RPUG
Road Profile Users' Group

# TOWARDS STANDARDIZED PAVEMENT SURFACE TEXTURE SPECTRAL ANALYSIS AND EVALUATION


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# OUTLINE

- Background
  - Texture Measurements, Smart Wave, and Spectral Analysis
  - Concluding Remarks and Future Work

# Pavement Friction Management

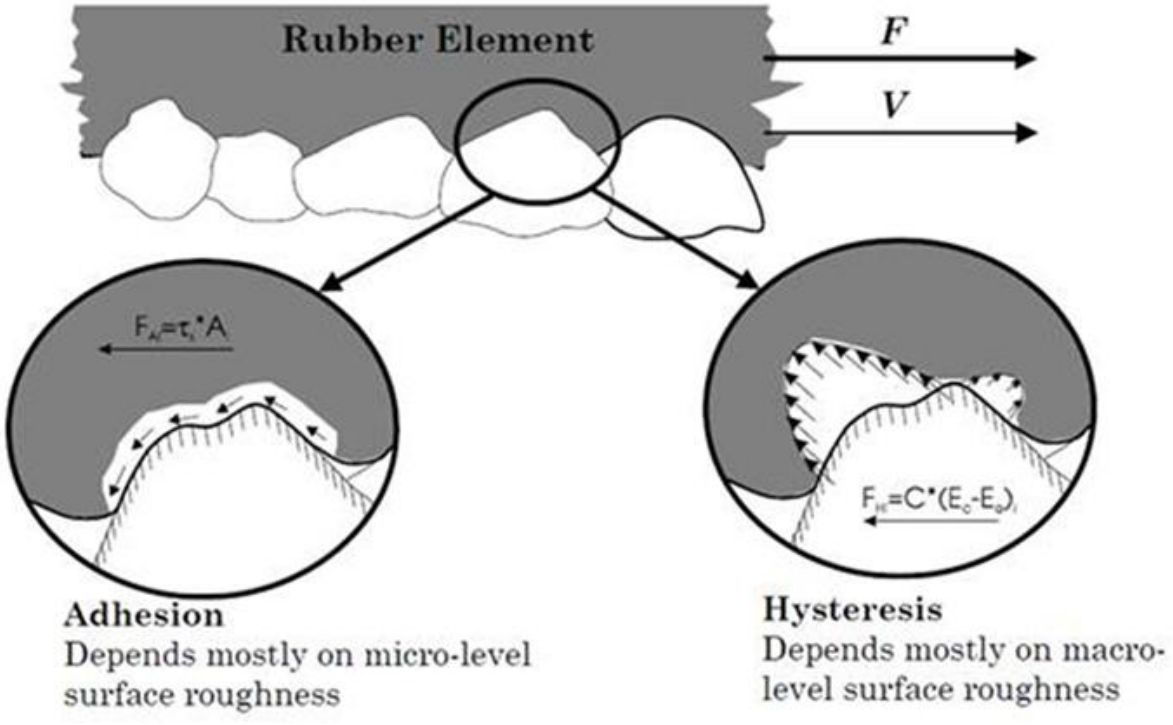
- Great progress has been achieved in standardizing continues friction measurements and their use in safety assessment.
- Still challenged with the physical systems need for water and tires, and the inconsistency between different systems.

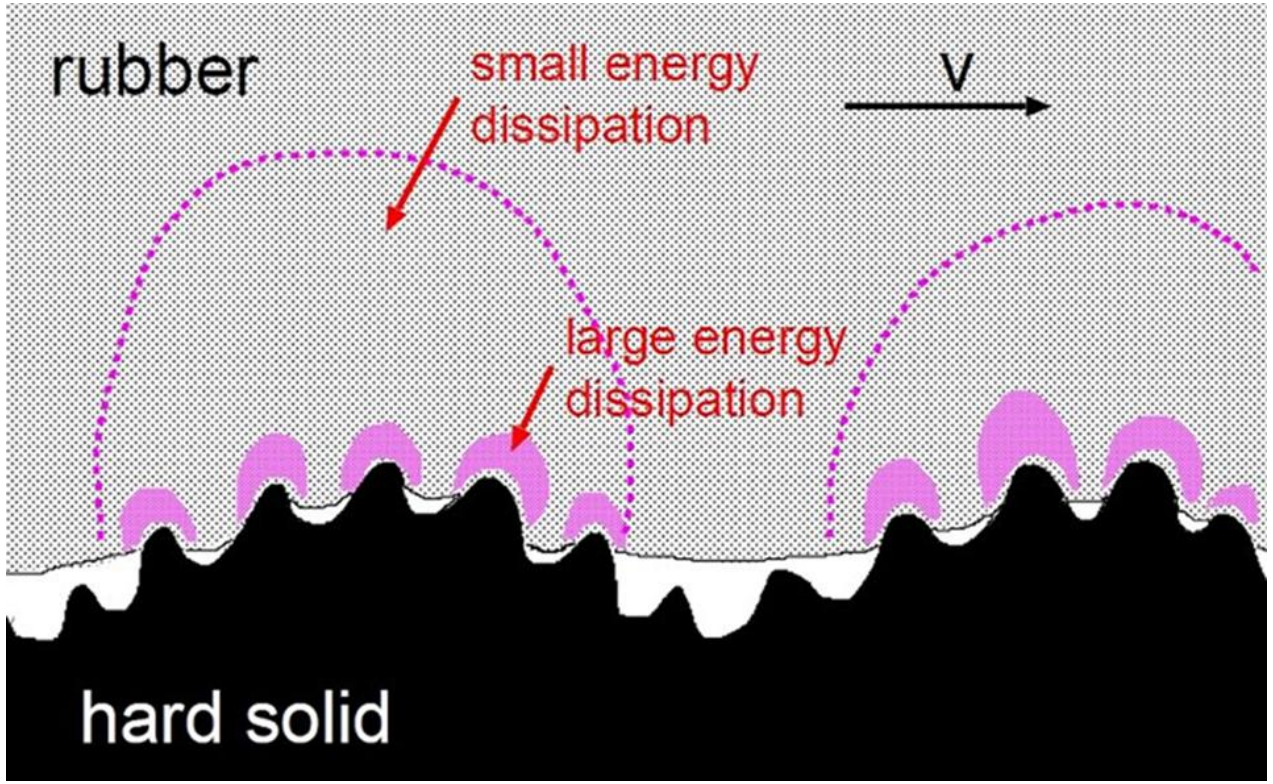
SCRIM, WDM USA

LWST, Iowa DOT

# Pavement Texture Scanning

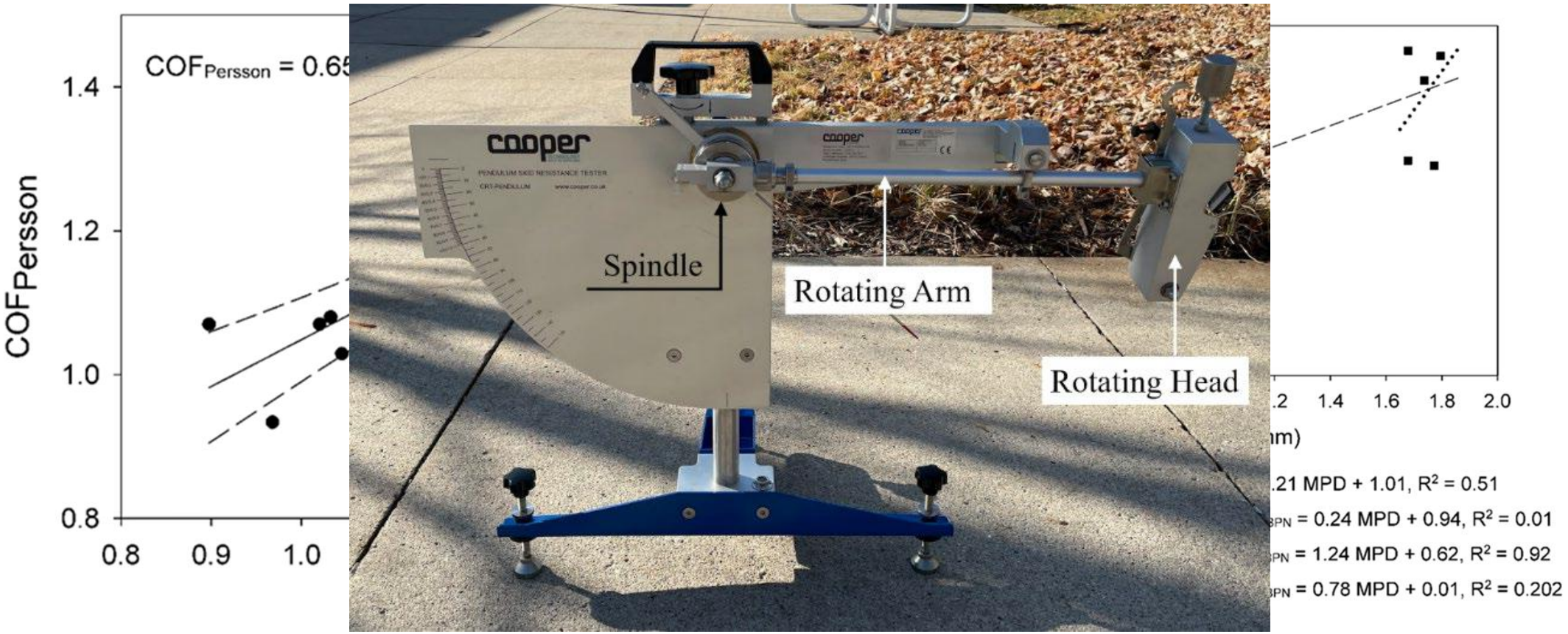
- Persson's friction model provided a robust physical and analytical solutions for a simple rubber block.



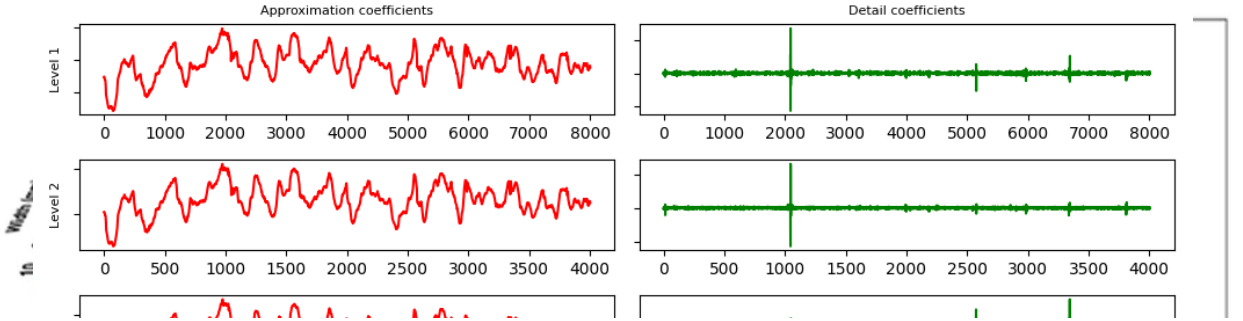



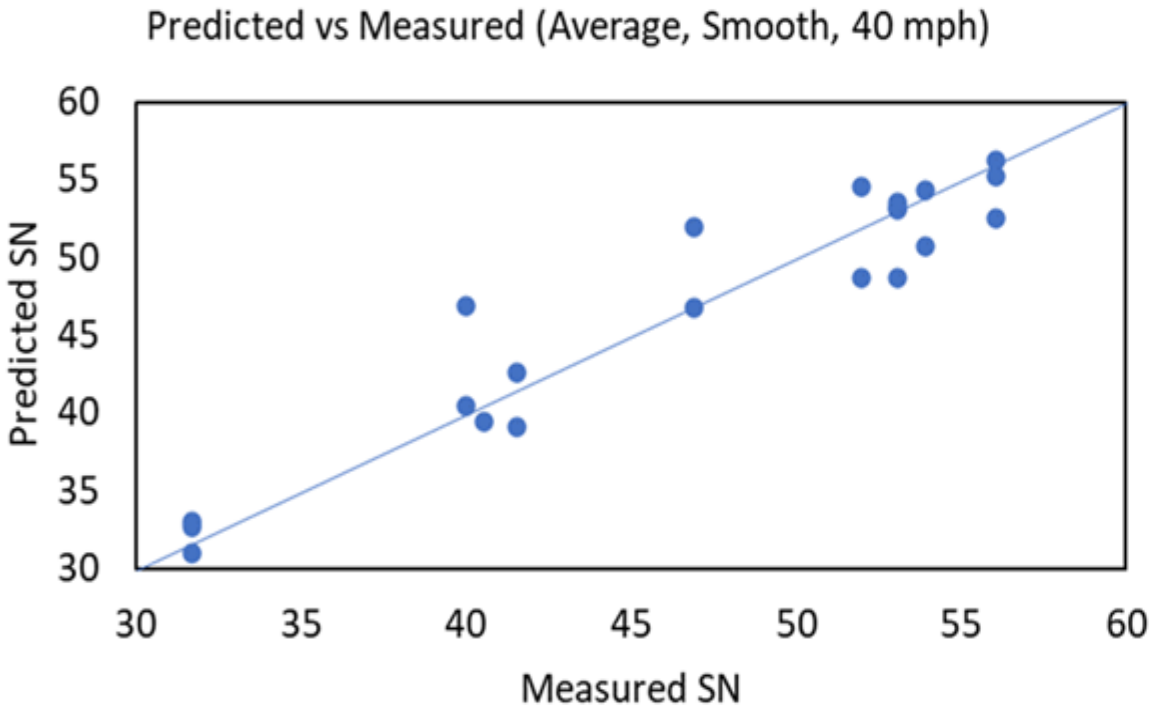
# Testing the Theory

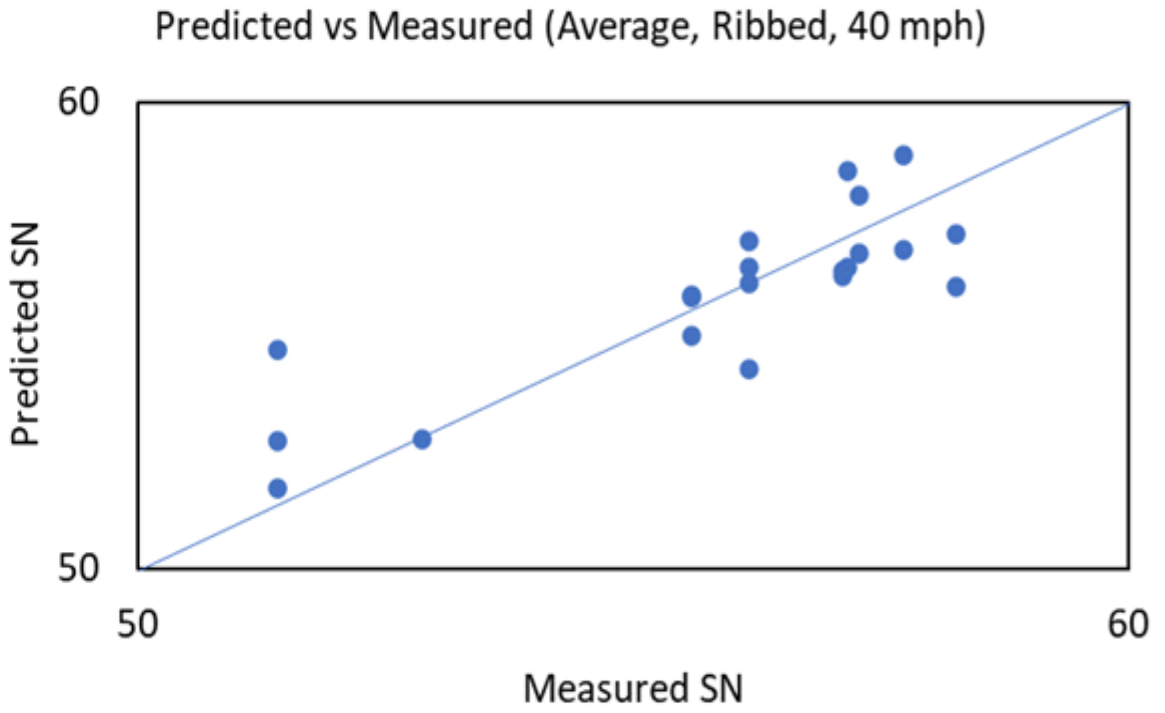
- Persson's friction model provided a robust physical and analytical solutions for a simple rubber block (British Pendulum).



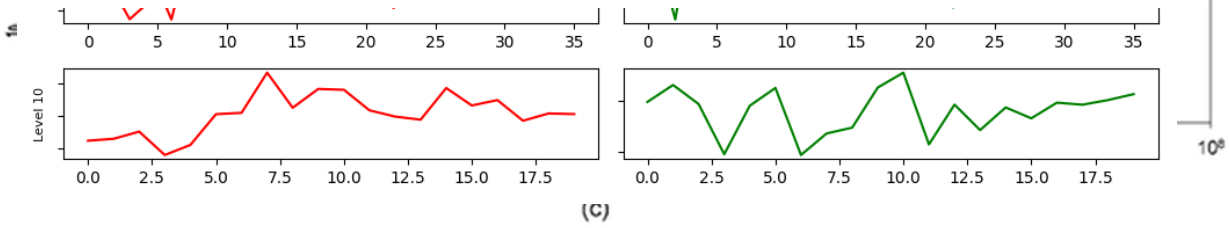
# Implementing A Concept




Measured SN

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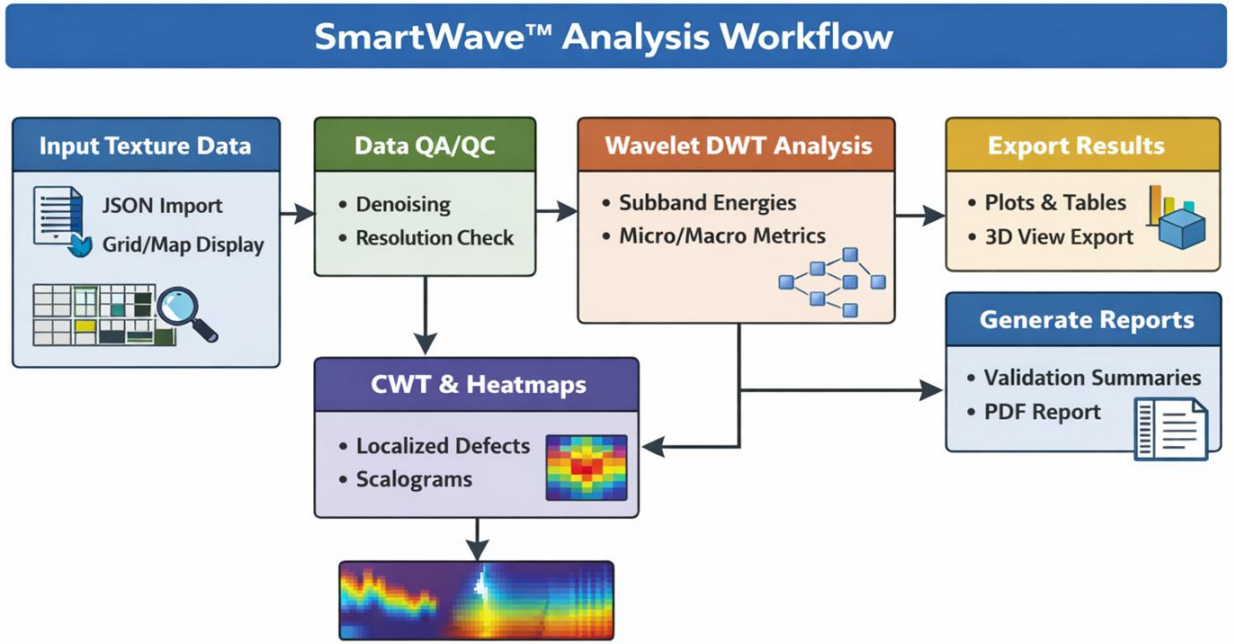
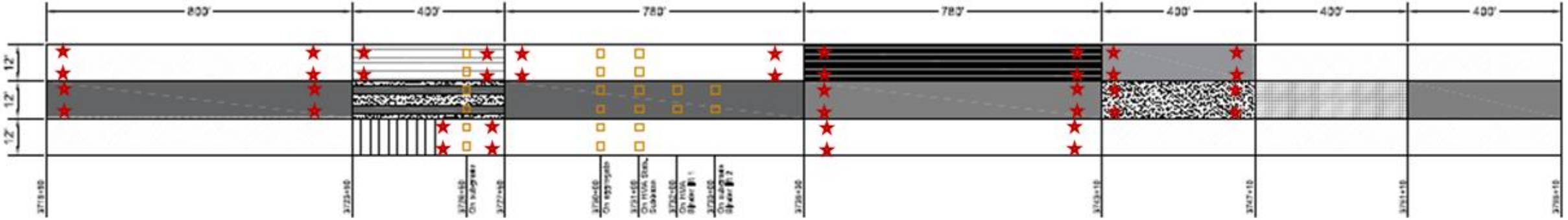
# Pavement Texture Data Standardization

- To move towards contactless tire-pavement friction we need improved standards for texture data and analysis.
- Smart Wave™ is a proprietary platform capable of supporting analysis and friction of texture and friction data.

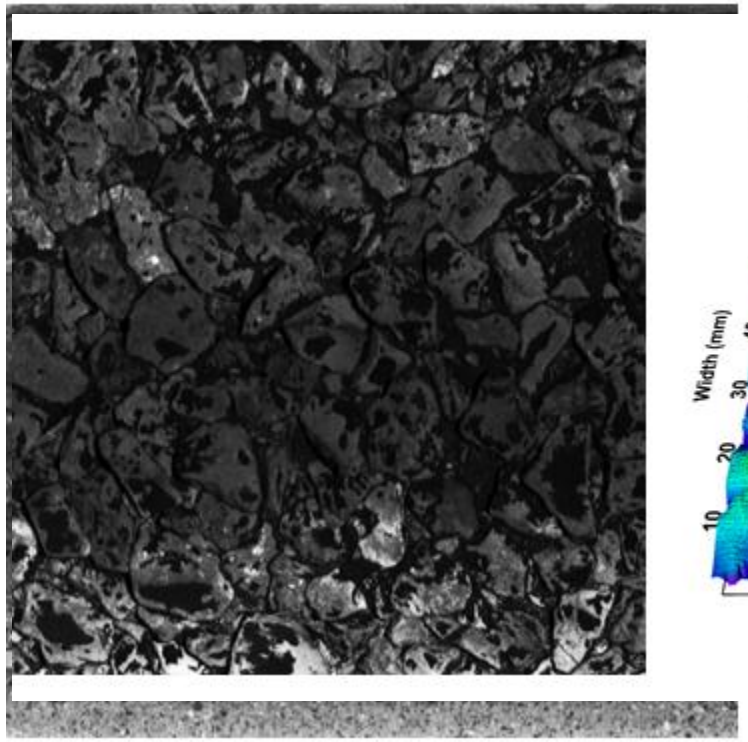


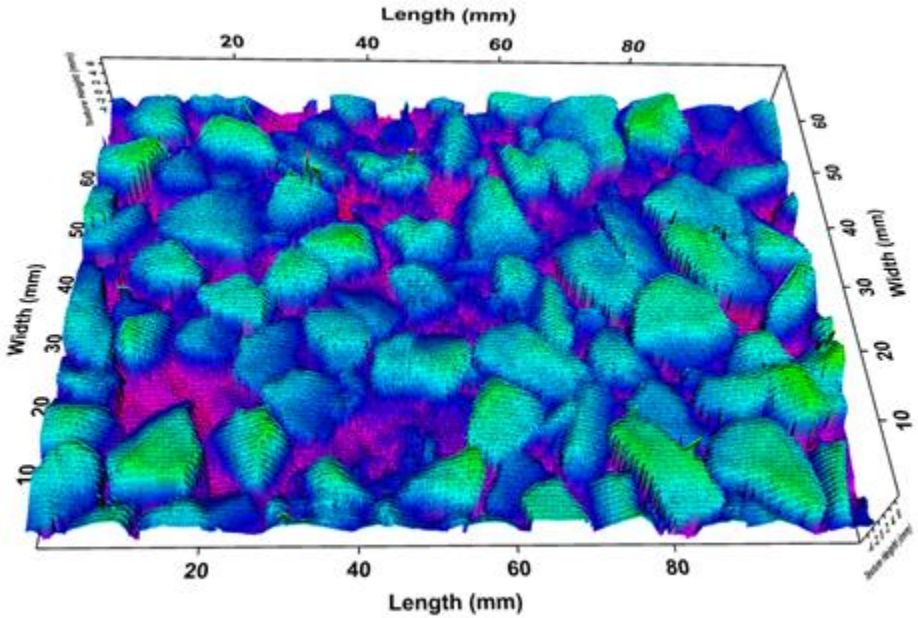
# ICART Data Collection

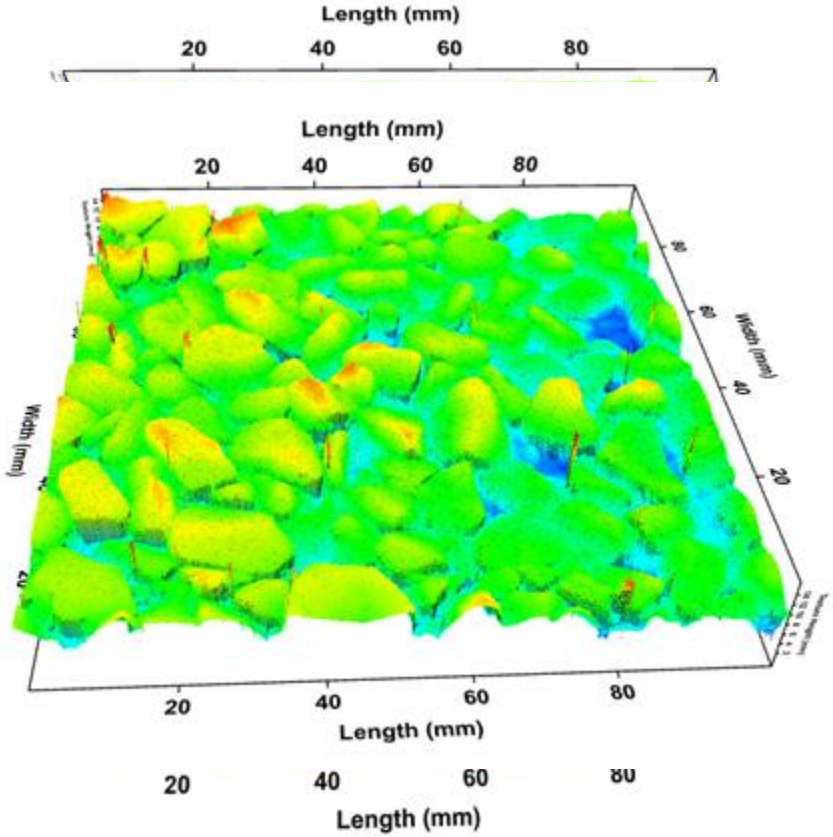



| | | | | | | |
|---|---|---|---|---|---|---|
| 8.5" CRCP - Turf Drag Finish | Smooth Finish with Diamond Grooving | Turf Drag Finish w/ Diamond Grooving | Smooth Finish with Diamond Grinding | Smooth Finish | Turf Drag Finish | Turf Drag Finish |
| 11.5" 12.5 mm SMA | Artificial Rutting | 12.5 mm SMA | 9.5 mm Dense Graded HMA | Mill surfacing with 30% Crushed Granite & 70% Slag | Single Chip Seal | 9.5 mm Dense Graded HMA |
| 8.5" JPCP - Turf Drag Finish | Artificial Faulting | Longitudinal Tining | Transverse Tining | Turf Drag Finish | Turf Drag Finish | Turf Drag Finish |

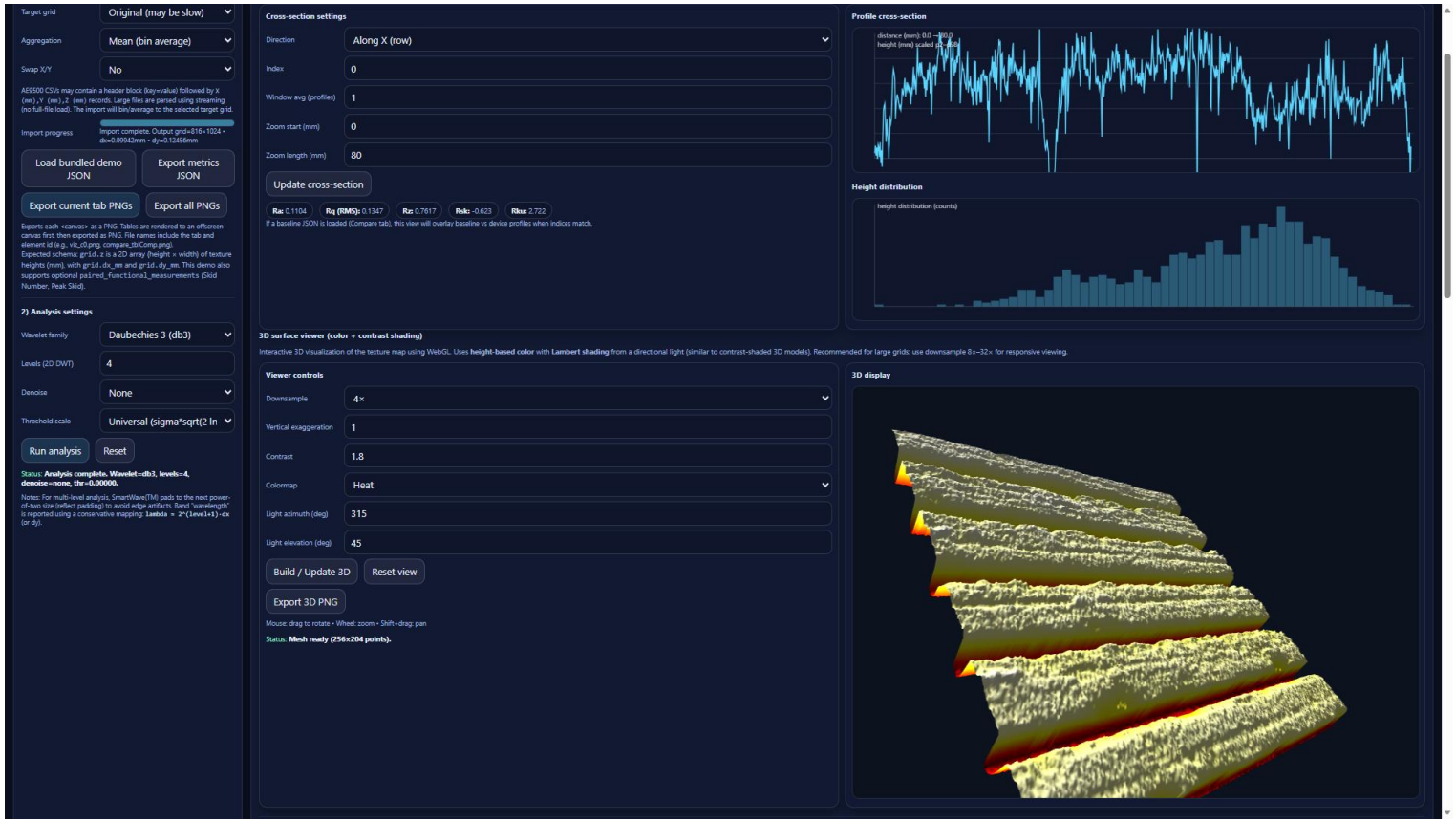
# Included a Wide Range of Surfaces

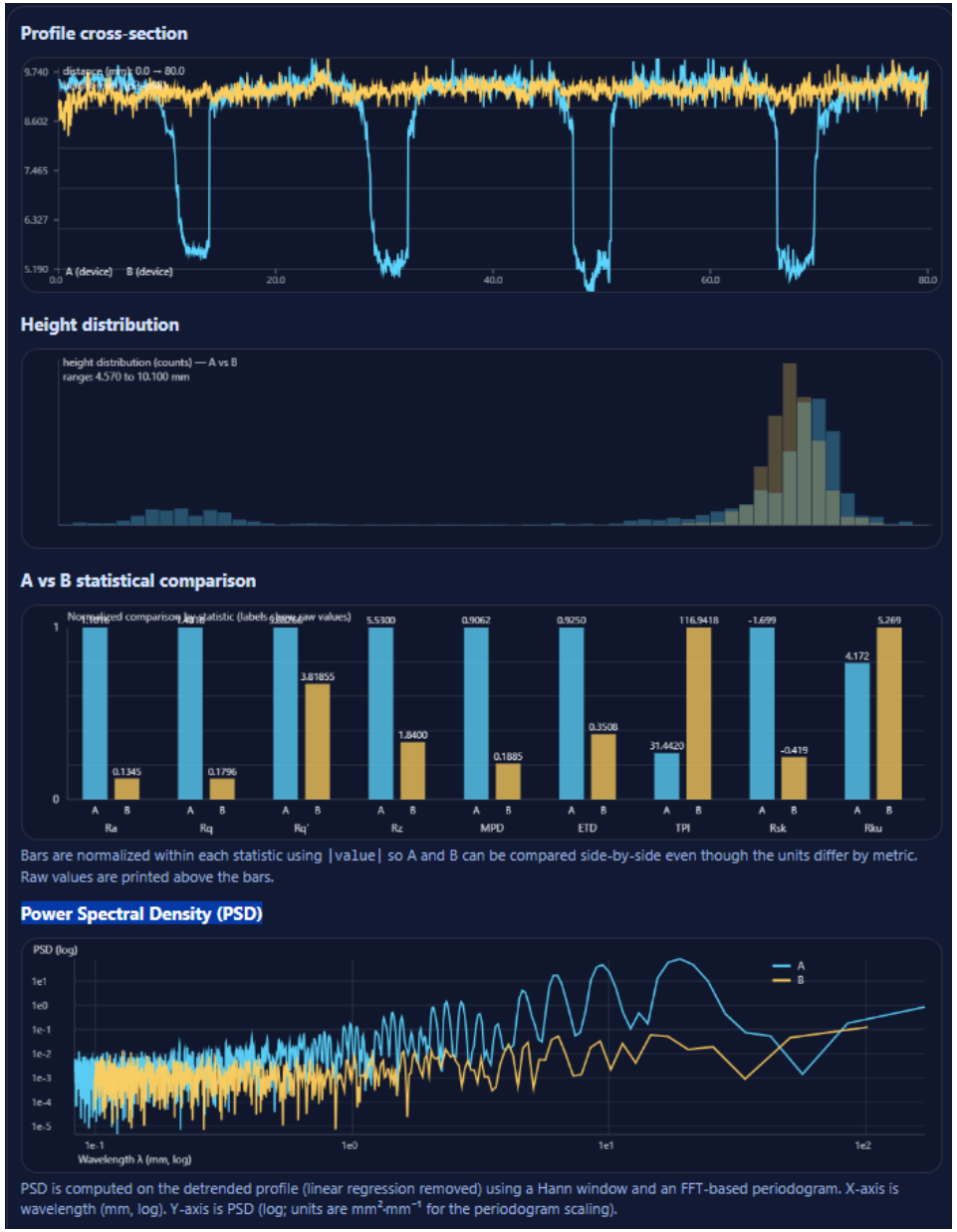




# Smart Wave is a Comprehensive Platform

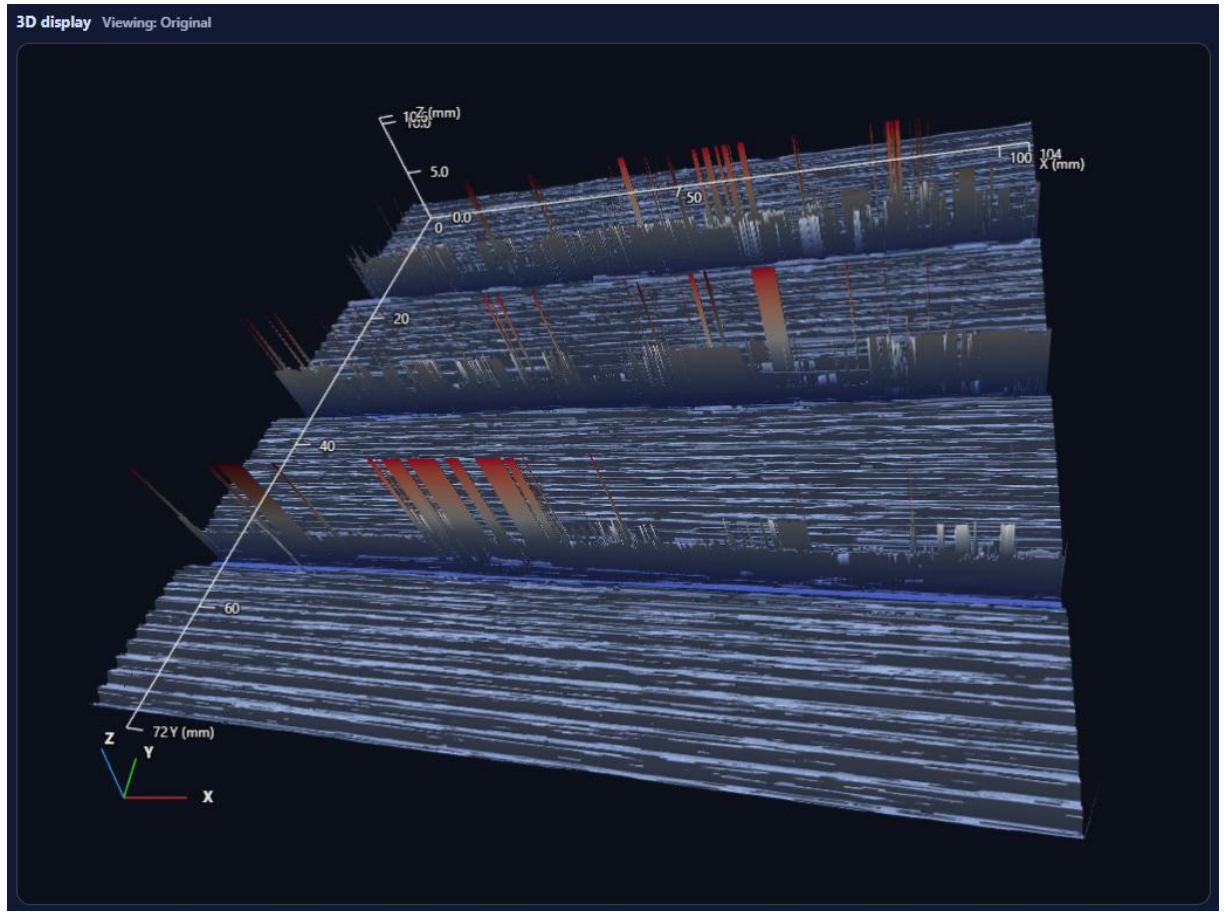


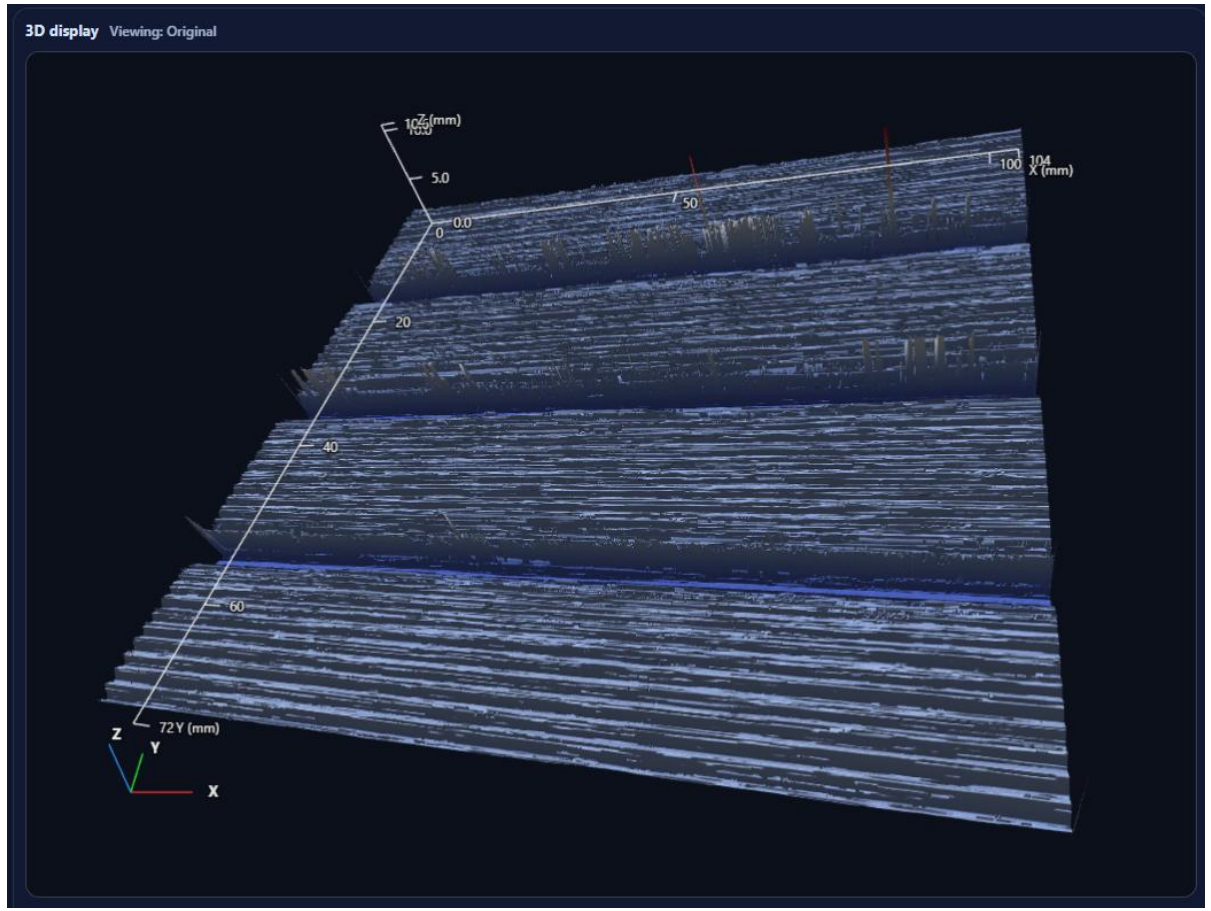




Bars are normalized within each statistic using |value| so A and B can be compared side-by-side even though the units differ by metric. Raw values are printed above the bars.

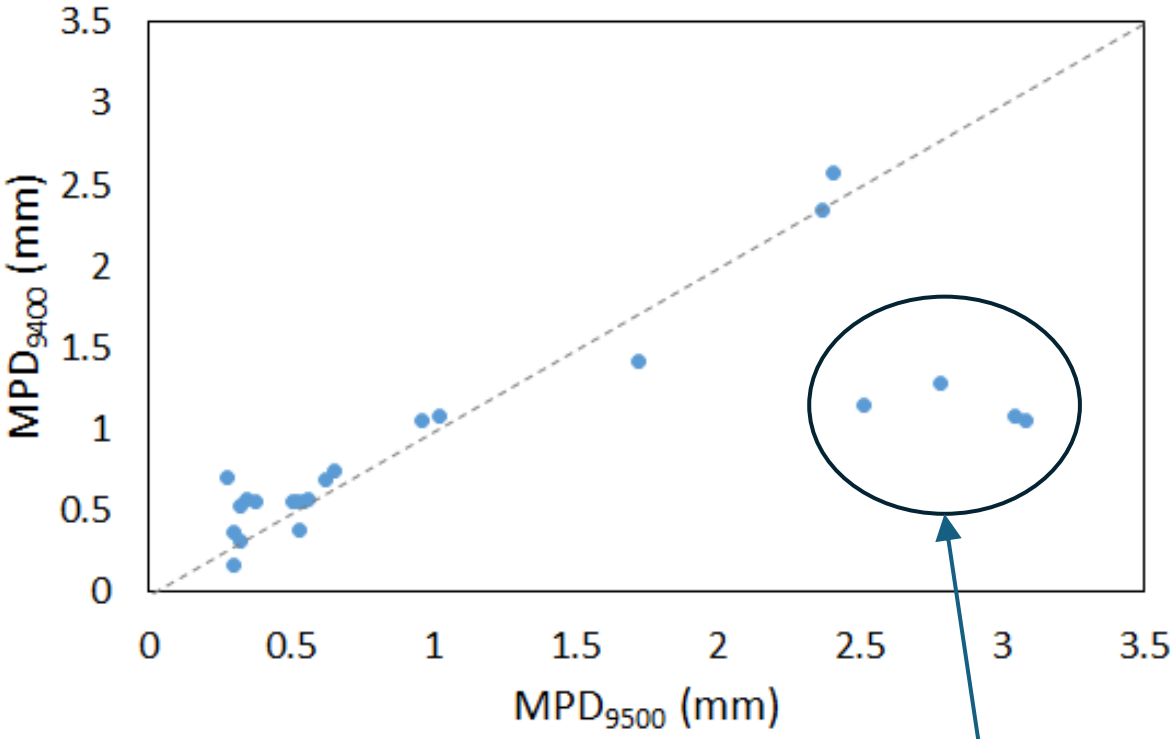
PSD is computed on the detrended profile (linear regression removed) using a Hann window and an FFT-based periodogram. X-axis is wavelength (mm, log). Y-axis is PSD (log; units are $mm^2 \cdot mm^{-1}$ for the periodogram scaling).

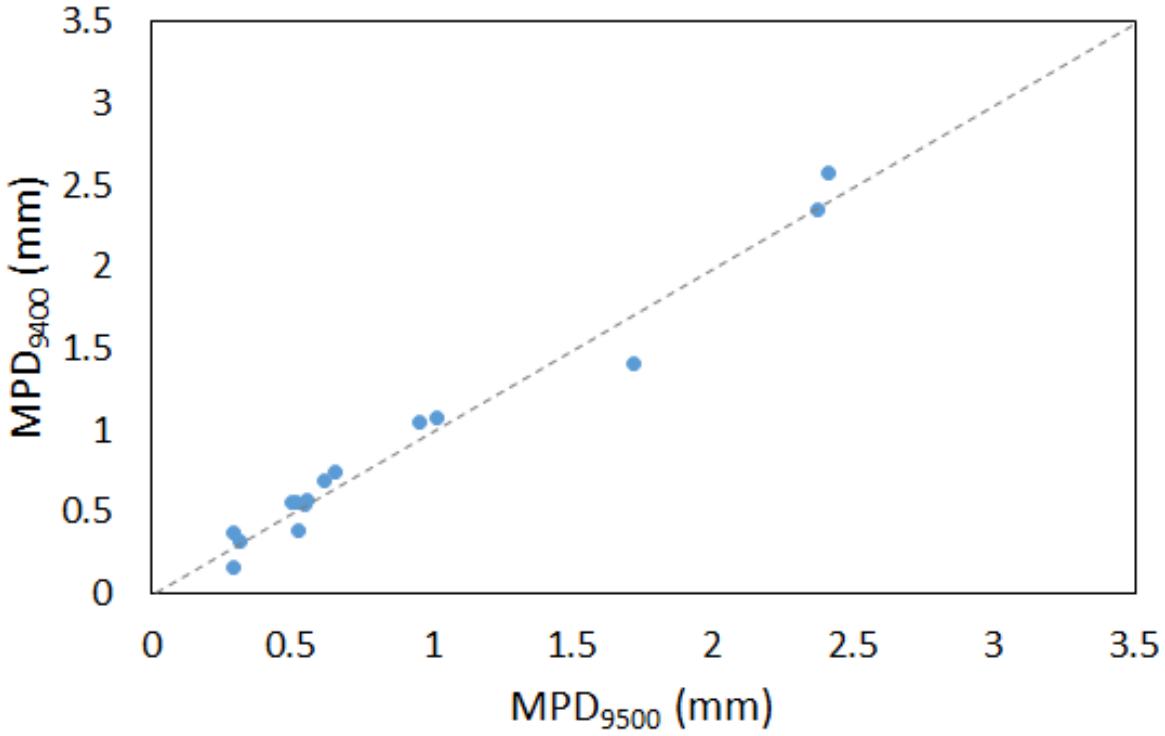
# Filtering Varies Based on Laser Type and Surface Texture



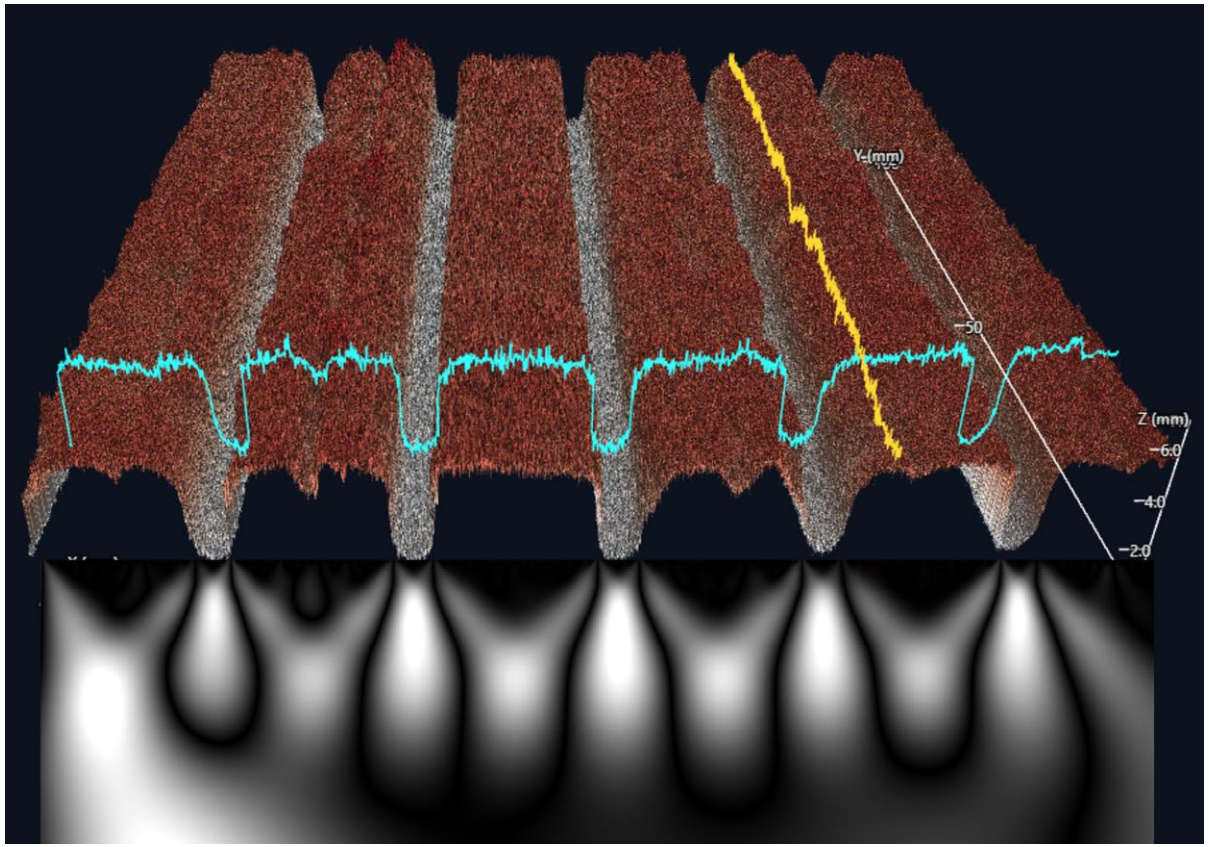
# MPD is Highly Sensitive to Different Laser Measurements



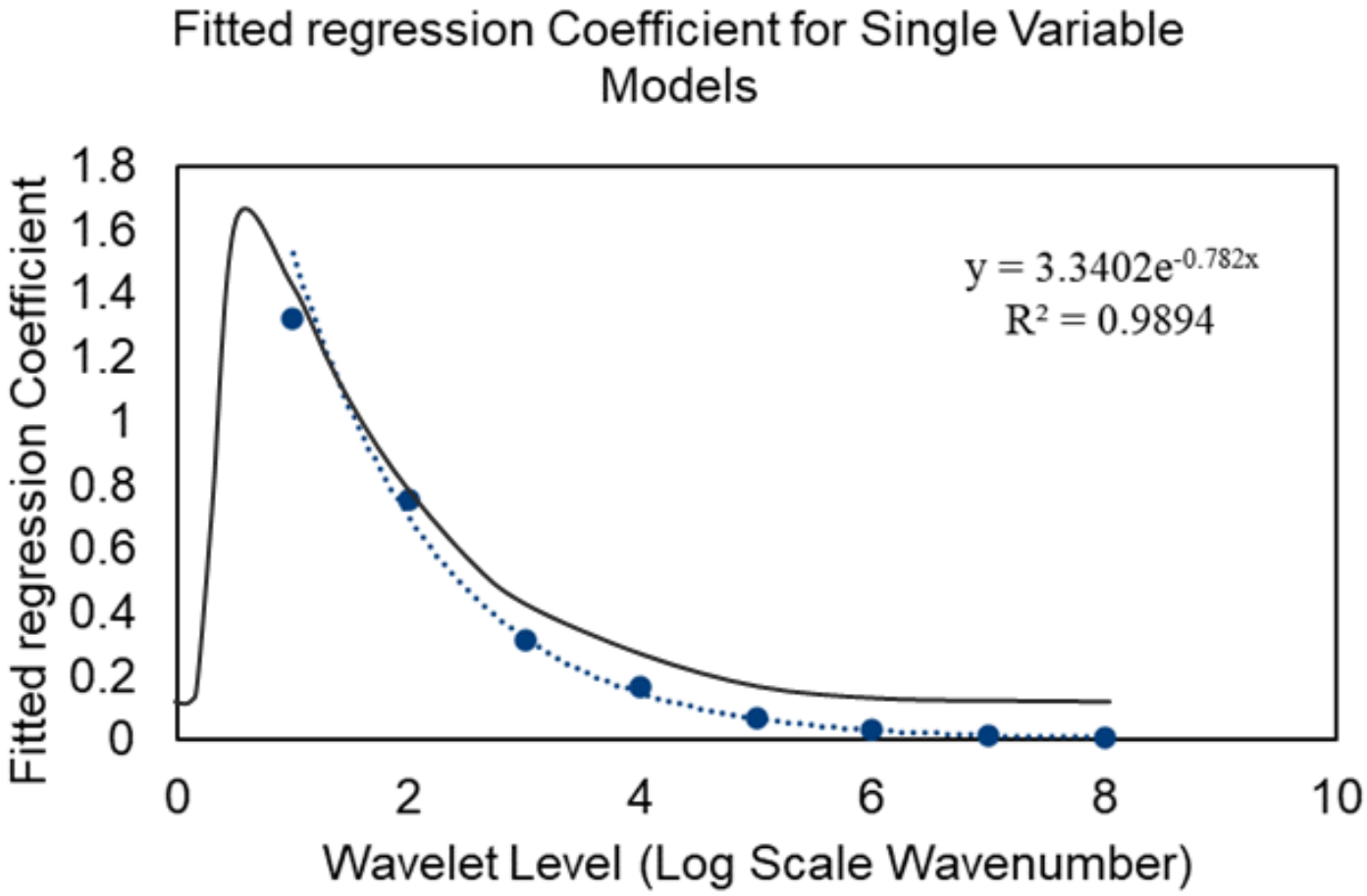




Transverse Grooving

# Wavelets Decompose Macro and Micro Texture




# Wavelets Decomposition Can Estimate the Impact of Texturing



# Towards a Global Friction Model

$$F = F[S, V, A, W, T, F_s]$$

$F_s$ is the base friction measurement (used LWST at 40 MPH for now)

$S$ tire slip ratio operator

$V$ nominal vehicle speed impact ratio operator

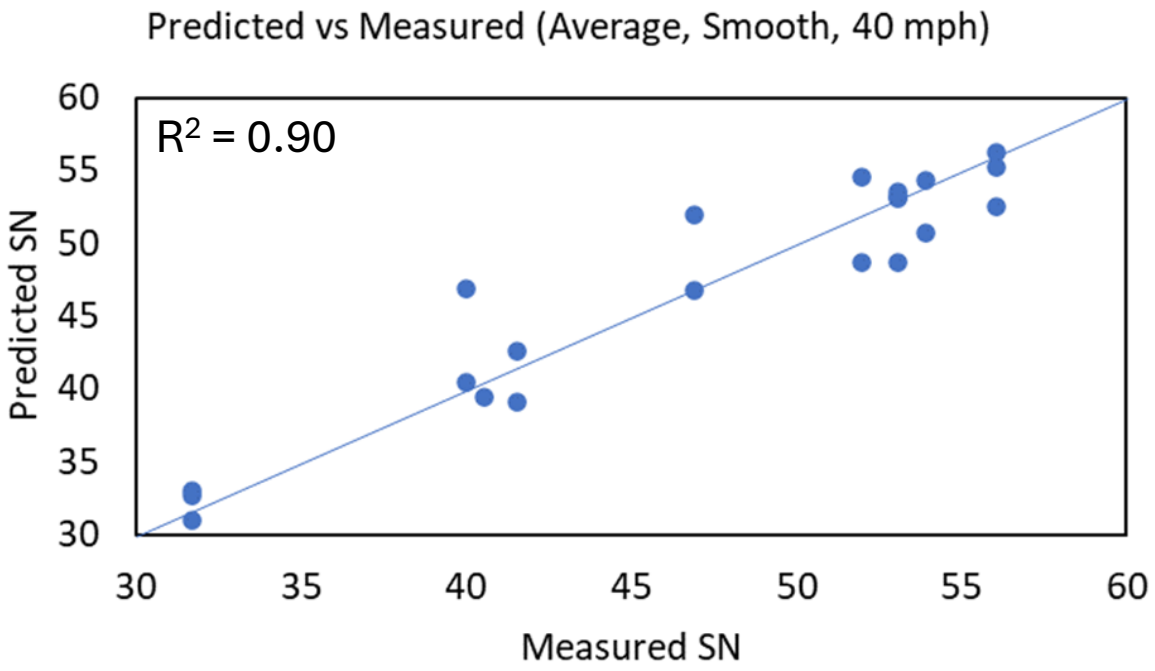
$A$ tire angle impact

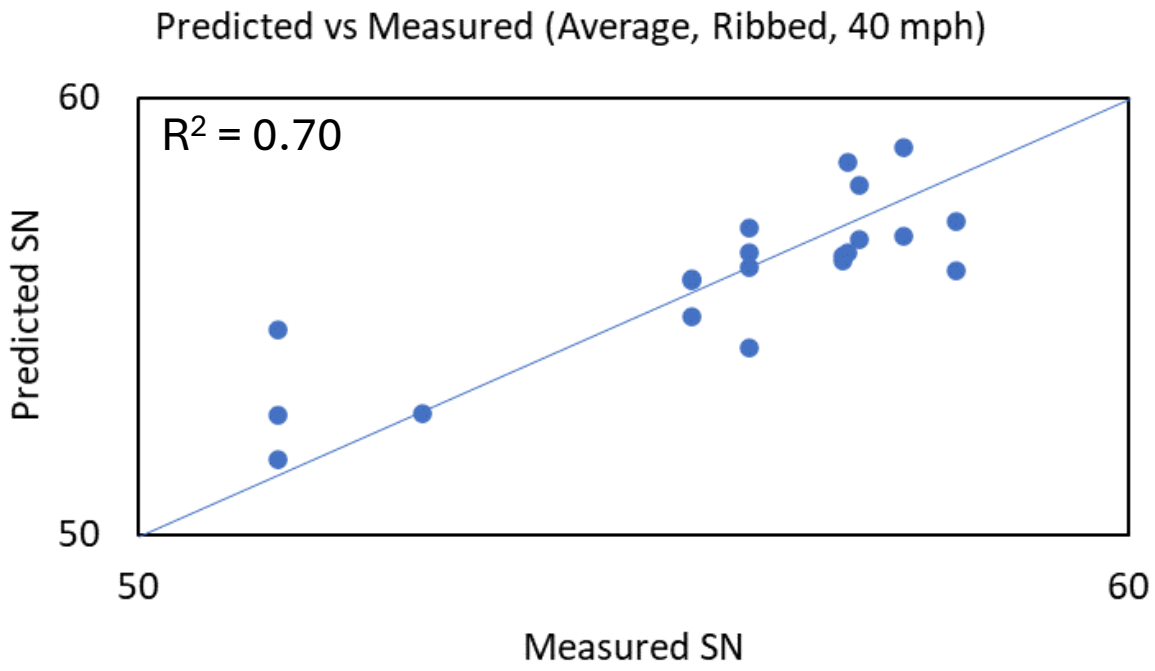
$W$ wet conditions operator

$T$ tire characteristics operator

# Base Friction Measurements

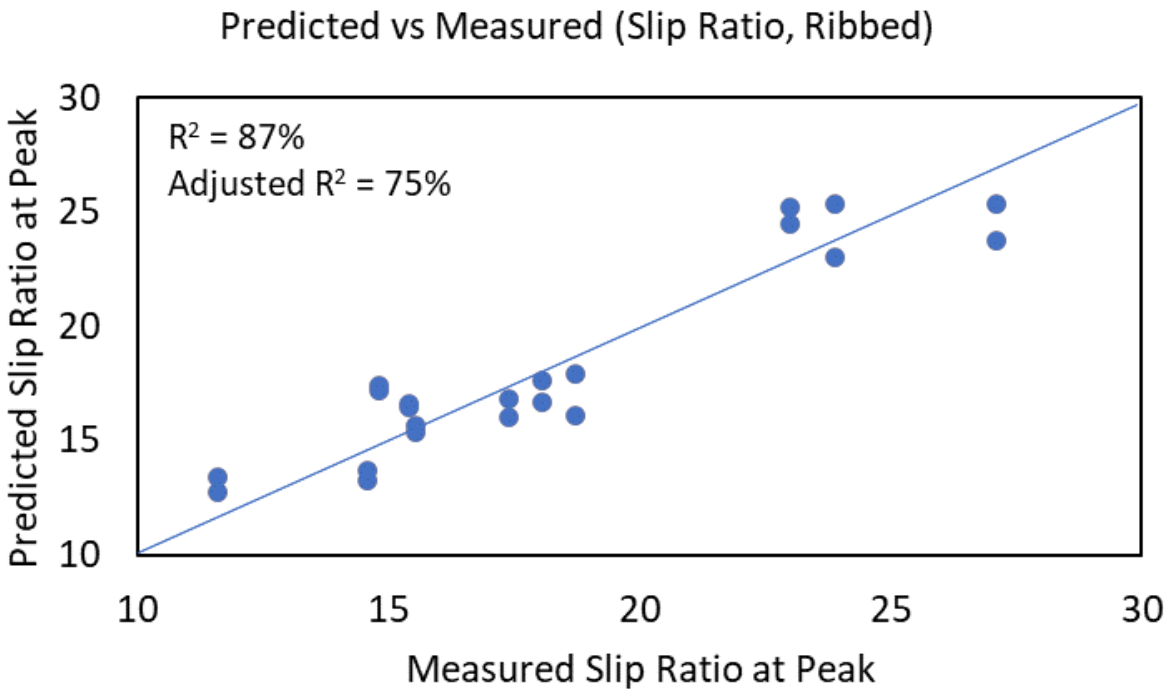
- Wavelets energy showed a strong to very strong correlations with LWST measurements.

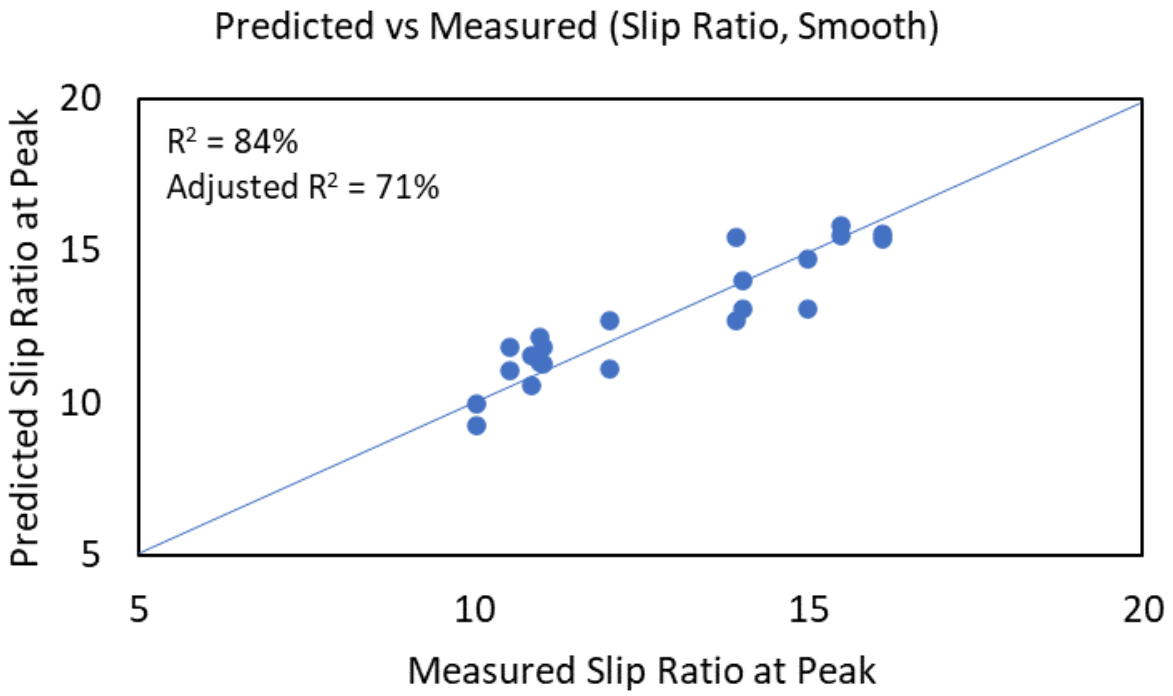


# Slip Ratio Impact

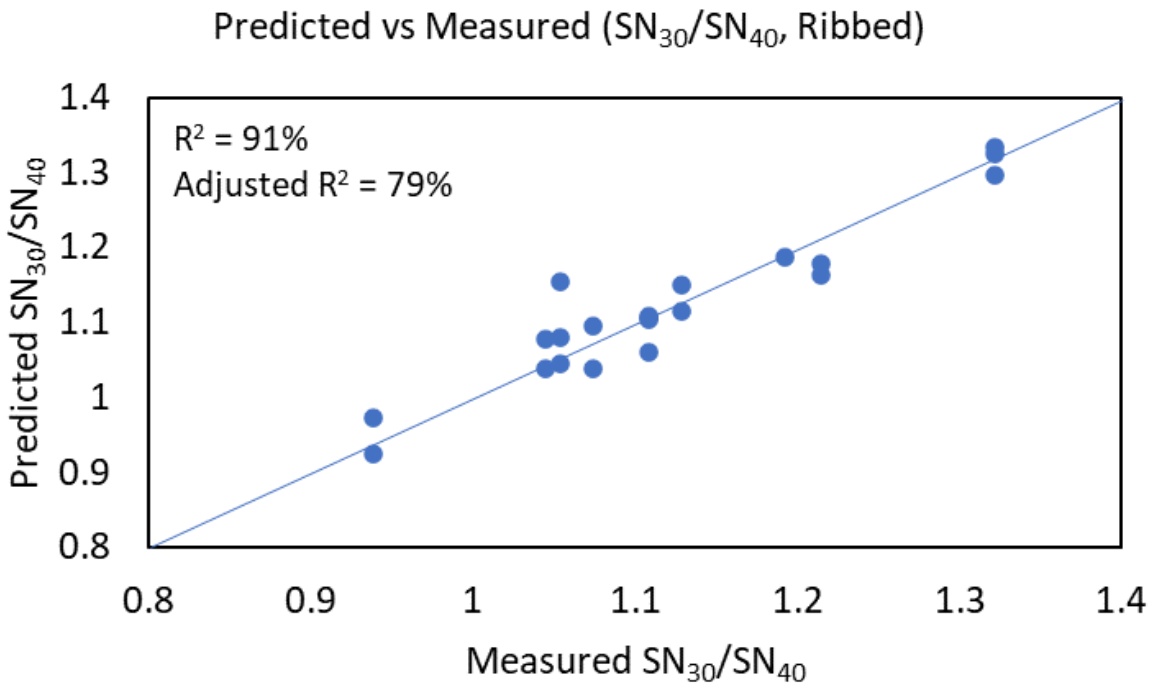
- $SR_{Peak} = \sum_{i=1}^{n} a_{SR,i} E_i$

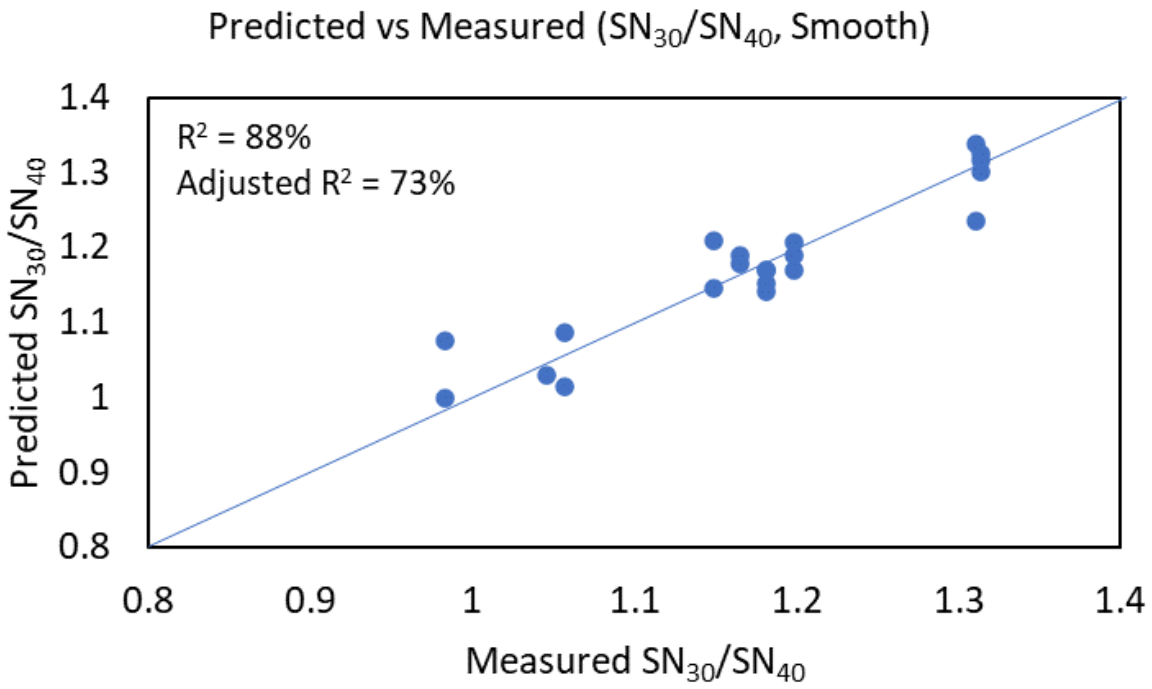


# Speed Impact

- $SN_v = SN_v \sum_{i=1}^{n} a_{v,i} E_i$



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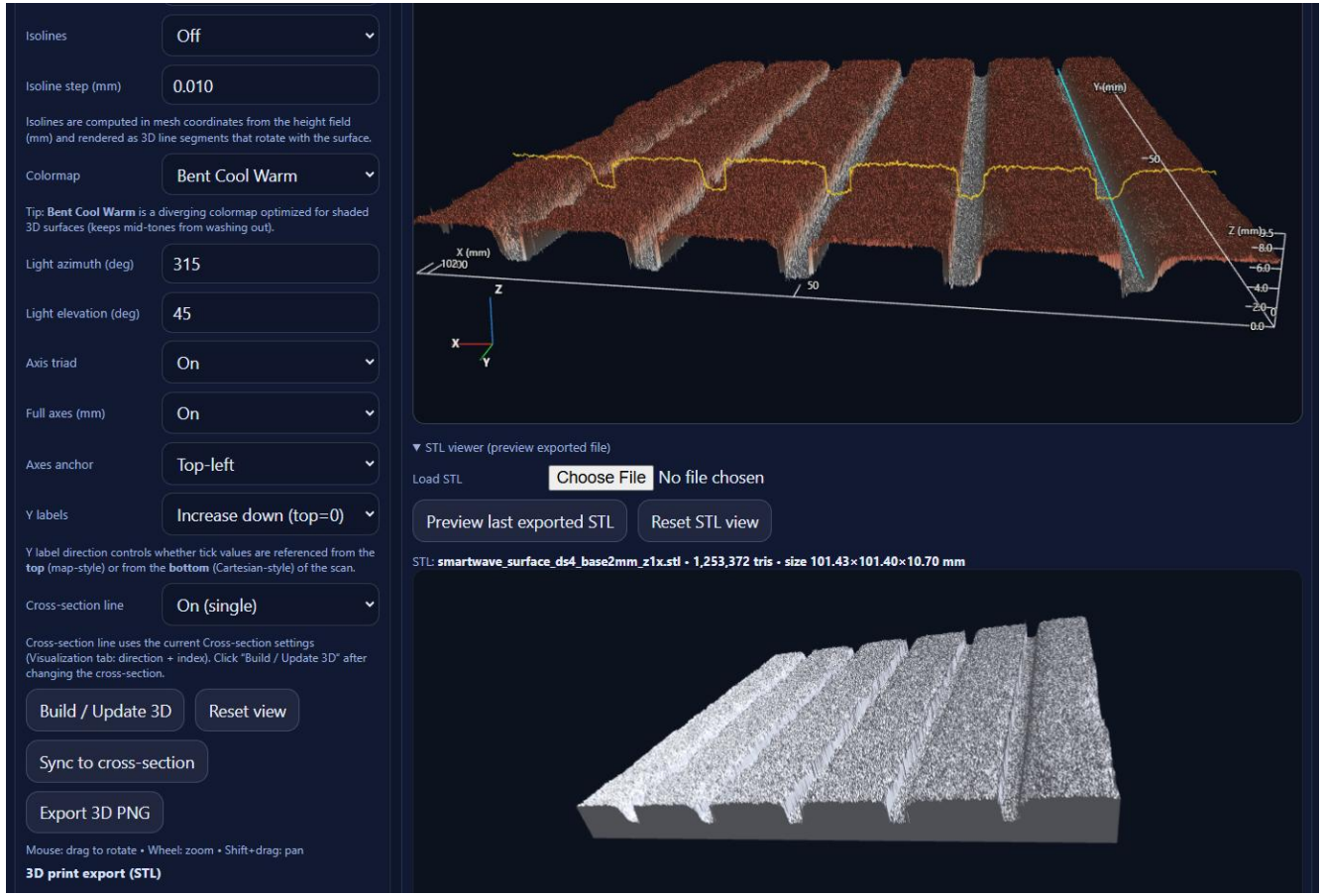
# Concluding Remarks

- Spectral analysis is crucial for filtering, decomposition, and advanced contactless friction models.
- Wavelets analysis allows for more stable and less sensitive analysis to outliers compared to traditional texture parameters.
- Defining ground truth is based on a combination of stable spectral content, measurements from engineered surfaces, and performance in relation to friction predictions.

# Engineered Surfaces Provide Stable Ground Truth




# Future Work

- We are working on defining the tuning parameters for the various filters needed for different measuring systems.
- Need consistent definitions, yet flexible enough, to define the spectral and wavelets analysis parameters.
- Global models and procedures require a wider range of data from different texture and friction devices and collected from different locations.

# QUESTIONS?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Ingios Geotechnics


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