Star Wars: Lunar Takeover Teacher Page

Purpose of "Star Wars: Lunar Takeover" Activity: This activity will allow students the opportunity to attempt to solve a problem, however fictional, using real astronomical equipment and data analysis. Using the scientific method, they will gather background information on a problem, create hypotheses, gather empirical data and analyze it, and finally draw conclusions and report their results.

Materials Required: There are some pieces of technology that will be required for optimal use of this lesson

1) Internet access
2) Contracted time on the 20m with the NRAO through SKYNET – more on this below
3) Microsoft Word, or some word processing program for students to write their reports

Content Learning Outcomes:

1) Students will understand the motions of the moon, including perigee and apogee, in the context of the motions of the Earth, including perihelion and aphelion.
2) Students will gain some understanding of lunar surface geomorphology.
3) Students will learn how to apply latitude and longitude to the moon as a coordinate system.
4) Students will learn how a radio telescope works and how radio data is converted to a temperature.
5) Students will learn about the Kelvin temperature scale.
6) Students will learn how to determine the best way to collect the data they need to answer a question.
7) Students will work through the scientific method and present their results.

Science Education Standards (NRC, Chapter 6):

1) Science As Inquiry Standards (Table 6.1)
   A. Abilities necessary to do scientific inquiry
   B. Understanding about scientific inquiry
2. Physical Science Standards (Table 6.2)
   A. Structure of atoms
   B. Structure and properties of matter
   C. Motions and forces
3. Earth and Space Science Standards (Table 6.4)
   A. Origin and evolution of the universe
   B. Origin and evolution of the Earth System

"Unifying Concepts in Science" That Are Addressed:

1) Systems, Order, and Organization
2) Evidence, Models, and Explanation
3) Constancy, Change, and Measurement
4) Form and Function

Obtaining access to the NRAO/SKYNET 20m Radio Telescope: Please download and read the relevant portions of the manual provided by the National Radio Astronomy Observatory. It outlines the procedures and contact information for teachers to use in order to gain access to this instrument.

Anticipatory Set: The story line for this lesson is based loosely upon Star Wars. So, any activities that you use for activating prior knowledge could certainly only benefit from your use of this theme, though the Star Wars theme is certainly not meant to be the learning outcome of the lesson. In some cases, it might be useful to show a clip from Star Wars, Episode IV that depicts the Death Star, storm troopers and Jedi so that students who have not seen Star Wars can identify with the story line.

Here are some ideas for activating prior knowledge:

1) Have your students take on the roles of storm troopers and other personnel on the invasion force and explore the parameters of the Earth/Moon system just prior to invading. This could include an “invasion council” where all the experts, your students, brainstorm facts about the Earth and Moon such as size, orbit, environment, atmosphere, etc.
2) Have your students role-play being astronomers at the National Radio Astronomy Observatory prior to the invasion and explore/brainstorm the kinds of science that take place there, the science behind radio/light emissions, the construction of radio telescopes and how they work, etc.
3) We use radio waves in our everday lives. Explore some of these with your students, including WiFi, cellular communication, satellite TV, microwave ovens, AM/FM radios, etc.

Ideas for Extension: There are plenty of ways in which to continue exploring the science behind radio astronomy and what it can tell us about the universe around us. Below is a short list:

1) Utilize some of the other lessons available from the NRAO for the 20m telescope.
2) Visit the NRAO in Green Bank, WV, tour the site and participate in some of the excellent education programs that are provided there.
3) Explore some of the science being done at other wavelengths, such as X-ray or Infrared.
4) Build an Itty-Bitty radio telescope (plans are available free online), or purchase one from SARA (society for Amateur Radio Astronomy), participate in Radio JOVE, INSPIRE, etc. in order to involve your students in the technology of receivers and to collect data from something that they built themselves!

Questions or Help: Contact Russell Kohrs (NRAO RET Summer 2012) at rkohrs@rockingham.k12.va.us

Star Wars: Lunar Takeover

Problem: It has taken millennia, but the Empire, long limited to a galaxy far, far away, has finally pushed its boundaries beyond the Milky Way. Originally intending to use the Earth as a base for various nefarious forms of commerce, it quickly became clear that the Earth was just too hot, due to the greenhouse effect created by its atmosphere. Given that the storm troopers involved in this inter-galactic mission were of a special variety, requiring cryogenics to keep them cold for the long journey from the center of the empire, landing on Earth caused them to melt rather quickly. Consequently, in order to help seal their conquest, they found it necessary to explore using the Earth's moon as the location of their base instead. This base would be used for collecting microwave radiation from the sun for transfer to a new Death Star that they plan to build in Earth's orbit. However, they need to locate these microwave transfer stations near a location that has a consistent temperature above 100°K. With the few Jedi left in the universe engaged in a fight for their very survival in that galaxy far, far away, you have no choice but to help the Empire develop this new power plant on the moon – your family needs to eat, after all! You have therefore been sub-contracted by the Emperor's Victorious Industry Liaison (EVIL) to use a 20m radio telescope to help determine the best lunar latitude at which to locate these microwave radiation collectors.

Resources: As a sub-contractor with EVIL, you will have a small amount of access time to a 20m radio telescope located on the property of what used to be called the National Radio Astronomy Observatory (now renamed the Imperial Dreaded Astronomical Reconnaissance Kontrol, or "IDARK") in order to conduct observations as a design consultant.

1) You will have access to the IDARK observatory 20m radio telescope in order to observe the Moon. Time is precious! You will have be observing at a frequency of 10GHz with a bandwdth of plus or minus 500 GHz.

2) You will have access to the internet during one (1) class period in order to conduct the relevant background research necessary for your report to EVIL.

Procedure: In a group of four, divide up your work so that you can complete this work as expediently. EVIL is a hard taskmaster and you are essentially its slave. You must decide how to divide up the tasks, but they are as follows:

A) Understand lunar orbital information.
B) Find any previously collected lunar temperature information, latitude-specific or not, for comparison with your data.
C) Conduct Daisy scans and Map scans of the moon using the 20m radio telescope.
D) Decide on a rough lunar latitude range at which to build the collectors
E) Report your findings and recommendations, in proper format, to the director of EVIL

You will have one (1) class period to work on this, during which time you will be introduced to the use of the telescope and have some time do take observations. Background research and reporting should be done primarily outside of class as a group.

Step 1: Questions for Backround Research Before Starting:

1) What is the Kelvin temperature scale and how does it compare to Celsius and Fahrenheit?
2) What type of lunar terrain would be appropriate for building a series of microwave collection stations?
3) How does lunar temperature change between the lunar poles and lunar equator?
4) How lunar temperature change when the earth is at aphelion and perihelion?
5) Are there lunar temperature variations between apogee and perigee?

Step 2: Observations and Data Collection

Create Hypothesis(es): Create a hypotheses, or multiple working hypotheses, as a prediction of the outcome of your observations based upon your background research. Write it below:

Take Observations

It's now time to use the telescope! You will be using a 'daisy' and 'map' scans to observe the objects. Daisy scans move the telescope in a pattern that looks like daisy petals. They are great for quick observations. You should take at least one of these. Map scans move the telescope in a sweeping pattern over the object a number of times depending upon the settings you input. There are two types of map scans, RA/Long and Dec/Lat. Read the observing manual to understand the difference. You will need to take at least one of each. They take longer, but produce more detailed data. Remember the telescope is as tall as a 6 story building and we use a daisy pattern to minimize the wear and tear on the telescope. We wouldn't want a 6 story building wildly swinging back and forth.

You can do these scans using SKYNET or manually through an armorhead Teamviewer session. Download the manual for using the 20m from the 20m website to learn how to set up access to either of these.

While You Were Observing: While you are taking your scans, zoom in to see what the telescope is doing.

1. How many daisy petals did your first daisy scan make?

2. Do a second daisy scan, but adjust these parameters (Radius=30arcmin, Radial Period=120s, Scan Duration=240s) so that your scan area will be just slightly larger than the moon. How did the pattern of your scan change?

3. Given the differences in your daisy scans above, which of your scans should give you more detailed data? Why?

4. Describe the difference in how RA/Long and Dec/Lat maps are made. You may wish to put a check in the “Show RA/Dec Grid” box under the Sky Viewer Settings. Zoom in to see what the telescope does.

Gather Your Data: You can freely download your data from www.gb.nrao.edu/20m/peak/log.htm Find it using the scan number in the name of the link along with the Messier number. Use the 2D and R(3D) plots to help you answer these questions:

1) Can you see a clear signal in your daisy scan(s)? If so, describe it:

2D:

3D:

2) Can you see a clear signal in your RA/Long Map? If so, describe it:

2D:

3D:

3) Can you see a clear signal in your Dec/Lat Map? If so, describe it:

2D:

3D:

Moon Observations

Date: ______________________

Time: ______________________

Observer(s): ____

Weather Conditions: ____

Purpose: ____

General Comments:

Type of Scan	Scan Number	Comments

Step 3: Data Analysis

First you'll want to figure out what you just observed! A good first step would be to correlate some of your data to lunar latitudes, at least as an estimate. Using your second daisy scan, and assuming that the base of the peaks are the lunar poles and the crest of the peaks are the lunar equator, scale one of your peaks to lunar latitude. To convert the intensities in the ASCII data on the 20m data website, use the procedure available in the extension section at the end of this activity.

1) What are the temperatures at the lunar equator?

2) What are the approximate temperatures at the lunar north and south poles?

3) Estimate the temperature at 45°N and 45°N.

4) Determine where the best location for the microwave collectors. Write your answer and explain your reasoning below.

Step 4: Report Your Findings to the EVIL Administrator

Report your findings in the form of a written paper. It should have several sections: Abstract, Introduction, Background Research, Observations and Data Collection, Data Analysis, and Conclusions (you may call it something like "recommendations" if you would like. Your paper should be at least two (2) typed pages, double-spaced, 12 point Cambria or times New Roman font with no more than 1" margins. When complete, turn your report into the EVIL administrator (your teacher) for consideration.

Step 5: Optional Math Skills Extension: Why was the Earth not suitable in the first place? Why is it too hot for these special storm troopers to survive? To explore this, EVIL has commanded you to run some calculations to determine the true extent of Earth's greenhouse effect. If the Earth had no atmosphere, what would the temperature be on the surface? They want to know how the presence of an atmosphere affects the temperature below. To do this, you should make the following assumptions in your calculations that follow:

*The Earth absorbs all the energy it receives from the Sun (it's a blackbody)
*The Earth's atmosphere is nonexistent and does not affect the temperature
*The albedo of Earth's surface is constant due to the lack of ice and water (as would be the case with no atmosphere)

Background: Fundamental Equation
Being the smart students you are you suddenly recall the Stephan- Boltzmann Law,

$$E = \sigma T^4$$

σ =6.57*10^-8 W/m^2/K^4

This says that the total Energy emitted by an object is equal to its temperature (T) to the fourth power multiplied by the Stephan Boltzmann constant (σ). In simple terminology, the hotter the object, the more energy it outputs.

Part 1: Energy Emitted from the Sun
The Sun gives off a constant rate of energy because of the nuclear fusion occurring in the core. First you'll need to calculate how much energy is given off by the Sun. Use the fact that the surface temperature of the sun is 5800 Kelvins. You will need to research and find the values of radii and distance you need. Make sure to record where you got these numbers and ALWAYS use the same units for all of the calculations and ALWAYS record the units you are using.

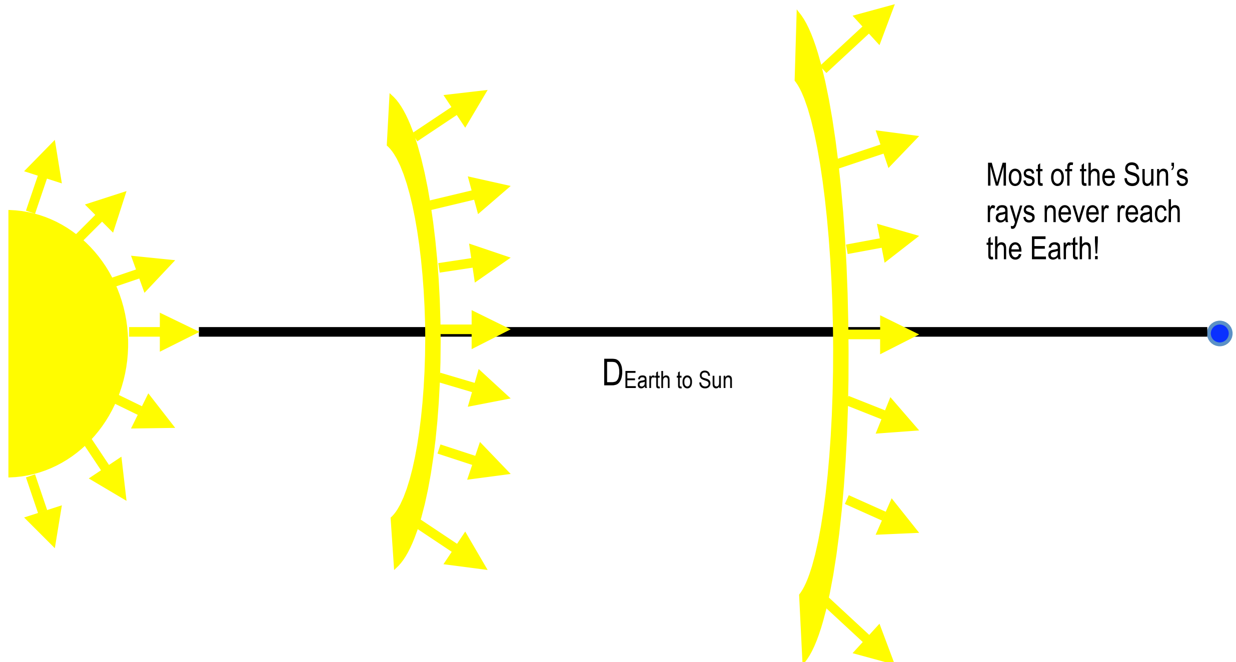
Energy from the Sun= (energy emitted per area)*(area of the Sun)

$$E_s = (\sigma T_S^{\ 4})(4\pi R_S^{\ 2})$$

T_S=surface temp. of Sun= 5800 K
R_S=Radius of the Sun

E_S =____

Part 2: Sun's Energy that reaches the Earth
The Sun radiates that amount of energy in all directions equally. As you go farther and farther away from the Sun, you will become cooler because there isn't as much energy in that area. As the energy travels away from the Sun it becomes more and more spread out. What you need to calculate is how much energy per area the Earth receives.



Energy that reaches Earth= (Energy from the sun)/ (area it must travel to reach Earth)

$$E_{ReachesEarth} = \frac{E_S}{4\pi D^2}$$

D=distance from Earth to the Sun

$E_{\text{reaches Earth}}$=____

Think about your answers! You should have gotten close to 1600 W/m^2. That means if the Sun were to suddenly disappear we would need one 1600W light bulb for every square meter on the Earth to get the same energy!

Part 3: Total energy falling on the Earth

$$E_E = E_{ReachesEarth} * \pi R_E^{\ 2}$$

E_E= (energy that reaches Earth)*(area of the Earth the sun hits)
R_E= is the radius of the Earth

E_E=____

Part 4: Calculate the temperature of the Earth!
Recall the Stephan Boltzmann law that relates energy to temperature, and factor in the Energy per unit area received by the Earth.

$$E_E = \sigma T_E^{\ 4}(4\pi R_E^{\ 2})$$

Using your answer for E_E from above, rearrange and solve this equation for the temperature of the Earth!

T_E =______________________________ Kelvins

T_E =______________________________ Celsius

Questions
1) How does this compare to the actual (room temperature) of the Earth?
2) Why is what you calculated different? What effects did we ignore that might cause the real temperature to be different?
3) The albedo of the Earth is known to be approximately .3. How would the calculated temperature of the Earth change if you took this into account in your equations?
4) Repeat the procedure to find the temperature of the moon.
5) What do you notice about the temperature on the two bodies? How do you explain this?
6) Compare your results for the Earth and the Moon, how can you explain any similarities or differences?

Extension:
In the data analysis, your teacher may prefer that you import ASCII data into Excel and convert the given left and right intensities (in counts) to kelvins or Janskys.

To convert to Kelvin:

1) The intensities in the ASCII file are total intensities, meaning the object intensity and the system intensity. You need to subtract the system values for the left and right polarizations (which can be found in the corner of the 2D plot) and then use the following conversion factors that can be found in an Excel table on the website.

To convert to Janskys:

Use the following equation (re-arrange as necessary):

$$S = \frac{2\sigma T_A}{A\eta_A}$$

Where:
S = Flux Density (Janskys)
σ = Stefan-Boltzman constant (1.38×10^{-23})
T_A = Average temperature (Left, Right polarization, in K)
η_A = Telescope Efficiency (elevation dependent, available on website)
A = Area of dish (available on website)