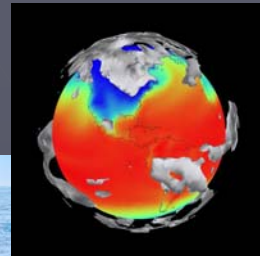


Climate Change 2008

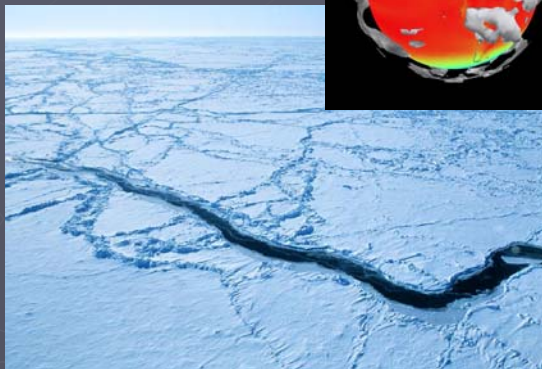
What's new, what we know,
and what it means



Robert Henson
bhenson@nasw.org

Terrestrial (Agriculture
And Forestry) Carbon
Sequestration
Opportunities in Colorado

29 February 2008



What's going
on here?
Let's look at...

The big picture

What's happening to
climate worldwide

The details

How the changes are
affecting our part of the world

The debates

Weren't they expecting a ice
age back in the 1970s?

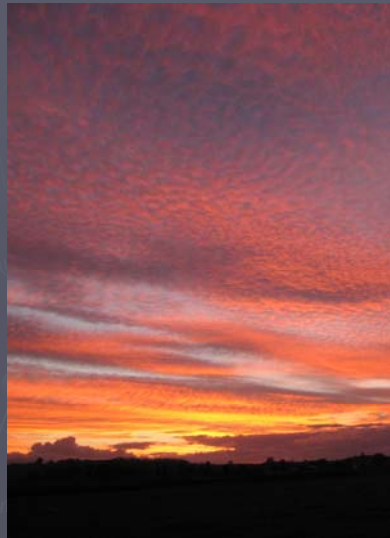


NASA

What to do?

Adapting to climate change that's on
the way and reducing the risk of more

All kinds of atmospheric cycles



Bob Henson

- **Diurnal**—warm days, cool nights
- **Multiday**—cold fronts, warm fronts, blizzards, heat waves
- **Annual**—the seasons
- **Interannual**—El Niño, La Niña
- **Multidecadal**—oceanic oscillations
- **Multicentury**—Medieval Warm Period, Little Ice Age
- **Multimillennial**—major ice age every 100,000 years

Climate is what you
expect; weather is
what you get.

—Robert Heinlein,
Time Enough for Love

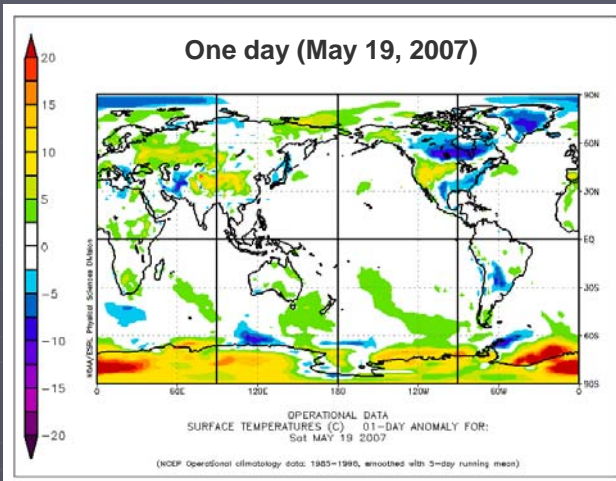


www.extremestability.com

Weather vs. climate

Weather varies in the short term and over local areas.

Climate change becomes more obvious when you look at longer periods and bigger areas.

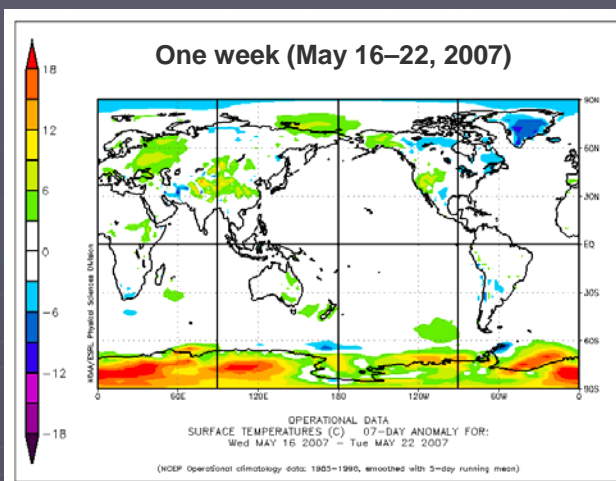


NOAA/ESRL/PSD

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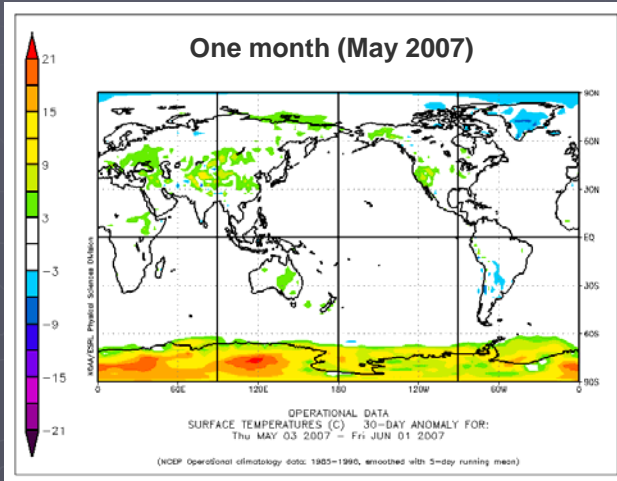


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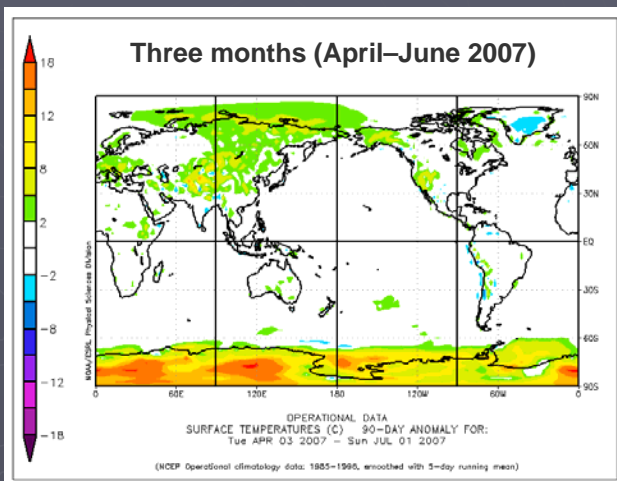


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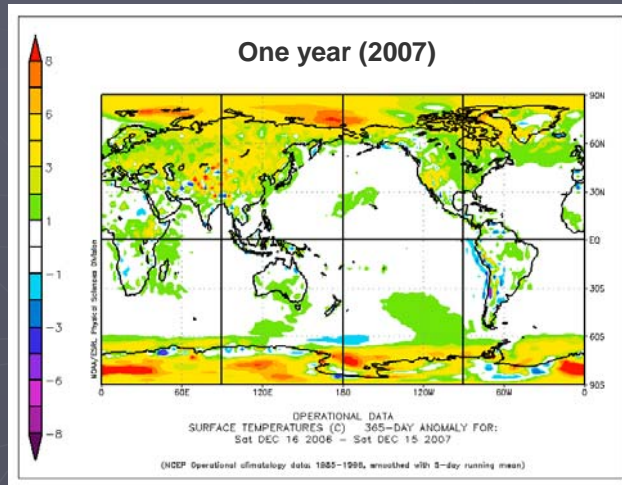


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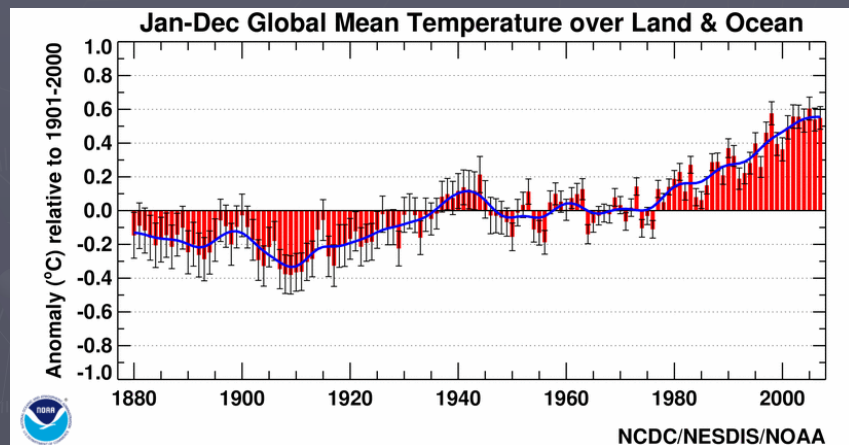
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NOAA/ESRL/PSD

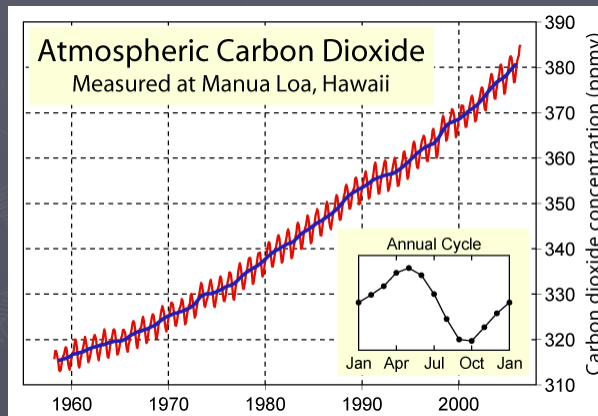
The big picture

Global average temperature: up nearly **0.8°C (1.4°F)** since the late 1800s



The big picture

Carbon dioxide: **up more than 30%** since preindustrial times



Robert Rhode, Global Warming Art

It's heavy stuff!

In 2006 we added **close to 30 billion metric tons** of carbon dioxide to the atmosphere by burning fossil fuels. How much is that per person?

- ▶ About **10,000 pounds**
- ▶ About 30 pounds per day
- ▶ For each American: about **180 pounds per day**



Who's responsible?

China now emits as much carbon dioxide as the US, but we put out **six times more per person**.

The US gets lots of economic benefit per ton of carbon—but **the atmosphere doesn't care!**

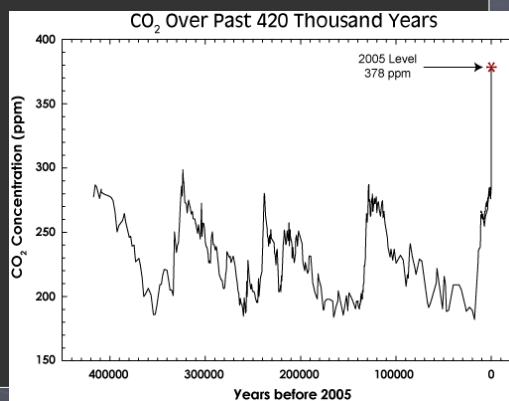
| Percentage of global CO ₂ emissions (fossil fuels, cement and gas flaring only) | | Emissions per capita (tonnes of CO ₂ emissions from fossil fuel use, per person) | | Carbon Intensity (tonnes of carbon emitted in CO ₂ per millions of dollars in GDP/PPP) | |
|--|------|---|------|---|-----|
| United States | 20.9 | Qatar | 21.6 | Ukraine | 483 |
| China | 17.3 | Kuwait | 10.1 | Russia | 427 |
| Russia | 5.3 | UAE | 9.3 | Saudi Arabia | 260 |
| India | 4.6 | Aruba | 8.3 | Poland | 230 |
| Japan | 4.3 | Luxembourg | 6.8 | Iran | 223 |
| Germany | 2.8 | Trinidad/Tobago | 6.8 | China | 201 |
| Canada | 2.2 | Brunei | 6.6 | South Africa | 200 |
| United Kingdom | 2.0 | Bahrain | 6.5 | Australia | 193 |
| South Korea | 1.6 | United States | 5.6 | South Korea | 185 |
| Italy | 1.6 | Canada | 5.5 | Canada | 172 |
| Mexico | 1.5 | Norway | 5.2 | United States | 162 |
| South Africa | 1.5 | Dutch Antilles | 5.1 | Turkey | 149 |
| Iran | 1.5 | Australia | 4.4 | Indonesia | 127 |
| Indonesia | 1.3 | Falkland Islands | 4.1 | Mexico | 125 |
| France | 1.3 | Faroe Islands | 3.9 | Pakistan | 112 |
| Brazil | 1.1 | Estonia | 3.8 | Germany | 111 |
| Spain | 1.1 | Oman | 3.7 | United Kingdom | 110 |
| Ukraine | 1.1 | Saudi Arabia | 3.7 | EU (collectively) | 107 |
| Australia | 1.1 | Gibraltar | 3.9 | Japan | 104 |
| Saudi Arabia | 1.1 | Kazakhstan | 3.6 | Spain | 104 |

Sequestration is one important way to help solve this problem.

The big picture

“The atmospheric concentration of carbon dioxide in 2005 **exceeds by far** the natural range over the last 650,000 years . . .”

—Summary for Policymakers Working Group 1, Intergovernmental Panel on Climate Change (2 February 2007)



Scripps Institution of Oceanography

What does it mean?

*Not the end of the world—
but no cakewalk, either*

- More intense hurricanes
- Increased risk of both floods and droughts
- Sea-level rise (possibly catastrophic after our lifetimes)
- And more . . .



Feedbacks—the scary part

Negative feedbacks
work to keep system
in check



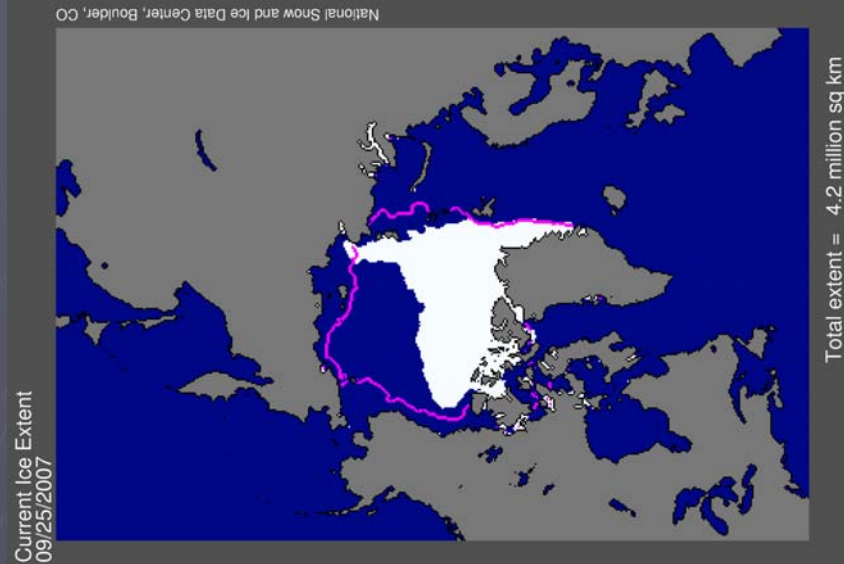
Bob Henson

Positive feedbacks
amplify a trend



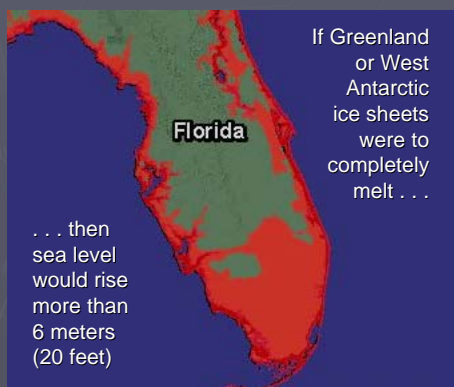
Josh Landis, National Science Foundation

Arctic: the big melt



How high the sea?

IPCC's new projection: +18-59 cm (7" to 24") by 2100.
This would be serious but not catastrophic.



Jonathan Overpeck/University of Arizona

If Greenland or West Antarctic ice sheets were to completely melt . . .

However, many researchers believe **far greater rises are possible** (due to speed of recent melting).

IPCC process is **inherently conservative.**

Stay tuned!

The precipitation paradox

As global temperatures rise, both **drought** and **heavy rains** are increasing.
How can this be?

Over land: warmer air sucks moisture from dry land, intensifying drought



UCAR

Over the oceans: more water evaporates into warmer air, helping increase precipitation intensity worldwide

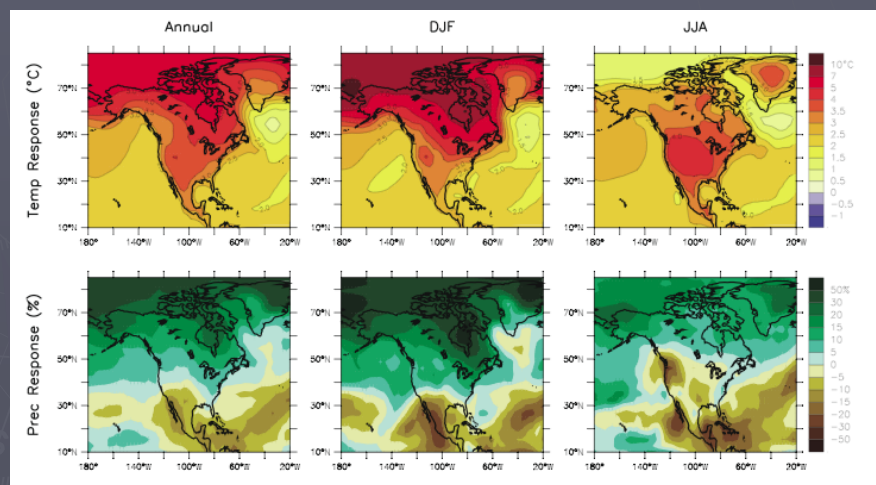


UCAR

The consensus from 21 IPCC models

IPCC WG1 AR4 (2007), Fig. 11-12 • Average of 21 model projections for 2080–2099 vs. 1980–1999 • www.ipcc.ch

Temperature change (°C) and precipitation (%) by 2080s-2090s



Full year

Winter

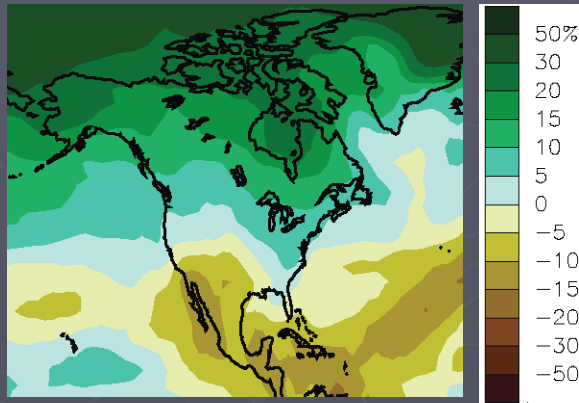
Summer

The Southwest at risk . . .

A major study shows that the U.S. Southwest may enter a **state of semipermanent drought** as soon as the 2030s.

“There is a broad consensus among climate models that this region will dry in the 21st century and that **the transition to a more arid climate should already be under way.**”

—Seager et al.,
Science, 25 May 2007

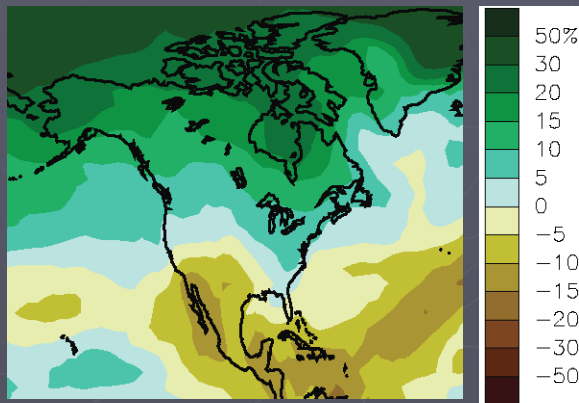


IPCC WG1 AR4 (2007), Fig. 11-12 • Average of 21 model projections for 2080–2099 vs. 1980–1999 • www.ipcc.ch

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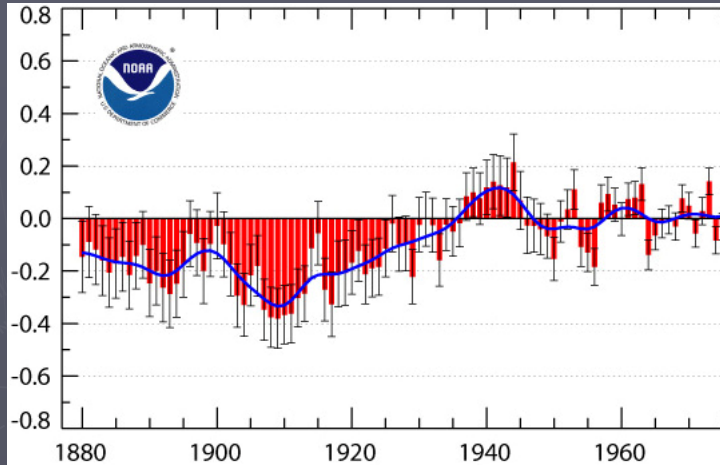
A major study shows that the U.S. Southwest may enter a **state of semipermanent drought** as soon as the 2030s.

“If these models are correct, the levels of aridity of the recent multiyear drought or the Dust Bowl and the 1950s droughts will become **the new climatology of the American Southwest** within a time frame of years to decades.”



IPCC WG1 AR4 (2007), Fig. 11-12 • Average of 21 model projections for 2080–2099 vs. 1980–1999 • www.ipcc.ch

The great global cooling scare



Land temps dropped slightly from 1940s to 1970s.

NOAA/NESDIS/NCDC

The great global cooling scare

“Climatological Cassandras are becoming increasingly apprehensive, for the weather aberrations they are studying may be the harbinger of another ice age.”

TIME magazine
June 24, 1974



But there was more to the story!

Although cooling got a lot of press, more scientists were actually concerned about *warming*

(see new analysis discussed in USA TODAY article, 2/21/08)

But Thomas Peterson of the National Climatic Data Center surveyed dozens of peer-reviewed scientific articles from 1965 to 1979 and found that only seven supported global cooling, while 44 predicted warming. Peterson says 20 others were neutral in their assessments of climate trends.

The study reports, "There was no scientific consensus in the 1970s that the Earth was headed into an imminent ice age.

“ . . . a strong case can be made that the present cooling trend will, within a decade or so, give way to a pronounced warming induced by carbon dioxide.”

“Climatic Change: Are We on the Brink of a Pronounced Global Warming?” W.S. Broecker, *Science* 189, 460 (1975)

A nonpartisan issue in 1988 . . .

“Those who think we are powerless to do anything about the greenhouse effect forget about the ‘White House effect.’ ”

George H.W. Bush, on the campaign trail
August 1988



. . . and again in 2007



“The problem isn't a Hollywood invention. . . . it is a serious and urgent economic, environmental and national security challenge.”

—John McCain, April 23, 2007



“I believe it's one of the greatest moral challenges of our generation.”

—Barack Obama, October 14, 2007



“For this generation of Americans, climate change is our Space Race.”

—Hillary Clinton, November 5, 2007

Addressing climate change as a society

**Everyone has a role—
but we face some steep hurdles**

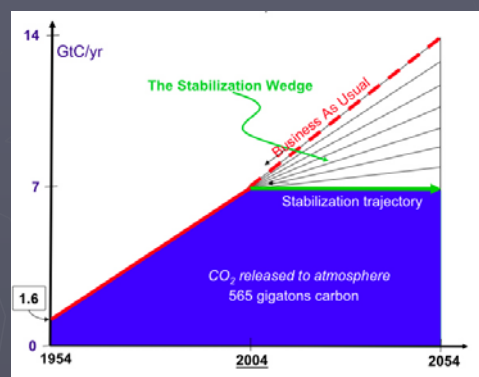
- It's **human nature** to put things off
- Wall Street and other aspects of our economy tend to **reward short-term profit**, penalize long-term investment
- **It's someone else's problem to fix—**corporations, Congress, China, etc.

Energy: complex choices

- **Oil and gas:** will it run out soon enough?
- **Coal:** huge reserves in US and China—a climate disaster if not burned cleanly
- **Solar and wind power:** each growing ~30%/year, yet we'll need more
- **Nuclear power:** potentially climate-friendly (and still problematic)
- **Biomass:** ethanol could help if we develop *cellulosic* forms (such as switchgrass)

Some hope: the wedge strategy

Divide and conquer—by chopping the task of emissions control into smaller slices, each slice becomes more manageable



Two key slices:

- **conservation tillage on all cropland**
- **reforestation of an area half the size of US**

Addressing climate change as individuals— what can we do?

Make our **homes** more energy-efficient

Reduce our emissions from
transportation

Consume smartly

Talk about this issue!



Where you can learn more

IPCC Web site: www.ipcc.ch

UCAR Web site: www.ucar.edu
(Feature story "Understanding Climate Change")

RealClimate blog:
www.realclimate.org



... and my
own book :-)



Here's to a healthier climate!

