Indiana's Precipitation: Will It Be Wetter or Drier?

Key Concepts:

- ✓ Greenhouse gases
- ✓ Carbon dioxide
- ✓ Global warming
- ✓ Climate
- ✓ Weather
- ✓ Precipitation
- ✓ Water cycle

WHAT YOU WILL LEARN

1. You will analyze precipitation data for Indiana to determine how Indiana's precipitation patterns have changed over the years.
2. You will learn how global warming is impacting the local water cycle in Indiana.
3. You will think about how changes in precipitation will impact Indiana's environment, people, and agriculture.

Engage Your Thinking

Global carbon dioxide emissions (greenhouse gases) are causing the Earth's temperature to increase. This global warming is causing the Earth's climates to change, which is affecting Indiana's climate. In this activity you will analyze precipitation data for the state to determine how global warming is impacting Indiana's climate. Before starting the activity, however, answer the following questions based on what you currently know and think.

1. How do you think global warming will impact, change, the local water cycle in Indiana?

2. Currently, Indiana's average annual precipitation is 37 inches for northern Indiana and 47 inches for southern Indiana. By how much do you think the average annual precipitation will change for Indiana over the years? Will Indiana become drier or wetter by 2070 and 2100 and by how much?

    a) 2070:
    b) 2100:

3. Do you think this change will be the same throughout Indiana? Or do you think some areas of Indiana will be wetter or drier than other areas? Why do you think that?

4. How do you think this change in precipitation will impact Indiana's environment, agriculture, and people?

Explore and Explain

Global greenhouse gas emissions, which carbon dioxide is the main gas, are causing the Earth's temperature to increase. This human caused global warming is changing the Earth's climates, impacting temperature, precipitation, humidity, wind, and cloudiness of the atmosphere; the day-to-day weather, for any given area on the Earth, including Indiana.

Precipitation, water, plays a vital role in maintaining healthy ecosystems, societies, and people. Rain, snow, and snowmelt affect the amount of water available to plants and animals—all of life on Earth. And climate change is and will impact precipitation levels across the United States, affecting different states and regions of the country in different ways, including Indiana (Figure 1).

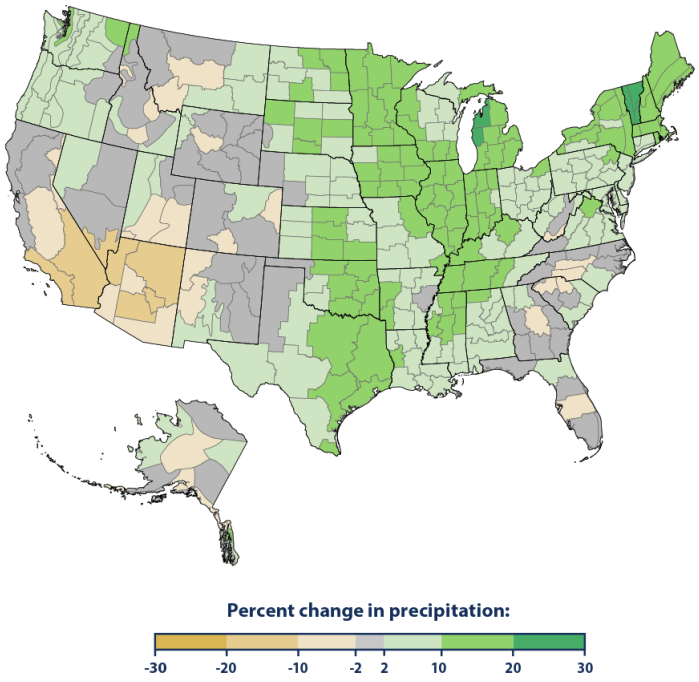

Figure 1. Changes in total annual U.S. Precipitation, 1901 to 2015. For Alaska the change is from 1925. Source: NOAA.

Think about it: Look at Figure 1. How has precipitation changed from 1901 to 2015 in the following regions: Northeast, Midwest, Great Plains, Southwest and Southeast? Have regions become drier or wetter over time? How might you explain these changes?

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.

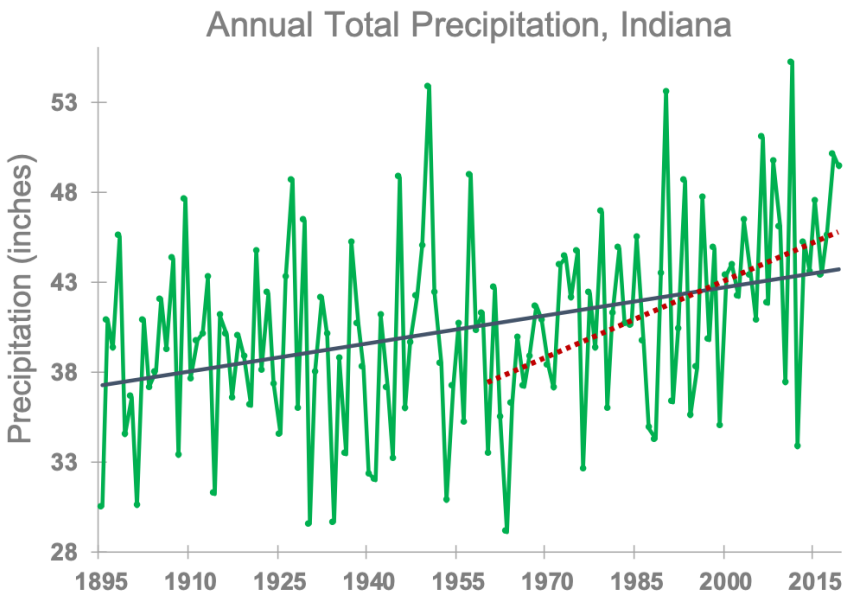

Figure 2. Statewide annual total precipitation for Indiana from 1895 to 2019. Black solid line shows the increasing trend in annual precipitation (0.52"/decade) for the period from 1895 to 2019. The red dotted line shows the precipitation trend since 1960 (1.4"/decade). Source: NOAA Climate at a Glance Database.

In the Midwest, precipitation is expected to become more intense, resulting in an increased threat of flooding, which will impact water quality and agricultural practices. But, how will global warming impact future precipitation in Indiana? How has Indiana's precipitation already changed? You will investigate these questions and others as you look at and analyze annual average precipitation data for Indiana. To study precipitation, scientists use the average daily precipitation from many locations within an area or region to determine annual average precipitation. Because climate is based on the average weather conditions for at least a 30-year period, scientists look at annual precipitation data for at least 30 years or longer to identify changes and trends in climate.

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

a) Between 1895 and 2019? (The solid trend line)

b) Between 1960 and 2019? (The dashed trend line)

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

Think about it: Indiana's annual average precipitation is about 37 inches per year in northern Indiana and about 47 inches per year in southern Indiana. If we assume that the 0.52-inch increase in annual precipitation per decade continues (Figure 2), what would the annual average precipitation be for each decade until the year 2100? What would the annual average precipitation be if we assume a 1.4-inch increase in annual precipitation per decade (Figure 2)? To answer the questions, complete the tables below.

0.52" Increase	2030	2040	2050	2060	2070	2080	2090	2100
Northern								
Southern								

1.4" Increase	2030	2040	2050	2060	2070	2080	2090	2100
Northern								
Southern								

Think about it: Based on your predicted data (Tables above), how might this change in precipitation impact Indiana's environment, people, rivers and lakes, and agriculture? See if you can come up with at least three possible impacts for each category in the table below.

Category	Possible Impacts
Environment	1. 2. 3.
People	1. 2. 3.
Rivers/Lakes	1. 2. 3.
Agriculture	1. 2. 3.

Which of your impacts do you think is the most important and why?

Indiana's annual precipitation has increased by about 15% or 6.5 inches since 1895 (Figure 2). As you might guess, Indiana's annual precipitation varies by region. The change in annual precipitation by region from 1895 to 2019 is shown in Figure 3.

Think about it: Look at Figure 3. What trends do you see in Indiana's annual average precipitation?

a) Overall, what does the data in Figure 3 tell you about the trend in Indiana's annual precipitation?

b) Which areas of the state would likely experience an increased threat of flooding due to climate change?

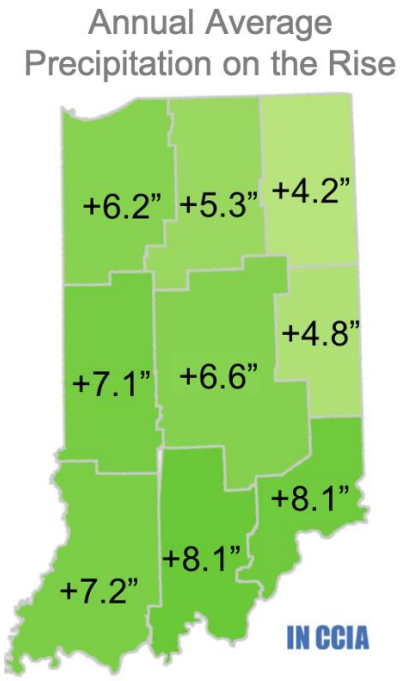

Figure 3. Increase in annual precipitation for Indiana's nine climate divisions, based on linear trend from 1895 to 2019. Source: NOAA Climate at a Glance.

Extend Your Thinking

How might a continued increase in atmospheric greenhouse gas concentrations impact Indiana's future precipitation? To answer this question scientists ran computer models that used different greenhouse gas emission scenarios. Scientists used different computer models and averaged the results to make a better prediction. Based on future emission scenarios, Indiana's annual precipitation is projected to increase by 6% to 8% by mid-century (2041-2070). This increasing precipitation, however, will not fall evenly across the entire year (Figure 4). So, what do these climate models project for Indiana's seasons?

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.

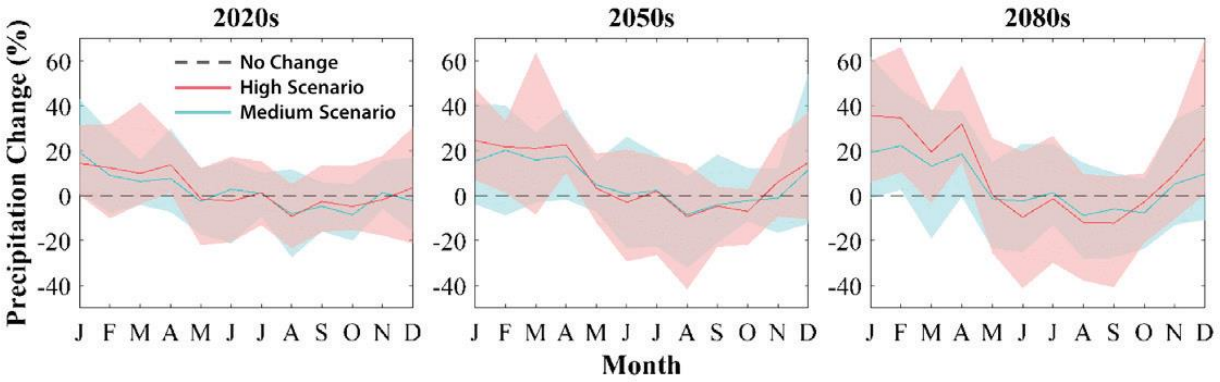

Figure 4. Projected changes in monthly average precipitation for the 2020s (2011-2040), 2050s (2041-2070), and 2080s (2071-2100). Historical baseline, zero, is based on precipitation from 1971 to 2000. The solid red and blue lines show the 10-model average for the high and medium emissions scenarios, respectively. Shaded areas show the corresponding range of results across the 10 climate models. Source: Hamlet et al. (2019).

Think about it. Look at the predicted change in average precipitation over time for the different emission scenarios shown in Figure 4.

a) What seasons, fall (Sept, Oct, Nov), winter (Dec, Jan, Feb), spring (March, April, May), or summer (June, July, Aug) suggest a greater increase in precipitation over time?

b) Based on the data, what seasons are likely to become drier over time?

c) What might these changes in precipitation mean for the state of Indiana? Its rivers and lakes, environment, agriculture, and people.

The climate models all predict a change in future precipitation over time for both emission scenarios. But what form of precipitation will this change take? Will it be in the form of rain taking the place of snow during winter or will it be more winter snow (Figures 5 and 6)?

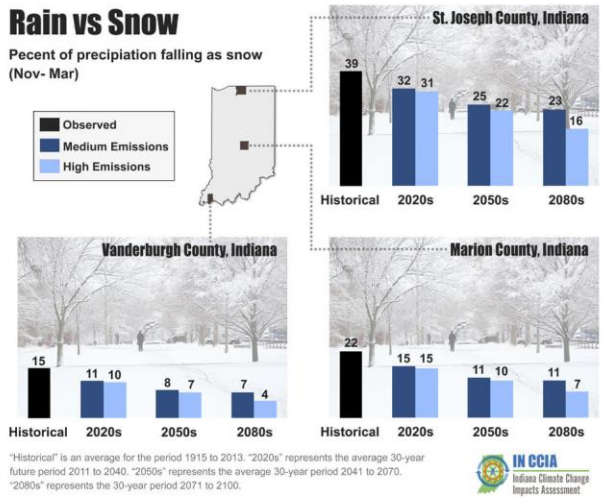

Figure 5. Percent of cold-season precipitation falling as snow for three Indiana counties. A value of 100 would mean that all precipitation from November to March fell as snow, while a value of 0 would mean none of the precipitation was snow. "Historical" is the average for the period 1915 to 2013. For future projections, "2020s" represents the average of the 30-year period from 2011 to 2040, "2050s" represents the average from 2041 to 2070, and "2080s" represents the average from 2070 to 2100. Source: Hamlet et al. (2019).

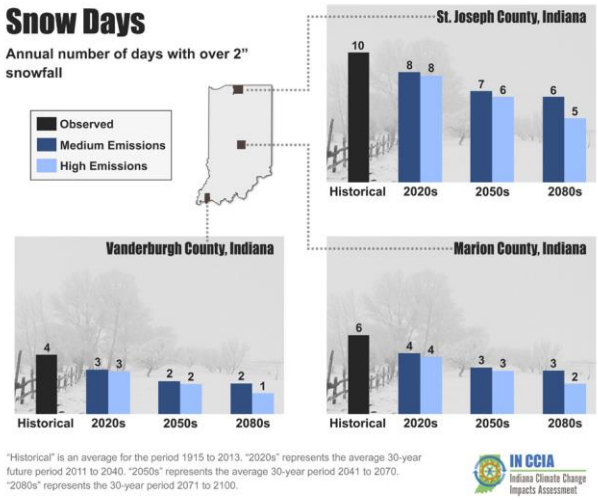

Figure 6. Number of days per year with more than 2 inches of snow for three Indiana counties. "Historical" is the average for the period from 1915 to 2013. For future projections, "2020s" represents the average of the 30-year period from 2011 to 2040, "2050s" represents the average from 2041 to 2070, and "2080s" represents the average from 2070 to 2100. Source: Hamlet et al. (2019).

Think about it: As Indiana becomes warmer, how does that impact the type of precipitation that falls on the ground? Look at Figures 5 and 6, how are Indiana winters expected to change and why?

As you now know, Indiana's future annual precipitation is going to increase because of global warming. This increased precipitation is more likely to fall as rain, instead of snow, during the winter and spring. In addition, there is likely to be an increase in extreme rain events, heavy downpours—more than 0.86 inches of rain in a day. The number of days of extreme rain events has been increasing since 1900 (Figure 7). Extreme rain events are expected to happen more often as Indiana's temperature increases throughout the century.

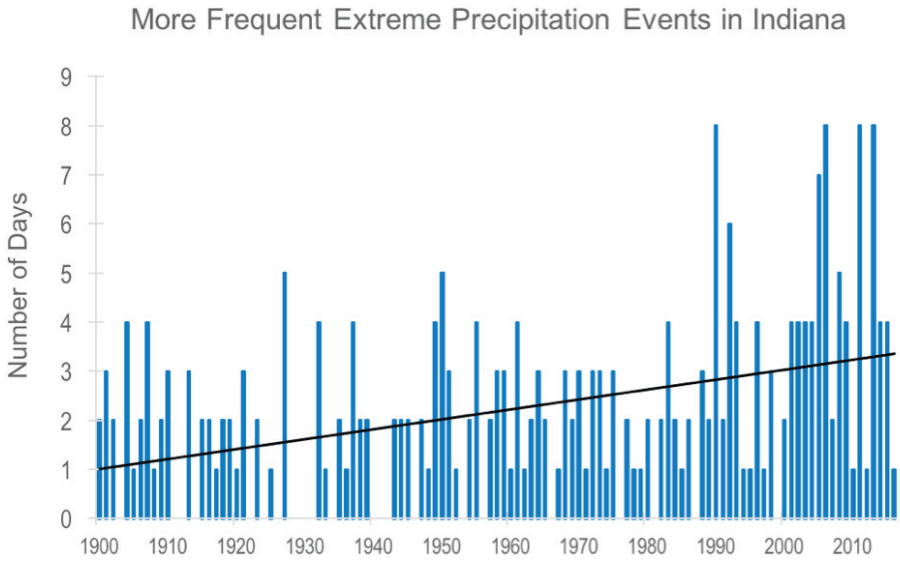

Figure 7. The statewide average number of days each year with extreme precipitation events from 1900 to 2016.The black line represents the trend line (0.2 days/ decade) for the 1900 to 2016 period. Source: Midwestern Regional Climate Center.

Think about it: Look at the extreme precipitation events for Indiana shown in Figure 7.

a) Based on the trend line how has the number of event days increased from 1900 to 2016?

b) Which timeframe (decade, 10-year span) has seen the greatest increase in the number of days of extreme rain events?

Think about it: There are pros and cons to fewer snow days and less snowfall, and more rain in winter and spring. In the T-chart below, list the pros and cons of this change in Indiana's precipitation. (Hint: Think about how it might impact transportation, agriculture, communities, environment, rivers, and people)

Pros	Cons

Apply What You Have Learned

Precipitation is a component of the water cycle as shown in Figure 8. In Indiana, precipitation primarily takes the form of rain and snow. As you learned in previous grades, the water cycle describes how water is stored and moved through the earth and atmosphere. The movement of water in and out of the atmosphere influences local weather patterns.

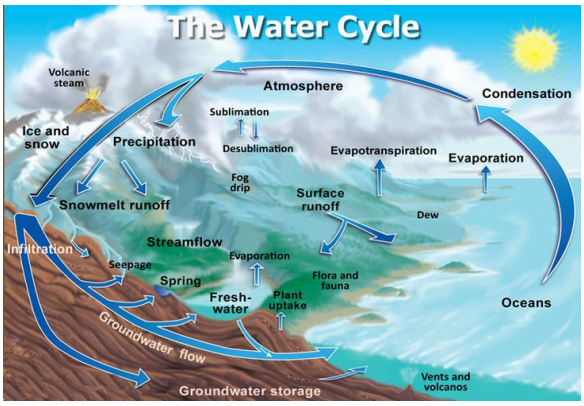

Figure 8. The Water Cycle. Source: USGS

The water cycle itself is influenced by temperature. Warmer temperatures increase evaporation, increasing the amount of water the atmosphere can hold. This increased evaporation in one area dries that area out and the evaporated water falls as precipitation in another area. Thus, possibly causing drought conditions in one location and extreme rainfall and flooding in another location. Warmer winter temperatures also influence the water cycle by changing the form of precipitation from snow to rain. In addition, warmer temperatures cause snow to melt earlier, changing runoff and streamflow patterns, influencing the water cycle.

Think about it: In what ways has the local water cycle changed in Indiana? What is the evidence or data that supports the idea that the local water cycle has changed? (Hint: Think about the intensity of storms, amount and form of precipitation.)

Think about it: If a changing water cycle influences evaporation in an area, causing or intensifying drought conditions, how might that impact people, agriculture, and the generation of electricity in that area?

Think about it. You have learned a lot about how global warming is changing the water cycle in Indiana. For example, how rain and snow amounts and storm intensities have changed and will change in the future. In the space below, create a concept map that illustrates your understanding about how the water cycle is changing in Indiana and how that is impacting precipitation, the environment, and people.

Reflect on What You Have Learned

Now that you have analyzed and thought about Indiana's precipitation data and the water cycle, reflect on your answers to the engage questions and explain how your ideas and thinking have changed.

5. How has your thinking about the impact of global warming on the local water cycle in Indiana changed?

6. How close was your prediction to that of the scientific projection for how much Indiana's average annual precipitation would increase? How would you explain the difference between your prediction and the scientific projections?

7. How has your thinking changed about how Indiana's precipitation will change throughout the state?

8. How has your thinking changed about how a change in precipitation will impact Indiana's environment, agriculture, and people?