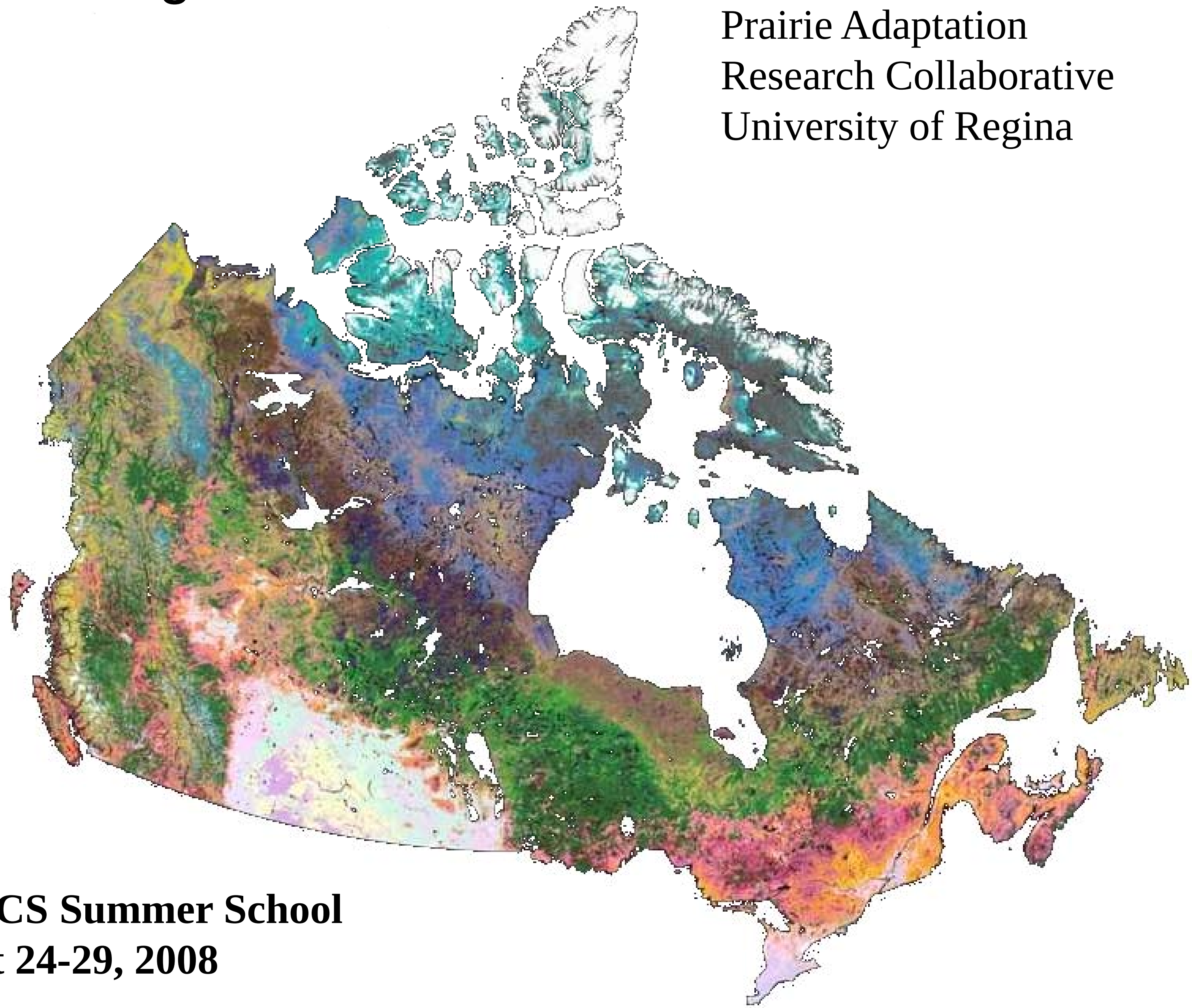
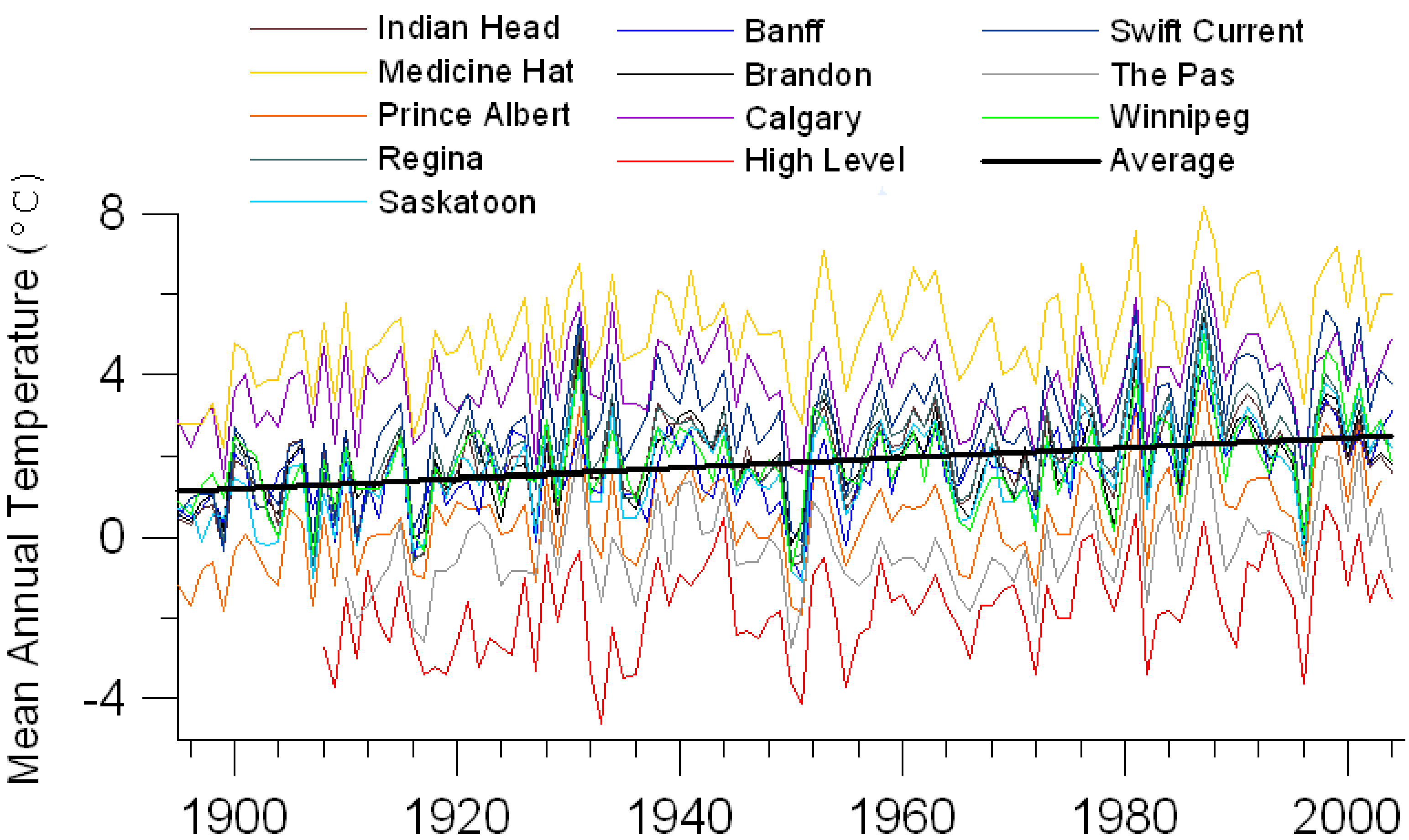
Climate Change Overview

Dave Sauchyn
Prairie Adaptation
Research Collaborative
University of Regina

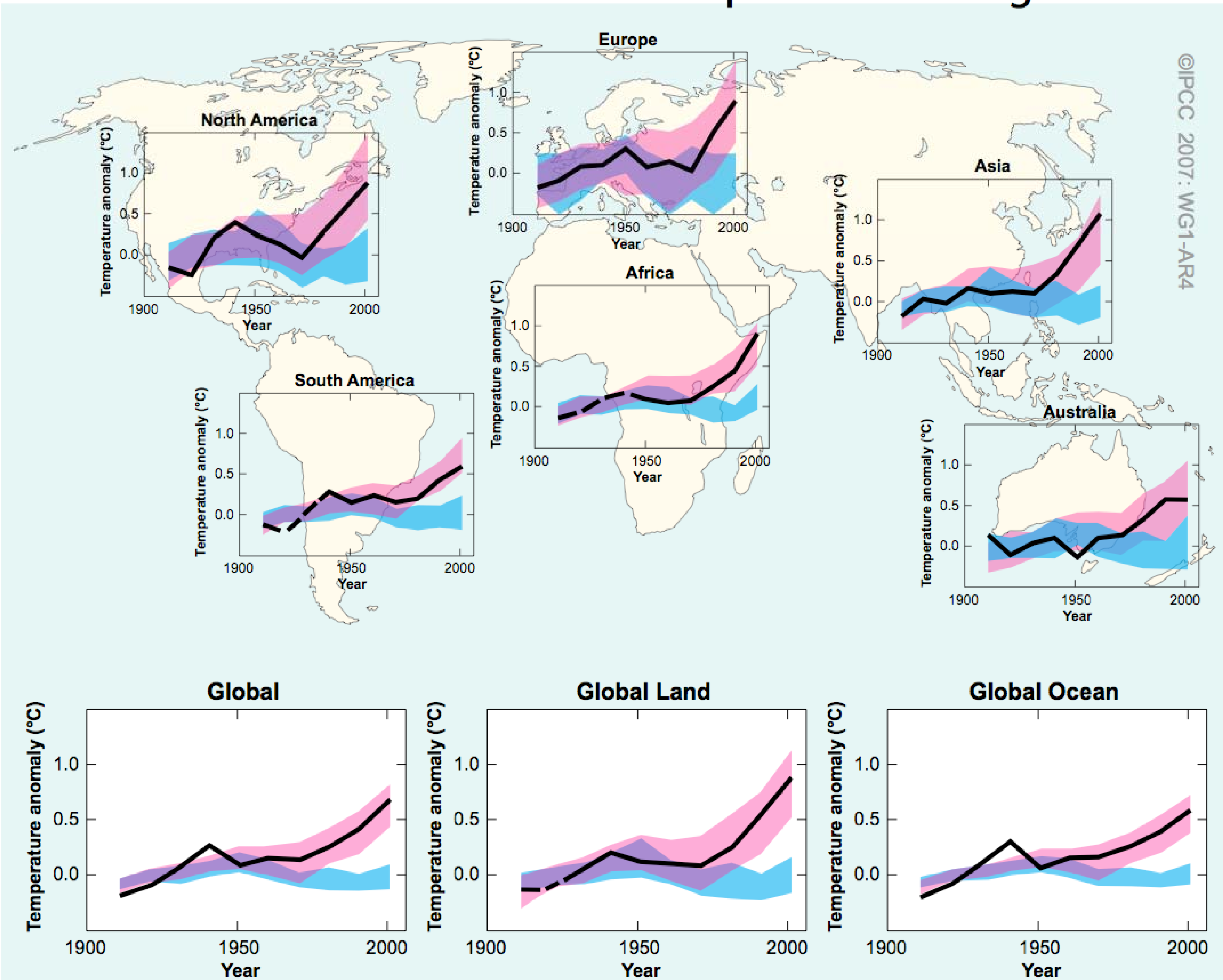


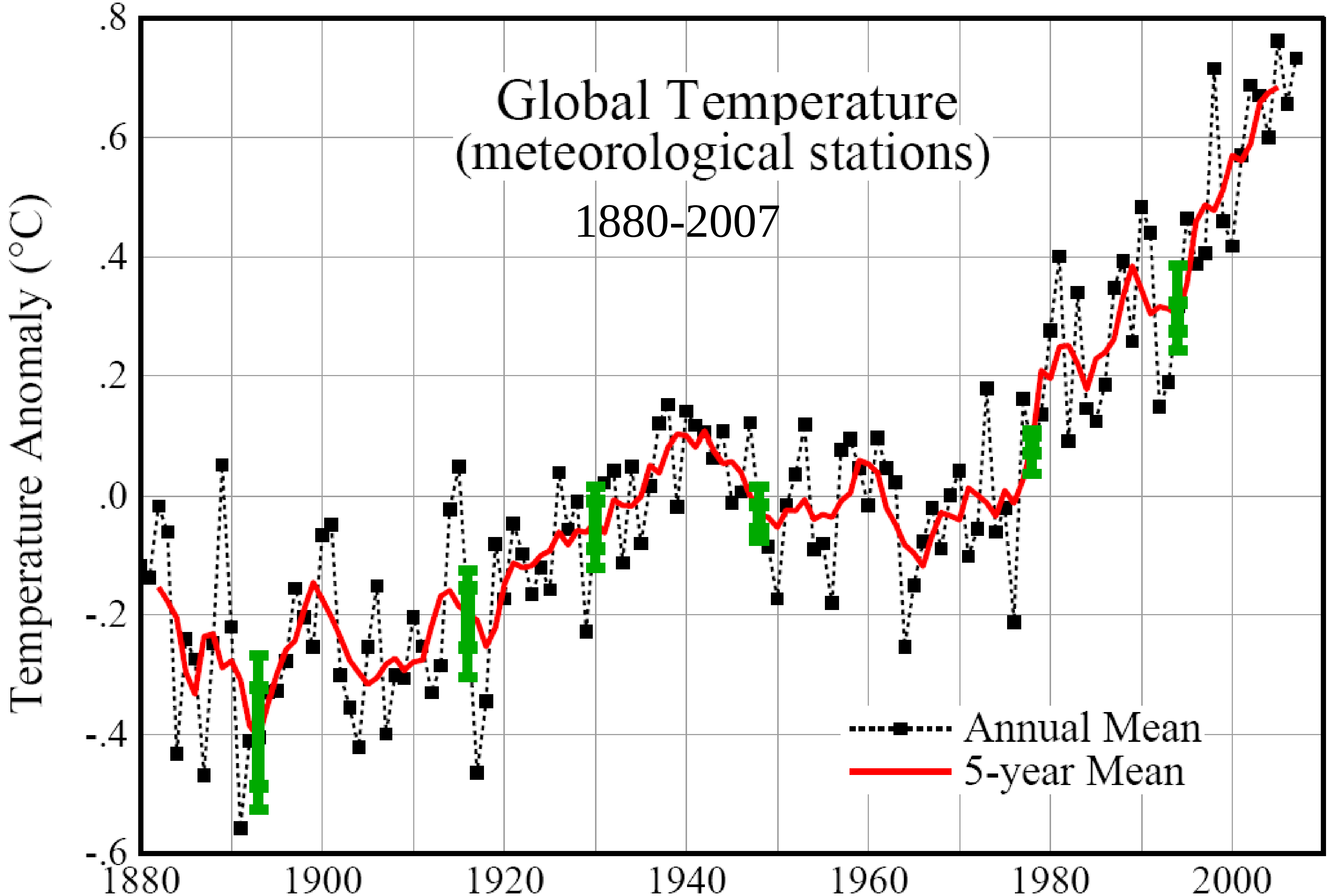
IEA GHG CCS Summer School
2008, August 24-29, 2008



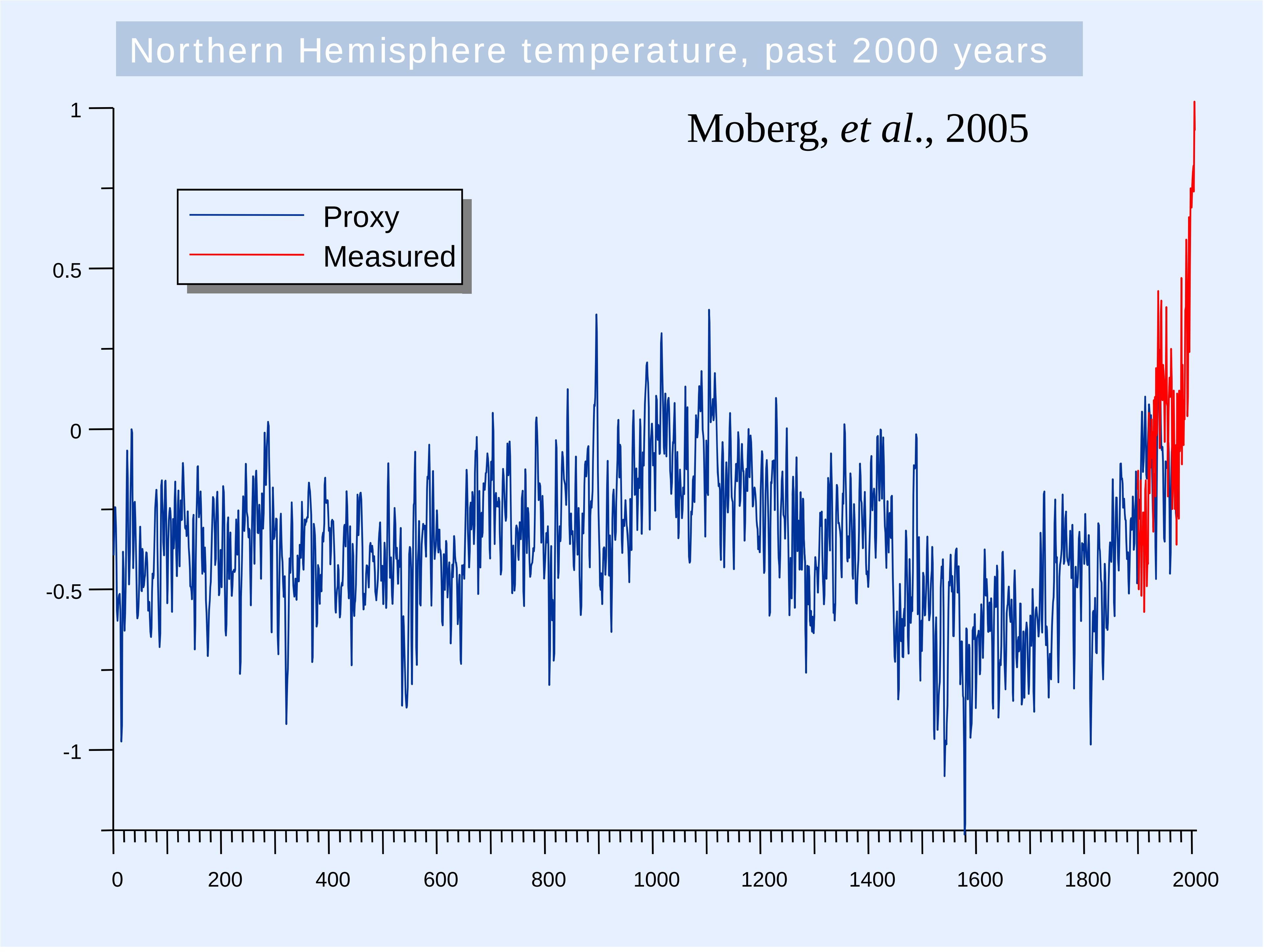
Trends in mean annual temperature since 1895 for 12 climate stations spread across the Prairies. The average increase in mean annual temperature for the 12 stations is 1.6°C.

Global and Continental Temperature Change



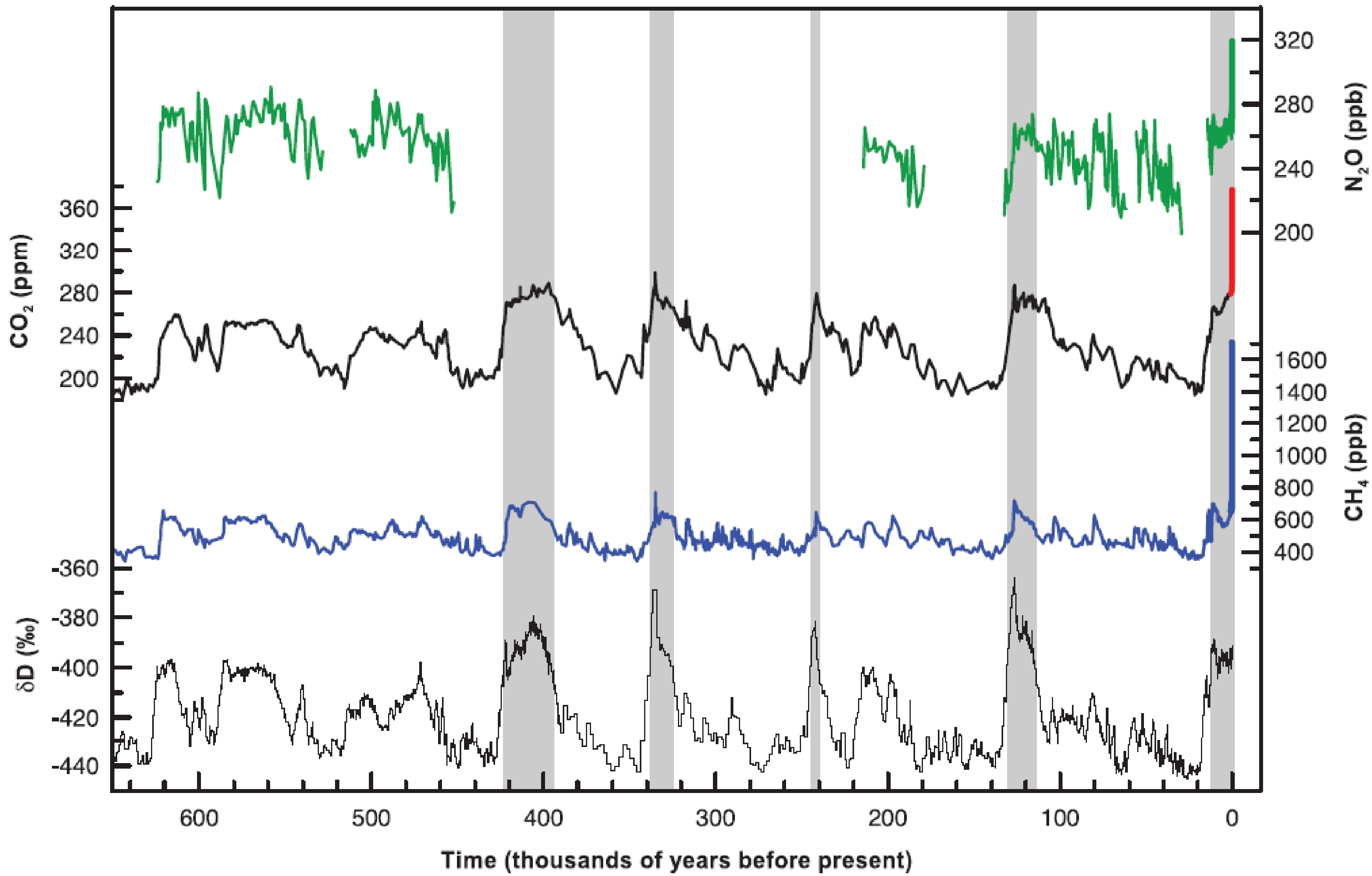


http://data.giss.nasa.gov/gistemp/

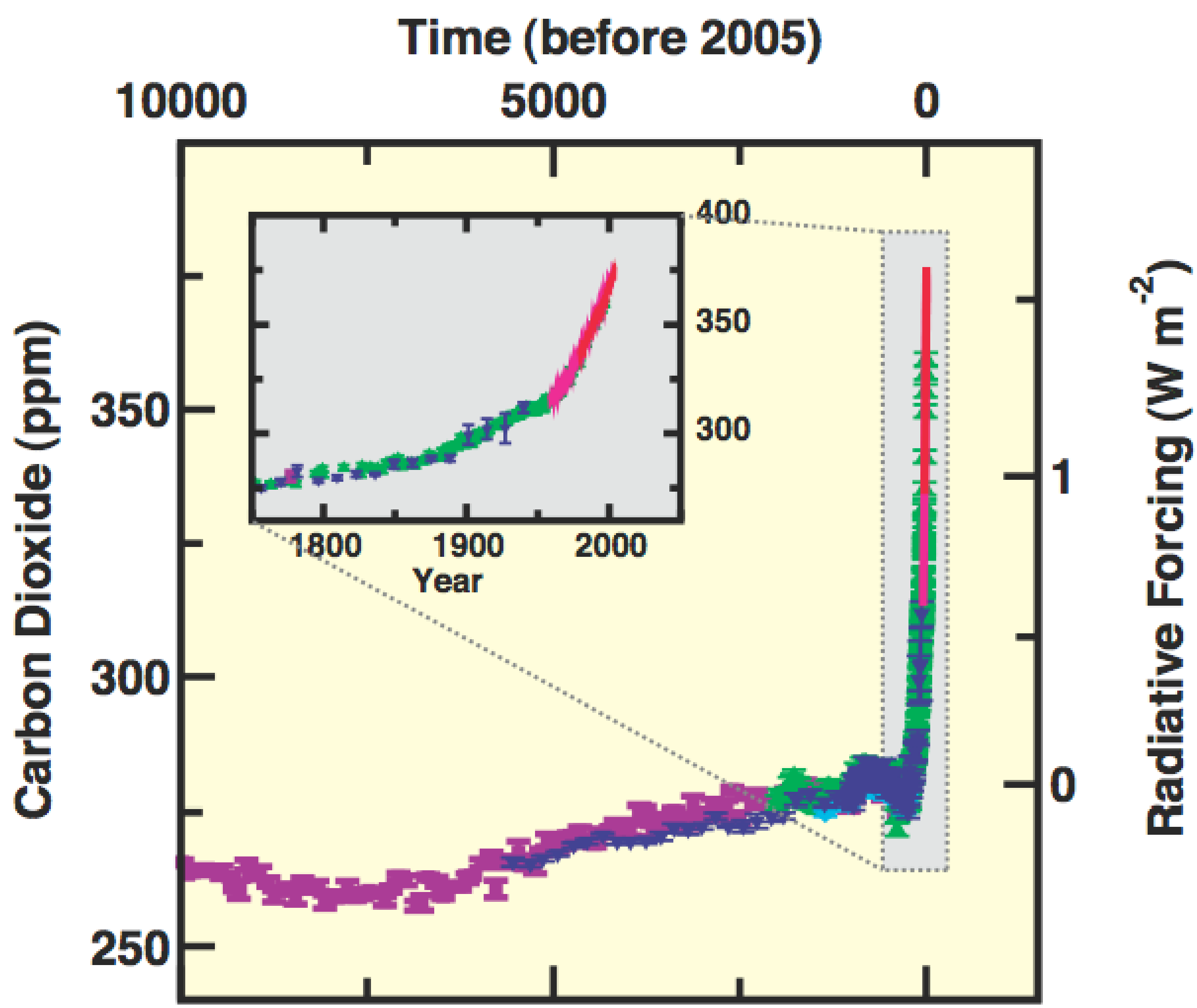


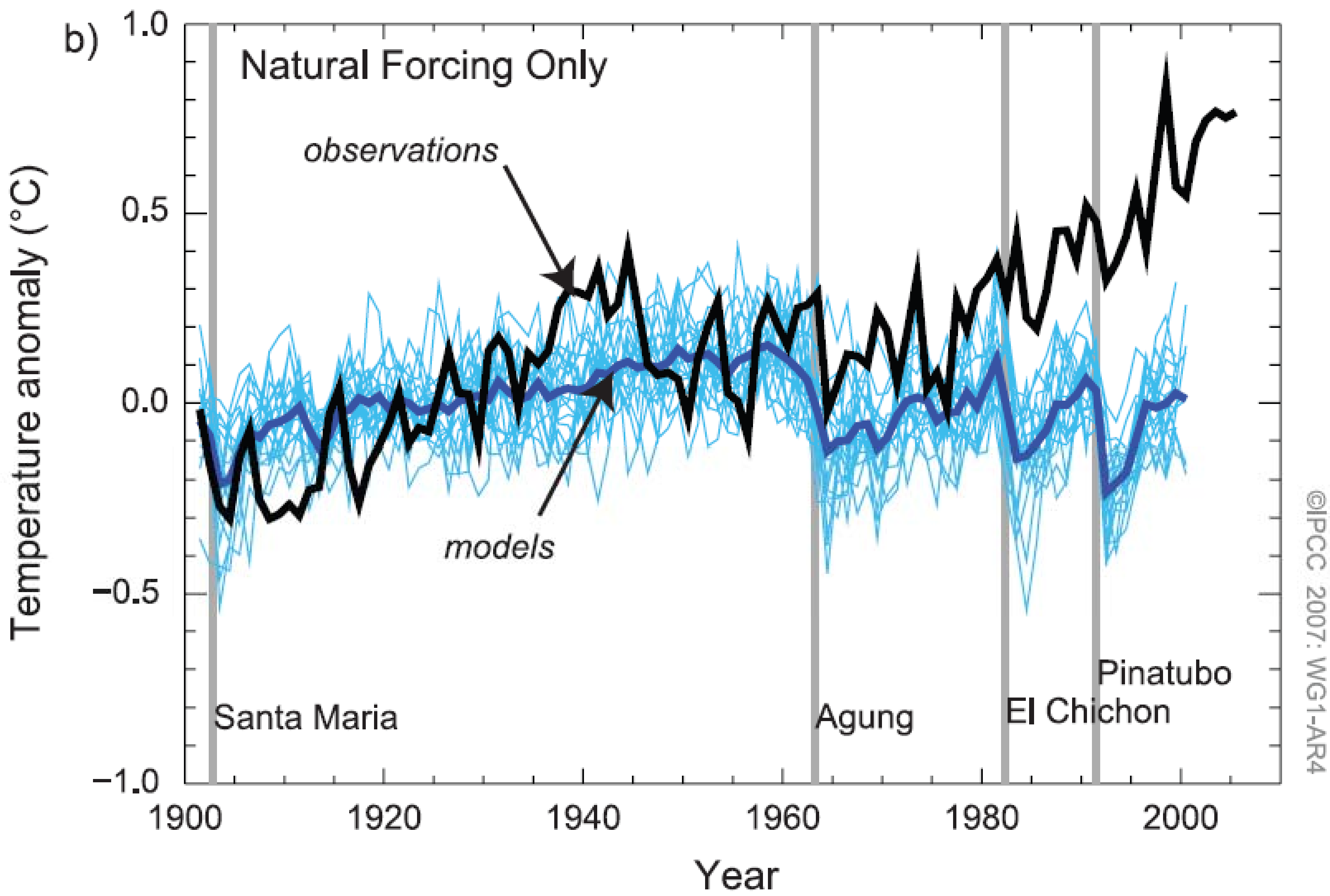
Northern Hemisphere temperature, past 2000 years
Moberg, *et al.*, 2005
Proxy
Measured
1
0.5
0
-0.5
-1
0
200
400
600
800
1000
1200
1400
1600
1800
2000

Glacial-Interglacial Ice Core Data

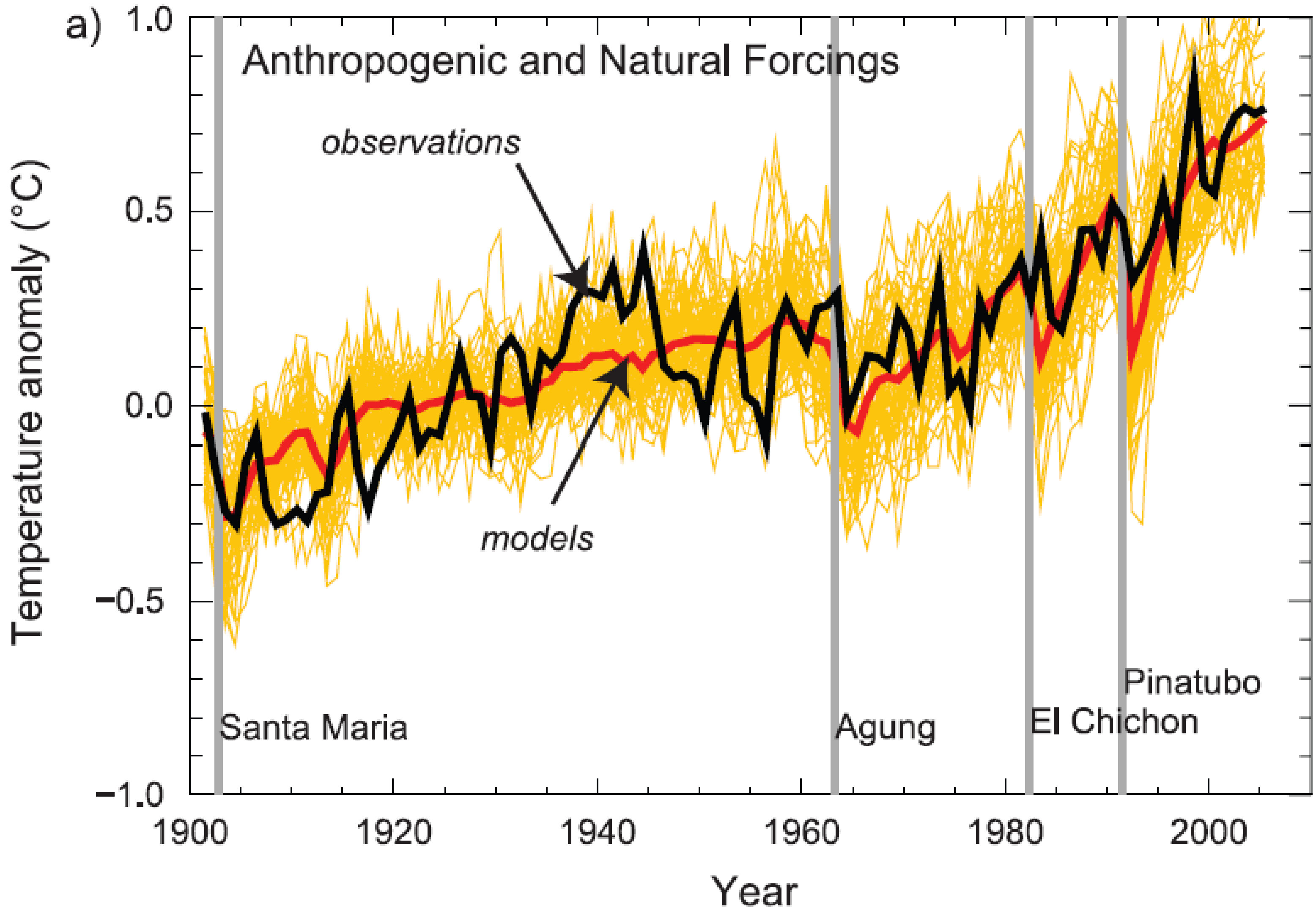


Deuterium (δD), a proxy for temperature, and the concentrations of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) in air trapped within the ice cores and from recent atmospheric measurements.

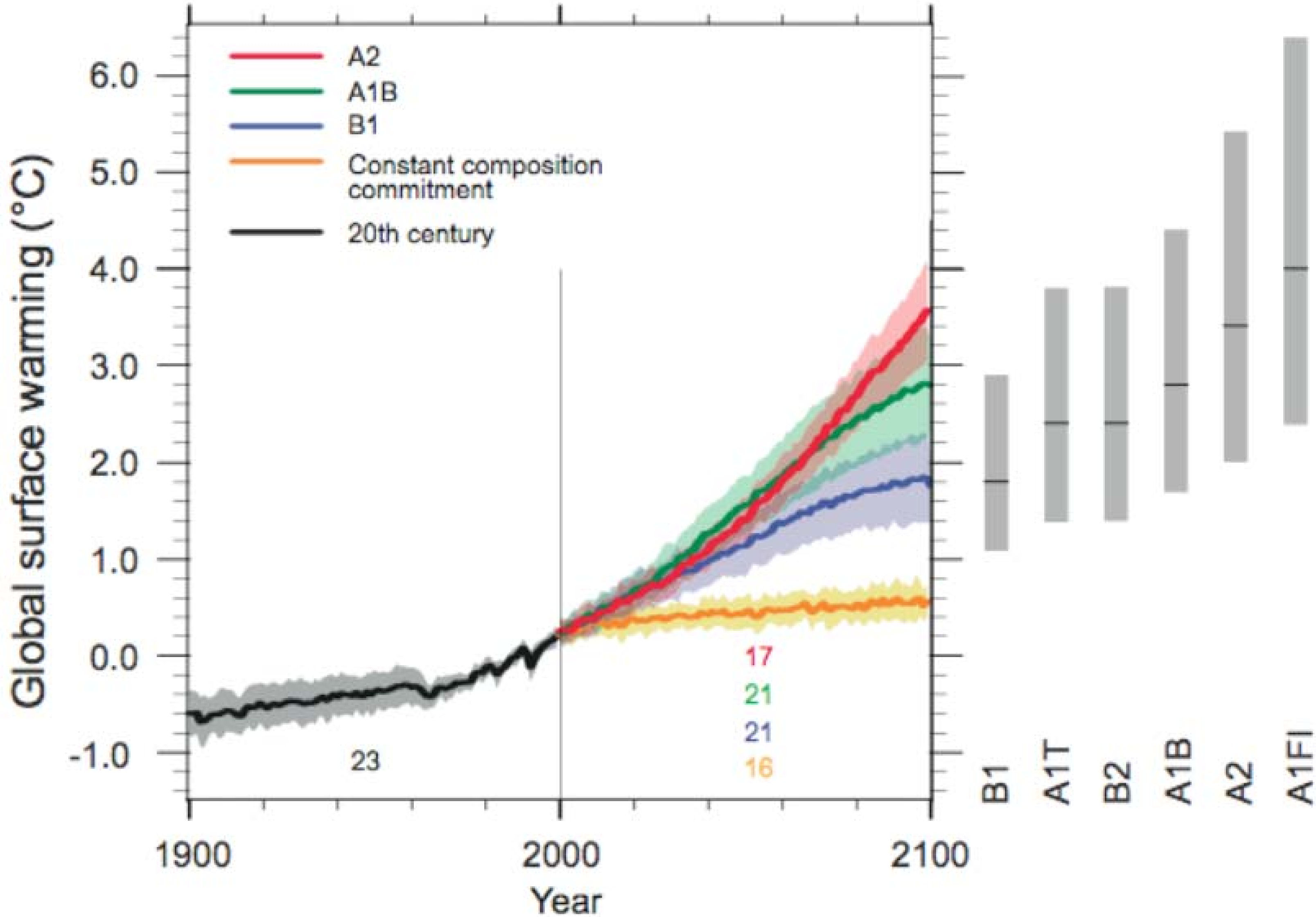

Time (before 2005)
10000
5000
0
Carbon Dioxide (ppm)
350
300
250
Radiative Forcing (W m^-2)
1
0
400
350
300
1800
1900
2000
Year



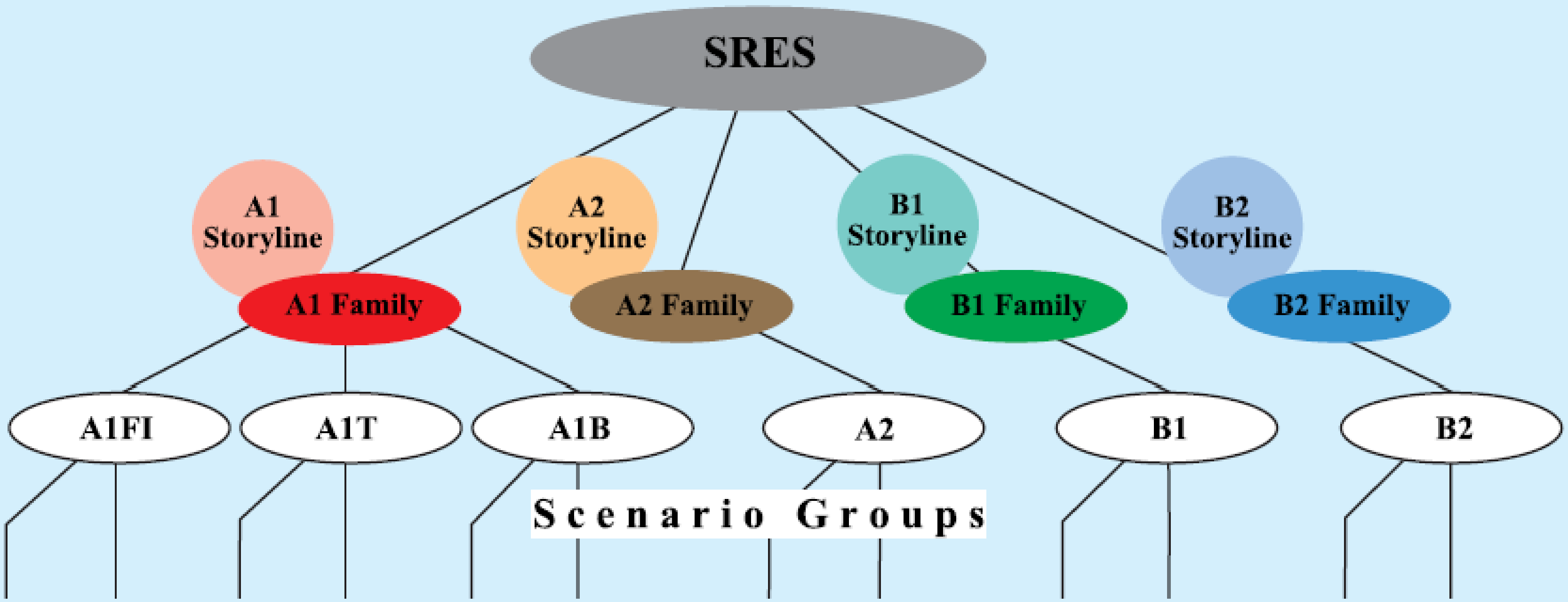
Global mean surface temperature anomalies relative to 1901 to 1950; the thick blue curve shows the multi-model ensemble mean and the thin lighter blue curves show individual simulations.



Global mean surface temperature anomalies relative to 1901 to 1950: the thick red curve shows the multi-model ensemble mean and the thin yellow curves show the individual simulations.



Anthropogenic warming and sea level rise would continue for centuries, due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized.



All SRES scenarios are equally valid with no assigned probabilities of occurrence. The set of scenarios consists of six scenario groups drawn from the four families: one group each in A2, B1, B2, and three groups within the A1 family, characterizing alternative developments of energy technologies: A1FI (fossil fuel intensive), A1B (balanced), and A1T (predominantly non-fossil fuel).

GHG Emission (SRES) Scenarios

	Temperature Change (°C at 2090-2099 relative to 1980-1999) [a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999)
Case	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations [c]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

IPCC 4th Assessment Report

- Most of the observed increase in globally averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations

- Warming would continue for centuries, even if greenhouse gas concentrations were to be stabilized

- A global assessment of data since 1970 has shown it is likely that anthropogenic warming has had a discernible influence on many physical and biological systems.

- Impacts due to altered frequencies and intensities of extreme weather, climate and sea-level events are very likely to change.

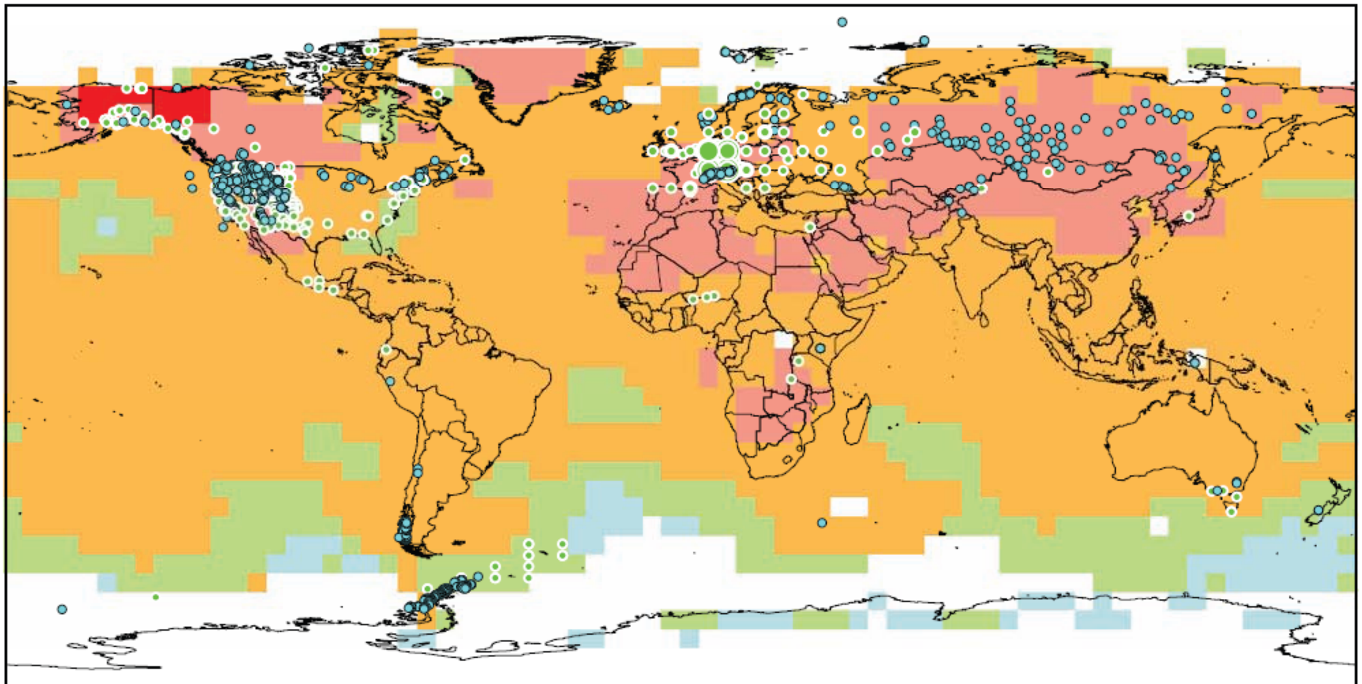
- Many impacts can be avoided, reduced or delayed by mitigation.

IPCC 4th Assessment Report

WMO INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE UNEP

800+ contributing authors
450+ lead authors from 130+ countries
2500+ scientitic expert reviewers
6 years of work
4 volumes

Oslo, 10 December 07
The Nobel Peace Prize



Region	Physical: number of significant observed changes	Biological: number of significant observed changes	Physical: percentage consistent with warming	Biological: percentage consistent with warming
NAM	355	455	94%	92%
LA	53	5	98%	100%
EUR	119	28,115	94%	89%
AFR	5	2	100%	100%
AS	106	8	96%	100%
ANZ	6	0	100%	–
PR*	120	24	91%	100%
TER	764	28,586	94%	90%
MFW**	1	85	100%	99%
GLO	765	28,671	94%	90%

Observed data series

- Physical systems (snow, ice and frozen ground; hydrology; coastal processes)
- Biological systems (terrestrial, marine, and freshwater)

Physical	Biological
Number of significant observed changes	Number of significant observed changes
Percentage of significant changes consistent with warming	Percentage of significant changes consistent with warming

Europe ***
1-30
31-100
101-800
801-1,200
1,201 -7,500

Temperature change °C 1970-2004

-1.0 -0.2 0.2 1.0 2.0 3.5

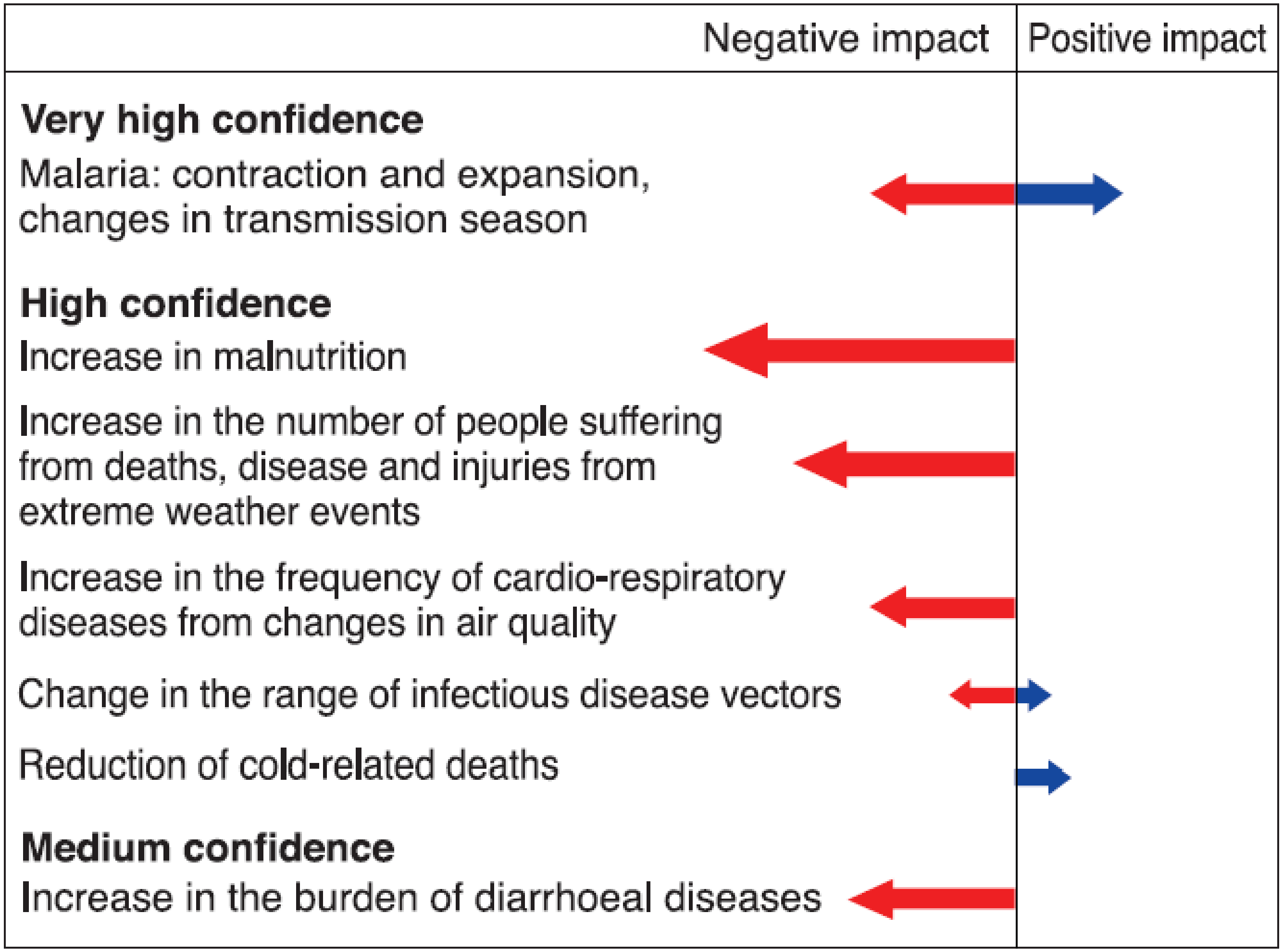
* Polar regions include also observed changes in marine and freshwater biological systems.

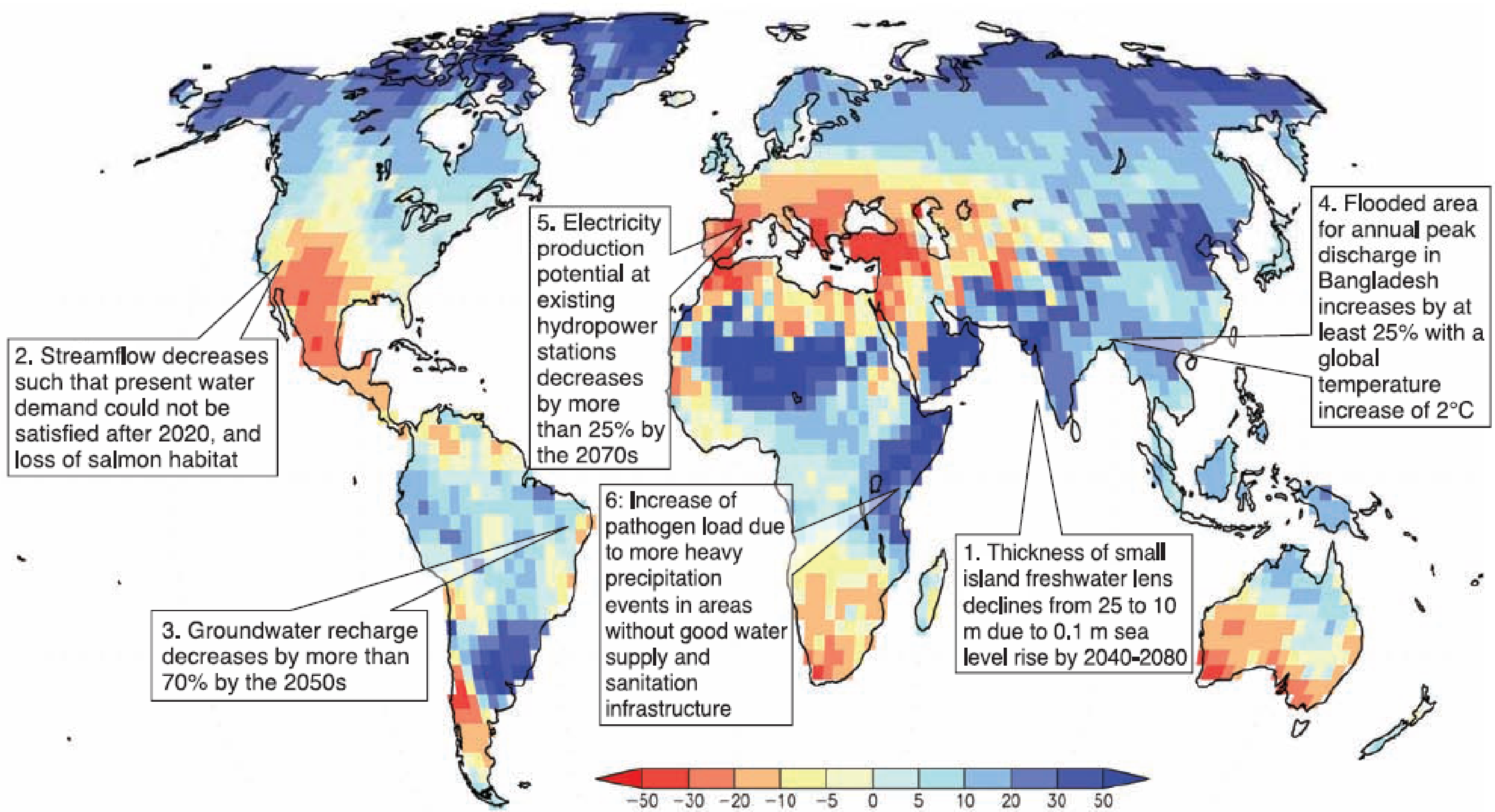
** Marine and freshwater includes observed changes at sites and large areas in oceans, small islands and continents. Locations of large-area marine changes are not shown on the map.

*** Circles in Europe represent 1 to 7,500 data series.

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* [e]	*Virtually certain* [e]
Warmer and more frequent hot days and nights over most land areas	*Very likely* [d]	*Likely (nights)* [e]	*Virtually certain* [e]
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]

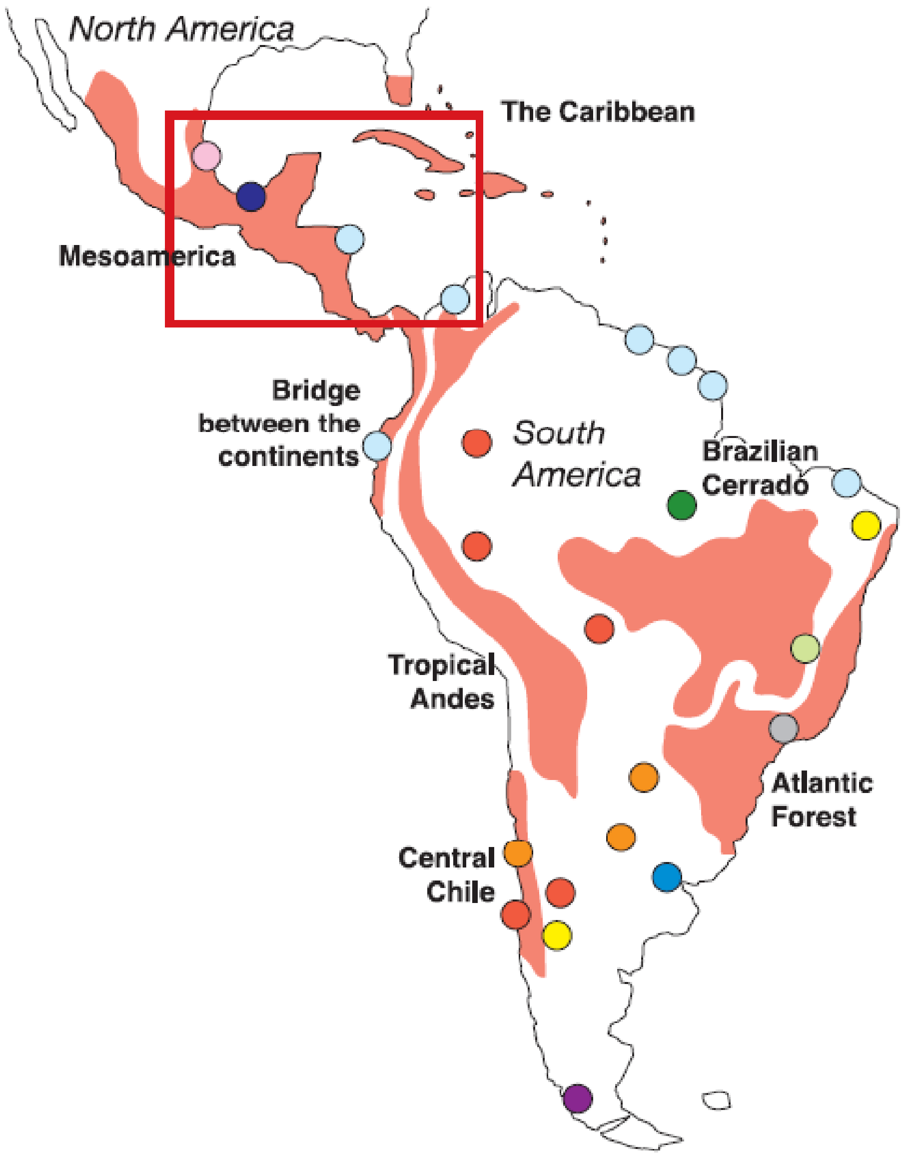
Health Impacts





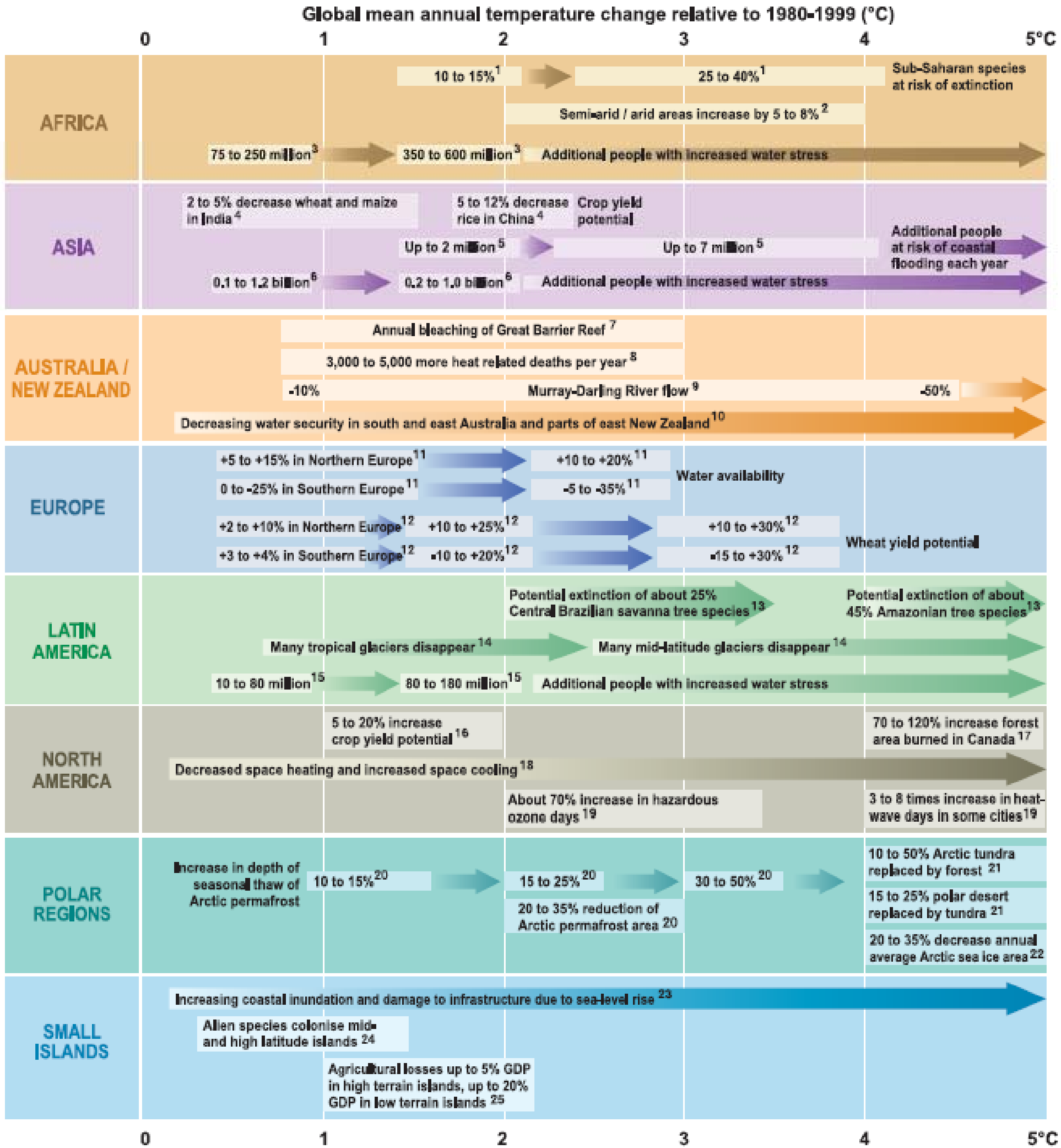
Map of future climate change impacts on freshwater. Background shows ensemble mean change of annual runoff, in percent, between the present (1981-2000) and 2081-2100

Climate Change Impacts – Latin America

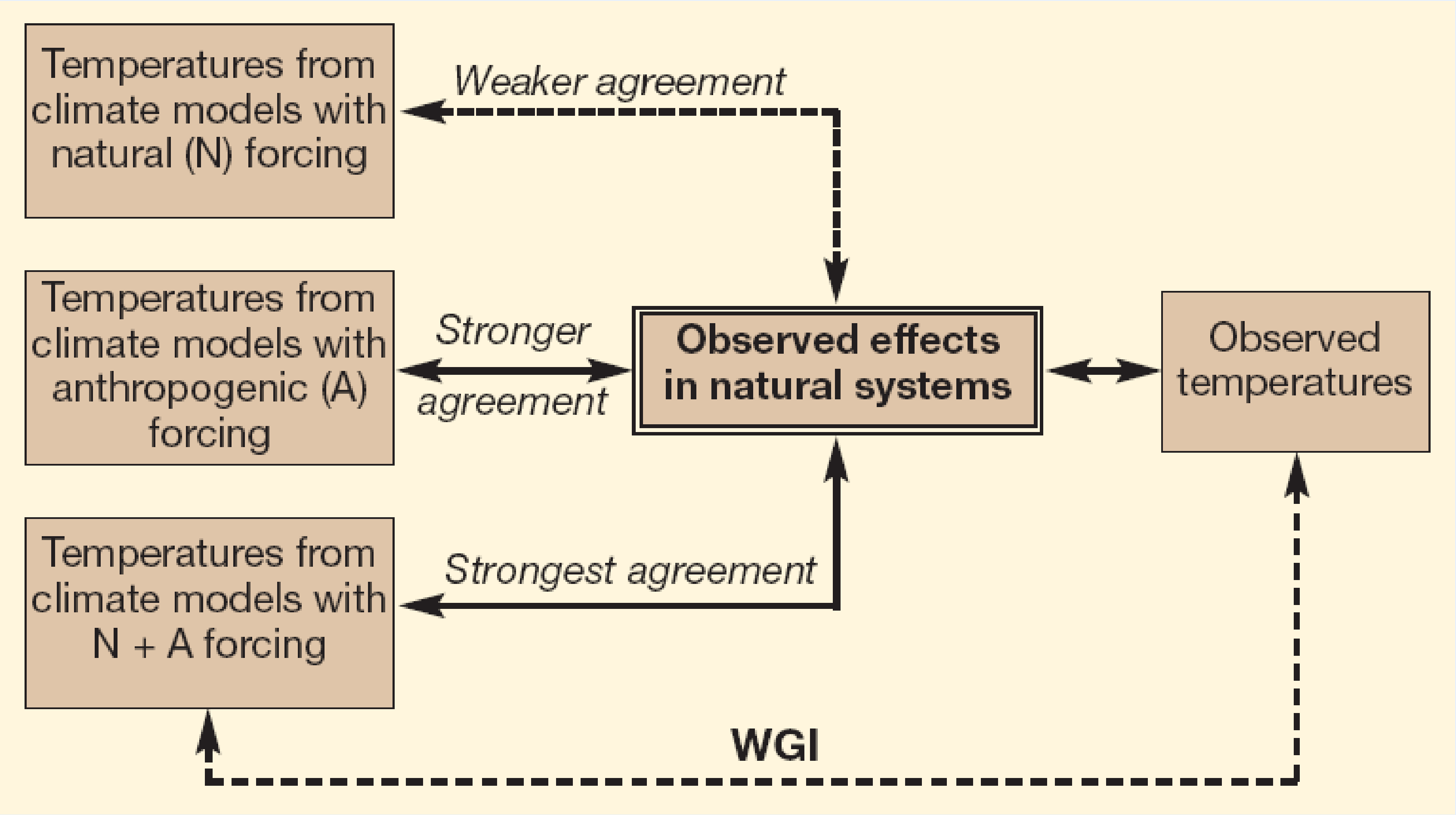


- Coral reefs and mangroves seriously threatened with warmer SST
- Under the worst sea-level rise scenario, mangroves are very likely to disappear from low-lying coastlines
- Amazonia: loss of 43% of 69 tree species by the end of 21st century; savannisation of the eastern part
- Cerrados: Losses of 24% of 138 tree species for a temperature increase of 2°C
- Reduction of suitable lands for coffee
- Increases in aridity and scarcity of water resources
- Sharp increase in extinction of: mammals, birds, butterflies, frogs and reptiles by 2050
- Water availability and hydro-electric generation seriously reduced due to reduction in glaciers
- Ozone depletion and skin cancer
- Severe land degradation and desertification
- Rio de la Plata coasts threatened by increasing storm surges and sea-level rise
- Increased vulnerability to extreme events

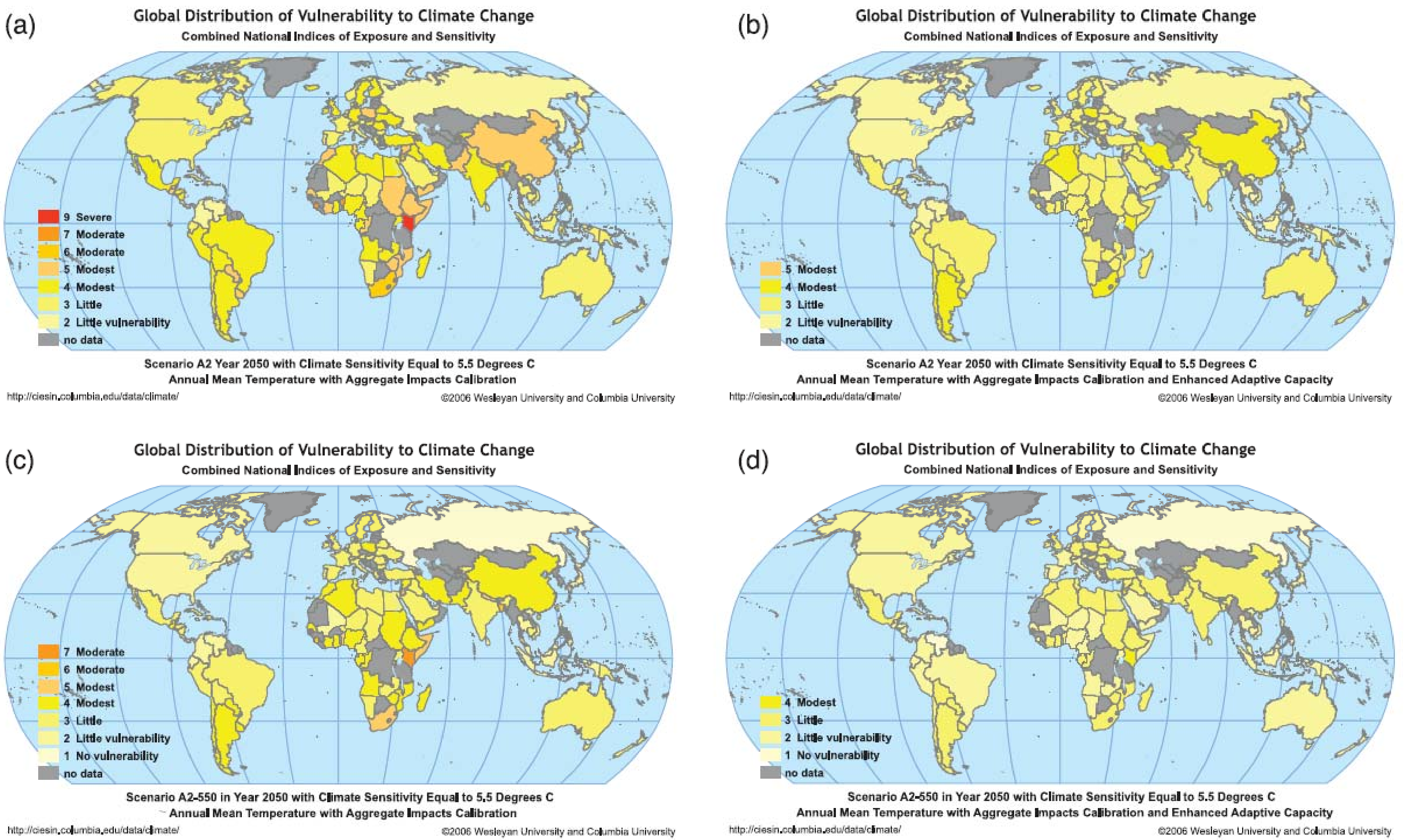
Areas in red correspond to sites where biodiversity is currently severely threatened and this trend is very likely to continue in the future


Global mean annual temperature change relative to 1980-1999 (°C)
0
1
2
3
4
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 35% 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

Impact Detection and Attribution

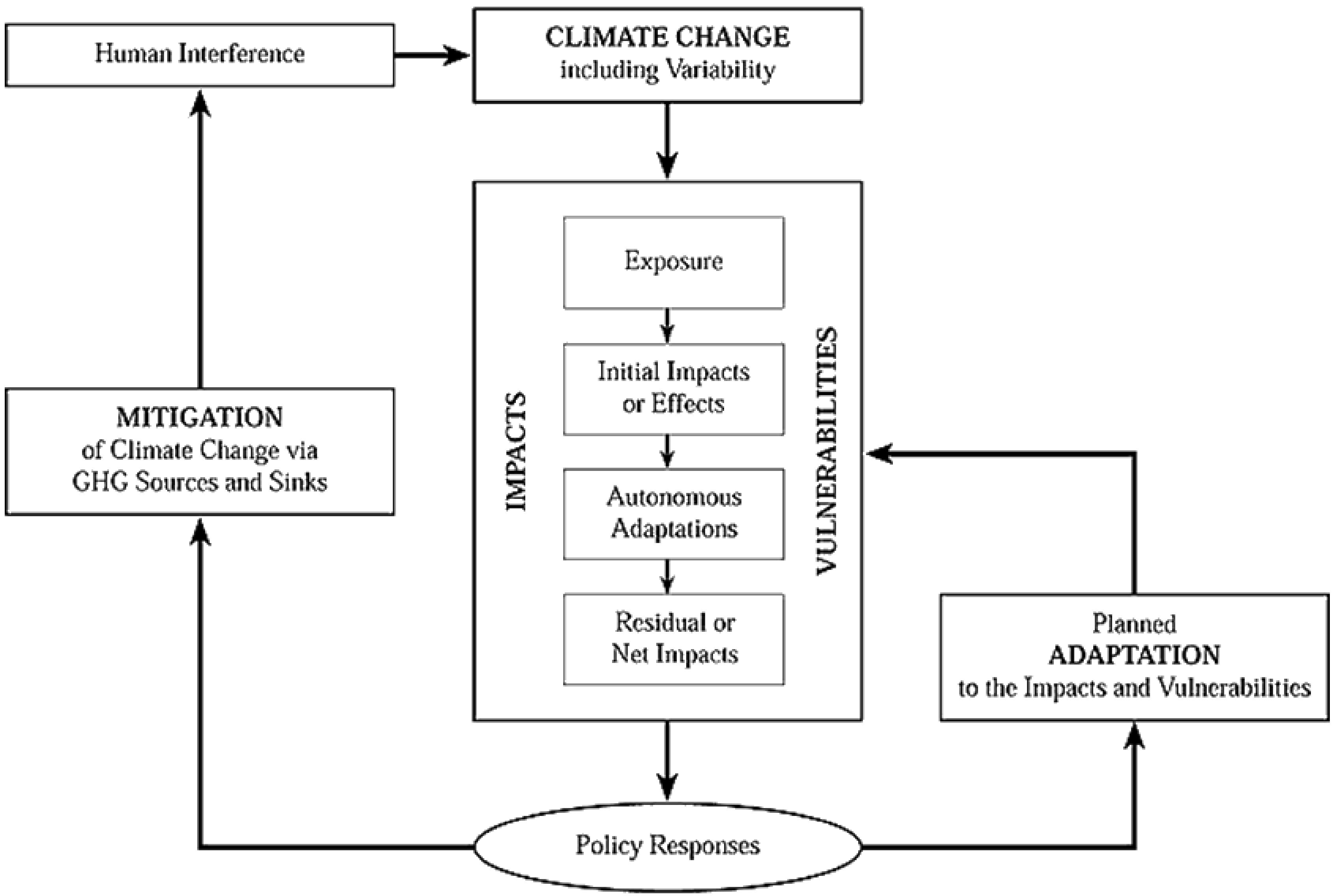


Geographical Distribution of Vulnerability in 2050 with and without Mitigation



SRES A2 and climate sensitivity of 5.5°C (a) current adaptive capacity (b) enhanced adaptive capacity (c) mitigation to cap GHGs at 550 ppm (d) mitigation (550 ppm) and enhanced adaptive capacity

Policy Options



Adaptation: adjustments in practices, processes, or structures of systems to projected or actual changes of climate (IPCC, 2001).

Premier's Forum on Climate Change
June 1, 2007, Regina

HOUSE OF COMMONS

39th Parliament 1st Session

Standing Committee on Environment and Sustainable Development (ENVI)

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Witness Information

Standing Committee on Environment and Sustainable Development

CANADA

NUMBER 010 | 2nd SESSION | 39th PARLIAMENT

EVIDENCE

Wednesday, January 30, 2008

Alberta Caucus, House of Commons, March 28, 2007

CLIMATE CHANGE: WE ARE AT RISK

Standing Senate Committee on Agriculture and Forestry

Senate of Canada **INTERIM REPORT**

CHAPTER 5:

EFFECTS OF CLIMATE CHANGE ON WATER

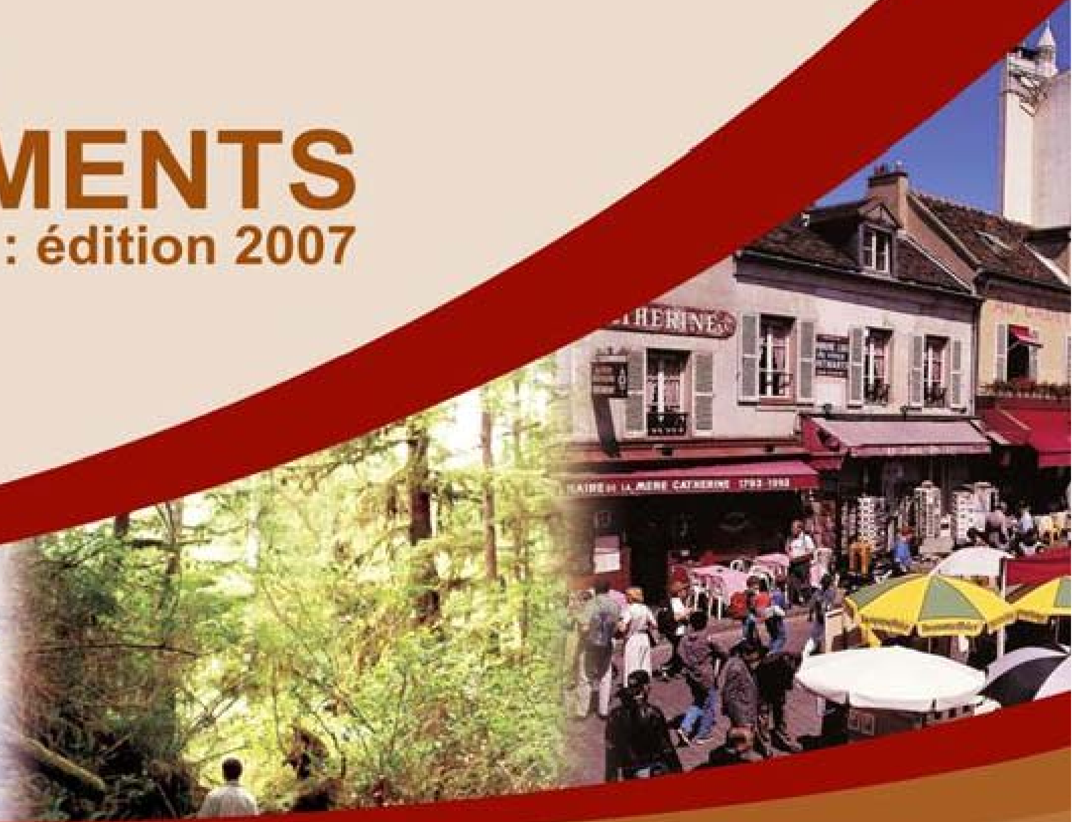
"…the climate anomaly of greatest concern is drought."

Dr. Dave Sauchyn, University of Regina[2]

Meeting the Challenge
Alberta's Climate Change Plan
International Expert Panel
June 8, 2007
Kananaskis, Alberta

FROM IMPACTS to ADAPTATION
Canada in a Changing Climate 2007

VIVRE AVEC LES CHANGEMENTS
climatiques au Canada : édition 2007

Government of Canada Gouvernement du Canada

Canada

A robust, scientific process with many partners:

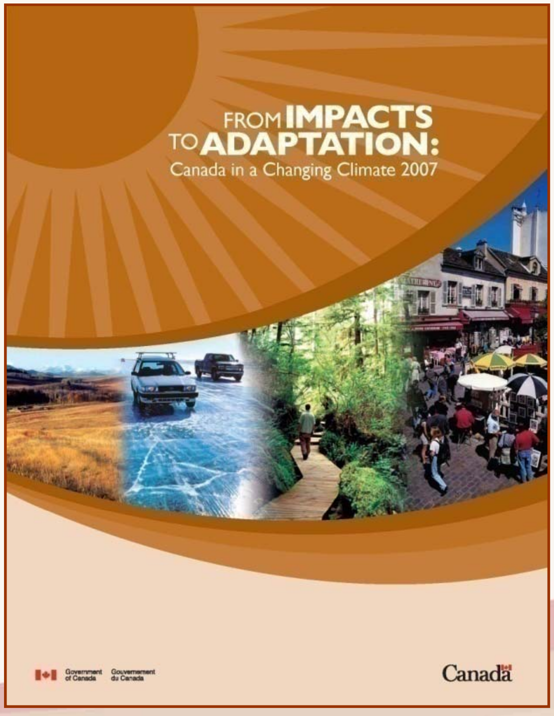
- The process was overseen by an advisory committee with representation from governments, academia, Aboriginal groups and the private sector.
- 145 authors from governments, universities and NGOs from across Canada participated, and over 3100 references were cited.
- Chapters were reviewed by 110 scientific experts and government (Federal, Provincial/Territorial) officials.

The Assessment Report

First national-scale assessment of climate change impacts and adaptation in Canada since the Canada Country Study (1997)

GOALS

- Highlight advances made in understanding Canada's vulnerability to climate change in past decade
- Provide a knowledge foundation that informs adaptation decision-making and policy development in a non-prescriptive manner



Conclusions: impacts

2 - Climate change will exacerbate many current climate risks, and present new risks and opportunities, with significant implications for communities, infrastructure and ecosystems.

Exacerbate current climate risks

- Reduced water quality and quantity across Canada
- Increasing demands for water
- Increased frequency and magnitude of extreme events

New risks and opportunities

- New diseases and pests
- New challenges to management of protected areas
- New opportunities for more profitable crops and tree species

MORE INFORMATION

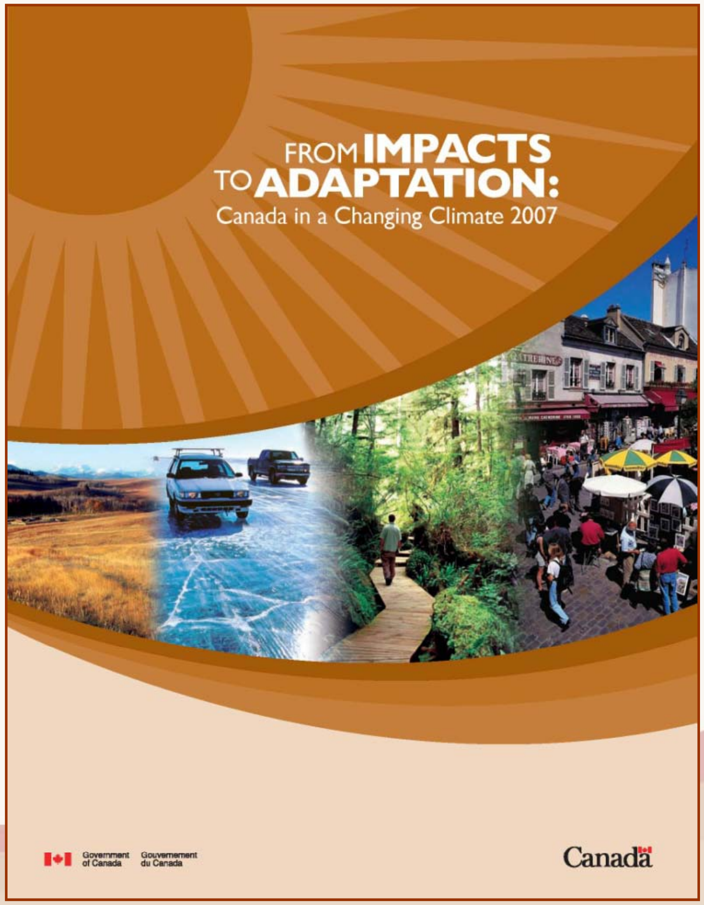
Available on-line on March 6:

http://adaptation2007.nrcan.gc.ca

- Download pdfs
- Author biography
- Order CDs

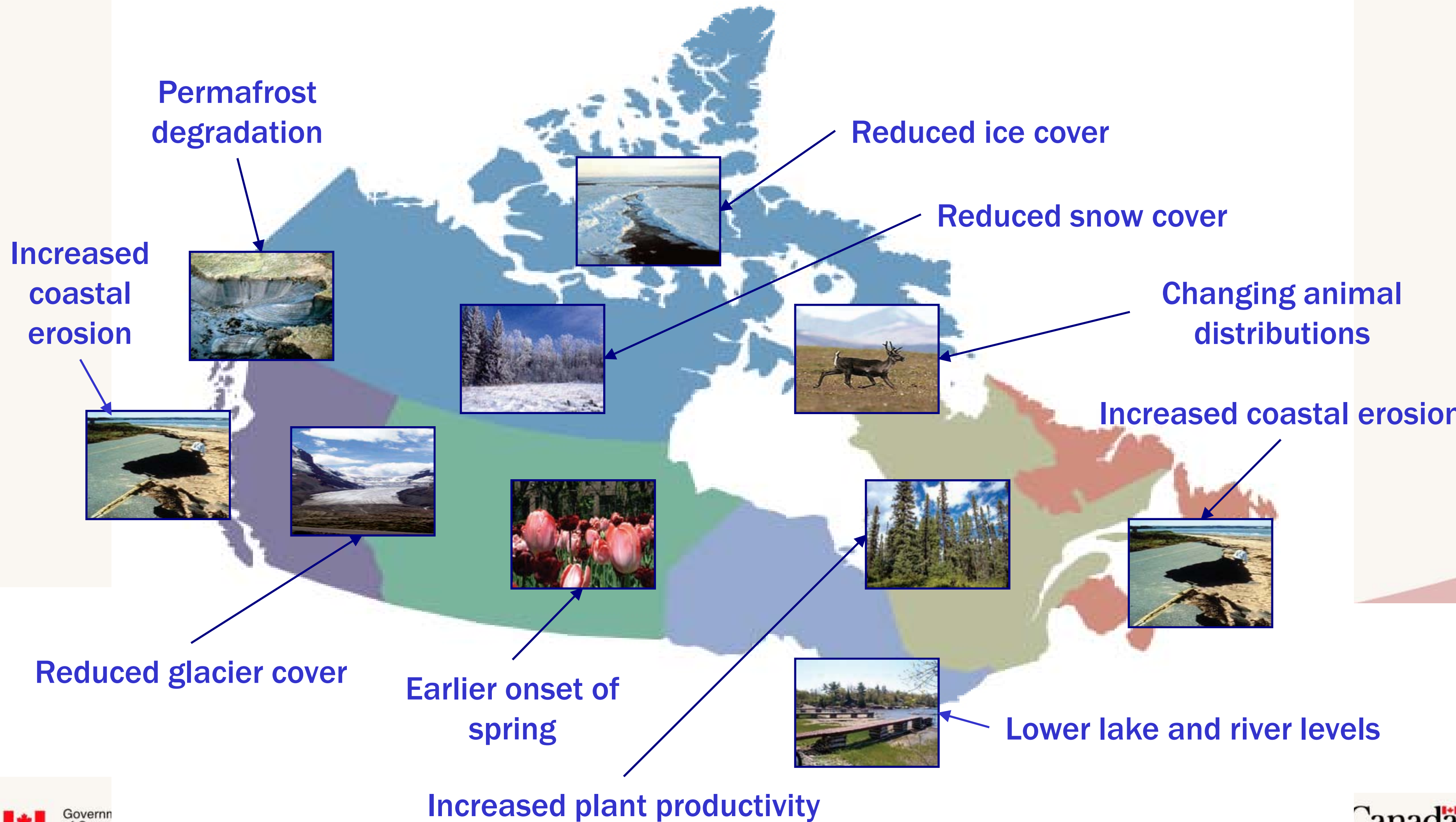
Questions? Contact us at:

adaptation@nrcan.gc.ca



Conclusions: impacts

1 - The impacts of changing climate are already evident in every region of Canada.



CHAPTER 7
Prairies

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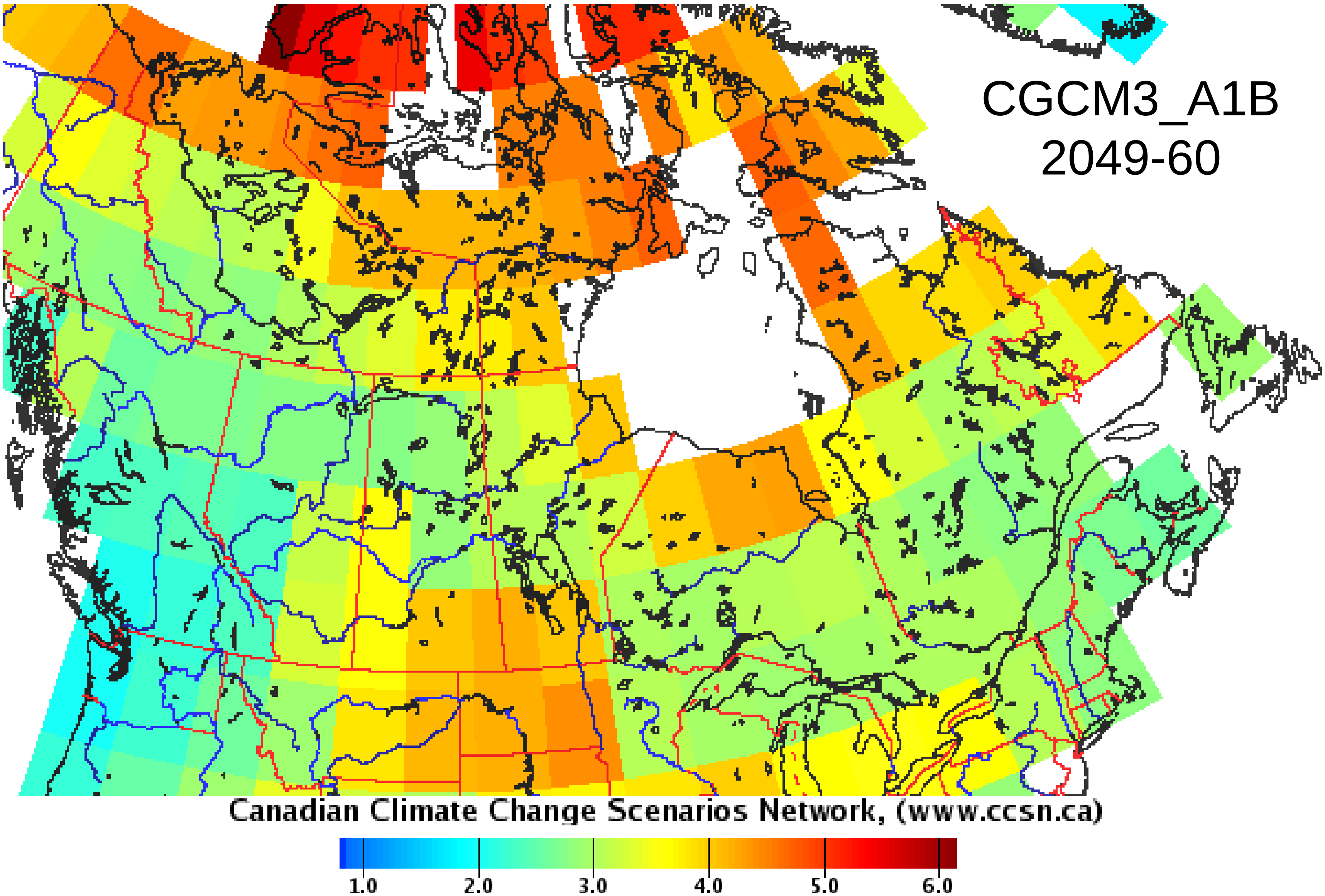
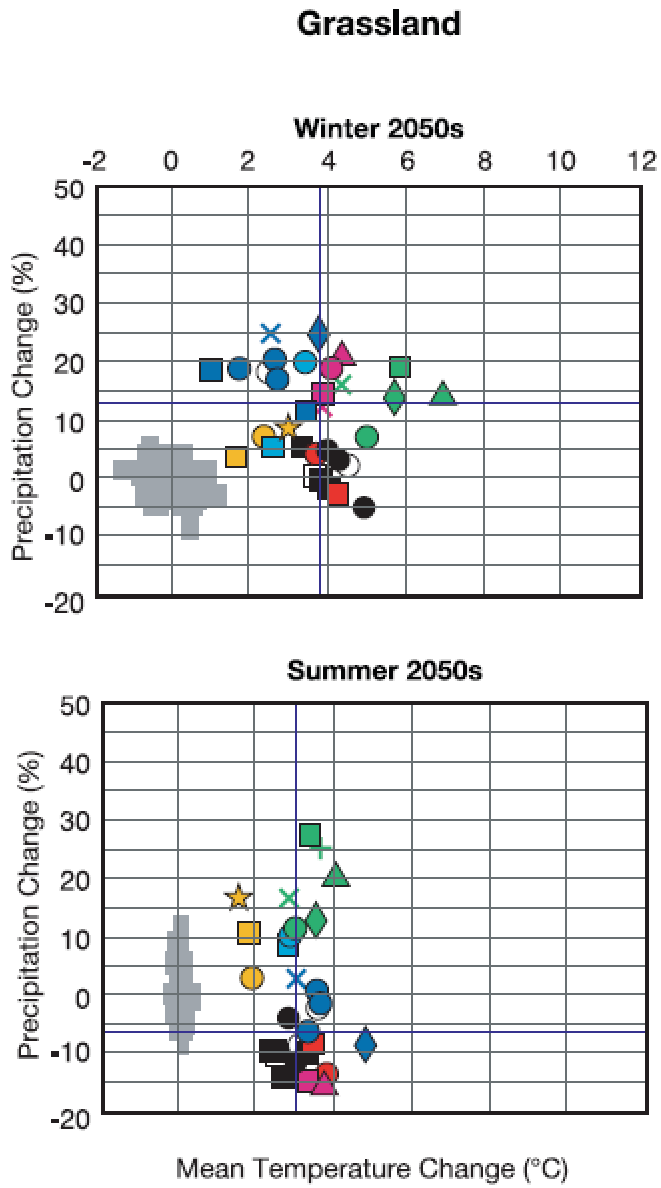
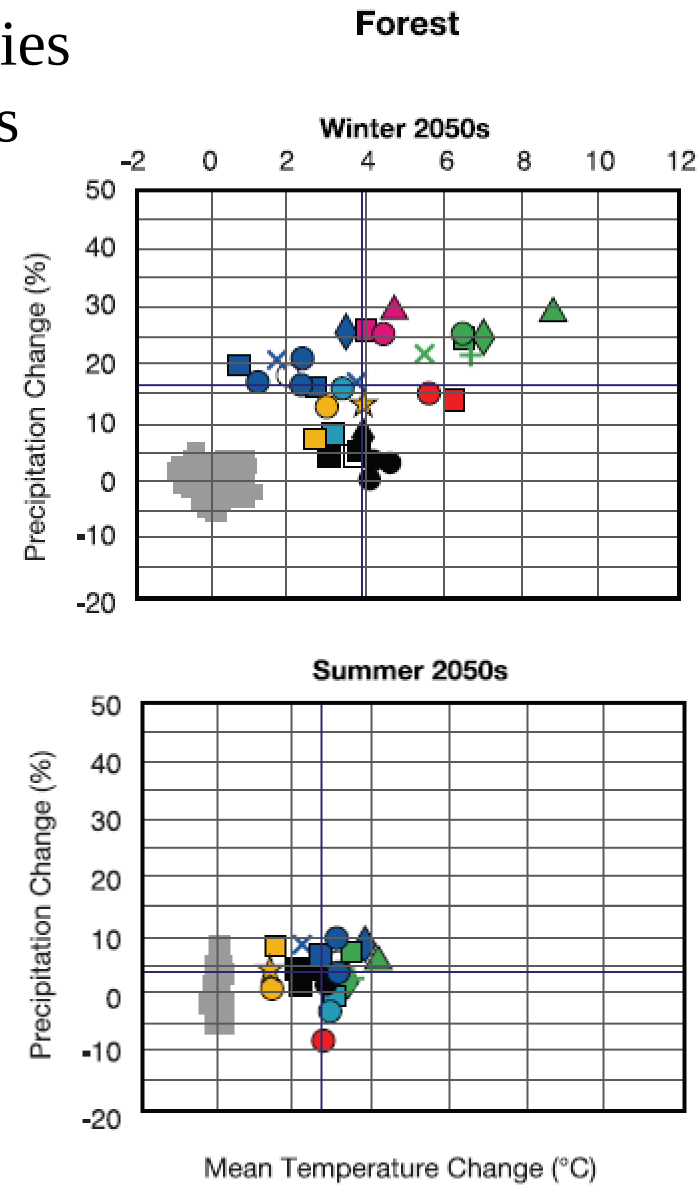
Mean Annual Temperature (° C) 2049-60 versus 1961-90



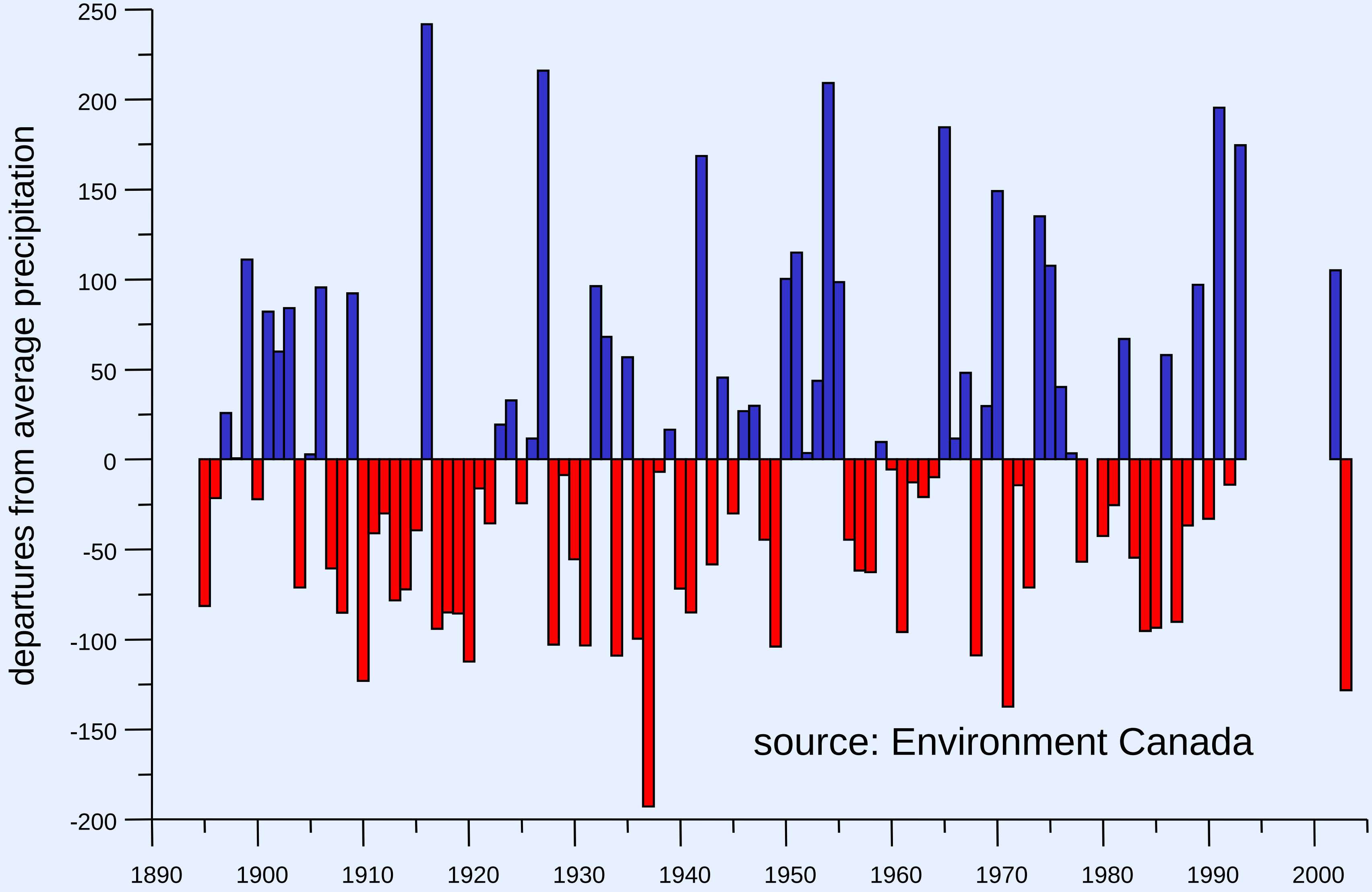
Canadian Prairies CC Scenarios



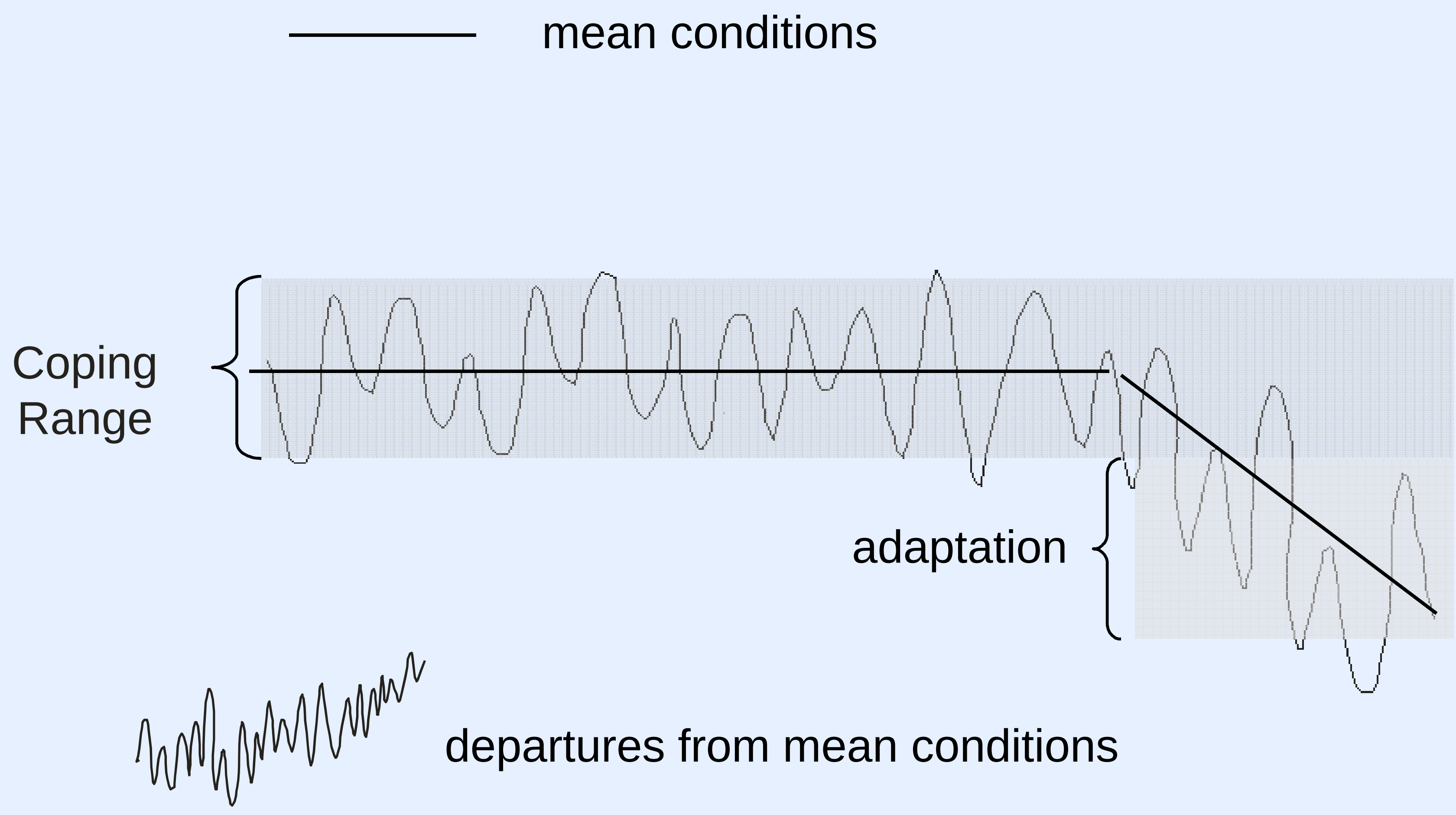


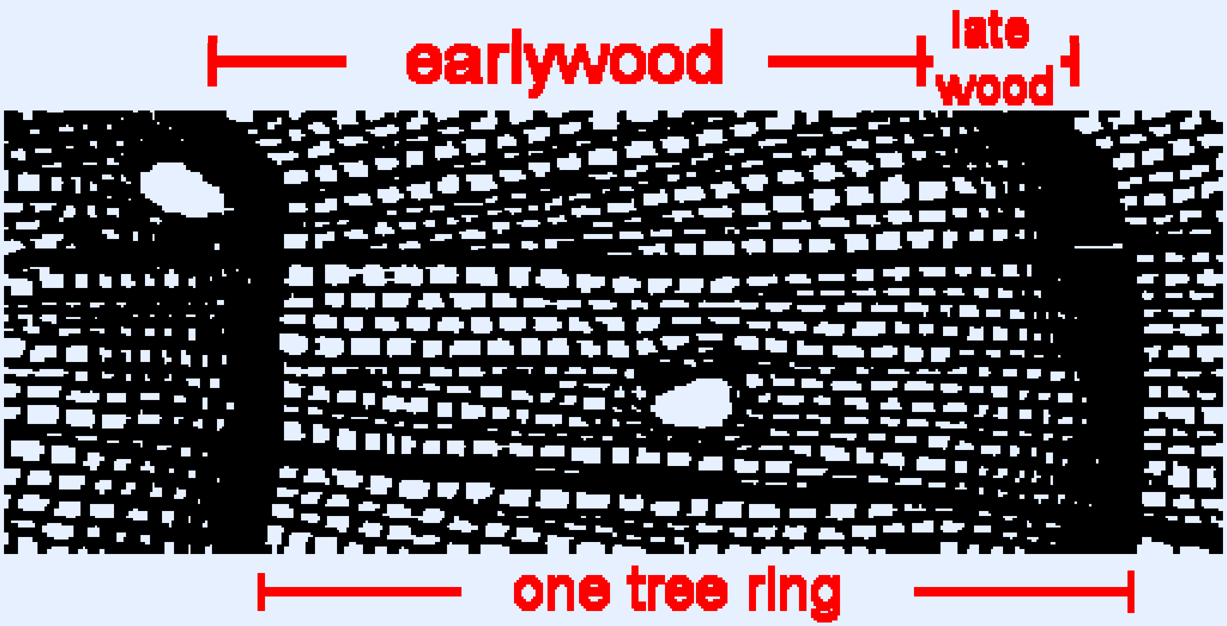
Projected changes in mean seasonal temperature and precipitation for the grassland forest regions. The grey squares indicate the 'natural' climate variability simulated by a long control run of the CGCM2.

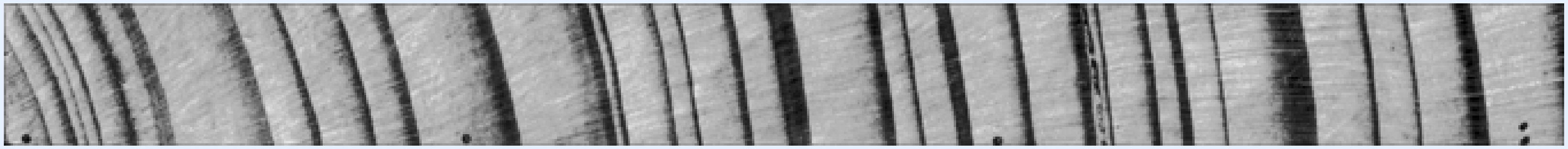
Annual Precipitation, Swift Current, 1895-2003



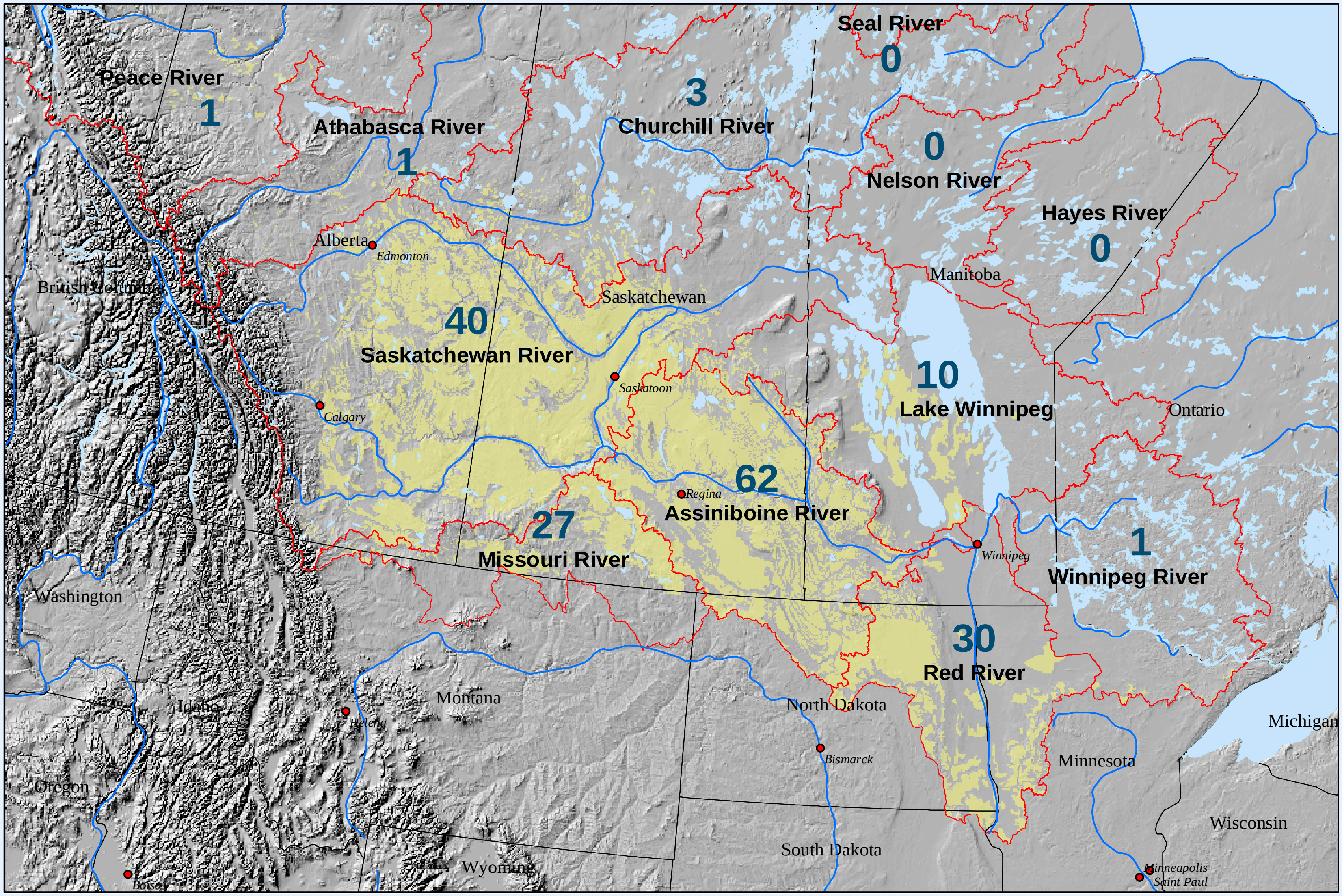
Climate Trends and Variability




earlywood
late
wood
one tree ring



Prairie Drainage Basins (source: PFRA)



South Saskatchewan River at Medicine Hat, 1402-2004

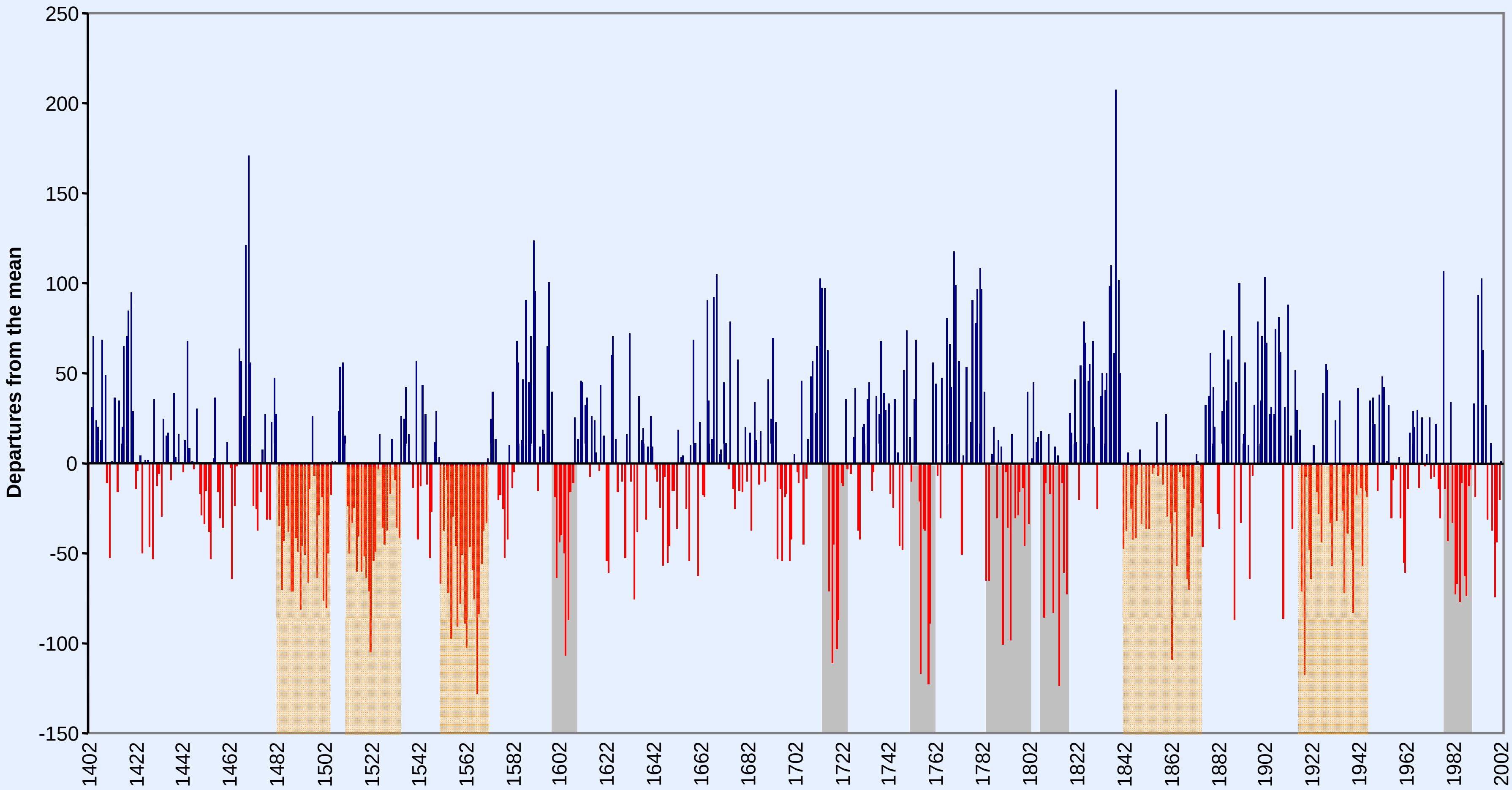
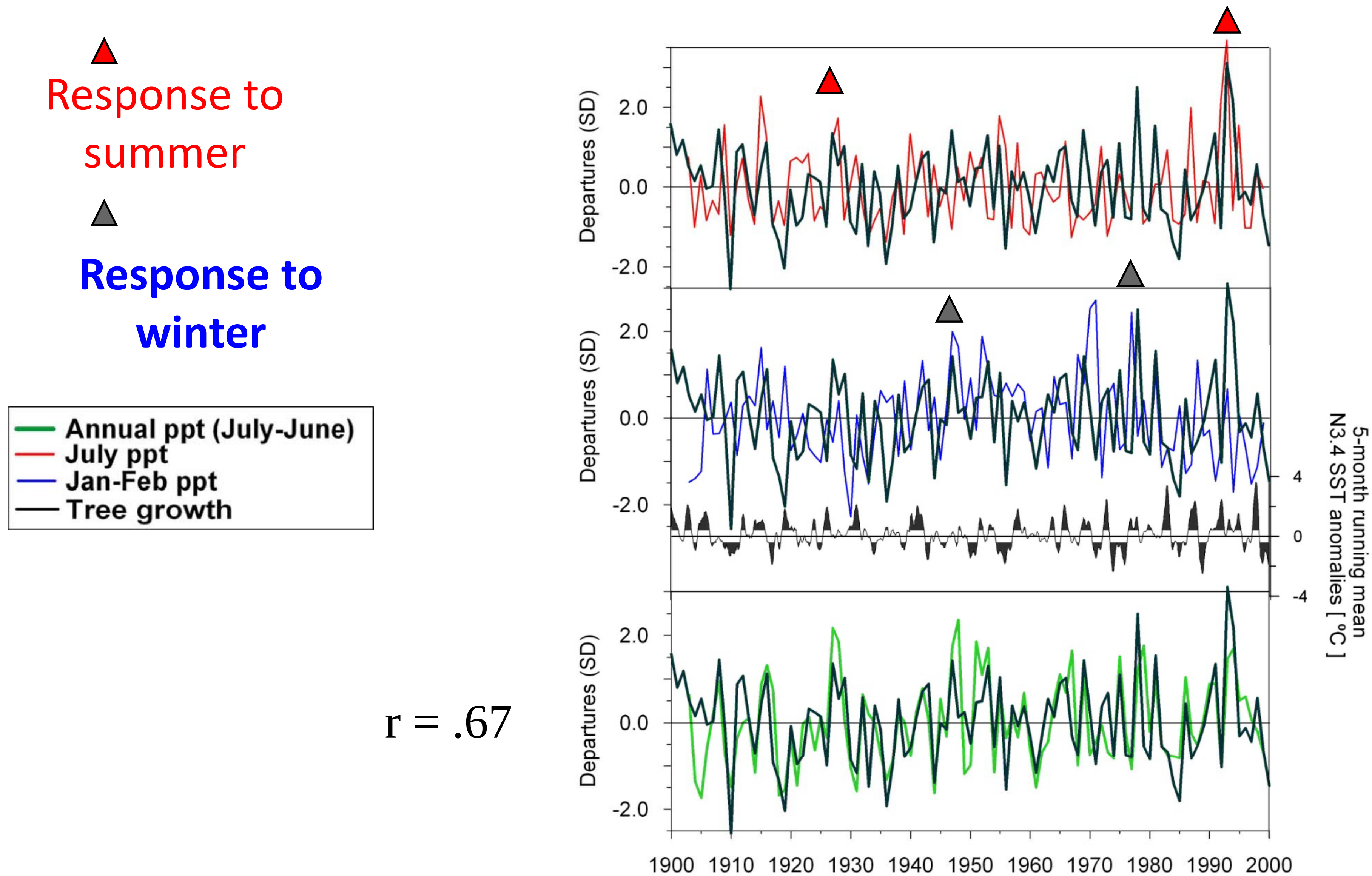


Figure 8. Seasonal precipitation, ENSO and tree growth response

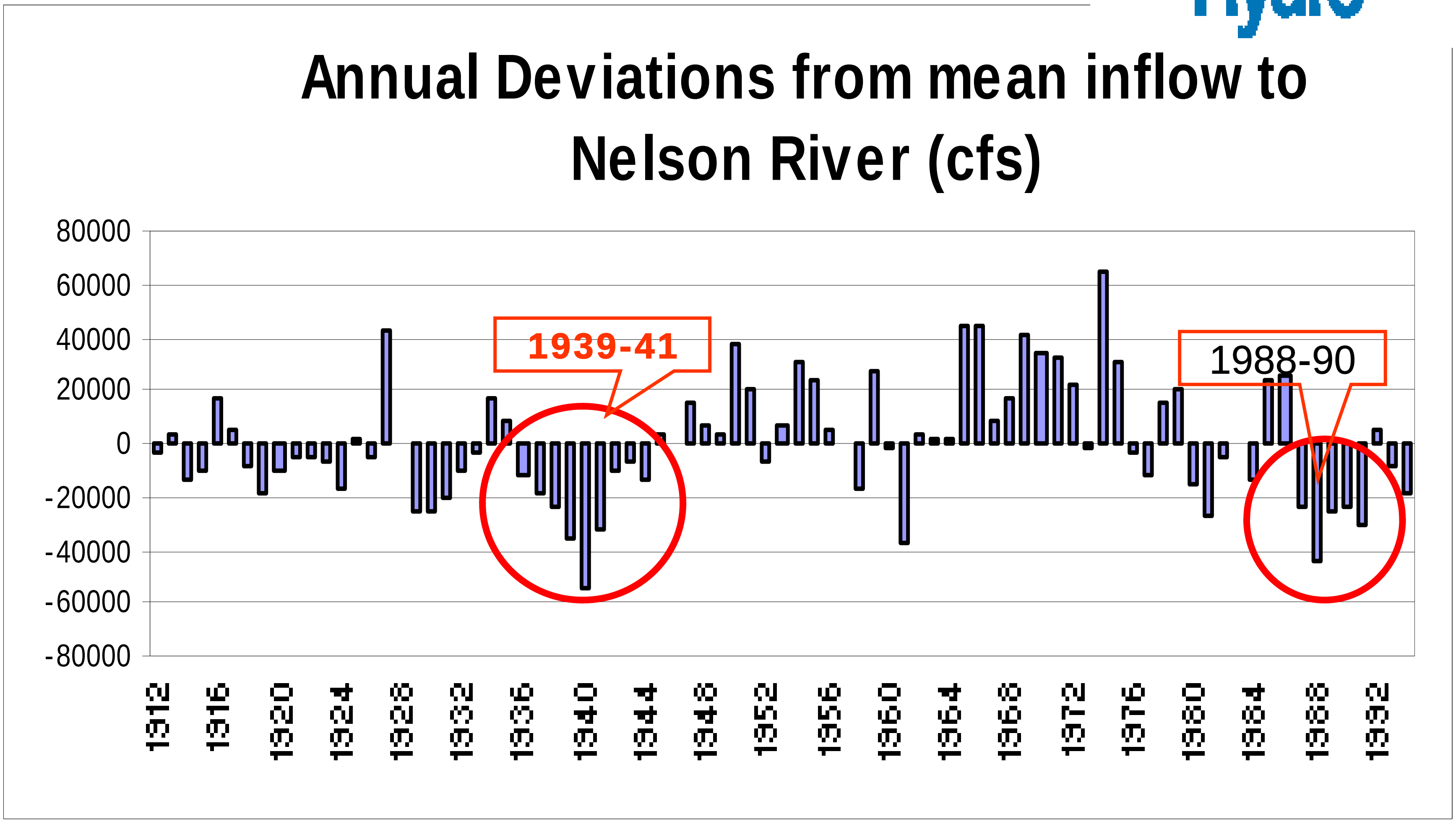
El Niño→ winter (-); summer (+)
La Niña→ winter (+); summer (-)

Response to summer

Response to winter



MB Hydro Watershed, Drought of Record



EPCOR

- EPCOR Water Services Inc. (EWSI) provides water, wastewater, and distribution services to over one million people in more than 50 communities across Western Canada.

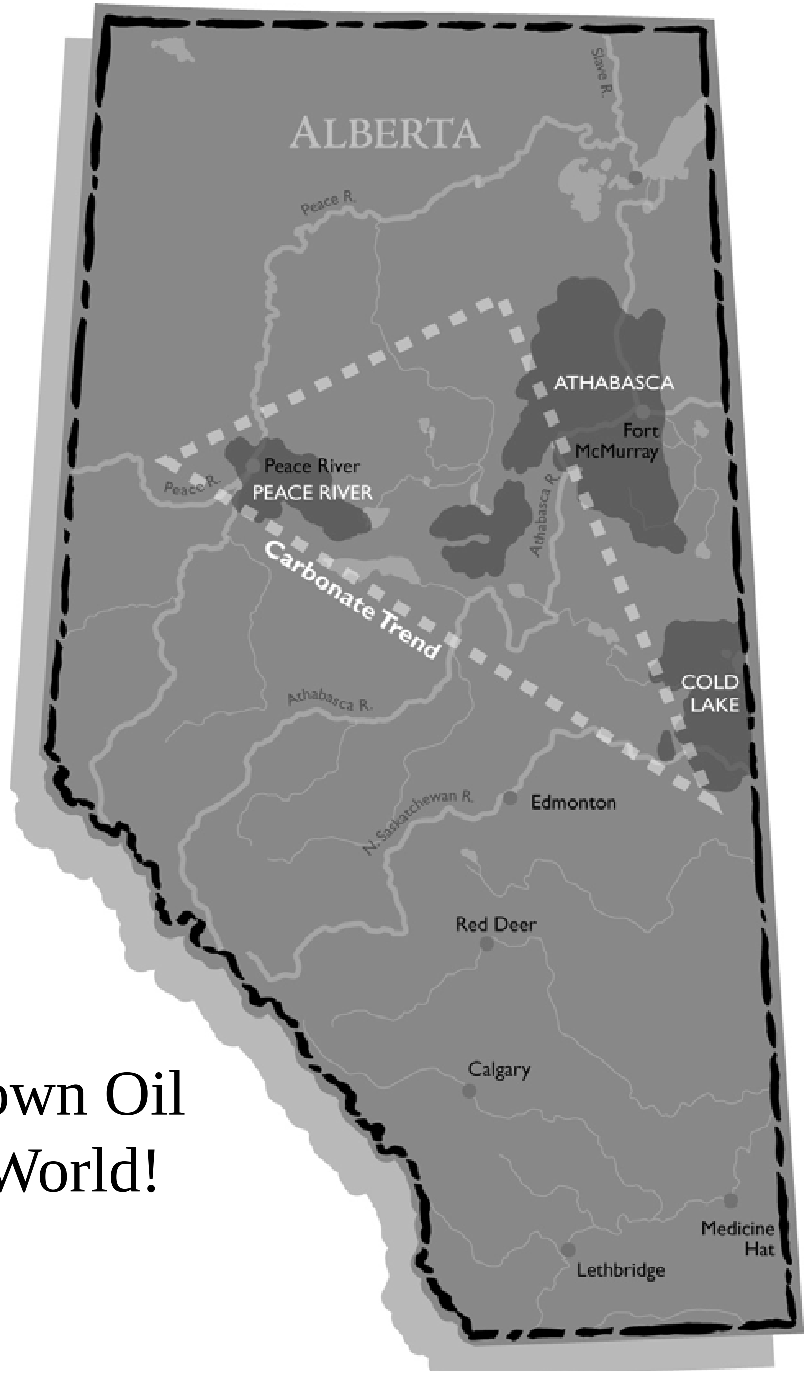
- EWSI utilizes an Integrated Resource Planning (IRP) approach for the development of capital and operational plans for the Edmonton water system.

- Traditional planning would consider flow characteristics of the raw water streams as “knowns” in the system.

Source: Climate Change – Potential IRP Impact areas

North Saskatchewan River, Edmonton, AB

On May 2 1796, furs could not be moved
“**there being no water in the river**.”



The Largest Known Oil Reserve in the World!

Liquid Asset

Could the oil sands, Canada's greatest economic project, come undone simply because no one thought about water?

ANDREW NIKIFORUK

Globe and Mail Update

March 28, 2008 at 7:00 AM EDT

Historically, the North Saskatchewan River has been subject to extreme variations in flow, notes **Dave Sauchyn**, a climate change specialist at the University of Regina. In 1796, a drought year, the Hudson's Bay Co. had trouble moving furs, "there being no water in the river," ... Sauchyn says that 80 years of record keeping on the river are insufficient to predict variability in water availability. "They should be thinking about whether it's judicious to proceed, or how to store water during low flows."