



LIVE INTERACTIVE LEARNING @ YOUR DESKTOP

## **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

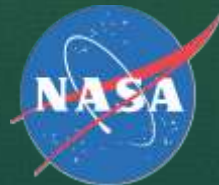
A web seminar for the NSTA community  
By the UCAR Office of Education and Outreach,  
with support from NASA.

# 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*



Presenter:  
**Becca Hatheway**  
Educational Designer  
UCAR  
Office of Education  
and Outreach







# Introduction: The Earth System and Climate





# Earth System Science

## Parts of the Earth System



Air



Water



Life



Land



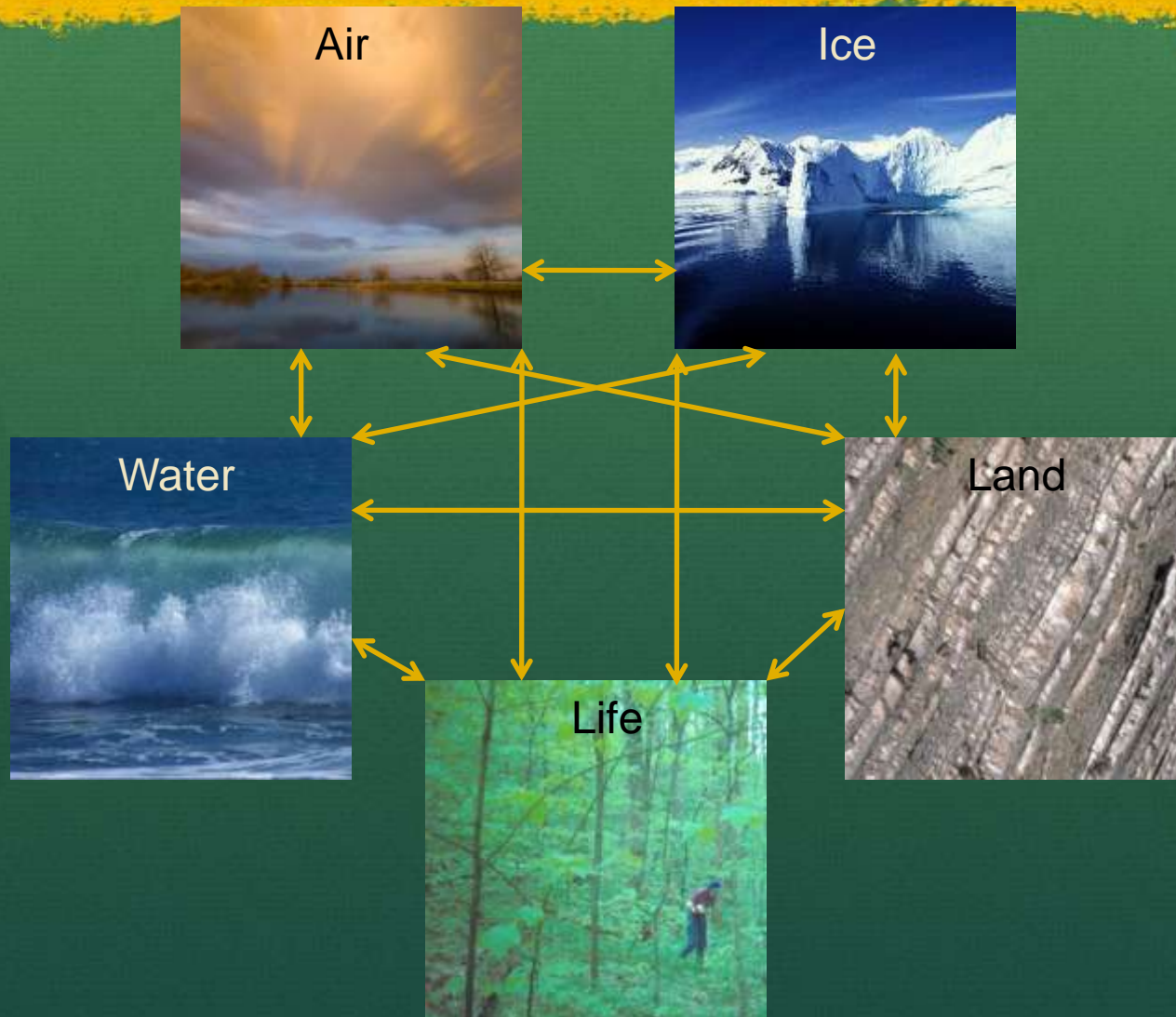
Ice

- 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!





# 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.*



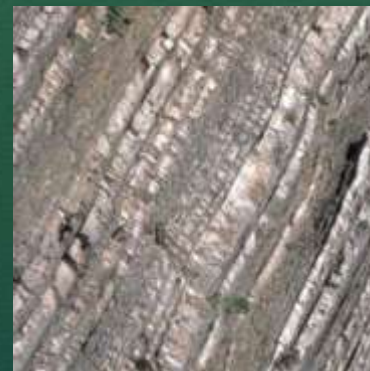
Air



Water



Life



Land



Ice



Climate change affects the  
Earth system.

Changes in the Earth system  
affect climate too.



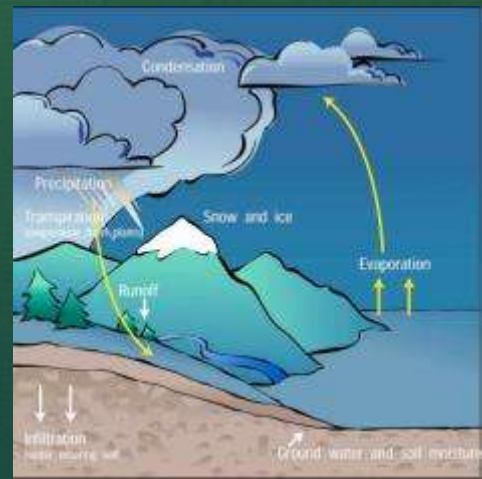
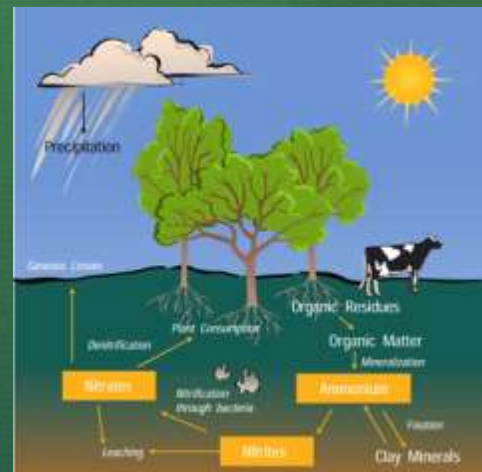
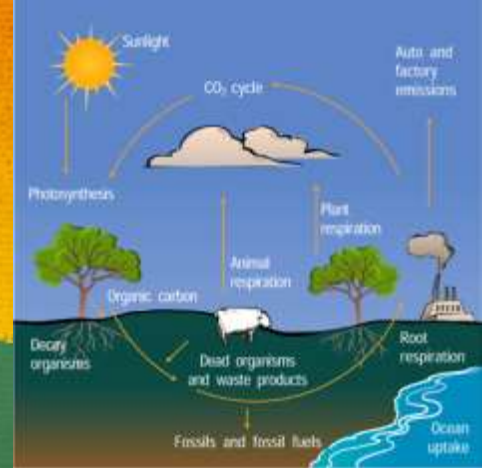


In this web seminar we will focus on cycles of the Earth system in which elements and molecules cycle between the *living* and *nonliving* parts of the planet.

These are called **biogeochemical cycles**.

We will explore:

- The water cycle
- The carbon cycle
- The nitrogen cycle





# Questions?

Air



Ice



Water



Land



Life







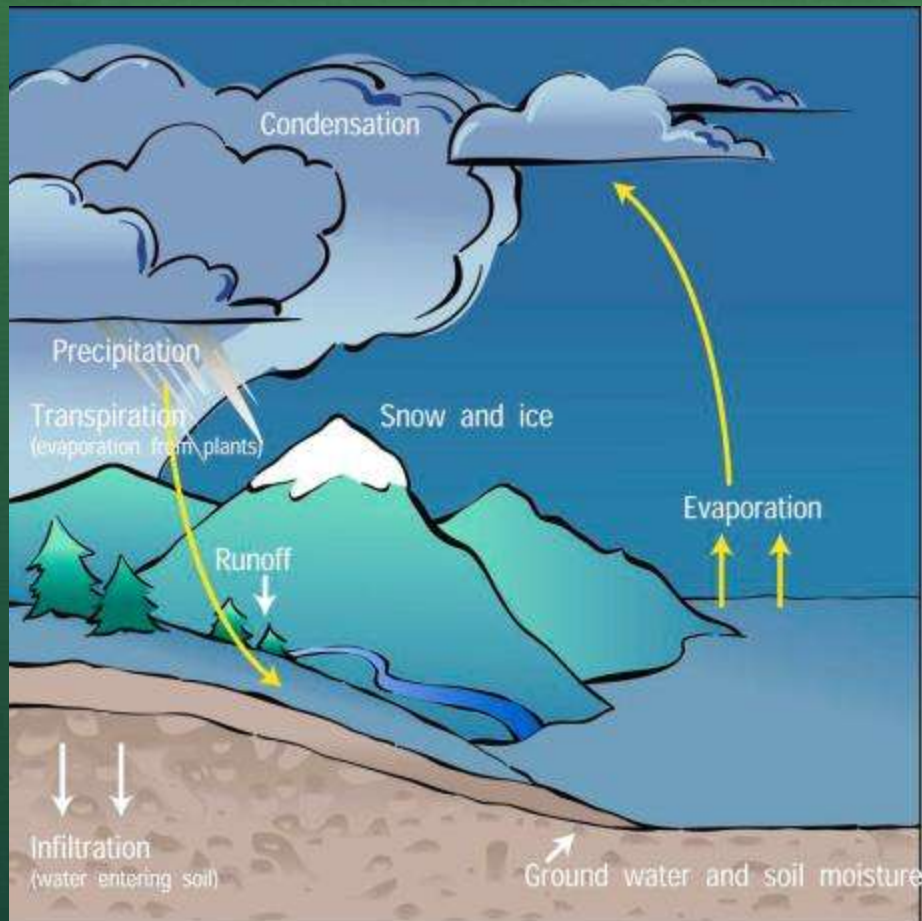
# The Water Cycle and Climate Change







# 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.*



# Web Tour: NASA interactive water cycle

## The Water Cycle

Earth's water is stored in ice and snow, lakes and rivers, the atmosphere and the oceans. **Mouse over** different parts of the cycle to learn more.



Describes the myriad of ways in which land surface water moves downhill to join the oceans and includes snowmelt runoff into streams, stream flow and river flow. Water carried by streams and rivers may be delayed for a time in lakes. A lot of runoff evaporates before reaching the ocean or infiltrates into the soil.

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>

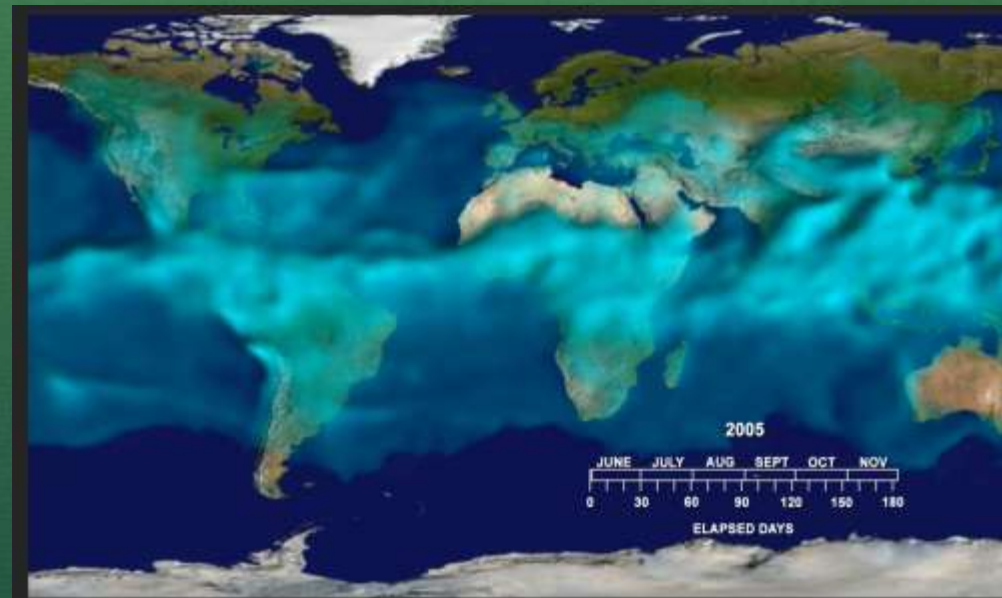




# Warming causes increased rate of evaporation which causes warming.

- 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](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.



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

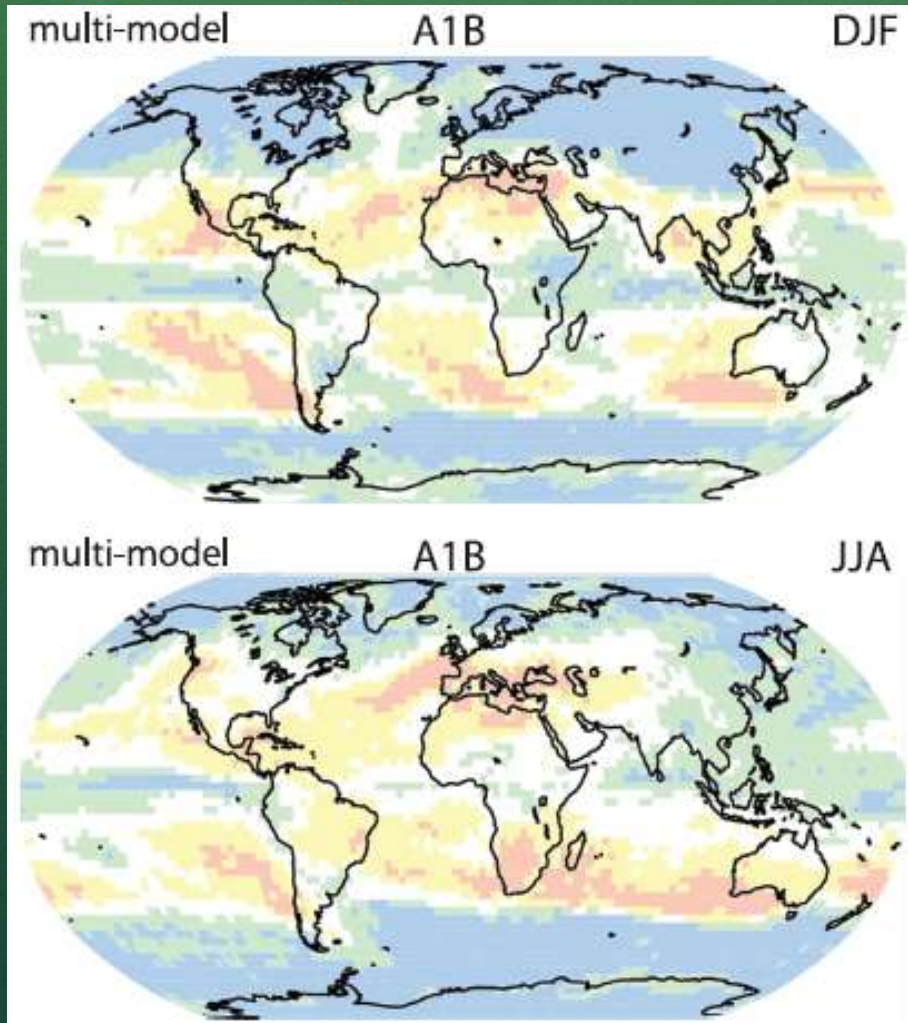


**Cooling clouds:** Low level stratocumulus clouds block sunlight from getting to Earth's surface

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



# Projected precipitation change by 2100

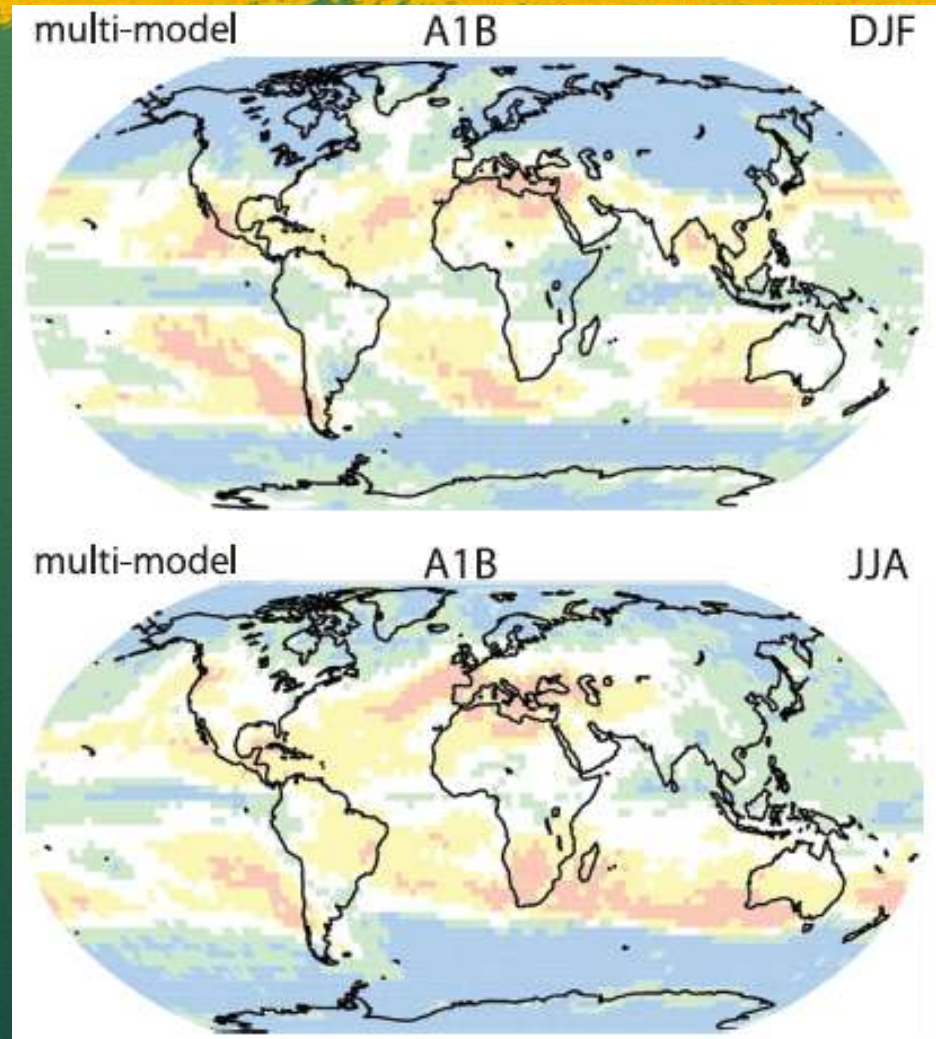


- Blue/ green: wetter
- Yellow/ red: drier
- Top image - precipitation change during December, January, and February.
- Bottom - precipitation change during June, July, and August.





# Where will there be **more** precipitation?

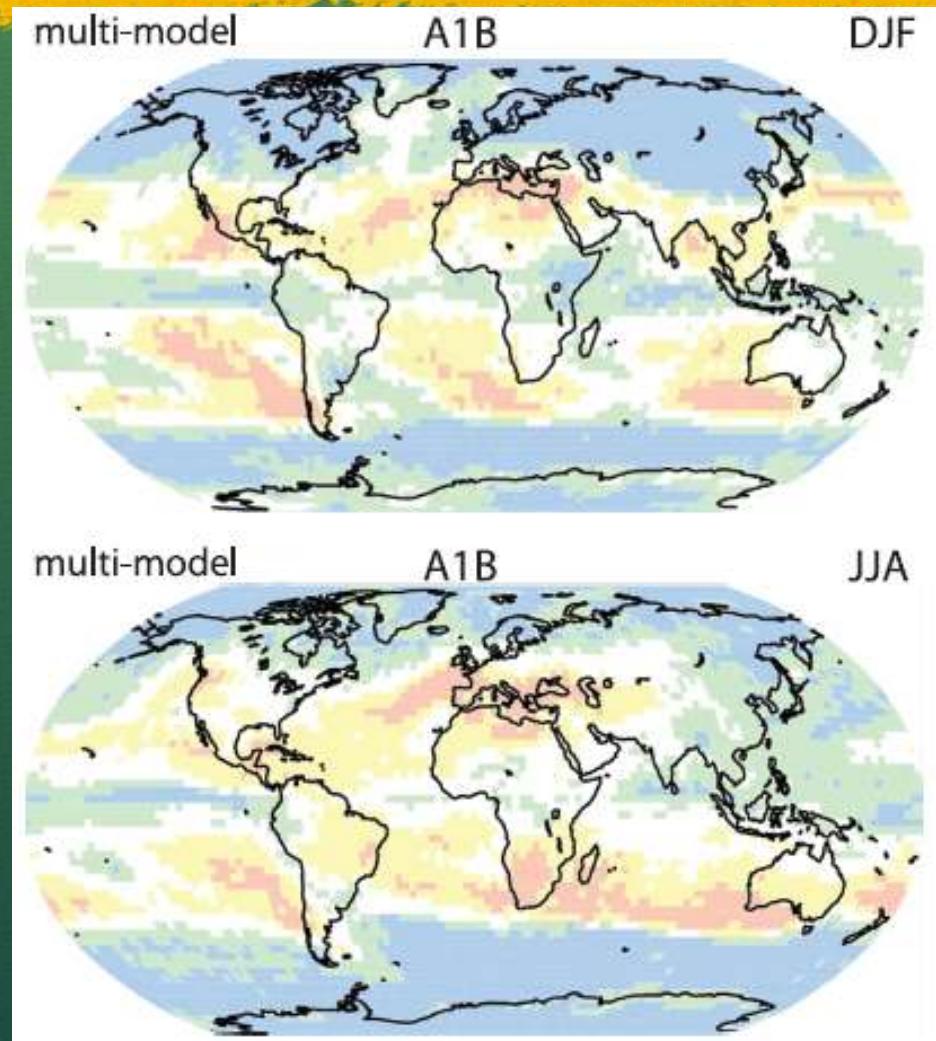


(Use the text tool and write a location.)





# 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?







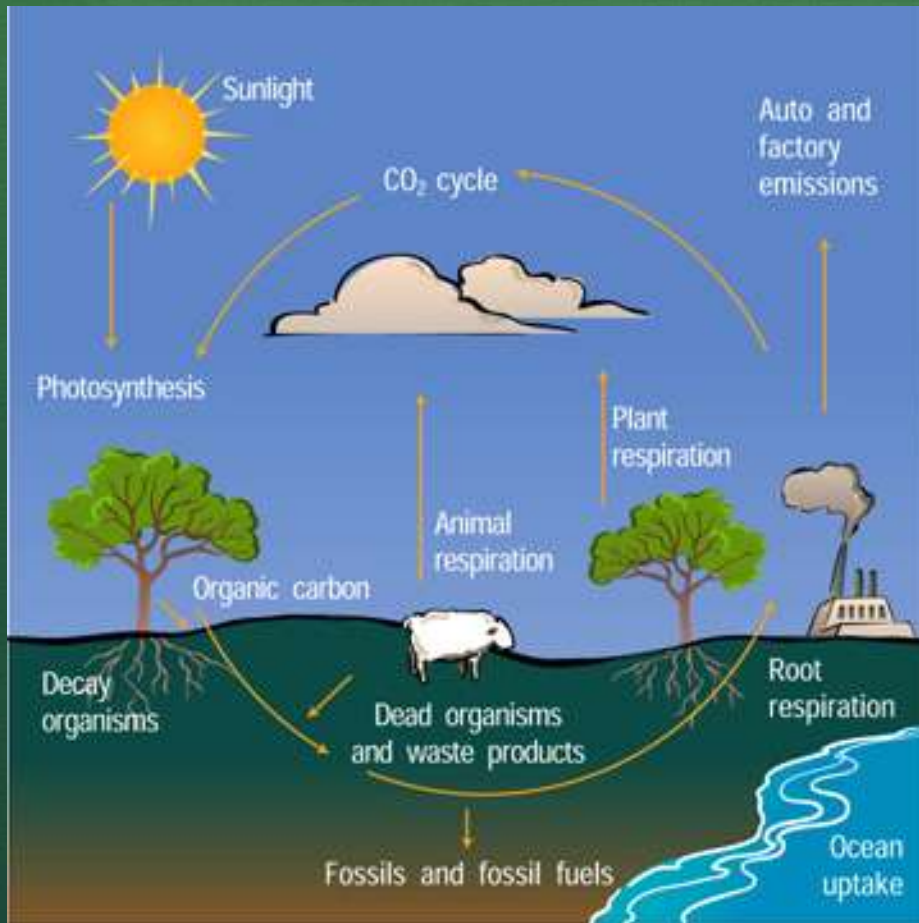
# The Carbon Cycle and Climate Change

*(And a classroom activity about CO<sub>2</sub>)*





# 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”.





# How is the carbon cycle related to climate?

- Greenhouse gases
  - Carbon dioxide ( $\text{CO}_2$ )
    - Released from burning fossil fuels, from respiration, and volcanoes
    - Taken out of the atmosphere by plants during photosynthesis
  - Methane ( $\text{CH}_4$ )
    - Released from farm animals, manure, landfills, and part of natural gas deposits
    - Methane is about 25 times more powerful a greenhouse gas than  $\text{CO}_2$
    - Used as an energy source: burning it releases  $\text{CO}_2$



# Fast carbon cycle and slow carbon cycle

- 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”.



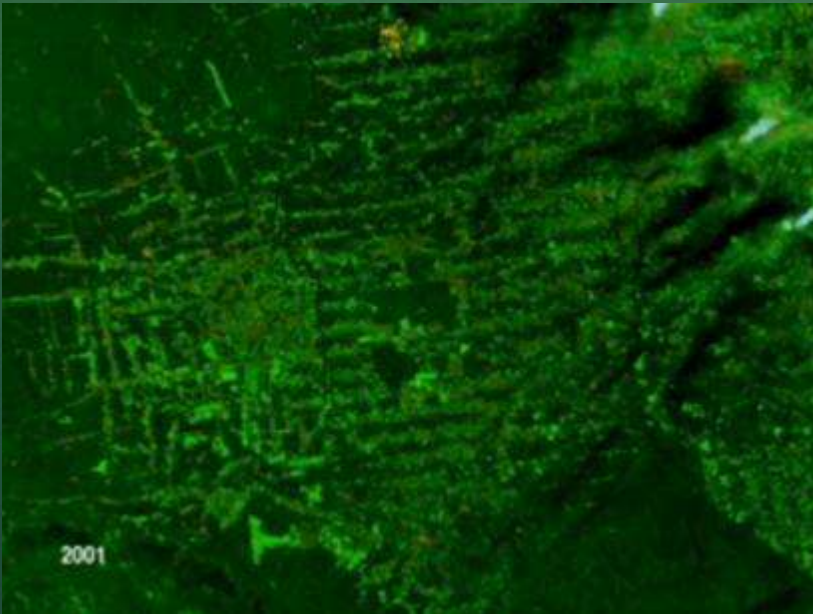


# Recent Changes in the Carbon Cycle: Carbon Dioxide in the Atmosphere



# 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





# Recent Changes to the Carbon Cycle: Increase in Plant Productivity

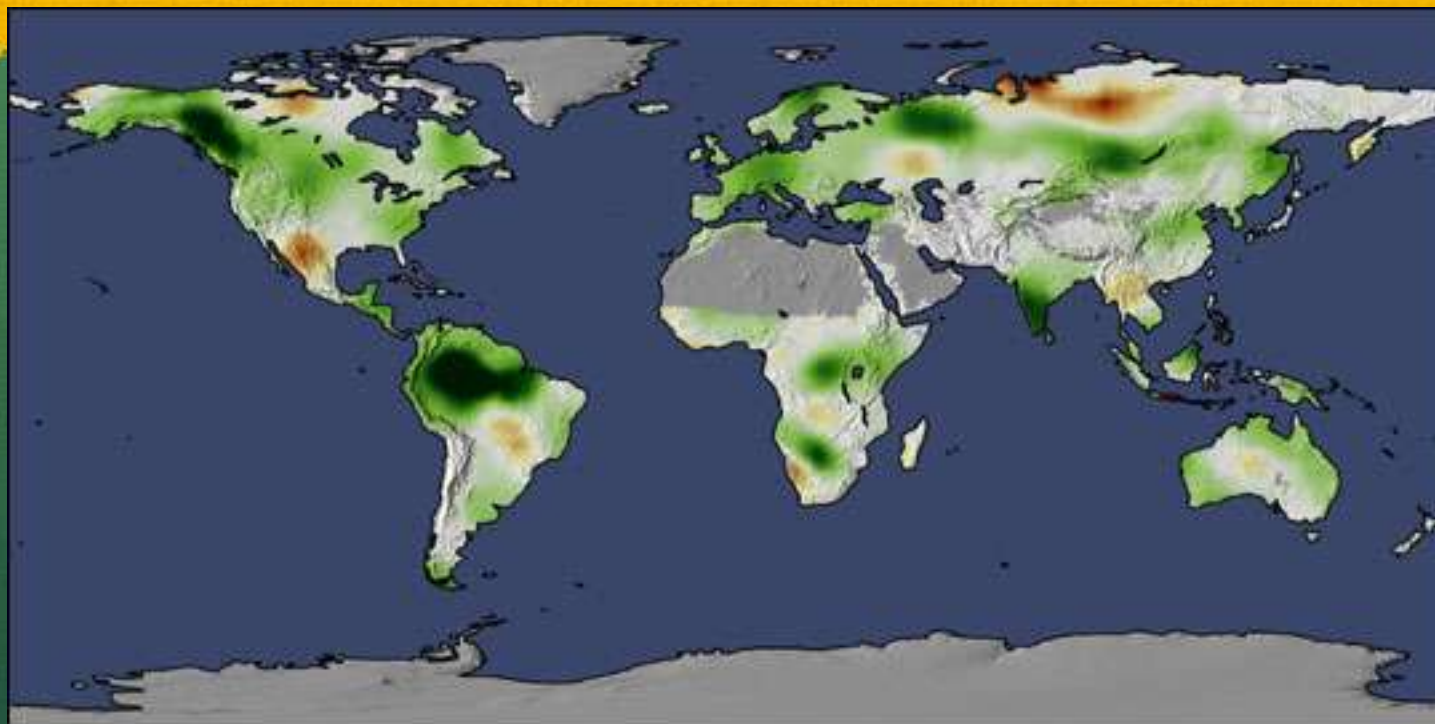


Image: NASA/Robert Simmon

- 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).



# Recent Changes to the Carbon Cycle: Ocean Acidification



NOAA sensor collecting data  
about ocean acidification in  
coral reef environments.

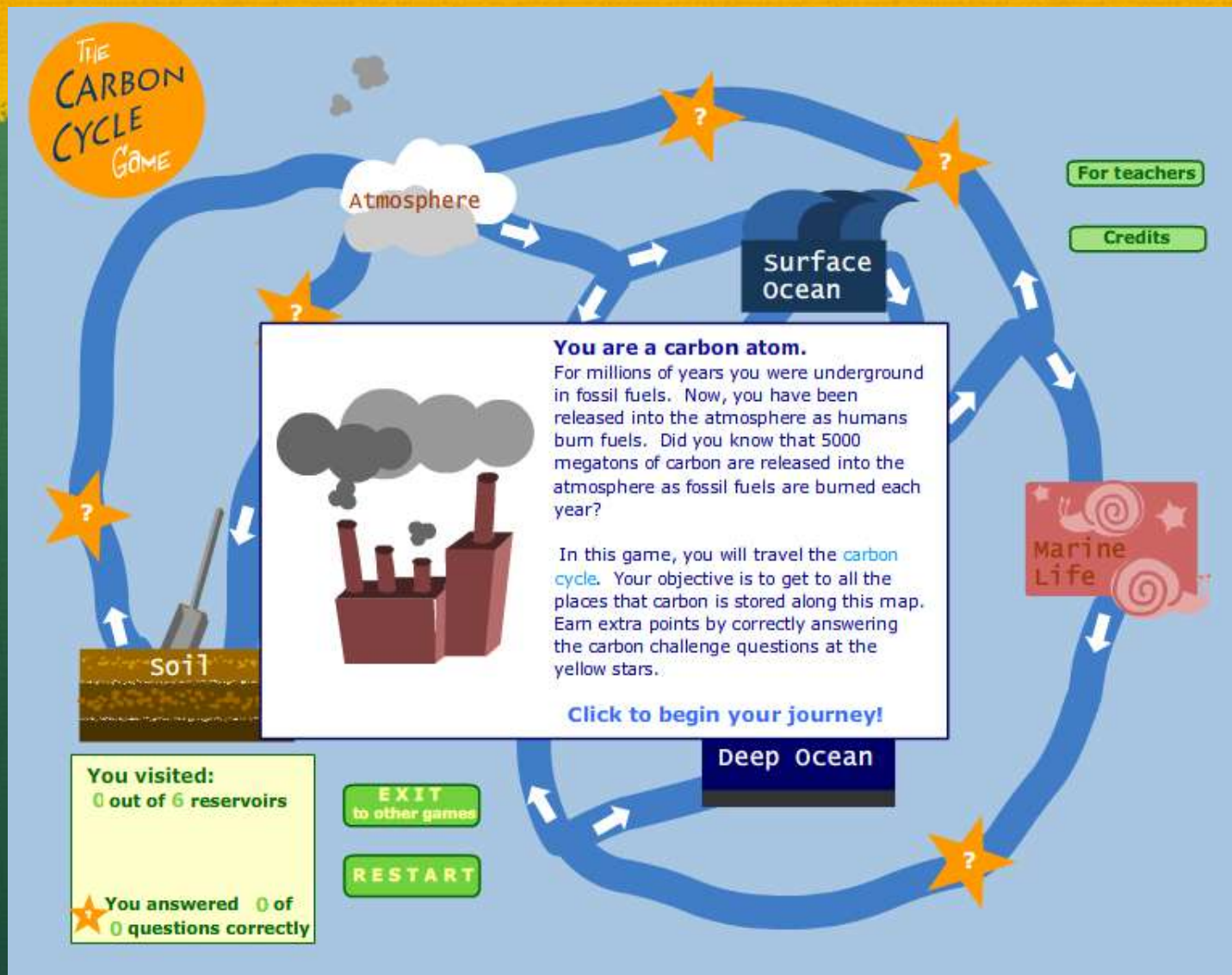
Image: Bernadette Charpentier

- 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  $\text{CaCO}_3$  skeletons.
- This can impact marine ecosystems.





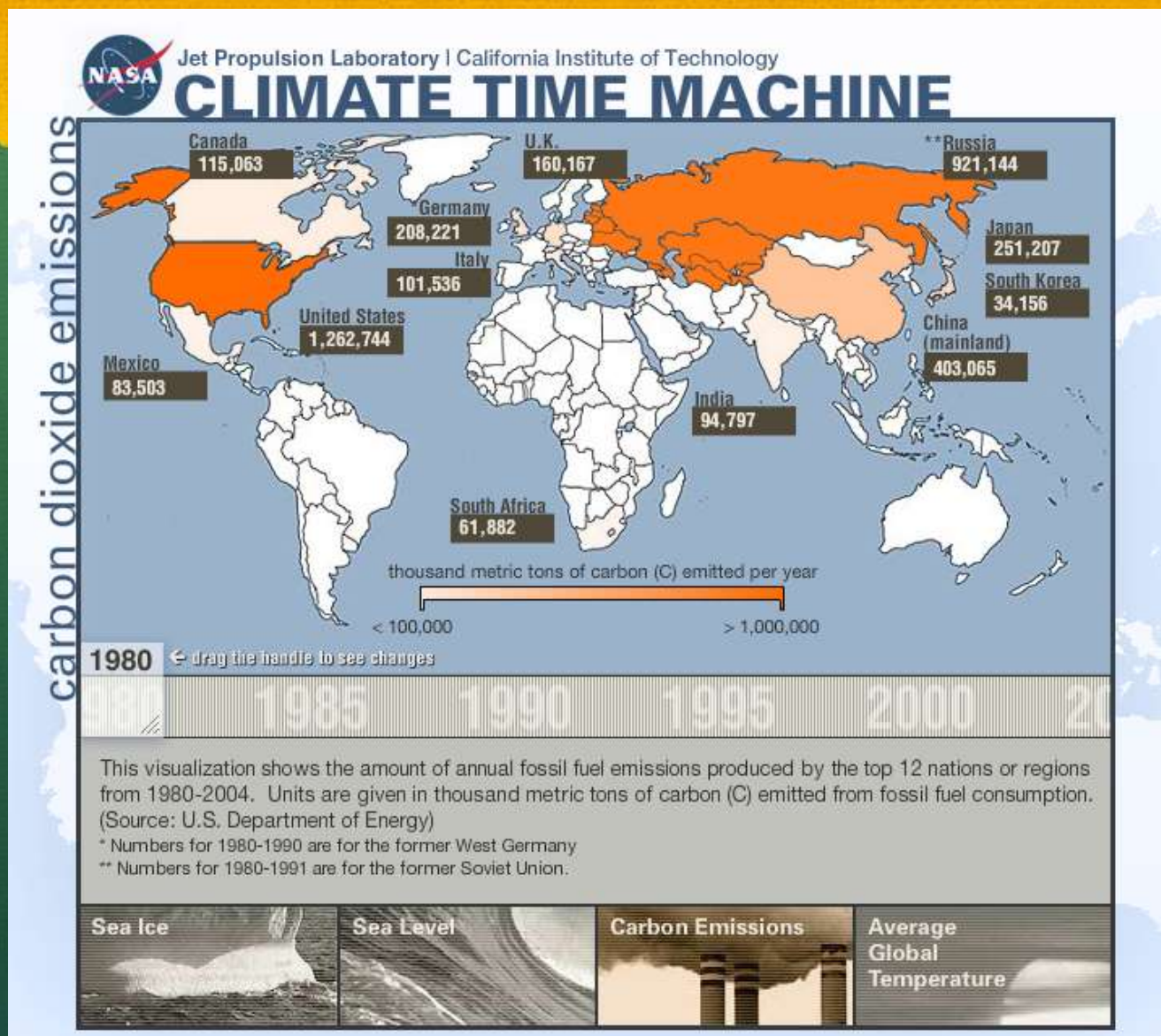
# Visit the Carbon Cycle Game!



[http://www.windows2universe.org/earth/climate/carbon\\_cycle.html](http://www.windows2universe.org/earth/climate/carbon_cycle.html)



# Visit the NASA Climate Time Machine!




<http://climate.nasa.gov/ClimateTimeMachine/ClimateTimeMachine.cfm>





# Classroom activity: Carbon Dioxide Sources and Sinks



Teacher Resources  
Lesson Plans and Activities for the Classroom  
[www.windows.ucar.edu](http://www.windows.ucar.edu)

Title:	Carbon Dioxide - Sources and Sinks
Summary:	Students will use a chemical indicator (BTB) to detect the presence of carbon dioxide.
Source:	Adapted from <i>Global Climates - Past, Present, and Future</i> . EPA Report No. EPA/600/R-93/126 and recommended by Sandra Henderson
Grade level:	7 - 10
Time:	This activity requires careful preparation the previous day. It is recommended to begin this activity at least one day before beginning this activity. <ul style="list-style-type: none"><li>• Materials preparation</li><li>• Class time: 40 minutes</li><li>• Discussion &amp; review</li></ul>
Student Learning Outcomes:	<ul style="list-style-type: none"><li>• Students will be able to identify 'sinks' as they relate to carbon dioxide.</li><li>• Students will understand how to use BTB to reveal the presence of carbon dioxide.</li><li>• Students will understand the role of animal and fossil fuel combustion in the carbon cycle.</li></ul>
Lesson format:	Laboratory Experiment
National Standards Addressed:	<ul style="list-style-type: none"><li>• <a href="#">5-8 Content Standard for Science</a></li><li>• <a href="#">9-12 Content Standard for Science</a></li><li>• <a href="#">9-12 Content Standard for Environmental Quality</a></li></ul>



- Students will use a chemical indicator (BTB) to detect carbon dioxide.
- A *source* is anything that releases CO<sub>2</sub> into the atmosphere.
- A *sink* is anything that absorbs and holds CO<sub>2</sub> from the atmosphere.



# Are animals a source or sink of carbon dioxide?



- A. Source
- B. Sink
- C. Both
- D. Neither





## Part 2:

# Are animals a source of CO<sub>2</sub>?



1. Fill test tube 1/3 full of BTB.
2. Place straw in test tube.
3. Place cotton ball at opening.
4. Gently blow in the straw.
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



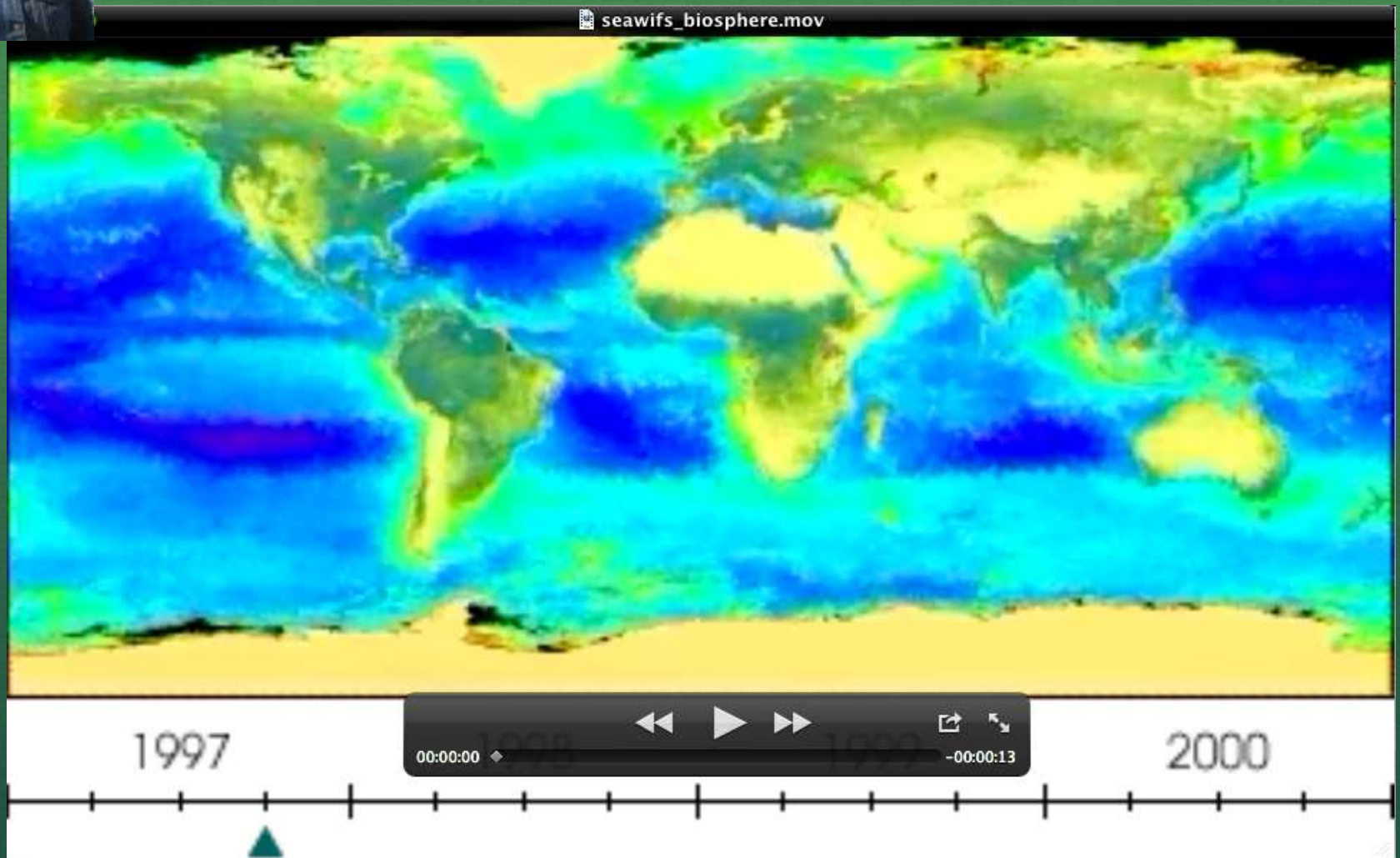


## Part 3:

# Are plants a source of CO<sub>2</sub>?



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

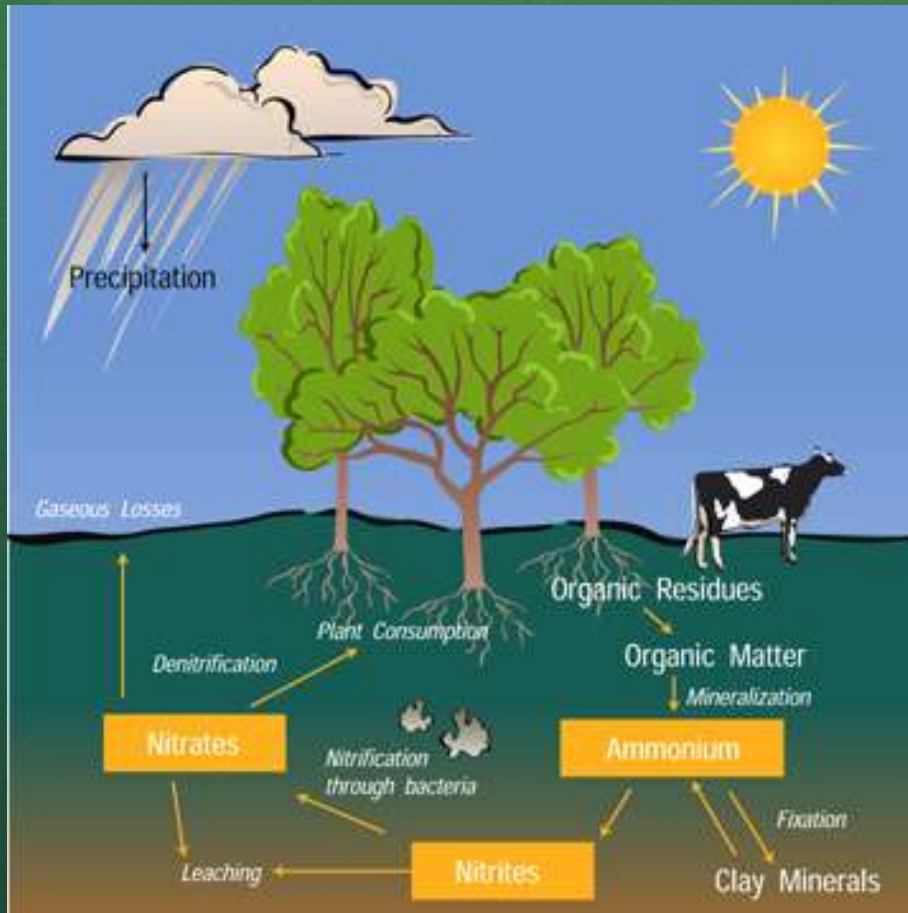
*(And a classroom activity about the nitrogen cycle)*







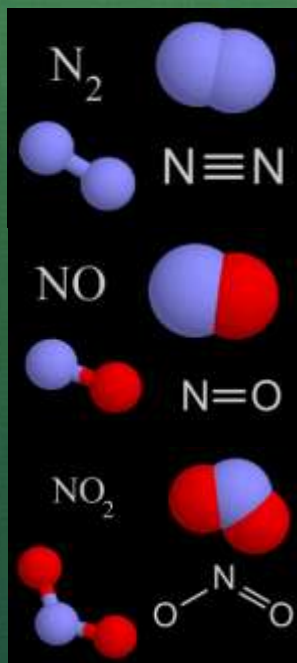
# What is the nitrogen cycle?



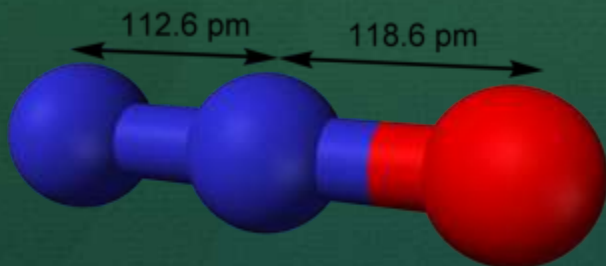
- Movement and storage of nitrogen (N) through the atmosphere, hydrosphere, biosphere and geosphere of the Earth system.



# Nitrogen in the Air



- Nitrogen ( $\text{N}_2$ )
  - 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 ( $\text{NO}_2$ )
  - Pollutant released from fossil fuels, part of smog and contributes to ground level ozone.
- Nitrous oxide ( $\text{N}_2\text{O}$ )
  - Greenhouse gas from burning fossil fuels, from farm animals, and fertilizers.
  - There is less  $\text{N}_2\text{O}$  in the atmosphere but it has nearly 300 times the warming effect as  $\text{CO}_2$ .







# Question:

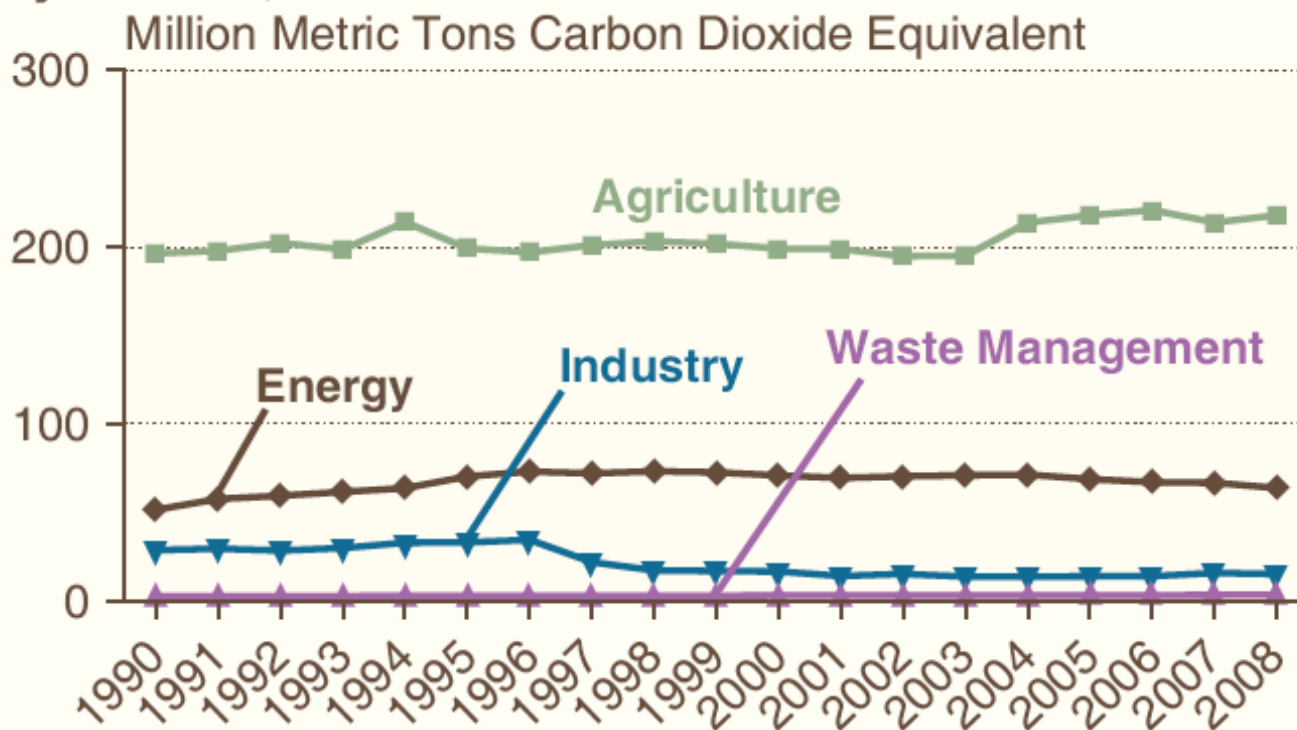
## Which is a greenhouse gas?

- A. Nitric oxide ( $\text{NO}$ )
- B. Nitrous oxide ( $\text{N}_2\text{O}$ )
- C. Nitrogen dioxide ( $\text{NO}_2$ )
- D. Nitrogen ( $\text{N}_2$ )



# Where does nitrous oxide come from?

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

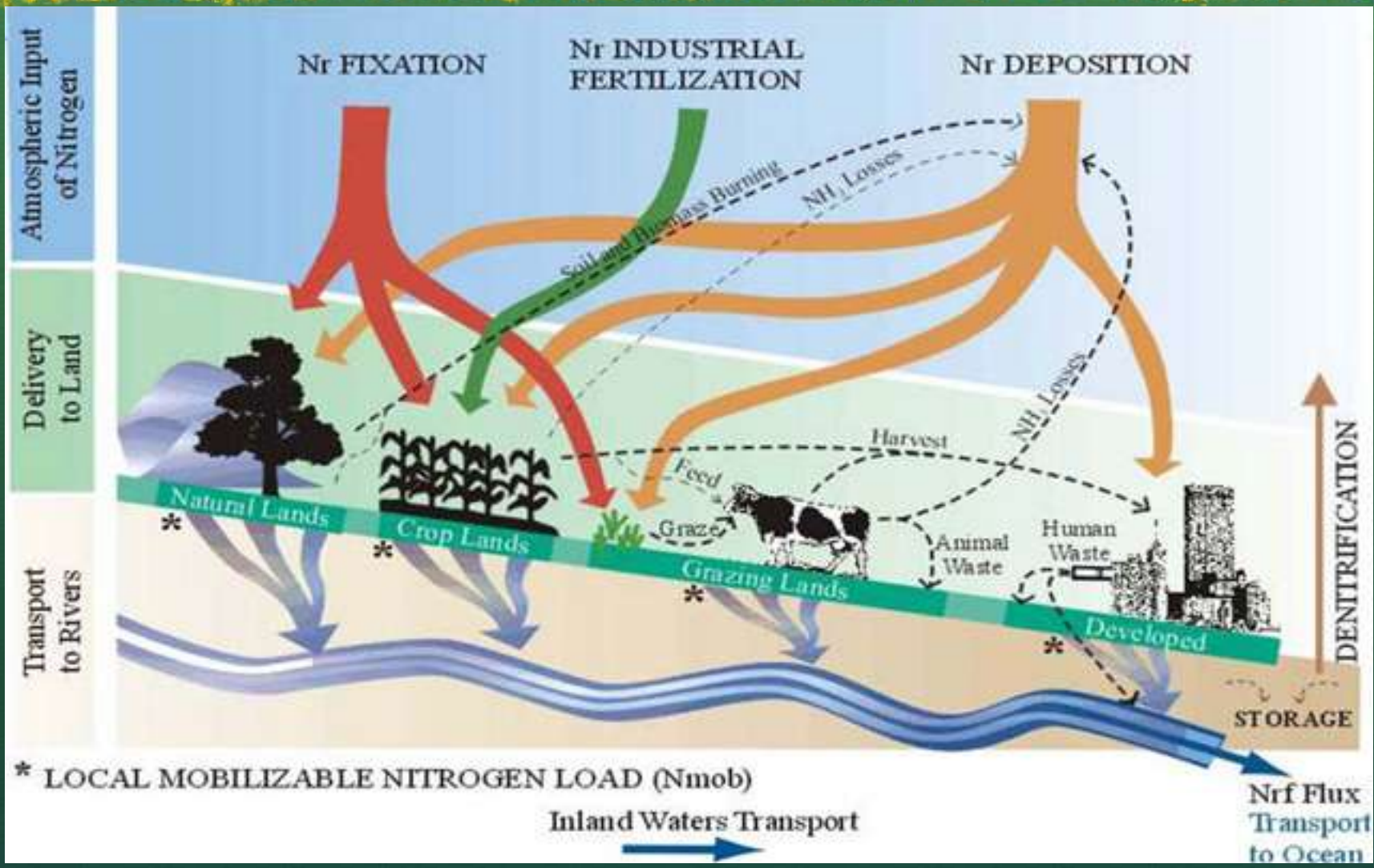


Source: EIA estimates.





# Another global change: nitrogen fertilizers and waterways



# Summer dead zone at the Mississippi River delta

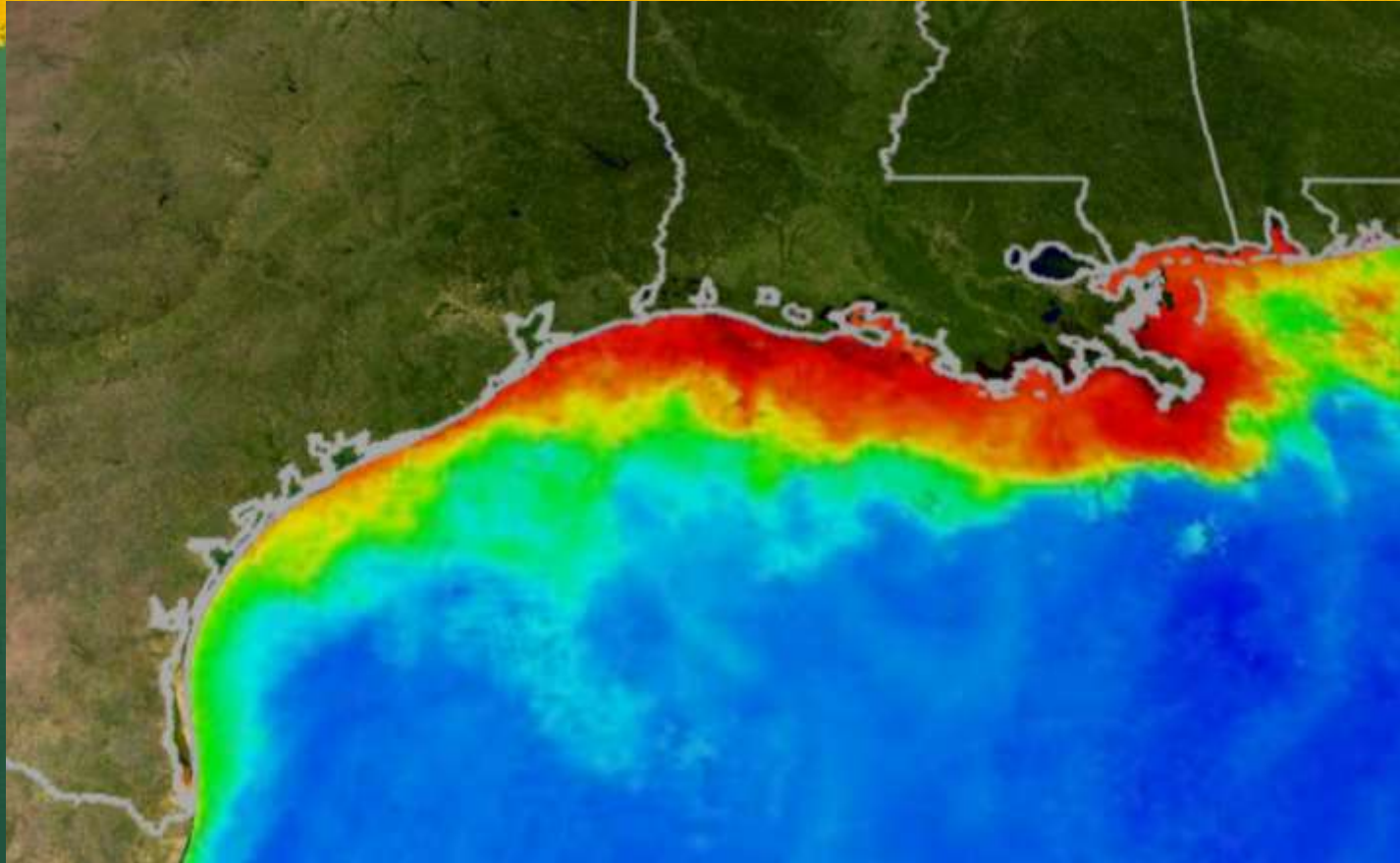


Image: NASA

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.



# 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.

Name: \_\_\_\_\_

## Traveling Nitrogen Passport

**Directions:**

1. Stamp your start location in the space below.

Start location

Stamp above

2. Roll the die to find out where to go next. Write *How I traveled* in the Trip #1 box below (see example at right).
3. Go to that location in the room and stamp the Trip #1 *Where I went* box. Then, roll the die to find out where to go next.

Guess what! In this game you are a nitrogen atom. You are going to travel the nitrogen cycle stopping in many exciting locations - some of which you probably never have been to before.

For each stop along your journey, remember to record where you went and how you got there.

Here's an example of how to fill out each stop along the way:

Trip#1: How I traveled:	Where I went:
Fertilizer washed into stream	

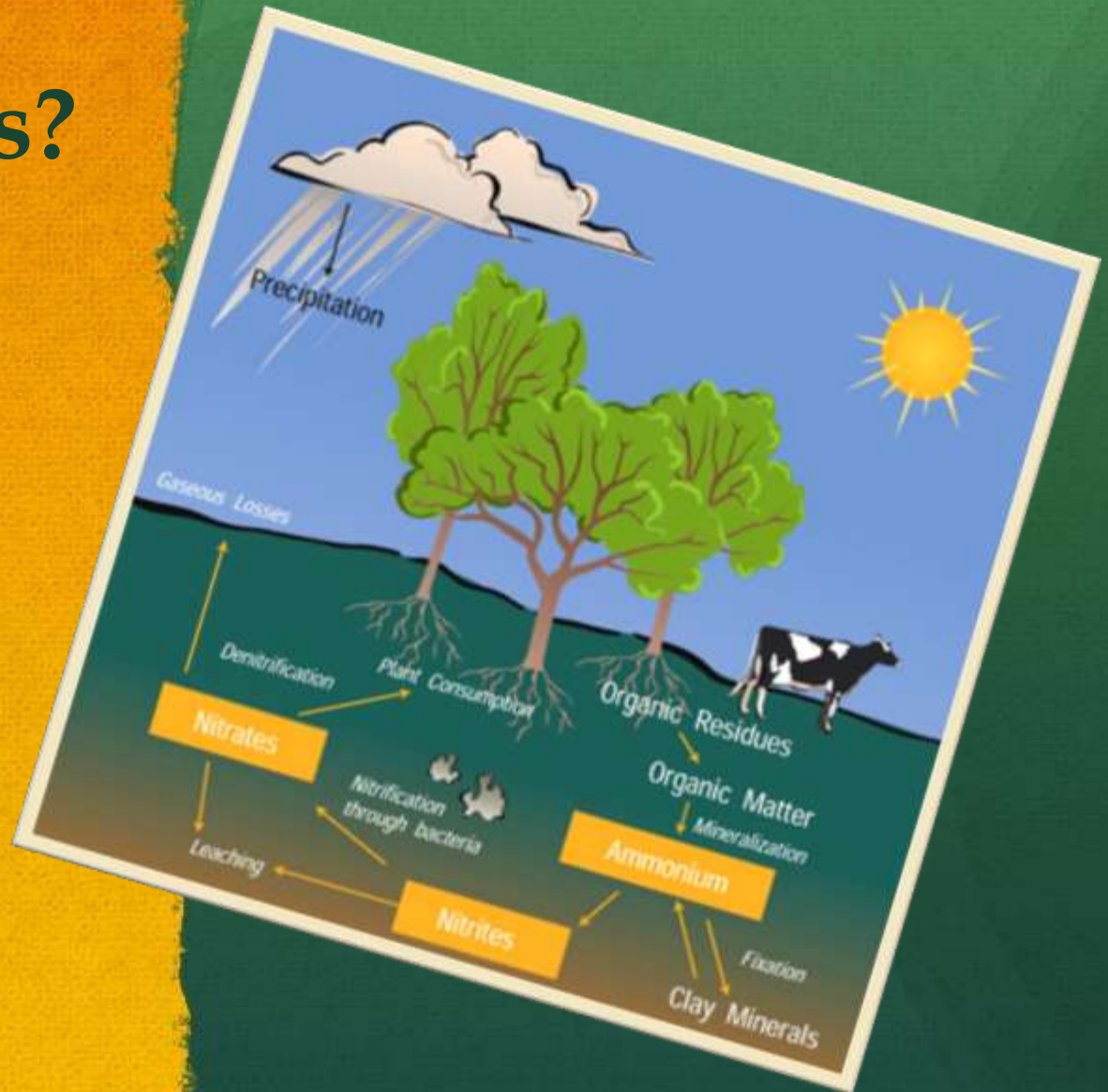
Trip #1: How I traveled:	Where I went:
Stamp above	Stamp above
Trip #2: How I traveled:	Where I went:
Stamp above	Stamp above
Trip #3: How I traveled:	Where I went:
Stamp above	Stamp above
Trip #4: How I traveled:	Where I went:
Stamp above	Stamp above
Trip #5: How I traveled:	Where I went:
Stamp above	Stamp above
Trip #6: How I traveled:	Where I went:
Stamp above	Stamp above
Trip #7: How I traveled:	Where I went:
Stamp above	Stamp above
Trip #8: How I traveled:	Where I went:
Stamp above	Stamp above

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# Questions?





# Climate and Global Change on Windows to the Universe

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A group of Emperor penguins wait their turn to dive into the ocean near Ross Island, Antarctica on November 3, 2004. Emperor penguins routinely dive to 500 meters in search of food. Scientists are interested in understanding how they can endure the stress of these dives in such an extreme environment.

*Image courtesy of Emily Stone, National Science Foundation*

1 2 3 4 5 6

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## Insights

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March 12 at 3:50pm · Comment · Like

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See More



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Time: 5:30PM Wednesday, April 28th

Location: (Time listed is Eastern Standard Time)



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<http://learningcenter.nsta.org>





**<http://www.lluminate.com>**

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