Rainwater Harvesting

Lesson 1: How do we increase outdoor water conservation while cooling our community?

INTRODUCTION

Climate change is generally defined as a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels. Research has shown that global surface temperatures have increased from 1.3 – 1.9 degrees Fahrenheit over the last century, with much of this increase occurring over the last 50 years.

Of particular concern to New Mexico are computer models that predict longer periods of warmer temperatures in the southwestern United States, resulting in a drier climate. Data from NOAA, and other organizations, clearly show a warming trend for New Mexico over the past 100 years that will increase by 5 degrees Fahrenheit by mid-century and 7 degrees Fahrenheit by 2070 leading to increased aridification. Such startling data is prompting forward-thinking community leaders to consider climate resilience protocols to help prepare their communities for climate change. Higher temperatures can affect surface water supplies, soil moisture, plant life, and snowpack – all critical factors for life in the Southwest.

One simple method of adapting to the localized impacts of climate change is encouraging people to use rain gardens to capture stormwater runoff for conservation and aquifer (groundwater) recharge, as well as to plant native trees and plants to help cool urban areas.

Teaching Strategies

Thinking questions are posed throughout this unit presentation to help students think metacognitively and to make **D**istinctions, identify **S**ystems, recognize **R**elationships, and look from different **P**erspectives. This is called Systems Thinking through DSRP.

Mental Models or "mental maps" are used throughout this unit to illustrate the Systems Thinking process. Mental maps are more than a concept map. In addition to mapping out ideas, mental maps help to illustrate relationships and include perspectives. They are a simple way to model systems, visualize concepts, define relationships and organize content to achieve a deeper level of understanding for both simple and complex subject matter.

NOTE: Keep copies of mental maps and charts from every lesson as they may be referred to throughout the unit.

Review the Rainwater Harvesting Unit Guide document to see how this lesson launches subsequent lessons within this unit.

Stormwater is perceived as a problem that needs to be removed from the system, but by retaining stormwater and moving it into our water storage (or groundwater) system, we can help to solve problems associated with increased aridification. This method improves our green stormwater infrastructure, improves soil health to assist in water retention for our groundwater system, increases habitat for native animal species, and increases water conservation by reducing our irrigation burden.

The Rainwater Harvesting Unit is adapted with permission from the Arizona Project WET, Rainwater Harvesting Aqua STEM Program.

OBJECTIVES

- **DISTINGUISH** between weather and climate.
- **BUILD THE SYSTEM:** Students will understand the parts of a weather system (daily phenomenon) and what weather is a part of (climate).
- **RELATE:** Students will explore **cause and effect relationships** between climate and heat buildup in our urban areas and examine ways to increase green stormwater infrastructure and mitigate excessive heat.
- **PERSPECTIVE:** From the perspective of a community leader, students will design a strategy to encourage residents to build rain gardens with native plants and trees at their homes.

MATERIALS & EQUIPMENT

For each cooperative group you will need:

- One "fun-size" bag of M&Ms per student
- One Weather Data Table – Santa Fe worksheet per student
- A spreadsheet of class data can be created from a Google or Microsoft365 form. Students input their data from their worksheet into the form, then download a spreadsheet with all class data.
  Click on the links below to see examples:
  - https://docs.google.com/forms/d/e/1FAIpQLSesebhiL1iXO0USjMucJgBQT2ZGBeYz4q01aI-0kW0Wnrk02A/viewform?usp=sharing
  - https://forms.office.com/r/up3h7ygALp

LESSON SUMMARY

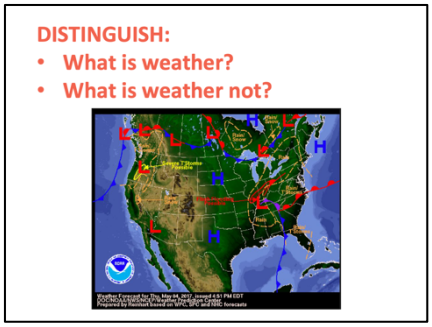
In this lesson, students will explore the difference between weather and climate. They will develop and use a model to record weather data over time, helping them understand how climate is based on long-term patterns. By comparing class averages to individual yearly data, students will look for patterns and unusual changes. Students will also analyze data on long-term and daily trends in temperature and precipitation—factors that contribute to rising heat levels in cities. They will investigate how climate and drought are connected to New Mexico's water supply. Finally, students will discover how changes to their urban environment—such as planting rain gardens with native plants and trees—can help manage stormwater runoff and cool their community.

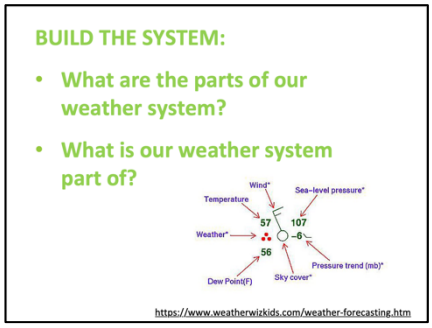
Connect to the Unit

In this Rainwater Harvesting unit, students will:

- Apply the Engineering Design Process (EDP) to construct ideas and design a solution for using rainwater in place of potable water.
- Ask questions and discover new technology and methods for saving drinking water and mitigating urban heat.
- Develop and demonstrate a mathematical and/or physical model to manage runoff in the schoolyard watershed.
- Analyze and interpret mathematical data to support decision making and planning of a passive rainwater harvesting system.
- Understand the cause-and-effect relationships of the heat island effect and learn how passive rainwater can be used to help cool our communities and supplement potable water supplies.

PRESENTATION GUIDE





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Launch the lesson

This lesson introduces students to the idea of passive rainwater harvesting by introducing DSRP as talking points and eliciting responses from the students. Students will learn the difference between weather and climate. They will explore the impacts of increasing heat in New Mexico and discover how passive rainwater harvesting, combined with planting native plants and shade trees, can help conserve water to build water supply resiliency and reduce the heat island effect.

DISTINGUISH

• What is weather?
When we think of weather, we think of what it is currently like outside. Students may say: rain, clouds, sunny, hot, monsoon storm, etc.

• What is weather not?
It is not always the same. It is not always predictable. It is not always pleasant. Weather is not a long term look at atmospheric conditions.

BUILD THE SYSTEM

• What are the parts of our weather system?
Parts of our weather includes temperature, wind (speed and direction), cloud cover, precipitation, dew point (related to humidity), barometric pressure. If students don't mention humidity, ask them how the air feels when a monsoon rainstorm is building in the summer.

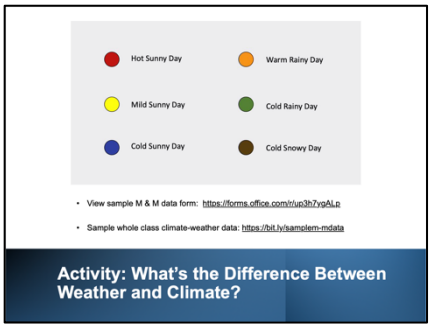
• What is our weather system a part of?
Weather is part of the earth's system; part of a regional pattern (why we have deserts vs. tropical rain forests; seasons; weather fronts; part of our daily lives).

Ask students to work in their table groups to write a definition of weather based on the above thinking. It should be something like: Weather is the daily state of the atmosphere, or air, in any given place.

Climate Simulation

1. Pass out a "fun size" bag of M&Ms and the *Weather Data Table – Santa Fe* worksheet handout to every student. Tell them they will be using the M&Ms to model or simulate the difference between weather and climate.

The M&Ms will be counted and recorded by color and will represent **daily weather conditions** for the month of February in the **calendar**



year that is assigned to each student. Each M&M represents one day in the month of February for their assigned year.

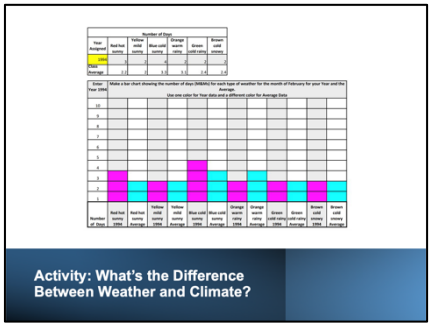
2. **Assign each student a calendar year**, starting with 1991 and ending with 2020 – our current Climate Normal Period. The **Climate Normal Period** is a 30-year average of key climate variables, such as temperature and precipitation, used to provide a standard reference for comparing weather and climate trends. These climate normals are updated every 10 years. The current Climate Normal Period includes weather data from 1991 – 2020.

If you have fewer than 30 students, just assign one year for every student that you have – i.e., if you have 24 students only do years 1991 through 2014. If you have more than 30 students, simply repeat some of the years to keep things simple.

3. Once all students have a worksheet, instruct them to **remove one M&M from their bag**. Explain to them that this represents weather for the first day of February in their assigned year.

Quickly compare Day 1 results for the students.

- How many hot sunny days? _____
- How many cold snowy days? _____



Make sure they understand that their M&M represents weather on February 1st for their assigned year. For the whole class, all the M&M's collectively represent the Climate Normal Period from 1991 to 2020.

- Is everyone's weather the same? Have them explain why or why not. Weather on the same day each year can vary.

4. Have them empty their bag of M&Ms and **record the number of colors of each M&M corresponding to the type of weather** as shown on the worksheet. **Make sure they write down the year that was assigned** to them in the space on the left-hand side of the worksheet.

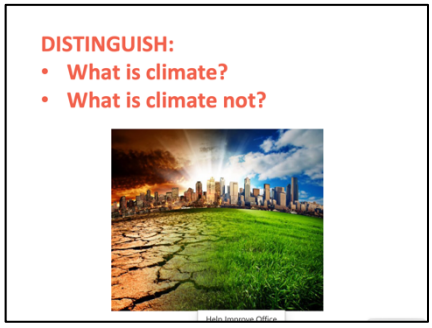
5. Have your students add the data into a Google or Microsoft365 Form.

6. Download a spreadsheet from the form with the Average Data. **Climate is the average weather in a location over many years.** Your weather pattern is for the Climate Normal Period of 1991-2020.

7. Instruct the students to **use their individual results to create a simple bar chart** in the space provided at the bottom of their worksheet.

8. Have the students **write down the class average results** on their worksheets and compare to the class average bar graph.

- How does their data compare to the class average?
- What trends do they see?
- What types of weather occurred more than average?
- What types of weather occurred less than average?

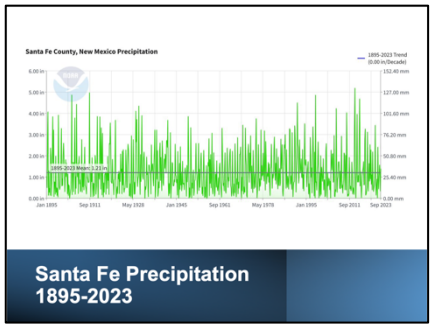


Inform the students that their combined class data over time represents climatic conditions but their individual data for the month of February in their assigned year represents weather conditions. Make sure they understand that weather is the daily state of atmospheric conditions whereas climate is long-term.

DISTINGUISH

• What is climate?

Climate is long term averages (30-years) in weather.



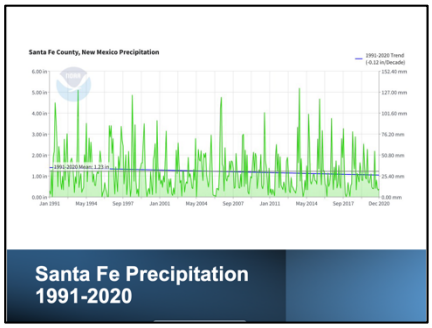
• What is climate not?

They may not know but climate is not static. It is changing as can be seen by the following slides.

Santa Fe Precipitation

What claims can you make based upon this evidence?

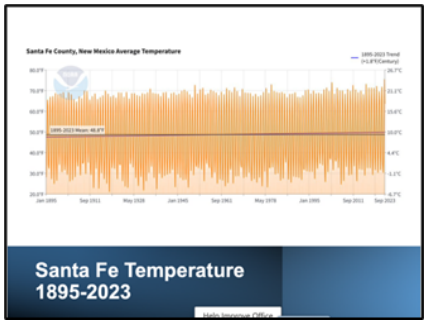
- The green line is yearly precipitation (inches).
- The grey line is the mean annual precipitation (inches).
- The blue line is the precipitation trend based on 30-year averages from 1991-2020 (the latest Climate Normal Period).



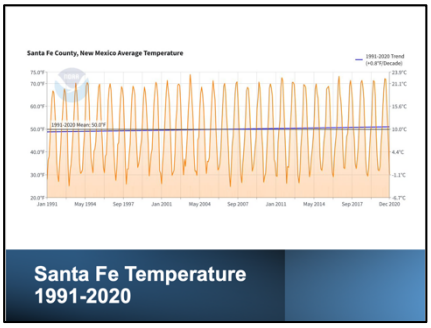
Looking at the longer record in the first slide (1895-2023), how has precipitation changed over time? Precipitation averages have not varied much over time. What would you predict for the trend line for the next Climate Normal Period (2001-2030)? Recent precipitation trends show lower than normal precipitation, but over longer periods are steady. The next Climate Normal Period *may* show lower precipitation from normal.

Santa Fe Temperatures

What claims can you make based upon this evidence?

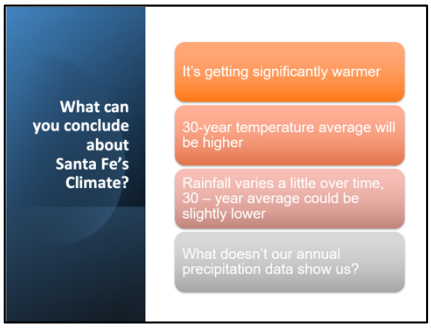


- The orange line is yearly temperature (Fahrenheit).
- The grey line is the mean annual temperature (Fahrenheit).
- The blue line is the temperature trend based on 30-year averages from 1991-2020 (the latest Climate Normal Period).



How has temperature changed over time? What would you predict for the temperature trend line for the next Climate Normal Period? (2001-2030)?

- The temperatures have been steadily increasing.
- Temperatures in the next Climate Normal Period will be higher than the last climate normal.



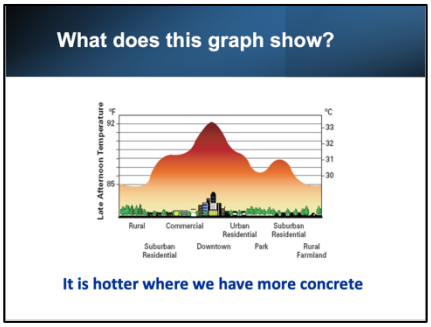
Santa Fe's Climate Summary

Have students discuss what conclusions they can make about Santa Fe's climate.

The annual precipitation data does not show us large storm events that can lead to flooding.

Extreme Storm Events

Here is an example of a large storm event that flooded Cerrillos Road in 2012. Rain that fell in the city ran off properties and streets, washing into arroyos and eventually into the Santa Fe River.



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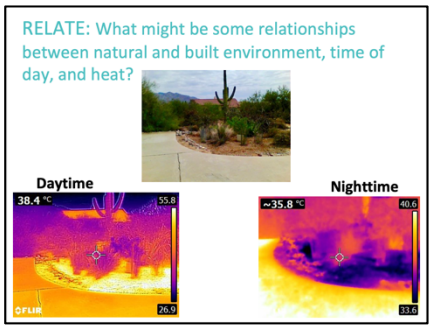
Local Climate Issues

Ask, "What does this graph show?" Have students analyze and interpret it in table groups.

An **Urban Heat Island,** or UHI, is a phenomenon that occurs in cities or metropolitan areas. In these areas, heat energy from the sun and human activities is absorbed by surfaces like pavement, buildings, and other structures, causing temperatures to rise. Because cities have fewer open spaces and limited airflow, the heat gets trapped and doesn't escape easily. As a result, urban areas stay warmer—even into the night—compared to surrounding rural areas.

RELATIONSHIP

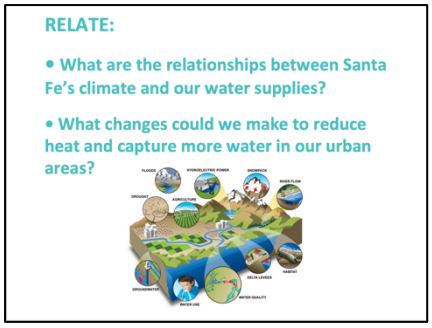
• What might be some relationships between natural and built environment, time of day, and heat?



This image shows a rain garden next to a concrete driveway. The image on the bottom left is taken in the daytime and the image on the bottom right is taken at night with an Infrared camera. The landscape is radiating heat out to the atmosphere and this radiation can be seen in the infrared spectrum. A temperature gauge is on the right.

The wood mulch in the garden is the hottest spot during the day but is the coolest spot at night. The concrete driveway remains hot even after the sun goes down.

• What are the relationships between Santa Fe's climate and our water supplies?



Santa Fe's average temperature has been increasing and while precipitation may go down slightly or stay the same, increased temperatures will cause more evaporation and decrease precipitation in the form of snow resulting in increased aridification. When snow melts, that slow moving water has a better chance of staying in our watershed. Rainstorms create faster moving stormwater runoff. Holding onto that water can help recharge our aquifer and decrease erosion caused by fast-moving water and flooding.

• What changes could we make to reduce heat and capture more water in our urban areas?

Plant trees – they cool an area by producing shade! Adding plants of any kind will help reduce heat. Build rain gardens that can slow stormwater and allow it to infiltrate into the ground to be used by those plants and trees or move into the groundwater system.

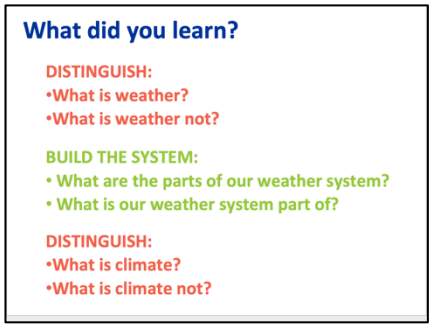
PERSPECTIVE

• From the perspective of a community leader, design a strategy to encourage residents to build rain gardens with native plants and trees at their homes.

Ask students, "What simple actions could we take at a local level to help reduce heat and retain water in our neighborhoods?"

- Planting trees will produce shade that reduces heat.
- Planting native plants or shade trees uses less water than planting non-native species, since they are adapted to the local climate.

Tell the students they'll be learning about rainwater harvesting over the next several lessons.



Conclusion

Discuss with students or have them write in their science notebooks the answers to these questions:

DISTINGUISH

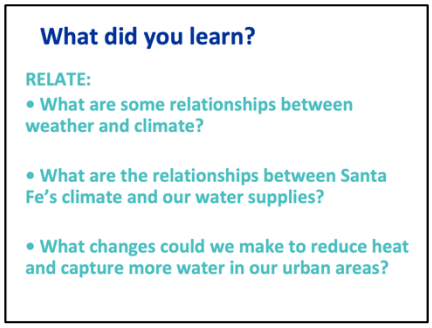
• What is weather? What is weather not?

BUILD THE SYSTEM

• What are the parts of our weather system? What is our weather system part of?

DISTINGUISH

• What is climate? What is climate not?

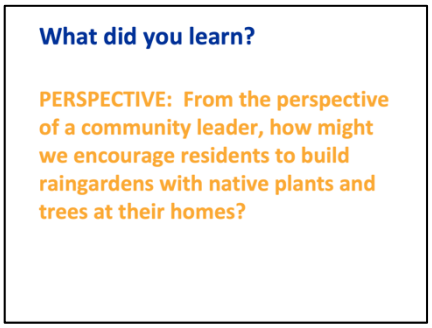


RELATE

• What are some relationships between weather and climate?

• What are the relationships between Santa Fe's climate and our water supplies?

• What changes could we make to reduce heat and capture more water in our urban areas?



PERSPECTIVE

• From the perspective of a community leader, how might we encourage residents to build rain gardens with native plants and trees at their homes?