LECTURE 2_3: CLIMATE CHANGE

IMPLICATIONS OF...

& MAP LITERACY 1 (MQ.1)

Text Reference: Dearden and Mitchell (2012), pp. 209-217

T. Randall, Lakehead University, WA 2014

Outline



<u>Activity</u>: Map Literacy List #1

Low-lying island nation in the Indian Ocean (Maldives) is planning to re-locate should predicted sea level rise occur. From: Dearden and Mitchell (2012)

Figure 7-6:

Summary of expected impacts in Canada over the 21st Century

- <u>Specific Impacts</u> {Terrestrial Systems; Agriculture; Freshwater Systems; Fisheries; Cryosphere; Oceans and Coastal Systems; Infectious Diseases}
- Other important global impacts {Ozone depletion; Global Sea Level Rise}

Map Literacy 1

Climate Change lectures January 14, 2014



Map Literacy (list 1, January 14, 2014)

Communities, Jurisdictions

- 1. Churchill, MB
- 2. Inuvik, NWT
- 3. Whitehorse, Yukon

Natural Features

- 1. Mackenzie River
- 2. Mackenzie Delta
- 3. Hudson Bay
- 4. Prairies
- 5. Rocky Mts
- 6. Wapusk National Park
- 7. Ellesmere Island

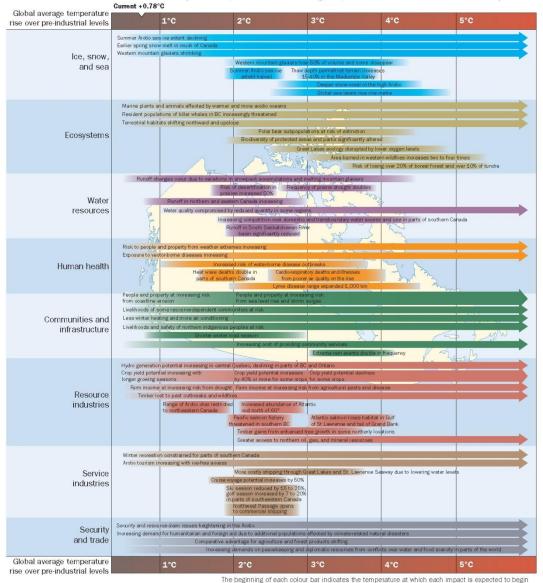
Basics (5):

• Vancouver; Toronto; Winnipeg; Halifax; Edmonton



DEGREES OF CHANGE

A summary of the impacts of climate change expected in Canada over the 21st century



Summary of Impacts

Figure 7.6:

Summary of the impacts of climate change expected in Canada over the twenty-first century. Source: NRTEE (2010).

From: Dearden and Mitchell (2012)

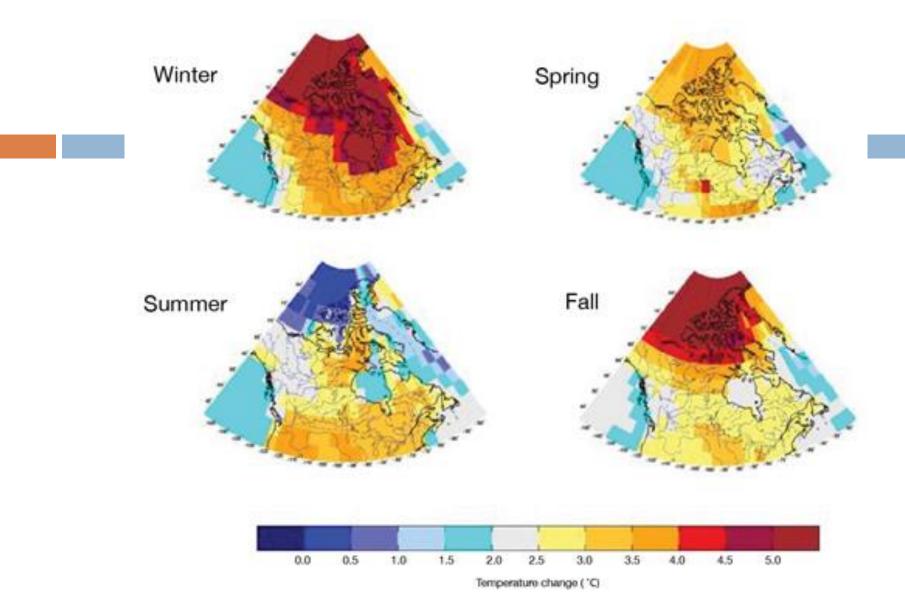
Trend likely to continue. potentially intensifying

Forecast within indicated range The NRTEE's Degrees of Change diagram (above) is a summary of the impacts of olimate change expected in Canada over the 21st century. It shows both risks and opportunities for Canada from different levels of global warming above pre-industrial levels. Each category in the diagram is an important part of our country's environment and economy, and only contains climate change impacts that we are confident could occur, as documented in scientific literature. Each regional map takes a dimate change impact and illustrates what it might look like across that specific region. Not all expected impacts of climate change are shown here. Nor is the diagram a prediction. It does not account for time lags between global temperature change and the response of our physical environment. Even if actions limit global temperature increases to just 2°C by 2050, climate change impacts will continue to build up for decades due to the slow response of Earth systems. Adapting to these impacts to reduce or avoid harm is not shown on the diagram but would lessen their effects

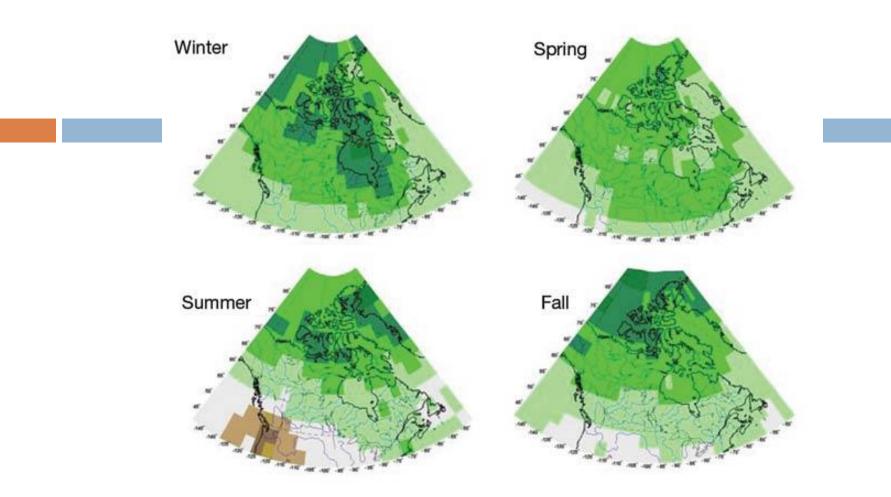
Figure 7.6 Summary of the impacts of climate change expected in Canada over the twenty-first century. Source: NRTEE (2010: O15).

Expected Implications of Climatic Change

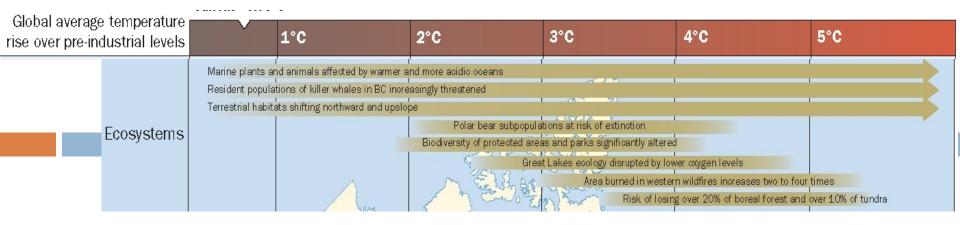
- Explore the range of physical, environmental, social and economic implications of expected climatic change;
- Current warming +0.78 deg C over pre-industrial levels;
- Projected temperature and precipitation changes are anticipated to have greater seasonal and latitudinal variations in Canada (see next slide)



Modeled Seasonal Change in Temperature across Canada by 2050 Source: Natural Resources Canada (2007b)



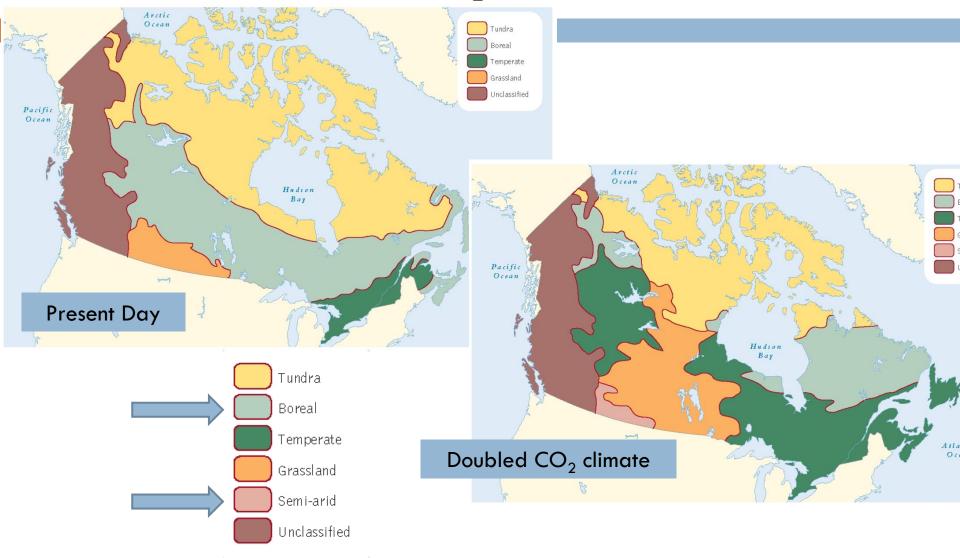
Modeled Seasonal Change in Precipitation (relative to 1960-1990) based on the median of seven global climate models across Canada by 2050 (green = wetter; brown = drier) Source: Natural Resources Canada (2007b)



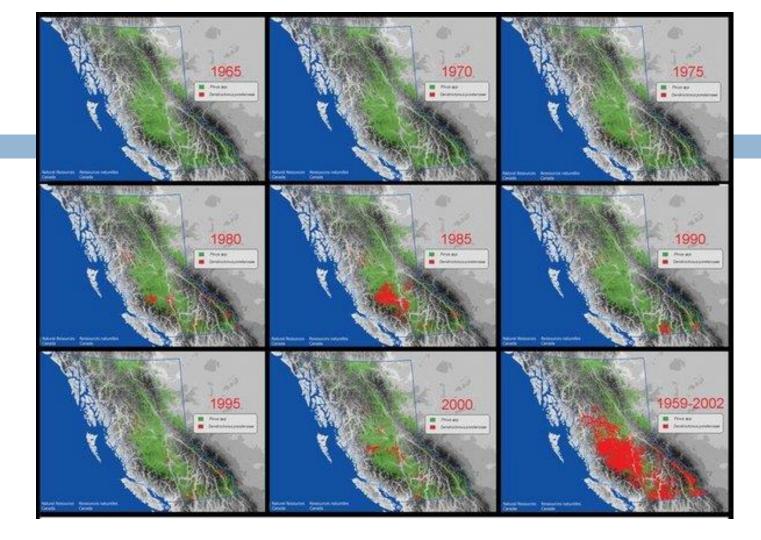
Impacts on the Ecosystems

- Significant changes for both terrestrial and aquatic systems (including those to flora and fauna)
- Dramatic shifts of boreal forest (e.g.), and these forests more susceptible to insect infestation, disease and fires
- Future of polar bear habitat along Hudson Bay (future of Wapusk National Park) – similarly other NPs may evolve away from the representative ecosystems they were created to protect

Figure 7.7 Changes in forest and grassland boundaries (modelled for a doubled CO_2 climate)

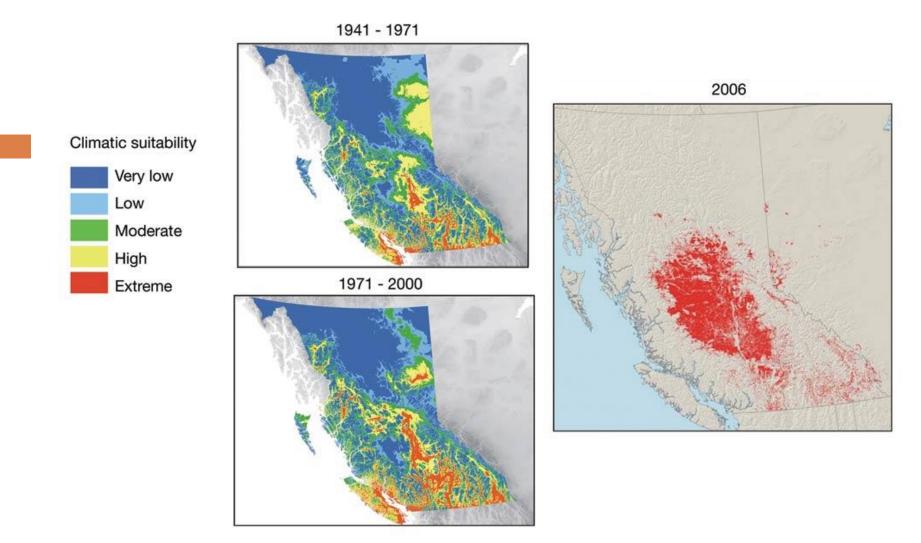


Adapted from Hengeveld 1991 and Curran 1991 by Dearden and Mitchell (2012)

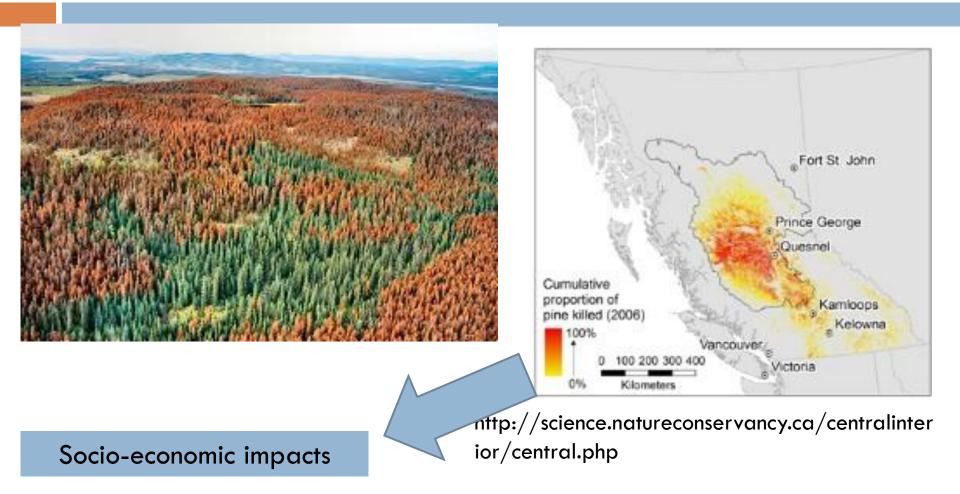


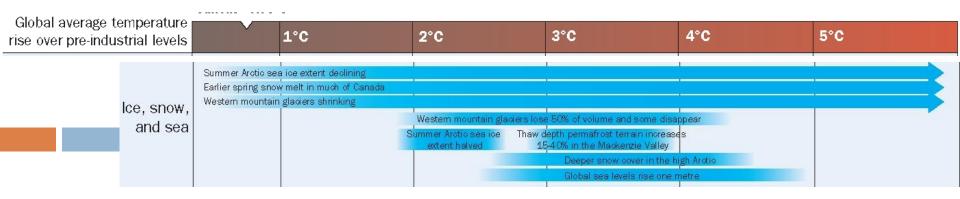
British Columbia is ground zero for mountain pine beetles with rapid increases in infestations starting in the late 1990s and early 2000s. The final image shows all the areas where infestations have been recorded between 1959 and 2002. Image: Natural Resources Canada

(Read more at: http://phys.org/news190275053.html#jCp)



(Left) Historical distributions of climatically suitable habitats for the mountain pine beetle (MPB) in British Columbia (adapted from Carroll et al., 2004). Areas with 'very low' suitability are unsuitable for MPB, where as 'extreme' areas are those considered climatically optimal. (Right) Total area affected by mountain pine beetle in British Columbia in 2006 (Natural Resources Canada, 2007a)





Impacts on the Cryosphere

- Higher prospective temperatures at higher latitudes;
 - □ → ice sheets (Greenland Ice Sheet, Fig. 7.8; Antarctic Ice Sheet,)
 - $extsf{i} extsf{i}$ reduced valley glacier extents
 - imes sea ice cover (albedo feedbacks)
 - imes o sea level forecasts
 - → shifting of permafrost zones and thawing of ground ice

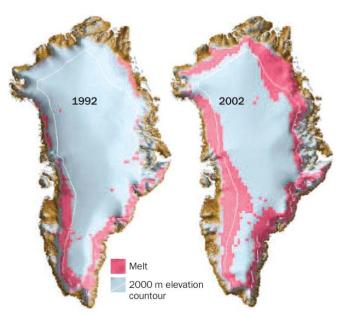
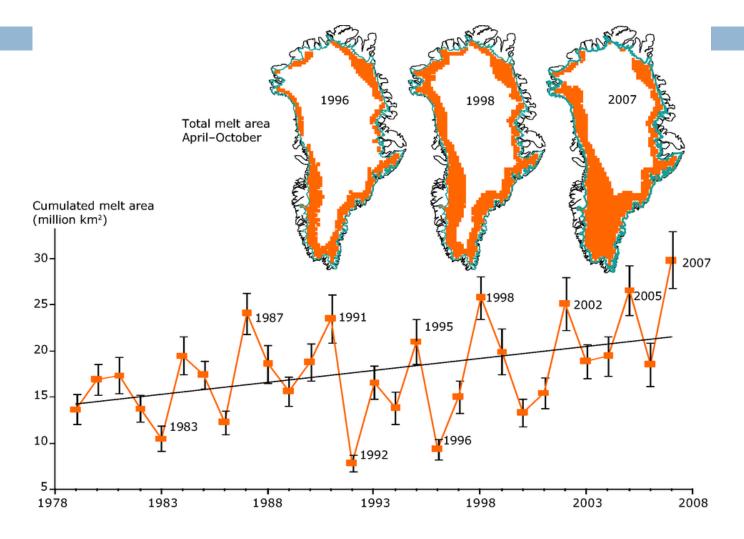


Figure 7.8 | Greenland ice sheet melt, 1992 and 2002. Source: Walsh et al. (2004: 205).

From: Dearden and Mitchell (2012)

Melt, Greenland Ice Sheet (1979 to 2007)

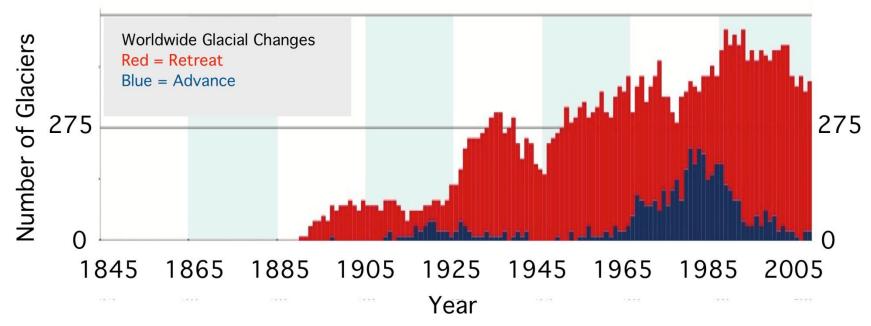


Source: European Environment Agency (2007)

http://wwws3.eea.europa.eu/data-and-maps/figures/area-of-greenland-ice-sheet-melting-1979-2007/image_xlarge

Other evidence of observed climate change / global warming

Negative mass balance in most of the world's glaciers and ice sheets



Sea Ice Extent (Polar Ice Cap)

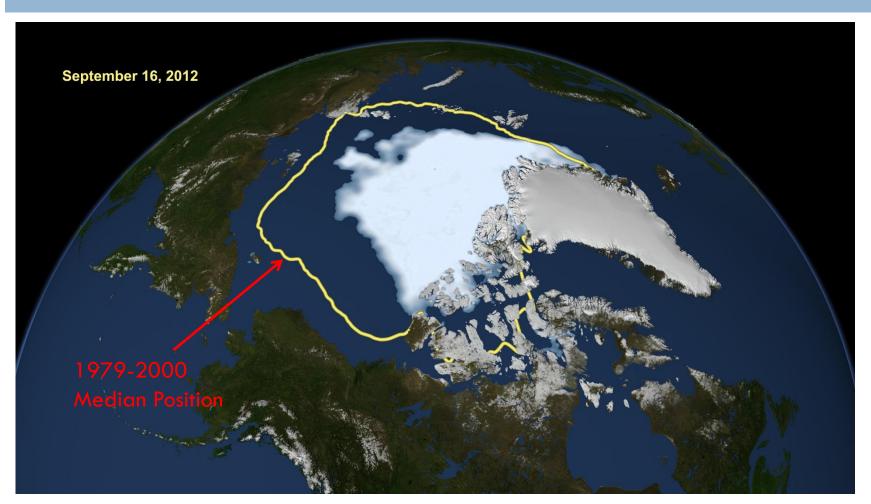
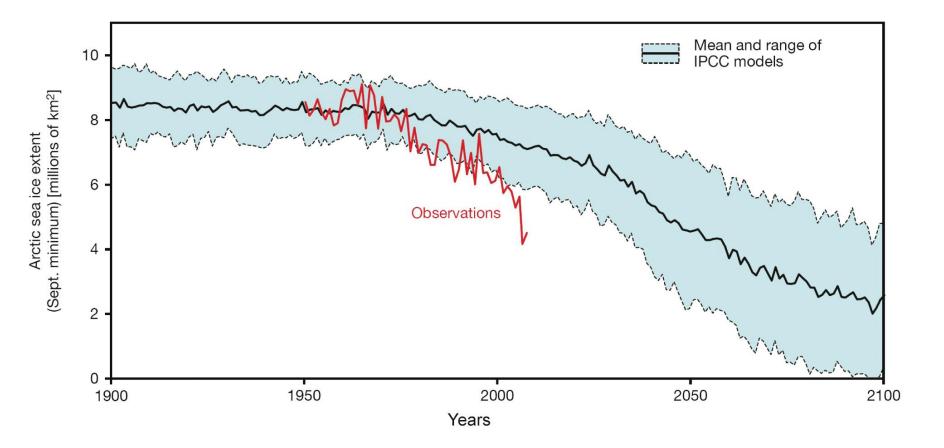


Image Source: NASA Interpretation: http://inhabitat.com/

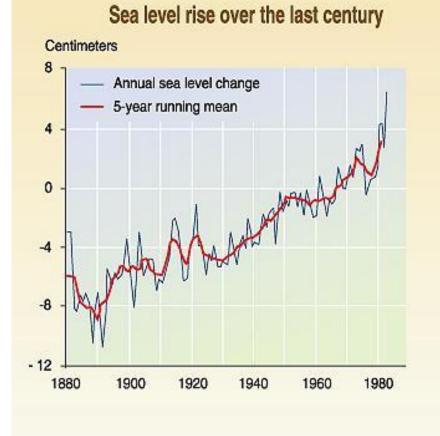
Arctic Sea Ice Extent (Observed & Forecast)



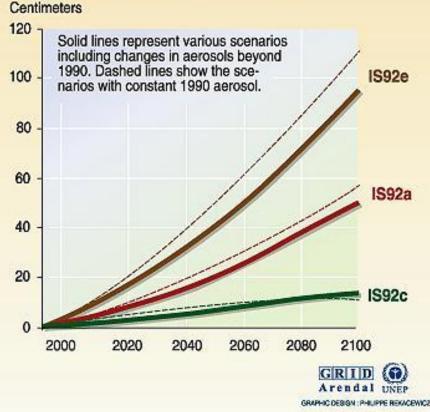
http://www.pik-potsdam.de/news/press-releases/files/sea-ice.jpg

Sea Level Changes (Observed & Forecast)

Sea level rise due to global warming



Sea level rise scenarios for 2100



Source: Climate change 1996, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996; Sea level rise over the last century, adapted from Gormitz and Lebedaff, 1987.

Sea Level Changes



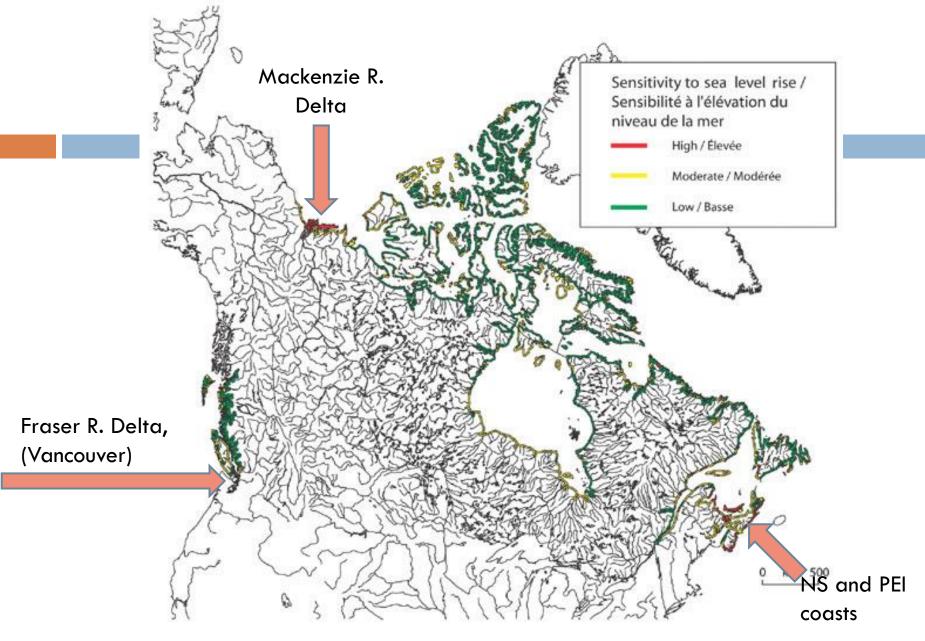
Predictions of sea level rise in responses to a modeled rise in global temperature by 2100

(compiled by Mallory Carpenter 2009)

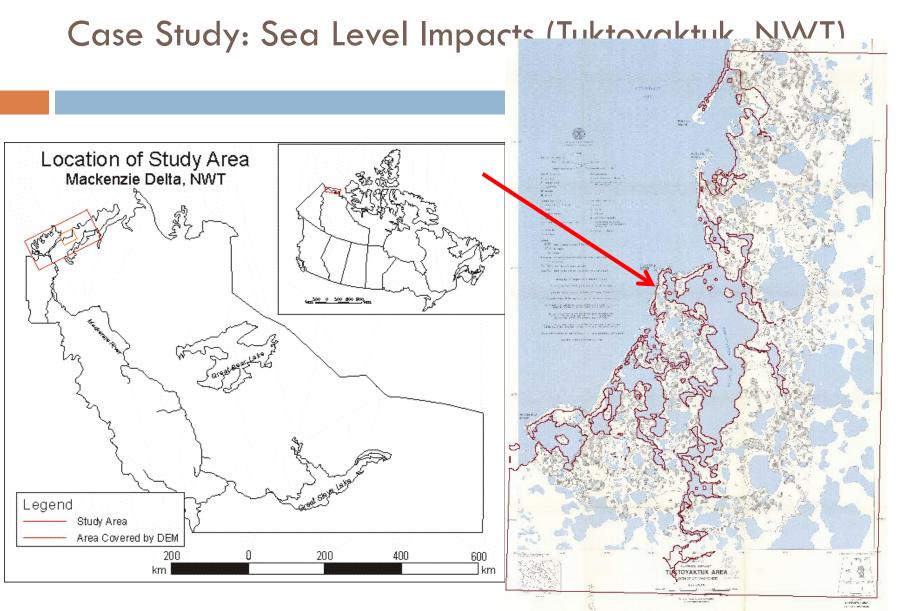
Author(s)	Area of Study	Modeled Temp. Change (C)	Minimum Prediction	Maximum Prediction
		onange (0)	Trediction	Trediction
Alley, R. B. <i>et al.</i> (2005)	Greenland	5°	40 cm	50 cm
Aunap, R. <i>et al.</i> (2001)	Estonia	2.3-4.5°	n/a	100 cm
Begin, Y. and Robichaud, A.	New Brunswick	n/a	20 cm	40 cm
(1997)				
Bray, M. J. and Hooke, J. M.	England	n/a	n/a	50 cm
(1997)				
Daniels, R. C. (1992)	South Carolina	1-5°	25 cm	200 cm
Ely. C. and Jorgenson, T. (2000)	Alaska	n/a	10 cm	90 cm
Fitzgerald, D. M. <i>et al.</i> (2008)	Conceptual	n/a	20 cm	60 cm
Harvey. N. and Woodroffe, C.	South Australia	n/a	33 cm	110 cm
(2008)				
IPCC (2001)	Conceptual	1.8 °	9 cm	88 cm
NRC (2007)	Canada	1.4°	9 cm	88 cm
Nicholls, R. J. (2002)	Global	n/a	23 cm	96 cm
Senior C. A. <i>et al.</i> (2002)	England	n/a	9 cm	88 cm
Shaw, J. <i>et al.</i> (1998)	Canada	2 °	n/a	49 cm
Thumerer, T. <i>et al.</i> (2000)	England	1.5°	49 cm	94 cm
USGS (2000)	Eastern USA	n/a	15 cm	95 cm

IPCC predicts 9 to 88 cm by 2100

> + Storm Surge

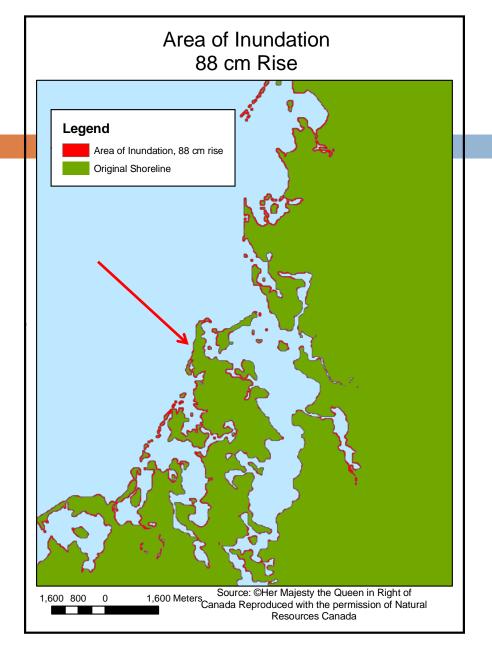


Sensitivity of Canadian coasts to sea level rise as determined by NRC's 2004 adaptation report. Source: NRC (2004)

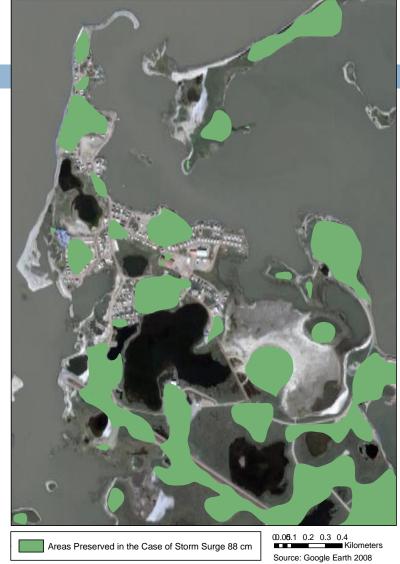


Source: Carpenter (2009).

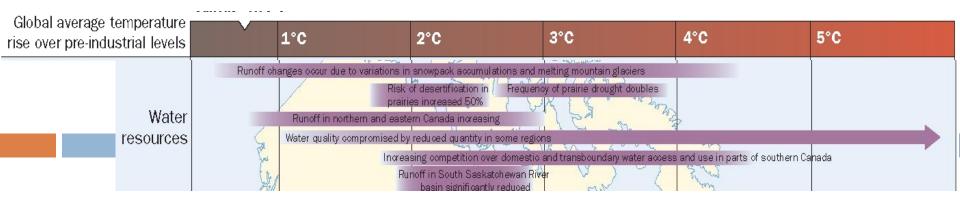
Surfcial Geology for coastline near Tuk



Areas Impacted by Storm Surge of 88 cm Tuktoyaktuk Community



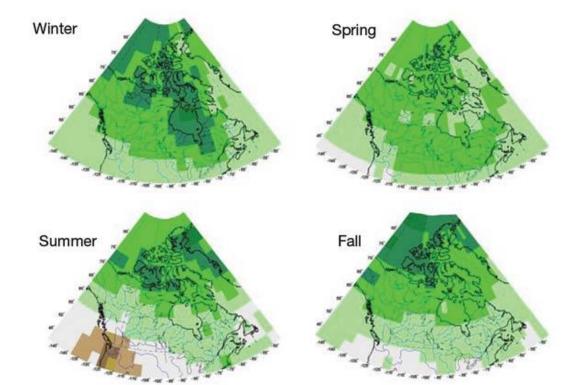
(L) Area of inundation in event of projected 88 cm sea level for Tuktoyaktuk and environs; (R) Areas affected by 88cm + 2.5m storm surge. Source: Carpenter (2009).



Impacts on Water Resources

 every part of Canada except the southern Prairies and southwestern BC has become wetter

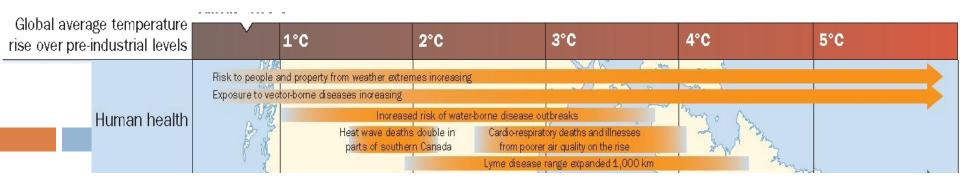
Modeled Seasonal Change in Precipitation (relative to 1960-1990) based on the median of seven global climate models across Canada by 2050 (green = wetter; brown = drier) Source: Natural Resources Canada (2007b)



Clobal avarage to	mporoturo -							
Global average temperature rise over pre-industrial levels			1°C	2°C	3°C	4°C	5°C	
	Resource industries	Crop yield potent longer growing s Farm income	ial increasing with easons at increasing risk from drought st to pest outbreaks and wildfire Range of Arctic char restricted to northeastern Canada	es Increased abundance of Atla cod north of 60° Pacific salmon fishery reatened in southern BC	Crop yield potential declines for some crops from agricultural pests and disc ntic Atlantic salmon loses habitat of St Lawrence and tail of Gra ree growth in some northerly loc	ase in Gulf nd Bank		

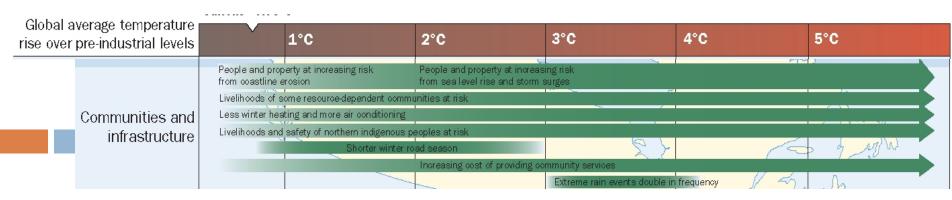
Impacts on Resource Industries

- (AGRICULTURE) Positive impact for all regions but the Prairies (one of the few countries in the world to benefit) – extended growing season; reduced frost damage
- (FORESTRY) Increasing losses of timber to pest outbreaks and wildfires
- (FISHERIES) Fish are vulnerable to changes in temperature, precipitation, wind patterns, and chemical conditions. If water levels drop or there are more periods of lower water levels, the mortality of spawning salmon in BC rivers is likely to increase.



Impacts on Human Health

- Given the prediction of the IPCC about climate change in North America, Health Canada has indicated that Canadians can expect to experience a greater incidence of disease
- This includes infectious diseases such as Lyme disease, dengue fever, West Nile virus, and malaria



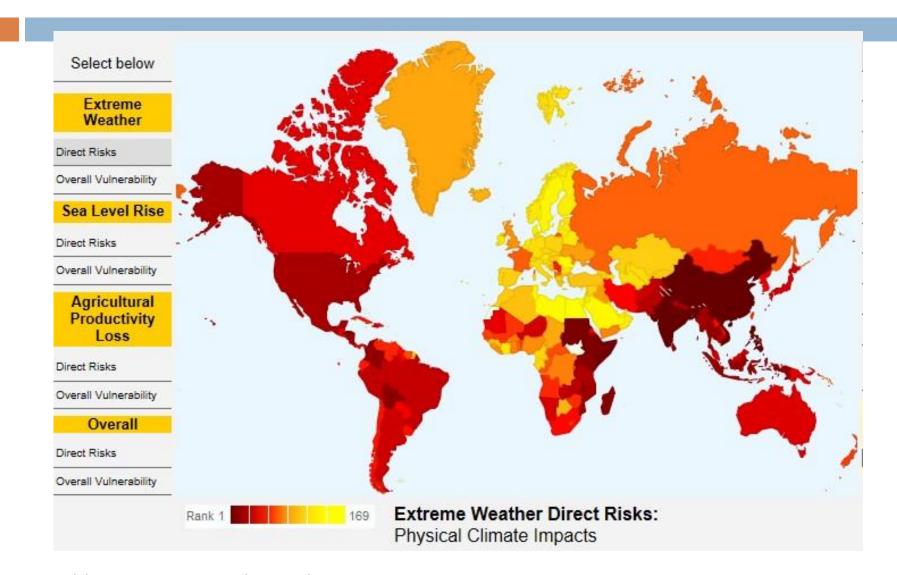
Impacts on Communities and Infrastructure

- Livelihoods affected in some resource-dependent communities, especially northern indigenous communities
- Shorter winter road season
- Property risks (coastal areas, including inland) from rising sea levels and increased storminess ...

Online interactive map – Impact of Climate Change (Wheeler, 2011)

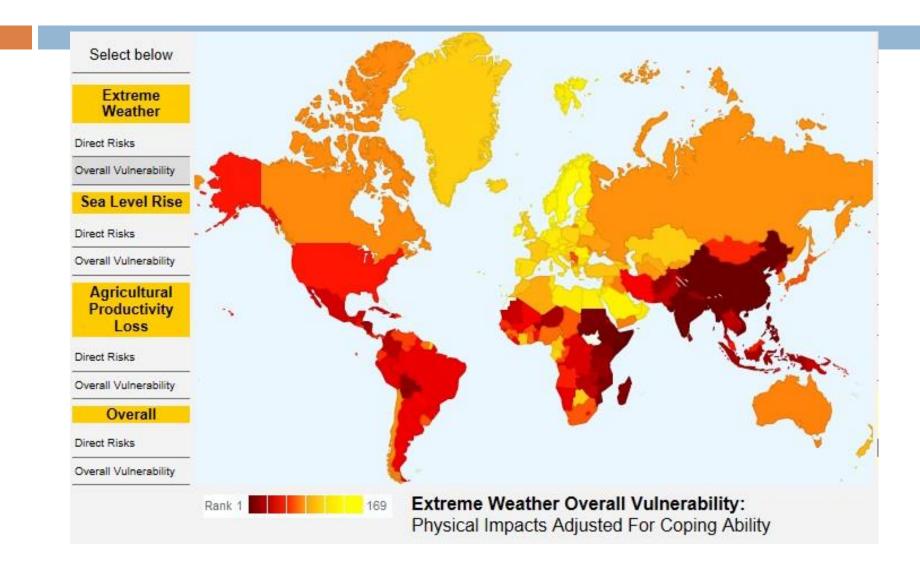
- Centre for Global Development (based in Washington DC) accessed January 2014
 - http://www.cgdev.org/page/mapping-impacts-climatechange?utm =
- Two dimensions of mapping impacts
 - "Direct Risk" (risk from physical climate impacts alone)
 - "Overall Vulnerability" (direct risks adjusted for countries' ability to cope with climate impacts).

Example 1: Risks: Extreme Weather



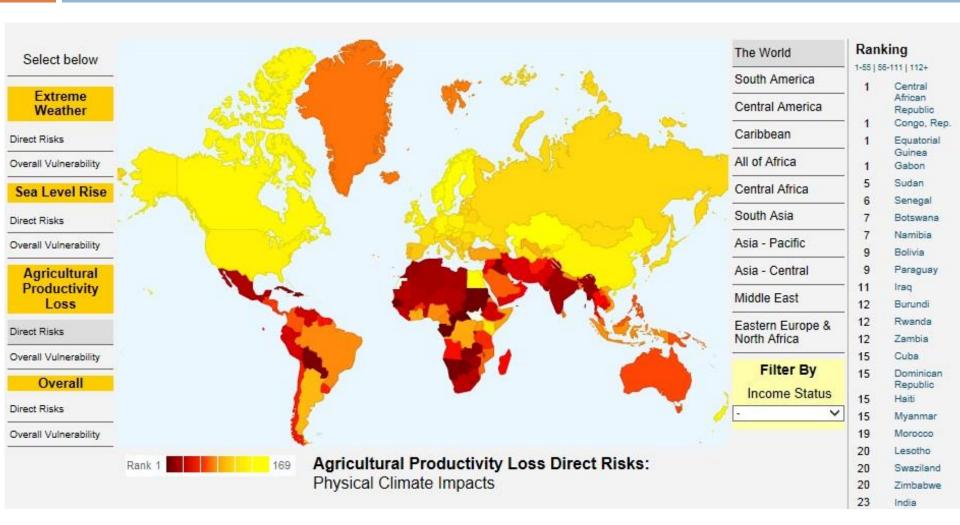
http://www.cgdev.org/page/mapping-impacts-climate-change?utm_=

Example 1: Overall Vulnerability: Extreme Weather



http://www.cgdev.org/page/mapping-impacts-climate-change?utm_=

Example 1: Risks: Agricultural Productivity Loss



http://www.cgdev.org/page/mapping-impacts-climate-change?utm_=

References

- Carpenter, M. 2009. <u>Modeled Impacts of Future Sea Level Changes for the Tuktoyaktuk</u> <u>Peninsula, NWT using a Geographic Information System</u>, Unpublished HBA thesis, Department of Geography, Lakehead University
- Dearden, P and Mitchell, B. 2012. <u>Environmental Change and Challenge</u>, Fourth Edition, Don Mills, Ontario: Oxford University Press {chapter 7}
- Wheeler, David 2011. <u>Quantifying Vulnerability to Climate Change: Implications for Adaptation Assistance</u>, Working Paper by Center for Global Development. Washington, DC, 53 pp. {pdf available at http://www.cgdev.org/sites/default/files/1424759 file Wheeler Quantifying Vulner ability FINAL.pdf}
- Natural Resources Canada (NRC). (2004) Climate Change Impacts and Adaptation: A Canadian Perspective. Ottawa: Natural Resources Canada.
- Natural Resources Canada 2007a. "Towards Adaptation: Case Studies in British Columbia" (date accessed January 14, 2014) <u>http://www.nrcan.gc.ca/environment/resources/publications/impactsadaptation/reports/assessments/2008/ch8/10393</u>
- Natural Resources Canada. 2007b. From Impacts to Adaptation: Canada in a Changing Climate 2007. Ottawa: Natural Resources Canada.

Clobal average te	mporatura 🗕							
Global average temperature rise over pre-industrial levels		· ·	1°C	2°C	3°C	4°C	5°C	
			n constrained for parts of south noreasing with ice-free access	lern Canada				
	Service industries		Sk go in	More costly shipping through G yage potential increases by 50% i season reduced by 15 to 25% If season increased by 7 to 20% parts of southeastern Canada Northwest Passage opens to commercial shipping		eaway due to lowering water leve	S	

Impacts on Service Industries

Global average temperature rise over pre-industrial levels								
			1°C	2°C	3°C	4°C	5°C	
	1	0 11 1						
	Socuring		rce daim issues heightening in t		, affected by climate-related natu	I nal d'a a stana		
		ind easing demand	I	antage for agriculture and fores	I	rai disasters	·	
						, ots over water and food scarcity	in parts of the world	
			Intercability (lemanao on peaverceping ana s			In parts of the world	

Impacts on Security and Trade