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Using NASA Earth-Observing Satellites to Help Improve Agriculture and Water Usage
5th grade

"Water for Wheaties?" Lesson Plan

Lesson Overview:
The overall goal for this lesson plan is to introduce students to STEM-related careers. Students will learn about Earth's freshwater resources and how NASA's Earth observing satellites are helping us better understand Earth's water. They will work in small "expert groups" to explore growing wheat, the differences in weather and climate in two wheat farming regions of the world, Pakistan and Kansas, and the scarcity of freshwater resources in Pakistan. Using this information, students will get into "teams" and work with NASA data from the GPM (Global Precipitation Measurement) mission to explore the amount of precipitation that has fallen in these two regions over the past two decades. They will make recommendations for how farmers in Pakistan could reduce their water usage based on the work that is being done by Faisal Hossain. Finally, they will consider ways they can reduce their use of freshwater resources in their own lives.

Time Required: This lesson can take from three to four 45-minute class periods, depending on how in depth the teacher decides to get into the data analysis part of the lesson.

Anchor Phenomenon: How do farmers make sure they have enough water for their crops?

NGSS:
5-PS3-1. Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.
5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water
5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
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
5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Background Information:

NASA has many Earth observing satellites that are studying Earth's systems. You can learn more about these missions here. The GPM (Global Precipitation Measurement) mission is a NASA mission that is measuring Earth's precipitation around the world. The data from this mission is being used in a wide variety of ways, from helping weather forecasters better predict hurricanes to responding to natural disasters to improving health around the world. In this lesson, we will focus on how GPM data are being used by Faisal Hossain to help wheat farmers reduce their use of precious freshwater resources. They will learn about the work he does as a Professor of Civil and Environmental Engineering, and learn more about his STEM-related career. We created a suite of resources, some of which will be found in this lesson, that you can look over to learn more about how and why we use NASA data to improve Earth's environment and have a positive impact of people around the world.

Materials:

Engage-

For the whole class-

- Plastic world globe
- Clear plastic cup
- Water in a larger container to pour into the cup
- Eyedropper/pipette

"Water for Wheaties?" PowerPoint presentation

Explore:

"Water for Wheaties?" PowerPoint presentation

Explain:

"Water for Wheaties?" PowerPoint presentation

GPM Precipitation Data to Compare/Contrast resource sheet to use in Project Teams

Copies of the Expert Group resource sheets below for each member of the "Expert Group". It will work best if students have access to these documents online with internet connectivity as there are some hyperlinks which lead to short videos in some Expert resource sheets. If this is not available, perhaps the students can watch the short videos on a computer.

"Expert Group" Student Resource Sheets-

- Growing Wheat
- Weather and Climate in Sargodha, Pakistan

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- Weather and Climate in Gypsum, Kansas
- Pakistan Freshwater Availability

- Notetaking Organizer (for each student to use in Expert Group)

Optional: a print copy of Interview with Faisal Hossain (You may decide to have students read this on the projector as a group, or have each student have their own copy.)

Evaluate:
"Water for Wheaties?" PowerPoint presentation

Water for Wheaties rubric: one copy for each student or small group (Teacher can decide if evaluation projects will be completed by individual students or in small groups.) The teacher should review the rubric and consider what types of projects (posters, PPT presentations, comics, skits, video product, etc. using a Universal Design for Learning approach)

Extend:
"Water for Wheaties?" PowerPoint presentation

Engage:
The purpose of the activities in this section are to begin to make students aware of the need for freshwater resources for agriculture. They begin by brainstorming about the foods they eat which are grown by farmers, and then move into understanding that farmers need freshwater to grow crops and raise animals.

Key Focus: Farmers need water to grow crops. Water moves through Earth's spheres as the spheres interact.
Ask each student to make a list of the things that he/she had to eat yesterday. Tell them to put a star by the things that needed to be grown by farmers. Have students share their list with a partner and circle items on their lists which include ingredients that originally came from farms. (slide 2)

As a class, think about what farmers need to have in order to grow their crops. Make a class list of the different things that are essential to growing food to meet the needs of people around the world. (slide 3)

Show students the short water cycle animation (2:59- it has no narration) on slide 4. Help them to name the different spheres and processes that are interacting as water moves through the water cycle. A few examples could be: water moves through Earth's atmosphere (evaporation, condensation, transpiration, precipitation) and

3

then falls to the geosphere (precipitation) and moves through the biosphere (groundwater, runoff) and the hydrosphere (rivers, lakes, oceans) and then moves through each of these spheres continually.

Have students draw a diagram showing how water causes interactions between Earth's atmosphere, geosphere, biosphere, and hydrosphere. An example could be the following: the sun's energy in the atmosphere heats up water in the lake in the hydrosphere which then evaporates and moves up into the atmosphere. The living creatures (biosphere) and vegetation (biosphere) in the lake are affected by how much water there is in the lake. Allow a few students to share their diagrams and explain the interactions that they discovered.

Key Focus: Most of Earth's water is salt water. Less than 2.5% of Earth's water is freshwater. Describe and view graphs to understand the amounts and percentages of water and fresh water in various reservoirs on Earth. Farmers use freshwater resources to water their crops.

Look at a globe and ask how much of Earth's surface is covered by water. Do the Globe activity to predict how much of Earth is covered by water. (slide 5)

Watch the video, "Show Me the Water". 02:49 (slide 6)

Use the bar graph on slide 7 to help students unpack the concepts of where the Earth's water is located. Ensure that they understand how little of Earth's water is actually freshwater. Help them identify the possible water sources on these bar graphs that would be used by farmers to water their crops. Examples of this would include groundwater if they use wells, surface water, atmospheric water (precipitation), rivers, and lakes.

Discuss the questions on slide 8 to help frame students' understanding about the usage of freshwater resources by farmers around the world. Guide students to compare and contrast how much water is used by developing countries and the U.S. for agriculture usage (developing countries- about 70% compared to US about 31 %) as well as the difference between irrigating crops and allowing precipitation to water them. This will be reinforced later as well.

Read the article, "Precious Freshness" and use the information to answer the questions as a class on slide 9. The class can read this article as a class or students can have paper copies (or read electronically on their own).

Explore:
Now the students will begin to think more specifically about the ways in which freshwater resources are used around the world. They will begin to learn about

4

wheat and its importance in our diet. Before they begin their "Expert Group" research, they will also learn the difference between having precipitation water crops and needing to irrigate the crops when there isn't adequate precipitation.

Key Focus: Watering crops by irrigating versus having them watered by precipitation

Help guide the students to understand the difference between having crops irrigated versus having enough precipitation to water them adequately. (slide 10)

Key Focus: Energy from the sun is used to create the energy that is found in wheat crops. That energy is then transferred to us when we eat wheat products.

Have students think about the many foods they eat that include wheat on slide 11. Have them draw a diagram that shows how energy from the sun is used to create the energy that is transferred from wheat products to our bodies when we eat such foods as pizza. This could be done in pairs or as a whole class, depending on the needs of the students.

Explain:
Now the students have some common background information and are ready to start working in their "Expert Groups". Divide the class into four small groups, each of whom will be responsible for becoming experts on one of these topics:
- Growing Wheat
- Weather and Climate in Sargodha, Pakistan
- Weather and Climate in Gypsum, Kansas
- Pakistan Freshwater Availability

Have each student take notes on the Notetaking Organizer to help them have notes to refer to when they get together in their Project Team. Each Project Team will consist of an expert from each group- and thus will be composed of 4 students.

A copy of the GPM Precipitation Data to Compare/Contrast for each Project Team (This will be much more meaningful if it can be printed in color. One for the team of four should be fine)

Key Focus: Understand the purpose of the Expert Groups and Project Teams

Explain to the students that they will work in smaller "Expert Groups" in order to become knowledgeable about one topic. This is how scientists and engineers work when they are working collaboratively on a project. They have different areas of expertise and get together in their "working groups" to build their common knowledge. (slide 12)

For this activity, they will focus on two different wheat growing regions in the world. One of these is in Kansas and the other is in Pakistan, which is a developing country. (slide 13)

After they work with their Expert Group and take notes and discuss their topic, they will assemble into different Project Teams. (slide 14)

Students will review the questions that they will be focusing on within each expert group to get a feel for the broader picture. (slide 15)

Key Focus: NASA has a satellite mission that measures global precipitation.

The Global Precipitation Measurement (GPM) mission is a NASA satellite mission that is able to measure the precipitation as it falls from the clouds to the ground. (slide 16)

Have students learn about this mission by watching "For Good Measure". (02:01) Clicking on the image will open the link that has the video. The video is 2 minutes long, and will play more smoothly if you have it open and ready to go or download it ahead of time. (slide 17)

Key Focus: Unpacking data from GPM to answer questions in Project Teams

Give the students the directions for what they will do when they break into "Project Teams". These will be small teams of 4, which will include an expert from the different teams in order to be able to share their collective expertise as they attempt to answer a few key questions while looking at GPM data. (slide 18)

Take a minute to review the two locations that they will be looking at GPM's precipitation data to try to determine whether there is enough precipitation to water the wheat crops during each location's wheat growing season, or if they will also need to use irrigation methods. (slide 19)

The data that students are looking at is what is known as "IMERG" data. IMERG data is composed of precipitation estimates from combining microwave data from the GMI, TMI, and other partner instruments. You can learn more about this data here, but the students may simply need to know that this is data that has been collected from the GPM mission. If you should want to find the IMERG monthly data for your school location, you can follow the directions here and obtain that data. That might be an interesting activity to do with the class after they have looked at the IMERG data for the two locations we are working with in this lesson.

Key Focus: Earth-observing satellites use remote sensing to gather data.

Ask them to think about how satellites are able to measure things like the amount of precipitation falling from the clouds. Let them suggest their ideas, and then show them slide 20 to offer them an example of something they use regularly that uses remote sensing.

Show them the short video (2:39) on slide 21 entitled "Getting the Big Picture" to help them understand how we are able to collect remotely sensed data from space to help us make measurements, or estimates, of Earth data.

Assign one member of each Expert Group to a Project Team, which will result in many small Project Teams with 4 members in each team. Allow them a few minutes to look over the data in their Project Team. Use the Graph Cube and question sheets from My NASA Data with your students to help them unpack what they are looking at with the interannual time series data graphs. If you have time, preparing the graph cubes ahead of time will enable students to interact with the graphs and help them to unpack the information in a more constructivist manner. There are accompanying student capture sheets that are scaffolded and thus ensure that all students can access the content (Universal Design for Learning). If time is a limitation, consider using gaming dice as an alternative or, for virtual instruction, consider using a free virtual gaming dice app found online.

After they have had enough time to begin to unpack the graphs, use slides 22 and 23 to ensure they are able to do the following:

- Understand that time is being shown on the x-axis using different colored lines. Each line represents a season- "DJF- December, January, February" and so on.
- Understand that the y-axis is showing how much precipitation was measured in *mm* per month (or estimated as it is using remotely sensed data).

Leave the questions on slide 24 and circulate to assist Project Teams as necessary.

They may find that using highlighters is helpful to figure out which data to look at for each location. For example, wheat growing season in Kansas (this information is in the Weather and Climate in Gypsum, Kansas resource) is fairly long. Wheat is planted in the fall, becomes dormant in the winter, and grows in the spring and is harvested in June and July. Thus, the growing season is longer, but the most water will be needed during the spring and early summer. The students could use their highlighters and find the lines that show MAM (March-April-May) as well as JJA (June-July-August). It will not be possible to be exact with this data, but they can be

looking for patterns and trends in the data. They may also need some assistance in finding and highlighting the important information that they will need to help them answer their Project Team questions as they look through their Expert Group resources.

It is helpful to work as a class and create a data table to compare and contrast the approximate amount of precipitation that fell during the primate growing season- MAM. It could be generated on the blackboard or using a projector. Students might have their own copies or create their own data table to fill in the data as it is a good exercise in learning how to approximate data from a graph.

Here is an example: (I ran out of room, but you would add 2019 as well.)

Comparison of Precipitation totals in mm for March-April-May

year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Sargodha	30	20	25	15	40	33	35	49	42
Gypsum	80	76	102	97	79	77	170	98	92

year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sargodha	13	22	26	41	72	102	70	40	42
Gypsum	86	70	58	98	47	102	118	126	56

They may also try to convert the mm units to cm units- easy enough with the metric system as they just divide by 10- to see if there is enough precipitation to grow wheat without needing to use other water to irrigate the wheat crops. (from the "Growing Wheat" resource- they will note that growing wheat requires between 31-38 cm of precipitation, which will be 310 -380 mm) This is not necessary, however, to understand that the farmers will need to irrigate their wheat crops dung the spring season when they do not receive much rain.

From time to time, you may want to use slides 22 and 23 to point out important information or have students assist others in interpreting the data.

Once students have had time to work in their Project Teams and you determine it is time to come together as a class and share in their answers, bring the class back together to answer the questions on slide 24 together. Help them use argumentation strategies to come to a class consensus on the answers.

Key Focus- Using technology to reduce the amount of freshwater resources needed in Pakistan for growing wheat

Now students are ready to use what they have learned to consider some possible ways in which technologies could be used to solve a real-world problem, that of

limited freshwater resources in Pakistan. Help them to begin this process by showing them slide 25 and having them brainstorm what is happening in this picture.

After they have thought about what was happening in the first picture, show them slide 26 as it will give them additional information to use to try to figure out how

Key Focus- Meet Faisal Hossain and learn about his STEM-related career

Faisal Hossain is a professor who teaches civil and environmental engineering at the University of Washington in Washington state. He uses the data from GPM and other NASA satellite missions to help wheat farmers in Pakistan. The farmers get text messages every day letting them know whether or not they should water their wheat crops. He will introduce himself in a short video (02:39) on slide 27. Have students read about his work in the resource: Interview with Faisal Hossain. (slide 28) You can show this document on the large screen and/or have each student have their own printed copy.

As students read the interview, have them use the questions on slide 29 to guide their reading. When they finish, use slide 30 to help them generate some questions they have about his career and work.

Show them the video on slide 31 entitled "Guiding Farmers with NASA Satellites", (4:04). This video reviews what they have learned and explains the complex reasons for the shortage of freshwater resources in Pakistan. Faisal Hossain is featured as he describes how he NASA and other data to assist farmers in using their cell phones to receive messages so they can irrigate less and rely on using precipitation when possible.

Here are some resources to learn more about the work Faisal is doing to reduce the use of freshwater resources using technology. Many are too complex for fifth grade students, but you might find portions of this information useful for yourself and your students.

- Growing More with Less: Smart Tech Solutions to Feed the World (video presentation by Faisal Hossain)
- Professor Faisal Hossain modernizes irrigation to feed the masses (article from The Daily with many links to more information)
- A collection of videos by Faisal Hossain

Evaluate:

Key Focus: Understand that most careers require us to communicate our findings to others. This is true for scientists and engineers as well.

Help students to understand that most careers require that people have a way to communicate what they learn to others. This is true for scientists and engineers as well. Use slide 32 to review the scientific research process and see where "Present Findings" falls within the scientific research process.

Key Focus: Understand the expectations for the project

Use slide 33 to frame the expectations for the content the students will include in their final project. This could be completed as an in class or homework assignment. Based on the needs of your students and your classroom environment, you can determine whether the projects will be completed individually or in small groups. The rubric includes four focal areas: oral presentation showing knowledge of topic; organization showing timely and appropriate completion of project; content showing quality of information including use of facts and details; and research showing use of facts versus opinion. The teacher may of course modify this rubric to meet the unique needs of their learners.

Elaborate/Extend:

Key Focus: Get GPM Data for Your Location

Slide 34: Students can input their longitude and latitude to find out how much precipitation the GPM mission measured for any location around the world. Start by having them enter their home locations. At this age level, you may want to guide them using the class computer to show the steps for the school address, and then helping them to find their own longitude and latitude for their home address. This could also be done as an at home activity with their family. The complete direcitons can be found here.

Key Focus- NASA Earth observing missions help us understand our home planet

Click on the image on slide 35 to open the link that has a short video entitled "Why Does NASA Study Earth?". This video is very short (1:52) and uses drawings to explain why and how NASA Earth observing satellites help us learn about Earth.

Key Focus: Using NASA Data to Insure Farmers and others

Slide 36: Another use of NASA data is to help small businesses and small farmers to be able to have insurance in case they are impacted by too much or too little water. In this short video (02:44), students meet Iker Llabres who explains a little bit about his STEM-related career and how and why he uses NASA's GPM data to help determine if individuals should receive payments. They could also read the written interview here.

Slide 37: This video "NASA Satellites Help Farmers in Central America's Dry Corridor" (02:46) explains how unexpected shocks from natural hazards can affect populations throughout the globe, threatening sustainable development and resilience. However, the impacts of these events, such as extreme precipitation or drought, disproportionately affect the developing world where individuals often are not insured and live and work in conditions that leave them vulnerable to natural disasters. This can lead to significant economic and environmental challenges if preventive measures or mitigating measures are not taken in time. To reduce risks from natural disasters and build climate resilience, decision makers are using NASA Earth observations to develop index-based insurance products and protect low-income customers in Central America, especially in the region known as the Dry Corridor. It is also available in Spanish here.

Key Focus: Saving Freshwater Resources
Slide 38: This slide has a link to the EPA's "WaterSense" website with activities and information for students and teachers.

Show students slide 39 and have them brainstorm on the question.
Have them read "Earth's Water Delivery:? No Passport Required" to learn more about Earth's freshwater resources and how they are inequitably distributed around the world. Students could have their own copies or read the article as a class on the projector screen.

Additional Resources:
There are more resources you and the students might want to explore on slide 40. You may also want to explore the resources in GPM's "Precipitation Education" website, as there are a rich array of educational resources on this website.

Credits:
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