NSTA WEB SEMINARS

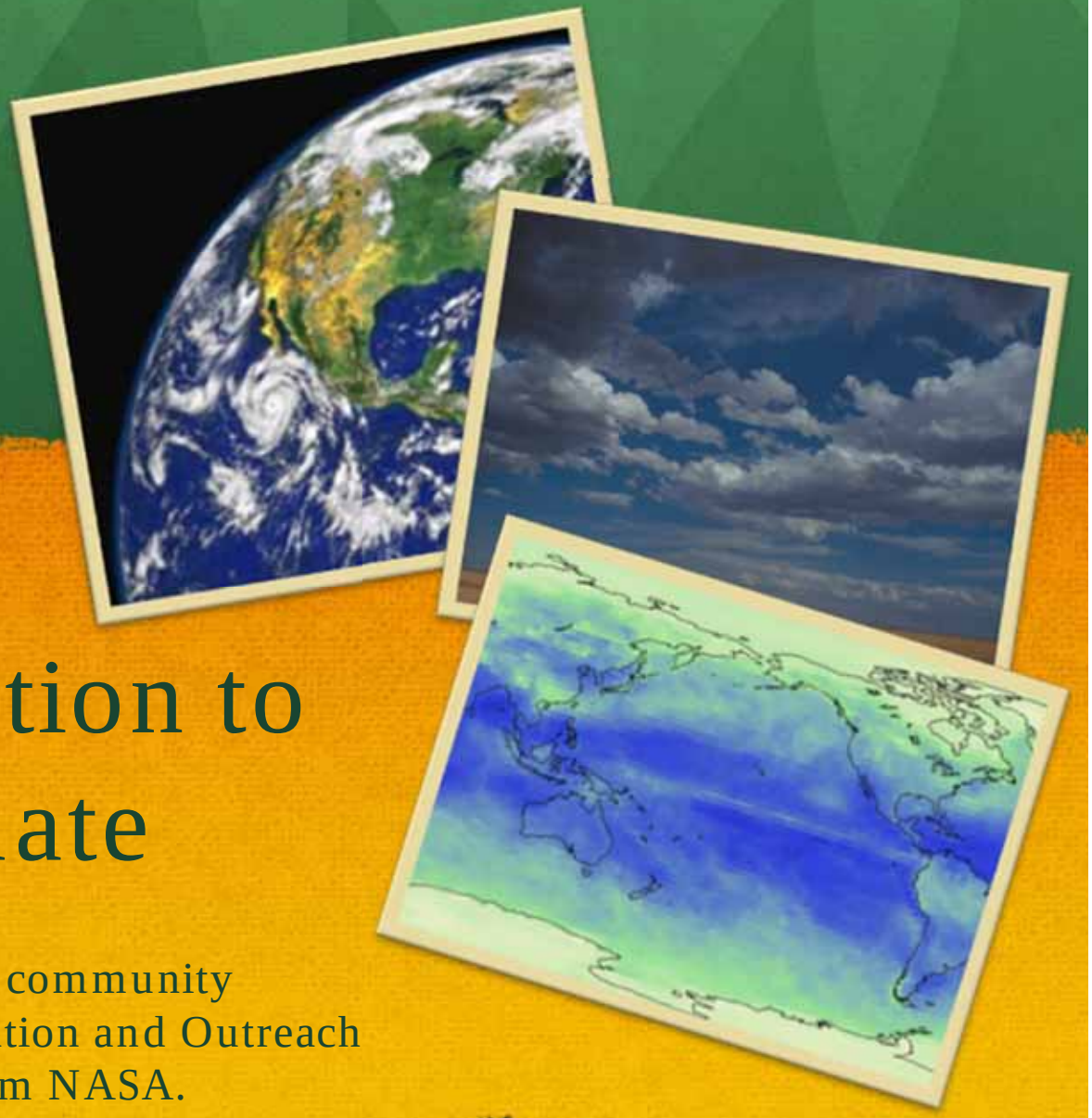
LIVE INTERACTIVE LEARNING @ YOUR DESKTOP

NASA/UCAR/NESTA:
An Introduction to Earth's Climate

Presented by: Dr. Randy Russell

Wednesday, September 22, 2010

6:30 p.m. - 8:00 p.m. Eastern time



An Introduction to Earth's Climate

A web seminar for the NSTA community
By the UCAR Office of Education and Outreach
and NESTA with support from NASA.

Overview

- The difference between climate and weather
  - *Climate & Weather activity*
- Regional versus global climate
- What controls the climate?
- Albedo and other feedbacks
  - *Global Balance Activity from NASA*

Presenter:
Dr. Randy Russell
Educational Designer
UCAR Office of
Education and Outreach

NASA

WINDOWS TO THE UNIVERSE

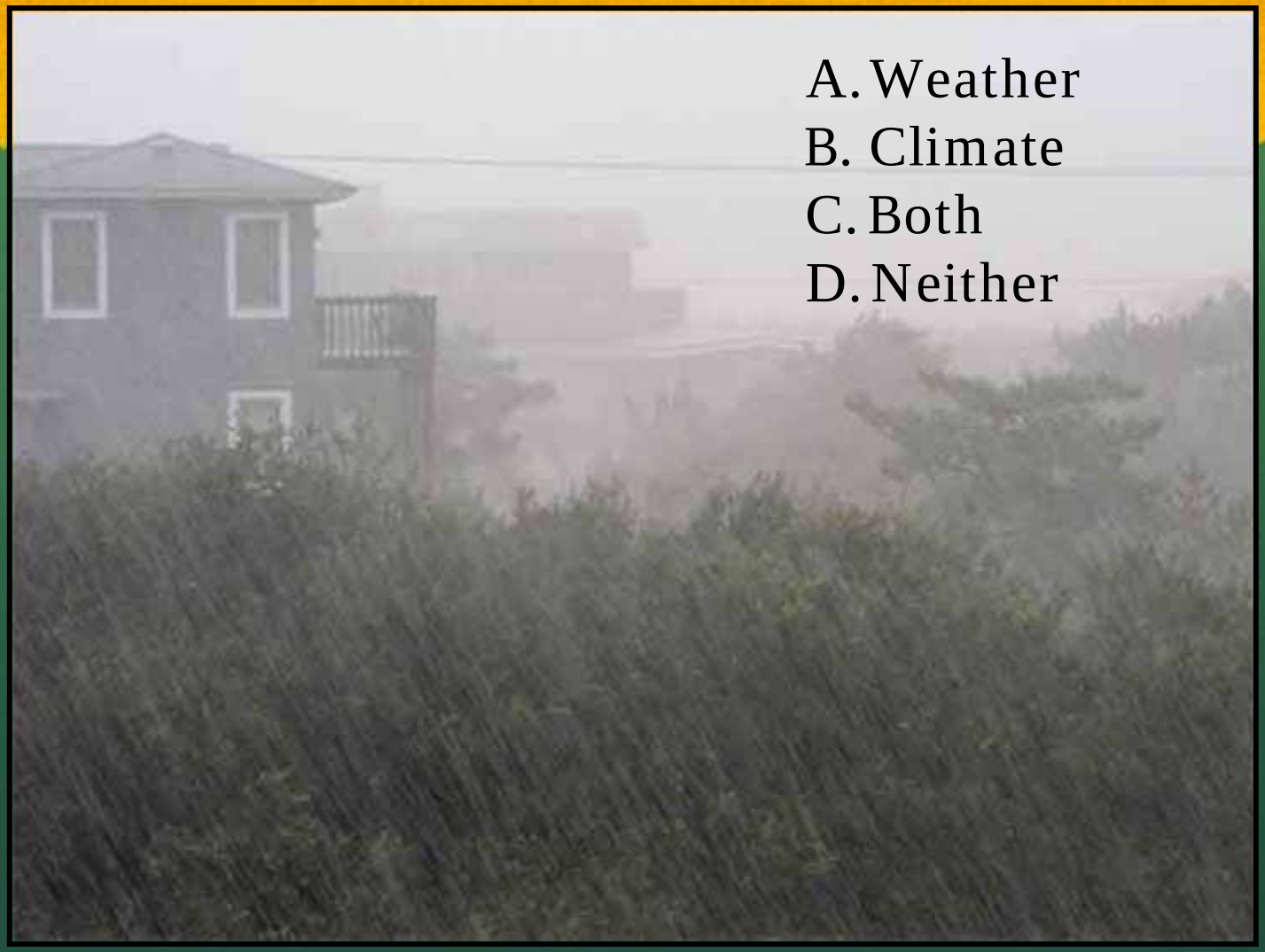
NATIONAL EARTH SCIENCE TEACHERS ASSOCIATION

UCAR
UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

The difference between climate and weather

(with an activity for the classroom)

Is this climate or weather?

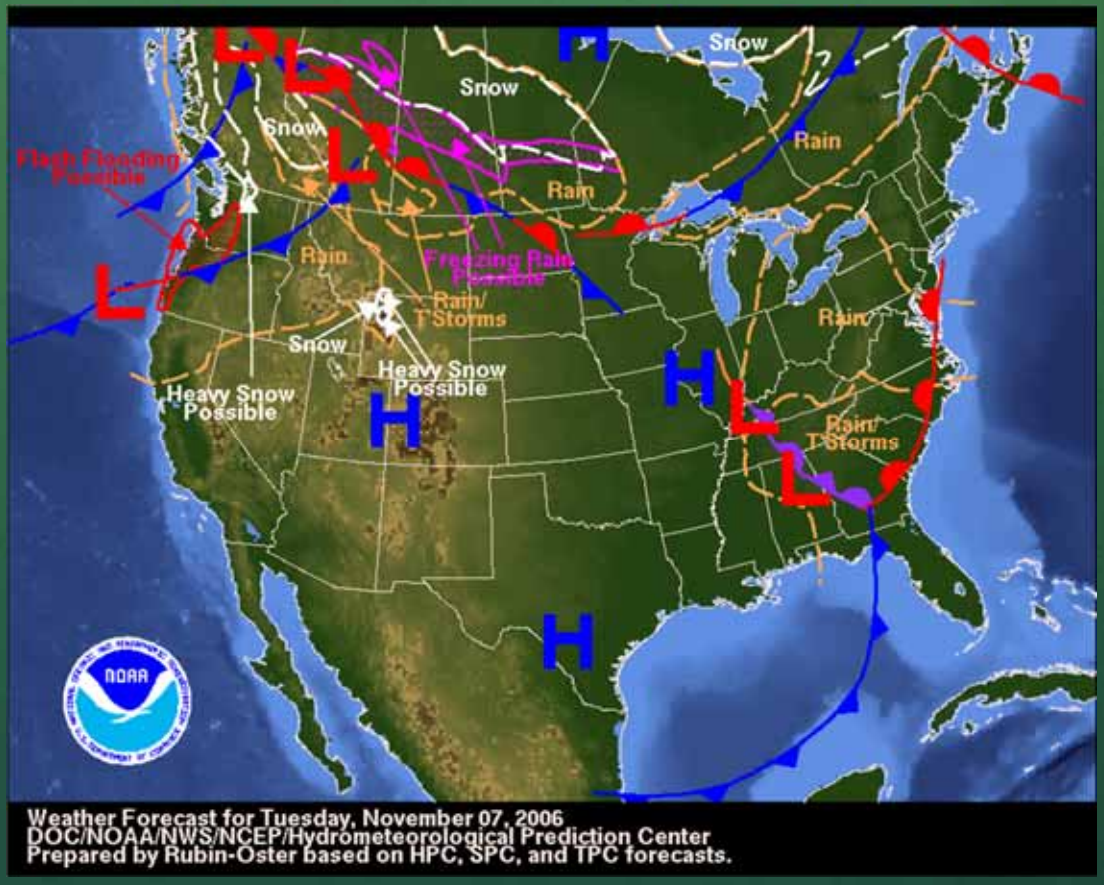


A. Weather
B. Climate
C. Both
D. Neither

Heavy rain along the Outer Banks of North Carolina
Photo by Carlye Calvin

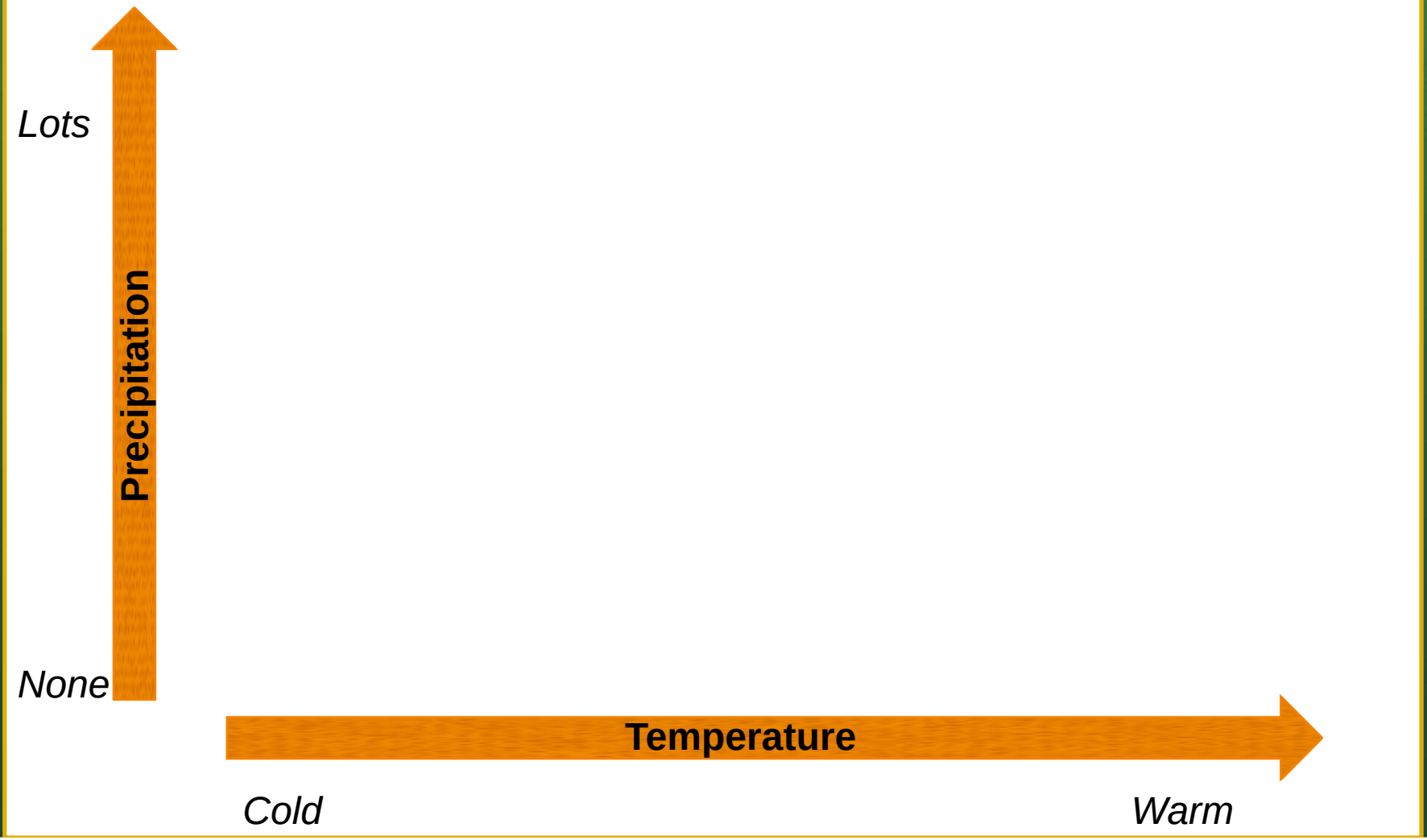
What is weather?

Weather, *n.*
The state of the atmosphere at a time and place described by precipitation, clouds, air pressure, winds, and temperature.



What's the *weather today* where you live?

Mark a location on the graph below to indicate precipitation and temperature

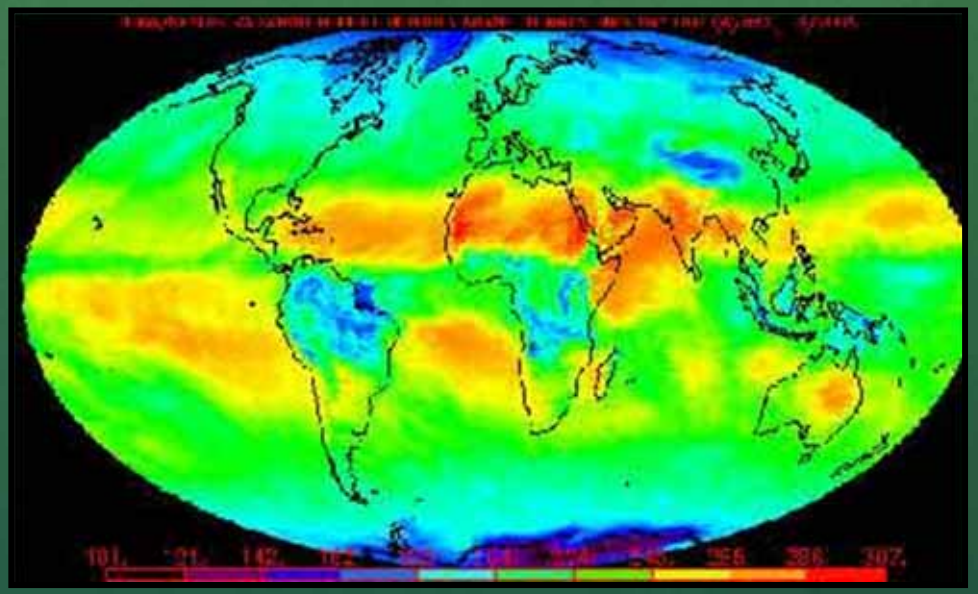


What is climate?

Climate, *n.*
The *typical* state of the atmosphere as described by precipitation, winds, and temperature.

Global Climate

The average climate over the entire Earth



Regional Climate

The climate in a particular place.

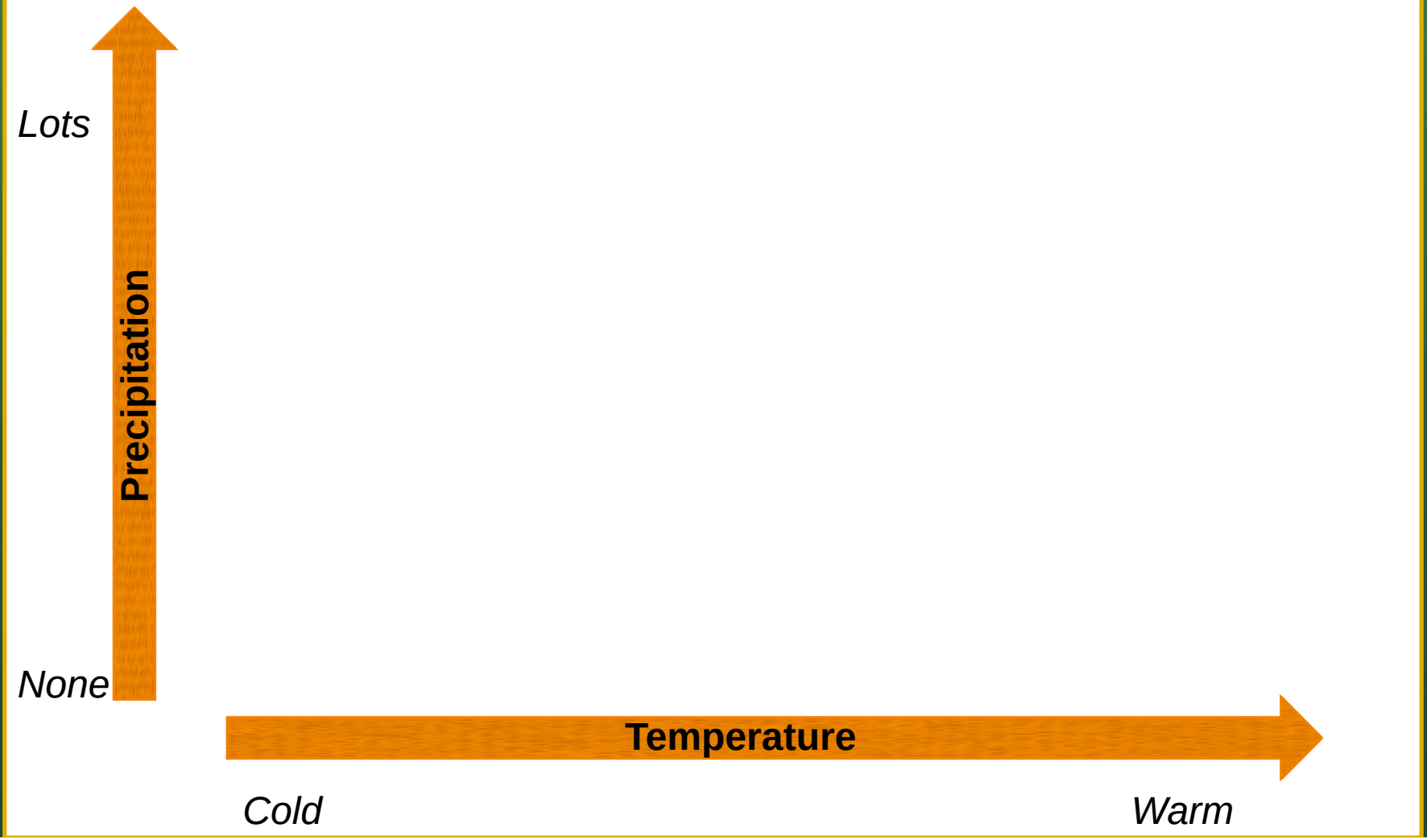
Naples, FL
Average Jan. high: 75 F (24 C)

Nome, AK
Average Jan. high: 13 F (-11 C)

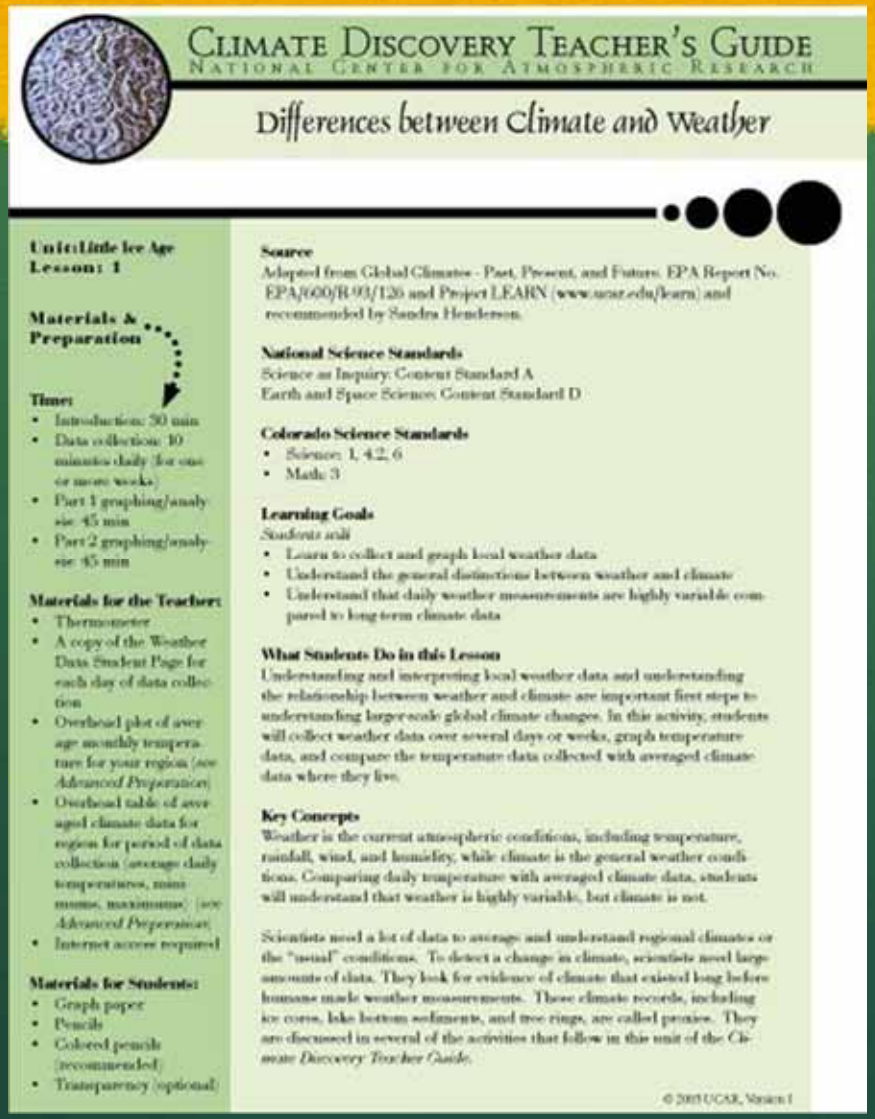
(Wikipedia/Marc Averette)

What's the *climate* where you live in September?

Mark a location on the graph below to indicate general precipitation and temperature



Climate & Weather, A Classroom Activity



CLIMATE DISCOVERY TEACHER'S GUIDE
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Differences between Climate and Weather

Unit: Little Ice Age
Lesson: 1

Materials & Preparation

Time:
- Introduction: 30 min
- Data collection: 10 minutes daily (for one or more weeks)
- Part 1 graphing/analysis: 45 min
- Part 2 graphing/analysis: 45 min

Materials for the Teacher:
- Thermometer
- A copy of the Weather Data Student Page for each day of data collection
- Overhead plot of average monthly temperature for your region (see *Advanced Preparation*)
- Overhead table of averaged climate data for region for period of data collection (average daily temperatures, minimums, maximums) (see *Advanced Preparation*)
- Internet access required

Materials for Students:
- Graph paper
- Pencils
- Colored pencils (recommended)
- Transparency (optional)

Source
Adapted from Global Climates - Past, Present, and Future. EPA Report No. EPA/600/R-93/126 and Project LEARN (www.ucar.edu/learn) and recommended by Sandra Henderson.

National Science Standards
Science as Inquiry: Content Standard A
Earth and Space Science: Content Standard D

Colorado Science Standards
- Science: 1, 4.2, 6
- Math: 3

Learning Goals
Students will
- Learn to collect and graph local weather data
- Understand the general distinctions between weather and climate
- Understand that daily weather measurements are highly variable compared to long-term climate data

What Students Do in this Lesson
Understanding and interpreting local weather data and understanding the relationship between weather and climate are important first steps to understanding larger-scale global climate changes. In this activity, students will collect weather data over several days or weeks, graph temperature data, and compare the temperature data collected with averaged climate data where they live.

Key Concepts
Weather is the current atmospheric conditions, including temperature, rainfall, wind, and humidity, while climate is the general weather conditions. Comparing daily temperature with averaged climate data, students will understand that weather is highly variable, but climate is not.

Scientists need a lot of data to average and understand regional climates or the "usual" conditions. To detect a change in climate, scientists need large amounts of data. They look for evidence of climate that existed long before humans made weather measurements. These climate records, including ice cores, lake bottom sediments, and tree rings, are called proxies. They are discussed in several of the activities that follow in this unit of the *Climate Discovery Teacher Guide*.

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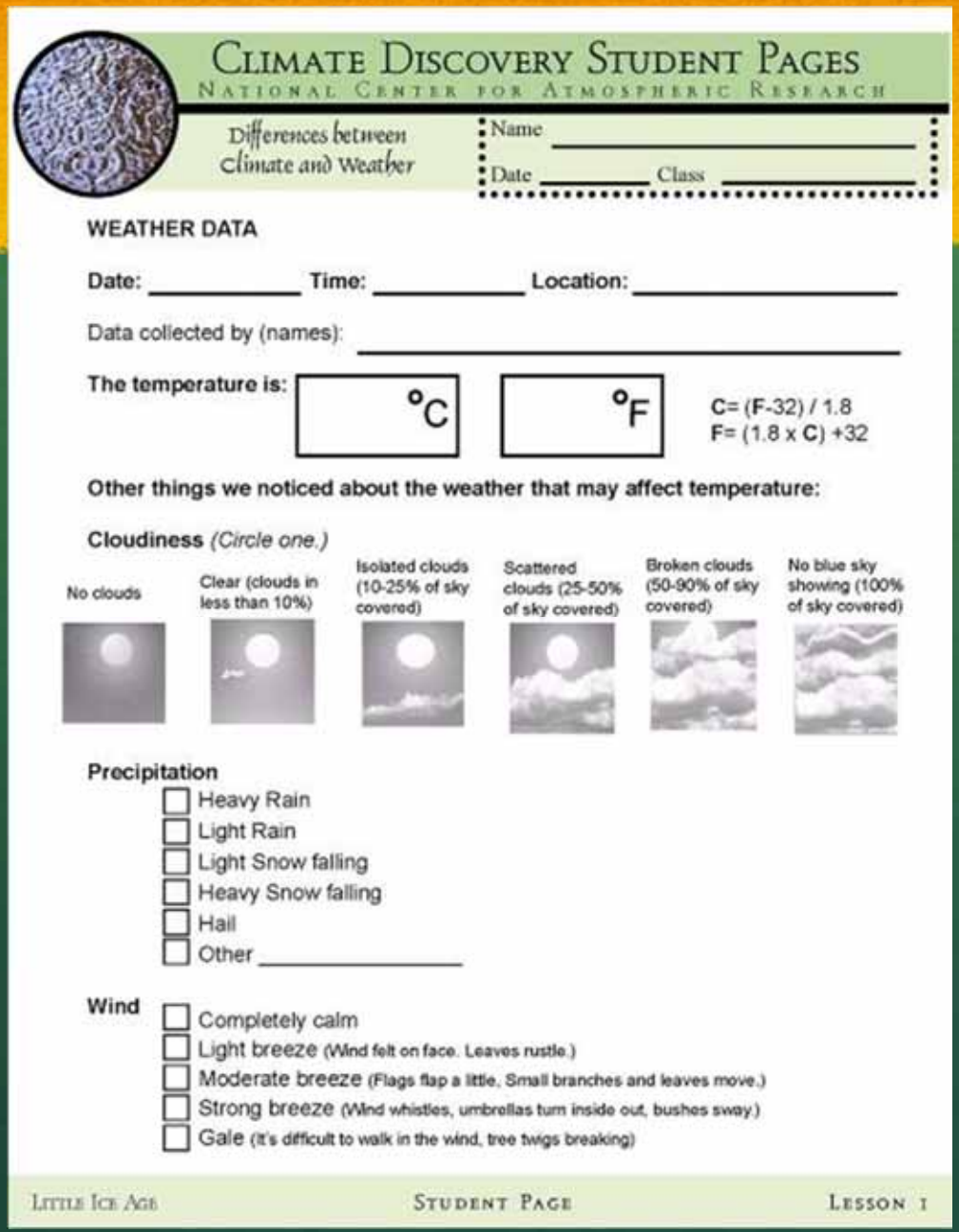
Students will:

- Collect weather data over several days or weeks
- Research climate data for their region online
- Graph and compare climate data and weather data.

http://eo.ucar.edu/educators/ClimateDiscovery/LIA_lesson1_9.28.05.pdf

Collecting Weather Data



CLIMATE DISCOVERY STUDENT PAGES
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Differences between Climate and Weather

Name _____

Date _____ Class _____

WEATHER DATA

Date: _____ **Time:** _____ **Location:** _____

Data collected by (names): _____

The temperature is: °C °F

C= (F-32) / 1.8
F= (1.8 x C) +32

Other things we noticed about the weather that may affect temperature:

Cloudiness *(Circle one.)*

No clouds | Clear (clouds in less than 10%) | Isolated clouds (10-25% of sky covered) | Scattered clouds (25-50% of sky covered) | Broken clouds (50-90% of sky covered) | No blue sky showing (100% of sky covered)

Precipitation

- ☐ Heavy Rain
- ☐ Light Rain
- ☐ Light Snow falling
- ☐ Heavy Snow falling
- ☐ Hail
- ☐ Other _____

Wind

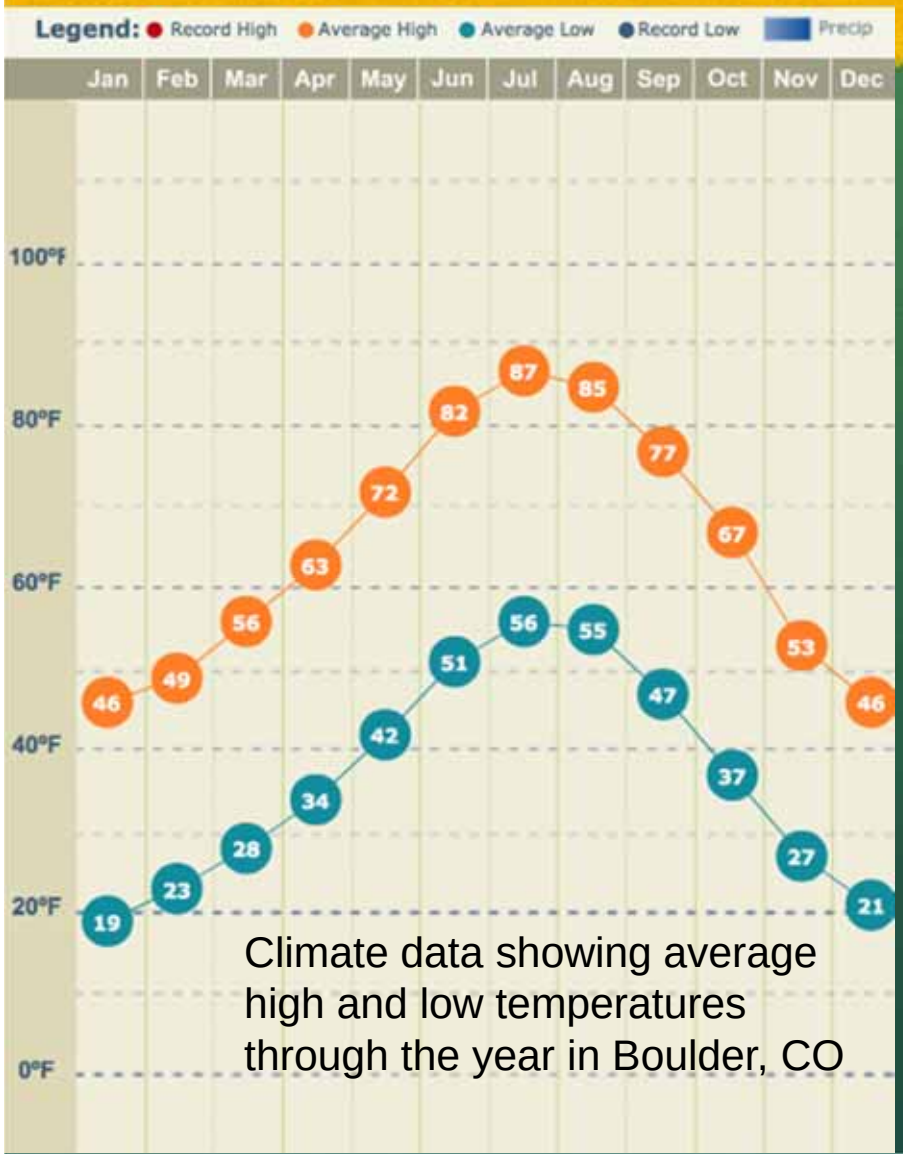
- ☐ Completely calm
- ☐ Light breeze (Wind felt on face. Leaves rustle.)
- ☐ Moderate breeze (Flags flap a little. Small branches and leaves move.)
- ☐ Strong breeze (Wind whistles, umbrellas turn inside out, bushes sway.)
- ☐ Gale (It's difficult to walk in the wind, tree twigs breaking)

LITTLE ICE AGE STUDENT PAGE LESSON 1

- Temperature
- Cloudiness
- Precipitation
- Wind

* This simple method can be done with just a thermometer. With other tools and sensors, data collecting can be more detailed.

Research climate data for your region



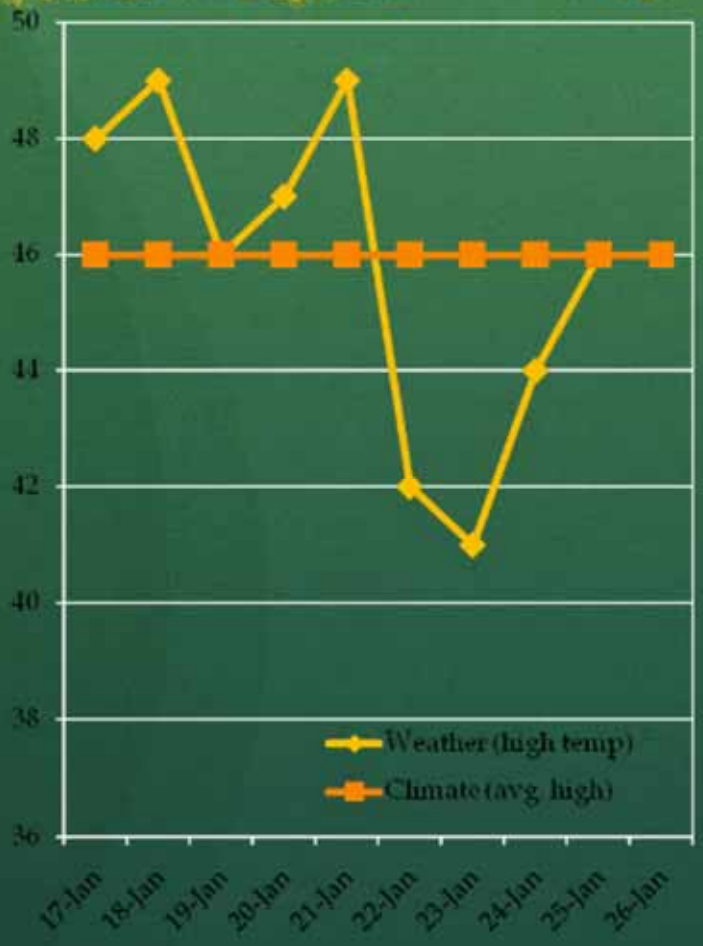
Climate data showing average high and low temperatures through the year in Boulder, CO

http://www.weather.com

- Search your zip code or city
- Click on "Month" and then "Averages" to see average data over the year.
- Discuss how average temperature changes with seasons.

* The climate data at weather.com comes from NOAA/NWS

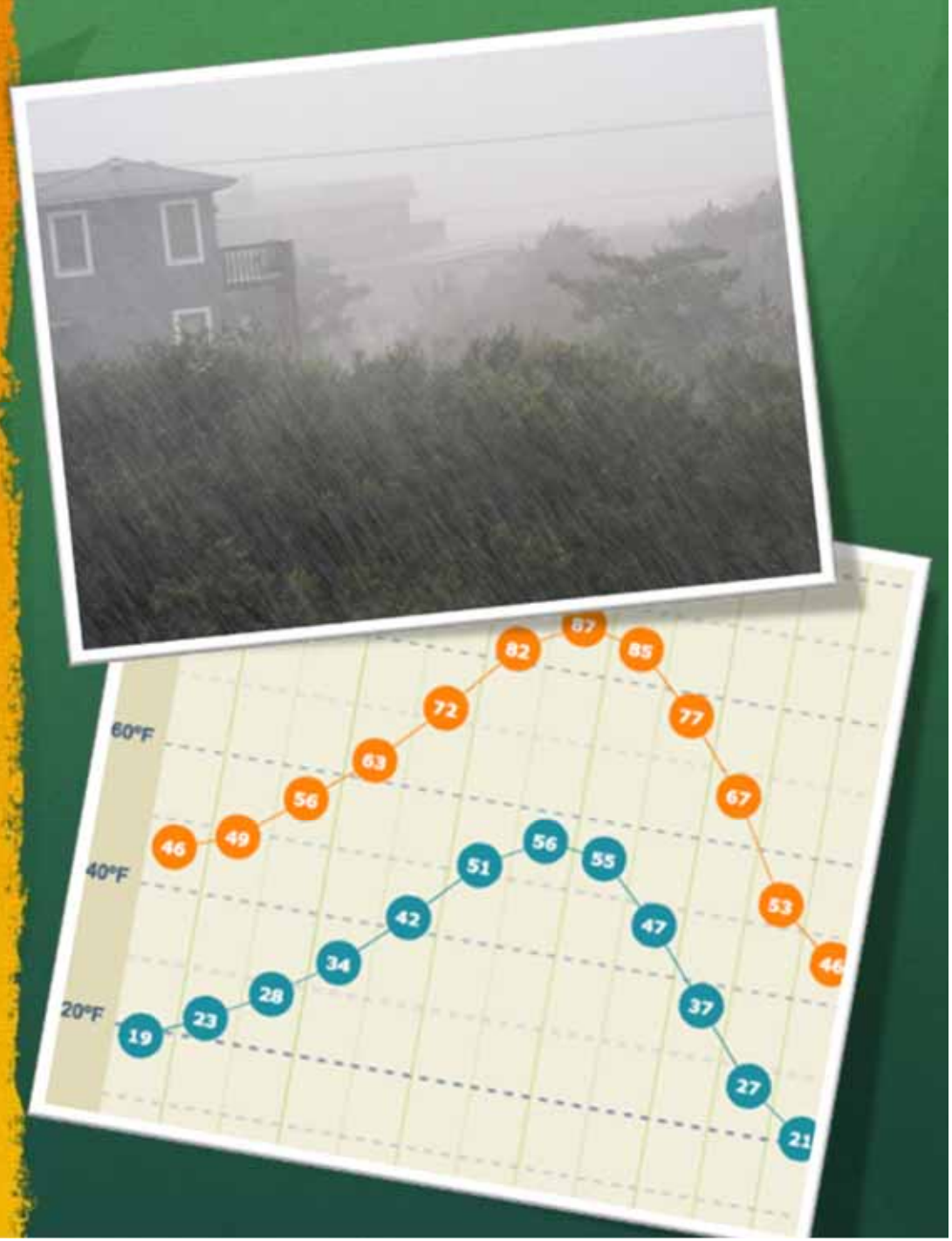
Compare weather data with climate data



2010 high temps compared with average highs for Jan 18-27

- At weather.com, choose the month in which you collected weather data.
- Have students graph daily average temperature.
- Then, students add their temperature measurements to this graph.
- Discuss!

Questions?


60°F
40°F
20°F
46
49
56
63
72
82
87
85
77
67
53
46
19
23
28
34
42
51
56
55
47
37
27
21

What Controls the Climate?

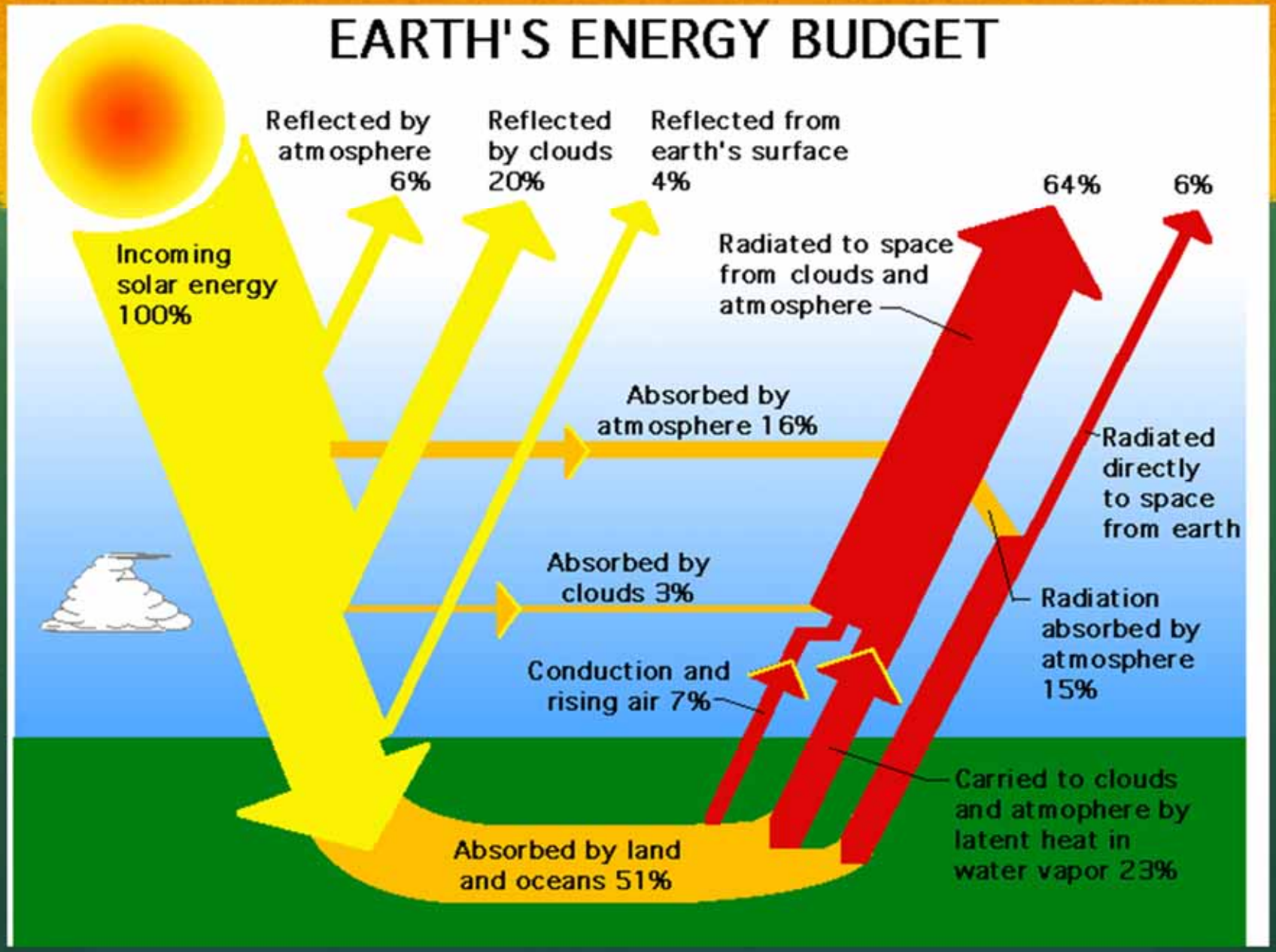
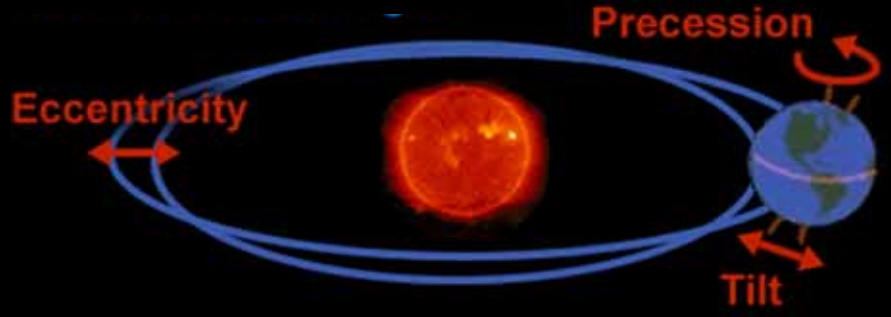


Image: NASA's ERBE Program

Many things affect how much energy gets to, and stays within, the Earth system.

The Sun & Earth's orbit



And the amount of greenhouse gases…

Greenhouse gases trap heat.

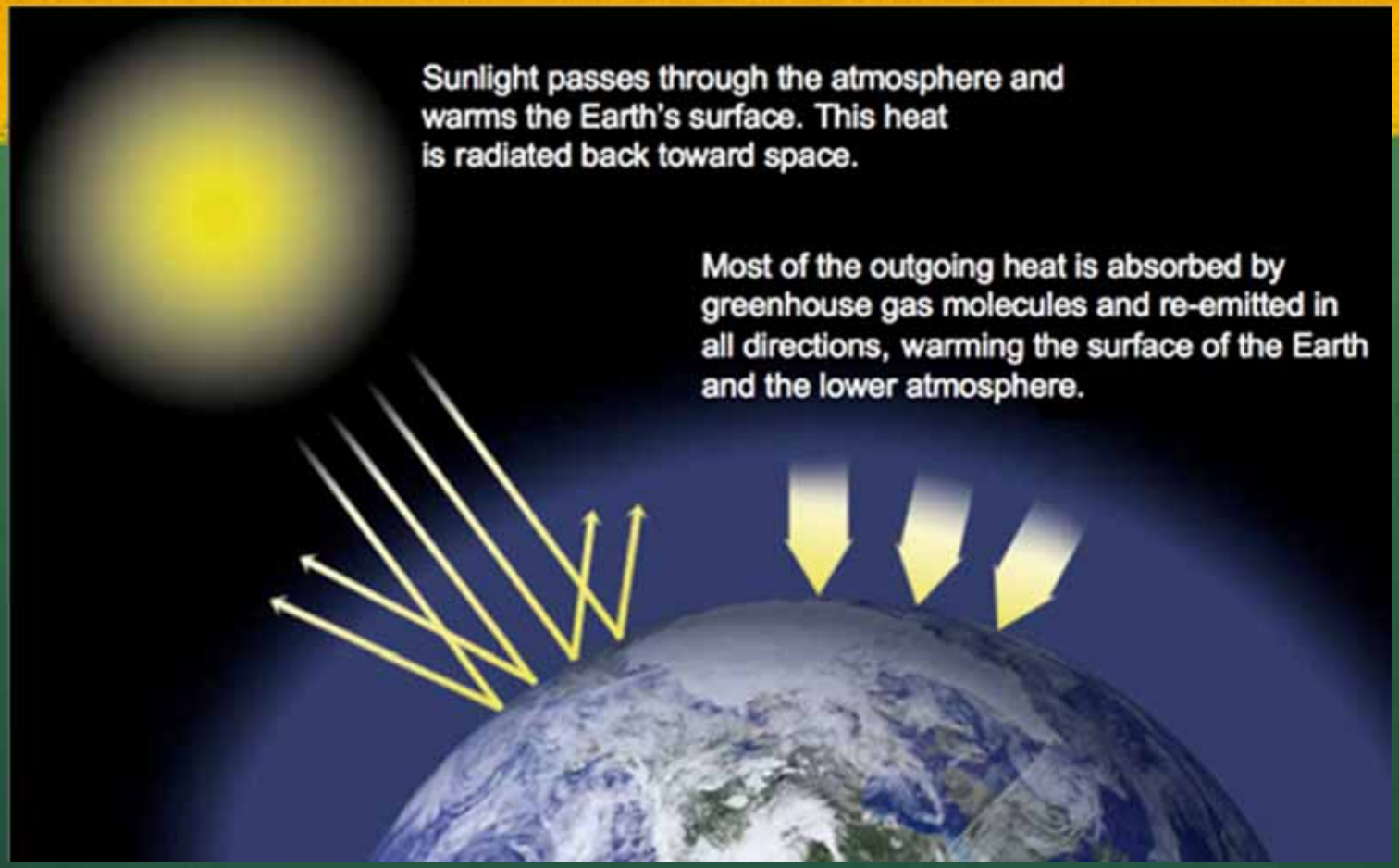
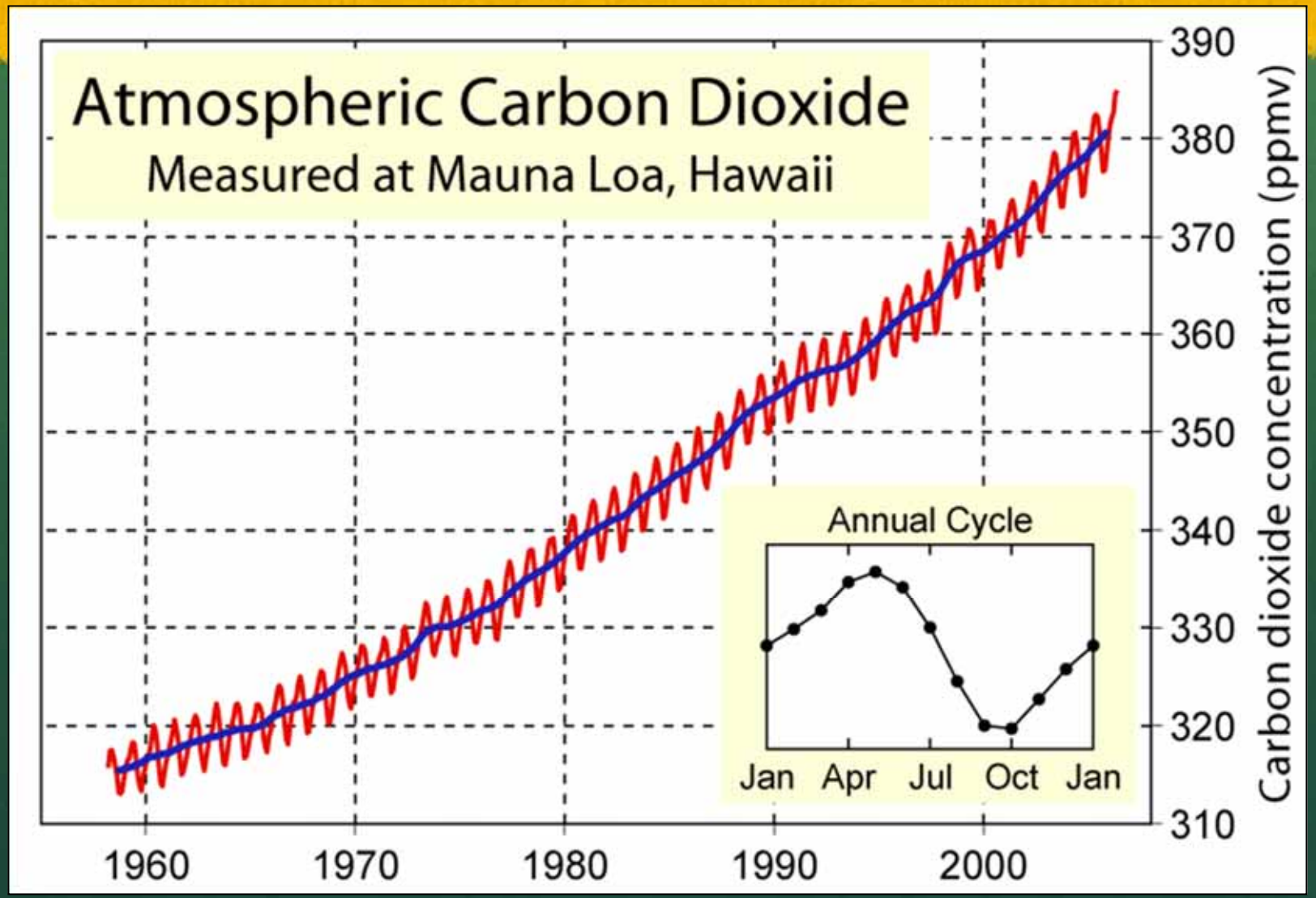


Image: NASA

- Greenhouse gases are a natural part of the atmosphere.
- The amount is now high due to emissions by humans.

Measurements of atmospheric CO2
(Keeling Curve)



5/2009
386.11

3/1958
315.71

Image courtesy: www.globalwarmingart.com, See also: www.esrl.noaa.gov/gmd/ccgg/trends/

Greenhouse gases and warming

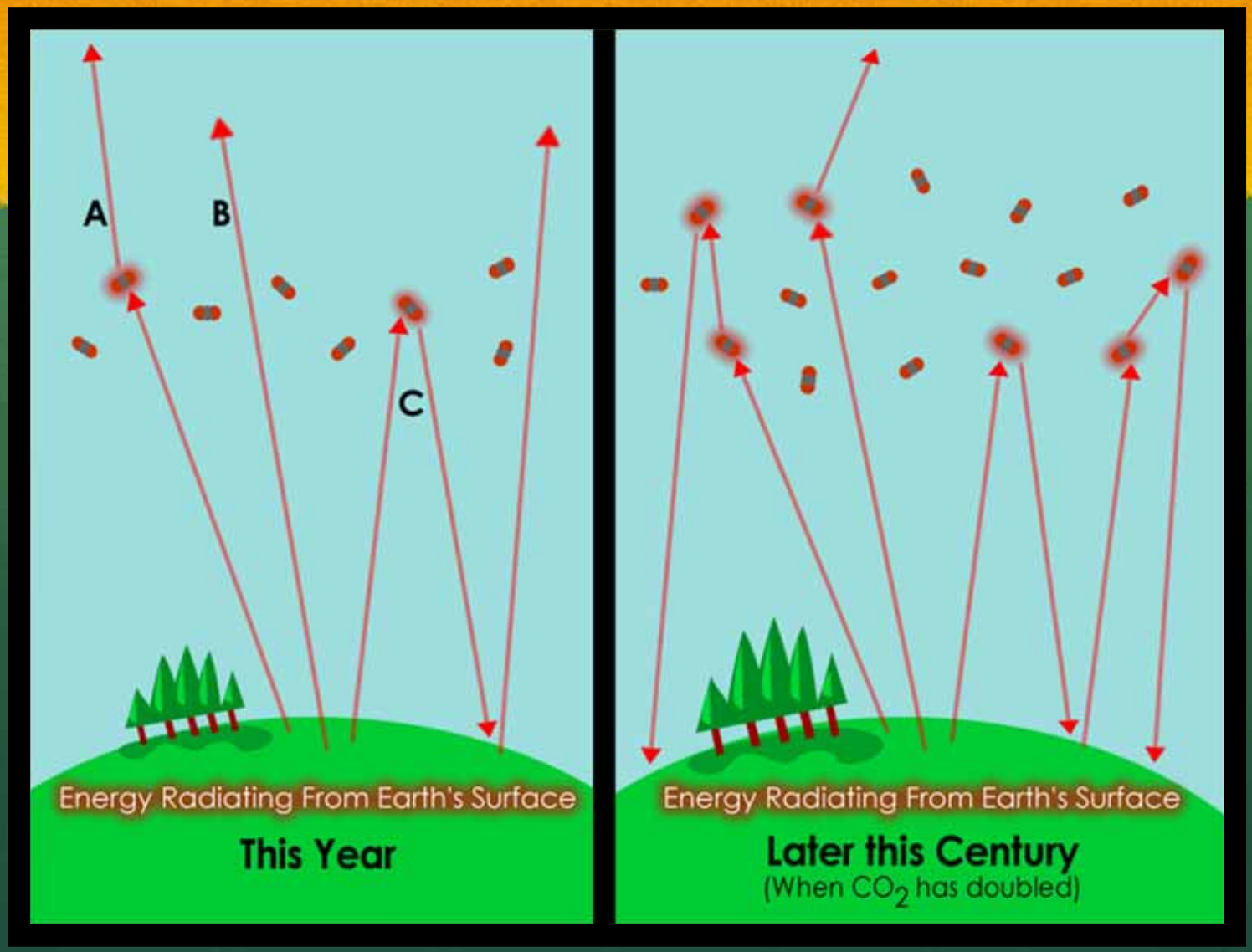


Illustration of effects of GHG on energy today and prediction for the future. Heat absorbed by CO2 radiated to space (A). Heat can make its way to space directly (B). Heat absorbed by CO2 radiated towards Earth (C).

The Effect of Volcanoes

- Volcanic aerosols stay in the atmosphere for a couple of years and have a cooling effect.
- Mixing air means that eruptions affect the whole planet.

Sulfur dioxide (SO2) in the stratosphere about 100 days after the 1991 Mt. Pinatubo eruption *(Red=high SO2, Purple=normal SO2)*

Global average temperature dropped ~1 F for two years after the eruption.

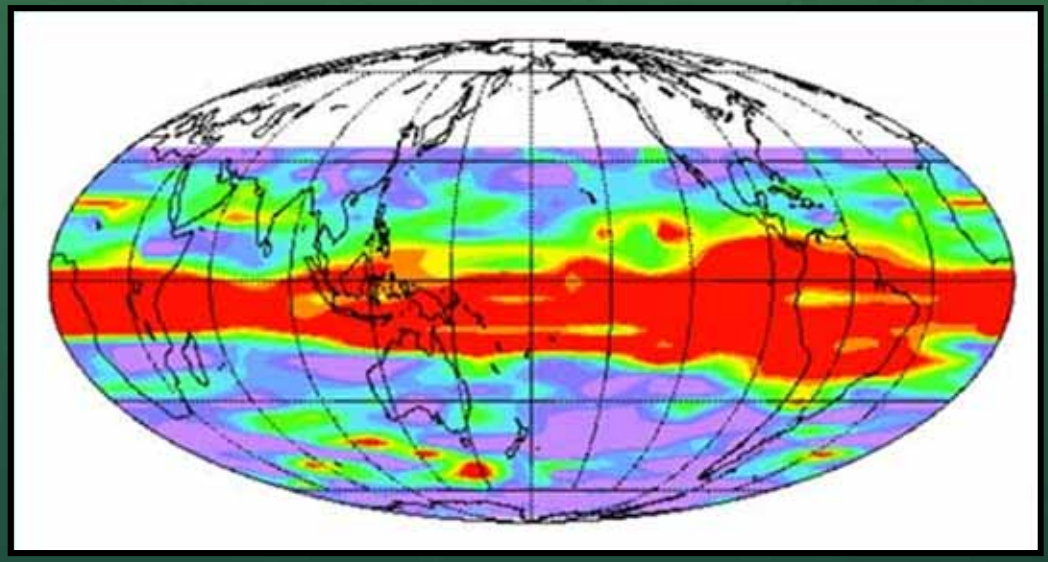
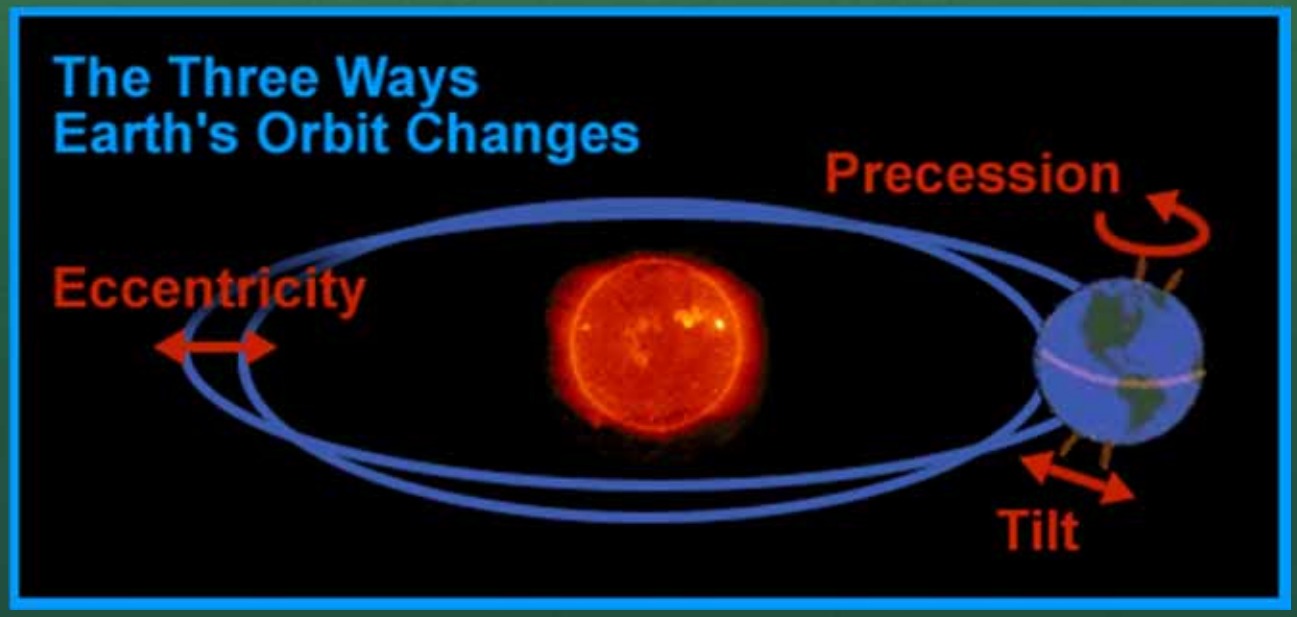


Image: NASA, Upper Atmosphere Research Satellite Microwave Limb Sounder

Effect of Earth’s Orbit

Changes to Earth’s climate happen due to changes in:

- Eccentricity - Shape of Earth’s orbit (100,000 year cycle)
- Precession - Earth’s wobble as it spins (23,000 year cycle)
- Tilt - The angle of Earth's axis (41,000 year cycle)



These are called Milankovitch Cycles.

Cloud Heights	Cloud Types
High Clouds	Cirrocumulus Cirrostratus Cirrus
Middle Clouds	Altocumulus Altostratus
Low Clouds	Cumulus Cumulonimbus Nimbostratus Stratocumulus Stratus

Effect of Clouds

High clouds have a warming effect.

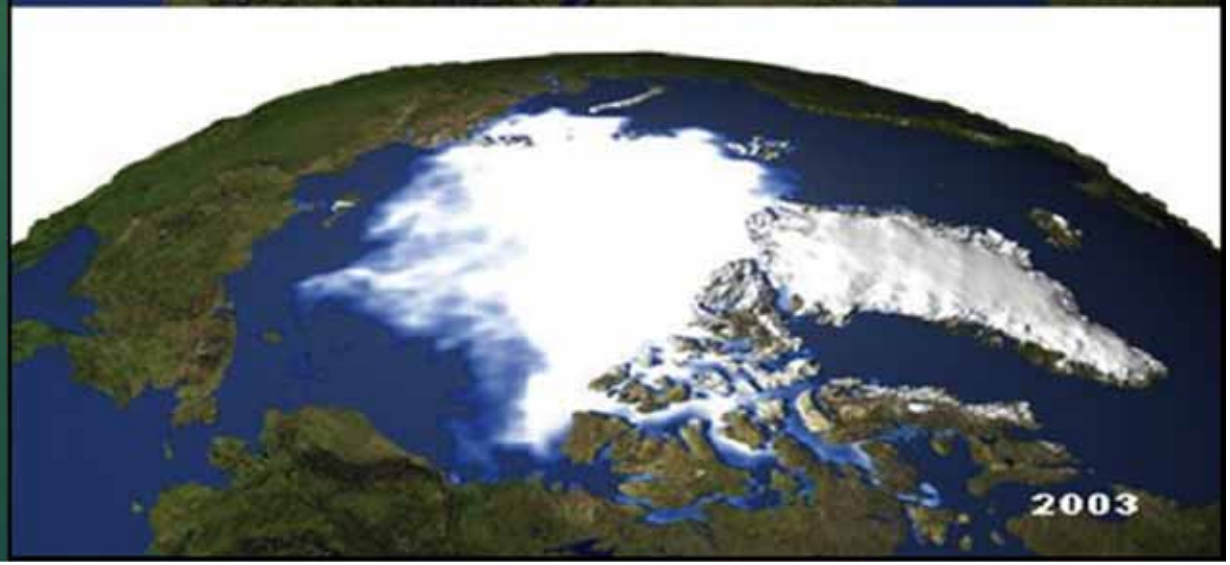
- Ice crystals absorb more energy than water droplets.
- Thin clouds allow sunlight to pass through to earth.

Low and middle clouds have a cooling effect.

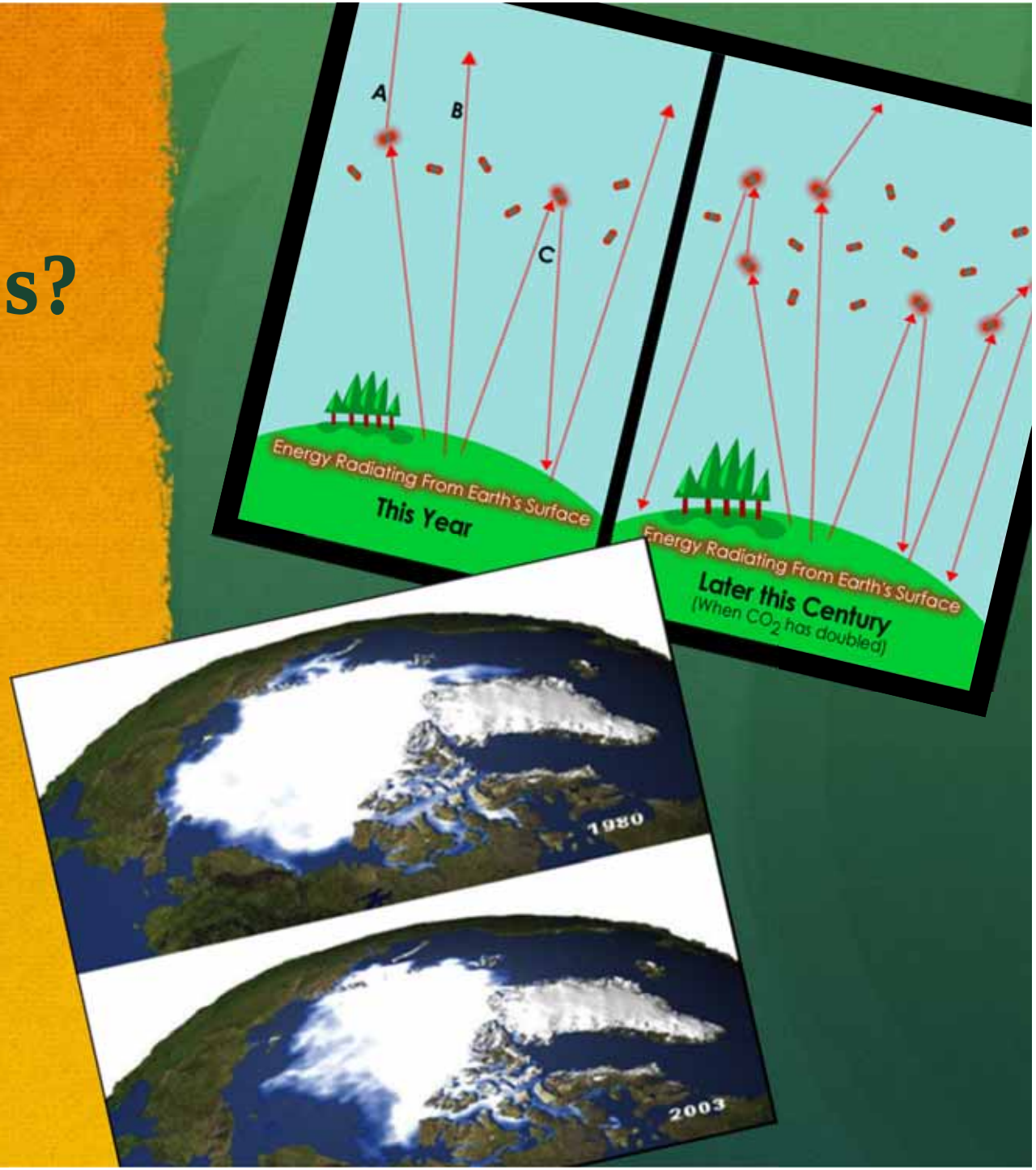
- Water droplets absorb less energy.
- Thick clouds reflect sunlight away from Earth.

Effect of Less Snow and Ice

- Decline in Arctic ice cover 1980 to 2003
- Less ice means less energy is reflected back out to space.
- NASA's ICESat satellite is measuring thickness and extent of sea ice.



Questions?

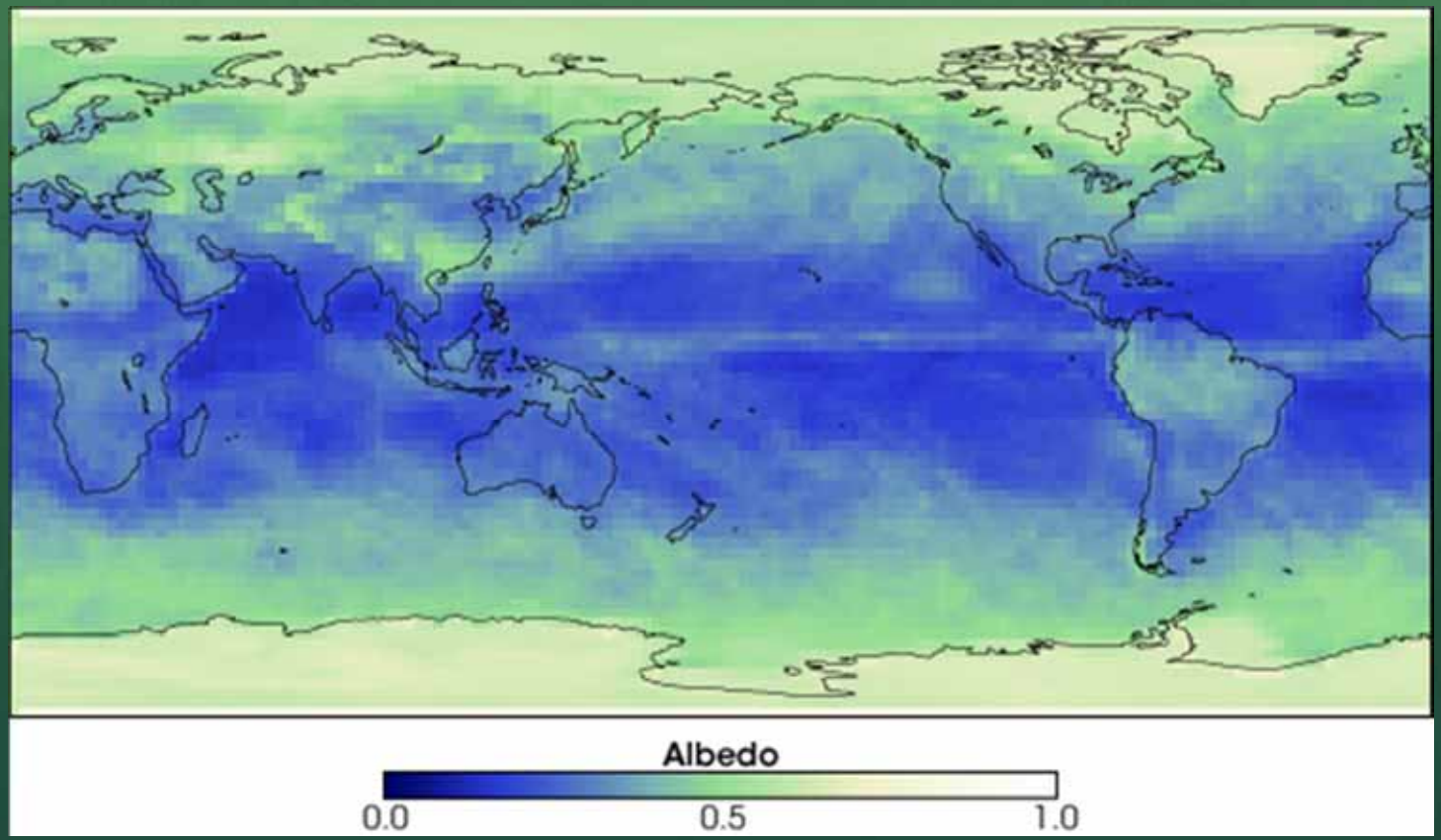

A
B
C
Energy Radiating From Earth's Surface
This Year
Energy Radiating From Earth's Surface
Later this Century
(When CO_2 has doubled)
1980
2003

The Impact of Albedo on Climate

(And a classroom activity about Daisyworld)

What is Albedo?

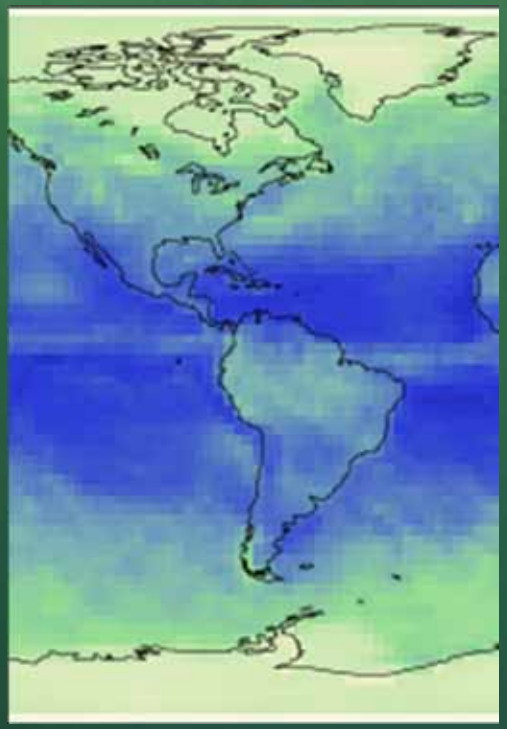
- The fraction of sunlight that is reflected back out to space.



Earth's average albedo for March 2005
NASA image http://visibleearth.nasa.gov/view_rec.php?id=17177

Why is albedo higher at the poles and lower at the equator?

High



Low

High

Choose the correct answer:

A. **Because more sunlight hits at the equator than the poles.**

B. **Because snow and ice at the poles reflects more sunlight.**

C. **Because higher temperatures at the equator allow the atmosphere to hold energy.**

About Daisyworld…

- Daisyworld: a mythical planet with dark soil, white daisies, and a sun shining on it.
  - The dark soil have low albedo – they absorb solar energy, warming the planet.
  - The white daisies have high albedo – they reflect solar energy, cooling the planet.
- Daisyworld was first described by Dr. James Lovelock who theorized that life has an active role in shaping the Earth's climate.

The Role of Life in Promoting Stability

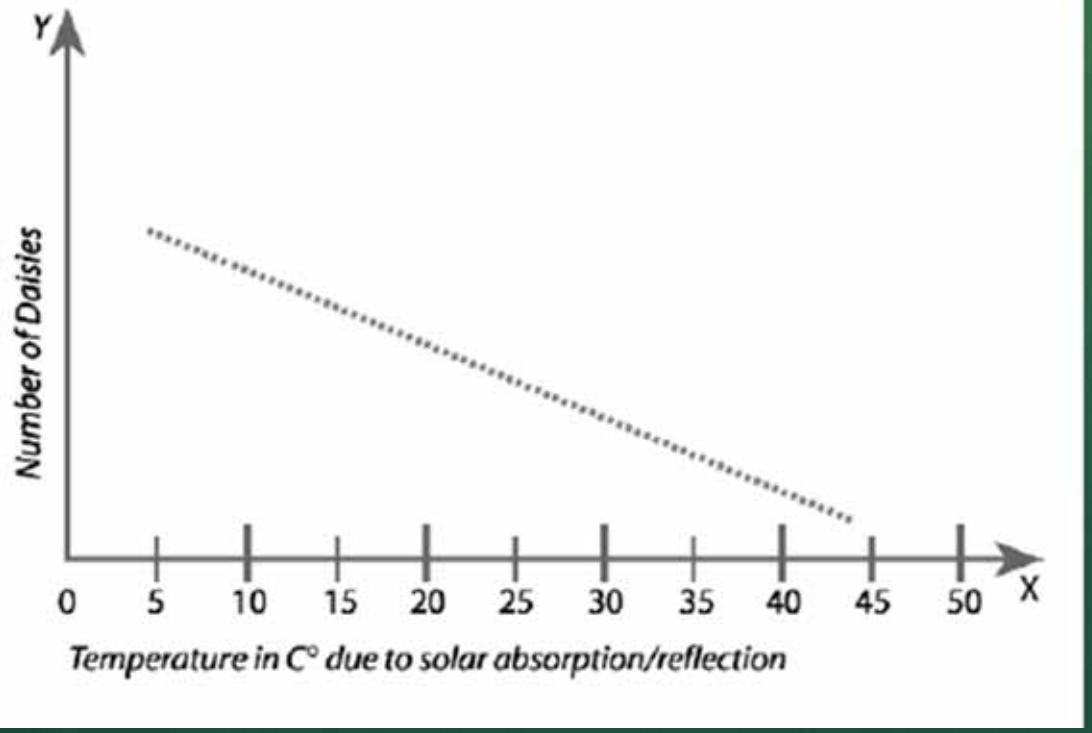
A Classroom Activity Featuring Daisyworld

Students will:

- Determine the effects life has on temperature stability
- Graph relationships
- Define steady states – when a planet is in balance, stable

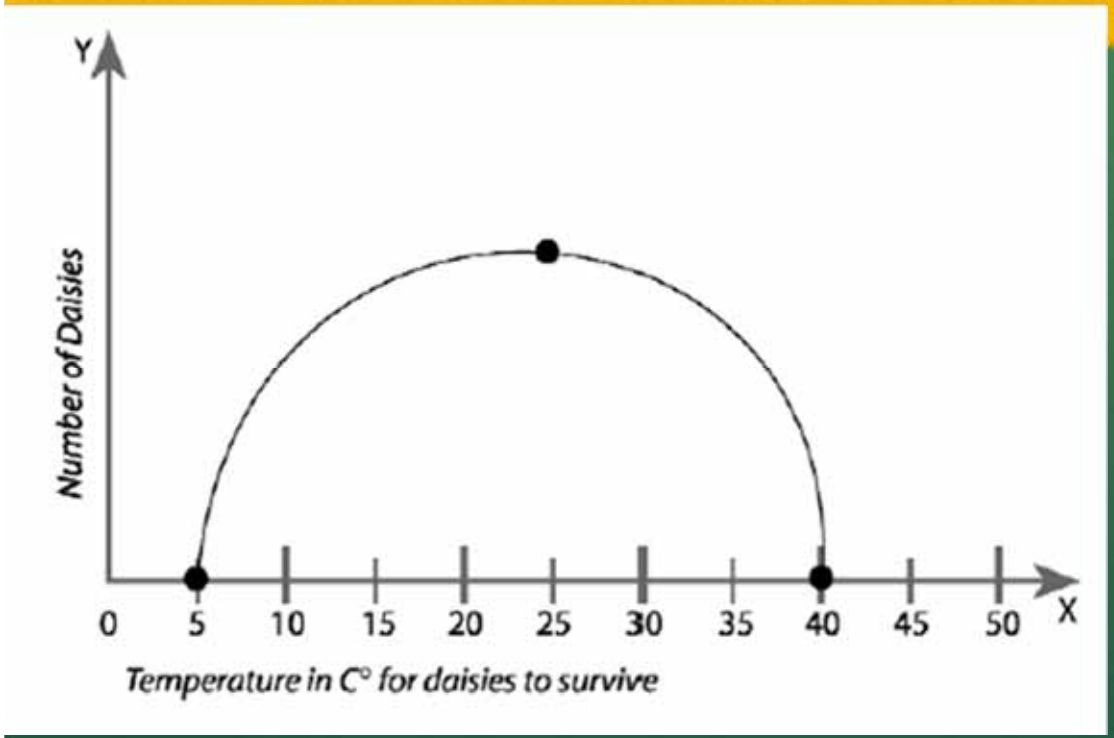
Developed by the Institute for Global Environmental Strategies with funding from NASA and the EPA. http://www.strategies.org/docs/GlobalBalance_May02.pdf

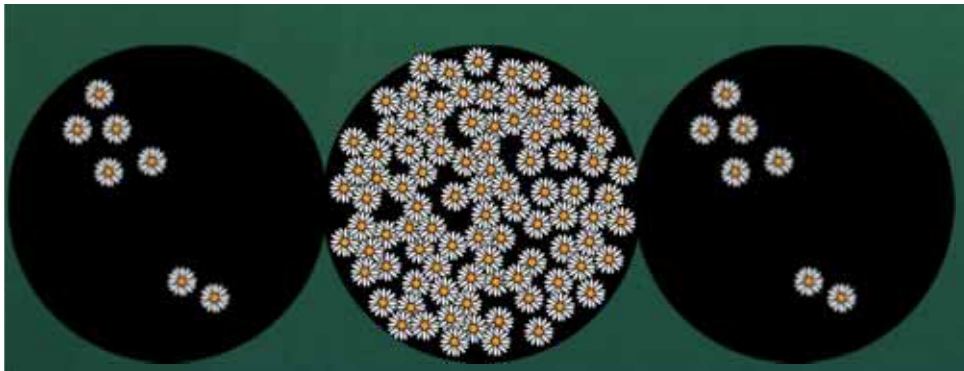
The number of daisies affects temperature.



- The number of daisies influences temperature of Daisyworld.
- More white daisies means a cooler planet.
- Students create a graph of how the number of daisies affects temperature.

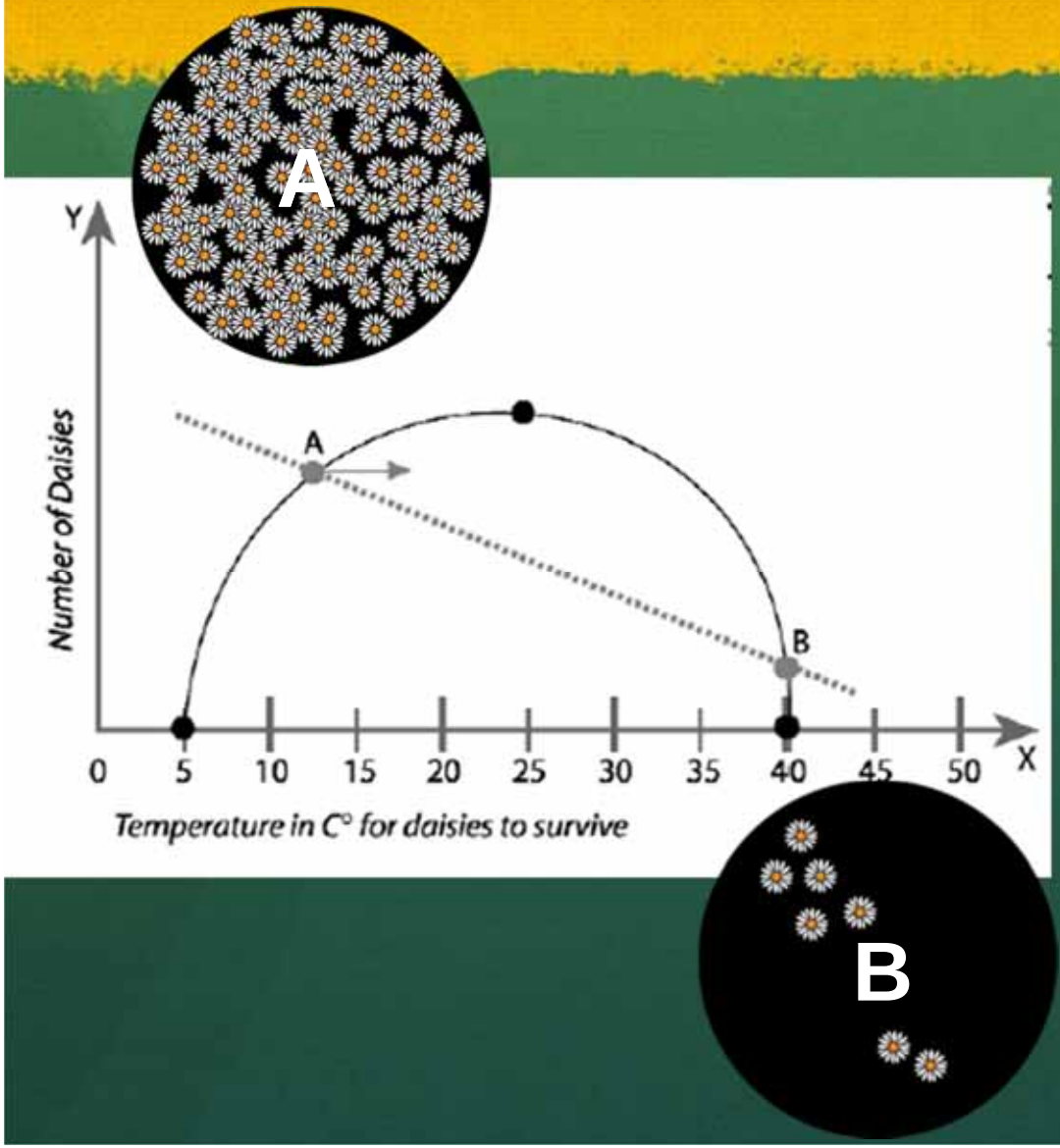
Temperature affects the number of daisies.





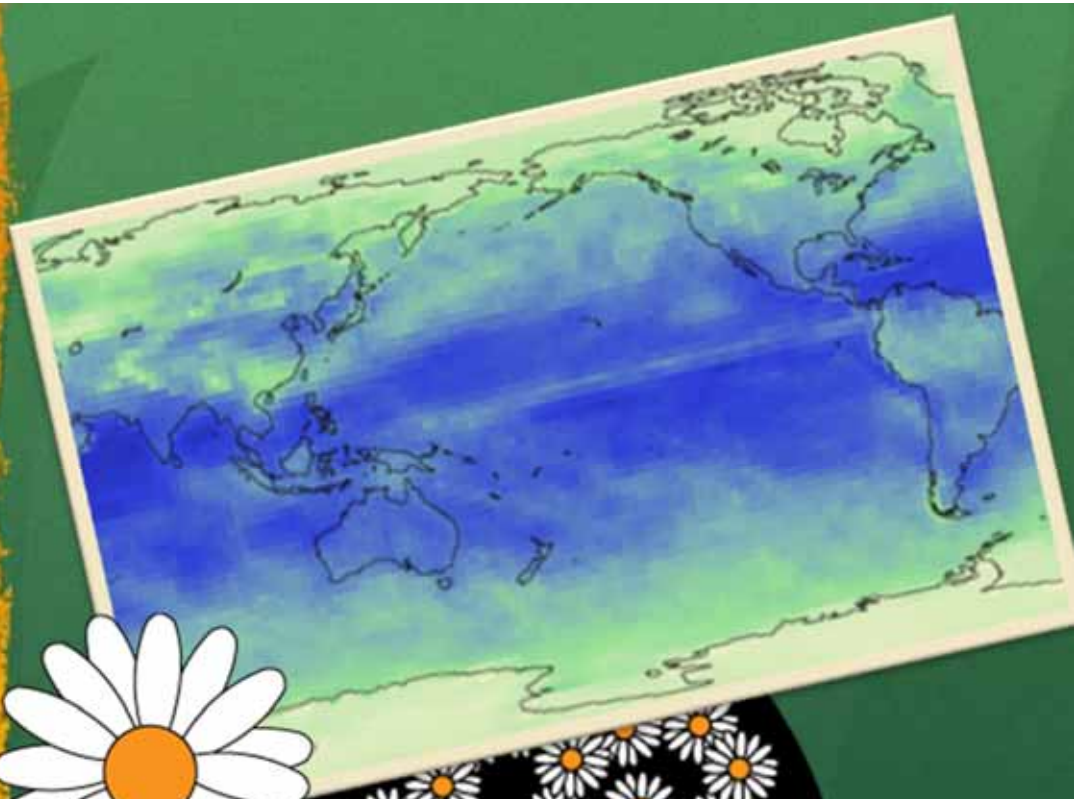
- At 25° C (77° F) many daisies cover the planet.
- Daisies can't survive below 5° C (41° F) or above 40° C (104° F).
- Students graph how temperature affects the number of daisies.

Daisyworld in Balance!



- Students overlay their two graphs and identify the points of steady state.
- These points (A, B) are where Daisyworld is in balance. Temperature and the number of daisies stay the same.
- Note that there are two steady states with different conditions.

Questions?



Climate and Global Change on Windows to the Universe

www.windows2universe.org

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Thanks!


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