

GLOBAL CLIMATE CHANGE AND CANADA'S WATER

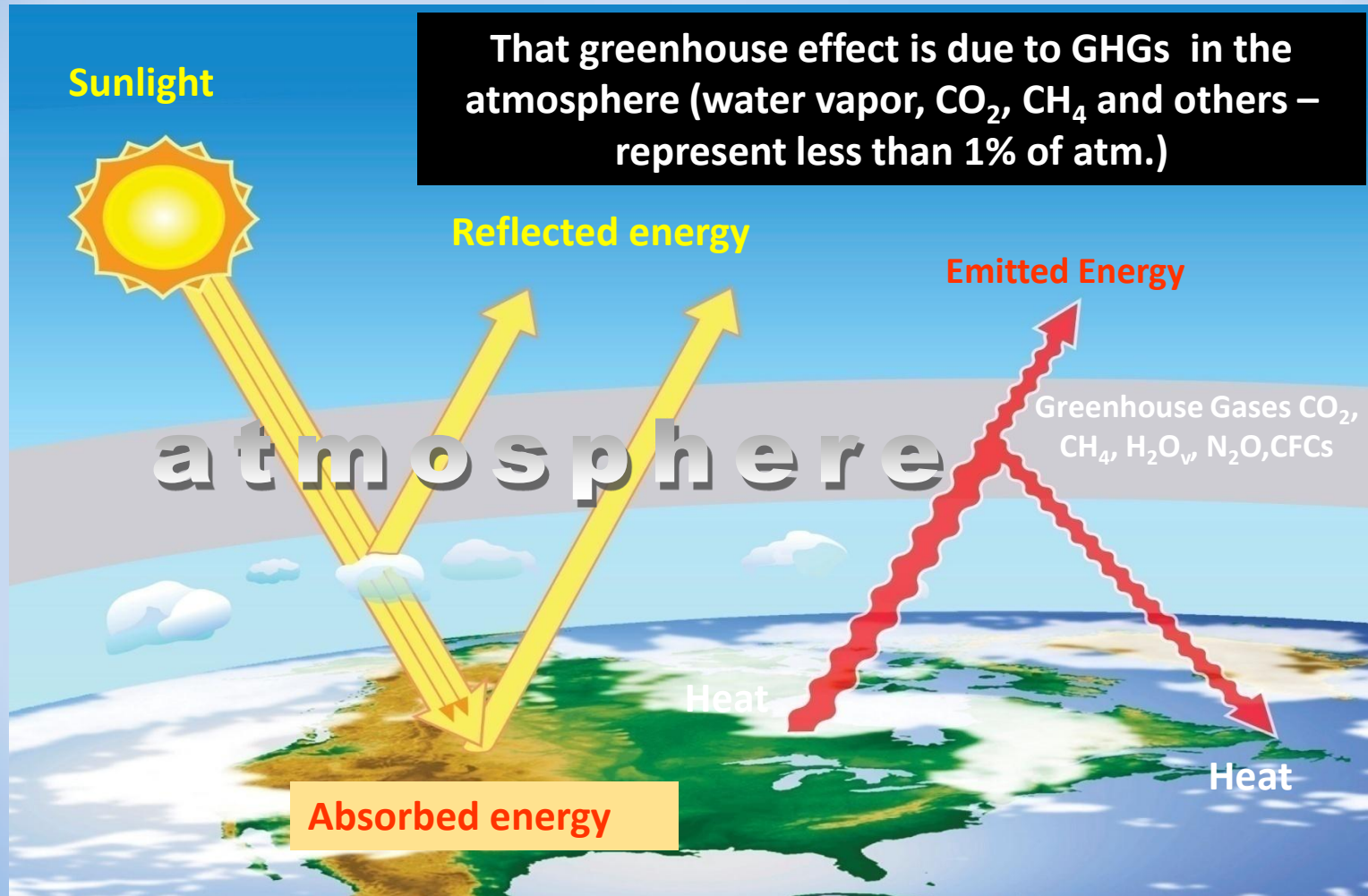
**CANMORE, ALBERTA,
21 Feb. 2013**

J. P. (Jim) Bruce, O.C., FRSC

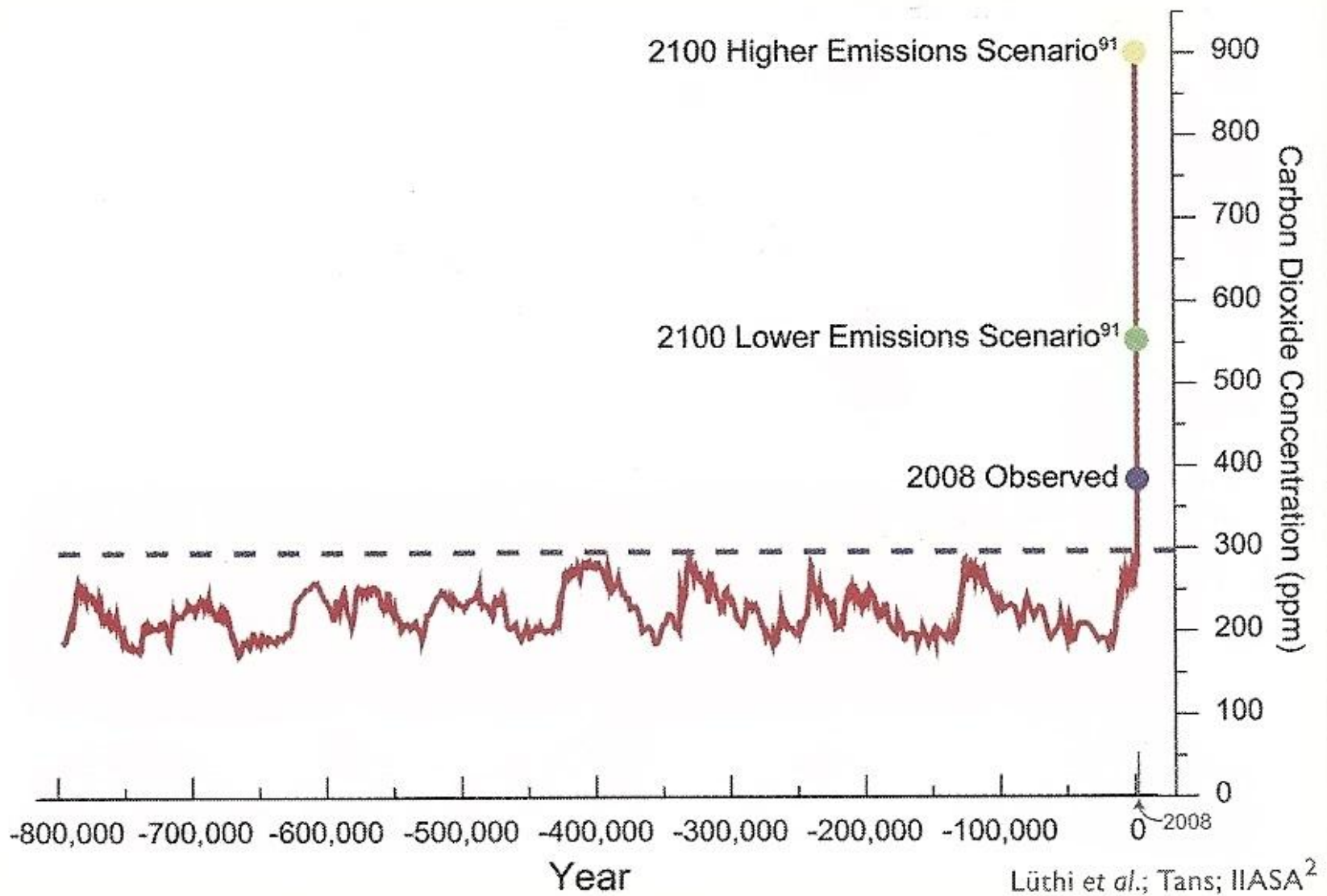
The Earth's atmosphere: thin but crucial
to a favourable climate for life.



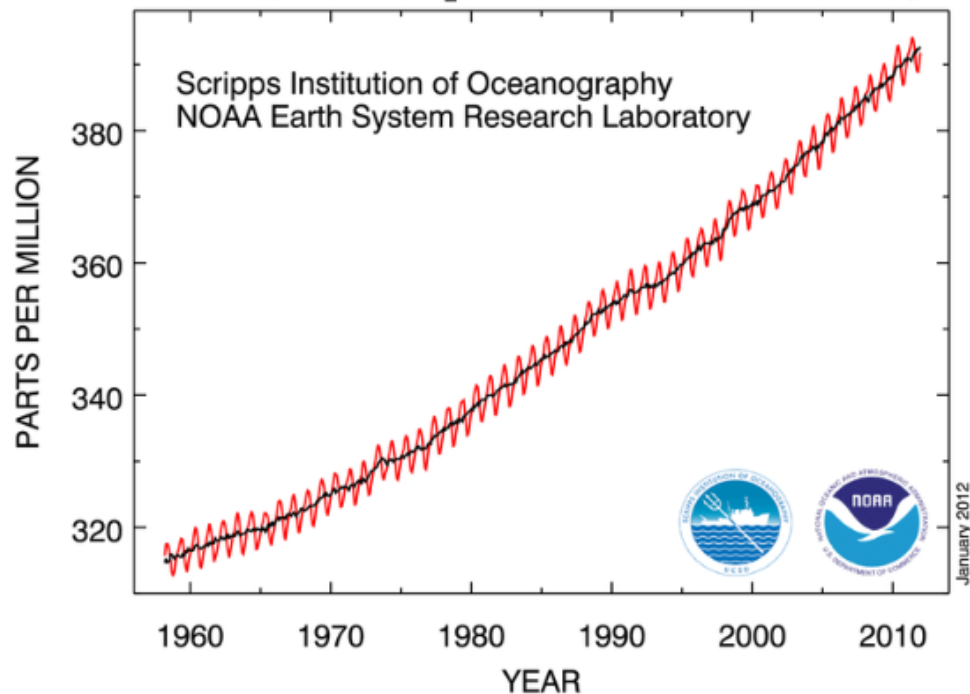
There is a **natural greenhouse** effect which makes Earth warm enough to be livable (+15°C).



800,000 Year Record of Carbon Dioxide Concentration



Atmospheric CO₂ at Mauna Loa Observatory



The concentration of carbon dioxide is higher today than in a million years.

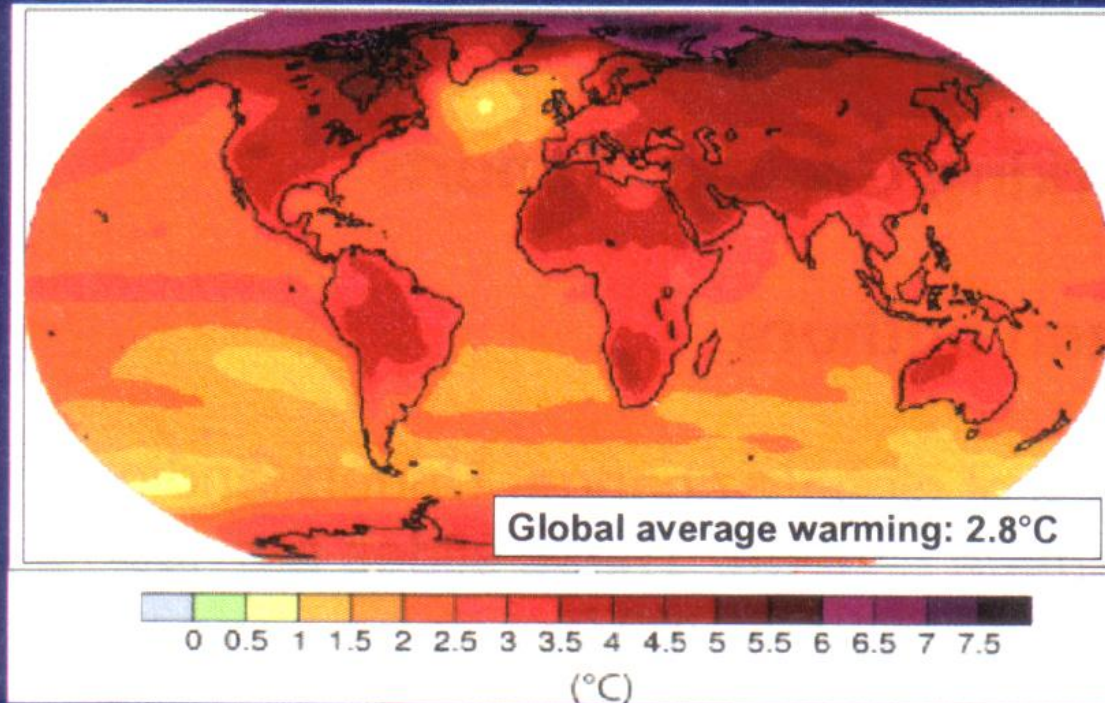
INTERNATIONAL ENERGY AGENCY REPORT: NOVEMBER 2007

GLOBALLY: between 2005 and 2030

- Primary energy requirements up 55%
- Unchecked growth in fossil fuel use will hasten climate change
- Emissions jump 57% - greater than highest IPCC scenario
- 2/3 of contributions from U.S.A., China, Russia and India
- warming and rain intensities will increase more rapidly than IPCC projections

How Much More Warming Can We Expect?

(2090s: medium emissions scenario)

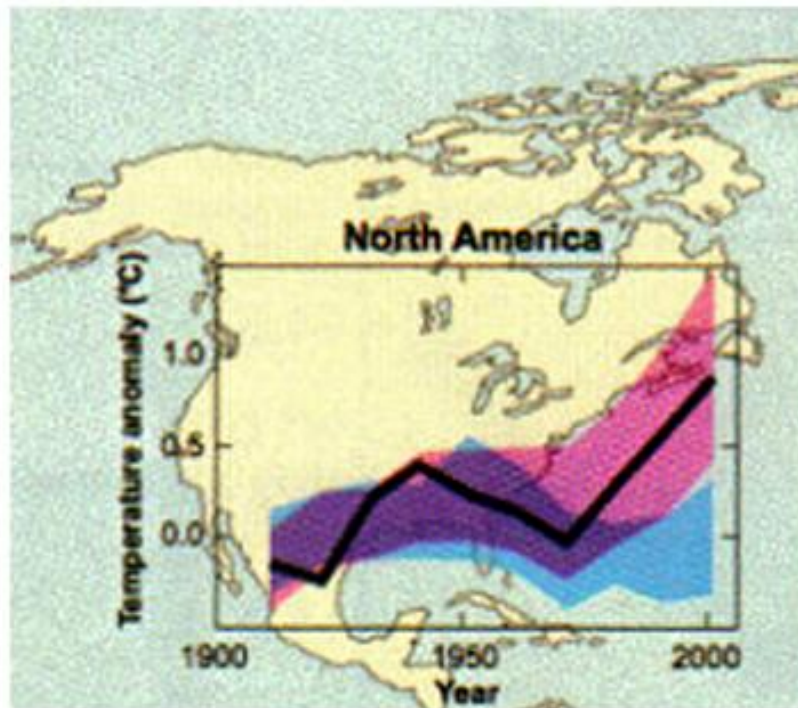


- Increases in hot extremes and heat waves (*very likely*)

IPCC - WGI

Expected pattern of temperature rise shows more warming over land than over ocean.

Global and Continental Temperature Changes

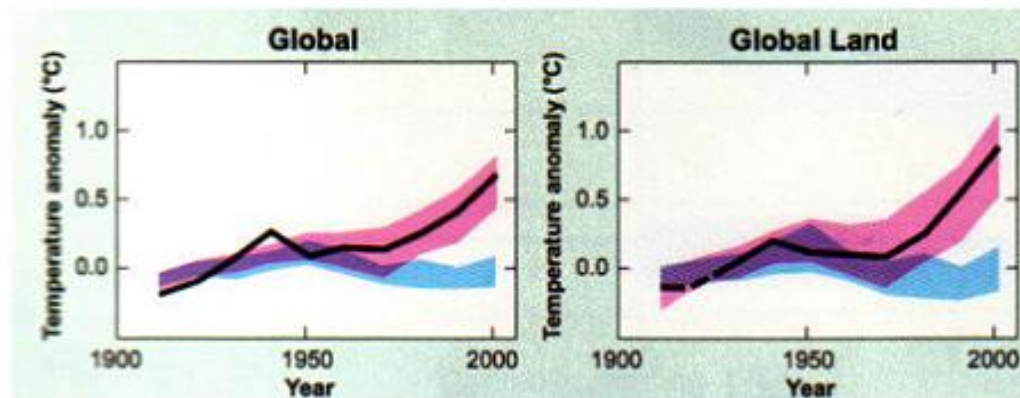


Observed mean temperature

Temperatures expected from natural external forcing

Temperatures expected from greenhouse gas forcing

(IPCC - WG1, 2007)



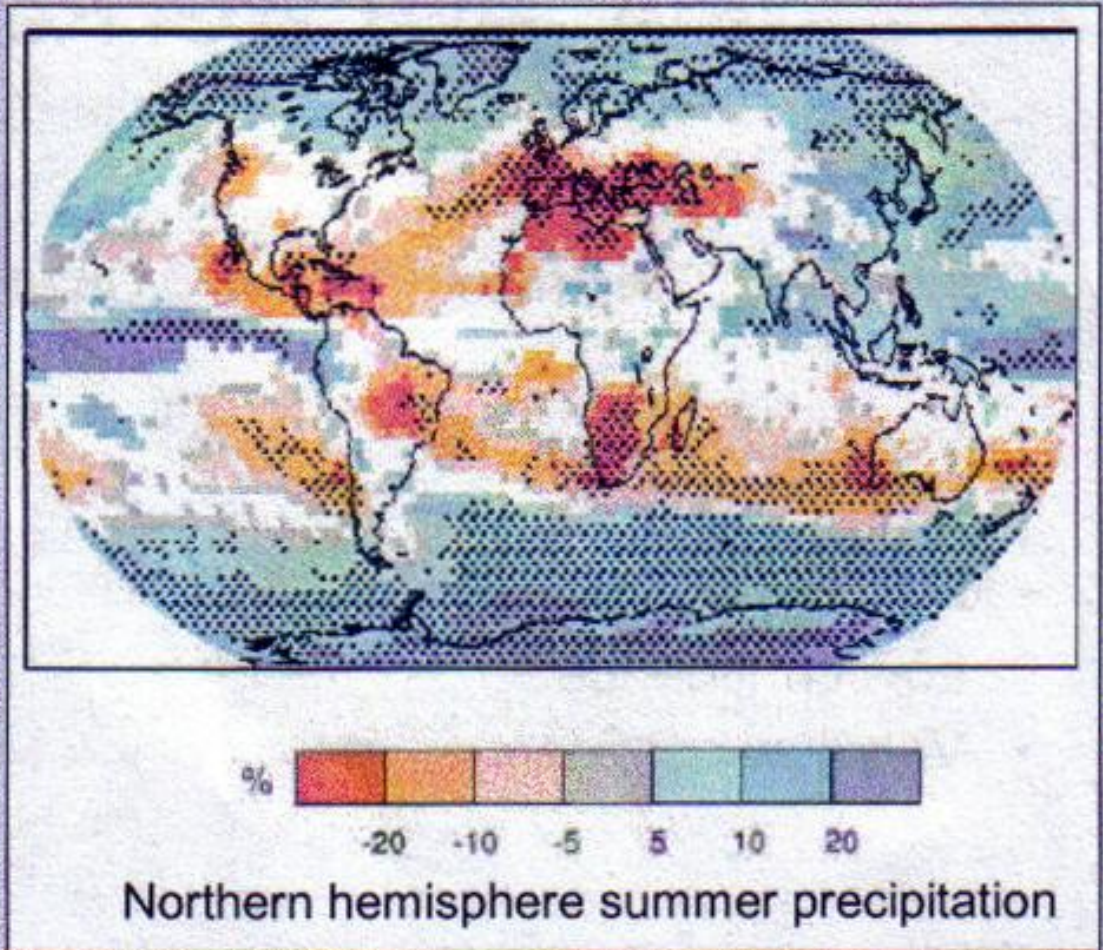
A World of Change: More Rain for Some, Less for Others

Regional changes (+/-)
of up to 20% in average
rainfall

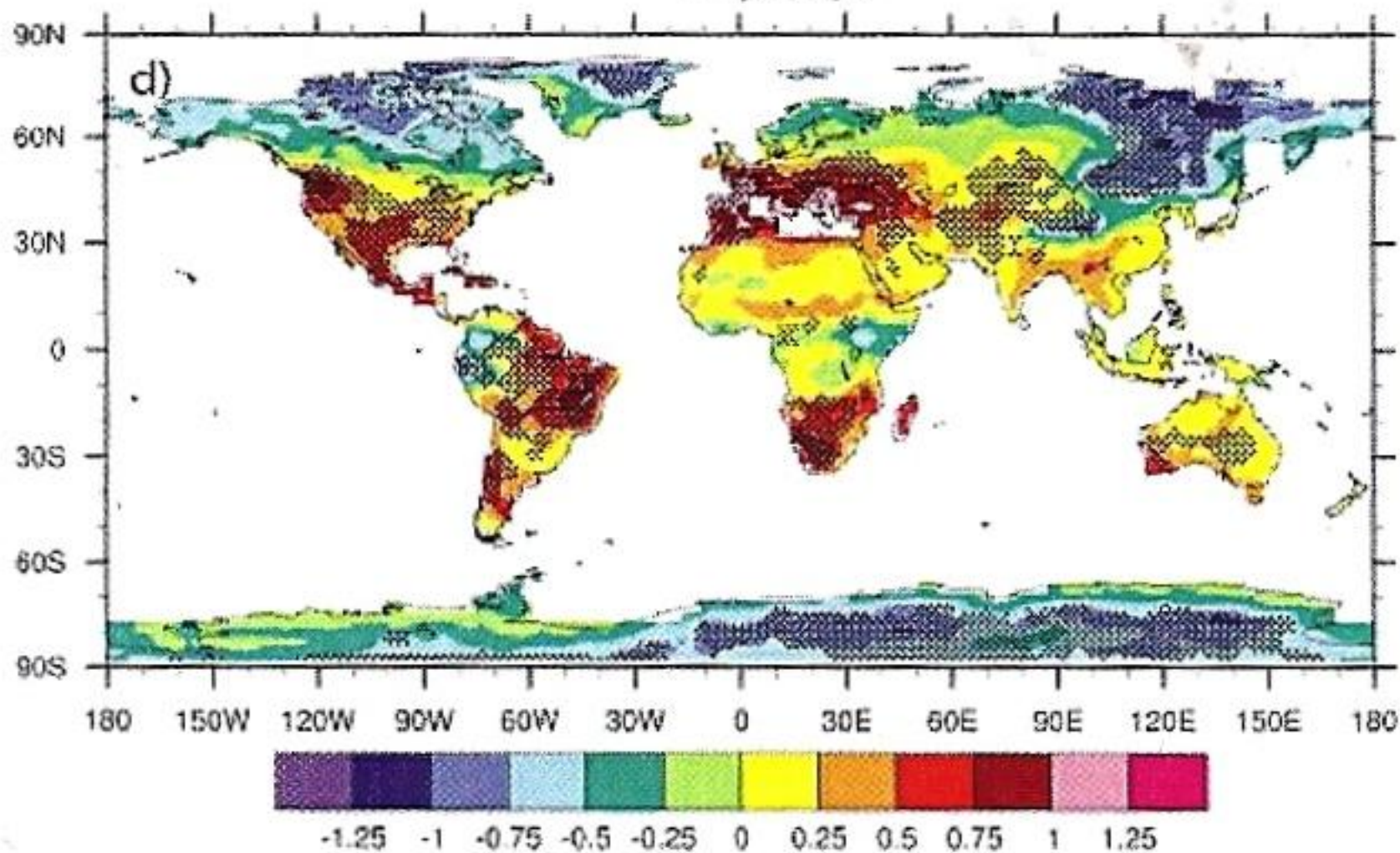
And also.....

- Increases in heavy rainfall
(very likely)
- Increases in drought
(likely)

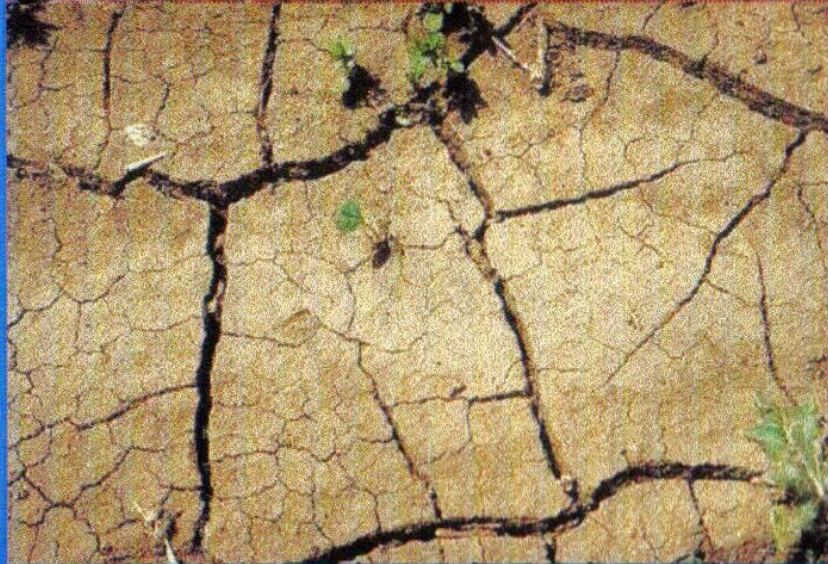
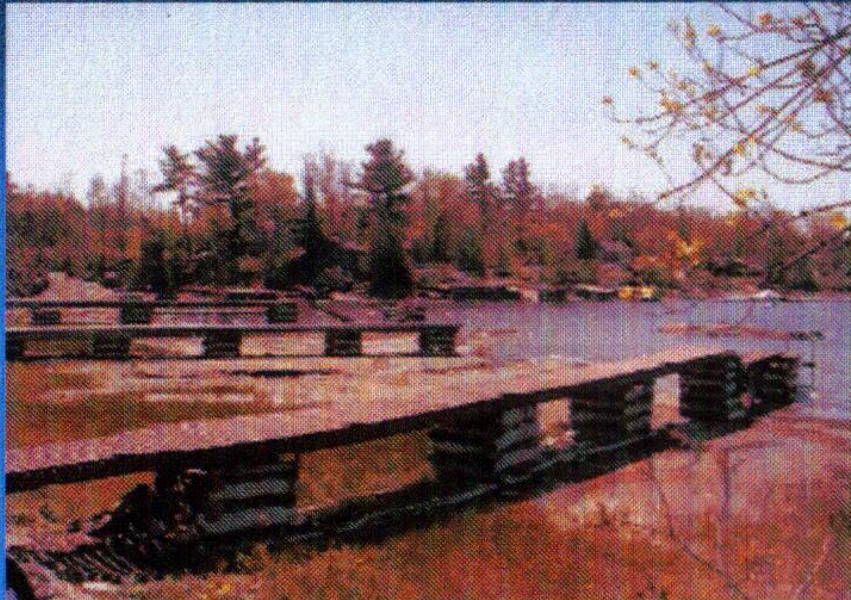
(2090s: medium emissions
scenario; high confidence
in stippled areas)



Dry days



Droughts in Canada



Drought, from coast to coast

St. Lawrence Seaway

Grain prices dip

2001

Drought going from bad to worse

Drought losses mount in Sask., Alta.

Drought fallout widespread

Drought puts pastures in peril

Hot, dry summer hits areas across Canada

Drought-stressed farmers need help

Farm earnings shrivel

Drought costs economy millions

Grain industry expected to generate \$770 million less than last year

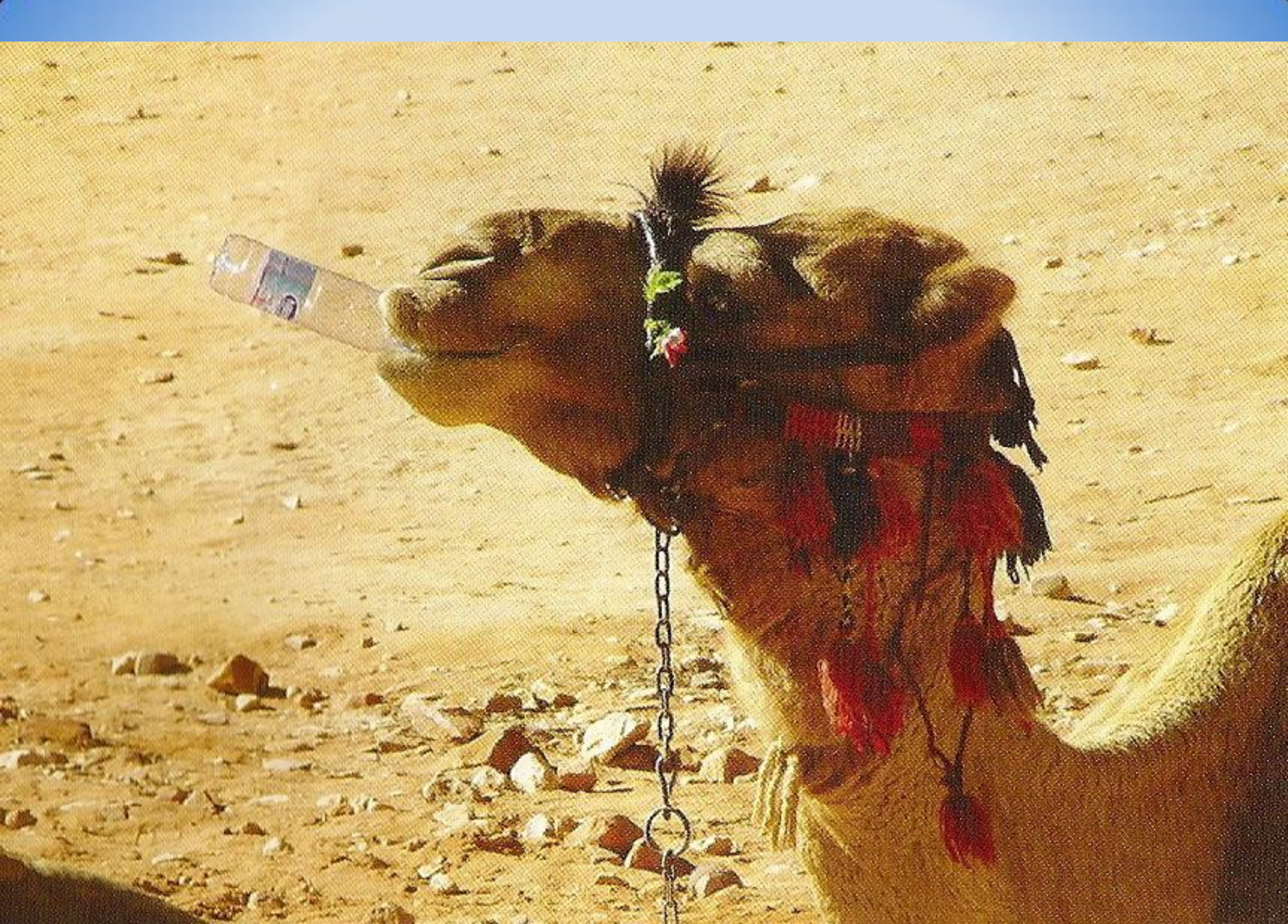
Not farm income

Province	2000	2001
Alberta	1,100	1,000
Saskatchewan	1,000	900
Manitoba	900	800
Ontario	800	700
Quebec	700	600
Atlantic	600	500
Total	5,100	4,500

122 per cent decline

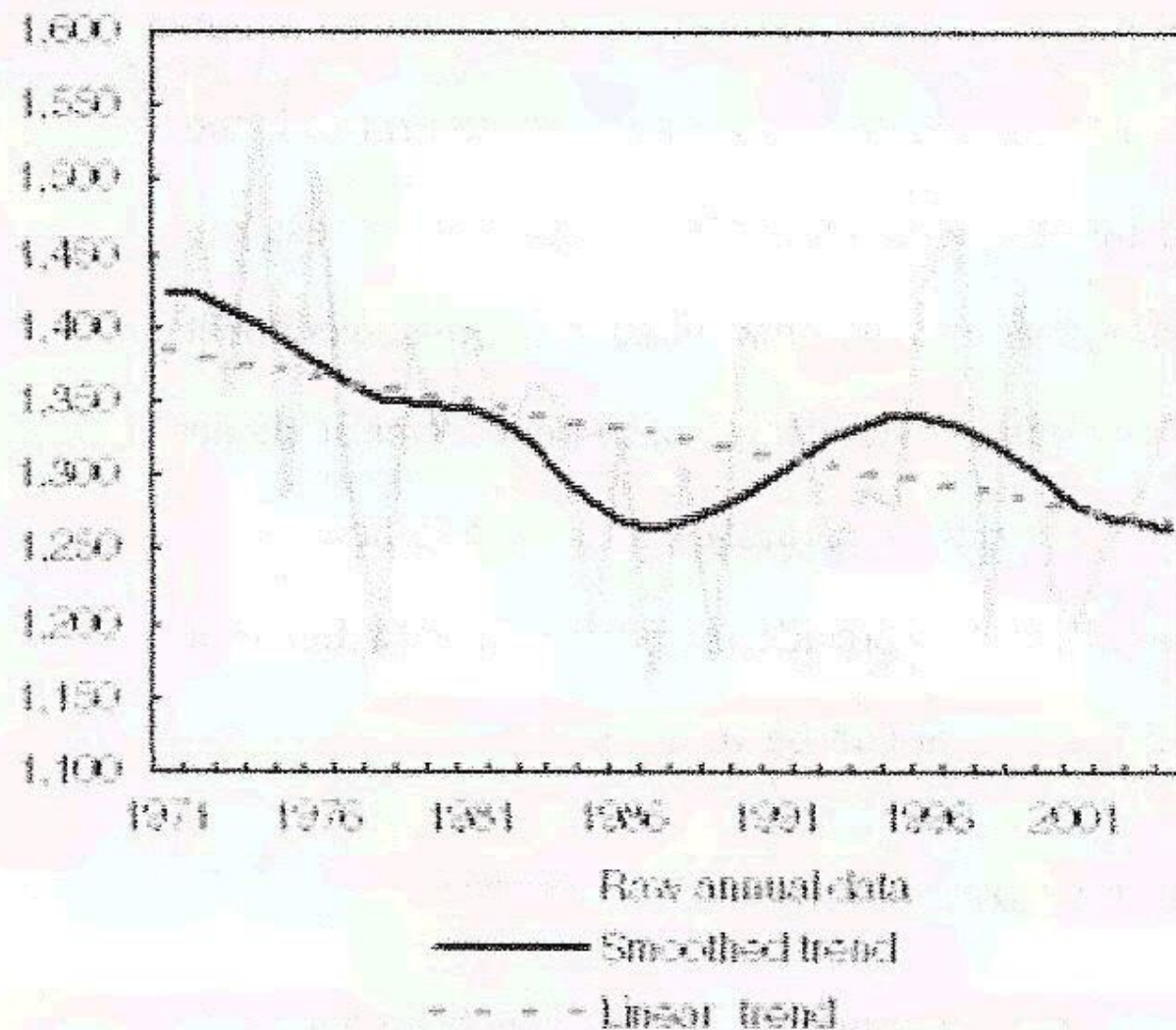
Grain industry

11



Trends in water yield for Southern Canada. 1971 to 2004

km³



The Marmot Creek drainage was chosen as a research site because it possessed all the biogeographic elements of a typical mountain headwaters. The watershed has its origins in the bare rock and snows of the upper alpine. The creek then flows through the alpine into Hudsonian forest before descending into the montane zone in the lower Kananaskis valley (see page 122).

Image courtesy of Dr. John Pomeroy, IP3

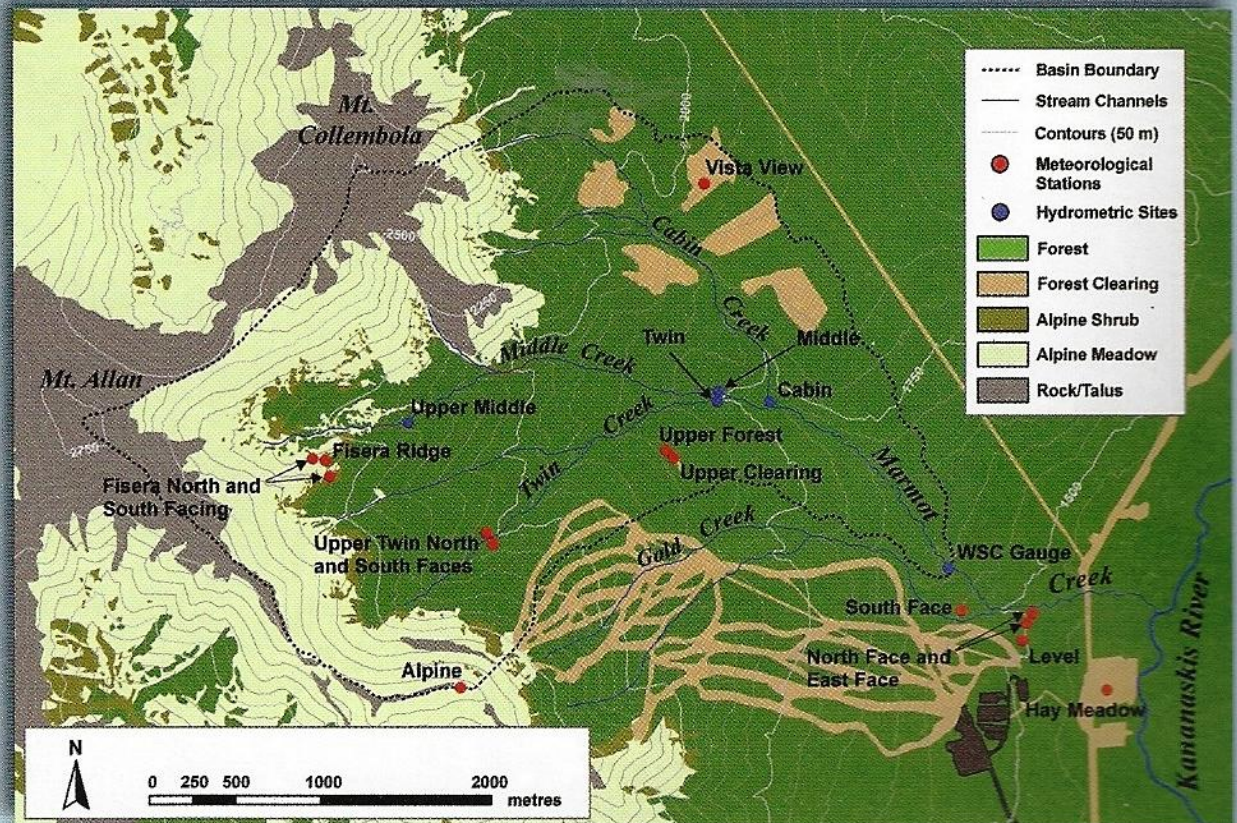
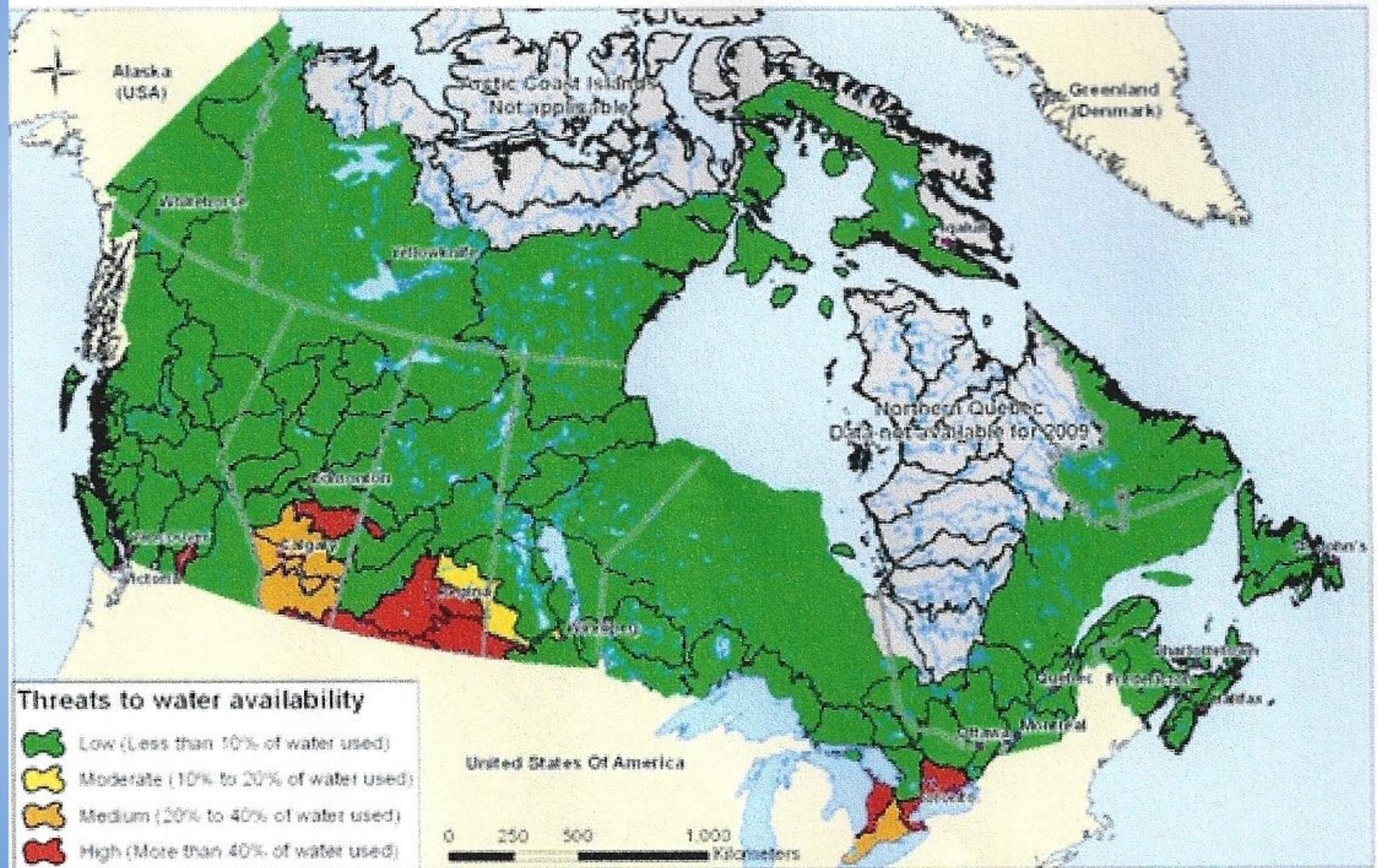
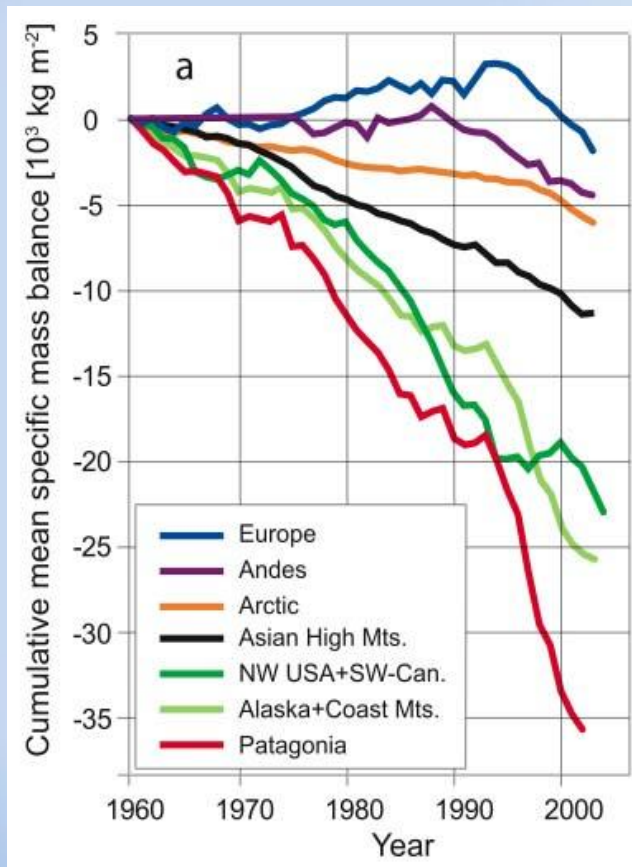


Figure 5: Water Availability Indicator for 2009



Mountain glaciers around the world are retreating



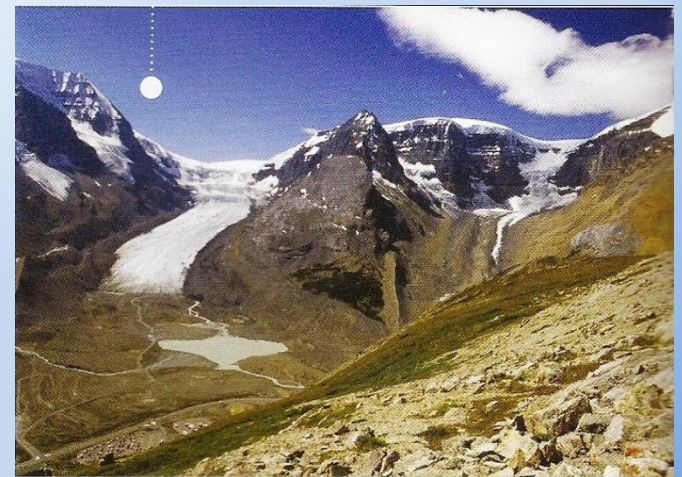
Ref: IPCC WGI Fig 4.15

ATHABASCA GLACIER, ROCKY MOUNTAINS, CANADA

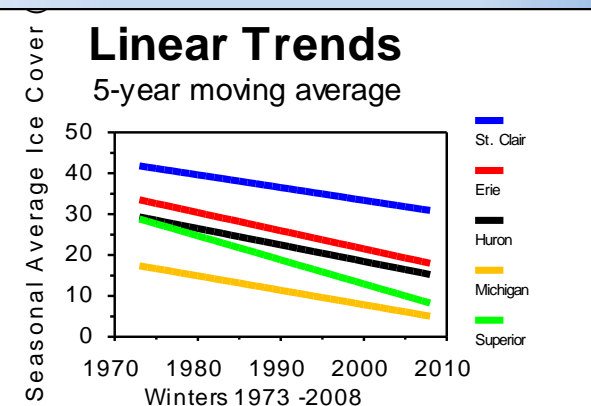
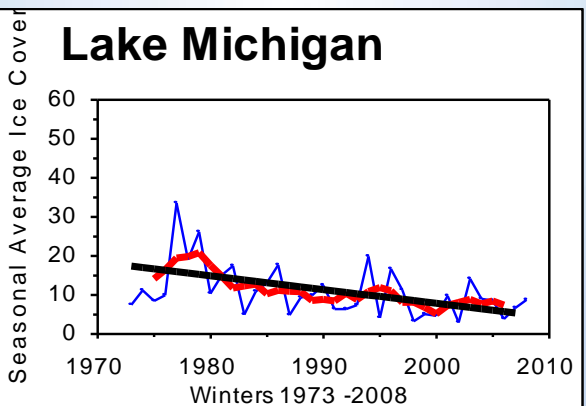
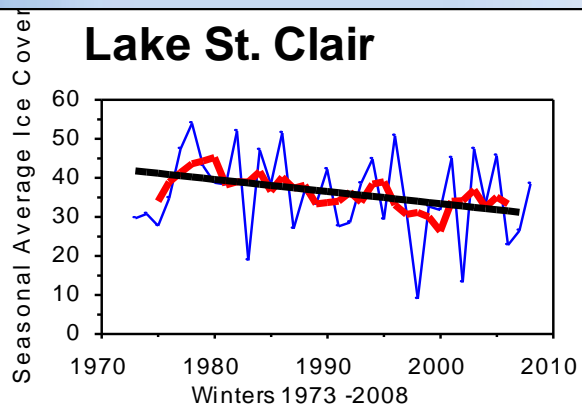
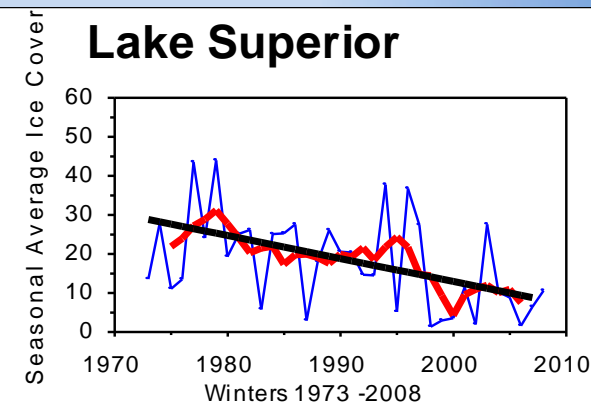
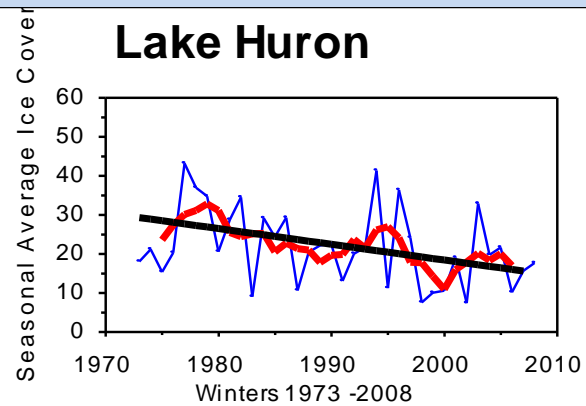
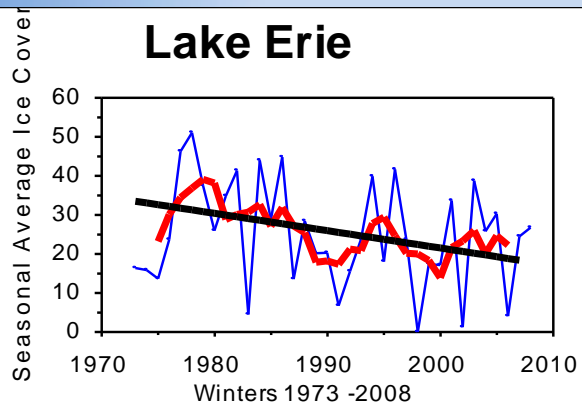


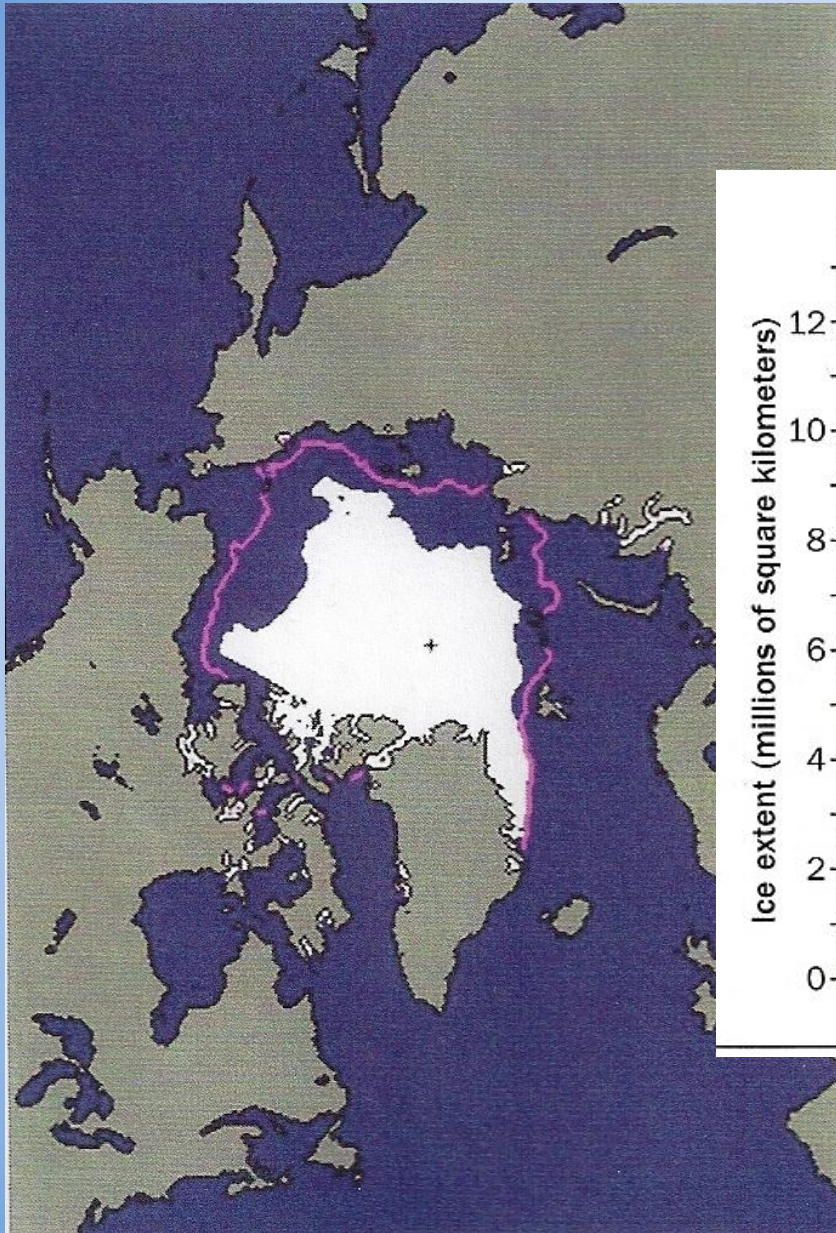
1917

2005

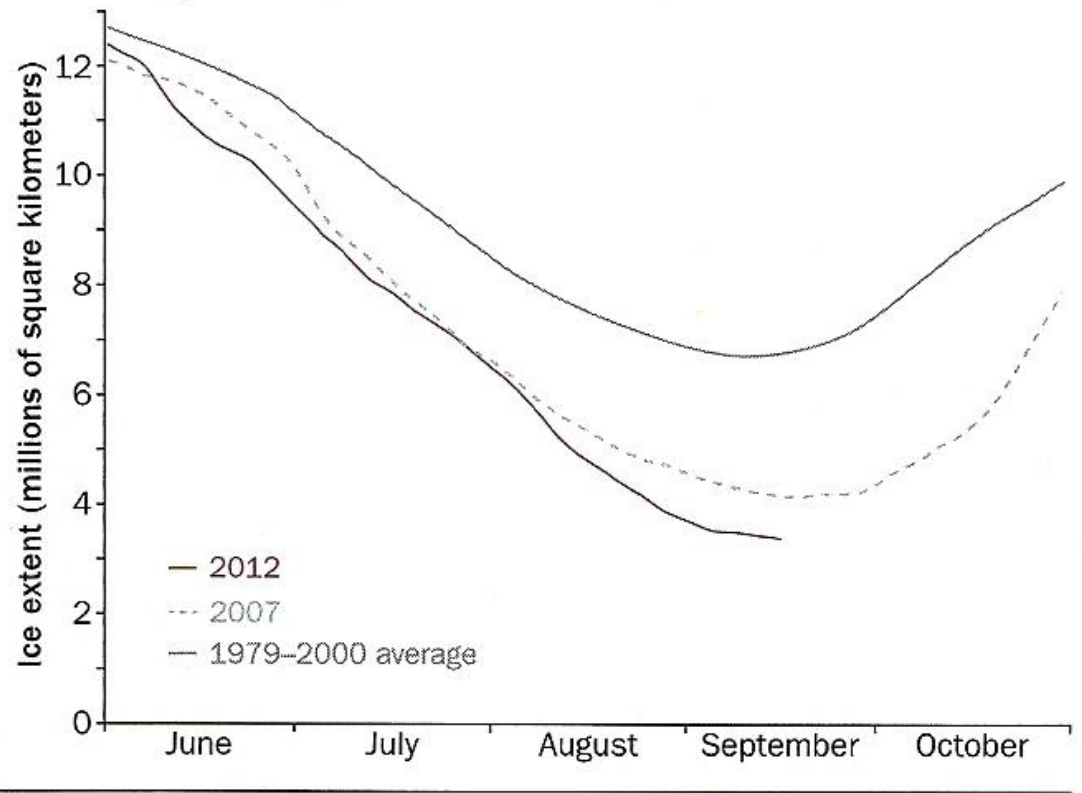


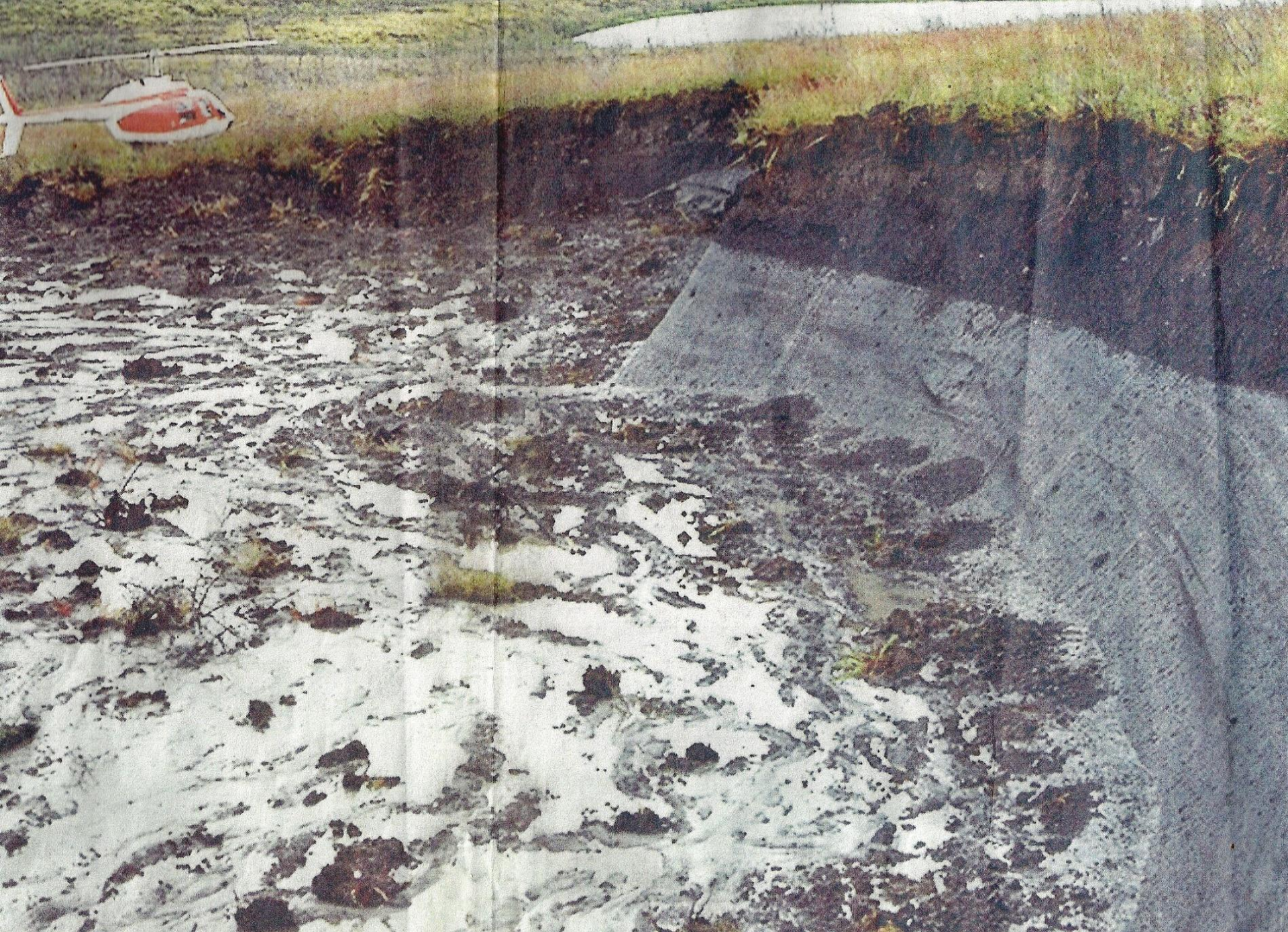
Luckman and Kavanagh, *Ambio*, 2000





Comparison of Arctic summer sea ice cover





A WORLD WITHOUT ICE

By Henry Pollack

Ice asks no questions, presents no arguments, reads no newspapers, listens to no debates. It is not bounded by ideology and carries no political baggage ... it just melts.

Estimated Sea Level Rise by 2100

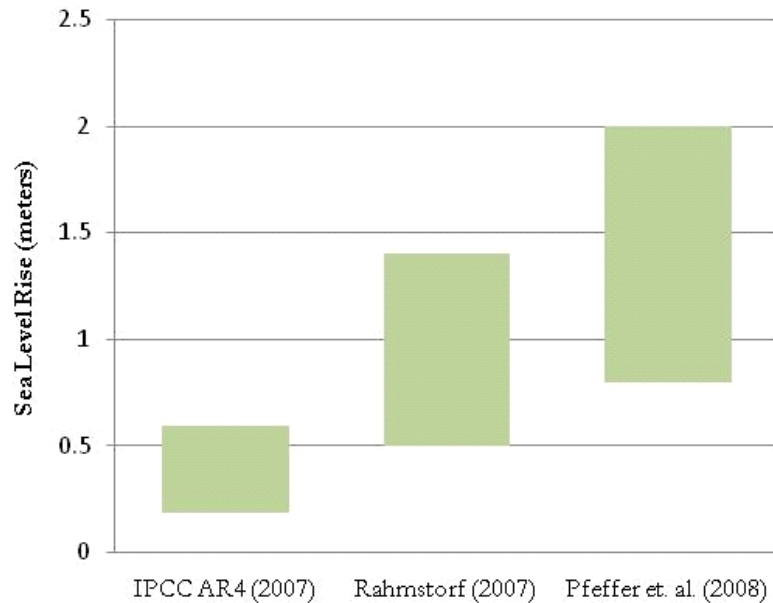


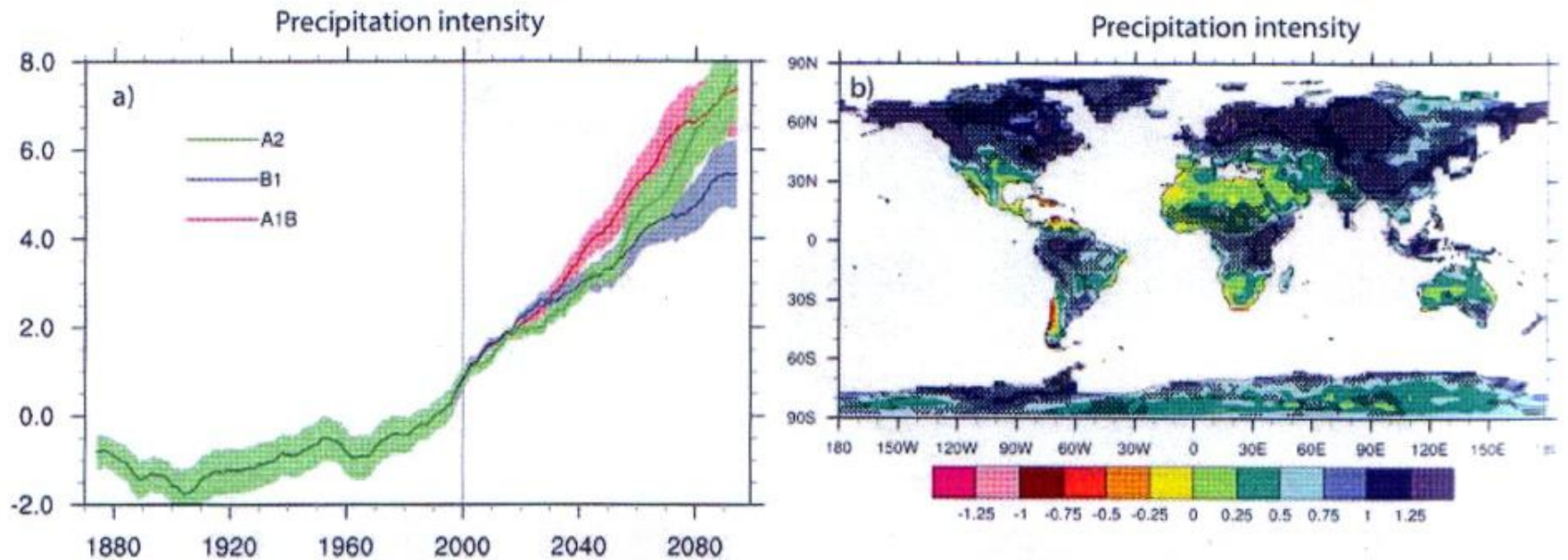
Figure 1. *Comparison of recent estimates of sea level rise in 2100, relative to 1990 levels.*

PEW Center 2009

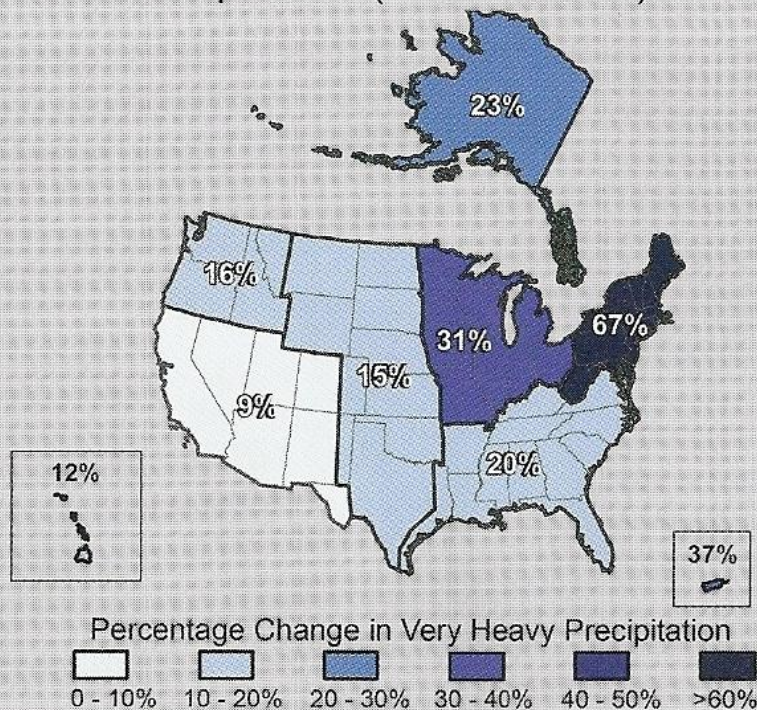


Figure TS.8. Relative vulnerability of coastal deltas as indicated by estimates of the population potentially displaced by current sea-level trends to 2050 (extreme >1 million; high 1 million to 50,000; medium 50,000 to 5,000) [B6.3]. Climate change would exacerbate these impacts.

Changes in extremes (a) Precipitation intensity and dry days for 2080-99



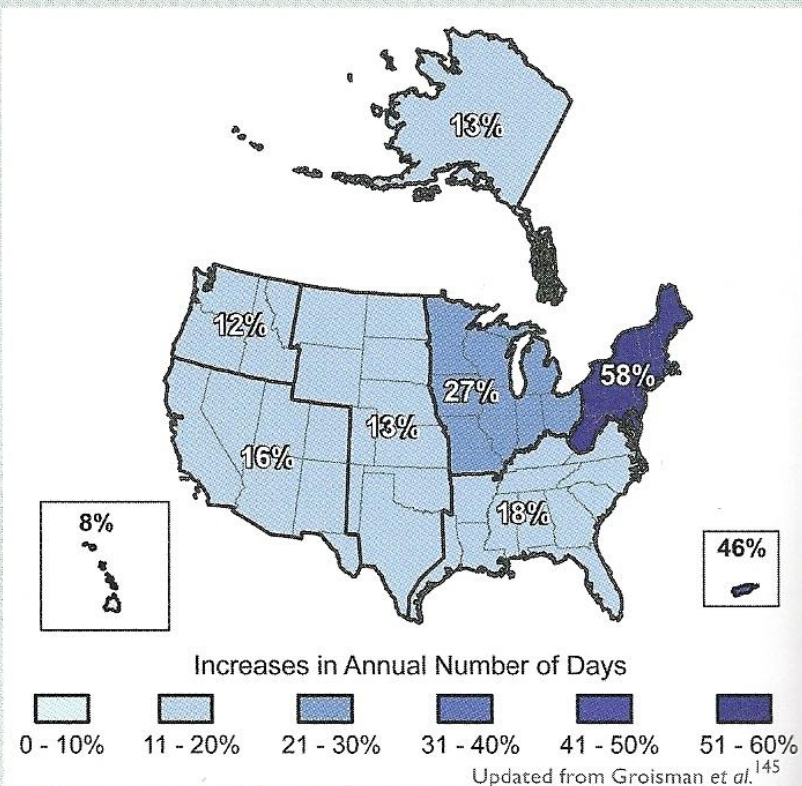
Increases in Amounts of Very Heavy Precipitation (1958 to 2007)



Updated from Groisman et al.¹¹³

The map shows percent increases in the amount falling in very heavy precipitation events (defined as the heaviest 1 percent of all daily events) from 1958 to 2007 for each region. There are clear trends toward more very heavy precipitation for the nation as a whole, and particularly in the Northeast and Midwest.

Increases in the Number of Days with Very Heavy Precipitation (1958 to 2007)



Updated from Groisman et al.¹⁴⁵

The map shows the percentage increases in the average number of days with very heavy precipitation (defined as the heaviest 1 percent of all events) from 1958 to 2007 for each region. There are clear trends toward more days with very heavy precipitation for the nation as a whole, and particularly in the Northeast and Midwest.

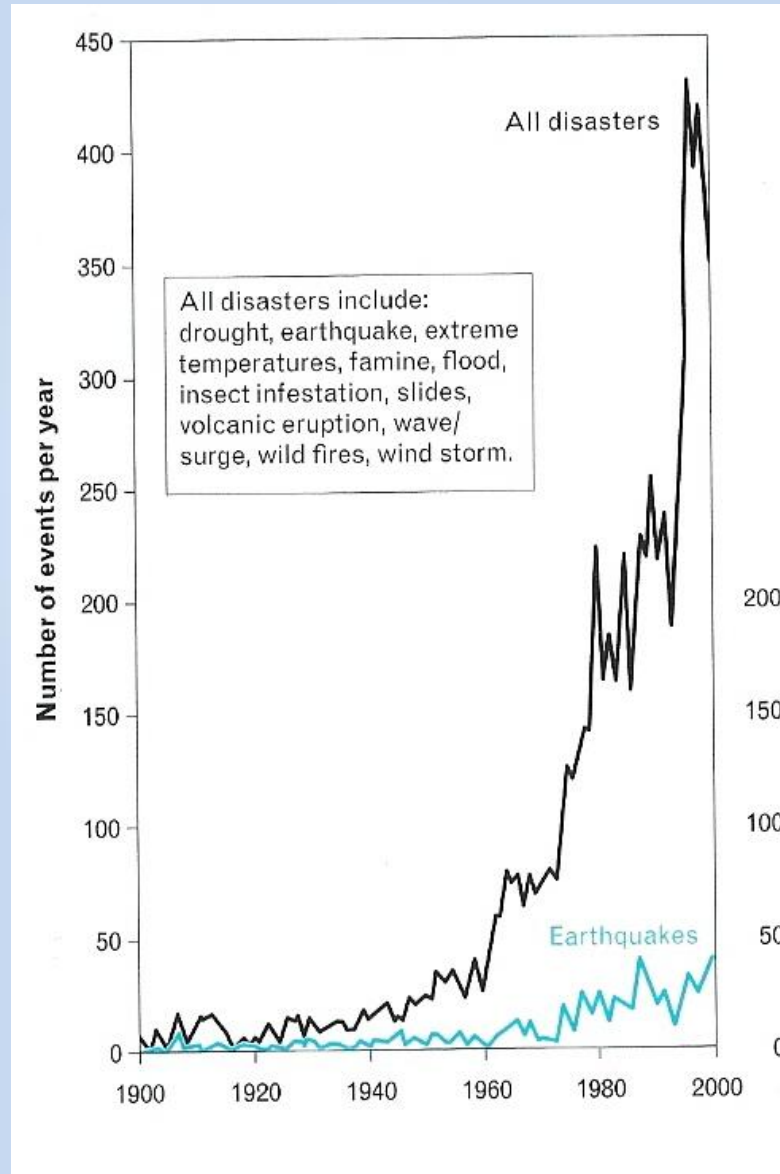
Toronto, August 2005



Pangnirtung 2008



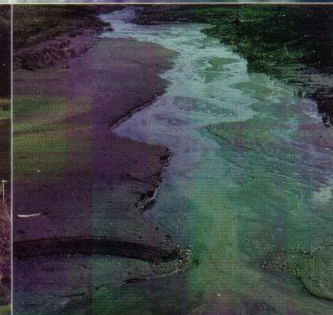
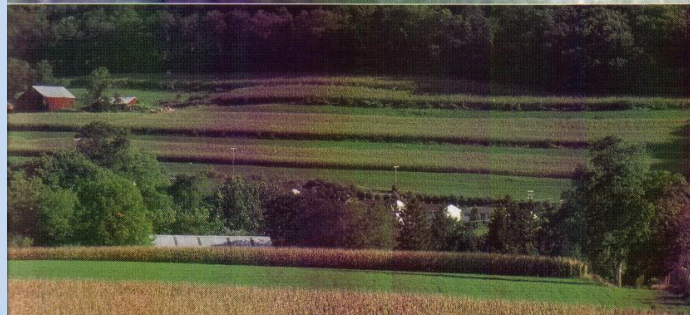
TRENDS IN REPORTED EVENTS / Per Year from Tiempo #70





CONSERVATION IMPLICATIONS OF CLIMATE CHANGE: SOIL EROSION AND RUNOFF FROM CROPLAND

A Report from the Soil and Water Conservation Society



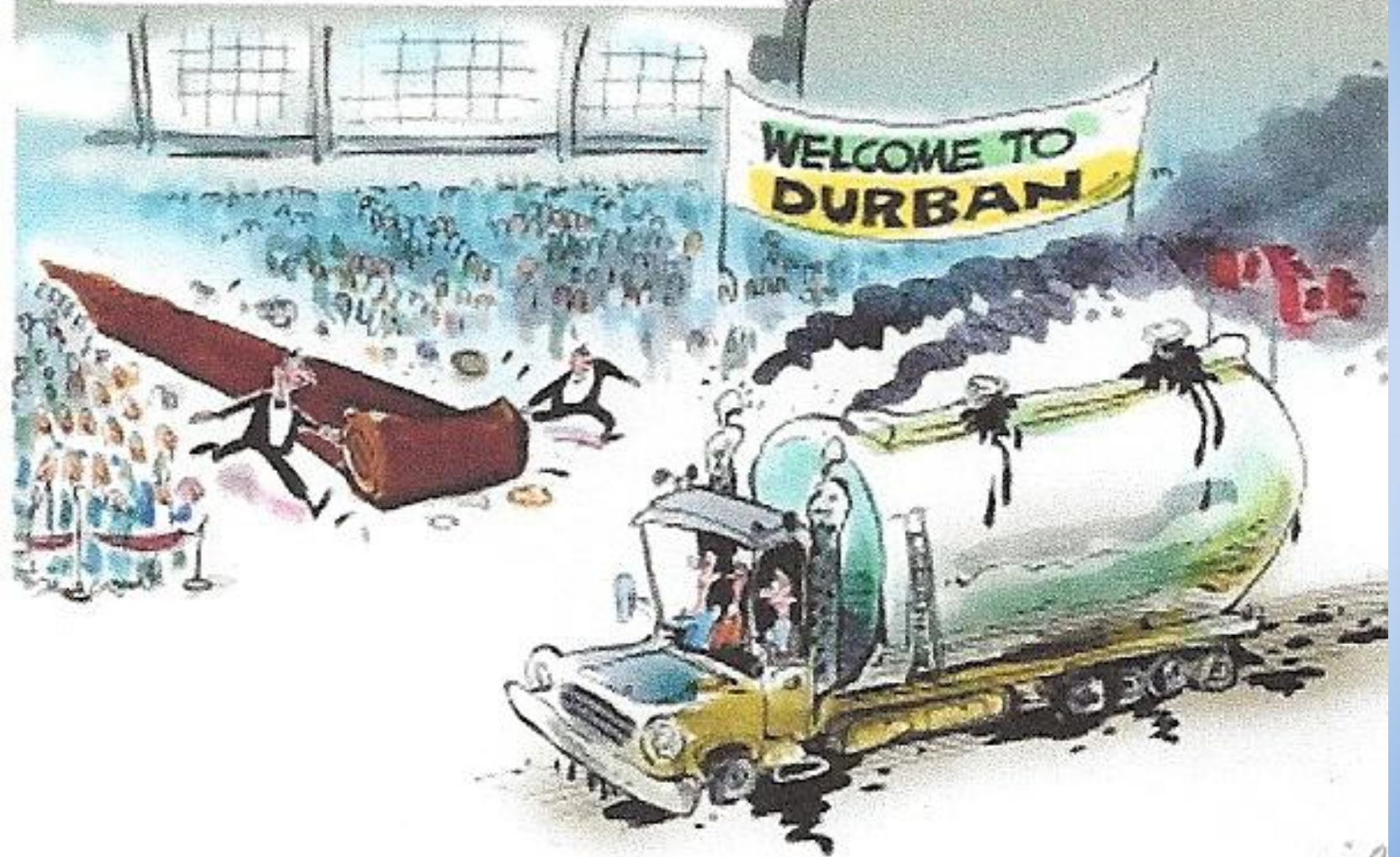


NATIONAL ROUND TABLE on ENVIRONMENT AND ECONOMY

Final Report, Oct. 2012 *(after 25 years)*

- **Impacts of climate change on Canada to 2100: up to \$43 bill/yr**
- **Low carbon goods and services global:
\$339 bill 2010
\$3,900 - \$8,300 bill 2050**
- **CANADA IS UNPREPARED TO COMPETE**

ROWING OUT THE BROWN CARPET:
THE CANADIAN DELEGATION ARRIVES...



WHY SWEDISH EYES ARE SMILING

In 1990 Sweden implemented a “green tax shift”. Taxes on energy and on carbon dioxide emissions were raised, while other taxes, such as those on payroll, were decreased by an equivalent amount.

Canada uses 50% more energy than Sweden to produce the same amount of goods and services as measured by per capita GDP.

KYOTO CRITICS ARE WRONG: YOU CAN GET RICH BY GOING GREEN. SWEDEN WILL HAPPILY SHOW YOU HOW.

Ambassador Lennart Alvin Globe & Mail 25 May, 2005

SOME ADAPTATION OPTIONS

– WATER QUANTITY

Increased level of flash flood protection e.g. TRCA-15-20⁰

Improve capacity of culverts and storm water systems

For low water periods institute demand-side management

SOME ADAPTATIONS

- WATER QUALITY AND HEALTH

Target erosion – prone areas of watersheds

Strengthen polluted runoff reduction measures - e.g. No Till

Larger buffer zones for streams and wellheads

More storage in storm water systems

- Permeable pavements, etc.**
- reduce overflow to sanitary sewage**

Alerts to treatment plant operators

CONCLUSIONS:

- 1. ANTHROPOGENIC CLIMATE CHANGE IS HERE**
- 2. IMPACTS WILL INCREASE FOR MANY DECADES**
- 3. WATER SECTOR FACING MAJOR IMPACTS**
- 4. GHG EMISSION REDUCTIONS NEEDED TO SLOW RATE OF CHANGE**
- 5. PORTFOLIO OF ADAPTATION MEASURES NEED IN WATER SECTOR**

“Climate change is the greatest economic challenge of the 21st century”

Christine Lagarde, Director International Monetary Fund