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Climate Change: Impacts, Adaptation and Vulnerability

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Climate Change:
Impacts, Adaptation and Vulnerability

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Overview

1. Context for assessing CC IAV
2. Climate change: impacts and adaptation
3. Impacts on and adaptation in energy systems
4. Summary and conclusions

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1. Context for Assessing Climate Change Impacts, Adaptation and Vulnerability

Climate Change – IPCC statements

- **FAR 1990: *little* observational evidence of a *detectable anthropogenic influence* on climate**
- **SAR 1995: “The balance of evidence suggests a *discernible human influence* on the climate of the 20th century.“**
- **TAR 2001: “There is new and stronger evidence that most of the warming observed over the last 50 years is *attributable to human* activities.”**
- **AR4 2007: “Warming of the climate system is *unequivocal*, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level”. (WGI SPM)**

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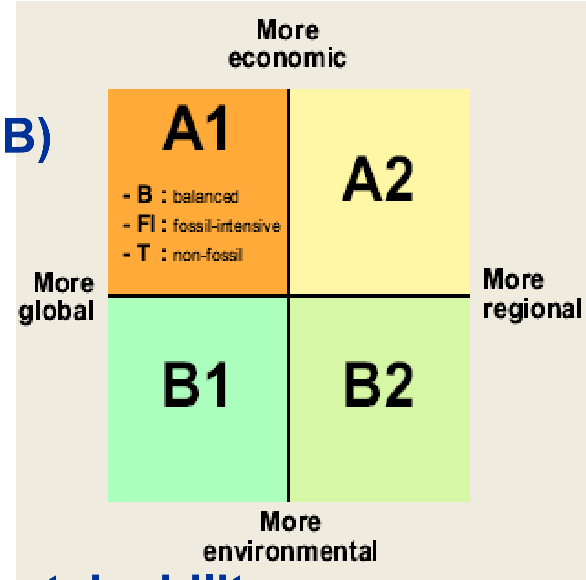
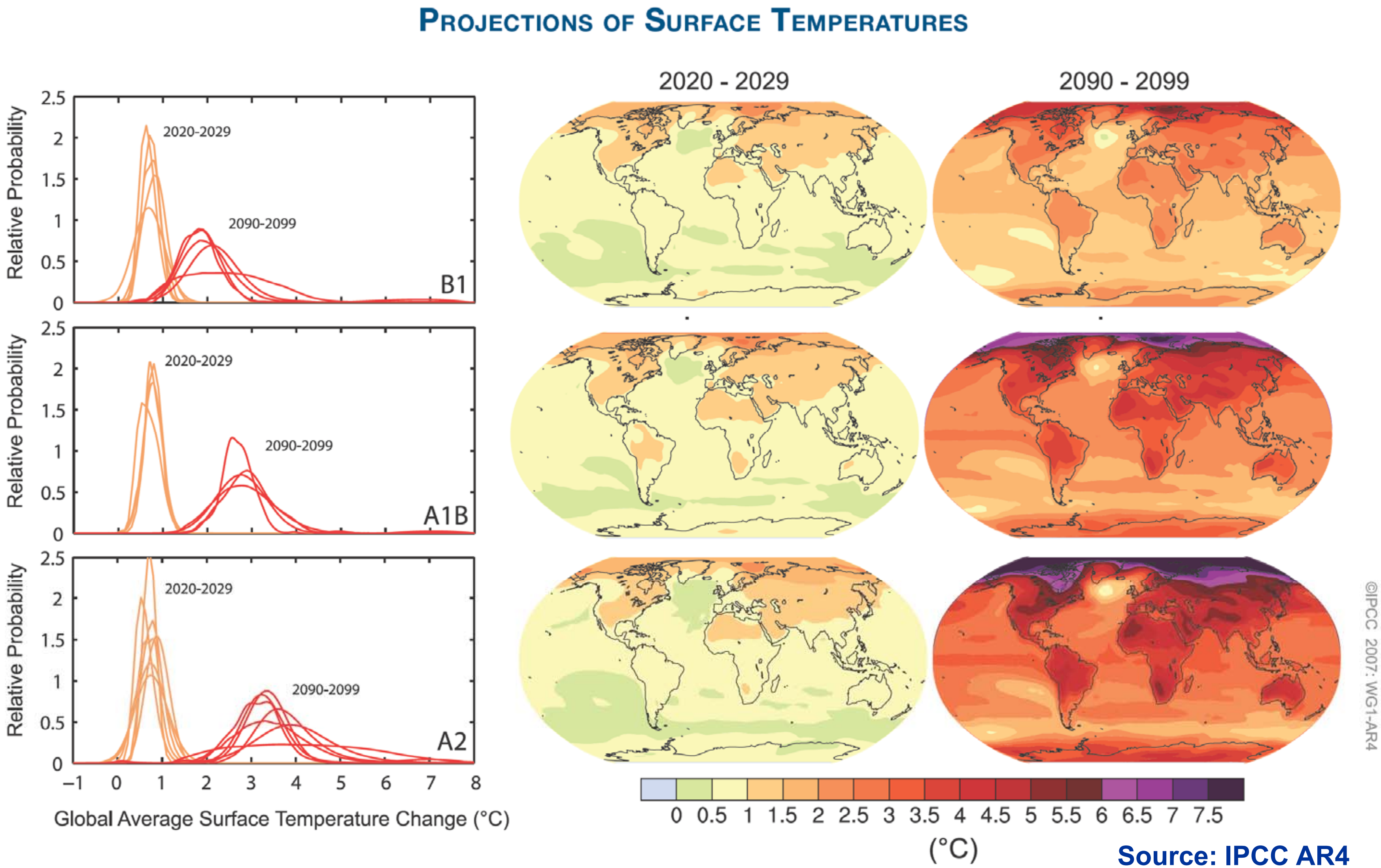
Exploring future emissions and impacts: IPCC Emissions Scenarios – SRES 2000



- Two orthogonal dimensions:
  - economic vs environmental orientation (A– B)
  - Globalization vs regionalization (1-2)
- Four storylines:
  - A1: rapid growth and global convergence
  - A2: slower growth and regional/local fragmentation
  - B1: global convergence and emphasizing sustainability
  - B2: slower growth and regional/local initiatives
- General features: future more affluent, regions converge, technology equally important (pop, econ)
- Focus: on key drivers of GHG emissions & emission profiles

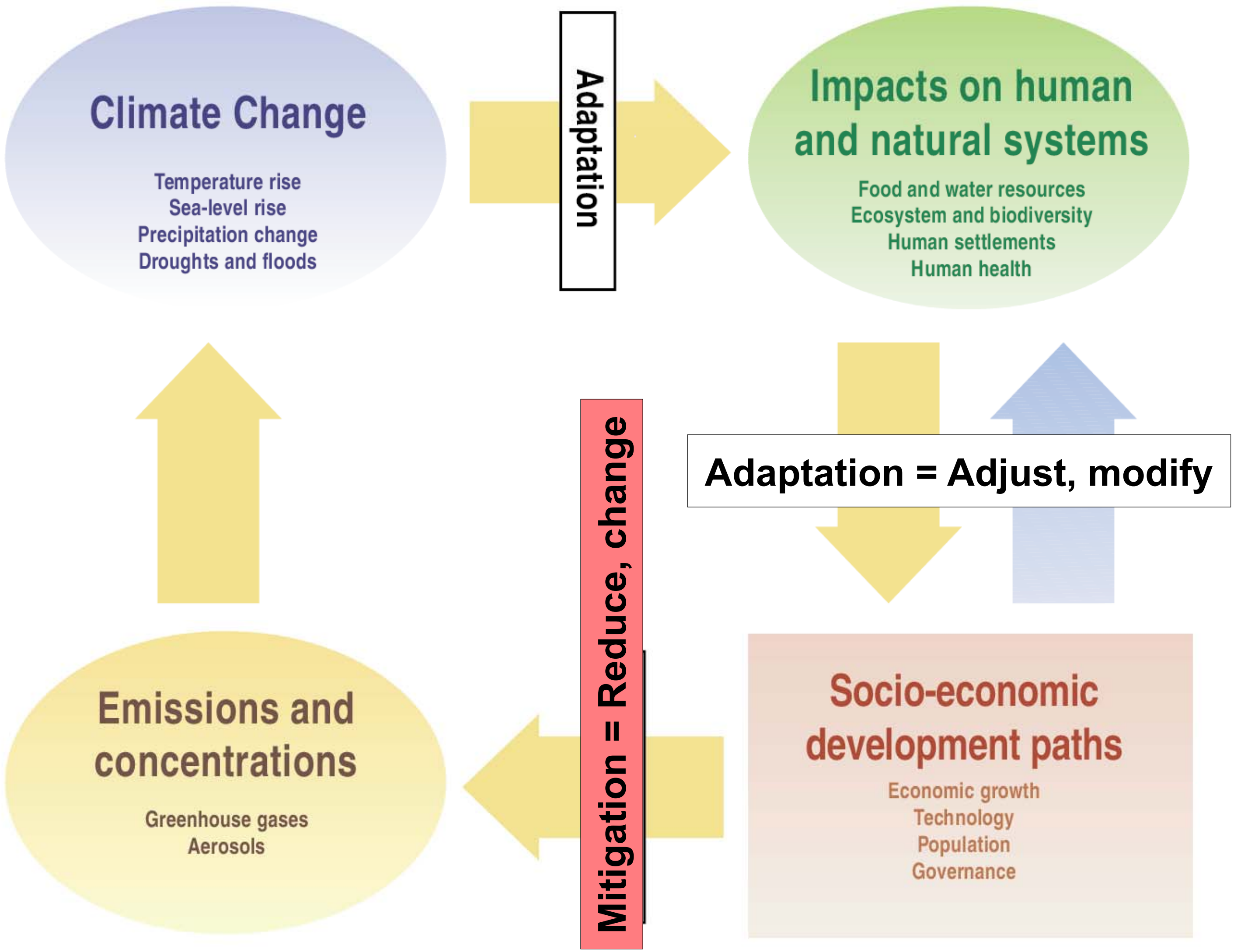
Note: limited applicability for VIA assessmts – New scenarios

Global mean temperature patterns



Source: IPCC AR4

Climate change response options: Mitigation and Adaptation



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2. Climate Change:
Vulnerability, Impacts and Adaptation

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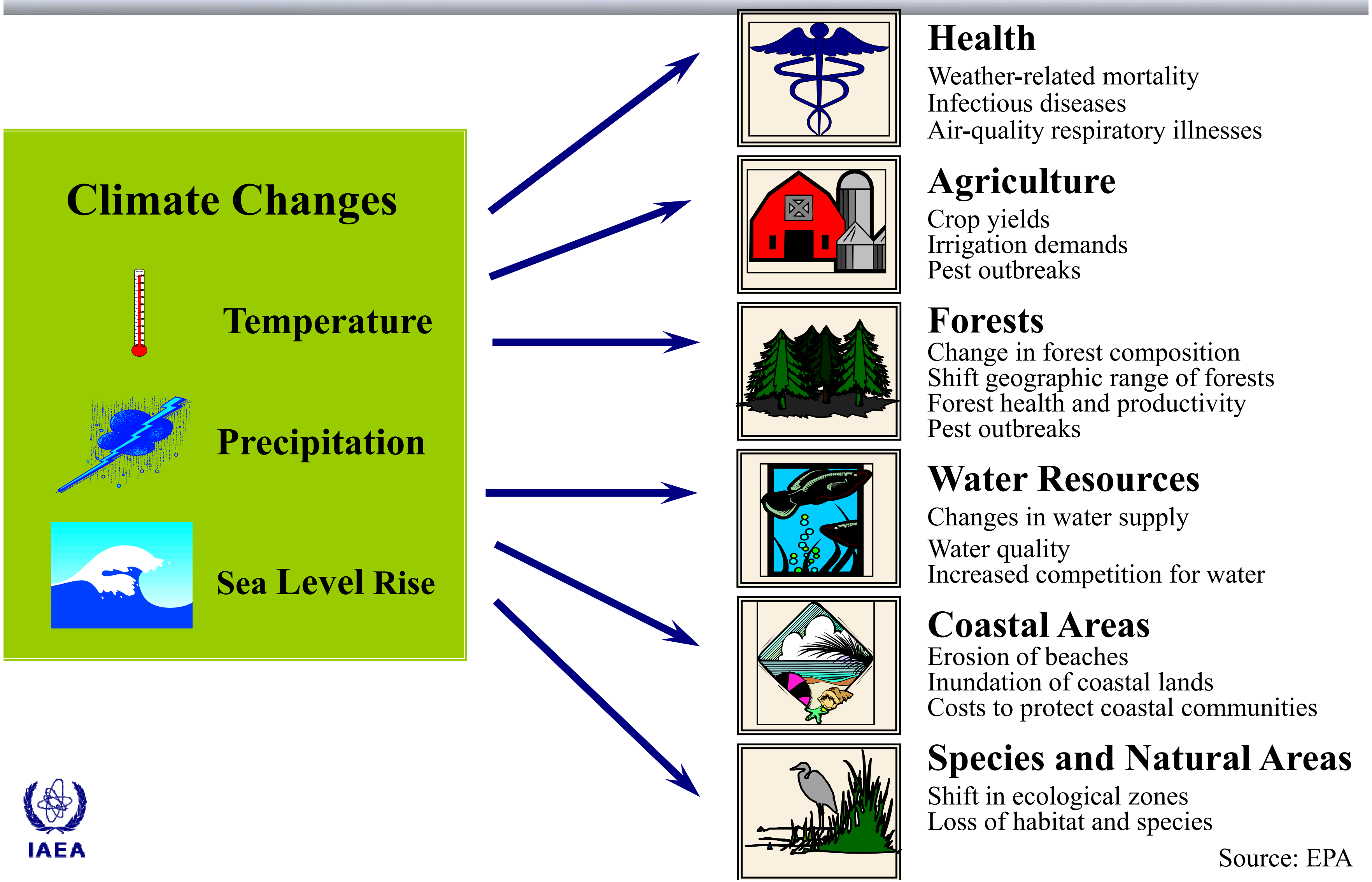
2. Potential Climate Change Impacts



Source: EPA

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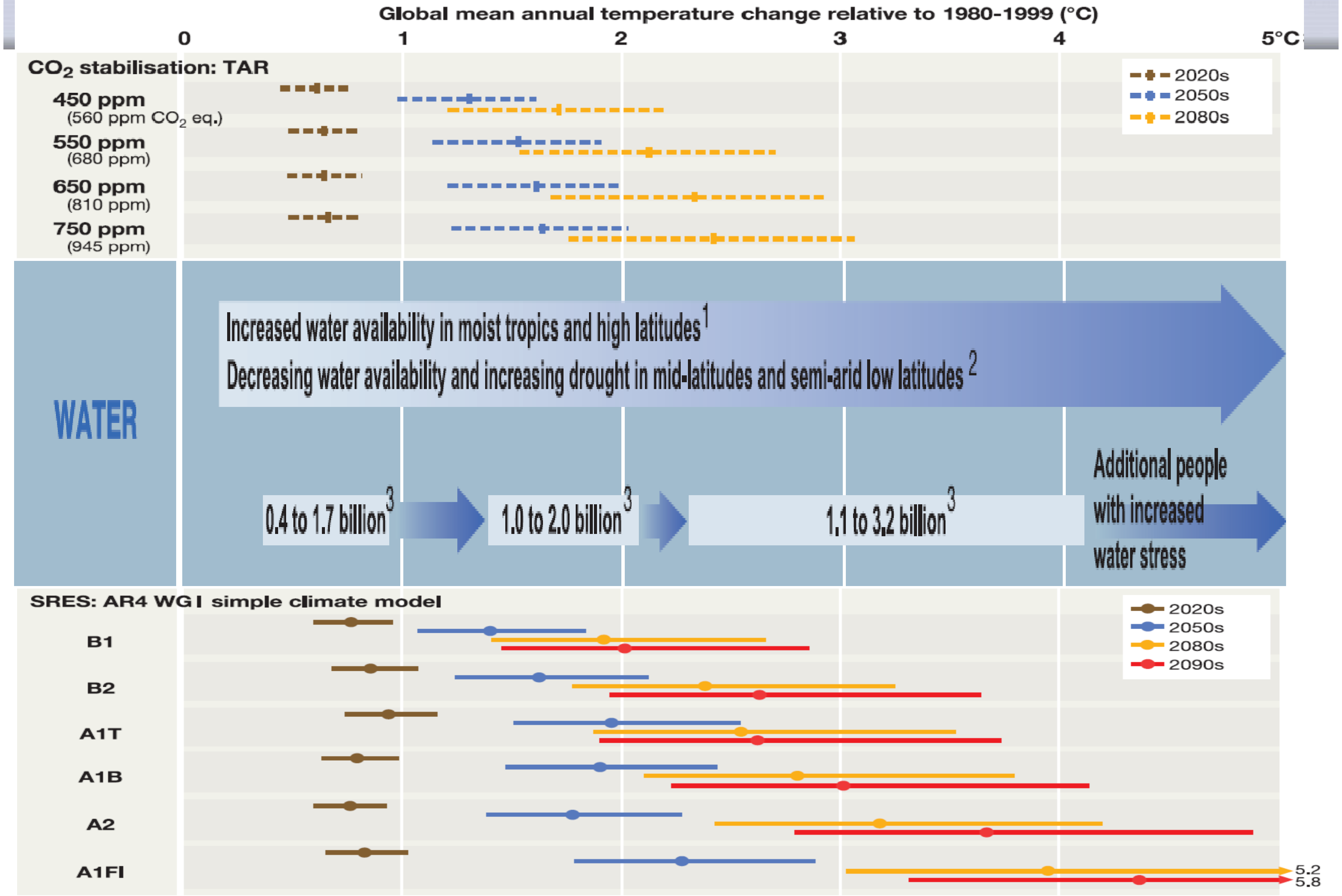
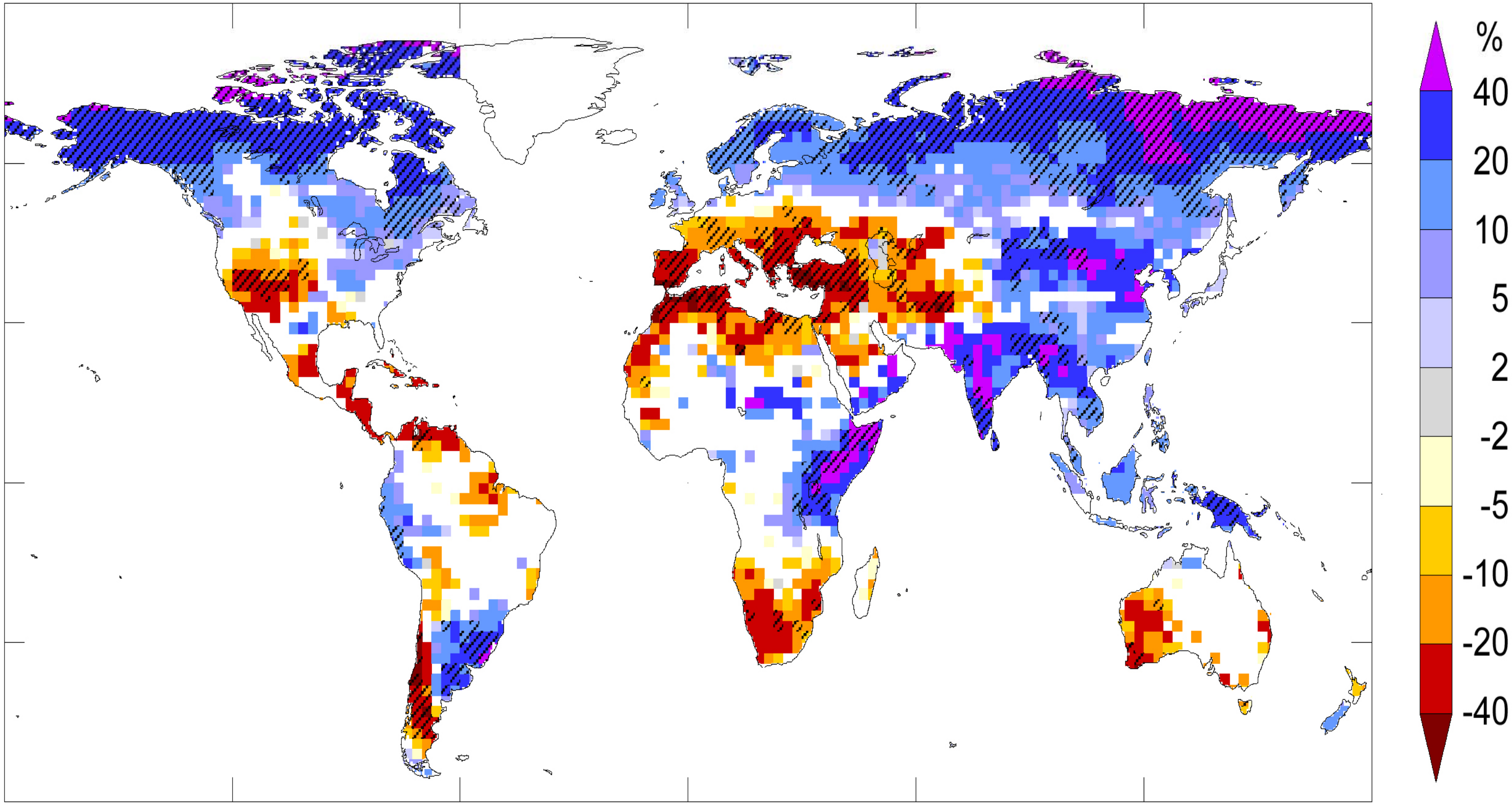
2. Heavier precipitation, more intense and longer droughts….

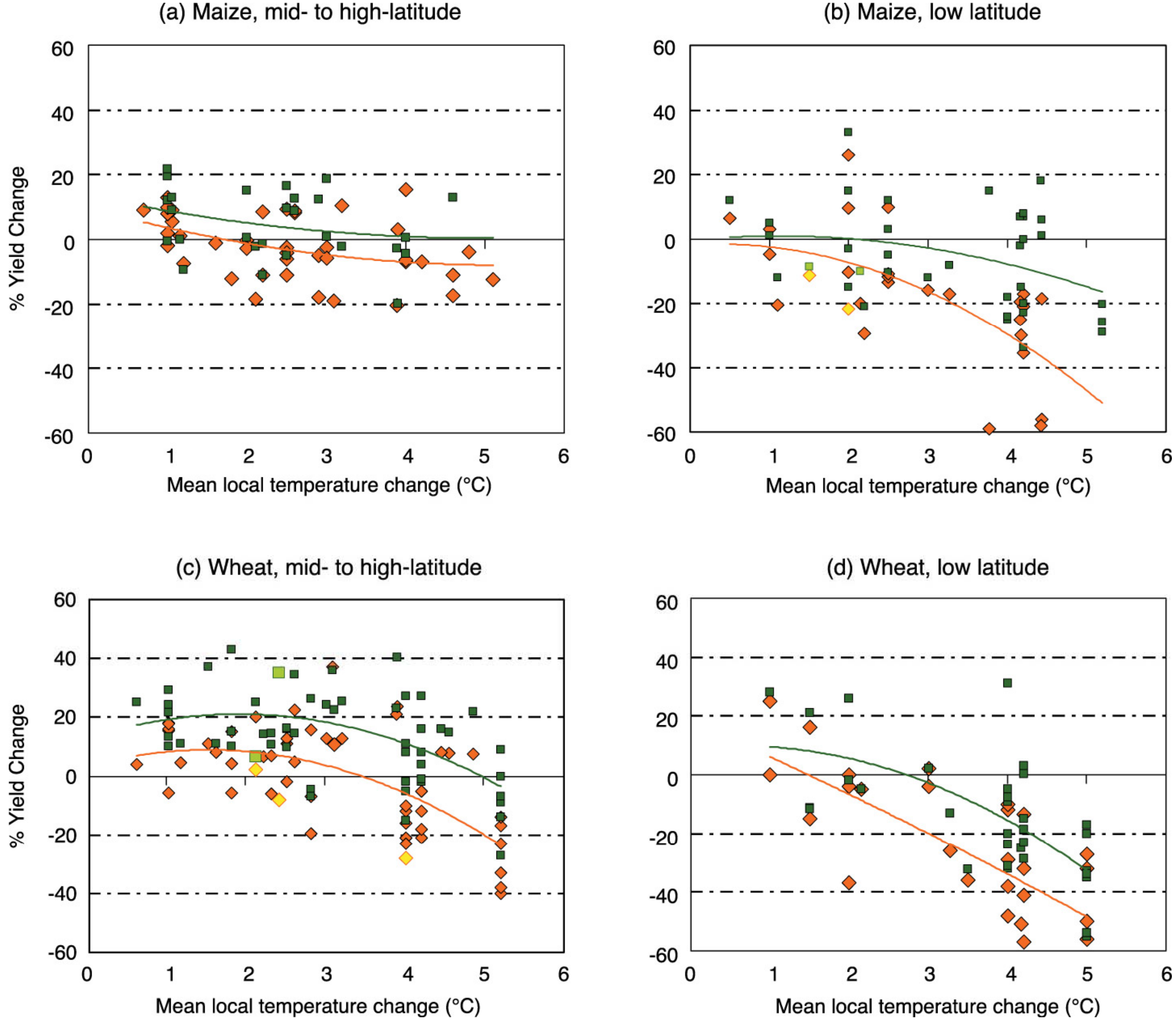
Most key impacts stem from reduced water availability



High confidence: hundreds of millions of people will be exposed to increased water stress. Here: Changes in run-off, 21st century. White areas are where less than two-thirds of models agree, hatched are where 90% of models agree (IPCC AR4 SYR)



Crop yield responses: Important regional differences
The point of inflexion for wheat yield downturn is crucial, but unclear



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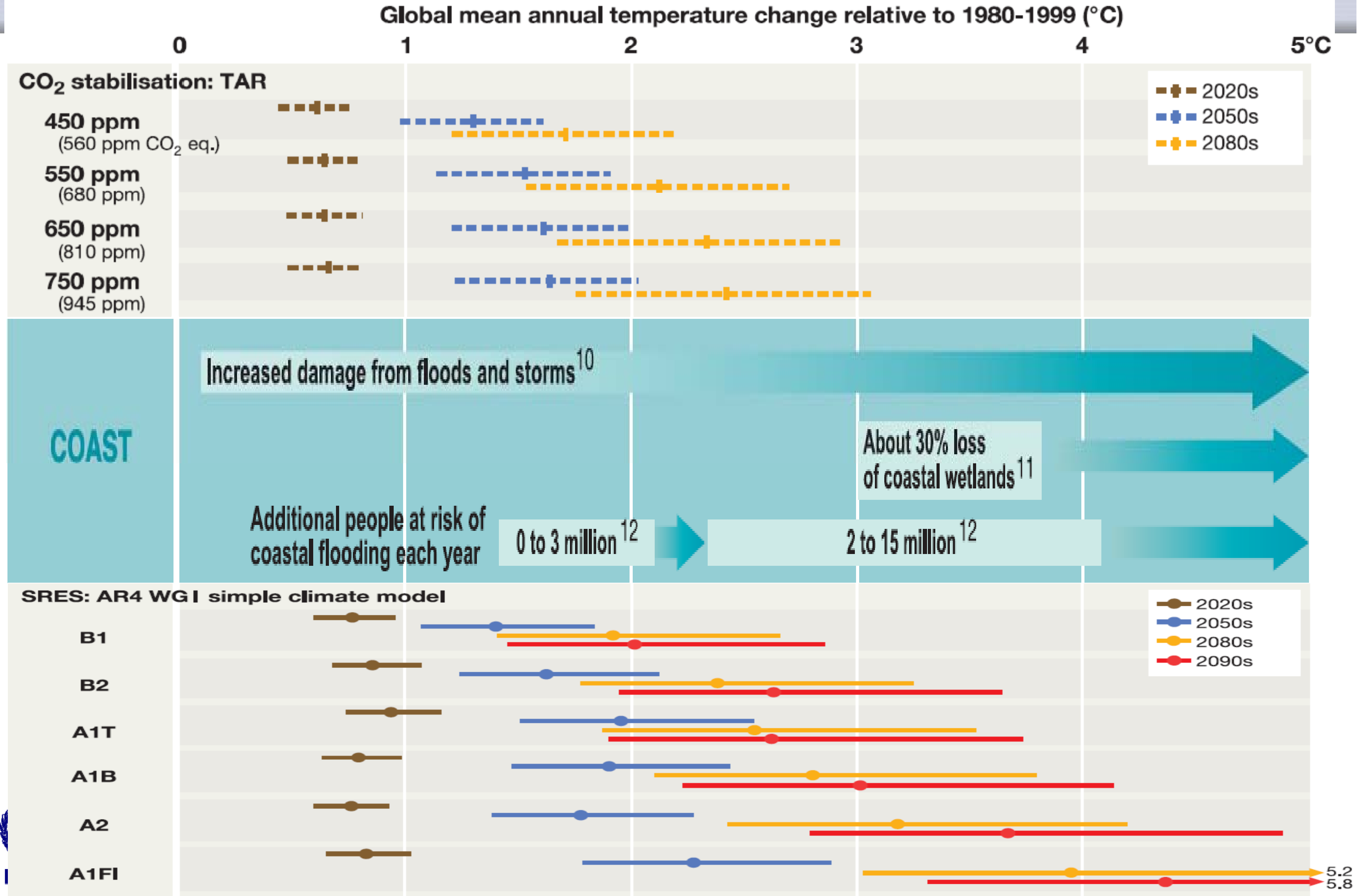
Coastal areas: increasingly vulnerable



COASTAL SETTLEMENTS

Densely populated "megadeltas" especially in Asia and Africa, are most at risk.

Tens of millions will be additionally at risk

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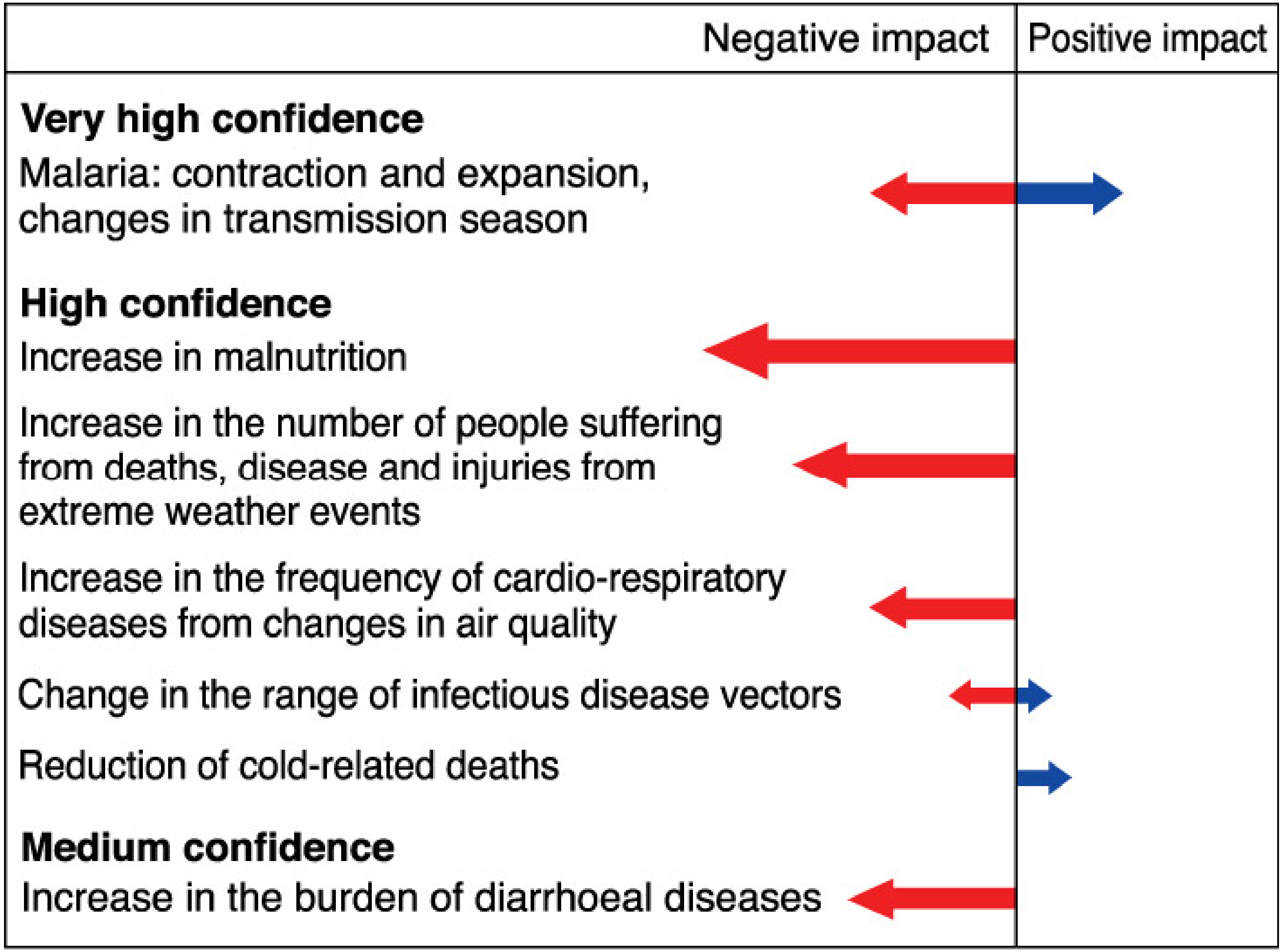
Selected health impacts of CC - Most affected will be: the poor, elderly, young & marginalised



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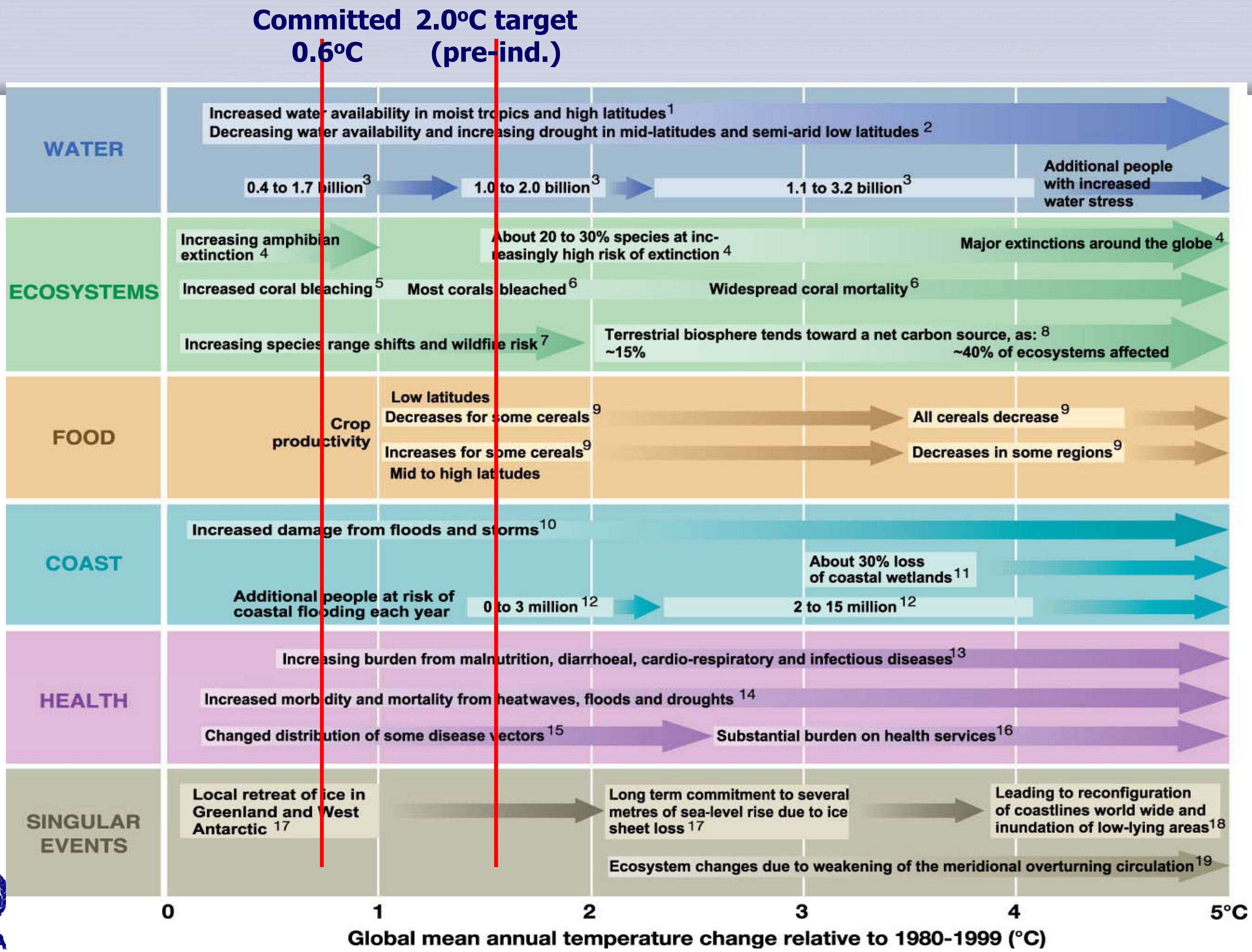

Committed 0.6°C
2.0°C target (pre-ind.)
WATER
Increased water availability in moist tropics and high latitudes 1
Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes 2
0.4 to 1.7 billion 3
1.0 to 2.0 billion 3
1.1 to 3.2 billion 3
Additional people with increased water stress
ECOSYSTEMS
Increasing amphibian extinction 4
About 20 to 30% species at increasingly high risk of extinction 4
Major extinctions around the globe 4
Increased coral bleaching 5
Most corals bleached 6
Widespread coral mortality 6
Increasing species range shifts and wildfire risk 7
Terrestrial biosphere tends toward a net carbon source, as: 8
~15%
~40% of ecosystems affected
FOOD
Crop productivity
Low latitudes
Decreases for some cereals 9
All cereals decrease 9
Increases for some cereals 9
Decreases in some regions 9
Mid to high latitudes
COAST
Increased damage from floods and storms 10
About 30% loss of coastal wetlands 11
Additional people at risk of coastal flooding each year
0 to 3 million 12
2 to 15 million 12
HEALTH
Increasing burden from malnutrition, diarrhoeal, cardio-respiratory and infectious diseases 13
Increased morbidity and mortality from heatwaves, floods and droughts 14
Changed distribution of some disease vectors 15
Substantial burden on health services 16
SINGULAR EVENTS
Local retreat of ice in Greenland and West Antarctic 17
Long term commitment to several metres of sea-level rise due to ice sheet loss 17
Leading to reconfiguration of coastlines world wide and inundation of low-lying areas 18
Ecosystem changes due to weakening of the meridional overturning circulation 19
0
1
2
3
4
5°C
Global mean annual temperature change relative to 1980-1999 (°C)

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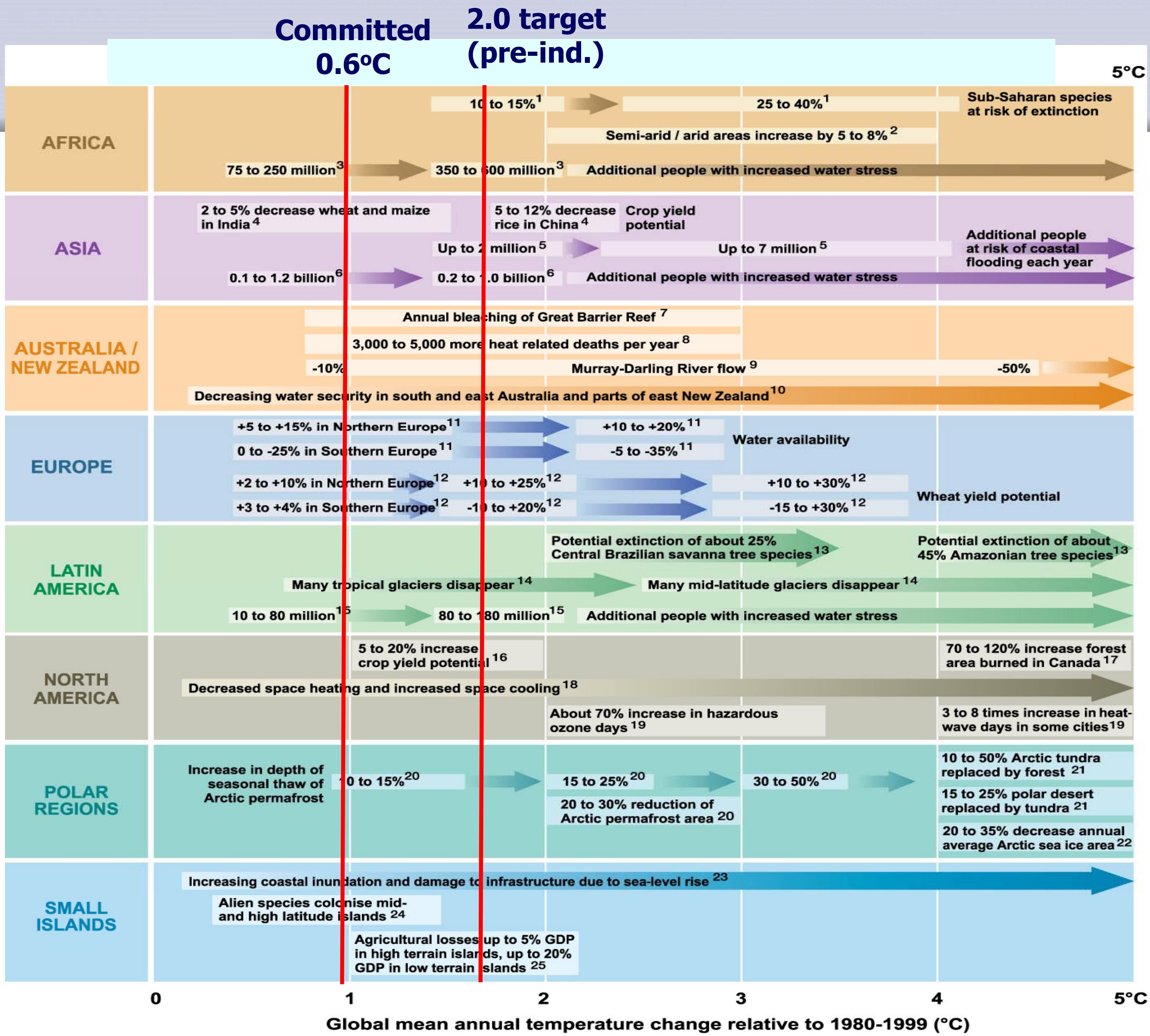

Committed 0.6°C
2.0 target (pre-ind.)
5°C
AFRICA
10 to 15%[1]
25 to 40%[1]
Sub-Saharan species at risk of extinction
Semi-arid / arid areas increase by 5 to 8%[2]
75 to 250 million[3]
350 to 600 million[3]
Additional people with increased water stress
ASIA
2 to 5% decrease wheat and maize in India[4]
5 to 12% decrease rice in China[4]
Crop yield potential
Up to 2 million[5]
Up to 7 million[5]
Additional people at risk of coastal flooding each year
0.1 to 1.2 billion[6]
0.2 to 1.0 billion[6]
Additional people with increased water stress
AUSTRALIA / NEW ZEALAND
Annual bleaching of Great Barrier Reef[7]
3,000 to 5,000 more heat related deaths per year[8]
-10%
Murray-Darling River flow[9]
-50%
Decreasing water security in south and east Australia and parts of east New Zealand[10]
EUROPE
+5 to +15% in Northern Europe[11]
+10 to +20%[11]
0 to -25% in Southern Europe[11]
-5 to -35%[11]
Water availability
+2 to +10% in Northern Europe[12]
+10 to +25%[12]
+10 to +30%[12]
+3 to +4% in Southern Europe[12]
-10 to +20%[12]
-15 to +30%[12]
Wheat yield potential
LATIN AMERICA
Potential extinction of about 25% Central Brazilian savanna tree species[13]
Potential extinction of about 45% Amazonian tree species[13]
Many tropical glaciers disappear[14]
Many mid-latitude glaciers disappear[14]
10 to 80 million[15]
80 to 180 million[15]
Additional people with increased water stress
NORTH AMERICA
5 to 20% increase crop yield potential[16]
70 to 120% increase forest area burned in Canada[17]
Decreased space heating and increased space cooling[18]
About 70% increase in hazardous ozone days[19]
3 to 8 times increase in heat-wave days in some cities[19]
POLAR REGIONS
Increase in depth of seasonal thaw of Arctic permafrost
10 to 15%[20]
15 to 25%[20]
30 to 50%[20]
20 to 30% reduction of Arctic permafrost area[20]
10 to 50% Arctic tundra replaced by forest[21]
15 to 25% polar desert replaced by tundra[21]
20 to 35% decrease annual average Arctic sea ice area[22]
SMALL ISLANDS
Increasing coastal inundation and damage to infrastructure due to sea-level rise[23]
Alien species colonise mid- and high latitude islands[24]
Agricultural losses up to 5% GDP in high terrain islands, up to 20% GDP in low terrain islands[25]
0
1
2
3
4
5°C
Global mean annual temperature change relative to 1980-1999 (°C)

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2. Climate change: impacts and adaptation
Summary

The most vulnerable people and places can now be identified

- **Most vulnerable regions** are:
  - Africa, Asian mega-deltas, small islands, the Arctic
- **Most vulnerable sectors** are:
  - water in the dry tropics
  - agriculture in low latitudes
  - human health in poor countries
  - ecosystems at the margins: e.g. tundra, boreal, mountains or already stressed: e.g. mangroves, coral

In all countries, even those with high incomes, some are especially at risk:

the poor, young children, the elderly

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3. Impacts on and adaptation in energy systems

Weather Extremes and Energy Systems:

"If there is a 50-50 chance
that something will go wrong
then 9 out of 10 times it will."

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3. CC - Weather extremes - energy systems

Vulnerability of Energy Systems to Climate Change and Extreme Events – less explored

Motivations:

- CC → possible increases in frequency and intensity of extreme weather events
- Energy systems: vulnerable under current climate regime and weather patterns; efforts to reduce vulnerability
- IEA: USD 26 trillion investments to provide demand; +10.5 trillion to reduce GHGs - Clim/weather proofing
- IAEA: account for WEs in energy planning

3. CC - Weather extremes - energy systems

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend[b]	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely*[c]	*Likely*[d]	*Virtually certain*[d]
Warmer and more frequent hot days and nights over most land areas	*Very likely*[e]	*Likely (nights)*[d]	*Virtually certain*[d]
Warm spells/heat waves. Frequency increases over most land areas	*Likely*	*More likely than not*[f]	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not*[f]	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not*[f]	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis)[g]	*Likely*	*More likely than not*[f,h]	*Likely*[i]

3. CC - Weather extremes - energy systems

Sector/ Extreme	Tempera -ture	Precipit-ation	Wind	Tropical cyclones	Floods	Droughts	Coastal storms	Forest + wild fire	Landslides
coal fuel cycle									
oil and gas									
thermal power plants									
hydropower									
nuclear power									
solar energy									
wind power									
electric grid									

3. Selected energy sources/technologies

Thermal and nuclear power plants –

vulnerable to many extremes:

Temperature: icing, frost, heat

Precipitation: hail, heavy rain/snow → floods/low water

Wind: storm, blizzard, tornado, thunderstorm

Key: cooling water

3. Selected energy sources/technologies

	Without CO_2 Capture	With CO_2 Capture	% change with CO_2 capture
*Water Consumption Factors (gallons per MWh net power)**			
Nuclear[8]	720	--	
Subcritical PC	520	990	+90%
Supercritical PC	450	840	+90%
IGCC, slurry-fed	310	450	+50%
NGCC	190	340	+80%
Cooling duty factors (MMBtu per MWh net power)			
Subcritical PC	4.7	11	+130%
Supercritical PC	4.1	9.3	+130%
IGCC, slurry-fed	3.0	3.7	+20%
NGCC	2.0	4.2	+110%

3. Selected energy sources/technologies

Thermal and nuclear power plants –

adaptation options:

Cooling: water recovery from condenser and heat exchangers

Reduction of evaporation losses (waste heat coal drying)

Secondary water usage (oil/gas field, coal mine discharge, municipal waste water)

Use ice to cool air before entering gas turbine

Dry cooling towers + other dry cooling options

3. Selected energy sources/technologies

Electricity grid: overhead lines, underground cables, substations, transformers, control centres

~50% of grid system faults caused by weather effects

Lightning: line, earth wire, transmission tower: flashover

Wind: debris blown against conductors: short circuit;

line conductors swing or oscillate: flashover

trees blown over → damage overhead line

very high winds: mechanical damage

High temperature: overhead line to trees: flashover

Ice: ice build-up on insulators, switchgear: flashover

Ice storms: freezes on overhead lines: collapse

Heavy snow: falling trees over overhead lines

3. Selected energy sources/technologies

Electricity grid – adaptation options:

Lightning: more earth wires, spark gaps, surge arresters

Protection: safety corridors, vegetation management,
physical protection

Network redundancy: alternative supply routes

Future: design changes –
heavier snow and ice loading
higher wind speeds

3. Weather extremes in energy supply models

IAEA: energy planning tools –

Energy supply model: MESSAGE

Model for Energy Supply System Alternatives and their General Environmental impacts

Software designed for setting up optimization models of *energy supply systems* to assess capacity expansion and energy production policies

A *physical flow model*: for a given vector of demands for energy goods or services, it assures sufficient supplies utilizing available technologies and resources

Based on specified criteria, it *optimizes* the system expansion and operation

3. Weather extremes in energy supply models

MESSAGE: powerful, flexible; Many options to include:

- *impacts* of extreme weather events: supply chains, technology availability factors, technological specifications
- *hedging* against impacts: supply reliability requirements, reserve margins, technology options (e.g., dry cooling)

➔ optimal (least cost) energy portfolio w/extremes

Renewables and storage: already included

Intermittency: simplified representation

Development need:

Better representation of extreme weather impacts – Integrate risk analysis methods

4. Summary and conclusions

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4. Summary and conclusions

- Anthropogenic GHG emissions enhance the natural GH effect
- Main anthropogenic GHG sources: CO_2 from fossil fuel use and land-use change
- IPCC AR4: “warming of the climate system is unequivocal”
- Future GHG emissions uncertain, driving forces → scenarios
- IPCC SRES scenarios imply 0.6°C - 3.8°C warming in 21st century
- Impacts differ across sectors/regions, getting severe beyond 2+°C above present (1980-1999) climate

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4. Summary:
Adaptation is necessary but not sufficient….

- Adaptation to climate change is necessary to address impacts resulting from the warming which is already unavoidable due to past emissions
- However:
  - Adaptation alone cannot cope with all the projected impacts of climate change
  - The costs of adaptation and impacts will increase as global temperatures increase

Making development more sustainable can enhance both mitigative and adaptive capacity, and reduce emissions and vulnerability to climate change

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4. Summary: Energy systems

Extreme weather – energy systems: need to prepare

Options for managing weather impacts:

adaptation: technological, operational adjustments

vulnerability reduction: existing: structural changes

new build: design and construction innovation

Energy planning - capacity expansions:

account for impacts on supply chains

seek optimal supply portfolio w/ hedging

Tool: energy supply model w/ risk analysis features

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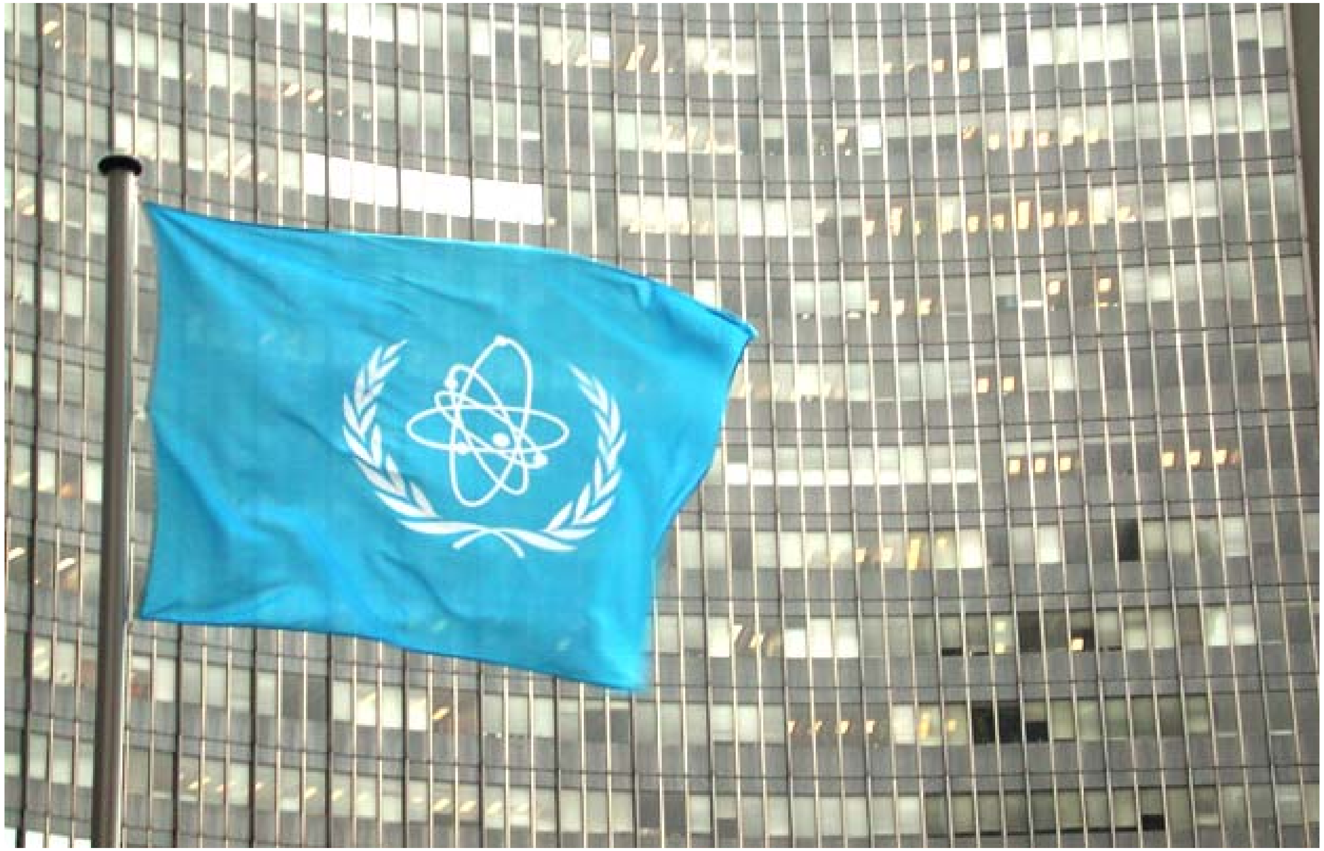

…atoms for peace.