Ground Validation and OLYMPEX Advanced Data Exercise Teacher Guide

Lesson Overview:
This data exercise has students look up precipitation ground data and satellite data for a site in Washington State and do a comparison using a data table and a graph. The activity is expected to take about 45 minutes. While not necessary, it may be helpful for them to complete the Ground Validation and OLYMPEX webquest to provide background before they delve into the data. That activity, with student capture sheet and teacher guide, can be found here: http://pmm.nasa.gov/education/interactive/ground-validation-webquest.

Learning Objectives:
- Students will compare data from ground-based citizen science data observations to satellite data for the same location and analyze similarities and differences.

Next Generation Science Standards: (www.nextgenscience.org)
This activity addresses the analysis component of the below standard, and could be used as a preliminary activity to later be extended to include long-term climate data and models in order to fully meet the performance expectation.

- HS-ESS3-5: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).]

Engineering Practices	Disciplinary Core Ideas	Connections to the Nature of Science
Analyzing and Interpreting Data • Analyze data using computational models in order to make valid and reliable scientific claims.	ESS3.D: Global Climate Change • Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**Scientific Investigations Use a Variety of Methods** • Science investigations use diverse methods and do not always use the same set of procedures to obtain data. **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based on empirical evidence.

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

- RST.11-12.7 - Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- HSN.Q.A.1 - Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

Background Information:

Data for this exercise comes from two primary sources. The first, the Community Collaborative Rain, Hail and Snow Network, or CoCoRaHS, is a unique, non-profit, community-based network of volunteers of all ages and backgrounds working together to measure and map precipitation (rain, hail and snow).

For more information, visit http://www.cocorahs.org/Content.aspx?page=aboutus

The second source of data is NASA satellites. 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 with instructions (one per student/group)
- spreadsheet software if you wish your student to graph using the computer

Engage:

Students may complete the OLYMPEX Ground Validation Webquest as a preliminary activity before this lesson, available http://go.nasa.gov/1W8ntv1. If they haven’t done this, you may wish to have them read at least the basic summary available at http://gpm.nasa.gov/education/olympex to give context for the data analysis exercise.

To start students thinking about precipitation measurement, ask them a series of questions to spark discussion:

- What type of data might be collected about precipitation? [*Ex: total amount of rain, rain rate, pH of rainwater, size of raindrops, frozen or liquid state, etc.]*
- How might that data be collected? *[Ex: rain gauges, radar, satellites, etc.]*
- Who might be interested in collecting this data? *[Ex: meteorologists doing forecasting or research, disaster response teams for hurricanes, landslides or floods, etc.]*
- How do we compare and contrast two different data sets that measure the same variable? *[Ex: a table, various types of graphs like line, bar, etc.]*

Then show them this video (http://go.nasa.gov/QGh3qQ) from the *Faces of GPM* series, about a GPM ground validation scientist, Dr. Steve Nesbitt, to introduce them to a scientist who does similar data analysis to what they are about to do.

A more time-consuming option, although potentially a rich experience for the students, would be to have them create and test their own rain gauge (http://go.nasa.gov/1j5PFMh, labelled for elementary/middle school students, but can certainly be used by older audiences). They could then make precipitation measurements at their homes, or you could set up a gauge at the school. Alternatively, you could have them look up online precipitation data for various locations around the school and do a quick comparison before they get into the full data analysis exercise. This will prepare them for the local variability they are likely to find in the data.

Explore:

Students will complete the data analysis exercise on their own or in pairs or small groups, as you prefer and have computers available. If students are having trouble picking a location for analysis, here is a list of good options. Note that these are just a few examples from a variety of locations around the state – there are many more good date ranges possible.

CoCoRaHS Station	Location Description	Good date range**
WA-PC-05	South part of west coast, near Ocean Park	10/5/2015 – 10/13/2015
WA-SP-36	Eastern Washington, north of Spokane, near Elk	9/2/2015 – 9/12/2015
WA-CM-4	North part of west coast, between Forks and La Push	8/27/2015 – 9/11/2015
WA-GH-16	Middle of the west coast, south of Ocean City	8/27/2015 – 9/10/2015
WA-KP-32	West of Seattle, on Bainbridge Island	1/1/2015 – 1/18/2015
WA-KG-79	In Seattle, northwest of downtown	1/1/2015 – 1/18/2015

**Date of precipitation accumulation – CoCoRaHS observation date will begin one day after.

A video that shows the entire process of getting the ground and satellite data, as well as graphing it, is available here: https://youtu.be/jkc6SKlbDG0 (The location used is the same one as in the example data sheet at the end of this document.)

Another method to get the data for a station (besides using the map as described in the student directions and in the video) is the precipitation summary used for finding latitude and longitude, http://www.cocorahs.org/ViewData/TotalPrecipSummary.aspx. Once you have chosen a state, county and date range, a list of stations with data reported during that period will come up. Click on the hyperlinked station name and you will be able to see a table of that station's reports by data. This may be easier for some students to navigate than clicking through the dates using the map.

Explain:

This is a great opportunity to discuss the challenges of data analysis of real data, which doesn't always come out neat and clean. There are a number of reasons why students might find that the ground observations do not match with the satellite data. The exact period of data collection is slightly different for CoCoRaHS and the satellite, since the citizen scientists empty their gauges anywhere from 7 am to 9 am in the morning, but the satellite is reporting for a calendar day, from midnight to midnight. In addition, there are a number of factors that can contribute to errors in the satellite data. Variable terrain, for example, such as the mountains on the Olympic Peninsula, can cause changes in how the satellite detects precipitation. That is one of the reasons that site was chosen for a ground validation field campaign and is why the computer algorithms and models need checking with ground data and modifications made over time.

An additional point to make to students: the particular satellite data set used reports on a 0.25° grid, which means each grid area is about 28 km/17 miles square, while the data reported by the ground station is a single point within that square. As students may have noted from the initial view of the CoCoRaHS ground stations in Washington State, there is a lot of variability within a small geographic area. As a side note, the more advanced GPM satellite can report data on a 0.1° grid, or 11km/7 miles square, which is an improvement over the data set from the TRMM algorithm.

Evaluate:

Students will complete a student capture sheet that includes a data table, graph and description of their observations of patterns in the data, which could easily be used as an assessment. Additionally, you may wish to have students prepare a poster of their analysis and conduct a gallery walk, or share the analyses virtually on a class webpage, workspace or shared folder.

Elaborate/Extend:

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

- The OLYMPEX website has a wealth of additional data, including science summaries of recent results, http://olympex.atmos.washington.edu/.
- A description of GPM ground validation more generally: http://go.nasa.gov/12EZEiN
- 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

- To extend this analysis beyond a single short time period, there are a number of sources of long-term averages. Giovanni, the NASA data service mentioned in the student instructions, also has many other datasets available. Another option is MY NASA DATA, which has, for example, TRMM precipitation climatologies. Many commercial weather pages (Intellicast, Weather.com, Weather Underground, etc.) also have a certain amount of historical data available.

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 and to analyze different locations. Students can also be paired or grouped in other ways to meet the special needs of your students. One option is to assign the webquest mentioned above as homework or used it in a “flipped classroom” model, followed by the more detailed data analysis activity.
- Answer Key: As student answers will vary greatly depending on the locations they choose to analyze, a comprehensive key is not available. See the example completed data sheet at the end of this teacher guide as a reference. A spreadsheet with data for the locations given in the table under the Explore heading is available upon request from http://gpm.nasa.gov/education/contact.

Name: SAMPLE DATA SHEET__________________ Date: _________________ Period: ____________

Ground Validation and OLYMPEX – Data Analysis Exercise

Data Sheet

CoCoRaHS Station number: WA-CM-26 Latitude: 48.098 (N) Longitude: -123.42 (W)

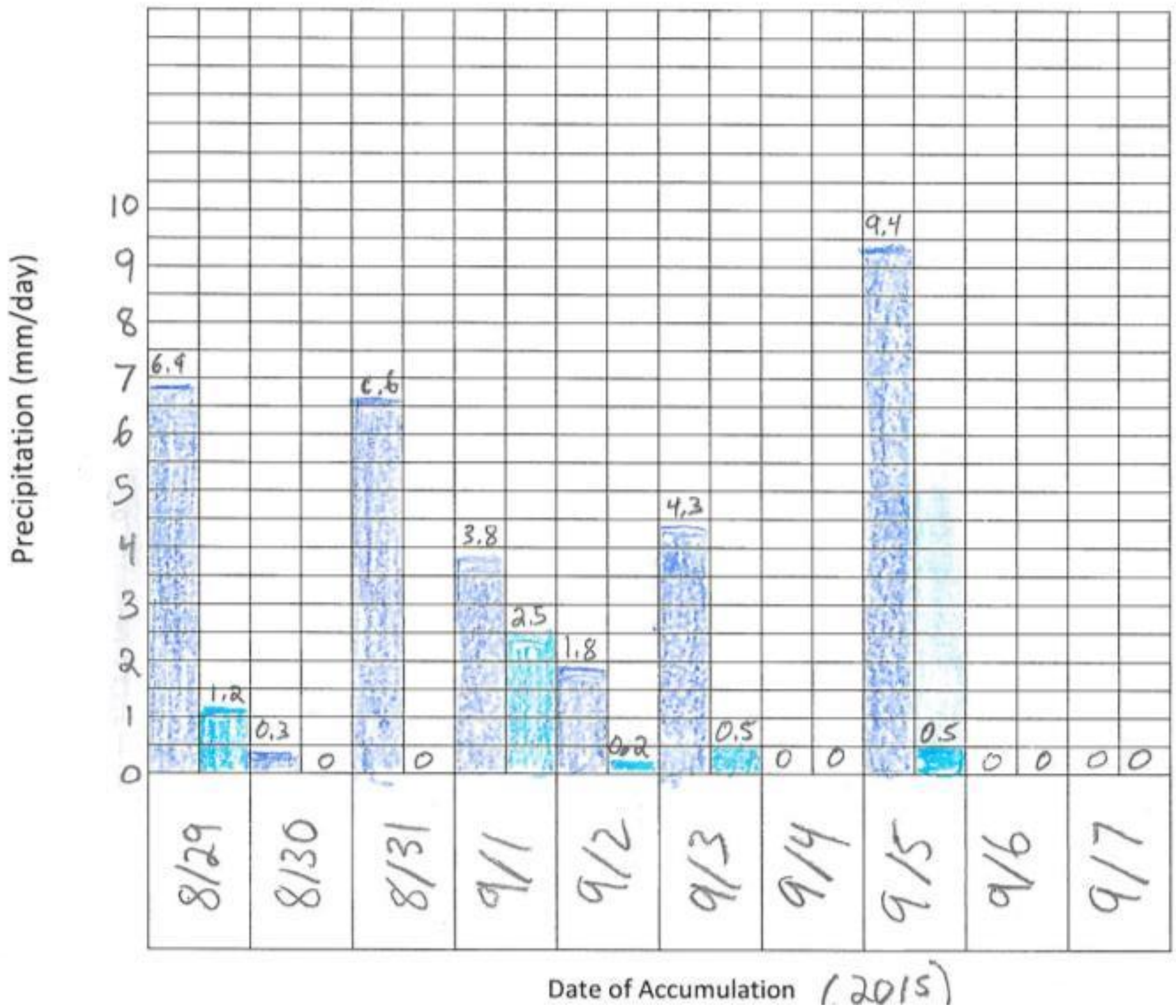
CoCoRaHS Report Date (Accumulation from Previous Day)	Date of Accumulation (One day before previous column)	Ground Observation Precipitation Amount (mm)	Satellite Observation Precipitation Amount (mm)**	Difference: ground - satellite
8/30/2015	8/29/2015	6.9	1.17	5.73
8/31/2015	8/30/2015	0.3	0	0.3
9/1/2015	8/31/2015	6.6	0	6.6
9/2/2015	9/1/2015	3.8	2.46	1.34
9/3/2015	9/2/2015	1.8	0.21	1.59
9/4/2015	9/3/2015	4.3	0.51	3.79
9/5/2015	9/4/2015	0	0	0
9/6/2015	9/5/2015	9.4	0.48	8.92
9/7/2015	9/6/2015	0	0	0
9/8/2015	9/7/2015	0	0	0
			Average difference:	2.83

**Remember the date offset: Data reported for one day in CoCoRaHS corresponds to data reported for the previous day from the satellite. For example, the ground data reported on 8/31 is accumulation from the previous day, 8/30, so matches with the satellite data reported on 8/30.

Describe your observations of the two data sets, based on the table and your graph:
The pattern does not seem to match well at all, perhaps due to differences in how the satellite and rain gauges collect data, or the variable terrain in the area. There are days where precipitation is reported on the ground, but nothing is reported by the satellite, although not the reverse. For example, on 8/31, the ground station reported 6.6 mm but the satellite reported none. There are three days that match, all zeros – 9/4, 9/6 and 9/7. Calculating the differences between the two measurements, it appears that the satellite consistently reports less than the ground station, an average difference of 2.83 mm, but up to 8.92 mm. Looking at a longer time period, or getting an average over a larger area, might show more correlation between the two data sets.

Title: Precipitation Data for 48.098 N, -123.42 W

Key:
- ground data
- satellite data



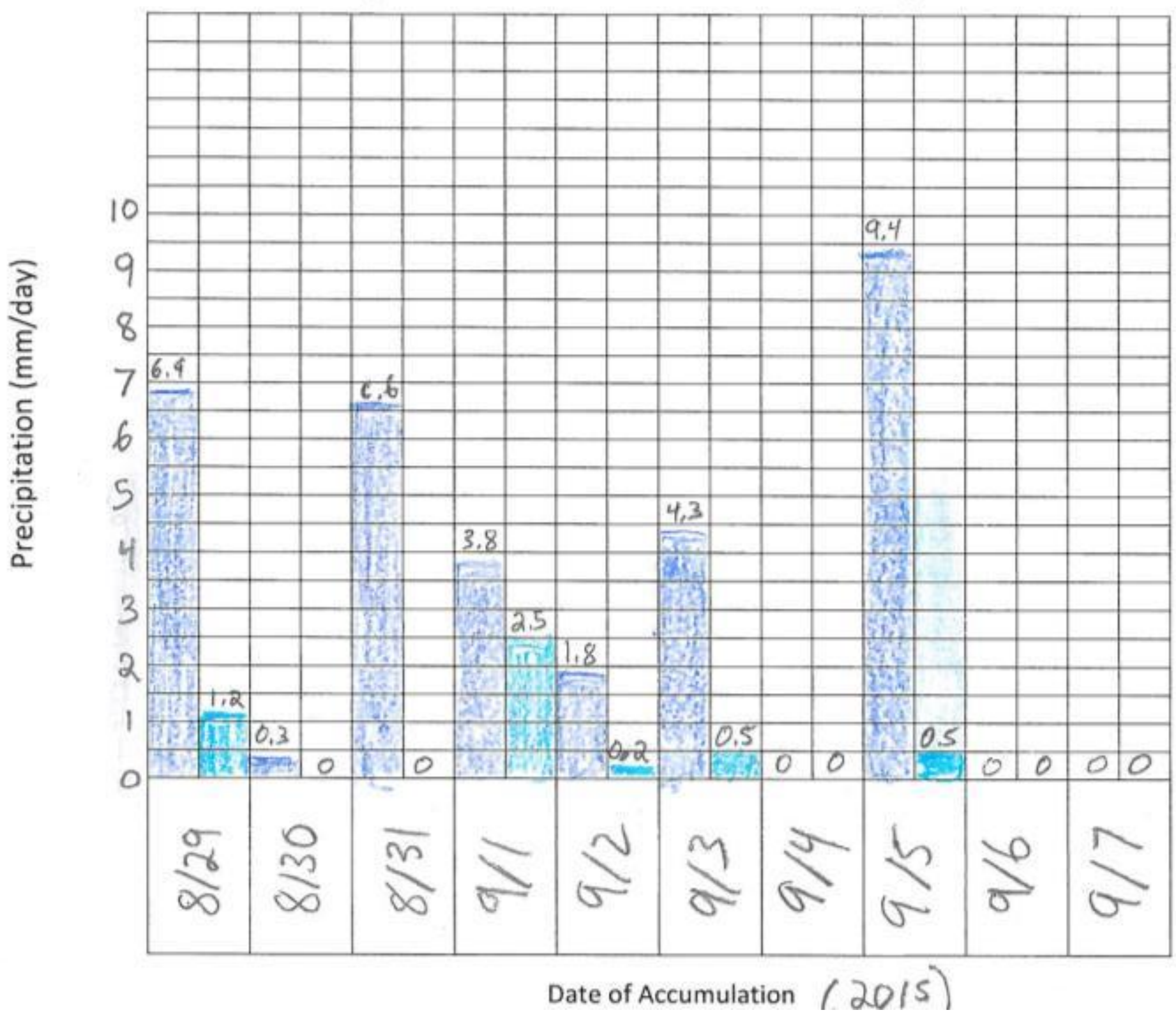
Reminders:

- Choose a meaningful title that tells what is being graphed.
- Look at all the values you will need to graph before numbering the y-axis, and choose an appropriate ending point and interim values for each line.
- Put the values for ground and satellite data next to each other for each date, to make comparisons easier.
- Don't forget to fill out the key with the colors or patterns you use in the graph.

Sample graph using spreadsheet software:

Title: Precipitation Data for 48.098 N, -123.42 W

Key:
- ground data
- satellite data



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