



Application of the Halliday RT3™ Road Grip Tester to Wintertime Pavement Friction Monitoring in North Dakota

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**2007 Eastern Snow Expo
30 August 2007 Columbus, OH**

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are needed to see this picture.

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Motivation

Images show the back-up of traffic along I-29 northbound.

February 21 2007 ice event on I-29



Top: Wide angle view looking south and including STWRC's Road Weather Field Research Facility. Light freezing precipitation earlier in the morning had ended by this time.

Middle: southeastern view, with zoom focusing on the northbound lane. Note the semi-trailer partially off the highway into the closed rest area interstitial area.

Lower: the same southeastern view as the middle photo but with wider angle. The backup on I-29 north has eased by this time as some solar heating of the pavement had melted the ice on the roadway.

Images from UND-STWRC Road Weather Field Research Facility Real-Time Cameras 1 Mile N of the I-29 Buxton Interchange

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Research Goal

Evaluate the utility of new technologies for measurement of weather impacts on roadway surfaces

- **Effectiveness of the RT3 technology for measuring pavement condition (dry, wet, damp, snow covered, ice covered, frost) and associated road grip**
- **Effectiveness of datasets from new technologies for better understanding the roadway environment, including use of such datasets as input to diagnostic/ forecast algorithms for blowing and drifting snow (see adjacent poster)**
- **Utility of the technologies as part of a strategy, including in-situ road weather information systems, for determining pavement winter maintenance actions**

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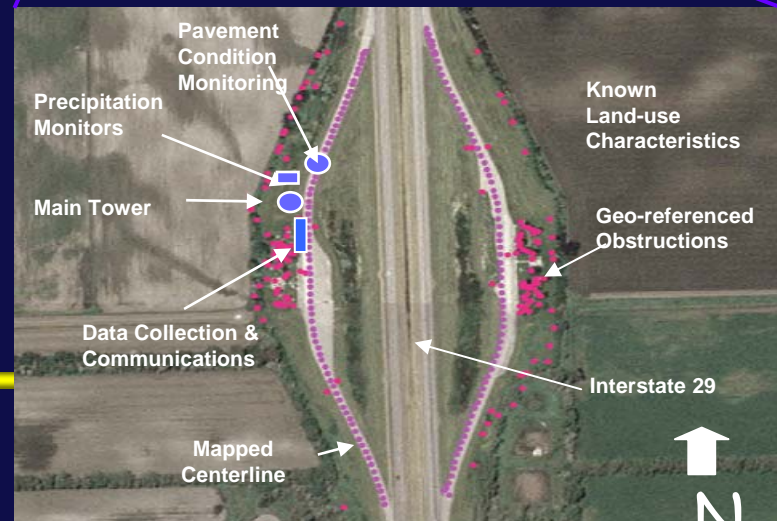
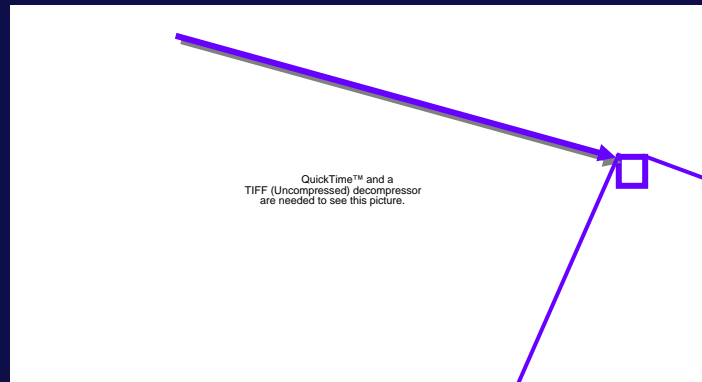
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Measurement and Analysis Methodologies

- Winter Observational Period 10/31/06 - 3/15/07
- 20 real-time on-the-road runs (primarily I-29 and US-2)
- 2 controlled experiments at UND/STWRC Road Weather Field Research Facility



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Measurement and Analysis Methodologies

- Measurements included Road Grip Number, Pavement temperature, and Air Temperature (latter two sensors installed on ODOT truck). GPS information provided via ThomTech AVI application or via local laptop combined with RedHen and/or Garmin GPS
- Prior to each run tread depths were measured in the center tread of the test tire; tire air pressures were checked when significant air temperature changes occurred between runs
- Many real-time on-the-road runs also included other measurements for Road Environment Characterization, some w/ audio commentary
- I-29 segment: Grand Forks to Buxton (MP 138 to MP 119)
- US-2 segment: I-29 interchange to ND Highway 18 (~28 miles).
- Summer testing at Wallops Island test facility to better understand how pavement surface differences affect measured Grip values.
- Analysis focus in ensuring that other factors (ie speed) does not unduly influence grip values

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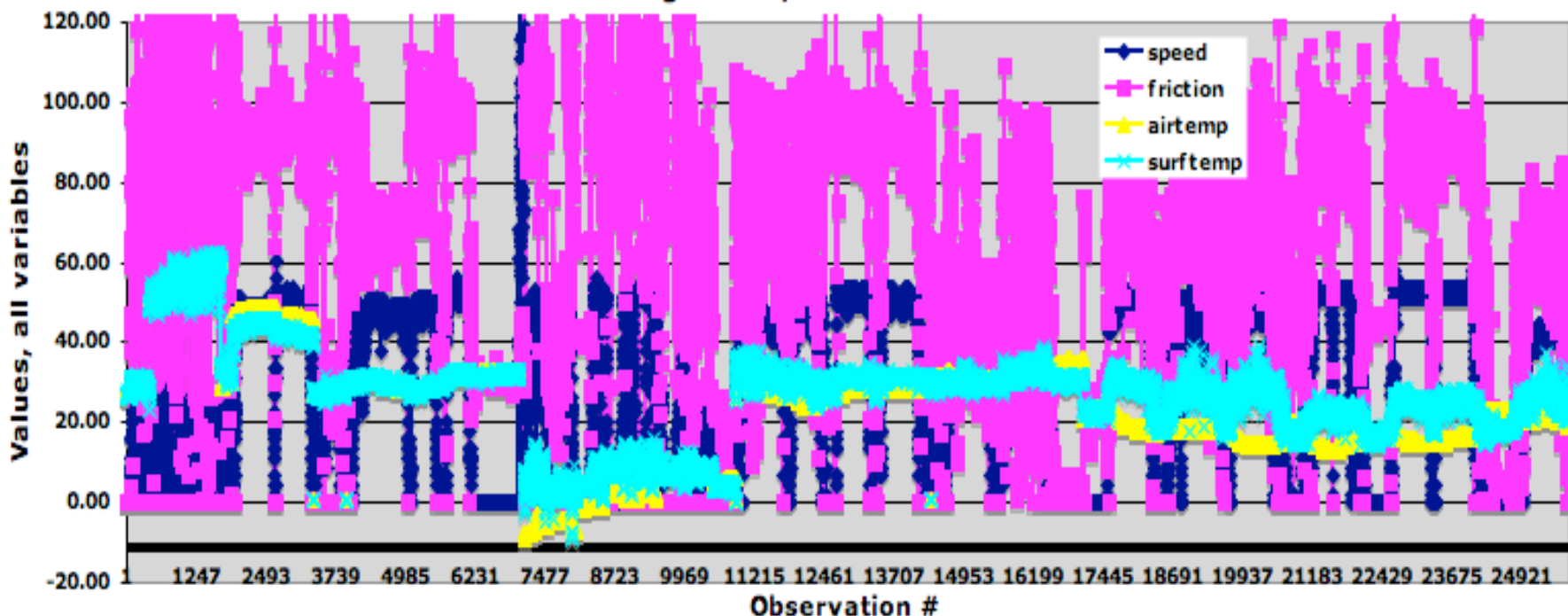
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Summary of Observations: Time Series

Merged Data, all 06-07 runs

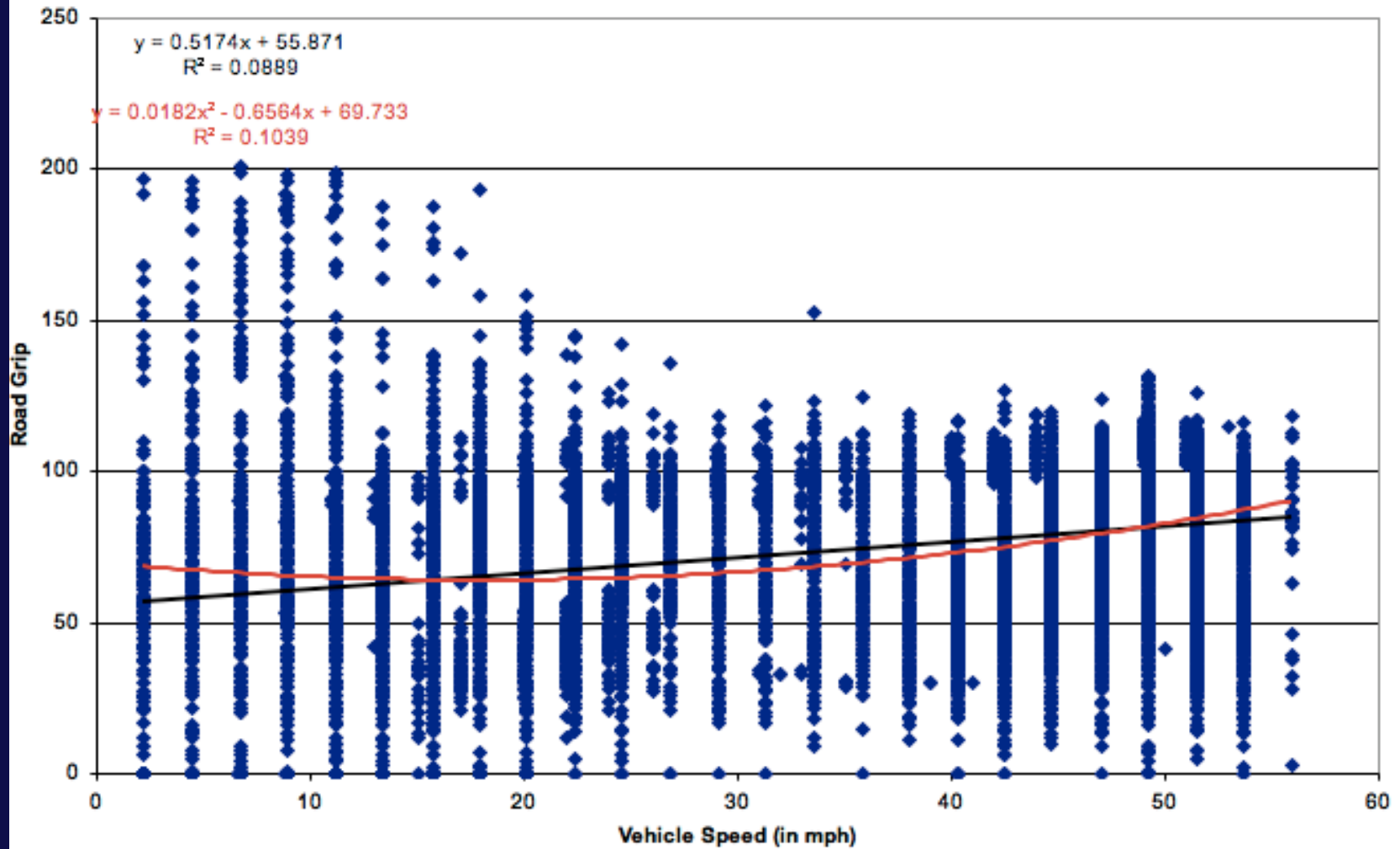


Mean Autocorrelations of PavT, Air T and Grip Values at various lags

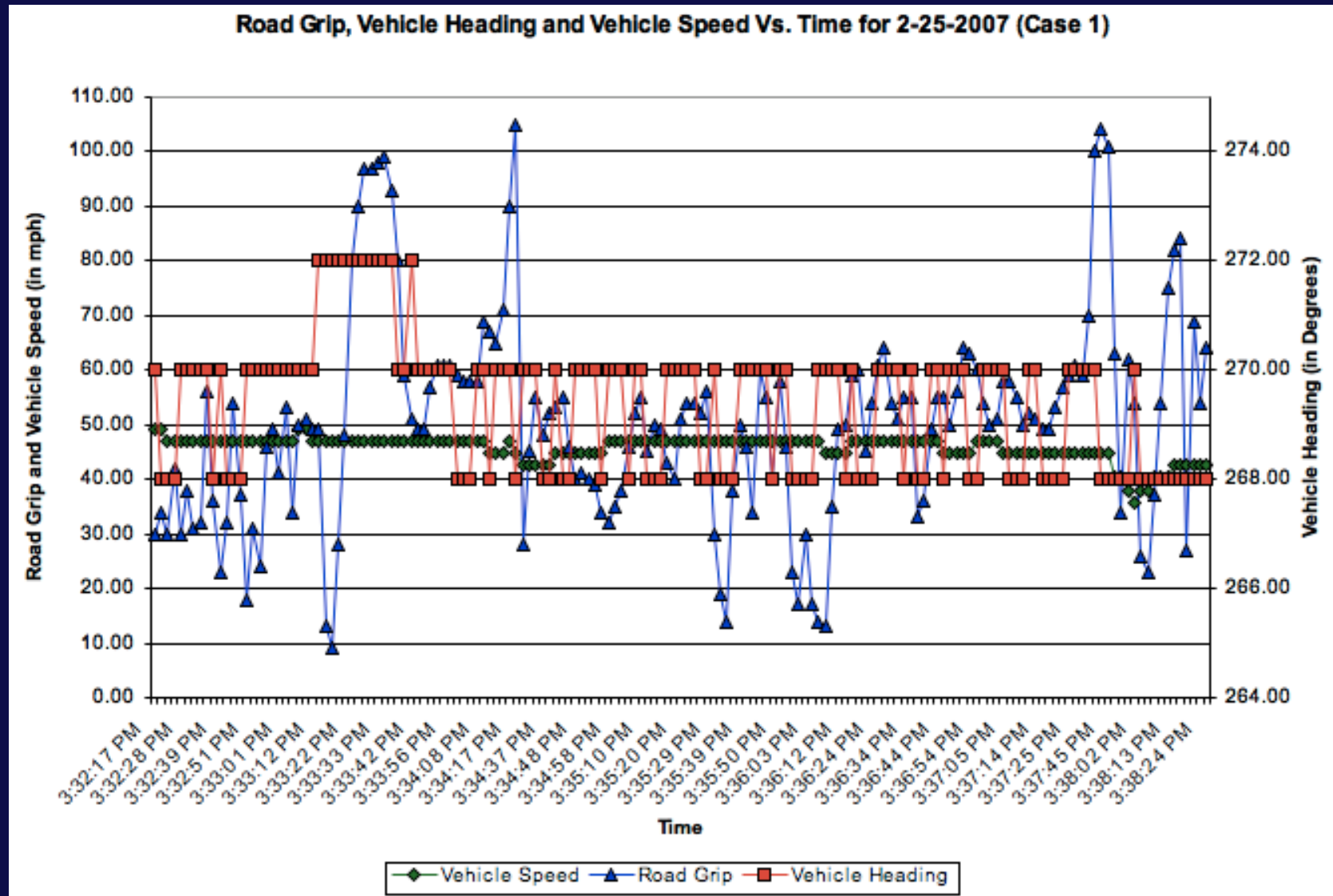
• 2 sec (< 150 ft):	0.784	0.963	0.77
• 10 sec (< 800 ft):	0.657	0.941	0.556
• 30 sec (< 2400 ft):	0.527	0.885	0.458
• 1 minute (< .9 mi):	0.415	0.847	0.353

Summary of Observations: Scatter Plots

Road Grip Vs. Vehicle Speed for all 2006 and 2007 Cases (Data Set 2)



25 February Case Time Series



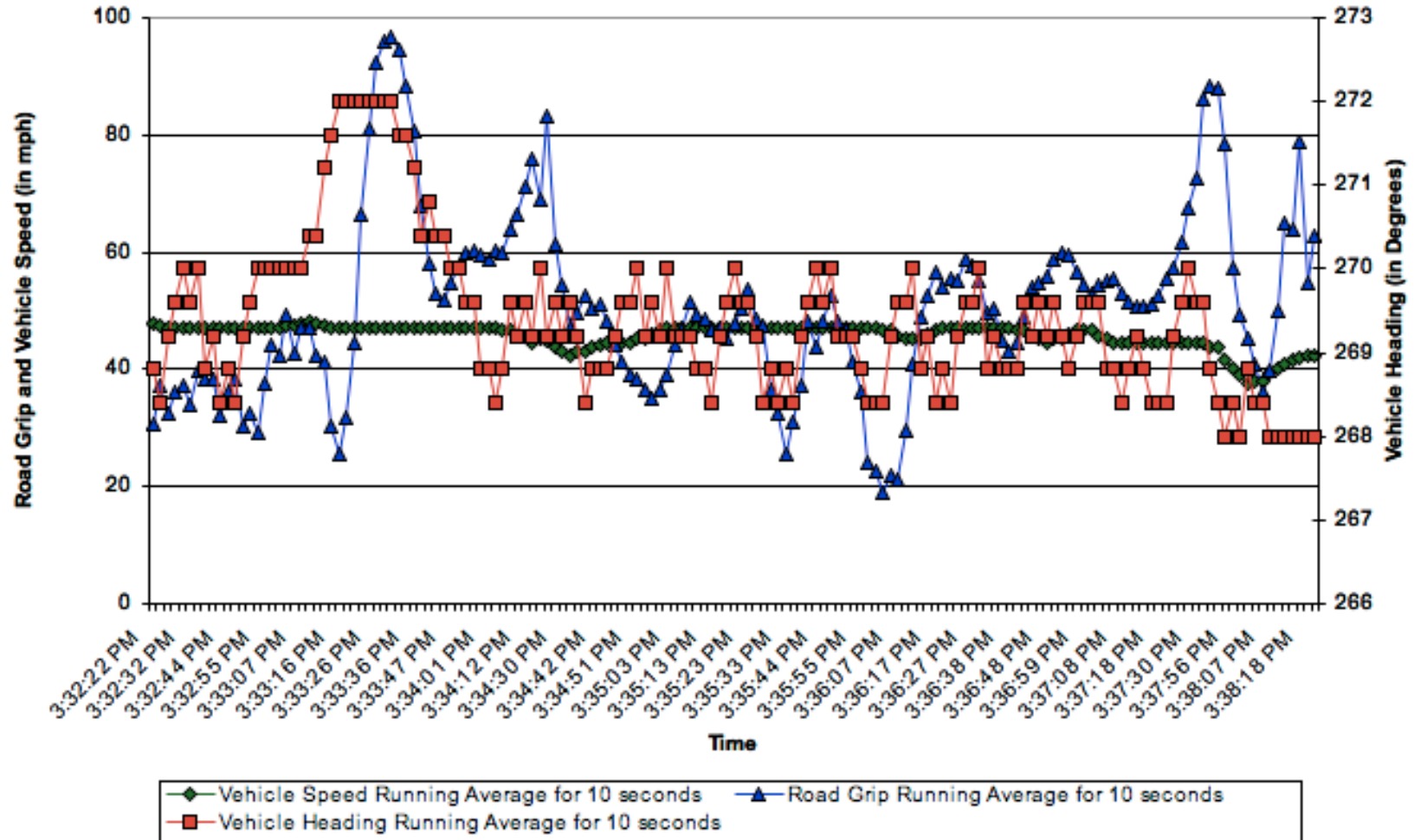
Add autocorrelations

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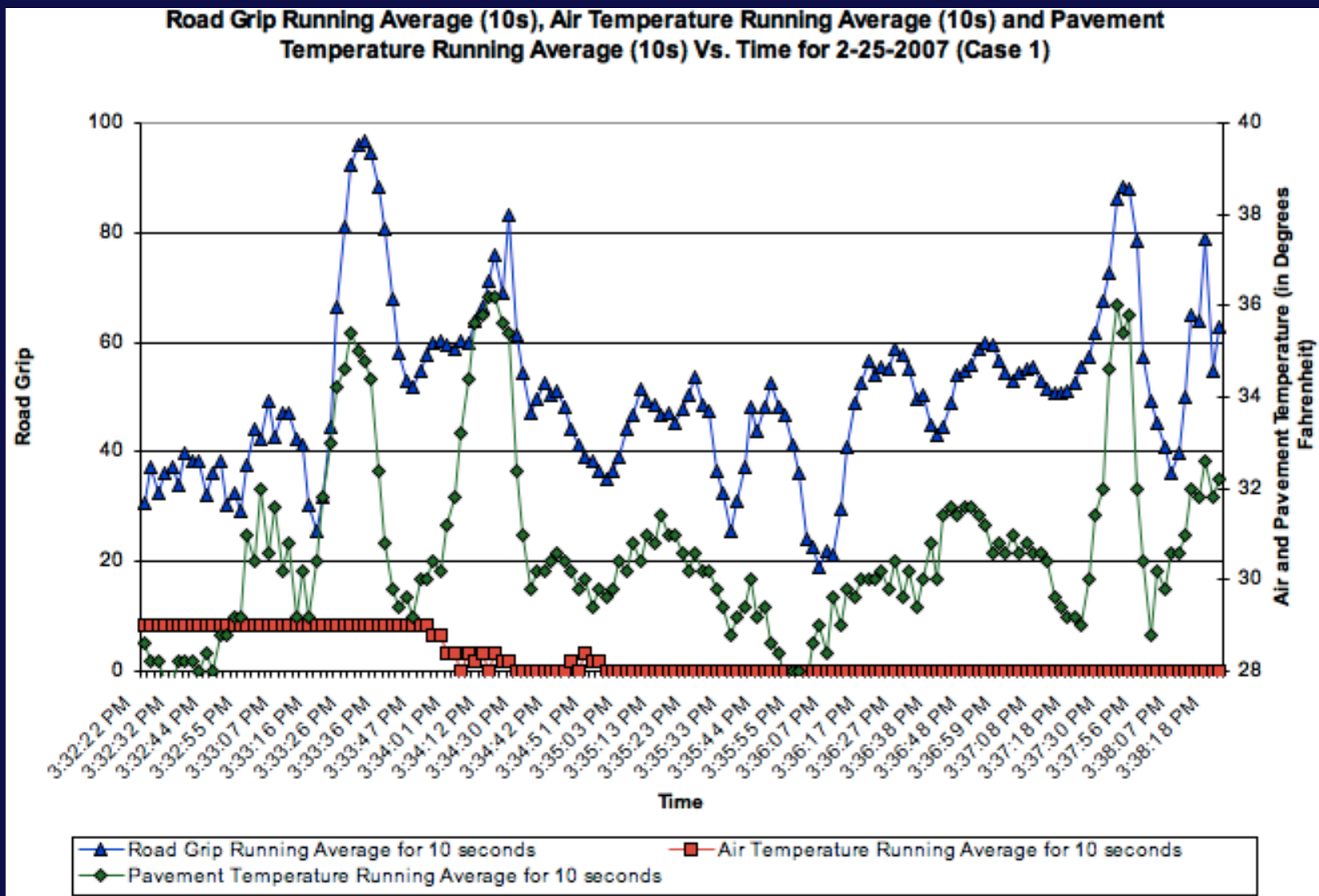
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25 February Case Time Series

Road Grip Running Average (10s), Vehicle Heading Running Average (10s) and Vehicle Speed Running Average (10s) Vs. Time for 2-25-2007



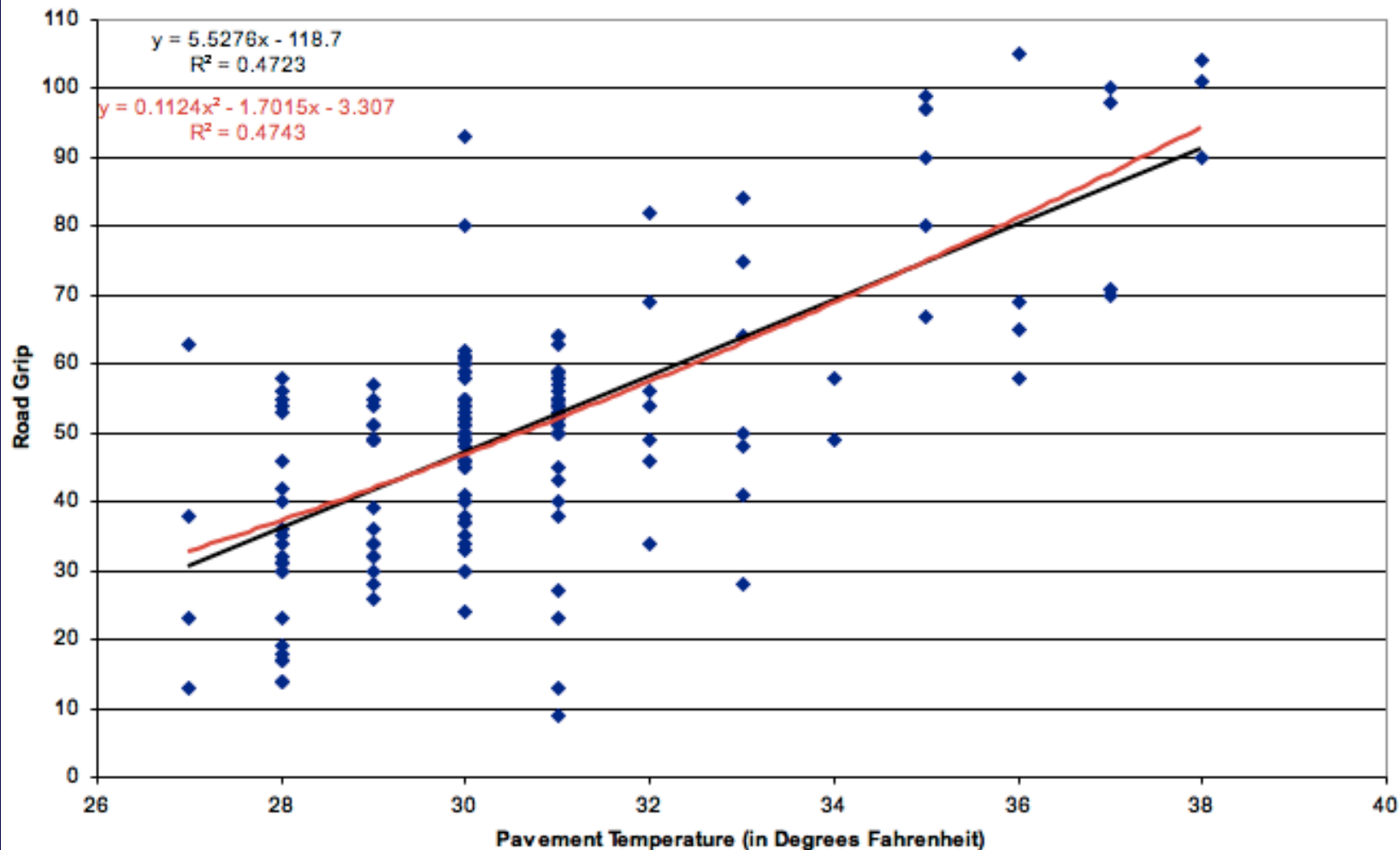
25 February Case Time Series



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25 February Case Scatter Plots

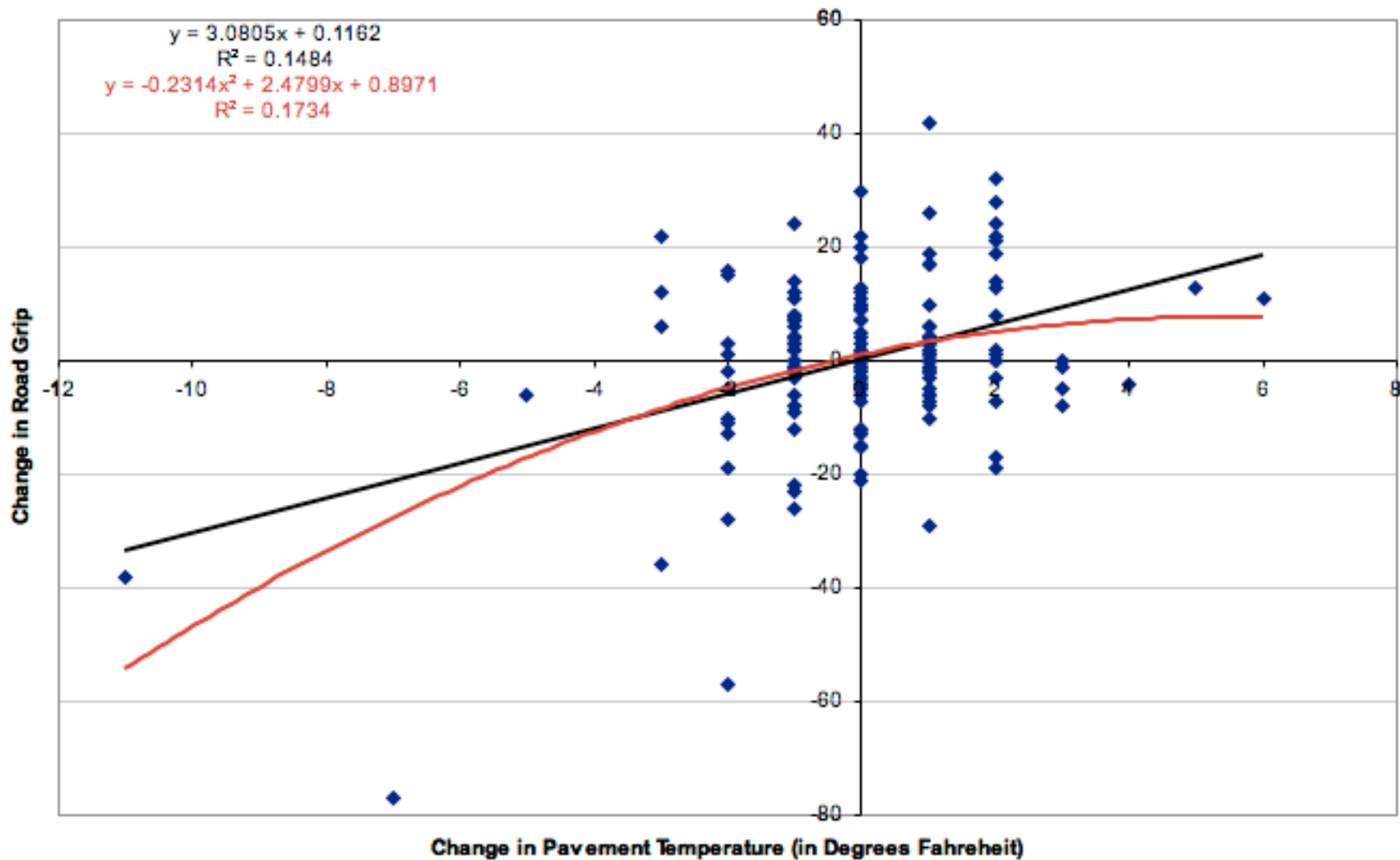
Road Grip Vs. Pavement Temperature for 2-25-2007 (Case 1)



QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

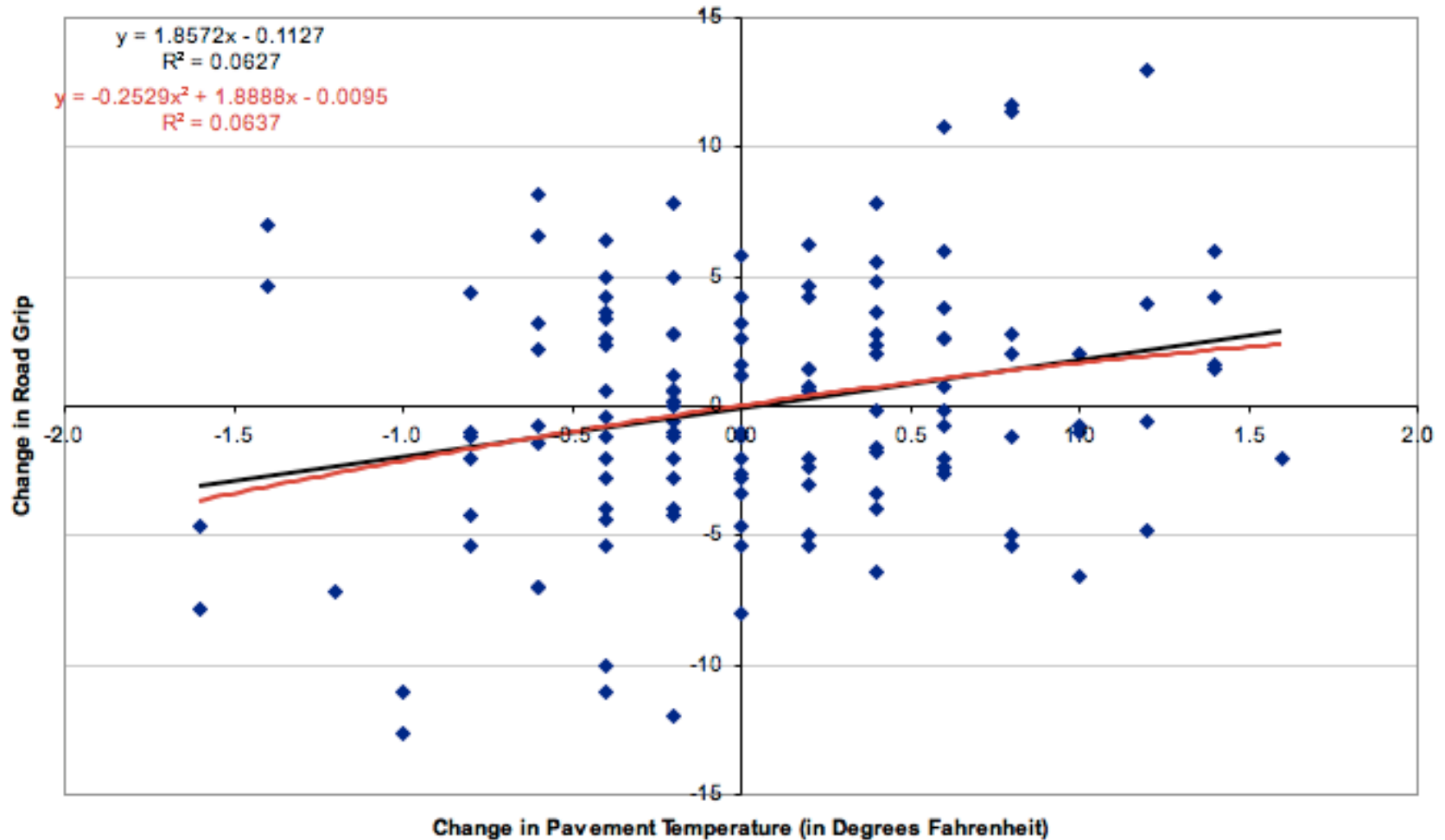
25 February Case Scatter Plots

Change in Road Grip Vs. Change in Pavement Temperature for 2-25-2007 (Case 1)



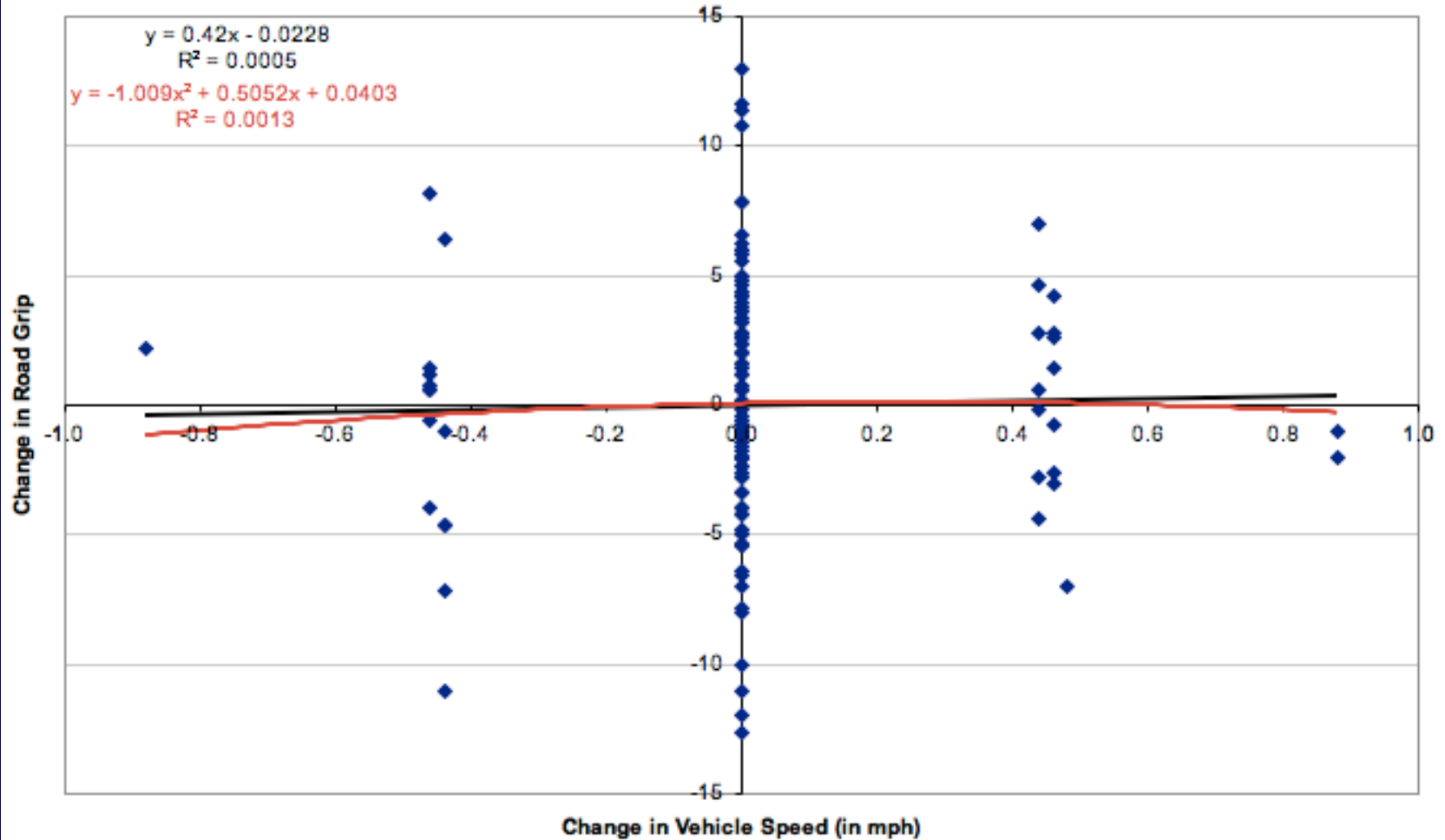
25 February Case Scatter Plots

Change in Road Grip Running Average (10s) Vs. Change in Pavement Temperature Running Average (10s) for 2-25-2007 (Case 1 Outliers Removed)



25 February Case Scatter Plots

Change in Road Grip Running Average (10s) Vs. Change in Vehicle Speed Running Average (10s) for 2-25-2007 (Case 1 Outliers Removed)



Road Weather Environment Characterization

The ability of the ODOT research vehicle) to measure roadway traction as well as air and pavement temperature allows, with the use of the RedHen GPS-Video system described below, to obtain more complete information on weather impacts to the roadway environment.

With the use of GIS database tools to determine high resolution (100s m) relationships between geospatial characteristics, weather processes and impacts to pavement from blowing and drifting snow.



Saltating snow across a North Dakota highway



Maintenance Decision Support System Routes (US2, I-29)

RedHen GPS-Video System

- **Sony DVD-video camcorder used for visual recording of roadway environment conditions**
 - **interfaces with RedHen unit so that Global Positioning System information can be encoded within the video recording; Allows for audio input so that observer comments can be included for future reference**

RedHen GPS unit records geospatial location information automatically and can also take manual input from the observer to mark specific conditions of interest



RedHen GPS unit, front view



RedHen GPS unit, rear view



Sony model DVD-Video camcorder

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Video Demonstration: 25 February Case

- Westbound US Highway 2 segment at the start of the real-time run
- Variety of pavement conditions
- Following movie illustrates data fusion capabilities. General track of vehicle is illustrated by direction of a series of colored dots which are advanced through on one side of display as the video advances on the opposite side of the display.
- Either pavement temperature or Halliday road grip values are plotted in the dots according to a preselected color scheme (either one defined by the user or a default scheme)

[Avi format movie](#)

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Video Demonstration II: 25 February Case

- Southbound Interstate 29 segment, midway through the real-time run
- The dots are either color-filled or not based upon whether GPS data was derived from the ThomTech AVI application (filled) or with the RedHen(open). Note that there are obviously data gaps in the transmission using the ThomTech satellite modem. In this video no attempt has been made to interpolate values between ThomTech points

Avi movie 2

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Video Demonstration III: 25 February Case

In this video, which shows the same segment as on the previous slide, data from the laptop has been merged in to fill in many of the gaps in Grip values that were seen before. Note, however, that there are still some gaps which may be a function of the laptop we used.

Avi Movie 3

QuickTime™ and a
TIFF (Uncompressed) decompressor
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Warm Season Testing

- Participated (with different ODOT truck) in May 2007 NASA/Wallops Friction Workshop with numerous other institutions
- Variety of pavement surface types are set up on runway and testing of various friction-measuring devices is done under controlled conditions.
- Although the measurement approach of the RT3 differed from other devices at the workshop, it had good repeatability, reliability & performance

Summary and Preliminary Conclusions

- Halliday RT3 unit performed reliably through the 2006-07 winter with little need for maintenance (ODOT truck itself required maintenance on the 4WD!).
- However, a tendency for RT3 readings to be affected when areas of deep snow/slush were encountered....as the treads filled up with compacted material.
- Minor dependencies of the RT3 road grip values on vehicle speed were noted, consistent with results from the summer Wallops workshop tests.
- Dependencies of RT3 grip values on pavement temperature were largely serendipitous...with both the RT3 and pavement temperatures reflecting snow and ice cover versus bare/wet pavement
- Dependencies of RT3 values on other variables essentially nil. When considering these results in tandem with the video records => good confidence that the RT3 is useful as a measure of road grip.

Summary and Preliminary Conclusions

- When combined with a *GPS-Video* positioning system and/or *AVL* technologies, the *RT3* has considerable potential for real-time operational use as a tool to help guide wintertime snow and ice control maintenance activities prior to, during, and after snow and ice events.
- Summer testing, as well as a winter run over both pavement and gravel surfaces, further show the *RT3's* ability to distinguish variable friction conditions

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Thanks for your attention!!!



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Extra Slides

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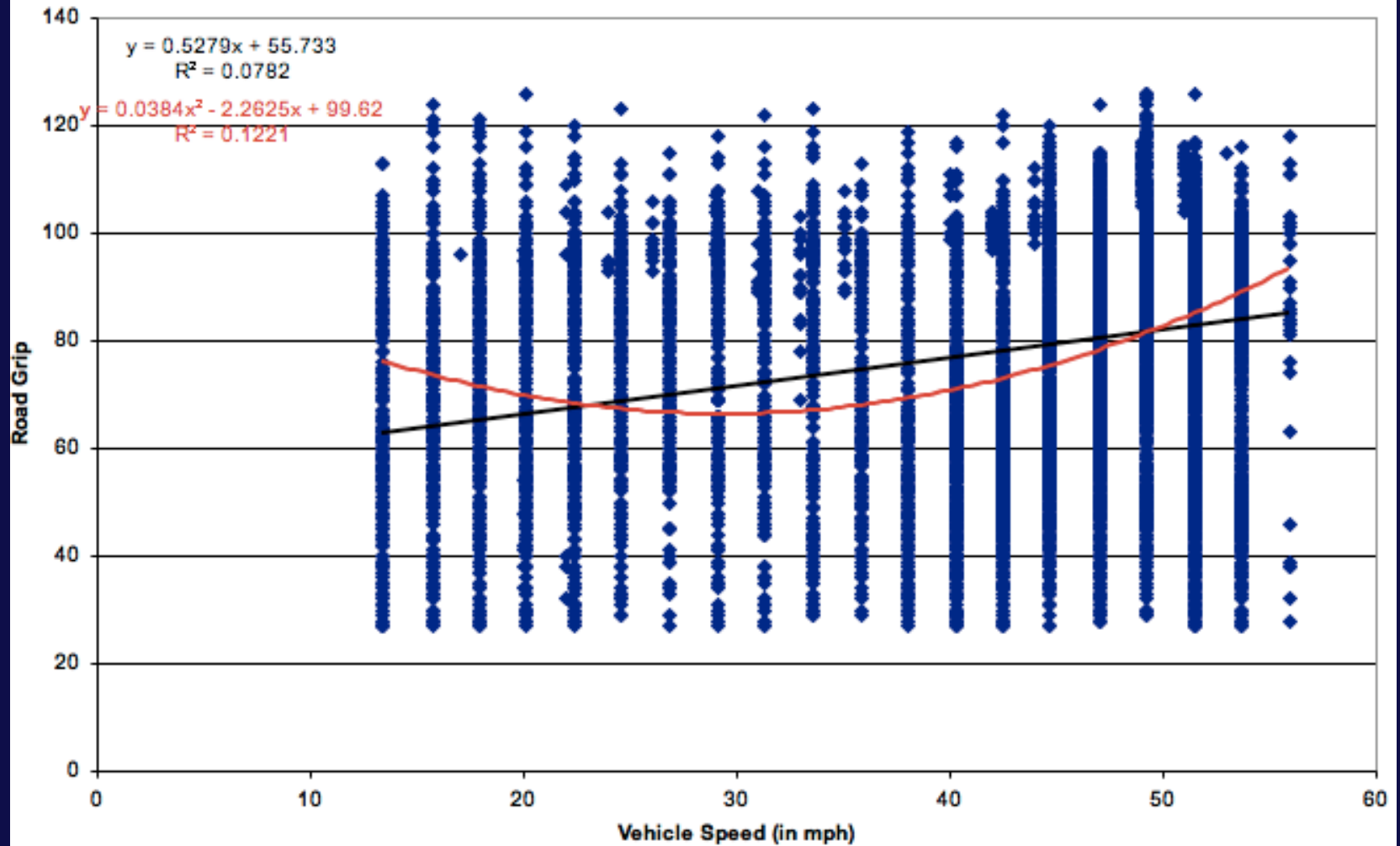
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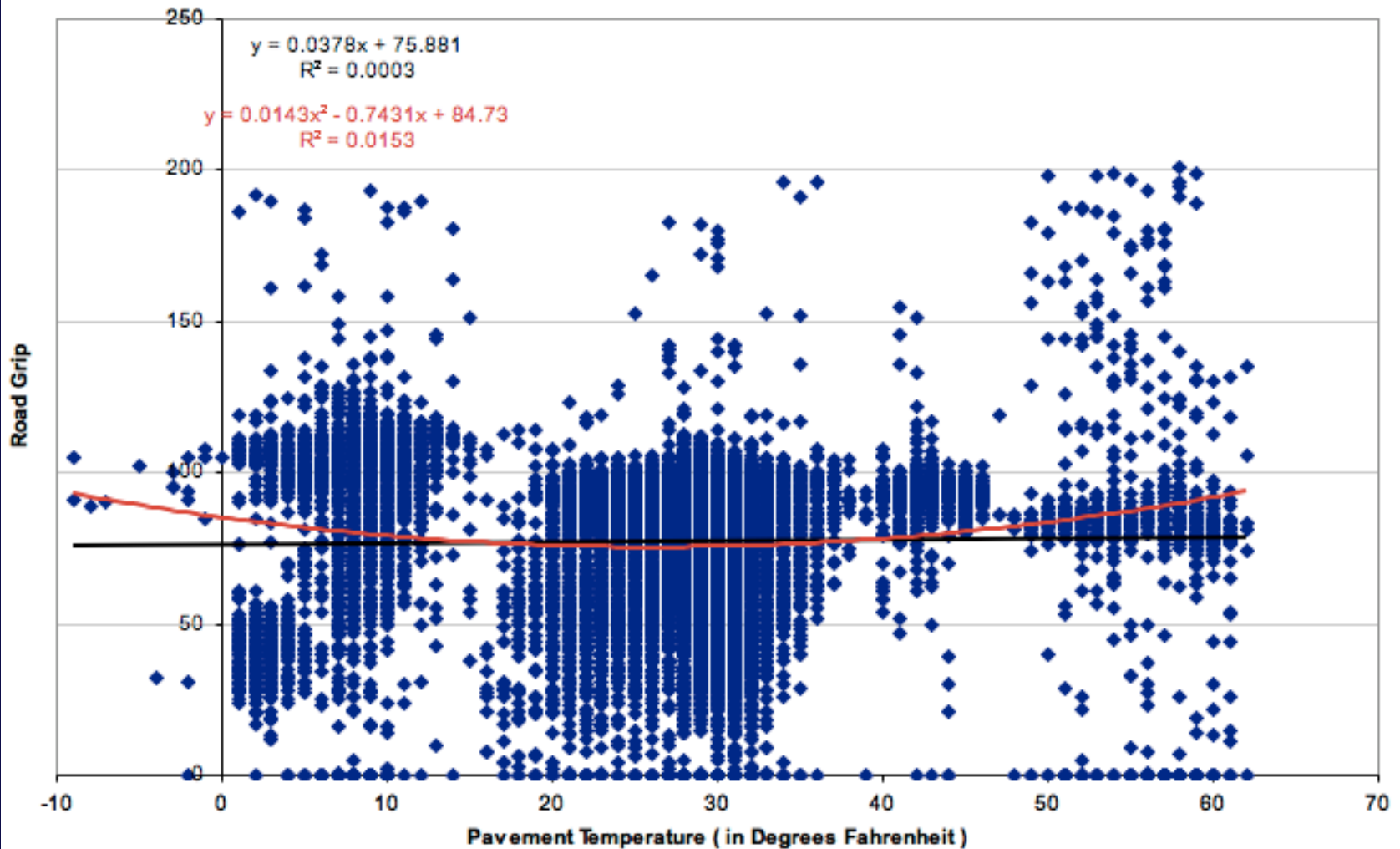
Summary of Observations: Scatter Plots

Road Grip Vs. Vehicle Speed for all 2006 and 2007 cases (Data Set 2 Outliers Removed)



Summary of Observations: Scatter Plots

Road Grip Vs. Pavement Temperature for all 2006 and 2007 Cases (Data Set 2)



Warm Season Testing

Site	Speed (km/h)	Run 1	Run 2	Run 3	Run 11	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10	Average	SD	SD/AVE
A	40	102	113	92	116	115	117	117	116	91	102	108	11.574	0.107
B	40	117	118	118	117	121	118	118	119	120	120	119	1.159	0.010
C	40	124	121	121	121	122	122	122	122	121	122	122	0.677	0.006
D	40	110	100	92	108	112	109	105	103	101	97	104	6.688	0.064
E	40	84	83	80	92	105	95	87	86	85	78	87	8.719	0.100
F	40	119	122	123	129	130	127	127	125	125	122	125	2.843	0.023
G	40	130	136	130	137	133	133	130	131	130	133	132	2.273	0.017

Actual Speed

Echo 1	40	118	106	108	104	107	104	102	103	107	105	106	2.150	0.020
EK 1	40	55	51	50	52	49	55	45	46	50	45	50	3.451	0.069
EK 2	40	119	112	109	110	111	107	104	107	108	106	109	2.456	0.022

Actual Speed

R 4	40			112	115	112	110	111	112	108	110	111	2.188	0.020
Echo 2	40			107	115	110	103	100	103	102	101	105	5.216	0.050
EK 3	40			106	110	110.7	105	104	106	104	100	106	3.463	0.033
EK 4	40			112	84	91	85	85	81	82	85	88	10.252	0.116

Actual Speed

Device: Operator:

Site	Speed (km/h)	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10	Average	SD	SD/AVE
A	60	85	82	78	75	74	66	81	77	65	71	76	5.611	0.074
B	60	114	113	104	112	113	116	116	111	109	111	112	3.925	0.035
C	60	104	104	103	108	109	109	100	105	103	106	105	3.274	0.031
D	60	88	91	71	83	109	74	72	71	66	70	80	13.760	0.173
E	60	70	83	55	53	60	46	52	51	42	37	55	7.476	0.136
F	60	115	119	107	106	113	102	115	105	103	103	109	4.819	0.044
G	60	131	132	131	131	132	128	133	128	129	128	130	2.038	0.016

Actual Speed

Echo 1	60	94	74		100	103	99	101	105	98	96	97	2.954	0.031
EK 1	60	21	31	29	22	25	31	29	24	23	25	26	3.131	0.120
EK 2	60	84	112	109	106	98	107	102	92	93	85	99	8.529	0.086

Actual Speed

R 4	60	92	88	95	110	98	93	107	101	98	93	97	6.192	0.064
Echo 2	60	85	83	87	86	85	86	87	86	92	87	86	2.046	0.024
EK 3	60	87	81	78	89	89	89	95	91	89	91	88	4.803	0.055
EK 4	60	56	43	50	59	55	51	61	52	48	60	53	4.924	0.092

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