
Climate science in context; providing teachers with tools to elevate climate science literacy

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Who we are and Why we are doing this

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- Climate Change Literacy and Education: ACS Student Perspectives from the Global Stage - Project and Book
- Teaching climate science in multiple courses for the last eight years, dedicated course *Chemistry and Society; Costa Rica Field Experience*

R. Leigh Foy, MS, MAT, Science Teacher, York Suburban High School

- Associate Editor, POGIL National High School Initiative (Chemistry, Biology, AP Chem, AP Bio)
- Attended COP 21 in Paris as an NGO through Moravian College; teaching climate science in HS Chemistry and AP Biology

Snapshot of the State of US Climate Education

2015 Study from the National Center for Science Education in *Science*

POSITIVES

- 75% of public school teachers “devote time” to climate change
- 90% of all public Middle Schools, and 98% of all public High Schools self report teaching about recent global warming in at least one class
- Two thirds of teachers surveyed *would* take advantage of continuing education courses focused on climate change
- Many teachers discuss positive efforts that industry, governments, or individuals can take to alleviate recent global warming

Snapshot of the State of US Climate Education

2015 Study from the National Center for Science Education in *Science*

NEGATIVES

- Most teachers are unaware of the scientific consensus that human activity is the primary cause of recent global warming (>96% climate scientists)
- Only ~60% of teachers see human activities as the primary cause of recent global warming
- Mixed Messages: 27% give equal time to perspectives that raise doubt about the scientific consensus
- Less than 30% reported “above average knowledge of climate change models”

Climate Literacy in US classrooms

Dueling Challenges

Teachers need more content knowledge on climate concepts - Greg's "Top Ten Data Sets that Every Climate Literate Citizen Should Know"

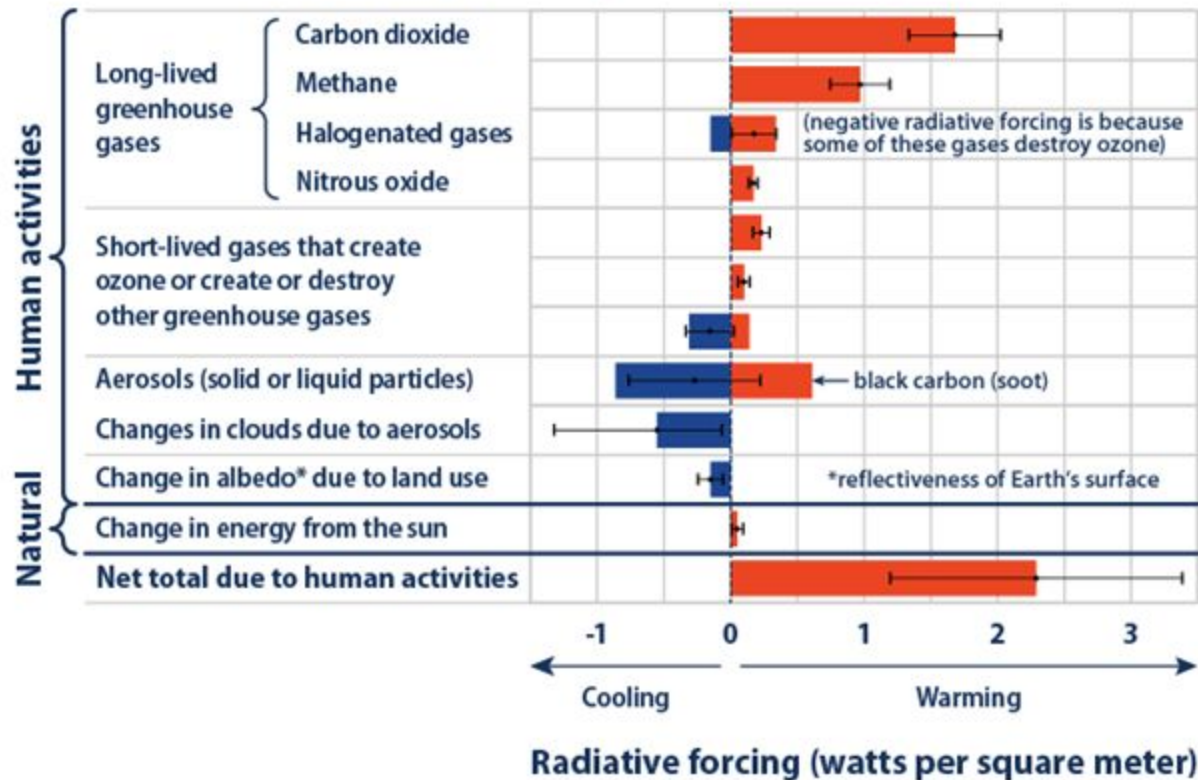
Teachers need climate concepts materials for their classrooms - Leigh's sharing of resources for high school teachers

Top Ten Climate Change Data Sets that a Science Literate Citizen Should Understand

Number 10

Earth's Energy Balance

Radiative Forcing Caused by Human Activities Since 1750



Data source: IPCC (Intergovernmental Panel on Climate Change). 2013. Climate change 2013: The physical science basis. Working Group I contribution to the IPCC Fifth Assessment Report. Cambridge, United Kingdom: Cambridge University Press. www.ipcc.ch/report/ar5/wg1.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.

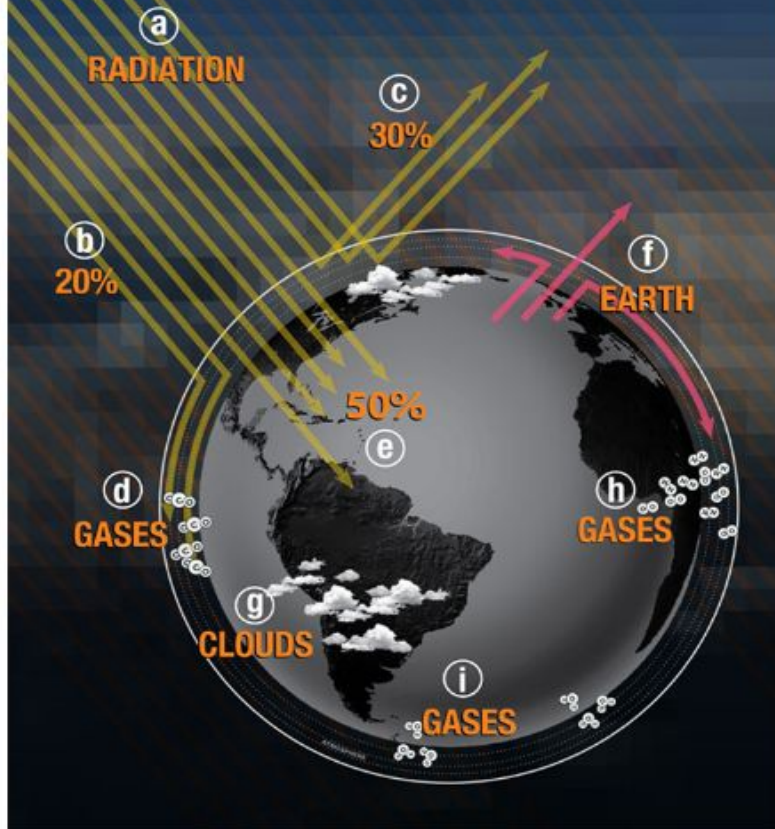
Top Ten Climate Change Data Sets that a Science Literate Citizen Should Understand

Number 9

The Greenhouse Effect

GREENHOUSE EFFECT

PREV



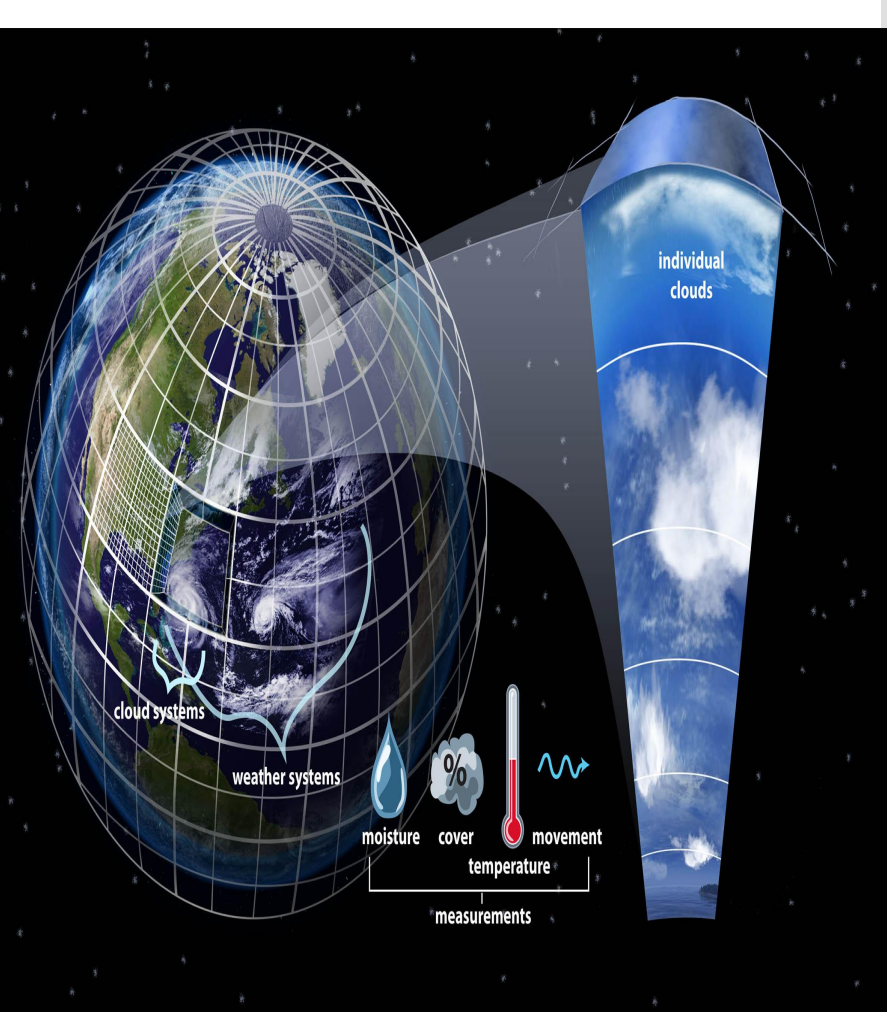
The Greenhouse Effect

- **a** Incoming radiation from the sun
- **b** 20% absorbed by atmosphere
- **c** 30% reflected back to space
- **d** Greenhouse gases (GHGs)
- **e** Earth absorbs 50%
- **f** Earth emits heat (infrared)
 - GHGs trap / some back into space
- **g** Cloud cover reflect heat back into space
- **h** Non absorbing atmospheric gases (N_2 , O_2)
- **i** Water vapor heat absorber and more plentiful as temp rises

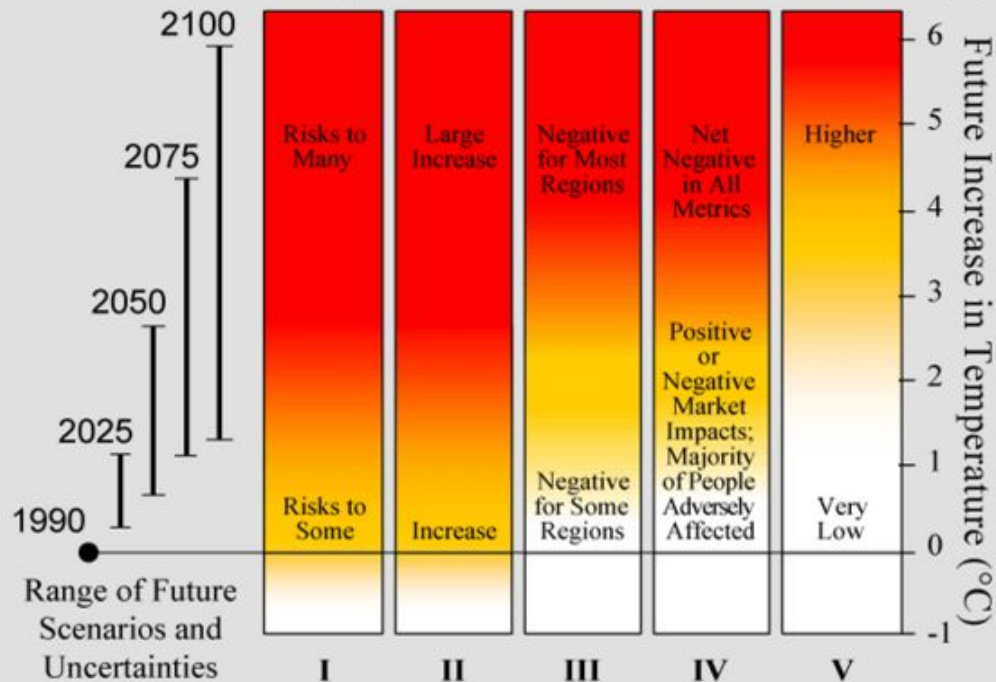
Top Ten Climate Change Data Sets that a Science Literate Citizen Should Understand

Number 8

Climate Projections from
Modeling



Risks and Impacts of Global Warming

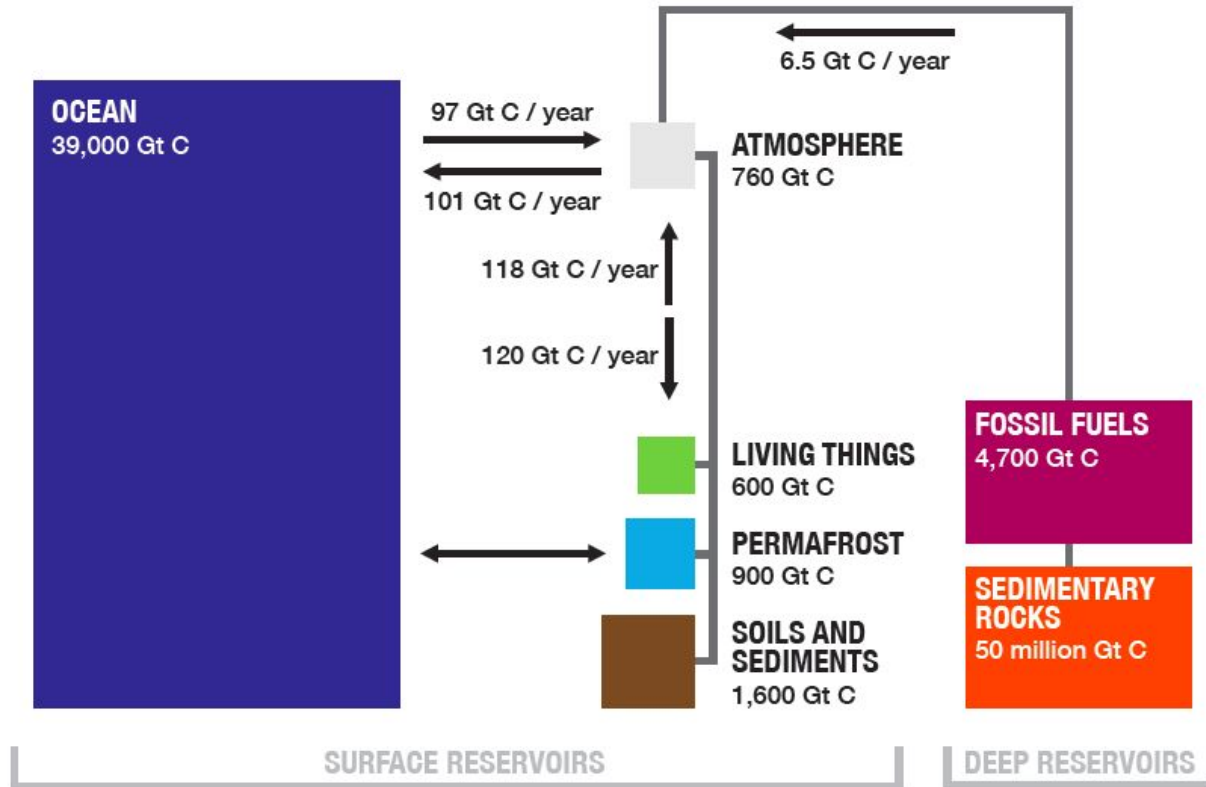


- I** Risks to Unique and Threatened Systems
- II** Frequency and Severity of Extreme Climate Events
- III** Global Distribution and Balance of Impacts
- IV** Total Economic and Ecological Impact
- V** Risk of Irreversible Large-Scale and Abrupt Transitions

Top Ten Climate Change Data Sets that a Science Literate Citizen Should Understand

Number 7

The Carbon Cycle

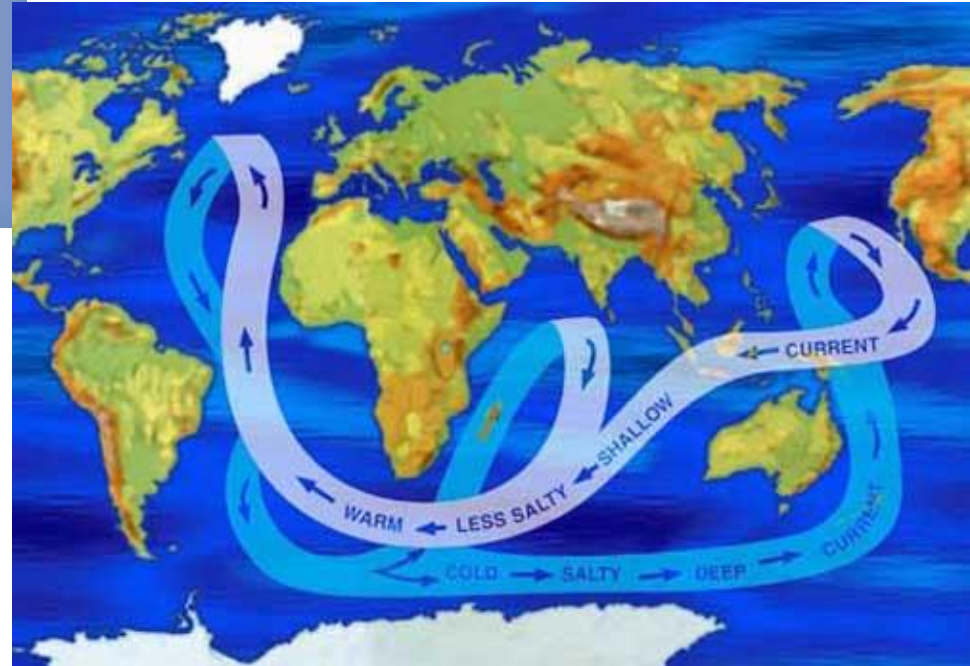
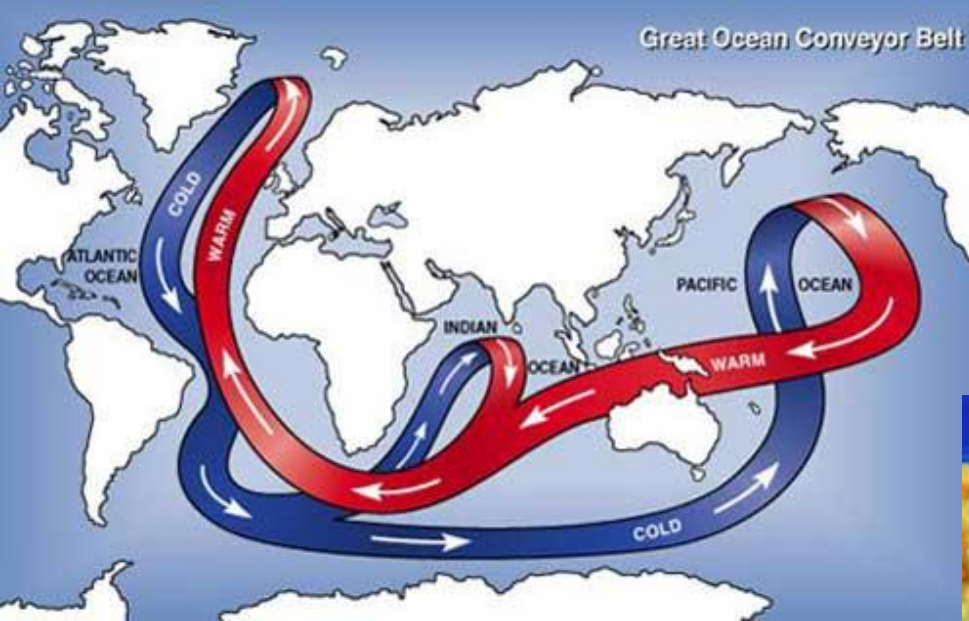


Top Ten Climate Change Data Sets that a Science Literate Citizen Should Understand

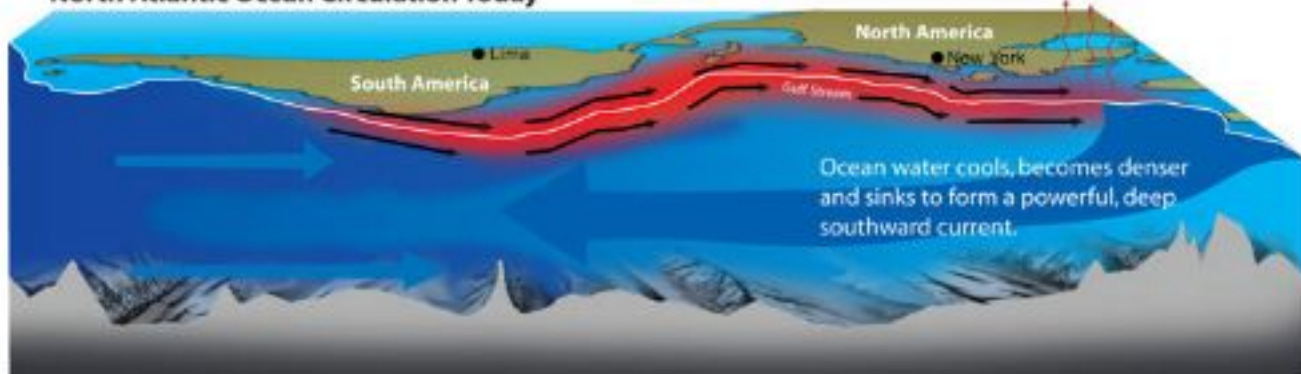
Number 6

The Ocean Conveyor Belt

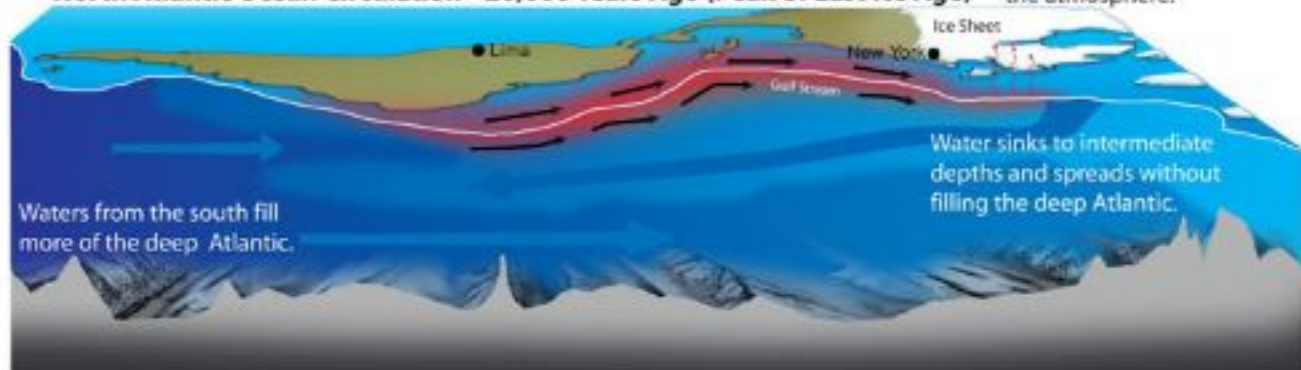
Great Ocean Conveyor Belt



North Atlantic Ocean Circulation Today



North Atlantic Ocean Circulation ~20,000 Years Ago (Peak of Last Ice Age)



Top Ten Climate Change Data Sets that a Science Literate Citizen Should Understand

Number 5

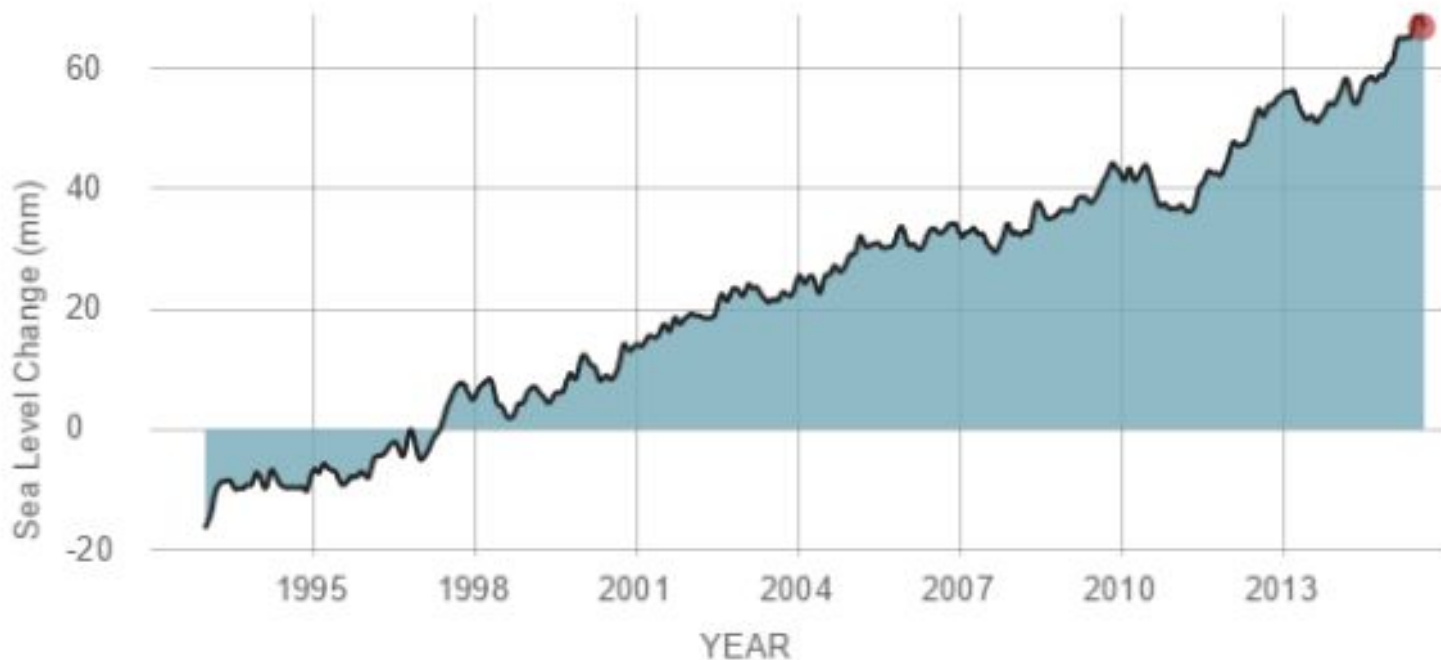
Sea Level Rise

SATELLITE DATA: 1993-PRESENT

Data source: Satellite sea level observations.
Credit: NASA Goddard Space Flight Center

RATE OF CHANGE

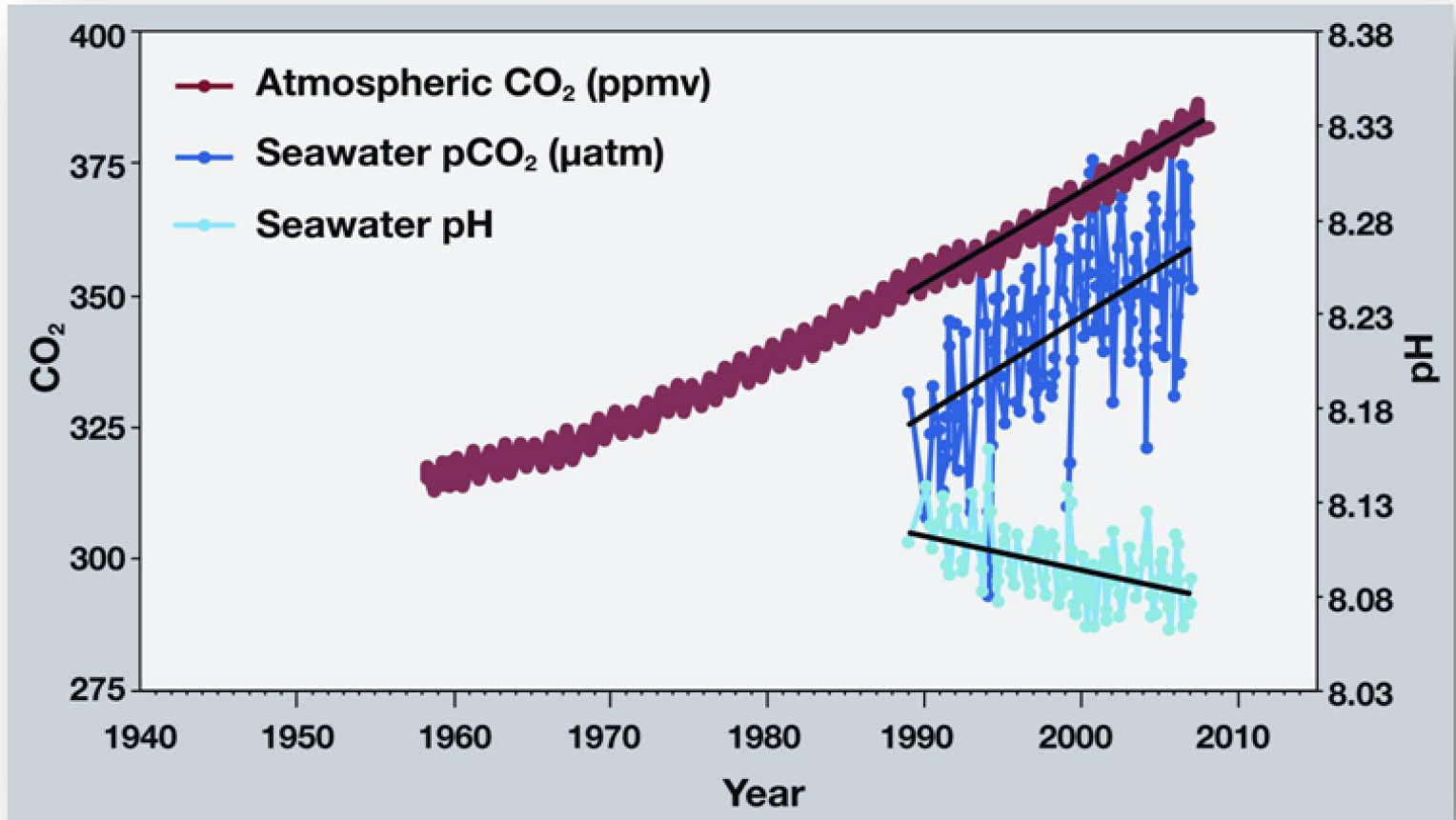
↑ 3.24
mm per year



Top Ten Climate Change Data Sets that a Science Literate Citizen Should Understand

Number 4

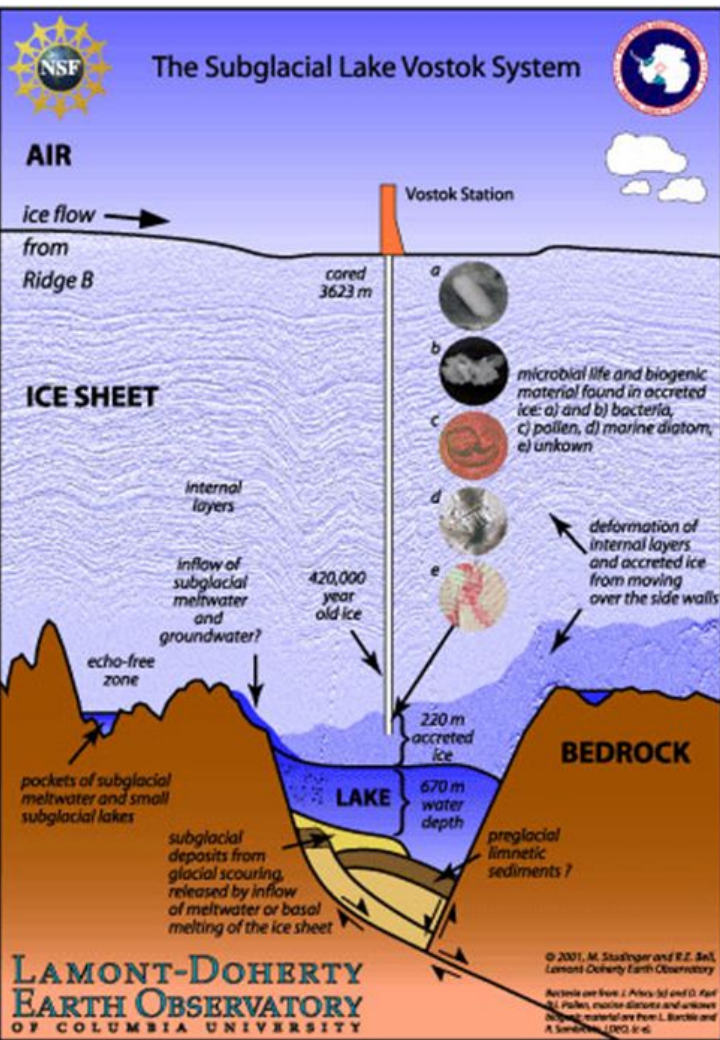
Ocean Acidification



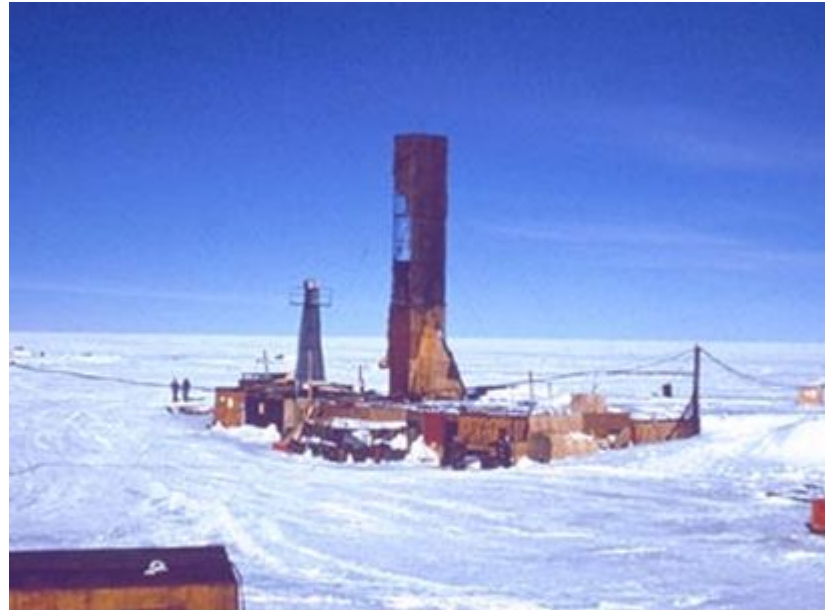
Top Ten Climate Change Data Sets that a Science Literate Citizen Should Understand

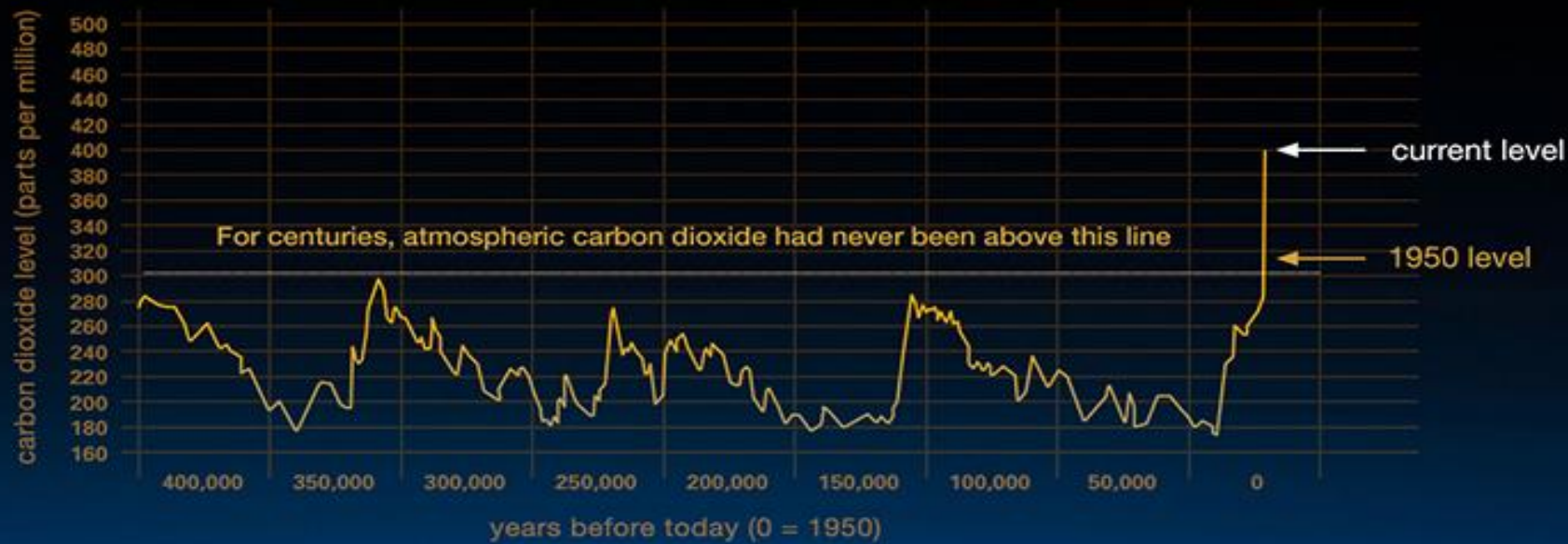
Number 3

Vostok CO₂ and Temperature
Data



Vostok Station Antarctica

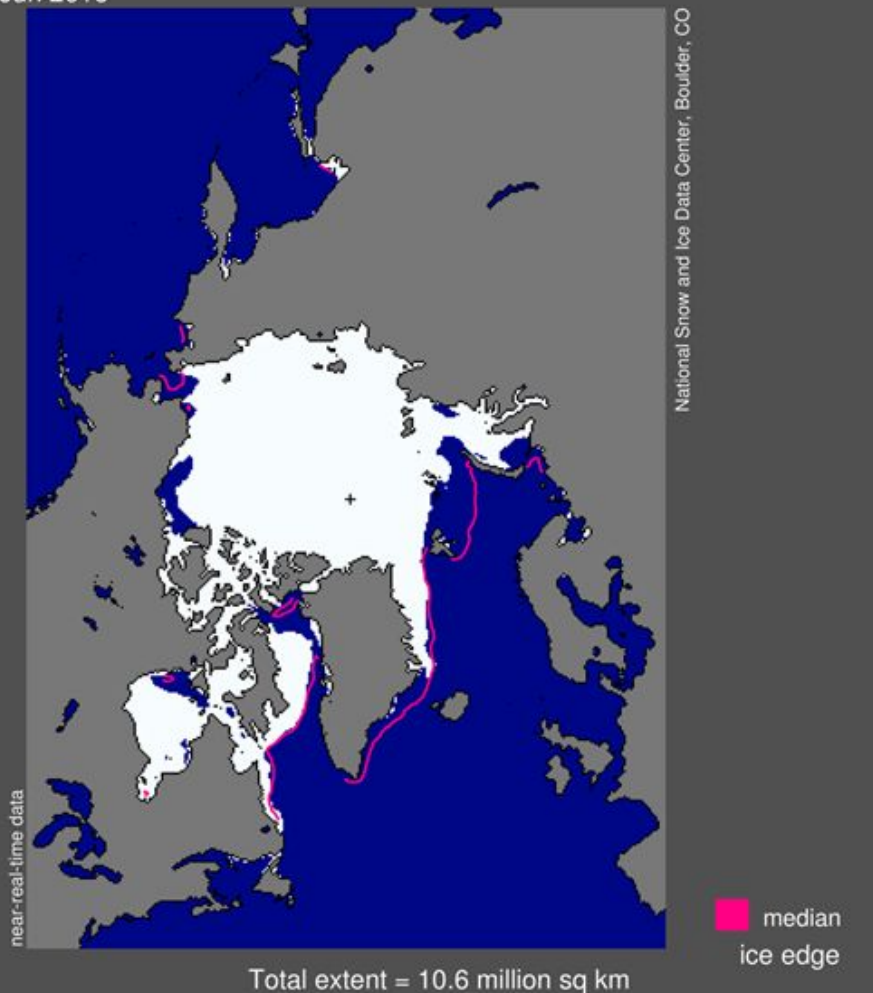




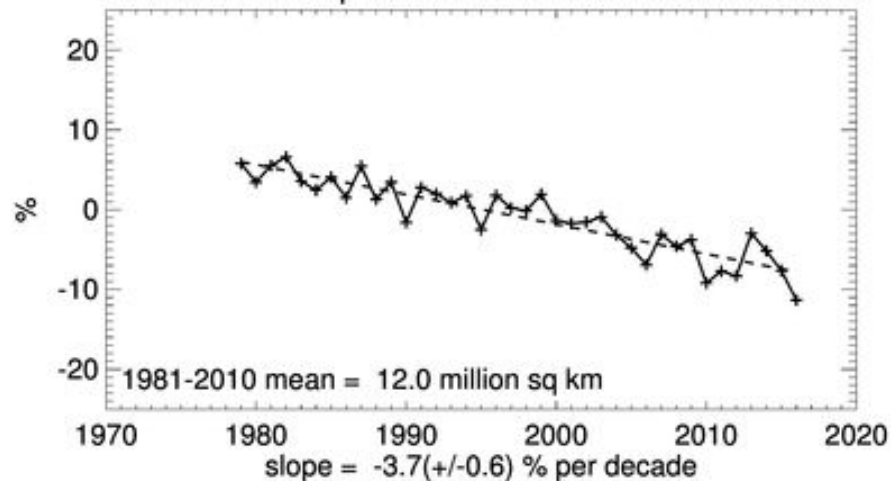
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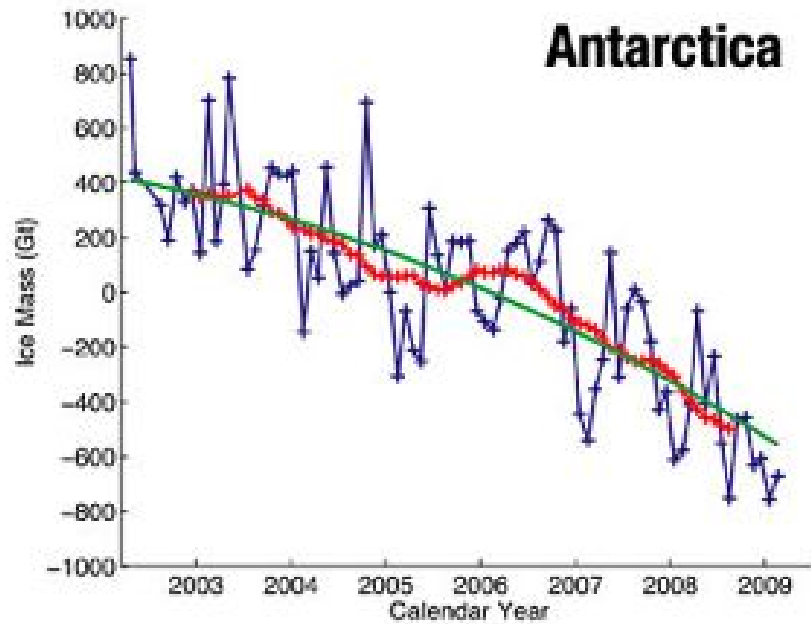
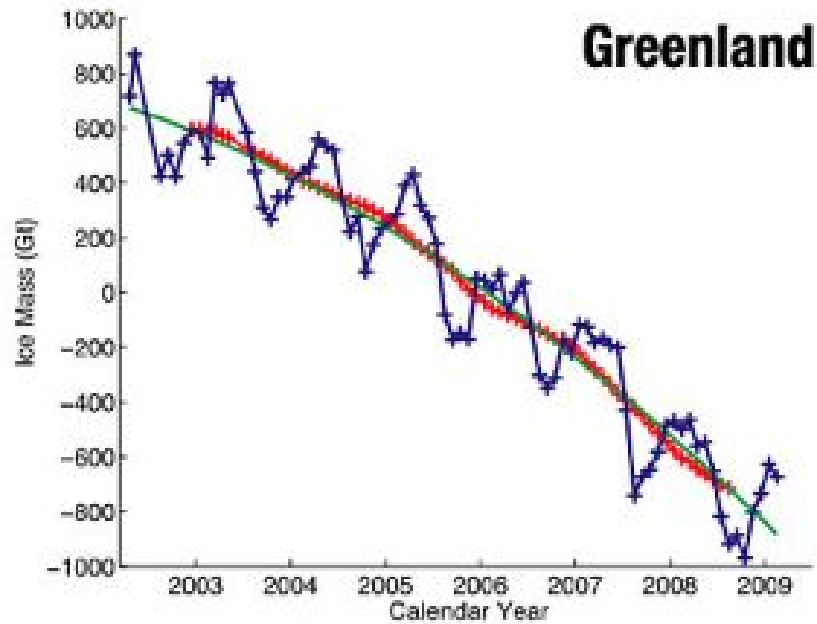
Number 2

Polar Ice Extent and
Significant Ice Sheet Loss



Northern Hemisphere Extent Anomalies Jun 2016





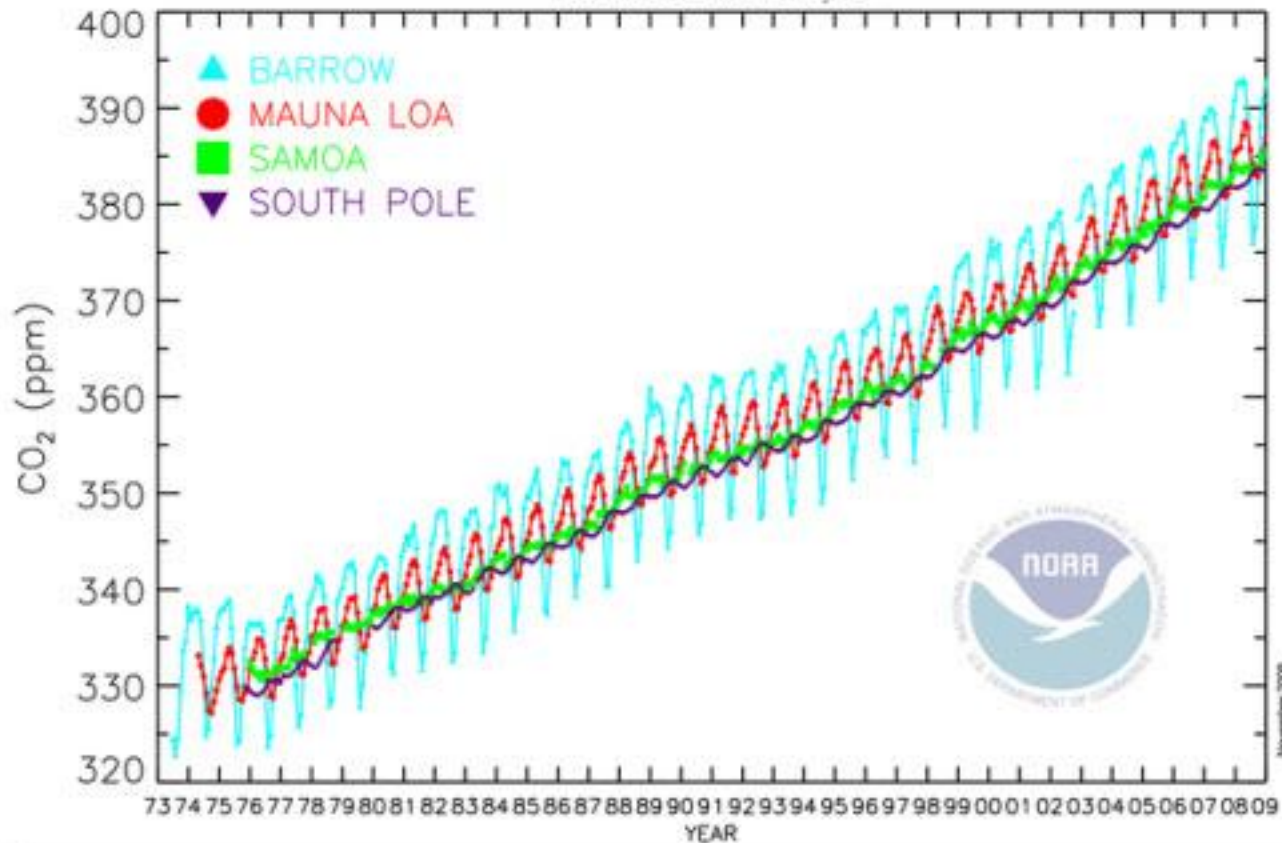
Top Ten Climate Change Data Sets that a Science Literate Citizen Should Understand

Number 1

The Keeling Curve

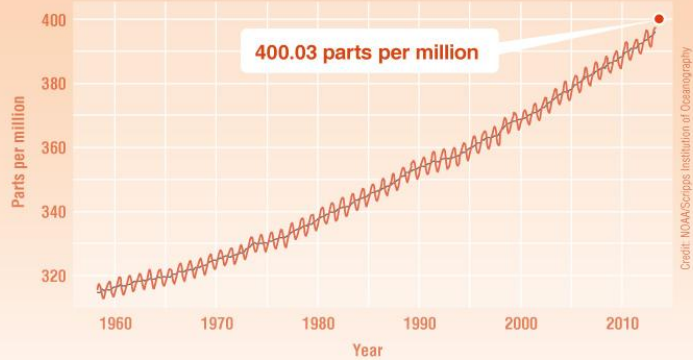
Monthly Mean Carbon Dioxide

NOAA ESRL Carbon Cycle

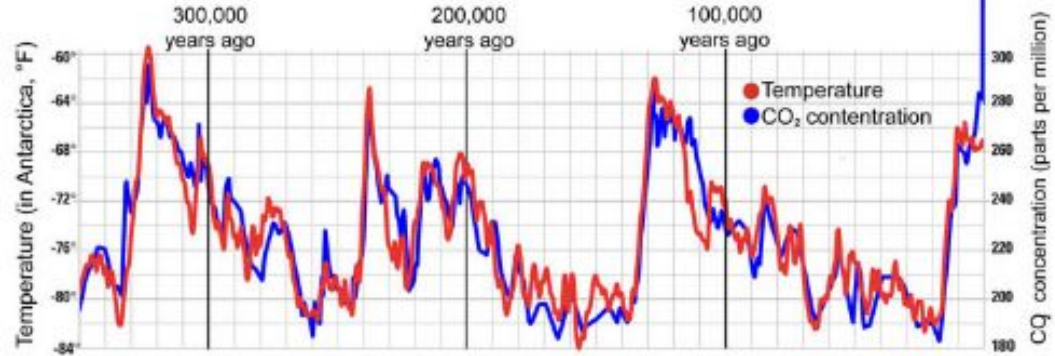


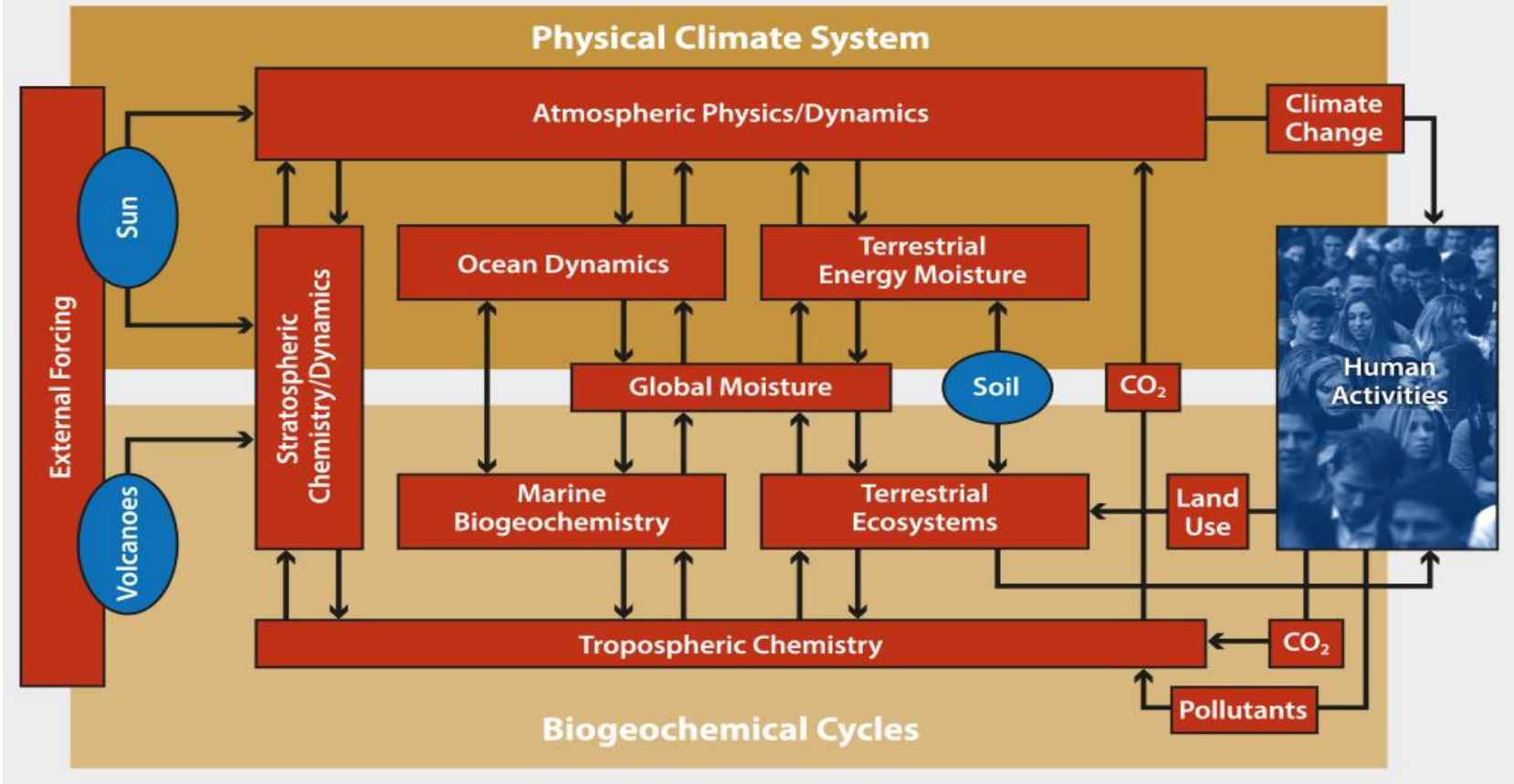
The last time carbon dioxide concentrations were this high ...

Carbon Dioxide Concentration

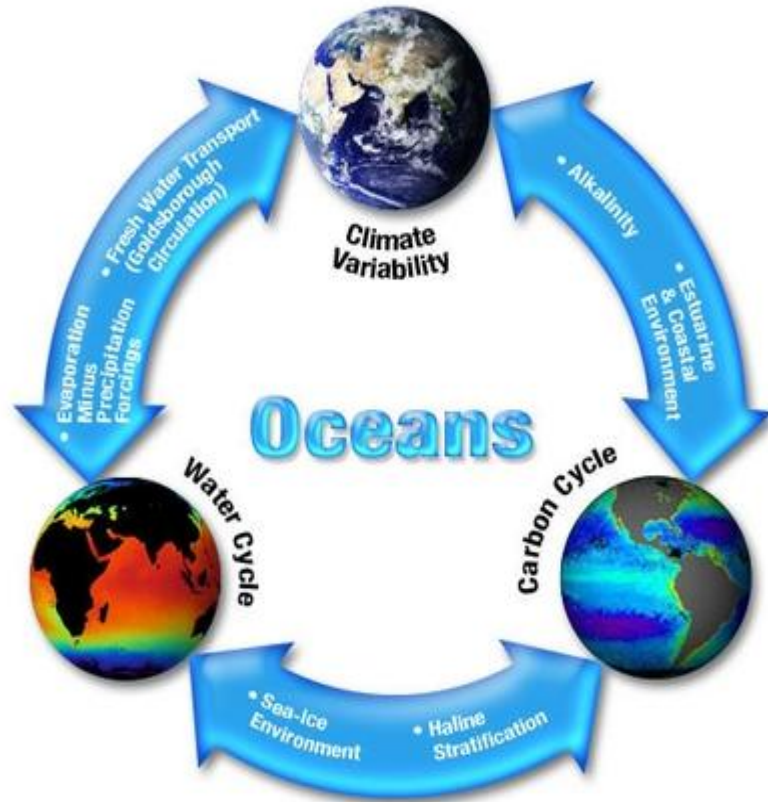


CO₂ Concentrations and Temperature Have Tracked Closely Over the Last 300,000 Years





Next Generation Science Standards (NGSS) - Global Climate Change is a *core concept*

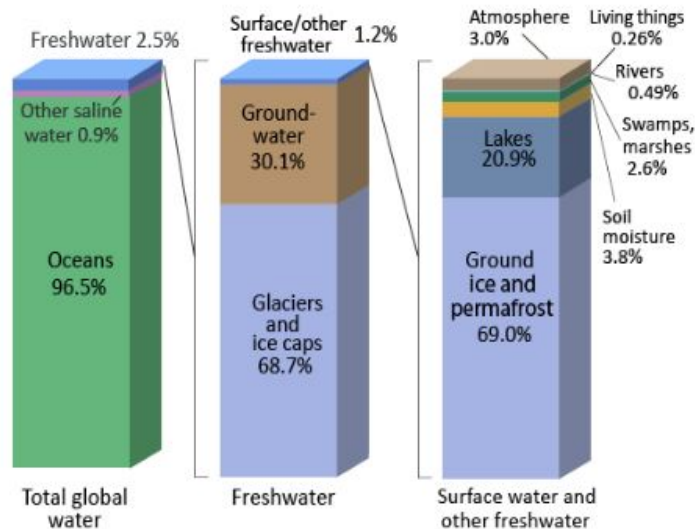


The “Other CO₂ Problem - Ocean Acidification” Unit for high school chemistry - email Leigh lfoy@yssd.org for entire unit!

Inquiry Lab 1 - What is the Atmospheric Carbon Dioxide Effects on Fresh vs Salt Water

The Earth is 70% covered by water but only 3% of that is freshwater and the rest is in the world's oceans. However, 2% of the freshwater is locked up in glaciers and ice at the poles, so only 1% of freshwater is readily available for humans.

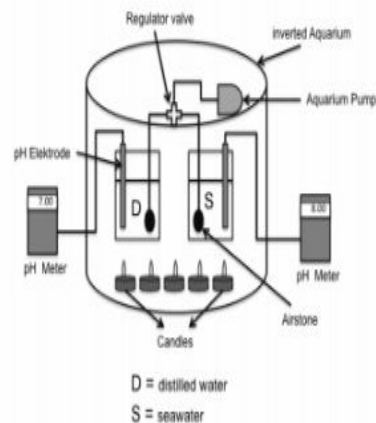
Where is Earth's Water?



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, *Water in Crisis: A Guide to the World's Fresh Water Resources*.

NOTE: Numbers are rounded, so percent summations may not add to 100.

The salinity of the oceans is determined by the concentration of compounds dissolved in the oceans. What effect does the salinity of water have on the pH? Does increasing CO_2 have a different effect on freshwater or saltwater? Would the increased atmospheric CO_2 have a different effect on lakes and streams vs the oceans?



Your teacher will show you the setup for quantitative measurements for this experiment. You will use your pH meters and your stopwatch to measure pH changes over time.

Inquiry Lab 2 - Solubility of CO₂ and Water Temperature Lab

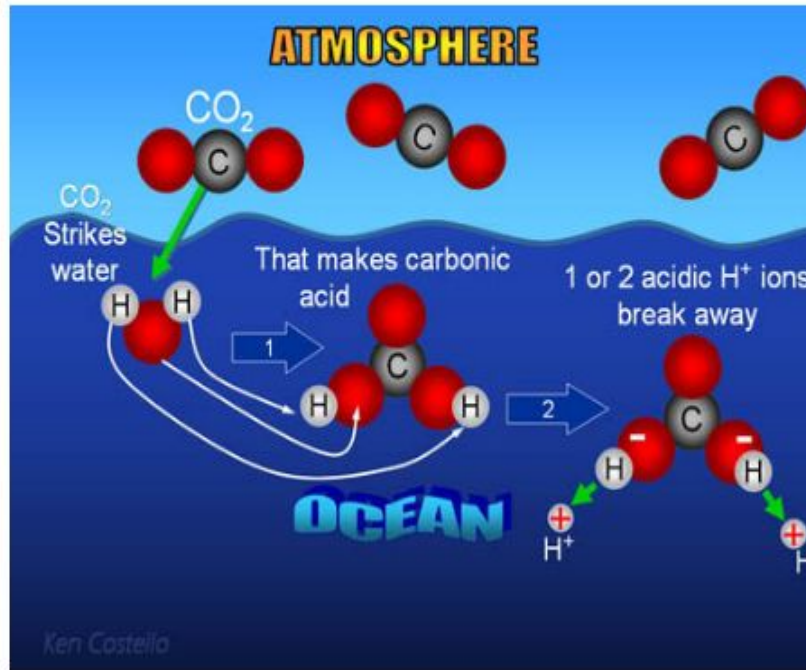
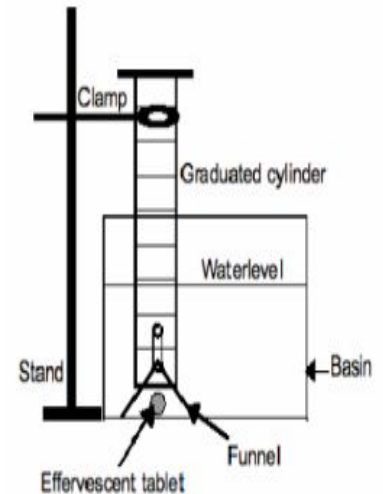


Image: chemistryland.com

Solubility of a gas in water is the measure of how much of the gas is dissolved in the water. Carbon dioxide is a gas that can dissolve in water and it goes through several different chemical reactions (see diagram above). Oxygen is another gas that is soluble in water. This is important to most living things that depend on oxygen in the water to “breathe in” and make ATP’s for their cellular functions.

This lab is going to look at the effect of water temperature on the solubility of CO₂ gas. Alka-Seltzer tablets are the source of CO₂ - they release CO₂ when reacted with water.

Your teacher will demonstrate the quantitative method for determining the volume of gas that is released from the water* (remember the solubility of gas is how much of the gas is *dissolved* in the water).



The “other CO₂ Problem” - Chemistry of CO₂ and the Oceans



Real Life Connection - Scenario

One of our local TV stations, WGAL, frequently holds “town hall” style meetings on different topics for our local community. You and your classmates attended a town hall meeting on climate change. A member of the audience stood and said that even though the CO₂ levels had recently risen in the atmosphere (he couldn't deny the hard data that shows this) there would not be a problem because the oceans would continue to absorb the excess CO₂ as it always had and

therefore there was not a problem. Because of your knowledge learned in your chemistry class you knew that there was a problem with what this person said at the meeting and you mentioned this to the WGAL director. Weren't you and your friends surprised when WGAL asked for you and your chemistry friends to prepare a scientific response to the misconception voiced at the town hall meeting on climate change?! You and your friends have divided up the work and plan on making a video to air on WGAL to present the scientific evidence about CO₂ and the oceans.

Each home lab group will divide up into 4 “specialty areas” each one focusing on a different aspect of the chemistry of CO₂ and the oceans. Your teacher has provided you with resources to get started on your research. Each specialty area will work together to process the resources provided. Each person will be responsible for his/her own Guiding Questions Notes to be used to lead you through the resources and to make your specialty area Google Presentation slides (see links at each resource below). Then, you will rejoin your home team group and each specialty person will contribute their Google Slides. Your home team group will then make a video using the classroom iPad's Explain Everything (or other screencasting app like Screencastify) that joins all 4 specialty areas slides into one video response for WGAL.

Specialty Group 3 Resources - Ocean acidification

Guiding Questions - Explain the process of ocean acidification and the connection to increasing atmospheric CO₂. What do scientists think are the effects of the oceans becoming more acidic?

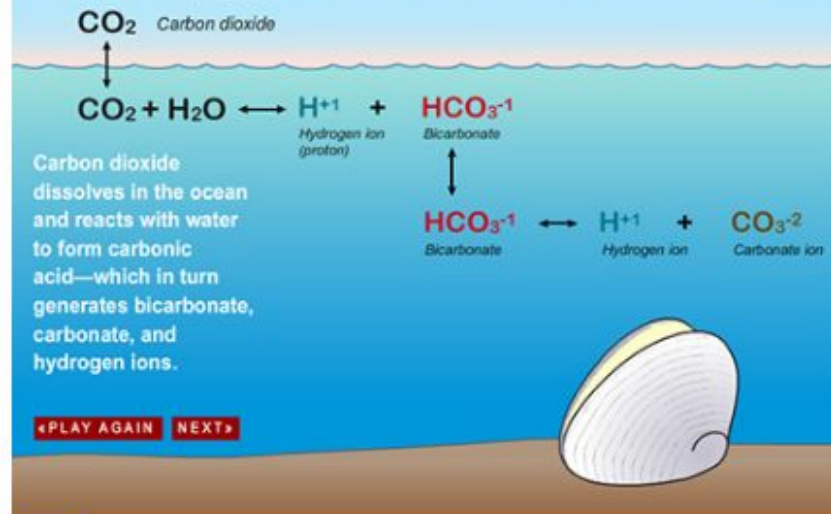
Guiding Questions Notes Template Specialty Group 3 -click [HERE](#)

Reading - Essay "Seawater, Sea Urchins, and Stress" - Dr. Gretchen Hofmann (hard copy)

Website 1 - Go to the Stanford University website Virtual Sea Urchin - "Our Acidifying Oceans" and complete the interactive [HERE](#)

Website 2 - Go through short tutorial at Woods Hole Oceanographic Institute webpage on the chemistry of how shelled animals make those shells click [HERE](#)

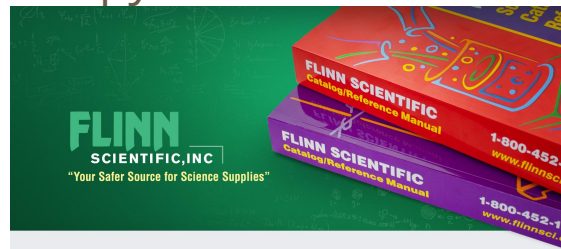
Carbon dioxide, shell building, and ocean acidification



Video - [NOAA Ocean Acidification 4 min video](#)

Other CC resources for teachers

POGIL activity on Climate Change - hard copy and teacher answer key



UCAR ([resources for high school chemistry climate science](#))



lfoy@yssd.org Leigh's Unit on "The Other CO₂ Problem - Ocean Acidification"