NASA/UCAR: Global Climate Change and the Earth System

Presented by: Becca Hatheway

Thursday, October 6, 2010
6:30 p.m. - 8:00 p.m. Eastern time
Global Climate Change & the Earth System

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

- Introduction to Earth as a System
- The Water Cycle and Climate
- The Carbon Cycle and Climate
  - CO2 Sources and Sinks Activity
- The Nitrogen Cycle and Climate
  - Travelling Nitrogen Activity

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Introduction:
The Earth System and Climate
Earth System Science

Parts of the Earth System

- The **atmosphere** (air) extends from the Earth surface for several hundred km.
- The **hydrosphere** (water) includes the ocean, rivers, lakes, groundwater, vapor.
- The **biosphere** (life) includes bacteria, protists, plants, and animals.
- The **geosphere** (land) includes minerals, rocks, molten rock, sediments, soils.
- The **cryosphere** (ice) includes snow, glaciers, and sea ice.
The Earth System: It’s all connected!

Air  
Water  
Life  
Land  
Ice
Do you teach about Earth as a system?

A. Yes
B. No
C. We cover some aspects of the Earth system in my class but not all.
Climate change affects the Earth system.

Changes in the Earth system affect climate too.
In this web seminar we will focus on cycles of the Earth system in which elements and molecules cycle between the *living* and *nonliving* parts of the planet.

These are called **biogeochemical cycles**.

We will explore:
- The water cycle
- The carbon cycle
- The nitrogen cycle
Questions?
The Water Cycle and Climate Change
What is the water cycle?

Movement and storage of water within the Earth system.

The water cycle includes…

• Water at the surface
• Water underground
• Water vapor in the atmosphere
• Snow and ice – although often considered to be the cryosphere, snow and ice are also part of the water cycle.
There’s evidence that:
• changes in climate are causing changes in the water cycle.
• changes in the water cycle can cause further change in climate.

http://climate.nasa.gov/h2oWaterCycle/index.cfm
Warming causes increased rate of evaporation which causes warming.

- Warming climate leads to an increased evaporation rate.
- More water vapor in the atmosphere.
- Water vapor is a greenhouse gas so causes even more warming.

(This is known as a positive feedback loop)

Still from a NASA visualization of water vapor distribution. 
http://www.nasa.gov/mov/291251main_L3_H2O_Final_576.mov
The effect of clouds on climate is complicated...

How clouds will affect climate depends on:
• Whether the amount of clouds changes as climate changes.
• How proportions of cloud types change as climate changes.
• Whether clouds become higher or lower in the atmosphere.

(*This is an area of active research. Scientists are using computer models to sort out these interactions of vapor, clouds, and climate.)

Warming clouds: High cirrus clouds keep sunlight from radiating away from Earth into space.

Cooling clouds: Low level stratocumulus clouds block sunlight from getting to Earth’s surface.
Projected precipitation change by 2100

- Blue/green: wetter
- Yellow/red: drier
- Top image - precipitation change during December, January, and February.
- Bottom - precipitation change during June, July, and August.

IPCC 2007
Where will there be **more** precipitation?

(Use the text tool and write a location.)
Where will there be less precipitation?

(Use the text tool and write a location.)
Climate change is causing more rain in some places, less rain in others.

- Precipitation patterns are changing in response to climate change.
- In general, areas prone to drought are expected to become drier.
- In general, wet areas are expected to receive more precipitation.

Sandbags contain a Midwest flood (top). Arid region of North Africa is expected to become more arid (bottom).
Questions?
The Carbon Cycle and Climate Change

(And a classroom activity about CO2)
What is the carbon cycle?

- Movement and storage of carbon (C) through the atmosphere, hydrosphere, biosphere and geosphere of the Earth system.
- The carbon cycle is often divided into a “fast carbon cycle” and a “slow carbon cycle”.

[Diagram showing the carbon cycle with labels for photosynthesis, respiration, carbon emissions, and uptake.]
How is the carbon cycle related to climate?

- **Greenhouse gases**
  - **Carbon dioxide (CO\textsubscript{2})**
    - Released from burning fossil fuels, from respiration, and volcanoes
    - Taken out of the atmosphere by plants during photosynthesis
  - **Methane (CH\textsubscript{4})**
    - Released from farm animals, manure, landfills, and part of natural gas deposits
    - Methane is about 25 times more powerful a greenhouse gas than CO\textsubscript{2}
    - Used as an energy source: burning it releases CO\textsubscript{2}
The “fast carbon cycle” includes primarily carbon moving between the atmosphere, biosphere, and hydrosphere.

However, most carbon is in deep storage (as limestone, coal, oil, and gas) moving through the Earth system on long timescales – the “slow carbon cycle”.

Today, burning fossil fuels releases deep storage carbon into the “fast carbon cycle”.
Recent Changes in the Carbon Cycle: Carbon Dioxide in the Atmosphere

For 650,000 years, atmospheric CO$_2$ has never been above this line ... until now.

Recent Changes to the Carbon Cycle: Deforestation

- Forests act as carbon sinks, taking carbon out of the atmosphere via photosynthesis.
- In this area of Brazil, a population boom created by inexpensive land for farming caused land use change.

Landsat images 1975-2001 showing clear cutting of tropical forests in Rondonia, Brazil.

Image: NASA/GSFC
Plant productivity (uptake of carbon by plants) increased by 6% worldwide from 1982-1999 (increase=green, decrease=orange).

Higher productivity in areas where climate became warmer, wetter, and/or sunnier (less clouds).
Carbon dioxide, dissolved into the ocean, forms carbonic acid, lowering the pH of seawater.

Since the start of the Industrial Revolution, pH of seawater has dropped about 0.1. In the next century it is expected to drop another 0.1-0.35.

More acidic waters make it difficult for marine life such as corals to build their CaCO3 skeletons.

This can impact marine ecosystems.
Visit the Carbon Cycle Game!

You are a carbon atom. For millions of years you were underground in fossil fuels. Now, you have been released into the atmosphere as humans burn fuels. Did you know that 5000 megatons of carbon are released into the atmosphere as fossil fuels are burned each year?

In this game, you will travel the carbon cycle. Your objective is to get to all the places that carbon is stored along this map. Earn extra points by correctly answering the carbon challenge questions at the yellow stars.

Click to begin your journey!

You visited:
0 out of 6 reservoirs

You answered 0 of 0 questions correctly

http://www.windows2universe.org/earth/climate/carbon_cycle.html
Visit the NASA Climate Time Machine!

This visualization shows the amount of annual fossil fuel emissions produced by the top 12 nations or regions from 1980-2004. Units are given in thousand metric tons of carbon (C) emitted from fossil fuel consumption. (Source: U.S. Department of Energy)

* Numbers for 1980-1990 are for the former West Germany
** Numbers for 1980-1991 are for the former Soviet Union.

http://climate.nasa.gov/ClimateTimeMachine/climateTimeMachine.cfm
Classroom activity: Carbon Dioxide Sources and Sinks

- Students will use a chemical indicator (BTB) to detect carbon dioxide.

- A source is anything that releases CO2 into the atmosphere.

- A sink is anything that absorbs and holds CO2 from the atmosphere.

http://www.windows2universe.org/teacher_resources/teach_CO2.html
Are animals a source or sink of carbon dioxide?

A. Source
B. Sink
C. Both
D. Neither
Part 2:
Are animals a source of CO2?

1. Fill test tube 1/3 full of BTB.
2. Place straw in test tube.
3. Place cotton ball at opening.
5. Note the color change.
6. What happened?
Are plants a source or sink of carbon dioxide?

A. Source
B. Sink
C. Both
D. Neither
Part 3: Are plants a source of CO2?

1. Fill test tube 1/3 full of BTB.
2. Place a sprig of *Elodea* into the test tube.
3. Wrap the tube in foil so that no light can get in.
4. Leave for at least 24 hours.
5. Unwrap the foil and note the color change.
SeaWIFS animation of photosynthesis

http://www.windows2universe.org/earth/Life/biosphere.html
Questions?
The Nitrogen Cycle and Climate Change

(And a classroom activity about the nitrogen cycle)
What is the nitrogen cycle?

- Movement and storage of nitrogen (N) through the atmosphere, hydrosphere, biosphere and geosphere of the Earth system.
Nitrogen in the Air

- **Nitrogen (N\textsubscript{2})**
  - 80% of the atmosphere is nitrogen gas.

- **Nitric oxide (NO)**
  - Pollutant released from burning fossil fuels that is part of smog and contributes to acid rain.

- **Nitrogen dioxide (NO\textsubscript{2})**
  - Pollutant released from fossil fuels, part of smog and contributes to ground level ozone.

- **Nitrous oxide (N\textsubscript{2}O)**
  - Greenhouse gas from burning fossil fuels, from farm animals, and fertilizers.
  - There is less N2O in the atmosphere but it has nearly 300 times the warming effect as CO2.
Question:
Which is a greenhouse gas?

A. Nitric oxide (NO)
B. Nitrous oxide (N₂O)
C. Nitrogen dioxide (NO₂)
D. Nitrogen (N₂)
Where does nitrous oxide come from?

Figure 20. U.S. Nitrous Oxide Emissions by Source, 1990-2008

Source: EIA estimates.

Another global change: nitrogen fertilizers and waterways
Summer dead zone at the Mississippi River delta

Red and orange = lots of phytoplankton and sediment
Classroom activity: Traveling Nitrogen

Students play the role of nitrogen atoms traveling through the nitrogen cycle to gain understanding of the varied pathways through the cycle and the relevance of nitrogen to living things.

http://www.windows2universe.org/teacher_resources/nitrogen_main.html
Traveling Nitrogen: How it works

- Students are nitrogen atoms.
- Signs around the room mark the 11 reservoirs that they are able to travel between.
- They roll a die to determine where they are going next.
- Students document their travels with the passport worksheet.
Questions?
Climate and Global Change on Windows to the Universe

http://www.windows2universe.org
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.

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

2 people like this.

Write a comment...

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...

See More

Web Seminar: Predicting Future Climate and Considering Solutions
Time: 5:30PM Wednesday, April 28th
Location: (Time listed is Eastern Standard Time)

March 12 at 3:41pm · Comment · Like · Share · RSVP to this event
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