Climate Change, Air Pollution, and Health: Co-Benefits and Cross-Benefits

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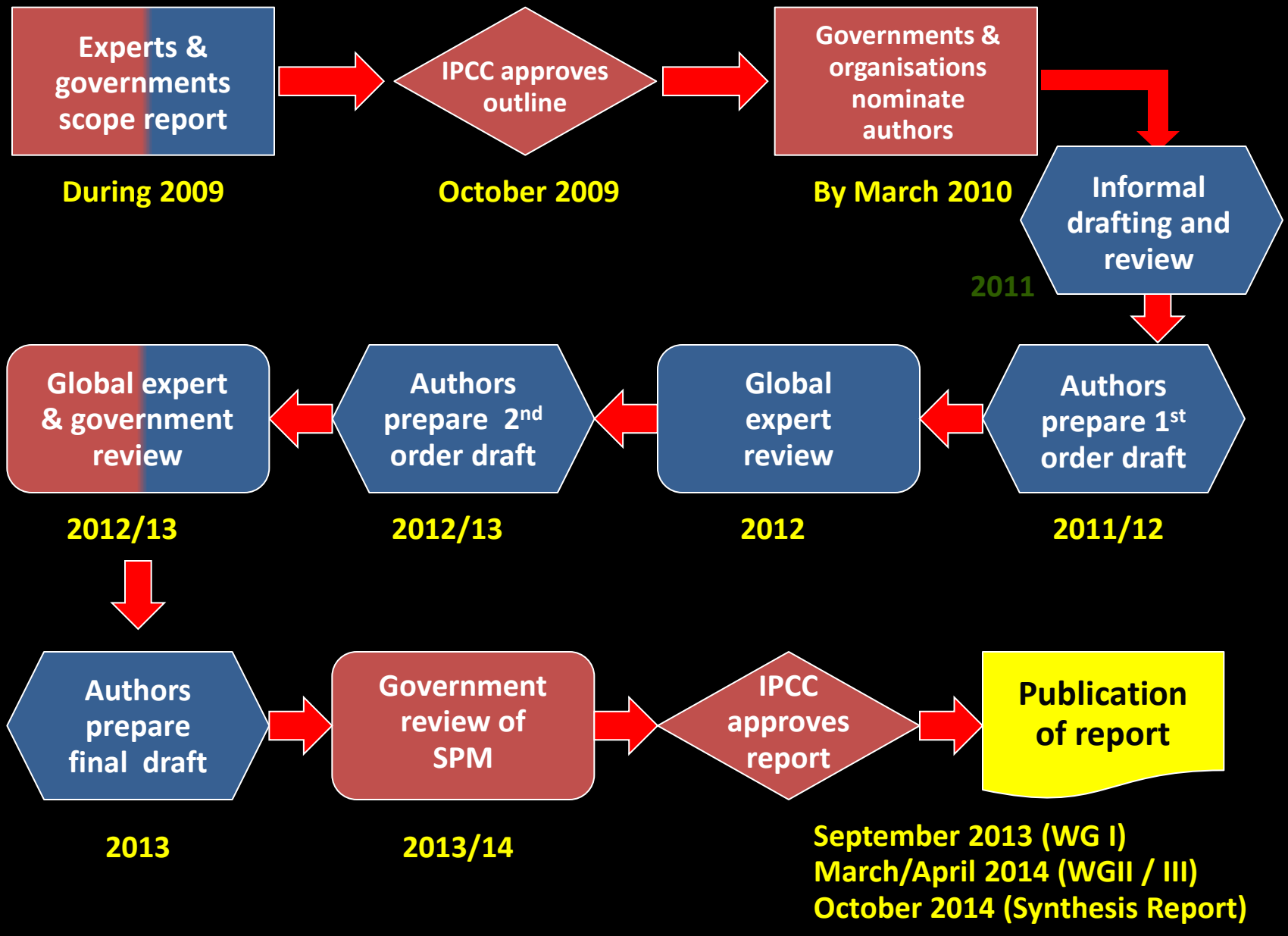
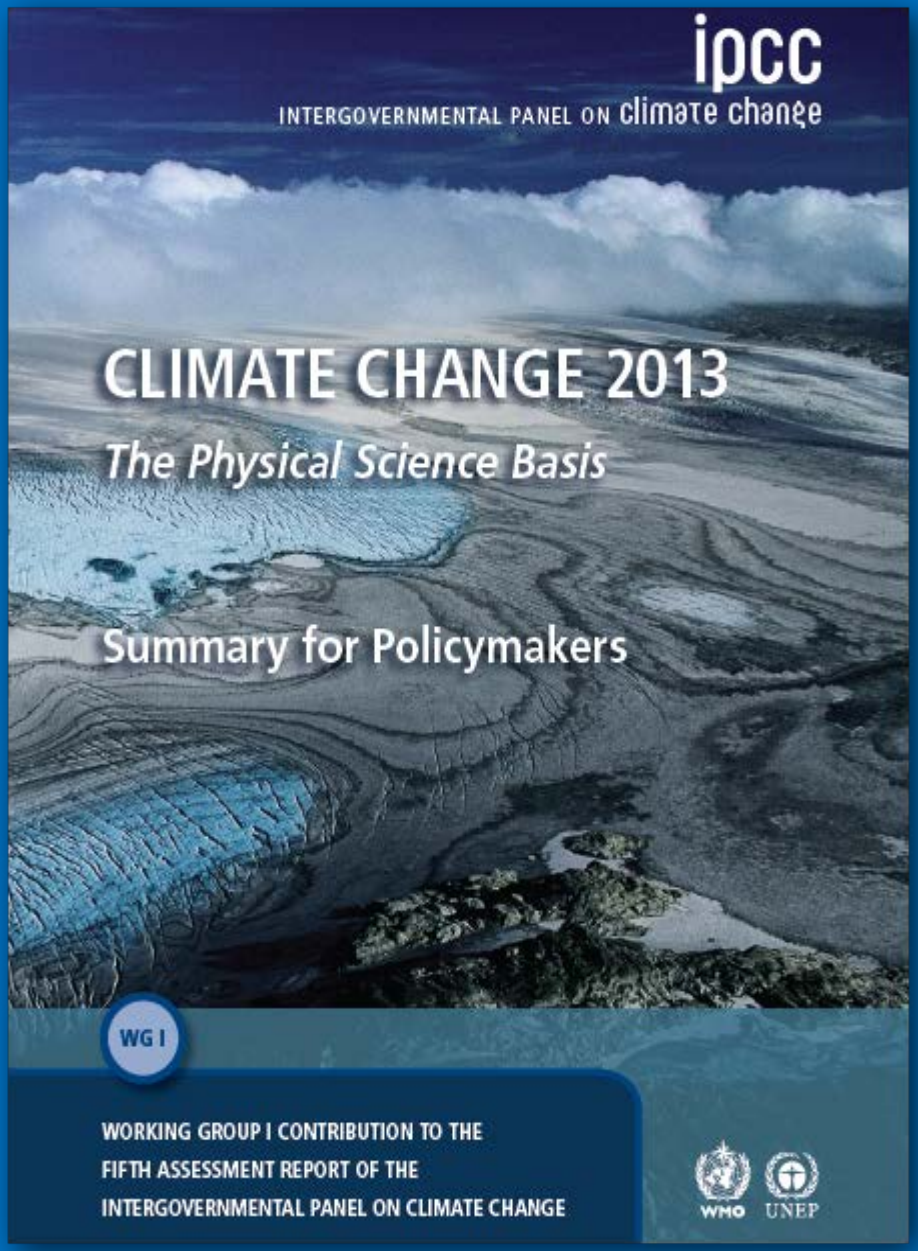
Map

- A brief summary of the IPCC process
- Brief results from WG I -- Climate Science
- WGII -- Impacts
- Ch 11 -- Health Impacts
- Co-Benefits
- Cross-Benefits

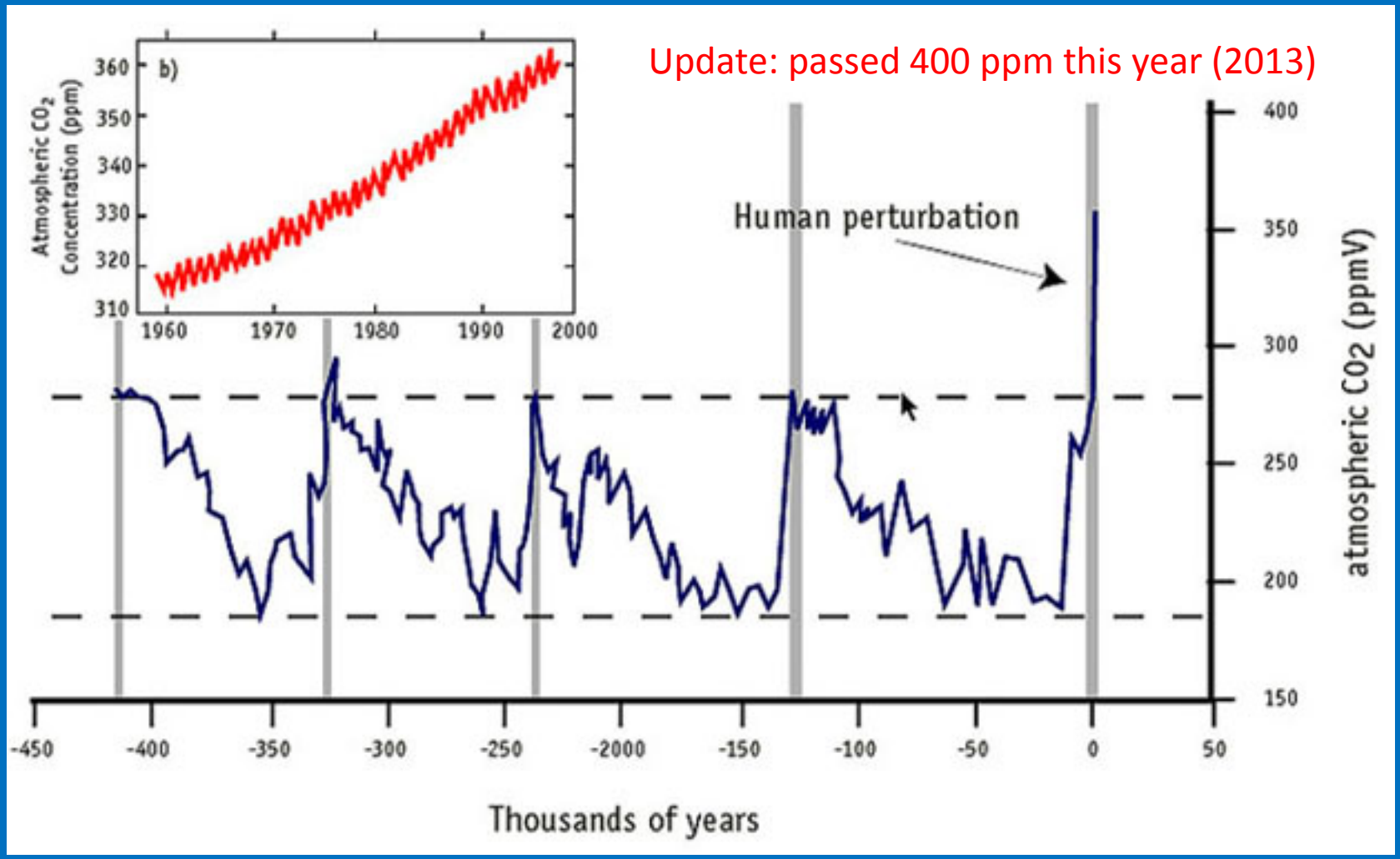
TIMELINE 5TH ASSESSMENT REPORT (AR5)



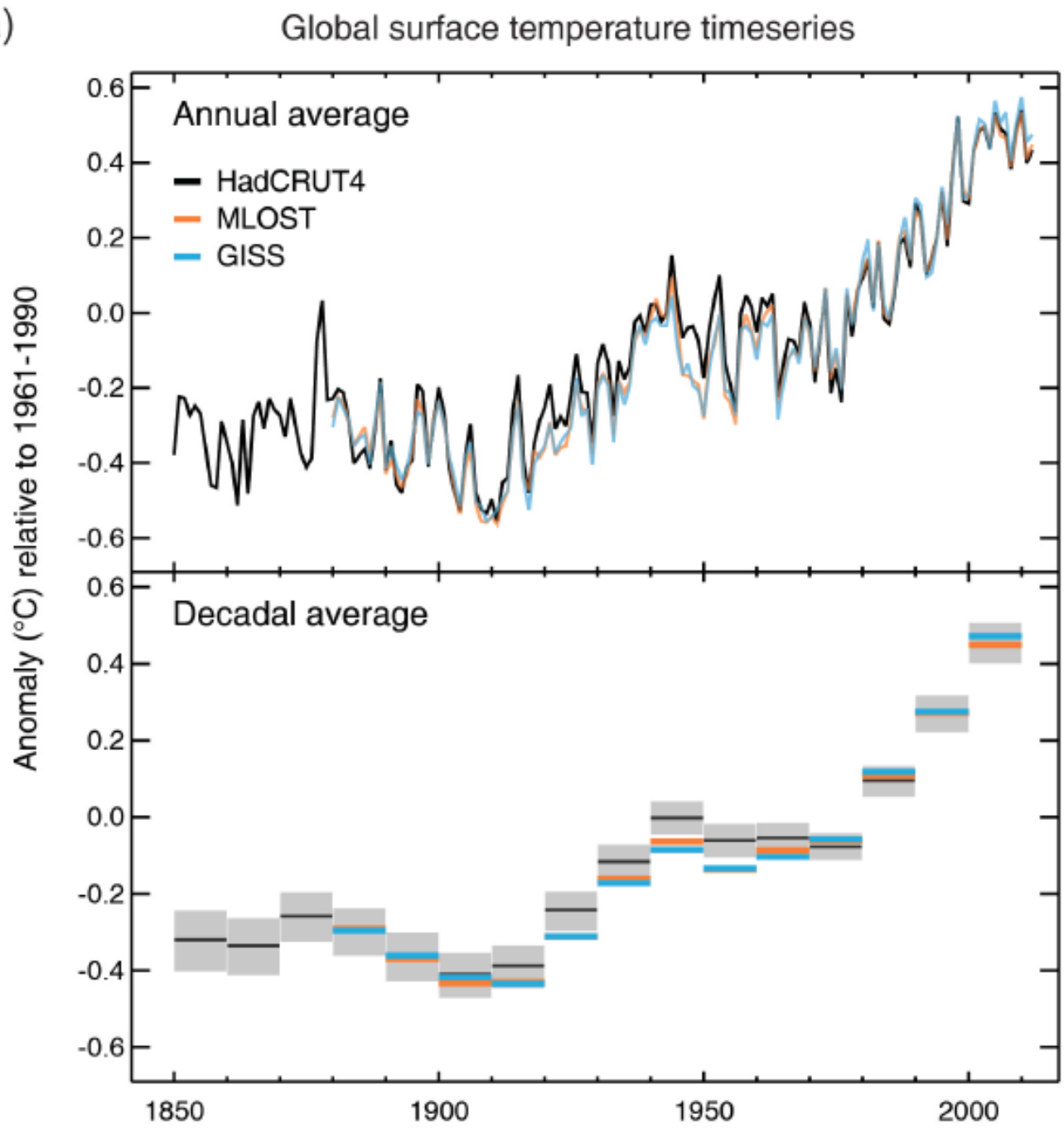


September 2013

CO_2 levels now higher than any time in last 400,000 years



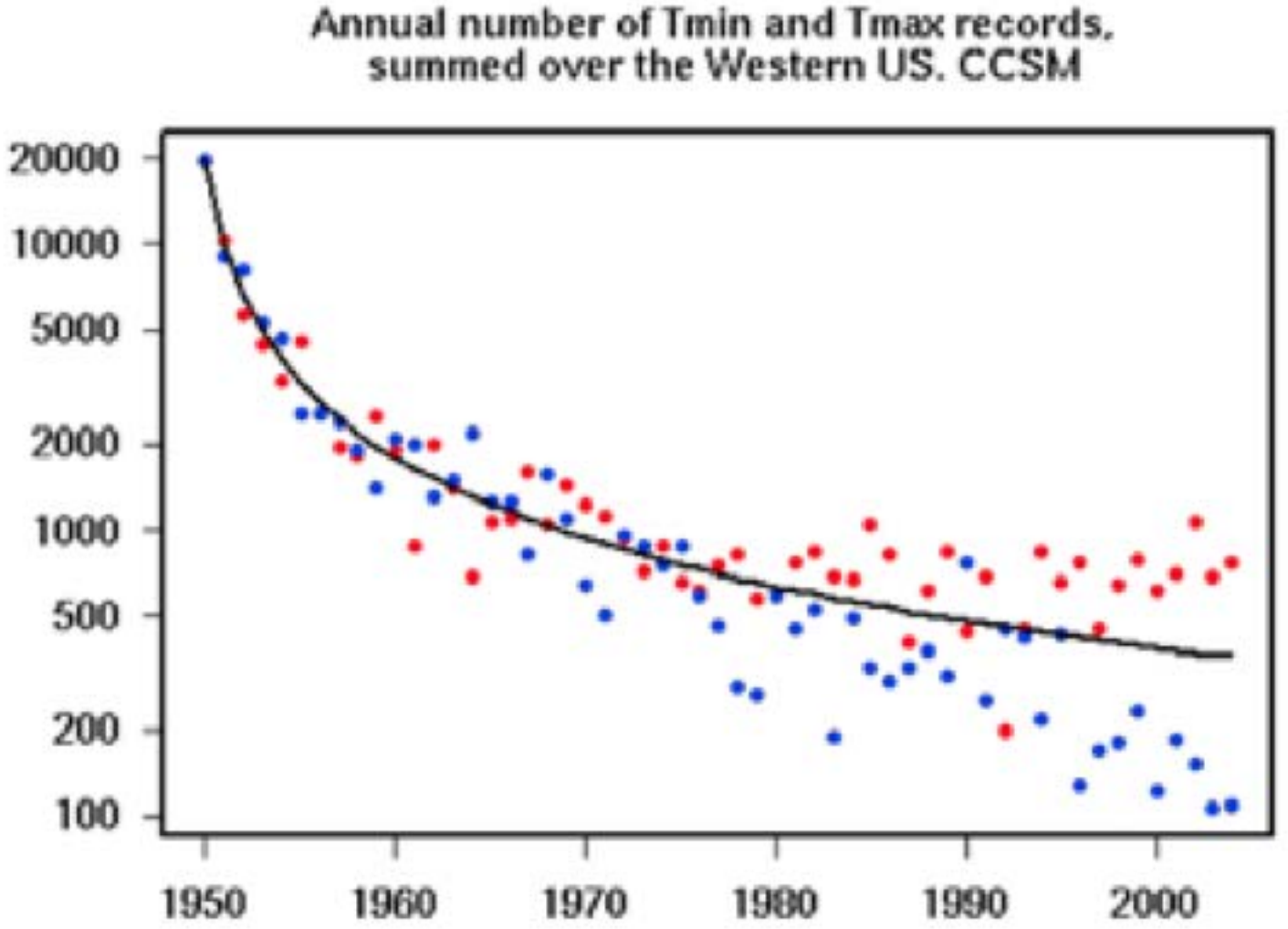
Petit et al. 1999; Keeling and Whorf 2000



Warming at the surface of the Earth – about 0.8 degrees C since pre-industrial era

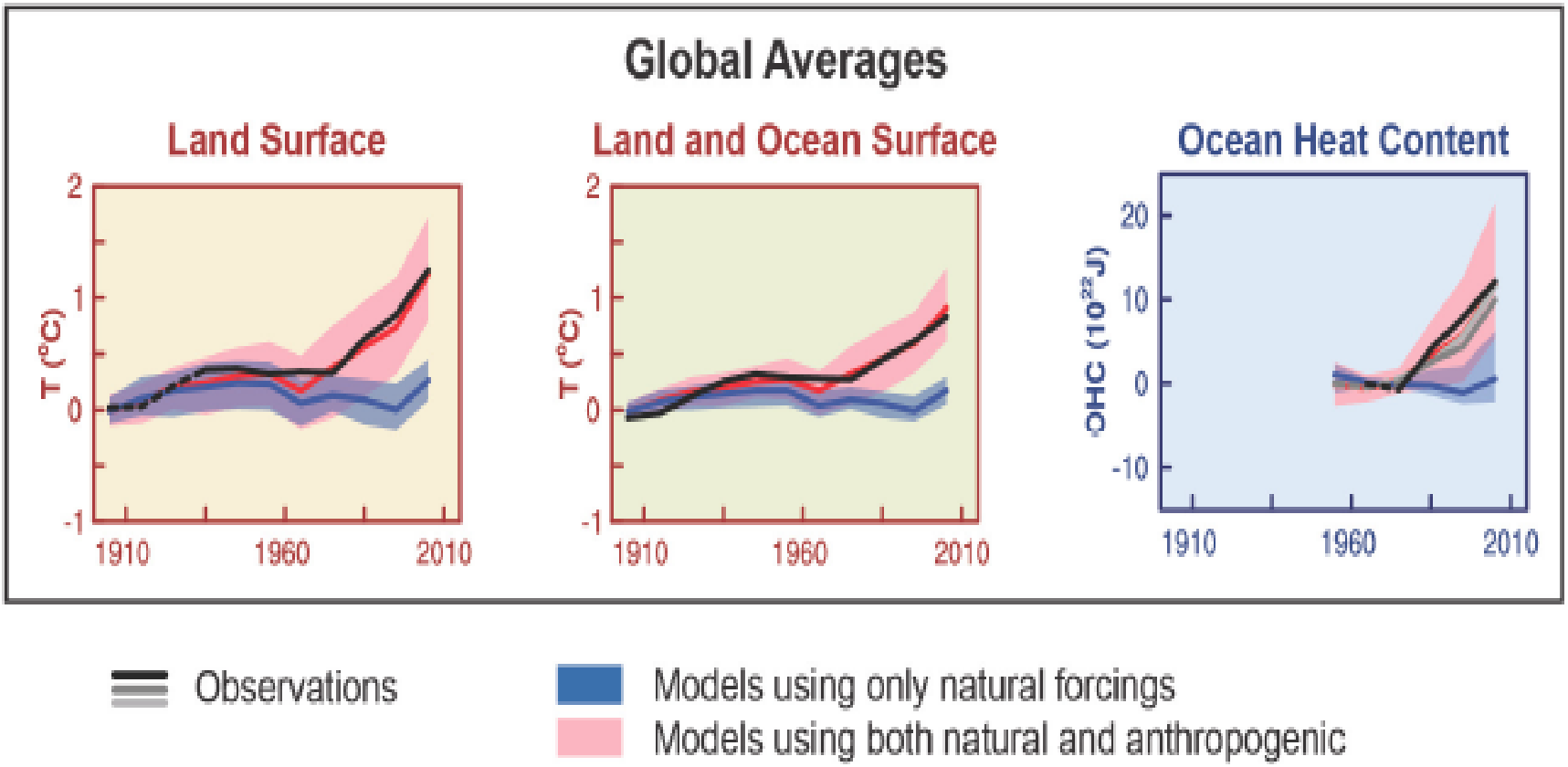
WG1 SPM

Evidence of warming – more record high maximum temperatures (in red) than record low minimum temperatures (in blue)



Meehl, Geophysical Research Letters 2009

Climate models that exclude greenhouse emissions do not match recent warming; models that incorporate both natural and anthropogenic forcings fit well with the temperature record



AR5, WG1 SPM

Summary for Policy Makers, WGI AR5

Phenomenon and direction of trend	Assessment that changes occurred (typically since 1950 unless otherwise indicated)		Assessment of a human contribution to observed changes	
Warmer and/or fewer cold days and nights over most land areas	*Very likely*	{2.6}	***Very likely***	{10.6}
	Very likely *Very likely*		*Likely* *Likely*	
Warmer and/or more frequent hot days and nights over most land areas	*Very likely*	{2.6}	***Very likely***	{10.6}
	Very likely *Very likely*		*Likely* *Likely* (nights only)	
Warm spells/heat waves. Frequency and/or duration increases over most land areas	***Medium confidence*** on a global scale *Likely* in large parts of Europe, Asia and Australia	{2.6}	***Likely***[a]	{10.6}
	Medium confidence in many (but not all) regions *Likely*		Not formally assessed *More likely than not*	
Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation	*Likely* more land areas with increases than decreases[c]	{2.6}	***Medium confidence***	{7.6, 10.6}
	Likely more land areas with increases than decreases *Likely* over most land areas		*Medium confidence* *More likely than not*	

The situation up to the present

Summary for Policy Makers, WGI AR5

Phenomenon and direction of trend	Likelihood of further changes	
	Early 21st century	Late 21st century
Warmer and/or fewer cold days and nights over most land areas	*Likely* {11.3}	*Virtually certain* {12.4}
		Virtually certain *Virtually certain*
Warmer and/or more frequent hot days and nights over most land areas	*Likely* {11.3}	*Virtually certain* {12.4}
		Virtually certain *Virtually certain*
Warm spells/heat waves. Frequency and/or duration increases over most land areas	Not formally assessed[b] {11.3}	*Very likely* {12.4}
		Very likely *Very likely*
Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation	*Likely* over many land areas {11.3}	***Very likely*** over most of the mid-latitude land masses and over wet tropical regions {12.4}
		Likely over many areas *Very likely* over most land areas

The future

Summary for Policy Makers, WGI AR5. cont.

Phenomenon and direction of trend	Assessment that changes occurred (typically since 1950 unless otherwise indicated)		Assessment of a human contribution to observed changes	
Increases in intensity and/or duration of drought	***Low confidence*** on a global scale *Likely* changes in some regions[d]	{2.6}	***Low confidence***	{10.6}
	Medium confidence in some regions *Likely* in many regions, since 1970[e]		*Medium confidence*[f] *More likely than not*	
Increases in intense tropical cyclone activity	***Low confidence*** in long term (centennial) changes *Virtually certain* in North Atlantic since 1970	{2.6}	***Low confidence***[i]	{10.6}
	Low confidence *Likely* in some regions, since 1970		*Low confidence* *More likely than not*	
Increased incidence and/or magnitude of extreme high sea level	*Likely* (since 1970)	{3.7}	***Likely***[k]	{3.7}
	Likely (late 20th century) *Likely*		*Likely*[k] *More likely than not*[k]	

The situation up the present

Summary for Policy Makers, WGI AR5. cont.

Phenomenon and direction of trend	Likelihood of further changes	
	Early 21st century	Late 21st century
Increases in intensity and/or duration of drought	*Low confidence*[g] {11.3}	***Likely*** *(medium confidence)* on a regional to global scale[h] {12.4} *Medium confidence* in some regions *Likely*[a]
Increases in intense tropical cyclone activity	*Low confidence* {11.3}	***More likely than not*** in the Western North Pacific and North Atlantic[i] {14.6} *More likely than not* in some basins *Likely*
Increased incidence and/or magnitude of extreme high sea level	*Likely*[l] {13.7}	***Very likely***[l] {13.7} *Very likely*[m] *Likely*

The future

E.3 Atmosphere: Air Quality

- The range in projections of air quality (ozone and PM2.5[17] in near-surface air) is driven primarily by emissions (including CH_4), rather than by physical climate change (*medium confidence*). There is *high confidence* that globally, warming decreases background surface ozone. High CH_4 levels (as in RCP8.5) can offset this decrease, raising background surface ozone by year 2100 on average by about 8 ppb (25% of current levels) relative to scenarios with small CH_4 changes (as in RCP4.5 and RCP6.0) (*high confidence*). {11.3}

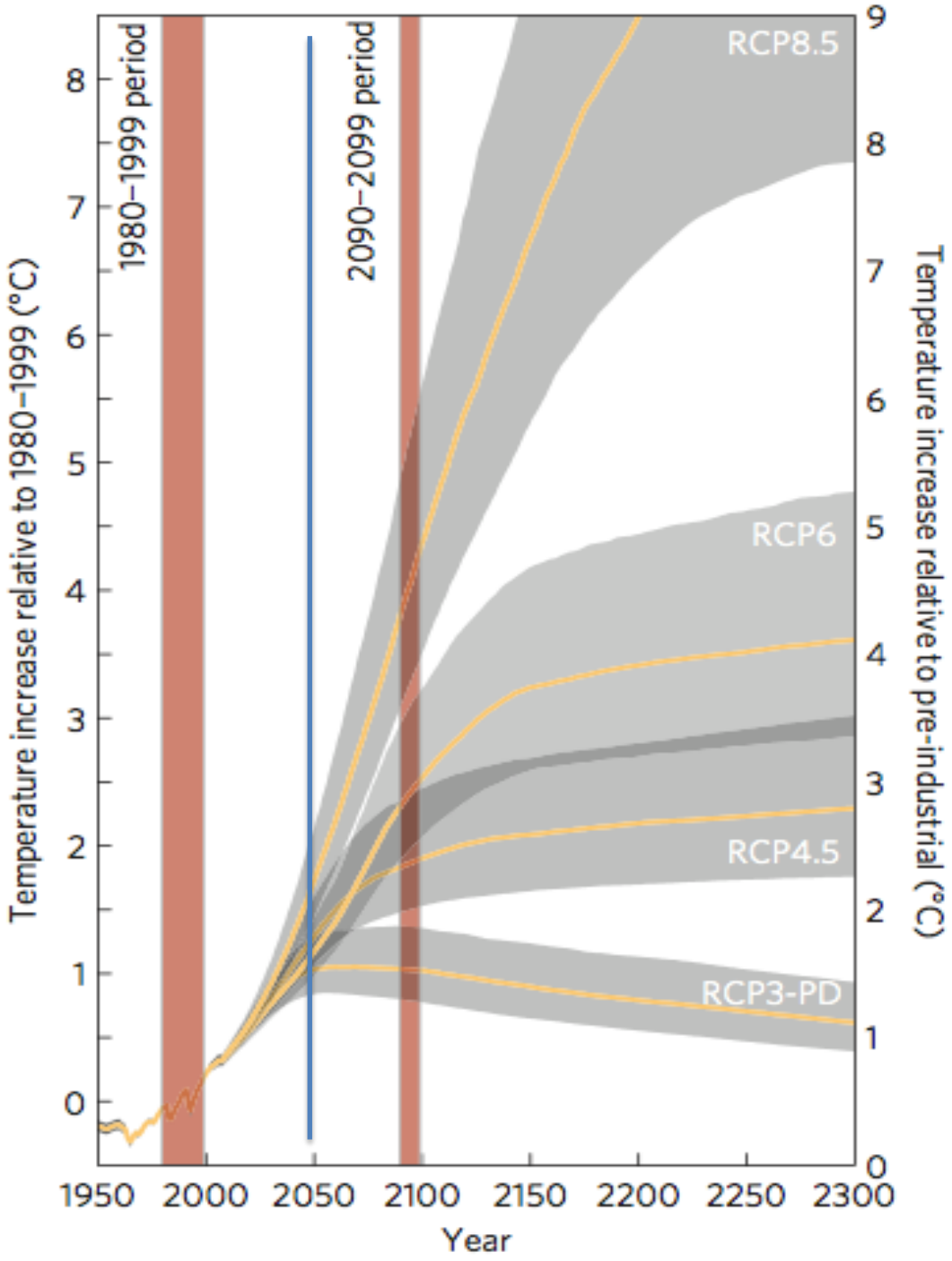
- Observational and modelling evidence indicates that, all else being equal, locally higher surface temperatures in polluted regions will trigger regional feedbacks in chemistry and local emissions that will increase peak levels of ozone and PM2.5 (*medium confidence*). For PM2.5, climate change may alter natural aerosol sources as well as removal by precipitation, but no confidence level is attached to the overall impact of climate change on PM2.5 distributions. {11.3}

Summary for Policy Makers, WGI AR5. cont.

Black carbon?

- “While removal of black carbon aerosol could also counter warming associated with sulphate removal, uncertainties are too large to constrain the net sign of the global temperature response to black carbon emission reductions, which depends on reduction of co-emitted (reflective) aerosols and on aerosol indirect effects.”

SPM, WGI



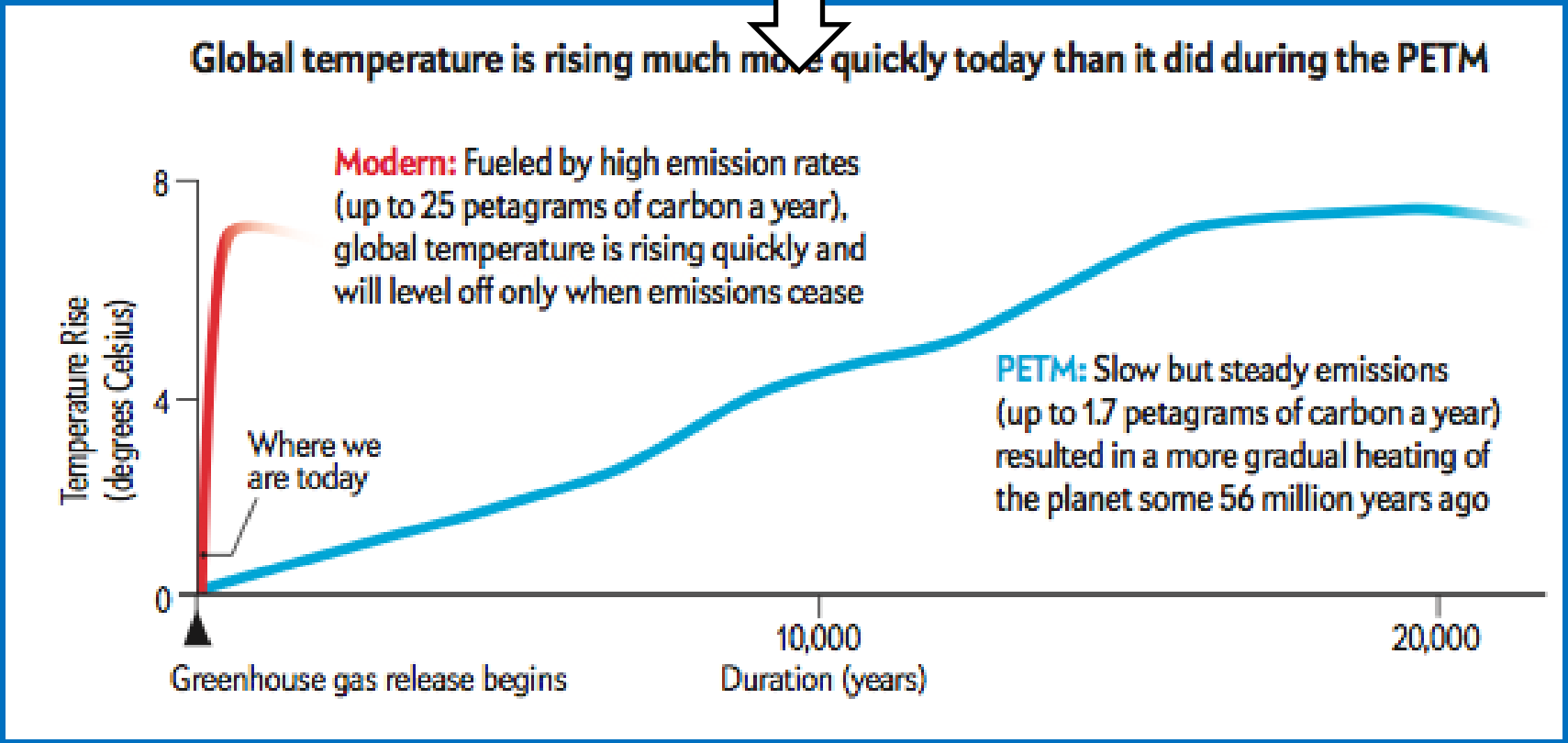
High end warming – assumes no restriction on use of fossil fuels, climate does not stabilize below about +12 degrees warming

Temperature projections for four concentration pathways, median (yellow) and uncertainty bound (gray), 2010 – 2300.

Nature Climate Change 2012;2:248
IPCC WG1

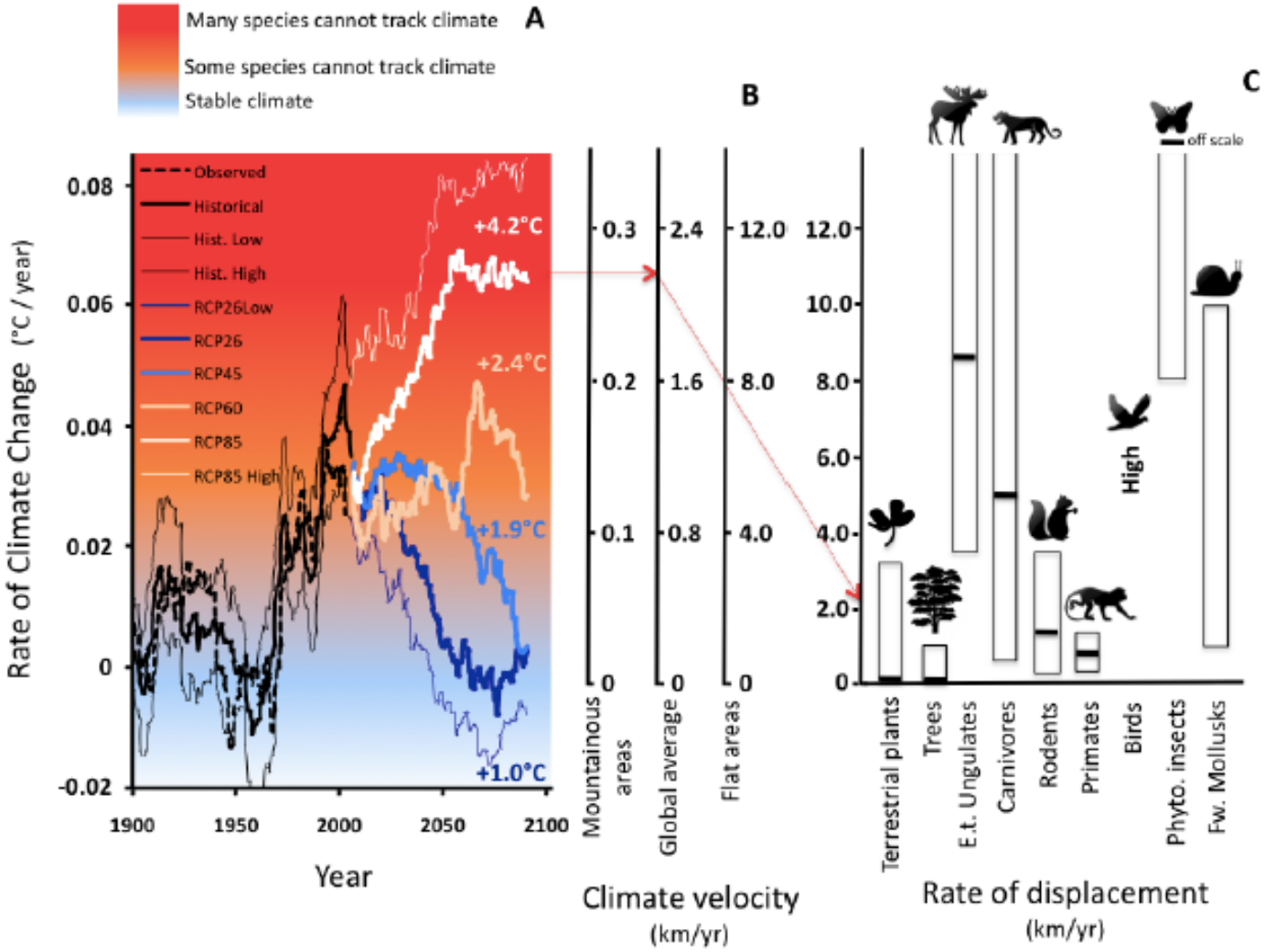
Rate makes a big difference

Rate of change over the next 100 years a hundred times greater than experienced previously (RCP 8.5). Even the RCP2.6 scenario warms ten times faster than the PETM.



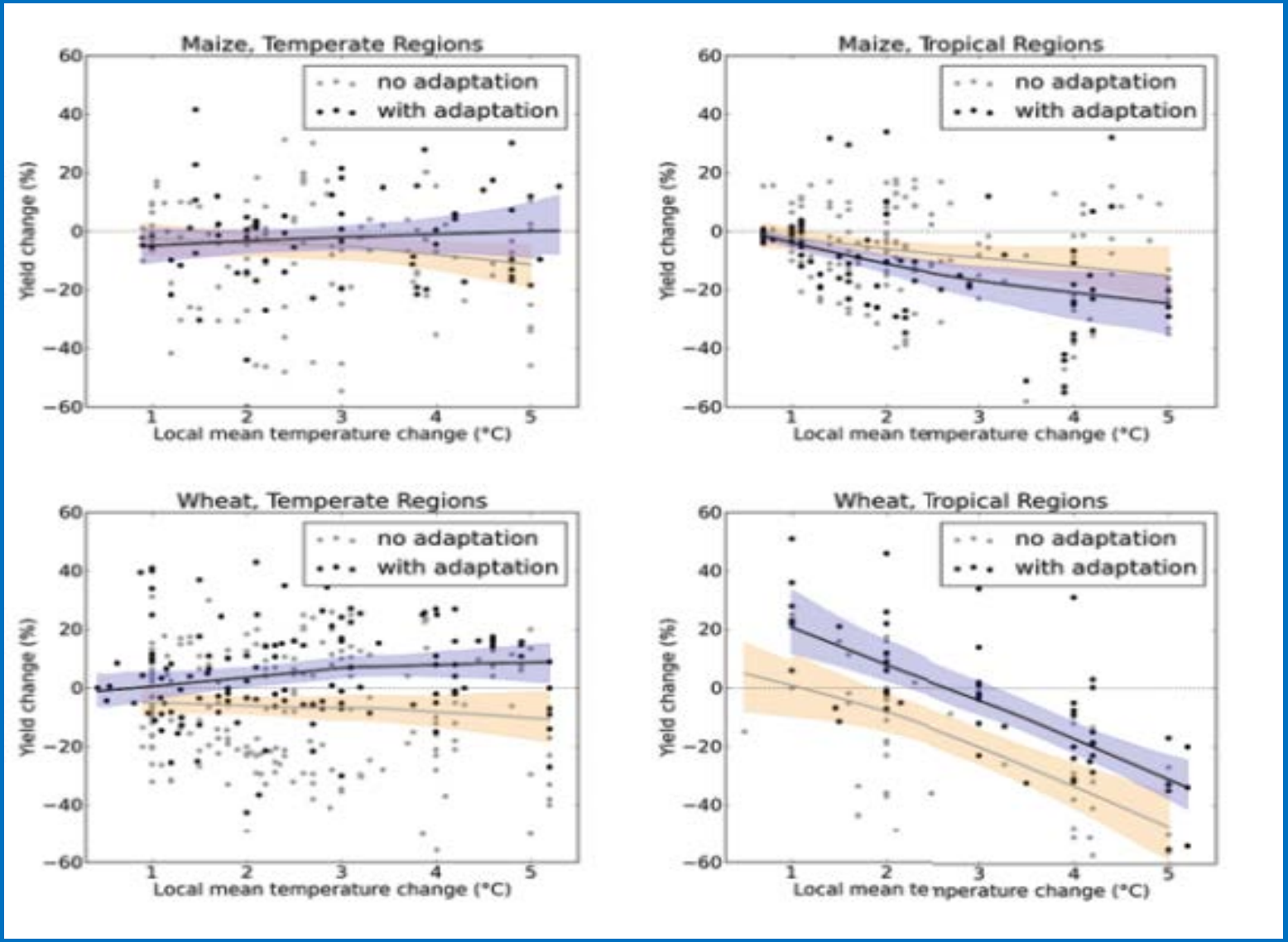
Palaeo-Eocene Thermal Maximum: caused by volcanoes, methane releases, peat fires

Source: Kump, Scientific American July 2011



Introducing the idea of climate velocity – a critical test of the limits of adaptation to global heating.

Summary for Policy Makers Fig 3, WG1



Rapid warming amplifies fall in maize and wheat yields in the tropics

Percent simulated yield change as a function of local temperature change, with 95% confidence interval, according to absence or presence of adaptation. Figure 7.5, WG1

And now highlights from the executive summary of Chapter 11: Health Impacts, Adaptation, and Co-benefits

of Working Group 2

WG2: *Impacts, Adaptation, and Vulnerability*

- 308 authors from 70 countries
- 50492 review comments (3 rounds)
- 30 chapters in two volumes
- Vol 1 sections:
  - Natural and managed ecosystems
  - Settlement sand infrastructure
  - Health, well-being, and security
  - Adaptation
  - Risks, vulnerabilities, and opportunities
- Vol 2: ten regional chapters

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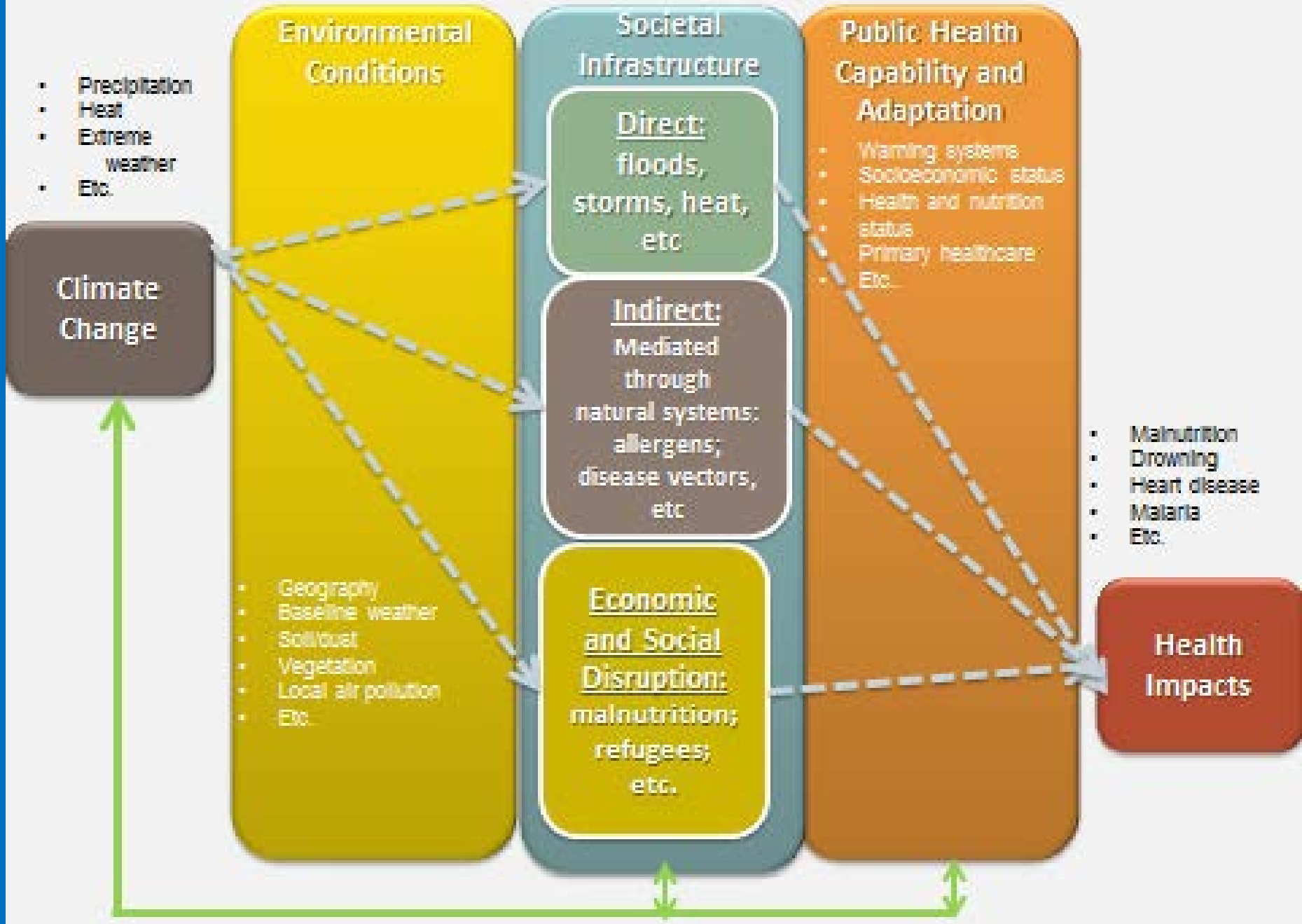

Climate Change
Precipitation
Heat
Extreme weather
Etc.
Environmental Conditions
Geography
Baseline weather
Soil/dust
Vegetation
Local air pollution
Etc.
Societal Infrastructure
Direct: floods, storms, heat, etc
Indirect: Mediated through natural systems: allergens; disease vectors, etc
Economic and Social Disruption: malnutrition; refugees; etc.
Public Health Capability and Adaptation
Warning systems
Socioeconomic status
Health and nutrition status
Primary healthcare
Etc.
Health Impacts
Malnutrition
Drowning
Heart disease
Malaria
Etc.

Chapter 11 Conclusions

- Until mid-century climate change will act mainly by exacerbating health problems that already exist *[very high confidence]*.
- New conditions may emerge under climate change *[low confidence] and e*xisting diseases (e.g. food-borne infections) may extend their range into areas that are presently unaffected *[high confidence]*.
- But the largest risks will apply in populations that are currently most affected by climate-related diseases.

Ch 11, cont.

- In recent decades, climate change has contributed to levels of ill-health (*likely*) though the present world-wide burden of ill-health from climate change is relatively small compared with other stressors on health and is not well quantified.
- Rising temperatures have increased the risk of heat-related death and illness *(likely).*
- Local changes in temperature and rainfall have altered distribution of some water-borne illnesses and disease vectors, and reduced food production for some vulnerable populations *[medium confidence].*
- .

Ch 11, cont.

- If climate change continues as projected across the RCP scenarios until mid-century, the major increases of ill-health compared to no climate change will occur through:
  - greater risk of injury, disease, and death due to more intense heat waves and fires *[very high confidence];*
  - increased risk of under-nutrition resulting from diminished food production in poor regions *[high confidence];*
  - consequences for health of lost work capacity and reduced labor productivity in vulnerable populations *[high confidence];*
  - increased risks of food- and water-borne diseases *[very high confidence]* and vector-borne diseases *[medium confidence];*
- There will also be some health benefits
  - modest improvements in cold-related mortality and morbidity in some areas due to fewer cold extremes *[low confidence]*,
  - Increased food production in some areas, and
  - reduced capacity of disease-carrying vectors due to exceedance of thermal thresholds *[medium confidence]*.
- These positive effects will be out-weighed, worldwide, by the magnitude and severity of the negative effects of climate change *[high confidence]*.

Ch 11, cont.

- Impacts on health will be reduced, but not eliminated, in populations that benefit from rapid social and economic development *[high confidence],* particularly among the poorest and least healthy groups *[very high confidence].*
- Climate change is an impediment to continued health improvements in many parts of the world.
- If economic growth does not benefit the poor, the health effects of climate change will be exacerbated.

Ch 11, cont.

- Some parts of the world already exceed the international standard for safe work activity during the hottest months of the year. The capacity of the human body to thermoregulate may be exceeded on a regular basis, particularly during manual labour, in parts of the world during this century.
- In RCP8.5, by 2100 some of the world's land area will be experiencing 4-7 degree higher temperatures due to anthropogenic climate change.
- If this occurs, the combination of high temperatures and high humidity will compromise normal human activities, including growing food or working outdoors, raising doubt about the habitability of some areas, for parts of the year *[high confidence]*.

Table 1 | The four RCPs

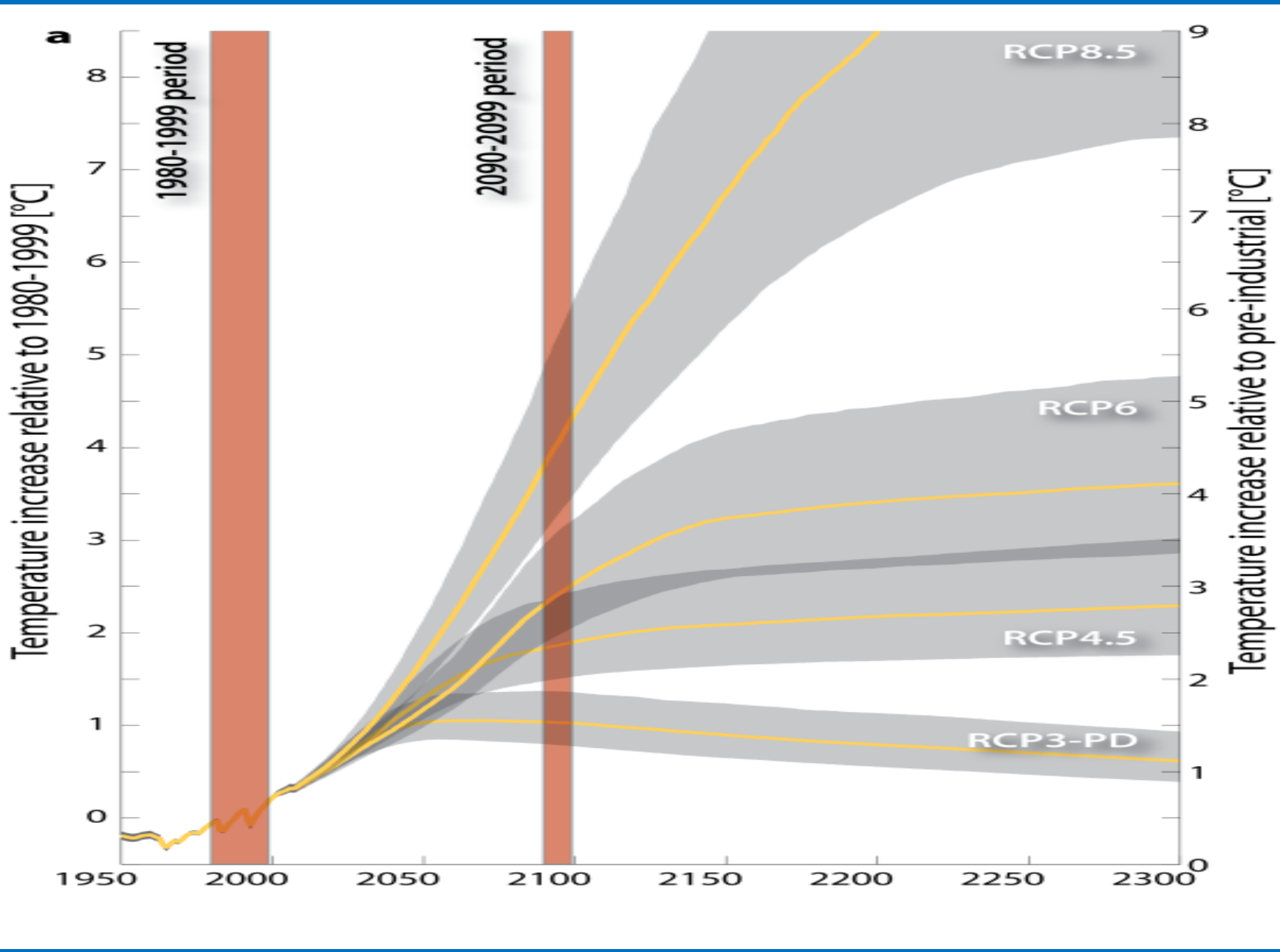
Name	Radiative forcing
RCP8.5	>8.5 W
RCP6.0	~6 W m^{-2} at s
RCP4.5	~4.5 W m^{-2} at
RCP2.6	Peak at ~3 W the

Table TS.5. *Best estimate, likely ranges and very likely lower bounds of global mean equilibrium surface temperature increase (°C) over pre-industrial temperatures for different levels of CO_2-equivalent radiative forcing, as derived from the climate sensitivity.*

Max temps committed but not yet reached by 2100

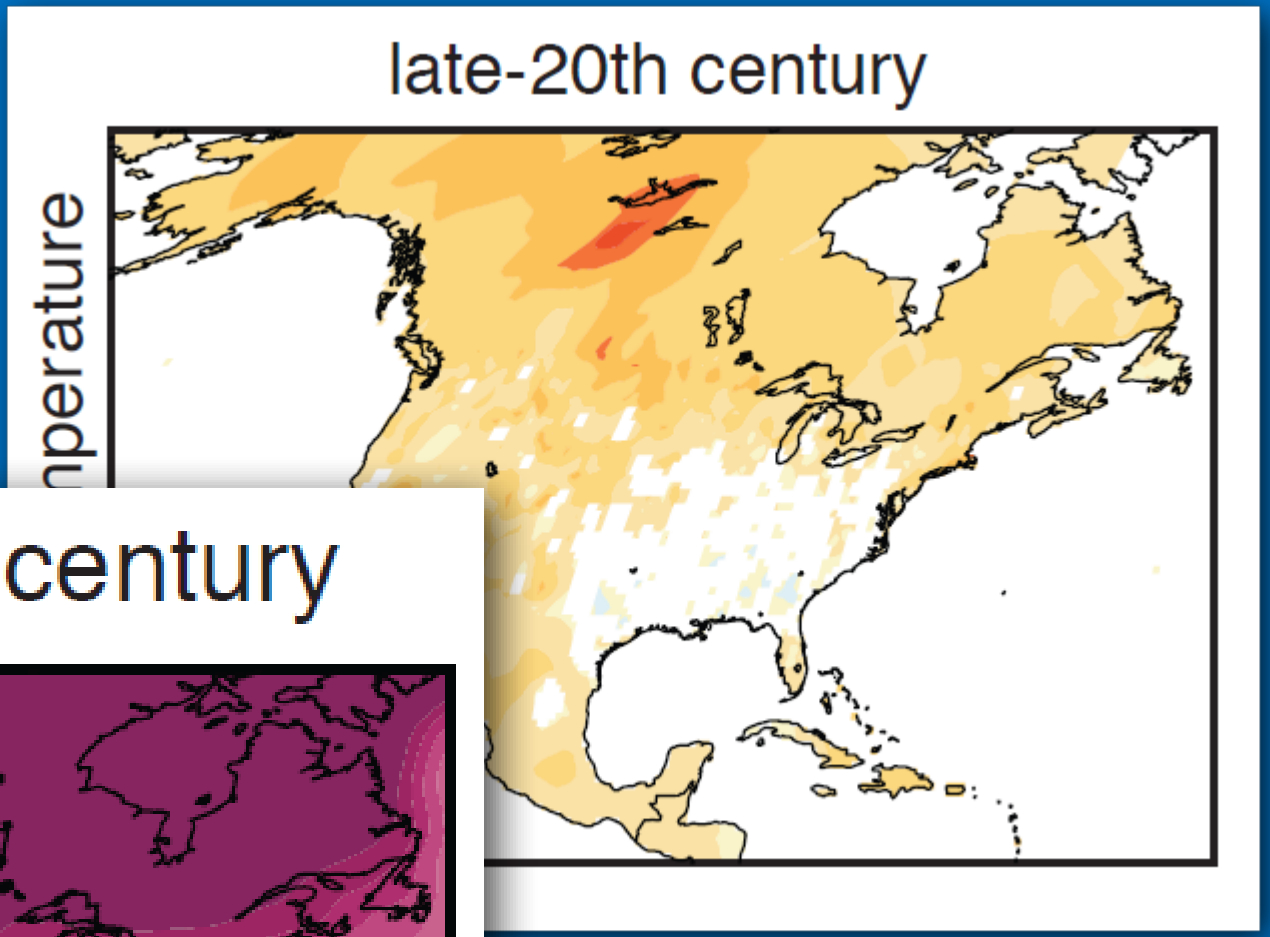
Equilibrium CO_2–eq (ppm)	Temperature Increase (°C) Best Estimate	*Very Likely* Above	*Likely* in the Range
350	1.0	0.5	0.6–1.4
450	2.1	1.0	1.4–3.1
550	2.9	1.5	1.9–4.4
650	3.6	1.8	2.4–5.5
750	4.3	2.1	2.8–6.4
1000	5.5	2.8	3.7–8.3
1200	6.3	3.1	4.2–9.4

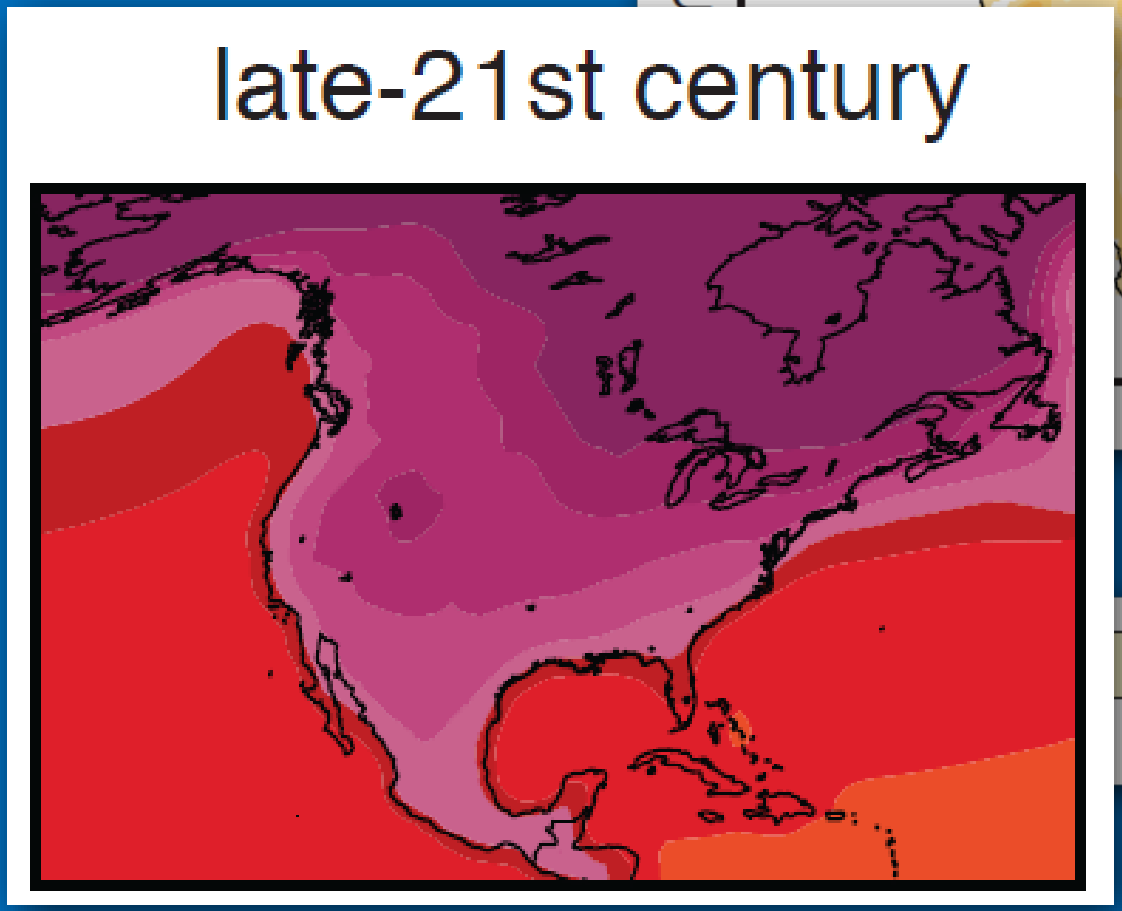
IPCC Fifth Assessment

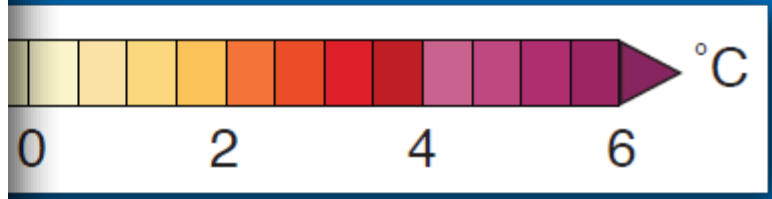


***Draft* IPCC Fifth Assessment**

RCP8.5

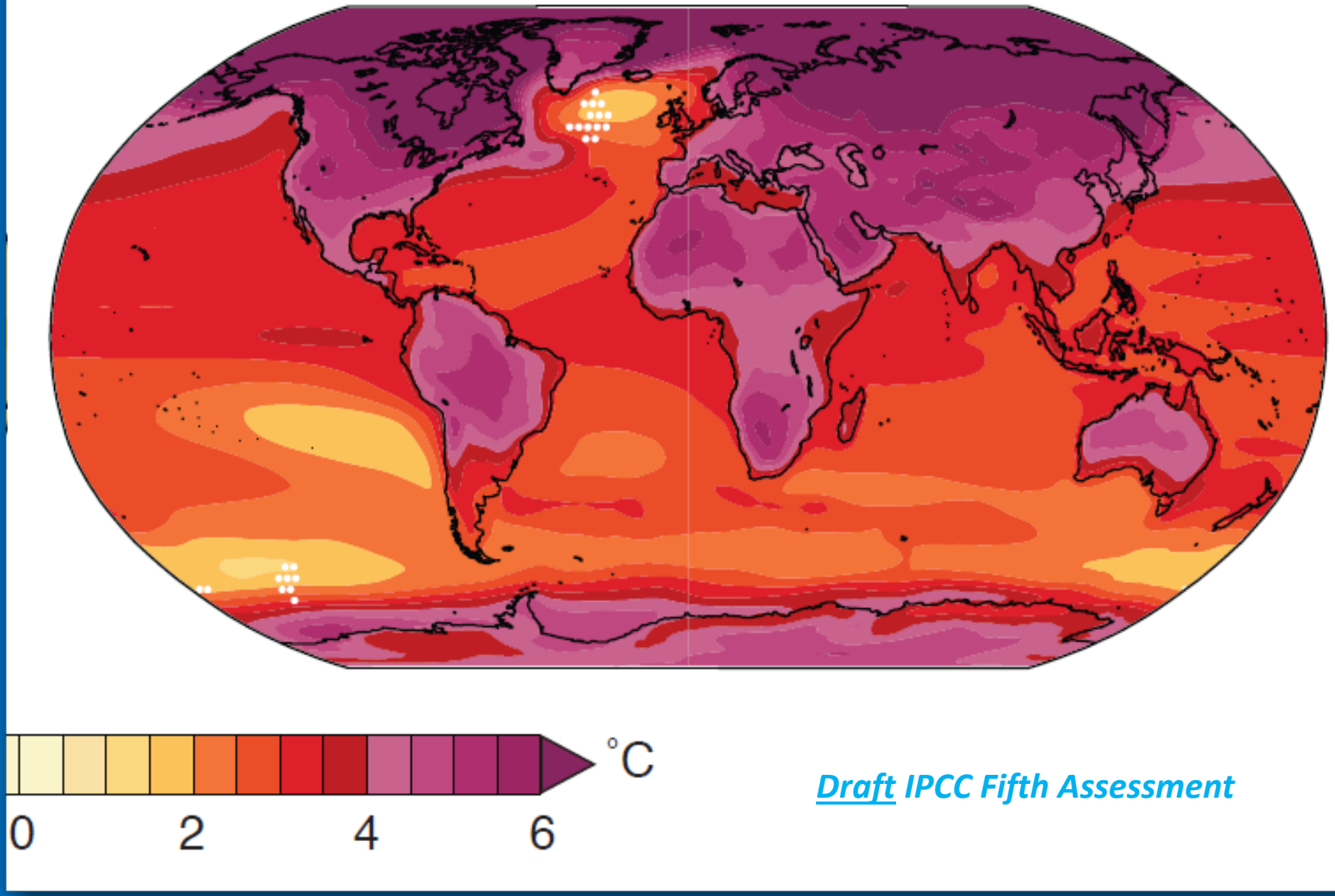






Draft IPCC Fifth Assessment

late-21st-century RCP8.5

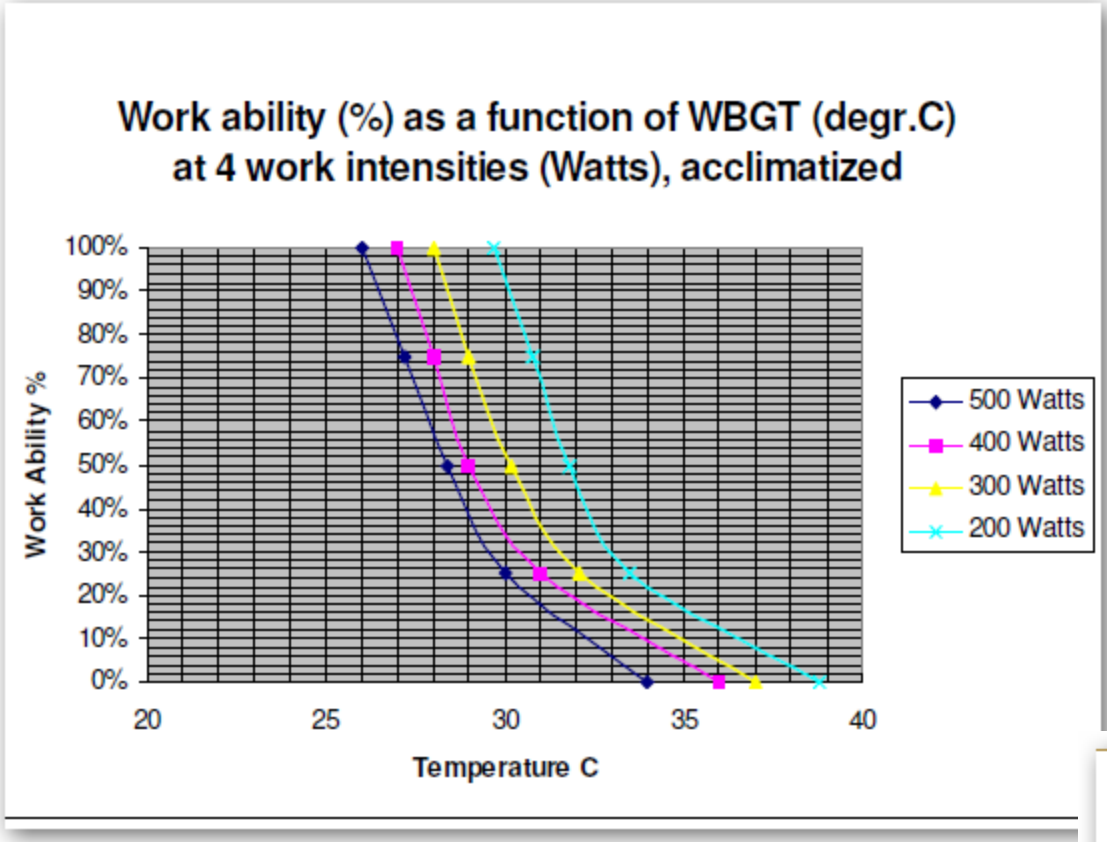


Draft IPCC Fifth Assessment

What most people consider with heat stress

Who died?

The vulnerable – mainly the old and others who should have been protected, but were not



Wet Bulb Globe Temperature =

Function of

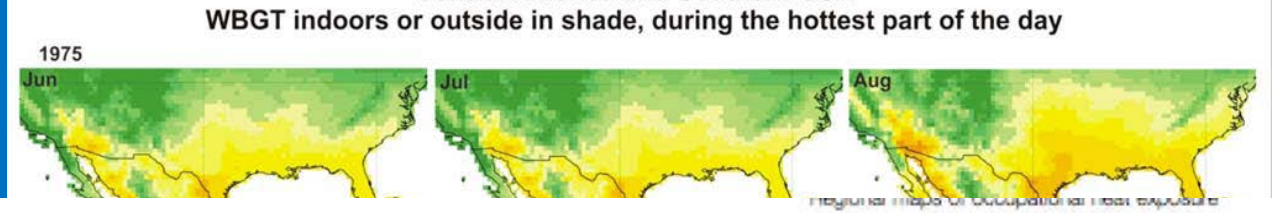
- temperature,
- humidity,
- wind speed, and
- radiative energy, e.g., sunlight

- No epidemiology needed
- Basic thermodynamics and
- Human physiology from exposure chamber studies
- The science is 60 years old – US military research in the 1950s and much since
- **Refers to healthy workers – not the most vulnerable**

Effects of heat exposure

- Sweating, dehydration, salt loss
- Loss of ability to work intensively
- Loss of perceptual motor performance
- Increased accident risk

- Increased body temperature (>38 °C)
- Heat stroke
- Unconsciousness
- Death



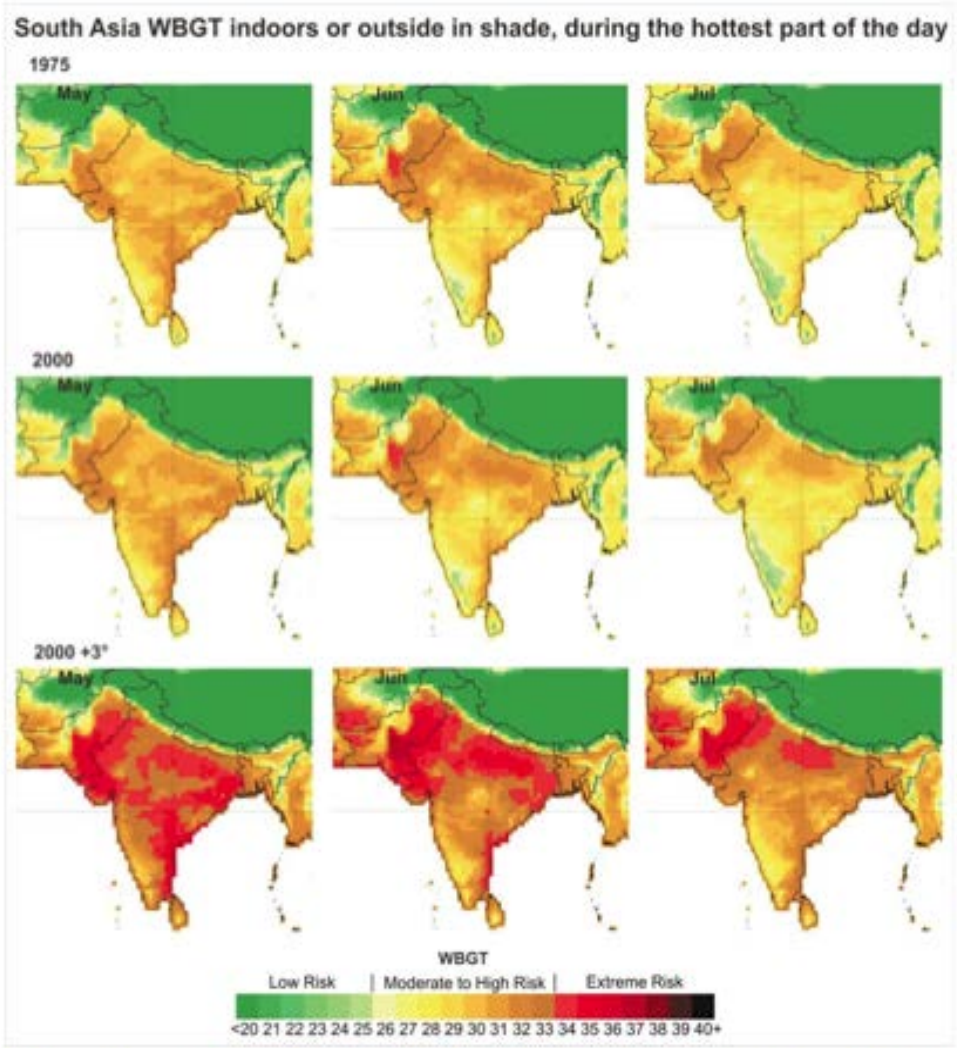


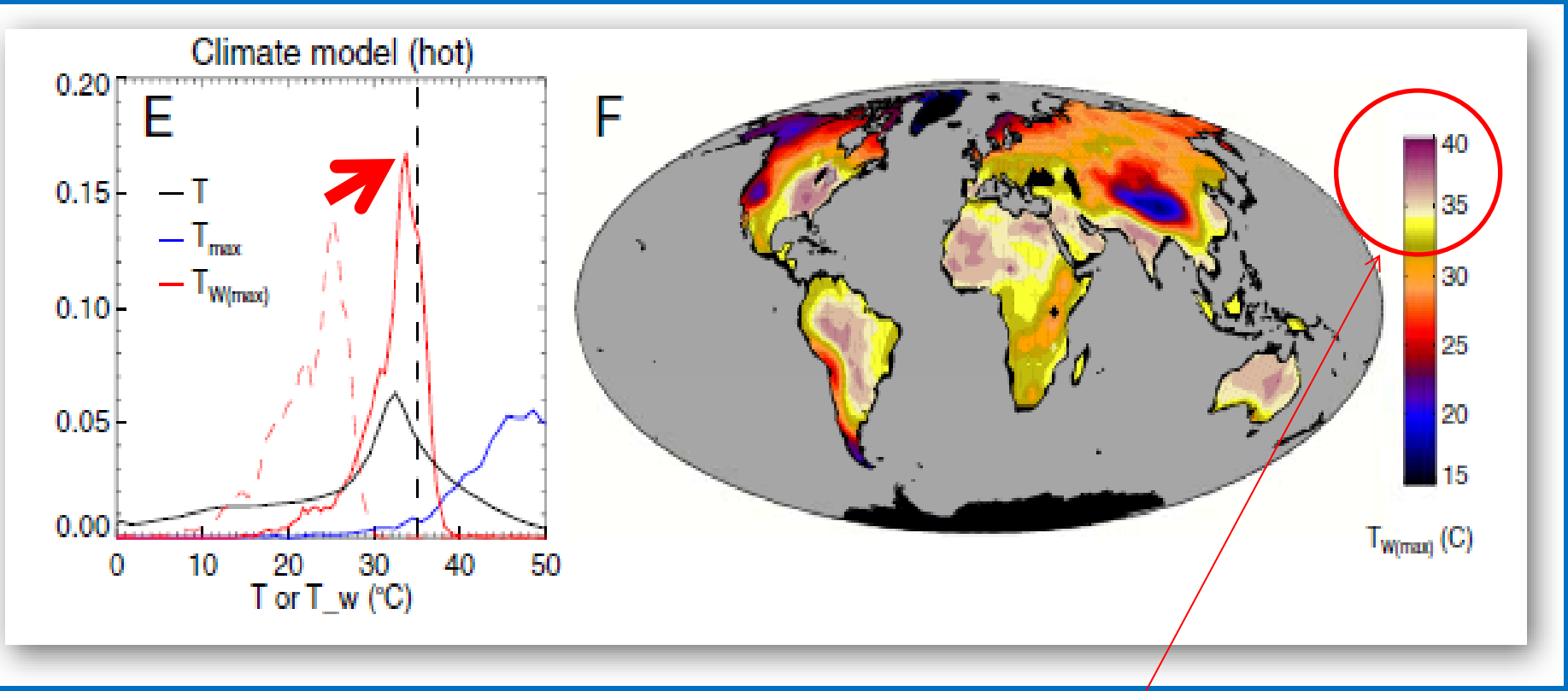
Fig. 2. WBGT (indoors and outside in the shade) for South Asia in 1975, 2000, and a scenario where WBGT is increased by 3° from the year 2000.

Here is what happens at 3 degrees

What about 6 **or 9 degrees?**

Hyatt, Lernke, Kelllstrom, 2010

Approximate 9-deg world



Places where people cannot work outdoors

Sherwood & Huber, PNAS, 2010

What is coming?

- Few places exist on Earth now where people cannot work outdoors nearly every day of the year with appropriate work practices
- More and more of such places with global warming if nothing is done
- When in major populated areas will it be possible only to work outdoors in winter or at night?
- Then only in the winter at night?
- Then what?

Ch 11, cont.

- The most effective adaptation measures for health in the near-term are programs that implement basic public health measures such as provision of clean water and sanitation, secure essential health care including vaccination and child health services, increase capacity for disaster preparedness and response, and alleviate poverty *[very high confidence*].

Co-benefits

The positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare.

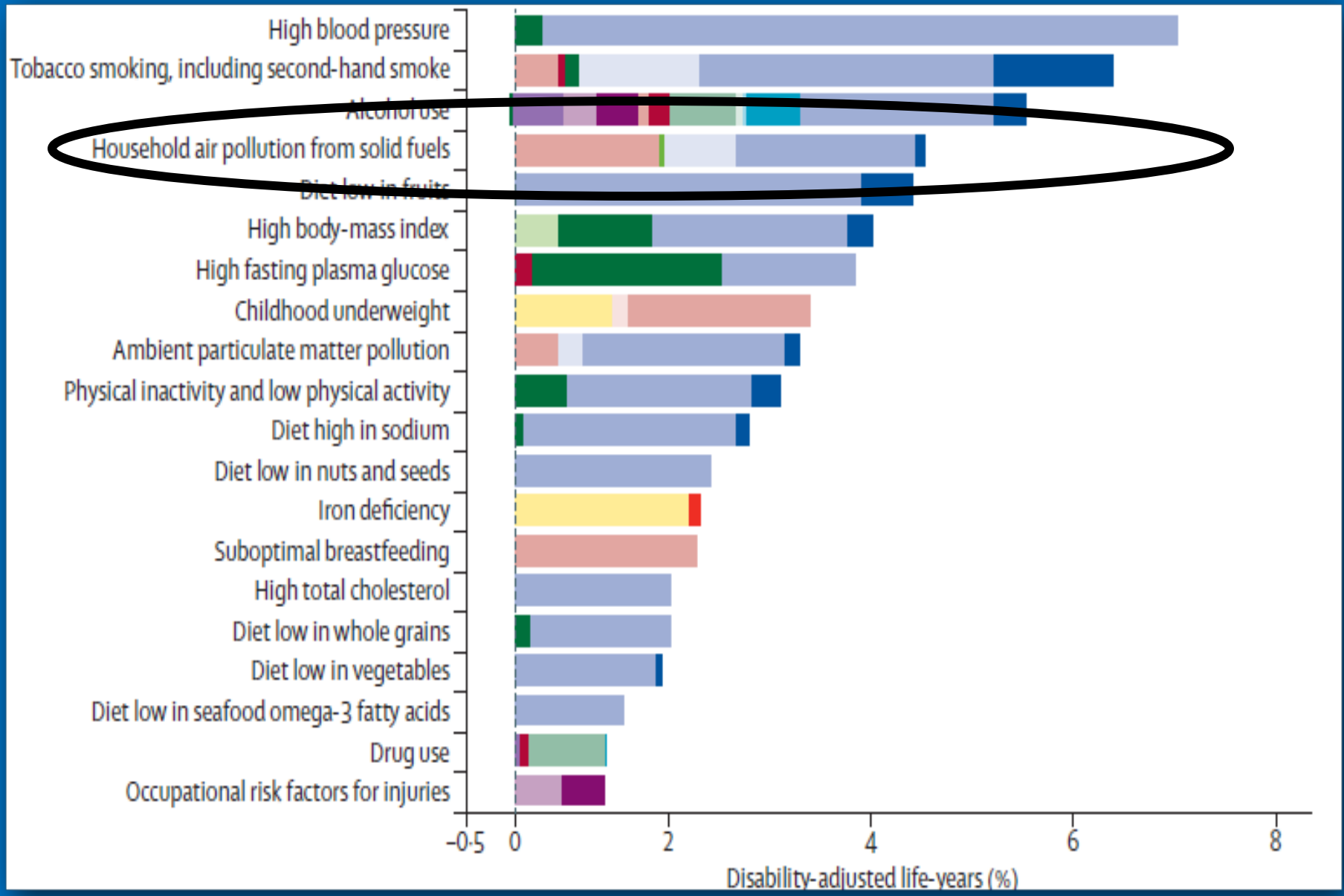
Examples include benefits in other sectors, such as health, urban development, transport, employment, and agriculture, of climate mitigation and adaption efforts. Another term used is “ancillary benefits”

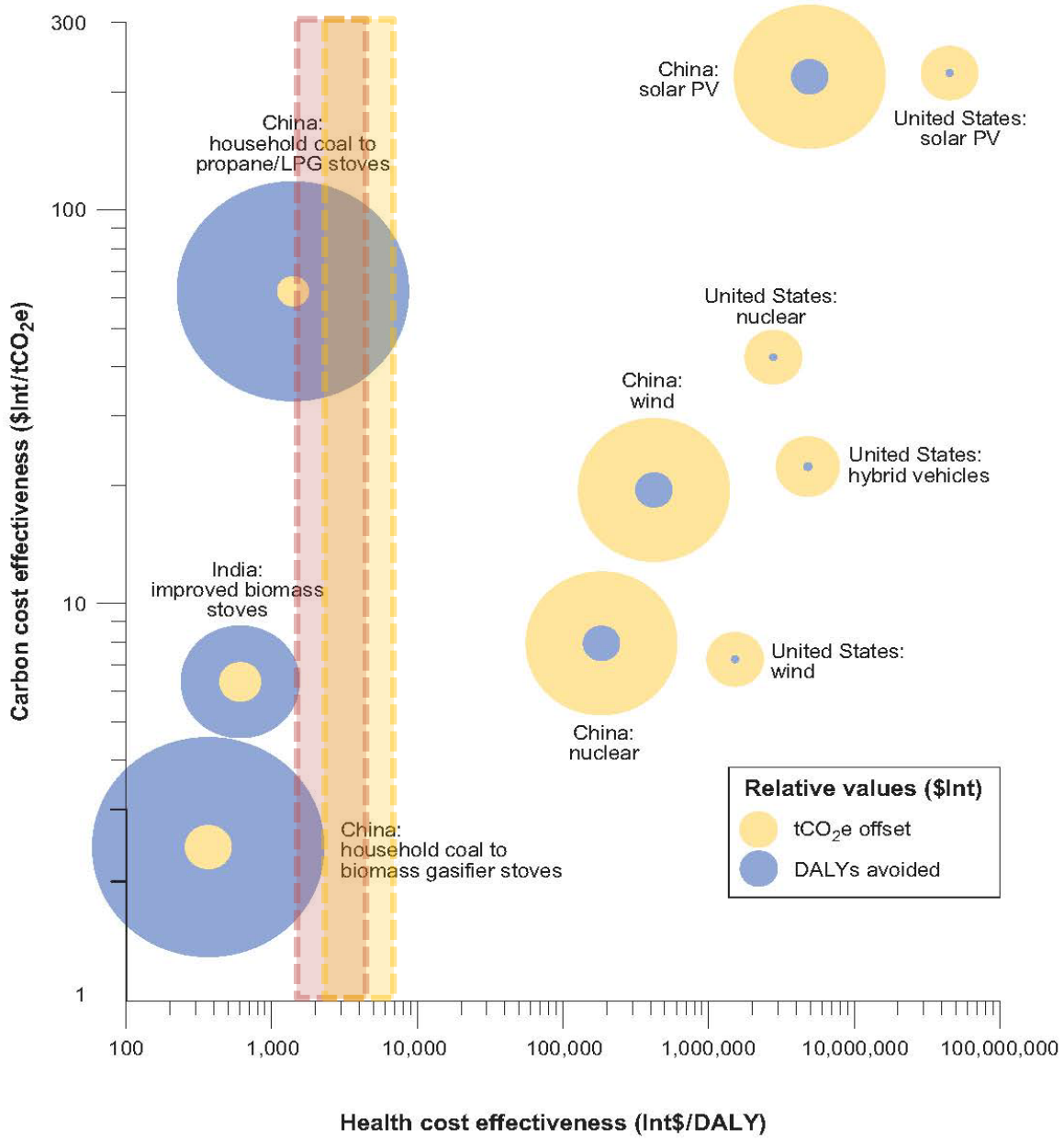
Glossary (IPCC WG2 AR5)

Ch 11, cont.

- There are opportunities to achieve **co-benefits** from actions that reduce emissions of CAPs and at the same time improve health. Among others, these include:
  - reducing local emissions of health-damaging and climate-altering air pollutants from energy systems, through improved energy efficiency, and a shift to cleaner energy sources *[very high confidence]*;
  - providing access to reproductive health services (including modern family planning) to improve child and maternal health through birth spacing and reduce population growth, energy use, and consequent CAP emissions over time *[medium confidence];*
  - shifting consumption away from animal products, especially from ruminant sources, in high-meat-consumption societies toward less CAP-intensive healthy diets *[medium confidence];*
  - designing transport systems that promote active transport and reduce use of motorized vehicles, leading to lower emissions of CAPs and better health through improved air quality and greater physical activity *[high confidence]*.

Global DALYs 2010: Top 20 Risk Factors

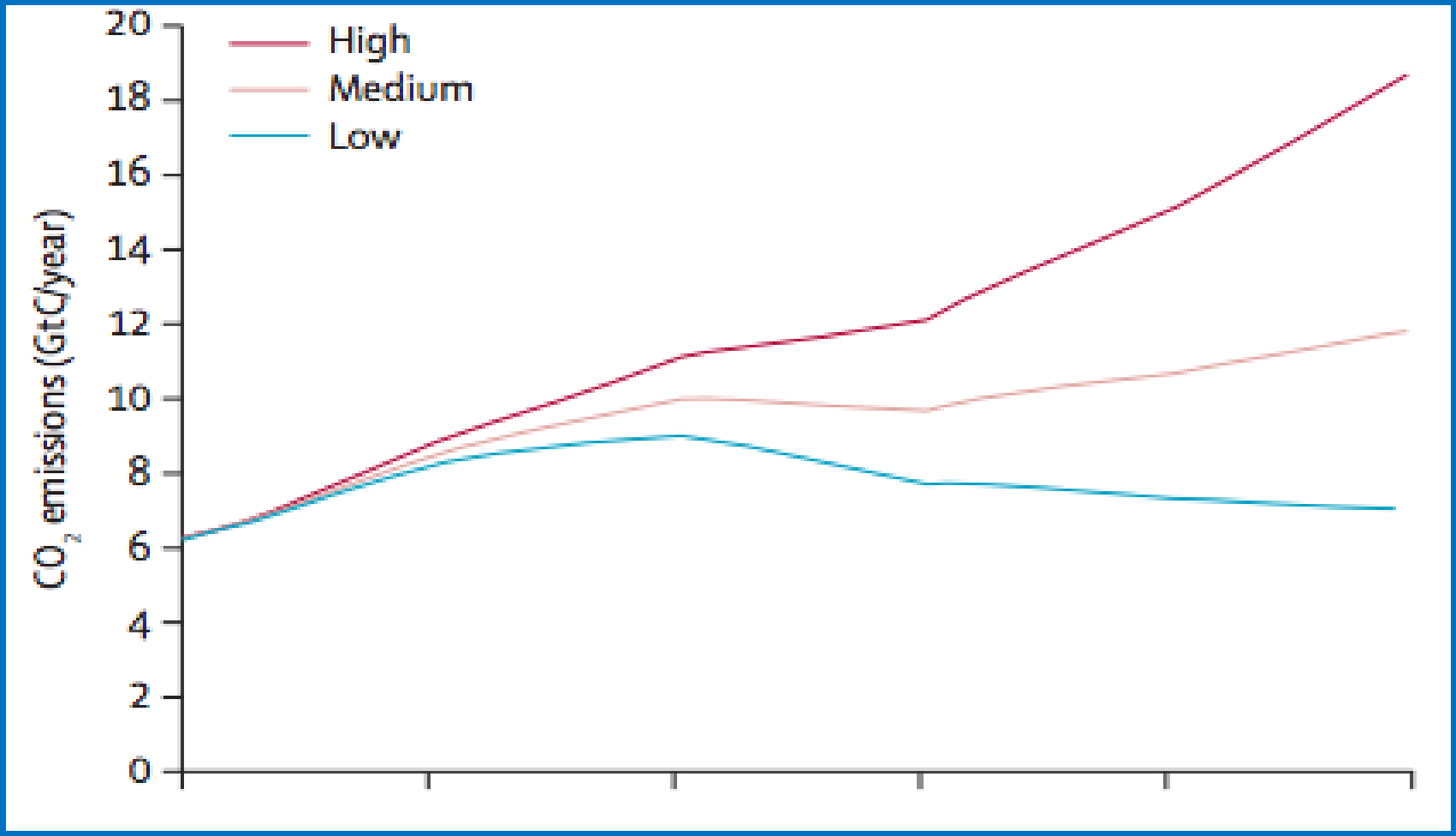




How (and where) to reduce carbon emissions and improve health in a cost-effective fashion

IPCC, WG2, chapter 11

Population growth and global greenhouse emissions – high, medium and low UN population projections, applying the B2 emissions scenario, 2000-2100.



O'Neill et al. Lancet 2012

Reproductive health services and climate change

- Several hundred million women have restricted access to reproductive health services and wish to limit their families
- Satisfying unmet demand for contraception would reduce fertility by about 0.5 births per woman (world-wide), equivalent to shifting from the UN medium growth projection to the low growth future
- Such a shift would lower CO_2 emissions by about 40% by 2100, and bring large health gains

O'Neill et al. PNAS 2010;107:17521

Health benefits associated with wider birth spacing

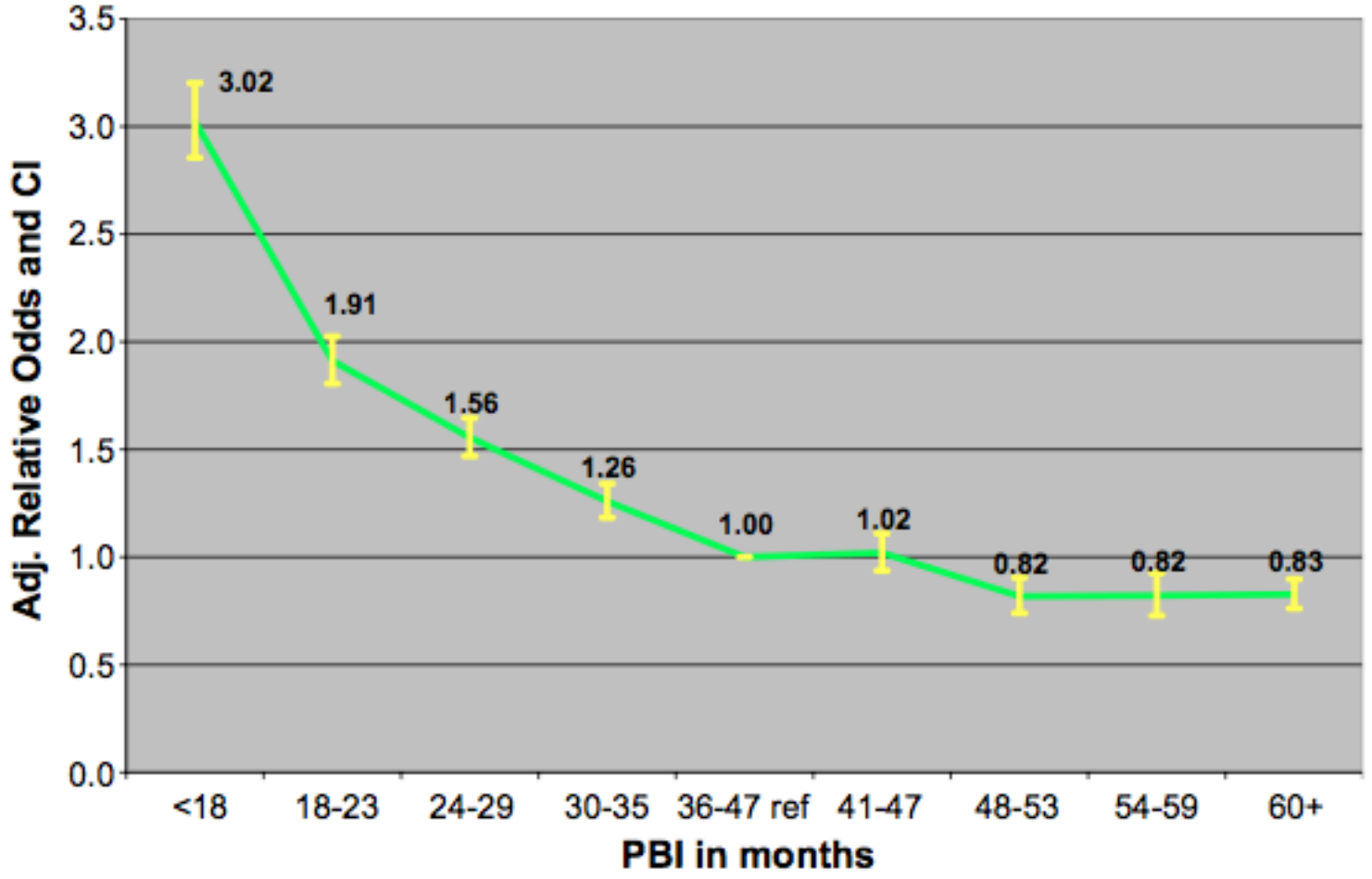
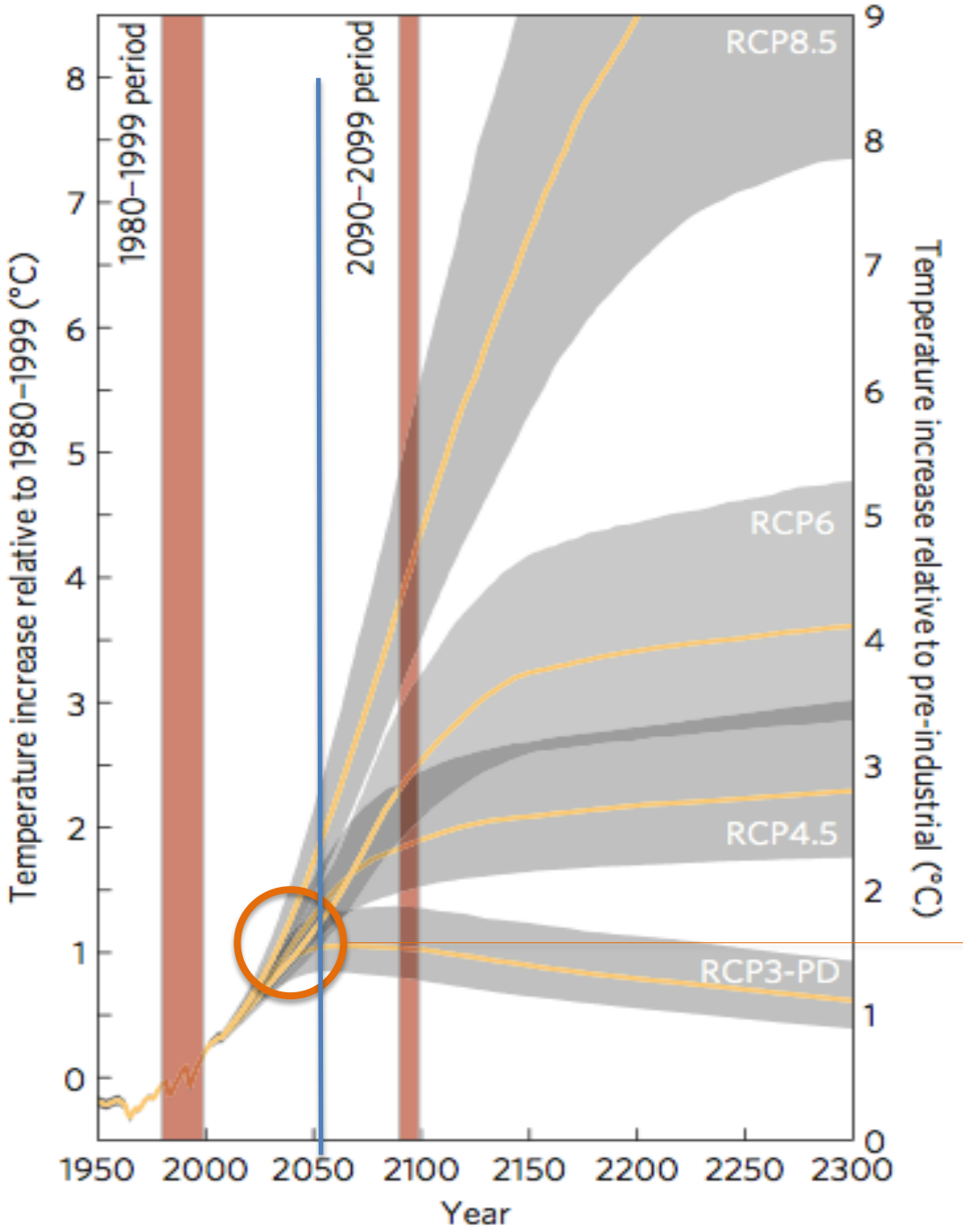


Figure 1 Under-five mortality by birth interval (17 DHS surveys).

Int J Gynecol Obstets 2005;89:S7



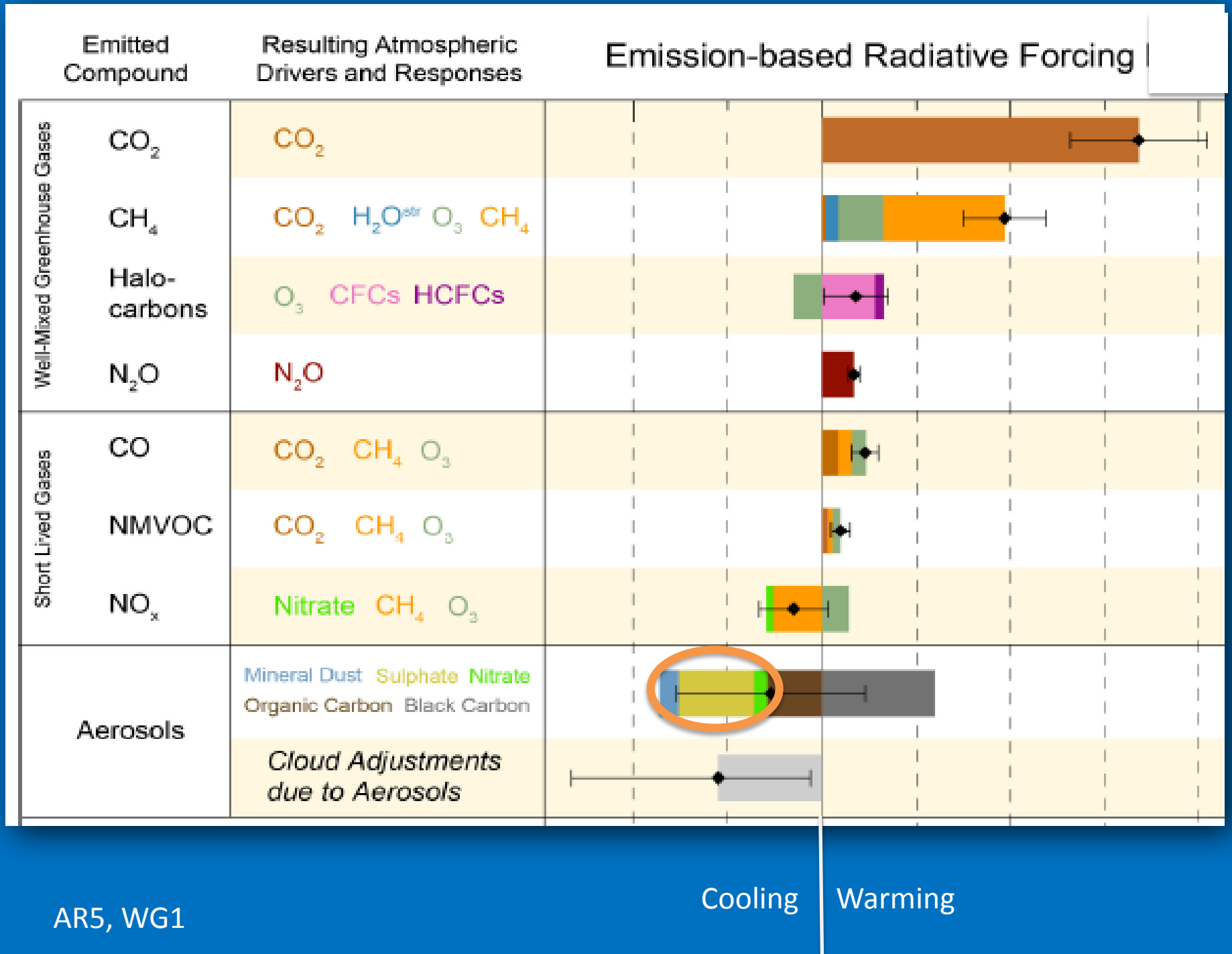
Temperature projections for four concentration pathways, median (yellow) and uncertainty bound (gray), 2010 – 2300.

Political appeal of co-benefits: no discernible impact of lowered emissions until around 2050

Nature Climate Change 2012;2:248

Cross-benefits?

- Good for health, but not for climate
- Reduce sulfur emissions from fossil fuel combustion

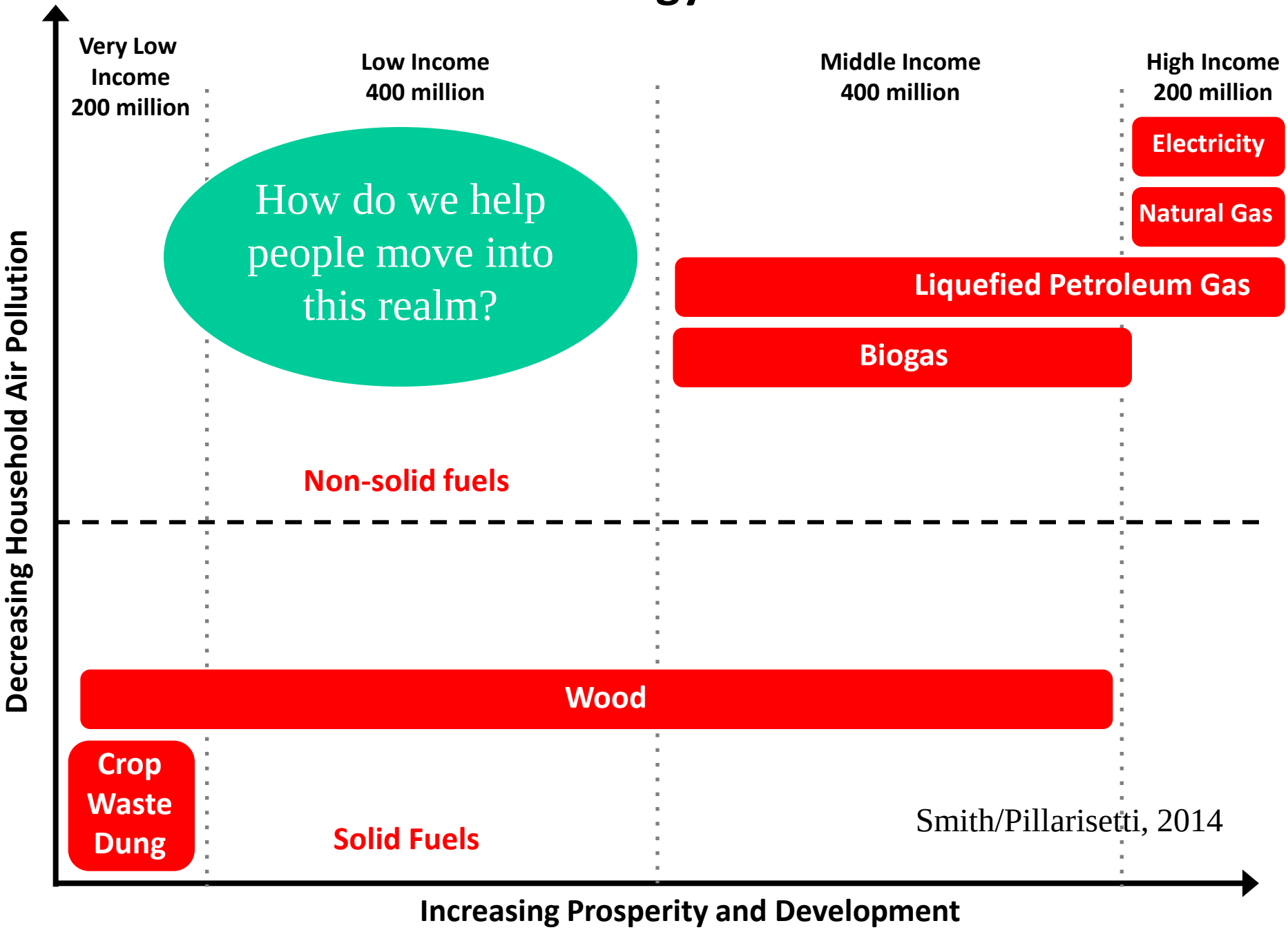

Emitted Compound
Resulting Atmospheric Drivers and Responses
Emission-based Radiative Forcing
Well-Mixed Greenhouse Gases
CO2
CO2
CH4
CO2 H2Ostr O3 CH4
Halo-carbons
O3 CFCs HCFCs
N2O
N2O
Short Lived Gases
CO
CO2 CH4 O3
NMVOC
CO2 CH4 O3
NOx
Nitrate CH4 O3
Aerosols
Mineral Dust Sulphate Nitrate
Organic Carbon Black Carbon
Cloud Adjustments due to Aerosols
Cooling
Warming

AR5, WG1

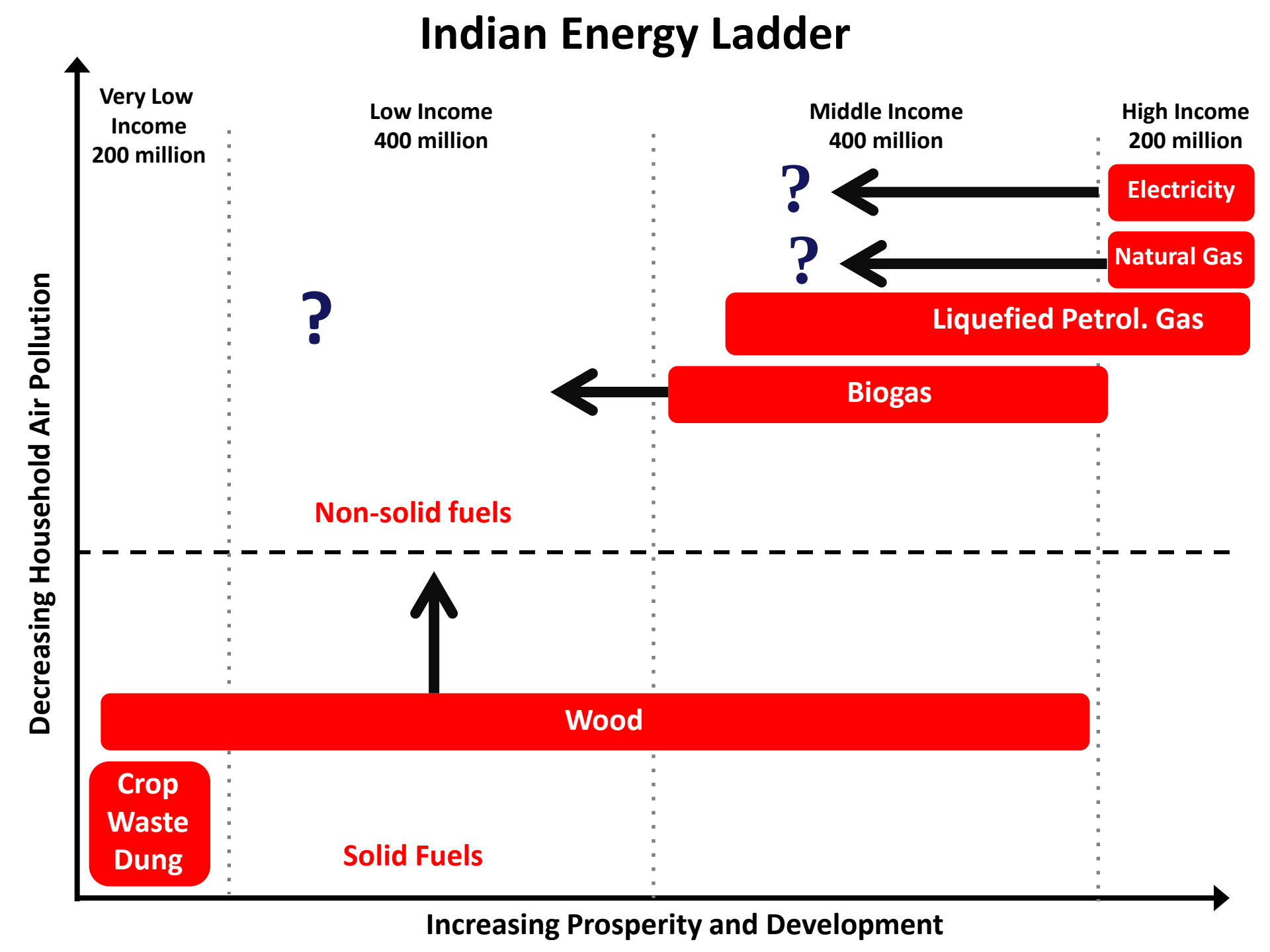
Cross-benefits?

- Good for health, but not for climate
- Reduce sulfur emissions from fossil fuel combustion
- Some development uses of energy such as
- Household fuels for clean cooking
  - Making the available clean – very difficult
  - Making the clean available – needs to be pursued as well

Indian Energy Ladder

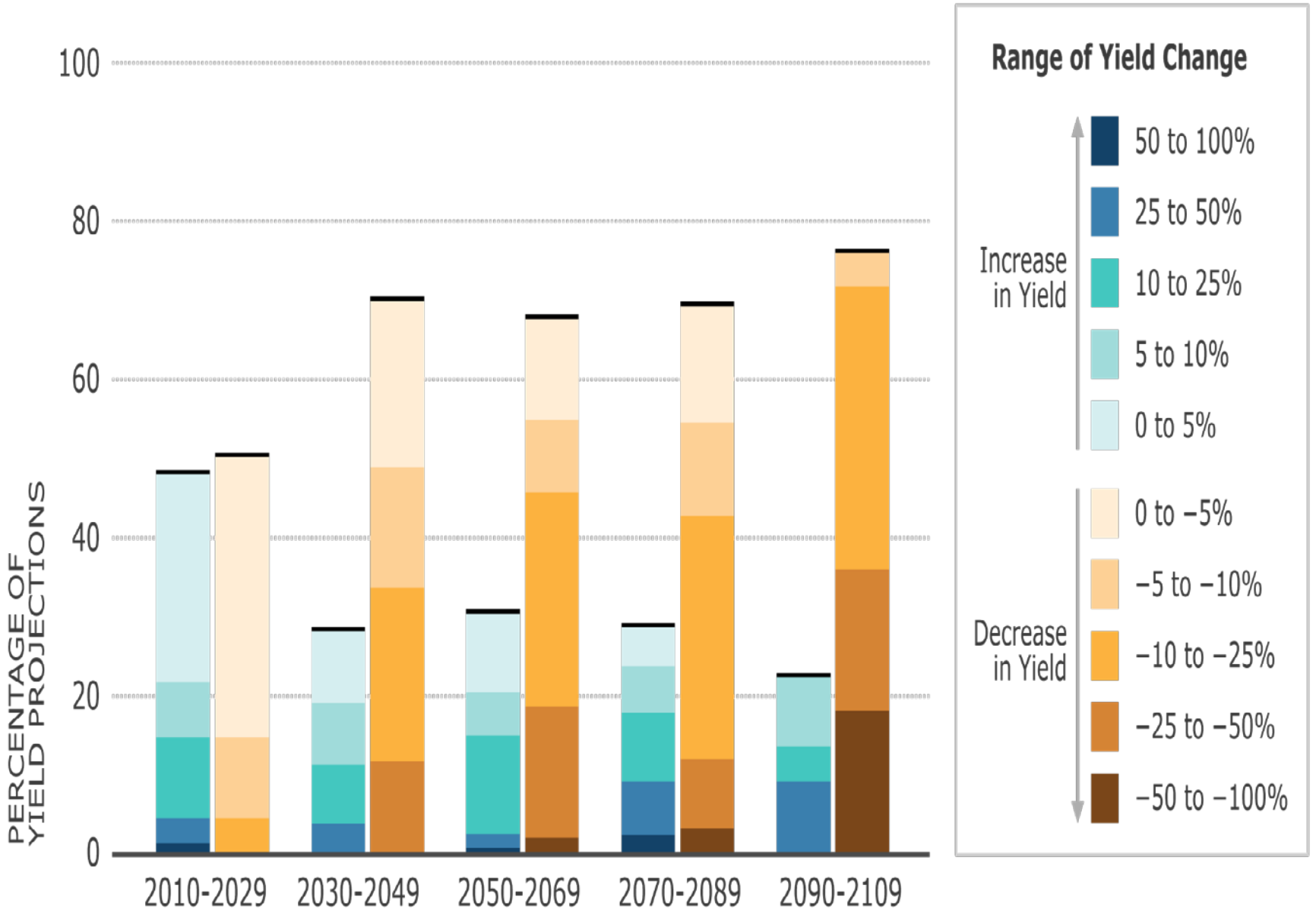


Smith/Pillarisetti, 2014

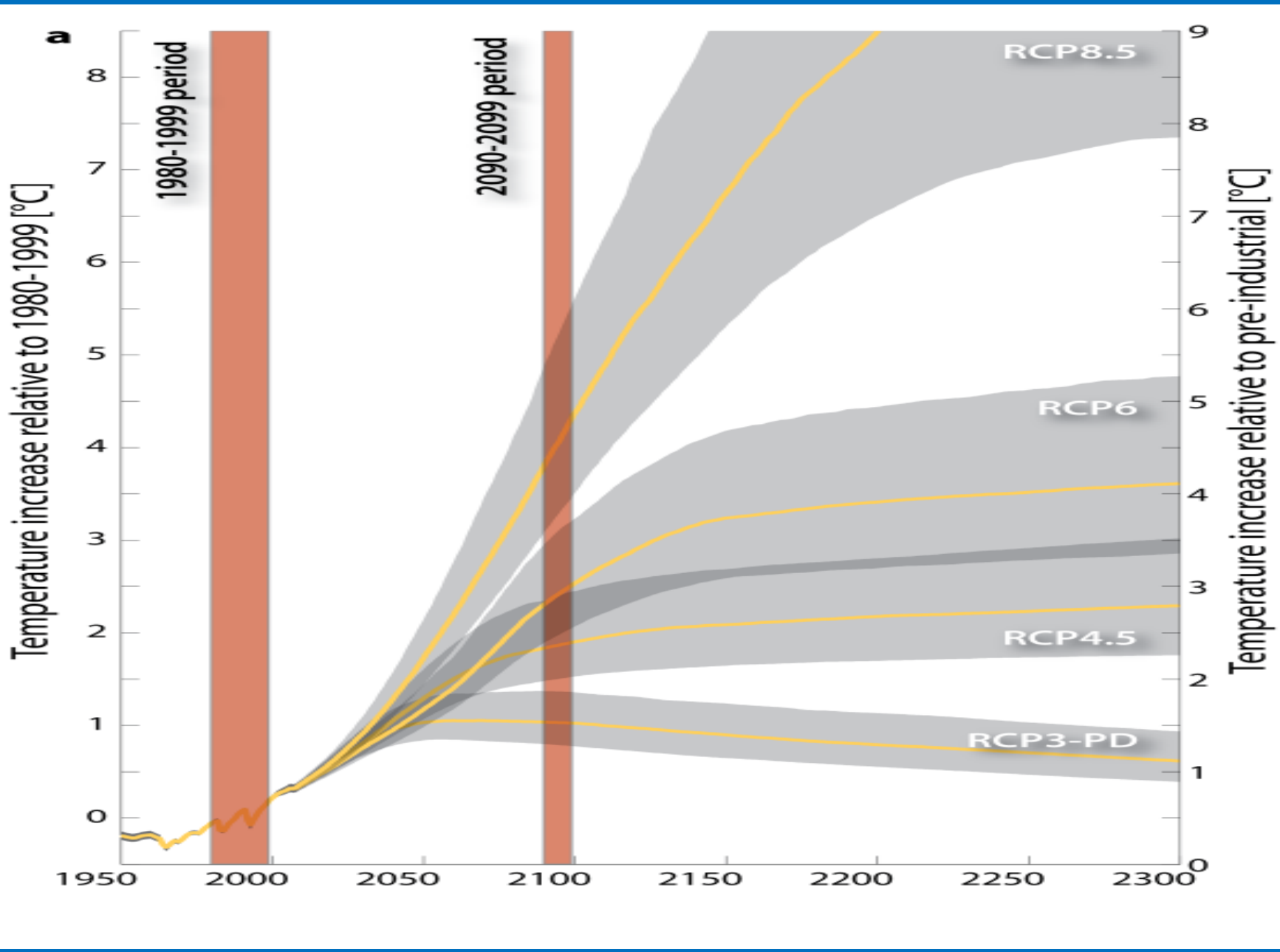

Indian Energy Ladder
Very Low Income 200 million
Low Income 400 million
Middle Income 400 million
High Income 200 million
Electricity
Natural Gas
Liquefied Petrol. Gas
Biogas
Wood
Crop Waste Dung
Non-solid fuels
Solid Fuels
Decreasing Household Air Pollution
Increasing Prosperity and Development

The three eras: bottom lines

- The present: very difficult to assign a significant burden of disease to human-caused climate change to date
- Up to 2050: Growing health impacts can be expected if adaptation measures are not taken, but could be greatly reduced if they are
- After 2050: risk in the higher emissions scenarios of exceeding conceivable adaptation potentials and thus leading to major impacts on health, particularly among the poor.
- Unfortunately, however, to wait until 2050 to take mitigation action will not be enough – need to work now – we must always act some 50 years ahead.



ipcc
INTERGOVERNMENTAL PANEL ON climate change



***Draft* IPCC Fifth Assessment**

Caveats

- Climate models do not handle the extreme scenarios well – few try and they do not agree
- Currently, these high temperature scenarios are low probability (although not that low)
- But definitely high consequence and we are doing little to reduce their probability
- But at least they are far off in the future – 2100+
- Or are they?

2100 – is it even the future?

Born Oct 26, 2012

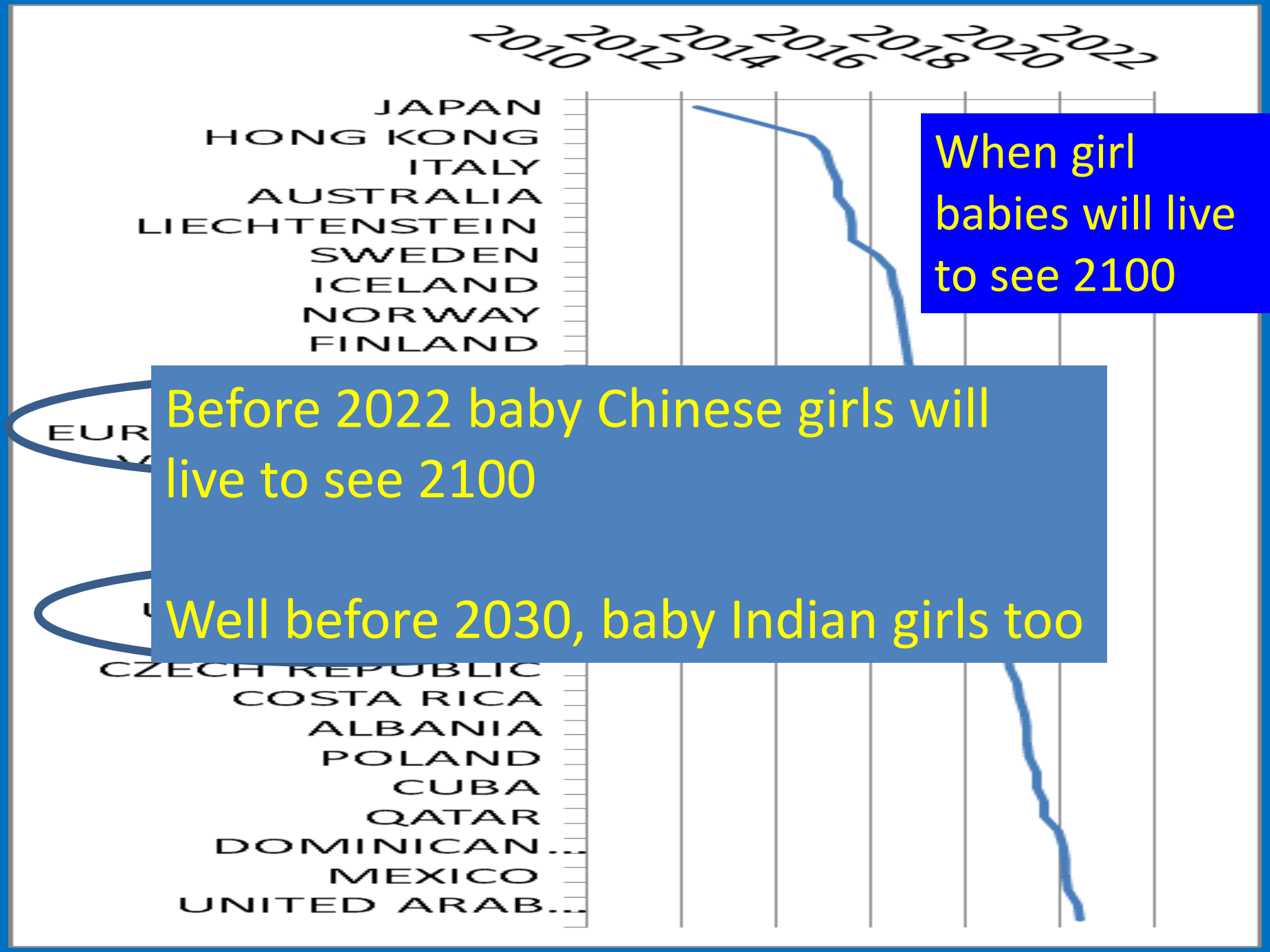
Yui Honda, Granddaughter of
Yasushi Honda, IPCC Author

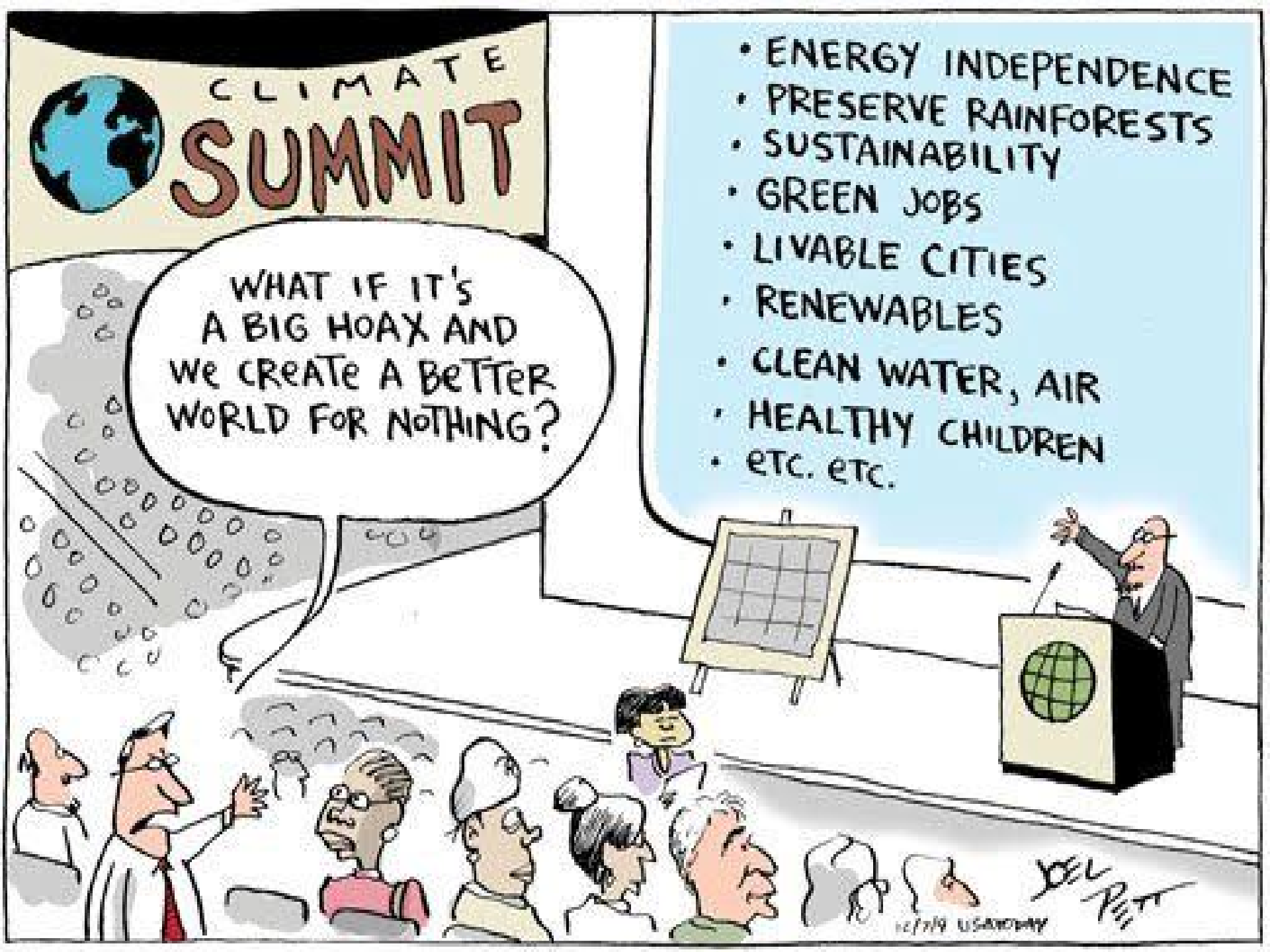
Japanese girl babies have the longest life expectancy on Earth

87.4 years

They are among the very first members of Earth's 22C Club

Twenty-second Century Club


2010
2012
2014
2016
2018
2020
2022
JAPAN
HONG KONG
ITALY
AUSTRALIA
LIECHTENSTEIN
SWEDEN
ICELAND
NORWAY
FINLAND
EUR
CZECH REPUBLIC
COSTA RICA
ALBANIA
POLAND
CUBA
QATAR
DOMINICAN...
MEXICO
UNITED ARAB...
When girl babies will live to see 2100
Before 2022 baby Chinese girls will live to see 2100
Well before 2030, baby Indian girls too


CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.
JOEL PETT

Thank you

IPCC website has a tremendous amount of useful material including summaries, full reports, ppt figures, press releases, review comments/responses, databases of literature cited, full copies of gray literature reports, etc.

JUST GOOGLE: IPCC