Ground Validation and OLYMPEX Webquest –Elementary Version 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 Olympic Mountain Experiment field campaign. Students will also look at examples of radar and rain gauge data, as well as climate patterns (which correlates with the focus of the standards.) This version of the webquest is aimed for upper elementary, although younger students could also complete it with guidance or if they are strong readers. Part 1 should take about 30-45 minutes to complete and Part 2 about 20-30 minutes. The version for middle school students and above is here: http://pmm.nasa.gov/education/interactive/ground-validation-webquest. 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.

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.
- Students will look at patterns in the precipitation data for the Olympic Peninsula and observe the effect of the mountains in creating a rain shadow, as well as seasonal precipitation differences.

Next Generation Science Standards: (www.nextgenscience.org)
Students who demonstrate understanding can:
- 3-ESS2-1: Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.
- 3-ESS2-2: Obtain and combine information to describe climates in different regions of the world.
- 5-ESS2-1: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere and/or atmosphere interact.
- 5-ESS2-2: Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships. (3-ESS2-1) **Obtaining, Evaluating, and Communicating Information** • Obtain and combine information from books and other reliable media to explain phenomena. (3-ESS2-2)	**ESS2.A: Earth Materials and Systems** • Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1) **ESS2.D: Weather and Climate** • Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (3-ESS2-1) • Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2)	**Patterns** • Patterns of change can be used to make predictions. (3-ESS2-1),(3-ESS2-2) **Systems and System Models** • A system can be described in terms of its components and their interactions. (5-ESS2-1)

Common Core State Standards: (www.corestandards.org)

- RI.3.1 - Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- W.3.8 - Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories
- RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.
- W.5.8 - Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

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.) A presentation that could be used for this purpose is available at http://gpm.nasa.gov/education/olympex.

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). Please note: if you use the presentation as noted above in the engage section, there is a video repeated between that and the beginning of the webquest. You could either skip that part of the presentation, or do the beginning of the webquest together as a class, for example before going to the computer lab for the rest of the exploration.

If your students have any trouble with the GPM 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
- "Too Much, Too Little" (4:44) - http://svs.gsfc.nasa.gov/goto?11091 or https://youtu.be/6cU5Rt0rcGA

(Unfortunately, alternate formats for the non-GPM-produced videos may not be available.)

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 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
- Summaries of Olympic Peninsula/Washington State weather from various sources:
    - The Community Collaborative Rain, Hail and Snow Network: http://www.cocorahs.org/Media/docs/ClimateSum_WA.pdf
    - The National Park Service, Olympic National Park: http://www.nps.gov/olym/planyourvisit/upload/weather.pdf
    - The Olympic Peninsula Tourism Commission: http://www.olympicpeninsula.org/general-resources/olympic-peninsula-weather
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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
field campaign	When scientists take instruments and set them up in a particular place to make measurements, usually over a short time frame and with a particular purpose in mind, such as looking at storms in an area with specific geography like mountains.
instrument	In this context, the tools used to collect scientific data, either from a satellite or on the ground.
peninsula	An area of land surrounded on three sides by water.
precipitation	Any product of the condensation of atmospheric water vapor that falls quickly out of a cloud. The main forms of precipitation include drizzle, rain, sleet, snow, graupel and hail.
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.)