The Science of Climate Change…
and its implications.

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Overview

• The Science of Climate Change : Update
  – the IPCC Third Assessment Report
  – the long term : 2100 and beyond...
  – in the context of natural variability & past climate change

• Three special issues
  – the transatlantic dimension : do US scientists agree?
  – the size of the problem, in a global & long term context
  – what is needed for a solution...
    • Conservation, renewables, economic incentives, carbon
taxes, direct CO₂ sequestration, the role of nuclear power
Northern Hemisphere temperature since 1000 AD
Source: Jones, Briffa and Osborn

Global Temperature Change, 1860-2000
CO₂ Concentration since 1000 AD

CO₂ emissions under various scenarios
CO$_2$ concentrations under various scenarios

GLOBAL TEMPERATURE RISE
due to “business-as-usual” greenhouse gas emissions
Projected temperature change under various scenarios (1750 to 2100 AD)

**CHANGE in TEMPERATURE**
by the 2050s, relative to present day, northern winter
CHANGE in PRECIPITATION
by the 2050s, relative to present day, northern winter

SEA LEVEL RISE and its components

Antarctica not included
Total
Thermal expansion
Glaciers
Greenland
• The third assessment states that
  – “The global-average surface temperature has increased over the 20th century by about 0.6 °C.”
  – “Most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations.”
  – “Global mean temperatures are likely to rise by between 1.4 and 5.8 °C by 2100...”
  – ... and to continue rising for a long time after that
• to stay near the bottom end of this range...
  – global CO₂ emissions will need to be reduced to less than 50% of their current global level
• to achieve this is going to be a massive problem
Climate Science
US scientists versus the rest?

- Commissioned by President Bush, as urgent task
- Panel composed of scientists not involved in the work of IPCC, including some influential sceptics
- Resounding endorsement of the IPCC conclusions
- Only one significant reservation: that not all qualifications were included in the summary for policymakers (q.v., see www.ipcc.ch)
Temperature in central Greenland

R.B. Alley, 2000, Two–Mile Time Machine

[Graph showing temperature changes over time]

CO₂ in air

Antarctic Temperature

R.B. Alley, 2000

Two–Mile Time Machine
The trouble with Kyoto

• After Bonn 2001, the Kyoto Protocol is now a very small step in the right direction
• It is flawed, because
  – it is short term (it includes targets for the first commitment period only)
  – it lacks a declared long term strategy (e.g. contraction & convergence)
  – there are too many loopholes (especially land carbon sinks, see Royal Society report at www.royalsoc.ac.uk)
  – the USA is not included!
• ...but the flaws may not be fatal

Global Warming: The Big Picture

• Reducing emissions by 50% : factor 2
• with population growth (global) : factor 2
• and increased energy use (per capita) in the developing world (to EU level only) : factor 5
• Altogether we need factor 20 (decarbonisation)
• Energy efficiency, renewables (etc) : maybe we can achieve factor 4 (?)  
  – (c.f. “Factor Four” by Weitzsacker, Lovins & Lovins)
• Hydrogen is only a carrier...
• Nuclear power ?
• We shall need to deploy CO₂ sequestration....
Carbon Dioxide Sequestration

- Must be physical/chemical
  - biological sinks are too small (maybe ~ 100 Gt total)
  - and too uncertain (easily remobilised)
- Options include
  - geological (liquid CO$_2$, into deep aquifers)
    - e.g. Sleipner Project (1 Mt/yr)
  - oceanic (liquid CO$_2$, to water depths > 3000m)
    - residence time ~ 500 years, ~ 80% permanent
    - good enough (?), favoured by Japan
  - chemical (CO$_2$ + serpentine $\rightarrow$ magnesite)
    - solid, and most can replace rock mined
    - use some to neutralise acidified surface ocean water ?
- Cost is non trivial, but maybe < $50/t  (and falling)

A way forward ?

- We should develop CO$_2$ sequestration technology
  - as a precautionary measure (“no regrets”)
  - on a large scale (plan for several/many Gt/yr)
  - building up over the next few decades
  - it will take a long time...
  - ... so we should start soon
- See DTI/IEA report (2000)
- We need to increase (global) R&D in this area substantially
  - expand existing UK & EU work
    - N.B. Tyndall Centre, small study, commencing 2001
  - the energy industry could and should take a lead
- We need economic incentives to make this happen
Economic incentives

- A carbon tax of 50 Eu/T(C) would probably be enough to make sequestration attractive…
- This corresponds to:
  - About 100 Eu per person per year (for UK/Europe)
  - About 3p/litre increase in the price of fuel (UK)
- To make this revenue neutral…
  - We would only need to reduce VAT from 17.5% to 15%
- This is not a big deal
  - But it would distort international trading relationships
  - So ideally it should be done by international agreement.
- Europe could take a lead: unilaterally ??
- Need to shift public & political opinion: by education?

Low Carbon Transportation...
A possible solution by Emily Boon & Fenella Martin
Class 4DS, Forres Sandle Manor School
Modelling & Philosophy

- "Science may be described as the art of oversimplification: the art of discerning what we may with advantage omit."


“Man has lost the capacity to foresee and to forestall. He will end by destroying the Earth”

Albert Schweitzer, quoted by Rachel Carson, in her dedication of “Silent Spring”, (1962)