Climate Change Inquiry Labs - Teacher Guide

Lesson Overview: Students will conduct labs investigating the drivers of climate change, including adding carbon dioxide and other greenhouse gases to the atmosphere, sea level rise, and the effect of decreasing sea ice on temperatures. They will become experts on one of these areas, conduct their own experiments and connect them to real-world data, and then make posters to present their findings to the class.

Expected time to complete: One 45-60 minute period to complete labs, one to two 45 minute periods to create and present posters (depending on whether posters are completed in class or as homework, and if presentations are done as a gallery walk or orally).

→ This lesson plan can be used as an introduction, supplement or substitute for the *GPM Climate Change Online Interactive Lesson.*

Learning Objectives:

- Students will investigate aspects of climate change's drivers by conducting experiments and reporting back on what they have learned.

National Standards:

ESS2.D Human activities, such as the release of carbon dioxide from burning fossil fuels, are major factors in global warming. Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

Background Information:

"The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 7,000 years ago marking the beginning of the modern climate era — and of human civilization. Most of these climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives.

The current warming trend is of particular significance because most of it is very likely human-induced and proceeding at a rate that is unprecedented in the past 1,300 years.

Earth-orbiting satellites and other technological advances have enabled scientists to see the big picture, collecting many different types of information about our planet and its climate on a global scale. Studying these climate data collected over many years reveal the signals of a changing climate."

From http://climate.nasa.gov/evidence

NASA is monitoring five main vital signs of the planet: carbon dioxide, global temperature, arctic sea ice, land ice and sea level. The investigations in this lesson will give students hands-on experience with models of these changes. For a more computer-based exploration of these vital signs, as a supplement or substitute for this lesson, see *GPM Climate Change Online Interactive Lesson*.

- For a kid-friendly look at climate change, see http://climatekids.nasa.gov/
- For more about sea ice, see http://nsidc.org/cryosphere/seaice/index.html

Materials:

Melting Ice and Sea Level Rise (per group)	Carbon Dioxide and Air Temperature (per group)	Sea Ice and Ocean Temperature (per group)
• large graduated cylinders (2) • water • ice cubes • funnel	• beakers or clear plastic containers (2) • plastic wrap • rubber band or string • thermometers or temperature probes (2) • tape	• flat containers (2) - plastic bins, cut open cardboard cartons, or something similar • thermometers or temperature probes (2) • tape • towels for insulation (optional, but recommended) • heat lamp and bulb • graduated cylinder or measuring cup • water • aluminum foil (to represent sea ice)

- Computers, or printouts of activities to complete while labs run
- Poster paper and markers (or computers to create digital presentations, if preferred)

Engage: Use *GPM Climate Change Inquiry Labs – Presentation* to show students a cartoon about Santa reading a newspaper about global warming and commenting about giving out lumps of coal (*slide 3*). Use it as a starting point to discuss what students have heard about climate change and global warming. Next, show students a graph of atmospheric carbon dioxide measured at Mauna Loa Observatory in Hawaii (*slide 4*) and ask them what they observe about the graph and what might have caused the change seen. Students will probably be able to make the connection between the increasing use of cars, as well as increasing demands for electricity, often produced by coal-burning power plants. Carbon dioxide is the greenhouse gas on which humans have the most impact. While the data in the graph is from ground sources, NASA also monitors climate indicators from space.

"The heat-trapping nature of carbon dioxide and other gases was demonstrated in the mid-19th century. Their ability to affect the transfer of infrared energy through the atmosphere is the scientific basis of many instruments flown by NASA. Increased levels of greenhouse gases must cause the Earth to warm in response."

From http://climate.nasa.gov/evidence

Explore: Divide students into groups, which will become experts on one lab investigation and share results with the larger group (*slide 5-6).* See the Teacher Notes section later in this document for tips on the set-up and implementation of the labs. In addition, these labs could serve as a hands-on introduction to the *GPM Climate Change Online Interactive Lesson* – the combination of experimentation and computer research could then be presented in the posters.

- Melting Ice and Sea Level Rise (adapted from http://serc.carleton.edu/eslabs/cryosphere/7a.html) Students will investigate whether melting land ice or sea ice will have a greater impact on sea level rise. For detailed instructions, see *GPM Climate Change – Melting Ice and Sea Level Rise Lab*. While the experiment runs, students can explore interactive maps (or printouts) of areas that might be affected by sea level rise while experiment runs. (http://www.pbslearningmedia.org/asset/ess05_int_icemelt/)

- Carbon Dioxide and Air Temperature (adapted from Glory and Global Warming Experiment http://glory.gsfc.nasa.gov/globalwarmingexperiment.html and Astro-Venture Greenhouse Gases Modeling Activity, http://astroventure.arc.nasa.gov/teachers/pdf/AV-Atmoslesson-3.pdf). Students will compare the temperature increase in two containers – one simulating greenhouse gases, one without. (NOTE: The plastic wrap is representing carbon dioxide in the model used for the experiment. Greenhouse gases don't hold in heat exactly the same way as the plastic wrap, but using various methods of adding actual carbon dioxide doesn't produce consistent results in the small scale.) For detailed instructions, see *GPM Climate Change – Carbon Dioxide and Air Temperature Lab*. While the experiment runs, students can explore their own carbon footprint on two different websites, http://www.footprintnetwork.org/en/index.php/GFN/page/personal_footprint/ and http://www.nature.org/greenliving/carboncalculator/index.htm.

- Sea Ice and Ocean Temperature. Students will compare the water temperature in two bins – one representing open ocean after all the sea ice has melted, one partially blocked by foil, representing the reflective sea ice. For detailed instructions, see *GPM Climate Change – Sea Ice and Ocean Temperature Lab.* While the experiment runs, students can read information about sea ice from the National Snow and Ice Data Center (http://nsidc.org/cryosphere/seaice/index.html) and explore an interactive map of predicted arctic sea ice (http://ngm.nationalgeographic.com/2007/06/vanishing-sea-ice/sea-ice-interactive) and learn about Inuit terms and knowledge of sea ice (http://sikuatlas.ca/sea_ice.html)

You will likely need to duplicate the labs and have several groups complete the same experiment, depending on your class size.

Explain:
After the experiments are complete, students will make posters outlining the problem they have researched – including data from their experiment, how it relates to the real world, as well as relevant data from NASA or other sources. You could have each group create a poster, or have individuals complete their own, in class or as homework. If computers are available, electronic presentations could be created instead of posters. Students should use the rubric (*slide 7* and at the end of this document) to guide them as they create the posters. The *GPM Climate Change Inquiry Labs – Student Capture Sheet* has space for students to make notes about each of the three topics when they are presented. Depending on the time you have available, you could have each group do an oral presentation to the class, divide students into smaller groups (each with a student who completed each experiment) to share the information as experts, or display the posters for a gallery walk.

Also in the presentation are videos to supplement student explanations from the posters.

- A Warming World - http://www.youtube.com/watch?v=fv11W5OODeM (*slide 8)*
- Melting Ice, Rising Seas - http://www.youtube.com/watch?v=VEuEqgdJXHg (*slide 9*)

The slides have questions for the students to think about while they watch, and there is space on the *Student Capture Sheet* for them to write the answers. See the notes of the PowerPoint for possible suggested answers.

Evaluate:
The rubric at the end of this document can be used to evaluate the posters.

Elaborate/Extend:

- One of the concerns with rising sea level is the increased severity of storm surges (*slide 11)*. See http://www.examiner.com/article/hurricanes-101-what-is-storm-surge for an explanation and animation of the problem.
- The video "NASA Real World – JASON-2" shows how the satellite, Jason 2, is able to use radar waves to determine the height of sea levels and evaluate the effects of global warming (*slide 12)*. http://www.nasa.gov/audience/foreducators/nasaeclips/search.html?terms=%22jason-2%22&category=0100
- For another explanation of how NASA studies oceans, see "Climate Change and the Global Ocean" (*slide 13)*, http://svs.gsfc.nasa.gov/goto?10502 or http://www.youtube.com/watch?v=BLR-DtxfHPY
- Have students calculate their water usage in addition to carbon footprint (from Carbon Dioxide and Air Temperature Lab). Several options for website to use:
  - http://environment.nationalgeographic.com/environment/freshwater/change-the-course/water-footprint-calculator/
  - http://www.gracelinks.org/1408/water-footprint-calculator,
  - http://www.saveourh2o.org/water-use-calculator

Teacher Notes:

- For differentiation purposes, the Melting Ice and Sea Level Rise Lab is the simplest and most fool-proof, so most suited to students with the least practice with lab skills.
- If you can use digital thermometers or temperature probes, they will work best, as the temperature differences between the two containers in both the Sea Ice and Ocean Temperature and Carbon Dioxide and Air Temperature can be only a few degrees (or even less than a degree in some trials attempted by the author.)
- For Sea Ice and Ocean Temperature, using relatively small containers (such as cut open, quart-sized cardboard cartons) and a relatively small amount of water (200 mL in those containers), as well as insulating the outside of the containers (cloth or towels wrapped around the outside and taped on) seemed to help. If you have longer than 30 minutes to leave the experiments set up, that will also help, but do be aware of the heat generated by heat bulbs, and make sure nothing gets near the bulb to burn.
- Sample results from the Sea Ice and Ocean Temperature Lab, set-up as pictured below: (200 watt incandescent bulb, about 25 cm from top of cartons, 200 mL of water in each carton)

Trial 1	Starting temperature	After 30 minutes	Change in temperature
No sea ice	26.4	32.1	5.7
Half sea ice (simulated by aluminum foil)	26.2	30.9	4.7

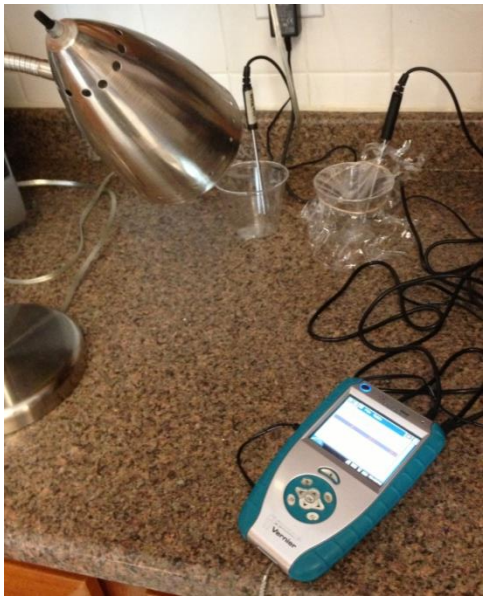
Trial 2	Starting temperature	After 30 minutes	Change in temperature
No sea ice	26.0	31.8	5.8
Half sea ice (simulated by aluminum foil)	26.1	31.4	5.3

Trial 3	Starting temperature	After 30 minutes	Change in temperature
No sea ice	22.0	25.5	3.5
Half sea ice (simulated by aluminum foil)	22.1	25.7	3.6

- Sample results from Carbon Dioxide and Air Temperature Lab, set up as pictured below: (200 watt light bulb, about 20 cm from the cups)

Trial 1	Starting temperature	After 30 minutes	Change in temperature
Regular air	29.3	32.8	3.5
Air with simulated CO_2 (covered with plastic wrap)	29.4	34.7	5.3

Trial 2	Starting temperature	After 30 minutes	Change in temperature
Regular air	24.1	32.2	8.1
Air with simulated CO_2 (covered with plastic wrap)	24.2	30.5	6.3



Additional Resources:

- For an interesting look at perceptions of climate change, see The Yale Project on Climate Change Communication, specifically, http://environment.yale.edu/climate-communication/files/Six-Americas-September-2012.pdf
- For another version of the carbon dioxide and temperature lesson, you can try http://www.srh.noaa.gov/jetstream/atmos/ll_gas.htm (although results seemed inconsistent when tested for the development of this lesson plan)

Name: _____ Date: _____ Period: _____

Climate Change Project Rubric

	Advanced (4)	Proficient (3)	Partially Proficient (2)	Basic (1)	
Content					
What is happening?	• Includes details about what is happening and who/what is affected. • Explanations are clearly written and make sense. • Evidence from the experiment or other sources is included.	• Some details are included, but explanations may not be as clear or insufficient evidence is given.	• Many details or evidence is lacking, or writing is very unclear, but the general picture comes across.	• An attempt is made to answer the question, but very little effort is shown.	x 2 =
Why is it happening?	• Explains the causes of what is happening and what we can do about it • Explanations are clearly written and make sense. • Evidence from the experiment or other sources is included.	• Some details are included, but explanations may not be as clear or insufficient evidence is given.	• Many details or evidence is lacking, or writing is very unclear, but the general picture comes across.	• An attempt is made to answer the question, but very little effort is shown.	x 2 =
Presentation					
Visuals	• Includes 2-3 pictures that clearly show what is happening and why. • If images are printed (not hand-drawn), citations are included.	• Includes 2-3 pictures, but may not be best ones to illustrate topic. • If images are printed (not hand-drawn), citations are included.	• Includes too few or completely irrelevant pictures, or citations are missing or incorrect.	• No pictures included.	x 1 =
Neatness	• Neatly drawn and written. • Very few errors in grammar or spelling. • Makes the viewer say "wow, that's great!"	• Neatly drawn and written. • Very few errors in grammar or spelling.	• Shows a lack of effort to be neat, or many distracting errors in grammar or spelling	• Shows poor effort at neatness and/or excessive errors in grammar or spelling.	x 1 =

Rubric Pts	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5 or fewer
% Grade	100	98	96	94	92	90	88	86	84	82	80	78	76	74	72	70	68	64	60	50