

Global Precipitation Measurement Mission

Weather and Climate IQuest Lesson Plan

Lesson Overview: This IQuest provides an introduction to the fundamentals of weather and climate, and gives students an opportunity to interact with climate change data. Students will need to have computers with Internet connectivity to complete this activity. Completing the IQuest will probably take from 45 to 90 minutes, depending on the speed at which the students complete the exercises. The ideal set up would be to have each student work on a computer, although they could work in pairs or even complete this activity in a whole class setting.

Learning Objectives:

- Understand and describe difference between weather and climate
- Describe how interactions between Earth's sphere can cause weather and climate
- Discuss how climate change might impact Earth's spheres
- Explain why it is hard to accurately predict weather accurately
- Understand that using Earth-observing satellites enhances our ability to predict and understand weather and climate

National Standards:

ESS2.D: Weather and Climate: What regulates weather and climate?

By the end of grade 8:

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can be predicted only probabilistically.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

ESS2: Earth's Systems: How and why is the earth constantly changing?

By the end of grade 8-

- All earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and the earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. The planet's systems interact over scales that range from microscopic to global in size, and they operate over

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fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

ESS2.C: The Roles of Water in Earth's Surface Processes: How do the properties and movements of water shape Earth's surface and affect its systems?

- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation, and precipitation as well as downhill flows on land. 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.

- Global movements of water and its changes in form are propelled by sunlight and gravity. Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. Water's movements both on the land and underground cause weathering and erosion, which change the land's surface features and create underground formations.

Background Information: from the NGSS at <http://www.nextgenscience.org>

“Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. Climate is longer term and location- sensitive; it is the range of a region's weather over one year or many years, and, because it depends on latitude and geography, it varies from place to place. Weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions can drive changes that occur over multiple time scales—from days, weeks, and months for weather to years, decades, centuries, and beyond for climate.

The ocean exerts a major influence on weather and climate. It absorbs and stores large amounts of energy from the sun and releases it very slowly; in that way, the ocean moderates and stabilizes global climates. Energy is redistributed globally through ocean currents (e.g., the Gulf Stream) and also through atmospheric circulation (winds). Sunlight heats Earth's surface, which in turn heats the atmosphere. The resulting temperature patterns, together with Earth's rotation and the configuration of continents and oceans, control the large-scale patterns of atmospheric circulation. Winds gain energy and water vapor content as they cross hot ocean regions, which can lead to tropical storms.

The “greenhouse effect” keeps Earth's surface warmer than it would be otherwise. To maintain any average temperature over time, energy inputs from the sun and

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from radioactive decay in the earth's interior must be balanced by energy loss due to radiation from the upper atmosphere. However, what determines the temperature at which this balance occurs is a complex set of absorption, reflection, transmission, and redistribution processes in the atmosphere and oceans that determine how long energy stays trapped in these systems before being radiated away. Certain gases in the atmosphere (water vapor, carbon dioxide, methane, and nitrous oxides), which absorb and retain energy that radiates from Earth's surface, essentially insulate the planet. Without this phenomenon, Earth's surface would be too cold to be habitable. However, changes in the atmosphere, such as increases in carbon dioxide, can make regions of Earth too hot to be habitable by many species.

Climate changes, which are defined as significant and persistent changes in an area's average or extreme weather conditions, can occur if any of Earth's systems change (e.g., composition of the atmosphere, reflectivity of Earth's surface). Positive feedback loops can amplify the impacts of these effects and trigger relatively abrupt changes in the climate system; negative feedback loops tend to maintain stable climate conditions.

Some climate changes in Earth's history were rapid shifts (caused by events, such as volcanic eruptions and meteoric impacts, that suddenly put a large amount of particulate matter into the atmosphere or by abrupt changes in ocean currents); other climate changes were gradual and longer term—due, for example, to solar output variations, shifts in the tilt of Earth's axis, or atmospheric change due to the rise of plants and other life forms that modified the atmosphere via photosynthesis. Scientists can infer these changes from geological evidence.

Natural factors that cause climate changes over human time scales (tens or hundreds of years) include variations in the sun's energy output, ocean circulation patterns, atmospheric composition, and volcanic activity. (See ESS3.D for a detailed discussion of human activities and global climate change). When ocean currents change their flow patterns, such as during El Niño Southern Oscillation conditions, some global regions become warmer or wetter and others become colder or drier. Cumulative increases in the atmospheric concentration of carbon dioxide and other greenhouse gases, whether arising from natural sources or human industrial activity (see ESS3.D), increase the capacity of Earth to retain energy. Changes in surface or atmospheric reflectivity change the amount of energy from the sun that enters the planetary system. Icy surfaces, clouds, aerosols, and larger particles in the atmosphere, such as from volcanic ash, reflect sunlight and thereby decreasing the amount of solar energy that can enter the weather/climate system. Conversely, dark surfaces (i.e. roads, most buildings) absorb sunlight and thus increase the energy entering the system. “

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Materials: computers with Internet access (see Teacher Notes for additional information on setting up and organizing computer usage), Student Capture sheet, (one per student), headsets (optional, as there are several video clips with audio in this IQuest)

Engage: Begin by showing students this short video, “Too Little, Too Much” <http://pmm.nasa.gov/education/videos/gpm-too-much-too-little> (4:44) to activate their background knowledge and stimulate their interest in the subject of weather and climate. This video explains why we need accurate and timely rainfall information to better understand and model where and when severe floods, frequent landslides and devastating droughts may occur. GPM’s global rainfall data will help to better prepare and respond to a wide range of natural disasters. After students have seen this video, have the students answer the first set of questions on the Student Capture sheet, as this serves as a pre-assessment for the lesson. Once they have finished answering these, have a class discussion about their responses. You might select a student to act as the “notetaker” and write down some of the different responses. Have the class work on coming up with a class definition of terms “weather” and “climate”.

Explore: Ask students how scientists collect data on weather, and let them share in some of the instruments that are used. As they share in these instruments, have them identify the variables that these instruments are measuring. Show them a local weather report for today by going to the National Weather Service website at <http://www.weather.gov/forecastmaps> and entering your school’s zip code. Have them identify the variables, such as temperature and wind speed, that are listed. Ask them a few questions about the information on the forecast page, such as “When were these conditions reported?”, “Why are percentages given for the chance of precipitation?”, and other questions you feel will enable them to focus on the data and think about it. Then scroll down to the bottom of the page where there are radar and satellite images. Ask them to think about how we use these types of technology to forecast and understand weather, and invite a few students to share in their ideas and information.

Explain: Tell the students that they will be working on an IQuest- a series of directed questions to answer while visiting different websites. They will go to the url that is listed on the Student Response sheet, and will read the information and follow the links to direct them to the different websites. As they go through the IQuest, they will use their Student Response sheet to write their responses. The Student Response sheet is in Word to enable the teacher to modify this document to meet the unique needs of the students. Some students may do better respond using word processing capabilities, while others may benefit from providing written responses. The teacher should circulate around the room and assist students as they

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work. It might be helpful to have a copy of the answer key to assist in steering students to the correct responses.

Evaluate: The completed Student Response sheet and observations from the class discussions will provide the teacher with pre-assessment and formative assessment data. Depending on the ability level of students and the desired outcomes for the course, the teacher may want to add additional summative items to the Student Response sheet or develop other summative assessment instruments. For example, students could write a two-page paper comparing and contrasting weather and climate. They could use their completed Student Capture sheet to guide them, and could revisit various websites to gather specific data to support their responses.

Extend: There are many extension activities that students could do to further their knowledge about weather and climate. Students could work in “Expert Groups” and focus on the NASA Climate Change Vital Signs, using the <http://climate.nasa.gov> website. Each group could become experts on a different “vital sign” and then teach what they learn to the rest of the class. They could make posters to inform others about these indicators and interesting facts that they learn, and could post these around the school to share with the school community.