Ground Validation and OLYMPEX Webquest - Teacher Guide

Lesson Overview:
This online lesson has been designed to teach students about how satellites measure precipitation and how that data is validated using various instruments, with a focus on specifics of the OLYMPEX field campaign. Students will also look at examples of radar and rain gauge data. The basic webquest (Parts 1 & 2) is aimed for a middle school level. Part 1 should take about 30-45 minutes to complete and Part 2 about 20-30 minutes. An extension with more detailed data analysis suitable for advanced middle school or high school students is available at http://pmm.nasa.gov/education/interactive/gv-data-exercise. A simplified short version is provided for elementary students here: http://pmm.nasa.gov/education/interactive/gv-webquest-elem.

Learning Objectives:
- Students will learn how satellites measure precipitation data, and the ground instruments used to validate that data (with a focus on the Olympic Mountain Experiment (OLYMPEX) field campaign.
- Students will examine data from ground-based instruments (radars and rain gauges) and interpret what they see.

Next Generation Science Standards: (www.nextgenscience.org)
Students who demonstrate understanding can:
- MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.

Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying out Investigations • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. (MS-ESS2-5)	**ESS2.C: The Roles of Water in Earth's Surface Processes** • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. **ESS2.D: Weather and Climate** • Because these patterns are so complex, weather can only be predicted probabilistically.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Common Core State Standards: (www.corestandards.org)
- RST.6-8.1 - Cite specific textual evidence to support analysis of science and technical texts.
- RST.6-8.9 - Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
- WHST.6-8.8 - Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Background Information:

The Global Precipitation Measurement (GPM) mission is an international network of satellites that provide next-generation global observations of rain and snow. Building upon the success of the Tropical Rainfall Measuring Mission (TRMM), the GPM concept centers on the deployment of a "Core" satellite carrying an advanced radar/radiometer system to measure precipitation from space and serve as a reference standard to unify precipitation measurements from a constellation of research and operational satellites. Through improved measurements of precipitation globally, the GPM mission will help to advance our understanding of Earth's water and energy cycle, improve forecasting of extreme events that cause natural hazards and disasters, and extend current capabilities in using accurate and timely information of precipitation to directly benefit society.

It is crucial to validate the GPM satellite measurements at various locations around the world. The NASA GPM Ground Validation Program is coordinating ground validation field campaigns at key locations. One of the most comprehensive ground validation field campaigns for GPM will be held from November 2015 through February 2016 on the Olympic Peninsula in the Pacific Northwest of the United States. The primary goal of this campaign, called OLYMPEX, is to validate rain and snow measurements in mid-latitude frontal systems moving from ocean to coast to mountains and to determine how remotely sensed measurements of precipitation by GPM can be applied to a range of hydrologic, weather forecasting and climate data.

For more information, see: http://pmm.nasa.gov and http://pmm.nasa.gov/OLYMPEX

Materials:

- computers with Internet access (see Teacher Notes for additional information on setting up and organizing computer usage)
- student capture sheets (one per student)
- headsets (optional, as there are several video clips with audio in this webquest)

Engage:

There are several ways to begin the discussion and activate students' background knowledge. One possibility is to ask students what they know about scientific field investigations and how they are conducted, or the types of instruments used to measure precipitation and other weather conditions. Since the campaign takes place in the Pacific Northwest, you could also ask students what they know about weather patterns there and how they compare to your location. If you have done previous lessons about precipitation or weather, this is a good time to tie that in. You could also frontload with a discussion of vocabulary that may be unfamiliar, especially for English language learners (see the list later in this teacher guide for suggestions for words to review.)

Explore:

Explain to the students that they will complete a webquest in which they will explore the ways satellites measure precipitation and the instruments used to validate, or check, that data. They will specifically learn about a new NASA mission that studies global precipitation, called GPM (Global Precipitation Measurement), and one of their upcoming validation campaigns. They should have a student capture sheet to write their

answers, and will interact with many different websites and data sets. The links are printed on the capture sheet in a shortened form to make it easier for students to type them in, but a full list of the links and questions can also be found at http://pmm.nasa.gov/education/interactive/ground-validation-webquest (short form: http://go.nasa.gov/1W8ntv1)

If your students have any trouble with the videos, here are some alternate links with different formats:

- "For Good Measure" (2:01) – http://svs.gsfc.nasa.gov/goto?11219 or https://youtu.be/6orv6v4ZLjQ
- "Getting the Big Picture" (2:39) – http://svs.gsfc.nasa.gov/goto?11877 or https://youtu.be/rA_VCLzvbvM
- "Too Much, Too Little" (4:44) - http://svs.gsfc.nasa.gov/goto?11091 or https://youtu.be/6cU5Rt0rcGA

Explain:

After the students complete the webquest, you may wish to go over the responses with the class. Alternatively, you could save the final wrap-up section to complete as a class to tie everything together.

Evaluate:

Students will complete a student capture sheet that includes short answer responses and a few longer responses and drawing of diagrams. In addition to using this as an evaluation tool, the teacher can elicit oral responses from students as they interact with the webquest and upon completion.

Elaborate/Extend:

Other resources to expand and deepen students' knowledge, or for the teacher's reference:

- A detailed explanation of Doppler radar: http://eo.ucar.edu/weather/images/3DopplerRadar.pdf
- A printable brochure about radar (same information as one of the webpages included in the webquest): https://www.eol.ucar.edu/system/files/Radar_handout_FullPage_f.pdf
- Another explanation of weather radars: http://wxguys.ssec.wisc.edu/2013/09/23/how-do-weather-radars-work/
- A video with more about airborne field campaigns: https://youtu.be/iNonPahJlK8
- And a one about the NASA aircraft used in airborne missions: https://youtu.be/jwWxwKLxpig
- Fact sheets about the DC-8 (http://go.nasa.gov/1iV4cin) and ER-2 (http://go.nasa.gov/1iV4iqb)
- A description of GPM ground validation more generally: http://go.nasa.gov/12EZEiN
- A video about a GPM ground validation scientist, Dr. Steve Nesbitt: http://go.nasa.gov/QGh3qQ

Teacher Notes:

- Classroom Organization: It is possible for this activity to be completed in a one computer per classroom setting, although it is ideal to have each student be able to use their own computer to work at their own pace. Students can also be paired or grouped in other ways to meet the special needs of your students. If time is limited, the webquest could be assigned as homework or used in a "flipped classroom" model, followed up with further discussion and investigation of the data sets.
- Answer Key: An answer key may be requested here: http://pmm.nasa.gov/education/contact
- Student Capture Sheet- The student capture sheet has been made available in Microsoft Word format to modifications to meet students' needs.

Vocabulary List:

Below are some terms that come up during the webquest, and may be useful to review ahead of time. This is intended as a guide only, and you may find other words your students are unfamiliar with, or may not need to address all of those listed below.

algorithm	In this context, the mathematics used by a computer program to process satellite observations into usable data
atmosphere	The envelope of gases that surround Earth.
calibration	Matching up measurements to a standard.
citizen science	The collection and analysis of data relating to the natural world by members of the general public, often in collaboration with professional scientists
drought	Long periods of low precipitation
instrument	In this context, the tools used to collect scientific data, either from a satellite or on the ground.
microwaves	A type of electromagnetic energy; the portion of electromagnetic energy between radio waves and infrared radiation, which is often measured by scientific instruments to determine atmospheric conditions from space.
radar	Radar uses radio waves to detect an object, such as particles of rain or snow in a cloud. The antenna sends out pulses of radio waves that are reflected back by the object they touch, which are then picked up by the dish.
remote sensing	Data collected from a distance, as a satellite does about Earth while orbiting above the atmosphere.
satellite	Anything that orbits or circles something else: man-made satellites are artificial machines that are put in space in order to collect information or for communication.
validation	Checking that data from a source is accurate and matches observation from other sources (for example comparing satellite data with ground observations.)