



Additional logo area (NASA, SwRI,  
etc)

Laboratory for Atmospheric and Space Physics  
University of Colorado **Boulder**

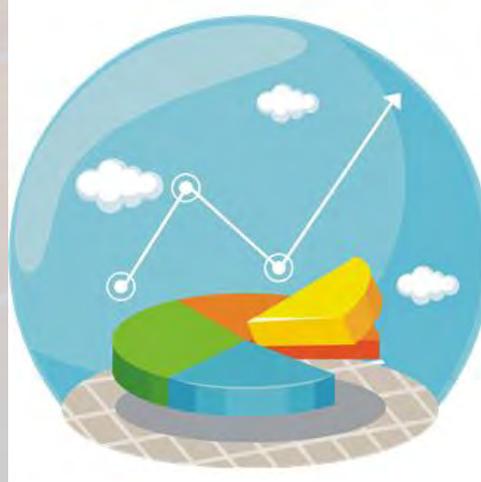
# Making Connections in Astronomical Science

Based upon ideas from a Framework for K-12  
Science Education

Erin Wood

# Next Generation Science Standards Science Practices

- Developing and using models
- Analyzing and interpreting data
- Constructing explanations
- Engaging in argument from evidence



**Do students understand the importance of models?**

*What types of models do you use in the classroom?*



## Analyzing and Interpreting Data: Types of real data for your class

- Raw
- Pre-processed for the class
- Citizen science (pre-packaged)
- Authentic classroom exploration

*Why is authentic data powerful?*

# Resources for Classroom Friendly Data Observing with NASA

The screenshot shows a web browser window titled "Observing With NASA" with the URL <http://mo-www.harvard.edu/OWN/>. The browser's address bar and search bar are visible. The website's header features the "OBSERVING WITH NASA" logo and the text "MicroObservatory Robotic Telescope Network Harvard-Smithsonian Center for Astrophysics". A navigation menu includes links for "CONTROL TELESCOPE", "PROJECTS & ACTIVITIES", "TOOLS & TRAINING", "DOWNLOAD SOFTWARE", "NEWS & VIEWS", and "ABOUT MICROOBSERVATORY".

**Control your OWN telescope using the MicroObservatory Robotic Telescope Network**

NASA's space science researchers control some of the world's most sophisticated space probes and orbiting telescopes to get amazing images of objects in space. Now YOU can join them by operating your **OWN** ground-based "MicroObservatories" - real robotic telescopes that you command through this website!

Top panel: Students controlling MicroObservatory Telescope, image taken with MicroObservatory telescope.  
Bottom panel: Scientists controlling Hubble Telescope, image taken with Hubble telescope

**NEWS & VIEWS**  
MicroObservatory joins Global Astronomy Month! Learn more [here!](#)

**SHARE YOUR IMAGES**  
Share your OWN images with the community & discover new ones!

**HISTORY OF TELESCOPES**  
Explore the history of telescopes with [Telescopes From The Ground Up](#)

Choose Target → Adjust Settings → Provide Information → Submit

### Adjust Your Telescope Settings

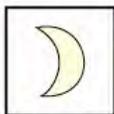
The options you choose will be sent to the telescope and it will take your image tonight using these settings.



#### Pinwheel Galaxy

Object Type: Galaxy Distance: 27 million light years Constellation: Ursa Major

#### Field of View



**Normal View - 1°**  
Good setting for most objects

There is only one field of view option for this object.

#### Exposure Time



15 seconds



30 second



45 seconds



60 seconds



optimal exposure time

#### Filter Selection



**No Filter**  
all light let through



There is only one filter option for this object. This filter is the optimal setting.

CONTINUE

Choose Target → Adjust Settings → Provide Information → **Submit**

### Your request for a telescope image has been submitted!

Here are your settings that will be used by the telescope to take an image tonight:



#### Target: Pinwheel Galaxy

Object Type: Galaxy Distance: 27 million light years Constellation: Ursa Major

Field of View: **normal** Exposure Time: **60 Seconds** Filter Selection: **none**

Your email address: [erin.wood@lasp.colorado.edu](mailto:erin.wood@lasp.colorado.edu)

Tomorrow or the next day you will receive an email notification from [MicroObservatorySupport@cfa.harvard.edu](mailto:MicroObservatorySupport@cfa.harvard.edu) with a link to download your image.

Keep your fingers crossed for clear skies!

What's next?

- To see recently-taken images, visit the [MicroObservatory Image Directory](#)
- To take more images, go to [Control Telescope](#)
- To find things to do with your images, explore [Projects & Activities](#)
- Compare your OWN images to NASA's Great Observatories - [Hubble](#) - [Chandra](#) - [Spitzer](#)
- [Give us your feedback](#) on your MicroObservatory experience



[HOME](#) - [SITE MAP](#) - [CREDITS](#) - [PRIVACY](#)



# Resources for Classroom Friendly Data

## MyNASAdata

The screenshot shows the MyNASAdata website with the following layout:

- Header:** NASA logo, "NATIONAL AERONAUTICS AND SPACE ADMINISTRATION", links to "Visit NASA.gov" and "Visit the ASDC", and a search bar.
- Hero Section:** "MY NASA DATA" logo with a tagline: "Mentoring and inquiry using NASA Data on Atmospheric and earth science for Teachers and Amateurs".
- Left Sidebar:**
  - Home
  - Overview and Sample Lesson
  - Project Brochure
  - Meet the Team
  - Science Glossary
  - Read our monthly E-notes
  - YouTube Tutorials
  - Workshop Materials
  - Data Archive: EOS - Website
  - + For Citizen Scientists
  - Student Cloud Observations Online - S'COOL
  - Observe Your World
  - The NASA Science Directorate EPO Blog
  - DATA - Live Access Server
  - Lessons/Unit Plans/Activities
  - Weather/Climate
  - Links to other Online Data
- Main Content Area:**
  - Featured Lessons:** Includes a text block about lesson requests and a list of "Top Lessons for 2012":
    - Solar Cell Energy Availability From Around the Country
    - Creating Climographs?
    - Rock Star Precipitation
    - Hurricane Frequency and Intensity
    - Investigating Factors that Influence Climate
    - The Reason for the Seasons
  - Data Updates:** "E-notes is now Observe Your World! Looking for E-notes? We've changed our format on how we inform you about the news happening within NASA's Science Directorate at NASA's Langley Research Center. Observe Your World is a blog that delivers you updates for MY NASA DATA, S'COOL, GLOBE and other Climate Education focused projects. Please be sure to check OYW and email us to be put on our bi-monthly email newsletter that is provided via RSS!"
  - Science Projects:** "MY NASA DATA Science Projects: Explore topics in Earth Science or find a Science Fair Project Idea." Lists projects like Cloud Observation, Dust Observation, Sky Color, and Using Cameras.
  - Our World:** "Mobile Web-Applications Got your mobile device? Try these links. We are developing new ways to access our data and provide you mobile access!"
  - Conferences:** "MY NASA Science Glossary"
- Footer:** Social media sharing (Like, Tweet, +1, Share), links to "Freedom of Information Act", "The President's Management Agenda", and "Privacy Policy and Important Notices", a language selector, "Powered by Google Translate", and curator information: "Curator: Daniel Oostra, NASA Responsible Officer: Dr. Lin Chambers, Contact Us, Interested in our Monthly E-note? Last updated: 05/29/2012 19:13:02".

# Resources for Classroom Friendly Data

## NASA Earth Observatory

The screenshot shows the NASA Earth Observatory website homepage. At the top, there is a navigation bar with the NASA logo and the text "EARTH OBSERVATORY". Below this, there are links for "Home", "Images", "Global Maps", "Features", "News & Notes", and a search bar. The main content area is divided into several sections:

- Image of the Day for June 5, 2012:** A satellite image of a river system in Botswana, labeled "Savuti-Swamp". To the right of the image is a text box titled "Not Your Usual Flooding in Botswana" with a brief description and a "Read More" link.
- Previous Images:** A small thumbnail of the current image and navigation arrows.
- GRID VIEW:** A button with a grid icon.
- EXPLORE ALL:** A button with a right-pointing arrow.
- Features:** A section titled "World of Change: Columbia Glacier, Alaska" with a date of "May 16, 2012". It includes a satellite image of the glacier and a brief description of its retreat. Below the image is a link "from the Archives" and "Earth's Temperature Tracker".
- Natural Hazards:** A section with three small satellite images and their corresponding dates and titles: "June 4, 2012: Dust Storm over Afghanistan, Pakistan, and Iran", "June 3, 2012: Typhoon Mawar", and "June 3, 2012: Whitewater-Baldy Fire in New Mexico".
- Right Sidebar:** Contains a "SUBSCRIBE TODAY" button, a "Blogs" section with three entries (dated Jun 4, May 30, and May 28, 2012) with titles like "I Can See My Home from Here" and "Mollusks, corals, carbon, and volcanoes", and a "Special Collections" section with "World of Change" and "Blue Marble".

# Resources for Classroom Friendly Data

## Pre-packaged data: Missions

Kepler: Transit Tracks

http://kepler.nasa.gov/education/activities/transitTracks/

The Hot Zone NASA Sun Earth Solar Images Clip Art - Free Office Online AAAS Bench...061 ~ AAAS CSAS - Dashboard

NASA - Sun-Earth... LASP: Laboratory... Kepler: Transit Tr... http://kepler.nas... MicroObservator

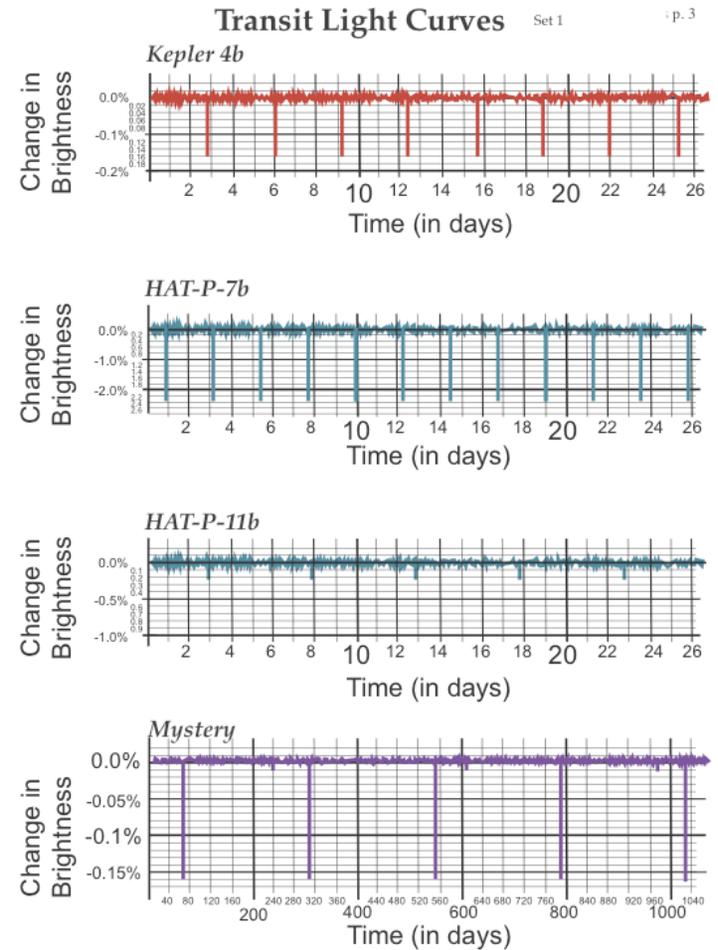
NASA Ames Research Center

# Kepler

A Search for Habitable Planets

Home Mission News Science Discoveries Multimedia Education

Home > Education > Activities > Transit Tracks



# Pre-Packaged Data: Institutes

Laboratory for Atmospheric and Space Physics

<http://lasp.colorado.edu/home/education/K-12/project-spectra/>

MD E/PO CU-Boulder Science Transfer Galileoscope Photos for Learning at Boulder ASP: Galileo...ution Report NASA Sun Earth Solar Images Climate Change

id Astronomy: Miscellaneous Laboratory for Atmospheric and Space Physics Experiments Top Sites

University of Colorado at Boulder CU: Home | Search | A to Z | Map



Laboratory for Atmospheric and Space Physics

About Science Engineering Mission Operations & Data Systems Education

## Education

- K-12
  - Space Weather Compendium
  - Climate Change Compendium
  - Dancing Lights
  - Project Spectra!
  - Space Science Teachers Summit
  - Outer Planets
  - The Sunspot Newsletter
  - Interactive Lessons
  - Additional Programming
- Research Experiences for Undergraduates
- Engineering for Success
- MAVEN mission E/PO
- CCLDAS E/PO
- Media/Journalist Professional Development
- Workshops
- Personnel

## Project Spectra!

### Current Update

"Project Spectra!" is a NASA Approved Product and is being developed with NASA funding. We will offer teacher professional development workshops in 2011; please contact us at [epomail@lasp.colorado.edu](mailto:epomail@lasp.colorado.edu) for more information.

### Introduction

"Project Spectra!" is a science and engineering program for 6th - 12th grade students, focusing on how light is used to explore the Solar System. "Project Spectra!" emphasizes hands-on activities, like building a spectrograph, as well as the use of real data to solve scientific questions.

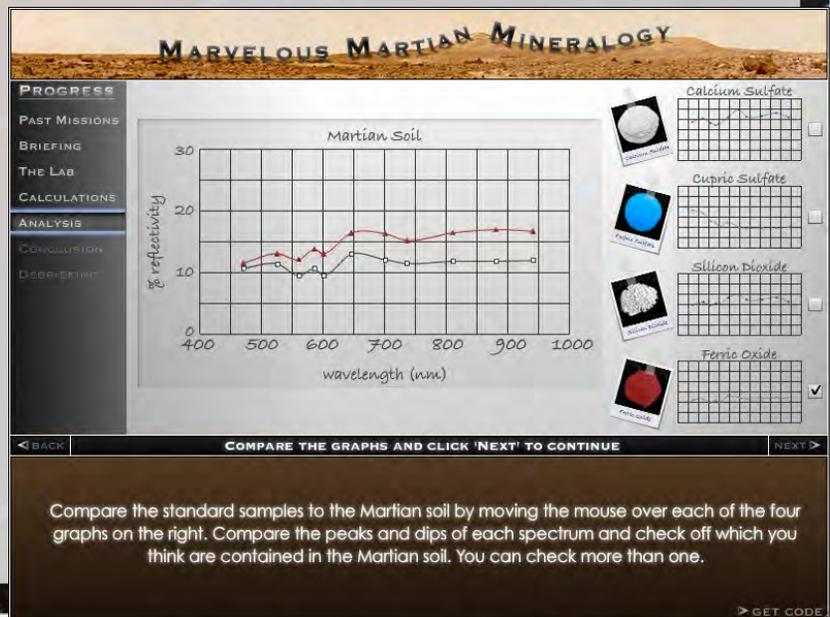
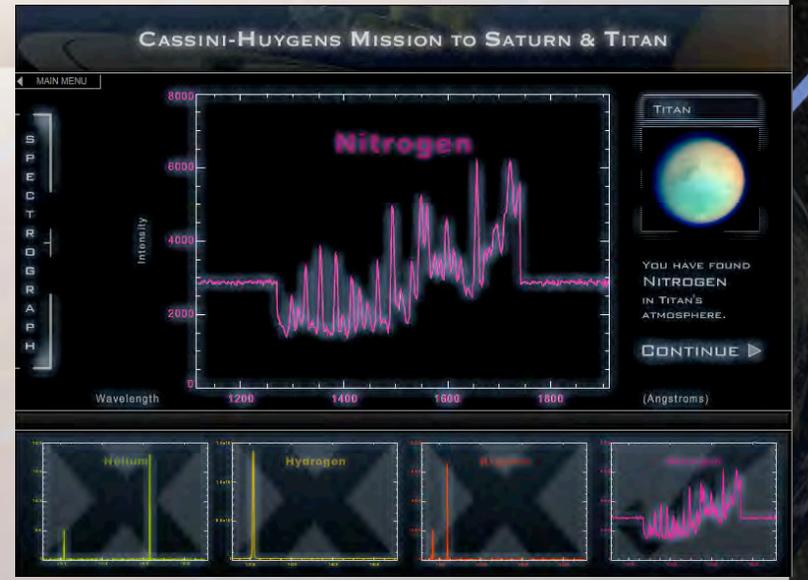
Here, you will find lessons for middle school students that can also be easily adapted for high school students or modified for elementary school students. Each lesson has a front page listing national standards in science and mathematics, prior knowledge students need for the lesson, materials, and time to complete the lesson. We have also provided tables listing national standards the lessons conform to, and a scope and sequence. We have included fun and informational links to explore the nature of light and spectroscopy further.

### What is a Data Story?

A data story is an inquiry driven, standards-based lesson using real data from actual spacecraft! Each data story is a cogent, well-bounded story of solar system exploration that is accessible to students.

### Activities

- Scope and Sequence (102 KB PDF)
- Standards (119 KB PDF)



Compare the standard samples to the Martian soil by moving the mouse over each of the four graphs on the right. Compare the peaks and dips of each spectrum and check off which you think are contained in the Martian soil. You can check more than one.

# If students engage in authentic science using real data will they...

- Construct explanations?
- Engage in argument using evidence?



*Are there differences between a student driven investigation and learning that occurs in a pre-packaged lesson?*

# Help students construct explanations of observations/ engage in arguments using data. Start simple!

- Phases of the moon
- Seasons
- Solar cycle
- Planetary motions
- Much much much more...



*Do your students walk in the door with pre/misconceptions? How do you probe for this?*

# Next Generation Science Standards: Crosscutting Concepts

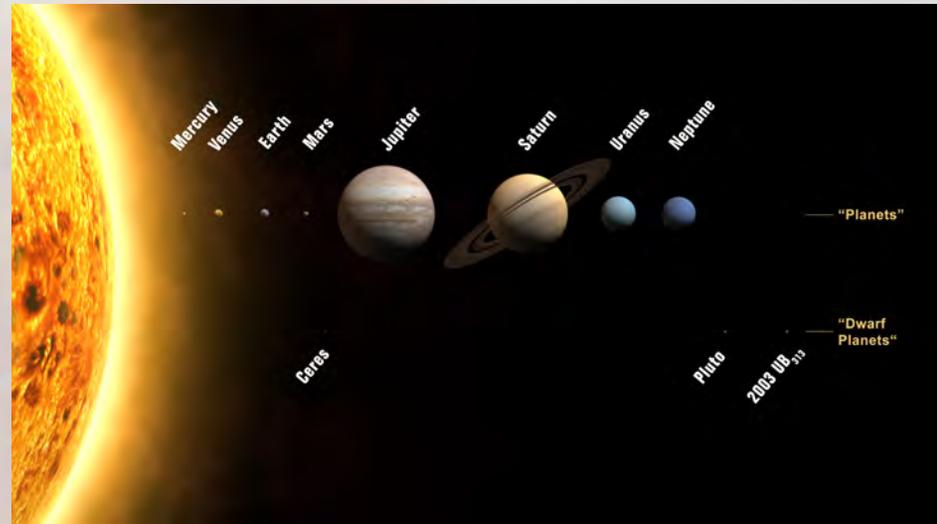
- Patterns
- Cause and Effect: Mechanisms and Explanation
- Systems and System Models



# No “march of the solar system” when discussing patterns

Earth is one body in our solar system. Are we alone?

- Weather systems
- Cycles
- Seasons
- Geology



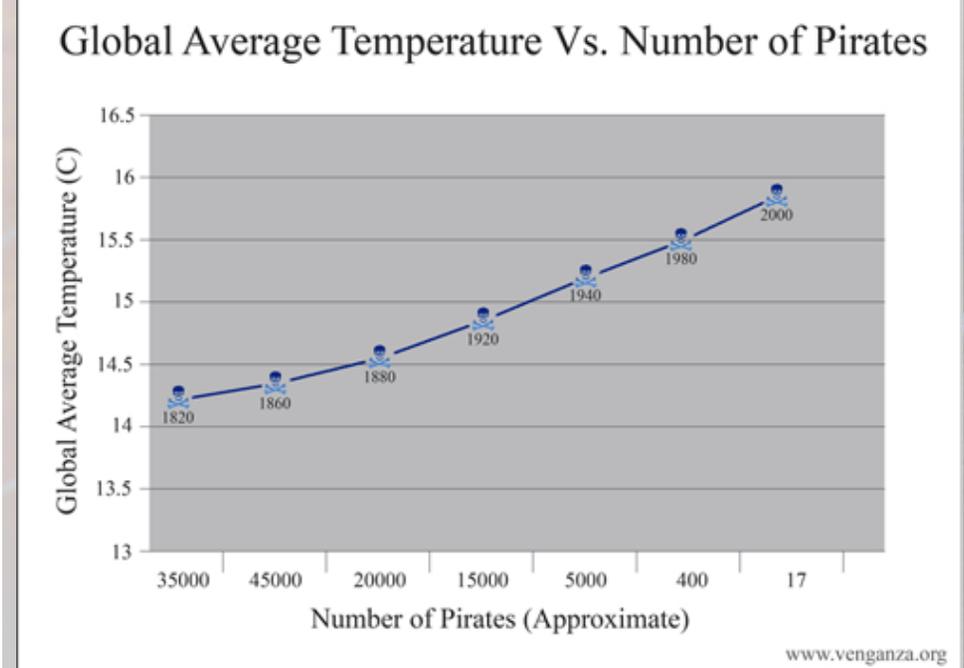
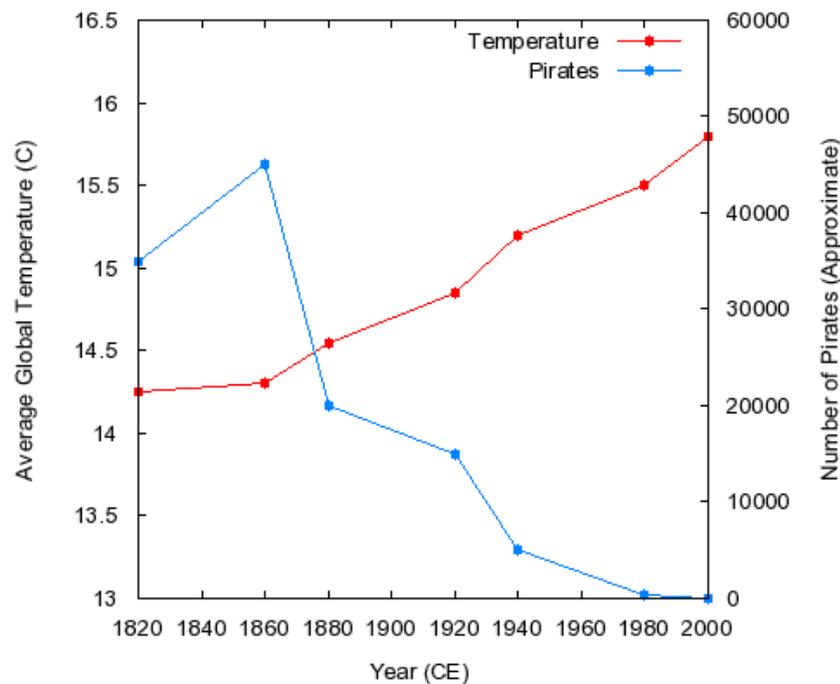
## Seeing the Bigger Picture

- How the Sun affects climate
- How the Sun influences wind/weather
- How the planets orbit the Sun (and how that effects temperature)
- How the Sun is one “middle of the road” star out of 100 billion stars in our galaxy and 100 billion galaxies
- How we are one planet, potentially out of billions, orbiting other stars

*What patterns do you use in your current teaching practice that you could tie to astronomy?*

# Cause and effect: Mechanisms and Explanation

- Can students identify causation v. correlation?



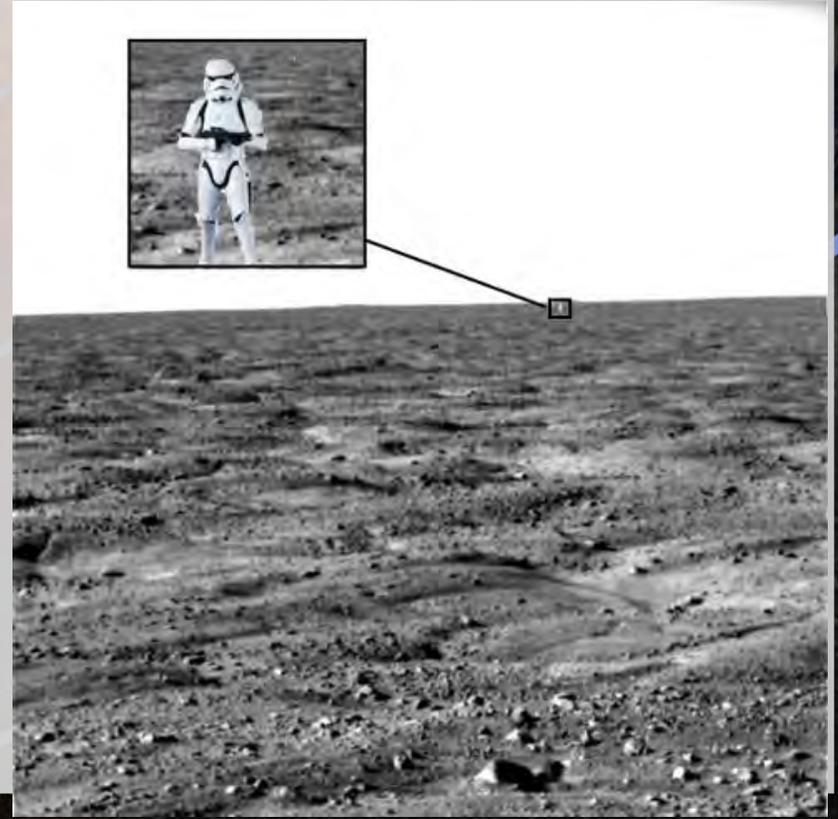
Note: Church of the Flying Spaghetti Monster's definition of pirate designates resent pirate activity as "pseudo piracy"

# Can students evaluate scientific evidence? Can they think critically?

Think of Examples of Media/public/conspiracy -Induced Misunderstandings...And ways to combat these misunderstandings.

## Think-Pair-Share

- 1 minute to think
- 1 minute to write
- 2 minutes to discuss with a neighbor



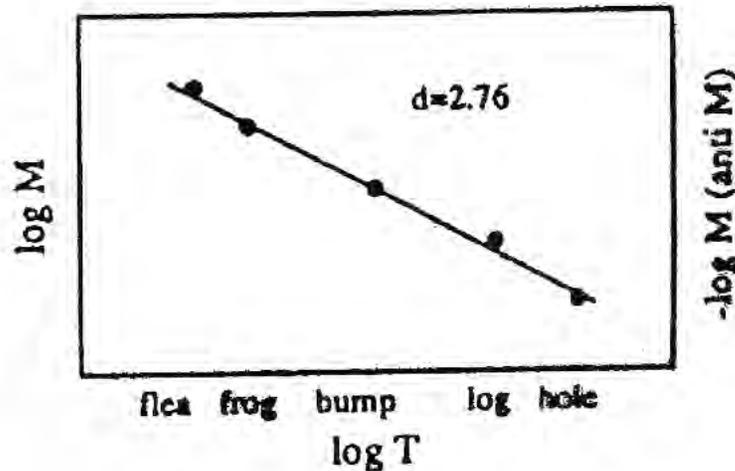
# Can Students Make Sense of Data?

T228-1<sup>o</sup> 1330h POSTER

## Fractal Analysis of Deep Sea Topography

Marc Spiegelman and Chris Scholz (Lamont-Doherty Geological Observatory, Palisades, NY 10964; 914-359-2900)

Recent high resolution mapping of deep-sea topography shows clearly that there's a hole in the bottom of the sea. To repeat, there's a hole in the bottom of the sea. There's a hole—there's a hole—there's a hole in the bottom of the sea. Moreover, more careful analysis indicates that there is a multitude of scale lengths in the bathymetric data. For instance, there's a log in the hole in the bottom of the sea. There's a bump on the log in the hole in the bottom of the sea. There's a frog on the bump on the log in the hole in the bottom of the sea. And there's a flea on a frog on a bump on a log in a hole in the bottom of the sea. There's a flea—there's a frog—there's a hole in the bottom of the sea. Figure 1 shows the 5 orders of magnitude inherent in the data plotted in log-log space and indicates a fractal dimension  $d = 2.76$ . Plotting in log-frog space gives  $d = 2.5$ . No attempt has been made to understand this result.



# Systems v. System models: How we observe the unobservable, predict, and explain

- Trace back through Mars history?
- Predict climate change?
- Understand the physics of the upper atmosphere?
- Understand Earth's radiation belts?
- Model motions of a star?
- Predict what's happening beneath the photosphere of the Sun?

*What teaching techniques do you use to explain how models support observations?*

And finally... It must be engaging. What are ways we can accomplish this?



And finally... It must be engaging. What are ways we can accomplish this?



And finally... It must be engaging. What are ways we can accomplish this?



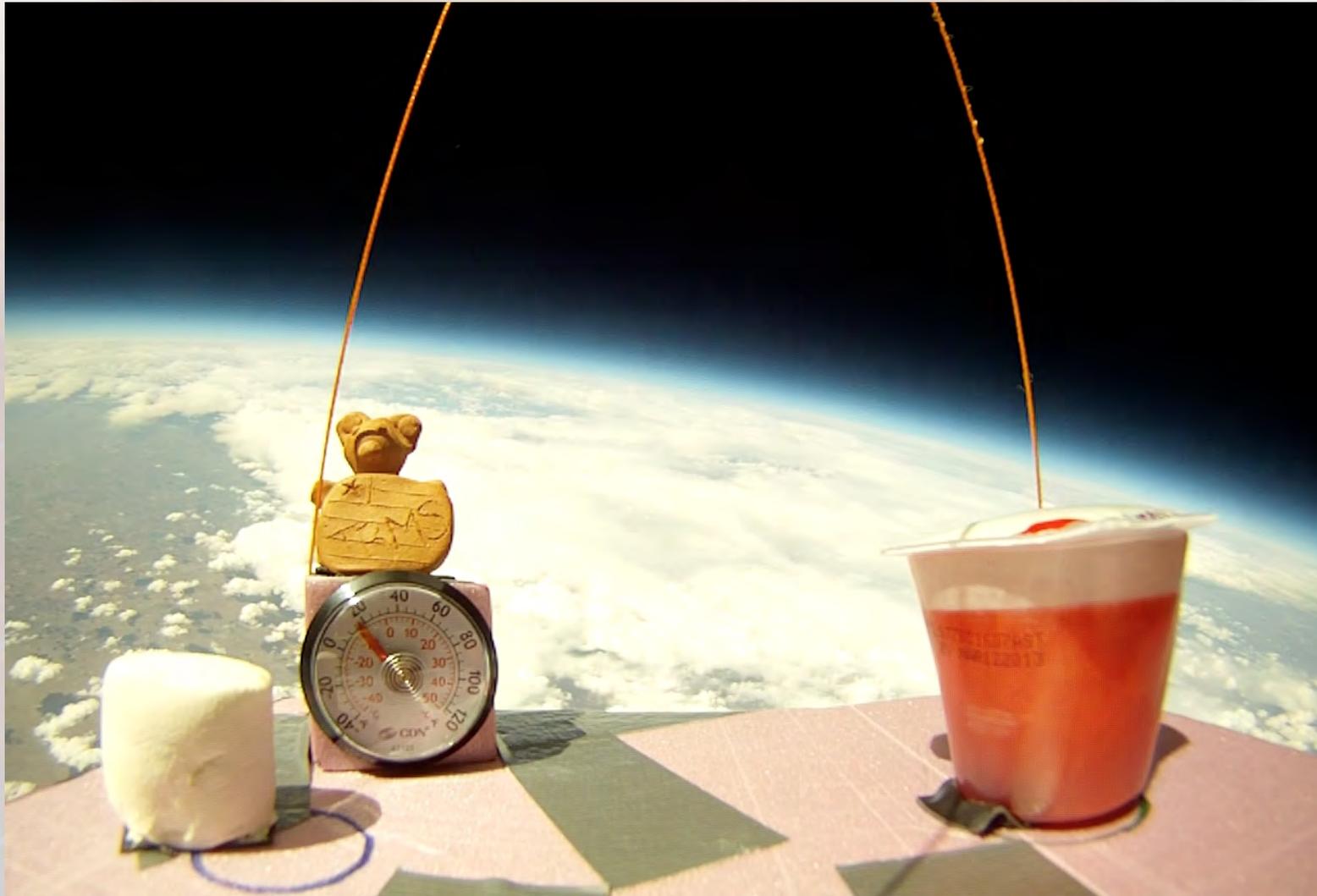
**And finally... It must be engaging. What are ways we can accomplish this?**



And finally... It must be engaging. What are ways we can accomplish this?



And finally... It must be engaging. What are ways we can accomplish this?



# Final thoughts?

