University of Minnesota

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Task 3. EICM Validation and Analysis

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Presentation Outline

1. Minimum AC thickness
2. Time of traffic opening
3. Comparisons of AC overlay and semi-rigid MEPDG models
4. Effect of weather station
5. MnROAD temperature data

Minimum PCC Thickness

- Objective
  - Determine minimum allowable AC thickness
- *Note*
  - The MEPDG produces a warning message when the input AC overlay thickness is less than 2 inches
- Case study:
  - 6-inch PCC with 1.9 or 2.0 inch AC overlay
  - Other inputs were identical
- Predicted transverse cracking in PCC layer
  - 1.9 in = 14.2%
  - 2.0 in = 1%
- Conclusion: The minimum AC thickness must be 2 in unless the EICM is modified

Effect of AC Sublayering

- Objective
  - Determine differences of MEPDG predictions
  - Case study
    - 6-inch JPCP with 4-inch AC overlays
    - One 4-inch thick AC layer, or
    - Two 2-inch thick AC layers
    - Other inputs were identical

Effect of AC Sublayering

- MEPDG results

	(1) – 4 in	(2) – 2 in
Terminal IRI	124.5	124.8
Transverse Cracking	8.7	8.7
AC Top-Down Cracking	4.5	4.6
AC Bottom-Up Cracking	0	0
Rutting – AC	0.46	0.47
Rutting – Total	0.46	0.47

- Conclusion
  - No significant differences in MEPDG output

Time of Traffic Opening

- Objective
  - Determine differences in MEPDG predcitions if the opening date to traffic is changed
- MEPDG input options:
  - Pavement construction
  - Overlay construction
  - Traffic opening
- Case study:
  - 6-inch JPCP with 4-inch AC overlay
  - Traffic opening months: June, July, August

Time of Traffic Opening

	June-July-August	May-June-June	June-July-July
Terminal IRI	124.4	123.8	123.6
Transverse Cracking	8.6	8.8	8.7
AC Top-Down Cracking	4.1	4.9	4.5
AC Bot-Up Cracking	0	0	0
Rutting - AC	0.46	0.46	0.46
Rutting - Total	0.46	0.46	0.46

Time of Traffic Opening

- Layer moduli were also examined
  - No significant differences
- Traffic opening month was also tested for a 4-inch overlay with two 2-inch layers
  - Yielded same results
- Conclusions
  - The month a pavement structure is opened to traffic does not affect pavement performance predictions produced by the MEPDG

AC/PCC vs AC/CTB

- Objective: compare MEPDG outputs of a 4-inch AC overlay of PCC and Cement Treated Base (CTB)
- All other inputs given were as close as possible

	PCC	CTB
Thermal Conductivity	1.25 BTU/hr-ft-ÞF	1.25 BTU/hr-ft-ÞF
Heat Capacity	0.28 BTU/lb-ÞF	0.28 BTU/lb-ÞF
Coefficient of Thermal Expansion	5.5 per ÞF x 10^-6	NA

PCC	Month		Month	CTB
Existing Pavement	June		May	Base/Subgrade
Overlay Construction	July		July	Pavement
Traffic Opening	August		August	Traffic Opening

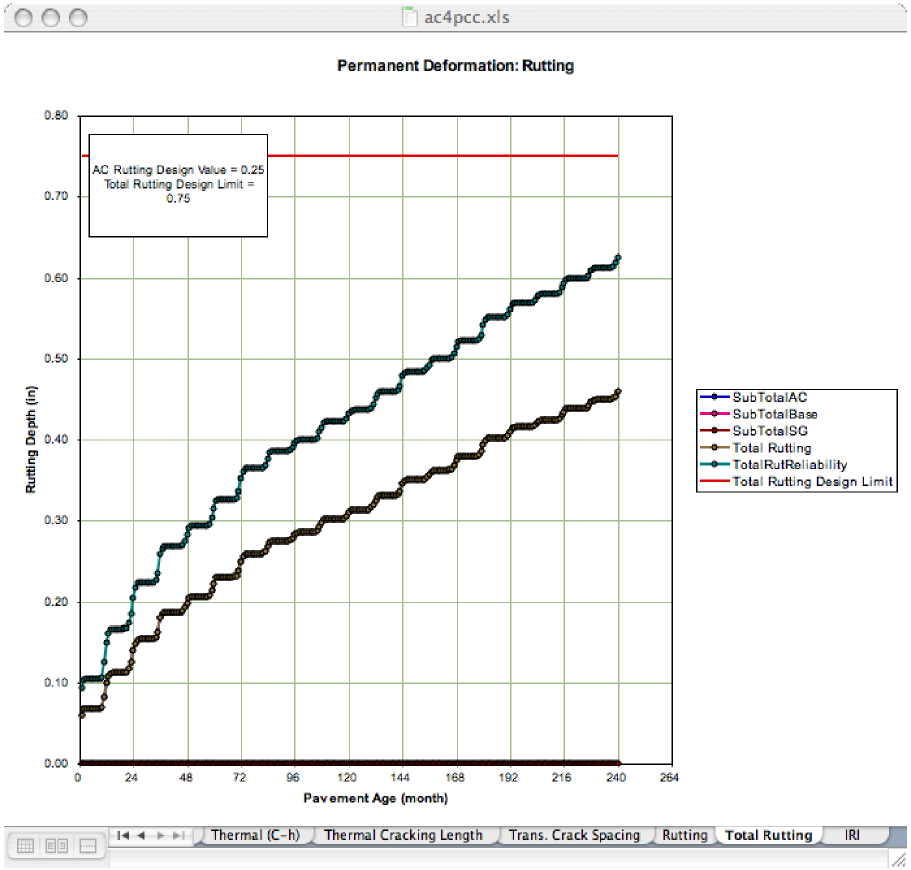
AC/PCC vs AC/CTB

Predicted Distresses

	PCC	CTB
Terminal IRI	124.4	142.5
Transverse Cracking	8.6	NA
AC Top-Down Cracking	4.1	0.4
AC Bot-Up Cracking	0	0
Rutting - AC	0.46	0.81
Rutting - Total	0.46	1.15

AC/PCC vs AC/CTB

Total rutting: AC over PCC structure



Surface Temperatures: AC over PCC structure

Average Monthly Quintile Temperatures - Surface

Month	1st Quintile (°F)	2nd Quintile (°F)	3rd Quintile (°F)	4th Quintile (°F)	5th Quintile (°F)	Mean Temp. (°F)	Std. Dev. (°F)
January	13.2	22.8	28.2	33	41.3	27.7	10
February	22.2	30	34.9	39.8	48	35	9.2
March	27	35.1	40.8	48	60.2	42.3	12
April	38.1	46.6	53.4	62.3	77.1	55.5	14.1
May	49	57.6	64.8	73.3	86.9	66.4	13.5
June	58.5	68.4	75.9	85.7	98.9	77.5	14.5
July	65.2	72.8	80.2	90	101.7	82	13.3
August	63.9	70.8	77.2	86.4	98.1	79.3	12.4
September	54	62.3	69.2	77.8	92.7	71.2	13.9
October	41.7	50.2	56.5	63.7	76.3	57.7	12.4
November	30.5	38.3	43.7	49.1	57.9	43.9	9.8
December	20.1	27.6	32.8	37.6	45.2	32.7	9

Surface Temperatures: AC over PCC structure

Average Monthly Quintile Temperatures - Surface

Month	1st Quintile (°F)	2nd Quintile (°F)	3rd Quintile (°F)	4th Quintile (°F)	5th Quintile (°F)	Mean Temp. (°F)	Std. Dev. (°F)
January	15	24.1	29	33.2	40.4	28.3	9
February	22	30	35.1	40.1	48.8	35.2	9.6
March	26.9	34.9	40.9	48.2	60.8	42.4	12.2
April	39	47.4	53.9	62.7	77.9	56.2	14
May	49.7	58.2	65.4	73.8	87.4	66.9	13.5
June	58	67.9	75.4	85.2	98.6	77	14.5
July	65.9	73.5	80.8	90.7	102.4	82.7	13.3
August	63.9	70.8	76.9	86.1	97.9	79.1	12.3
September	54.2	62.6	69.7	78.4	93.4	71.7	14.1
October	42.2	50.6	56.9	64.2	76.7	58.2	12.4
November	31.7	39.7	45	50.5	59.7	45.3	10
December	19.8	27.5	32.8	37.7	45.7	32.7	9.3

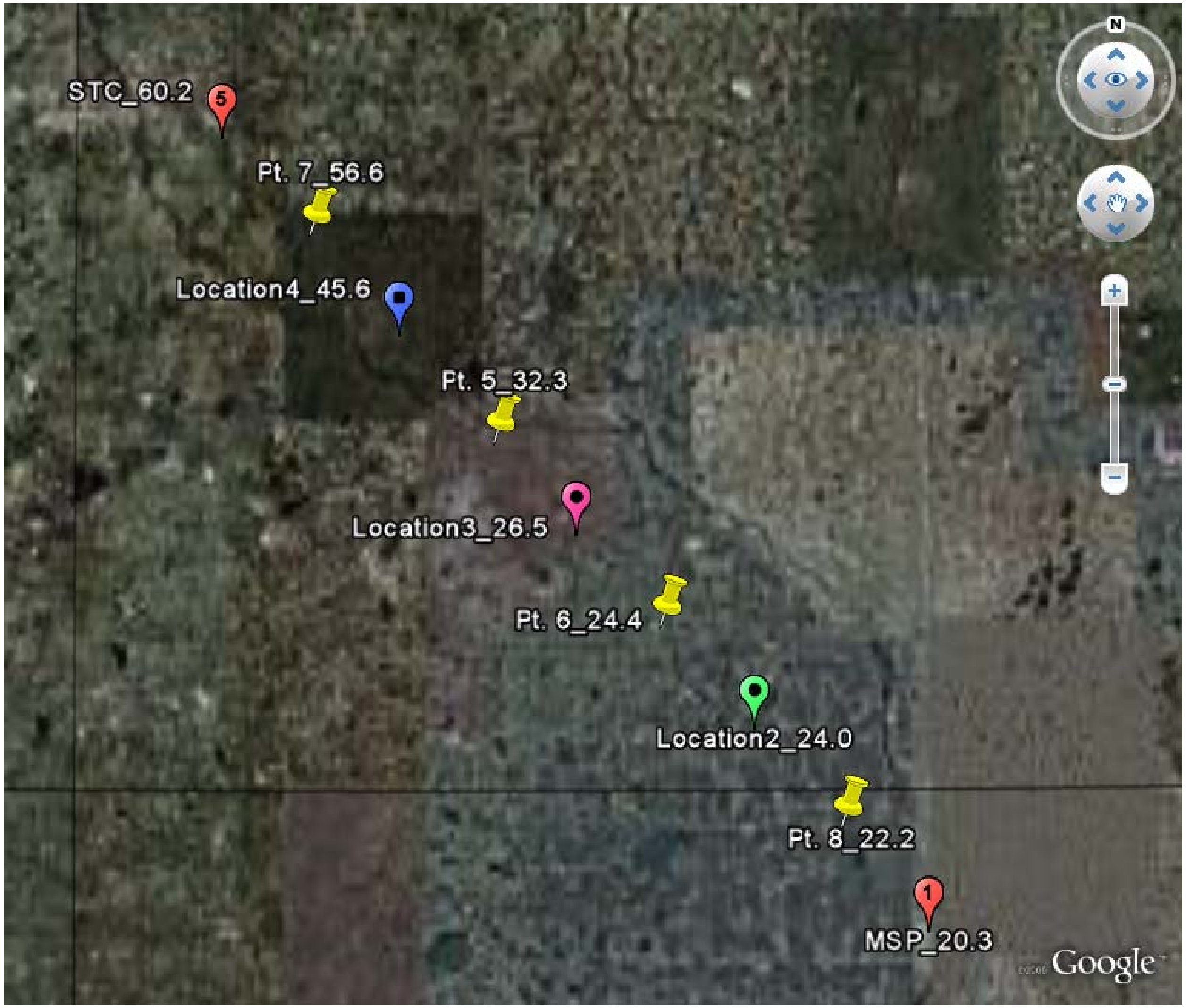
Conclusions

- Significant differences are found
  - Rutting
  - IRI
  - Surface temperatures
    - Given the same EICM files, and thermal property values
  - Layer Moduli
    - Not just in PCC and CTB layers, but throughout pavement structure
- AC/CTB should not be used for composite pavements

Effect of Weather Stations

- Objective
  - Study the effect of weather stations used to generate an .icm file for composite and flexible pavements
- Case studies
  - 6-inch PCC with 2-inch AC overlay, various weather stations
  - MEPDG provides 6 available stations to select when generating an .icm file using interpolation. Three categories were created:
    - Nearest only
    - All except nearest
    - All

Case 1. Minneapolis - St. Cloud



Percent Slabs Cracked

Locations	Lat.	Long.	Elev.	% Cracking after 20 years using all weather stations
Minneapolis	44.53	-93.14	874	20.3
Pt. 8	44.581	-93.20	910	22.2
Location 2	45.027	-93.261	918	24.0
Pt. 6	45.08	-93.325	950	24.4
Location 3	45.125	-93.383	869	26.5
Pt. 5	45.17	-93.44	957	32.3
Location 4	45.223	-93.506	961	45.6
Pt. 7	45.272	-93.568	971	56.6
St. Cloud	45.32	-94.03	1024	60.2

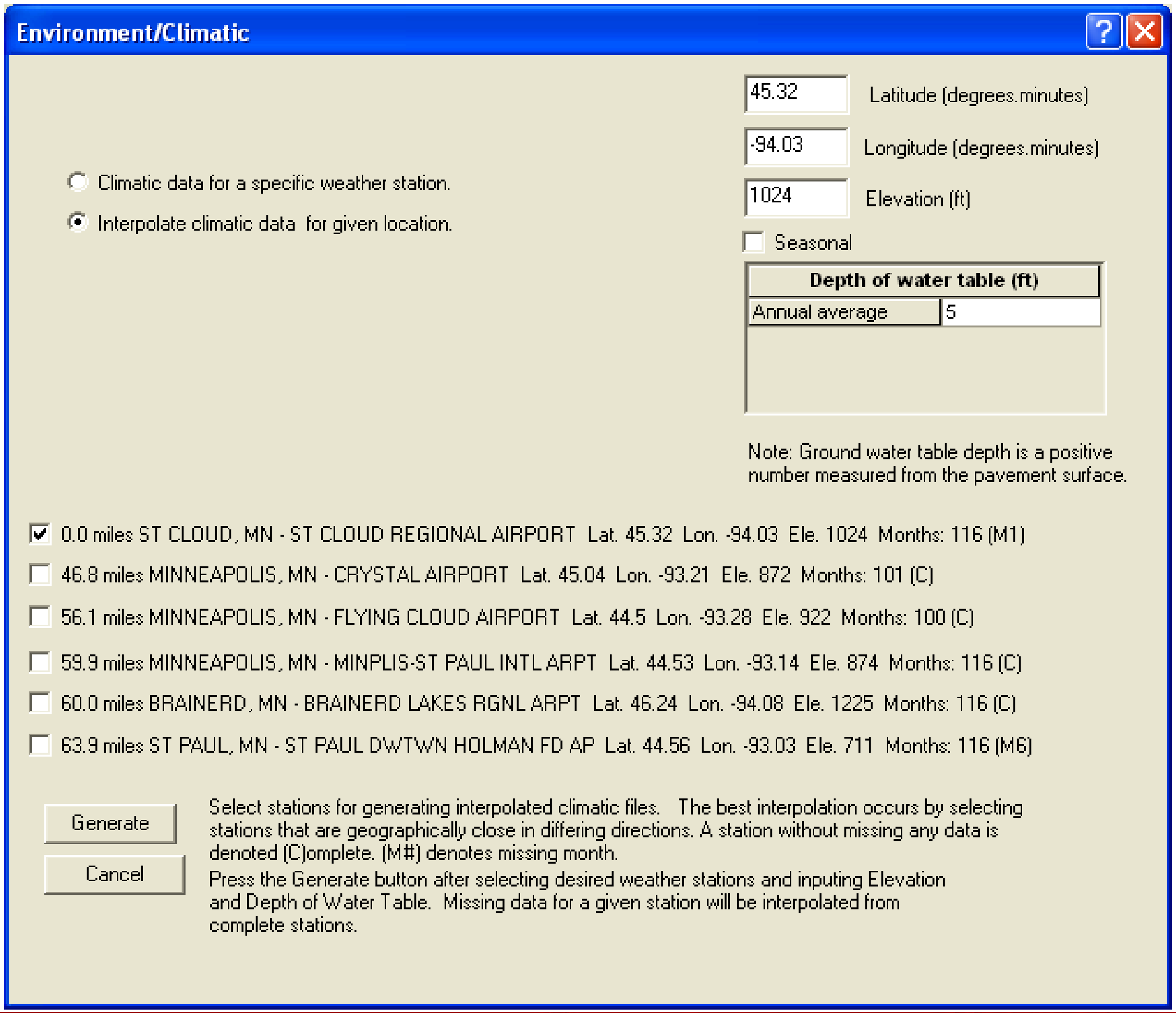
- As the location becomes closer to St. Cloud, the percentage of cracking increases

Missing Months

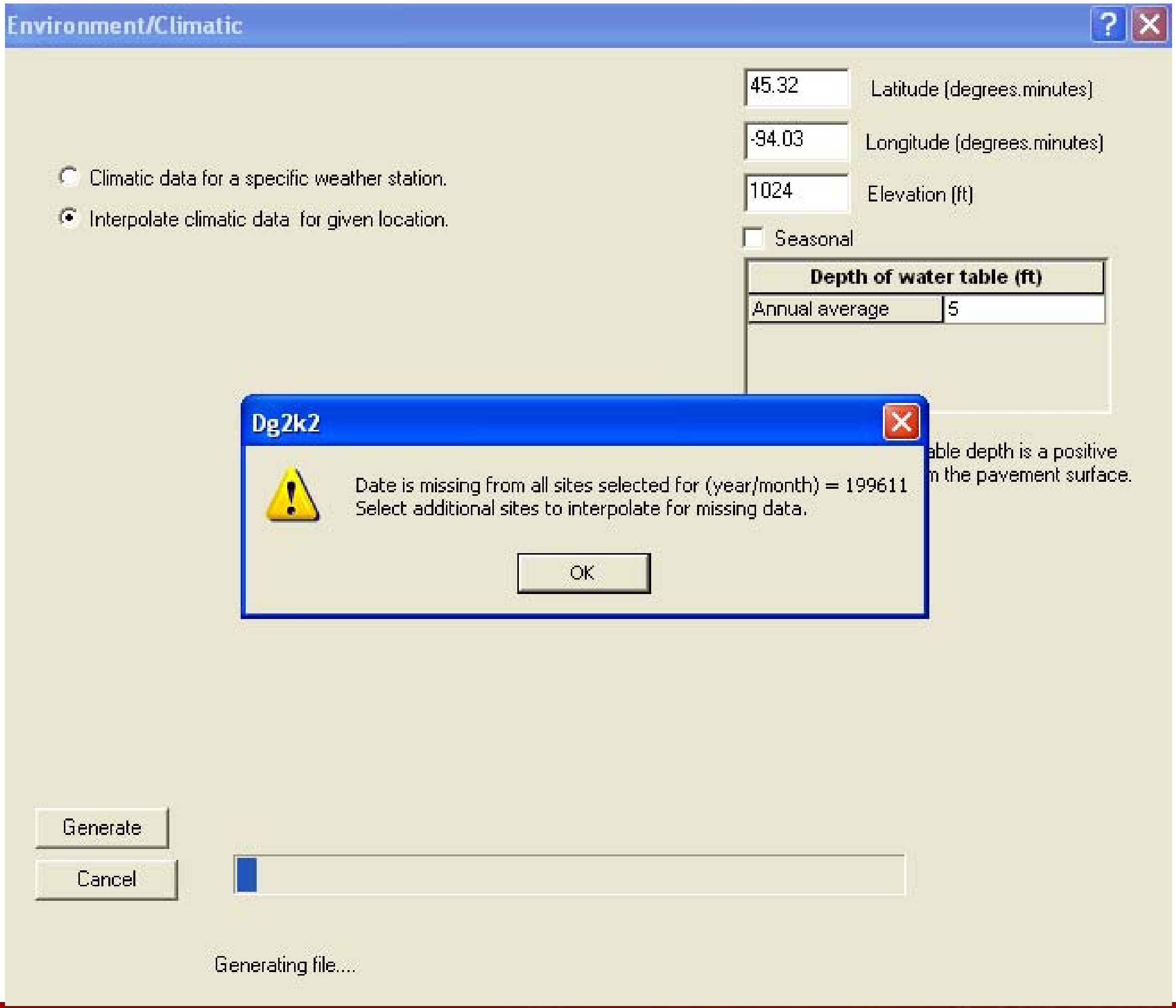
- Not all stations have a complete hourly climatic data (hcd) files
- MEPDG uses nearby stations to interpolate for missing data
- This is a possible reason for extreme cracking values for St. Cloud

Effect of Weather Stations

MEPDG Interface showing number of missing months



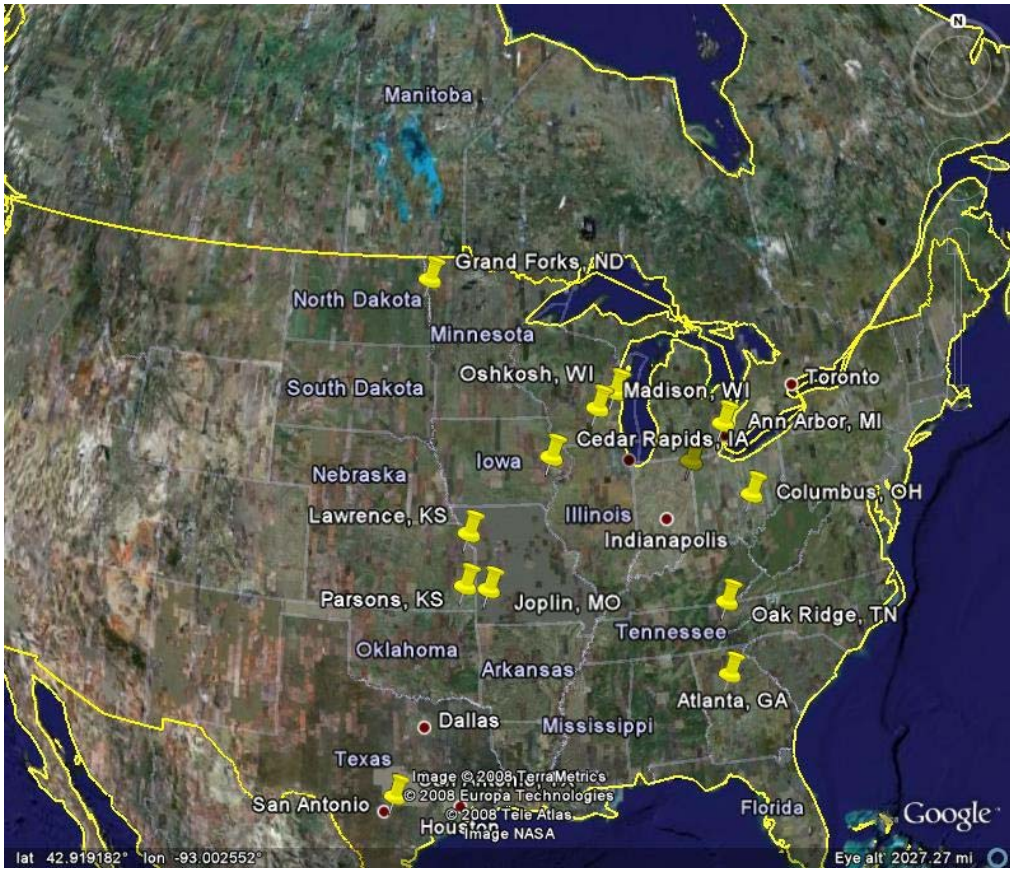
MEPDG Interface Showing Error for Missing Data



Case 2.

- 13 locations were selected across the US
  - Elevation of each location is between 800-1000ft
    - This is similar to Minneapolis (Elev. 874ft)
  - Covered a large area climatologically
- Factorials were ran at each location
  - "Nearest Only" "All except nearest" "All"
  - Identical composite pavement structure as used in Minneapolis - St. Cloud experiments

Selected Locations Across the US



Effect of Weather Stations

Locations	Lat.	Long.	Elev.	% Cracking after 20 years for weather station		
				Nearest only	All except nearest	All
Fort Wayne, IN	41.01	-85.13	806	44.4	57.8	44.4
Oshkosh, WI	43.59	-88.34	816	64.5	59.4	64.5
San Antonio, TX	29.32	-98.28	821	47.5	70.2	47.5
Lawrence, KS	39.01	-95.13	833	78.3	66.8	78.3
Ann Arbor, MI	42.13	-83.44	836	68.2	45.2	59.5
Grand Forks, ND	47.57	-97.11	842	43.1	43.5	43.3
Columbus, OH	39.59	-82.53	849	27.5	69.8	27.5
Madison, WI	43.08	-89.21	860	57.3	56.1	57.3
Cedar Rapids, IA	41.53	-91.43	870	65.4	67.3	65.4
Parsons, KS	37.2	-95.3	901	78.8	72.4	61.5
Oak Ridge, TN	36.01	-84.14	916	81.5	57.3	77.9
Atlanta, GA	33.38	-84.26	974	80	80	78.5
Joplin, MO	37.09	-94.3	985	73.8	72.9	72.6

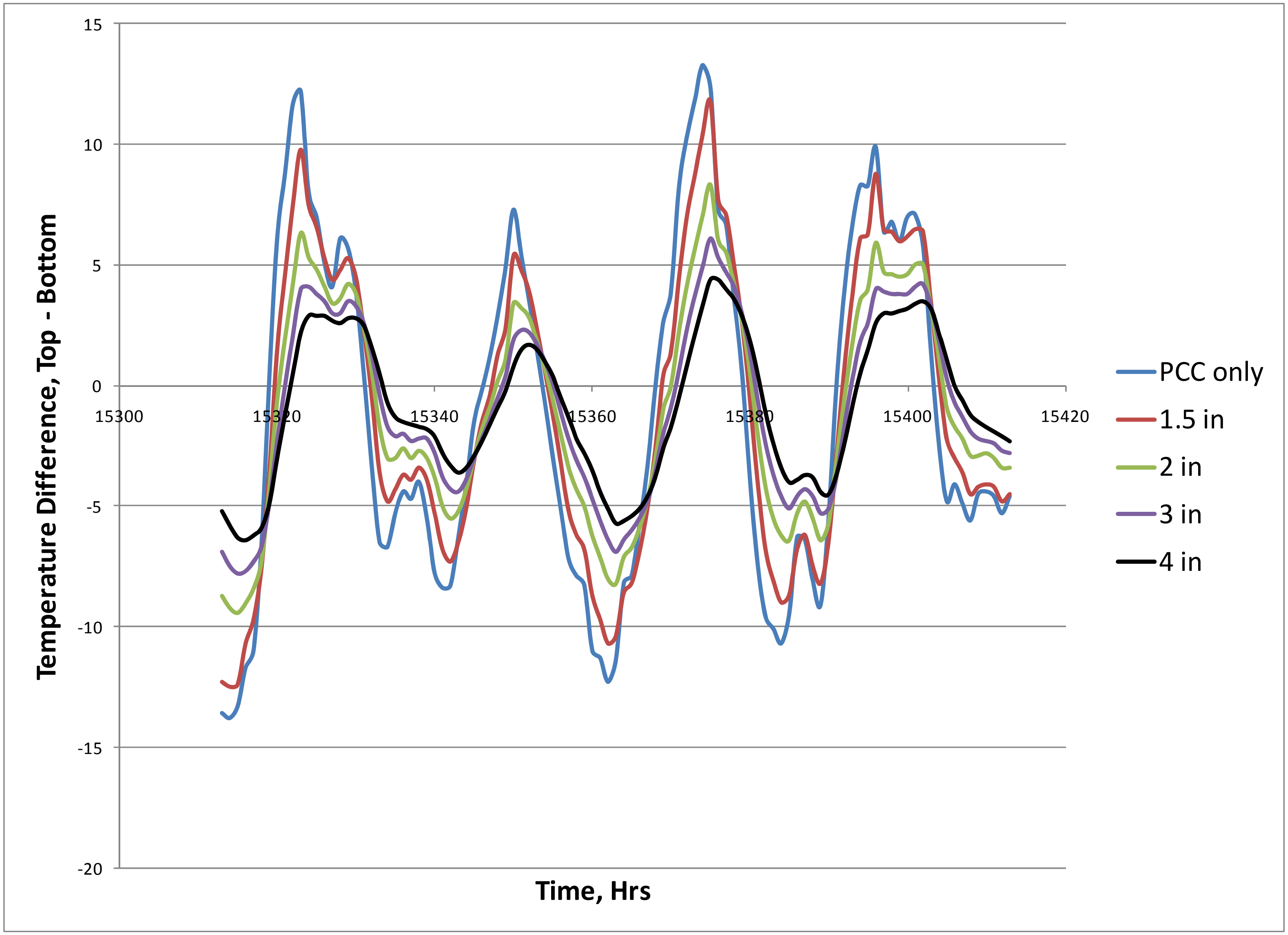
Effect of Weather Stations

Conclusion: Quality of weather station data should be carefully evaluated.

Effect of AC Thickness on PCC Temperature Gradients

- Objective
  - Compare EICM predictions of PCC temperature gradients with and w/o AC overlays
- Case study: 8-inch PCC
  - No AC layer
  - 1.5 in AC overlay
  - 2 in AC overlay
  - 3 in AC overlay
  - 4 in AC overlay

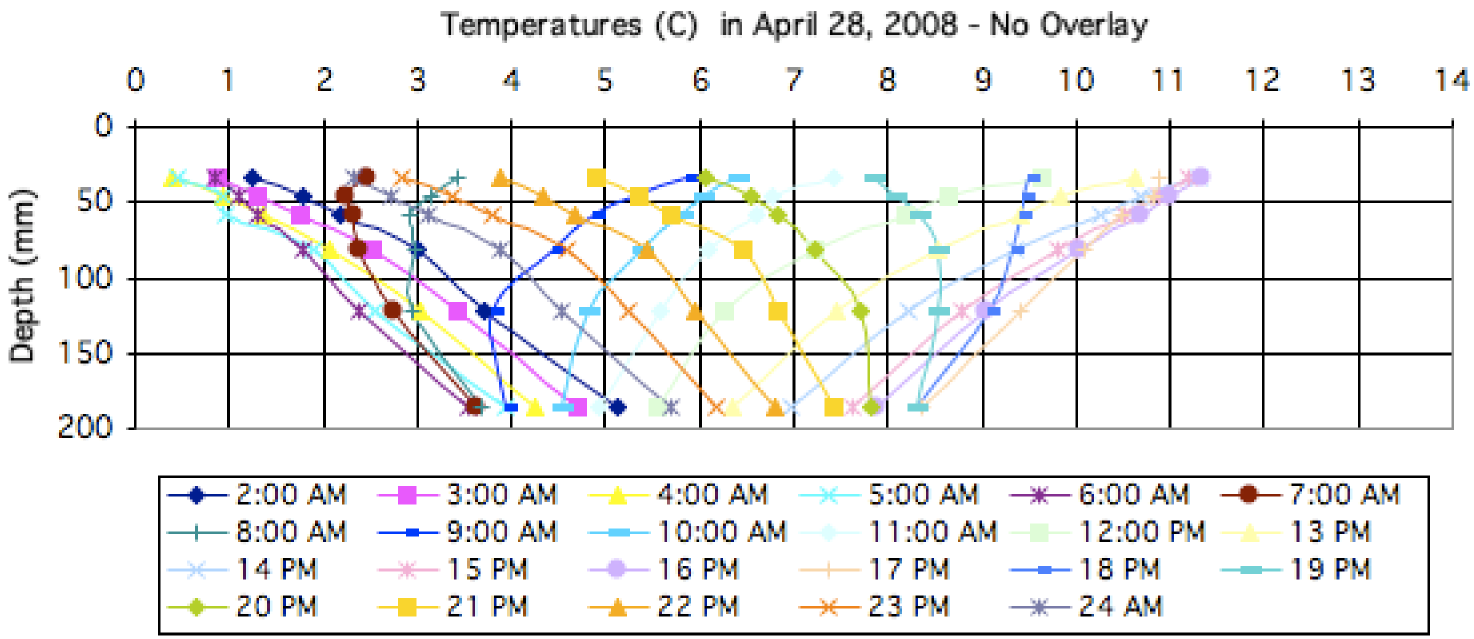
Effect of AC Thickness on PCC Temperature Gradients



Effect of AC Thickness on PCC Temperature Gradients

Field Validation of EICM

- MnROAD Cell 53
- Data from Overlay and No-Overlay sections were compared


Temperatures (C) in April 28, 2008 - No Overlay
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Depth (mm)
0
50
100
150
200
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
8:00 AM
9:00 AM
10:00 AM
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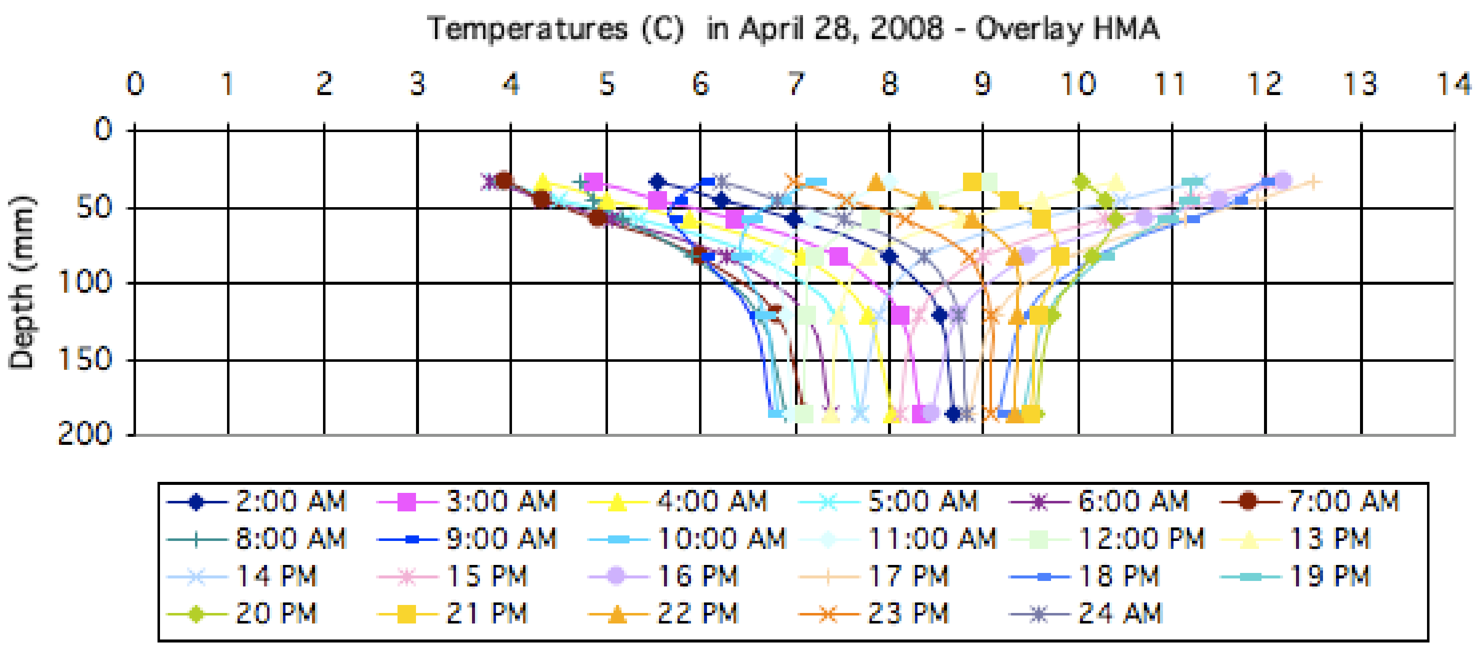
24 AM


Temperatures (C) in April 28, 2008 - Overlay HMA
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Depth (mm)
0
50
100
150
200
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
8:00 AM
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10:00 AM
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Field Validation of EICM

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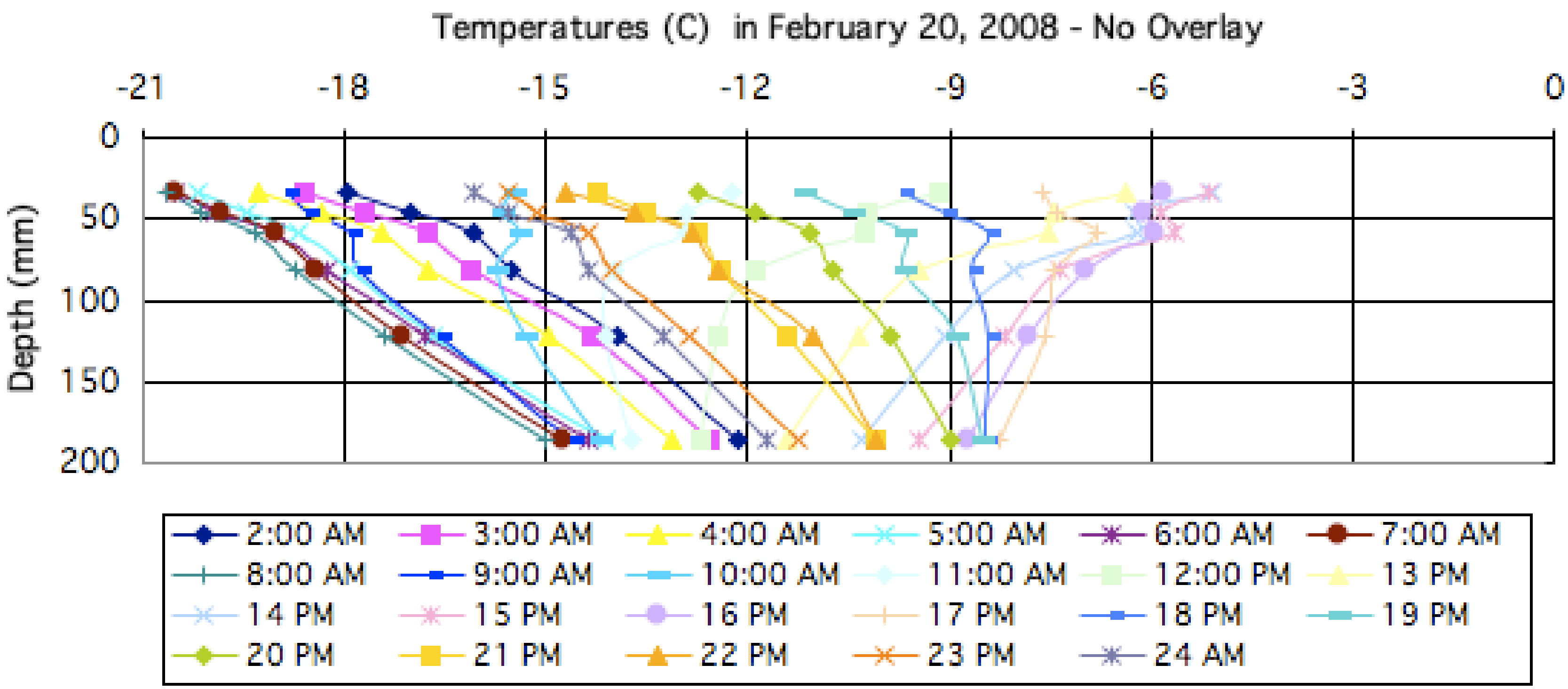

Field Validation of EICM

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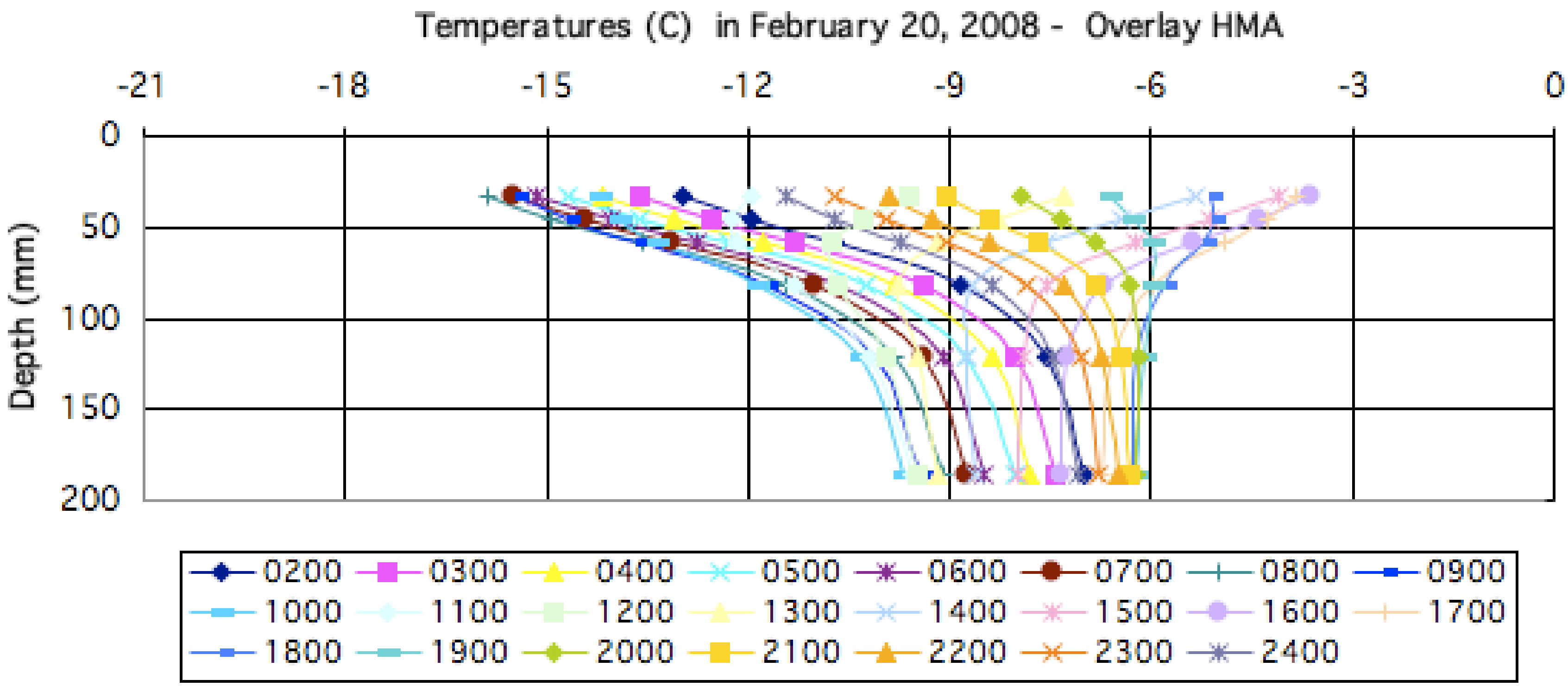

Remaining Work

- “Global” sensitivity of EICM to weather stations and locations
- Effect of other EICM inputs
- Effect of design features
- Attempt to salvage Cell 53 data
- Comparisons with MnROAD data.