LIVE INTERACTIVE LEARNING @ YOUR DESKTOP

NASA/UCAR Global Climate Change & the Earth System

Presented by: Dr. Lisa Gardiner

Tuesday, April 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.

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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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Office of Education
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UCAR
UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

NASA

WINDOWS TO THE UNIVERSE

Introduction:
The Earth System and Climate

Earth System Science

Parts of the Earth System

Air

Water

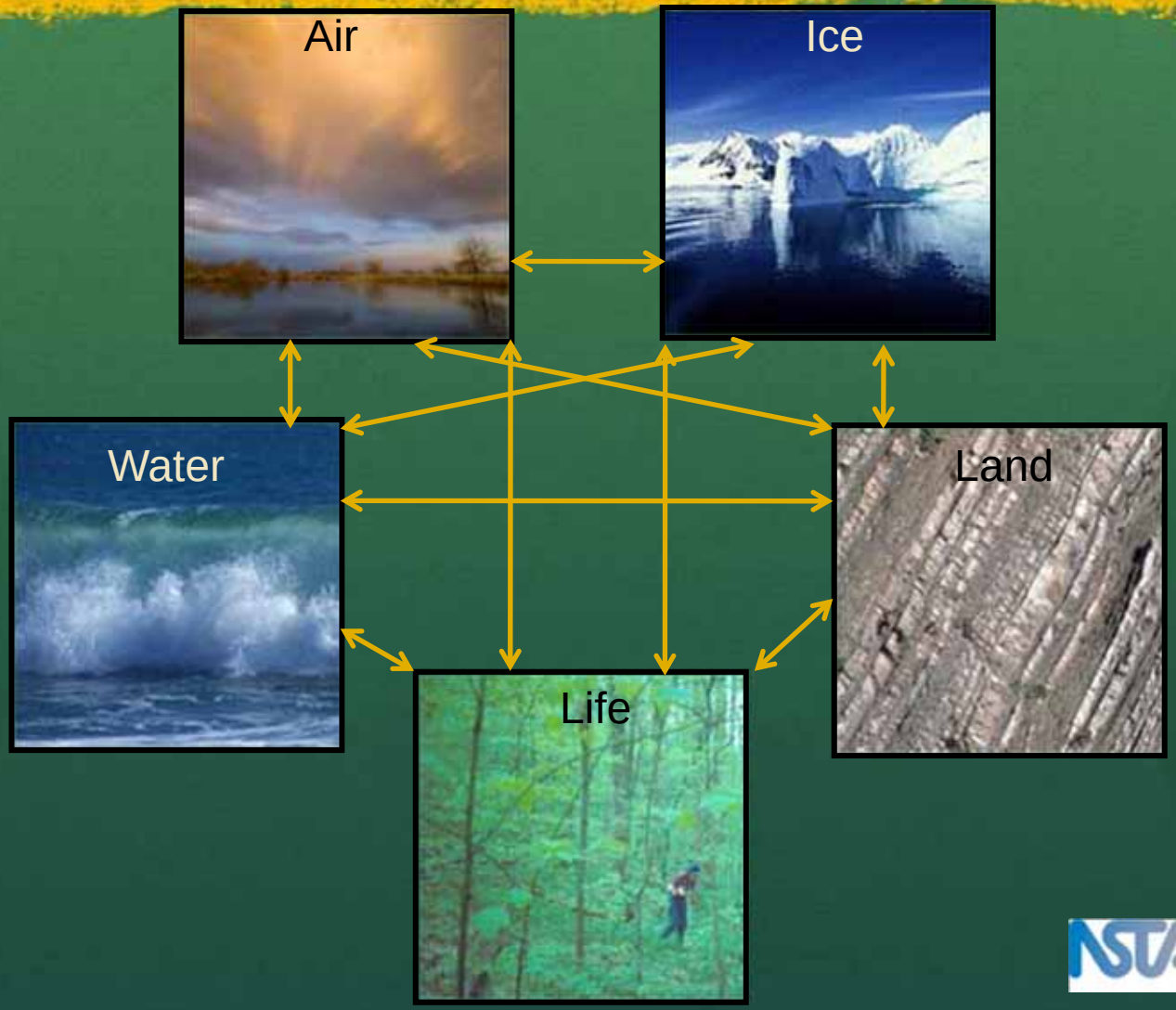
Life

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.

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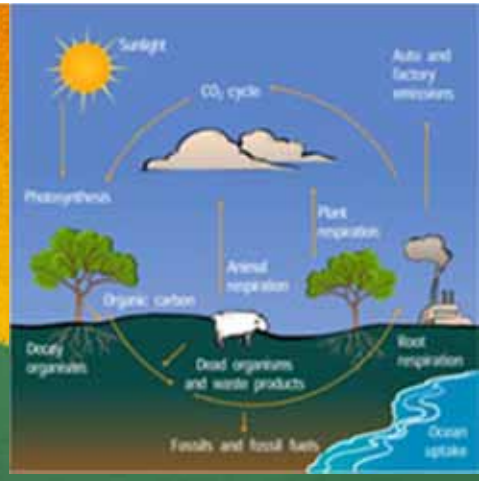
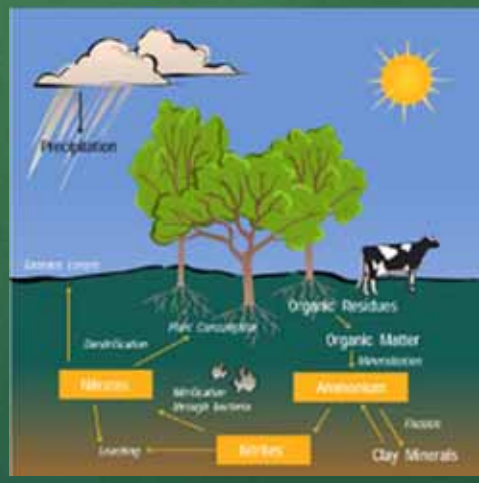
In this web seminar we will focus on cycles of the Earth system in which elements and molecules cycle between the *living* and *nonliving* parts of the planet.

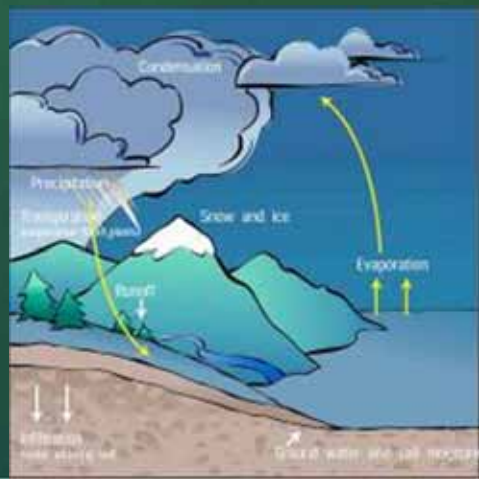
These are called **biogeochemical cycles**.

We will explore:

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







Let's Stop Two Minutes for Questions?

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The Water Cycle and Climate Change

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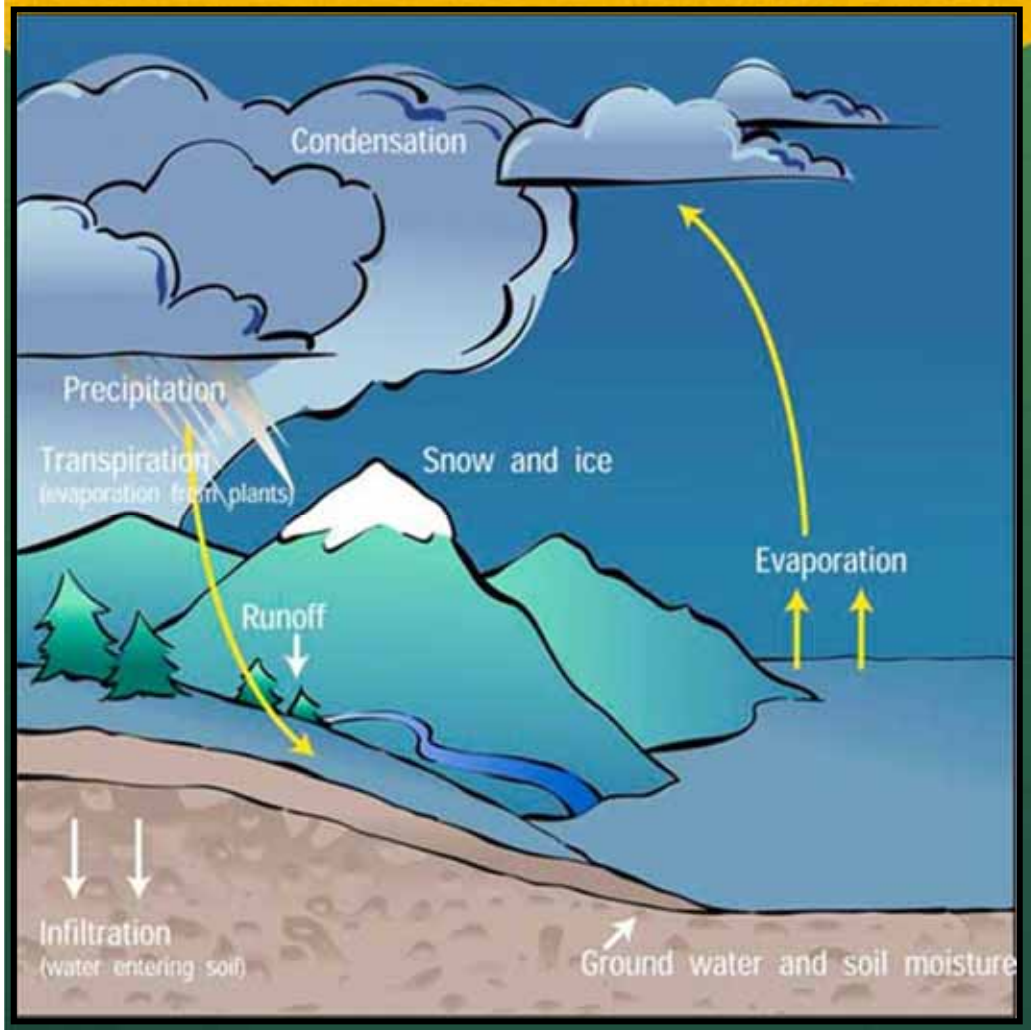
What is the water cycle?



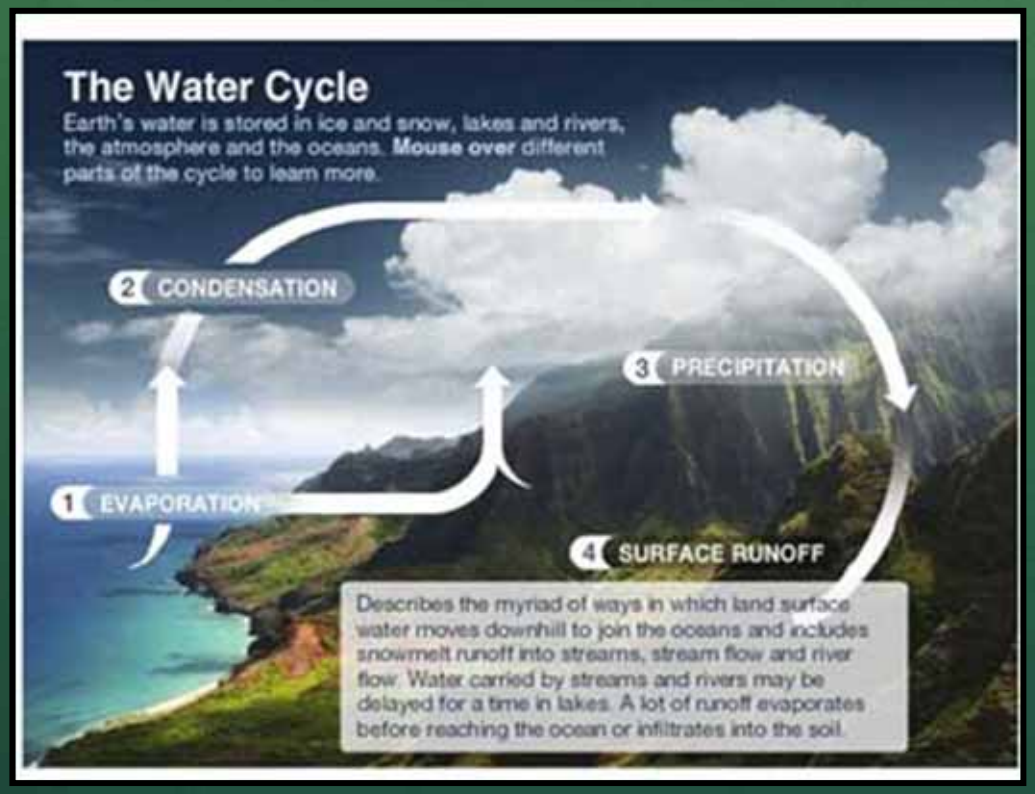
Movement and storage of water within the Earth system.

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.*

Courtesy of UCAR

Web Tour: NASA interactive 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

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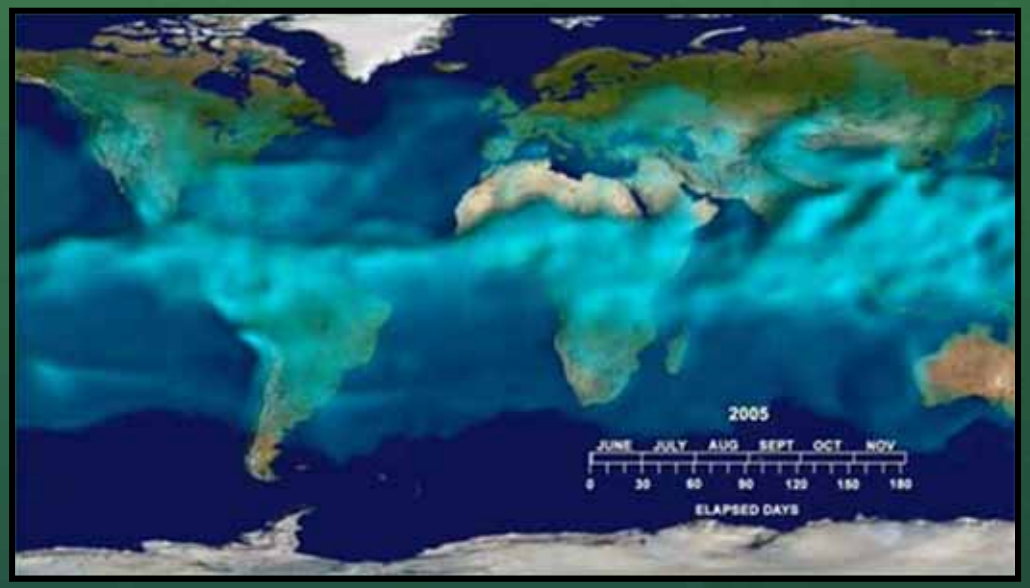
Warming causes increased rate of evaporation which causes warming.

- 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:

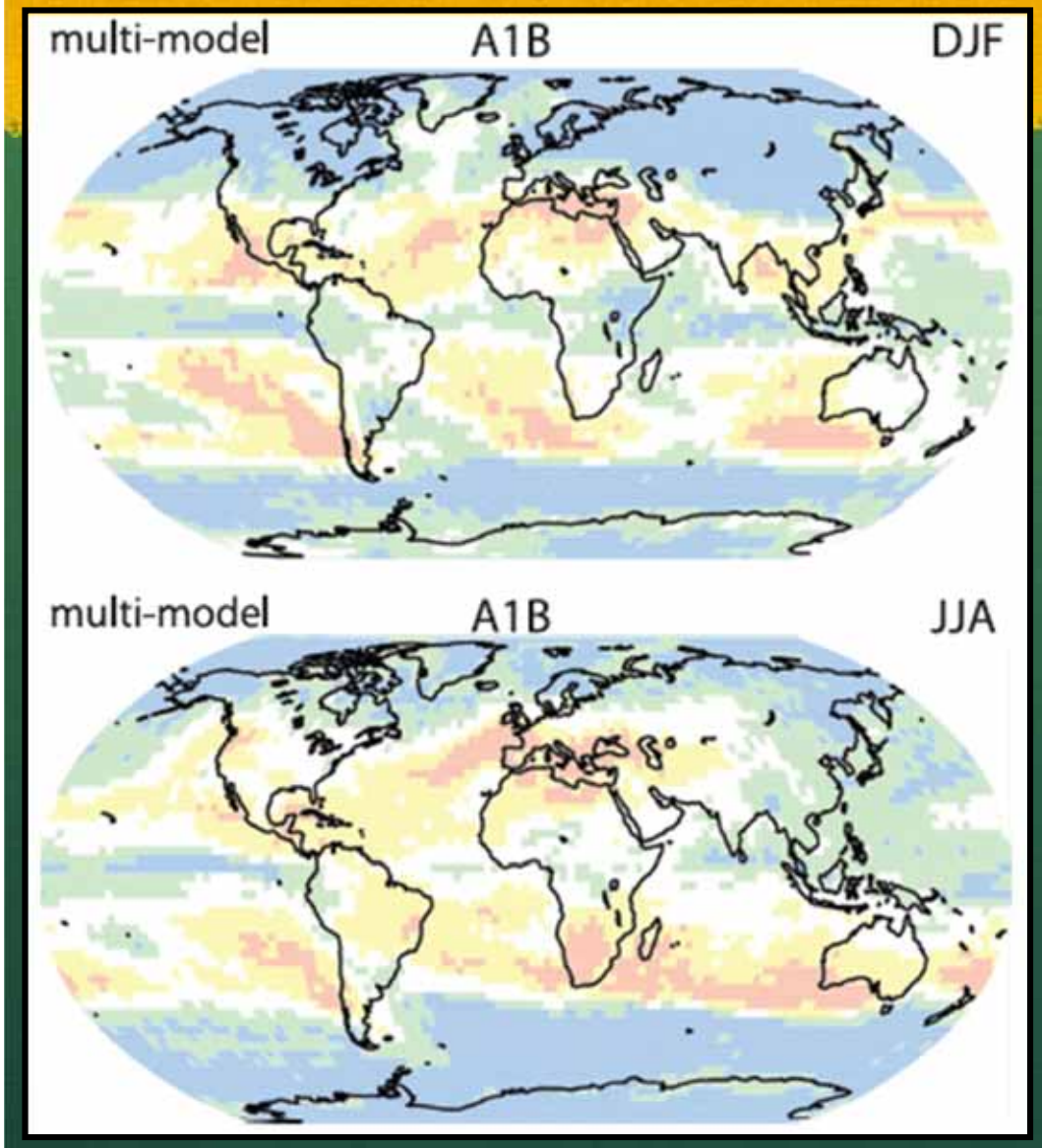
- Whether the amount of clouds changes as climate changes.
- How proportions of cloud types change as climate changes.
- Whether clouds become higher or lower in the atmosphere.

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.)*

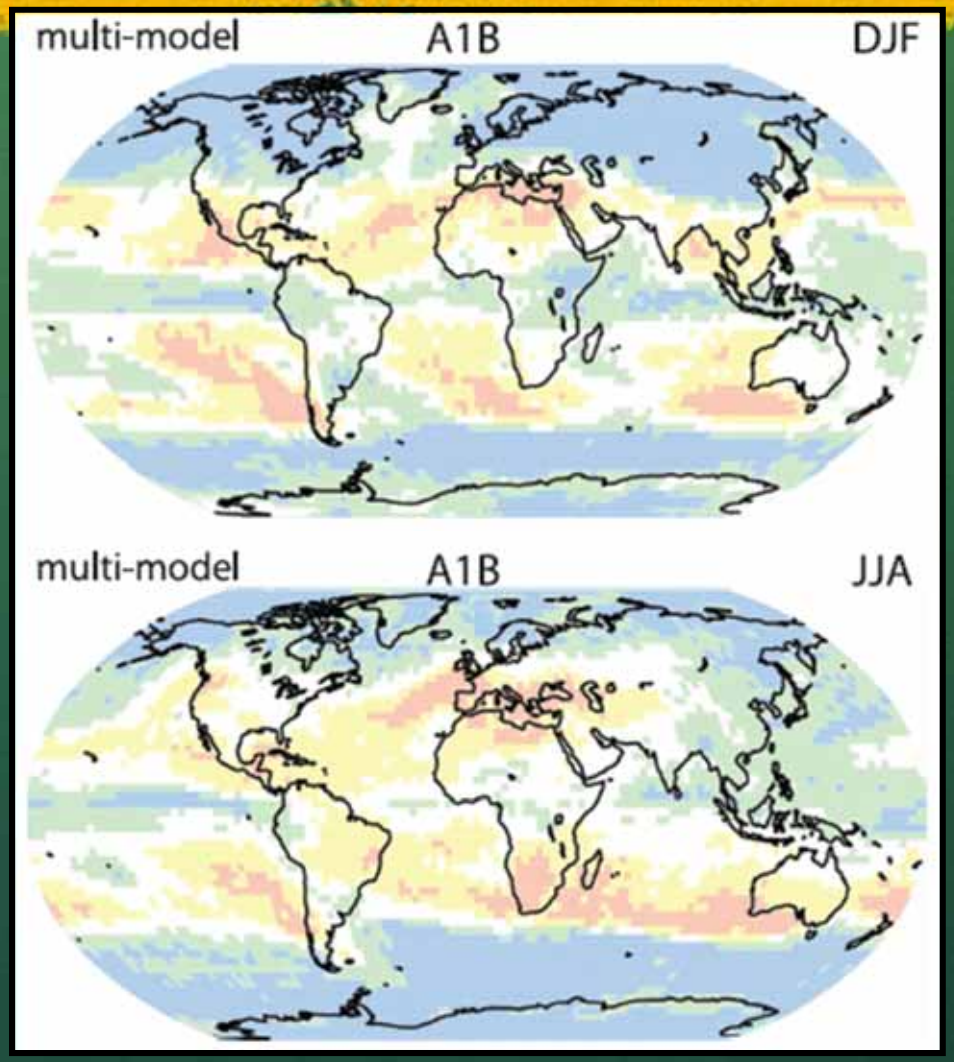
Projected precipitation change by 2100



IPCC 2007

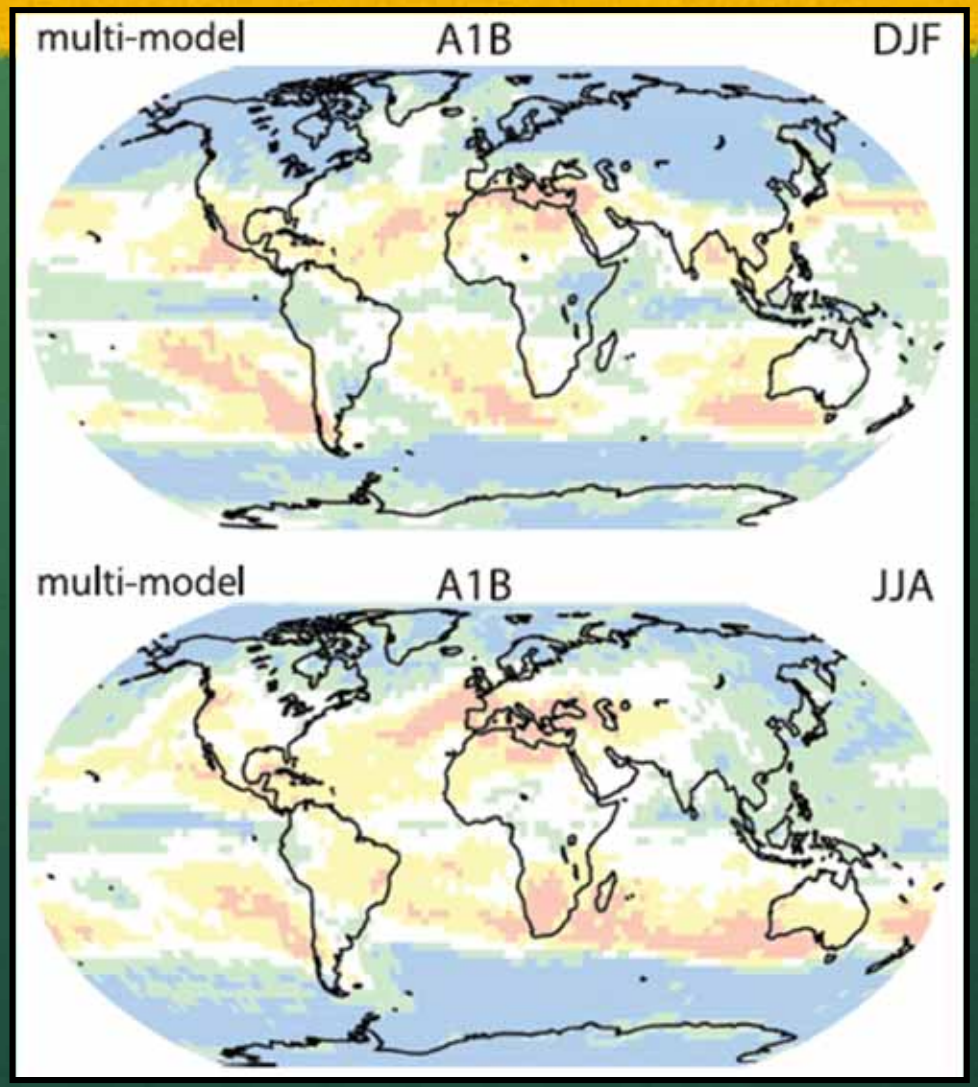
- Blue / green: wetter
- Yellow / red: drier
- Top image - precipitation change during December, January, and February.
- Bottom - precipitation change during June, July, and August.

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).

Images: UCAR

Let's Stop Two Minutes for Questions?

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The Carbon Cycle and Climate Change

(And a classroom activity about CO2)

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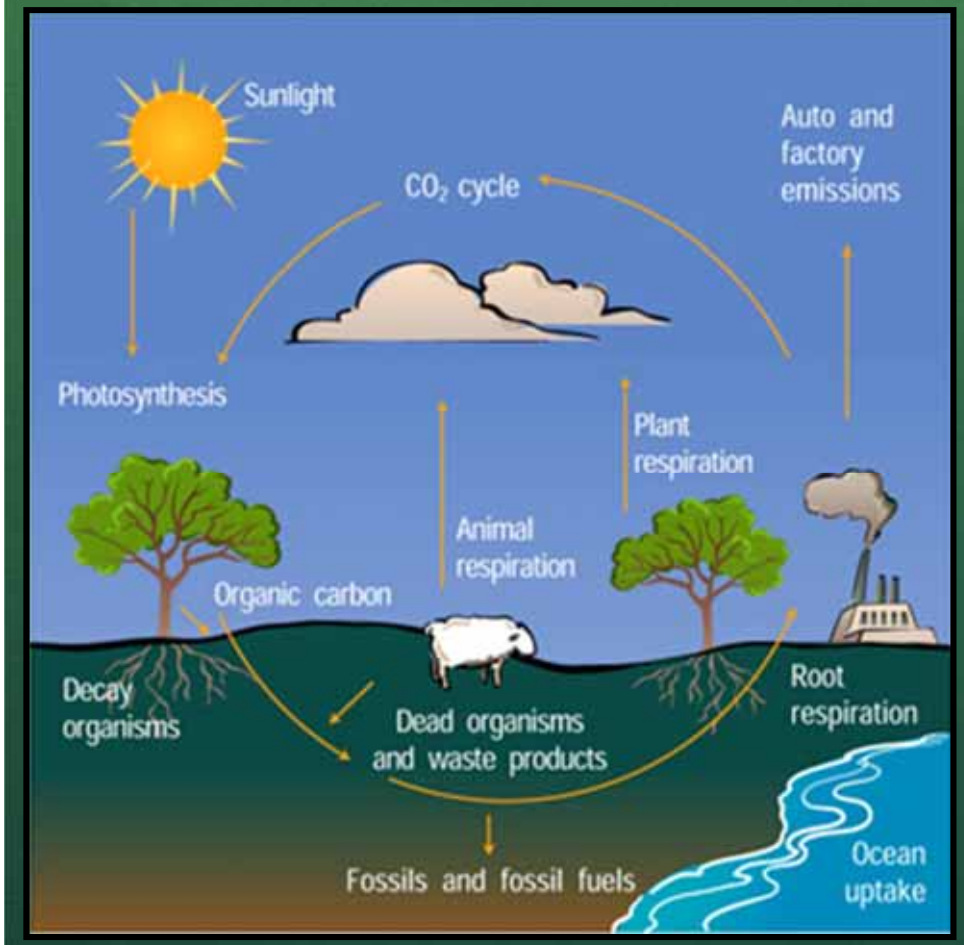
What is the carbon cycle?



- 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”.

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How is the carbon cycle related to climate?

- Greenhouse gases
  - Carbon dioxide (CO_2)
    - Released from burning fossil fuels, from respiration, and volcanoes
    - Taken out of the atmosphere by plants during photosynthesis
  - Methane (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 CO2
    - Used as an energy source: burning it releases CO2

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

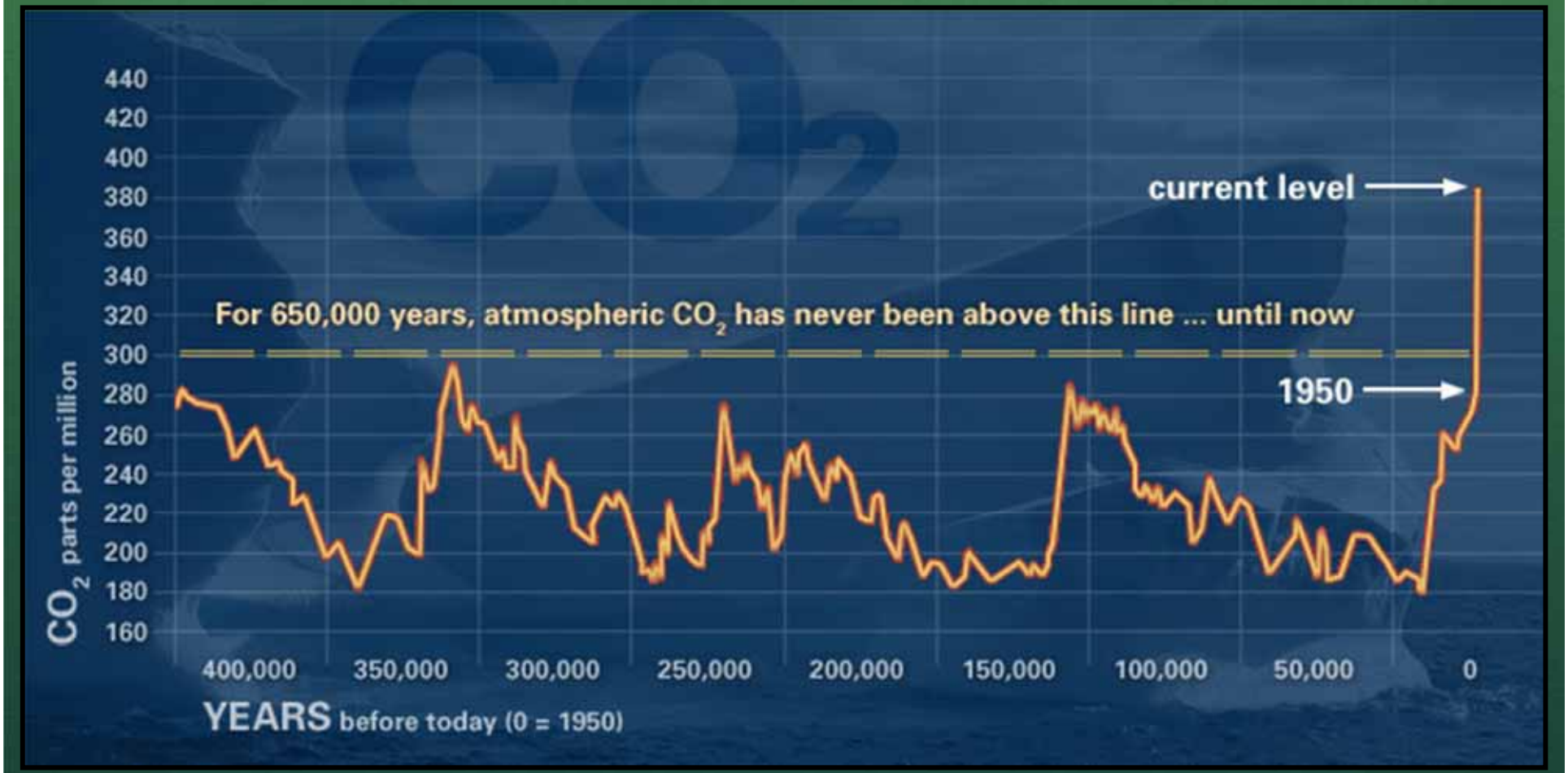
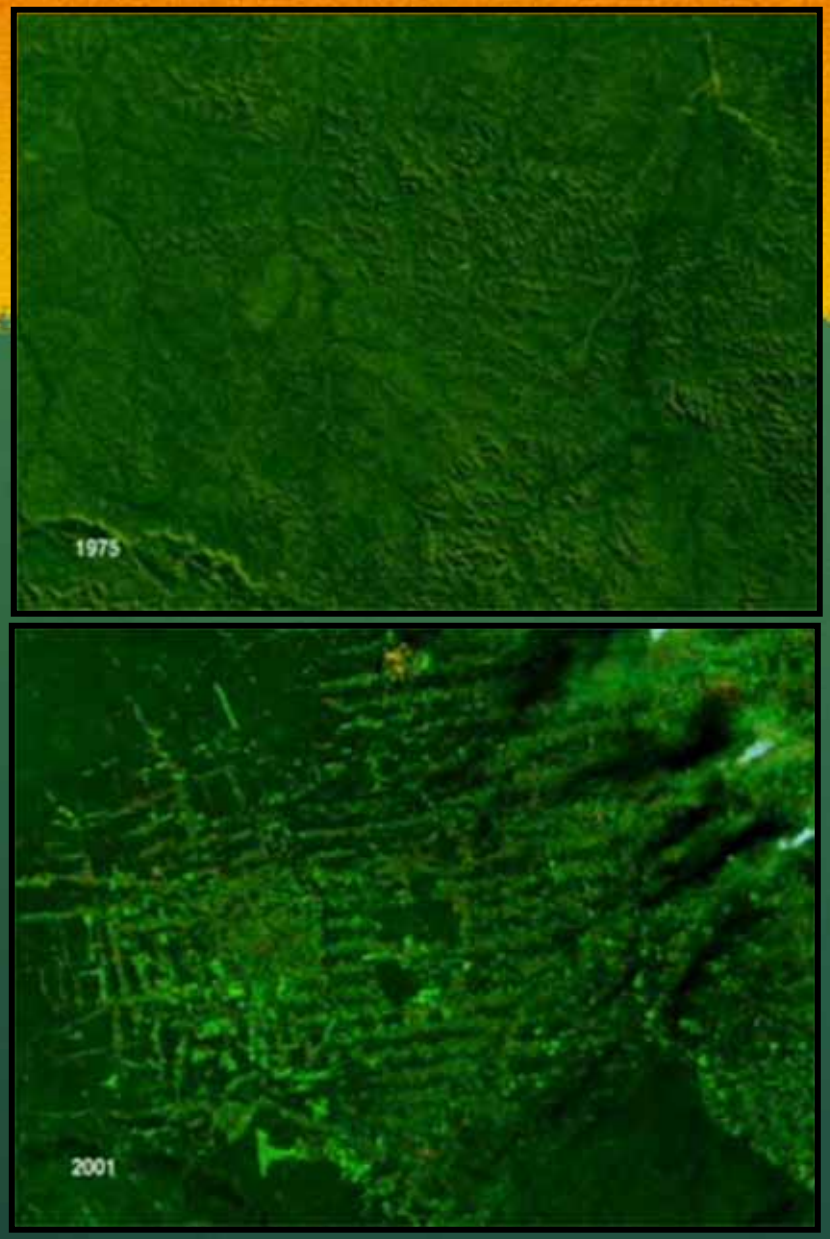


Image: NASA http://climate.nasa.gov/evidence/

Recent Changes to the Carbon Cycle: Deforestation



Landsat images 1975-2001 showing clear cutting of tropical forests in Rondonia, Brazil.
Image: NASA/GSFC

- 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.

Recent Changes to the Carbon Cycle: Increase in Plant Productivity

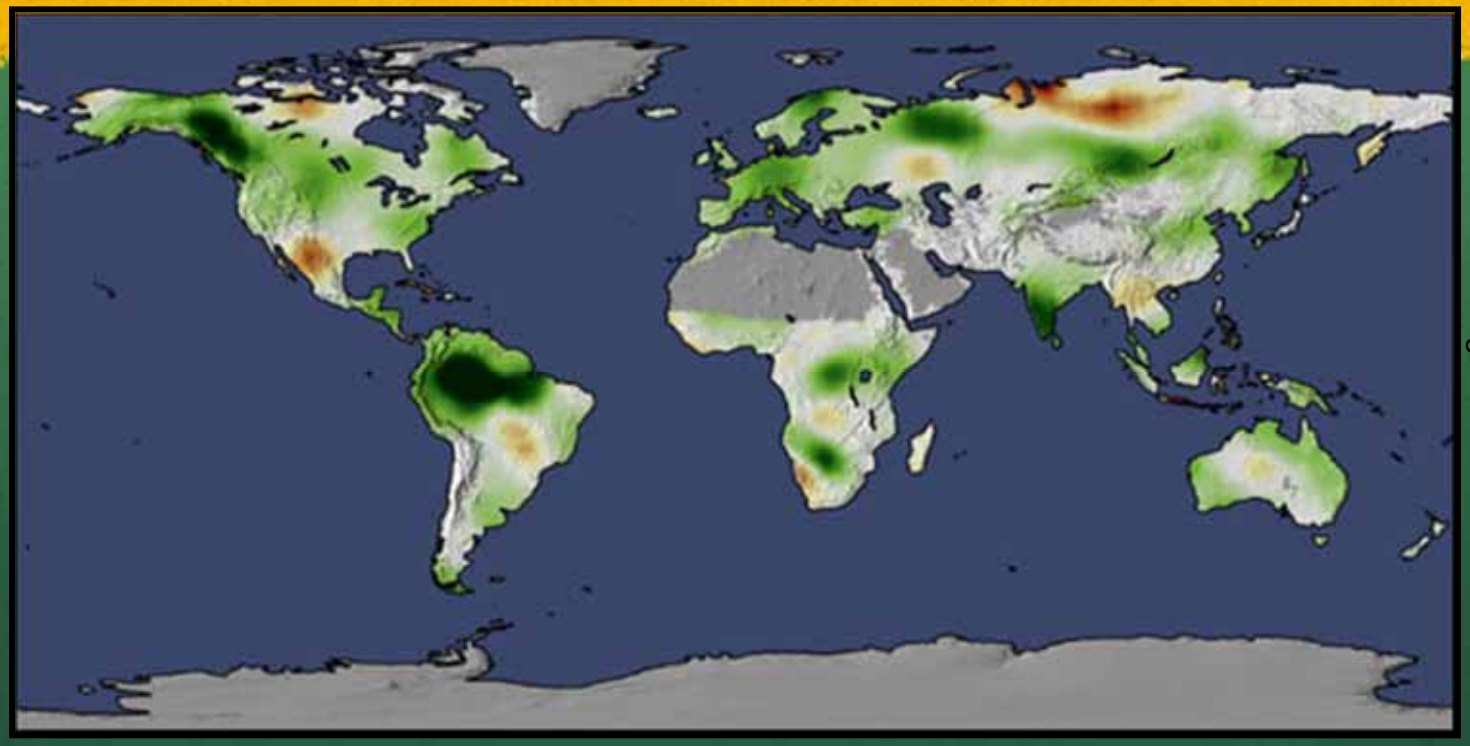


Image: NASA/Robert Simmon

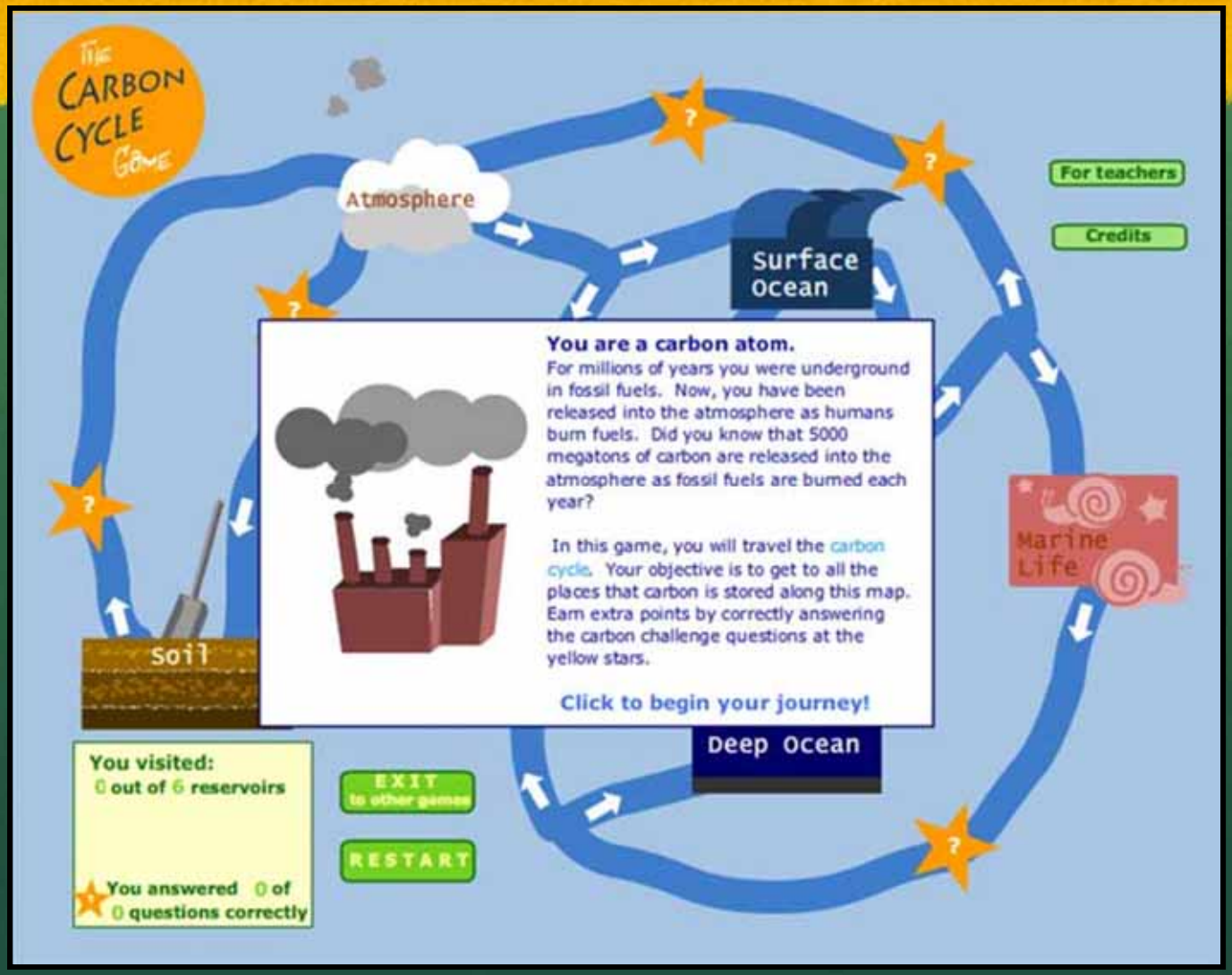
- Plant productivity (uptake of carbon by plants) increased by 6% worldwide from 1982-1999 (increase=green, decrease=orange)
- Higher productivity in areas where climate became warmer, wetter, and / or sunnier (less clouds).

Recent Changes to the Carbon Cycle: Ocean Acidification

NOAA sensor collecting data about ocean acidification in coral reef environments.
Image: Bernadette Charpentier

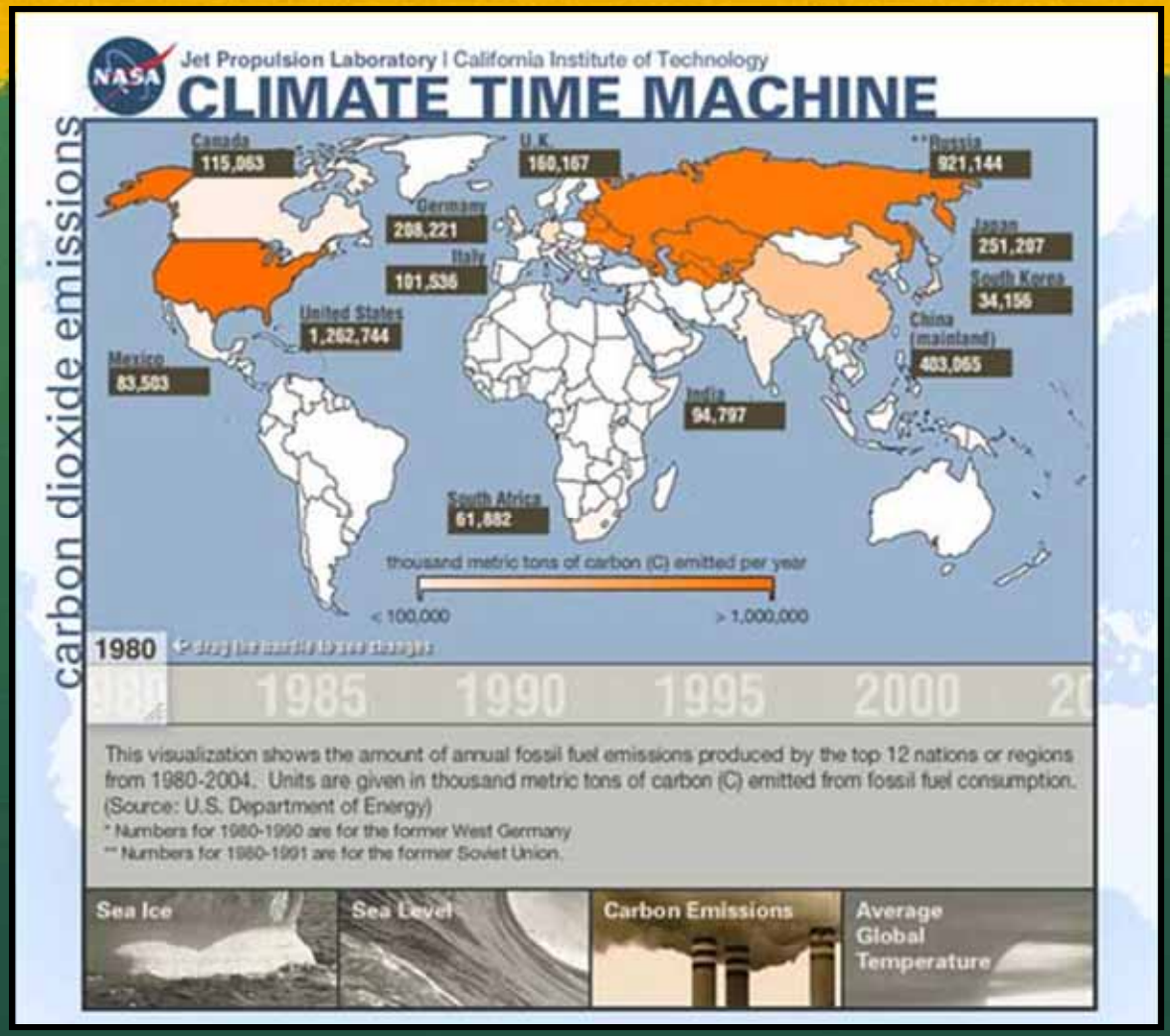
- Carbon dioxide, dissolved into the ocean, forms carbonic acid, lowering the pH of seawater.
- Since the start of the Industrial Revolution, pH of seawater has dropped about 0.1. In the next century it is expected to drop another 0.1-0.35.
- More acidic waters make it difficult for marine life such as corals to build their $CaCO_3$ skeletons.
- This can impact marine ecosystems.

Visit the Carbon Cycle Game!



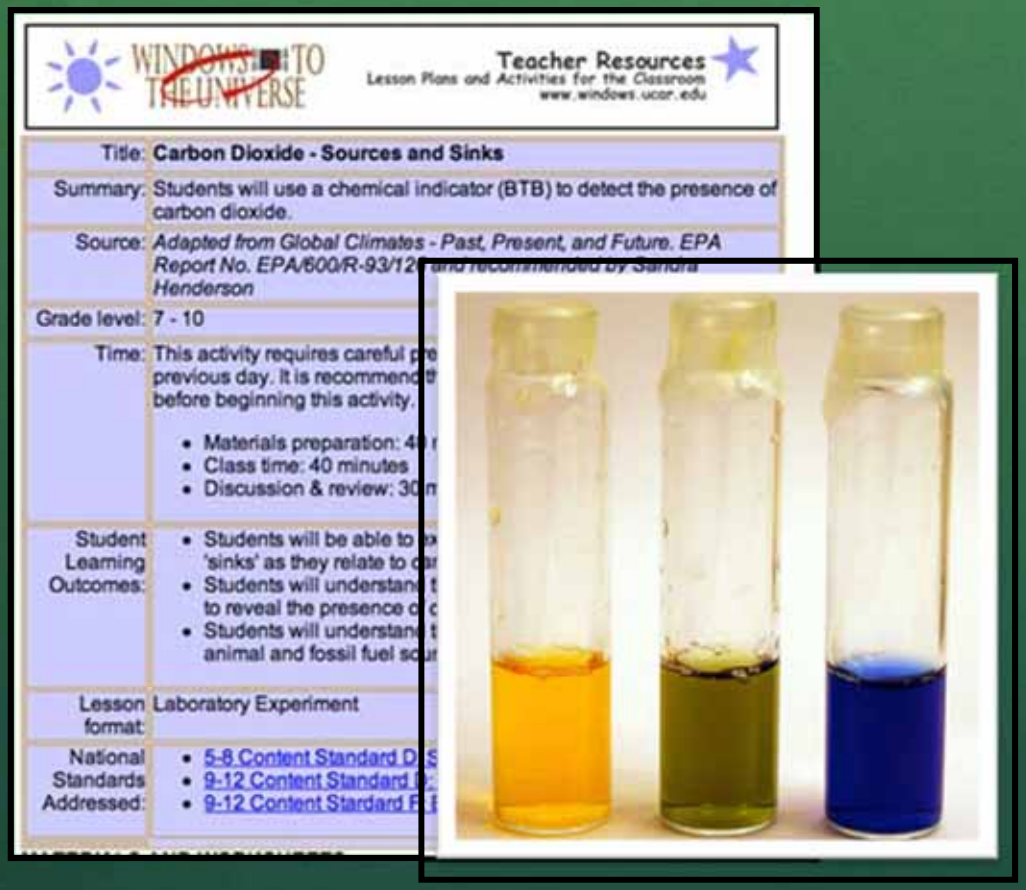
http://www.windows.ucar.edu/earth/climate/carbon_cycle.html

Visit the NASA Climate Time Machine!



http://climate.nasa.gov/ClimateTimeMachine/climateTimeMachine.cfm

Classroom activity:
Carbon Dioxide Sources and Sinks



WINDOWS TO THE UNIVERSE

Teacher Resources
Lesson Plans and Activities for the Classroom
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 Global Climates - Past, Present, and Future. EPA Report No. EPA/600/R-93/12* ... *Henderson*
Grade level:	7 - 10
Time:	This activity requires careful pr... previous day. It is recommend... before beginning this activity. • Materials preparation: 4... • Class time: 40 minutes • Discussion & review: 30...
Student Learning Outcomes:	• Students will be able to ... 'sinks' as they relate to c... • Students will understan... to reveal the presence o... • Students will understan... animal and fossil fuel so...
Lesson format:	Laboratory Experiment
National Standards Addressed:	• 5-8 Content Standard D: S... • 9-12 Content Standard ... • 9-12 Content Standard F: ...

- 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.windows.ucar.edu/tour/link=/teacher_resources/teach_CO2.html

Are animals a source or sink of carbon dioxide?

Image: L.Gardiner

A. Source

B. Sink

C. Both

D. Neither

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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.
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

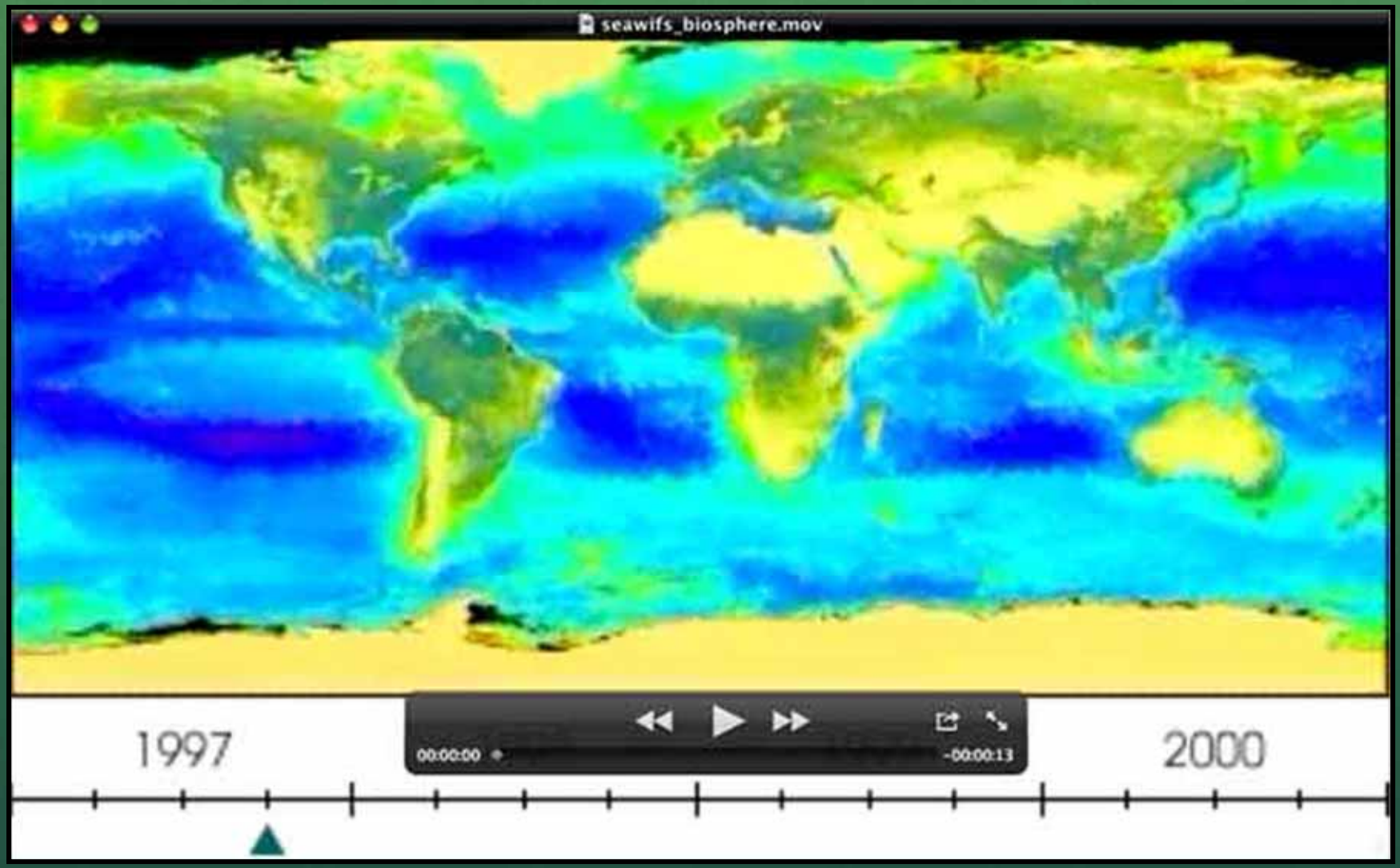
D. Neither

Image: L.Gardiner

Part 3:
Are plants a source of CO2?

Image: L.Gardiner

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.windows.ucar.edu/tour/link=/earth/Life/biosphere.html

Let's Stop Two Minutes for Questions?

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The Nitrogen Cycle and Climate Change

(And a classroom activity about the nitrogen cycle)

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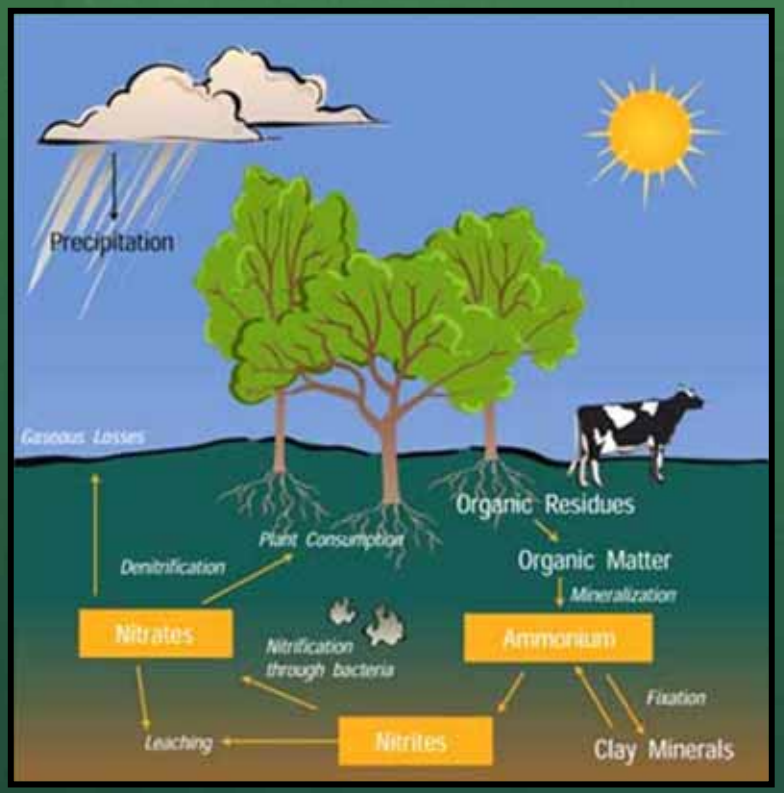
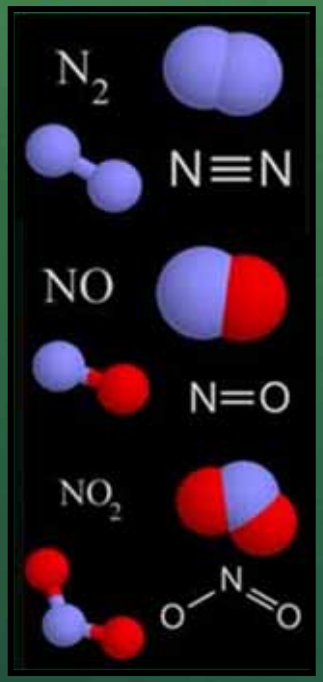
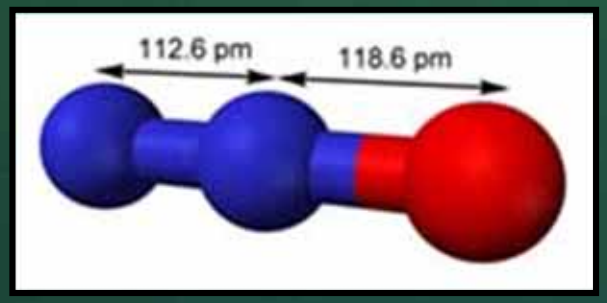
What is the nitrogen cycle?



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

Nitrogen in the Air





- Nitrogen (N_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_2)
  - Pollutant released from fossil fuels, part of smog and contributes to ground level ozone.
- Nitrous oxide (N_2O)
  - 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?

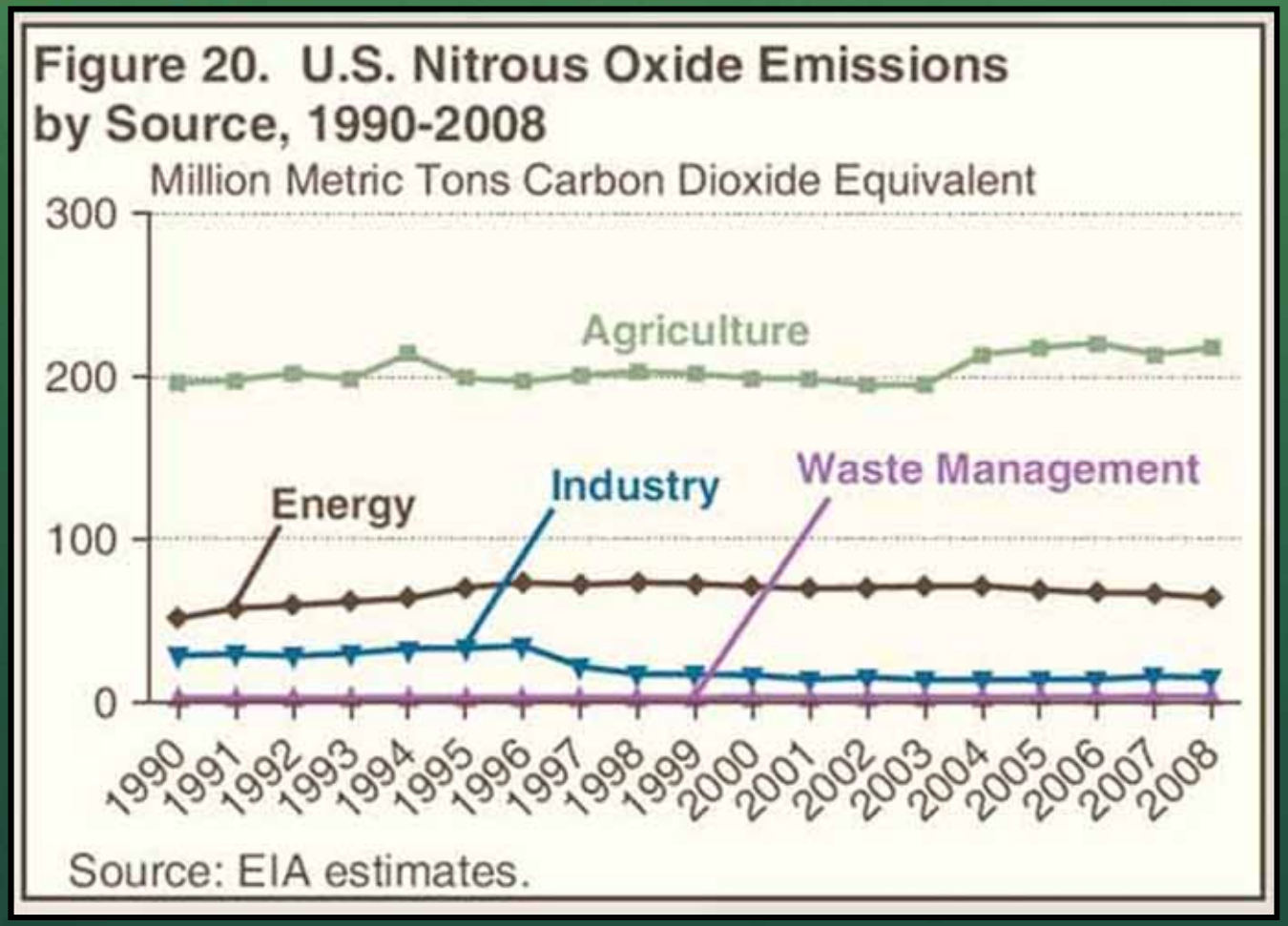
A. Nitric oxide (NO)

B. Nitrous oxide (N_2O)

C. Nitrogen dioxide (NO_2)

D. Nitrogen (N_2)

Where does nitrous oxide come from?



US DOE Pub. DOE/EIA-0573(2008)

Another global change: nitrogen fertilizers and waterways

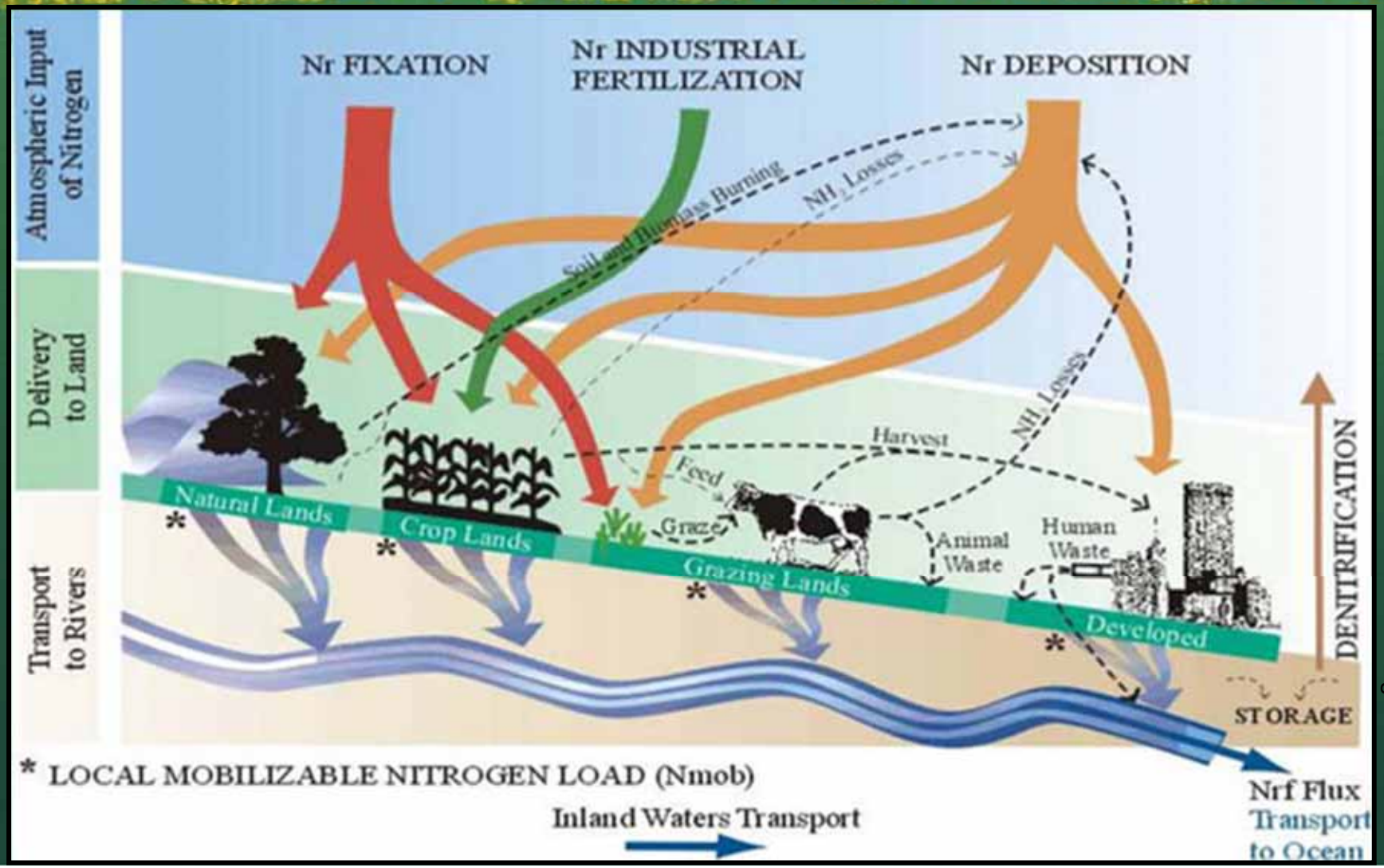


Image: NOAA

Summer dead zone at the Mississippi River delta

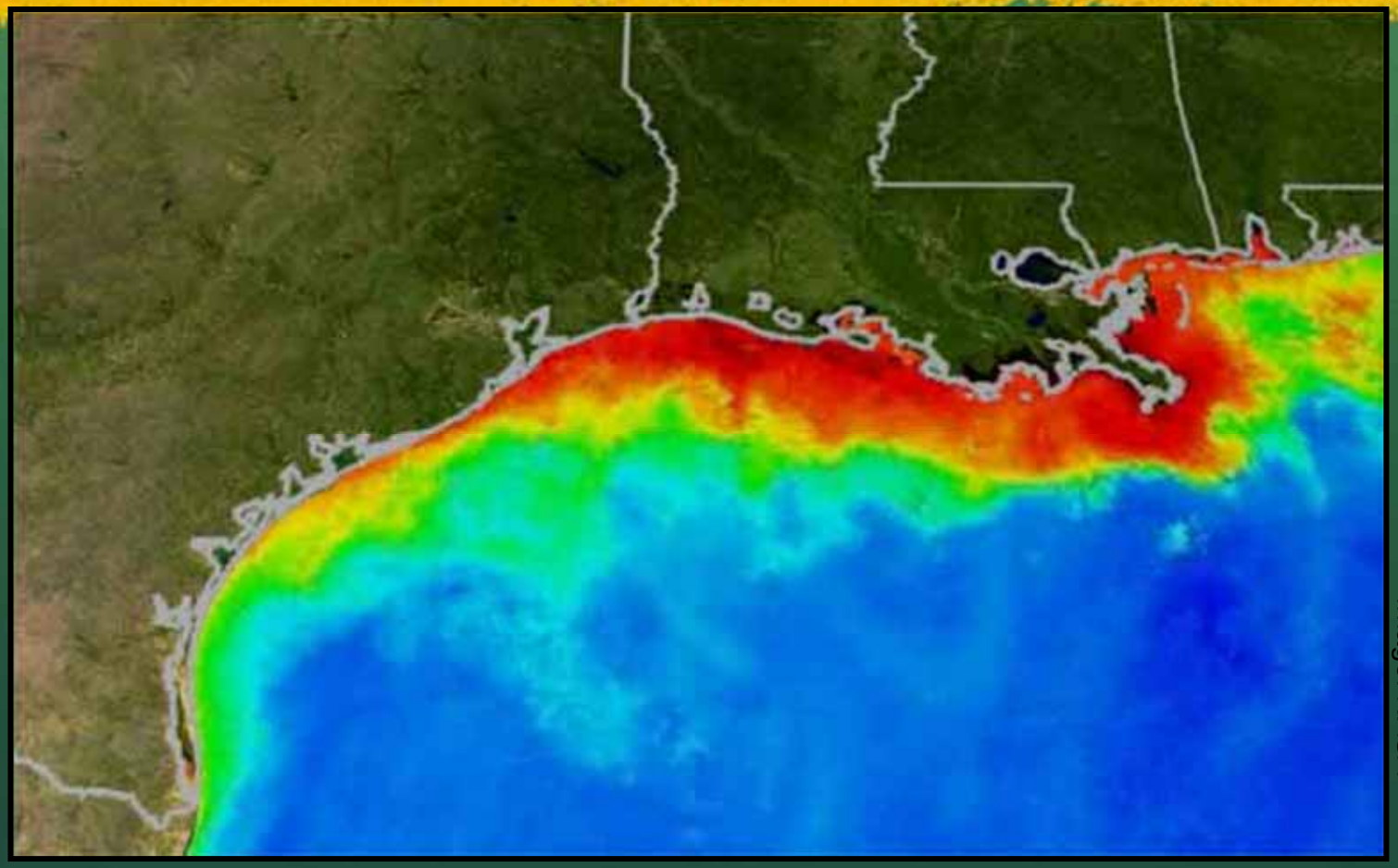


Image: NASA

Red and orange = lots of phytoplankton and sediment

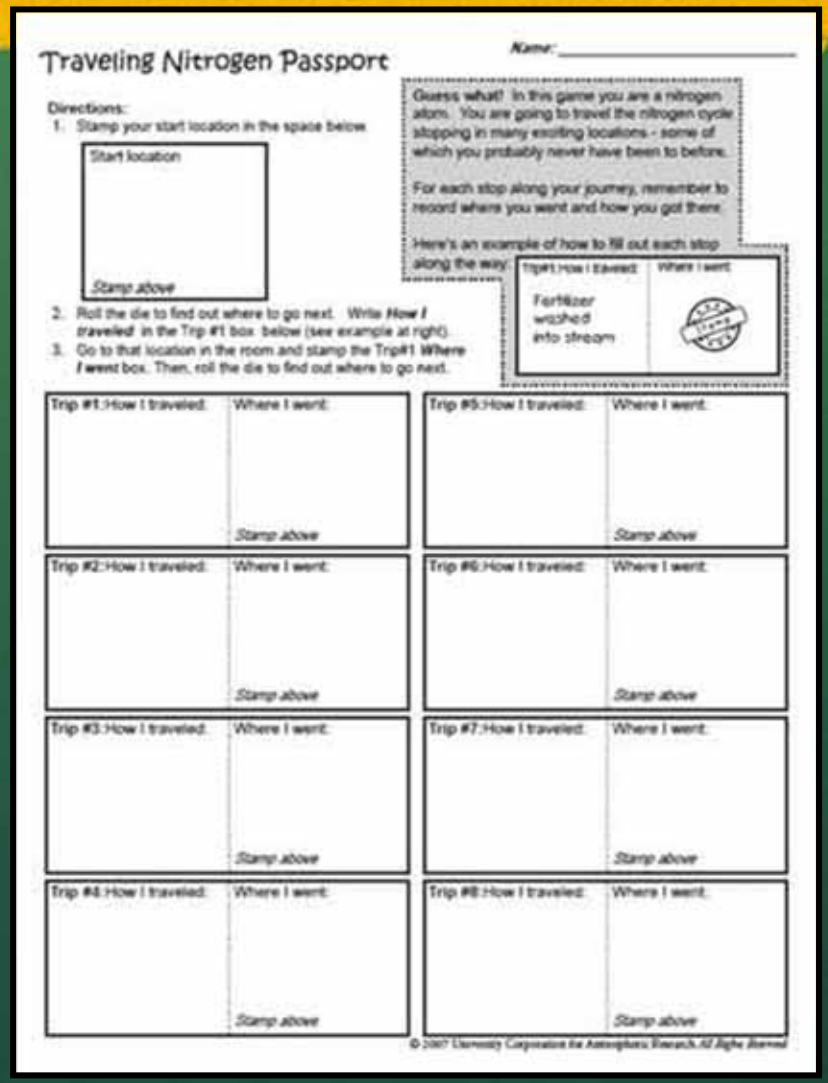
Classroom activity: Traveling Nitrogen

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.

http://www.windows.ucar.edu/tour/link=/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.



Traveling Nitrogen Passport

Name: _____

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.

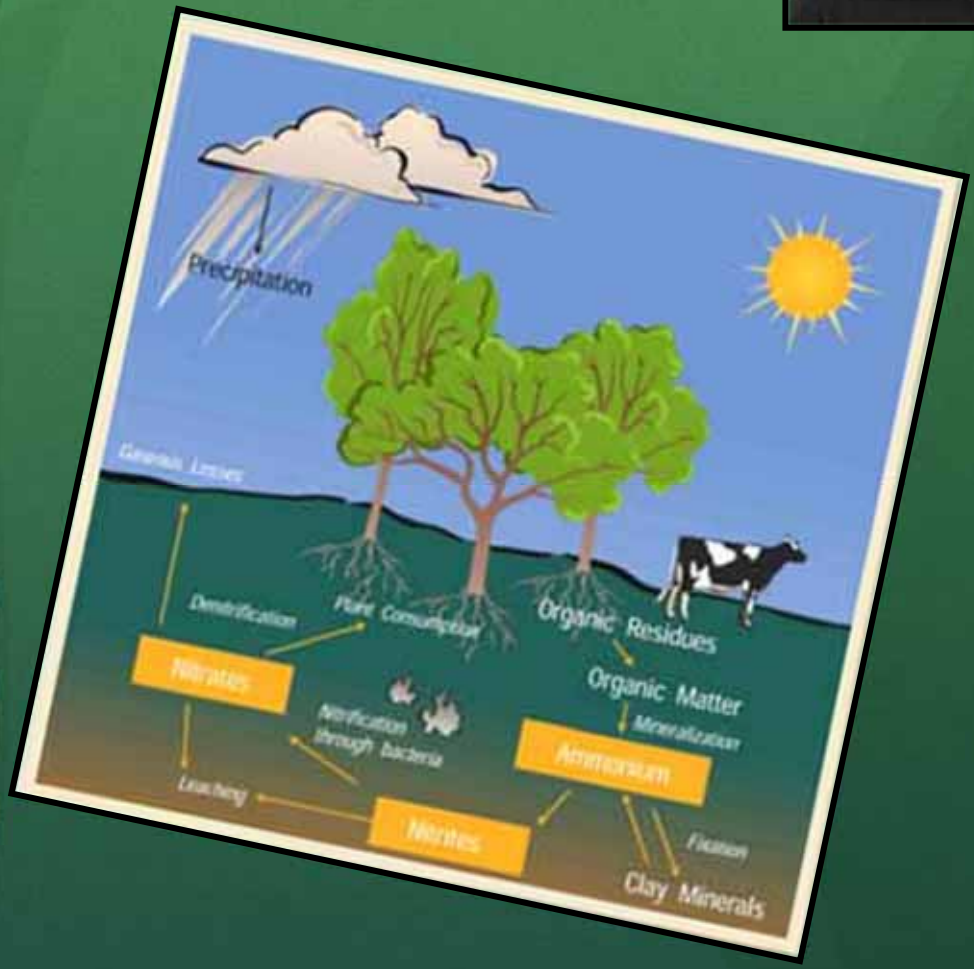
For each stop along your journey, remember to record where you went and how you got there.

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

Let's Stop Two Minutes for Questions?



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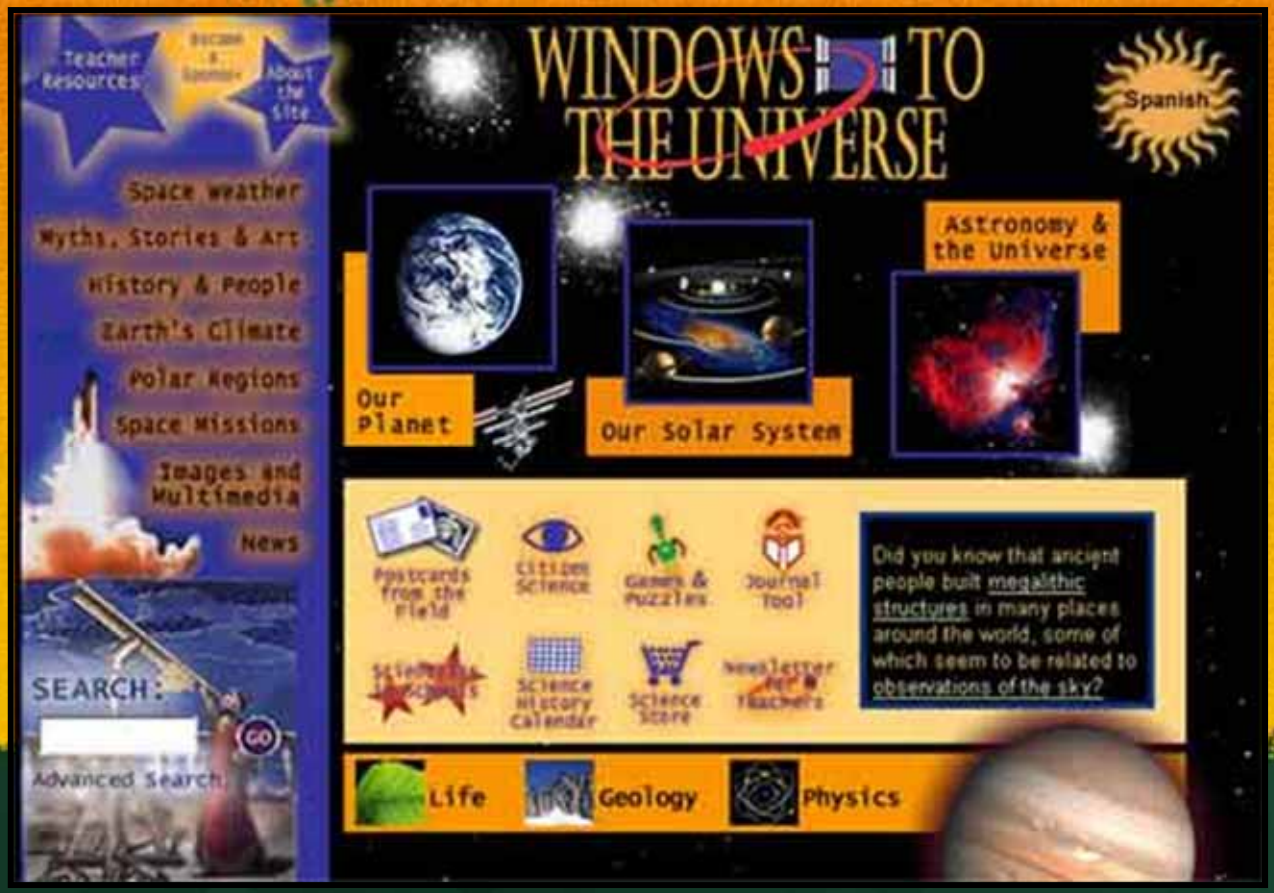
Climate and Global Change on Windows to the Universe



http://www.windows.ucar.edu

Climate Discovery

A series of online professional development courses for middle and high school educators

CD 501 – Introduction to Climate Change

CD 502 – Earth System Science: A Climate Change Perspective

CD 503 – Understanding Climate Change Today

http://ecourses.ncar.ucar.edu

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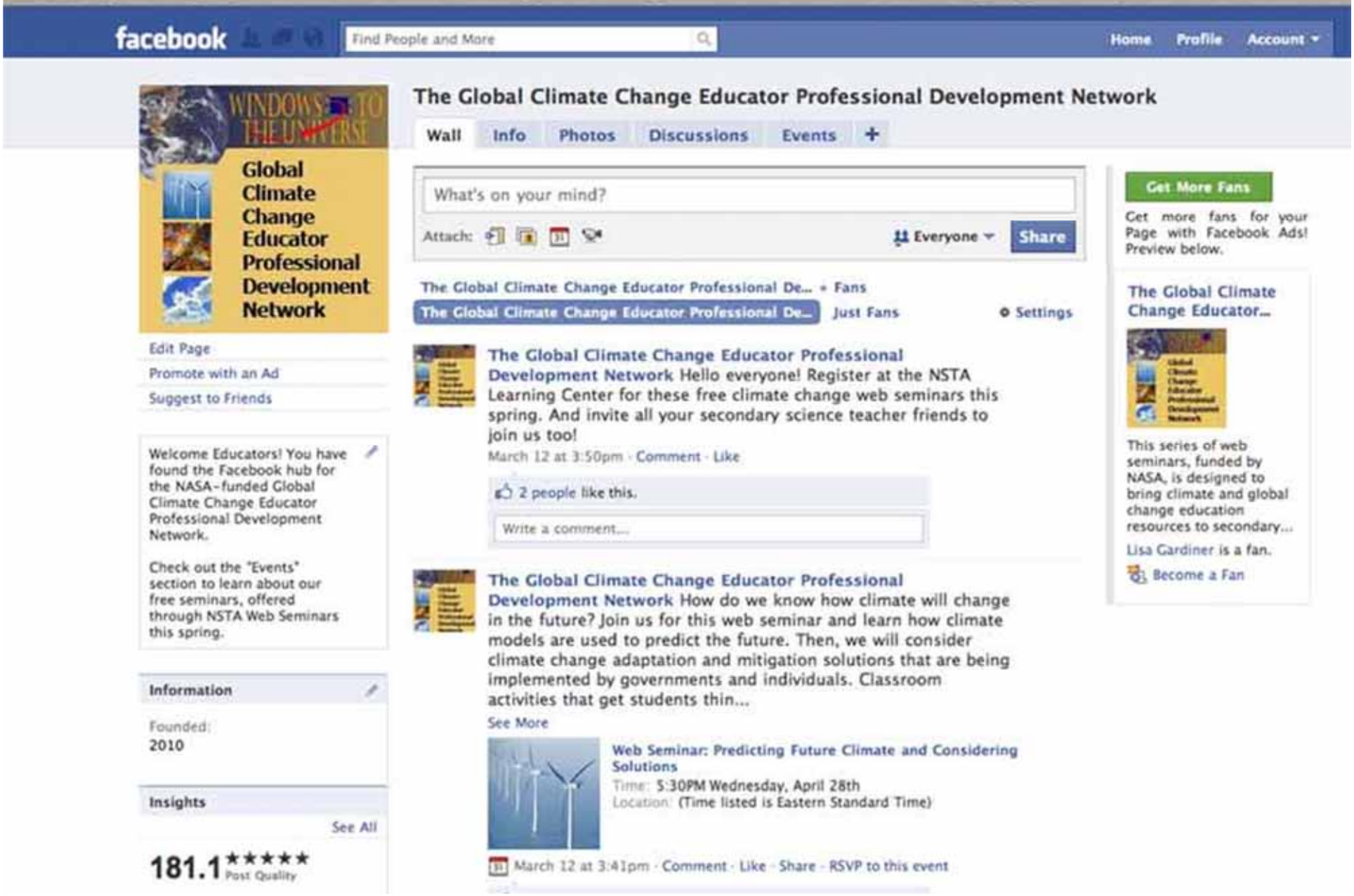

Thanks!

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