Understanding the Low Carbon Economy

Birmingham 14 November 2007

Global Climate Change: an Account of the Scientific Background

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Overview

Mechanisms for maintaining a stable climate:

- Greenhouse effect
- Greenhouse gases
- Carbon cycles

Evidence of change

- Levels of greenhouse gases
- Climatic change
- Changes in the natural world

Assessing human impacts on climate systems

Environmental, human and economic consequences

- Global
- Local

Taking Action

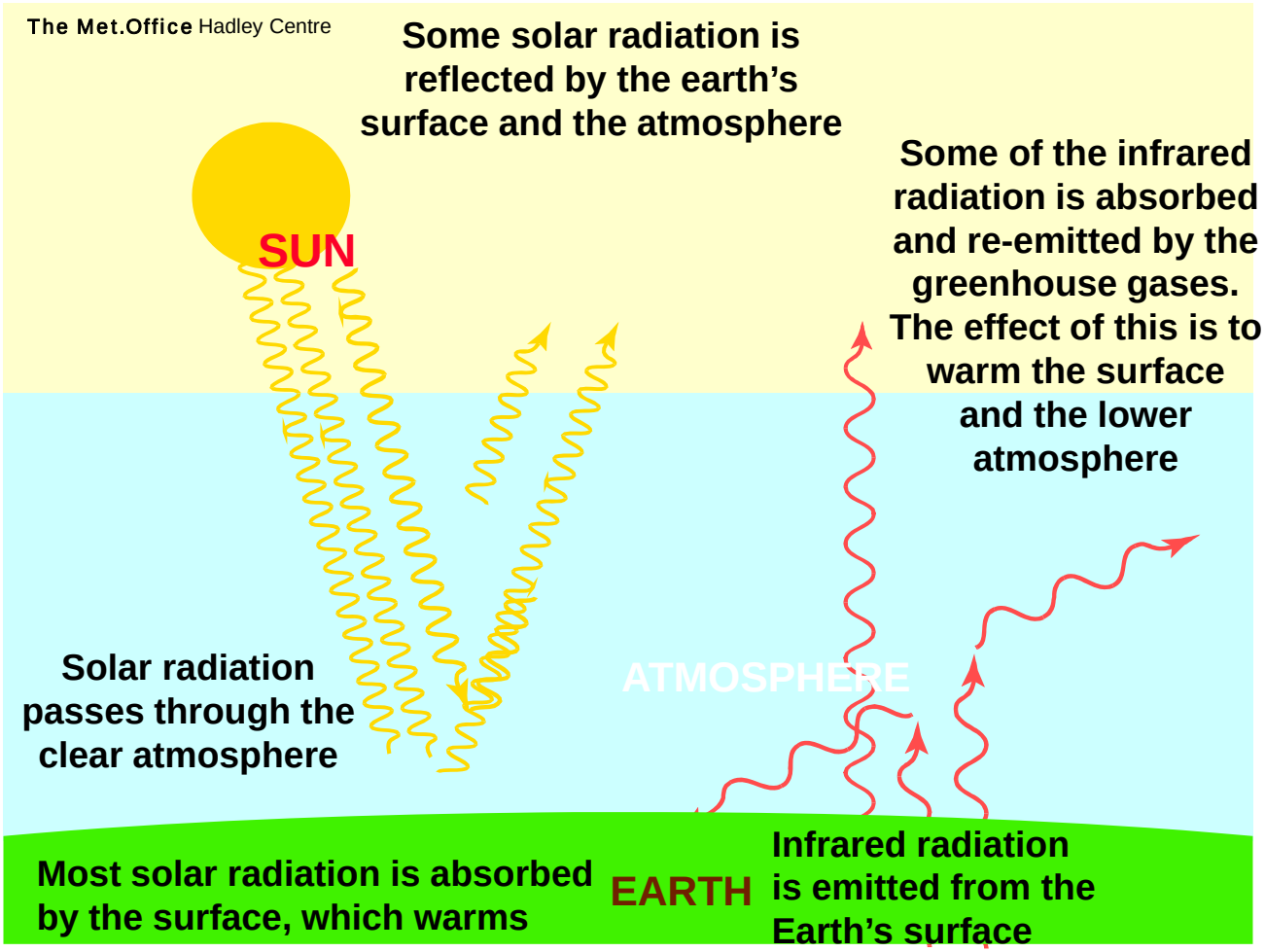
- Mitigation
- Adaptation

Conclusions

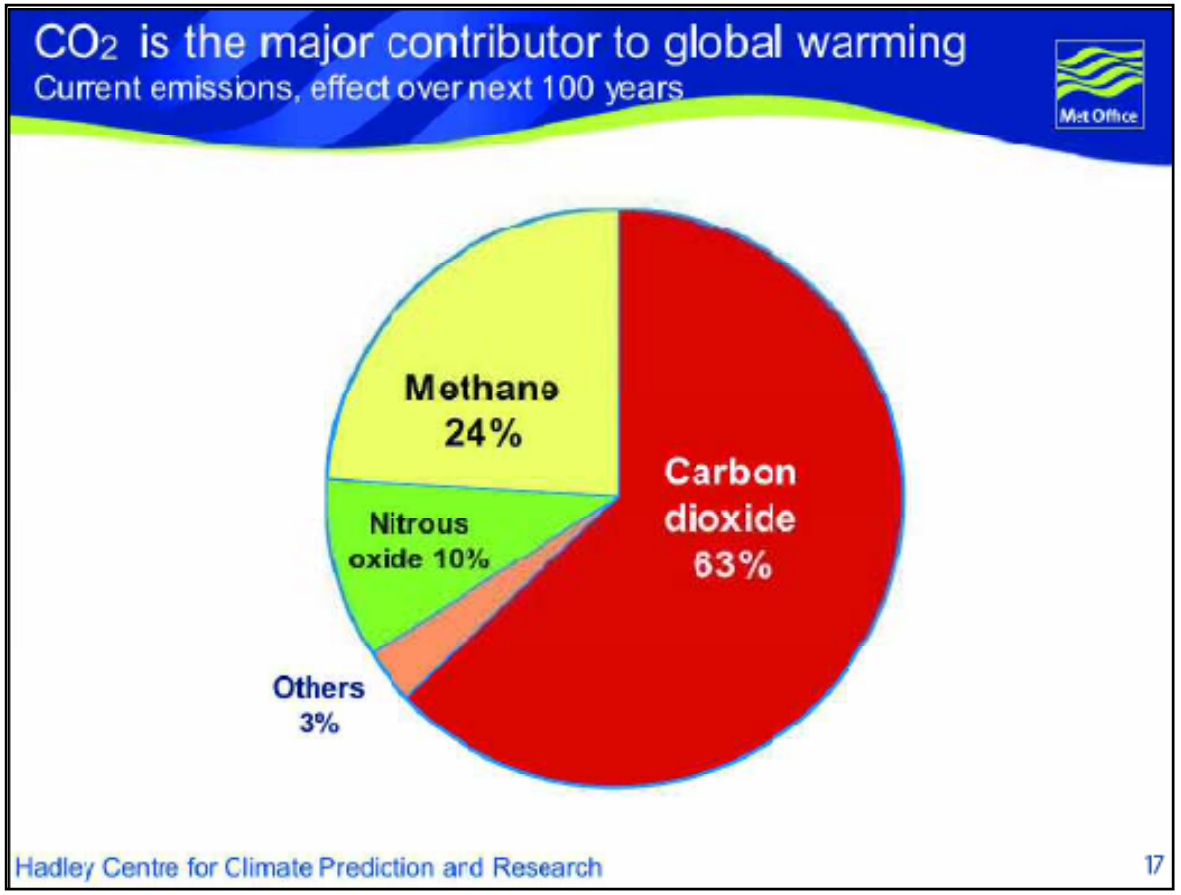
Earth has a Climate Conducive to Life

Average Surface Temperature about 14 C

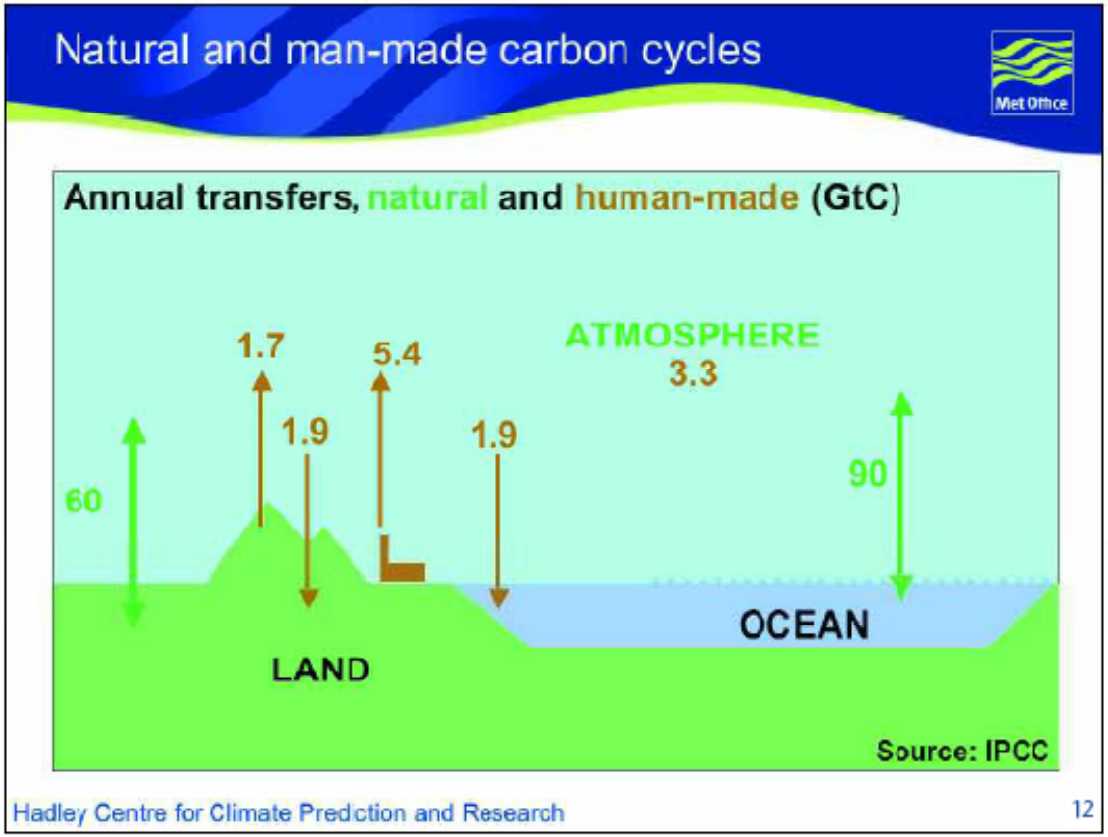
The Greenhouse Effect Maintains Surface Temperature



Trace Molecules in the Atmosphere Act as Greenhouse Gases



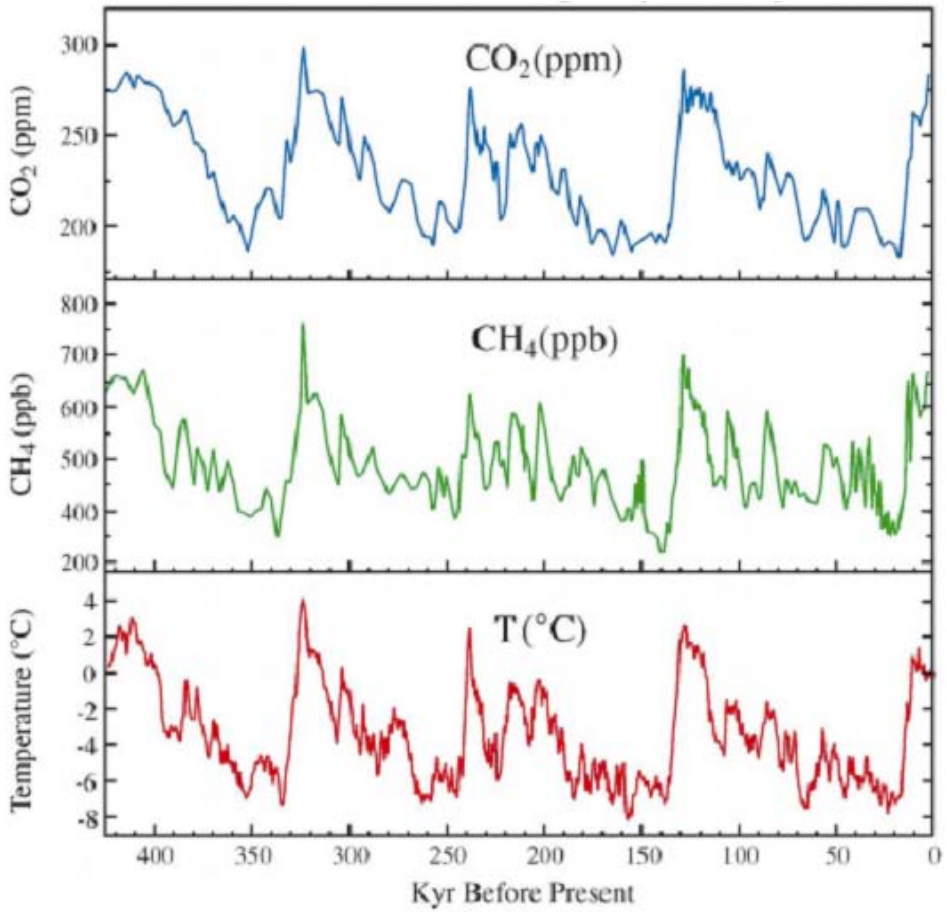
Carbon exchanges are large and the difference finely balanced



Emissions of CO_2 from human activities become involved in the natural carbon cycle, a system of fluxes of CO_2 between land (vegetation and soils),

Similar cycles (known by the general term of biogeochemical cycles) exist for other greenhouse gases such as methane and nitrous oxide. In the

Antarctic Time Series for CO2, CH4 and Temeperature



CO_2, CH_4 and temperature records from Antarctic ice core data

Source: Vimeux, F., K.M. Cuffey, and Jouzel, J., 2002, "New insights into Southern Hemisphere temperature changes from Vostok ice cores using deuterium excess correction", *Earth and Planetary Science Letters*, **203**, 829-843.

Greenhouse mechanisms

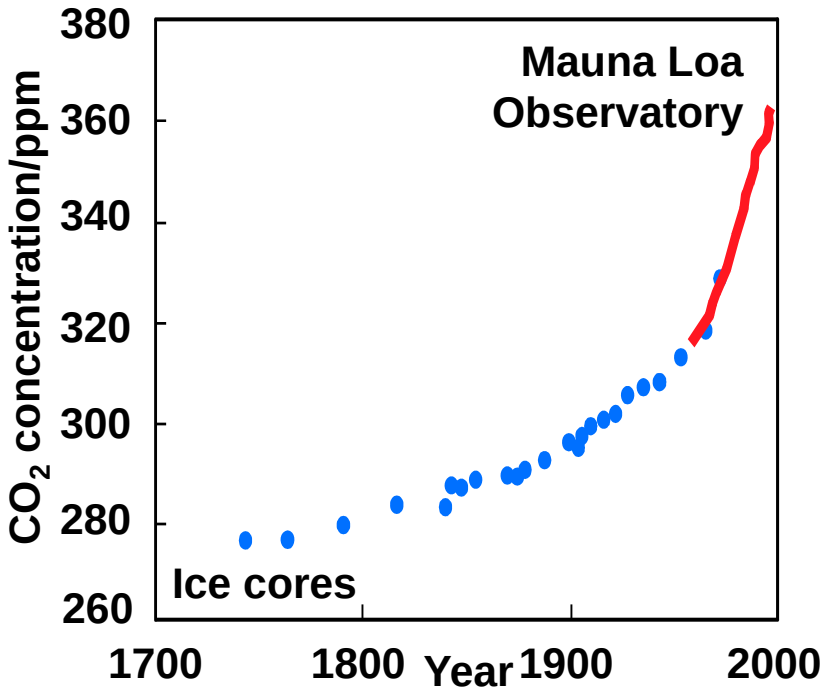
- The greenhouse effect is natural
- It maintains a liveable climate for life on Earth
- In the past changes in temperature were linked to changes in levels of greenhouse gases
- Changes in the carbon cycle driven by small temperature changes give positive feed back

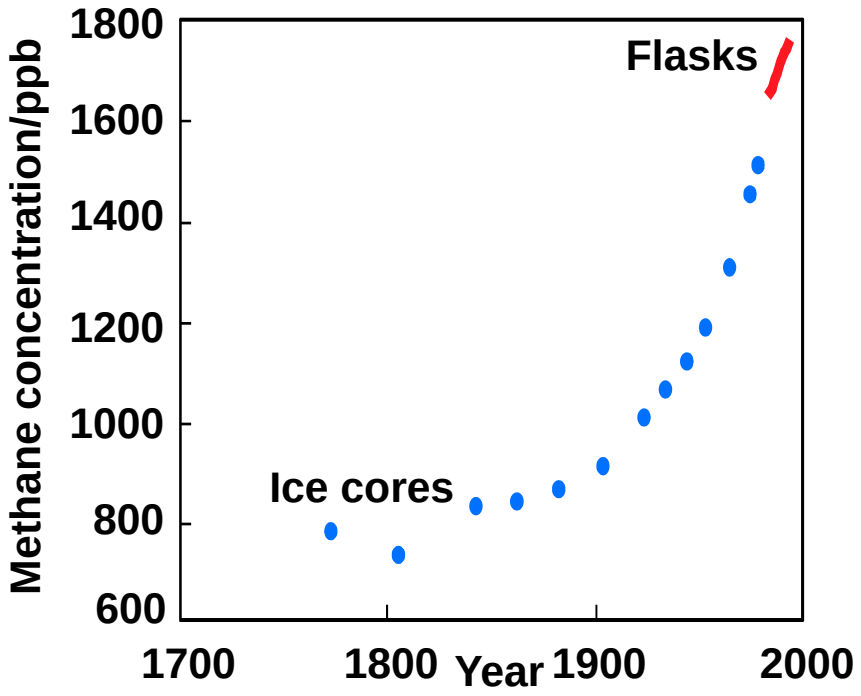
Greenhouse Gas Emissions

Carbon dioxide: 33% rise

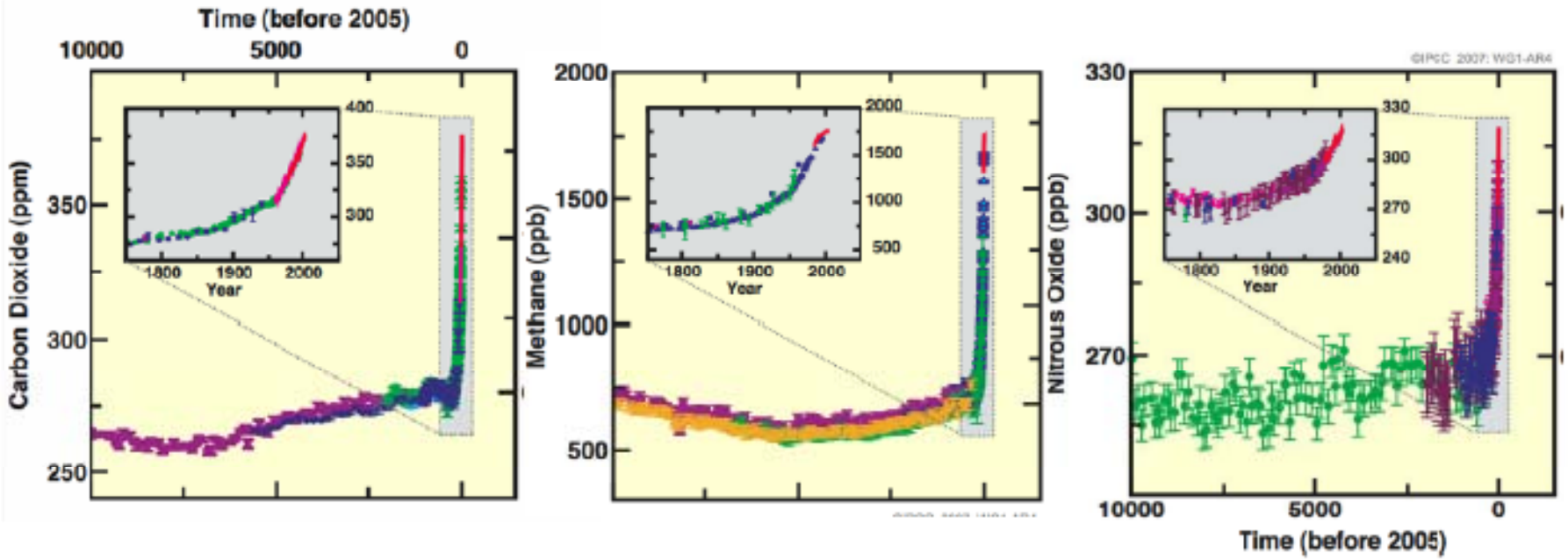
Methane: 100% rise

Source: IPCC

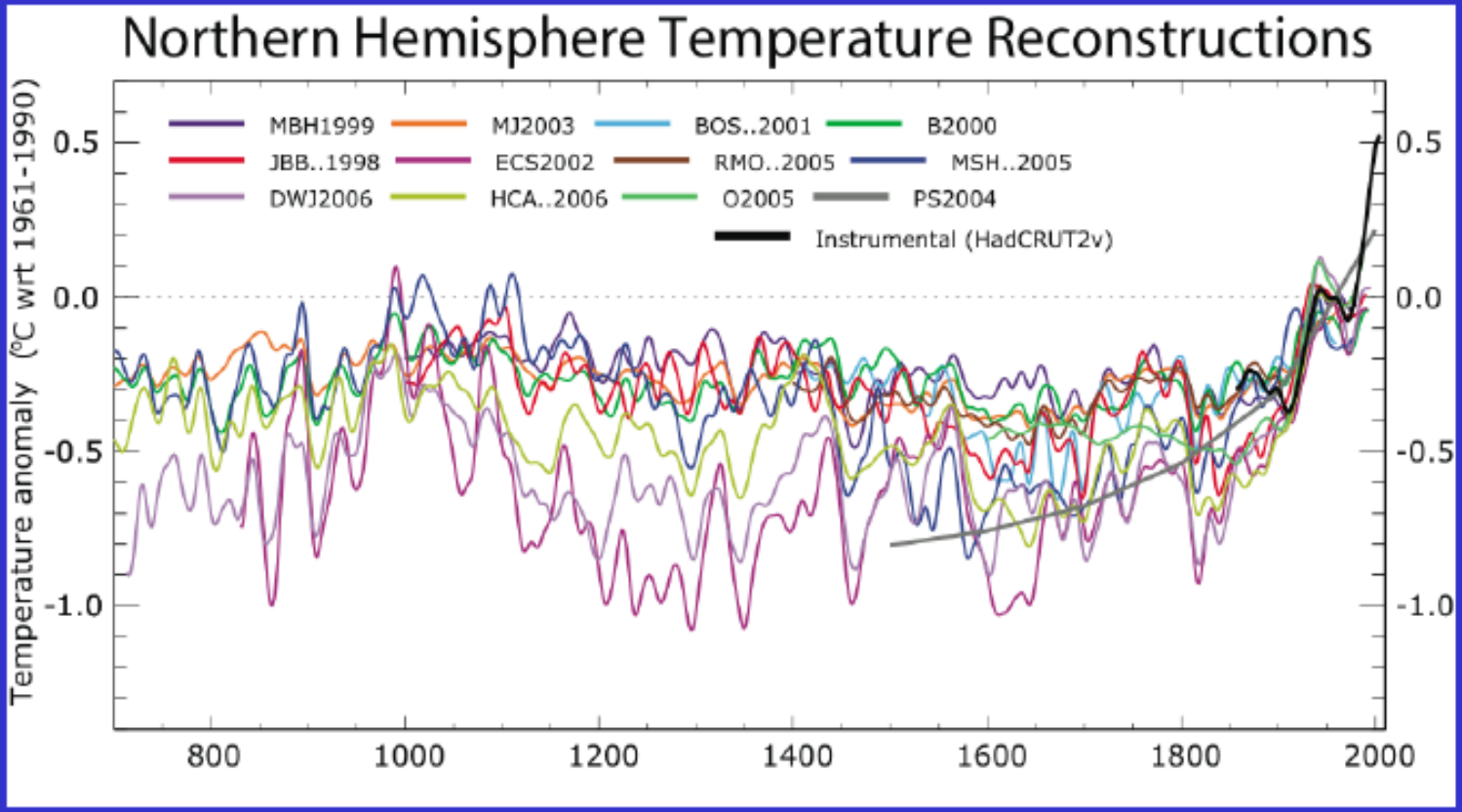


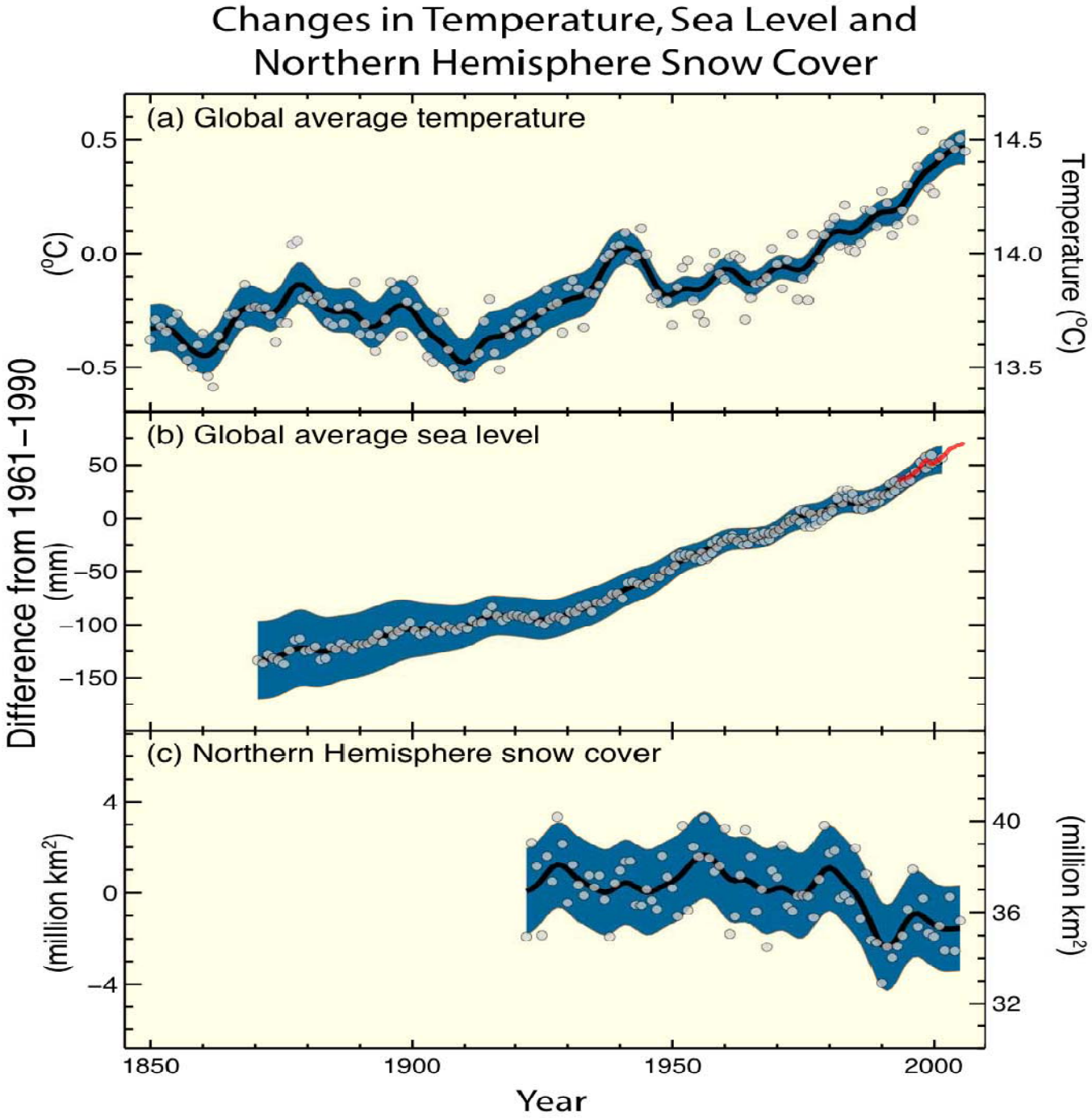


Changes in Levels of the Principal Greenhouse Gases



Warmth of the last half century is unusual in at least the previous 1300 years.

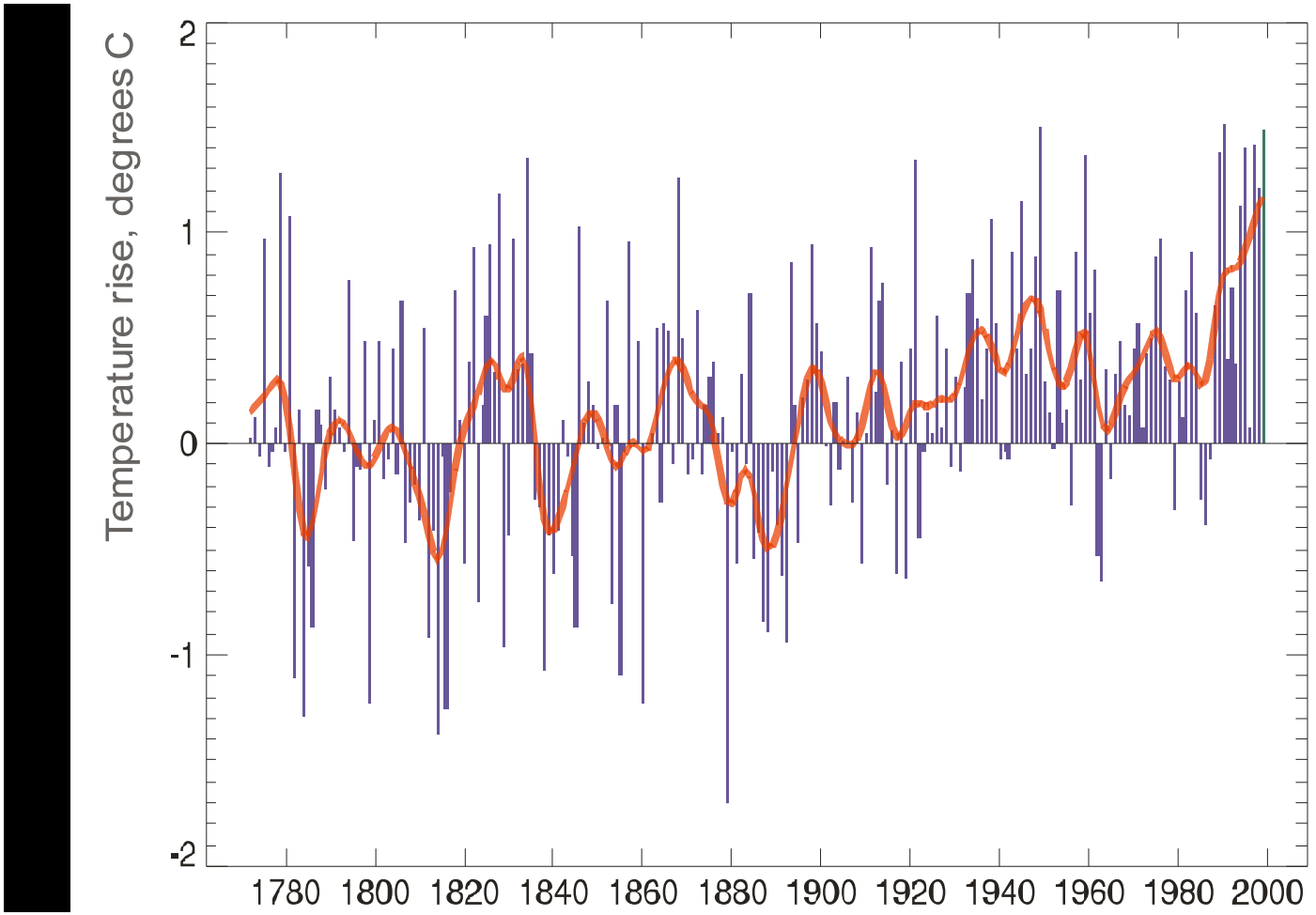



Changes in Temperature, Sea Level and Northern Hemisphere Snow Cover
(a) Global average temperature
(b) Global average sea level
(c) Northern Hemisphere snow cover
Difference from 1961–1990
(°C)
(mm)
(million km²)
Temperature (°C)
(million km²)
0.5
0.0
−0.5
14.5
14.0
13.5
50
0
−50
−100
−150
4
0
−4
40
36
32
1850
1900
1950
2000
Year

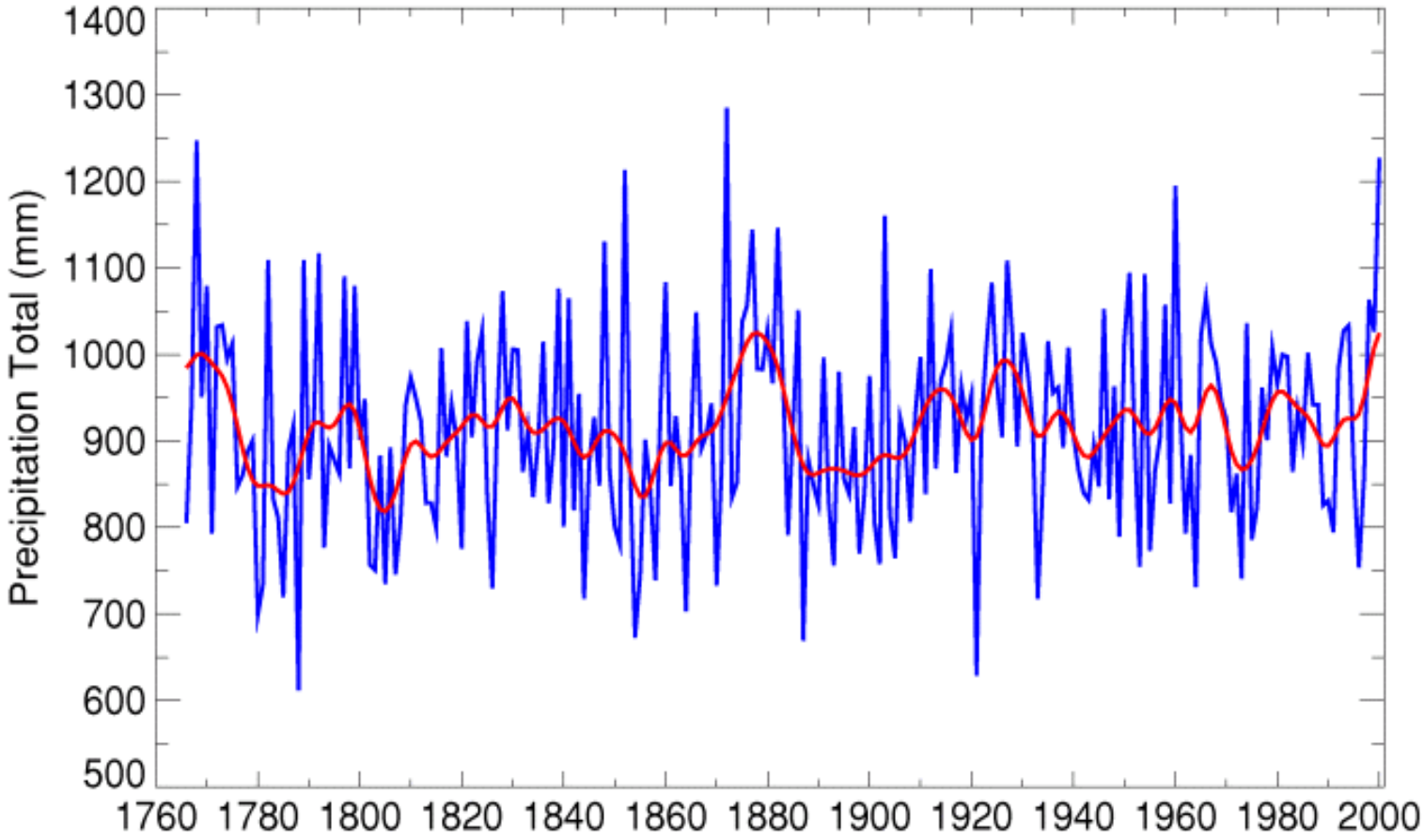
Glaciers in Retreat: Toboggan Glacier (Alaska) in 1909 and 2000

Coral bleaching: response to ocean warming

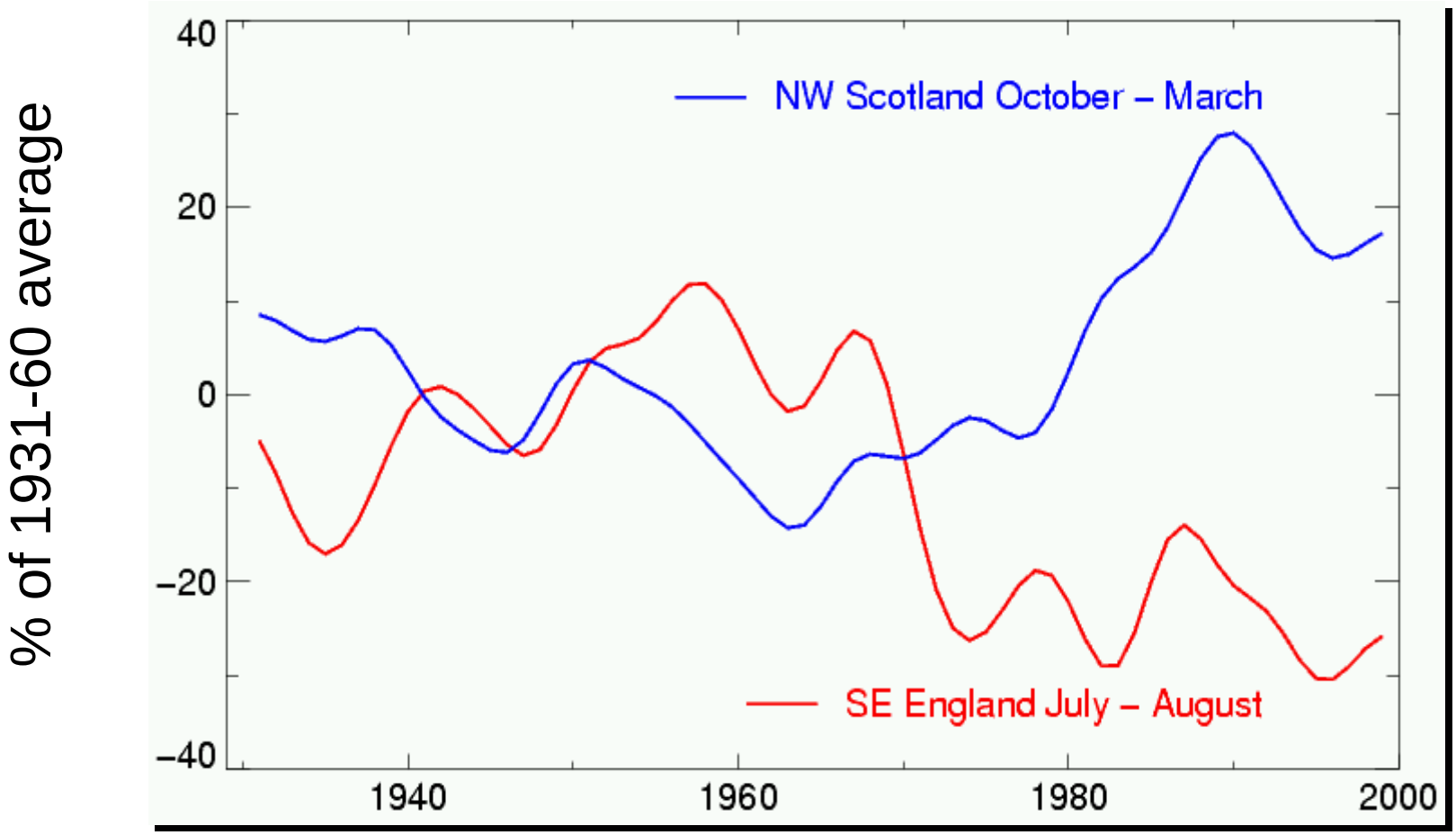
Warming In Central England



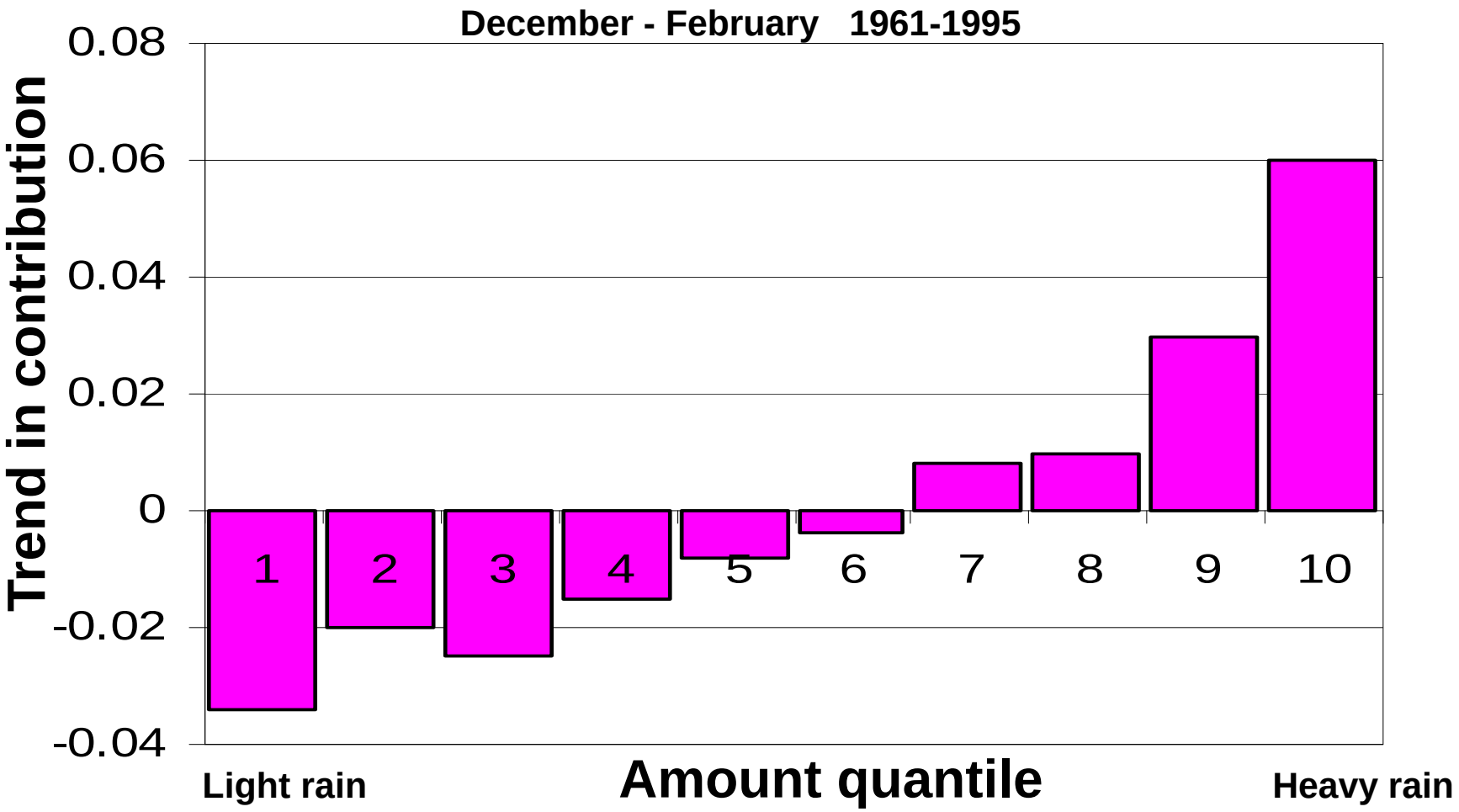
England & Wales Annual Rainfall



Seasonal Rainfall Changes in the UK



Change in intensity of UK rainfall



Measured Climate Change

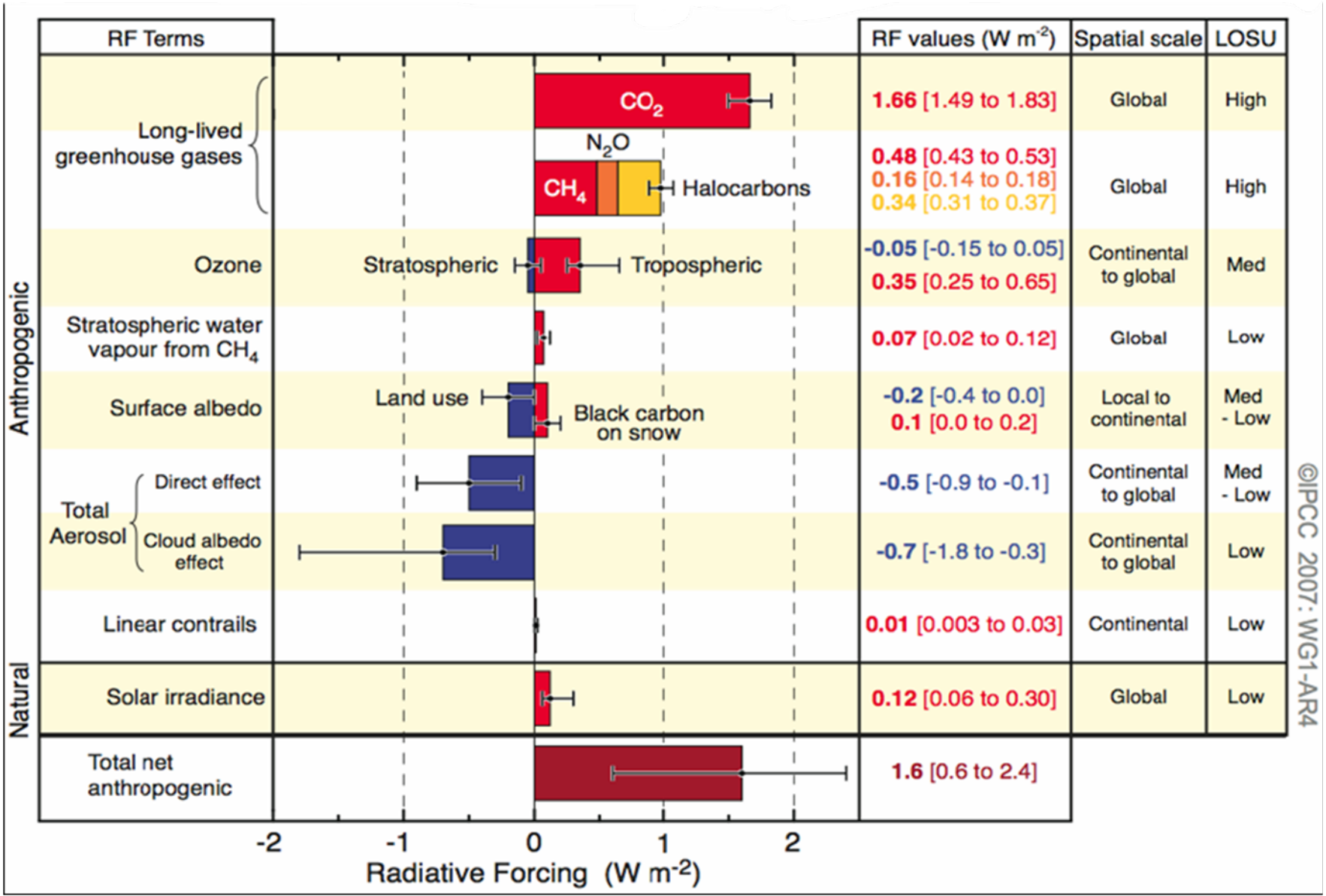
Records show that Earth is warming

- Globally
- Locally

There is strong evidence of positive feedback, from loss of ice and snow

Oceans are warming and sea levels are rising

Radiative Forcing Components



Agents of Climate Forcing

Now understand to good degree of accuracy impacts of different agents of forcing

Some natural phenomenon, volcanic activity, changes in solar output

BUT

Human activity is now the principal cause

Global Climatic Consequences of Further Change

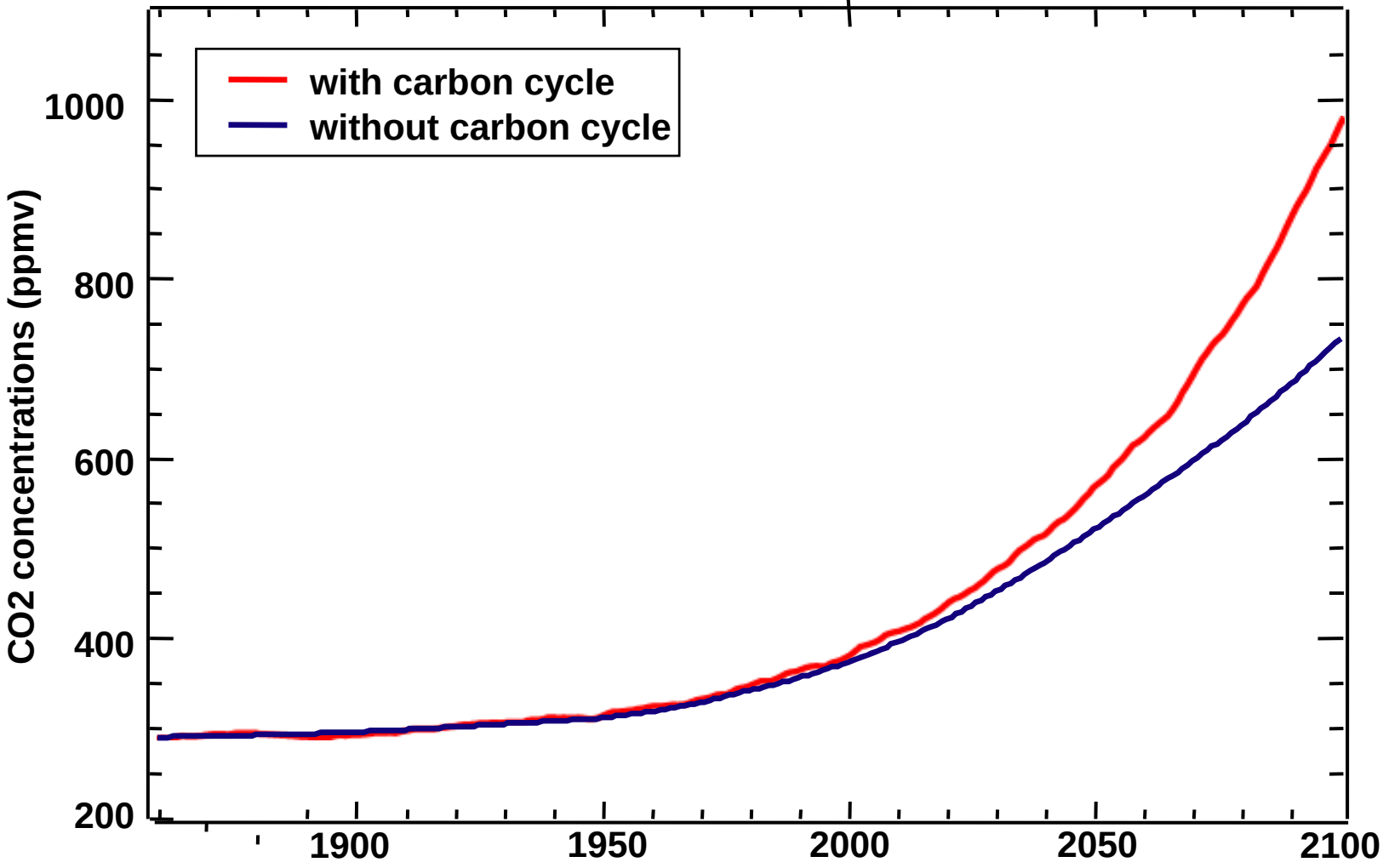
- Greater intensity of heat waves
- Greater intensity of storms
- Loss of key ecosystems

- Loss of productivity in marginal land
- Loss of habitation in coastal margins
- Human migration

- Societal stress
- Economic losses

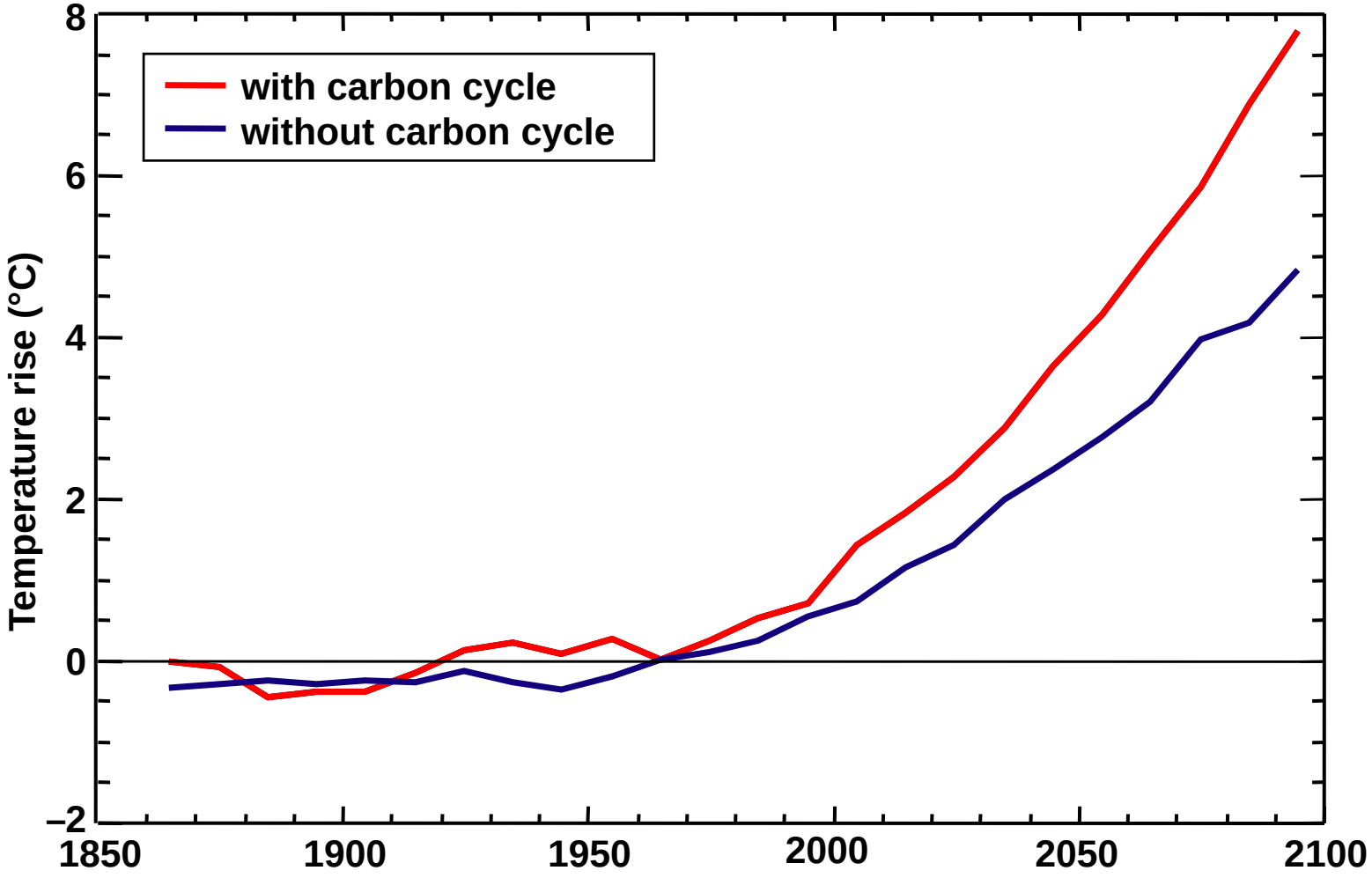
- Health impacts from:
  - rise of vector borne-diseases
  - Heat stress

Atmospheric CO2 Concentrations
due to business-as-usual emissions (IPCC IS92a)



Temperature Rise Over Land

due to IPCC business-as-usual (IS92a) emissions

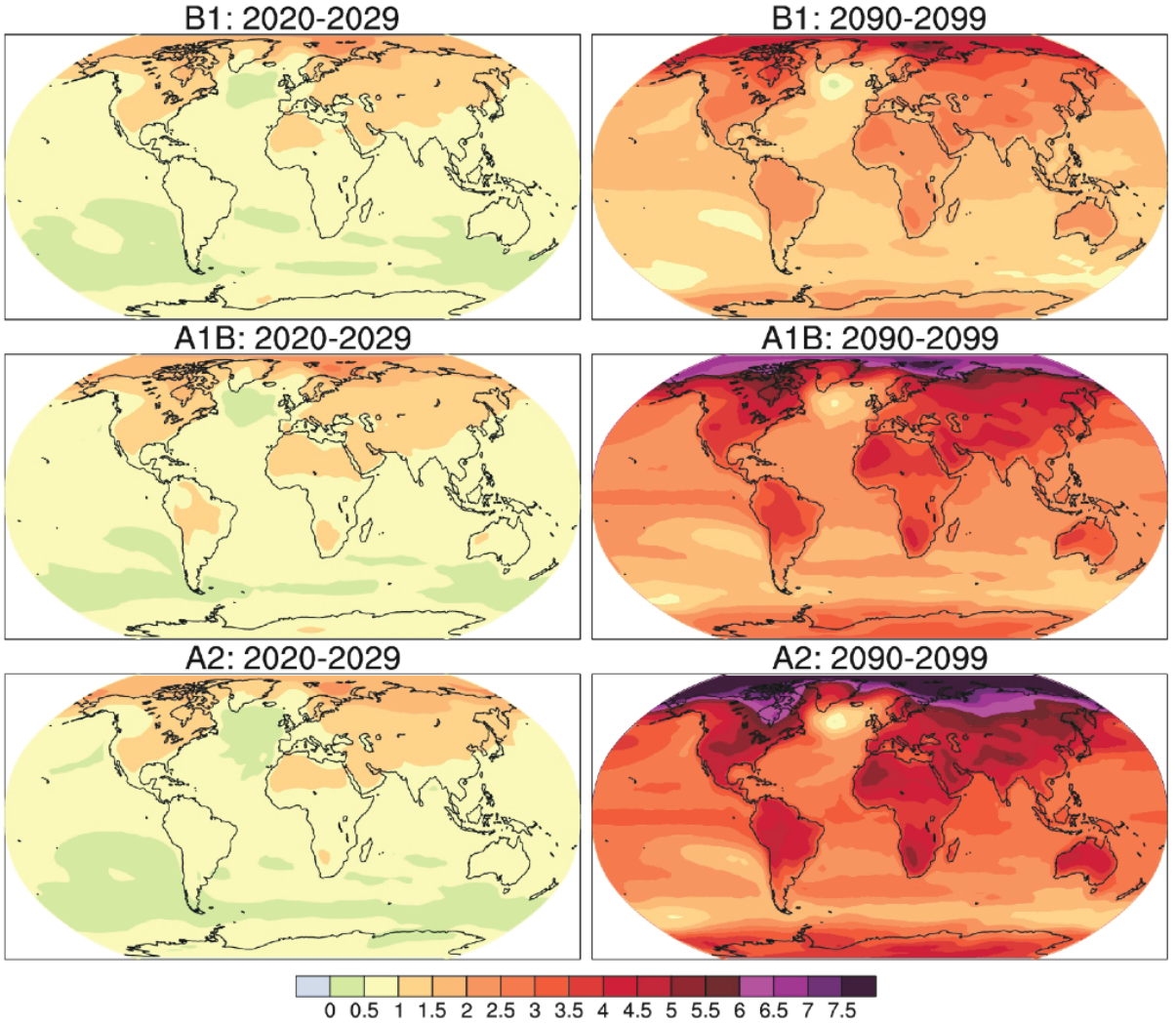


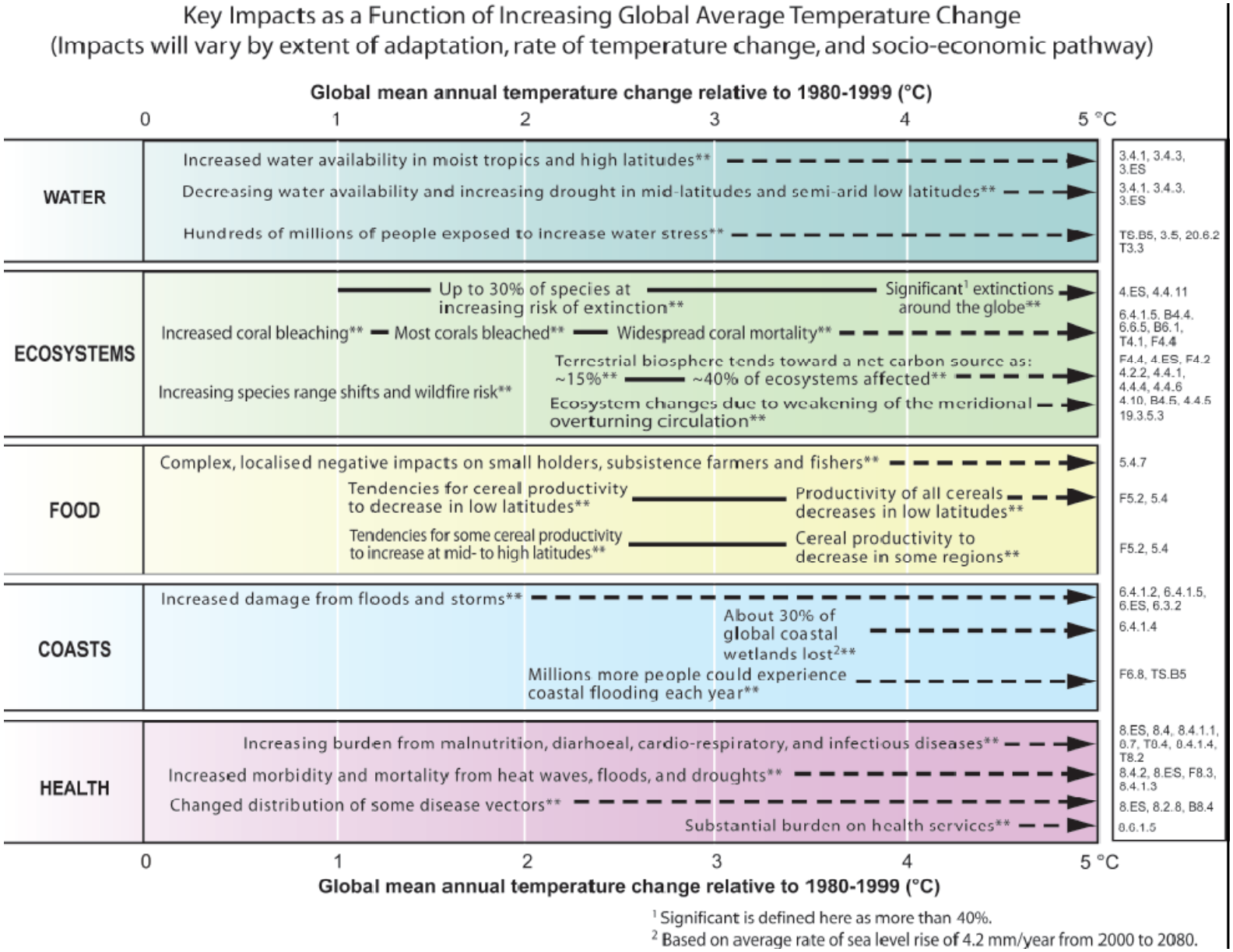
Projections of Future Changes in Climate

Projected warming in 21st century expected to be

greatest over land and at most high northern latitudes

and least over the Southern Ocean and parts of the North Atlantic Ocean




Key Impacts as a Function of Increasing Global Average Temperature Change
(Impacts will vary by extent of adaptation, rate of temperature change, and socio-economic pathway)
Global mean annual temperature change relative to 1980-1999 (°C)
0
1
2
3
4
5 °C
WATER
Increased water availability in moist tropics and high latitudes**
Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes**
Hundreds of millions of people exposed to increase water stress**
3.4.1, 3.4.3, 3.ES
3.4.1, 3.4.3, 3.ES
TS.B5, 3.5, 20.6.2 T3.3
ECOSYSTEMS
Up to 30% of species at increasing risk of extinction**
Significant[1] extinctions around the globe**
Increased coral bleaching**
Most corals bleached**
Widespread coral mortality**
Terrestrial biosphere tends toward a net carbon source as: ~15%** ~40% of ecosystems affected**
Increasing species range shifts and wildfire risk**
Ecosystem changes due to weakening of the meridional overturning circulation**
4.ES, 4.4.11
6.4.1.5, B4.4, 6.6.5, B6.1, T4.1, F4.4
F4.4, 4.ES, F4.2 4.2.2, 4.4.1, 4.4.4, 4.4.6 4.10, B4.5, 4.4.5 19.3.5.3
FOOD
Complex, localised negative impacts on small holders, subsistence farmers and fishers**
Tendencies for cereal productivity to decrease in low latitudes**
Productivity of all cereals decreases in low latitudes**
Tendencies for some cereal productivity to increase at mid- to high latitudes**
Cereal productivity to decrease in some regions**
5.4.7
F5.2, 5.4
F5.2, 5.4
COASTS
Increased damage from floods and storms**
About 30% of global coastal wetlands lost[2]**
Millions more people could experience coastal flooding each year**
6.4.1.2, 6.4.1.5, 6.ES, 6.3.2
6.4.1.4
F6.8, TS.B5
HEALTH
Increasing burden from malnutrition, diarhoeal, cardio-respiratory, and infectious diseases**
Increased morbidity and mortality from heat waves, floods, and droughts**
Changed distribution of some disease vectors**
Substantial burden on health services**
8.ES, 8.4, 8.4.1.1, 0.7, T0.4, 0.4.1.4, T8.2
8.4.2, 8.ES, F8.3, 8.4.1.3
8.ES, 8.2.8, B8.4
0.6.1.5
0
1
2
3
4
5 °C
Global mean annual temperature change relative to 1980-1999 (°C)
[1] Significant is defined here as more than 40%.
[2] Based on average rate of sea level rise of 4.2 mm/year from 2000 to 2080.

Local Consequences of Further Change

Immediate UK:

- Hotter, drier summers, warmer, wetter winters
- Increased storminess
- Increase in intensity and frequency of droughts
- Increase in intensity and frequency of flooding

Further Information from www.ukcip.org.uk

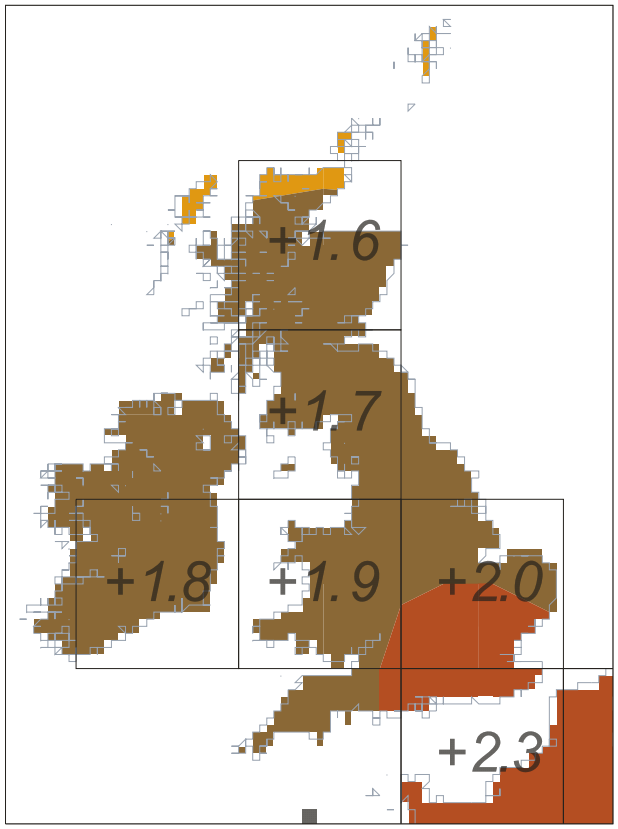
Local consequences of further climate change

Longer term change

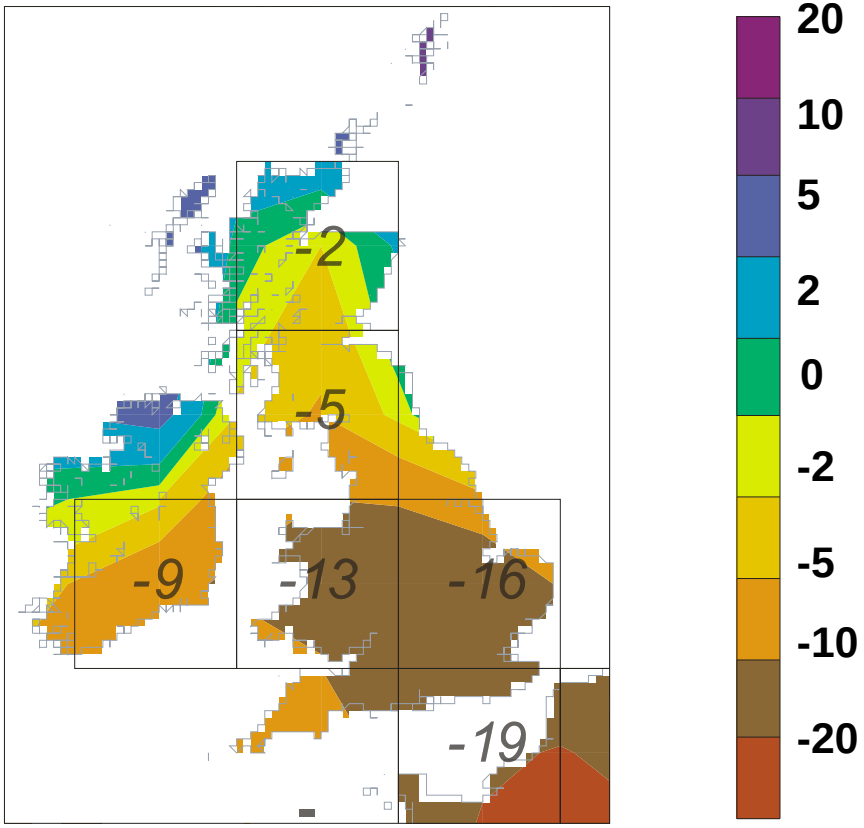
- Sea level rise from loss of Greenland ice: several meters
- London and other UK cities flooded
- Climate instability due to weakening of gulf stream
- Very cold winters (as Labrador is now)
- Hydrological cycles and soils radically altered
- Extreme droughts and floods (as in parts of Africa now)
- Changes in seasonal mortality (lower winter, higher summer)

Changes in UK Climate by the 2050s

Relative to the present day

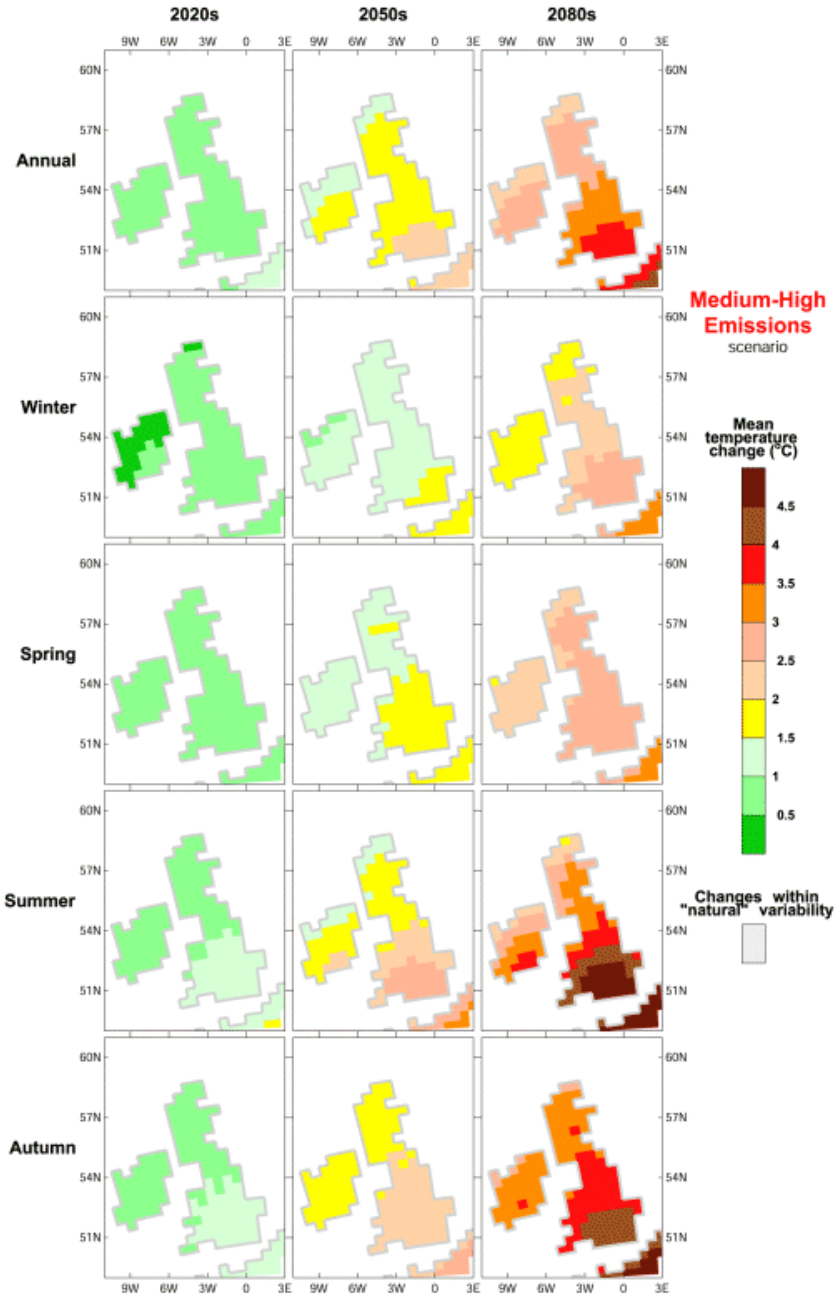


Annual mean temperature change (deg C)



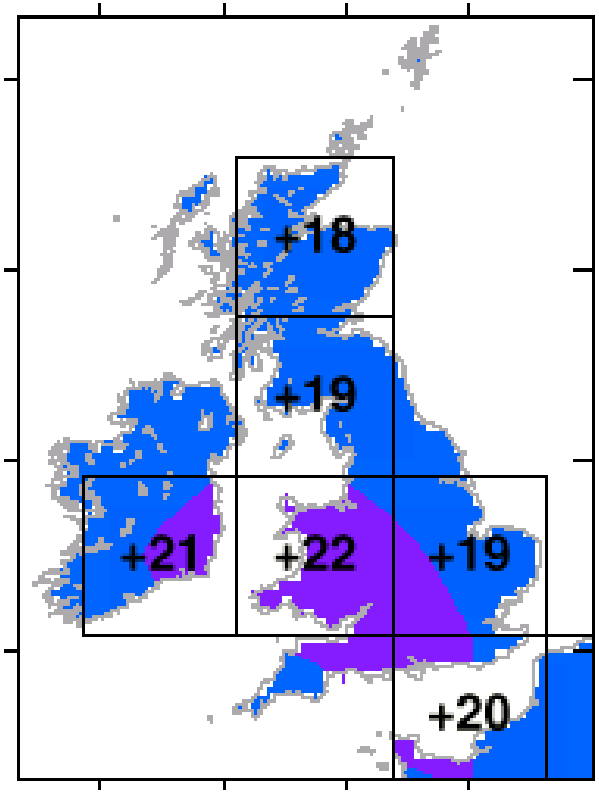
Summertime (JJA) rainfall change (%)

UEA NORWICH UKCIP HadCM2GHGx4



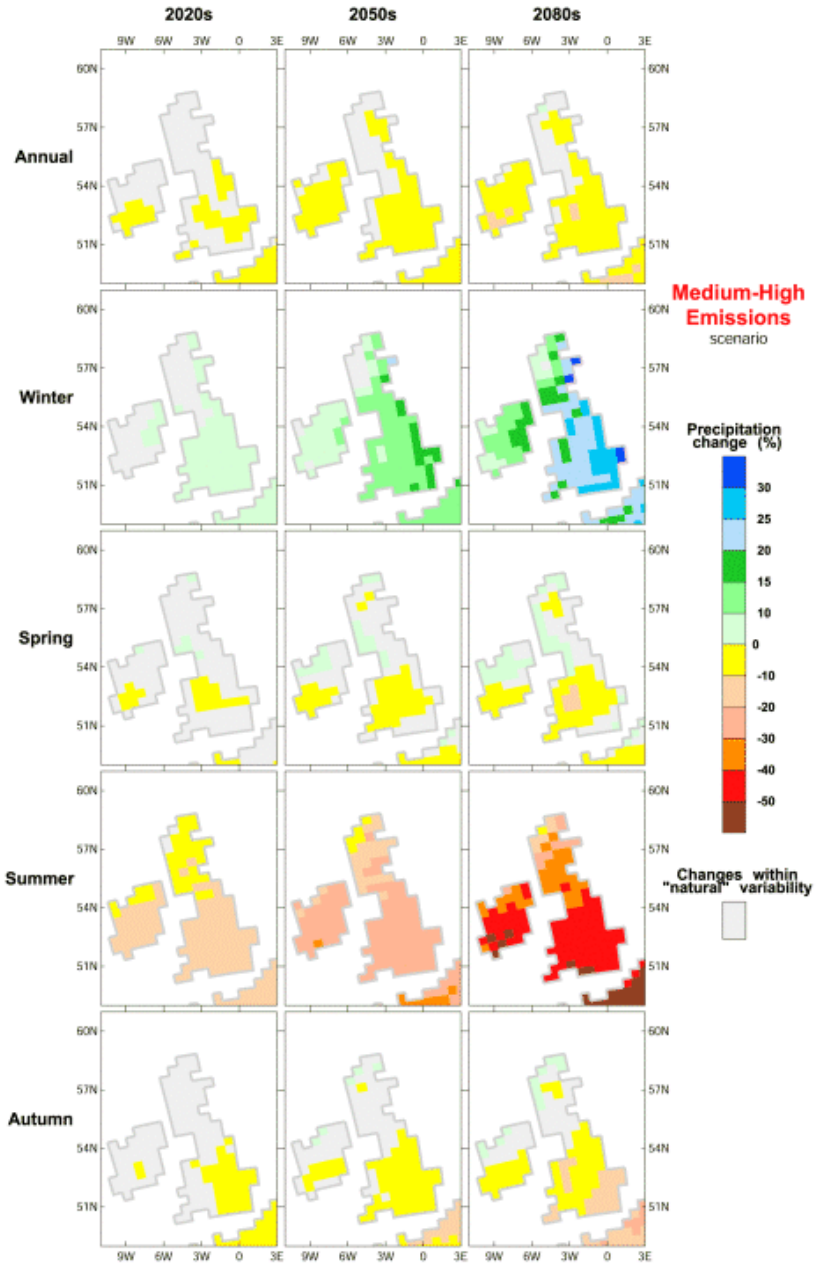
Source: UKCIP02 Climate Change Scenarios (funded by DEFRA, produced by Tyndall and Hadley Centres for UKCIP)

Change in winter rainfall by the 2080s



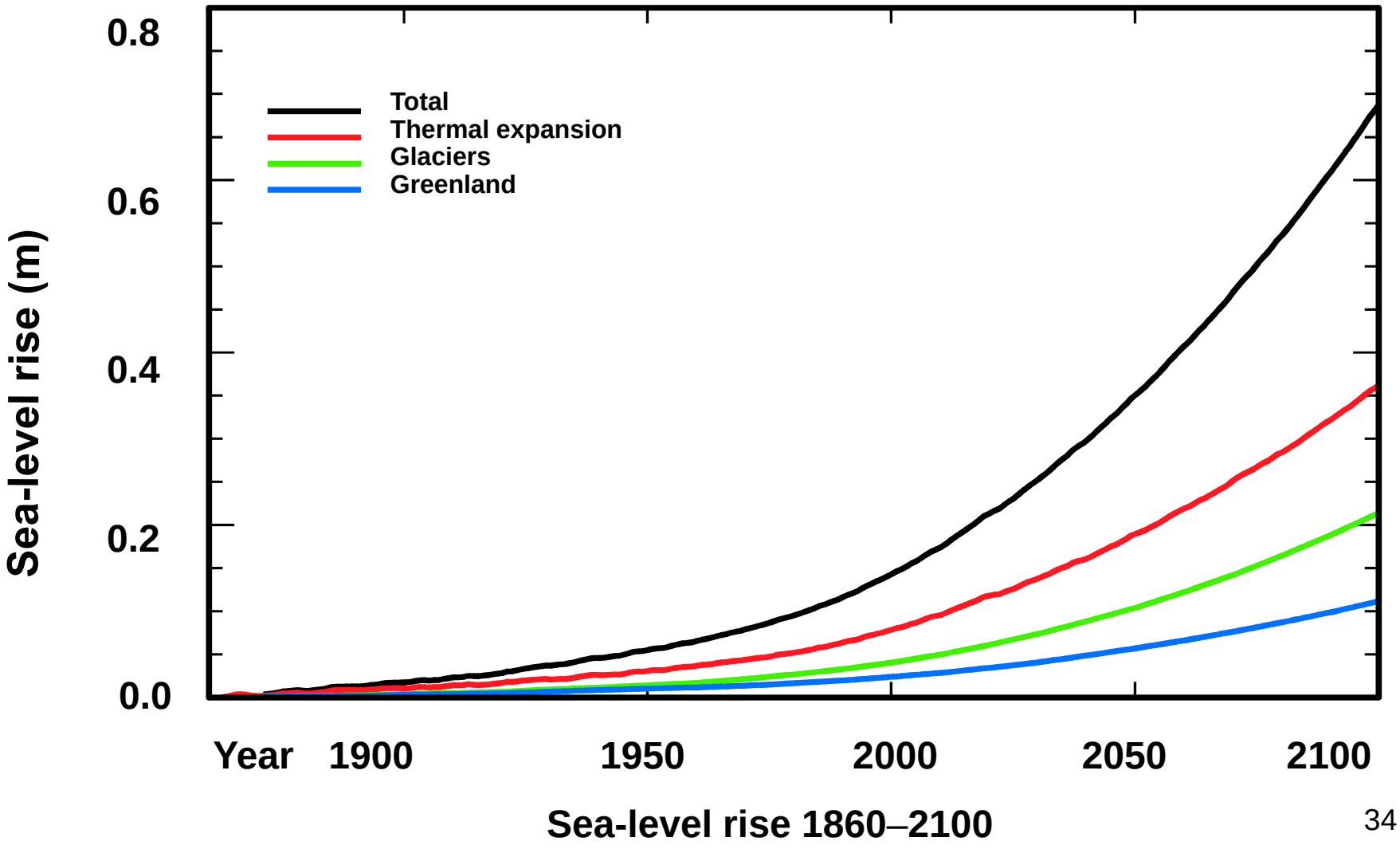
Hadley Centre/UEA

UKCIP98 scenario

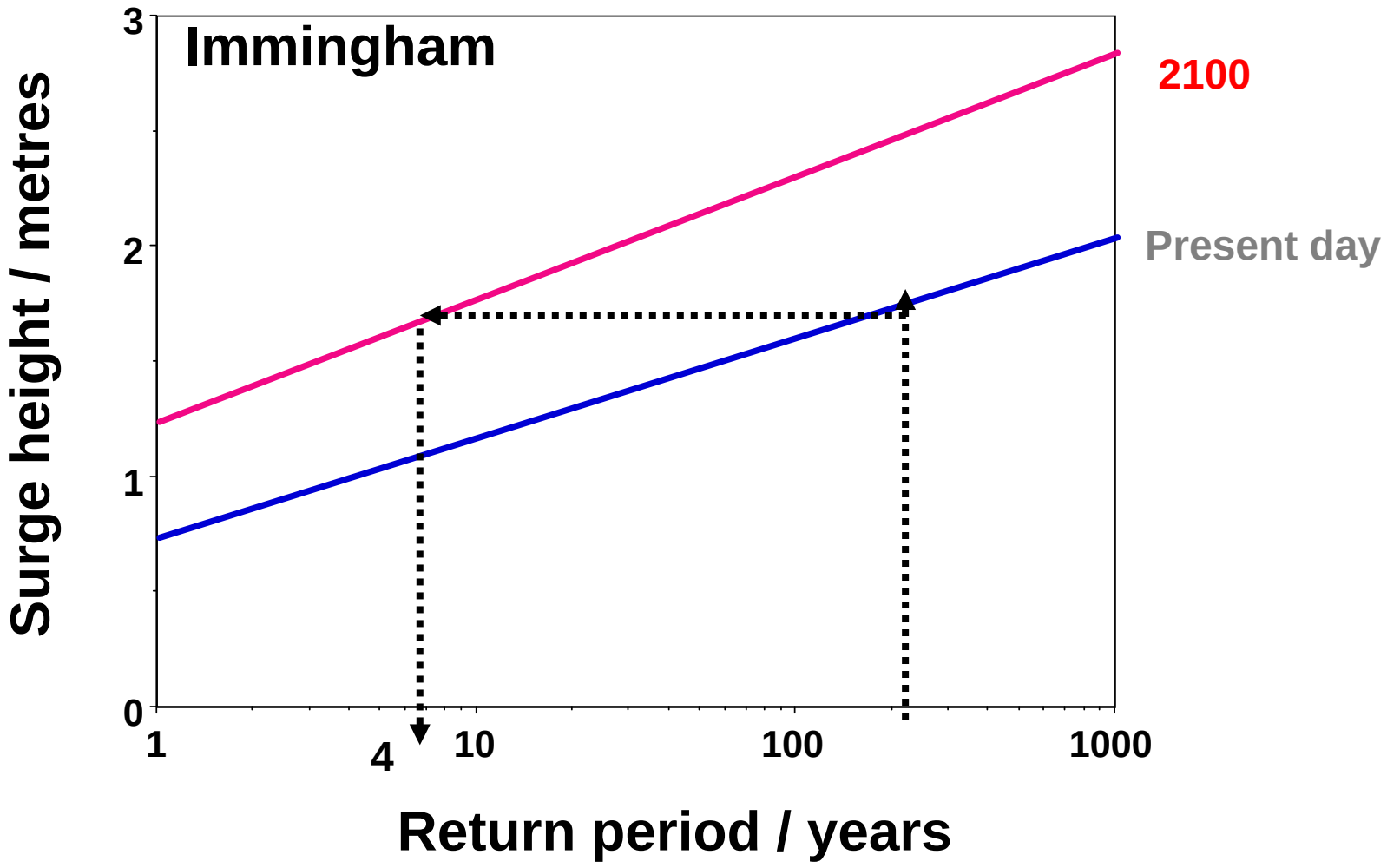


Source: UKCIP02 Climate Change Scenarios (funded by DEFRA, produced by Tyndall and Hadley Centres for UKCIP)

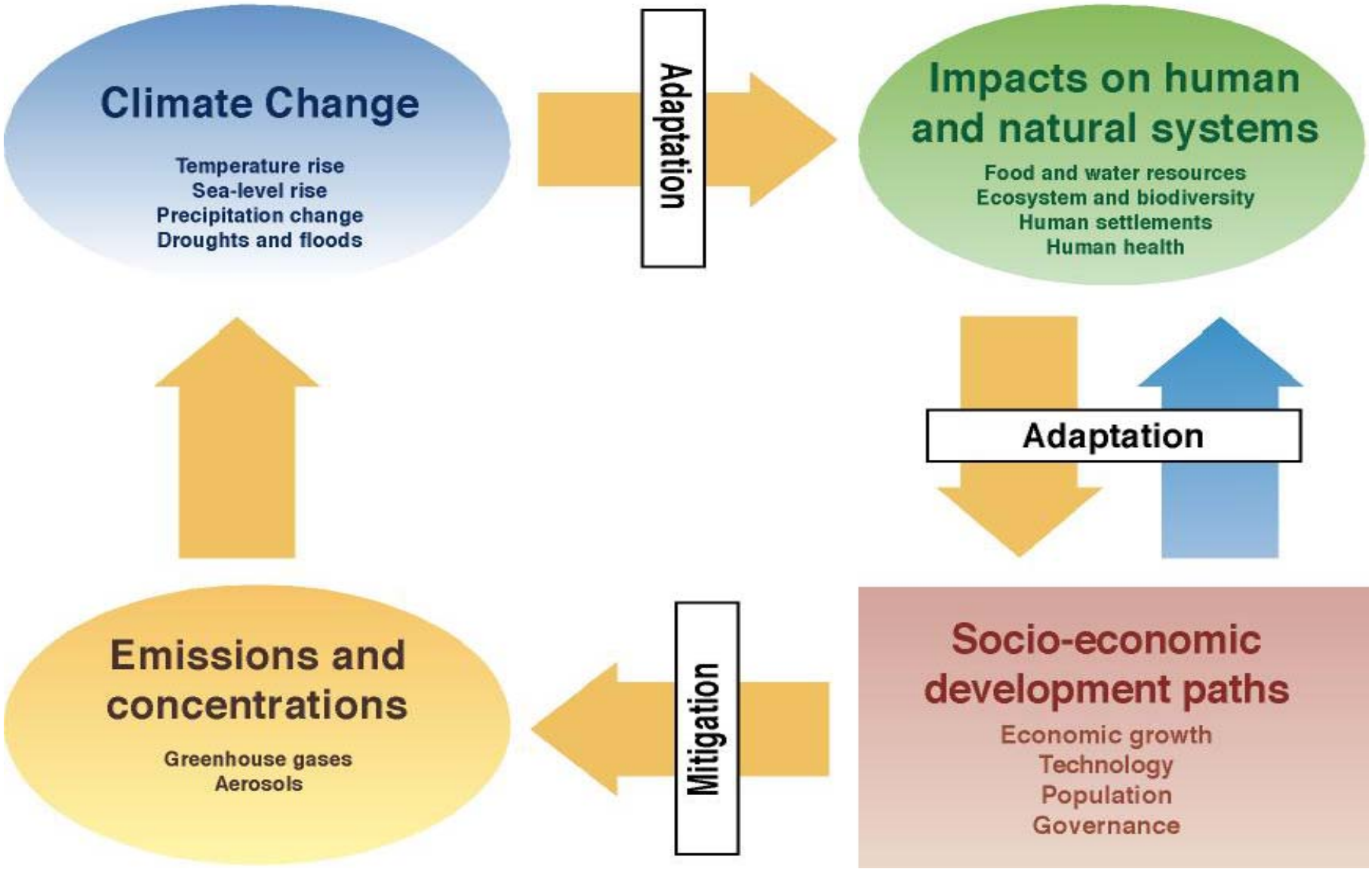
Sea-level rise and its components



Storm Surge Frequency



Climate Change – An integrated framework



Rising to the Challenge: Managing further change

Mitigation: aim to stabilise greenhouse gas levels in the atmosphere

Large reductions in emissions needed (60% or more) to stabilise before catastrophic change is inevitable (e.g. loss of Greenland ice sheet)

How can emissions be reduced?

Sector	(Selected) Key mitigation technologies and practices currently commercially available.
Industry	More efficient electrical equipment; heat and power recovery; material recycling; control of non-CO_2 gas emissions
Agriculture	Land management to increase soil carbon storage; restoration of degraded lands; improved rice cultivation techniques; improved nitrogen fertilizer application; dedicated energy crops
Forests	Afforestation; reforestation; forest management; reduced deforestation; use of forestry products for bioenergy
Waste	Landfill methane recovery; waste incineration with energy recovery; composting; recycling and waste minimization

How can emissions be reduced?

Sector	**(Selected) Key mitigation technologies and practices currently commercially available.**
Energy Supply	efficiency; fuel switching; nuclear power; renewable (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; early applications of CO2 Capture and Storage
Transport	More fuel efficient vehicles; hybrid vehicles; biofuels; modal shifts from road transport to rail and public transport systems; cycling, walking; land-use planning
Buildings	Efficient lighting; efficient appliances and airco; improved insulation ; solar heating and cooling; alternatives for fluorinated gases in insulation and aplliances

What are the macro-economic costs in 2030?

Stabilization levels (ppm CO_2-eq)	Median GDP reduction [1] (%)	Range of GDP reduction [2] (%)	Reduction of average annual GDP growth rates [3] (percentage points)
590-710	0.2	-0.6 – 1.2	< 0.06
535-590	0.6	0.2 – 2.5	<0.1
445-535 [4]	Not available	< 3	< 0.12

[1] This is global GDP based market exchange rates.
[2] The median and the 10th and 90th percentile range of the analyzed data are given.
[3] The calculation of the reduction of the annual growth rate is based on the average reduction during the period till 2030 that would result in the indicated GDP decrease in 2030.
[4] The number of studies that report GDP results is relatively small and they generally use low baselines.

Rising to the Challenge in the UK: Mitigation

Mitigation: reducing agents of climate forcing
For the UK:

- Aim of policy: 60% reduction by 2050
- Investment in new technology
  - Clean Coal Carbon Capture and Storage
  - Low carbon vehicles
  - Bio fuels
  - Renewable energy sources
  - Hydrogen
- Managing carbon cycles
  - Improving soils
  - Better land use, forestry

Adaptation: preparing for the inevitable

For the UK this means:

- Flood defence (new London barrier)
- Water supply management (water grid)
- Securing infrastructure
    - Roads and railways
    - Harbours
    - Power stations
- Adopting arid agricultural practices
- Preparing health systems for new challenges

Conclusions

- Climate is changing
- The change is driven by human activity
- Consequences will be severe and costly
- We must take urgent action to reduce emission of greenhouse gases (at least 60%)
- Delay will be costly and preclude some options
- We must climate proof infrastructure and other key systems, including health care
- Businesses of all kinds will come under pressure to improve carbon performance
- This is challenging, but there are some great opportunities too for companies with effective solutions.