TOOLS FOR INTEGRATING CLIMATE CHANGE AND COMMUNITY DISASTER RISK MANAGEMENT IN CANADA

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1. INTRODUCTION

1.1 Need for climate risk information in operational decision making

As the impacts of climate change become more apparent in the form of severe weather, communities will continue to manage threats to public safety and infrastructure by incorporating climate change adaptation strategies into operational decision making. In contrast to traditional crisis management approaches, which are designed for response during emergencies, countries, including Canada and its Provinces, are now implementing legislation that mandates more proactive emergency planning (Auld, 2008). In 2003, the Province of Ontario passed the Emergency Management Act, requiring every municipality and region within the Province to implement a comprehensive emergency management plan. These comprehensive plans include strategies related to response, but also, preparedness, mitigation and recovery (Auld, 2008). As part of the comprehensive emergency plan, community specific risks to infrastructure and public safety must be identified, assessed and prioritized into a list of top ranked hazards. This process is called Hazard Identification and Risk Assessment (HIRA). In a survey conducted by Environment Canada in 2009, risks associated with atmospheric hazards were ranked highest by Ontario municipalities (MacIver et al., 2009). For this reason, it is imperative that emergency managers, in Ontario, and nationwide, have access to scientifically valid historical climate data and model projections that provide reliable illustrations of changing climate conditions when it comes to extremes.

1.2 Changing climate extremes

The Environment Canada survey of Ontario municipalities illustrated that, under current climate conditions, severe weather is of great concern to Canadian communities. As climate changes, understanding how extremes may increase both in frequency and magnitude will become even more important for disaster management. According to the IPCC, climate change is likely to alter climate processes around the globe and, in recent years, trends have already been observed (Parry et al., 2007). Climate models show that temperature extremes are very likely to be affected under climate change. Alterations to heat and cold extremes could mean an increase in the frequency of hot days above certain temperature thresholds, and a decrease in the frequency of cold days below certain temperature thresholds. Climate models also predict increased precipitation and more intense rainfall for high latitudes. The impacts of increased temperature extremes and more frequent, intense, rainfall could cause more recurrent flooding and longer duration droughts in some areas (Parry et al., 2007). Strategies are available to help communities lessen the impacts of changing extremes, and providing decision makers with climate science information and integrated decision making tools may be a starting point to adaptation.

The next section describes decision making tools that can be used to place climate change in a disaster risk management context. These are also identified in Table 1.

2. INTEGRATED DECISION MAKING TOOLS

2.1 Adaptive Collaborative Risk Management (ACRM) and the Rapid Assessment of the Impacts of Climate Change (RAICC)

Translating the science of climate change into usable adaptation metrics for emergency managers has been an ongoing challenge. The move from impact assessments to decision strategies often requires approaches that can be characterized as embodying collaboration and social learning. One approach to this is the idea of adaptive, collaborative risk management (ACRM) (May and Plummer, 2011). ACRM is being applied to a climate change project in the Niagara Region of Ontario, Canada.

Another technique that has been applied to a number of biosphere reserves and communities in Canada is the Rapid Assessment of the Impacts of Climate Change (RAICC) (Fenech and MacLellan, 2007). RAICC takes existing approaches to impact assessment and climate risk management and goes further, by using a suite of community-specific indicators to assess both historical data, future climate (using validated scenarios) and measurement of relative risk (Fenech and MacLellan, 2007).

2.2 Canadian Atmospheric Hazards Network (CAHN) (www.hazards.ca)

In response to the needs of the disaster management community, particularly from legislated requirements for conducting HIRAs at the local level, as mandated some Provinces, the Canadian Atmospheric Hazards Network (CAHN) was developed (Auld et al, 2007) in order to meet the demands for specific atmospheric hazard information. In partnership with regional nodes and partners, CAHN allows decision makers to access scientifically valid historical hazard information for their community. This input is crucial in determining the most relevant, historical atmospheric hazards.

2.3 Canadian Climate Change Scenarios Network (CCCSN) (www.cccsn.ca)

Similarly, the Canadian Climate Change Scenarios Network (CCCSN) is a partnership web site that provides a single window for access to all model output from all Intergovernmental Panel for Climate Change (IPCC), as well as Canadian Regional Climate Models (CRCMs). The site provides ensemble maps for different regions of Canada as a an entry point for location-specific information about climate change. In addition, there are a number of features that provide useful extreme indices of relevance to the disaster management community. Bioclimate profiles (climate at a glance) have been developed for climate stations across Canada. These provide a historical overlay from which to examine extremes under a changing climate.

2.4 Adaptation Baseline

In addition to understanding the impacts that a changing climate will have on their communities, emergency managers will also need to consider how they will adapt to hazards associated with climate change. In 2007, Environment Canada developed an adaptation baseline research study in which adaptation measures and adaptive capacity, for both climate variability and future climate change, can be measured (Koshida and Mirza, 2007). The purpose of creating an adaptation baseline is to aid in the development of effective adaptation strategies based on sound climate science, as well as, lessons learned from past events (Koshida and Mirza, 2007). Creating an adaptation baseline involves developing indicators that will help emergency managers evaluate how successful adaptation measures have been in the past (Koshida and Mirza, 2007). Indicators can be quantitative or qualitative and will depend on the type of hazard selected in a particular geographical study area.

As part of this, re-creation of past significant events through case studies are important starting points for discussion of how communities have responded and adapted and how this might influence future events. In the case of the Niagara Region, four such significant events have been identified: The Blizzard of 1977, a severe blizzard that stranded thousands and crippled the Region for days, The October Surprise, an out of season snowstorm that lead to extensive damage and power outages, the May 12, 2000 thunderstorm which caused power outages and damage to trees and buildings, and the cold, wet summer of 2009, which may have increased the need for sewage by-passes and high bacteria levels in local waters.

Table 1 – Tools for Integrating Climate Change In Disaster Risk Management

Climate in Context	
Adaptive Collaborative Risk Management (ACRM) (May and Plummer, 2011)	
Rapid Assessment of the Impacts of Climate Change (RAICC) (Fenech and MacLellan, 2007)	
Historical & Current Climate	Future Climate
Canadian Atmospheric Hazards Network www.hazards.ca	Canadian Climate Change Scenarios Network www.cccsn.ca
Adaptation Baseline (Koshida and Mirza, 2007)	

3. APPLICATION TO THE NIAGARA REGION, SOUTHWESTERN ONTARIO, CANADA

Two examples, from the rural town of Lincoln, and the city of St. Catharines, both located in the Niagara Region of south-western Ontario, illustrate how emergency managers may apply the above tools to decision making processes. As discussed, both Lincoln and St. Catharines have developed emergency plans that include a Hazard Identification and Risk Assessment (HIRA). In order to keep these assessments up to date, and ensure accurate ranking of risk priorities, emergency managers can use integrated tools to consult historical data records, and may now begin looking forward to future climate scenarios.

3.1 Application to the Niagara Region – Extreme heat in Lincoln, Ontario

The town of Lincoln has a population of 21,722 and is known for its vineyards and tender fruit groves. The prioritized list of hazards developed for this municipality, typical of other rural municipalities in the Niagara Region, is entirely made up of atmospheric related risks. Extreme heat which appears eighth on the list will be used an example to demonstrate the steps by which an emergency manager may utilize web-based integrated decision making tools.

Table 2 –Extreme heat occurs eighth on list of prioritized hazards for Lincoln, Ontario.

Town of Lincoln: Top Ten Risks	
1	Fog
2	Snowstorms
3	Ice/Sleet
4	Hailstorms
5	Lightning/Wind
6	Hurricane
7	Tornado/Flooding
8	**Extreme Cold/Heat**
9	Drought/Low Water
10	Water Quality Emergencies

An emergency manager can access place-specific climate information by navigating to the Canadian Atmospheric Hazards Network (CAHN) website (www.hazards.ca) and clicking on the `Look for Place by Name` feature.

Once the place name is found, a colour-coded data summary will appear that can be used to analyze the place specific historical climate extremes. Parameters shown in green indicate extremes that occur within the bottom third of the historical data range, those shown in yellow occur within the middle third, and variables shown in red occur within the top third of the data range.

According to the data summary, the town of Lincoln may be at risk from extreme heat. Days with temperatures above 30 and 35 degrees Celsius are occurring within the middle range of the historical data, and cooling degree days, or days with temperatures above 18 degrees Celsius, occur within the top range of the data.

Other informational sources found on CAHN, such as prepared maps, can provide a geographical interpretation of historical extreme heat in Lincoln.

The Canadian Climate Change Scenarios Network (CCCSN) can provide climate model projections of future extreme heat in the town of Lincoln.

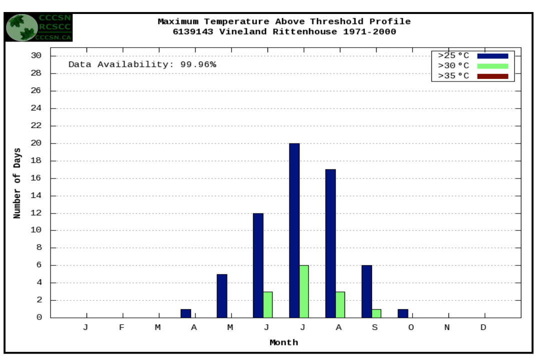
Bioclimate profiles, found on CCCSN, graphically show how extremes will change over time. Emergency managers can select the climate station and climate profile they wish to view, as well as apply a climate model and scenario or experiment.

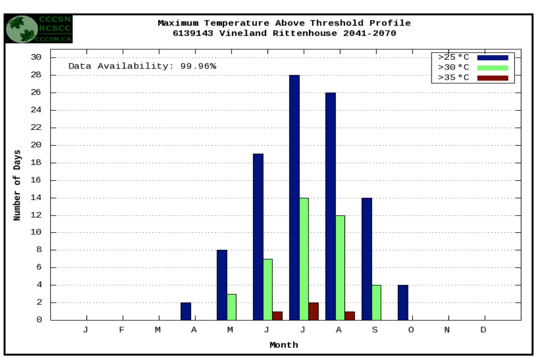
In this example, the Vineland station located in Lincoln, Ontario is chosen. The profile selected is maximum temperature above threshold. This profile will illustrate changes in extreme heat days for this area. There are several climate models that have been validated for the Niagara Region, including CGCM3T47, GISSAOM, GISS-EH, HADGEM1 and MIROC3.2medres (Fenech and Shaw, 2010). In this case, the third generation coupled global climate model, CGCM3T47, developed by the Canadian Centre for Climate Modelling and Analysis is selected for illustrative purposes in this paper. Analyzing results from a variety of models would generate a range of values for further study.

The SR-A1B scenario is used in this example. Users must also select a baseline time period and projection start date. The baseline shown in the tables below is 1971-2000 and the projection period is 2041-2070.

Once retrieved, the bioclimate profiles provide a visualization of the selected data. The maximum temperature above threshold profile for Lincoln shows that extreme heat days and temperature maximums are likely to continue to increase during the spring, summer and fall months into the 2070s.

Figure 1 –Max temperature above threshold profile for Lincoln, Ontario, 1971-2000 and 2041-2070.





3.2 Application to the Niagara Region – Water emergencies in the City of St. Catharines

The City of St. Catharines is the largest metropolitan area in the Niagara Region, with a population of 390,317. Risk priorities for St. Catharines include both atmospheric and non-atmospheric related risks. In contrast to rural communities, densely populated municipalities will often incorporate a broader range of risks, such as those related to infrastructure and public health. Water emergencies, which appear seventh on the list of prioritized risks for St. Catharines, will serve as an example to illustrate how integrated decision making tools can help emergency managers in urban areas plan for water related hazards.

Table 3 – Water emergencies occur seventh of the list of prioritized hazards for St. Catharines, Ontario.

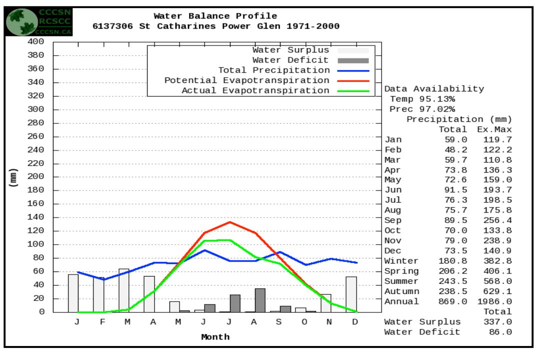
City of St. Catharines: Top Ten Risks	
1	Human health emergencies: epidemics
2	Hazardous materials transport incident
3	Energy emergency: hydro
4	Hazmat chemical release
5	Major structural fire
6	Transportation emergency: road, rail. marine
7	**Water Emergency**
8	Snowstorm/blizzard
9	Windstorms
10	Tornado

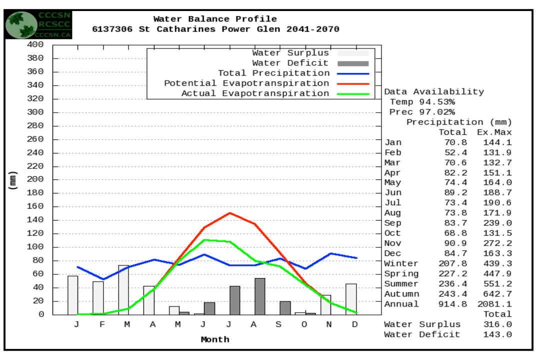
In addition to the data summary described for St. Catharines, prepared maps found on CAHN can further illustrate historical water emergencies, such as drought, in relation to neighbouring communities.

Bioclimate profiles found on the Canadian Climate Change Network website (CCCSN) provide details of how water emergencies may impact St. Catharines in the future. A water balance profile is selected for Power Glen Station, located in St. Catharines. As in the previous example, the third generation coupled global climate model, CGCM3T47 and SR-A1B scenarios are used, as well as a baseline time period of 1971-2000.

The profile below, which compares the years 2041-2070 with the baseline, shows that precipitation will likely increase for St. Catharines into the 2070s and water surplus will rise during the winter months. However, these profiles also show that the summer and fall months may become drier when water deficits increase.

Figure 2 – Water Balance profile for St. Catharines, Ontario, 1971-2000 and 2041-2070.





4. SUMMARY/CONCLUSION

There is a continued, if not growing demand, for atmospheric scientists to consider how climate information is used as part of operational decision making. A key challenge is how best to organize and present accurate information that is targeted to specific requirements. Extremes for disaster management are an essential part of this, particularly as the IPCC examines the impact of climate change on changes in extreme atmospheric processes. The process outlined in this paper demonstrates how an adaptive collaborative risk management (ACRM) approach was applied in a rural and urban setting for the Niagara Region of Canada as part of a larger climate change study. Incorporation of Rapid Assessment of the Impacts of Climate Change (RAICC), the Canadian Atmospheric Hazards Network (www.hazards.ca), the Canadian Climate Change Scenarios Network (www.cccsn.ca) and an adaptation baseline can provide useful information for community disaster managers as they plan for atmospheric hazards based on historical information, in addition to what might occur under a changing climate.

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