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XIII INTERNATIONAL WINTER ROAD CONGRESS

QUÉBEC, FEBRUARY 8 TO 11, 2010

SUSTAINABLE WINTER SERVICE FOR ROAD USERS

Night Icing Potential Prediction System

Paul Richard and **Paul Delannoy**

Nova Scotia Transportation And Infrastructure Renewal
Manager Mtce & Operations
richarpa@gov.ns.ca

AMEC Earth And Environmental
Senior Associate
paul.delannoy@amec.com

WORLD ROAD ASSOCIATION MONDIALE DE LA ROUTE
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NOVA SCOTIA CANADA

Night Icing Potential (NIP) Prediction System

Infrared thermal mapping achieved cost-effectively and applied operationally in Canada.

Outline

- **IR Data Acquisition – Paul Richard**
  - **Collaborative approach**
  - **Equipment used**
  - **Demonstration area**
- **Prediction System – Paul Delannoy**
  - **IR data analysis & Thermal Fingerprint generation;**
  - **NIP Maintenance Decision Aid**
  - **Conclusions**

Working in Collaboration

IR Data Runs

Data Analysis

NS TIR

- Terms of collaboration
- Patrol Vehicle & driver
- IR Sensor – Road temp
- Automatic Vehicle Location (AVL) service

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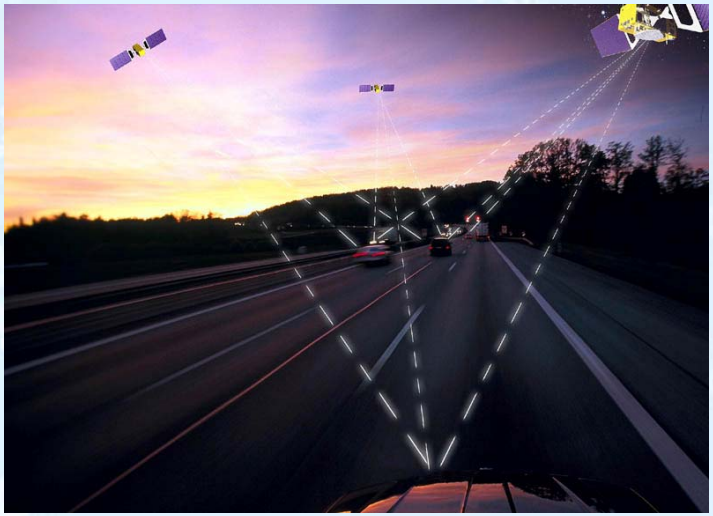
- Orientation session
- IR Data Run coordination
- IR Data analysis
- Thermal Fingerprints
- NIP Decision Aid

Equipment Used – Road Temp Data

- **Sprague RoadWatch surface temperature measuring system;**
  - **Rd Temp accuracy: ± 1 °C**
  - **Response Time: 0.1 sec.**
  - **Emissivity: fixed at 0.96**
  - **RS-232 connection: to feed signal directly into – AVL unit**

- **Will accurately sense a 1 °C change in road surface temperature in 1/10th of a second.**

Equipment Used – Location Data



- **Automatic Vehicle Location (AVL) service**:
  - **Global Positioning System (GPS) fixes for position and time; and**
  - **Cellular communications and Internet data display and recovery.**

- **Sensing**
  - **Runs performed in early morning hours;**
  - **Maximum frequency of fixes was at 2 seconds;**
  - **Average vehicle speed: ~ 35 km/hr (9.7 m/sec);**
  - **Date points with position, time, air and road temperatures every 20 meters;**
  - **Coarser than recommended in literature but worked well in highway application.**

Demonstration Area


MAPQUEST
Hillsborough Bay
Belfast
315
17
Prince Edward Island
4
Murray Harbour
18
1
0
8mi
8km
Northumberland Strait
Pictou Island
Malagash
6
Tatamagouche
106
Scotsburn
Pictou
TCH
Antigonish
New Glasgow
104
4
St Andrews
Westville
Stellarton
104
42 kms.
West River Station
Hwy-374
7
Debert
Sunny Brae
Truro
2
Goshen
23 IR Runs completed
Aspen
St Mary's
Brookfield
06-02-2007 to
Upper Musquodoboit
Sherbrooke
102
13-03-2007
Shubenacadie
© 2007 MapQuest, Inc.
©2007 NAVTEQ
RWIS Site

IR Data Analysis

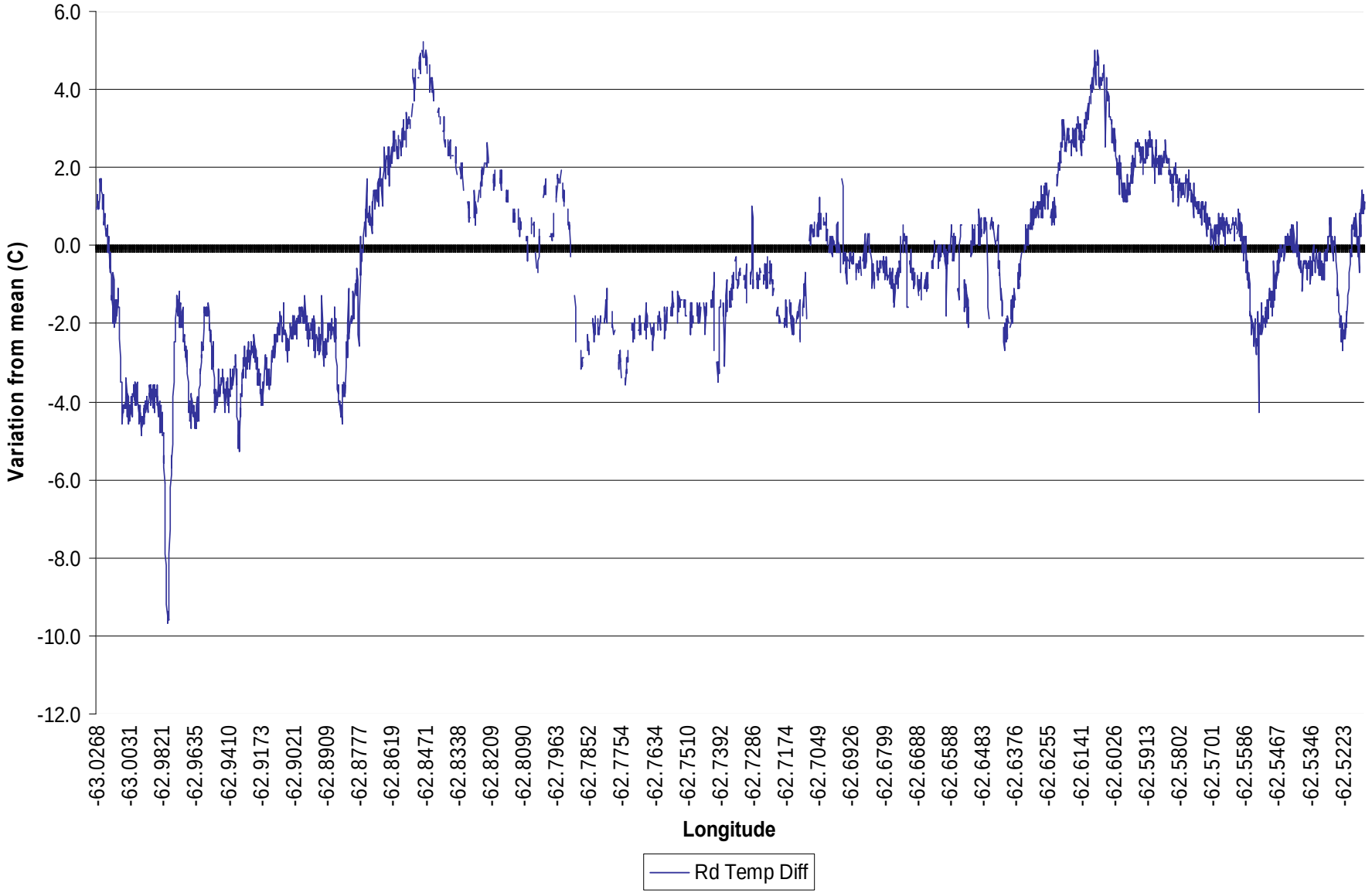
- Coordinated IR runs with NS TIR;
- Compiled and analysed data against actual observed weather conditions along the route at the time of the run;
  - Categorized runs into Extreme, Intermediate, or Damped;

- Generated thermal profile for each run;
- IR data filtered & collection of runs in a class (E, I, D) are averaged;
- Generated Static Thermal Fingerprint for each of 3 classes.

CLASS	Cloud Cover	Wind Speed
EXTREME	Clear	Calm
INTERMEDIATE	Broken	Light - Moderate
DAMPED	Overcast	Moderate to Strong
UNSUITABLE	Precipitation Fronts	Very Strong

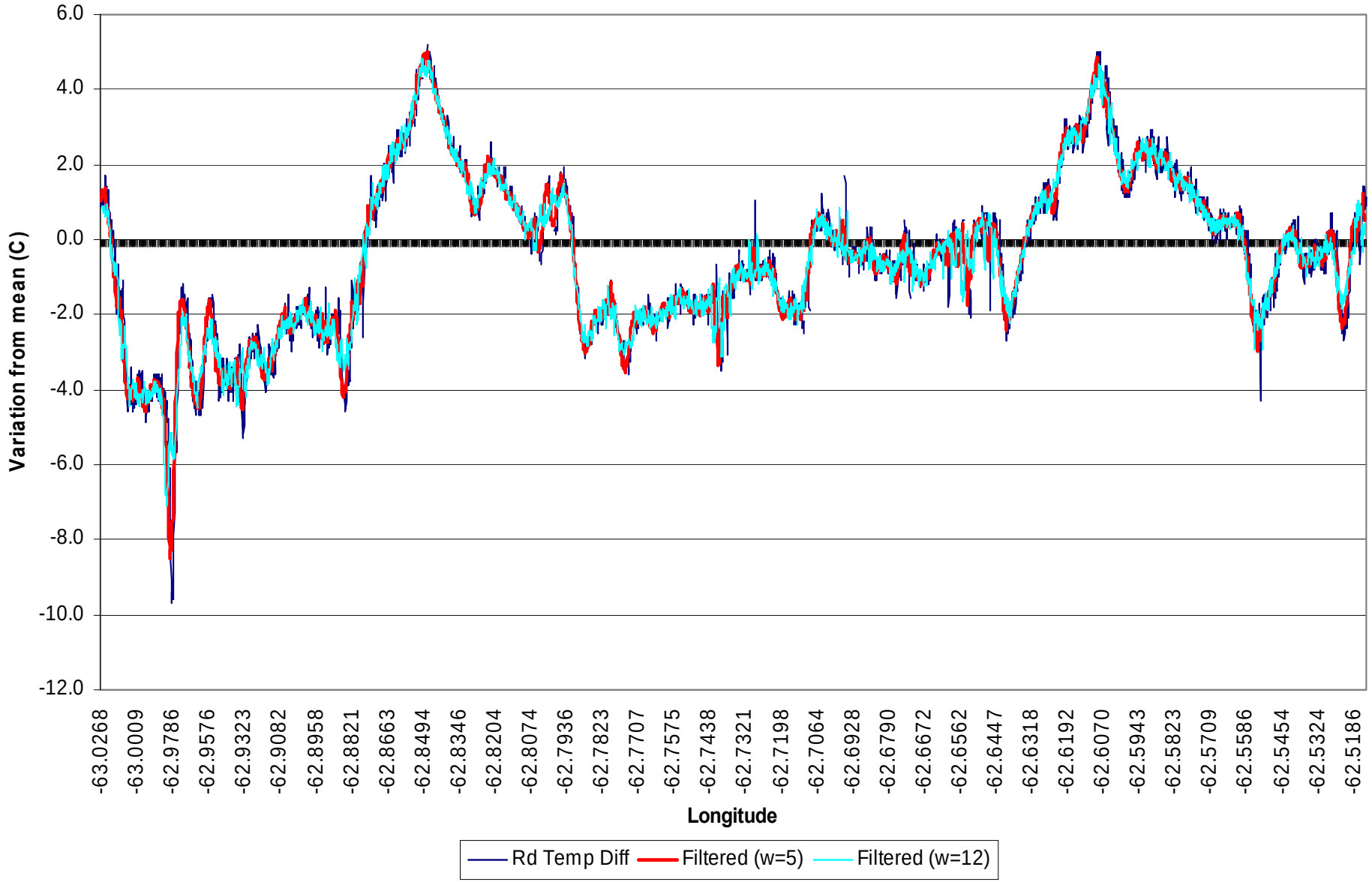
Raw IR Data – Extreme Case

TCH 104: 07-03-08

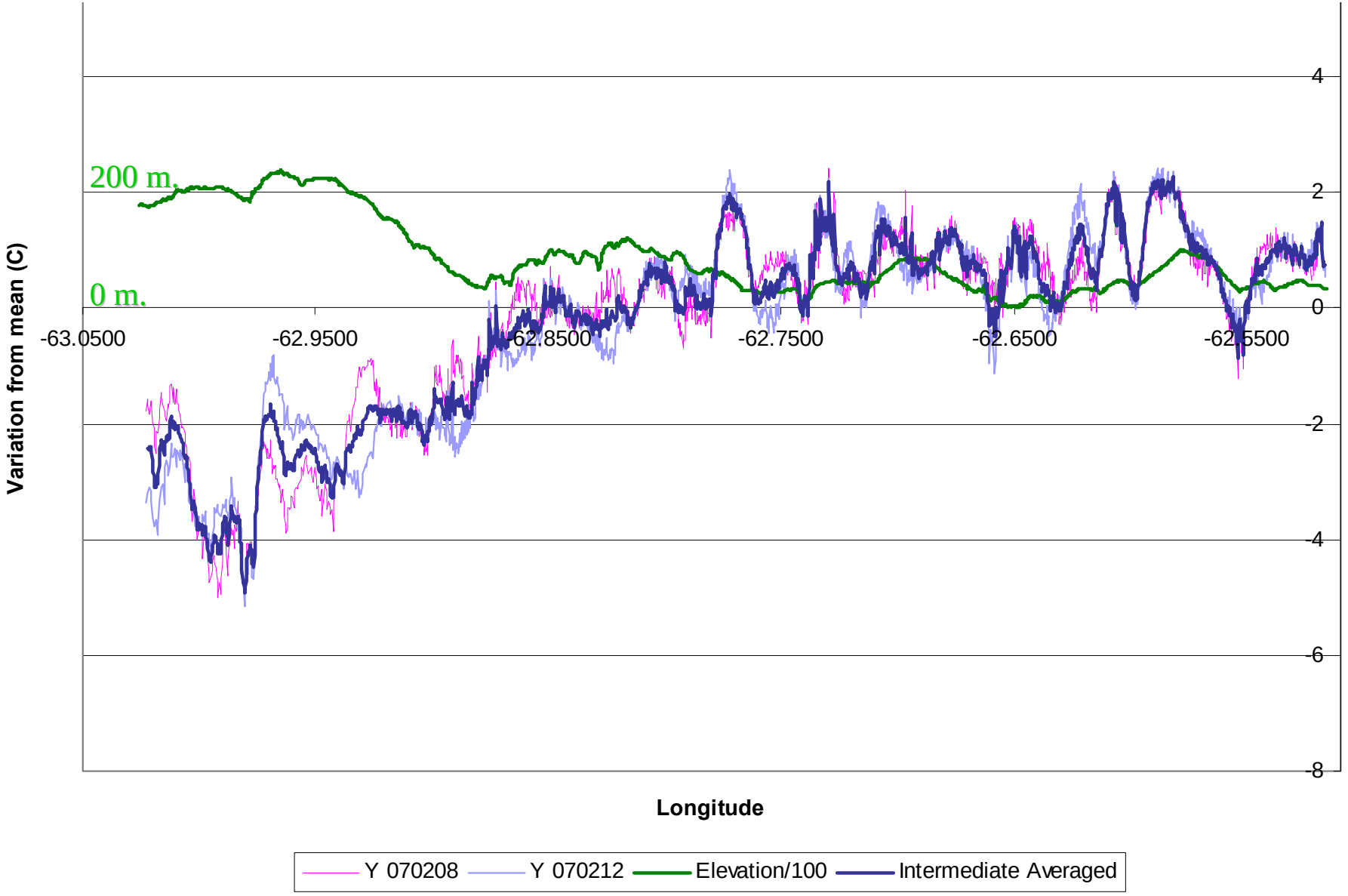


Filtered IR Data

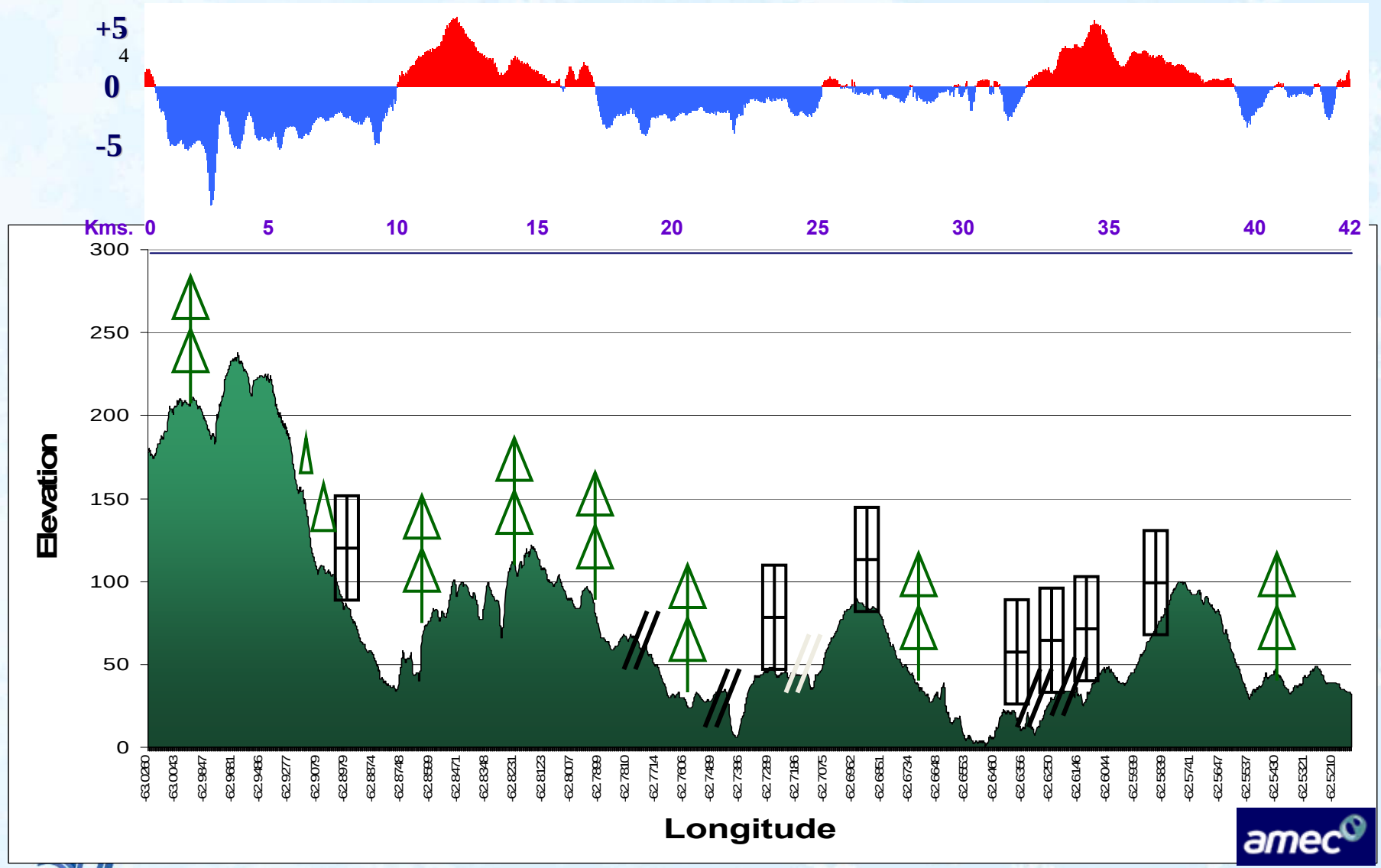
TCH 104: 07-03-08



Filtered & Averaged Runs - Intermediate



Extreme Thermal Fingerprint - TCH 104



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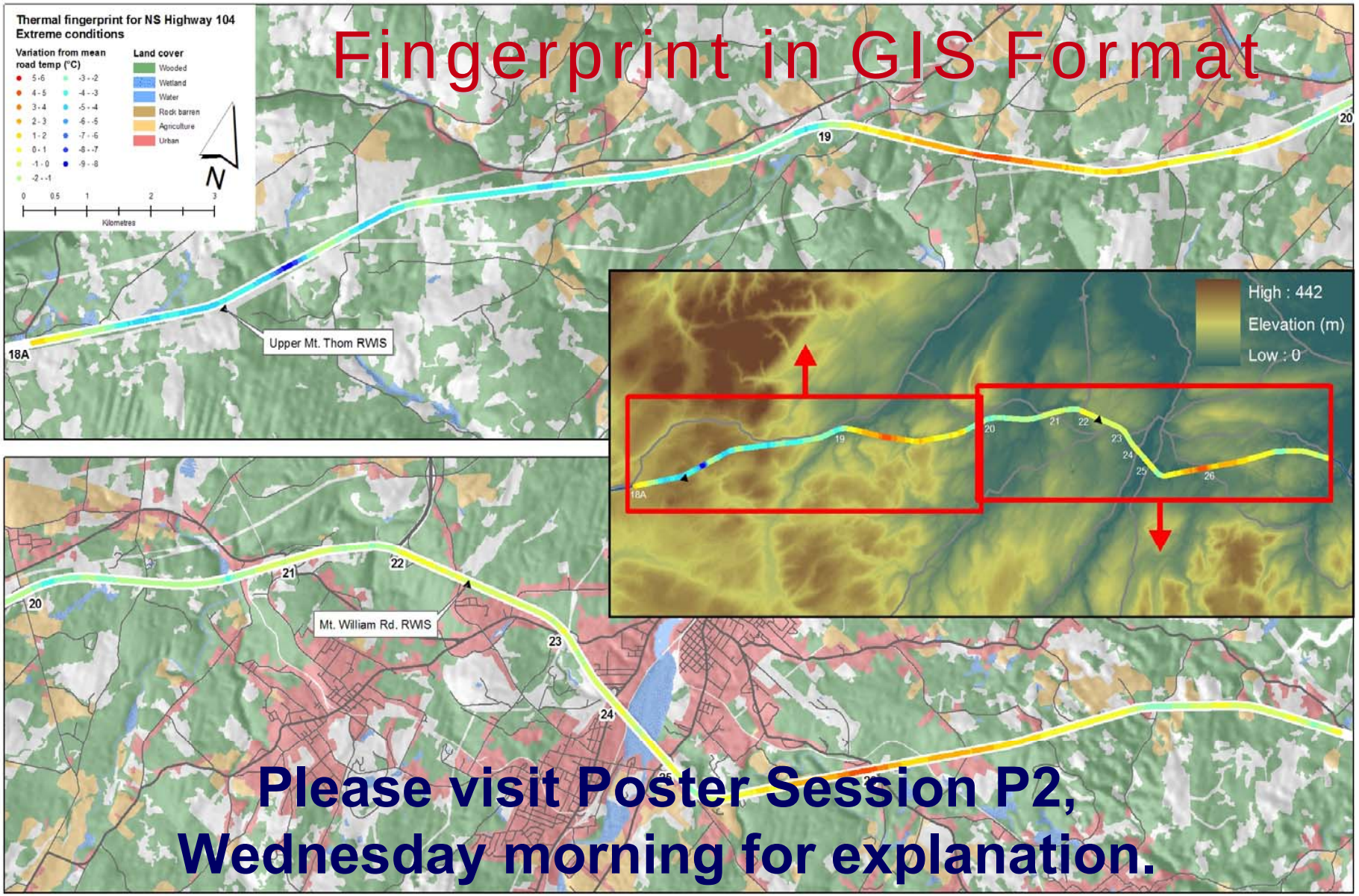
Fingerprint in GIS Format

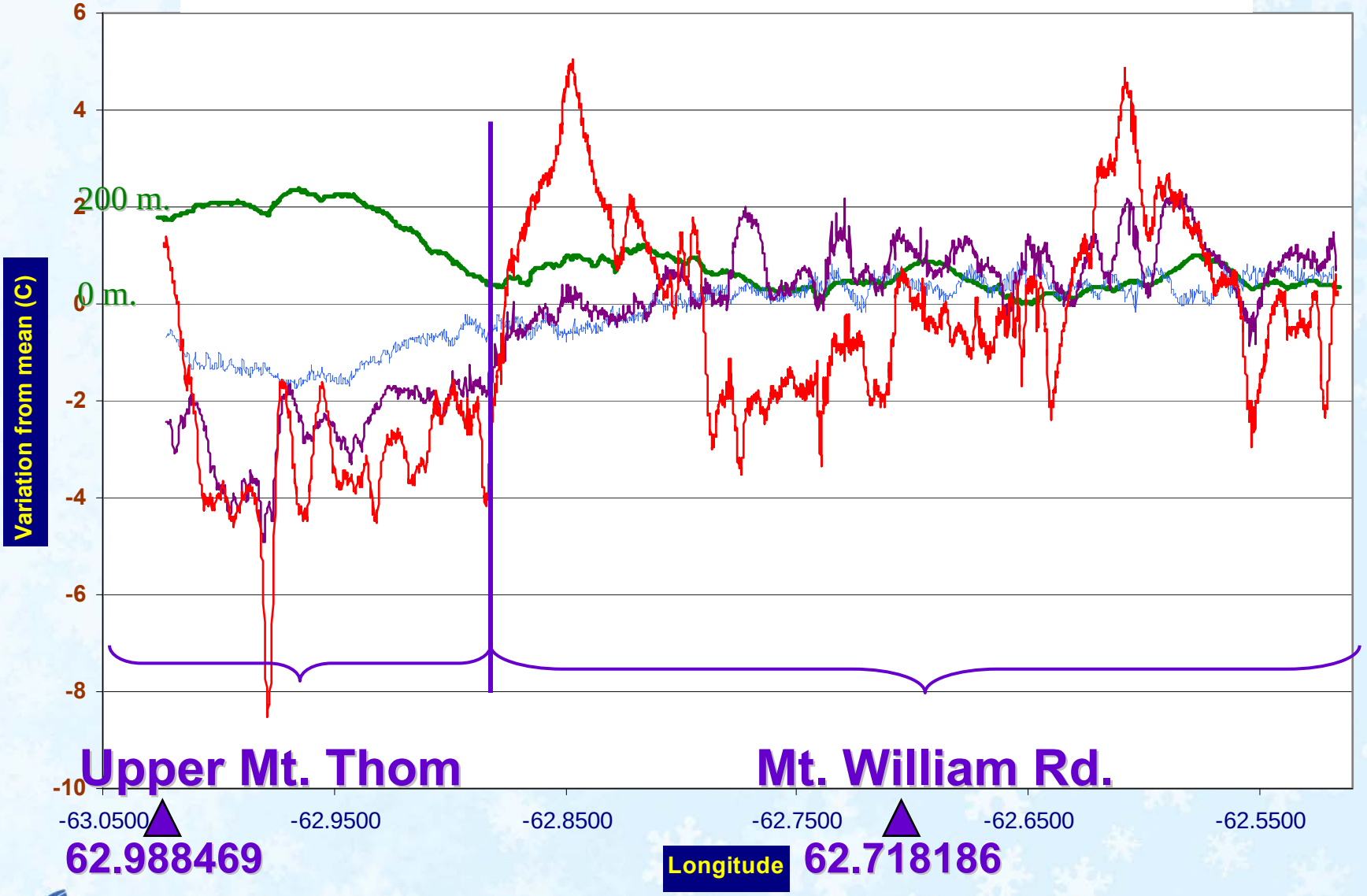


Please visit Poster Session P2, Wednesday morning for explanation.

NIP Maintenance Decision Aid

- Goal is to use Thermal Fingerprint and Road Temperature forecast at a nearby RWIS site to determine where and when frosting of roads is likely in cold climates – where road temperatures are below 0 ºC all night on most nights;
- Set up an association between road sections and available RWIS sites;
- Divide route up into workable segments;
- Establish relationship between each road segment and associated RWIS for each weather class (E, I, D); and
- Use this operationally on a daily basis.

Association with RWIS Sites



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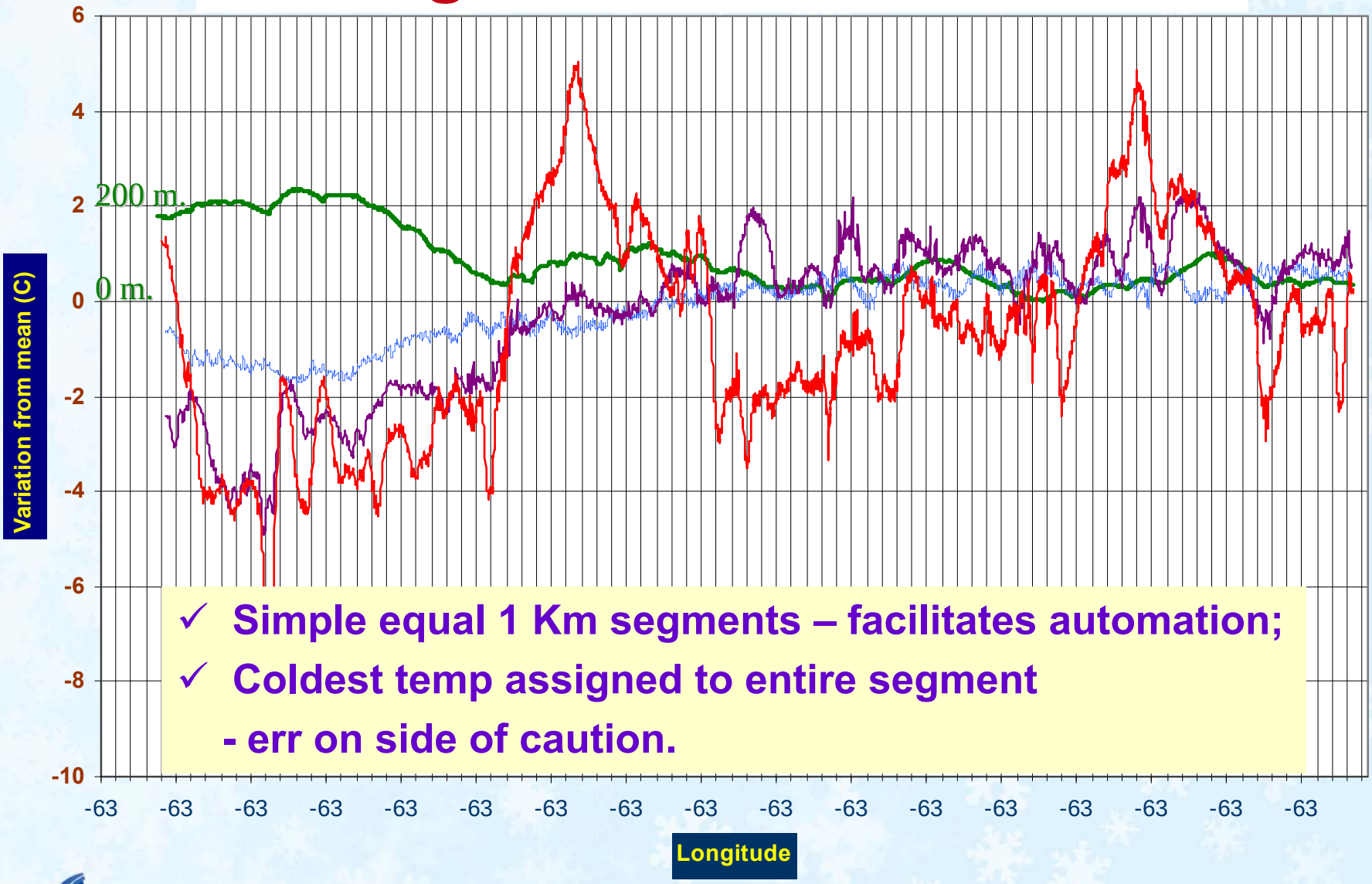
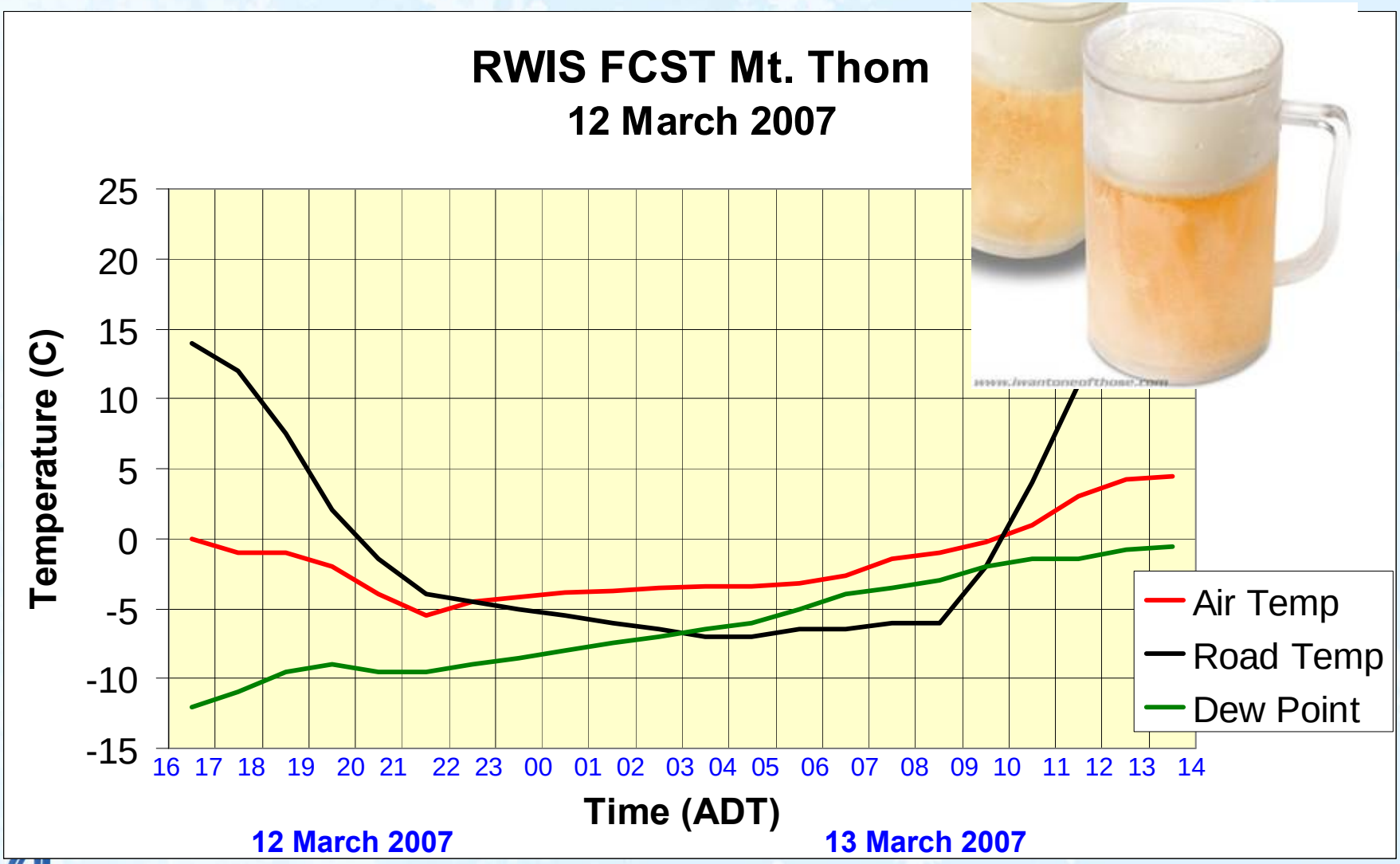
Segmentation of Route



- ✓ Simple equal 1 Km segments – facilitates automation;
- ✓ Coldest temp assigned to entire segment
  - err on side of caution.

Test Case – March 2007



Test Case – March 2007

	ADT	FORECAST	
DATE	TIME	T_{road}	T_{dew}
12	9	-4	-9.5
12	10	-4.5	-9
12	11	-5	-8.5
12	12	-5.5	-8
13	1	-6	-7.5
13	2	-6.5	-7
13	3	-7	-6.5
13	4	-7	-6
13	5	-6.5	-5
13	6	-6.5	-4
13	7	-6	-3.5
13	8	-6	-3
13	9	-2	-2
13	10	4	-1.5

Forecast Logic

$T_{road} \leq 0\ °C$

&

$T_{road} \leq T_{dew\ point}$

Then

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Test Case – March 2007

	ADT	FORECAST		
DATE	TIME	T_{road}	T_{dew}	$T_r - T_d$
12	9	-4	-9.5	5.5
12	10	-4.5	-9	4.5
12	11	-5	-8.5	3.5
12	12	-5.5	-8	2.5
13	1	-6	-7.5	1.5
13	2	-6.5	-7	0.5
13	3	-7	-6.5	-0.5
13	4	-7	-6	-1
13	5	-6.5	-5	-1.5
13	6	-6.5	-4	-2.5
13	7	-6	-3.5	-2.5
13	8	-6	-3	-3
13	9	-2	-2	0
13	10	4	-1.5	5.5

Forecast Logic

$T_{road} \leq 0\ °C$

&

$T_{road} \leq T_{dew\ point}$

Then

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Test Case – March 2007

	ADT	FORECAST			FCST
DATE	TIME	Troad	Tdew	Diff	
12	9	-4	-9.5	5.5	
12	10	-4.5	-9	4.5	
12	11	-5	-8.5	3.5	
12	12	-5.5	-8	2.5	
13	1	-6	-7.5	1.5	
13	2	-6.5	-7	0.5	
13	3	-7	-6.5	-0.5	NIP
13	4	-7	-6	-1	NIP
13	5	-6.5	-5	-1.5	NIP
13	6	-6.5	-4	-2.5	NIP
13	7	-6	-3.5	-2.5	NIP
13	8	-6	-3	-3	NIP
13	9	-2	-2	0	NIP
13	10	4	-1.5	5.5	

Forecast Logic

$T_{road} \leq 0\ °C$

&

$T_{road} \leq T_{dew\ point}$

Then

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Test Case – March 2007

ADT		FORECAST			FCST	ROAD SEGMENTS					
DATE	TIME	Troad	Tdew	Diff		+3	+2	+1	-1	-2	-3
12	9	-4	-9.5	5.5							
12	10	-4.5	-9	4.5							
12	11	-5	-8.5	3.5							
12	12	-5.5	-8	2.5							
13	1	-6	-7.5	1.5							
13	2	-6.5	-7	0.5							
13	3	-7	-6.5	-0.5	NIP						
13	4	-7	-6	-1	NIP						
13	5	-6.5	-5	-1.5	NIP						
13	6	-6.5	-4	-2.5	NIP						
13	7	-6	-3.5	-2.5	NIP						
13	8	-6	-3	-3	NIP						
13	9	-2	-2	0	NIP						
13	10	4	-1.5	5.5							

Test Case – March 2007

ADT		FORECAST			FCST	ROAD SEGMENTS					
DATE	TIME	Troad	Tdew	Diff		+3	+2	+1	-1	-2	-3
12	9	-4	-9.5	5.5						3.5	
12	10	-4.5	-9	4.5						2.5	
12	11	-5	-8.5	3.5						1.5	
12	12	-5.5	-8	2.5						0.5	
13	1	-6	-7.5	1.5						-0.5	
13	2	-6.5	-7	0.5						-1.5	
13	3	-7	-6.5	-0.5	NIP					-2.5	
13	4	-7	-6	-1	NIP					-3	
13	5	-6.5	-5	-1.5	NIP					-3.5	
13	6	-6.5	-4	-2.5	NIP					-4.5	
13	7	-6	-3.5	-2.5	NIP					-4.5	
13	8	-6	-3	-3	NIP					-5	
13	9	-2	-2	0	NIP					-2	
13	10	4	-1.5	5.5						3.5	

Test Case – March 2007

ADT		FORECAST			FCST	ROAD SEGMENTS					
DATE	TIME	Troad	Tdew	Diff		+3	+2	+1	-1	-2	-3
12	9	-4	-9.5	5.5			7.5			3.5	
12	10	-4.5	-9	4.5			6.5			2.5	
12	11	-5	-8.5	3.5			5.5			1.5	
12	12	-5.5	-8	2.5			4.5			0.5	
13	1	-6	-7.5	1.5			3.5			-0.5	
13	2	-6.5	-7	0.5			2.5			-1.5	
13	3	-7	-6.5	-0.5	NIP		1.5			-2.5	
13	4	-7	-6	-1	NIP		1			-3	
13	5	-6.5	-5	-1.5	NIP		0.5			-3.5	
13	6	-6.5	-4	-2.5	NIP		-0.5			-4.5	
13	7	-6	-3.5	-2.5	NIP		-0.5			-4.5	
13	8	-6	-3	-3	NIP		-1			-5	
13	9	-2	-2	0	NIP		2			-2	
13	10	4	-1.5	5.5			7.5			3.5	

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Test Case – March 2007

ADT		FORECAST			FCST	ROAD SEGMENTS					
DATE	TIME	Troad	Tdew	Diff		+3	+2	+1	-1	-2	-3
12	9	-4	-9.5	5.5		8.5	7.5	6.5	4.5	3.5	2.5
12	10	-4.5	-9	4.5		7.5	6.5	5.5	3.5	2.5	1.5
12	11	-5	-8.5	3.5		6.5	5.5	4.5	2.5	1.5	0.5
12	12	-5.5	-8	2.5		5.5	4.5	3.5	1.5	0.5	-0.5
13	1	-6	-7.5	1.5		4.5	3.5	2.5	0.5	-0.5	-1.5
13	2	-6.5	-7	0.5		3.5	2.5	1.5	-0.5	-1.5	-2.5
13	3	-7	-6.5	-0.5	NIP	2.5	1.5	0.5	-1.5	-2.5	-3.5
13	4	-7	-6	-1	NIP	2	1	0	-2	-3	-4
13	5	-6.5	-5	-1.5	NIP	1.5	0.5	-0.5	-2.5	-3.5	-4.5
13	6	-6.5	-4	-2.5	NIP	0.5	-0.5	-1.5	-3.5	-4.5	-5.5
13	7	-6	-3.5	-2.5	NIP	0.5	-0.5	-1.5	-3.5	-4.5	-5.5
13	8	-6	-3	-3	NIP	0	-1	-2	-4	-5	-6
13	9	-2	-2	0	NIP	3	2	1	-1	-2	-3
13	10	4	-1.5	5.5		8.5	7.5	6.5	4.5	3.5	2.5

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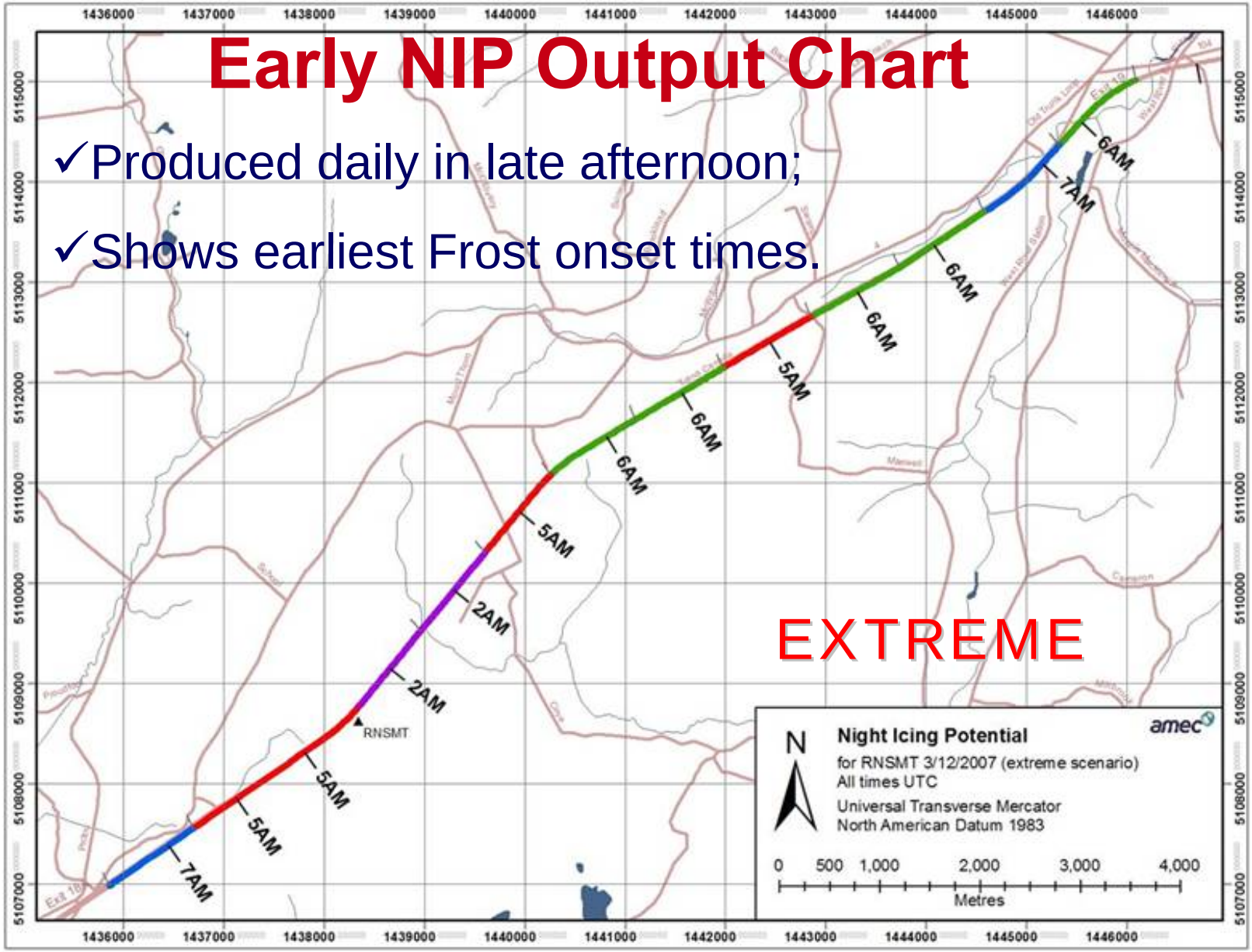
Early NIP Output Chart

- ✓Produced daily in late afternoon;
- ✓Shows earliest Frost onset times.



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CONCLUSIONS

Performance

- ✓ Results from a short operational test period (2 spring + 6 fall weeks) (*results in the paper*);
- ✓ Correct nearly three quarters of the time;
- ✓ Overforecasts icing events – errs on side of safety;
- ✓ Did not miss any icing events – most serious error;

Limitations

- ✓ NIP assumes uniform moisture distribution along a route;
- ✓ NIP dependant on accurate RWIS forecast;

Latest NIP Developments

- ✓ NIP for 'weather' nights outputs lowest overnight road temperature for each segment – visit Poster Session P2 Wednesday A.M.
- ✓ Service now extends to many more routes in Nova Scotia.

Thank you very much!

Questions?

richarpa@gov.ns.ca

paul.delannoy@amec.com