Vejdirektoratet
DANISH ROAD DIRECTORATE

ERPUG

Development of new performance models for the Danish Road Network

ERPUG 2023
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The Danish Road Directorate have bought and implemented a new Asset Management system.

Visual inspections → Data based pavement management system

2

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Visual inspections → Data based pavement management system

- Understand our data
- Understand the development on our road network

3

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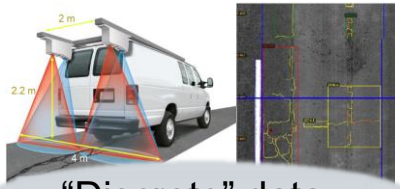
Visual inspections → Data based pavement management system

- Understand our data
- Understand the development on our road network

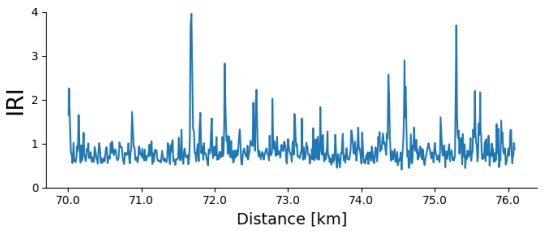
Internal project in DRD

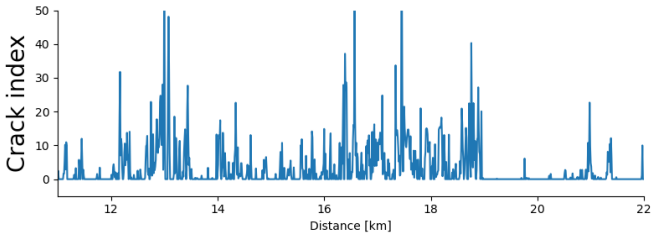
Analysing historical data → performance models for individual parameters

“Continuous” data



“Discrete” data



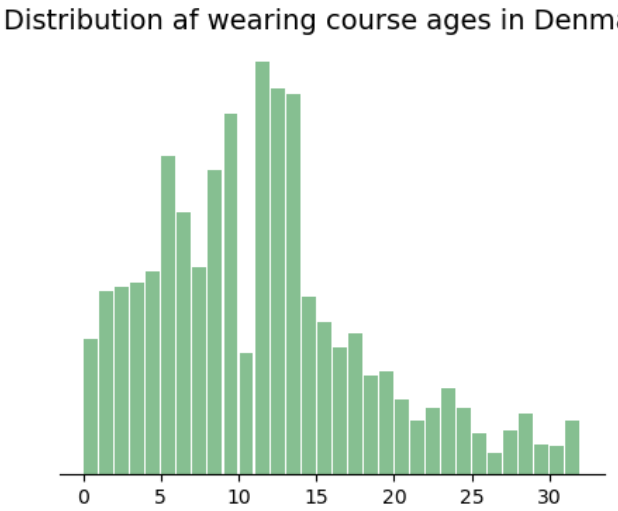


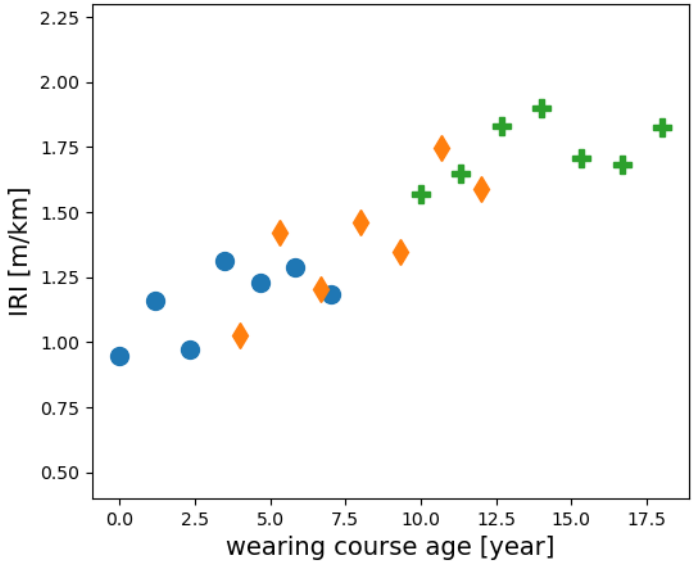
New data types

dTIMS Business Analytics

IRI development over time
- data driven approach

- Based on historical data collected in the period 2010-2022
- Aim: describe the IRI development over a waring courses lifetime
- take advantage of the fact that the road network has a distribution of ages





IRI development over time
- data driven approach

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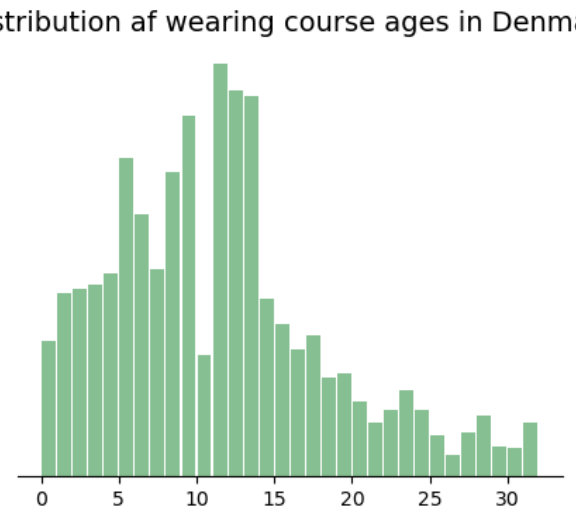
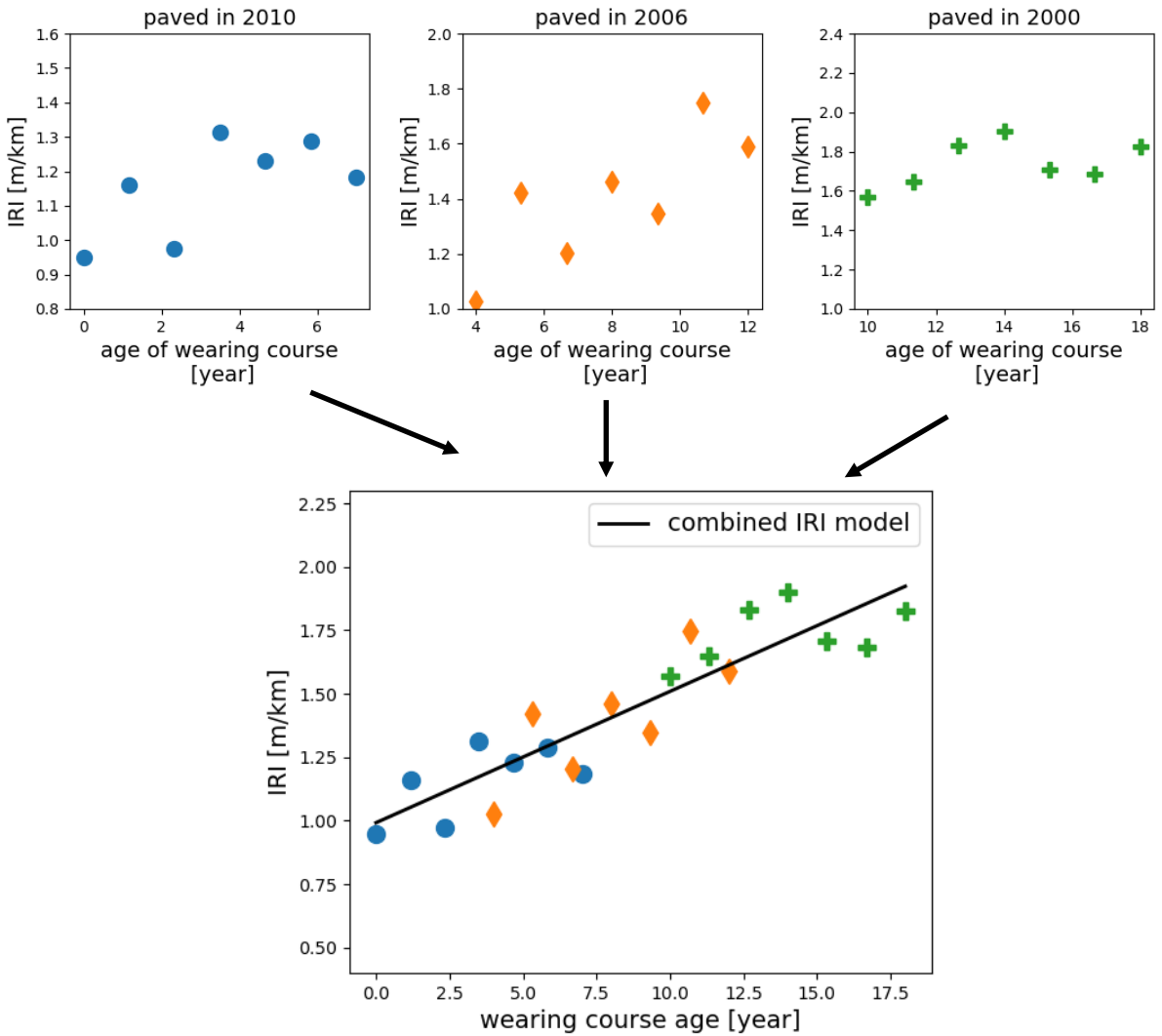




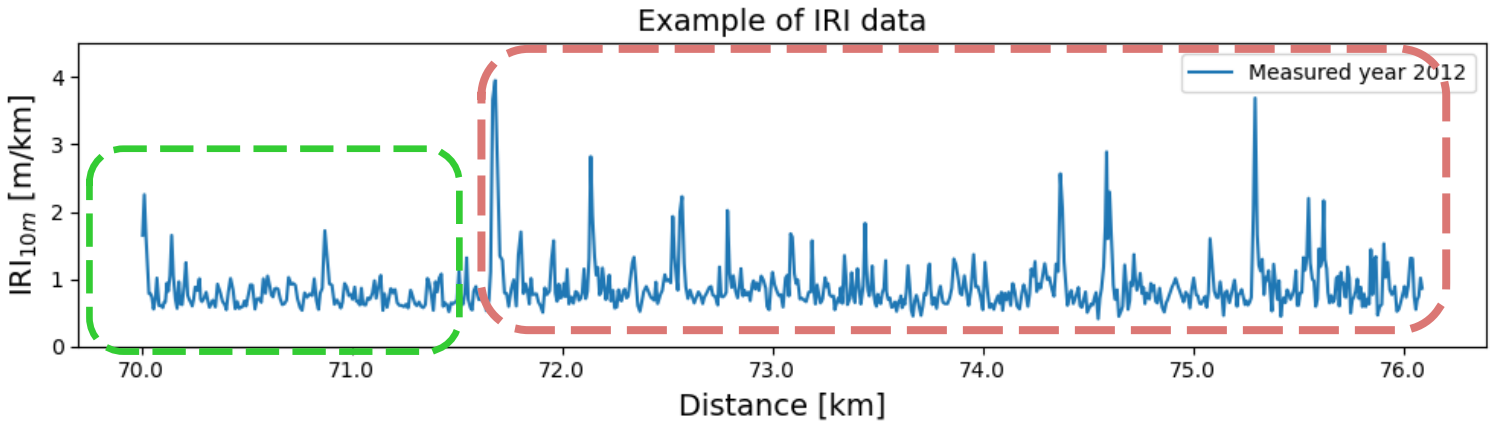
Identifying uniform sections

- We want to describe the sections with statistical measures and track the development in these over time

Identifying uniform sections

- We want to describe the sections with statistical measures and track the development in these over time
- Need sections where IRI behaves the same

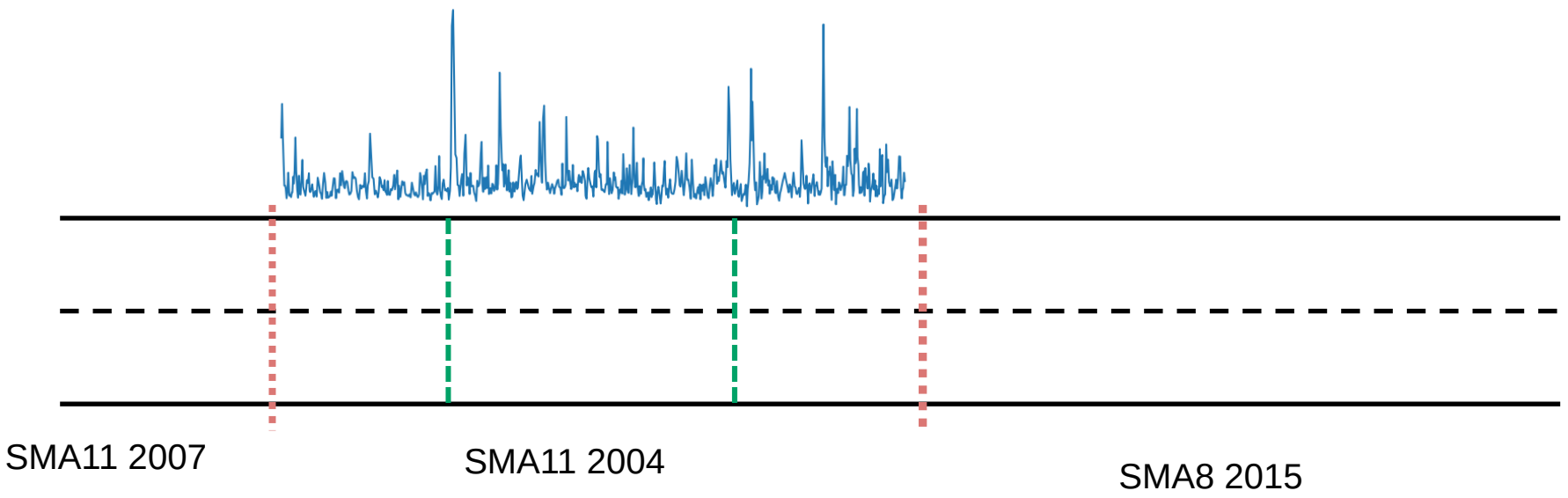
How to make this division into homogeneous sections?



Identifying uniform sections

1. Division based on waring course information
   I. Asphalt material
   II. Date of paving

2. Division based on cumulative difference approach[1]

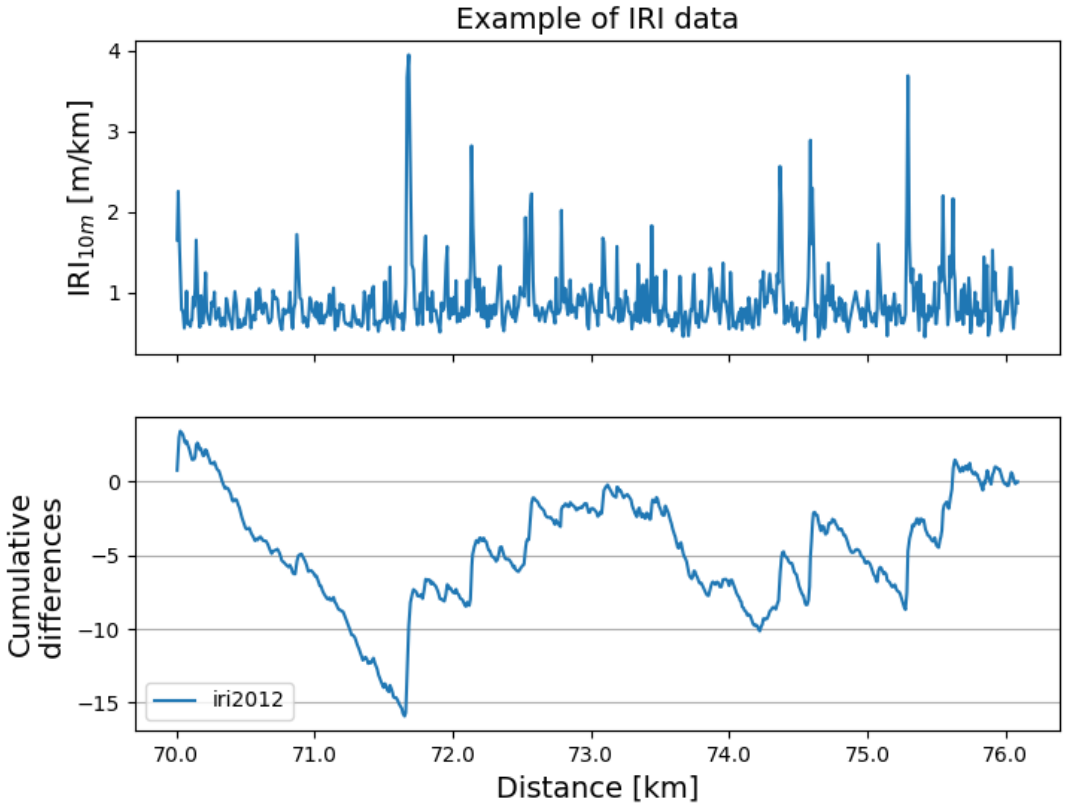


[1]F. Thomas, »Generating homogeneous road sections based on surface measurements: available methods«.

Identifying uniform sections

1. Division based on waring course information
   I. Asphalt material
   II. Date of paving

2. Division based on cumulative difference approach
   I. Section boarders are identified where the slope of CD changes



Cumulative difference

Given a data series $y_1, y_2, \ldots, y_k, \ldots, y_n$, the cumulative difference CD is calculated as

$$CD_k = \underbrace{\sum_{i=1}^{k} x_i}_{\text{Cumulative sum at point k}} - \underbrace{k\frac{1}{n}\sum_{i=1}^{n} x_i}_{\text{The sum if using the data series average}} \text{ for all } k = 1,..,n$$

Identifying uniform sections

1. Division based on waring course information
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1. Division based on cumulative difference approach
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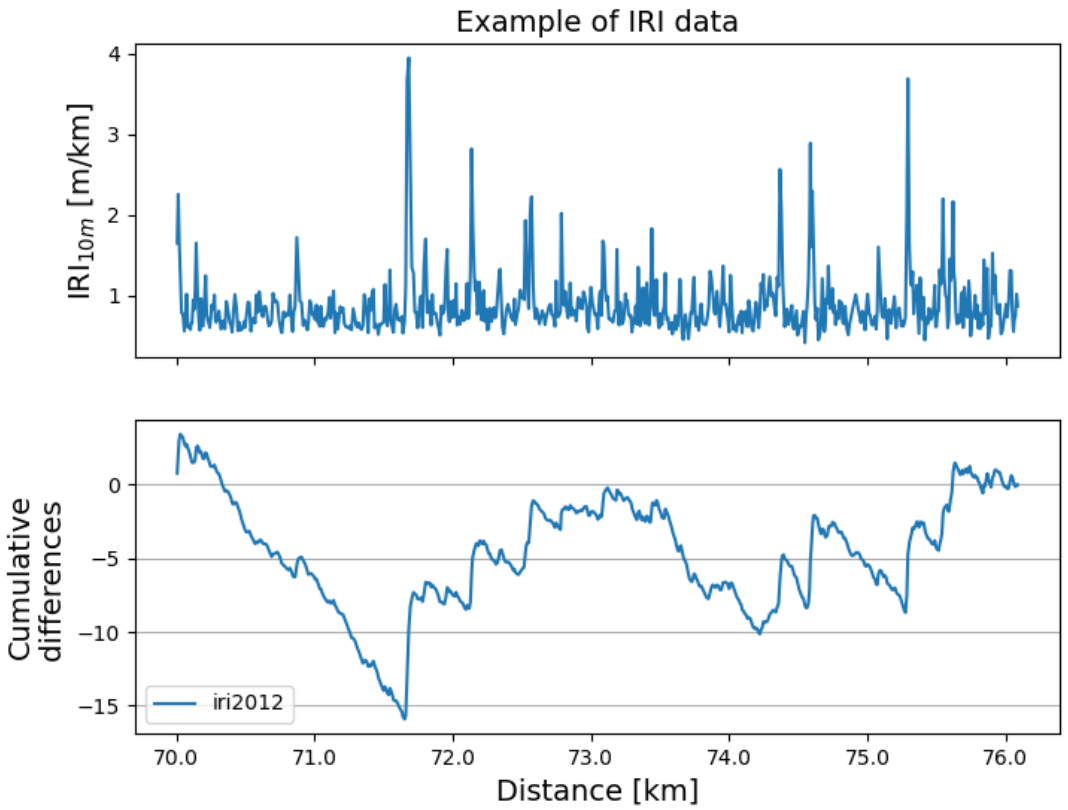
   II. For our purpose we are interested in significant changes – looking for the big trends



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   I. Section boarders are identified where the slope of CD changes
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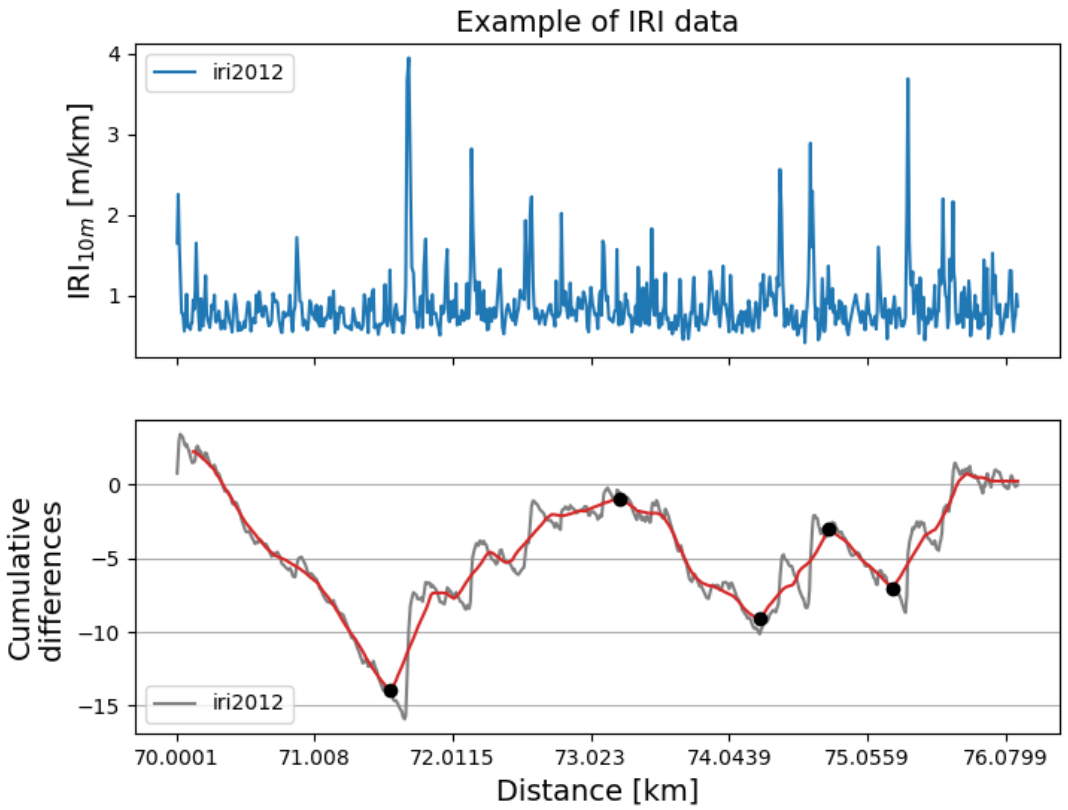
   III. Applying a lowpass filter to smooth the signal
   IV. Identify local maxima and minima
   V. Semi-automatic prosses.



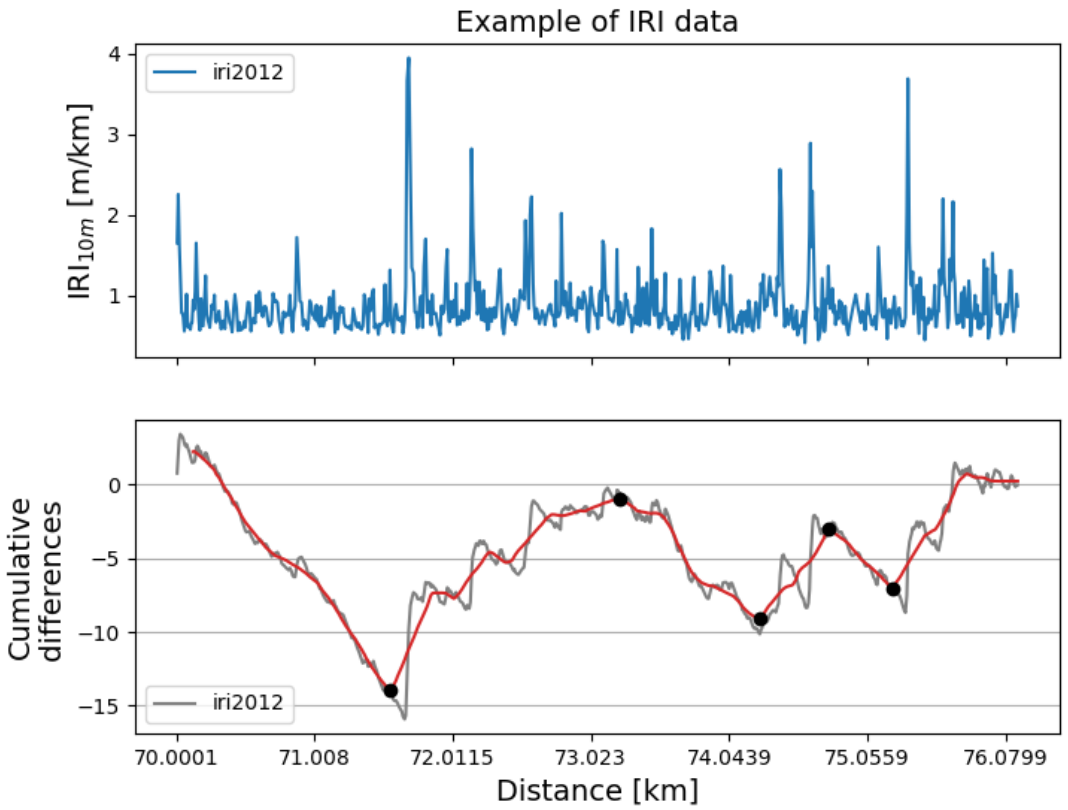
Identifying uniform sections

- Strong tool for finding homogeneous subsections based on data behavior
- Have many different applications
  - good with all “continuous” data types (IRI, Rutting, MPD)
  - Promising on some “discrete” datatypes.

- The parameter values have to be adapted for the purpose. Are we looking for long section or local behavioral changes?

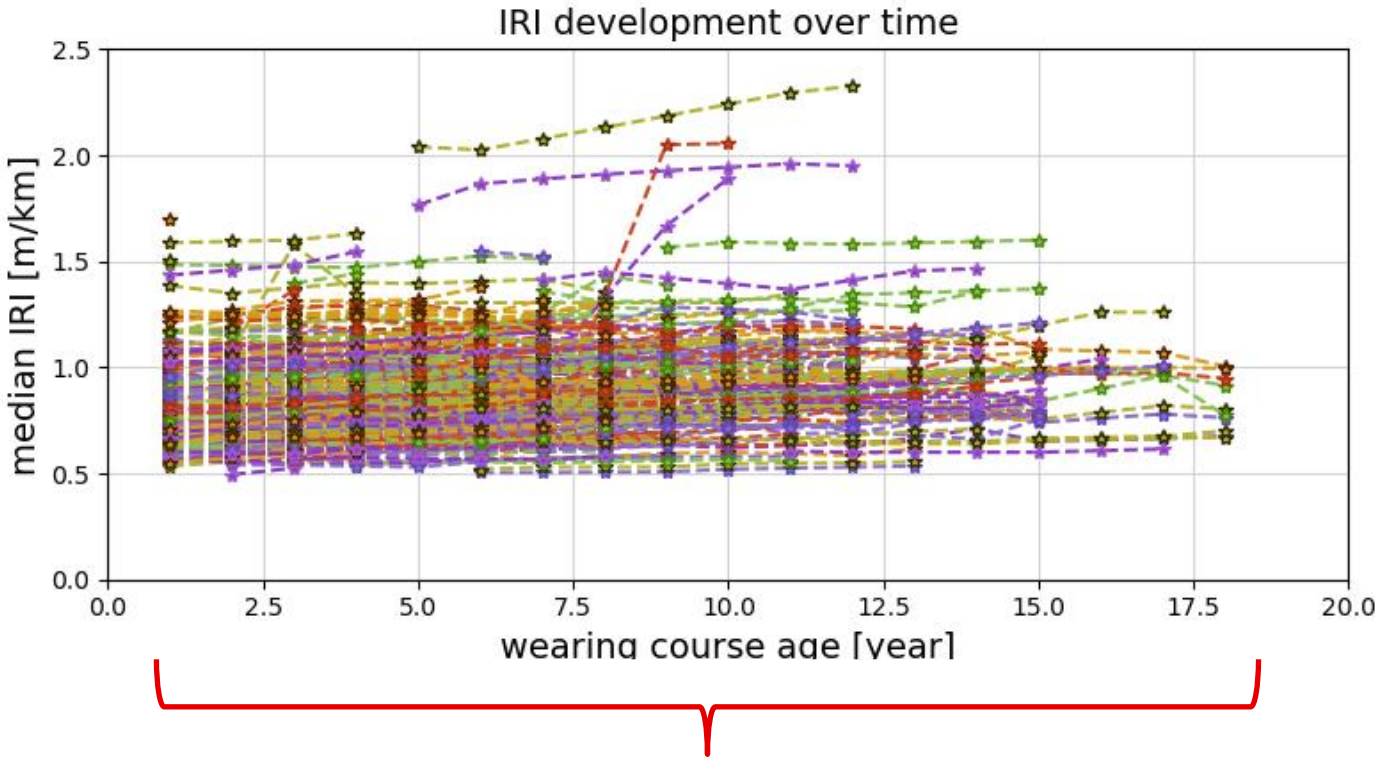
- Very dependent on the used input data
- Always find minimum one boarder in a signal.

- How to combine data from different functional properties to make a subsection?



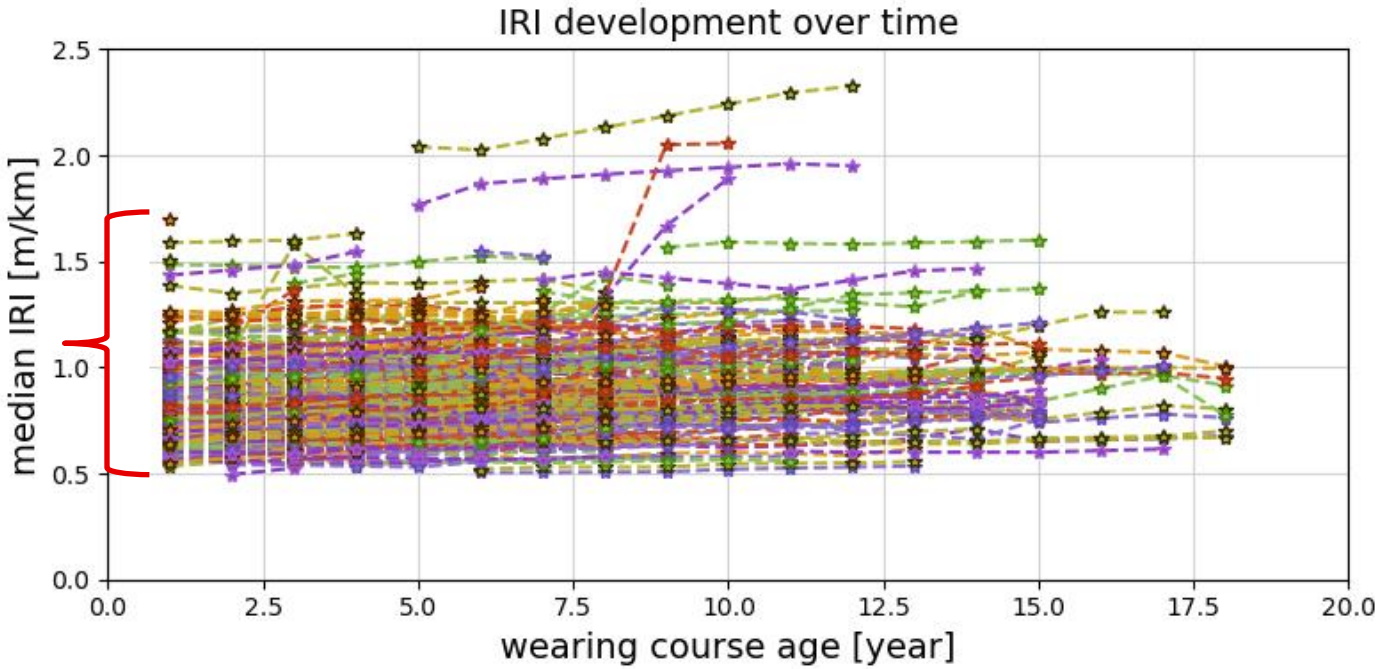
IRI development over time

- Covers the expected lifespan of the pavements



IRI development over time

- Covers the expected lifespan of the pavements
- Large spread in initial IRI value
  - Road type: motorway, highway, smaller road
  - Traffic
  - Pavement material



IRI development over time

- Covers the expected lifespan of the pavements
- Large spread in initial IRI value
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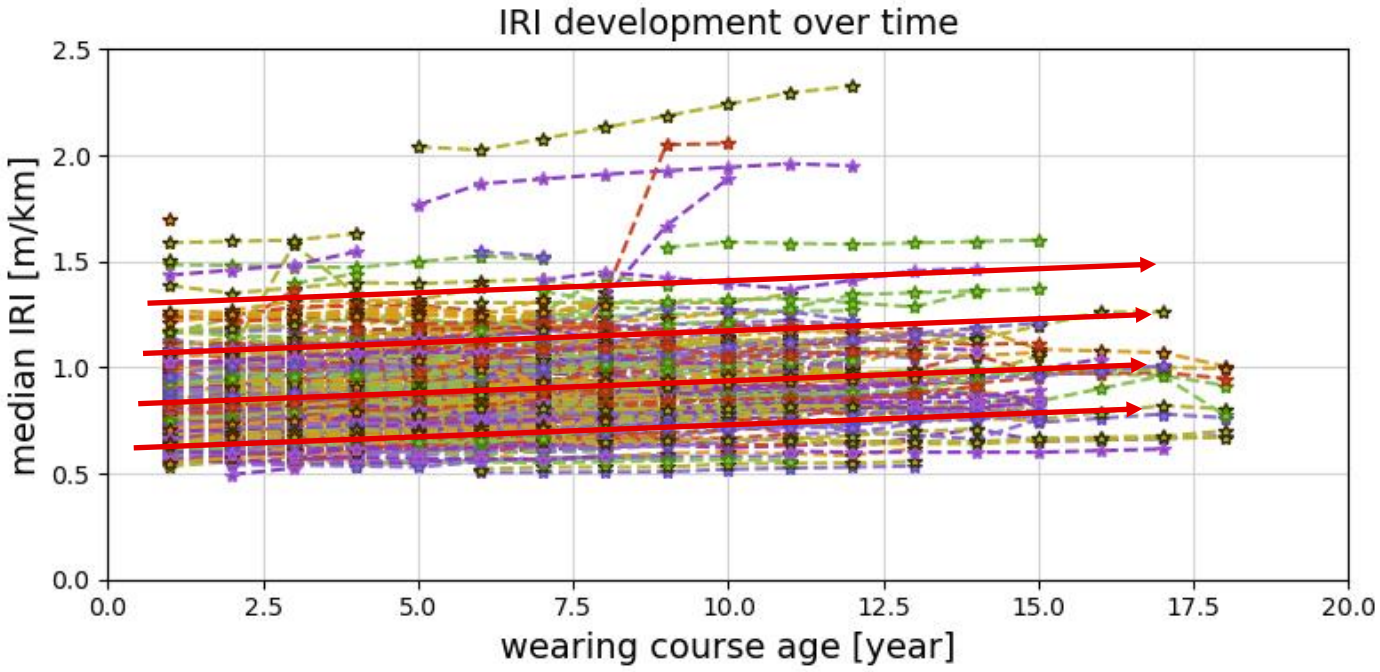
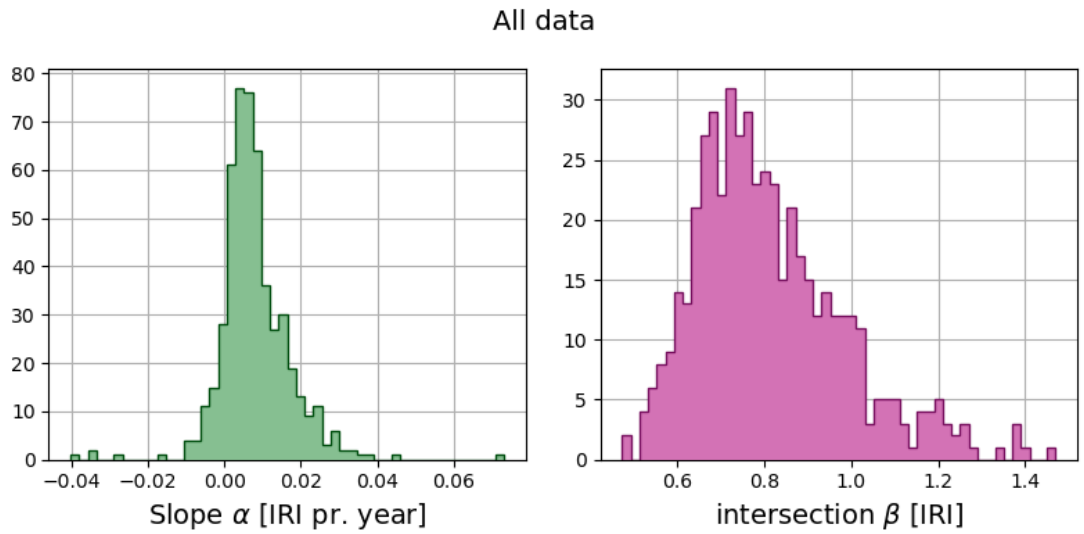
- Similar development trend

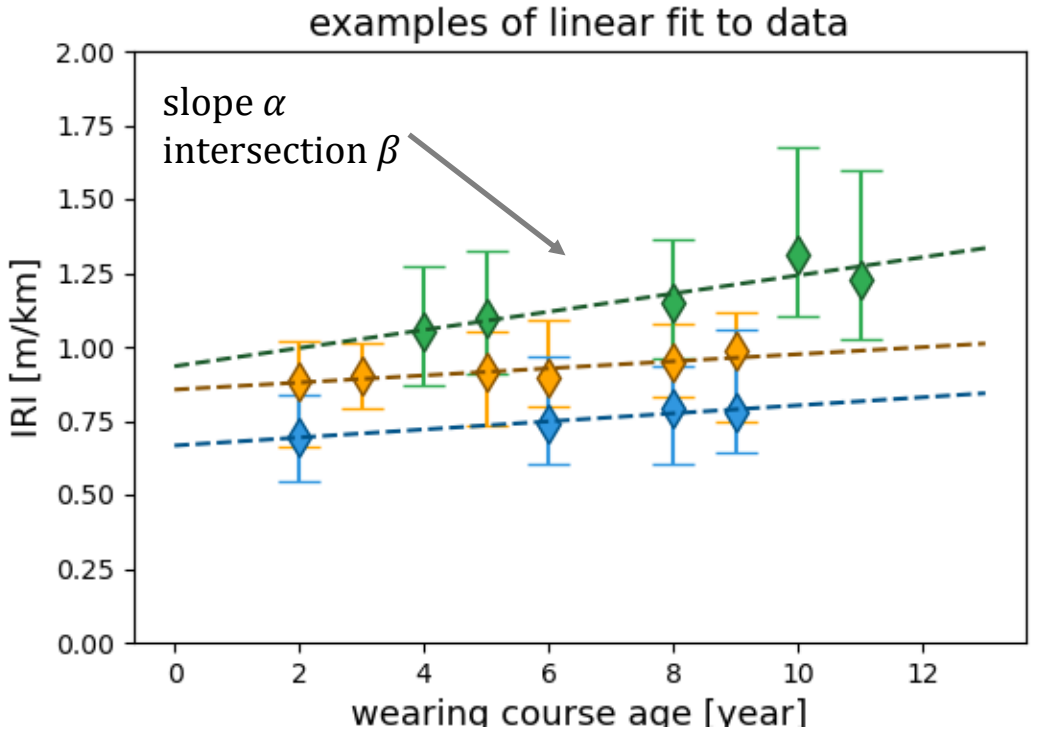


IRI development over time

Analysis of development

I. Linear regression to each individual section
II. Estimate parameters slope (α) and intersection (β)
III. Analyse distribution for entire dataset





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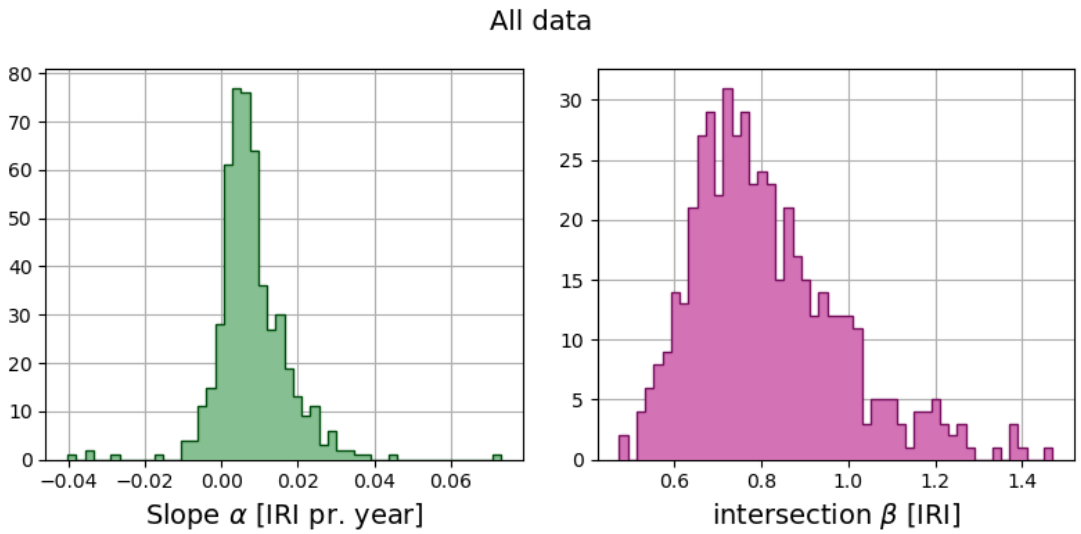
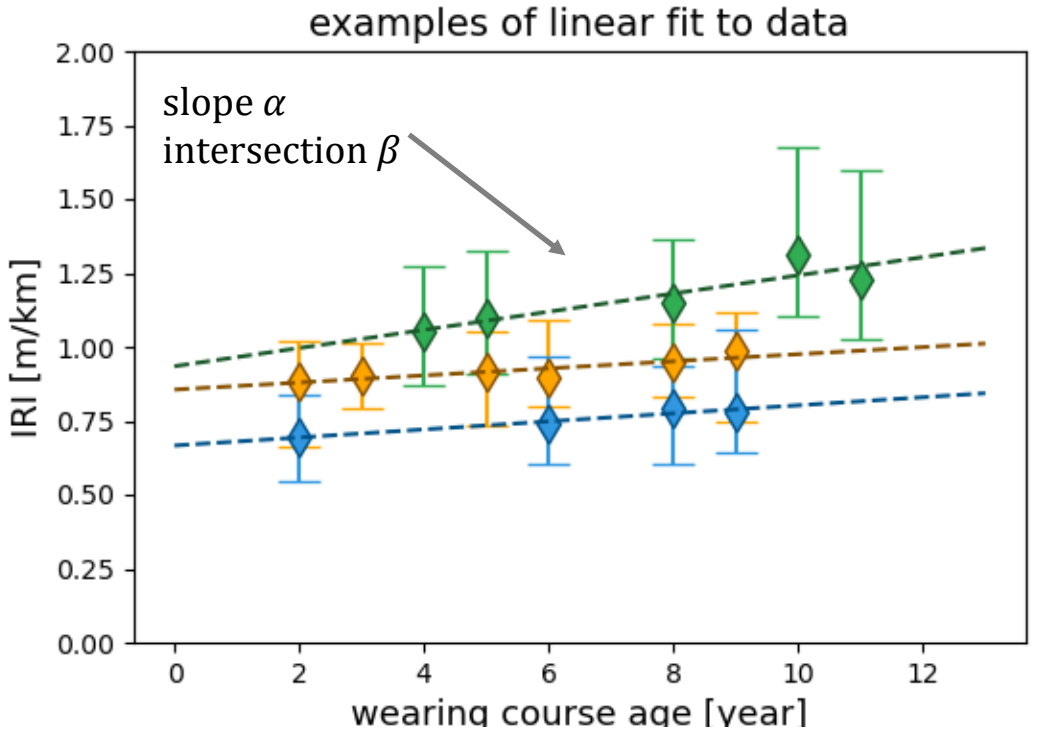
Assumption: IRI increases linearly with waring course age





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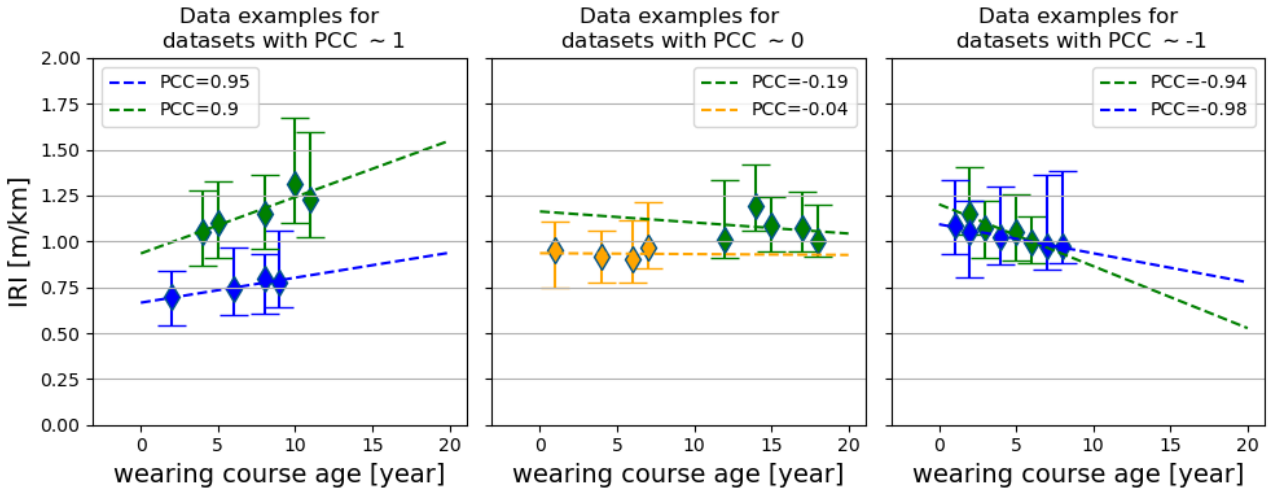
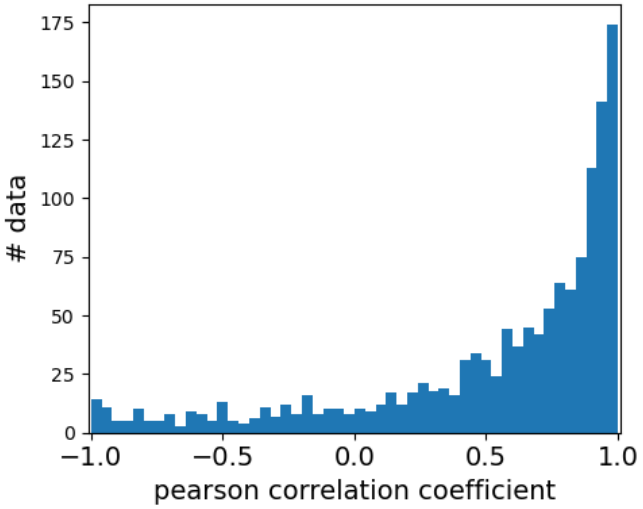
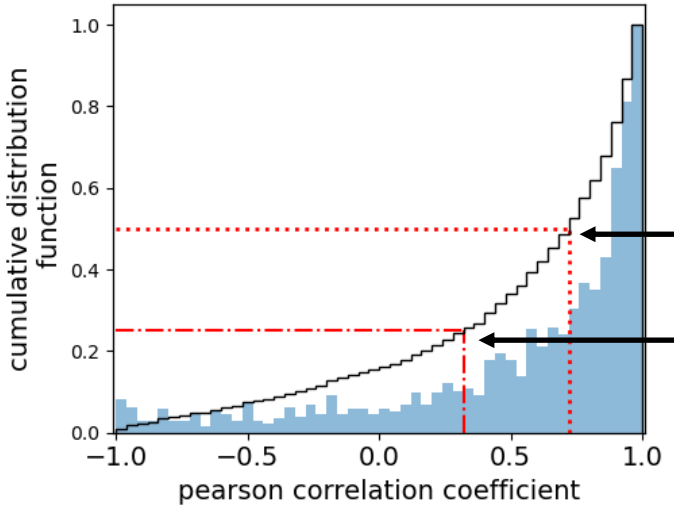
Test validity of assumption by using *pearson correlation coefficient*.
Measures the linear correlation between two datasets.
1=perfect positive linear correlation, 0=no correlation, -1=perfect negative linear correlation







50% of datasets have PCC>0.72

75% of datasets have PCC>0.32

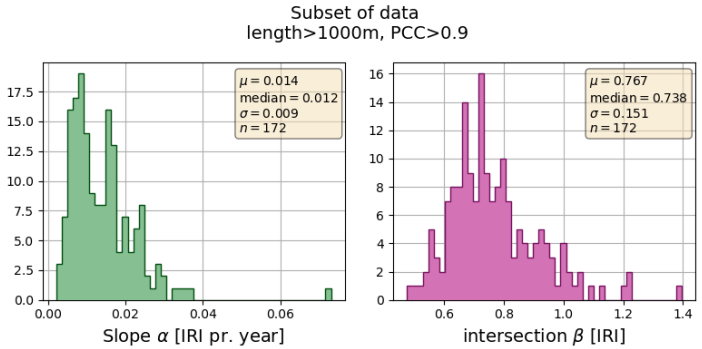
IRI development over time

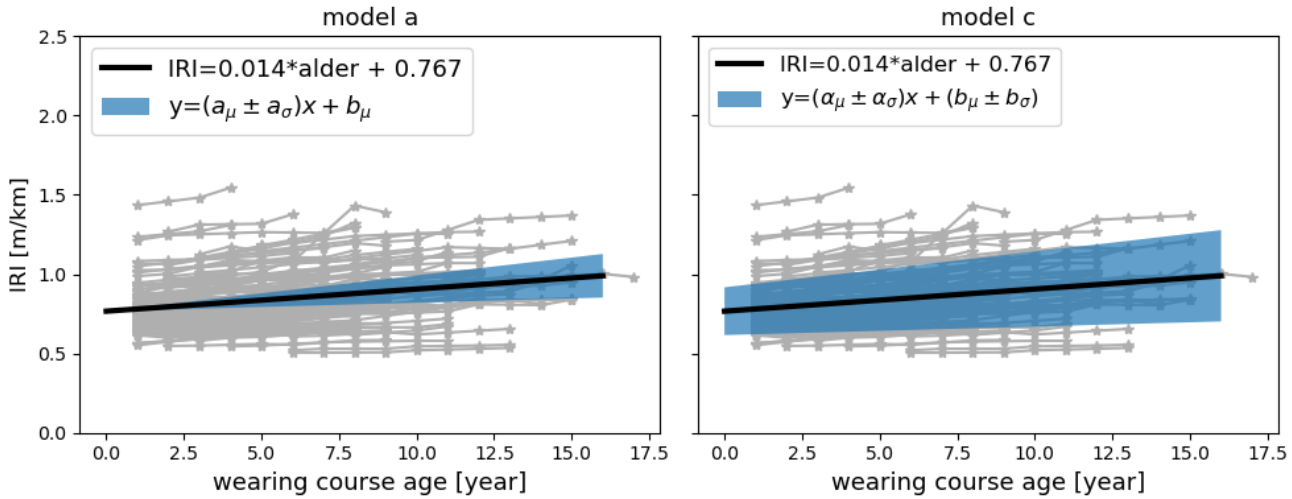
Analysis of development

Model for IRI

$$IRI(t) = \alpha \cdot t + \beta$$

$$IRI(t) = (\alpha_\mu \pm \alpha_\sigma) \cdot t + (\beta_\mu \pm \beta_\sigma)$$





IRI development over time

Analysis of development

A few remarks:

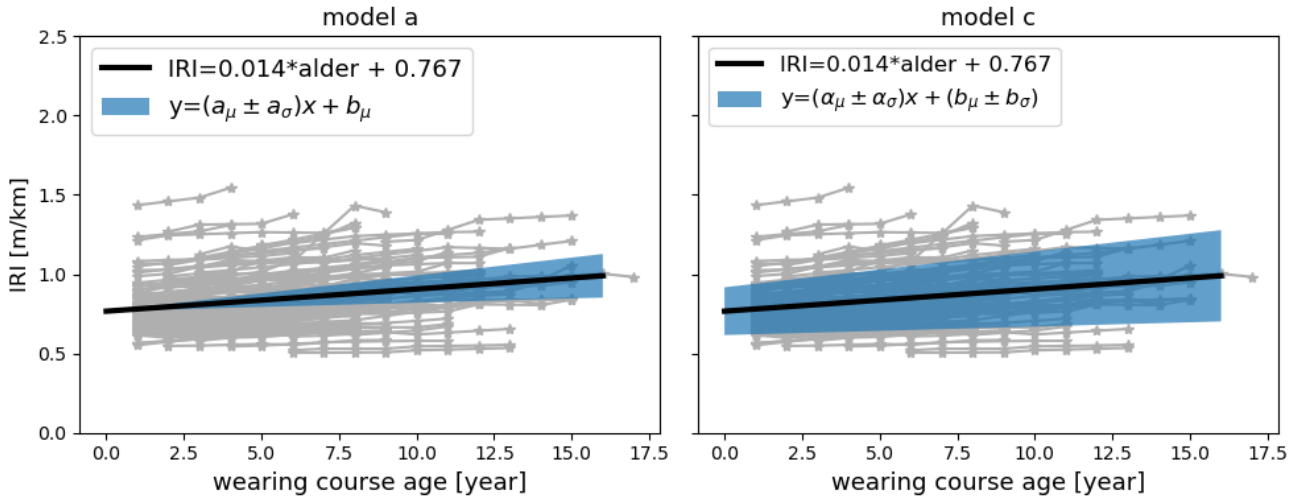
- The development if IRI is very low in DK
- The IRI level is very low

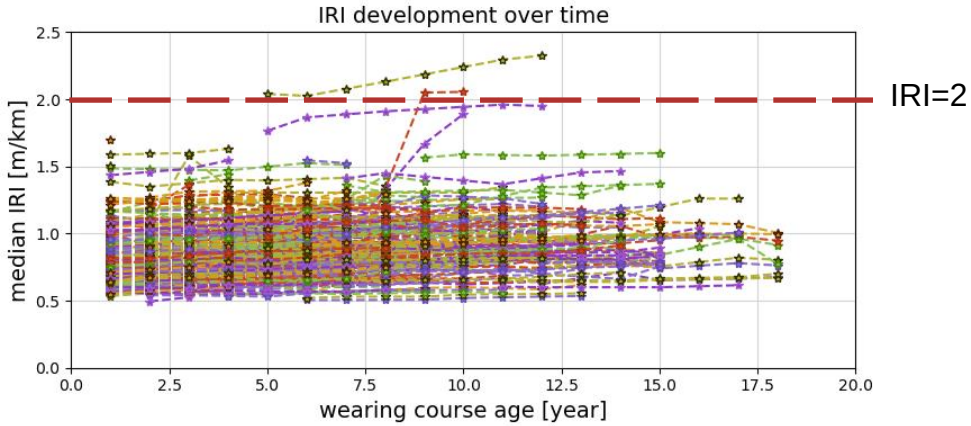
- When used, combine with IRI(t)$_{measured}$

$$IRI(t) = IRI(t_i)_{meas} + \Delta IRI(t)$$

This can be used as a model framework

1) Homogeneous subsections based on waring course info and data behavior
2) statistic analysis on the development of X over time
3) use the estimated parameter values to make a generalized model

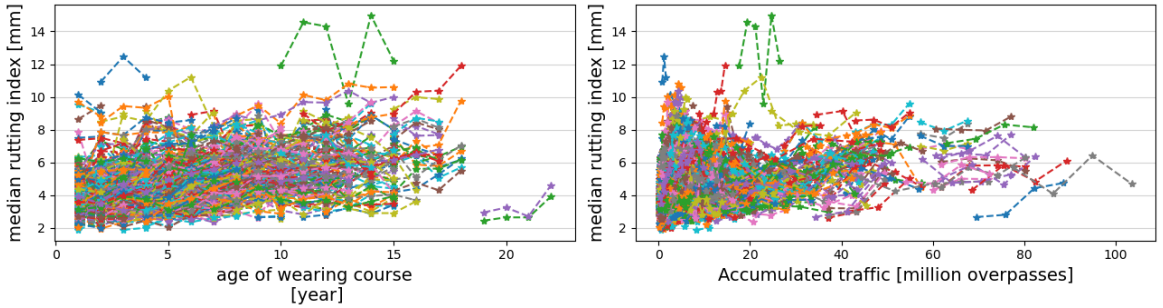




Rutting development over time

Applying model framework

1) Make homogeneous subsections
   i. investigate dependencies



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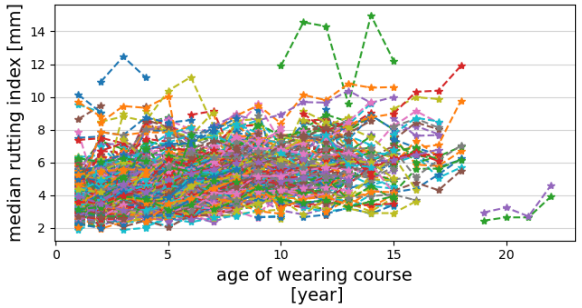
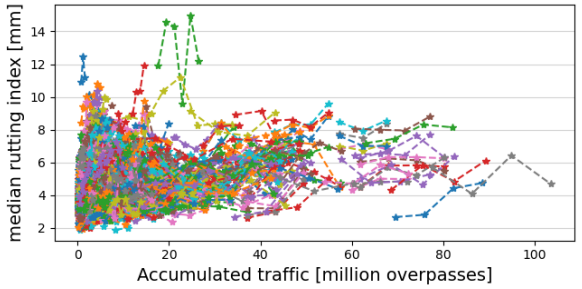
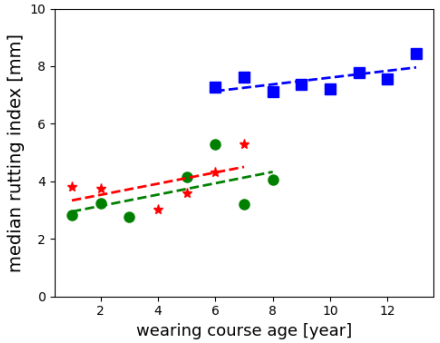
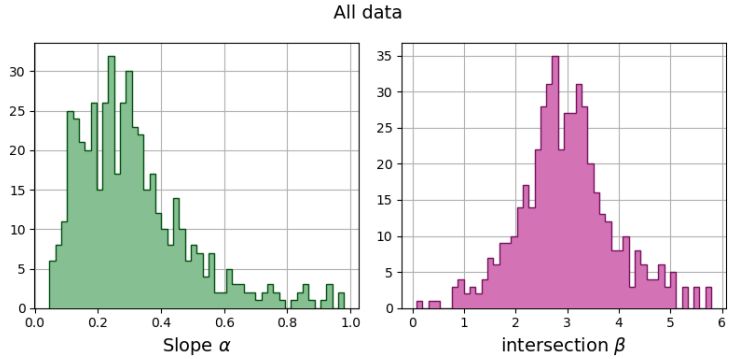




2) Analyse development of each subsection
   i. First approach is linear regression.
   ii. Analyse distribution of estimated parameters





Rutting development over time

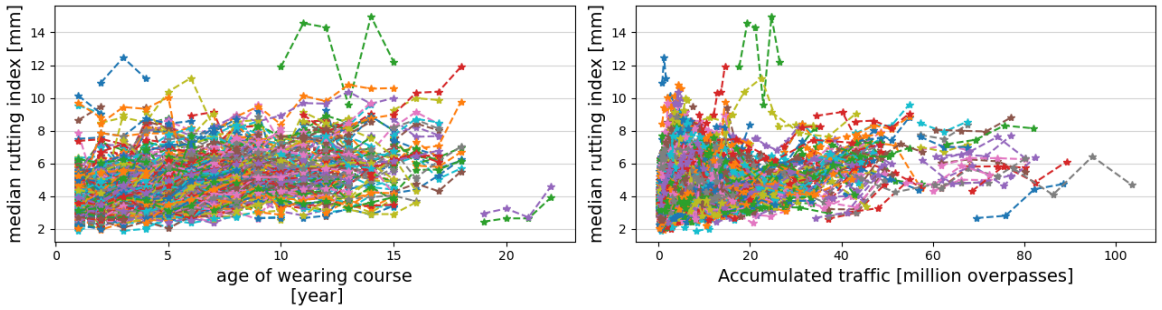
Applying model framework

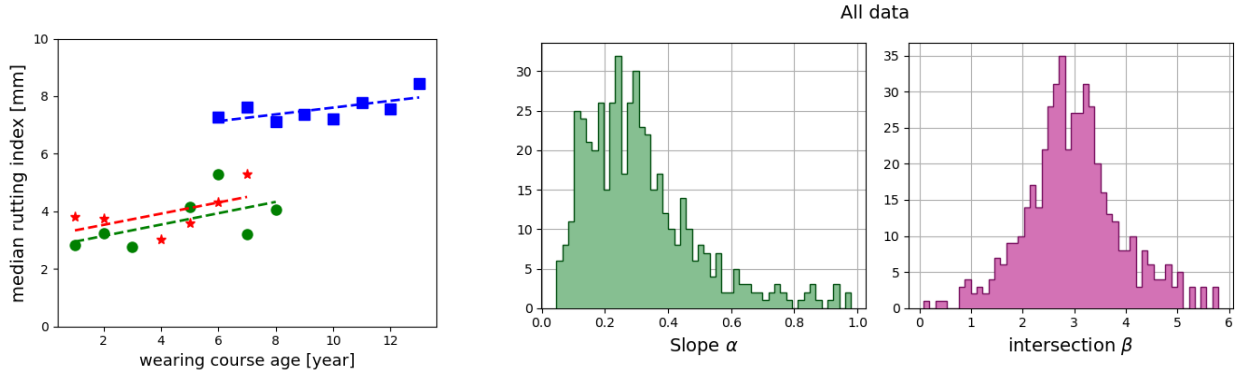
1) Make homogeneous subsections
   i. investigate dependencies

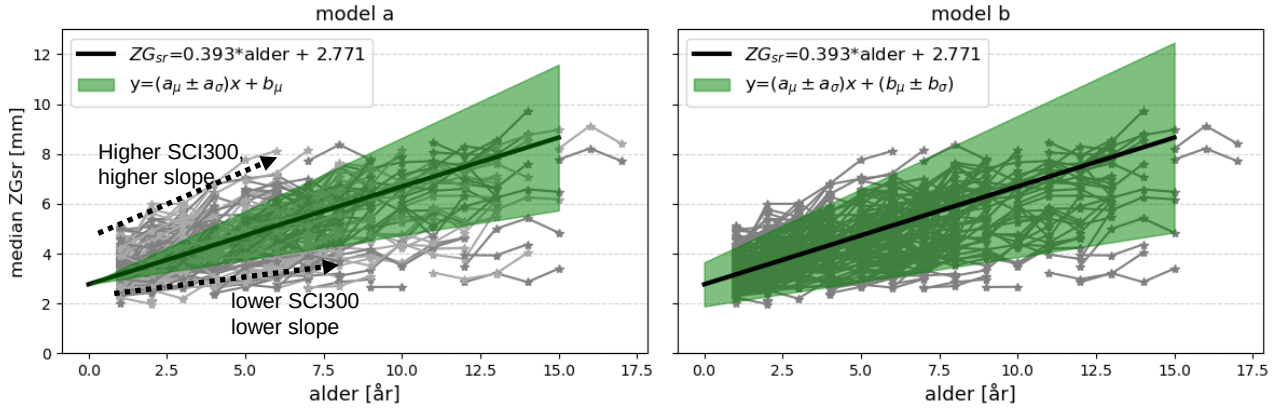
2) Analyse development of each subsection
   i. First approach is linear regression.
   ii. Analyse distribution of estimated parameters

3) Develop generalized model
   i. Investigate dependencies

Notes:
- Bigger variance in rutting model
- Want to combine with structural information







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