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is funded principally  
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The Society gratefully acknowledges  
those companies that support the program  
by allowing their professionals  
to participate as Lecturers.

And special thanks to The American Institute of Mining, Metallurgical,  
and Petroleum Engineers (AIME) for their contribution to the program.

# **The Growing Demand for Oil & Gas and the Related Global Warming Issues**

**Past, Present and  
What the Future  
May Bring**



George Stosur, SPE/DL

# Outline

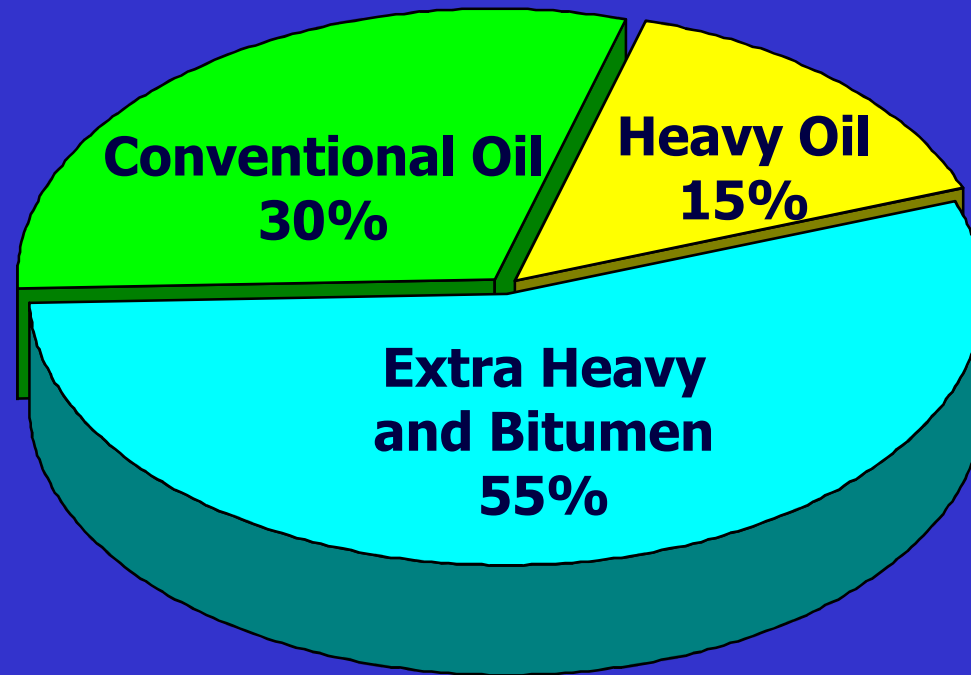
- **World Supply and Demand of Oil and Gas**
- **What Does Science Say About Global Warming?**
- **What Do Analyses Tell Us About the Solutions?**
- **Why Technical/Policy Solutions Will Be Very Difficult**
- **Conclusions**

“Hydrocarbons in the form of oil, gas, and coal, exist in such abundance, that challenge of technology is how to burn them cleanly, not to how to survive without them”

Source: President, Shell Oil Company

# World Oil Endowment (OOIP)

(Total: 9-13 Trillion Barrels)



Source: MacGregor and UNITAR

# Conventional vs. unconventional oil reserves (billion bbls)

Heavy and Tar





# #1 Concern – rapid CO<sub>2</sub> increase

- Well documented increase of CO<sub>2</sub>
- Correlates well with T
- Observed glacier melt
- Kyoto agreement



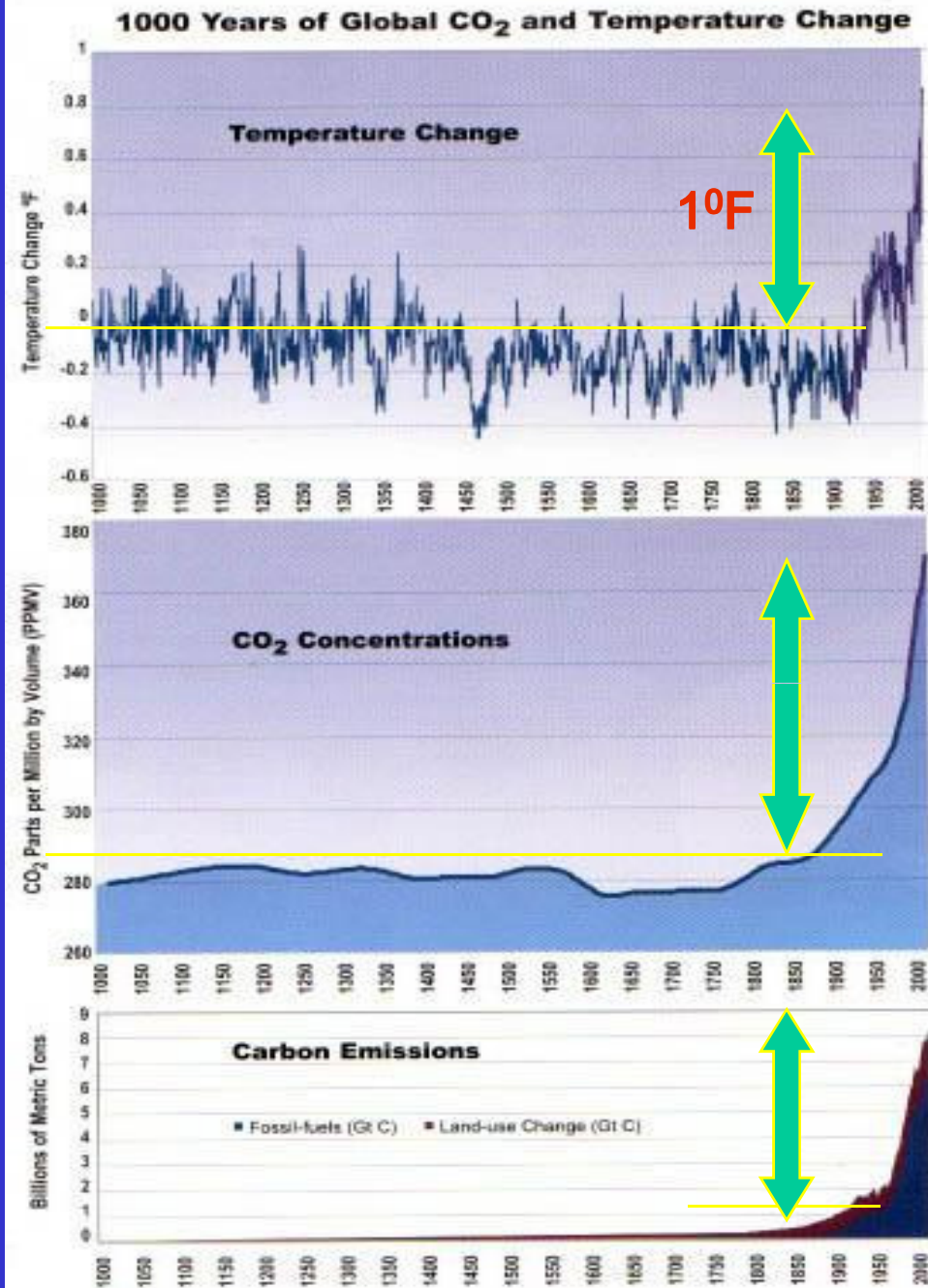
# Greenhouse gases

- Act like glass in a greenhouse
  - Control infrared solar energy entering/leaving atmosphere
  - Without these gases, the infrared radiation would be lost. Then, avg. air temp. would be  $-18^{\circ}\text{C}$ , not  $+15^{\circ}\text{C}$
- Water vapor  $\text{H}_2\text{O}$
  - Carbon dioxide  $\text{CO}_2$
  - Ozone  $\text{O}_3$
  - Nitrous oxide  $\text{N}_2\text{O}$
  - Methane  $\text{CH}_4$
  - Some synthetics



# Primary causes of global warming

- #1. Caused primarily by burning fossil fuels in power plants, cars, factories, houses
- #2. Methane from rice paddies, both ends of animals, garbage in landfills, mining operations
- #3. Nitrous oxide (from fertilizers, other chemicals)



2000 Climate Change Impacts on the United States  
Cambridge University Press

# Often quoted evidence of global warming

- Etching from 1850 showing glacier above the town of Argentière, France
- Photograph from 1966, showing the valley above town is ice free



1912



Kilimanjaro,  
Africa

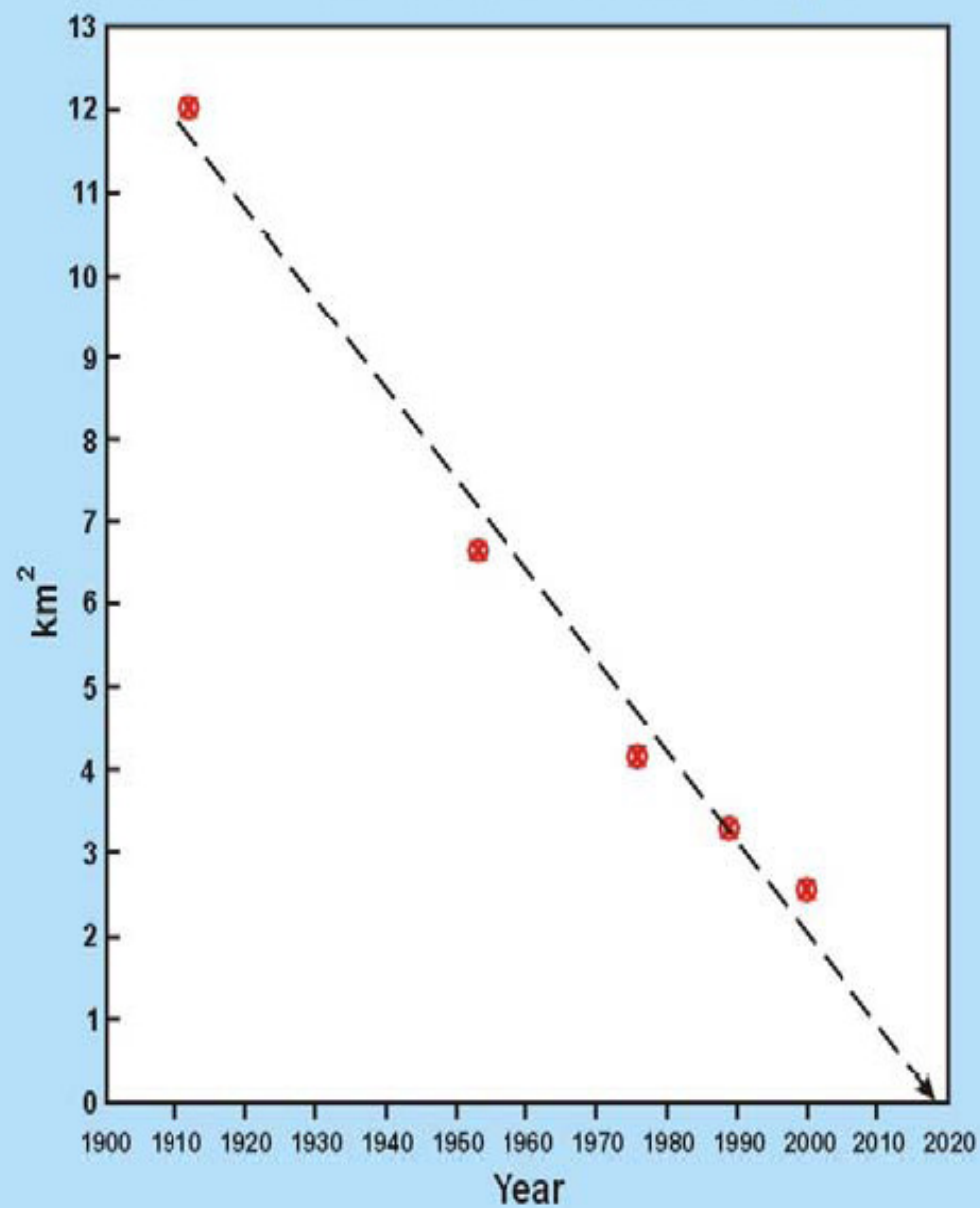
1970



2000



## Total Area Of Ice On Kilimanjaro

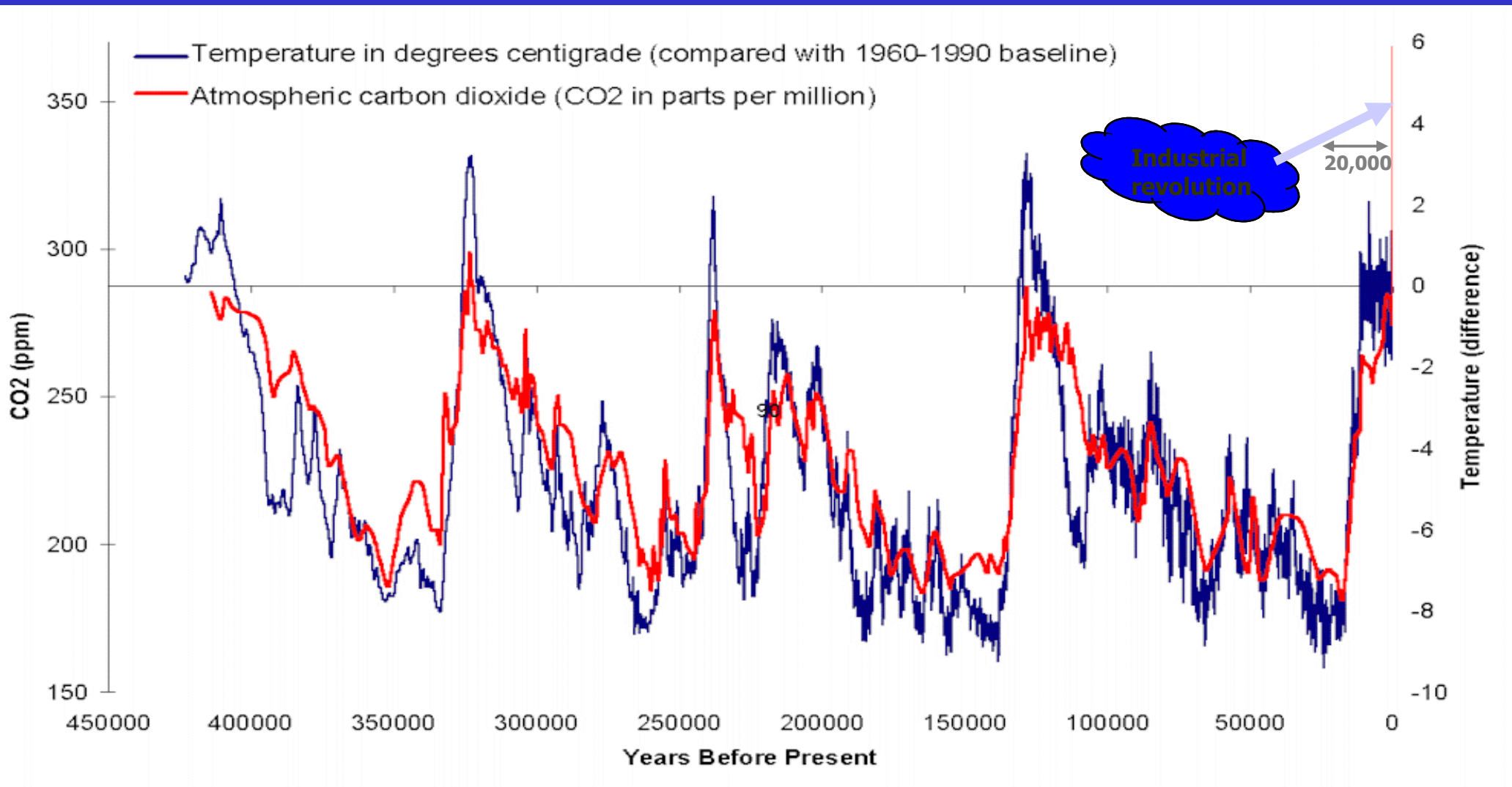


*“The farther backward you can look,  
the farther forward you are likely to see”*

*- Winston Churchill-*

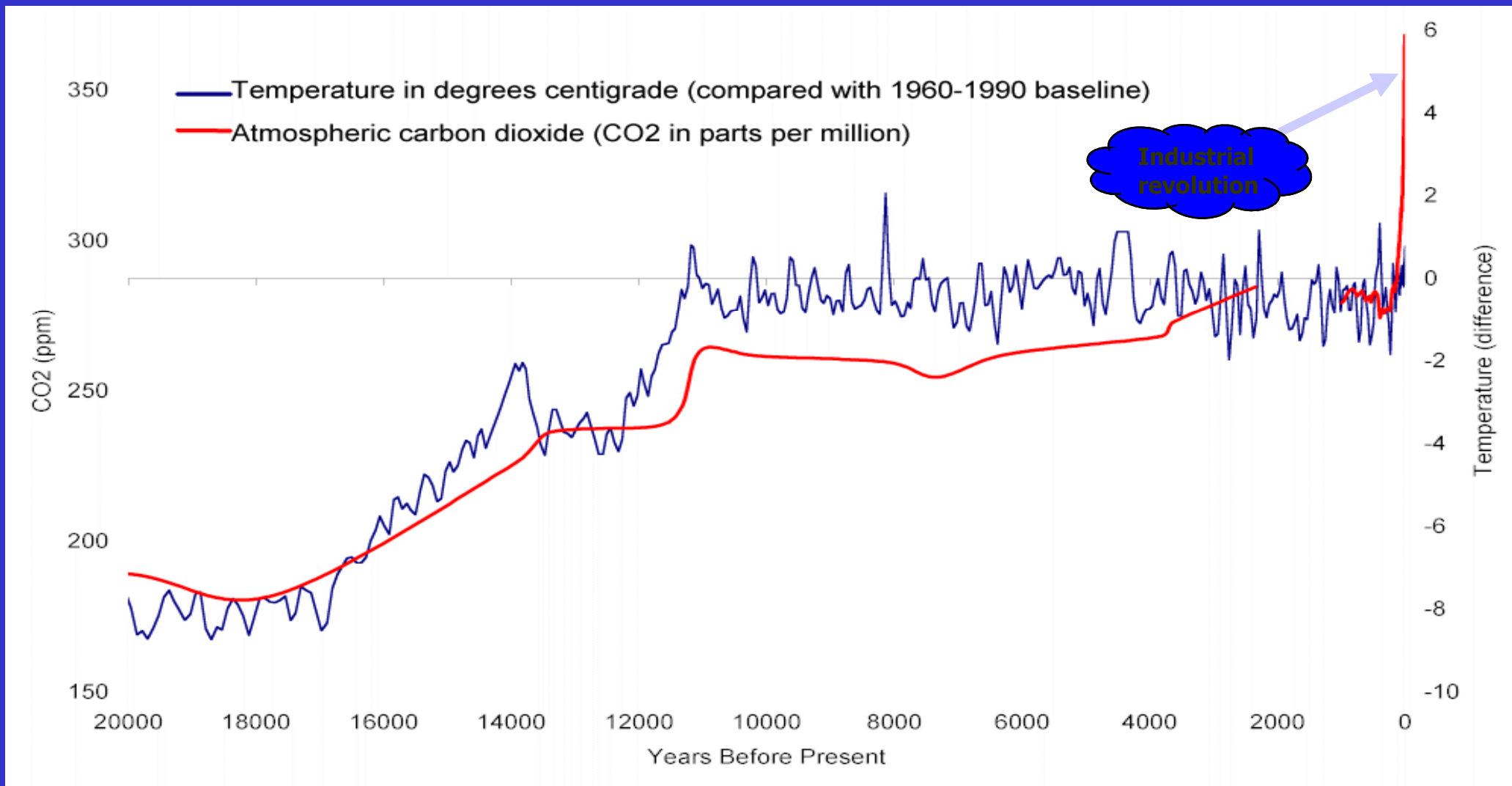


# Excellent correlation of global T and CO<sub>2</sub> concentration over 400,000 years

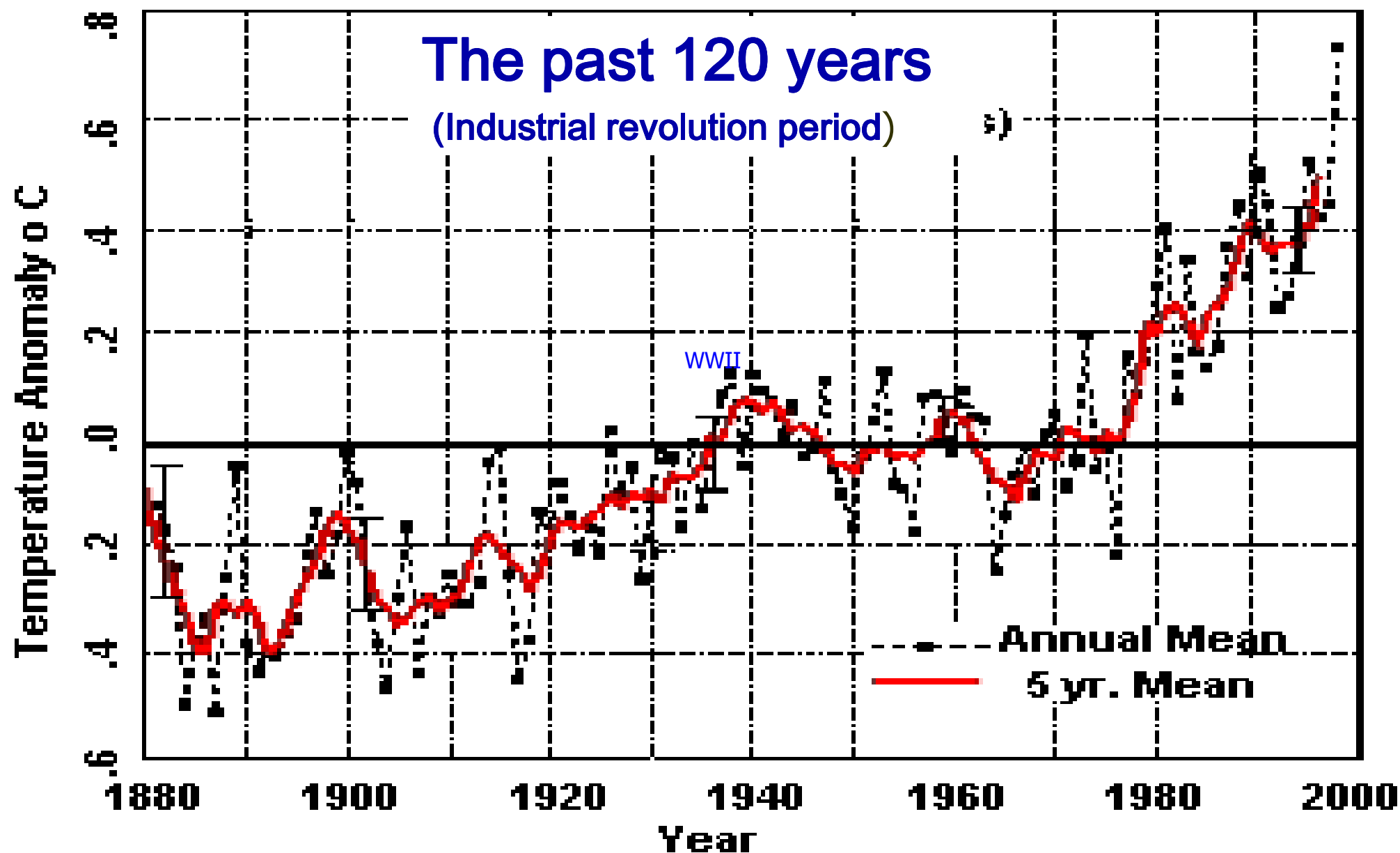


Source: Intergovernmental Panel on Climate Change (1990, 1995, 2001)

# Excellent correlation of global T and CO<sub>2</sub> concentration over 20,000 years



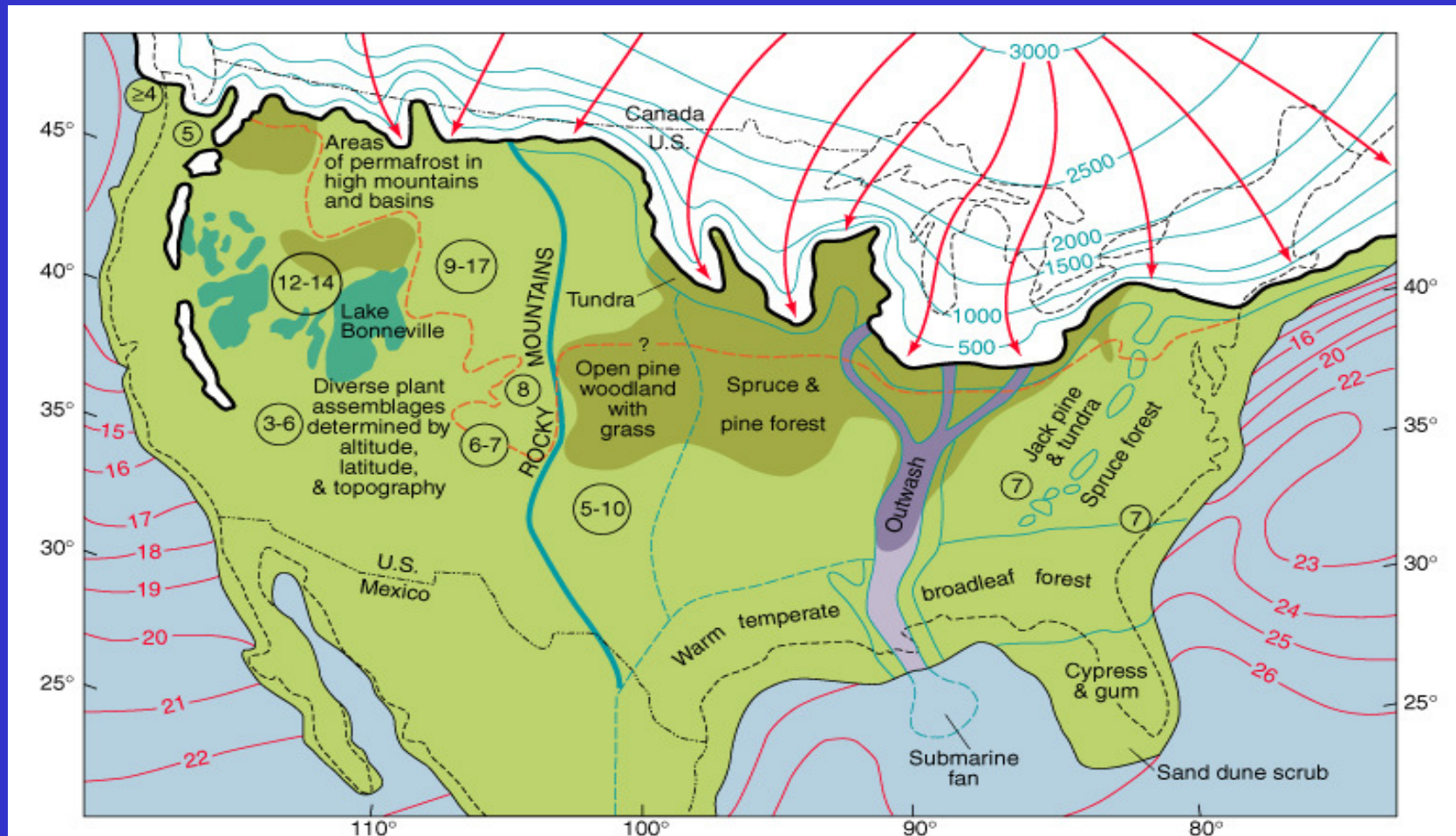
Source: Intergovernmental Panel on Climate Change (1990, 1995, 2001)



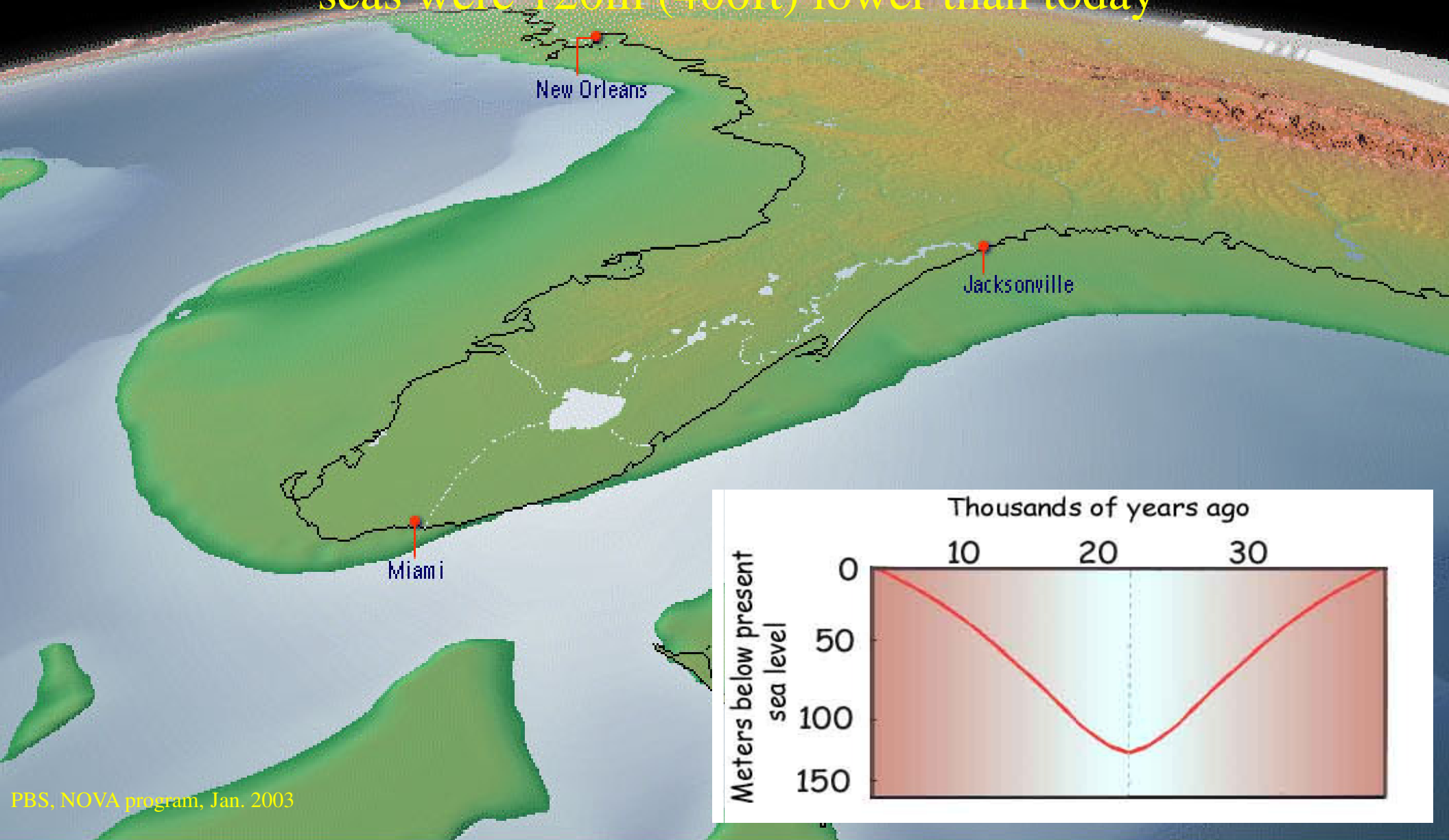


# N. America – 20,000 years ago

- America's last glaciation -- ice thickness in meters
- Greater coastlines because sea level about 120 m lower



Florida 20,000 years ago at the height of the last Ice Age;  
seas were 120m (400ft) lower than today



# Evidence from ice cores

- USGS retrieving ice core, Greenland
- Arctic/Antarctic ice cores hold Earth's climatic history in ice -- trapped air bubbles, volcanic dust, other

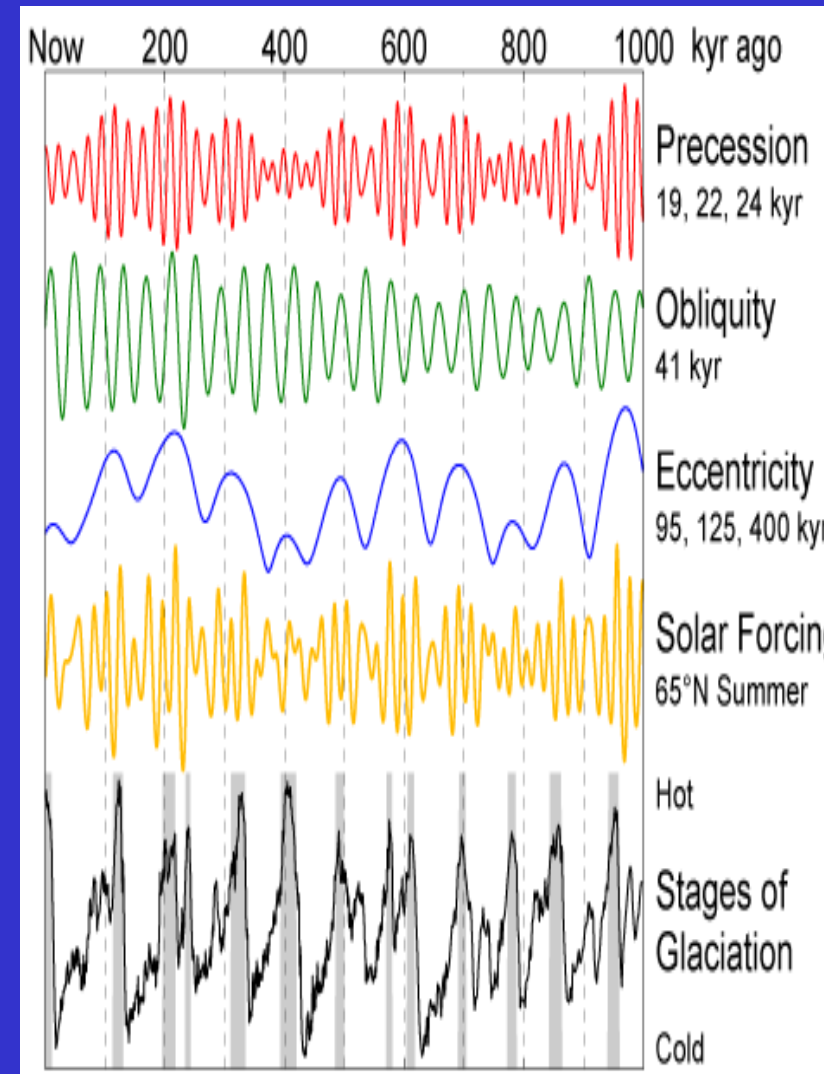


Data on global temperature reached 125,000 years.

At that time the Earth was in a warm period and moving into ice ages that ended about 10,000 years ago

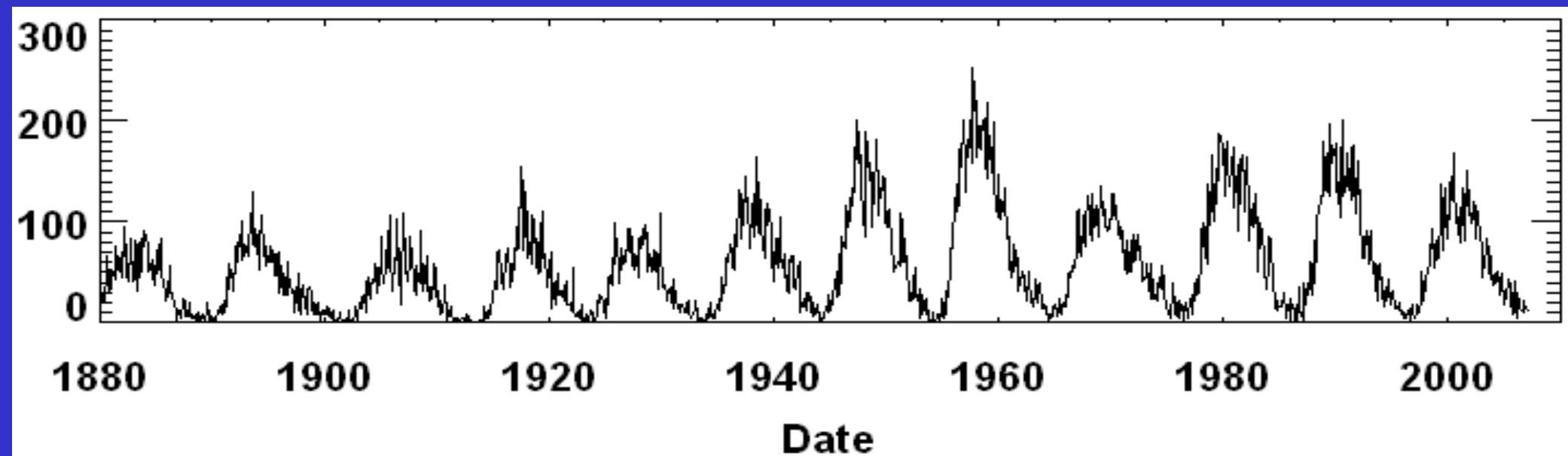
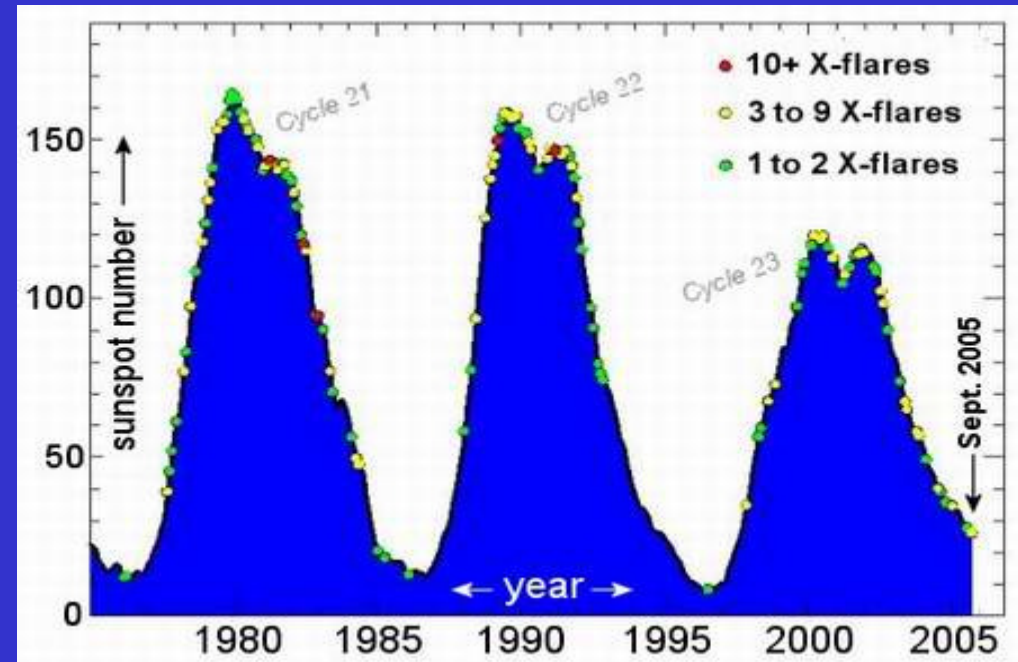
# Three natural forces that together lead to periodic ice ages on Earth

- Changes of Earth's orbit around the sun:
  - ✓ the shape of Earth's orbit (eccentricity) elongates every 100,000 yrs
  - ✓ the tilt of the Earth's axis (obliquity) -- changes  $22^{\circ}$  to  $24^{\circ}$  every 40,400 yrs
  - ✓ the wobble of Earth's axis (precession) -- wobbles in a circle every 23,000 yrs
  - ✓ the solar forcing – effect unknown



# Solar cycles

- Well established solar cycles – 11 years
- There may be much longer and unknown solar cycles



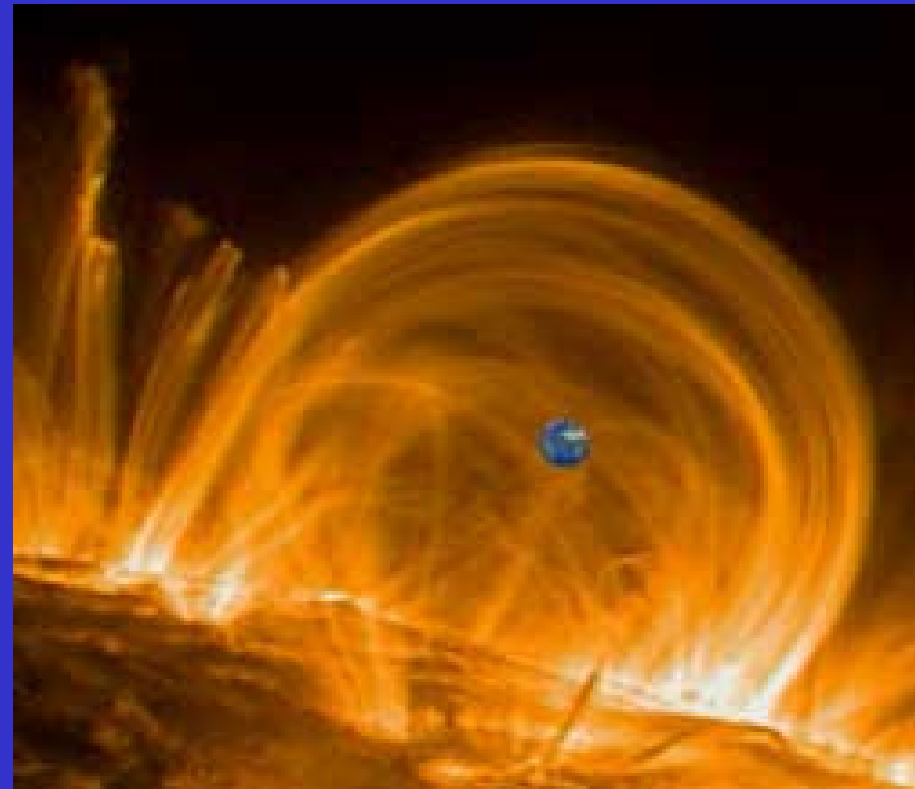
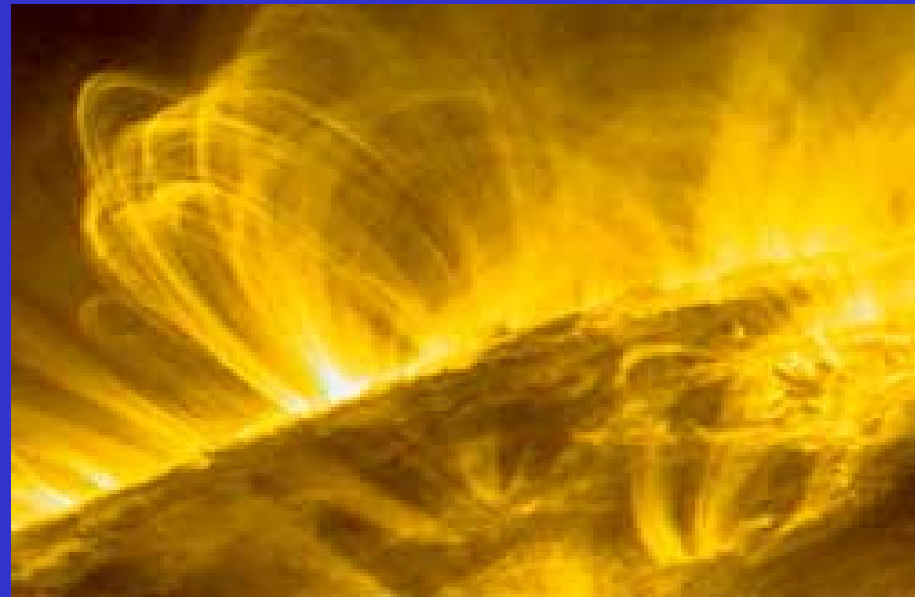




# Unsteady solar activity

“The Sun’s turbulent dynamics is linked with the Earth’s complex ecosystem”

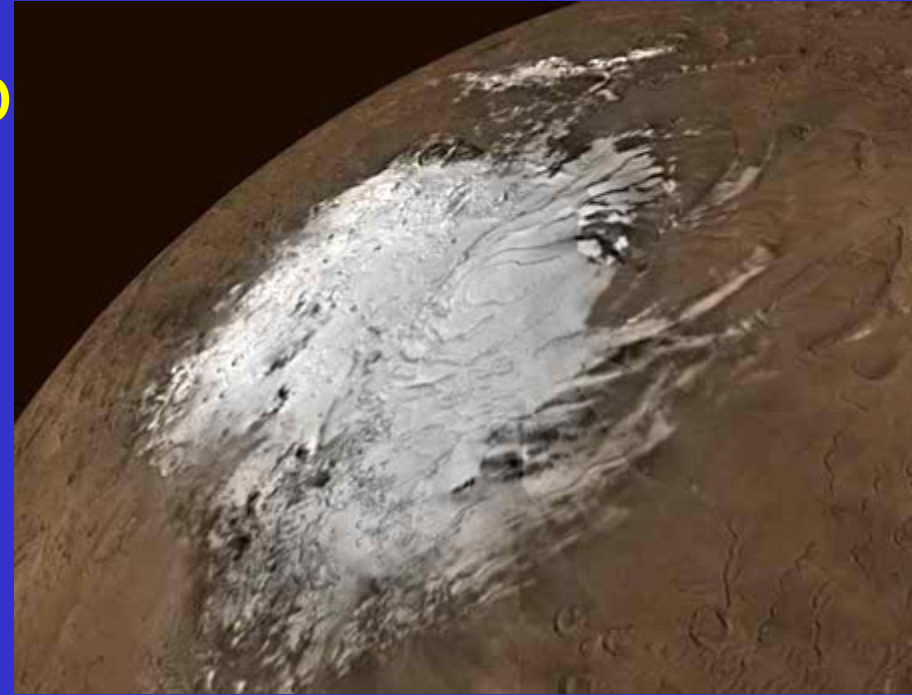
- Multimillion-degree gas fountains on the Sun
- Hundreds of thousands of miles high (note Earth for size) -- loops temp. up to 9 million  $^{\circ}\text{F}$
- Blast energy into space at irregular intervals





# Mars Melt -- Humans on Mars?

- Mars's southern polar ice cap has shrunk in recent years
- Simultaneous warming of Earth and Mars
- NASA's Mars Global Surveyor and Odyssey missions -- CO<sub>2</sub> "ice caps" diminishing
- Mars and Earth, experienced periodic ice ages throughout their histories



# Catastrophic releases of $\text{CH}_4$ from methane hydrates

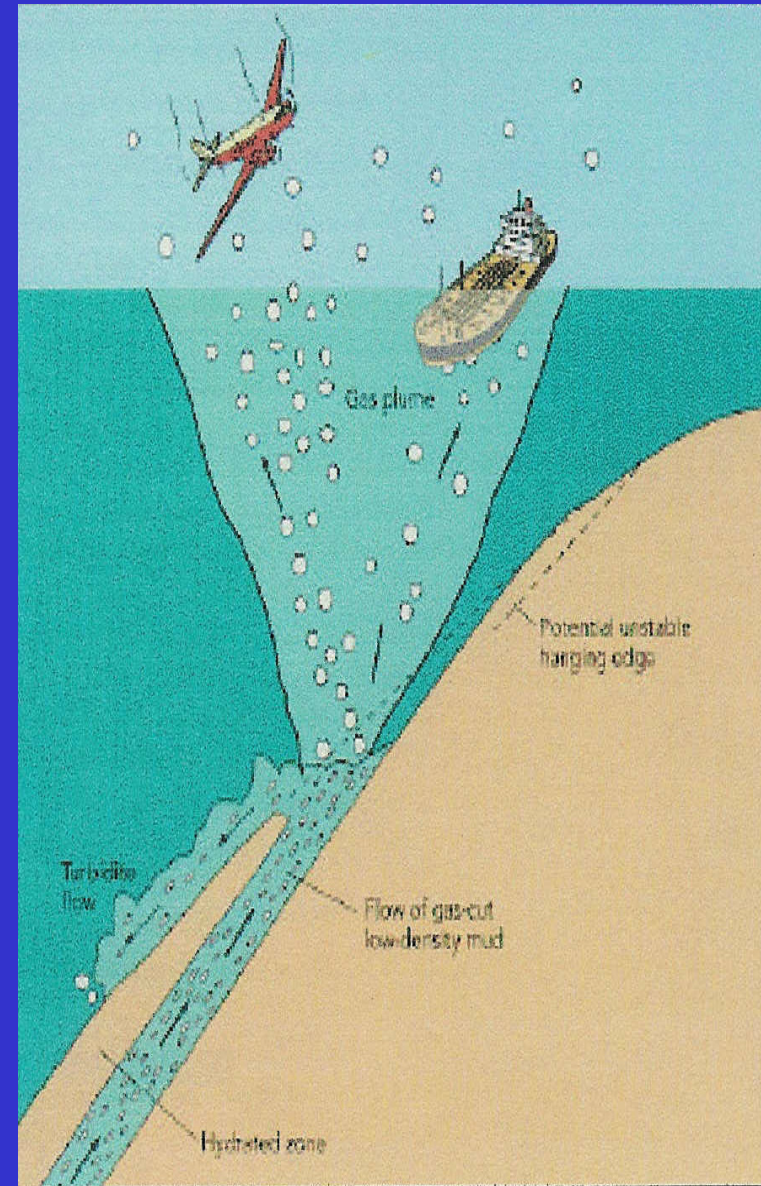
- $\text{CH}_4$  linked to past T changes?
- 21 times more potent than  $\text{CO}_2$
- Far more plentiful in nature than natural gas; occurs everywhere, even along the equator
- Looks like snow; ignites as easily as gasoline



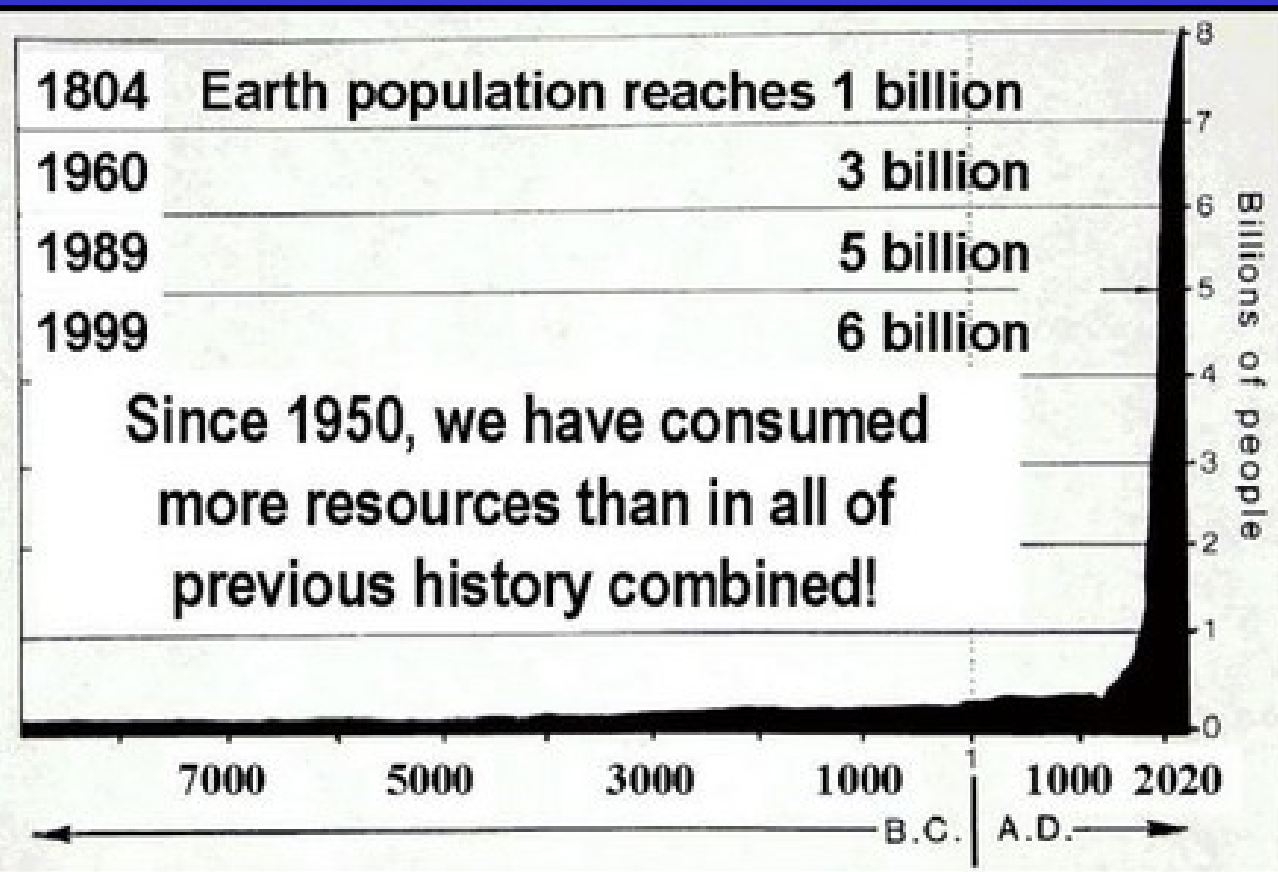


# Methane Hydrates, the Bermuda Triangle and Global Warming

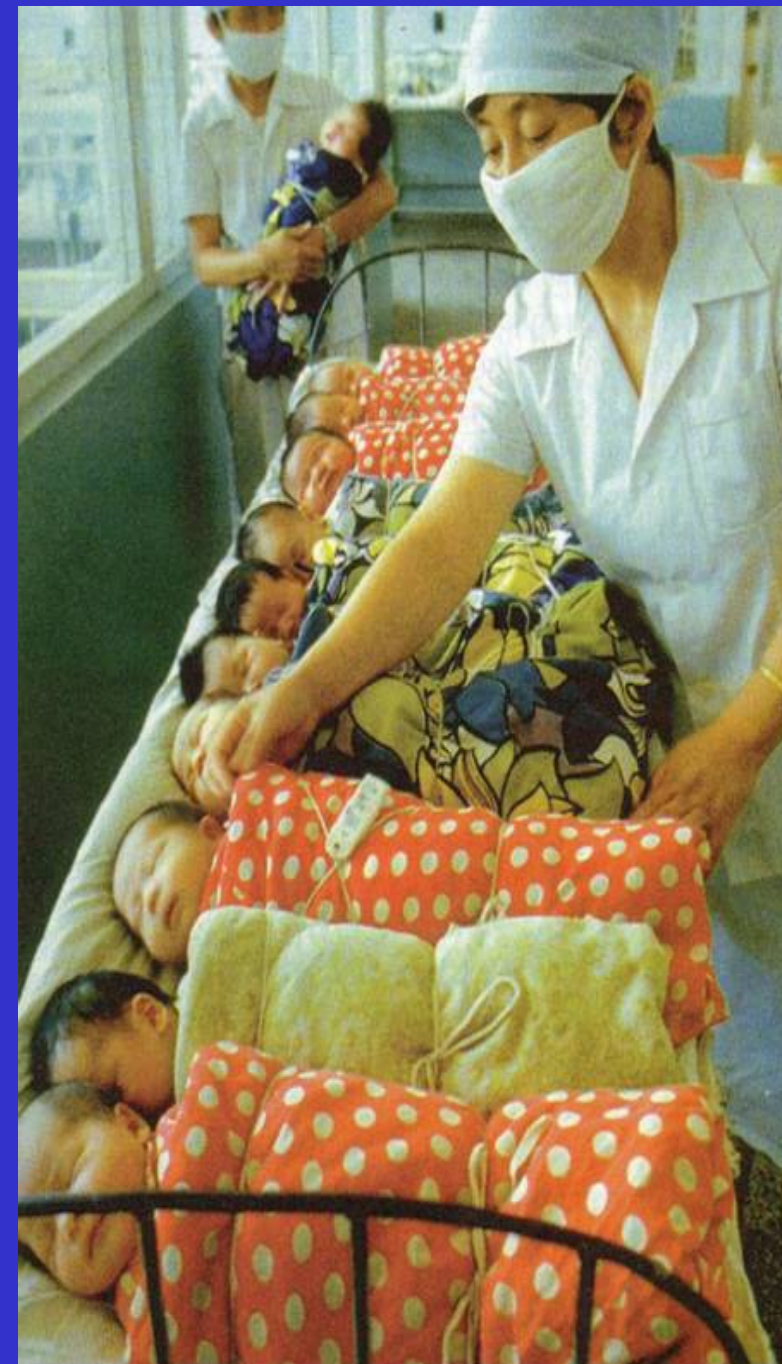
- 1998 conf. on Earth Sciences at Cardiff, Wales; Dr. Clennel proposed:
- Methane hydrates explain mysterious disappearances of ships and planes
- Claimed that subterranean landslides can unlock vast beds of methane
- "...would make any floating ship sink like a rock." ... "gas could ignite hot aircraft engines"



**Explosive population growth**  
**Explosive demand for energy**  
**Explosive emissions of CO<sub>2</sub>**



**Human Population Explosion**





# Albert Gore: “The Inconvenient Truth”

- Movie and film (Academy Award)
- Neither presents arguments of dissenting scientists
- Contain *useful* information; educational value
- Publicity/political motivation?
- Feb. 2009 survey – Gore’s influence waning



# The *Inconvenient* Scientists

- Some scientists disagree strongly with some issues
- Accuse of being intimidated into silence
- Dissenting scientists see their grants disappear, their work derided, labeled as industry stooges
- Most dissenting scientists are retired; need no grants
- Alarm, rather than genuine scientific interest appears essential to maintaining funding

# Starve the people; feed the cars (1)

(Washington Post, Sept. 10, 2006)

- Brazil, world's largest sugar exporter, converts half of its crop to ethanol; caused doubling of sugar price in 2 yrs
- Meat producers fear there may not be enough corn to feed animals; shortages in milk, eggs, beef, pork
- Whenever food value of a crop drops below its fuel value, the market will convert it into fuel





# Starve the people; feed the cars (2)

(Washington Post, Sept. 10, 2006)

- Everything we eat can be converted to fuel
- At \$60/bbl, the conversion can be hugely profitable
- Battle between 800 million auto owners (want to maintain their mobility) and world's 2 billion poorest people (want just to survive)



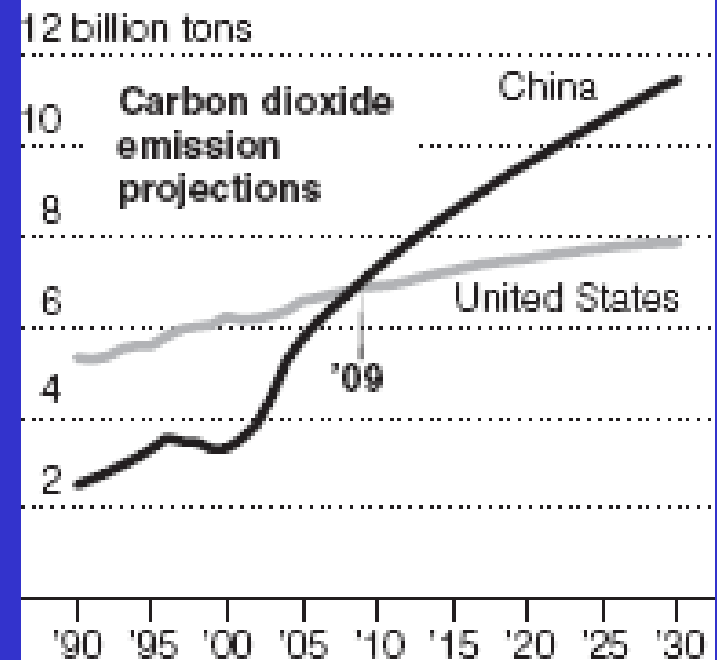
# Even dissenting scientists agree that...

- Global T. has risen about 1°F since late 19<sup>th</sup> century
- Levels of CO<sub>2</sub> have increased about 30%
- CO<sub>2</sub> contributes to future warming
- **BUT:** not true that there is consensus
- Insufficient understanding of natural variability of climate change – despite efforts to suggest otherwise
- Numerical modeling good, but not good enough

China will surpass  
the U.S. as the  
biggest emitter of  
CO<sub>2</sub> in 2009

## The New No. 1 Emitter

The International Energy Agency has concluded that China will surpass the United States in 2009 as the biggest emitter of the main gas linked to global warming. But given China's much larger population, it will still emit far less per person.

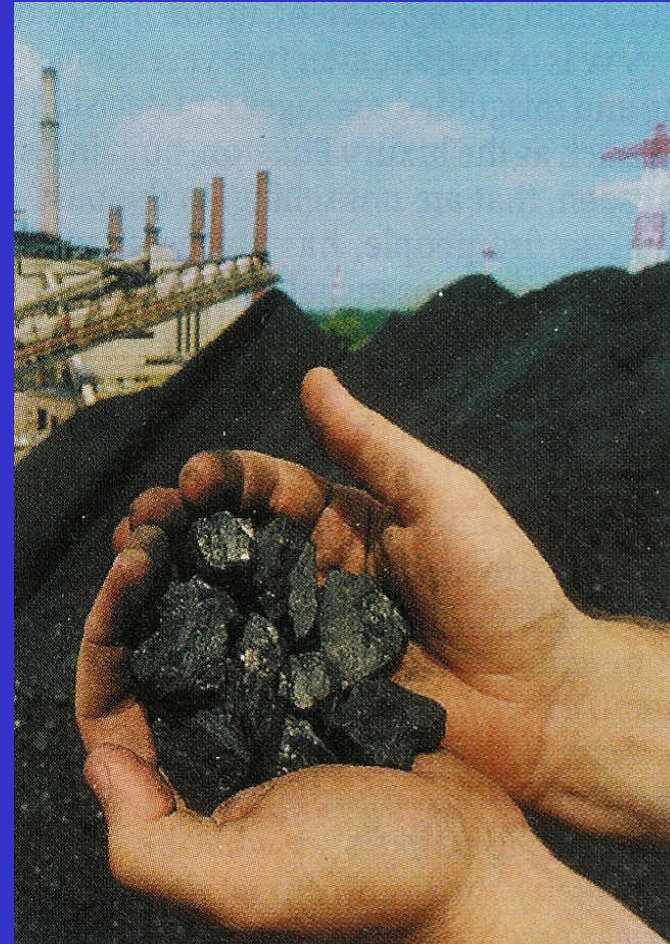


Source: International Energy Agency

The New York Times

# Coal need not be a filthy fuel

- Declared dead many times over 50 years, but we now use it more than ever
- Thanks to economic growth of China and India, coal price had doubled
- Huge problem: environment
- Clean coal: fluidized bed combustion, hybrid of gasification and combustion, in-situ gasification
- Within 15 years, new coal plants could be as clean as any others



# CO<sub>2</sub> sequestration options

- Injecting in depleted oil/gas reservoirs
- Deep ocean disposal
- Chemical binding (limestone)



# Carbon Capture and Storage

- CCS challenges not only technical, but economic, legislative, winning public acceptance.
- EOR provides the first step toward a CCS business but limited by scale and geography. Short term solution.
- Deep saline formation injections below 1000m will be the main type of storage in the future.

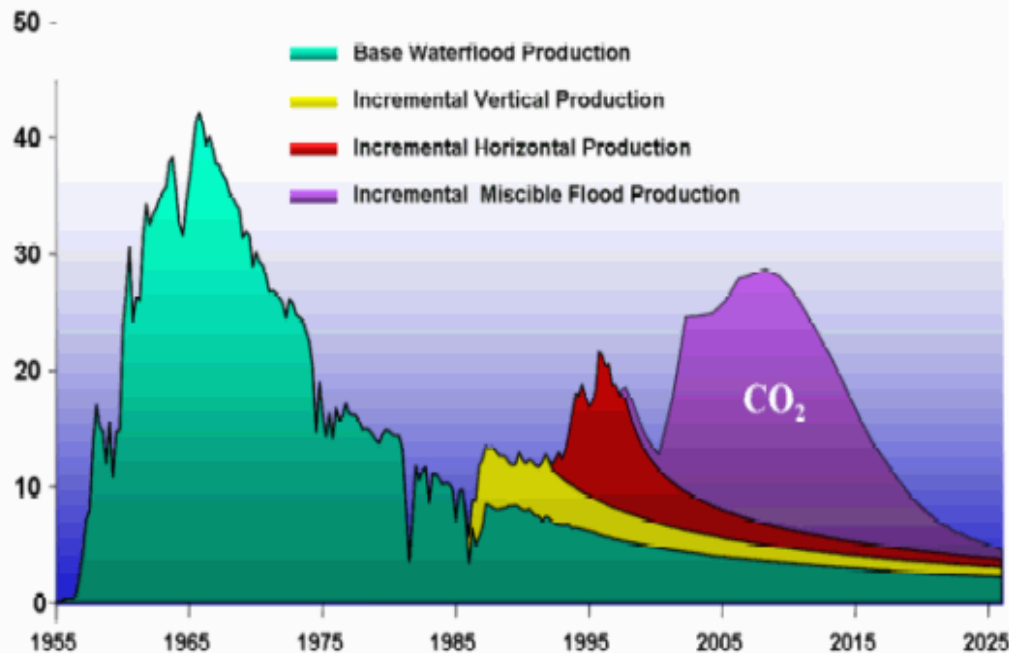


# Good News for Petroleum Engineers

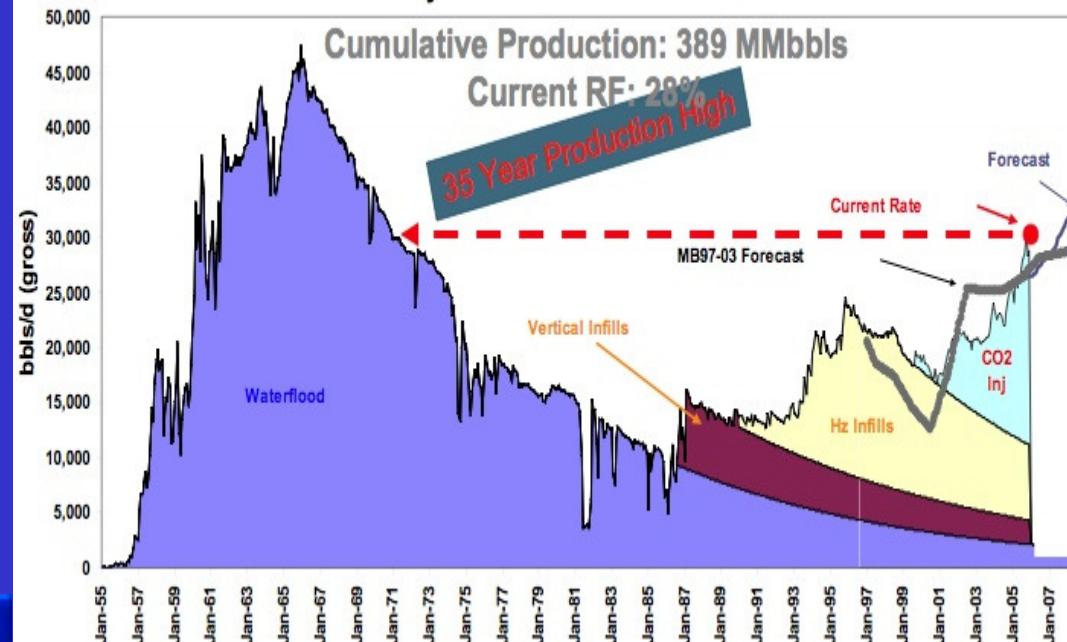
- CO<sub>2</sub> storage -- a substantial new business
- Uses skills of petroleum engineers/geologists
- Is an absolute necessity to make significant reductions in CO<sub>2</sub> emissions
- Also: opens up the use of vast coal stocks
- Enables hydrogen to be used as energy carrier
- Provides energy security through diversity



## Enhanced oil production at Weyburn



## Weyburn Unit Oil Production



= Producer Well

= CO<sub>2</sub> Injection Well

# Gas, LNG imports to Rise

- Regs on CO<sub>2</sub> emissions will increase demand for nat. gas
- Int. competition for LNG
- Already, 275 tankers deliver LNG to 40 ports, worldwide
- Further European dependency on Russia
- Gas price likely to increase



# Conservation/Energy Rating



ENERGY STAR program protects the environment through energy efficiency, saves energy and money

Last year alone, the ENERGY STAR program helped avoid greenhouse gas emissions equivalent to that of 12 million cars – while saving \$6 billion

Televisions  
VCRs  
TV Combination Units  
DVD Products  
Home Audio  
Set-Top Boxes  
Cordless Phones  
Answering Machines  
Cordless Phone/Answering Machine Units

Clothes Washers  
Dishwashers  
Refrigerators  
Room-Air Conditioners

Computers  
Monitors  
Printers  
Fax Machines  
Copiers  
Scanners  
Multifunction Devices

Compact Fluorescent Bulbs (CFLs)  
Lamps  
Outdoor Lights  
Suspended Lights  
Cabinet Lighting  
Ceiling-Mounted Lighting  
Wall-Mounted Lights  
Recessed Lights  
Architectural



# CNG; not a new idea – but it works!

- There is abundance of natural gas in Zigong
- The bags of rubber on top of buses contain gas
- The weight of the bag forces gas into the engine
- Some parts of China have natural gas but no pipelines for gas distribution



**Natural Gas Bus in Zigong**

There is an abundance of natural gas in this part of Sichuan. All of the local buses in Zigong use natural gas to fuel. The bags of rubber on the top of the bus contain the gas. The sheer weight of the bag forces the gas into the engine. From time to time they stop at a station to get a fresh supply of gas. Certain parts of China have natural gas but China doesn't have much in the way of pipelines to distribute the gas to other parts of China.

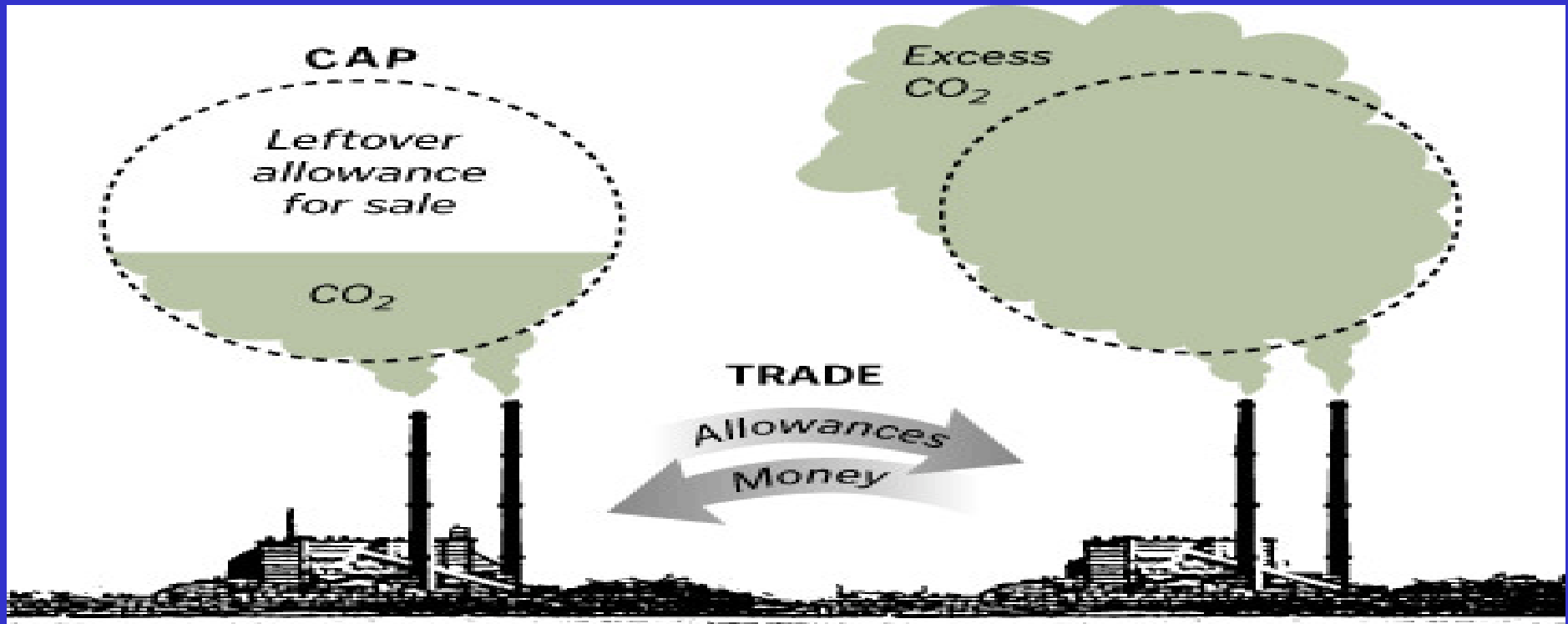
# Transporting natural gas – a biker's approach



Source: China Newsphoto/Reuters/Corbis



# Cap and Trade: How It Would Work



Innovative companies that develop ways to reduce emissions, earn income by selling unneeded allowances

Economic pressure encourages companies that exceed caps to find ways to reduce emissions

# Reaction of the petroleum industry

- Slowly changing attitude-- a reflection of political reality
- Majors have long opposed emission constraints; now cooperate on structuring rules
- Industries starting to argue who will pay for CO<sub>2</sub> sequestration

# Who will pay?

- Economy-wide cap-and-trade program to reduce greenhouse gas emissions by 80% by 2050
- Pledges to make the U.S. a global leader in addressing climate change
- Whatever the cost, it will be passed on to consumers

# *An Inconvenient Tax*

- “Climate Revenue” from the cap-and-trade program is in the new White House budget:
- Expects \$646 billion revenue through 2019
- But do not call it t.. -- which is very unpopular
- Mr. Chu (DOE) worries that new taxes may drive jobs to countries where costs are cheaper
- Mid-west worries that their tax will subsidize CA
- Huge fights about who gets to divvy up the spoils

# Two excellent references for agnostics:

- **William Happer**, Prof. of Physics, Princeton University: Statement to the U.S. Senate on Feb. 25, 2009: “Global Warming and Climate Change in Perspective: Truths and Myths About Carbon Dioxide, Scientific Consensus, and Climate Models”
- **Richard Lindzen**, Prof. of Meteorology, MIT: “Global Warming: The Origin and Nature of the Alleged Scientific Consensus”



# Conclusions -- future trends

- Near term: pressure to reduce CO<sub>2</sub> emissions, monetize stranded gas, LNG, GTL, CNG, security
- Mid term: environmentally acceptable ways to utilize heavy oil, coal; diversify supplies
- Long term: permanent solution to CO<sub>2</sub> sequestration
- Role of technology: develop unconventional oil and gas resources, decrease environmental footprint
- Renewables significant, will not replace hydrocarbons

THANK YOU

