

# Indiana's Temperature: How Hot Will It Get?

## Key Concepts:

- ✓ Climate
- ✓ Weather
- ✓ Greenhouse gases
- ✓ Carbon dioxide
- ✓ Global warming
- ✓ Temperature

## WHAT YOU WILL LEARN

1. You will learn about the relationship between greenhouse gases and the Earth's temperature.
2. You will analyze past temperature data for Indiana to determine how greenhouse gas emissions have impacted the state's temperature.
3. You will analyze predicted temperature data for Indiana that is based on different greenhouse gas emission scenarios.

## *Engage Your Thinking*

Global carbon dioxide emissions are causing the Earth's temperature to increase. This global warming is changing the Earth's climates. In this activity you will analyze temperature data for the state of Indiana to determine how global warming is impacting Indiana's atmospheric temperature. Before starting the activity, however, answer the following questions based on what you currently know and think.

1. How would you explain the relationship between atmospheric greenhouse gases and the Earth's temperature?
2. Indiana's current annual average temperature is 51.7°F. Annual average temperature is determined by adding the temperature measurement for each day of the year divided by the number of day's in the year. What do you think the annual average temperature will be for Indiana for the time periods listed below?
  - a) 2041-2070:
  - b) 2071-2100:
3. Explain why you think this?
4. How do you think future global carbon dioxide emissions will impact Indiana's annual average temperature? Explain your thinking.

## Explore and Explain

Atmospheric carbon dioxide and Earth's surface temperature (1880-2019)

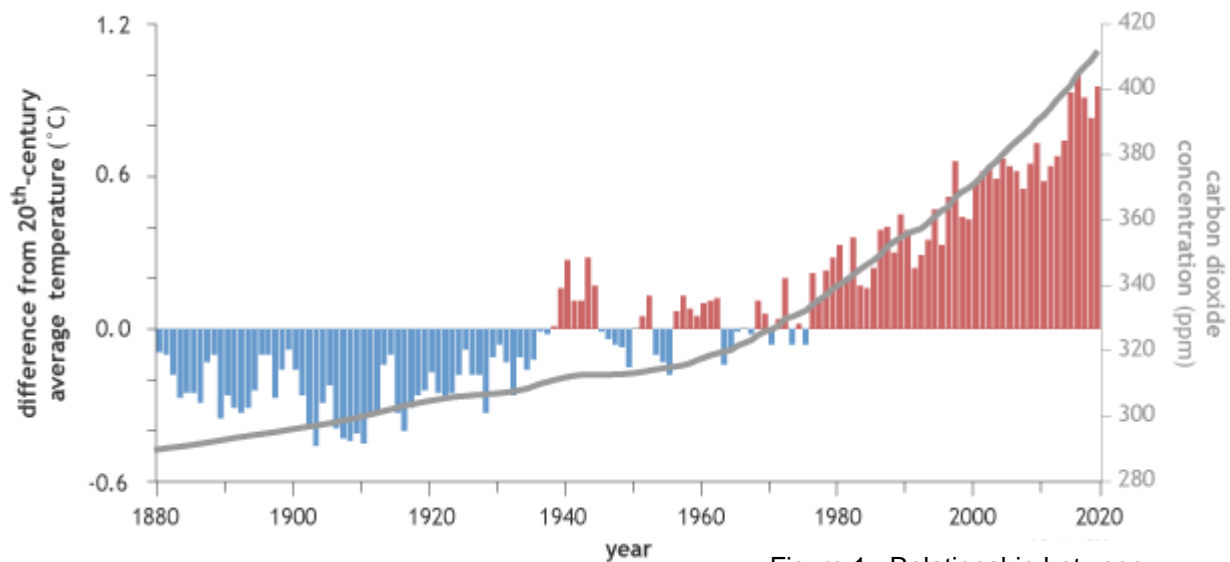


Figure 1. Relationship between temperature and atmospheric carbon dioxide levels. Source: NOAA

Global greenhouse gas emissions, which carbon dioxide is the main greenhouse gas, have been increasing since the industrial revolution (1800s). This has caused the Earth's temperature to increase (Figure 1). This human caused temperature increase is called global warming.

**Think about it:** Making sense of the data shown in Figure 1. The temperature graph shows the yearly difference (blue and red bars) from the average temperature for the time period 1880 to 2019. Annual temperatures that are warmer than average are shown in red while temperatures that are colder than average are shown in blue. The gray line shows the concentration of atmospheric carbon dioxide. Look at the temperature and carbon dioxide graph (data) shown in Figure 1.

- What relationship do you see between the Earth's temperature and carbon dioxide levels?
- If carbon dioxide levels continue to increase, explain how that might impact the Earth's future temperature?

Because temperature drives the weather, scientists use temperature as a key indicator of climate and climate change. Climate is the average temperature (or other weather condition) for a location for a 30-year time period. Looking at annual temperature data for at least 30 years or longer makes it easier to identify changes and trends in climate over time.

Not only is the Earth's temperature changing, so too is Indiana's annual average temperature (Figure 2).

### Weather vs. Climate

The difference between weather and climate is a matter of scale. Weather is the short-term (hours, days, weeks) conditions of the atmosphere. Weather fluctuates from day-to-day and season-to-season. Climate is the average in weather over a 30 year or longer time period. It is the "smoothing" of the variation in weather.

**Think about it:** Look at the temperature data for Indiana shown in Figure 2. How has Indiana's annual average temperature changed?

a) Between 1895 and 2019? (Hint look at the solid trend line)

b) Between 1960 and 2019? (Hint look at the dashed trend line)

c) Based on this data what can you say about Indiana's annual average temperature?

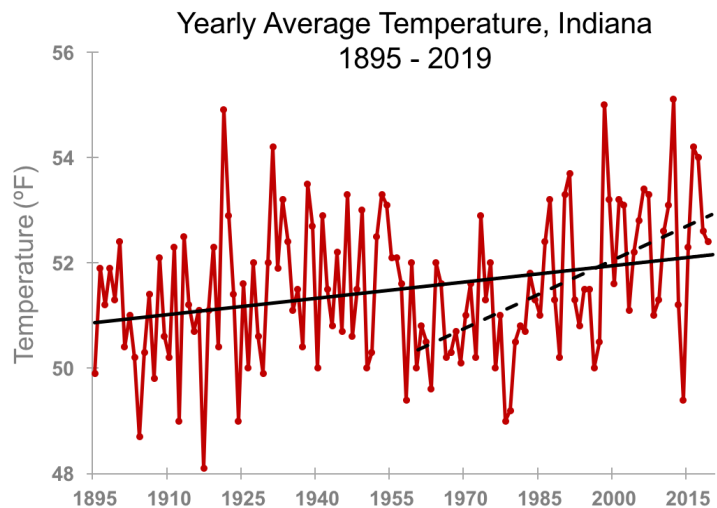


Figure 2. Annual Average Temperature (1895-2019). Average annual temperature is shown in red. Solid black line shows average temperature trend for 1895 to 2019. Dashed line shows average temperature trend for 1960 to 2019. Source: NOAA Climate at a Glance Database.

## Indiana's Temperature

Table 1. Change in Indiana's Average Temperature, 1895 to 2019.

Temp/Season	Winter	Spring	Summer	Fall	Annual
Average High Temp	1.3°F	1.4°F	-1.7°F	0.1°F	0.3°F
Average Temp	2.0°F	1.9°F	0.0°F	0.9°F	1.3°F
Average Low Temp	2.8°F	2.4°F	1.8°F	1.9°F	2.3°F

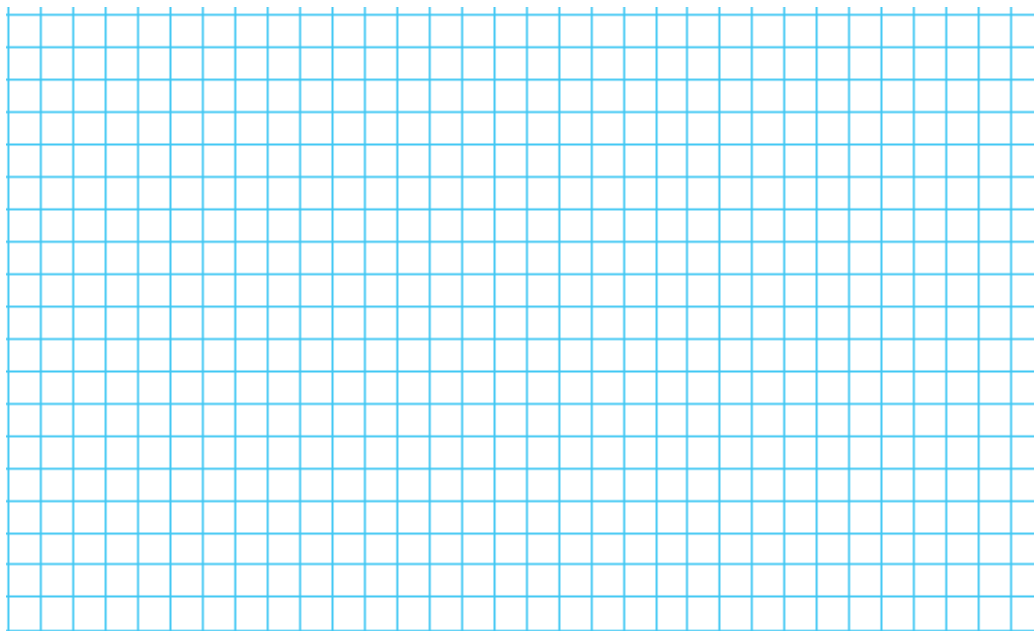
Table 2. Change in Indiana's Average Temperature, 1960 to 2019.

Temp/Season	Winter	Spring	Summer	Fall	Annual
Average High Temp	3.7°F	2.9°F	0.4°F	0.9°F	2.1°F
Average Temp	4.3°F	2.9°F	1.5°F	1.4°F	2.6°F
Average Low Temp	4.9°F	2.8°F	2.7°F	1.8°F	3.1°F

As you might guess, Indiana's temperature varies by season. The change or trend in this seasonal temperature over the years is shown in Tables 1 and 2. The tables also show the change in the average high and average low temperature for each season during the time period covered by each table.

**Think about it:** Making sense of Tables 1 and 2. Scientists make sense of data by analyzing and interpreting the data, looking for patterns and trends. Next, scientists construct explanations using scientific concepts and principles that explain the patterns and trends observed in the data.

- a) Scientists often create graphs to visualize data, making it easier to see trends and patterns. In the space below graph the data shown in Tables 1 and 2.





## Extend Your Thinking

You have investigated and learned about how greenhouse gases, such as carbon dioxide, impact global temperature and how Indiana's temperature has changed, but what does the future hold for Indiana? How hot will Indiana get? How might a continued increase in atmospheric greenhouse gases impact Indiana's future annual average temperature? To answer these questions scientists ran computer models that used different greenhouse gas emission scenarios. By inputting different emission scenarios (medium and high), the computer models made temperature predictions based on different levels of atmospheric carbon dioxide. The scientists used different computer models and average the results to make better predictions. The predicted changes in Indiana's annual average temperature under different greenhouse gas emission scenarios and over different time periods is show in Table 3. This data shows the increase in temperature above the average temperature from the 1971-2000 time period. Looking at the data in Table 3, for the medium emission scenario, it is predicted that Indiana's average spring temperature for the period 2041-2070 will be 4.2F warmer than the 1971-2000 average.

### What are Scenarios?

Scenarios are like stories that are based on scientific data and principles. They are developed to predict levels of greenhouse gas emissions based on different demographic, social, economic, political, technological, and environmental factors. These predicted levels of greenhouse gas emissions are then used to predict future global temperatures. These emission scenarios are often classified as low, medium, and high greenhouse gas emissions.

### About the Emission Scenarios

To achieve the medium scenario, global greenhouse gas emissions must be significantly reduced almost immediately and peak in the 2040s before declining. Under the high scenario, greenhouse gas emissions continue to increase until late this century. We are currently on, or near, the high emissions path (Source: IN CCIA).

GHG Scenarios	Time Periods	Winter (°F)	Spring (°F)	Summer (°F)	Fall (°F)	Annual (°F)
Medium Emissions	2011-2040	2.8	2.6	3.0	3.3	2.9
	2041-2070	5.1	4.2	5.1	5.1	4.9
	2071-2100	5.8	5.1	6.7	6.2	5.9
High Emissions	2011-2040	3.4	2.5	3.3	3.2	3.1
	2041-2070	6.2	5.1	7.0	6.5	6.2
	2071-2100	9.4	8.2	11.8	10.9	10.1

Table 3. Predicted Change in Indiana's Annual Average Temperature Over Time by Greenhouse Gas (GHG) Emission Scenario. The Average is Based on the Temperature from 1971-2000.

**Think about it:** Look at Table 3. What trends do you see in Indiana's future temperature based on the data?

- a) Overall, how does an increase in greenhouse gas emissions impact Indiana's temperature in the future?
  
- b) What season is the temperature predicted to increase the most? Why do you think that will happen?
  
- c) How does the emission scenario (the amount of greenhouse gasses emitted to the atmosphere) impact Indiana's future temperature over time?

What might this future increase in temperature look like in one city? Table 4 shows the current average high and low temperature for Indianapolis for each month of the year. If you are interested in the current average temperature data for your community go to the U.S. Climate Data website:

<https://www.usclimatedata.com/>. Use that data to answer the **Think About It** questions.

Table 4. The Current Average High and Low Temperature in °F for Indianapolis

Temp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg High	36	40	52	63	73	82	85	84	78	65	52	39
Avg Low	20	24	33	43	53	62	66	64	56	45	35	24

**Think about it:** Using the current average high and low temperature for Indianapolis (or your community) shown in Table 4 and the predicted trends in Indiana's temperature (Table 3) answer the following:



- a) What would the “new” average high and low temperature be for Indianapolis or your community in January (winter)?

Emission Scenario	2041-2070 Avg. Low	2071-2100 Avg. Low	2041-2070 Avg. High	2071-2100 Avg. High
Medium				
High				

- b) What would the “new” average high and low temperature be for Indianapolis or your community in July (Summer)?

Emission Scenario	2041-2070 Avg. Low	2071-2100 Avg. Low	2041-2070 Avg. High	2071-2100 Avg. High
Medium				
High				

- c) What would the “new” average high and low temperature be for Indianapolis or your community in October (Fall)?

Emission Scenario	2041-2070 Avg. Low	2071-2100 Avg. Low	2041-2070 Avg. High	2071-2100 Avg. High
Medium				
High				

- d) How do you feel about this change in Indianapolis’ or your community’s temperature? What health, environmental, or agricultural issues might this cause?

## *Apply What You Have Learned*

In the space below, create a concept map that demonstrates your understanding about the relationship between greenhouse gases (carbon dioxide), global warming, and Indiana's annual average temperature. This is an opportunity for you to show what you have learned from this activity.

## *Reflect on What You Have Learned*

Now that you have analyzed and thought about Indiana's temperature data, reflect on your answers to the Engage Your Thinking questions and explain how your ideas and thinking have changed.

5. Explain how your understanding about the relationship between atmospheric greenhouse gases and the Earth's temperature has changed?
  
  
  
  
  
  
  
  
  
  
6. How close were your predictions to that of the scientific projections for how much Indiana's annual average temperature would change for the years 2041-2070 and for 2071-2100? How would you explain the difference between your prediction and the scientific prediction?
  - a) 2041-2070:
  - b) 2071-2100:
  
  
  
  
  
  
  
  
  
  
7. How has your thinking changed about how Indiana's temperature will change in the future?
  
  
  
  
  
  
  
  
  
  
8. How has your thinking changed about the impact of global carbon dioxide emissions on Indiana's annual average temperature?