Climate change and biodiversity: interactions and implications for conservation

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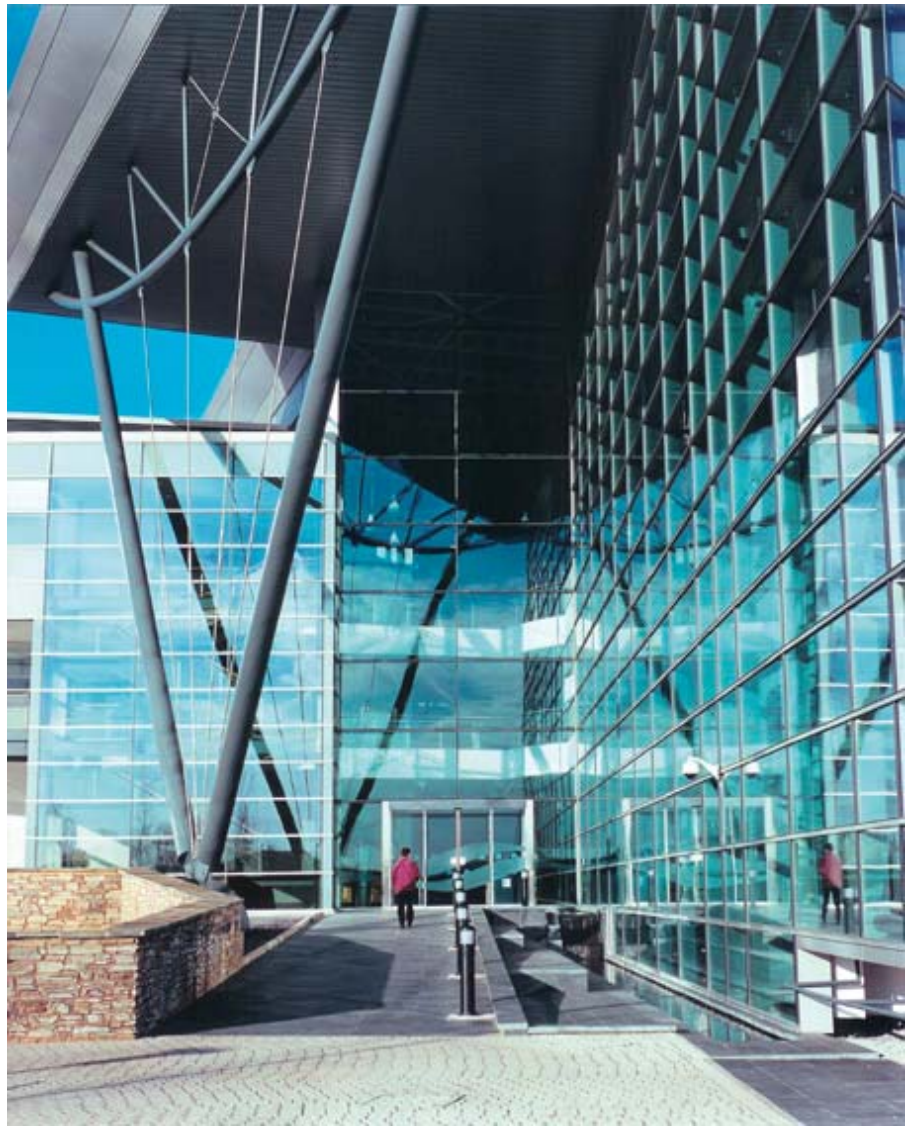
Darwin Initiative Workshop, London Zoo, 24th October 2006

Met Office Hadley Centre

- The Hadley Centre for Climate Change is part of the Met Office
- Based in Exeter, approx 150 staff
- UK government research centre on climate change
- Most funding is from UK government (mainly DEFRA, also MOD, FCO and others)
- Carry out policy-relevant research, provide briefings, answer Parliamentary Questions on climate change…



How do we engage with global policy processes?

- **United Nations Framework Convention on Climate Change (UNFCCC)**

- Engagement via the Intergovernmental Panel on Climate Change (IPCC)
- 10 Hadley Centre staff are lead authors or review editors on IPCC 4th Assessment Report
- Numerous others are contributing authors
- The Technical Support Unit for the "Impacts, Adaptation and Vulnerability" working group is based in the Hadley Centre

- Engagement via Conferences of the Parties (COP) to the UNFCCC
- Hadley Centre staff attend COP side events, giving briefings and providing a stand where delegates can ask science questions
- Brochure of latest research results is distributed at COP
- Next meeting: COP12 Nairobi, Nov 2006

How do we engage with global policy processes?

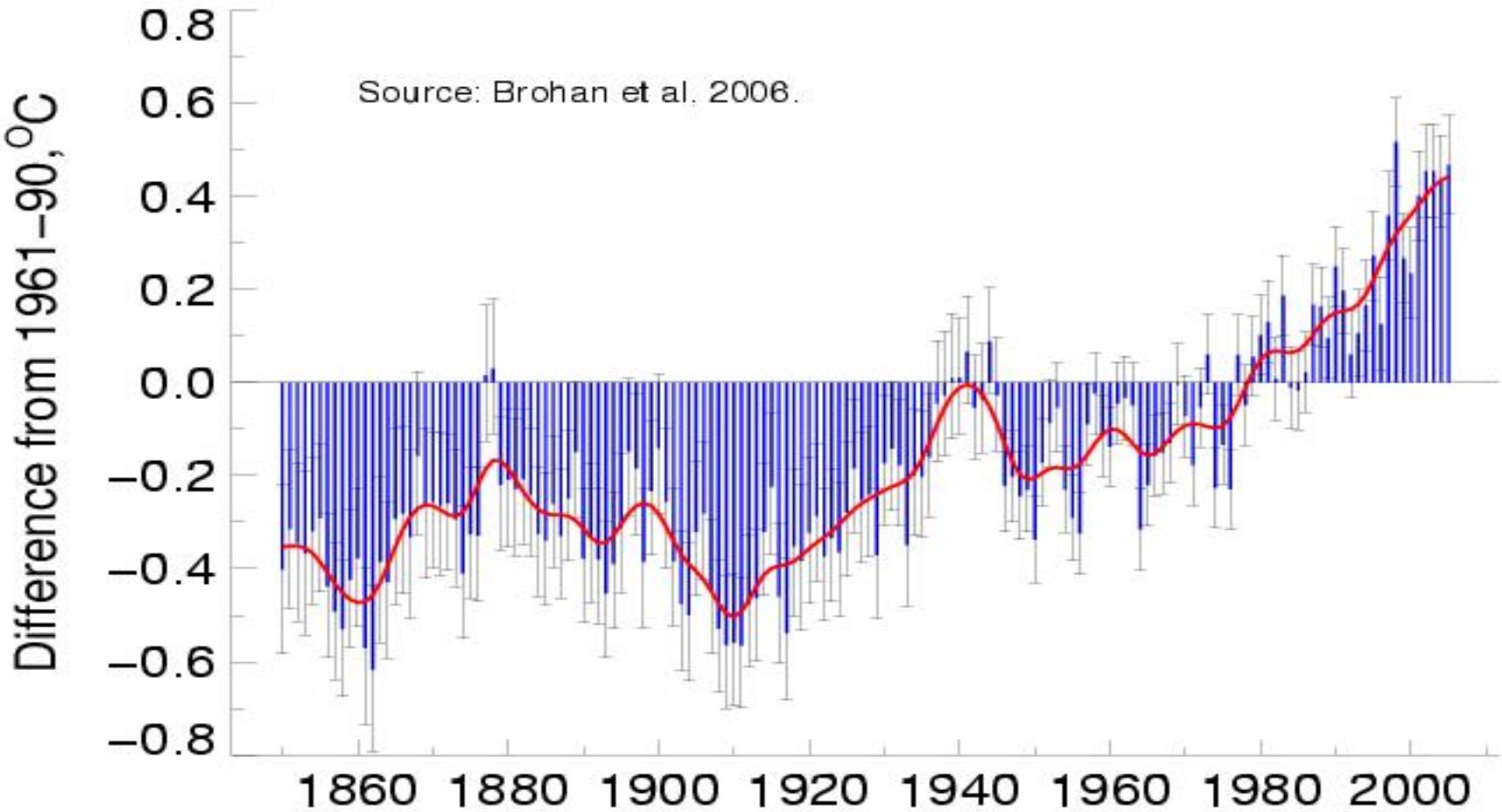
- **Convention on Biological Diversity**
- **United Nations Convention to Combat Desertification**

- Engagement via the Millennium Ecosystem Assessment (MA)

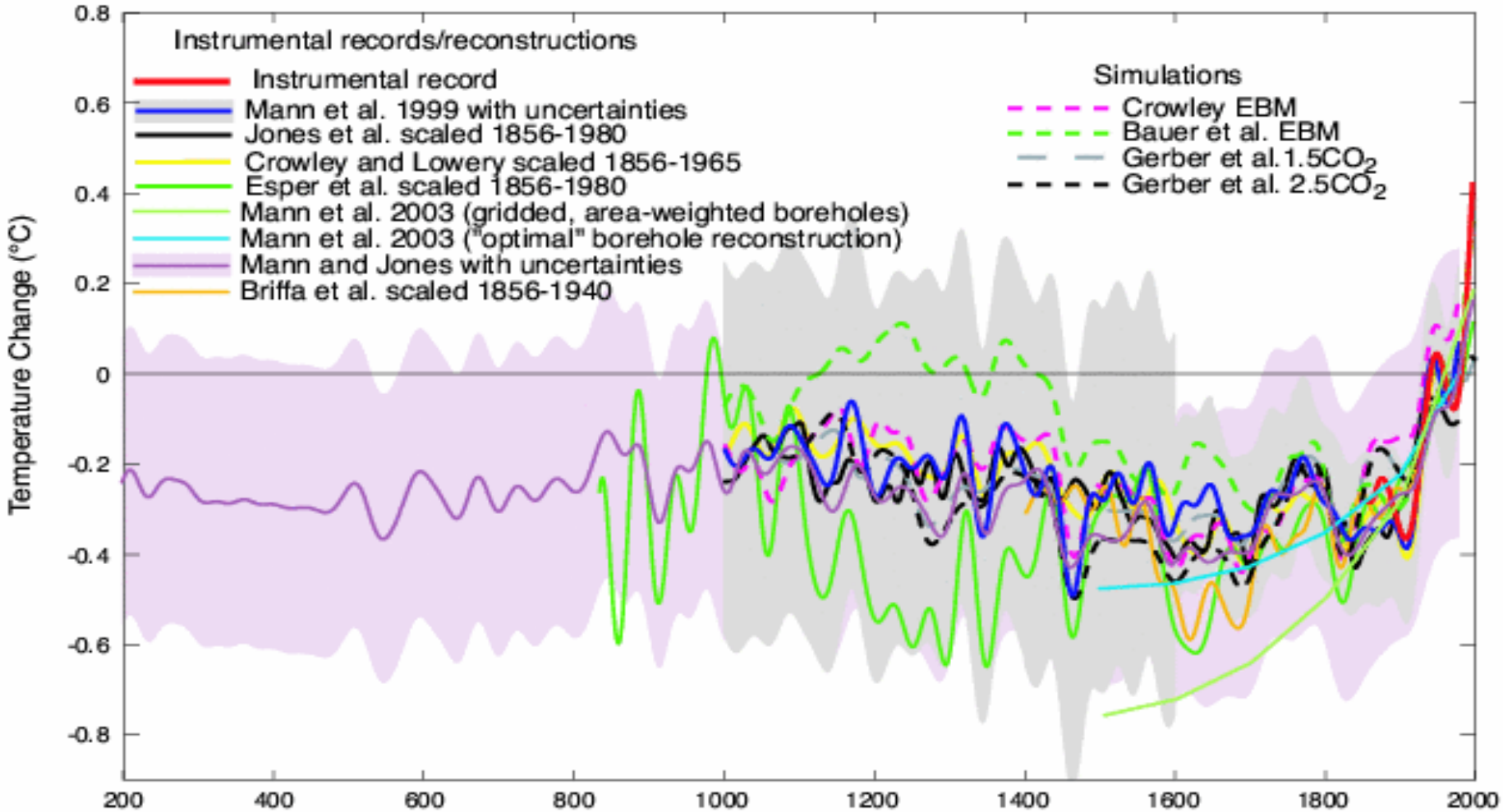
- 1 Hadley Centre staff was lead author on MA

Recent climate change and observed changes in ecosystems

Global mean temperature measurements 1850-present

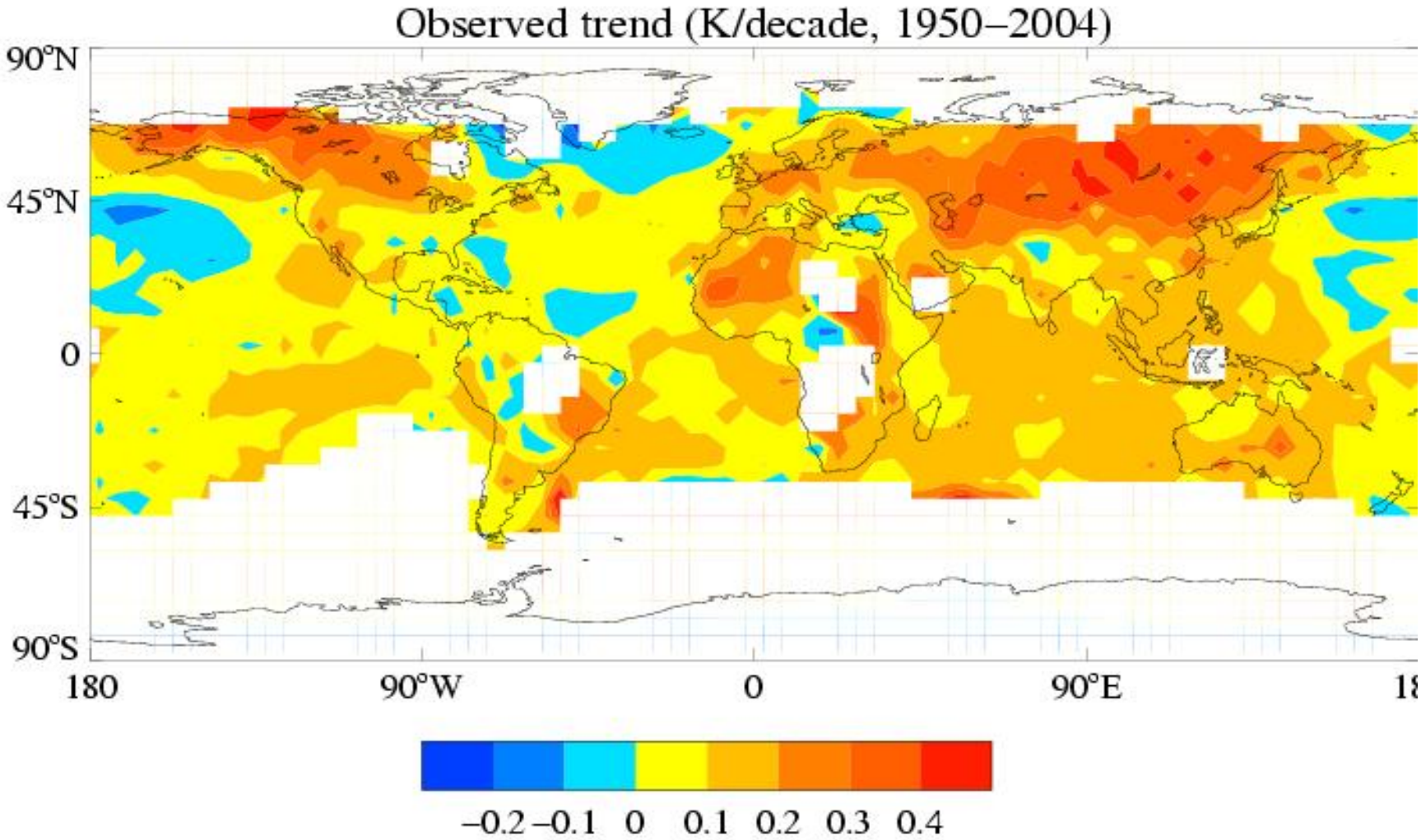


Measurements and reconstructions of Northern Hemisphere temperature over the last 1,800 years.

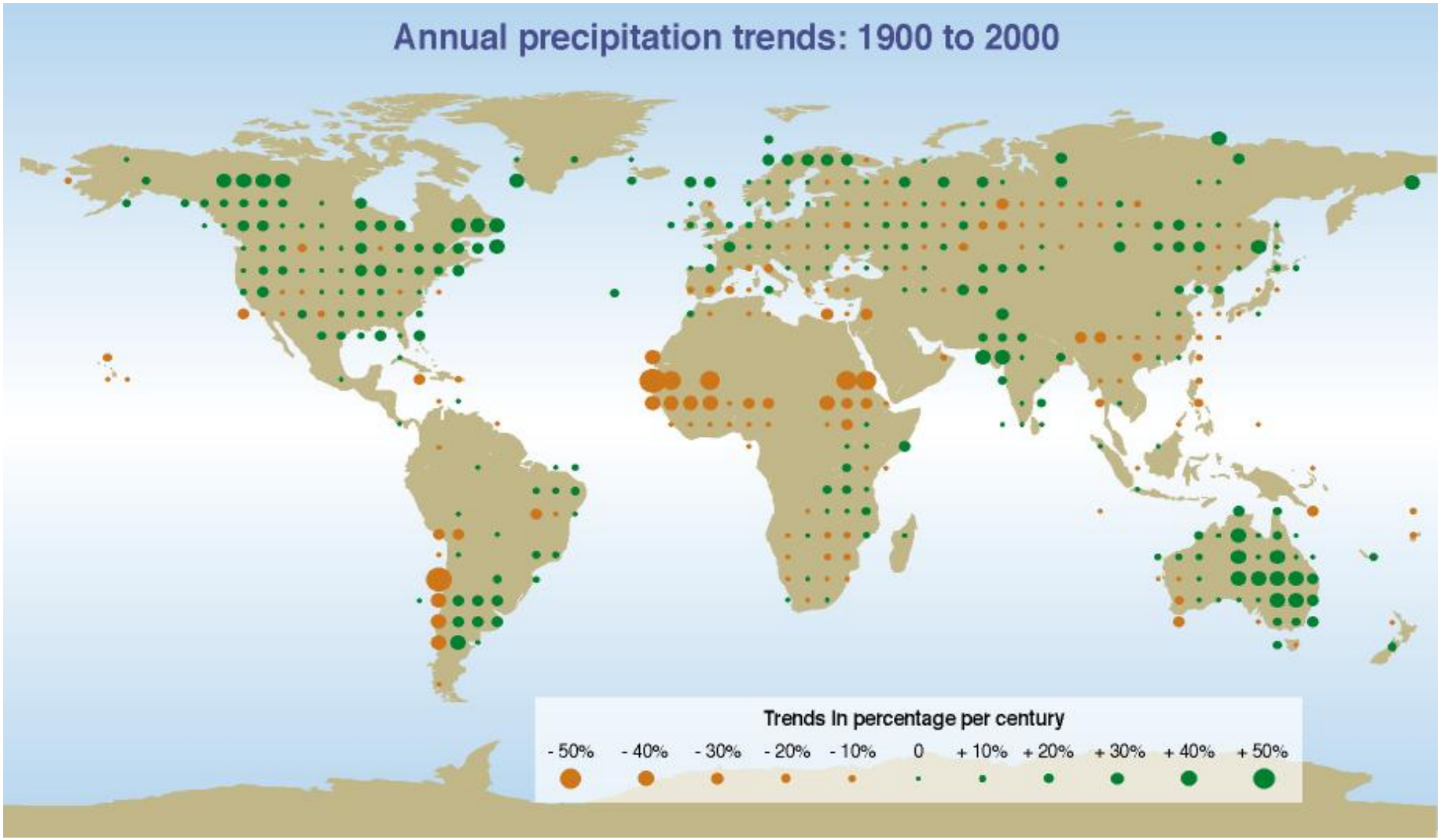


Mann *et al* (2003)

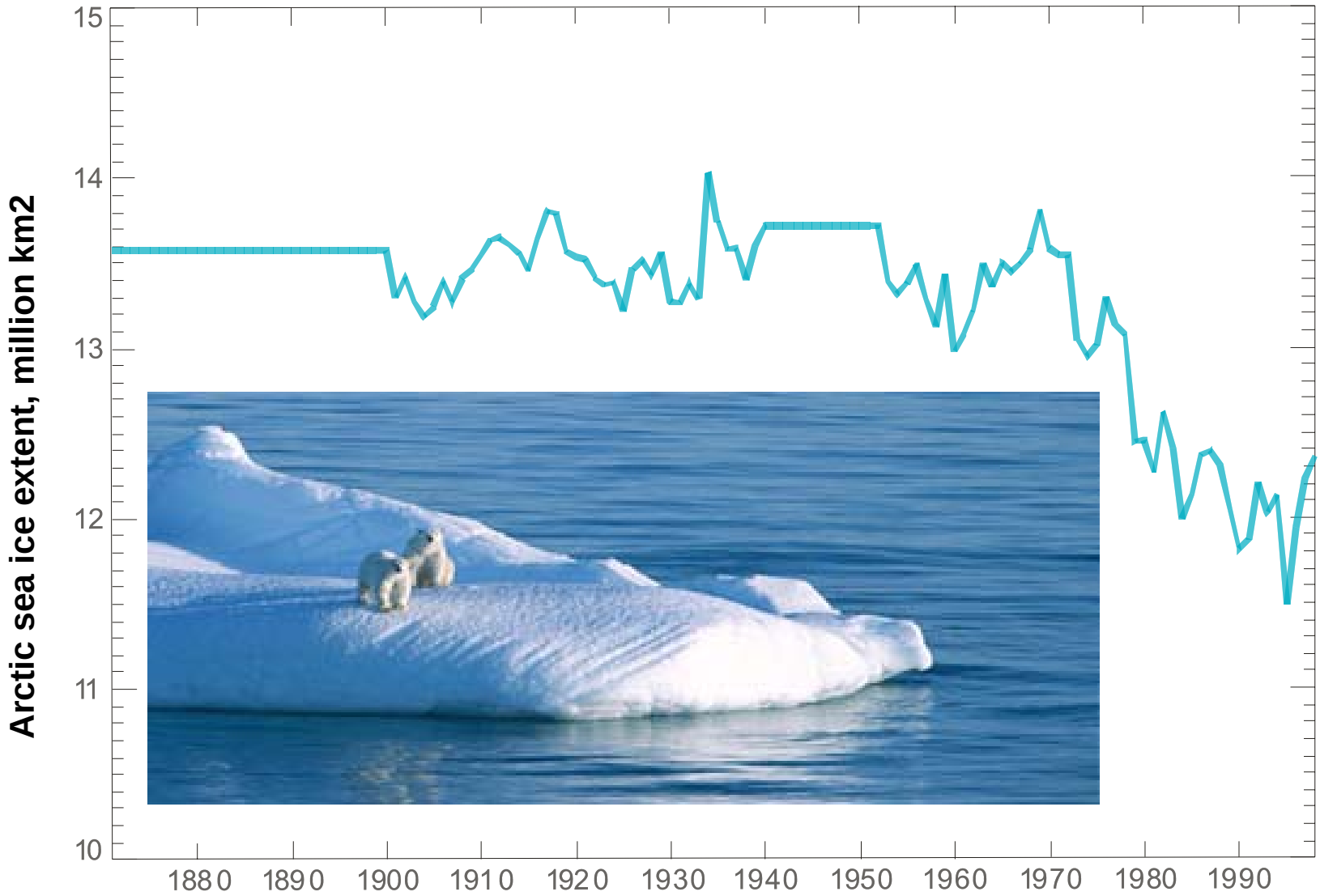
Climate change varies from place to place



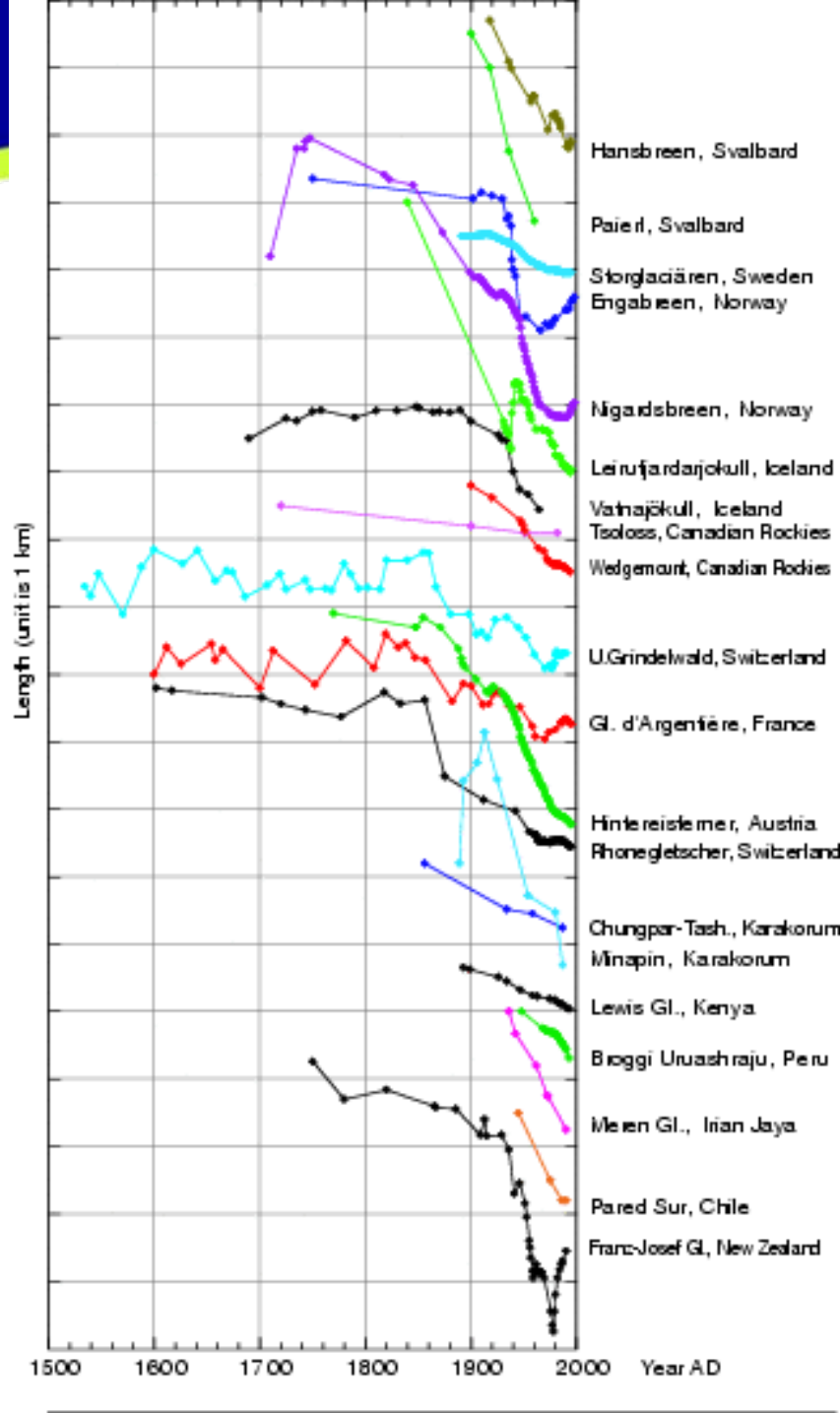
Precipitation patterns have changed



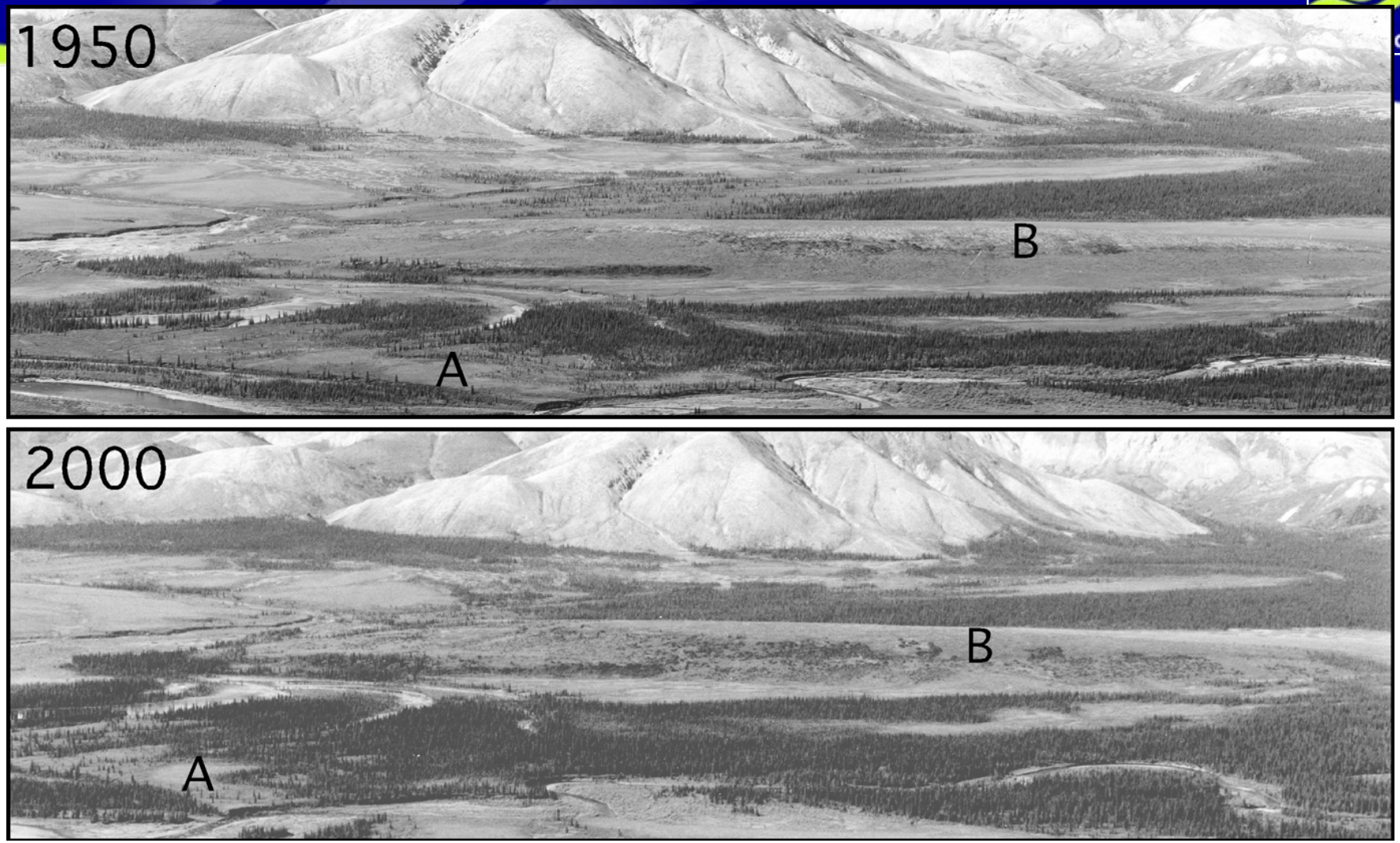
Arctic sea-ice extent is shrinking



Glaciers are retreating worldwide



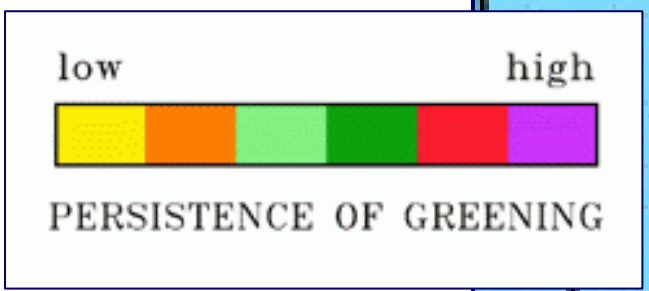
Increased forest and shrub cover in Alaska

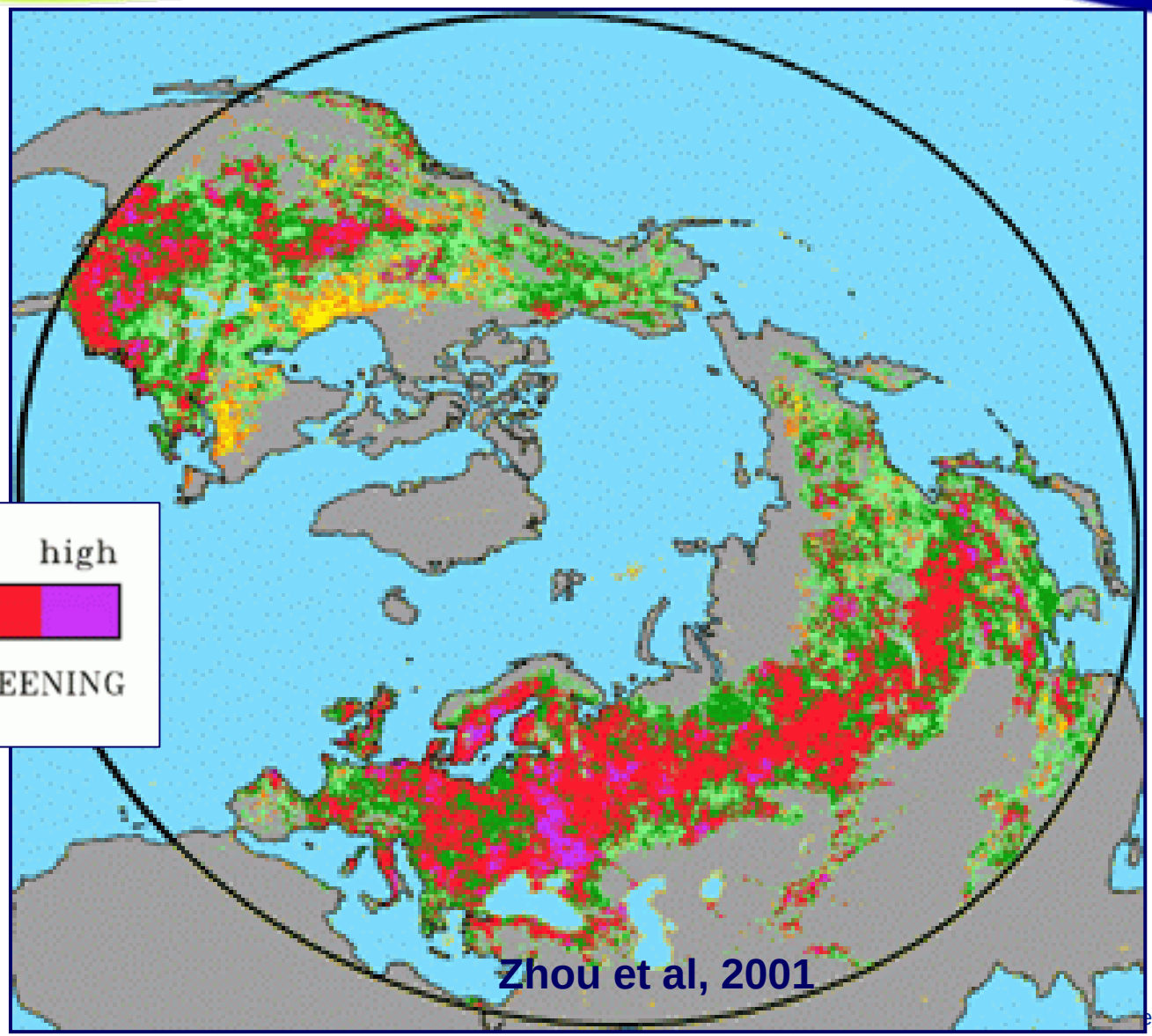


66 sites over 320 km^2 surveyed in 1950 and 2000. 36 showed increased tree or shrub cover, 30 showed no change (Sturm et al, *Nature*, 2001).

Vegetation is becoming leafier

Satellite measurements of leaf cover 1982-1999



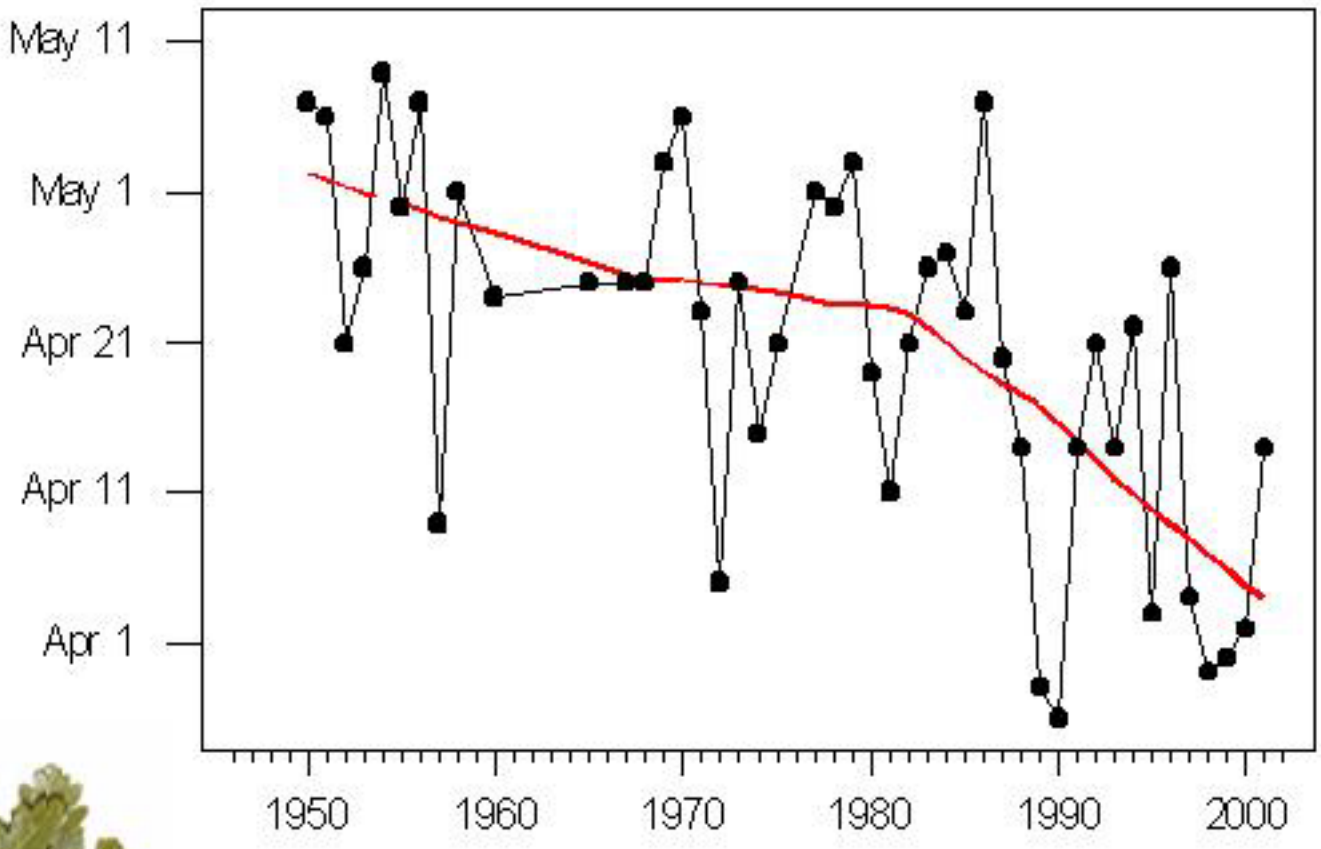


Zhou et al, 2001

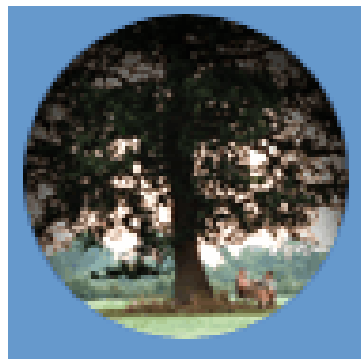
Trees are leafing-out earlier in spring

Oak leaf-out date

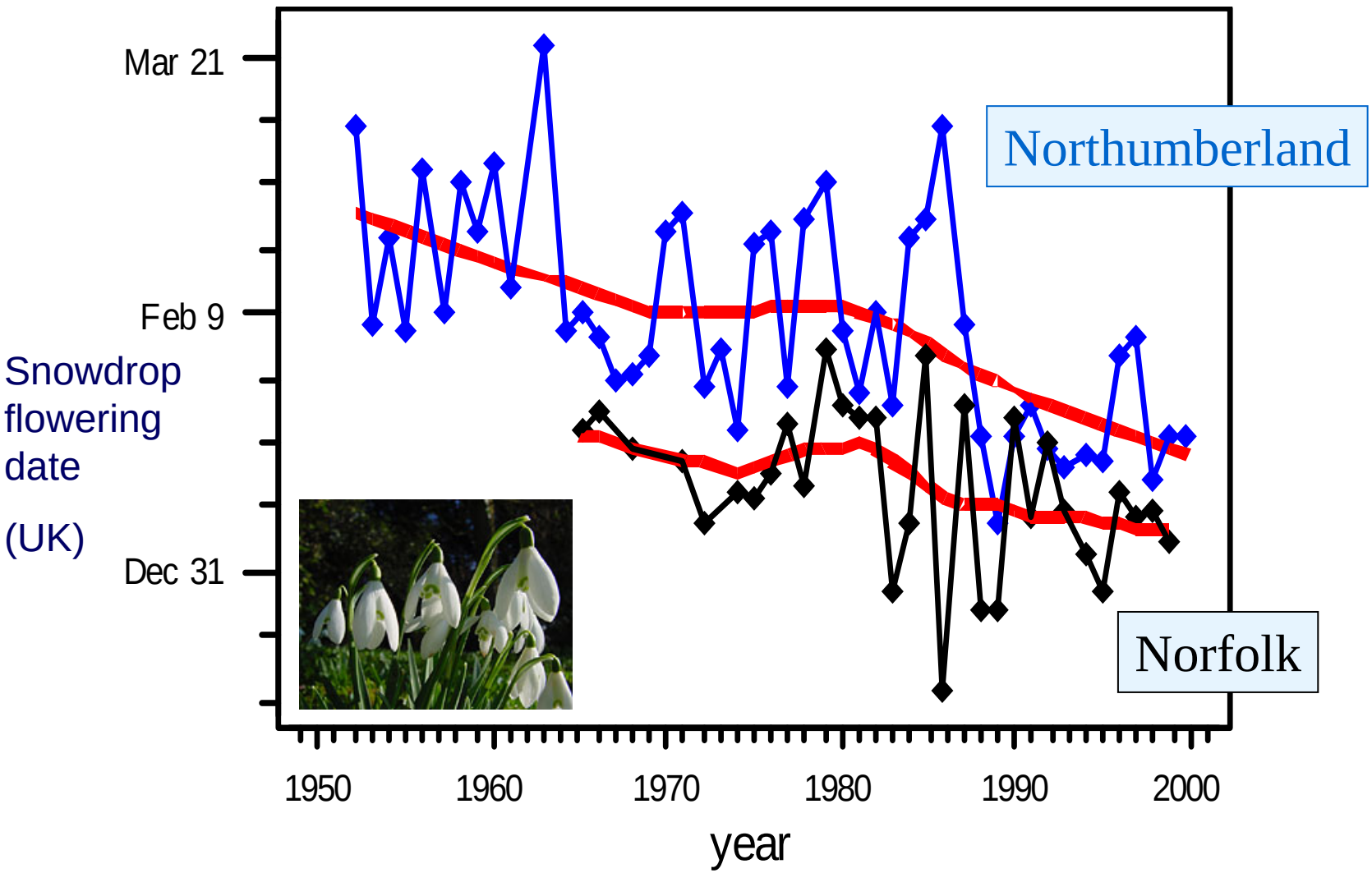
(Surrey, UK)



Source: UK Phenology Network (www.phenology.org.uk)

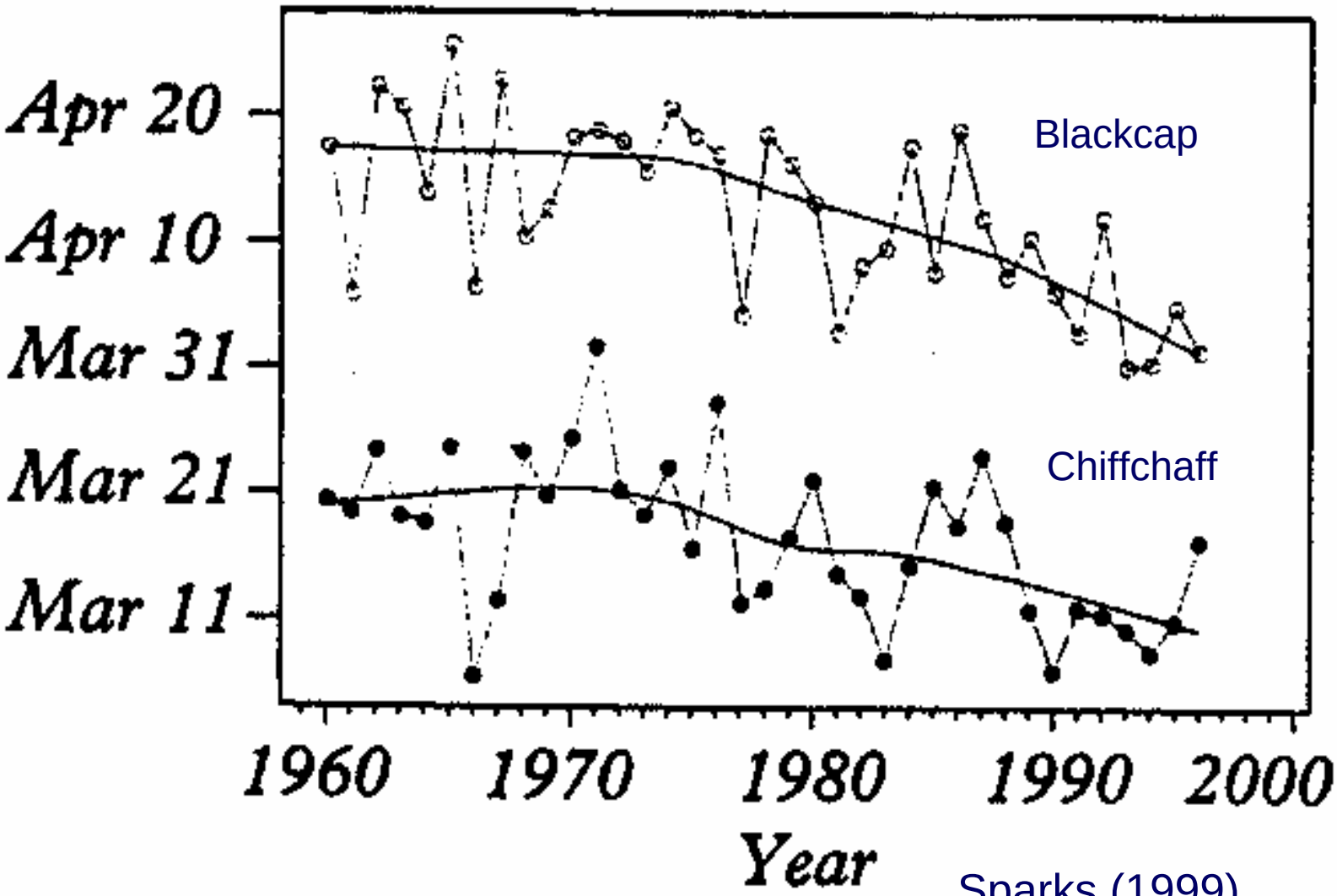


Flowers are opening earlier in spring



Source: UK Phenology Network (www.phenology.org.uk)

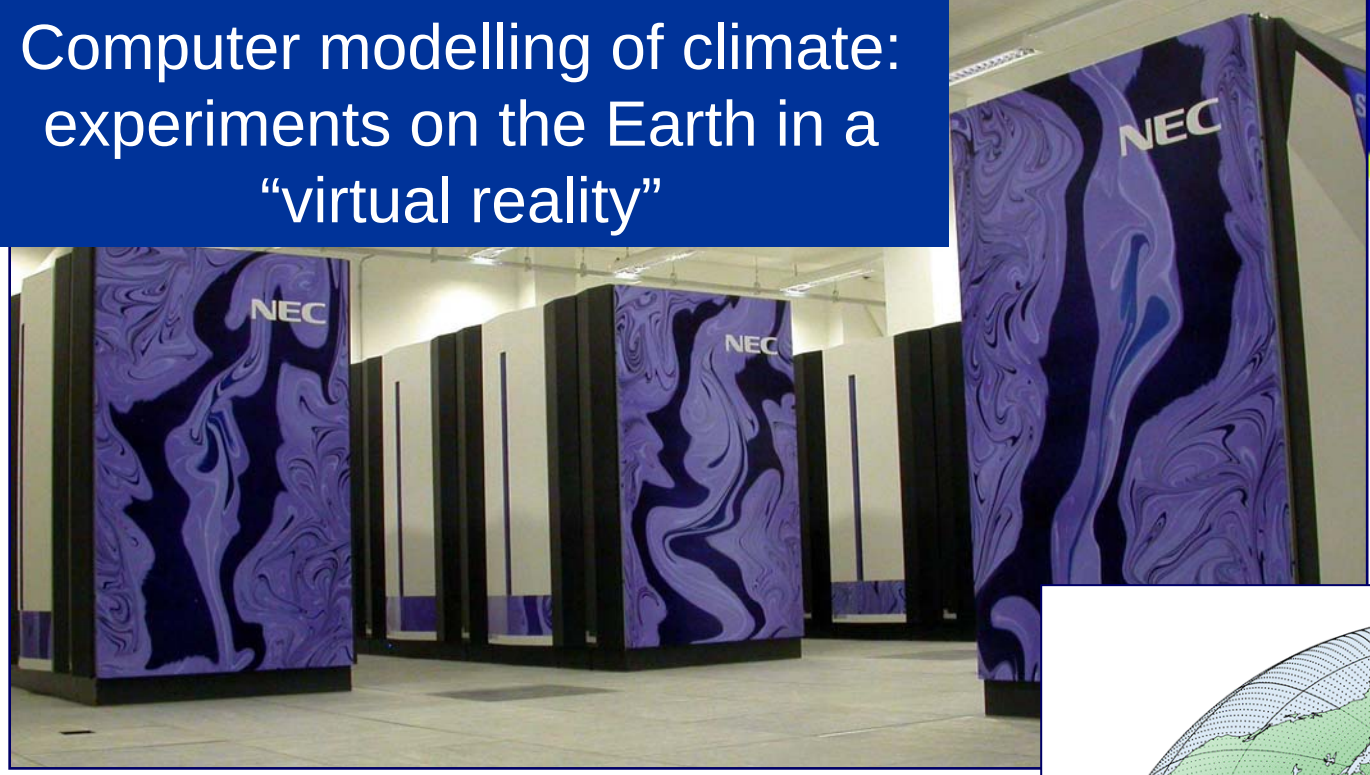
Migratory birds are arriving in UK earlier in spring



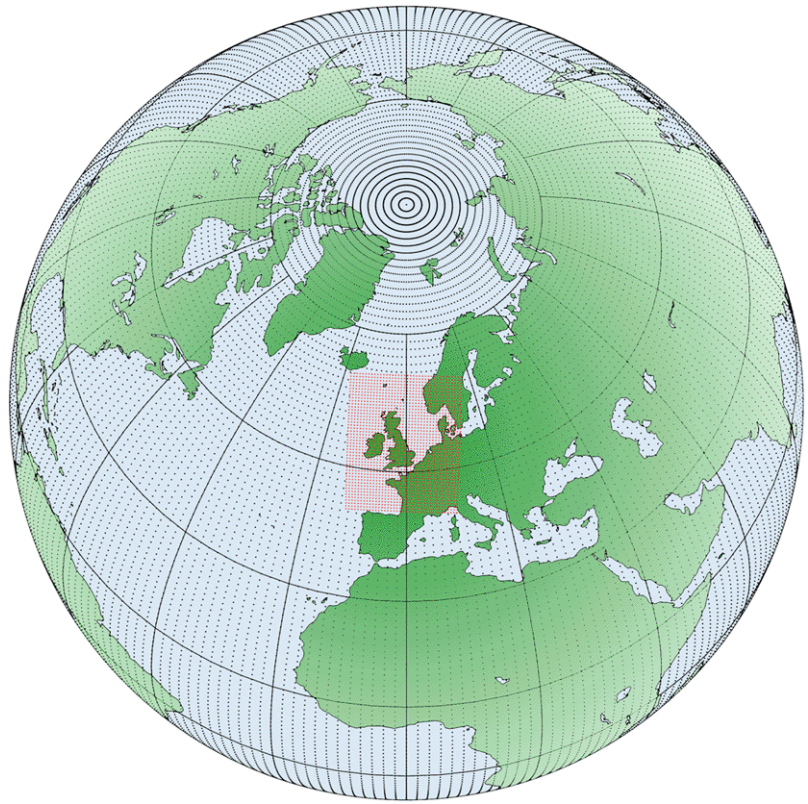
Sparks (1999)

Future climate change predictions and implications for conservation

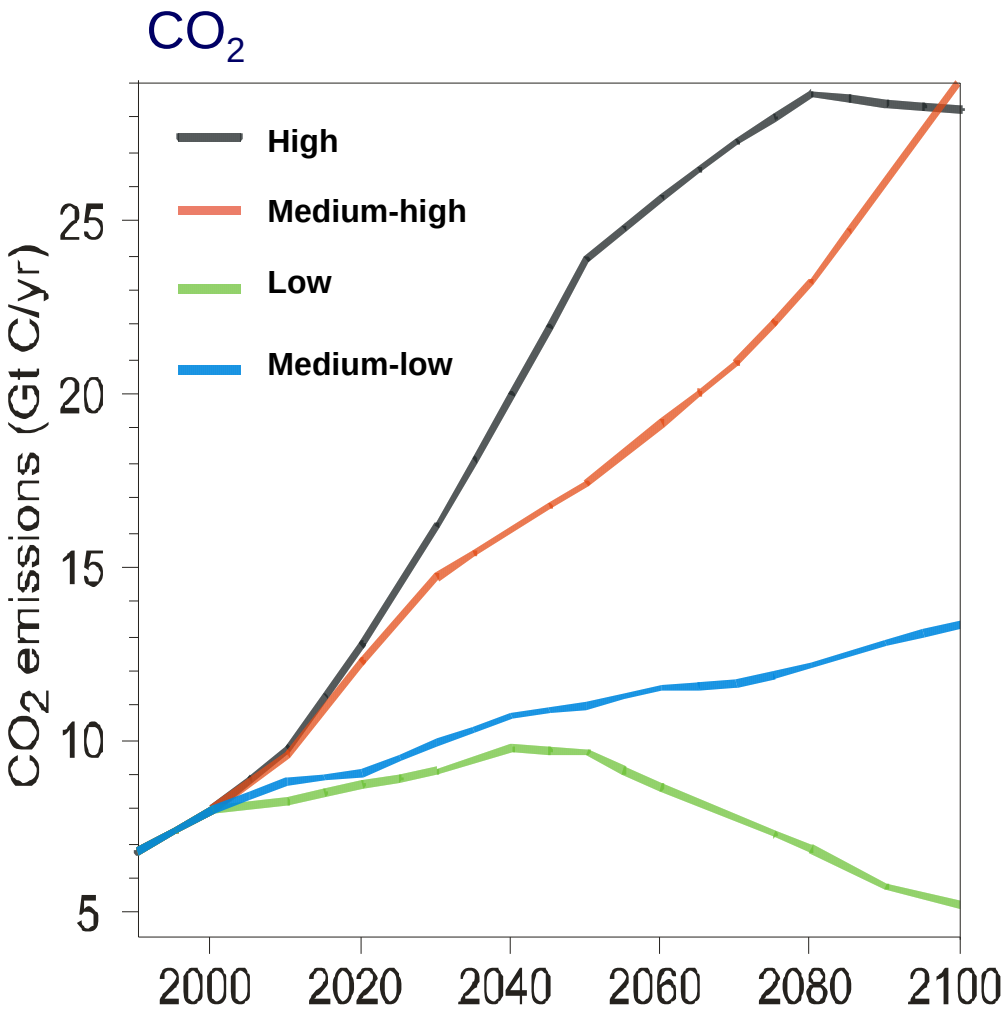
Computer modelling of climate: experiments on the Earth in a "virtual reality"



- Mathematical equations of Newton's laws of motion, thermodynamics, gas properties, atmospheric chemistry, plant physiology…
- 1,000,000 lines of FORTRAN
- 200 output variables
- Approx 15,000 grid points
- 20-40 layers in atmosphere and ocean
- 30 minute timestep
- 250 years of simulation requires 1-6 months of real time

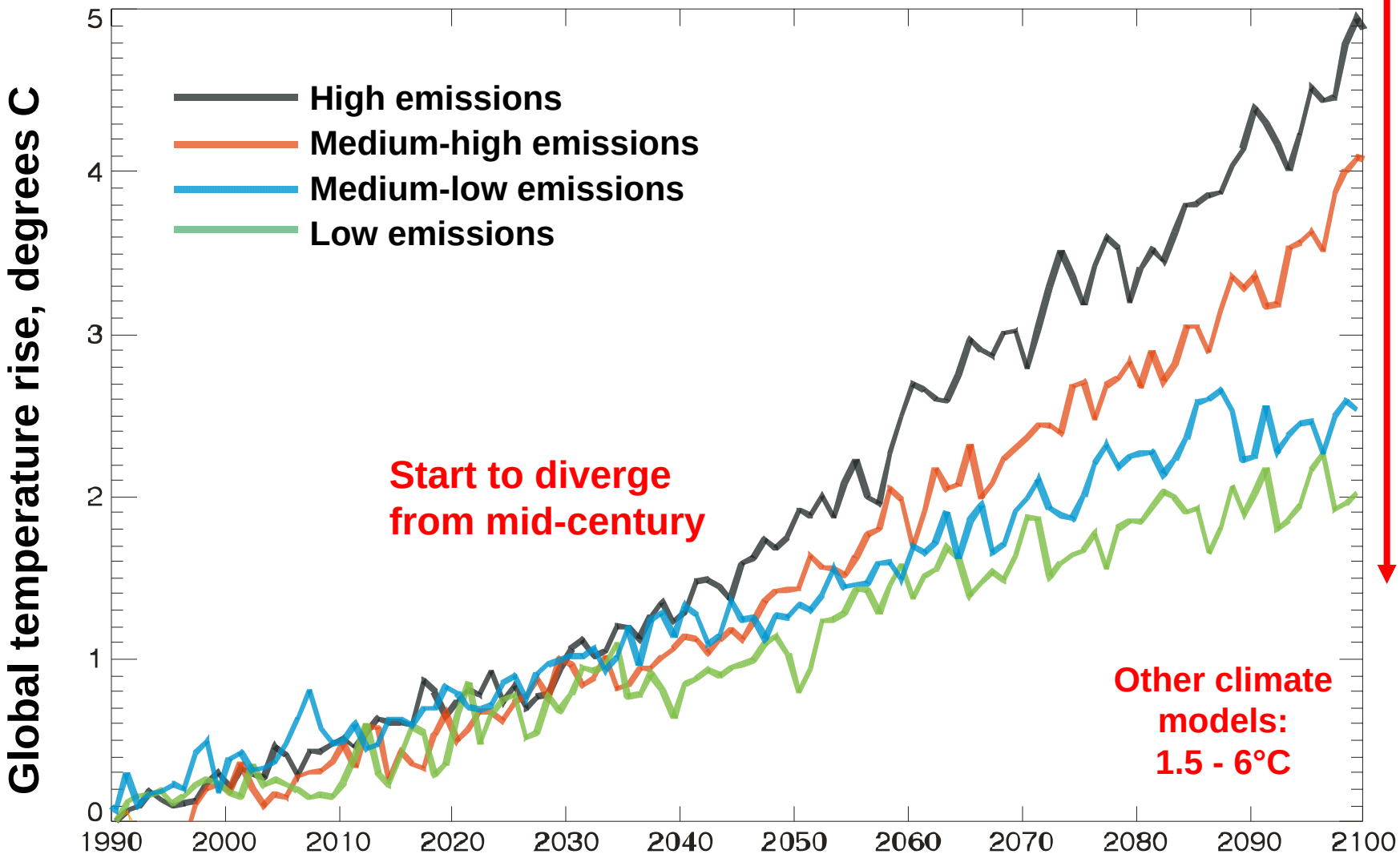


IPCC emissions scenarios



- Population
- Socio-economic development
- Technology changes
- No probabilities assigned

Projections of global temperature rise



How will future climate change affect biodiversity?

- Example question: “Will climate change increase extinction risks in my favourite biodiversity hotspot?”

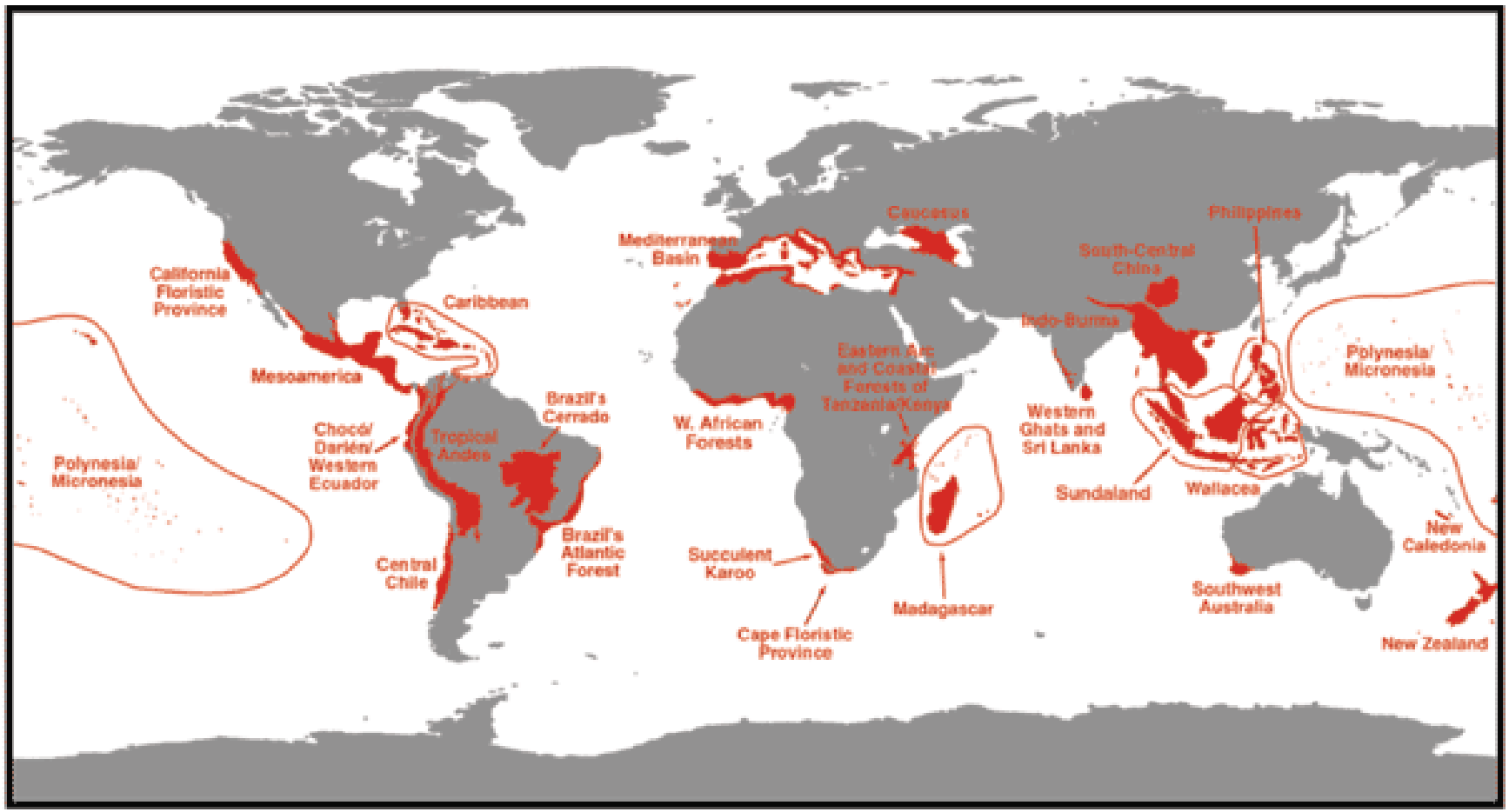
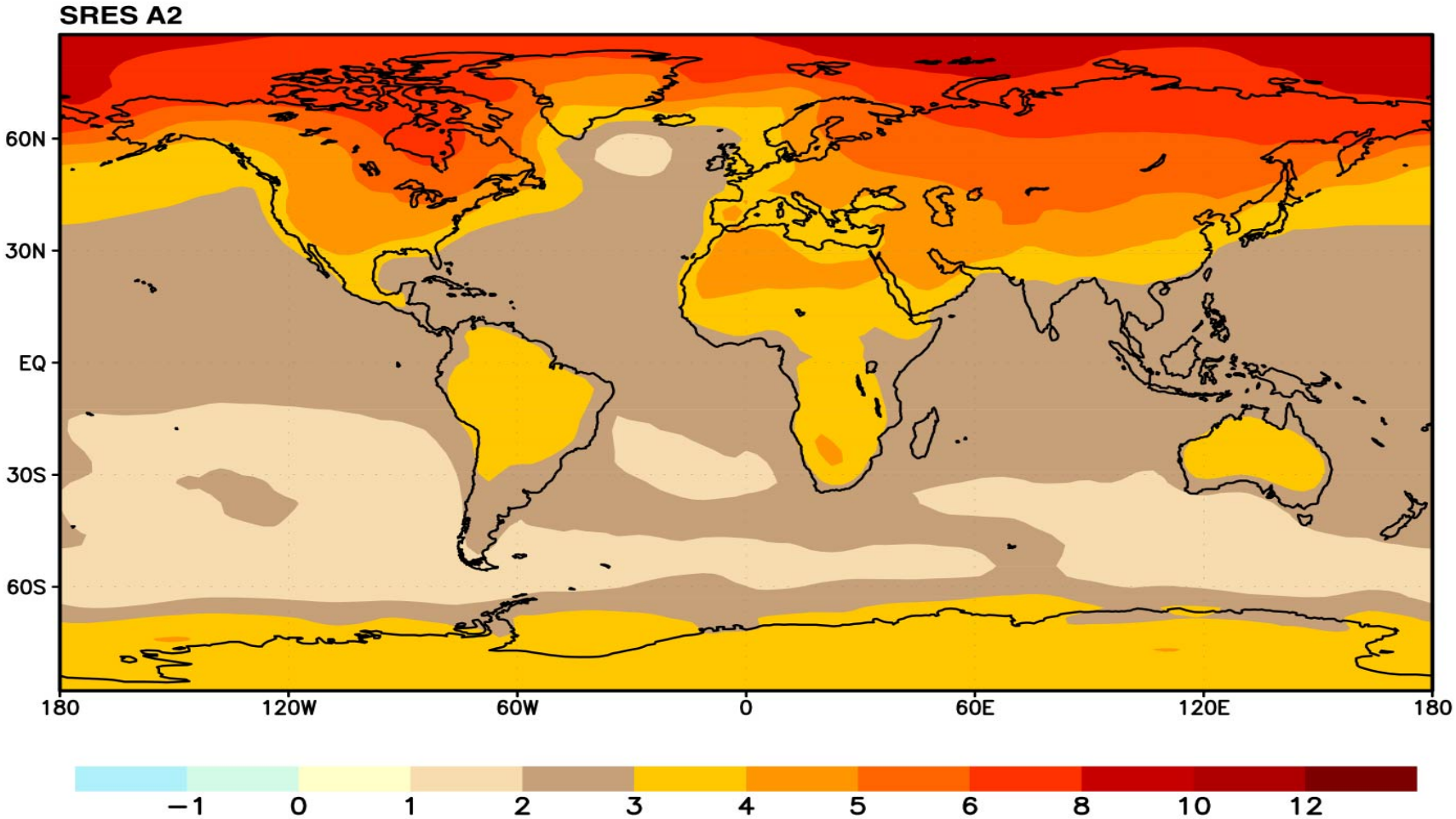


Figure from Myers *et al* (2000)

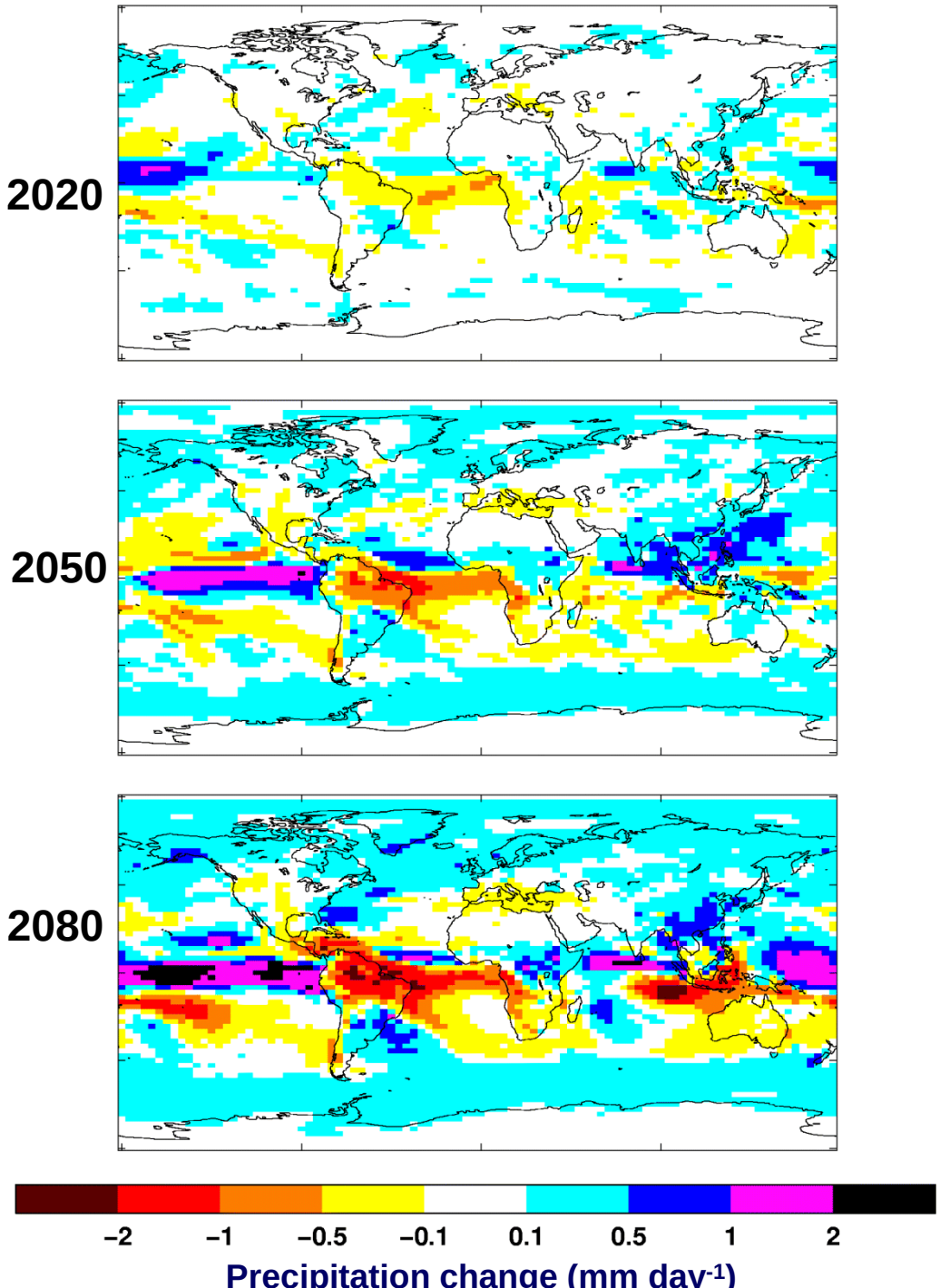
Land areas are projected to warm more than the oceans
Greatest warming at high latitudes



Annual mean temperature change, 2071 to 2100 relative to present day:
Global Average in 2085 = 3.1°C in this simulation

Simulated precipitation change relative to 2000

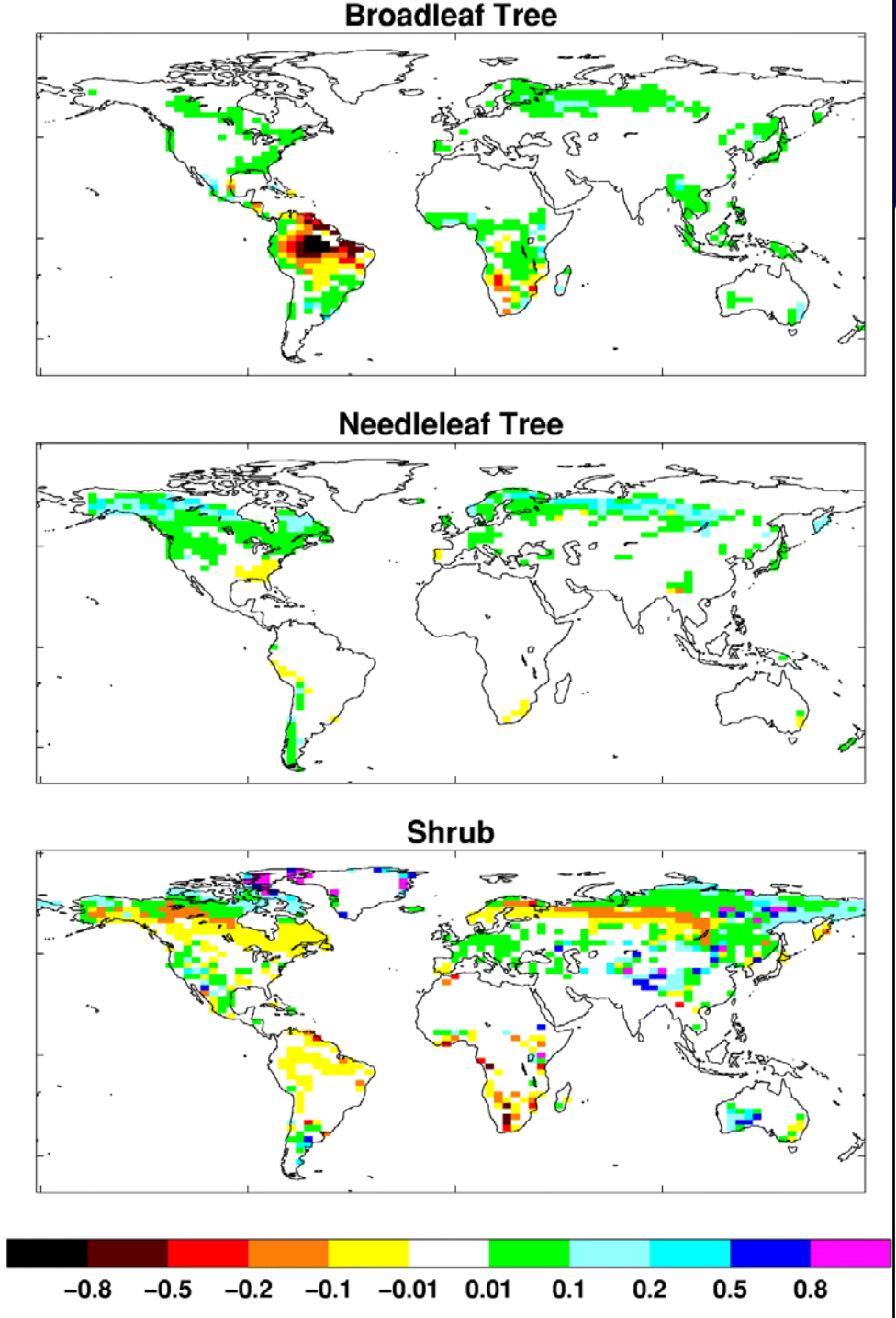
- Global average precipitation (rainfall + snowfall) increased with global warming
- Differing rates of local warming cause changes in atmospheric circulation
- Amazonian rainfall declines due to responses to sea surface temperature changes in Atlantic and Pacific



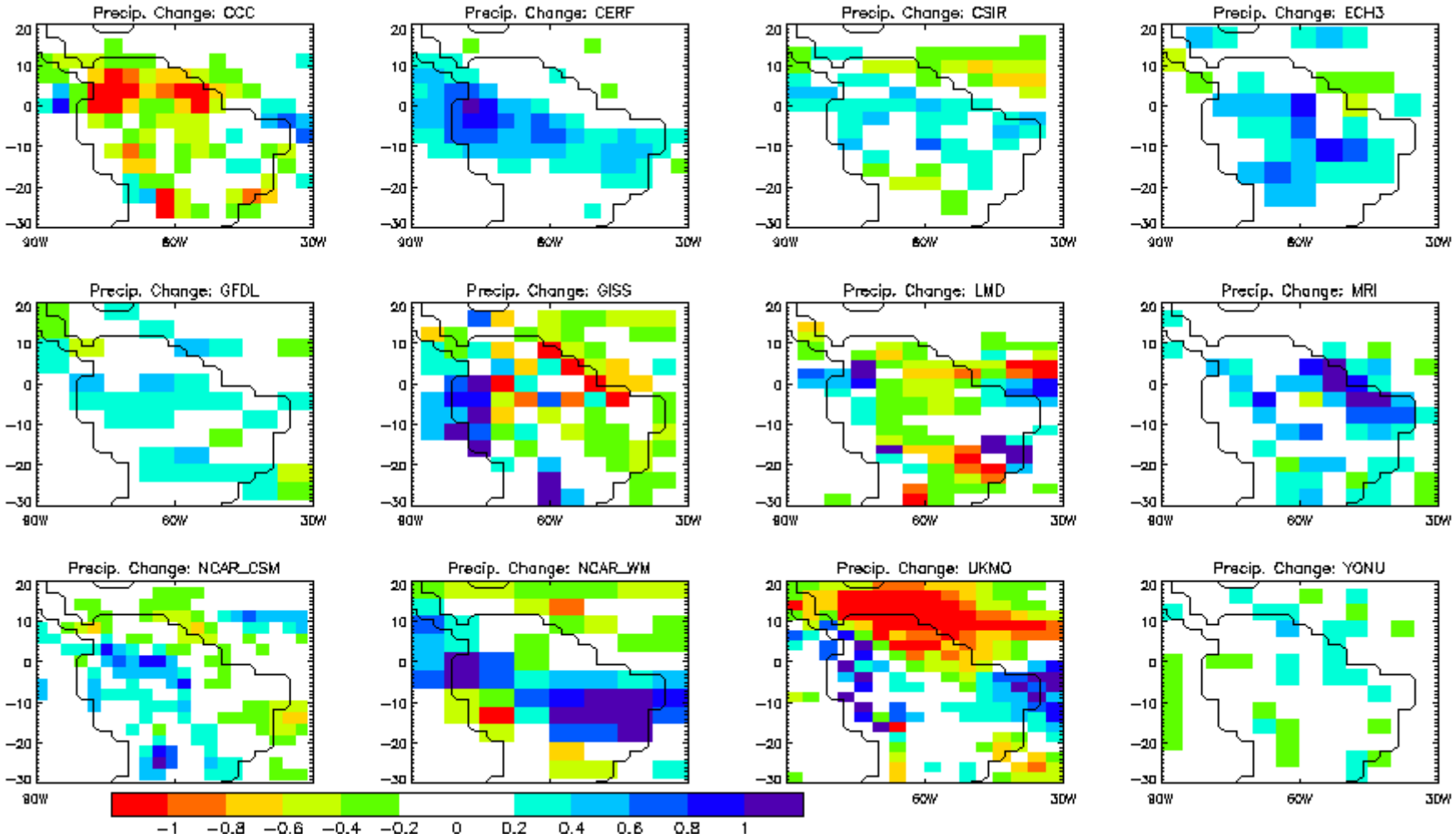
Simulated vegetation change 2000 to 2100

Change in fractional cover of woody plant functional types

"Die-back" of Amazon forest results in a new source of carbon which contributes to acceleration of CO_2 rise and climate change

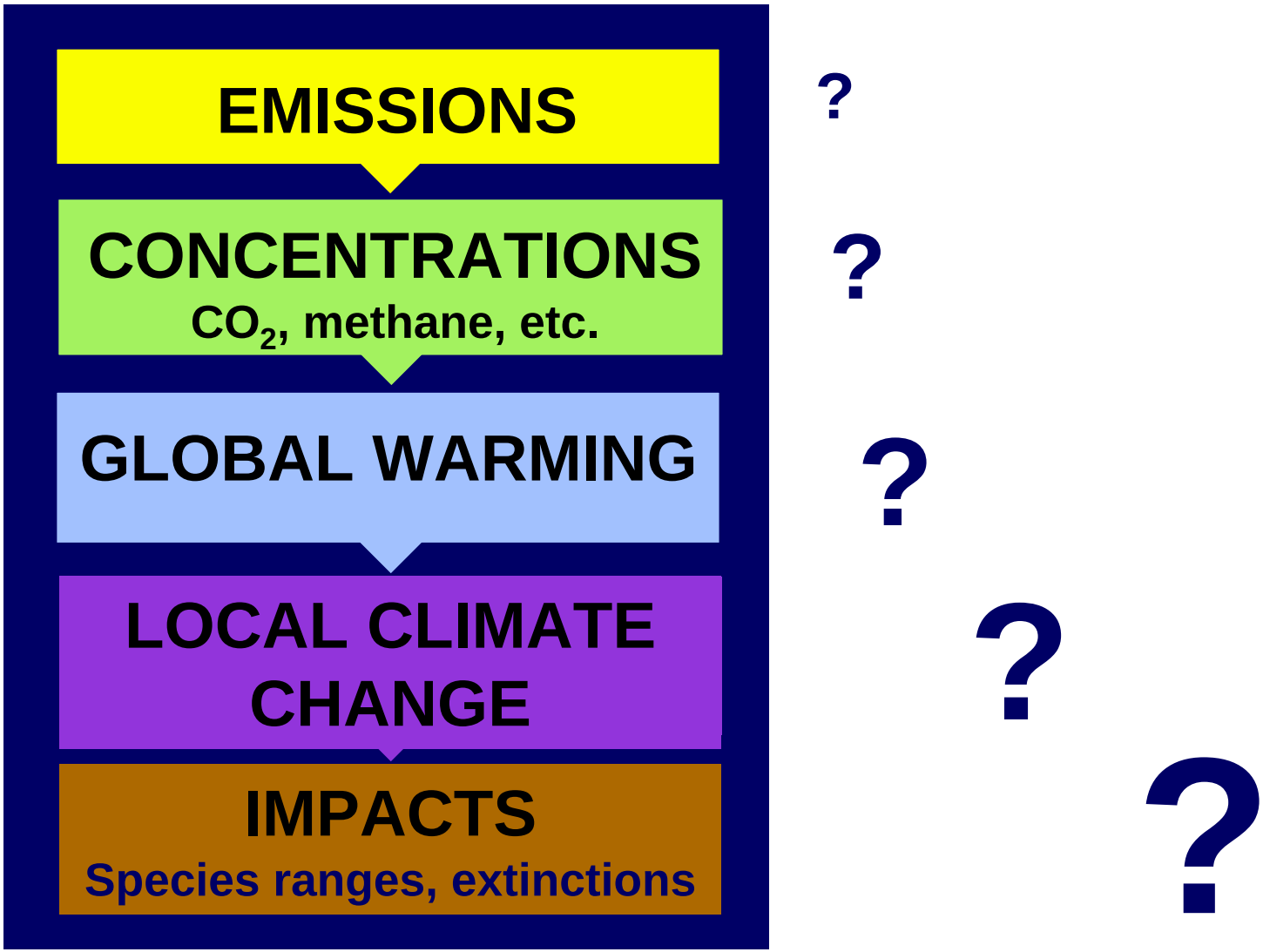


But different climate models give different predictions…



Precipitation changes (mm day^{-1}) from 12 GCMs: 100-year runs with 1% CO_2 increase per year

“Cascade of uncertainty” makes local impact predictions highly uncertain



At present, conservation plans should consider general nature of climate risks rather than expect robust predictions

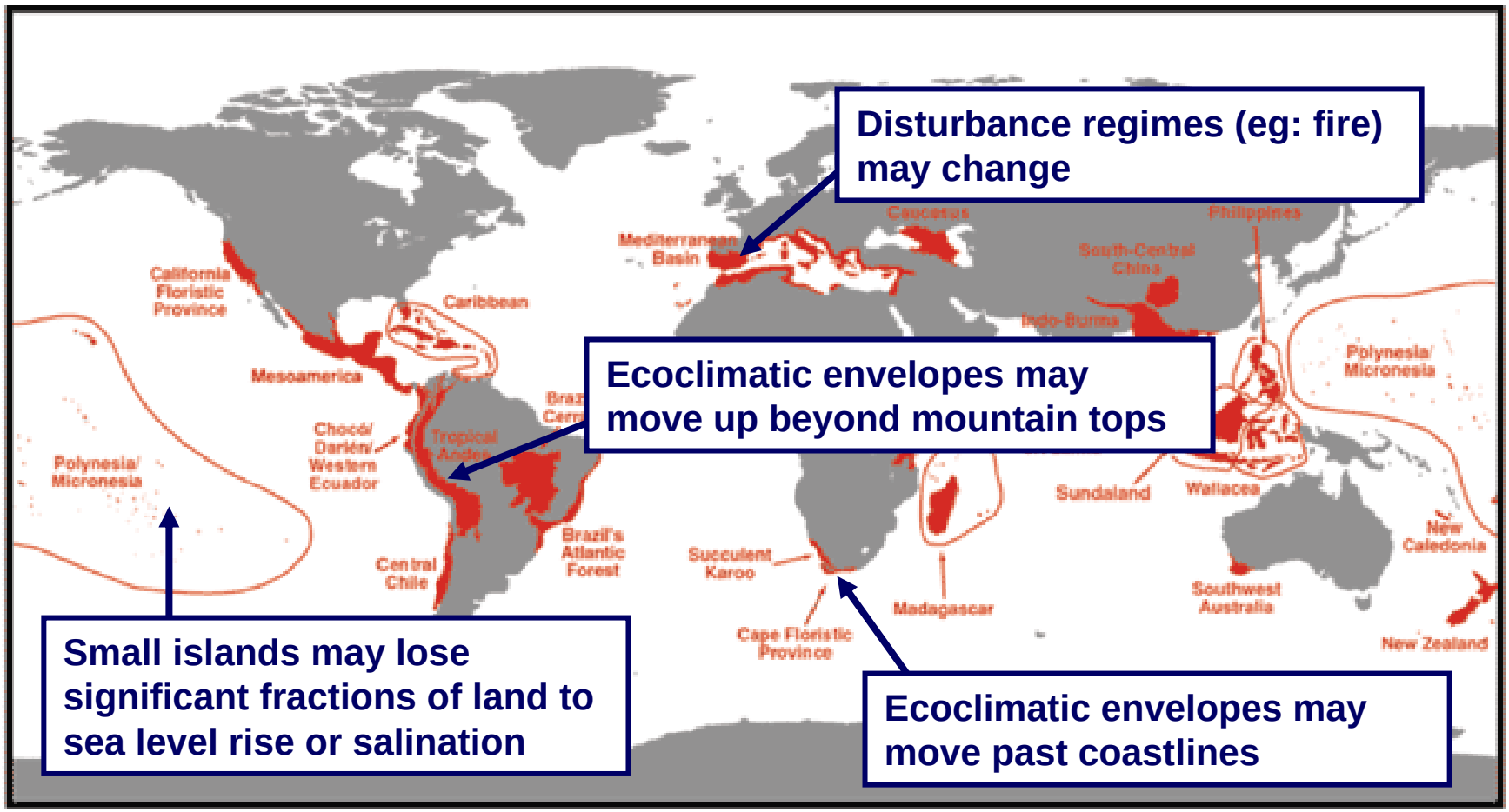


Figure from Myers *et al* (2000)

Conserving biodiversity and managing climate change

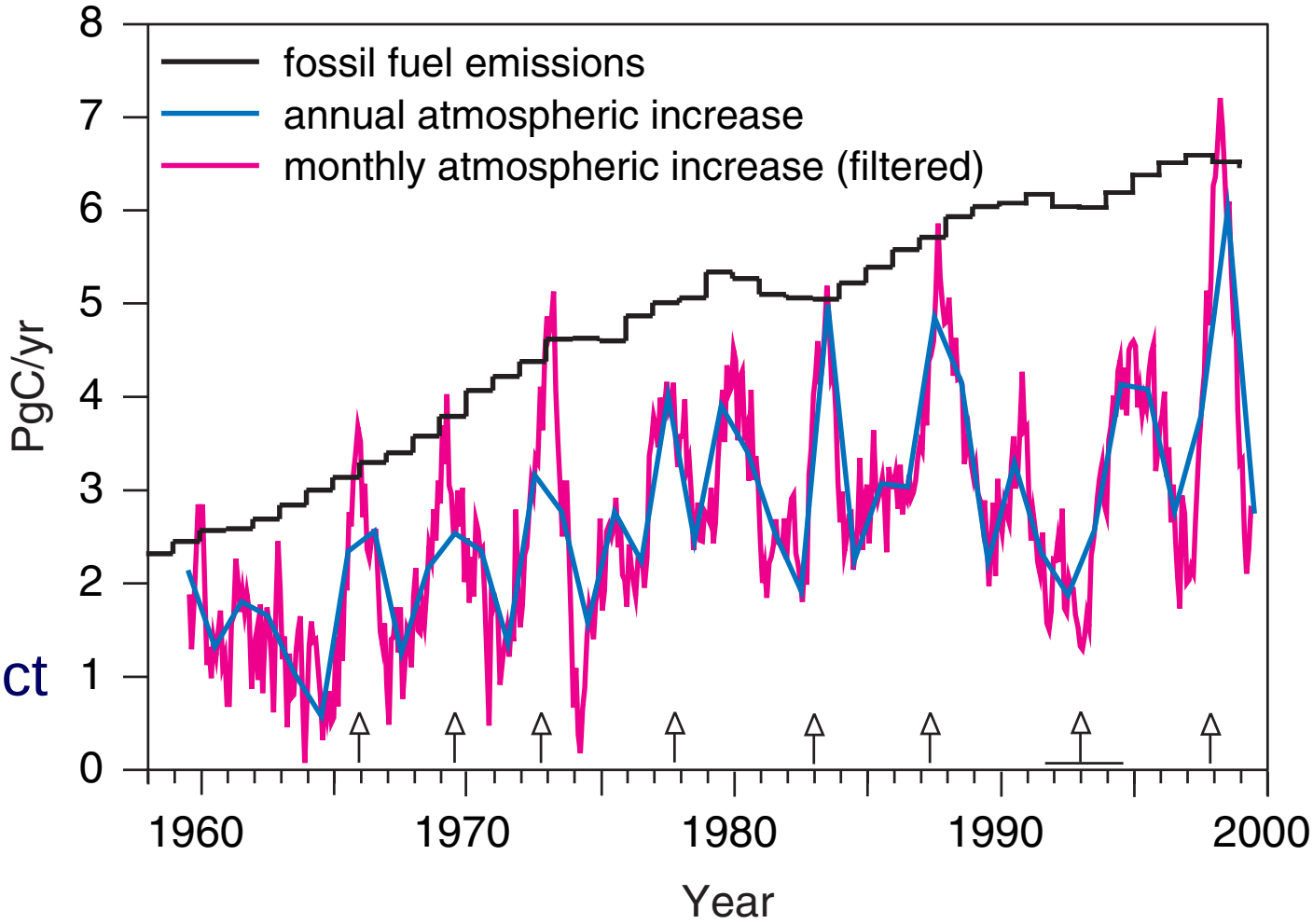
Contribution of deforestation to CO_2 emissions (1990s)

Fossil fuel emissions: 6,300,000,000 tonnes of carbon per year

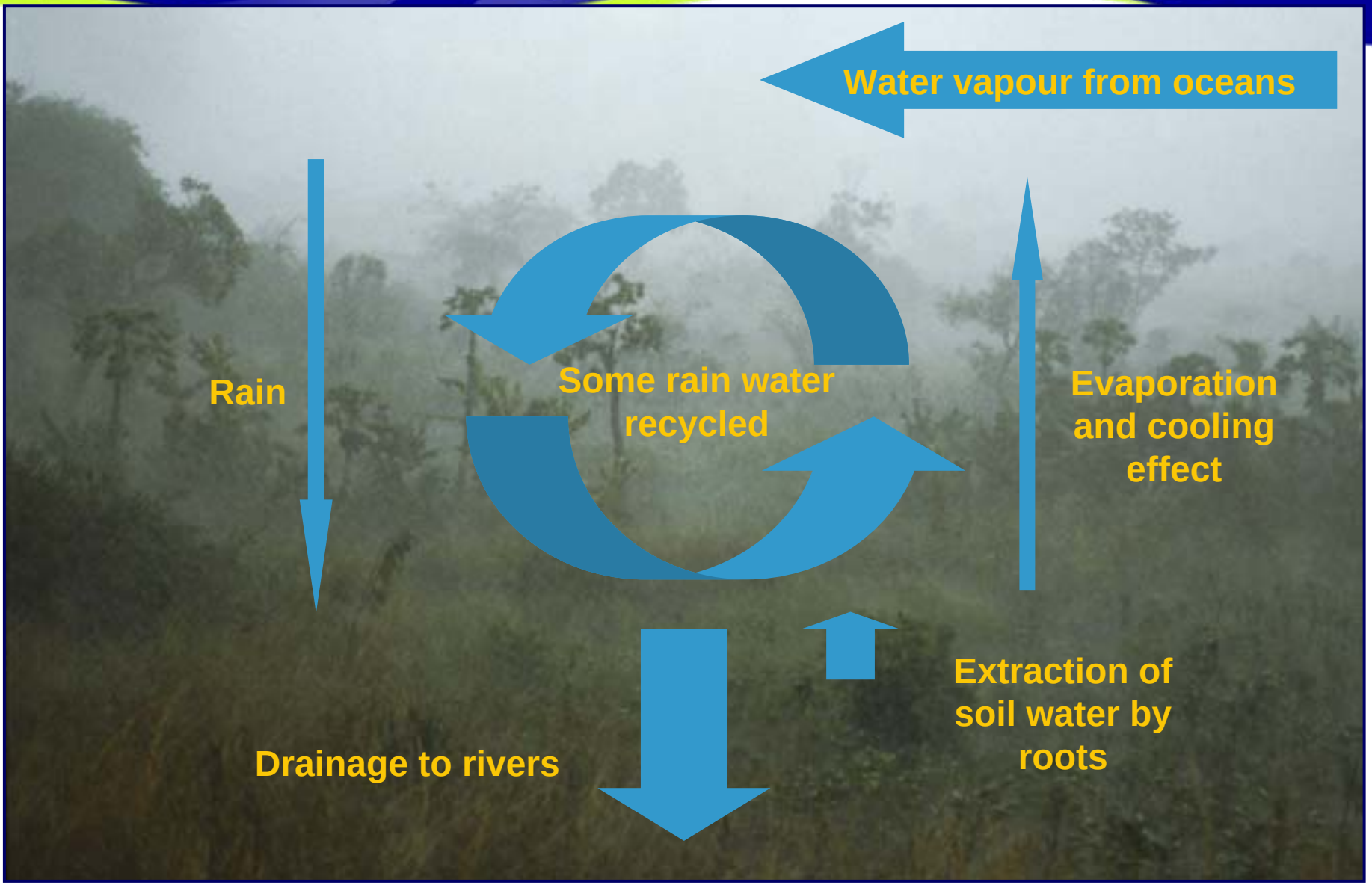
Deforestation emissions: 1,600,000,000 tonnes of carbon per year

Ecosystem service: CO_2 concentration is increasing at only half the rate of emissions

- 50% of emissions taken up by land ecosystems and oceans
- Conservation of natural ecosystems helps to protect carbon sink



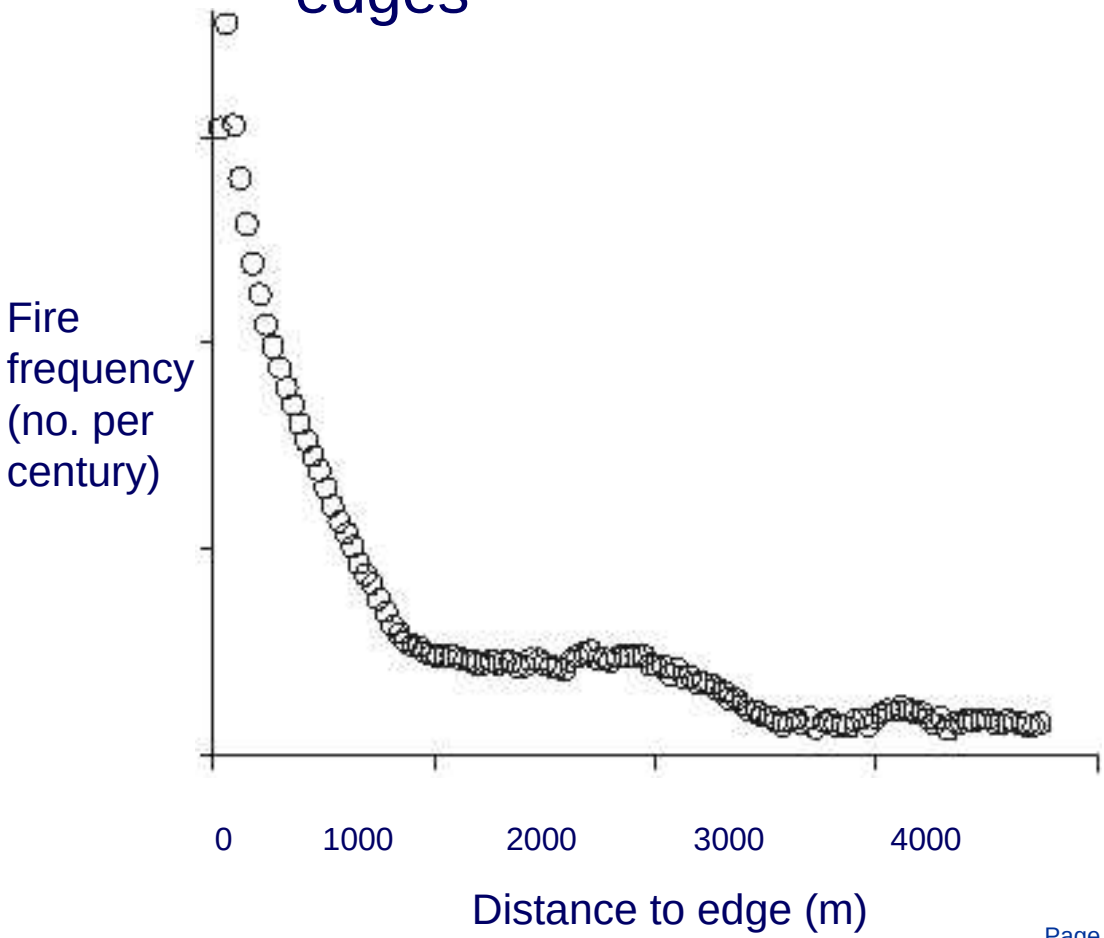
Ecosystem service: recycling rain water and cooling via evaporation



Fragmentation of forest increases vulnerability to climate change

Fragmentation creates more forest edges

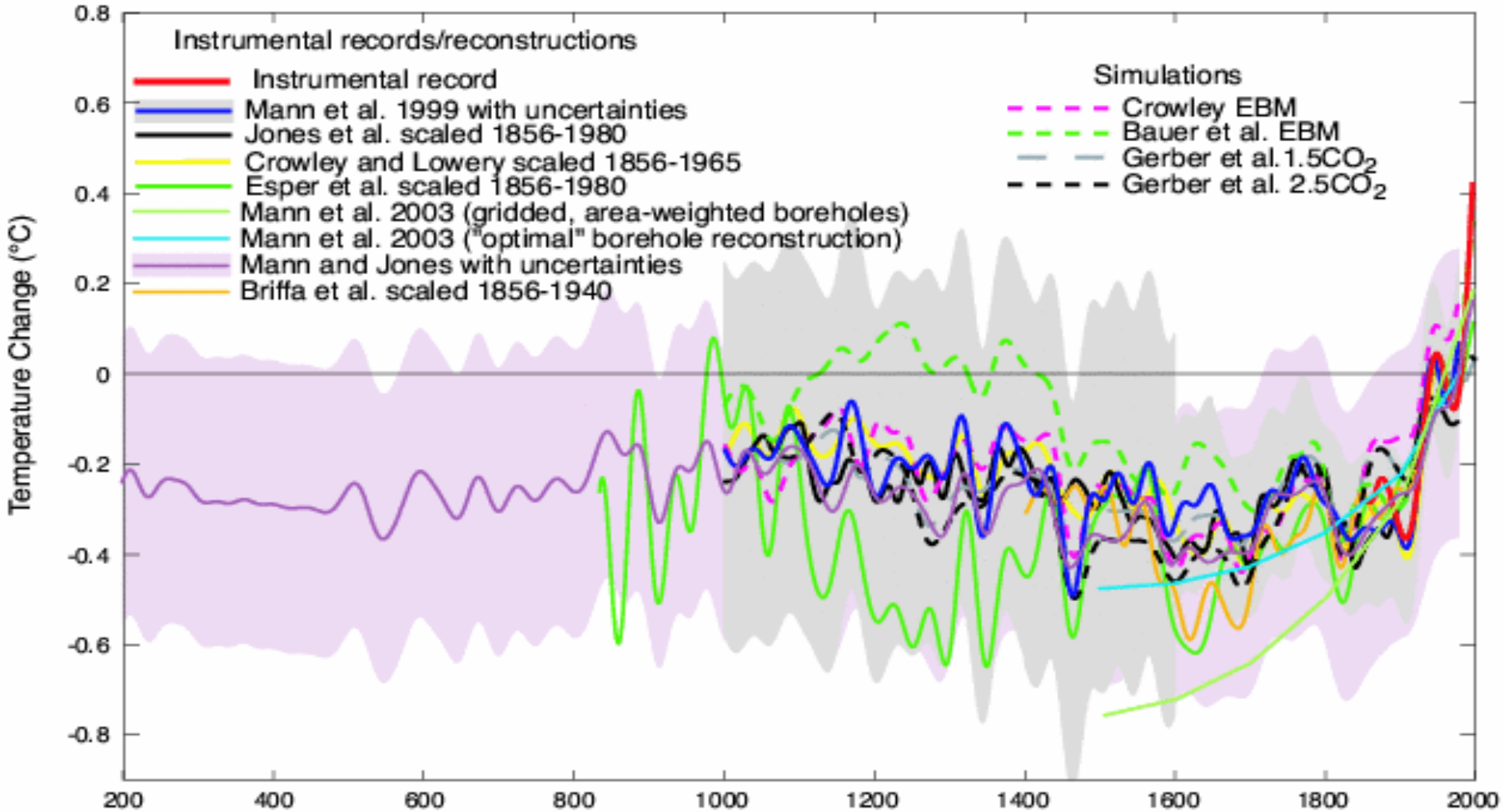
Increased fire risk near forest edges



Conclusions

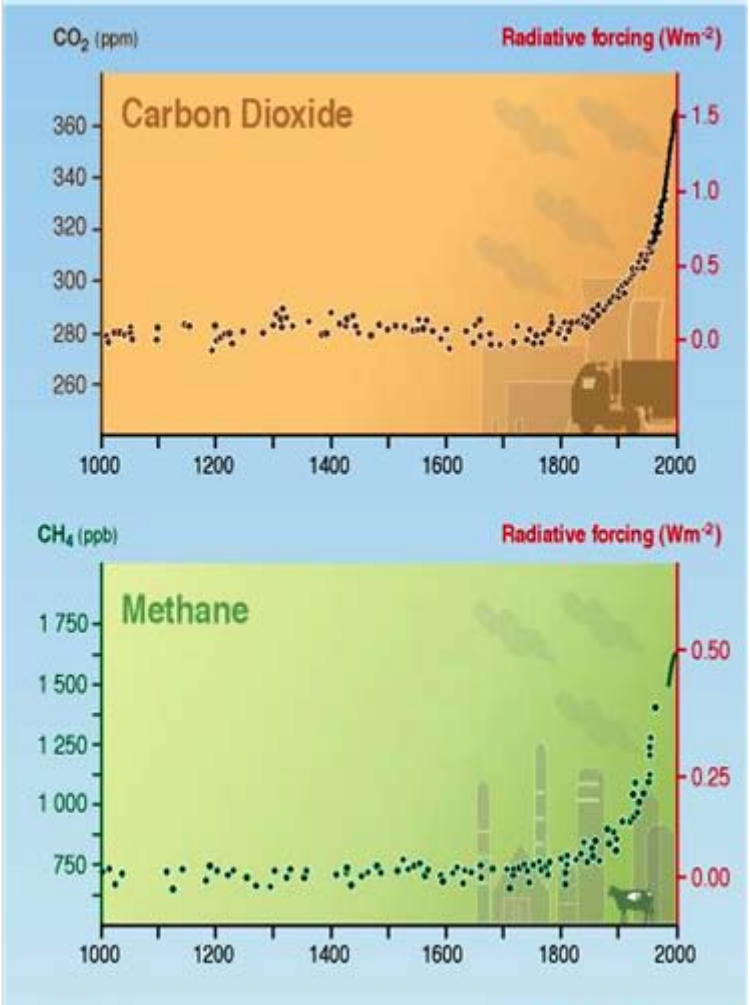
- The climate is changing: the world is getting warmer
- Many ecosystems are showing changes consistent with a warming world
- Continued climate warming is confidently predicted, but the magnitude is uncertain
- Warming is expected to continue to be more rapid over land and near the poles
- Local changes in precipitation are hard to predict
- Conservation of natural ecosystems can help reduce emissions, maintain carbon sinks and preserve beneficial influences on local climates
- Fragmentation of forests can increase their vulnerability to climate change

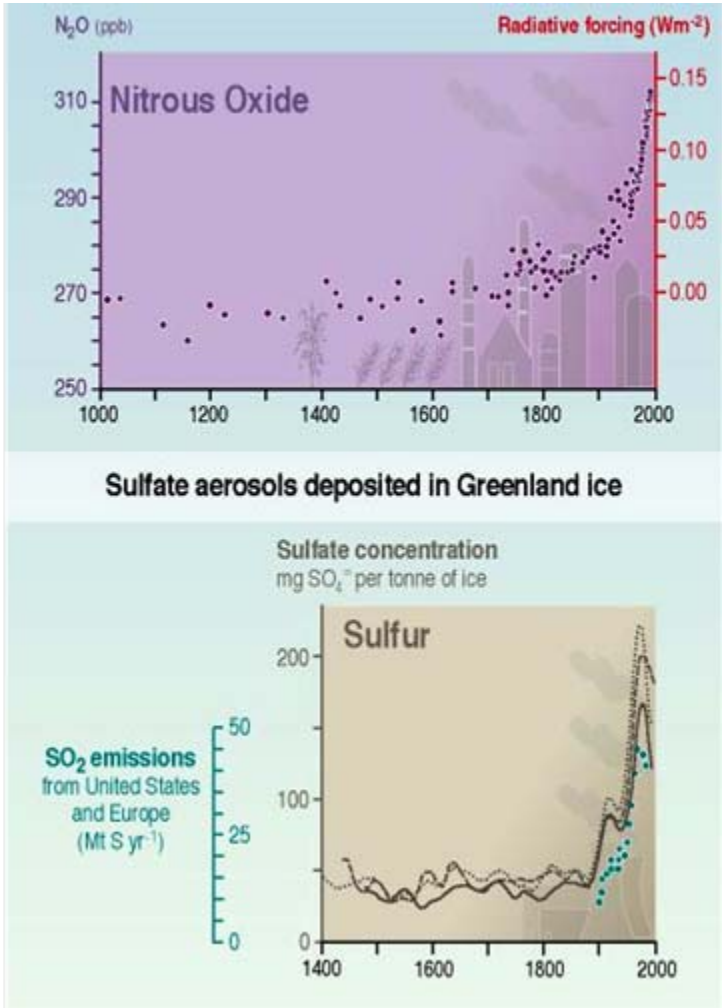
Measurements and reconstructions of Northern Hemisphere temperature over the last 1,800 years.



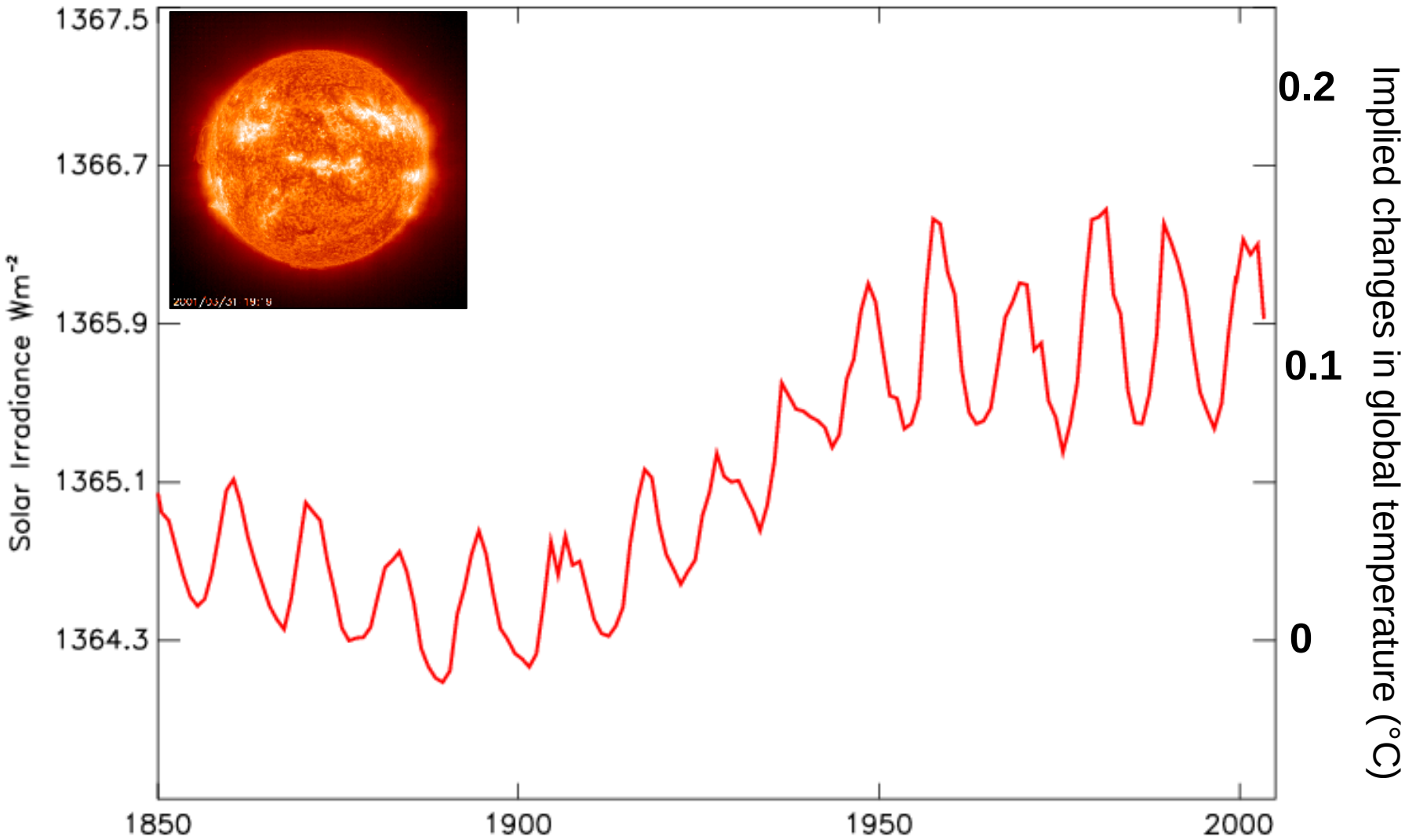
Mann *et al* (2003)

Human activities have changed the composition of the atmosphere since the pre-industrial era





Energy from the Sun; stable over last 50 years



Source: Lean, 2003

Change in volcanic aerosol

Optical depth

0.20
0.16
0.12
0.08
0.04
0.00

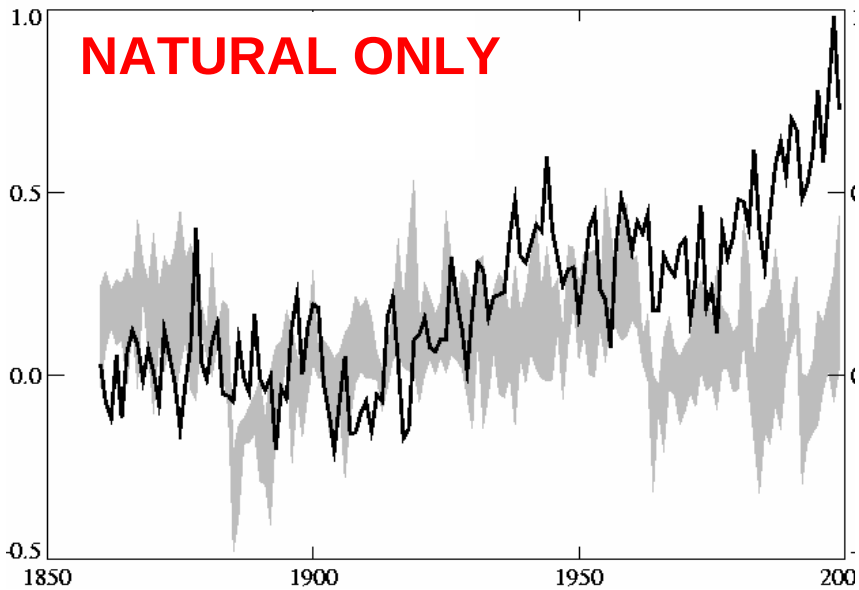
1850
1900
1950
2000

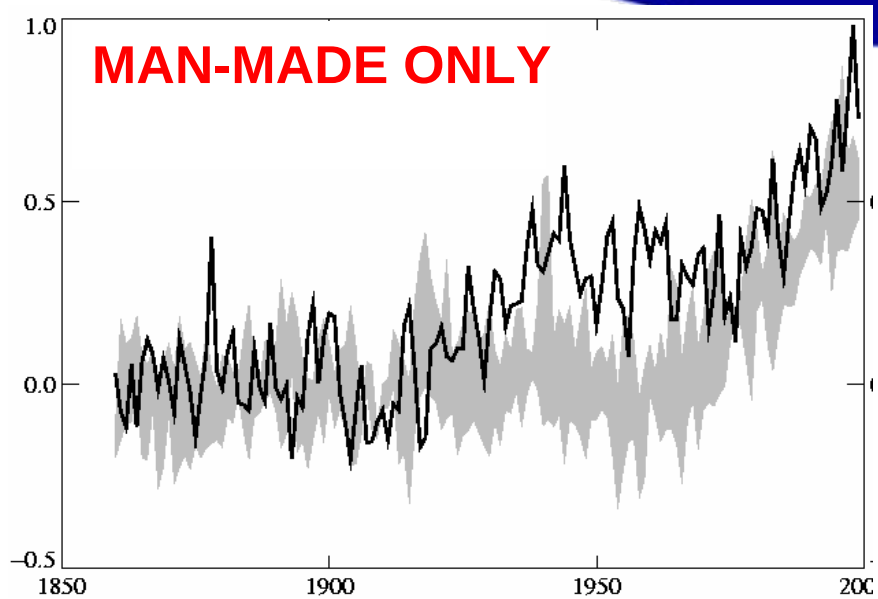
Estimated cooling effect, Wm^{-2}

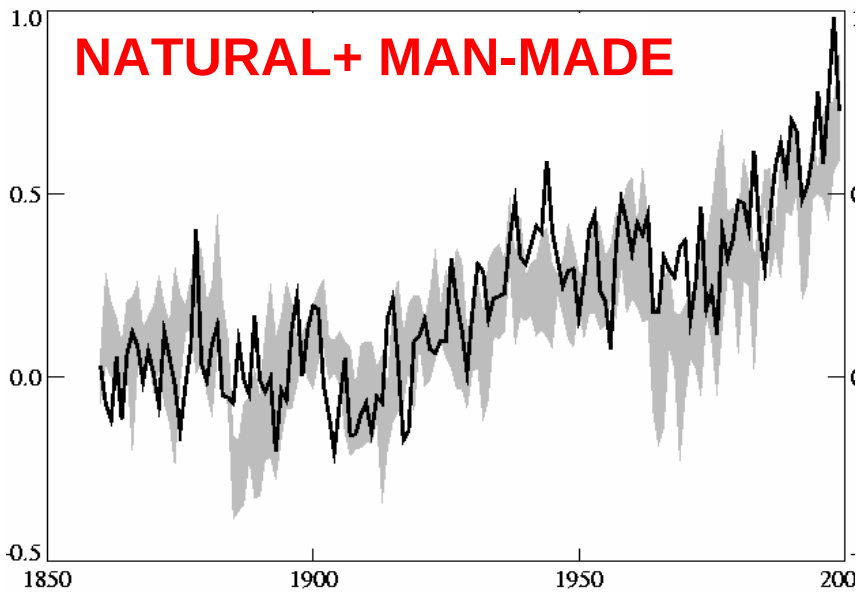
5
4
3
2
1
0

Source: Sato et al, GISS, NASA

Attribution of climate change to its causes







‘A large part of the warming is likely to be attributable to human activities’

CO_2 concentrations in the past and projected for the future

CO_2 concentration is now higher than at anytime in the last 440,000 yrs