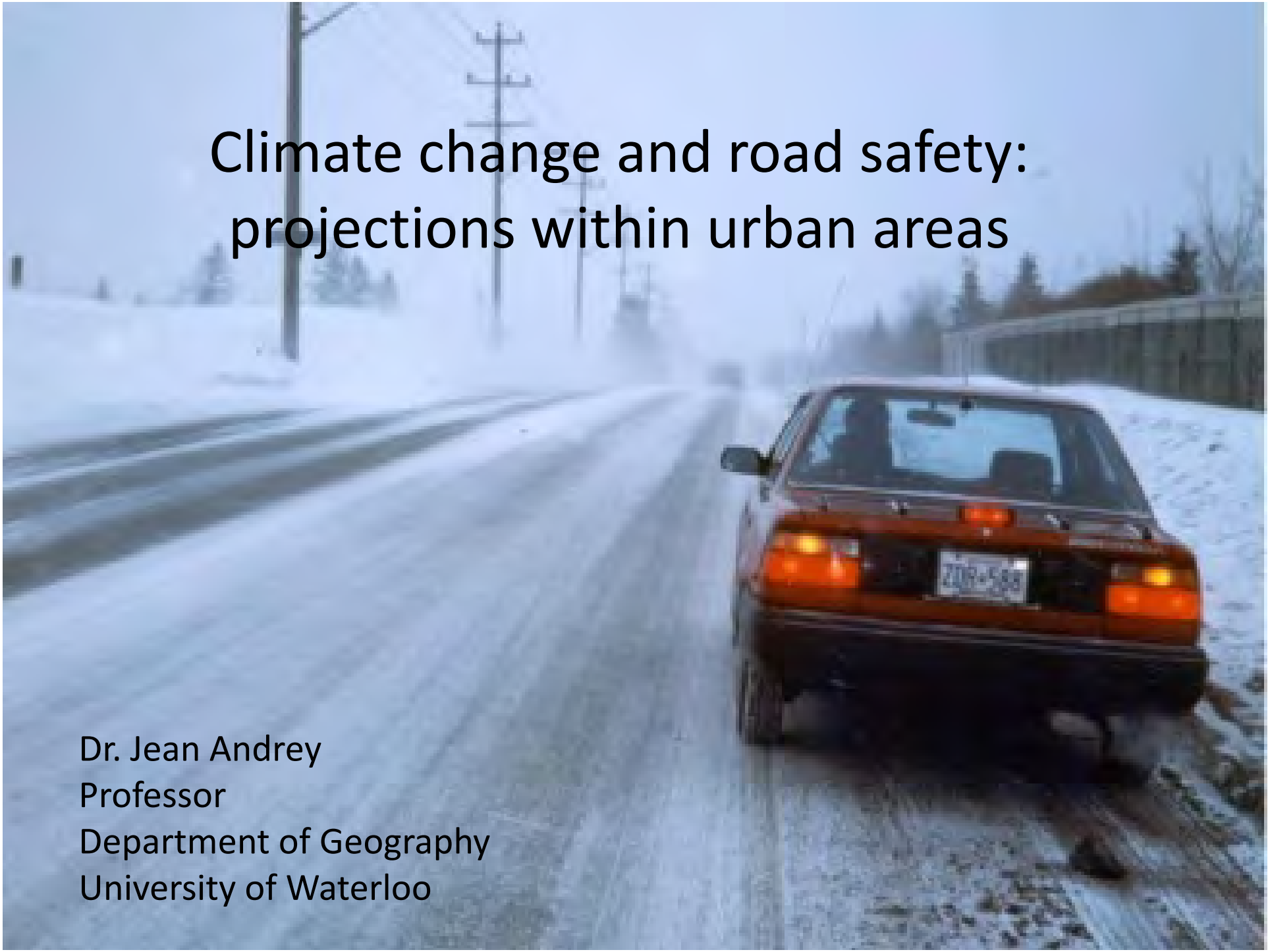

Climate change and road safety: projections within urban areas

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Acknowledgements

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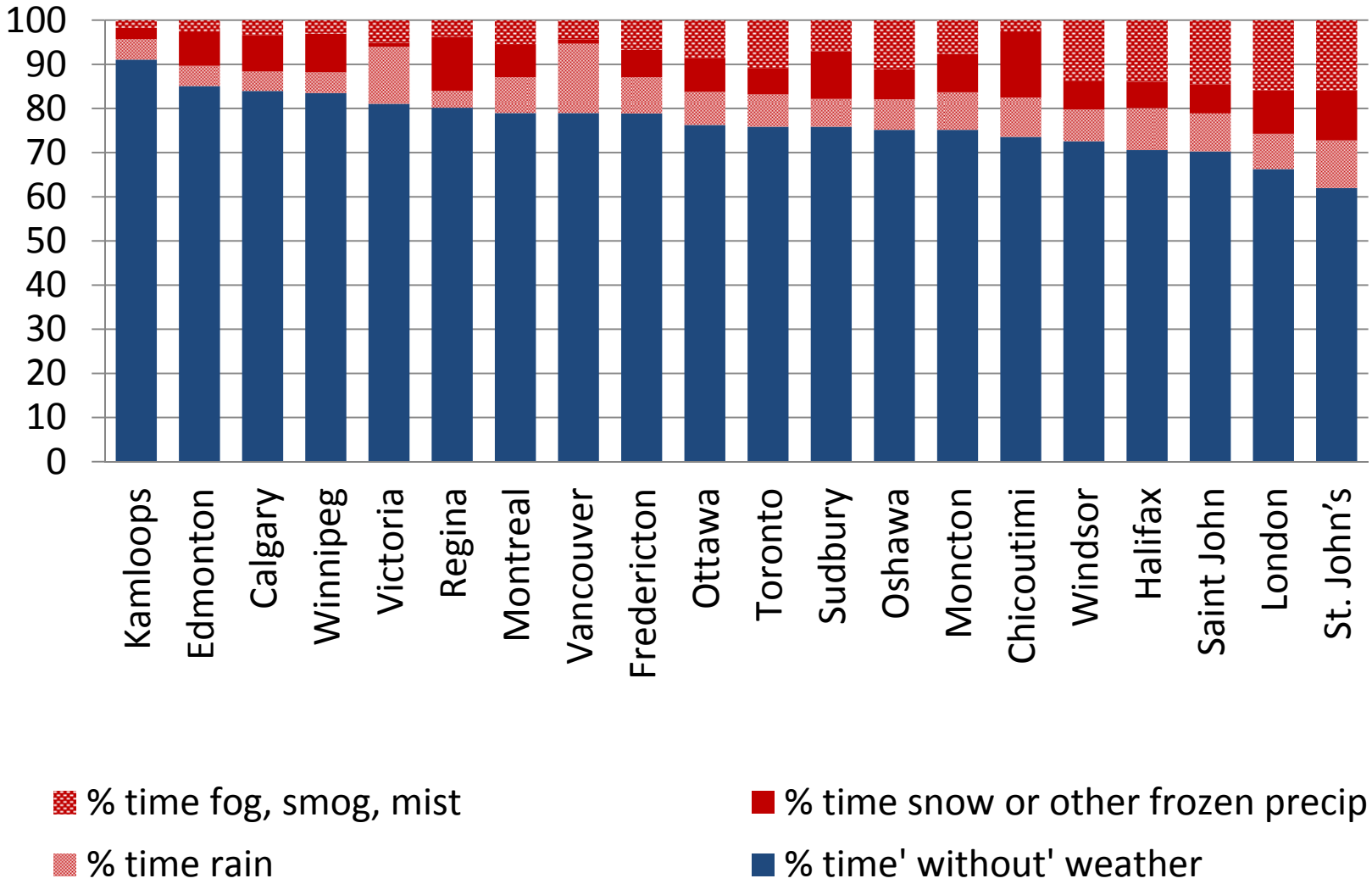
Transport Canada: collision data
Environment Canada : weather data
OURANOS Consortium: climate change projections
Derrick Hambly, University of Waterloo: data analysis

Weather-related driving hazards

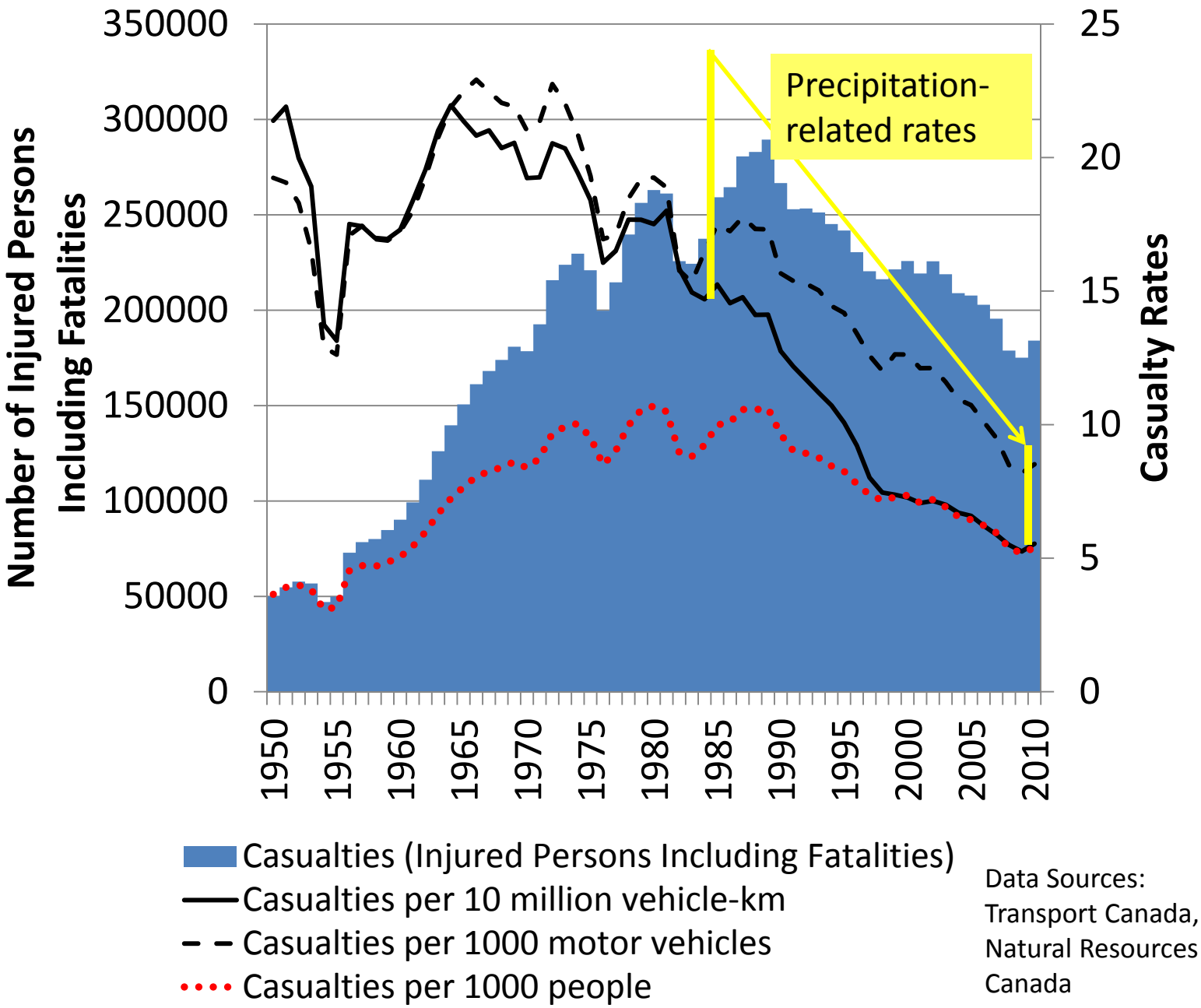
Nature of hazard	***Relevant weather conditions***
Compromised infrastructure	•Washouts, debris flows, rock falls
Reduced friction or control	•**Snowy, icy or wet roads** • Extreme heat leading to asphalt bleeding
Impaired visibility	•**Falling precipitation** •Splash and spray •Blowing snow •Fog and ice fog •Dust storms, haze, smog, glare
Decreased stability	•High-velocity cross winds •Buffeting (gusts with passing trucks)

Weather Occurrences Across Canada



Weather-related Driving Risks: The Good News

1. Overall casualty rates have declined in most 'western' nations.
2. Most drivers adjust to inclement weather. Not surprisingly, therefore, property-damage-only collisions increase the most during inclement weather, and serious crashes increase the least.
3. In most cases, risks return to near-normal as soon as rain/snow stop falling.
4. In Canada, precipitation-related driving risks have decreased over time.



Data Sources:
Transport Canada,
Natural Resources
Canada

Weather-related Driving Risks:

The Not-So-Good News

1. Collision rates remain highly elevated during heavy rains and moderate-heavy snowfalls.
2. The frequency of precipitation and heavy precipitation events in particular, has been increasing and are projected to increase even more in future decades.

Progression of Risk with Precipitation Intensity

based on data for 10 cities in central and eastern Canada, 1984-2002

6-hour precipitation amount	Rain Major Injuries	Rain Minimal and Minor Injuries	Snow Major and Fatal Injuries	Snow Minimal and Minor Injuries
All precipitation	1.5	1.7	1.5	1.9
0.39 to 2.00 mm	1.2	1.6	1.5	1.6
2.01 to 10.00 mm	1.5	1.8	1.6	2.3
>10 mm	1.7	2.0	1.6	1.9

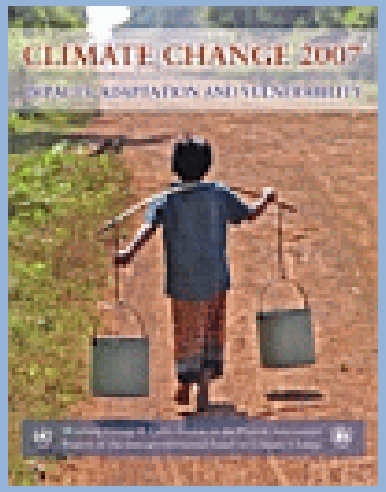
(Andrey, 2010, *Journal of Transport Geography*)

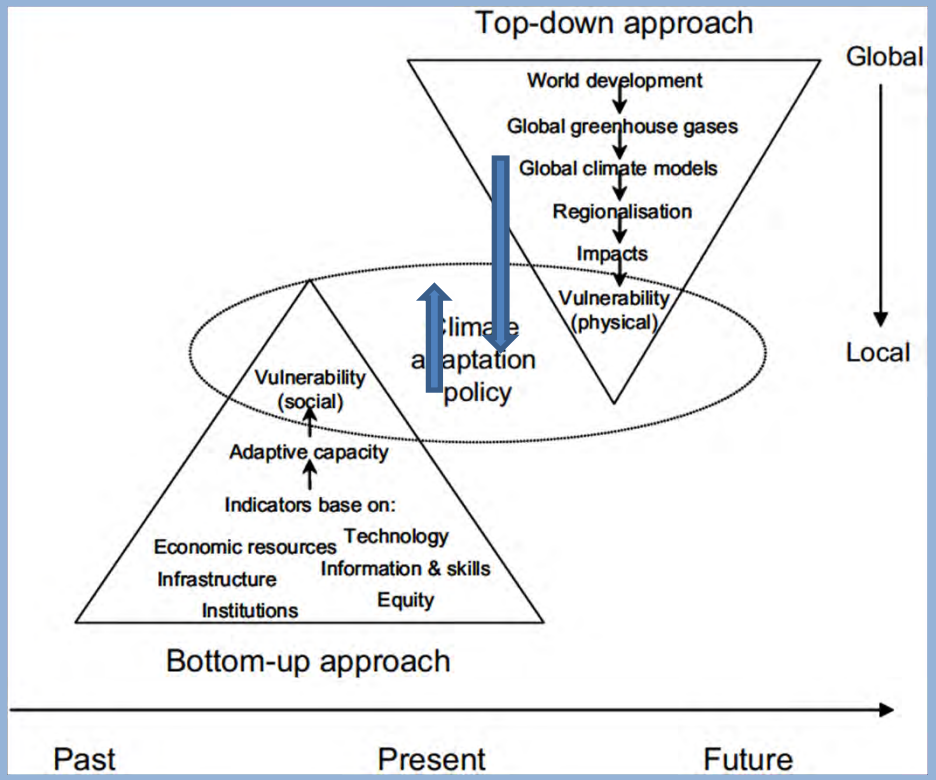
Observed changes in precipitation over Canada, 1950-2003

	# stations significant ↑	No significant change	# stations significant ↓
Total precipitation	27	184	5
Summer precipitation amount	20	294	4
Days with rain > trace	168	52	3
Days with rain > 10 mm	32	179	12
Days very wet (>95th percentile)	25	185	13

Source: Vincent and Mekis (2006)
https://ams.confex.com/ams/pdfpapers/140963.pdf

Climate Change Impacts and Adaptations and Vulnerability -- Approaches



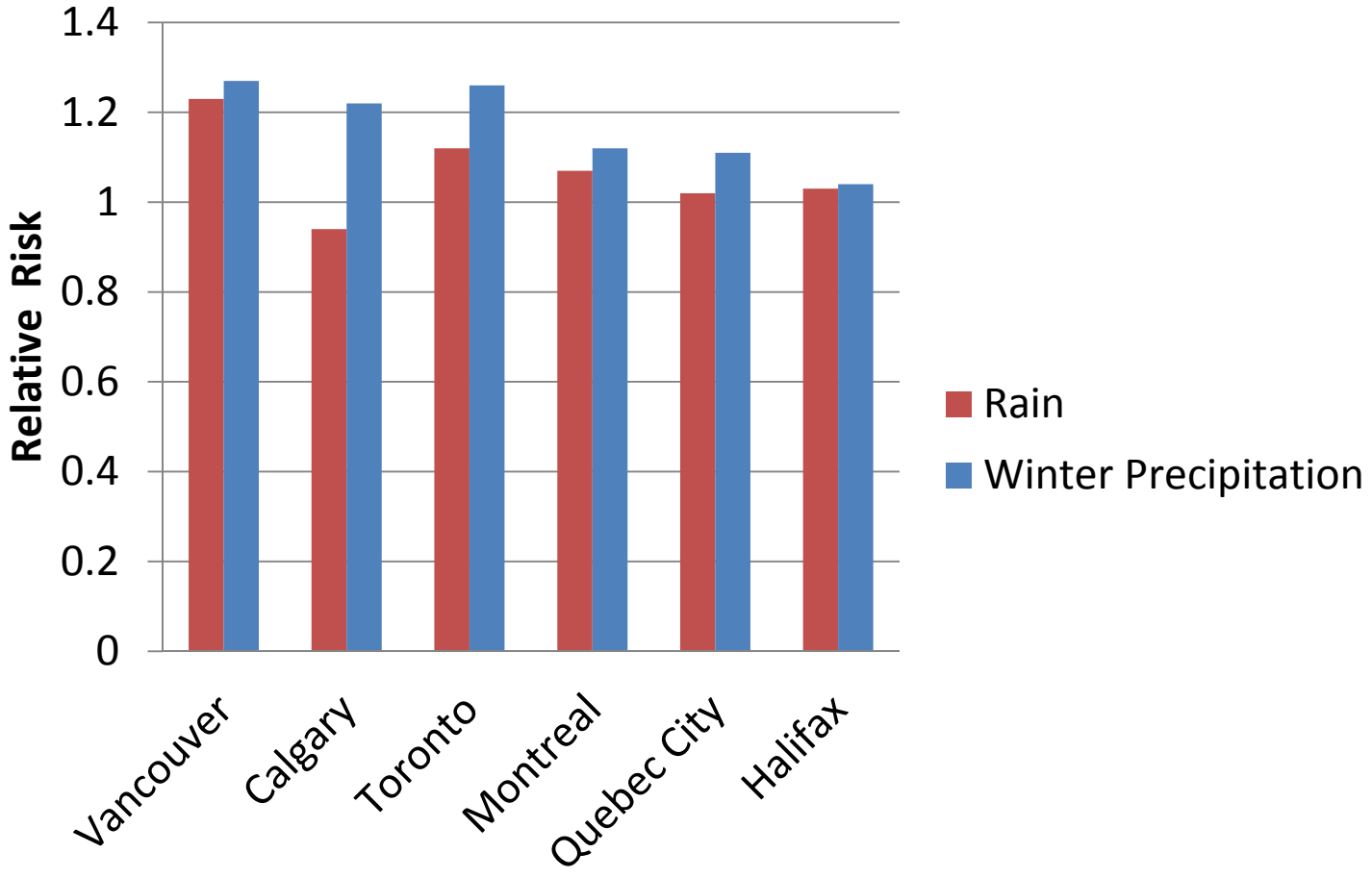


Sources: IPCC, 2007 and Intechopen.com, 2013

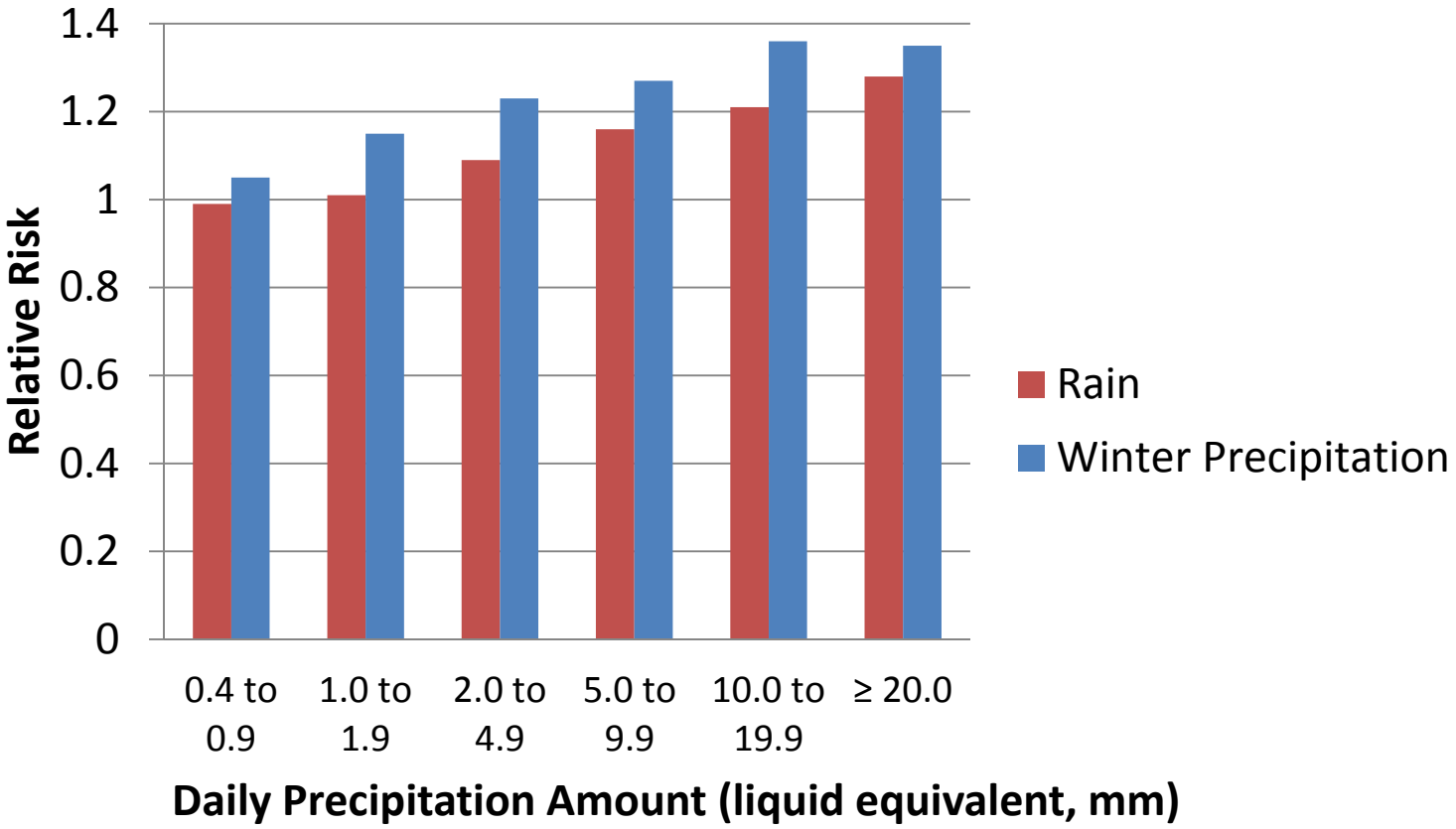
Steps Taken

1. Quantify the risks today using a method appropriate to the data and to projections of future conditions
2. Extract projections of future climate scenarios from various sources for the study areas.
3. Combine with present-day risk analysis
4. Identify areas of greatest vulnerability and work toward informed adaptation

Relative Risk of Injury Collisions On Days with Precipitation by City



Relative Risk of Injury Collisions On Days with Precipitation By Precipitation Amount



Global and Regional Climate Models

Each simulation is based on an assumed future state of population, energy and technology globally.

Selection of

A2 Emission Scenario

Ensemble of 8 projections based on the Canadian and German GCMs

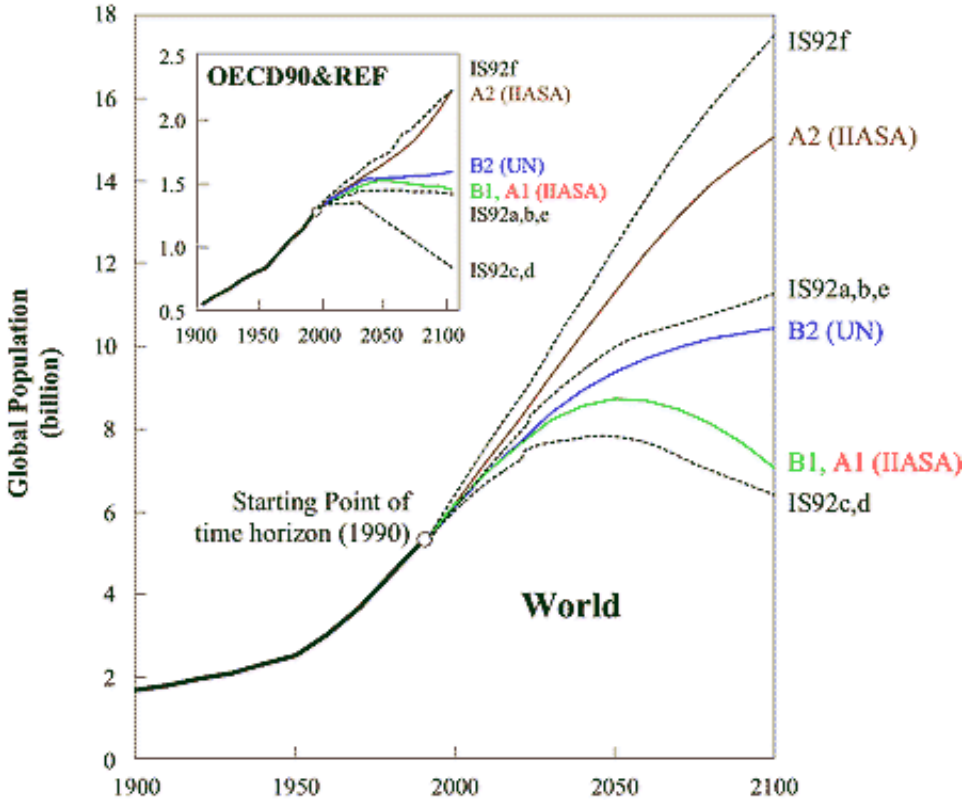


Image Source: IPCC (2007)
http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=14

Study Areas

Urban Area	**Current Climate** (mean temperature, annual precipitation days, annual precipitation amount)	**Future Climate** (mean temperature, annual precipitation days, annual precipitation amount)		
Vancouver, BC	10.4℃, 166 days, 1199 mm	↑	↑↓	↑
Calgary, AB	3.7℃, 114 days, 413 mm	↑	↑↓	↑↓
Toronto, ON	7.3℃, 146 days, 793 mm	↑	↑↓	↑
Montreal, QC	5.4℃, 163 days, 979 mm	↑	↓	↑
Quebec, QC	3.2℃, 182 days, 1230 mm	↑	↑↓	↑
Halifax, NS	6.3℃, 171 days, 1452 mm	↑	↑↓	↑

Climate-Change Effects on Injury Collisions

Urban Area (a)	Average Annual Injury Collisions (b)	Annual Injury Collisions Attributable to Precipitation (c)	Climate Change Effect on Column (c)
Vancouver, BC	7,421	729	-0.7% to +4.0%
Calgary, AB	3,359	55	-29.2% to -11.4%
Toronto, ON	20,518	1,065	-11.1% to -6.1%
Montreal, QC	7,773	240	-4.8% to +3.2%
Quebec, QC	1,985	47	-4.4% to +2.5%
Halifax, NS	975	14	-10.2% to -0.2%

Projections of Changes in Road Safety Associated with Climate Change

- Nationally, climate change is expected to produce a net safety benefit because of fewer days with “winter precipitation”. However, much of the potential benefit of shorter and milder winters is offset by more frequent rains, and especially heavier rains.
- Locality matters as it affects level of driving risks as well as present-day and future climate.

Areas of Continuing Vulnerability

Image Sources:
Around the World 2008 http://www.aroundtheworld.org/australia/top-end
The Vancouver Sun , Mar 1 2013 http://www.vancouversun.com/technology/Metro+Vancouver+heavy+rainfall/8035657/story.html

Winter Weather

While winter driving is less risky today than in previous decades, collision rates remain elevated during snowfall events.

Particularly problematic situations include

- First snowfalls of the season
- Heavy snowfall amounts
- Freezing rain

A range of possible interventions exist from encouraging the use of snow tires to encouraging behaviour changes based on forecasts/nowcasts.

Speed Management: Weather Linkages

Driving risks during inclement weather tends to be disproportionately elevated

- on urban expressways and arterials vs. city streets, and
- in rural areas vs. urban areas.

A substantial number of weather-related collisions involve driving speeds that are well above the posted limit.

A range of interventions are possible—from technology-assisted speed enforcement to condition-based variable speed limits

Pedestrian Crashes: Weather Linkages

In a cross-Canada look at pedestrian collisions, it becomes clear that rain is problematic not just for drivers but for pedestrians as well.

- Whereas rain occurred approximately 8.5% of the time, 14% of all collisions involving a motor vehicle hitting a pedestrian occurred during rainfall.

- Pedestrian safety interventions range from intersection control to traffic calming.

Summary Comments

Approximately 5% of road casualties in Canada can be tied directly to the weather (15% of time x 1/3 occurrences)

While snowfall has been the greatest weather hazard in past centuries, more emphasis will have to be placed on heavy rains in the future.