Unit Plan
Long Term Data Patterns
Astronomy and Space Science Fall 2018
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Standards

Tracking Water
N.G.S.S.
MS-LS2-1
MS-ESS3-1
MS-ESS3-2
MS-ESS3-3
MS-ESS3-4
Common Core Math
5.G.A.2
8.SP.A.1
8.SP.A.2

Graphing Global Temperature Trends
N.G.S.S.
HS-ESS2-2
HS-ESS2-4
HS-ESS3-5
MS-ESS3-5
Common Core Math
HSS.ID.B.6.A
HSS.IC.B.6

Graphing Sea Level Trends
N.G.S.S.HS-ESS2-2
HS-ESS3-5
Common Core Math
HSS.ID.B.6.C
HSS.ID.C.8
HSS.ID.B.6.A
HSS.ID.C.7
HSS.IC.B.6

Objectives Discipline Knowledge Proficiency

Tracking Water with GRACE Data
Students will track water mass changes in the U.S. using real data from NASA's GRACE satellites.
Students will estimate water resources using heat-map data.
Students will construct a line graph for a specific location.
Students will identify and explain patterns, assess trends, and discuss implications related to their line graph.
Students will critique experimentally collected as they analyze data from the selected locations MASCON.

Graphing Global Temperature Trends
Students will use global temperature data to create models,
Students will compare short-term trends to long-term trends.
Students draw conclusions and determine whether global temperature is rising based on the data.
Students will develop a logical argument citing evidence from their data that analyzes global temperature trends.

Graphing Sea Level Trends
Students will use sea-level rise data to create models.
Students will compare short-term trends to long-term trends.
Students draw conclusions and determine whether sea-level rise is occurring based on their data.

Pre-Assessment

Tracking Water
Show map of global water storage from:
https://gracefo.jpl.nasa.gov/resources/48/map-of-groundwater-storage-trends-for-earths-37-largest-aquifers/
Ask: What does this map show and how does the map key relate? Why might it be important to measure the groundwater? Can you think of ways we could measure the amount of water below the ground?

Activating

Use this video to active how Grace-FO will track water on the globe.
https://www.youtube.com/watch?time_continue=20&v=hsdjssgbZoU

Background Knowledge

The GRACE-FO mission, a partnership between NASA and the German Research Centre for Geosciences (GFZ), will measure small variations in Earth's mass to track how and where water is moving across the planet. This is no easy task, as water can be solid, liquid or gas; it can be in plain sight (as in a lake or glacier); it can be in the atmosphere or hidden underground; and it's always on the move. But one thing all this water has in common, regardless of what state of matter it is in or where it is located, is mass.

Everything that has mass exerts a gravitational force. It is this gravitational force that GRACE-FO measures to track the whereabouts of water on Earth. Most of Earth's gravitational force, more than 99 percent, does not change from one month to the next because it is exerted by Earth's solid surface and interior. GRACE-FO is sensitive enough to measure the tiny amount that does change – mostly as a result of the movement of water within the Earth system.

GRACE-FO works by flying two spacecraft in tandem around Earth – one spacecraft trailing the other at a distance of about 137 miles (220 kilometers). By pointing their microwave ranging instruments at each other, the satellites can measure tiny changes in the distance between them – within one micron (the diameter of a blood cell) – caused by changes in Earth's gravitational field. Scientists can then use those measurements to create a map of Earth's global gravitational field and calculate local mass variations.

Pre-Assessment

Graphing Global Temperature Trends

Ask: What do you know about global temperature trends? Possible answer will include differing opinions and perhaps the beginning of a heated debate

Ask: Does has any one ever looked at global temperature source data (data measurements from science institutions) themselves? Possible: some students will say they have seen graphs. If they do, ask them if they know whether the graphs represent all available data and what the source of that data is.

Differentiate between weather and climate. What was our definition of weather from chapter 1, how does this relate to weather?

Scientists have concluded that our climate is changing, that global temperatures are on the rise, and that there are serious consequences to these rising temperatures. But in an age of plentiful yet opposing information, how do students separate fact from fiction? Simple: Examine the source data and do the math.

Weather and climate are two frequently confused terms that refer to events with broadly different spatial and time scales. Weather refers to atmospheric conditions that occur locally over short periods of time – from minutes to hours or days. Familiar examples include rain, snow, clouds, winds, floods or thunderstorms. Remember, weather is local and short-term. Climate, on the other hand, refers to the long-term regional or even global average of temperature, humidity and rainfall patterns over seasons, years or decades. Climate is regional or global and long-term; weather is local and short-term. Erratic weather in your neighborhood – whether rain or drought – may or may not be a symptom of global climate change. To know, we must monitor weather patterns over many years.

Activating

View the following video: focus on the 1:00 min mark of the video for possible symptoms. Earth's average temperature has risen over 1º F in the past century. It is projected to rise an additional 3º to 10º over the next 100 years. Data from NASA's global network of satellites,

airborne missions and surface monitoring systems is used to build climate models that help us understand the causes and effects of global warming.
https://www.youtube.com/watch?list=PL9TFrgFq75552g7qVa-iTOeuo7Fy11o5f&time_continue=7&v=nAuv1R34BHA

Background Knowledge
Two other terms that are often incorrectly used interchangeably are "global warming" and "climate change."

Global warming refers to the upward temperature trend across the entire Earth since the early 20th century – and most notably since the late 1970s – due to the increase in fossil-fuel emissions since the beginning of the Industrial Revolution. Though there are many different greenhouse gases, carbon dioxide, or CO2, is the one that has been on the rise during the last century. Since the beginning of the Industrial Revolution, the concentration of CO2 in the atmosphere has increased by 39 percent. Increasing the concentration of greenhouse gases causes the Earth greenhouse to overheat. Worldwide since 1880, the average Earth surface temperature has gone up by about 1.4 degrees Fahrenheit (0.8 degrees Celsius) relative to the mid-20th-century baseline (measured between 1951 and 1980.)

Climate change refers to a broad range of global phenomena created predominantly by burning fossil fuels, which add heat-trapping gases to Earth's atmosphere. These phenomena include the increased temperature trends described by global warming, but also encompass changes such as sea-level rise; ice-mass loss in Greenland, Antarctica, the Arctic and mountain glaciers worldwide; shifts in flower and plant blooming; and extreme weather events.

Pre-Assessment
Graphing Sea Level Trends
Display the following graphic:
https://climate.nasa.gov/climate_resources/125/infographic-sea-level-rise/

Ask: What happens to water as it warms? Possible response, the molecules increase their kinetic energy moving around more, spreading out and taking up a larger volume.
How much has the sea level risen since the start of the 20th century? Answer 8"
What is the predicted level of rise by 2100? Answer 3'
What percentage of the heat added to the earth system is the ocean absorbing? Answer 80-90%

Activating
Show https://www.youtube.com/watch?v=6Fthw65WUpU
This classroom demonstration uses a water balloon to show how Earth's oceans are absorbing most of the heat being trapped on our warming world.

Background Knowledge
Show: https://climate.nasa.gov/vital-signs/sea-level/
Using a variety of methods, scientists have concluded that global sea level – the average height of the sea surface across the planet – has varied substantially throughout history, especially in response to the ice ages. In recent history, starting around 7,000 years ago, sea level became

quite steady, but over the last century, it's been rising. Global tide measurements from tide gauges suggest the global sea level rose approximately 3.4 millimeters (0.13 inches) per year over the past century. The New York City area, alone, has experienced roughly a foot of sea-level rise in the past century. (That's measured at a tide gauge near Battery Park just off the southern tip of Manhattan. While tide gauges are one way we measure sea level, changes in global sea level should not be confused with tides. Tides are the regular rise and fall of the sea surface and make it appear as if the water level of the ocean is always changing. But tides represent normal changes in the sea level that we expect to see daily and monthly.)

How do we know sea level is rising? Sea level is measured by monitoring stations on the shoreline and at sea. Satellites also collect data on the height of the sea level. There are more than 120 sea-level monitoring stations in the US and 240 additional stations worldwide. By looking at data from these stations over periods of 30 years or more, trends can be identified at individual stations and compared with other stations. This gives scientists useful information about local conditions. Those data can also be used to calculate the global average sea level and study it over time, giving scientists a picture of what's happening to the ocean on a planet-wide scale. Sea level has been measured at some stations for more than a century, providing data about sea level going back to 1880.

It's important to note that when sea level rises, the total amount of water on Earth isn't increasing. Instead, the volume of liquid that fills the ocean basins is growing, raising the elevation of the sea's surface and spilling ocean water onto low-lying land. The extra volume of seawater comes from two places:

1. Melting ice sheets and glaciers on land add water to the sea.
https://climate.nasa.gov/vital-signs/ice-sheets/

2. The second, and less obvious, cause for rising sea level is thermal expansion.
https://climate.nasa.gov/vital-signs/global-temperature/

Adaptations: Differentiation/ UDL Considerations

Tracking Water

Print materials for students that do not have internet connections at home.

For classes that have trouble graphing work through setting up vertical and horizontal graph axis titles and labelling. Use small groups to have students work together for checking of their graphs.

Use quadrille ruled graph paper with major lines highlighted in bold to make it easier for students that may have difficulty determining graph scale. Monitor students closely while they are plotting data points to be sure they are using a consistent scale. A consistent scale allows data to be combined seamlessly and accurately.

For students that may have trouble reading heat maps review Earth Science Data Visualizations – How to Read a Heat Map:
https://www.jpl.nasa.gov/edu/teach/activity/earth-science-data-visualizations-how-to-read-a-heat-map/

Graphing Global Temperature Trends
Adaptations: Differentiation/ UDL Considerations
For 9th grade students that have trouble working with spreadsheets break the data into smaller pieces using the following steps for groups of students.

The data file for this activity contains 137 years of average global annual temperature measurements

Divide the data so that each group or individual has approximately the same number of data points.

Help students determine an appropriate vertical scale. Determine the range of data by subtracting the maximum and minimum temperature values (e.g., 14.87-13.54=1.33). Placing the graph paper in portrait orientation allows for approximately 40 lined intervals. Determine scale by asking which place value (ones, tenths, hundredths, etc.) should be used. Demonstrate that counting by ones on each line will not allow for accurate resolution of data. Have students determine how many lines they will need if they count by tenths and if they count by hundredths.

Help students determine an appropriate horizontal scale. It is important to evenly space the years. The group that has the most years of data to graph will determine the scale that all groups will use.

Monitor students closely while they are plotting data points to be sure they are using a consistent scale. A consistent scale allows data to be combined seamlessly and accurately.

When combining individual graphs into the class graph, be sure to fold back or cut off extra paper so that the year spacing remains constant throughout the graph.

For classes that will use the spreadsheets but are unfamiliar with spreadsheet software, have them create their own graphs while following along as the instructor shows them the steps.

Graphing Sea Level Trends
Check in with students to make sure they understand the lesson. Explain with visual aids how to work with the data to produce the graph. Break down the directions by providing an outline of the steps. At the beginning of the lesson that provides a checklist with details of the grading of the lab activity.

Preparing Class for Lesson
Tracking Water
Show: https://www.youtube.com/watch?time_continue=9&v=oNWAerr_xEE
Describes groundwater.
Use the video at 1:45 min to show the molecules of water percolating into the ground. Have the kids develop a working idea of aquifers.
Use the video at about 4:00 min to show how use of ground water can impact recharge of aquifers.

Graphing Global Temperature Trends
Discuss with students the importance of analyzing data, carefully scrutinizing graphs themselves and drawing their own conclusions rather than relying on sources that may not be factual.

Tell students they are going to be looking at data sets that show monthly measurements of the average global land and ocean temperature over approximately 136 years. They will make a determination about what they think is happening to the global temperature over time.

Graphing Sea Level Trends
Ask students what sea level is and what tides are. Clear any misconceptions and make sure students understand that tides are an expected rise and fall of ocean water in an area on a daily basis, while sea level is an overall measurement of the average height of the ocean.

Ask students if they think sea level is rising, falling or remaining steady. Ask students to explain their thought process. If students mention that sea level in a specific area is rising or falling, clarify by telling them that certain parts of the world, such as some areas in the Pacific Northwest of the United States, are experiencing drops in sea level, while other areas, such as the Gulf Coast, are experiencing rises in sea level. Tell them that what they are being asked about is the average global sea-level height.

Tell students they are going to be looking at data sets that show measurements of the average global sea-level height over a period of approximately 130 years. Let them know they won't be looking at all 130 years at once, but rather will be examining approximately 6.5 years per group or individual. They will make a determination about what they think is happening to the sea level for their time period. Then, all the data sets will be combined, and an assessment of sea level over a longer period of time will be made.

Resources: Materials Technology Integration
Tracking Water
https://www.jpl.nasa.gov/edu/teach/activity/tracking-water-using-nasa-satellite-data/

Graphing Global Temperature Trends
https://www.jpl.nasa.gov/edu/teach/activity/graphing-global-temperature-trends/

Graphing Sea Level Trends
https://www.jpl.nasa.gov/edu/teach/activity/graphing-sea-level-trends/

Daily Lessons and Activities
Tracking Water
See attachment Tracking Water Using NASA Satellite Data Student Blank

Graphing Global Temperature Trends

See attachment Graphing Global Temperature Trends

Graphing Sea Level Trends
See attachment Graphing Sea Level Trends

Summarize

Tracking Water
The GRACE mission ended in 2017, but the GRACE-FO mission will pick up data collection in 2018. Show this video to conclude.
https://www.youtube.com/watch?v=fKVPFyu_tHQ

Graphing Global Temperature Trends
Greenhouse gases are vital to life on Earth, but the growing concentration of certain gases, such as carbon dioxide, is throwing the planet's delicate balance out of whack. NASA is on the case, studying carbon dioxide on a global scale and its effects on our weather and climate. Show the following videos to summarize. https://www.youtube.com/watch?v=K9kga9c0u2I&feature=youtu.be&list=PL9TFrgFq75552g7qVa-iTOeuo7Fy11o5f

Graphing Sea Level Trends
Compare satellite images taken at different periods to see how Earth is changing. Have students focus on the dynamic earth using these images. Ideally they become a student of change and begin to see the importance of make decisions that reduce the likely hood of accelerated human impacts on earth's system. Show these images to conclude.
http://climate.nasa.gov/images-of-change?id=597#597-landslide-in-glacier-bay-national-park-and-preserve-alaska

Evaluate/Reflect

Tracking Water

- Assess that students can read a heat map and graph the data.
- Assess that students can interpret and evaluate the data through oral discussion of how water mass is changing in their location over one year.
- Assess that students understand the implications of water mass movement and can infer the reasons why or predict what will happen.

Suggested rubric:

0	1	2
Students are unable to articulate what a heat map communicates and did not graph data.	Students produced a graph but are unable to articulate what data the heat map provides.	Students are able to articulate the data presented in their heat maps and how the data translate to their graph.

Graphing Global Temperature Trends

Assess student ability to use spreadsheet software to analyze data.
Assess student ability to identify trends in graphically represented data.
Assess student ability to associate human activity with global temperature trends.

Graphing Sea Level Trends
Complete the GMSL student record sheet at:
https://www.jpl.nasa.gov/edu/pdfs/sealevel_graphing_worksheet.pdf

Unit Plan Lessons from JPL Site
https://www.jpl.nasa.gov/edu/teach/tag/search/8.SP.A.2

Tracking Water
https://www.jpl.nasa.gov/edu/teach/activity/tracking-water-using-nasa-satellite-data/

Graphing Global Temperature Trends
https://www.jpl.nasa.gov/edu/teach/activity/graphing-global-temperature-trends/

Graphing Sea-Level Trends
https://www.jpl.nasa.gov/edu/teach/activity/graphing-sea-level-trends/

Precipitation Towers Modeling Weather Data
https://www.jpl.nasa.gov/edu/teach/activity/precipitation-towers-modeling-weather-data/

Webbs Depth of knowledge
https://static.pdesas.org/content/documents/M1-Slide_19_DOK_Wheel_Slide.pdf