Weather Alert: Adapting and Withstanding the Storms of Tomorrow

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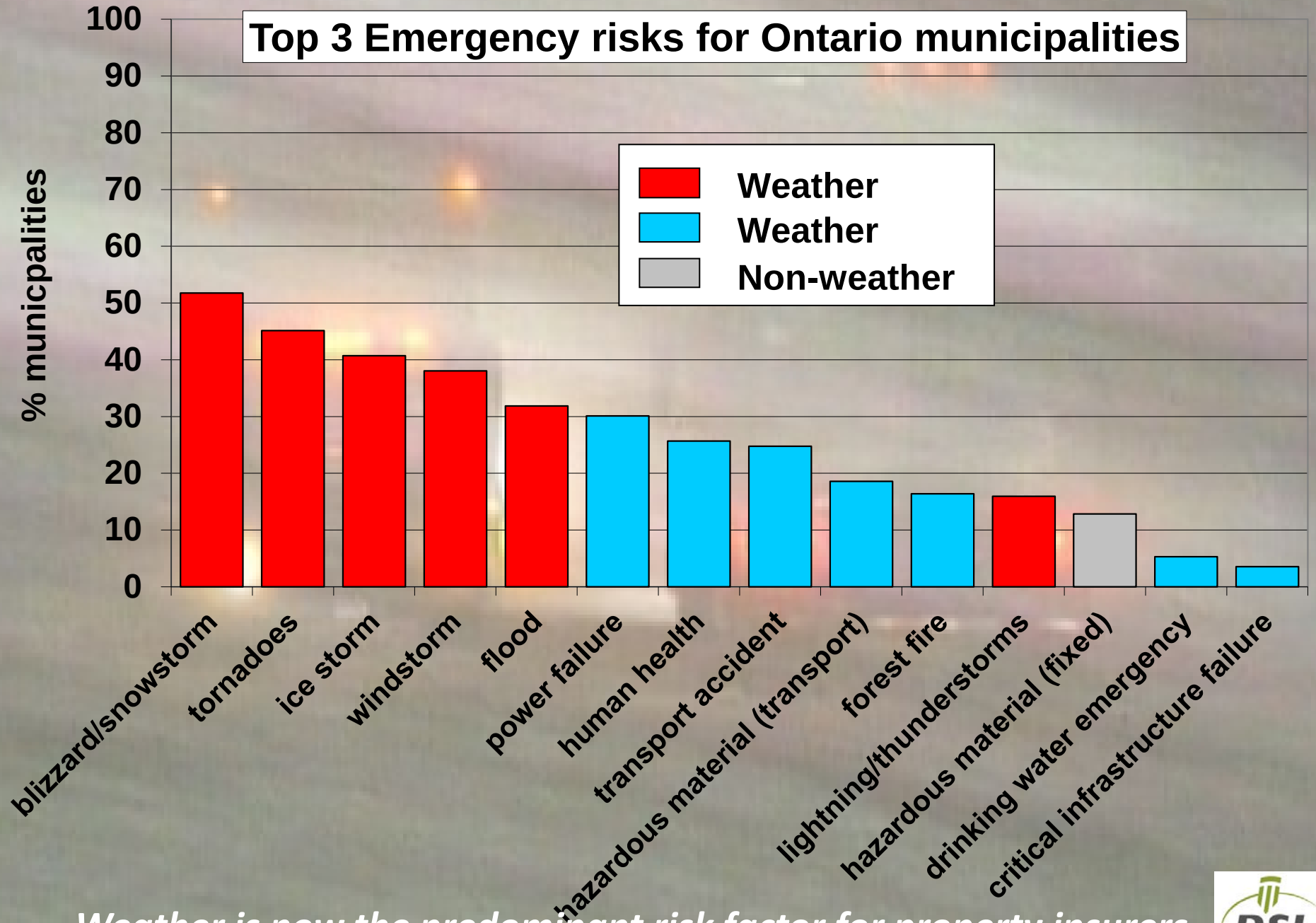
Will Canada be ready for the next natural disaster?

Toronto Star, May 27, 2014

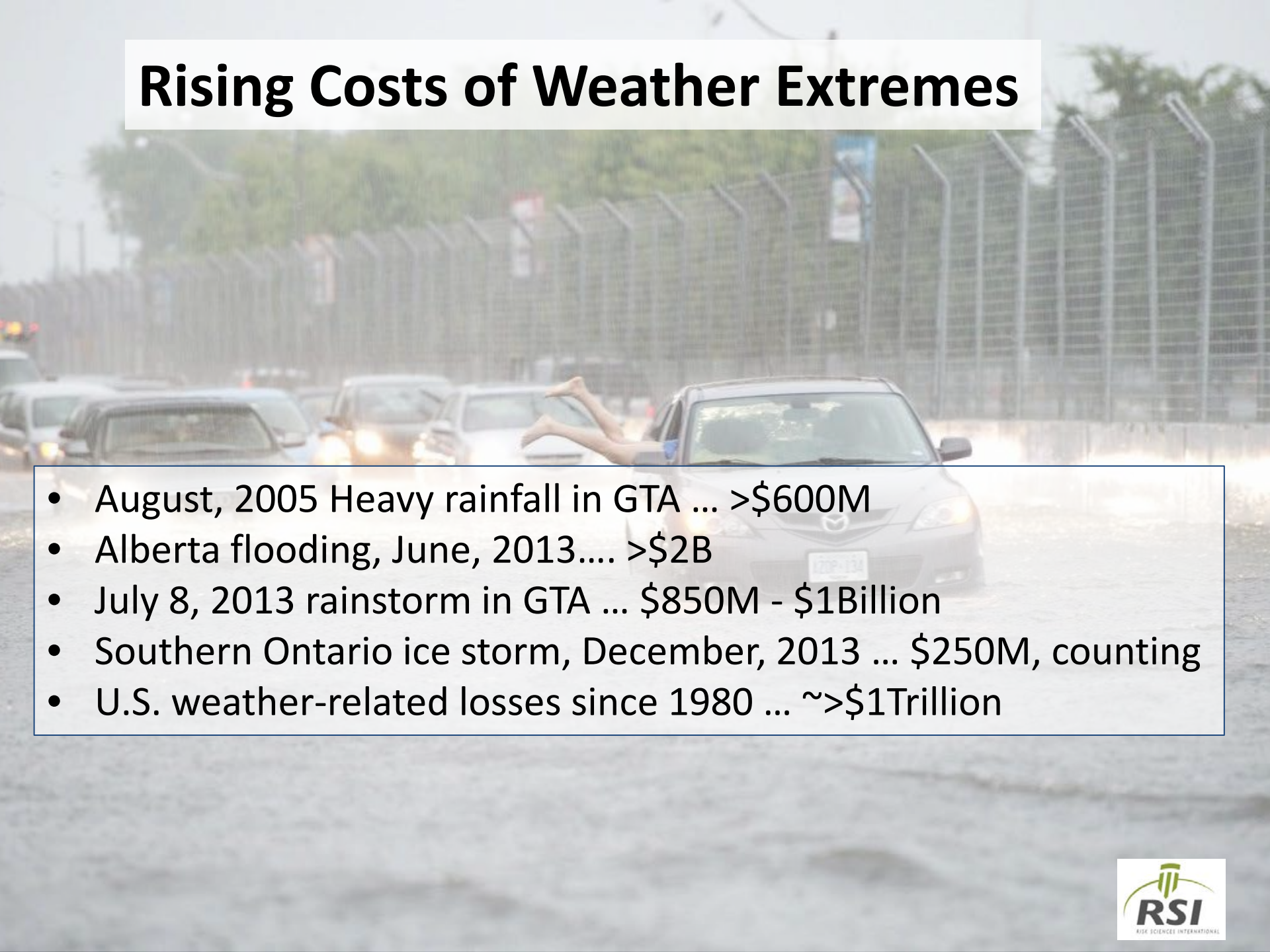
Recent survey of disaster management professionals finds most are concerned about extreme weather events, but don't have funding to prepare for them. (Toronto Star)

Toronto's July flood ranked as most costly natural disaster in Ontario history



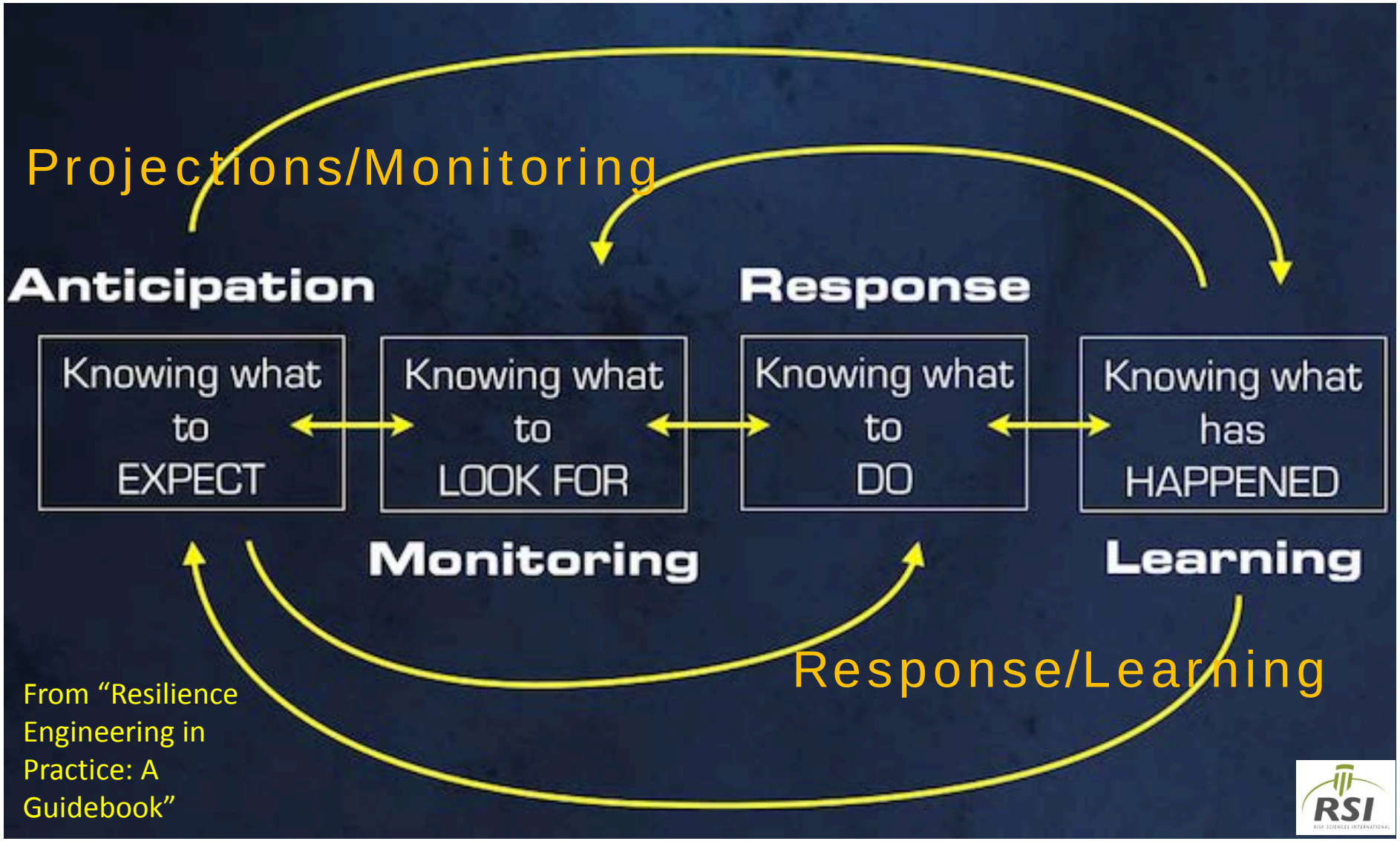
Weather is now the predominant risk factor for property insurers.

Rising Costs of Weather Extremes



- August, 2005 Heavy rainfall in GTA … >$600M
- Alberta flooding, June, 2013…. >$2B
- July 8, 2013 rainstorm in GTA … $850M - $1Billion
- Southern Ontario ice storm, December, 2013 … $250M, counting
- U.S. weather-related losses since 1980 … ~>$1Trillion

Climate Change and “4” Cornerstones of Resilience



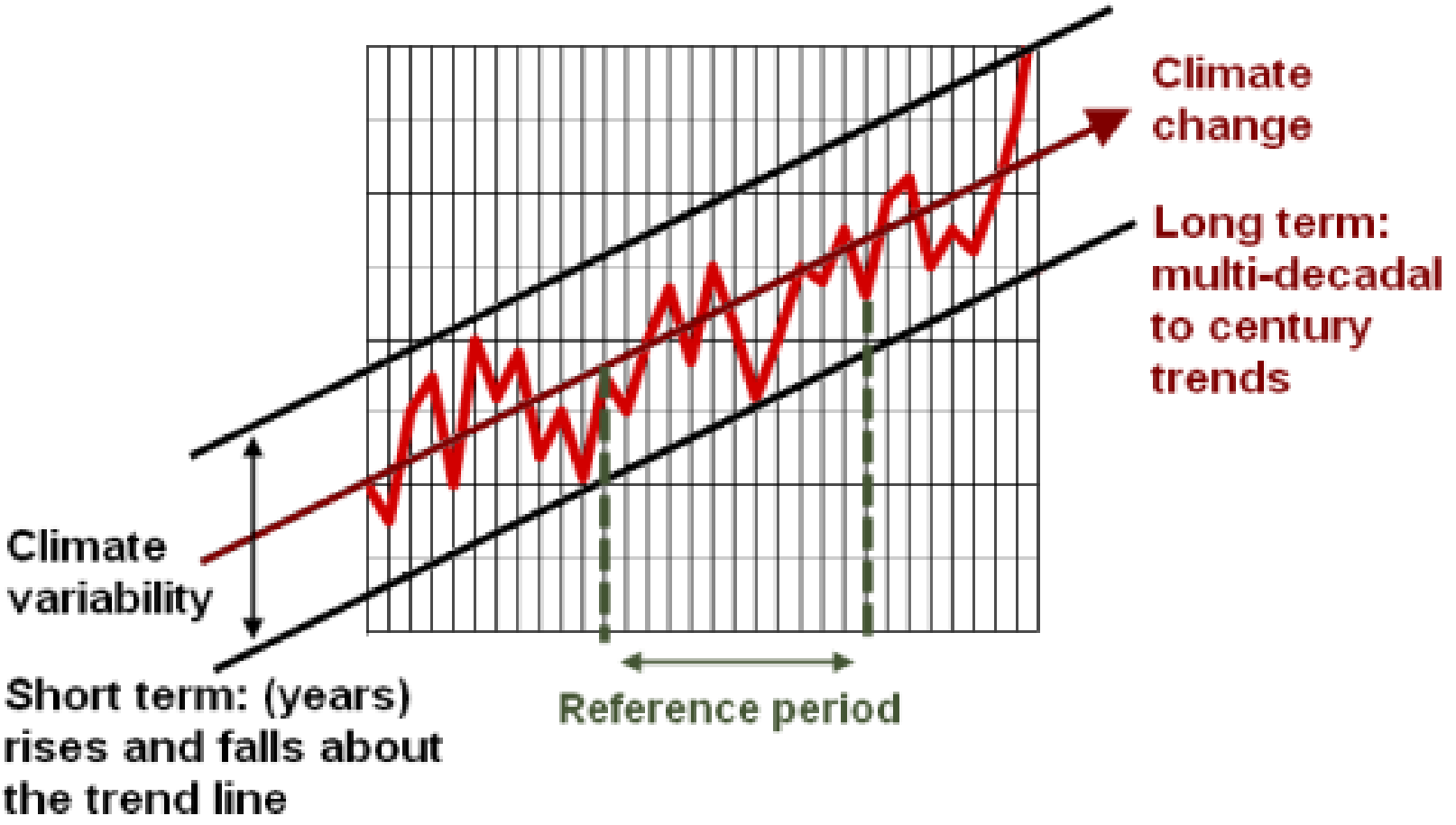
What to expect; Update knowledge

Thresholds; Gaps; Able to Detect

Detected; Emergency response; Operations

Forensics; Fix it!

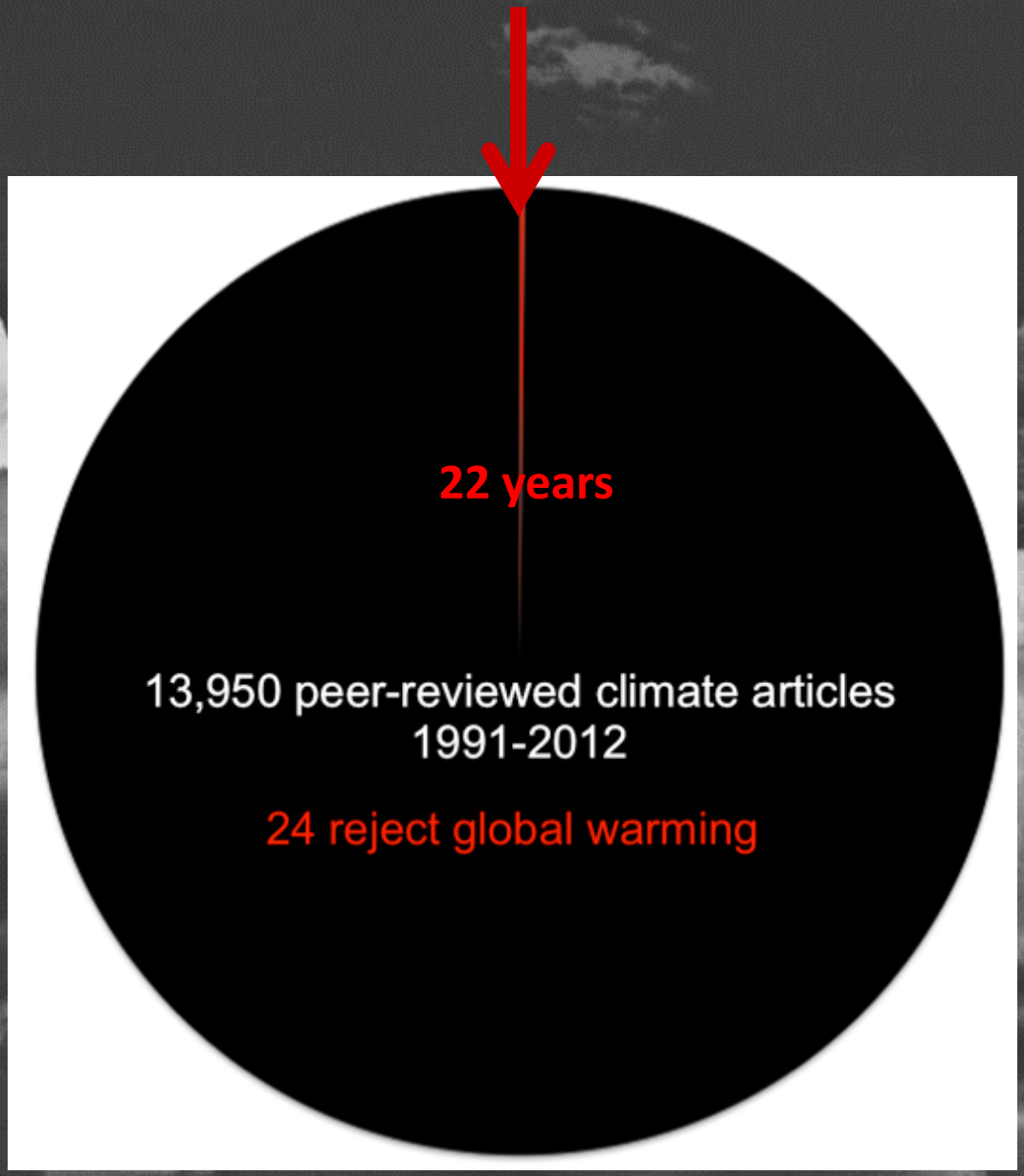
Resilience *(1&2)*: Anticipation and Monitoring



The climate change evidence has become stronger…

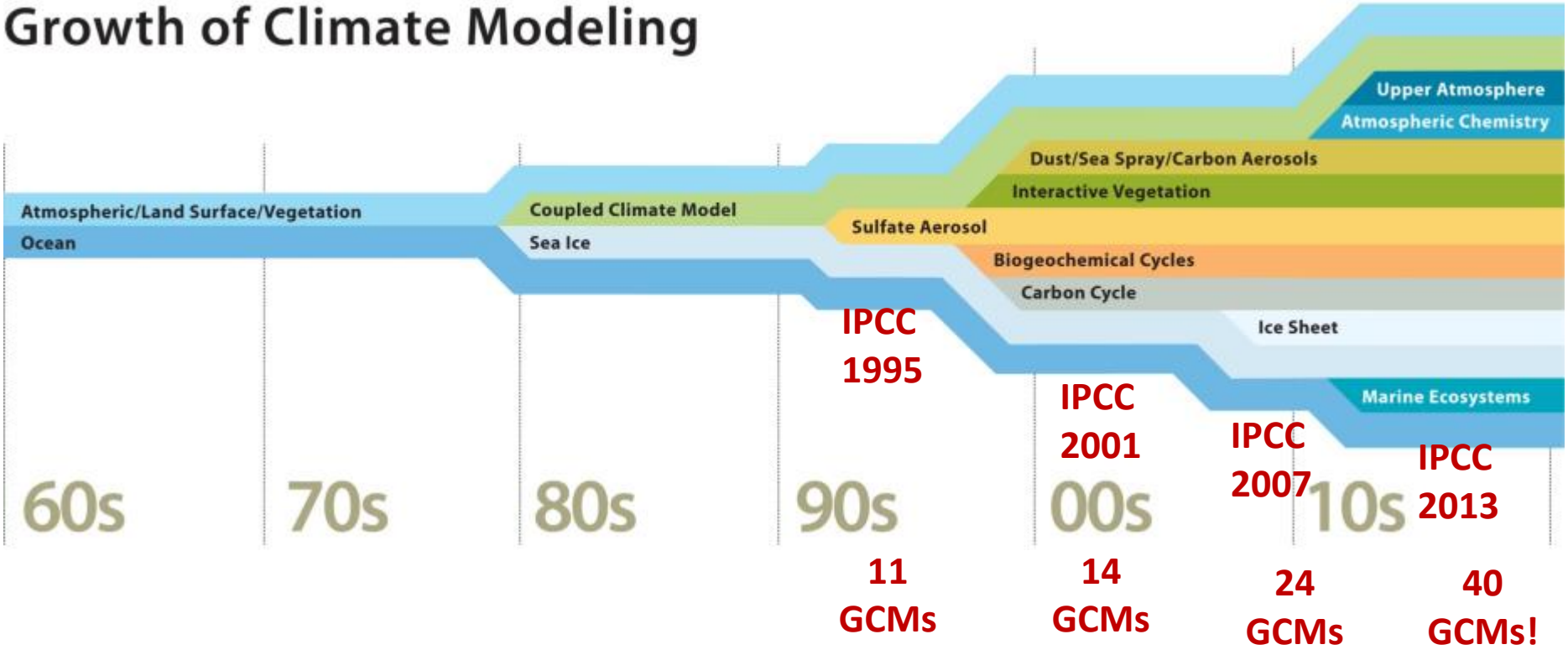
Irreversible

Unequivocal warming



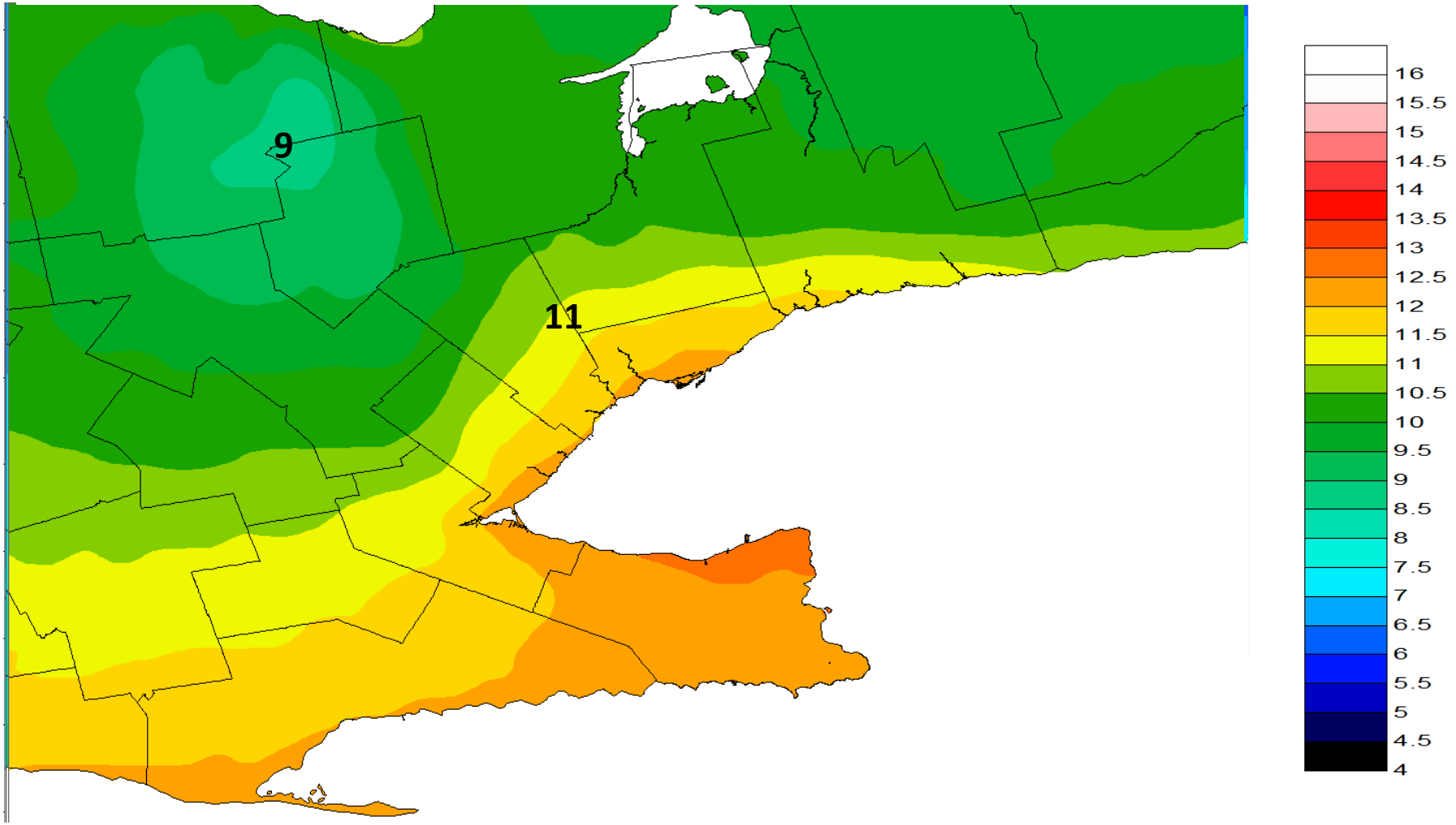
Scientists tend to be cautious in making statements – need evidence

Many More Climate Change Models Today … Increasingly sophisticated



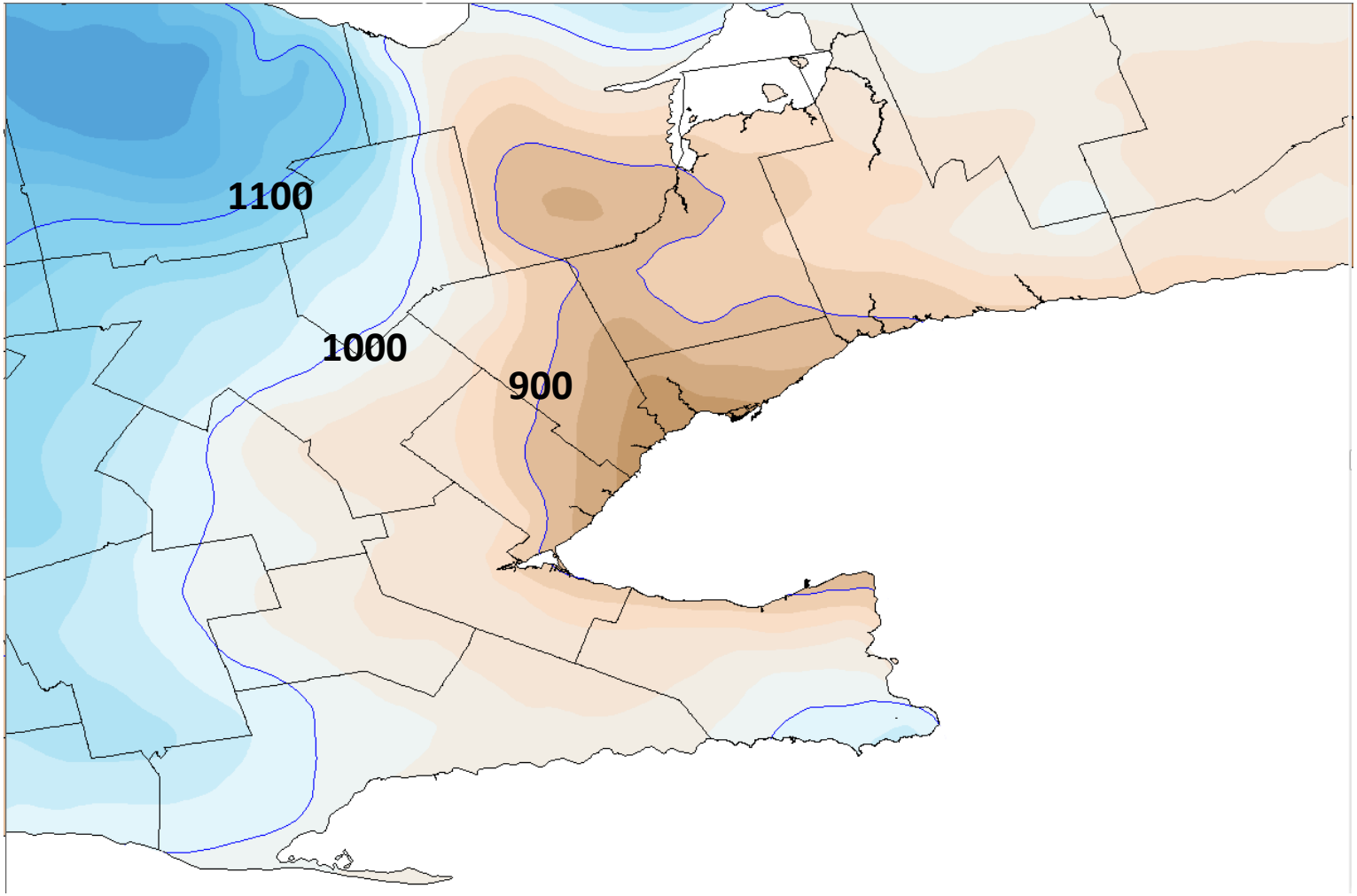
Mean Annual Temperature Trends: Ongoing Warming

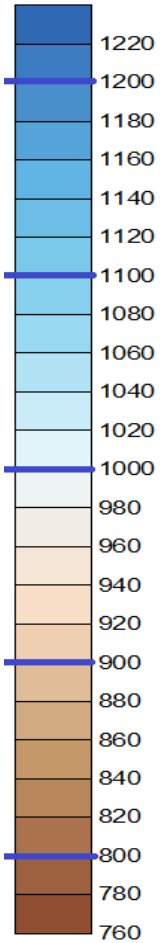
Our Mid-Century Future … 2050s Average Annual Temperature (AR5-RCP8.5)



Mean Annual Precipitation Trends: Becoming Wetter

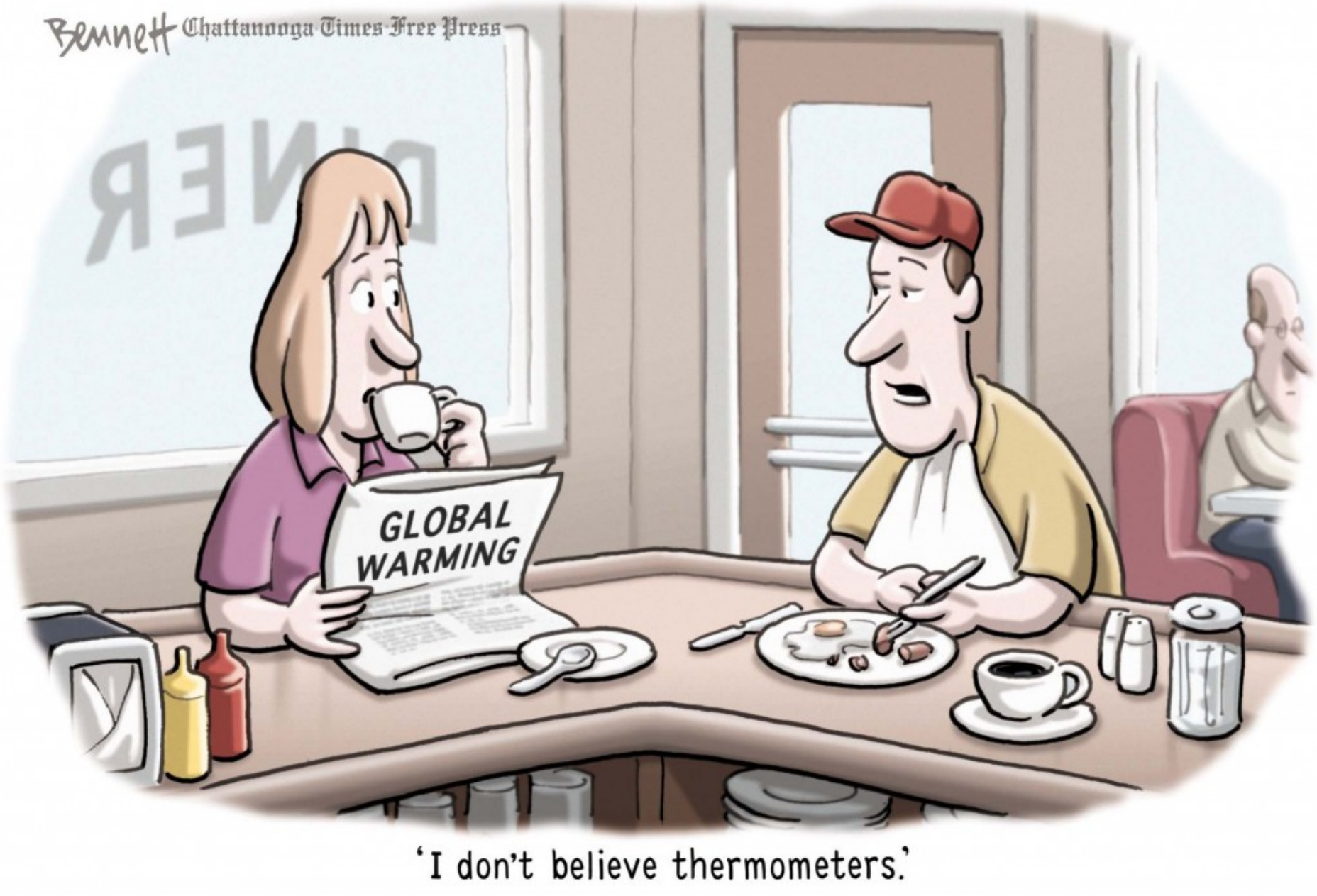
Our Mid-Century Future … 2050s Average Annual Precipitation (AR5-RCP8.5)





(mm)

The Science is Valid… The Evidence grows Stronger



Small changes in climate will matter…

As thresholds are approached

Removed Figure showing analyses of actual insurance losses and number of claims (comprising ~95% of ALL insurance claims filed) vs peak wind speeds and threshold since results still under publication.

Results from analyses of insurance claims and wind gust extreme data indicate that insurance claims for this southern Ontariomunicipality increase >~500% for a 15% increase in wind speeds above threshold of ~90kph.

For further details, contact Risk Sciences International

Wind force increases generally with wind speed squared

Critical Freezing Rain Thresholds for Above Ground Power Line Failures – Eastern North America

Failures under Extreme Ice Storms - *freezing rain (mm)*

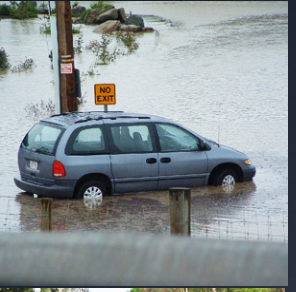
Communication towers

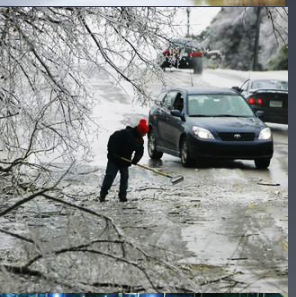
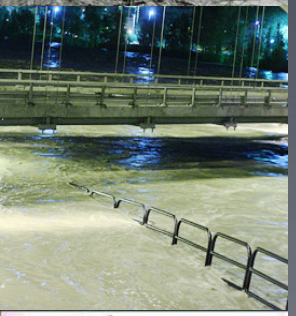
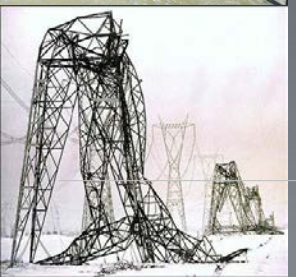
Transmission line failures

Distribution line failures – ice loads

Distribution Line Outages – <u>tree breakage</u>

Slippery roads



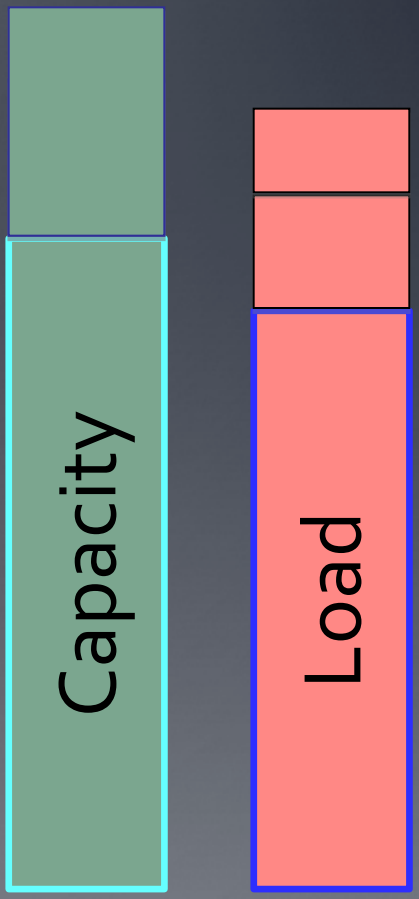




How do Small Changes Lead to Catastrophic Failure?????

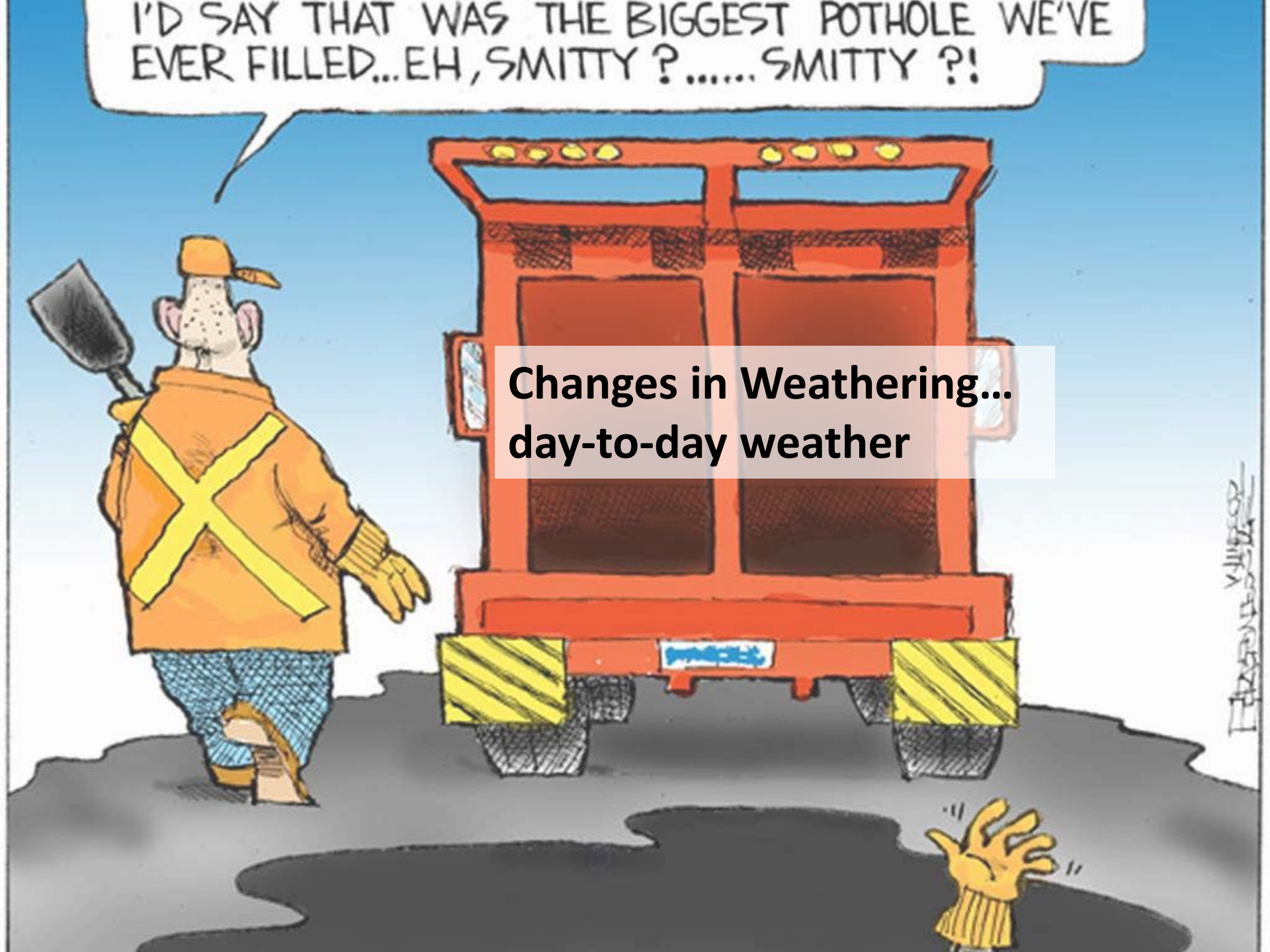
Failure

- Design Capacity
- Safety Factor
- Impact of age on structure
- Impact of unforeseen weathering

- Design Load
- Change of use over time
  - For example – population growth
- Severe climate event



(Courtesy Engineers Canada; Nodelcorp)


I'D SAY THAT WAS THE BIGGEST POTHOLE WE'VE EVER FILLED...EH, SMITTY?..... SMITTY?!
Changes in Weathering…
day-to-day weather

Climate Information & Infrastructure Performance

Structures	Ice & Snow Loads	Extreme Rain (Intensity, Duration, Freq)	Extreme Winds
Roads, Bridges	Road safety, Flooding risks, Operations. Deterioration	FAILURE RISKS – drainage & erosion	Failure risks for signs, some bridge components
Electrical power distribution structures	FAILURE RISKS	Underground, Vaults, Towers if widespread flooding	FAILURE RISKS
Buildings (including airports)	FAILURE RISKS	Flooding; failure risk	FAILURES

Risk of failure

Risks to infrastructure services

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The changing climate and Uncertainties

- Most Confidence
- Least / Less Confident

Warmer winters

More heat waves

More winter precipitation

Longer growing season (frost-free)

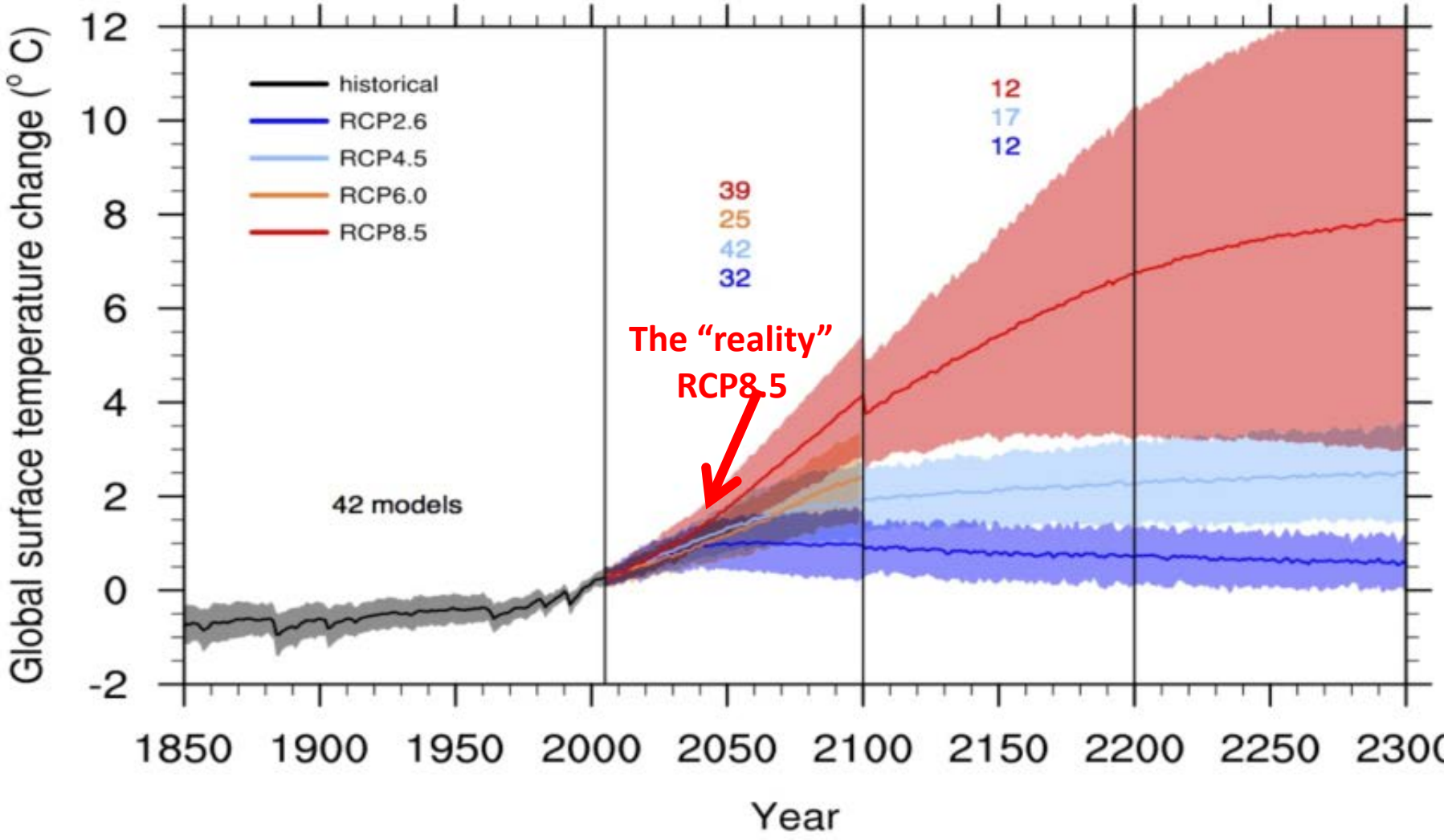
More intense rainfalls

More severe ice storms

Increase in wind extremes

Recommendation: Use multiple climate change models

Global and Local Temperature Changes will be very sensitive to Ongoing and Future Accumulated GHGs



Recommendation: Use multiple climate change models & realistic GHG assumptions

Latest Climate Change Projections for Toronto area Precipitation (RCP8.5 emissions, ensemble) … Wetter

- Figure removed
- % **Change/increases** in Toronto area precipitation (mean, extremes) relative to 1981-2010 conditions using the latest IPCC AR5 projections (40 climate models)
- Projections for 2020s, 2050s, 2080s
- For more details, see Risk Sciences International

Mean Annual Precipitation Change

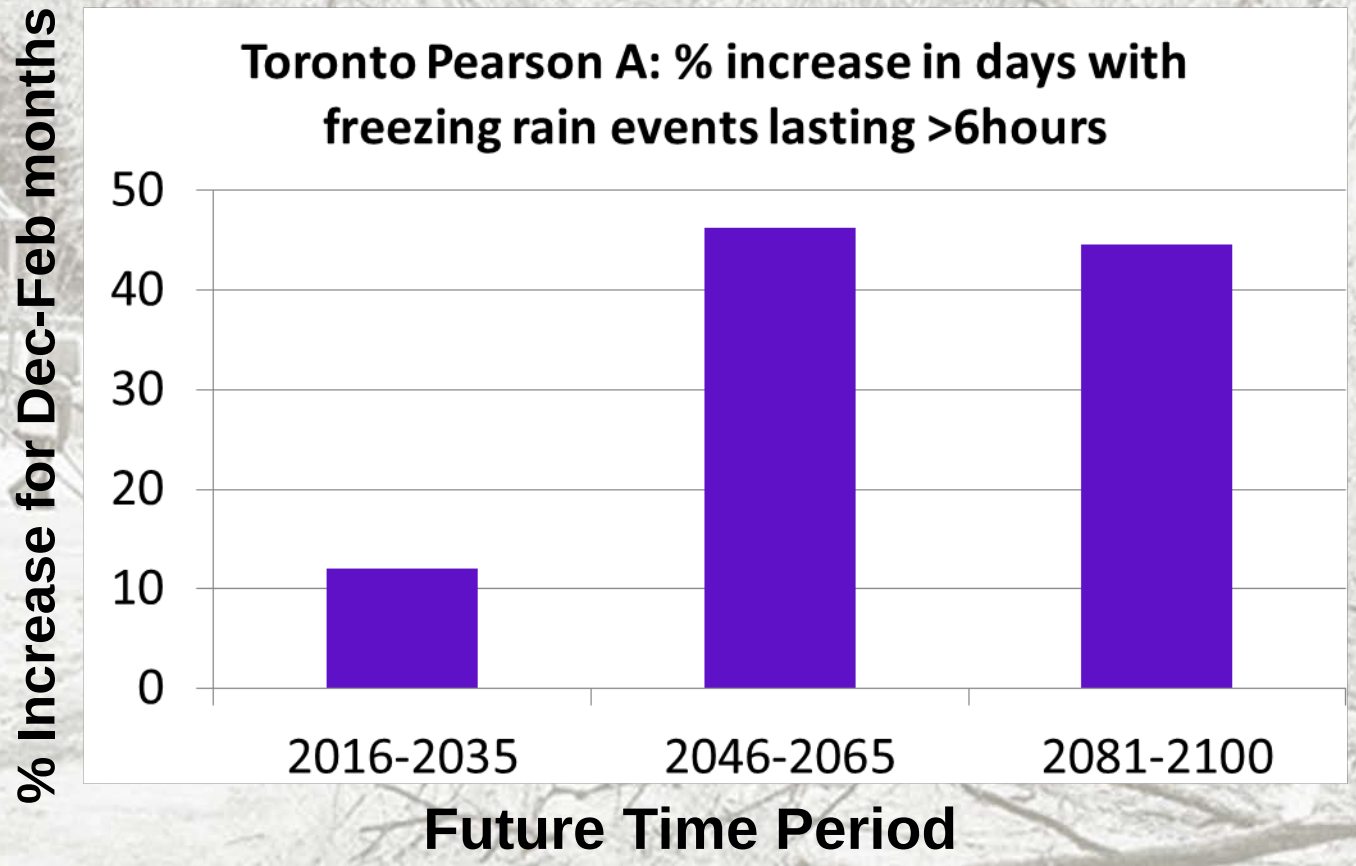
One Day Max Precipitation Change

Five Day Max Precipitation Change

Daily Precipitation Intensity Index

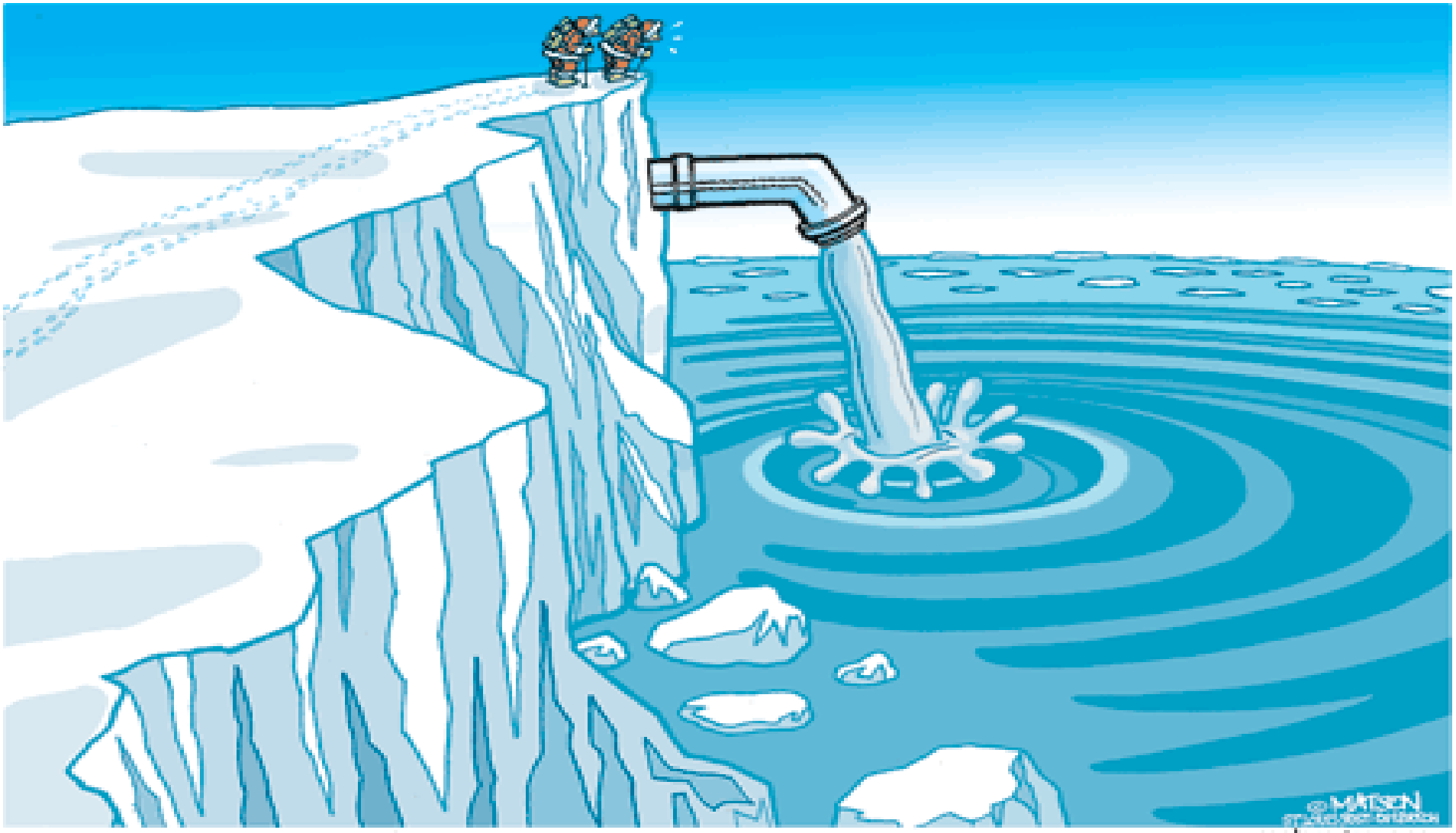
Important: Always use multiple climate change models

The Mix of Precipitation will also change…
Probable increases in longer lasting ice storms



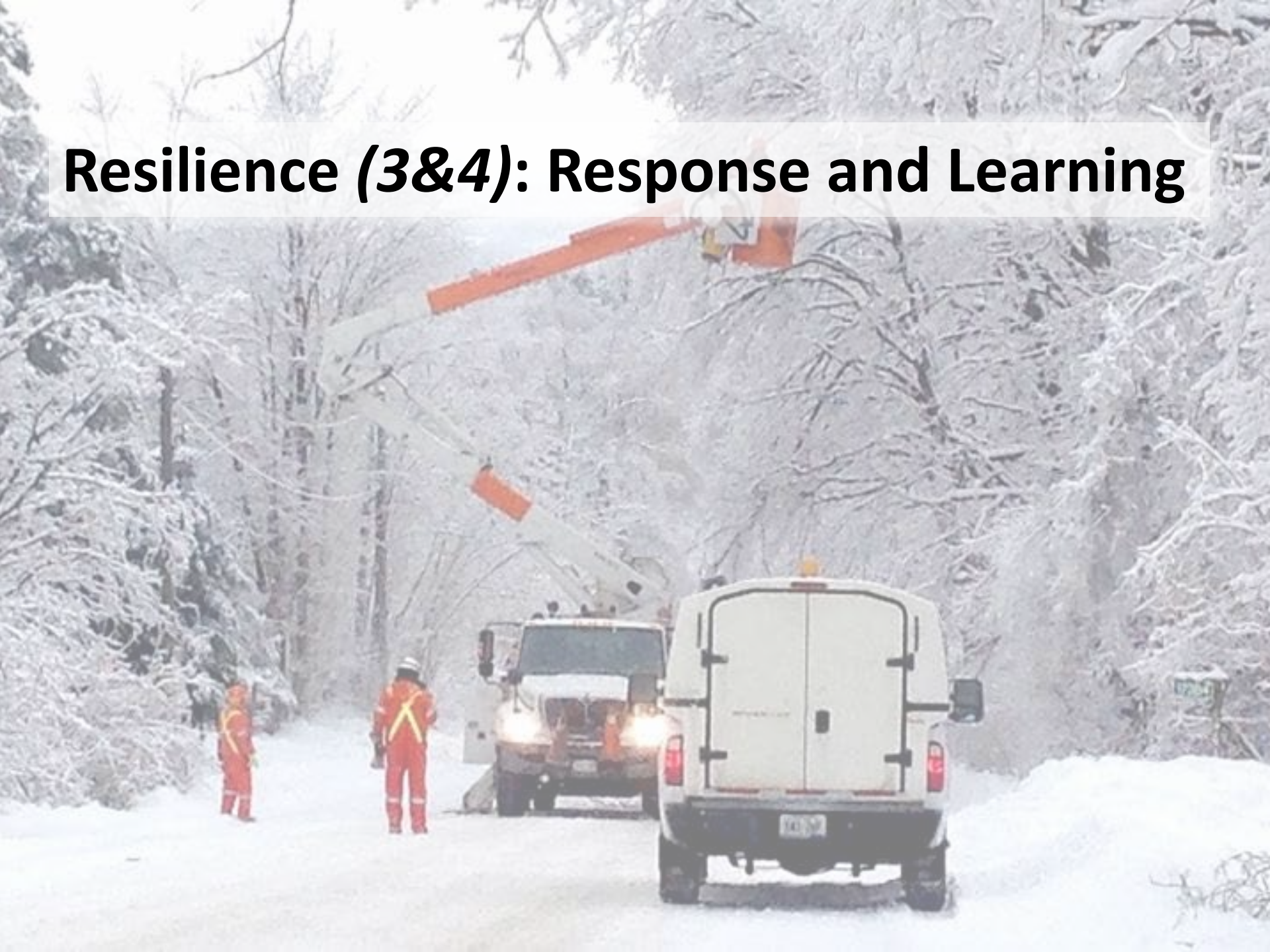
From: Cheng et al, 2007 & 2011

Climate Change is here to stay…



"HOW ON EARTH DO WE TURN IT OFF?"

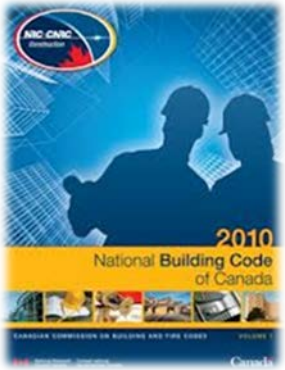
Resilience *(3&4)*: Response and Learning



Range of adaptation actions: From “no/low regrets” for current climate to incorporation of future climate

“Low hanging fruit”… “higher up the tree”…

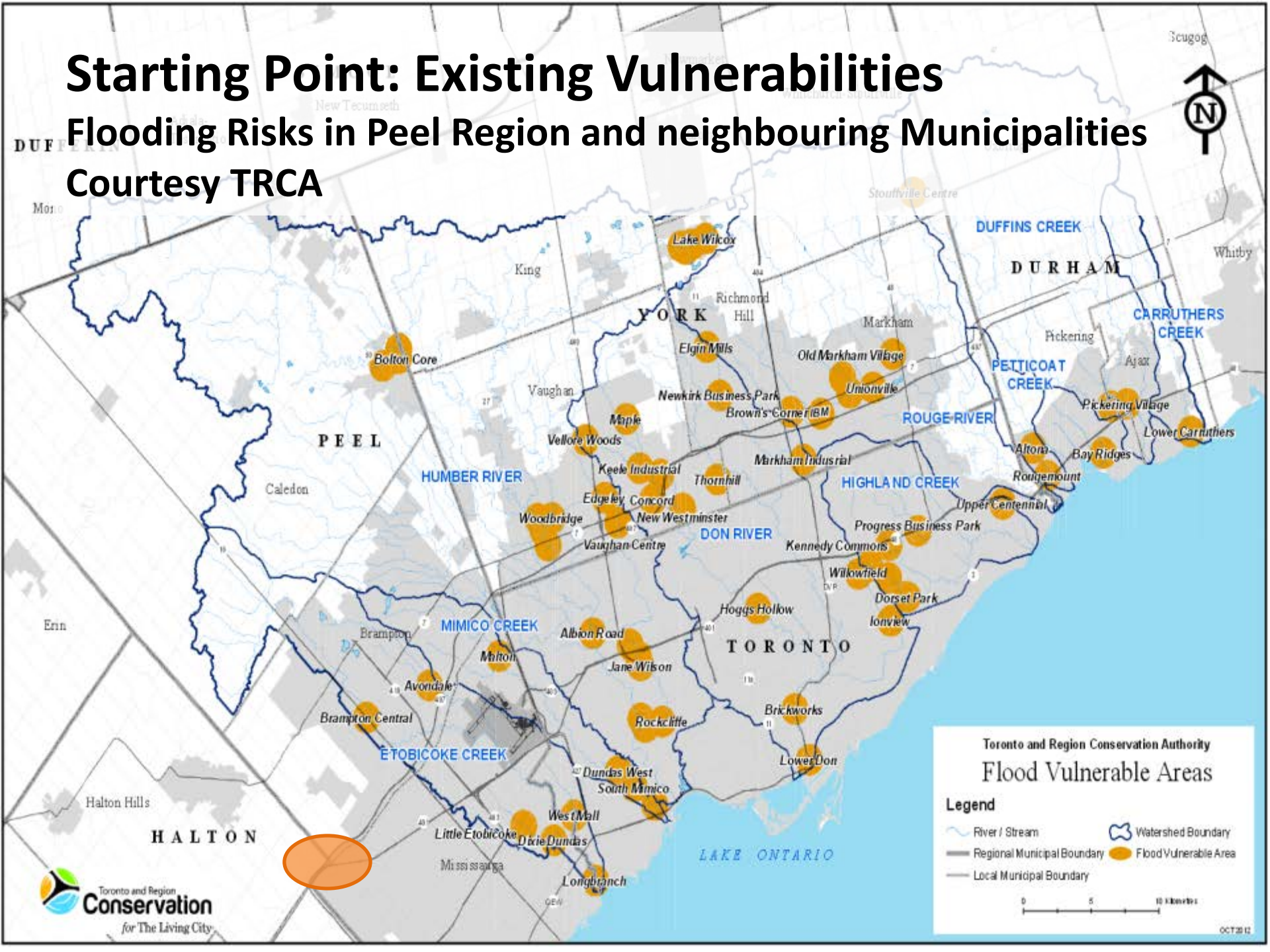
- **Updated climate data and improvements for *codes & standards*;**
- ***New* standards for climate change adaptation (e.g. new Northern CSA standards, IDF standard)**
- **PIEVC vulnerability assessments (current + future climate)**
- **Vulnerability/Forensic studies – “at risk” regions & infrastructure, learning from failures**
- **Added safety factors, longer return periods, more redundancy**
- **Maintenance, maintenance – ↑ weathering;**
- **Consider “win-win” solutions (e.g. energy efficiency)**



Starting Point: Existing Vulnerabilities

Flooding Risks in Peel Region and neighbouring Municipalities

Courtesy TRCA



Adaptation Choices for Climate & Weather Resilience

Do nothing

New approaches
(e.g. district cooling)

Current Climate

Strengthen existing & new
(e.g. safety factors; return periods; retrofits)

Manage extremes
(e.g. disaster planning; PIEVC risk assessment)

Monitor; Improve science

With Climate Change

DESIGN (new/existing)

OPERATIONS (existing/new)

Add Resilience; Safety factor; Return period; Stage; Flexible

Include future climate (PIEVC); codes/standards

Improve (*Repair & retrofit; maintenance)*

Financial *(insurance; Mun. reserves)*

Mainstreaming Climate Change into Decisions

Moving beyond NATO ("No Action Talk Only") to Action

- ***Meaningful*** **climate information**
- **"Due diligence" – best practices, not perfect**
- **Multi-disciplinary**
- **Support from regulations, codes, standards, legal community…**

Mainstreaming climate change science

Traditional approach

Climate model-led

What if climate extremes change according to scenarios x, y, z?

Climate Change Models

↓

Sensitivities? Impacts?

↓

Is Adaptation needed?

No → **No new measures.**

Yes → **New measures needed.**

Risk management approach

Risk-Thresholds-led

What can infrastructure cope with? "Thresholds", priorities for action?

Climate sensitivities? Vulnerabilities?

↓

Failure thresholds? Lifespan?

↓

Risk? Various adaptation options?

↓

Are new adaptation measures needed by ~ 20xx?

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CLIMATE RESILIENT SYSTEMS TRAINING

Flexible adaptation options working with *Infrastructure Lifecycle Timeframes*

Structures	Expected Lifecycle
Houses/Buildings	Retrofit/alterations 15-20 yrs Demolition 50-100 yrs
Sewer	Major upgrade 50 yr
Dams/Water Supply	Refurbishment 20-30 yrs Reconstruction 50 yrs
Bridges	Maintenance annually Resurface concrete 20-25 yrs Reconstruction 50-100 yrs

Improved Asset management

More Intense Rainfall & Precipitation Events

- Intense thunderstorms, tropical moisture, major weather systems, snowmelt + rainfall…
- **CC Projection:** ~40% increase in days with rainfall > 25mm
- **Implications:** Increased failures – culverts, rail, bridges, flooding, reservoirs, water treatment, building…
- Riverine and urban flooding risks will differ
- **Responses:** Good rainfall data, updated climate design values, codes & standards, lifecycle replacement to higher standards, backflow valves, berms…
- **But, challenges to incorporating climate change extremes into designs, codes, standards**

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Adaptation Examples: Extreme Rainfall

Municipalities, Conservation Authorities:

- More rainfall data, better rainfall design values
- Low impact development:
  - Rain gardens
  - Roof collection
- Stormwater infrastructure upgrades
- Back-water valves & sump pumps; Downspout disconnects

Listen to Berta, Ryan, Fabio

Municipalities, Michigan:

- Home owner water credit for increasing infiltration, rain water collection
- Tax credit for planting approved trees

Staged Adaptation and Flood Protection Landforms:

Berms and Toronto's Don River (Corktown Common) Park

"the meadows that will save Bay Street"…

New park doubles as flood protection for downtown financial district

- Brownfield site on Western bank of lower Don River
- $135M - doubles as a 8.5-metre-high berm designed to protect the eastern downtown from a major flood (~500 year r.p., approx. H Hazel)
- Passed the July 8, 2013 test for downtown protection… elsewhere?
- Additional protection can be added – height, land for biodiversity
- Adaptation response to a largely impervious watershed

Winter Storms, Extreme Winds: Risk Implications

- **Projections:** Shorter snow season, nil snow periods…BUT
- POTENTIAL for more **intense** snow storms (Gulf of Mexico moisture, bigger storms)
- Lake effect snow will continue to increase… for some time
- Potential for ~ 40% increase in days with winds > 90 kph

- **Implications:** Transportation operations, all infrastructure (winds), salt use, building ice damming & roof damage, power and communications outages
- Critical infrastructure and Public safety concerns
- **Responses:** Enhanced emergency planning, codes & standards, tree trimming, enhanced maintenance, added safety factors

Adaptation Examples: Winter storms

CSA S502 Changing Snow Load standard for North: Under public review

City of Ottawa, other Municipalities: Winter road and sidewalk maintenance, By-Law

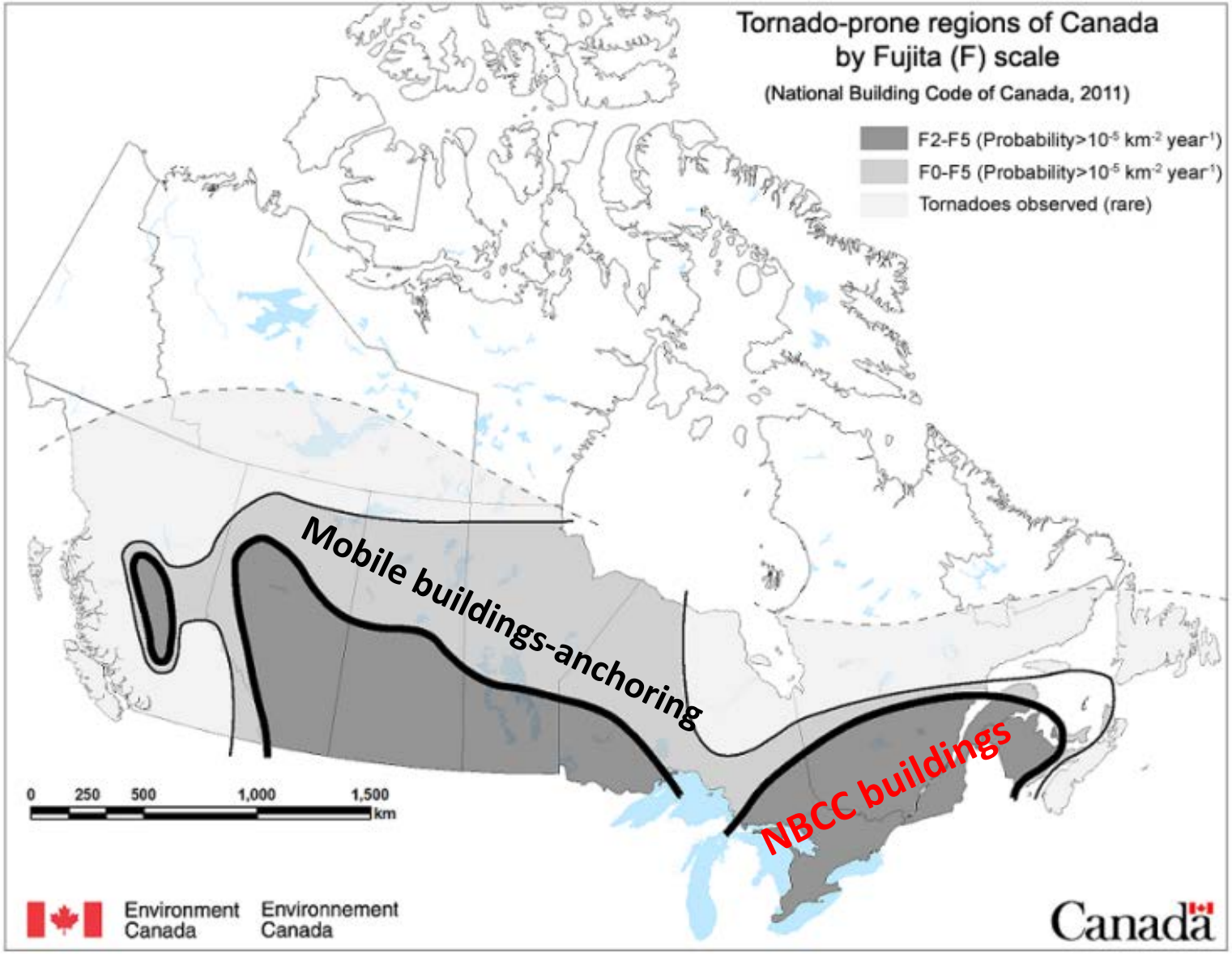
- New equipment for ice breakage
- New maintenance practices – Mixed precipitation, flooding and flash freeze - all in one day; Road Weather Information Systems – equipment, prediction sensitive

Toronto Hydro & Ontario Power Authority PIEVC risk assessments

- Ice storm ‘98 recommendations
- Tree trimming

Listen to Ivano

Anchorage and Life-saving Tornado Measures: NBCC & CSA



Increasing Climate Resilience through new and updated Codes and Standards

- Many have outdated climate values (*Highway & Bridge Code*)
- National Building Code of Canada 2015: Option to include CC adaptation, given scientific evidence
- New CSA standards (IDFs) and New Northern CSA standards
- Changes to & new Codes/Standards: Require "**evidence**"
- Need forensic analyses – learn from failures, vulnerabilities

Changing Climate and Uncertainties

- **Climate change: Imperfect data and perpetual uncertainty… now adding another layer of uncertainty**
- **Uncertainty is not new nor a good reason for inaction**
- **Opportunity costs associated with inaction**

- **Can't fix, harden, replace, or climate-proof everything – have to prioritize**
- **Must use multiple climate change models**
- **A stitch in time saves four - $1 invested in prevention saves $4 in response… or $15!**

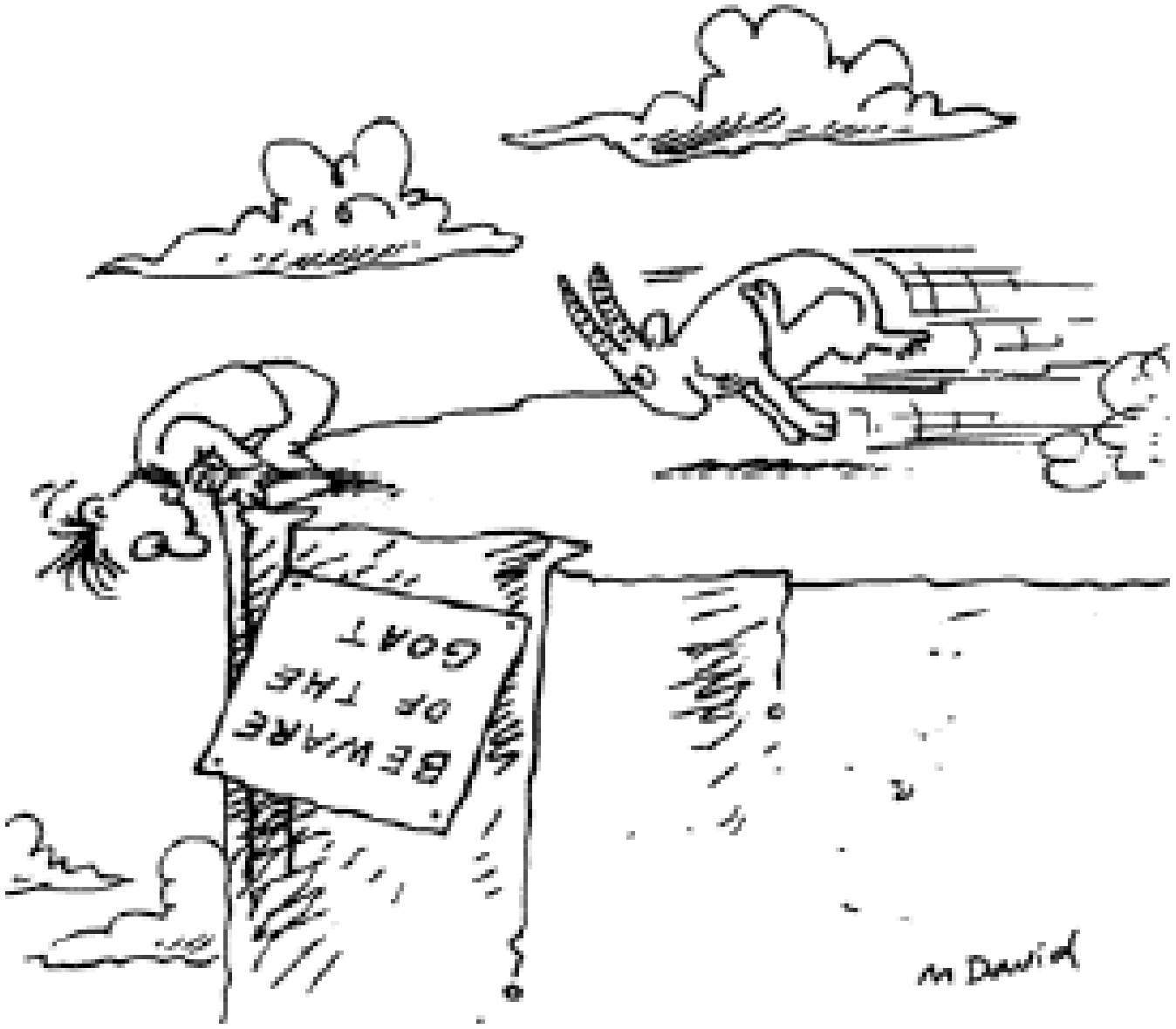
Engineers Canada PIEVC Vulnerability Assessments: Tools, Training and Lessons Learned

25 Canadian & two international risk assessments… Some common issues. For example:

- Combinations & sequences of events can have more impact than discrete events.
- Infrastructure systems are almost always vulnerable to interruptions in power supply

Online Climate Resilience System Training available: http://climateresilientsystems.com/

Climate Change: Risk Management for a Moving Target



Thank You!

For further information, contact:

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