



VIRGINIA TECH   
TRANSPORTATION INSTITUTE



# ASSESSING PAVEMENT NETWORK PERFORMANCE USING CROWD SOURCED CONNECTED VEHICLE DATA

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# INTRODUCTION



- KEEPING PAVEMENTS IN GOOD CONDITION IS THE GOAL OF ROAD AGENCIES.
- INTERNATIONAL ROUGHNESS INDEX(IRI) IS USED IN FUNCTIONAL HEALTH MONITORING.
- EFFECTIVE AND EFFICIENT MAINTENANCE REQUIRES FREQUENT MONITORING.
- MONITORING IS DONE ANNUALLY WITH SPECIALIZED VEHICLES.
- CROWD SOURCED DATA CONNECTED VEHICLES USING ON-BOARD SENSORS CAN PROVIDE CONTINUOUS DATA.

# OBJECTIVES



- COMPARISON OF CV-IRI WITH REFERENCE IRI FOR NETWORK LEVEL MONITORING.
- ANALYZING SEASONAL VARIATIONS IN CV-IRI.
- ANALYZING RELATIONSHIP OF CV-IRI WITH STRUCTURAL INDICATORS FROM TSD .

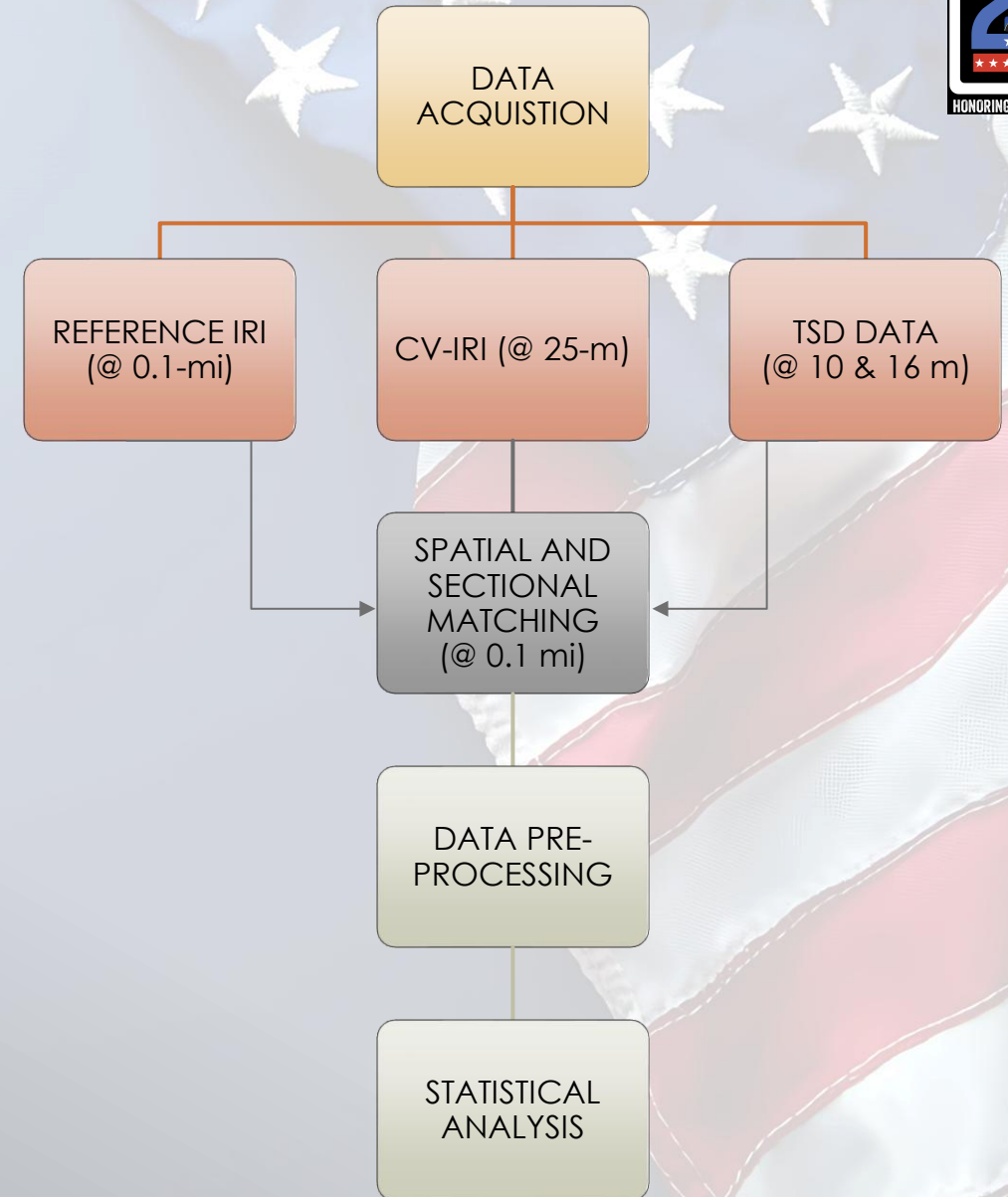
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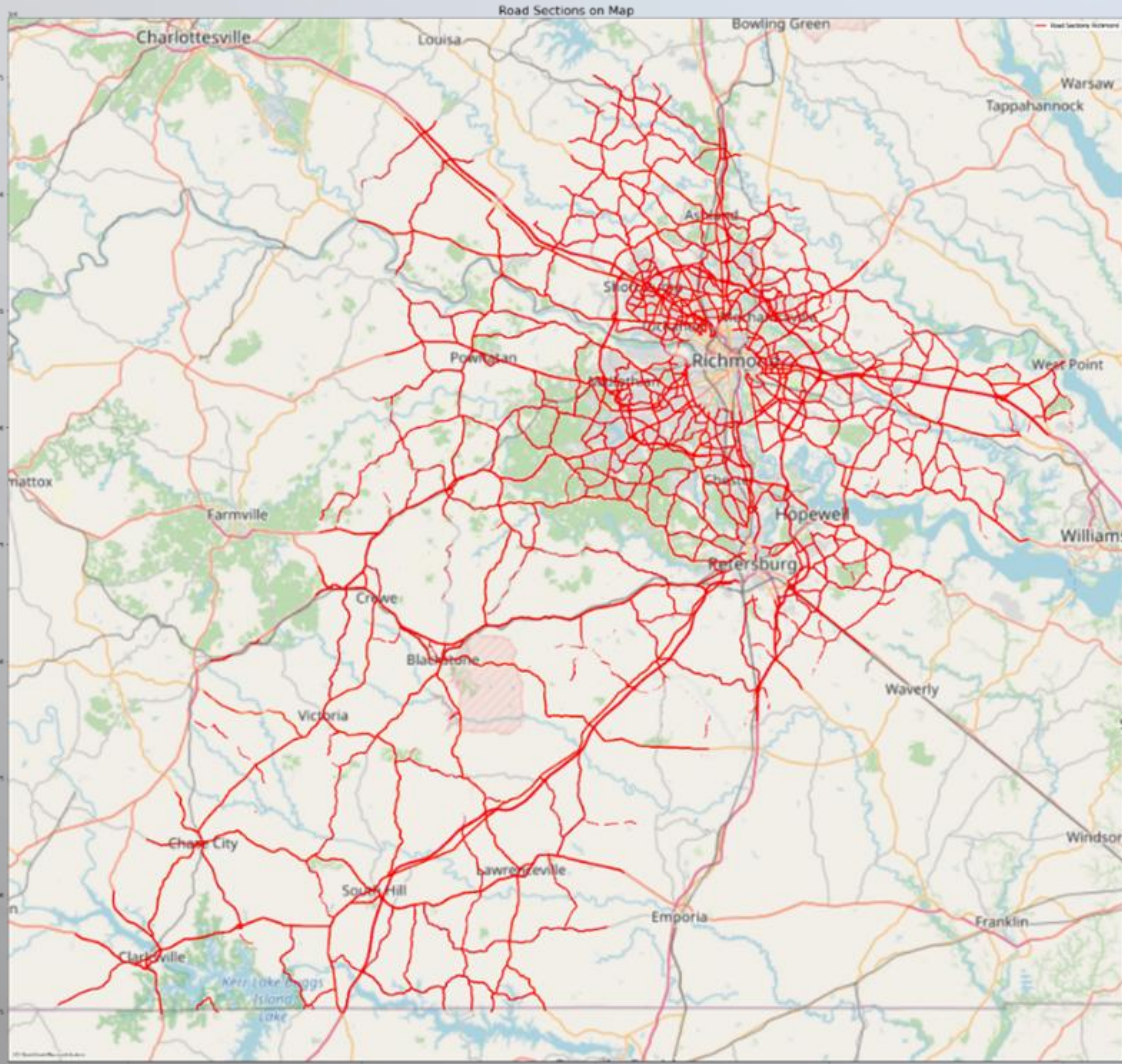
- THIS STUDY EXPLORES POTENTIAL OF CONNECTED VEHICLE DATA FOR NETWORK LEVEL MONITORING.
- ROAD AGENCIES CAN MONITOR ENTIRE NETWORKS WITH MINIMUM EFFORT.
- COLLECT DATA FOR ROADS WHICH ARE NOT MONITORED FREQUENTLY.

# METHODOLOGY

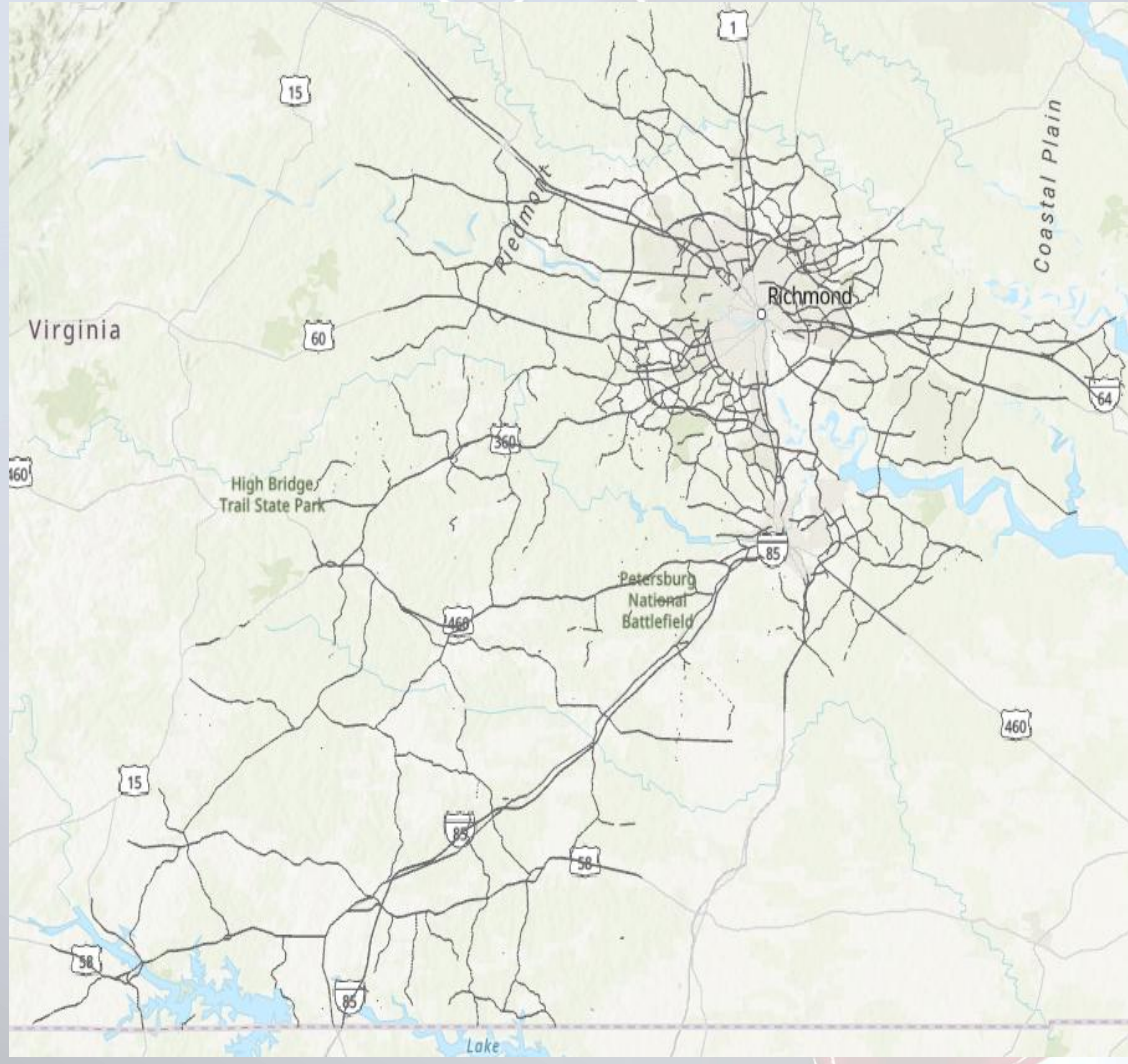
- DATASETS:
  - CONNECTED VEHICLE DATA (COMMERCIAL)
  - REFERENCE IRI DATA (PMS)
  - TSD DATA
- SPATIAL AND SECTIONAL MATCHING USING GIS (0.1 MI AND 1-MILE AGGREGATIONS)
- FILTERING DATA (TRIMMING OUTLIERS, REHAB) – 21013 SECTIONS LEFT
- STATISTICAL ANALYSIS ( $R^2$ , MAE, RMSE, CLASSIFICATION ACCURACY)



# LOCATION



CV DATA (2023)



VDOT COVERAGE (2023)

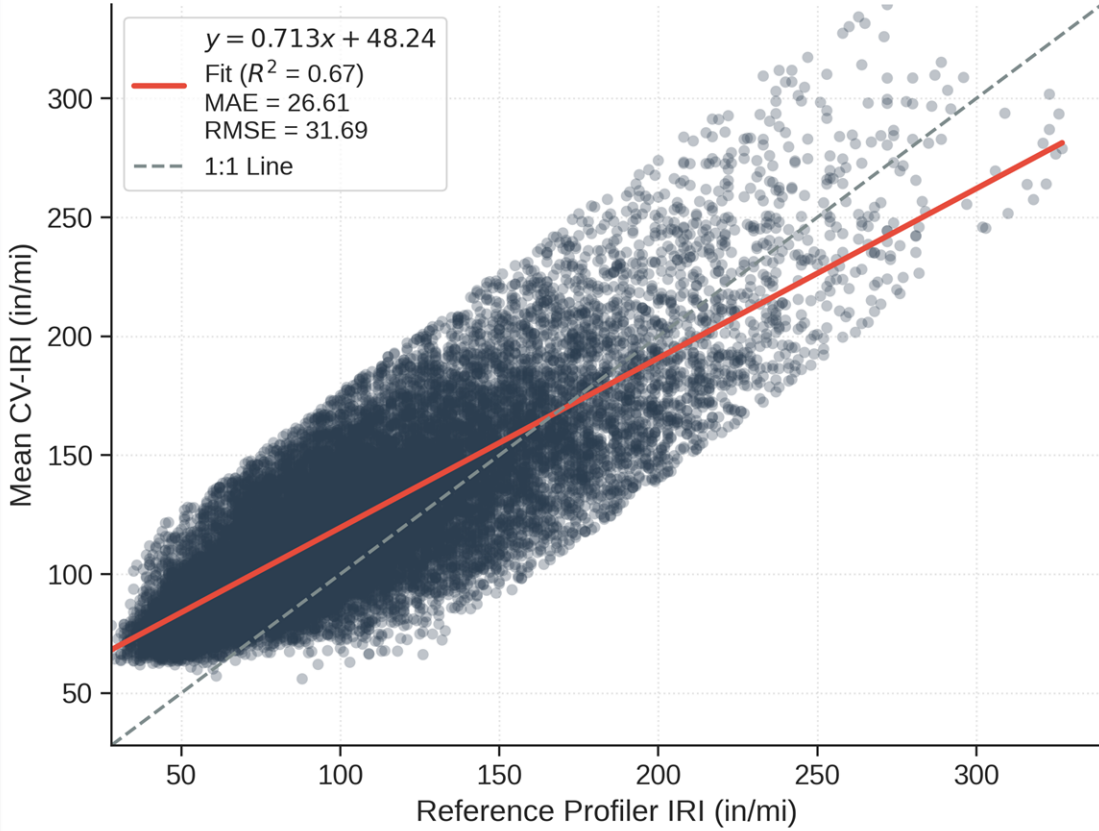
- RICHMOND, VA – 2000 + MILES (2023)



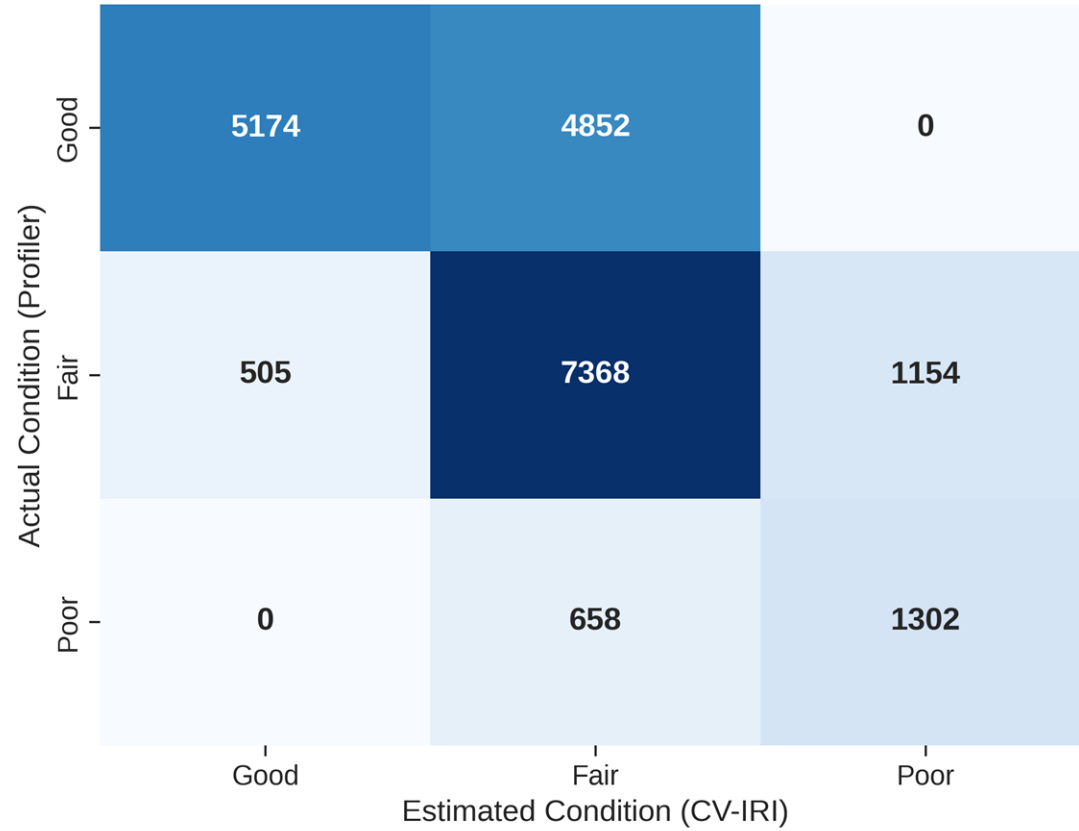
# RESULTS



Profiler vs. CV-IRI Comparison  
(n = 21013)



Classification Performance  
(Accuracy: 65.9%)

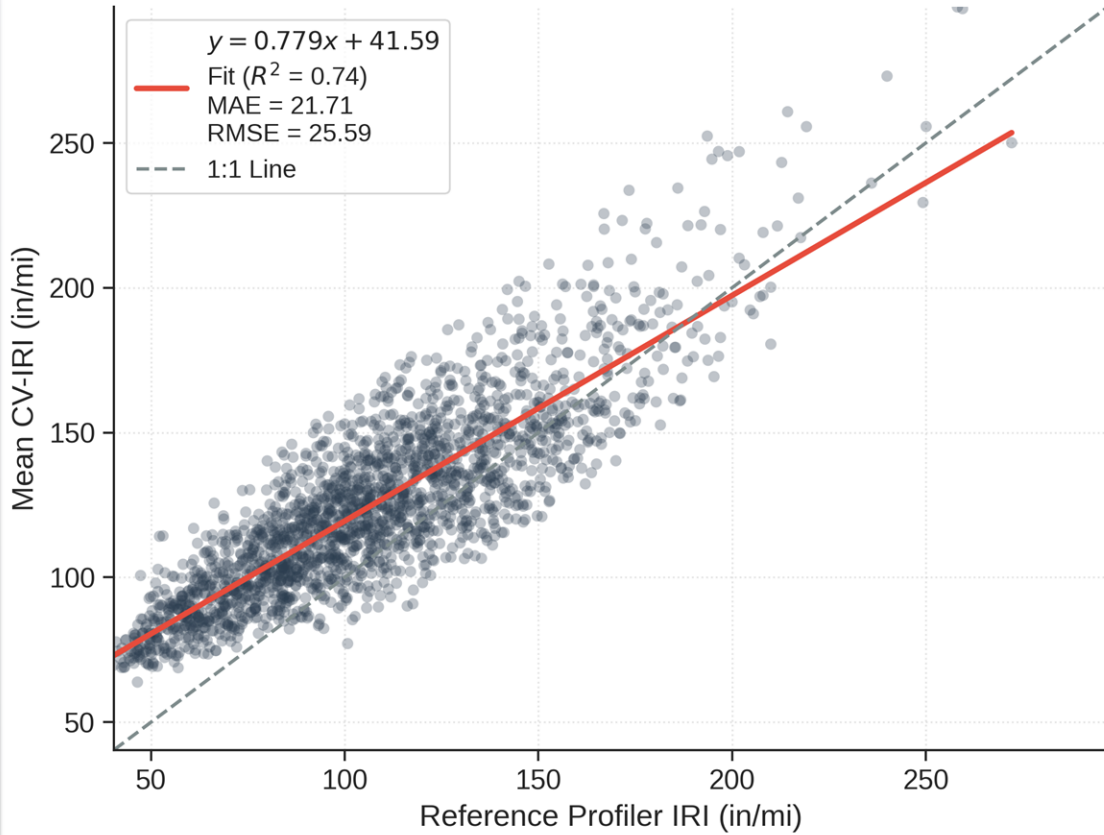


- LINEAR FIT WITH AN  $R^2$  OF 0.67
- CLASSIFICATION ACCURACY OF 66 %

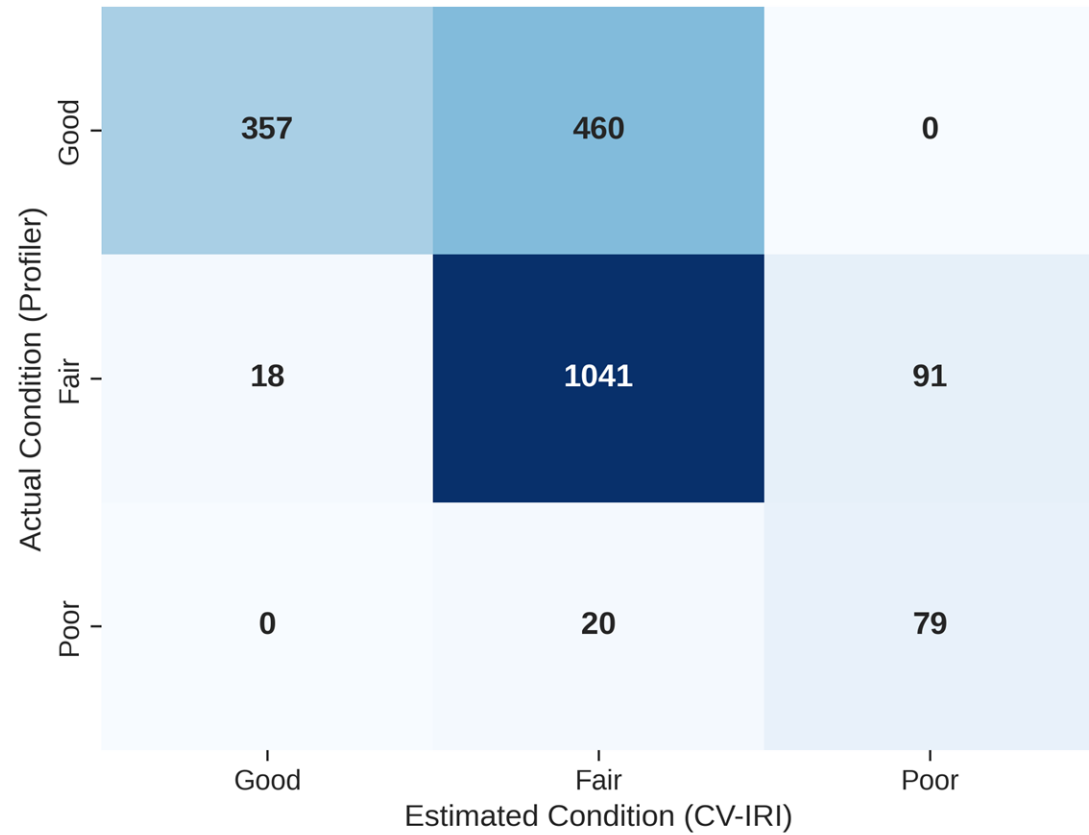
# RESULTS



Profiler vs. CV-IRI Comparison  
(n = 2066)



Classification Performance  
(Accuracy: 71.5%)



- LINEAR FIT WITH AN  $R^2$  OF 0.74
- CLASSIFICATION ACCURACY OF 72 %

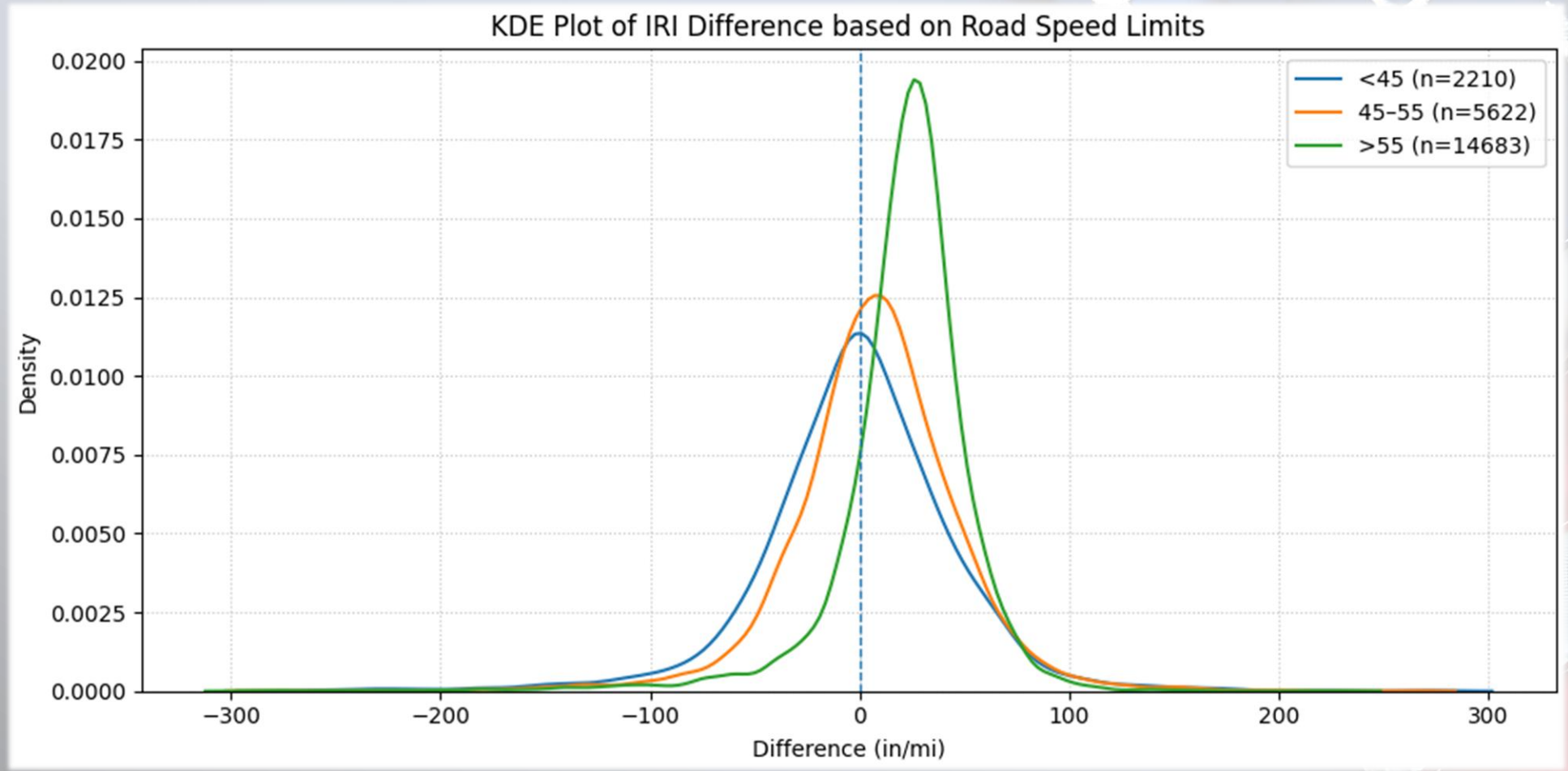
# RESULTS



Aggregation Level	Road Classification	Number of Sections (n)	R <sup>2</sup> Value	Classification Accuracy
0.1-mi	Interstate	5095	<b>0.73</b>	<b>72.0%</b>
	Highway	12406	0.56	61.3%
	Secondary	3512	0.66	<b>73.1%</b>
1-mi	Interstate	485	<b>0.78</b>	<b>72.2%</b>
	Highway	1304	0.62	69.5%
	Secondary	277	<b>0.75</b>	<b>79.8%</b>

- BETTER RESULTS FOR LONGER SEGMENT AGGREGATION.

# DIFFERENCE

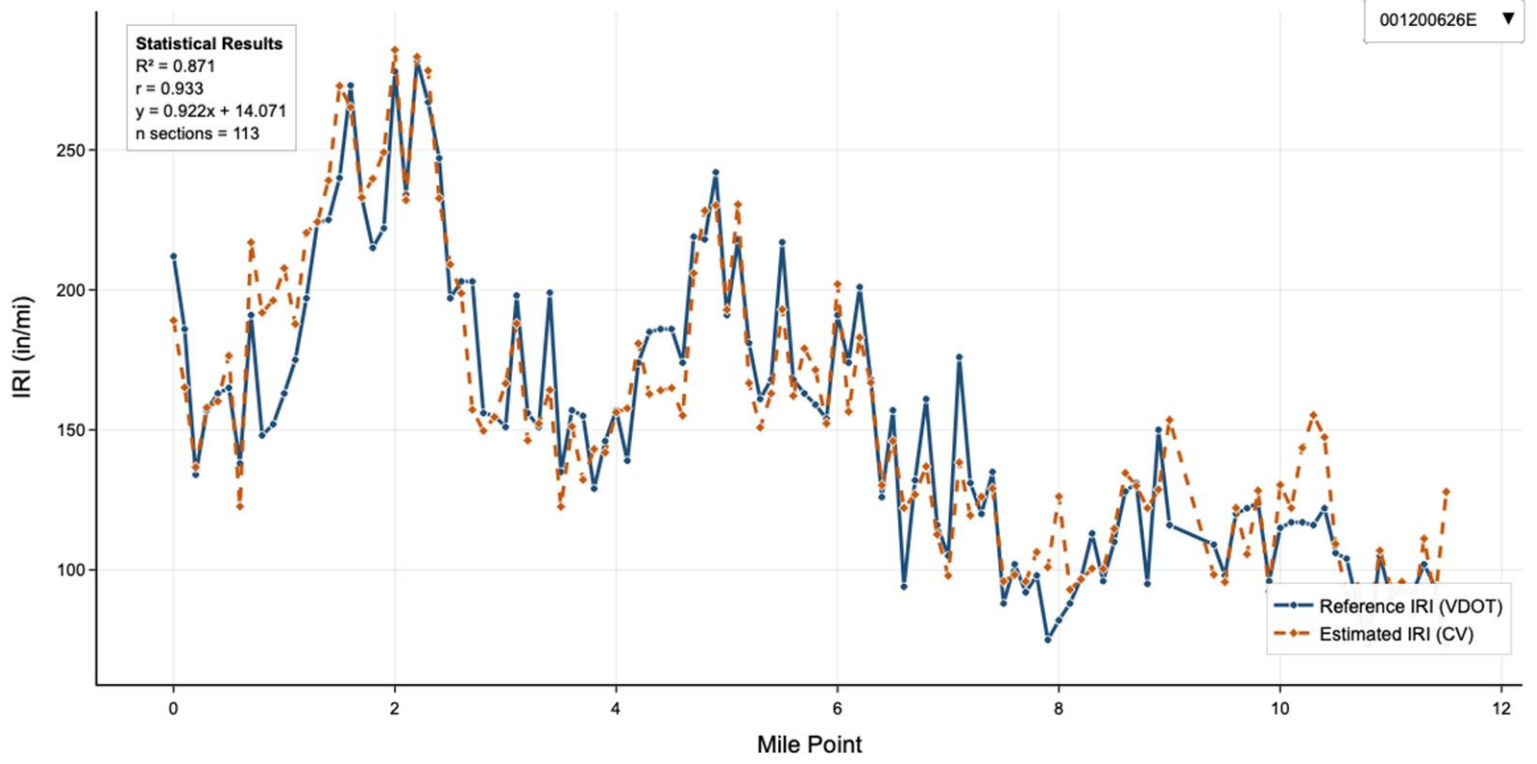


- SEGREGATING THE SECTIONS BY ROAD SPEED LIMITS HIGHLIGHTS A DIFFERENCE IN BIAS WITH HIGHER ERROR FOR HIGH-SPEED SECTIONS AS COMPARED TO LOW-SPEED SECTIONS

# CV-IRI ACCURACY (EXAMPLE SECTION)



Comparison of CV and Reference IRI for Route 001200626E ( $R^2 = 0.871$ )

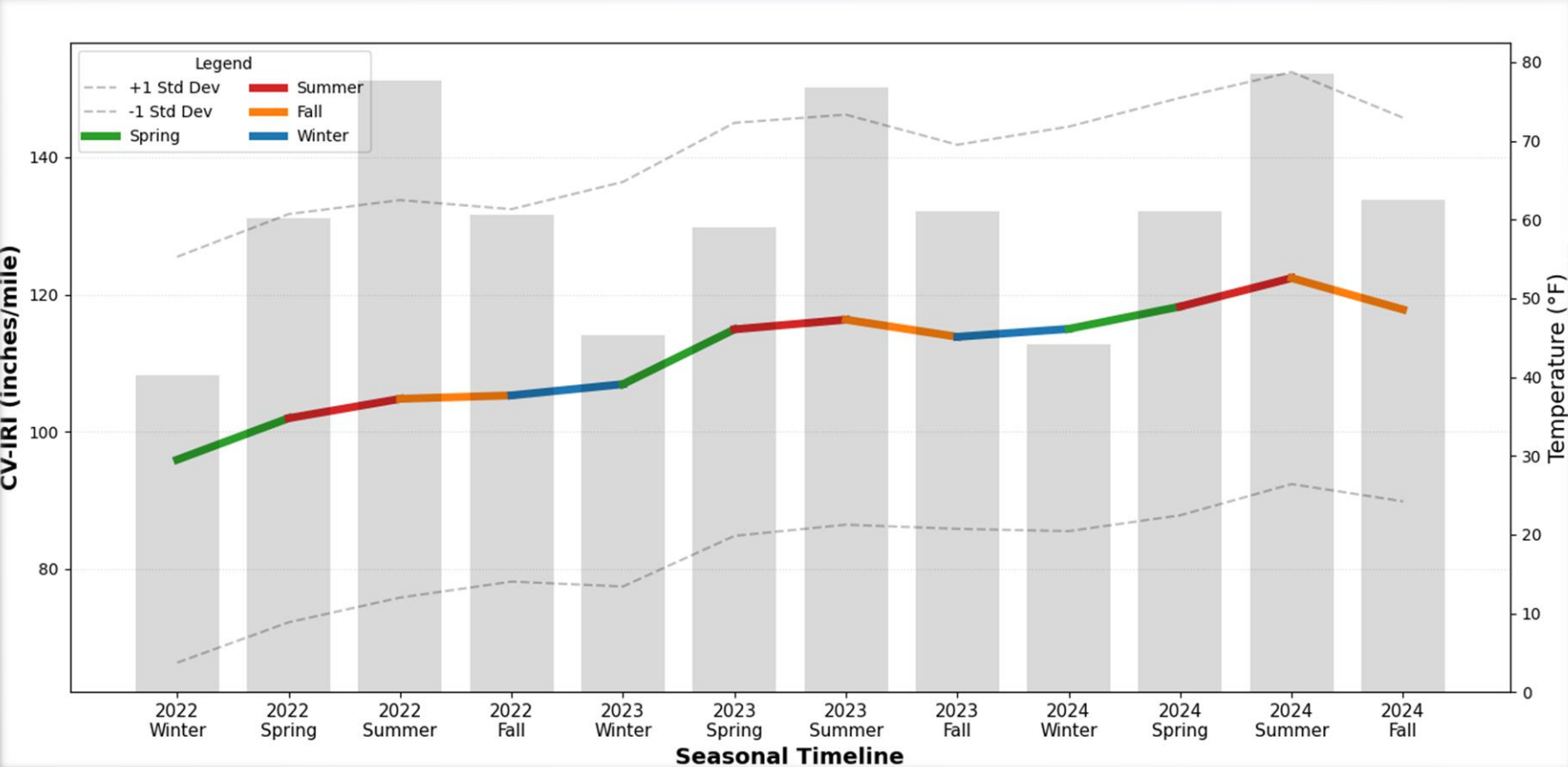


Source: Google Earth Images

Road Name – VA-626EB  
 $R^2 = 0.87$   
Miles – 11.3 (113 sections)  
Speed Limit – 45 mph

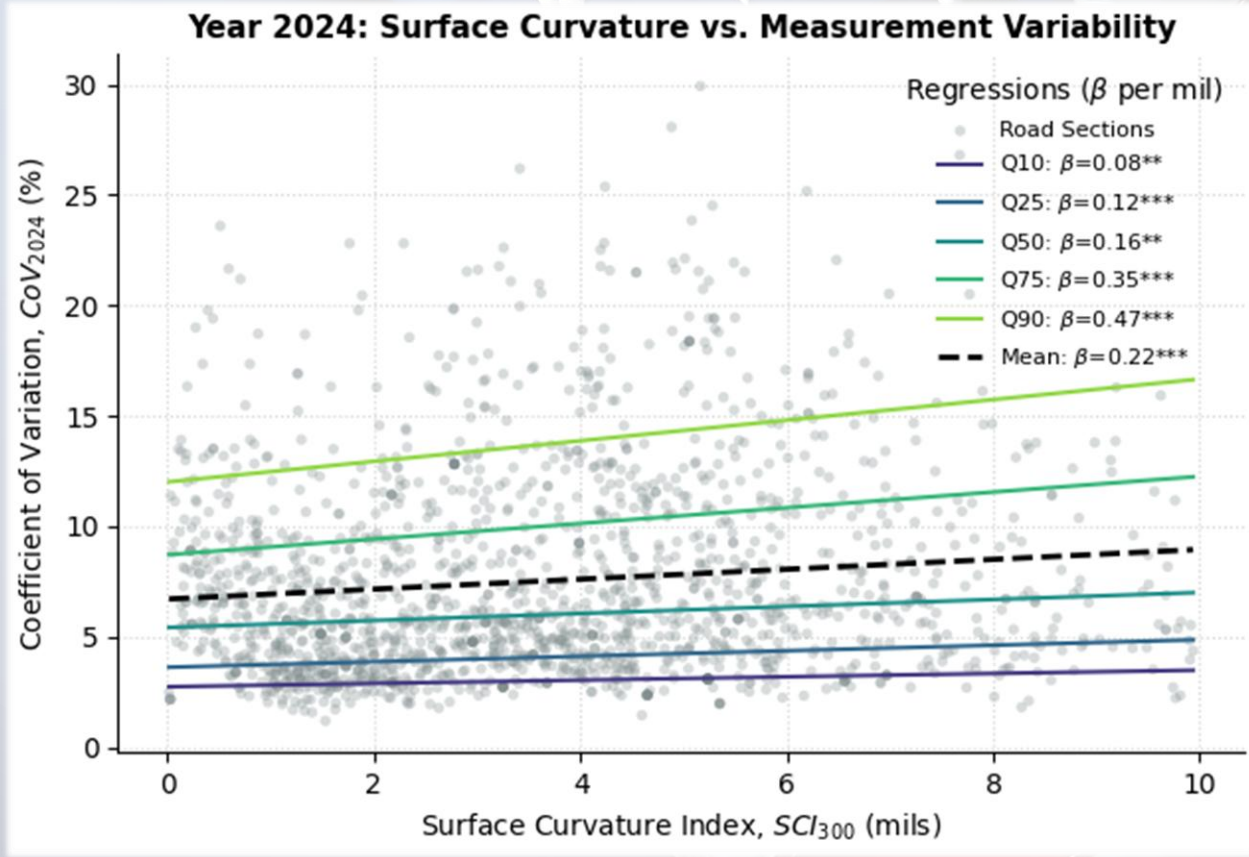
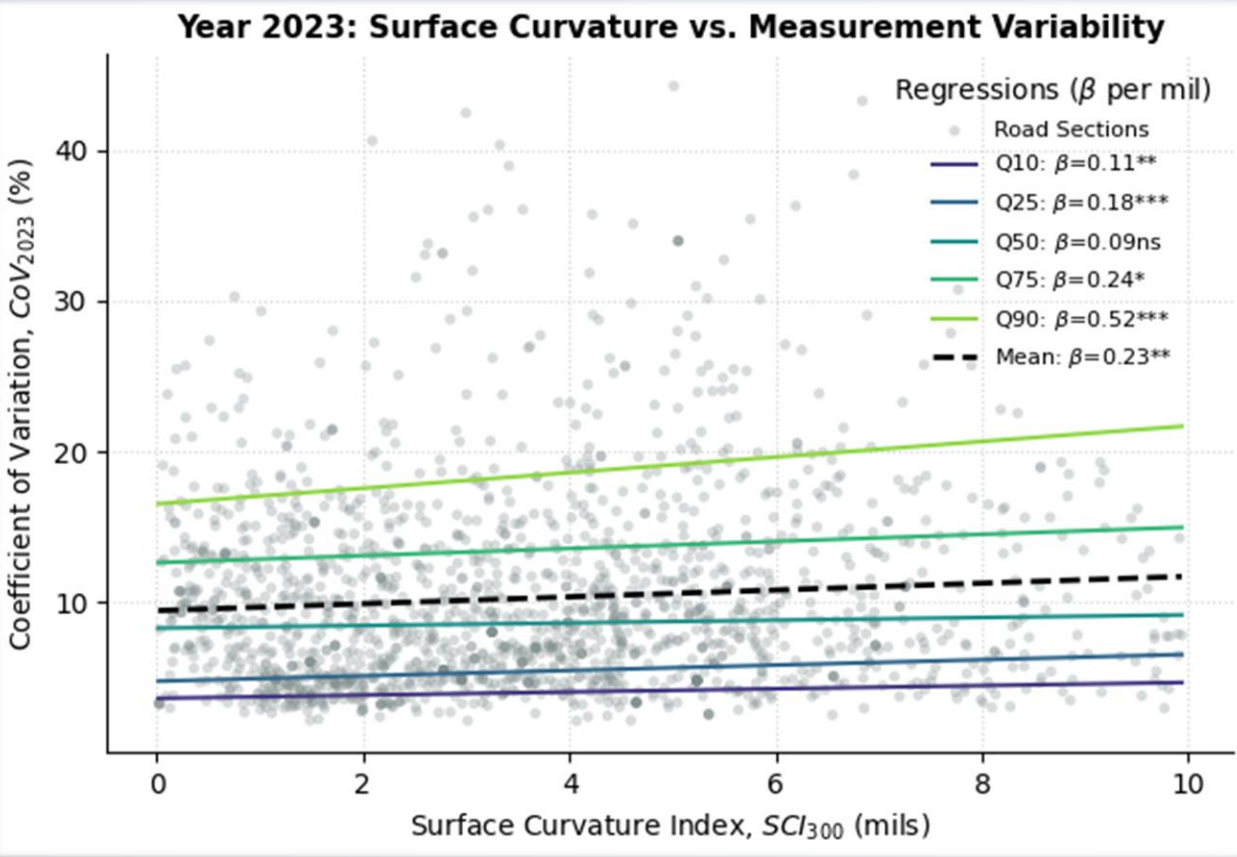
- STRONG CORRELATION WITH REFERENCE IRI

# SEASONAL VARIATION CV-IRI (200 MI)



- AVERAGE IRI FOR 200+ MILES SHOWS SEASONAL DIFFERENCES.
- HIGHER GROWTH DURING THE 1<sup>ST</sup> HALF OF THE YEAR AND LOWER GROWTH IN 2<sup>ND</sup> HALF.

# COV (CV-IRI) V/S SCI300



- INDICATES SECTIONS WITH HIGHER VARIABILITY HAVE STRONGER RELATIONSHIP WITH LOWER STRUCTURAL CONDITION

# FINDINGS



- MODERATE-TO-STRONG CORRELATION FOR NETWORK LEVEL ANALYSIS, FIT WITH  $R^2$  0.67 TO 0.74 AND CLASSIFICATION ACCURACY OF 66 % TO 72 % GOING FROM 0.1 MI TO 1 MI SECTIONAL AGGREGATIONS.
- SEASONAL VARIATIONS INDICATES HIGHER GROWTH RATES AFTER WINTER TILL SPRING AND SLOWER GROWTH RATES AFTER SUMMER AND FALL.
- RELATIONSHIP BETWEEN COV OF CV-IRI AND SCI300 FROM TSD SHOWS A HIGHER POSITIVE SLOPE FOR SECTIONS EXPERIENCES MORE VARIABILITY IN A YEAR.

# CONCLUSIONS

- NETWORK LEVEL COMPARISON SUGGESTS THAT THE CROWD SOURCED CONNECTED VEHICLE ROUGHNESS DATA HAS POTENTIAL TO BE USED AS A SUPPLEMENTARY TOOL.
- ROADS MONITORED INFREQUENTLY, LIKE SECONDARY ROADS COULD BENEFIT MORE.
- SEASONAL VARIATIONS INDICATES HIGHER GROWTH RATES AFTER WINTER TILL SPRING AND SLOWER GROWTH RATES AFTER SUMMER AND FALL.
- CoV ANALYSIS FOR CV-IRI INDICATES INCREASED VARIABILITY MIGHT BE RELATED WITH LOWER STRUCTURAL STRENGTH.



# FUTURE WORK

- LANE LEVEL SEGMENTATION OF CV-IRI DATA.
- EXPLORE SEASONAL EFFECTS BASED ON PAVEMENT TYPES.
- BIAS CORRECTION USING BAYESIAN METHODS.
- LCA USING LANE LEVEL CV-IRI DATA.



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HONORING THE PAST. PAVING THE FUTURE.

# THANK YOU

## QUESTIONS ?

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