



Small weather station  
Denali National Park, Alaska

# LET'S LEARN ABOUT WEATHER AND CLIMATE SCIENCE

A MIDDLE SCHOOL CURRICULUM BY DR. THOMAS DORMODY  
AND DR. PETER SKELTON



**BE BOLD. Shape the Future.**  
**College of Agricultural, Consumer  
and Environmental Sciences**  
Agricultural and Extension Education



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**College of Agricultural, Consumer  
and Environmental Sciences**  
Cooperative Extension Service  
Extension & Research Youth Agricultural Science Center

# LESSONS IN THIS WEATHER AND CLIMATE SCIENCE CURRICULUM

- ▶ Lesson 1 (1 day): The Water Cycle
- ▶ Lesson 2 (1 day): The Greenhouse Effect
- ▶ Lessons 3 and 4: Measuring and Analyzing Weather and Climate Data (Precipitation and Temperature)
- ▶ Lesson 5: Mitigating and Adapting to Weather and Climate Extremes in Agriculture and Natural Resources



Rain gauge, Rio Mora National Wildlife Refuge, New Mexico

# LESSON 1: THE WATER CYCLE

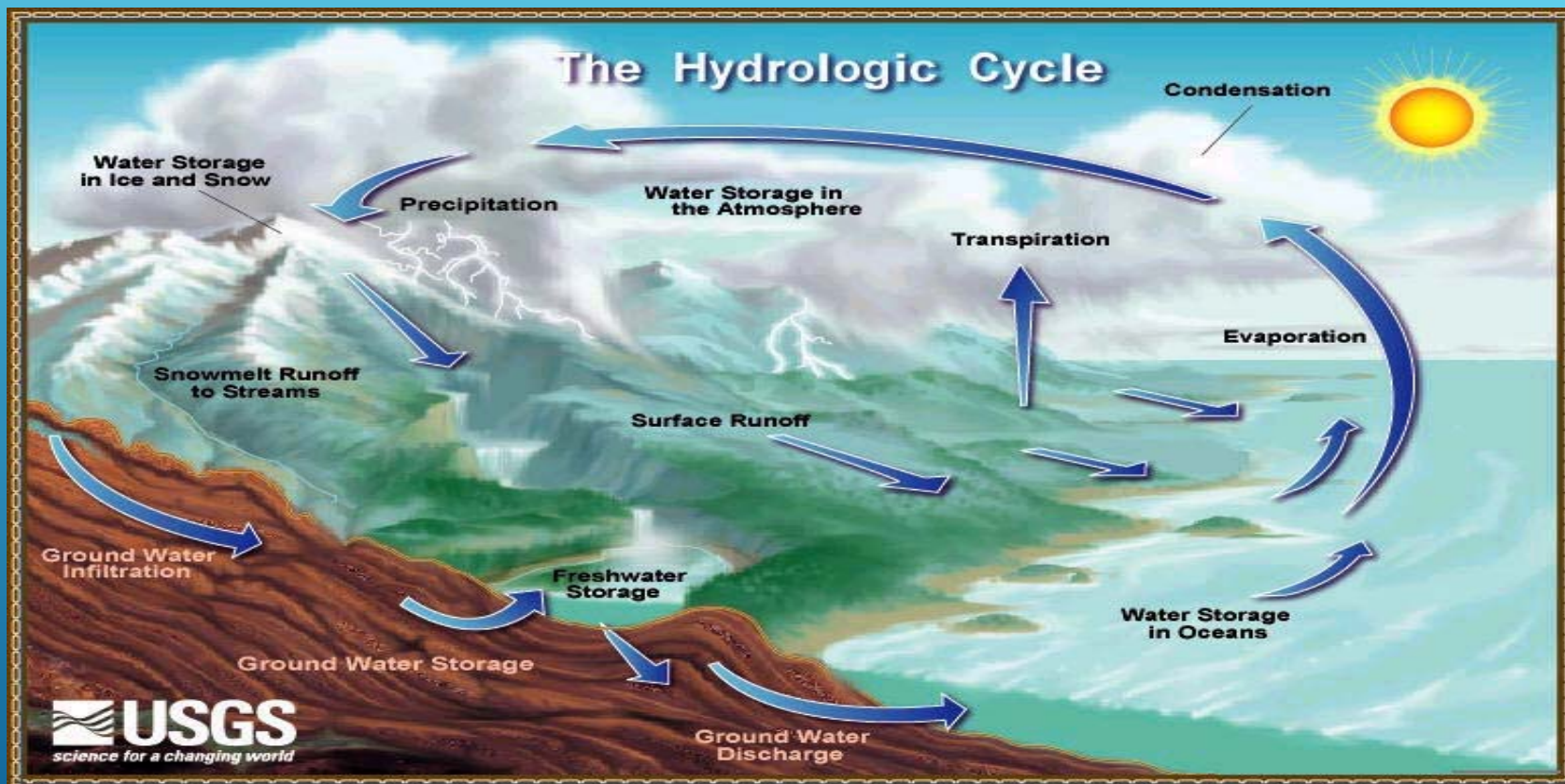
Also known as the Hydrologic Cycle

Snow in Las Cruces, New Mexico





# THE WATER CYCLE



United States Geological Survey. <https://water.usgs.gov/edu/watercyclesummary.html>

# DESCRIPTION OF THE WATER CYCLE

- ▶ Water from ocean and land surfaces evaporates, turning into water vapor in the atmosphere.
- ▶ Water also transpires off of plant leaves joining with the water vapor from the ocean and land surfaces (evapotranspiration).
- ▶ Snow and ice can transform directly from a solid to water vapor (sublimation).
- ▶ As the water vapor rises into cooler air it then condenses into clouds.
- ▶ The water will then fall as precipitation (rain, snow, and hail).
- ▶ As water falls it is dispersed, and then is stored in snow, ice, ground water storage, lakes, or returned back into the oceans.

# WATER CYCLE VOCABULARY

1. **Evaporation** – The transformation of water from liquid to gas (water vapor) as it moves from land or bodies of water into the atmosphere. Water vapor is a gas that cannot be seen.
2. **Transpiration** – The release of water vapor from plants into the air.
3. **Condensation** – The transformation of water vapor into liquid water droplets in the air, creating clouds and fog. This happens when, as water vapor rises in the atmosphere, the air temperature falls below the dew point.
4. **Precipitation** – Condensed water vapor that falls to the Earth's surface. Forms include rain, snow, hail, fog drip, and sleet.
5. **Freshwater Storage** – Sources of freshwater like wetlands, lakes, ponds, and large rivers.
  - There is also **freshwater storage** in ice and snow.
6. **Snowmelt Runoff** – Snow melts into streams.
7. **Ground Water Storage** – The water present beneath the Earth's surface in soil pore spaces and fractures in rock formations.

## FUN FACTS ABOUT THE WATER CYCLE

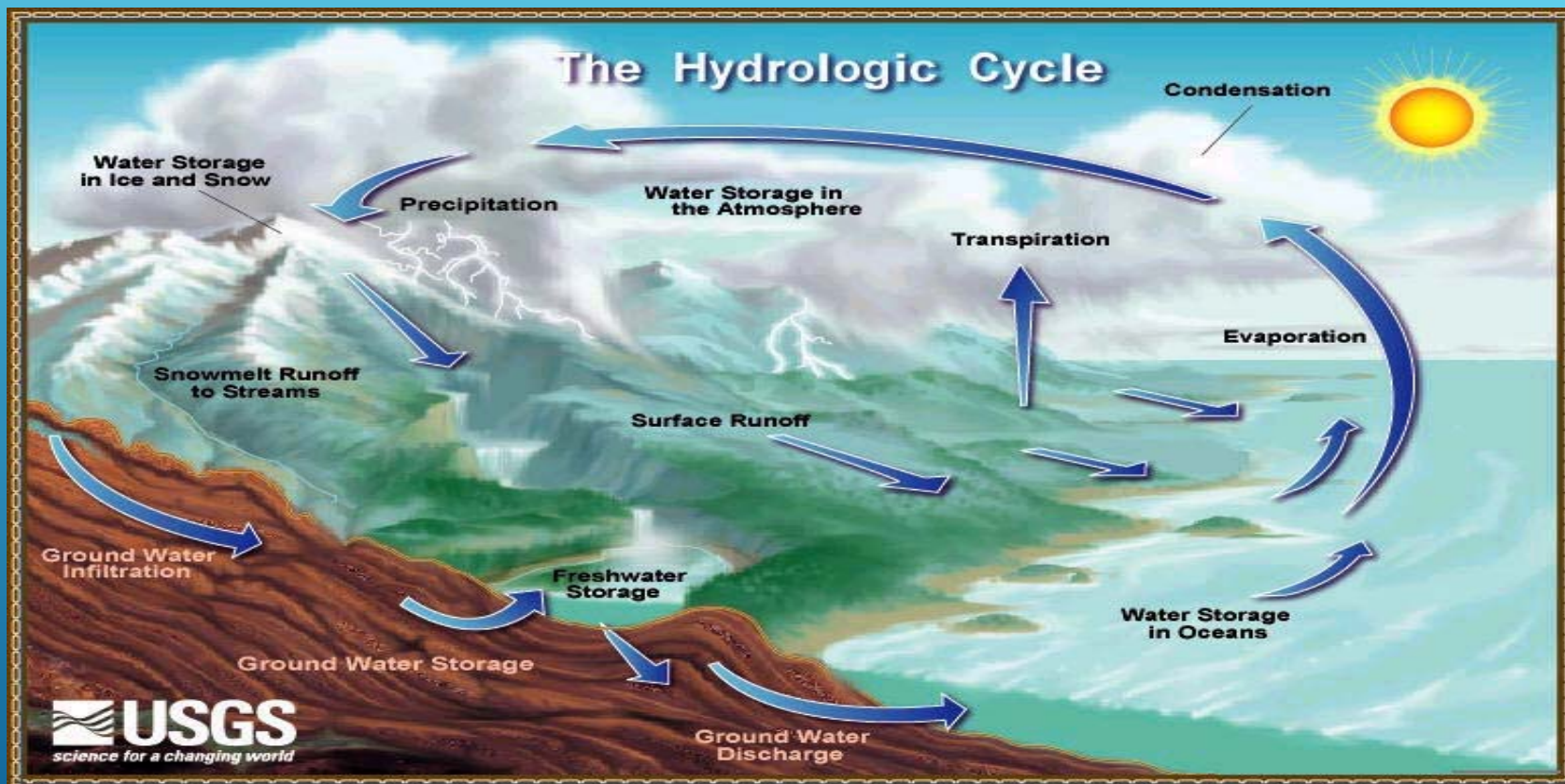
Really old ground water  
is called fossil water!

**Did you know the sun causes  
the water cycle to move?**

The water cycle has  
no starting point!



# THE WATER CYCLE



United States Geological Survey. <https://water.usgs.gov/edu/watercyclesummary.html>



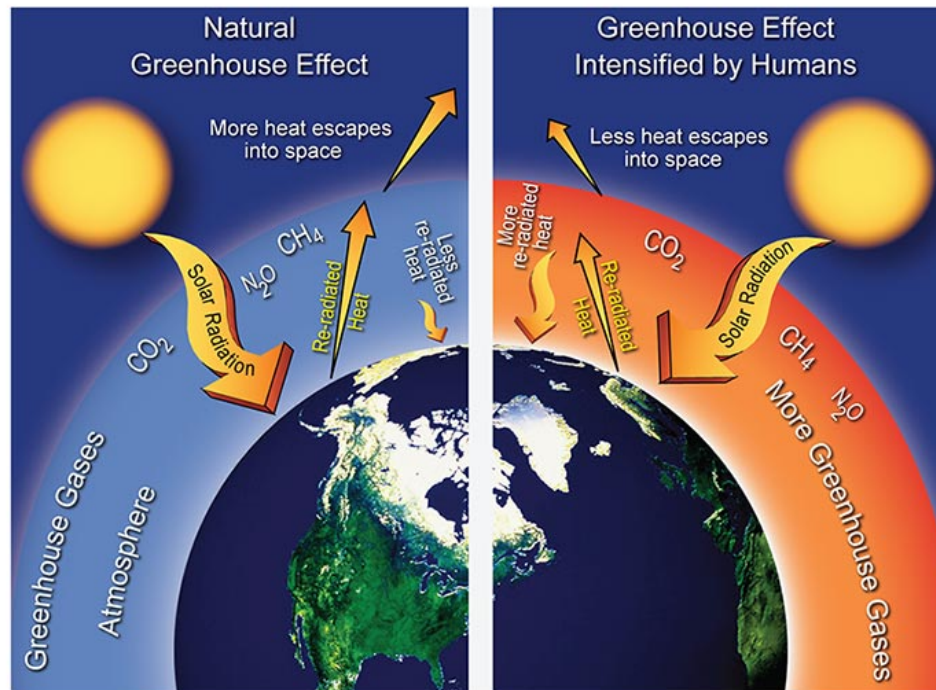


Greenhouse at Memorial Middle School campus in Las Vegas, New Mexico

## LESSON 2: THE GREENHOUSE EFFECT

The greenhouse effect naturally increases the Earth's air temperature by about 60 °F

## Human Influence on the Greenhouse Effect



Estimated that human activity has increased the Earth's air temperature by an additional 1.4 °F

# HUMAN INFLUENCE ON THE GREENHOUSE EFFECT

National Climate Assessment. (2014). <https://nca2014.globalchange.gov/report/appendices/faqs/graphics/human-influence-greenhouse-effect>

# DESCRIPTION OF THE GREENHOUS EFFECT

- ▶ Short wave solar (radiant) energy enters the atmosphere from the sun
- ▶ Some waves reflect off of clouds and greenhouse gasses (GHGs) and return to space
- ▶ Other solar energy waves make it to the earth's surface
- ▶ When they hit the earth, they slow down and form longer heat (thermal) energy waves.
- ▶ These longer heat energy waves have trouble getting back out into space through the GHGs. Trapped heat warms the planet.
- ▶ As human activity and natural sources put more GHGs into the atmosphere, it becomes even harder for the heat waves to escape into space, warming the planet more.
- ▶ The GHGs act like a the glass or plastic covering of a “greenhouse” as they trap heat.

# GASSES THAT INCREASE THE GREENHOUSE EFFECT AS THEY INCREASE IN THE ATMOSPHERE

1. **Carbon Dioxide Gas ( $\text{CO}_2$ ) is given off by:**
  - a. The burning of organic matter like wood, coal, and gasoline in the presence of oxygen
  - b. Destroying of forests (deforestation)
  - c. Living things (respiration)
    - See: NASA's [The Earth's Carbon Cycle is Off Balance](#)
2. **Methane Gas ( $\text{CH}_4$ ). Its three main sources are:**
  - a. Fossil fuel production, distribution, and use (26%)
  - b. Natural release from plant decomposition, wetlands, and oceans (22%)
  - c. Livestock farming (21%)
3. **Nitrous Oxide Gas ( $\text{N}_2\text{O}$ ). Its two main sources are:**
  - a. Natural release by soil bacteria and oceans
  - b. Agricultural sources like livestock waste and fertilizing crops
4. **Water Vapor ( $\text{H}_2\text{O}$ ): Is produced naturally by evaporation, sublimation, and transpiration**



# FUN FACTS ABOUT THE GREENHOUSE EFFECT

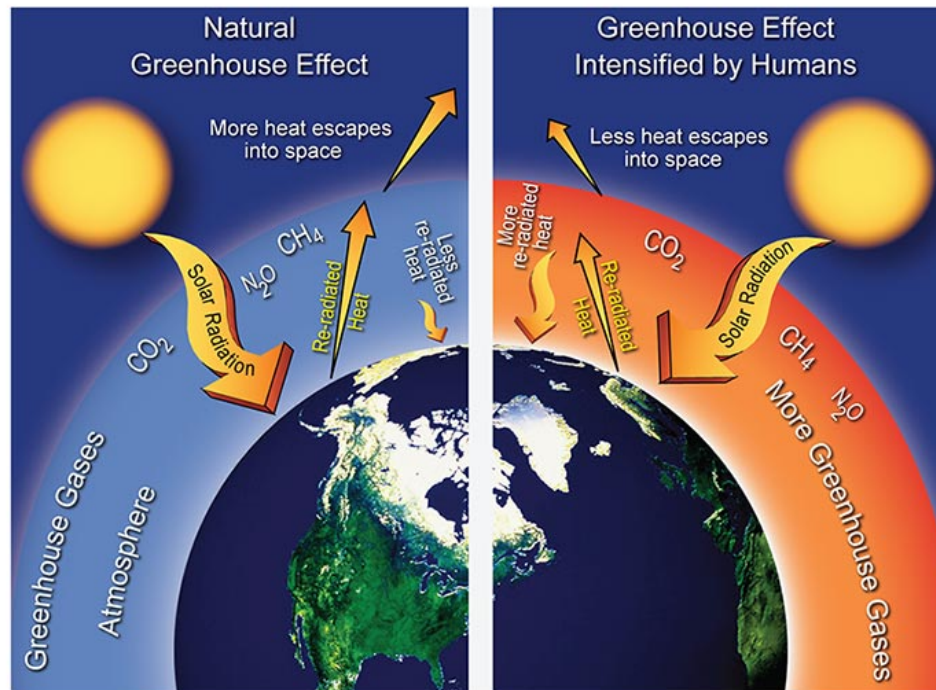
The right amounts of greenhouse gasses  
keeps us from freezing to death and getting skin cancer!

**Greenhouse gasses come from  
natural and man-made sources!**

$\text{N}_2\text{O}$  is 300 times more efficient at trapping heat  
than an equal weight of  $\text{CO}_2$ !

Naturally increases the Earth's air temperature by about 60 °F

## Human Influence on the Greenhouse Effect



Estimated that it has increased the Earth's air temperature by an additional 1.4 °F

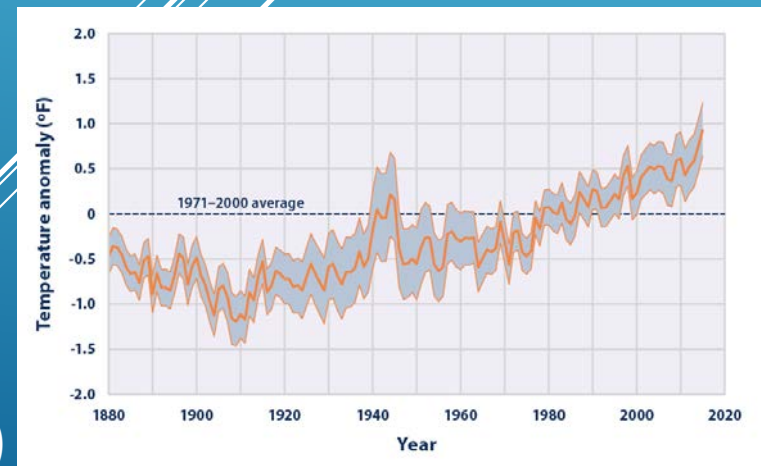
# HUMAN INFLUENCE ON THE GREENHOUSE EFFECT

National Climate Assessment. (2014). <https://nca2014.globalchange.gov/report/appendices/faqs/graphics/human-influence-greenhouse-effect>

# GLOBAL SEA SURFACE TEMPERATURE

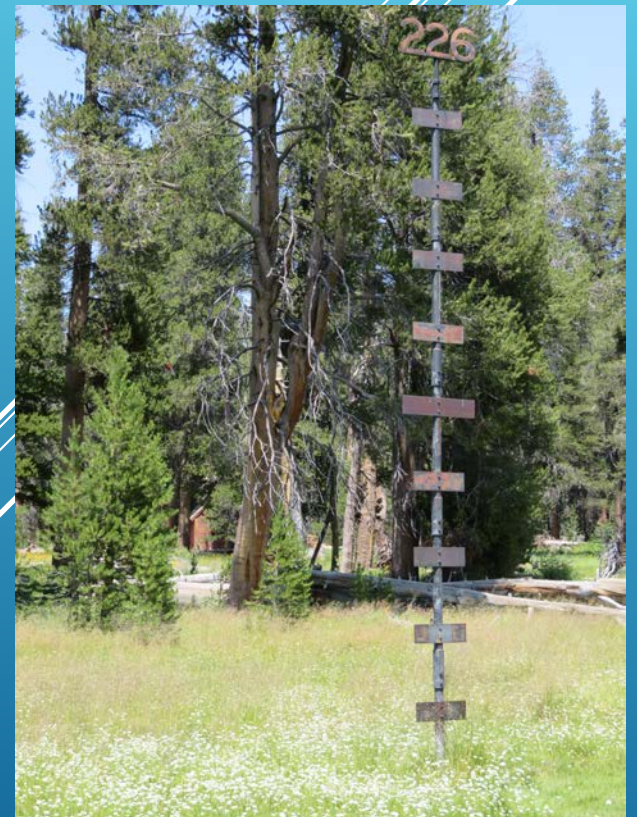
1. Our oceans cover about 70% of the Earth's surface and absorb about 90% of the excess heat caused by the intensifying greenhouse effect
2. Hence, the average global sea surface temperature has climbed about 0.9 °F above the 1971-2000 average (see the graph)
3. This is causing:
  - a. Rising sea levels because water expands as it warms and warmer water speeds up melting of sea ice
  - b. Threatened marine ecosystems (examples: Bleaching of coral reefs and low oxygen for fish in parts of the ocean)
  - c. More water vapor over the oceans leading to disruptive weather patterns (examples: heavier rains and snows in some places and drought in others)
  - d. Threatened human livelihoods (EPA, 2016; NOAA, 2018)

Average Global Sea Surface Temperature, 1880-2015 (EPA, 2016)



# LESSONS 3 AND 4: MEASURING AND ANALYZING WEATHER AND CLIMATE DATA

Old snow depth gauge in Rowell Meadow,  
Outside of Kings Canyon National Park, California





# DEFINITIONS OF WEATHER AND CLIMATE

Weather: The state of the atmosphere at a place and time in terms of precipitation, temperature, humidity, wind, and pressure.

Climate: The prevailing or long term general weather conditions in a particular area over a long period of time.

(National Weather Service, 2015)

What's the Difference Between Weather and Climate?  
<http://eo.ucar.edu/kids/green/what1.htm>



# NATIONAL WEATHER SERVICE COOPERATIVE WEATHER STATION

NMSU Tucumcari Agricultural  
Science Center, NM

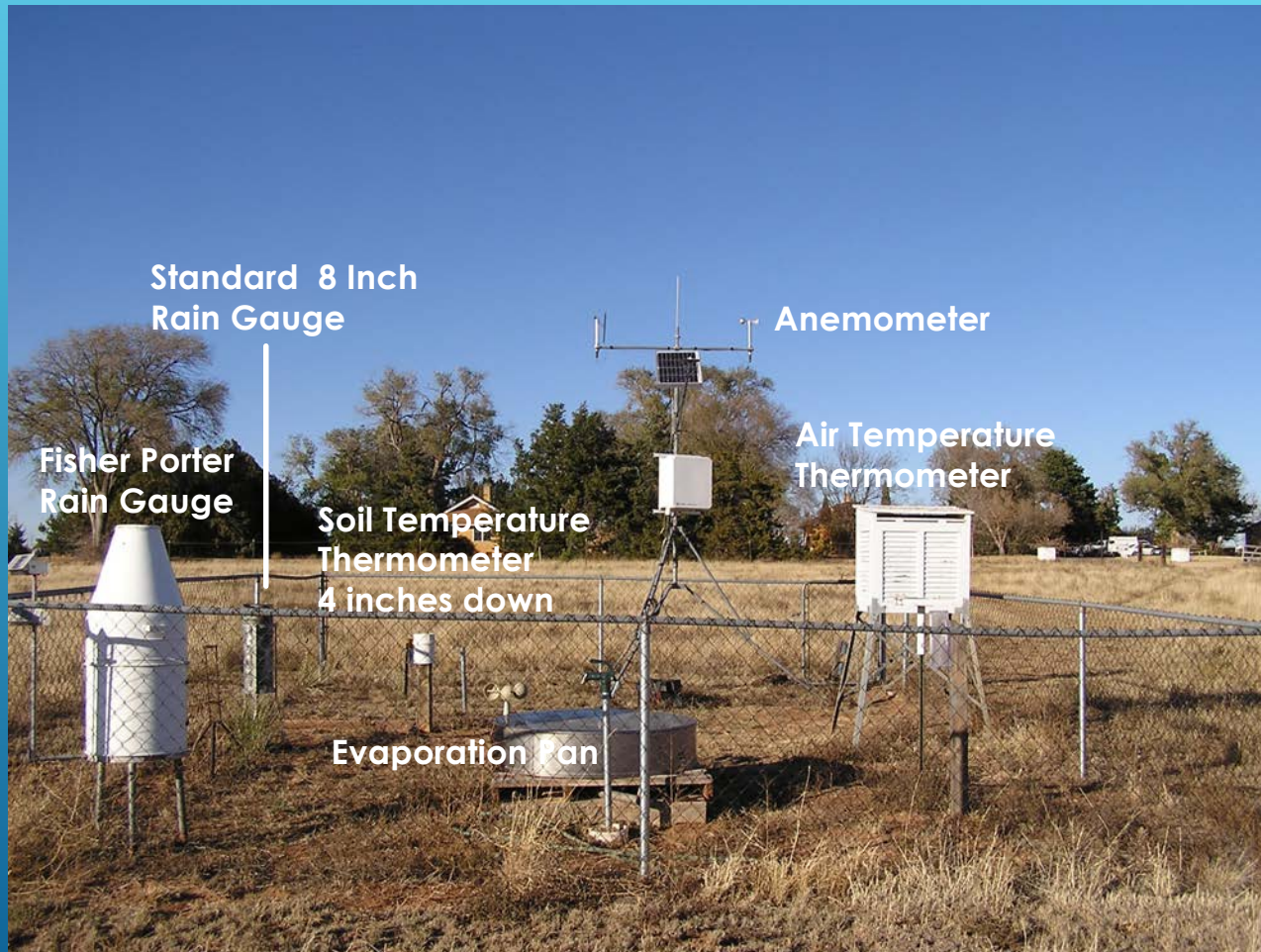


Photo Courtesy of New Mexico State Climatologist, Dr. David DuBois

# FUNCTIONS OF THE COMMON COMPONENTS OF A WEATHER STATION

(ALL BUT THE STANDARD RAIN GAUGE CAN REMOTE TRANSMIT DATA TO SATELLITES)

- Anemometer: Measures wind speed
- Barometer: Measures atmospheric pressure
- Evaporation pan: Measures pan evaporation which integrates the effects of precipitation, humidity, temperature, wind, and other factors
- Hygrometer: Measures humidity
- Pyranometer: Measures solar radiation
- Rain gauges
  - Standard: A non-recording rain gauge that gives inches of precipitation
  - Fisher & Porter: Converts weight into inches of precipitation
- Air and soil thermometers: Measure air and soil temperature

Hand-held infrared thermometers



# HYPERLINK TO NASA GLOBAL TEMPERATURE ANIMATION

**LINK: GLOBAL WARMING FROM 1880 TO 2017**

# HYPERLINK TO OCEAN TEMPERATURE CHANGE ANIMATION

(Cheng et al., 2017)

**LINK: HOW OCEAN TEMPERATURE HAS CHANGED FROM  
1940 TO 2016**

Weather buoy operated by NOAA





# LESSON 5: MITIGATING AND ADAPTING TO WEATHER AND CLIMATE EXTREMES

In Agriculture and Natural Resources

Launching a weather balloon for research



# KEY DEFINITIONS

**Climate change:** A change in climate that is measured over several decades or longer. The change may be due to natural causes (example: a volcanic eruption) or human causes (example: car exhaust). (National Weather Service, 2015)

**Adaptation:** A response or action we take to cope with the actual or anticipated impacts of climate change (example: cooling stations for the poor).

**Mitigation:** An effort to stop or slow climate change (example: buying a more fuel efficient car).

**Resilience:** The combination of mitigation and adaptation strategies that allow us to minimize or avoid the bad effects from climate change.

(Jonassen, R et al, 2012).

Ocotillos in the New Mexican Desert



# ECONOMIC, ENVIRONMENTAL, AND HEALTH CONCERNS WITH A CHANGING CLIMATE

What are some concerns we should have with a changing climate?

- Economic?
- Environmental?
- Health?

Columbia Glacier in Alaska



- ▶ Reduce energy consumption (conserve energy)
  - Electricity production is the #1 source of greenhouse gases (GHGs) in New Mexico (42%)
  - Transportation (20%) is the #3 source of GHGs in New Mexico (producing 20 pounds of CO<sub>2</sub> per gallon of gas burned)
  - If your car gets 20 miles per gallon of gas and you drive 10,000 miles a year, how many pounds of CO<sub>2</sub> does your car make a year?
  - What can we do individually to conserve electricity and fuel?
- ▶ Reduce emissions from existing processes
  - Scrubbers on power plants and cars
- ▶ Switch to renewable energy sources that don't produce GHGs
  - What are some examples?

## WAYS TO MITIGATE HUMAN EMISSIONS OF GREENHOUSE GASSES

Solar panels





- ▶ Increase shade and improve ventilation in barns for livestock
- ▶ Breed crops that are drought tolerant or can thrive in more variable temperatures
- ▶ Breed disease resistant crop and livestock species
- ▶ Change the crops grown in an area to ones that can thrive in changing climate conditions
- ▶ Harvest and plant seeds from forest trees that are doing well in the changing climate conditions
- ▶ Use only the water and fertilizer needed by the crop
  - Precision agriculture
- ▶ Use cultural practices like composting and mulching to conserve water and improve soil temperatures
- ▶ Others?

## WAYS TO ADAPT TO CLIMATE CHANGE IN AGRICULTURE AND NATURAL RESOURCES

Compost pile



# FUN FACTS ABOUT MULCH

Mulch insulates the soil providing a buffer from extremely hot and cold root temperatures

**Mulch helps eliminate weeds to prevent root competition and helps prevent soil compaction**

Mulch retains water, helping to keep roots moist

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