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Teacher's Guide: Observations of Climate Change

Overview

Observations of Climate Change is a student-directed learning experience. However, while students are expected to direct their own investigations, teachers must be fully engaged to keep the activity on track, organize groupings, facilitate discussions, and ensure that all learning goals are met.

In this investigation, students are asked to explore the changes to Arctic sea ice by studying observational evidence and satellite data. Rather than having students develop a hypothesis about possible climate change, for which they likely do not have enough information yet, the focus is on exploring questions. After they have completed their investigation, students are asked to propose an answer based on the data that they collected. They then repeat this process with their own investigation about possible climate change in their own community. [Note: To learn more about focusing an inquiry on a question instead of a hypothesis, read the article that appears at the end of this document, "To Hypothesize or Not to Hypothesize?" by Jerome Pine.]

The following notes include suggestions for how you might enhance the learning experience of students by providing additional context for the content presented and troubleshooting technology. The notes have been written to correspond with the flow of the activity.

Activity Objectives

- Understand the differences between qualitative and quantitative data, including how they are derived and their strengths and limitations
- Learn to design a scientific investigation based on a question, and then analyze results
- Recognize the role of Earth's poles in enhancing our understanding of global climate change
- Demonstrate the importance and validity of different ways of knowing

Grade Level: 9–12

Suggested Time: Two to three class periods

Materials: Science notebooks for the "Write It Down" sections

Before the Activity

- Before students begin, provide an overview of the activity in order to set expectations. Suggest a timeline for completing the different parts of the activity, mention the different types of media they will encounter, and identify what they will have to do to demonstrate learning. For example, beyond participating in class discussions ("Talk About It" sections), communicate which notebook entries ("Write It Down" sections) you'll want students to turn in as assignments.
- Arrange computers with Internet access so students can work in pairs and/or small groups.
- If students will not have access to printers at their individual computers, print out all PDF documents ahead of time.

The Activity

Introduction

The Arctic has been described as the "front line" of global warming. Evidence suggests that the changes observed there—by its human inhabitants and by satellite monitoring instruments—are occurring more rapidly than anywhere else on Earth. The object of this student activity is to help students understand that what is happening in a remote corner of the world is not a localized phenomenon. Rather, it is creating reverberations felt all over the world.

1. How Does Global Warming Affect You?

This page asks students to consider changes that they may have personally noticed in their region. If students get stuck, you may want to suggest local waterways or other areas in the region for them to consider.

2. How Does Global Warming Affect the Arctic?

To stimulate their writing, have students think about the issues behind recent headlines and awareness campaigns broadcast on television or the Internet.

5. The Weather at Banks Island

Determine the appropriate viewing size for your class. During this first viewing, students should get a broad overview of the Inuvialuit residents' observations. Students will have the opportunity to make more detailed observations in a second viewing on the next page.

6. Observe Changes on Banks Island

Encourage students to list one to two observations for each space on the observations chart. They can fill in the chart online, and then print the screen for later reference. Note that this chart may not be saved once students have navigated away from the student activity page, so they should print their work before they move on. There is also a limit to how much text will appear in the cells that make up the online chart. If students need more space for their entries, provide them with additional pages from the printable version of the chart. If students' individual computers are not hooked up to a printer, you may want to have some printed versions available ahead of time.

7. Relate the Arctic to You

This discussion asks students to begin summarizing some of their observations about the weather factors affecting the Sachs Harbour community. Encourage students to reflect on the unique perspectives that these qualitative data present.

After each student pair has had a chance to discuss its observations, bring the pairs together for a class discussion. Ask each student pair to share some of its more surprising observations. Then lead the class in a brief discussion of the nature of qualitative data. What are their strengths? What are their weaknesses?

8. Satellite Observations

On this page, students are asked to begin thinking about the kinds of data that satellites gather. Some of the uses of satellite technology that they will likely recognize in their everyday lives include satellite television, online maps, and GPS navigation tools.

Students can also begin to think about how satellite data are very useful for providing a quantitative measure of how environmental conditions and weather change over time. Because climate is measured over longer time scales than satellite technology has existed, students will not be able to definitively determine that climate change is happening when looking at satellite data. However, the students will be looking at the same patterns in data that scientists are, and making hypotheses about what they believe to be happening. You may explain that one of the reasons climate change has been so controversial is because scientists haven't had enough time to say definitively that change is taking place on the temporal scale that defines climate—the average conditions over a 30-year period.

(To provide advanced students with additional opportunities for exploring climate-related data sets, see the resources listed in For Further Exploration on page 16 of the activity.)

10. Examine Satellite Data

In this activity, students are given the opportunity to select one of two questions about Arctic sea ice that they would like to explore. However, you may want to make sure that enough students choose each question so that there are a variety of observations about each visualization and data set for the discussion on page 12.

11. Measure the Sea Ice

This activity allows students to assess the surface area and concentration of the sea ice to better quantify their observations about changes to it. Again, because students are given a choice of the region they would like to focus on, you may want to make sure that a fairly even number of student groups select each region.

If students do not have access to printers at their computers, provide each group with printouts of the detailed region it selects.

The March printouts will be used to help students compare the maximum sea ice coverage in the years 1982 and 2007. Let students know whether you want them to count only fully filled squares or both fully filled and partially filled squares in their estimations. This will affect how much time they spend on calculations. Each square represents 10,000 square kilometers (3,860 square miles), which is about the size of Jamaica, or one-fourth the size of Switzerland. Students analyzing the North Bering Sea region should note that there is (perhaps surprisingly) greater ice cover in 2007 than in 1982. If they were to look again at the interactive activity, they would notice that the 2007 ice appears to be less concentrated. You may want to use this occasion to emphasize that climate change research is complicated. Scientists expect to see annual fluctuations, and they also know to consider more than one factor in their analyses.

The June printouts will be used in a different way. Instead of calculating area, students are asked to determine areas within the selected region where, for example, ice is no longer present in 2007 where it was in 1982, or where ice concentration is demonstrably less than it was. Students should shade or circle these areas on their printouts and make comments directly on the pages. Although each of these scenarios may suggest that ice is receding earlier today than in past years, you should be careful to emphasize that this is too small a sample size to make definitive conclusions about climate change.

You may choose to encourage advanced students to look at other years in the data set and make similar observations and comparisons.

12. Propose an Answer

During this discussion, students should share and compare their findings with those of their classmates. To facilitate the discussion, you may choose to set up charts for each region on which students can copy or post their findings. Ask students to consider whether any trends that they see in their own data set are also apparent across the other data sets.

13. Is the Climate Changing in My Community?

Because people answer questions in different ways, qualitative data can be more difficult to analyze than quantitative data. However, both kinds of data are only as valid as the sampling strategy and research design created by the investigator.

As students begin to design their survey, you may wish to communicate the following tips with respect to phrasing questions and compiling the data:

- Responses to "Yes/No," "Agree/Disagree," multiple-choice, and "On a scale of 1-5..." questions are easier to collect and record than responses to open-ended questions.
- Test survey questions on each other to see if they produce the data being sought, and revise as needed.

When they are ready to administer their survey, be sure that students approach a cross-section of the local population that represents a variety of age groups, including peers, family members, and neighbors well known to the students (safety first!).

14. Make a Data Set from Your Community Observations

Students should try to list one to two observations for each space on the observations chart based on the data that they have collected. As with the Banks Island chart, they can fill in the chart online and then print the screen for their reference. They can also change the row and column headers, if needed, to best reflect the type of data that they collected.

Note that this chart may not be saved once students have navigated away from the student activity page, so they should print their work before they move on. There is also a limit to how much text will appear in the cells that make up the online chart. If students need more space for their entries, provide them with additional pages from the printable version of the chart. If students' individual computers are not hooked up to a printer, you may want to have some printed versions available ahead of time.

15. What Do the Survey Data Say?

Now that students have collected and summarized climate data from a variety of sources—Inuit observational data, Arctic satellite data, and local observational data—they can try to make a prediction about what the data say regarding climate change. As students reflect on the guiding questions, remind them to base their prediction on the data they have already collected. It should not just be a guess. Their prediction should be something that is testable by scientific data gathering and/or local observations.

To Hypothesize or Not to Hypothesize?

By Jerome Pine
Professor of Physics and Neuroscience
California Institute of Technology

As a research scientist who is involved with elementary science education, I often notice teachers recalling from their past education a Scientific Method, which usually includes many attributes of scientific inquiry, among them observation, collection of data, analyzing data, drawing inferences, reaching a conclusion. Very often this method is presented as a linear sequence of activities, which it need not be. Scientists move back and forth among the processes, to refine their knowledge as the inquiry unfolds. Inquiry is an artistic endeavor and not the following of a recipe.

Frequently the scientific method as taught by non-scientists requires that a scientific inquiry must stem from a hypothesis, which in fact is not usually true. Did Darwin board the Beagle with the hypothesis of natural selection in hand? Did Galileo experiment with falling bodies with the hypothesis that they would all exhibit the same acceleration? Did Mendeleev invent the periodic table based on a hypothesis that there should be one? In these three cases, as well as a great majority of other crucial scientific inquiries, there was an exploration of the unknown, with not nearly enough prior knowledge to support an initial hypothesis on which to focus the exploration.

If we don't begin with a hypothesis, than what does initiate a scientific inquiry? A question. Sometimes it can be a very specific question: Do bean seeds germinate better in the light or the dark? Sometimes it can be a much more general question: How do crayfish relate to one another? If we have a great deal of prior knowledge, perhaps we might hypothesize. After some study of electric circuits, we might hypothesize: Two lengths of resistance wire in parallel will have less resistance than either one. But we could just as well have asked the question: How does the resistance of two lengths of resistance wire in parallel compare to that of either one?

We can begin every scientific inquiry with a question. If we insist on a hypothesis we will often merely force an unscientific guess. If there is a valid hypothesis it can always be stated as a question, for example: "Is it true that... (insert the hypothesis here)?"

So the answer to our initial query is:

To hypothesize or not to hypothesize? Don't. Pose a question instead.