Provincial Climate Change Projections
2018 Update

Government of Newfoundland and Labrador

August 2018

Overview

1. Introduction
2. Key Findings: Temperature and Precipitation
3. Key Findings: Extreme Precipitation Events
4. Risks, Impacts and Vulnerabilities
5. Conclusion

1. Introduction

Why do this work?

- **Climate change is happening**
- **Changes will be significant over time, and will impact on different industries and stakeholders in different ways**
- **Governments, businesses, individuals and communities need information to plan**
  - **Better information leads to better planning and better decision making**
  - **Better decision making can lead to reduced risks and costs**

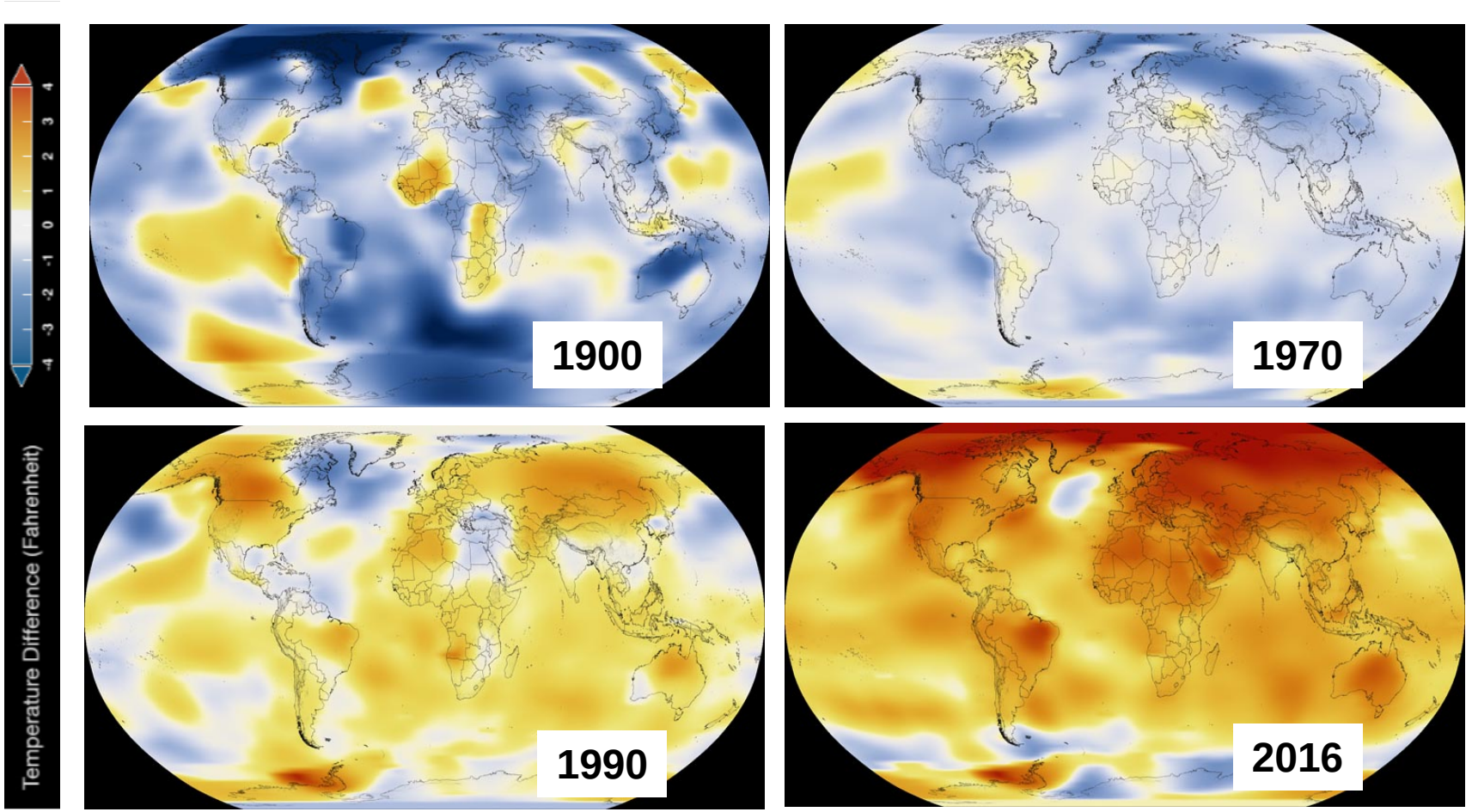
Climate Change is happening – temperatures are rising

White indicates temperatures at historical norms.

Yellow, orange and red shades indicate areas warmer than average.

Blue shades indicates areas cooler than average.

2016 was the warmest year on record.



Newfoundland Labrador

Overview of Work Since 2013

- **Provincial Government funded Memorial University to develop provincial climate change projections in 2013**
  - **Projections "downscaled" global climate models to make provincial projections**
- **Main findings: By mid-century the province will experience higher temperatures, more precipitation, more intense extreme precipitation events**
  - **Higher temperatures particularly pronounced in winter months**
- **Since 2013, models have been updated, new information is available, and change in projected climate variables have been more pronounced than anticipated**
- **Provincial Government funded Memorial University to update projections in 2018 using North American downscaling techniques**
  - **Same prediction approaches used by Ouranos (QC) and Pacific Climate Impacts Consortium (BC)**
  - **Methodology is peer reviewed by academic and industry experts**

Technical Overview of 2018 Study

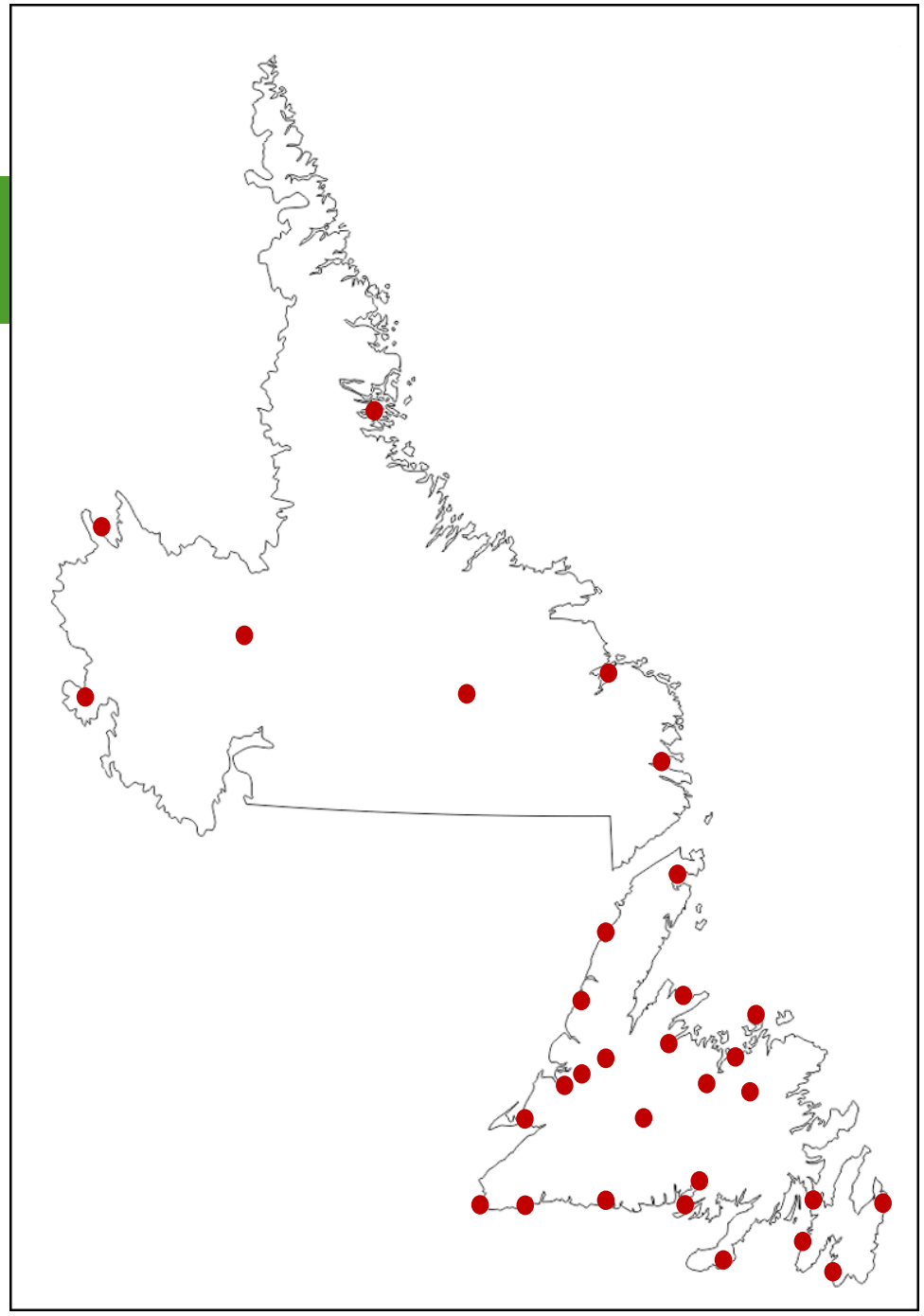
- **Based on 5th Report from Intergovernmental Panel on Climate Change (2014)**
  - **Previous study based on 4th Report (2007)**
  - **Focus is on RCP8.5 (business as usual) scenario**
- **Ensemble approach – 6 Pacific Climate Impact Consortium (PCIC) statistical downscaling simulations and 6 NA-CORDEX dynamic downscaling simulations**
  - **Previous study used 7 North American Regional Climate Change Assessment Program (NARCCAP) downscaling simulations (NA-CORDEX is the successor to NARCCAP)**
- **Projections for 2041-2070 and 2071-2100**
  - **Previous study used 2041-2070 only**
- **25x25 km grids where possible, 50x50 km grids otherwise**
  - **Previous study used 50x50 grids only**

Newfoundland Labrador

Location Overview

- **28 weather stations in the province assessed for temperature and precipitation, plus 1 in Schefferville, QC**
  - **Previous study used 16 locations (did not include Schefferville)**

Newfoundland		Labrador (and Quebec)
Argentia	LaScie	Cartwright
Bay d'Espoir	North Harbour	Churchill Falls
Burgeo	Plum Point	Goose Bay
Comfort Cove	Port aux Basques	Mary's Harbour
Corner Brook	Springdale	Nain
Daniel's Harbour	St. Alban's	Wabush Lake
Deer Lake	St. Anthony	Schefferville (Quebec)
Exploit's Dam	St. John's	
Gander	St. Lawrence	
Grand Falls	Stephenville	
Isle aux Morts	Twillingate	



Temperature and Precipitation Overview

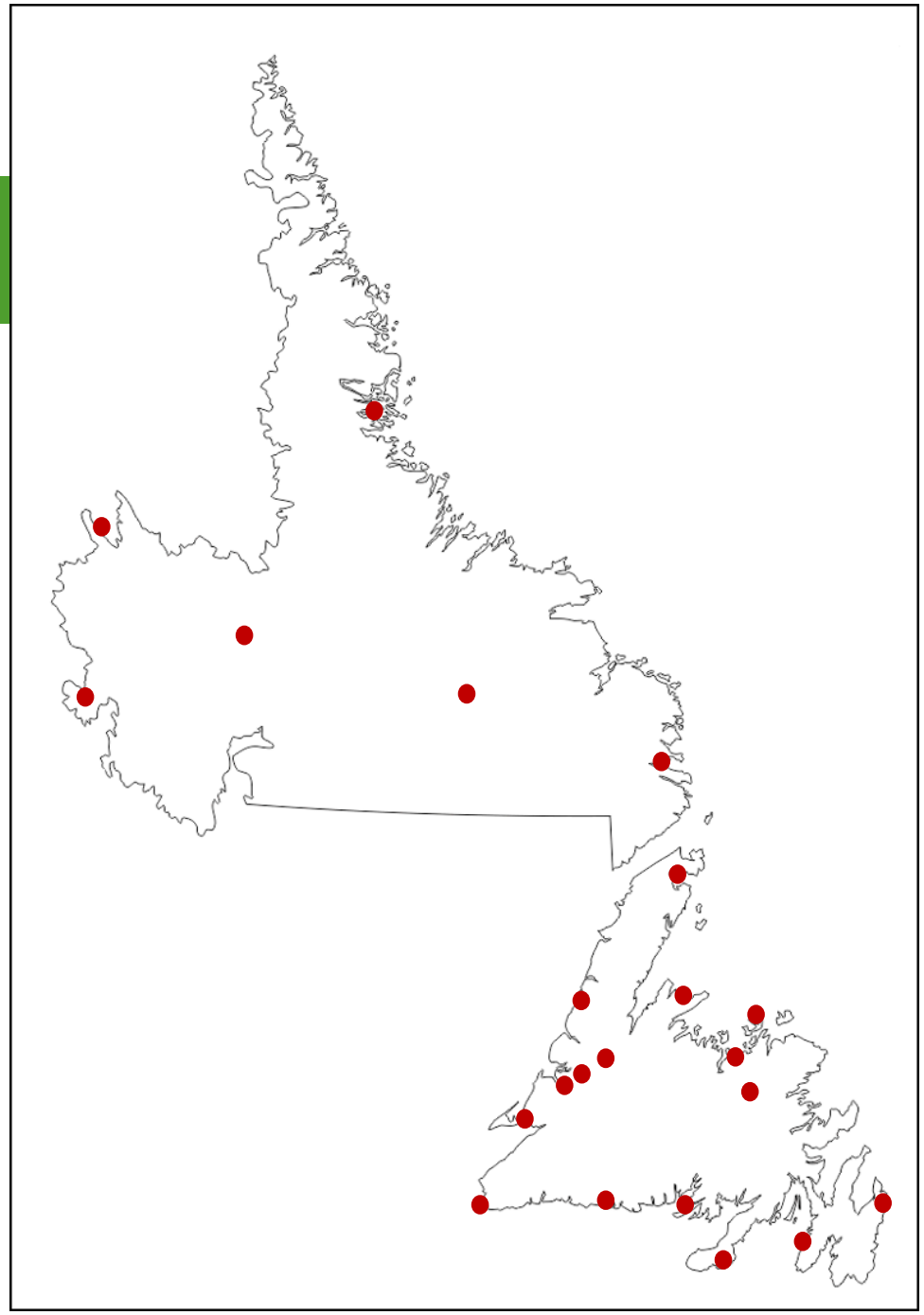
- **Projections completed for 20 temperature and precipitation variables**
  - **Previous study projected 19 variables (did not include number of frost-free days)**

Temperature	Precipitation
Average Daily Mean Temperature	Mean Daily Precipitation
Mean Daily Minimum Temperature	Mean Intensity of Precipitation Events
Mean Daily Maximum Temperature	90th Percentile of Precipitation Events
Cooling Degree Day	Maximum 3-day Precipitation
Heating Degree Day	Maximum 5-day Precipitation
Growing Degree Day	Maximum 10-day Precipitation
Number of Frost Days	Number of Days With 10mm or More of Precipitation
Number of Frost Free Days	Maximum Number of Consecutive Dry Days
Maximum Heat Wave Duration	Average Dry Spell Length
	Median Dry Spell Length
	Standard Deviation of Dry Spell Length

Extreme precipitation overview

- **Projections for 7 intervals and 6 return periods for 20 locations**
  - **Previous study projected 3 intervals and 6 return periods**

Locations		Intervals	Return periods
Argentia Burgeo Comfort Cove Daniel's Harbour Deer Lake Gander LaScie Port aux Basques St. Alban's St. Anthony Stephenville St. John's St. Lawrence Twillingate	Churchill Falls Goose Bay Mary's Harbour Nain Schefferville (QC) Wabush Lake	5 minutes 10 minutes 15 minutes 30 minutes 1 hour 2 hours 6 hours 12 hours 24 hours	2 years 5 years 10 years 25 years 50 years 100 years



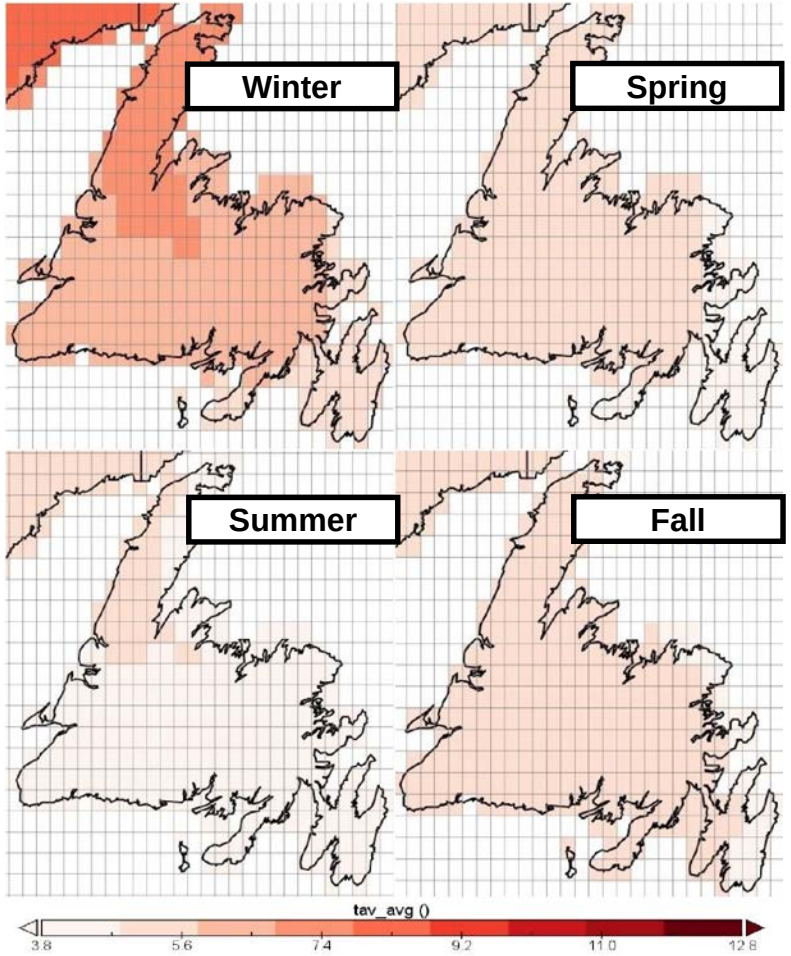
2. Key Findings:
Temperature and Precipitation

Key Messages from the Study

- Current study includes more locations, more recent data and improved modeling from 2013
- Key messages from 2013 remain – province is projected to become warmer, wetter, stormier
- However, current study projects even more pronounced trends - with the province becoming even warmer, even wetter and even stormier than projected in 2013
  - Winter temperature growth, especially in Labrador, is projected to be 7.3°C higher by-mid-century as opposed to the 3.8°C projected in 2013
  - Frost days (proxy for winter) are projected to decline by 4-5 weeks by mid-century and 7-8 weeks by late century
  - Degree growing days projected to grow by as much as 50% by mid century and to more than double by late century
  - Number of precipitation days projected to remain relatively stable, but precipitation events projected to be more intense

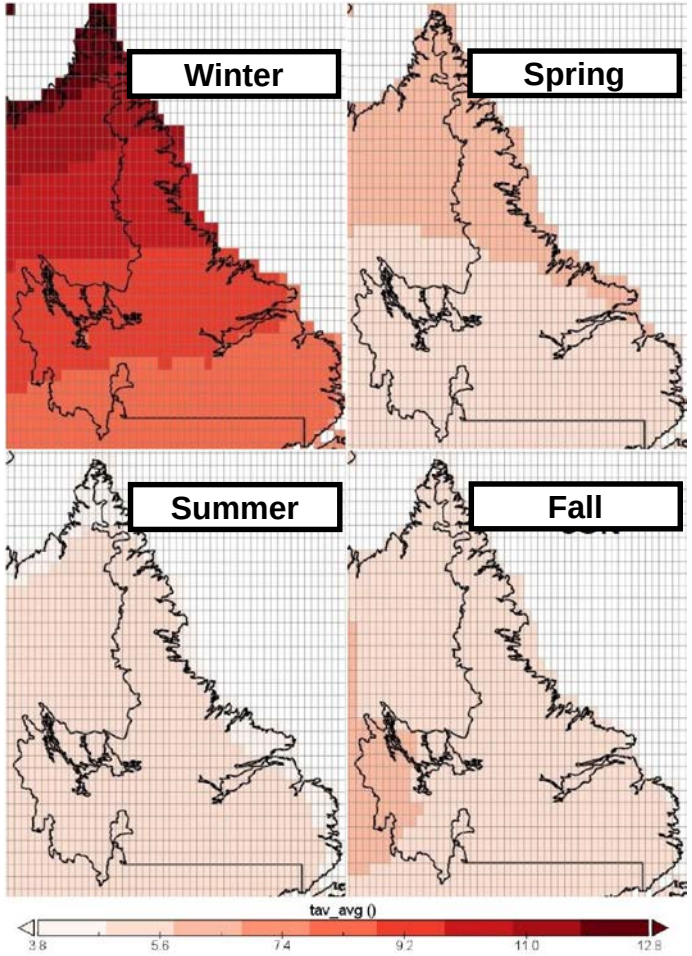
Temperatures are projected to rise (1)

Change in average daily temperature – end of 20th century to mid 21st century



Highest projected temperature growth in winter and in Labrador.

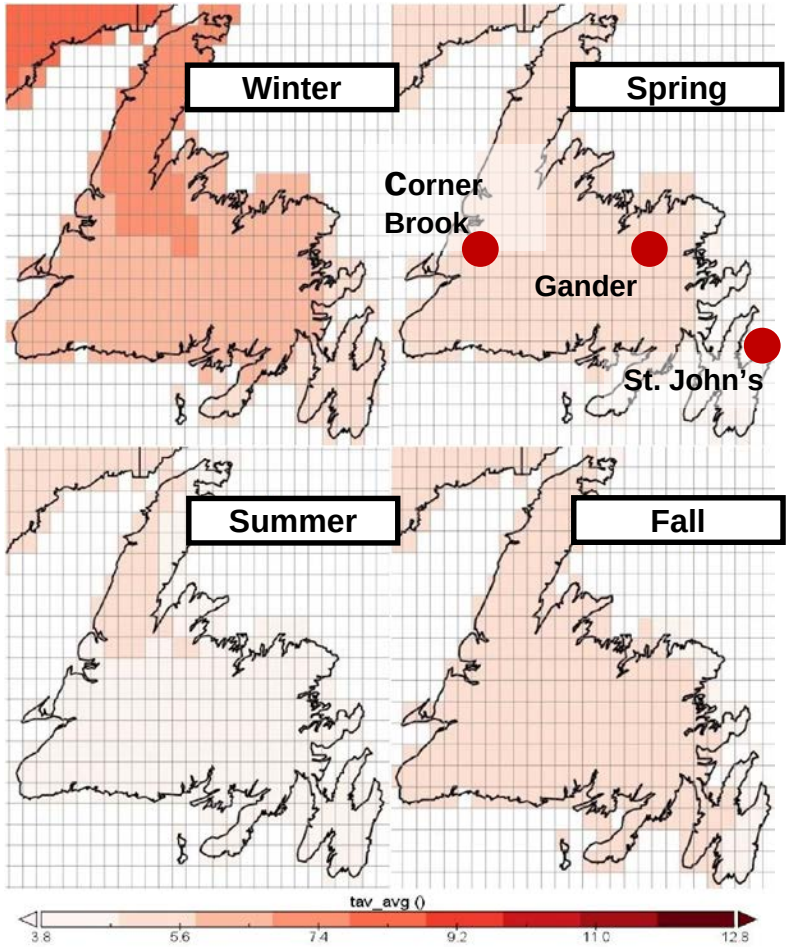
Lowest projected temperature growth in summer and on south half of island.



Newfoundland Labrador

Temperatures are projected to rise (2)

Change in average daily temperature – end of 20th century to mid 21st century



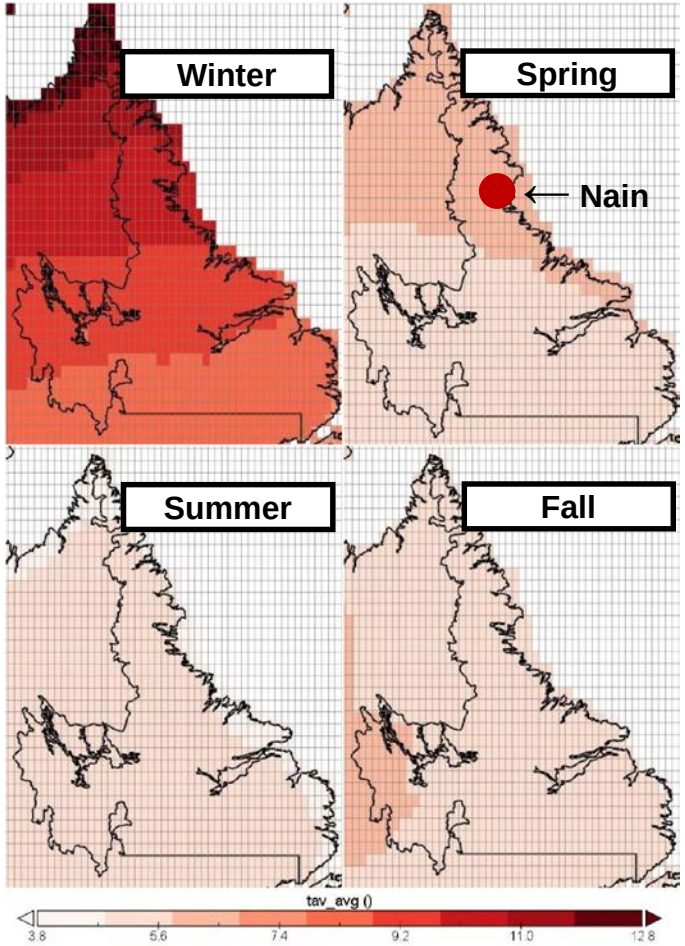
Select locations

Nain
+7.3°C in winter
+2.6°C in summer

Corner Brook
+4.4°C in winter
+3.0°C in summer

Gander
+4.3°C in winter
+2.6°C in summer

St. John's
+3.4°C in winter
+2.4°C in summer



Newfoundland Labrador

Temperatures are projected to rise (3)

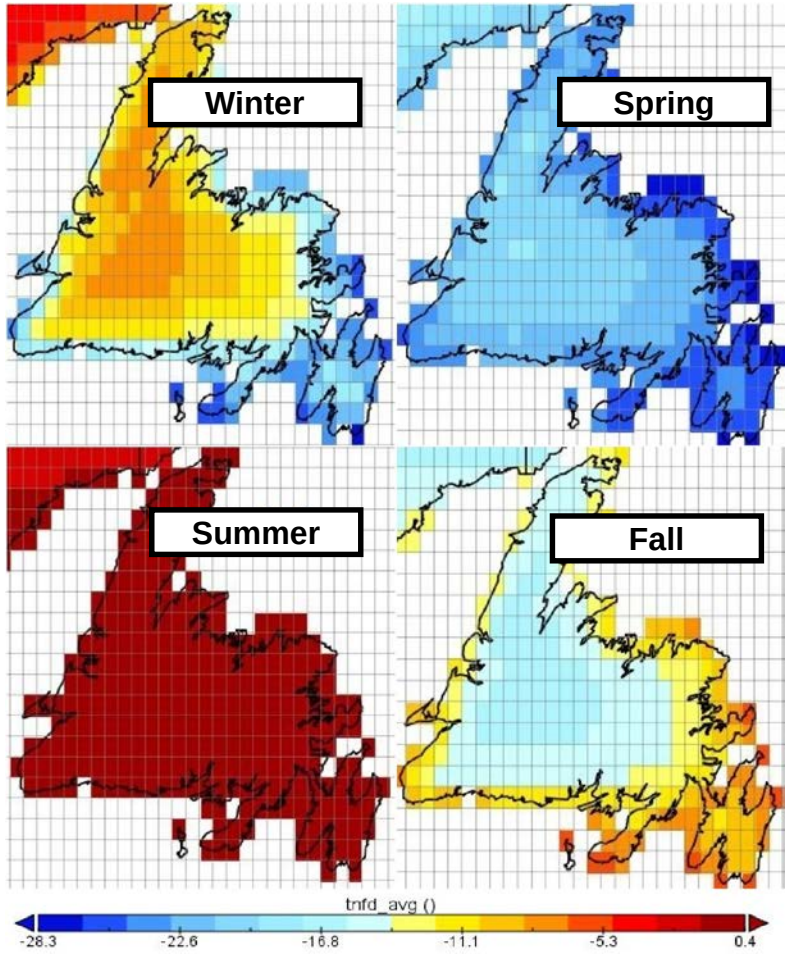
Change in average daily temperature – end of 20th century to end of 21st century

Select locations – Change in °C				
	By mid century		By late century	
	Summer	Winter	Summer	Winter
St. John's	+2.4	+3.4	+4.2	+5.3
Gander	+2.6	+4.0	+4.7	+6.6
Corner Brook	+3.0	+4.4	+5.0	+6.8
St. Anthony	+2.7	+5.0	+4.7	+7.5
Goose Bay	+2.9	+6.0	+5.0	+9.2
Nain	+2.6	+7.3	+4.8	+10.9

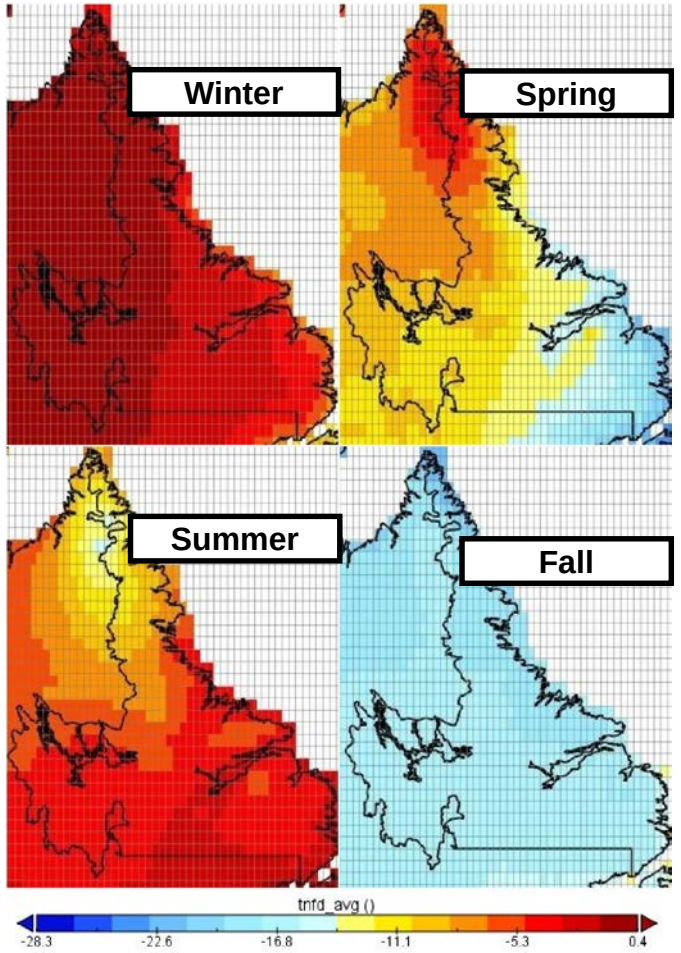
Newfoundland Labrador

Number of days with frost is projected to decline (1)

Change in number of frost days – end of 20th century to mid 21st century



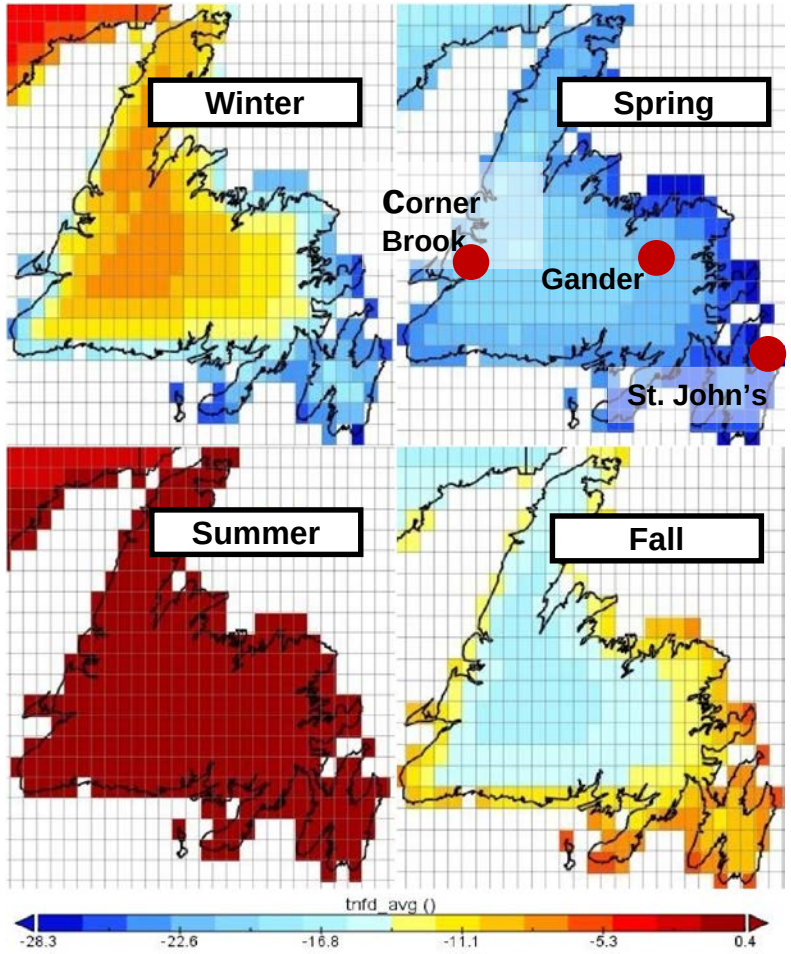
The number of frost days is a rough proxy for change to and from winter season, and a rough proxy for the potential number of days when there may be snow.



Newfoundland Labrador

Number of days with frost is projected to decline (2)

Change in number of frost days – end of 20th century to mid 21st century



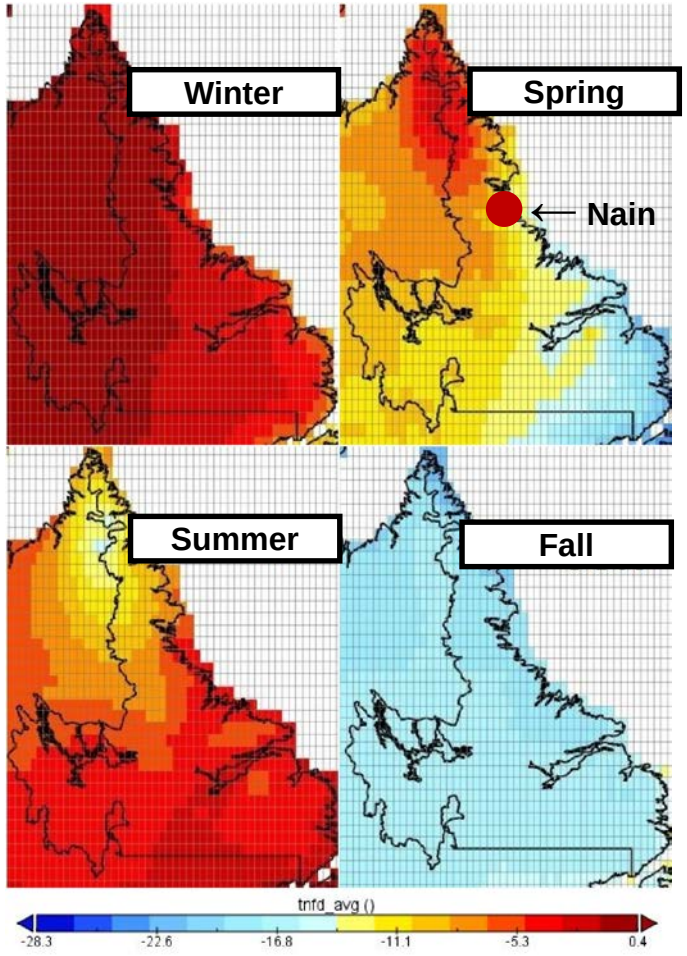
Select locations

Nain
-21.6 Days in Fall
-11.4 Days in Spring

Corner Brook
-12.8 Days in Fall
-20.3 Days in Spring

Gander
-14.2 Days in Fall
-24.9 Days in Spring

St. John's
-12.8 Days in Fall
-19.3 Days in Spring



Newfoundland Labrador

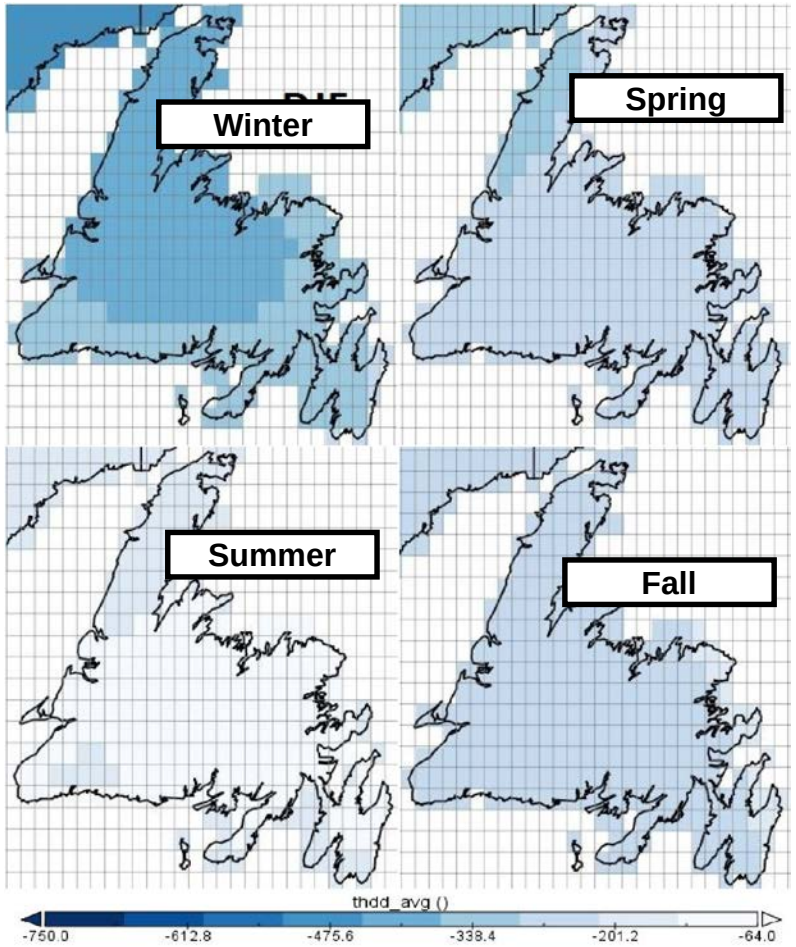
Number of days with frost is projected to decline (3)

Change in number of frost days – end of 20th century to end of 21st century

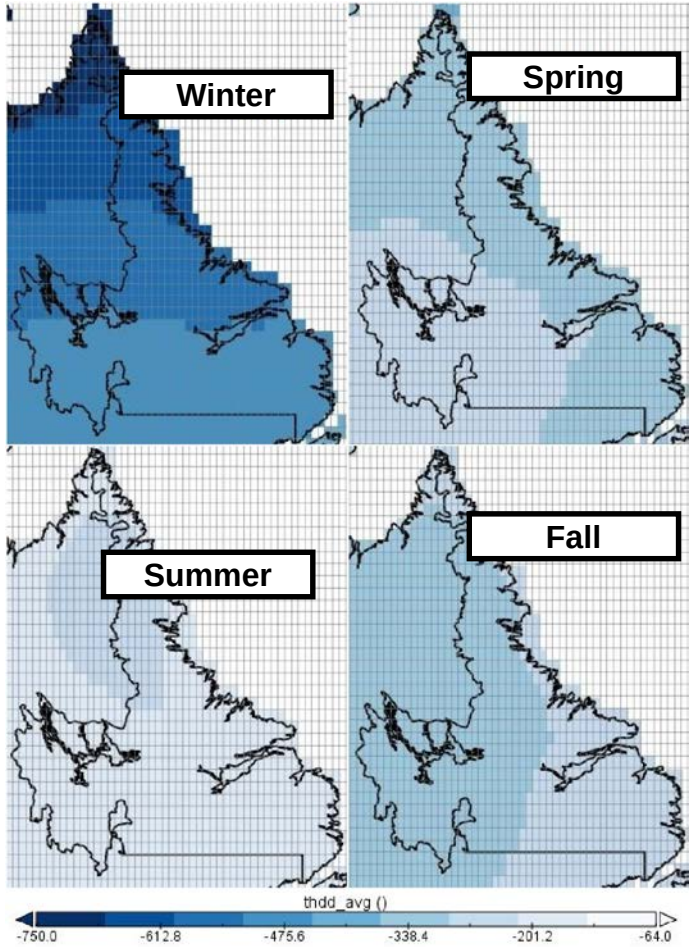
Select locations – Change in number of frost days				
	By mid century		By late century	
	Fall	Spring	Fall	Spring
St. John's	-12.76	-19.26	-15.80	-35.61
Gander	-14.21	-24.89	-19.75	-38.36
Corner Brook	-12.84	-20.26	-16.73	-31.39
St. Anthony	-15.88	-20.72	-22.07	-35.09
Goose Bay	-19.50	-15.56	-28.19	-26.90
Nain	-21.57	-11.41	-30.77	-24.07

Warmer temperatures mean less demand for space heat (1)

Change in heating degree days – end of 20th century to mid 21st century



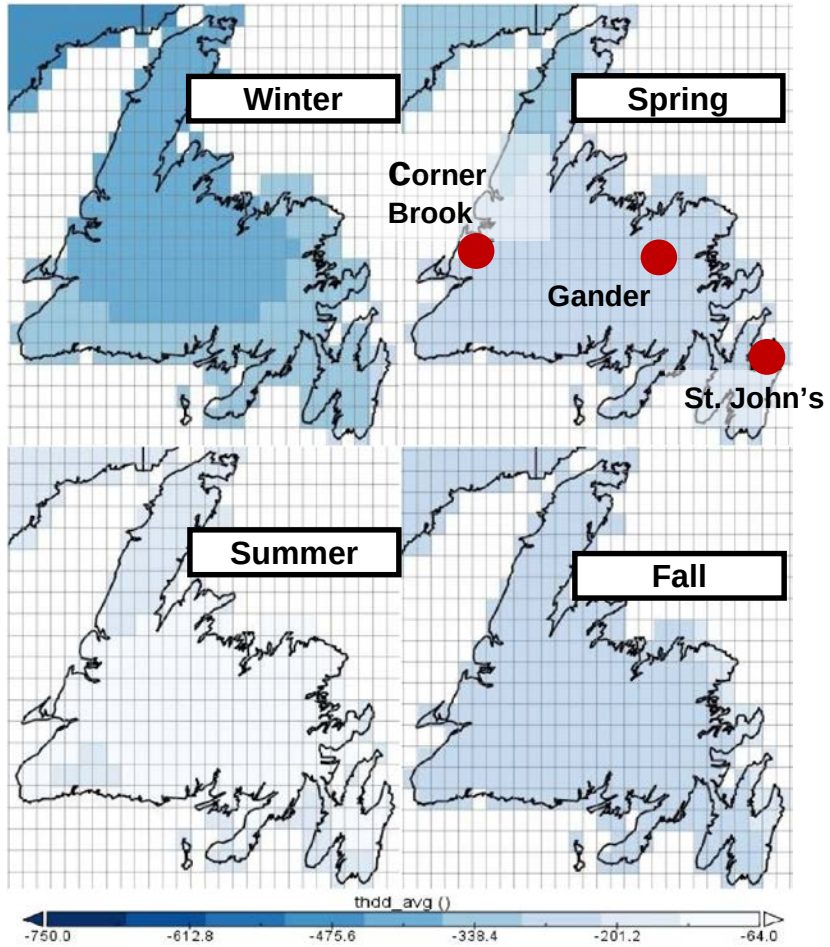
Demand for space heating correlated with winter, spring and fall temperature change as most space heating is required during colder months



Newfoundland Labrador

Warmer temperatures mean less demand for space heat (2)

Change in heating degree days – end of 20th century to mid 21st century



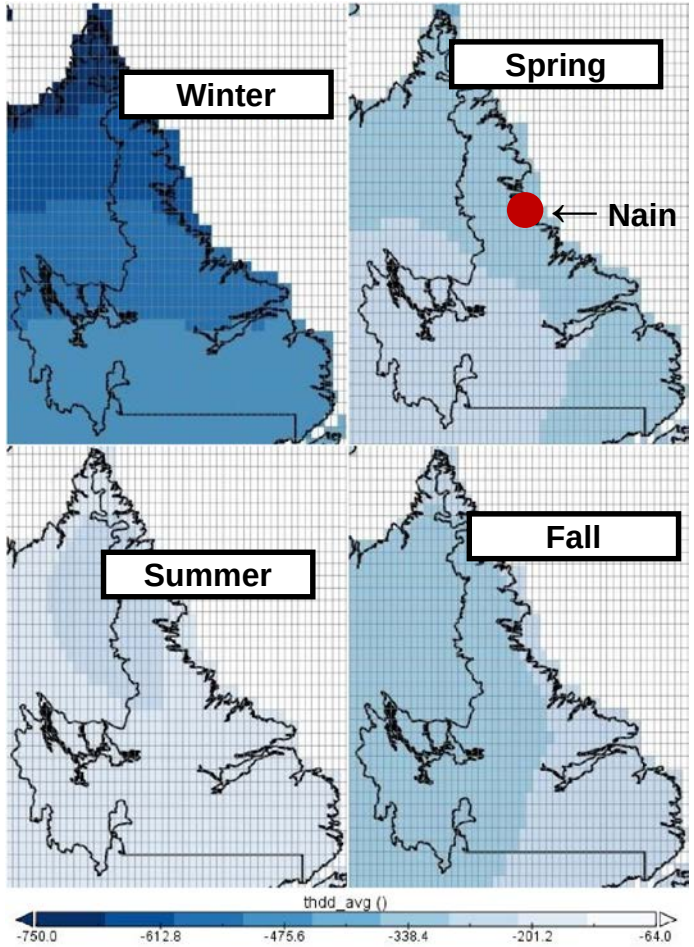
Select locations

Nain
-23% in winter
-21% annually

Corner Brook
-21% in winter
-24% annually

Gander
-20% in winter
-22% annually

St. John's
-18% in winter
-20% annually



Newfoundland Labrador

Warmer temperatures mean less demand for space heat (3)

Change in heating degree days – end of 20th century to end of 21st century

Select locations – Percent change				
	By mid century		By late century	
	Winter	Annual	Winter	Annual
St. John's	-18%	-20%	-28%	-33%
Gander	-20%	-22%	-31%	-35%
Corner Brook	-21%	-24%	-32%	-38%
St. Anthony	-20%	-21%	-31%	-33%
Goose Bay	-20%	-21%	-30%	-33%
Nain	-23%	-21%	-34%	-34%

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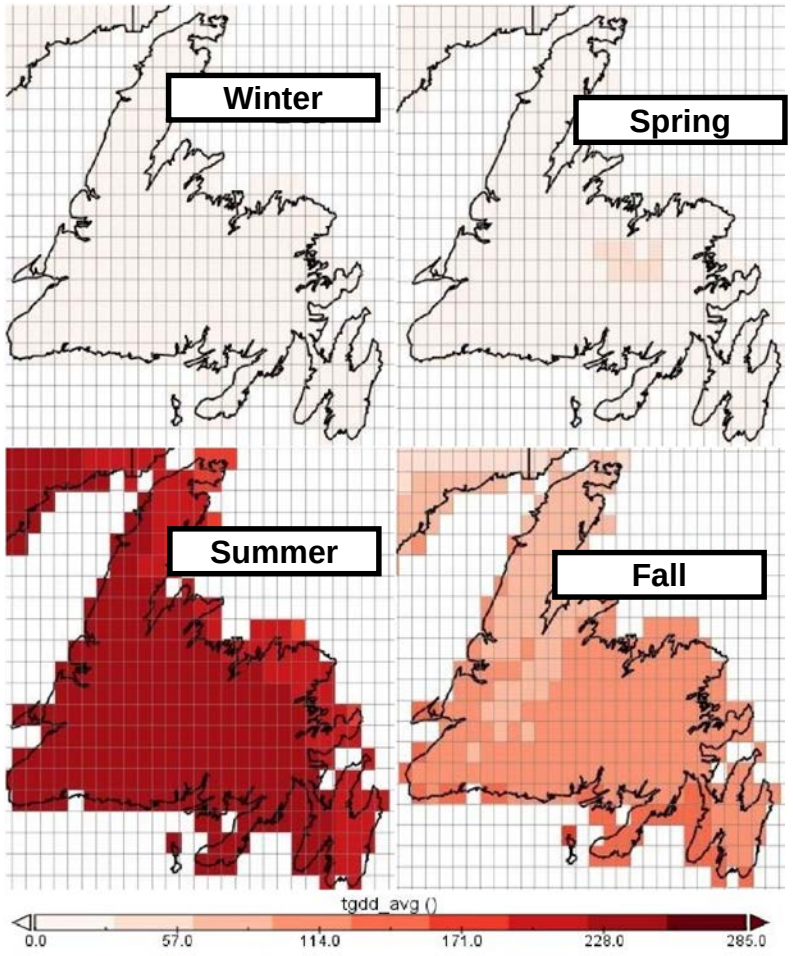
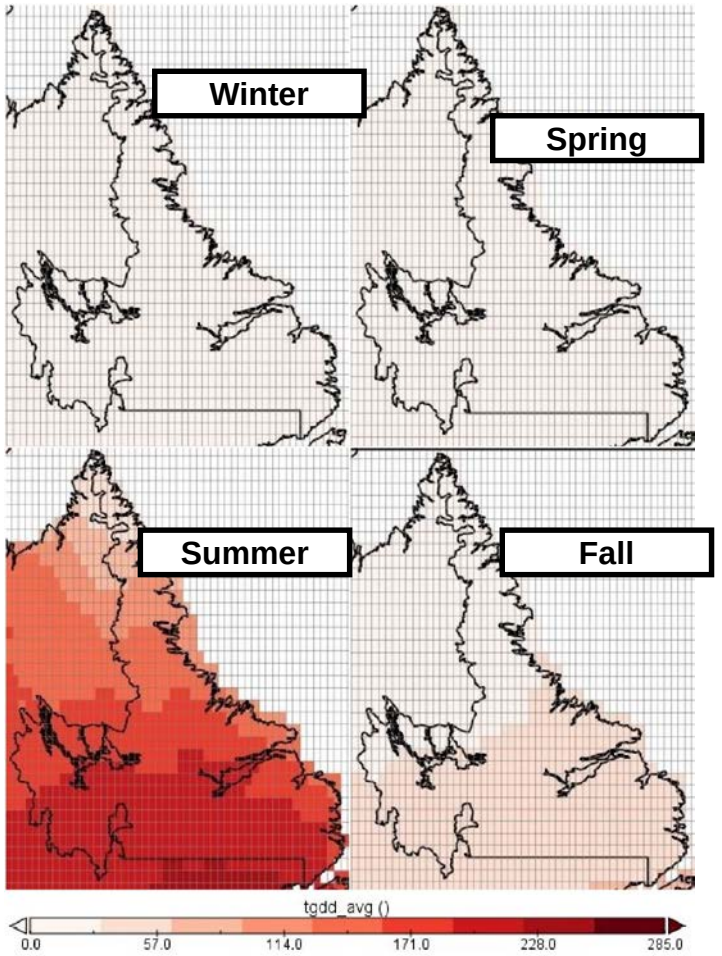
Warmer temperatures mean more resource productivity (1)

Change in growing degree days – end of 20th century to mid 21st century



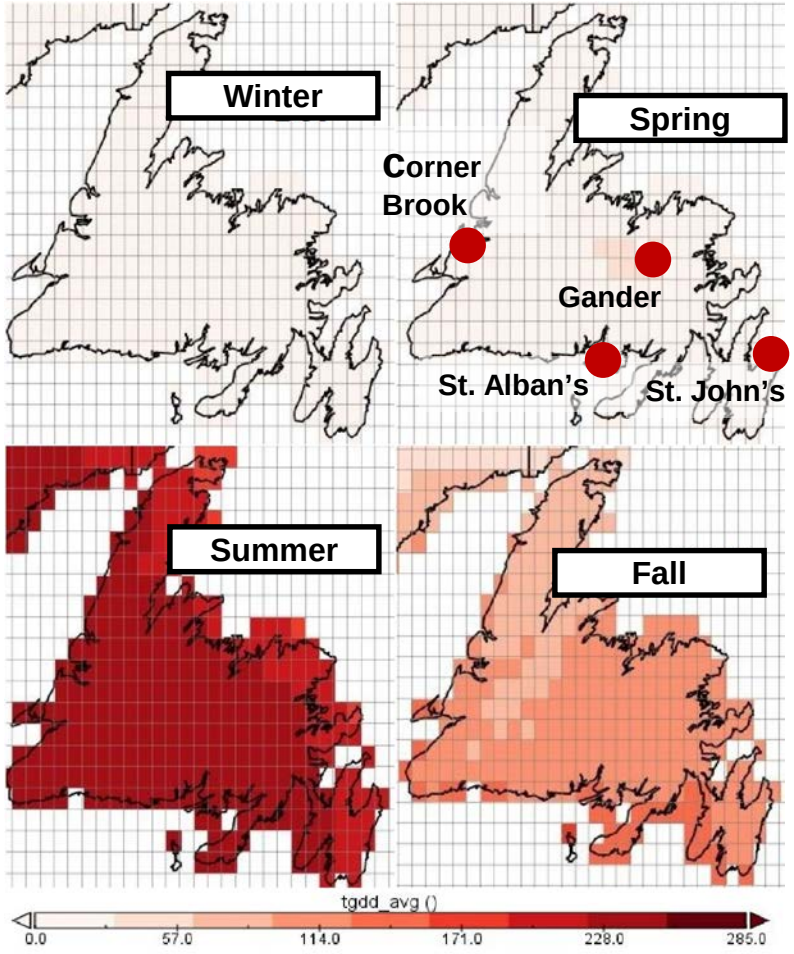
Growing degree days is a measure for warmth in soil and water and impacts on agriculture, forestry and fisheries productivity. It is correlated with rising temperatures in summer, spring and fall.



Newfoundland Labrador

Warmer temperatures mean more resource productivity (2)

Change in growing degree days – end of 20th century to mid 21st century



Select locations

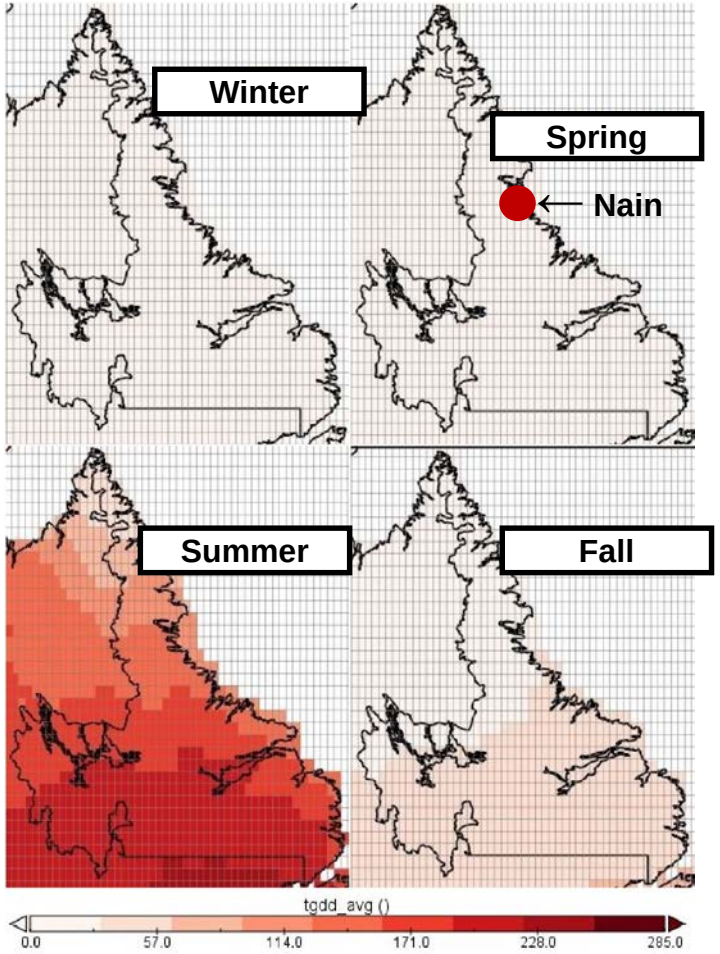
Nain
+126% annually

Corner Brook
+64% annually

Gander
+59% annually

St. John's
+61% annually

St. Alban's
+75% annually



Newfoundland Labrador

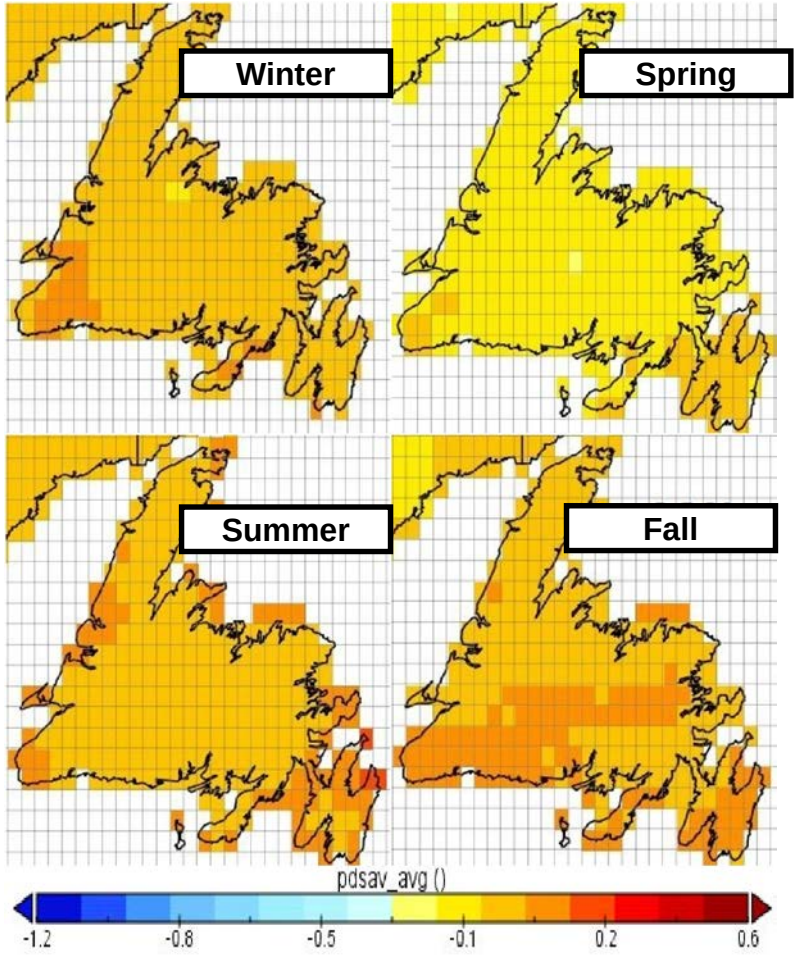
Warmer temperatures mean more resource productivity (3)

Change in growing degree days – end of 20th century to end of 21st century

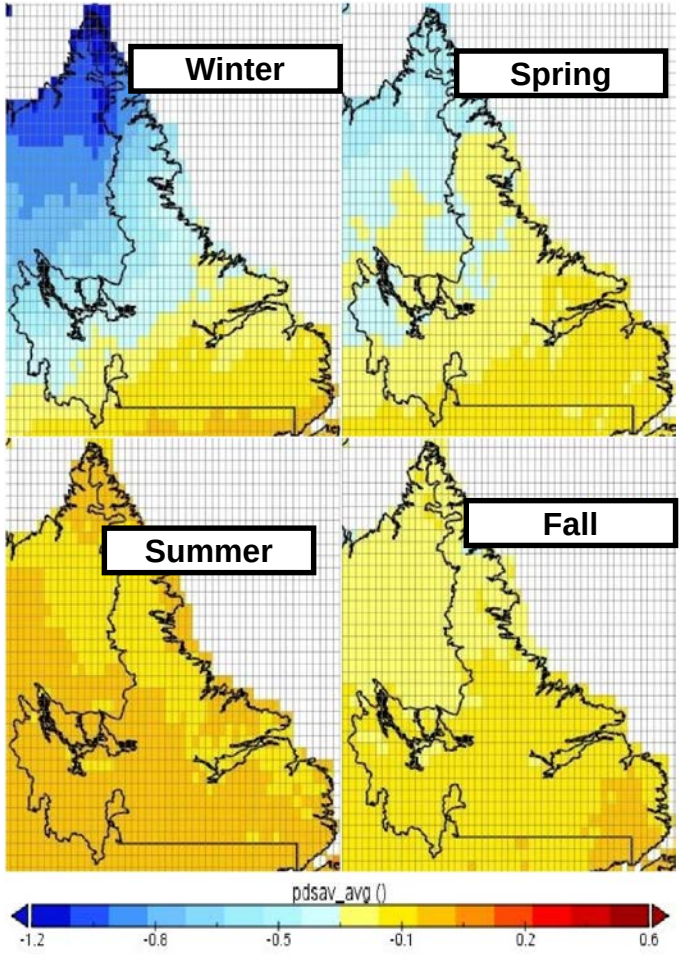
Select locations – Percent change		
	By mid century	By late century
	Annual	Annual
St. John's	61%	117%
Gander	59%	111%
St. Alban's	75%	137%
Corner Brook	64%	115%
St. Anthony	78%	149%
Goose Bay	69%	130%
Nain	126%	294%

The average dry spell is expected to remain stable (1)

Change in average dry spell – end of 20th century to mid 21st century



Dry spells are a measure for frequency of precipitation, stress on vegetation (from lack of water), and propensity for flooding (if waterways have more or less time to clear after major precipitation events)



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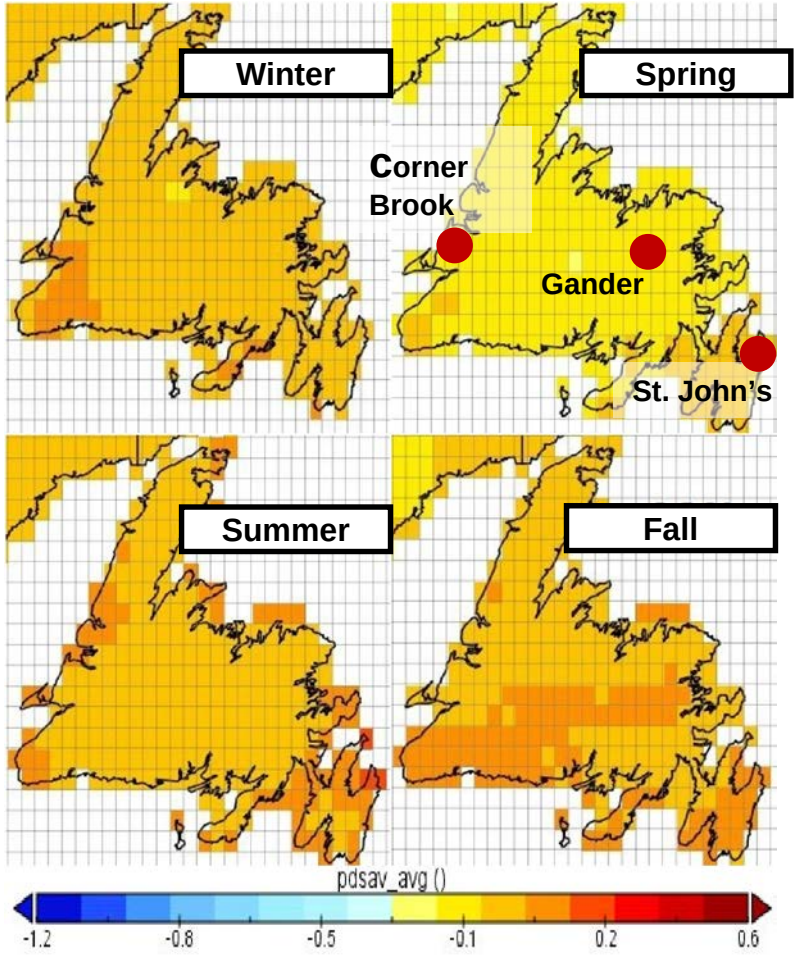
The average dry spell is expected to remain stable (2)

Change in average dry spell – end of 20th century to mid 21st century



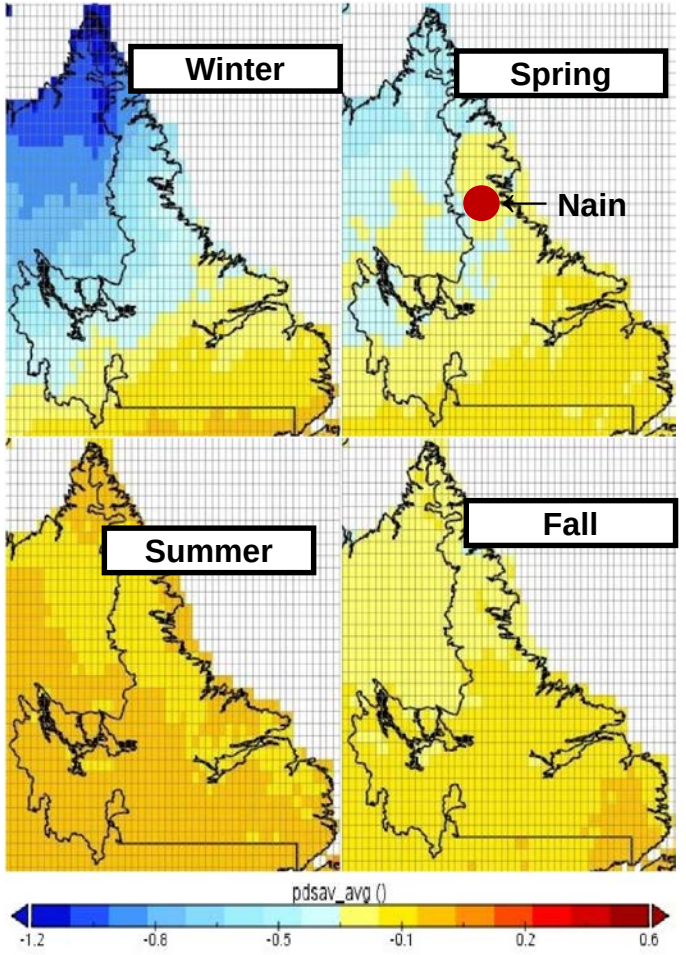
Select locations

Nain
-0.4 days in Fall
-0.7 days in Spring

Corner Brook
+0.5 days in Fall
+0.5 days in Spring

Gander
+0.3 days in Fall
+0.3 days in Spring

St. John's
+0.9 days in Fall
+0.2 days in Spring



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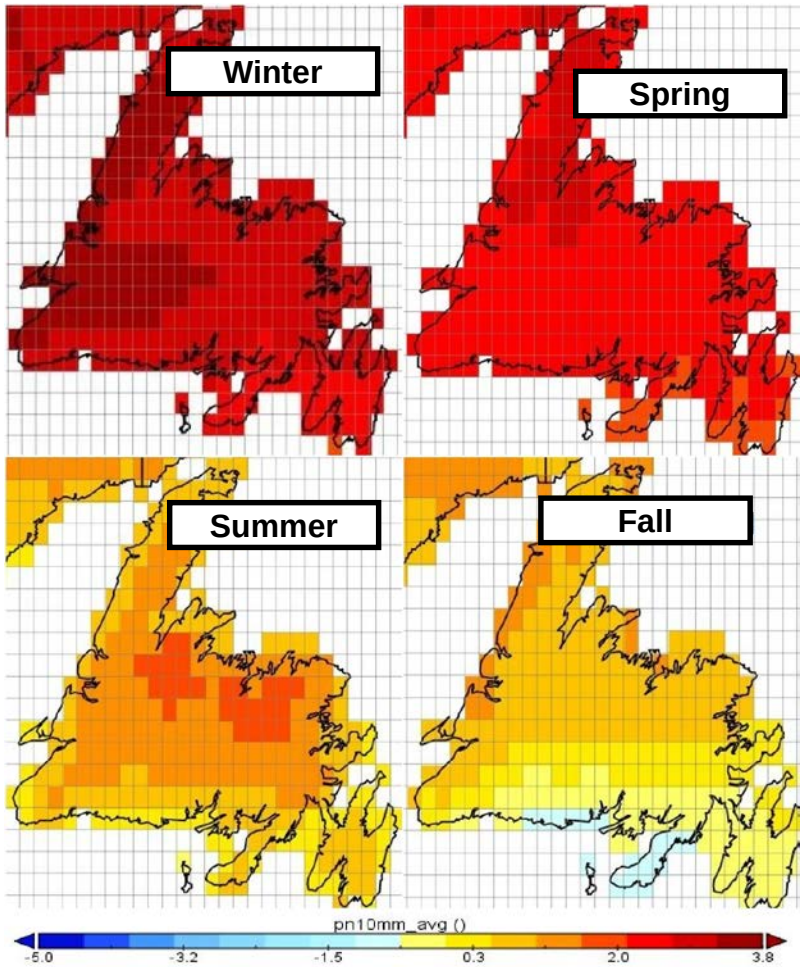
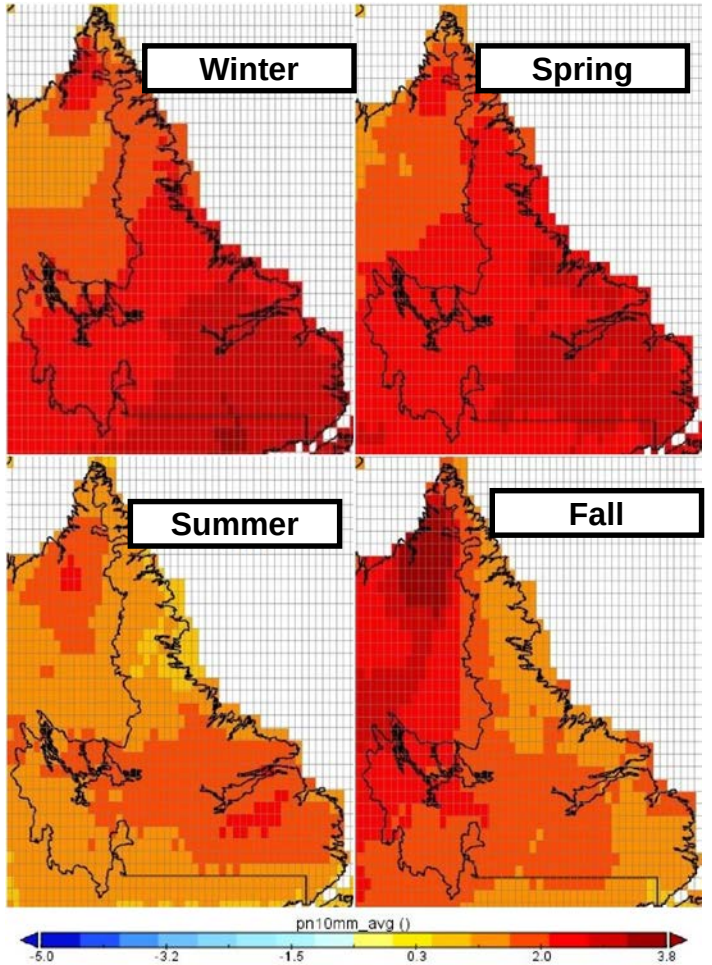
Number of high precipitation days is expected to increase (1)

Change in precipitation day with 10+ mm – end of 20th century to mid 21st century



High precipitation days are a proxy for erosion and flooding propensity.

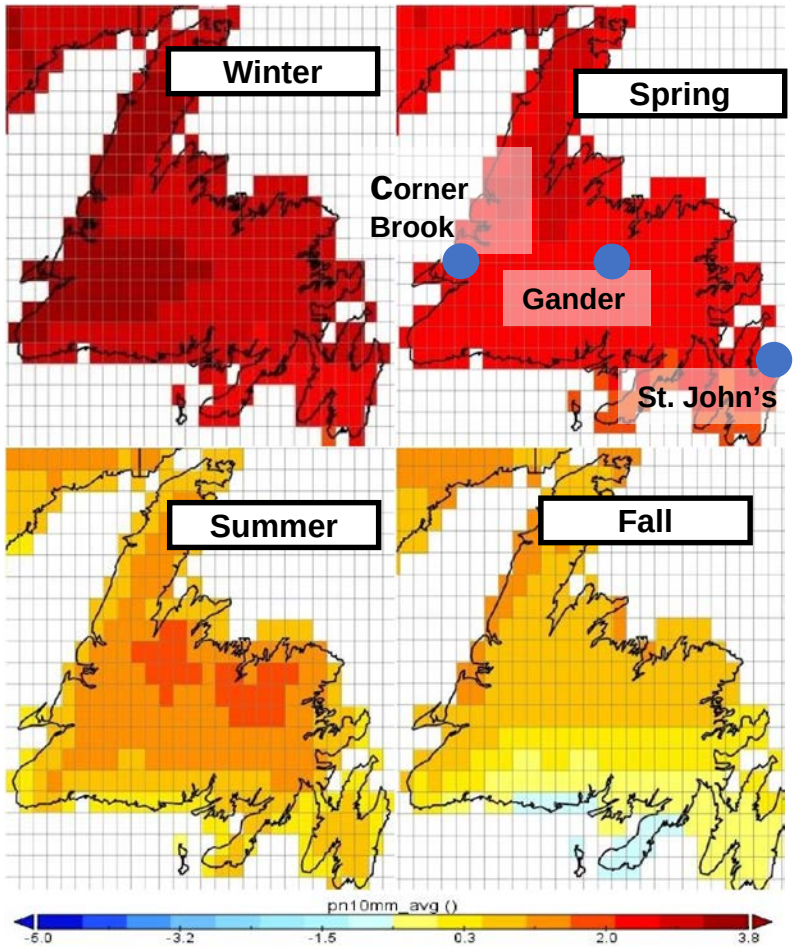
10mm of rain precipitation equates to at least 10cm of snow precipitation.



Newfoundland Labrador

Number of high precipitation days is expected to increase (2)

Change in precipitation day with 10+ mm – end of 20th century to mid 21st century



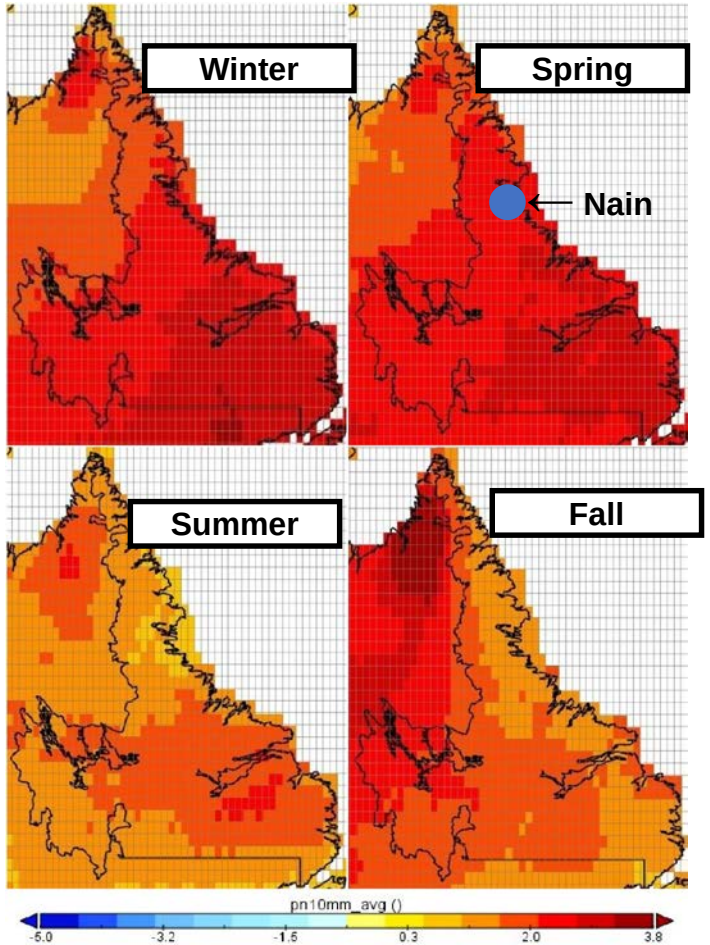
Select locations

Nain
+2.3 days in Fall
+4.3 days annually

Corner Brook
+2.1 days in Fall
+6.8 days annually

Gander
+1.1 days in Fall
+5.4 days annually

St. John's
+1.8 days in Fall
+2.6 days annually



Newfoundland Labrador

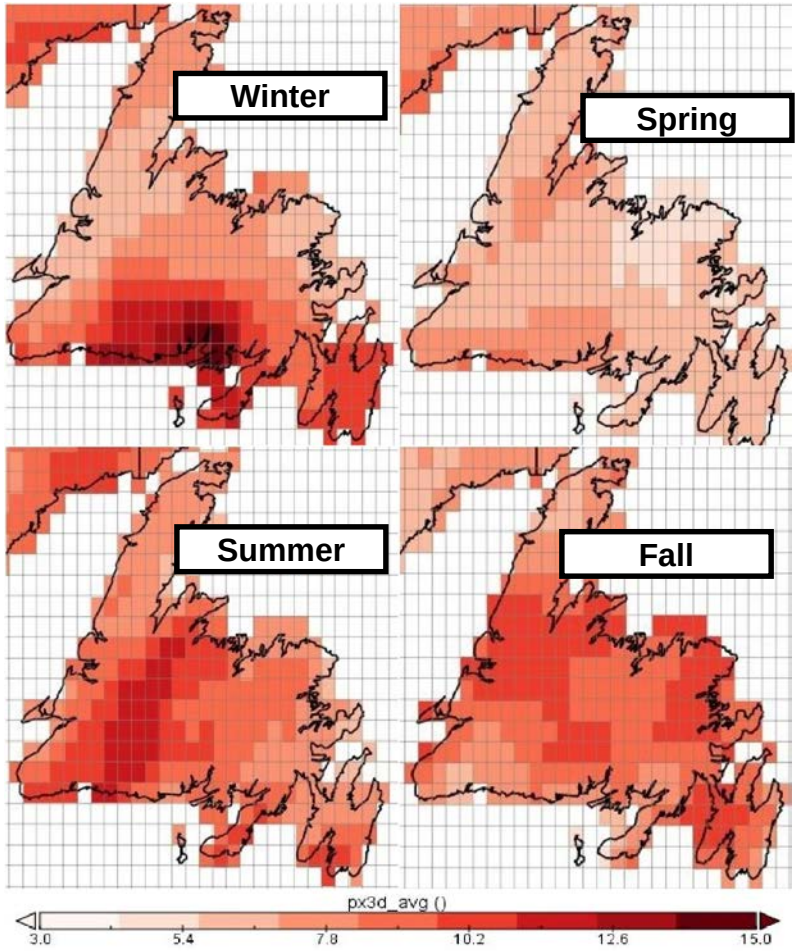
Number of high precipitation days is expected to increase (3)

Change in precipitation day with 10+ mm – end of 20th century to end of 21st century

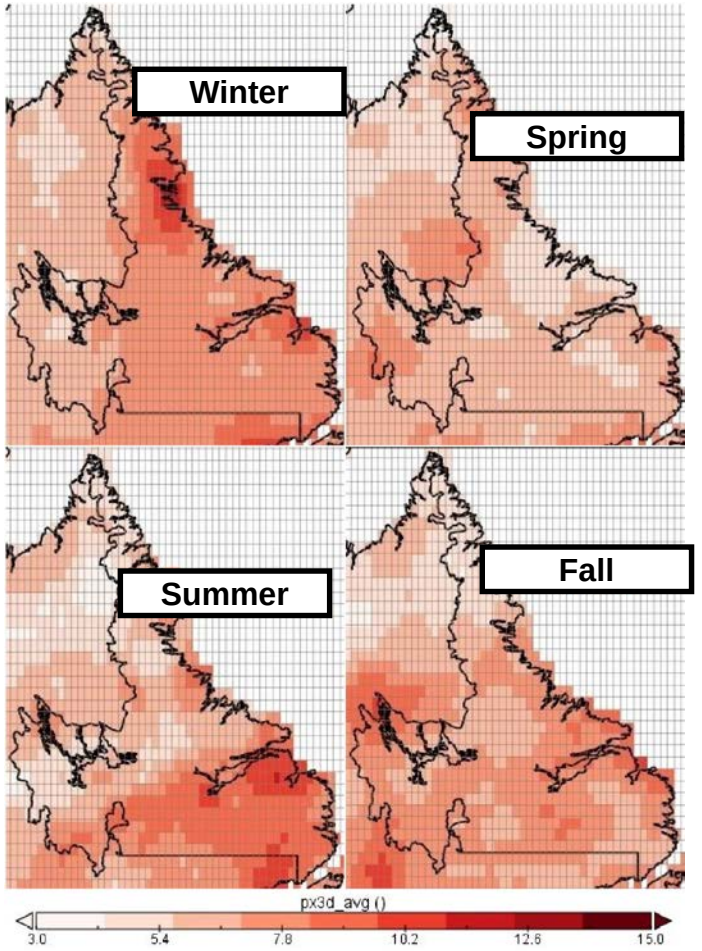
Select locations – Number of days				
	By mid century		By late century	
	Fall	Annual	Fall	Annual
St. John's	1.8	2.6	0.7	2.2
Gander	1.1	5.4	1.0	8.1
Corner Brook	2.1	6.8	1.5	8.7
St. Anthony	3.2	8.2	3.2	10.9
Goose Bay	1.8	6.0	1.9	8.7
Nain	2.3	4.3	2.3	5.7

Maximum 3-day precipitation is expected to increase (1)

Change in precipitation – end of 20th century to mid 21st century

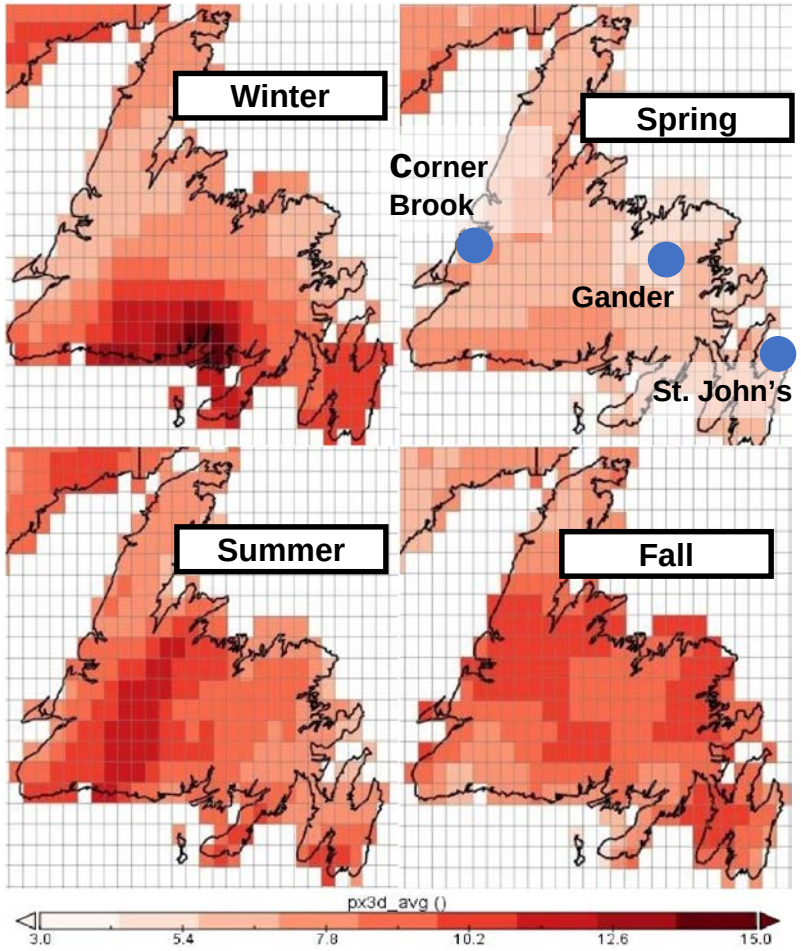


Precipitation over several days is a proxy to measure flooding as it impacts on reservoir levels, soil moisture capacity, water drainage systems and water body capacity.



Maximum 3-day precipitation is expected to increase (2)

Change in precipitation – end of 20th century to mid 21st century



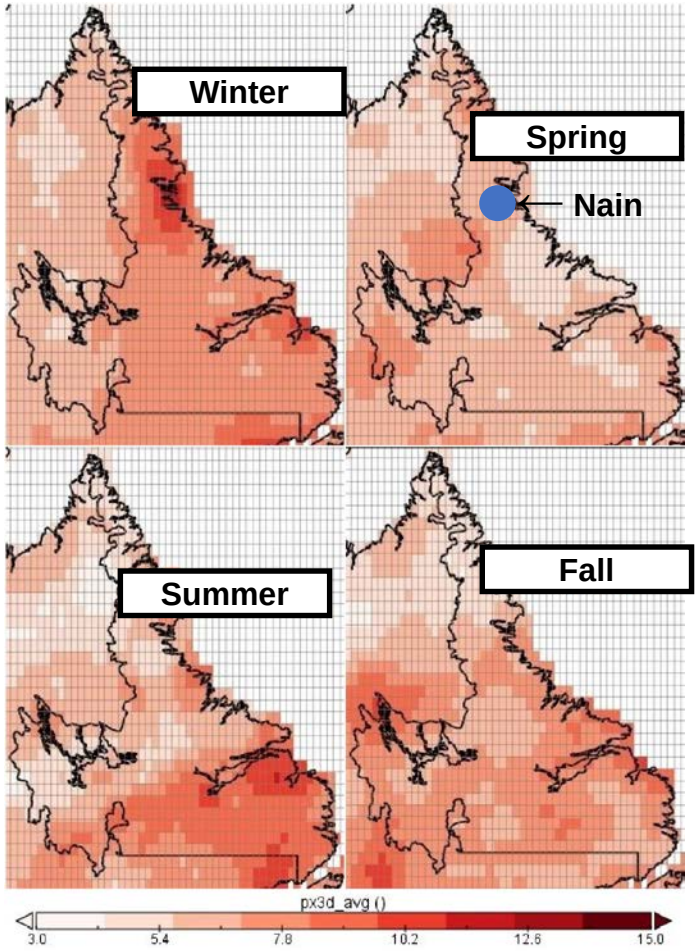
Select locations

Nain
+31.5% in Fall
-8.2% annually

Corner Brook
+22.4% in Fall
+15.5% annually

Gander
+19.3% in Fall
+13.3 annually

St. John's
+19.3% in Fall
+8.3% annually



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Maximum 3-day precipitation is expected to increase (3)

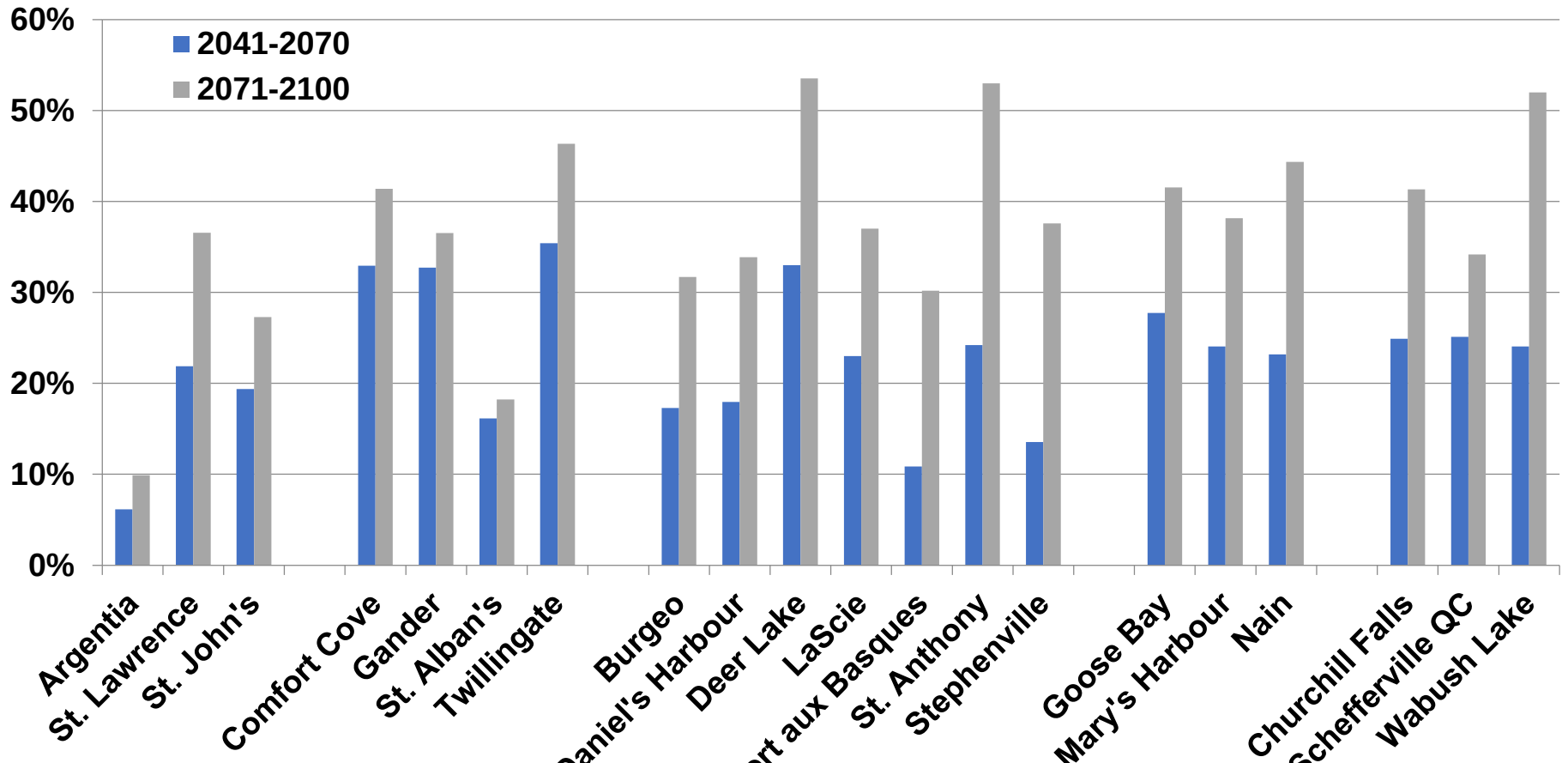
Change in precipitation – end of 20th century to end of 21st century

Select locations – Percent change				
	By mid century		By late century	
	Fall	Annual	Fall	Annual
St. John's	19.3%	8.3%	23.1%	13.9%
Gander	19.3%	13.3%	26.9%	22.4%
Corner Brook	22.4%	15.5%	32.6%	27.0%
St. Anthony	33.6%	19.3%	47.1%	30.3%
Goose Bay	21.7%	17.8%	27.9%	28.9%
Nain	31.5%	8.2%	34.1%	14.0%

3. Key Findings:
Extreme Precipitation Events

Extreme precipitation events are projected to intensify

Average of all intervals and all durations relative to end of 20th century

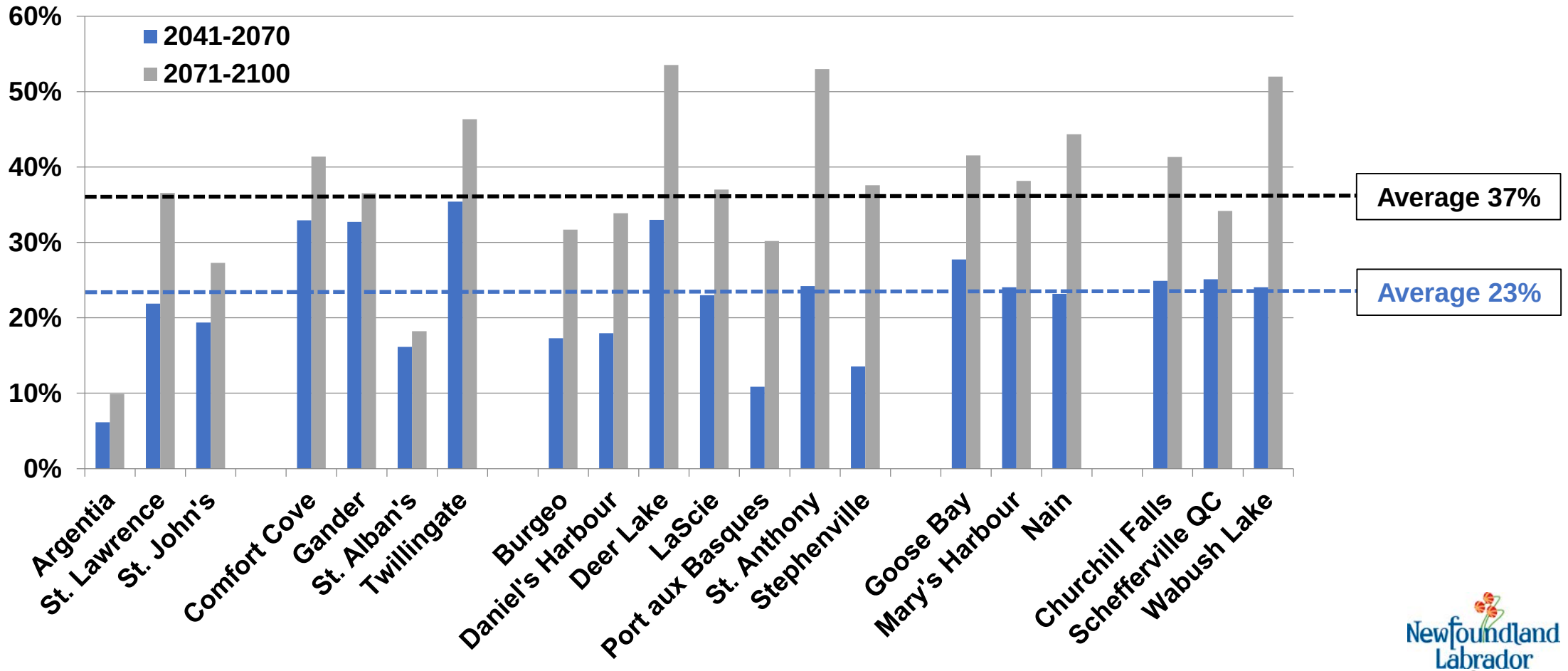


Based on maximum likelihood estimation techniques for all locations except Argentia, St. Albans, Daniel's Harbour and Stephenville. These locations use method of moments estimation.

Newfoundland Labrador

Extreme precipitation events are projected to intensify

Average of all intervals and all durations relative to end of 20th century



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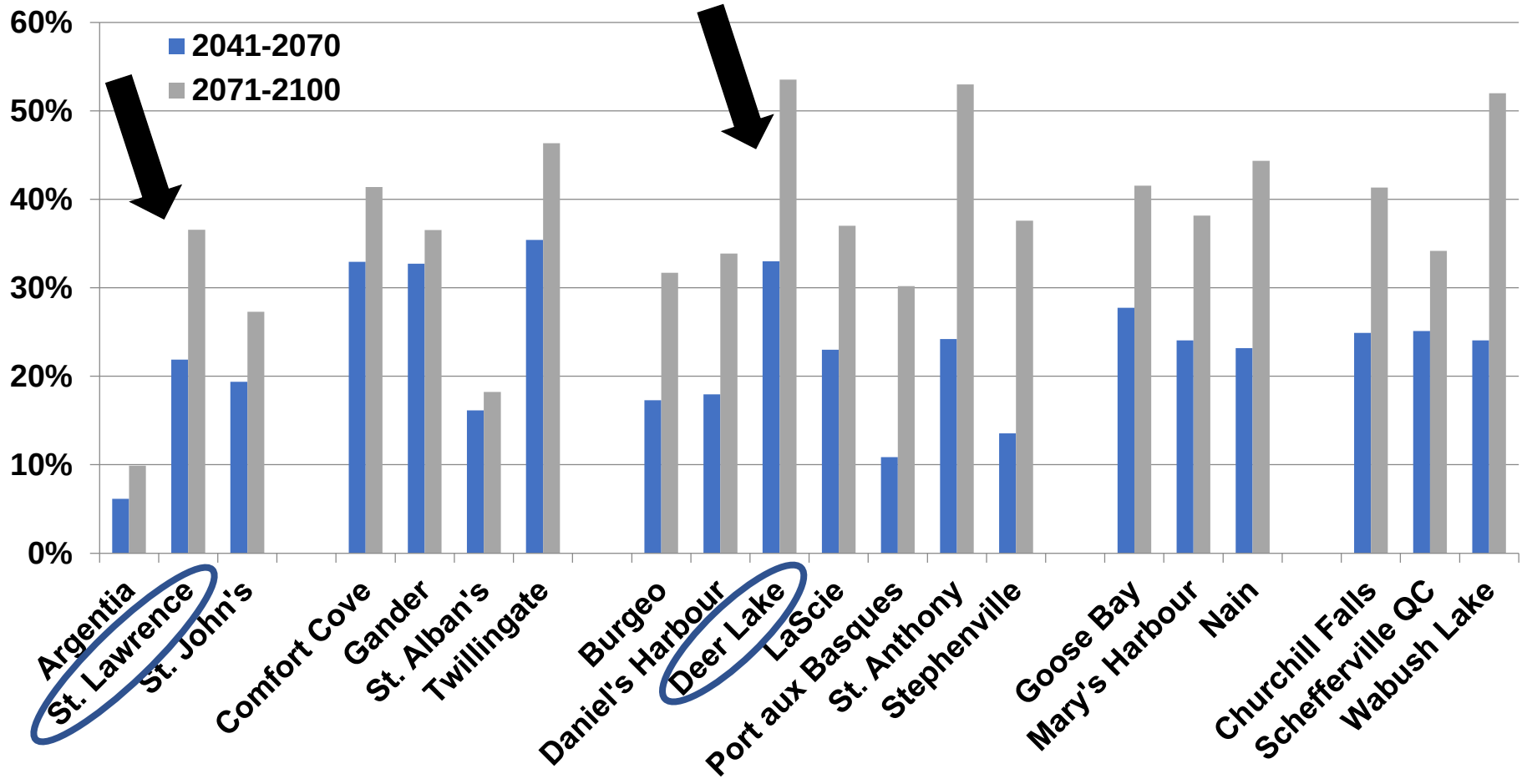
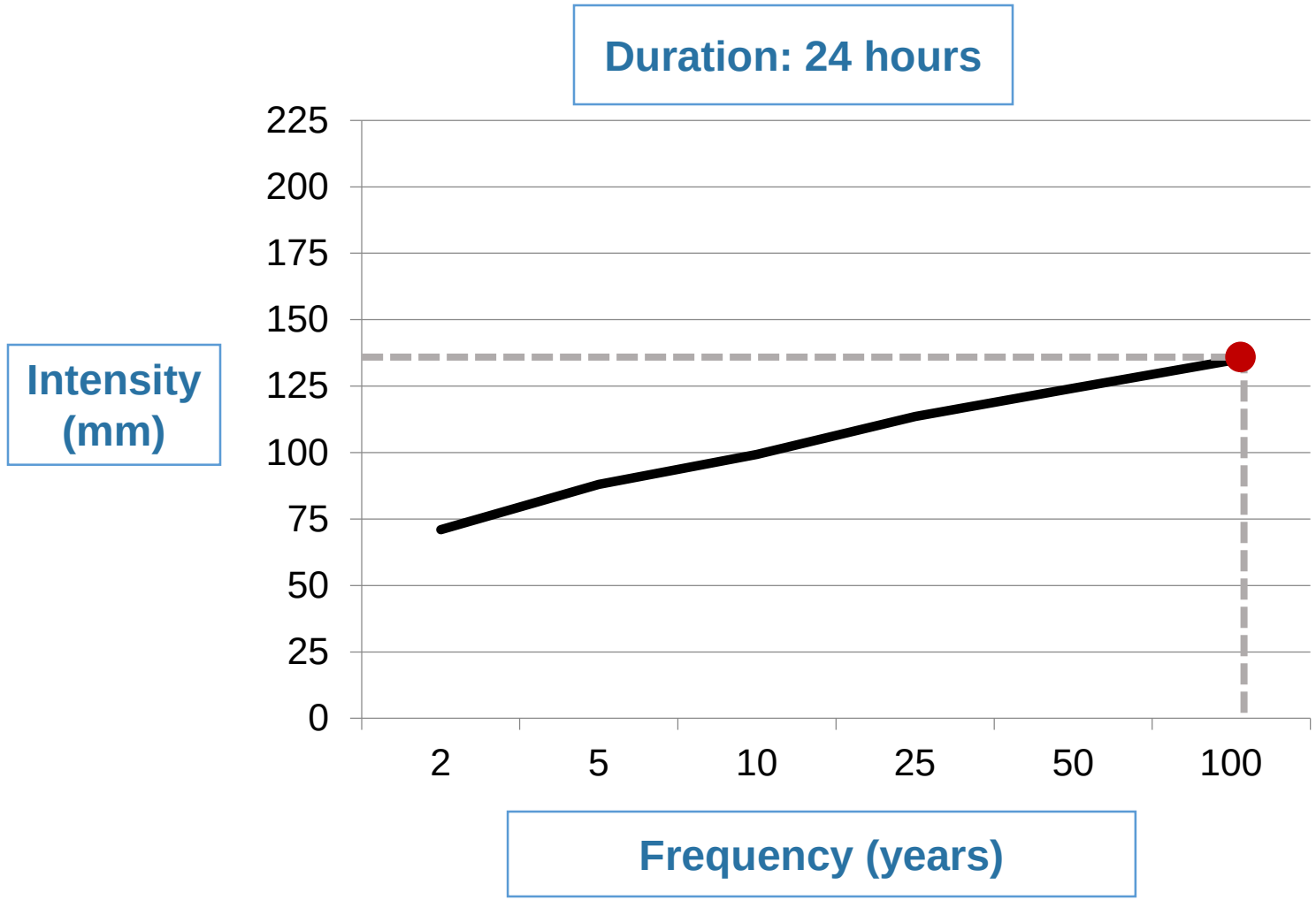


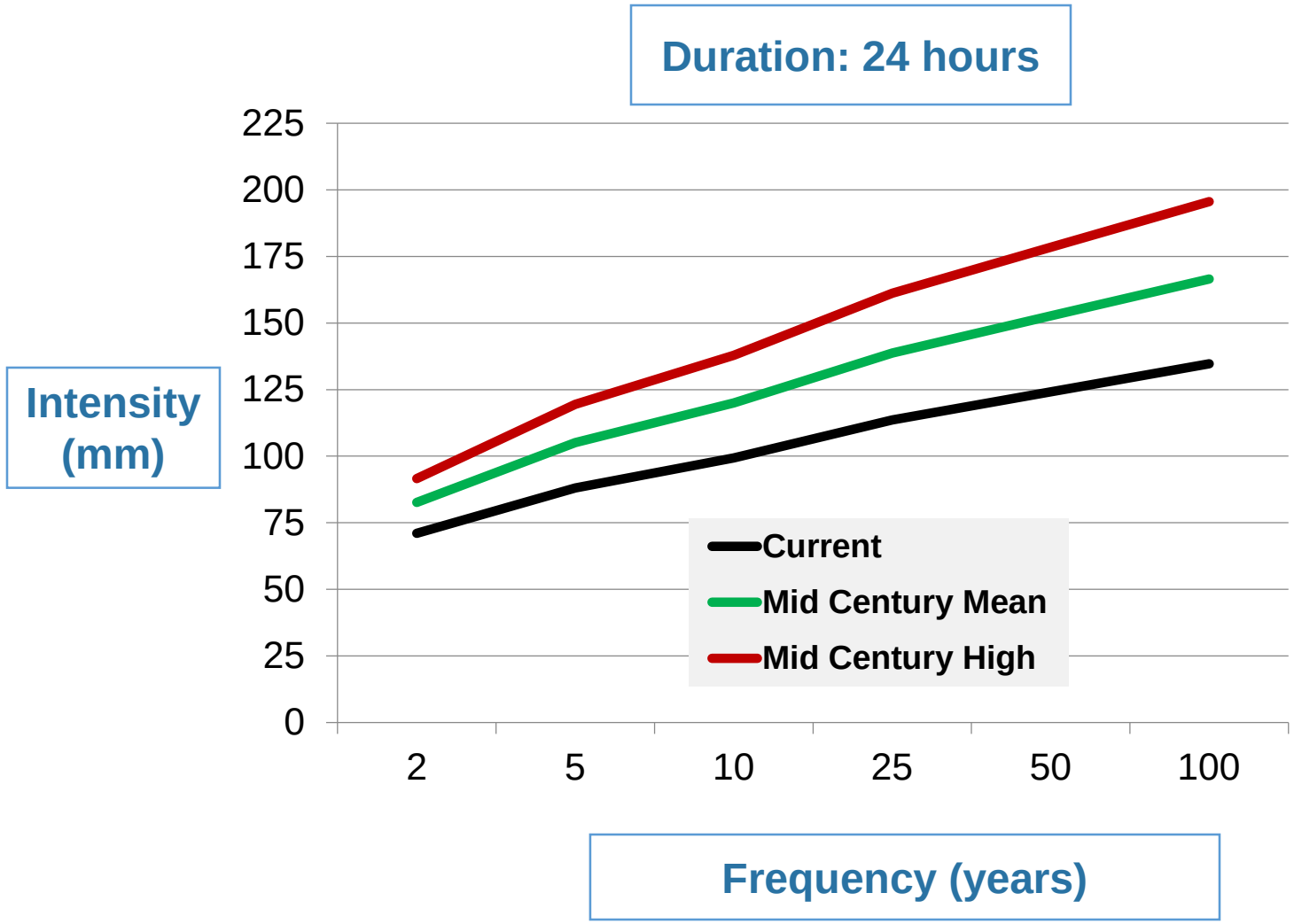
Extreme Precipitation: St. Lawrence

Current IDF projections



Extreme Precipitation: St. Lawrence

Current and mid-21st century IDF projections



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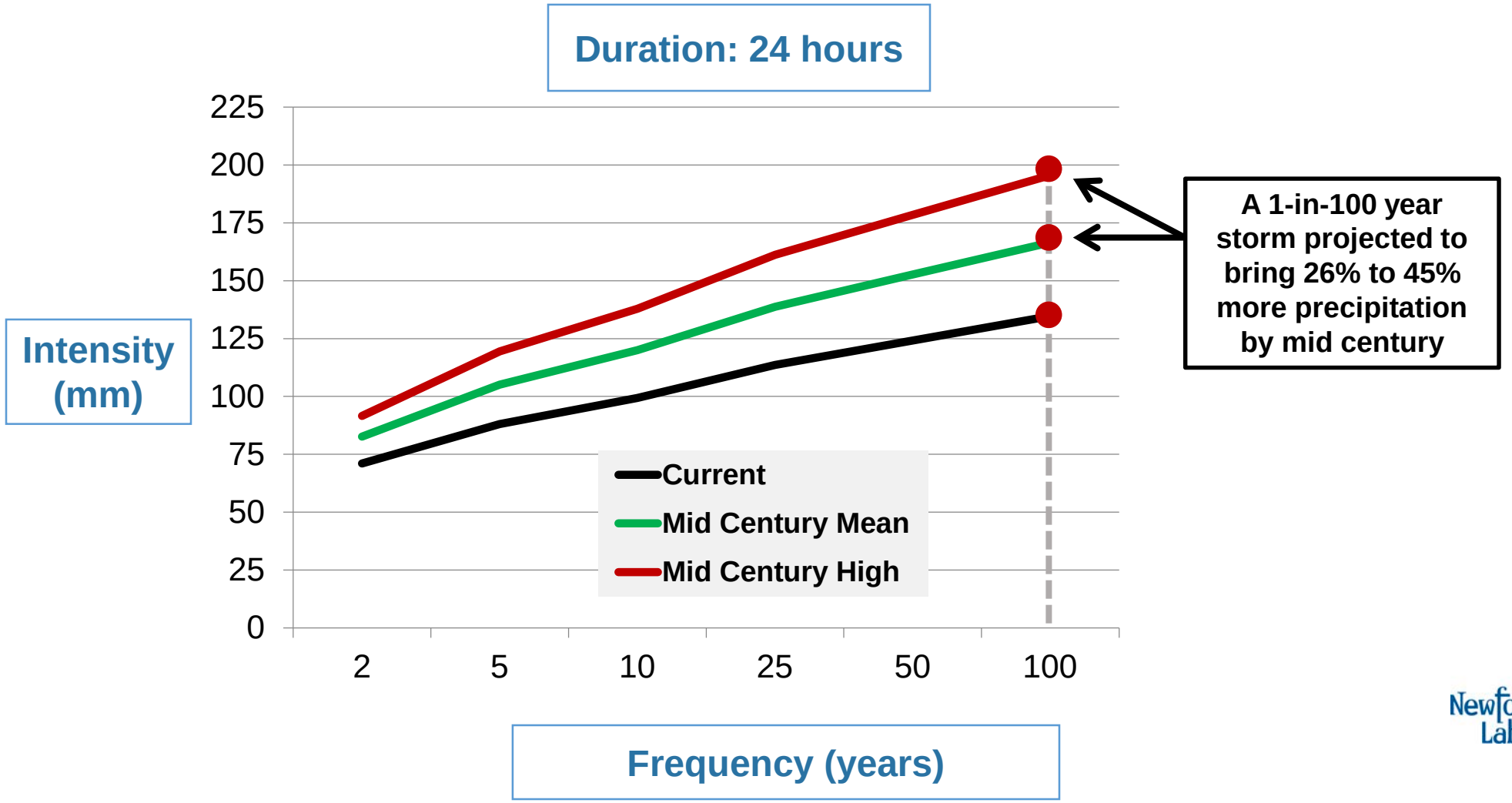

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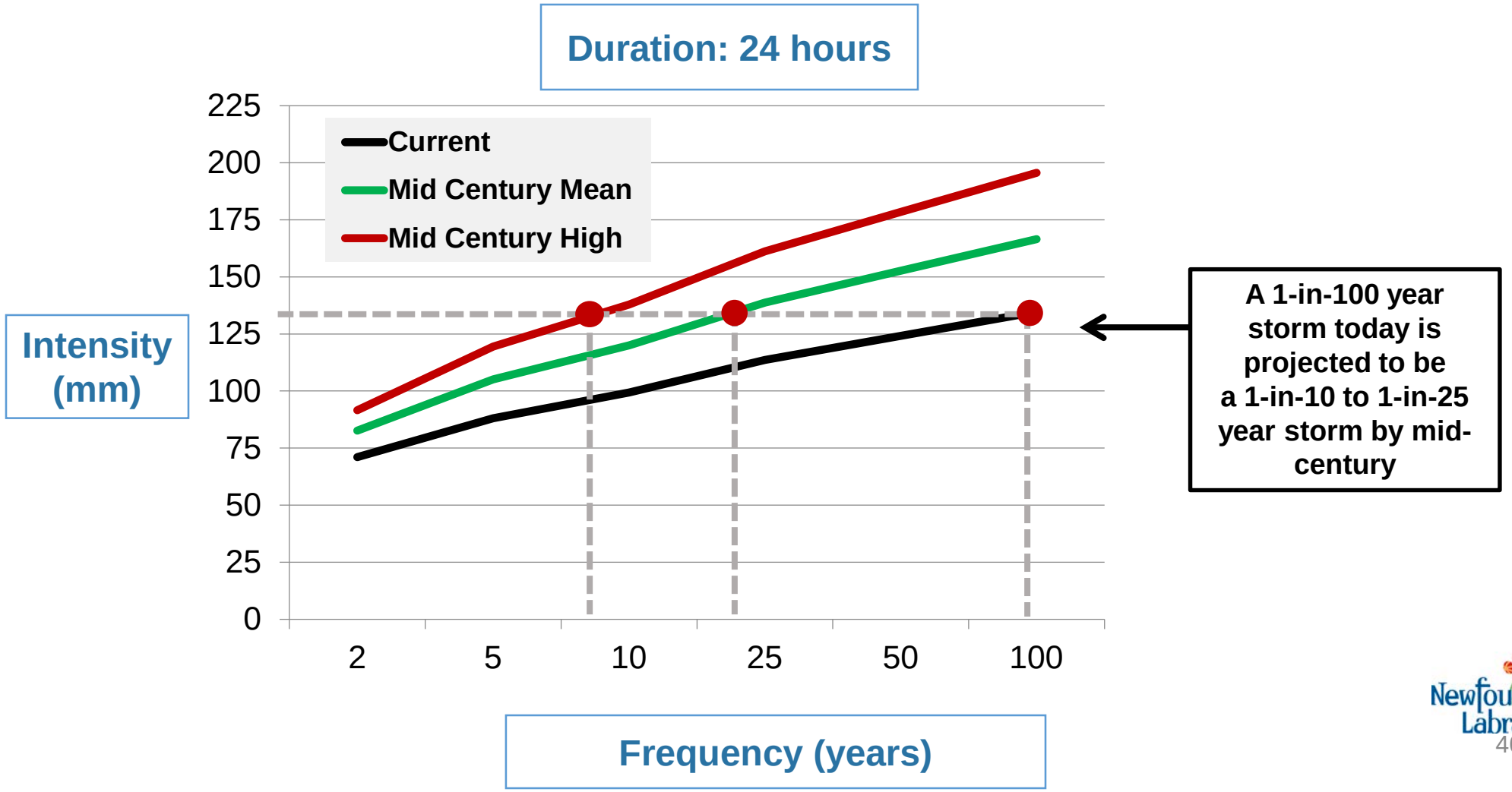
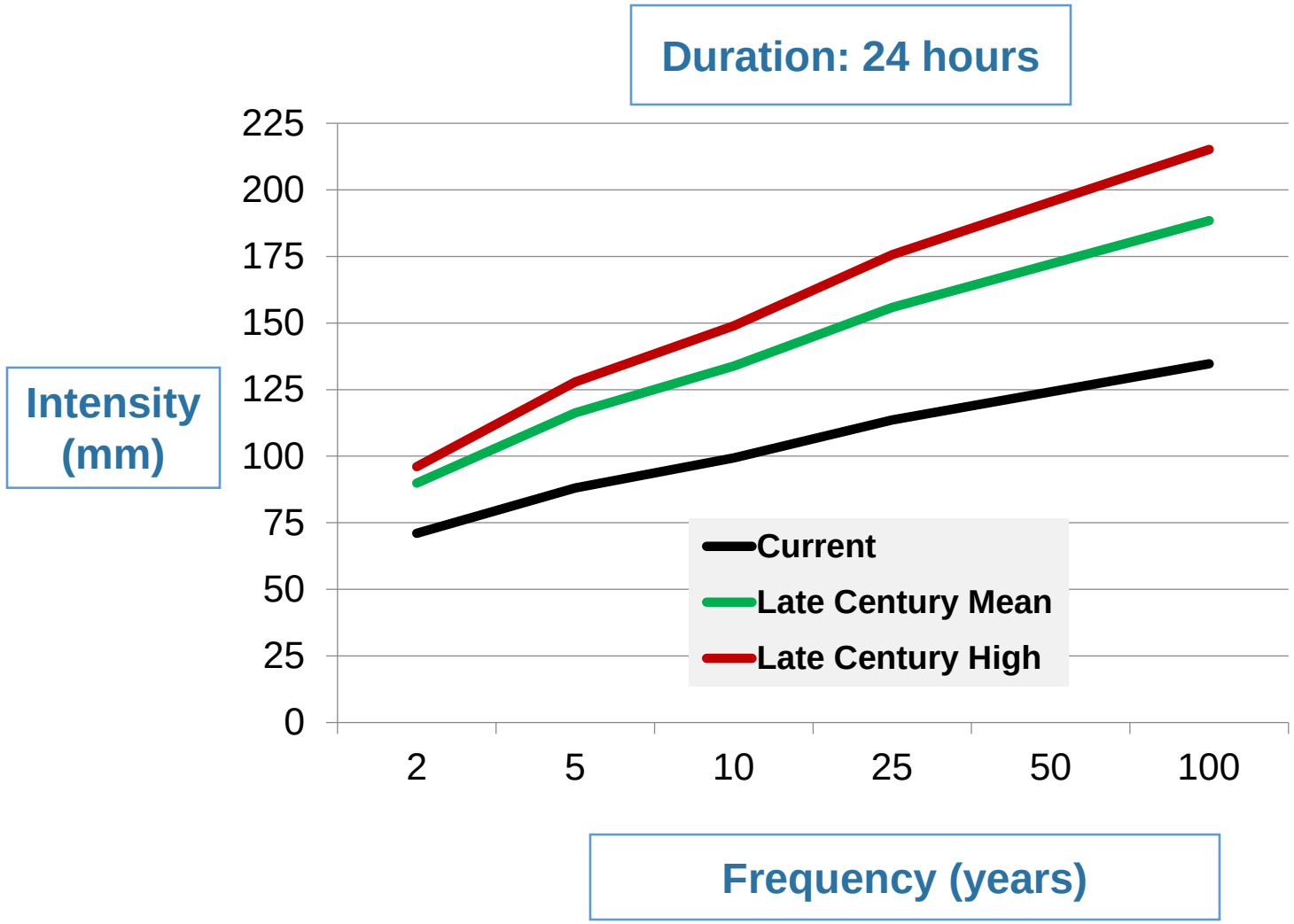


Extreme Precipitation: St. Lawrence

Current and late-21st century IDF projections



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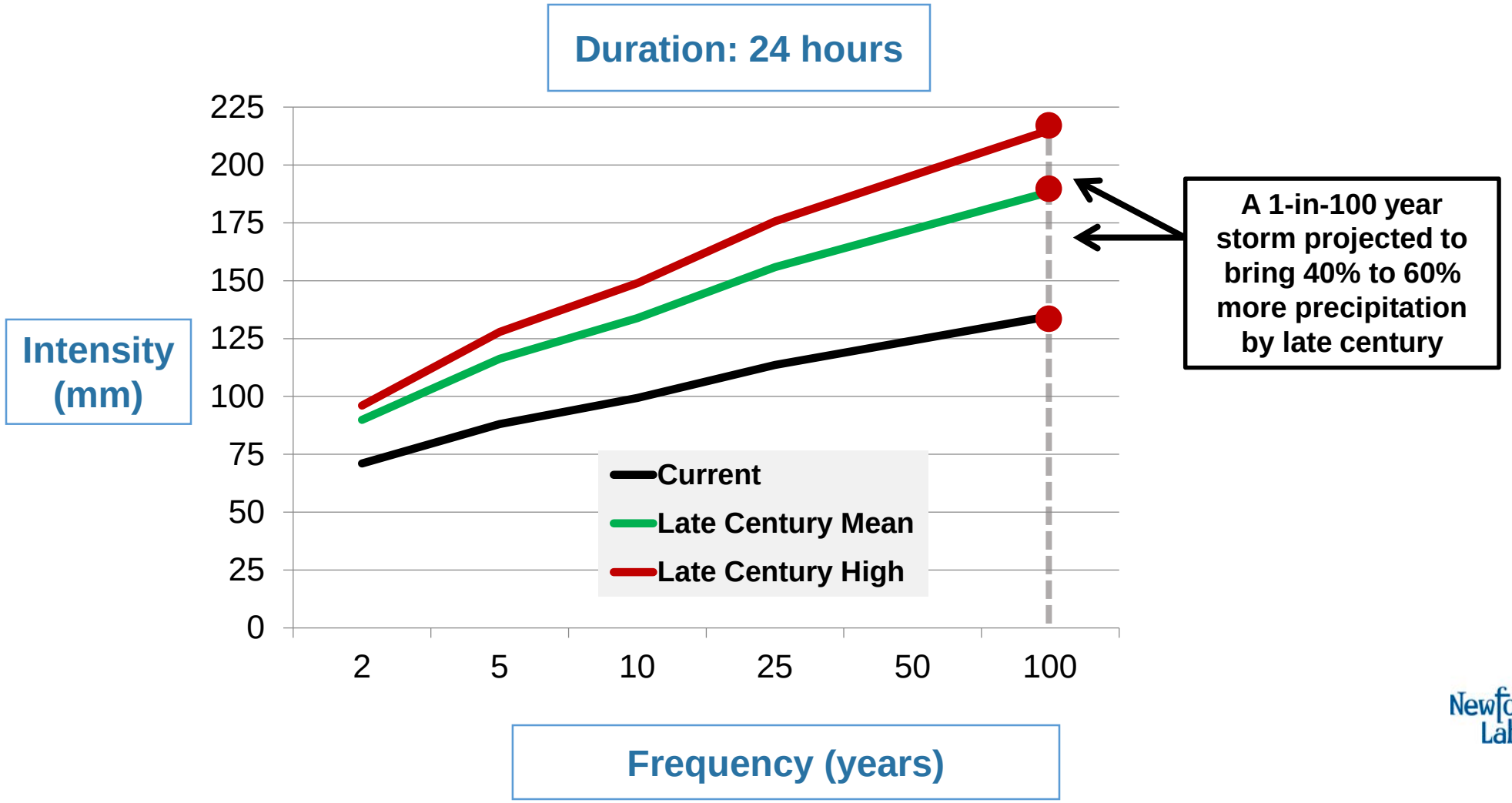

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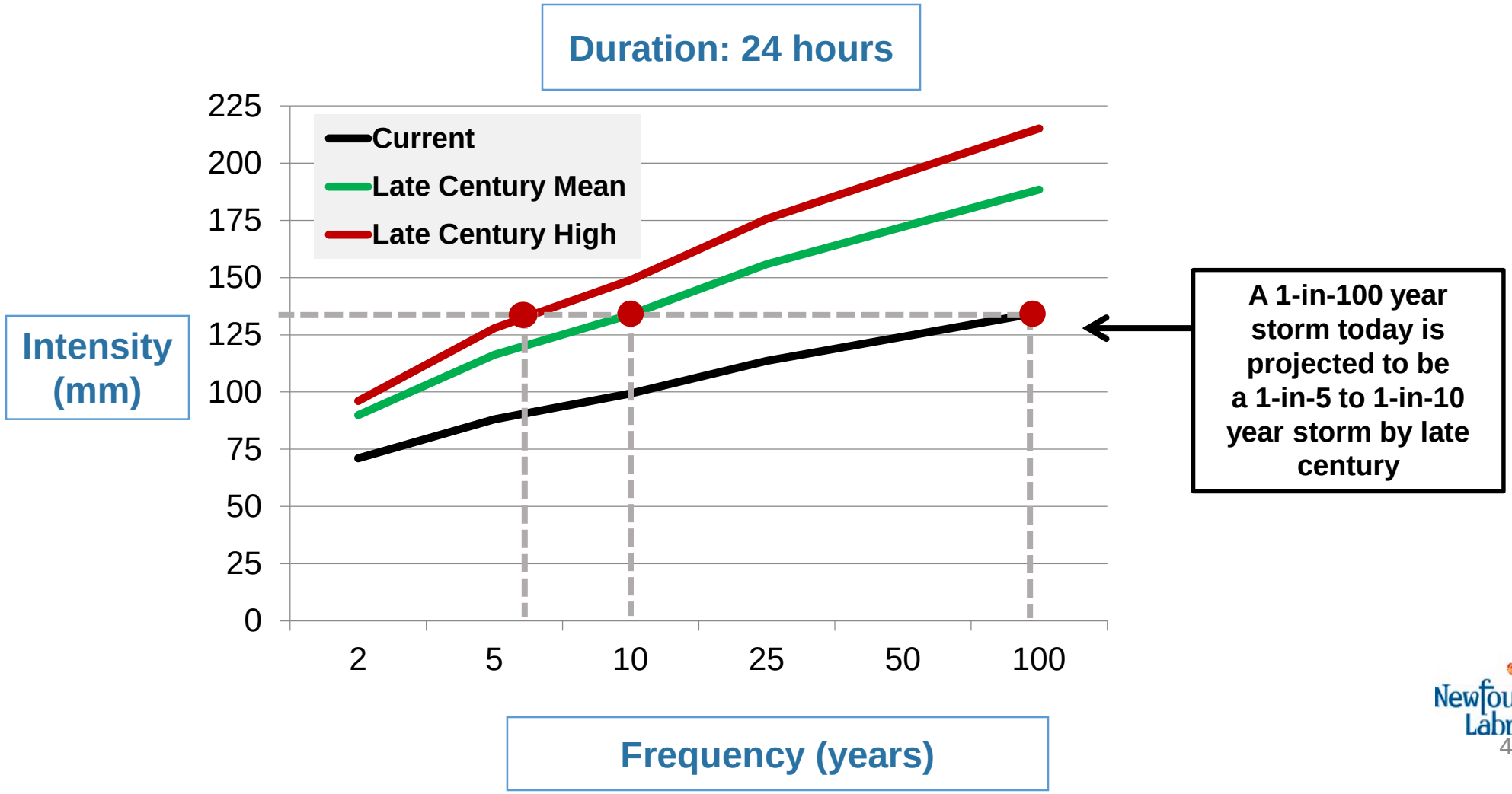
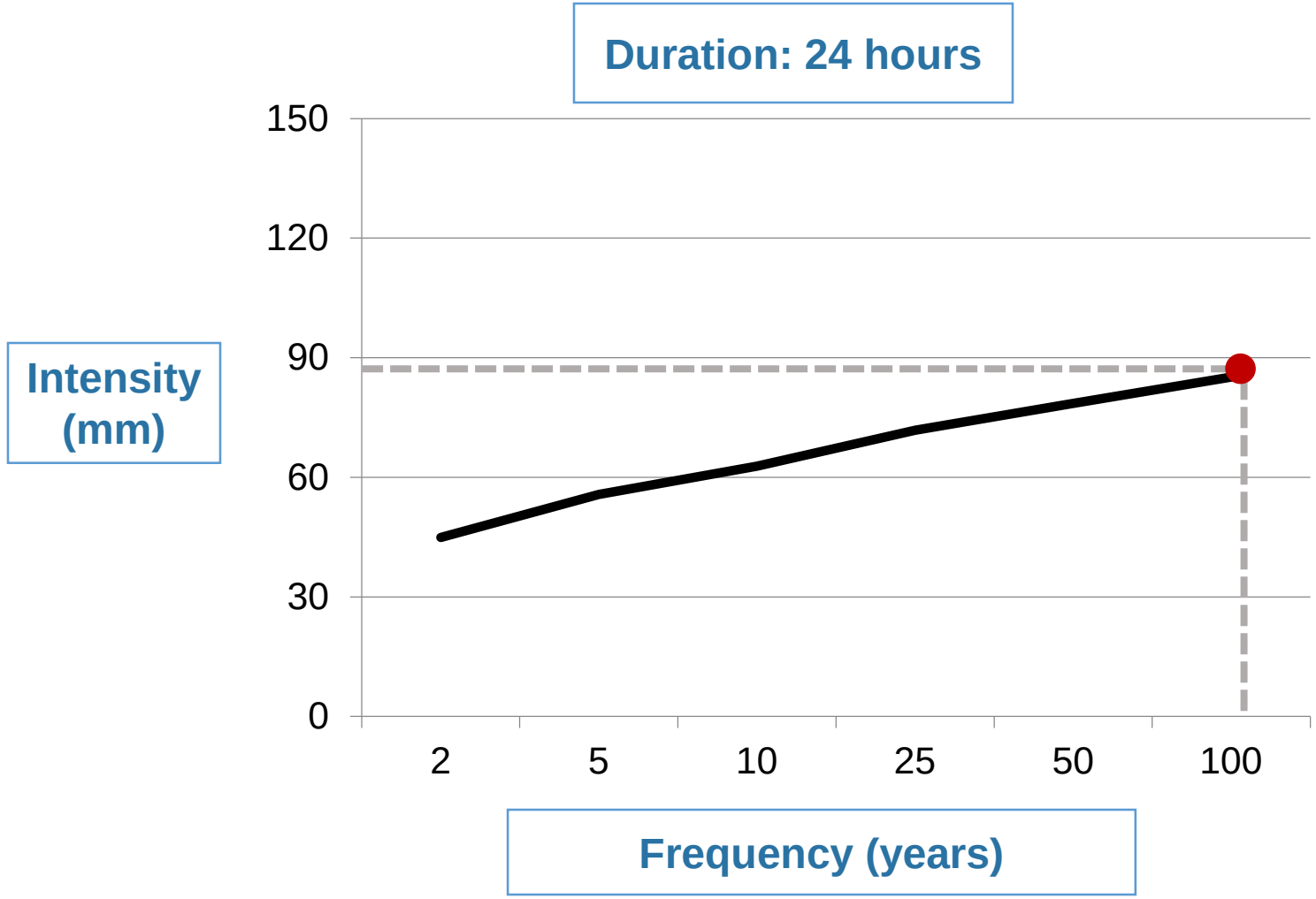


Extreme Precipitation: Deer Lake

Current IDF projections



Extreme Precipitation: Deer Lake

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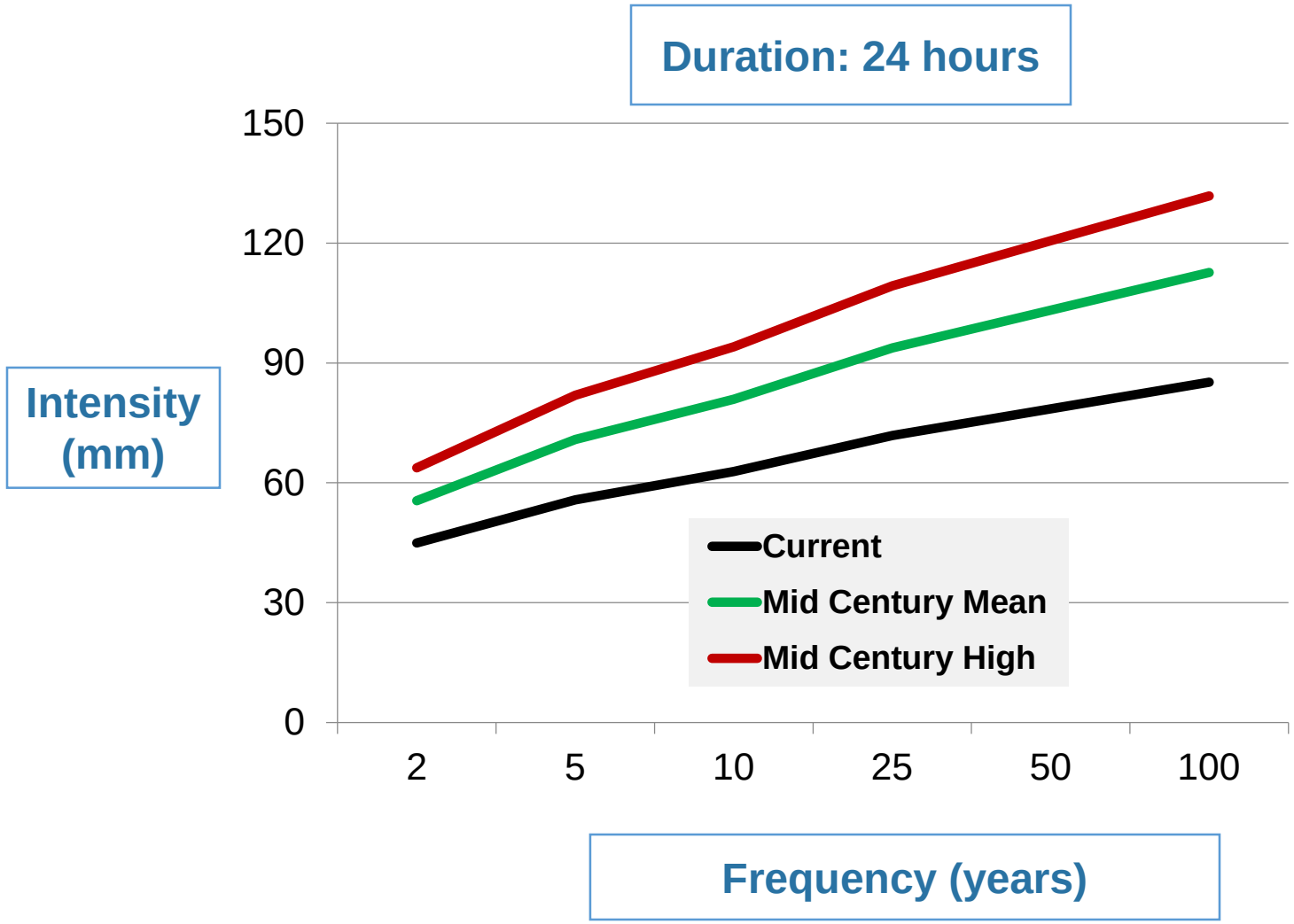

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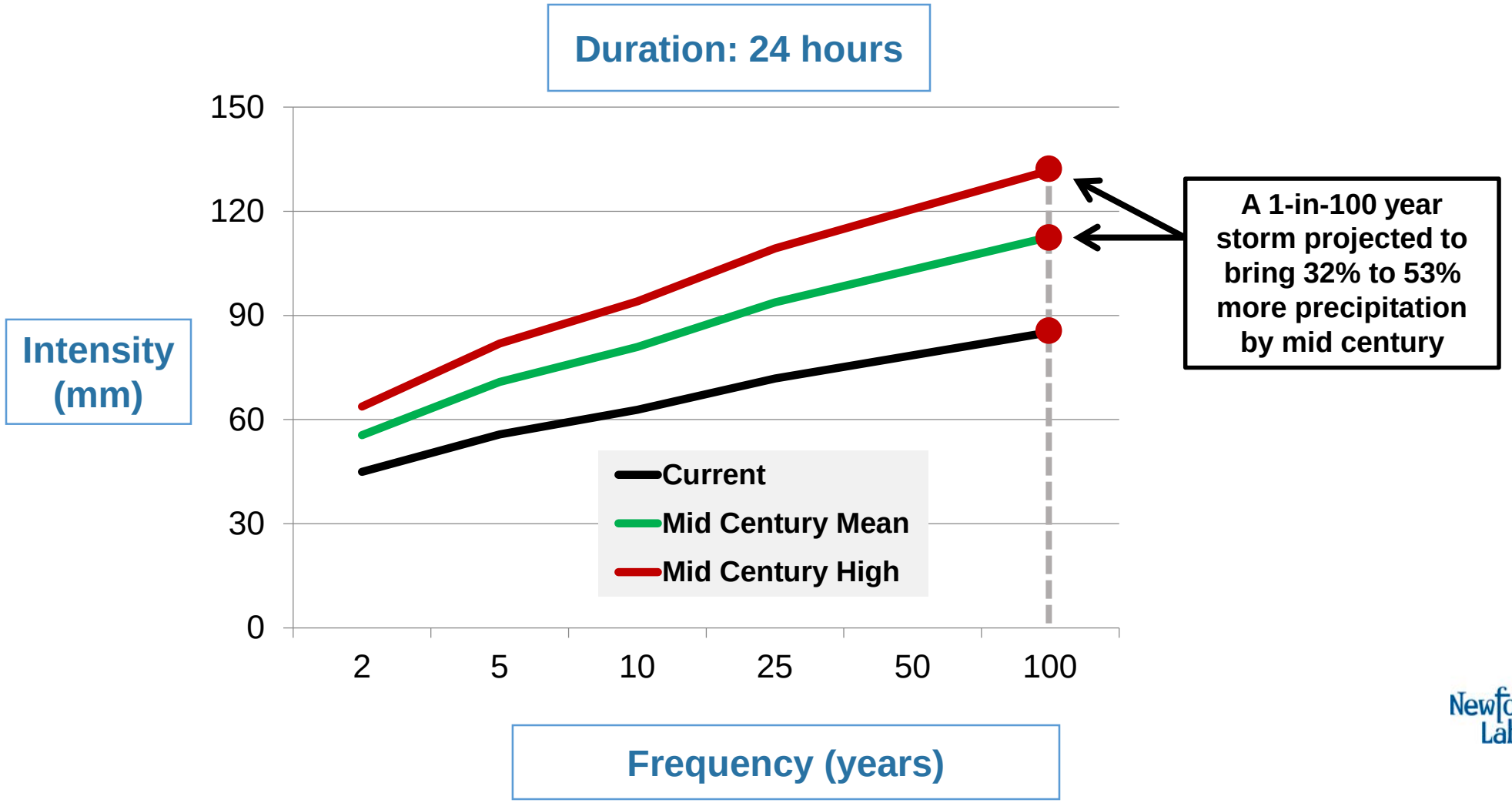

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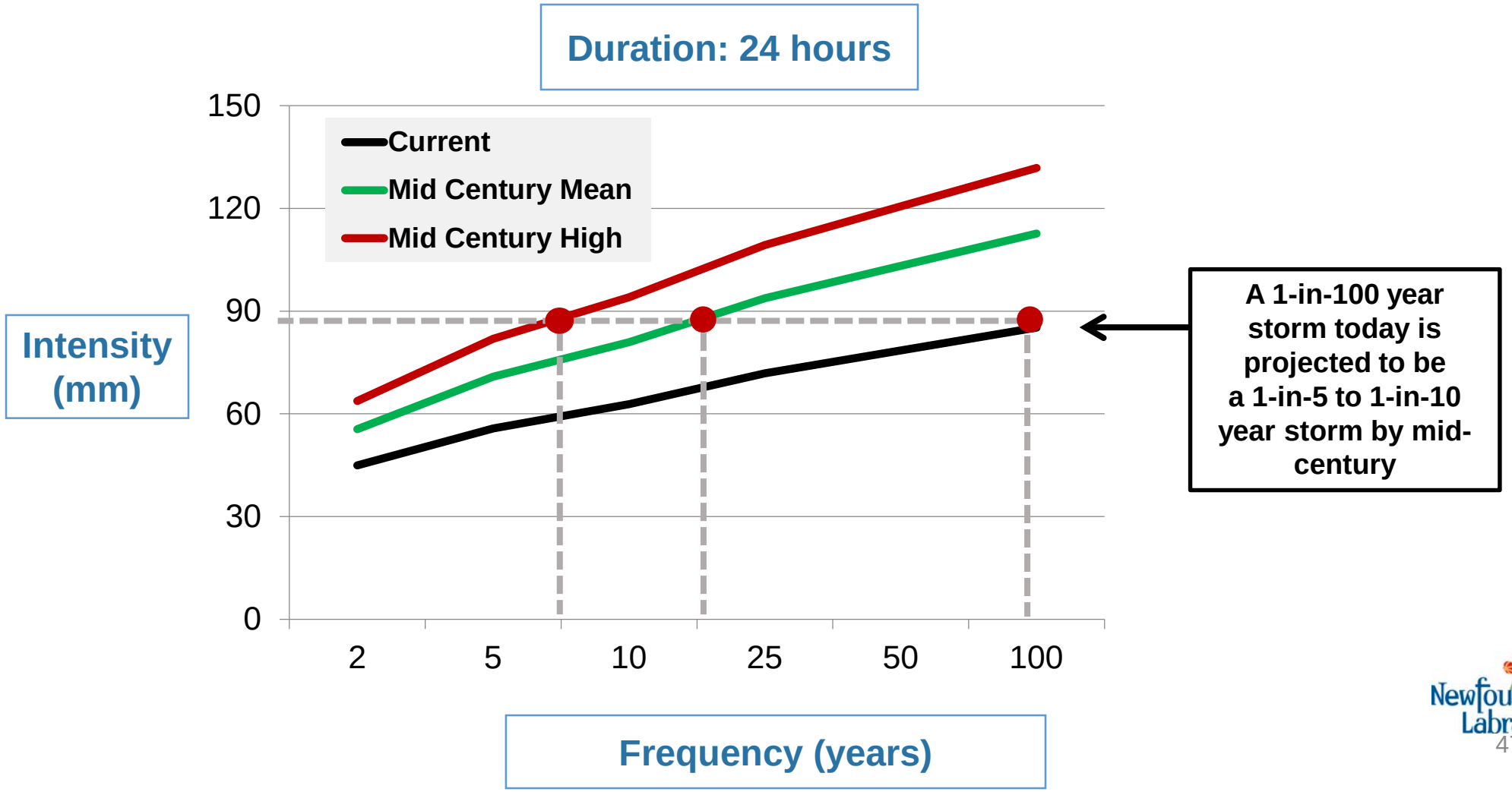
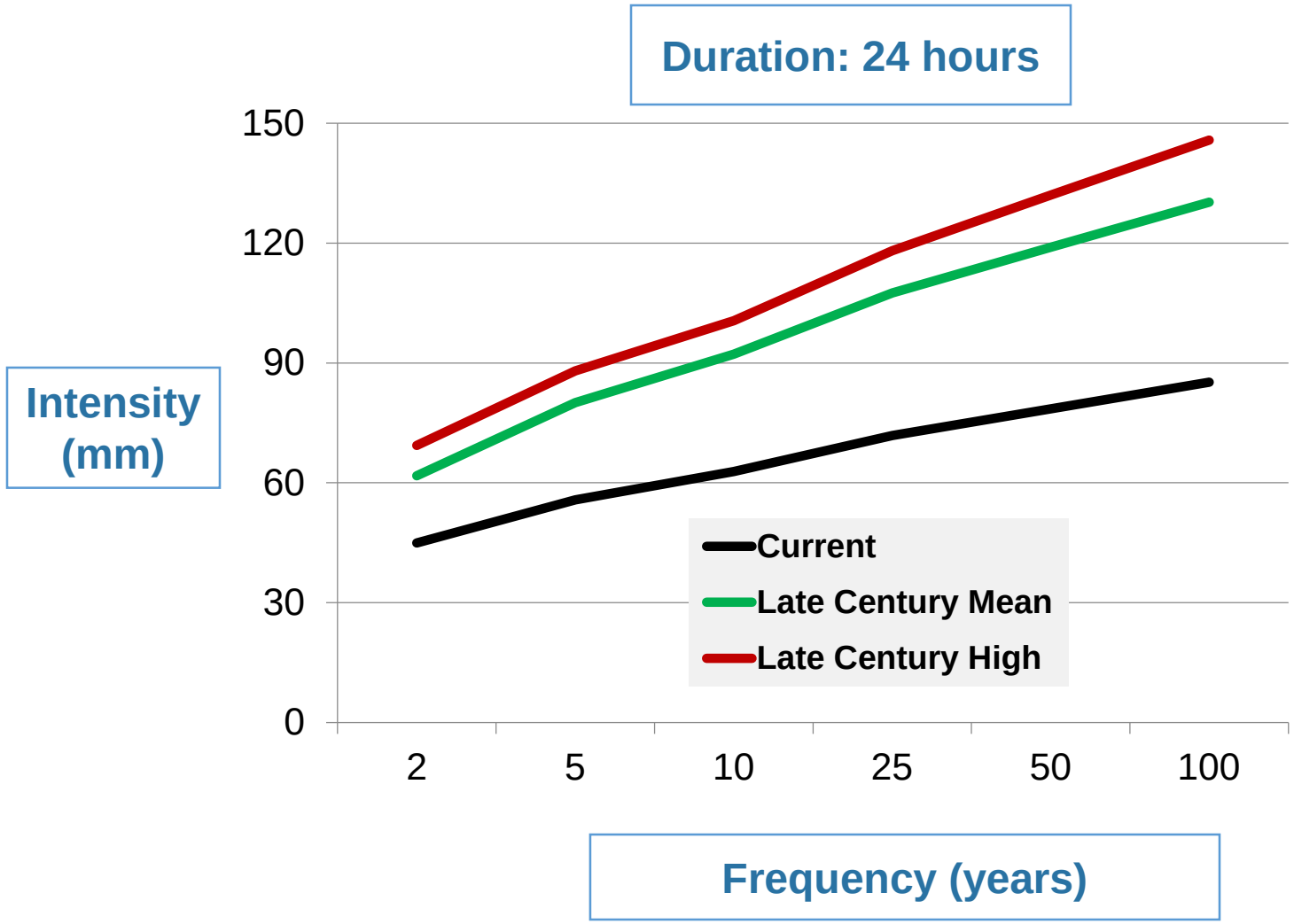


Extreme Precipitation: Deer Lake

Current and late-21st century IDF projections



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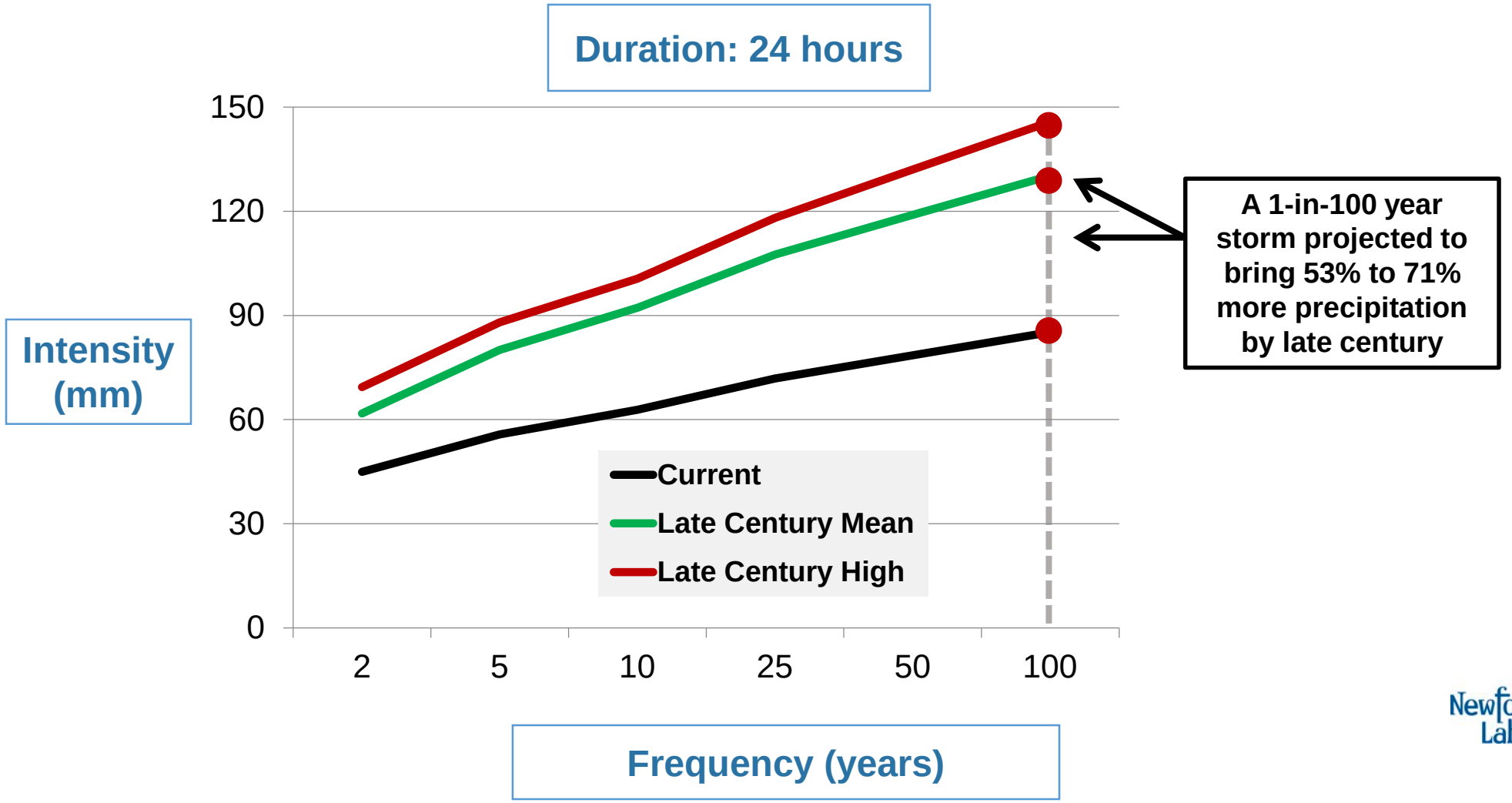

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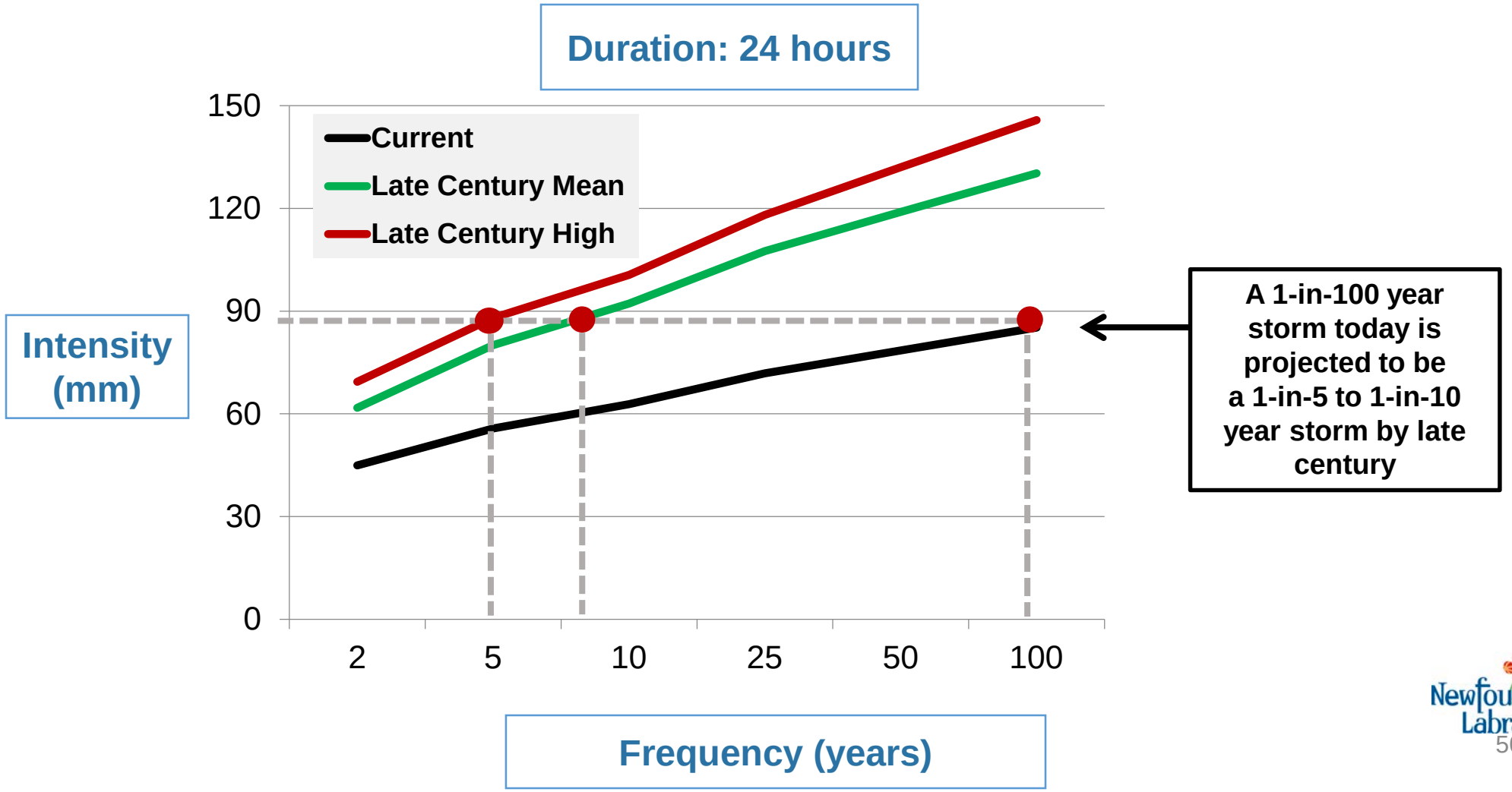


Key Messages

- Current study includes more locations, more recent data and improved modeling from 2013
- Key messages from 2013 remain – warmer, wetter, stormier
- However, current study indicates more warmer, more wetter and more stormier than projected in 2013
  - Winter temperature growth, especially in Labrador, is projected be especially high
  - Frost days (proxy for winter) are projected to decline by 4-5 weeks by mid-century and 7-8 weeks by late century
  - Degree growing days projected to grow by 50% by mid century and to more than double by late century
  - Number of precipitation days projected to remain relatively stable, but precipitation events projected to be more intense

Newfoundland Labrador

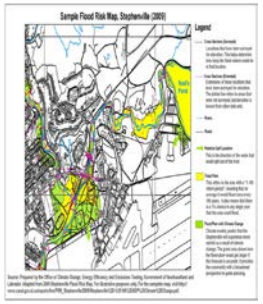
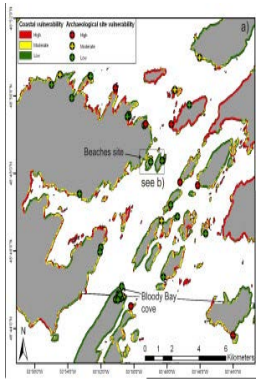
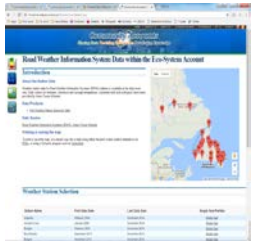
4. Risks, Impacts and Vulnerabilities

Potential Risks, Impacts and Vulnerabilities

- **Some potential impacts and vulnerabilities are positive – focus on seizing opportunities**
  - **Potentially more productive agriculture, forestry, fisheries and aquaculture industries**
  - **Longer summer tourism seasons**
  - **Technology development opportunities to address risks, impacts and vulnerabilities**
  - **Lower demand for space heating in winter months**
- **Potential risks, impacts and vulnerabilities – focus on adapting to change**
  - **Sea level rise, coastal erosion, saltwater erosion, changing sea ice conditions and ocean acidification**
  - **Private and public infrastructure damage from flooding and sea level rise**
  - **Invasive species and pests, including human health vulnerabilities**
  - **Shifts in tourism seasons (e.g., big game hunting) and shorter winter tourism seasons**
- **Potential for positive and negative impacts in same sector – balance and adapt**
  - **More productive resource industries (e.g., fisheries) but more invasive species (e.g., green crab)**
  - **Changes in tourism seasons**

Newfoundland Labrador

Tools and Resources

IDF Curves	Flood Risk Maps	Flood Alert System	7 Steps Tool	CARRA	Smart ICE	Coastal Erosion Monitoring	Climate Data Information Portal
All IDF curves updated (and have projections)	Climate change flood risk maps	Seasonal Hurricane Flood Alert System	Community Vulnerability Assessment Tool	Coastal Archaeological Resources Risk Assessment Tool	Sea ice monitoring system for coastal communities	~120 monitoring sites	Historical data (80 weather stations)
							

Emerging Areas for Further Analysis

- **Sub-daily (<24 hours) extreme precipitation projections, particularly for durations of 3 hours or less**
  - **Improve projection accuracy**
- **Wind conditions**
  - **New area for analysis facilitated by enhanced data collection and expanded modeling techniques**
- **Rain-snow precipitation mix**
  - **New area for analysis facilitated by enhanced data collection and expanded modeling techniques**

5. Conclusion

Conclusion

- In 2018 Provincial Government funded Memorial University to update climate change projections first developed in 2013
- This work projected that by mid-century the province will experience higher temperatures, more precipitation, more intense extreme precipitation events
- These changes will bring both risks and opportunities
- By using the updated climate change projections to inform planning and decision-making, it is possible to improve resilience and reduce vulnerability to climate impacts across sectors
- There are also a range of other tools and resources freely available to assist decision-makers incorporate climate considerations into decision-making

Newfoundland Labrador

Conclusion
Accessing the Data and Information

- **All climate data is freely available online, and can be accessed on the provincial government website.**
  - **To access climate projections data and technical report, visit: http://www.exec.gov.nl.ca/exec/occ/climate-data/index.html**
  - **To access climate change flood risk maps, visit: http://www.mae.gov.nl.ca/waterres/flooding/frm.html**

Thank You

For additional information, please contact:

Climate Change Branch

Department of Municipal Affairs and Environment

Tel: 709 729 1210

Email: climatechange@gov.nl.ca

Newfoundland Labrador