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 variablity & 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 CO_2 sequestration, the role of nuclear power

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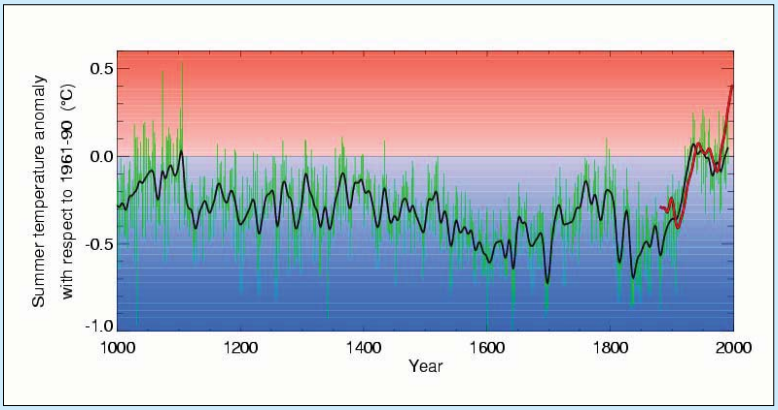
Northern Hemisphere temperature since 1000 AD

Source: Jones, Briffa and Osborn



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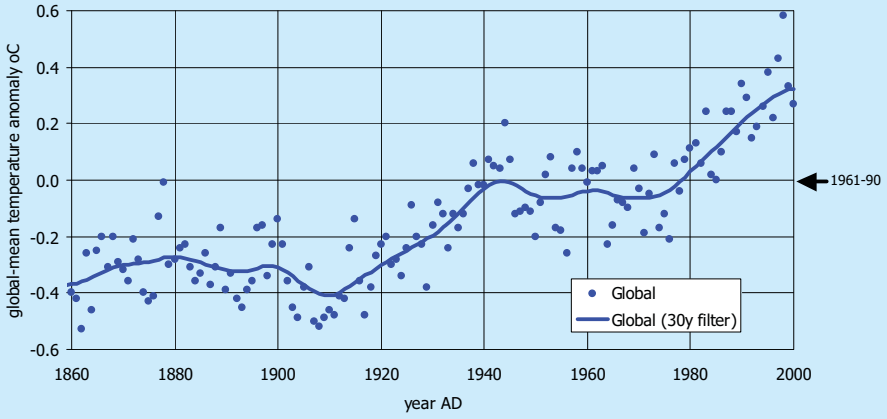
Global Temperature Change, 1860-2000



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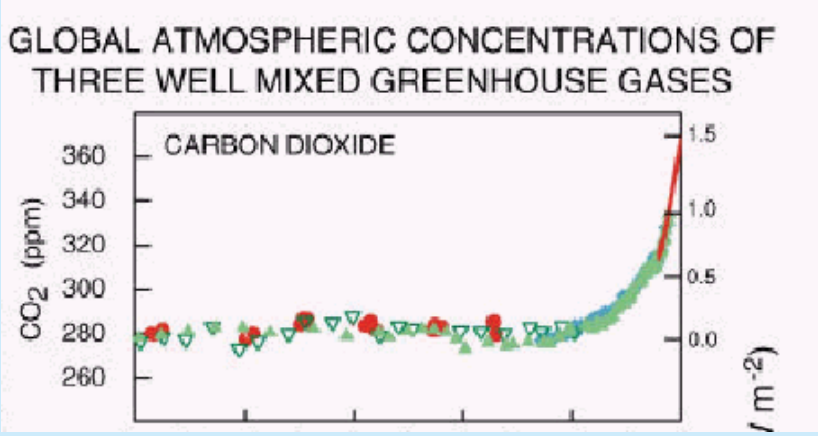
CO_2 Concentration since 1000 AD



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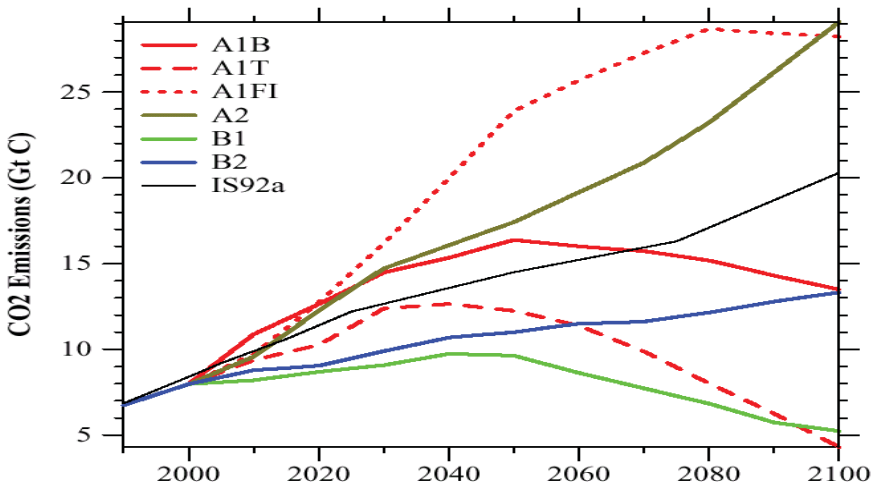
CO_2 emissions under various scenarios



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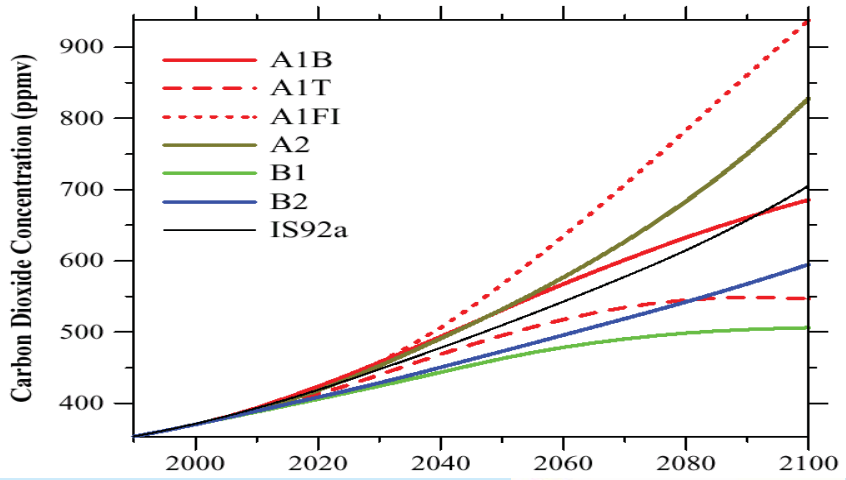
CO_2 concentrations under various scenarios



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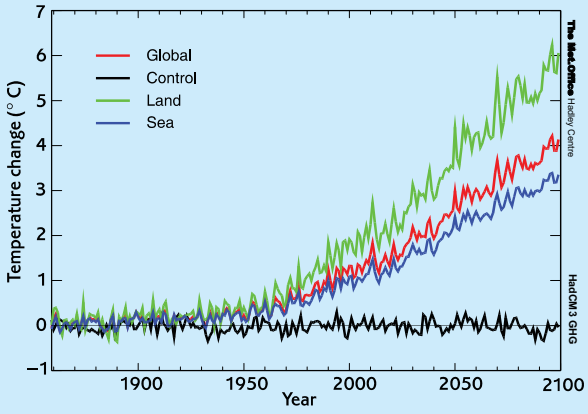
GLOBAL TEMPERATURE RISE

due to "business-as-usual" greenhouse gas emissions



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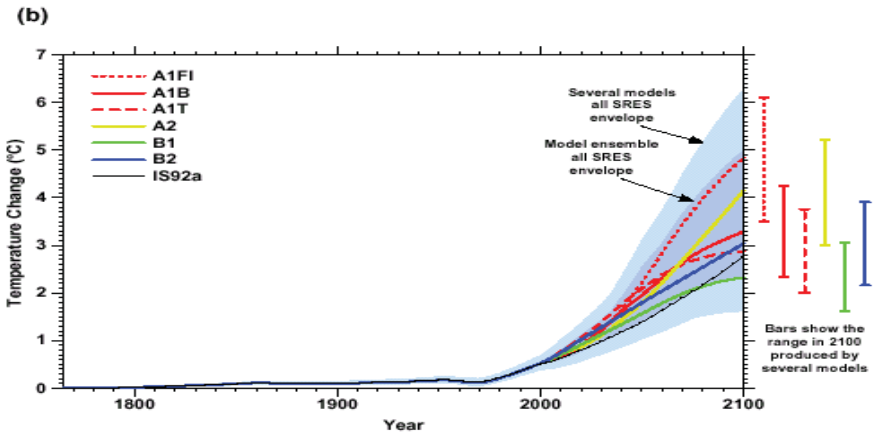
Projected temperature change under various scenarios (1750 to 2100 AD)



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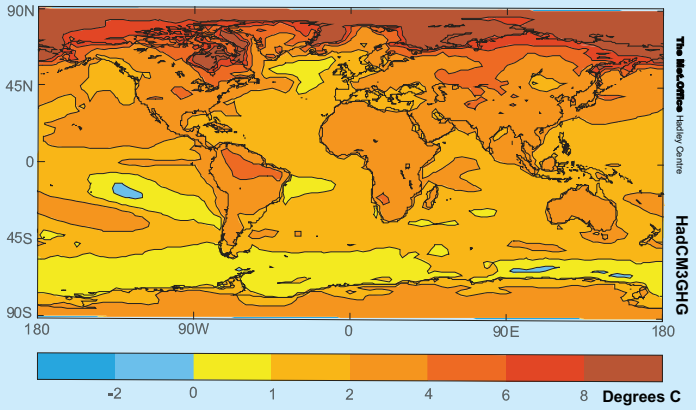
CHANGE in TEMPERATURE

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



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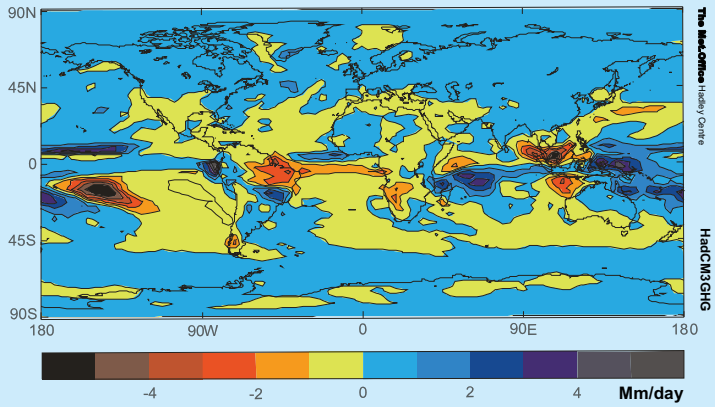
CHANGE in PRECIPITATION

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



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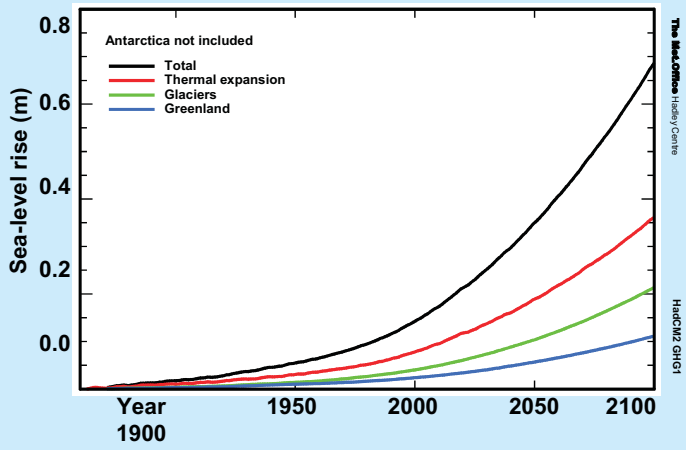
SEA LEVEL RISE and its components



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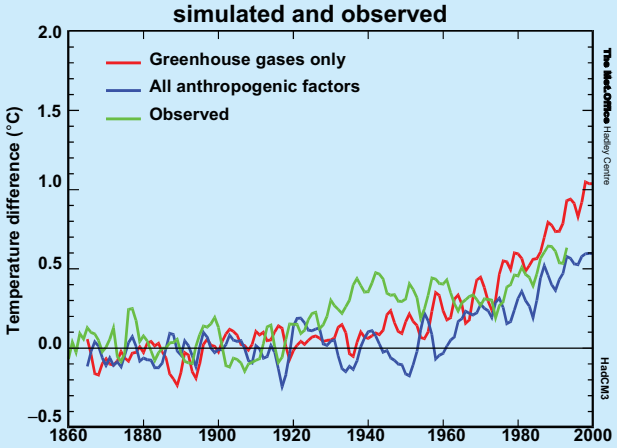
GLOBAL MEAN SURFACE TEMPERATURE

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** CO_2 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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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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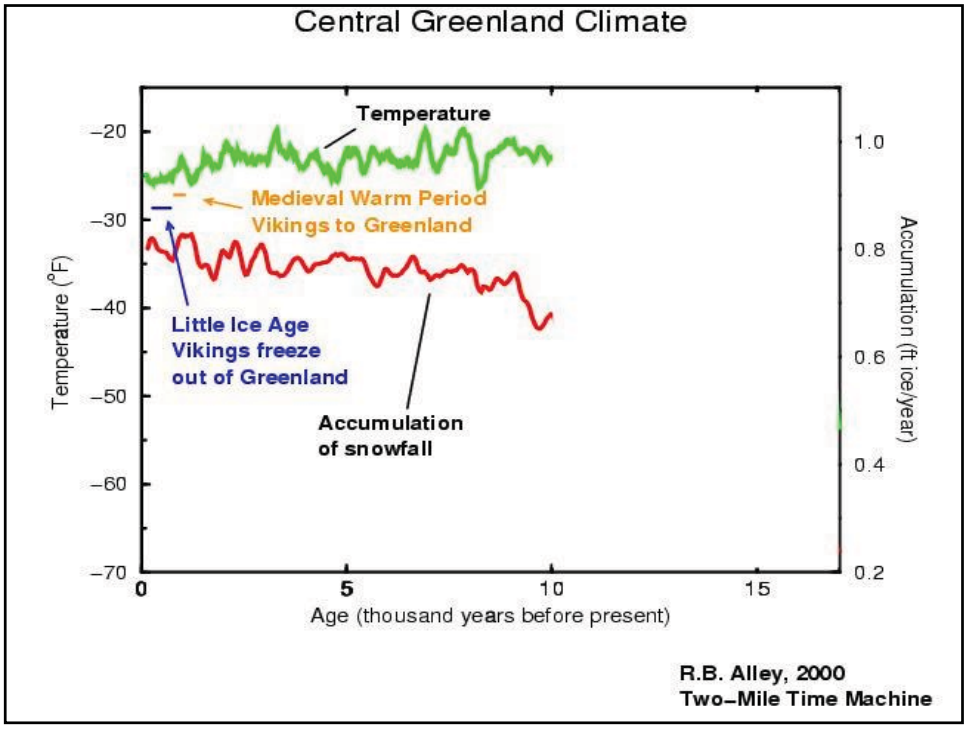
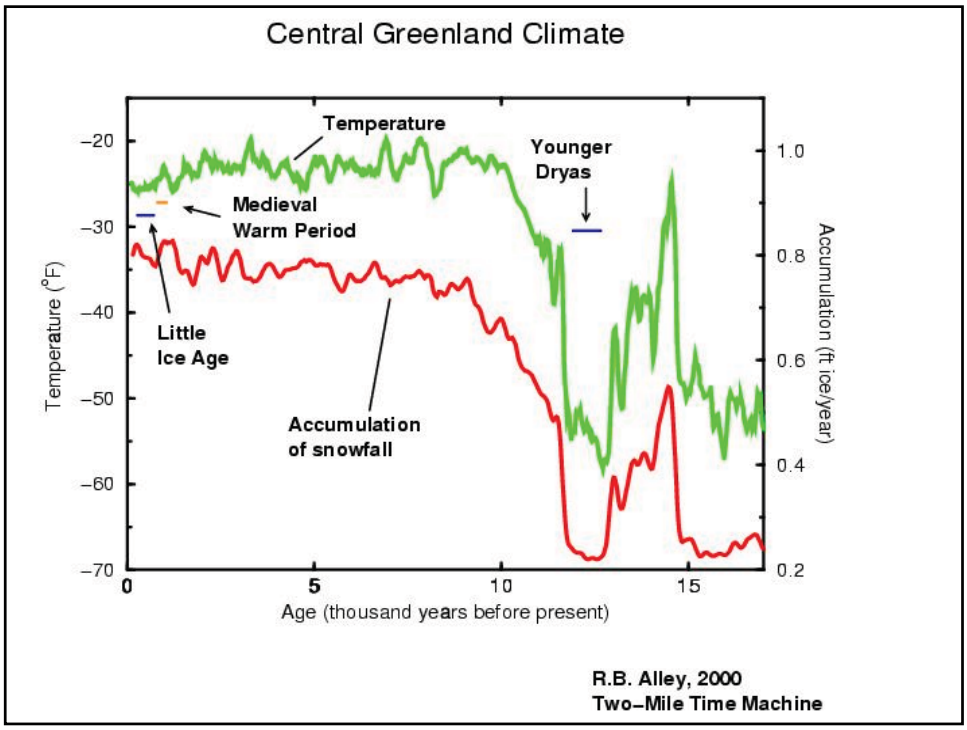
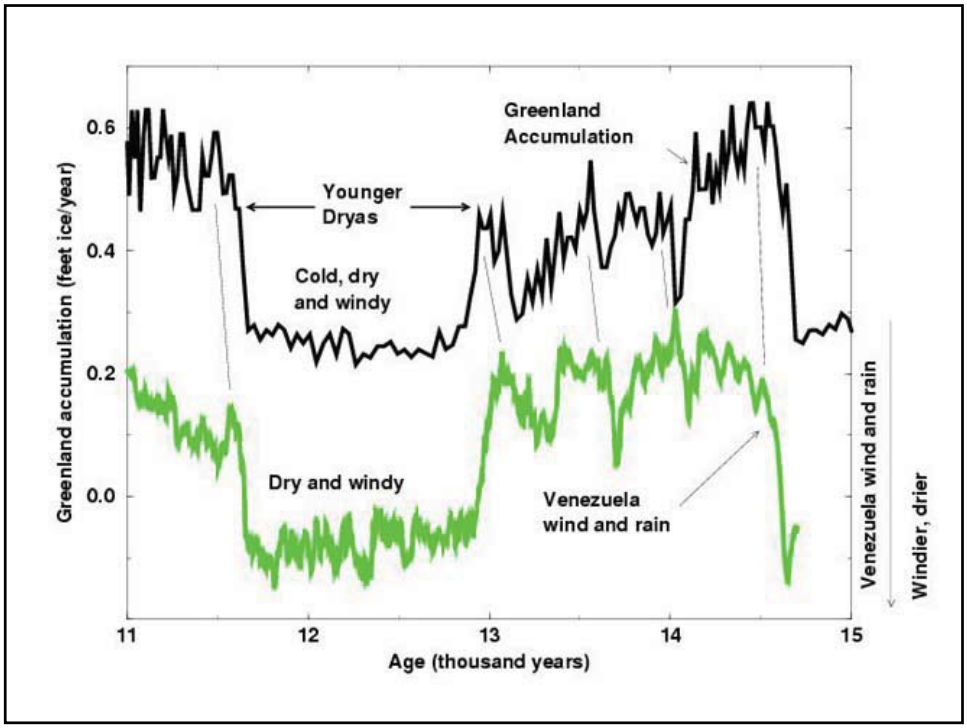
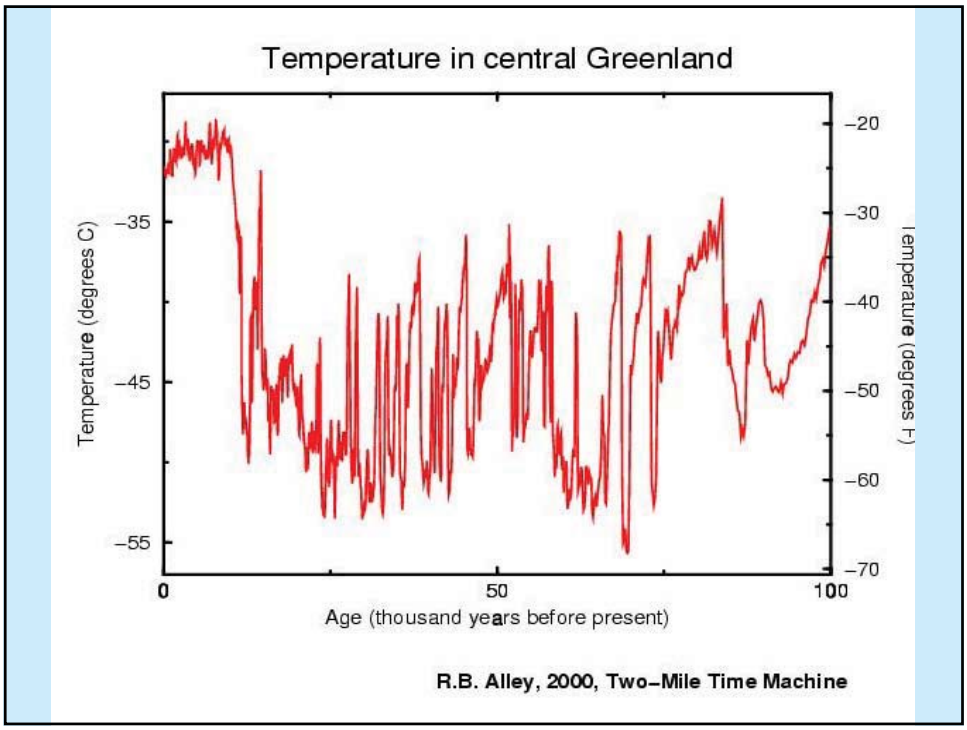
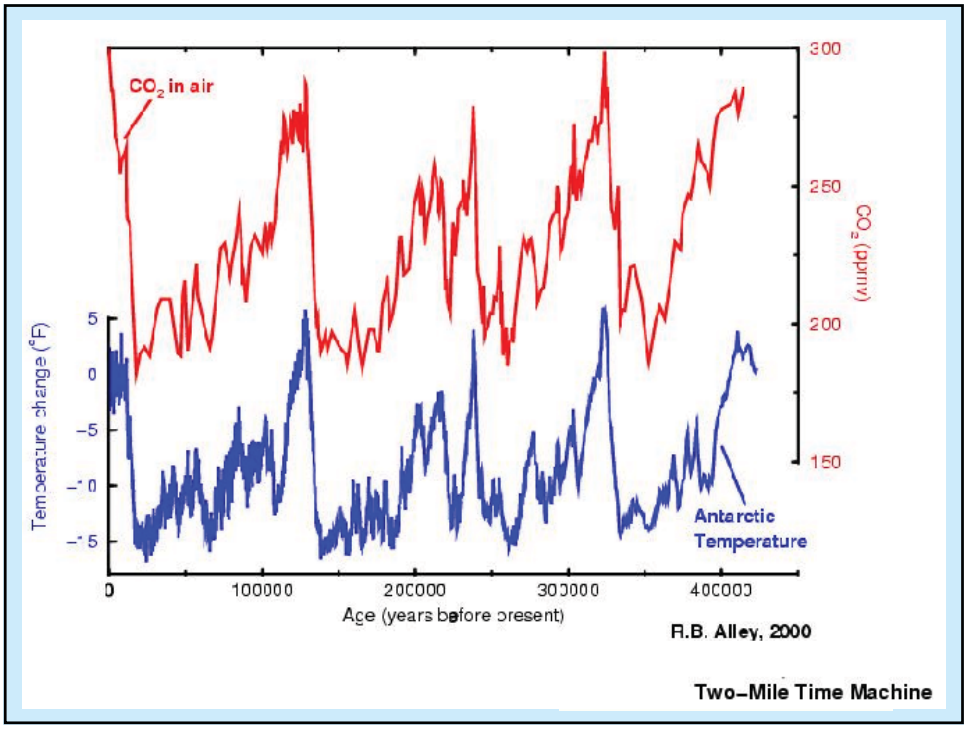



Central Greenland Climate
Temperature
Younger
Dryas
Medieval
Warm Period
Little
Ice Age
Accumulation
of snowfall
Temperature (°F)
Accumulation (ft ice/year)
Age (thousand years before present)
R.B. Alley, 2000
Two–Mile Time Machine


Greenland
Accumulation
Younger
Dryas
Cold, dry
and windy
Dry and windy
Venezuela
wind and rain
Greenland accumulation (feet ice/year)
Venezuela wind and rain
Windier, drier
Age (thousand years)


Temperature in central Greenland
Temperature (degrees C)
−35
−45
−55
−20
−30
−40
−50
−60
−70
0
50
100
Age (thousand years before present)
R.B. Alley, 2000, Two−Mile Time Machine


CO2 in air
Antarctic Temperature
Temperature change (°F)
5
0
−5
−10
−15
CO2 (ppmv)
300
250
200
150
0
100000
200000
300000
400000
Age (years before present)
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 committment 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

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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 **CO_2 sequestration....**

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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 → 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)

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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***

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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 ?

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Low Carbon Transportation...

A possible solution by Emily Boon & Fenella Martin
Class 4DS, Forres Sandle Manor School

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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)

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"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)

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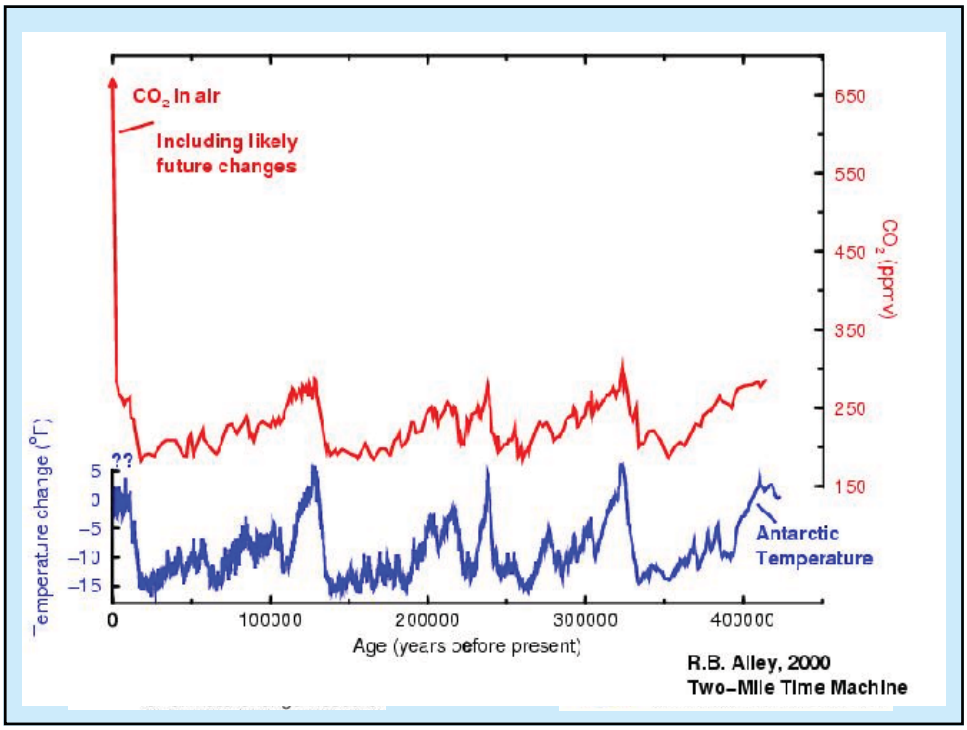
CO_2 in air
Including likely future changes
650
550
450
350
250
150
CO_2 (ppmv)
??
5
0
−5
−10
−15
Temperature change (°F)
Antarctic Temperature
0
100000
200000
300000
400000
Age (years before present)
R.B. Alley, 2000
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