

Regional perspectives on climate change impacts and adaptation

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(Lead Author, Chapter 21, Regional Context)



Climate Change 2014

Impacts, Adaptation and Vulnerability

Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Part A: Global and Sectoral Aspects

1. Point of Departure
2. Foundations for Decision Making
3. Freshwater Resources
4. Terrestrial and Inland Water Systems
5. Coastal Systems and Low-Lying Areas
6. Ocean Systems
7. Food Security and Food Production Systems
8. Urban Areas
9. Rural Areas
10. Key Economic Sectors and Services
11. Human Health: Impacts, Adaptation, and Co-Benefits
12. Human Security
13. Livelihoods and Poverty
14. Adaptation Needs and Options
15. Adaptation Planning and Implementation
16. Adaptation Opportunities, Constraints, and Limits
17. Economics of Adaptation
18. Detection and Attribution of Observed Impacts
19. Emergent Risks and Key Vulnerabilities
20. Climate-Resilient Pathways: Adaptation, Mitigation, and Sustainable Development

Climate Change 2014: Impacts, Adaptation, and Vulnerability Part B: Regional Aspects

Chapters

21. Regional Context

22. Africa

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24. Asia

25. Australasia

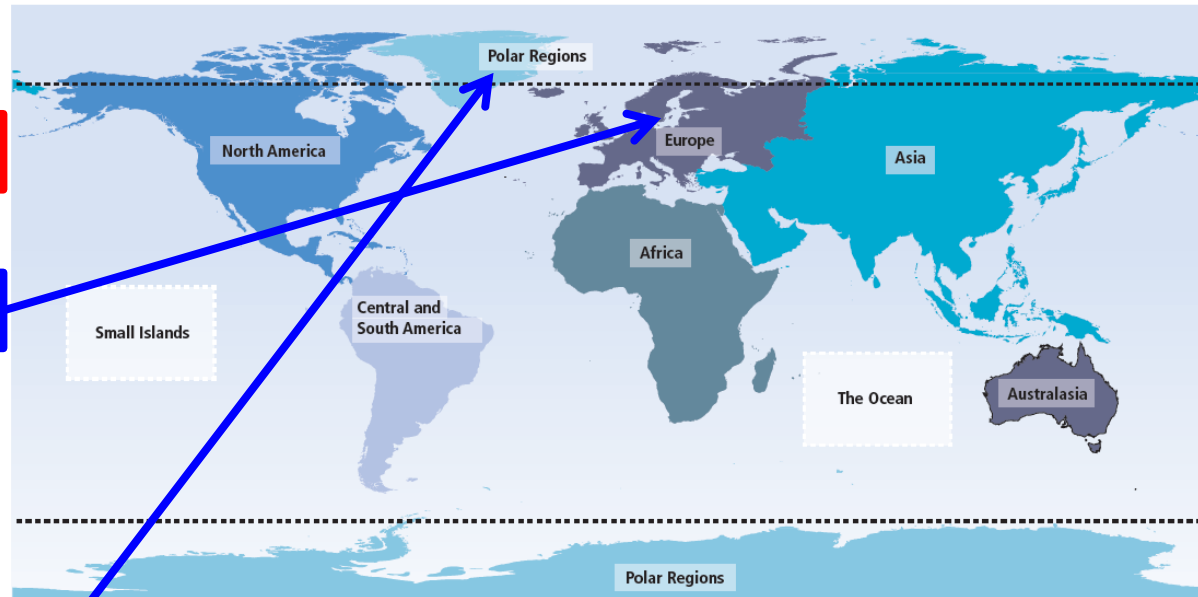
26. North America

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28. Polar Regions

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30. The Ocean



Larsen et al. (2014)

Regional perspectives

- A. Observed impacts, vulnerability, and adaptation**
- B. Future risks and opportunities for adaptation**
- C. Managing future risks and building resilience**

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Observed impacts attributed to climate change in Europe reported in the scientific literature since the AR4

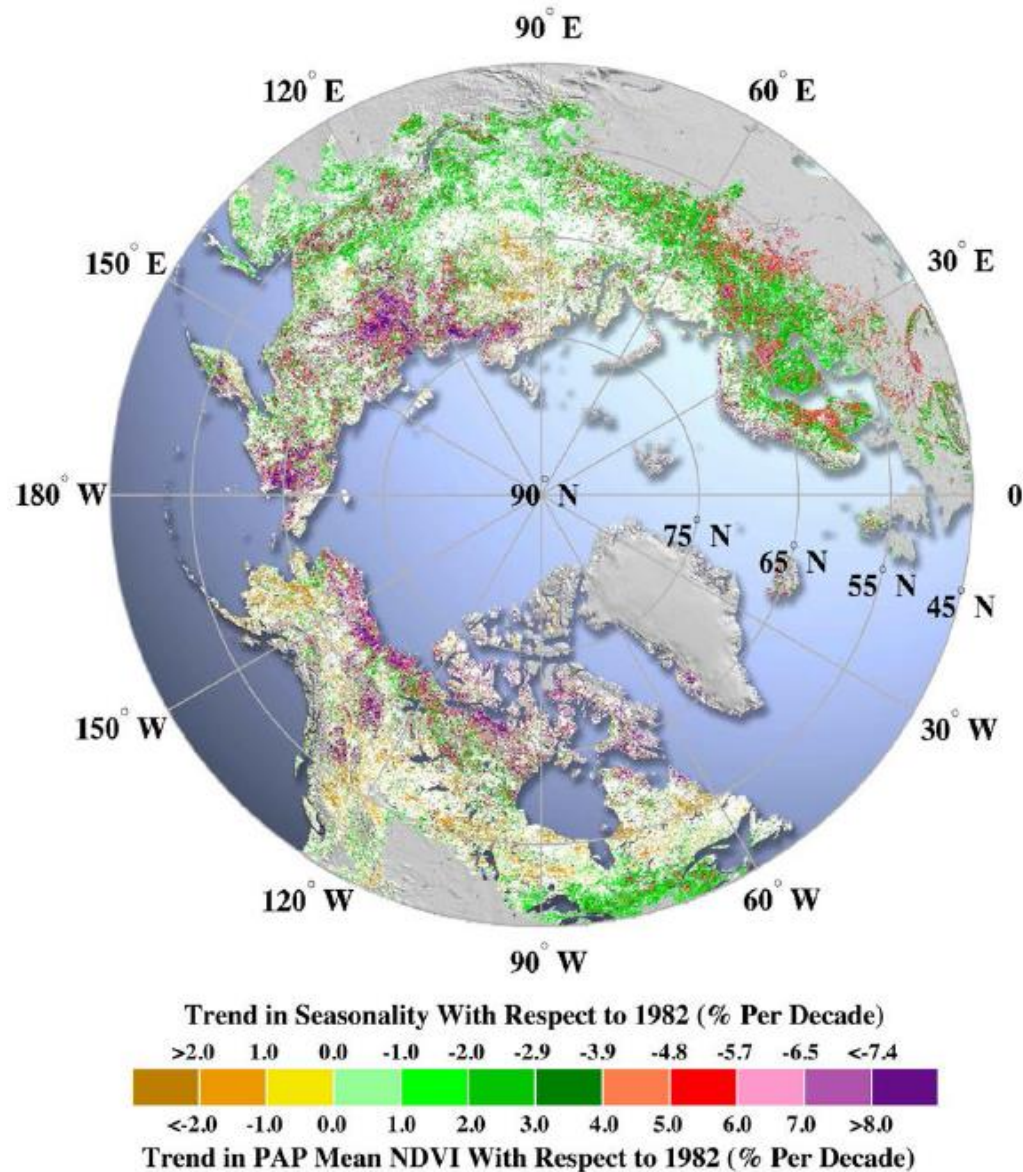
Europe	
Snow & Ice, Rivers & Lakes, Floods & Drought	Retreat of Alpine, Scandinavian, & Icelandic glaciers (<i>High confidence</i>, Major contribution from climate change) Increase in rock slope failures in western Alps (<i>Medium confidence</i>, Major contribution from climate change) Changed occurrence of extreme river discharges & floods (<i>Very low confidence</i>, 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 (<i>High confidence</i>, Major contribution from climate change) Increased colonization of alien plant species in Europe, beyond a baseline of some invasion (<i>Medium confidence</i>, Major contribution from climate change) Earlier arrival of migratory birds in Europe since 1970 (<i>Medium confidence</i>, Major contribution from climate change) Upward shift in tree-line in Europe, beyond changes due to land use (<i>Low confidence</i>, Major contribution from climate change) Increasing burnt forest areas during recent decades in Portugal & Greece, beyond some increase due to land use (<i>High confidence</i>, 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 (<i>High confidence</i>, Major contribution from climate change) Northward & depth shift in distribution of many fish species across European seas (<i>Medium confidence</i>, Major contribution from climate change) Plankton phenology changes in northeast Atlantic (<i>Medium confidence</i>, Major contribution from climate change) Spread of warm water species into the Mediterranean, beyond changes due to invasive species & human impacts (<i>Medium confidence</i>, 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 (<i>Low confidence</i>, Major contribution from climate change) Impacts on livelihoods of Sámi people in northern Europe, beyond effects of economic & sociopolitical changes (<i>Medium confidence</i>, Major contribution from climate change) Stagnation of wheat yields in some countries in recent decades, despite improved technology (<i>Medium confidence</i>, Minor contribution from climate change) Positive yield impacts for some crops mainly in northern Europe, beyond increase due to improved technology (<i>Medium confidence</i>, Minor contribution from climate change) Spread of bluetongue virus in sheep & of ticks across parts of Europe (<i>Medium confidence</i>, Minor contribution from climate change) [18.4, 23.4-5, Table 18-9, Figure 7-2]

Observed impacts attributed to climate change in Polar Regions reported in the scientific literature since the AR4

Polar Regions	
Snow & Ice, Rivers & Lakes, Floods & Drought	Decreasing Arctic sea ice cover in summer (<i>High confidence</i>, Major contribution from climate change) Reduction in ice volume in Arctic glaciers (<i>High confidence</i>, Major contribution from climate change) Decreasing snow cover extent across the Arctic (<i>Medium confidence</i>, Major contribution from climate change) Widespread permafrost degradation, especially in the southern Arctic (<i>High confidence</i>, Major contribution from climate change) Ice mass loss along coastal Antarctica (<i>Medium confidence</i>, Major contribution from climate change) Increased river discharge for large circumpolar rivers (1997–2007) (<i>Low confidence</i>, Major contribution from climate change) Increased winter minimum river flow in most of the Arctic (<i>Medium confidence</i>, Major contribution from climate change) Increased lake water temperatures 1985–2009 & prolonged ice-free seasons (<i>Medium confidence</i>, 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 (<i>High confidence</i>, 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 (<i>High confidence</i>, Major contribution from climate change) Advance of Arctic tree-line in latitude & altitude (<i>Medium confidence</i>, Major contribution from climate change) Changed breeding area & population size of subarctic birds, due to snowbed reduction &/or tundra shrub encroachment (<i>Medium confidence</i>, Major contribution from climate change) Loss of snow-bed ecosystems & tussock tundra (<i>High confidence</i>, Major contribution from climate change) Impacts on tundra animals from increased ice layers in snow pack, following rain-on-snow events (<i>Medium confidence</i>, Major contribution from climate change) Increased plant species ranges in the West Antarctic Peninsula & nearby islands over the past 50 years (<i>High confidence</i>, Major contribution from climate change) Increased phytoplankton productivity in Signy Island lake waters (<i>High confidence</i>, Major contribution from climate change) [28.2, Table 18-7]
Coastal Erosion & Marine Ecosystems	Increased coastal erosion across Arctic (<i>Medium confidence</i>, Major contribution from climate change) Negative effects on non-migratory Arctic species (<i>High confidence</i>, Major contribution from climate change) Decreased reproductive success in Arctic seabirds (<i>Medium confidence</i>, Major contribution from climate change) Decline in Southern Ocean seals & seabirds (<i>Medium confidence</i>, Major contribution from climate change) Reduced thickness of foraminiferal shells in southern oceans, due to ocean acidification (<i>Medium confidence</i>, Major contribution from climate change) Reduced krill density in Scotia Sea (<i>Medium confidence</i>, 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 (<i>Medium confidence</i>, Major contribution from climate change) Increased shipping traffic across the Bering Strait (<i>Medium confidence</i>, Major contribution from climate change) [18.4, 28.2, Tables 18-4 & 18-9, Figure 28-4]

Source: IPCC (2014)

Significant changes in photosynthetically active period NDVI between 1982 and 2012



Source: IPCC (2014)

Adaptation is becoming embedded in some planning processes, with more limited implementation of responses (*high confidence*)

Adaptation experience is accumulating across regions in the public and private sector and within communities (*high confidence*). Governments at various levels are starting to develop adaptation plans and policies and to integrate climate-change considerations into broader development plans.

<http://climate-adapt.eea.europa.eu/>



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Adaptation strategies

EEA member countries are at different stages of preparing, developing and implementing adaptation strategies. This development depends on the magnitude and nature of the observed impacts, the assessment of current and future vulnerability and the capacity to adapt. All countries have submitted information on their adaptation plans and actions in their 5th National Communication (NC) to the United Nations Framework Convention on Climate Change (UNFCCC) due on 1 January 2010, and most have submitted their 6th NC to UNFCCC (due on 1 January 2014). Increasingly, additional actions and measures are being taken at regional and local levels.

Adaptation strategy adopted
 No adaptation strategy adopted




European Commission

European Environment Agency

In Europe, adaptation policy has been developed across all levels of government, with some adaptation planning integrated into coastal and water management, into environmental protection and land planning, and into disaster risk management

Regional perspectives

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Assessment of risks in the WGII AR5 relies on diverse forms of evidence. Expert judgment is used to integrate evidence into evaluations of risks

Examples of evidence:

- empirical observations
- experimental results
- process-based understanding
- statistical approaches
- simulation and descriptive models

Dimensions of assessments of impacts and vulnerability and of adaptation (illustrative)

Approach/field: Scale:	Impacts/vulnerability	Adaptation	Target field
Global	Resource availability ^{1,2,3} Impact costs ^{4,5,6,7} Vulnerability/risk mapping ^{8,9,10} Hotspots analysis ¹¹	Adaptation costs ^{4,5,6,7,12}	- Policy negotiations - Development aid - Disaster planning - Capacity building
Continental/ biome	Observed impacts ^{13,14,15} Future biophysical impacts ^{16,17} Impact costs ^{5,16} Vulnerability/risk mapping ¹⁸	Adaptation costs ⁵ Modelled adaptation ¹⁹	- Capacity building - International law - Policy negotiations - Regional development
National/ state/province	Observed impacts ^{20,21,22} Future impacts/risks ^{23,24} Vulnerability assessment ²⁴ Impact costs ²⁵	Observed adaptation ²⁶ Adaptation assessment ^{24,27}	- National adaptation plan/strategy - Nat. Communication - Legal requirement - Regulation
Municipality/ basin/patch/ delta/farm	Hazard/risk mapping ²⁸ Pest/disease risk mapping ²⁹ Urban risks/vulnerabilities ³⁰	Adaptation cost ²⁸ Urban adaptation ^{30,31}	- Spatial planning - Extension services - Water utilities - Private sector
Site/field/tree/ floodplain/ household	Field experiments ³²	Coping studies ^{33,34} Economic modelling ³⁵ Agent-based modelling ³⁶	- Individual actors - Local planners

Source: Hewitson et al. (2014)

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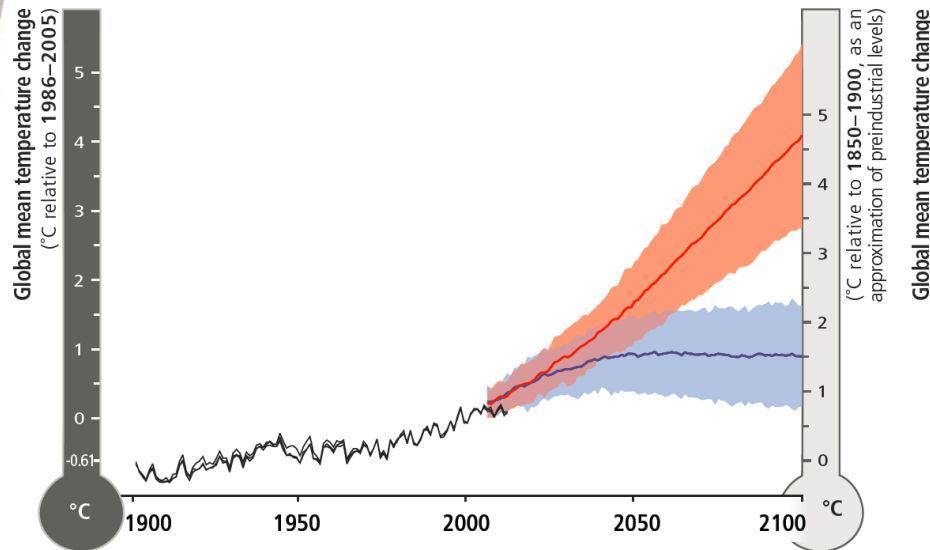
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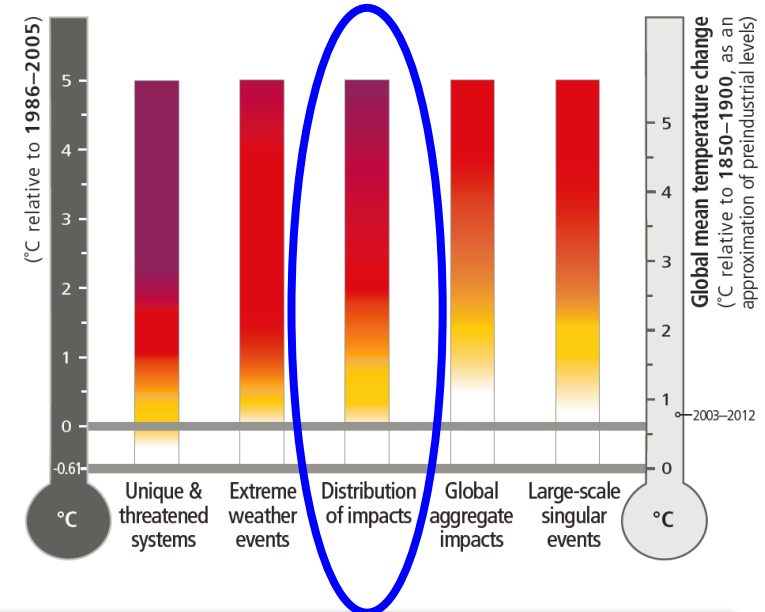
Scenarios:

- RCPs (Representative Concentration Pathways) NEW
- SRES (IPCC Special Report on Emission Scenarios) OLDER

Global perspective on climate-related risks associated with reasons for concern. Colour shading shows additional risk due to climate change



— Observed
 RCP8.5 (a high-emission scenario)
 Overlap
 RCP2.6 (a low-emission mitigation scenario)



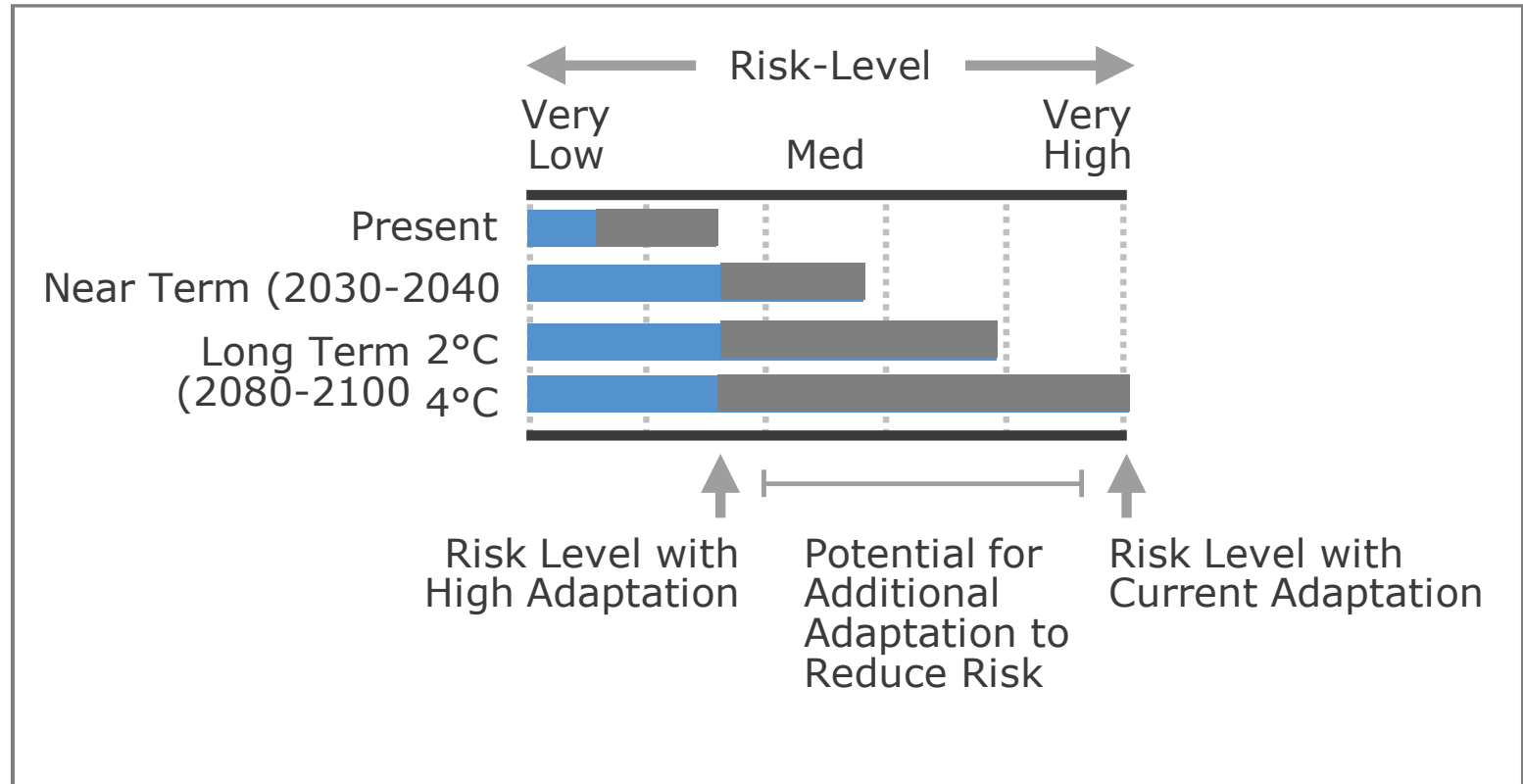
Level of additional risk due to climate change

Undetectable Moderate High Very high

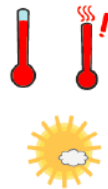
REASONS FOR CONCERN:

1. Unique and threatened systems
2. Extreme weather events
3. Distribution of impacts
4. Global aggregate impacts
5. Large-scale singular events

Key risks from climate change and the potential for reducing risks through adaptation and mitigation



Key risks from climate change in Europe and the potential for reducing risks through adaptation and mitigation

Europe				
Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Flooding 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 (<i>high confidence</i>)	Adaptation can prevent most of the projected damages (<i>high confidence</i>). • 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			Very low Medium Very high
			Present	
			Near-term (2030-2040)	
			Long-term (2080-2100) 2°C 4°C	
Drought Increased water restrictions. Significant reduction in water availability from river abstraction and from groundwater resources combined with increased evaporation, particularly in southern Europe (<i>high confidence</i>) [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			Very low Medium Very high
			Present	
			Near-term (2030-2040)	
			Long-term (2080-2100) 2°C 4°C	
Extreme heat 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 (<i>medium confidence</i>)	• 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			Very low Medium Very high
			Present	
			Near-term (2030-2040)	
			Long-term (2080-2100) 2°C 4°C	

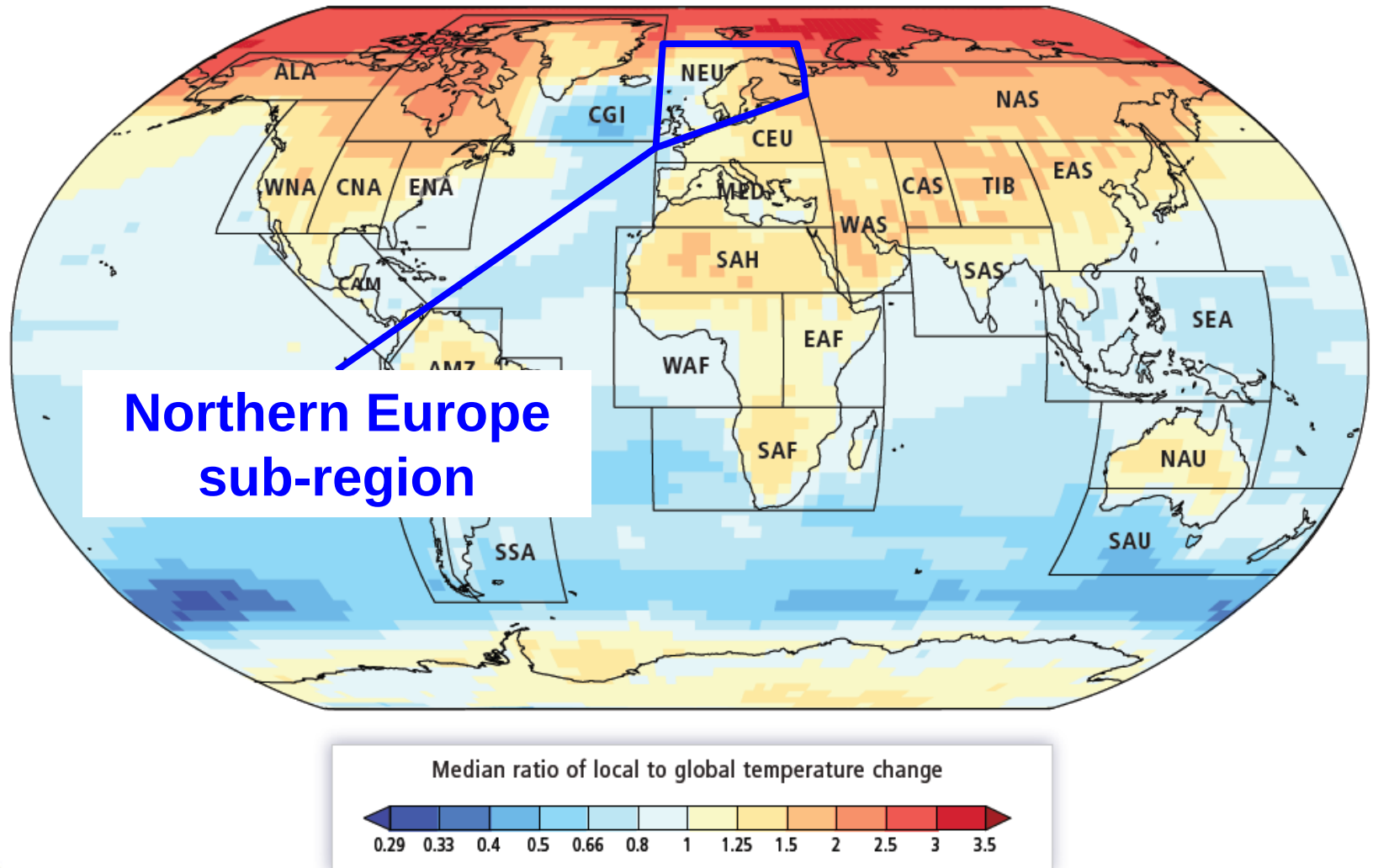
Key risks from climate change in Polar Regions and the potential for reducing risks through adaptation and mitigation

Polar Regions				
Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Risks for freshwater and terrestrial ecosystems (<i>high confidence</i>) and marine ecosystems Ecosystems 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	 		Very low Medium Very high
			Present	
			Near-term (2030-2040)	
			Long-term (2080-2100) 2°C	
Risks for the health and well-being of Arctic residents resulting from injuries and illnesses Health & well-being [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	 		Very low Medium Very high
			Present	
			Near-term (2030-2040)	
			Long-term (2080-2100) 2°C	
Unprecedented challenges for northern communities due to complex inter-linkages Social [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	 		Very low Medium Very high
			Present	
			Near-term (2030-2040)	
			Long-term (2080-2100) 2°C	
			4°C	

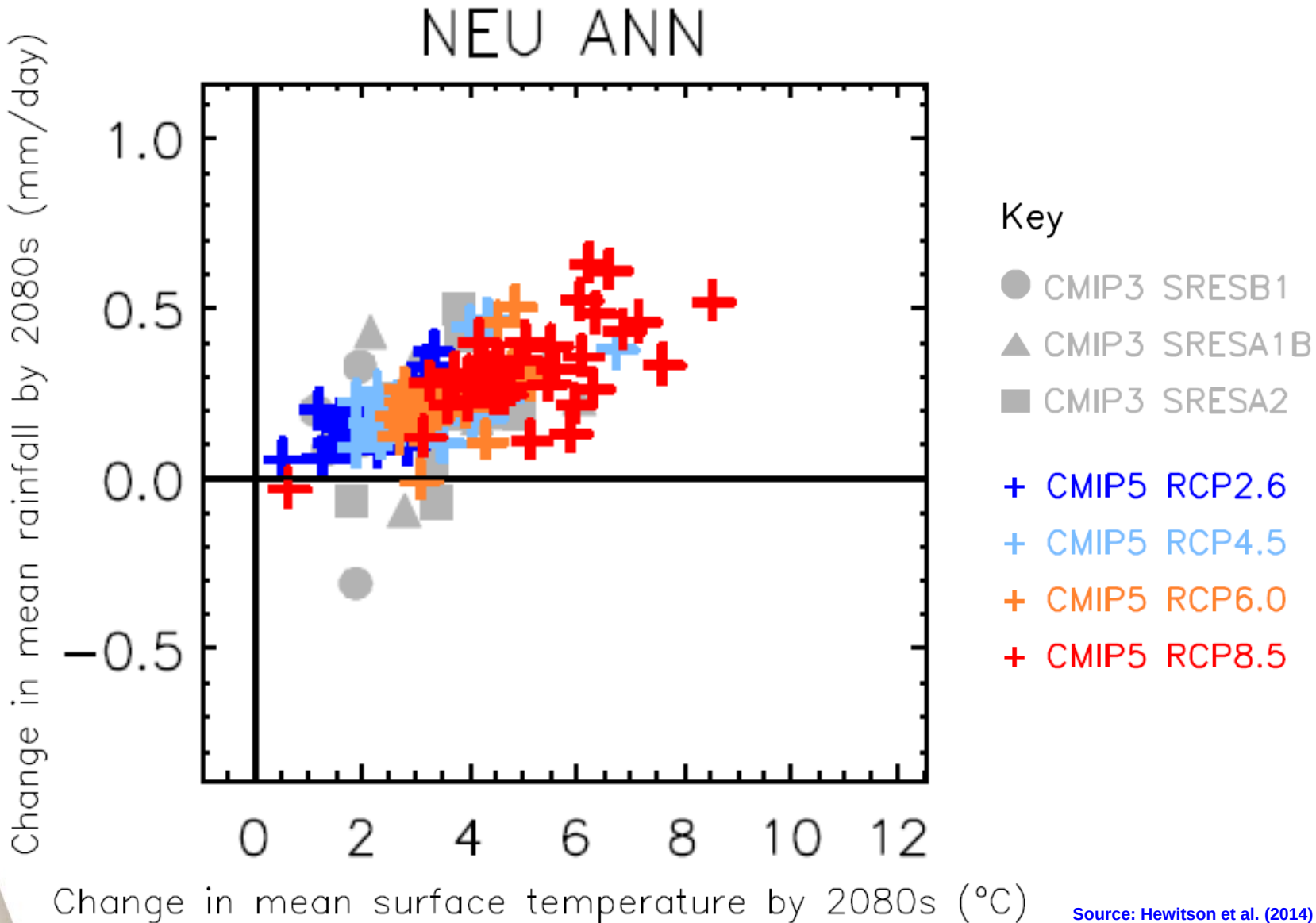


Sub-regions used for climatological analyses in WG II AR5

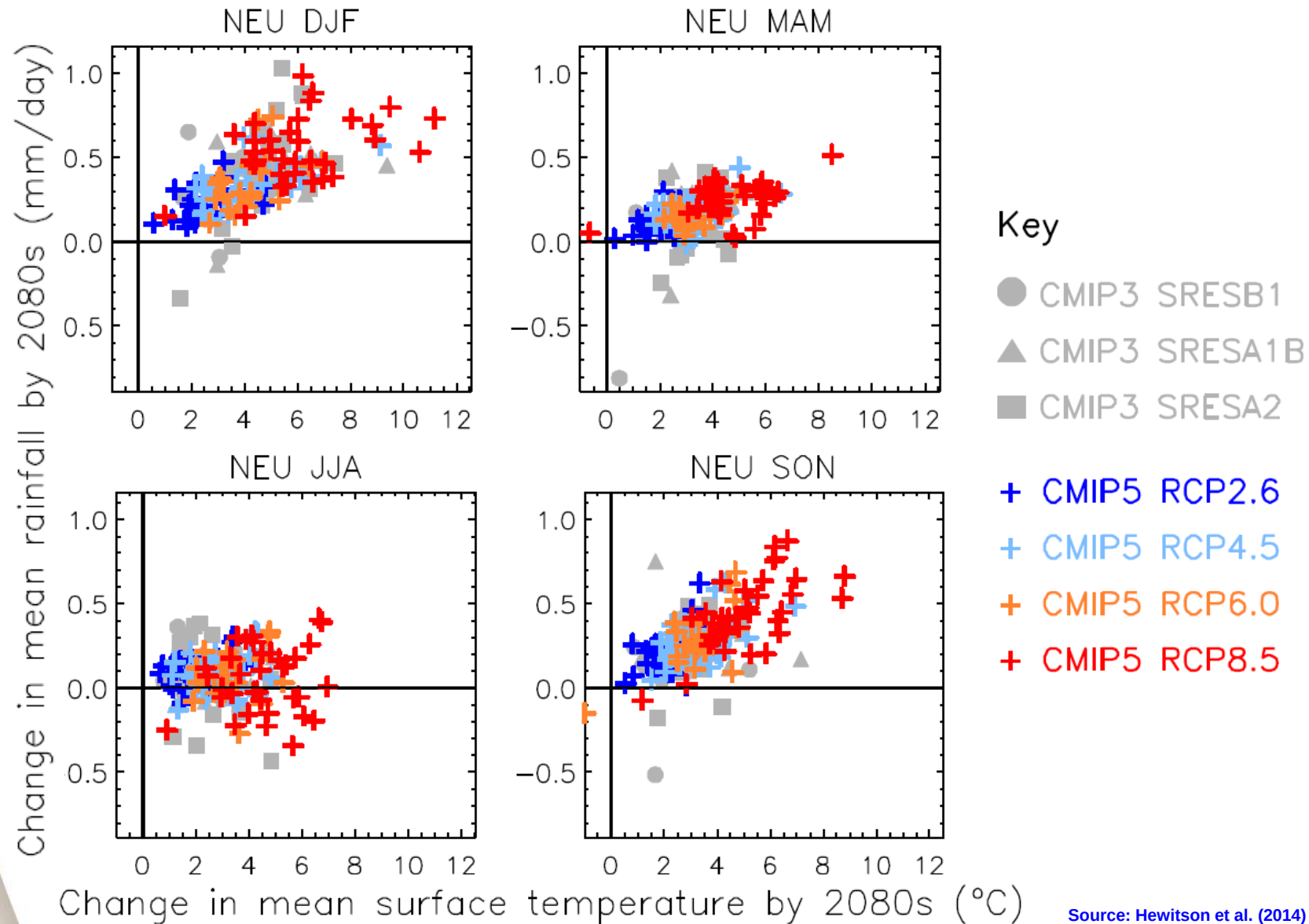
Background map: CMIP5 ensemble median ratio of local:global average temperature change (2071-2100 w.r.t. 1961-1990) under RCP8.5



Comparison of projected regional annual climate change over northern Europe (2071-2100 w.r.t. 1961-90) between 35 CMIP5 GCMs (RCP scenarios) and 22 CMIP3 GCMs (SRES scenarios)



Comparison of projected regional seasonal climate change over northern Europe (2071-2100 w.r.t. 1961-90) between 35 CMIP5 GCMs (RCP scenarios) and 22 CMIP3 GCMs (SRES scenarios)



Changes in climate extremes observed (from 1950) and projected (to 2071-2100) relative to 1961-1990

Region/ region code	Trends in daytime temperature extremes (frequency of hot and cool days)	
	Observed	Projected
Northern Europe NEU, 11	 Increase in hot days (decrease in cool days), but generally not significant at the local scale ^a	 <i>Very likely</i> increase in hot days (decrease in cool days) [but smaller trends than in central and southern Europe] ^b

Changes in climate extremes observed (from 1950) and projected (to 2071-2100) relative to 1961-1990

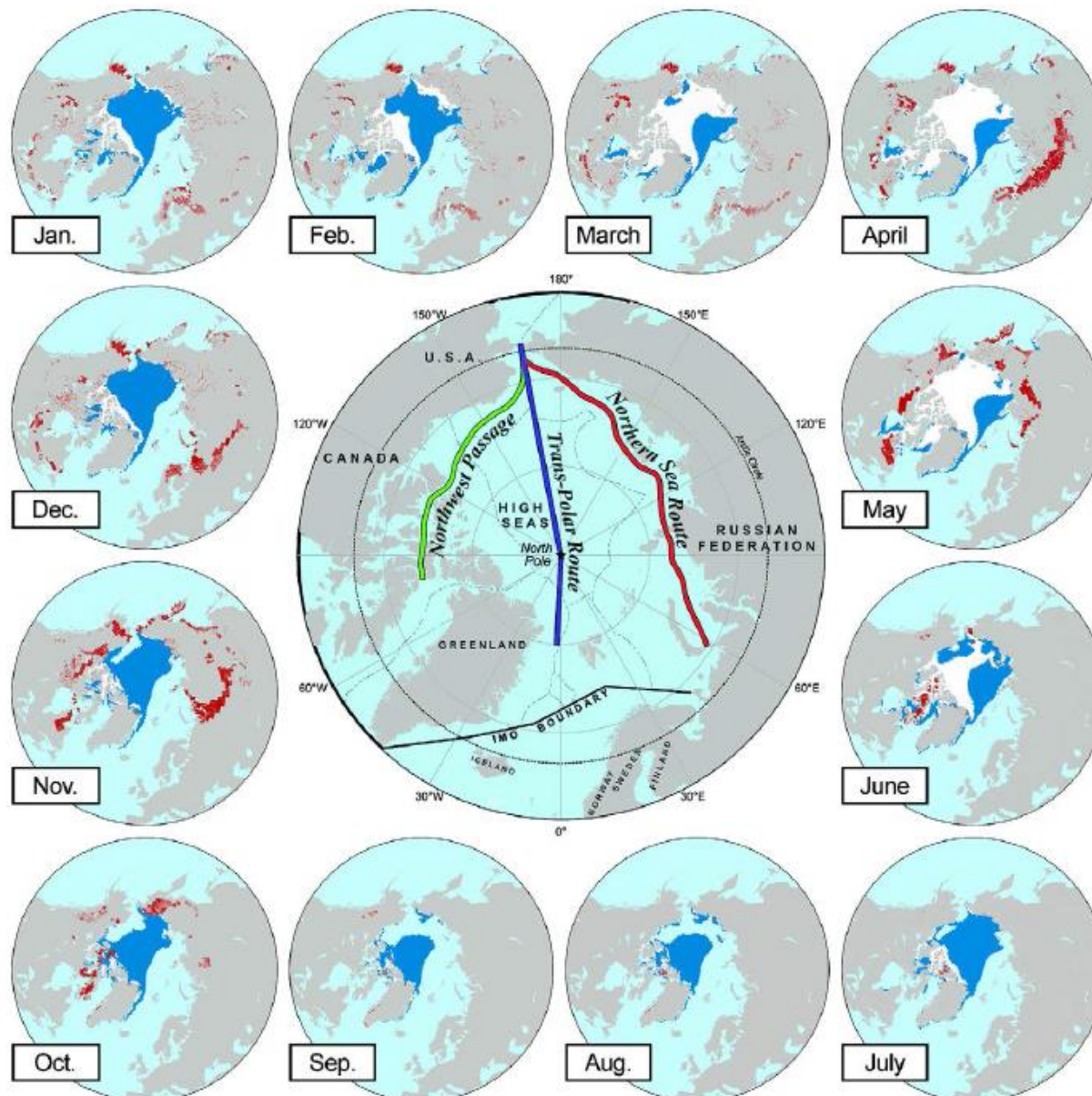
Region/ region code	Trends in heavy precipitation (rain, snow)	
	Observed	Projected
Northern Europe NEU, 11	 Increase in winter in some areas, but often insignificant or inconsistent trends at subregional scale, particularly in summer ^a	 <i>Likely</i> increase in 20-year return value of annual maximum daily precipitation. <i>Very likely</i> increases in heavy precipitation intensity and frequency in winter in the north ^b

Cross-regional phenomena can be crucial for understanding the ramifications of climate change at regional scales, and its impacts and policies of response

Examples:

- **Global trade**
- **International financial transactions**
- **Migration (people, ecosystems)**

Projected change in accessibility of maritime and land-based transportation (2045-2059 w.r.t. 2000-2014); SRES A1B scenario



Dark blue: new maritime access to Polar Class 6 vessels

White: inaccessible

Red: areas of lost winter road potential for ground vehicles > 2 metric tonnes

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Adaptation planning and implementation can be enhanced through complementary actions across levels, from individuals to governments (*high confidence*)

Dimensions of the institutions and actors involved in climate change decision making (illustrative)

	Level	Coherent policies and decision making across domains				
		Economy	Energy	Food/fiber	Technology	Environment
Multi-level organization and governance	Global	- International Monetary Fund - World Bank - World Trade Organization - Millennium Development Goals - NGOs	- International Energy Agency - NGOs	- UN Food and Agriculture Organization - World Trade Organization - UN Convention on the Law of the Sea (fisheries) - NGOs	- World Intellectual Property Organization - NGOs	- UN Framework Convention on Climate Change - Convention on Biological Diversity - Montreal Protocol - NGOs
	Transnational	- Multilateral Financial Institutions/Multilateral Development Banks - Bilateral Financial Institutions - Organisation for Economic Cooperation and Development - EU - UN Convention on the Law of the Sea (transport)	- Organization of the Petroleum Exporting Countries - Electric grid operators - Oil/gas distributors	- Association of Southeast Asian Nations Free Trade Area - Common Market for Eastern and Southern Africa - Mercado Común del Sur (Southern Common Market) - EU Common Agricultural/Fisheries Policies	- Multi-nationals' research and development - EU Innovation Union	- Convention on Long-range Transboundary Air Pollution (Europe, North America, Central Asia) - Mekong River Commission for Sustainable Development - Lake Victoria Basin Commission - EU Directives
	National	- Ministries/governments - Departments/agencies - Banks - Taxation	- Ministries/governments - Departments/agencies - Energy providers - Energy regulators	- Ministries/governments - Departments/agencies - Tariffs, quotas, regulations	- Ministries/governments - Departments/agencies - Education - Innovation - Research and development	- Ministries/governments - Departments/agencies - Environmental law
	Subnational	- States/provinces/counties/cities - Taxation	- States/provinces/counties/cities - Public/private energy providers	- States/provinces/counties/cities - Extension services - Land use planning	- States/provinces/counties/cities - Incentives - Science parks	- States/provinces/counties/cities - Protected areas - Regional offices
	Local	- Microfinance - Cooperatives - Employers - Voters - Consumers	- Renewables - Producers - Voters - Consumers	- Farmers - Foresters - Fishers - Landowners - Voters - Consumers	- Entrepreneurs - Investors - Voters - Consumers	- Environmentalists - Landowners - Voters - Consumers

Source: Hewitson et al. (2014)

Constraints can interact to impede adaptation planning and implementation *(high confidence)*

Some limits to climate change adaptation in Europe

Area/Location	System	Adaptation measures	Limits to adaptation measure(s)	References
Low altitude/ small-size ski resorts	Ski tourism	Artificial snowmaking	Climatic, technological and environmental constraints Economic viability Social acceptability of charging for previously free skiing. Social acceptability of alternatives for winter sport/leisure.	Landauer et al, 2012 ; Steiger, 2010; Steiger, 2011; Steiger and Mayer, 2008, Unbehau et al., 2008
Thermal power plants/ cooling through river intake and discharge	Once-through cooling systems	Closed- circuit cooling	High investment cost for retrofitting existing plants	van Vliet et al., 2012, Koch and Vögele, 2009, Hoffman et al., 2013
Rivers used for freight transport	Inland transport	Reduced load factor of inland ships	Increased transport prices (Rhine and Moselle market)	Jonkeren, 2009, Jonkeren et al., 2007
		Use of smaller ships	Existing barges below optimal size (Rhine)	Demirel, 2011
Agriculture, Northern and Continental Europe.	Arable crops	Sowing date as agricultural adaptation	Other constraints (e.g. frost) limit farmer behaviour	Oort, 2012
Agriculture, Northern and Continental Europe.	Arable crops	Irrigation	Groundwater availability, competition with other users.	Olesen <i>et al.</i> , 2011
Agriculture, Viticulture	High value crops	Change distribution	Legislation on cultivar and geographical region	Box 23-1
Conservation Cultural landscapes	Alpine meadow/	Extend habitat	No technological adaptation option.	Engler <i>et al.</i> , 2011, Dullinger <i>et al.</i> , 2012
Conservation of species richness	Movement of species	Extend habitat	Landscape barriers and absence of climate projections in selection of conservation areas.	Butchart et al., 2010, Araújo <i>et al.</i> , 2011; Filz <i>et al.</i> , 2012; Virkkala <i>et al.</i> , 2013
Forests	Movement of species and productivity reduction	Introduce new species	Not socially acceptable, Legal barriers to non-native species	Giuggiola <i>et al.</i> , 2010; Hemery <i>et al.</i> , 2010; García-López J.M. and Alluéa, 2011, Casalegno <i>et al.</i> , 2007

Source: Kovats et al. (2014)

**Limited evidence indicates a gap
between global adaptation needs and
the funds available for adaptation
(medium confidence)**

Selected published cost estimates for planned adaptation in European countries

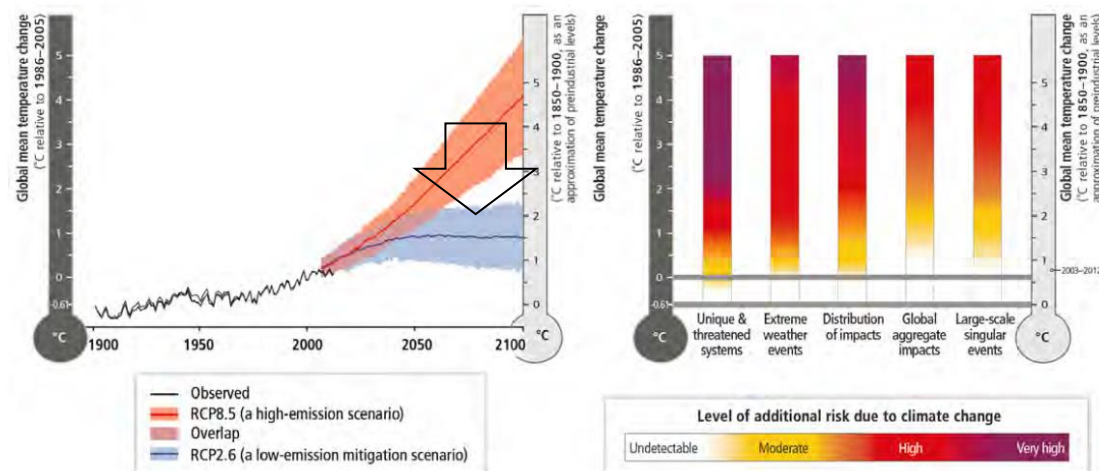
Region	Cost estimate	Time period	Sectors/Outcomes	Reference
Europe	€2.6-3.5 billion/a	In 2100	Coastal adaptation costs	Hinkel et al. 2010
Europe	€1.7 billion/a €3.4 billion/a €7.9 billion/a	By 2020s By 2050s By 2080s	Protection from river flood risk for EU27	Rojas et al., in press
Netherlands	€1.2–1.6 billion/a €0.9–1.5 billion/a	up to 2050 2050–2100	Protection from coastal and river flooding	Delta Committee, 2008
Sweden	total of up to €10 billion	2010-2100	Multi sector	Swedish Commission on Climate and Vulnerability, 2007
Italy	€0.4-2 billion Up to € 44 billion	By 2080s	Coastal protection Hydrogeological protection	Bosello et al. 2012, Medri et al. 2013.
Greece	€0.4-3.3 billion	Up to 2100	Coastal protection	Bank of Greece, 2011
UK	€1.8 billion €2.2 billion €7-8 billion	Until 2035 2035-2050 At 2100	Maintain and improve Thames flood protection Renew and improve Thames flood protection New Thames barrier for London	EA, 2011

Existing and emerging economic instruments can foster adaptation by providing incentives for anticipating and reducing impacts (*medium confidence*)

Instruments include:

- public-private finance partnerships
- loans
- payments for environmental services
- improved resource pricing
- charges and subsidies
- norms and regulations
- risk sharing and transfer mechanisms

Prospects for climate-resilient pathways for sustainable development are related fundamentally to what the world accomplishes with climate-change mitigation (*high confidence*)



Thank you for your attention

WG II SPM, TS and chapters can be found at:

<http://www.ipcc.ch/>