Mar 6th, 9:25 AM - 10:05 AM

Keynote address: Climate change and sustainability: The Reality and impacts of global warming

Roberta M. Johnson

Director of Education & Outreach, University Corporation for Atmospheric Research, & Executive Director, National Earth Science Teachers Association

Climate Change and Sustainability:
The Reality and Impacts of Global Warming

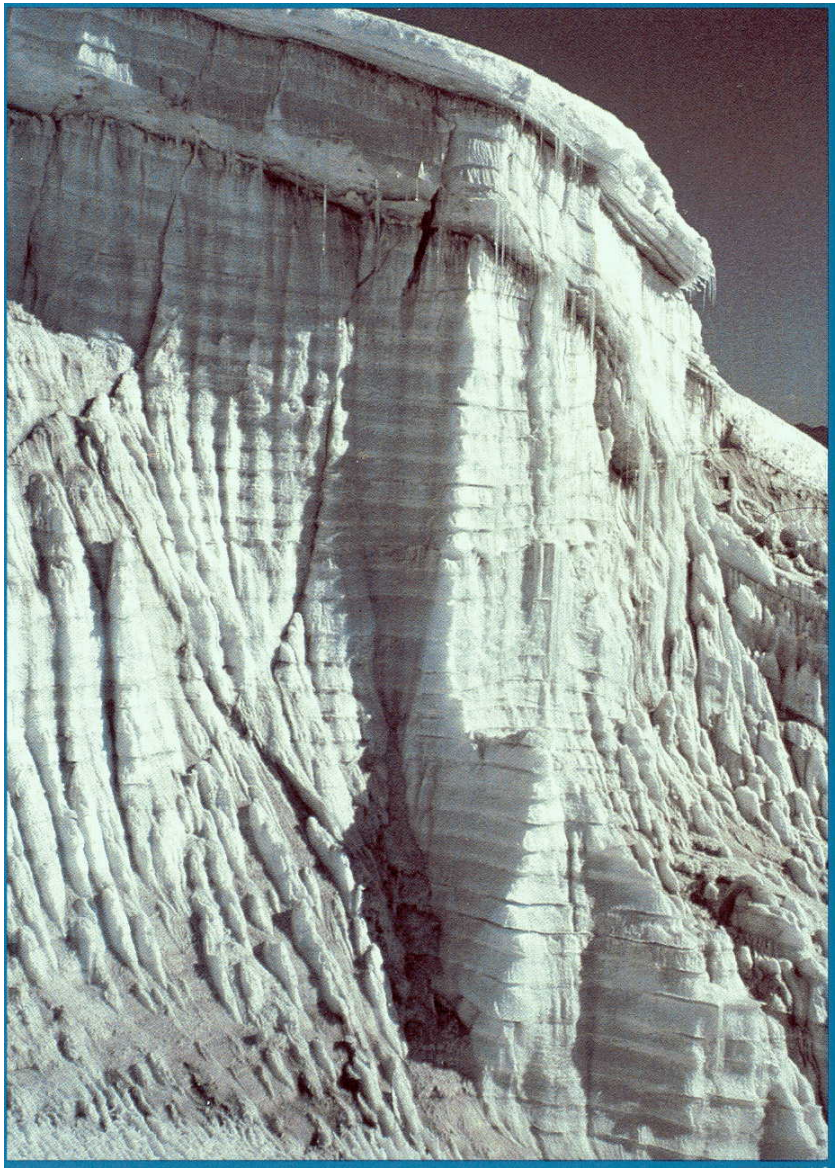
Dr. Roberta Johnson

University Corporation for Atmospheric Research

Boulder, Colorado

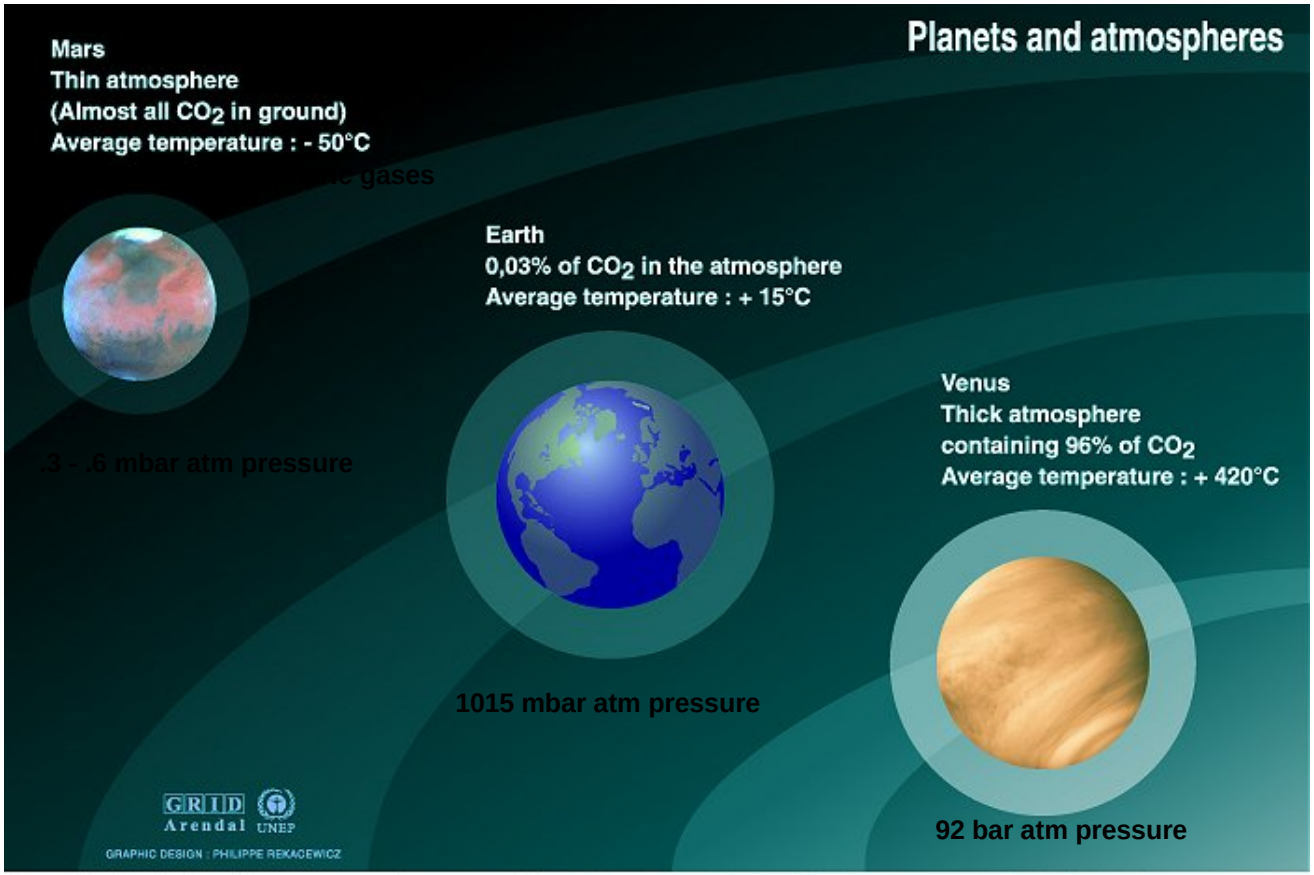
Overview

- What determines the Earth's climate?
- What's happening to Earth's climate today?
- What do models tell us will happen in the future?
- What is sustainability and why does it matter?
- What's happening nationally regarding K-12 climate change and sustainability education?



Annual layers of ice, Quelccaya Ice Cap, Peru
Courtesy of Lonnie Thompson

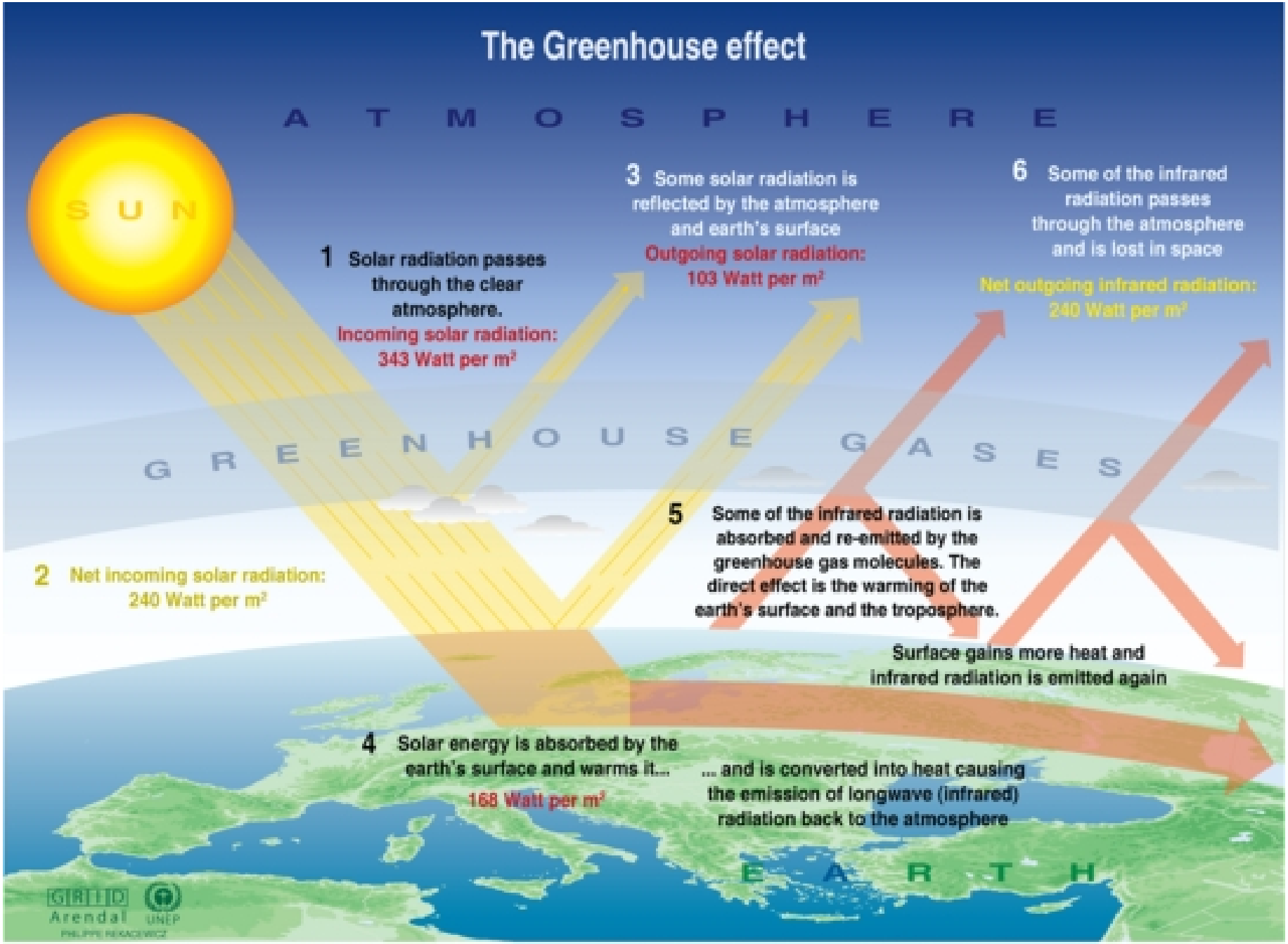
Global Climate



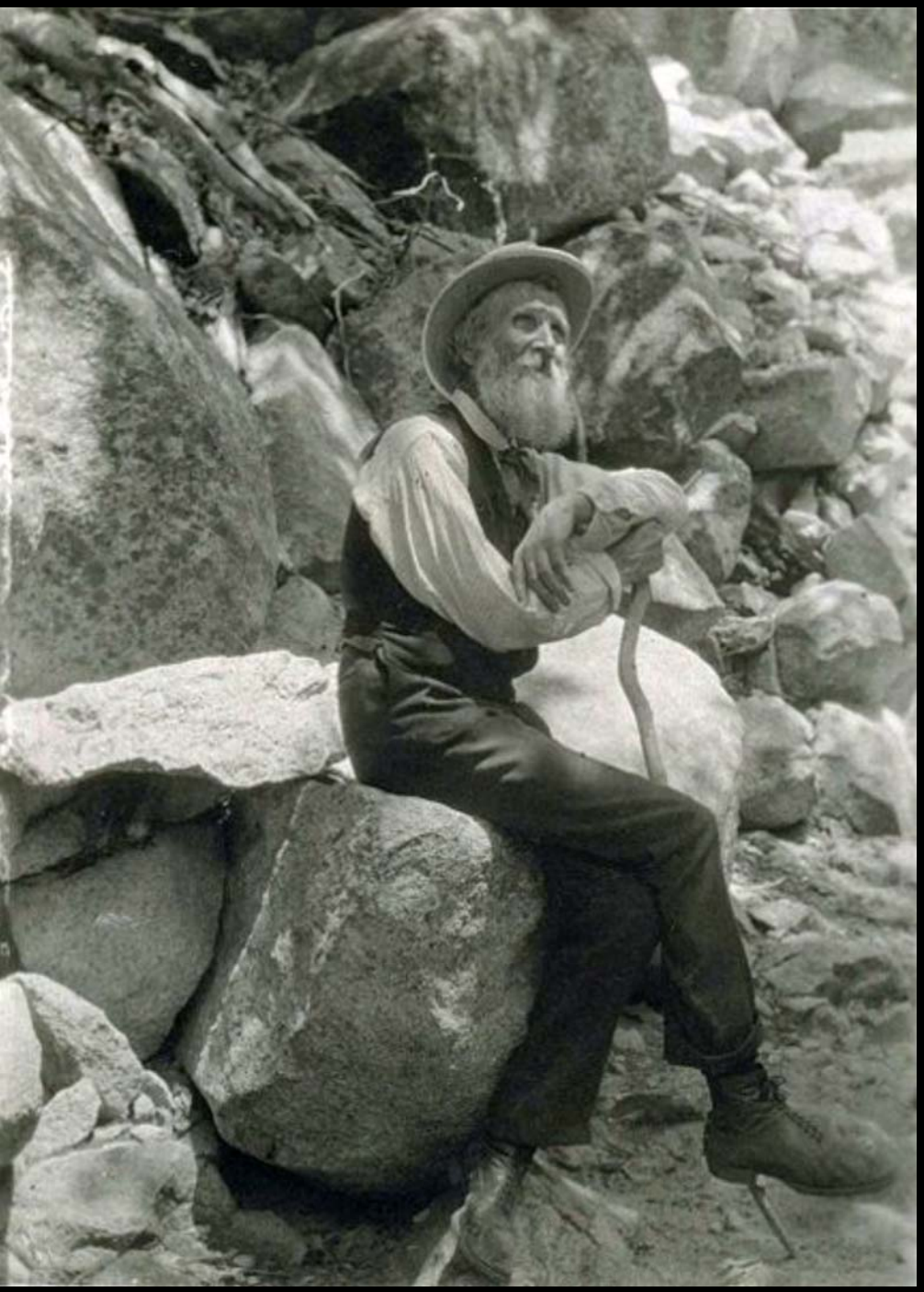
- The Earth's global climate is driven by energy from the Sun and modulated by the composition of our atmosphere
- Earth's climate is "just right", compared to Venus and Mars

Changes in Climate are driven by different sources operating on different time scales

- Natural climate variability
  - From sources external to the climate system
    - Solar variations (years to billions of years)
    - Volcanic eruptions (years)
    - Plate tectonics (millions of years)
    - Orbital variations (~tens to ~hundreds of thousands of years)
- Anthropogenic changes in climate
  - from increases in greenhouse gases in the atmosphere (effecting the absorption and re-emission energy) due to (non-sustainable) technological choices, growing population and intensification of agriculture, changes in land use and albedo

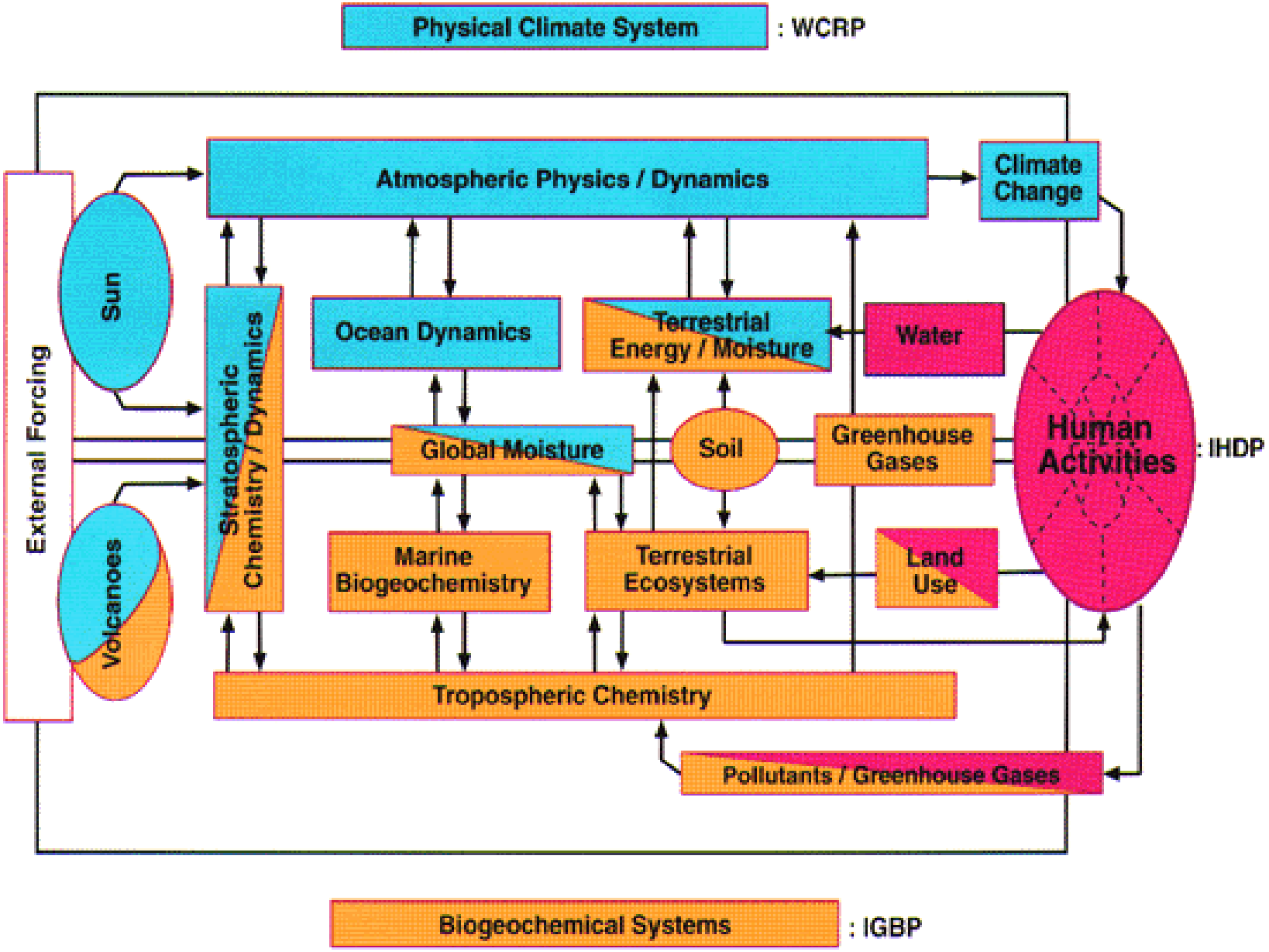


Sources: Okanagan university college in Canada, Department of geography; University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

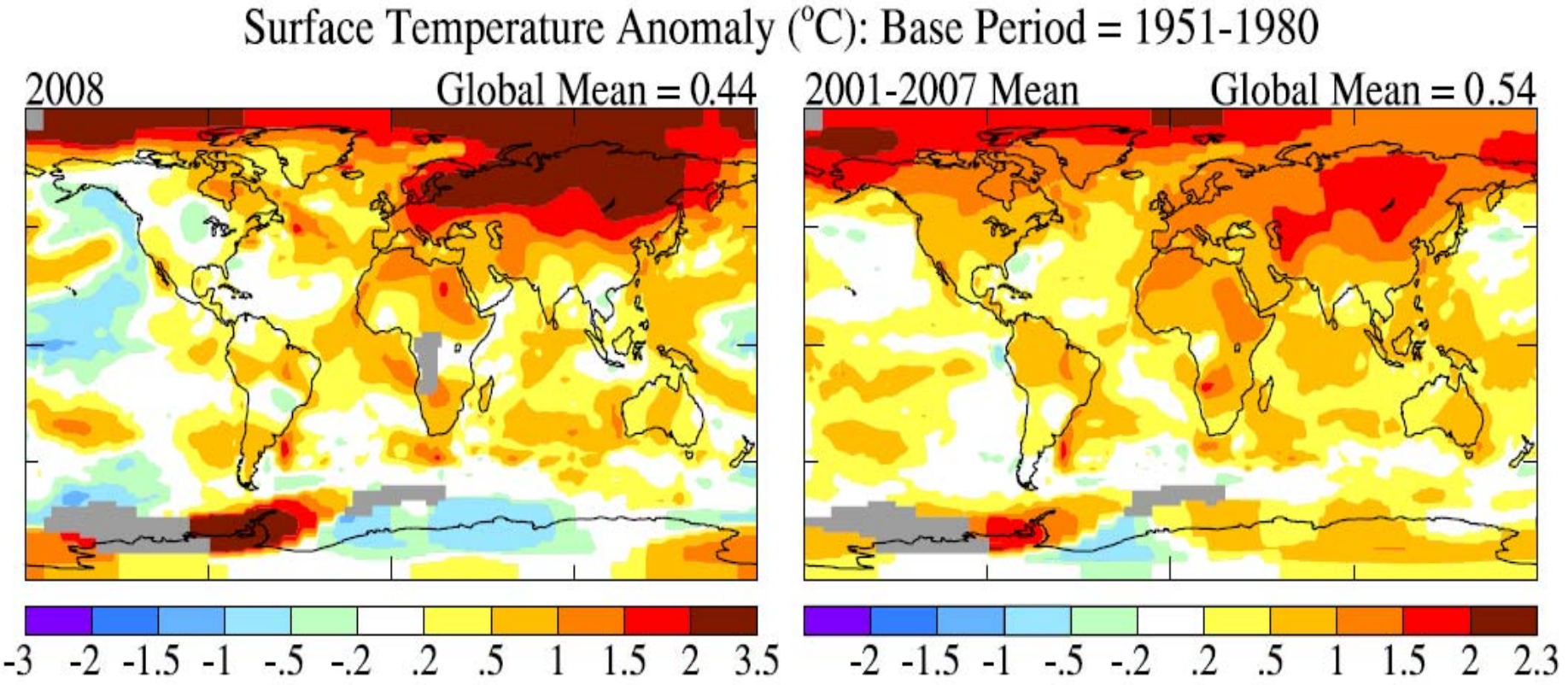


“When we try to pick out anything by itself, we find it hitched to everything else in the universe.”
John Muir

“My First Summer in the Sierra”
1911


Physical Climate System
: WCRP
Atmospheric Physics / Dynamics
Climate Change
External Forcing
Sun
Volcanoes
Stratospheric Chemistry / Dynamics
Ocean Dynamics
Terrestrial Energy / Moisture
Water
Global Moisture
Soil
Greenhouse Gases
Human Activities
: IHDP
Marine Biogeochemistry
Terrestrial Ecosystems
Land Use
Tropospheric Chemistry
Pollutants / Greenhouse Gases
Biogeochemical Systems
: IGBP

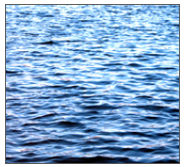
A Warming World…



NASA

Direct observations of recent climate change

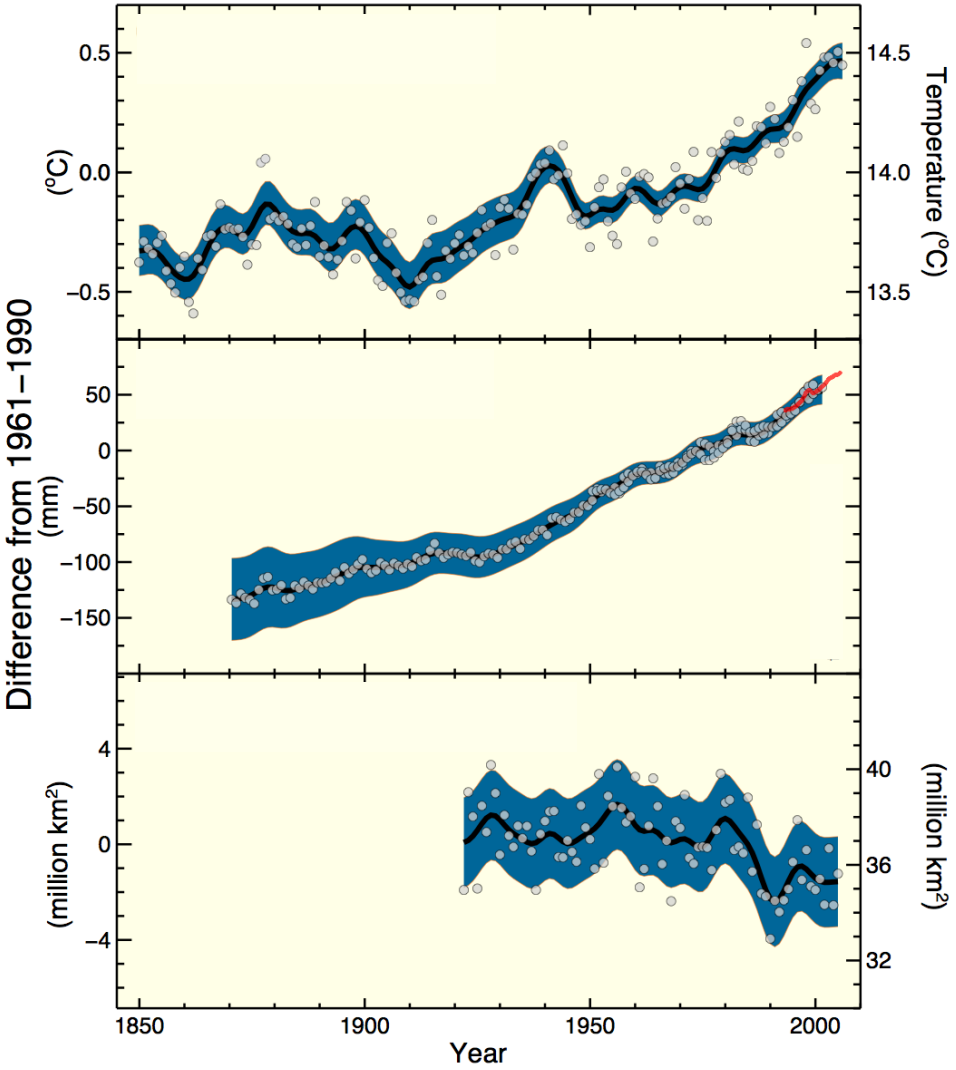
Global average temperature



Global average sea level

Northern hemisphere snow cover

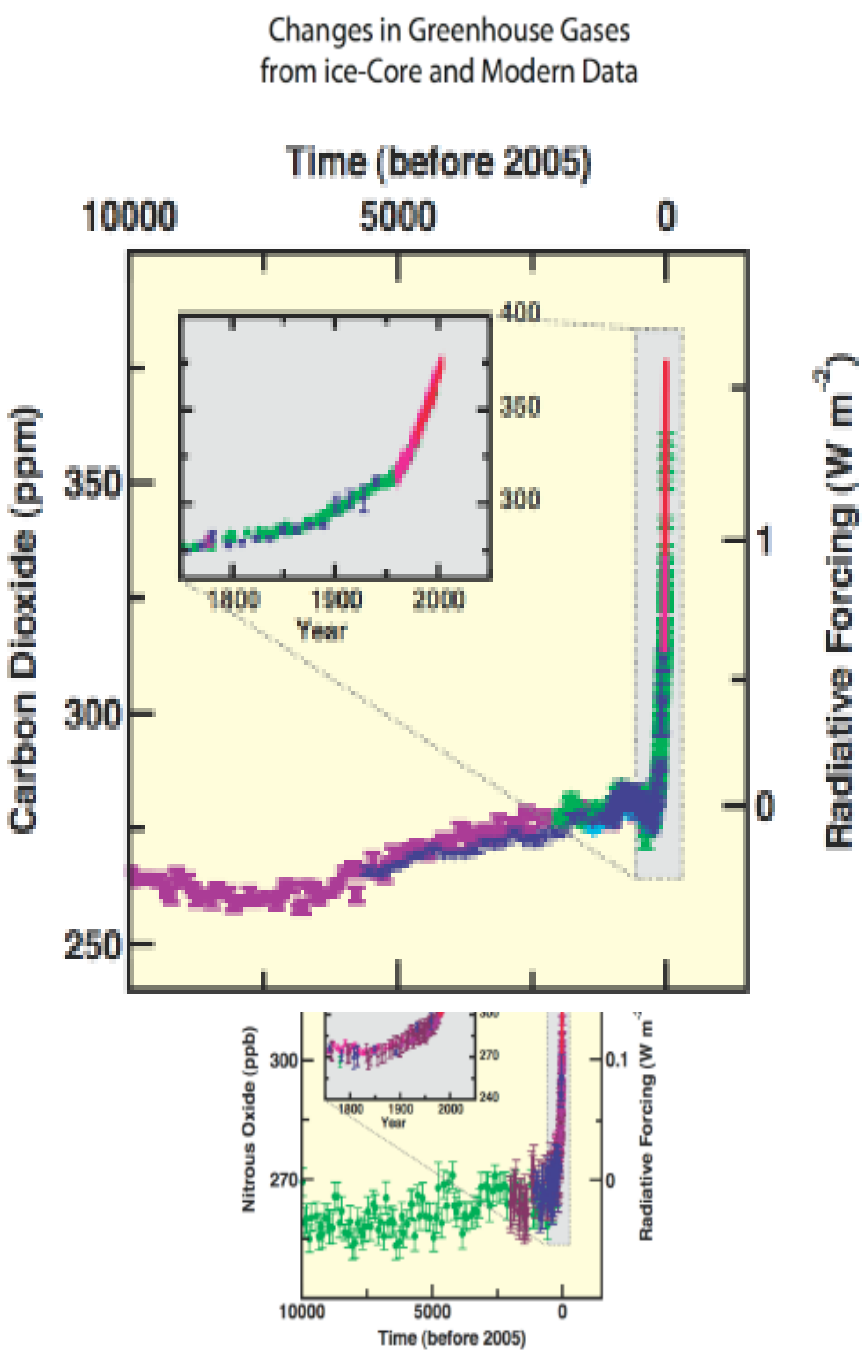
Changes in temperature, sea level and northern hemisphere snow cover



Greenhouse Gases

Greenhouse gas concentrations have increased markedly as a result of human activities since 1750

- now far exceed pre-industrial values.
- CO_2 increase from fossil fuel and land-use changes
- Methane, nitrous oxide due to agriculture



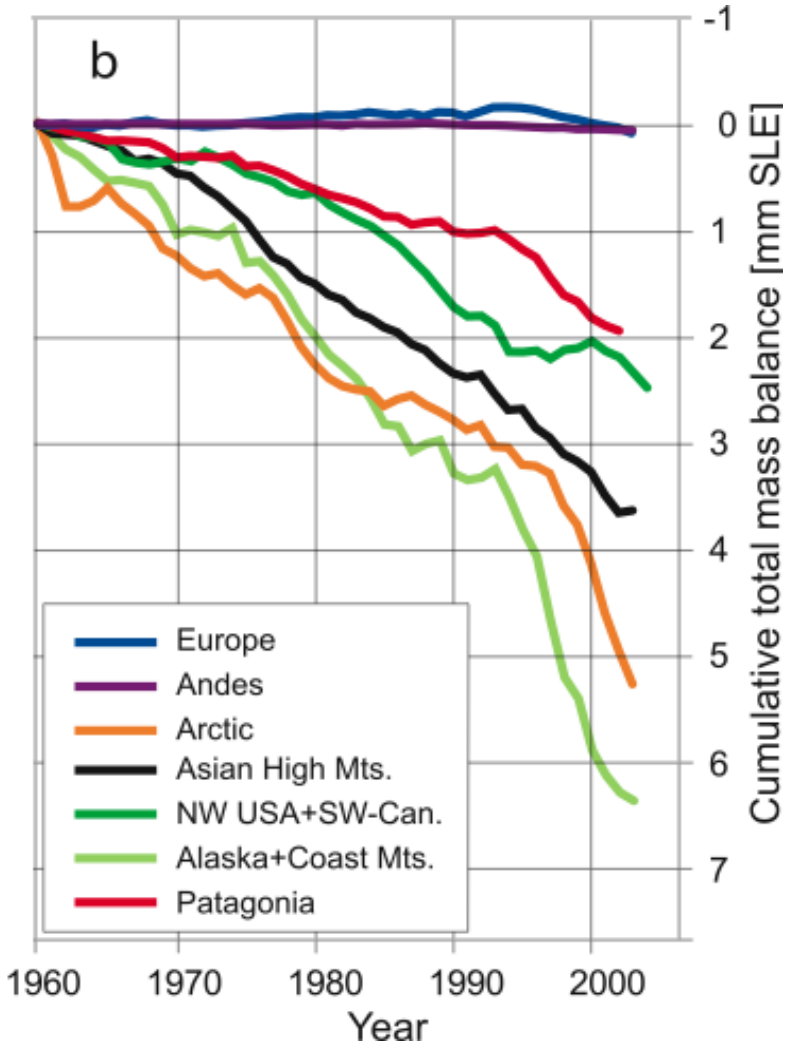
IPCC 4th Assessment Summary for Policy Makers, 2007

Glacier mass balance

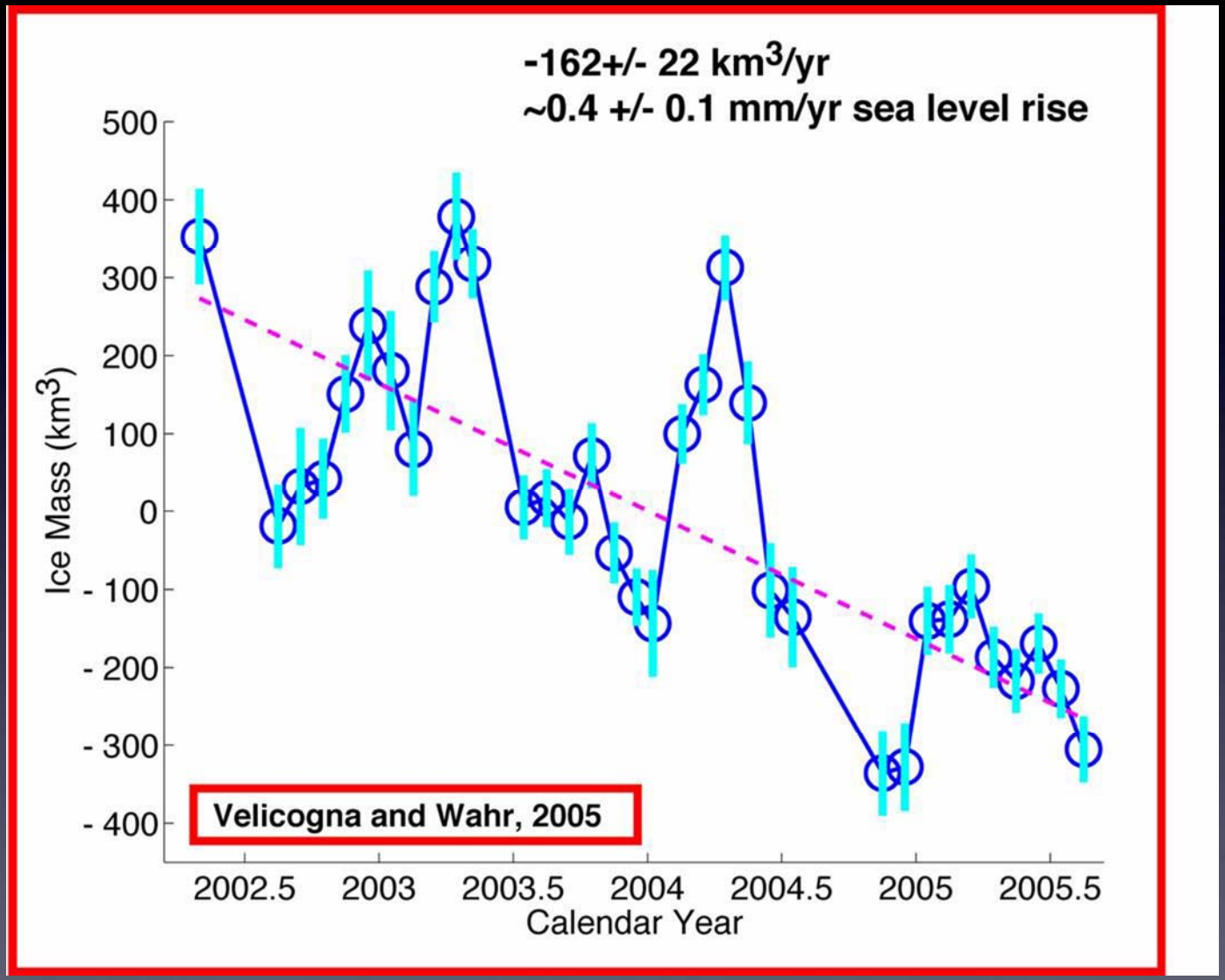
During the 20th century, glaciers and ice caps have experienced **widespread mass losses** and have contributed to **sea level rise**

Further **decline of mountain glaciers** projected to **reduce water availability** in many regions

Cumulative balance of glacier mass in some regions

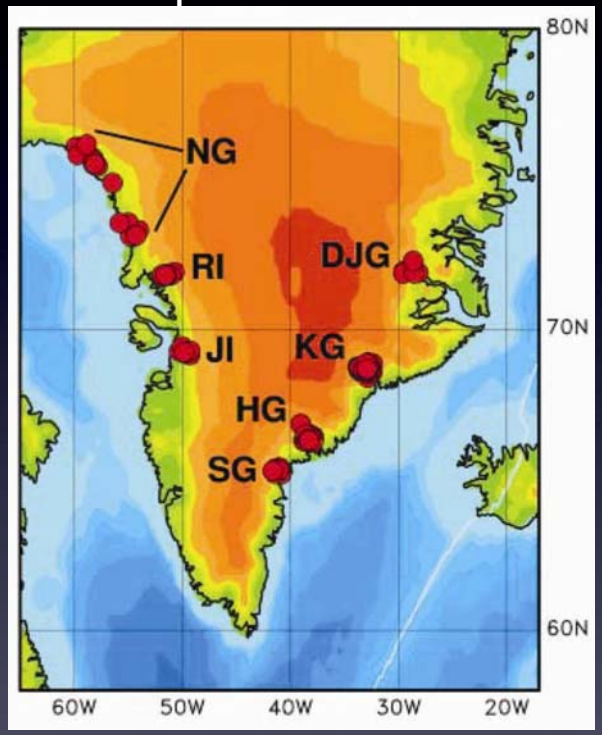


Greenland Mass Loss – From Gravity Satellite

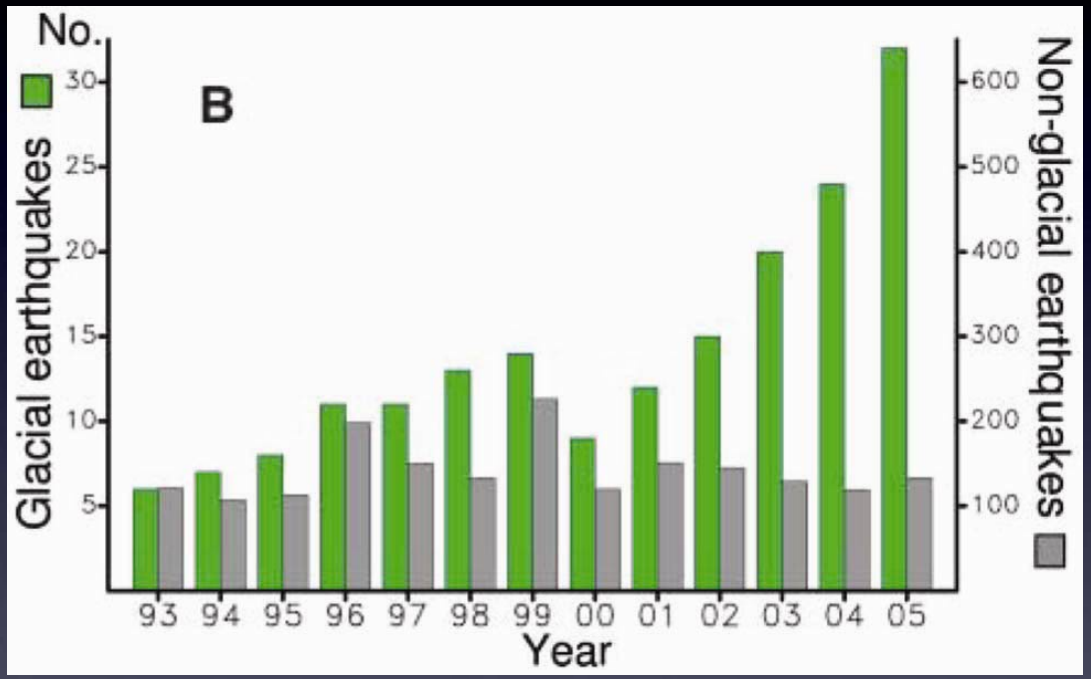


Glacial Earthquakes on Greenland

Earthquake Locations



Annual Number of Quakes*

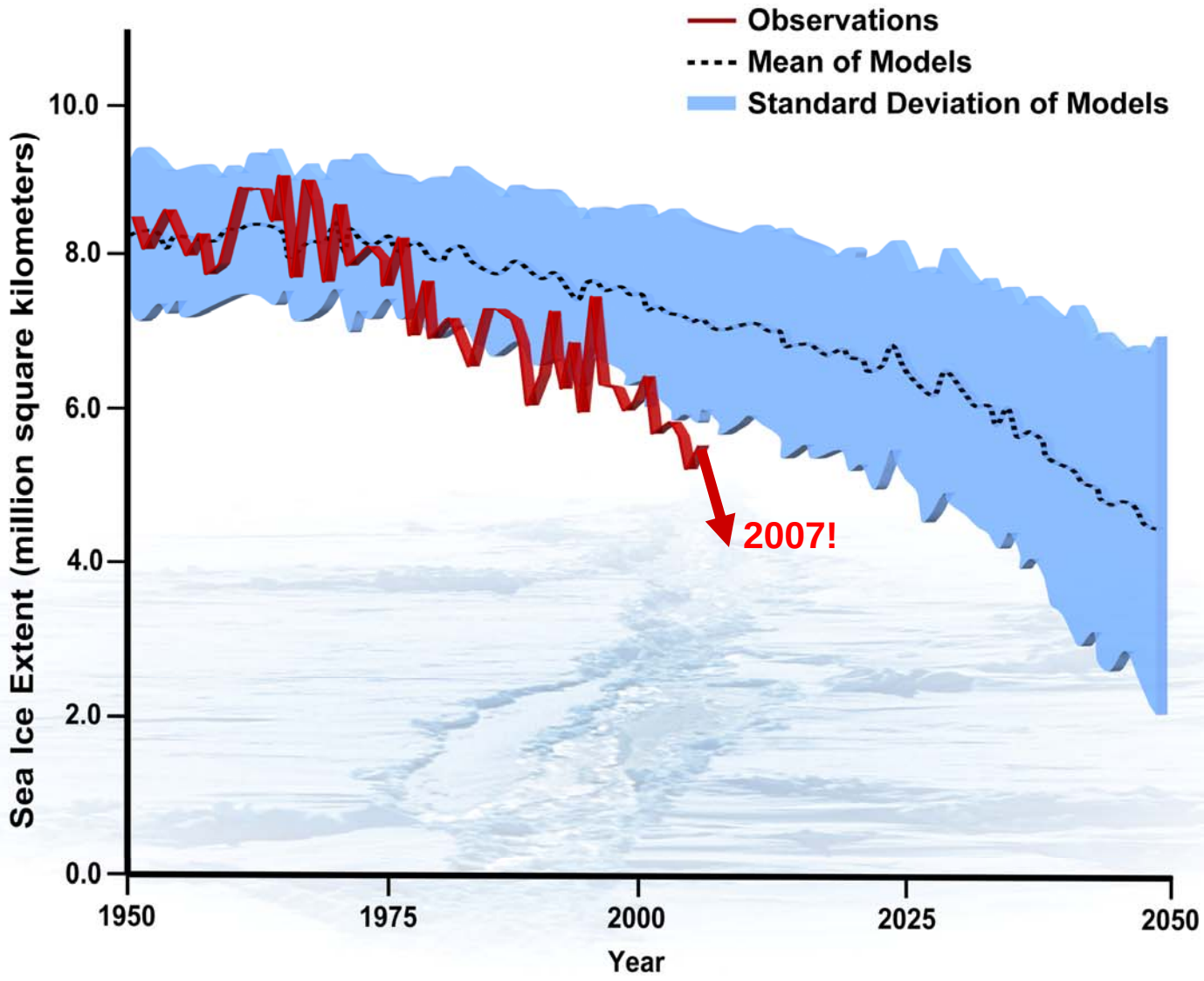


* 2005 bars capture only first 10 months of 2005

Location and frequency of glacial earthquakes on Greenland. Seismic magnitudes are in range 4.6 to 5.1.

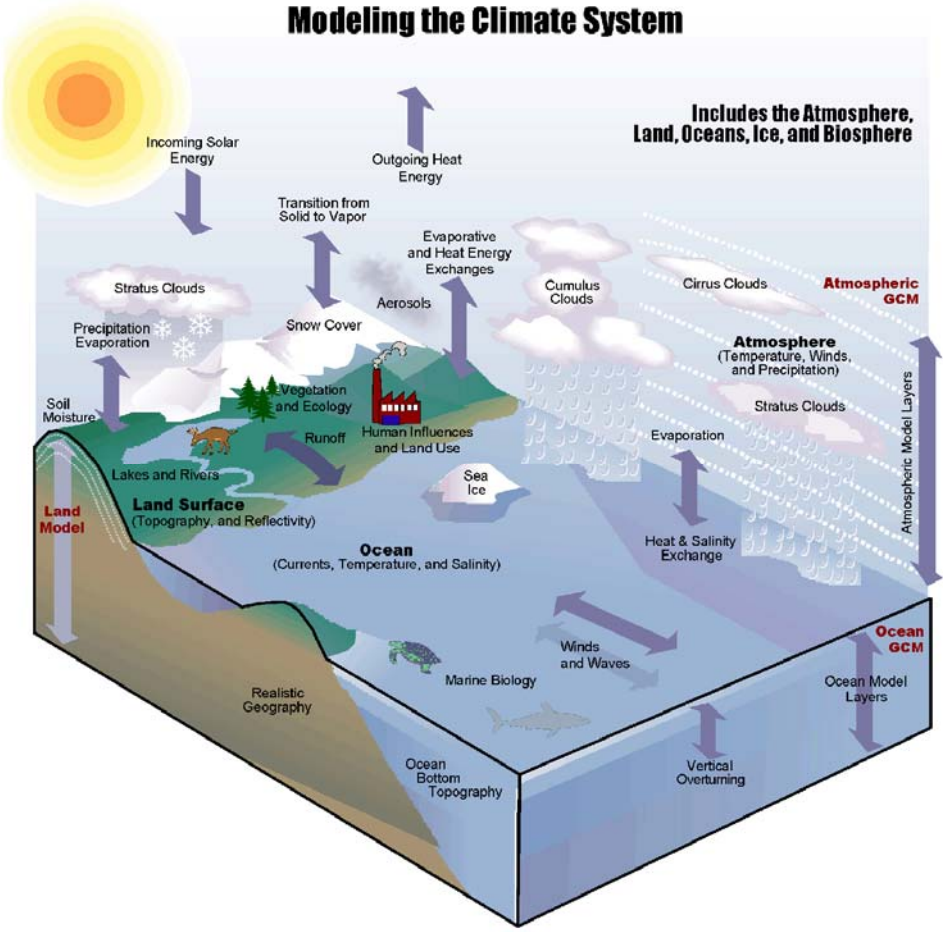
Source: Ekstrom, Nettles and Tsai, *Science*, **311**, 1756, 2006.

Arctic September Sea Ice Extent: Observations and Model Runs



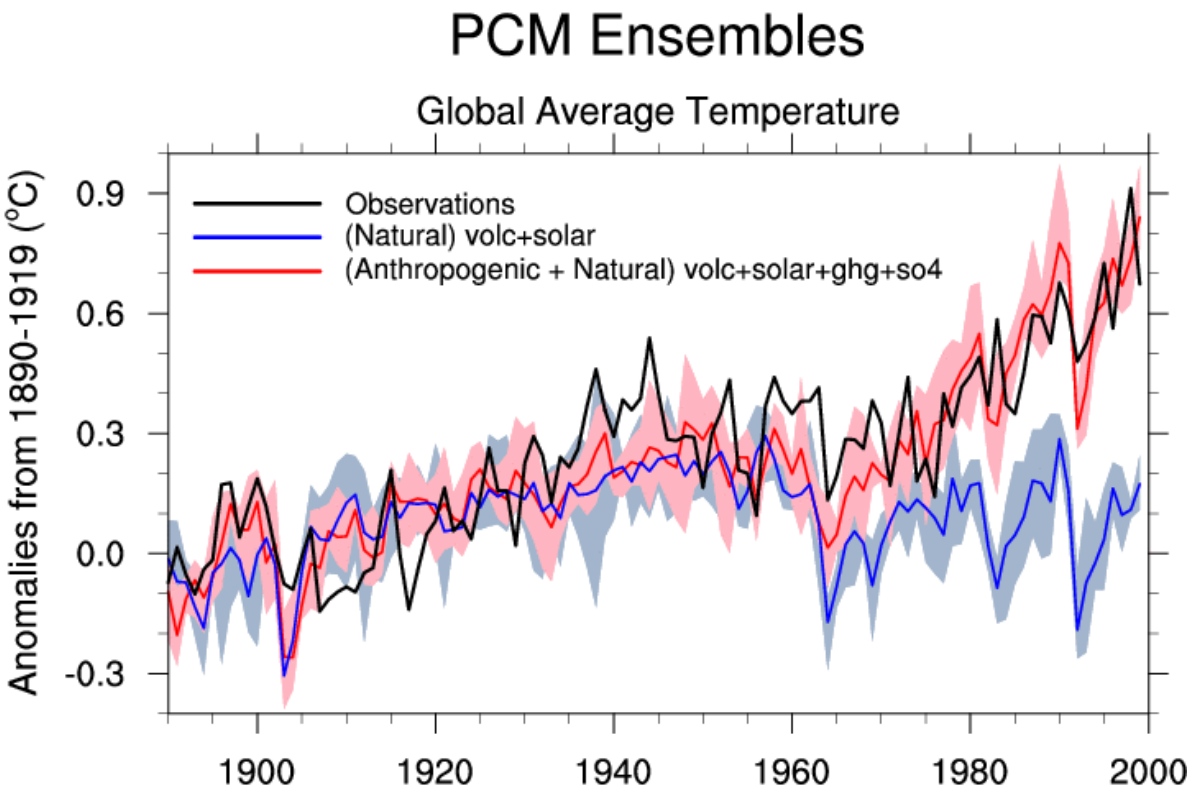
Climate Models

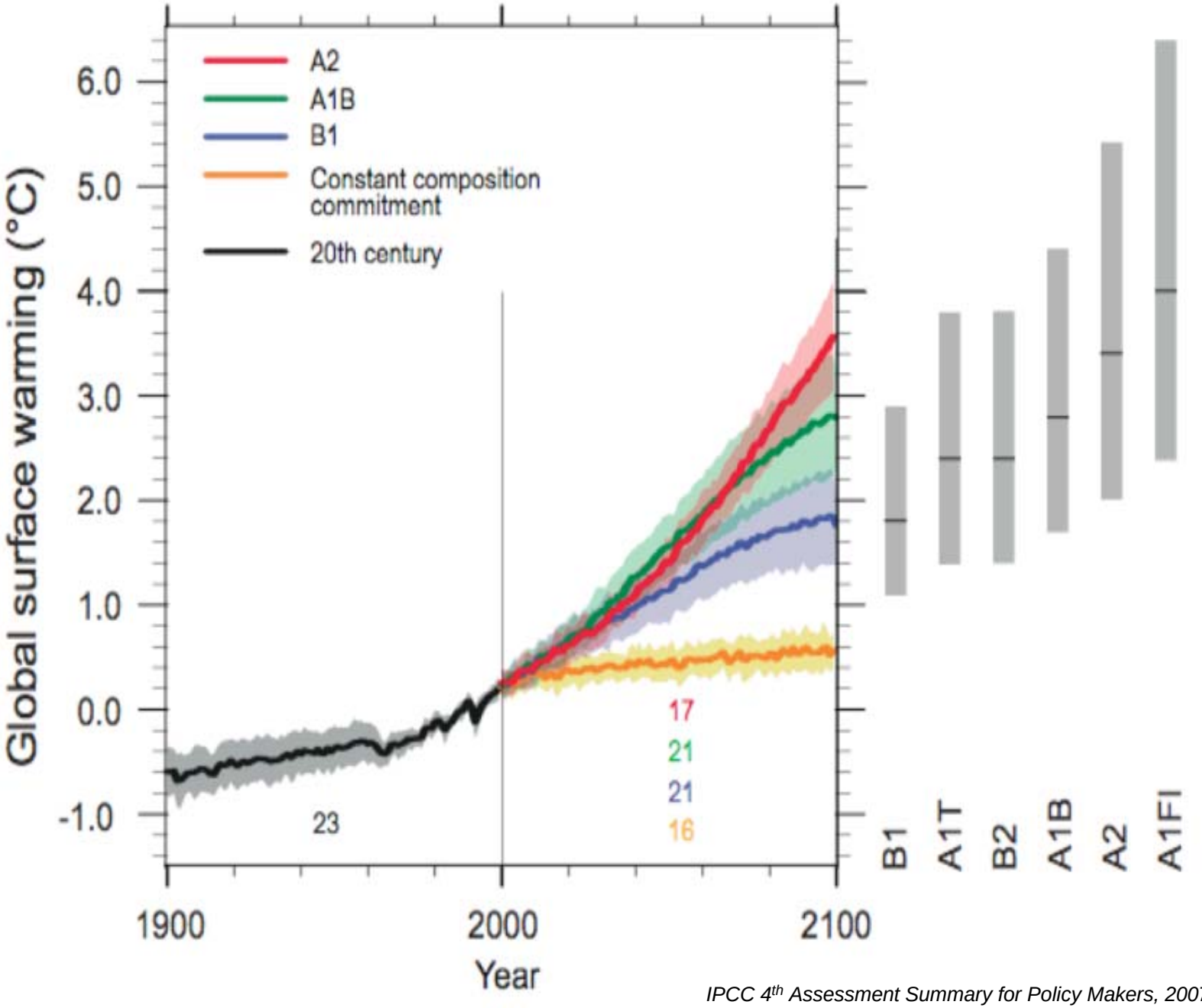
- Based on our best models that predict the weather
- Have been steadily improved by a global community of weather and climate scientists over the past 45 years.
- Processes included and model resolution have been steadily improved



Natural Variations do not explain observed climatic change

- Climate models with natural forcing (including volcanic and solar) do not reproduce warming
- When increase in greenhouse gases is included, models do reproduce warming
- Addition of increase in aerosols (cooling) improves agreement





IPCC 4th Assessment Summary for Policy Makers, 2007

IPCC 2007 Summary for Policymakers

Projected patterns of warming will continue currently observed trends:

- warming greatest over land and at most high northern latitudes (least over Southern Ocean and parts of NA ocean)
- snow cover will contract
- widespread increases in thaw depth over most permafrost regions
- sea ice will shrink in both Arctic and Antarctic, in some projections late summer sea ice disappears in the Arctic by latter part of 21st century
- very likely that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent
- likely that typhoons and hurricanes will become more intense
- extra-tropical storm tracks will move poleward
- precipitation at high latitude very likely to increase, while decreases are likely in most subtropical land regions
- Very likely that meridional overturning circulation of the Atlantic Ocean will slow down during the 21st century. Average reduction by 2100 is 25% (0-50%). Very abrupt transition is very unlikely in 21st century.

Anthropogenic warming and sea level rise will continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were stabilized

Big Problem!

- Most recent studies of greenhouse gas emissions increase and climate impacts show that
  - Greenhouse gases are increasing faster than even the worst IPCC scenario assumptions (tripling rather than doubling by 2100)
  - Observed climate change/impacts are worse than worst IPCC scenario predictions

Faced with this challenge…

Society has three options:

- Mitigation: reducing the pace & magnitude of the changes in global climate being caused by human activities.

  Examples of mitigation include moving to **sustainability** - reducing emissions of GHG, enhancing "sinks" for these gases, using sustainable fuels (solar, wind, tidal) and "geoengineering" to counteract the warming effects of GHG.

- Adaptation: reducing the adverse impacts on human well-being resulting from the changes in climate that do occur.

  Examples of adaptation include changing agricultural practices, strengthening defenses against climate-related disease, and building more dams and dikes.

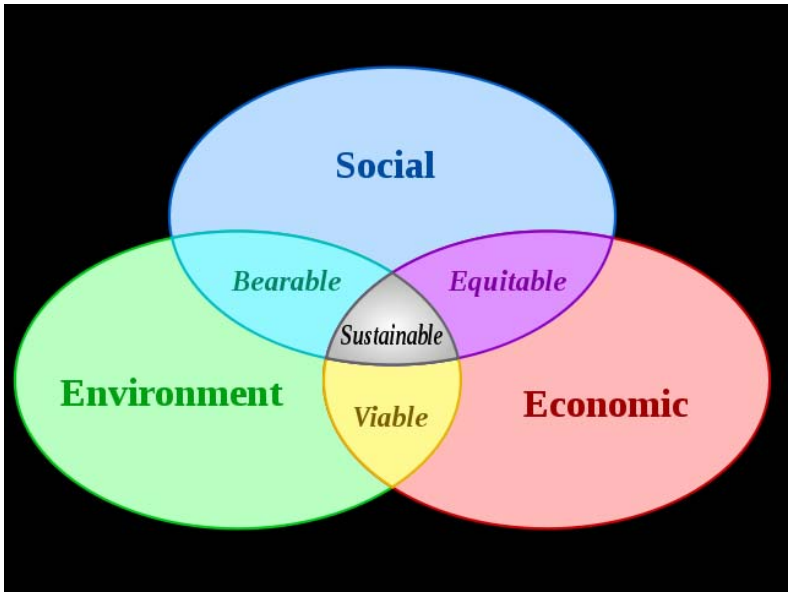
- Suffering the adverse impacts that are not avoided by either mitigation or adaptation.

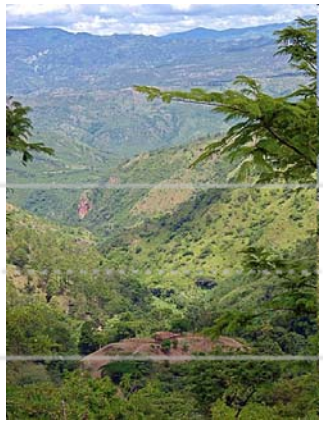
We need to move fast to a new low-carbon economy for the 21st Century!

“Sustainability”

- In general, the capacity to maintain a certain process or state indefinitely.
- For **human community**, a sustainable system meets the needs of the present without compromising the ability of future generations to meet their own needs.
- In **ecology**, the ability of an ecosystem to maintain ecological processes, functions, biodiversity and productivity into the future.
- To be **sustainable**, nature’s resources must be used at a rate at which they can be replenished naturally.

There is now clear scientific evidence from environmental science that humanity is living unsustainably, and that an unprecedented collective effort is needed to keep human use of natural resources within sustainable limits.





Key technologies to reduce emissions

Key mitigation technologies and practices currently commercially available

Energy Supply

Efficiency; fuel switching; renewable (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; nuclear power; early applications of CO2 capture and storage

Transport

More fuel efficient vehicles; hybrid vehicles; biofuels; modal shifts from road transport to rail and public transport systems; cycling, walking; land-use planning

Buildings

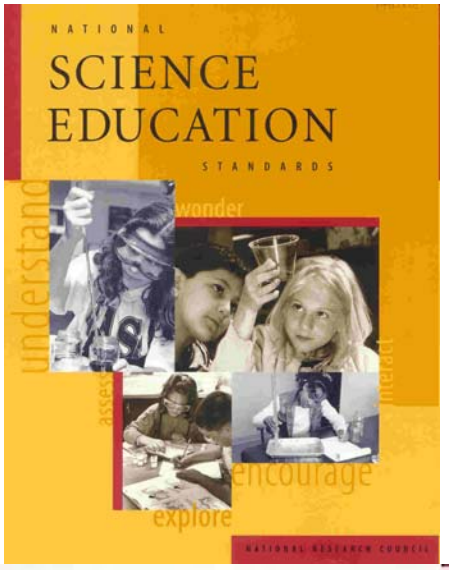
Efficient lighting; efficient appliances and air conditioning; improved insulation ; solar heating and cooling; alternatives for fluorinated gases in insulation and appliances

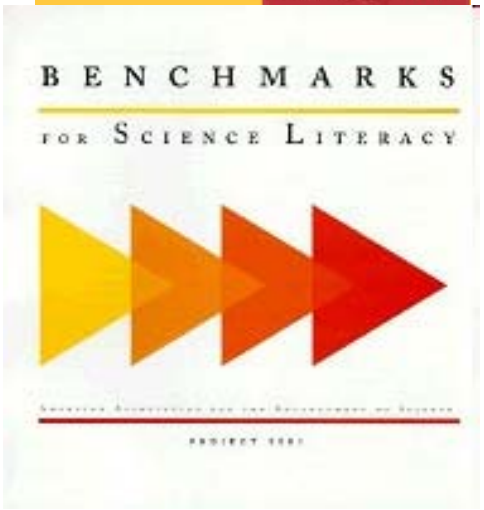
Key policies to reduce emissions

- Appropriate incentives for **development of technologies**
- Effective **carbon price** signal to create incentives to invest in low-GHG products, technologies and processes
- Appropriate **energy infrastructure** investment decisions, which have long term effects on emissions
- Changes in **lifestyle and behavior** patterns, especially in building, transport and industrial sectors

Climate change and sustainability in K-12

- In the US, curricula are set mainly at the district/state level – there is not a national curriculum
- *Benchmarks for Science Literacy* (AAAS, 1993, 2009) and *National Science Education Standards* (NRC, 1996) provide guidance on grade level appropriate standards
  - Include standards associated with climate, climate change, ecosystem science, and recycling
  - State standards frequently based to some extent on national standards
  - Nevada Science education standards include both climate change (Earth Science) and sustainability topics (Life Science, Earth Science, Nature of Science)





However…

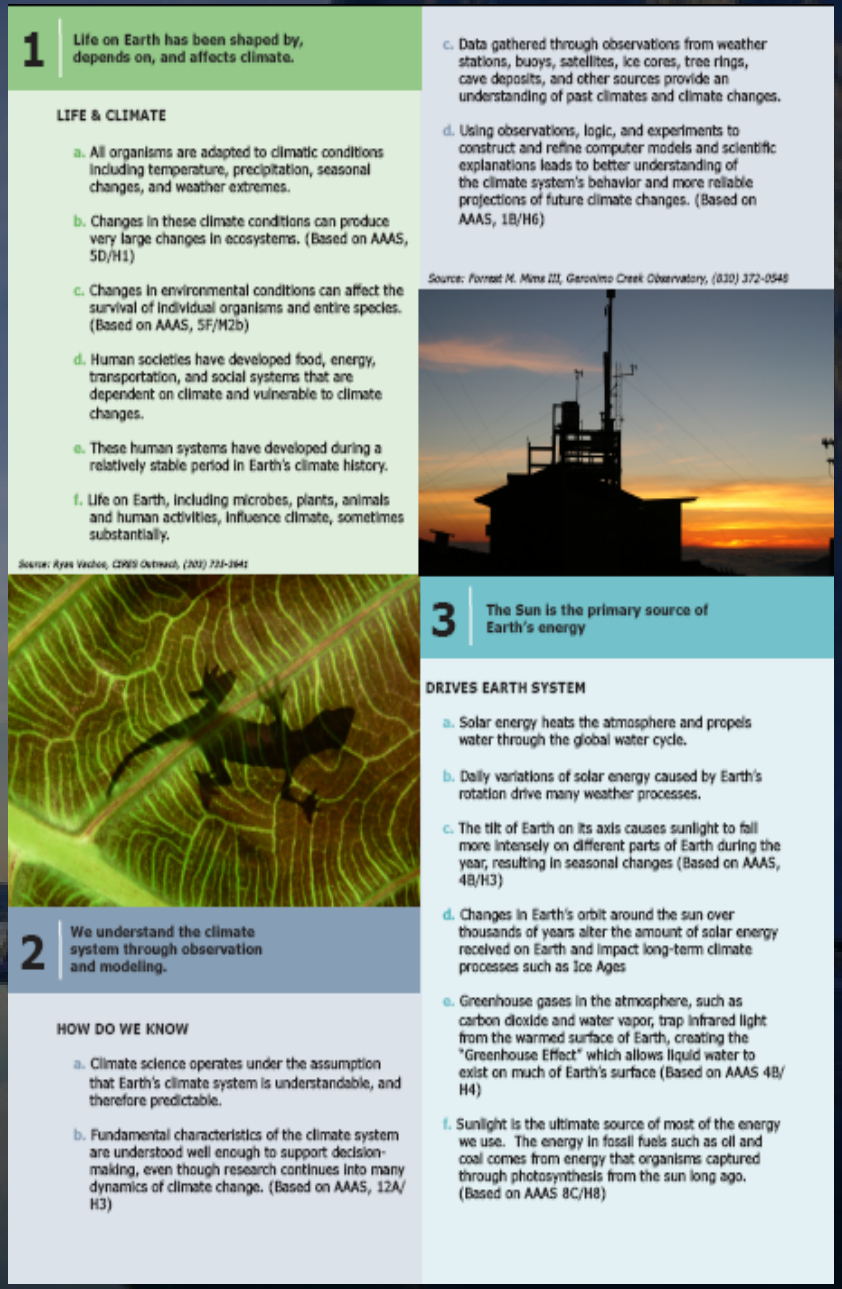
- Just because content appears in the science standards doesn't mean it will be taught or tested
- Emphasis over past several years on reading and math in state-wide tests (NCLB) has limited attention on science in many states
- Science teachers report a lack of professional development on these topics as well as a lack of educational resources
- Teachers report that they sometimes struggle with politicization of science
- There appears to be a growing level of public understanding about climate change and the need to adopt more sustainable life styles

Some Common MS/HS Climate Misconceptions

- Personal actions don’t make a difference
- It’s hot today – must be global warming! Or – It’s cold today, can’t be any global warming!
- Student assume that all places on earth receive the same amount of sunlight each day, all year
- Student have a tough time believing in "light"- radiation- they cannot see. The idea that the earth is giving off energy they cannot see is very difficult for them
- Because of negative feedback systems the earth is cyclical and it will always correct itself.
- Global warming we are currently experiencing is a natural part of the Earth’s cycle
- The world reacts to change only with negative feedback. Many of my kids believe that no matter what we do to the planet, the planet will always correct itself. Any rise in carbon dioxide levels will somehow magically come out in the wash on a global level
- The idea that global warming and the hole in the ozone layer are the same thing
- Climate is the same as weather.
- Climate stands alone, not as a inter-related part of the earth as a whole.
- Climate has never changed before, only recently with human activity.
- Climate is not really changing, it is all hype.
- The trees will absorb extra carbon dioxide because they need it for photosynthesis, therefore greenhouse gases are not a problem.
- Carbon dioxide can’t be a problem because it isn’t in the graphs of the composition of the atmosphere.
- Earth's climate will change only because of using fossil fuel
- Nothing to worry about if we’re not by the ocean
- Many kids were scared that the Earth was going to turn into a global oven within their lifetimes

Climate Literacy: Essential Principles and Fundamental Concepts

Climate Literacy is an understanding of the climate's influence on you and society and your influence on climate



1 Life on Earth has been shaped by, depends on, and affects climate.

LIFE & CLIMATE

a. All organisms are adapted to climatic conditions including temperature, precipitation, seasonal changes, and weather extremes.

b. Changes in these climate conditions can produce very large changes in ecosystems. (Based on AAAS, 5D/H1)

c. Changes in environmental conditions can affect the survival of individual organisms and entire species. (Based on AAAS, 5F/M2b)

d. Human societies have developed food, energy, transportation, and social systems that are dependent on climate and vulnerable to climate changes.

e. These human systems have developed during a relatively stable period in Earth's climate history.

f. Life on Earth, including microbes, plants, animals and human activities, influence climate, sometimes substantially.

Source: Ryan Vachon, CIRES Outreach, (303) 735-3641

2 We understand the climate system through observation and modeling.

HOW DO WE KNOW

a. Climate science operates under the assumption that Earth's climate system is understandable, and therefore predictable.

b. Fundamental characteristics of the climate system are understood well enough to support decision-making, even though research continues into many dynamics of climate change. (Based on AAAS, 12A/H3)

c. Data gathered through observations from weather stations, buoys, satellites, ice cores, tree rings, cave deposits, and other sources provide an understanding of past climates and climate changes.

d. Using observations, logic, and experiments to construct and refine computer models and scientific explanations leads to better understanding of the climate system's behavior and more reliable projections of future climate changes. (Based on AAAS, 1B/H6)

Source: Forrest M. Mims III, Geronimo Creek Observatory, (830) 372-0548

3 The Sun is the primary source of Earth's energy

DRIVES EARTH SYSTEM

a. Solar energy heats the atmosphere and propels water through the global water cycle.

b. Daily variations of solar energy caused by Earth's rotation drive many weather processes.

c. The tilt of Earth on its axis causes sunlight to fall more intensely on different parts of Earth during the year, resulting in seasonal changes (Based on AAAS, 4B/H3)

d. Changes in Earth's orbit around the sun over thousands of years alter the amount of solar energy received on Earth and impact long-term climate processes such as Ice Ages

e. Greenhouse gases in the atmosphere, such as carbon dioxide and water vapor, trap infrared light from the warmed surface of Earth, creating the "Greenhouse Effect" which allows liquid water to exist on much of Earth's surface (Based on AAAS 4B/H4)

f. Sunlight is the ultimate source of most of the energy we use. The energy in fossil fuels such as oil and coal comes from energy that organisms captured through photosynthesis from the sun long ago. (Based on AAAS 8C/H8)

http://www.cpo.noaa.gov/Temp/Climate_Science_Literacy_Brochure_Final_v2.pdf

A Few Closing Comments

- Many quality educational resources and professional development opportunities on climate change and sustainability already exist!
  - See websites offered by EPA, NASA, NOAA, UCAR to mention just a few.
    - http://www.epa.gov/teachers/teachresources.htm
    - http://www.education.noaa.gov/tclimate.html
    - http://www.eo.ucar.edu/educators/index.html
    - http://www.windows.ucar.edu/earth/climate/climate.html
- When tackling topic of climate change in the classroom, critically important to empower students, focus on hope, and that they can make a difference!
  - Make choices to get the right educational background to be prepared to contribute in jobs that will help solve these problems

Are you looking for an online Professional Development Opportunity?

Climate Discovery, a series of online professional development courses for middle and high school educators

Summer Semester – June 19 to August 9, 2009

CD 501 – Introduction to Climate Change

CD 502 – Earth System Science: A Climate Change Perspective

CD 503 – Understanding Climate Change Today

NCAR

For registration information visit

http://ecourses.ncar.ucar.edu

NSF

WINDOWS TO THE UNIVERSE

Thanks very much!

rmjohnsn@ucar.edu

Find out more about the National Earth Science Teachers Association at http://www.nestanet.org

NATIONAL EARTH SCIENCE TEACHERS ASSOCIATION

UCAR