ID	Assignment 1 20/Sept/2017 2.75%	Assignment 2 28/Sept/2017 2.75%	Exam 1 (added 3 points) 2/Oct/2017 20%
201204553	80%	100%	
201704578	95%	100%	102%
201705557	95%	100%	105%
201506659	75%	85%	34%
201401964	70%	100%	61%
201706633	80%	92%	86%
201706793	90%	85%	104%
201201165	60%	100%	58%
201104732	70%	0%	46%
201705582	75%	100%	85%
201705237	75%	100%	88%
201706533	70%	100%	62%
201706581	95%	90%	95%
201704270	75%	90%	
201705115	95%	100%	87%
201703563	90%	90%	36%
201603159	0%	85%	51%
201601348	78%	90%	39%
201702109	75%	100%	80%
201606073	95%	85%	
201404603	85%	85%	61%
201702645	85%	88%	70%
201501743			
20103889	80%	88%	93%
201000225	95%	100%	109%
201604417	80%	85%	60%
201503349	75%	0%	83%
	70%	85%	46%
Class Average	78%	86%	73%

Average: 73%

Lowest grade: 34%
Highest grade: 109%

below 60%: 7Fs
60-69%: 4Ds
70-79%: 1C
80-89%: 6Bs
90-99%: 2As
greater than 100%: 4A++

I added 3 points to all grades

Reflect

- Are you reading the chapters before the lectures, instead of the day before the exam?
- Are you reviewing the slides after the lectures?
- Are you focusing during class?
- Monday, we will go through the exam carefully and thoroughly as a class.

The Story of Stuff

- See the original 20 minute video of the Story of Stuff: http://storyofstuff.org/movies/story-of-stuff/ - See it on your own time

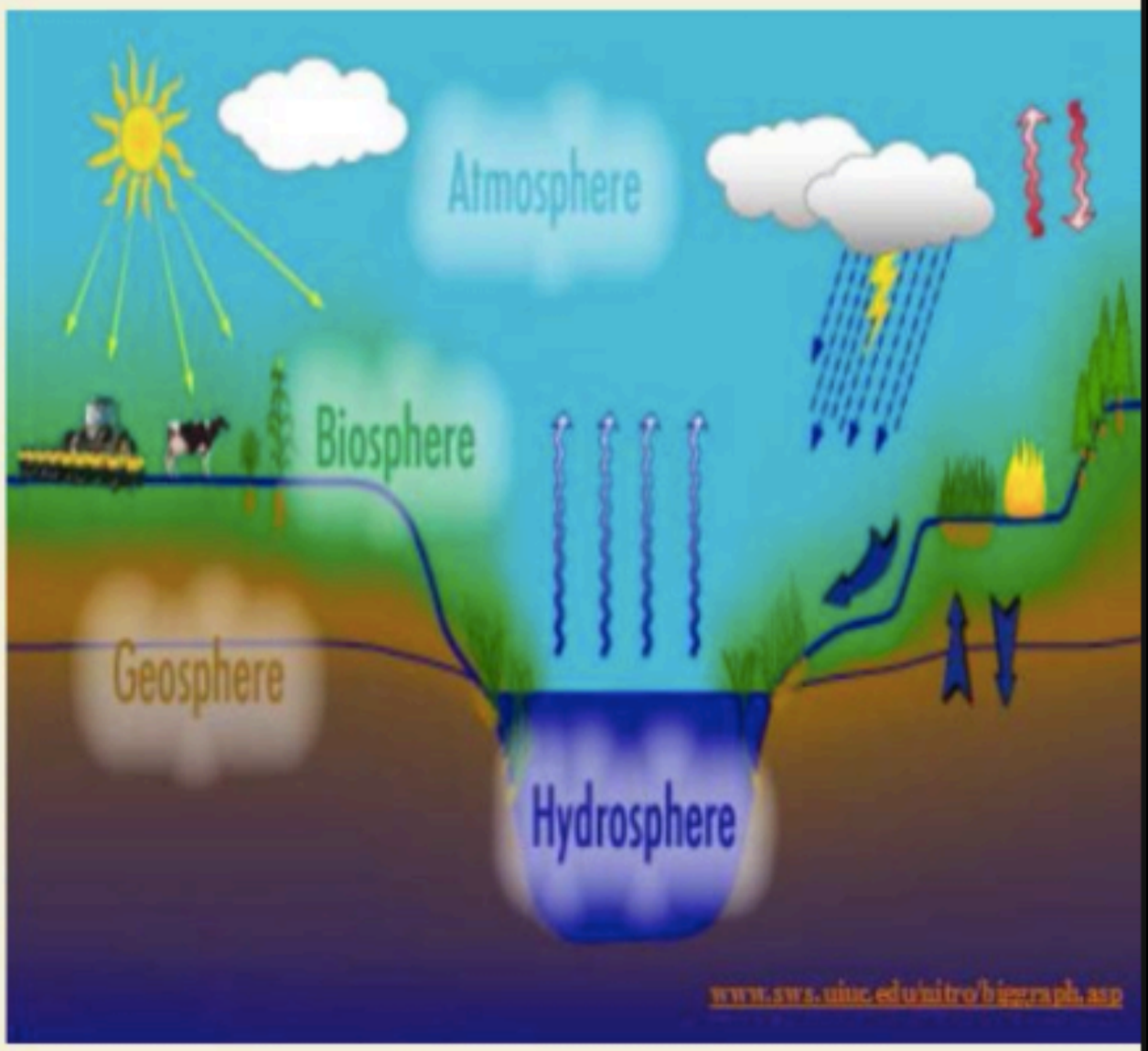
- We shall see together the 9 minute video of the Story of Solutions: http://storyofstuff.org/movies/the-story-of-solutions/

- (You can download the script if you have difficulty following the English.)

Chapter 3: Ecosystems

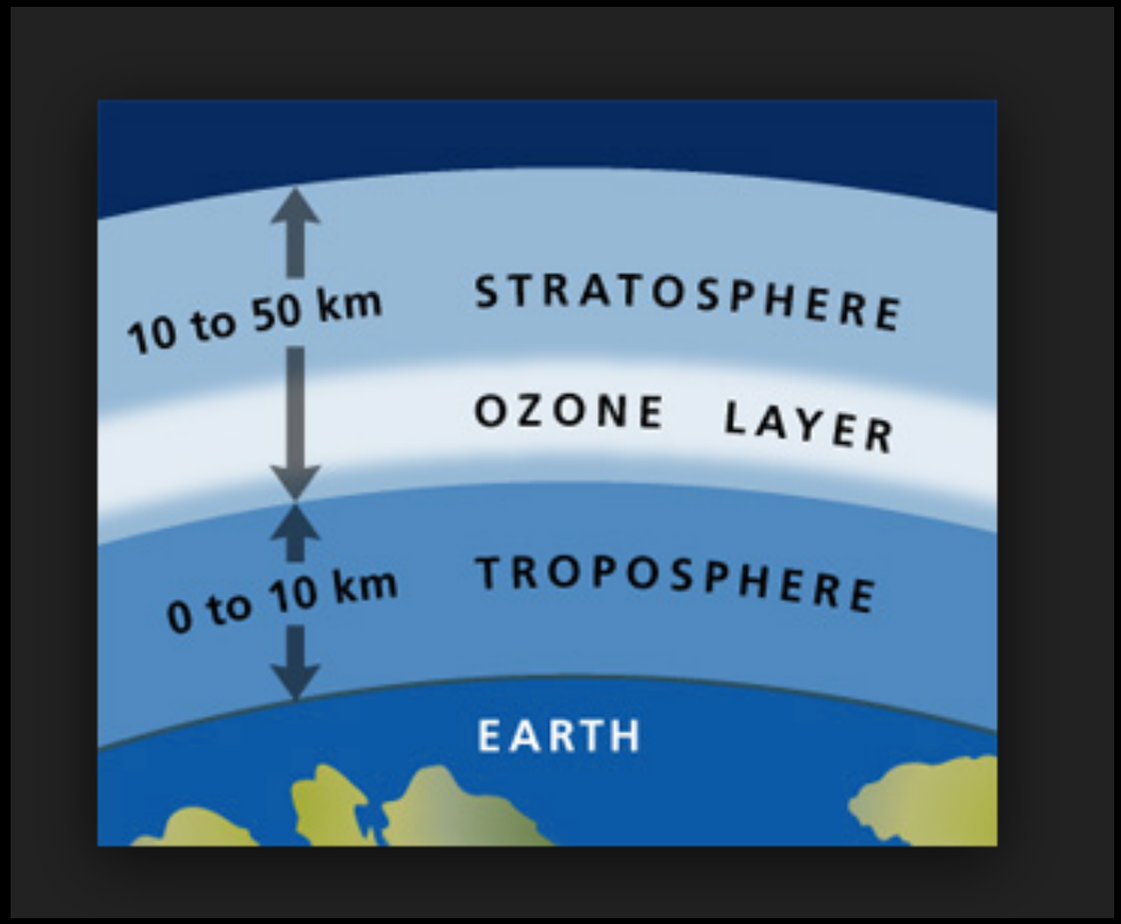
The Earth's Life-Support System Has Four Major Components

- **Atmosphere**
  - **Troposphere**: where weather happens
  - **Stratosphere**: contains ozone layer
- **Hydrosphere**
- **Geosphere**
- **Biosphere**



Atmosphere

- - thin spherical envelope of gases surrounding the earth's surface
    - inner layer: **<u>troposphere</u>**, from 7-17 km; air we breathe (78% N; 21% oxygen; 1% water vapor, CO2, methane)
        - greenhouse gases: water vapor, CO2, methane; absorb and release energy that warms the lower atmosphere
        - weather occurs in this
- **<u>stratosphere</u>**: 17-50 km; lower portion, holds ozone (O3) gas to filter around 95% of the sun's UV light (global sunscreen)

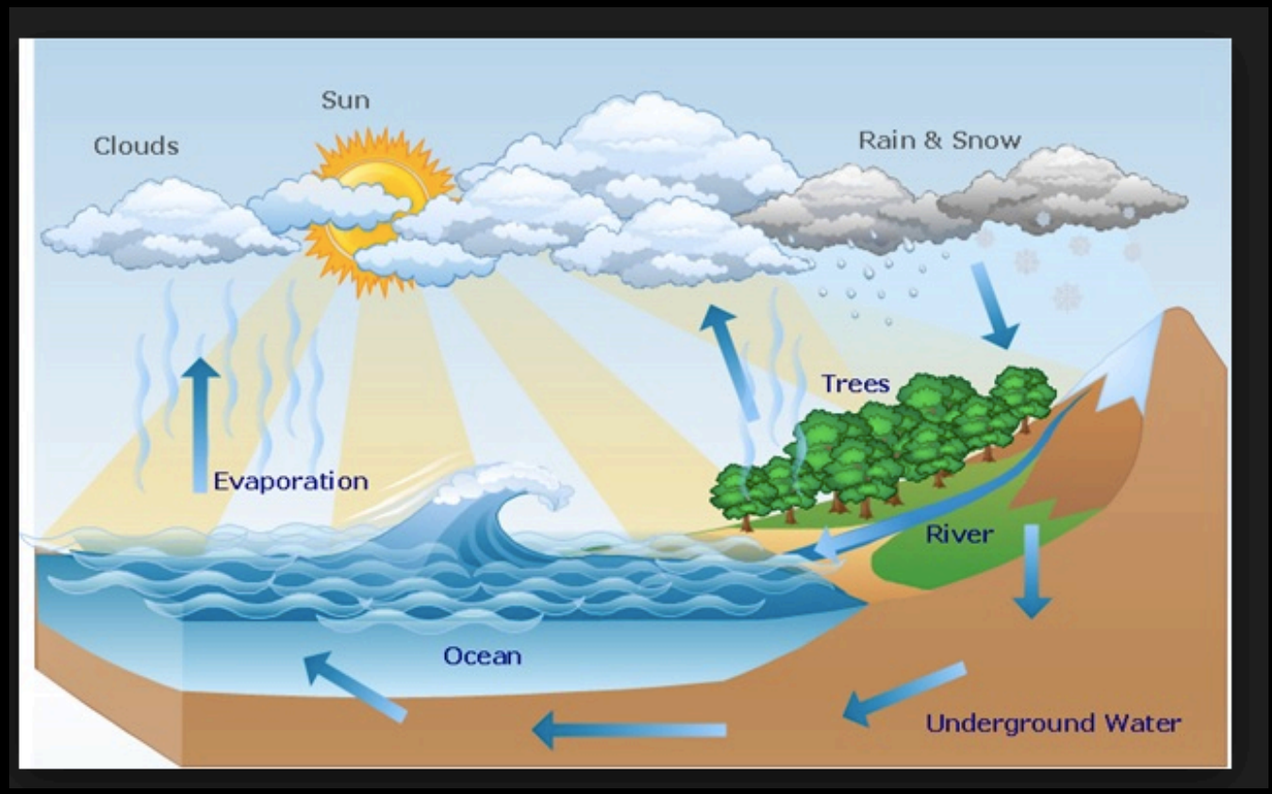


hydrosphere

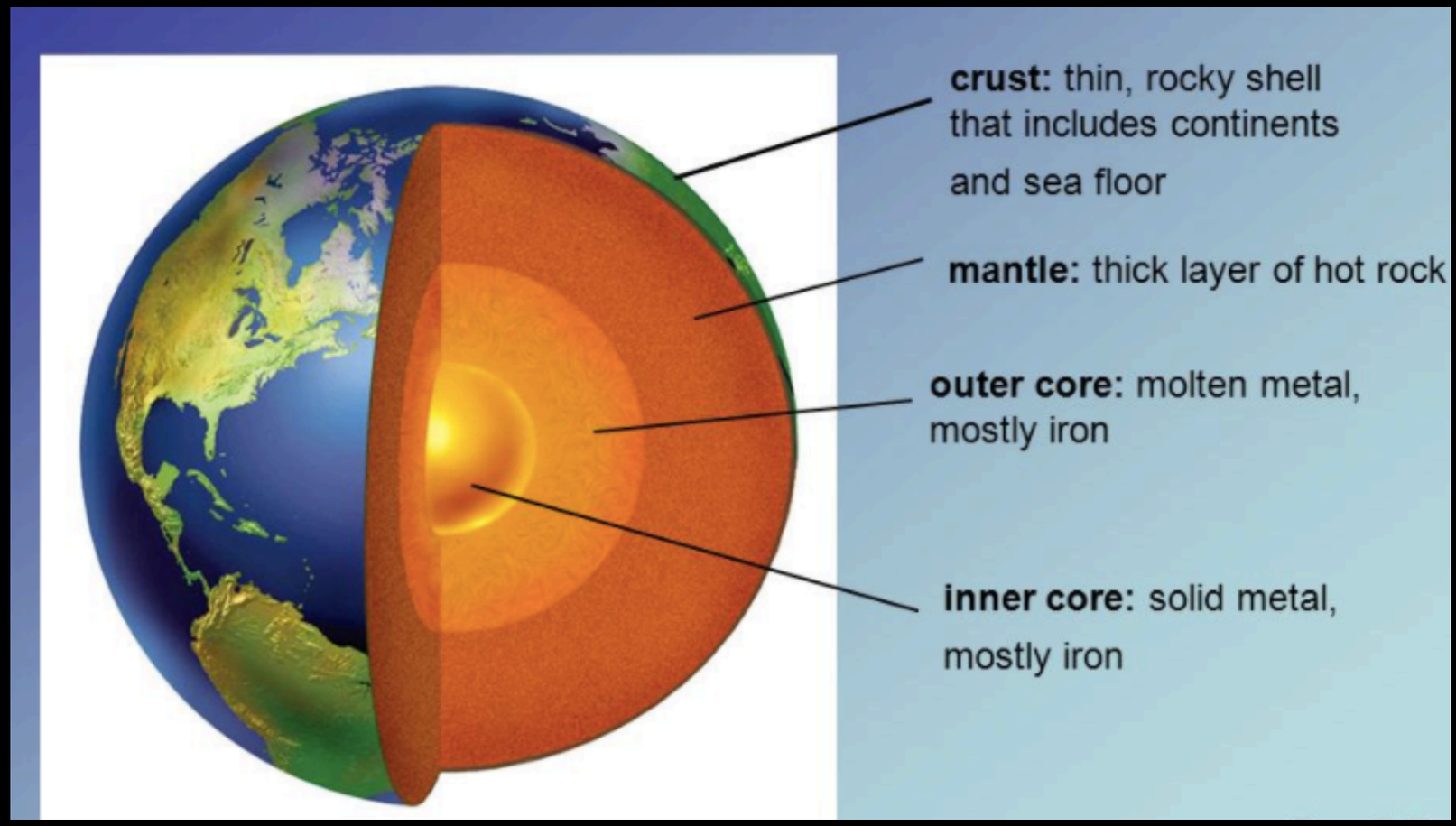
- all the water on or near the earth's surface

- water vapor; liquid water; permafrost

- oceans: 71% of the globe; contain 97% of the water



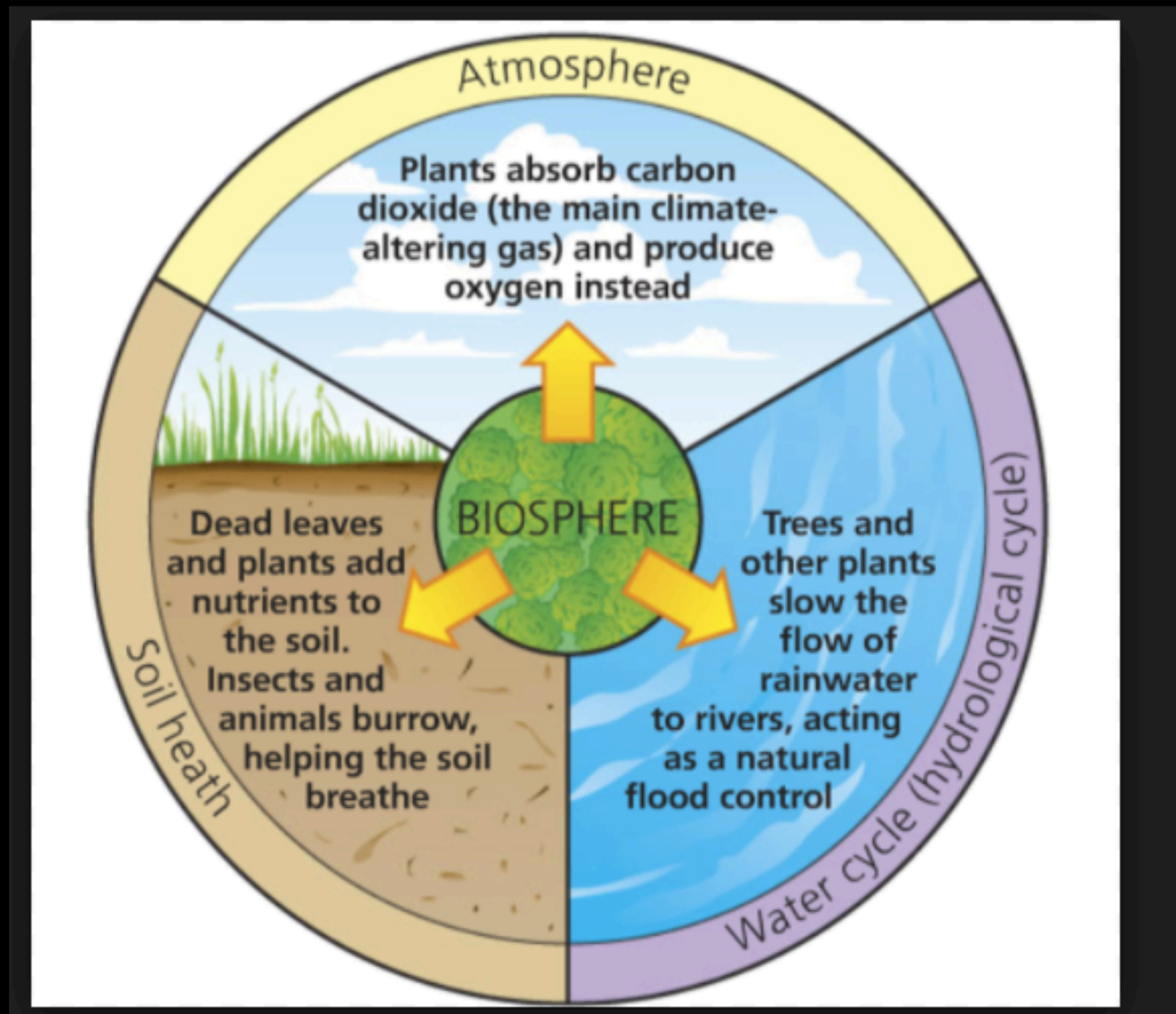
geosphere



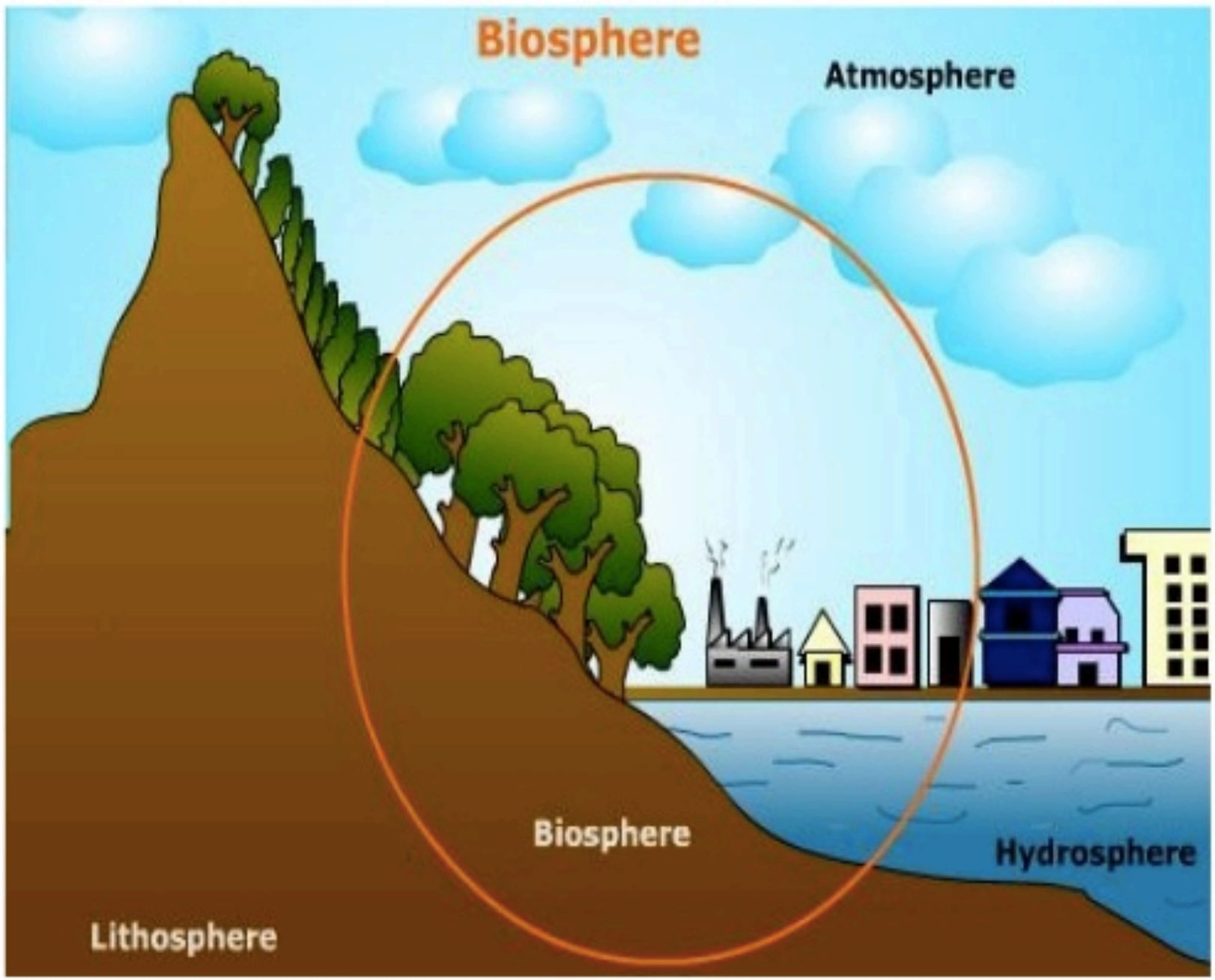
- earth's intensely hot core; a think mantle composed mostly of rock, and a thin outer crust
- **lithosphere**: the rigid outer part of the earth, consisting of the crust and upper mantle.
- upper portion contains nonrenewable fossil fuels and minerals + renewable soil nutrients

biosphere

- the parts of the atmosphere, hydrosphere and geosphere were life is found;
- **biosphere** is the global ecological system integrating all living beings and their relationships, including their interaction with the elements of the lithosphere, geosphere, hydrosphere, and atmosphere
- if the earth were an apple, the biosphere would be no thicker than the apple's skin



“One important goal of environmental science is to the understand the interactions that occur within this thin layer of air, water, soil, and organisms.”



The Earth…

- Earth's support system has 4 major components (atmosphere; hydrosphere; geosphere; biosphere). Life on earth depends on three interconnected factors:

1.one-way flow of high-quality from the sun

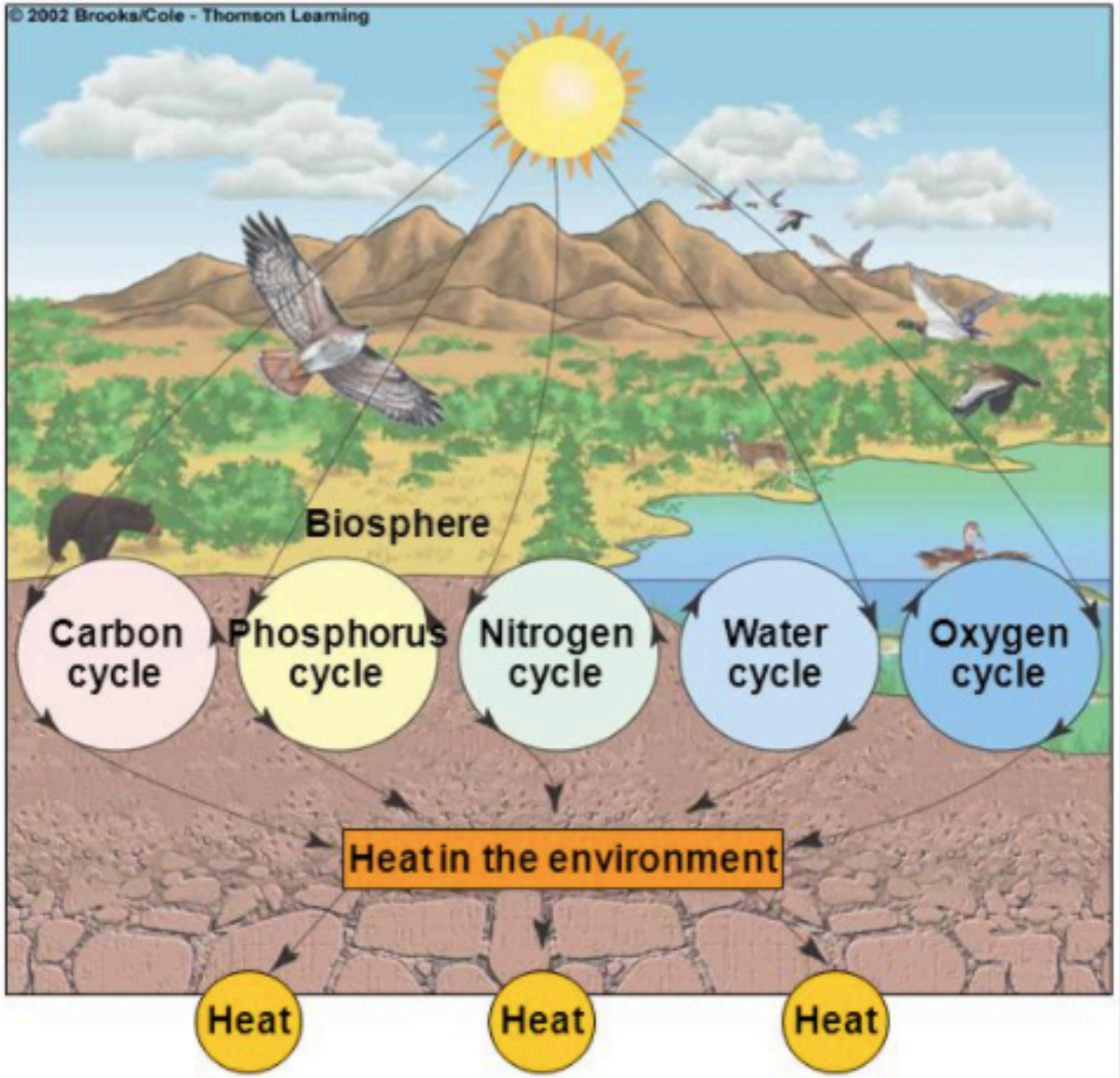
  - high-quality energy cannot be recycled
  - flow through living thing sin their feeding interactions; into the env as heat dispersed into air or water at allow temperature; and back into space as heat
  - two laws of thermodynamics govern this energy flow

2.cycling of nutrients (atoms, ions and molecules) through parts of biosphere

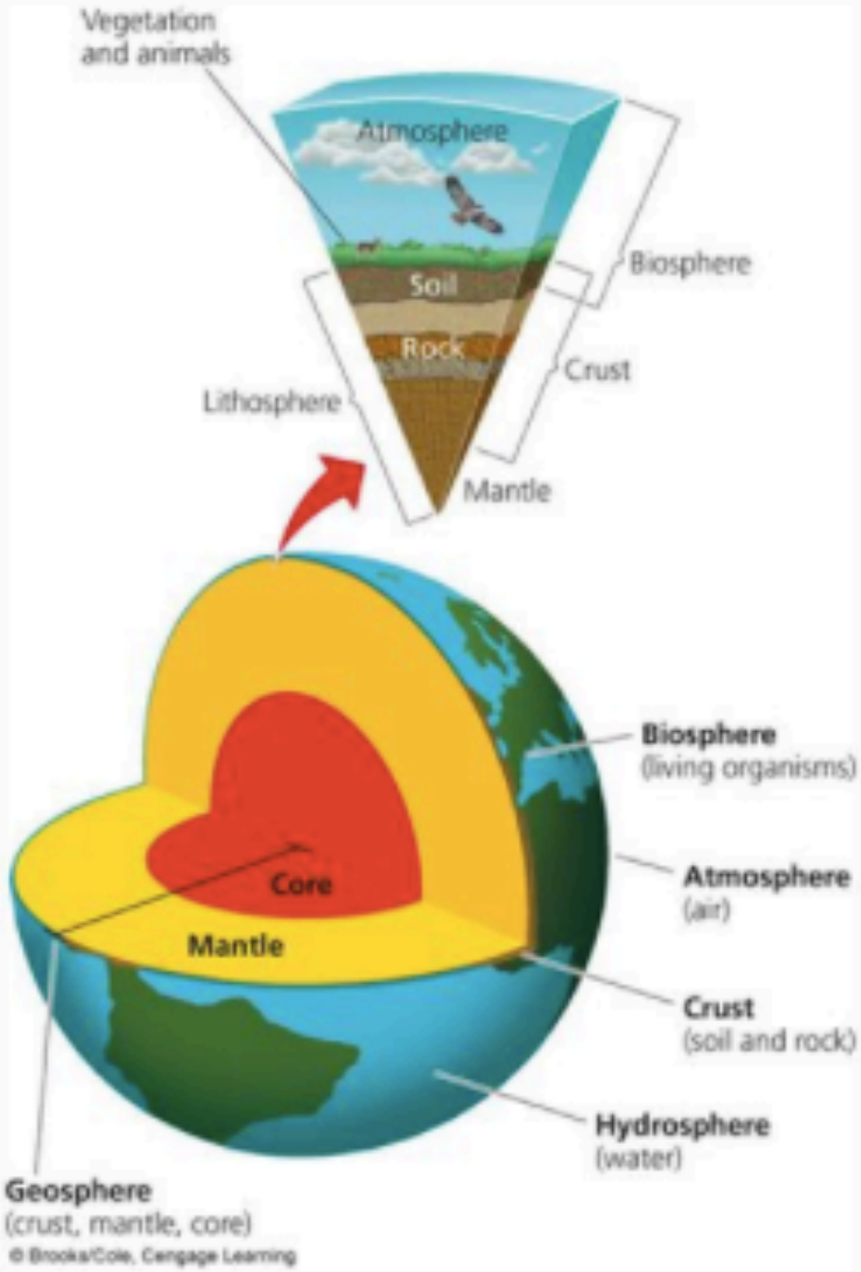
  - earth is closed to significant inputs of matter from space, the fixed supply of nutrients must be recycled
  - nutrient cycles are round-trips
  - law of conservation of matter governs this nutrient cycling

3.gravity

  - allows the planet to hold onto its atmosphere; helps enable movement and cycling of chemicals through air, water, soil and organisms

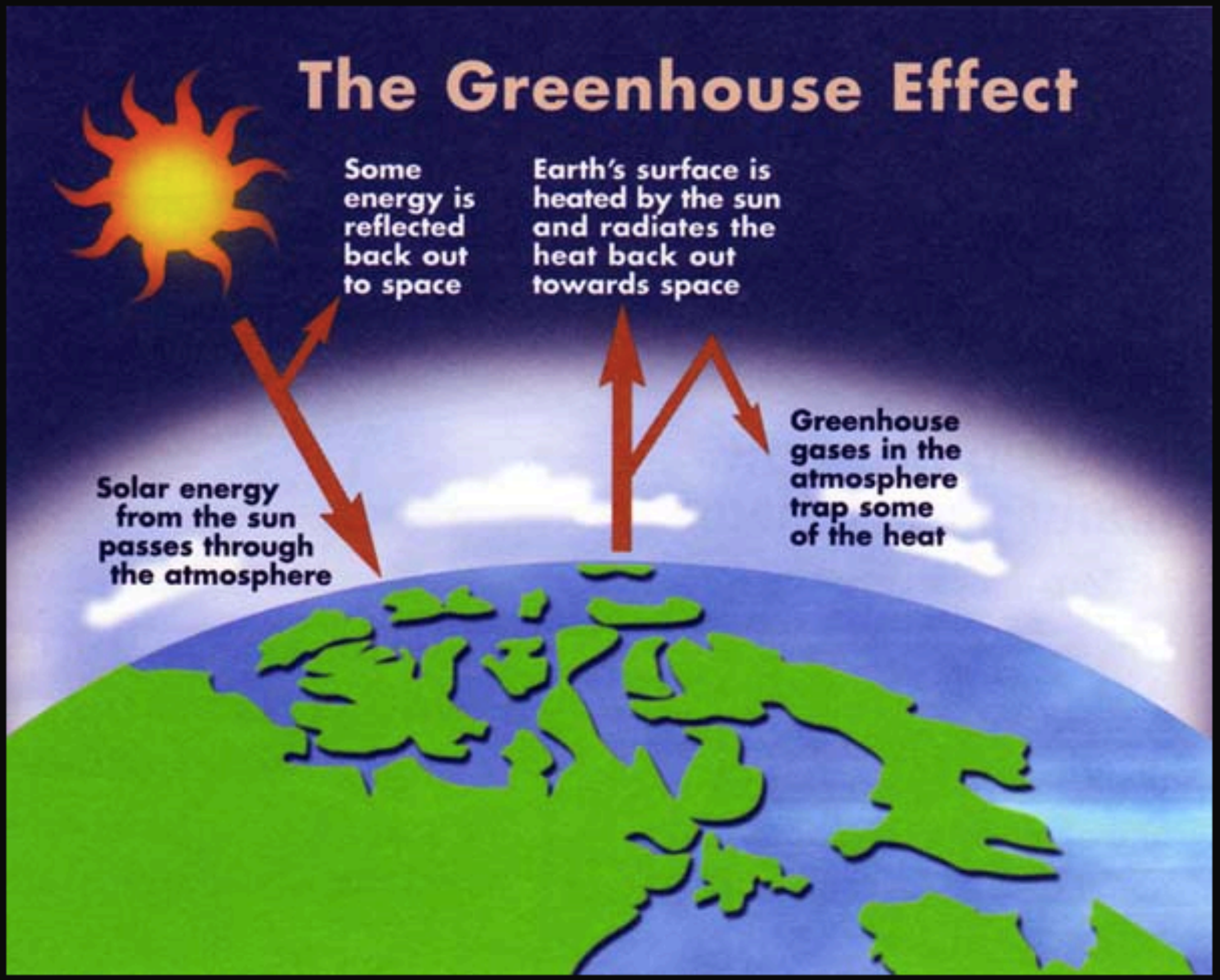


Natural Capital: General Structure of the Earth



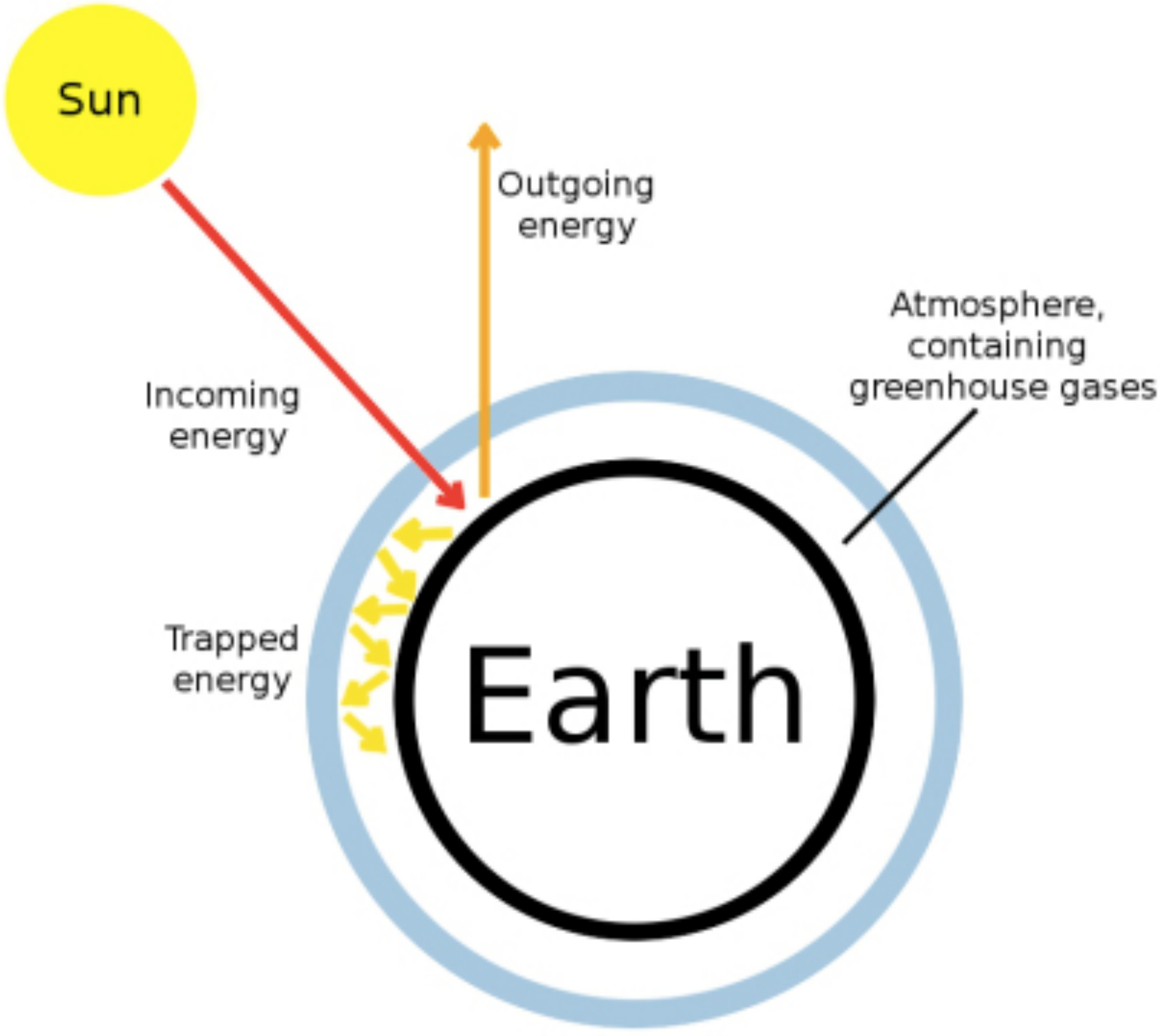
Sun, Earth, Life, and Climate

let’s talk about climate change


The Greenhouse Effect
Some energy is reflected back out to space
Earth's surface is heated by the sun and radiates the heat back out towards space
Greenhouse gases in the atmosphere trap some of the heat
Solar energy from the sun passes through the atmosphere

The Earth's Climate System

- Light from the Sun is absorbed by land and water, and is converted to heat.
- Some heat is emitted back into space as radiant heat, just as heat is radiated from hot pavement on a July day.
- Some of this radiant heat is absorbed by water vapor and clouds, carbon dioxide, methane, nitrous oxide and other trace atmospheric gases.
- These gases act like the glass windows in a car creating the "**hot car effect**."


Sun
Outgoing energy
Incoming energy
Atmosphere, containing greenhouse gases
Trapped energy
Earth

The Greenhouse effect

A T M O S P H E R E

S U N

Some solar radiation is reflected by the atmosphere and earth's surface
Outgoing solar radiation: 103 Watt per m²

Some of the infrared radiation passes through the atmosphere and is lost in space

G R E E N H O U S E G A S E S

Solar radiation passes through the clear atmosphere.
Incoming solar radiation:
343 Watt per m²

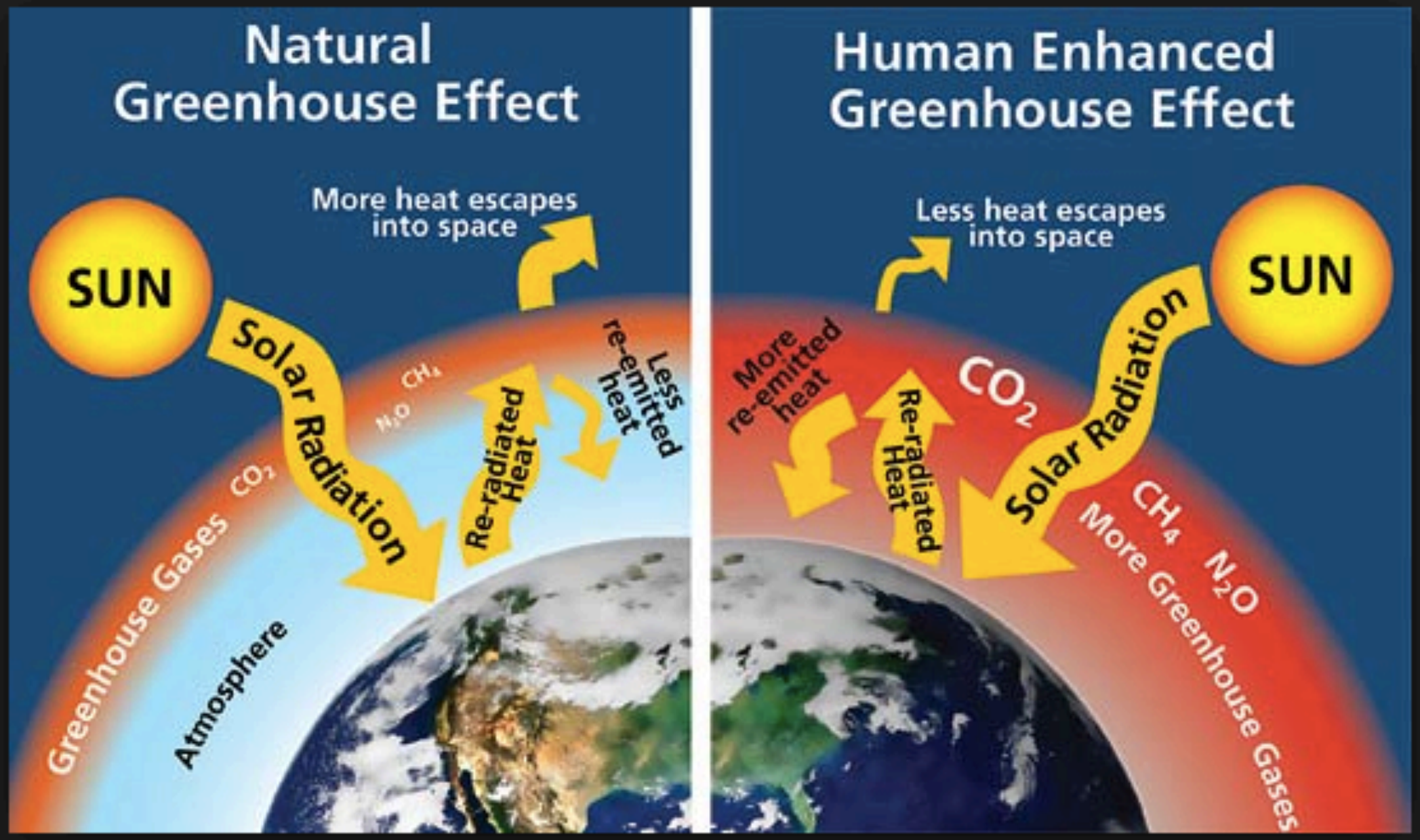
Some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules. The direct effect is the warming of the earth's surface and the troposphere.

Surface gains more heat and infrared radiation is emitted again

Solar energy is absorbed by the earth's surface and warms it...
168 Watt per m²

... and is converted into heat causing the emission of longwave (infrared) radiation back to the atmosphere

E A R T H


Natural
Greenhouse Effect
More heat escapes
into space
SUN
Solar Radiation
Re-radiated
Heat
Less
re-emitted
heat
CH_4
N_2O
Greenhouse Gases CO_2
Atmosphere
Human Enhanced
Greenhouse Effect
Less heat escapes
into space
SUN
Solar Radiation
Re-radiated
Heat
More
re-emitted
heat
CO_2
CH_4 N_2O
More Greenhouse Gases

The Earth is habitable because of a natural greenhouse effect brought about mainly by water vapor (60%) and carbon dioxide (26%). Otherwise its average temperature would be below zero Fahrenheit. Humans are altering the composition of the atmosphere, mainly by burning fossil fuels. As a result carbon dioxide has gone up over 35% since pre-industrial times and over half of that is since 1970. This changes the greenhouse effect and traps radiation that would otherwise escape to space, producing warming. The warming is manifested in many ways, not just increasing surface temperatures, but also melting ice, and changing the hydrological cycle and thus rainfall. Since 1970 the effects are large enough to be outside the bounds of natural variability for global mean temperatures, but global warming does not mean inexorable increases in temperature year after year owing to natural variability.”

- Kevin Trenberth, head of the Climate Analysis Section at the US National Center for Atmospheric Research

What is the evidence for human caused climate change?

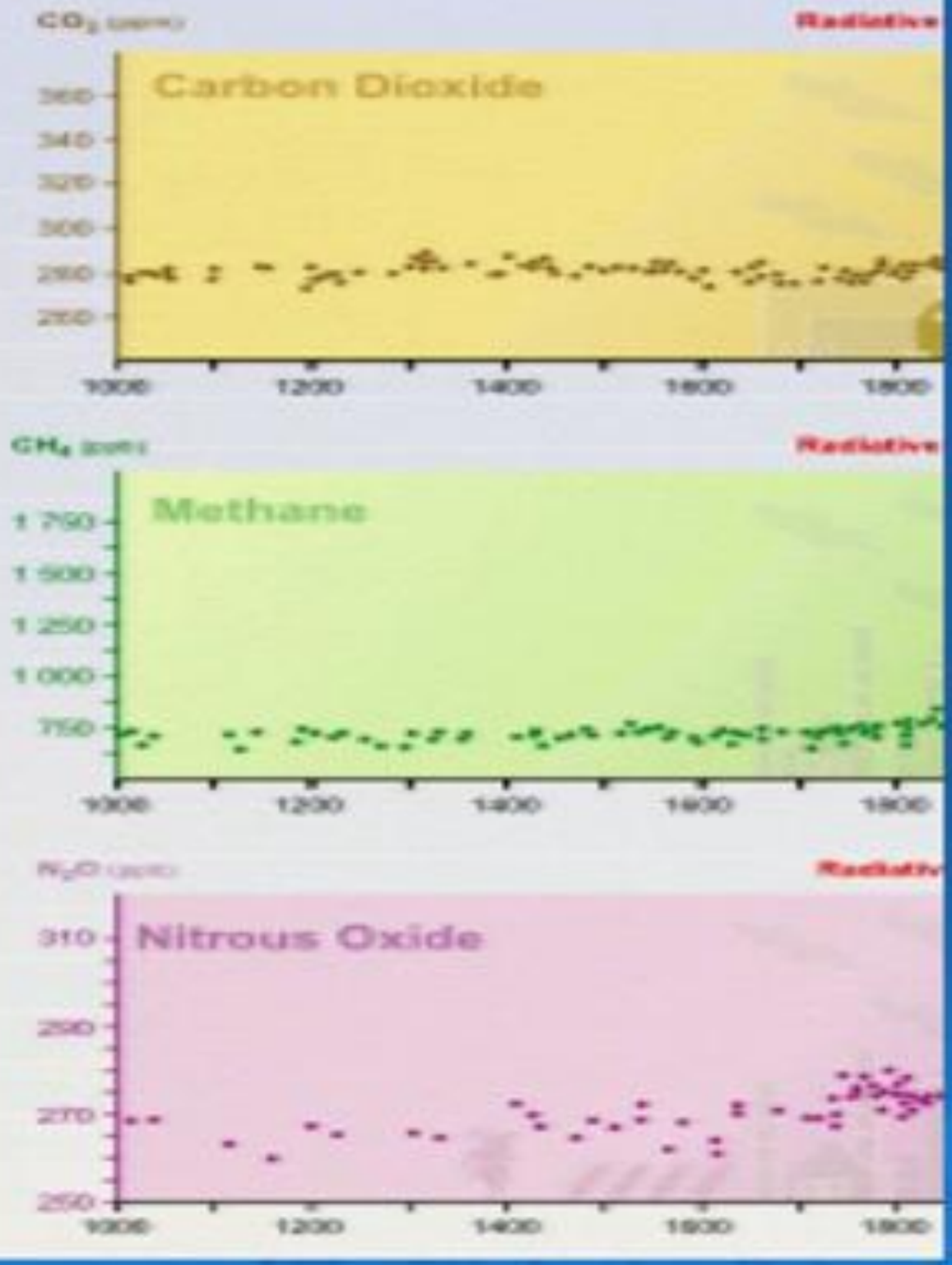
- Direct measurement of changes in atmospheric composition
- Direct measurement of temperatures
- Direct measurement of precipitation and other climate indicators
- Direct measurement of shifts in species
- Paleoclimate records
- Climate model verification
- Testing models with other planet climates

What human activities are affecting climate?

- Carbon dioxide from fossil fuels release about 6 billion tons of carbon each year to the atmosphere
- Atmospheric carbon dioxide concentrations have increased by nearly 32%
- Methane from agriculture, livestock, landfills and industry have increased by 133%
- Nitrous oxide from agriculture and industry has increased by 15%
- Change in land use and land cover release 1 billion tons of carbon plus other gases

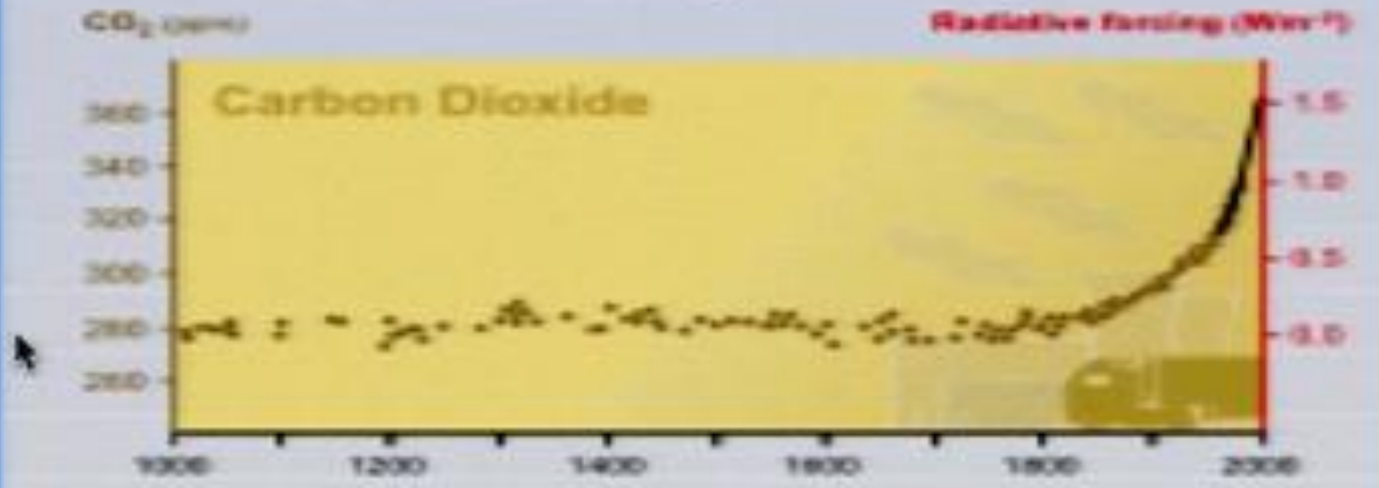
Indicators of the human influe
the atmosphere during the indus

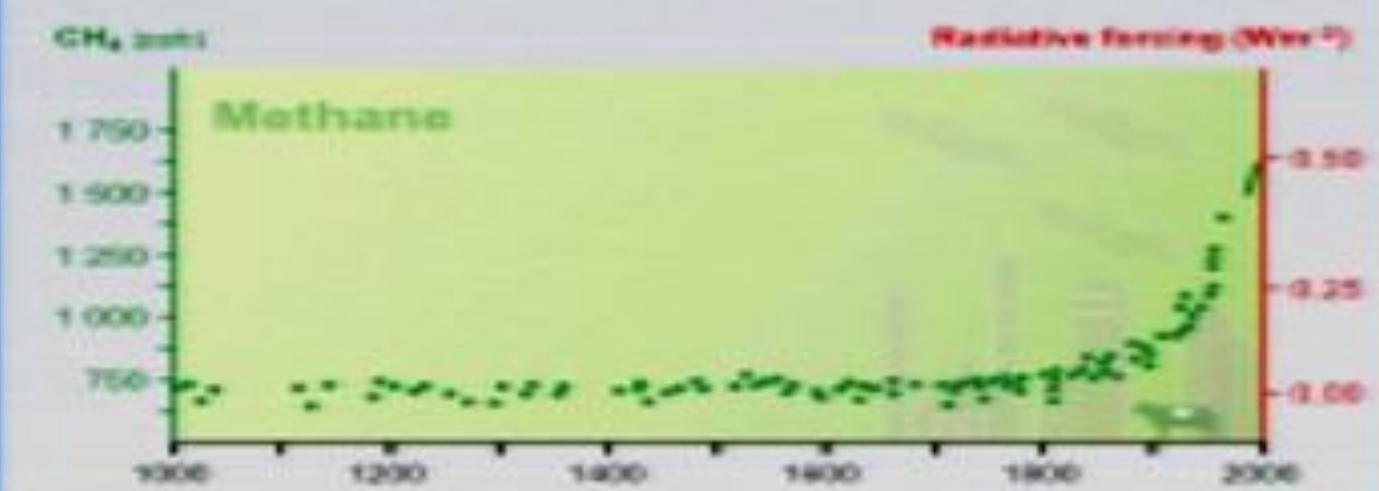
Global atmospheric concentrations
of three well-mixed greenhouse gase

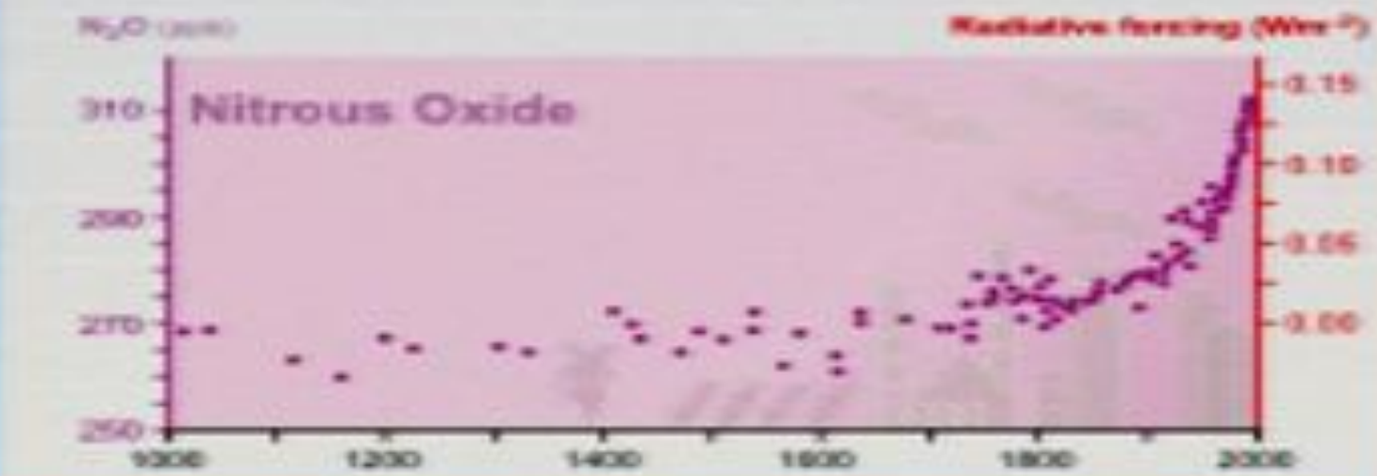


Indicators of the human influence on the atmosphere during the industrial era

Global atmospheric concentrations of three well-mixed greenhouse gases

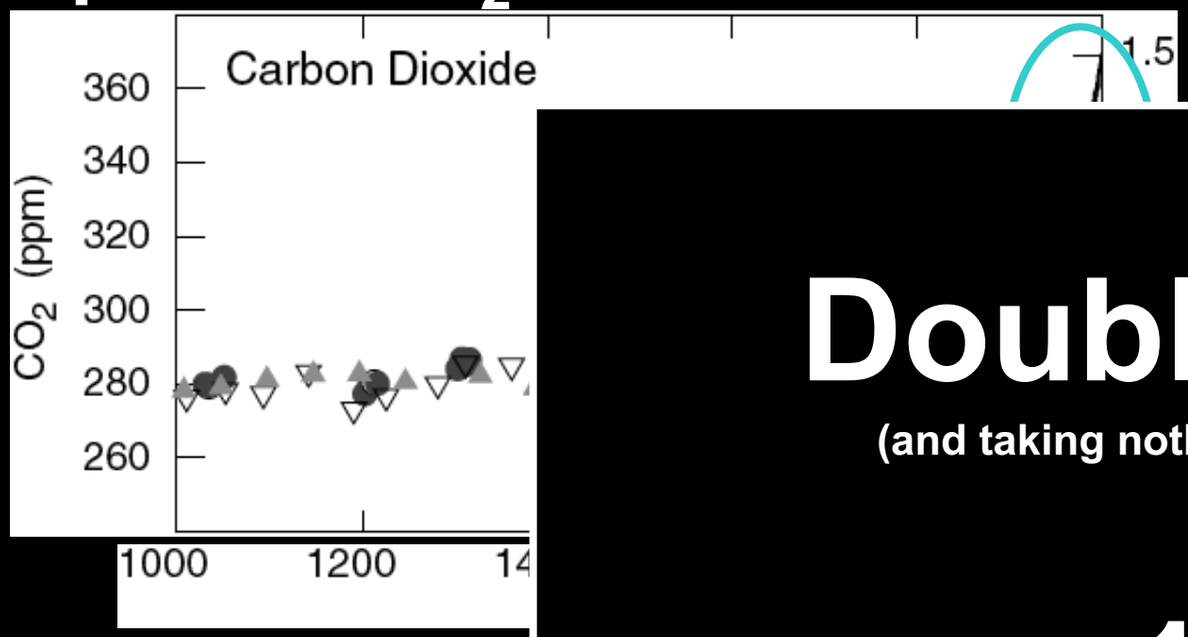




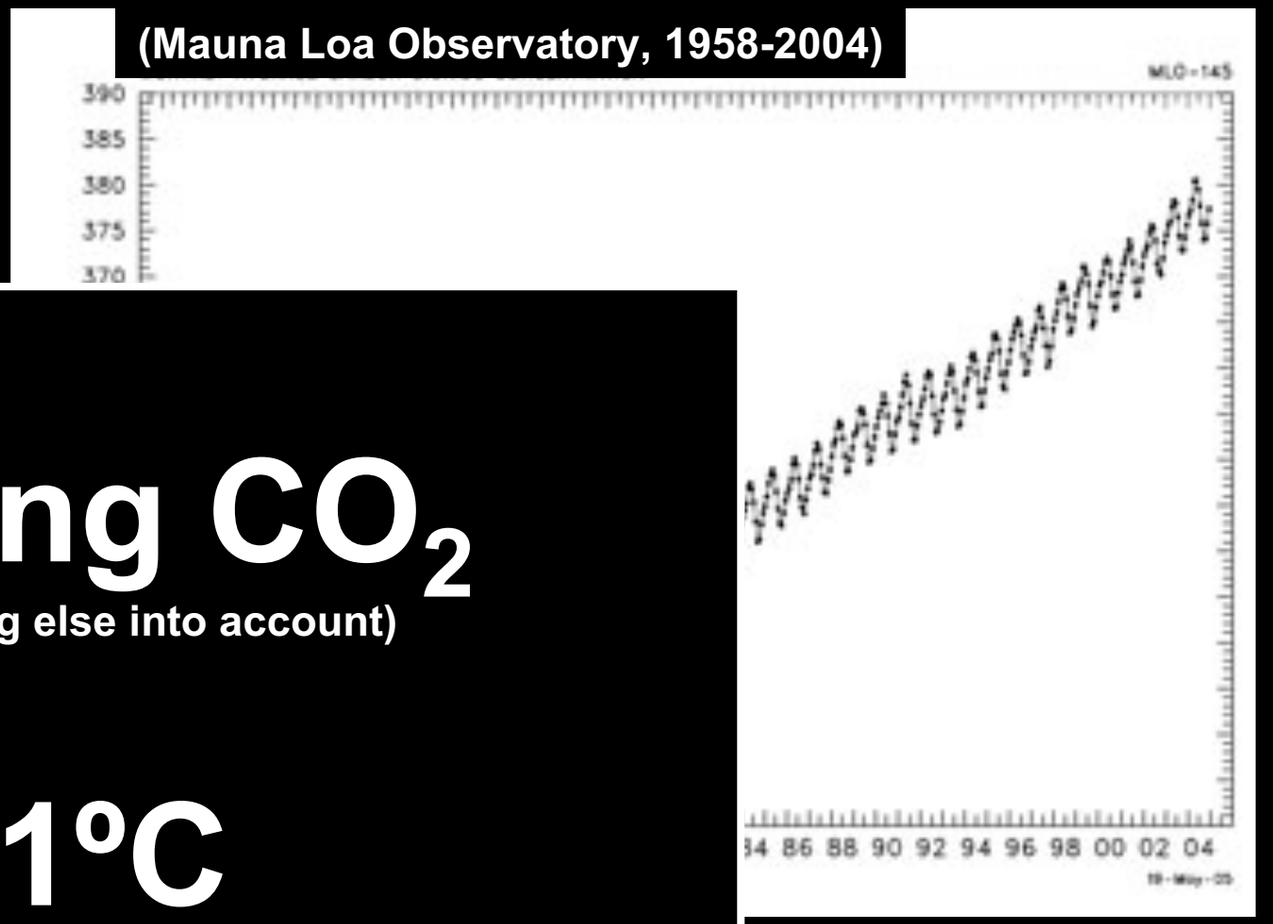


Carbon Dioxide Basics

ospheric CO_2 concentrations:



(Mauna Loa Observatory, 1958-2004)



Doubling CO_2

(and taking nothing else into account)

+1.1ºC

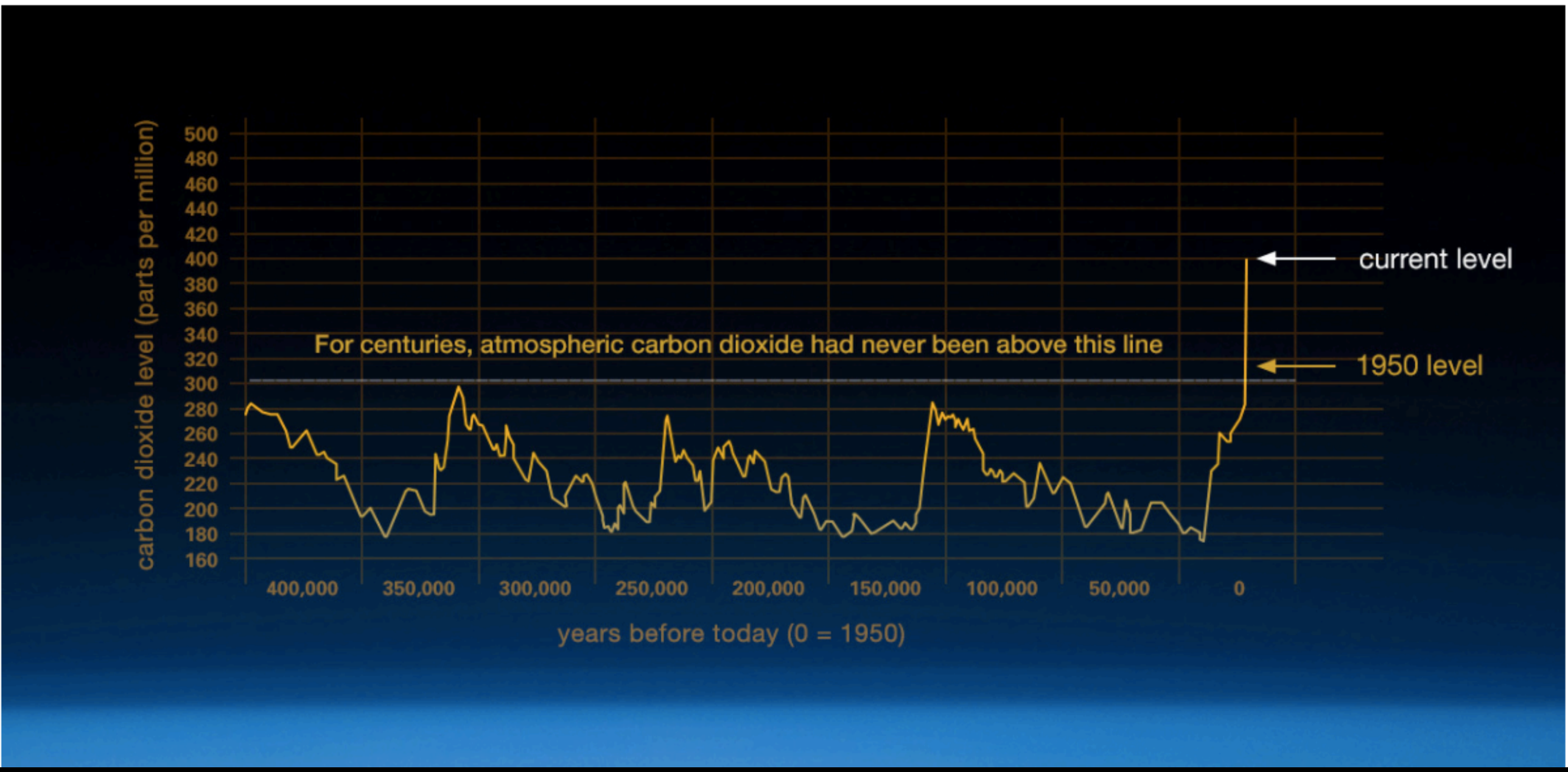
(annual average global surface temperature)

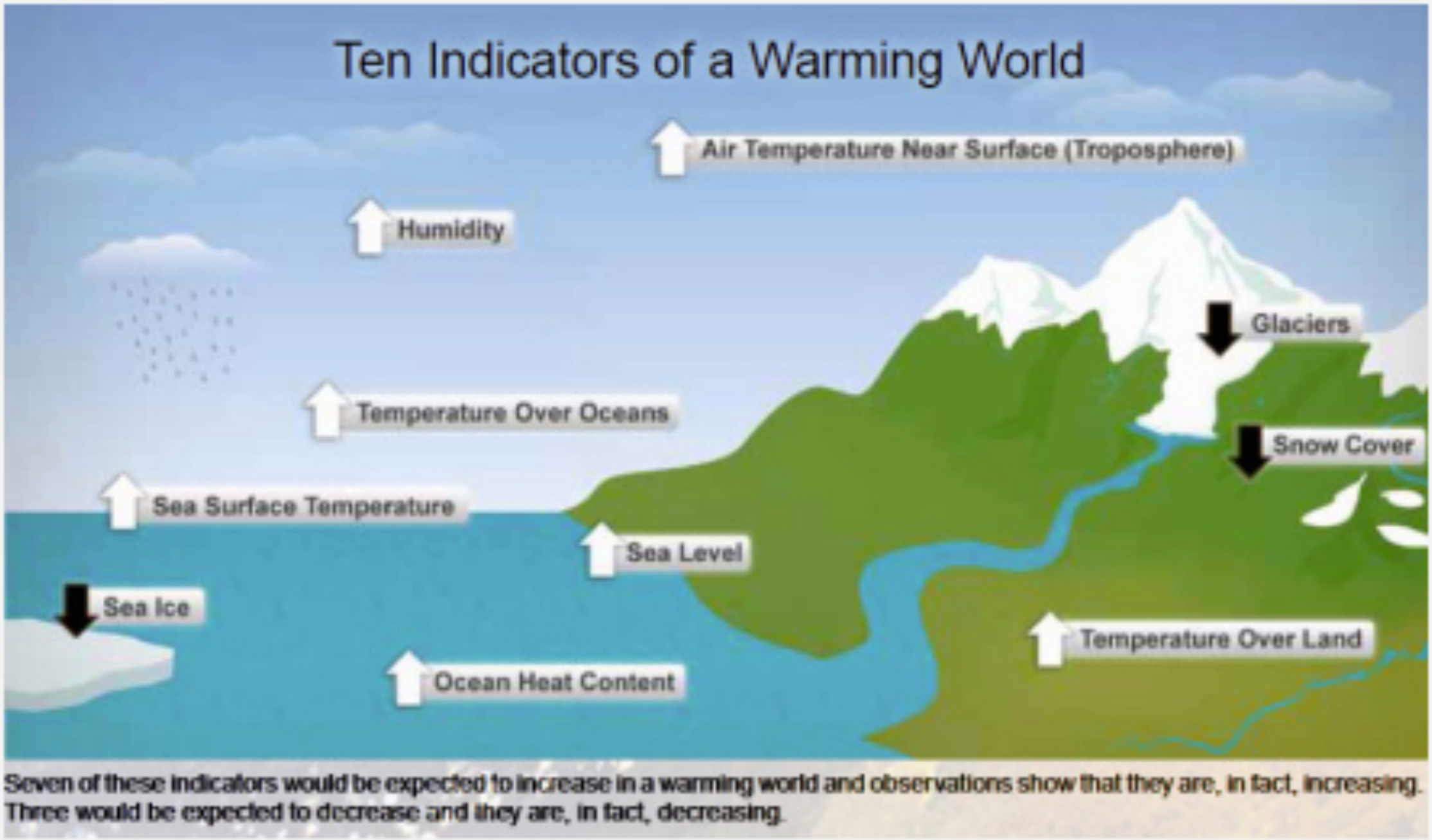
Useful Num ks:

Preindustrial atmospheric CO_2: ~ 280 ppm
Current atmospheric CO_2 : ~ 390 ppm (see: co2now.org)
Fossil CO_2 emissions: ~ 7.2 GtC/yr
CO_2 sinks: ~3 GtC/yr (depends on year)
Conversions: 1 ton C ~ 3.7 ton CO2
2.1 GtC ~ 1 ppm CO2 (in atmos.)
Average CO_2 lifetime (in atmos.): 5-200+ years

Fossil fuel use (coal, oil, gas)
Land use changes (deforestation / forest fires)
Cement production
Natural sources

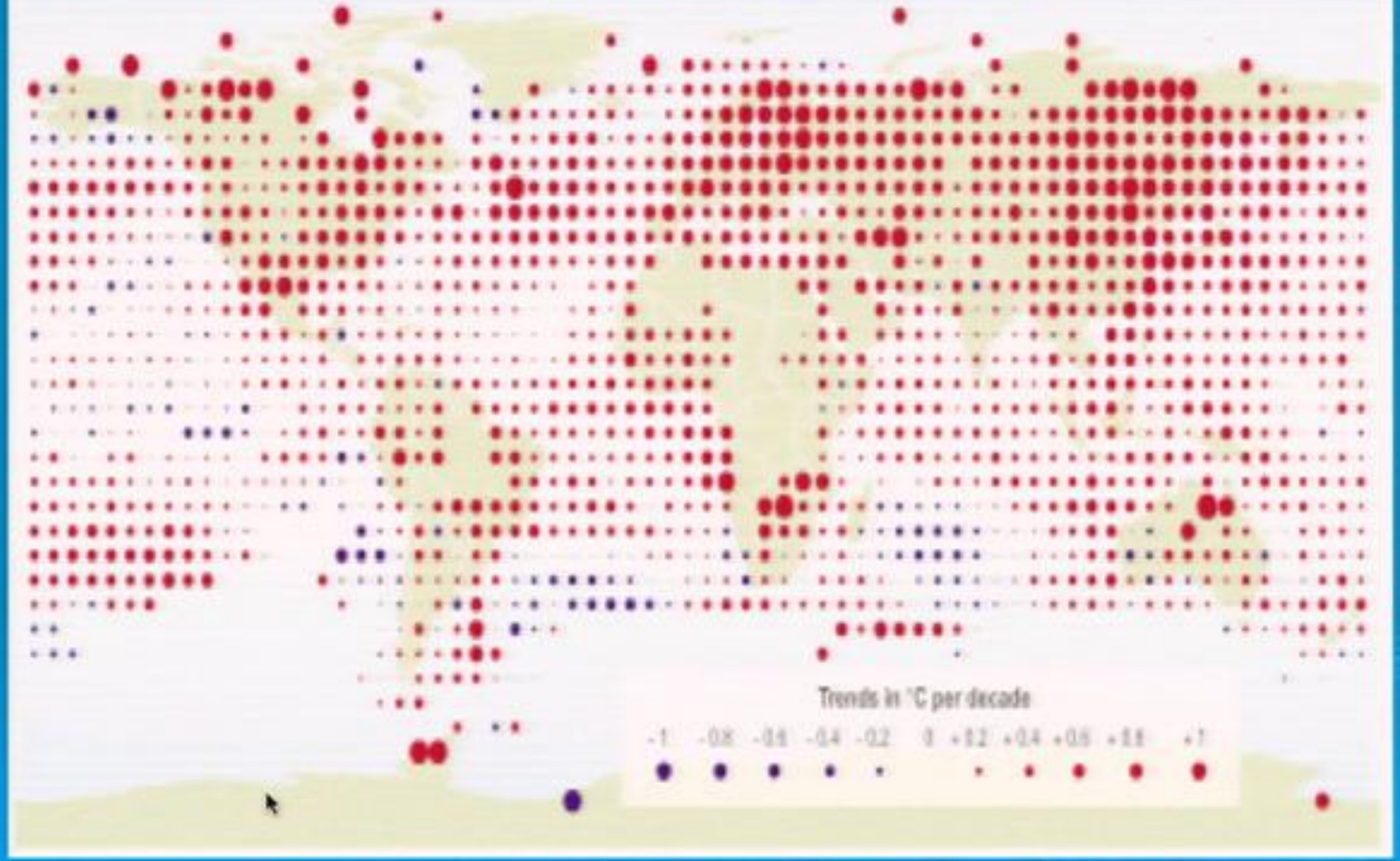
Biologic utilization
Absorption by seawater
Weathering


carbon dioxide level (parts per million)
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
For centuries, atmospheric carbon dioxide had never been above this line
current level
1950 level
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
years before today (0 = 1950)

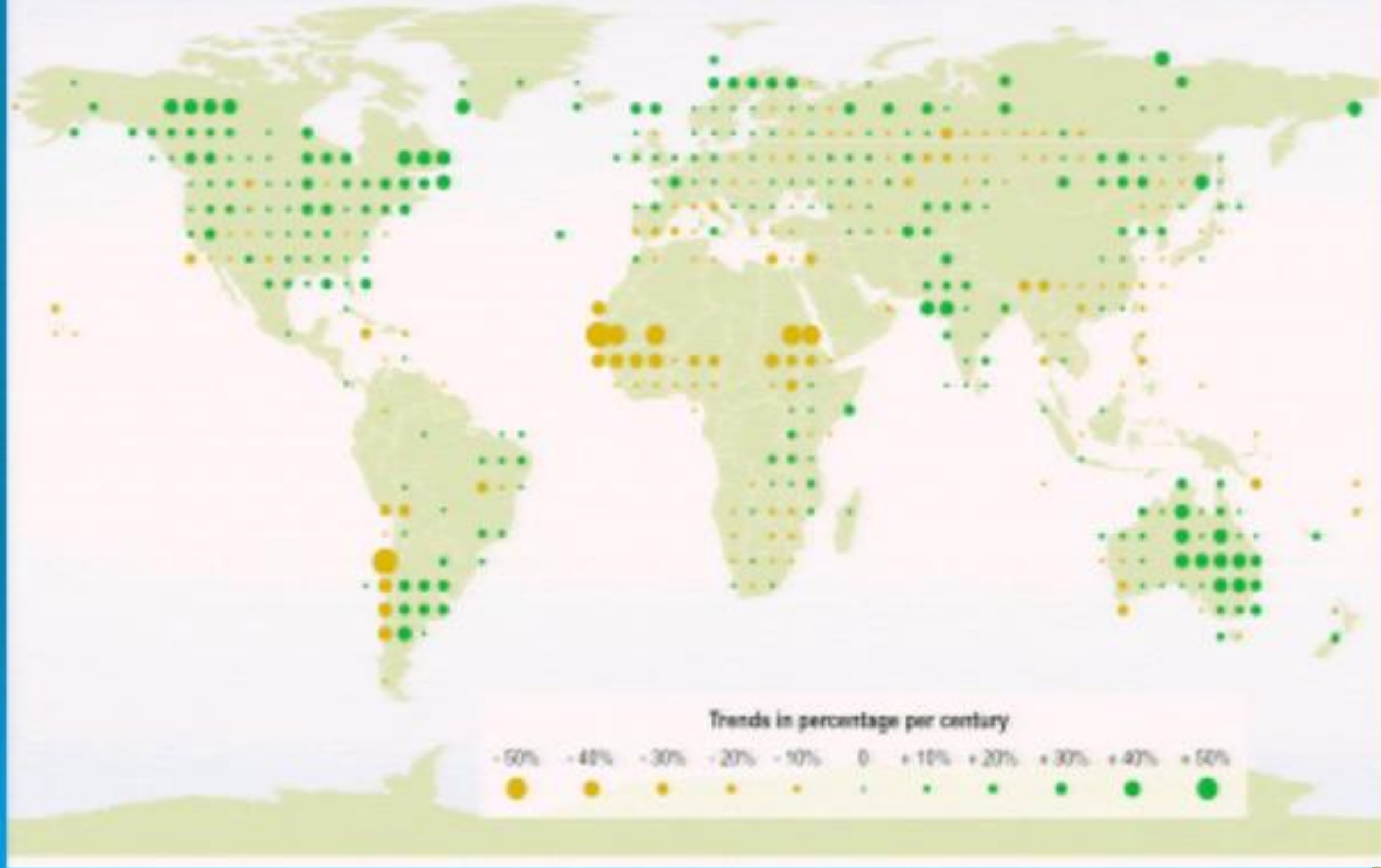


Ten indicators with increasing or decreasing values that demonstrate that the planet is warming. Credit: NOAA

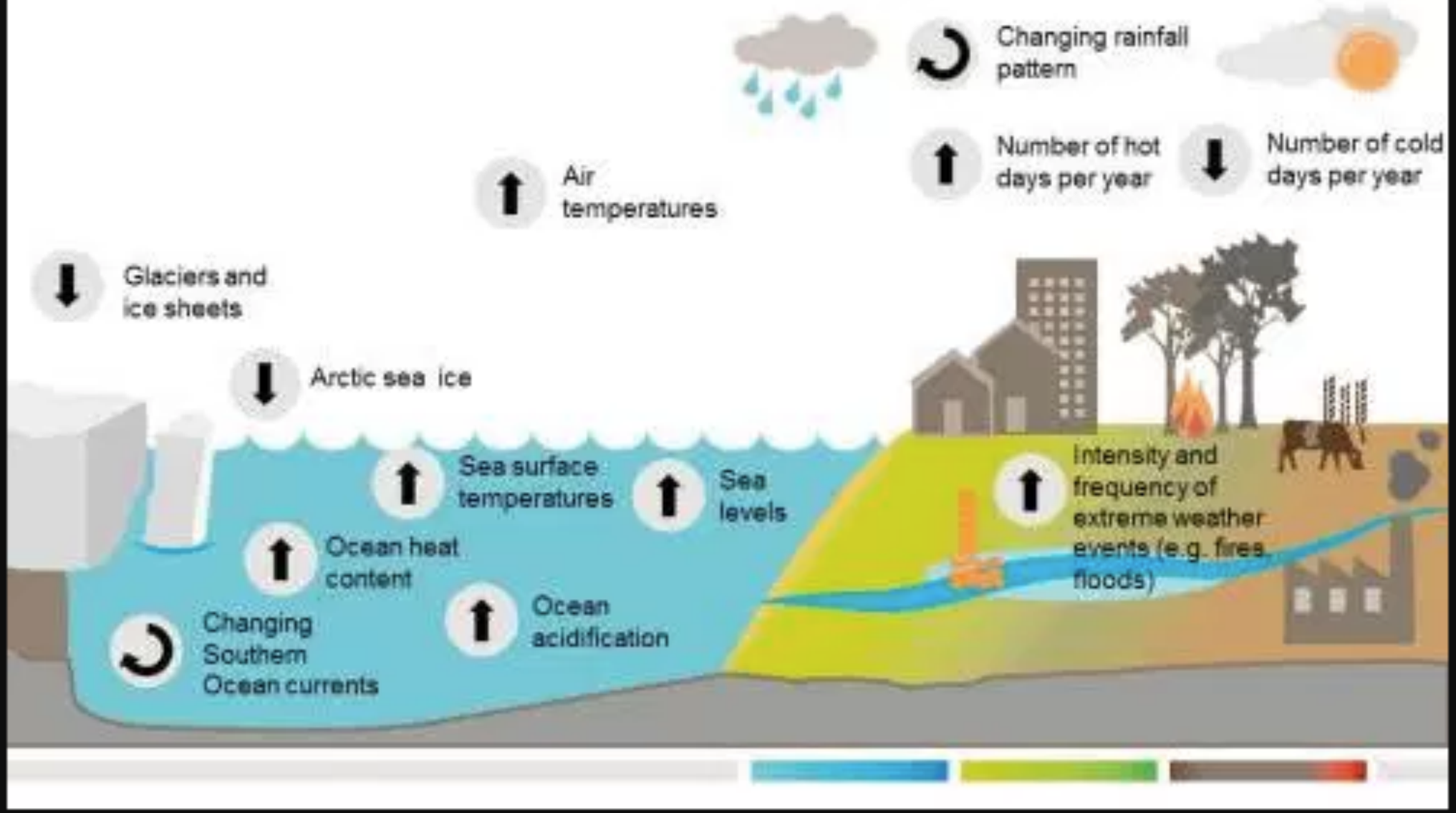
Annual temperature trends: 1976 to 2000



Annual precipitation trends: 1900 to 2000



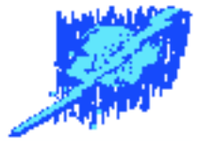
There are multiple lines of evidence that show the climate system is changing



Potential Climate Change Impacts

Climate Changes

Temperature



Precipitation

Sea Level Rise

Health Impacts

Weather-related Mortality
Infectious Diseases
Air Quality-Respiratory Illnesses

Agriculture Impacts

Crop yields
Irrigation demands

Forest Impacts

Change in forest composition
Shift geographic range of forests
Forest Health and Productivity

Water Resource Impacts

Changes in water supply
Water quality
Increased Competition for water

Impacts on Coastal Areas

Erosion of beaches
Inundate coastal lands
Costs to defend coastal communities

Species and Natural Areas

Shift in ecological zones
Loss of habitat and species

EPA

United States Environmental Protection Agency

IMPACTS

PREDICTIONS FOR 100 YEARS

UP 1°C
- RARE SPECIES EXTINCT
- CORAL REEFS DESTROYED
- ISLAND NATIONS UNDER WATER

UP 2°C
- GREENLAND MELTS
- POLAR BEARS EXTINCT
- WATER SUPPLY AFFECTED

UP 3°C
- FOOD SHORTAGES
- AMAZON COLLAPSES

UP 4°C
- MILLIONS OF REFUGEES
- ENVIRONMENTAL REFUGEES

UP 5°C
- MOST OF THE WORLD UNINHABITABLE
- TSUNAMIS

UP 6°C
- 1/3 RD OF BANGLADESH UNDER WATER
- PERMAFROST MELTS. GASES RELEASED
- EARTH HOTTER THAN IN 55 MILLIONS YEARS
- MASS EXTINCTION

WARMED BY 0.8°C-EFFECTS
- SPECIES EXTINCTION
- EXTREME WEATHER EVENTS
- INCREASED EARTHQUAKES
- HEATWAVES
- OCEANS WARMING
- ARCTIC ICECAP MELTING
- SEA LEVELS RISING

ECONOMICS
- STERN REPORT
- ACT NOW
- MUST INVEST 1% GDP
- FAIL TO ACT — GLOBAL GDP 20% LOWER

GLOBAL WARMING WORSE THAN
- WAR
- FAMINE
- PLAGUE
- GLOBAL NUCLEAR WAR

DEPRESSED?

https://climate.nasa.gov/evidence/

Global temperature rise

The planet's average surface temperature has risen about 2.0 degrees Fahrenheit (1.1 degrees Celsius) since the late 19th century, a change driven largely by increased carbon dioxide and other human-made emissions into the atmosphere.[5] Most of the warming occurred in the past 35 years, with 16 of the 17 warmest years on record occurring since 2001. Not only was 2016 the warmest year on record, but eight of the 12 months that make up the year — from January through September, with the exception of June — were the warmest on record for those respective months.[6]

Warming oceans

The oceans have absorbed much of this increased heat, with the top 700 meters (about 2,300 feet) of ocean showing warming of 0.302 degrees Fahrenheit since 1969.[7]

Shrinking ice sheets

The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost 150 to 250 cubic kilometers (36 to 60 cubic miles) of ice per year between 2002 and 2006, while Antarctica lost about 152 cubic kilometers (36 cubic miles) of ice between 2002 and 2005.

Image: Flowing meltwater from the Greenland ice sheet

Decreased snow cover

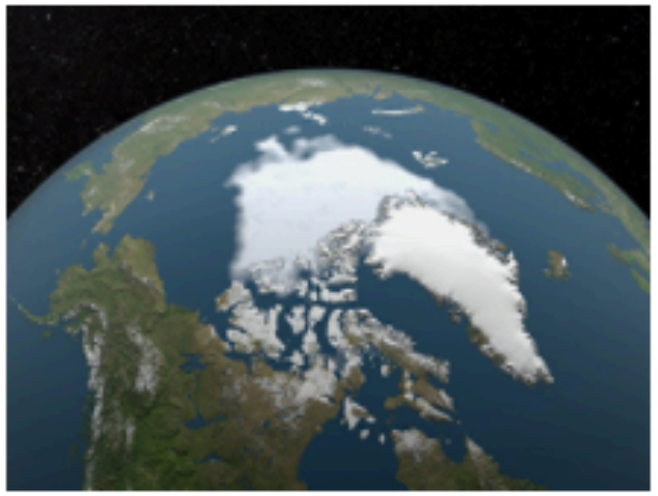
Satellite observations reveal that the amount of spring snow cover in the Northern Hemisphere has decreased over the past five decades and that the snow is melting earlier.[15]

Sea level rise

Global sea level rose about 8 inches in the last century. The rate in the last two decades, however, is nearly double that of the last century.[4]

Image: Republic of Maldives: Vulnerable to sea level rise

Declining Arctic sea ice



Both the extent and thickness of Arctic sea ice has declined rapidly over the last several decades.[8]

Image: Visualization of the 2012 Arctic sea ice minimum, the lowest on record

Extreme events

The number of record high temperature events in the United States has been increasing, while the number of record low temperature events has been decreasing, since 1950. The U.S. has also witnessed increasing numbers of intense rainfall events.[10]

Ocean acidification

Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30 percent.[11, 12] This increase is the result of humans emitting more carbon dioxide into the atmosphere and hence more being absorbed into the oceans. The amount of carbon dioxide absorbed by the upper layer of the oceans is increasing by about 2 billion tons per year.[13, 14]