

KING'S College LONDON

University of London

AIR QUALITY and CLIMATE CHANGE – THE BEST OF BOTH WORLDS?

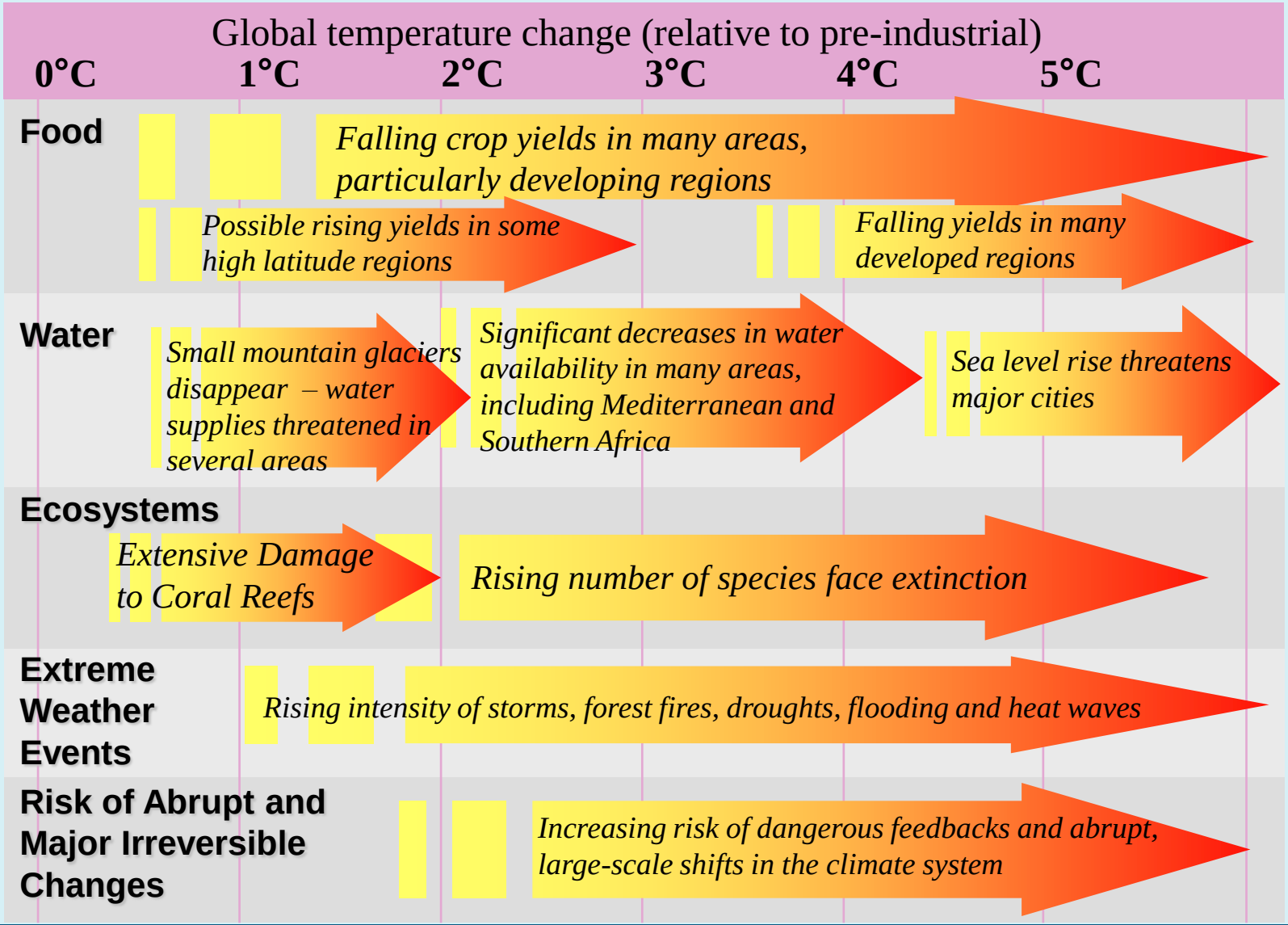
Prof. Martin Williams
King's College London

Kent & Medway Air Quality Partnership
Urban Change. Aylseford, 14 October 2010

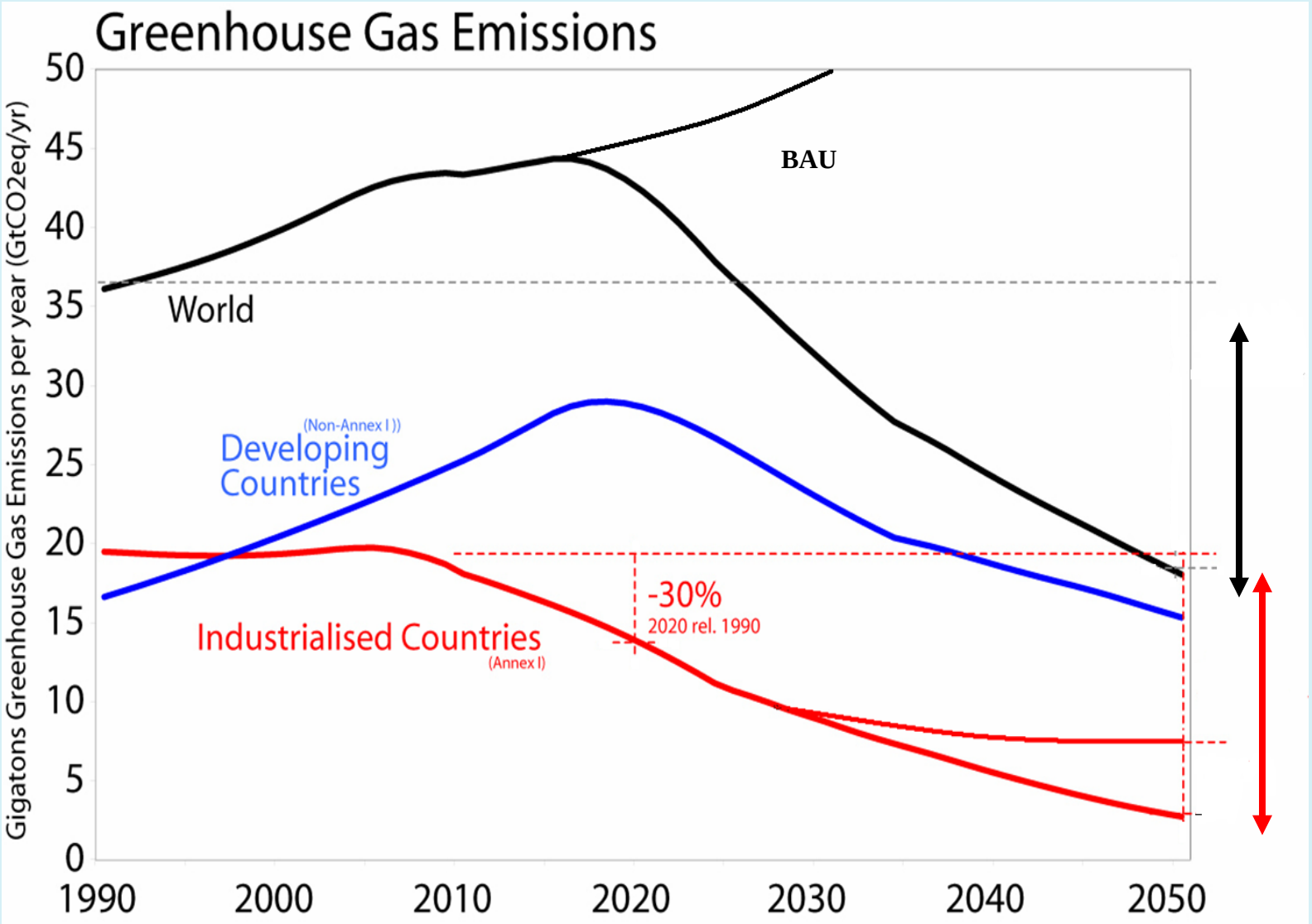
Climate Change and Air Quality

- Both are important and are caused by common sources – ‘One Atmosphere’
- A rational approach suggests common, or at least very closely co-ordinated, management
- This tends not to happen – DECC/Defra, EC separate DGs
- New developments might force closer links

Projected temperature increases and impacts



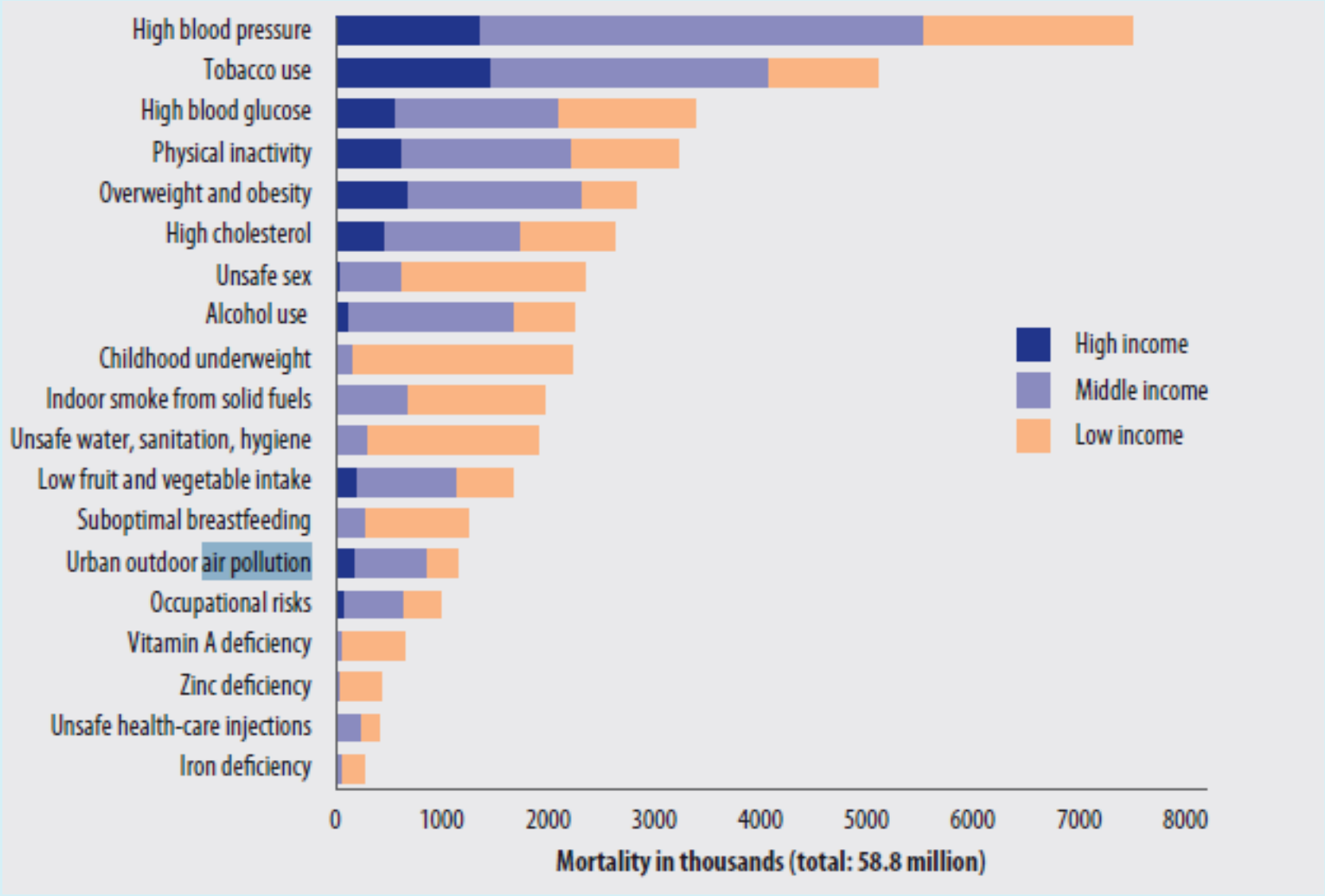
So how might we stay below 2º Celsius?



Global emissions 50% lower by 2050 on 1990 levels

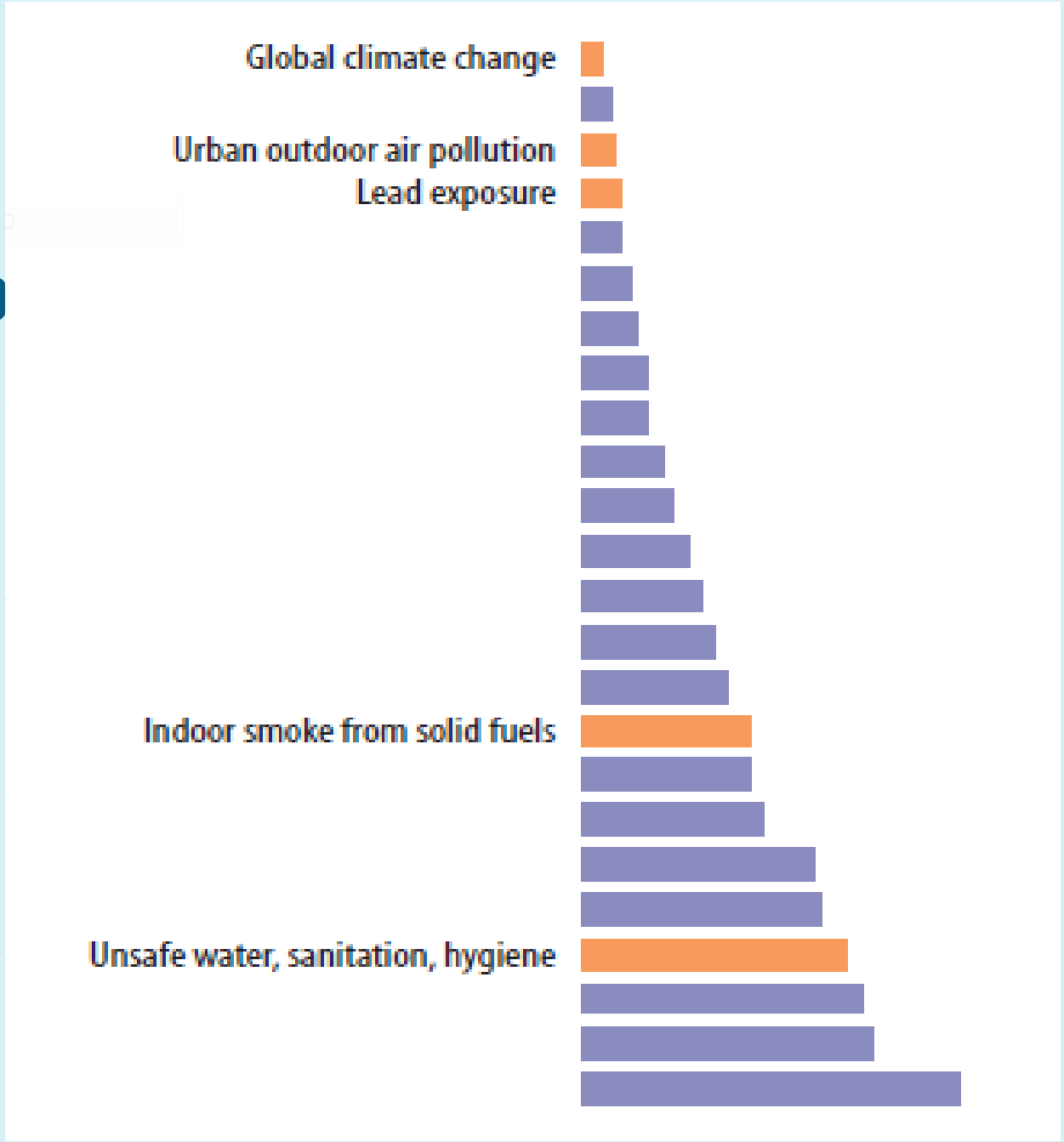
Developed country emissions 60-80% lower by 2050 on 1990 levels

Deaths attributed to 19 leading risk factors by country income level, 2004 (WHO Global Health Risks 2009)

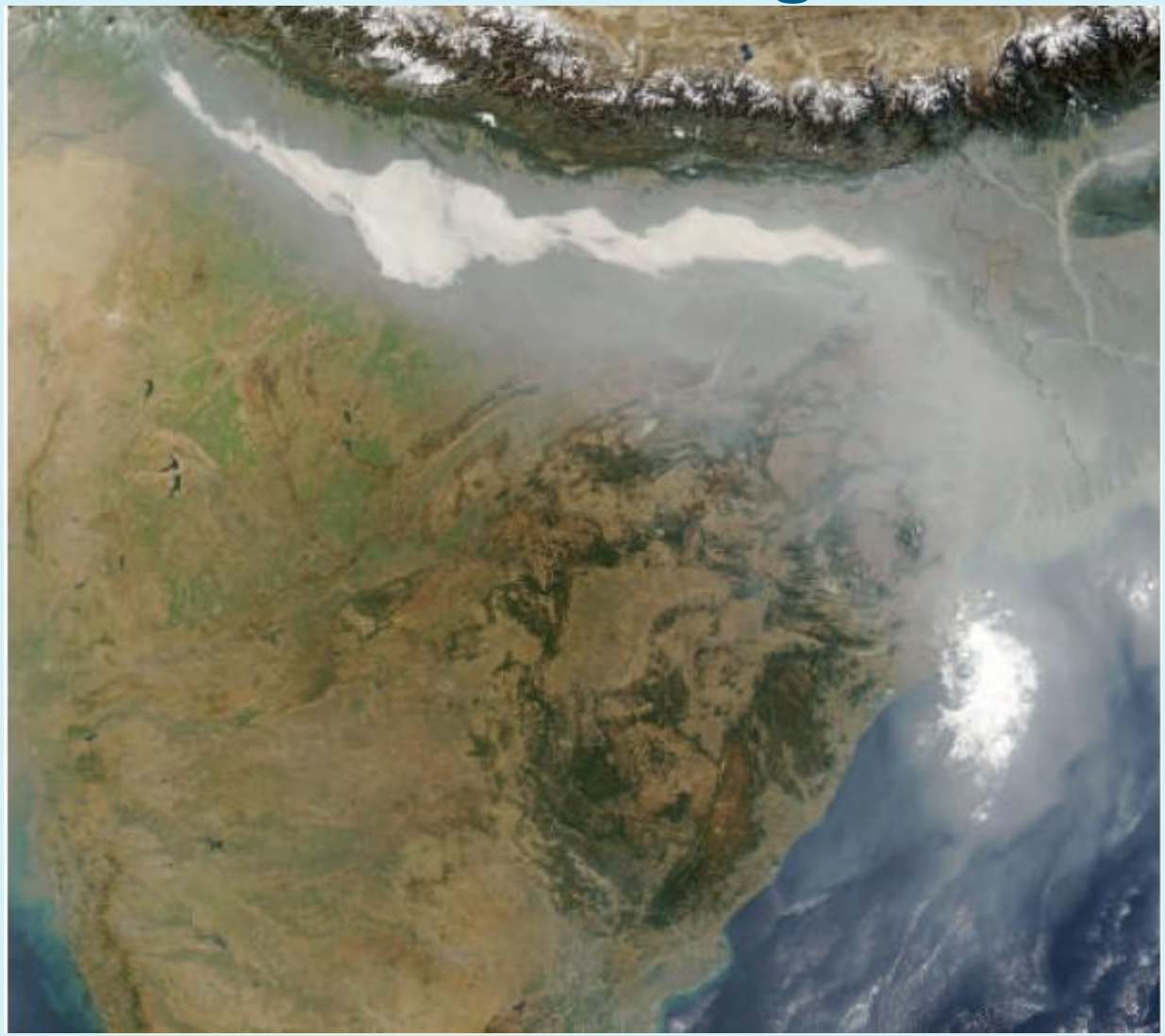


Presented by Martin Williams

Environmental risks from WHO Global Health Risks, WHO 2009



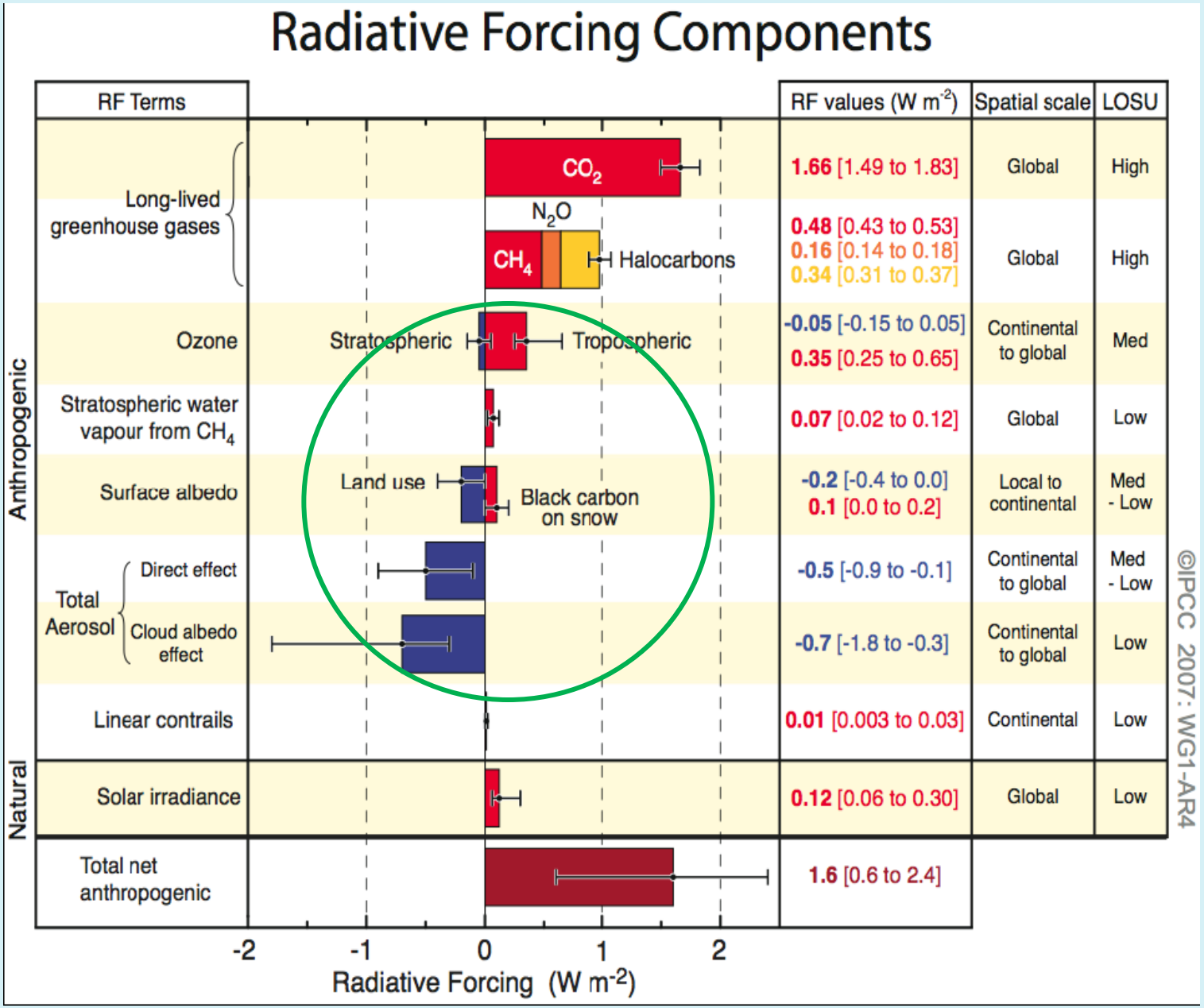
Particles pose problems world-wide: ‘Brown Cloud’ over the Ganges delta



Indoor cooking practices in Asia pose health problems and add to global emissions

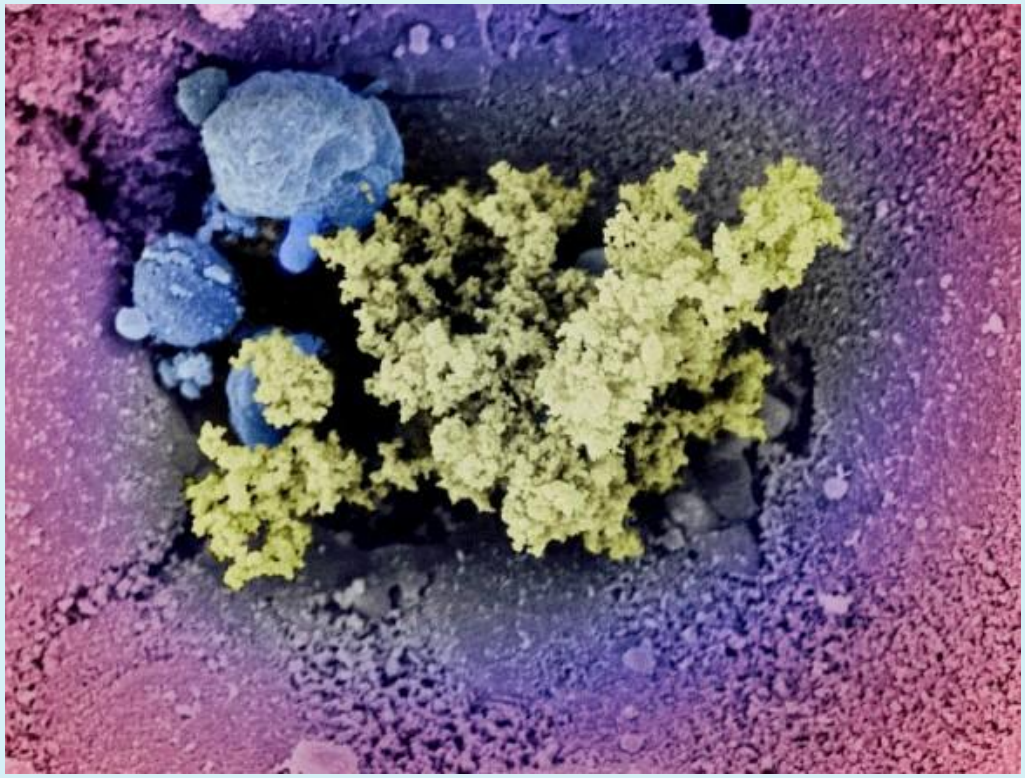
Air pollutants with climate impacts

- **Sulphate aerosol (cooling)**
- **Black carbon (warming)**
- **Ozone (warming)**
- **Methane (creates ozone but also in Kyoto)**
- **CO, NO_X and VOCs (create ozone)**
- **Ammonia (combines with SO_2 to form sulphate aerosol)**

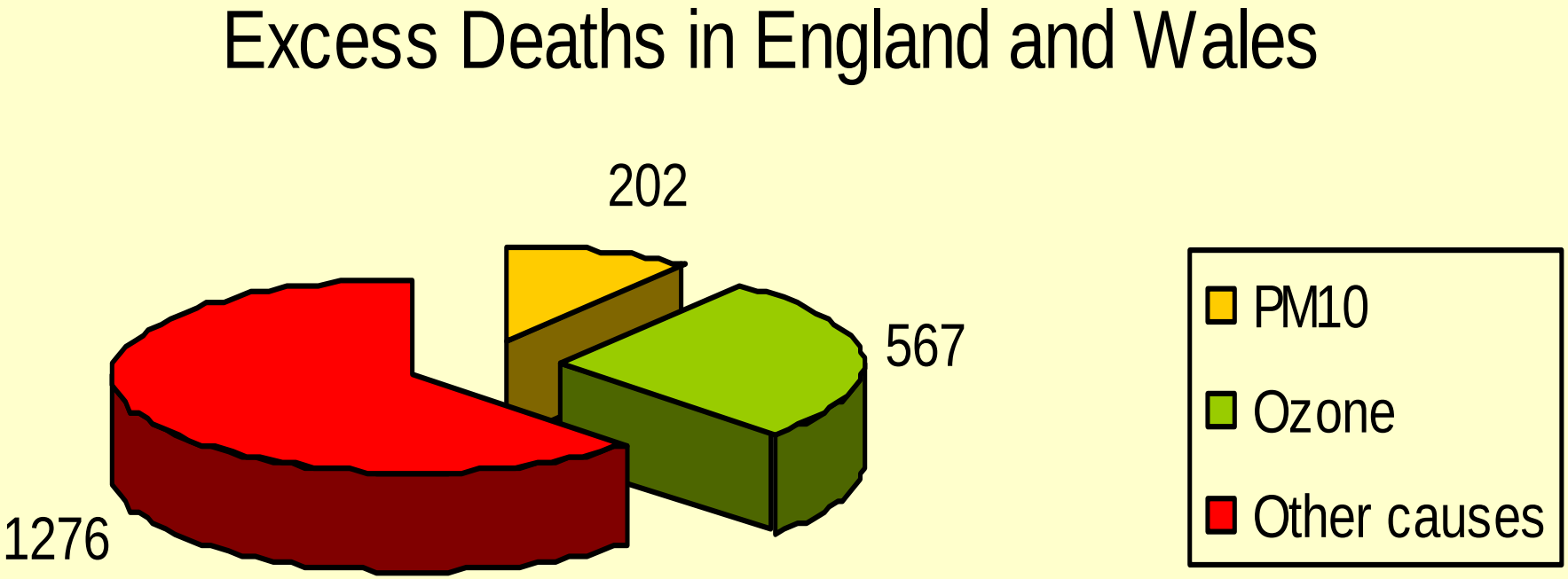

Radiative Forcing Components
RF Terms
RF values (W m-2)
Spatial scale
LOSU
Anthropogenic
Natural
Long-lived greenhouse gases
CO2
N2O
CH4
Halocarbons
1.66 [1.49 to 1.83]
Global
High
0.48 [0.43 to 0.53]
0.16 [0.14 to 0.18]
0.34 [0.31 to 0.37]
Global
High
Ozone
Stratospheric
Tropospheric
-0.05 [-0.15 to 0.05]
0.35 [0.25 to 0.65]
Continental to global
Med
Stratospheric water vapour from CH4
0.07 [0.02 to 0.12]
Global
Low
Surface albedo
Land use
Black carbon on snow
-0.2 [-0.4 to 0.0]
0.1 [0.0 to 0.2]
Local to continental
Med - Low
Total Aerosol
Direct effect
-0.5 [-0.9 to -0.1]
Continental to global
Med - Low
Cloud albedo effect
-0.7 [-1.8 to -0.3]
Continental to global
Low
Linear contrails
0.01 [0.003 to 0.03]
Continental
Low
Solar irradiance
0.12 [0.06 to 0.30]
Global
Low
Total net anthropogenic
1.6 [0.6 to 2.4]
-2
-1
0
1
2
Radiative Forcing (W m-2)
©IPCC 2007: WG1-AR4

Particles

- The health impact of current levels of air pollution in the UK is valued at a cost of **£15 billions per annum** (range £8-17 Bn);
- Reduces life expectancy for the whole UK population by **~6 months**

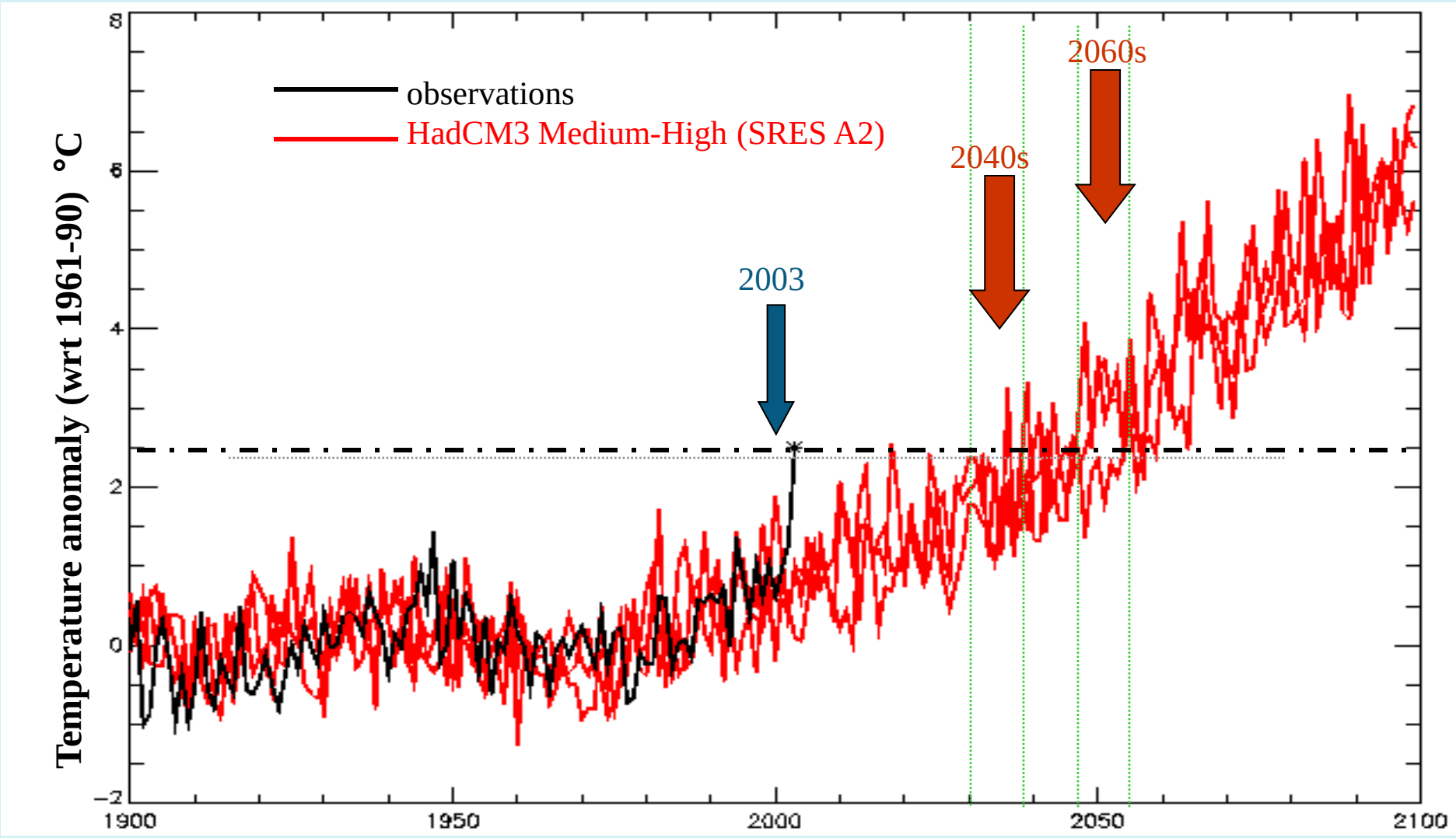


Pollution Episode 4-13 August 2003



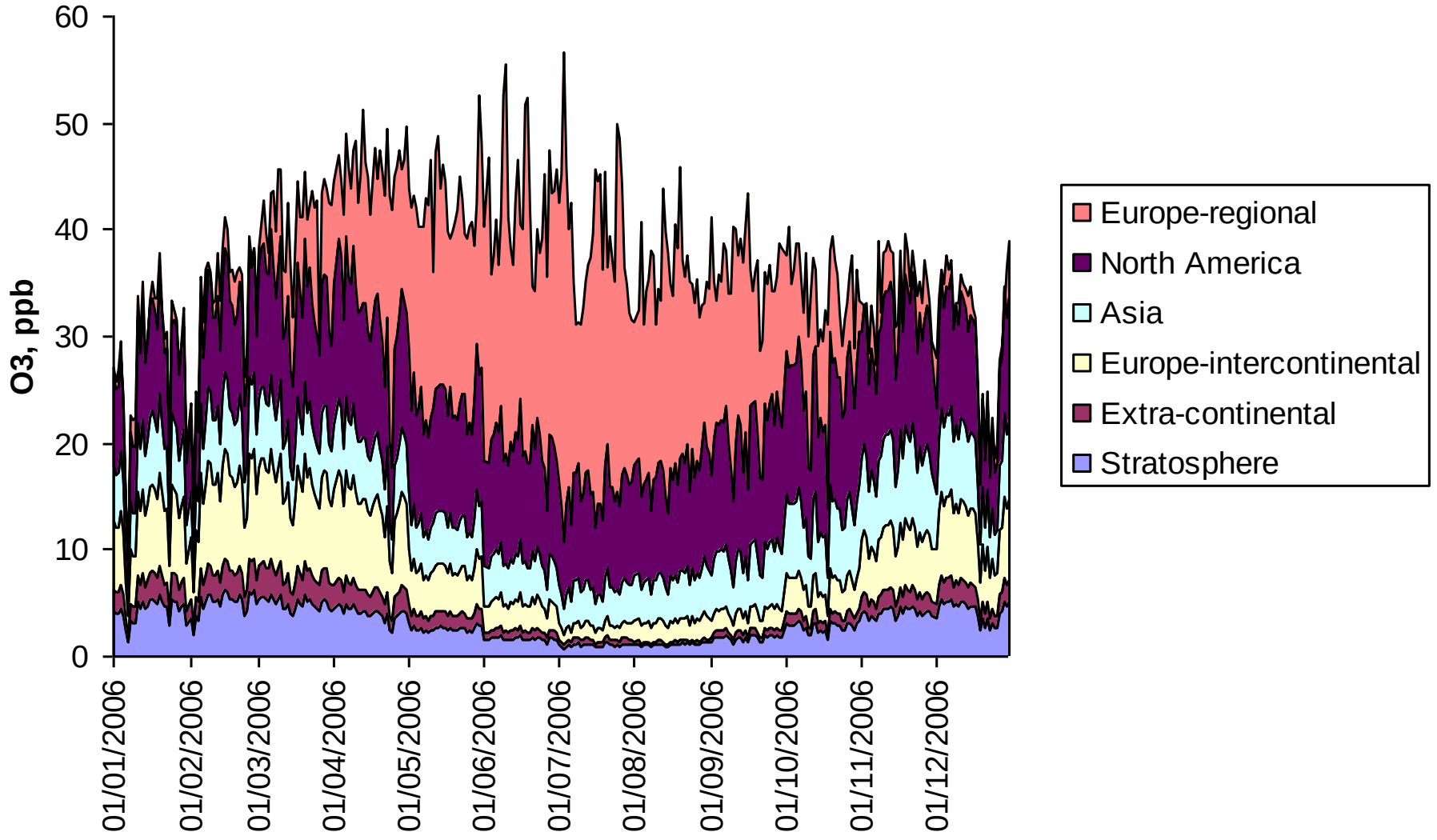
Source: Stedman, J.R.; Atmospheric Environment, 2004

Anticipated Increase in UK Summer Temperatures: By the 2040s Summer 2003 will be "normal" 2003



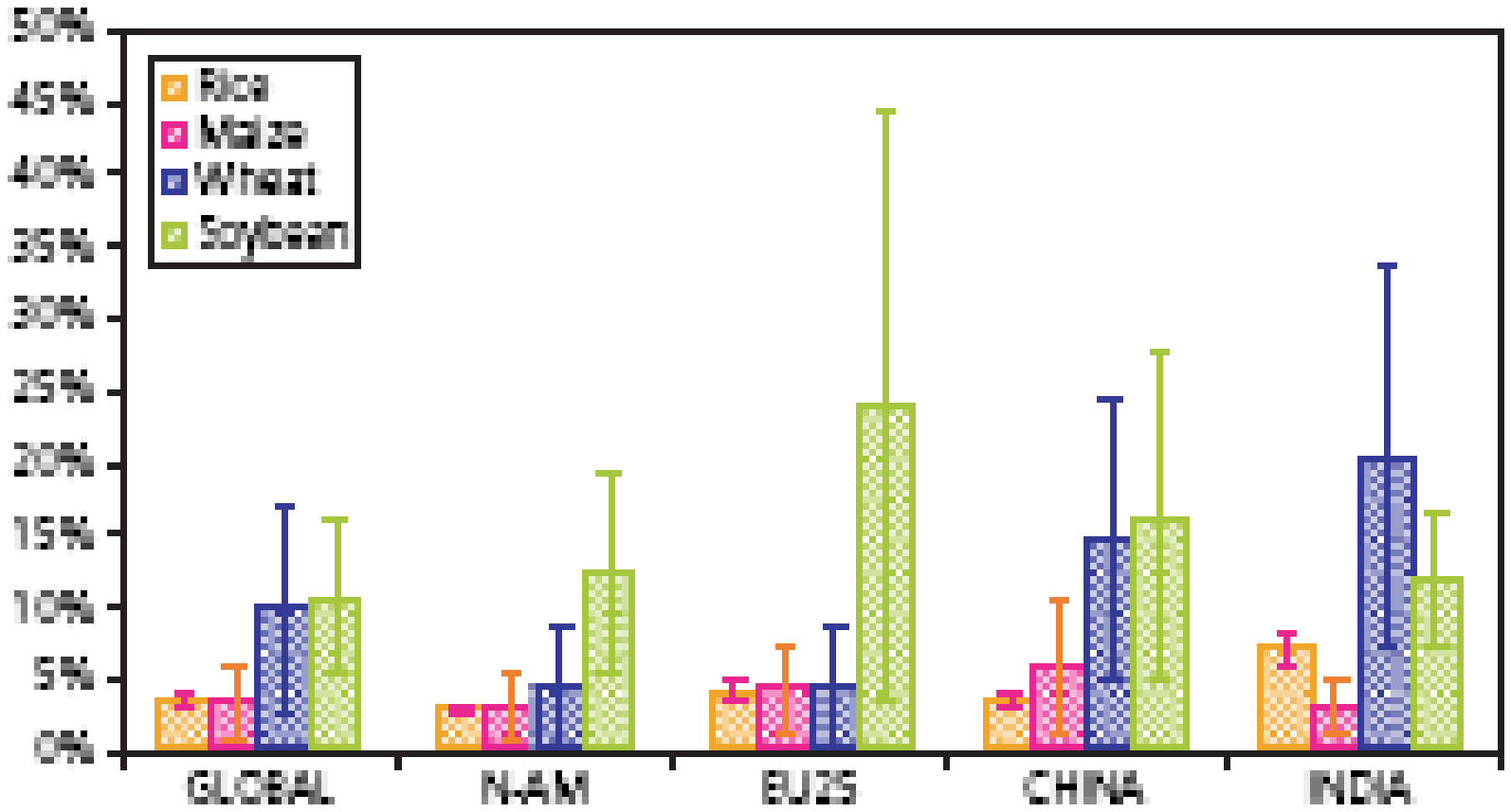
Hadley Centre

Ozone is a global problem - world-wide Sources of UK Ozone (Derwent, Atm. Env, 2008)



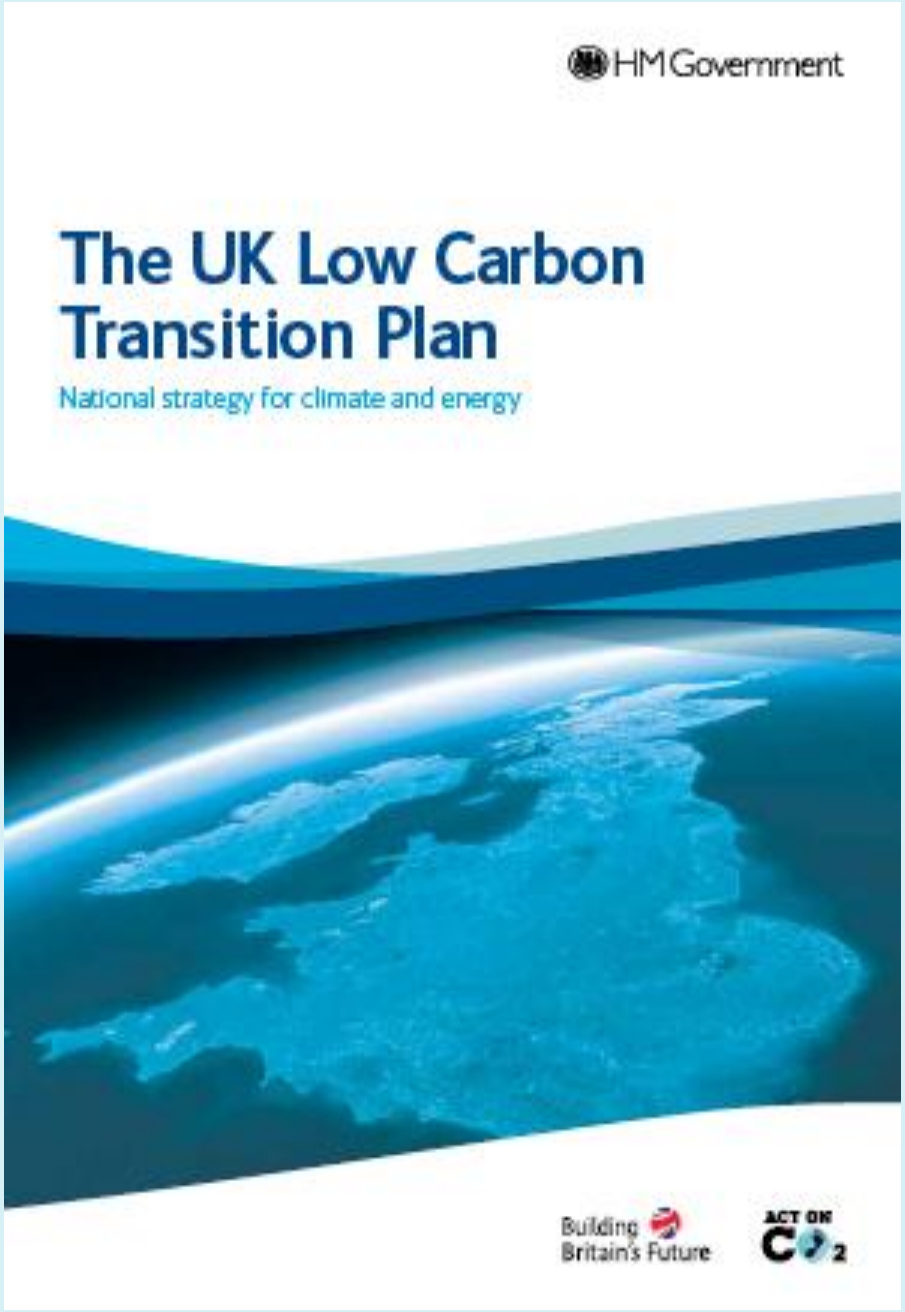
Presented by Martin Williams

Crop yield loss due to ozone, 2000 (van Dingenen et al,2009)

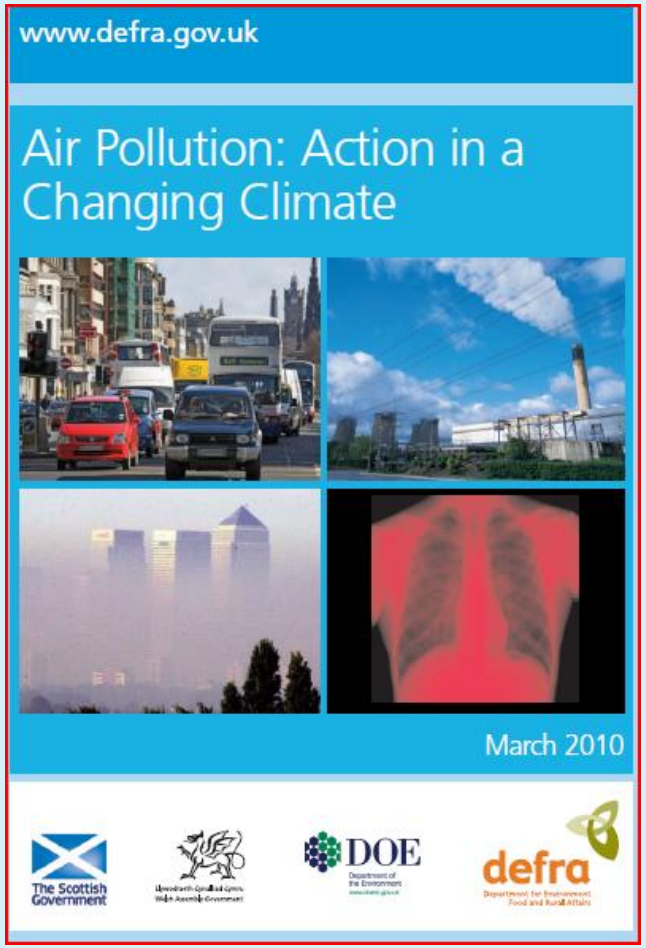


UK Climate Change Act 2008

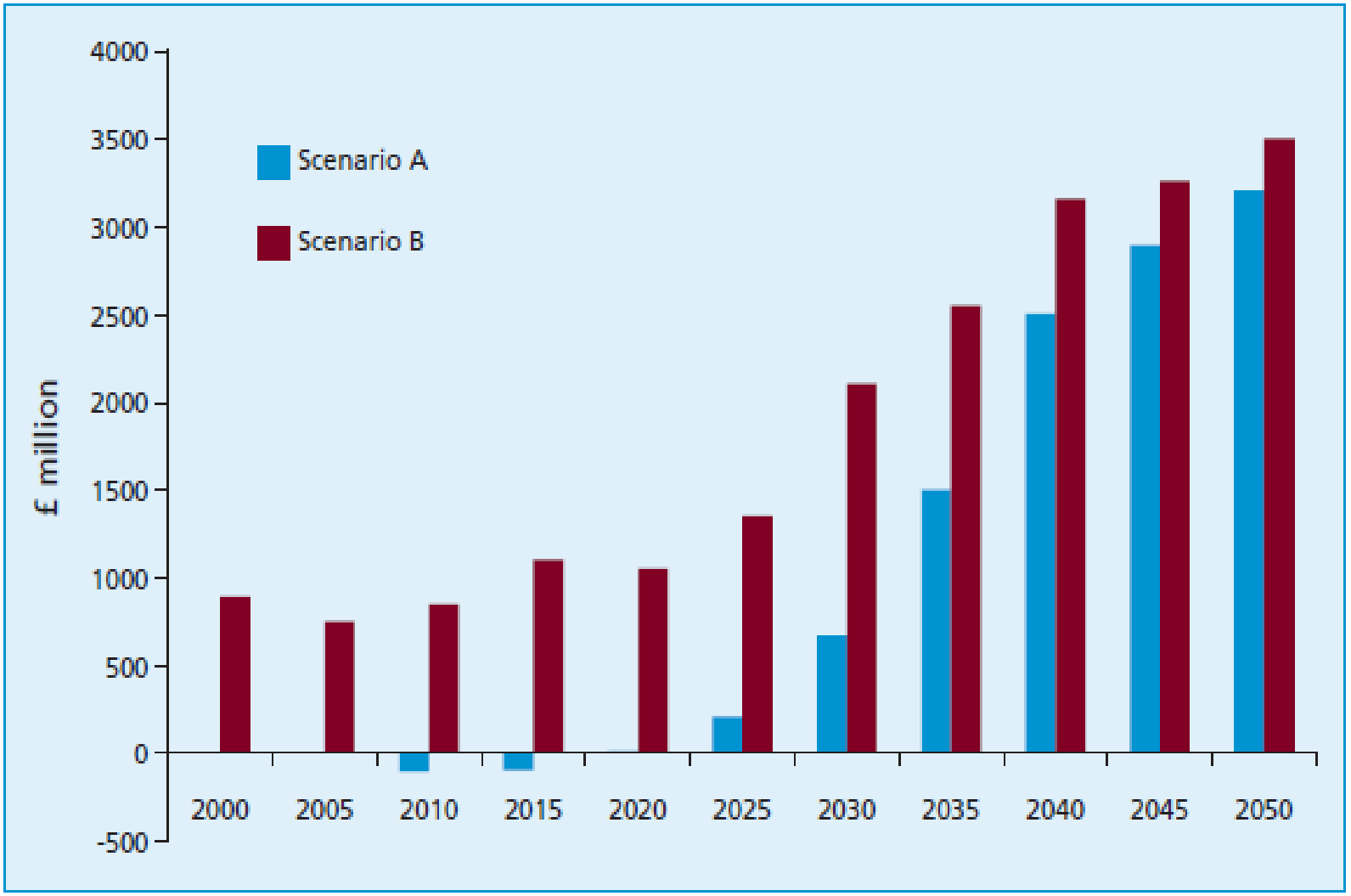
- The UK has incorporated a target of 80% reduction in CO_2 equivalents by 2050 (on a 1990 base)
- Choosing optimal technologies (Scenario A) purely on **climate change considerations** gives benefits of ~£15 billion
- **BUT** incorporating **air quality co-benefits** (Scenario B) gives much bigger co-benefits **~ £ 40 billion in total**


HM Government
The UK Low Carbon Transition Plan
National strategy for climate and energy
Building Britain's Future
ACT ON CO2

Air quality and climate links in UK policy document 2010

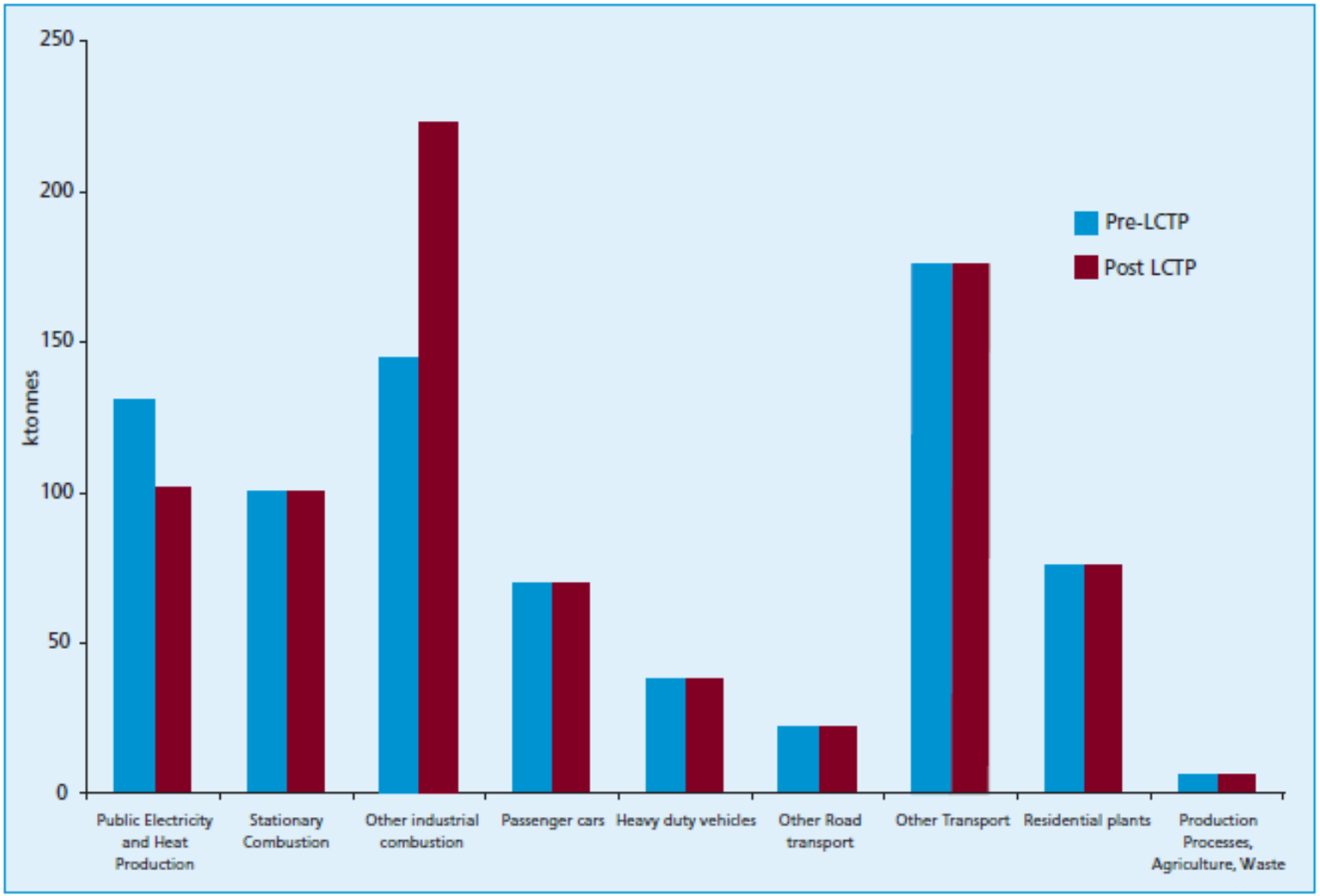


MARKAL modelling of the benefits of integrating Air Quality and Climate Change policies in the UK



But the initial stages are not easy!

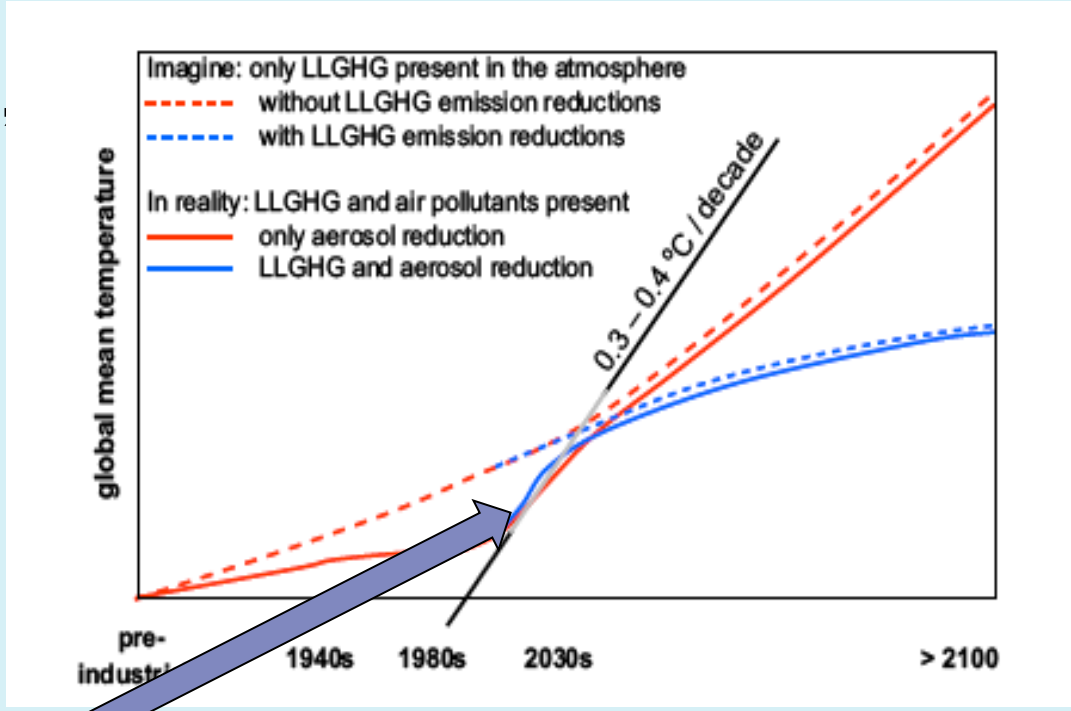
Impact on UK NO_x emissions of the Low Carbon Transition Plan in 2020



The final key result from this analysis, omitted from the results up to this point, identified the potential consequences of an unmanaged major uptake of residential biomass. The initial analysis indicated that this change alone would outweigh the air quality benefits from all the other changes identified across all the sectors. Taken together the package was estimated to impose a net air quality cost of £112 million in 2012 rising to £2.6 billion in 2022.

Optimal policies for the Atmosphere(Raes & Seinfeld, 2009)

- **In the long term to 2050+, aggressive climate policies should be optimal and benefit both climate and air quality**
- **We need to manage the trade-offs in the short - medium term to get us over the 'bumpy road'- much of the scientific and policy challenges are here**



Air pollutants with climate impacts – 'Short-lived climate forcers'

- **Sulphate aerosol (cooling)**
- **Black carbon (warming)**
- **Ozone (warming)**
- **Methane (creates ozone but also in Kyoto)**
- **CO, NO_X and VOCs (create ozone)**
- **Ammonia (combines with SO_2 to form sulphate aerosol)**

Short lived climate forcers offer potential benefits to air quality AND climate change

- mitigating near-term (20-30 years) global temperature increases which reductions in the Kyoto gases will do little to reduce, and will also contribute to a lower global temperature in the long term
- reductions in SLCFs could offset some of the unmasking effect of reductions in the cooling aerosols (chiefly sulphate)
- the effects of SLCFs on climate are regional and reductions could help to reduce temperature increases in sensitive regions like the Arctic and the Himalayas
- ozone can damage plants and hinder the uptake of CO_2 from the atmosphere
- reductions in black carbon and ozone could bring substantial public health benefits and ozone reductions would potentially increase crop yields, notably in developing countries.

Current activities on SLCFs

- CLRTAP Task Force on Hemispheric Transport of Air Pollution reports in December 2010
- CLRTAP Expert Group on Black Carbon reports in December 2010
- CLRTAP is discussing inclusion of PM in Gothenburg Protocol
- UNEP Global Assessment of Black Carbon and Tropospheric Ozone reports early in 2011
- US EPA report on Black Carbon – response to call from Senate
- Now is the time to begin thinking in practical terms about approaches to managing these pollutants internationally
- But it will not be easy!

Think globally - act locally?

Measures that could increase AQ & CC emissions

Measure		Effect
Increased demand for products/services		For example plasma TVs, larger cars
Transport modal shifts		Increase in short-haul flights at expense of rail
Increased use of coal for energy generation		If used in place of nuclear, gas, or some renewables
Certain use of biofuels?		N_2O from fertiliser Import and fuel-chain emissions ↑ AQ emissions

AQ measures that could increase CC emissions

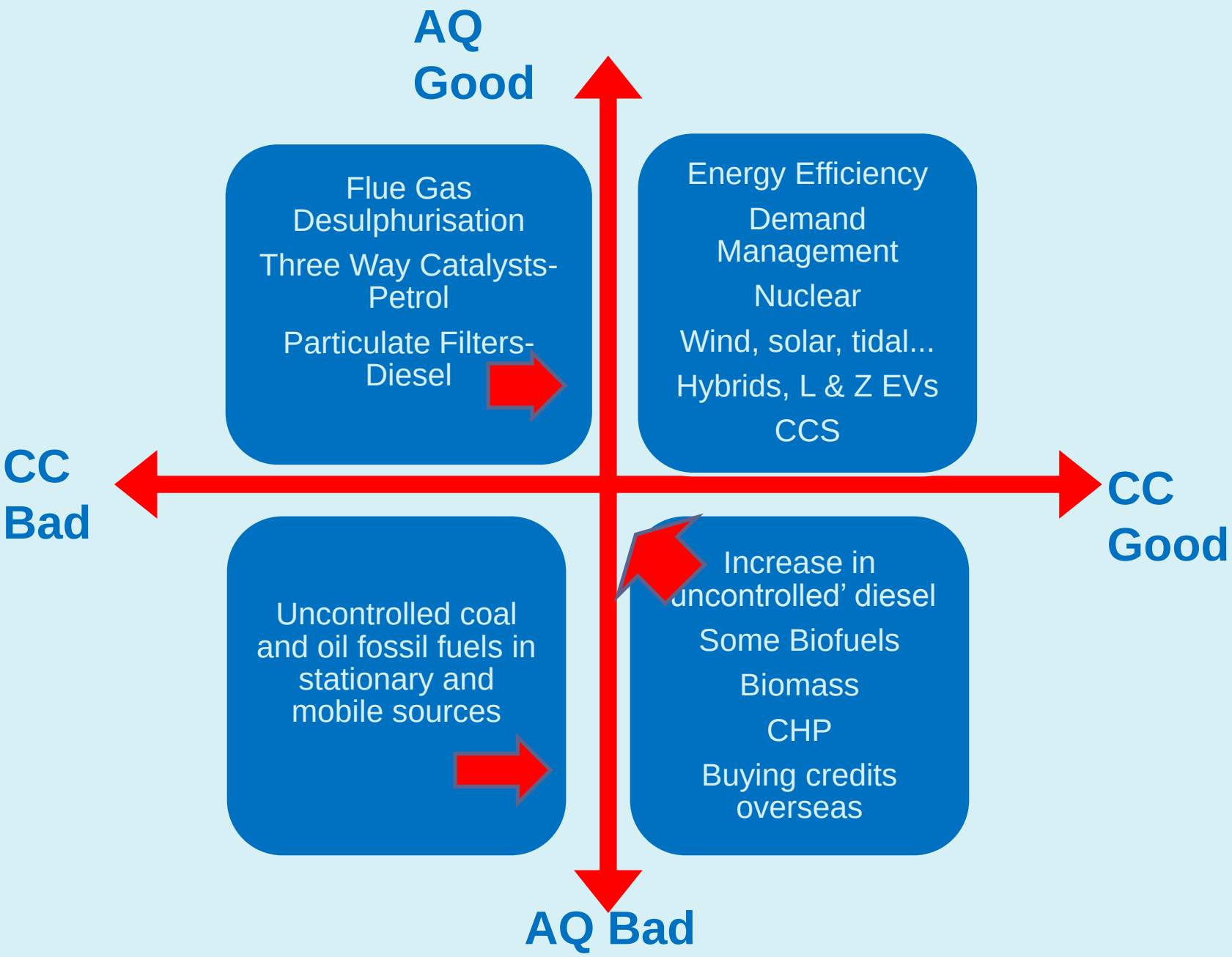
Measure		Effect
Power Generation		Reduced generation efficiency
Flue gas desulphurisation		CO_2 formation through wet scrubbing
Transport		Efficiency costs → increased CO_2
Abatement of AQ emissions		Potential to increase N_2O
Reduced S in fuel		Increased refinery CO_2 emissions

CC measures that could increase AQ emissions

Measure		Effect
Fuel-switching (transport)		Increased use of diesel in place of petrol → increased NO_x and PM
Certain use of biofuels		N-based fertilisers → increased NH_3
General Transport fuels Domestic use		Increased emissions of AQ pollutants from processing and use (esp. energy from biomass in poorly controlled appliances)
Waste management		Incineration in place of landfill
Forests as a sink for carbon		Increased biogenic emissions

Measures that could improve AQ & CC emissions

Measure		Effect
Power Generation Fuel switching to low C renewables Nuclear power Combined heat and power (?) Carbon capture and storage		Reduction in CO_2, SO_2 and NO_x Reduction in AQ and CC pollutants
Transport New technologies and fuels, Hybrids, electric Low emissions zones		Reduce point of use and fuel chain emissions Incentivise more efficient vehicles
Efficiency Improvements Demand management, conservation and Behaviour change		Proportionate reduction in AQ and CC pollutants Benefits can be reduced through increased demand


AQ Good
Flue Gas Desulphurisation
Three Way Catalysts-Petrol
Particulate Filters-Diesel
Energy Efficiency
Demand Management
Nuclear
Wind, solar, tidal...
Hybrids, L & Z EVs
CCS
CC Bad
CC Good
Uncontrolled coal and oil fossil fuels in stationary and mobile sources
Increase in 'uncontrolled' diesel
Some Biofuels
Biomass
CHP
Buying credits overseas
AQ Bad