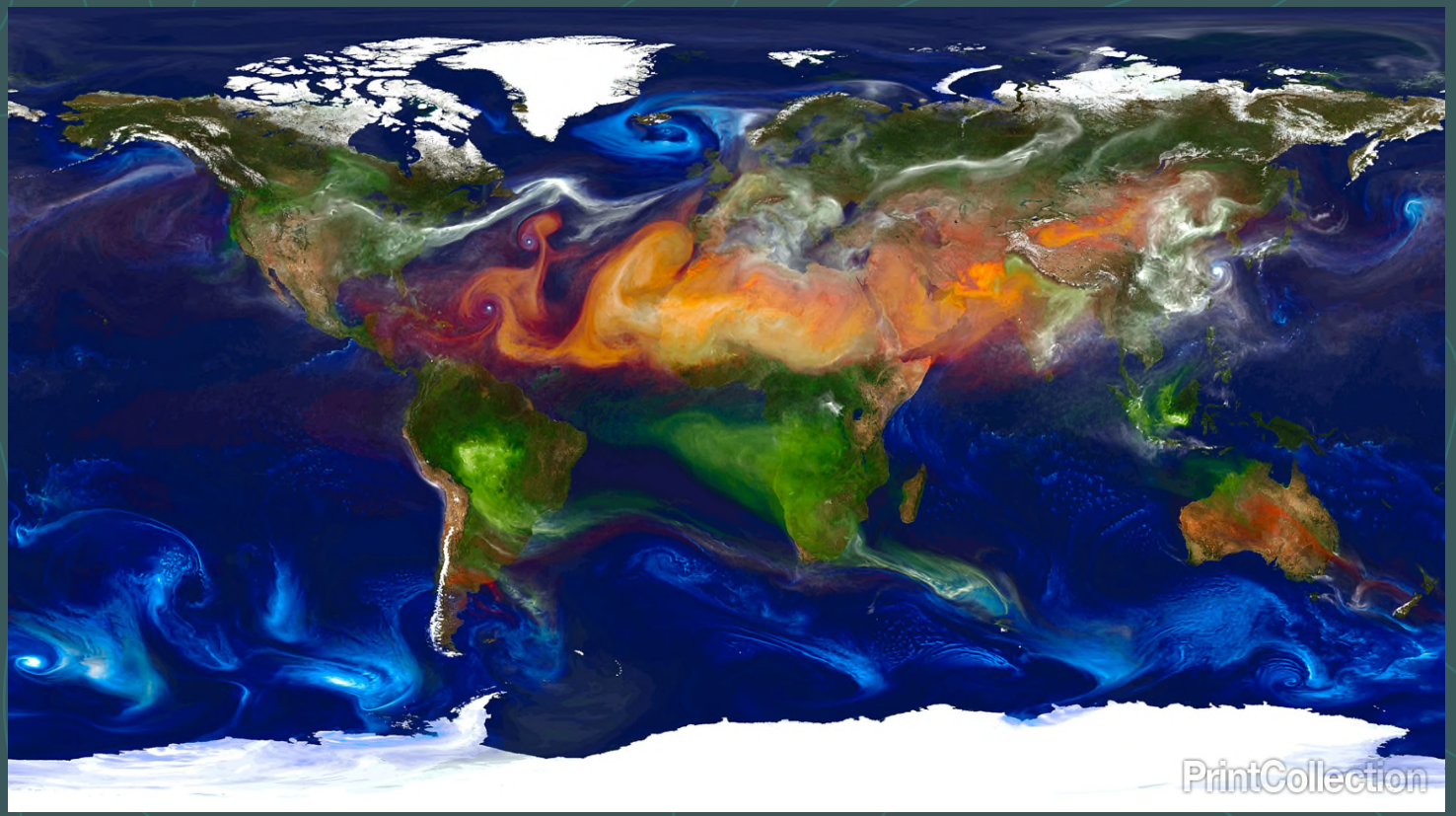
Climate Change

Causes, Evidence, Hazards, and Solutions



EOSC 105 – Natural Disasters

Ray Rector: Instructor

Global Warming and Climate Change

A. Terms Defined:

1) Global Warming: Increase in average global surface temperature

2) Climate Change: Change in location and character of regional climate belts

B. Causes of Global Warming

1) Increase in heat-absorbing atmospheric gases
   - ✓ Methane, carbon dioxide, carbon monoxide, water
   - ✓ Natural and human-induced emissions

2) Increase in solar radiation striking earth's surface
   - ✓ Long-term cyclic changes in earth orbit and axis tilt
   - ✓ Cyclic changes in sun's output

C. Evidence for Global Warming

1) Melting glaciers
   - ✓ Polar ice caps and sheets and mountain glaciers

2) Rise in global sea level
   - ✓ Input from melting land ice
   - ✓ Warming of ocean waters (thermal expansion)

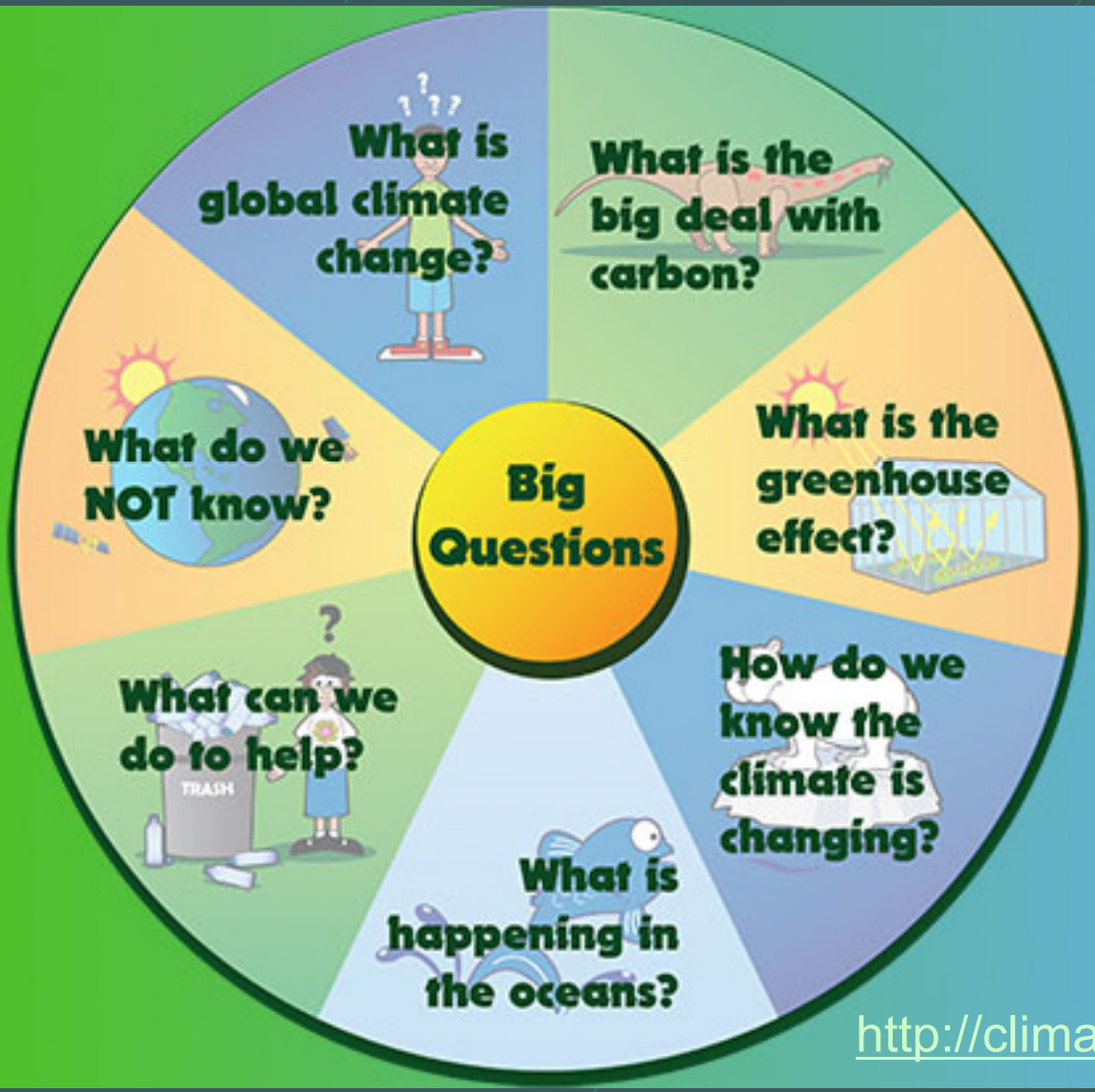
3) Rising Levels of Global Temperature and Atmospheric Carbon Dioxide
   - ✓ Atmosphere, land and ocean

D. Anthropogenic Sources of Greenhouse gases

1) Burning fossil fuels
2) Burning down forests

E. Solutions to Slowing Down GW and Climate Change

Global Warming and Climate Change



http://climate.nasa.gov/

Intro to Climate Change: Short Video

https://www.youtube.com/watch?v=n4e5UPu1co0&feature=youtu.be

Climate Change / Global Warming Video

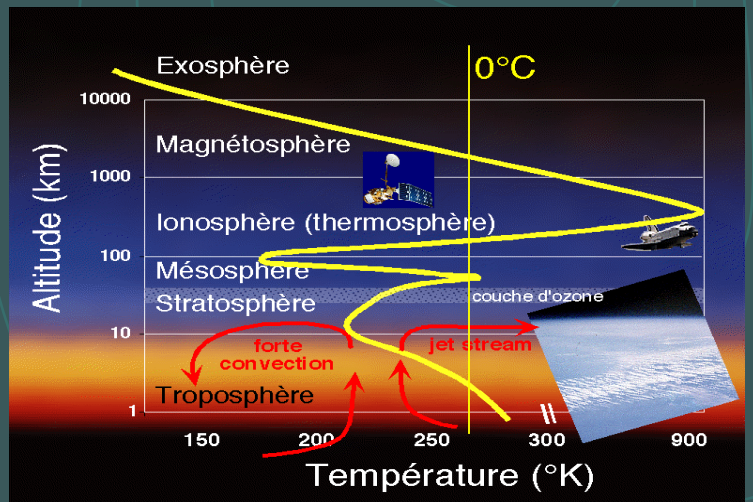
1) https://www.youtube.com/watch?v=qEPVyrSWfQE&list=PL38EB9C0BC54A9EE2

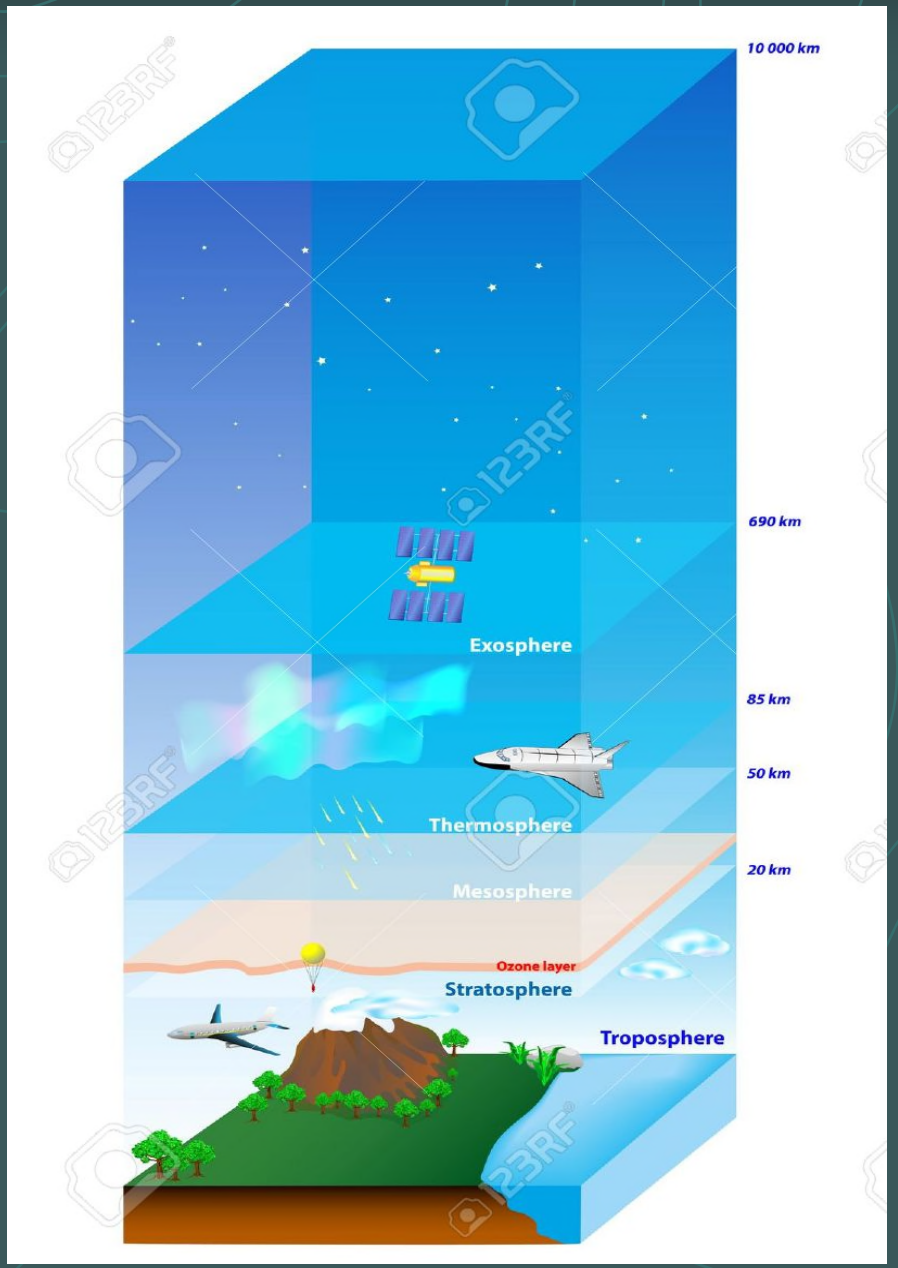
2) https://www.youtube.com/watch?v=6yiTZm0y1YA

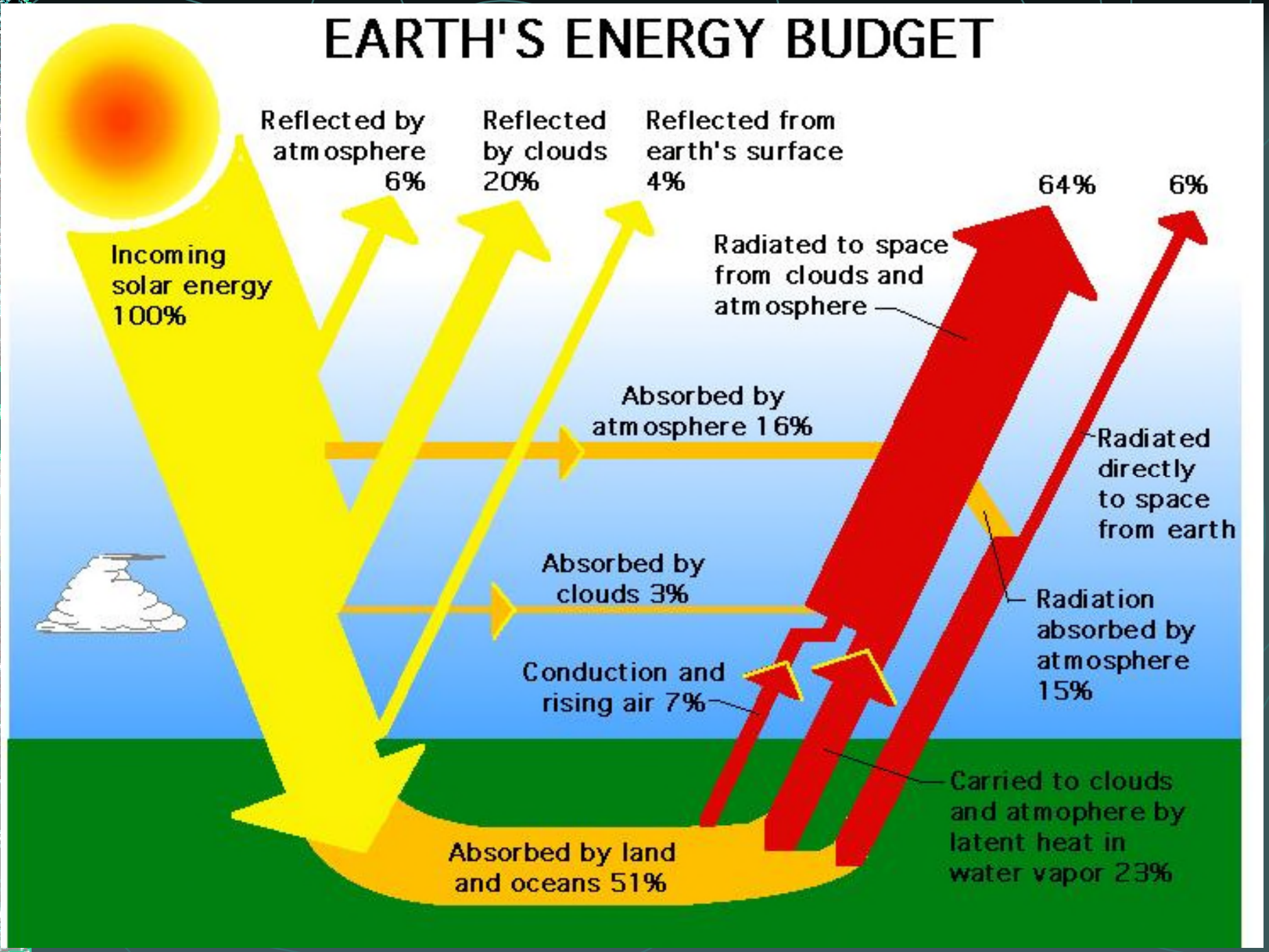
Vertical Structure of Atmosphere

Key Ideas

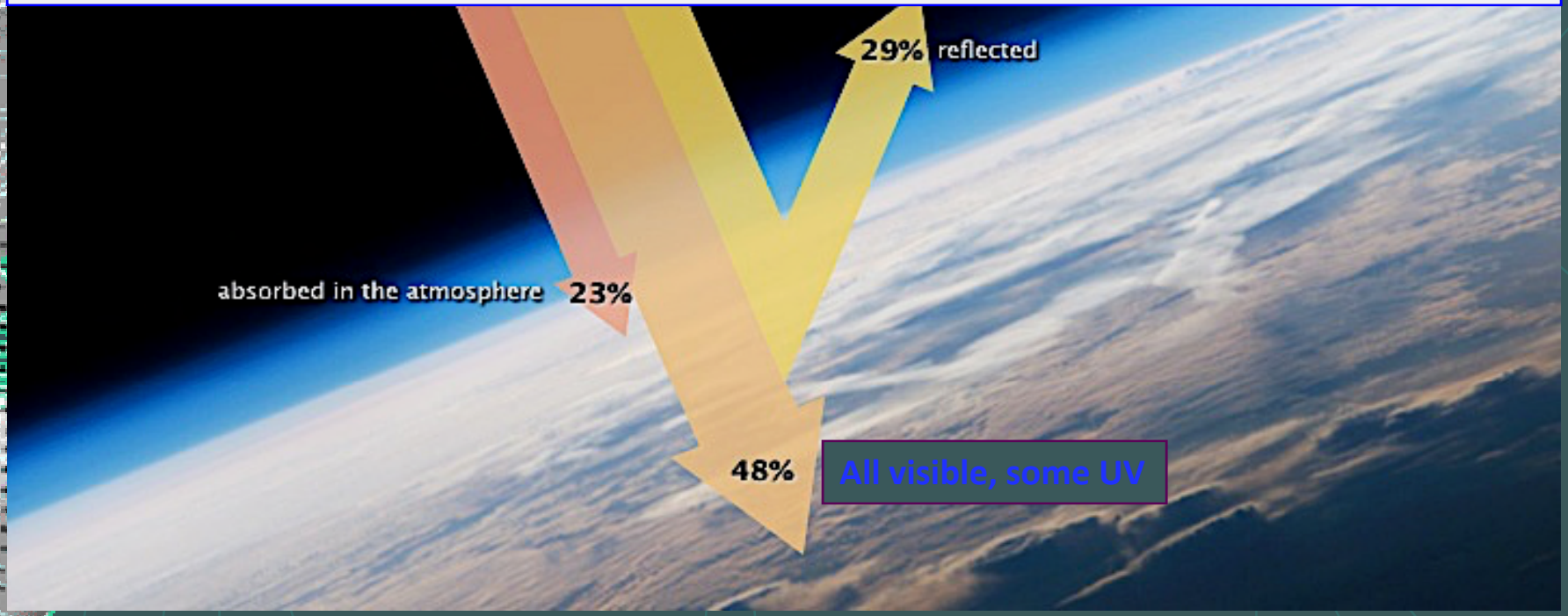
- Density-stratified air column
- Most of air found in troposphere
- Weather occurs in troposphere
- Jet stream at top of troposphere
- Ozone found in stratosphere
- Temperature inversions at the layer boundaries






EARTH'S ENERGY BUDGET
Reflected by atmosphere 6%
Reflected by clouds 20%
Reflected from earth's surface 4%
64%
6%
Incoming solar energy 100%
Radiated to space from clouds and atmosphere
Absorbed by atmosphere 16%
Radiated directly to space from earth
Absorbed by clouds 3%
Radiation absorbed by atmosphere 15%
Conduction and rising air 7%
Carried to clouds and atmophere by latent heat in water vapor 23%
Absorbed by land and oceans 51%

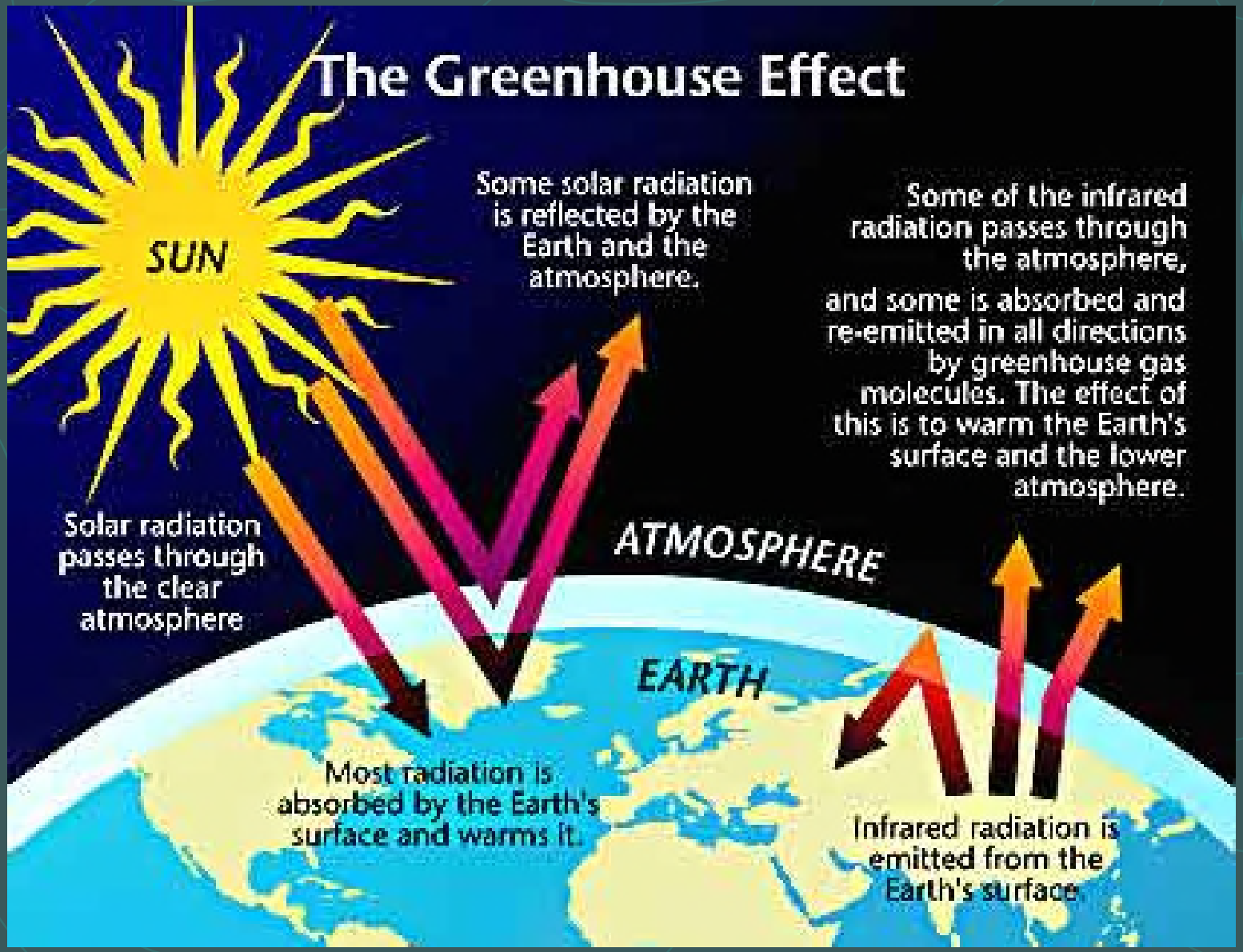
EARTH'S DYNAMIC ENERGY BUDGET: The flow of incoming (sunlight) and outgoing energy (reflected sunlight and surface heat)



29% (**30%**) of **incoming sunlight is reflected back** to space by particles in the **atmosphere and** bright **ground** surfaces,

71% (**70%**) of **incoming sunlight is absorbed by both, the atmosphere** (23% = **20%**) and the **Earth's surface** (48% = **50%**).

Earth's Greenhouse Effect



Greenhouse Gases

Greenhouse gases	Chemical formula	Pre-industrial concentration	Concentration in 1994	Atmospheric lifetime (years)***	Anthropogenic sources	Global warming potential (GWP)
Carbon-dioxide	CO_2	280 ppmv	358 ppmv	50-200	Fossil fuel combustion Land use conversion Cement production	1
Methane	CH_4	700 ppbv	1720 ppmv	12-17	Fossil fuels Rice paddies Waste dumps Livestock	21 **
Nitrous oxide	N_2O	275 ppbv	312 ppmv	120-150	Fertilizer industrial processes combustion	310
CFCs	CFC-12	0	503 pptv	102	Liquid coolants. Foams	125-152
HCFCs	HCFC-22	0	105 pptv	13	Liquid coolants	125
Perfluoromethane	CF_4	0	1 10 pptv	50 000	Production of aluminium	6 500
Sulphur hexafluoride	SF_6	0	72 pptv	1 000	Production of magnesium	23 900

Note : pptv = 1 part per trillion by volume; ppbv = 1 part per billion by volume, ppmv = 1 part per million by volume

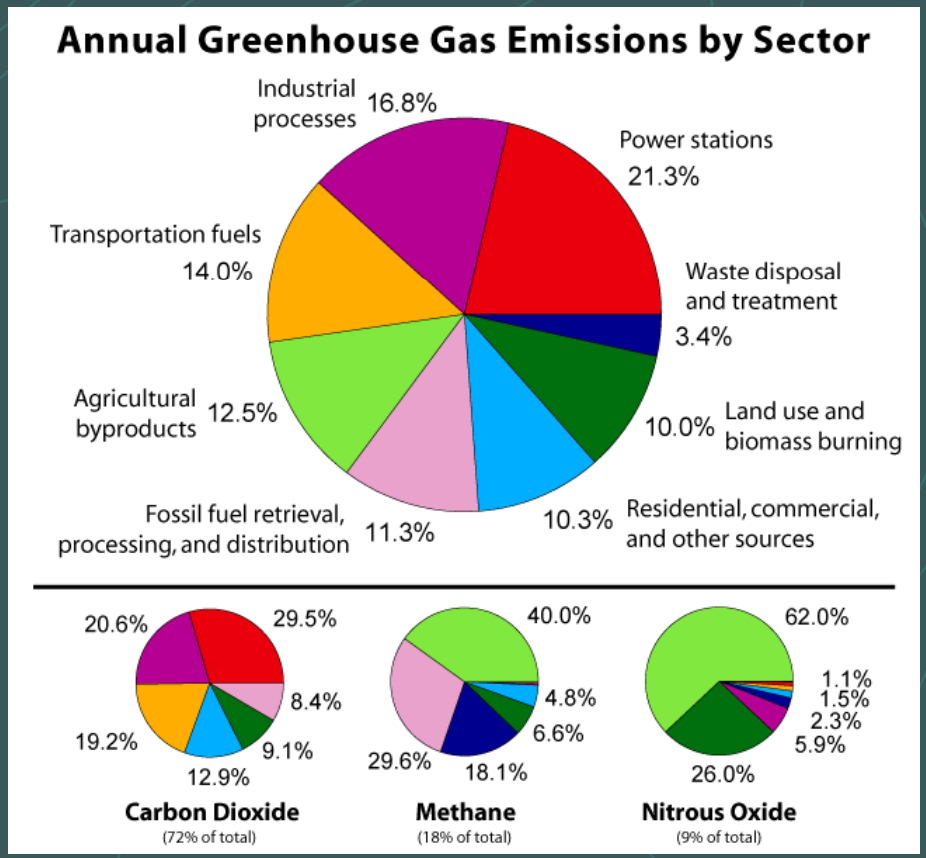
* GWP for 100 year time horizon. ** Includes indirect effects of troposphericozone production and stratospheric water vapour production. *** On page 15 of the IPCC SAR. No single lifetime for CO can be defined because of the different rates of uptake by different sink processes.

GRID Arendal UNEP

Source: IPCC radiative forcing report ; Climate change 1995, The science of climate change, contribution of working groupe 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

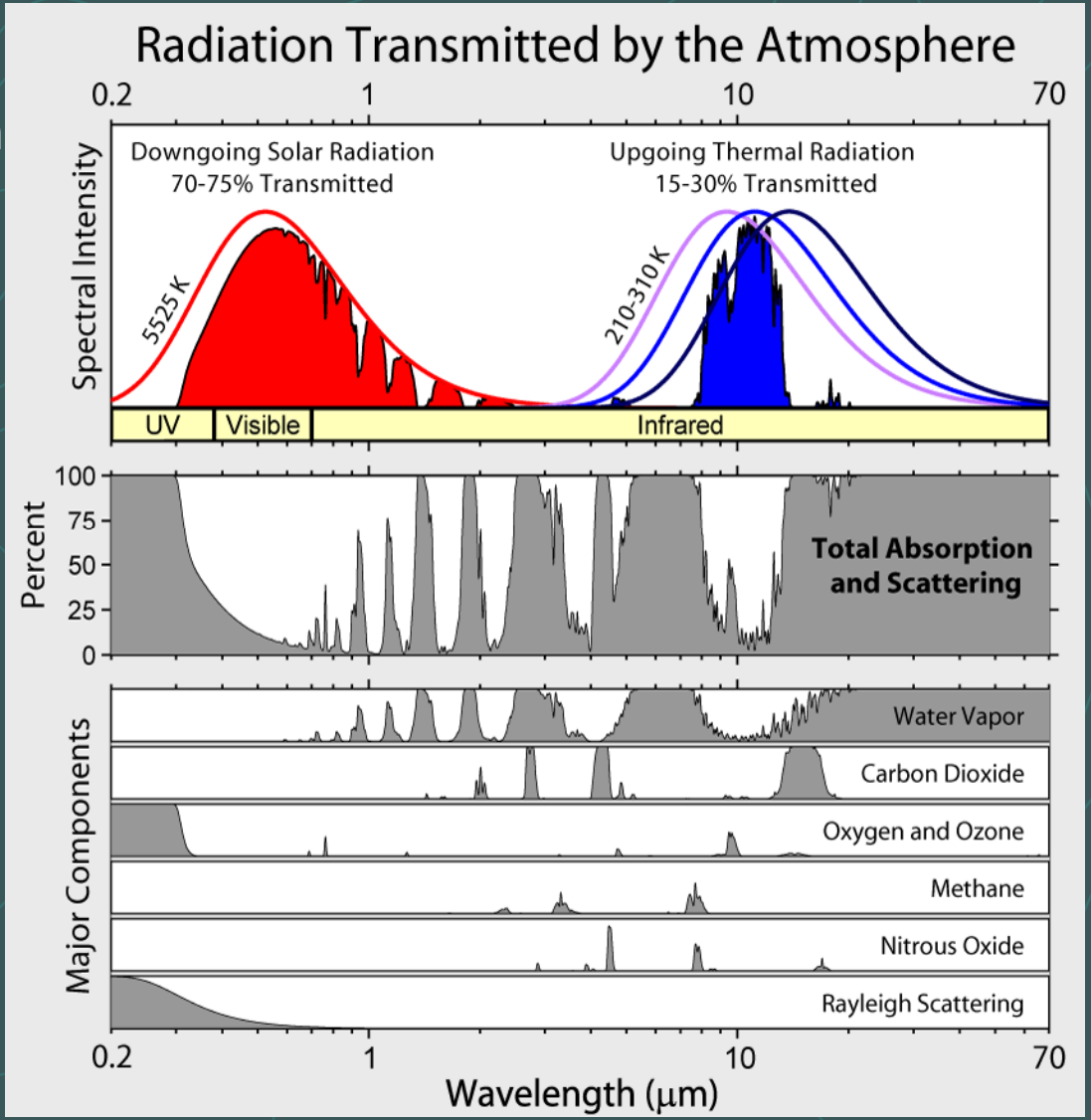
Anthropogenic Sources of Greenhouse Gases

Seven main fossil fuel combustion sources	(%)
Liquid fuels (e.g., gasoline, fuel oil)	36 %
Solid fuels (e.g., coal)	35 %
Gaseous fuels (e.g., natural gas)	20 %
Cement production	3 %
Flaring gas industrially and at wells	< 1 %
Non-fuel hydrocarbons	< 1 %
"International bunker fuels" of transport not included in national inventories	4 %



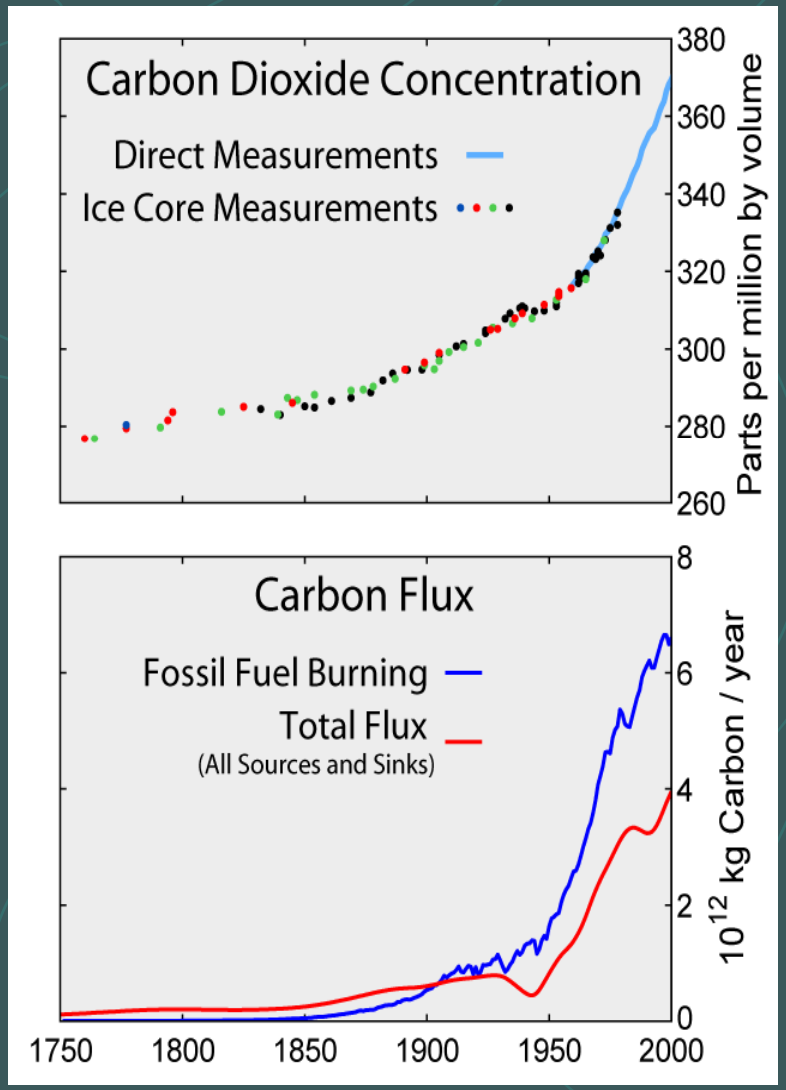
Greenhouse Gases – Heat Traps

Gas	Formula	Contribution (%)
Water vapor	H_2O	36 – 72 %
Carbon dioxide	CO_2	9 – 26 %
Methane	CH_4	4 – 9 %
Ozone	O_3	3 – 7 %

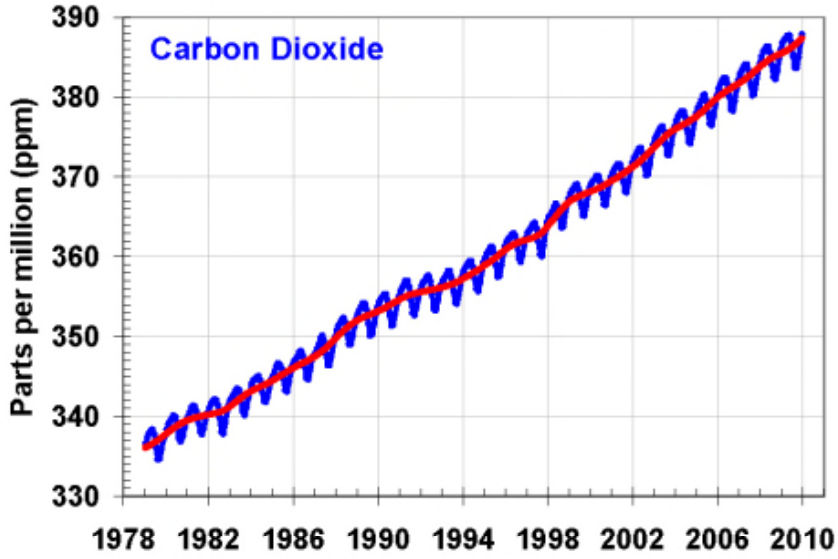


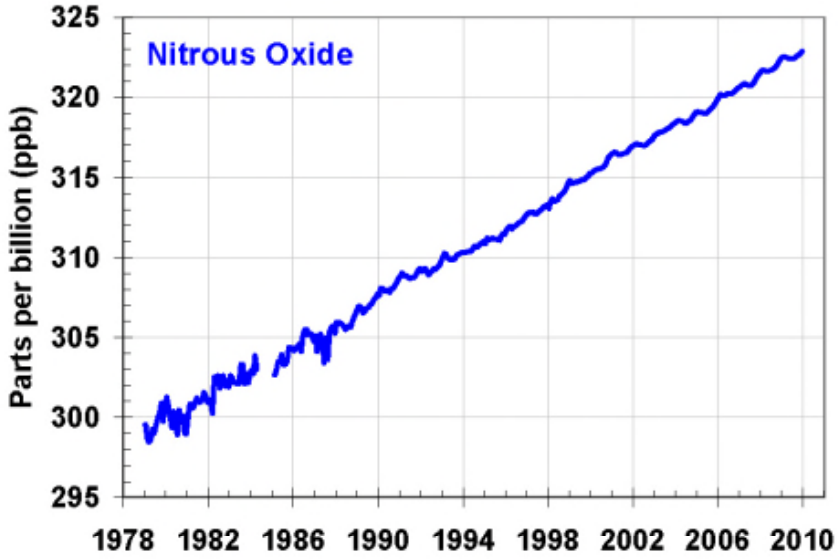
Major Increases in Atmospheric Greenhouse Gases

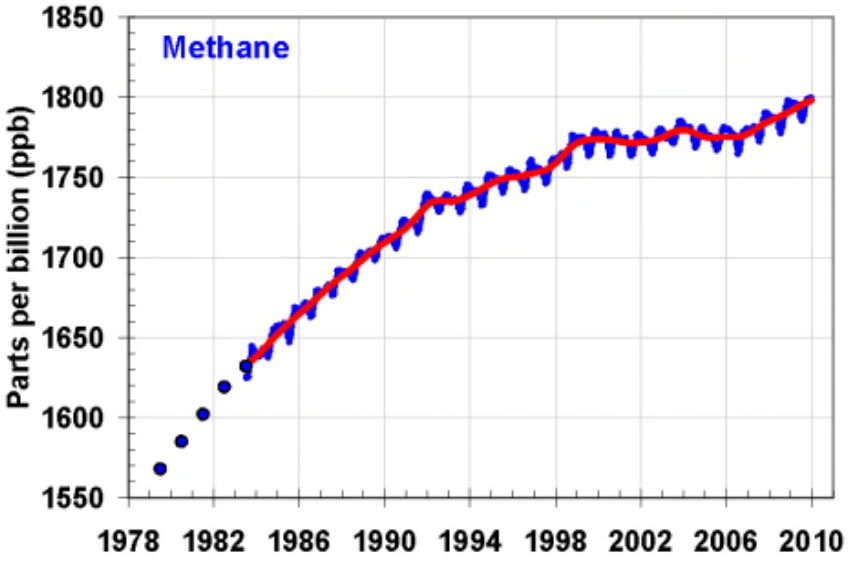
Gas	Preindustrial level	Current level	Increase since 1750
Carbon dioxide	280 ppm	394 ppm	114 ppm
Methane	700 ppb	1745 ppb	1045 ppb
Nitrous oxide	270 ppb	314 ppb	44 ppb
CFC-12	0	533 ppt	533 ppt

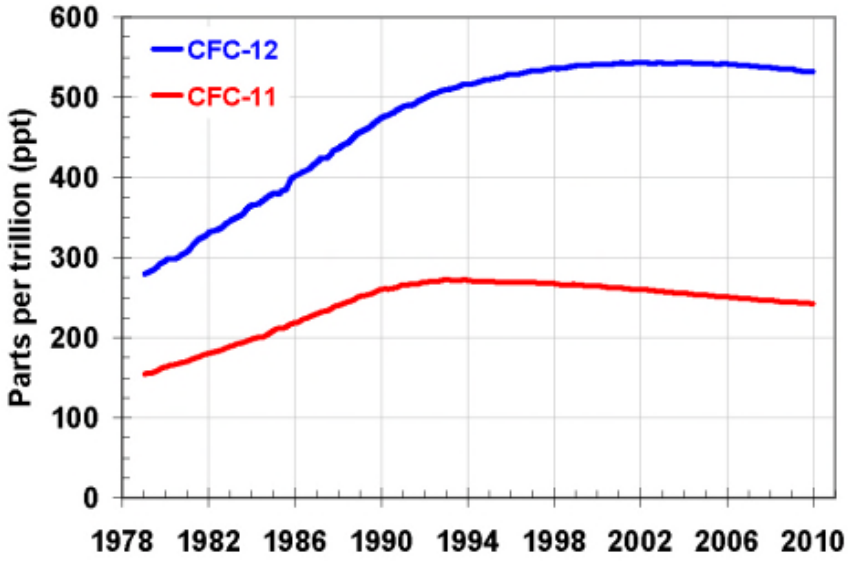


Trends of Greenhouse Gases in Atmospheric

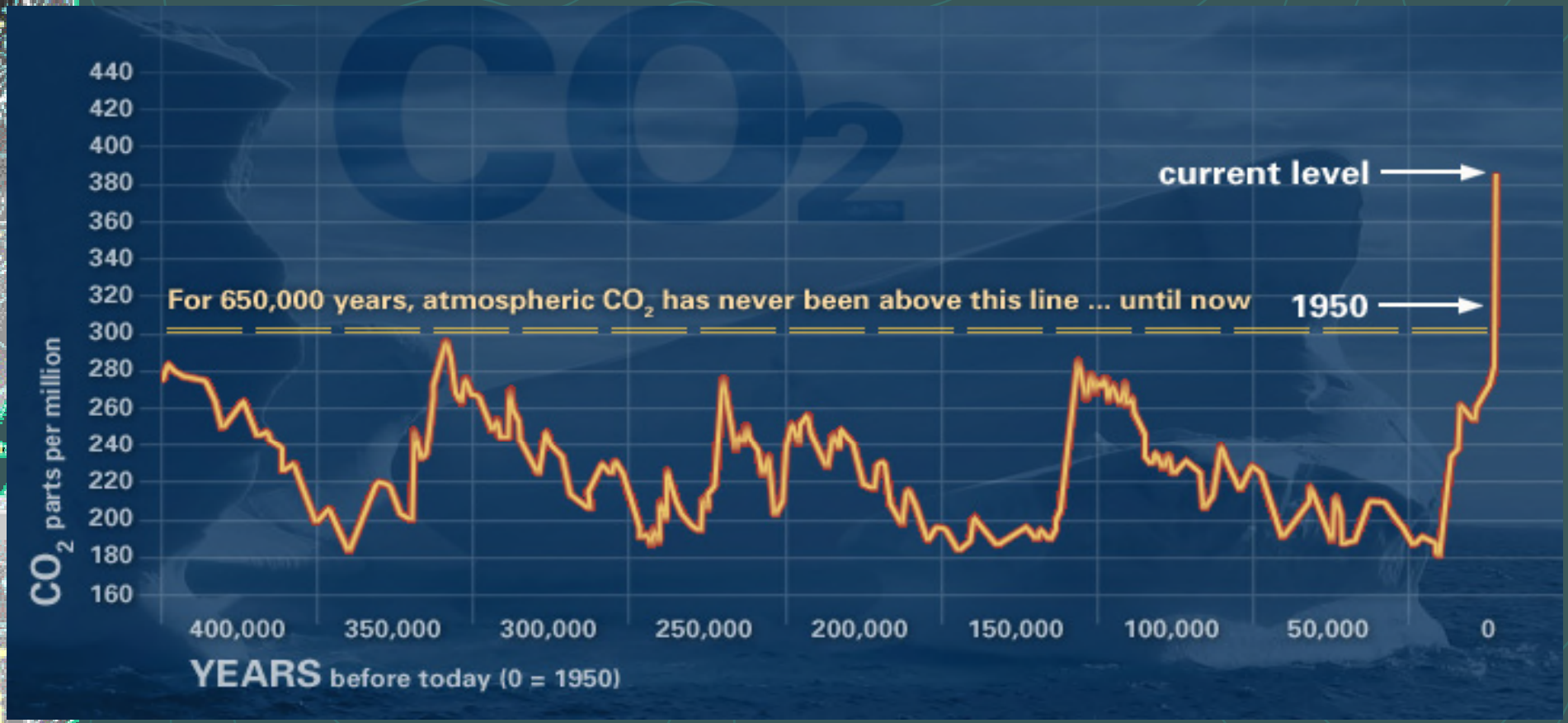








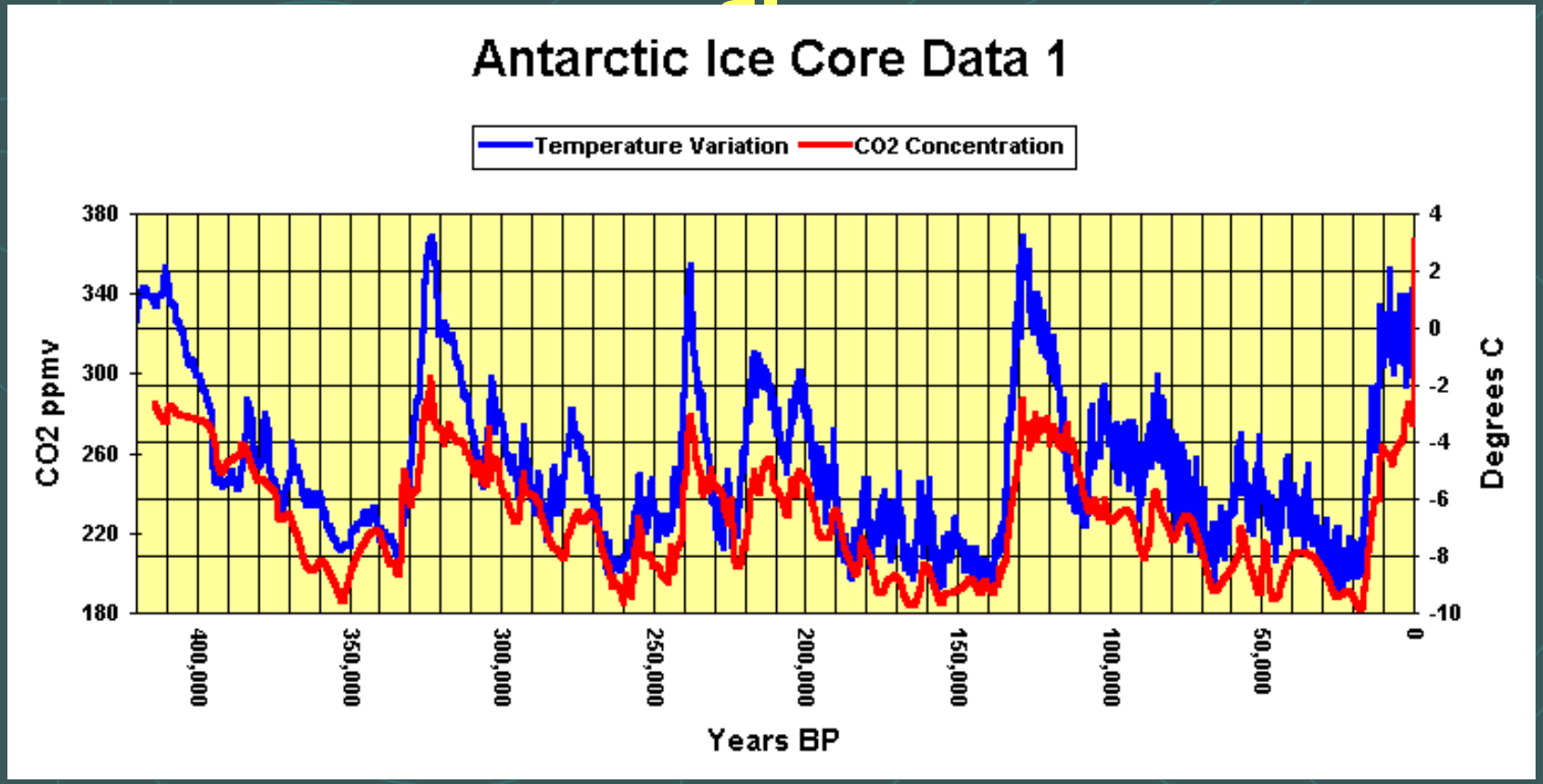
Long term Variations in Atmospheric Carbon Dioxide Levels



Atmospheric carbon dioxide levels have never exceeded 300 ppm over the last half a million years until 1950. Today the level is at 400 ppm and steadily climbing.

Long-term Global Warming

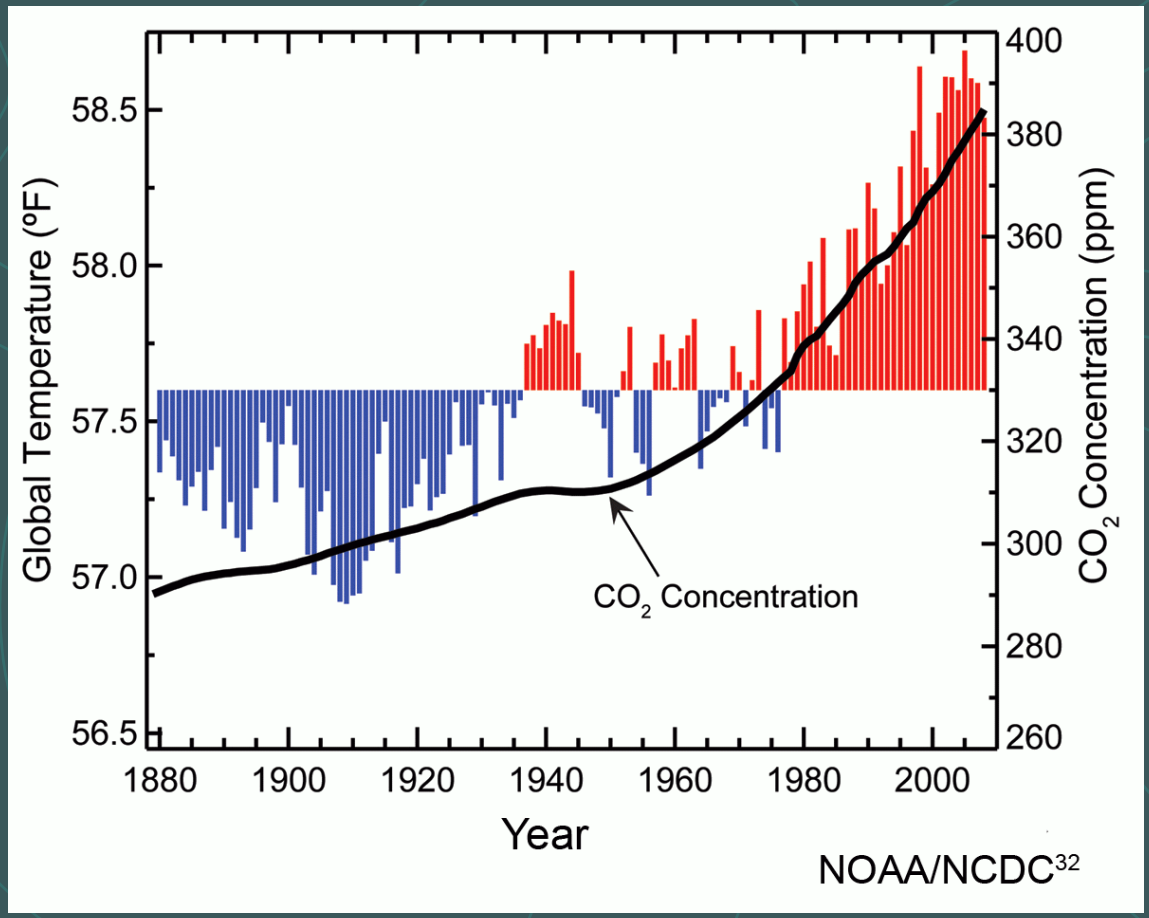
Atmospheric CO_2 versus Global Temperature



Above data for last 500,000 years showing variations in atmospheric carbon dioxide levels and global temperature comes from ancient ice cores and sea bottom sediments

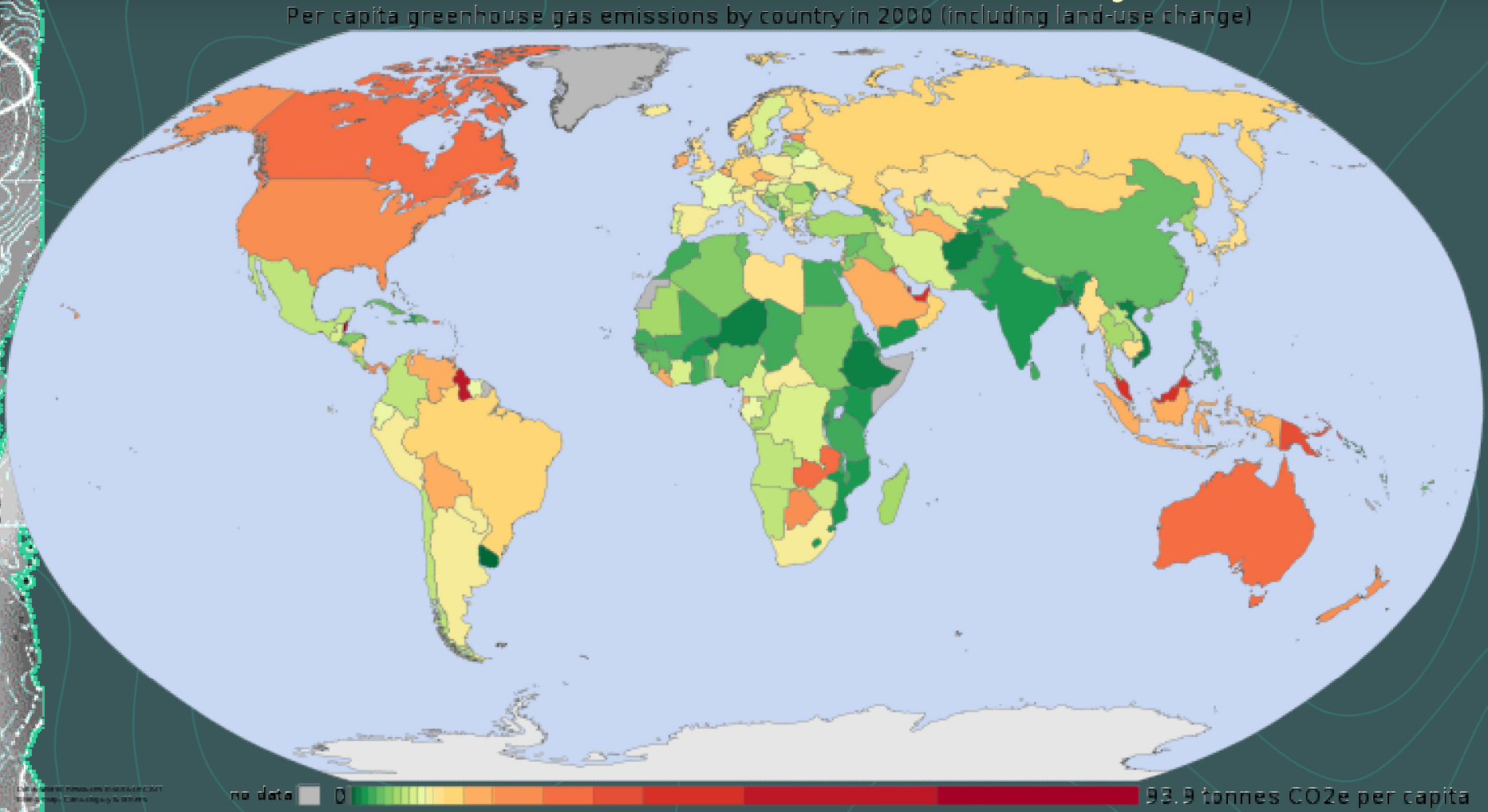
Short-term Global Warming

Atmospheric CO_2 versus Global Temperature



Data for global temperature and atmospheric carbon dioxide over last 130 years

Greenhouse Gas Emissions by Nation



Per capita anthropogenic greenhouse gas emissions by country for the year 2000, including land-use change

Global Warming – Cause and Effect

What is Global Warming?

Greenhouse gases trap some of the sun's energy within our atmosphere and increase the temperature of the Earth's surface and atmosphere. This is called the greenhouse effect.

1. Solar energy passes through the atmosphere, is absorbed by the Earth's surface, and warms it up.

2. Greenhouse gases absorb some of the reflected heat energy. Without them the Earth's avarage temperature would be around -18 degrees Celsius.

3. Human actions gradually increase concentration of greenhouse gases in the atmosphere and lead to global warming.

Agriculture

- Agriculture is a huge source of methane and nitrous oxide, and responsible for 15% of worldwide greenhouse gas emissions.
- Climate-friendly agricultural management (i.e. organic farming) could reduce emissions significantly.

Traffic

- One quarter of all man-made CO_2 emissions is transportation-related.
- 750 million cars worldwide emit a total of approx. 2.25 billion tons of CO_2 each year.

Industrialization

- Industrial production is responsible for more than half of all CO_2 emissions.
- Largest quantities of CO_2 emitted by energy producers and energy-intensive industries
- New filtration technologies could reduce CO_2 emissions by 30 to 50%.

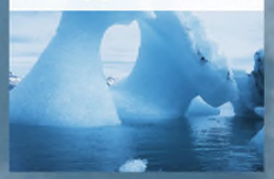
Deforestation

- A quarter of CO_2 emissions worldwide result from deforestation.
- Net forest loss since 2000: 7.3 mill. hectares per year (roughly the size of Panama)
- Improvement measures: afforestation, reforestation, avoided deforestation

Following effects emerge:

4. The accelerated warming process has a number of dangerous impacts (see below).

Melting glaciers/icecaps

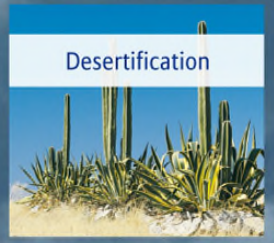


- Since the early 1960s, mountain glaciers around the world have experienced an estimated net loss of over 4.000 cubic kilometers of water; this loss was more than twice as fast during the 1990s as in the previous decades.
- Projection: 4°C rise in average global temperatures would cause nearly all of the world's glaciers to melt, resulting in rising sea levels

Increase of storms

- Globally, the annual number of strong storms doubled from around 8 (early 1970s) to 18 (2000-2004).
- Hurricane Katrina in 2005 was the 6th-largest hurricane on record, and caused over 60 billion US dollars in damage.
- The magnitude and damages caused by the 27 tropical storms in the Atlantic during 2005 were the highest yet recorded.

Desertification



- 2 bill. people in 110 countries are affected and threatened by accelerating desertification.
- The UN projects that 30 % of the world's fertile land surface will turn into desert in the future.
- Example: In Niger, 250,000 hectares, an area about the size of Luxembourg, becomes desert each year.

Sources: **www.panda.org** and **www.fao.org**

10 Indicators of a Human Fingerprint on Climate Change

Less heat escaping to space

Shrinking thermosphere

Cooling stratosphere

Rising tropopause

Less oxygen in the air

More fossil fuel carbon in the air

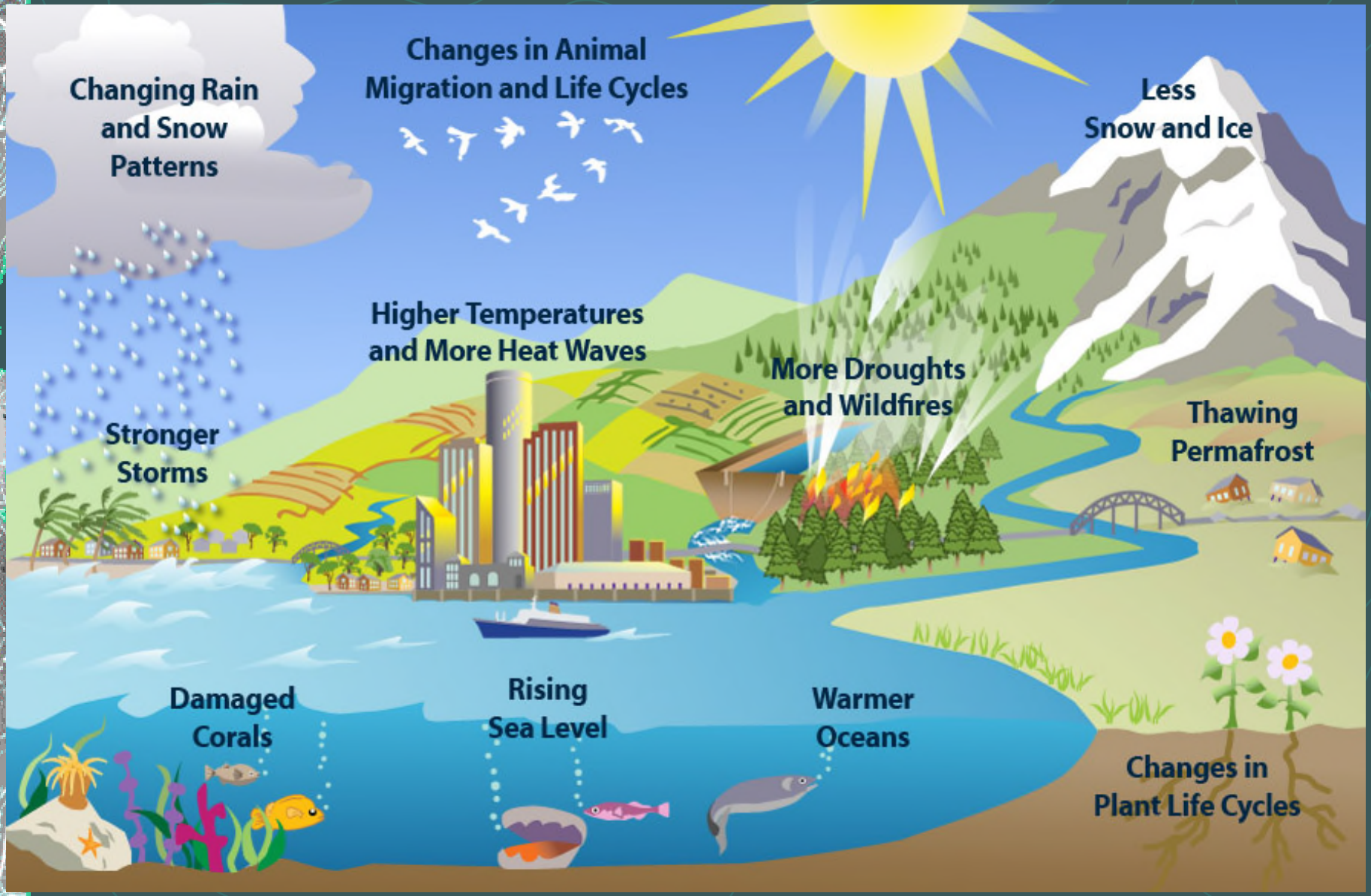
30 billion tonnes of CO_2 per year

More heat returning to Earth

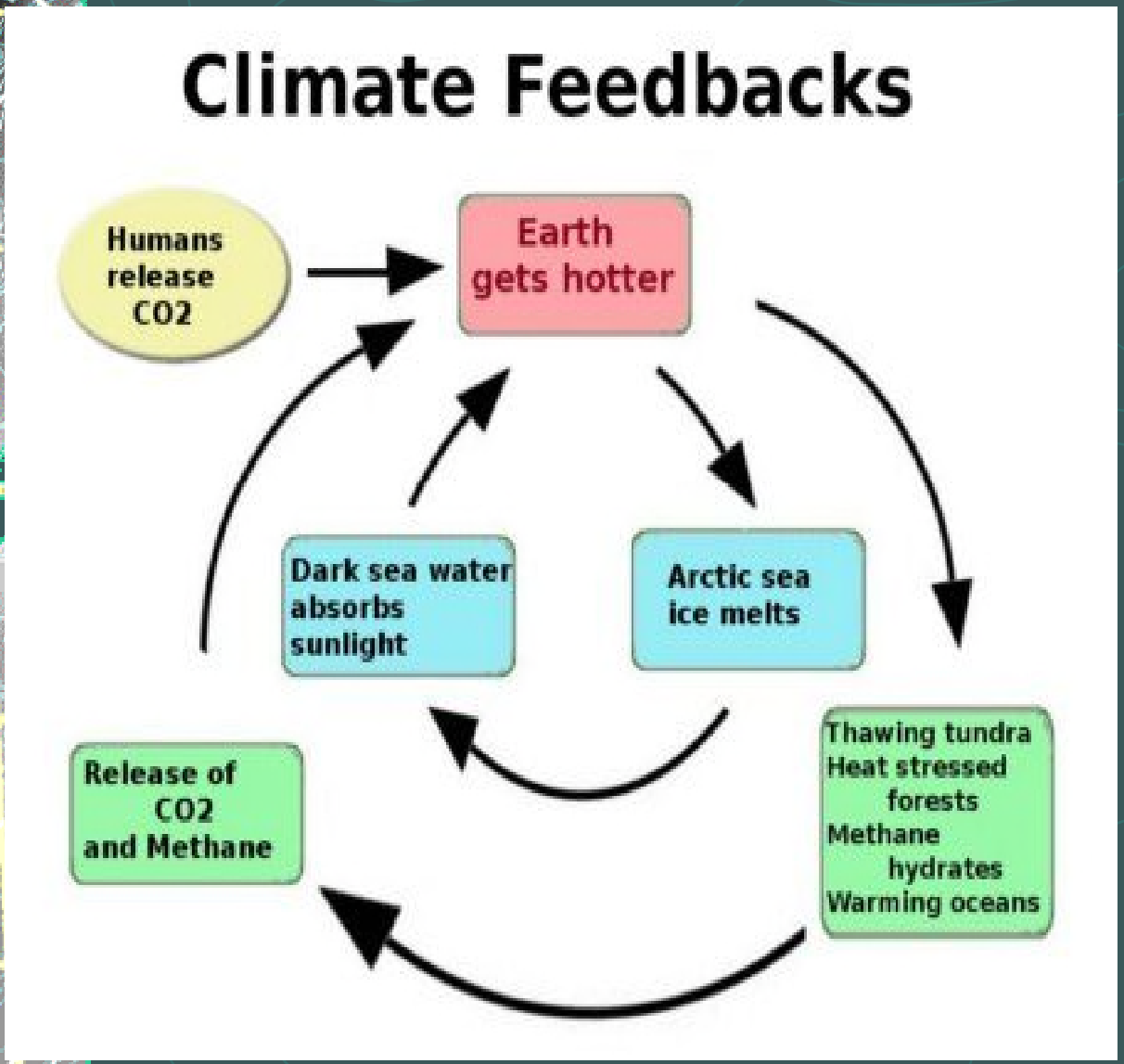
Nights warming faster than days

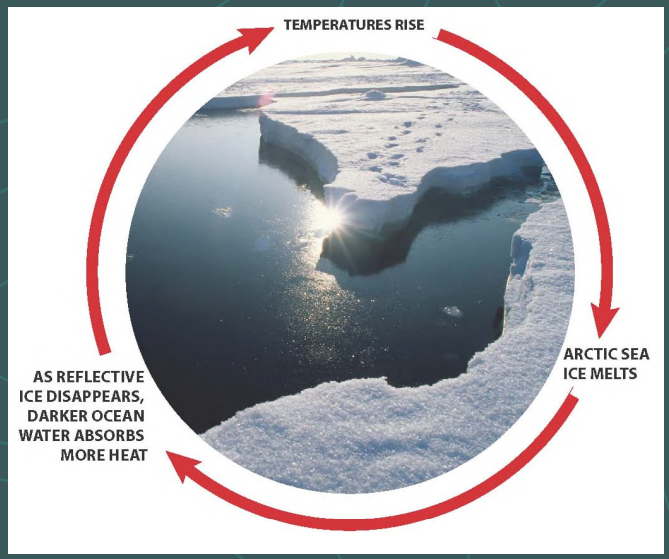
More fossil fuel carbon in coral

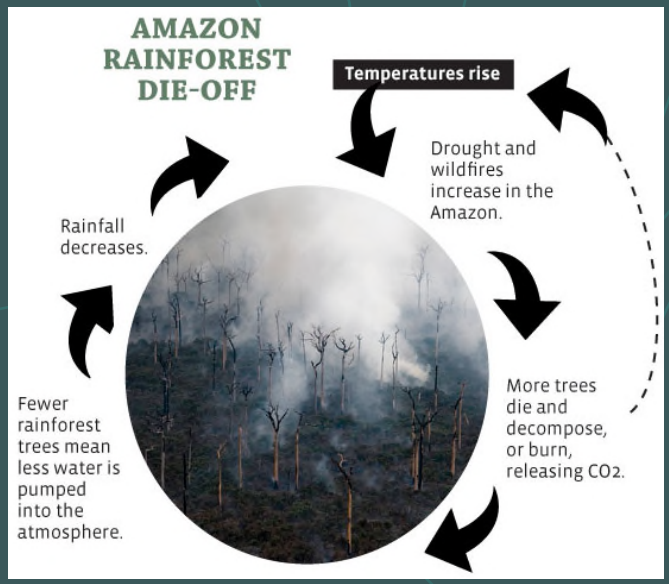
Effects of a Warming of Global Climate



Global Climate Change: Feedback Loops



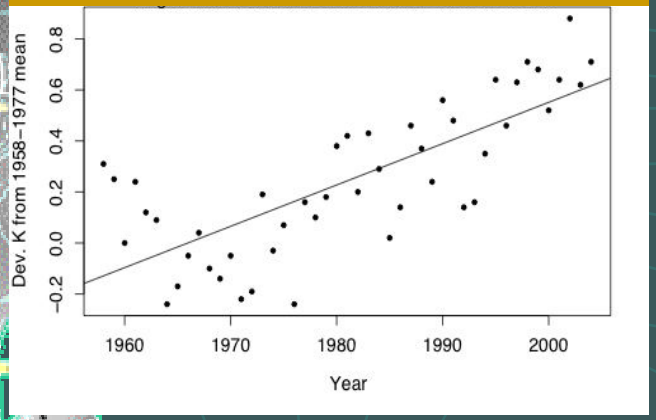




The Big Thaw is Happening

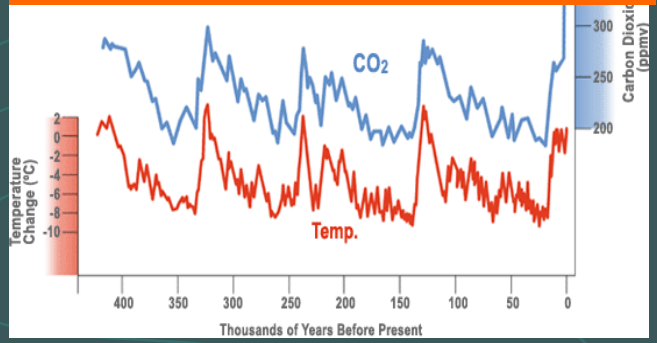
Global Warming – The Evidence

Rising Air and Ground Temperatures



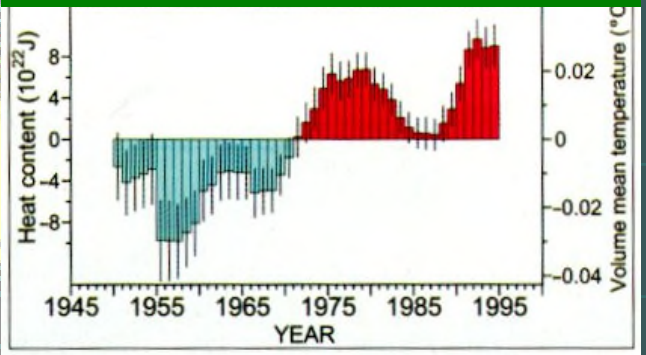
Glacier Retreat

Historic CO_2 vs. Temp



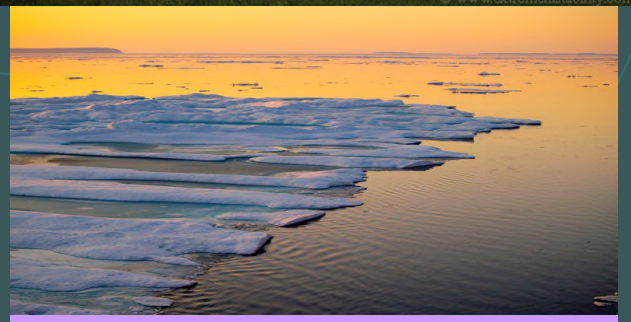
Extreme Weather

Rising Ocean Temperatures



A long, deep warming. Inclusion of neglected data shows that the ocean's top 3000 meters have been warming.

Ocean Acidification



Sea Ice Retreat

Accelerated Melting of Polar Ice Caps

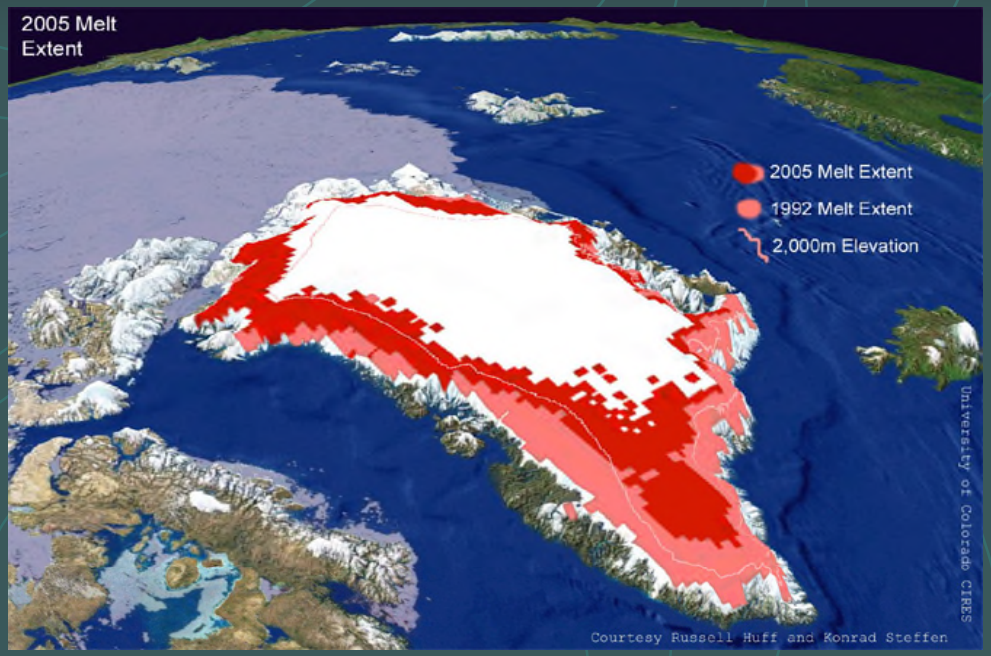
1) Progressive reduction in extent and thickness of polar ice caps

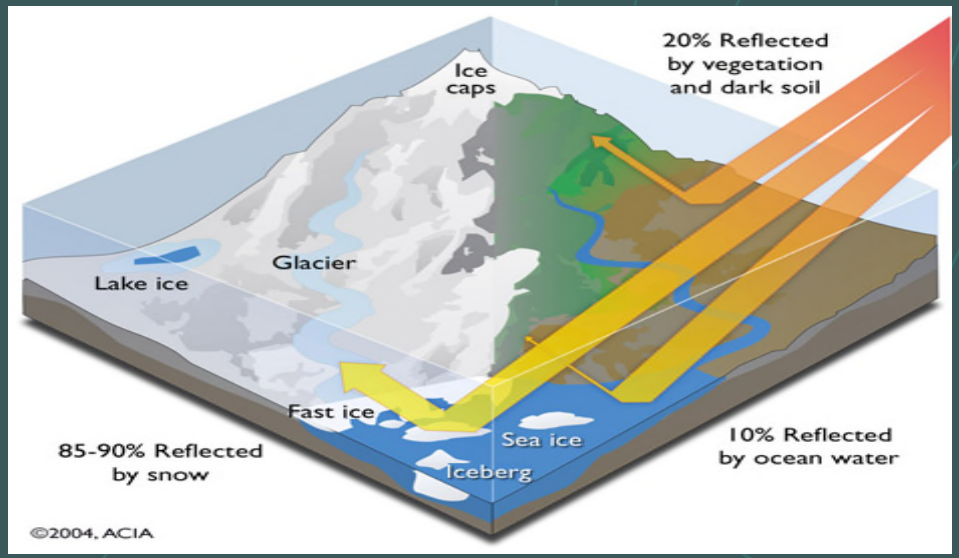
2) Secondary effects:

✓ Reduced sunlight reflection and increased light absorption into land surface

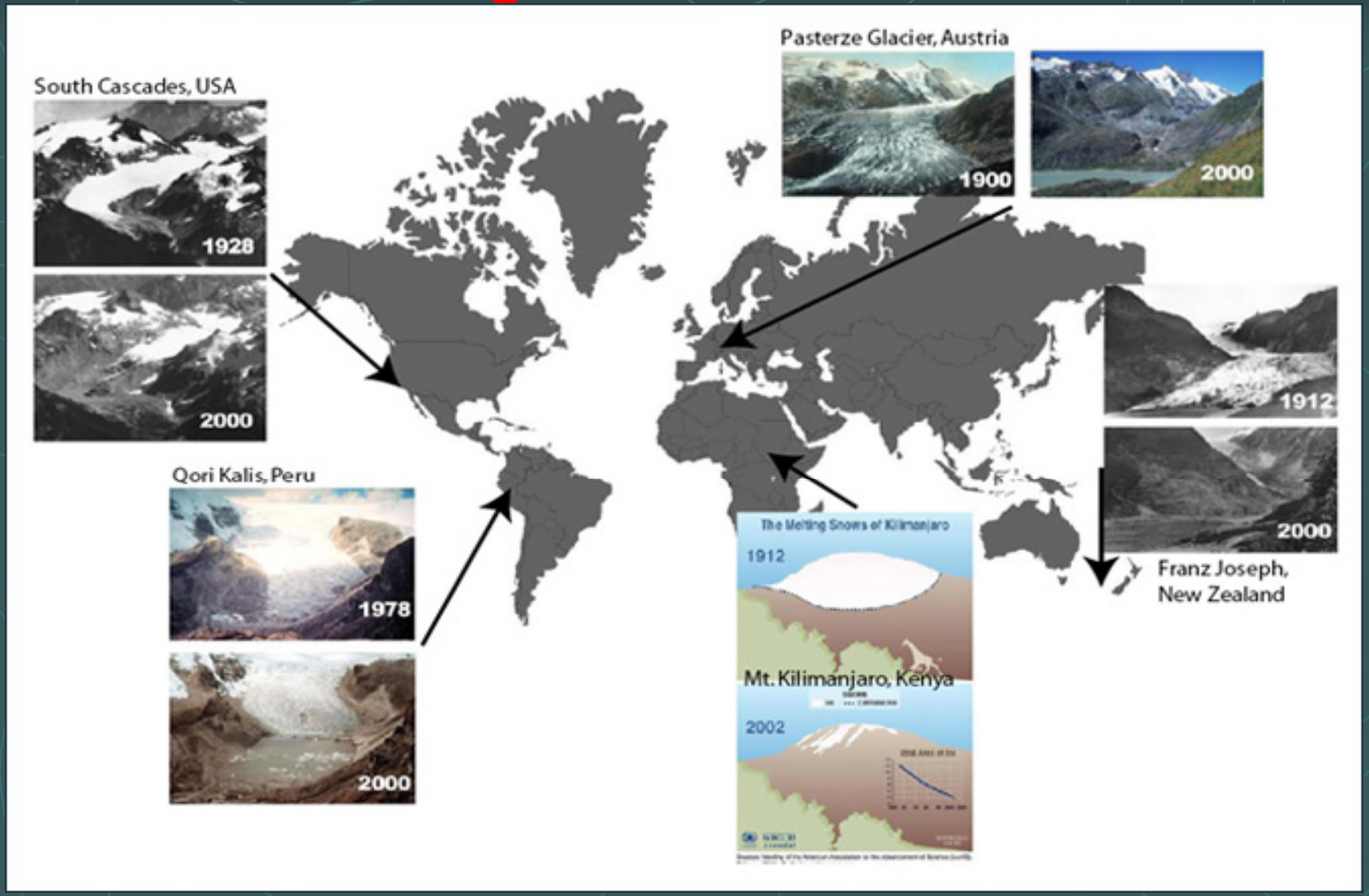
✓ Increase sea levels

✓ Massive influx of freshwater into polar sea surface waters





Melting Mountain Glaciers



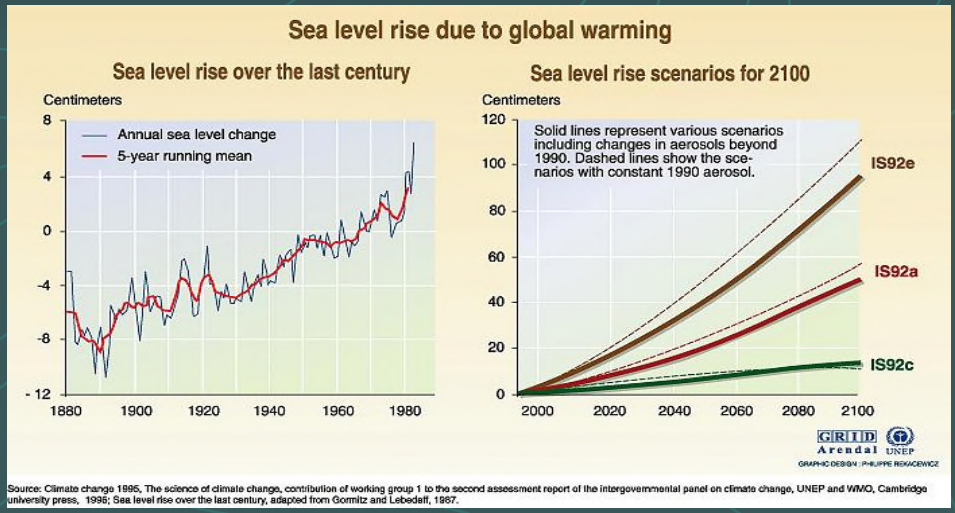
Mountain glaciers on every continent are quickly receding or disappearing altogether

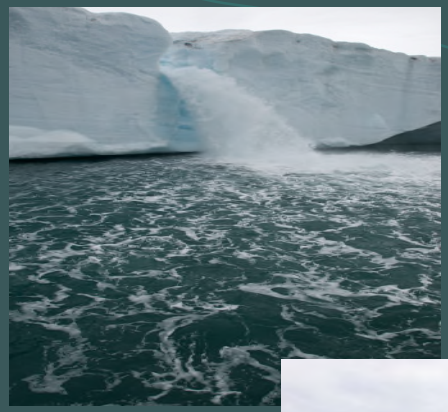
Global Warming Effects –Sea Level

1) Progressive melting of polar ice caps will increase global sea level by tens of centimeters over the next several decades

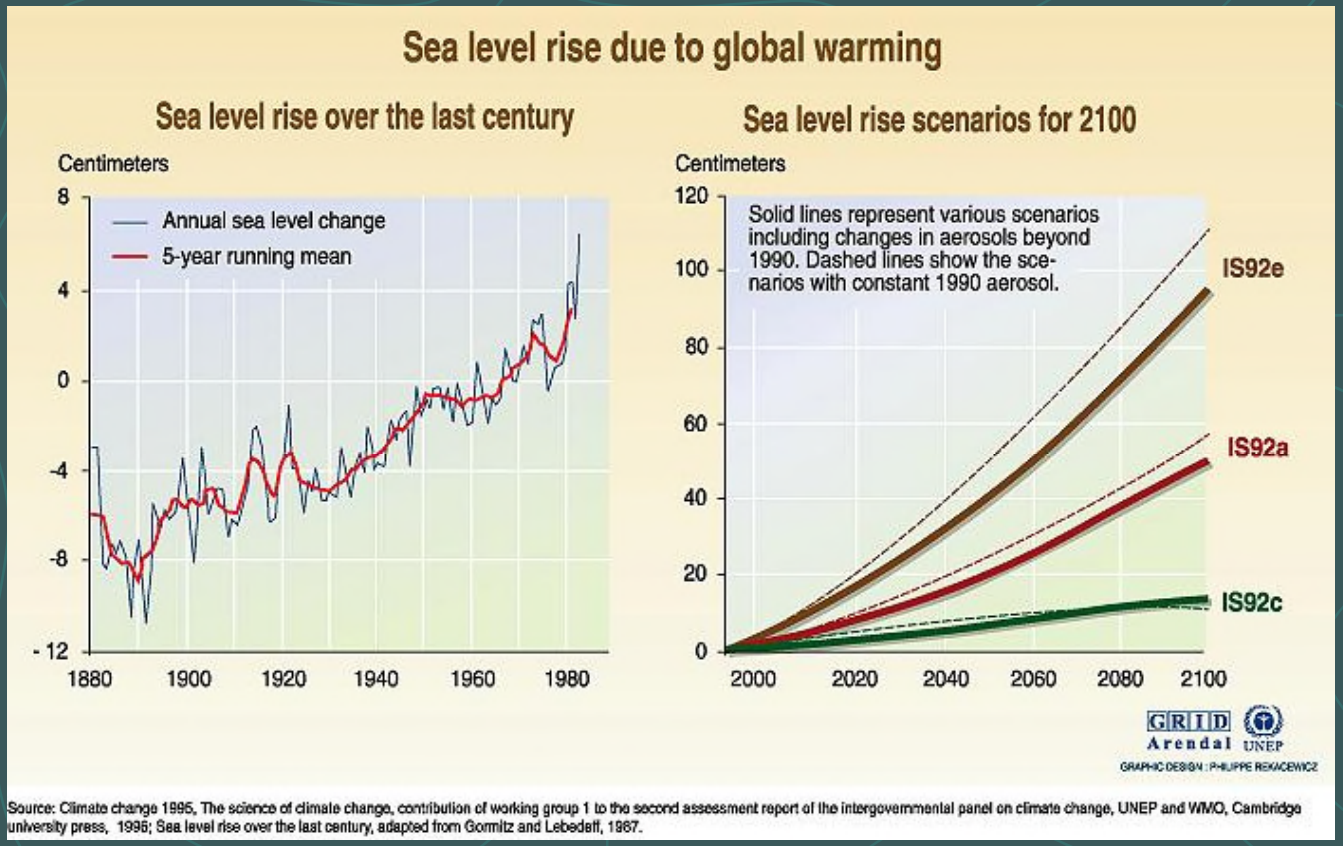
2) Thermal expansion of ocean is also causing rise in sea level by 8 cms for every degree rise in global temperature

2) Low-lying coastal areas under increased risk of marine flooding and eventual inundation





Global Warming and Sea Level Fluctuations



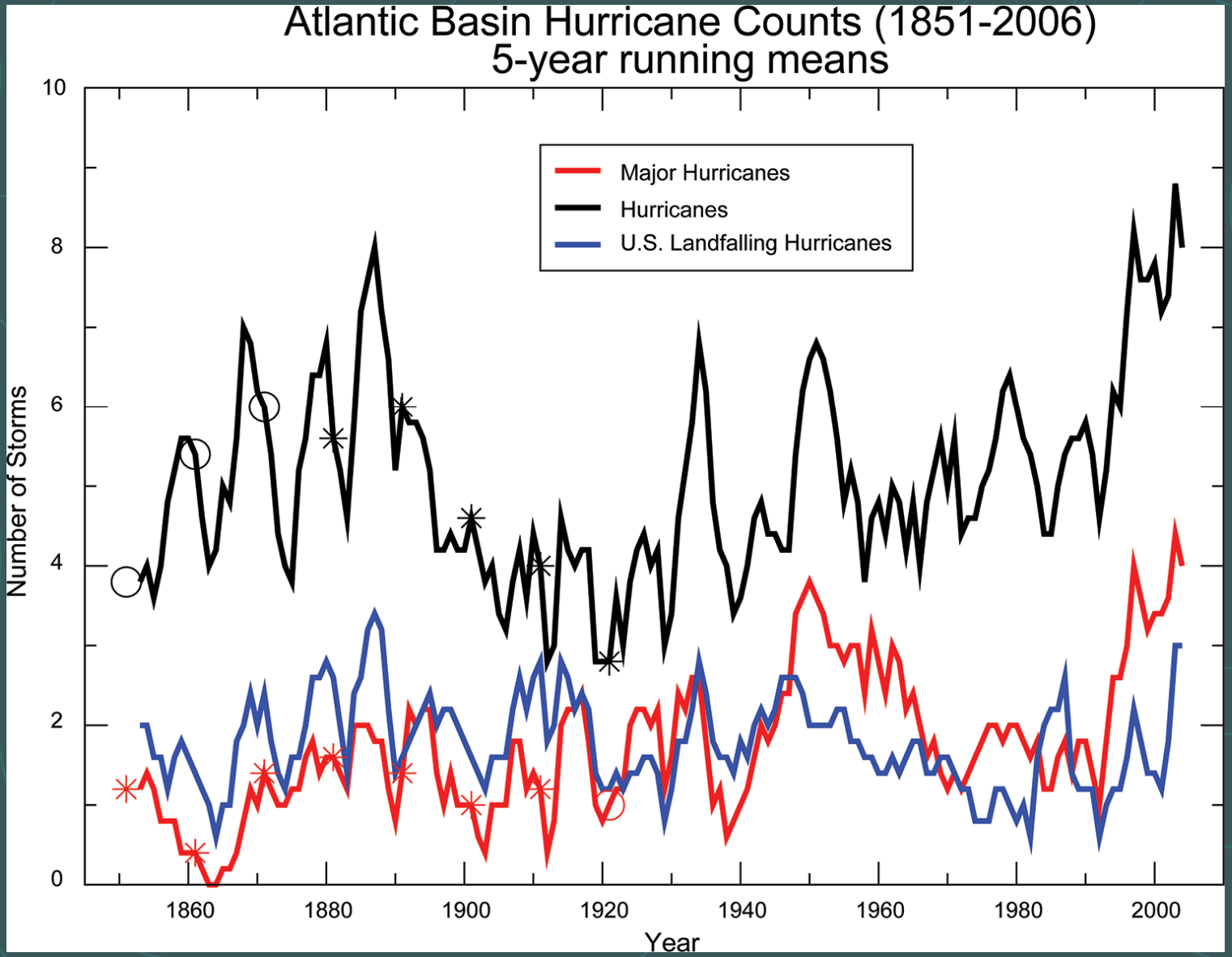
Source: Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996; Sea level rise over the last century, adapted from Gornitz and Lebedeff, 1987.

Global Warming Effects on Weather

1) More extreme weather fluctuations in most regions

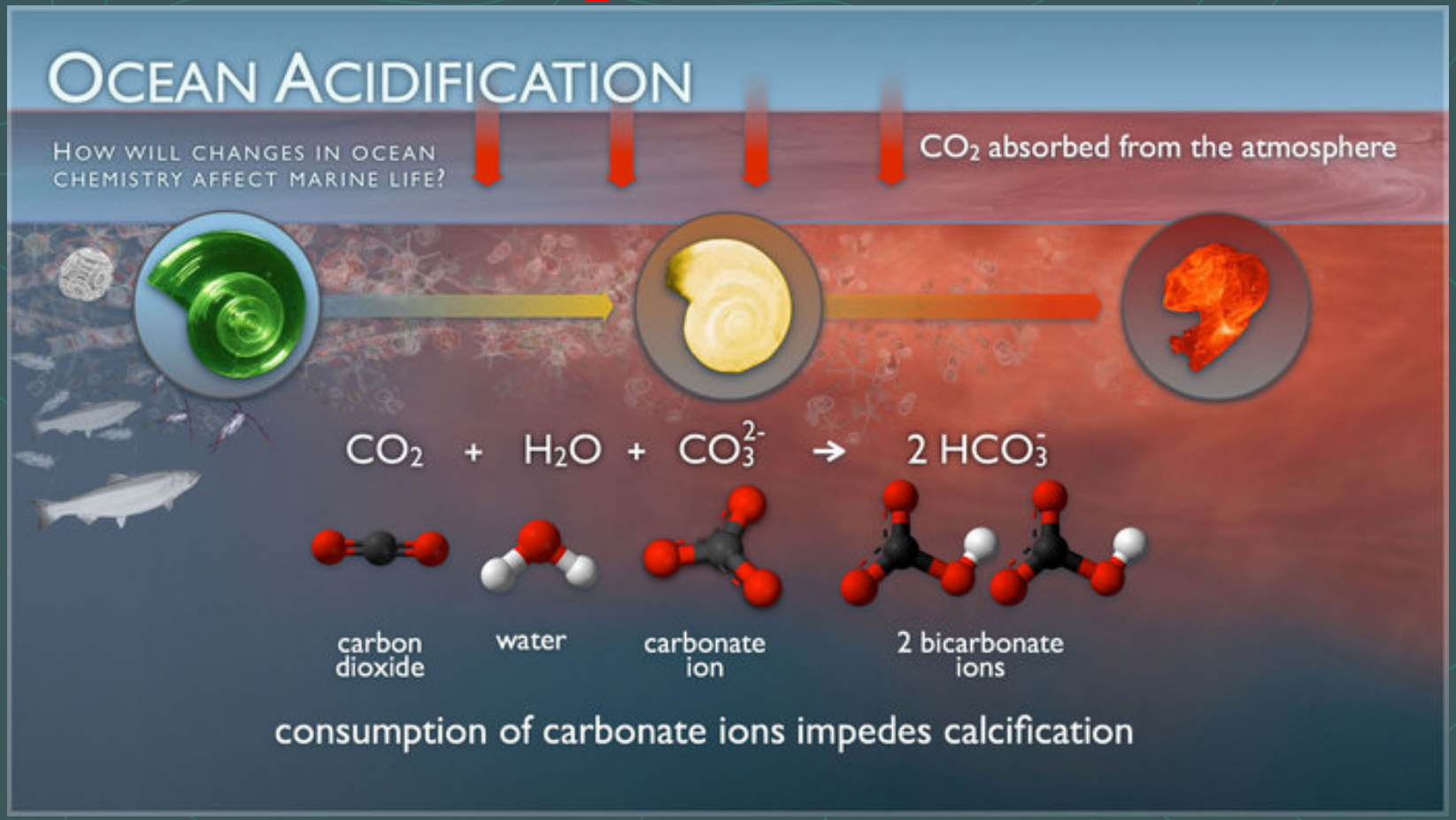
2) More frequent severe weather

Global Warming Effects on Weather



Ocean Acidification

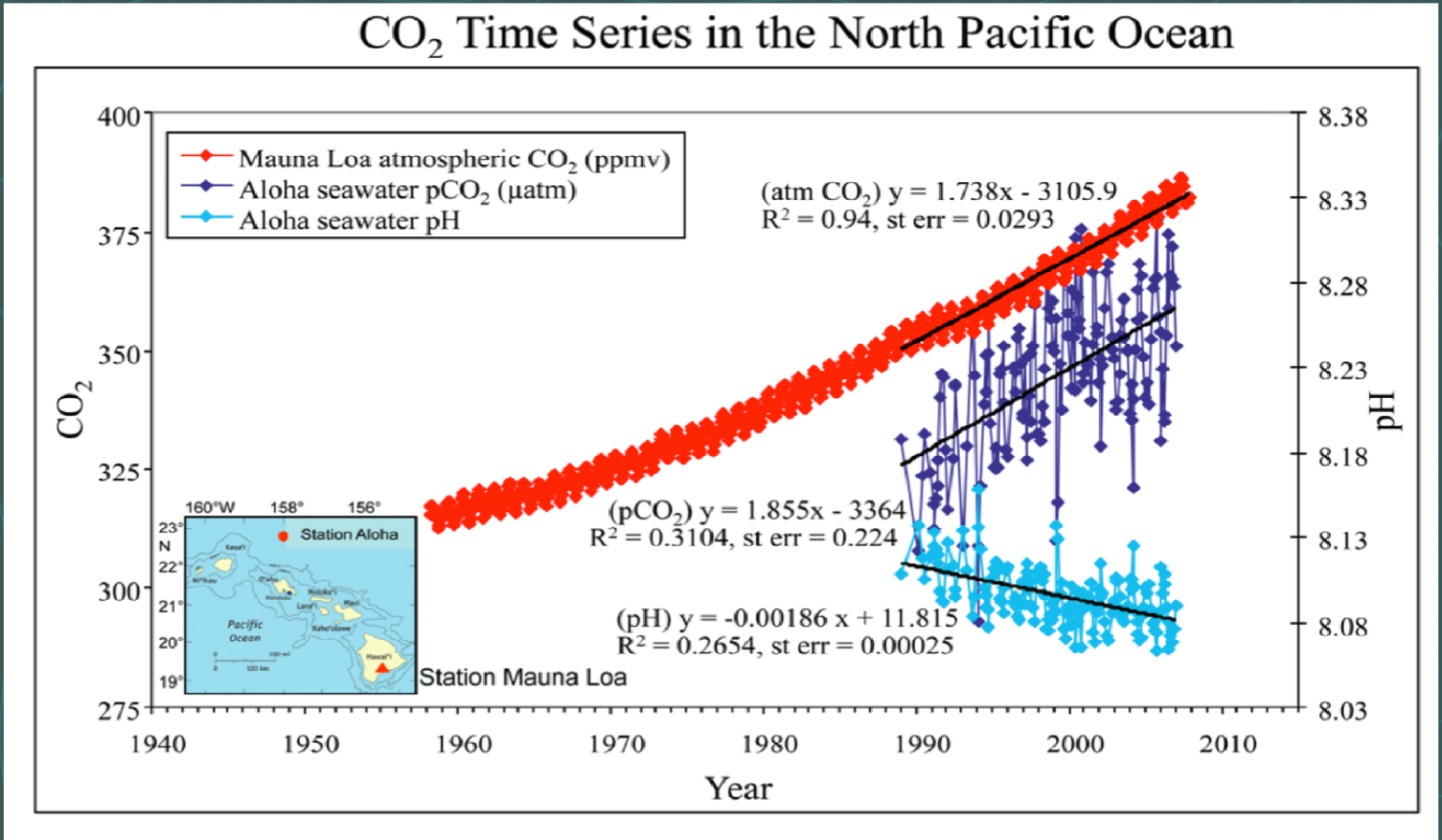
Atmospheric CO_2 versus Ocean pH Level



Increase in atmospheric CO2 leads to increase in absorbed CO2 by ocean, which leads to increase in ocean acidity, which leads to increase in carbonate dissolution levels = bad day for shelled marine life

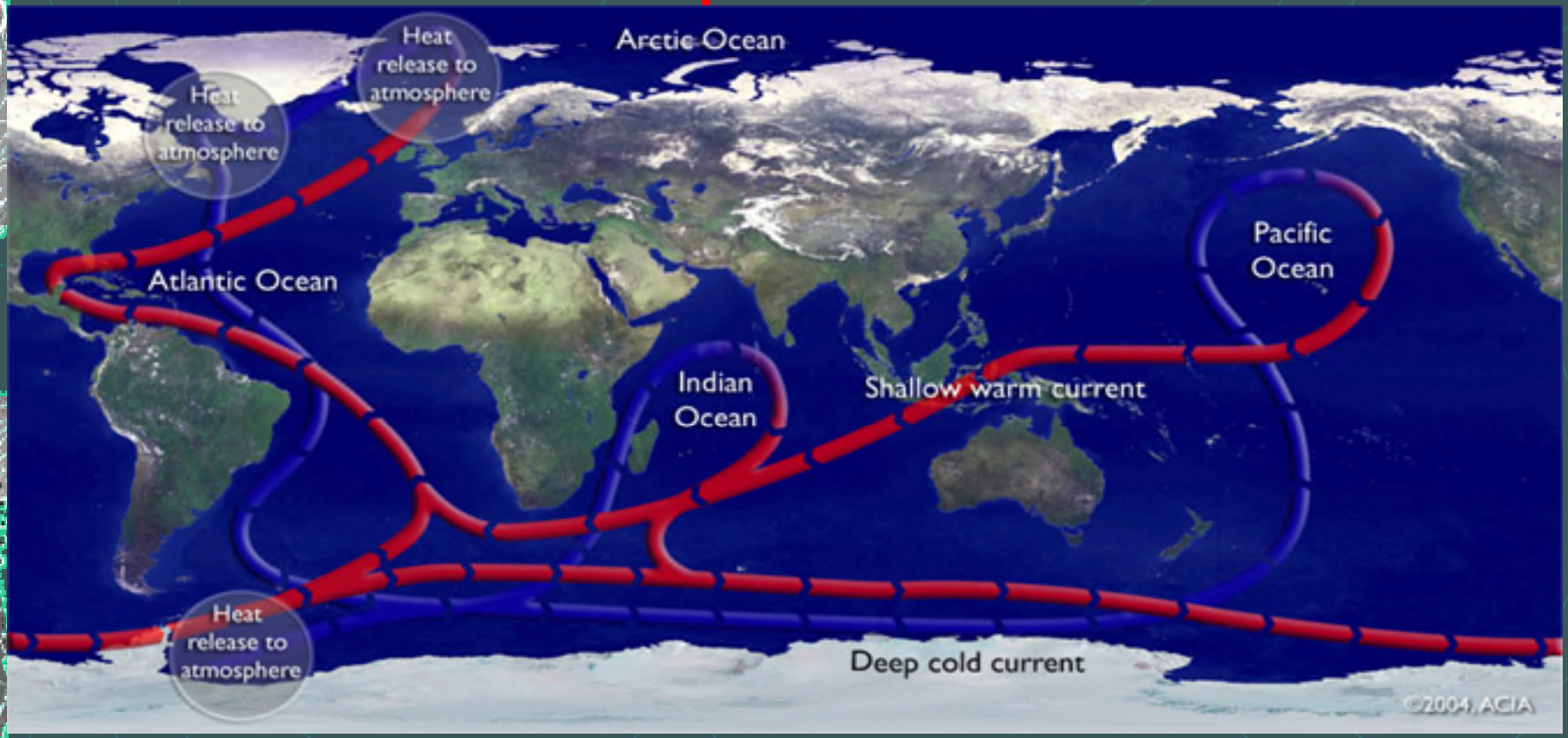
Ocean Acidification

Atmospheric CO_2 versus Ocean pH Level



Increase in atmospheric CO2 leads to increase in absorbed CO2 by ocean, which leads to increase in ocean acidity, which leads to increase in carbonate dissolution levels = bad day for shelled marine life

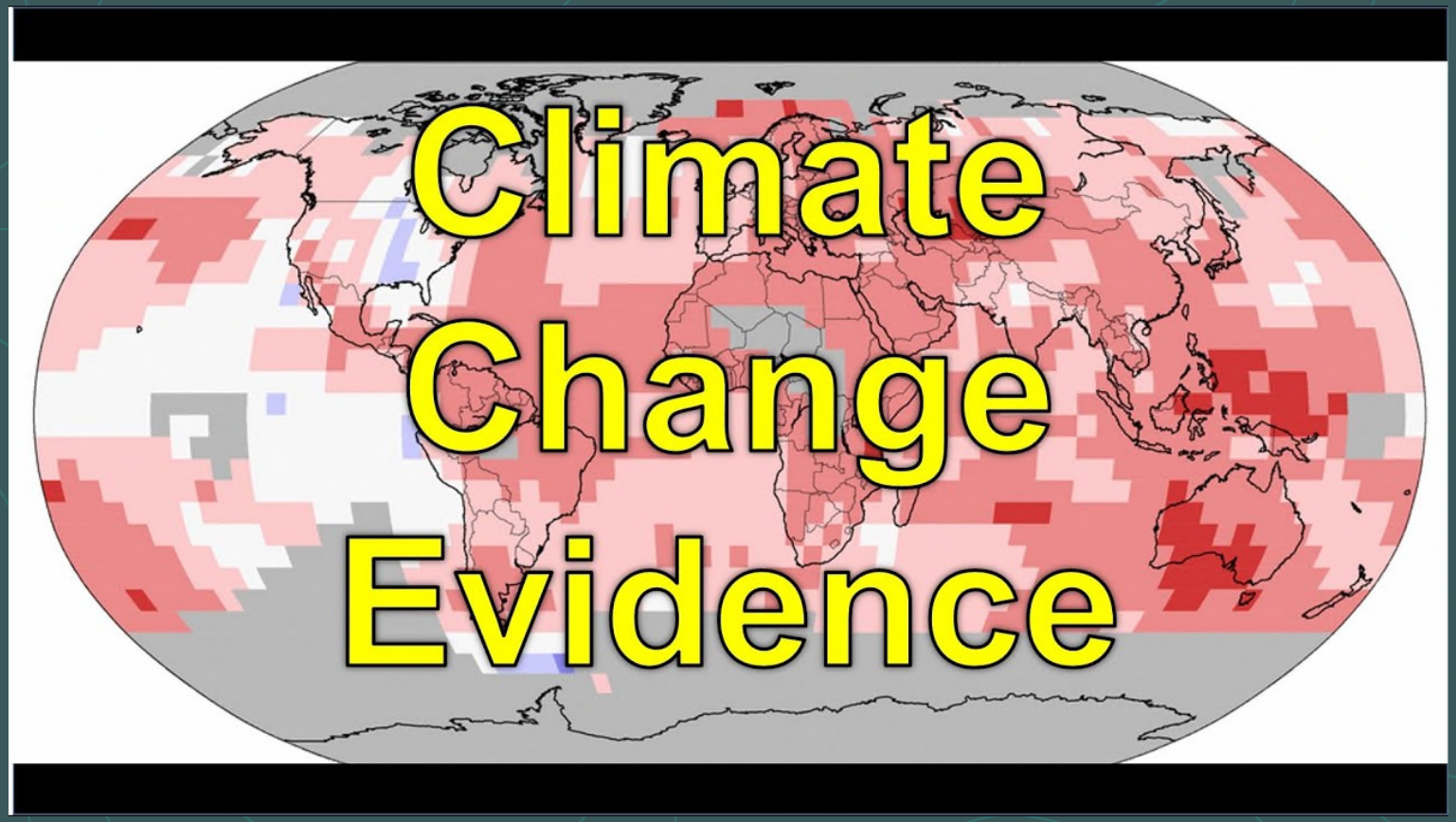
Global Warming Effects on Ocean and Atmospheric Circulation



1) Climate-controlling *Global Ocean Conveyor Current System* will change – most likely slow down

2) Result will be greater temperature differences between the poles and the equator

Evidence for Climate Change Video

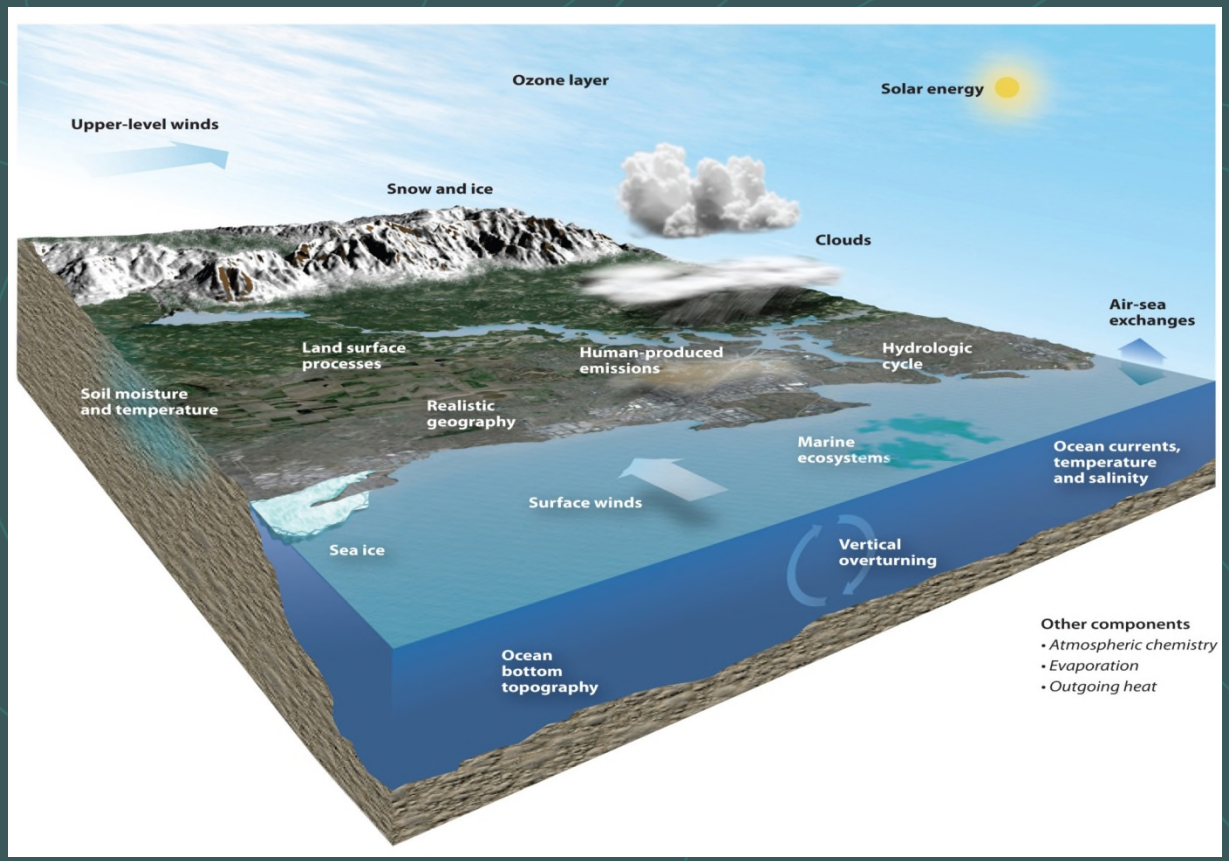


Short Version https://www.youtube.com/watch?v=-IuVzcp39rs

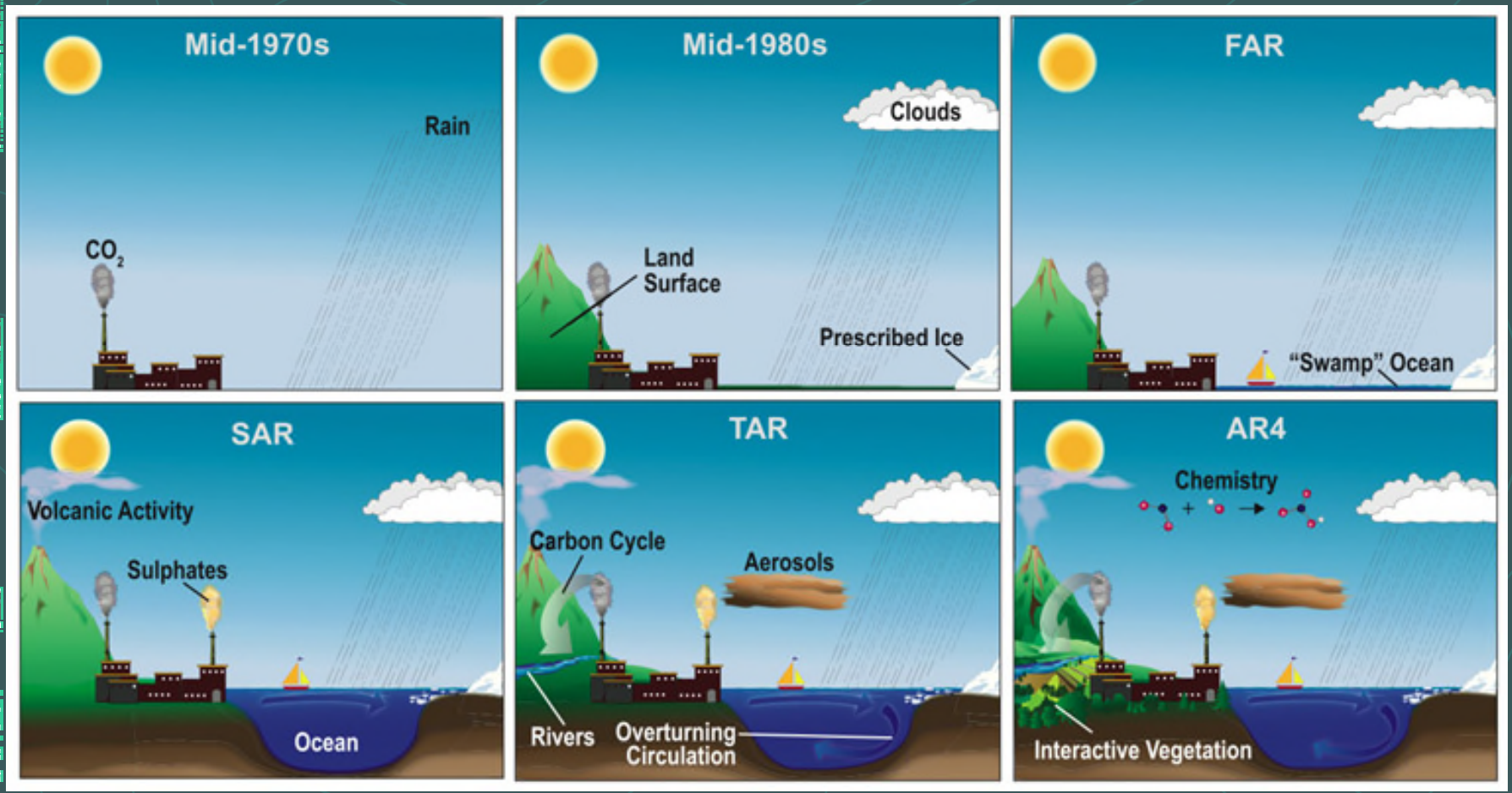
Long Version https://www.youtube.com/watch?time_continue=791&v=gIUN5ziSfNc&feature=emb_logo /

Climate Modeling: The Components

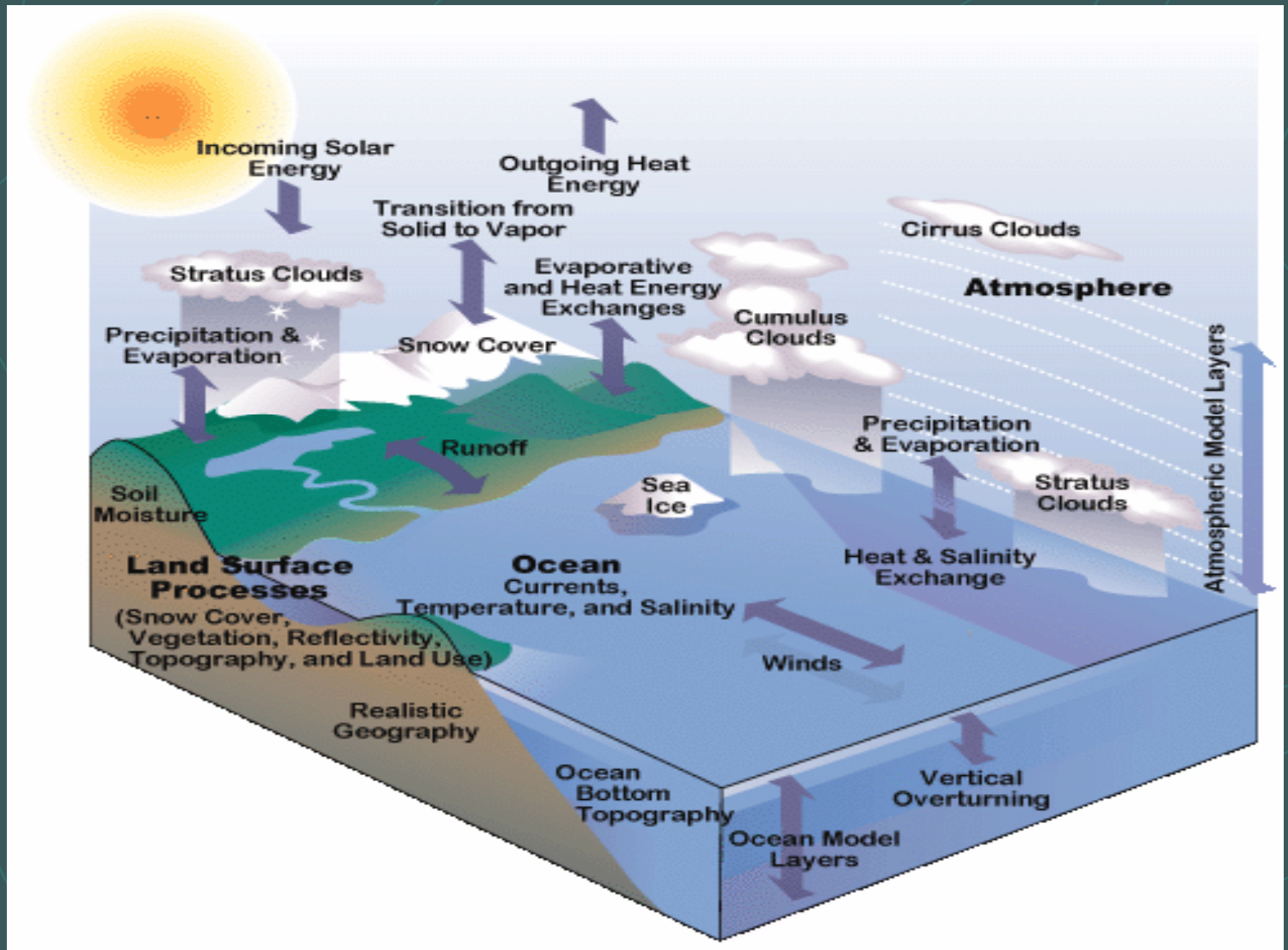
A climate model's ability to reflect what is actually occurring (observed) in nature over time is only as good as the integration of the various number of inputted climate-affecting components within a climate system



Climate Model Evolution – Better and Better -



Climate Modeling: The Components



Climate Modeling Results

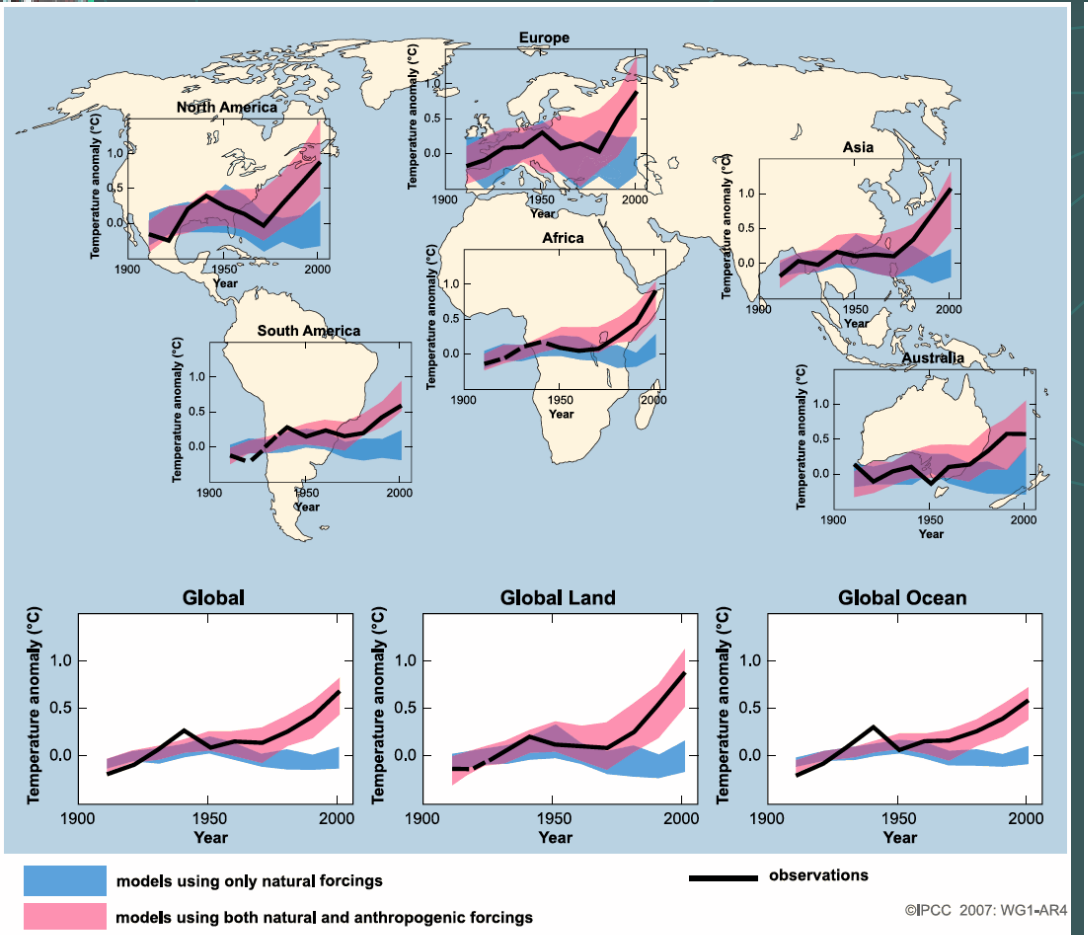
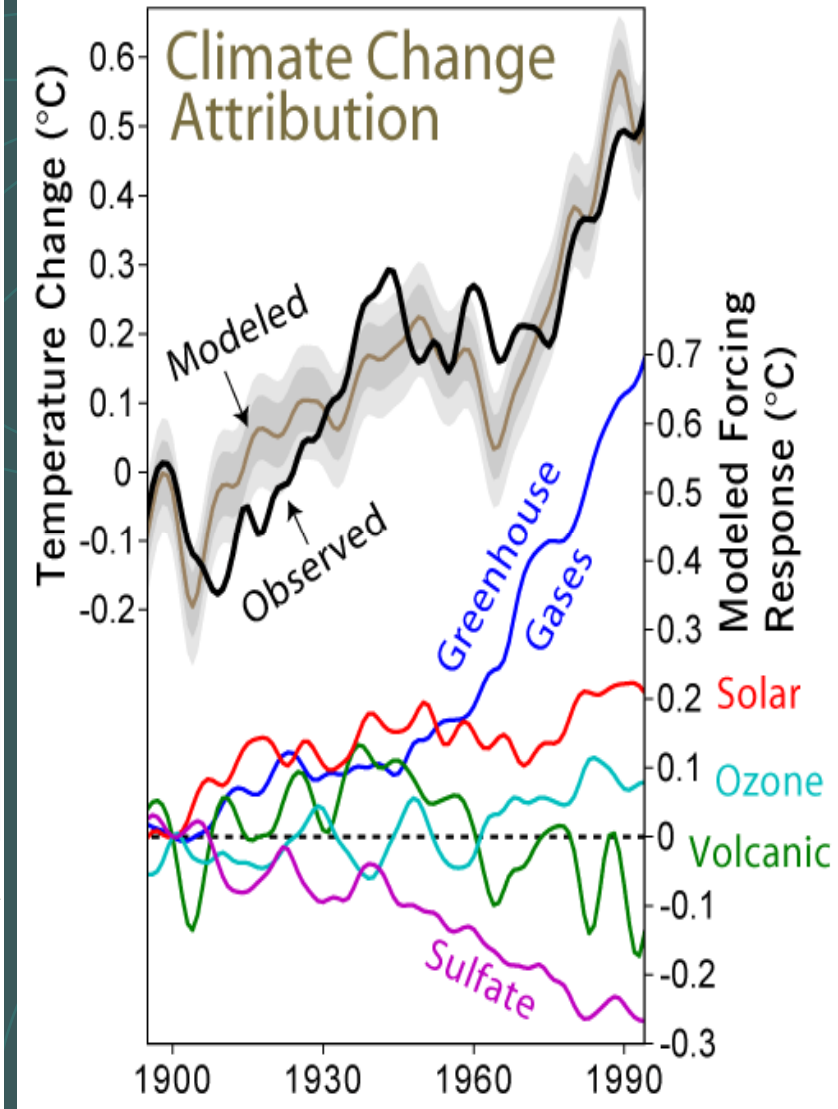
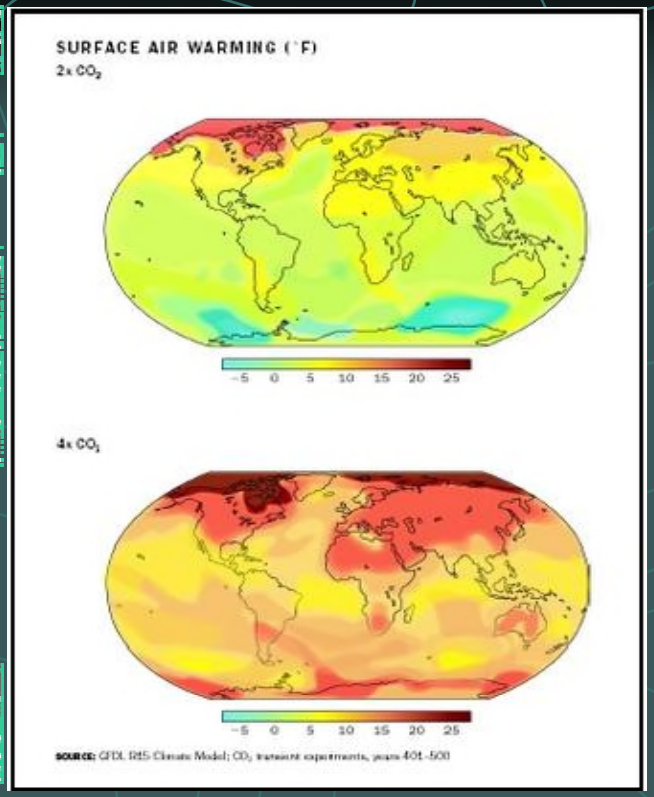
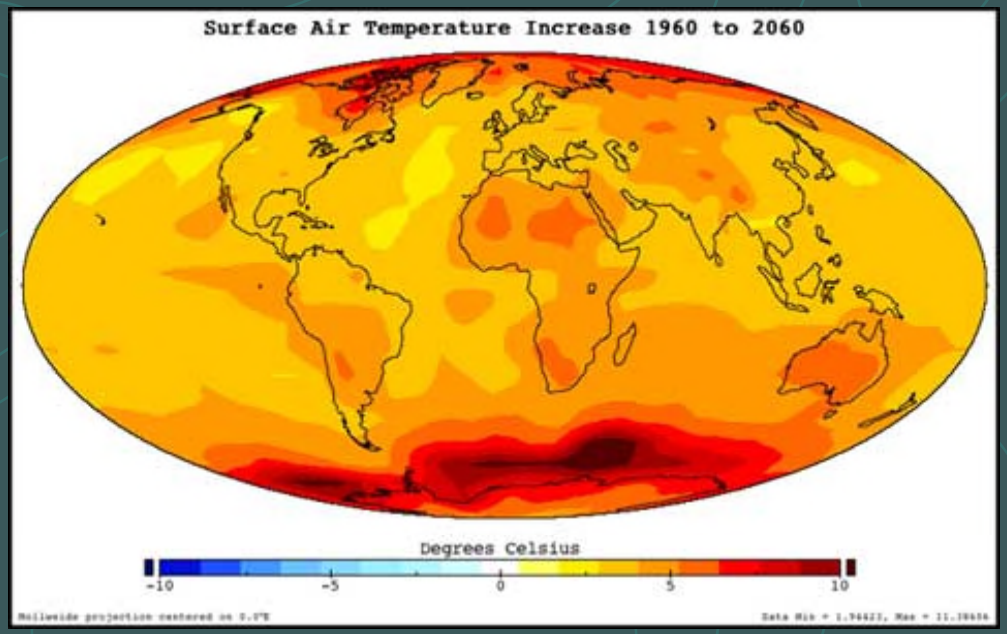


Figure SPM.4. *Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906 to 2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5–95% range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5–95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings. {FAQ 9.2, Figure 1}*



GW – Temp Models





100-Year Projected Increase in Risks and Impacts

1) **Polar regions will be affected the most**
2) **Warmer climate belts will expand and shift pole-ward**
3) **More extreme swings in climate from region to region**
4) **Global sea level will rise by 10's of centimeters**

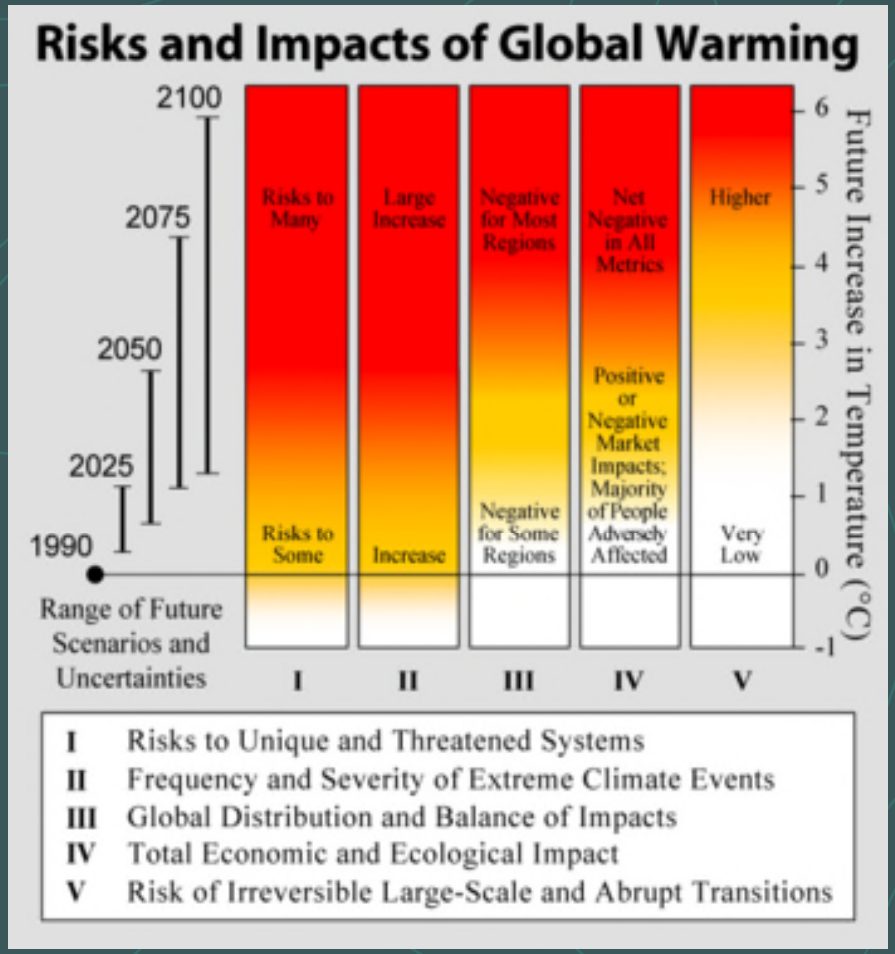
Climate Change – Risk Modeling:

1) Risks and Impacts are proportional to the amount of temperature increase

2) The future predicted increase in temperature varies with:

a) computer model

b) greenhouse gas values



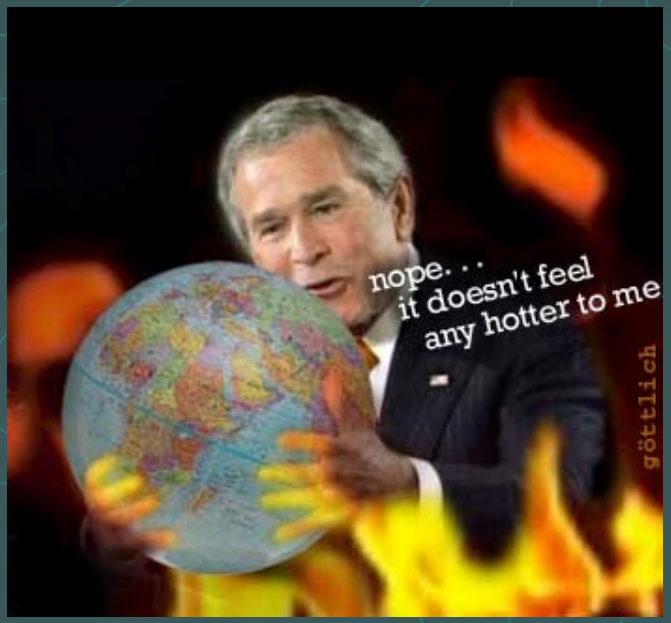
100-Year Projected Increase in Risks and Impacts

US Politics and Climate Change

Some Are Warning of Global Warming

✓Believe climate scientists

✓ Sounding the alarm and a call to action



Some Deny Global Warming

✓ Mistrust in climate scientists

✓ Media sources providing false or misleading information

✓ Organizations that profit on greenhouse gas emissions

GW - Science and Distortion

Is There a "Controversy"?

Corporations and Climate Change

Climate Science versus Alternative Facts

Oil Company PR

* **Watch this**

✓ Business and politics distort science for self-serving reasons

✓ The private media is sponsored by private interests and thus may provide false or misleading information that reflects their sponsorship

TED Talk – Climate Change

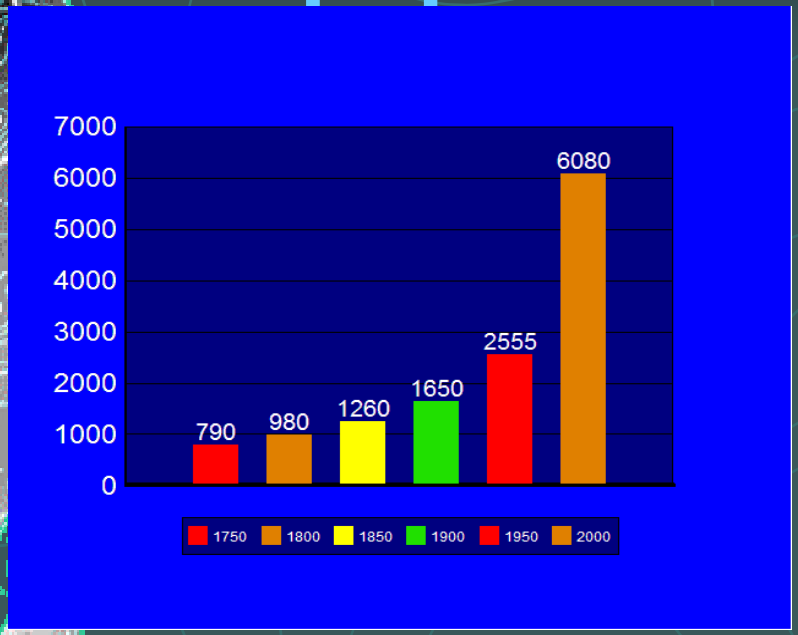
TEDxNASA - Bruce Wielicki - Climate Change: Fact And Fiction

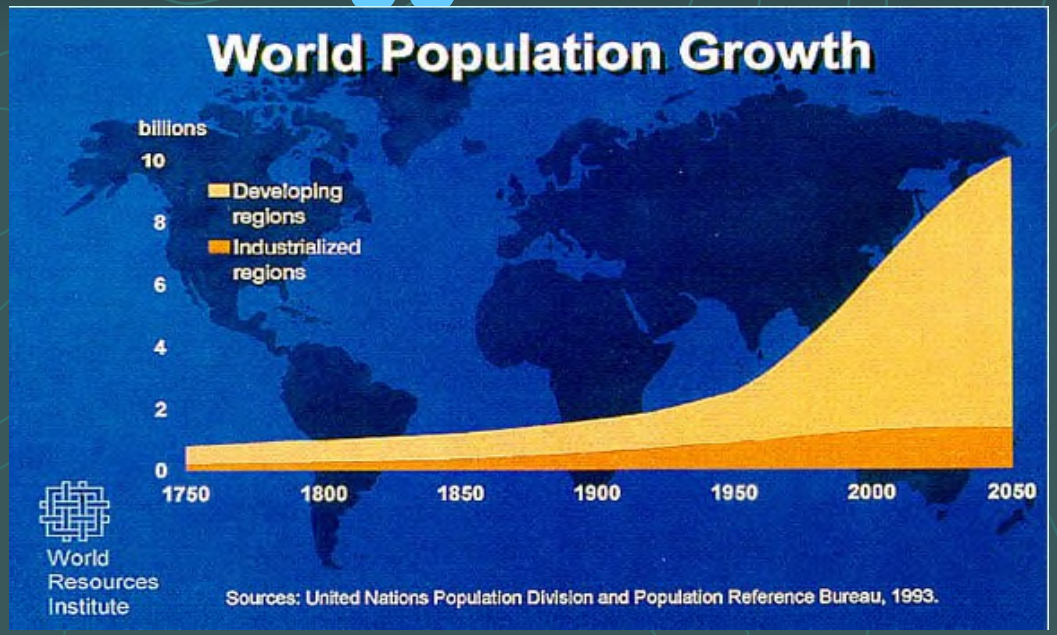
Overpopulation: The Biggest Concern

1) Earth has over 7 billion people today

2) Population doubles every 30 to 40 years

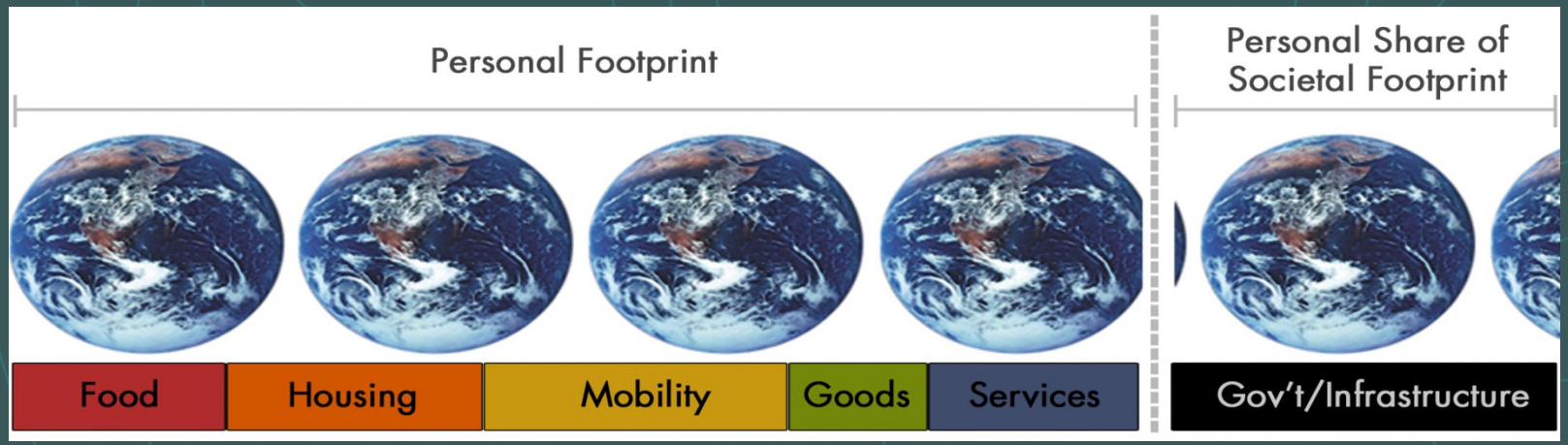
Overpopulation: The Biggest Concern





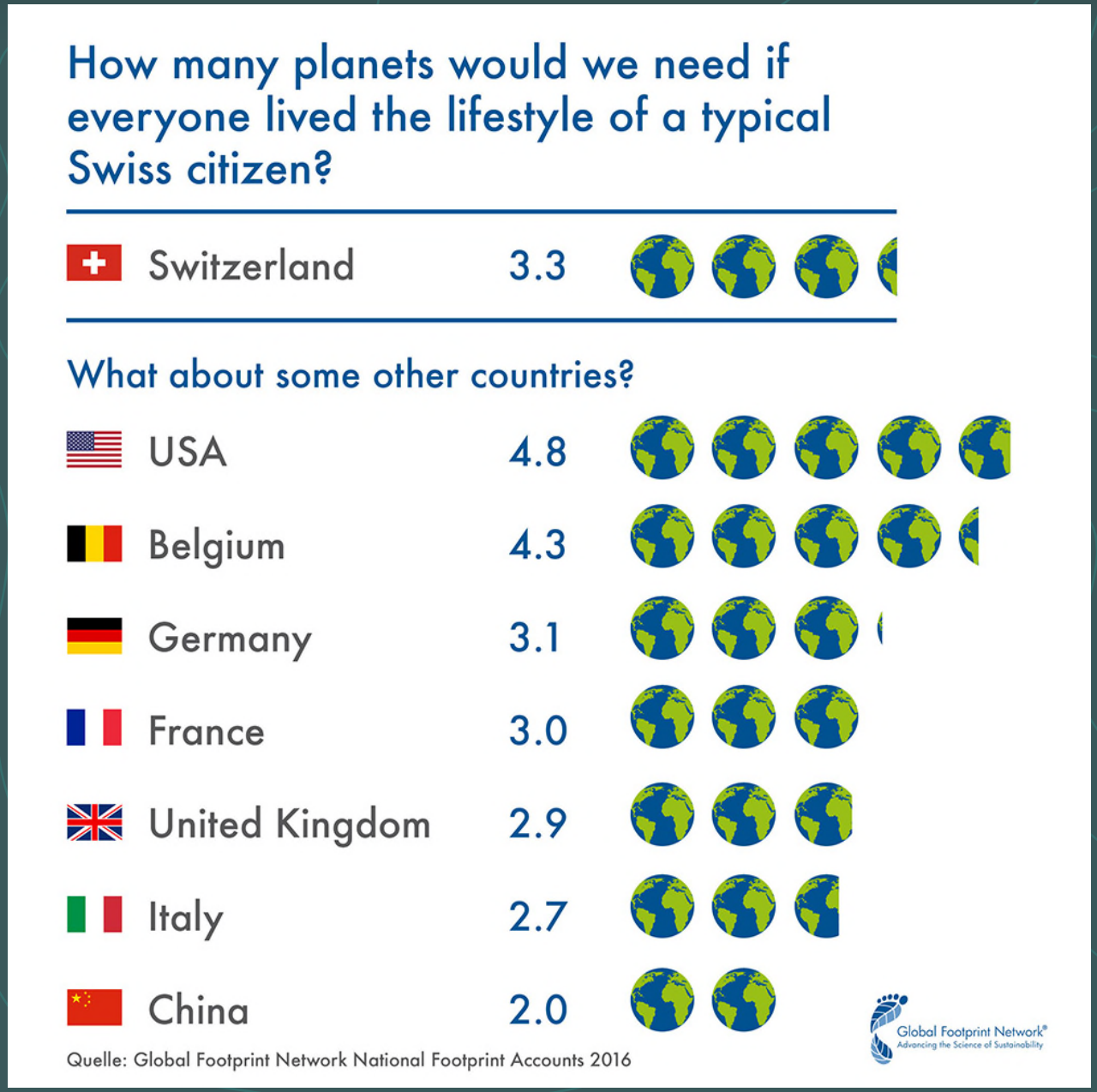
Earth has 7 billion today.

Population doubles every 40 years.



Each human consumes resources in attempt to meet their wants/needs.

Sustainability and Lifestyles



HOW MUCH DOES FOOD CONTRIBUTE TO OUR ECOLOGICAL FOOTPRINT?

IT TAKES **1.7** EARTHS

TO SUPPORT

HUMANITY'S DEMAND ON NATURE

We use more ecological resources and services than nature can regenerate through overfishing, overharvesting forests, and emitting more carbon dioxide into the atmosphere than forests can sequester.

IF WE CUT FOOD WASTE IN HALF AND THE ENTIRE WORLD ATE LOWER PROTEIN-INTENSIVE FOOD AND ADEQUATE-CALORIE DIETS, WE COULD REDUCE HUMANITY'S ECOLOGICAL FOOTPRINT

16%

AND MOVE THE OVERSHOOT DATE

42 DAYS

THE WAY WE EAT IS A FUNDAMENTAL AGENT OF CHANGE TOWARDS SUSTAINABILITY

INCREASE THE PROPORTION OF CEREALS, VEGETABLES AND FRUITS

HOW?

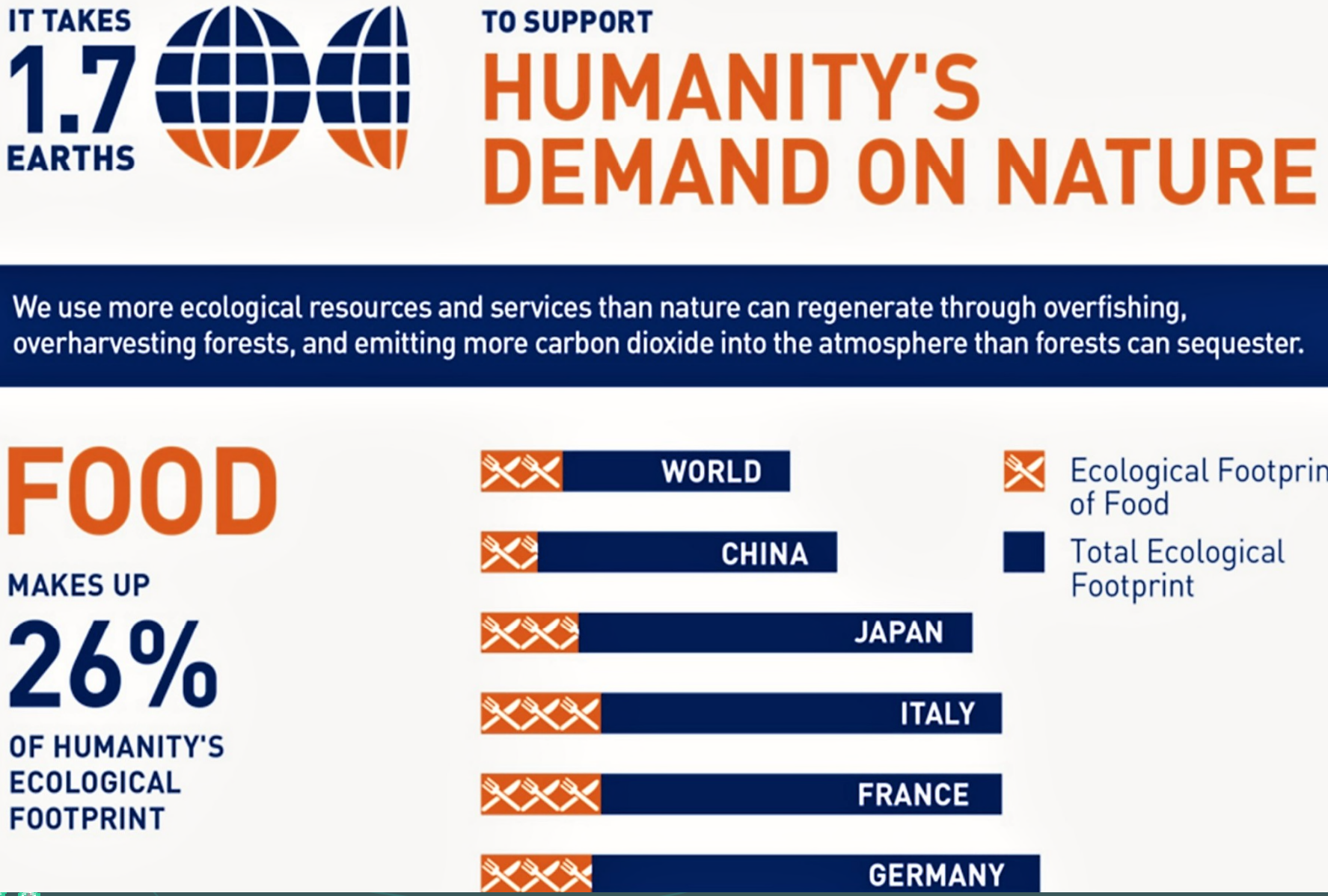
DECREASE FOOD WASTE

Global Footprint Network®
Advancing the Science of Sustainability
www.footprintnetwork.org

EARTH OVERSHOOT DAY
www.overshootday.org

Barilla Center FOR FOOD & NUTRITION
www.barillacfn.com

Sustainability and Food



SHOPPING

The choices we make at the checkout have a considerable impact on our sustainable future.

When shopping for food and groceries, electrical appliances or household furniture, there are environmental-friendly choices. Be a wise consumer, show retailers and manufacturers that we want sustainable options.

OPT FOR EFFICIENCY

Grade 1
Grade 2
Grade 3

If you are buying a TV, washing machine, refrigerator or dishwasher, buy the most energy and water efficient model you can afford. There is 97% energy saving for Grade 1 refrigerating appliances over Grade 5 appliances.

REDUCE MEAT CONSUMPTION

Have at least one meat-free day a week. Livestock farming produces large amounts of greenhouse gas emissions. We can reduce our environmental impact exponentially with this simple switch.

AVOID LANDFILLS

Landfills release large amounts of methane, which contributes to climate change. Buy products with minimal packaging and look for the recycle trademark on any packaging.

SHOP LOCAL

Whenever possible, buy local, seasonal produce that hasn't crossed the globe to get to you – so there is less of a carbon footprint.

BYOB

Bring your own bag when shopping, instead of using the plastic or paper ones provided by stores.

BUY RECYCLED

FSC

Choose sustainably sourced wood and paper with the Forest Stewardship Council (FSC) label. Consider recycled, pre-loved furniture and wooden products.

GO NATURAL

Choose biodegradable products that have less negative impacts on the soil and water system after you have finished using them. Or try a natural alternative.

SUSTAINABLE SEAFOOD

CERTIFIED SUSTAINABLE SEAFOOD MSC www.msc.org
FARMED RESPONSIBLY asc CERTIFIED

When buying seafood, look for the Marine Stewardship Council (MSC) or the Aquaculture Stewardship Council (ASC) logos and eat sustainable seafood listed in WWF-Hong Kong's Seafood Guide, available as a mobile app.

Android | iOS

Reduce – Reuse – Recycle - Rethink

REDUCE THE AMOUNT OF MATERIALS YOU USE, WHICH

REDUCES THE AMOUNT OF WASTE YOU CREATE.

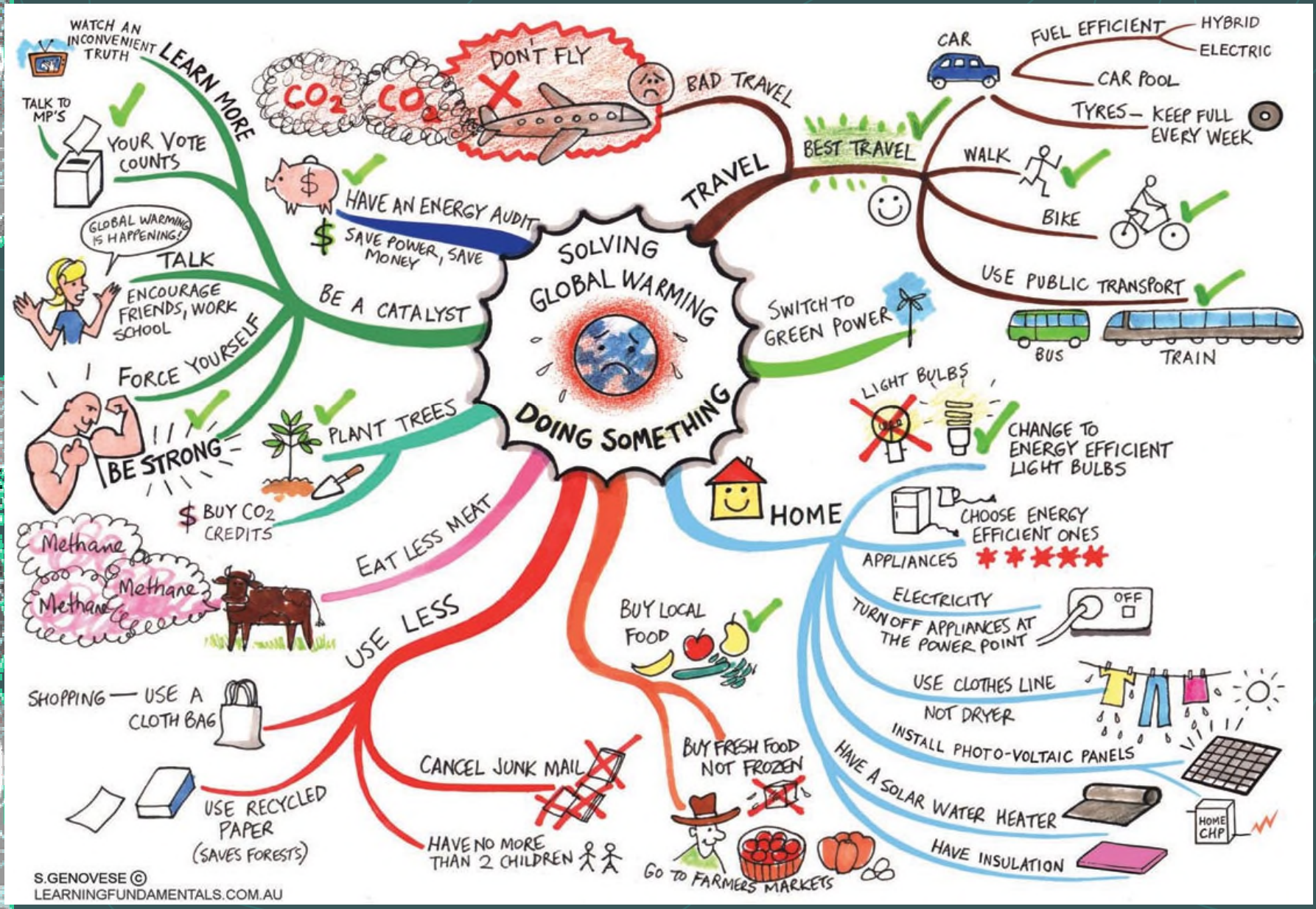
REUSE MATERIALS **WHEN POSSIBLE**

RECYCLE *WHENEVER* **POSSIBLE**

RETHINK THE MATERIALS

YOU USE *AND* THOSE YOU **THROW** *AWAY*

Global Warming: The Solution



Ways You Can Reduce Carbon Footprint

- 1) Reduce personal consumption as much as possible
- 2) Reuse as much as possible
- 3) Recycle as much as possible
- 5) Drive a high MPG vehicle
- 6) Drive/fly less
- 7) Plant trees
- 8) Family Planning – Less kids
- 9) Support leaders and legislation that are pro-environment

What other ways to reduce greenhouse gas emissions?

Drop in the Ocean

http://www.topdocumentaryfilms.com/drop-ocean/

Global Warming and Climate Change

A. Terms Defined:

1) Global Warming: Increase in average global surface temperature

2) Climate Change: Change in location and character of regional climate belts

B. Causes of Global Warming

1) Increase in heat-absorbing atmospheric gases
   - ✓ Methane, carbon dioxide, carbon monoxide, water
   - ✓ Natural and human-induced emissions

2) Increase in solar radiation striking earth's surface
   - ✓ Long-term cyclic changes in earth orbit and axis tilt
   - ✓ Cyclic changes in sun's output

C. Evidence for Global Warming

1) Melting glaciers
   - ✓ Polar ice caps and sheets and mountain glaciers

2) Rise in global sea level
   - ✓ Input from melting land ice
   - ✓ Warming of ocean waters (thermal expansion)

3) Rising Levels of Global Temperature and Atmospheric Carbon Dioxide
   - ✓ Atmosphere, land and ocean

D. Anthropogenic Sources of Greenhouse gases

1) Burning fossil fuels
2) Burning down forests

E. Solutions to Slowing Down GW and Climate Change

Ways You Can Reduce Ocean Pollution

- 1) Reduce personal consumption as much as possible
- 2) Reuse as much as possible
- 3) Recycle as much as possible
- 4) Drive a non-leaky, high mileage vehicle
- 5) Organic maintenance of your lawn and garden
- 6) Use non-phosphate soaps and detergents
- 7) Dispose of all non-recyclable wastes like paints and other chemicals at a proper disposal site
- 8) Support leaders and legislation that is pro-environment

Can you think of other ways to reduce ocean pollution?

OCEAN POLLUTION - Preview Concepts

A. Pollutants: Substances which directly or indirectly damage life forms or environment

B. Point Sources Versus Non-Point Sources of Pollution

1) Point sources are any single identifiable source of pollution
2) Non-point sources are not singly identifiable sources
   - ✓ Far greater contributor to ocean pollution than the point sources
   - ✓ Much tougher to manage and control than point sources

C. Ten Major Types of Marine Pollutants

1) Crude Oil and Petroleum Products
   - ✓ Crude Oil, Motor Oil, Fuel Oils, Distillates
2) Heavy Metals
   - ✓ Mercury; Cadmium; Nickel, Copper, Lead
3) Synthetic Organic Chemicals
   - ✓ DDT; PCB's; CFC's; TCE; Dioxin; Vinyl Chloride
4) Solid Waste
   - ✓ Plastics; Trash; Sediment
5) Sewage
   - ✓ Fecal matter; Bacteria, Viruses
6) Eutrophication and Hypoxia
   - ✓ HAB's due to excessive Nutrients
7) Ocean Acidification
8) Greenhouse Gases
9) Radioactive Wastes
10) Thermal Pollution
11) Noise Pollution
12) Invasive Species

D. Solutions to Minimizing or Eliminating Ocean Pollution

Ocean Environmental Concerns

Discussion