

# **Climate Threat to the Planet\***

## **Implications for Energy Policy**

**Jim Hansen**

**4 July 2008**

**United Nations University  
Tokyo, Japan**

\* Any statements relating to policy are personal opinion

# Global Warming Status

## 1. Knowledge Gap Between

- What is Understood (science)
- What is Known (public/policymakers)

## 2. Planetary Emergency

- Climate Inertia → Warming in Pipeline
- **Tipping Points → Could Lose Control**

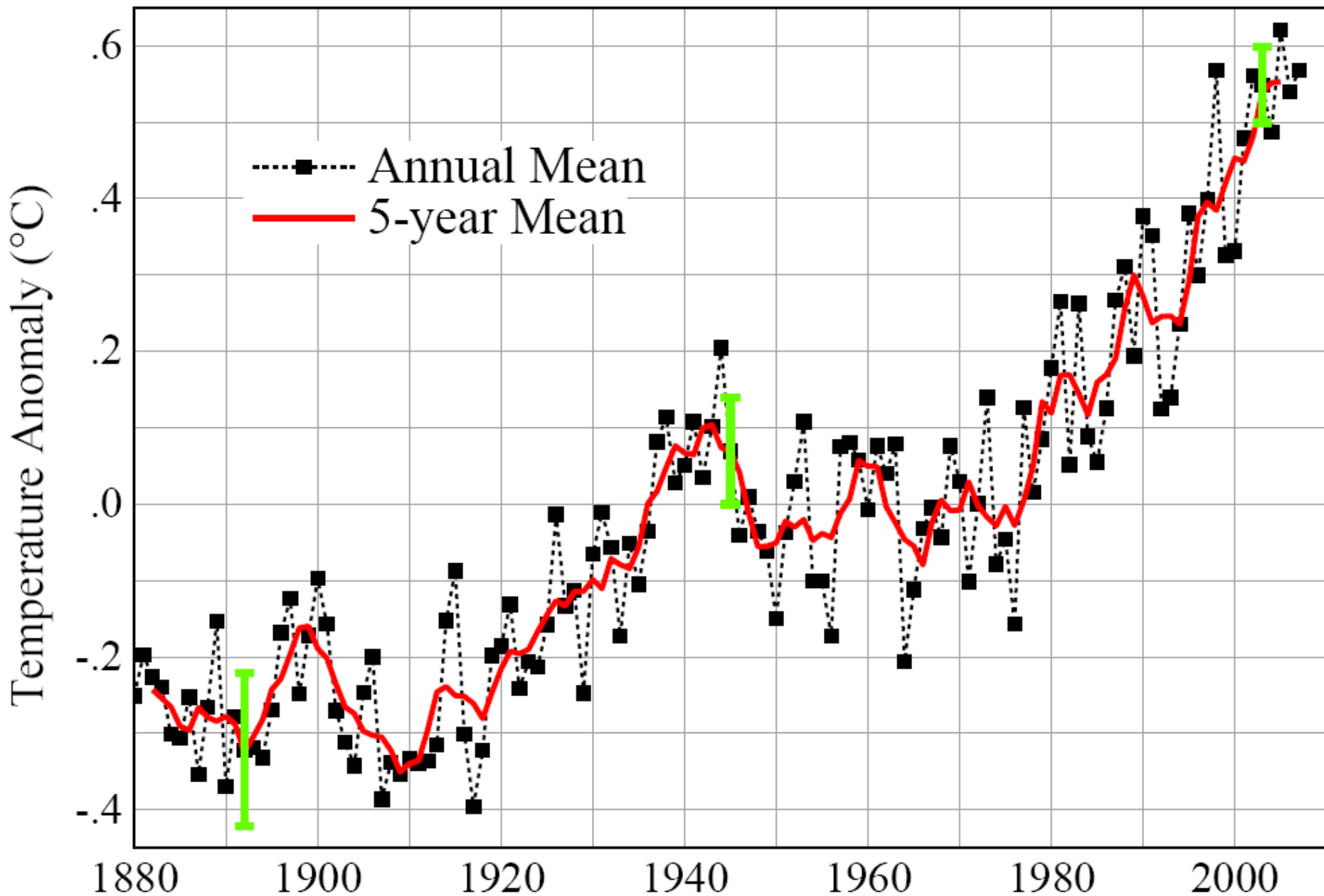
## 3. Good News & Bad News

- Safe Level of CO<sub>2</sub> < 350 ppm
- Multiple Benefits of Solution

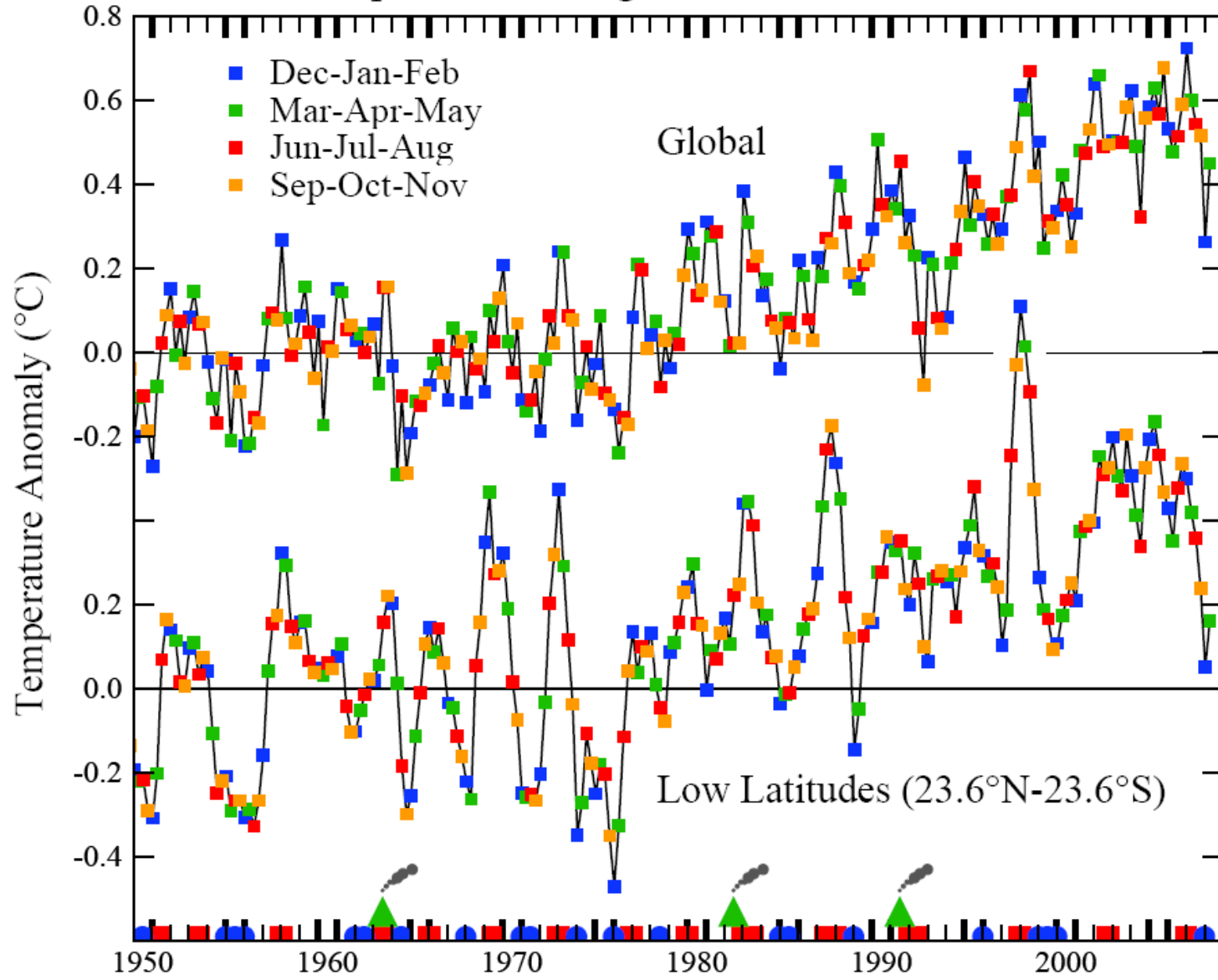
# **Basis of Understanding**

- 1. Earth's Paleoclimate History**
- 2. On-Going Climate Changes**
- 3. Climate Models**

# Global Temperature Land-Ocean Index



# Temperature Change at Seasonal Resolution



Green Triangle = Volcano; Red Box = El Niño; Blue Semicircle = La Niña

# United Nations Framework Convention on Climate Change

*Aim is to stabilize greenhouse gas emissions...*

*“...at a level that would prevent dangerous anthropogenic interference with the climate system.”*

# Metrics for “Dangerous” Change

## Extermination of Animal & Plant Species

1. Extinction of Polar and Alpine Species
2. Unsustainable Migration Rates

## Ice Sheet Disintegration: Global Sea Level

1. Long-Term Change from Paleoclimate Data
2. Ice Sheet Response Time

## Regional Climate Disruptions

1. Increase of Extreme Events
2. Shifting Zones/Freshwater Shortages

# Tipping Point Definitions

## 1. Tipping Level

- Climate forcing (greenhouse gas amount) reaches a point such that no additional forcing is required for large climate change and impacts

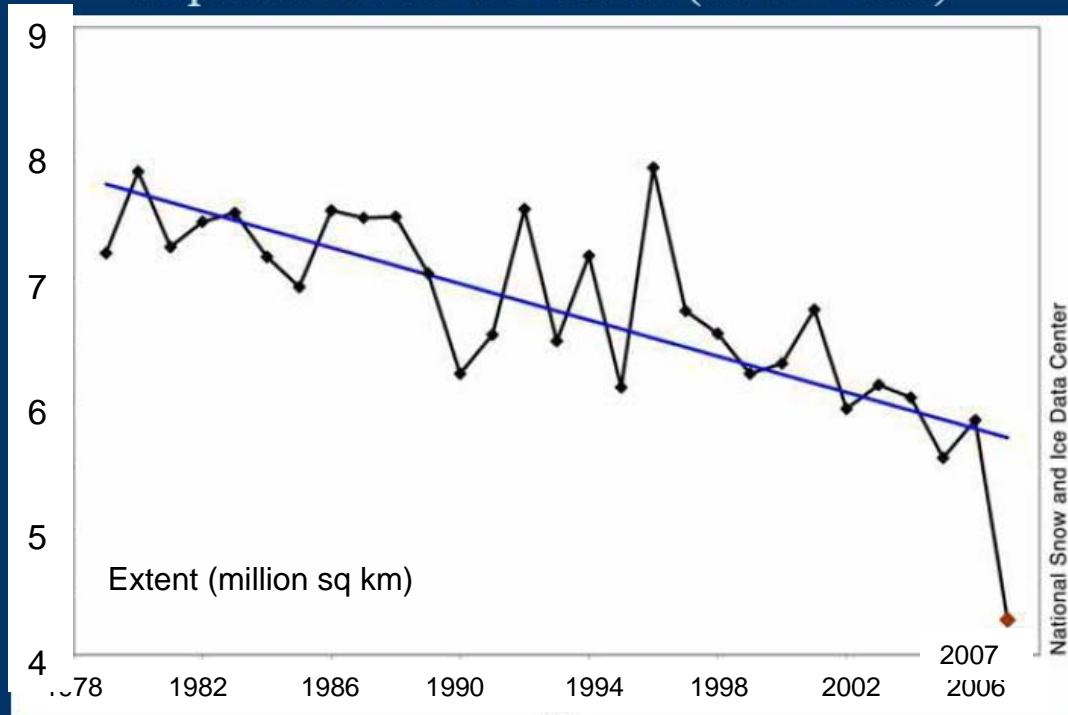
## 2. Point of No Return

- Climate system reaches a point with unstoppable irreversible climate impacts (irreversible on a practical time scale)  
Example: disintegration of large ice sheet



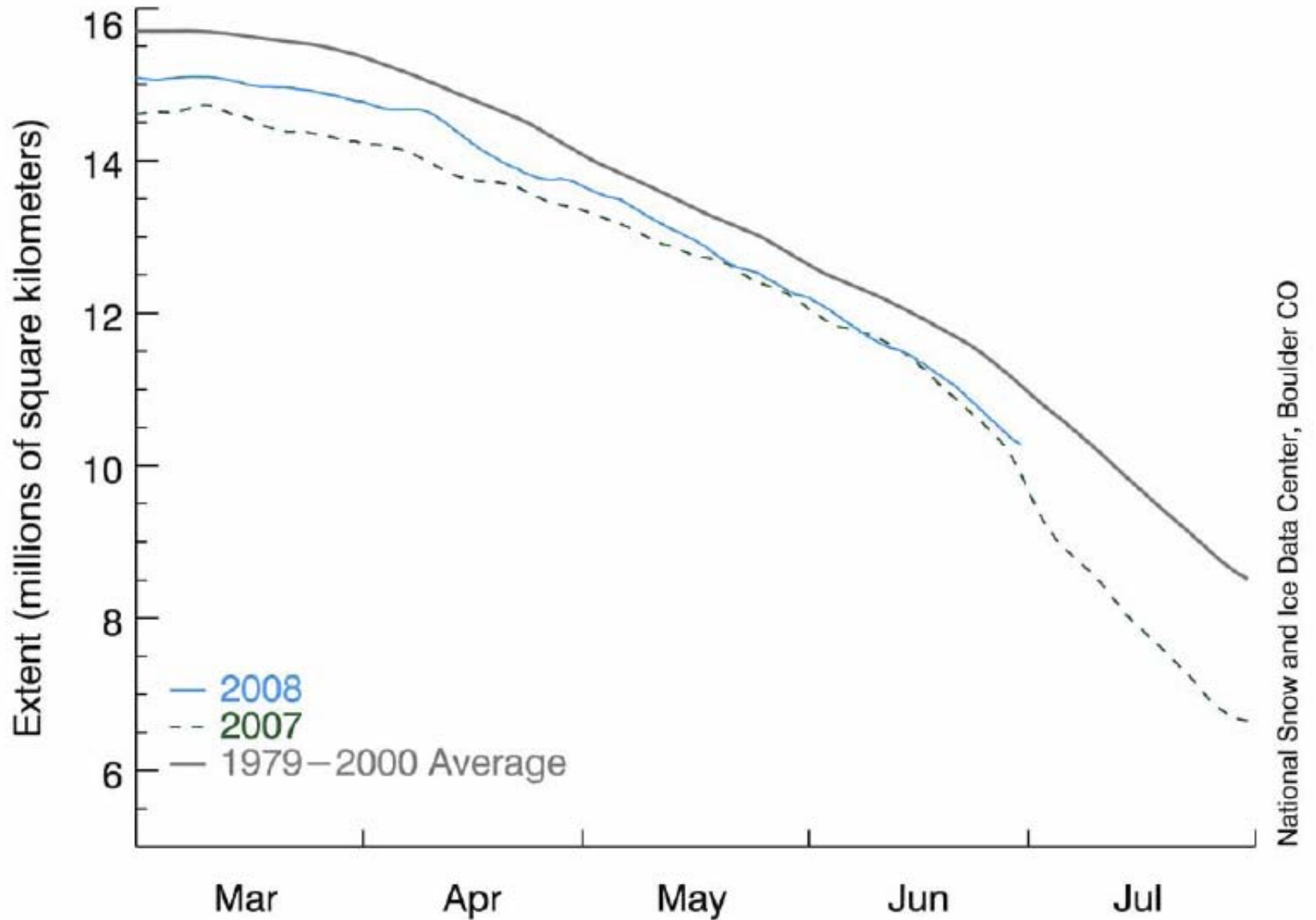
# 2007 Sea ice conditions in context

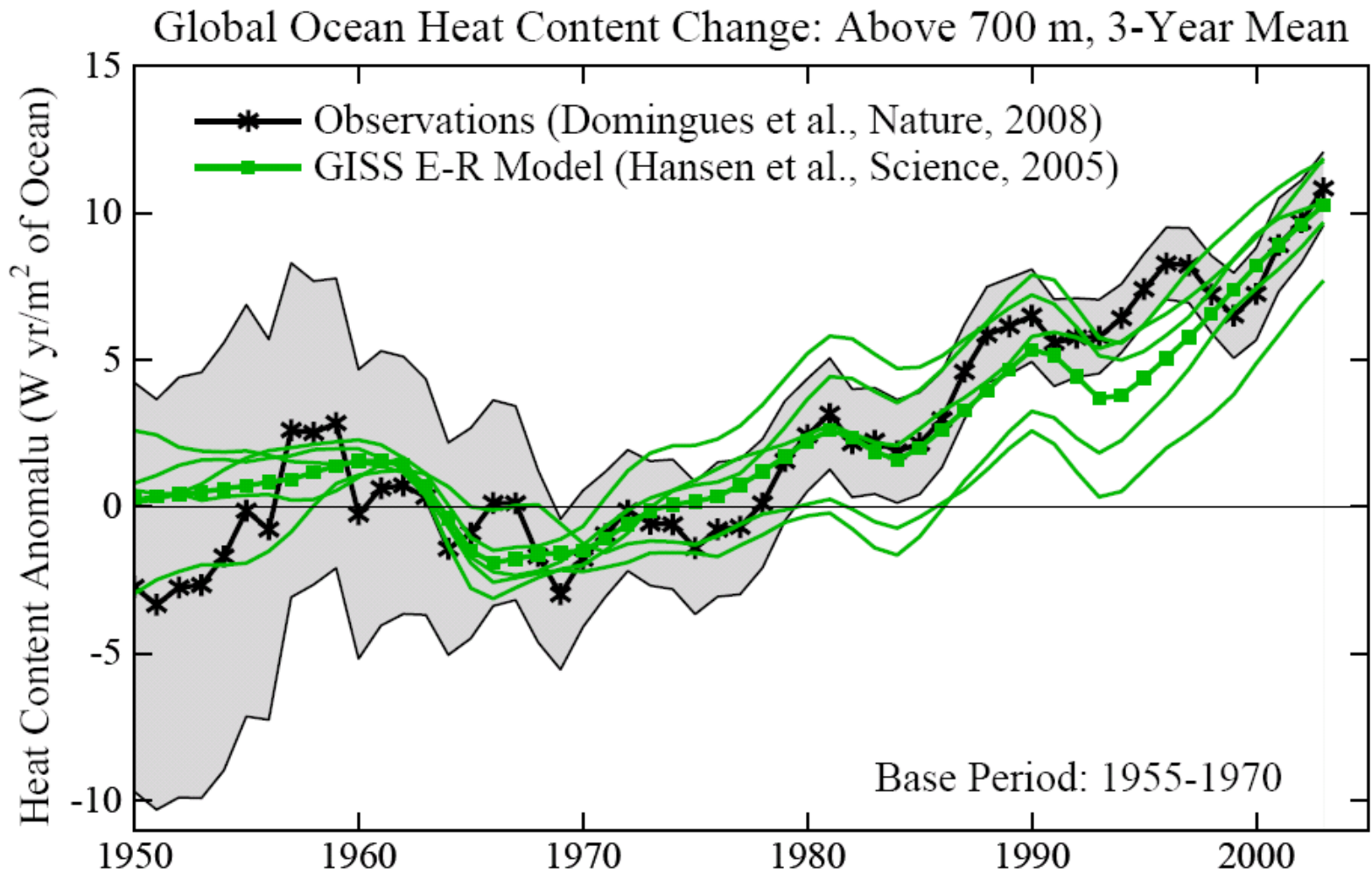
## September Sea Ice Extent (1979–2007)



September 2007  
4.28 million km<sup>2</sup>

# Arctic Sea Ice Extent (Area of ocean with at least 15% sea ice)





Observations: Domingues, C.M. et al., Nature 453, 1090-1093, 2008.

Model: Hansen, J. et al., Science 308, 1431-1435, 2005.

# Arctic Sea Ice Criterion\*

## 1. Restore Planetary Energy Balance

→ CO<sub>2</sub>: 385 ppm → 325-355 ppm

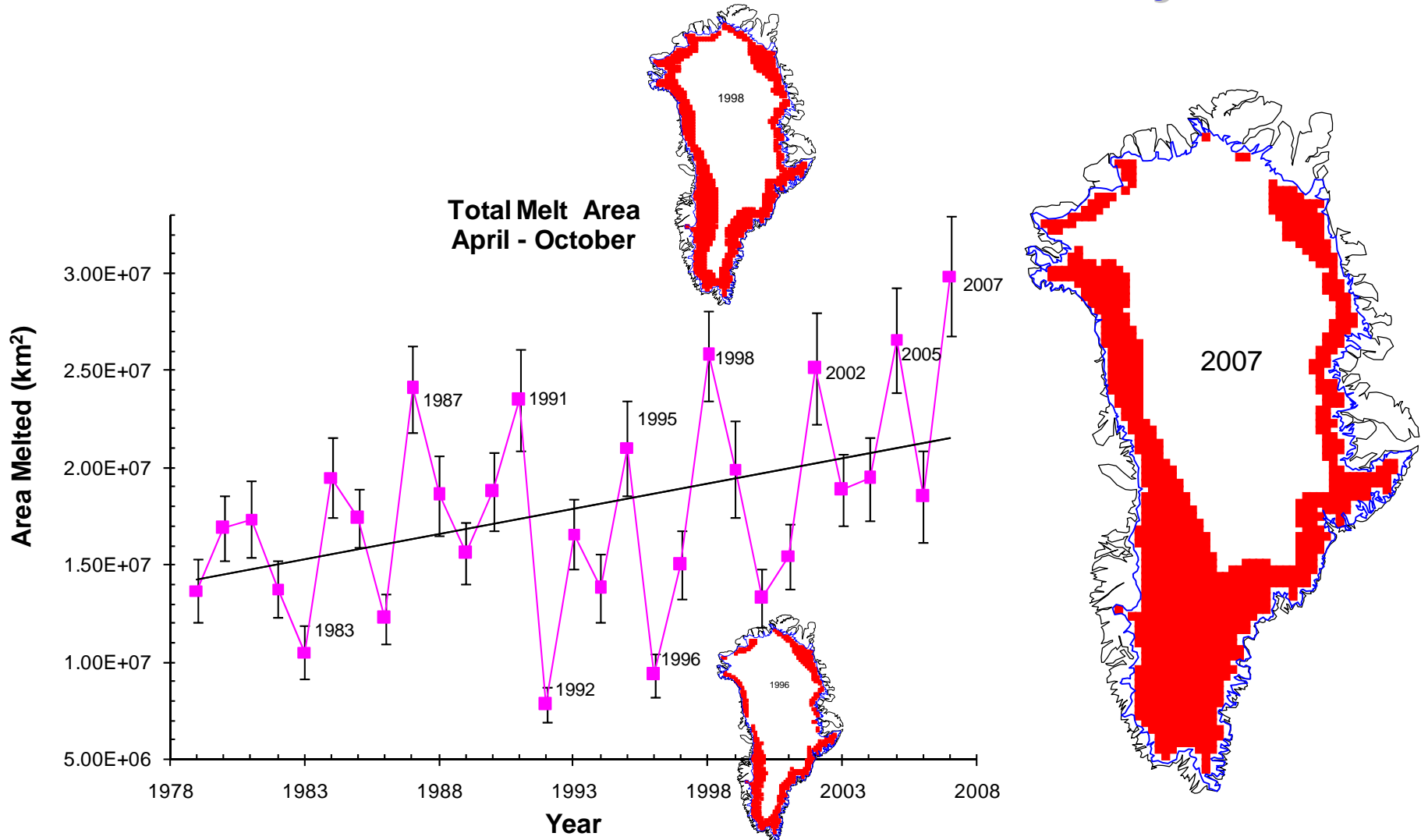
## 2. Restore Sea Ice: Aim for -0.5 W/m<sup>2</sup>

CO<sub>2</sub>: 385 ppm → 300-325 ppm

Range based on uncertainty in present planetary energy imbalance (between 0.5 and 1 W/m<sup>2</sup>)

\* Assuming near-balance among non-CO<sub>2</sub> forcings

# Greenland Total Melt Area - 2007 value exceeds last maximum by 10%





# Surface Melt on Greenland

Melt descending into a moulin, a vertical shaft carrying water to ice sheet base.



*Source: Roger Braithwaite,  
University of Manchester (UK)*



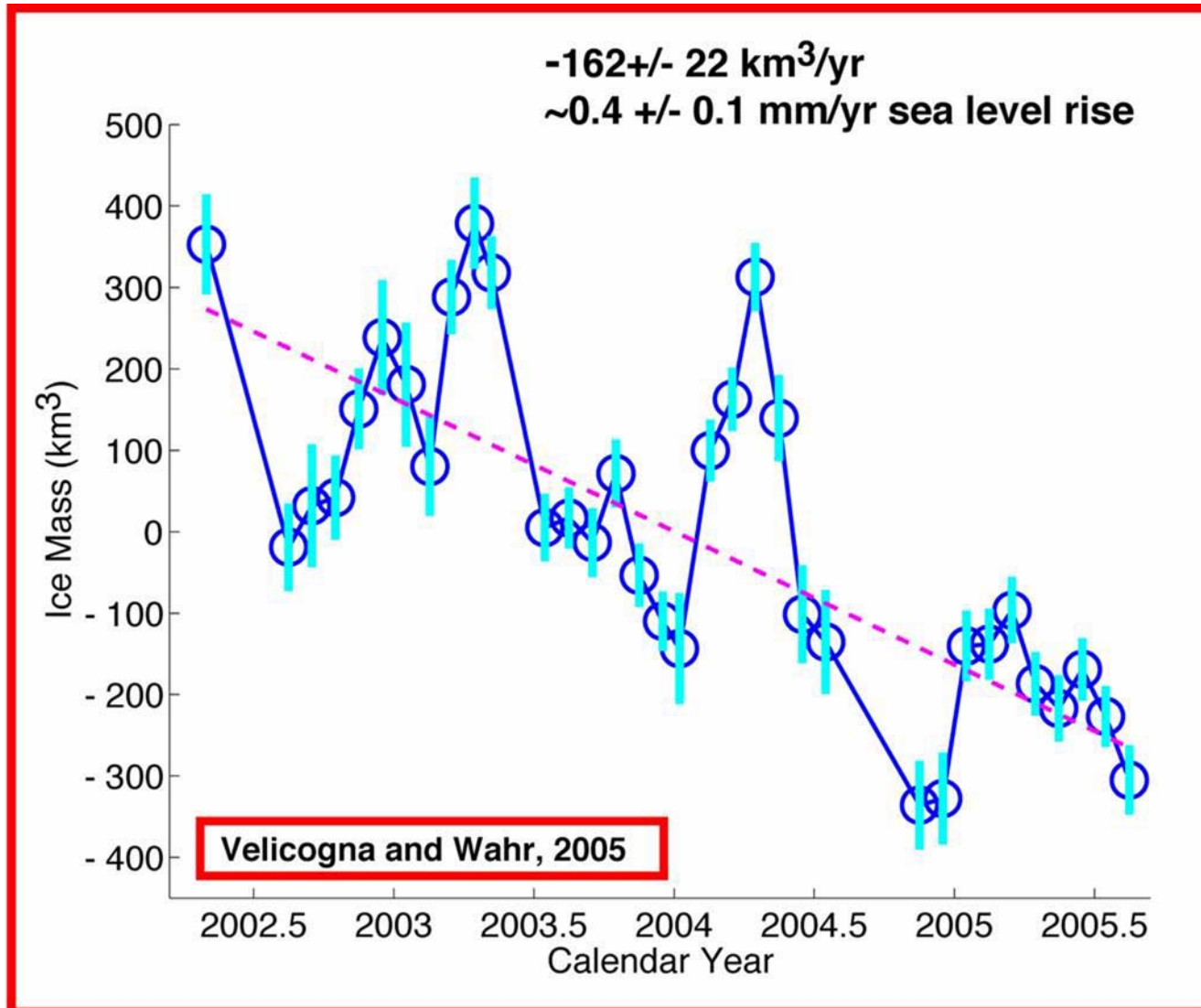
# Jakobshavn Ice Stream in Greenland

Discharge from major Greenland ice streams is accelerating markedly.



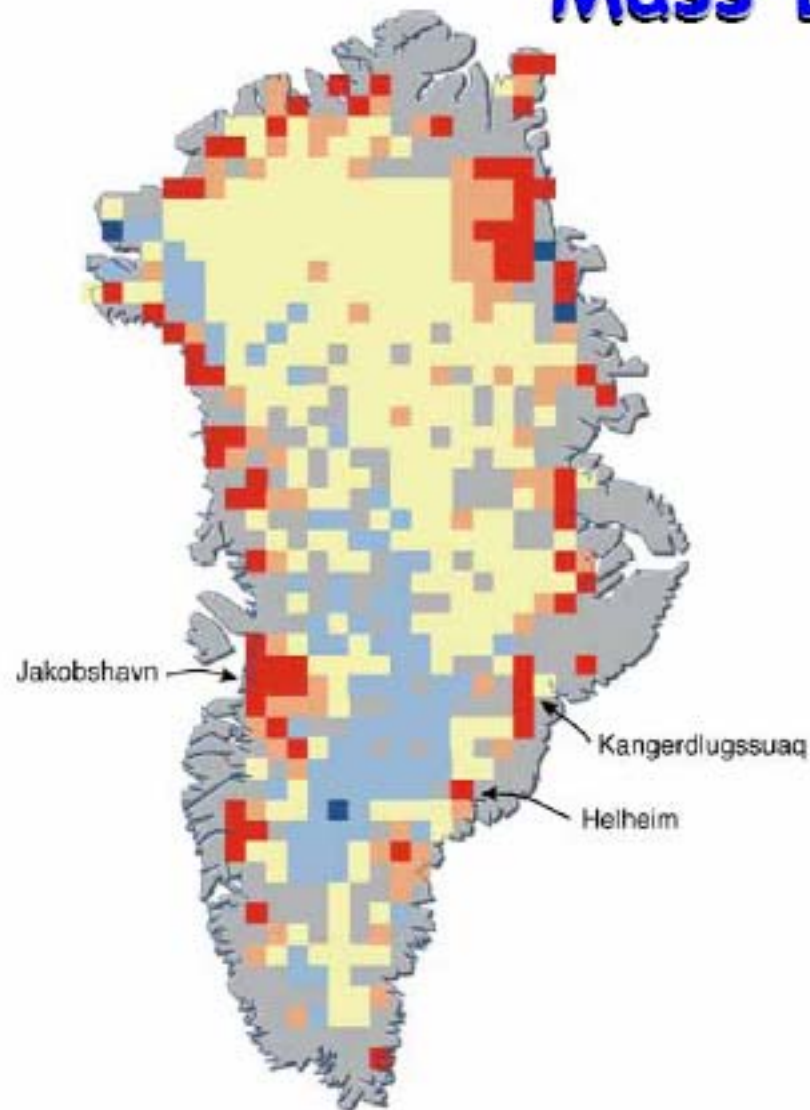
*Source: Prof. Konrad Steffen,  
Univ. of Colorado*

# Greenland Mass Loss – From Gravity Satellite

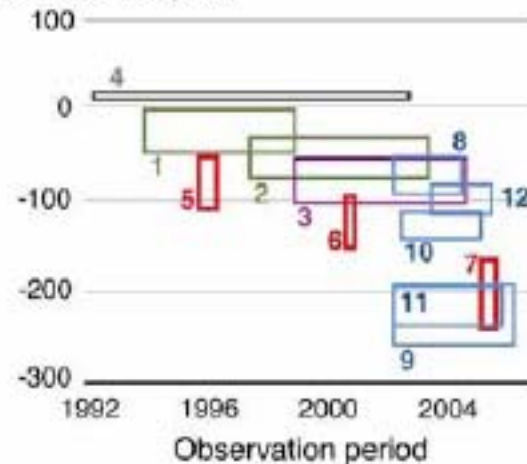




# Mass Balance of Greenland



Rate of mass increase (Gt/year)



**365 Gt/year = 1 mm SLR**

Greenland ice-sheet: rate of change from airborne laser-altimeter surveys (green), airborne/satellite laser-altimeter surveys (purple), mass-budget calculations (red), temporal changes in gravity (blue).

Sources (corresponding to numbers on rectangles): 1 and 2 Krabill and others 200016 and 2004[; 3 Thomas and others 200617; 4 Zwally and others 20055; 5 to 7 Rignot and Kanagaratnam 200618; 8 and 9 Velicogna and Wahr 2005[ and 2006b; 11 Chen and others 2006[; 10 Ramillien and others 200632; 12 Luthke and others 2006[

# Sea Level Criterion\*

## 1. Prior Interglacial Periods

→  $\text{CO}_2 < \sim 300 \text{ ppm}$

## 2. Cenozoic Era

→  $\text{CO}_2 < \sim 300 \text{ ppm}$

## 3. Ice Sheet Observations

→  $\text{CO}_2 < 385 \text{ ppm}$

\* Assuming near-balance among non- $\text{CO}_2$  forcings



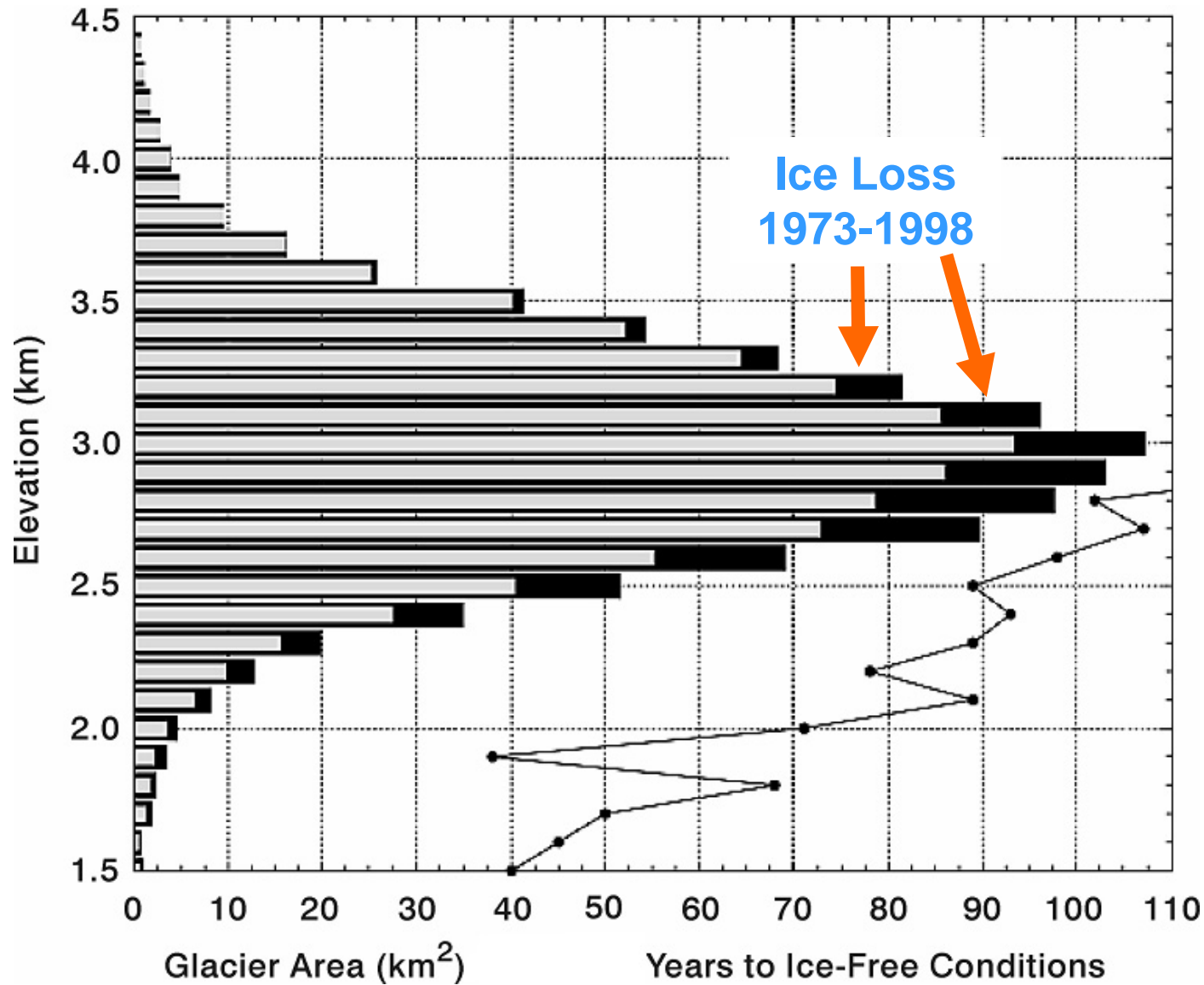
Pier on Lake Mead.



# Rongbuk Glacier



Rongbuk glacier in 1968 (top) and 2007. The largest glacier on Mount Everest's northern slopes feeds Rongbuk River.



Black bar: ice loss in 1973-1998. Curve: years until ice gone, at that loss rate.

Paul, F. et al., Geophys. Res. Lett. 31, L21402, 2004.



# Stresses on Coral Reefs



**Coral Reef off Fiji (Photo: Kevin Roland)**

# Assessment of Target CO<sub>2</sub>

## Phenomenon

## Target CO<sub>2</sub> (ppm)

- |                              |         |
|------------------------------|---------|
| 1. Arctic Sea Ice            | 300-325 |
| 2. Ice Sheets/Sea Level      | 300-350 |
| 3. Shifting Climatic Zones   | 300-350 |
| 4. Alpine Water Supplies     | 300-350 |
| 5. Avoid Ocean Acidification | 300-350 |

→ Initial Target CO<sub>2</sub> = 350\* ppm

\*assumes CH<sub>4</sub>, O<sub>3</sub>, Black Soot decrease

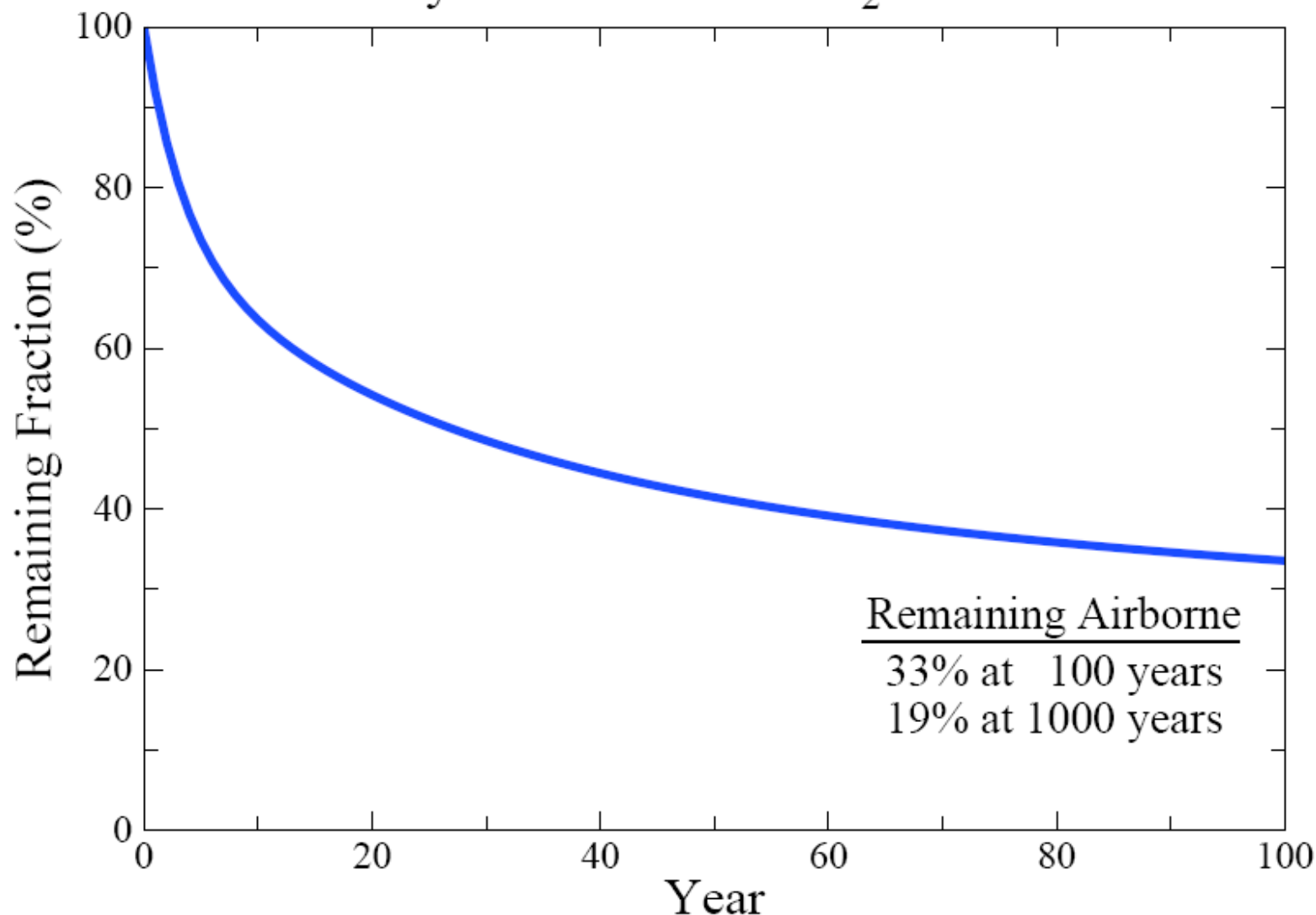
**Target CO<sub>2</sub>:**

**< 350 ppm**

**To preserve creation, the planet  
on which civilization developed**

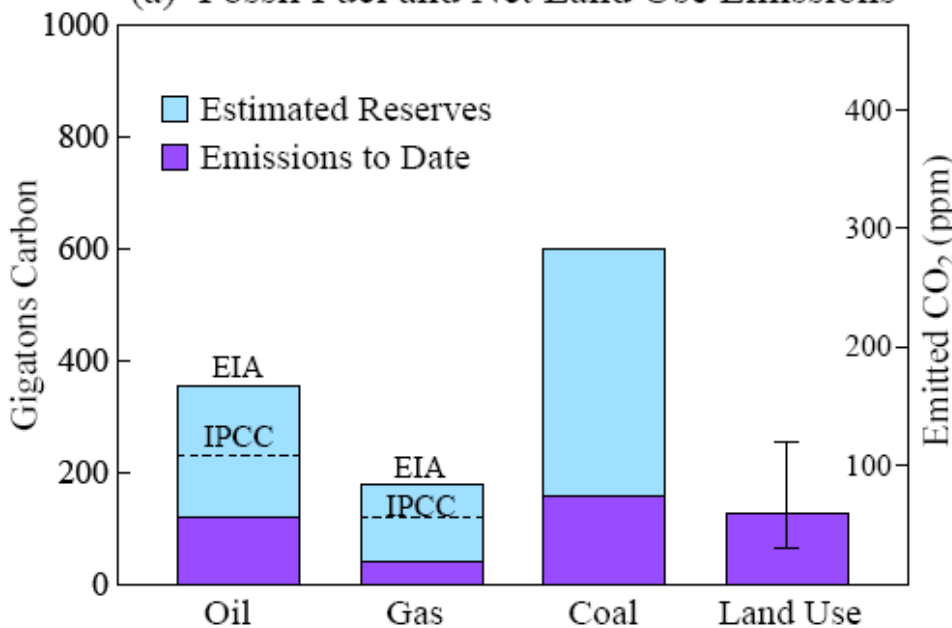


## Decay of Fossil Fuel CO<sub>2</sub> Emission

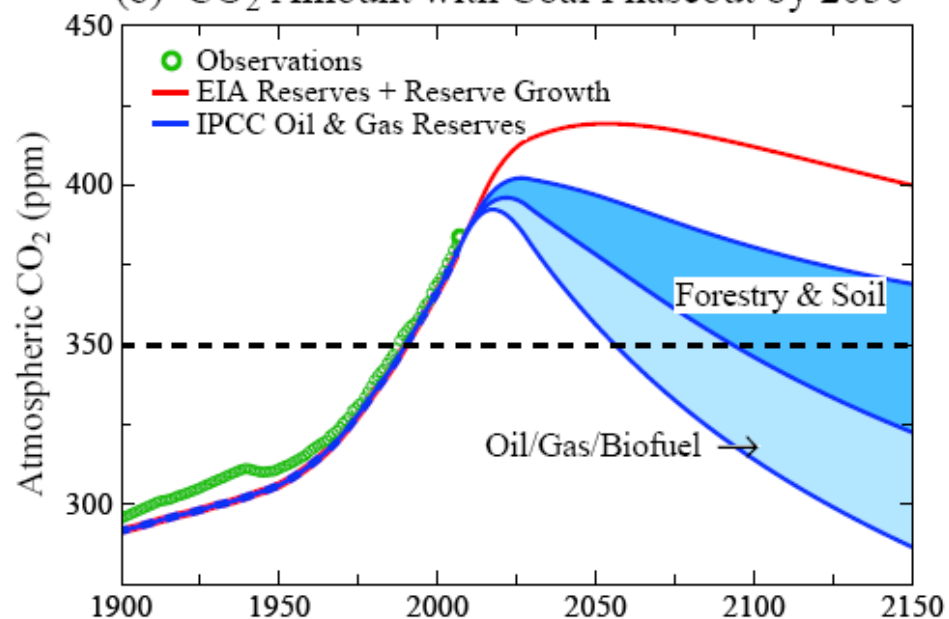


The fraction of CO<sub>2</sub> remaining in the air, after emission by fossil fuel burning, declines rapidly at first, but 1/3 remains in the air after a century and 1/5 after a millennium (*Atmos. Chem. Phys.* **7**, 2287-2312, 2007).

(a) Fossil Fuel and Net Land Use Emissions



(b) CO<sub>2</sub> Amount with Coal Phaseout by 2030



# **Initial Target CO<sub>2</sub>: 350 ppm**

## **Technically Feasible**

**(but not if business-as-usual continues)**

## **Quick Coal Phase-Out Critical**

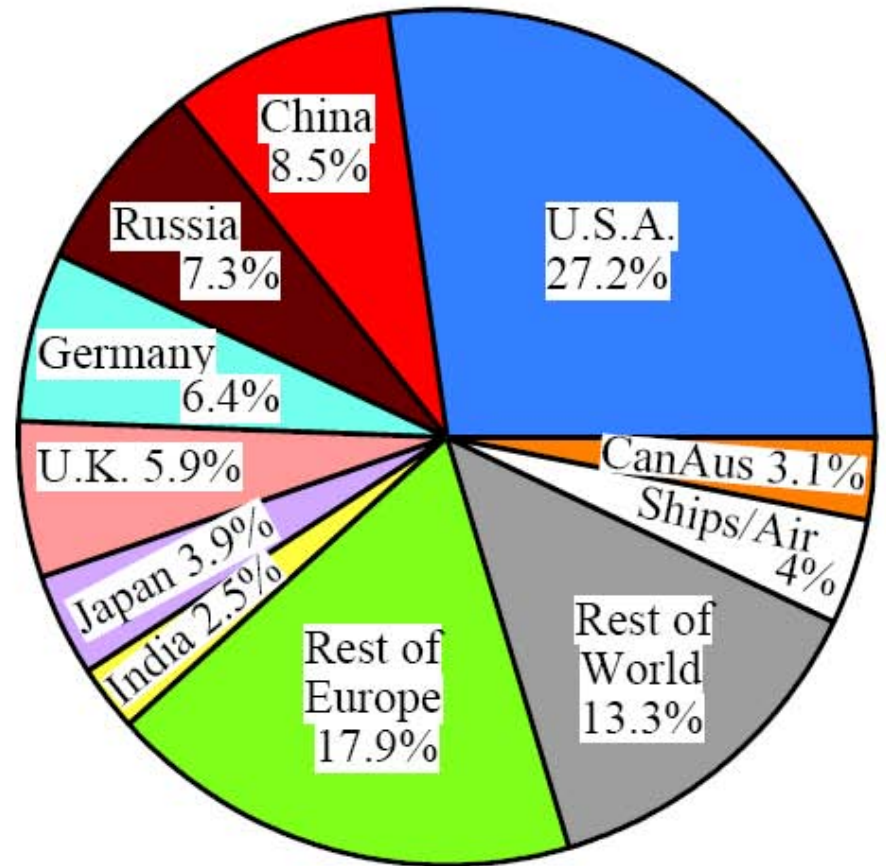
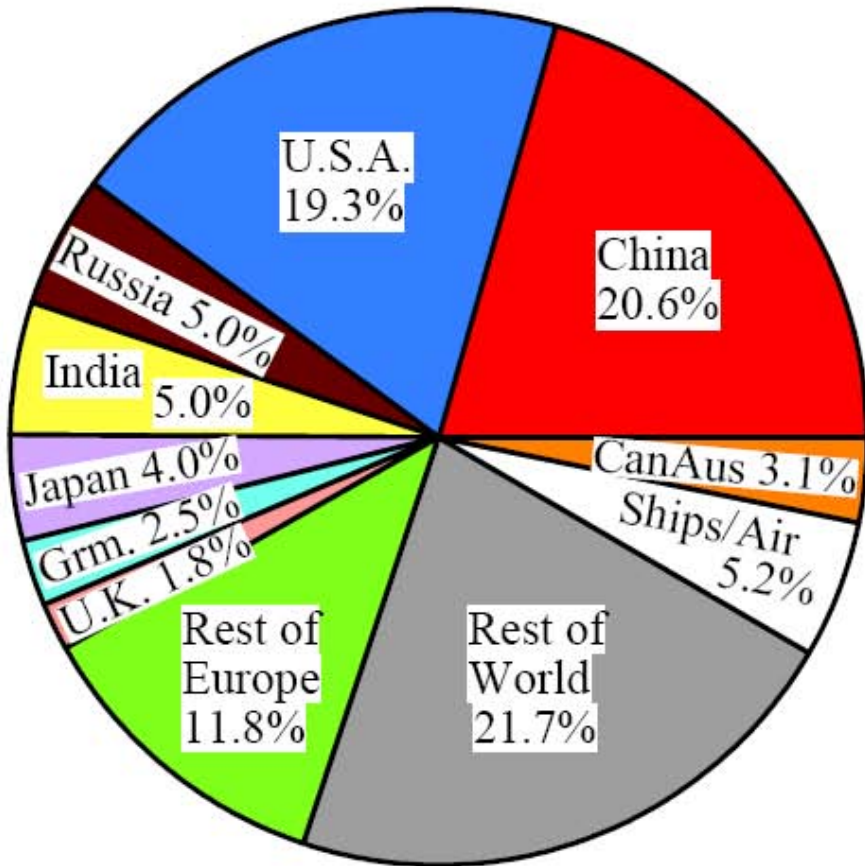
**(long lifetime of atmospheric CO<sub>2</sub>)**

**(must halt construction of any new coal plants that do not capture & store CO<sub>2</sub>)**

# Fossil Fuel CO<sub>2</sub> Emissions

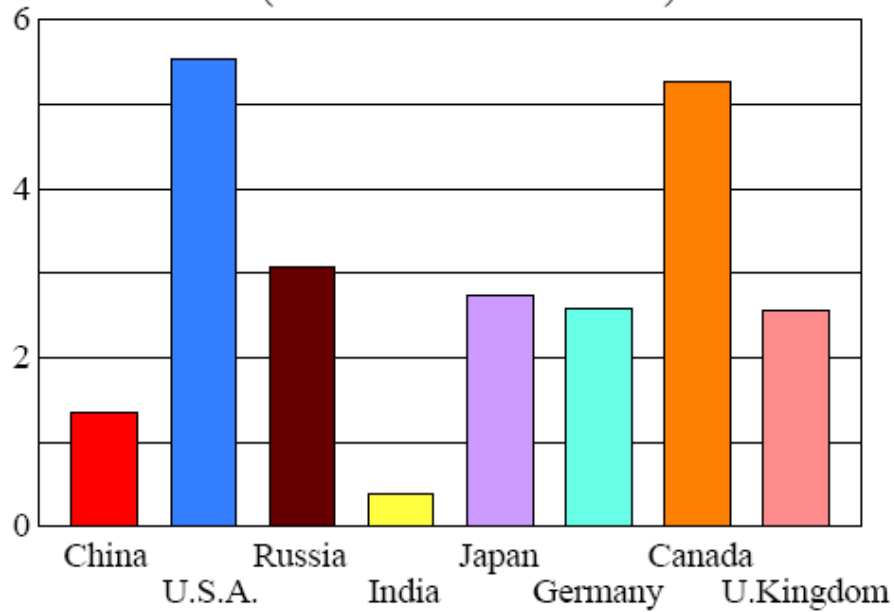
(a) 2007 Annual Emissions

(b) 1751-2007 Cumulative Emissions

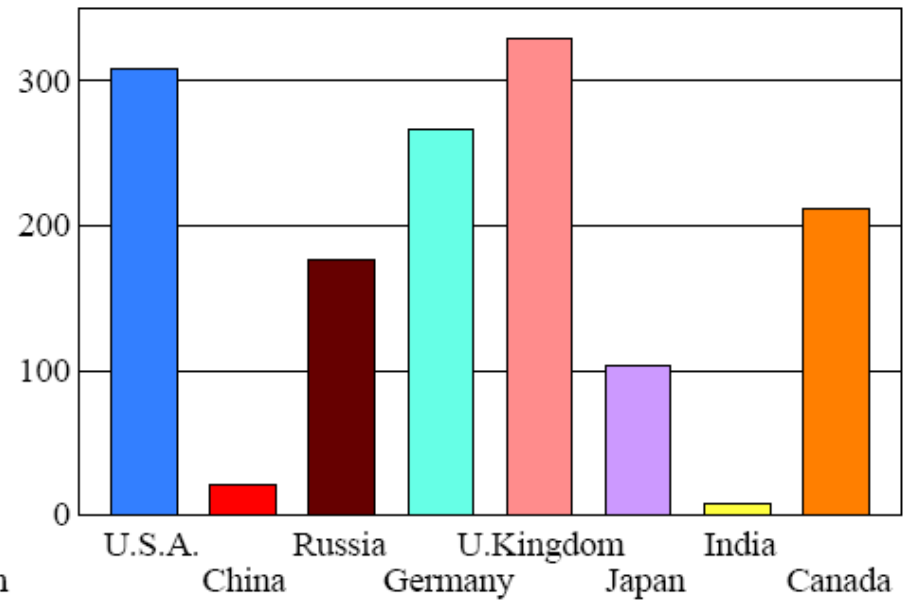


### Per Capita Fossil Fuel CO<sub>2</sub> Emissions

(a) 2007 Annual Emissions  
(Tons Carbon/Year/Person)



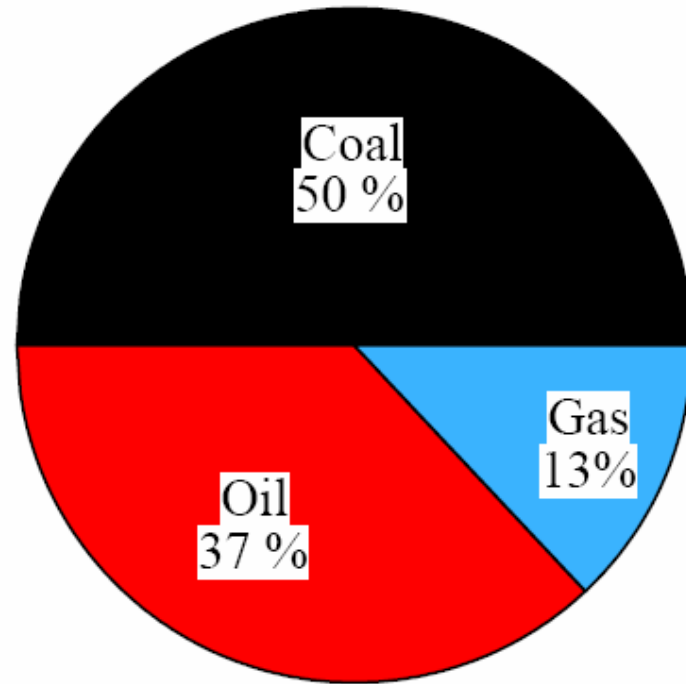
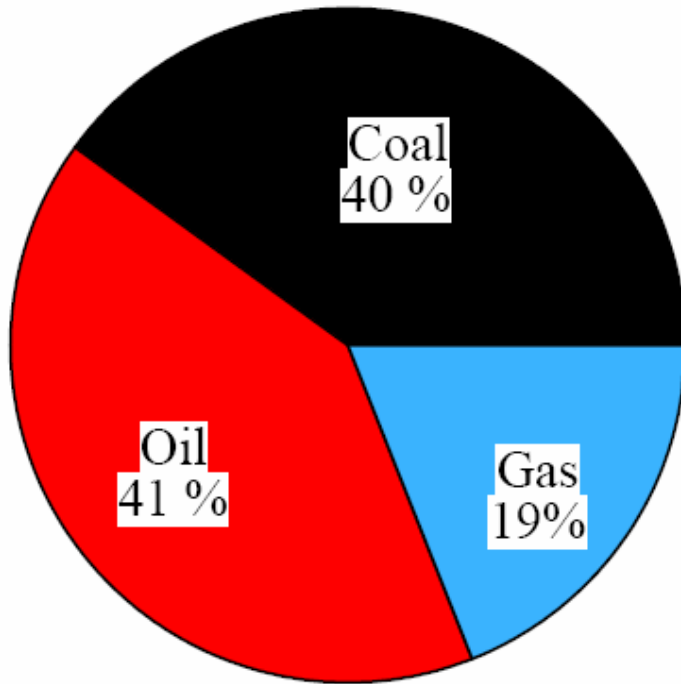
(b) 1751-2007 Cumulative Emissions  
(Tons Carbon/Person)



# Source of Fossil Fuel CO<sub>2</sub>

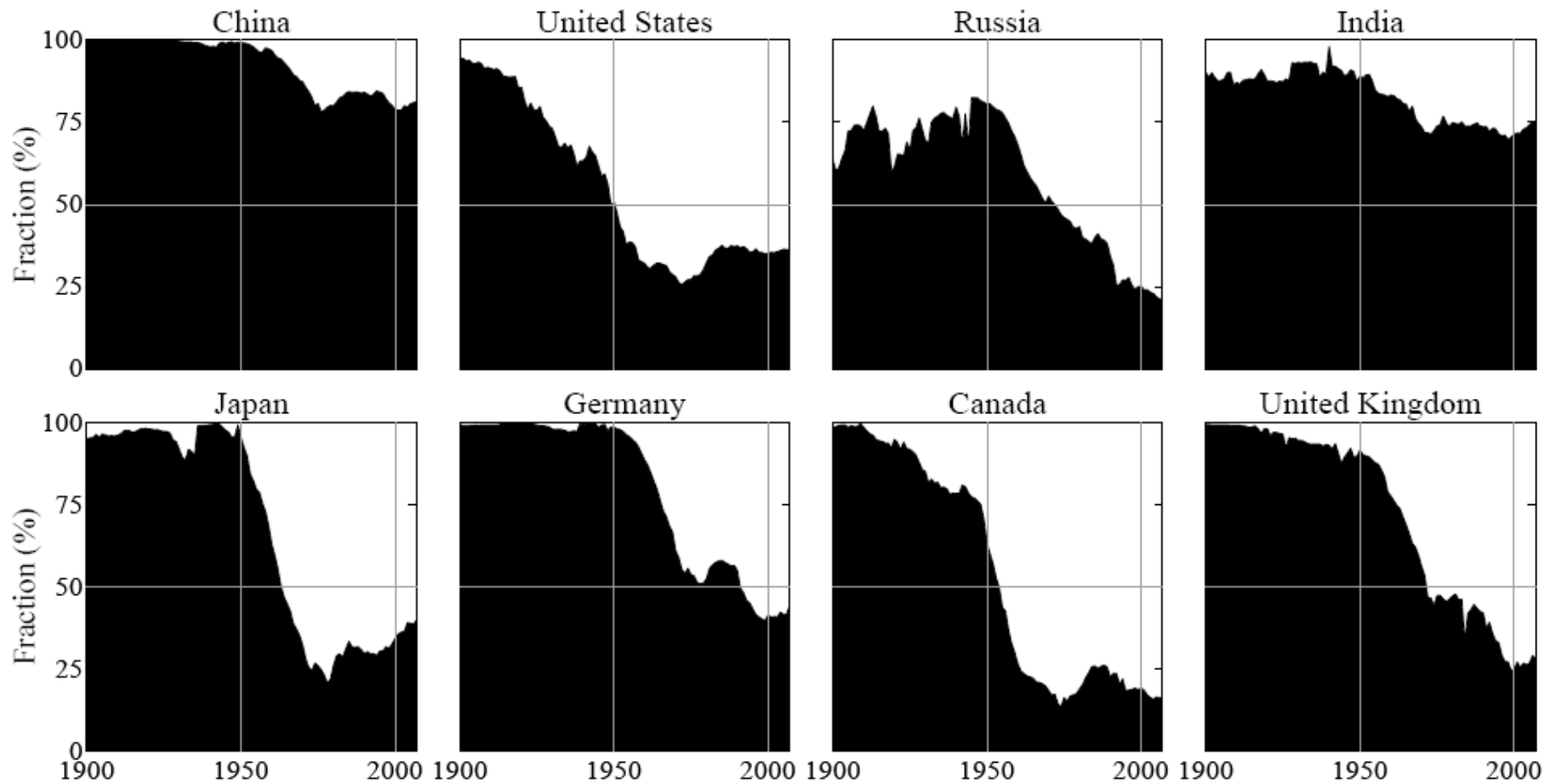
(a) Today's Emissions

(b) In the Air Today



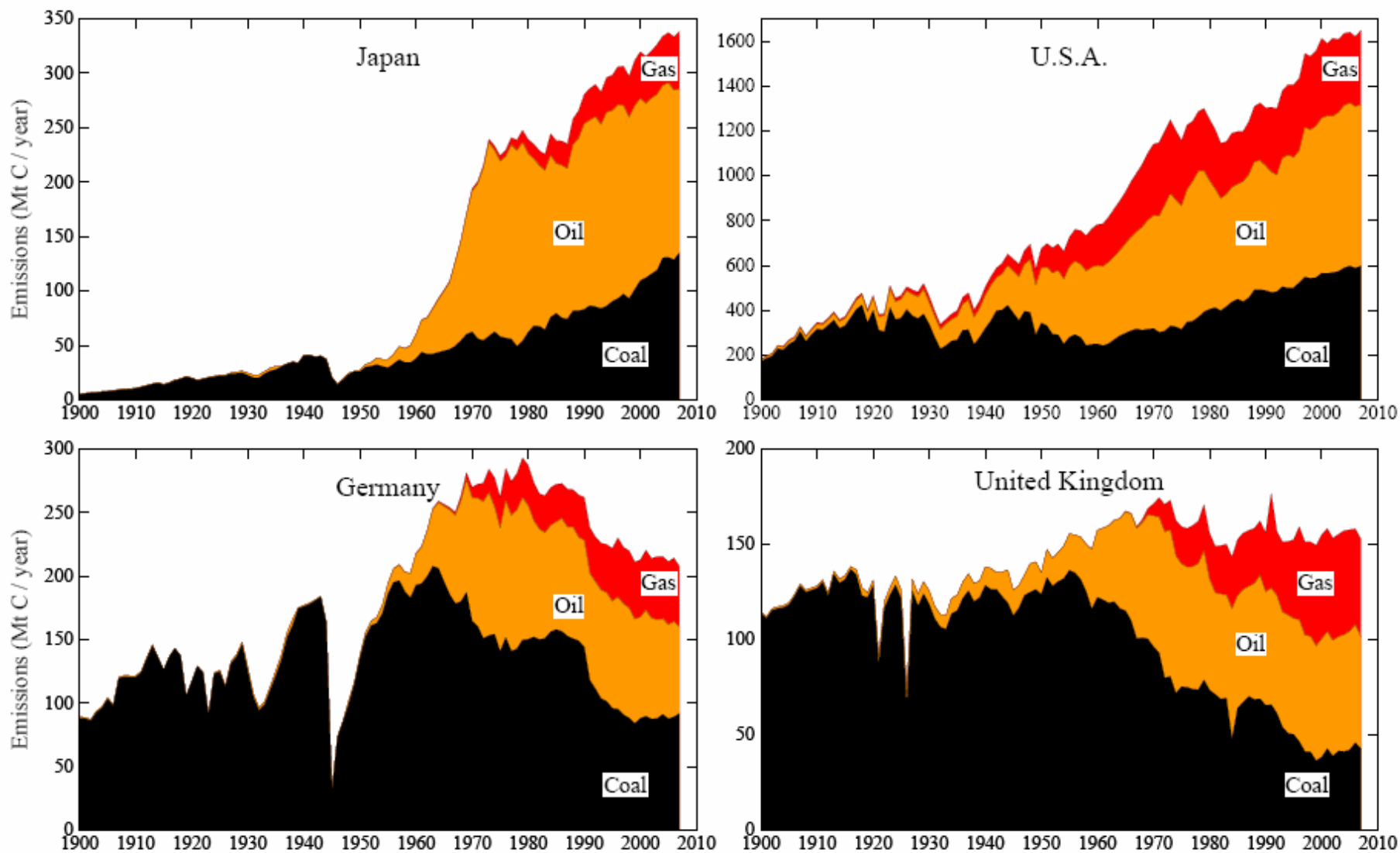
**(a) Fraction of each fossil fuel in 2007 CO<sub>2</sub> emissions**  
**(b) Fraction of each in today's airborne CO<sub>2</sub> amount**

## Coal Fraction of Fossil Fuel CO<sub>2</sub> Emissions



$$\text{Fraction} = \text{Coal} / (\text{Coal} + \text{Oil} + \text{Natural Gas})$$

## CO<sub>2</sub> Emissions by Fossil Fuel Type





# “Free Will” Alternative

## 1. Phase Out Coal CO<sub>2</sub> Emissions

- by 2025/2030 developed/developing countries

## 2. Rising Carbon Price

- discourages unconventional fossil fuels & extraction of every last drop of oil (Arctic, etc.)

## 3. Soil & Biosphere CO<sub>2</sub> Sequestration

- improved farming & forestry practices

## 4. Reduce non-CO<sub>2</sub> Forcings

- reduce CH<sub>4</sub>, O<sub>3</sub>, trace gases, black soot

# Carbon Tax & 100% Dividend

- 1. Tax Large & Growing (but get it in place!)**
  - tap efficiency potential & life style choices
- 2. Entire Tax Returned**
  - equal monthly deposits in bank accounts
- 3. Limited Government Role**
  - keep hands off money!
  - eliminate fossil subsidies
  - let marketplace choose winners
  - change profit motivation of utilities
  - watch U.S. modernize & emissions fall!

# **Key Elements in Transformation**

## **Low-Loss Electric Grid**

**Clean Energy by 2020 (West) & 2030**

**Allows Renewable Energy Ascendancy**

## **Carbon Tax and 100% Dividend**

**Tax at First Sale of Coal/Oil/Gas**

**Tax Can Rise & Spur Transformations**

**“100% or Fight! No Alligator-Shoes!”**

# Basic Conflict

**Fossil Fuel Special Interests**

**VS**

**Young People & Nature (Animals)**

**Fossil Interests:** God-given fact that all fossil fuels will be burned **(no free will)**

**Young People:** Hey! Not so fast!  
Nice planet you are leaving us!

# What are the Odds?

**Fossil Interests:** have influence in capitals world-wide

**Young People:** need to organize, enlist others (parents, e.g.), impact elections

**Animals:** not much help (don't vote, don't talk)

# The Challenge

**We can avoid destroying creation!  
(+cleaner planet, + good jobs!)**

**We have to figure out how to live  
without fossil fuels someday...**

**Why not now?**

# What's the Problem?\*

- 1. No Strategic Approach**  
**%CO<sub>2</sub> Reduction Approach Doomed**
- 2. No Leadership for Planet & Life**  
**Businesses Rule in Capitals**
- 3. Greenwash Replaces Strategy**

\*Just my opinions, of course

# Web Site

[www.columbia.edu/~jeh1](http://www.columbia.edu/~jeh1)

includes

**Letter to Prime Minister Fukuda**

**Global Warming Twenty Years Later:  
Tipping Points Near (today's statement)**

**Target Atmospheric CO<sub>2</sub>: Where Should  
Humanity Aim?**