

The Science of Climate Change... and its implications.

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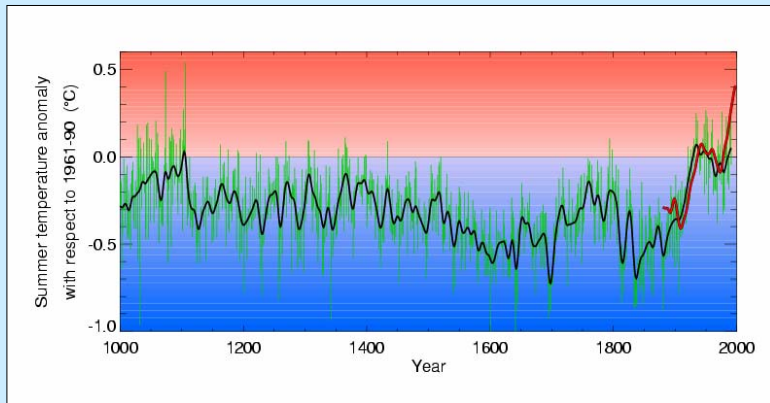
Overview

- 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 trans atlantic 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

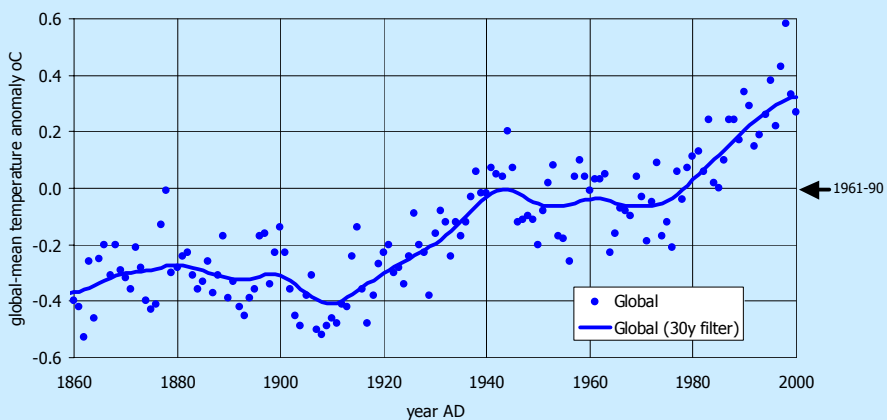
Source: Jones, Briffa and Osborn



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Global Temperature Change, 1860-2000

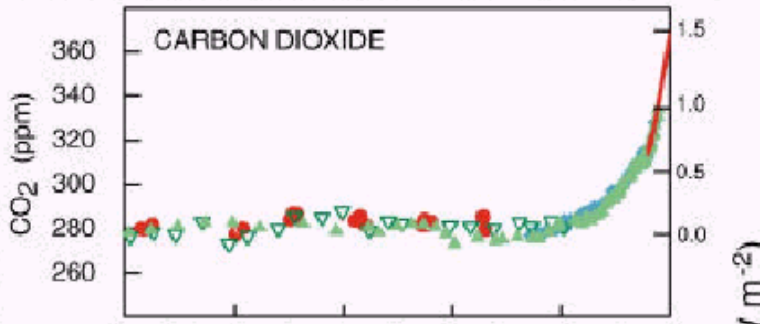


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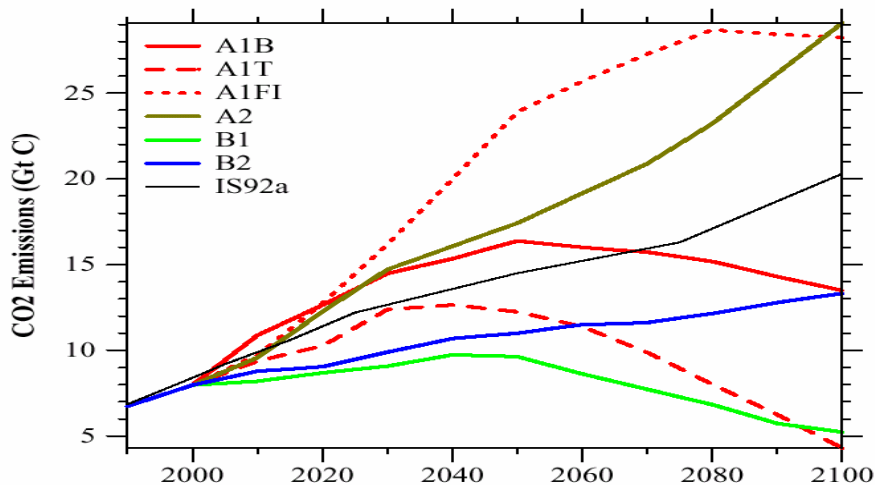
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CO₂ Concentration since 1000 AD

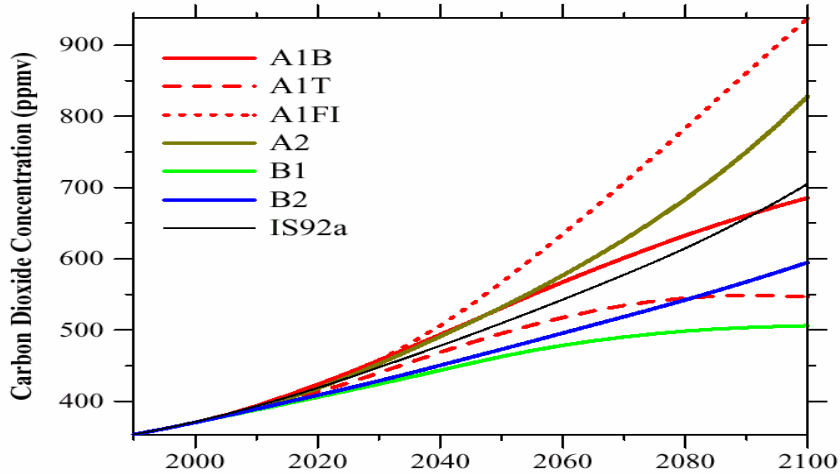
GLOBAL ATMOSPHERIC CONCENTRATIONS OF THREE WELL MIXED GREENHOUSE GASES



CO₂ emissions under various scenarios



CO₂ concentrations under various scenarios

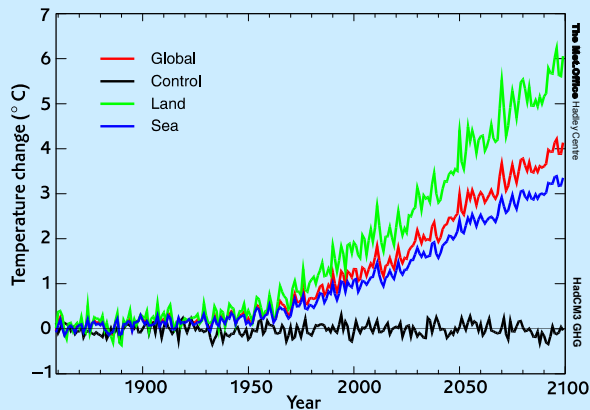


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GLOBAL TEMPERATURE RISE due to "business-as-usual" greenhouse gas emissions

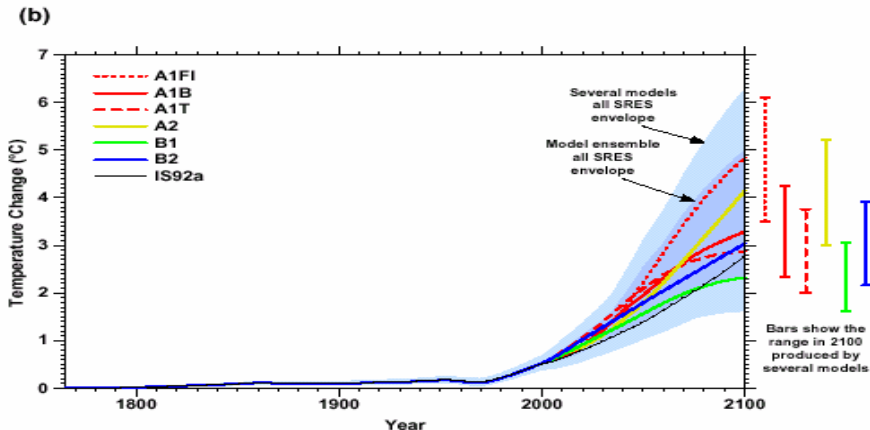


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Projected temperature change under various scenarios (1750 to 2100 AD)

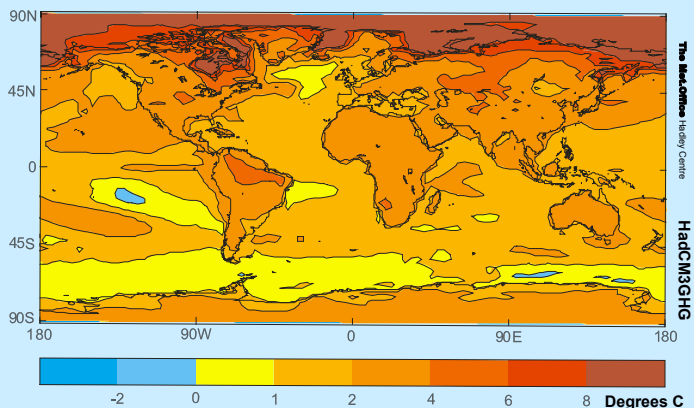


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CHANGE in TEMPERATURE by the 2050s, relative to present day, northern winter



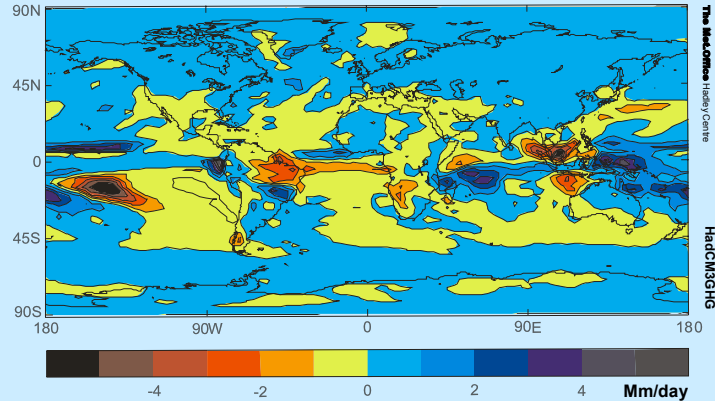
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CHANGE in PRECIPITATION

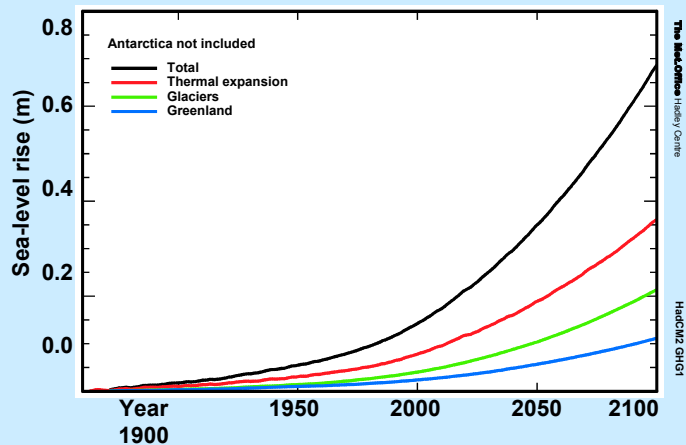
by the 2050s, relative to present day, northern winter



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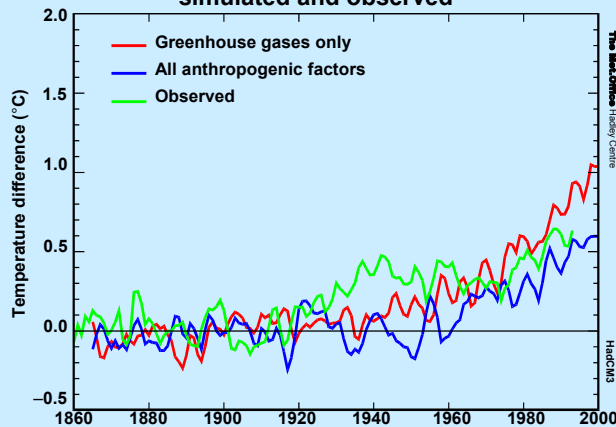
SEA LEVEL RISE and its components



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GLOBAL MEAN SURFACE TEMPERATURE simulated and observed



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Global Warming : the IPCC view

- 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

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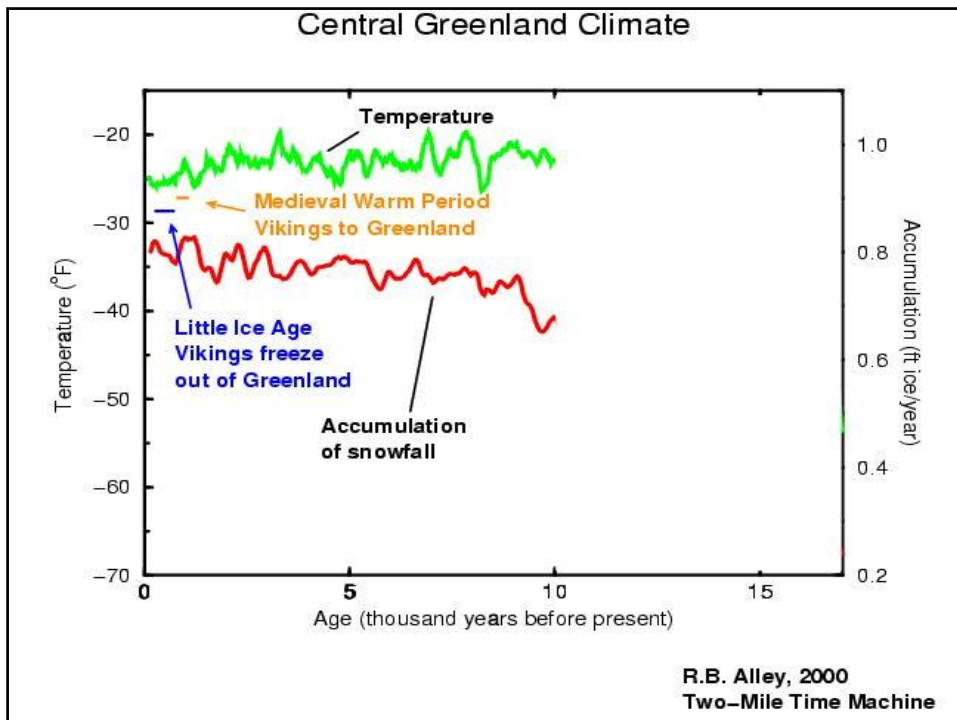
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Climate Science

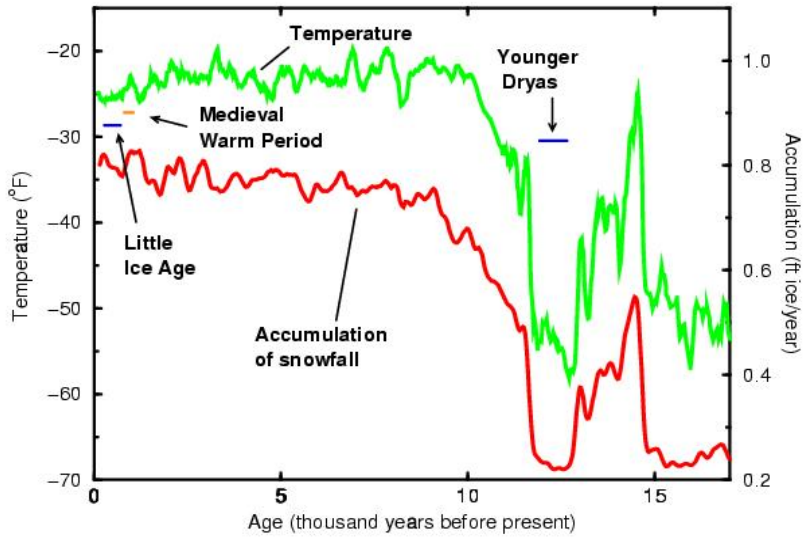
US scientists versus the rest ?

- Report by US National Academy of Sciences (www.nas.edu), June 2001
- 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)

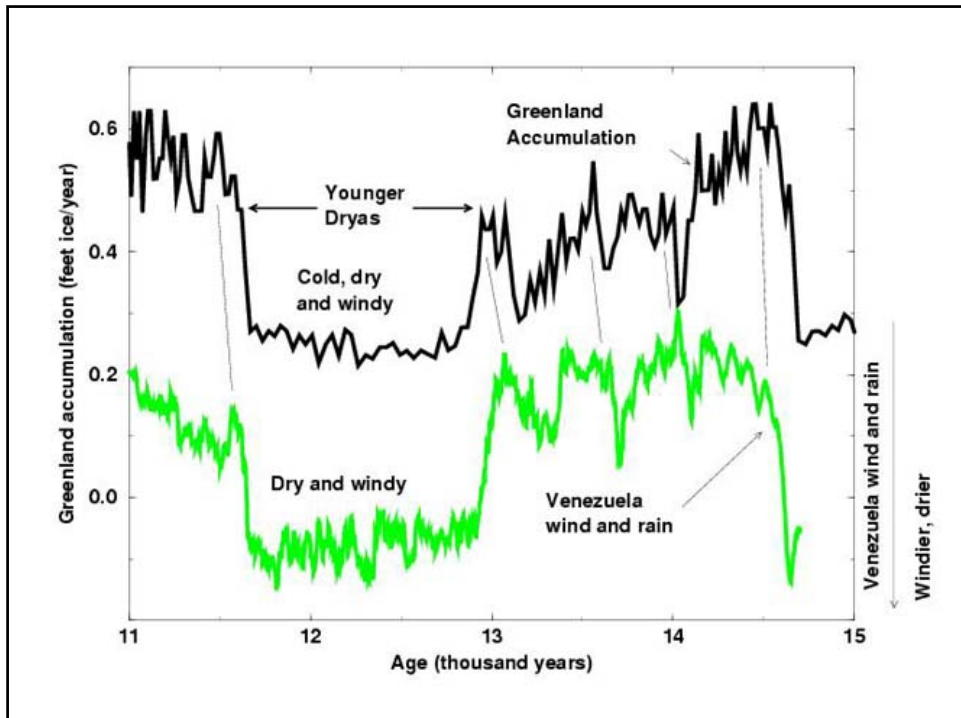
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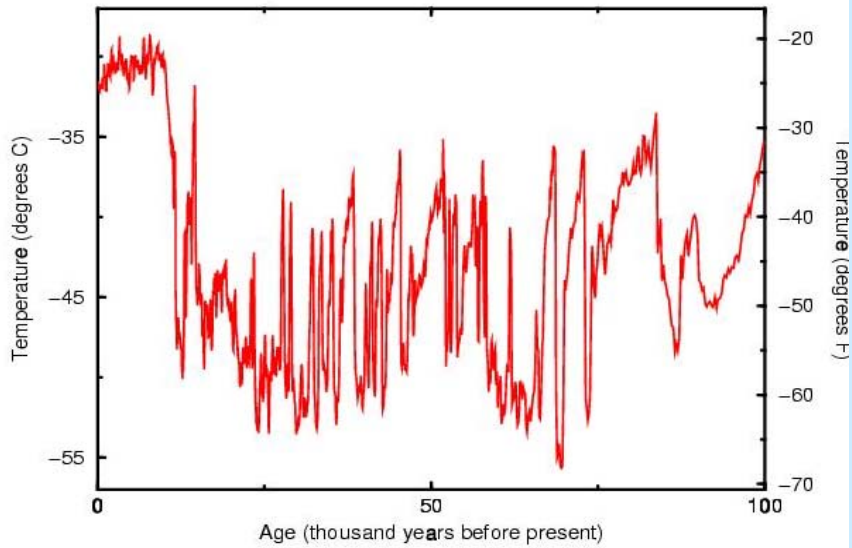
Central Greenland Climate



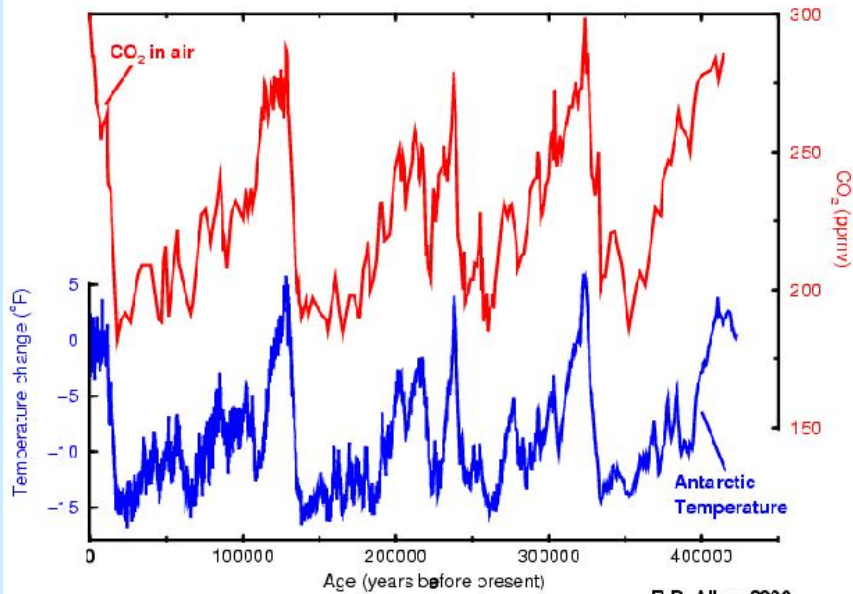
R.B. Alley, 2000
Two-Mile Time Machine



Temperature in central Greenland



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



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 Weizsacker, 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 CO₂, into deep aquifers)
 - e.g. Sleipner Project (1 Mt/yr)
 - **oceanic** (liquid CO₂, to water depths > 3000m)
 - residence time ~ 500 years, ~ 80% permanent
 - good enough (?), favoured by Japan
 - **chemical** (CO₂ + serpentine → 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 CO₂ 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."**

– Karl Popper, "The Open Universe", Hutchinson, London (1982)

***“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)

