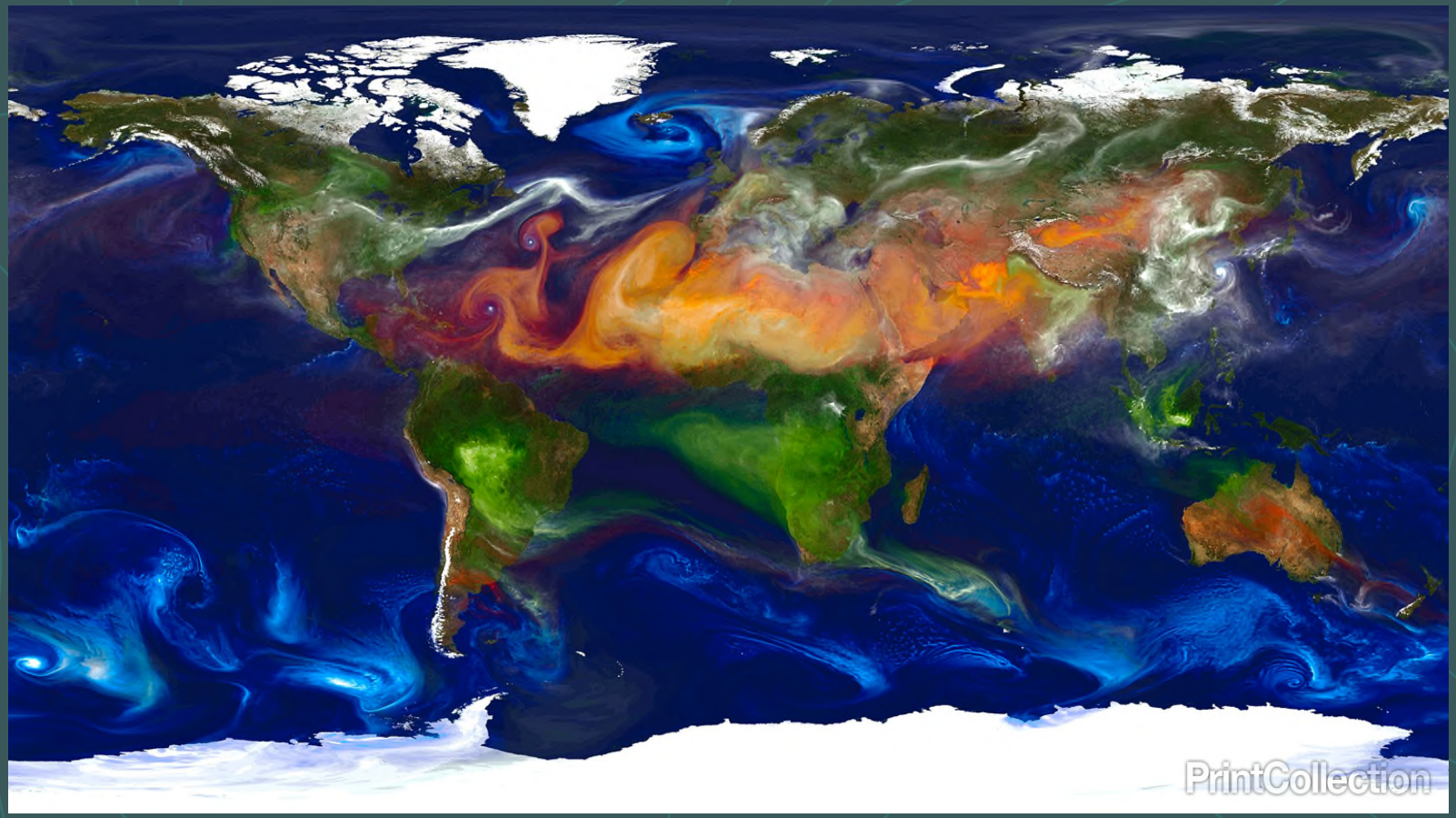
# Global Warming and Climate Change

## Causes, Evidence, Hazards, and Solutions




**Physical Geology – GEOL 100**

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

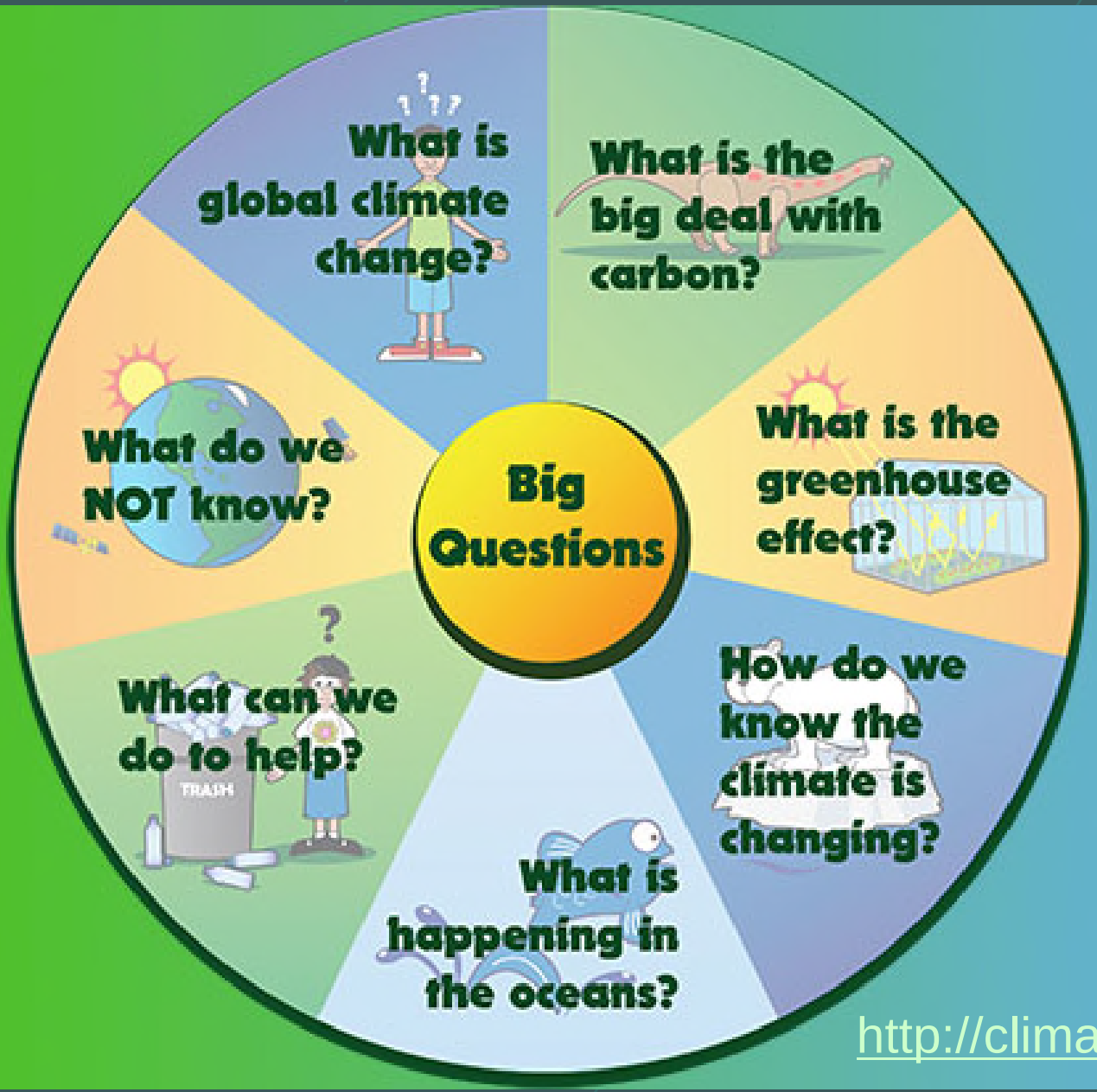
## D. Anthropogenic Sources of Greenhouse gases

1) Burning fossil fuels

2) Burning down forests

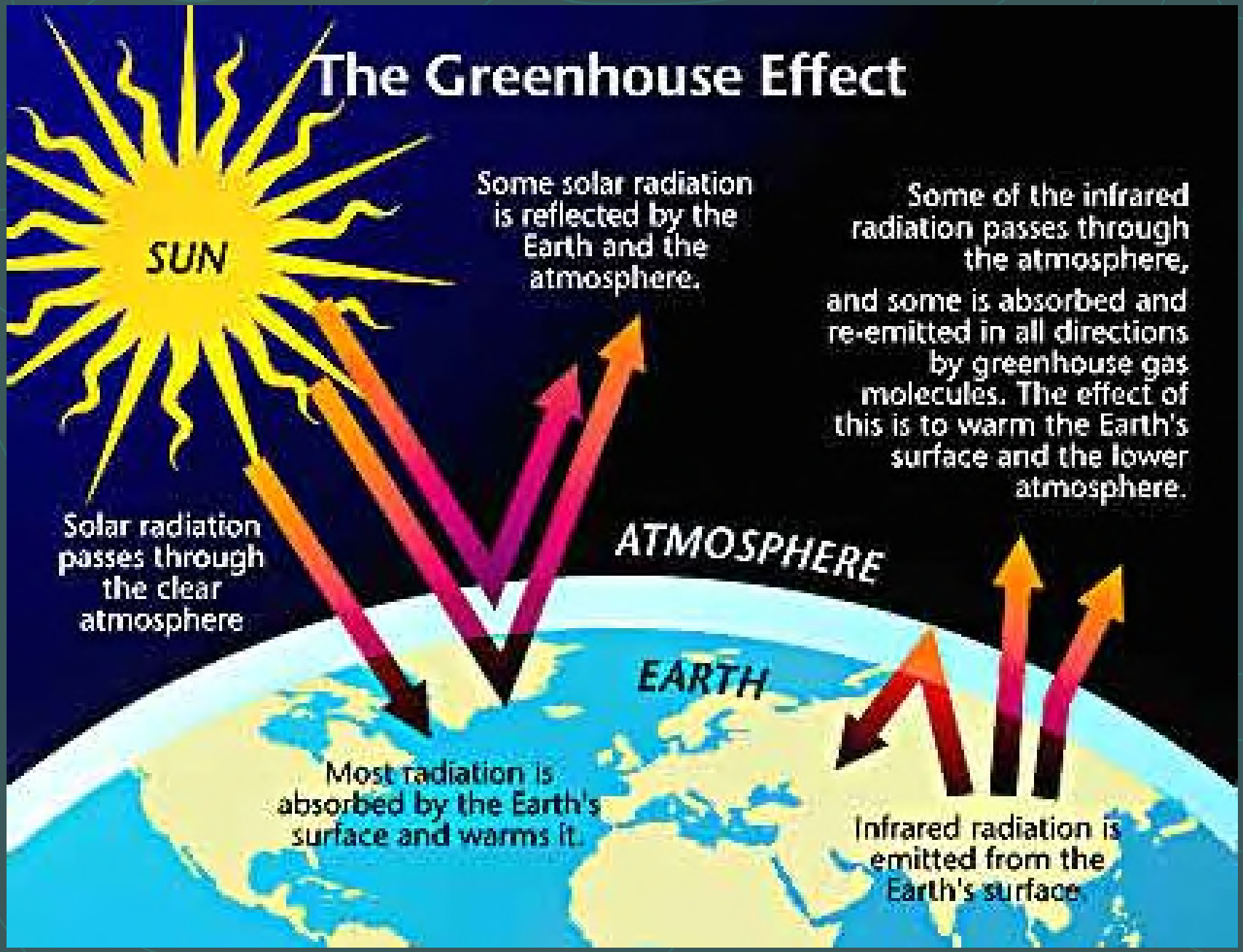
## E. Solutions to Slowing Down GW and Climate Change

# Global Warming and Climate Change




http://climate.nasa.gov/

# 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<br>Land use conversion<br>Cement production | 1 |
| Methane | $CH_4$ | 700 ppbv | 1720 ppmv | 12-17 | Fossil fuels<br>Rice paddies<br>Waste dumps<br>Livestock | 21 ** |
| Nitrous oxide | $N_2O$ | 275 ppbv | 312 ppmv | 120-150 | Fertilizer<br>industrial processes<br>combustion | 310 |
| CFCs | CFC-12 | 0 | 503 pptv | 102 | Liquid coolants.<br>Foams | 125-152 |
| HCFCs | HCFC-22 | 0 | 105 pptv | 13 | Liquid coolants | 125 |
| Perfluoromethane | $CF_4$ | 0 | 1 10 pptv | 50 000 | Production<br>of aluminium | 6 500 |
| Sulphur hexafluoride | $SF_6$ | 0 | 72 pptv | 1 000 | Production<br>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

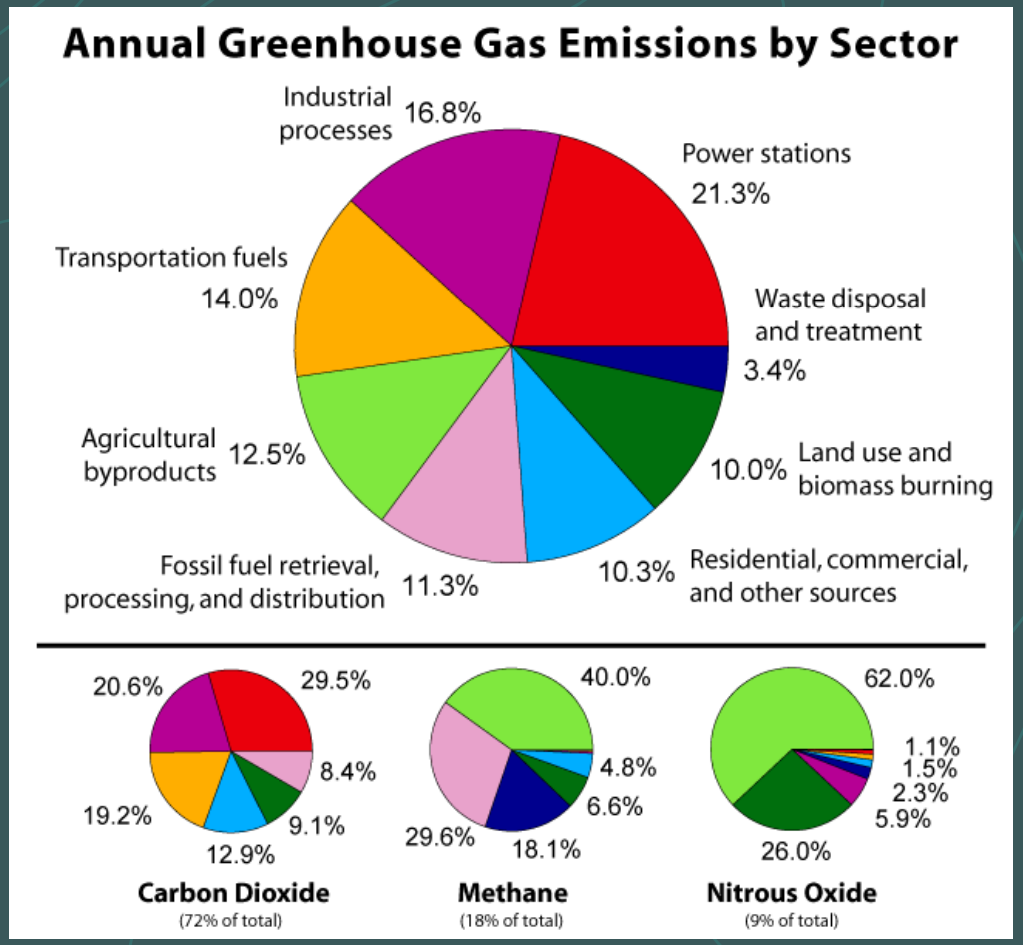
* GWP for 100 year time horizon. ** Includes indirect effects of troposphericozone production and stratospheric water vapour production. *** On page 15 of the IPCC SAR. No single lifetime for CO can be defined because of the different rates of uptake by different sink processes.

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.

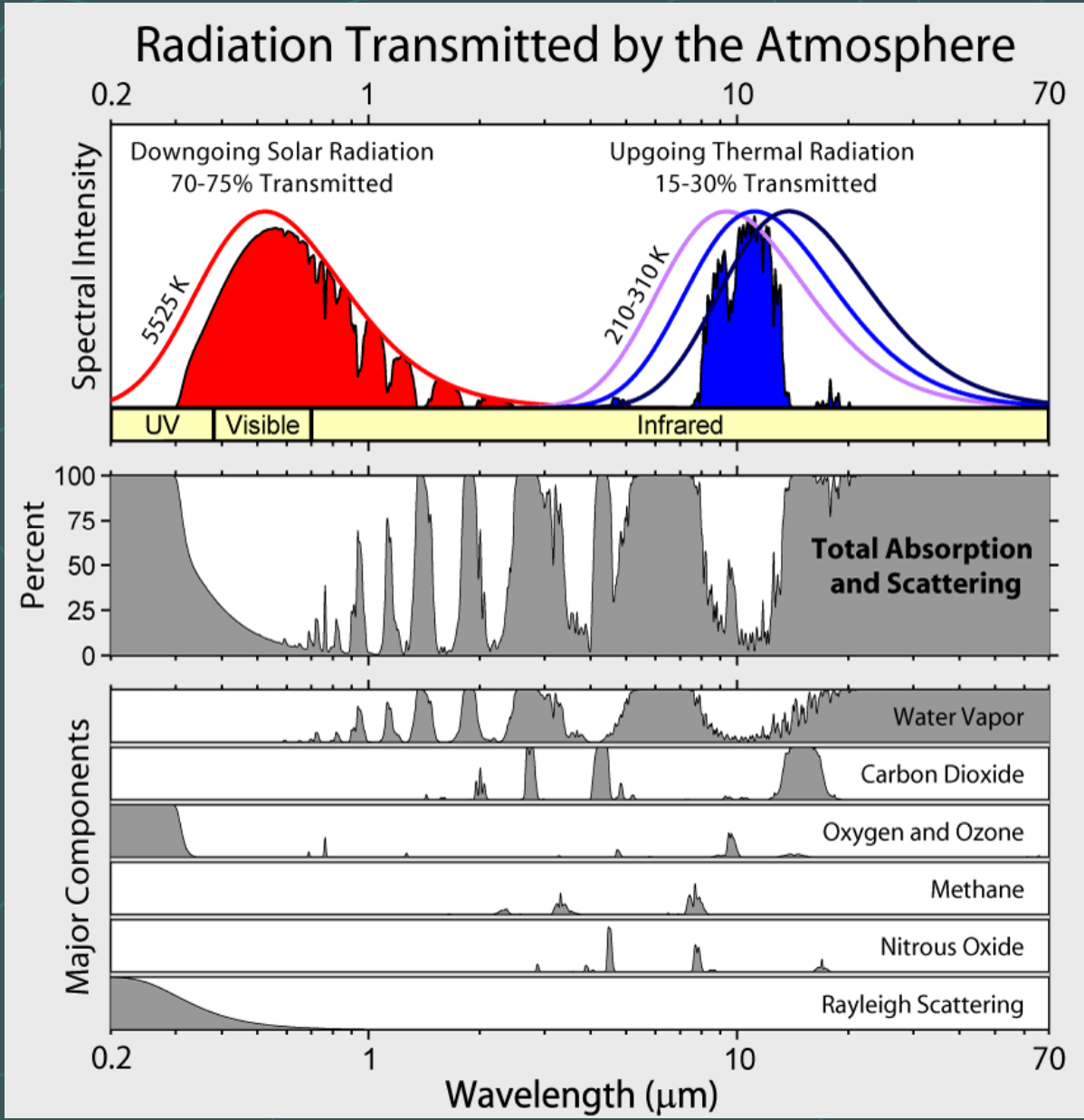
# Anthropogenic Sources of Greenhouse Gases

| 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 % |

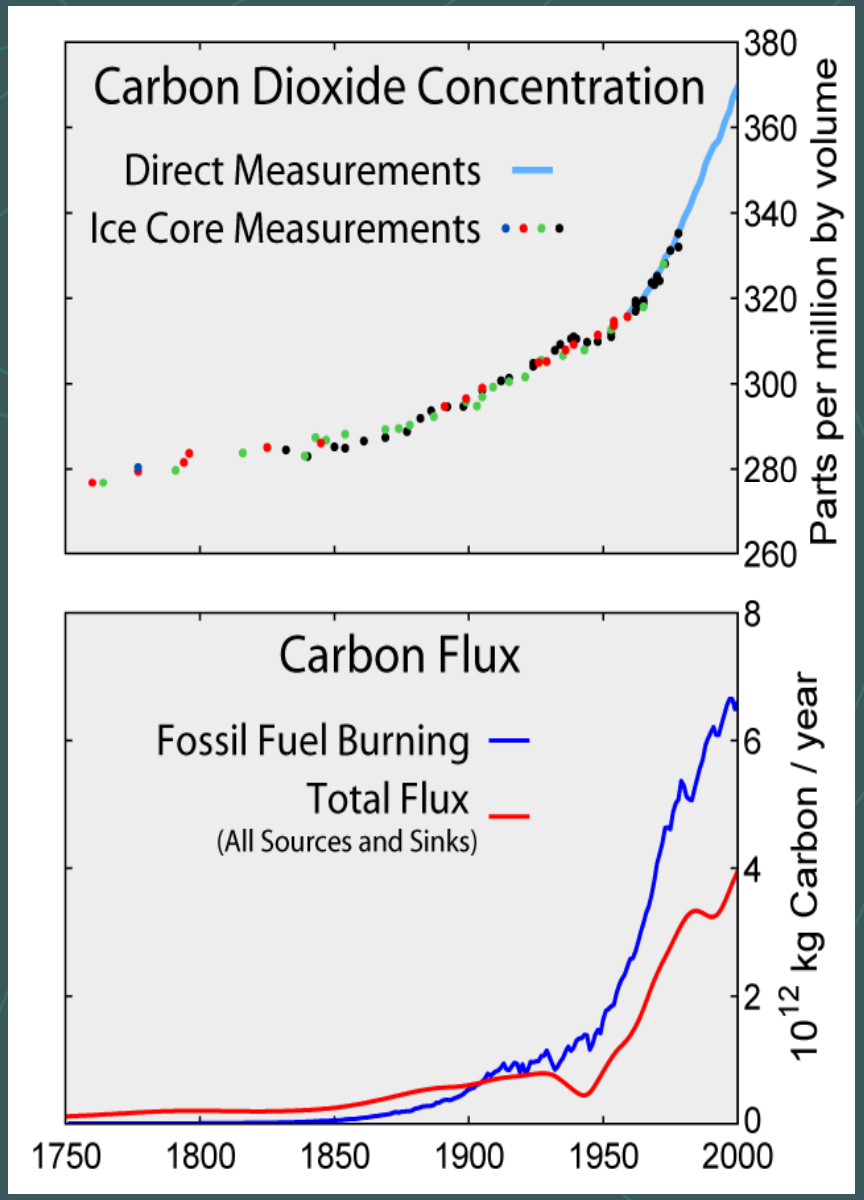
# Greenhouse Gases – Heat Traps

| 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 % |

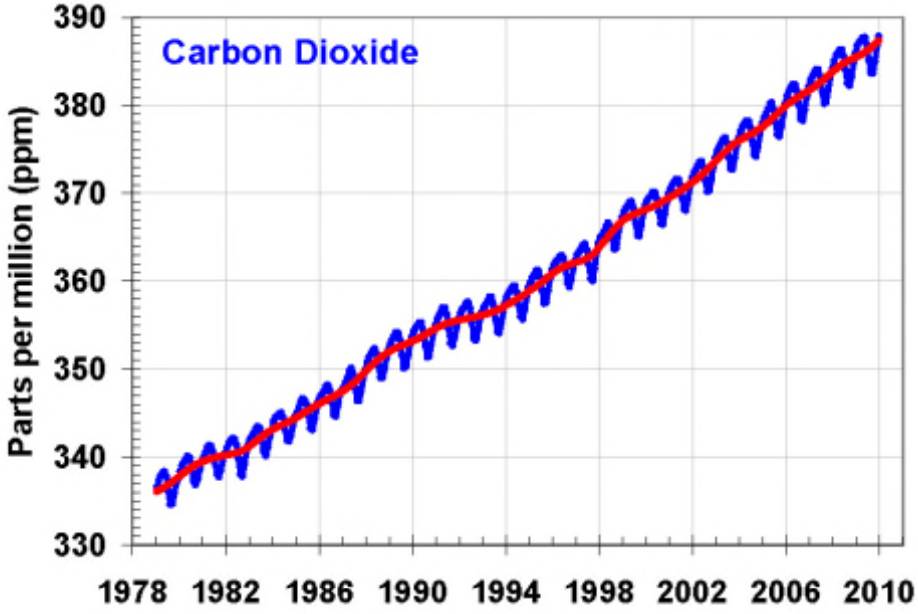


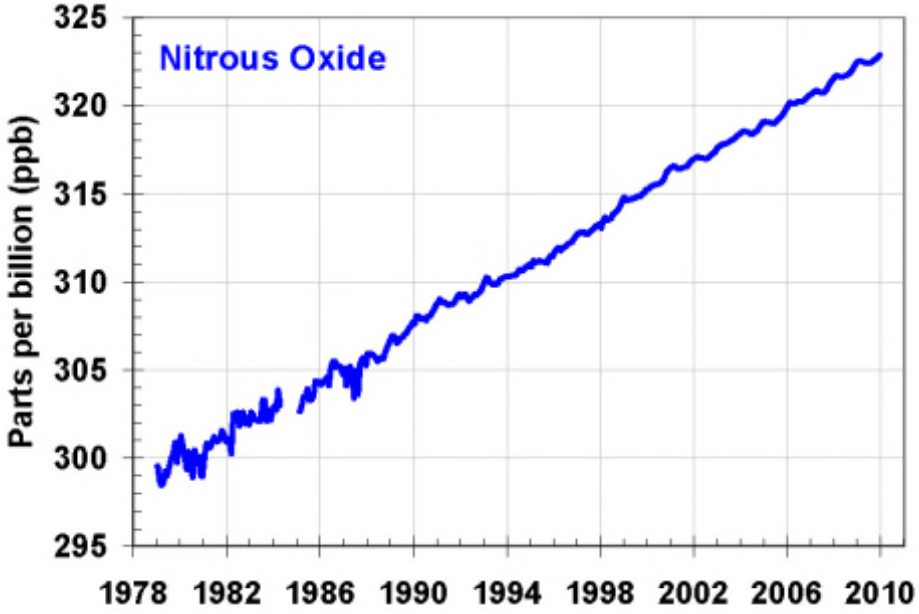
# Major Increases in Atmospheric Greenhouse Gases

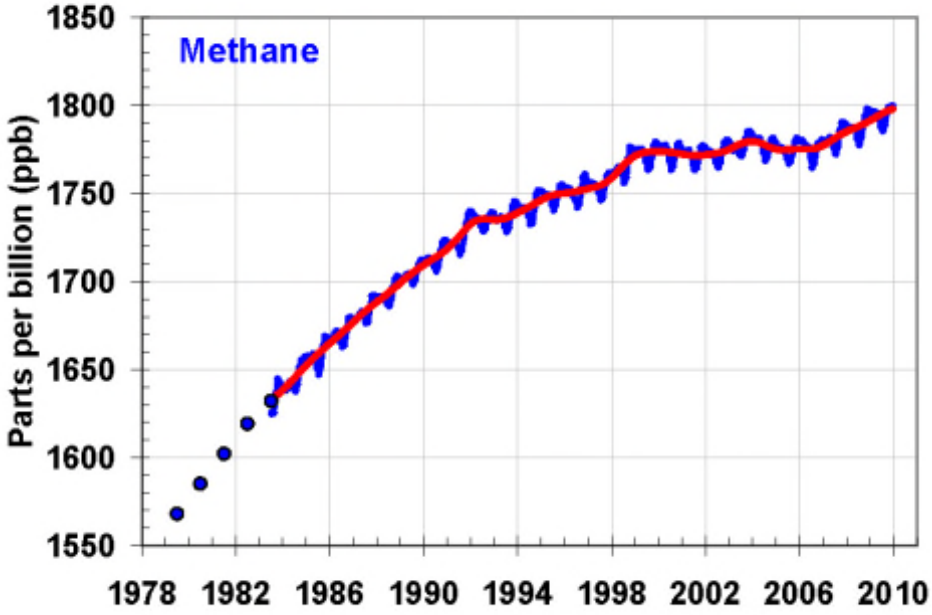
| Gas | Preindustrial level | Current level | Increase since 1750 |
|---|---|---|---|
| Carbon dioxide | 280 ppm | 394 ppm | 114 ppm |
| Methane | 700 ppb | 1745 ppb | 1045 ppb |
| Nitrous oxide | 270 ppb | 314 ppb | 44 ppb |
| CFC-12 | 0 | 533 ppt | 533 ppt |

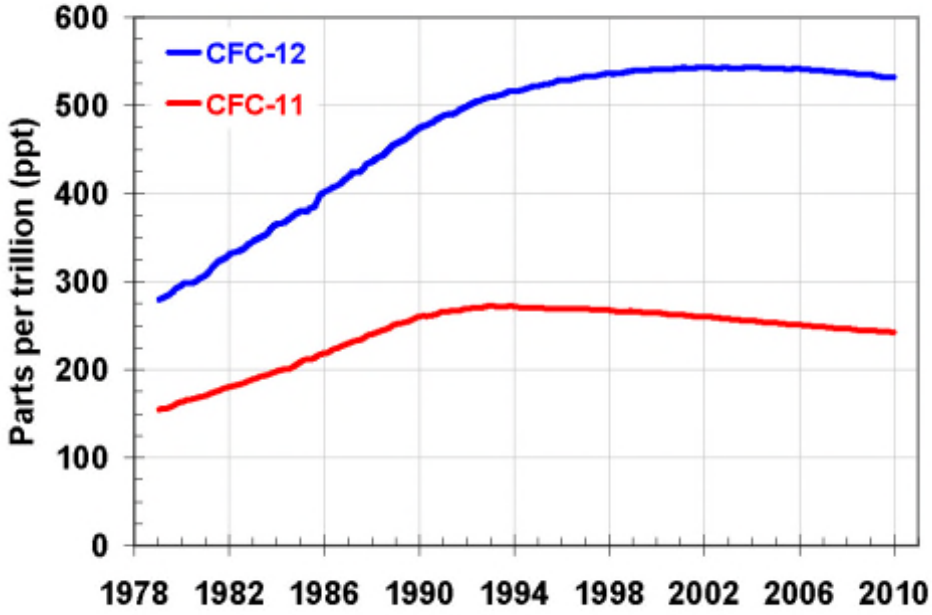


# Trends of Greenhouse Gases in Atmospheric

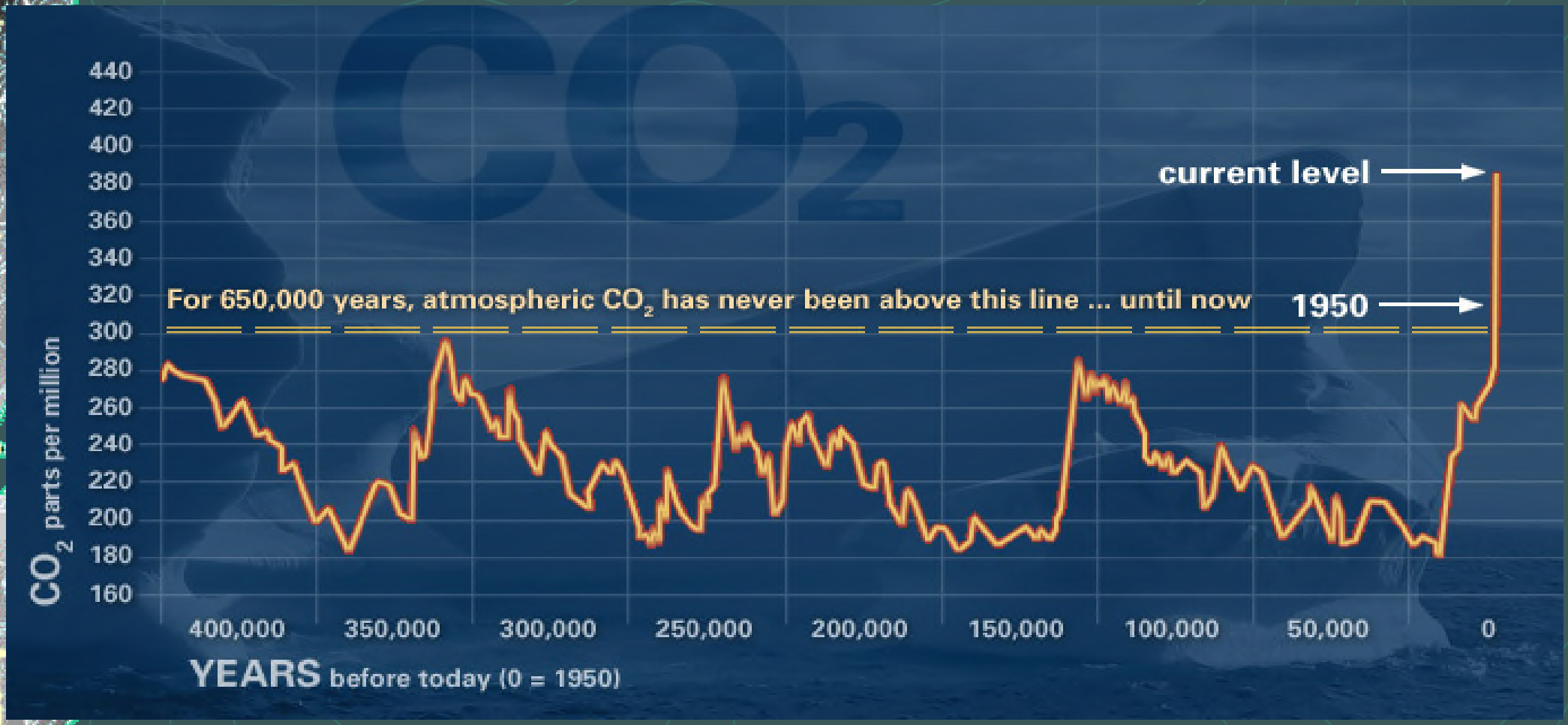


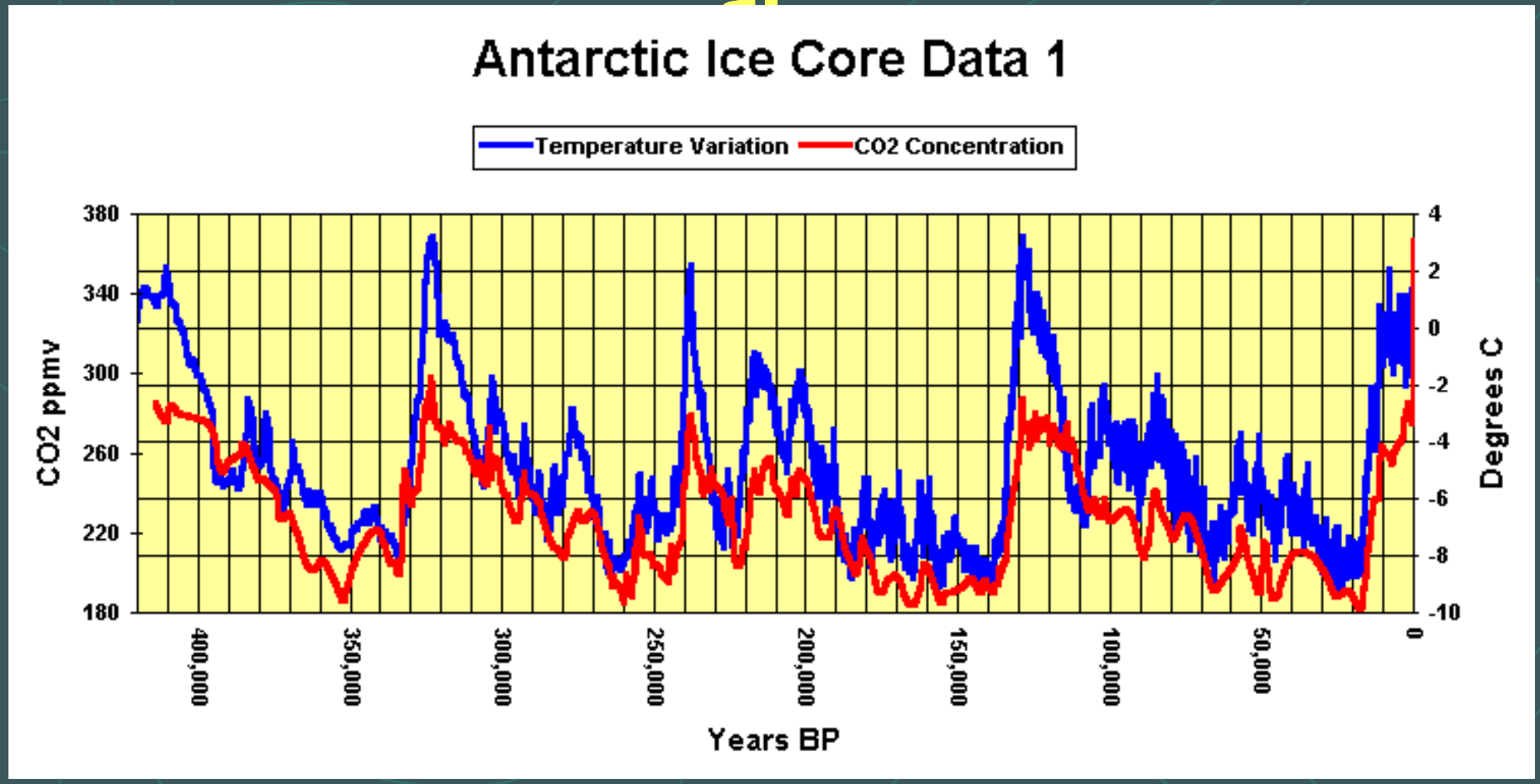
# Long term Variations in Atmospheric Carbon Dioxide Levels




**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

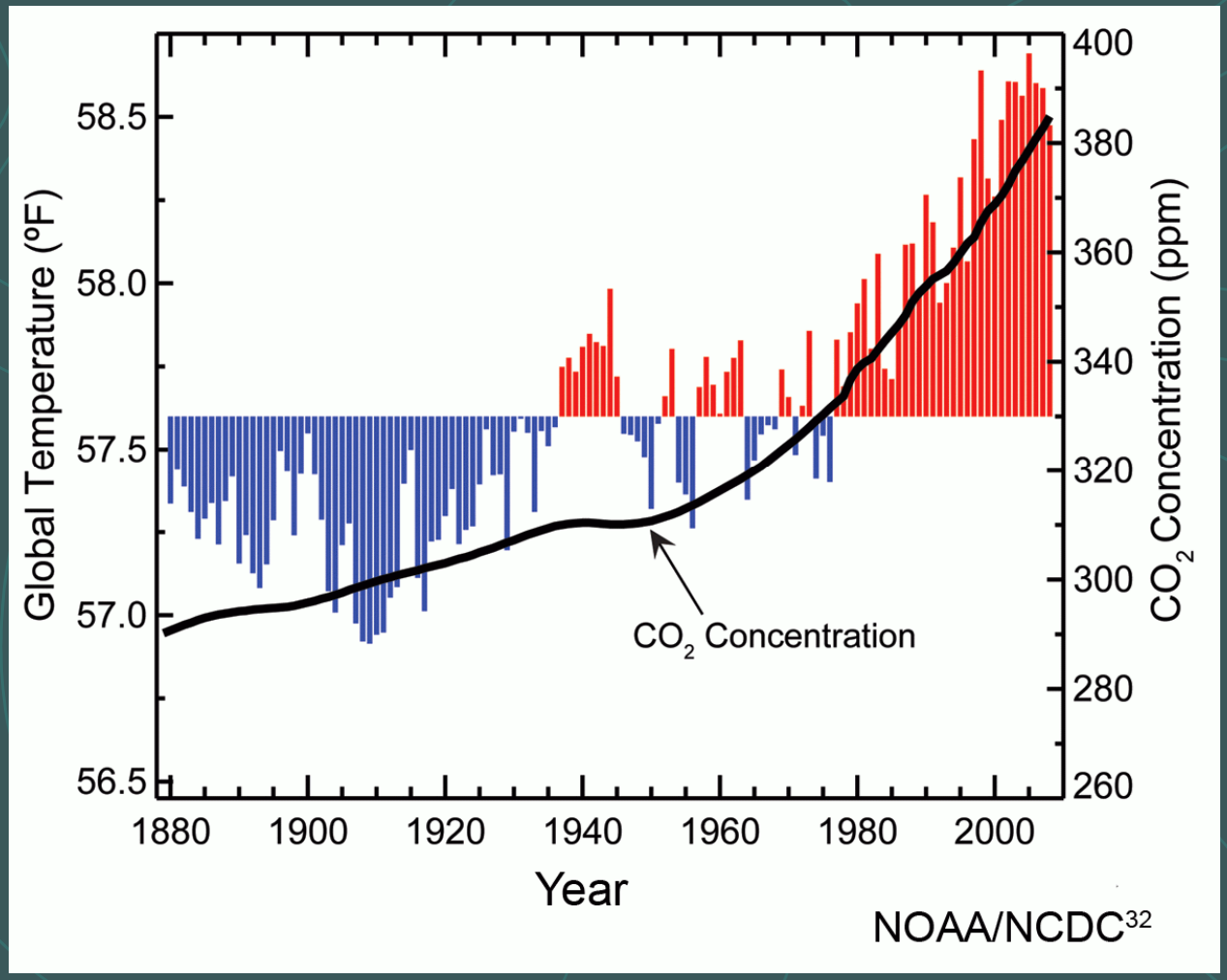
## Atmospheric $CO_2$ versus Global Temperature




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

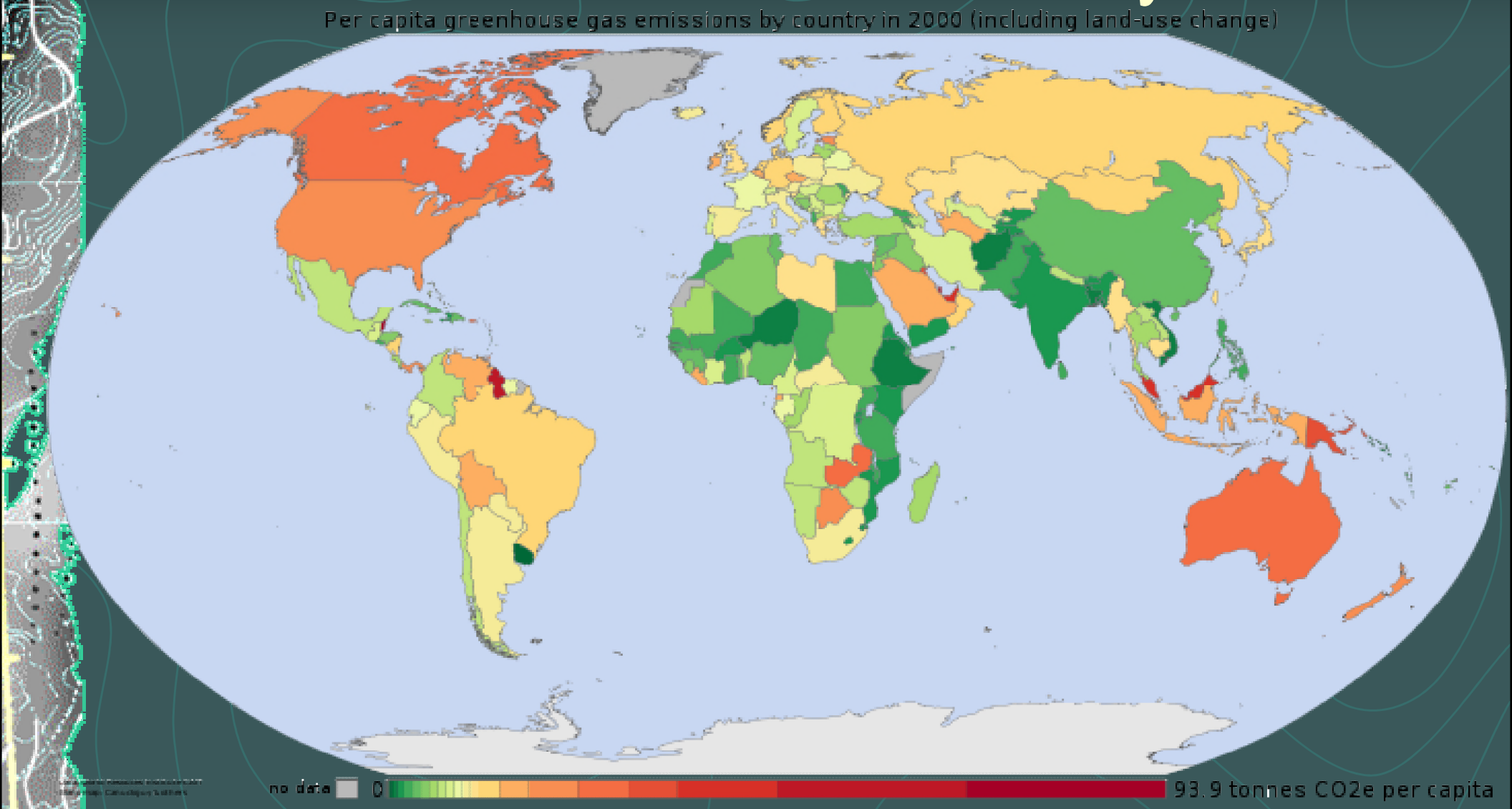
# Short-term Global Warming

## 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).

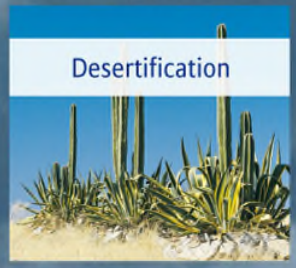
### Melting glaciers/icecaps

- 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

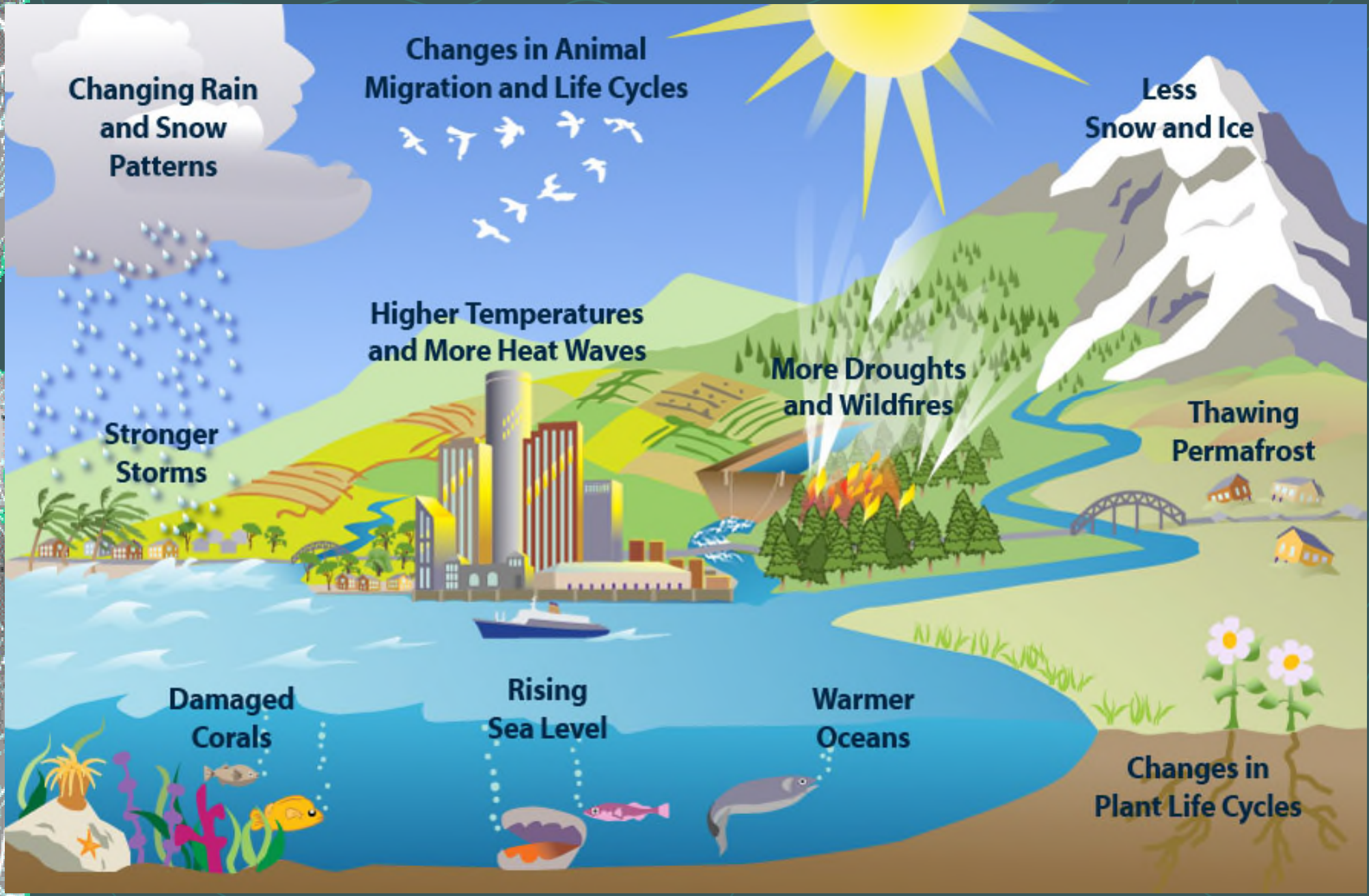


- 2 bill. people in 110 countries are affected and threatened by accelerating desertification.
- The UN projects that 30 % of the world's fertile land surface will turn into desert in the future.
- Example: In Niger, 250,000 hectares, an area about the size of Luxembourg, becomes desert each year.

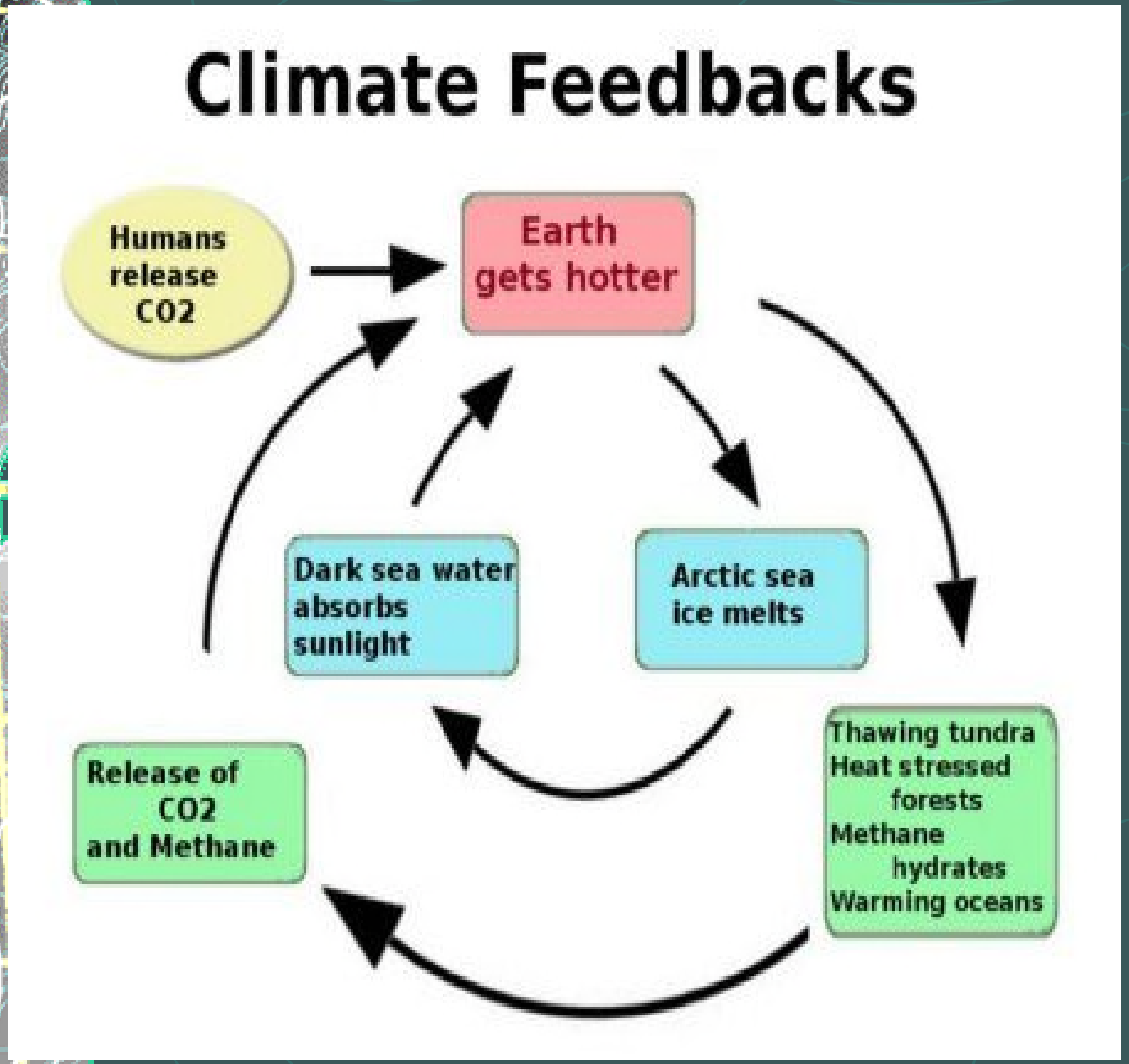


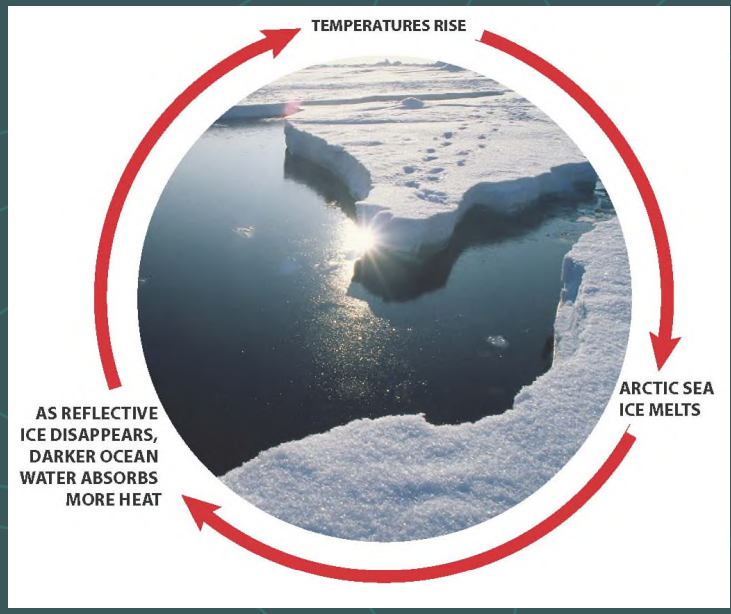
Sources: **www.panda.org** and **www.fao.org**

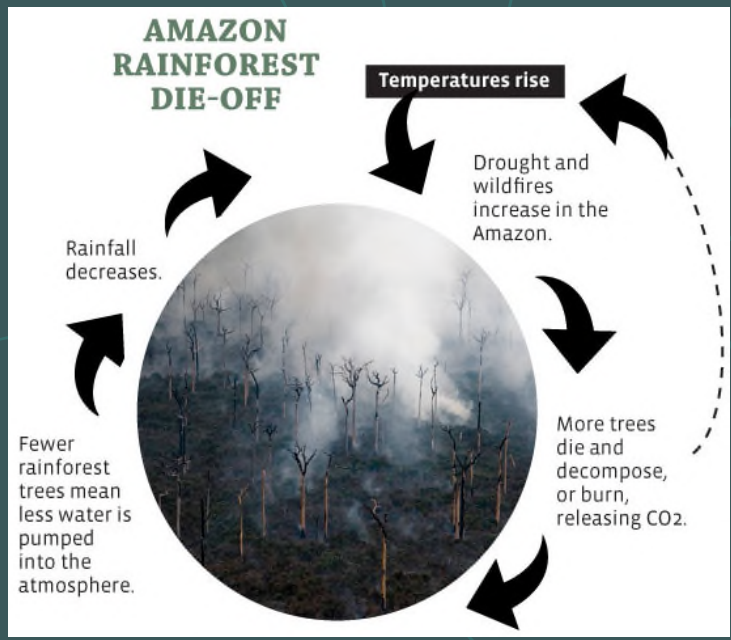
# Effects of a Warming of Global Climate



# Global Climate Change: Feedback Loops



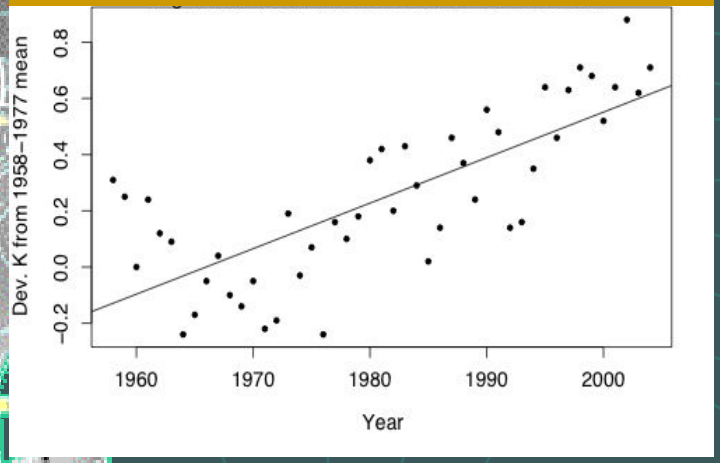



# The Big Thaw is Happening

# Global Warming – The Evidence

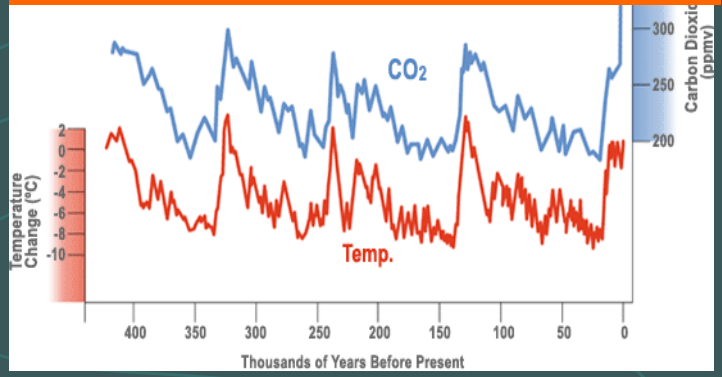
## Rising Air and Ground Temperatures





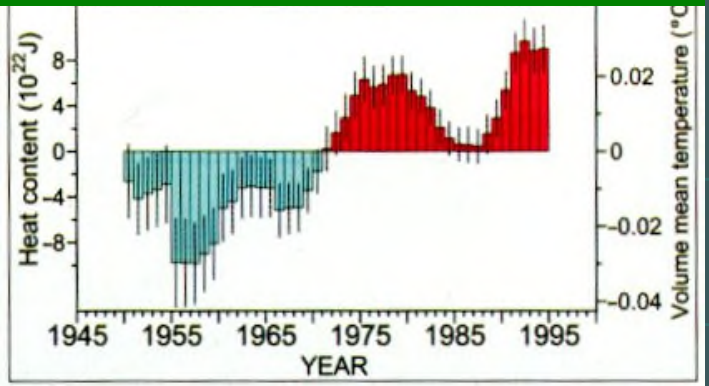
## Glacier Retreat


## Historic $CO_2$ vs.Temp



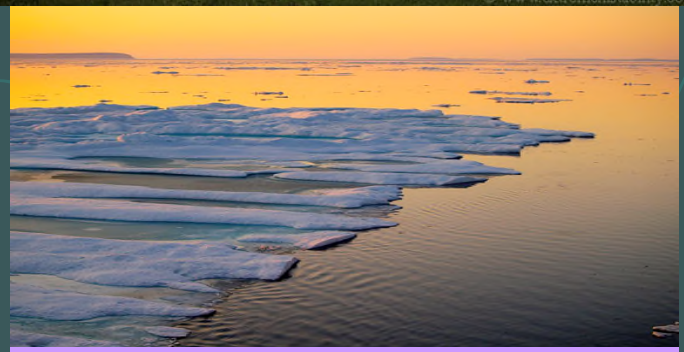

## Extreme Weather

## 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

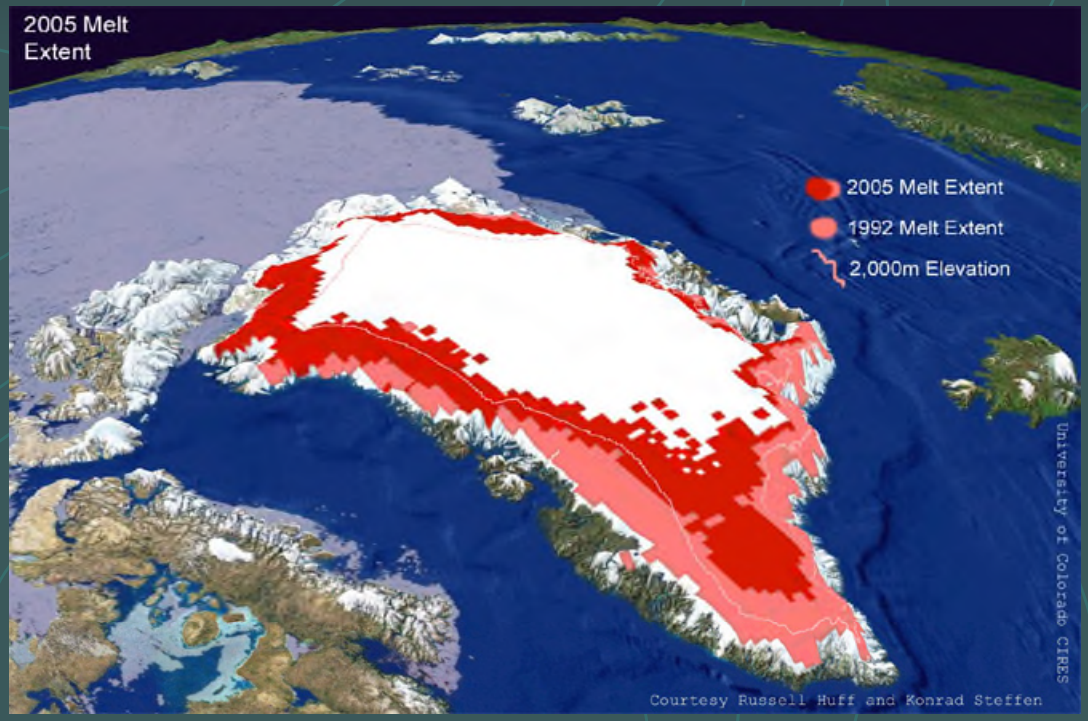
1) Progressive reduction in extent and thickness of polar ice caps

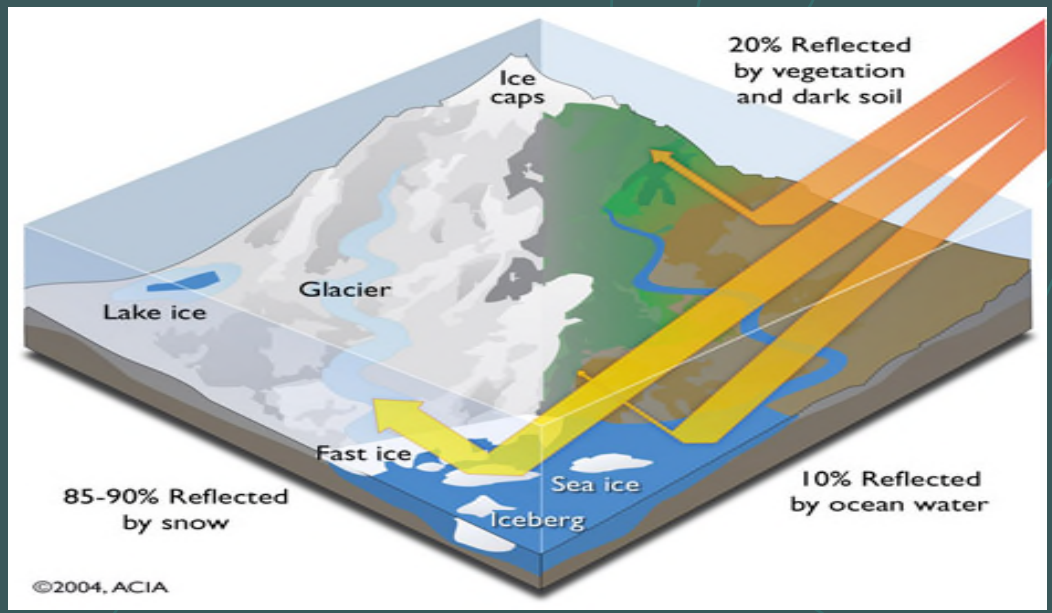
2) Secondary effects:

✓ Reduced sunlight reflection and increased light absorption into land surface

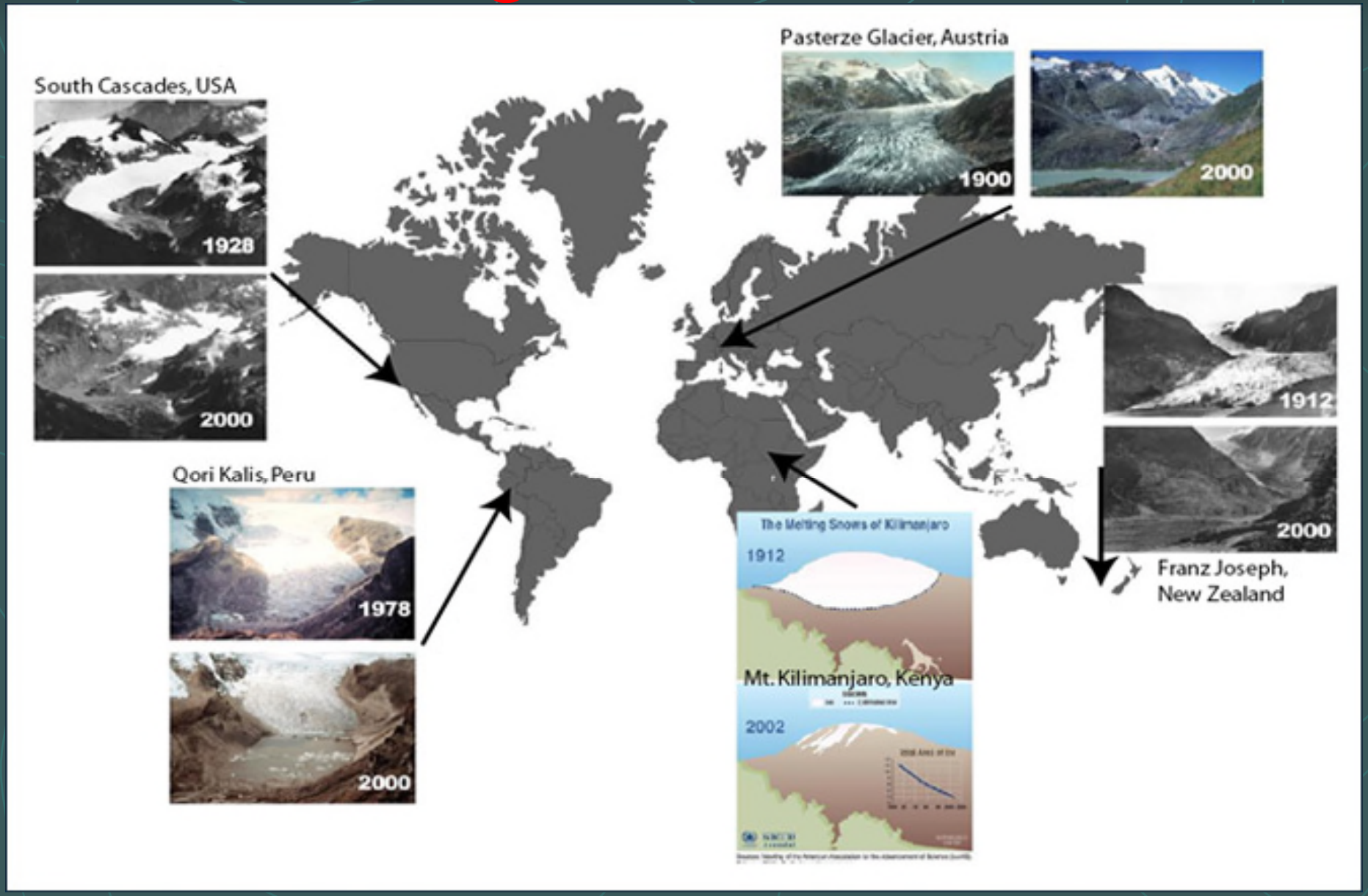
✓ Increase sea levels

✓ Massive influx of freshwater into polar sea surface waters



# Melting Mountain Glaciers



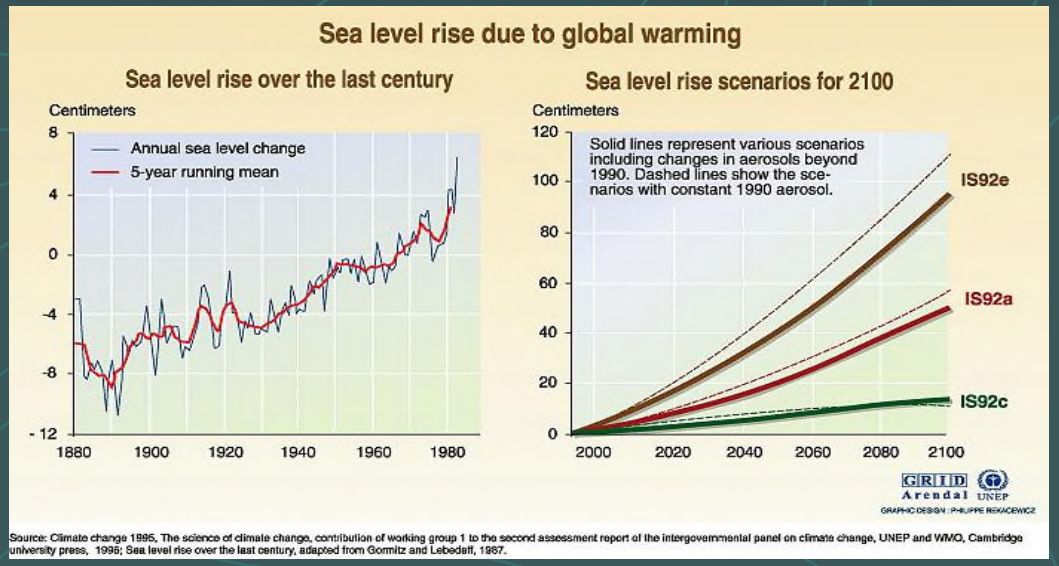

**Mountain glaciers on every continent are quickly receding or disappearing altogether**

# Global Warming Effects –Sea Level

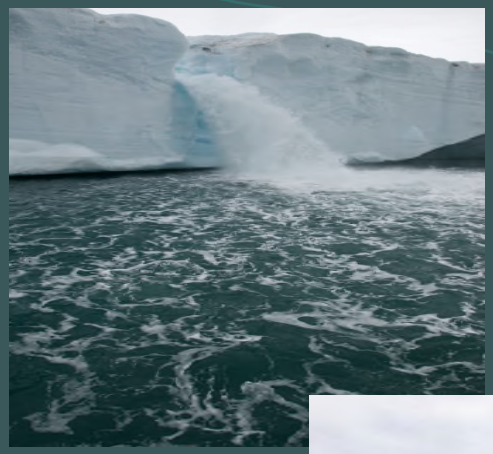
1) Progressive melting of polar ice caps will increase global sea level by tens of centimeters over the next several decades

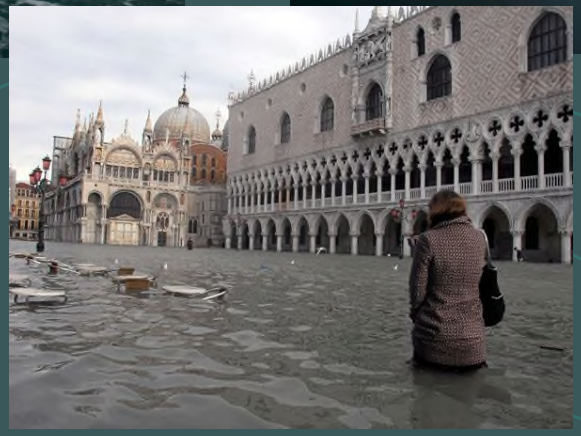
2) Thermal expansion of ocean is also causing rise in sea level by 8 cms for every degree rise in global temperature

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

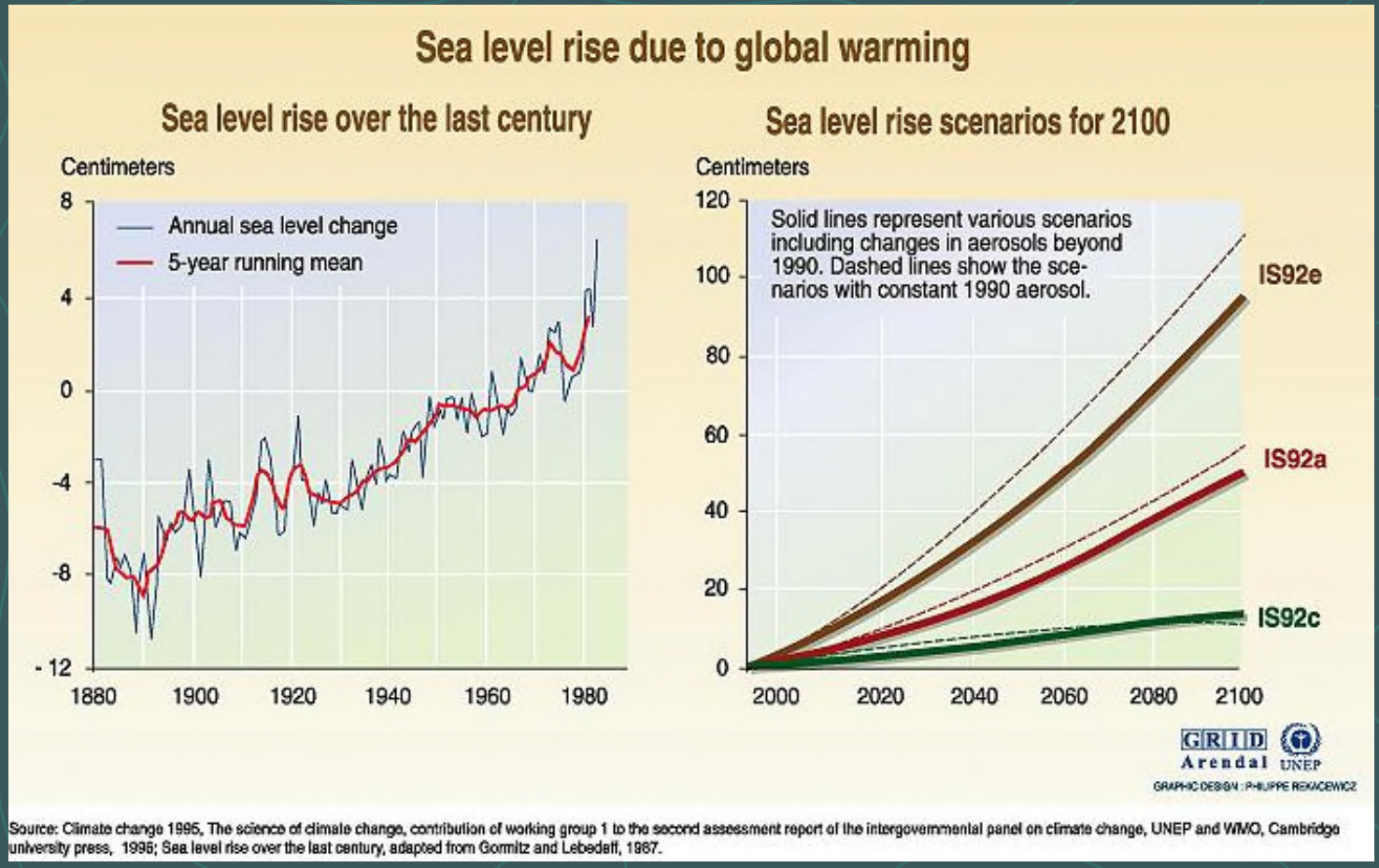


Source: Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1995; Sea level rise over the last century, adapted from Gornitz and Lebedeff, 1987.





# Global Warming and Sea Level Fluctuations



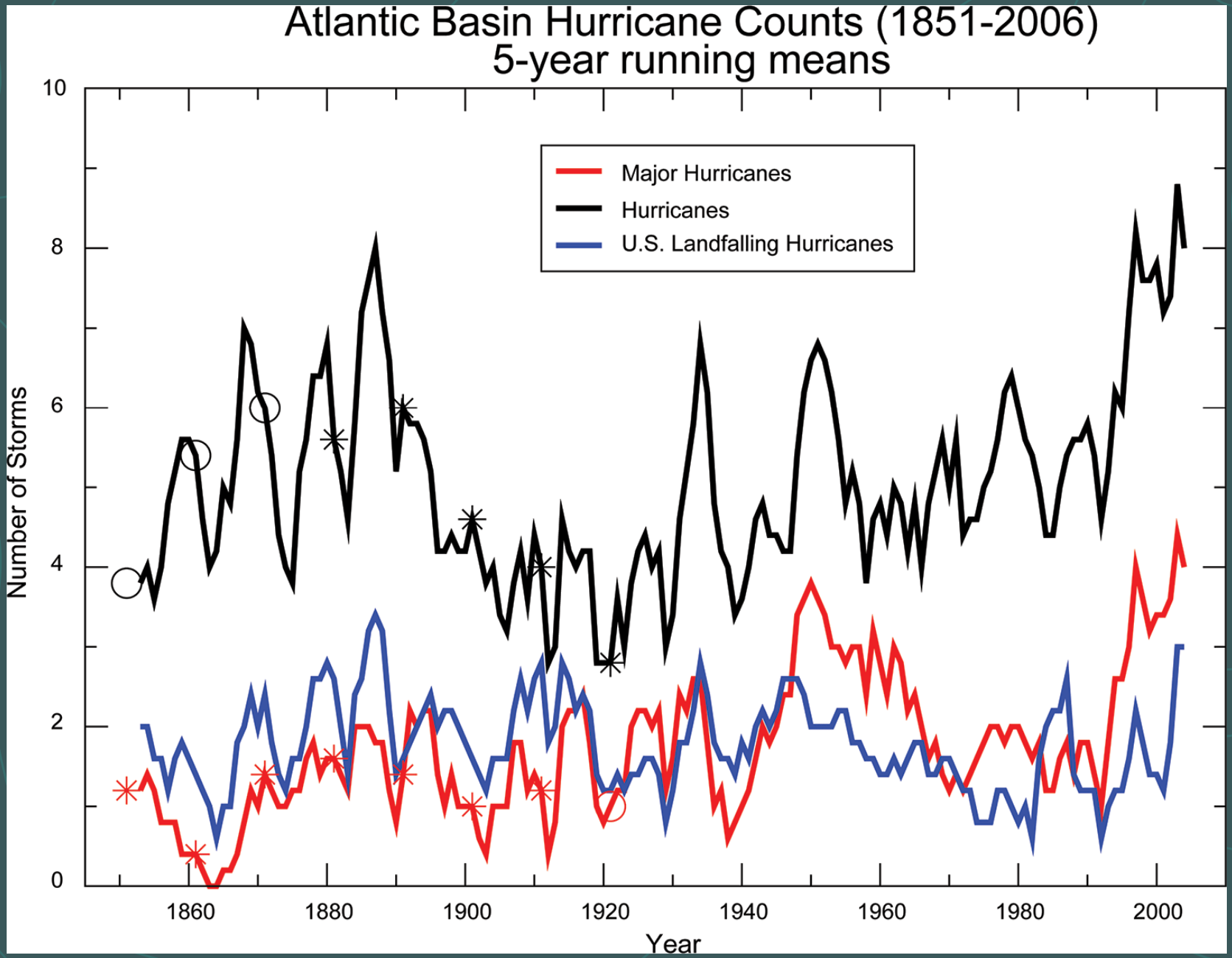

Source: Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1995; Sea level rise over the last century, adapted from Gornitz and Lebedeff, 1987.

# Global Warming Effects on Weather

1) More extreme weather fluctuations in most regions

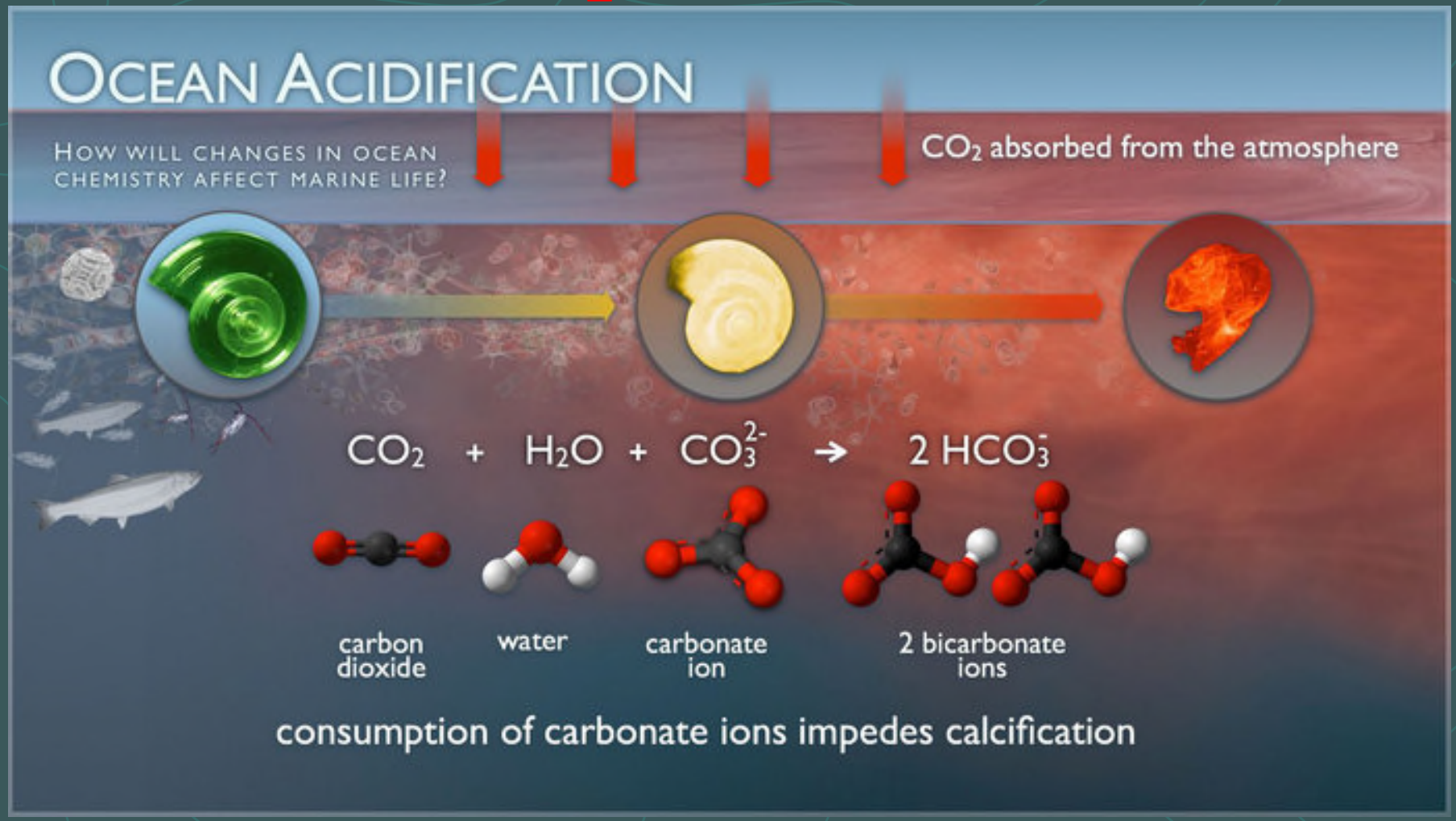
2) More frequent severe weather

# Global Warming Effects on Weather



# Ocean Acidification

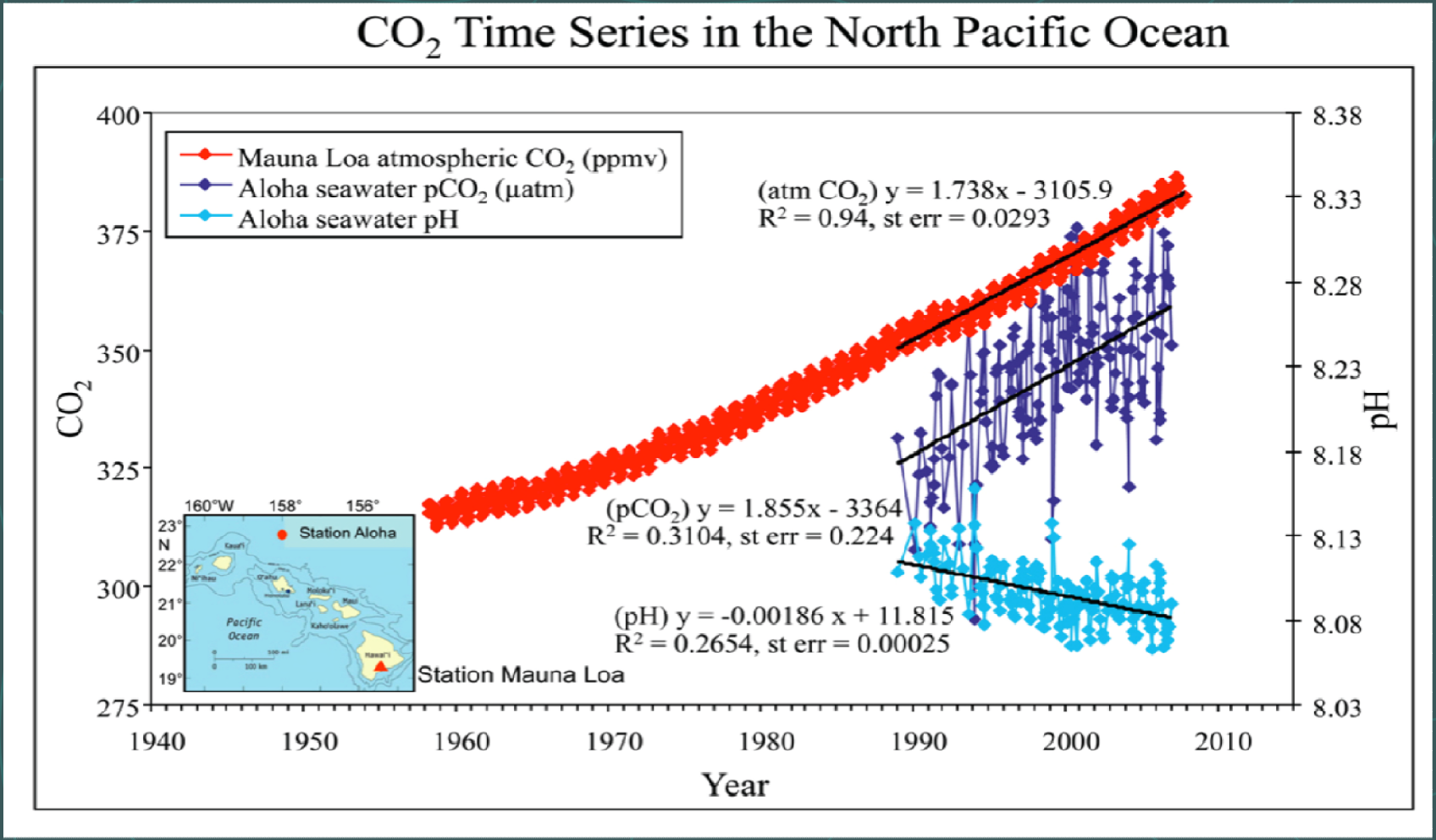
## Atmospheric $CO_2$ versus Ocean pH Level




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

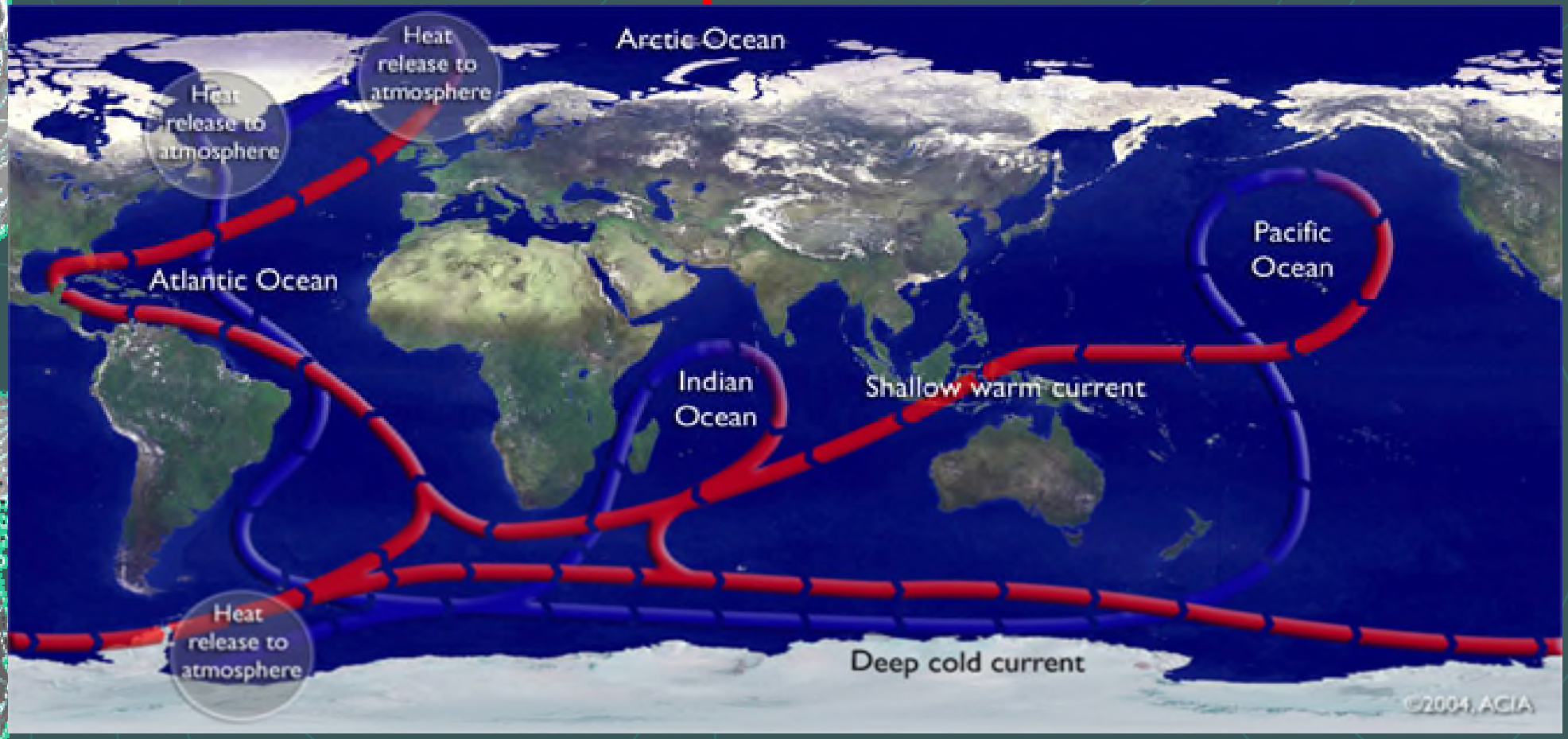
# Ocean Acidification

## 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

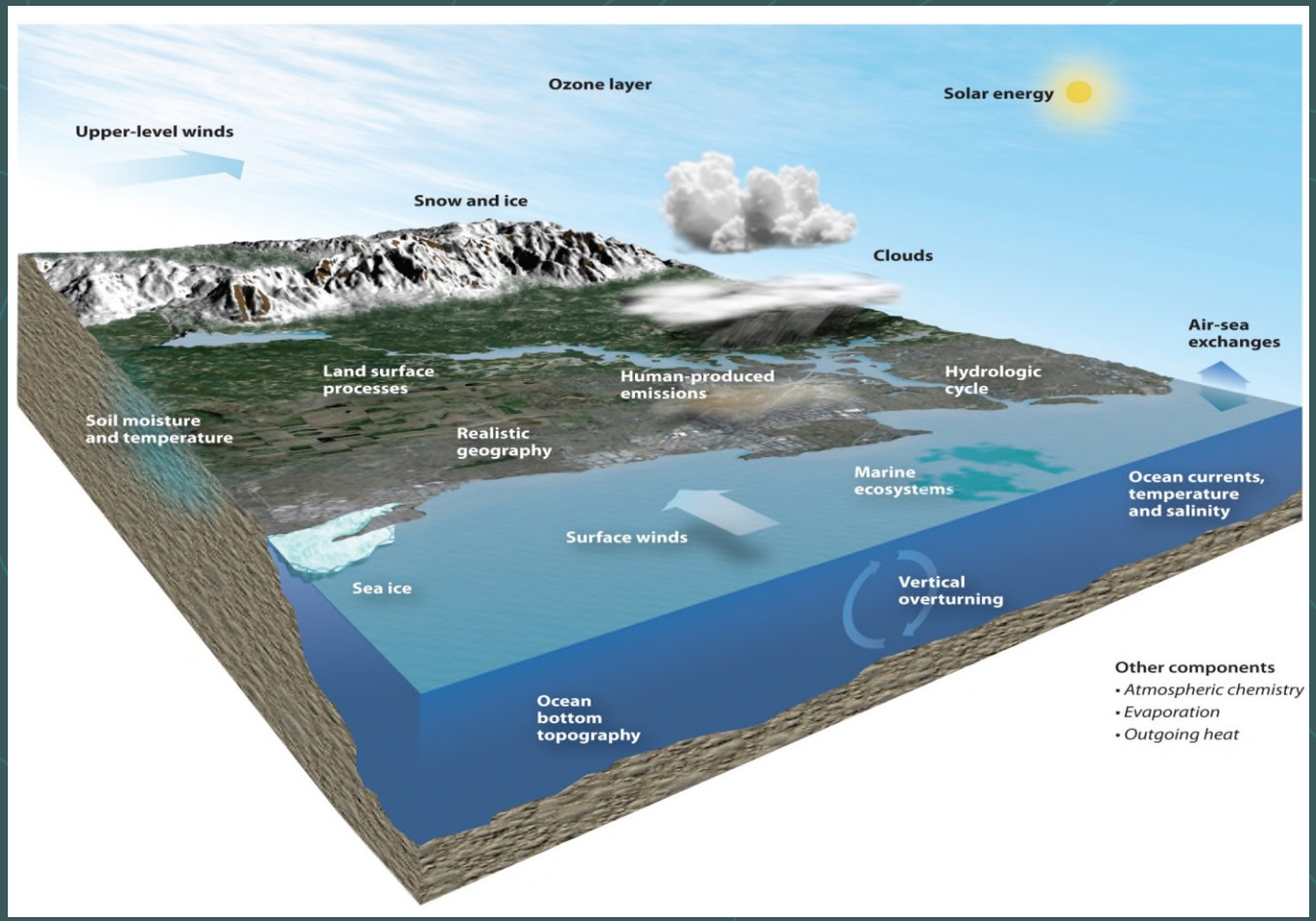



1) Climate-controlling *Global Ocean Conveyor Current System* will change – most likely slow down

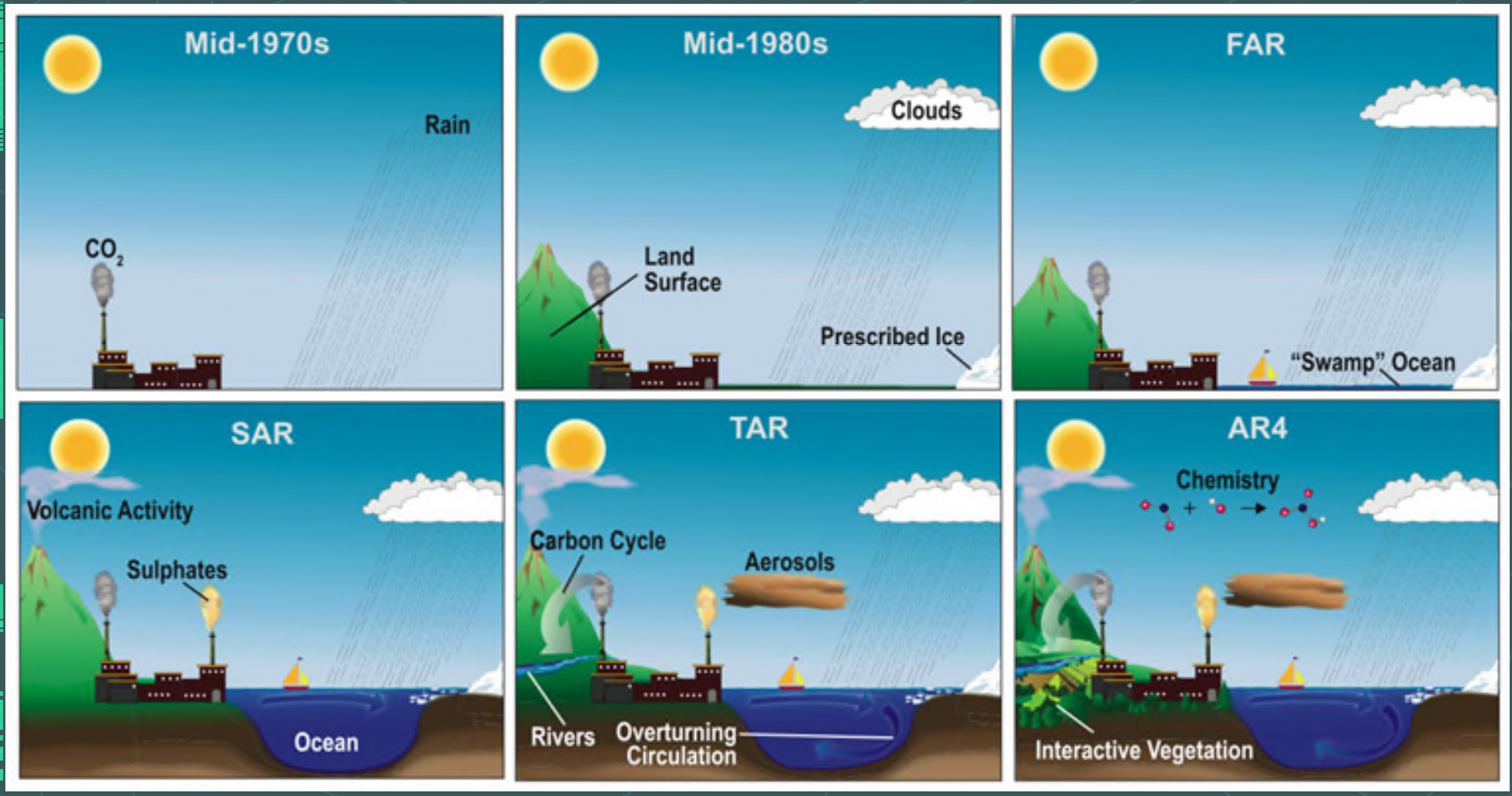
2) Result will be greater temperature differences between the poles and the equator

# Climate Modeling: The Components

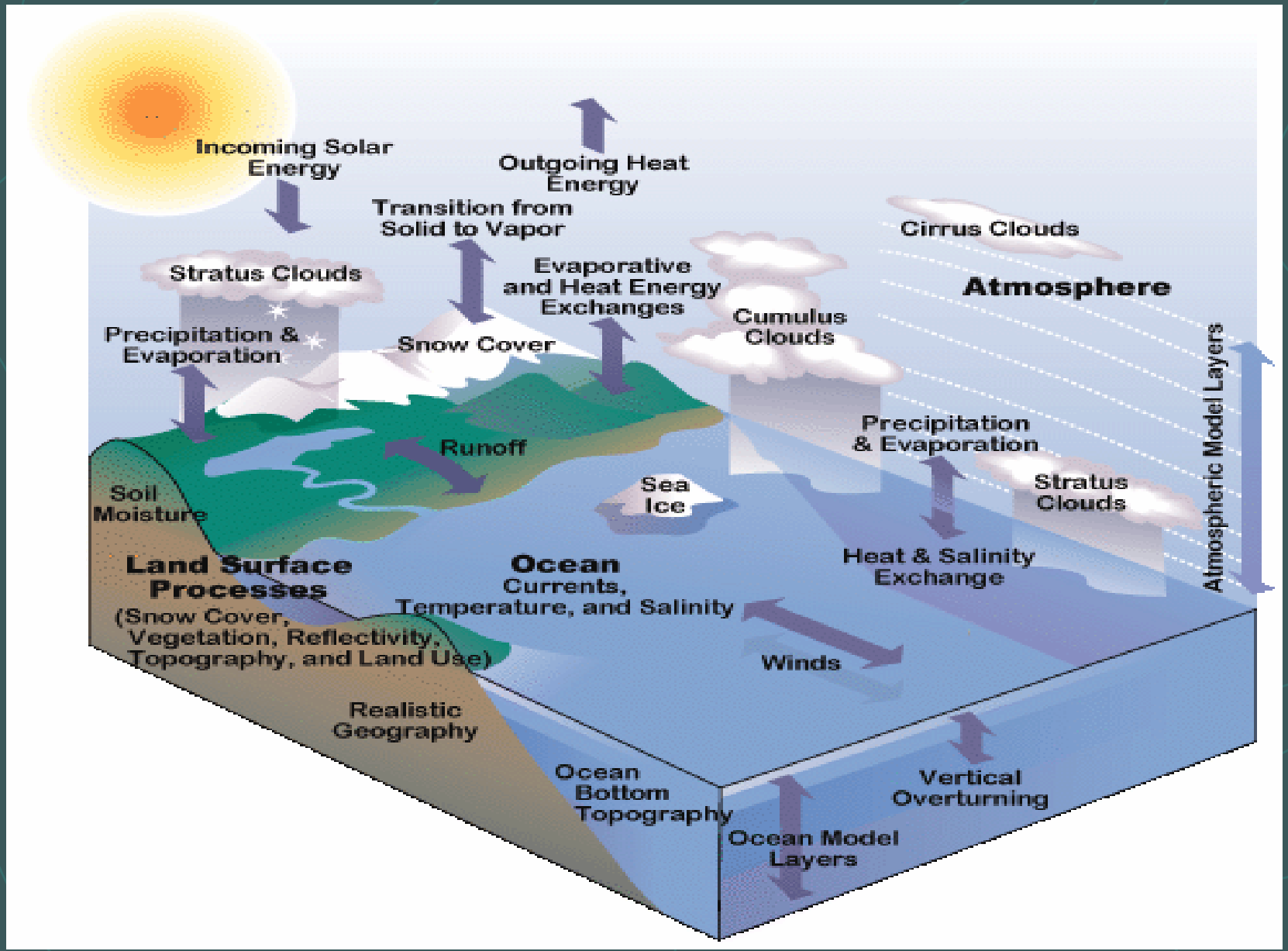
A climate model's ability to reflect what is actually occurring (observed) in nature over time is only as good as the integration of the various number of inputted climate-affecting components within a climate system



# Climate Model Evolution
# – Better and Better -



# Climate Modeling: The Components



# Climate Modeling Results

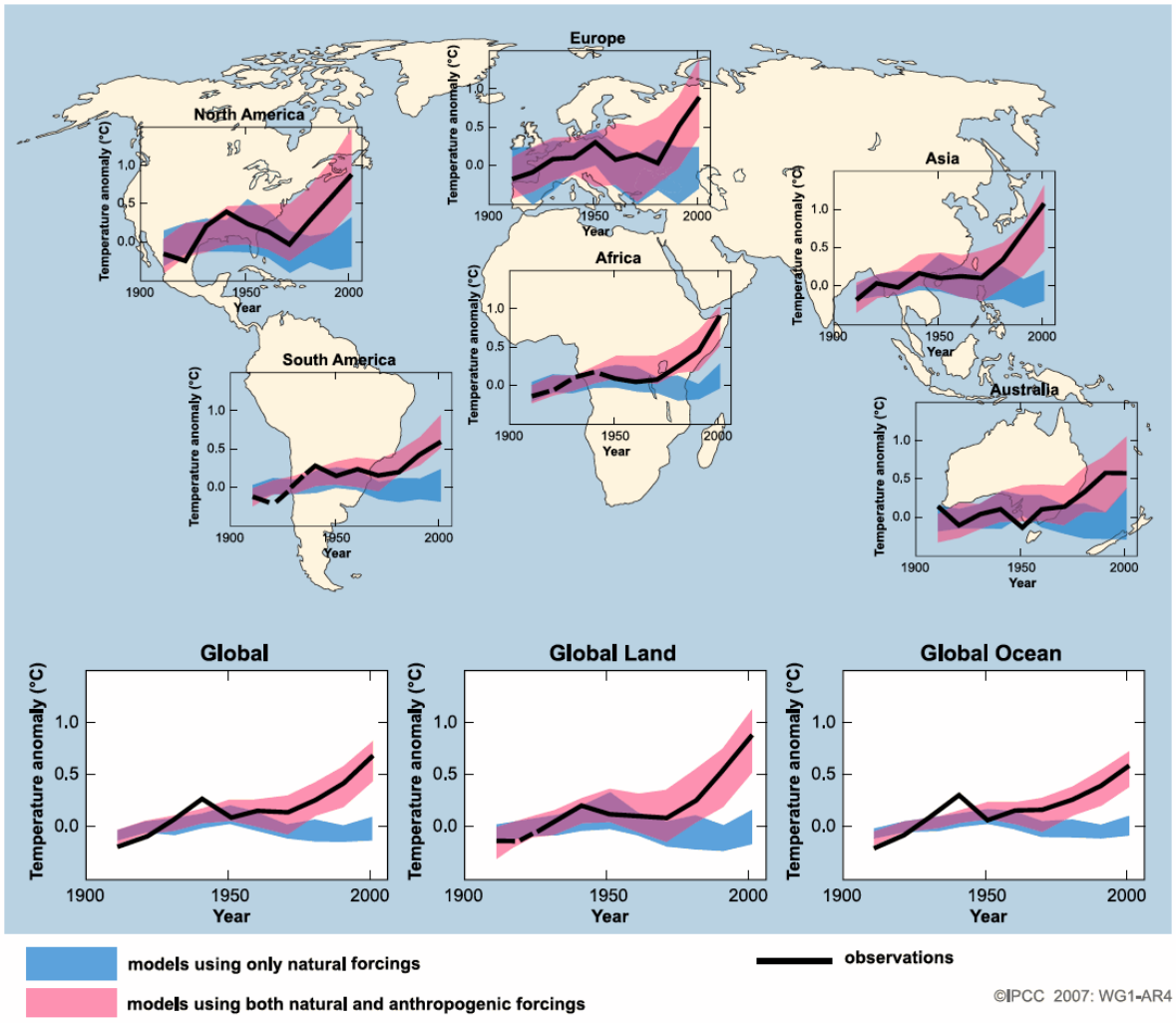
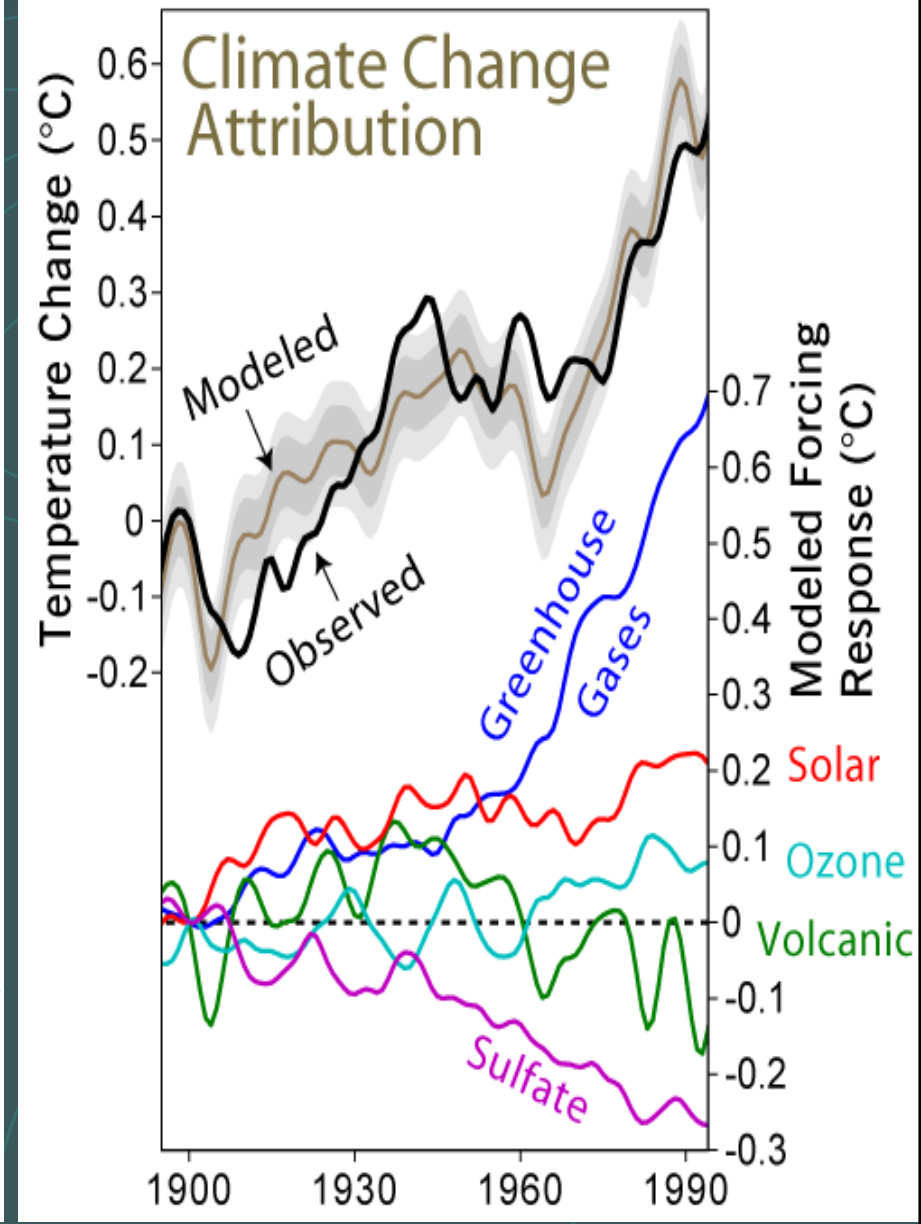
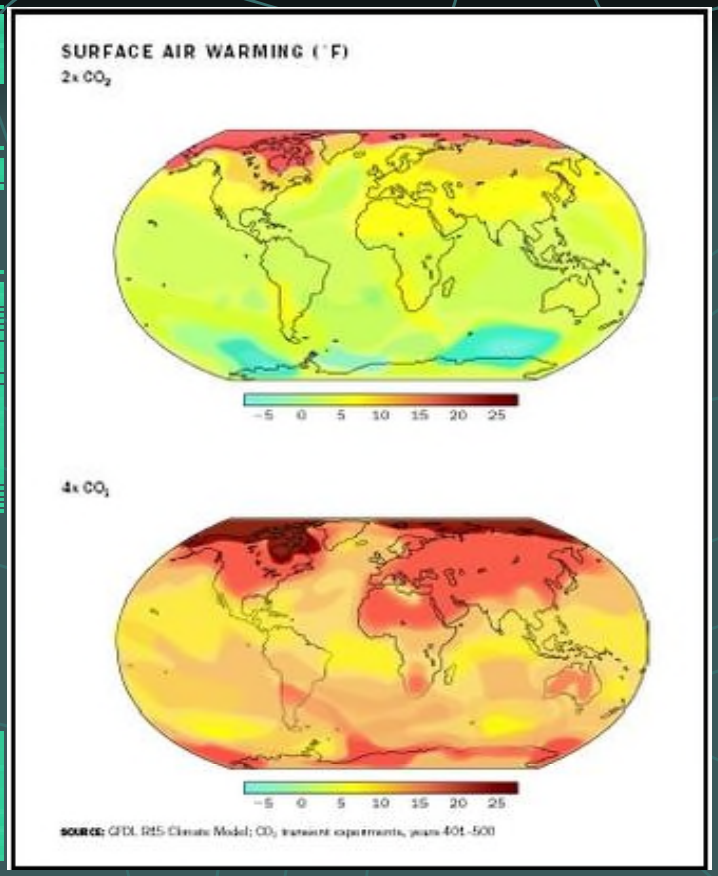
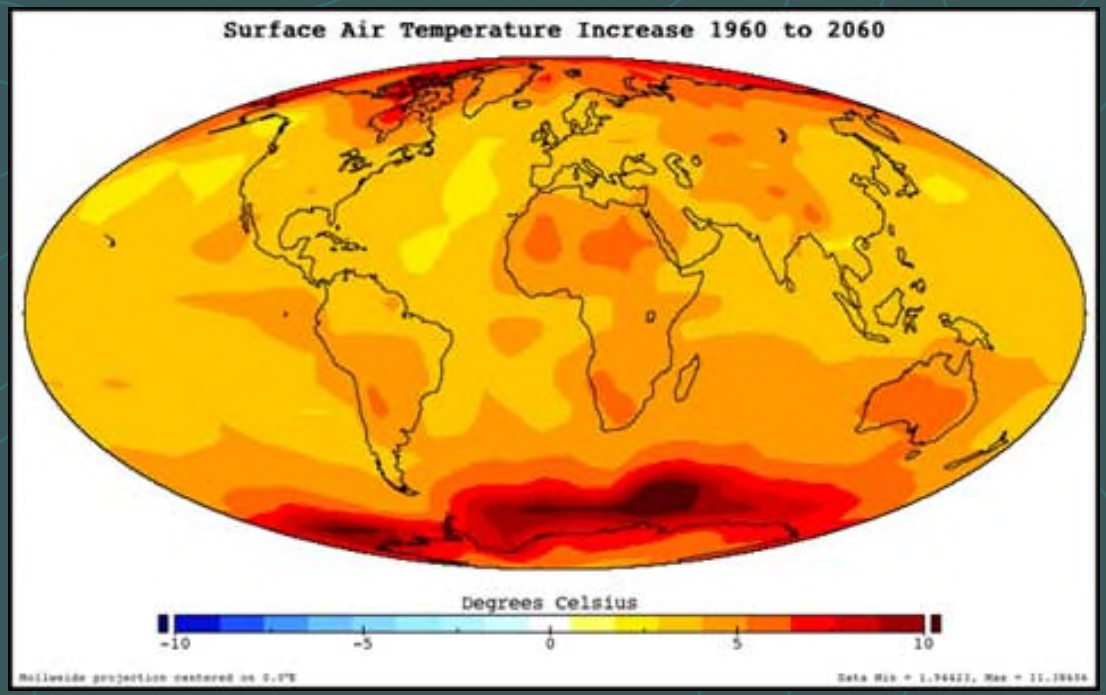



**Figure SPM.4.** *Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906 to 2005 (black line) plotted against the centre of the 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**

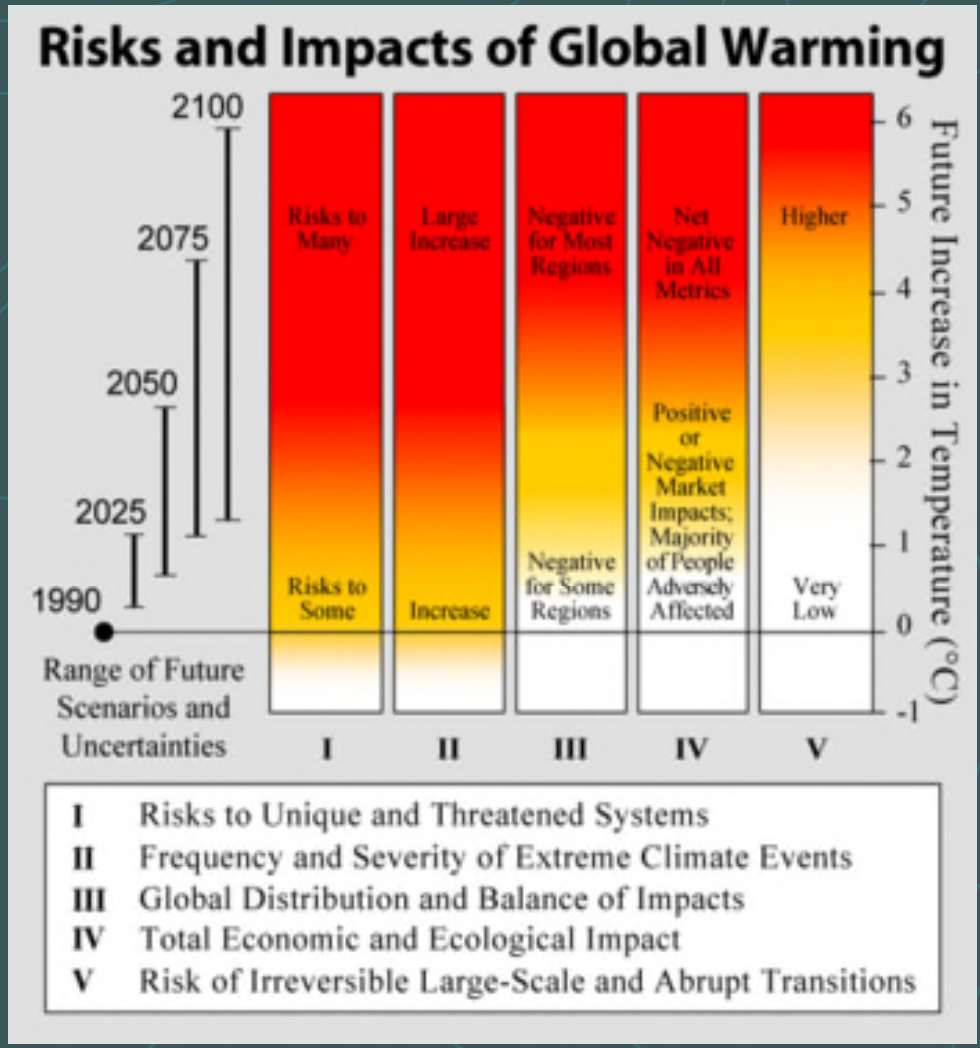
# Climate Change – Risk Modeling:

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

2) The future predicted increase in temperature varies with:

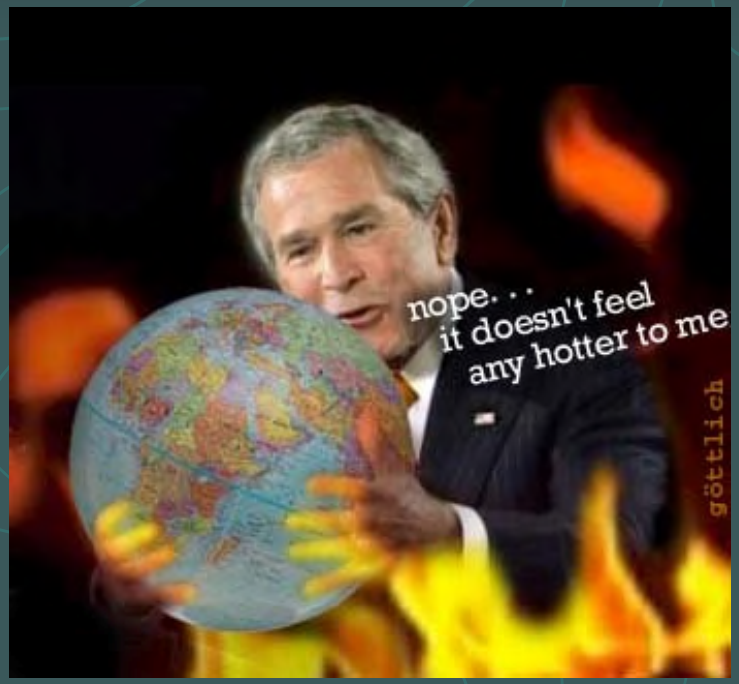
a) computer model

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

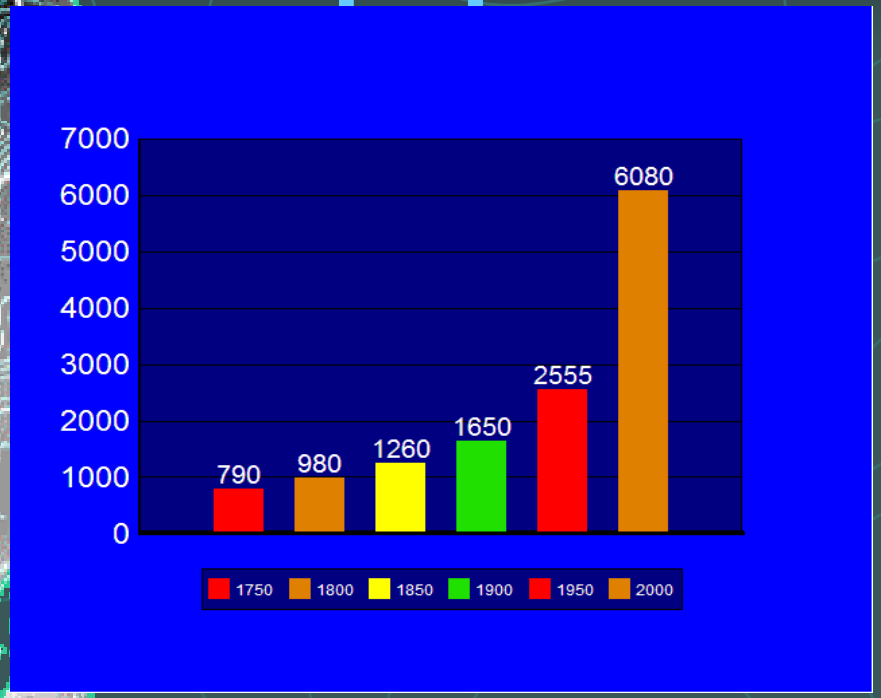
✓ The private media is sponsored by private interests and thus may provide false or misleading information that reflects their sponsorship

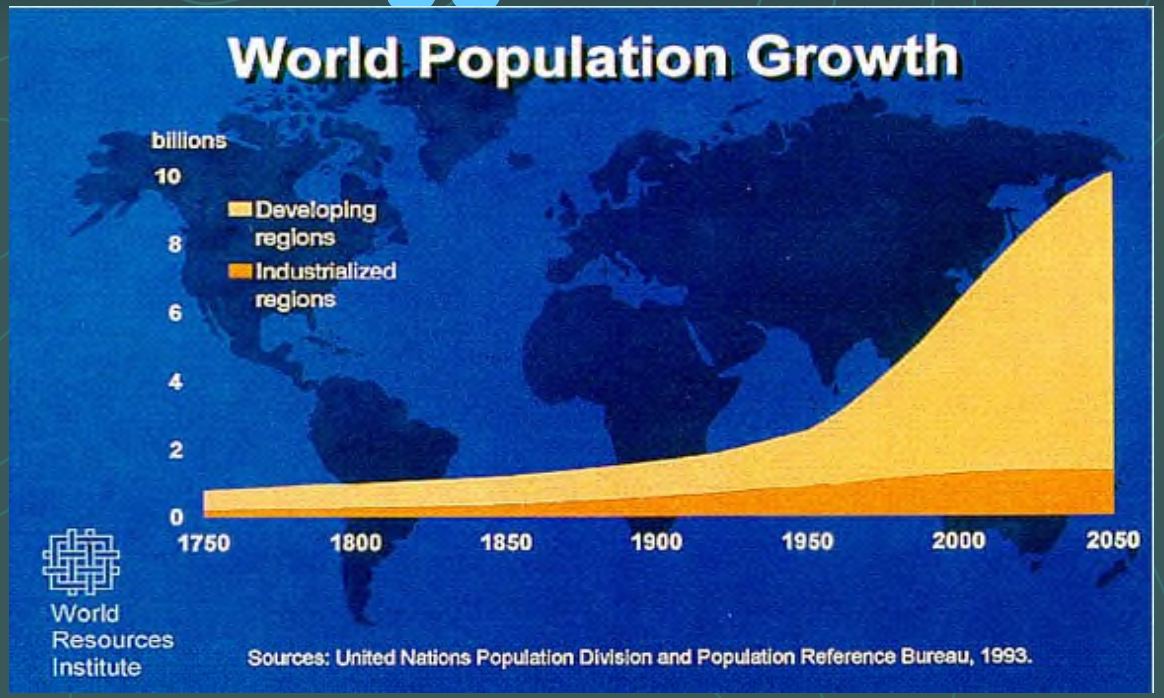
# Overpopulation: The Biggest Concern

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 many planets would we need if everyone lived the lifestyle of a typical Swiss citizen?

| | | |
|---|---|---|
| Switzerland | 3.3 |  |

## What about some other countries?

| | | |
|---|---|---|
| USA | 4.8 |  |
| Belgium | 4.3 |  |
| Germany | 3.1 |  |
| France | 3.0 |  |
| United Kingdom | 2.9 |  |
| Italy | 2.7 |  |
| China | 2.0 |  |

Quelle: Global Footprint Network National Footprint Accounts 2016

Global Footprint Network®
Advancing the Science of Sustainability

# 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

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.

## FOOD

MAKES UP

**26%**

OF HUMANITY'S ECOLOGICAL FOOTPRINT

# 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**

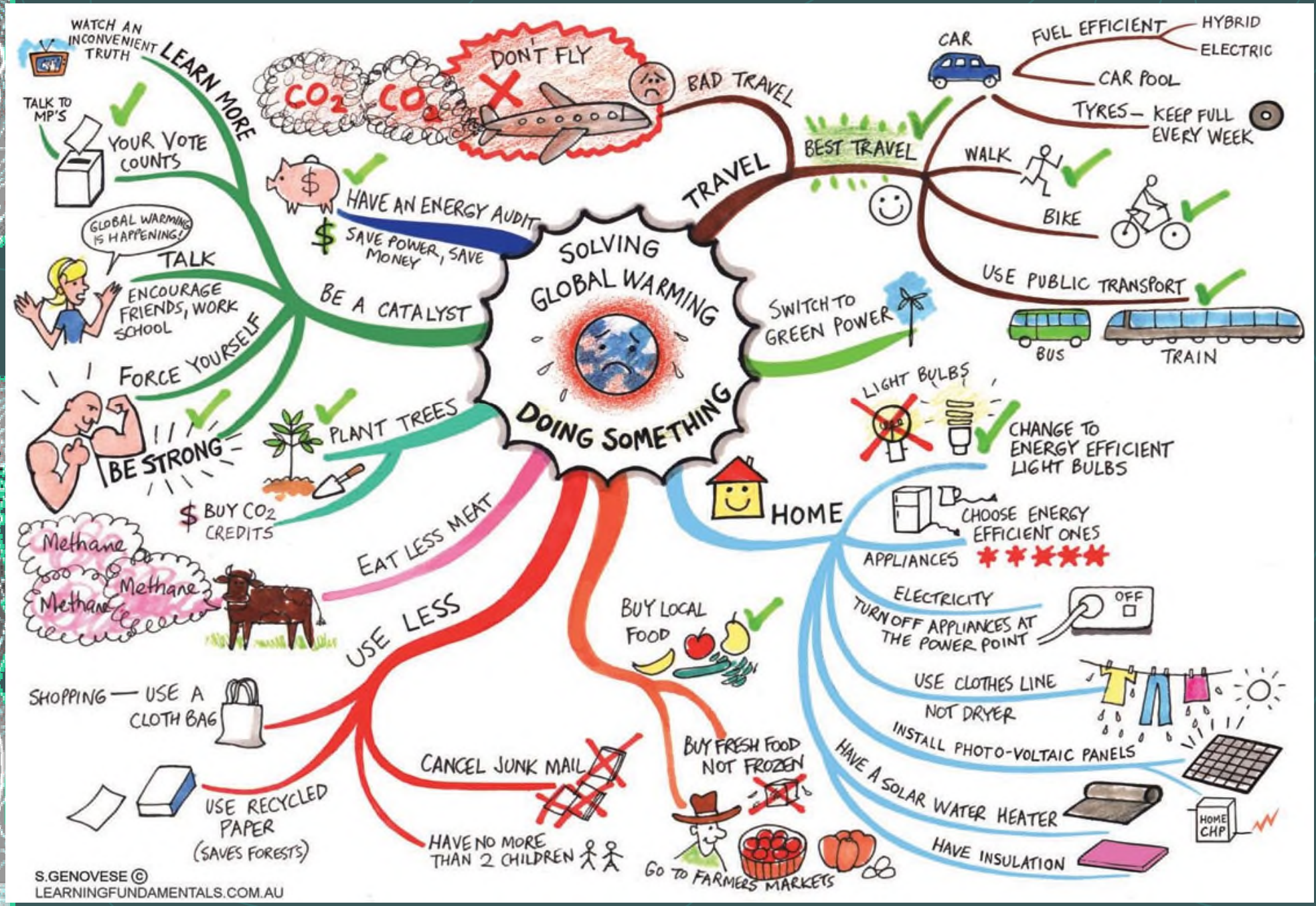
**RETHINK** THE MATERIALS

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?

# Environmental Concerns

## Discussion