The Social Science of Meteorology—An Introduction

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http://www.wmo.int/pages/prog/arep/wwrp/new/weather_society.html

Outline

- *The "life & times" of Brian*
- *What is social science?*
- *Social science contributions to the "weather enterprise"*
- *A work (plan) in progress*
- *Discussion*

Life & times…

Meteorological Research Division S&TB (2011-?)

Adaptation & Impacts Research Section S&TB (2010-2011)

Adaptation & Impacts Research Division S&TB (2005-2010)

Adaptation & Impacts Research Group MSC (1999-2005)

Environmental Adaptation Research Group AES (1994-1998)

Canadian Climate Centre, AES (1992-1993)

wallpaper.imcphoto.net

Collaborations and co-locations

MEMORANDUM OF AGREEMENT
BETWEEN

HER MAJESTY THE QUEEN IN RIGHT OF CANADA
as represented by the Minister of Environment,
hereinafter referred to as "Environment Canada"

AND

THE FACULTY OF ENVIRONMENTAL STUDIES
OF THE UNIVERSITY OF WATERLOO,
hereinafter referred to as "University"

WHEREAS Environment Canada and the University, through this Agreement intend to co-operate in the further development of environmental adaptation research within Canada;

WHEREAS Environment Canada designates its Environmental Adaptation Research Group of the Atmospheric Environment Services, and the University designates its Faculty of Environmental Studies, to implement this agreement;

AND WHEREAS it is desirable for these two designated units to be collocated

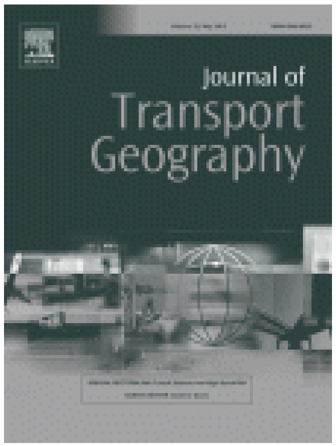
NOW THEREFORE THIS AGREEMENT WITNESSETH that in consideration of premises, covenants and agreements herein contained, the Parties hereto covenant and agree as follows:

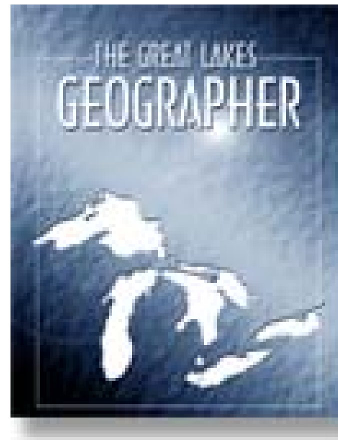
2. For the purpose of this Agreement:
   - 2.1. "Group" shall mean that part of the Environmental Adaptation Research Group of the Atmospheric Environment Service of Environment Canada, or its successors, to be housed at the University; and
   - 2.2. "FES shall mean the Faculty of Environmental Studies, or its successors, of the University.

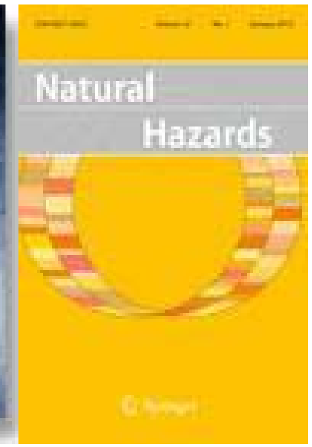
2. The objectives of Environment Canada and the University are:
   - 2.1. to achieve a high level of interaction between the activities of the Group and the University's faculty and students; and
   - 2.2. to promote and undertake high-quality research and related activities, including collaborative research on social and economic impacts on, and adaptive responses of, natural and human ecosystems to major atmospheric and related environmental stresses.

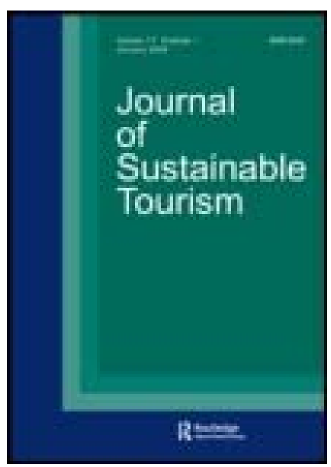
- *Geography & Environmental Management*
- *Environment & Resource Studies*
- *School of Planning*
- *Civil & Environmental Engineering*
- *Sociology*
- *Economics*
- *Psychology*
- *Applied Health Sciences and School of Public Health*
- *Other universities and research centres*

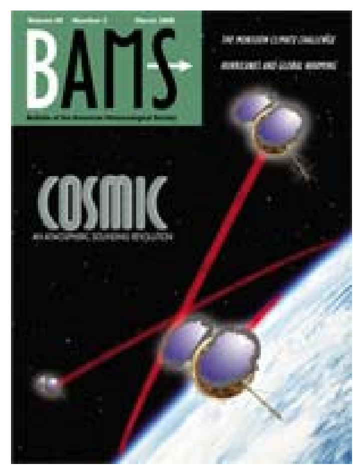
Across and between disciplines











Although under a climate change umbrella, it's mostly about the weather…

Drought Sensitivity of Municipal Water Supply Systems in Ontario

Reid Kreutzwiser[1], Liana Moraru[2], Rob de Loë[1], Brian Mills[3] and Karl Schaefer[4]
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The Great Lakes Geographer, Vol. 9 No. 2, 2003

Int J Biometeorol (2000) 44:190–197

ORIGINAL ARTICLE

Karen E. Smoyer · Daniel G.C. Rainham
Jared N. Hewko

Heat-stress-related mortality in five cities in Southern Ontario: 1980–1996

THE POTENTIAL IMPACT OF CLIMATE CHANGE IN ONTARIO'S GRAND RIVER BASIN: WATER SUPPLY AND DEMAND ISSUES

Submitted June 1999; accepted November 1999
Written comments on this paper will be accepted until June 2000

Charles F. Southam,[1] Brian N. Mills,[2] Ralph J. Moulton[1] and Douglas W. Brown[1]

1. Water Issues Division, Atmospheric Environment Branch, Environment Canada-Ontario Region
2. Adaptation and Impacts Research Group, Atmospheric Environment Service, Environment Canada

Canadian Water Resources Journal
Vol. 24, No. 4, 1999

Duncan, K. 1996. Anthropogenic greenhouse gas-induced warming: Suitability of temperatures for the development of *Vivax* and *Falciparum* Malaria in the Toronto region of Ontario,

in L.D. Mortsch and B. N. Mills (eds.) ***Great Lakes - St. Lawrence Basin Project Progress Report 1: Adapting to the Impacts of Climate Change and Variability***. (Downsview: Environment Canada), pp. 112-118.

Climate Change Implications for Flexible Pavement Design and Performance in Southern Canada

Brian N. Mills[1]; Susan L. Tighe, Ph.D., P.E.[2]; Jean Andrey, Ph.D.[3]; James T. Smith[4]; and Ken Huen[5]

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Vol. 23: 171–181, 2003 | CLIMATE RESEARCH Clim Res | Published January 31

Climate change and the skiing industry in southern Ontario (Canada): exploring the importance of snowmaking as a technical adaptation

Daniel Scott[1,*], Geoff McBoyle[2], Brian Mills[1]

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[2]Department of Geography, Faculty of Environmental Studies, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada

What is social science?

PHYS. & NAT. SCIENCES | **SOCIAL SCIENCES** | HUMANITIES

- *Anthropology* →
- *Communication Studies*
- *Economics*
- ← *Geography*
- *History* →
- *Political Science*
- ← *Psychology*
- *Sociology*

Different approaches to risk

Treatment of Risk	Perspective/key reference	Primary discipline	Example study/application focused on natural hazards
Real and objective	Technical risk assessment		
↓	Actuarial (expected value)	Natural sciences	Deaths from natural events in the U.S. (Thacker et al. 2008)
	Epidemiology	Health sciences	Heat-related mortality risk (Rocklöv and Forsberg 2010)
	Probabilistic risk assessment	Engineering	Flood and levee failure risk (Apel et al. 2003)
	Psychometric paradigm and cognitve heuristics (Fischhoff et al. 1978, Khaneman and Tversky 1979)	Psychology	Relative perception of natural, technological and social risks (McDaniels et al. 1997)
	Natural hazards paradigm (Burton et al., 1993)	Geography	Perception of volcanic and flood/landslide hazards in Mexico (Tobin et al. 2011)
	Edgework (sensation- seeking) (Lyng 1990)	Sociology and psychology	Storm chasing for thrill and recreation (Robertson 1999)
	Cultural theory (Douglas and Wildavsky 1982)	Anthropology and sociology	Cross-cultural differences in risk perceptions of disasters (Gierlach et al. 2010)
Socially constructed			

Perception and communication issues

Contextual Factors Affecting Risk Perception

Characteristic	Influence	Natural Hazard Interpretation
Personal control	Increases risk tolerance	Overestimation of one's ability to drive in poor weather
Institutional control	Depends upon confidence in institutional performance	Municipality will have the roads/sidewalks cleared and salted before my trip
Voluntariness	Increases risk tolerance	Risks associated with weather and natural phenomena generally seen as involuntary
Familiarity	Increases risk tolerance	I've driven in this weather before and not been in an accident
Dread	Decreases risk tolerance	Tornadoes, hurricanes seen as much more serious than day-to-day weather
Blame [trust]	Increases quest for social and political responses	Toronto snow emergency in 1998

Renn 2008, based largely on work of Fischhoff, Slovic and colleagues; interpretation added

What is social science?

"…the goal of social science is to uncover proximate causes of behaviour." (Elster 2010)

- No universal social theory akin to those developed in the physical sciences (myth of the rational actor)
- Theories of the "middle-range" and "contextualized conceptualizations"

Objectives: Description, explanation, and prediction

Data and methods

Original data collection

- *Surveys and questionnaires (various sampling designs)*
- *Structured, semi-structured, unstructured interviews*
- *Focus groups*
- *Direct observation (overt, covert; in situ, remote)*
- *Experimentation and simulation*

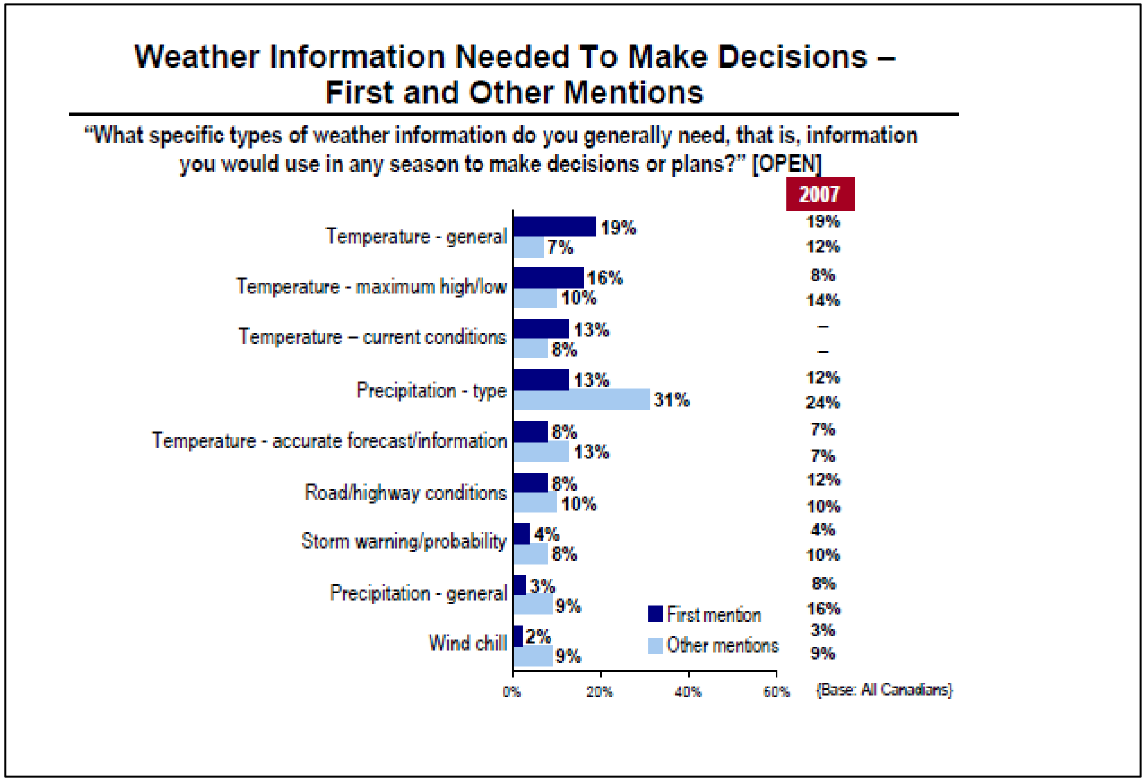
Secondary data collection

- *National, regional or thematic censuses/surveys (e.g., Canadian Community Health Survey)*
- *Government, media, industry or non-governmental records (e.g., newspaper reports)*
- *Mining past research (for meta-analyses, benefit/impact transfer functions)*

Research design and analytical methods

- *One-shot case studies are common, also quasi-experimental designs for field trials, simulations, and secondary data analysis*
- *Various statistical methods (descriptive, correlational, inferential), content analysis, and qualitative techniques used*

Survey example



Source: Ekos, 2011 (Weather and Environmental Services Quality of Services survey)

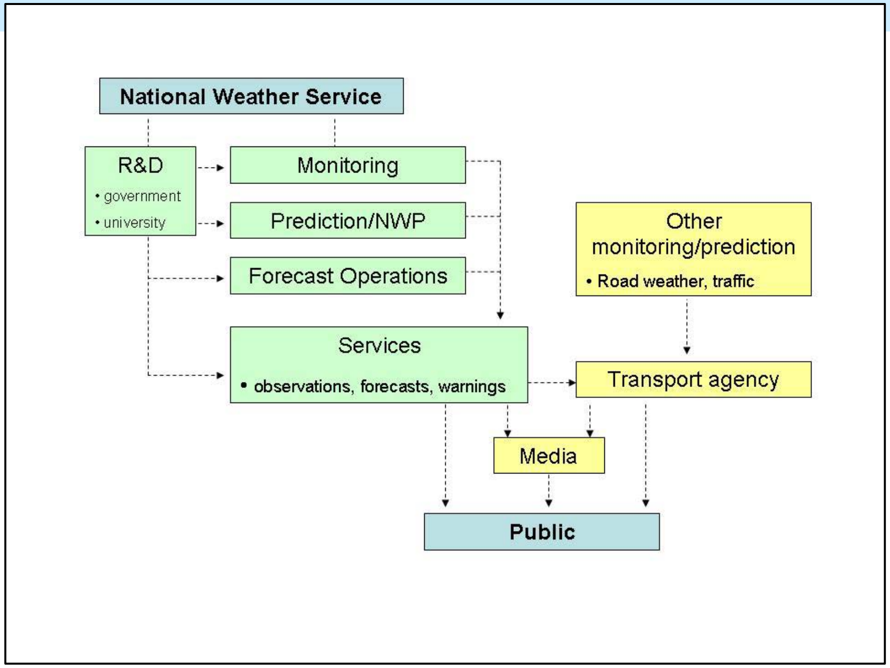
Content analysis example

```
ACCN10 CWTO 020710
Forecast of thunderstorm potential for the province of Ontario
Issued by Environment Canada at 1:50 AM EDT Wednesday 2 May 2012.
The next statement will be issued at 4.30 PM today.
----------------------------------------------------------------------
Forecast of thunderstorm potential.

Today..Over Southwestern Ontario beginning this afternoon, slight
risk of severe thunderstorms with wind gusts of 90 km/h, torrential
downpours giving local rainfall amounts of 25 to 50 mm in an hour or
less, intense lightning and large hail. An isolated tornado isn't
completely out of the question. Otherwise over Southern Ontario
About as far northeast as a line from Kincardine to St Catharines a
few non-severe thunderstorms with heavy downpours and frequent
lightning are possible as a warm front approaches from the Ohio
Valley and the us midwest. Isolated non-severe thunderstorms with
brief downpours, wind gusts to 70 km/h and small hail are possible
across Northwestern Ontario extending northeast towards Southern
James Bay as a sharp Arctic cold front approaches from the northwest.
```

Social science contributions to/from the "weather enterprise"

- *Justification for past and planned investments*
- *Complementary role in the selection, design, testing, implementation and evaluation of system changes/improvements (publication quantity and quality; standard verification procedures; simple measures of public use, awareness, satisfaction)*
- *Advancement of broader social science theory, conceptualization, and analytical methods*



Specific questions, example studies

- *What are the social and economic impacts of weather-related hazards?*
  - *relative to a problem/decision scale and outcome-oriented*
  - *establishes a baseline, priority and order*
  - *reveals exposure and other characteristics relevant to decisions (e.g., magnitude, frequency, duration, severity, location and extent, timing, interactions)*

- *How much of the impact can be affected by improved weather and related risk information and associated services?*
  - *basis for estimating social and economic value*
  - *assumptions concerning information, behaviour, and outcomes*

Specific questions, example studies

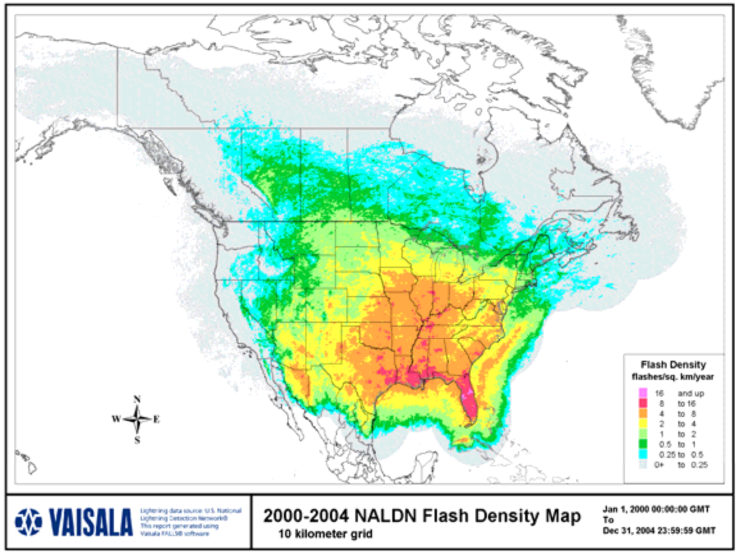
<u>Ranking of selected causes of weather-related fatalities</u>

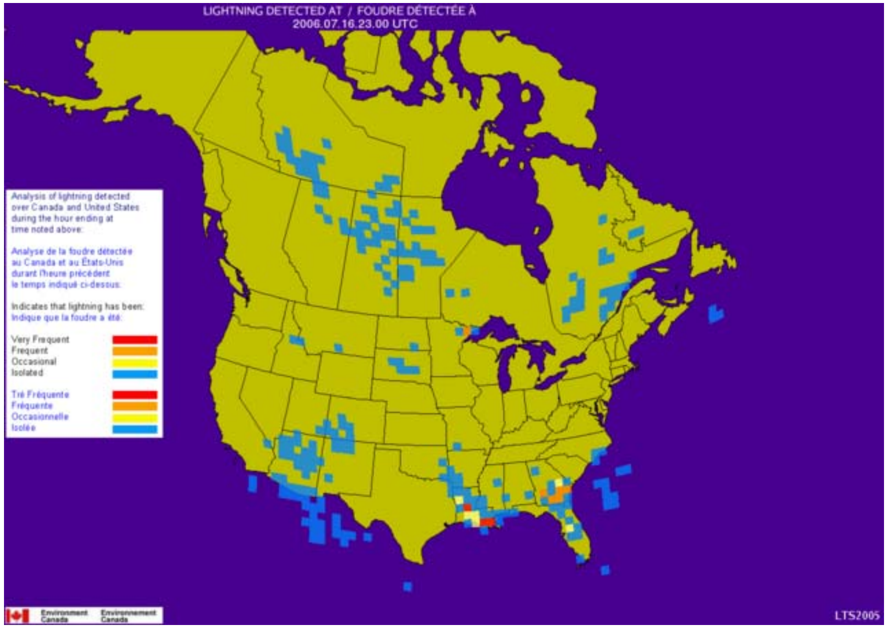
1. Ambient air pollution
2. Motor vehicle collisions
3. Exposure to heat
4. Exposure to cold
5. Snow avalanche
6. Lightning
7. Flooding
8. Tornadoes

Slips and falls?

Lightning injuries and costs

- *Common meteorological hazard yet little current Canadian information on baseline risks/costs*
- *Investment in CLDN and climatological, detection, and forecast information—basis for planning, design and evaluation from the user's perspective*





Lightning injuries and costs

Mills, B., D. Unrau, L. Pentelow, and K. Spring 2010. Assessment of lightning-related damage and disruption in Canada, *Natural Hazards*, 52(2):481-499.

Mills, B., D. Unrau, C. Parkinson, B. Jones, J. Yessis, K. Spring, and L. Pentelow. 2008. An assessment of lightning-related fatality and injury risk in Canada, *Natural Hazards*, 47(2):157-183.

Author	Timeframe	Location	Deaths and injuries	Annual mortality, injury or casualty rates per million population (unless otherwise stated)	Data Sources
Bains and Hoey (1998)	1991-1995	Canada	27 deaths	n/a	Death certificates (government)
Baker (1984)	1941-1980	England and Wales	263 deaths	7.0 million to one	Unknown
Baker (1984)	1951-1980	Scotland	9 deaths	17.3 million to one	Unknown
Baker (1984)	1954-1969	Ireland	7 deaths	n/a	Unknown
Baker (1984)	1941-1980	Northern Ireland	1 death	57.1 million to one	Unknown
Cherington (2001)	1989-1995	Rocky Mountains (Colorado)	39 deaths	n/a	Newspapers
Coates *et al.* (1993)	1824-1991	Australia	650 deaths	0.08 per 100,000 (1910-89) 0.01 per 100,000 (1980-89)	Newspapers, Australian Bureau of Statistics
Curran *et al.* (2000)	1959-1994	United States	3239 deaths	0.42 (0.0-1.88, Alaska-New Mexico)	US NOAA Storm data
			9818 injuries	1.26 (0.0-5.74, Alaska-Wyoming)	
Duclos *et al.* (1990)	1978-1987	Florida	101 deaths	0.09 per 100,000	Death certificates, autopsy reports, Florida Hospital Cost Containment Board, US NOAA Storm data, hospitals
			44 injuries[a] (1987)	0.54 casualties[b] per 100,000 (1987)	
ten Duis (1998)	1910-1995	Netherlands	602 deaths[c]	n/a	Unknown
Elsom (1993)	1975-1990	England and Wales	56 deaths	n/a	Office of Population Censuses and Surveys
Elsom (2001)	1993-1999	United Kingdom	22 deaths	0.05	Tornado and Storm Research Organisation database (reports in journals, news media, voluntary thunderstorm observer network)
			341 injuries	n/a	
Ferrett and Ojala (1992)	1959-1987	Michigan	81 deaths	n/a	US NOAA Storm Data
			527 injuries	n/a	
Gourbière (1999)	1979-1996	France	180 deaths	0.17	Newspapers, physicians, survivor accounts
Hornstein (1961,1962)	1939-1958	Canada	320 deaths	1.1	Bureau of Government Statistics
Lopez and Holle (1996)	1959-1990	United States	2983 deaths	n/a	US NOAA Storm Data
Lopez and Holle (1998)	1900-1991	United States	20758 deaths	0.3-6.3 (1991, 1901)	Bureau of the Census and Public Health Service (mortality and vital statistics)
			8233 injuries	n/a	
Lopez *et al.* (1993)	1980-1991	Colorado	36-51 deaths[d]	n/a	Colorado Department of Health (death certificates), US NOAA Storm Data, newspapers, Colorado Hospital Association (discharge data)
			46-82 injuries[e] (1988-1991)	n/a	
Lopez *et al.* (1995)	1950-1991	Colorado	103 deaths	n/a	US NOAA Storm Data
			299 injuries	0.1 casualties[b] per million people per 10,000km^2	
Nguyen and Bailey (2004)	1991-1996	Canada	5 deaths (0-19 years)	0.01 per 100,000 children 0-19 years old	Provincial and territorial coroners offices, Canadian Hospitals Injury Reporting and Prevention Program data
			9 injuries(0-19 years)	n/a	
Pakiam *et al.* (1981)	1956-1979	Singapore	80 deaths	1.7 (1961-79)	Meteorological Services Singapore, report on Registration of Birth and Deaths, Ministry of Health, newspapers
Shearman and Ojala (1999)	1978-1994	Michigan	39-47 deaths[f]	n/a	US NOAA Storm data, Michigan Department of Public Health (death certificates, hospital discharge records)
			203-246 injuries[g]	n/a	

[a] estimated

Lightning injuries and costs

Methods

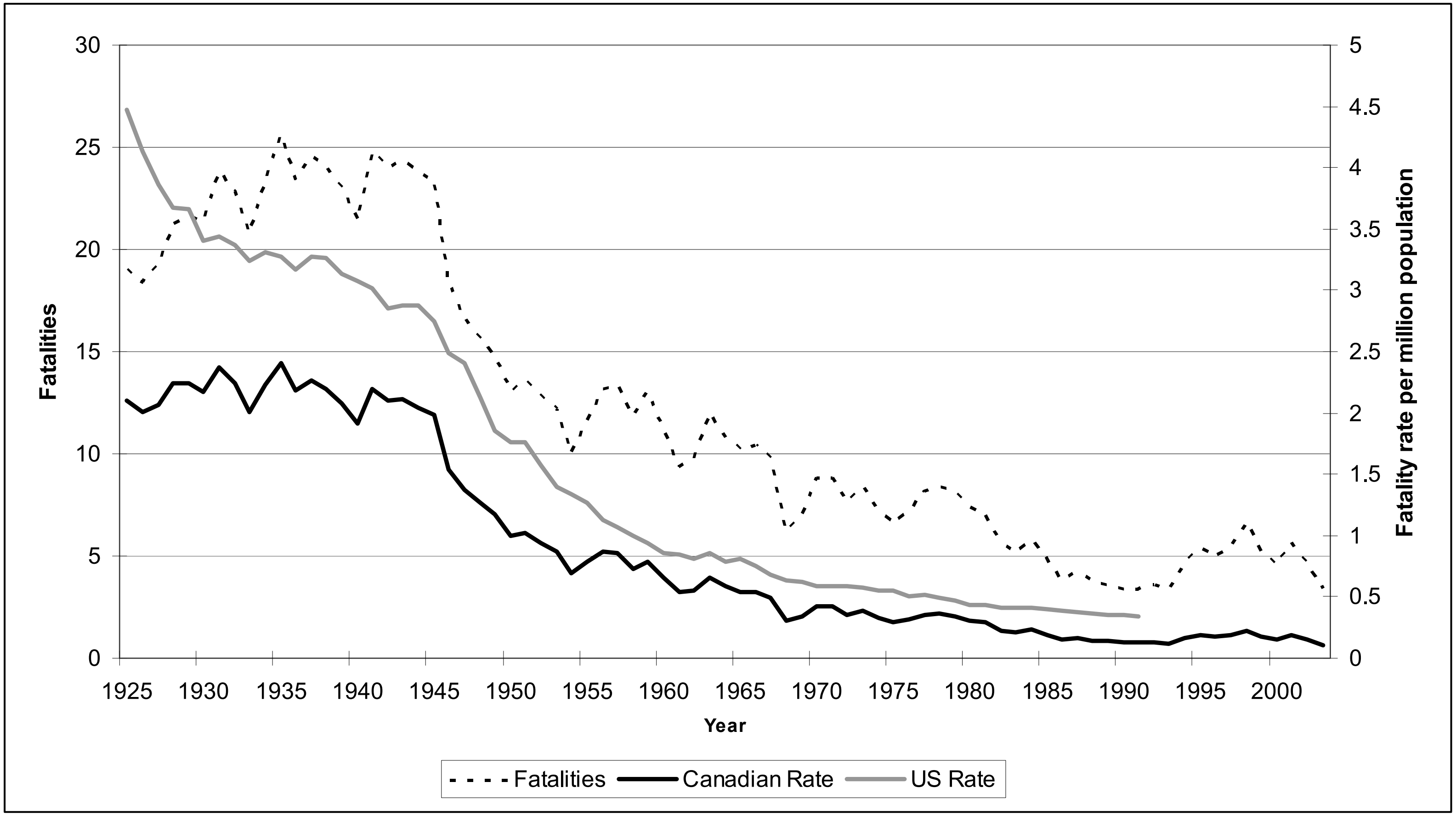
- *Collection of government data and development of media report database*
- *Simple filtering and statistical analyses of data*
- *Spatial and temporal extrapolation and aggregation to develop national estimates*

Mortality and morbidity data sources

Data	Period	Source	Region	Completeness
Vital statistics – cause-of-death by gender	1921-2002	Statistics Canada	National and provincial (except 1950-64)	– based on ICD codes (E907) and place of residence – non-Canadians excluded
National Trauma Registry – admissions to acute care hospitals	1999-2003*	Canadian Institute for Health Information (CIHI)	National	– based on ICD-9 code (E907) and ICD-10 code (X33 victim of lightning) – data collected only for acute care hospitals
National Ambulatory Care Registry System – emergency room visits	2002-2003[a]	Canadian Institute for Health Information (CIHI)	Ontario	– based on ICD-10 code (X33 victim of lightning)
Injuries and fatalities caused by fires ignited by lightning	1986-2001	Council of Canadian Fire Marshals and Fire Commissioners (CCFMFC)	National and provincial	– based on standard code of fires by source of ignition (CCFMFC 2002) – includes fires where response was from a government fire department – does not include forest fires that do not affect structures
Media reports of injuries and fatalities	1994-2006	460 daily and weekly Canadian newspapers	National	– incidents derived from qualitative interpretation of specific articles – *Factiva* online searchable worldwide database used to access 20+ year archive of articles in major daily Canadian newspapers – Four online databases provided links to community newspapers with archives ranging from 7 days to 21 years

[a]based on fiscal year (April 1-March 31)

Fatalities and rates



Sources: Statistics Canada, vital statistics; Lopez & Holle, 1998

Injuries

Fiscal Year	NTR Hospital Admissions (cases)*	NACRS Emergency Room Visitation (Ontario only)**
1999	33	n/a
2000	30	n/a
2001	7	n/a
2002	16	59
2003	12	52
Annual Average	**20.0**	**55.5**

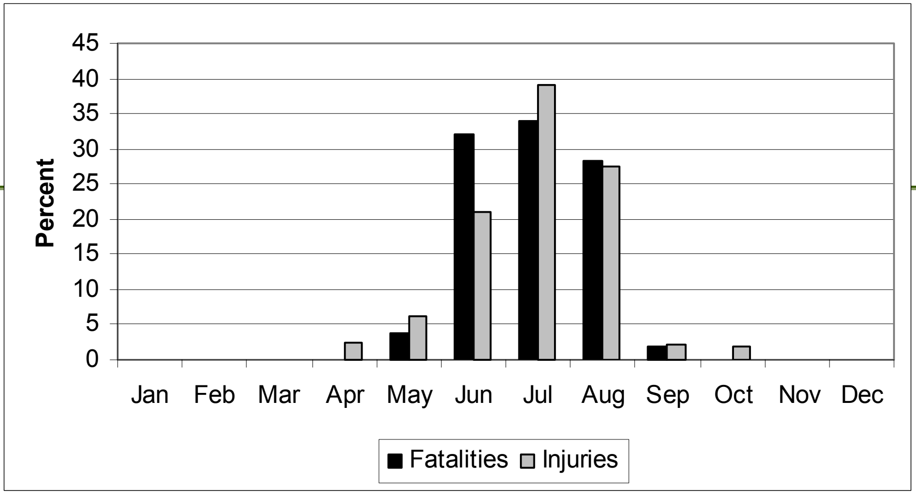
*does not include those who later died in-hospital

**does not include those received in ER and later admitted to hospital

Source: Canadian Institute for Health Information (CIHI)

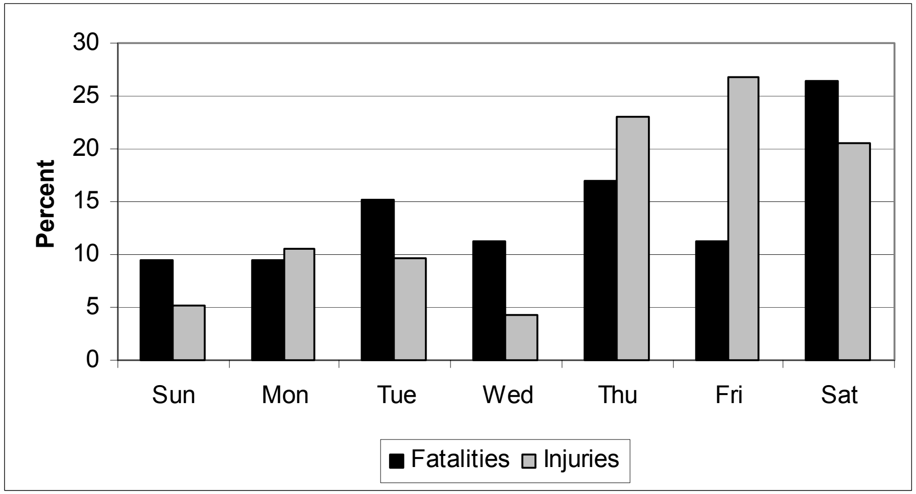
AGE	DEATHS		INJURIES	
	Count	Percentage of total*	Count	Percentage of total*
<16	6	11.3 (14.6)	12	4.3 (17.1)
16-30	10	18.9 (24.4)	21	7.6 (30.0)
31-45	11	20.8 (26.8)	22	7.9 (31.0)
46-60	8	15.1 (19.5)	10	3.6 (14.2)
> 60	6	11.3 (14.6)	5	1.8 (7.1)
Unknown	12	22.6	207	74.7
TOTAL	53	100.0**	277	100.0**

*numbers in parentheses refer to percentage of known deaths or injuries
**numbers may not add to 100 due to rounding



ACTIVITY	DEATHS			INJURIES		
	Count	% of total*	Per Incident	Count	% of total*	Per Incident
Golf	4	7.5 (8.3)	1.0	29	10.5 (11.3)	1.9
Camp/Hike	11	20.8 (22.9)	1.1	47	17.0 (18.4)	3.6
Picnic	5	9.4 (10.4)	1.7	11	4.0 (4.3)	2.2
Boating	8	15.1 (16.7)	1.1	18	6.5 (7.0)	1.6
Soccer	1	1.9 (2.1)	1.0	11	4.0 (4.3)	11.0
Baseball	1	1.9 (2.1)	1.0	28	10.1 (10.9)	9.3
Other Sport**	4	7.5 (8.3)	1.0	15	5.4 (5.9)	2.5
Work	3	5.7 (6.3)	1.0	41	14.8 (16.0)	2.3
In Home	4	7.5 (8.3)	2.0	24	8.7 (9.4)	1.6
In Shelter	1	1.9 (2.1)	1.0	7	2.5 (2.7)	3.5
Other	6	11.3 (12.5)	1.0	25	9.0 (9.8)	1.8
Unknown	5	9.4	1.0	21	7.6	1.8
TOTAL	53	100.0*		277	100.0*	

*numbers in parentheses refer to percentage of known deaths or injuries; numbers may not add to 100 due to rounding
**other sport includes cycling, equestrian, tennis



Lightning-related fatality/injury estimates

- *9-10 deaths and 90-160 injuries per year*
- *Lightning mortality has declined significantly over the past century*
- *The majority of lightning-related fatalities and injuries in Canada occur in Ontario. With the exception of B.C., the distribution of fatalities reflects current provincial population and CG lightning frequencies*
- *Most lightning-related fatalities and injuries occur during the June-August summer season. The Thursday-Saturday period accounted for almost 55% of all fatalities and over 70% of all injuries, most likely related to higher rates of participation in outdoor activities.*
- *Most victims are male, less than 45 years old, and engaged in outdoor recreational activities when injured or killed in a lightning incident*

Cost/loss estimates

Sector	Key impact/cost	Estimated Annual Costs/Losses[1]	
		Low	High
Health	Lightning-related injuries and fatalities	$3,648,793	$79,291,126
Property	Lightning-ignited municipal fires	$14,858,541	$16,414,436
	Insured losses and deductibles	$7,906,521	$23,540,272
Forestry	Forest fire suppression and pre-suppression	$306,981,081	$437,611,328
Electricity	Sustained and momentary outage costs to customers	$266,940,187	$444,900,311
	Lost revenue	$16,187	$16,187
TOTAL		**$600,351,310**	**$1,001,773,660**

[1] low and high estimates taken from report tables; electricity low and high values determined by subtracting and adding 25% to baseline estimates (Mills et al., 2008b)

Value of the National Doppler Radar Program

Cost-benefit analysis by Vodden and Smith (2003)

- *Benefits assessed using contingent valuation and benefits transfer approaches*
- *Stratified random sample of over 1000 households surveyed via telephone interview to determine WTP for improved services above and beyond the annual $11 in taxes already paid*
- *Subset of individual decisions examined using transfers from existing studies to estimate benefits of reduced motor vehicle collisions and hail damage, and efficiencies in winter road maintenance and truck routing*

Value of the National Doppler Radar Program

Exhibit 1 Annual and present value (2003 $ Million) of costs and benefits, total and by benefit component

Year		Costs	Total Benefits Contingent value	Benefit by components: Sub-total	Vehicle trips*	Hail damage	Winter road	Trucking
	1997	6.65						
	1998	6.65						
	1999	6.65						
	2000	6.65						
	2001	6.65						
	2002	6.65						
	2003	4.95	55.6	27.5	4.0	1.5	13.0	9.9
	2004	4.95	56.4	27.5	4.0	1.5	13.0	9.9
	2005	4.95	57.1	27.5	4.0	1.5	13.0	9.9
	2006	4.95	57.9	27.5	4.0	1.5	13.0	9.9
	2007	4.95	58.7	27.5	4.0	1.5	13.0	9.9
	2008	4.95	59.5	27.5	4.0	1.5	13.0	9.9
	2009	4.95	60.4	27.5	4.0	1.5	13.0	9.9
	2010	4.95	61.2	27.5	4.0	1.5	13.0	9.9
	2011	4.95	62.0	27.5	4.0	1.5	13.0	9.9
	2012	4.95	62.9	27.5	4.0	1.5	13.0	9.9
	2013	4.95	63.7	27.5	4.0	1.5	13.0	9.9
	2014	4.95	64.6	27.5	4.0	1.5	13.0	9.9
	2015	4.95	65.5	27.5	4.0	1.5	13.0	9.9
	2016	4.95	66.4	27.5	4.0	1.5	13.0	9.9
	2017	4.95	67.3	27.5	4.0	1.5	13.0	9.9
	2018	4.95	68.2	27.5	4.0	1.5	13.0	9.9
	2019	4.95	69.2	27.5	4.0	1.5	13.0	9.9
	2020	4.95	70.1	27.5	4.0	1.5	13.0	9.9
	2021	4.95	71.1	27.5	4.0	1.5	13.0	9.9
	2022	4.95	72.1	27.5	4.0	1.5	13.0	9.9
Present value	SDR*							
10 years	5.0%	87.6	477.2	223.0	32.4	11.8	105.4	80.3
	7.5%	**88.3**	**433.1**	**202.9**	**29.5**	**10.8**	**95.9**	**73.1**
	10.0%	89.9	395.8	185.9	27.0	9.9	87.9	66.9
20 years	7.5%	106.3	674.0	301.4	34.7	16.0	142.5	108.5

* The minimum of the likely range is used to assess this benefit.

** SDR = Social Discount Rate. A rate of 7.5% is used as a base case with sensitivity analyses performed at 5.0% and 10.0%.

A work (plan) in progress

- *Assess current situation, use and need for societal and economic research (various elements of the system within EC; key weather-sensitive agencies, organizations and sectors within Canada; and the international community)*
- *Establish a social and economic research framework and virtual network of interest and expertise to guide the selection of particular applications*
- *Longer term goal is to populate the framework with studies that produce immediate value to ASTD (e.g., evaluations of current research projects) and MSC (e.g., cases based on signature projects) and contribute to the development of new and better methods.*

A work (plan) in progress

<u>Two sets of potential studies envisioned:</u>

- *Large projects that are national in scope and/or involve considerable resource and effort (2+ years)*
- *Meteorological Research Division/MSC projects that are smaller in scope but with potential to expand as warranted (6 months to 1.5 years)*

A work (plan) in progress

<u>*Type 1 example: Sensitivity of the Canadian economy to weather*</u>

- *Estimates the sensitivity of annual gross domestic product at the national and provincial levels in Canada using the general empirical approach adopted by Lazo et al. (2011)*
- *12 sectors: agriculture; communications; construction; finance, insurance, and real estate; manufacturing; mining; retail trade; services; transportation; utilities; wholesale trade; and government services.*
- *Results will provide a first order approximation of the weather sensitivity of the Canadian economy by sector and province, and at the national aggregate level (by percent and in absolute terms, $xx billion).*
- *Provides an initial baseline against which the impact of improved weather information can be derived and a starting point for the evaluation of sub-regional, disaggregated, and interactive effects.*

A work (plan) in progress

Type 2 generic approach

1. *Identification of a new, changing, or proposed technology, capacity, infrastructure, or investment for which we require an understanding of potential societal use and/or economic value in decision-making*
2. *Define, characterize and quantify where possible the historic, existing and potential uses, decision-makers, problems or opportunities that are of primary importance (safety, livelihood, economic and environmental damage; number affected/exposed)*
3. *Select a subset of uses, users, and problems for detailed decision analysis*

A work (plan) in progress

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A work (plan) in progress

Type 2 generic approach

4. *Develop a tailored experimental approach, using multiple methods and sources of data where feasible, to discern the impact of the improved system, model, forecast, service, etc. relative to an established basis for comparison.*
5. *Conduct a sensitivity analysis to ascertain the effects of the assumptions and methods adopted.*
6. *Translate results to an economic value as appropriate and required.*
7. *Report, interpret, publish and communicate results*
8. *Assess need for further monitoring and research*

A work (plan) in progress

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A work (plan) in progress

<u>Type 2 potential project topics that have been identified</u>

- *The existing and potential value of sub-seasonal to seasonal weather and related risk forecasts in Canada: Comparison of deterministic and ensemble-based prediction systems*
- *Evaluation of changes to the Canadian Lightning Risk Display (CLRD), associated CLDN services, and incorporation of lightning forecast information*
- *Analysis of the impact of vigilance and other early warning/nowcasting systems on decision-making and behaviour in Canada*
- *Benefits of an enhanced Great Lakes-St. Lawrence River prediction system*
- *Urban-scale applications of high resolution land surface classification and meso-scale models: Costs and benefits*
- *A societal impact perspective to data denial and targeted observations: Reanalysis of past experiments*

Discussion

Especially ideas regarding possible projects