Using Localized Pseudo Damage as a Characterization Tool for Longitudinal Profiles

By

Craig Altmann

Vehicle Terrain Performance Laboratory
Virginia Tech

RPUG Road Profile Users' Group

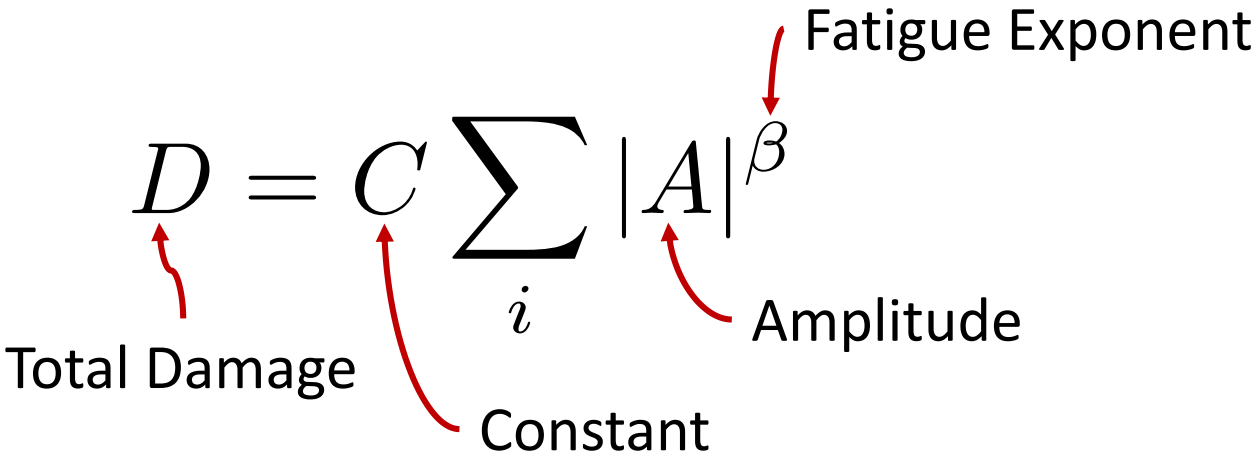
Pseudo Damage

Simple Definition

Calculate damage using forces, instead of stress/strain

Apply the same damage principles as stress/strain analysis

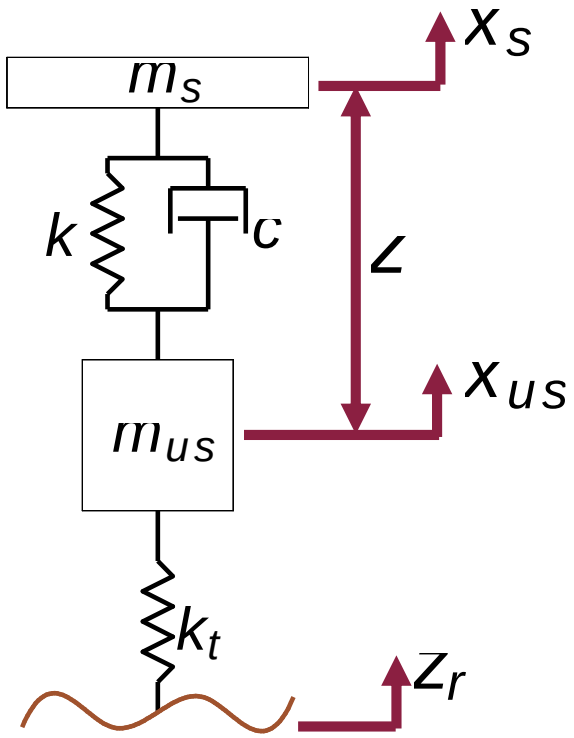
- Palmgren-Miner's Rule
- Basquin's Damage Model



NOT fake/artificial/bogus damage

Characterizing a Road Profile

International Roughness Index (IRI)



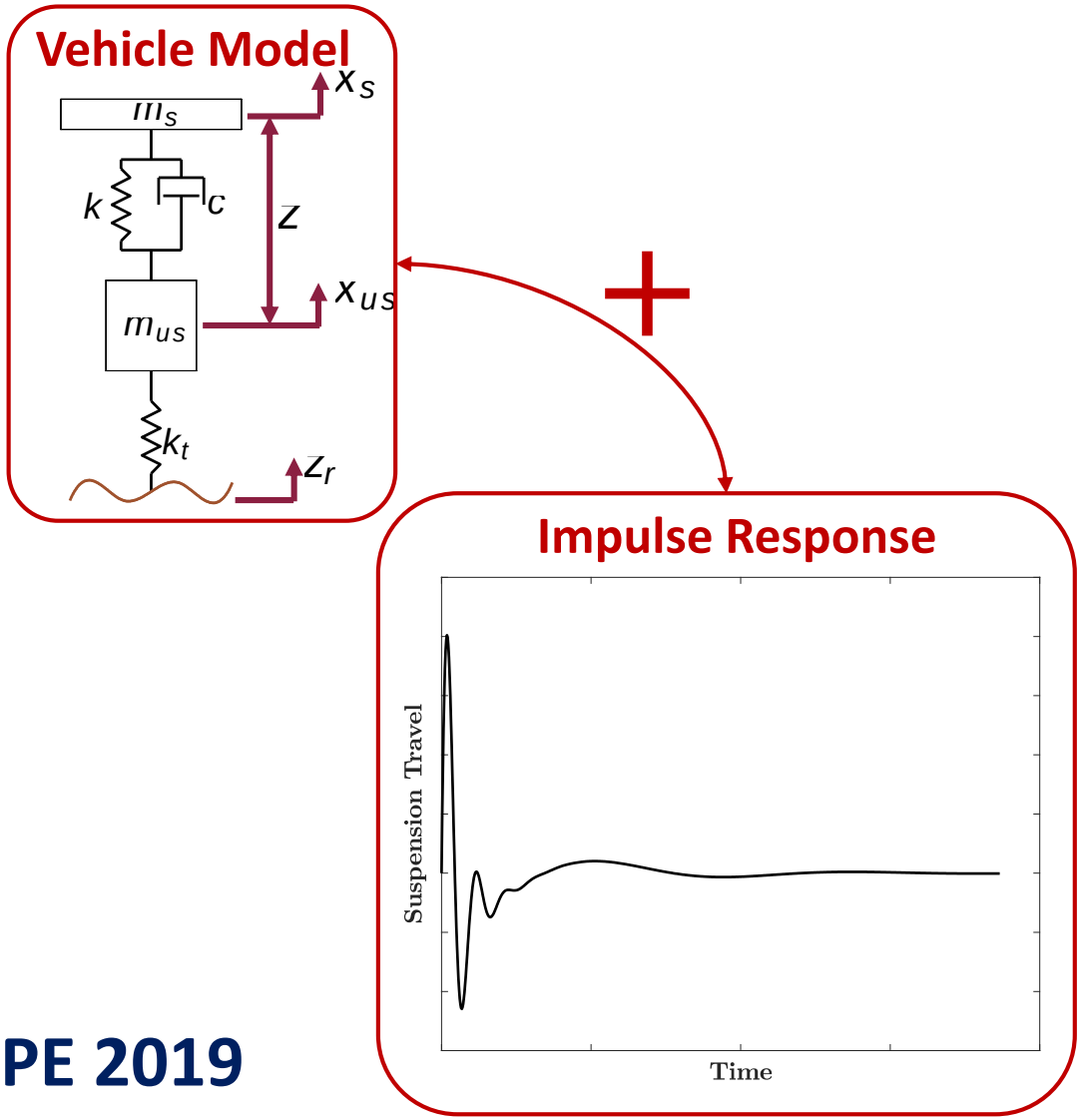
IRI is calculated based on the average accumulated suspension travel

Vehicle is modeled as a Golden Quarter car traveling at 80 kph (49.7 mph)

Roads can be quickly and easily categorized by a roughness number

Characterizing a Road Profile

Discrete Roughness Index (DRI)



DRI is a roughness which is attributed to a particular excitation from a road profile.

Utilizes the suspension travel impulse response to identify individual excitation contributions.

Not limited to a specific vehicle model or forward speed

(Zamora Alvarez, 2016)

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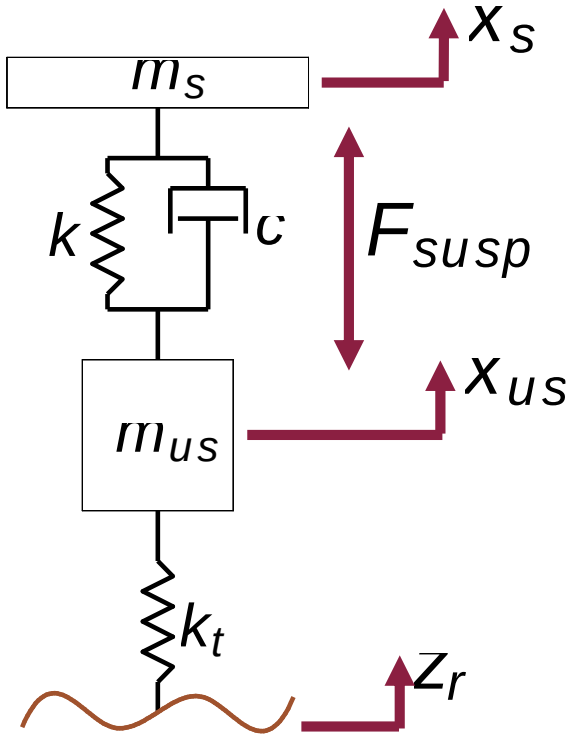
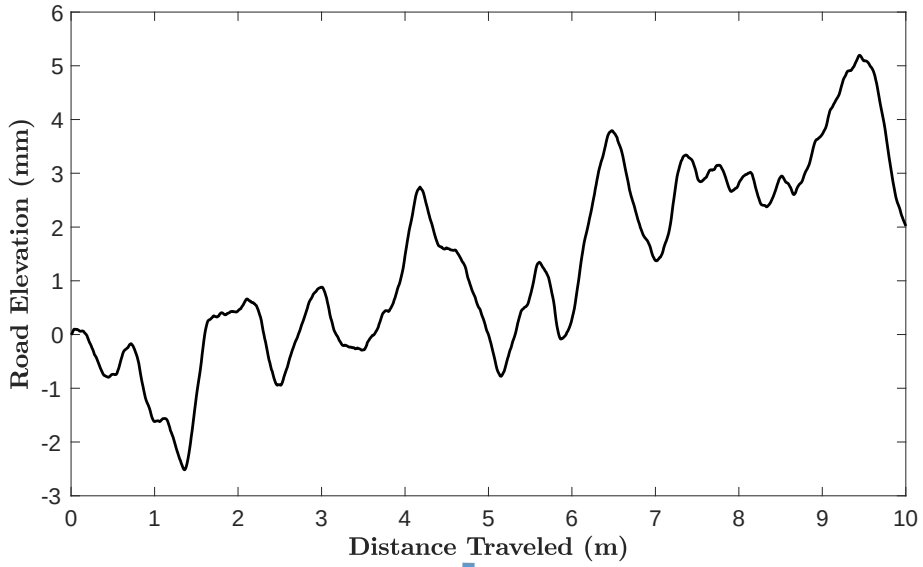
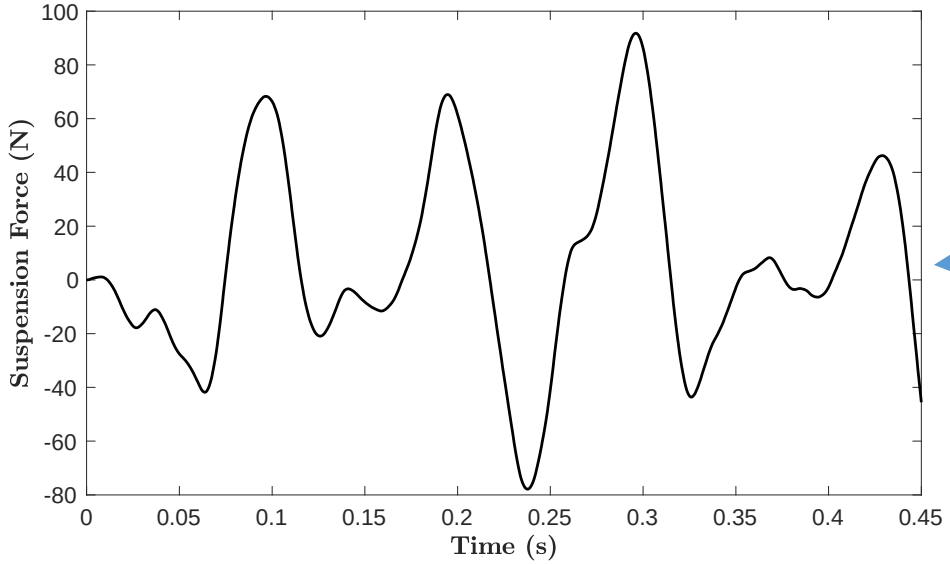
Characterizing a Road Profile

Localized Pseudo Damage Introduction







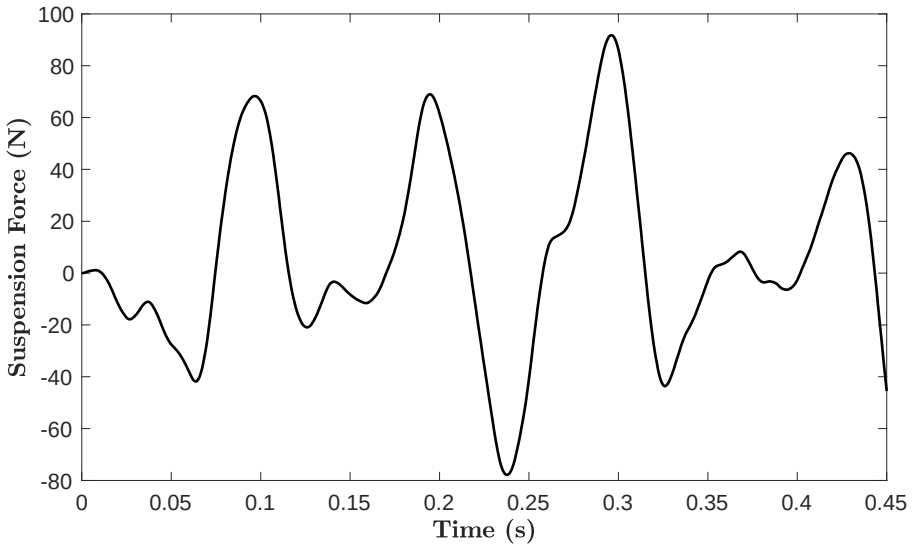
For a given vehicle model and speed

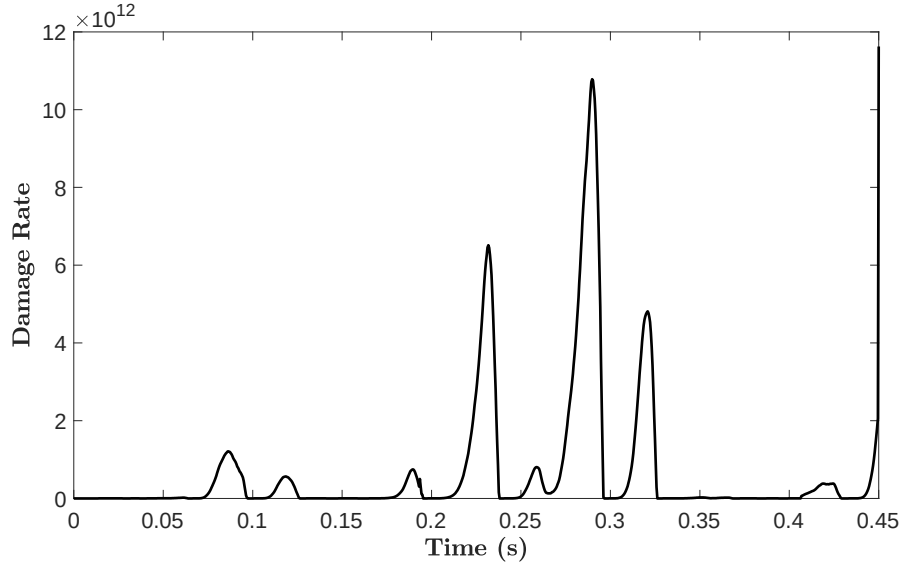
Localized Pseudo Damage Background

Damage Rate

The rate of change in damage is related to a relative suspension force and the rate of change of suspension force

$$\dot{D}(t) = G\left|F_{susp}(t) - F^{p}_{susp}(t)\right|^{(\beta-1)}\left|\dot{F}_{susp}(t)\right|$$

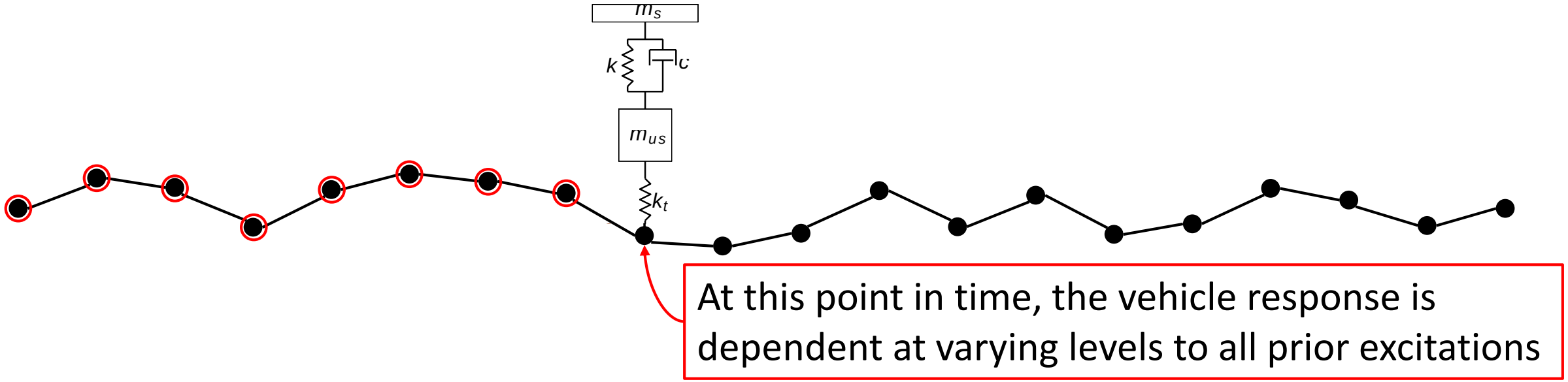




We can calculate a measure of pseudo damage for the complete time history

Localized Pseudo Damage Background

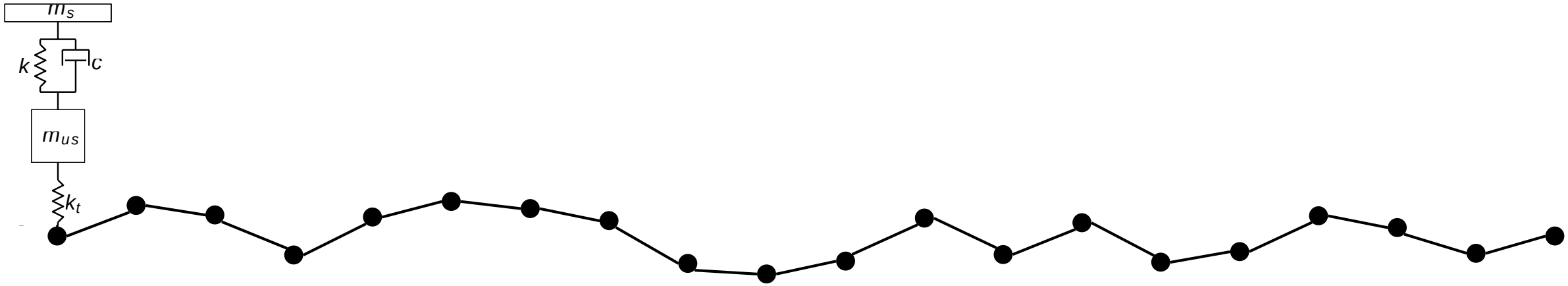
Relationship Between Time and Position



With damage rate being nonlinear how do we determine the connection between a single event and discrete time instances?

Localized Pseudo Damage Background

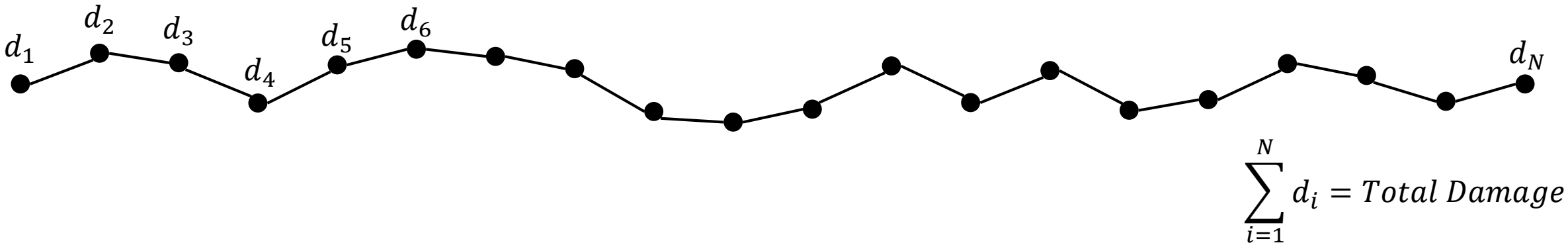
Relationship Between Time and Position



- Omit each excitation individually
- Simulate the vehicle model over the ‘new’ road profile
- Calculate the damage rate over time
- Repeat for all excitations

Localized Pseudo Damage Background

Relationship Between Time and Position



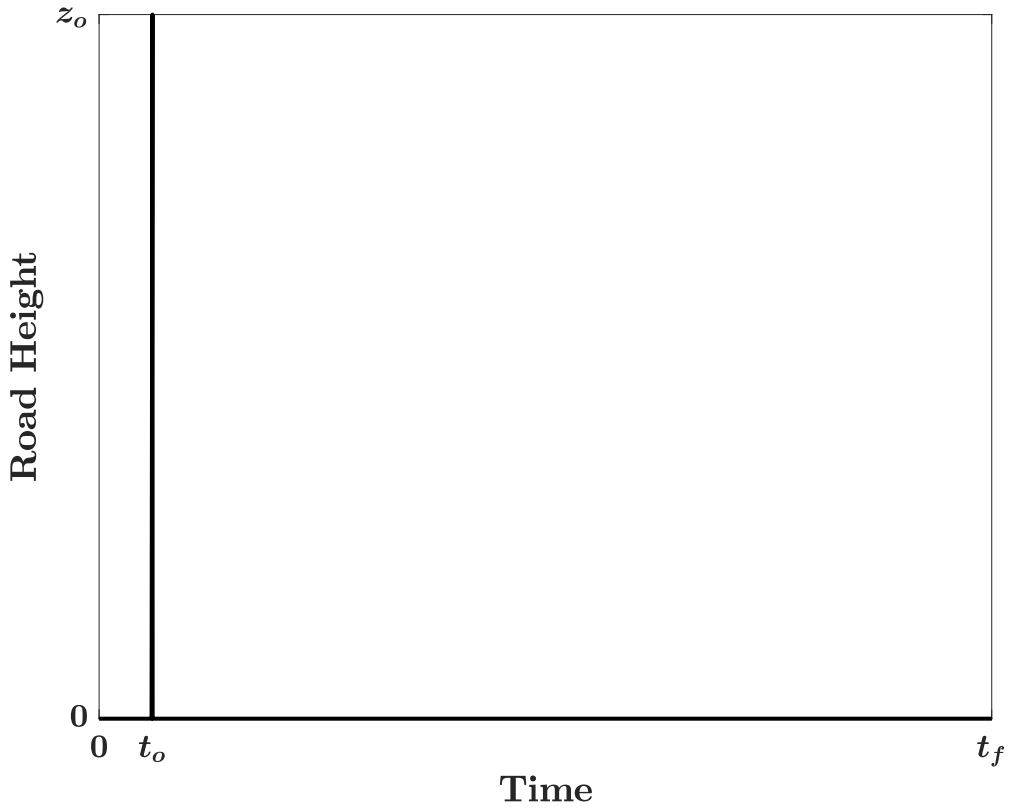
$$\sum_{i=1}^{N} d_i = Total\ Damage$$

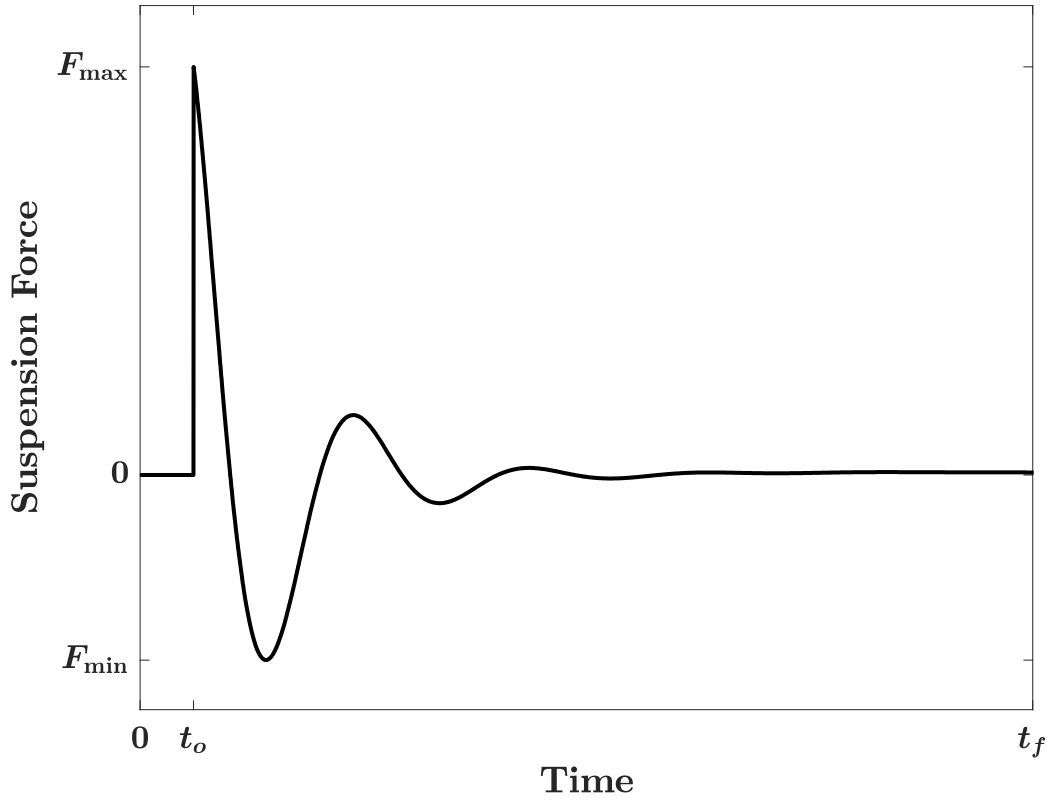
- We can determine the relative affect a single road excitation has on the damage rate and total damage

- Therefore, we can establish a **localized pseudo damage (d_i)** measure for each road excitation.

Localized Pseudo Damage

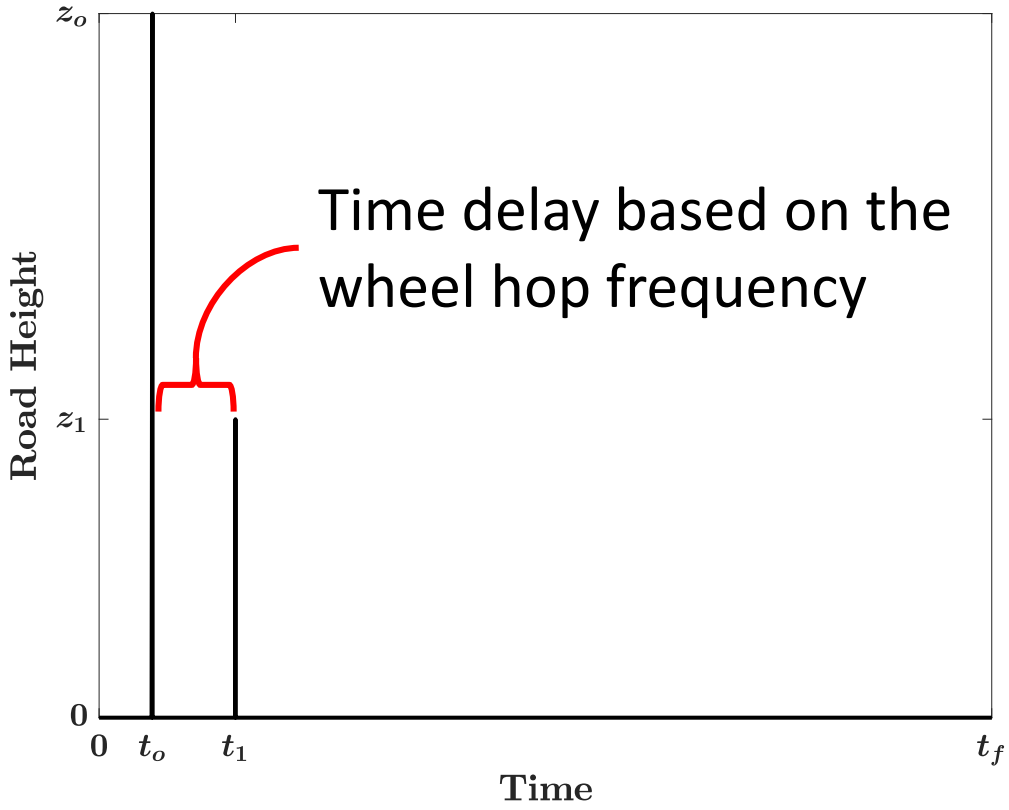
Not all bumps are damaging

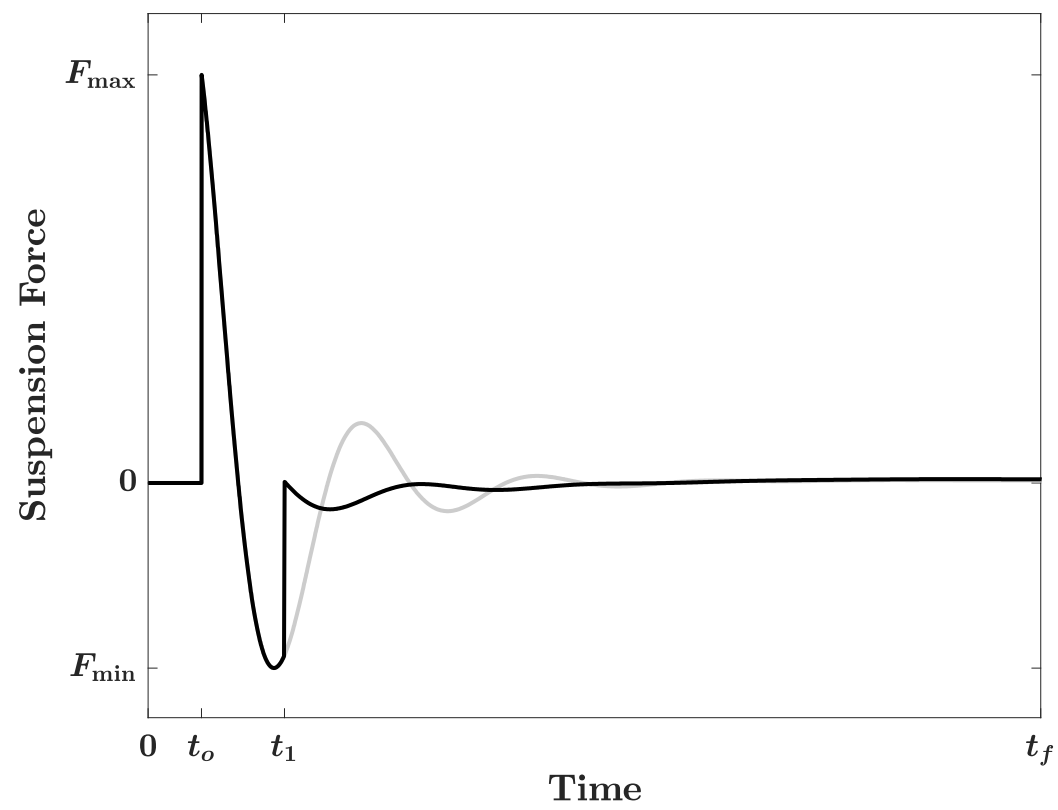




Localized Pseudo Damage

Not all bumps are damaging



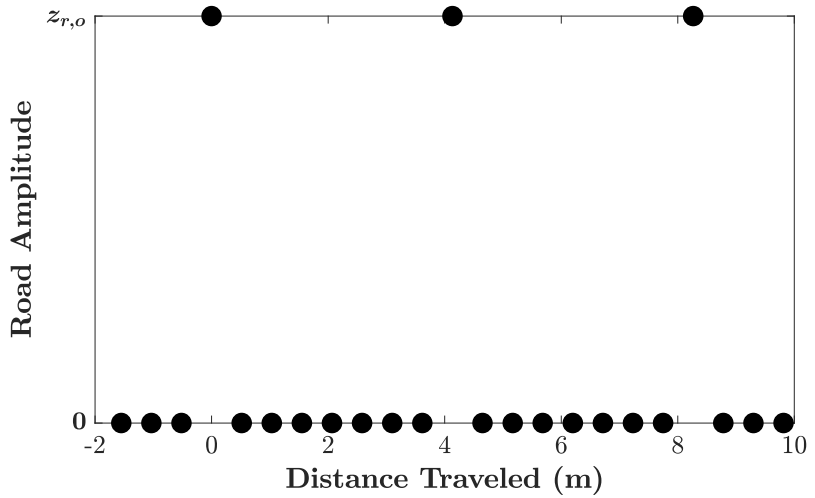


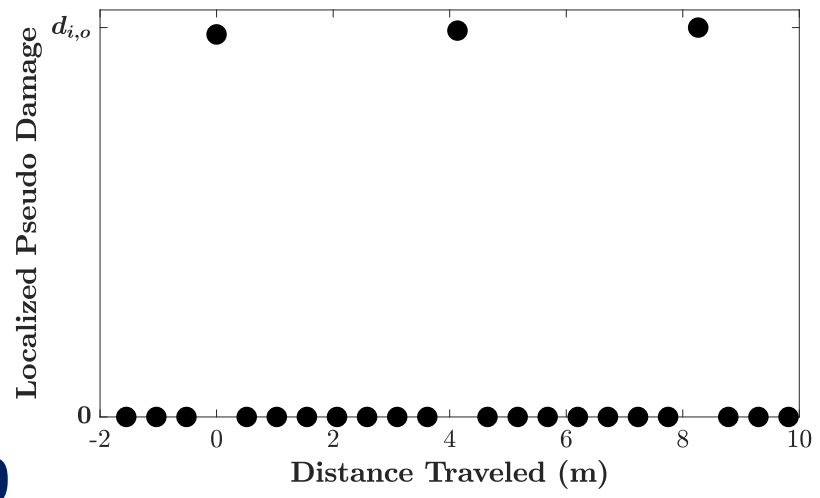
Second impulse reduced the suspension force and consequently the accumulated pseudo damage

Localized Pseudo Damage

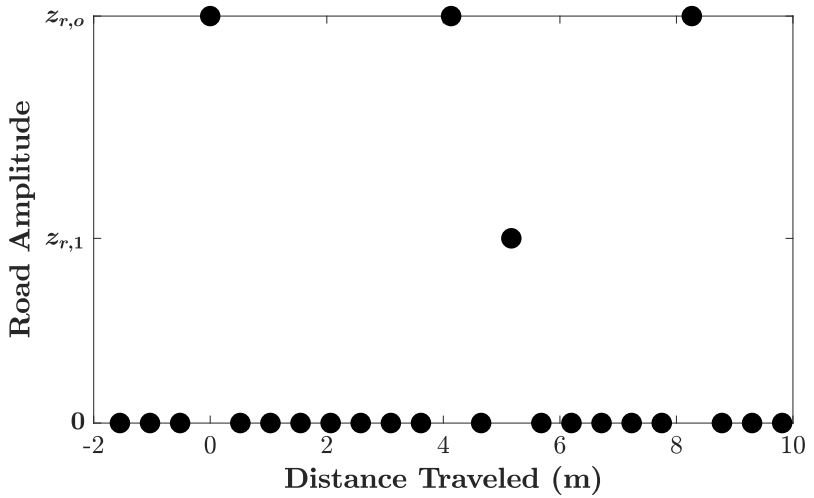
Not all bumps are damaging

Road 1





Road 2



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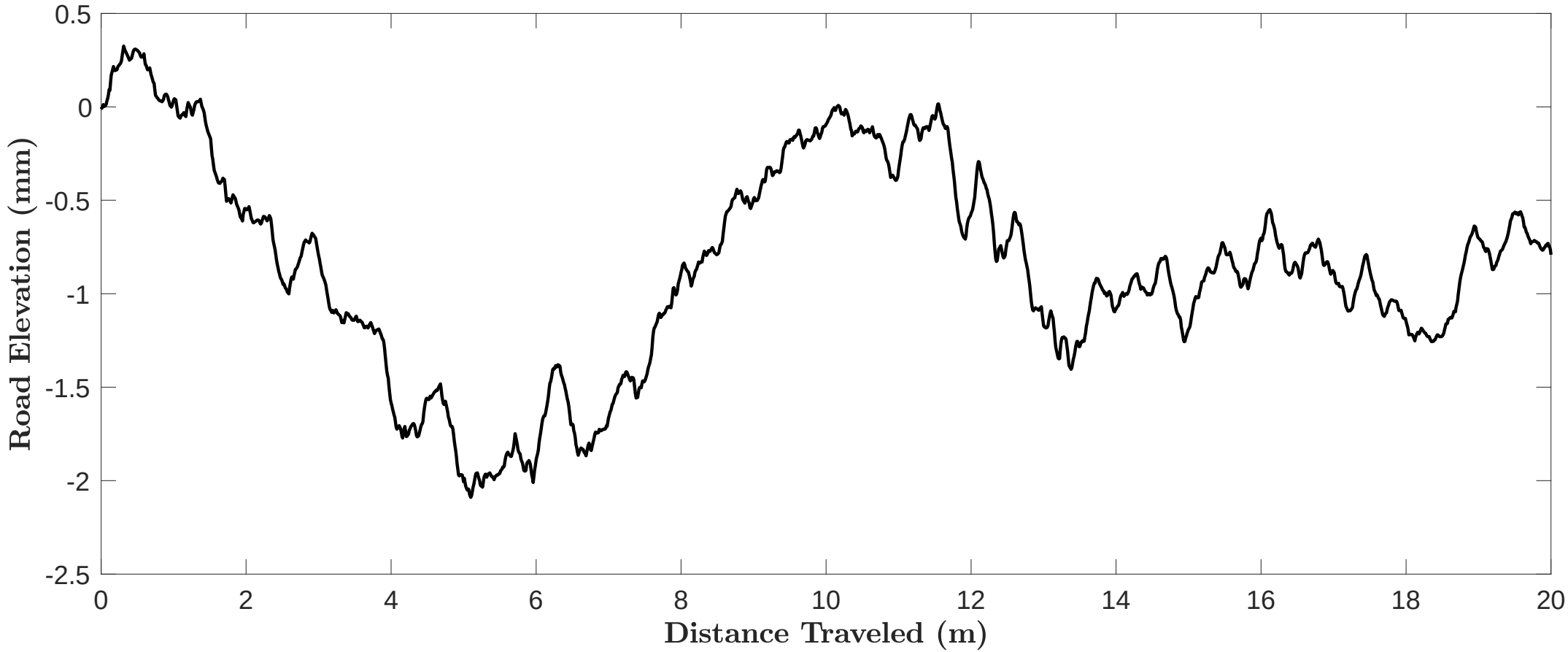
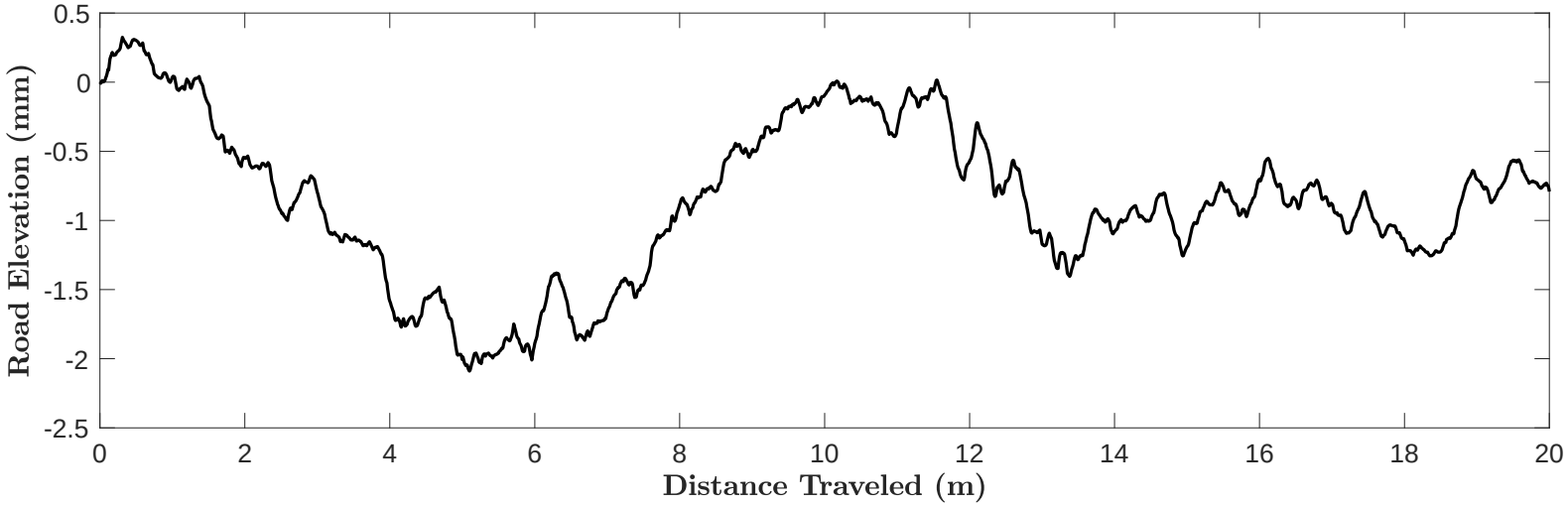
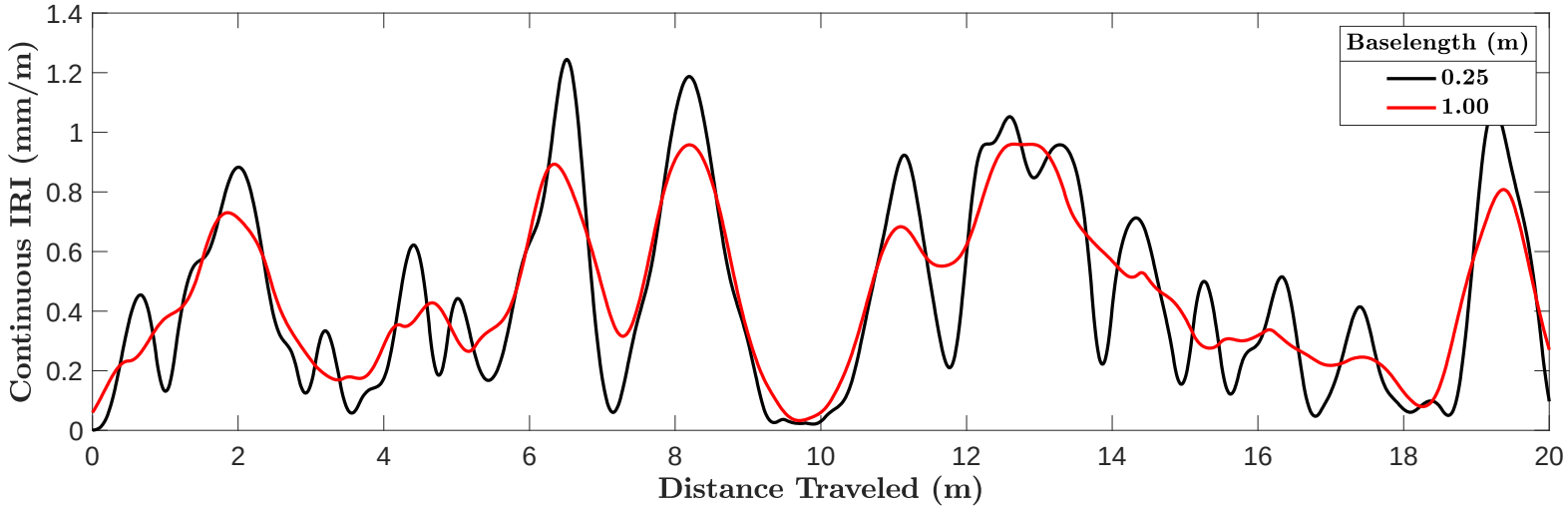
Example Road Profile



Example Road Profile

International Roughness Index





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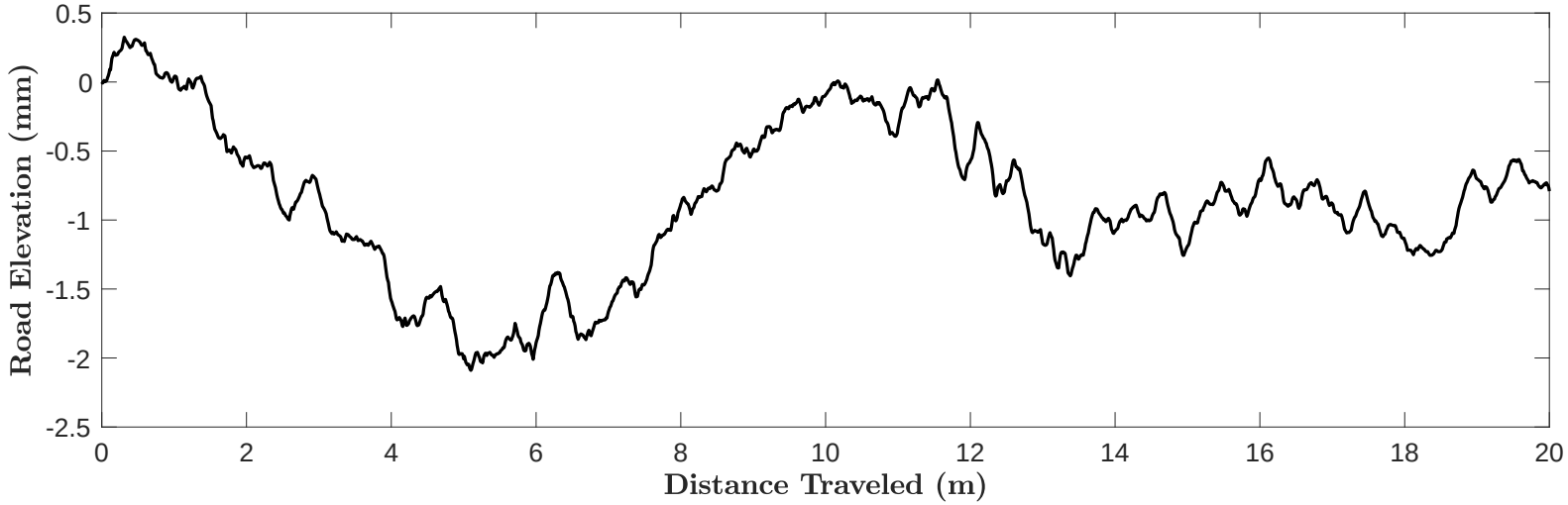
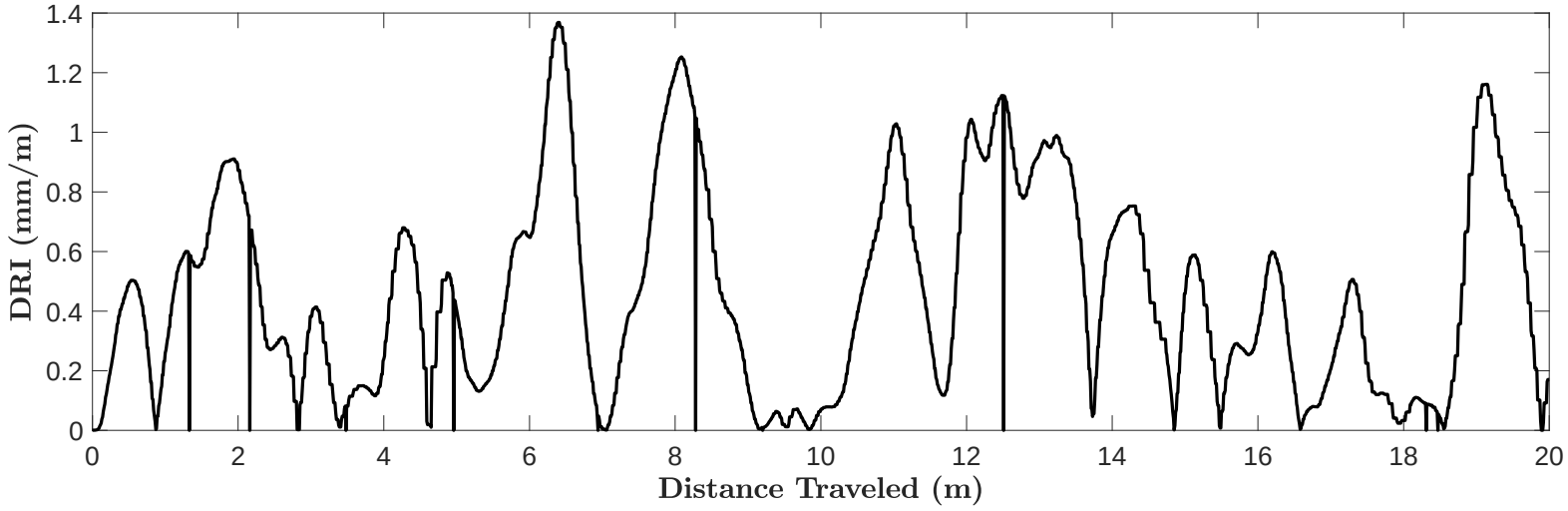
Example Road Profile

Discrete Roughness Index (DRI)





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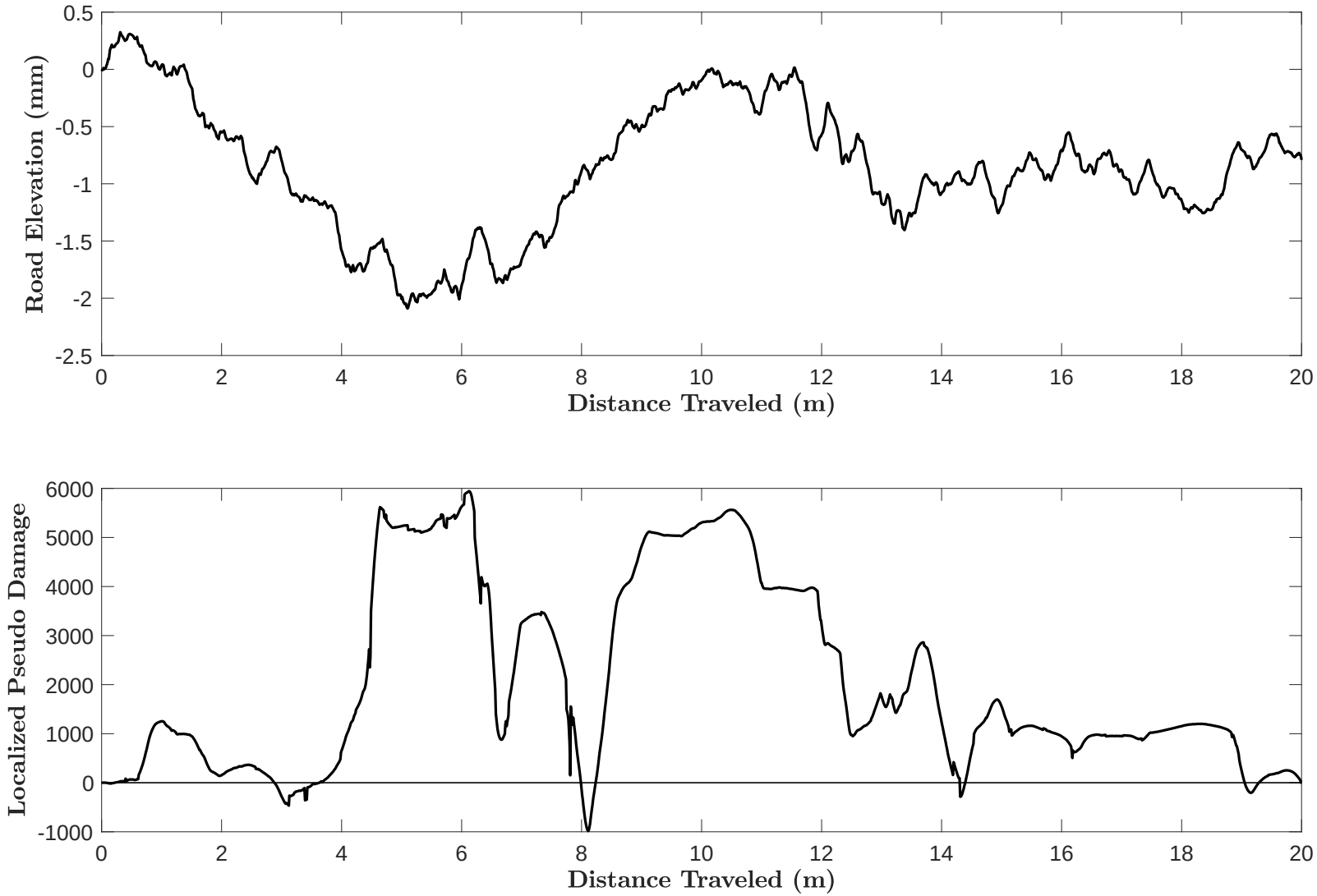
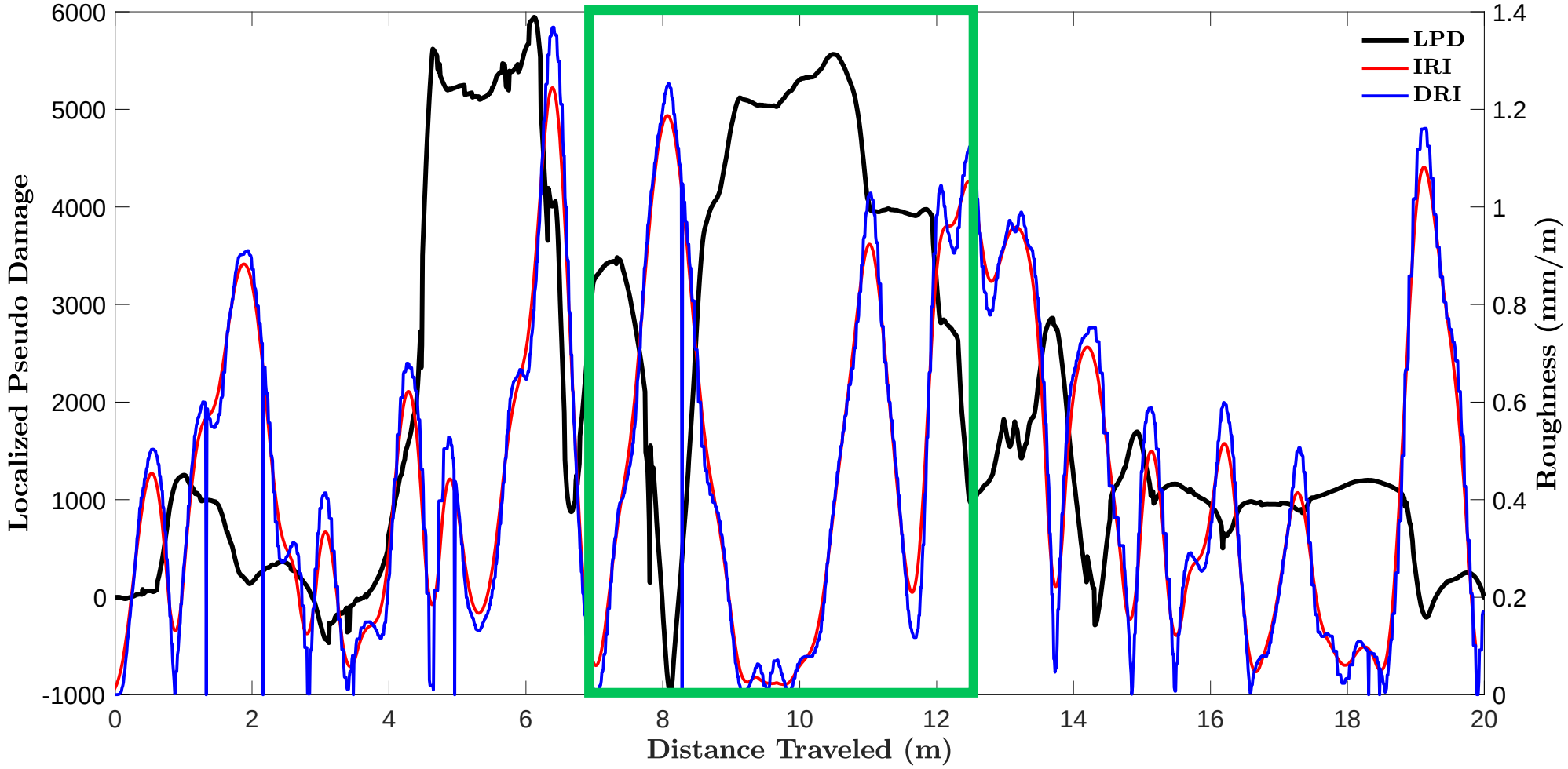
Example Road Profile

Localized Pseudo Damage

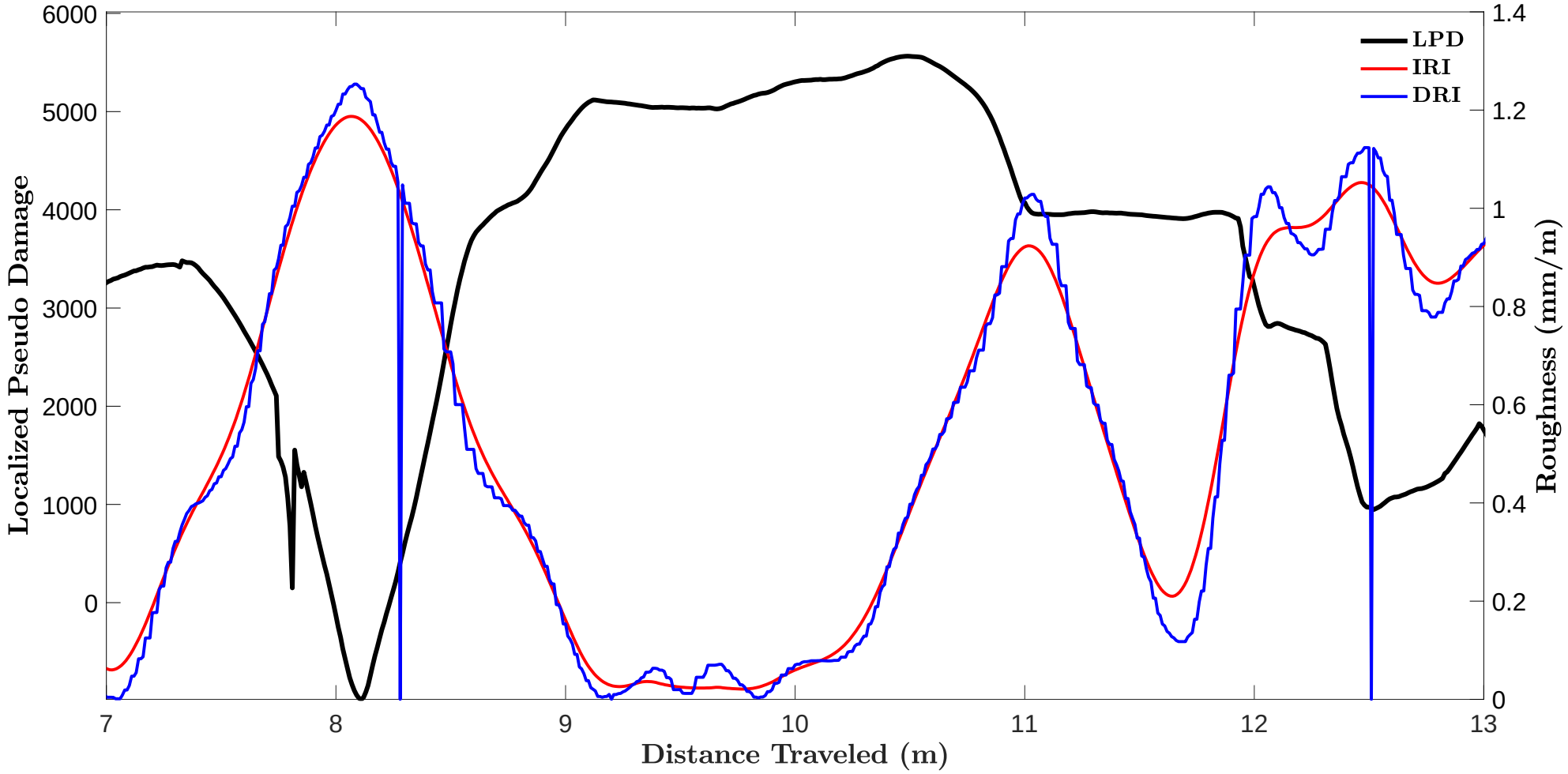


Example Road Profile

Overlay Comparison



Example Road Profile
Overlay Comparison



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Concluding Comments

- DRI and IRI are useful measures, but they don’t always tell the full story
- Vehicle durability vs. Road surface durability
- Not all Bumps are Damaging to a vehicle