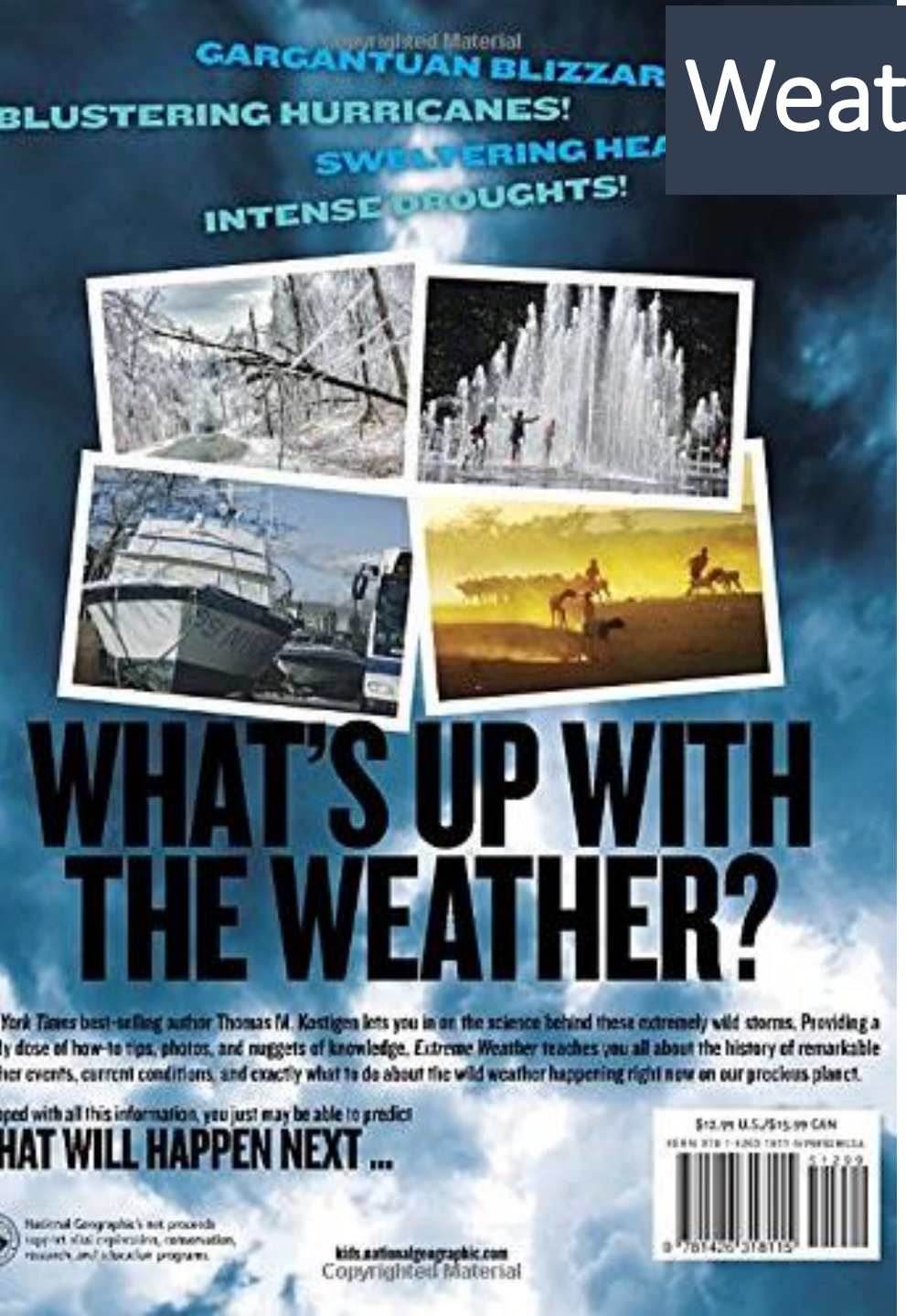
CLIMATE 101: INTRODUCTION to CLIMATE CHANGE DATA and VOCABULARY

Heather Auld, Neil Comer & Norm Shippee
Risk Sciences International

OCC's Climate Data Training Session for Engineers, Planners and Decision-makers



Weather/Climate: Going to Extremes?

Weather/Climate Headlines

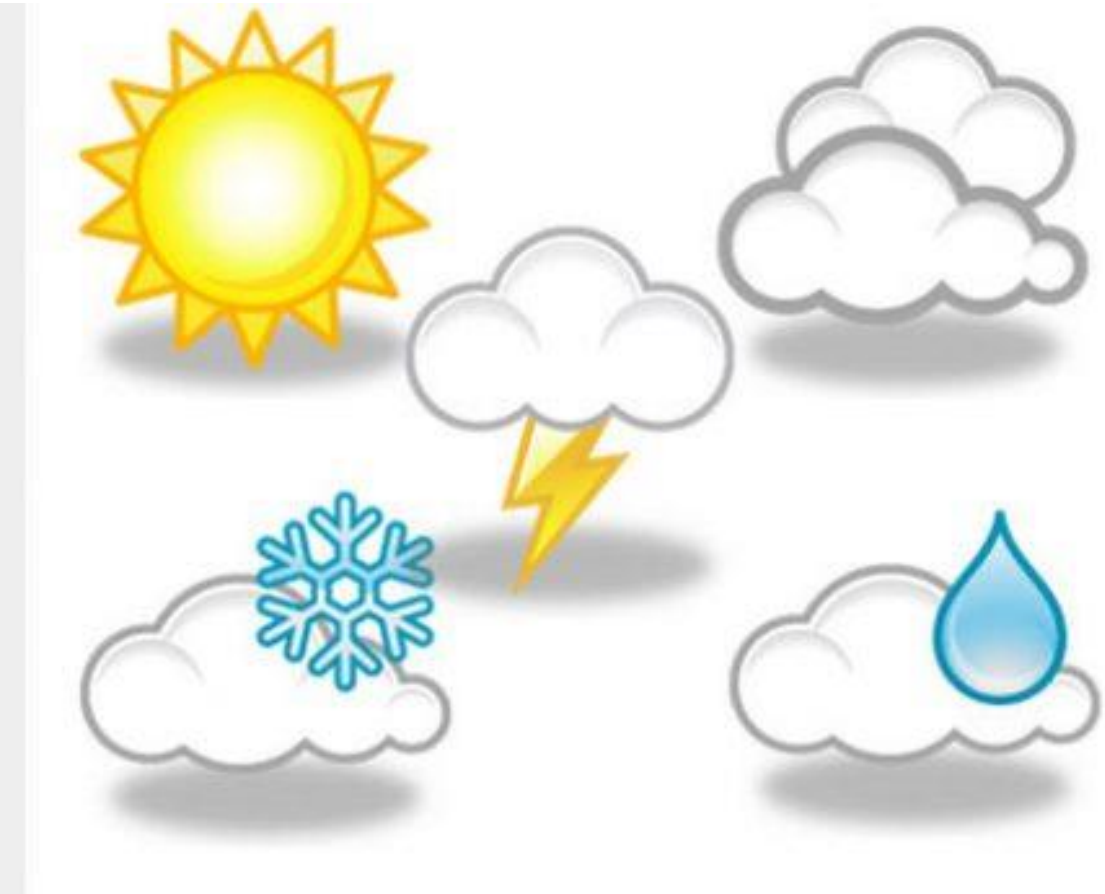
Extreme Weather in Canada Here to Stay: Experts

Environment Canada inspecting damage after storm in central Ontario – Oct, 2016

***IBC commends federal government's focus on infrastructure and flood mitigation in 2016 fall economic statement* – Nov, 2016**

Severe weather, natural disasters cause record year for insurable damage in Canada – Jan, 2017

Weather vs Climate: Is it “news” or is it “history”?



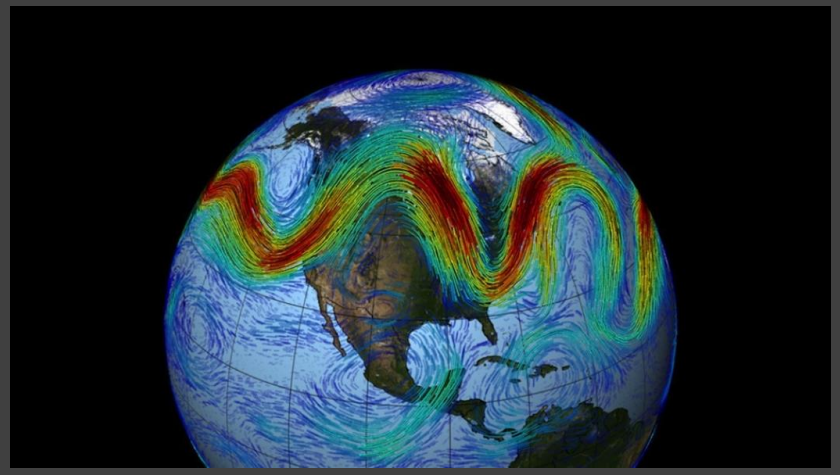
Weather (*what you get*)**:**

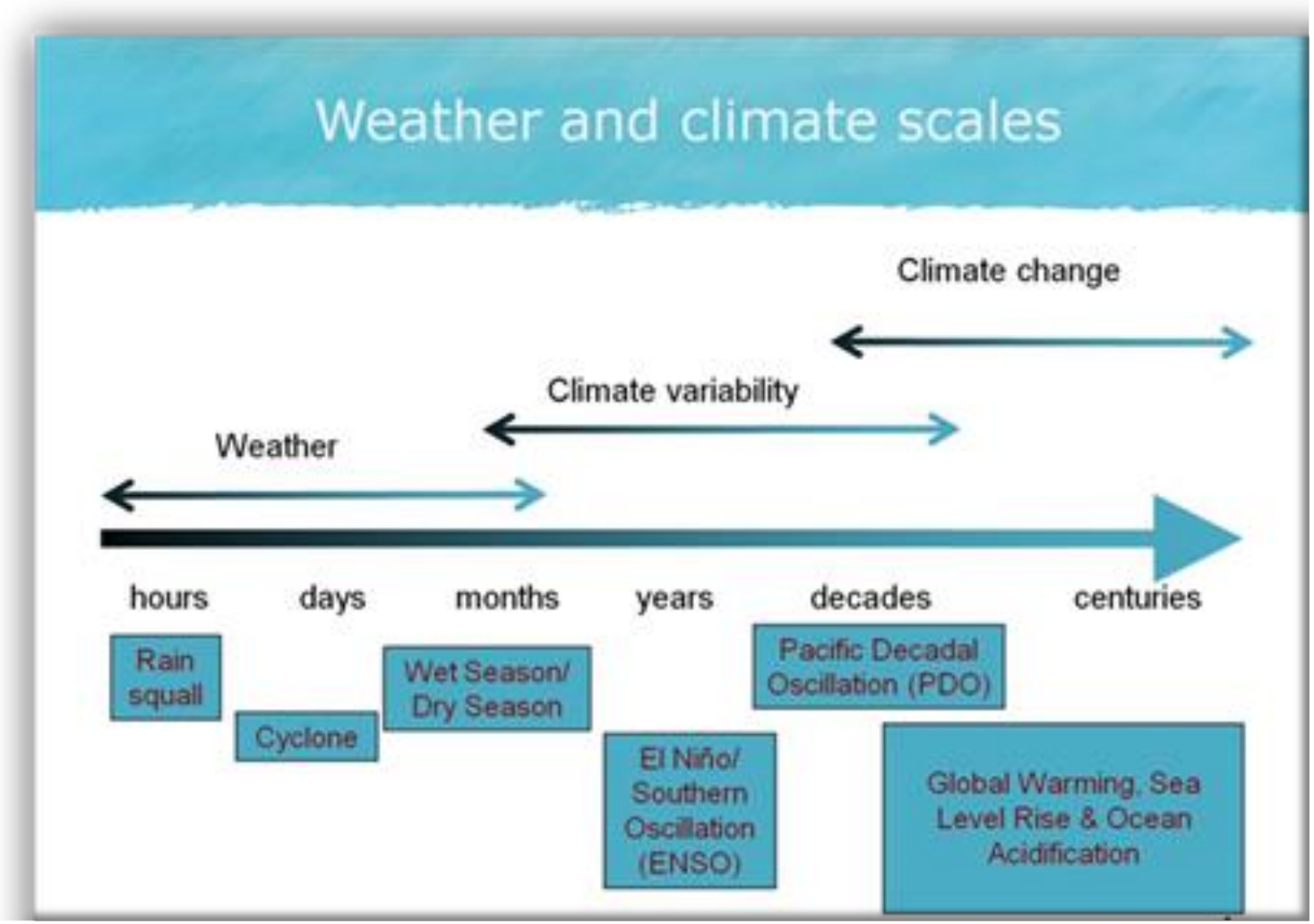
- Conditions today and over the next few days;
- “we *operate* infrastructure day-to-day on the basis of weather”

Climate (*what you typically expect*):

- Weather over time: Extremes, Trends, Changes;
- “we *plan* and *design* for the longer term on the basis of climate” (*spans local to global scales*)

Climate and Weather Linkages: Global Oscillations

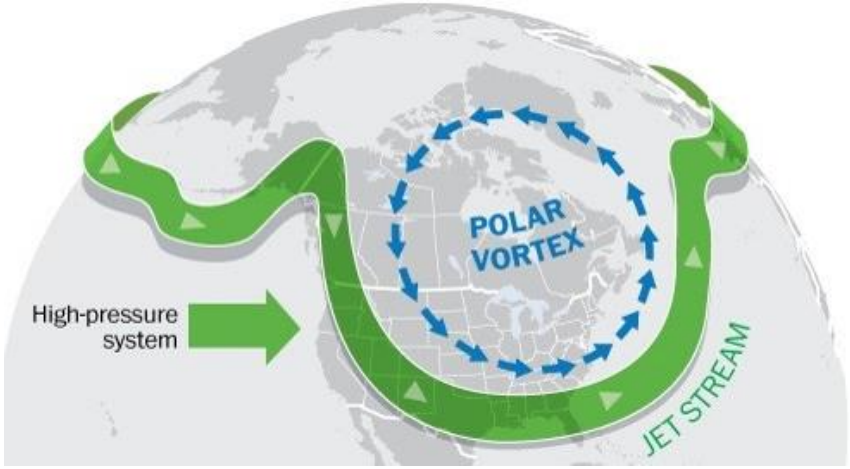




- **Global Oscillations have a large influence on climate & weather – come in varying lengths/frequencies**

- ***But* largely unpredictable, especially when acting together!**
- **Sometimes in phase, sometimes not**

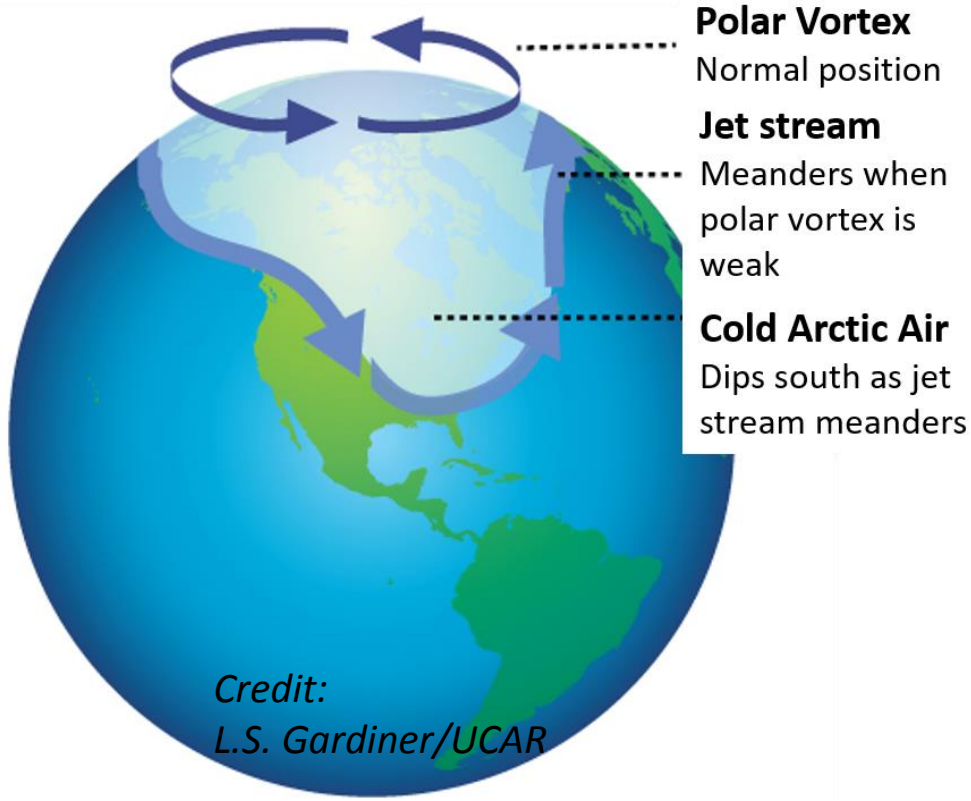
What happened with Winter and Spring, 2013-14: Polar Vortex?

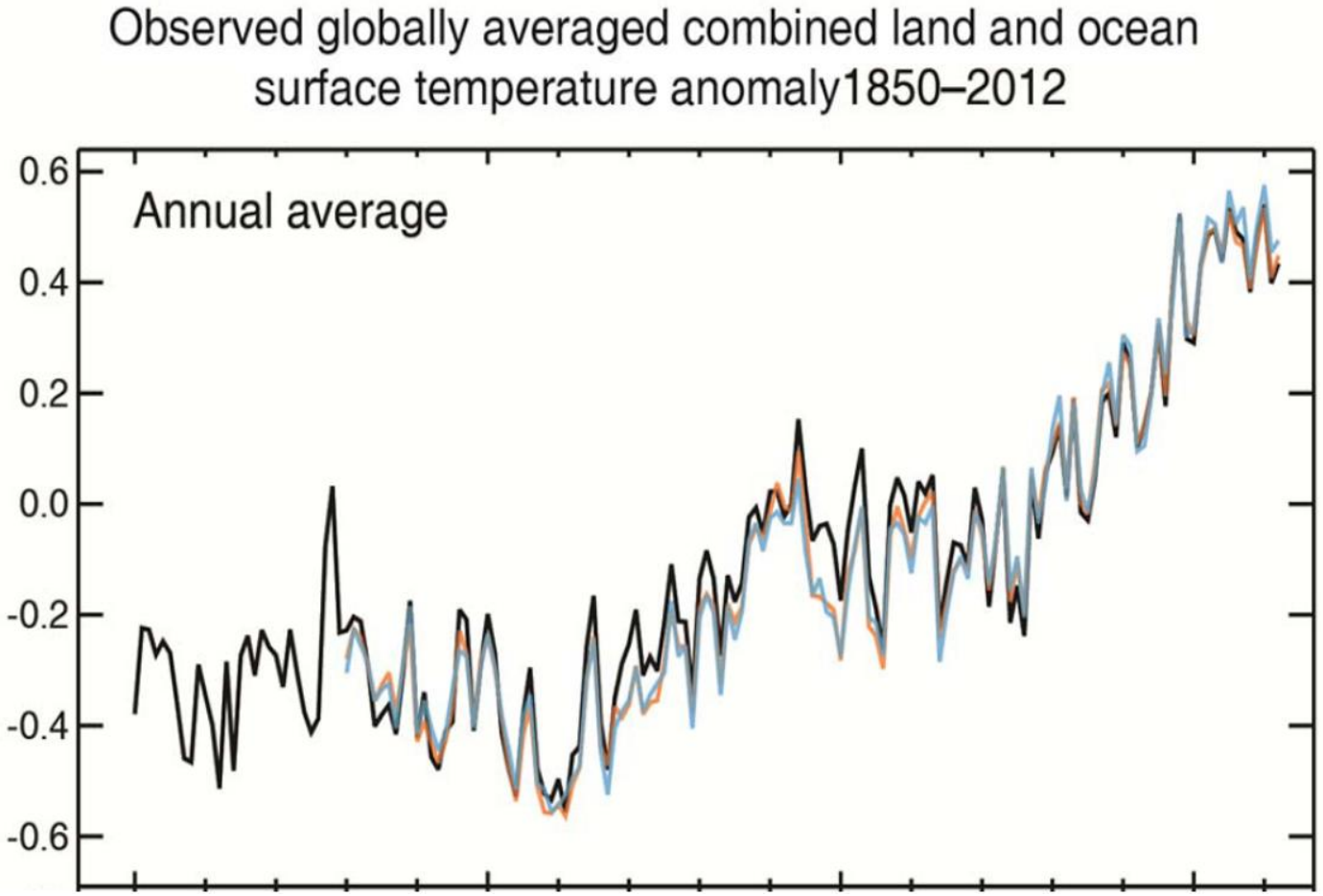


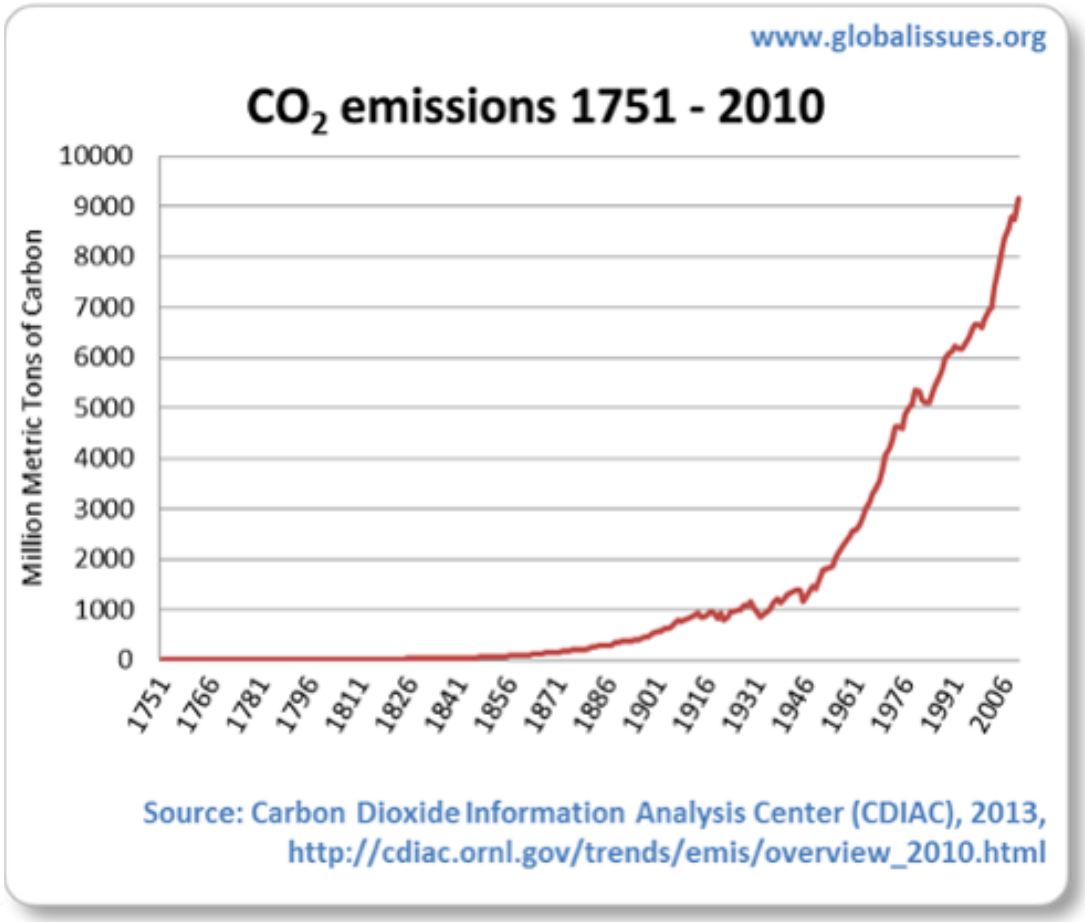
- Cold here, *BUT…*
- **Globally**: 4th warmest January & 8th warmest winter since 1880.

- Polar Vortex "slumped" southward – link to ↓ Arctic ice?

- Climate variability

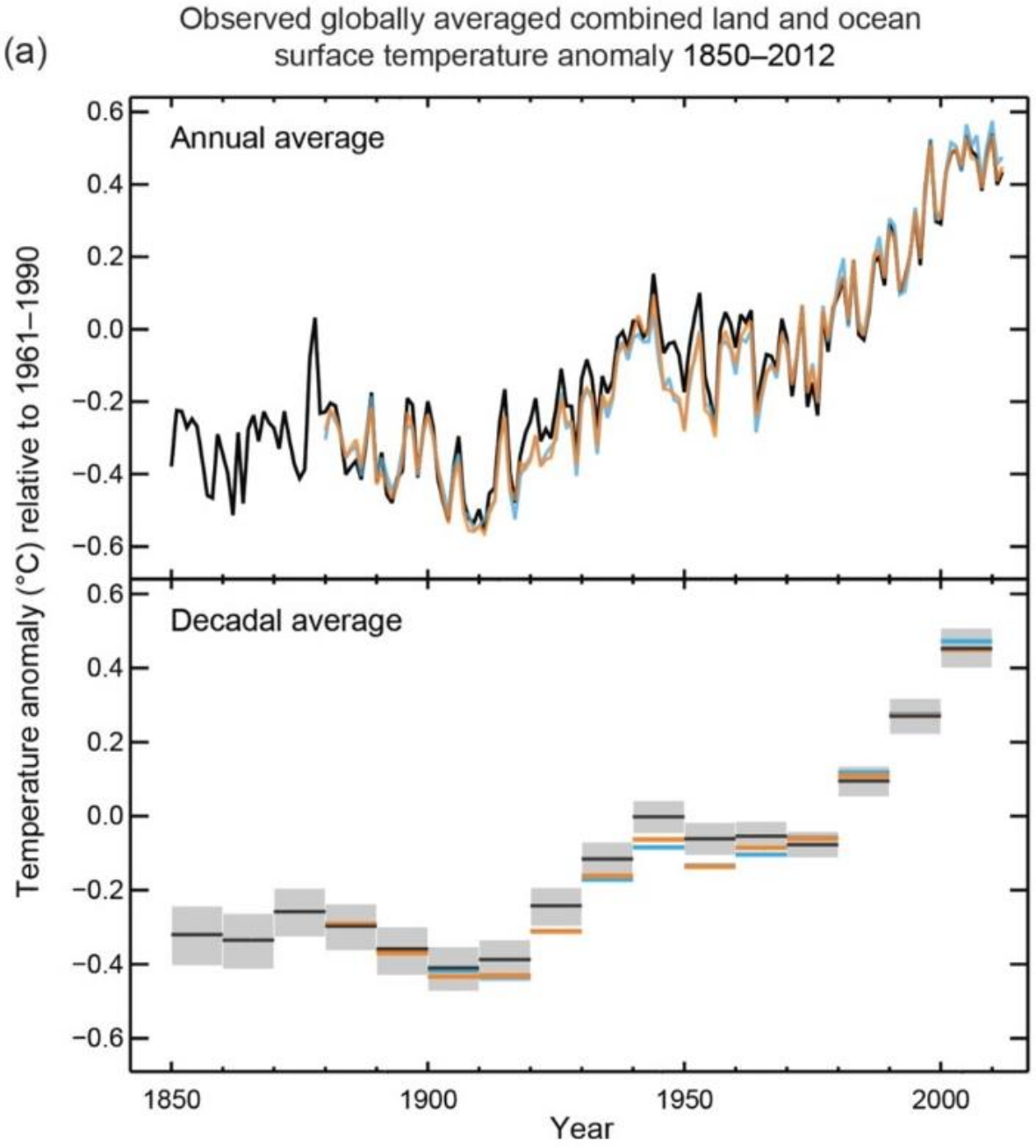


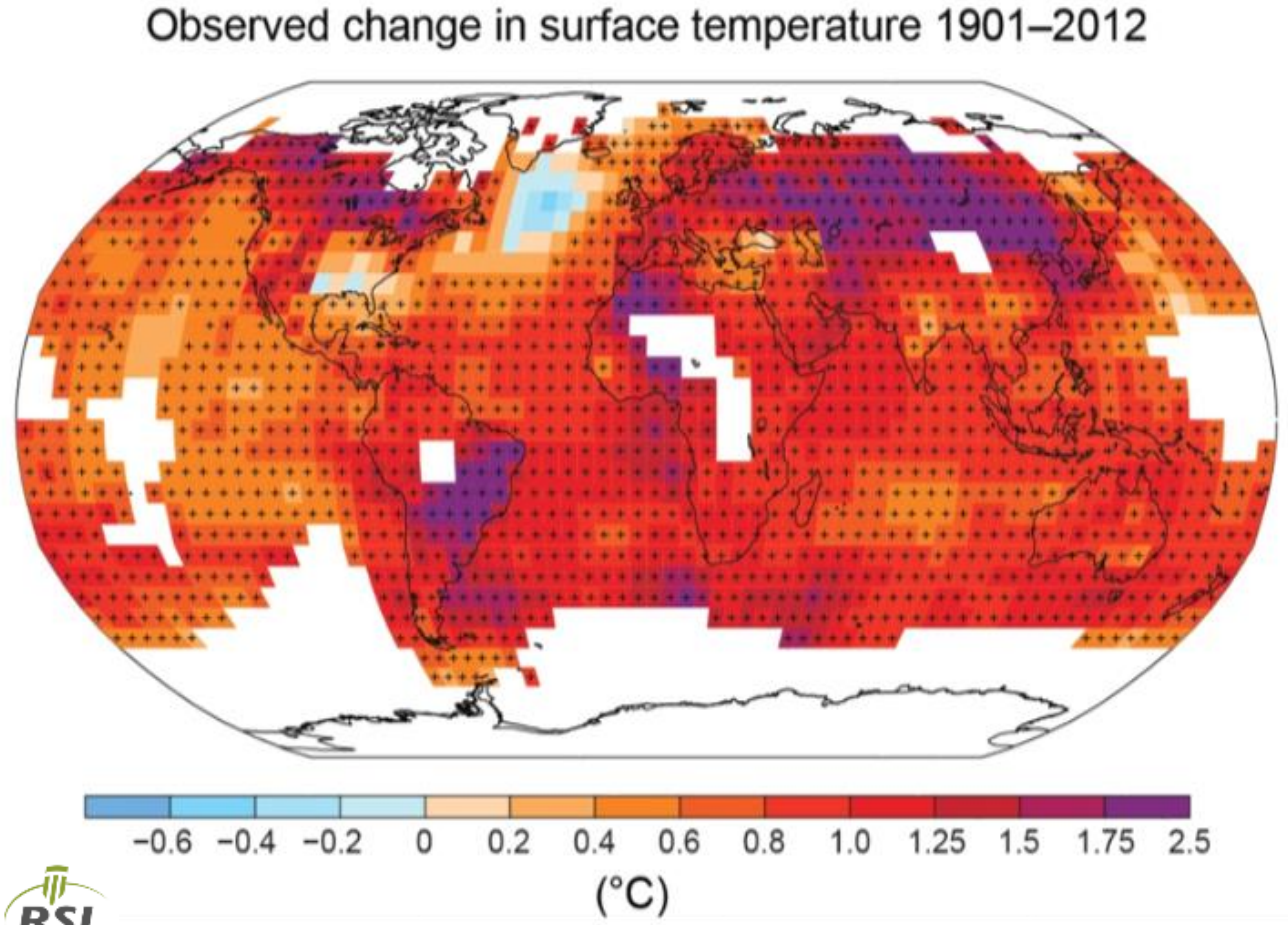


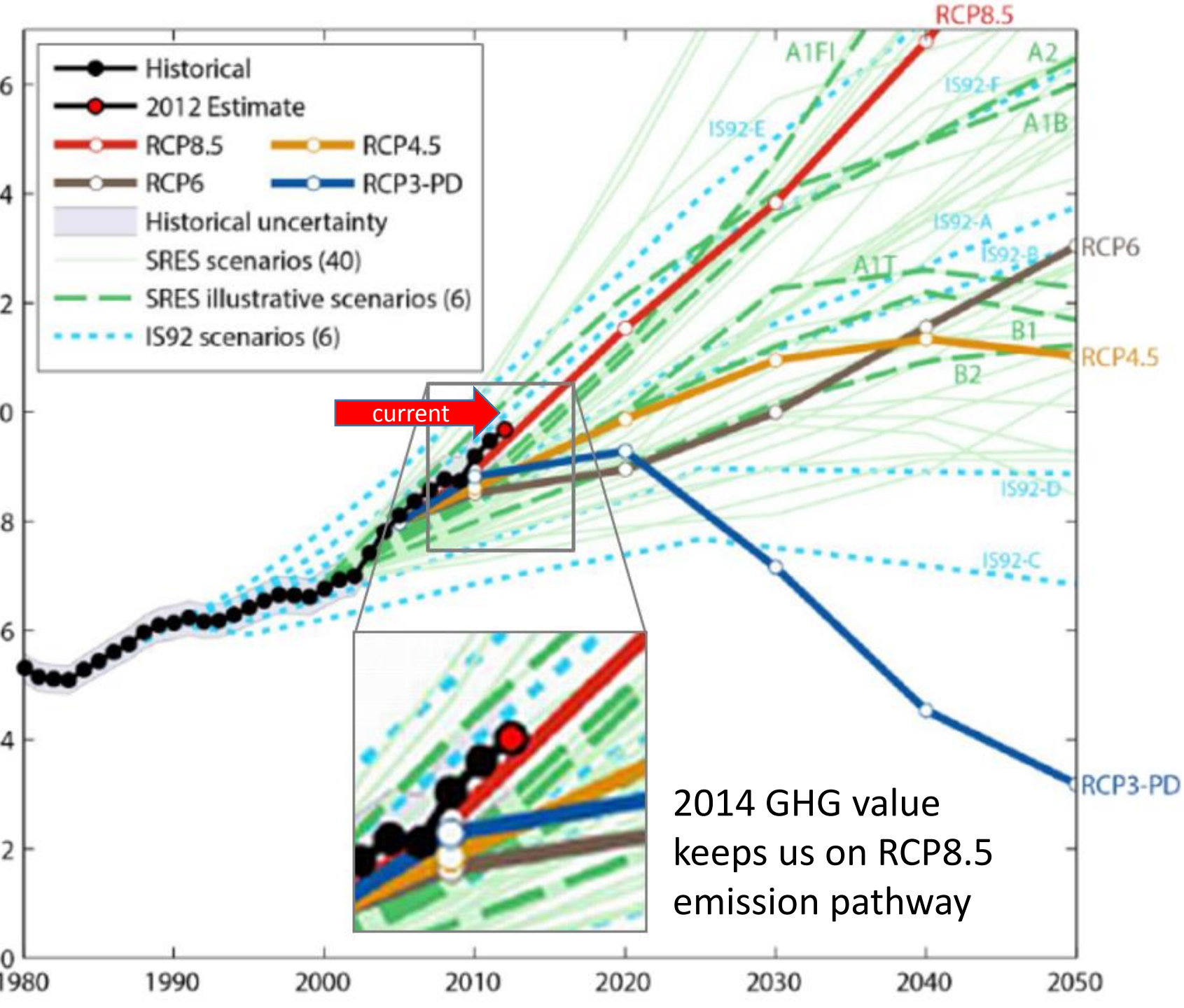


Global Temperatures and GHG emissions linked

The Climate is changing…



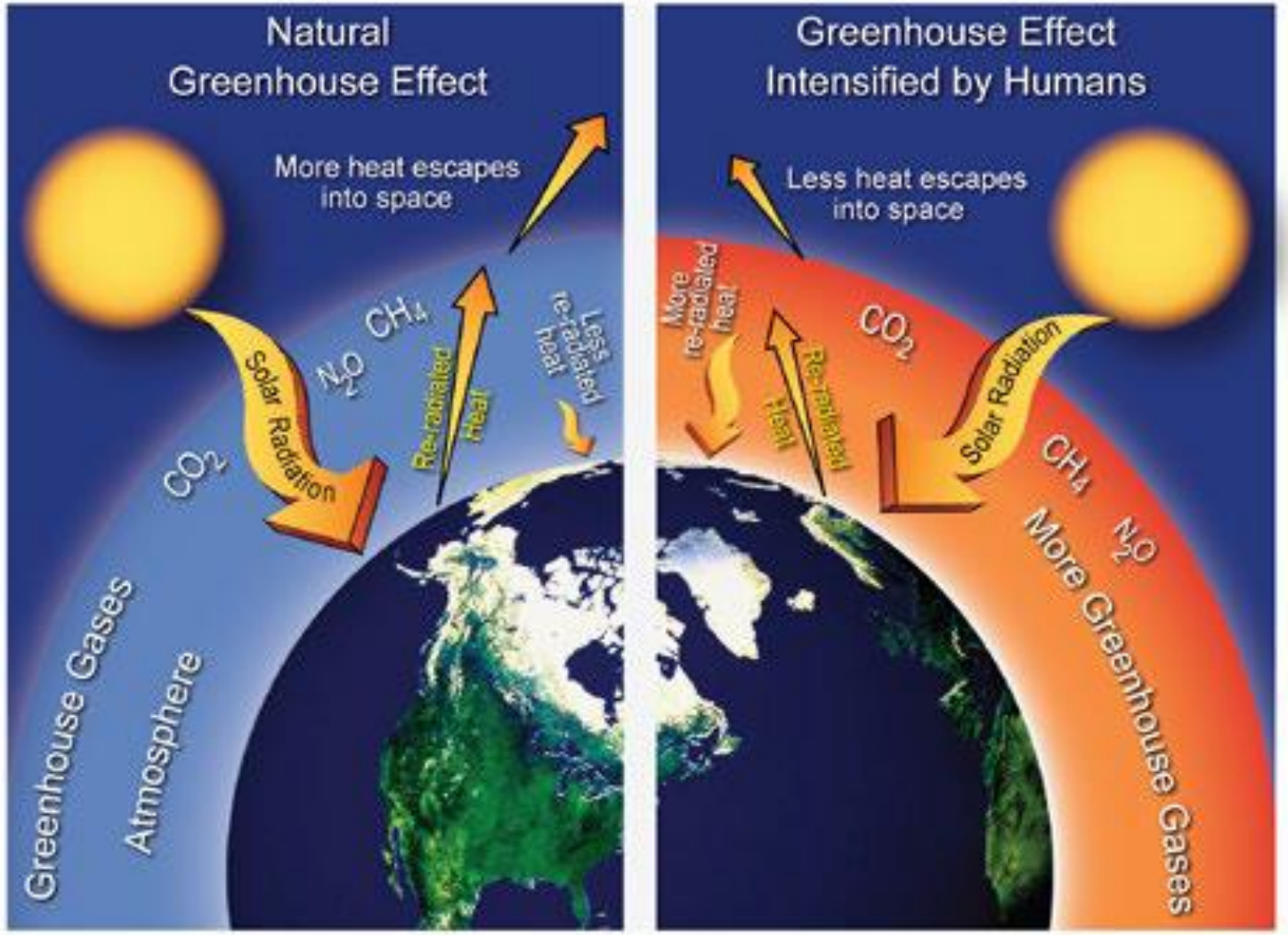




and will continue to change…

Currently on path of highest GHG emissions

Small changes in GHG emissions matter…



- Natural GHG effect – *keeps Earth at an average temperature of 15°C (-18°C without)*
- Delicate balance of GHGs to support life on Earth and our current climate system
- Anthropogenic GHGs changing the Earth's balance **rapidly**

Inter-governmental Panel on Climate Change (IPCC) Reports

95% certainty warming is due to climate change

Unequivocal warming

Irreversible

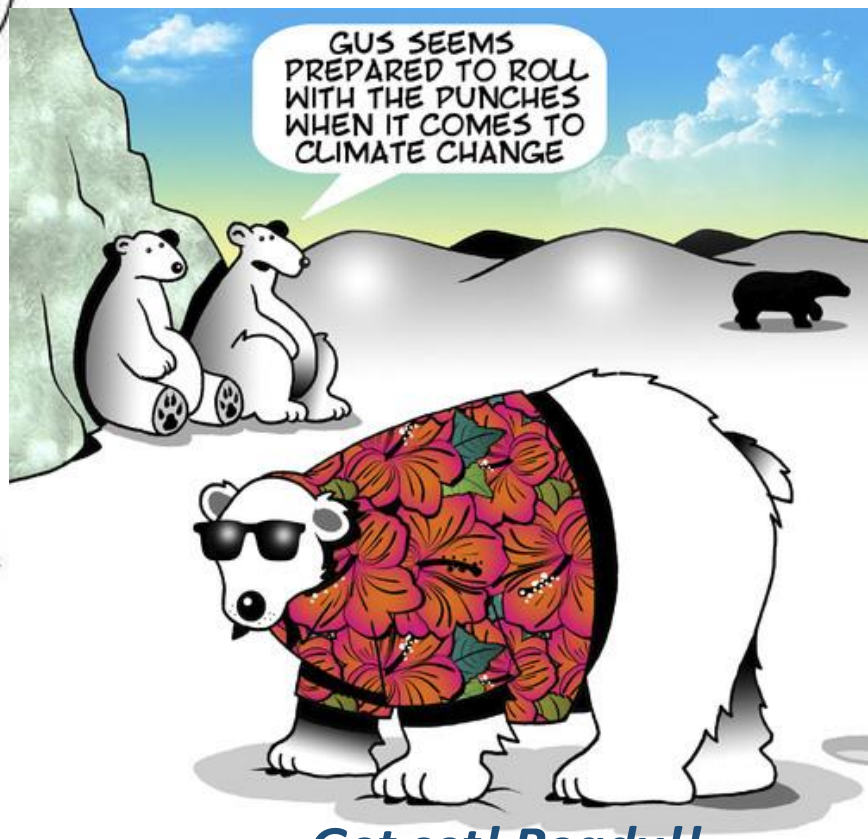
- 2012: IPCC Special Report on Extremes (SREX)
- 2013-14: IPCC 5th Assessment Report – Science, Adaptation, Mitigation

Stronger language than other reports – considering that scientists make 'conservative' statements

Adaptation to Climate Change: Confused, Concerned and/or Ready for Action?

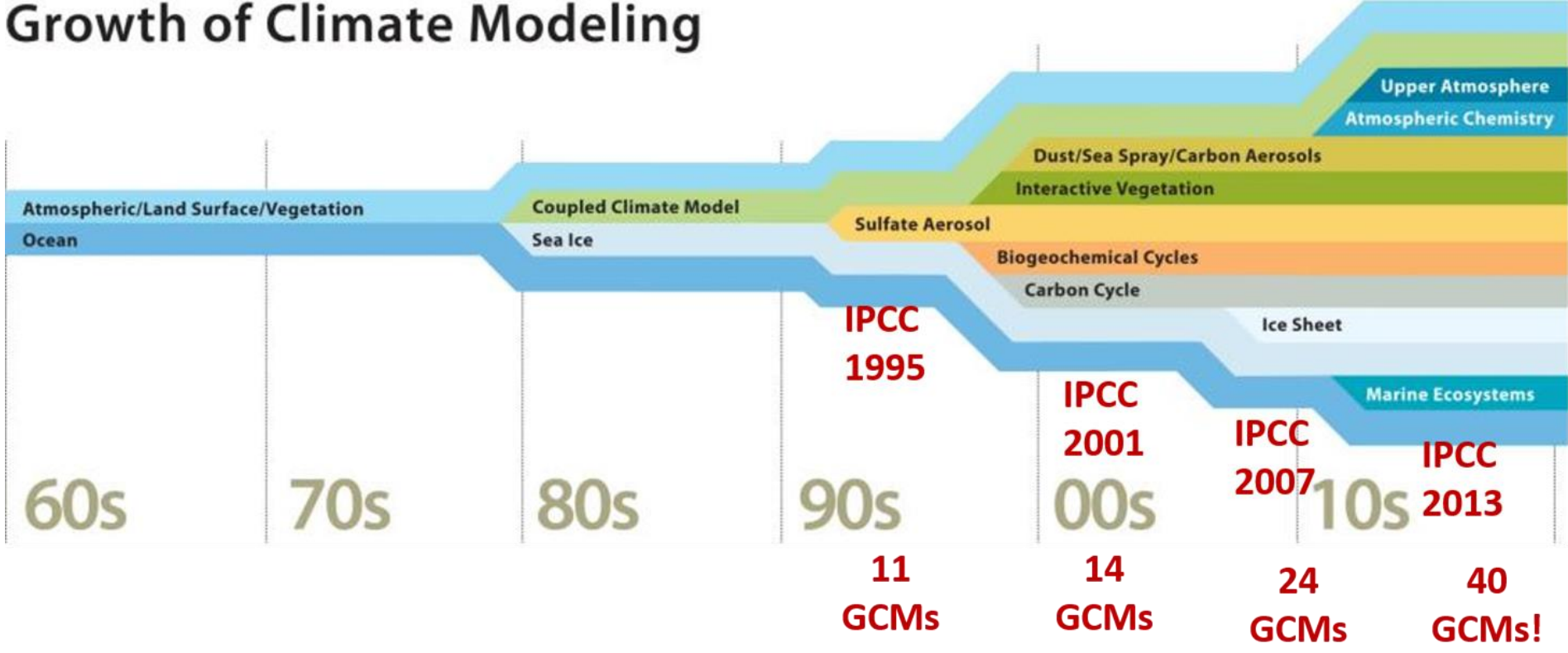
Confused, Skeptical

Concerned/Adapt to What?

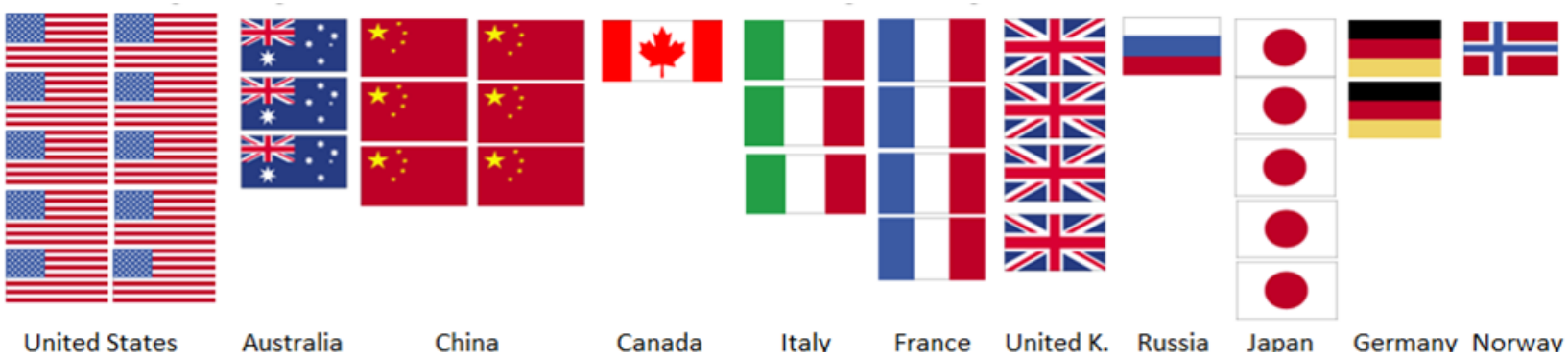


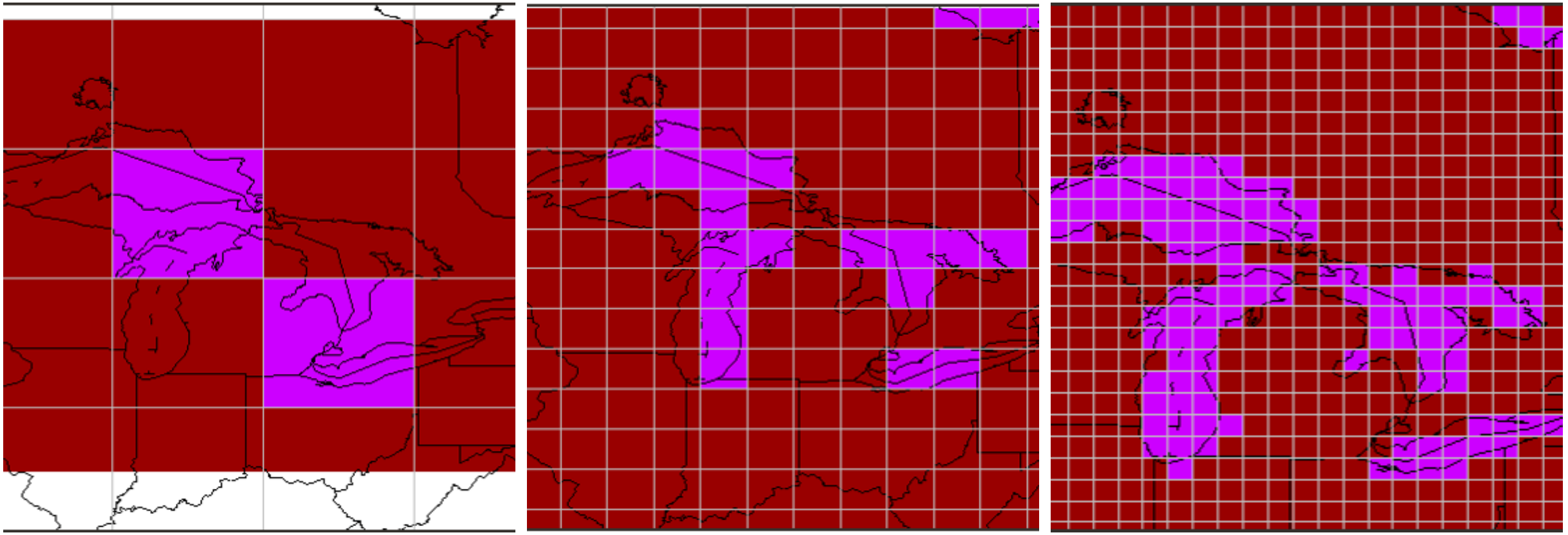
Get set! Ready!!

Confused? Skeptical? …



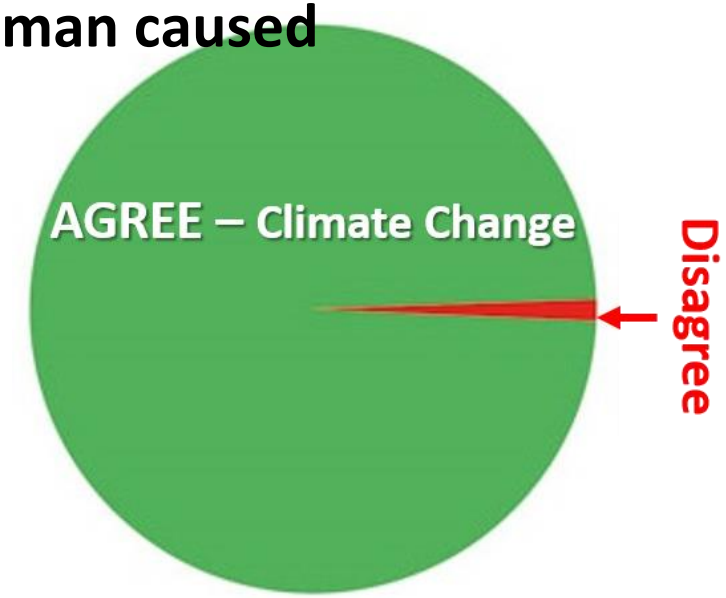
More and improved climate models (for larger scale)





Climate Change Model Resolutions are Improving with each IPCC Assessment Run: Great Lakes Example

According to Climate Scientists … human caused



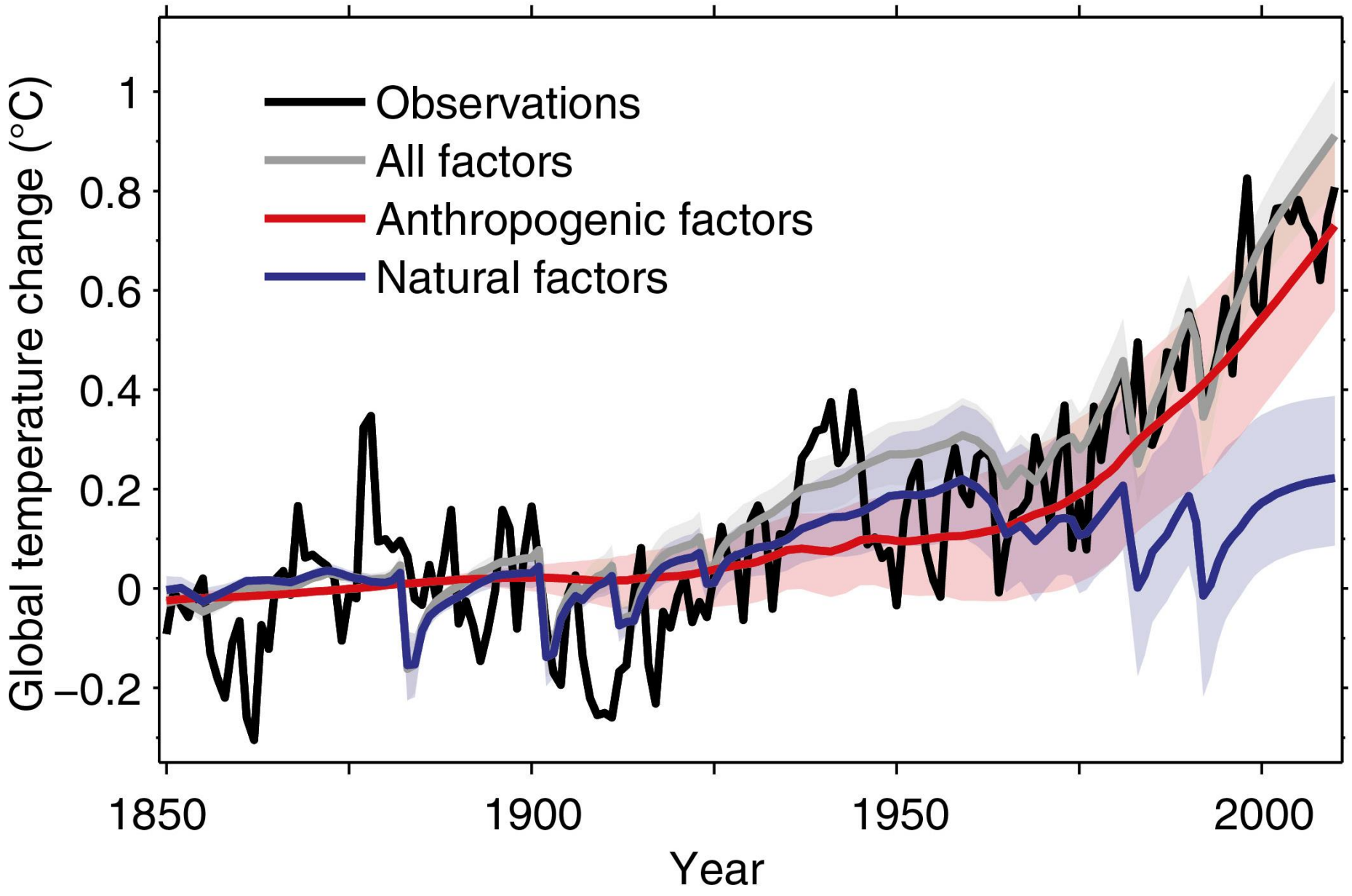
97- 98.5%

Cook et al 2013
10,306 scientists

According to the Atmosphere …

Debates over Climate Change? The Climate Change Science is Valid… and the Evidence grows Stronger every year

Climate… with and without GHG emissions

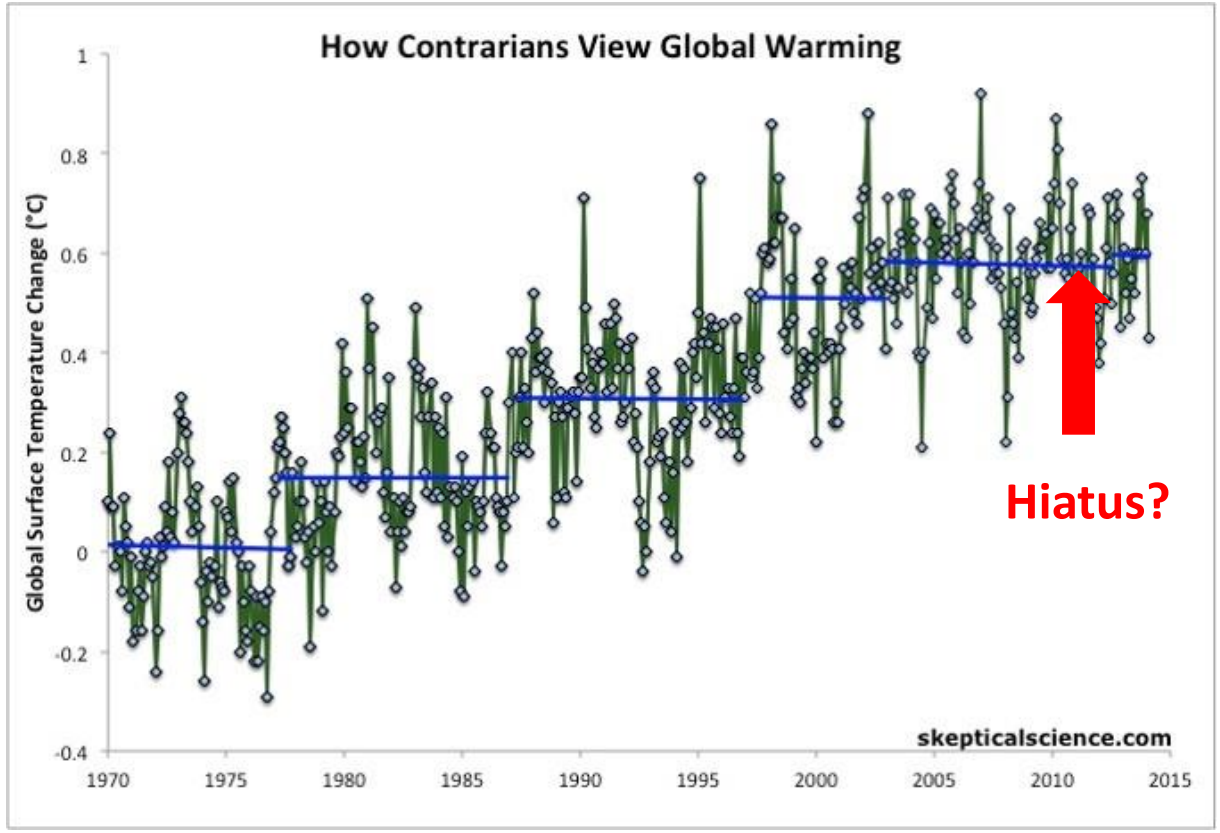


All factors

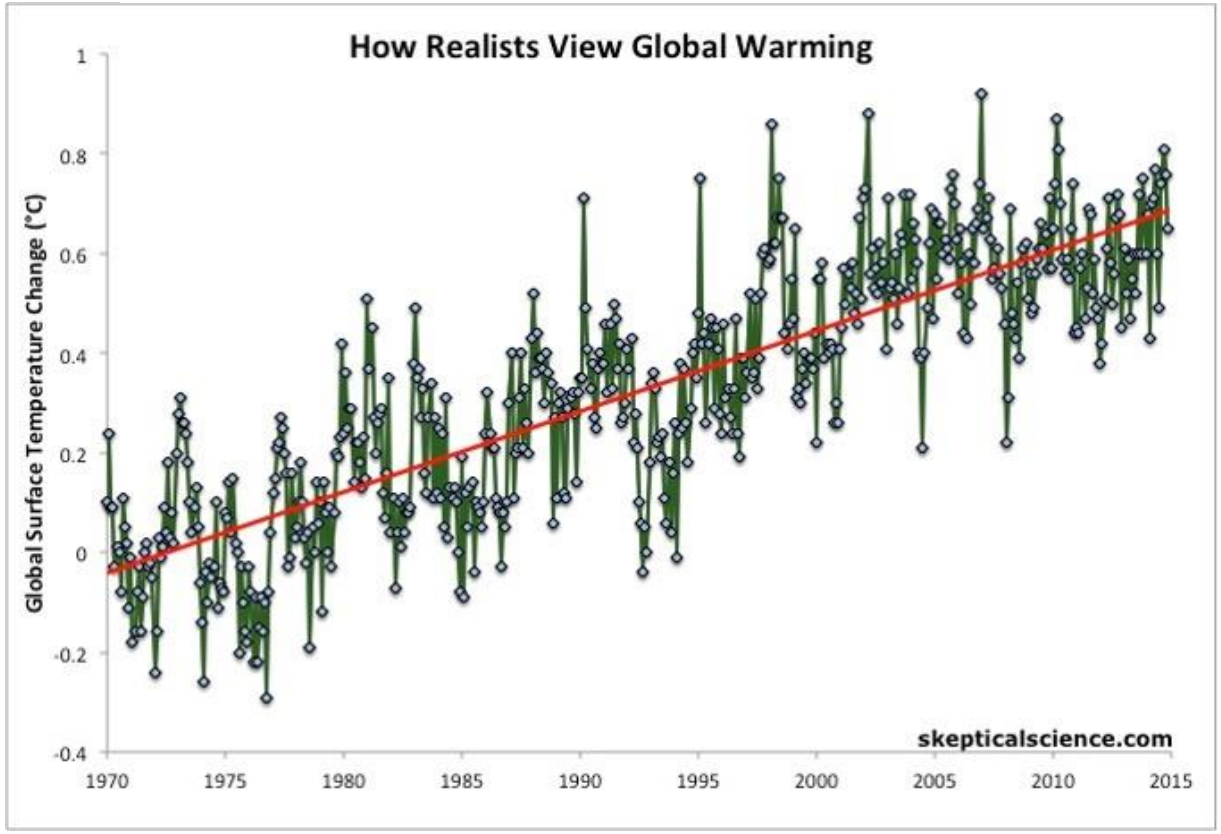
Anthropogenic factors

Natural factors only

Using short record periods – Contrarian's view



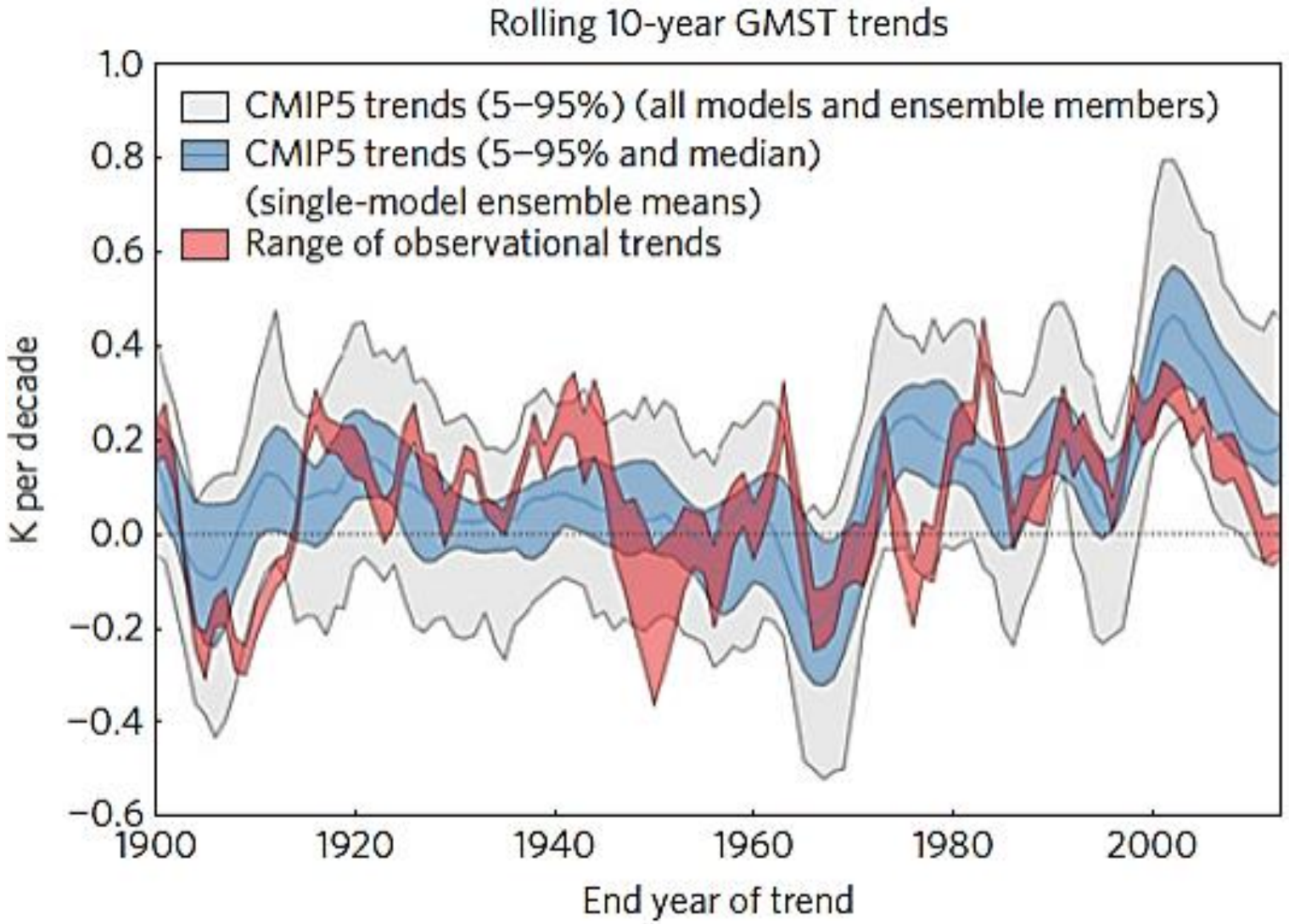
Using longer record periods – Realist's view



Length of Climate Record is important: Skeptics and Short-term Climate Variability vs Longer-term Signal

Our Recent Reality – *Global Warming Hiatus*? Or Natural Variability?

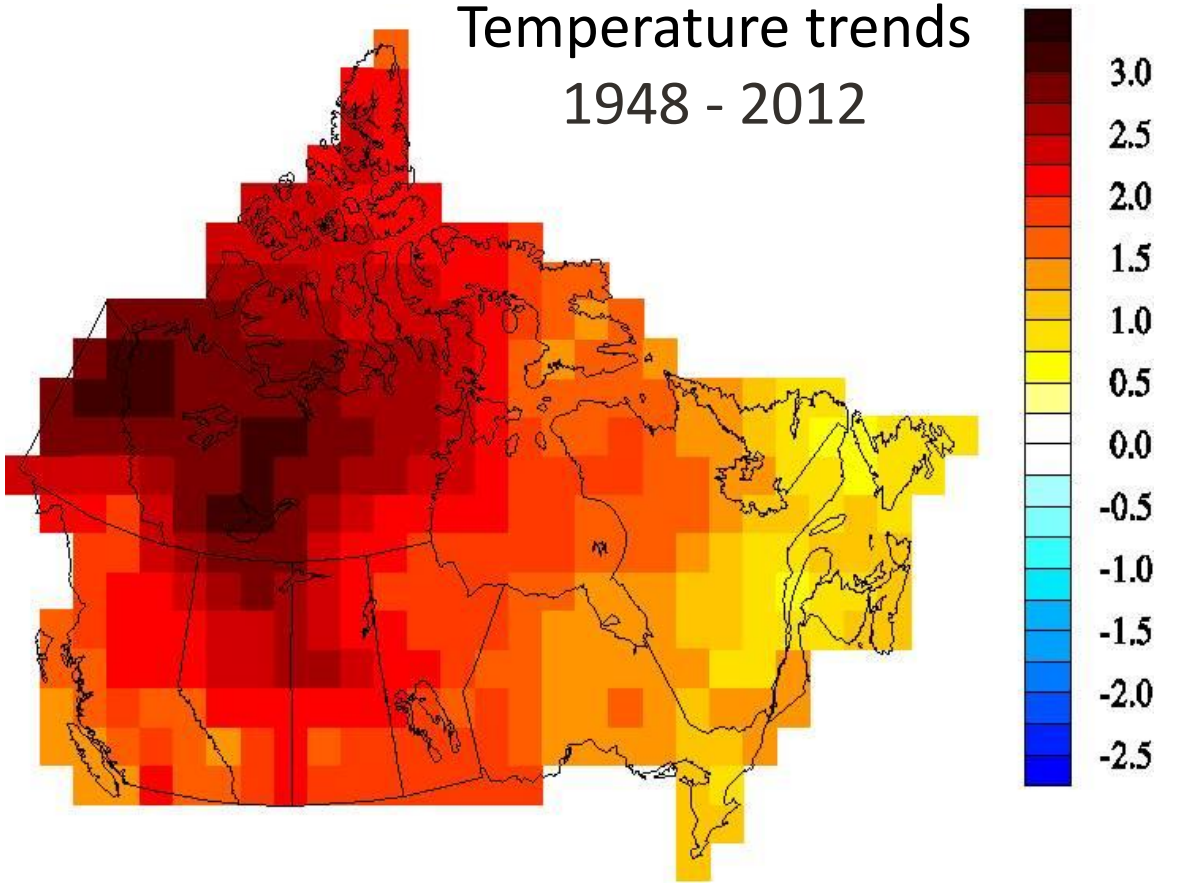
- New research recent on 15 year '*global warming hiatus*'
- Generally accepted that warming hasn't gone away – instead, likely warming the oceans (possible PDO link)
- Recent reduced warming still within range indicated by climate models
- Possible that "hiatus' could continue for 20 years, but likelihood low (<1%)



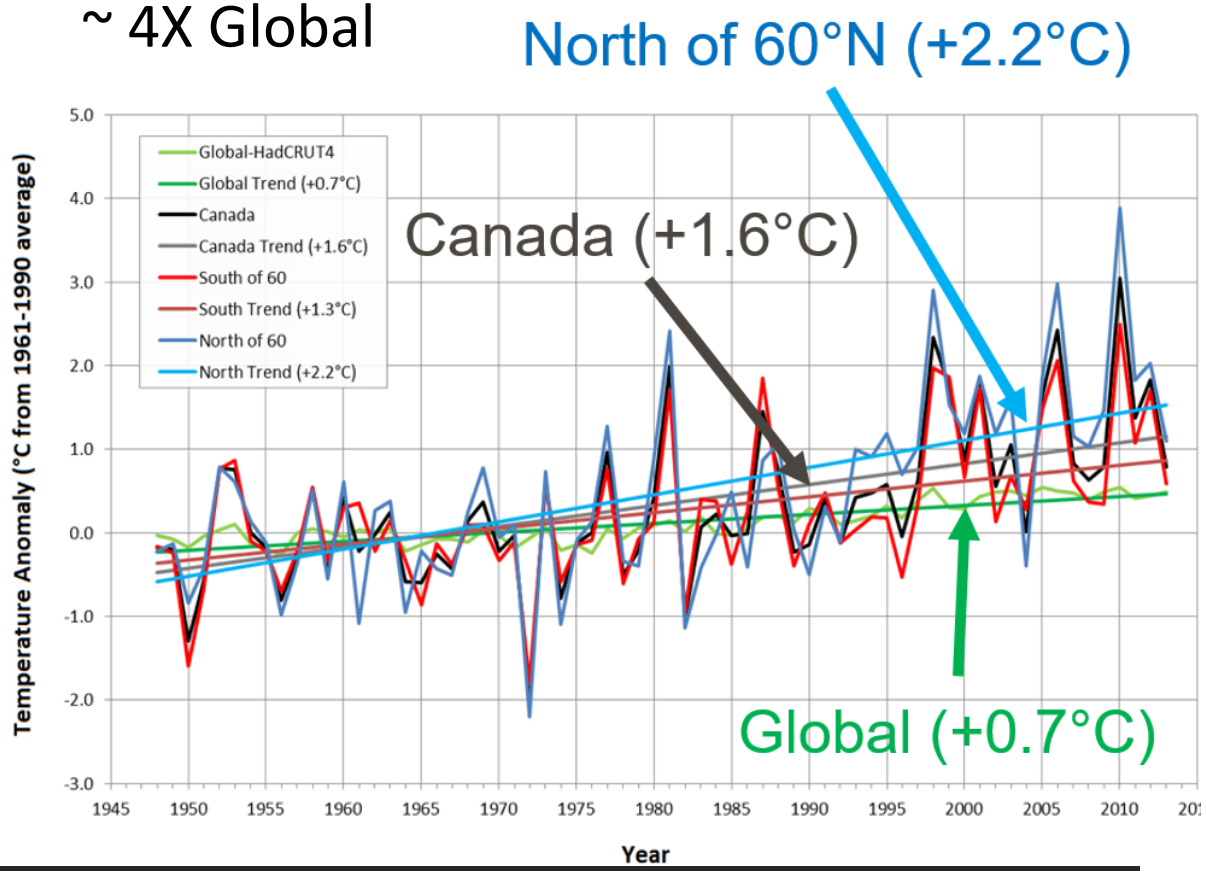
NOTE: *Increased* likelihood of accelerated warming after this latest phase

Concerned? Adaptation to WHAT?

National and Regional Changes in Climate



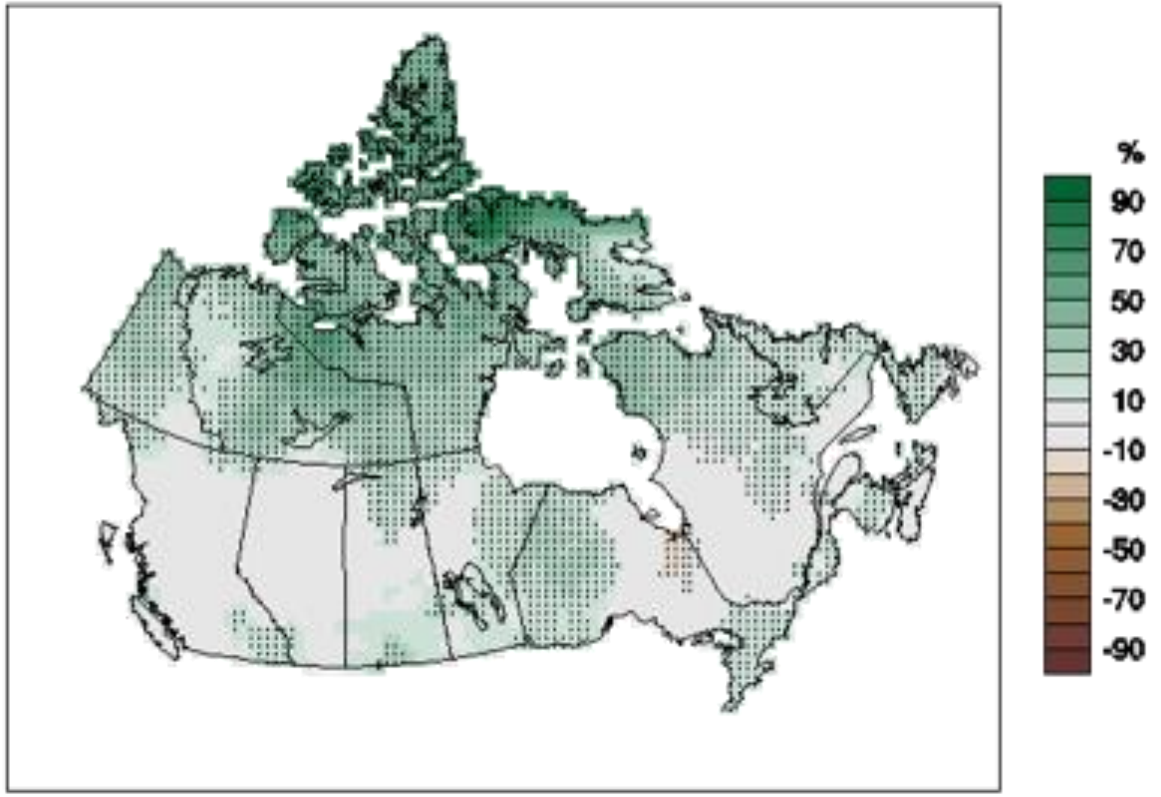
North warming
~ 4X Global



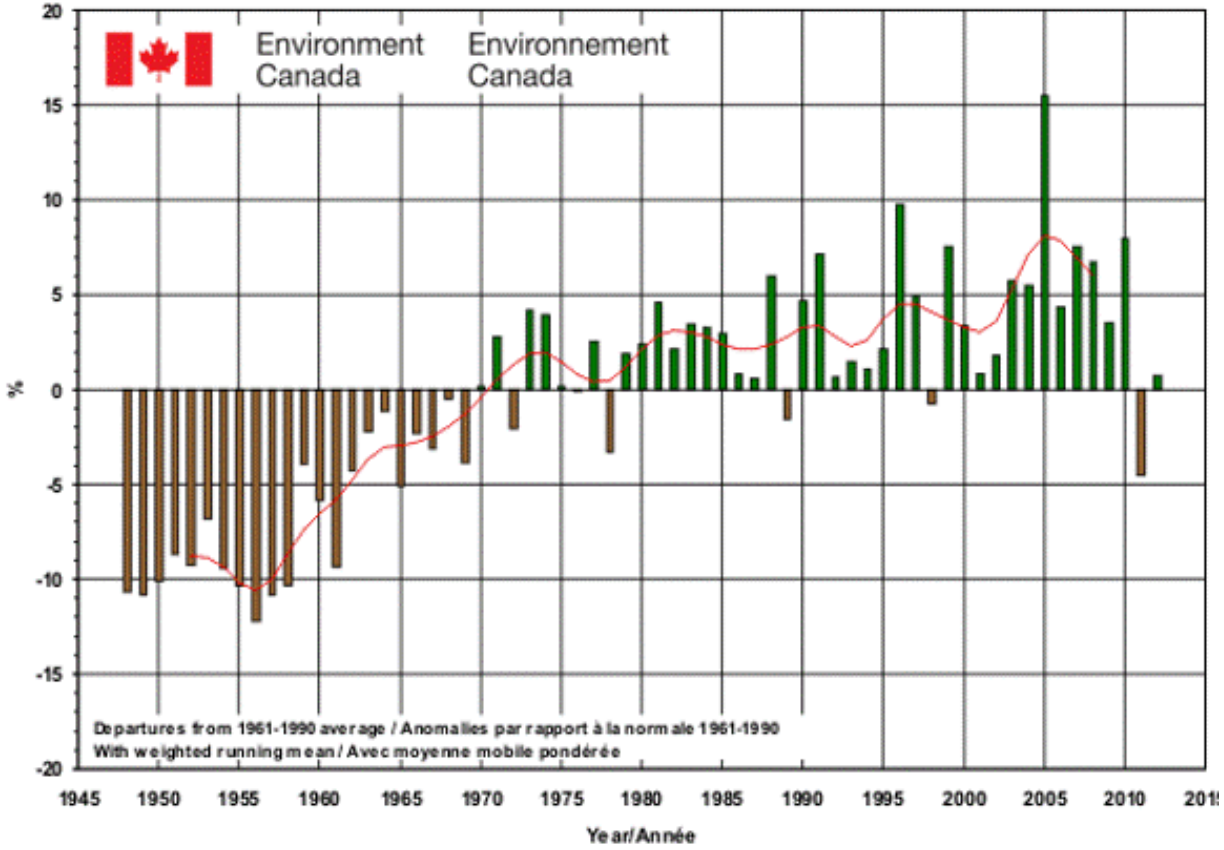
Trends: Canada, compared to the World

Harder to detect national and regional trends

Annual total precipitation trends 1948-2012



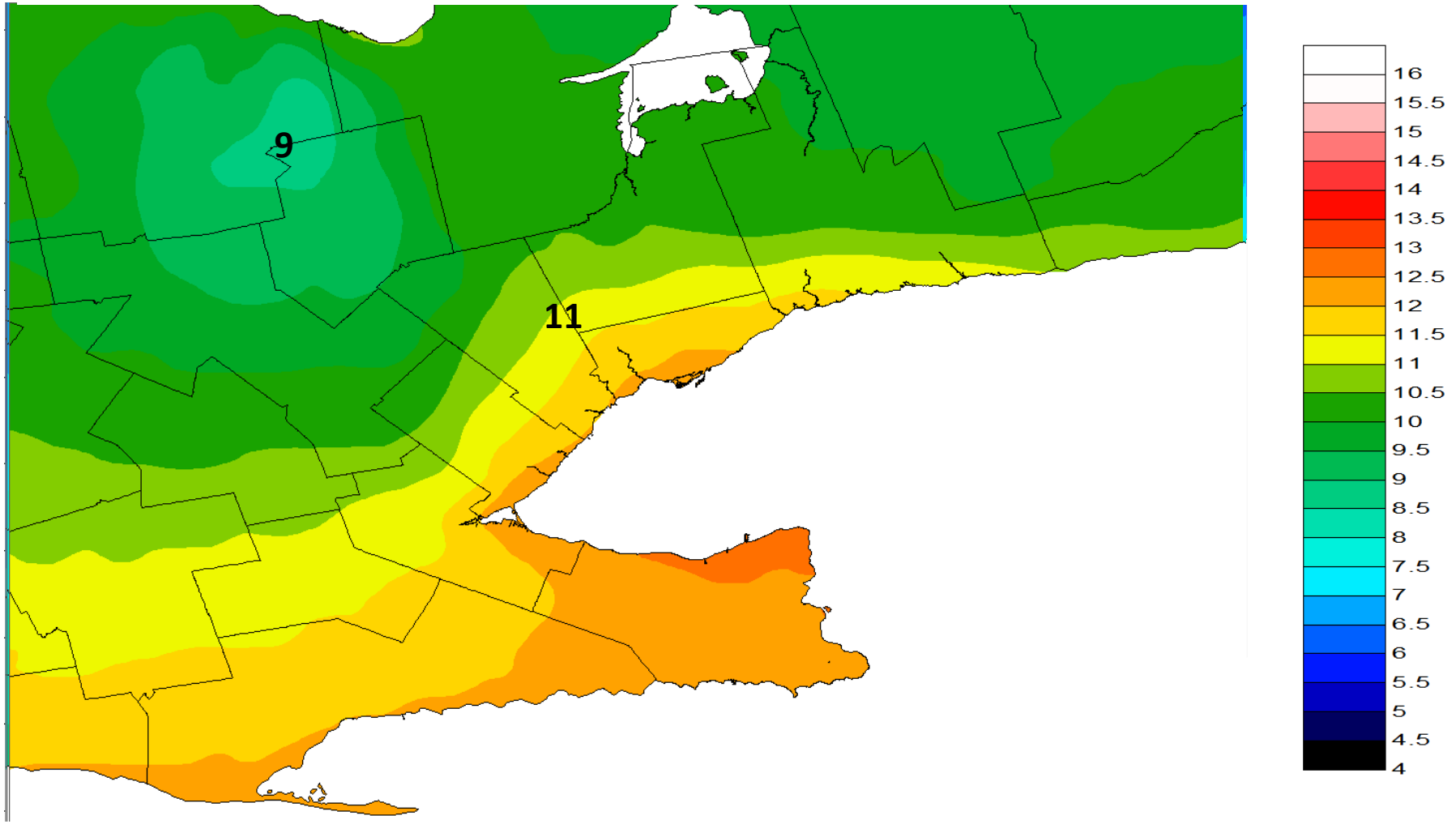
Nationally averages annual precipitation trends



Precipitation Trends – More Challenging

Mean Annual Temperature Trends: Ongoing Warming

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



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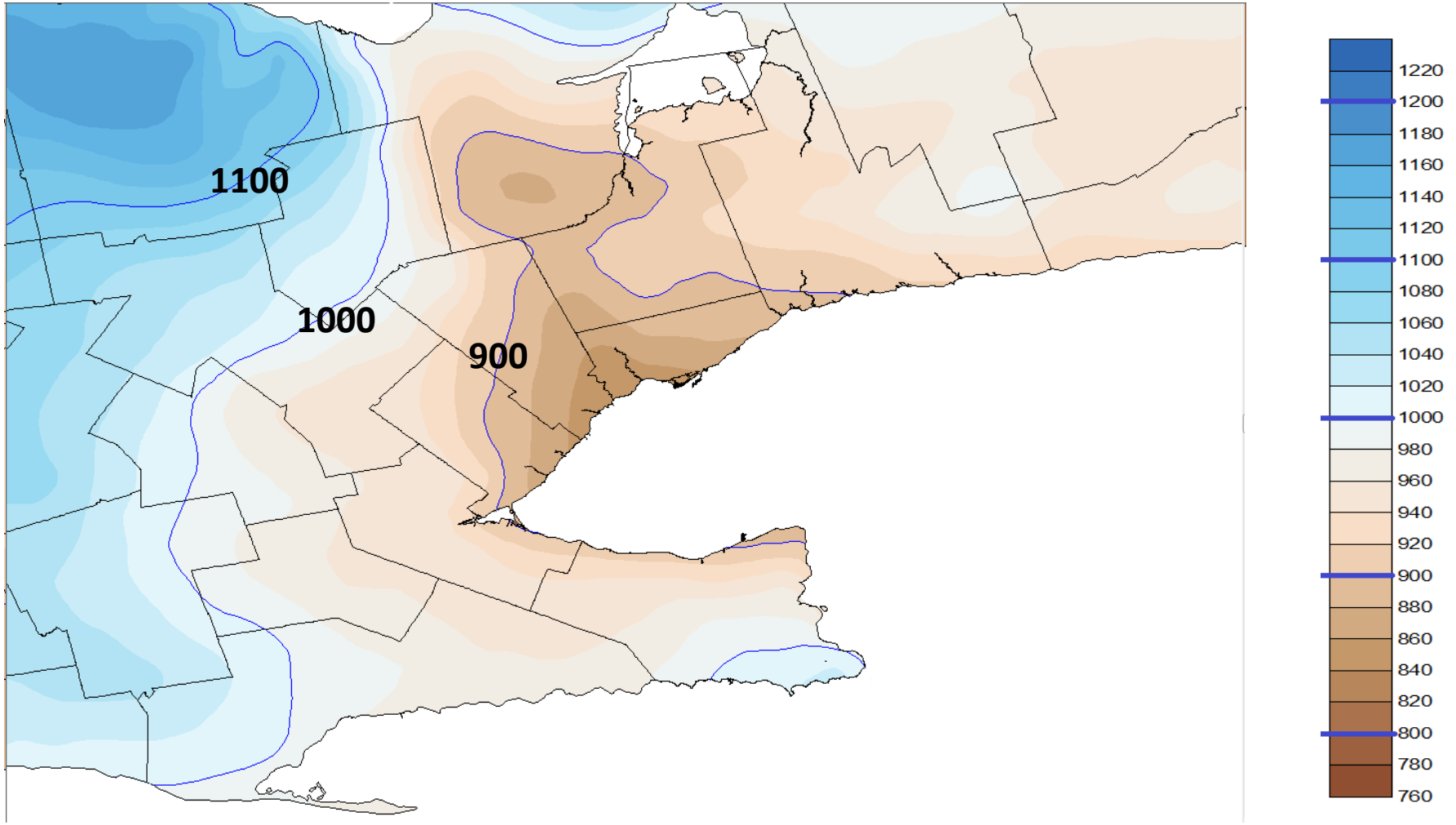
Mean Annual Precipitation Trends: Becoming Wetter

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



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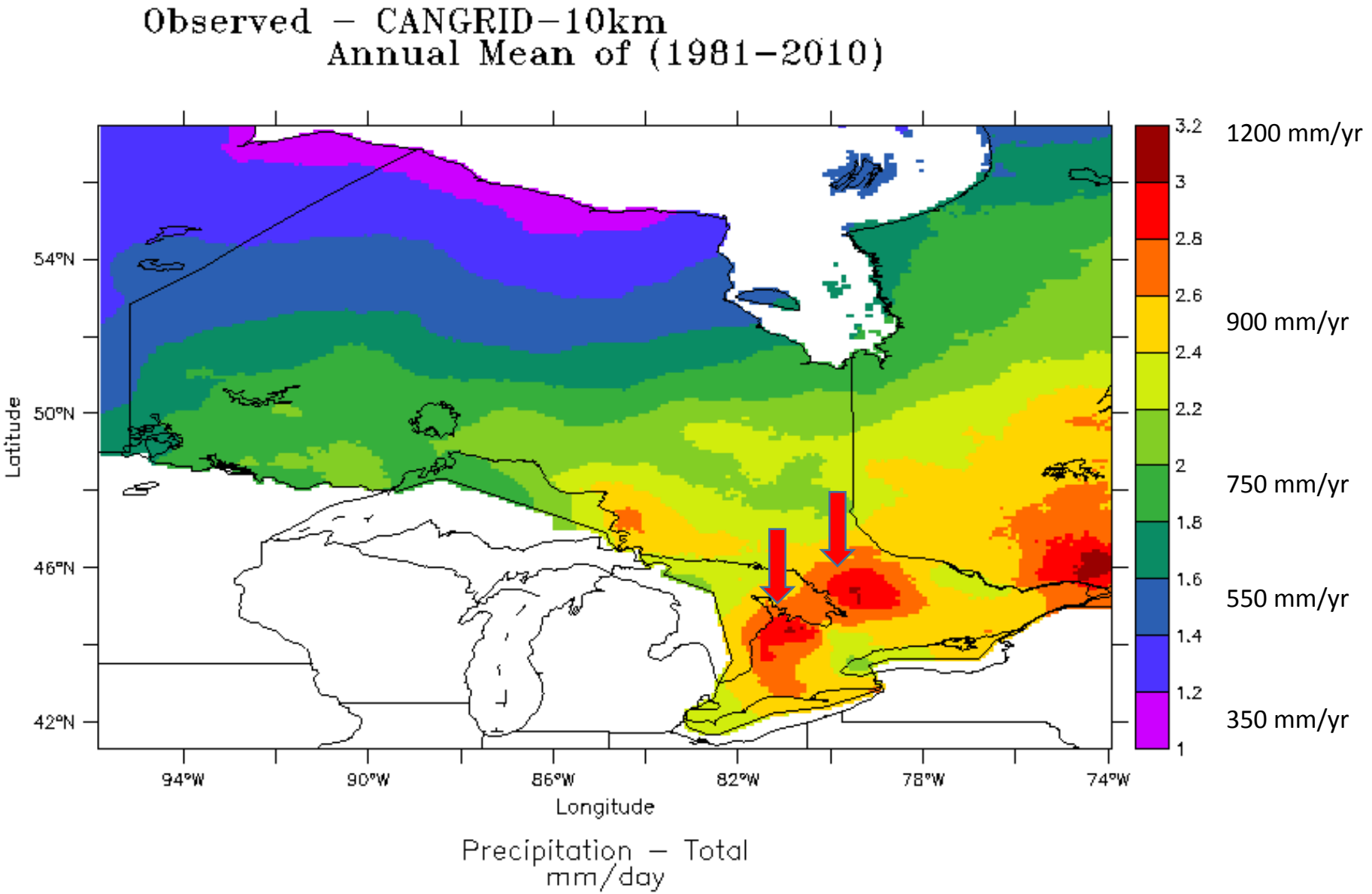
Ontario Historically – Precipitation increasing regionally



1200 mm/yr

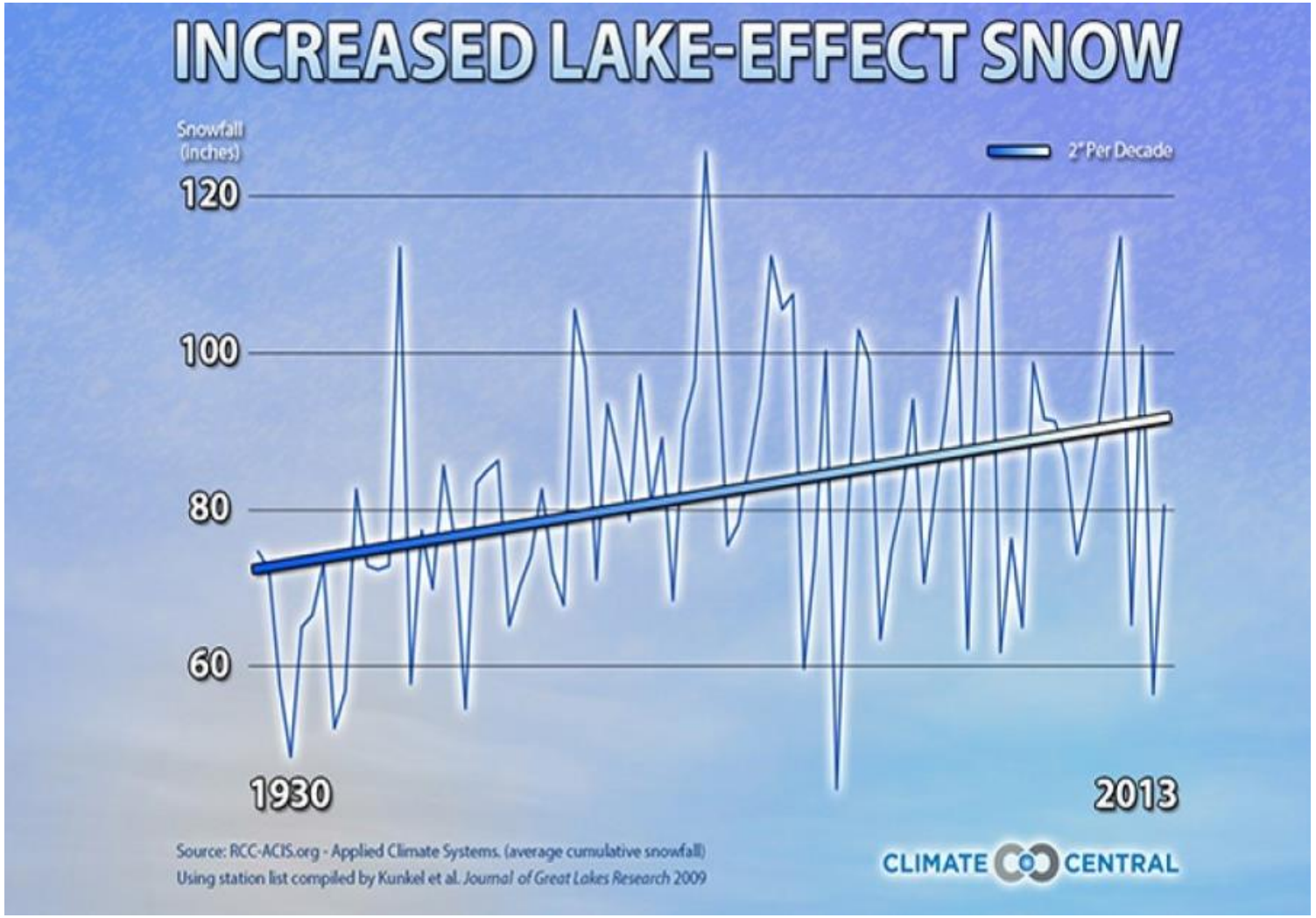
900 mm/yr

750 mm/yr

550 mm/yr

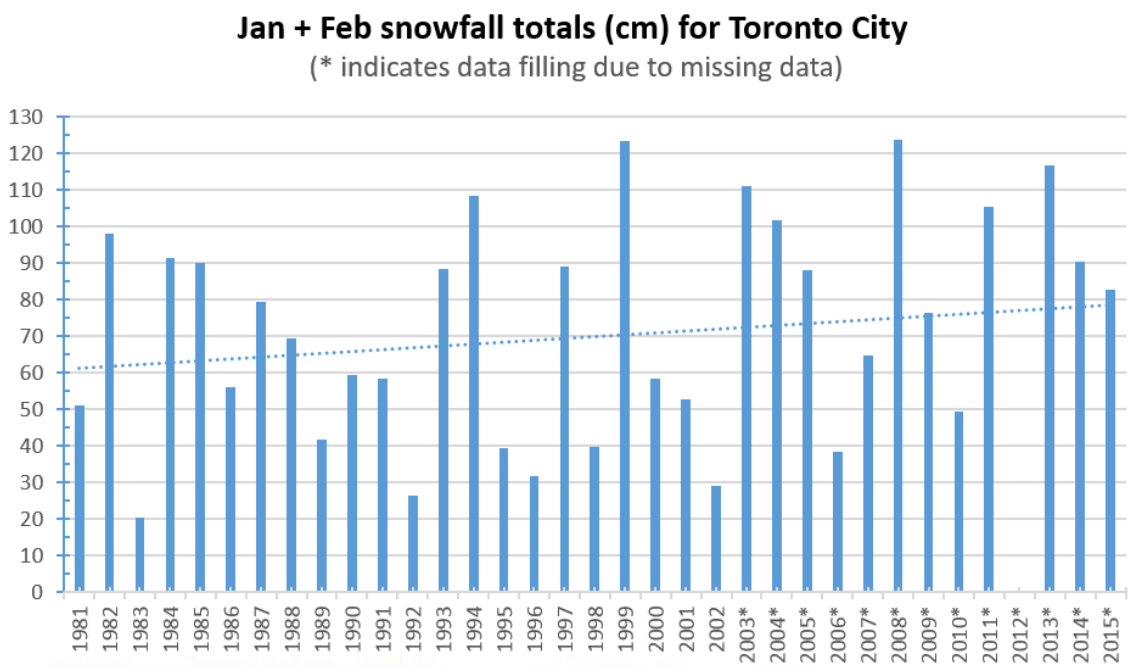
350 mm/yr

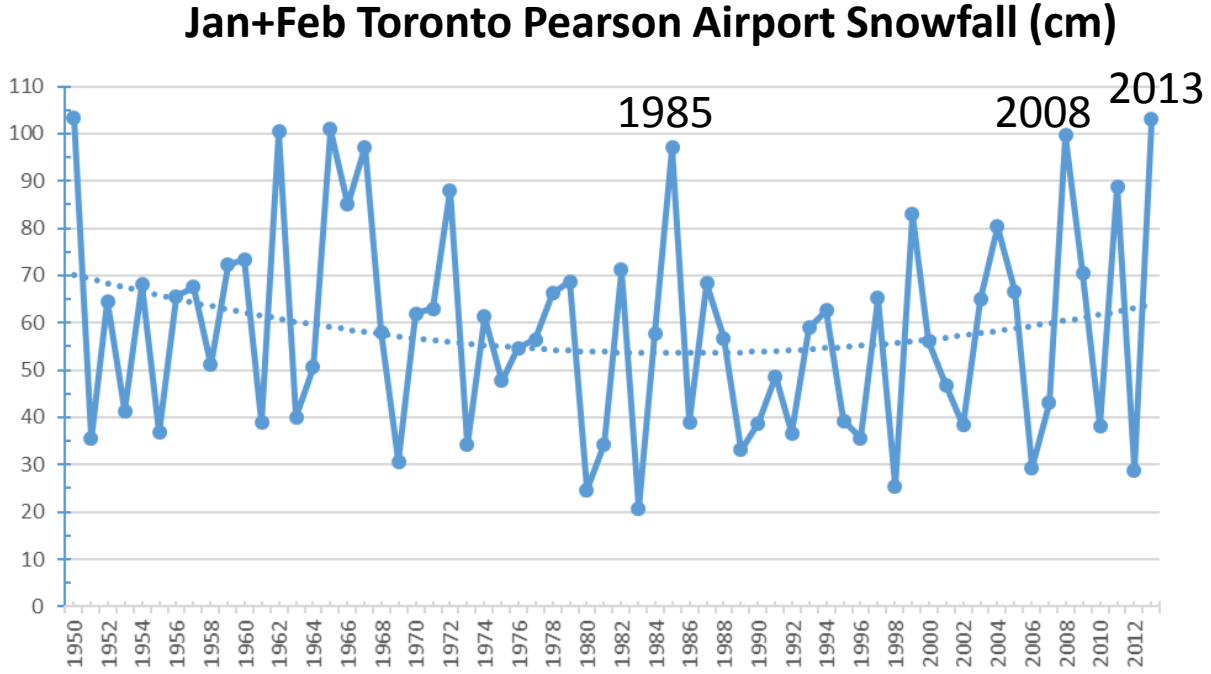
Data Source:
NRCAN/EC



Snowbelt regions observing increased lake-effect snow
(*lee Great Lakes winter flows*)

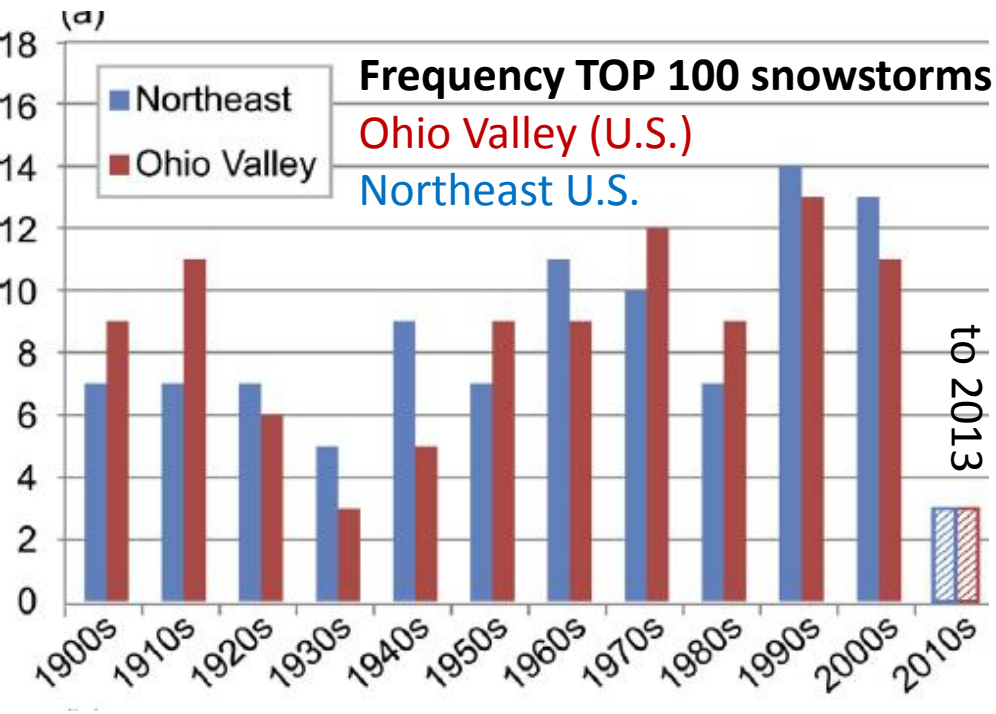
On average, Great Lakes are open longer (more winters)
… snowsqualls





Shorter and warmer winters… Less snow?

Outside of the “snowbelts”

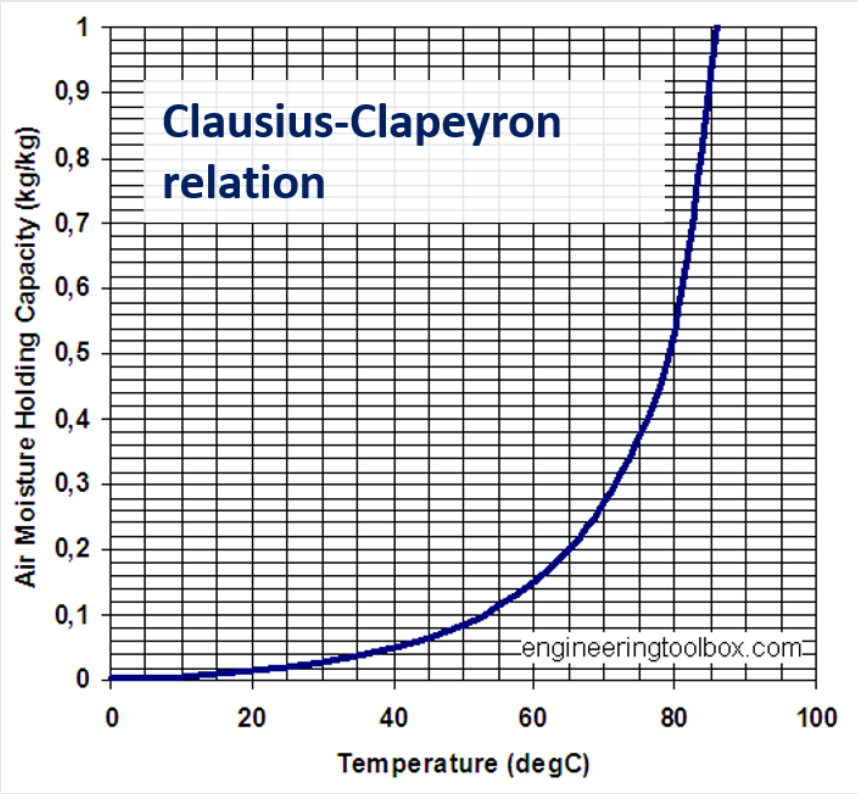


"It is likely that frequency and intensity of snowstorm events will increase in northern U.S."

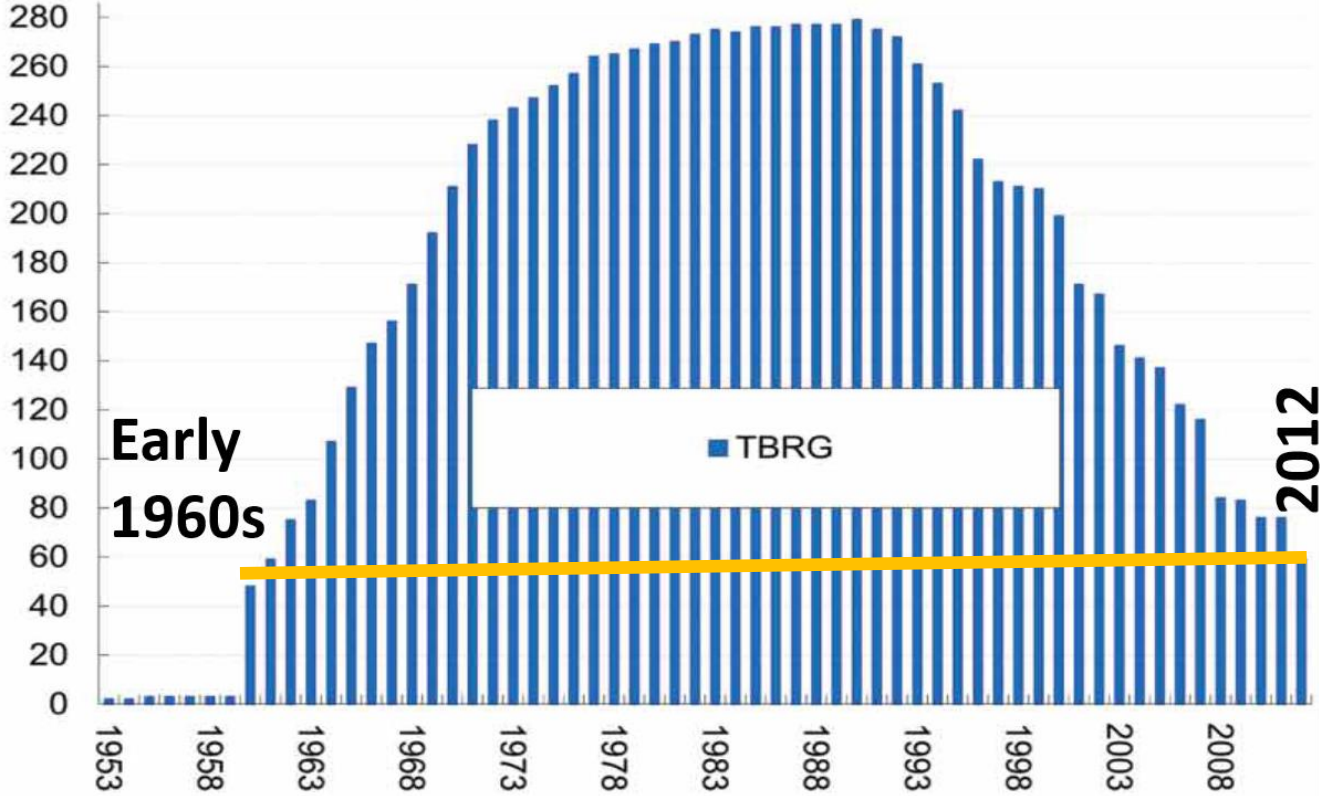
Note trends in frequencies of Top 100 Snowstorms in the U.S. Ohio Valley *(U.S. Climate Change Report, 2014)*

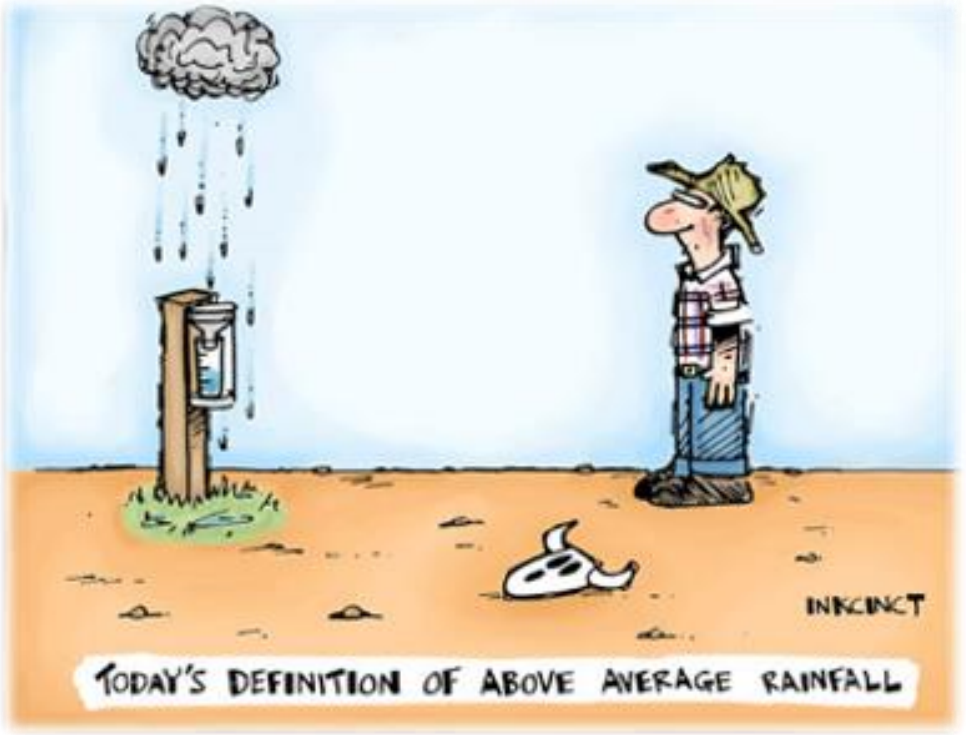
Warmer air can hold more water.. Potential for more precipitation

- Amount of moisture in air grows rapidly with temperature increases (Clausius-Clapeyron relation)
  - Provided moisture source exists;
  - Increasingly used for future projection of rainfall extremes.
- Warming can lead to more intense rainfalls and snow events;
- Can also evaporate more water from surfaces (i.e., faster drying).



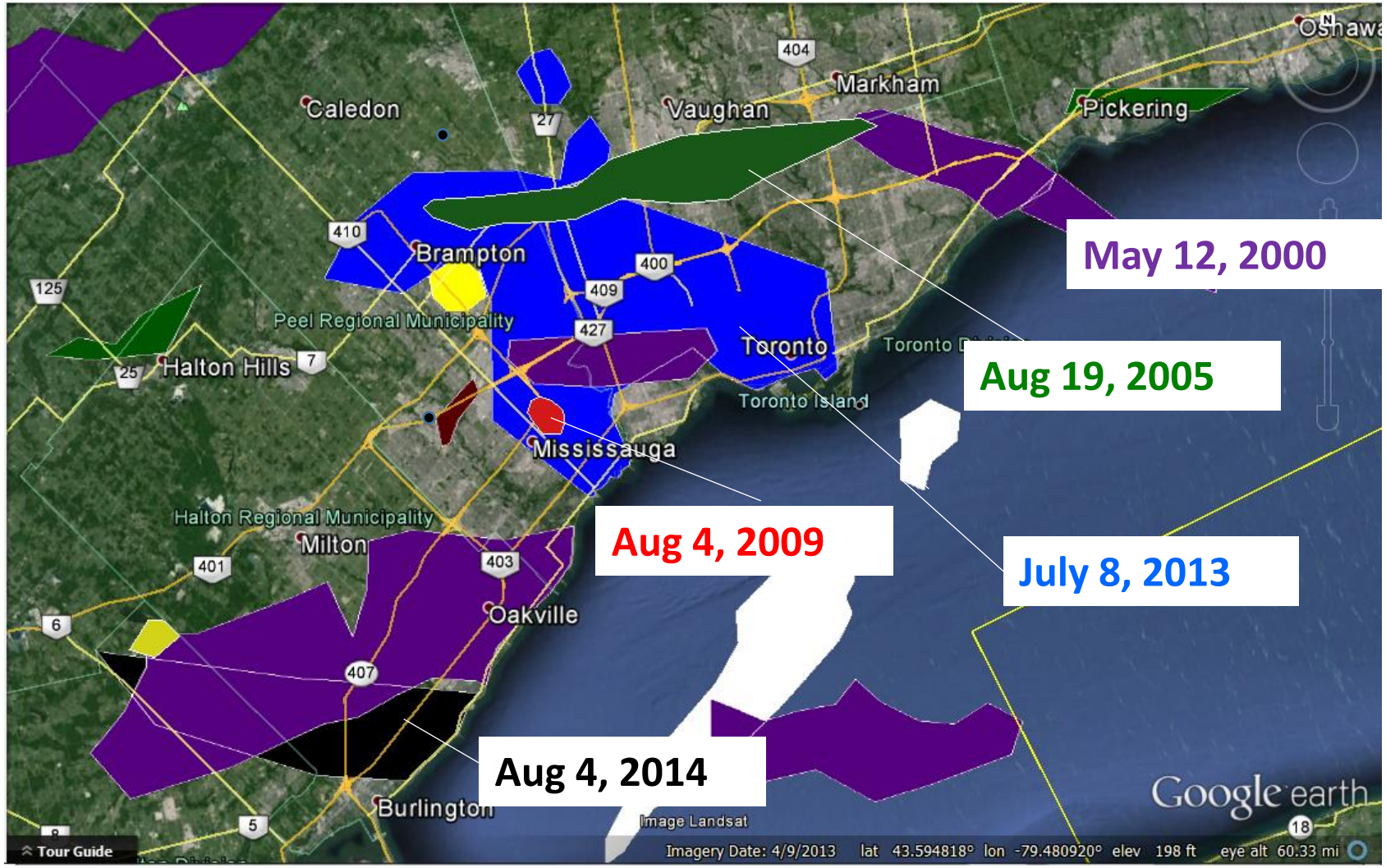
Declining long-term climate stations: e.g. Rate-of-rainfall





Data challenges in Canada: Detecting changes in Rainfall Extremes

Extreme Rainfall BIG events in GTA from 2000-2014 with “Improved” Event Mapping

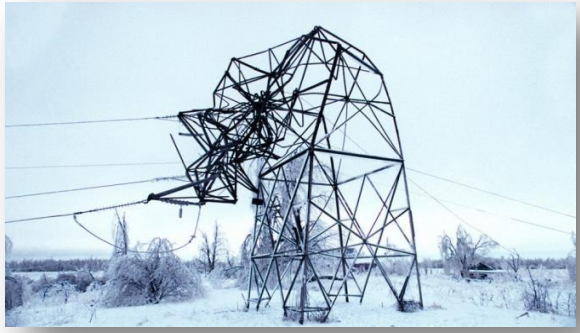


Community Impacts will be wide-reaching

Structures	Ice & Snow Loads	Extreme Rain (Intensity, Duration, Freq)	Extreme Winds, Tornadoes
Electrical structures	FAILURES	Towers	FAILURES
Water Structures	FAILURE, Power outages	FAILURES	Power outages; failure-tornado
Roads, Bridges	Driving hazard, snowmelt RISK	FAILURES – drainage & erosion	Signs, bridge failure risks
Buildings	Snowload FAILURES	Weathering; flooding, moisture	FAILURES
High Rise Buildings	Neighbouring buildings (+ ice sheets)	Flooding low levels, moisture problems	FAILURE RISKS

Risk of failure

Risks to infrastructure services



READY! GET SET!
How to get good local climate guidance, climate change models for decisions?

Decision-maker NEEDs are important…

- Accuracy
- Credibility
- Saliency / relevance
- Reliability
- Up-to-date
- Available on-time and on-demand

Fundamentally impossible for the future

To be developed - uncertainties

Limitations in input data

- Easily applied and useful in decision-making (assumes Those processes exist)
- Dialogue and ongoing relationships with creators of info.
- Minimization of uncertainty / lack of excessive uncertainty

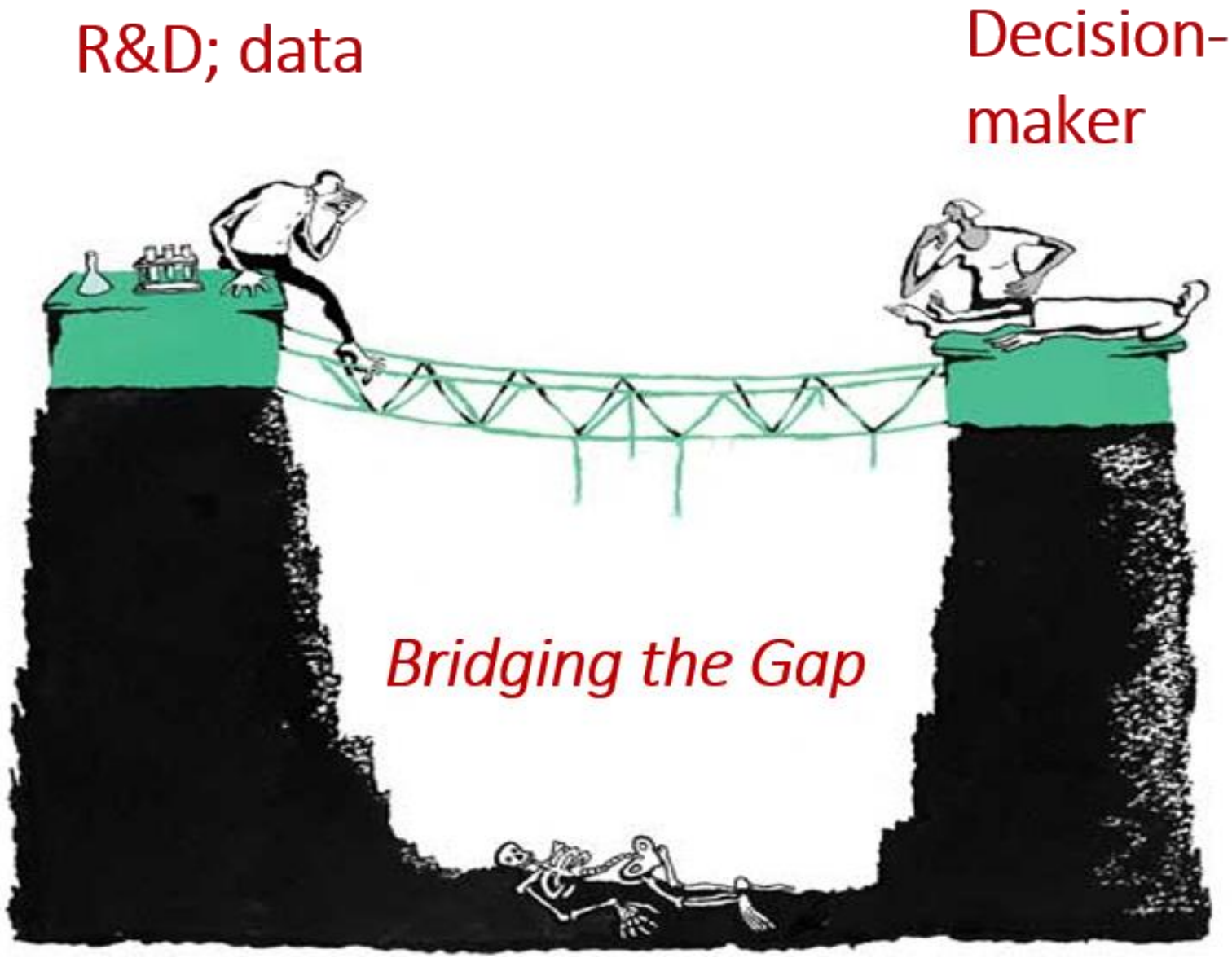
Many sources, some fundamental, others manageable

But, the science also has its **limitations**

User NEEDS are important…

The GAP between climate science and user needs is still huge

- Important to advocate for "decision relevant" info, policies & regulations – PIEVC *assessments informed by good data, defensible science*
- ***Partnerships*** are key – no one agency/party has enough resources to provide all data



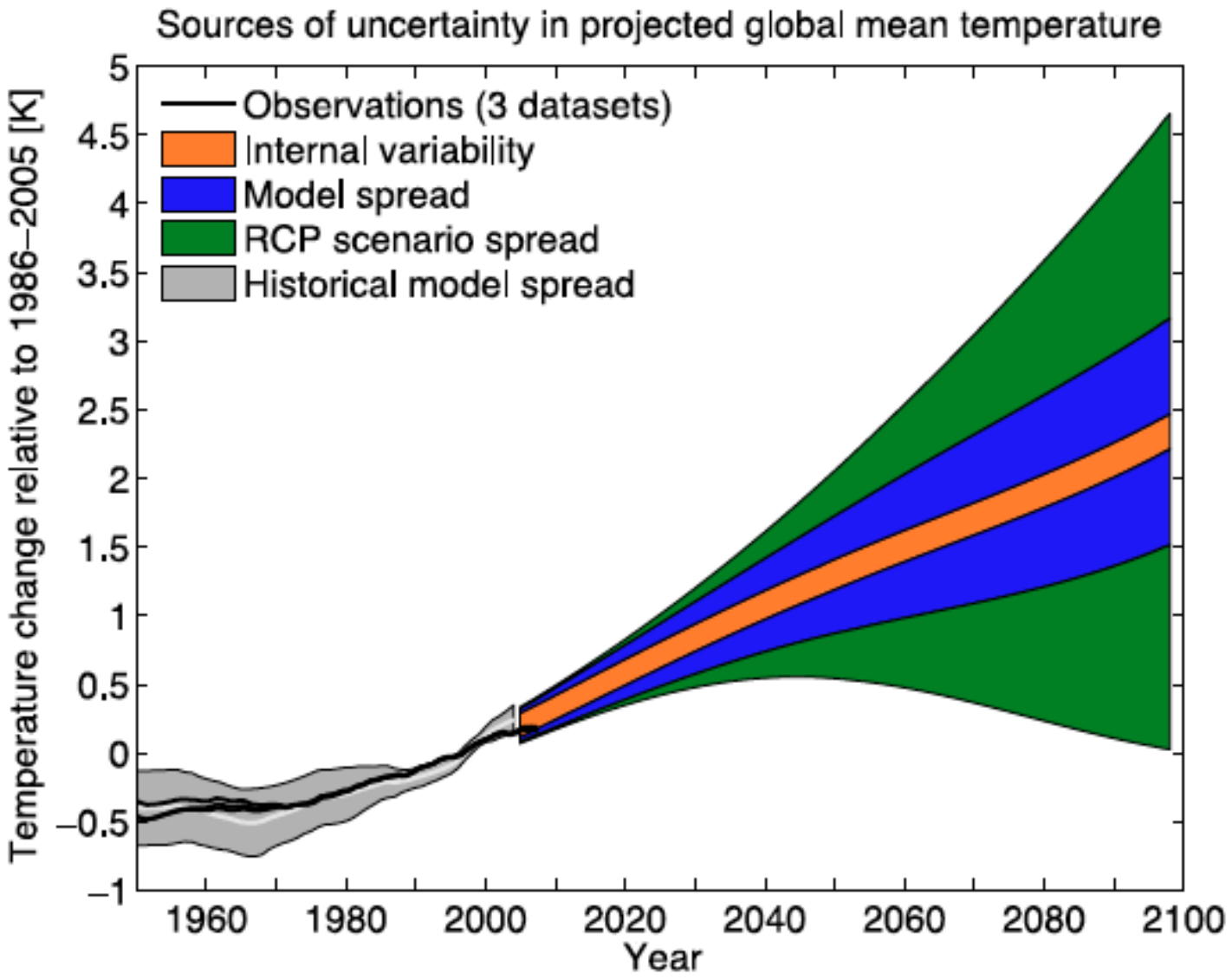
Composite image composed of 100 photos of Santa Claus with a child on knee.
Source: J. Salavon

NOTE: Climate models are designed to capture the larger scale climate processes and longer term climate trends
- not the subdaily weather extremes

Model outputs are NOT the same as weather predictions

An analogy to the resolution and skill of a "good" regional climate model – merging of Santa pictures

Sources of Uncertainty in Global Climate Models: Mean Temperatures



GHG Emissions: Human decisions

Climate model processes, data & uncertainty

Natural climate variability

Source: IPCC AR5 Figure 11.8

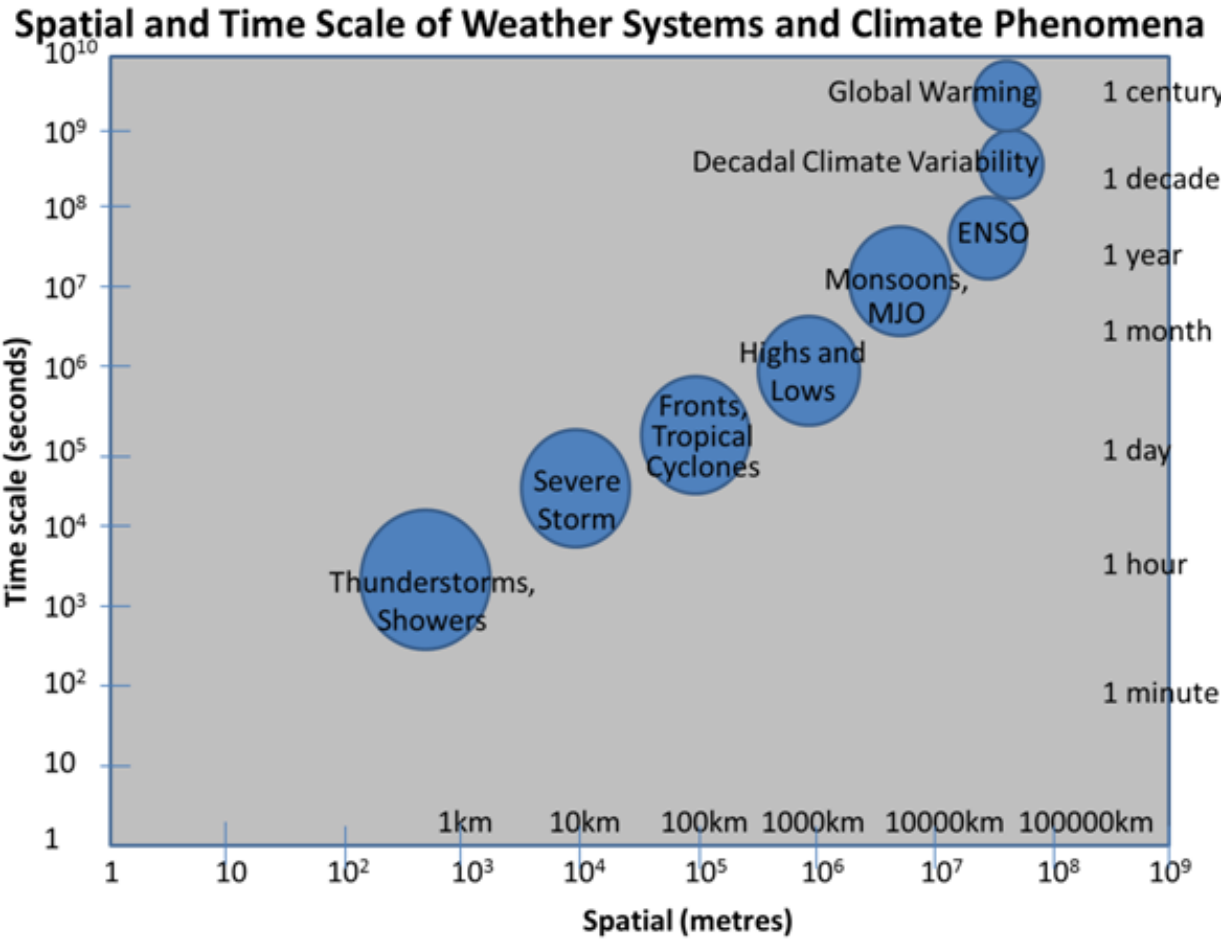
Uncertainties in climate change model outputs vary…

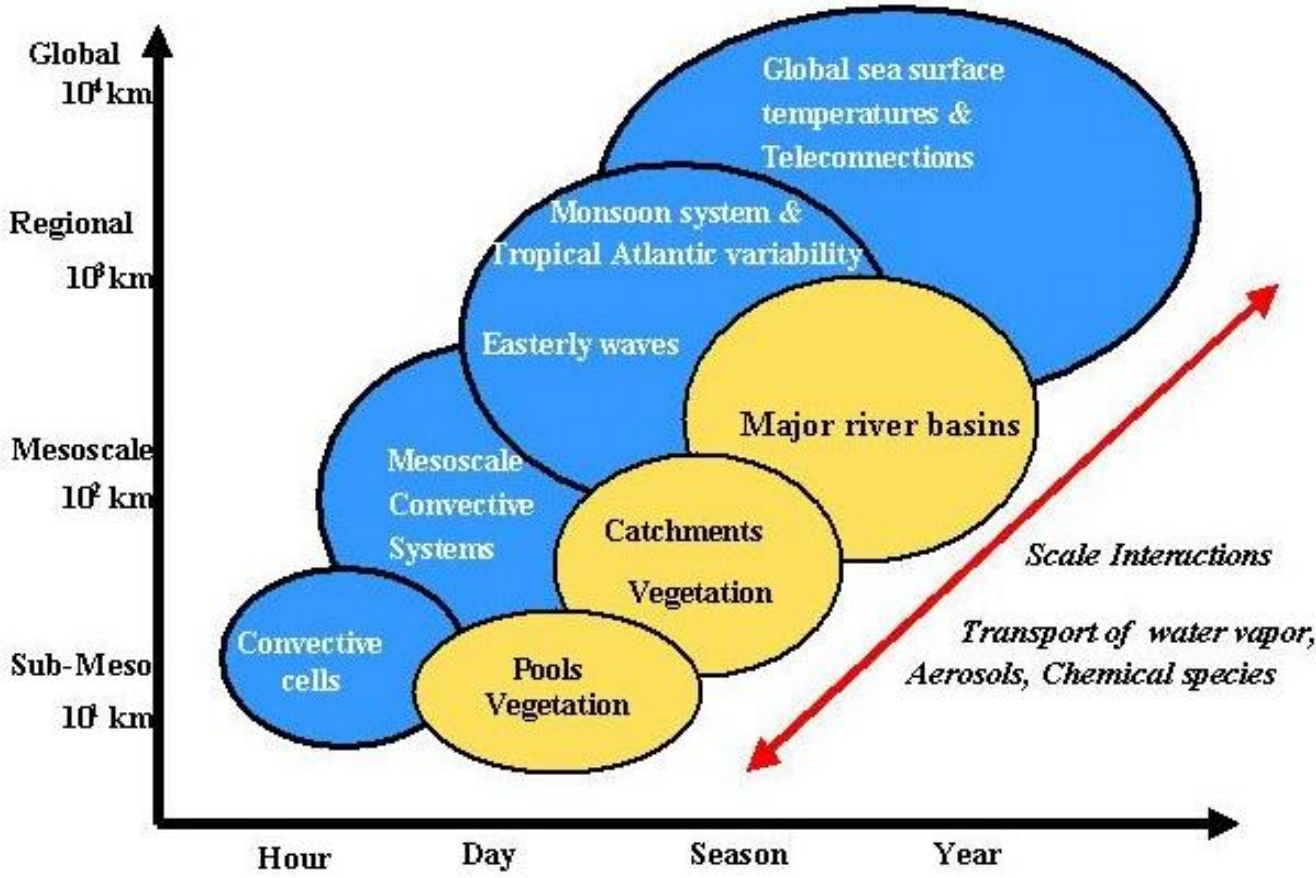
Most Confident

Least / Less Confident

More CERTAINTY → **Less CERTAINTY**

- Longer growing season
- More heat waves
- Warmer winters
- More winter precipitation
- More intense rainfall
- More severe ice, snow storms
- Increase in wind extremes

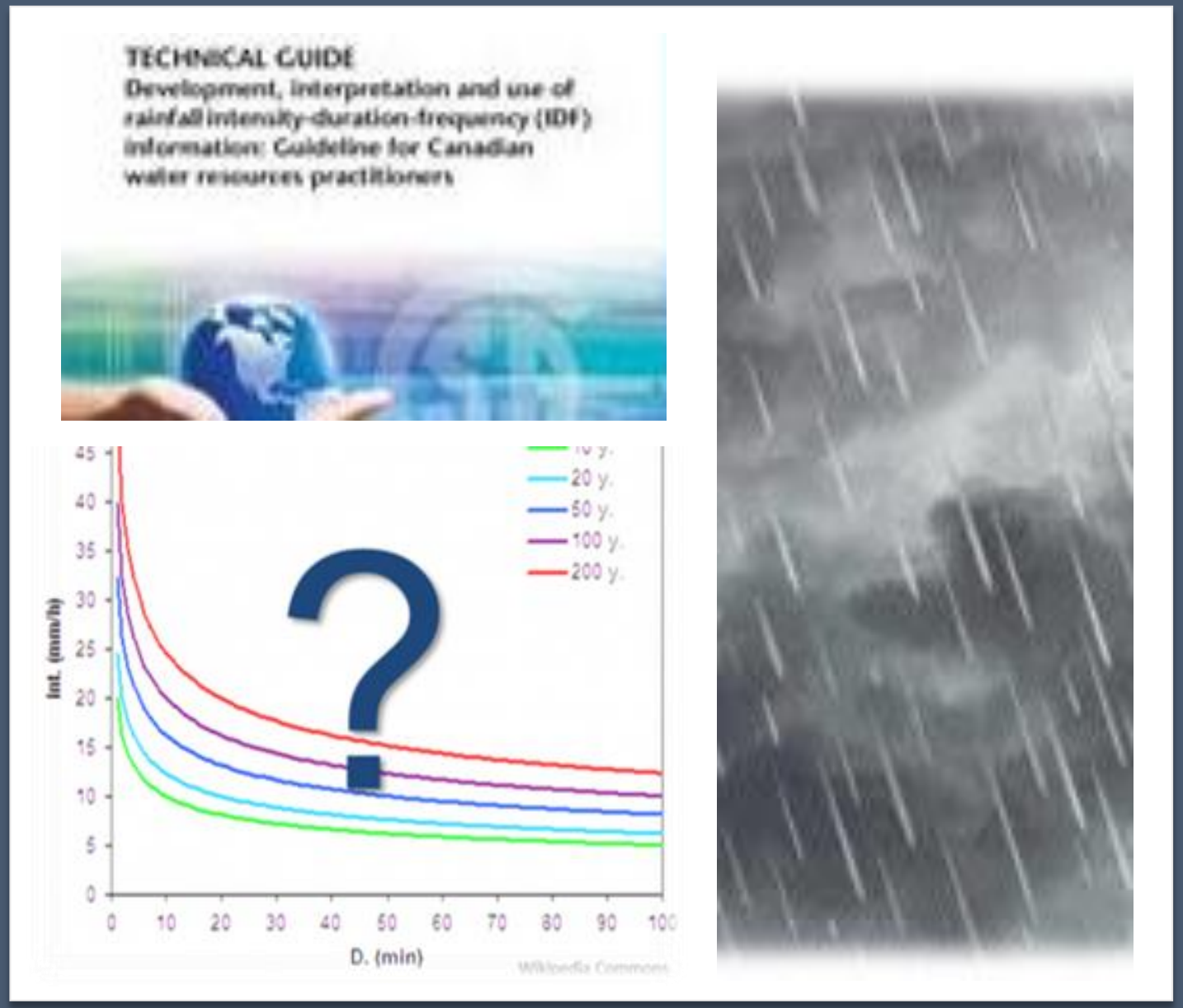




Varying Spatial and Temporal Scales of Weather and Climate: A Major Challenge

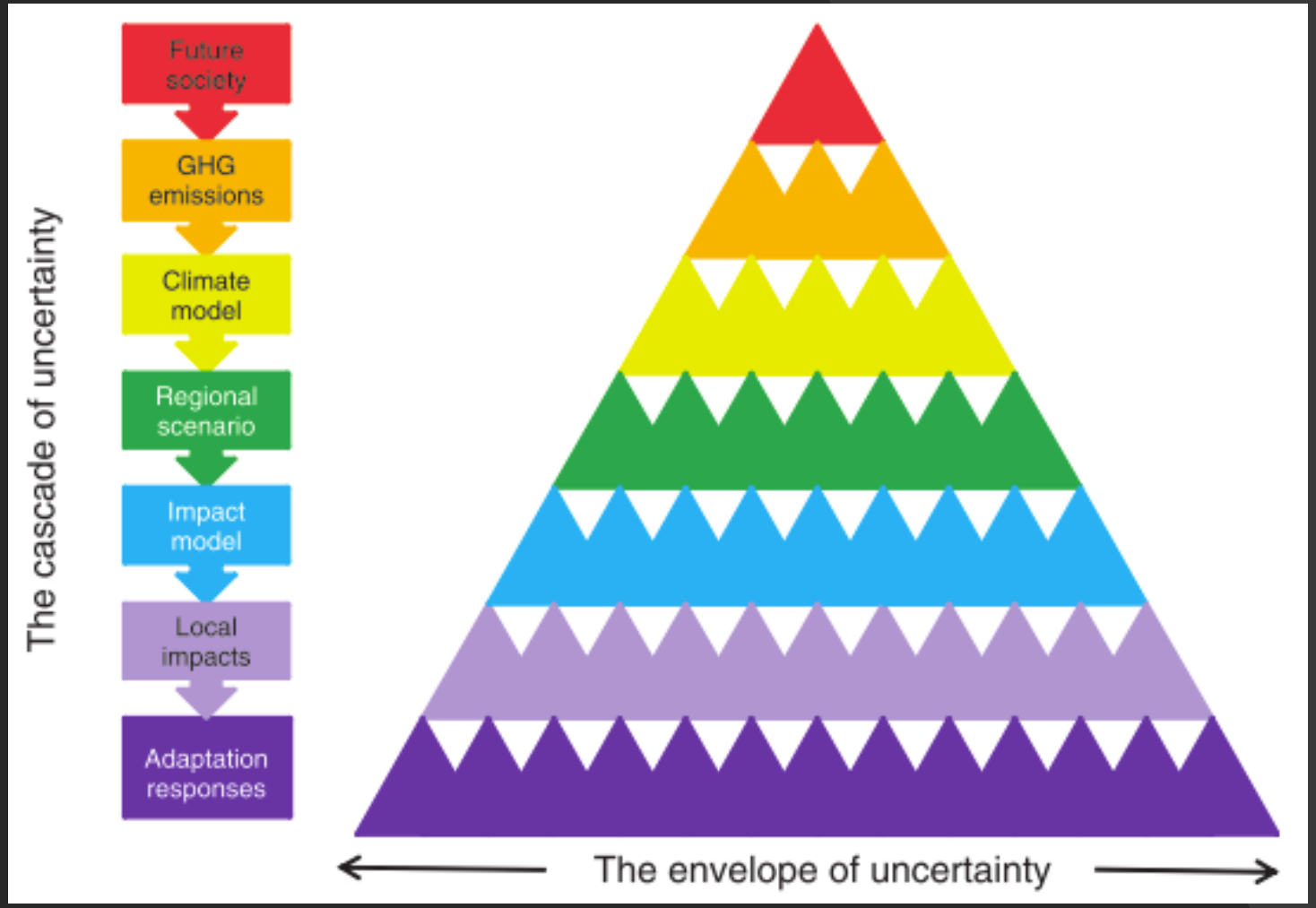
Challenge: Uncertainties in Projecting Future Rainfall IDFs

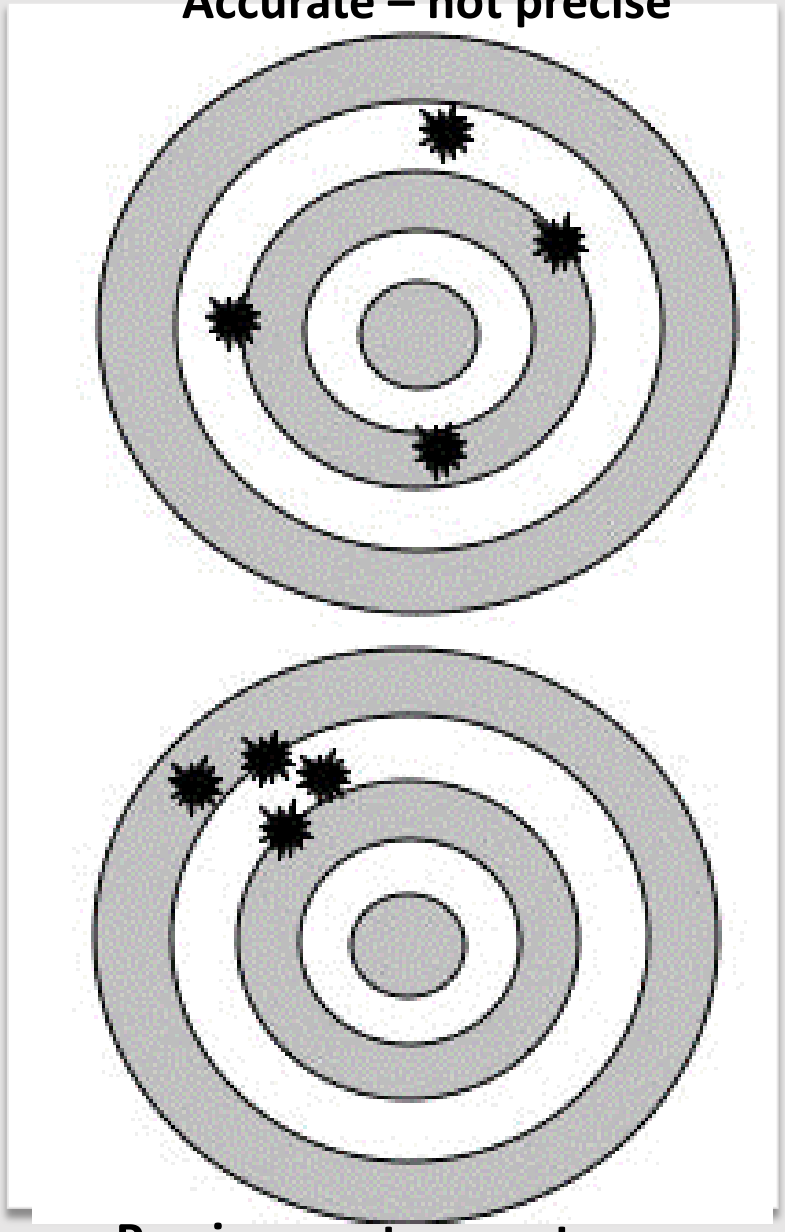
- Southern Ontario study evaluation of different approaches for future IDFs;
- McMaster U, U Waterloo, Conservation Authorities, Toronto and Essex CAs;
- **Large** variations among approaches - Large inconsistencies, discrepancies
- ***Greatest uncertainties in short-duration, high-intensity events (15 minute to 1-hour events) and larger than the 25-year return periods;***
- Difficult for stakeholders to interpret future IDFs and understand their uncertainty levels – *Consider using best management practices for current climate*



Cascading Climate Change Projection Uncertainties

- Uncertainties grow from:
  - larger to the finer scales;
  - longer to shorter time periods;
  - means to extremes.
- Some climate fields are more uncertain – *extreme & finer scale rainfall (convective) among most uncertain*
- IPCC advises use of ensemble (multiple) climate models - consider uncertainties





Climate Change Projections: Guidance and Cautions

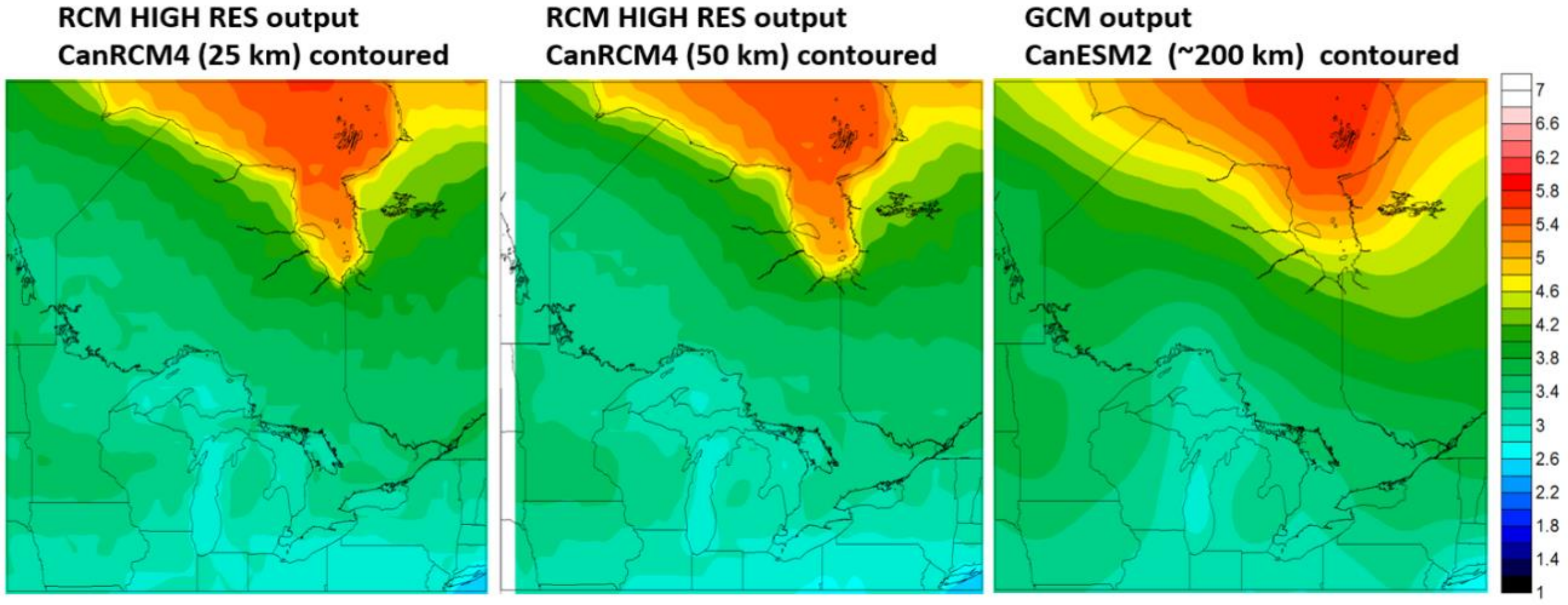
- Consider different GHG assumptions (or take a higher GHG scenario, depending on project risk tolerance)
- Caution on the signal to noise ratios!

Generally right vs Precisely wrong??!!

Other Climate Change Projection Limitations

- Many parameters will not be available from climate models
- Alternate approaches (literature, professional judgement, climate analogues)
- All models have biases (even in replicating historical climate) – varying approaches to adjust
- Get the current or baseline climate as accurate as the data allows

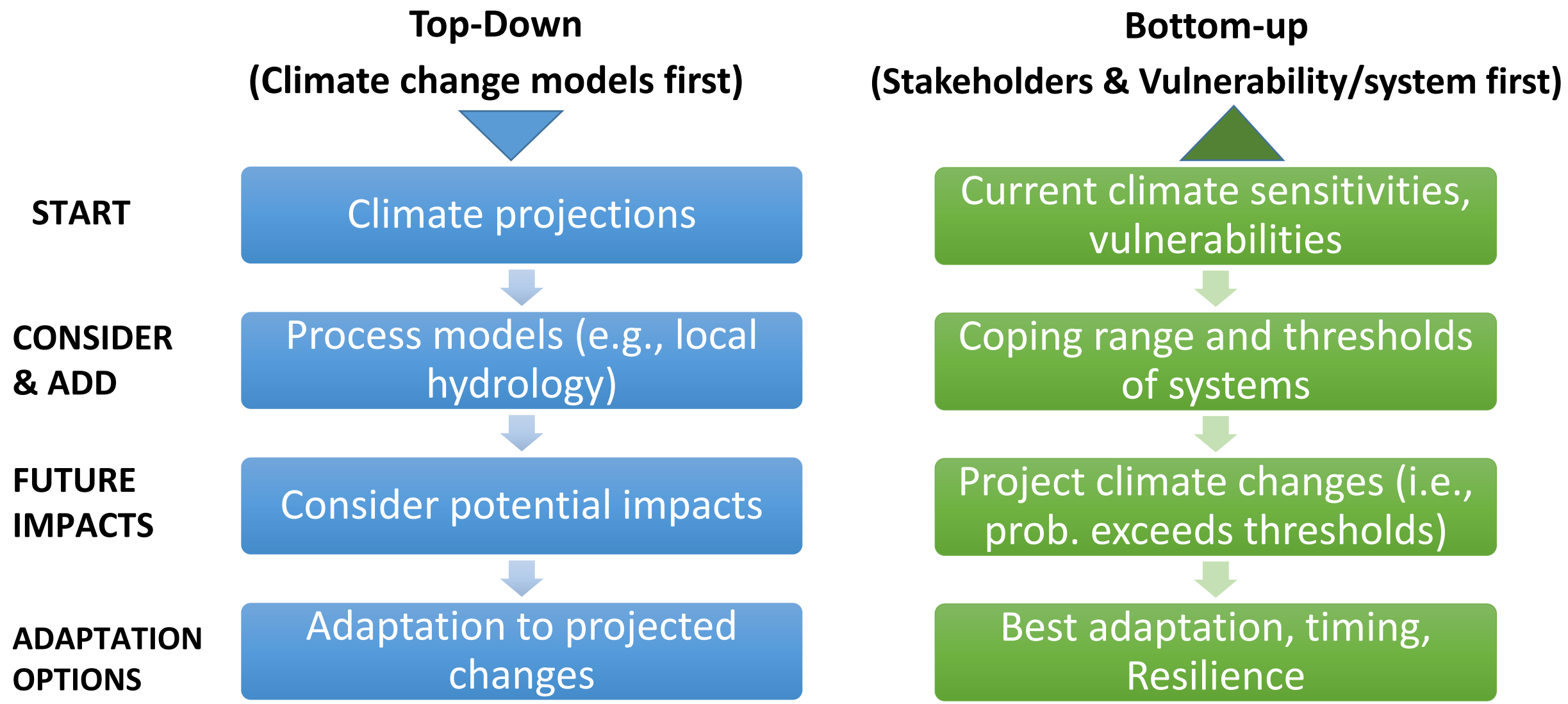
Global climate models (GCMs)? Regional scale models (RCMs)?



- Depends on region– RCMs likely better for complex terrain, mountains, coasts (IPCC, 2013)…
- Models likely underestimate thunderstorm rainfalls – need finest scale models, current data
- “Good” baseline current climate is the foundation for projections

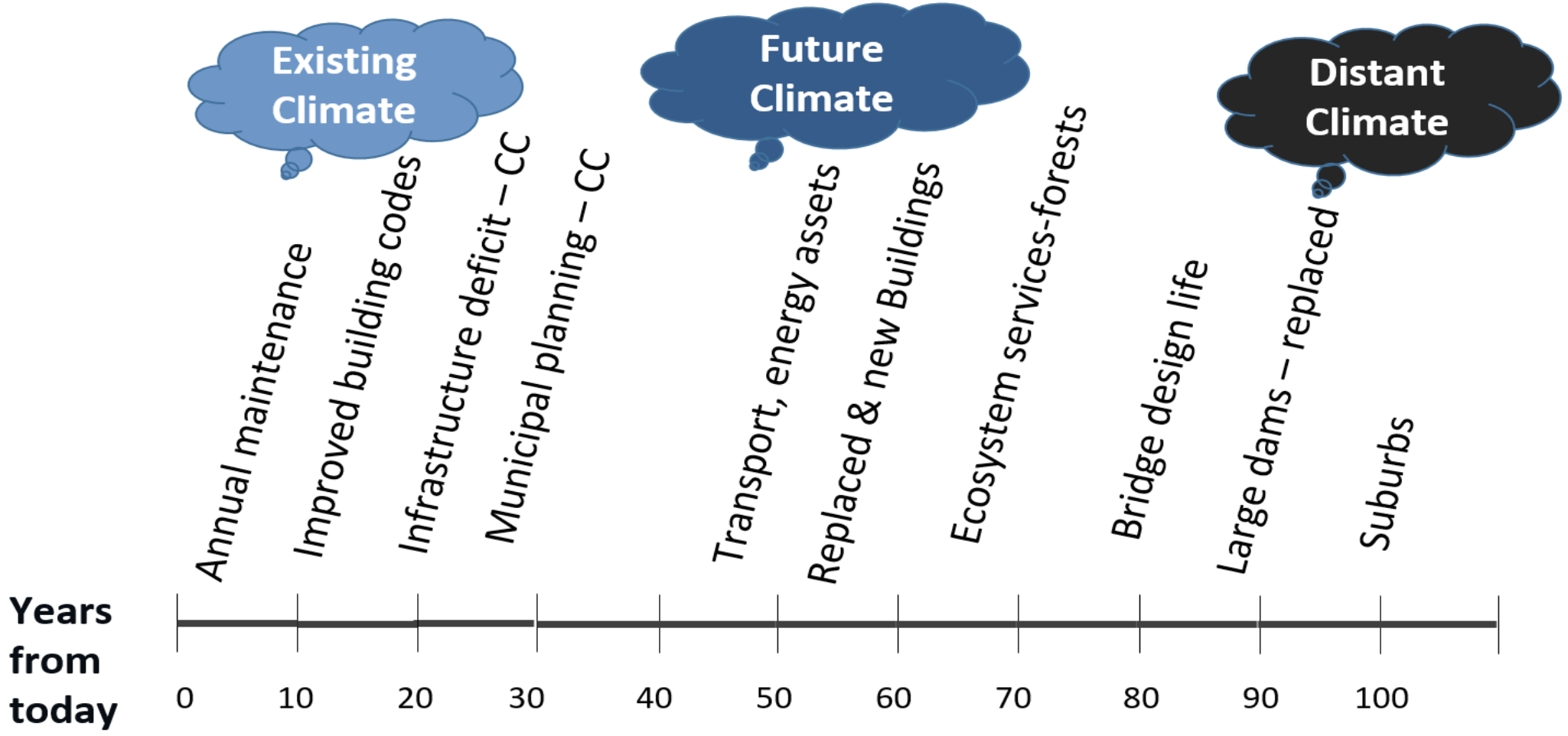
Filling the Gap: PLANNING Adaptation Options

Types of approaches for Decision-making



Adapted From IPCC SREX report (2012). Source (Ch 6): Lal, P.N., T. Mitchell, P. Aldunce, H. Auld, R. Mechler, A. Miyan, L.E. Romano, and S. Zakaria, 2012: National systems for managing the risks from climate extremes and disasters

Adaptation Options: Consider asset lifespan, rate of CC, uncertainties, risks...



Adaptation Choices for Climate & Weather Resilience

Do nothing

New approaches ***(e.g. district cooling, LID)***

Current Climate

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

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

Monitor; Improve science

With Climate Change

DESIGN (new structures?)

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)*

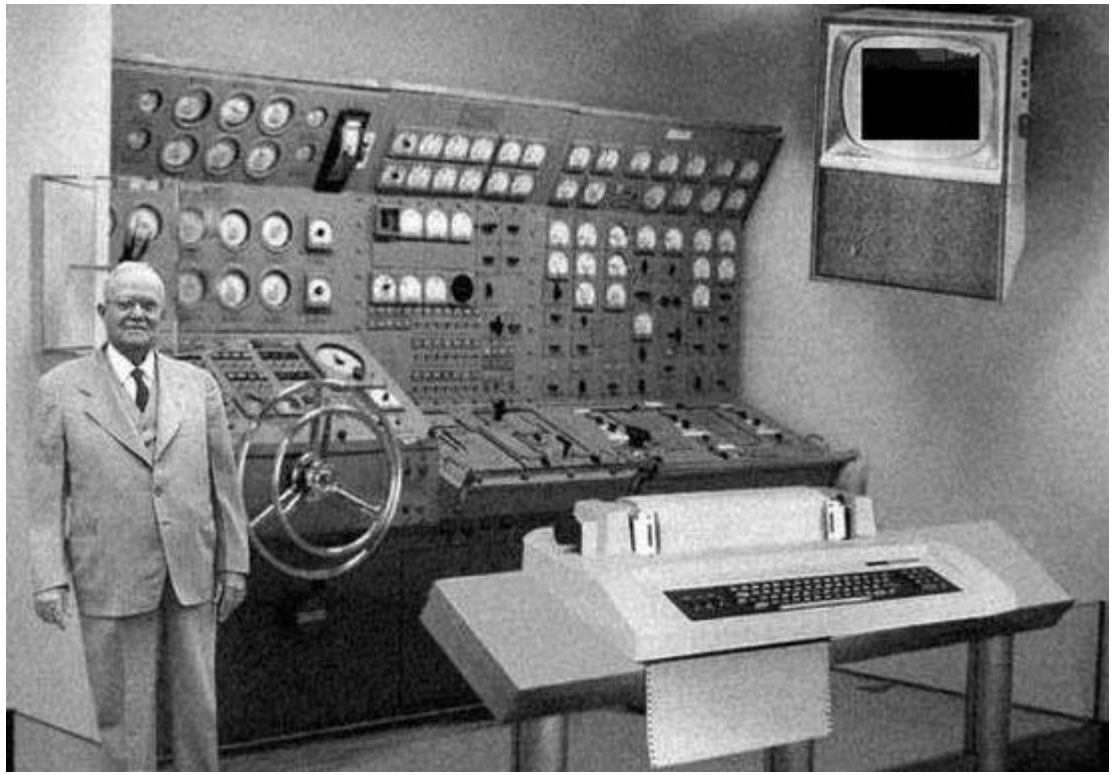
Sources of Climate Information

For specialized projections – undoubtedly requires experienced climate specialists

There is no standard or certification for the provision of climate chang information – user beware, *‘wild west’*

Most Authoritative Source of CC info

- Intergovernmental Panel on Climate Change (IPCC)
- Worldwide (climate) scientific community reports every 6 years
- **Our best science uses complex atmospheric models**
- Climatological/meteorological expertise is also important and needed



We've come a long way

Notably, changes we have seen are totally consistent with future projections

Sources of Climate Information - Examples

- **Ontario Climate Consortium (OCC) – wide range of guidance**
  http://climateontario.org/wp/about/

- **Environment and Climate Change Canada (ECCC) Historical data (IDF, normals, trends):**
  http://climate.weather.gc.ca

- **ECCC Climate Model (Note: one GCM model)**
  http://ec.gc.ca/ccmac-cccma/default.asp?lang=En&n=4A642EDE-1

- **ECCC Regional scale model (Note: one driving GCM model)**
  http://www.cccma.ec.gc.ca/data/canrcm/CanRCM4/index_cordex.shtml

- **(Ontario) OMECC Climate Change Adaptation Tool Box:**
  http://tinyurl.com/ClimateOntario

Sources of Climate Information – Examples (/2)

- **Ontario Climate Change Data Portal (developed U Regina)**
  http://www.ontarioccdp.ca/

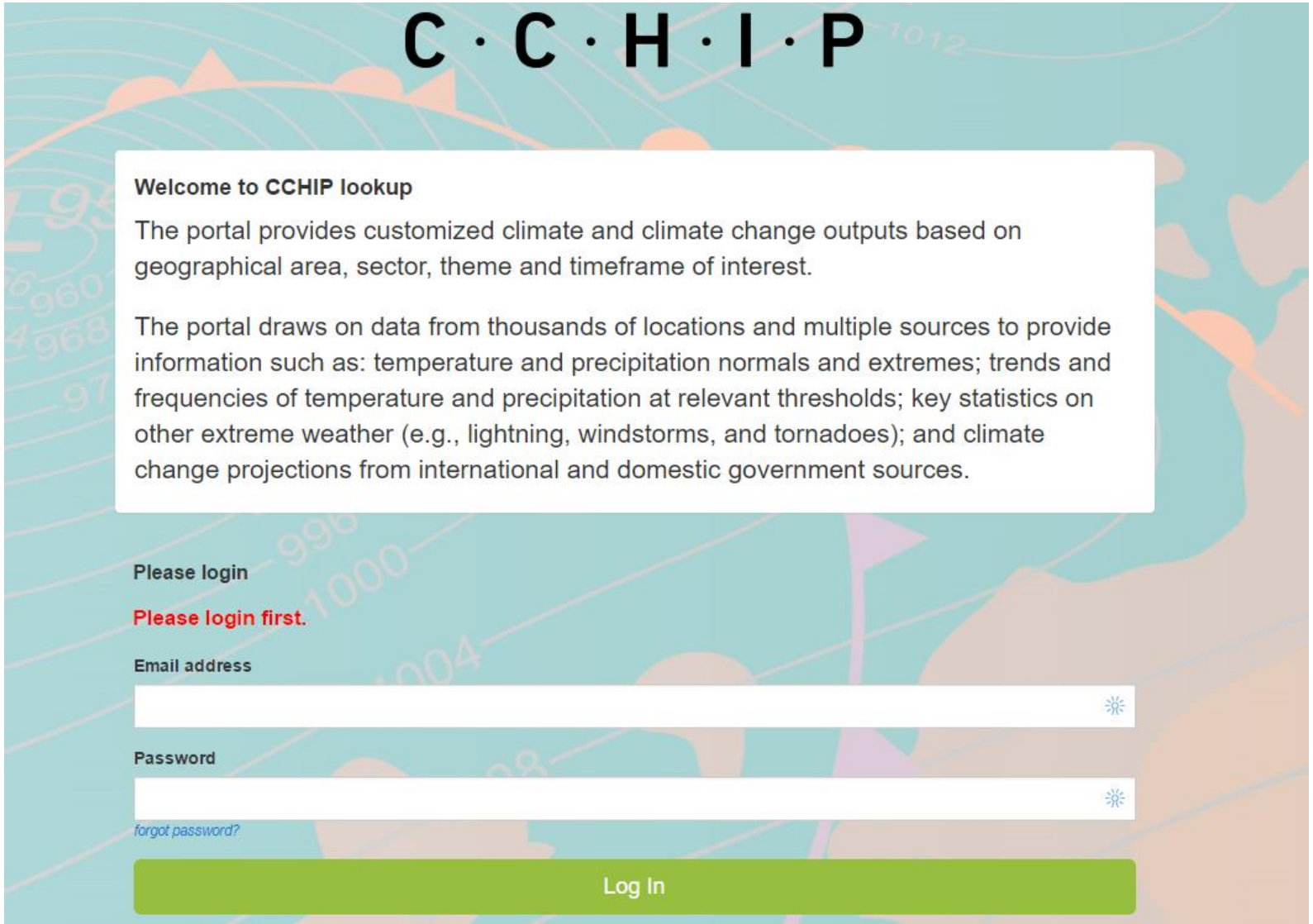
- **(Ontario) OCCIAR has a Data Page with Links to Historical and Projection Data:**
  http://www.climateontario.ca/CData.php

- **York U Ontario Climate Change Projections**
  http://lamps.math.yorku.ca/occp/node/181

- **Pacific Consortium Beta regional analysis tool (12 driving climate models)**
  http://tools.pacificclimate.org/select

- **Climate change hazards information Portal (CCHIP), Risk Sciences International with historical climate, thresholds and climate change projections, tools**
  http://cchip.ca/

RSI Climate Change Hazards Information Portal



- Web-based turnkey product
- Works for any location
- Customized outputs – thresholds
- All climate models (incl. AR5)
- Continuously updated climate data
- User support
- Available in French

Thank You!

- For further information, contact:
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  Risk Sciences International
  905-737-6026 or
  905-596-5992