Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts

Lesson Plan for Grades: High School Science and Math **Length of Lesson:** 90 Minutes
Authored by: UT Environmental Science Institute **Date created: 4**/1/2023
Subject area/course: • Earth Science
Materials: • CO_2 Temperature Trends Table • Graphing Paper • Exploring CO_2 and Temperature Trends Questions
TEKS/SEs: **§112.6. Science, Grade 4** (6) Earth and space science strands. ESS has three strands used throughout each of the three themes: systems, energy, and relevance. • (C) Relevance. The interacting components of Earth's system change by both natural and human-influenced processes. Natural processes include hazards such as flooding, earthquakes, volcanoes, hurricanes, meteorite impacts, and climate change. Some human influenced processes such as pollution and non-sustainable use of Earth's natural resources may damage Earth's system. Examples include climate change, soil erosion, air and water pollution, and biodiversity loss. The time scale of these changes and their impact on human society must be understood to make wise decisions concerning the use of the land, water, air, and natural resources. Proper stewardship of Earth will prevent unnecessary degradation and destruction of Earth's subsystems and diminish detrimental impacts to individuals and society. • (I) Communicate valid conclusions supported by data using several formats such as technical reports, lab reports, labeled drawings, graphic organizers, journals, presentations, and technical posters.
Lesson objective(s): • To enable students to graph past and present carbon dioxide concentrations and Earth's temperature trends on a double line graph. • To encourage students to analyze the graph and identify patterns that emerge from the data. • To deepen students' understanding of the implications of present carbon dioxide concentrations in the atmosphere and the potential consequences of climate change. • To familiarize students with the use of ice core data as a tool for understanding past climate changes. • To promote critical thinking and scientific inquiry skills by asking analysis questions that require students to apply their knowledge and interpret data. • To provide students with graph paper to facilitate their graphing and analysis of the data. • To provide students with answer keys to help them check their work and assess their understanding of the concepts covered in the activity.
Differentiation strategies to meet diverse learner needs: • The teacher should ask students whether they prefer to read or watch videos to learn about concepts; then have students learn in their preferred learning style. However, the teacher may assign students certain methods to improve their skills. For example, if a student prefers

Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts

reading, teachers may have them watch a video and take notes to improve their listening skills.

- ELL students and students with learning disabilities should have multiple forms of instruction including visual and written instruction sheets as well as a verbal instruction and demonstration.

ENGAGEMENT (10 minutes)

- To begin the lesson, the teacher will show pictures from Dr. Persad's *Hot Science – Cool Talk* slides, which can be found in the *Engagement Handout* section. The slides contain information on increasing temperatures in Austin, a photo from hurricane Harvey, and CO_2 trends from the Mauno Loa observatory (sourced from the NOAA). After displaying these images, the teacher will ask students to discuss with a partner what they think could be causing these changes in temperatures and intense weather events like hurricanes like hurricane Harvey.
- Once students have discussed their ideas, the teacher will ask for volunteers to share their thoughts with the class.
- The teacher will then introduce the topic of climate change, explaining that it is the gradual warming of the Earth's surface caused by an increase in greenhouse gases such as carbon dioxide.

QUESTIONS: Have you been keeping up with the recent natural disasters making headlines? It's alarming to see the intensity and frequency of these events. But have you ever thought about their impact on the environment? What steps can we take to reduce their intensity and limit their damage to our planet? And most importantly, what can we do to prevent climate change from exacerbating these disasters in the future?

EXPLORATION (45 minutes)

- In pairs or small groups, students will analyze a data set that shows carbon dioxide emissions and temperature trends over time. They will look for patterns and trends and make predictions about what happened during that time. The teacher will provide guidance and instructions on how to graph the data set using a blank example graph projected in class.
- After analyzing the data set, students will discuss their findings and reflect on what they learned about carbon dioxide emissions, temperature trends, and how they relate to climate change. They will work together to create a graph of the data set and use it to validate their predictions on when ice ages occurred.
- During this time, the teacher will allow for student-directed learning while remaining highly engaged, asking questions of the students one-on-one or while they work in groups. They will also be available to answer any questions and provide guidance as needed.
- At the end of the *Exploration* activity, the teacher may bring the class together for a discussion of their findings. They may ask students to share their predictions and explain how they arrived at their conclusions. They may also ask students to reflect on what they learned about carbon dioxide emissions and temperature trends, and how this information is relevant to our understanding of climate change.

EXPLANATION (25 minutes)

- The teacher will distribute the "Exploring CO_2 and Temperature Trends" worksheet to the groups, allowing them 15-20 minutes to complete it. Then, the teacher will facilitate a discussion in which groups can share their answers and how they arrived at them.

- Throughout the explanation section, the teacher will ask higher-order thinking questions during the discussion to help students connect their exploration to the concept being examined and to support their explanations.
- By the end of the explanation section, students should have a clear understanding of the relationship between carbon dioxide emissions, temperature trends, and ice ages, as well as a broader understanding of climate change and global warming.

ELABORATION (15 minutes)
- During the exploration and explanation activity, students have had the opportunity to examine a data set that includes carbon dioxide emissions, year, and temperature trends. They have: noticed the correlation between temperature trends and carbon dioxide emissions, created a graph illustrating what these trends look like, and answered questions relating to these connections and data.
- The teacher will lead a classroom conversation to assist students in linking their thoughts to the subject of climate change. To start, the teacher will display a slide from Dr. Persad's presentation, addressing the impacts of rising temperatures on the Earth and humanity. Once the slide is presented and explained, students will be asked to discuss, in small groups, their observations from the activity's dataset and how it relates to Dr. Persad's slide.
- <u>**Sample questions to foster discussion:**</u>
  - What was your initial reaction to the image presented by the teacher?
  - How does the data set from the activity relate to the information on Dr. Persad's slide?
  - In what ways do you think the temperature increases shown in the image can impact the planet and our daily lives?
  - How can we use the information from the activity and Dr. Persad's talk to better understand the concept of climate change?
  - What steps can we take as individuals and as a society to address the effects of climate change?
  - Are there any potential solutions or interventions you can think of that could mitigate the effects of climate change?
  - How do you think climate change will continue to impact our planet and future generations?
  - Do you feel like you have a better understanding of the connection between the data set and the concept of climate change after this discussion? Why or why not?
- The teacher will then ask higher-order thinking questions, such as: How do changes in carbon dioxide emissions affect temperature trends? What evidence do we have that ice ages have occurred in the past? What might be causing the current increase in carbon dioxide emissions? How might climate change affect different parts of the world?
- By asking these types of questions, the teacher will help students to justify their explanations and connect their observations to the larger concept of climate change. The teacher will also introduce key terms and concepts, such as the greenhouse effect, and provide additional information to help students deepen their understanding of the topic.
- The teacher will encourage student participation and allow for student-directed learning during this time. The teacher may also provide additional resources for students to explore on their own, such as articles or videos about climate change.

Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts

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| **EVALUATION (throughout entire lesson)**
• Students will demonstrate that they have achieved the lesson objective by creating a graph of the data provided including the carbon dioxide emissions, year, and temperature trend. They will also need to accurately answer questions on their data table such as identifying the years in which ice ages occurred and identifying the highest and lowest temperature trends. The teacher will provide ongoing feedback to students as they work on the graph and answer questions.
• Students will submit their graph and data table worksheets for evaluation at the end of the lesson. The teacher will use a rubric to assess the accuracy and completeness of the students' graphs, as well as their ability to answer questions based on the data set. |
| **SOURCES AND RESOURCES**
• Dr. Geeta Persad *Hot Science – Cool Talks #124,* **"Climate Change: Science to Solutions",** www.esi.utexas.edu/talk/climate-change-science-to-solutions/
• NOAA Mauna Loa Observatory Data for Carbon Emissions and Temperature Anomaly, www.temperaturerecord.org/ |

Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts
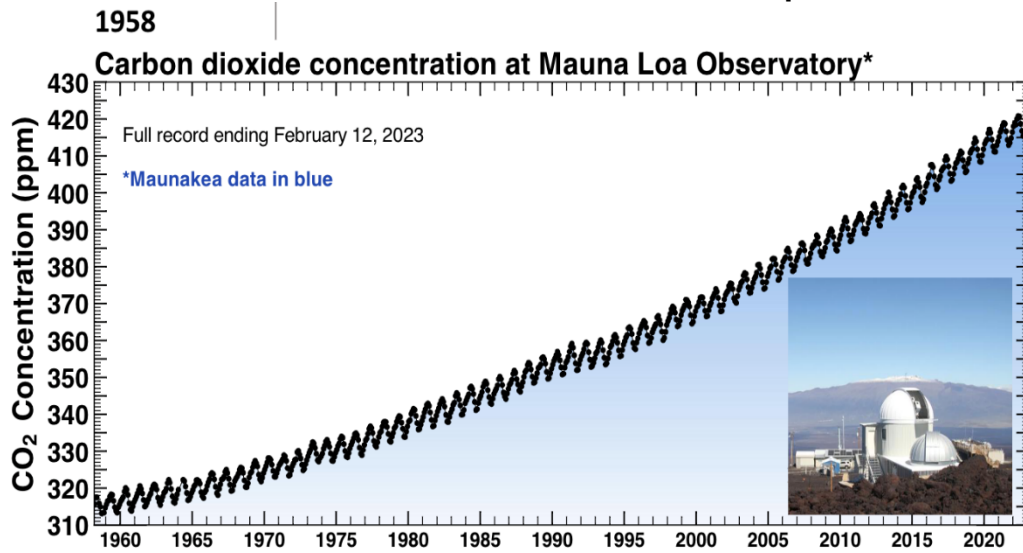
Teacher Resource for Engagement:
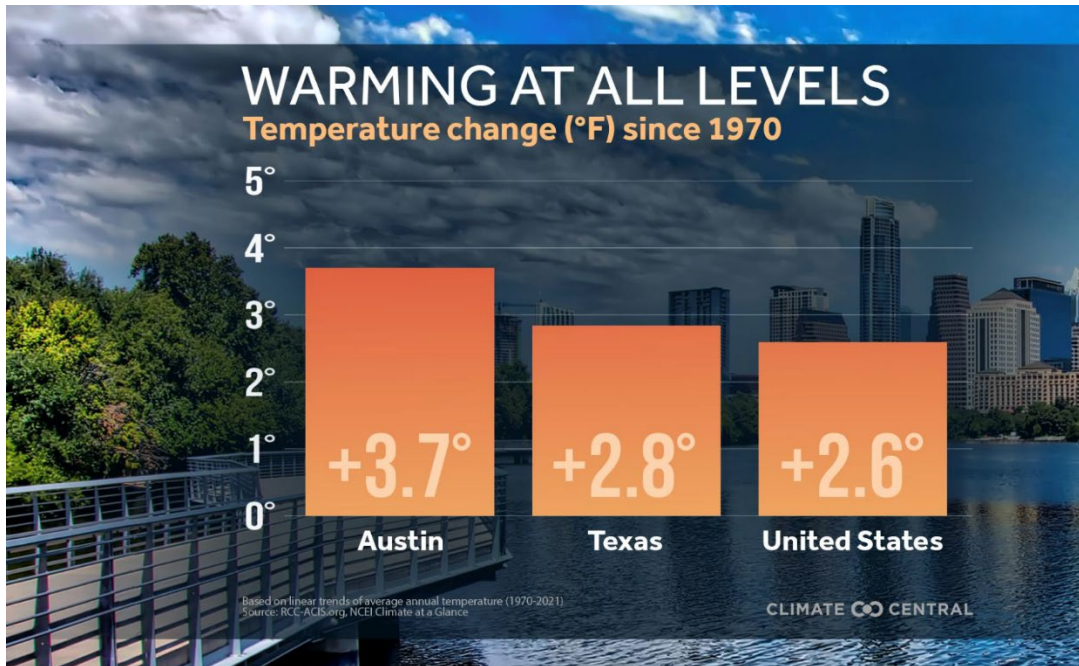
Source: Dr. Geeta Persad Hot Science Cool Talks, "Climate Change: Science to Solutions"

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Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts

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Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts
<u>**Student Handout for Exploration:**</u>

<u>CO_2 Temperature Trends</u>

The table below shows information from the NOAA's Mauna Loa Observatory about how much carbon dioxide (CO_2) was in the atmosphere and how much warmer or colder the Earth's temperature was compared to the period of 1850 to 1900. This period is important because it represents a time when human industrial activity was low, and the climate was relatively stable. Scientists use this period as a reference point to compare current and future temperature changes.

To analyze the data, create a graph that looks like the example graph given by your teacher. Then, you can answer the two questions at the bottom of the sheet.

Year	CO_2 Emissions (ppm)	Temperature Anomaly ($^{\circ}$C)
1000	280	0.07
1050	281	-0.08
1100	283	0.25
1200	284	-0.21
1300	283	-0.48
1350	282	-0.33
1450	281	-0.63
1500	282	-0.60
1600	276	-0.77
1700	277	-0.57
1750	277	-0.3
1800	283	-0.28
1850	285	-0.31
1950	311	-0.16
2000	367	0.58
2010	390	0.64
2020	414	0.88

1) At what point in time did the temperature reach its highest value in the data set?

2) At what point in time did the temperature reach its lowest in the data set?

Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts

<u>**Student Handout for Explanation:**</u>

<u>Exploring CO_2 and Temperature Trends Questions</u>

1) What is the relationship between the CO_2 emissions and temperature trends in the dataset provided?

2) How have CO_2 emissions changed since the year 1000 and what impact has this had on temperature trends?

3) How has Earth's temperature changed over time, and what factors might have contributed to these changes?

4) What is the significance of the CO_2 emissions level in the year 2020, and what are the potential consequences of this level on future temperature trends?

5) How does the rate of change of CO_2 emissions compare to the rate of change of temperature trends over time?

6) What are some possible solutions to reducing CO_2 emissions and mitigating the effects of climate change?

7) How have human activities contributed to the changes in CO_2 emissions and temperature trends over time?

8) What are the potential consequences of continued increases in CO_2 emissions and temperature trends for ecosystems and human societies?

9) What are some natural factors that can impact CO_2 emissions and temperature trends, and how do they compare to human-caused factors?

Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts

Teacher Handout: Example Graph for Exploration

Ask your students to create a graph with specific guidelines. Label the x-axis with the years, and the primary y-axis with the numbers for CO_2. Additionally, include a secondary y-axis with the numbers for temperature trends. The data for the axes is the same data on their data table. Instruct students to use color-coding to show how temperature and CO_2 levels vary over the years. Ensure that they include two different lines on the graph to represent these data trends.
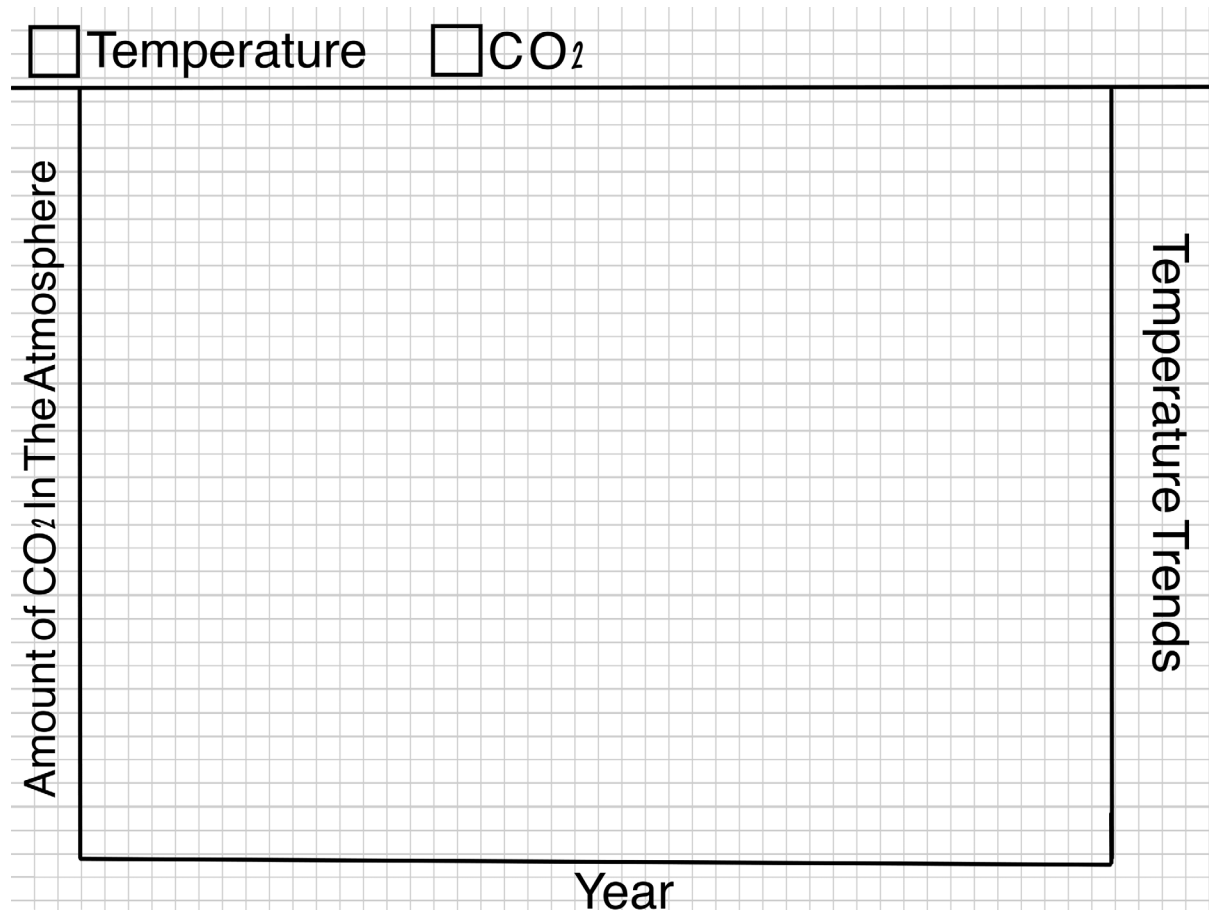
☐Temperature   ☐CO₂

Amount of CO₂ In The Atmosphere

Temperature Trends

Year

Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts
Teacher Handout: Answer Keys for Exploration and Explanation

CO_2 Temperature Trends

1) At what point in time did the temperature reach its highest value in the data set?

   The temperature reached its highest value in 2022 (.88 ºC increase)

2) At what point in time did the temperature reach its highest value in the data set?

   The lowest temperature anomaly value recorded was -0.77 ºC, and it was reached in the year 1600.

Exploring CO_2 and Temperature Trends Questions

1) What is the relationship between the CO_2 emissions and temperature trends in the dataset provided?

   The dataset shows a correlation between the rise in CO_2 emissions and an increase in Earth's temperature. As the levels of CO_2 in the atmosphere increase, the temperature of the Earth also increases.

2) How have CO_2 emissions changed since the year 1000 and what impact has this had on temperature trends?

   Since the year 1000, CO_2 emissions have steadily increased, with a more rapid increase in recent years. This increase in CO_2 emissions has contributed to the warming of the Earth's temperature, as indicated by the positive temperature anomaly values in the dataset.

3) How has Earth's temperature changed over time, and what factors might have contributed to these changes?

   Earth's temperature has varied over time, with some periods being colder or warmer than others. Factors that may have contributed to these changes include natural processes such as volcanic activity and changes in the Earth's orbit, as well as human activities such as burning fossil fuels and deforestation.

4) What is the significance of the CO_2 emissions level in the year 2020, and what are the potential consequences of this level on future temperature trends?

Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts

The CO_2 emissions level in the year 2020 was 414 ppm, which is the highest level recorded in the dataset. This level of CO_2 emissions could lead to further increases in Earth's temperature and potentially more severe consequences of climate change, such as rising sea levels, more extreme weather events, and loss of biodiversity.

5) How does the rate of change of CO_2 emissions compare to the rate of change of temperature trends over time?

The rate of change of CO_2 emissions has increased more rapidly in recent years, whereas the rate of change of temperature trends has also increased but at a slightly slower pace.

6) What are some possible solutions to reducing CO_2 emissions and mitigating the effects of climate change?

Some possible solutions to reducing CO_2 emissions and mitigating the effects of climate change include transitioning to renewable energy sources, improving energy efficiency, and implementing policies and regulations to reduce greenhouse gas emissions.

7) How have human activities contributed to the changes in CO_2 emissions and temperature trends over time?

Human activities such as burning fossil fuels and deforestation have contributed significantly to the changes in CO_2 emissions and temperature trends over time.

8) What are the potential consequences of continued increases in CO_2 emissions and temperature trends for ecosystems and human societies?

The consequences of continued increases in CO_2 emissions and temperature trends for ecosystems and human societies include more severe weather events, loss of biodiversity, and disruption of food systems and water supplies.

9) What are some natural factors that can impact CO_2 emissions and temperature trends, and how do they compare to human-caused factors?
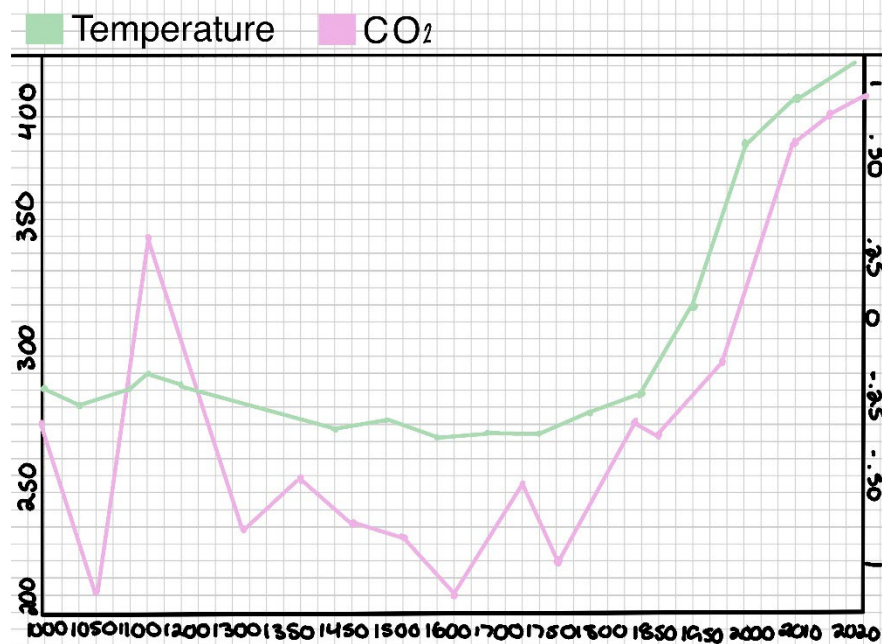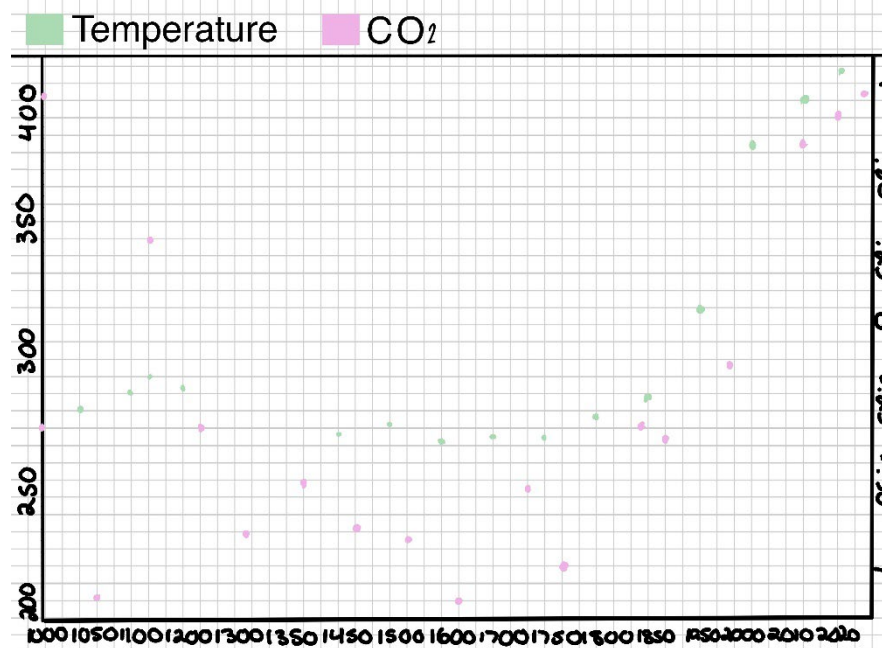
Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts

Natural factors that can impact CO_2 emissions and temperature trends include volcanic activity, changes in solar radiation, and natural cycles such as El Niño. However, human-caused factors such as burning fossil fuels are currently the primary contributors to climate change.

Rubric for Graph

Make sure student's graph have the following form(s):
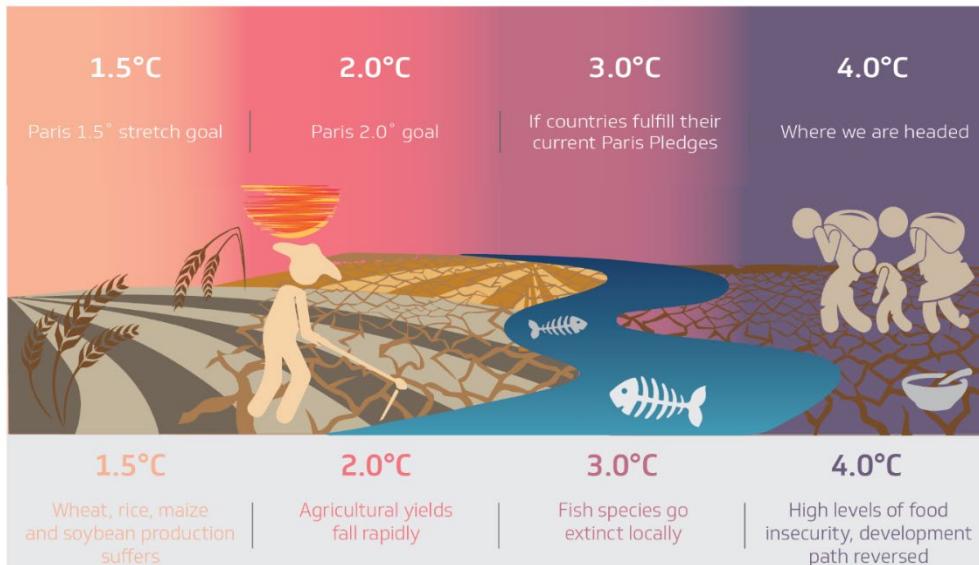

For full credit, students must have the correct graph trend demonstrated as above

Rising Temperatures and Climate Change: Exploring the Connections Between Data Sets and Real-World Impacts

Teacher Resource for Elaboration

Every bit of climate action helps

Source: Dr. Geeta Persad Hot Science Cool Talks, "Climate Change: Science to Solutions"