Climate Change and Atmospheric Hazards

A Risk Management Approach

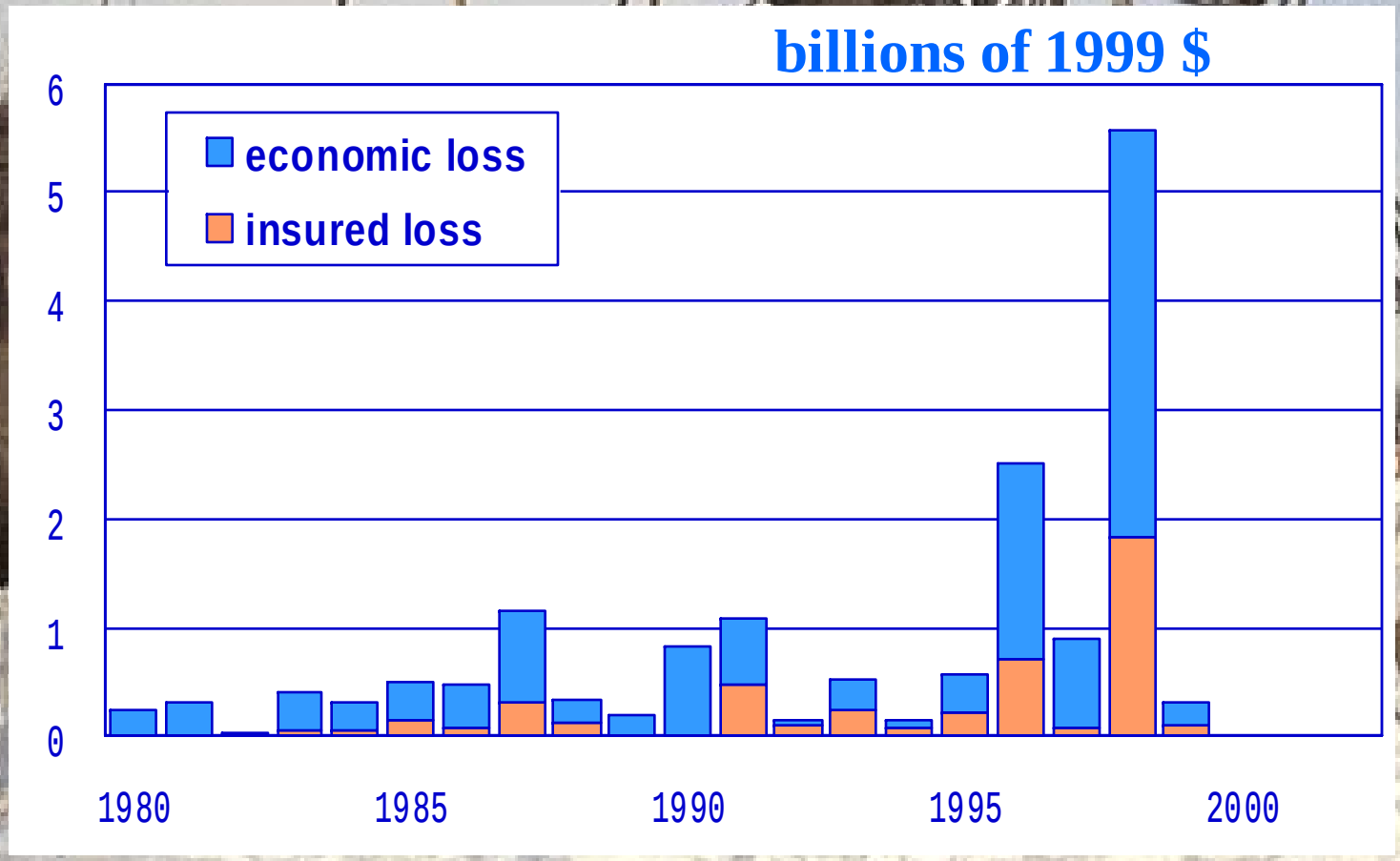
Joan Klaassen

MSC- Ontario Region

Environment Canada Environnement Canada

Increasing Natural Disaster Losses

Is Vulnerability of Communities Increasing??



Source: ICLR, based on data from IBC and Emergency Preparedness Canada

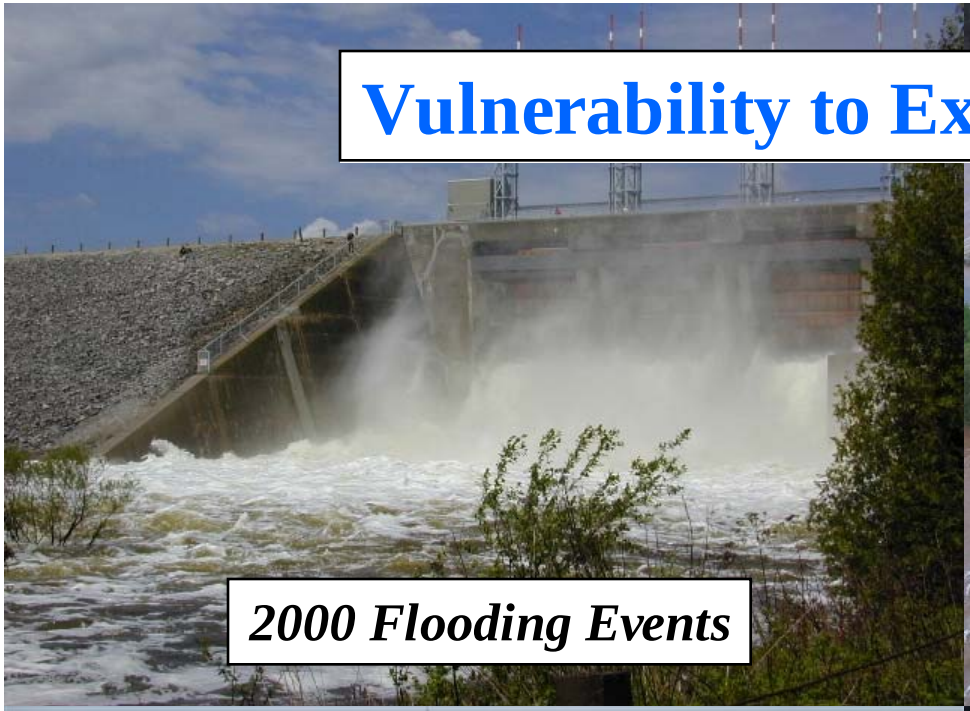
Is Community Vulnerability to High Impact Weather Increasing?

- Increasing population…more targets
- More affluence and property
- Increasing urbanization

Coupled with

- Aging, deteriorating infrastructure
- Fewer $ spent on new infrastructure
- Continued/increasing dependence on electricity, electronics, communication

Vulnerability to Extreme Rainfall/Flooding



2000 Flooding Events

2002 NW Ontario

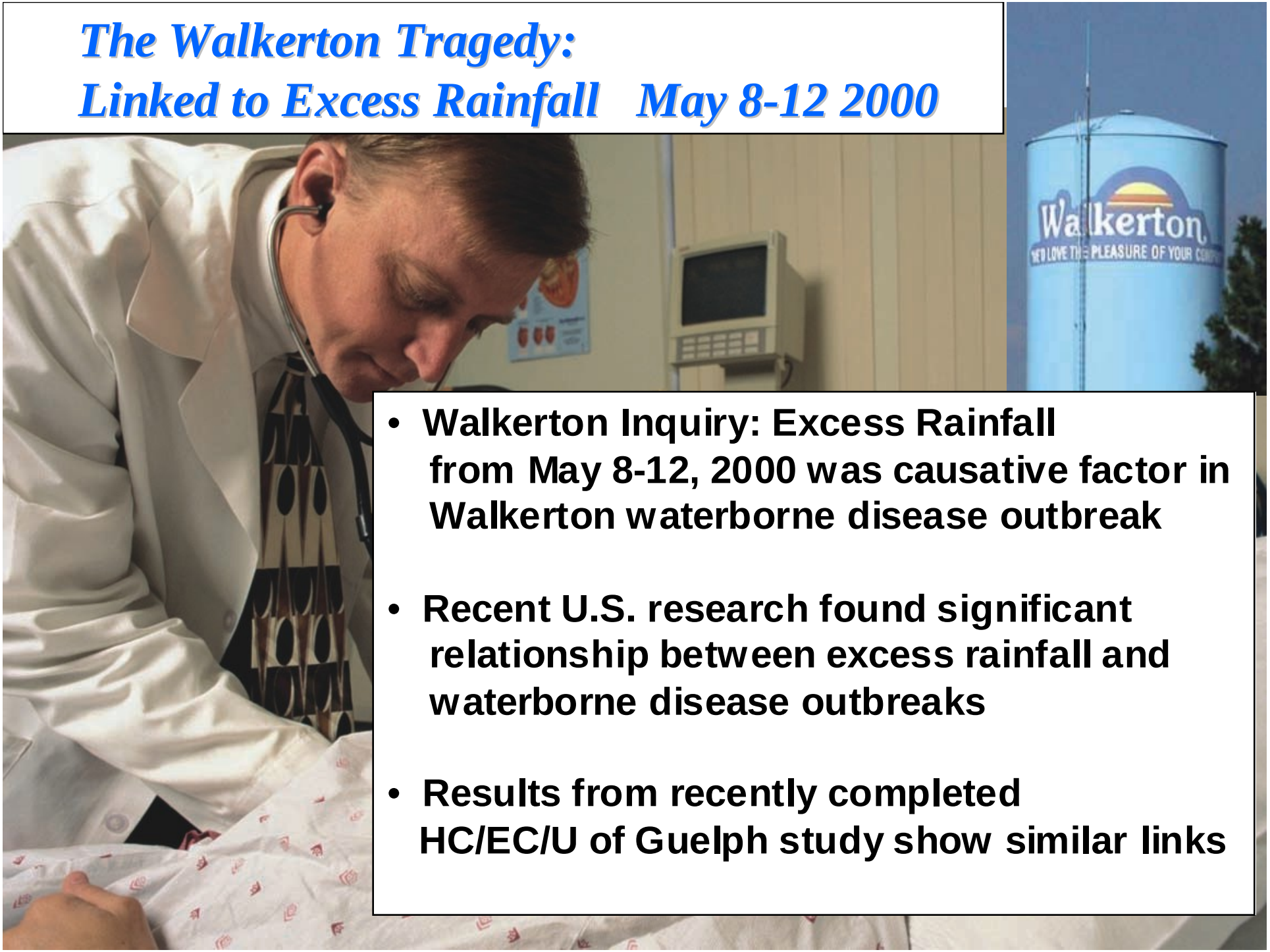
Peterborough 2004

Toronto 2005

Storm Rainfall Events of Spring/Summer 2000

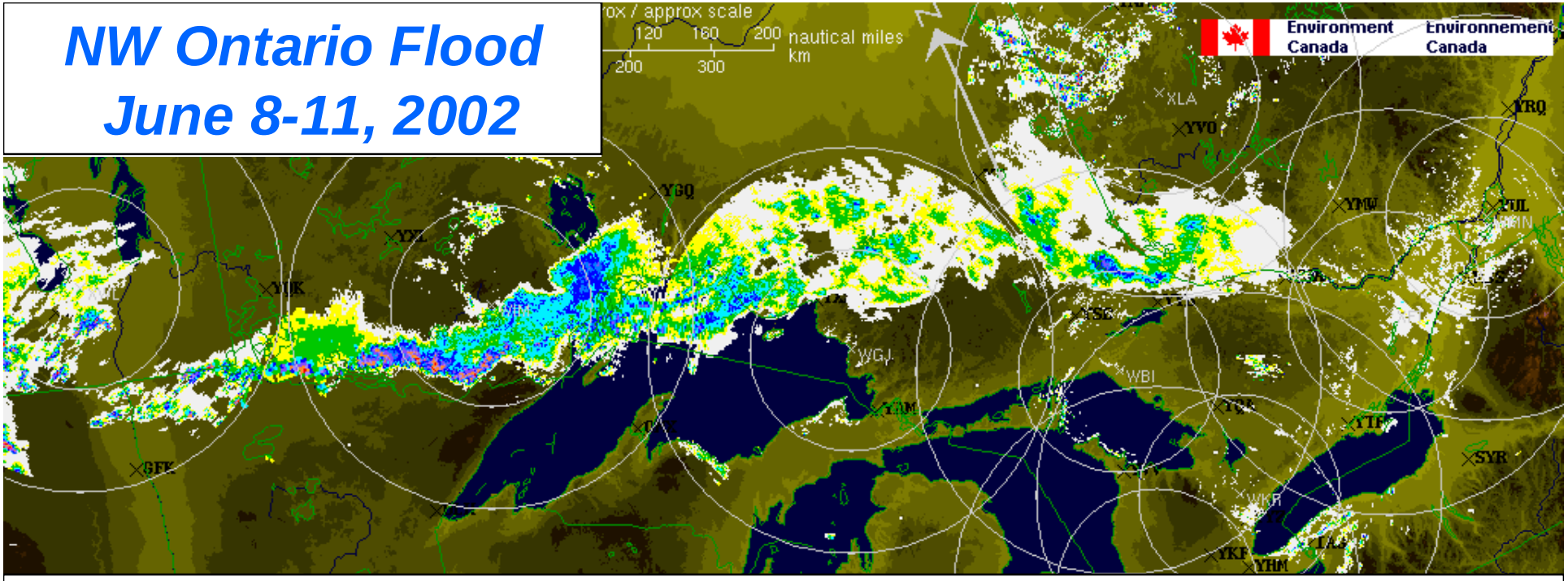
- Several high impact storm rainfall events in southern, central Ontario during spring, summer 2000
- Flood damage estimates totalled in millions
- Several storms in excess of 100 year return frequency of occurrence, in excess of design standards
- Implications for update of ***design criteria*** for water infrastructure??

The Walkerton Tragedy: Linked to Excess Rainfall May 8-12 2000



- **Walkerton Inquiry: Excess Rainfall from May 8-12, 2000 was causative factor in Walkerton waterborne disease outbreak**
- **Recent U.S. research found significant relationship between excess rainfall and waterborne disease outbreaks**
- **Results from recently completed HC/EC/U of Guelph study show similar links**

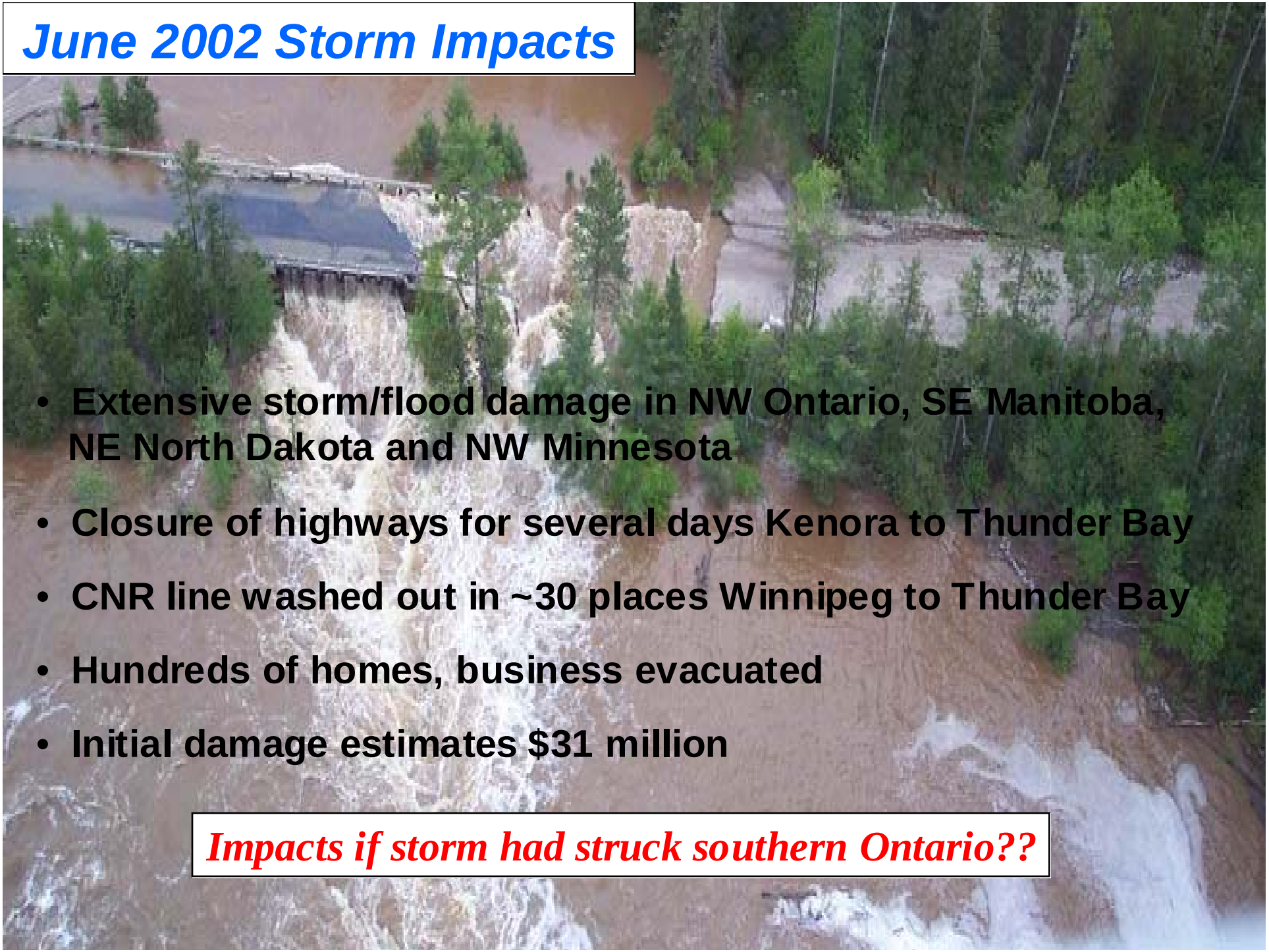
NW Ontario Flood
June 8-11, 2002



- **~400 mm of rain in 48 hours over NW Ontario region bordering Manitoba and Minnesota**
- **Rainfall of over 360 mm for small basin area (100 km^2) exceeded current regulatory flood "*Timmins Storm*" by 2 to 3 times for 48 hour period**

New "Design Storm" for this area based on this event???

June 2002 Storm Impacts



- Extensive storm/flood damage in NW Ontario, SE Manitoba, NE North Dakota and NW Minnesota
- Closure of highways for several days Kenora to Thunder Bay
- CNR line washed out in ~30 places Winnipeg to Thunder Bay
- Hundreds of homes, business evacuated
- Initial damage estimates $31 million

Impacts if storm had struck southern Ontario??

Storms and Flooding in Summer 2004

Several High Impact Rainfall/Flooding Events

June-August 2004

Southern/Eastern Ontario

Focusing on 3 storms:

- ✓ **"Urban" Peterborough July 14-15**
- ✓ **"Rural" Grand River June 14**
- ✓ **"Frances" Eastern Ontario**

Peterborough
July 14-15, 2004

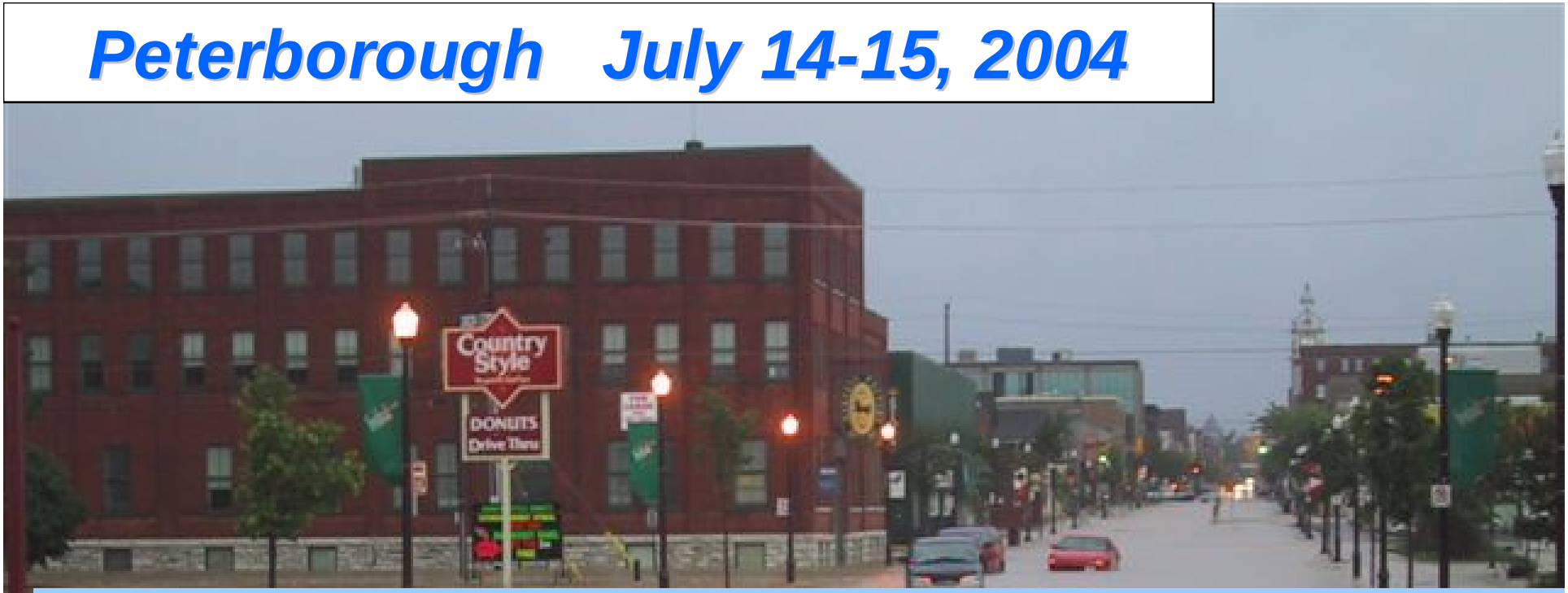
"Frances"
Ottawa/Eastern Ontario
Sept 9-10, 2004

Peterborough July 14-15, 2004

- Up to 250 mm of rain storm total recorded in City of Peterborough just over 24 hours
- BUT 150 mm of total in only 2 hours
- Province declared City a disaster area
- State of emergency declared in City

- Extensive & significant flooding of Peterborough's 2 main waterways
- Roof collapses under sheer weight of rainfall
- Gas and power outages in some areas for several days
- Private & commercial property insurance claims of $87M (Sep 2005)

Peterborough July 14-15, 2004

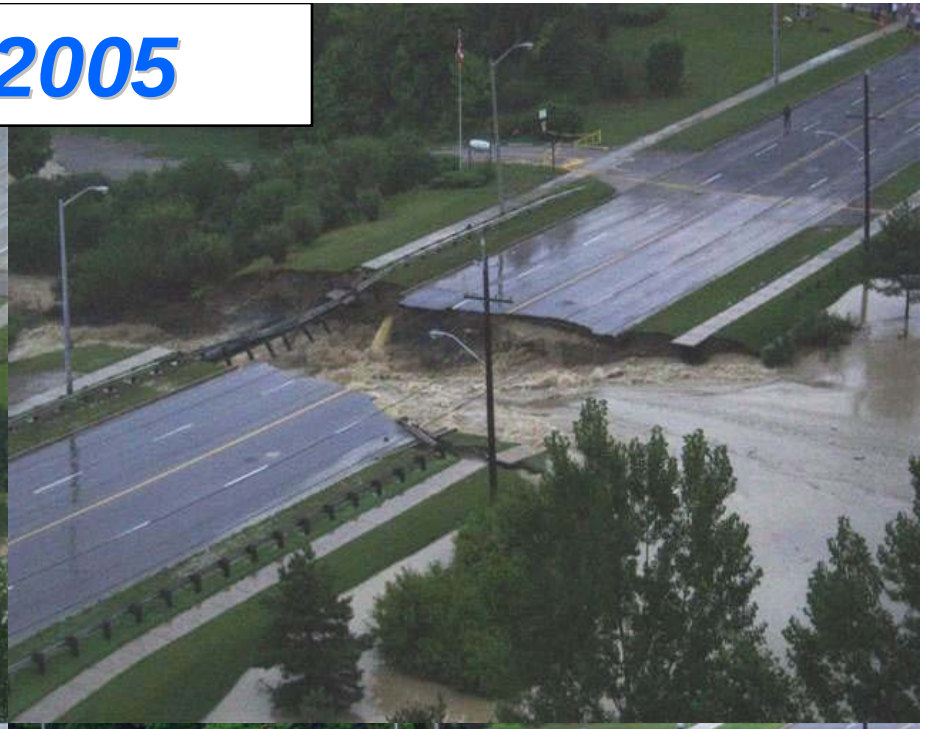


Consultants' report commissioned by City of Peterborough indicates 3 main infrastructure deficiencies served to worsen flood impacts:

1. **Majority of City's sewer systems designed for 2 year storm event**
2. **Lack of overland routes for excess storm water (ex. older parts of city)**
3. **Excessive ground water seeping into city's sewer system (over 5 times normal amount of sewage through treatment plant)**

Estimated cost of actions to deal with infrastructure deficiencies: $200M

Toronto August 19, 2005



Finch Avenue During and After the Storm

Toronto August 19, 2005

Rain gauge data available from over 90 gauges in the immediate Toronto area

Environment Canada data supplemented by extensive collection of Conservation Authority, municipal, volunteer rain gauge information

Rainfall amounts up to 175 mm recorded in Yonge/Steeles area
103 mm recorded in 1 hour at Environment Canada Downsview

Ice Storm ‘98

- Canada’s most costly ($) weather disaster ever
- Up to ***95 mm*** of freezing rain accumulation in 3 separate “storms” over 1st week January
- Impacted 4 provinces; 7 states
- Collapsed communication towers, electrical transmission/distribution systems, phone lines
- <u>Deaths</u>: 28 in Canada; 19 in U.S.

Communities are Vulnerable to All High Impact Weather Events

Toronto January 1999 Snowstorms; Roof Collapses 2001-02 Winters

Heat, Poor Air Quality Summers 2001, 2002,2005

Tornadoes 2004, 2005

Drought/Low Water Levels 1997-April 2000, 2001 & 2002

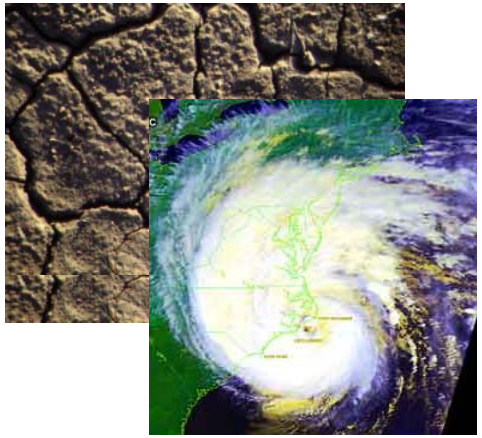
CLIMATE CHANGE

Changes in Extremes

Very Likely

- More extreme ***maximum temperatures*** (less extreme ***mins***)
- More intense, more frequent, longer lasting ***heat waves***
- More intense, more frequent ***precipitation events***

Likely

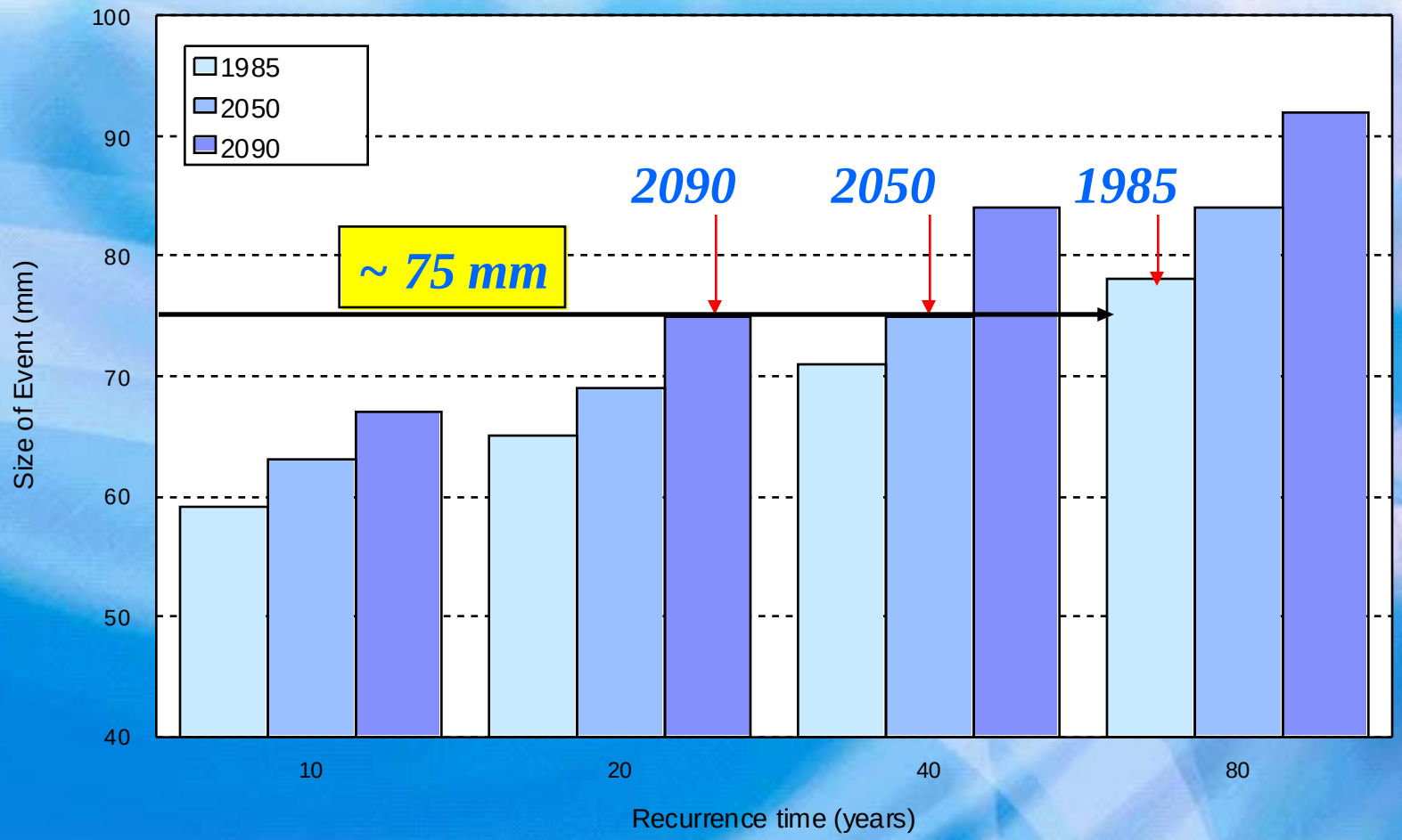


- Increased frequency, severity of **drought**
- Increases in tropical storms/hurricane wind and precipitation intensity

Possible???

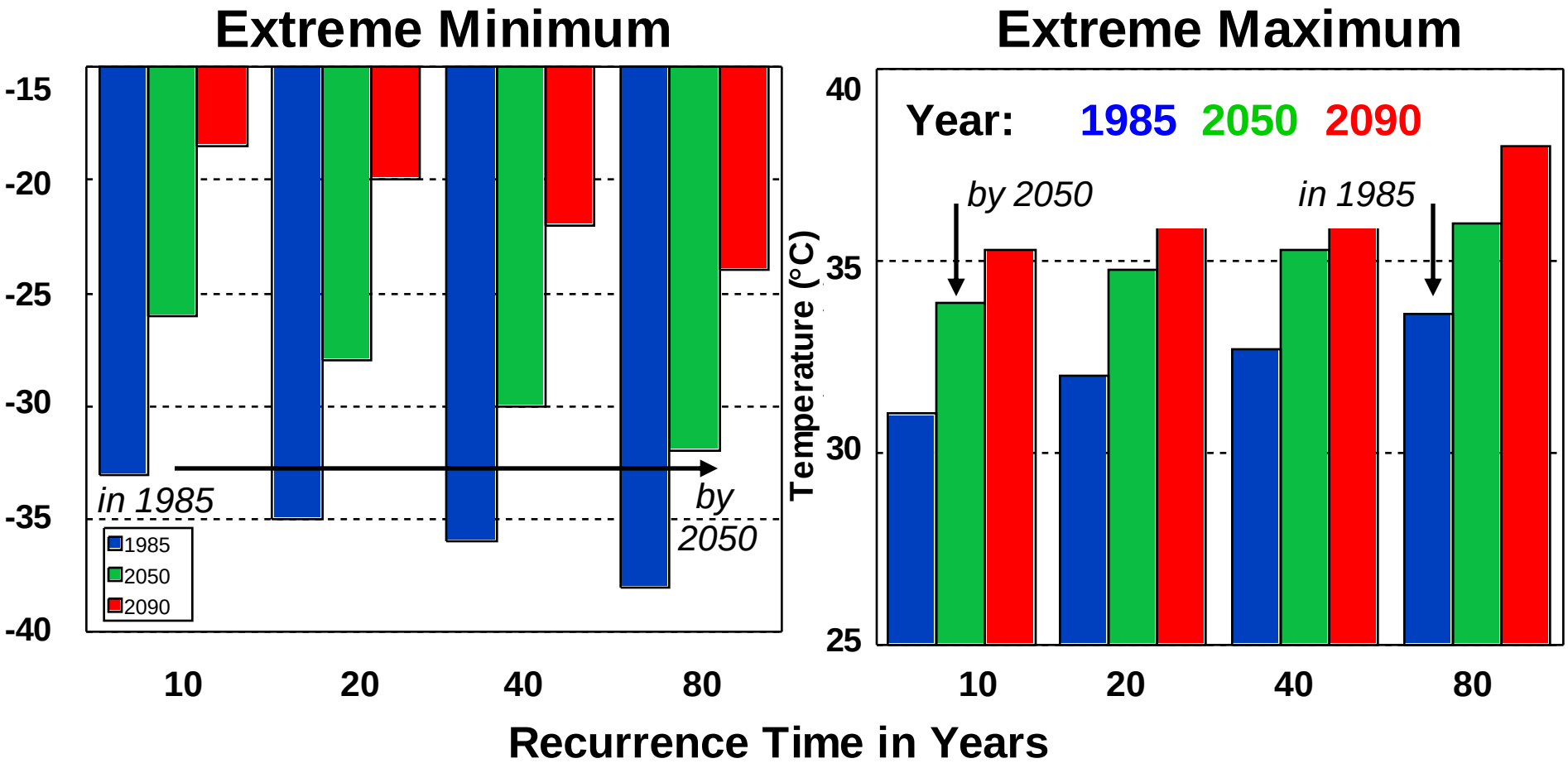
- Increased risk extreme events such as tornadoes, hail, lightning, ice storms

Projected Changes in Canadian Extreme Precipitation



Projections of changes in average Canadian extreme 24-hour rainfall events that can be expected to recur once every 10, 20, 40, or 80 years.
(Canadian Model, CGCM1, with Combined Effects of Projected Greenhouse Gas and Sulphate Aerosol Increases)

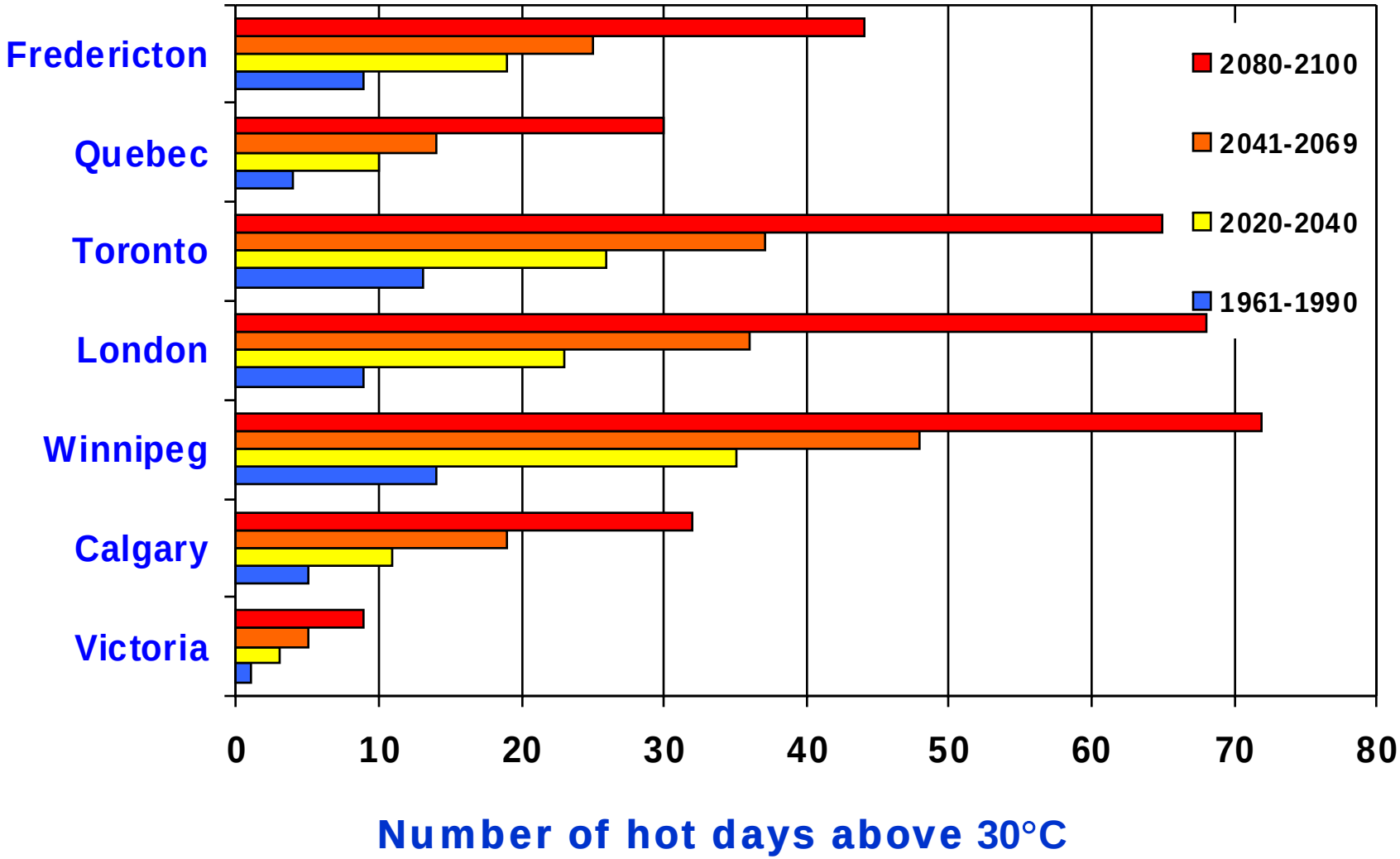
Projected Changes in Canadian Extreme Temperatures



Canadian Model (CGCM1) projections of changes in average Canadian extreme temperatures that can be expected to recur once every 10, 20, 40, or 80 years.
(Combined Effects of Projected Greenhouse Gas and Sulphate Aerosol Increases)

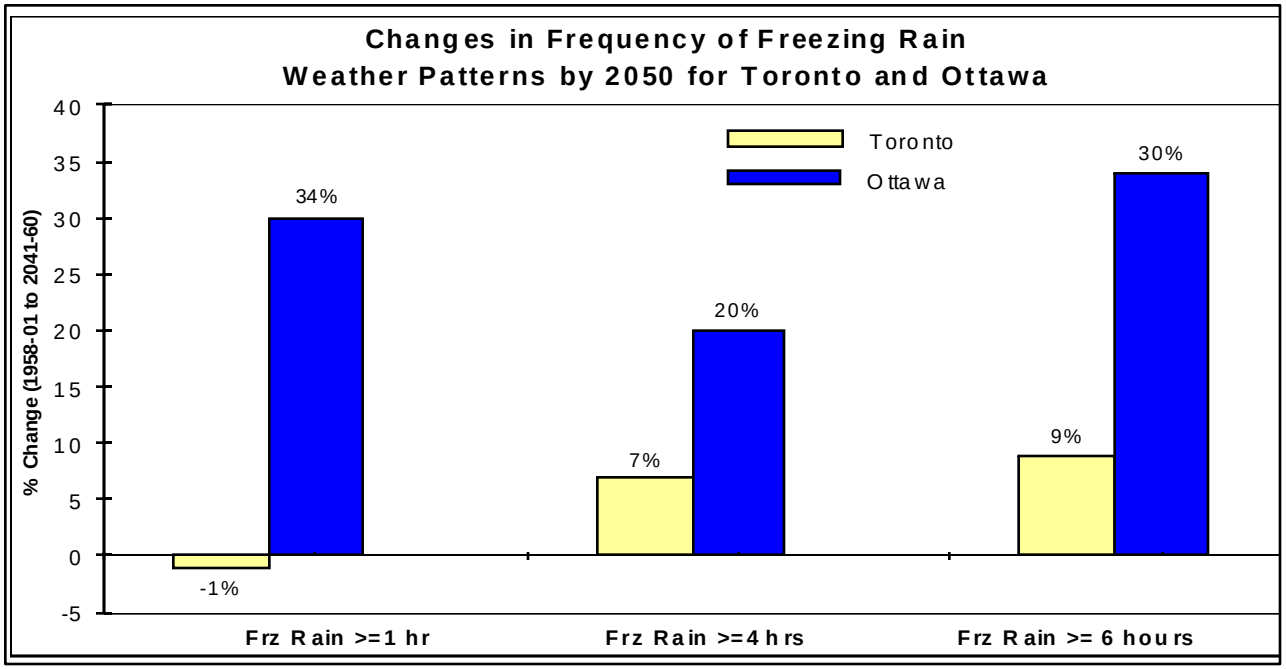
Source: Kharin and Zwiers (2000)

Number of Hot Days in Canadian cities is projected to become more frequent



Source: Kharin and Zwiers (2000)

Increased Vulnerability to Ice Storms with Climate Change?



2003
MSC-Ontario study

By 2050, increases in frequency of weather types associated with freezing rain for locations across Ontario

Results suggest
possible increased risk of ice storms in a future climate

Reducing Community Risks to Weather Related Disasters in Ontario

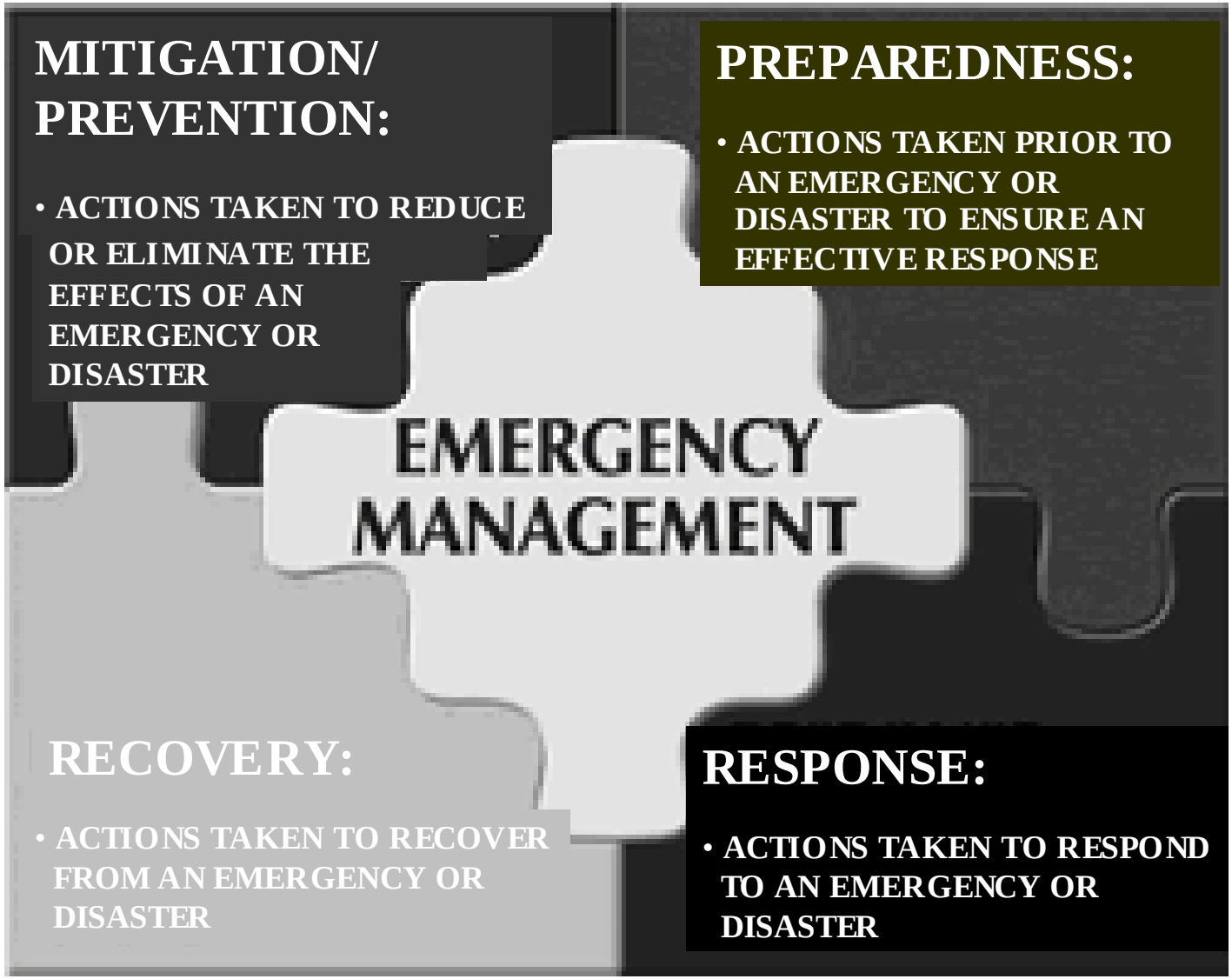
Ontario's
Emergency Management Act
(Bill 148)

Atmospheric Hazards in Ontario Website
Developed By
Environment Canada
in partnership with
Emergency Management Ontario

Ontario's
Emergency Management Act

- **2003 legislation adopted under "Bill 148"**
- **Legally mandates Ontario municipalities/ministries to implement risk-based emergency management programs**
- **First Phase: The HIRA Process**
  - **Municipalities/ministries MUST perform hazard risk assessment & critical infrastructure identification**
  - **Part of assessment involves risk assessment to weather hazards**
  - **Completed December 2004**
- **Ongoing Phases: By 2006-2007, prepare comprehensive emergency preparedness/response plans**

Ontario's Emergency Management Act



Weather Hazard Risk Assessment

Ontario's Emergency Management Act (Bill 148)

- **Part of assessment involves assessment of risks to weather hazards:**

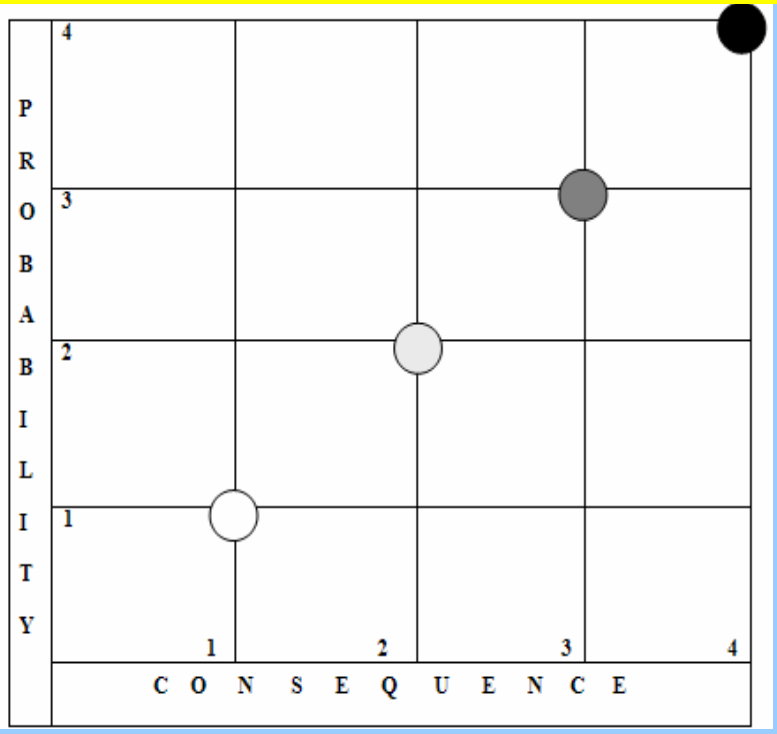
Fog	**Lightning**
Heavy Rain	**Heavy Snow**
Hurricanes	**Wind Storms**
Extreme Heat/Cold	**Ice Storms**
Drought	**Tornadoes**

Extreme Air Quality Events



Hazard and Impact Risk Assessment (HIRA)

Community Risk Assessment Grid



Lowest Priority, consequence score 1, probability score 1,total score= 1+1=2

Lower Priority, consequence score 2, probability score 2,total score= 2+2=4

Higher Priority, consequence score 3, probability score 3,total score= 3+3=6

Highest Priority, consequence score 4, probability score 4,total score= 4+4=8

Probability of Occurrence	*Consequence*
1- No history in last 10-15 years *2- Greater than 5 years* *3- One incident in the last 5 years* *4- Greater than one incident in the last 5 Years*	*1- Negligible* *2- Limited* *3- Substantial* *4- High*

Source: EMO, 2003

Meteorological Service of Canada
Core Mission

Help the Canadian Public reduce the threat to life and property from high impact weather

"MSC wants to improve society's capacity to adapt to, anticipate, mitigate, withstand and recover from severe weather and related hazards"

- **Ontario government supports this mandate through the**

  Emergency Management Act

- **Bill's objectives align with MSC core mission…**

- **Partnership of MSC, Emergency Management Ontario (EMO) in development and launching of the**

  Atmospheric Hazards in Ontario

  website in 2004

- **Relaunch of site in summer 2005 with updated and new information**

IDENTIFIYING and ASSESSING THE RISK

Atmospheric Hazards in Ontario

www.hazards.ca

Weather, Air Quality
And Great Lakes Marine
Hazards
information
in support of
Ontario's
Emergency Management Act

***HARD-COPY* publication**
release summer 2004;
also available through the
Website

Ontario
Meteorological, Air Quality & Marine Hazards
Maps, Data and Information available on:
www.hazards.ca

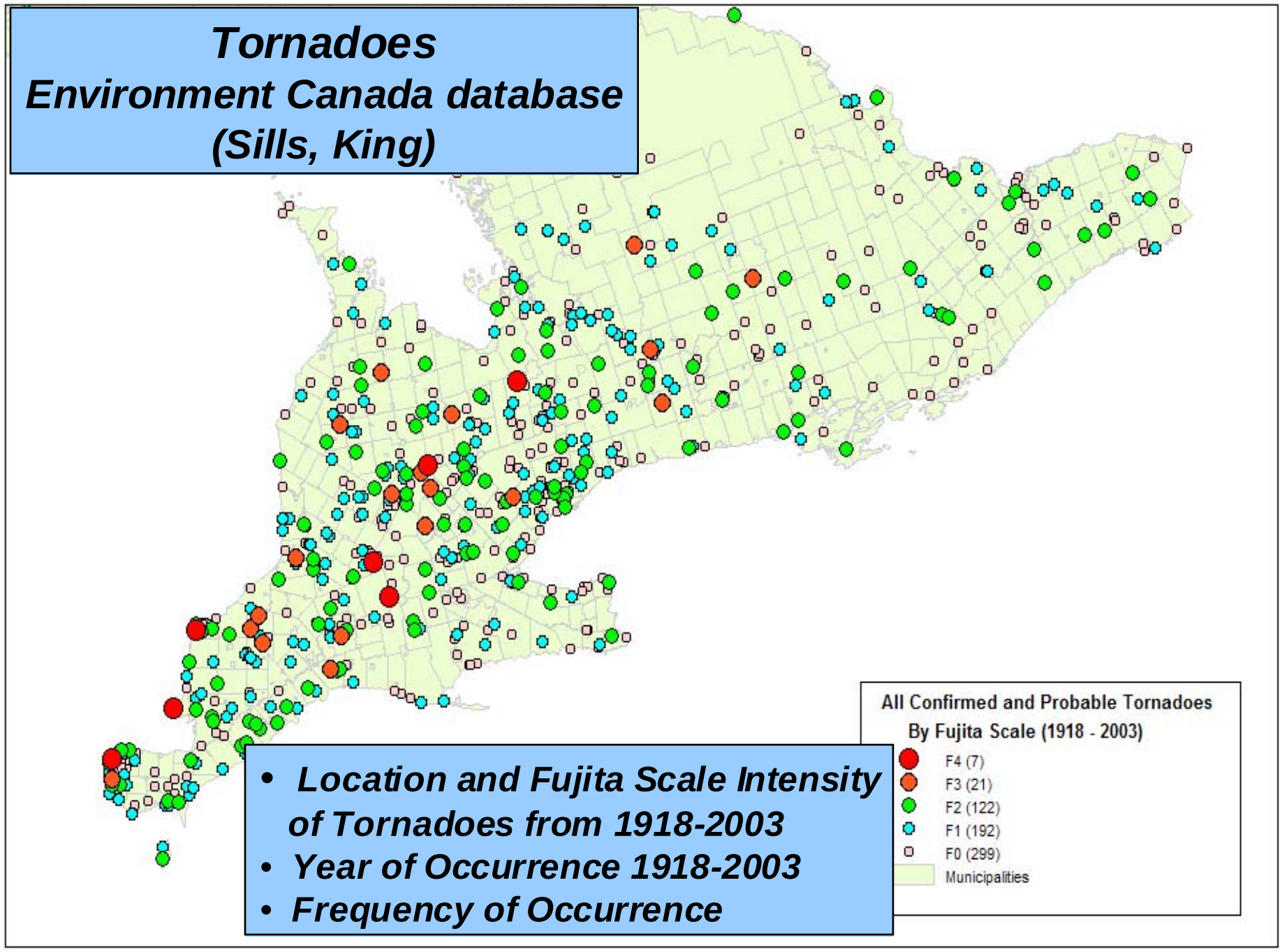
Municipal and Ontario Emergency Management Coordinators **identify and assess community risks to atmospheric hazards**

Industry, Universities, General Public also access/use site

- **Search by location or hazard**
- **Adjust significance of parameters to narrow field**
- **Identify most relevant atmospheric hazards in community**
- **Compare frequency of hazards in different parts of Ontario**

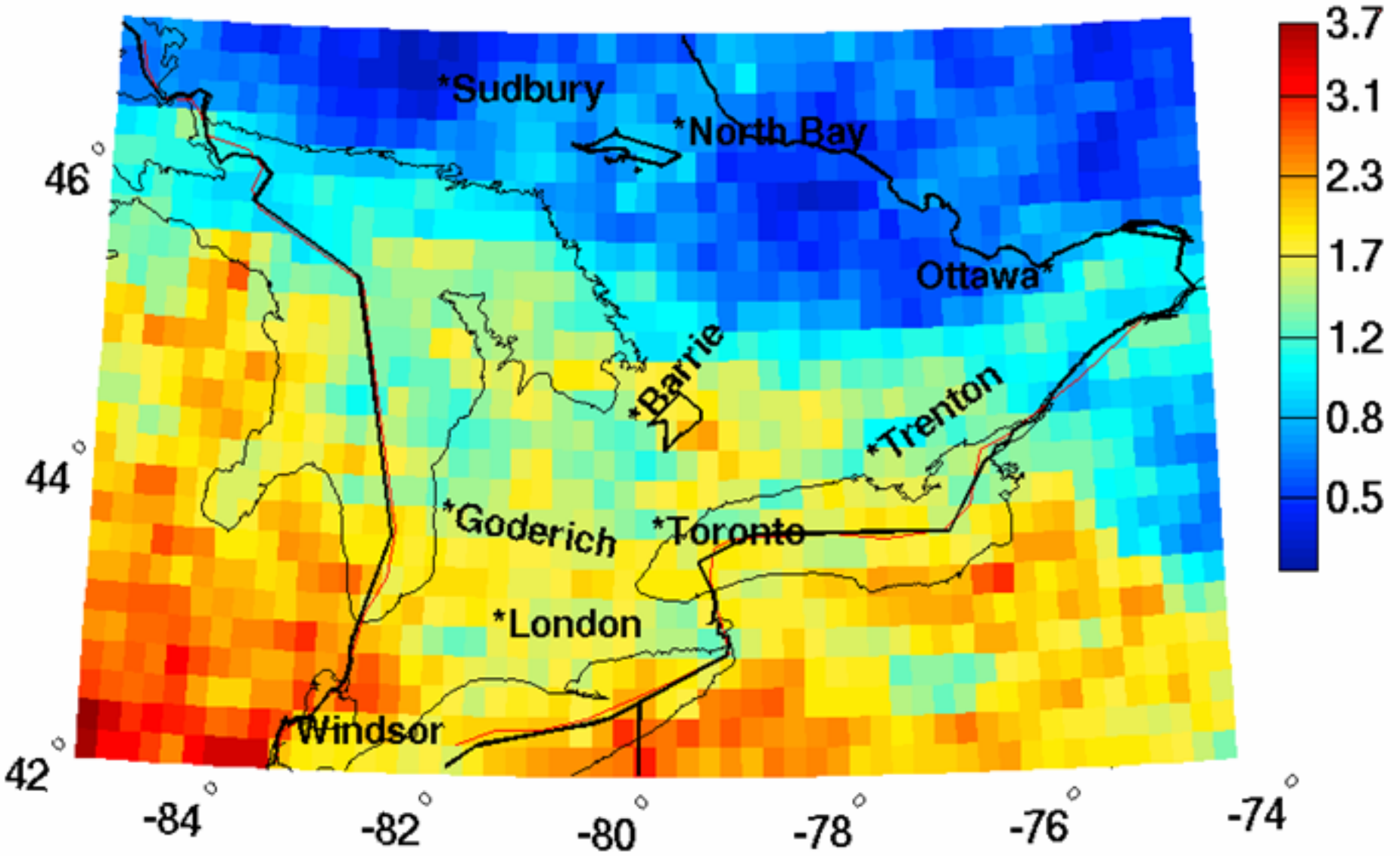
- **Assess *historical trends* in key temperature, precipitation, air quality indicators**
- **Information on *specific historical weather events, marine hazards***

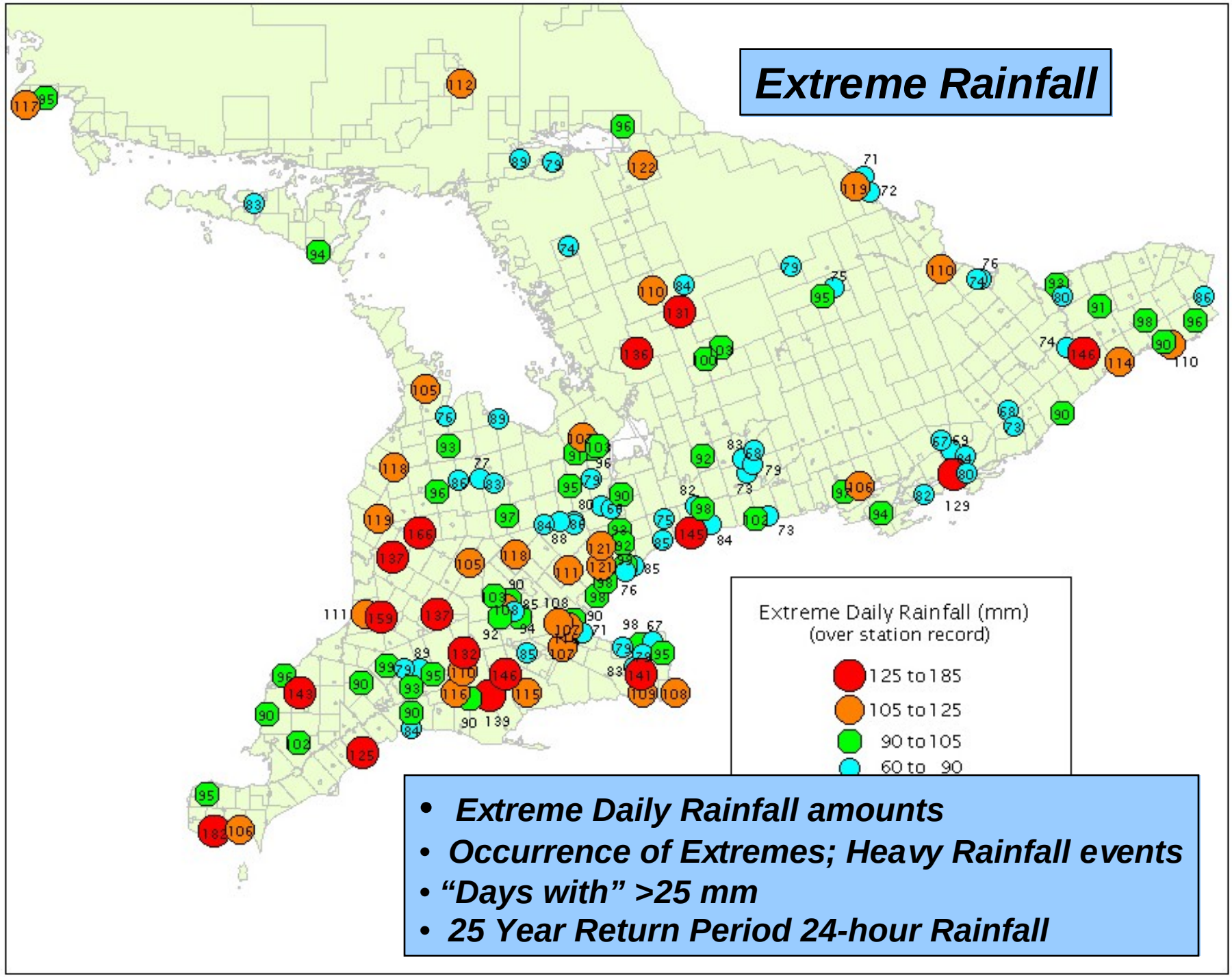
Tornadoes
Environment Canada database (Sills, King)



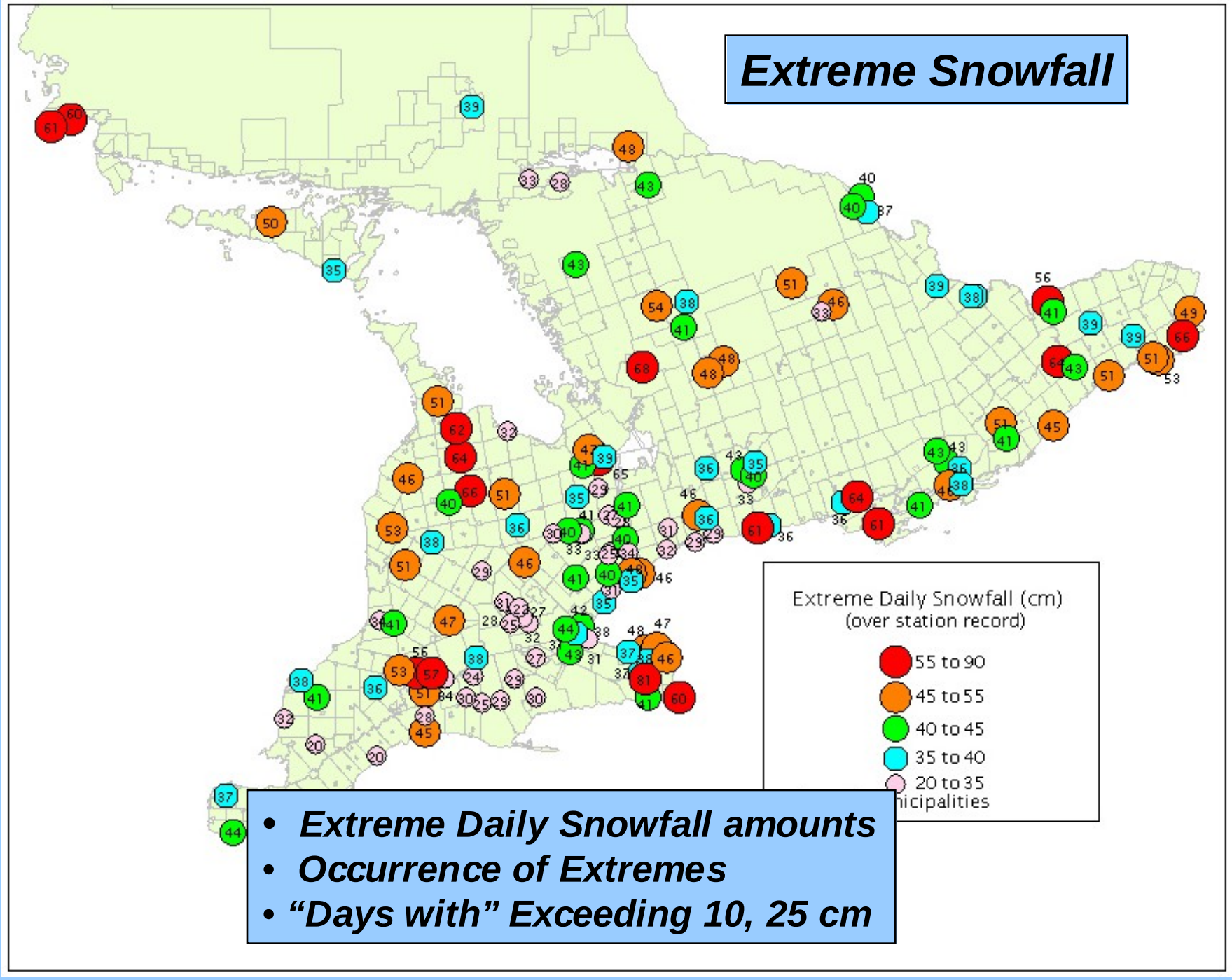
- *Location and Fujita Scale Intensity of Tornadoes from 1918-2003*
- *Year of Occurrence 1918-2003*
- *Frequency of Occurrence*

Lightning Flash Density (Burrows et al., 2002, 2004)

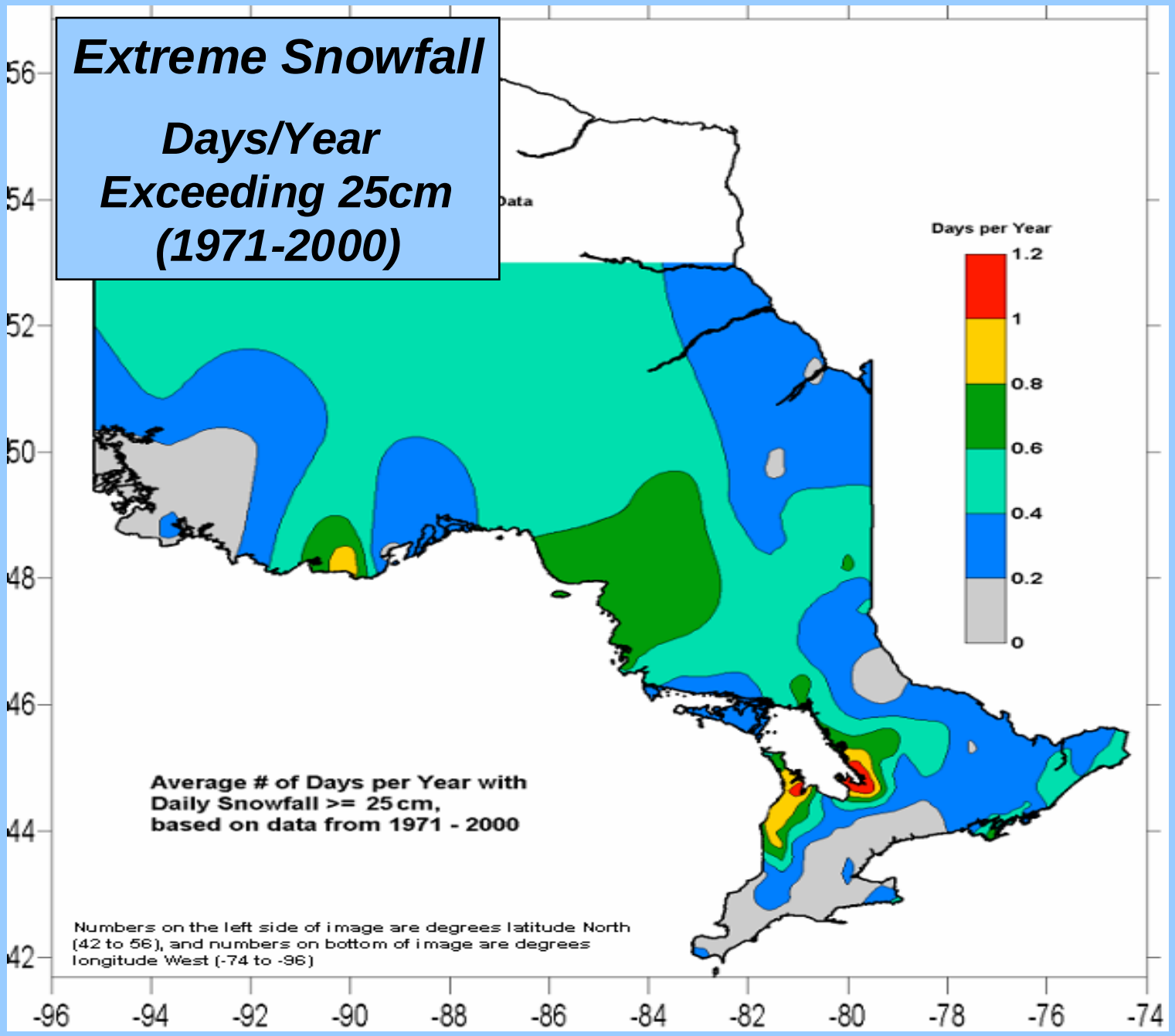



Extreme Rainfall
Extreme Daily Rainfall (mm)
(over station record)
125 to 185
105 to 125
90 to 105
60 to 90
• Extreme Daily Rainfall amounts
• Occurrence of Extremes; Heavy Rainfall events
• "Days with" >25 mm
• 25 Year Return Period 24-hour Rainfall

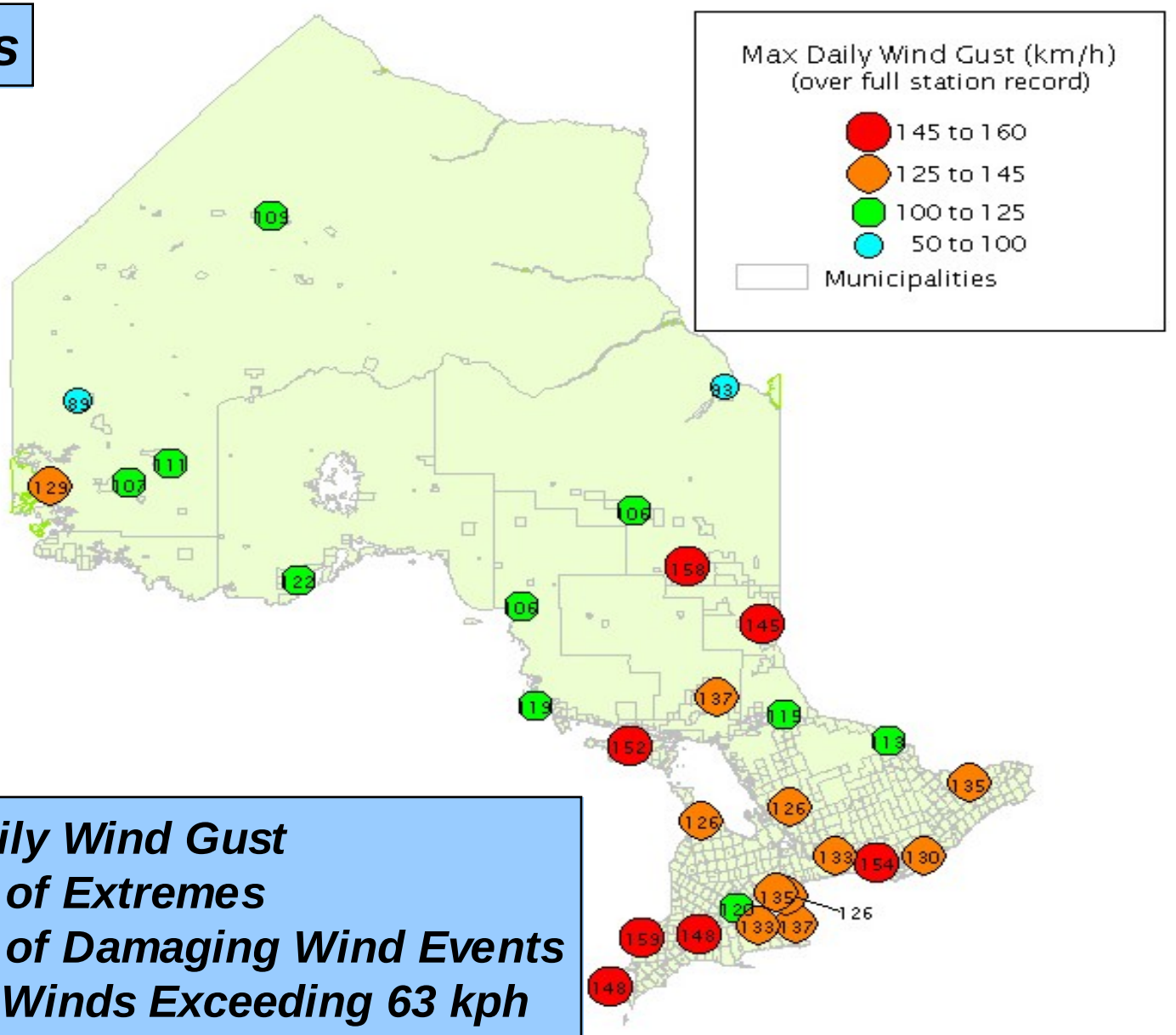
Extreme Snowfall



- *Extreme Daily Snowfall amounts*
- *Occurrence of Extremes*
- *"Days with" Exceeding 10, 25 cm*

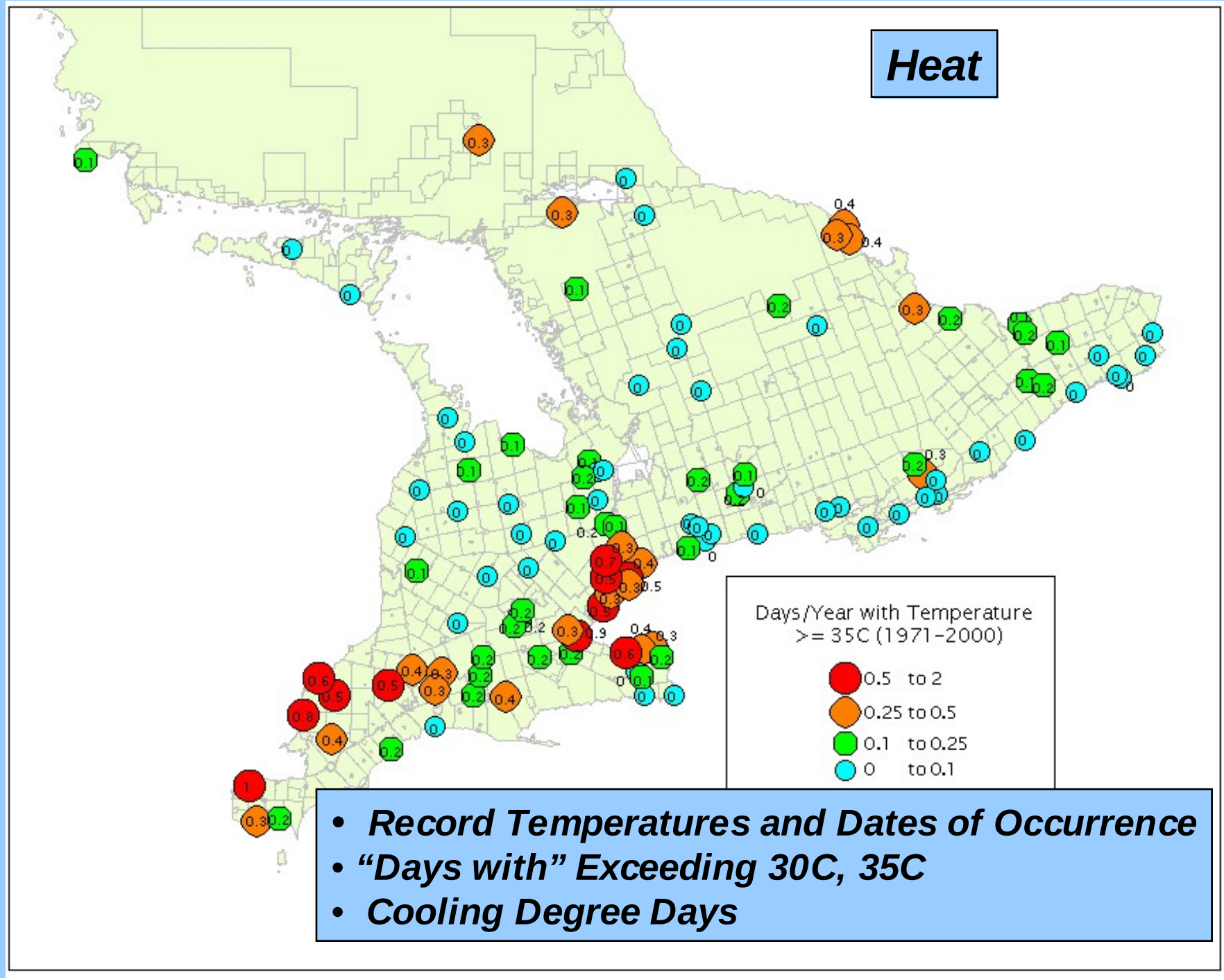

Extreme Snowfall
Days/Year
Exceeding 25cm
(1971-2000)
Days per Year
1.2
1
0.8
0.6
0.4
0.2
0
Average # of Days per Year with
Daily Snowfall >= 25 cm,
based on data from 1971 - 2000
Numbers on the left side of image are degrees latitude North
(42 to 56), and numbers on bottom of image are degrees
longitude West (-74 to -96)
56
54
52
50
48
46
44
42
-96
-94
-92
-90
-88
-86
-84
-82
-80
-78
-76
-74

Winds



- *Extreme Daily Wind Gust*
- *Occurrence of Extremes*
- *Occurrence of Damaging Wind Events*
- *"Days with" Winds Exceeding 63 kph*
- *50 Year Return Period Winds*

Heat



- ***Record Temperatures and Dates of Occurrence***
- ***"Days with" Exceeding 30C, 35C***
- ***Cooling Degree Days***

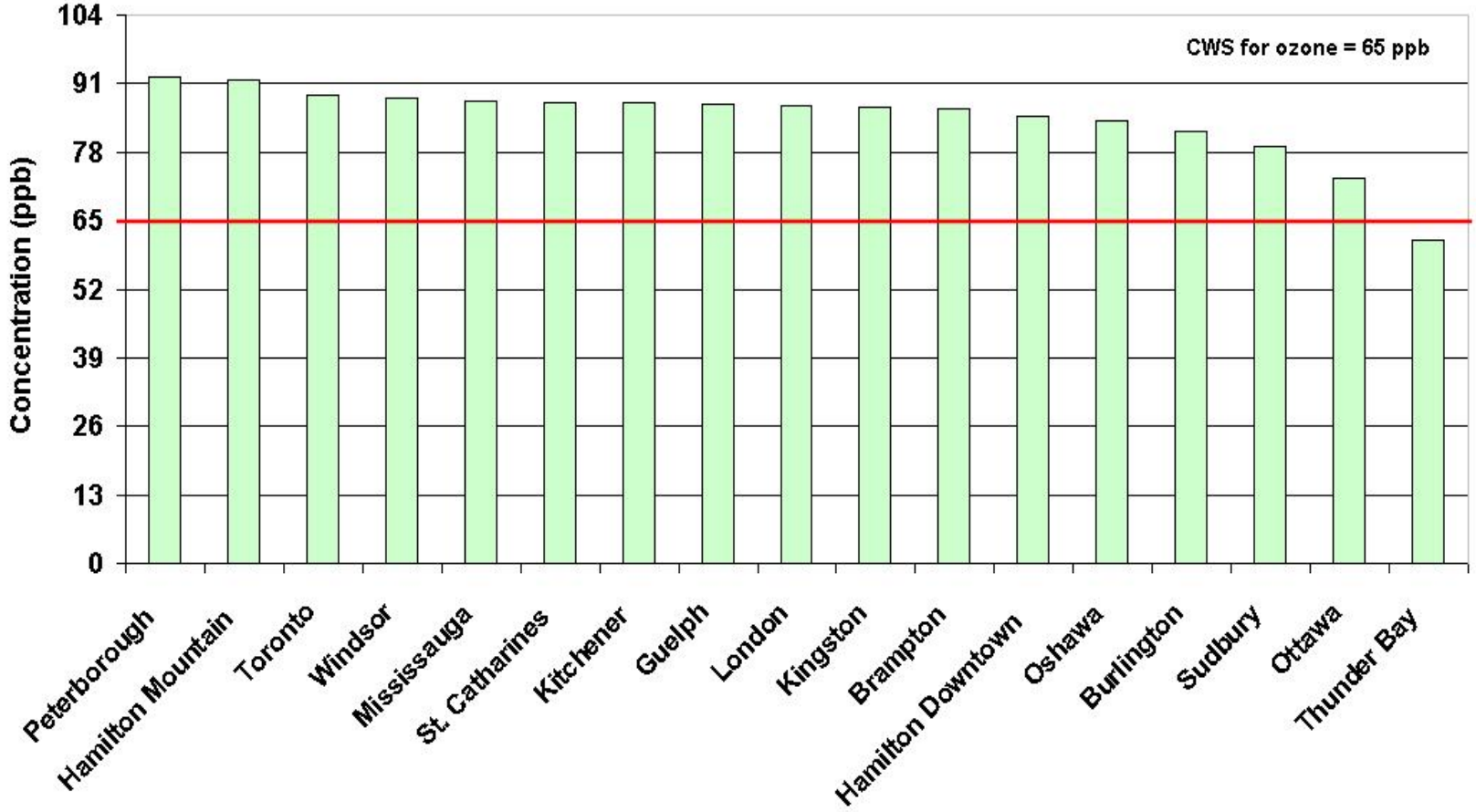
Health issues:
Air Quality
Acid Rain
UV Radiation

Ozone Levels at Selected Sites Across Ontario

4th Highest Ozone 8-Hour Daily Maximum

(2001 - 2003)

Air Quality (Ozone; MOE)



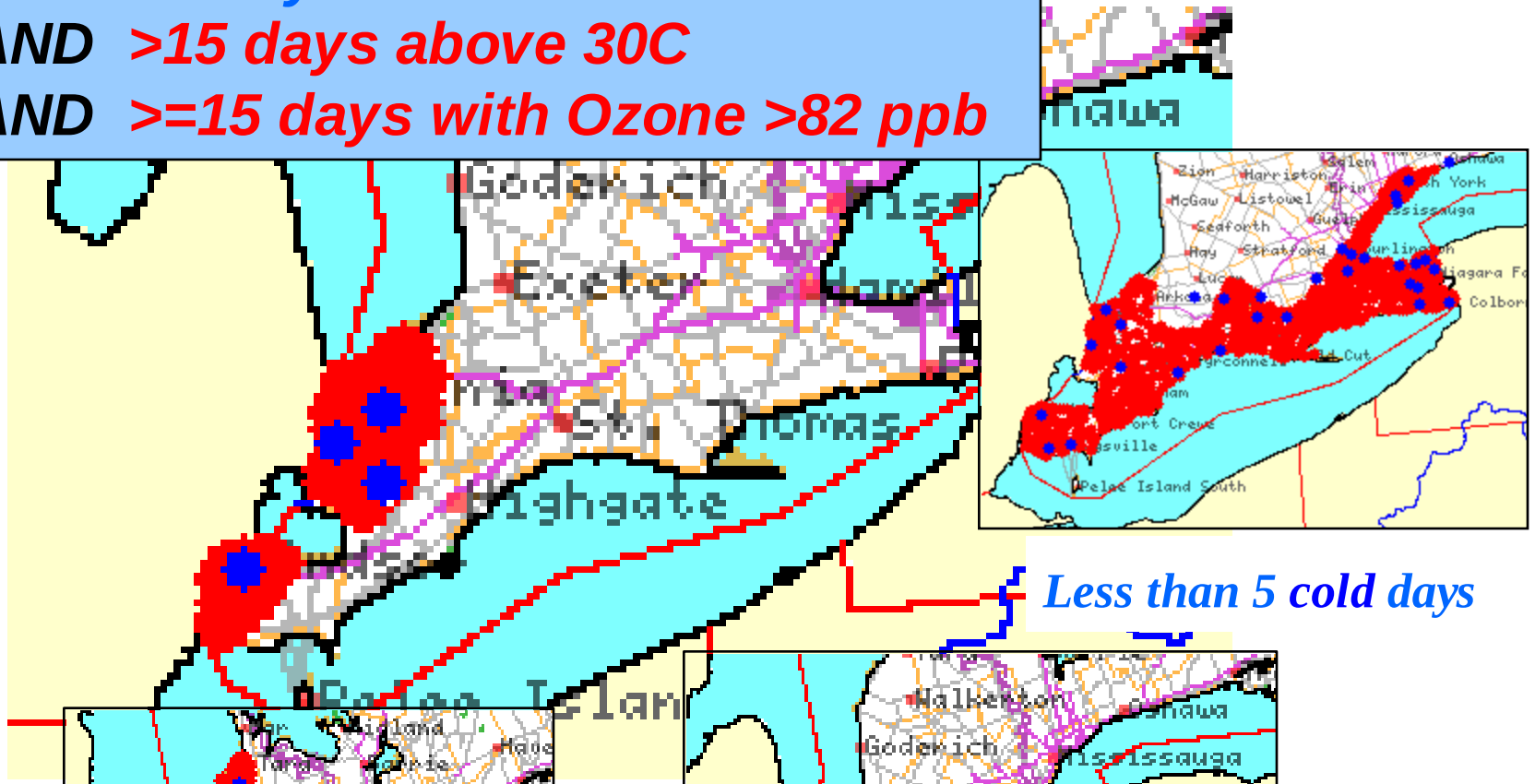
Note: Displayed sites are selected based on future requirements for Canada-wide Standard (CWS) reporting.
Toronto reporting is based on Toronto Downtown, Toronto North, Toronto East and Toronto West sites.

Communities with:

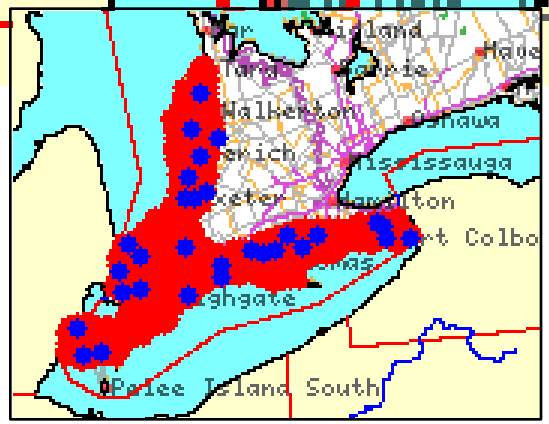
<5 days below -20C

AND >15 days above 30C

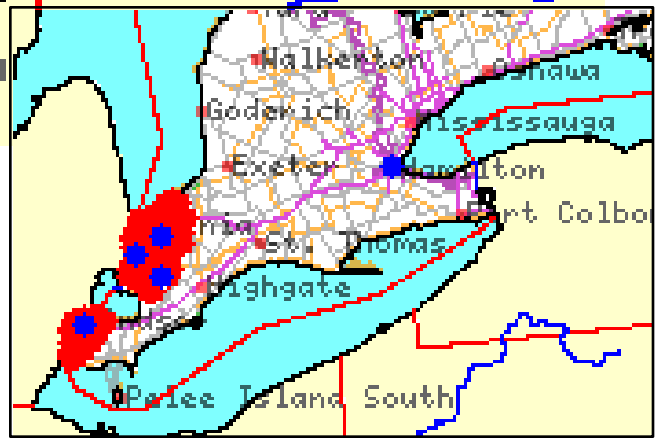
AND >=15 days with Ozone >82 ppb



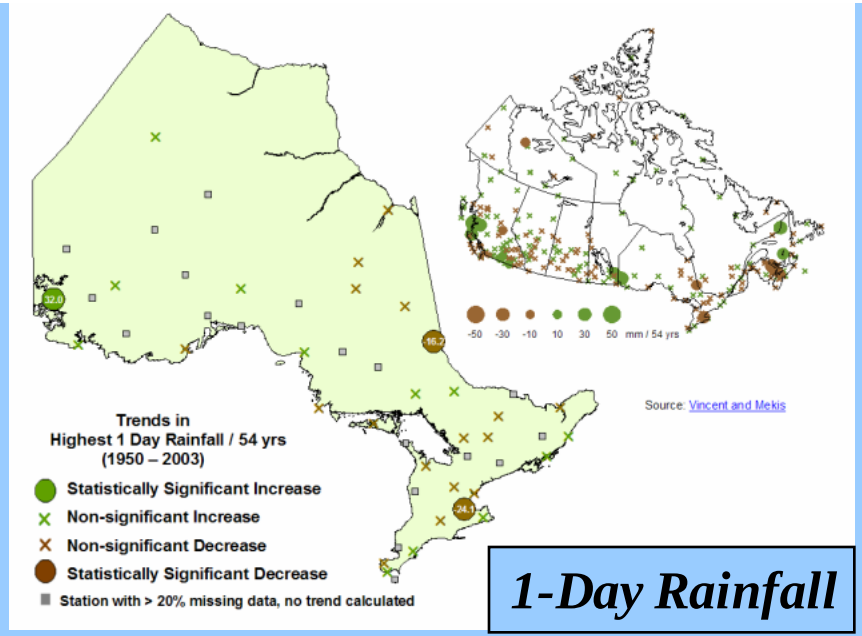
Less than 5 cold days



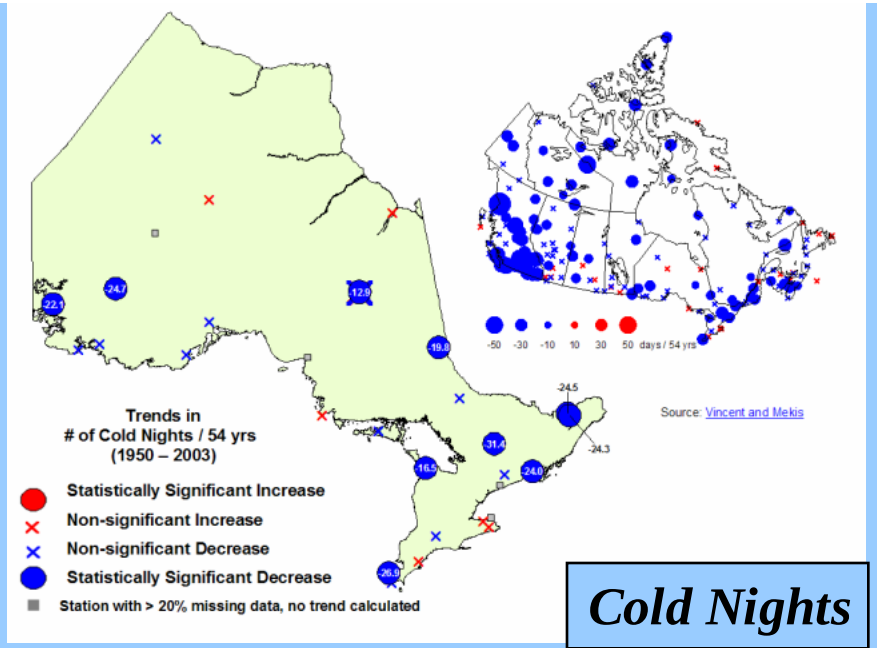
>=15 poor AQ days



15 or more hot days



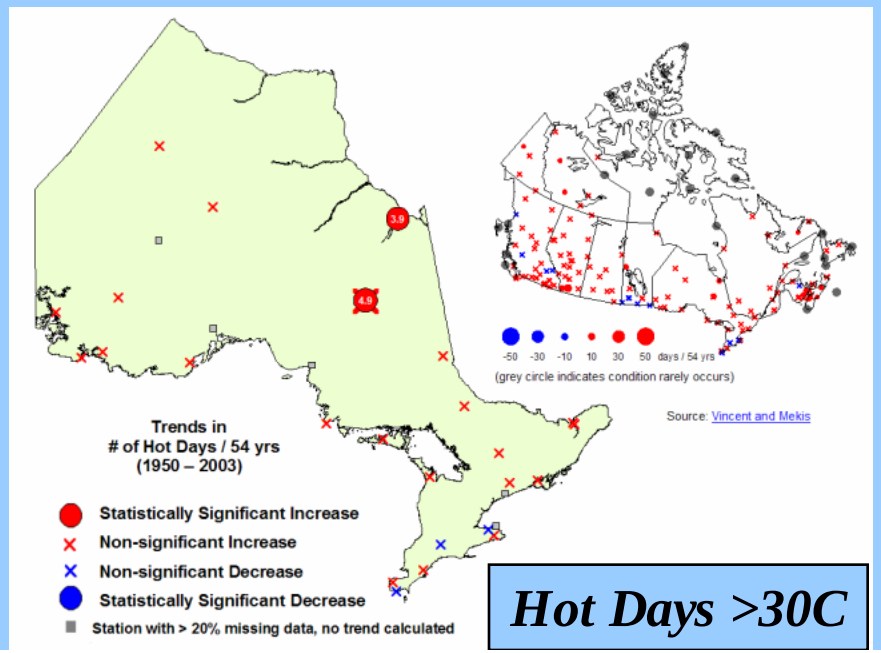
1-Day Rainfall



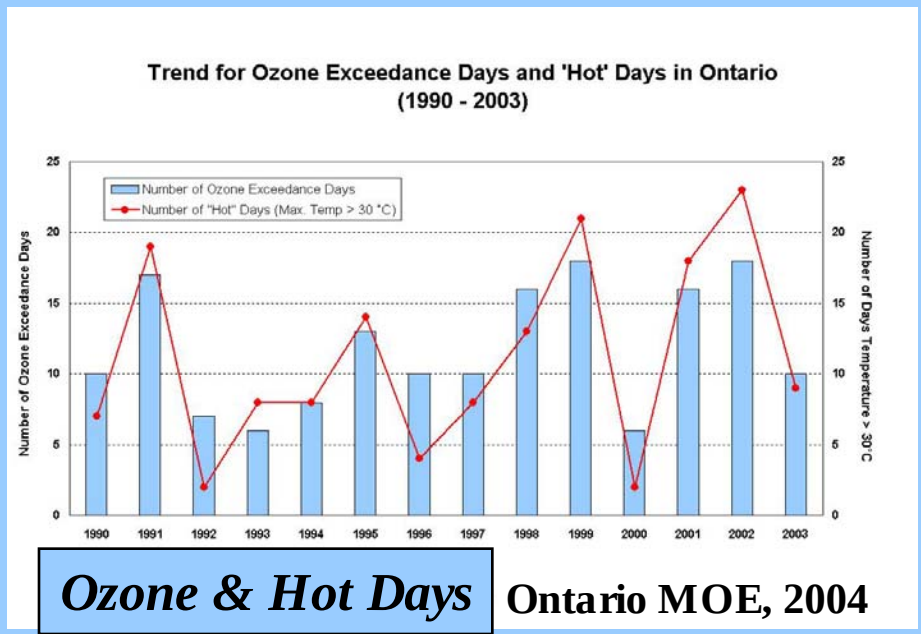
Cold Nights

Trends in Climatic Indicators

Temperature, Precipitation, Air Quality



Hot Days >30C



Ozone & Hot Days

Ontario MOE, 2004

Reducing Community Risks to Weather Related Disasters in Ontario

Ontario's
Emergency Management Act
(Bill 148)

Atmospheric Hazards in Ontario Website
Developed By
Environment Canada
in partnership with
Emergency Management Ontario