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

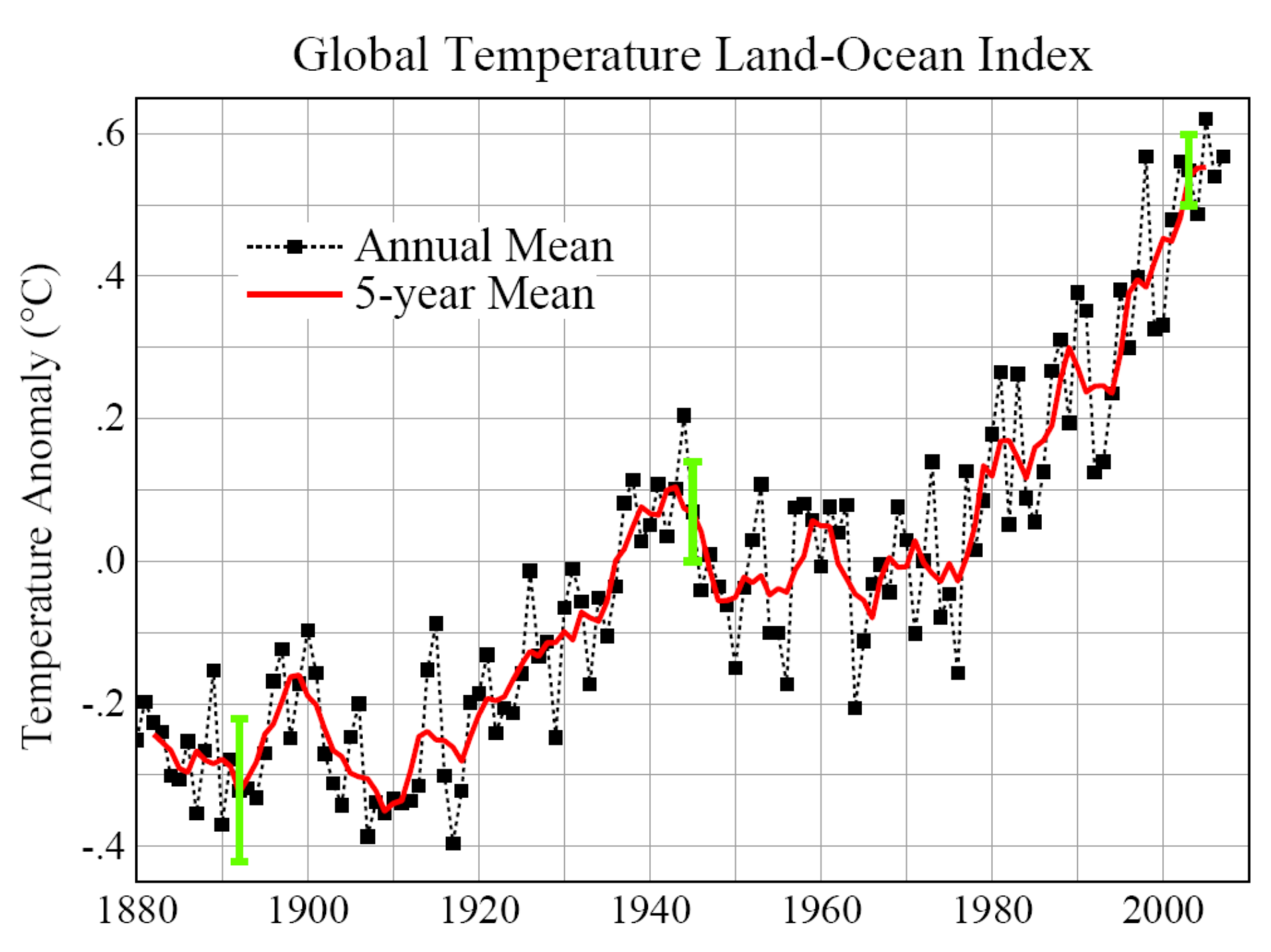
- Safe Level of CO_2 < 350 ppm
- Multiple Benefits of Solution

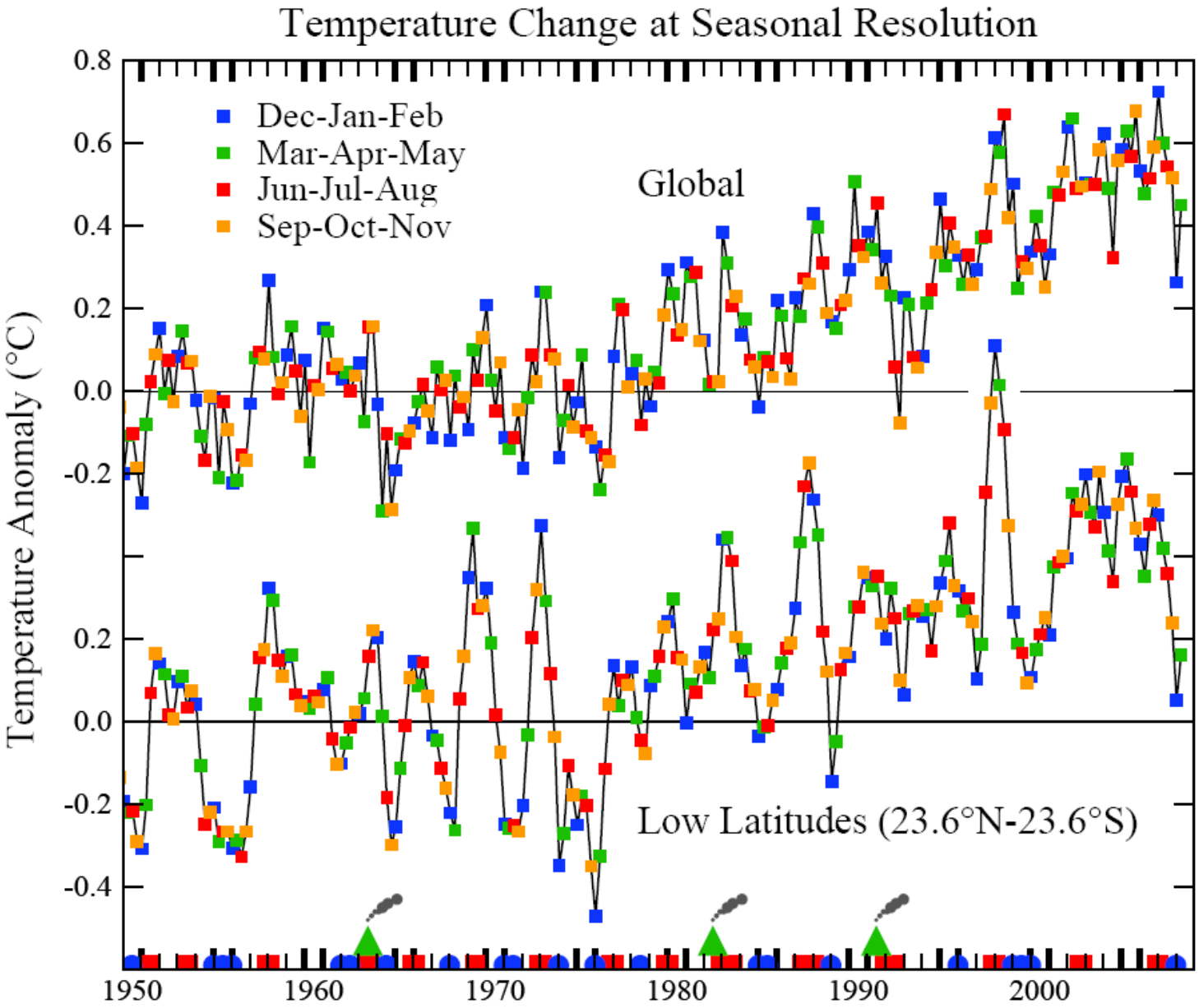
Basis of Understanding

1. Earth's Paleoclimate History

2. On-Going Climate Changes

3. Climate Models


Global Temperature Land-Ocean Index
Annual Mean
5-year Mean
Temperature Anomaly (°C)
.6
.4
.2
.0
-.2
-.4
1880
1900
1920
1940
1960
1980
2000



Green Triangle = Volcano; Red Box = El Nino; Blue Semicircle= La Nina

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

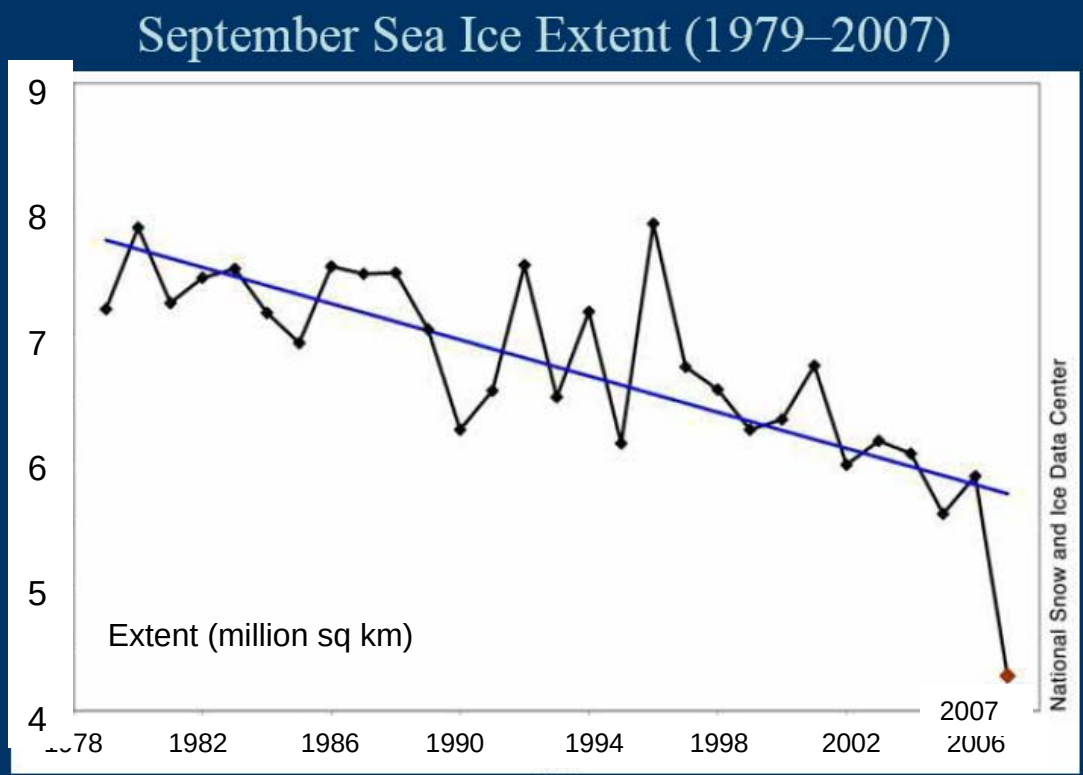
1. Tipping Level

- 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

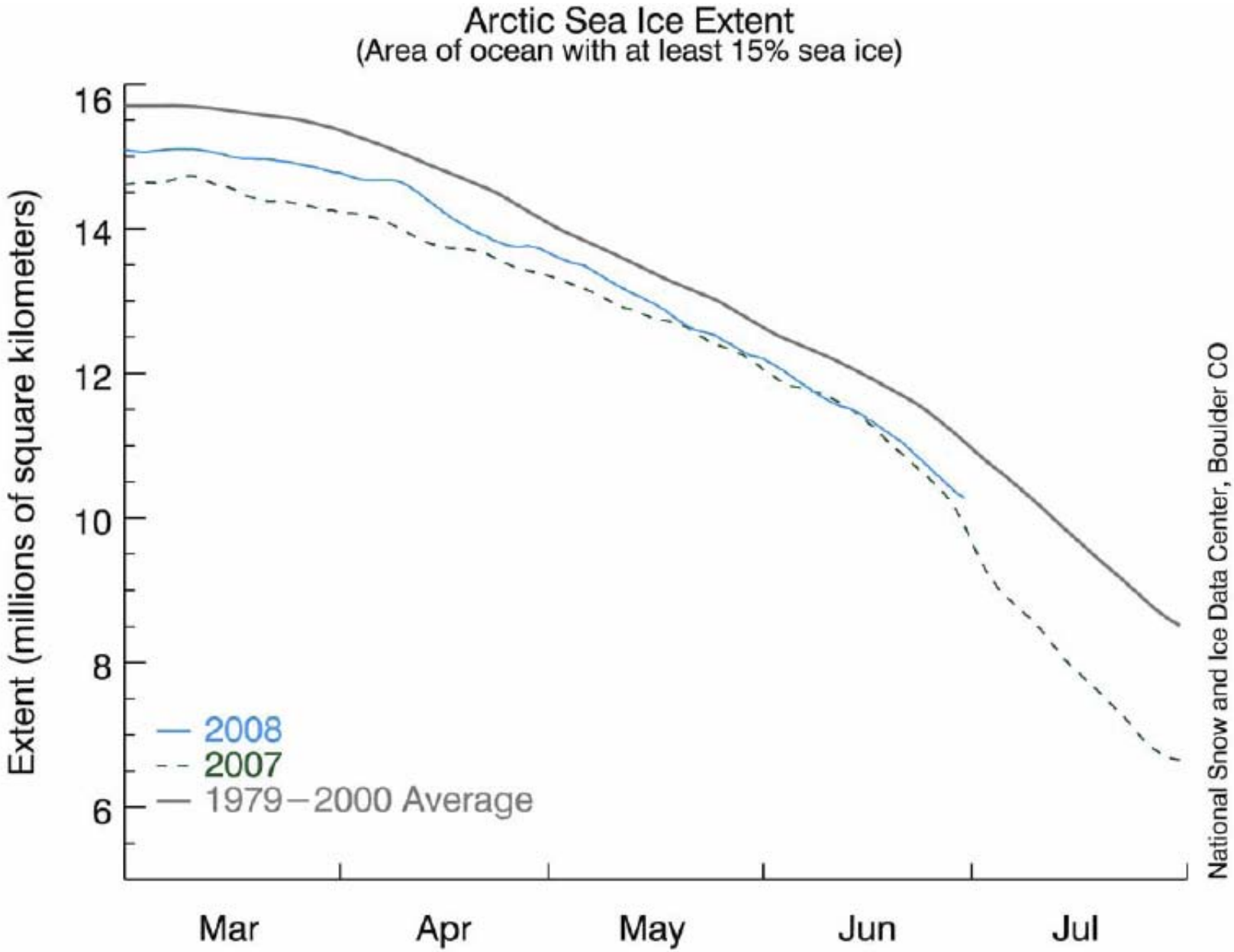
2007 Sea ice conditions in context

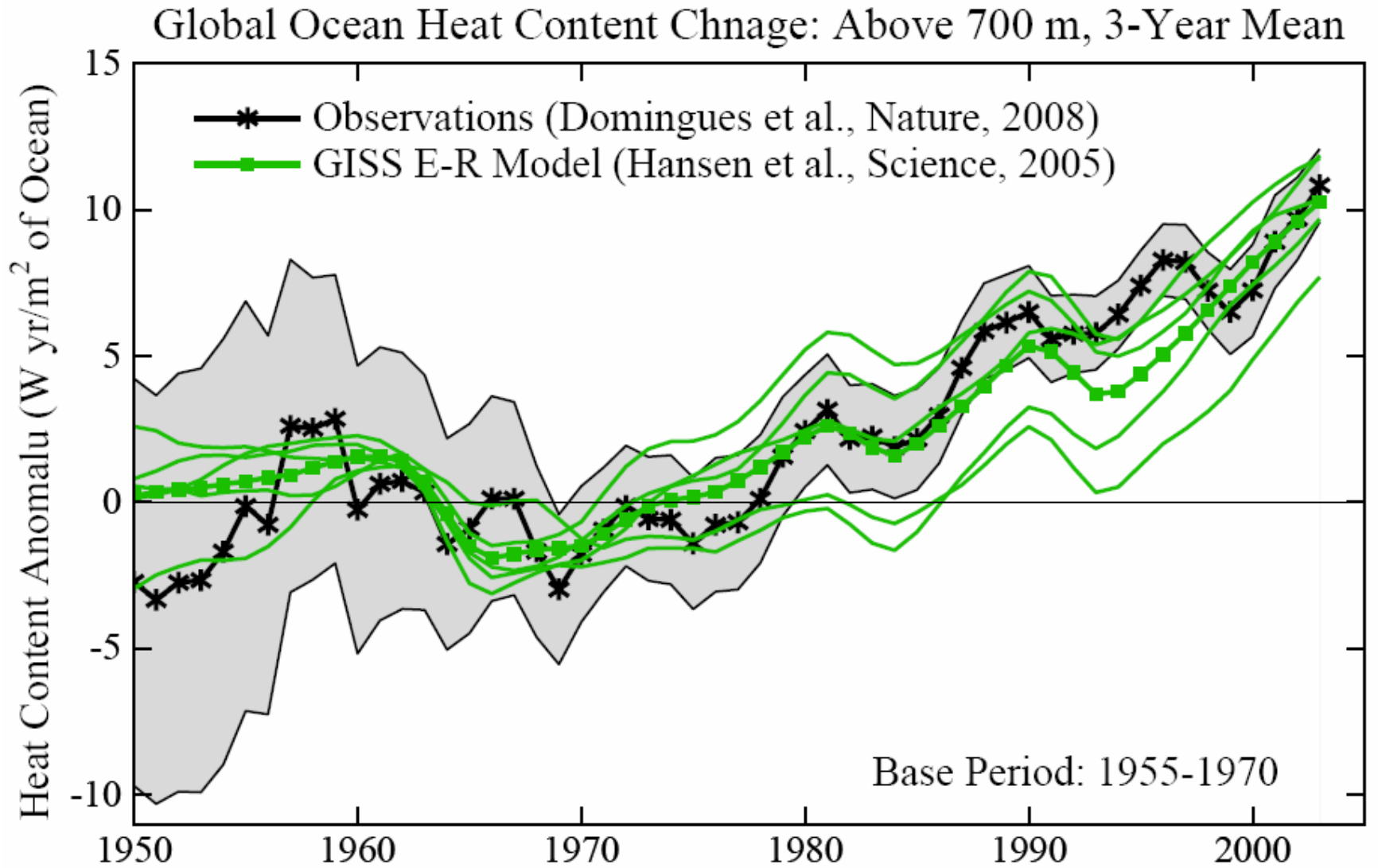


September 2007
4.28 million km^2

Mark Serreze, Julienne Stroeve, Walt Meier, Ted Scambos, Marika Holland, Jim Maslanik, Stephanie Renfrow, Matt Savoie

NSIDC


Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)
Extent (millions of square kilometers)
16
14
12
10
8
6
2008
2007
1979–2000 Average
Mar
Apr
May
Jun
Jul
National Snow and Ice Data Center, Boulder CO



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_2: 385 ppm → 325-355 ppm

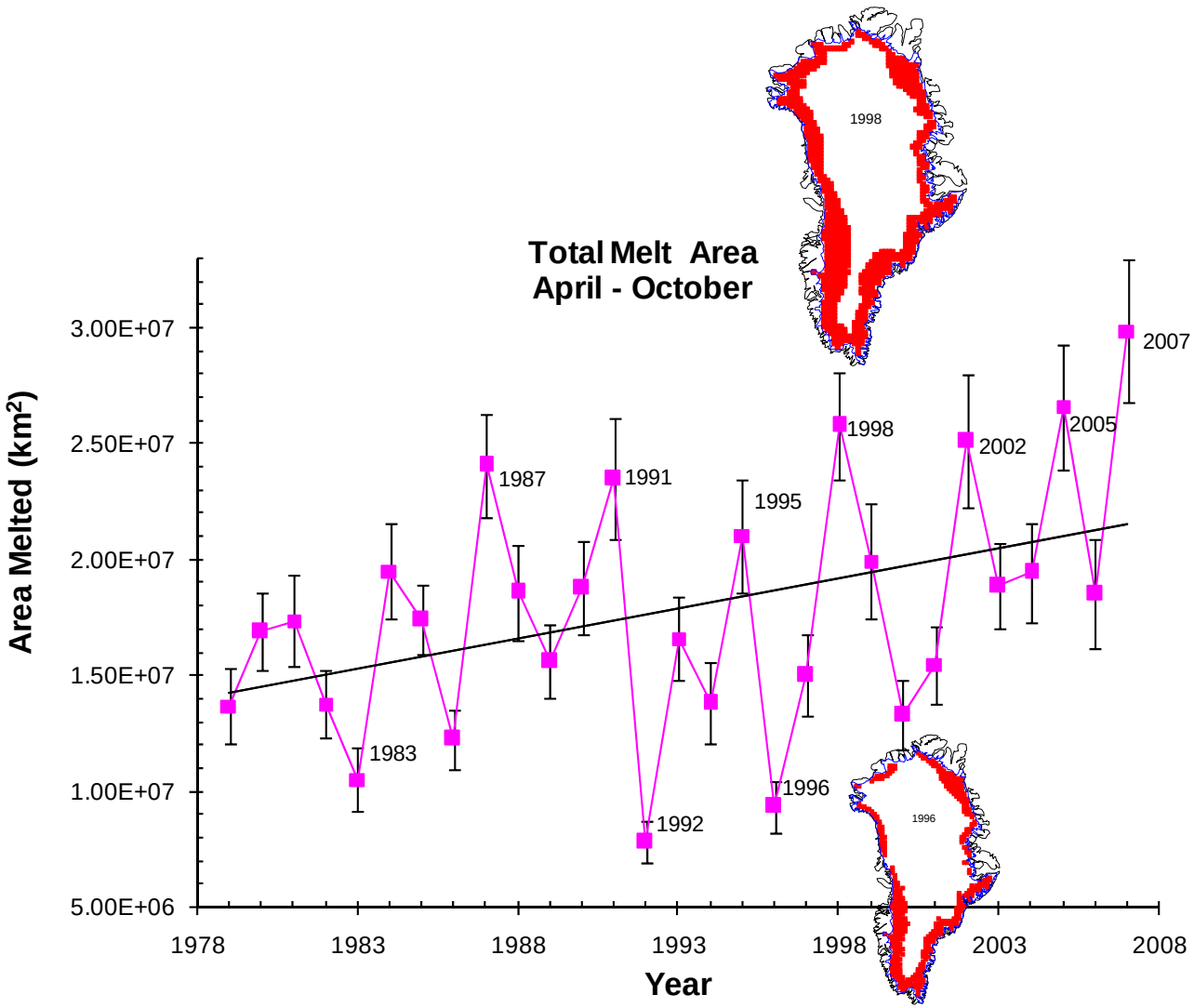
2. Restore Sea Ice: Aim for -0.5 W/m^2

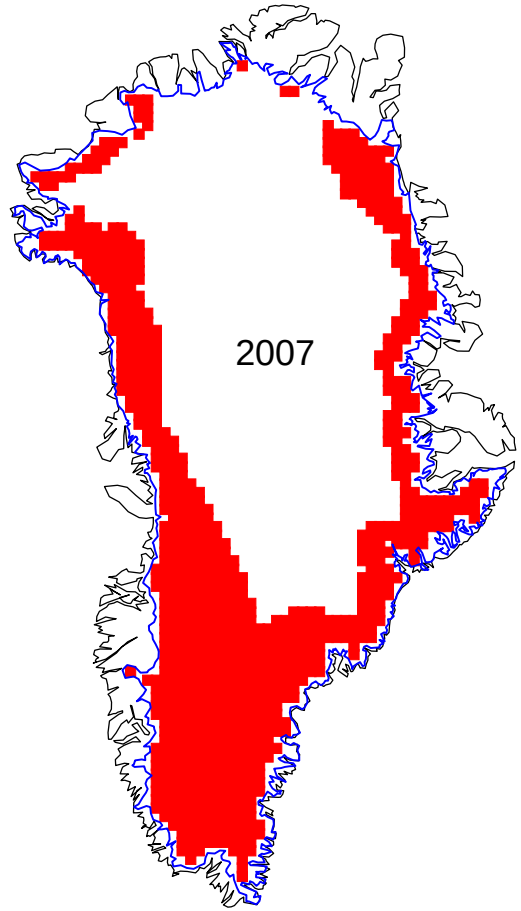
CO_2: 385 ppm → 300-325 ppm

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

***Assuming near-balance among non-CO_2 forcings**

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





Konrad Steffen and Russell Huff, CIRES, University of Colorado at Boulder

Surface Melt on Greenland

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

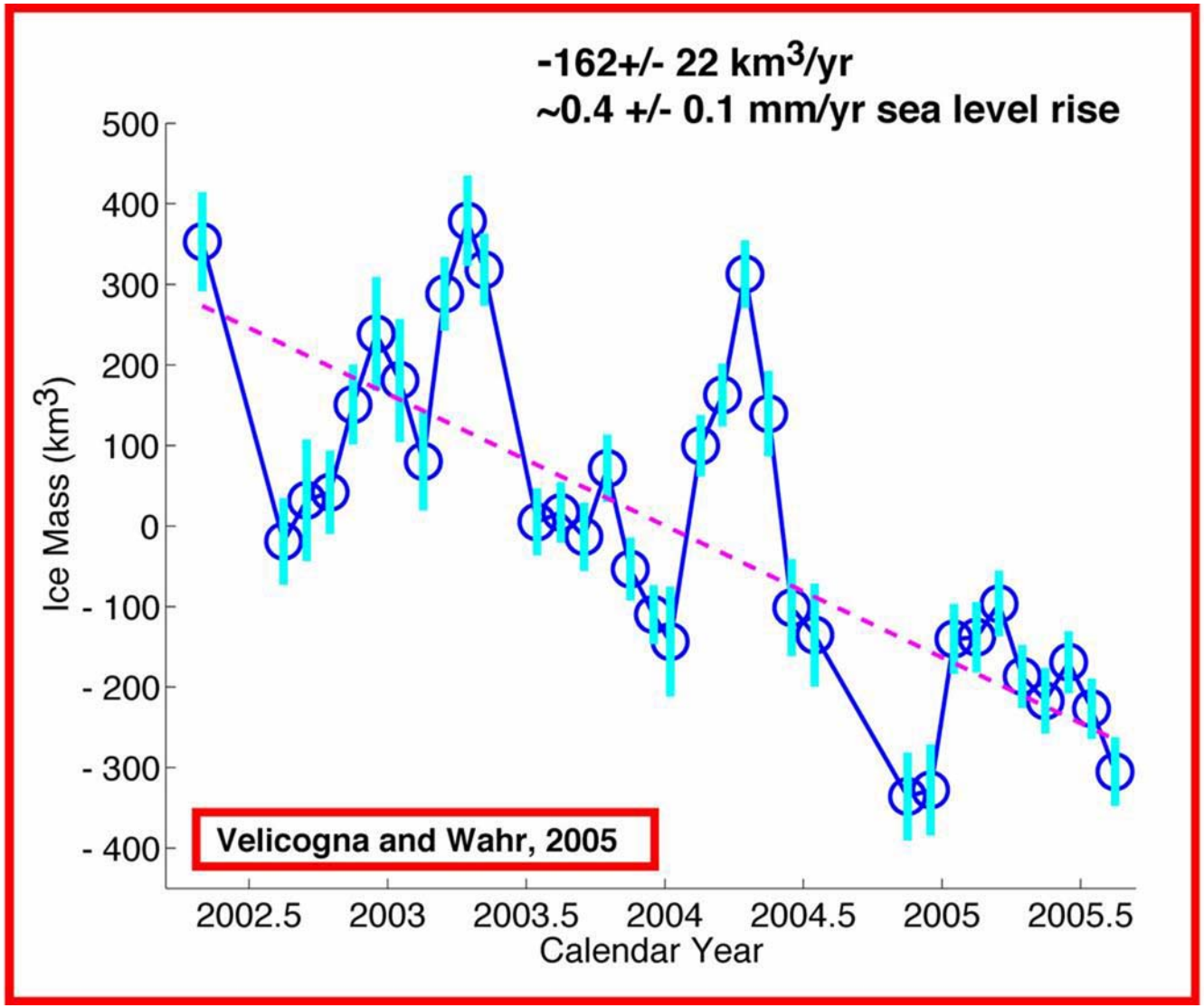
Source: Roger Braithwaite, University of Manchester (UK)

Jakobshavn Ice Stream in Greenland

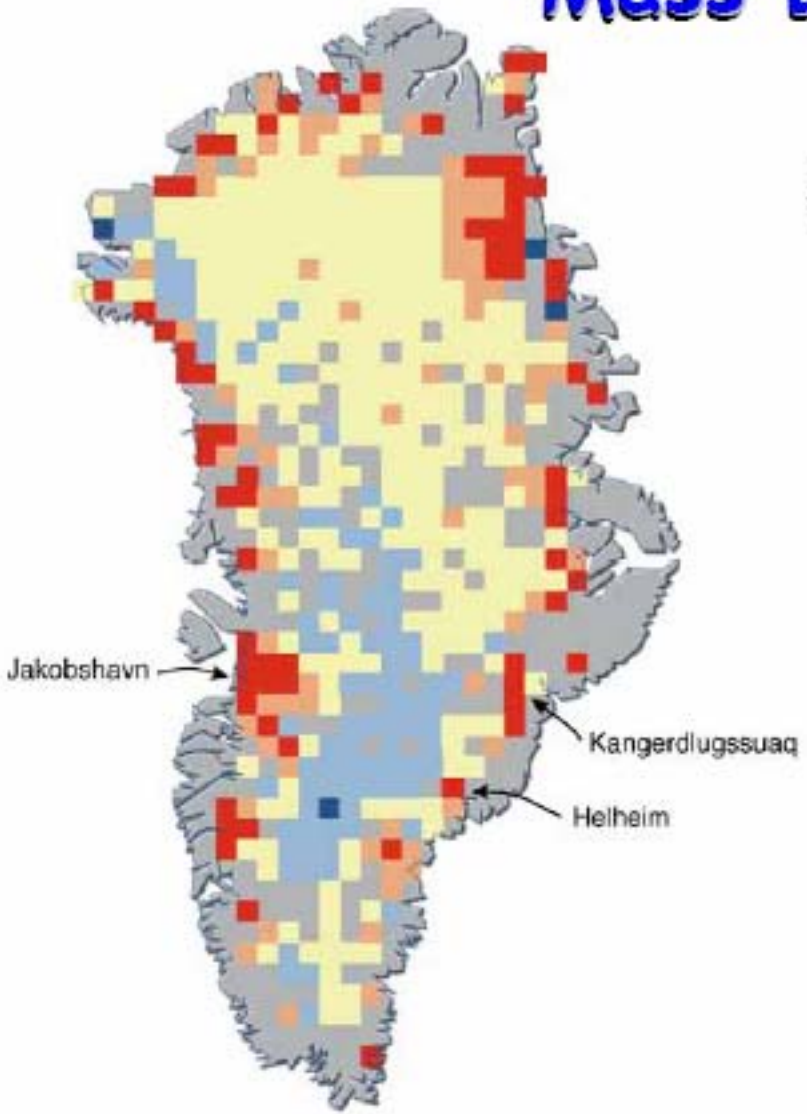
Discharge from major Greenland ice streams is accelerating markedly.

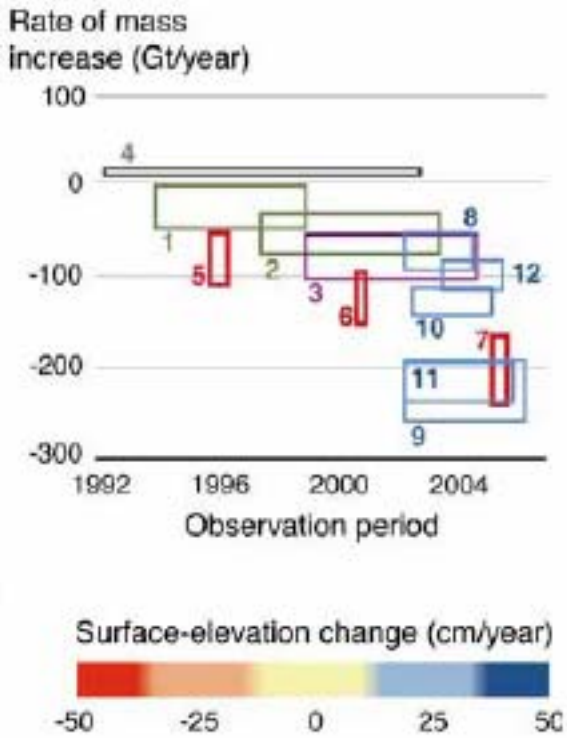
Source: Prof. Konrad Steffen, Univ. of Colorado

Greenland Mass Loss – From Gravity Satellite



Mass Balance of Greenland





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[

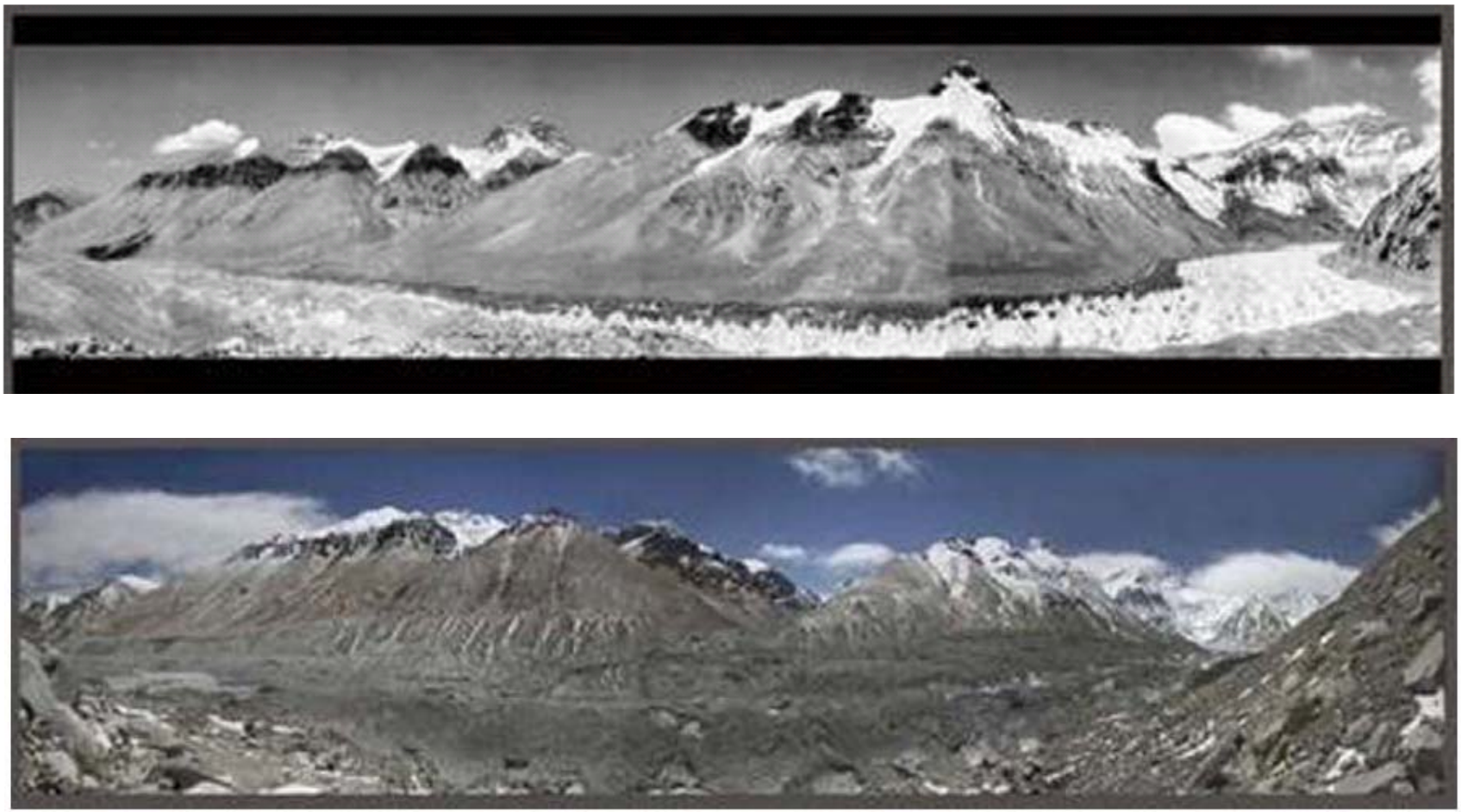
Sea Level Criterion*

1. **Prior Interglacial Periods**
   → CO_2 <~ 300 ppm
2. **Cenozoic Era**
   → CO_2 <~ 300 ppm
3. **Ice Sheet Observations**
   → CO_2 < 385 ppm

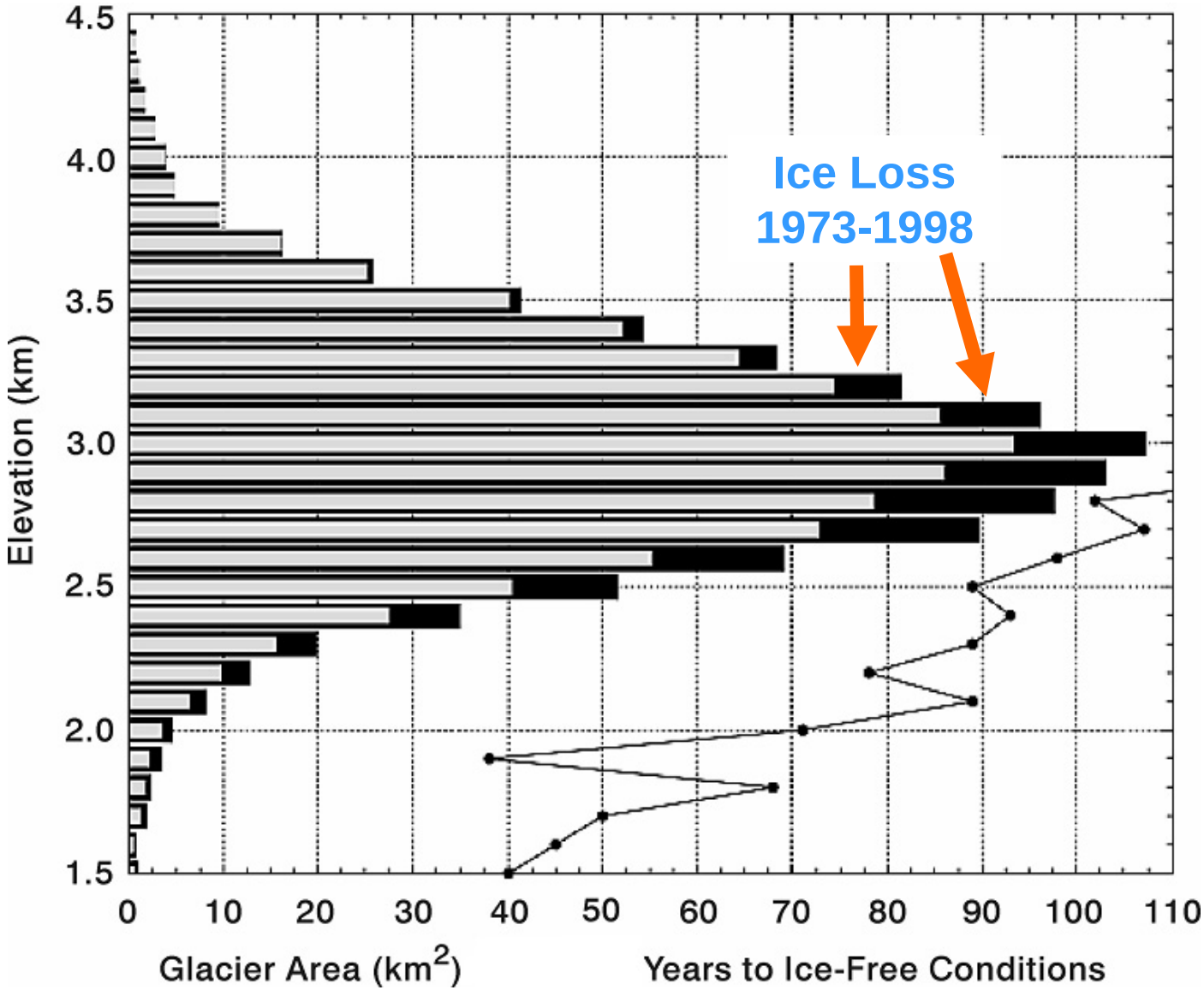
*Assuming near-balance among non-CO_2 forcings

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_2

Phenomenon	Target CO_2 (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

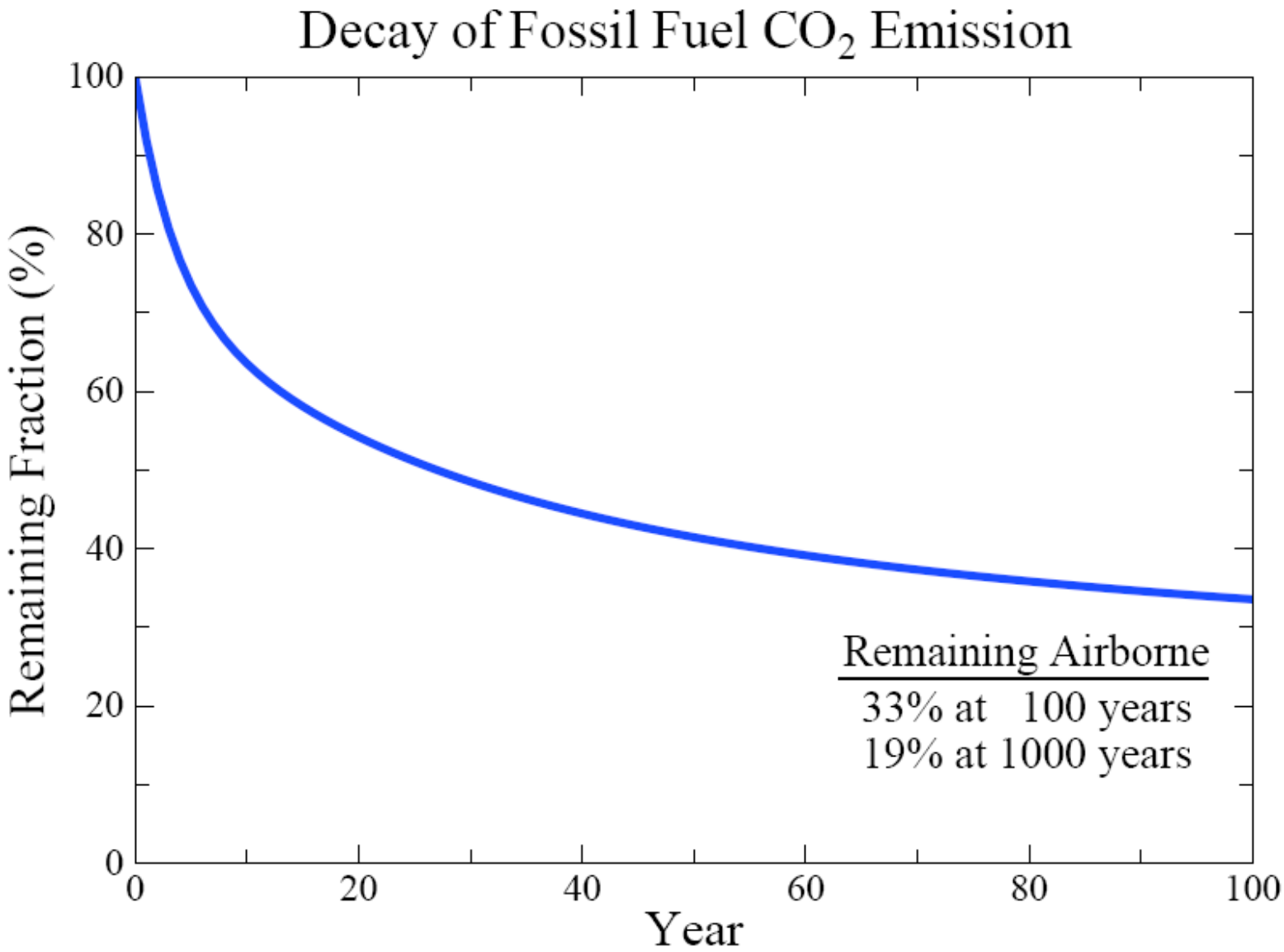
→ **Initial Target CO_2 = 350* ppm**

***assumes CH_4, O_3, Black Soot decrease**

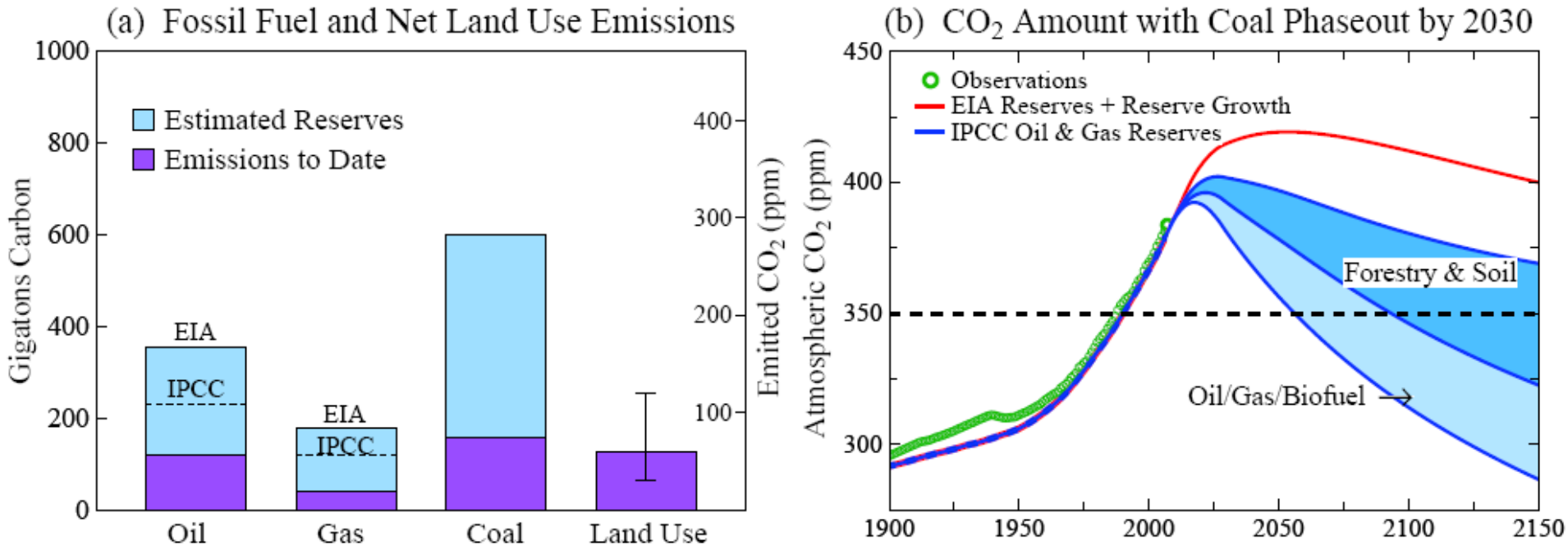
Target CO_2:

< 350 ppm

To preserve creation, the planet on which civilization developed



The fraction of CO_2 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
Gigatons Carbon
Emitted CO_2 (ppm)
Estimated Reserves
Emissions to Date
EIA
IPCC
EIA
IPCC
Oil
Gas
Coal
Land Use
(b) CO_2 Amount with Coal Phaseout by 2030
Atmospheric CO_2 (ppm)
Observations
EIA Reserves + Reserve Growth
IPCC Oil & Gas Reserves
Forestry & Soil
Oil/Gas/Biofuel

Initial Target CO_2: 350 ppm

Technically Feasible

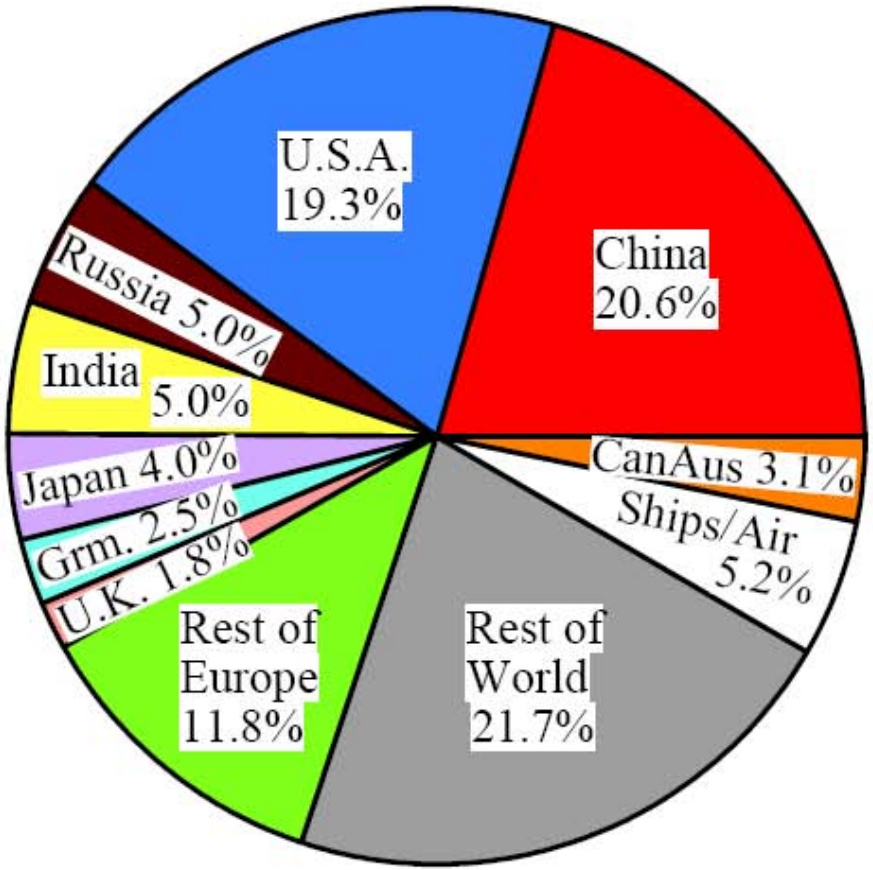
(but not if business-as-usual continues)

Quick Coal Phase-Out Critical

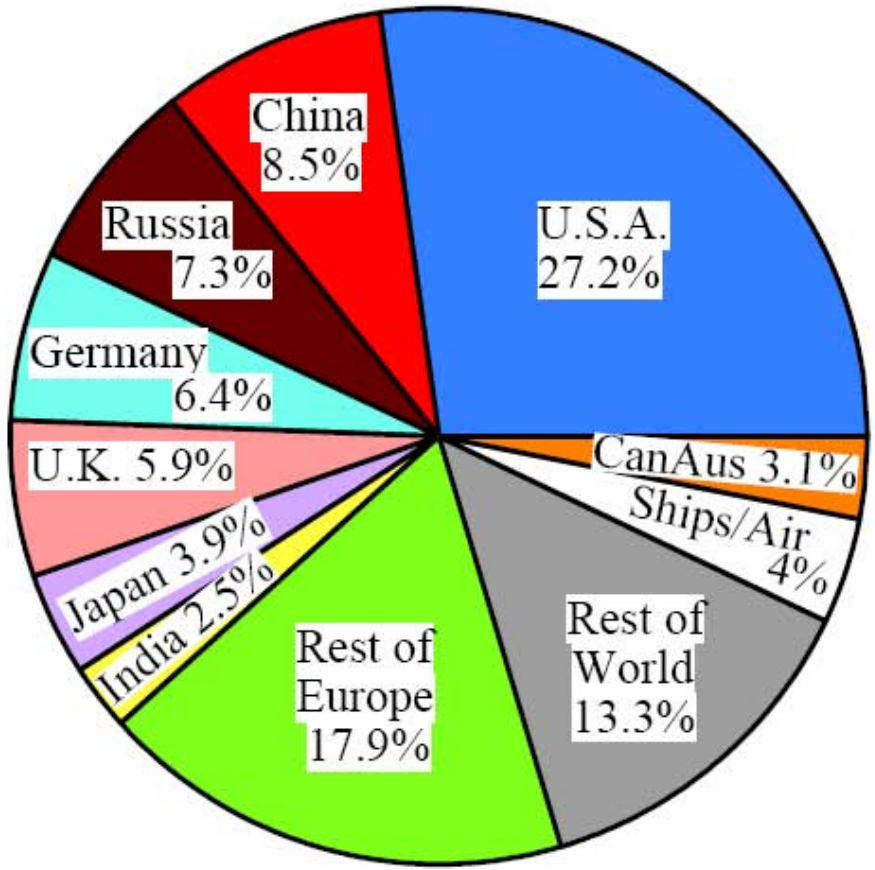
(long lifetime of atmospheric CO_2)
(must halt construction of any new coal plants that do not capture & store CO_2)

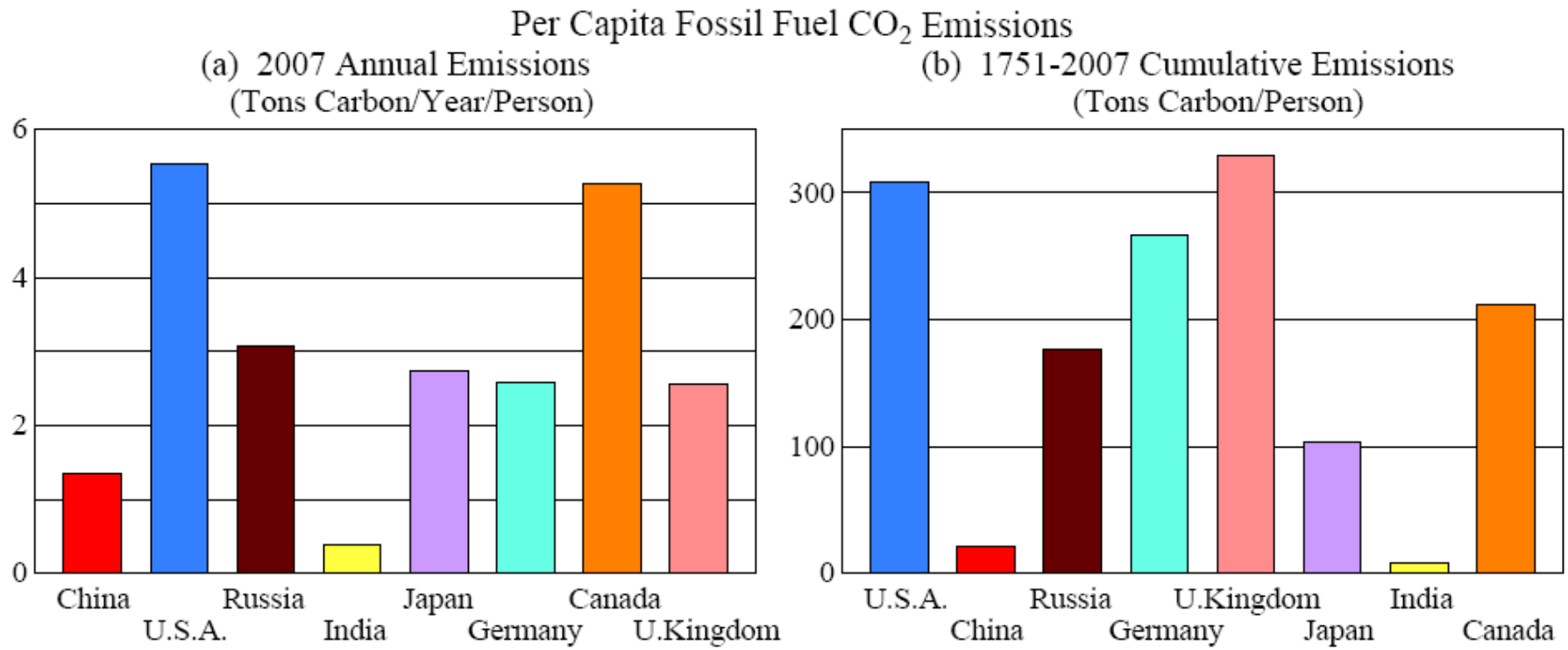
Fossil Fuel CO_2 Emissions

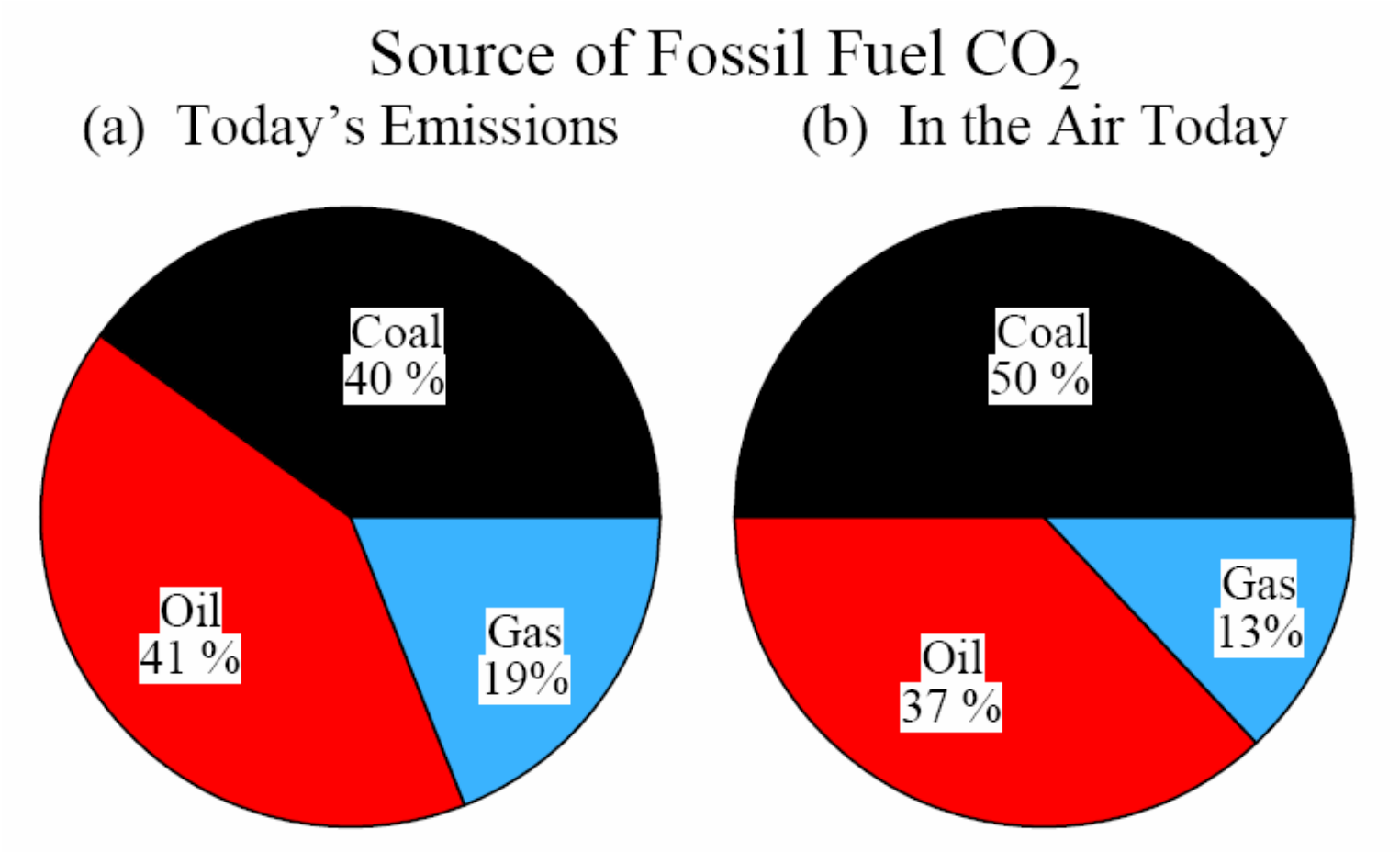
(a) 2007 Annual Emissions



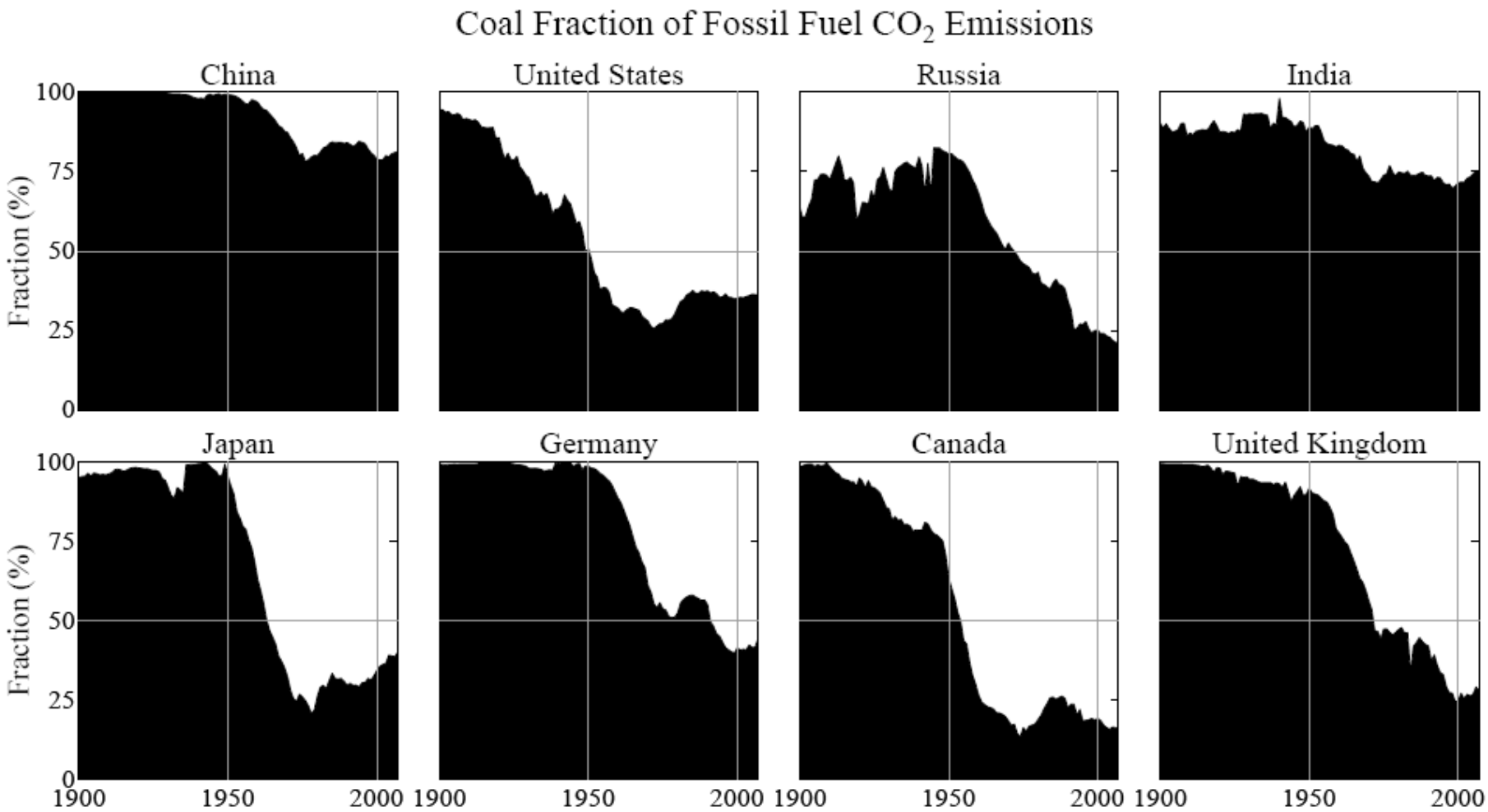
(b) 1751-2007 Cumulative Emissions



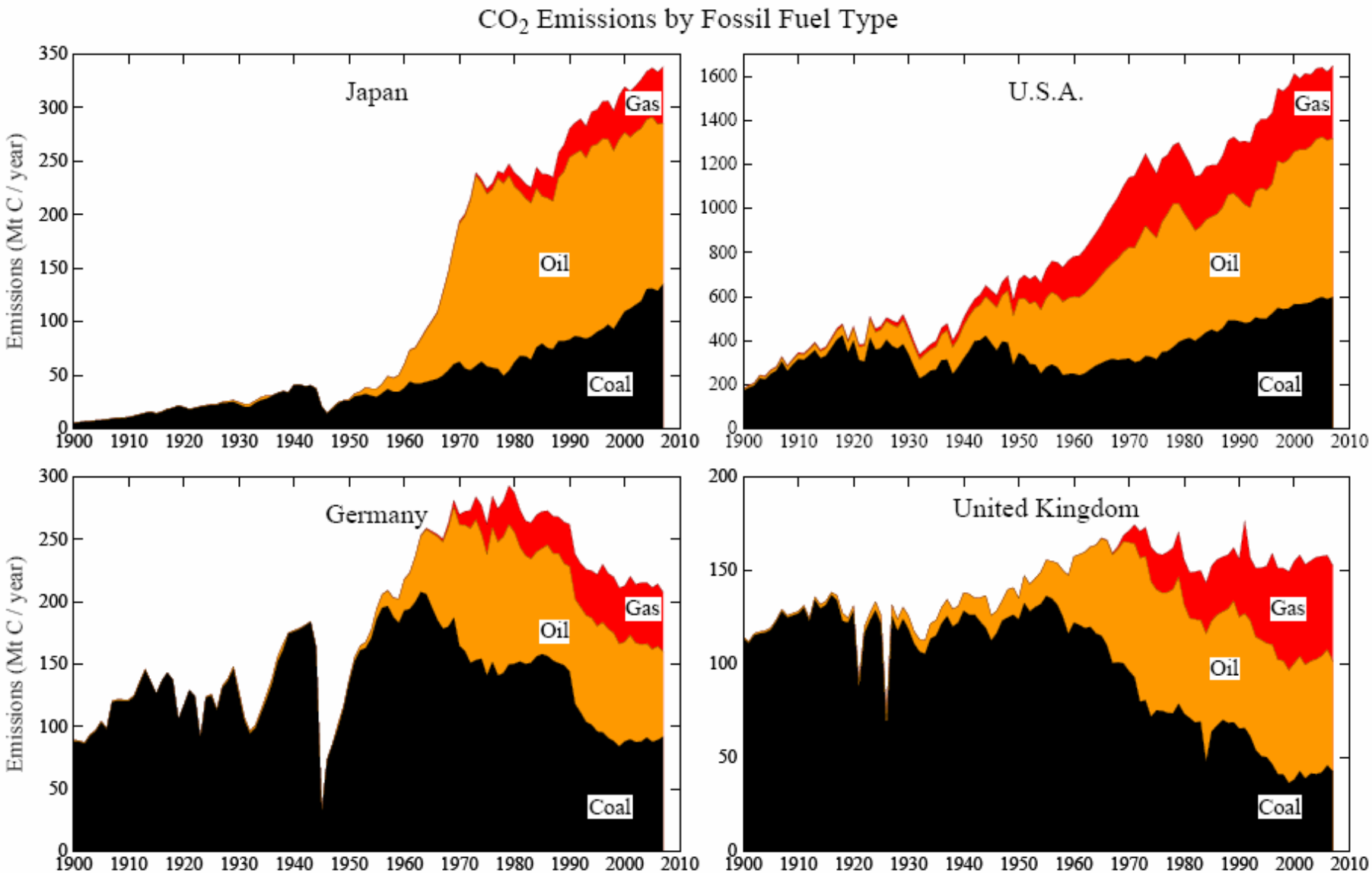

Per Capita Fossil Fuel CO_2 Emissions
(a) 2007 Annual Emissions
(Tons Carbon/Year/Person)
6
4
2
0
China
U.S.A.
Russia
India
Japan
Germany
Canada
U.Kingdom
(b) 1751-2007 Cumulative Emissions
(Tons Carbon/Person)
300
200
100
0
U.S.A.
China
Russia
Germany
U.Kingdom
Japan
India
Canada



(a) Fraction of each fossil fuel in 2007 CO2 emissions
(b) Fraction of each in today's airborne CO2 amount



Fraction = Coal / (Coal + Oil + Natural Gas)


CO_2 Emissions by Fossil Fuel Type
Japan
U.S.A.
Germany
United Kingdom
Gas
Oil
Coal
Emissions (Mt C / year)
0
50
100
150
200
250
300
350
400
600
800
1000
1200
1400
1600
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

“Free Will” Alternative

1. **Phase Out Coal CO_2 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_2 Sequestration**
   - improved farming & forestry practices
4. **Reduce non-CO_2 Forcings**
   - reduce CH_4, O_3, 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_2 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

includes

Letter to Prime Minister Fukuda

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

Target Atmospheric CO_2: Where Should Humanity Aim?