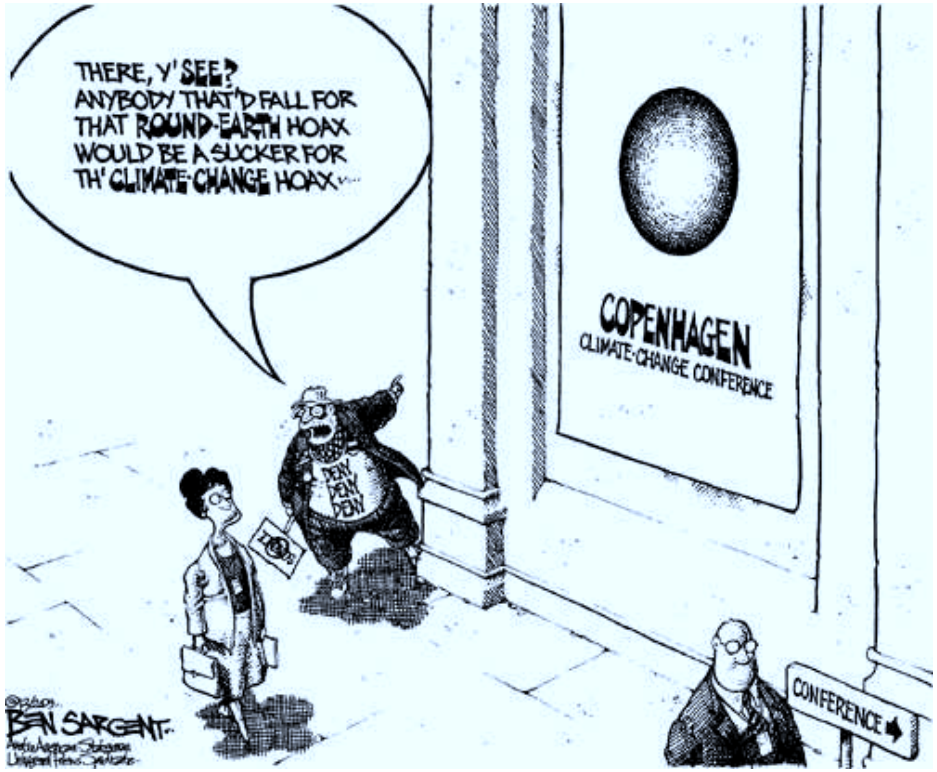
Welcome to ATMS 111 Global Warming

http://www.atmos.washington.edu/2010Q1/111



Ben Sargent

Tom Toles

Questions posed in Ch 1 Rough Guide

Is the planet really warming up?

But don't many experts claim that the science of climate is uncertain?

Is a small temperature rise a big deal?

How could humans change the climate?

When did we discover the issue?

Couldn't the changes have natural causes?

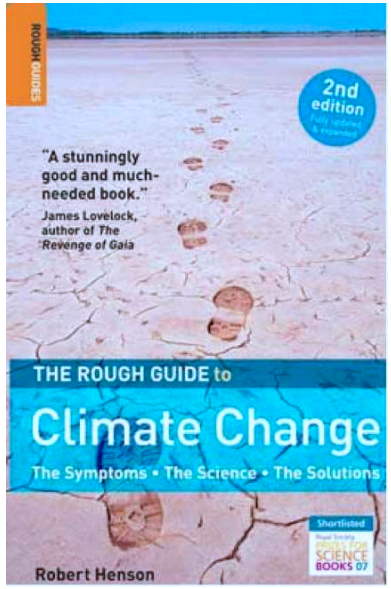
Could some undiscovered phenomenon be to blame?

How do rainforests fit into the picture?

Was Hurricane Katrina related to global warming?

Whatever happened to global cooling?

And the ozone hole?



No uncertainty about the greenhouse effect
and the amount CO_2 has risen

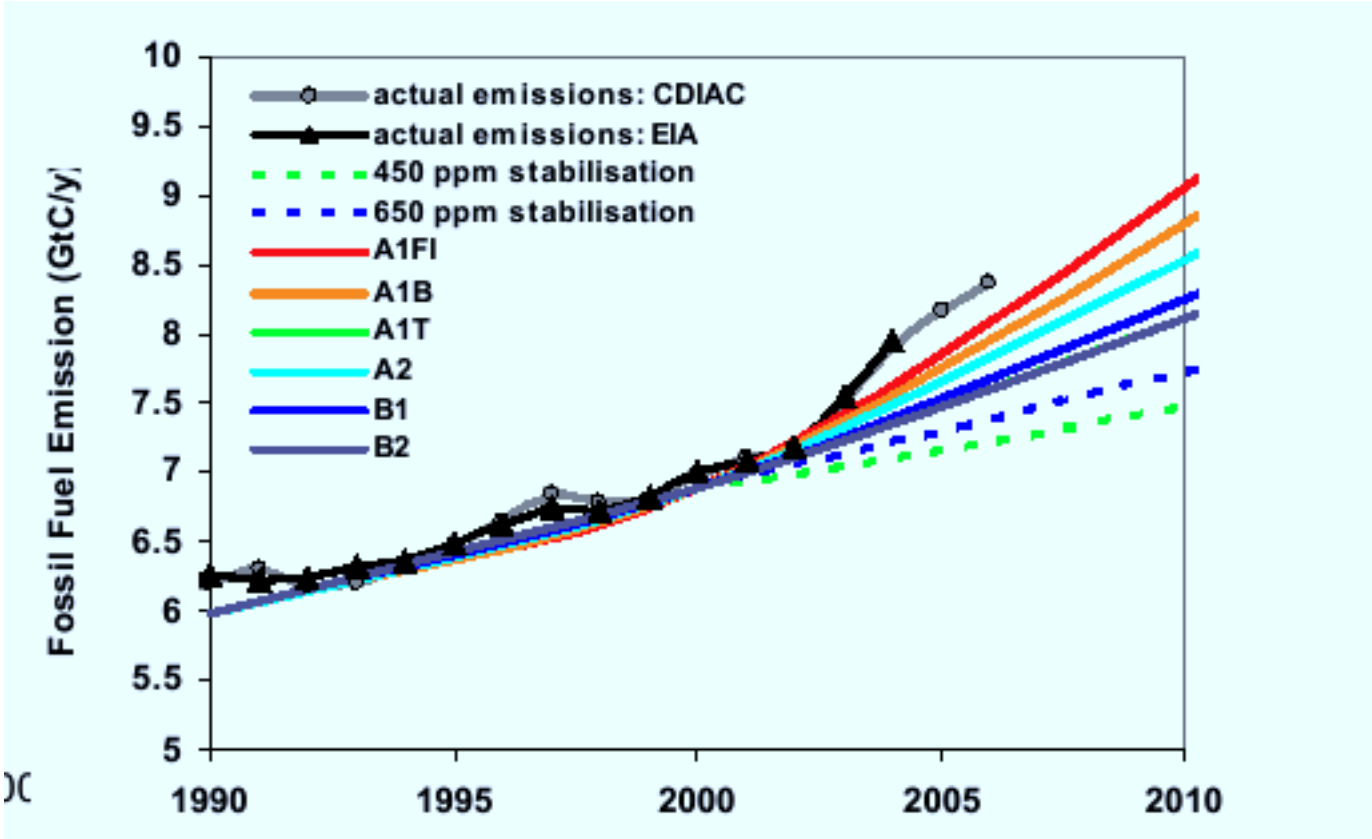
Not much disagreement that rising CO_2 could cause warming

There is valuable scientific debate about unsettled issues

Are there tipping points?
How much will sea level rise?
etc

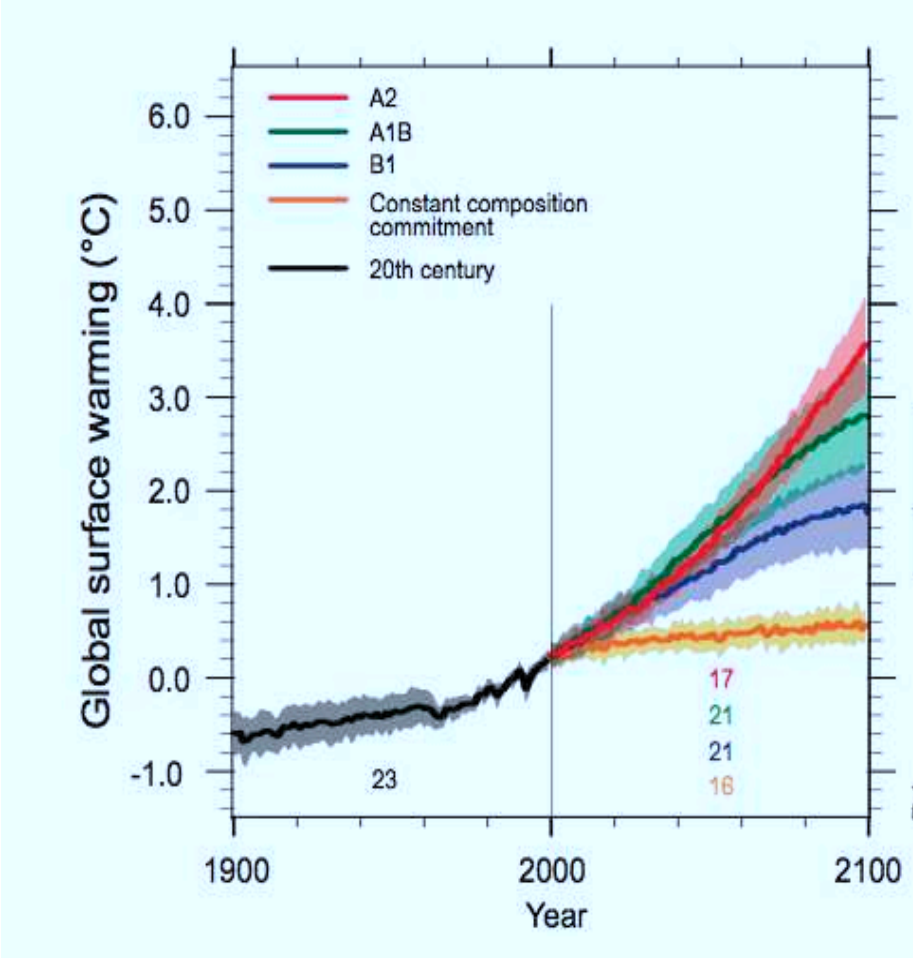
Definitely there is uncertainty in climate observations
and predictions (often called projections)

Famous figure comparing emissions “scenarios” made in 2000 with reality. Scenarios are based on hypothetical political and economic conditions and models of Earth’s carbon cycle.



Raupach et al 2007

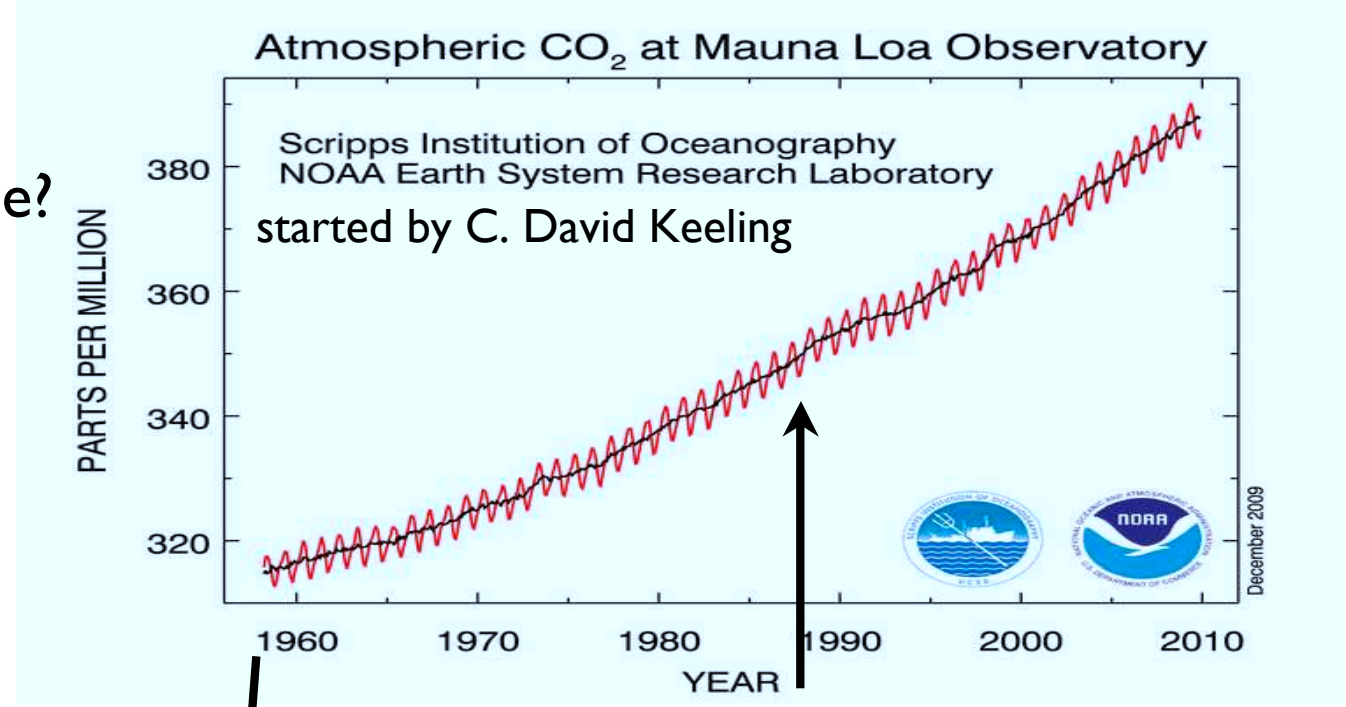
Projections of Future Warming in Climate Models



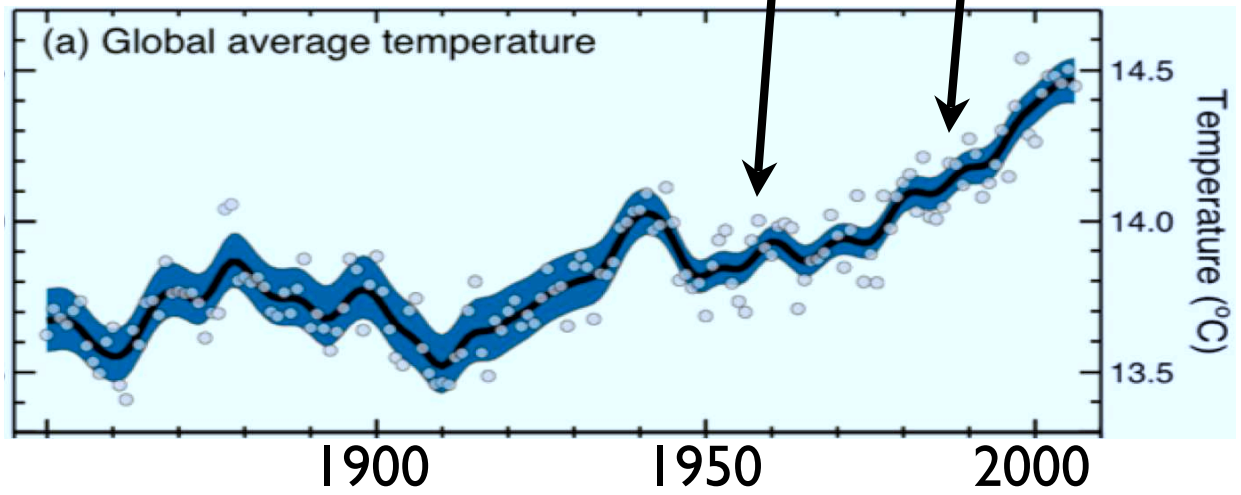
2007 IPCC Figure

Detection of human imprint in past warming has its purpose
(to test our hypothesis, etc),
But the real danger lies ahead (if models are right)

When did we discover the issue?

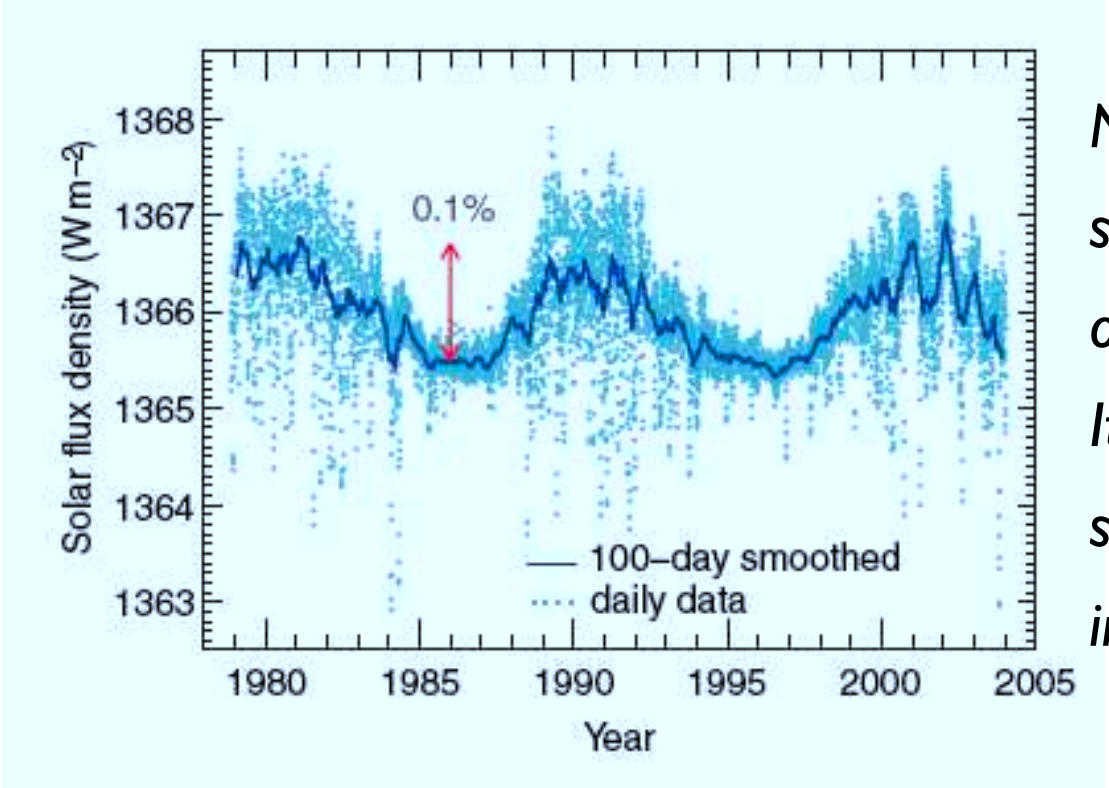


James Hansen congressional testimony, summer 1988



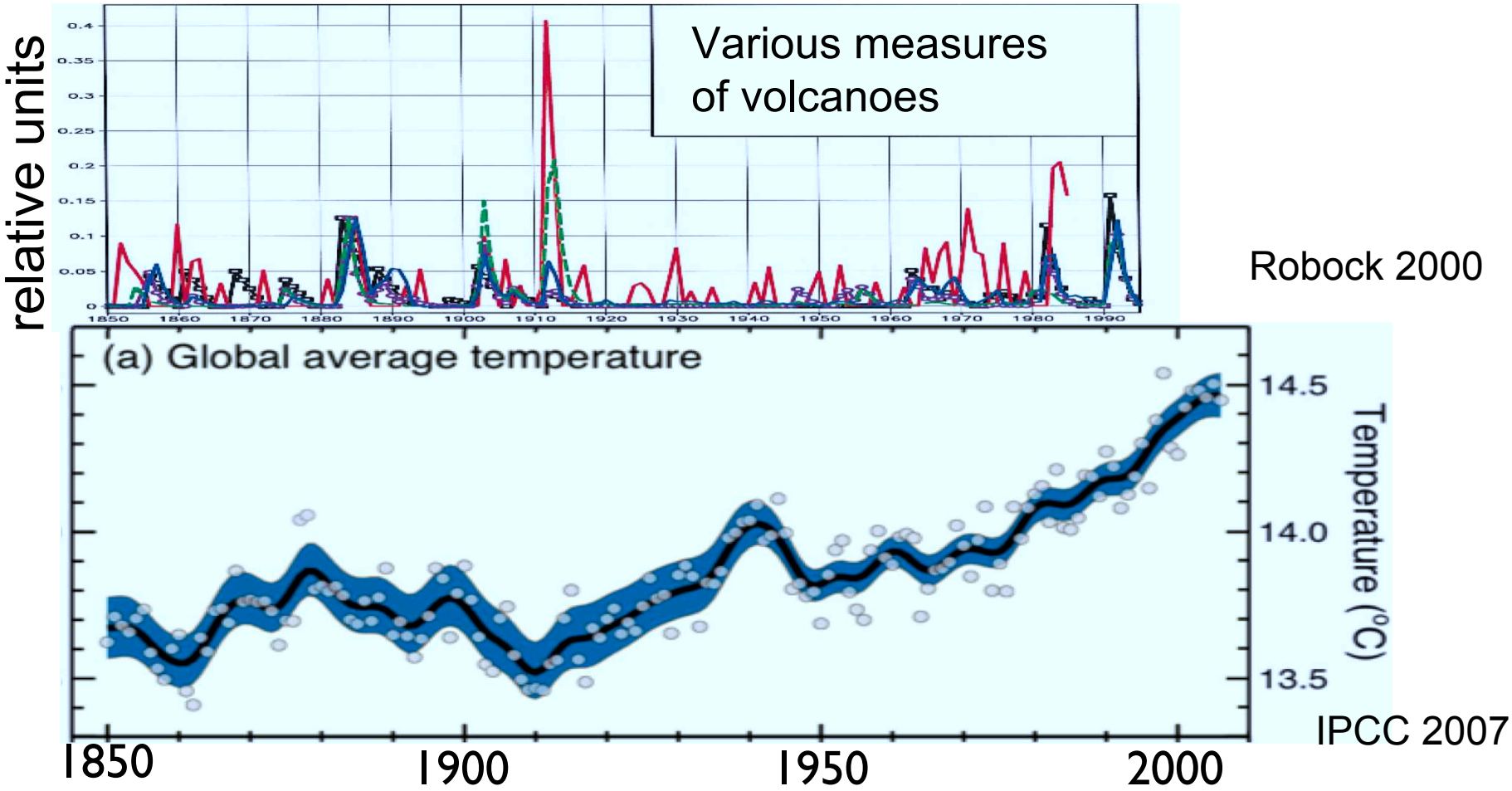
Couldn't the changes have natural causes?

Such as increase in incoming solar radiation?



No, we've been monitoring the sun's emission using instruments on board satellites since 1979. It's varied with the 11-year sunspot cycle but it hasn't increased.

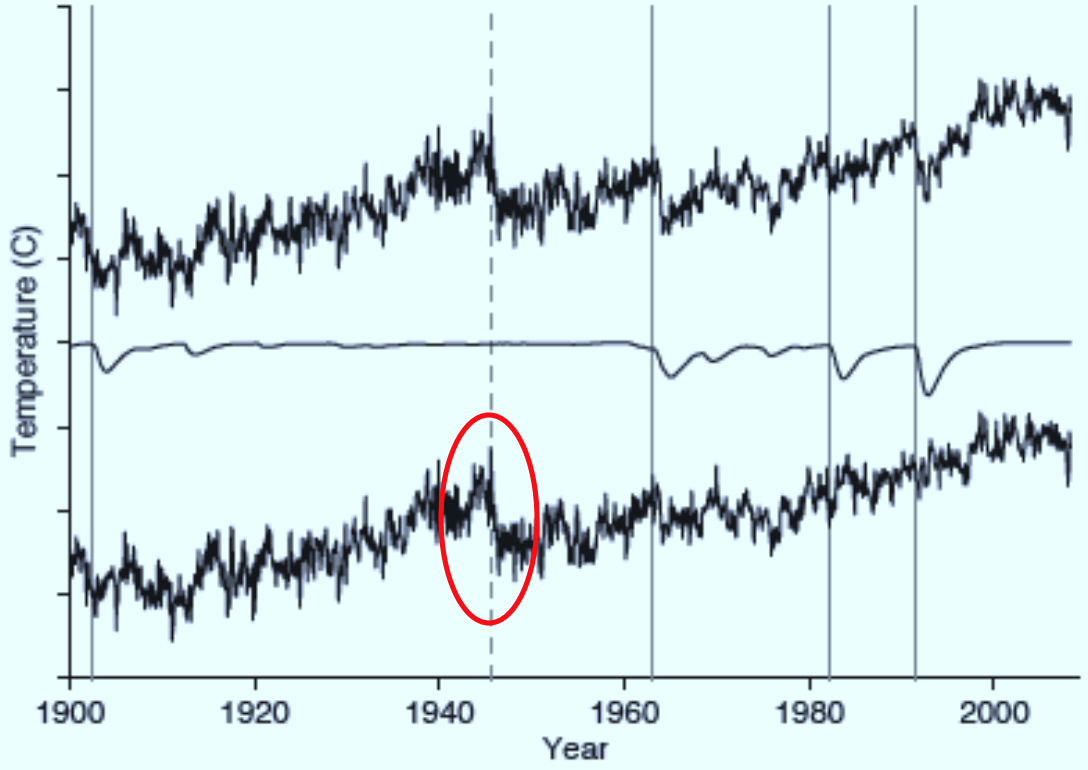
What about an absence of volcanic eruptions?



We can see the signature of volcanic eruptions (as cooling) in the record.

There are several big volcanoes 1960-2000, so no absence of volcanoes.

Global Average Temperature, but after removing el nino and other natural climate variability



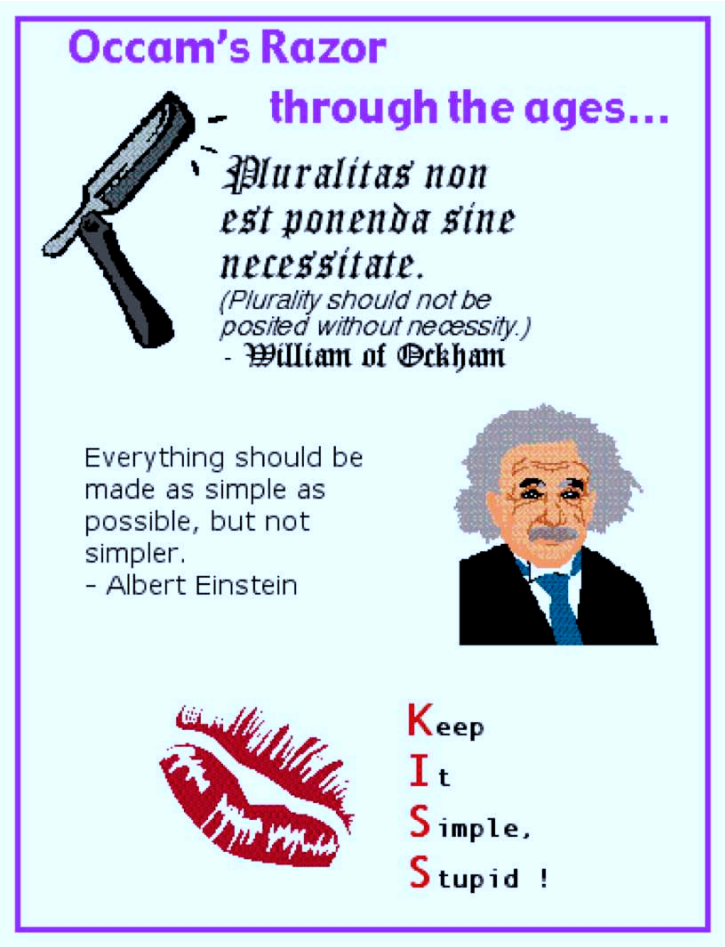
Thompson et al 2009

Could this be the effect of atomic bombs? Stay tuned.

Could some undiscovered phenomenon be to blame?

Sure, it's possible, but...

If you had all the symptoms of a well known, treatable disease, would you refuse treatment because it's possible you might have an undiscovered disease?



Keep an open mind, but don't reject obvious explanations.

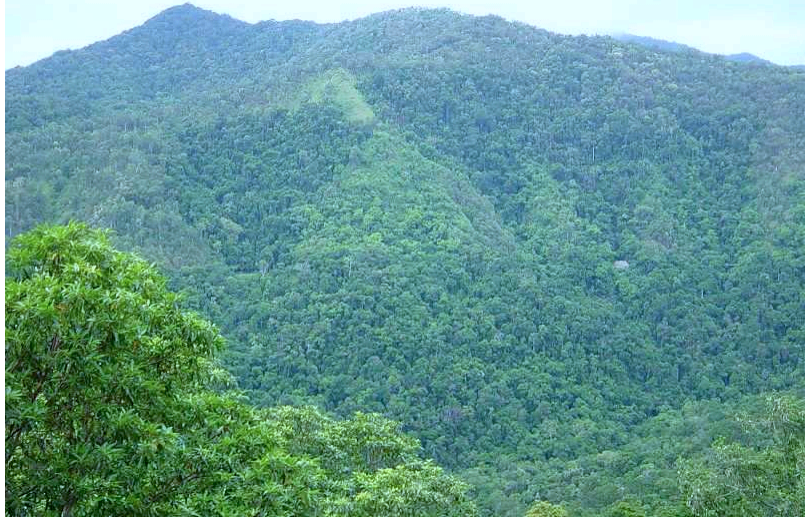
How do rain forests fit into the picture?

Tropical forests are reservoirs of carbon. If they are destroyed, the carbon will go into the atmosphere.

They may well be vulnerable to global warming.

They are an example of a fragile ecosystem that will be destroyed if temperatures rise too much. Many plants in the tropics are already living above their optimal temperature.

Without tropical forests, large areas of the tropics would be hotter and drier.




Hurricane Katrina
August 28, 2005
Related to global warming?

There is good reason to believe that greater warmth of the tropical oceans favors the development of more intense tropical cyclones.

It's impossible to prove that any individual storm was due to global warming.

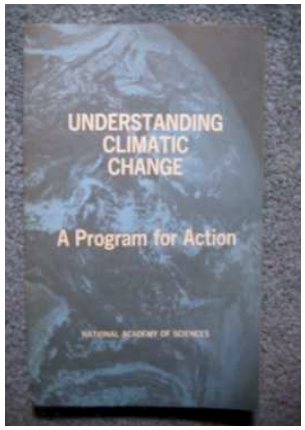
Records of intense Atlantic hurricanes date back to early colonial days.

Whether there's a detectable long term trend toward more intense hurricanes is unsettled in the scientific literature.

Whatever happened to global cooling?

News magazine articles and a few science papers in 1970s are held up by skeptics as evidence that climate scientists flip flopped when they realized global warming has more mileage

Books that make no mention of global cooling

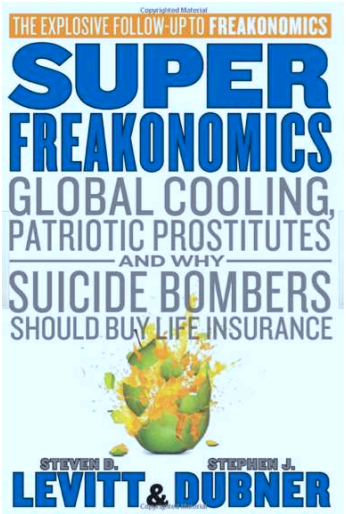


1975
National Academy of Sciences

1979
Famous Textbook by UW authors

A new top selling book in America

(about geoengineering as well)

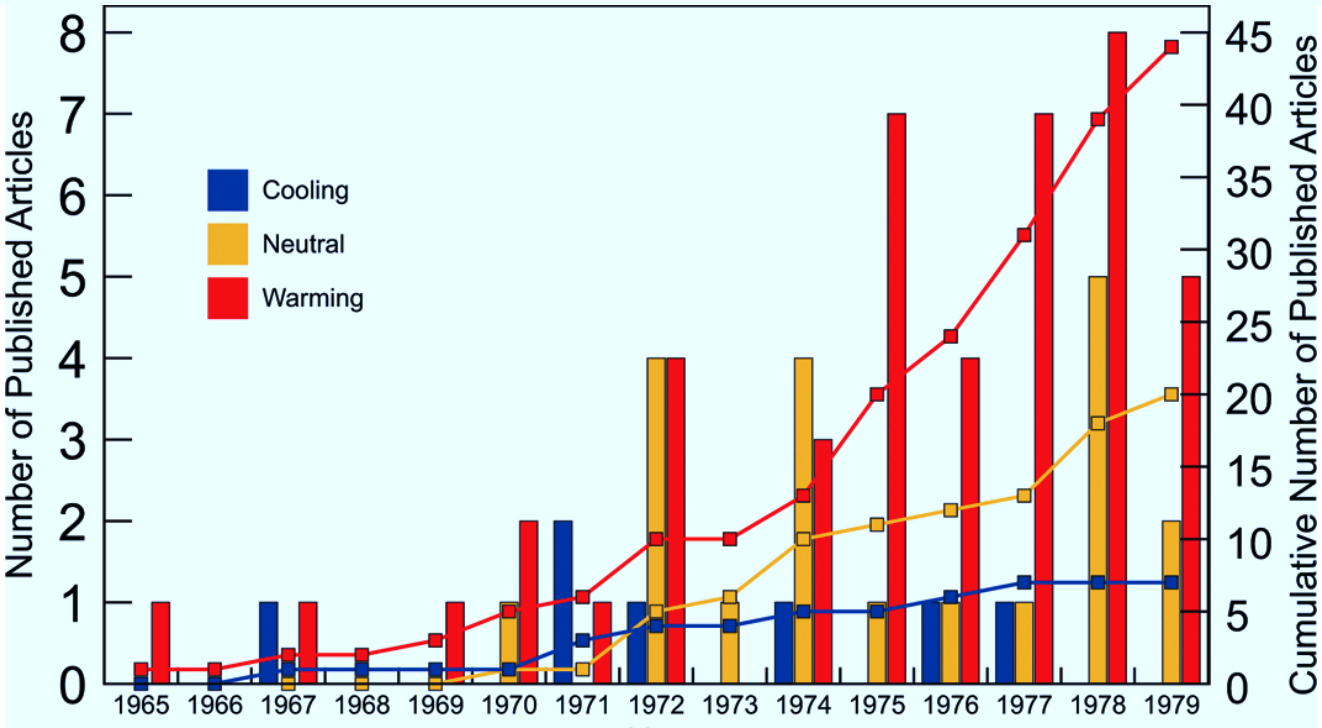


2009

A Research Paper in 2008:

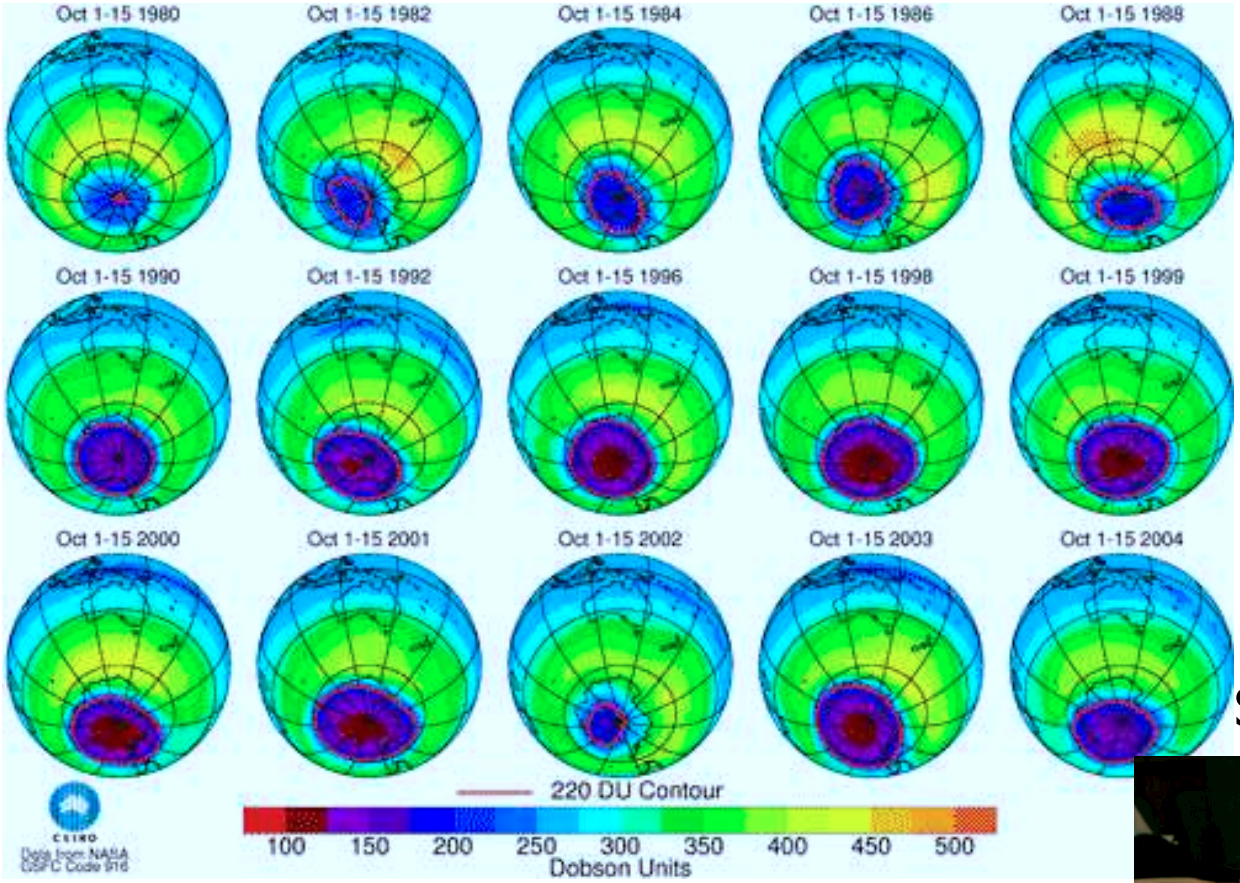
THE MYTH OF THE 1970s GLOBAL COOLING SCIENTIFIC CONSENSUS

BY THOMAS C. PETERSON, WILLIAM M. CONNOLLEY, AND JOHN FLECK



How could humans change the climate?

Human activity has already caused the Antarctic ozone hole.



Susan Solomon

the blue/purple splotch is an absence of ozone, occurs each year in SH spring, measured well by satellite

Greenhouse Warming and the Ozone Hole are separate issues

Greenhouse Warming	Ozone Hole
trapping of outgoing radiation	destruction of ozone
GHGs	CFCs
global	Antarctic
out of control	under control

But they are related?

CFCs are GHGs

Both are international, climate-related issues

We can learn from experience in dealing with the ozone hole

Copenhagen Accord December 2009

•Not a treaty and not legally binding but an agreement to cooperate in reducing emissions. May be considered politically binding.

•What does it mean that the conference parties “took note”? How does it differ from adopting?

•Governments will submit country-level commitments by Jan 31, 2010, to be added to appendixes

UNFCCC Vocabulary

- UNFCC = United Nations Framework Convention on Climate Change
- Annex I country = industrialized
- Dangerous Anthropogenic Climate Change = 2 deg C
- COP = Conference of the Parties
- REDD = Reduced Emissions from Deforestation and forest Degradation

Copenhagen Accord December 2009

A statement of intent, negotiated by US, China, Brazil, India, and South Africa, other countries “took note”, countries can offer specifics by end of this month

Key points

•Aim to keep temperatures from rising more than 2 deg Celsius (3.6 deg F) above preindustrial levels

•Developing nations will report every two years on their voluntary actions to reduce emissions, richer nations can “commit”, which would be verified

•Richer nations will finance up to $30 billion from 2010-12 for poorer nations' projects to mitigate and adapt to climate change

•Set a "goal" of mobilizing $100 billion-a-year by 2020 for further developing world adaptation and mitigation purposes

REDD, or Reduced Emissions from Deforestation and forest Degradation

Bali (COP 13) Action Plan (called REDD-plus)

“Policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries”.

Controversial because of indigenous peoples’ rights, carbon trading in forests may offer “loop hole”, distracts against reducing fossil fuel use

Who is responsible? Rough Guide p. 32-42

How much greenhouse gas (GHG) is in the air and what are we adding?

What happens to the GHGs that we put into the atmosphere?

The carbon balance

What type of fossil fuel contributes most?

How much do different activities contribute?

Energy and power units

Which countries are most responsible?

The per person emissions of CO_2 each year are

4600 kg = 4.6 metric tons

your weight every 6 days!

But this is the global average

In the US it is more than 20,000 kg /year

Beware, error in the table on page 41.
It is in tons of C, although it says tons of CO_2

Estimates may be given for either CO_2 or C emissions

They differ by the ratio of molecular weights

$$\frac{M_{CO2}}{M_C} = \frac{44}{12} = \text{about } 4$$

so per person CO2 emissions 4600 kg
is equal to C emissions 1400 kg

so multiply the numbers in table on page 41.
by about 4 to get the right value

Burning one gallon of gas emits 8.7 kg of CO_2

We usually give concentrations of trace gases in the atmosphere in terms of the number of molecules relative to the total

ppm = parts per million (by volume)

also called a “mixing ratio”

Today’s CO_2 level 385 ppm = 0.0385 % of the atmosphere

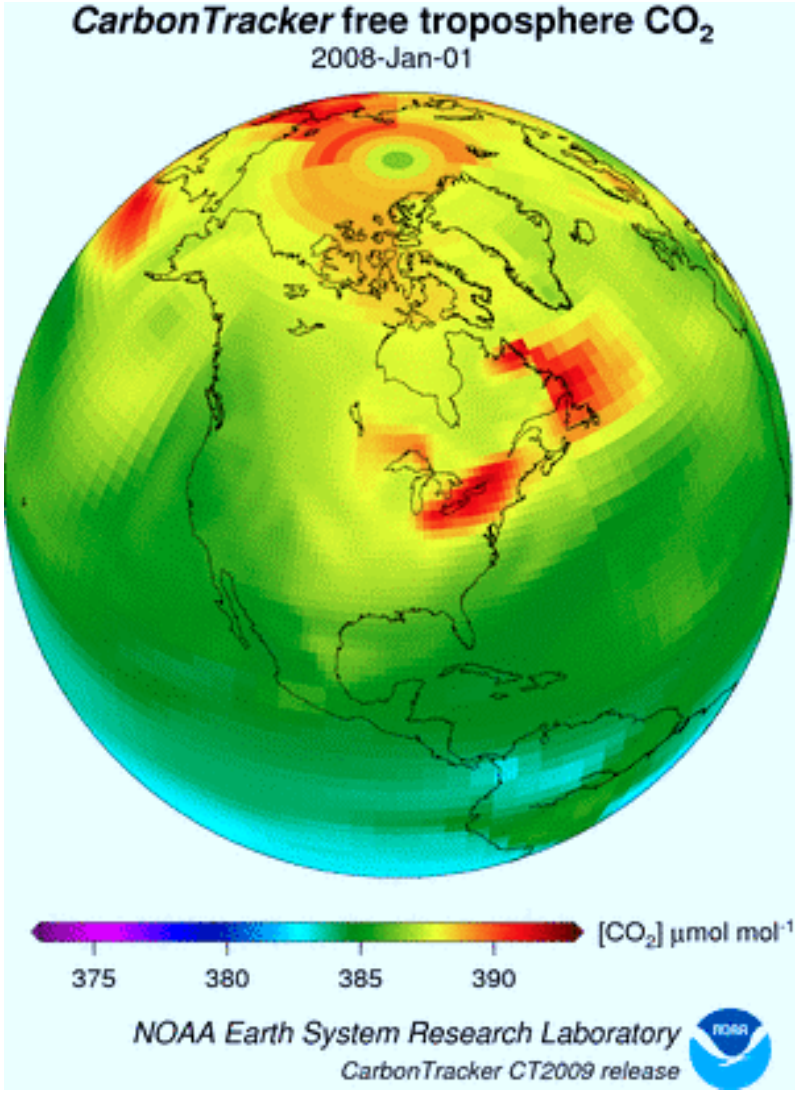
of 1 million molecules, 385 are CO2

What happens to the GHGs that we put into the atmosphere?

CO2 is non reactive
it is an inert gas

long lasting in the atmosphere so fairly "well mixed"

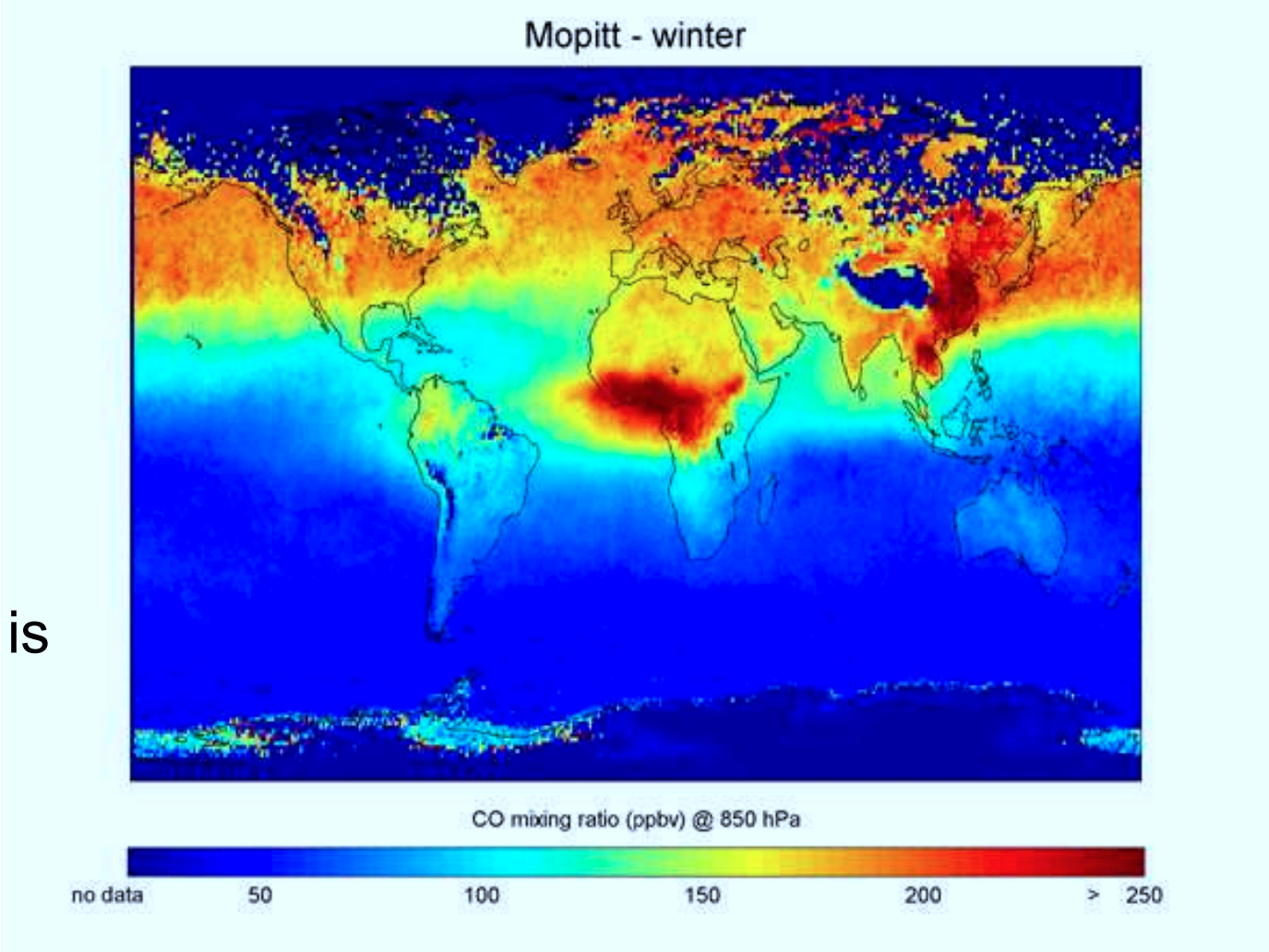
Movie estimate is a combination of modeling and observations



Carbon Monoxide CO, a reactive gas

1-2 month residence time
but wait, is it a greenhouse gas?

the satellite is named "Mopitt"



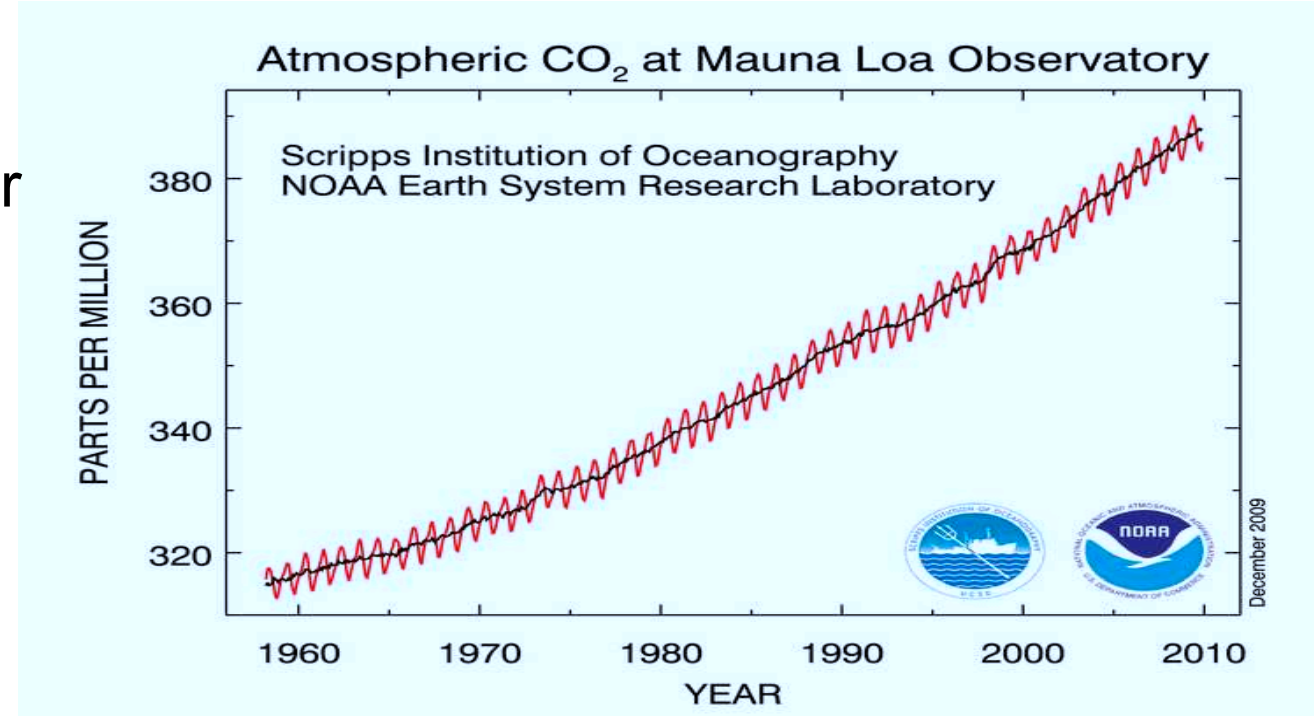
What happens to the GHGs that we put into the atmosphere?

Atmospheric total is about 3,000 gigatons CO2

1 gigaton = 1 billion metric tons

Humans are adding 31 gigatons *each year*
or approximately 1% each year

But this curve isn't rising by 1% a year



What happens to the GHGs that we put into the atmosphere?

At present when humans add CO_2
about 45% stays in the atmosphere

of the rest
1) about 25% goes into the ocean
2) about 30% goes into increasing land biota

Explanation for

1) Consider the reverse. Once you open a can of soda, the CO2 begins to escape from the drink and go into the atmosphere because the drink has much higher CO2 than the atmosphere.
2) The normal cycle of plants producing leaves and their decomposition is the “breathing of the biosphere”, which produces no net change. Trees growing taller or more numerous is necessary to soak up CO2

What happens to the GHGs that we put into the atmosphere?

Atmospheric CO_2 Account		gigatons of CO2 per year
Date	Origin	Balance
annual	Biosphere	-8
annual	Ocean	-12
annual	Fossil Fuel Burning	+32
annual	Deforestation	+4
Annually Reported Atmospheric Balance		+16

these numbers are approximate and are for the whole globe

Like balancing your checkbook

Can only lower atmosphere concentration if the annual balance is negative (higher deductions than deposits)

For example, if annual fossil fuel burning is reduced by 25%, the balance is still above zero and CO2 in the atmosphere still rises

(the number for oceans was wrong in class - sorry)

http://www.eia.doe.gov/

U.S. Energy Information Administration

Independent Statistics and Analysis

Features:

- Energy Explained
- 2010 Energy Conference
- Monthly Energy Review
- Energy Kids
- Internships at EIA

Energy Sources

Petroleum

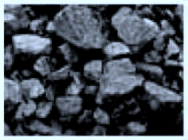
Crude oil, gasoline, heating oil, diesel, propane, jet fuel, and other petroleum products...

Natural Gas

Exploration and reserves, storage, imports and exports, production, prices, sales...

Electricity

Sales, revenue and prices, power plants, fuel use, stocks, generation, trade, demand & emissions...



Coal

Reserves, production, prices, employment and productivity, distribution, stocks, imports and exports...

Renewable & Alternative Fuels

Includes hydropower, solar, wind, geothermal, biomass and ethanol...

Topics

Forecasts & Analysis

Monthly and yearly energy forecasts, analysis of energy topics, financial analysis, Congressional reports...

Environment

Greenhouse gas data, voluntary reporting, electric power plant emissions...

Households, Buildings & Industry

Energy use in homes, commercial buildings, manufacturing and transportation...

Geography

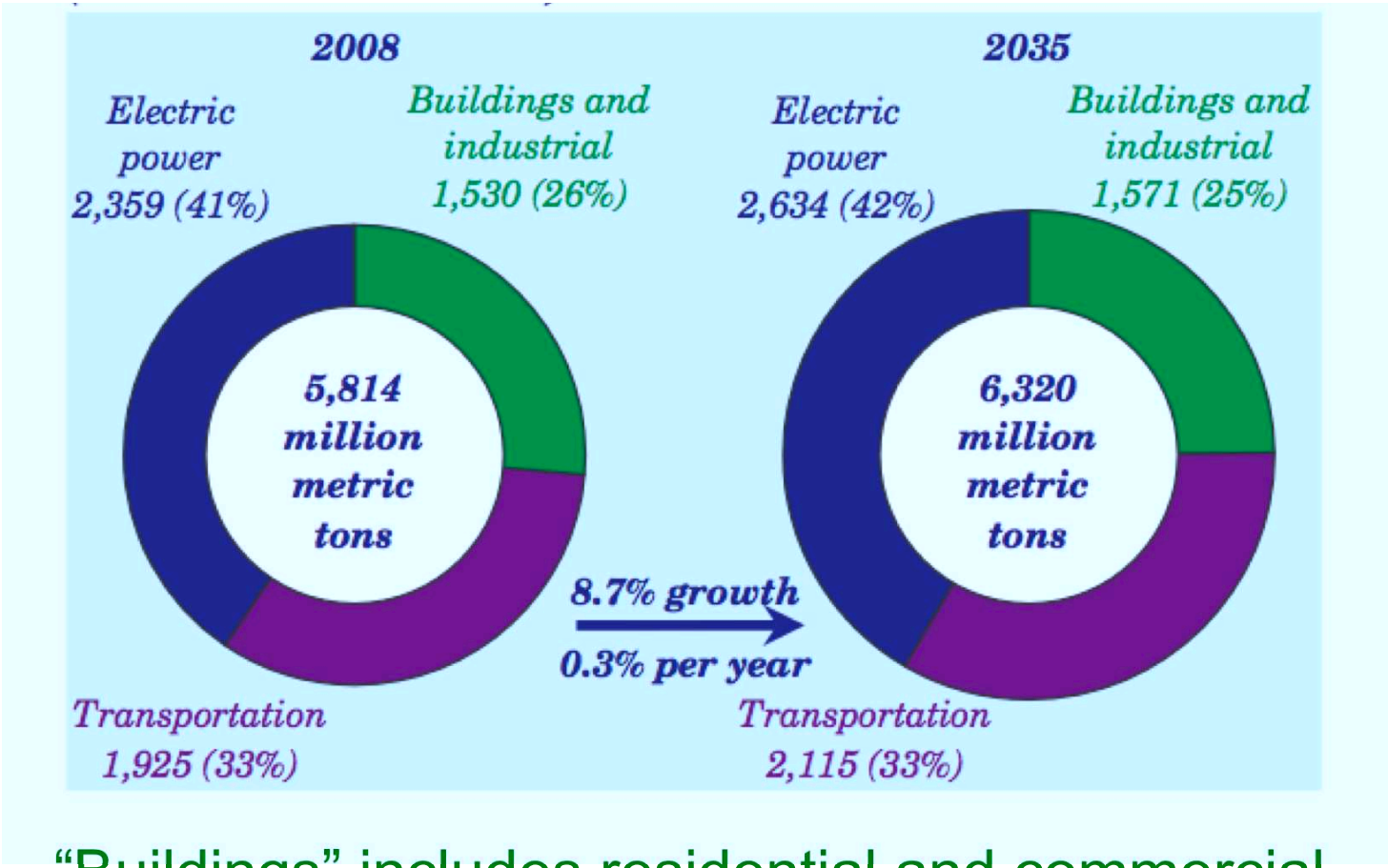
International

Country energy information, detailed and overviews...

State & U.S. Historical Data Overview

US energy-related CO2 emissions
expected growth from electricity and transportation
assuming current laws and regulations

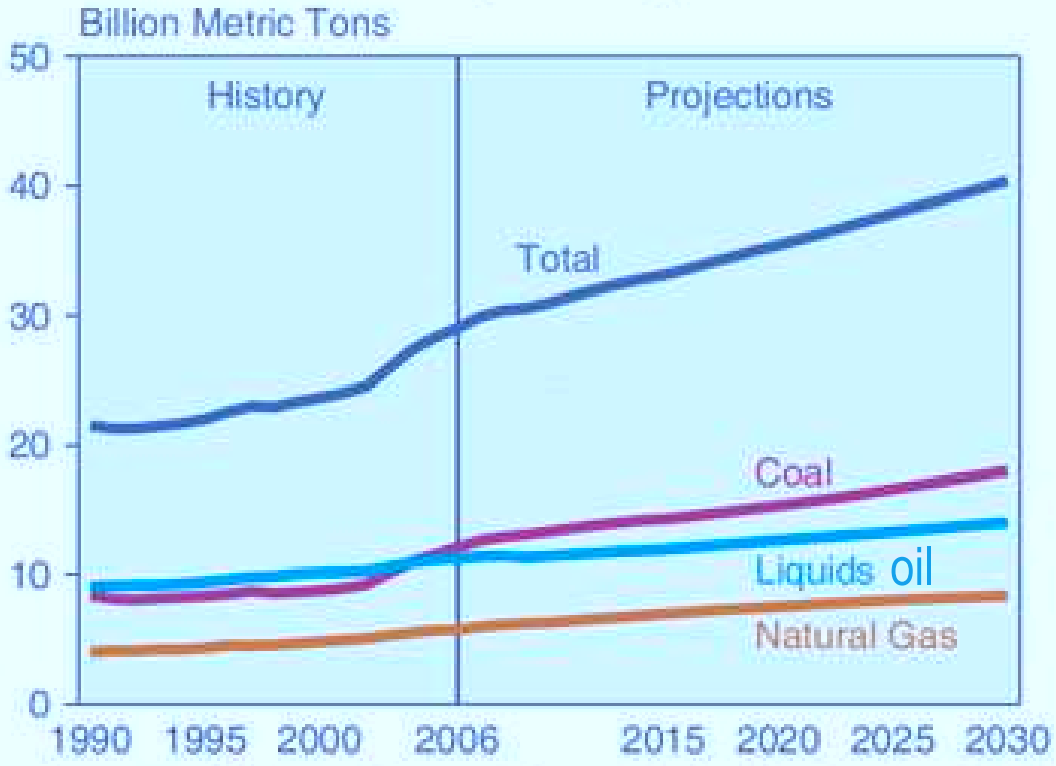
more than 5 billion metric tons - wow!



"Buildings" includes residential and commercial

Which Fuels do we use?

Figure 81. World Energy-Related Carbon Dioxide Emissions by Fuel Type, 1990-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

80% of emissions from Oil & Coal

Oil for transportation

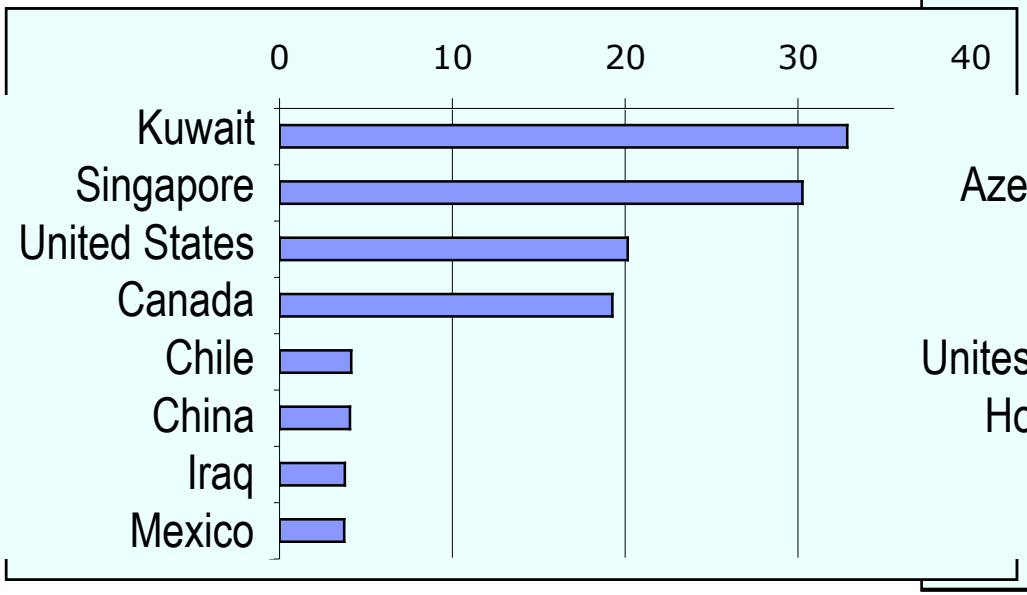
Coal used for electricity

Which countries contribute most to the emissions problem?

It depends on how you measure…

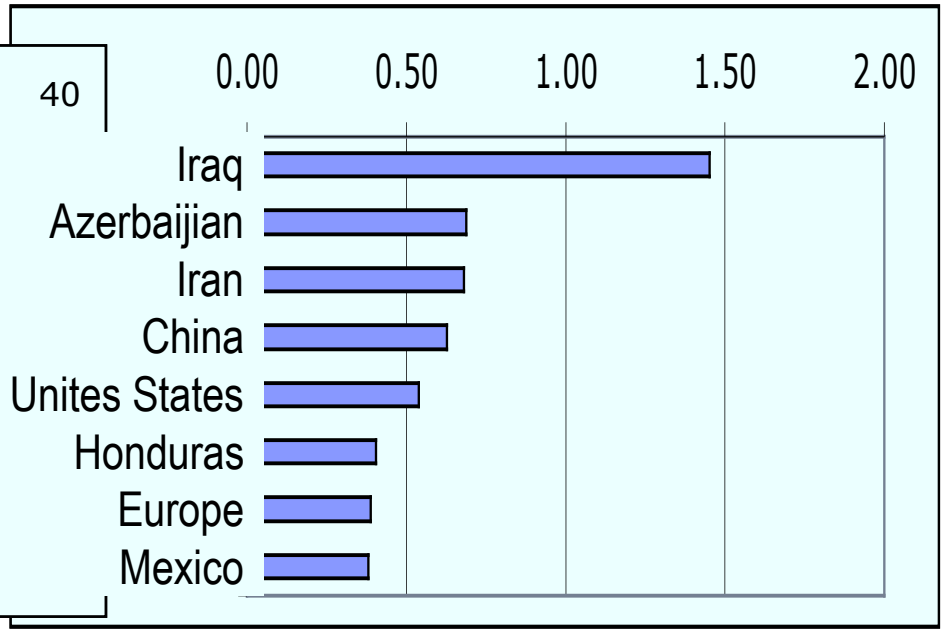
Depends on how you look at the data

Per Capita (tons CO2)



Per $GDP (tons CO2 per $1k)

Carbon dioxide intensity

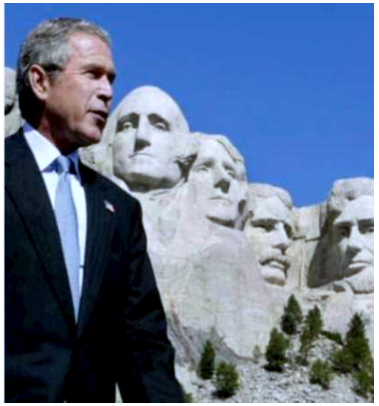


Advanced countries look "bad"
Developing countries "good"

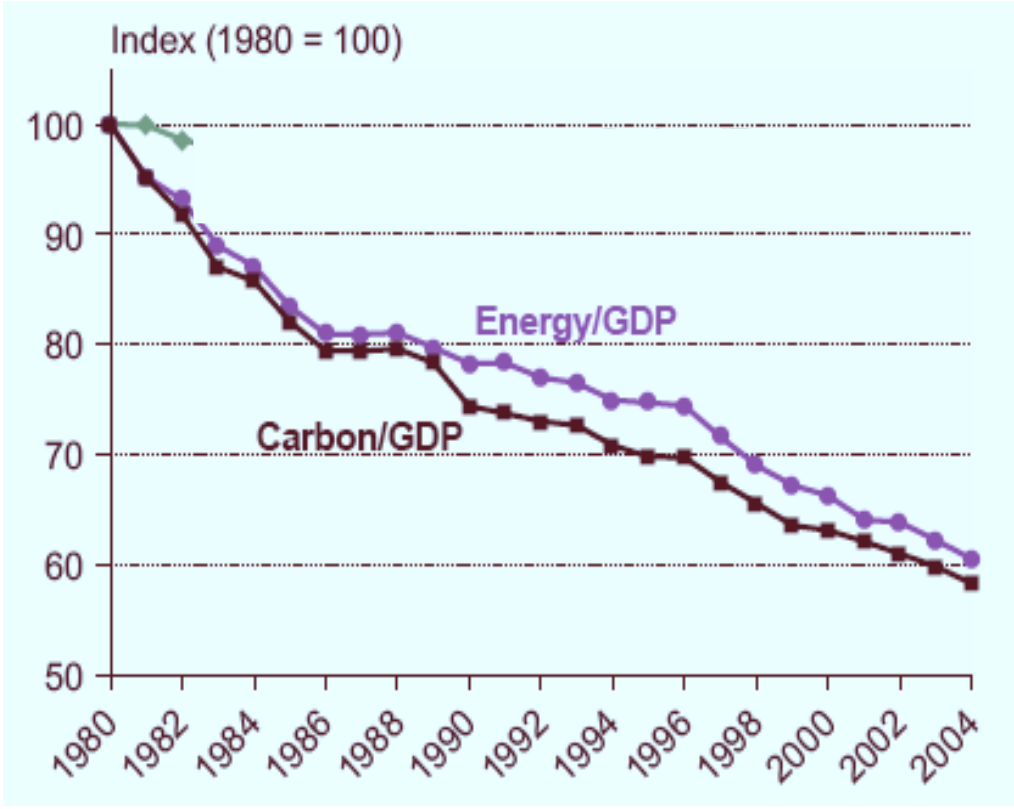
More mixed. US tends to look better.

Data from US dept of energy

The Bush Plan



Carbon intensity or energy intensity

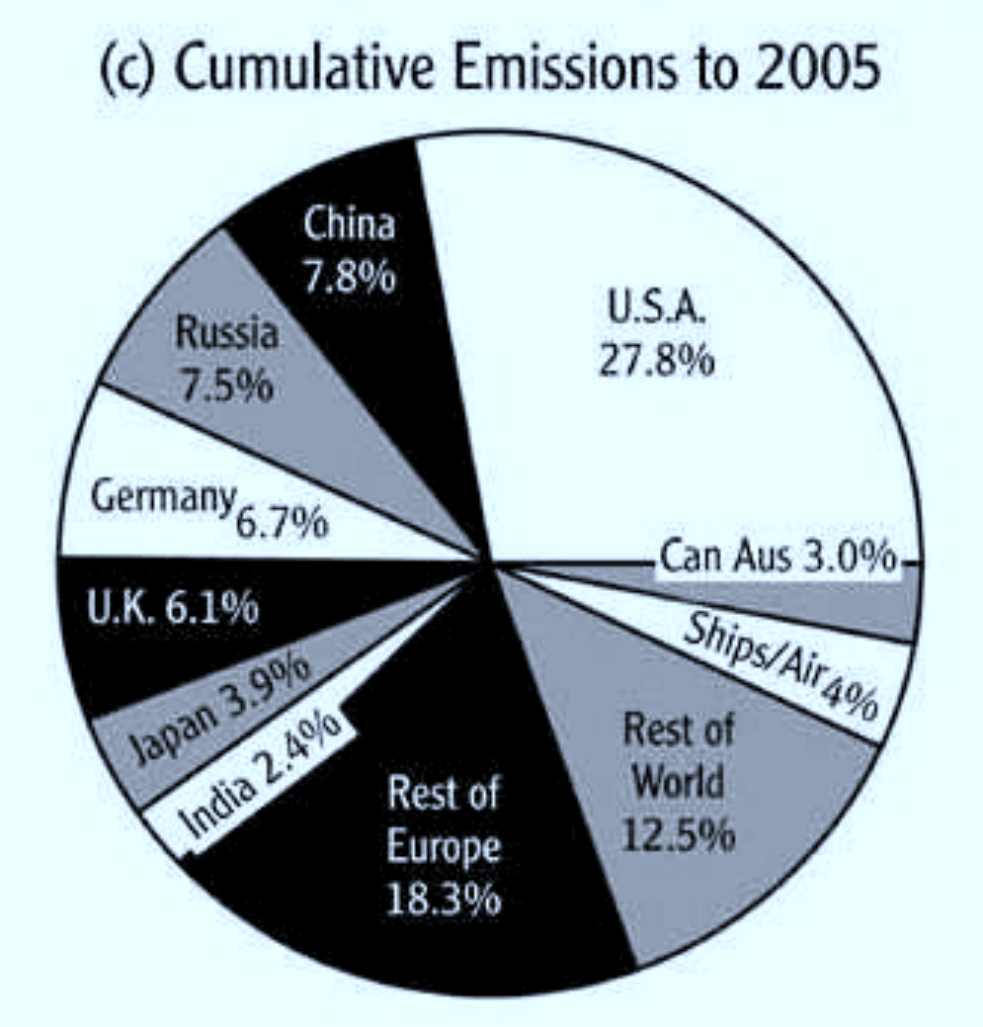


Goal: 18% decrease in Carbon/$GDP by 2012

Reality: 17% decrease per decade since 1980

Data from US dept of energy

Meanwhile, US emissions continue to increase by 1.7% per yr



http://jcwinnie.biz/wordpress/?author=2

Cumulative CO2 Emissions, 1850–2002
Country % of World (Rank)
United States 29.3 (1)
EU-25 26.5 (2)
Russia 8.1 (3)
China 7.6 (4)
Germany 7.3 (5)
United Kingdom 6.3 (6)
Japan 4.1 (7)
France 2.9 (8)
India 2.2 (9)
Ukraine 2.2 (10)
Canada 2.1 (11)
Poland 2.1 (12)
Italy 1.6 (13)
South Africa 1.2 (14)
Australia 1.1 (15)
Mexico 1.0 (16)
Spain 0.9 (20)
Brazil 0.8 (22)
South Korea 0.8 (23)
Iran 0.6 (24)
Indonesia 0.5 (27)
Saudi Arabia 0.5 (28)
Argentina 0.5 (29)
Turkey 0.4 (31)
Pakistan 0.2 (48)
Developed 76
Developing 24
Source: WRI, CAIT.