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PLANNING FOR ATMOSPHERIC HAZARDS AND DISASTER MANAGEMENT UNDER CHANGING CLIMATE CONDITIONS

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ABSTRACT: Reducing societal vulnerability to weather related disasters under current and changing climate conditions will require a diverse and interconnected range of adaptive actions. Included among these actions are hazard identification and risk assessment, comprehensive emergency and disaster management, improved predictions of high impact weather, better land use planning, strategic environmental and ecosystem protection, continuously updated and improved climatic design values and changes to infrastructure codes and standards to support disaster resistant infrastructure. These actions will need to be undertaken by all levels of government, by individuals, planners, professional associations and investors. One critical disaster reduction response is that of emergency and disaster preparedness, which involves the development of an emergency response and management capability long before a disaster occurs. The provinces of Ontario and Quebec, in central Canada, have both passed provincial legislation requiring that all municipal and regional governments adopt emergency management planning. In support of these legislated measures in Ontario, Environment Canada along with its partner Emergency Management Ontario, have developed an atmospheric hazards publication and web site that supports municipalities in accessing climatological, extreme weather and air quality information, customizing atmospheric hazards maps for their localities and in linking hazards maps. Maps can be functionally linked through cumulative co-recognition software that allows the user to select specific thresholds per hazard map and to display the cumulative result of regional combinations of hazards. Information on climate trends for the hazards variables is presently available on the site, and future plans for the site include climate change trend projections, where appropriate.

Keywords: hazards, extreme weather, emergency management, climate change

1. Introduction

One of the most threatening aspects of global climate change is the likelihood that extreme weather events will become more variable, more intense and more frequent. While debate still continues on whether or not climate variability and weather extremes are already on the increase, evidence in Canada and from around the world indicates that the costs of weather related disasters are exponentially increasing over time while the costs of non-weather natural hazards show little change (IPCC, 2001).

Several factors, in addition to changing regional climate hazards, have contributed to these rising trends in disaster losses and vulnerabilities to atmospheric hazards (IPCC, 2001), including:

- increasing populations;
- increasing urbanization and dependence on uninterrupted services in communities;
- increasing prosperity and insured property in developed countries;
- an increasing dependence in developed countries on high technology computer-based technologies and just-in-time delivery systems that are vulnerable to interruptions;
- infrastructure sited in higher risk locations;
- an aging infrastructure, changes to the design of infrastructure (e.g. performance based design) and a highly competitive construction industry;
- increasing poverty in lesser developed nations, ensuring that vulnerable populations remain unable to remove themselves from high risk locations;
- regional environmental degradation, which can transform a climatic hazard (e.g. heavy downpour) into a disaster;
- regional increases in frequencies or intensities of extreme events;
- failure to use best climatic design hazard information as well as best mitigation and engineering practice (including enforcement of codes and standards).

According to Burton (2004), the rising losses from weather-related hazards reflect a failure of societies to adapt well enough to current climate variability and extremes. Burton uses the term "adaptation deficit" to describe the shortfalls in current adaptation practices, recognizing that most countries are still far away from realistically achievable adaptation to current climate and its extremes. In essence, Burton reports that failure to adapt adequately to existing climate risks, largely accounts for the growing adaptation deficit, as noted by growing losses from extremes. Controlling and eliminating the adaptation deficit through better adaptation to today's extremes is a necessary (but not sufficient) step in the longer run project of adapting to climate change (Burton, 1997;2004). As climate change accelerates, the adaptation deficit has the potential to rise much higher, unless a serious programme of adaptation is implemented and includes improved disaster management planning. In addition, the role of resource and ecosystem management in helping to manage disaster risks also needs to be considered (Burton, 2004).

The IPCC (2001) refers to adaptation to climate change as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation actions that can be taken to reduce vulnerabilities to today's weather hazards include atmospheric hazard identification, risk assessment, comprehensive community risk and disaster management planning, improved predictions of high impact weather, new early warning environmental prediction services and products, better land use planning, strategic environmental and ecosystem protection, continuously updated and improved climatic design values for disaster resistant infrastructure codes and standards, more enforcement of building codes and improved structural design methods and materials. In order to coordinate and implement these actions, there is a need to develop an integrated weather and climate change science, scenarios, impacts and adaptation plan and implementation strategy that is based on numerous partnerships at the local and regional scales.

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 2001). The growing vulnerability to and rising losses from today's climate-related disasters foreshadows future losses from the impacts of climate change and signals an urgent need for immediate disaster management measures (IPCC, 2001). However, planning for future extremes under changing climate conditions will be significantly limited by considerable uncertainty in projections on future extremes and by the difficulties of retrofitting or changing the existing built environment.

By definition, a hazard is an event or phenomenon that has the potential to cause harm or loss (Etkin, 2004; ISDR, 2002) and includes hurricanes, tornadoes, heavy rainfalls, severe ice storms, wind storms and similar events as well as technological accidents (often triggered by climate hazards). A risk is "the probability of harmful consequences, or expected loss resulting from interactions between natural hazards and vulnerable or capable conditions", and a disaster is understood as "the actual impact causing widespread losses which exceed the ability of the affected community/society to cope with such a situation using its own resources" (ISDR, 2002). Disaster management then is the planned development and application of policies, strategies and practices to reduce disaster risk. Disaster management tries to minimize the existing vulnerability and to prevent or to limit adverse impacts of hazards (mitigation and preparedness) with comprehensive plans to react to emergencies and act after disaster impacts (rehabilitation and reconstruction) (ISDR, 2002).

The most important element of a disaster management plan is prevention. Prevention includes steps to reduce vulnerabilities that cause damages in the first place and requires information on hazards and vulnerabilities. This paper deals with information on atmospheric hazards and the changing climate needed to consider prevention and disaster management planning on a regional scale. The paper outlines the measures undertaken by the province of Ontario, Canada to enforce disaster management planning at municipal and provincial scales and describes the atmospheric hazards information developed to meet these measures.

2. Measures to Manage Risks and Vulnerabilities

2.1 Emergency and Disaster Management Planning Frameworks

The most successful disaster management systems take advantage of the existing government structures and policies and involve all levels of government and other institutions (ISDR, 2004). Legislation also increases the likelihood that a national disaster management plan will become sustainable. Legislation provides a formal basis for counter-disaster action, allocates major responsibilities in legal form, and provides a measure of protection for governments, organizations, and individuals by outlining the limited responsibilities of each in the disaster management process (Asian Urban Disaster Mitigation Program, 2002). But, the best laws are useless if not effectively and impartially enforced.

A very critical part of a disaster reduction strategy is the completion of a Vulnerability and Risk Assessment that integrates the probability of hazards in a region with critical infrastructure risk assessments. For example, risk assessments identify weather and other types of hazards, identify critical infrastructure at risk to these hazards, identify vulnerable groups and develop potential prevention interventions that increase adaptive capacity.

The identification and prioritization of hazards requires documentation and studies on the probable location and severity of dangerous phenomena, such as high impact weather, as well as information on the probability of occurrence within a specific time period in a given area. These studies rely heavily on available scientific information, including climate and hydrological data and maps. Forensic studies or other historical information, in the form of written reports and oral accounts from long-term residents, can also be used at the community level to help characterize potential hazardous events (Government of Ontario, 2003; Environment Canada, 2004). To ensure success, hazard assessments can benefit from defensible analyses by experienced scientific teams.

3. Implementing Hazards and Risk Management Legislation

The Canadian provinces of Ontario and Quebec have both passed provincial legislation requiring that all municipal and regional governments adopt emergency management planning. For example, the province of Ontario passed its provincial *Emergency Management Act* legislation in April 2003 requiring that all municipal and regional governments adopt disaster management planning within a 3 to 4 year timeframe. According to the legislation, emergency management is defined as "an organized and comprehensive program and activities taken to deal with actual or potential emergencies or disasters. These include mitigation against, preparedness for, response to and recovery from emergencies or disasters" (Government of Ontario, 2003). The legislation requires that municipalities undertake a Hazard Identification and Risk Assessment (HIRA) process to identify priority risks to infrastructure and public safety giving rise to emergencies in their communities and develop prioritized emergency response plans for each of the prioritized hazards. The HIRA process, which is unique to individual municipalities, requires information and tools to support it and the provincial legislation. The four pillars of emergency management are mitigation/prevention, preparedness, response, and recovery. These actions are defined in more detail in Table 1.

The purpose of the new legislation is "to improve and promote the sustainable management of hazards and to encourage communities to achieve acceptable levels of risk." According to Emergency Management Ontario's Guidelines for Provincial Emergency Management Programs in Ontario (Emergency Management Ontario, 2004), a realistic risk based program, properly resourced and including funding for staff training and exercises, will save lives and money. The legislation requires that all Ontario

Municipalities and Ministries identify and assess various hazards and risks to public safety that may give rise to an emergency situation. Municipalities and Ministries are also required to identify the facilities, as well as other elements of their infrastructure, that are at risk of being affected by these emergencies. The Act requires that the HIRA process be completed in three graduated phases or levels: 1) essential, 2) enhanced, and 3) comprehensive. Municipalities are expected to progressively develop their emergency management program until the comprehensive level is reached.

The first or *essential* emergency management program requires several components, including the identification and ranking of hazards as well as the identification of critical infrastructure (HIRA). The next phase, the *enhanced* emergency management program, builds on the Essential Program and requires additional components. Finally, the *comprehensive* emergency management program builds on the first two phases and is designed to ensure the protection of public health, the environment, property and economic stability. Table 2 summarizes the requirements of the three phases for the Ontario Framework for Community Emergency Management Programs (Emergency Management Ontario, 2004).

TABLE 1

Four Pillars of Emergency Management (Emergency Management Ontario, 2004; Etkin, 2004)

ACTION	DEFINITION
Mitigation/ Prevention	Actions taken to reduce or eliminate the effects of an emergency or disaster or actions taken to prevent an emergency or disaster.
Preparedness	Actions taken prior to an emergency or disaster to ensure an effective response. These actions include the formulation of an emergency response plan, a business continuity plan, training, exercises and public awareness and education.
Response	Actions taken to respond to an emergency or disaster.
Recovery	Actions taken to recover from an emergency or disaster.

TABLE 2

Framework For Community Emergency Management Programs (Adapted From Emergency Management Ontario, 2004)

ESSENTIAL PROGRAM	ENHANCED PROGRAM	COMPREHENSIVE PROGRAM
• Designation of a community emergency management coordinator • Formation of an Emergency Management Program Committee • Formation of an approved emergency response plan • Establishment of an appropriate Emergency Operations Centre • Publication of an appropriate community emergency operations centre • Identification of priority hazards, critical infrastructure and prioritization of risks to community	• Publication of an enhanced emergency response plan to include supporting plans for high risks such as flood, severe weather, transportation accidents, hazardous facility, critical infrastructure, etc.) • Publication of a supporting plan for the dissemination of emergency information including the designation and arrangements for a local information centre • Development of an enhanced emergency operations centre to include detailed operating procedures, arrangements, and provision for appropriate specialist and auxiliary staff during an emergency	• Development of a prevention/ mitigation strategy and plan for identified high risks • Publication of a recovery plan for identified high risks • Development of a response strategy for identified hazards • Implementation of guidelines for risk–based land use planning • Designation of dangerous goods routes • Development of a comprehensive community evacuation plan
• Conduct of annual training for the community control group and emergency operations centre staff • Conduct of an annual exercise to evaluate the emergency response plan • Identification of individuals to act as emergency information staff	• Development and implementation of an annual emergency management training program involving appropriate staff, volunteer organizations, auxiliary staff and emergency services • Development and implementation of an annual emergency management exercise program involving appropriate staff, volunteer organizations, auxiliary staff and emergency services	• Development and implementation of a detailed risk-based public education program • Development of a management program that recognizes the contribution of all partners
• Development and implementation of an emergency management public awareness program	• Development and implementation of a public education program based on identified high risks	• Designation of an emergency management week to publicize the emergency management program and recognize the contribution of all partners
• Conduct of an annual review of the emergency management program	• Development and implementation of an annual self – assessment process to determine the quality and effectiveness of the emergency management program	• Development and implementation of an external assessment process to determine the quality and effectiveness of the emergency management program • Development and implementation of an Incident Management System

4. The HIRA Process

The HIRA process recognizes that each municipality has different and distinct hazards and risks. Hazards include natural, technological and human-caused events. The risk assessment determines how often and how severe the effects could be on public safety and is generally understood as being a function of probability and consequences (impacts and vulnerability).

The managing provincial agency, Emergency Management Ontario (EMO), provided a HIRA template for municipalities and provincial Ministries that is based on the probability of a hazard occurring and the consequence of an event or risk. Some municipalities expanded this template to include observed frequency ("How often has the event happened in the past?") and municipal response capability. The risk characteristics were ranked and scored according to the following guidance (Emergency Management Ontario, 2004):

1. ***Frequency or Probability:*** Hazards were assigned a rank from 1 to 4, with "1" reflecting a low occurrence rate and "4" reflecting high occurrence within the past 15 years. A ranking of "4" was used to indicate that an event was likely to occur within five years or had occurred within the past five years. The lowest score of "1" indicated that an occurrence of that specific risk had never been documented in the past 10 to 15 years or that the known relative frequency was low.

2. ***Consequences:*** The consequences or impacts from the hazards on the municipality were ranked from 1 (negligible) to 4 (high).The degree of consequence was determined through expert opinion and consultation with experts. Negligible consequence is defined as damage with relatively lower impacts. A "high" consequence score reflects a likelihood of severe damage and consequences, which may include fatalities and the loss of essential services.

3. ***(Optional) Response Capabilities:*** Response capabilities could also be used to guide the assessment of consequences and ranked from 1 (excellent) to 4 (poor). Determining the municipality's response capability involved evaluating human, capital and technological resource capacity, including equipment, personnel, communications, technical support, training, experience and contingency plans. The process also included evaluating the ability of outside agencies to provide support. Higher

weighting could be assigned to those emergencies that jurisdictions would have difficulty responding to because of limited response capability.

In the case of new and evolving threats (for example, Severe Acute Respiratory Syndrome (SARS), changing climate hazards), the record from the past 15 years may not be useful in representing the risk. In other cases, low probability but high impact events that happened prior to 15 years can reoccur and need to be considered (for example, Hurricane Hazel in 1954). In these cases, jurisdictions were encouraged to use the best information available (climatic information from Environment Canada, expert advice and academic journals) to determine probabilities (Emergency Management Ontario, 2004). This also includes information on historical trends and climate change scenarios that indicate an increasing frequency of specific hazards.

A sample HIRA grid using the above ranking or scoring system for hazards frequency and for consequences is shown in Figure 1.

5. Changing Atmospheric Hazards and the HIRA Process

In response to demands from municipalities seeking atmospheric hazards information and guidance required for the HIRA process and to comply with the Emergency Management Act, Environment Canada developed a website to consistently present packages of data, documentation and peer-reviewed maps for atmospheric and climatological hazards in Ontario (www.hazards.ca). The purpose of the hazards web site and publication, based on the website holdings (Auld *et al.*, 2004), is to enable the evaluation of multiple hazards and to assist in the preparation of Municipal Emergency Management Programs (Auld *et al.*, 2004). The site contains maps of various weather hazards, their trends, Environment Canada Weather Warning criteria and guidance on potential impacts of specific hazards which include extreme heat and cold, drought, extreme rainfall, fog, hail, heavy snow, blizzards, lightning, hurricanes, ice storms, tornadoes, wind storms, smog, UV radiation and acid rain. In particular, the site can be used by municipalities and Regional ministries to determine the frequency or probability of occurrence of each hazard (as defined in Step 1 of the HIRA description), as well as to compare the relative frequency of these hazards in various regions of Ontario. It is important to note that legislation requires the HIRA process and that this process requires information such as that provided by the hazards web site to support both HIRA and provincial legislation.

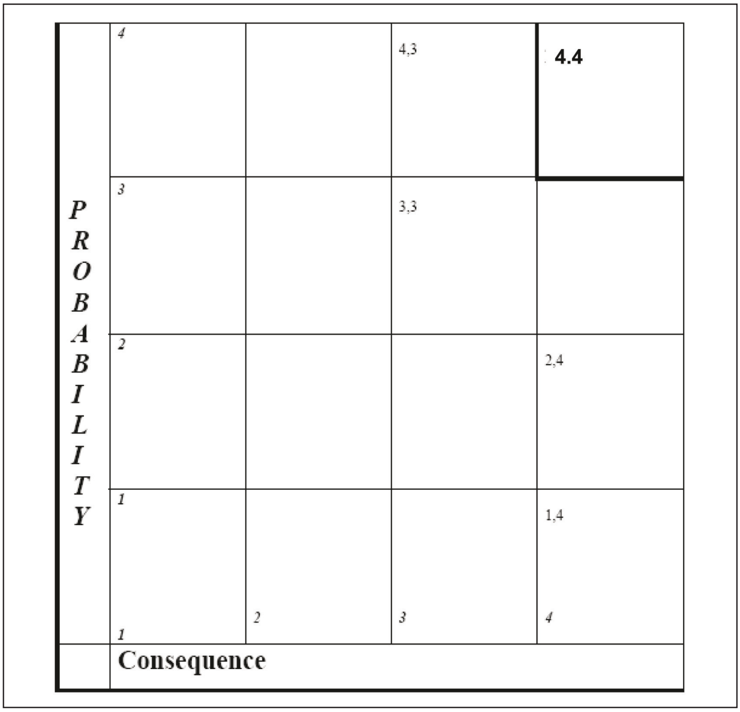

FIGURE 1

Emergency Management Ontario sample risk assessment grid. The y-axis indicates the frequency or probability of a hazard while the x-axis indicates the impact or consequences to the community from the incidence of the hazard. (Adapted from Emergency Management Ontario, 2004.)

The web site and publication (Auld *et al.*, 2004) reference a collection of maps from the Environment Canada led project known as Integrate Mapping and Assessment Project or IMAP (Auld *et al*, 2002 and www.can-imap.ca), as well as peer-reviewed maps developed by many other agencies. The web site also includes a feature that allows maps to be "stacked" together in order to align places on the different maps using co-recognition software, even though the maps might have different scales and projections.

All maps included in the Atmospheric Hazards collection are scientifically defensible (for example, journal publication, meeting World Meteorological Organization requirements for weather data archiving and analyses). These maps, graphs and information were then assembled and assessed by themes. For example, maps assembled under the theme of extreme heat included information on record extremes, as well as the frequencies of temperature values exceeding thresholds deemed to be significant (for example, high temperatures that could typically trigger municipal heat response programs aimed at reducing health risks for susceptible populations). Other themes included frequencies for selected periods of record (for example, past 15 years), the average number of days per year with conditions exceeding specific thresholds, extreme precipitation and temperature records, probabilities of an event at a location, most recent occurrences of an extreme, return period estimates, climatic design values for engineering codes and standards, etc. Each map theme is accompanied by documentation describing its information holdings, the data used to develop the mapped fields, uncertainties and limitations for use of the maps and references. The documentation for each hazard theme also provides listings of historical events having significant impacts on communities and hazards trends information. Samples of two of the hazards maps that are provided on the website are shown in Figures 2 and 3 (Environment Canada-Ontario Region, 2003; and Etkin and Brun, 2001, respectively).

It is important that the hazards database and web site meet the emergency and disaster management planning needs of a wide variety of users. A significant challenge is the requirement to convey information on hazards to all users, including non-technical users responsible for emergency planning, and that this information is scientifically sound and defensible in spite of simplifications.

Some municipalities with greater experience in emergency planning expressed interest in integrating multiple hazards and in having the ability to tailor thresholds or sensitivities for frequencies or probabilities of hazards. Others expressed interest in comparing various maps from a single theme to discern regional differences and better appreciate the uncertainties or conflicting implications for risk and emergency planning. As a result, the hazards web site was equipped with software to quickly link and compare multiple hazards for hazard specific thresholds, allowing the visual display of combinations of hazard conditions. This stacking feature made mapped information readily accessible to all users for a variety of map scales, regardless of their computer type and comfort with technology, and allowed the visual integration of contoured maps from a variety of sources and formats.

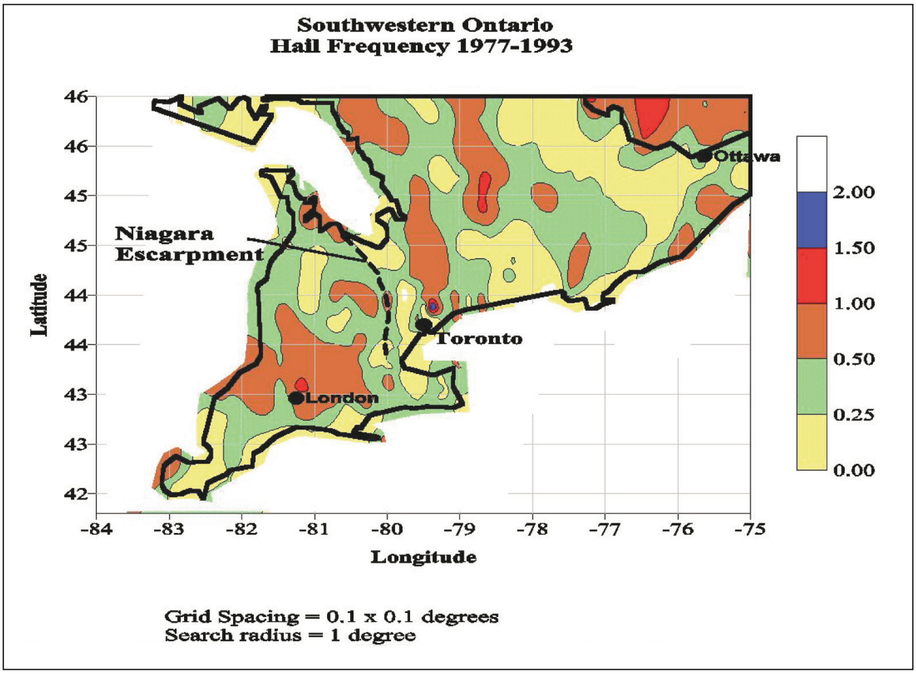

FIGURE 2

Average number of days per year with hail for Southwestern Ontario, data 1977-1993. Source: Etkin, D. and S.E. Brun, 2001

An additional benefit to the process of assessing, integrating and documenting atmospheric hazards maps is the identification of mapping gaps, conflicting hazards information and requirements for updated information. For example, the process of overlaying peer-reviewed tornado probability maps (Newark, 1983; Environment Canada-Ontario Region, 2003) highlighted the impact of changed methodologies, assumptions and data collection procedures used over time to determine site tornado frequencies. The lessons learned by assessing the tornado probability maps will contribute to improved event data collection, better data quality control, enhanced mapping algorithms, scientifically defensible assumptions on tornado probabilities and better interpolation schemes for developing tornado risk probabilities in the future. In other cases, the process revealed gaps in information holdings, requiring that new knowledge, analysis and maps be developed to fill in noted gaps. For example, the hazards assessment

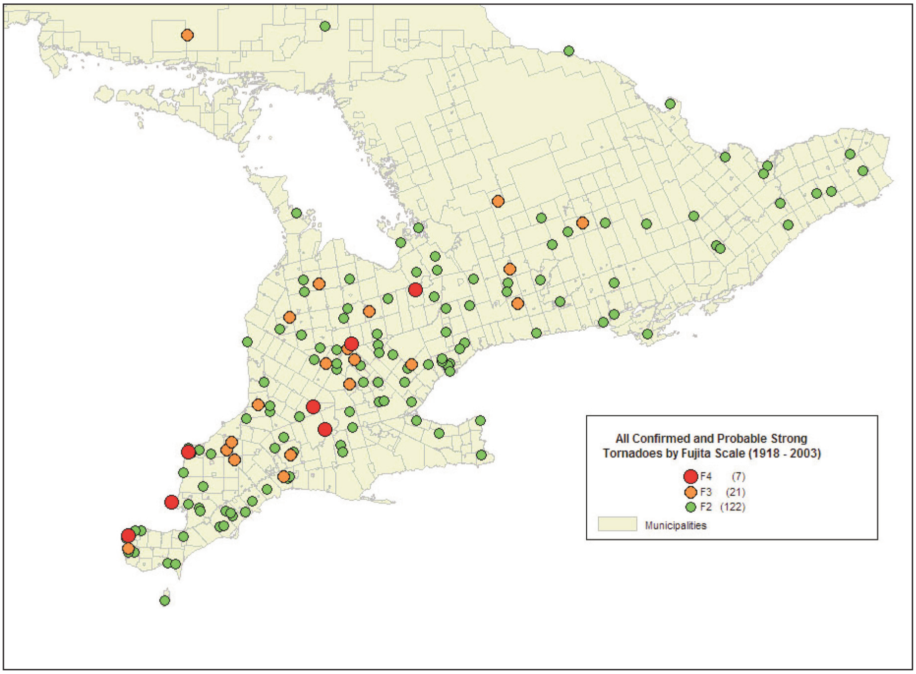

FIGURE 3

All confirmed and probable significant (F2, F3 and F4) tornadoes plotted by location, based on data from 1918-2003 (Southern Ontario). Source: Environment Canada-Ontario Region, 2003.

indicated that drought risk information needed by municipalities for response planning was scarce. Work is underway to develop and calibrate drought risk maps using a variety of precipitation and drought indices, including development of new risk information that is based on legislated requirements in Ontario for municipal low water response planning.

6. Hazards Information for a Changing Climate

When new hazards and threats are emerging (for example, Severe Acute Respiratory Syndrome (SARS), West Nile Virus) or evolving (for example, changing climate hazards), the Emergency Management Process requires that best efforts be undertaken to understand the changing probabilities and to proactively plan for a response to their risks. Soon after the release of the initial hazards site, municipalities and regional emergency coordinators requested information on trends in changing atmospheric hazards, perhaps reflecting a growing awareness on potential climate change impacts for communities.

One of the incentives for passing emergency management legislation in Ontario and Quebec was the need to reduce growing losses from disasters. Recent Ontario examples of disasters include the 1998 ice storm, 1999 Toronto snowstorm, 1999 Windsor fog road disaster, 2000 southern Ontario flood events, 2000 Walkerton water contamination tragedy, the 2001-02 drought, 2003 power blackout, 2003 Severe Acute Respiratory Syndrome (SARS) outbreak, 2002 and 2004 Peterborough floods, 2002 Northwestern Ontario flooding disaster and Ontario's most costly weather disaster to date, the 2005 Toronto flood. The evidence indicates that the costs of weather related disasters are increasing over time almost everywhere while vulnerabilities to weather hazards are also increasing (IPCC, 2001; Munich Re, 2001). In regions where the frequencies or probabilities of weather hazards are also increasing with time, it is critically important that communities monitor and capture changing frequencies and magnitudes of atmospheric hazards and implement disaster mitigating actions as soon as possible.

The hazards web site provides atmospheric hazards trend information for selected weather variables. The trend information has been developed using "internationally standardized" and scientifically proven methodologies for climate change detection analyses (that is, methodologies used to develop internationally recognized homogenized temperature and adjusted precipitation datasets for these analyses, Vincent and Mekis, 2005). As a result, the climatic hazard trends shown on the Hazards site represent changes over time for the climate signal only. These trends have been developed using climate datasets that have been statistically "adjusted" to remove inconsistencies in the data that may have been caused by station relocation and/or changes in instrumentation and observing practices (Vincent and Mekis, 2005). In general, climate trend results indicate that on average, precipitation has increased in Canada over the past 50 years. The total precipitation has increased by about 5 to 35 percent in southern Canada and by 25 to 45 percent over most of Nunavut. Surface temperatures warmed between 0.5 and 1.5 degrees Celsius during the past century in Southern

Canada. The greatest warming has occurred in the west, and also in summer and spring (Environment Canada, 2005). Figure 4 illustrates Canadian and Ontario trends in the number of days with 95th percentile and greater high daily rainfall amounts. Future plans for the tool package and web site include the provision of regionally appropriate climate change projection scenarios to inform users on potential changes in hazards. However, a first necessary (but not sufficient) step in the longer run project of adapting to climate change extremes is to ensure that communities are adapted to current hazards.

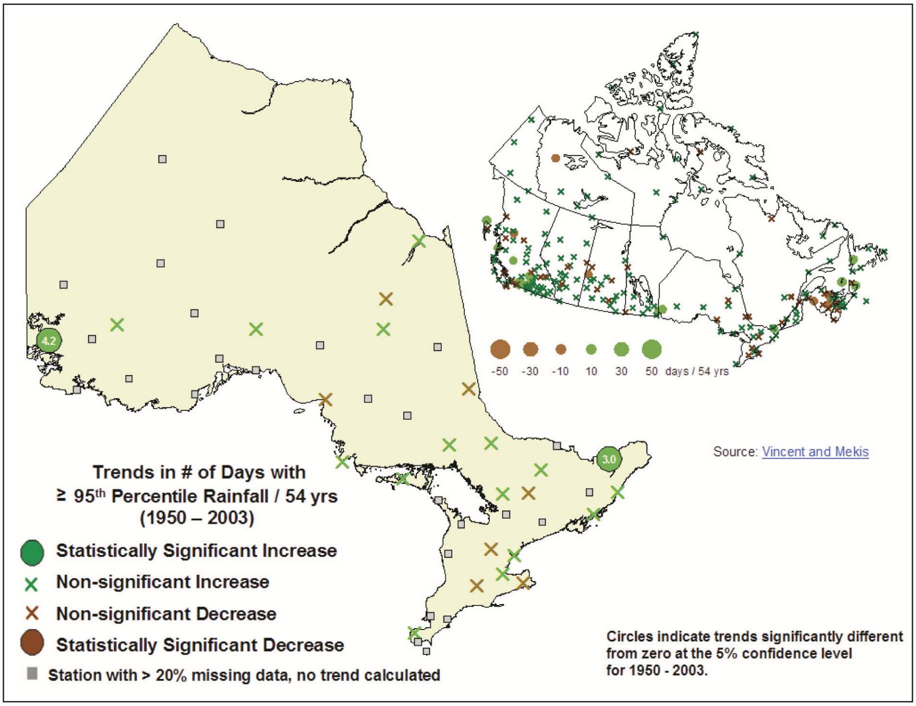

FIGURE 4

Trends in the Number of Days with ≥ 95th percentile daily heavy rainfall amounts for the period 1950-2003. Green circles indicate statistically significant increases in amounts while brown circles indicate significant decreases. Stations with "X" symbols indicate statistically non-significant trends. Source: Climatic trend data and Canadian map provided courtesy of Vincent and Mekis, 2005.

7. Planning Responses to Atmospheric Hazards

Many Municipalities in Ontario have highlighted weather and climate hazards among their Top 10 lists of hazards (Morton, 2005). Some of these identified hazards were expected while others such as lightning frequencies require more explanation. The more typical atmospheric hazards identified by municipalities include tornado, severe ice storm, severe snowstorm and heavy rainfall and flooding risks. The less obvious hazards include lightning strikes, freeze-thaw cycles and air quality events. Lightning strikes, for example, have significance for municipal emergency coordinators needing to plan for protection of their emergency dispatch communications centres from outage risks. As a result, regions with relatively higher risks for lightning strikes and also housing emergency communications and coordination centres need to plan for grounding and for greater communications systems redundancies. Freeze-thaw cycles were identified for their threat to buried infrastructure (for example, water distribution systems), interruptions to municipal services and challenges for quick municipal response. Extreme air quality episodes were identified as having concern for municipal health departments needing to develop health response plans to reduce risks for their vulnerable and aging populations.

8. Benefits of Emergency Management Planning

The net result of the project, including the hazards web site and publication (Auld *et al.*, 2004), is to assist municipalities in more effectively meeting planning requirements for emergency management (that is, Ontario's *Emergency Management Act* or Bill 148). The information and site also allows atmospheric hazards identification to become more complete and consistent from one municipality to the next and provides municipalities with the information to better inform and protect their citizens from a greater variety of hazards. The hazards website project has enhanced our understanding of the information needs of municipalities and provided insight into more effective means of both meeting the varied needs of municipalities while advancing the mandates of Environment Canada. It has also provided insight into measures that can be used to improve effectiveness in communicating atmospheric science and risk-based information to the public. As the gaps are filled and the assessments reveal weaknesses in the information holdings, the hazards databases and web materials will need to be updated. Further learning will follow on optimal means to convey scientific information for municipal decision-making. It is expected that the work will be expanded to other regions in Canada, including the province of Quebec in support of their *Civil Securities Act*.

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