



**“Global Climate Change –  
The Evidence, Science and How  
We Can Impact Our Environment”**

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**IEEE Aerospace and Electronics Systems Society**

**Dallas, Texas**

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Heat waves, ozone alerts, unhealthy air



Burning fossil fuels



Deforestation



Landfills – consumer waste



Glacial melting

***“The significant problems we have cannot be solved at the same level of thinking with which we created them”*** [17]

**- Albert Einstein**

# Agenda

- **Global Climate Change**
  - Key Facts of Today - The Evidence is **Real** !
  - Key Causes – Human combustion of fossil fuels [1,2,4]
  - Impacts to Air, Oceans, Land and Future Projections
- **What We Can Do**
- **Summary / Questions**

***“The IPCC Fourth Assessment [report] finds that the Earth is warming, and that major components of the Earth’s climate system are already responding to that warming.” [4]***



Dr. K. Trenberth, member of the IPCC (Intergovernmental Panel on Climate Change);  
Senior Climate Scientist, National Center for Atmospheric Research (NCAR);  
Testimony before the U.S. House of Representatives Science Committee, Feb 8, 2007

# U.S. Leaders Vow Action on Climate Change

February 8, 2007 “the U.S. House Committee on Science and Technology held the first Congressional conversation with climate scientists who authored the Intergovernmental Panel on Climate Change (IPCC) assessment report released last weekend in Paris.”

*“There’s no denying we face a big challenge ... We must explore ways to reduce emissions, to adapt to coming changes and to mitigate the negative effects of a changing climate. We cannot accomplish all this overnight, but we must begin in earnest now to address this serious issue”* - Bart Gordon, Committee Chairman [2]

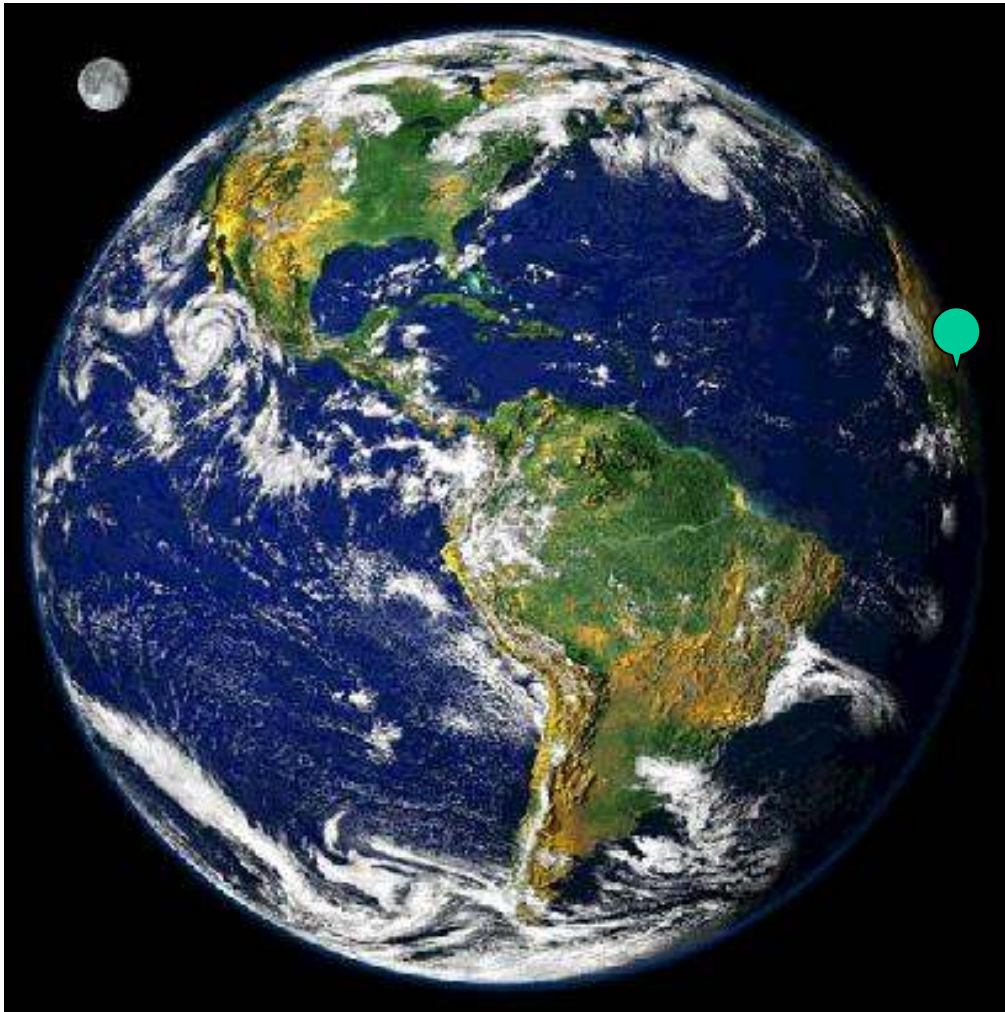
June 25, 2007 the United Church of Christ (UCC) approved “A Resolution on Climate Change” prepared by the UCC’s Energy and Climate Work Group.

*“... BE IT RESOLVED that the Twenty-sixth General Synod of the United Church of Christ admits Christian complicity in the damage human beings have caused to the earth’s climate system and other planetary life systems, and urges recommitment to the Christian vocation of responsible stewardship of God’s creation ...”*  
- 26<sup>th</sup> General Synod of the UCC [49]

December 10, 2007 the Nobel Peace Prize was awarded to the IPCC and to Al Gore.

*“... So today, we dumped another 70 million tons of global-warming pollution into the thin shell of atmosphere surrounding our planet, as if it were an open sewer ... As a result, the earth has a fever and the fever is rising... something basic is wrong. We are what is wrong, and we must make it right ...”*

- Al Gore, Acceptance Speech [48]



## Earth's Climate

The atmosphere is a "global commons."

As shown by manned balloon flights, Air over one place is typically half way round the world a week later.

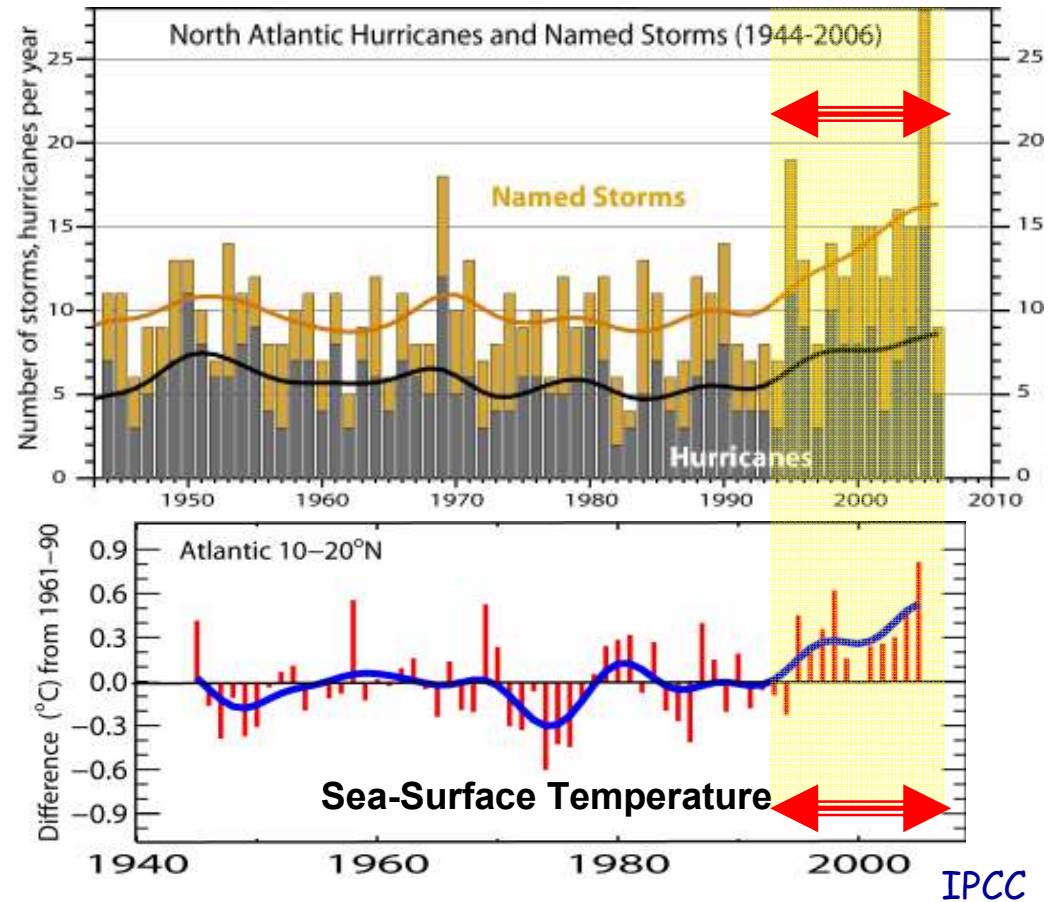
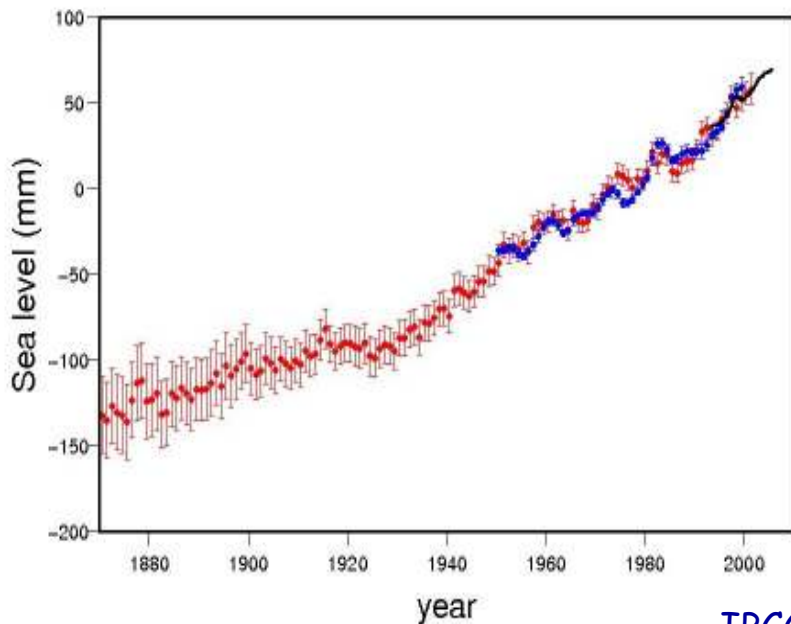
The atmosphere is a dumping ground for all nations for pollution of all sorts. Some last a long time and are shared with all. **One consequence is global warming!**

Source: K. Trenberth [43]

# Global Warming - The Evidence Today

**Since 1970, increases in:**

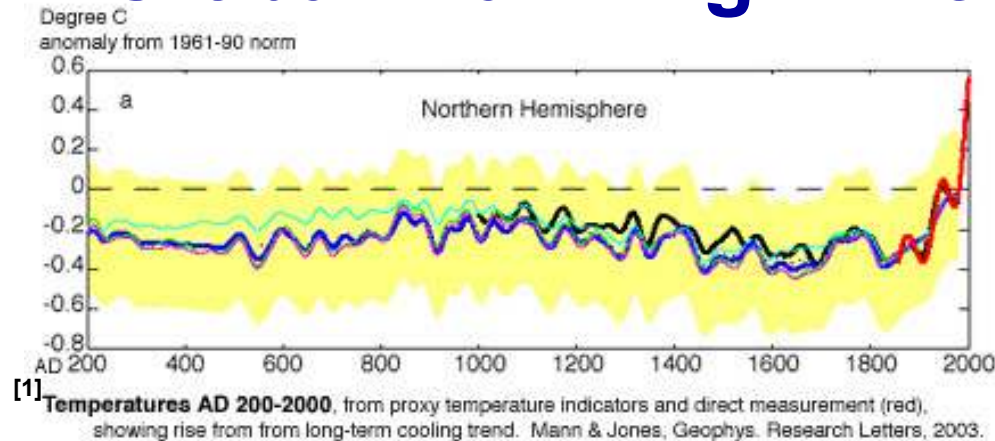
- Global average air temperature
- Ocean temperature
- Widespread snow melting
- Atmospheric water vapor content
- Reduced duration of freeze seasons
- Heat waves, droughts and floods
- Rising global mean sea level
- Hurricane intensity and activity



- Decreases in Arctic sea-ice extent and mass
- Decreases in glacier and ice cap extent and mass
- Changes in precipitation patterns and atmospheric winds

Sources: [1,2,4,9]

# Global Warming - The Evidence (Air)



- In 20<sup>th</sup> Century, the Global Average Temperature has Increased 1.4°F – and its accelerating! [1,4]

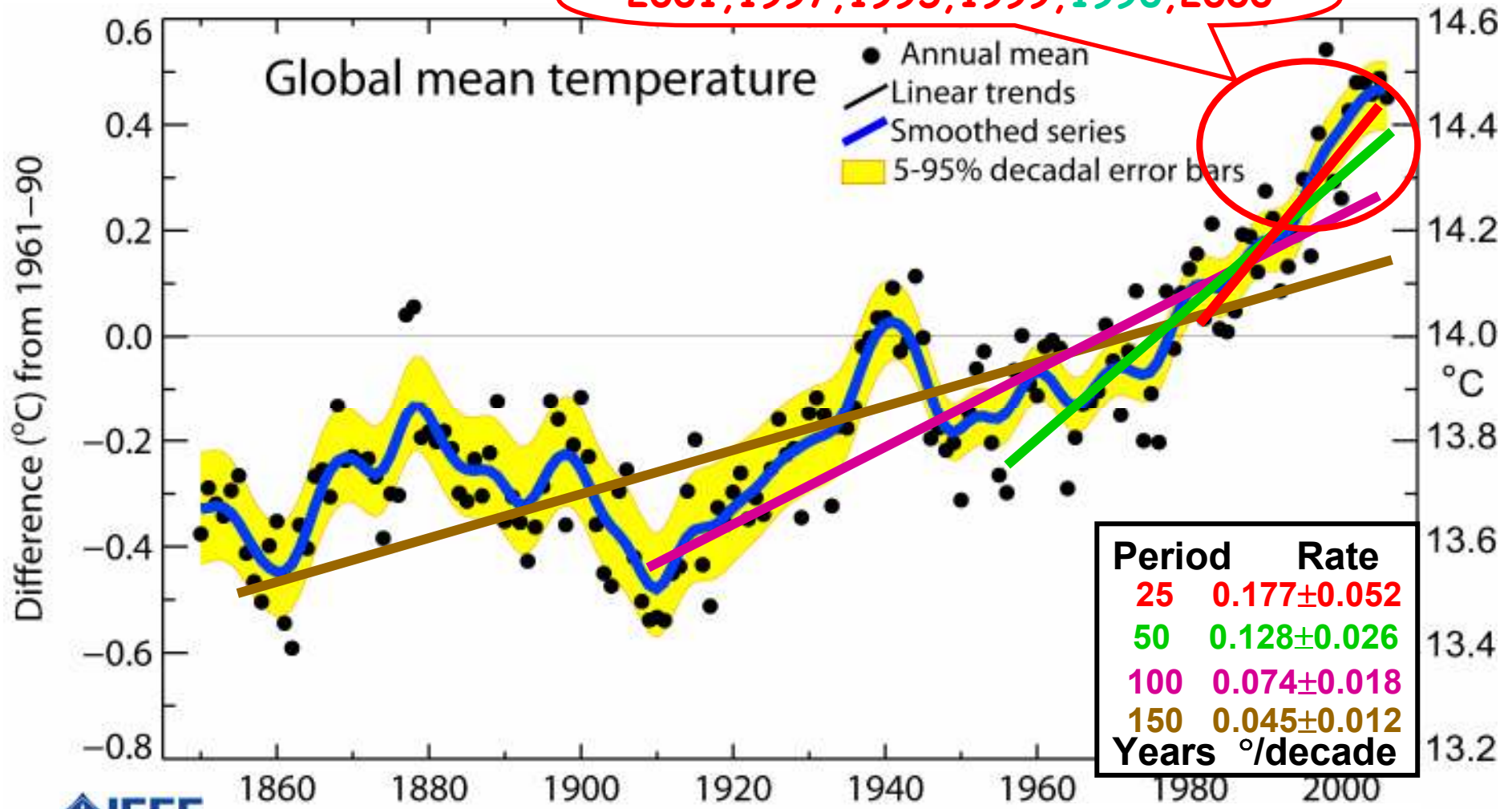
- Warming 0.63°F from 1910s to 1940s and 1.0°F from 1970s to present
- Current warming rate is 0.3°F per decade (an additional 1.5°F by 2050)
- 11 of the 12 warmest years on record have occurred in the last 12 years
- 2006 ranks 6<sup>th</sup> globally and 1<sup>st</sup> in the U.S. as the warmest year on record
- Global ocean average temperature increased significantly indicating heat absorption
- Average sea-level rise due to expansion is about 1.8 mm per year from 1993-2003
- Average water-vapor in atmosphere has increased by 4% since 1970.

- Average Arctic temperatures increased 2x global average rate in past 100 years [1,4]

- Permafrost top layer has increased by up to 3°C (5.4°F) since 1980s [1,4]
- Areas of permafrost are thawing – releasing methane into air (additional warming) [6,11]
- Animals are changing feeding and migration patterns [6,9,10,11]

# Global Mean Temperatures Rising Faster With Time

**Warmest 12 years:**  
 1998, 2005, 2003, 2002, 2004, 2006,  
 2001, 1997, 1995, 1999, 1990, 2000

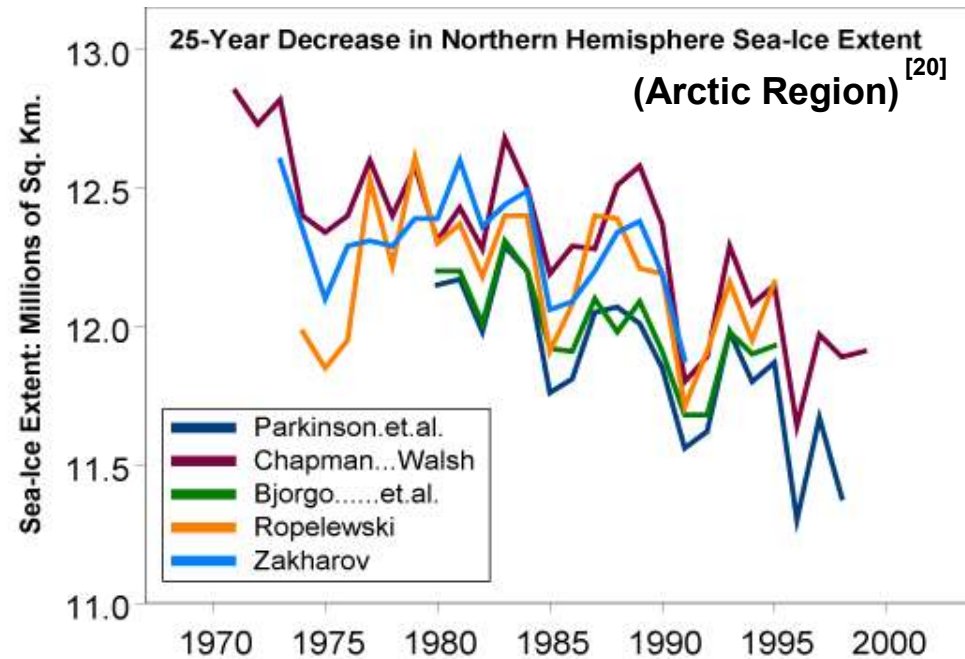




# Global Warming - The Evidence (Sea Ice)



Breakup of Larsen B Ice Shelf in 2002  
(Antarctic Peninsula)



- Sea-Ice Extents have decreased in the Arctic since 1978 at about 7.4% per decade <sup>[1,4]</sup>
  - Record low values in 2005, warmest year since records began in 1850 for the north Arctic
  - Significant decreases in sea-ice thickness (measured)
  - Break up of ice shelves along the Antarctic Peninsula has occurred since late 1980's
- Polar Bears rely on sea-ice to survive <sup>[6,7,10,20]</sup>
  - Population decline is directly linked to early break-up of sea-ice in spring (by global warming)
  - Less time to hunt for food before ice melts – increased bear drowning and starvation
  - Population tracked by US, Canadian wildlife service: 1194 bears in 1987, less than 940 in 2004

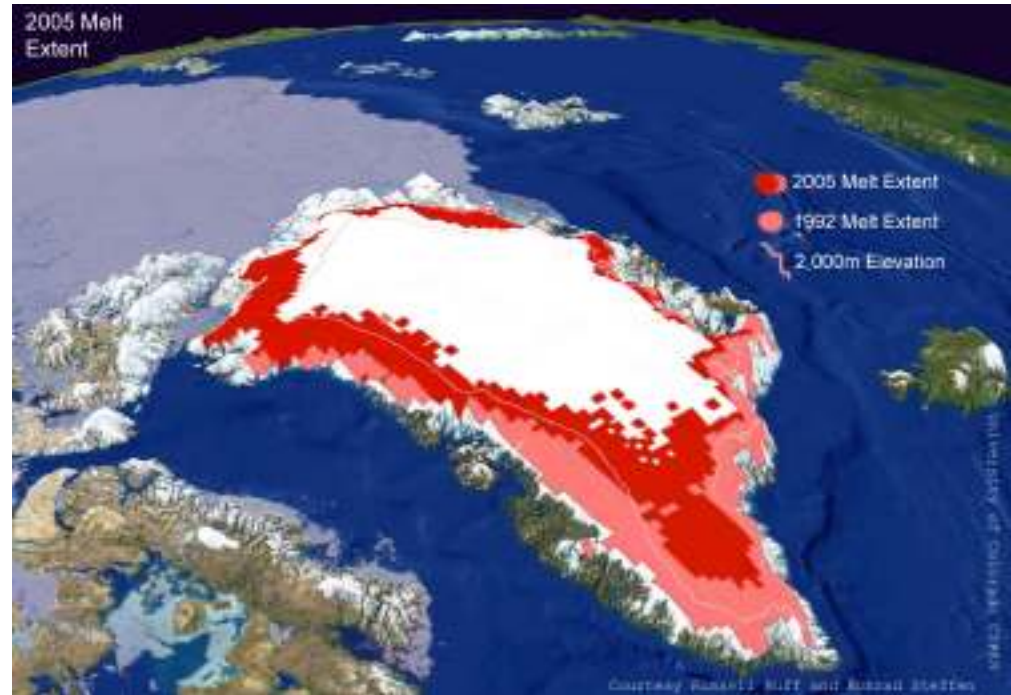
# Global Warming - Ice Sheet Melting

***“The melting ice [in Greenland] is the ‘canary in the coal mine’”***

- Dr. Michael Oppenheimer, Climatologist<sup>[10,36]</sup>



An ‘Ice-Chip’ from Greenland Ice Sheet - Sept 2006 <sup>[32]</sup>



- **Melting of the Greenland Ice Sheet is increasing and contributing to global sea-level rise** <sup>[4,18]</sup>
  - **Outflow of icebergs (see photo) has doubled twice-over in the last 20 years due to temp. rise** <sup>[10,18]</sup>
  - **The Ice Sheet covers 81% of Greenland; it’s 465 miles wide, 1540 miles long and 1.6 miles thick** <sup>[39]</sup>
  - **The Ice Sheet contains the equivalent of 23 feet of global sea-level rise** <sup>[10]</sup>
  - **An estimated -50 to -100 Gt / year of mass loss occurred from 1993-2003; larger losses in 2005** <sup>[1]</sup>
  - **Southern Greenland’s ice liquefying rate has jumped 250% in the last 4 years** <sup>[32]</sup>
- **Each day 500 million tons of ice mass from the Greenland and Antarctic Ice Sheets is lost** <sup>[11]</sup>

Note: 1 Gt = 1 Gigaton = 1 billion (10<sup>9</sup>) tons

# Global Warming – Glacial Melting



Pasterze Glacier, 1875, Austria <sup>[21]</sup>



Pasterze Glacier, 2004 <sup>[21]</sup>

- Glacier melting contributed 1 inch to global sea-level rise from 1961-2003 <sup>[1,5]</sup>
  - Glacial land ice melting makes up 40% of global sea-level rise <sup>[1,4]</sup>
  - Less than 40 glaciers remain in Glacier NP, Montana which had 150 in 1850 <sup>[15]</sup>
  - In alpine areas, glaciers provide 50% of fresh water for local towns <sup>[11]</sup>
  - 87% of water supply for western Americans comes from glacier sources <sup>[11,33]</sup>
  - Snows of Mt. Kilimanjaro (in the Himalayas) are melting <sup>[11,33]</sup>
  - Peruvian glaciers lost 25% of surface area since 1970's <sup>[11,33]</sup>
- Satellites are used to measure ocean sea levels, SST, glacial melting and ice mass thickness <sup>[1,11,57]</sup>

# Global Warming – Oceans & Coral Reefs

- Average global sea-level rose 3.5 inches from 1961-2003 [1,4]
  - Rate of increase from 1993-2003 was 3.1mm (~1/8 inch) per year
  - Measurements made from altimeters in space
  - 60% of rise is from ocean warming and expansion, 40% is from glacial melting
  - **Potential global sea-level rise of 1 to 2 feet by the end of this century** [11]



- Rising water temperatures, coupled with the strong El Niño of 1998 devastated much of the world's coral reefs. High water temperatures caused coral bleaching and subsequent death or adverse change to 16% of the world reefs and up to 46% in portions of the Indian Ocean.

- *World View of Global Warming, 2005* [21]

- Rising water temperatures in the Yukon River make Chinook salmon more susceptible to a parasite called *Ichthyophonus*. Salmon populations are already dwindling, and now, because of the disease.

- *Natural Resources Defense Council, 2007* [12]

# Global Warming – Key Cause

## GLACIAL-INTERGLACIAL ICE CORE DATA

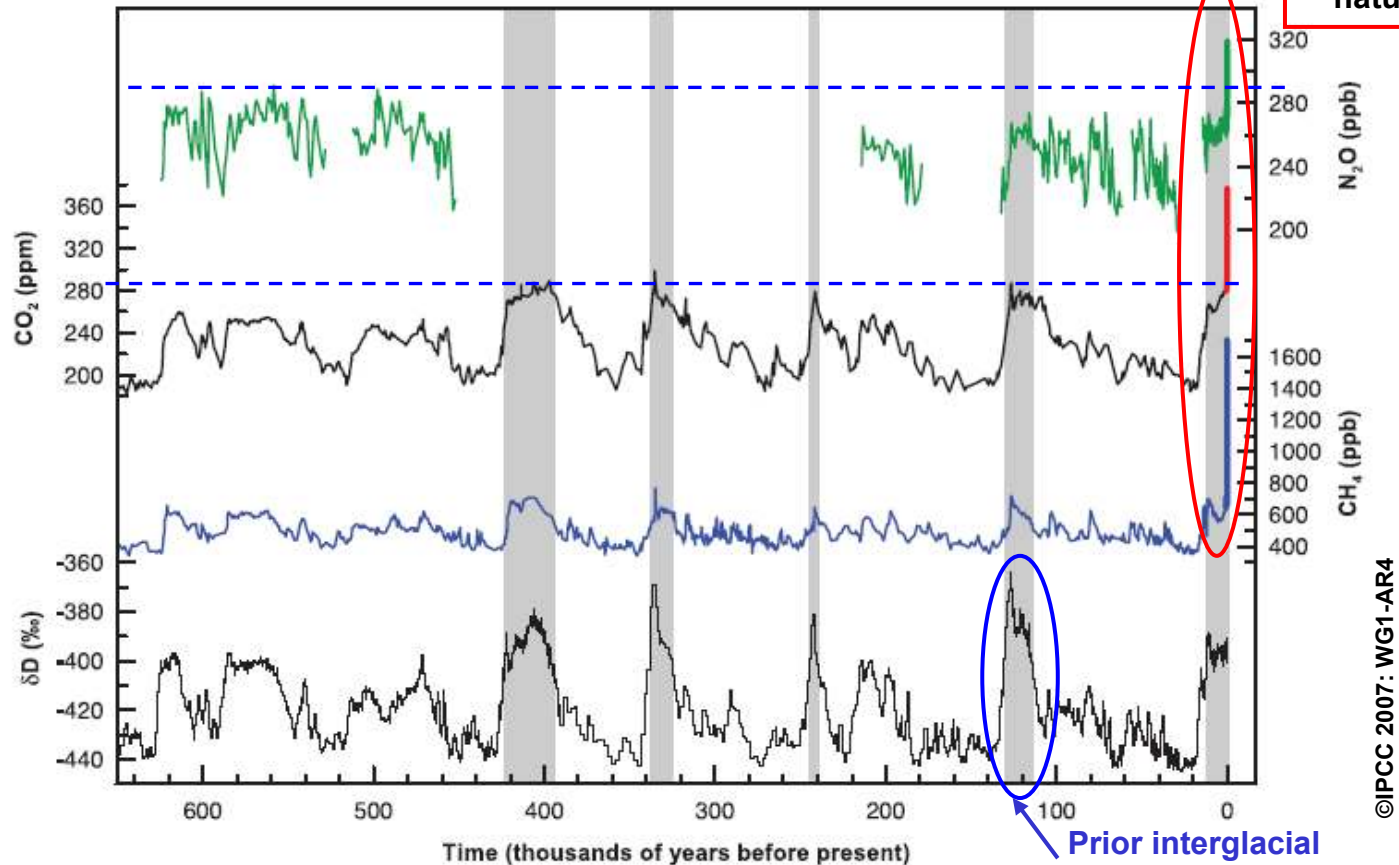
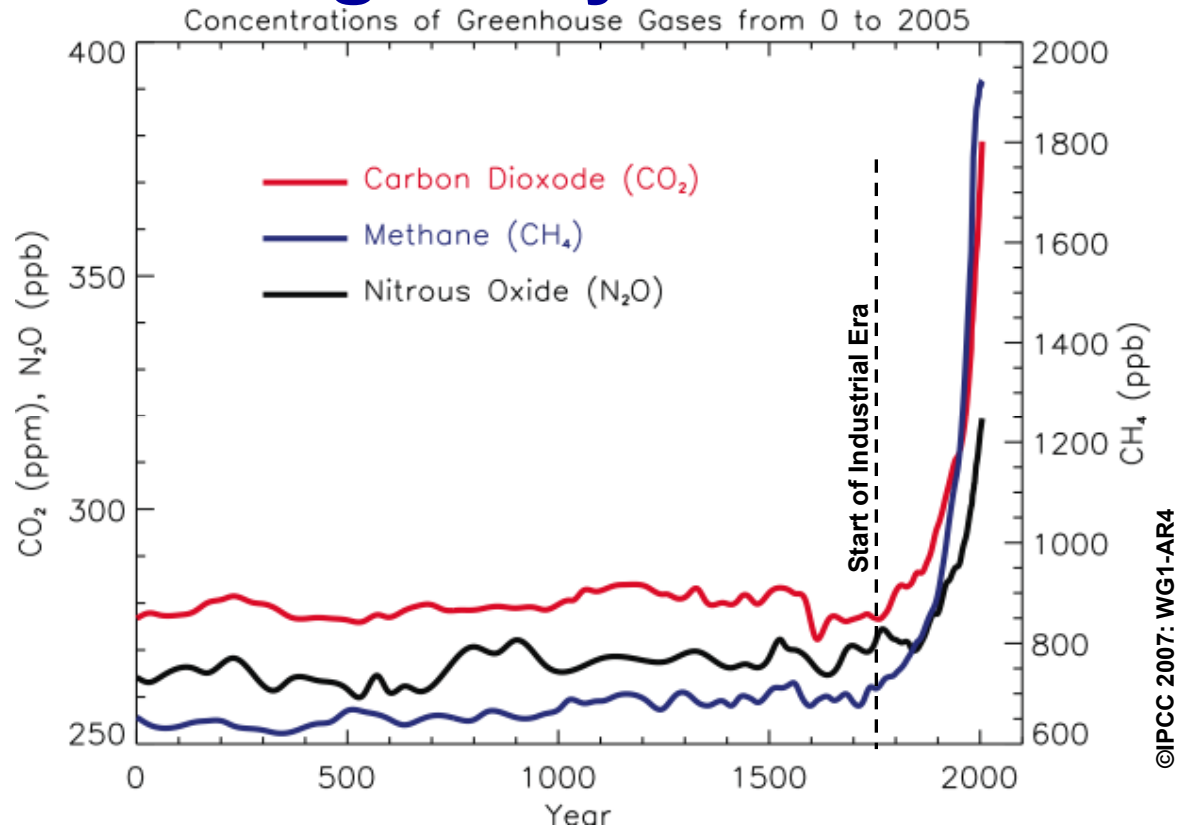


Figure TS.1. Variations of deuterium ( $\delta D$ ) in antarctic ice, which is a proxy for local temperature, and the atmospheric concentrations of the greenhouse gases carbon dioxide ( $CO_2$ ), methane ( $CH_4$ ), and nitrous oxide ( $N_2O$ ) in air trapped within the ice cores and from recent atmospheric measurements. Data cover 650,000 years and the shaded bands indicate current and previous interglacial warm periods.

Gas concentrations for past 650,000 years taken from ice cores in Antarctica & Greenland [1]

# Global Warming – Key Cause

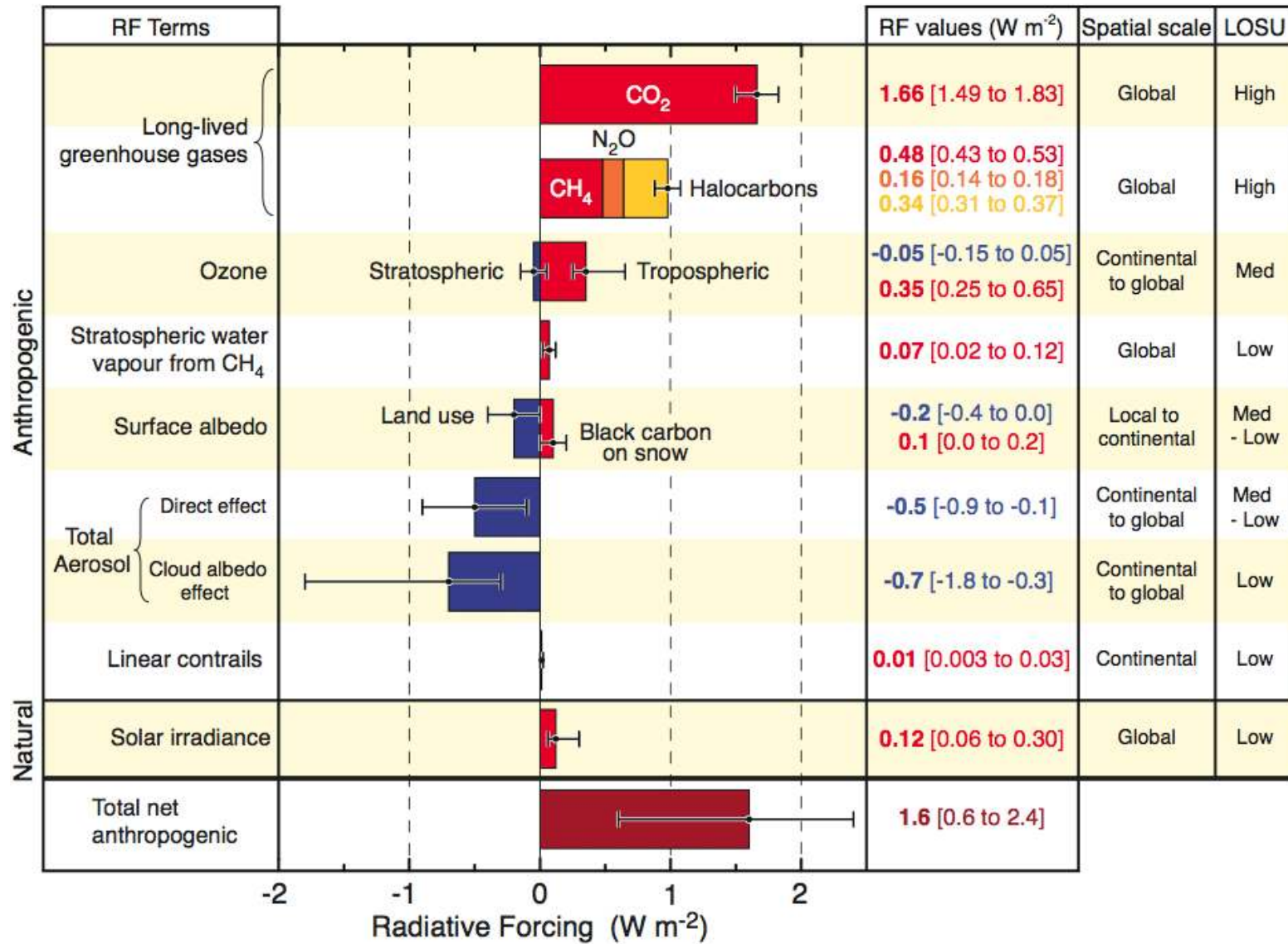


- **The cause is from human contribution of greenhouse gases: CO<sub>2</sub>, N<sub>2</sub>O, Methane** [1,4,7]

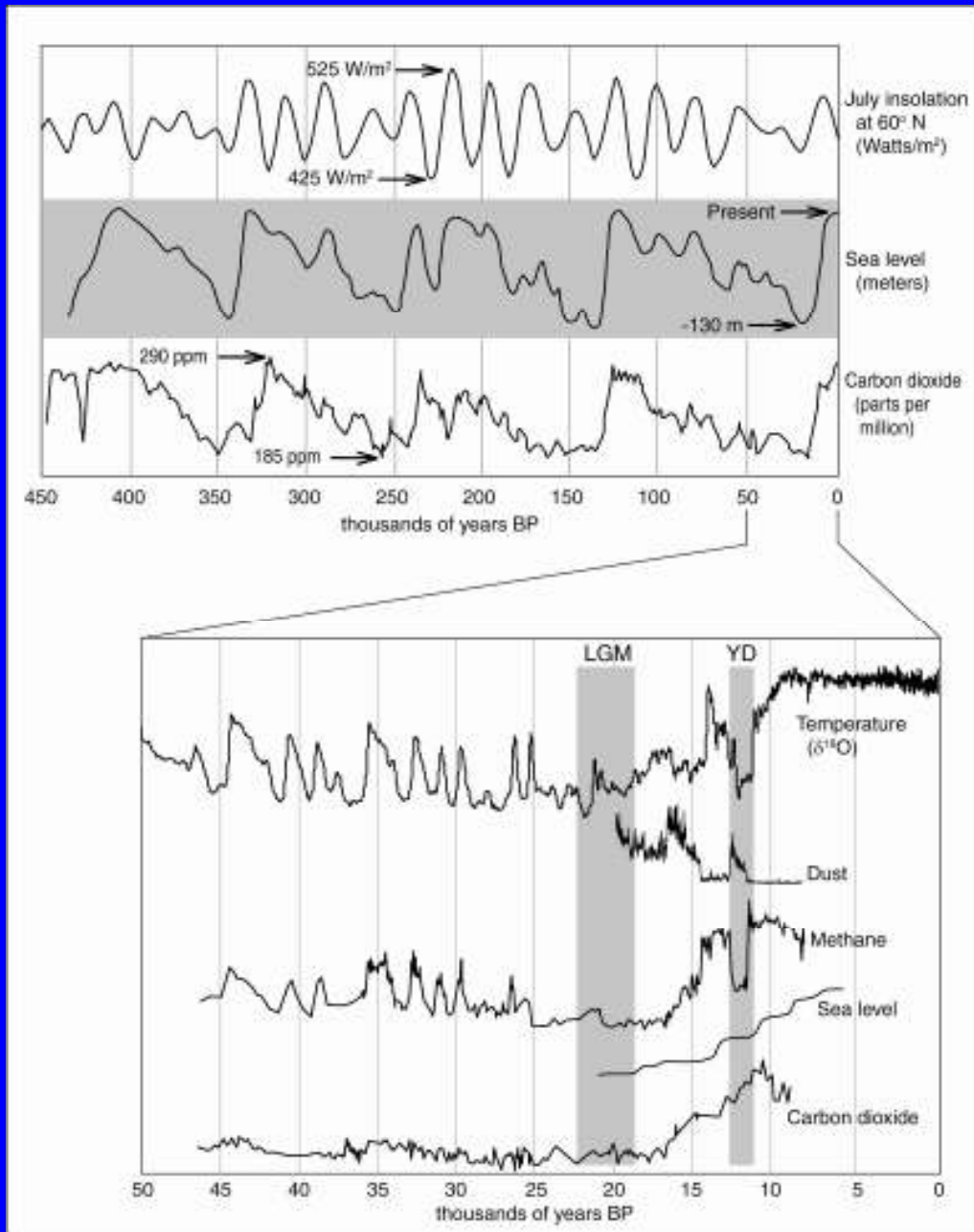
- Normal CO<sub>2</sub> levels (pre-Industrial Era) were less than 280 ppm; CO<sub>2</sub> level today is 383 ppm [1,31]
- CO<sub>2</sub> isotopes differentiate old carbon (ie - fossil fuel combustion) in air from stable carbon [3]
- Once emitted, CO<sub>2</sub> remains in the atmosphere for centuries; effect of reductions takes time [1,4]

***“The human influence is now well outside the natural range of variability”*** [50]

# Radiative Forcing Components



©IPCC 2007: WG1-AR4



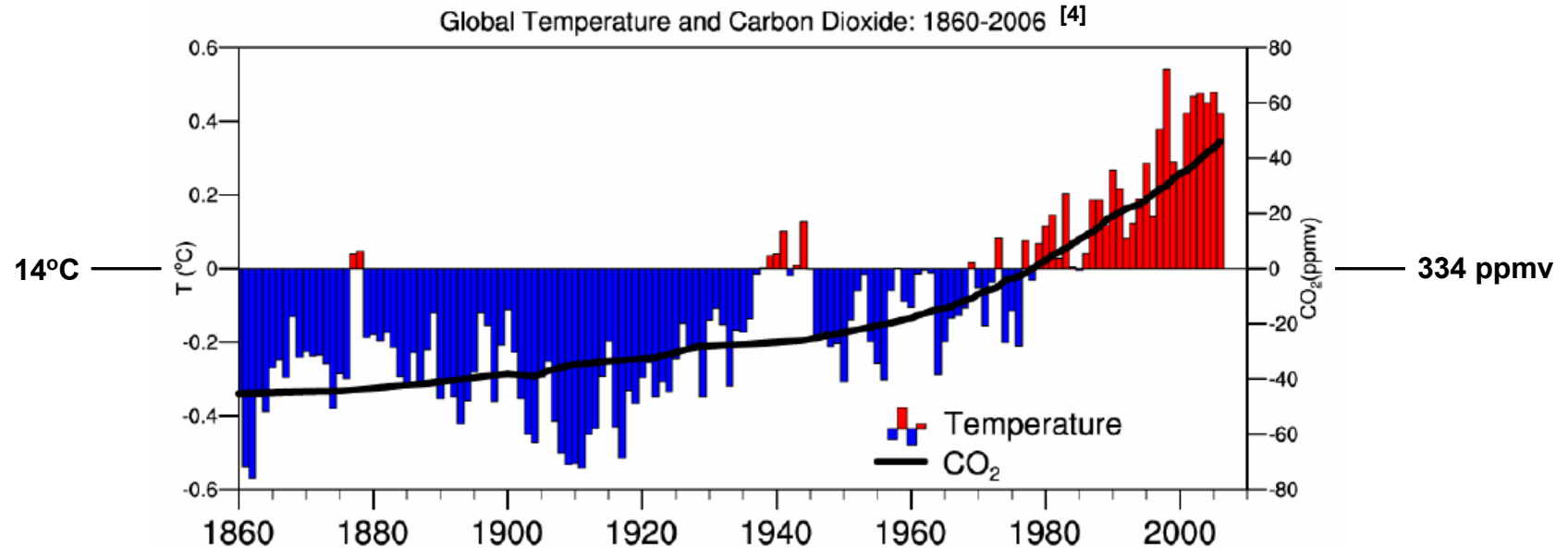
**Shows Tracking of Global Sea Level and CO<sub>2</sub> (warming) [51]**

**Meltzer 2009: Fig 5 [51]**

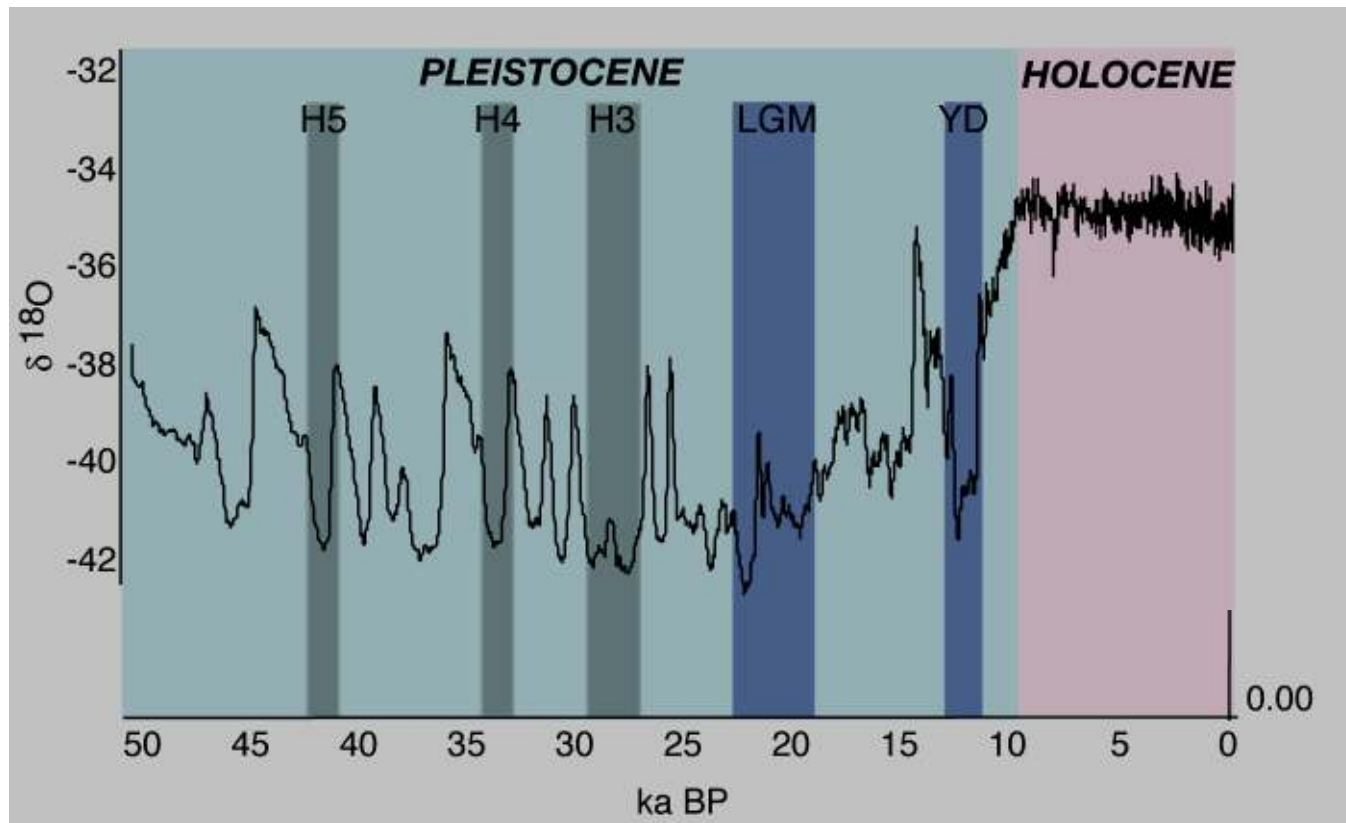


# Global Warming – Human Sources

- **Modern Industrialization (200 years ago to present)** [1, 9, 29, 13]
  - Combustion of fossil fuels for transportation, electricity, manufacturing, cement prod., etc.
- **Deforestation**
  - Urban growth
  - Depletion of the rain forests due to logging, farming and drought
- **Farming**
  - Vegetation decomposing in stagnant water (man-made or natural wetlands) yields methane
  - Cattle emit methane to atmosphere; Burning of grasslands also produces methane
  - Plowing soil and exposing earth releases CO<sub>2</sub> into the atmosphere



# Isotopically Inferred Temperature from Greenland Ice Cores 50,000 BP to Present



Oldfield and Alverson 2002: Fig 1.1 <sup>[51]</sup>

**Warming during the Holocene period was in part anthropogenic  
– humans started clearing forests and farming <sup>[51]</sup>**

# Agenda

- Global Climate Change

- Key Facts of Today - The Evidence is *Real* !

- Key Causes – Human combustion of fossil fuels



- Impacts to Air, Oceans, Land and Future Projections

- What We Can Do

- Summary / Questions

***“The dangers posed by climate change are nearly as dire as those posed by nuclear weapons. The effects may be less dramatic in the short term ... , but over the next three to four decades climate change could cause irremediable harm to the habitats upon which human societies depend for survival”***

Board Statement for *The Bulletin of the Atomic Scientists*, Jan. 17, 2007 <sup>[28]</sup>

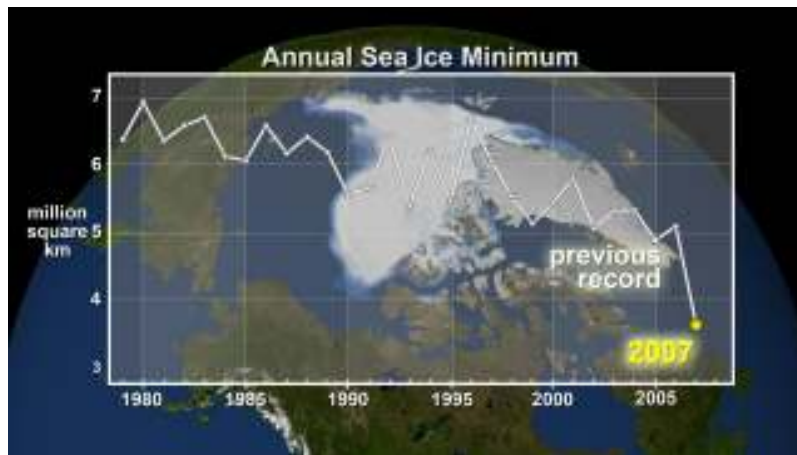
# Global Warming – Impacts to Climate

## Air

- Air Particulates (from volcanoes, meteorites, etc) have a cooling effect
- Increases in Greenhouse Gases have a warming effect on the atmosphere
- Increases in Air temperature is accelerating glacial ice and Ice Sheet melting
- Increases in Air *and* Water temperatures are accelerating sea ice melting
- Increases in Water Vapor in atmosphere has a *doubling* effect on CO<sub>2</sub>; creates added warming

## Land

- Permafrost in Arctic is thawing => releasing methane & CO<sub>2</sub> => accelerates warming
- Glacial melting & less snow => less fresh water; challenges water resources in local regions
- Disruption in weather patterns => increases in heat waves, droughts, floods and more intense wildfires and thunderstorms



Sources: [4, 8, 9, 14, 18, 40, 42]

# Global Warming – Impacts to Climate

## Water

- Melting sea ice reduces the reflective surface area on the planet
- Reflectivity of solar radiation is decreasing  
(Earth's "air-conditioner" is becoming inadequate) <sup>[38]</sup>
- Less reflective surface area causes more temp. absorption by oceans
- Increases in ocean temp. accelerates sea ice melting
- Sea levels rise due to:
  - Warming water temperatures which causes water expansion
  - Melting of glaciers and Ice Sheets; adding water to oceans
- Increased CO<sub>2</sub> in atmosphere increases CO<sub>2</sub> absorption by oceans
- Increased CO<sub>2</sub> absorption by oceans causes ocean pH to drop, becoming more acidic
- Acidic pH impacts ocean vegetation and survival of many aquatic species
  - Coral bleaching from warming water causes coral to die
  - Algae takes over, suffocating the coral reefs
  - Destruction of coral reefs impacts food sources of many types of fish – disrupting ecosystems
- Disruption of ecosystems and over-fishing impacts one of our primary food sources <sup>[9]</sup>

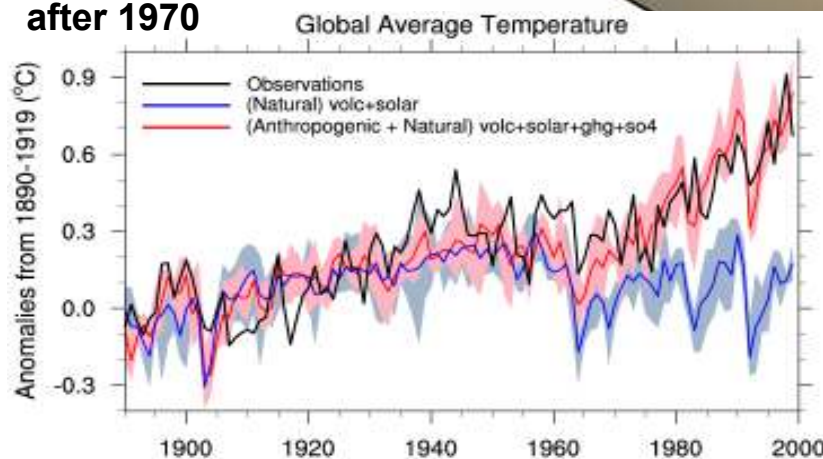
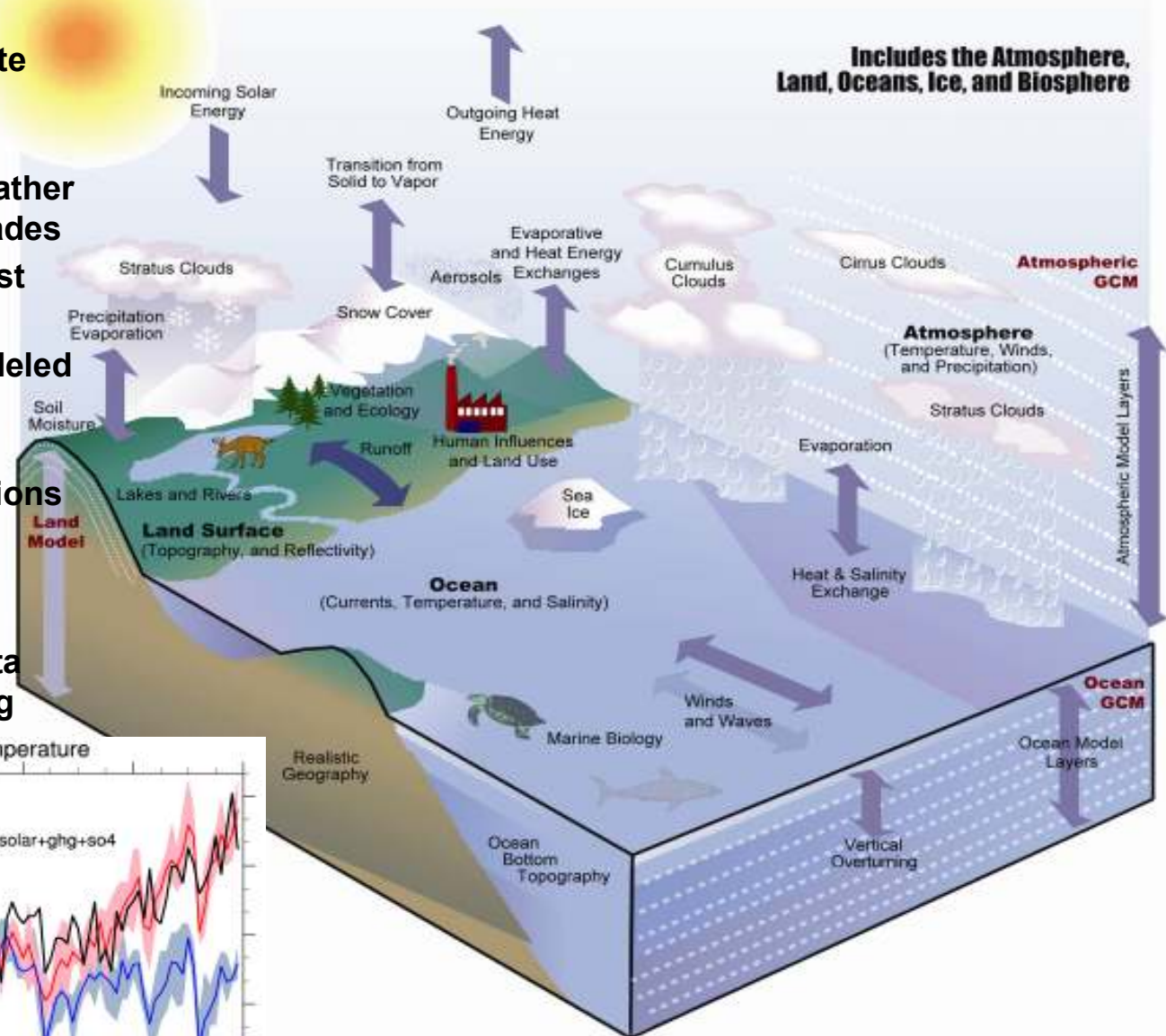


**Greenland ice melt descending into a Moulin: A vertical shaft carrying water to the base of the ice sheet <sup>[43]</sup>**

Sources: [1, 4, 8, 14, 42]

# Modeling the Climate System

- Sophisticated climate models are used to simulate major elements of the global climate system and to make future projections
- Climate models project weather trends out to years and decades
- Models are validated against known observation data
- Example below shows modeled natural global temperature trend versus observations
- Only with human contributions to radiative forcing does the modeled data correlate with measured data
- Results show observed data diverges from natural forcing after 1970



Meehl et al, 2004: J. Climate.

Sources: K. Trenberth [43]

# Air Projections – Temperature Related

- Global temperatures will increase at a rate of 0.4°F per decade over next 20 years [8]
- NASA measurements and models show **CO<sub>2</sub> levels rising at a rate of about 2 ppm per year** [19, 37]
- 2020-2099 models estimate increases from 1.8 to 4°C (3.2-7°F) for various scenarios [8,42]
- As Earth warms, natural processes of CO<sub>2</sub> removal by land and oceans become less efficient [8]
- Scientists predict all mountain glaciers will be gone by 2050 [11]

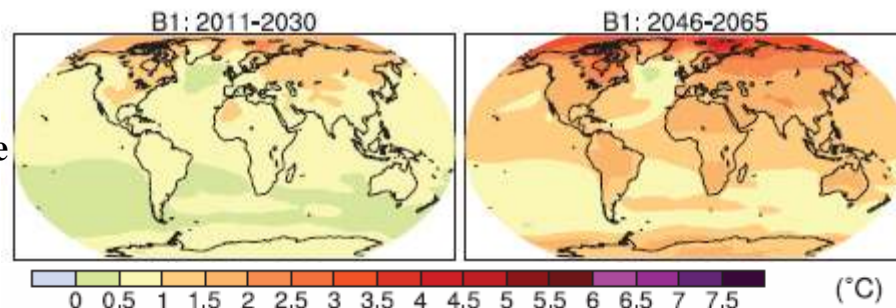
## Oceans

- 21<sup>st</sup> century Sea-Level Rise (SLR) is predicted to be 1 to 1.3 feet (60% by thermal expansion) [8,42]
- Melting from the ice sheets could add an additional 4 to 8 inches of SLR to this number [8,42]

## Land / Coastlines

- One foot of sea-level rise (SLR) causes sea to extend into land by 100 feet [11]
- For flat low-lands, such as the Gulf, 1 foot of sea-level rise could extend into land by 1000 feet [11]
- In southern Louisiana, “...every day, 50 acres of land is turning to water” [11]
- As sea-levels rise, the destructive potential of coastal storms is magnified [4,11,14]
- Many barrier islands, such as Galveston Island are endangered from both erosion and SLR [26]
- Infectious diseases, such as malaria and West Nile virus, will spread into new regions [8,10]
- By 2100, ½ the plant and animal species on the planet could be lost [8,10,30,42]

Low Emission  
Climate Change  
Scenario:

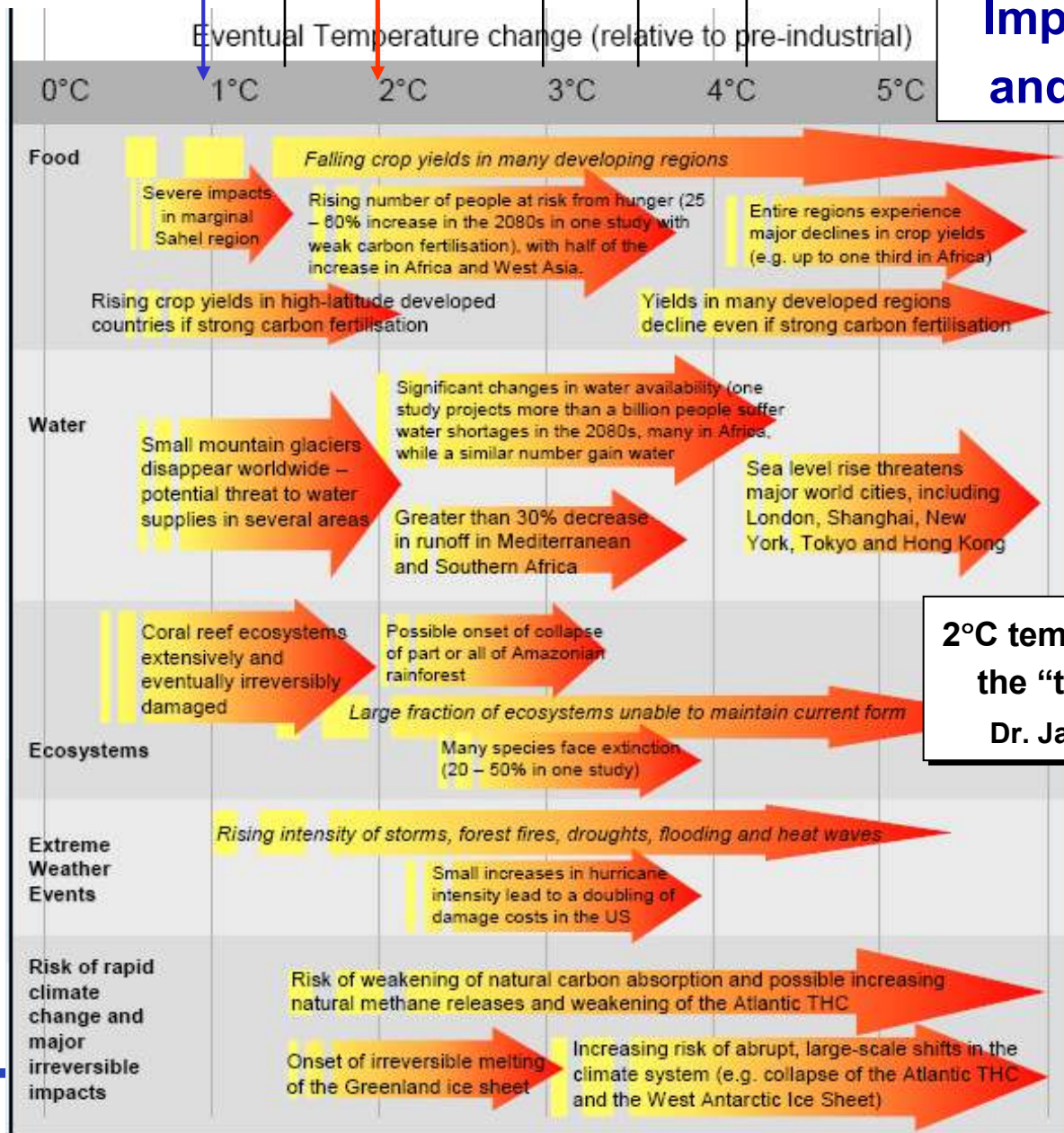


Source: [42]

mean CO<sub>2</sub>e level (ppm): **383** **400** **450** **550** **650** **750**

**today** **“catastrophic”** [8,19,29]

# Projections - Impact of CO<sub>2</sub> and Warming



**2°C temp. change is likely the “tipping point”** [19]  
**Dr. James Hansen - NASA**

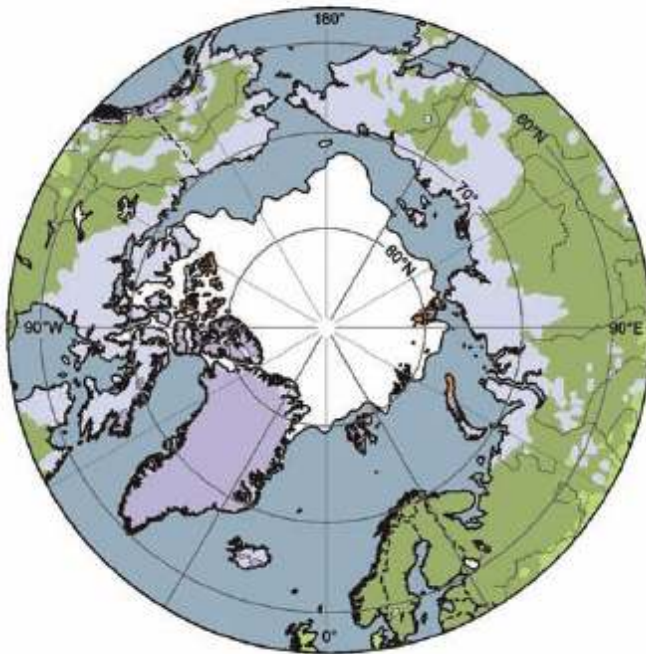
Sources: “Stern Review: The Economics of Climate Change” [22, 29]



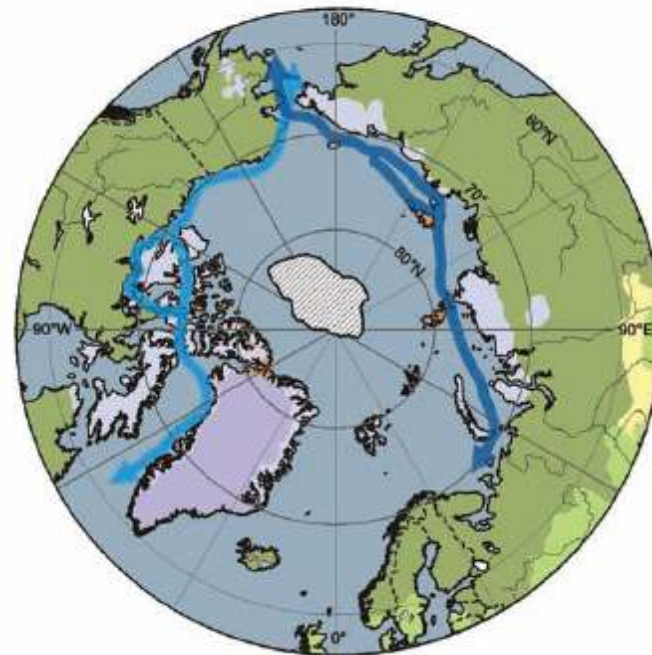


# Projections – Arctic

Current Arctic Conditions



Projected Arctic Conditions



Opening of the Arctic is already causing countries to make claims which need approval by the U.N.

Source: [35]

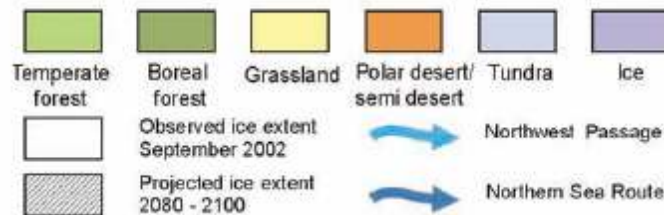


Figure TS.16. Vegetation of the Arctic and neighbouring regions. Top: present-day, based on floristic surveys. Bottom: modelled for 2090-2100 under the IS92a emissions scenario. [F15.2]

**“We may see an ice-free Arctic Ocean in summer within our lifetimes”**  
 - Mark Serreze, NSIDC Scientist [41]

Sources: IPCC WG2-AR4 [29,34]

# Agenda

- **Global Climate Change => We're Responsible!**

- Key Facts of Today - The Evidence is *Real* !
- Key Causes – Human combustion of fossil fuels
- Impacts to Air, Oceans, Land and Future Projections



- **What We Can Do**

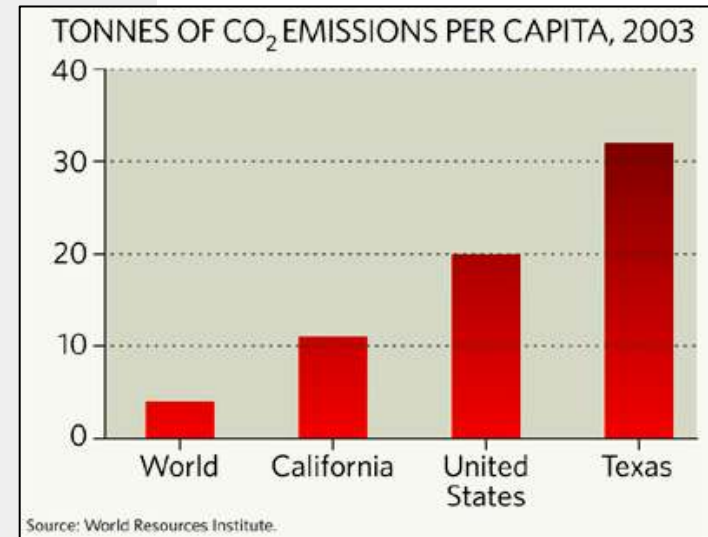
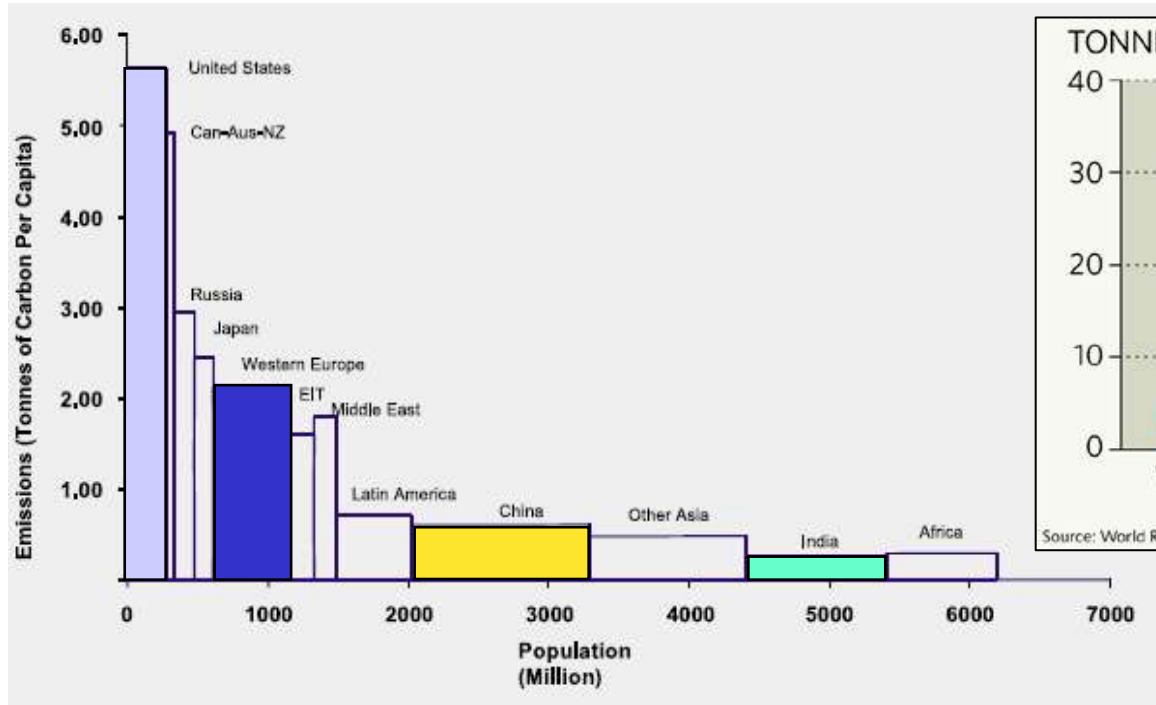
- The Problem: **CO<sub>2</sub> Emissions**
- The Solution: **Policymakers, Industry and You**
- The Challenge: **Conserve, Adapt, Innovate**
- Make a Difference: **Start Now ...**

- **Summary / Questions**

**“One Climate  
One Future  
One Chance”**

Step-It-Up2007 <sup>[17]</sup>

# The Problem - Global CO<sub>2</sub> Emissions



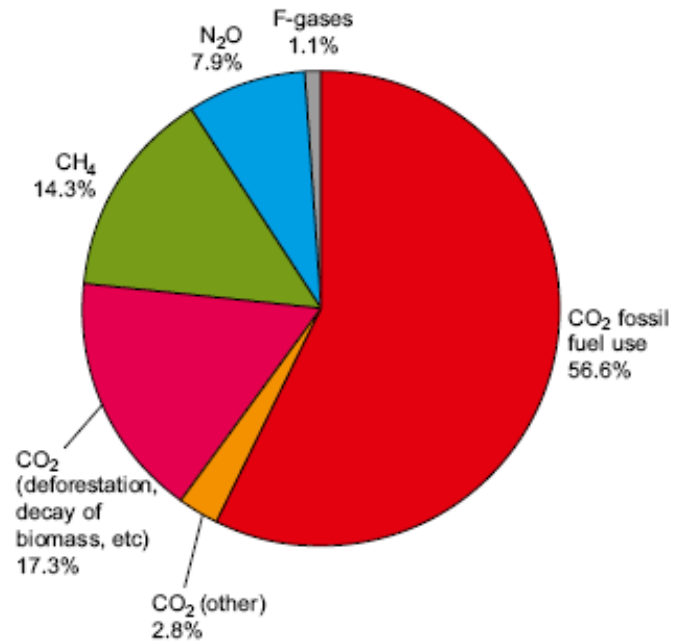
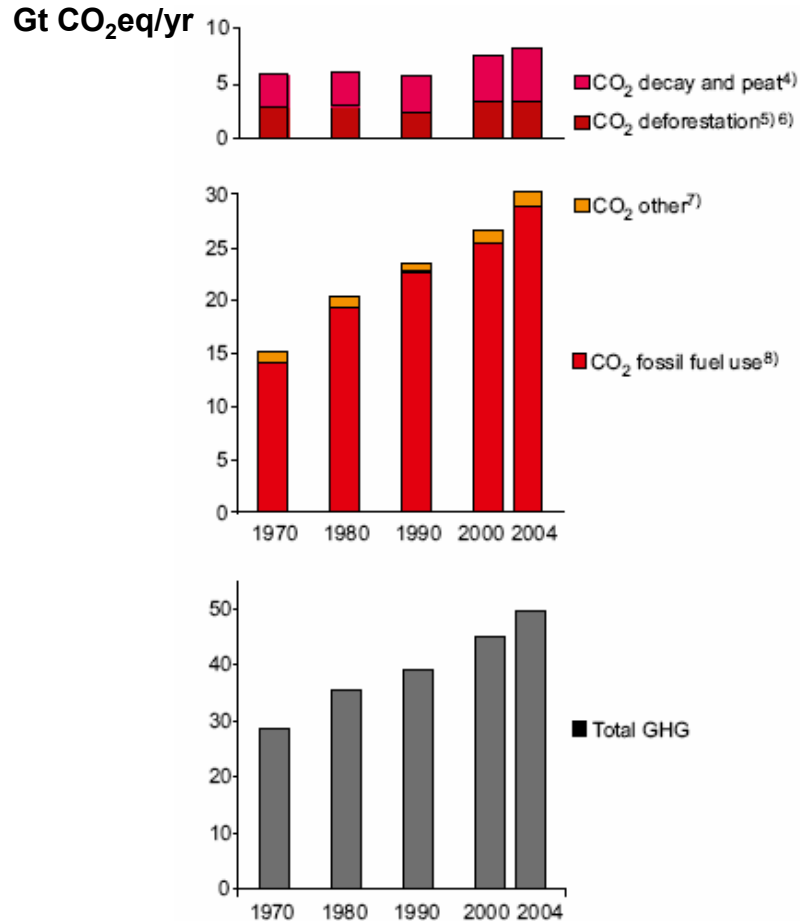
Carbon-equivalent = CO<sub>2</sub> x 0.2727

Carbon Emissions in different regions for year 2000 in terms of:

- Emissions per capita (height of each block)
- Population (width of each block), and
- Total emissions (product of population and emissions per capita = area of block)

**The U.S. is only 5% of world population, is responsible for 20% of CO<sub>2</sub> emissions and is the #1 polluter [44]**

# Global Anthropogenic GHG Emissions

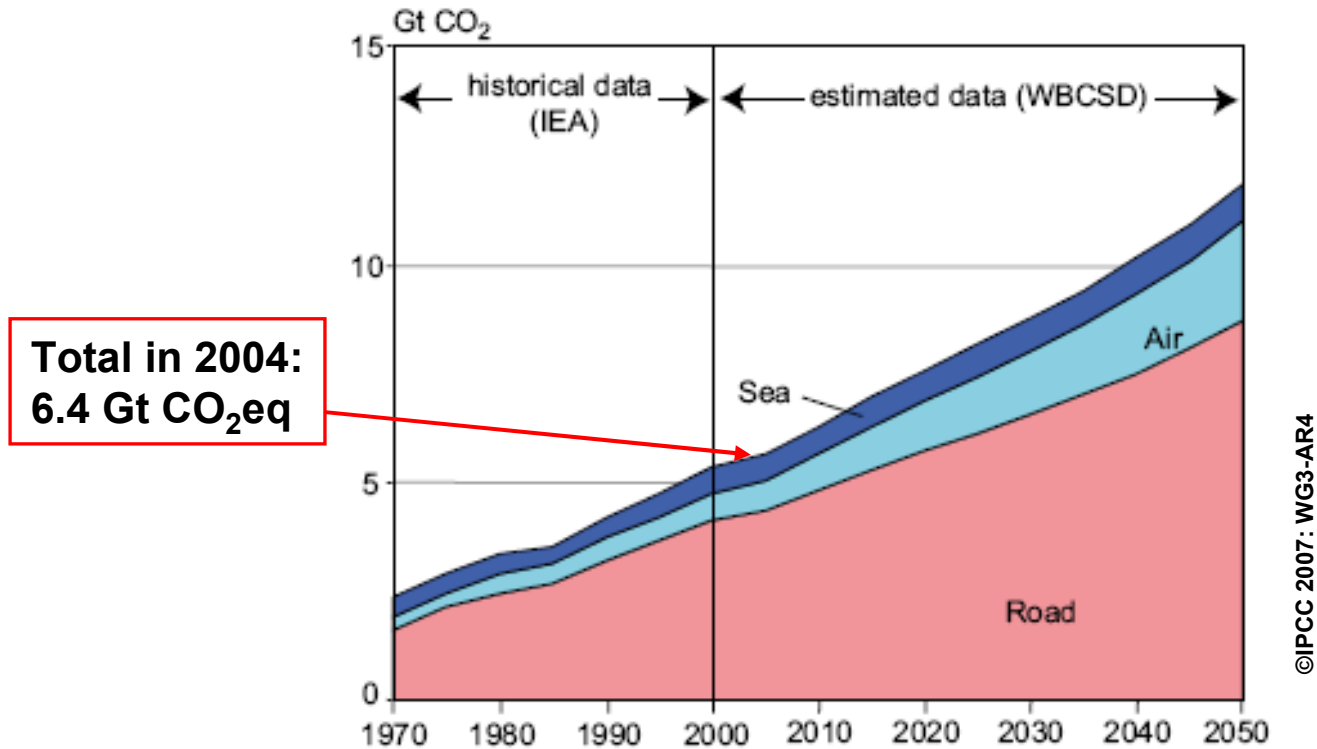


## Global GHG Emissions in 2004

- 77% is CO<sub>2</sub>, 14% is CH<sub>4</sub>, 8% is N<sub>2</sub>O
- 57% of makeup is CO<sub>2</sub> Fossil Fuel Use
- 23% of CO<sub>2</sub> FF is from Transport Sources

• The IPCC estimates “the world must stabilize greenhouse gases at 445 ppm by 2015” [8]  
 • Levels above 450 ppm, coupled with higher temperatures, could trigger “catastrophic” events [8]

# Global Transport CO<sub>2</sub> Emissions

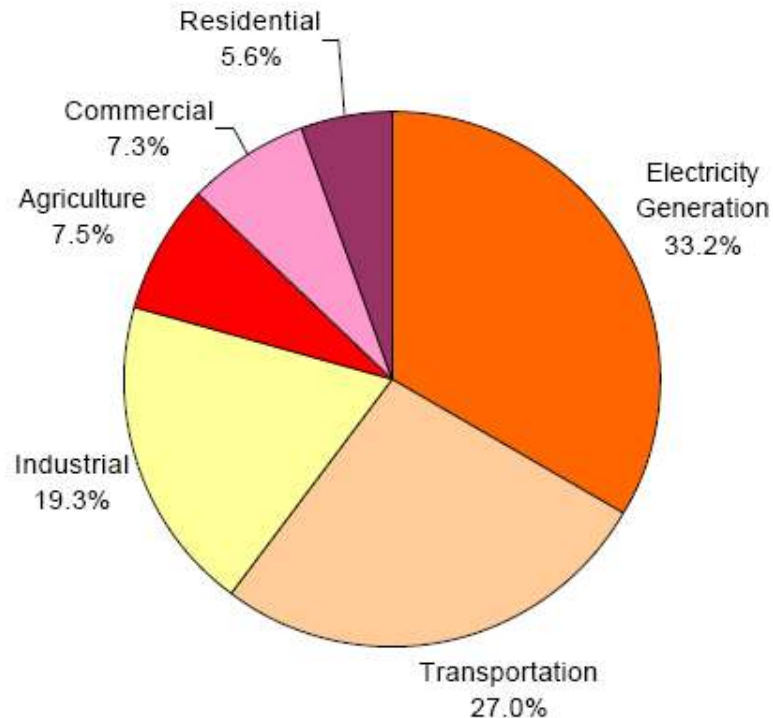


- Road emissions account for 74% of total transport emissions
- Aviation emissions account for 2% and will continue to grow strongly
- Aircraft emissions of NO<sub>x</sub> contribute to GHG ozone formation at cruising altitudes
- World transport energy use is projected to grow 2% per year
- Transport CO<sub>2</sub> emissions projected 80% higher by 2030 than 2002 levels

Sources: IPCC WG3-AR4 [44]

# U.S. GHG Emissions by Sector

## (with Electricity Separated)



SECTOR	MMT <sub>CO2E</sub>
Electricity Generation	2,286.8
Transportation	1,861.4
Industrial	1,331.9
Agriculture	519.8
Commercial	500.4
Residential	387.7
TOTAL	6,888.0

NOTE: Does not include U.S. territories.

**MMT<sub>CO2E</sub> = Million Metric Tons of CO<sub>2</sub>-equivalent  
(1 MetricTon CO<sub>2</sub>eq = 2204 lbs CO<sub>2</sub>eq)**

**Note: CO<sub>2</sub> accounts for 84% of U.S. greenhouse gas (GHG) emissions**

**Electricity Generation and Transportation are the 2 largest sectors – both of which Individuals and local organizations (i.e. businesses) can impact**

# What We Can Do –

The Solution: U.S. policymakers, Industry **and You!**

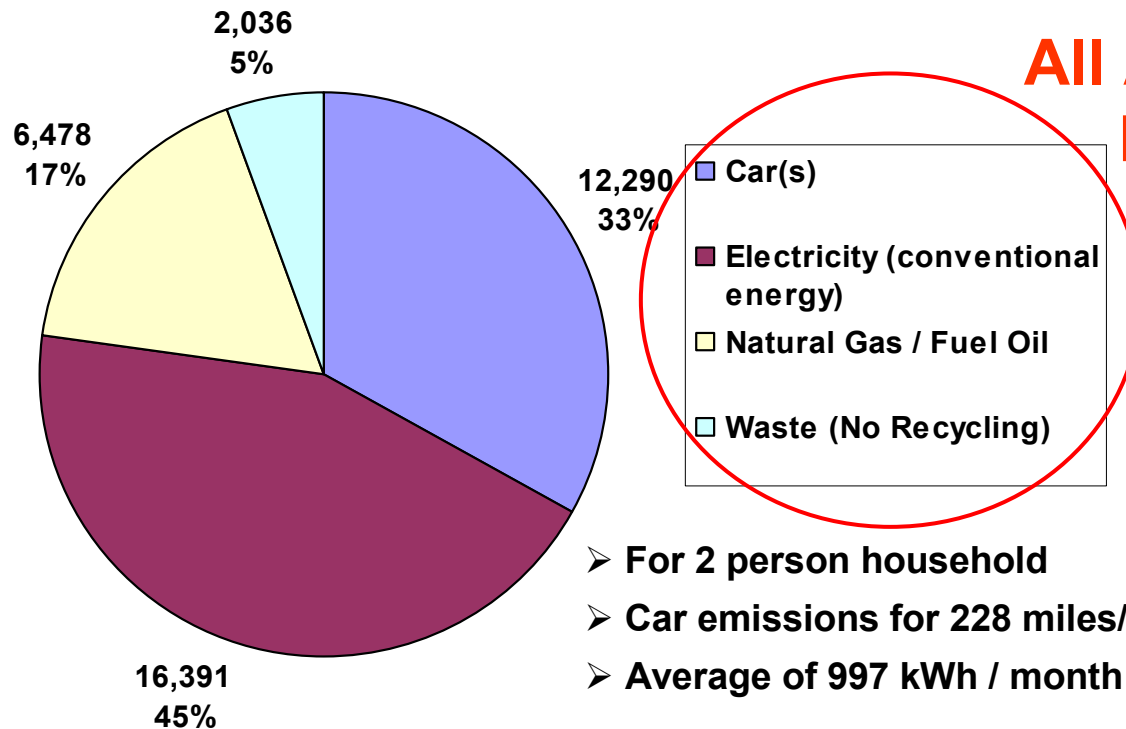
The Challenge: **We need to be a “Collective Force of Change”** [10]

- **Reduce your Carbon Footprint!** - make lifestyle changes
- **Adapt to a changing world** (weather, cost increases, shortages, etc)
- **Innovations in renewable energy technology that are affordable**
- **Urge policymakers to do what’s best for all – not just industry**

Make a Difference: **Start Now ...**

- **Calculate your Carbon Footprint and Identify Areas for Reduction**
- **Boost Energy Efficiency at home and in business**
- **Use low emission vehicles, mass transit, car pool, reduce driving**
- **Buy products that minimize waste in manufacture (less energy to make)**
- **Join local and national organizations chartered to protect the environment**
- **Become active in your community, business, local organizations, etc.**
- **Exercise your right to vote**

# Annual CO<sub>2</sub> Emissions per Average U.S. Single-Family Home



**All Areas Can Be Reduced !**

- For 2 person household
- Car emissions for 228 miles/week (19.7 mpg average)
- Average of 997 kWh / month @ 1.39 lbs CO<sub>2</sub> / kWh

- Total per household is 37,200 lbs CO<sub>2</sub> / year = 16.7 metric tons / year
- 4.6 acres of forest needed to sequester the equivalent carbon produced

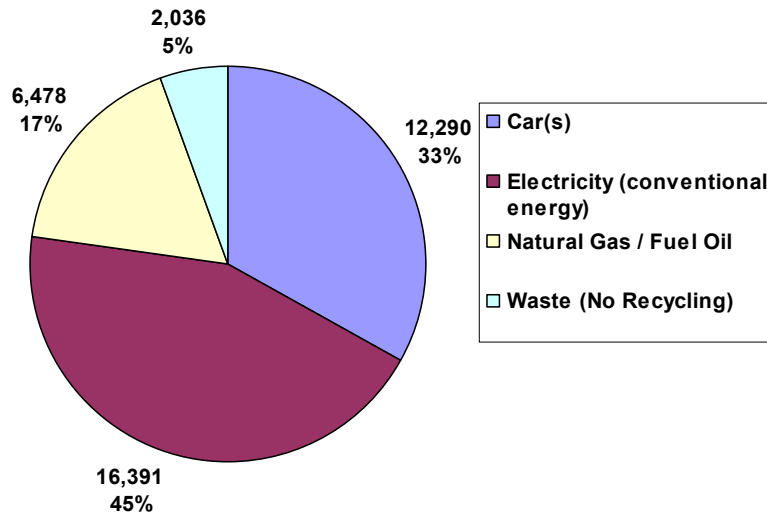
(Note: 1 acre of forest sequesters 2,200 lbs Carbon / year = 8148 lbs CO<sub>2</sub> / year)

Sources: U.S. EPA [45, 46, 47]



# Example of Annual CO<sub>2</sub> Emissions with Reduced Carbon Footprint

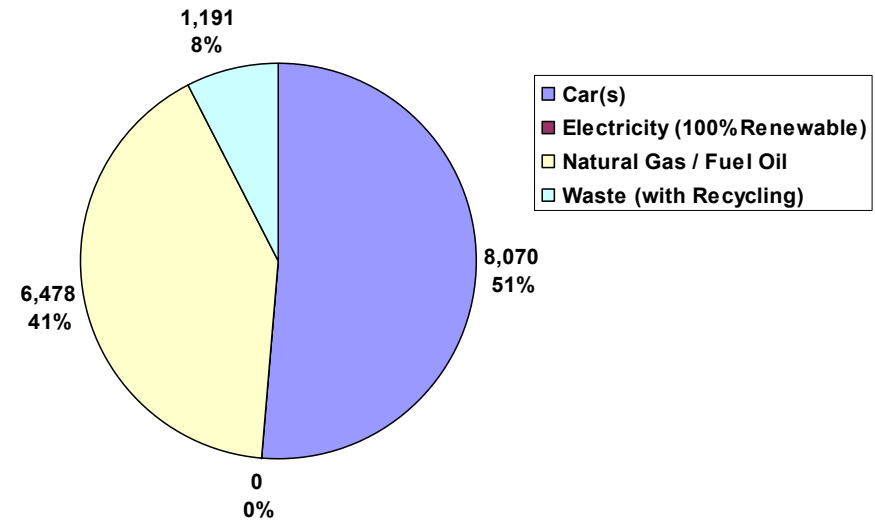
Annual CO<sub>2</sub> Footprint (pounds) for Average U.S. Single-Family Home



- For a 2 person household
- Average of 997 kWh / month @ 1.39 lbs CO<sub>2</sub> / kWh
- Car emissions for 228 miles per week @ 20 mpg

• Total US Average / yr: 37,200 lbs CO<sub>2</sub>  
 • Requires 4.6 acres of forest to absorb

Annual CO<sub>2</sub> Footprint (pounds) for Single-Family Home with Emission Reductions

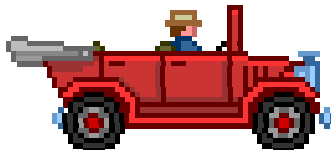
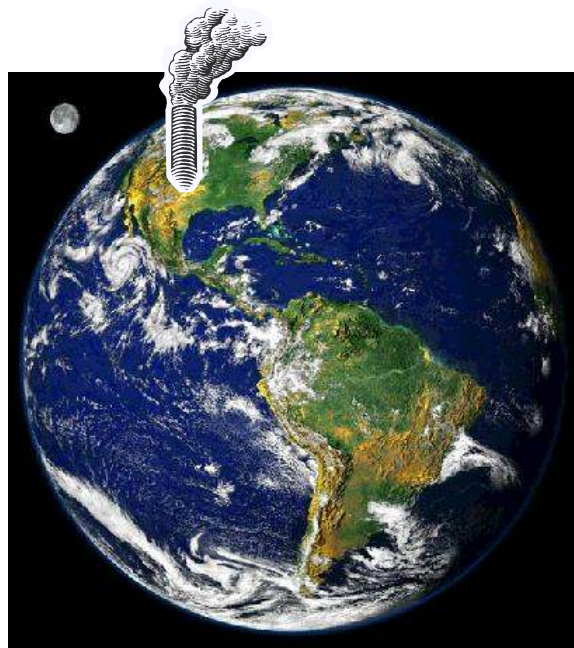


- 16,391 lbs reduced to 0 with renewable energy
- 4220 lbs saved with car avg 10 mpg more
- Save 2000 lbs more by cutting # miles by 25%

• With Reductions: 15,740 lbs CO<sub>2</sub>  
 • Requires 2 acres of forest to absorb

Calculator Reference: U.S. EPA [47]

# What's Your Carbon Footprint ?



***Go Calculate it on-line at:***

**[www.epa.gov/climatechange/wycd/calculator/ind\\_calculator.html](http://www.epa.gov/climatechange/wycd/calculator/ind_calculator.html)**



Note: Contact the author if you're interested in a modified Excel version of this calculator

# Boost Energy Efficiency at Home

( listed from relatively lower to higher CO<sub>2</sub> savings) [23]

- **Replace regular incandescent light bulbs with compact fluorescent light bulbs (CFL)**
  - CFLs use 60% less energy than a regular bulb. Save about 300 pounds of CO<sub>2</sub> per year
- **Set thermostat to 78° or higher when home in summer and to 82° or higher when out**
  - Almost 50% of energy used at home is for heating and cooling. Can save 1000 lbs / year
- **Clean / replace air filters regularly**
- **Install a Programmable Thermostat**
- **Choose Energy efficient appliances (check Energy Star rating)**
- **Use less hot water**
  - Use a low-flow shower head; Wash clothes in cold or warm water
- **Turn off electronic devices when not in use**
  - Unplug DVD players, stereos, TVs that are seldom used (power leakage when off)
- **Insulate and weatherize your home**
  - Properly insulated walls and ceilings can save 25% of your home heating bill and 2,000 pounds of carbon dioxide a year.
  - Caulking and weather-stripping can save another 1,700 pounds per year.
- **Recycle at home**
  - You can save up to 2,400 pounds of CO<sub>2</sub> a year by recycling half of your household waste
- **Buy recycled paper products**
  - It takes less 70 to 90% less energy to make recycled paper and it saves trees worldwide.
- **Switch to a renewable energy source provider!**
  - Its easy to do, and you're helping reduce CO<sub>2</sub> and mercury emissions from coal power plants
- **Install Solar electric panels and reduce power use from the grid during daylight hours**



# Switch to Renewable Energy

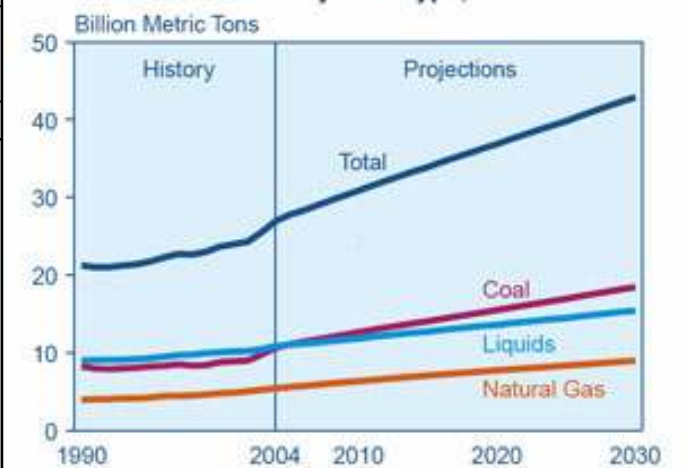
State-Specific Retail Green Power Product Offerings <sup>1</sup> (last updated October 2007)				
State	Company	Product Name	Resource Mix <sup>2</sup>	Certification
TX	Commerce Energy	Clear Choice All-In (12-mo fixed rate)	100% wind	Green-e
TX	Commerce Energy	Clear Choice All-In Plus (24-mo fixed rate)	100% wind	Green-e
TX	First Choice Power	Simply Better Renewable	100% renewable	—
TX	Gexa Energy	Gexa Green	100% renewable	—
TX	Green Mountain Energy Company	100% Wind: Month-to-Month	wind	—
TX	Green Mountain Energy Company	Pollution Free	10% wind, 90% hydro	—
TX	Green Mountain Energy Company	Pollution Free: Reliable Rate	10% wind, 90% hydro	—
TX	Reliant Energy	Renewable Plan	100% wind	—
TX	TXU Energy	TXU Energy 100% EarthWise	100% wind	—
TX	TXU Energy	TXU Energy 100% EarthWise 18	10% wind	—

Source: National Renewable Energy Laboratory ( [www.nrel.gov/learning](http://www.nrel.gov/learning) ) <sup>[25]</sup>

*In 2030 global emissions will likely be up by 59% relative to 2004*

U.S. Energy Information Administration,  
Annual International Energy Outlook, 2007

Figure 78. World Energy-Related Carbon Dioxide Emissions by Fuel Type, 1990-2030



# Energy Technologies



## Carbon Mitigation

- **Carbon Capture – Power plant or ambient air capture & storage**
  - 4700 ft<sup>3</sup> of ambient air is needed to process 2 ounces of CO<sub>2</sub> [52]
  - Estimated \$35-45 per MWh cost added to electricity generation, assuming 90% capture [53]
  - Texas is using old oil fields and aquifers for sequestering; selling CO<sub>2</sub> to pump in ground [56]
- **Clean Coal (gasification) – Extracts CO<sub>2</sub> via conversion of emissions to gas steam**
  - Refractories currently have a lifespan of 12 to 16 months. Gasifier relining costs \$1 million [55]
- **Electricity from Natural Gas – Utilities shifting from coal to NG and renewable energy**
  - Rising use makes U.S. more reliant on imported liquefied NG; cost 20% more in next 10 years
  - Some say NG turbines less reliable when used for 'base load' power rather than peak loads [56]

## Renewable

- **Wind – Cost Competitive with Coal or Gas: 10 to 15 cents per KWh in 2006 [59]**
  - California leads development in U.S. with 2,043 megawatts of wind capacity by 2004
  - Texas ranks 2<sup>nd</sup> in US wind capacity; consumer growth in both residential and corporate areas [63]
- **Solar – Potential US sites for 200 GW of solar gen. power (20% of total energy in US) [60]**
  - Thermal prototype system in New Mexico produces 150kW with 35% efficiency [61]
  - Photovoltaic modules popular for homes; ~\$5/W uninstalled (about \$22k for 4.3kW system) [62]
- **Hydroelectric – Currently provides about 80 GW of generating power in U.S.**
  - Predicted to decline through 2020 to about 6% from about 10% today due to environmental issues, regulatory complexity, and energy economics [58]

**U.S. electricity cost from coal expected to double by 2030 (\$40-50 / MWh) [54]**

# Reduce Emissions When On the Go

- **Reduce the number of miles you drive by walking, biking, carpooling or taking mass transit wherever possible**
  - Avoiding 10 miles of driving every week cuts 500 lbs of CO<sub>2</sub> emissions a year.
- **Start a carpool with your coworkers or classmates**
  - Sharing a ride with someone 2 days a week can reduce your CO<sub>2</sub> emissions by 1,590 lbs / year
- **Keep your car tuned up**
  - Regular maintenance helps improve fuel efficiency and reduces emissions. When just 1% of car owners properly maintain their cars, nearly a billion pounds of CO<sub>2</sub> are kept out of the atmosphere.
- **Check your tires monthly to make sure they're properly inflated**
  - Proper inflation can improve gas mileage by more than 3%. Every gallon of gasoline saved keeps 20 pounds of CO<sub>2</sub> out of the atmosphere.
- **Choose a more fuel efficient vehicle**
  - You can save 3,000 lbs of CO<sub>2</sub> every year if your new car gets only 3 miles per gallon more than your current one. Get up to 60 miles per gallon with a Hybrid.
- **Biofuels are not a solution to global warming!**
  - Clearing forests for ethanol farming emits CO<sub>2</sub>. A corn-fueled SUV emits twice the CO<sub>2</sub> compared with conventional gasoline.
- **Telecommute from home**
- **Fly Less**
  - Cutting back by one or two trips a year can significantly reduce your emissions (jet fuel: 21 lb CO<sub>2</sub> per gallon)



Source: [www.climatecrisis.net](http://www.climatecrisis.net) [23]

# Buy Products that are Green - Minimal Energy to Produce

- **Use a refillable water bottle instead of buying bottled water**
  - 1.5 million tons of plastic are used each year to make water bottles
- **Buy locally grown and produced foods**
  - The average meal in the United States travels 1,200 miles from the farm to your plate. Buying locally will save fuel and keep money in your community.
- **Buy fresh foods instead of frozen**
  - Frozen food uses 10 times more energy to produce.
- **Seek out and support local farmers markets**
  - They reduce 1/5 the amount of energy required to grow and transport the food to you
- **Buy organic foods as much as possible**
  - Organic soils capture and store carbon dioxide at much higher levels than soils from conventional farms. If we grew all of our corn and soybeans organically, we'd remove 580 billion pounds of carbon dioxide from the atmosphere.
- **Avoid heavily packaged products**
  - You can save 1,200 pounds of carbon dioxide if you cut down your garbage by 10%
- **Eat less meat**
  - Methane is the second most significant greenhouse gas and cows are one of the greatest methane emitters. Their grassy diet and multiple stomachs cause them to produce methane, which they exhale with every breath.
- **National Green Pages**, [www.coopamerica.org/pubs/greenpages](http://www.coopamerica.org/pubs/greenpages)
  - Directory listing nearly 3,000 businesses that have made firm commitments to sustainable, socially just principles, including the support of sweatshop-free labor, organic farms, fair trade, and cruelty-free products

**Think Green !**

# Take Action - Locally, Nationally

- **Encourage local schools, businesses and churches to reduce emissions and recycle**
  - [www.dallascityhall.com/oeq/index.html](http://www.dallascityhall.com/oeq/index.html) - **Dallas City Hall Office of Environmental Quality**
  - [www.freecycle.org](http://www.freecycle.org) - **The Freecycle Network™** has 4,062,000 members across the globe. It's a grassroots, nonprofit org for people to give (& get) stuff for free in their own towns. It's all about reuse and keeping good stuff out of landfills. Free membership.
- **Join national organizations on conservation, environment preservation, green living, etc.**
  - **Natural Resources Defense Council**, [www.nrdc.org](http://www.nrdc.org) - **GRIST**, [www.grist.org](http://www.grist.org)
  - **Nature Conservancy**, [www.nature.org](http://www.nature.org)
  - **Environmental Defense**, [www.environmentaldefense.org](http://www.environmentaldefense.org)
- **Join the virtual march to reduce emissions and curb global warming**
  - **Step-It-Up 2007**, [www.stepitup2007.org](http://www.stepitup2007.org), **"Cut Carbon 80% by 2050"**
  - **Stop Global Warming**, [www.stopglobalwarming.org](http://www.stopglobalwarming.org)
- **Protect and conserve our national parks and wildlife**
  - **National Parks Conservation Association**, [www.npca.org](http://www.npca.org)
  - **NRDC BioGems**, [www.biogems.org](http://www.biogems.org)
  - **Nature Conservancy**, [www.nature.org](http://www.nature.org)
- **Encourage others to switch to Renewable Energy, including solar** ([www.nrel.gov/learning](http://www.nrel.gov/learning))
  - **Solar Home**, [www.solarhome.org](http://www.solarhome.org); **Green Mountain Energy**, [www.greenmountainenergy.com](http://www.greenmountainenergy.com);
  - Reliant Energy**, [www.reliant.com](http://www.reliant.com); **TXU Energy**, [www.txu.com](http://www.txu.com)
- **Contact your congressman – make your voice heard – tell Congress to act!**
  - **US House Committee on Science and Technology**, [www.science.house.gov](http://www.science.house.gov), [www.house.gov](http://www.house.gov)
  - **US Senate**, [www.senate.gov](http://www.senate.gov)





# Closing Remarks

- **The Earth is warming and there is no stopping it – accept it - the debate is over!** <sup>[31]</sup>
- **Humankind has created this problem of:**
  - **Depleting the Earth's resources at accelerating rates**
  - **Damaging natural ecosystems, some to the extinction of many species**
  - **Overloading one of the most precious natural systems that sustains life on this planet – our atmosphere!**
- **Earth and its natural resources is ours to care for**
- **Scientists have connected the human element to global warming**
- **We must free ourselves from the dependence of fossil fuels**
- **There's plenty we can do today to reduce our carbon footprint**
- **Policymakers and industry must focus on long-term solutions**
- **Carbon tax is one means for putting a price on CO<sub>2</sub> pollution** <sup>[63]</sup>
- **Innovation in energy technology is needed for clean energy solutions**
  - **Renewable, Sustainable, Non-fossil fuel based**
  - **New generation, distribution systems needed for 2030 and beyond**

**Reduce your Carbon Footprint and Innovate to Save Our Planet !**

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**Tim D. Reichard** is a Senior Principal Systems Engineer with Raytheon Company and is an active member of the Institute of Electrical and Electronic Engineers (IEEE), serving as an IEEE officer for the past 8 years. He holds both a Master of Science and Bachelor of Science degrees in Electrical Engineering.

Tim is an avid nature enthusiast and his avocation, in recent years, is the study and research of efforts concerned with protecting nature, our national parks, our environment and wildlife from urban expansion, industry air and water pollution and global climate change. Tim is a partner with the National Parks Conservation Association (NPCA) and member of the Natural Resources Defense Council (NRDC), the Nature Conservancy Association and Environmental Defense.

Tim and his wife, Sydney, enjoy hiking in the mountains and have seen global warming impacts on glacial ice in areas such as the Swiss Alps, Glacier NP (Montana), Rocky Mountain NP (Colorado), Banff and Jasper NPs (Canada) and recently at Denali and Kenai Fjords NPs in Alaska.

## Professional Background:

- 28+ years with Raytheon Company / Texas Instruments, Dallas, TX
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- Senior Member of the Institute of Electrical and Electronics Engineers (IEEE)
- Chair of the IEEE Aerospace and Electronics Systems Society (AES), Dallas Chapter
- Author of one U.S. Patent (pending) #2005-0152487-A1; “*Adaptive Channel Equalization Technique and Method for Wideband Passive Digital Receivers*”