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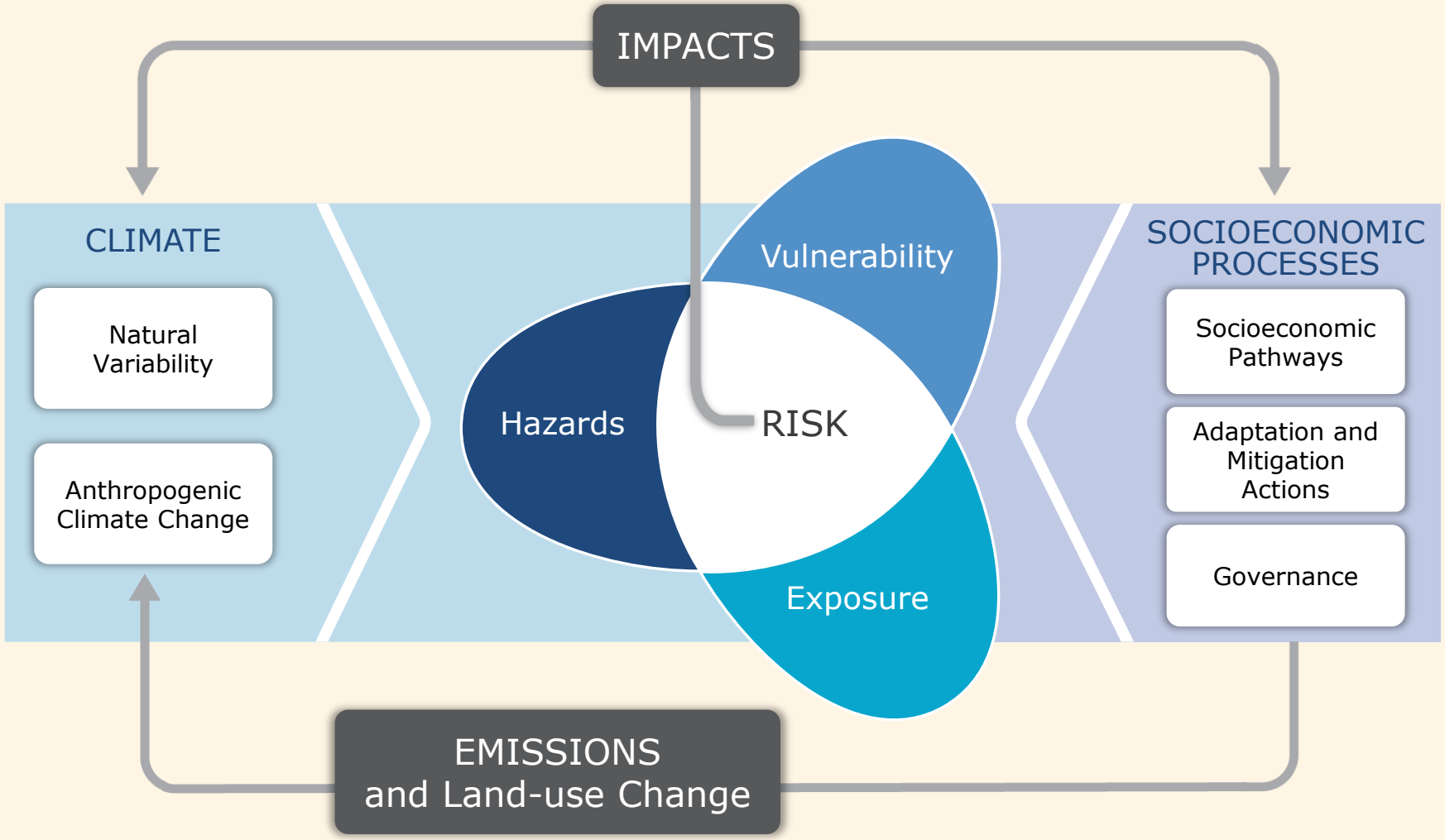
INTERGOVERNMENTAL PANEL ON climate change

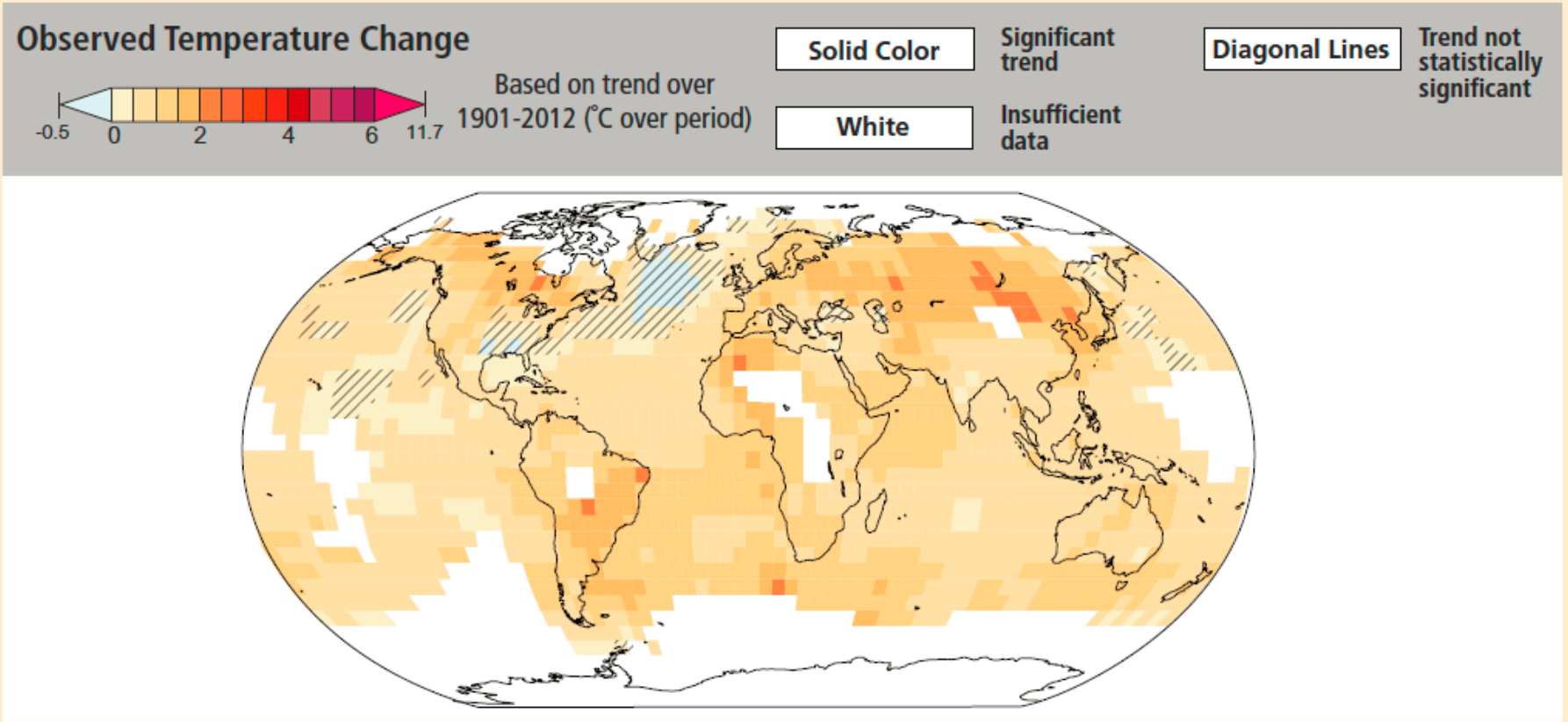
CLIMATE CHANGE 2014: WGII

NEW APPROACHES & FINDINGS RELEVANT TO BOTH THEMES OF THE 2013-2015 REVIEW

IPCC WGII
Chris Field, Co-Chair


IMPACTS
CLIMATE
Natural Variability
Anthropogenic Climate Change
Vulnerability
Hazards
RISK
Exposure
SOCIOECONOMIC PROCESSES
Socioeconomic Pathways
Adaptation and Mitigation Actions
Governance
EMISSIONS and Land-use Change

Warming over the past century




OBSERVED IMPACTS
OF CLIMATE CHANGE
ARE WIDESPREAD
AND CONSEQUENTIAL
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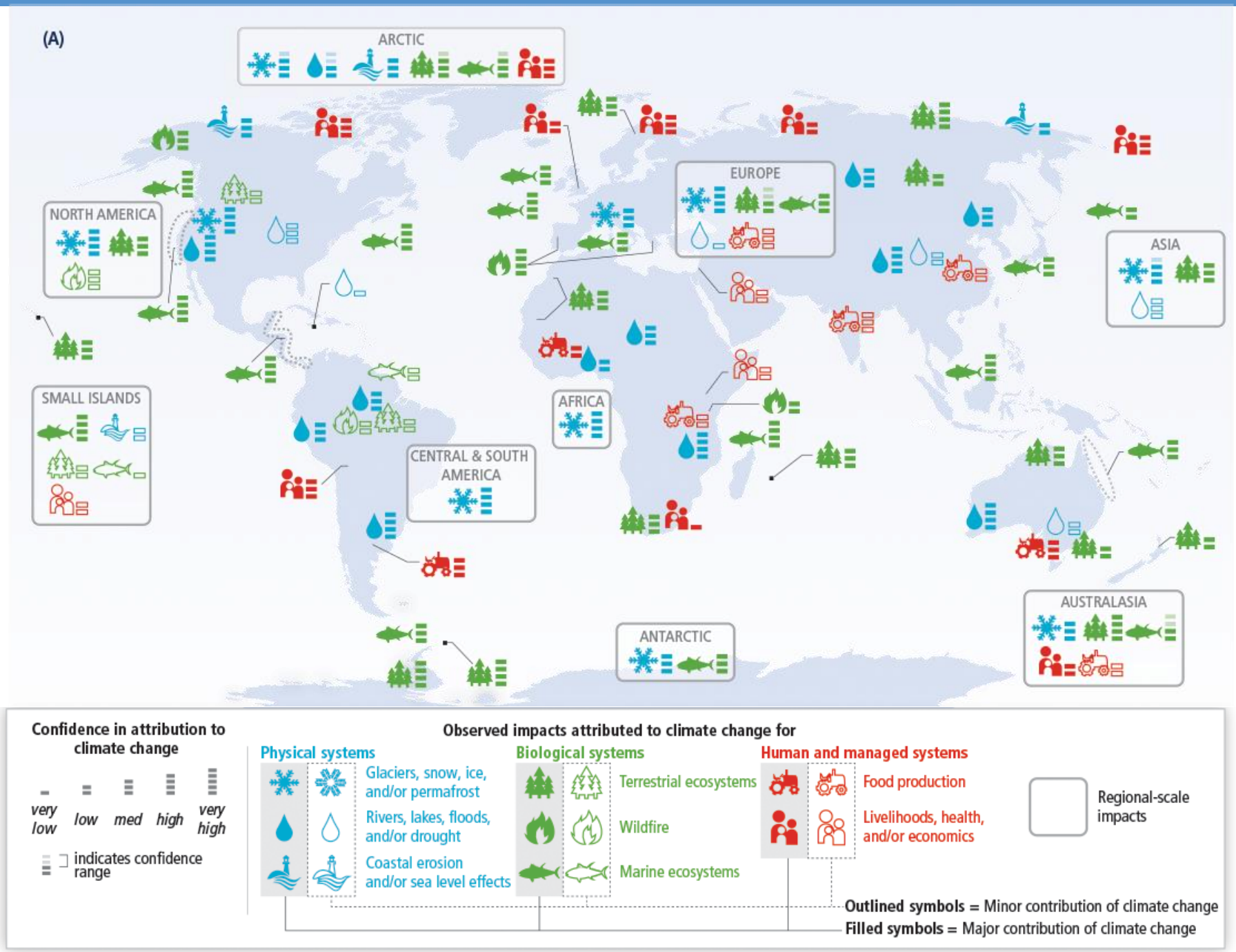
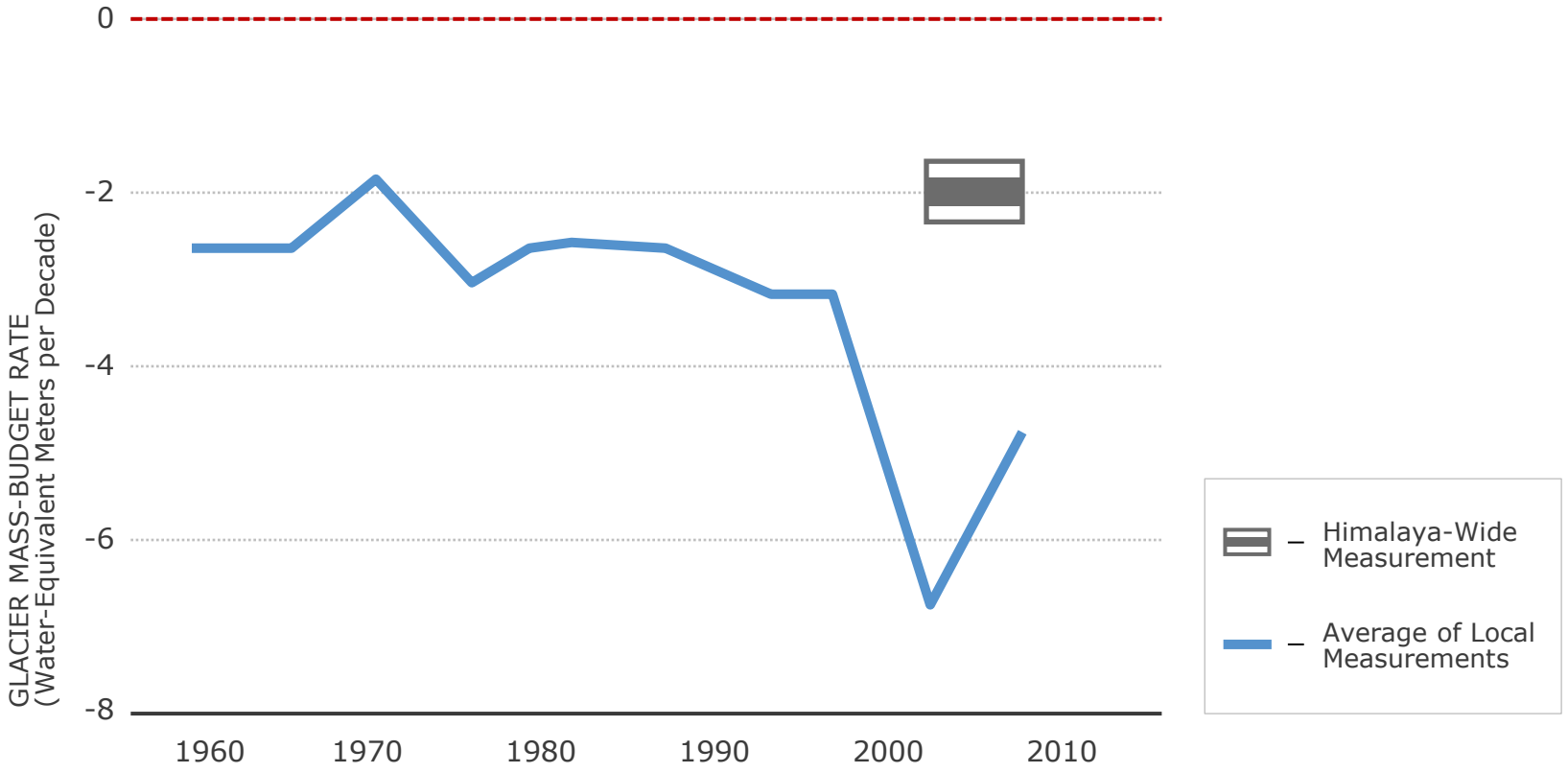
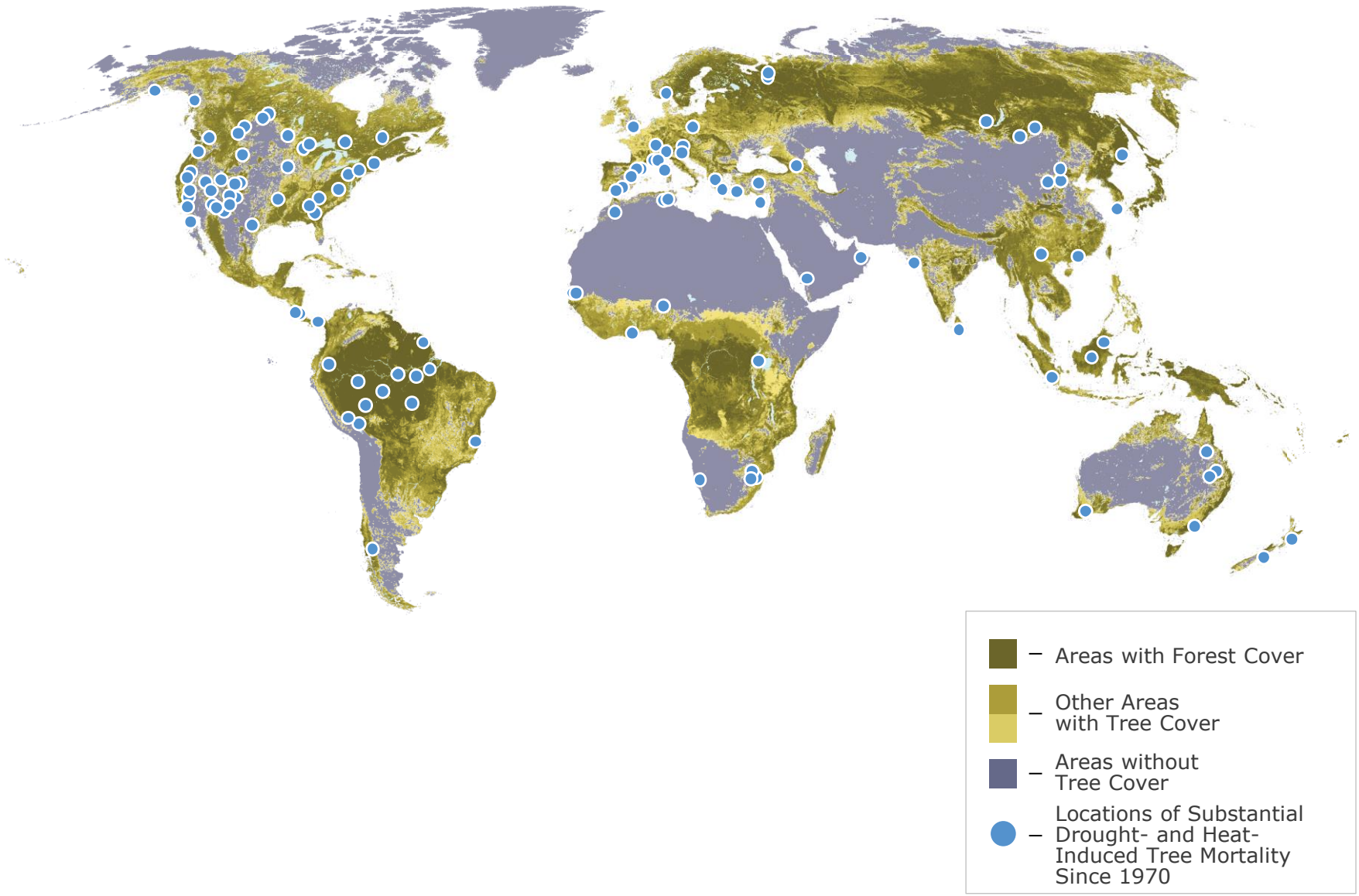
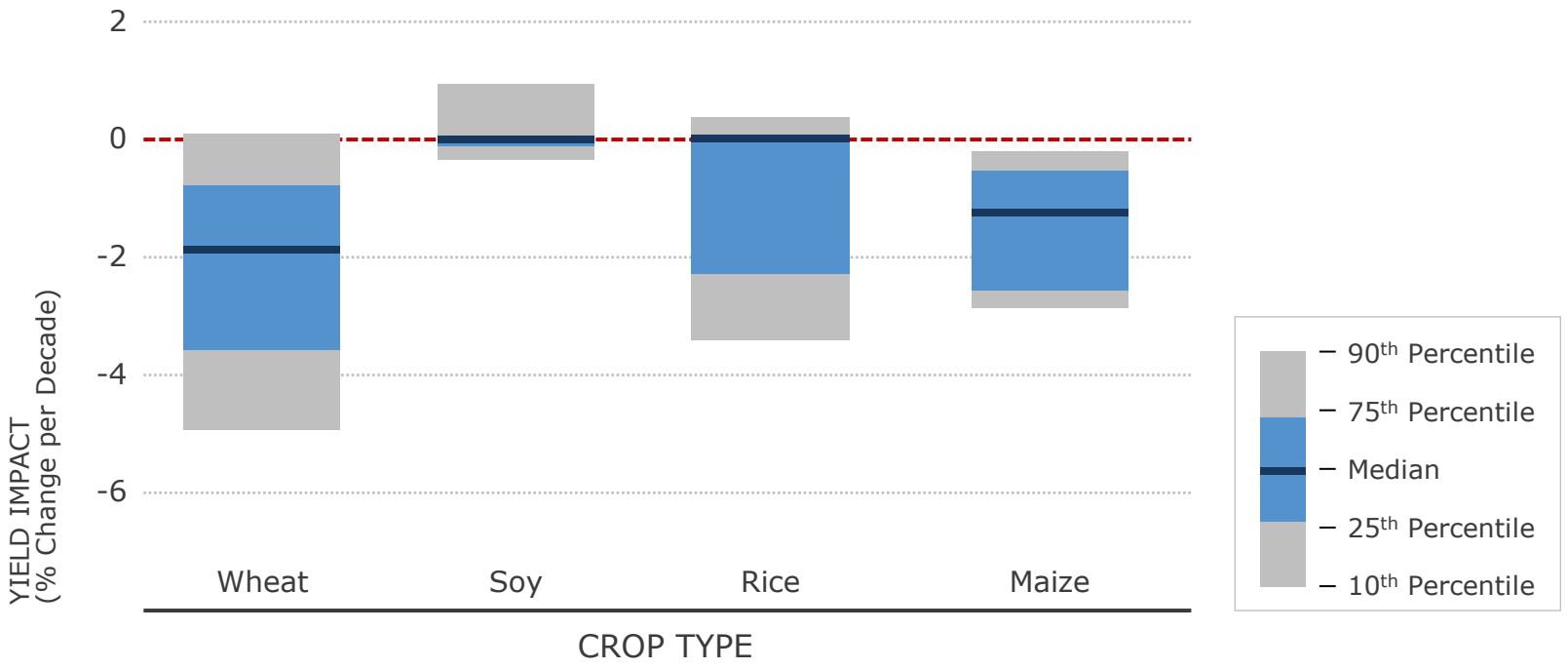
INTERGOVERNMENTAL PANEL ON climate change


(A)
ARCTIC
NORTH AMERICA
EUROPE
ASIA
SMALL ISLANDS
AFRICA
CENTRAL & SOUTH AMERICA
AUSTRALASIA
ANTARCTIC
Confidence in attribution to climate change
very low
low
med
high
very high
indicates confidence range
Observed impacts attributed to climate change for
Physical systems
Glaciers, snow, ice, and/or permafrost
Rivers, lakes, floods, and/or drought
Coastal erosion and/or sea level effects
Biological systems
Terrestrial ecosystems
Wildfire
Marine ecosystems
Human and managed systems
Food production
Livelihoods, health, and/or economics
Regional-scale impacts
Outlined symbols = Minor contribution of climate change
Filled symbols = Major contribution of climate change

	Africa
Snow & Ice, Rivers & Lakes, Floods & Drought	• Retreat of tropical highland glaciers in East Africa (high confidence, Major contribution from climate change) • Reduced discharge in West African rivers (low confidence, Major contribution from climate change) • Increased soil moisture drought in the Sahel since 1970, partially wetter conditions since 1990 (medium confidence, Major contribution from climate change) [22.2-3, Tables 18-5, 18-6, & 22-3]
Terrestrial Ecosystems	• Tree density decreases in western Sahel & semi-arid Morocco, beyond changes due to land use (medium confidence, Major contribution from climate change) • Range shifts of several southern plants & animals, beyond changes due to land use (medium confidence, Major contribution from climate change) • Increases in wildfires on Mt. Kilimanjaro (low confidence, Major contribution from climate change) [22.3, Tables 18-7 & 22-3]
Coastal Erosion & Marine Ecosystems	• Decline in coral reefs in tropical African waters, beyond decline due to human impacts (high confidence, Major contribution from climate change) [Table 18-8]
Food Production & Livelihoods	• Adaptive responses to changing rainfall by South African farmers, beyond changes due to economic conditions (very low confidence, Major contribution from climate change) • Decline in fruit-bearing trees in Sahel (low confidence, Major contribution from climate change) • Malaria increases in Kenyan highlands, beyond changes due to vaccination, drug resistance, demography, & livelihoods (low confidence, Minor contribution from climate change) • Reduced fisheries productivity of Great lakes & Lake Kariba, beyond changes due to fisheries management & land use (low confidence, Minor contribution from climate change) [7.2, 11.5, 13.2, 22.3, Table 18-9]


0
-2
-4
-6
-8
GLACIER MASS-BUDGET RATE
(Water-Equivalent Meters per Decade)
1960
1970
1980
1990
2000
2010
Himalaya-Wide Measurement
Average of Local Measurements


Areas with Forest Cover
Other Areas with Tree Cover
Areas without Tree Cover
Locations of Substantial Drought- and Heat-Induced Tree Mortality Since 1970



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INCREASING MAGNITUDES
OF WARMING INCREASE
THE LIKELIHOOD OF
SEVERE AND
PERVASIVE IMPACTS
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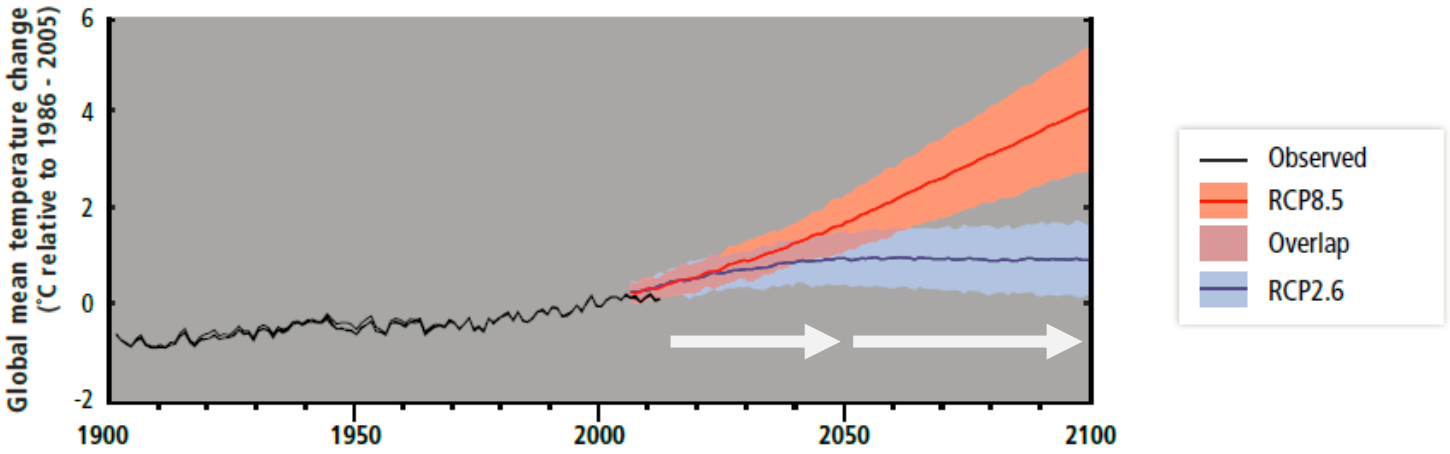
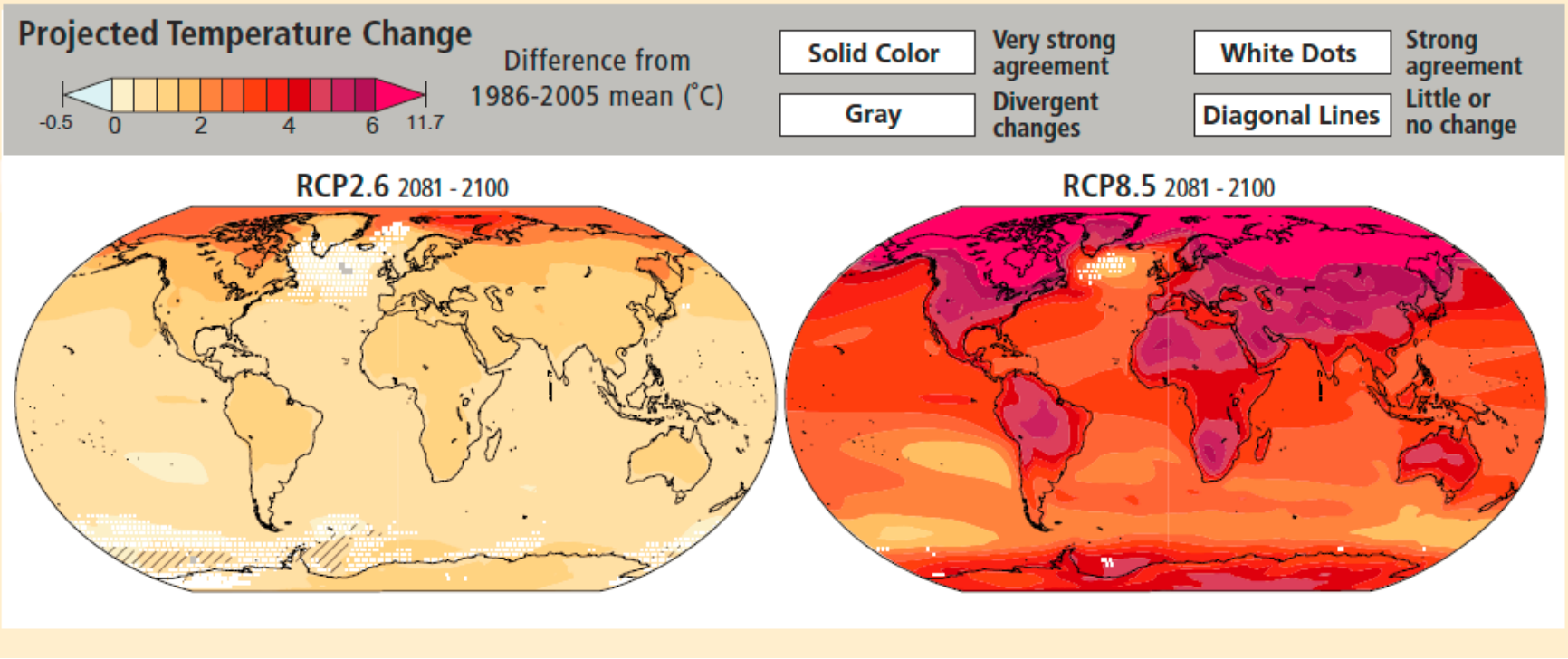
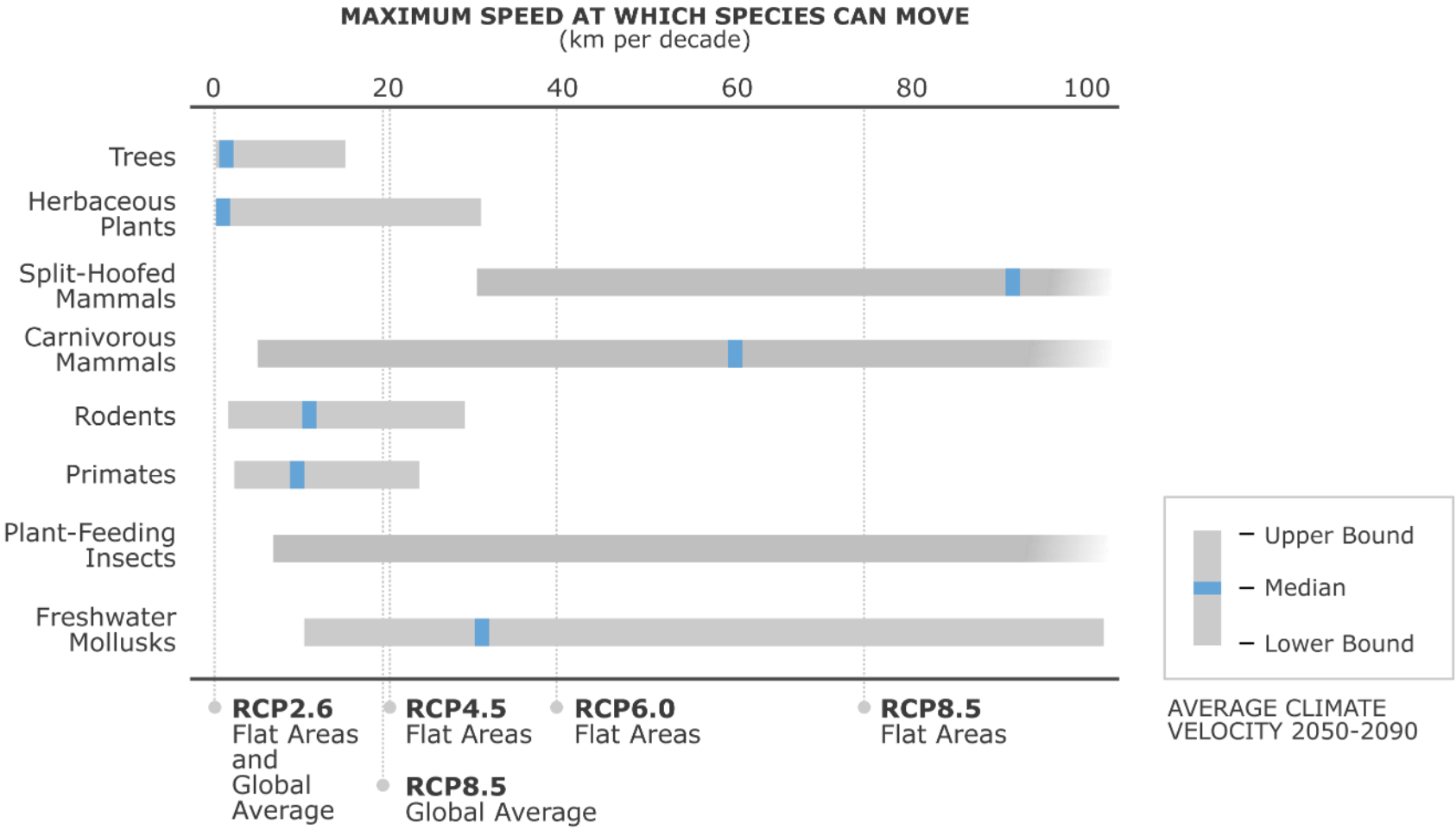
INTERGOVERNMENTAL PANEL ON climate change

Warming over the 21st century







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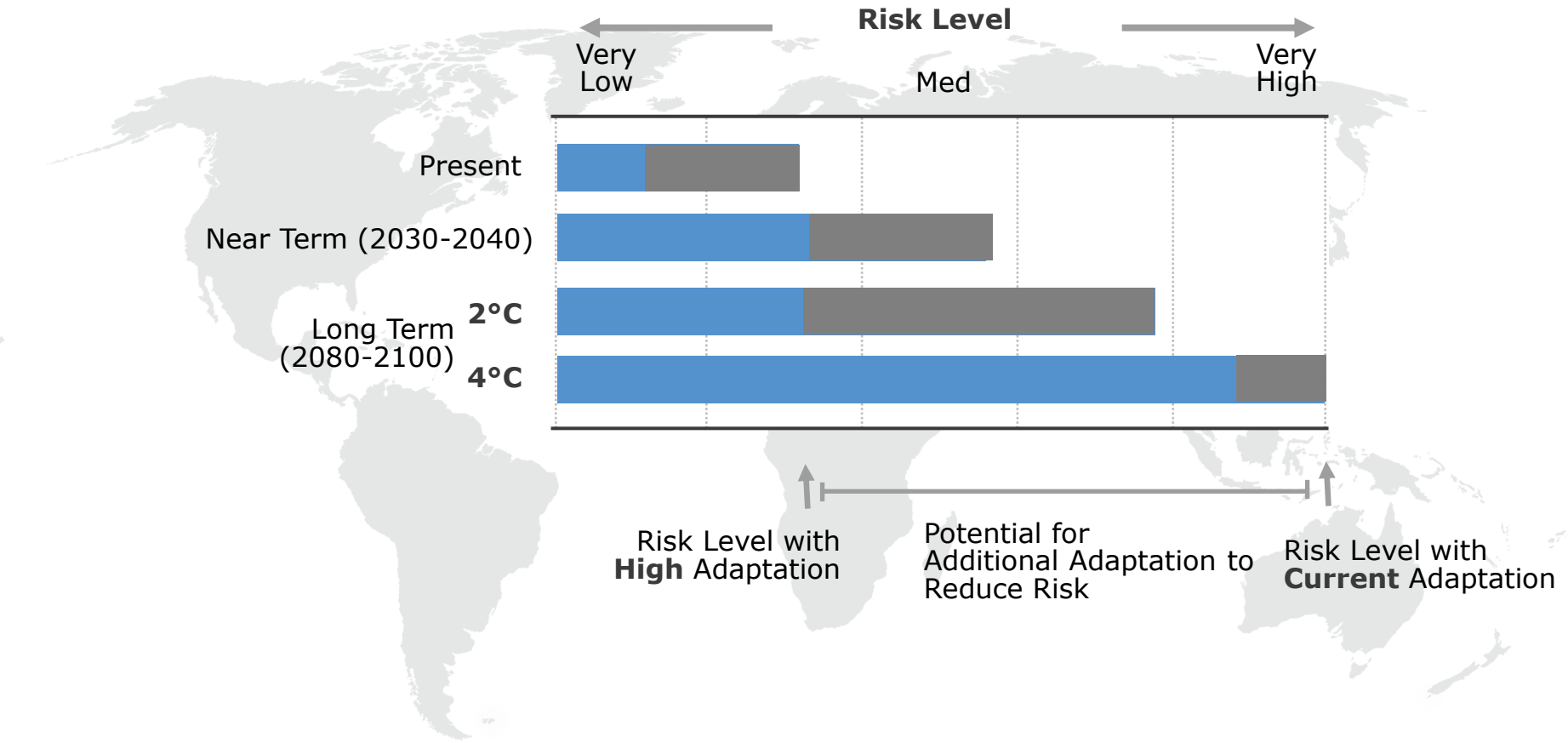
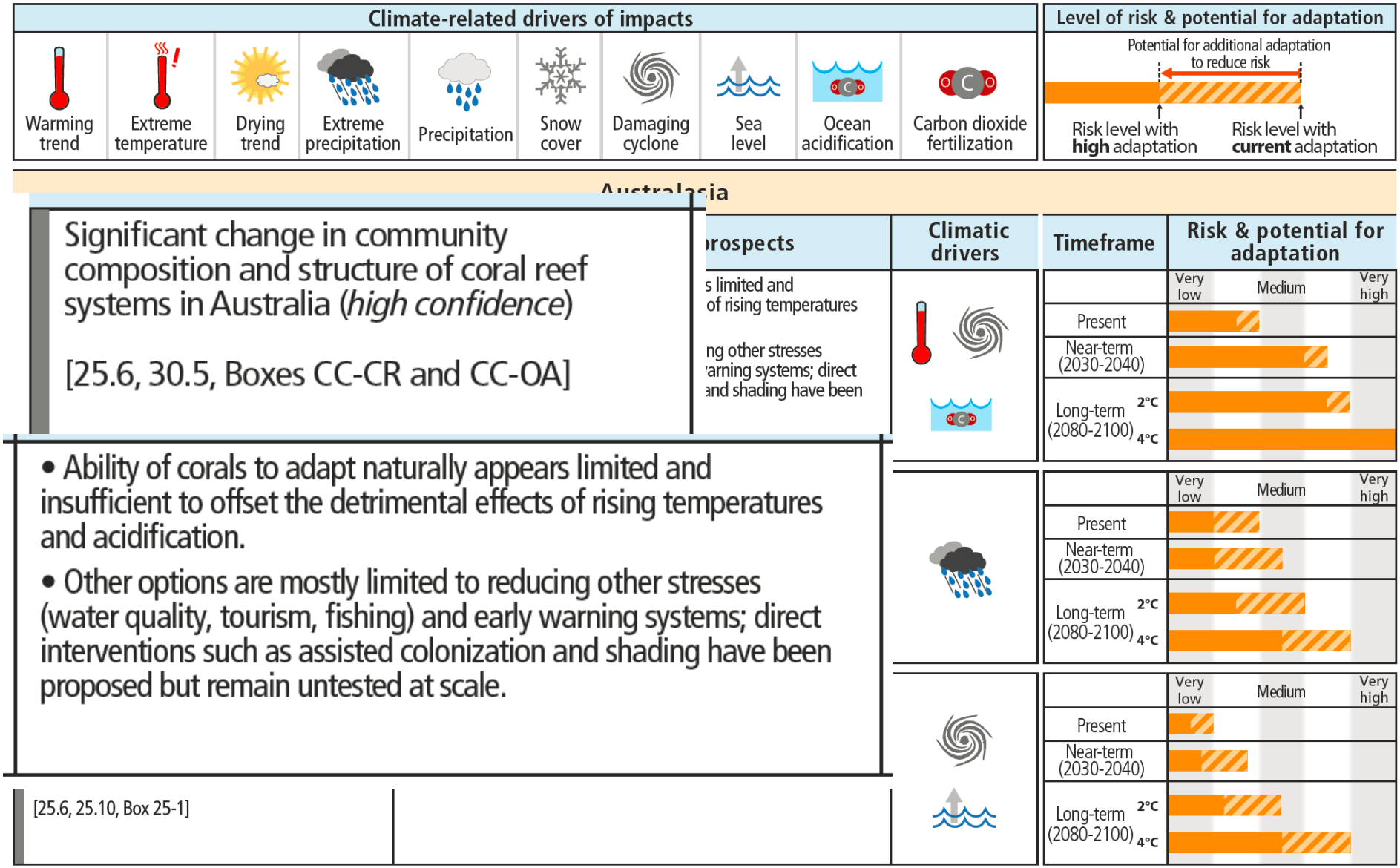
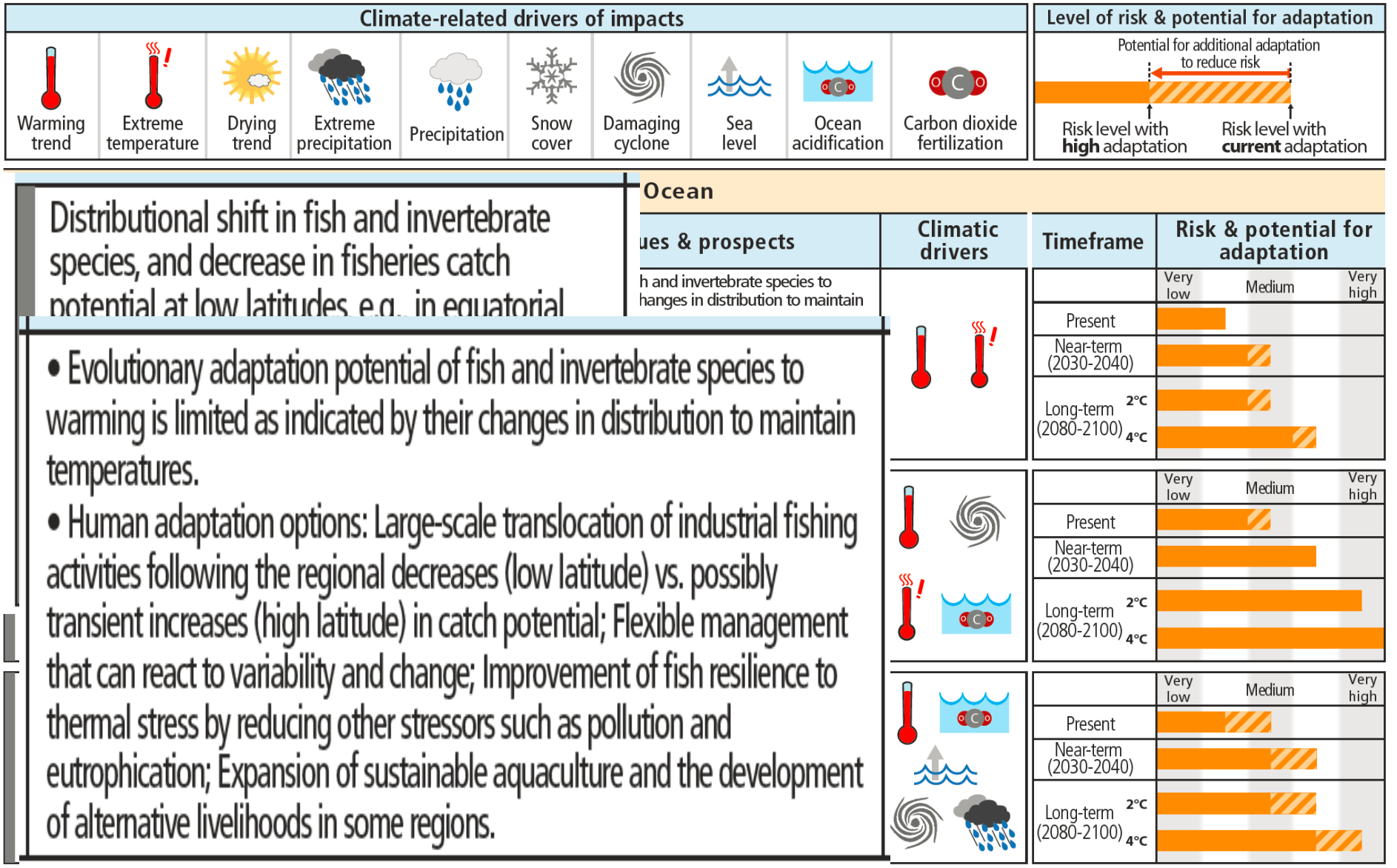
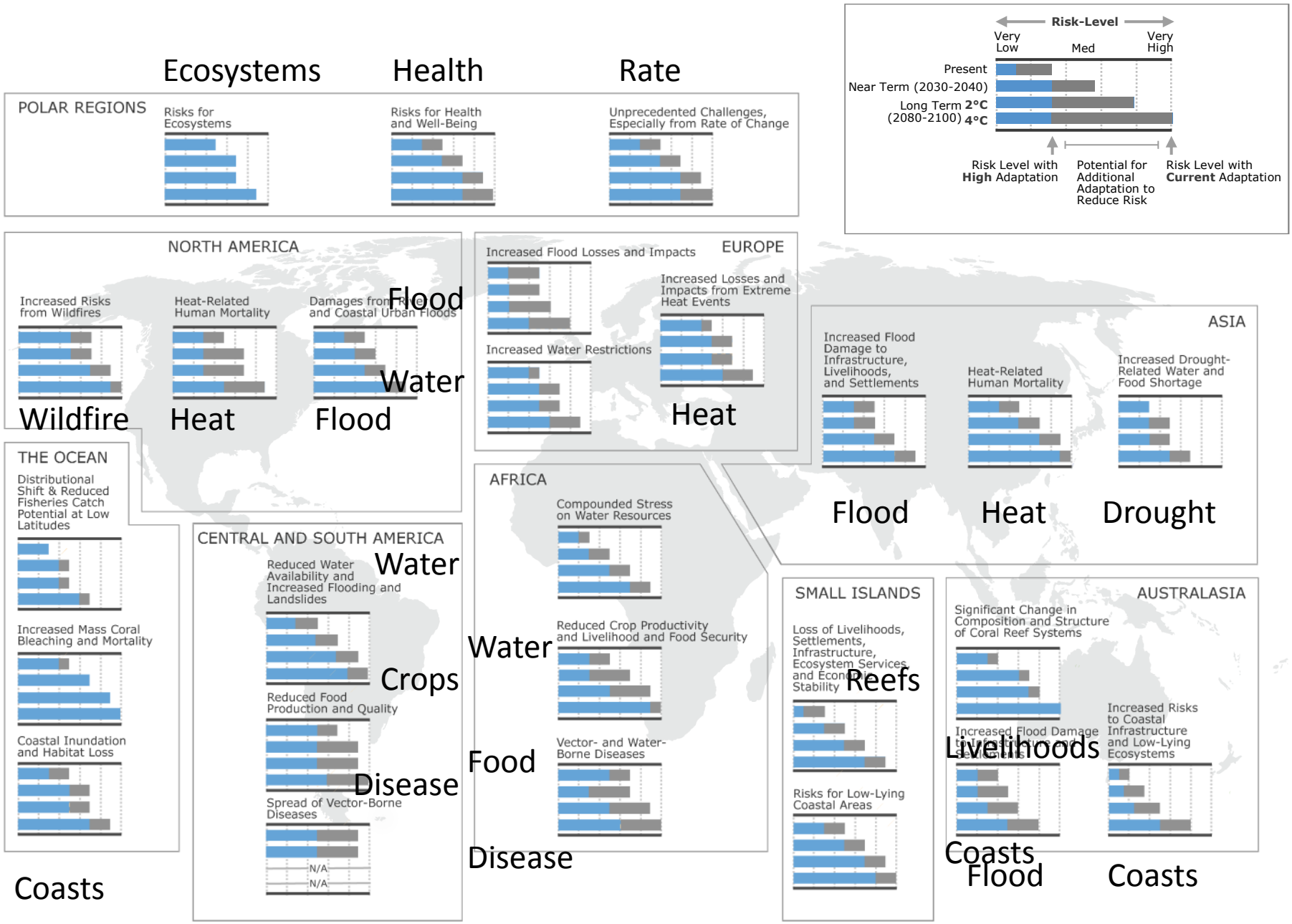
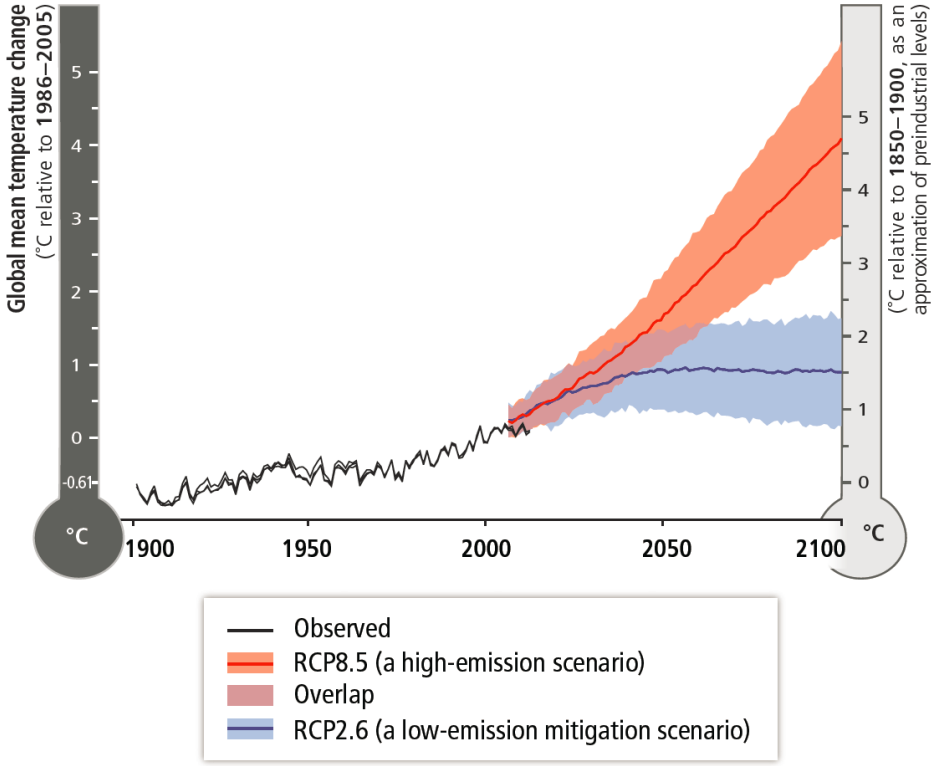
Assessing risk

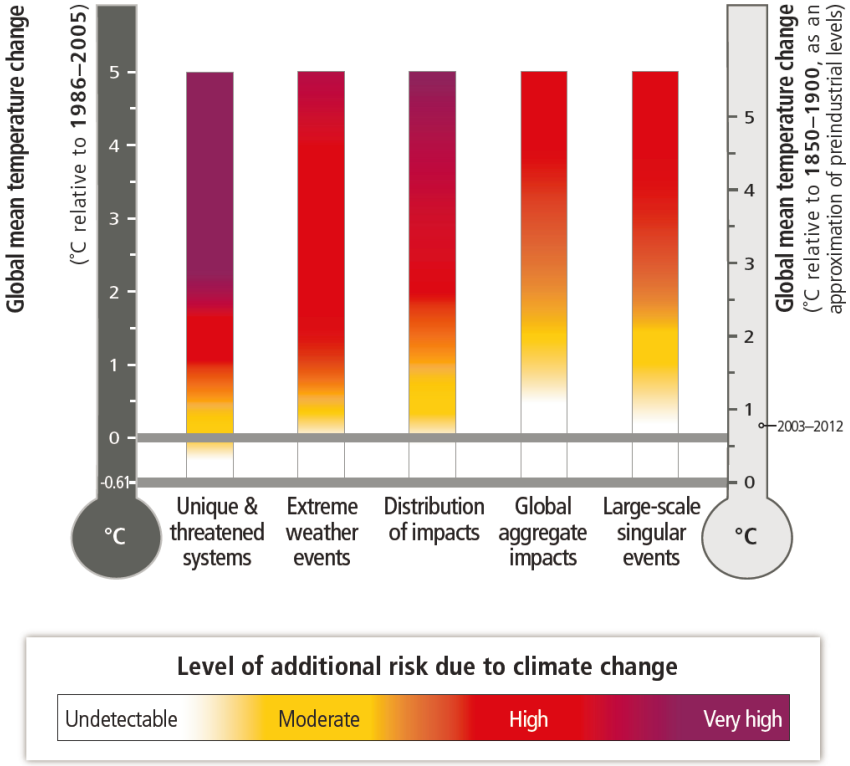



Climate-related drivers of impacts
Warming trend
Extreme temperature
Drying trend
Extreme precipitation
Precipitation
Snow cover
Damaging cyclone
Sea level
Ocean acidification
Carbon dioxide fertilization
Level of risk & potential for adaptation
Potential for additional adaptation to reduce risk
Risk level with high adaptation
Risk level with current adaptation
Australasia
Significant change in community composition and structure of coral reef systems in Australia (high confidence)
[25.6, 30.5, Boxes CC-CR and CC-OA]
• Ability of corals to adapt naturally appears limited and insufficient to offset the detrimental effects of rising temperatures and acidification.
• Other options are mostly limited to reducing other stresses (water quality, tourism, fishing) and early warning systems; direct interventions such as assisted colonization and shading have been proposed but remain untested at scale.
[25.6, 25.10, Box 25-1]
rospects
s limited and
of rising temperatures
ng other stresses
arning systems; direct
and shading have been
Climatic drivers
Timeframe
Risk & potential for adaptation
Very low
Medium
Very high
Present
Near-term (2030-2040)
Long-term (2080-2100)
2°C
4°C


Climate-related drivers of impacts
Warming trend
Extreme temperature
Drying trend
Extreme precipitation
Precipitation
Snow cover
Damaging cyclone
Sea level
Ocean acidification
Carbon dioxide fertilization
Level of risk & potential for adaptation
Potential for additional adaptation to reduce risk
Risk level with high adaptation
Risk level with current adaptation
Ocean
ues & prospects
Climatic drivers
Timeframe
Risk & potential for adaptation
h and invertebrate species to
hanges in distribution to maintain
Distributional shift in fish and invertebrate species, and decrease in fisheries catch potential at low latitudes, e.g., in equatorial
• Evolutionary adaptation potential of fish and invertebrate species to warming is limited as indicated by their changes in distribution to maintain temperatures.
• Human adaptation options: Large-scale translocation of industrial fishing activities following the regional decreases (low latitude) vs. possibly transient increases (high latitude) in catch potential; Flexible management that can react to variability and change; Improvement of fish resilience to thermal stress by reducing other stressors such as pollution and eutrophication; Expansion of sustainable aquaculture and the development of alternative livelihoods in some regions.
Very low
Medium
Very high
Present
Near-term (2030-2040)
Long-term (2080-2100)
2°C
4°C


Ecosystems
Health
Rate
POLAR REGIONS
Risks for Ecosystems
Risks for Health and Well-Being
Unprecedented Challenges, Especially from Rate of Change
Risk-Level
Very Low
Med
Very High
Present
Near Term (2030-2040)
Long Term (2080-2100)
2°C
4°C
Risk Level with High Adaptation
Potential for Additional Adaptation to Reduce Risk
Risk Level with Current Adaptation
NORTH AMERICA
Increased Risks from Wildfires
Heat-Related Human Mortality
Damages from River and Coastal Urban Floods
Flood
Water
Wildfire
Heat
Flood
EUROPE
Increased Flood Losses and Impacts
Increased Losses and Impacts from Extreme Heat Events
Increased Water Restrictions
Heat
ASIA
Increased Flood Damage to Infrastructure, Livelihoods, and Settlements
Heat-Related Human Mortality
Increased Drought-Related Water and Food Shortage
Flood
Heat
Drought
THE OCEAN
Distributional Shift & Reduced Fisheries Catch Potential at Low Latitudes
Increased Mass Coral Bleaching and Mortality
Coastal Inundation and Habitat Loss
Coral
Fisheries
Coasts
CENTRAL AND SOUTH AMERICA
Reduced Water Availability and Increased Flooding and Landslides
Water
Reduced Food Production and Quality
Crops
Spread of Vector-Borne Diseases
Disease
N/A
N/A
AFRICA
Compounded Stress on Water Resources
Reduced Crop Productivity and Livelihood and Food Security
Water
Vector- and Water-Borne Diseases
Food
Disease
SMALL ISLANDS
Loss of Livelihoods, Settlements, Infrastructure, Ecosystem Services and Economic Stability
Reefs
Risks for Low-Lying Coastal Areas
AUSTRALASIA
Significant Change in Composition and Structure of Coral Reef Systems
Increased Flood Damage to Infrastructure and Settlements
Livelihoods
Increased Risks to Coastal Infrastructure and Low-Lying Ecosystems
Coasts
Flood
Coasts


Global mean temperature change
(°C relative to 1986–2005)
5
4
3
2
1
0
-0.61
°C
1900
1950
2000
2050
2100
Global mean temperature change
(°C relative to 1850–1900, as an approximation of preindustrial levels)
Observed
RCP8.5 (a high-emission scenario)
Overlap
RCP2.6 (a low-emission mitigation scenario)


Global mean temperature change
(°C relative to 1986–2005)
Global mean temperature change
(°C relative to 1850–1900, as an approximation of preindustrial levels)
2003–2012
Unique & threatened systems
Extreme weather events
Distribution of impacts
Global aggregate impacts
Large-scale singular events
Level of additional risk due to climate change
Undetectable
Moderate
High
Very high

CLIMATE CHANGE

REDUCING AND MANAGING RISKS

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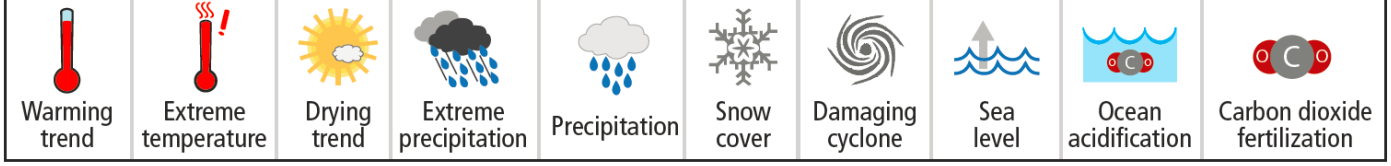
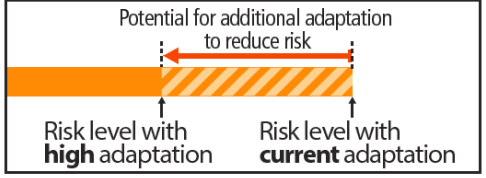
INTERGOVERNMENTAL PANEL ON Climate change

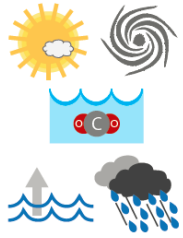
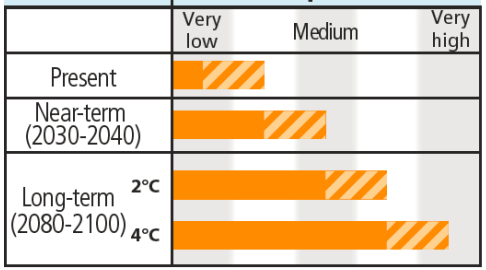
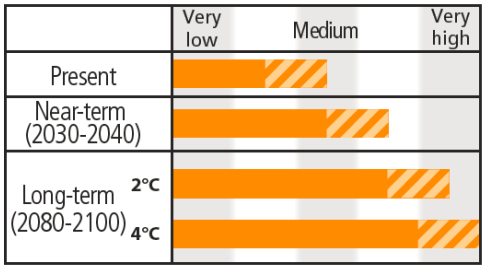
Climate-related drivers of impacts

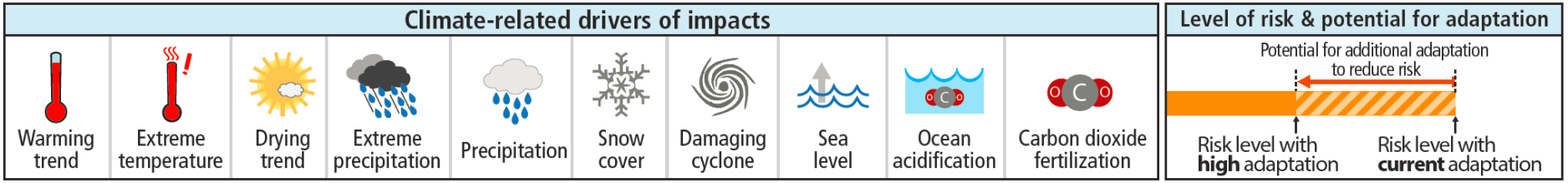


Level of risk & potential for adaptation



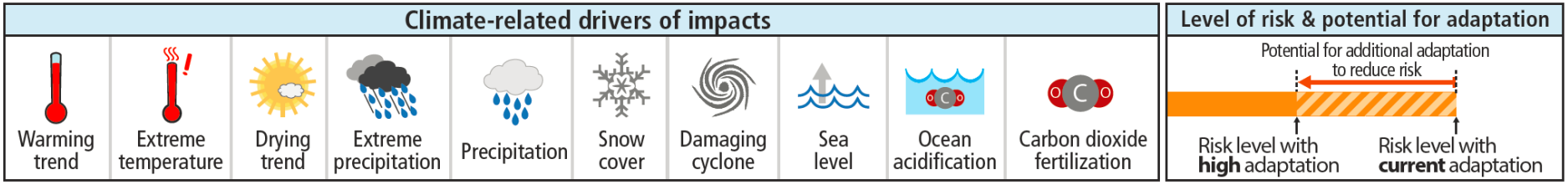
Small Islands

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Loss of livelihoods, coastal settlements, infrastructure, ecosystem services, and economic stability (*high confidence*) [29.6, 29.8, Figure 29-4]	• Significant potential exists for adaptation in islands, but additional external resources and technologies will enhance response. • Maintenance and enhancement of ecosystem functions and services and of water and food security • Efficacy of traditional community coping strategies is expected to be substantially reduced in the future.			
The interaction of rising global mean sea level in the 21st century with high-water-level events will threaten low-lying coastal areas (*high confidence*) [29.4, Table 29-1; WGI AR5 13.5, Table 13.5]	• High ratio of coastal area to land mass will make adaptation a significant financial and resource challenge for islands. • Adaptation options include maintenance and restoration of coastal landforms and ecosystems, improved management of soils and freshwater resources, and appropriate building codes and settlement patterns.			



Central and South America

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Water availability in semi-arid and glacier-melt-dependent regions and Central America; flooding and landslides in urban and rural areas due to extreme precipitation (*high confidence*) [27.3]	• Integrated water resource management • Urban and rural flood management (including infrastructure), early warning systems, better weather and runoff forecasts, and infectious disease control		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	Very low / Medium / Very high
Decreased food production and food quality (*medium confidence*) [27.3]	• Development of new crop varieties more adapted to climate change (temperature and drought) • Offsetting of human and animal health impacts of reduced food quality • Offsetting of economic impacts of land-use change • Strengthening traditional indigenous knowledge systems and practices		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	Very low / Medium / Very high
Spread of vector-borne diseases in altitude and latitude (*high confidence*) [27.3]	• Development of early warning systems for disease control and mitigation based on climatic and other relevant inputs. Many factors augment vulnerability. • Establishing programs to extend basic public health services		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	Very low / Medium / Very high not available not available



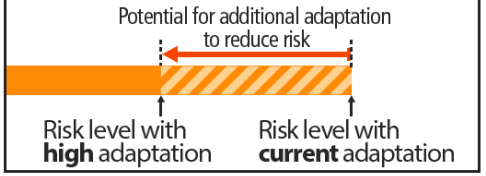
Polar Regions

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Risks for freshwater and terrestrial ecosystems (*high confidence*) and marine ecosystems (*medium confidence*), due to changes in ice, snow cover, permafrost, and freshwater/ocean conditions, affecting species´ habitat quality, ranges, phenology, and productivity, as well as dependent economies [28.2-4]	• Improved understanding through scientific and indigenous knowledge, producing more effective solutions and/or technological innovations • Enhanced monitoring, regulation, and warning systems that achieve safe and sustainable use of ecosystem resources • Hunting or fishing for different species, if possible, and diversifying income sources		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high
Risks for the health and well-being of Arctic residents, resulting from injuries and illness from the changing physical environment, food insecurity, lack of reliable and safe drinking water, and damage to infrastructure, including infrastructure in permafrost regions (*high confidence*) [28.2-4]	• Co-production of more robust solutions that combine science and technology with indigenous knowledge • Enhanced observation, monitoring, and warning systems • Improved communications, education, and training • Shifting resource bases, land use, and/or settlement areas		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high
Unprecedented challenges for northern communities due to complex inter-linkages between climate-related hazards and societal factors, particularly if rate of change is faster than social systems can adapt (*high confidence*) [28.2-4]	• Co-production of more robust solutions that combine science and technology with indigenous knowledge • Enhanced observation, monitoring, and warning systems • Improved communications, education, and training • Adaptive co-management responses developed through the settlement of land claims		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high

Climate-related drivers of impacts

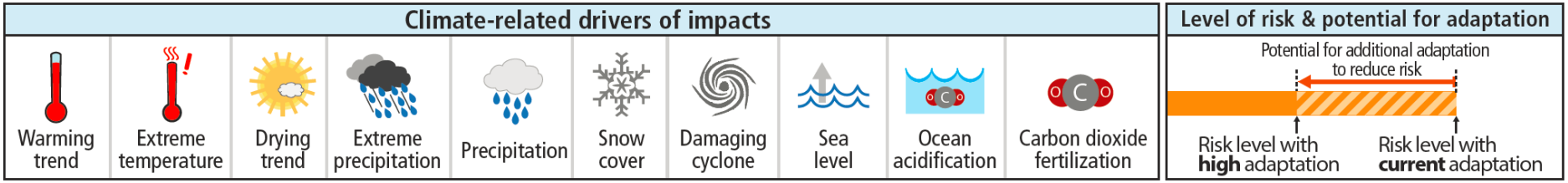
Warming trend | Extreme temperature | Drying trend | Extreme precipitation | Precipitation | Snow cover | Damaging cyclone | Sea level | Ocean acidification | Carbon dioxide fertilization

Level of risk & potential for adaptation



North America

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation (Very low / Medium / Very high)
Wildfire-induced loss of ecosystem integrity, property loss, human morbidity, and mortality as a result of increased drying trend and temperature trend (*high confidence*) [26.4, 26.8, Box 26-2]	• Some ecosystems are more fire-adapted than others. Forest managers and municipal planners are increasingly incorporating fire protection measures (e.g., prescribed burning, introduction of resilient vegetation). Institutional capacity to support ecosystem adaptation is limited. • Adaptation of human settlements is constrained by rapid private property development in high-risk areas and by limited household-level adaptive capacity. • Agroforestry can be an effective strategy for reduction of slash and burn practices in Mexico.	Warming trend; Drying trend	Present Near-term (2030-2040) Long-term (2080-2100) 2°C / 4°C	
Heat-related human mortality (*high confidence*) [26.6, 26.8]	• Residential air conditioning (A/C) can effectively reduce risk. However, availability and usage of A/C is highly variable and is subject to complete loss during power failures. Vulnerable populations include athletes and outdoor workers for whom A/C is not available. • Community- and household-scale adaptations have the potential to reduce exposure to heat extremes via family support, early heat warning systems, cooling centers, greening, and high-albedo surfaces.	Extreme temperature	Present Near-term (2030-2040) Long-term (2080-2100) 2°C / 4°C	
Urban floods in riverine and coastal areas, inducing property and infrastructure damage; supply chain, ecosystem, and social system disruption; public health impacts; and water quality impairment due to sea-level rise, extreme precipitation, and cyclones (*high confidence*) [26.2-4, 26.8]	• Implementing management of urban drainage is expensive and disruptive to urban areas. • Low-regret strategies with co-benefits include less impervious surfaces leading to more groundwater recharge, green infrastructure, and rooftop gardens. • Sea-level rise increases water elevations in coastal outfalls, which impedes drainage. In many cases, older rainfall design standards are being used that need to be updated to reflect current climate conditions. • Conservation of wetlands, including mangroves, and land-use planning strategies can reduce the intensity of flood events.	Extreme precipitation; Damaging cyclone; Sea level	Present Near-term (2030-2040) Long-term (2080-2100) 2°C / 4°C	



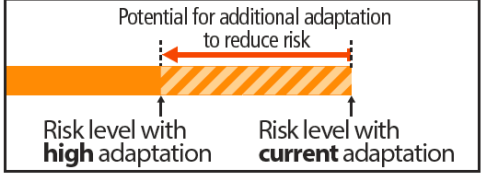
Asia

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Increased riverine, coastal, and urban flooding leading to widespread damage to infrastructure, livelihoods, and settlements in Asia (*medium confidence*) [24.4]	• Exposure reduction via structural and non-structural measures, effective land-use planning, and selective relocation • Reduction in the vulnerability of lifeline infrastructure and services (e.g., water, energy, waste management, food, biomass, mobility, local ecosystems, telecommunications) • Construction of monitoring and early warning systems; measures to identify exposed areas, assist vulnerable areas and households, and diversify livelihoods • Economic diversification		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	Very low / Medium / Very high
Increased risk of heat-related mortality (*high confidence*) [24.4]	• Heat health warning systems • Urban planning to reduce heat islands; improvement of the built environment; development of sustainable cities • New work practices to avoid heat stress among outdoor workers		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	Very low / Medium / Very high
Increased risk of drought-related water and food shortage causing malnutrition (*high confidence*) [24.4]	• Disaster preparedness including early-warning systems and local coping strategies • Adaptive/integrated water resource management • Water infrastructure and reservoir development • Diversification of water sources including water re-use • More efficient use of water (e.g., improved agricultural practices, irrigation management, and resilient agriculture)		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	Very low / Medium / Very high

Climate-related drivers of impacts

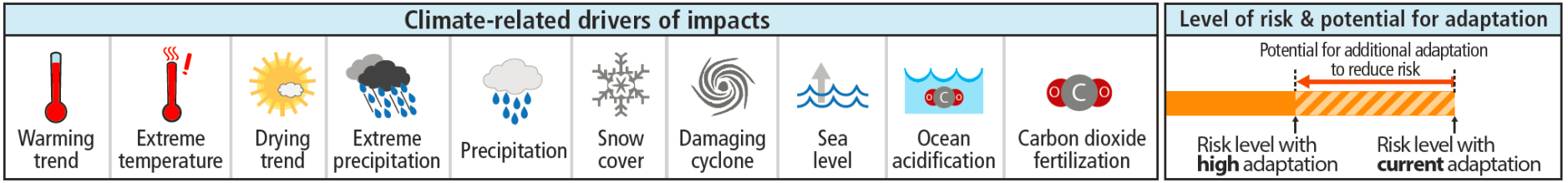
Warming trend | Extreme temperature | Drying trend | Extreme precipitation | Precipitation | Snow cover | Damaging cyclone | Sea level | Ocean acidification | Carbon dioxide fertilization

Level of risk & potential for adaptation



Africa

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Compounded stress on water resources facing significant strain from overexploitation and degradation at present and increased demand in the future, with drought stress exacerbated in drought-prone regions of Africa (*high confidence*) [22.3-4]	• Reducing non-climate stressors on water resources • Strengthening institutional capacities for demand management, groundwater assessment, integrated water-wastewater planning, and integrated land and water governance • Sustainable urban development		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	Very low – Medium – Very high
Reduced crop productivity associated with heat and drought stress, with strong adverse effects on regional, national, and household livelihood and food security, also given increased pest and disease damage and flood impacts on food system infrastructure (*high confidence*) [22.3-4]	• Technological adaptation responses (e.g., stress-tolerant crop varieties, irrigation, enhanced observation systems) • Enhancing smallholder access to credit and other critical production resources; Diversifying livelihoods • Strengthening institutions at local, national, and regional levels to support agriculture (including early warning systems) and gender-oriented policy • Agronomic adaptation responses (e.g., agroforestry, conservation agriculture)		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	Very low – Medium – Very high
Changes in the incidence and geographic range of vector- and water-borne diseases due to changes in the mean and variability of temperature and precipitation, particularly along the edges of their distribution (*medium confidence*) [22.3]	• Achieving development goals, particularly improved access to safe water and improved sanitation, and enhancement of public health functions such as surveillance • Vulnerability mapping and early warning systems • Coordination across sectors • Sustainable urban development		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	Very low – Medium – Very high



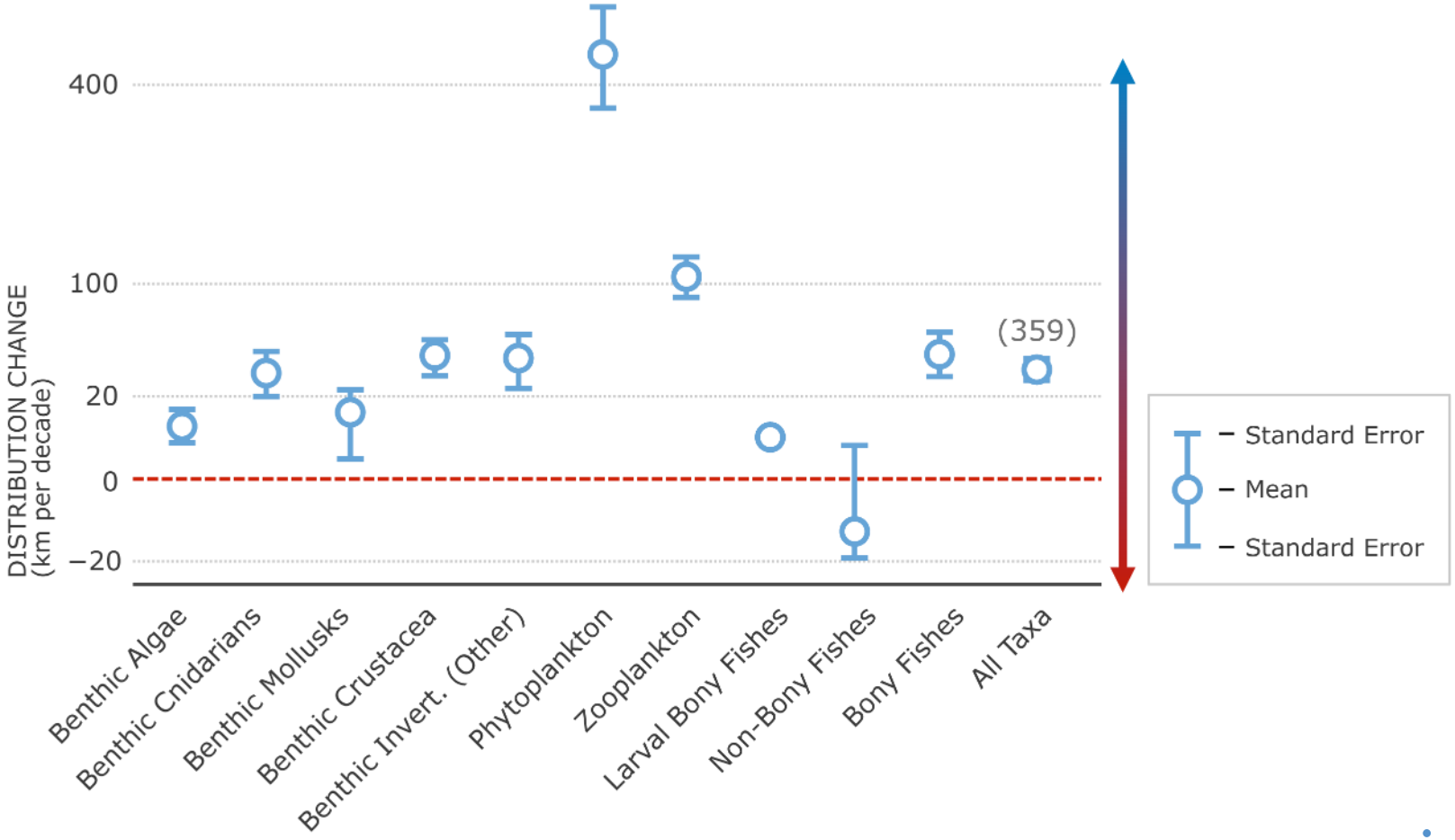
Europe

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Increased economic losses and people affected by flooding in river basins and coasts, driven by increasing urbanization, increasing sea levels, coastal erosion, and peak river discharges (*high confidence*) [23.2-3, 23.7]	Adaptation can prevent most of the projected damages (*high confidence*). • Significant experience in hard flood-protection technologies and increasing experience with restoring wetlands • High costs for increasing flood protection • Potential barriers to implementation: demand for land in Europe and environmental and landscape concerns		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high
Increased water restrictions. Significant reduction in water availability from river abstraction and from groundwater resources, combined with increased water demand (e.g., for irrigation, energy and industry, domestic use) and with reduced water drainage and runoff as a result of increased evaporative demand, particularly in southern Europe (*high confidence*) [23.4, 23.7]	• Proven adaptation potential from adoption of more water-efficient technologies and of water-saving strategies (e.g., for irrigation, crop species, land cover, industries, domestic use) • Implementation of best practices and governance instruments in river basin management plans and integrated water management		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high
Increased economic losses and people affected by extreme heat events: impacts on health and well-being, labor productivity, crop production, air quality, and increasing risk of wildfires in southern Europe and in Russian boreal region (*medium confidence*) [23.3-7, Table 23-1]	• Implementation of warning systems • Adaptation of dwellings and workplaces and of transport and energy infrastructure • Reductions in emissions to improve air quality • Improved wildfire management • Development of insurance products against weather-related yield variations		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high

Africa	
Snow & Ice, Rivers & Lakes, Floods & Drought	• Retreat of tropical highland glaciers in East Africa (*high confidence*, Major contribution from climate change) • Reduced discharge in West African rivers (*low confidence*, Major contribution from climate change) • Lake surface warming & water column stratification increases in the Great Lakes & Lake Kariba (*high confidence*, Major contribution from climate change) • Increased soil moisture drought in the Sahel since 1970, partially wetter conditions since 1990 (*medium confidence*, Major contribution from climate change) [22.2-3, Tables 18-5, 18-6, & 22-3]
Terrestrial Ecosystems	• Tree density decreases in western Sahel & semi-arid Morocco, beyond changes due to land use (*medium confidence*, Major contribution from climate change) • Range shifts of several southern plants & animals, beyond changes due to land use (*medium confidence*, Major contribution from climate change) • Increases in wildfires on Mt. Kilimanjaro (*low confidence*, Major contribution from climate change) [22.3, Tables 18-7 & 22-3]
Coastal Erosion & Marine Ecosystems	Decline in coral reefs in tropical African waters, beyond decline due to human impacts (*high confidence*, Major contribution from climate change) [Table 18-8]
Food Production & Livelihoods	• Adaptive responses to changing rainfall by South African farmers, beyond changes due to economic conditions (*very low confidence*, Major contribution from climate change) • Decline in fruit-bearing trees in Sahel (*low confidence*, Major contribution from climate change) • Malaria increases in Kenyan highlands, beyond changes due to vaccination, drug resistance, demography, & livelihoods (*low confidence*, Minor contribution from climate change) • Reduced fisheries productivity of Great Lakes & Lake Kariba, beyond changes due to fisheries management & land use (*low confidence*, Minor contribution from climate change) [7.2, 11.5, 13.2, 22.3, Table 18-9]
Europe	
Snow & Ice, Rivers & Lakes, Floods & Drought	• Retreat of Alpine, Scandinavian, & Icelandic glaciers (*high confidence*, Major contribution from climate change) • Increase in rock slope failures in western Alps (*medium confidence*, Major contribution from climate change) • Changed occurrence of extreme river discharges & floods (*very low confidence*, Minor contribution from climate change) [18.3, 23.2-3, Tables 18-5 & 18-6; WGI AR5 4.3]
Terrestrial Ecosystems	• Earlier greening, leaf emergence, & fruiting in temperate & boreal trees (*high confidence*, Major contribution from climate change) • Increased colonization of alien plant species in Europe, beyond a baseline of some invasion (*medium confidence*, Major contribution from climate change) • Earlier arrival of migratory birds in Europe since 1970 (*medium confidence*, Major contribution from climate change) • Upward shift in tree-line in Europe, beyond changes due to land use (*low confidence*, Major contribution from climate change) • Increasing burnt forest areas during recent decades in Portugal & Greece, beyond some increase due to land use (*high confidence*, Major contribution from climate change) [4.3, 18.3, Tables 18-7 & 23-6]
Coastal Erosion & Marine Ecosystems	• Northward distributional shifts of zooplankton, fishes, seabirds, & benthic invertebrates in northeast Atlantic (*high confidence*, Major contribution from climate change) • Northward & depth shift in distribution of many fish species across European seas (*medium confidence*, Major contribution from climate change) • Plankton phenology changes in northeast Atlantic (*medium confidence*, Major contribution from climate change) • Spread of warm water species into the Mediterranean, beyond changes due to invasive species & human impacts (*medium confidence*, Major contribution from climate change) [6.3, 23.6, 30.5, Tables 6-2 & 18-8, Boxes 6-1 & CC-MB]
Food Production & Livelihoods	• Shift from cold-related mortality to heat-related mortality in England & Wales, beyond changes due to exposure & health care (*low confidence*, Major contribution from climate change) • Impacts on livelihoods of Sámi people in northern Europe, beyond effects of economic & sociopolitical changes (*medium confidence*, Major contribution from climate change) • Stagnation of wheat yields in some countries in recent decades, despite improved technology (*medium confidence*, Minor contribution from climate change) • Positive yield impacts for some crops mainly in northern Europe, beyond increase due to improved technology (*medium confidence*, Minor contribution from climate change) • Spread of bluetongue virus in sheep & of ticks across parts of Europe (*medium confidence*, Minor contribution from climate change) [18.4, 23.4-5, Table 18-9, Figure 7-2]

	• Earlier timing of maximum spring flood in Russian rivers (*medium confidence*, Major contribution from climate change) • Reduced soil moisture in north-central & northeast China (1950-2006) (*medium confidence*, Major contribution from climate change) • Surface water degradation in parts of Asia, beyond changes due to land use (*medium confidence*, Minor contribution from climate change) [24.3-4, 28.2, Tables 18-5, 18-6, & SM24-4, Box 3-1; WGI AR5 4.3, 10.5]
Terrestrial Ecosystems	• Changes in plant phenology & growth in many parts of Asia (earlier greening), particularly in the north & east (*medium confidence*, Major contribution from climate change) • Distribution shifts of many plant & animal species upwards in elevation or polewards, particularly in the north of Asia (*medium confidence*, Major contribution from climate change) • Invasion of Siberian larch forests by pine & spruce during recent decades (*low confidence*, Major contribution from climate change) • Advance of shrubs into the Siberian tundra (*high confidence*, Major contribution from climate change) [4.3, 24.4, 28.2, Table 18-7, Figure 4-4]
Coastal Erosion & Marine Ecosystems	• Decline in coral reefs in tropical Asian waters, beyond decline due to human impacts (*high confidence*, Major contribution from climate change) • Northward range extension of corals in the East China Sea and western Pacific, and of a predatory fish in the Sea of Japan (*medium confidence*, Major contribution from climate change) • Shift from sardines to anchovies in the western North Pacific, beyond fluctuations due to fisheries (*low confidence*, Major contribution from climate change) • Increased coastal erosion in Arctic Asia (*low confidence*, Major contribution from climate change) [6.3, 24.4, 30.5, Tables 6-2 & 18-8]
Food Production & Livelihoods	• Impacts on livelihoods of indigenous groups in Arctic Russia, beyond economic & sociopolitical changes (*low confidence*, Major contribution from climate change) • Negative impacts on aggregate wheat yields in South Asia, beyond increase due to improved technology (*medium confidence*, Minor contribution from climate change) • Negative impacts on aggregate wheat & maize yields in China, beyond increase due to improved technology (*low confidence*, Minor contribution from climate change) • Increases in a water-borne disease in Israel (*low confidence*, Minor contribution from climate change) [7.2, 13.2, 18.4, 28.2, Tables 18-4 & 18-9, Figure 7-2]
Australasia	
Snow & Ice, Rivers & Lakes, Floods & Drought	• Significant decline in late-season snow depth at 3 of 4 alpine sites in Australia (1957-2002) (*medium confidence*, Major contribution from climate change) • Substantial reduction in ice & glacier ice volume in New Zealand (*medium confidence*, Major contribution from climate change) • Intensification of hydrological drought due to regional warming in southeast Australia (*low confidence*, Minor contribution from climate change) • Reduced inflow in river systems in southwestern Australia (since the mid-1970s) (*high confidence*, Major contribution from climate change) [25.5, Tables 18-5, 18-6, & 25-1; WGI AR5 4.3]
Terrestrial Ecosystems	• Changes in genetics, growth, distribution, & phenology of many species, in particular birds, butterflies, & plants in Australia, beyond fluctuations due to variable local climates, land use, pollution, & invasive species (*high confidence*, Major contribution from climate change) • Expansion of some wetlands & contraction of adjacent woodlands in southeast Australia (*low confidence*, Major contribution from climate change) • Expansion of monsoon rainforest at expense of savannah & grasslands in northern Australia (*medium confidence*, Major contribution from climate change) • Migration of glass eels advanced by several weeks in Waikato River, New Zealand (*low confidence*, Major contribution from climate change) [Tables 18-7 & 25-3]
Coastal Erosion & Marine Ecosystems	• Southward shifts in the distribution of marine species near Australia, beyond changes due to short-term environmental fluctuations, fishing, & pollution (*medium confidence*, Major contribution from climate change) • Change in timing of migration of seabirds in Australia (*low confidence*, Major contribution from climate change) • Increased coral bleaching in Great Barrier Reef & western Australian reefs, beyond effects from pollution & physical disturbance (*high confidence*, Major contribution from climate change) • Changed coral disease patterns at Great Barrier Reef, beyond effects from pollution (*medium confidence*, Major contribution from climate change) [6.3, 25.6, Tables 18-8 & 25-3]
Food Production & Livelihoods	• Advanced timing of wine-grape maturation in recent decades, beyond advance due to improved management (*medium confidence*, Major contribution from climate change) • Shift in winter vs. summer human mortality in Australia, beyond changes due to exposure & health care (*low confidence*, Major contribution from climate change) • Relocation or diversification of agricultural activities in Australia, beyond changes due to policy, markets, & short-term climate variability (*low confidence*, Minor contribution from climate change) [11.4, 18.4, 25.7-8, Tables 18-9 & 25-3, Box 25-5]
North America	
Snow & Ice, Rivers & Lakes, Floods & Drought	• Shrinkage of glaciers across western & northern North America (*high confidence*, Major contribution from climate change) • Decreasing amount of water in spring snowpack in western North America (1960-2002) (*high confidence*, Major contribution from climate change) • Shift to earlier peak flow in snow dominated rivers in western North America (*high confidence*, Major contribution from climate change) • Increased runoff in the midwestern and northeastern US (*medium confidence*, Minor contribution from climate change) [Tables 18-5 & 18-6; WGI AR5 2.6, 4.3]
Terrestrial Ecosystems	• Phenology changes & species distribution shifts upward in elevation & northward across multiple taxa (*medium confidence*, Major contribution from climate change) • Increased wildfire frequency in subarctic conifer forests & tundra (*medium confidence*, Major contribution from climate change) • Regional increases in tree mortality & insect infestations in forests (*low confidence*, Minor contribution from climate change) • Increase in wildfire activity, fire frequency & duration, & burnt area in forests of the western US and boreal forests in Canada, beyond changes due to land use & fire management (*medium confidence*, Minor contribution from climate change) [26.4, 28.2, Table 18-7, Box 26-2]
Coastal Erosion & Marine Ecosystems	• Northward distributional shifts of northwest Atlantic fish species (*high confidence*, Major contribution from climate change) • Changes in musselbeds along the west coast of US (*high confidence*, Major contribution from climate change) • Changed migration & survival of salmon in northeast Pacific (*high confidence*, Major contribution from climate change)

	[27.3, Tables 18-5, 18-6, & 27-3; WGI AR5 4.3]
Terrestrial Ecosystems	• Increased tree mortality & forest fire in the Amazon (*low confidence*, Minor contribution from climate change) • Rainforest degradation & recession in the Amazon, beyond reference trends in deforestation & land degradation (*low confidence*, Minor contribution from climate change) [4.3, 18.3, 27.2-3, Table 18-7]
Coastal Erosion & Marine Ecosystems	• Increased coral bleaching in western Caribbean, beyond effects from pollution & physical disturbance (*high confidence*, Major contribution from climate change) • Mangrove degradation on north coast of South America, beyond degradation due to pollution & land use (*low confidence*, Minor contribution from climate change) [27.3, Table 18-8]
Food Production & Livelihoods	• More vulnerable livelihood trajectories for indigenous Aymara farmers in Bolivia due to water shortage, beyond effects of increasing social & economic stress (*medium confidence*, Major contribution from climate change) • Increase in agricultural yields & expansion of agricultural areas in southeastern South America, beyond increase due to improved technology (*medium confidence*, Major contribution from climate change) [13.1, 27.3, Table 18-9]
Polar Regions	
Snow & Ice, Rivers & Lakes, Floods & Drought	• Decreasing Arctic sea ice cover in summer (*high confidence*, Major contribution from climate change) • Reduction in ice volume in Arctic glaciers (*high confidence*, Major contribution from climate change) • Decreasing snow cover extent across the Arctic (*medium confidence*, Major contribution from climate change) • Widespread permafrost degradation, especially in the southern Arctic (*high confidence*, Major contribution from climate change) • Ice mass loss along coastal Antarctica (*medium confidence*, Major contribution from climate change) • Increased river discharge for large circumpolar rivers (1997–2007) (*low confidence*, Major contribution from climate change) • Increased winter minimum river flow in most of the Arctic (*medium confidence*, Major contribution from climate change) • Increased lake water temperatures 1985–2009 & prolonged ice-free seasons (*medium confidence*, Major contribution from climate change) • Disappearance of thermokarst lakes due to permafrost degradation in the low Arctic. New lakes created in areas of formerly frozen peat (*high confidence*, Major contribution from climate change) [28.2, Tables 18-5 & 18-6; WGI AR5 4.2-4, 4.6, 10.5]
Terrestrial Ecosystems	• Increased shrub cover in tundra in North America & Eurasia (*high confidence*, Major contribution from climate change) • Advance of Arctic tree-line in latitude & altitude (*medium confidence*, Major contribution from climate change) • Changed breeding area & population size of subarctic birds, due to snowbed reduction &/or tundra shrub encroachment (*medium confidence*, Major contribution from climate change) • Loss of snow-bed ecosystems & tussock tundra (*high confidence*, Major contribution from climate change) • Impacts on tundra animals from increased ice layers in snow pack, following rain-on-snow events (*medium confidence*, Major contribution from climate change) • Increased plant species ranges in the West Antarctic Peninsula & nearby islands over the past 50 years (*high confidence*, Major contribution from climate change) • Increased phytoplankton productivity in Signy Island lake waters (*high confidence*, Major contribution from climate change) [28.2, Table 18-7]
Coastal Erosion & Marine Ecosystems	• Increased coastal erosion across Arctic (*medium confidence*, Major contribution from climate change) • Negative effects on non-migratory Arctic species (*high confidence*, Major contribution from climate change) • Decreased reproductive success in Arctic seabirds (*medium confidence*, Major contribution from climate change) • Decline in Southern Ocean seals & seabirds (*medium confidence*, Major contribution from climate change) • Reduced thickness of foraminiferal shells in southern oceans, due to ocean acidification (*medium confidence*, Major contribution from climate change) • Reduced krill density in Scotia Sea (*medium confidence*, Major contribution from climate change) [6.3, 18.3, 28.2-3, Table 18-8]
Food Production & Livelihoods	• Impact on livelihoods of Arctic indigenous peoples, beyond effects of economic & sociopolitical changes (*medium confidence*, Major contribution from climate change) • Increased shipping traffic across the Bering Strait (*medium confidence*, Major contribution from climate change) [18.4, 28.2, Tables 18-4 & 18-9, Figure 28-4]
Small Islands	
Snow & Ice, Rivers & Lakes, Floods & Drought	Increased water scarcity in Jamaica, beyond increase due to water use (*very low confidence*, Minor contribution from climate change) [Table 18-6]
Terrestrial Ecosystems	• Tropical bird population changes in Mauritius (*medium confidence*, Major contribution from climate change) • Decline of an endemic plant in Hawai'i (*medium confidence*, Major contribution from climate change) • Upward trend in tree-lines & associated fauna on high-elevation islands (*low confidence*, Minor contribution from climate change) [29.3, Table 18-7]
Coastal Erosion & Marine Ecosystems	• Increased coral bleaching near many tropical small islands, beyond effects of degradation due to fishing & pollution (*high confidence*, Major contribution from climate change) • Degradation of mangroves, wetlands, & seagrass around small islands, beyond degradation due to other disturbances (*very low confidence*, Minor contribution from climate change) • Increased flooding & erosion, beyond erosion due to human activities, natural erosion, & accretion (*low confidence*, Minor contribution from climate change) • Degradation of groundwater & freshwater ecosystems due to saline intrusion, beyond degradation due to pollution & groundwater pumping (*low confidence*, Minor


DISTRIBUTION CHANGE
(km per decade)
400
100
20
0
−20
(359)
Benthic Algae
Benthic Cnidarians
Benthic Mollusks
Benthic Crustacea
Benthic Invert. (Other)
Phytoplankton
Zooplankton
Larval Bony Fishes
Non-Bony Fishes
Bony Fishes
All Taxa
Standard Error
Mean
Standard Error

CHANGE IN MAXIMUM CATCH POTENTIAL (2051-2060 COMPARED TO 2001-2010, SRES A1B)