LESSON 16: When It Rains It Pours
More Drought and More Heavy Rainfall

PURPOSE/QUESTION
Students will analyze precipitation data to identify trends.

GRADE LEVEL
9-12

TIME TO COMPLETE
2-3 days

STANDARDS
See appendix below-page 10

LEARNING OUTCOMES
- Students will examine precipitation trends for Phoenix, AZ, and New York City, NY.
- Students will learn how climate change is affecting precipitation.
- Students will consider impacts of precipitation trends.
- Students will see how multiple data sets are used to validate results.

STUDENT OBJECTIVES
- Access precipitation data.
- Plot time series data and analyze trends in both monthly and annual data.
- Learn the relationship between increasing temperature and water availability.
- Analyze and draw conclusions about how precipitation trends affect communities, agriculture, and wildlife.

TEACHER BACKGROUND

Changes in extreme weather and climate events — such as heat waves, droughts, and heavy precipitation — are the most tangible experience of climate change for many people. Indeed, such extreme events are showing noticeable trends across the United States and promise to become more severe, especially if climate change continues unabated.

Climate change projections over this century indicate that there will be an increasing probability of drought for the Southwest region of the United States, which is consistent with observations of declining average precipitation and increasing average temperature over recent decades. Increase in temperature leads to increase in evaporation which results in drier conditions. At the same time, changes in global circulation of the atmosphere are leading to a poleward expansion of the arid areas that are found around the Earth at about 30° North and South latitude. Future droughts will diminish the fresh water supply, which is already limited in the Southwest. The decreasing water supply will not only limit water for human consumption, but it also threatens healthy ecosystems, agriculture and energy production.

At the same time, climate change is bringing more heavy rainfall events because warmer air can hold more water. Thus, when it does rain, there is more water available. For every 1°F warming, atmospheric water vapor has increased by about 3 to 4 percent. For the continental United States, the most intense precipitation events have seen an increase in total rainfall of about 20 percent over the last 100 years. These increases are correlated with a corresponding increase in days with heavy stream flow in the medium and large river basins of the Eastern United States. With more moisture in the air, the trend towards increasingly intense precipitation events will continue. In the Midwest and Northeast, big storms that historically would only be seen once every 20 years are projected to happen as much as every 4 to 6 years by the end of the 21st century.

PREREQUISITES

- Difference between Weather and Climate
- Water Vapor
- Water Cycle
- Trend
- Grid Box

MATERIALS & TOOLS

- Computer with Internet
- Microsoft Excel
- Color printer (optional)
- Calculator

VOCABULARY

- Precipitation
- Drought
- Global Precipitation Climatology Project (GPCP)
- Global Historical Climatology Network (GHCN)
- Tropical Rainfall Measuring Mission (TRMM)

LESSON LINKS

- **Live Access Server**
- **Opening MY NASA Data microsets in Microsoft Excel**
- **NWF Climate Change and Flooding Report**

PART 1 – Trends in average precipitation for Phoenix and New York City

ESSENTIAL QUESTIONS

1. How does the average of monthly precipitation in New York City compare to that in Phoenix? How does the range from the lowest to the highest values compare for the two cities?
2. What does the pattern of precipitation in each city tell you about the typical climate conditions there?
3. How has monthly precipitation in Phoenix and New York City changed from 1980 to 2006?
4. What impacts might the precipitation trends in each location have for local communities, agriculture, and wildlife?

PROCEDURE

1. Examine monthly precipitation time series data for Phoenix, AZ (latitude = 33.4°N, longitude = 112.1°W) to see how precipitation has changed since 1980.
   a. In Live Access Server (Advanced Edition), click on the ***Choose Dataset*** button. Then choose ***Atmosphere > Precipitation > Monthly Precipitation (GPCP)***. A map will automatically appear.
   b. Under "LINE PLOTS", select: ***Time Series***
   c. Enter the latitude and longitude for Phoenix into the appropriate boxes just below the small grey map on the left of the screen.
   d. Set the time settings in ***Date Range*** to be ***Jan 1980*** and ***Dec 2006***.
   e. Click ***Update Plot*** and a time series plot will appear.
   f. We want to access the data used to create this plot, so that we can do our own calculations. Click the ***Show Values*** button and then click ***OK*** to accept the defaults. The data will appear in a second window.
   g. Follow the instructions in the Eco-Schools CCC Tech Tips Sheet to import the data into the Microsoft Excel worksheet for this lesson. Put the raw data in the tab titled "Phoenix – GPCP Raw Data".
   h. Copy the precipitation column into the sheet "Phoenix-GPCP data +charts" in the column titled "Monthly Precipitation (mm/day)". A chart of the Monthly Precipitation of Phoenix will automatically be created to the right of the data.

2. Repeat steps in Part 1 for New York City (latitude = 41.2°N, longitude = 73.8°W). Import the data into the Excel sheet "NYC – GPCP Raw Data". Then copy the precipitation column into the sheet "NYC – GPCP data + charts" in the column titled "Monthly Precipitation (mm/day)". A chart of the Monthly Precipitation of New York City will automatically be created to the right of the data.

PART 2 – Data validation approaches

ESSENTIAL QUESTIONS

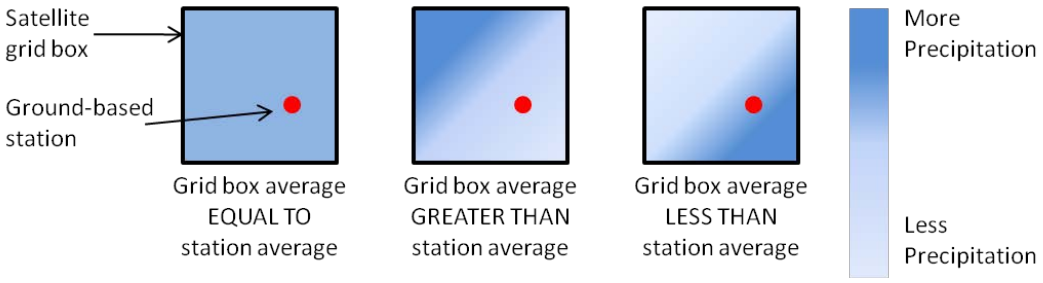
1. According to the descriptions of the data sets, what is the spatial distribution of the GPCP and GHCN data? How far back in time does each data set extend? Which would be better for examining large-scale patterns of precipitation? Which would be better for studying long-term trends?
2. Upon visual inspection of the chart with both data sets, do you think that they generally agree with each other? Are there any obvious differences (e.g., is one typically higher or lower than the others on average? does one have more extreme high or low values?)?
3. Examine the chart of the percent difference between the two data sets. What is the average percent difference between the two data sets? What are some possible explanations for the differences? Is there any significant trend in the differences?
4. Why is it important to take measurements with different kinds of instruments and observation strategies?

PROCEDURE

The Global Historical Climate Network (GHCN) provides daily observation of precipitation (and other meteorological variables) at weather stations across the globe. Many of these weather stations in the United States are located at airports. We will compare the satellite observations of precipitation for the New York City area with ground-based observations from LaGuardia airport.

1. Learn about how each data set is collected. More information about the GPCP mission can be found at <http://www.gewex.org/gpcp.html>. More information about the GHCN data can be found at <http://www.ncdc.noaa.gov/oa/climate/ghcn-daily/>. In reading about each data set and answering the first essential question above, consider the area footprint of each type of measurement, the time resolution (e.g., daily versus monthly), and the length of the record available for each.

2. Compare the GPCP and GHCN data for their period of overlap (1980-2006).
   a. In your Excel spreadsheet, you will find the monthly average GHCN data for LaGuardia airport in the tab titled "NYC GPCP+GHCN Data+Charts". Copy the GPCP data for New York City into the column titled "GPCP Monthly Precipitation (mm/day)". Percent differences between the two data sets will be automatically computed and two charts created to the right of the data.
   b. Calculate the average percent difference between the two data sets.



The GPCP data provides a single average precipitation total for the entire are of each grid box, but the GHCN data is the precipitation at one observation station. In this example, average precipitation is the same for all three grid boxes, but differs for the station located within the same area.

PART 3 – Trends in heavy precipitation for New York City, NY

ESSENTIAL QUESTIONS

1. Why would increasing atmospheric temperature lead to more heavy precipitation events?
2. Examine the chart for daily vs. monthly data for 1980-1981. How does the magnitude of daily precipitation compare to the magnitude of monthly average precipitation? Which data set will be better for analyzing precipitation extremes?
3. How have the daily extreme precipitation values changed for each precipitation threshold?
4. What impacts might the trend in heavy precipitation events have for local communities, agriculture, and wildlife?

PROCEDURE

For some places where average precipitation has not changed significantly over the past century, climate change is leading to more heavy rainfall events. We'll explore whether this is the case for New York City.

1. Determine whether trends in extreme events are more apparent in monthly or daily precipitation data.
    a. Copy New York City GPCP monthly data for 1980-1981 to "NYC GHCN Daily Data+Chart". GHCN daily data for 1980-1981 are already in the worksheet.
    b. A chart is automatically produced to the right of the data.
2. Because we are dealing with only a small fraction of the precipitation events, we need to use a data set that extends over several decades to get statistically significant results. The GHCN data set for LaGuardia airport extends back to 1948. This data set is very large (daily values for 62 years!), so we have already compiled some statistics about it in the table below for you to consider.
    a. Using the table below, calculate the percent change in the number of days exceeding each precipitation threshold and in the amount of precipitation that was measured on those days that exceeded each threshold.

	Precipitation threshold (mm/day)	**Number of days when precipitation exceeded threshold**		**Percent change in number of days exceeding threshold**	**Average precipitation (mm/day) on days exceeding threshold**		**Percent change in average precipitation on days exceeding threshold**
		1948-1972	*1985-2009*		*1948-1972*	*1985-2009*	
Heavy event	18	444	471		31.9	33.8	
Very heavy event	25	256	292		39.8	41.4	
Extremely heavy event	42	79	93		58.9	62.2	

TOOLS FOR ASSESSMENT

- **Concept Quiz – found on pg. 15**
- **Essay – found on pg. 18**
- **Foldables®**
- **Student Reading and Science Notebook Assessment Tool – found in the *Rubrics* folder**

WEBSITES FOR FURTHER LEARNING

- National Drought Mitigation Center
- The Hows and Whys of Flood
- National Geographic – Flood 101
- National Geographic – Drought 101

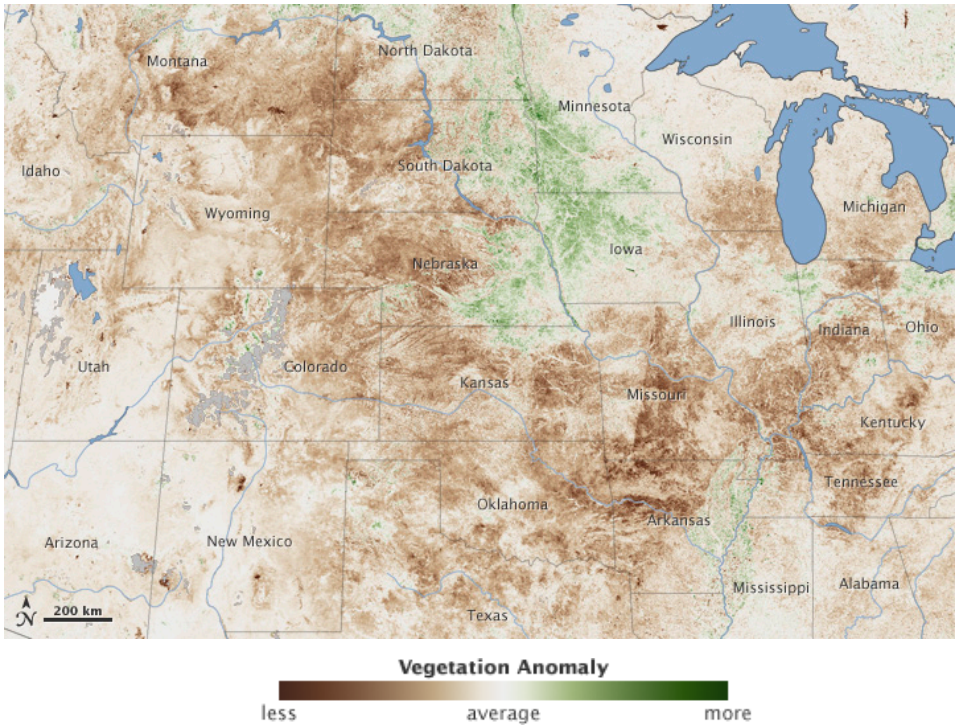
STUDENT READING RESOURCES

- Verner Suomi-The Father of Satellite Meteorology
- Alfred Wegner
- Joanne Simpson
- Flooding in Memphis
- Drought: The Creeping Disaster
- Dry Times in North America
- Heavy Rains and Dry Lands Don't Mix: Reflections on the 2010 Pakistan Flood

Drought Grips the United States
July 17, 2012

Farmers across the United States hoped for rain in July 2012 as a drought of historic proportions parched key commodity crops, including corn, soybeans, and wheat. On July 11, the United States Department of Agriculture announced that more than 1,000 counties in 26 states qualified as natural disaster areas—the largest total area ever declared a disaster zone by the agency.

NASA's Earth Observatory



LESSON 16-APPENDIX

HYPERLINKS WEB ADDRESSES

PREREQUISITES

- **Weather**
  http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=W
- **Climate**
  http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=C
- **Water vapor**
  http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=W
- **Water cycle**
  http://ga.water.usgs.gov/edu/watercyclesummary.html
- **Trend**
  http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=T
- **Grid box**
  http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=G

VOCABULARY

- **Precipitation**
  http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=P
- **Drought**
  http://amsglossary.allenpress.com/glossary/search?id=drought1
- **Global Precipitation Climatology Project (GPCP)**
  http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=G
- **Global Historical Climatology Network (GHCN)**
  http://lwf.ncdc.noaa.gov/oa/climate/ghcn-daily/
- **Tropical Rainfall Measuring Mission (TRMM)**
  http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=T

LEARNING LINKS

- **Live Access Server, LAS – Portal used to access NASA data for students**
  http://mynasadata.larc.nasa.gov/live-access-server/
- **Importing My NASA Data microsets into Excel**
  http://mynasadata.larc.nasa.gov/opening-my-nasa-data-microsets-in-excel/
- **NWF – Climate Change and Flooding Report**
  http://www.nwf.org/Global-Warming/What-is-Global-Warming/Global-Warming-is-Causing-Extreme-Weather/Floods.aspx

WEBSITES FOR FURTHER LEARNING

- **National Drought Mitigation Center – Helps people and institutions develop and implement measures to reduce societal vulnerability to drought, stressing preparedness and risk management rather than crisis management.**
  http://www.drought.unl.edu/
- **The How's and Why's of Floods**
  http://www.pbs.org/newshour/infocus/floods/science.html
- **National Geographic – Flood 101 – Video about 3 ½ minutes in length**
  http://video.nationalgeographic.com/video/environment/environment-natural-disasters/landslides-and-more/floods/
- **National Geographic – Drought 101 – Video about 3 minutes in length**
  http://video.nationalgeographic.com/video/environment/environment-natural-disasters/landslides-and-more/droughts/

STUDENT READING RESOURCES

- **Verner-Suomi – The Father of Satellite Meteorology**
  http://earthobservatory.nasa.gov/Features/Suomi/
- **Alfred Wegner**
  http://earthobservatory.nasa.gov/Features/Wegener/wegener_3.php
- **Joanne Simpson**
  http://earthobservatory.nasa.gov/Features/Simpson/simpson2.php
- **Flooding in Memphis**
  http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=50549
- **Drought: The Creeping Disaster**
  http://earthobservatory.nasa.gov/Features/DroughtFacts/
- **Dry Times in North America**
  http://earthobservatory.nasa.gov/Features/NAmerDrought/NAmer_drought.php
- **Heavy Rains and Dry Lands Don't Mix: Reflection on the 2010 Pakistan Flood**
  http://earthobservatory.nasa.gov/Features/PakistanFloods/page1.php

Tech Tips for Eco-Schools USA Climate Change Connections Curriculum

How do I import data into an Excel spreadsheet?

1. Access data from My NASA Data:
    a. Once you have all the parameters set for your desired data set (and have clicked "Update Plot" to have your preferences processed), click the "Show Values" button. A new window will pop up with a Table of Values.
    b. The first several lines of the Table will provide information that describes the data set, often called "metadata", such as the name of the variable, what subset of the data is included in the file, and what time range. Make sure to keep this metadata with the rest of the data when you copy it into Excel. This way you'll be able to easily keep track of which data you have!
2. Copy the data from the browser (note that these instructions are for Internet Explorer running on a PC, and may need to be modified for other platforms):
    a. In this new window, select all. You can do this by clicking anywhere in the window and then typing "Ctrl-A". Or you can right-click in the window, which will pop up a menu, and then choosing "Select All" from the options.
    b. Next, copy this data. Again there are two options. You can use the keyboard shortcuts, and type "Ctrl-C". Or you can right-click and choose "Copy" from the pop-up menu.
3. Paste the data into Excel:
    a. Now open your Excel worksheet and go to the tab where you want to put the raw data. Click in the A1 cell.
    b. Paste the data, either by typing "Ctrl-V", by clicking "Paste" (located at the left under the "Home" tab), or by right-clicking in the A1 cell and choosing "Paste".
4. Convert the data from text to columns:
    a. Now, we have the data in Excel, but we can't manipulate it very well because all the data for each row is lumped into one cell. We want to split out each data value into its own cell.
    b. Starting at the row where the column headers are located (probably around row 7), highlight the A column down to the end of the data.
    c. Click on the Data tab at the top of the window, and then choose the "Text to Columns" wizard (located a little to the right of center).
    d. A dialogue box will pop up to help you through the process.
    e. The first page of the wizard asks you to identify whether the data is "Delimited" or "Fixed width". In most cases, the My NASA Data data will be "Fixed Width", so select that option and click "Next".
    f. The next page of the wizard gives you a chance to check whether the column breaks make sense and to adjust them as necessary. Make any changes that are needed. Or, go back and switch to "Delimited" on page 1 if you notice that the columns are not lining up as you expected. Once you are satisfied with the columns, click "Next".
    g. The final page of the wizard allows you to designate what kind of data values are in each column and a destination for the data. For the purposes of the CCC curriculum, we'll just accept the defaults and click "Finish".
    h. Now your data should be in beautiful columns and the values should make sense. It's always a good idea to double check that nothing crazy happened!

My NASA Data isn't working! What should I do?

1. Double check that you entered everything correctly. Especially check that you have the right data set and that you have entered dates and latitude/longitude values within the range of available data. Usually the user interface will prevent you from entering invalid data ranges, but sometimes there are glitches.
2. Refresh the browser and/or restart the browser. Occasionally, a fresh start is the easiest way to clear out any mistakes or glitches.
3. Update your browser and/or JAVA. If you have older versions of the software, then you might find that some functionality is lost.
4. If you're still struggling, consider whether problem might be at the My NASA Data website. It might be a temporary problem, in which case taking a break and returning to the site at a later time could be a good choice. Or it could be a more significant problem, in which case you'll want to explore the "help" resources provided by My NASA Data (link in upper right hand corner of page).
5. Ask your Eco-Schools contact for help or email eco-schoolsusa@nwf.org!

How do I print or save a map or graph?

1. Use the "Print" button to generate a version of your map or graph that is suitable for saving or printing. Once you click on the "Print" button, a new window will pop up with your map or graph.
2. Print a map or graph by using the print option on your browser.
3. Save a map or graph in one of two ways:
    a. By choosing "Save as" in the browser. Use the defaults to save as a "Web Archive, single file (*.mht)".
    b. By right clicking and choosing "Save picture as…" Use the defaults to save as a *.png file.
4. When saving, make sure to give your new file a descriptive name and put it somewhere that you'll remember!

How do I find my latitude and longitude?

A number of sites help you find your latitude and longitude. For example:

1. http://itouchmap.com/latlong.html
2. http://www.findlatitudeandlongitude.com/

LESSON 16-STANDARDS

National Science Education Standards

Unifying Concepts and Processes

- Systems, order, and organization
- Evidence, models, and explanations
- Change, constancy, and measurement

Standard A – Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Standard C – Life Science

- Interdependence of organisms

Standard D – Earth and Space Science

- Geochemical cycles

Standard E – Science and Technology

- Abilities of technological design
- Understandings about science and technology

Standard F – Science in Personal and Social Perspectives

- Natural resources
- Environmental quality
- Natural and human induced hazards
- Science and technology in local, national, and global challenges

Standard G – History and Nature of Science

- Science as a human endeavor
- Nature of scientific knowledge

National Education Technology Standards

Standard 1: Creativity and Innovation

- Use models and simulations to explore complex systems and issues
- Identify trends and forecast possibilities

Standard 3: Research and Information Fluency

- Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
- Process data and report results

Standard 4: Critical Thinking, Problem Solving, and Decision Making

- Collect and analyze data to identify solutions and/or make informed decisions.

Standard 5: Digital Citizenship

- Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.

Standard 6: Technology Operations and Concepts

- Understand and use technology concepts
- Select and use applications effectively and productively
- Troubleshoot systems and applications
- Transfer current knowledge to learning of new technologies

National Council of Teachers of Mathematics- Math Standards and Expectations

Algebra

- Understand patterns, relations, and functions
- Use mathematical models to represent and understand quantitative relationships
- Analyze change in various contexts

Measurement

- Understand measurable attributes

Data Analysis and Probability

- Develop and evaluate inferences and predictions that are based on data

Process

- Connections
  - Recognize and apply mathematics in contexts outside of mathematics
- Representation
  - Use representations to model and interpret physical, social, and mathematical phenomena

Climate Literacy Principles

Principle 1: The sun is the primary source of energy for earth's climate system.
Principle 2: Climate is regulated by complex interactions among components of the Earth system.
Principle 4: Climate varies over space and time through both natural and man-made processes.
Principle 5: Our understanding of the climate system is improved through observations, theoretical studies, and modeling
Principle 7: Climate change will have consequences for the earth system and human lives.

Energy Literacy Principles

Principle 3: Biological Earth processes depend on energy flow through the earth system.

LESSON 16-ESSENTIAL QUESTIONS ANSWER KEY

ESSENTIAL QUESTIONS-1

1. How does the average of monthly precipitation in New York City compare to that in Phoenix? How does the range from the lowest to the highest values compare for the two cities?
   [From looking at the graph as well as the values in column "GPCP Monthly Precipitation", the average monthly precipitation for New York City is quite a bit higher than Phoenix. Average monthly precipitation for New York City is 3.32 mm/day, and Phoenix is 0.86 mm/day. The range (lowest to highest value of rainfall) is larger for New York City around 10 mm/day while Phoenix is around 5.0 mm/day.]

2. What does the pattern of precipitation in each city tell you about the typical climate conditions there?
   [The patterns explain why Phoenix, which is in the Southwest part of the United States, typically has drier conditions than New York City, in the Northeast region of the United States. With wetter conditions, New York City area has more lush vegetation and fewer concerns about freshwater supply.]

3. How has monthly precipitation in Phoenix and New York City changed from 1980 to 2006?
   [The monthly precipitation for Phoenix has decreased as indicated by the solid black line on the graph. The monthly precipitation value for Phoenix was 1.25 mm/day in the early 1980s and it decreased substantially to about 0.5 mm/day by the mid 2000s. The monthly precipitation for New York City changed very little from 1980 to 2006.]

4. What impacts might the precipitation trends in each location have for local communities, agriculture, and wildlife?
   [For Phoenix, declining water supply can affect drinking water, supply of electricity (need water for thermoelectric power plants), industry, landscaping, and agriculture. Types of plants will change due to more competition for sparse water resources and the potential for more wildfires. The decrease in average precipitation will increase the chance for droughts, with more acute impacts on water supply and wildlife.

   Without a significant trend in average precipitation the New York City region, we would not expect a major impact on local communities, agriculture, or wildlife there.]

ESSENTIAL QUESTIONS-2

1. According to the descriptions of the data sets, what is the spatial distribution of the GPCP and GHCN data? How far back in time does each data set extend? Which would be better for examining large-scale patterns of precipitation? Which would be better for studying long-term trends?
   [The GPCP is available in a grid that covers the entire globe at 2.5-degree resolution. It combines global precipitation observations from satellites with rain gauges and other weather observational platforms (such as weather balloons) for more accuracy. The GHCN data is from rain gauges at about 40,000 individual observation stations around the world so doesn't have as complete spatial coverage.

   The GPCP data set extends back to 1979. GHCN varies by station, with some going as far back as the 1800's.

   GPCP would be better for studying spatial patterns and GHCN would be better for long-term trends.]

2. Upon visual inspection of the chart with both data sets, do you think that they generally agree with each other? Are there any obvious differences (e.g., is one typically higher or lower than the others on average? does one have more extreme high or low values?)?
   [Visually, the charts of both datasets generally agree with each other with high and low values occurring at the same time and of similar magnitudes. It is expected that the data sets will be quite similar given that the GPCP data incorporates the GHCN data.]

3. Examine the chart of the percent difference between the two data sets. What is the average percent difference between the two data sets at this location? What are some possible explanations for the differences? Is there any significant trend in the differences?
   [The GPCP measures on average 10% more precipitation than the GHCN at this location. GPCP measures a single average precipitation value for all of the points within the grid box, whereas GHCN is the point value of the precipitation at one location. LaGuardia airport must get somewhat less precipitation than grid box on average, similar to the middle box in the grid box versus station example provided in the lesson.]

4. Why is it important to take measurements with different kinds of instruments and observation strategies?
   [It is important because instruments and observation strategies have different strengths and weaknesses, such as how large of an area they observe, how often they observe, how far back in time the measurements go, and how accurate they are. Also, when measuring the same variable (such as rain, temperature), one can compare values to determine if the measurements are accurate or biased (consistently high or low) or if the measurements are drifting over time.]

ESSENTIAL QUESTIONS-3

1. Why would the increasing atmospheric temperature lead to more heavy precipitation events?
   [Global warming is bringing more heavy rainfall events because warmer air can hold more water. Thus when it does rain there is more moisture available to form rain. For every 1 degree Fahrenheit warming, atmospheric water vapor increases by about 3 to 4 percent. Satellite-based observations over the past 20 years combined with climate model studies have confirmed that such increases are indeed happening around the globe.]

2. Examine the chart for daily vs. monthly data for 1980-1981. How does the magnitude of daily precipitation compare to the magnitude of monthly average precipitation? Which data set will be better for analyzing precipitation extremes?
   [The daily precipitation has a much larger range – the highest value for the average daily precipitation is around 87 mm/day while the average monthly maximum is around 7 mm/day. The daily averages are better for analyzing precipitation extreme than monthly averages – it better captures the precipitation amount of single events. The monthly average data smoothes out the high precipitation days with days that have no precipitation.]

3. How have the daily extreme precipitation values changed for each precipitation threshold?
   [

	% change in number of days exceeding threshold	% change in average precipitation on days exceeding threshold
Heavy Event	6.1	5.8
Very Heavy Event	14.1	4
Extremely Heavy Event	17.7	5.6

Example Calculation: Calculate the % change for days exceeding threshold for *Heavy Events*:

% change in number of days exceeding threshold = [**(471-444)/444] * 100 = 6.1%**

% change in average precipitation on days exceeding threshold = **[(33.8-31.9)/31.9] *100 = 5.8 %**

The number of days with extreme precipitation for each precipitation threshold has increased for all three categories (heavy, very heavy and extremely heavy event) with the largest percent change with the most extreme heavy rainfall events.]

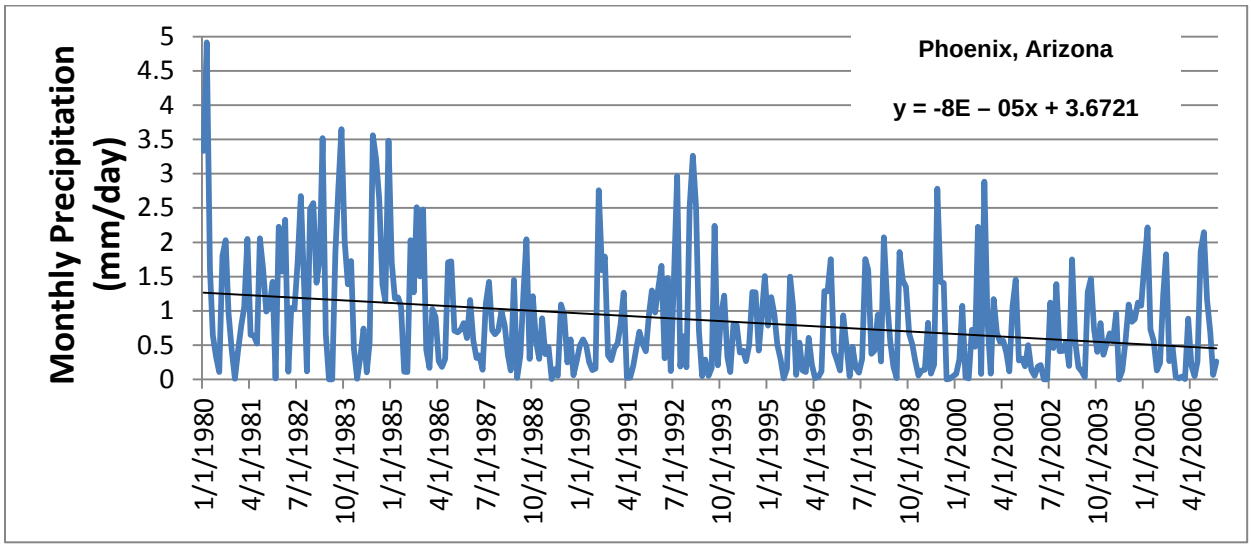
4. What impacts might the trend in heavy precipitation events have for local communities, agriculture, and wildlife?

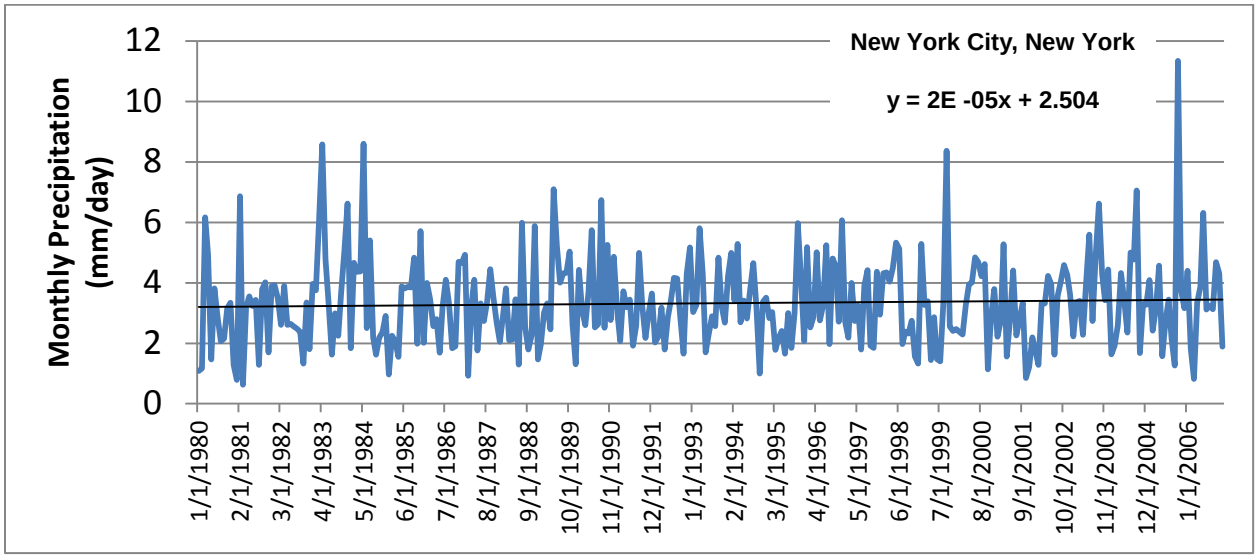
[Flooding destroys houses and agricultural lands, and can be very dangerous for local communities (people and wildlife) in terms of water contamination and debris. Flooding also destroys the food supply and the local habitats for wildlife.]

Name: _____ Date: _____

Science Concept Quiz
Lesson 16: Now You See It, Now You Don't
Investigating Trends in Droughts and Floods

Use these graphs to answer questions found on the subsequent pages.





What conclusions can be drawn about the two locations over the last sixteen years?

A. Both cities are receiving more rainfall.
B. Phoenix is experiencing an increase in the amount of rainfall while New York is experiencing a decrease in the amount of rainfall.
C. Both cities show a declining trend in the amount of rainfall they are receiving.
D. Phoenix is experiencing greater incidence of drought due to a decrease in the amount of rainfall whereas New York is experiencing greater incidence of flooding due to an increase in the amount of rainfall.

_____ points out of 20

I. Answer

A.◯ B. ◯ C. ◯ D. ◯

_____ points out of 15

II. What is the main concept behind the question?

1. Drawing Conclusions
2. Making Predictions
3. Understanding what causes droughts and floods
4. Identifying locations where droughts and floods have increased

_____ points out of 25

III. Provide the reasoning for choosing your answer in part II.

_____points out of 40

IV. Why are the other responses in part I not the best answer choice?

1.

2.

3.

4.

Teacher Answer Key

1. D

2. 1

3. Answers will vary. Based on the information in the two graphs for Phoenix and New York, the trends over time show that Phoenix is experiencing fewer significant rain events thus causing serious drought conditions, while New York, however slight, is showing an increase in the number of heavy rain events causing atypical flooding.

4. Answers will vary.
   A) The trend line for Phoenix shows a definite decrease making the statement false.

   B) The trend lines in the graph show the opposite of what the statement says, Phoenix's trend shows a decrease and New York's trend shows an increase.

   C) The trend line for New York shows a slight increase making the statement false.

   D) Correct Answer

Student Name
Teacher/Class
Date

Lesson 16: Now You See It, Now You Don't
Investigating Patterns in Precipitation

Consider the area in which you live. Based on your location think about what you have learned regarding the incidence of drought and floods due to climate change. Are you more likely to experience flooding or drought like conditions? Explain how your local community might be affected. Include thoughts on the economy, agriculture and wildlife.

What Is the Expectation?

Use NWF reports and student readings to support your position

Evidence of understanding trends in droughts and floods

Visual representations if applicable

Key vocabulary

Evidence of on grade level spelling and grammar usage