Assessing Pavement Design Temperatures and Performance Grades in Atlantic Canada

Chris Barnes, Ph.D., P.Eng.
Technical Aviation Director, Materials/ Pavement
WSP Canada Inc.

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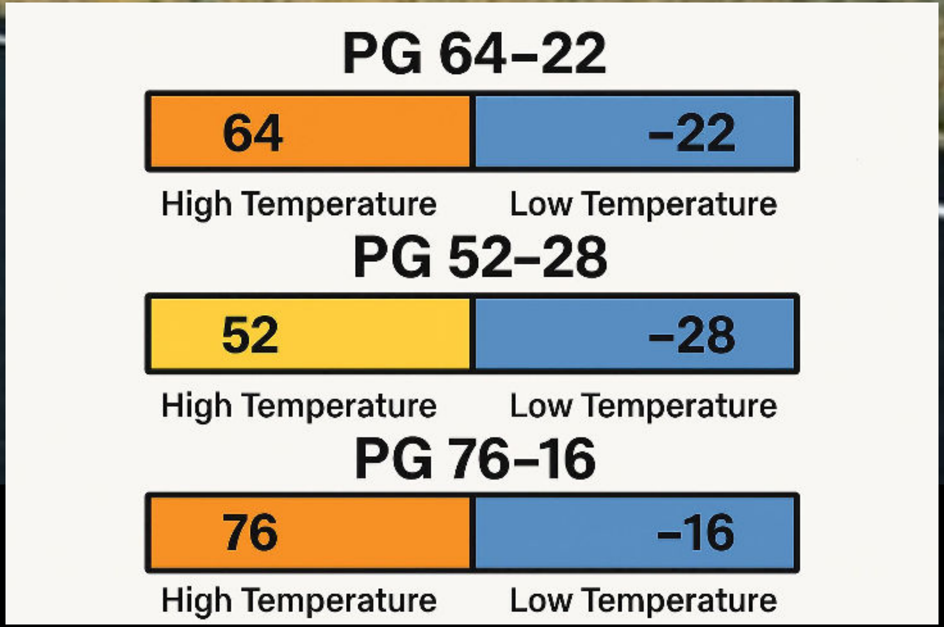
Why do we need Pavement Design Temperatures?

- The properties of Asphalt Binder change with temperature
  - High temperatures – soft/ stretchy, can cause **<u>rutting</u>**
  - Low temperatures – stiff/ brittle, can cause **<u>low temperature cracking</u>**
  - High and low design temperatures depend on project location

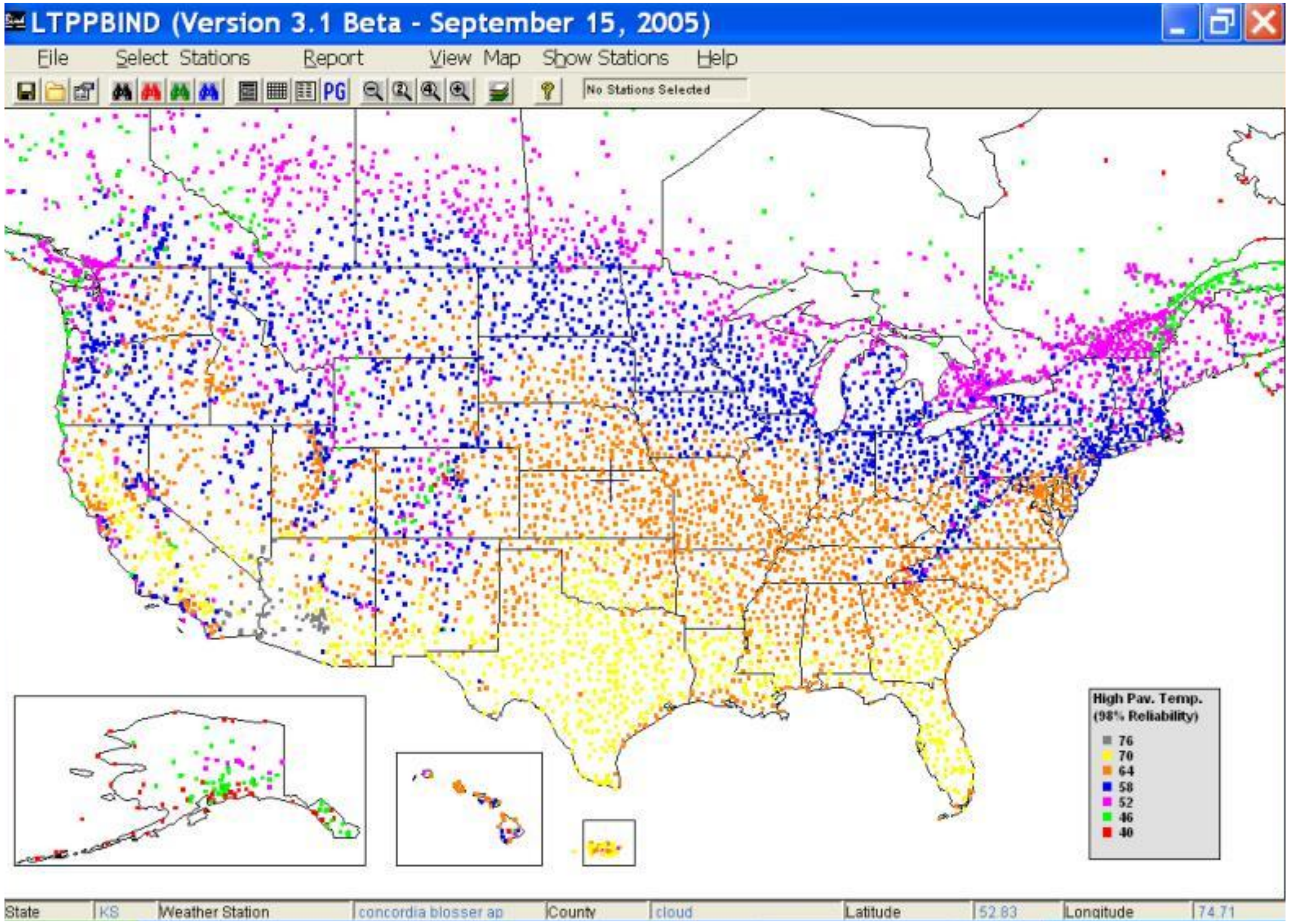


Asphalt Performance Grades

- Asphalt cements / binders are graded to provide certain behaviour at design temperatures
- High and Low design temperatures depend on climate at the project location
- Modified for traffic levels and speeds
  - High Temperature (HT) grades are “bumped” up to get stiffer binders and less rutting

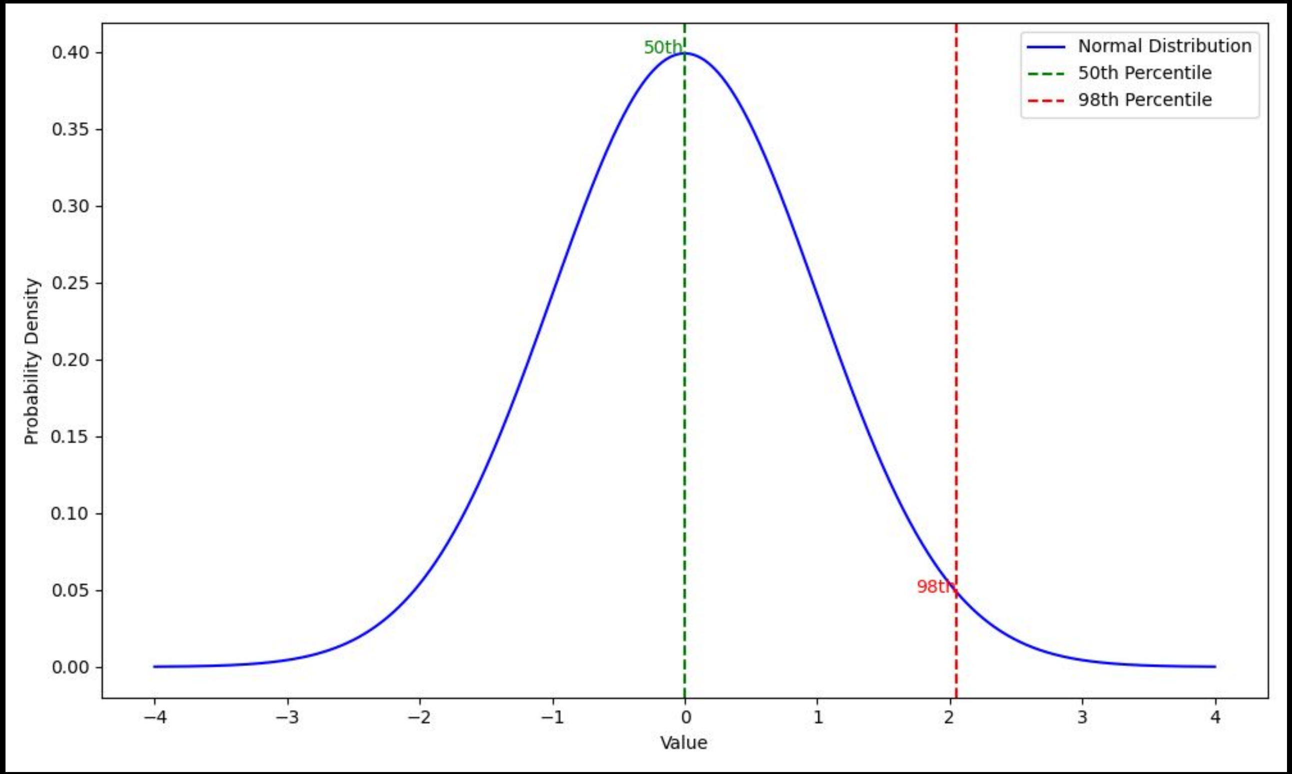
LTPPBind v3.1

- Developed in 1980's
  - Very few roads were instrumented for temperature measurements
  - Relied on weather station air temperatures
  - Air temperature measurements were used to model and predict pavement temperatures



Design Temperature Calculation

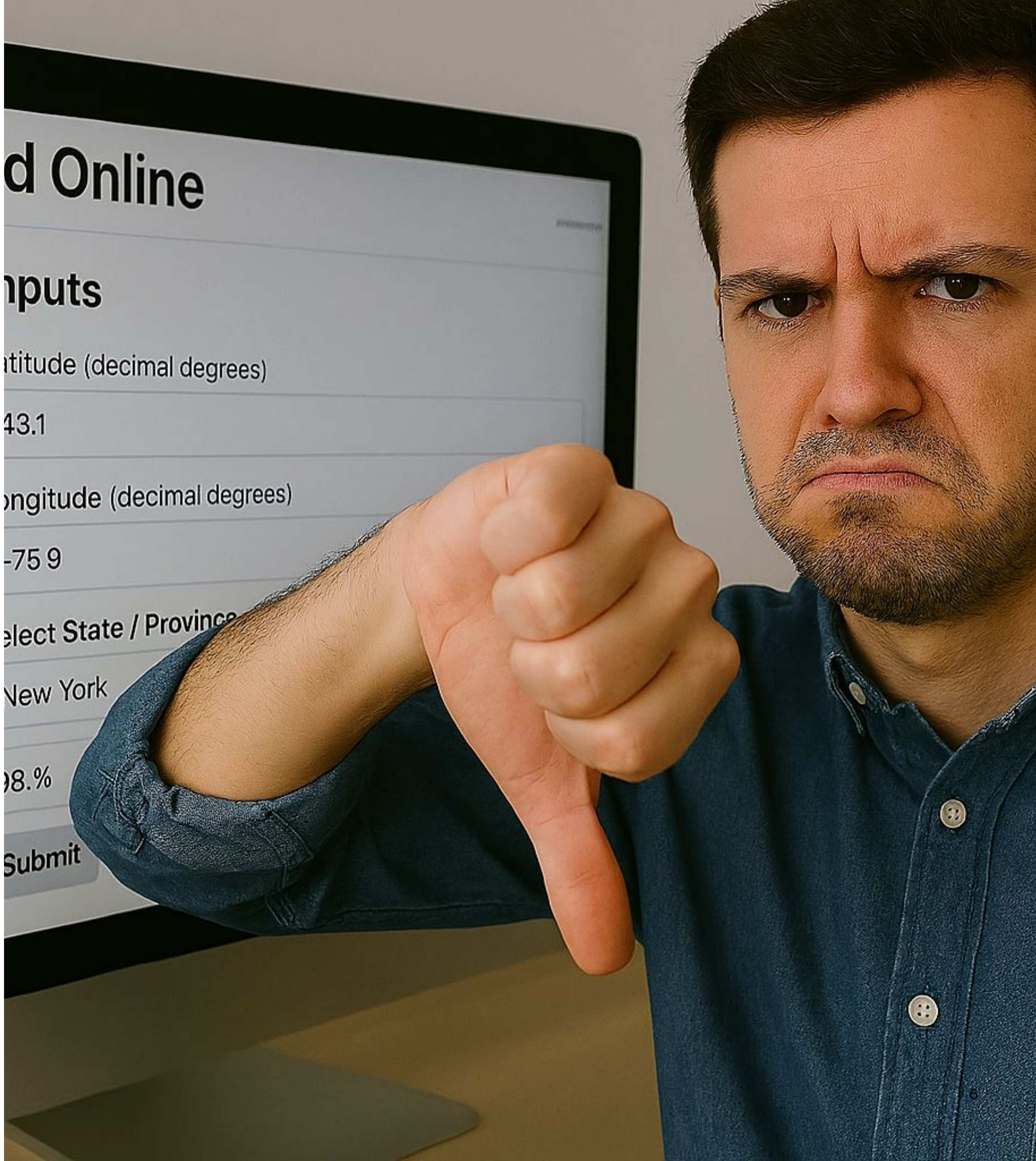
- **Design temperature = μ + Z σ**
- Z-value depends on what level of reliability you want
- Higher reliability means the design is less likely to fail
- Asphalt Performance Grades are defined over 6 °C temperature ranges based on both High and Low temperatures



Percentile	μ	σ	Z	High Temperature	Performance Grade
50.0%	46.0 °C	4.5 °C	0.000	46.0 °C	PG 46
98.0%	46.0 °C	4.5 °C	2.054	55.2 °C	PG 52
99.9%	46.0 °C	4.5 °C	2.054	59.9 °C	PG 58

“New” LTPPBind Online (2016)

- Updated version released in 2016 by US FHWA to replaced outdated temperature database in original software
- Includes NASA’s MERRA remote sensing climate database for air temperatures
- WSP (formerly Wood E&I) found strange results for Atlantic region
- Site now indicates performance grade (PG) algorithms were developed only for U.S. locations



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“RWIS-PG” (2018)

- WSP (formerly Wood E&I Solutions) completed studies in 2018 and 2024 to evaluate design PG temperatures for Atlantic Canada based on data from **Road Weather Information Systems (RWIS)** sites.
- These results are relied on by the NB, NS, PEI, and NL Transportation Departments for their Provincial pavement networks

Road Weather Information Systems (RWIS)

- Network of roadway monitoring stations
- Often used to optimize timing for de-icing maintenance
- Monitors various weather and pavement conditions every 15 to 30 minutes, such as:
  - Air temperature
  - Relative humidity
  - Wind speed
  - Pavement surface conditions
  - **Dual pavement temperatures recorded**

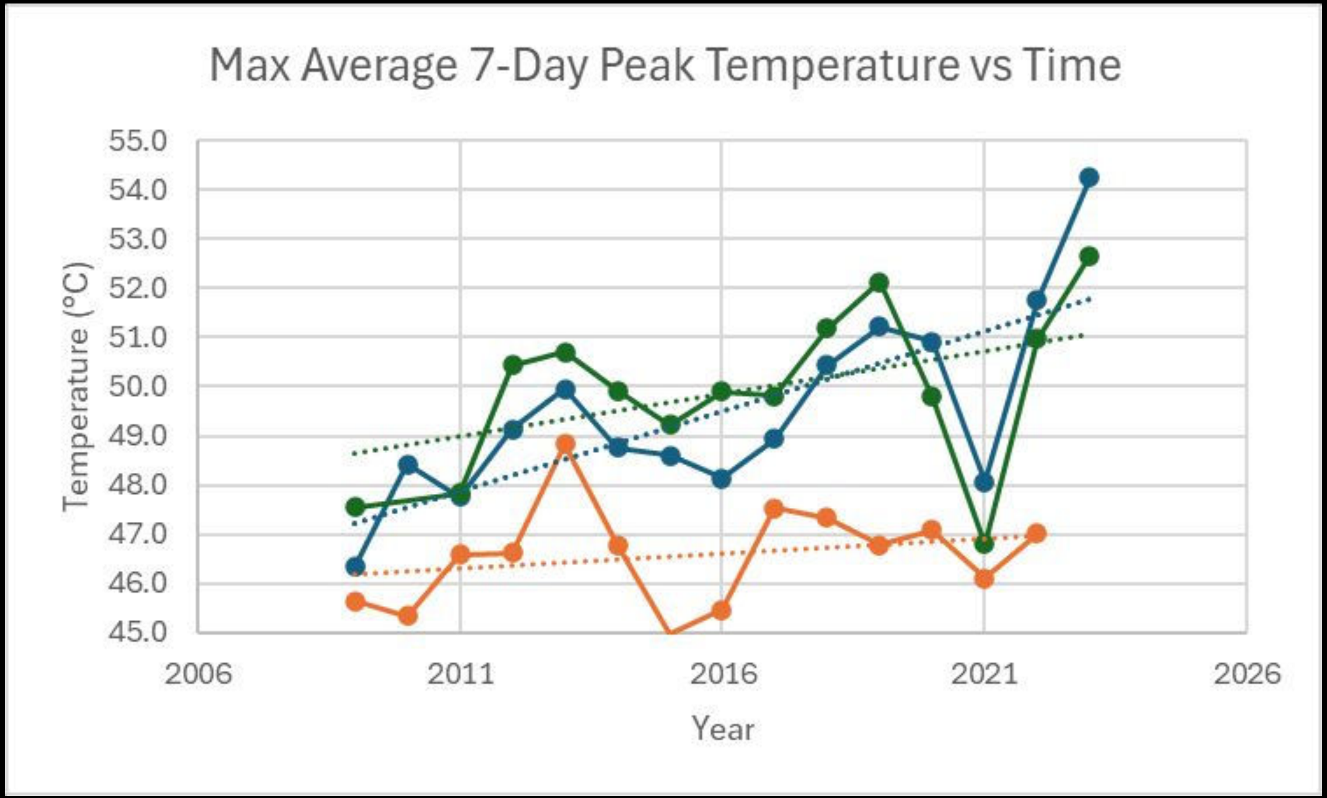
Embedded pavement temperature sensors

Atlantic Canadian RWIS Network

- Approximately 130 RWIS stations throughout NB, NS, PEI, and NL
- Concentrated along major highways and trunks
- Some significant gaps in coverage
- **Approximately 70 million temperature measurements from 2008 to 2024**

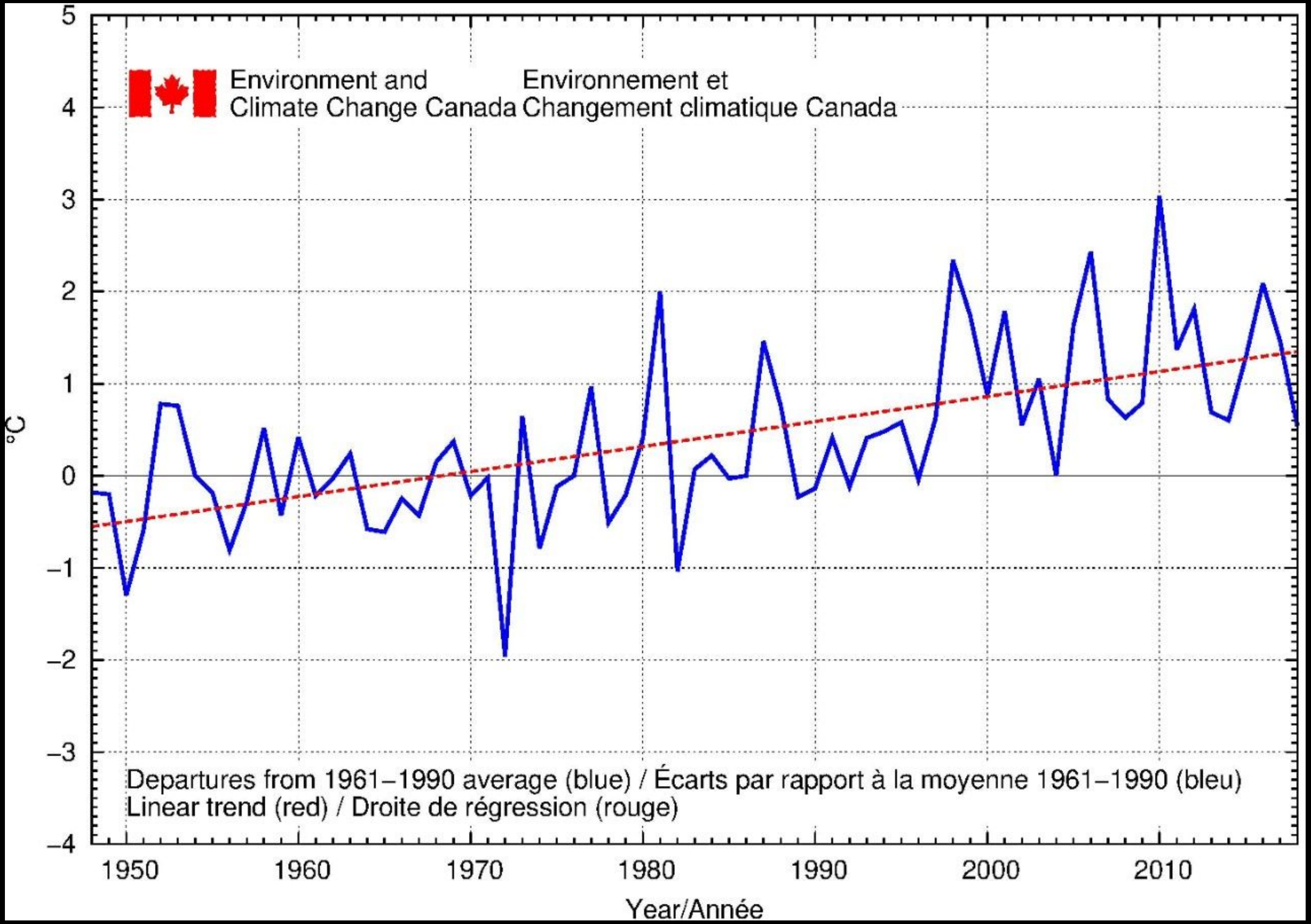
Climate Change

- Many RWIS sites exhibited pavement temperature changes over time
- Rate increase most noticeable in the High Temperature (HT) statistics
- Different locations exhibited different rates of change
- Some locations actually appeared to cool



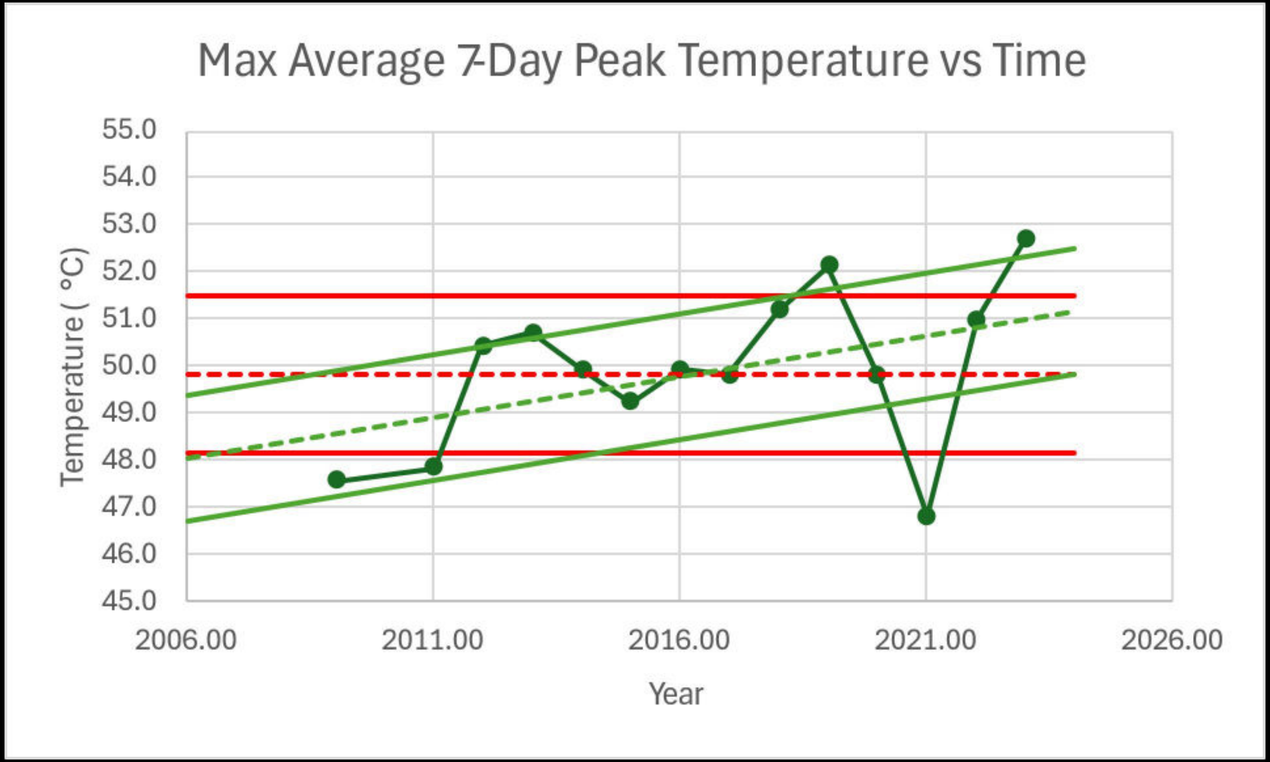
Climate Change

- Environment Canada indicated approximately 1.9 °C average temperature rise from 1948 to 2018.
- Likely increasing at a faster rate over time.



Impact on Design Temperatures

- LTPPBind approach assumes constant mean and constant variability
  - Increasing temperature over time will inflate the standard deviation
- Temperature change over time can be modelled
  - Lower standard deviation about the model



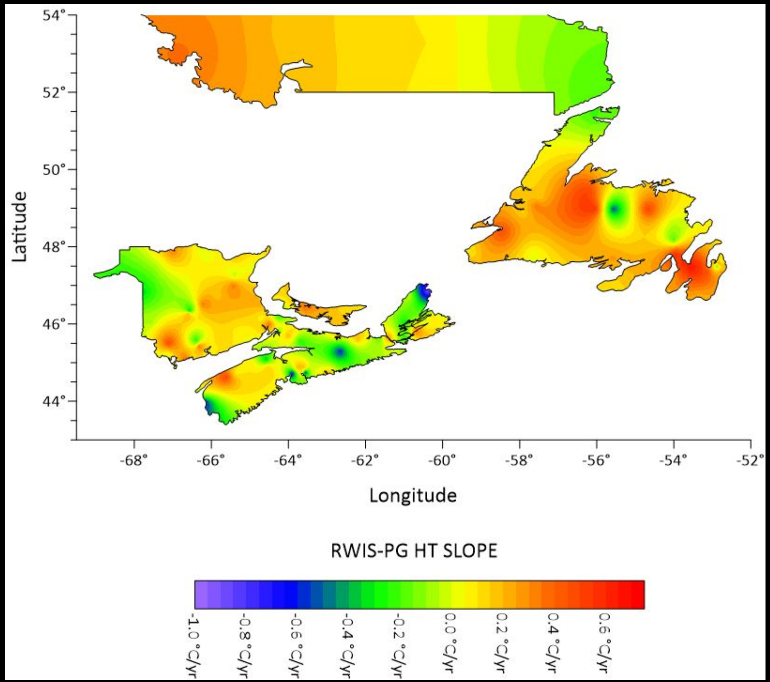
Impact on Design Temperatures

- LTPPBind approach with **constant mean** yields higher variability
- RWIS-PG **model** yields more accurate estimate at a given year and lower variability

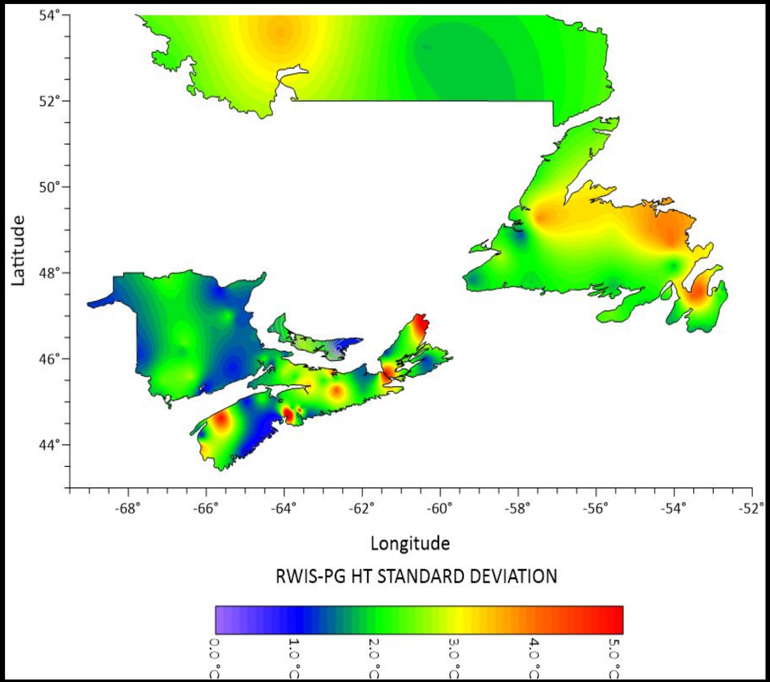
Approach	Year	μ	σ	98% HT	HT PG
Constant	2024	49.8 °C	1.67 °C	53.2 °C	PG 58
Constant	2030	49.8 °C	4.10 °C	58.7 °C	PG 64
Model	2024	51.2 °C	1.35 °C	53.9 °C	PG 58
Model	2030	52.2 °C	1.35 °C	55.0 °C	PG 58

Temperature Change Trends

- **Rate of Change in High and Low Temperatures**
  - Influence of location
  - HT seems to be changing faster than LT
  - Variability at certain sites is playing a significant role



Rate of Change in HT



HT Standard Deviation

Temperature Change Trends

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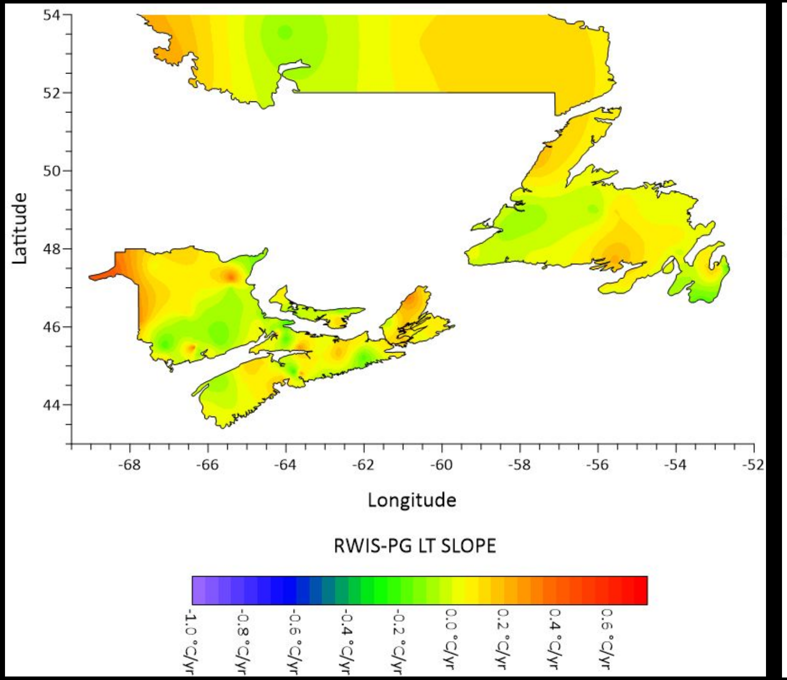
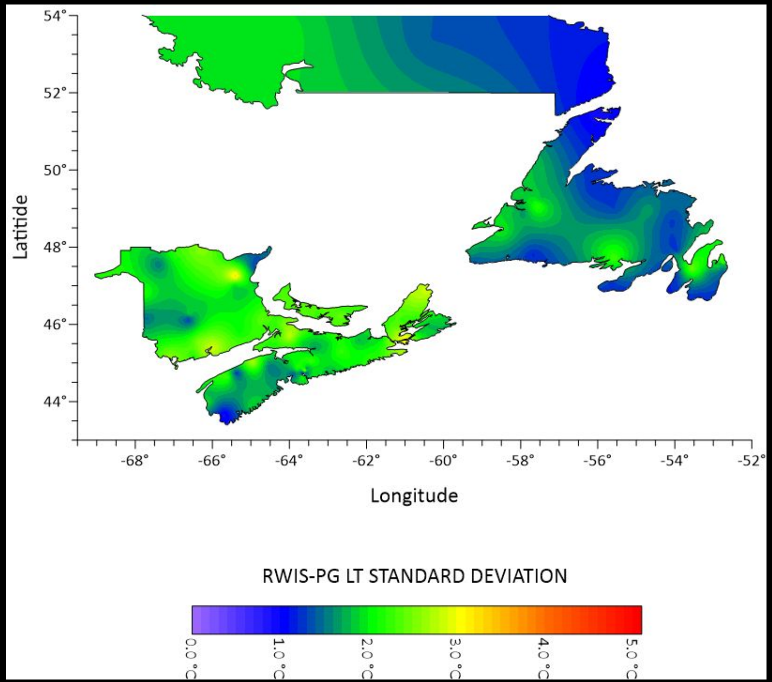


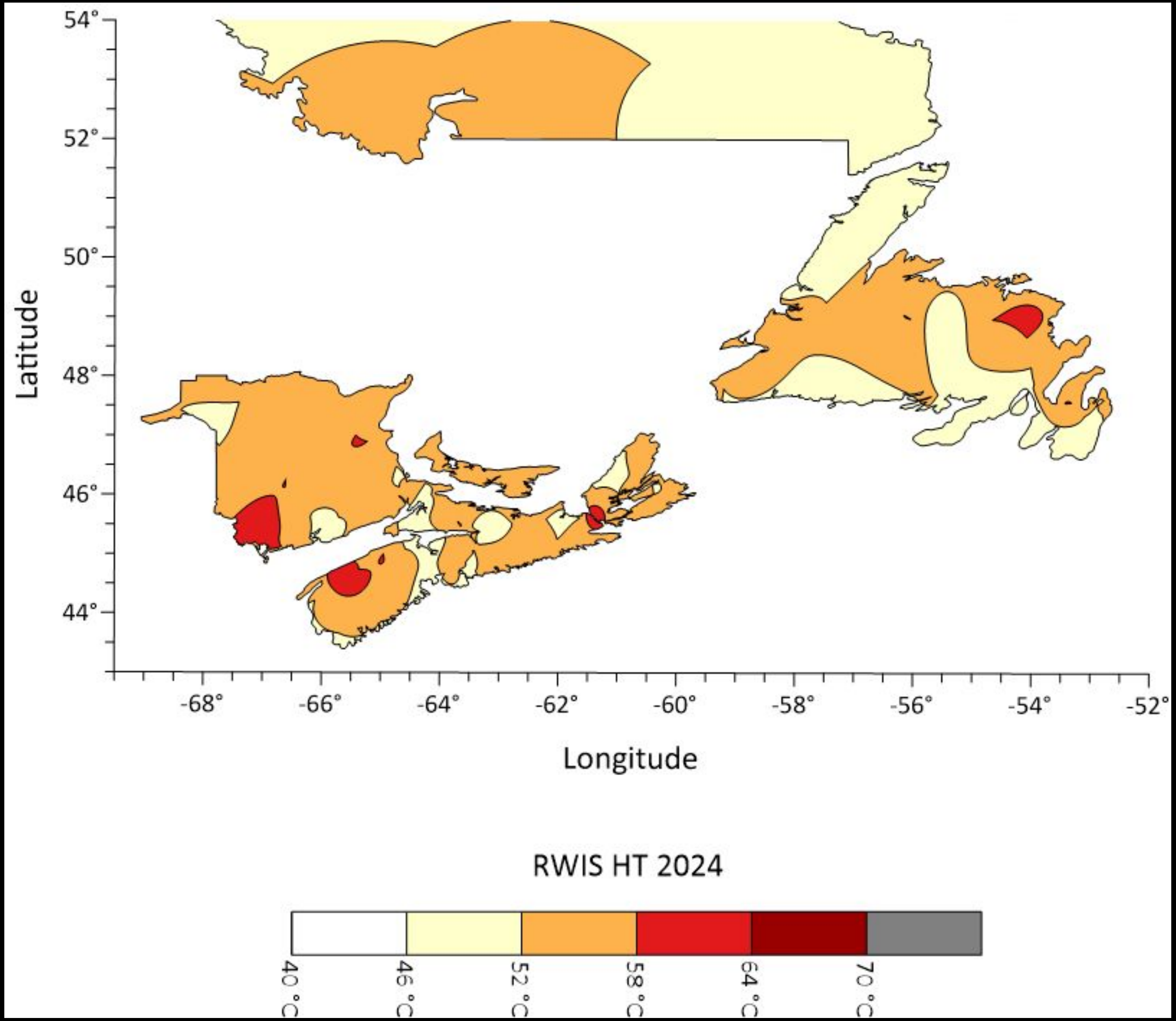
Rate of Change in HT



HT Standard Deviation

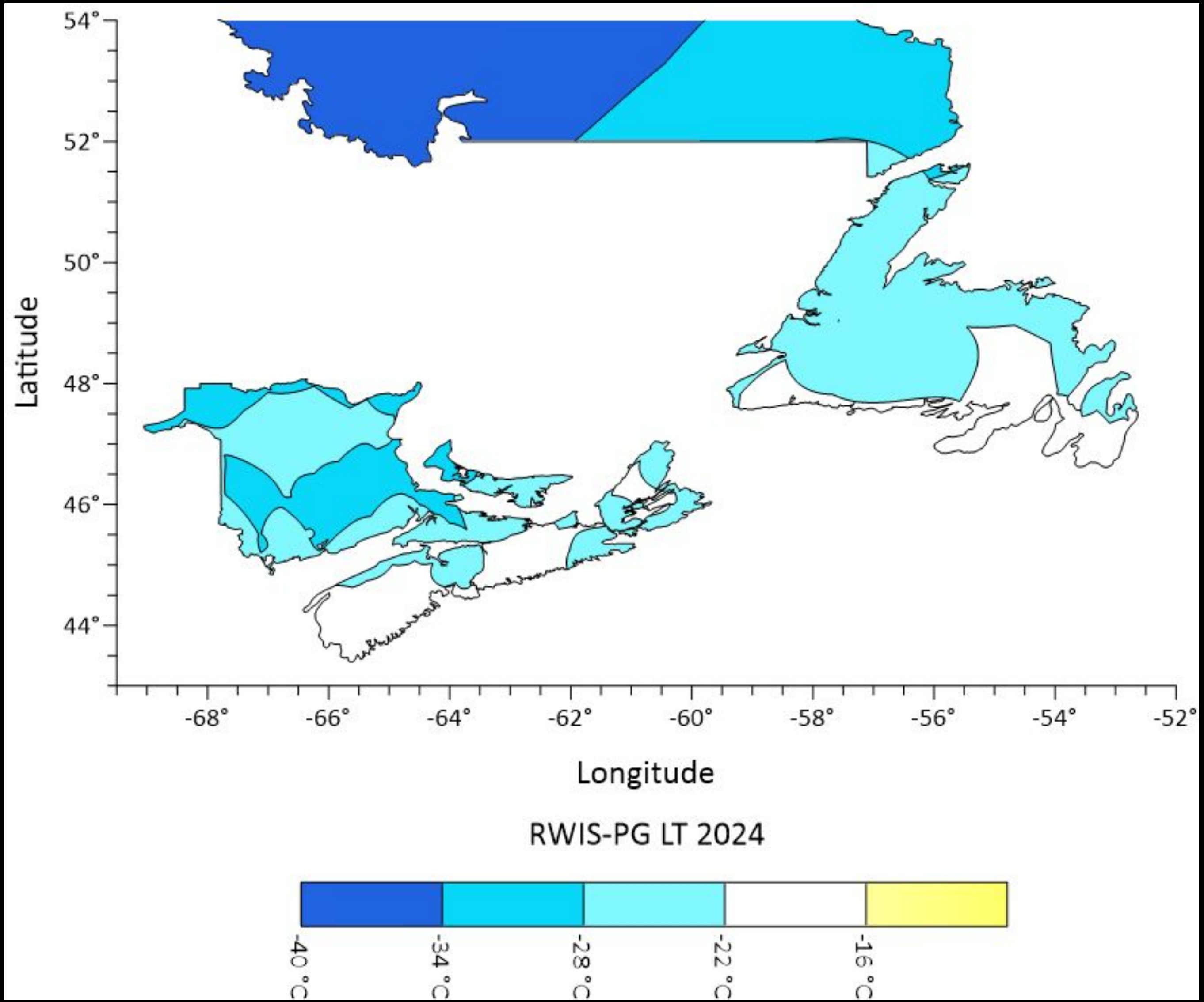
Asphalt Binder Performance Grade Requirements

- **Analysis of 98th percentile pavement HT PG**
  - Generally PG 58 in NB, NS, and PEI with some sparse areas of PG 52 and PG 64
  - Balance of PG 52 and PG 58 in NL with small area of PG 64



Asphalt Binder Performance Grade Requirements

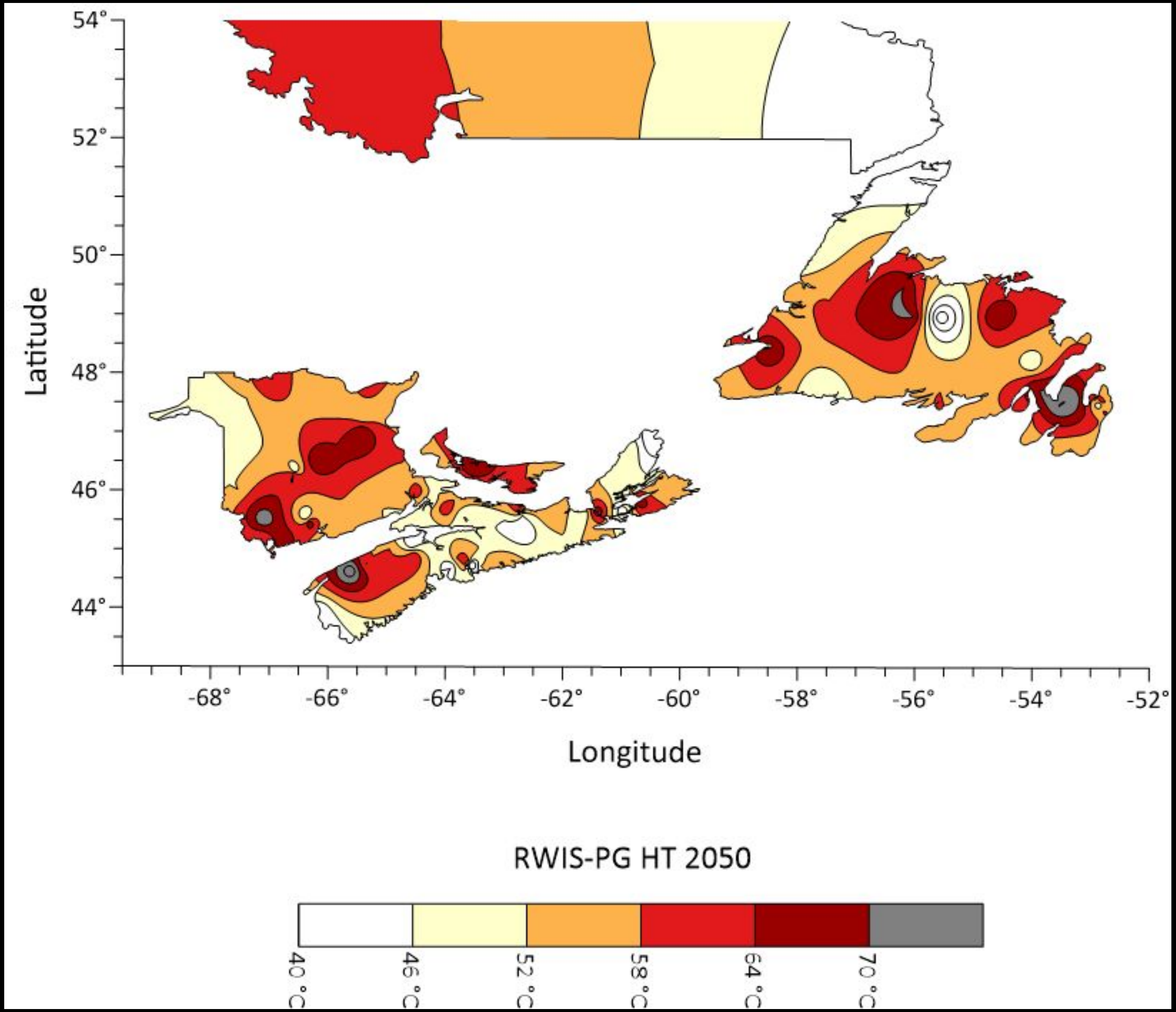
- **Analysis of 98th percentile pavement LT PG**
  - Generally a balance PG -22 and PG -28 in NS and Island of Newfoundland
  - Generally a balance of PG -28 and PG -34 in NB and PEI
  - Balance of PG -34 and PG -40 in Labrador



CAN WE APPLY OUR SIMPLE MODELS TO FORECAST PG REQUIREMENTS IN THE FUTURE?

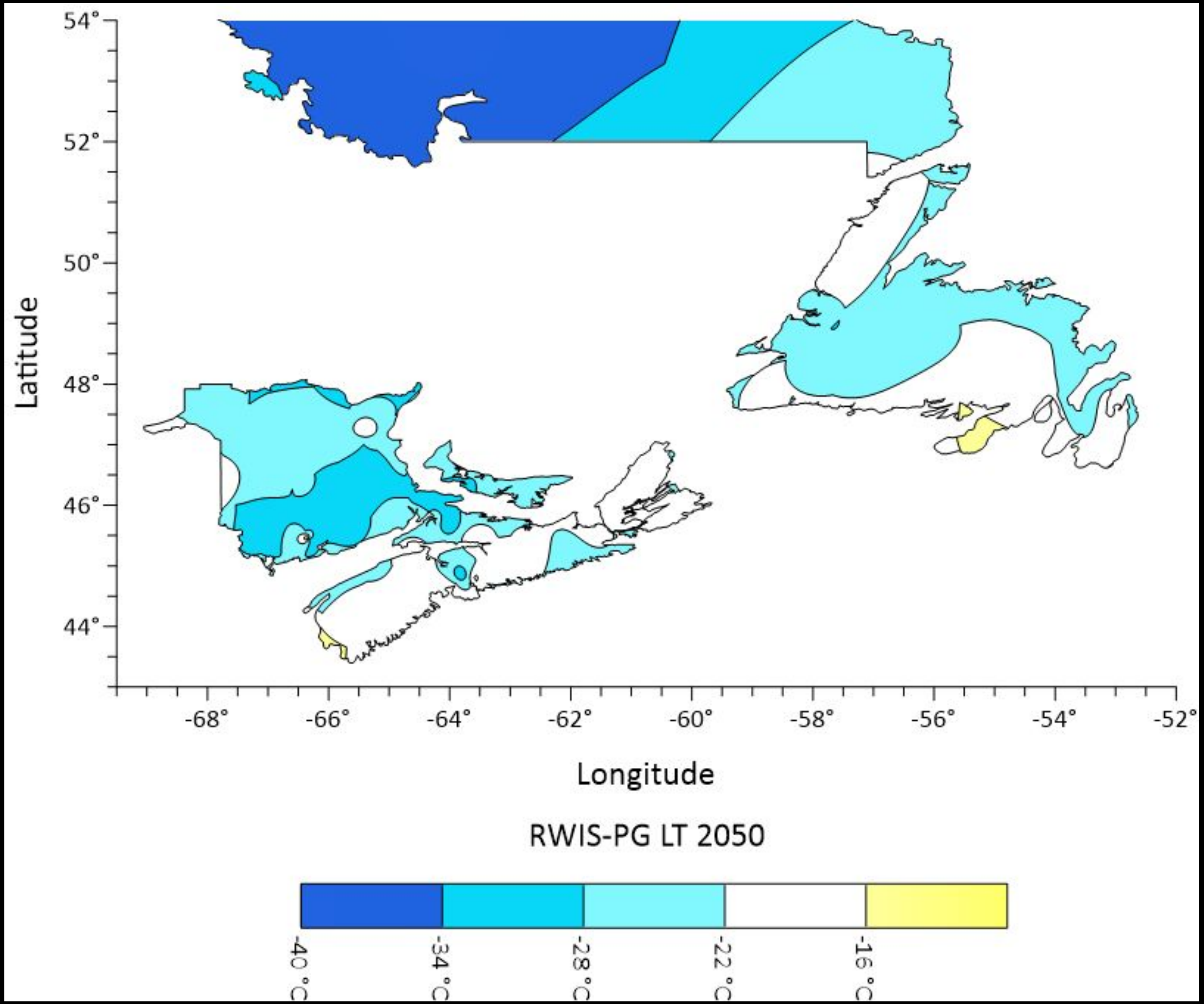
Project HT model forward

- If these “short term” linear model are correct
  - Larger areas of PG 64 evolving in 2030 which may require specification change
  - Potential for PG 70 developing in 2040
  - 2050 (long reach to the future) may see PG 76
- Trends may be nonlinear – need more data over a longer term



Project LT model forward

- If these “short term” linear model are correct
  - Slight shift to more PG -28 areas in 2030
  - Subtle shift toward PG -22 in NS and PG -28 in northern NB in 2040
  - 2050 (long reach to the future) may see PG -16 develop in southerly areas of NS and NL



Conclusions

- RWIS pavement temperature measurements provide a direct basis for determining PG requirements without relying on correlation to air temperatures.
- Local variability in pavement temperatures at some RWIS sites had significant impact in the calculated design temperatures and PG requirements.
- Modelling climate change effects in pavement temperatures can reduce variability and improve accuracy when determining PG requirements
- A range in rates of pavement temperature change was observed throughout Atlantic Canada
- Medium term forecasts of pavement temperature change appear to indicate a change in PG specifications may be required within the next 10 to 15 years.

THANK YOU

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