on Sept 6th happened at 11:53am. Why did the loss of radio communications at Earth not happen until 12:01pm?

3. If the largest solar flare and CMEs occurred on Sept 6th, what explains the disturbances that happened on Sept 8th?

Write your conclusions in the space below. Be sure to explain what caused the events and provide specific examples of evidences that validate your conclusions. Use what you know about solar flares and CMEs in your explanation.

TEACHER ANSWER KEY

Artifact #1: "Internet Research"

You've done some research and have learned that it takes 8 minutes to travel from the Sun to Earth at the speed of light.

You've learned that it takes CME gusts two to three days to reach the Earth from the Sun.

Evidence :

It takes light energy 8 minutes to get from the Sun to the Earth.

It takes protons and electrons from CME gusts 2-3 days to reach Earth.

Artifact #2: "Military Satellite Report"

Sept. 5- Normal

Sept 6 - Alert

12:01pm - Increase in X-ray and gamma ray levels detected.
Defense system on alert: Def Con 3.

12:11pm - Increased X-rays and gamma rays identified as not coming from Earth. Defense system taken off alert.

12:34pm - Communications with all other nuclear powers confirm that no detonation of nuclear weapons occurred.

11:59pm X-ray and Gamma-ray levels returned to normal

Sept. 7 - Normal

Sept. 8 - Normal

Evidence :

Increased X-ray and Gamma rays, which can be released by solar flares, were detected on Sept. 6 @ 12:01pm

Hint: On what day and times did the alert occur?
When was the increase in rays detected?

Artifact #3: "Hourly Record of Sept 6th Solar Flares and CMEs"

S = small

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03:00 - 03:59		1				
04:00 - 04:59		1			1	
05:00 - 05:59						
06:00 - 06:59						
07:00 - 07:59	1					
08:00 - 08:59						
09:00 - 09:59		1				
10:00 - 10:59	1					
11:00 - 11:59			1			1
12:00 - 12:59	1					
13:00 - 13:59	1					
14:00 - 14:59						
15:00 - 15:59						
16:00 - 16:59	1			1		
17:00 - 17:59	1	1			1	
18:00 - 18:59						
19:00 - 19:59						
20:00 - 20:59	1					
21:00 - 21:59						
22:00 - 22:59						
23:00 - 23:59						

Flare Data from www.solarmonitor.org/?date=20170906

Evidence :

The largest solar flare and CME both occurred on Sept. 6th between 11am and noon

Hint: At what time did the largest CME and Solar Flare occur?

Questions:

1. What was the cause of all of these disruptions?

A large solar flare occurred on Sept. 6th between 11am and noon. There was a large CME that happened at the same time.

2. The largest solar flare on Sept 6th happened at 11:53am. Why did the loss of radio communications at Earth not happen until 12:01pm?

Solar flares release light energy. It takes light 8 minutes to reach Earth from the Sun.

3. If the largest solar flare and CMEs occurred on Sept 6th, what explains the disturbances that happened on Sept 8th?

These issues could have been caused by increased magnetic field and particles ejected from the sun interfering with the Earth's magnetic field. The protons and electrons and magnetic field released in the large CME take 2-3 days to reach Earth from the Sun. This is why it took 2 days after the big CME for these disturbances to happen..

Write your conclusions in the space below. Be sure to explain what caused the events and provide specific examples of evidences that validate your conclusions. Use what you know about solar flares and CMEs in your explanation.

These events seem to have been caused by a large solar flare and CME that occurred on Sept 6th at 11:53am. Evidence to support solar flare involvement include increased x-ray and gamma rays detected at Earth on Sept. 6th @ 12:01pm. Solar flares release large amounts of light energy such as x-rays and gamma rays. These types of light energy take approximately 8 minutes to reach Earth from the Sun. Thus, a large solar flare occurring at 11:53am, was likely the source of the increase in energy rays detected on Earth at 12:01pm (8 minutes later). This is what caused interference with radio waves and communications. [Note to teachers: Flare radiation doesn't directly interfere with radio waves. The actual cause of radio interference is as a result of solar flare radiation ionizing the Earth's outer atmosphere, making our ionosphere thicker. Radio waves bounce off the ionosphere to travel long distances, so unexpected changes in that layer of the atmosphere can cause radio signals to be lost.]

CMEs release protons and electrons along with magnetic field. These protons and electrons take 2-3 days to reach Earth (evidence from artifact #1) and can sometimes interfere with Earth's magnetic field. This explains why disturbances continued to happen until Sept. 8th. CMEs can also excite the atoms in our atmosphere, causing them to glow (i.e. Aurora Borealis). Although it would be extremely rare to see aurora in Hawai'i, it would be possible if the CME was large enough. This would explain the unusual colors in the sky that were observed by the UHMC students.