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
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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.
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)
What’s the climate where you live in September? Mark a location on the graph below to indicate general precipitation and temperature.
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/L1A_lesson1_9.28.05.pdf
Collecting Weather Data

- 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

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

Climate data showing average high and low temperatures through the year in Boulder, CO
Compare weather data with climate data

- 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!

2010 high temps compared with average highs for Jan 18-27
Questions?
What Controls the Climate?
Earth's Energy Budget

Incoming solar energy 100%
- Reflected by atmosphere 6%
- Reflected by clouds 20%
- Reflected from earth's surface 4%
- Absorbed by atmosphere 16%
- Absorbed by clouds 3%
- Conduction and rising air 7%
- Absorbed by land and oceans 51%
- Radiated to space from clouds and atmosphere 64%
- Radiated directly to space from earth 6%
- Carried to clouds and atmosphere by latent heat in water vapor 23%
Many things affect how much energy gets to, and stays within, the Earth system.

The Sun & Earth’s orbit

Volcanic eruptions

Reflective snow & ice

And the amount of greenhouse gases...
Greenhouse gases trap heat.

- 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)

Atmospheric Carbon Dioxide
Measured at Mauna Loa, Hawaii

Carbon dioxide concentration (ppmv)

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.
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?
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?

Choose the correct answer:

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

B. Because snow and ice at the poles reflect 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
Join the conversation on Facebook!

Welcome Educators! You have found the Facebook hub for the NASA-funded Global Climate Change Educator Professional Development Network.

Check out the “events” section to learn about our free seminars, offered through NSTA Web Seminars this spring.

Information

Founded:
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The Global Climate Change Educator Professional Development Network Hello everyone! Register at the NSTA Learning Center for these free climate change web seminars this spring. And invite all your secondary science teacher friends to join us too!
March 12 at 3:50pm - Comment - Like

The Global Climate Change Educator Professional Development Network How do we know how climate will change in the future? Join us for this web seminar and learn how climate models are used to predict the future. Then, we will consider climate change adaptation and mitigation solutions that are being implemented by governments and individuals. Classroom activities that get students thin...
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  - Physical Science

- By Grade Level
  - Elementary
  - Middle School
  - High School
  - College

- By State Standards

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Most Popular Science Objects

- Viewed
- Enrolled

1. Energy: Different Kinds of Energy
2. Plate Tectonics: Layered Earth
4. Universe: The Sun as a Star

Multimedia Overview

- View
- Overview of the NSTA Learning Center

Free Learning Resources

Solar System: A Look at the

http://learningcenter.nsta.org
http://www.elluminate.com
National Science Teachers Association
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