How Warm is Too Warm?

Avoiding Dangerous Climate Change

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The Global Warming Problem...

Greenhouse gases are accumulating in the atmosphere at an exponential rate...

IPCC 2007
Today

Taking the atmosphere far outside its natural range...
As a result, climate is already changing...
• Temperature higher: at land, sea surface, underground, under ice, aloft, northern hemisphere, south hemisphere.

• Ice-covered areas are receding: glaciers, snow and ice-lines retreating, freeze-season shorter for lakes and streams, less extreme cold.

• More intense heat, less intense cold: potential heat wave mortality

• Precipitation more intense: potential for flooding

• Tropical storms appear to be more intense

• Greenland and West Antarctic ice sheets fraying at edges

• Ocean acidification has already begun

• Atmospheric circulation changing

• Some changes are accelerating
...threatening us with large and potentially dangerous hazards
If the situation is so serious, why has action proven so difficult to initiate?

- Fossil fuels are cheap, convenient, and pervasive
- Related interests (including you and me) resist change
- Lack of political leadership
- *But the science itself is an obstacle to action...*
...because this is not a traditional political issue; the scientific fundamentals are unusual:

- **Persistence** of emissions in atmosphere

- **Lag** between emissions and consequences ---in temperature and responses

- **No apparent limit** on climate change unless emissions are reduced
Persistence

emissions

concentrations
Lag between emissions and consequences, and no apparent limit

IPCC AR4 2007
Yet some approaches have been tried at the global, national, and local level, falling into three categories:

- Set a technological objective
- Set a politically-determined objective
- Set an environmentally-driven objective
Technology objective

For example:

• Starting in 2020, require all new electric power plants burning coal to employ carbon capture and storage

• Provide subsidies in the meantime to stimulate research to resolve technical issues

• Provide preferential tax treatment for new plants

Problem: picking winners…what if storage leaks?
Projecting technology trends has a poor track record...fuels
and fuel-using technologies
Politically-determined objective (Kyoto Protocol)

- Set binding (or voluntary) international, national, and local targets and timetables for reductions of emissions determined by cost as well as technical and political feasibility

- Learn about feasibility from experience

- Set additional goals

- Problem: Does this approach get you where you want to go? Is it enough? Is it too much?
...and international deals are difficult
Environmental Objective

- Determine “how warm is too warm”
- Set targets on greenhouse gas concentrations to avoid this level of warming
- Set emissions reductions accordingly
- Problem: Uncertainties connecting emissions, concentrations, and climate change are very large
A combination of all 3 may work best

• Set a long term (100-year) objective but be prepared to change it as we learn

• Set 10, 20, 30-year emissions targets aimed at meeting this objective

• Provide some financial and regulatory incentives but without picking winners
A framework exists for doing so: UN Framework Convention on Climate Change

"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."
Each stable concentration level corresponds to a stable temperature.
Stabilization of concentrations at any plausible level requires large reductions in emissions...but how fast?

What is the appropriate concentration?

Meinhausen 2006
One such target under discussion requires very stringent policy and large emission reductions.
But what is dangerous depends on who you are and where you live...

Some possibilities:

- Drying at lower latitudes
- Loss of unique ecosystems
- Intensification of extreme events
- Abrupt climate changes (ocean circulation)
- Sea level rise
Widespread drying predicted...

**FIGURE SPM-6.** Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. [Figure 10.9]
Projected Changes in Annual Runoff, 2041-2060
Percentage change relative to 1900-1970 baseline. Any color indicates that >66% of models agree on sign of change; diagonal hatching indicates >90% agreement. Nature, 438, 347-350, 2005.)

...threatening supplies of water and food
Ecosystems Changing, Shifting, Species Disappearing... **undermines sustainable development**
Extreme events

• May be broadly destructive

• While at the same time affecting most heavily particular, vulnerable elements of the population

• Several types of extremes are expected to intensify with warming, e.g., heat waves, torrential rainstorms, tropical cyclones
Death Rate, European Heat Wave 2003: Probability of occurrence amplified by global trend

Share and Jendritsky, Nature, 2004
Hurricane Katrina may not have had a greenhouse-gas component...
...but it bears lessons about the ability to adapt to changing extremes.
Abrupt climate changes occurred in the past. Could it happen again?

Temperature above northern ice sheet, 20-60Kyr bp

Marshall and Koutnik, Paleooc. 2006
Changes in ocean circulation, sensitive to warming, may have been responsible.
Next Time...

Ultimately, sea level rise may be the biggest problem