Examining the influence of urban design on cyclist route choice in different weather conditions

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Contents

1. Introduction

Introduction

Motivation

- Changing climate and air pollution
- Rising interest in sustainable transportation modes
- **Utilitarian** cycling to replace car trips
- Expanding the cycling range: **electric bicycles**
- Governments want to stimulate utilitarian cycling
- Requires understanding of cyclist's preferences
  - What drives cyclists when deciding upon transportation mode?
  - What drives cyclists when deciding upon a route?

Introduction

Cyclist travel behavior

Main influence:

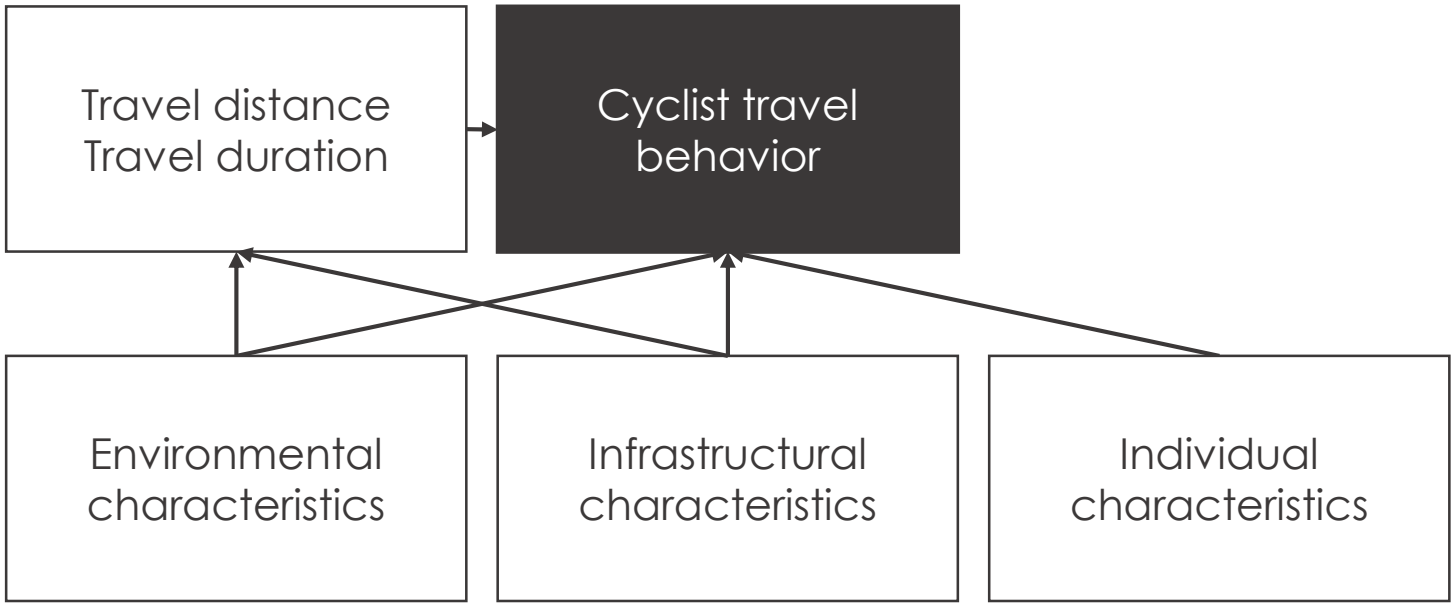
- Minimization of effort
- Minimization of duration

Introduction

Cyclist travel behavior

Other influences:

- Factors influencing effort and duration
- Safety
- Individual preferences

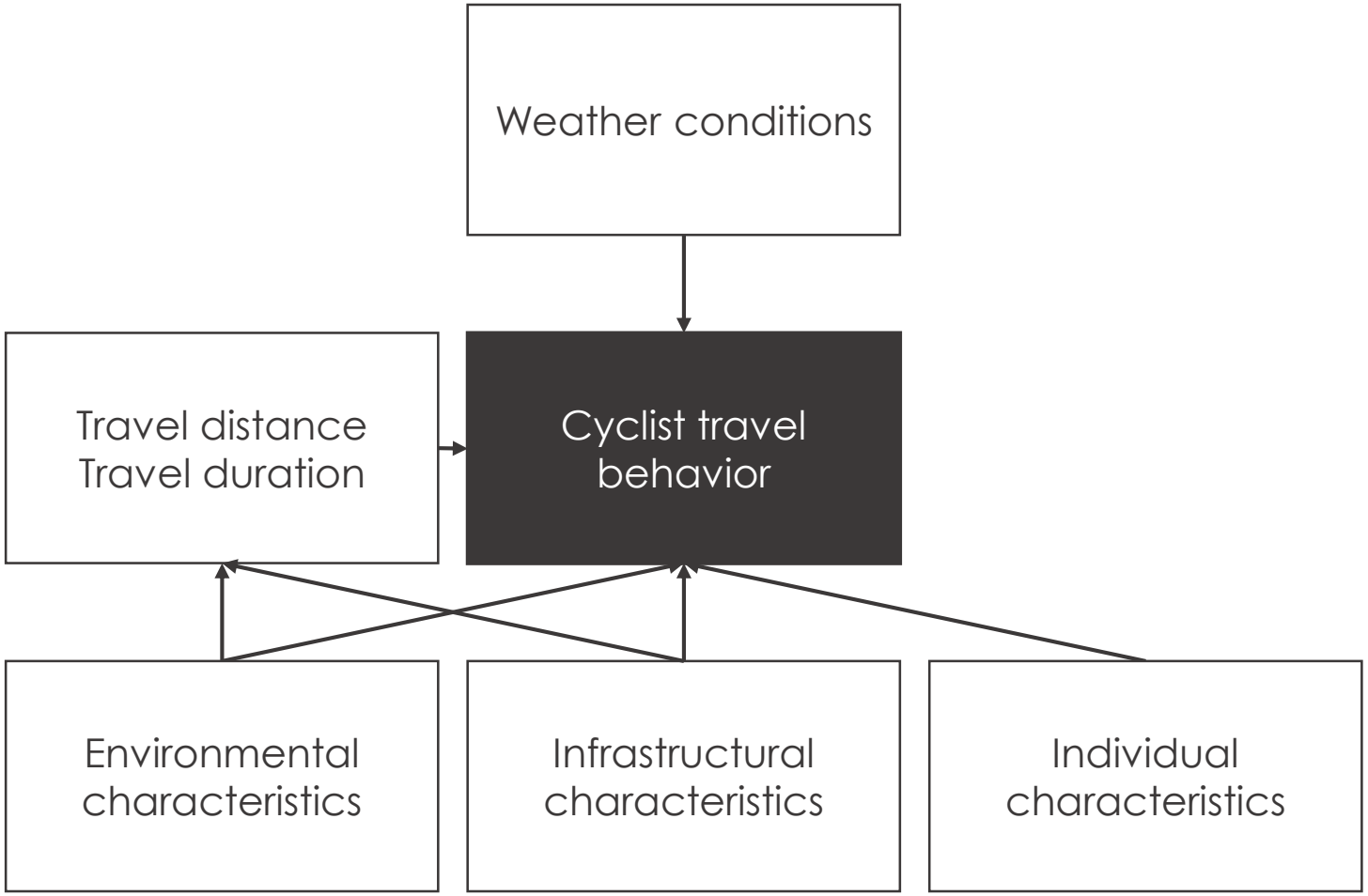


Introduction

Cyclist travel behavior

Weather conditions:

- Main deterrent
- Reduce travel time

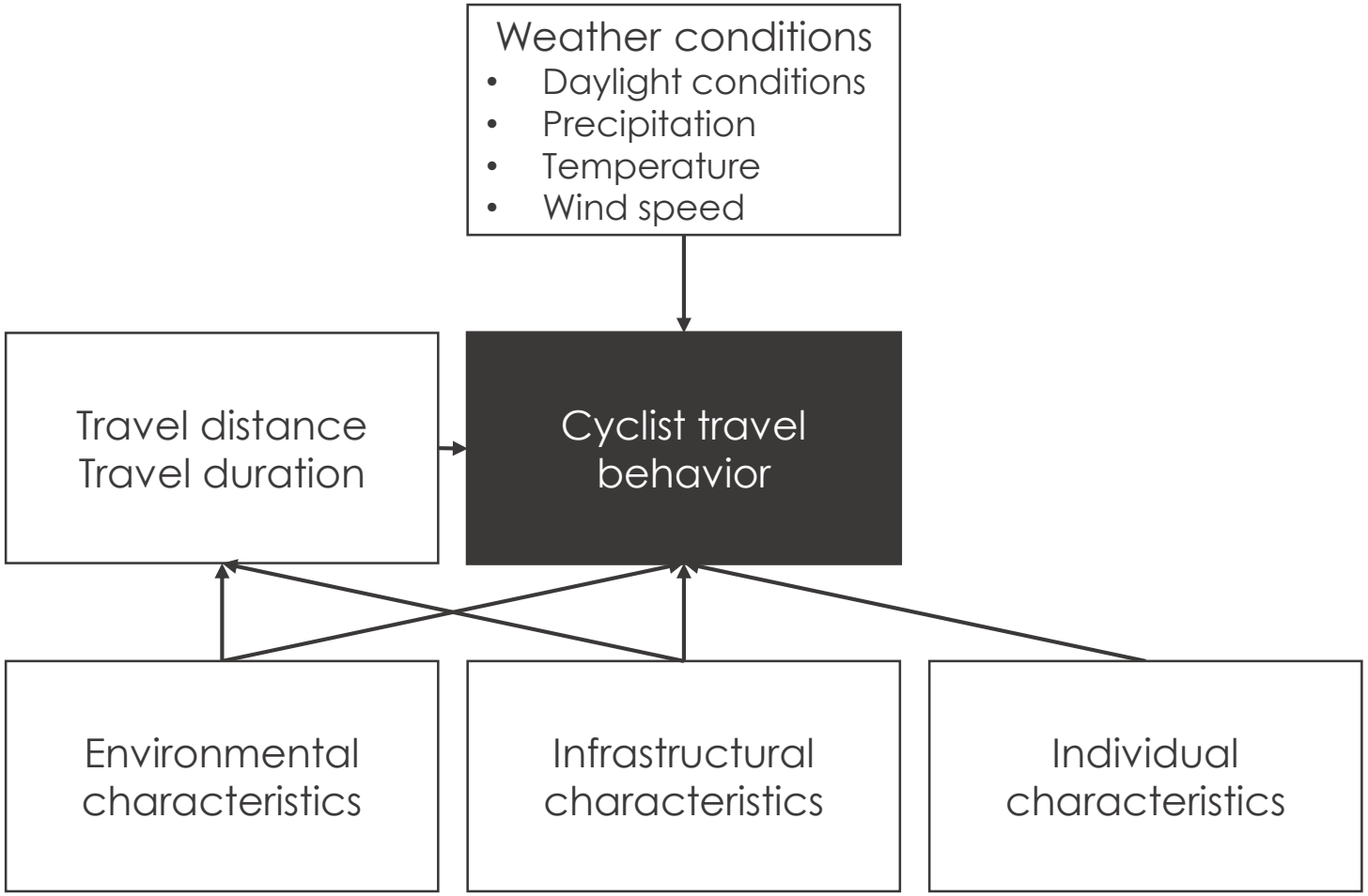


Introduction

Cyclist travel behavior

Weather conditions:

- Main deterrent
- Reduce travel time
- Four main parameters



Introduction

Problem statement

- Is it possible to **mitigate** the influence of weather conditions on cyclists?
- Research gap: cyclist route choice in different weather conditions, and determinants for the choice of route

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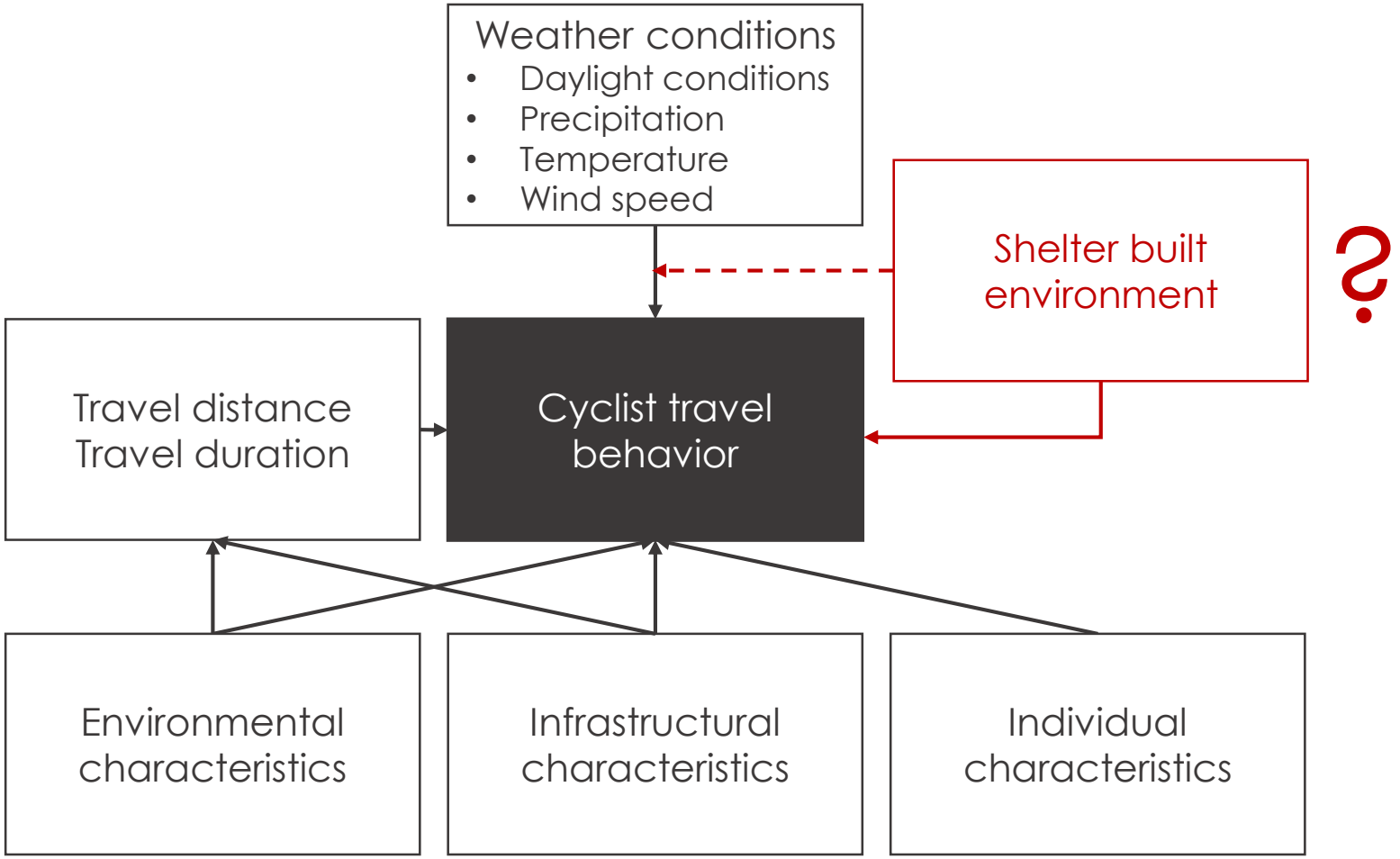
Pedestrian route choice:

- Experience of weather conditions heavily affected by urban design
- Pedestrians seek or avoid **shelter by the built environment** in different weather conditions
- Directly related to exposure to/shelter from weather conditions
- Shelter from **buildings** and **trees**

Introduction

Research objective

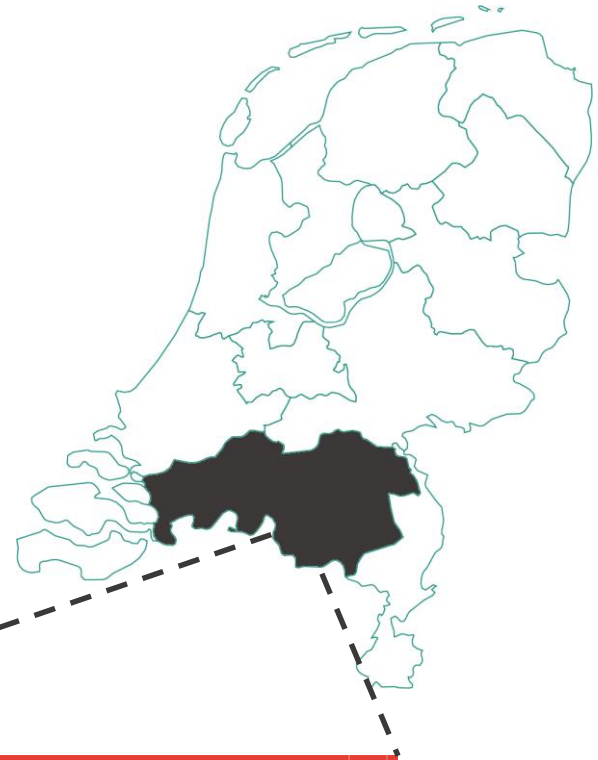


Research question

To what extent does the degree of shelter provided by the built environment explain cyclist route choice in different weather conditions?

Case study

Noord-Brabant

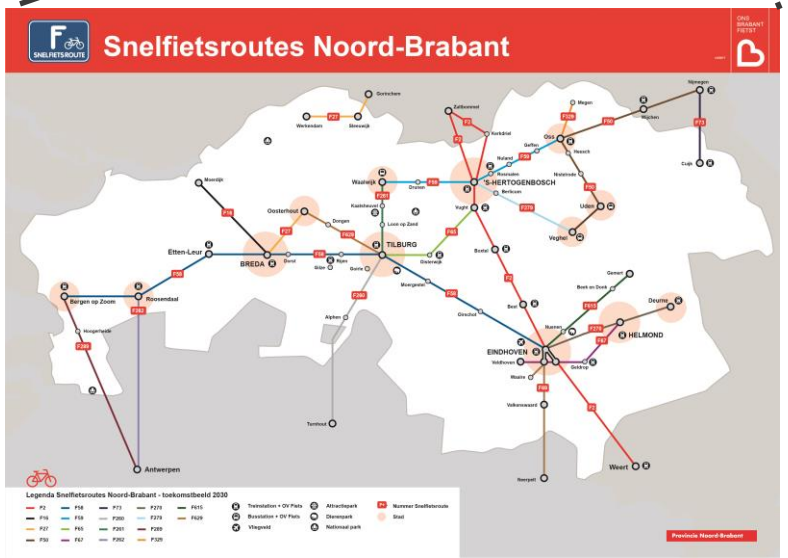


Development: fast bike lanes

- Connecting larger cities
- Significant investment

Observed travel data: B-Riders

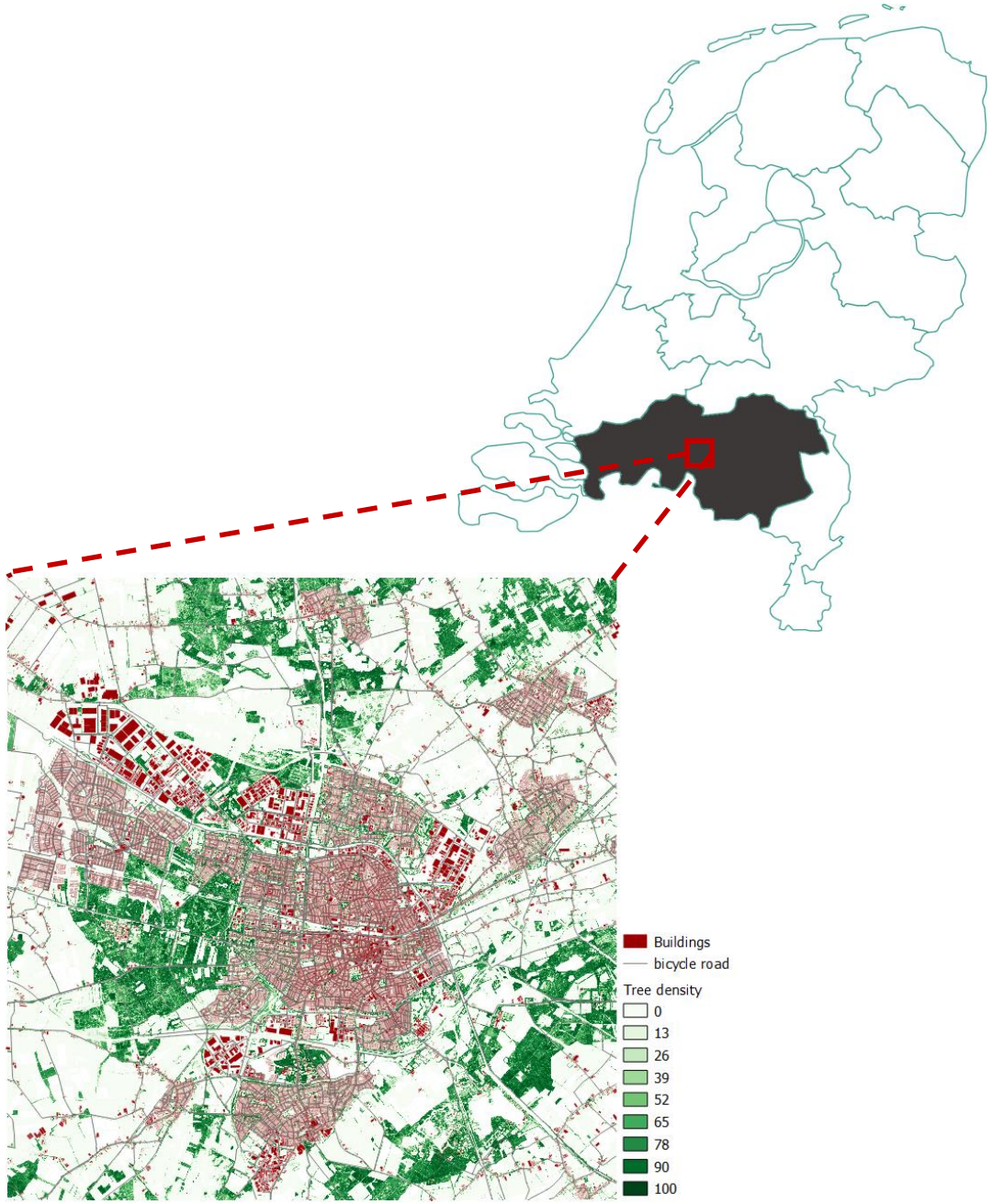
- Bicycle commuters (conventional + electric bicycles)
- Registration of GPS measurements and route info
- Reward: money or points
- Anonymized data



Case study

Study area

- **Study area**: Tilburg
  - For development methodology
  - Mix of urban and rural areas
  - Sufficient travel data



2. Methodology

Breaking down the methodology

To what extent does the degree of shelter provided by the built environment explain cyclist route choice in different weather conditions?

Breaking down the methodology

To what extent does the degree of shelter provided by the built environment explain **cyclist route choice** in different weather conditions?

Route choice

Definition

Focal group:

- Utilitarian cyclists

Route choice

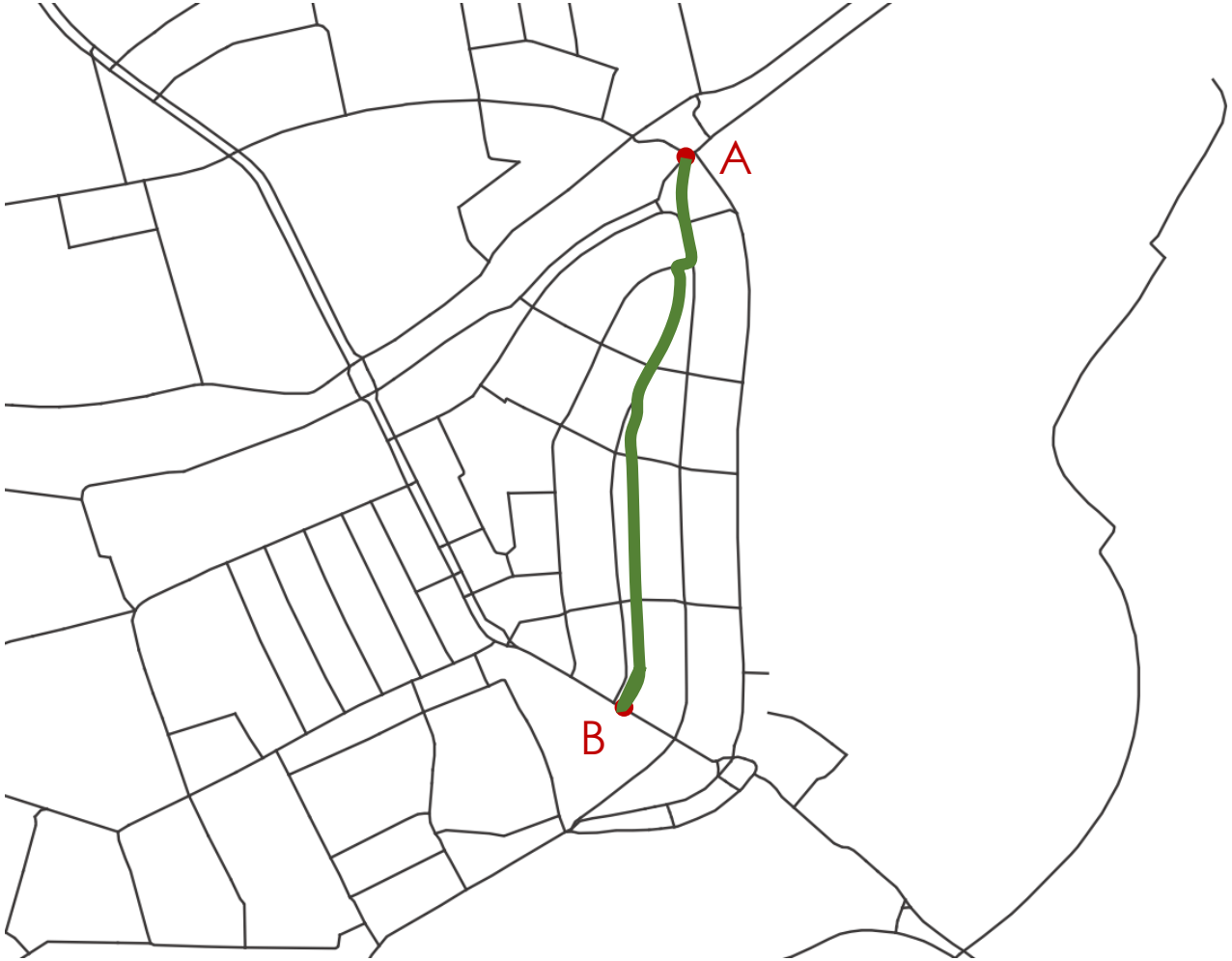
Definition

Utilitarian cyclists:

- Minimization of effort

Optimal route:

- Shortest route



Route choice

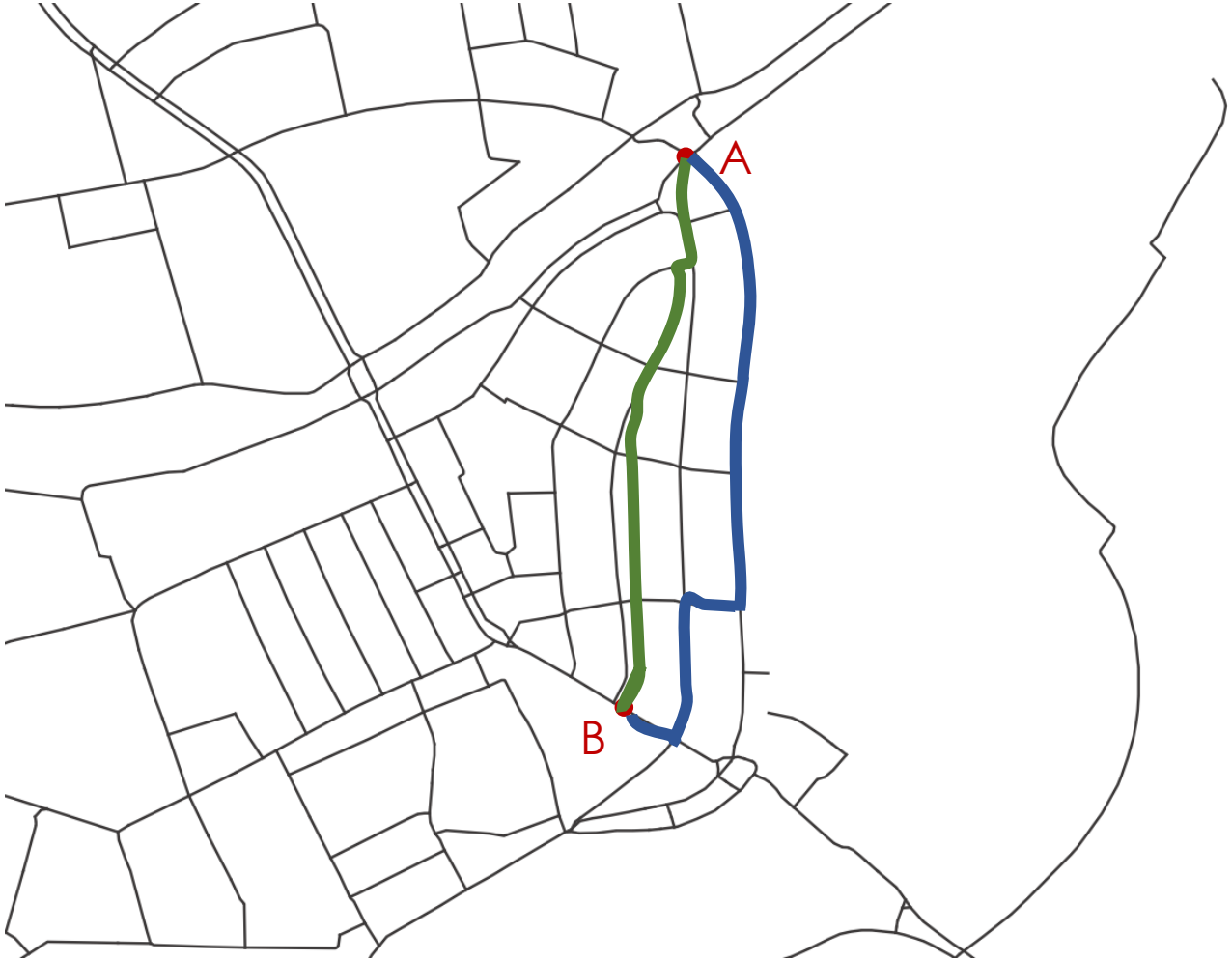
Definition

Utilitarian cyclists:

- Minimization of effort
- Minimization of travel time

Optimal route:

- Shortest route
- Fastest route



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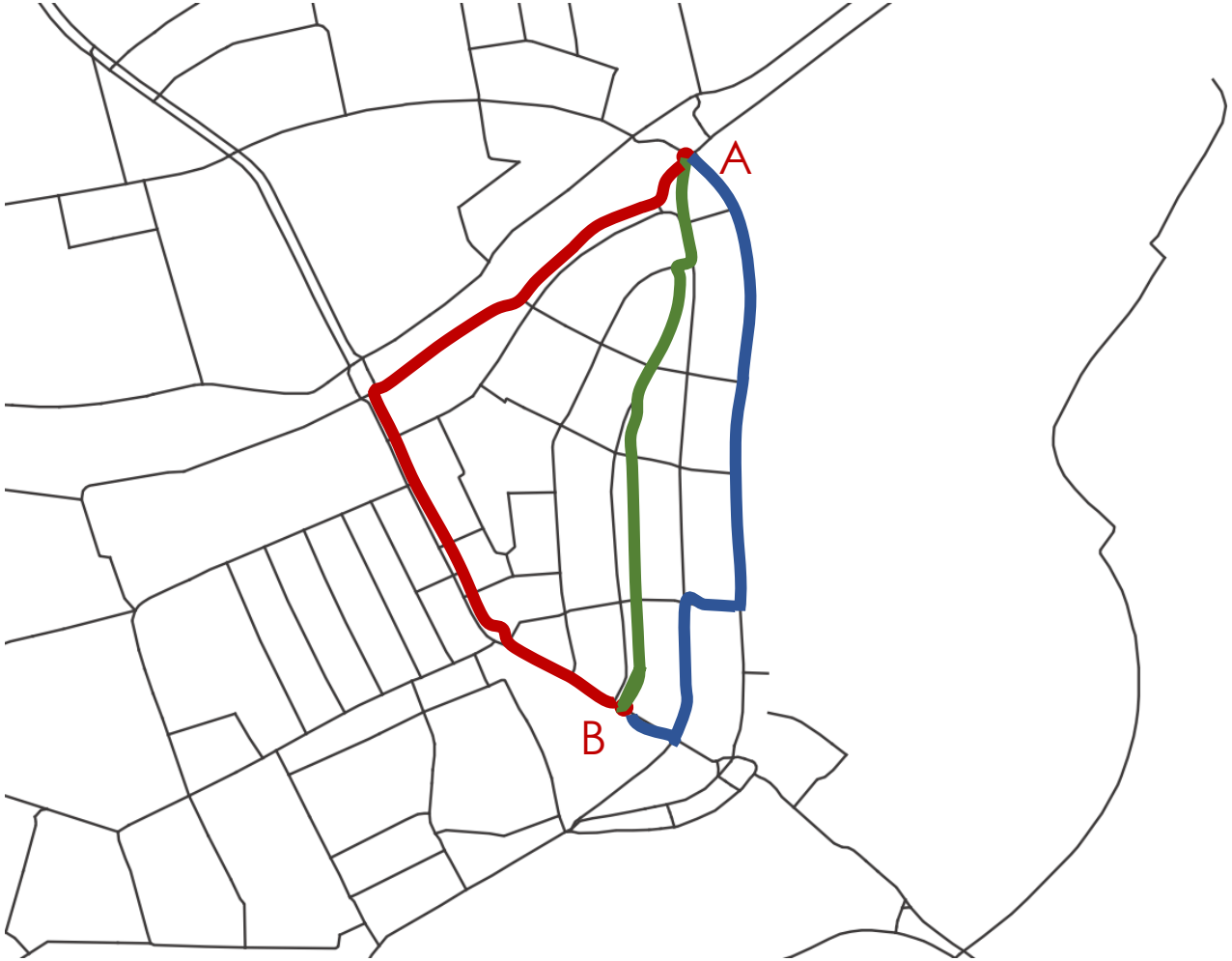

Route choice

Definition

Utilitarian cyclists:

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Optimal route:

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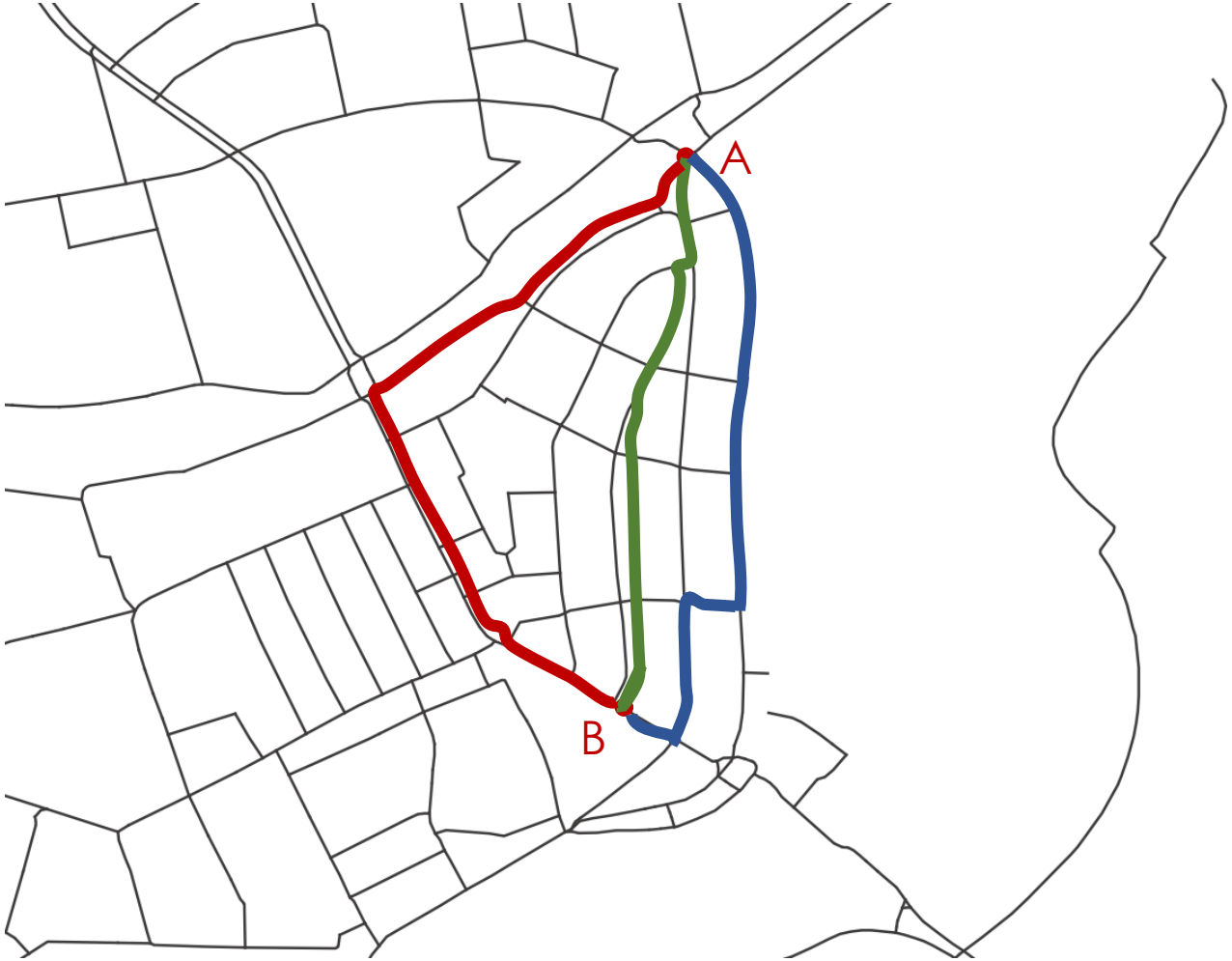
- Fastest route

Route choice:

- % divergence from shortest or fastest route

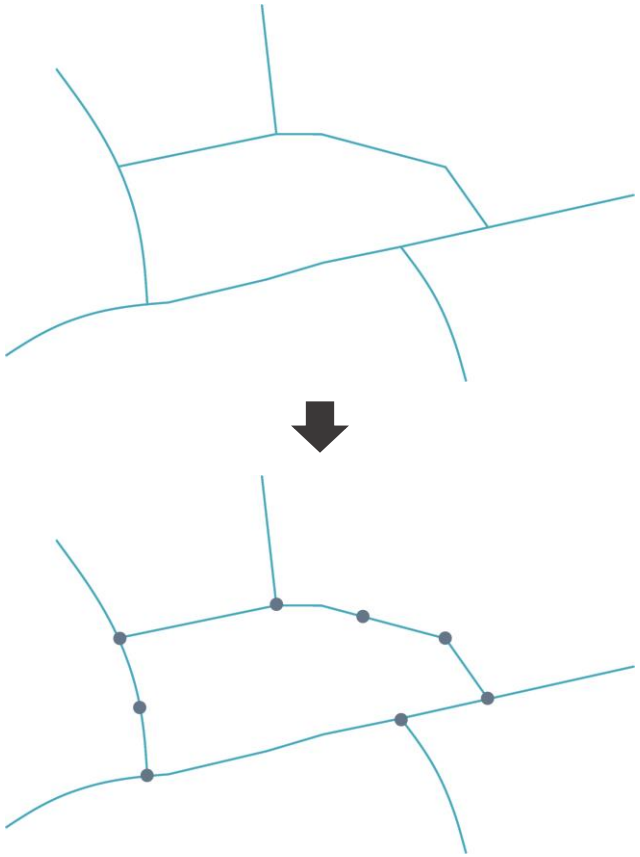


Route choice

Operationalization

Input

Enabling routing functionalities



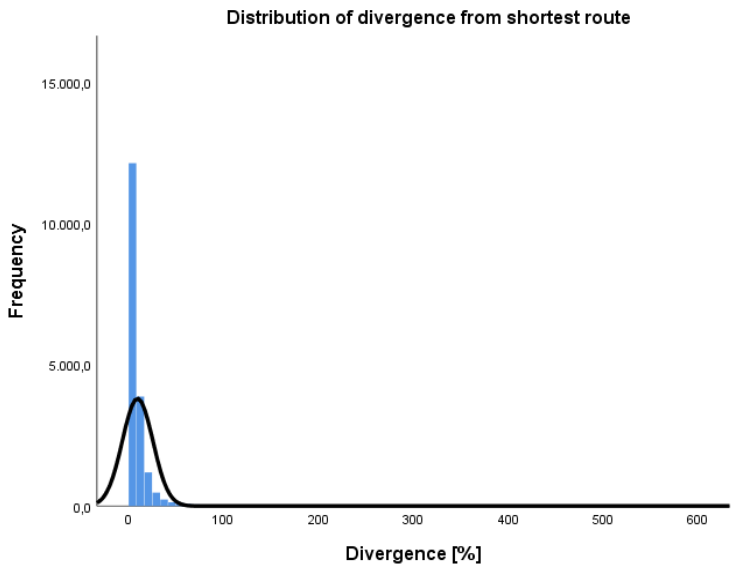
Shortest/fastest path algorithm

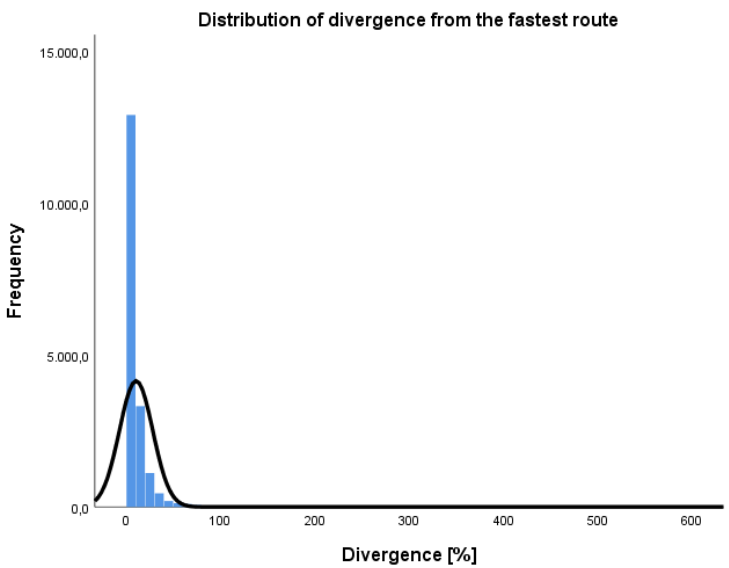
A* algorithm

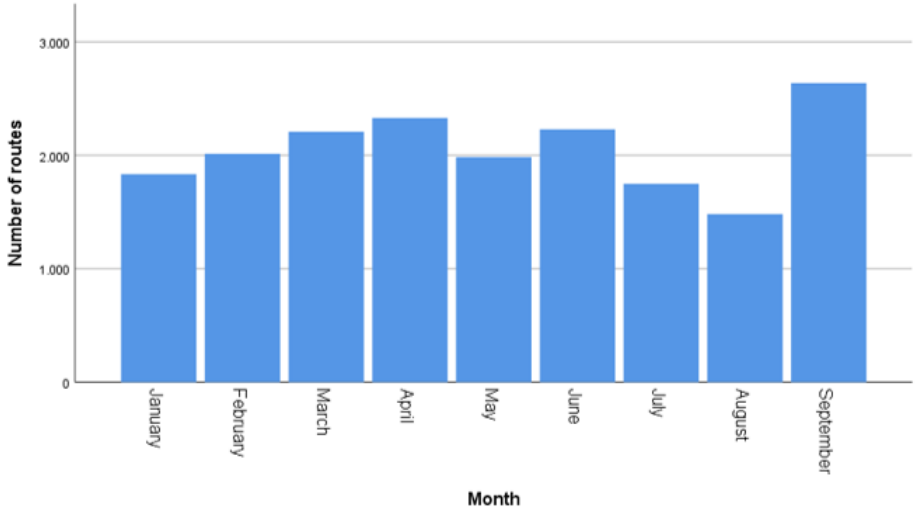
Route choice

Route model

- 18424 **routes**
- 322 **cyclists**
- Majority of observed routes: **divergence < 10%**







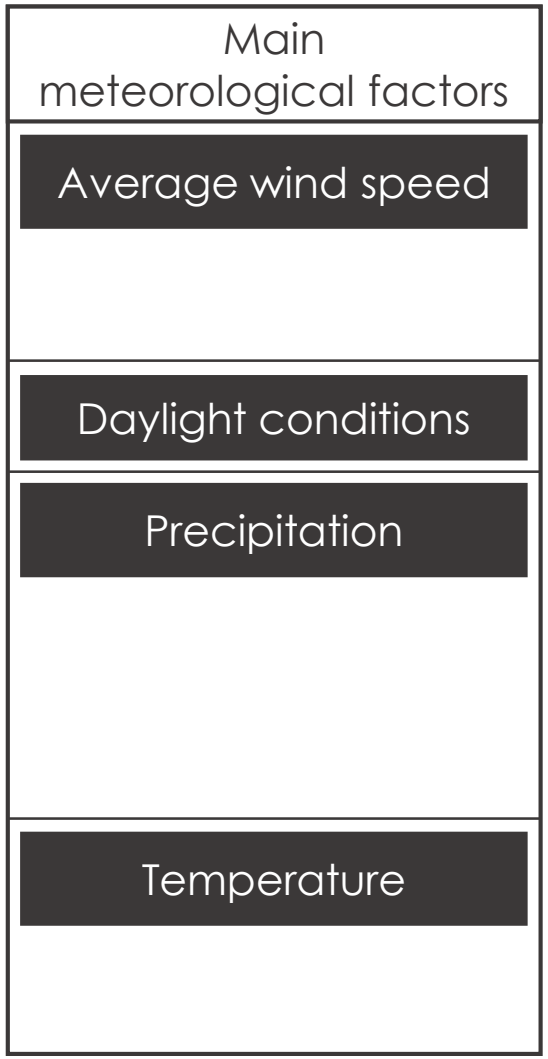
Breaking down the methodology

To what extent does the degree of shelter provided by the built environment explain cyclist route choice in different **weather conditions**?

Weather conditions

Meteorological factors

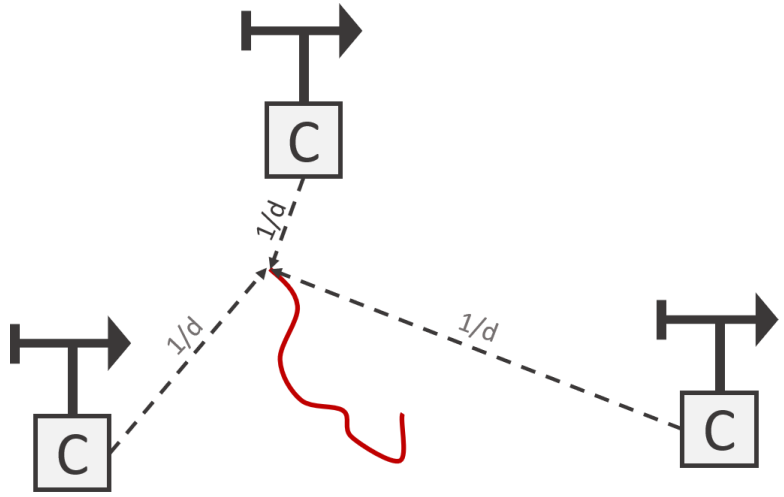
- Influencing factors based on literature:



Weather conditions

Meteorological factors

- Extra factors based on data KNMI
- Measured at departure of route
- Obtained from three closest weather stations
- Inverse distance weighted interpolation



Main meteorological factors	Additional meteorological factors
Average wind speed	Wind direction
Daylight conditions	
Precipitation	Fog Ice formation Snowfall
Temperature	Solar radiation

Breaking down the methodology

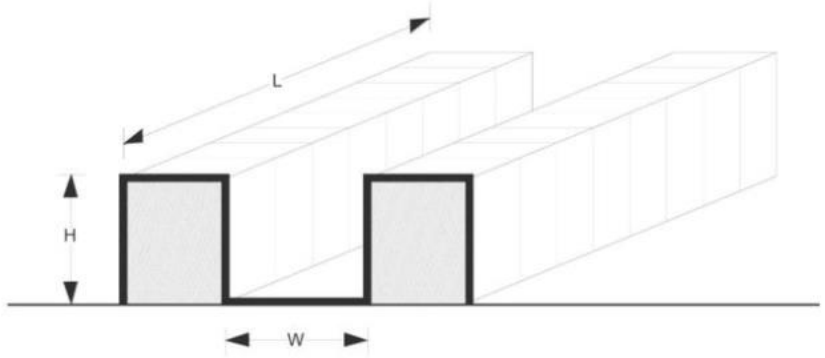
To what extent does the degree of **shelter provided by the built environment** explain cyclist route choice in different weather conditions?

Shelter

Fundament

Street climate design studies:

- Shelter from buildings
- Built environment as **urban canyons**
- Metric: height/width ratio of urban canyon
- Minimum ratio to find shelter:
  - Closed canyons: **H/W > 0.4**
  - Half-open canyons: **H/W > 0.8**



[1]

Shelter

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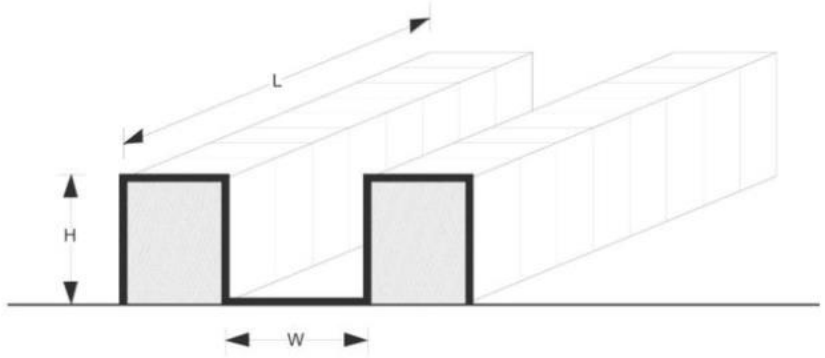

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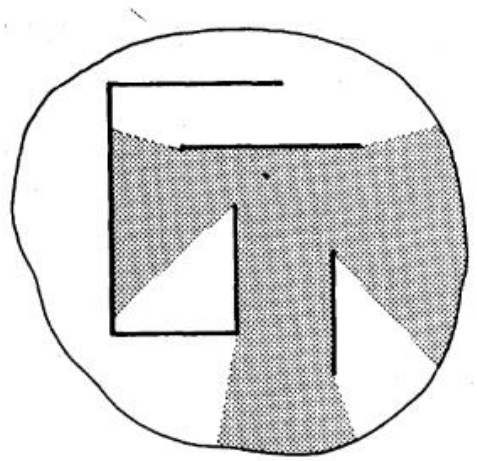
Visibility studies:

- Isovist
- Using more detail to describe built environment geometries
- Set of all **visible points** from a point in space in relation to surrounding environment



[2]

Shelter
Fundament

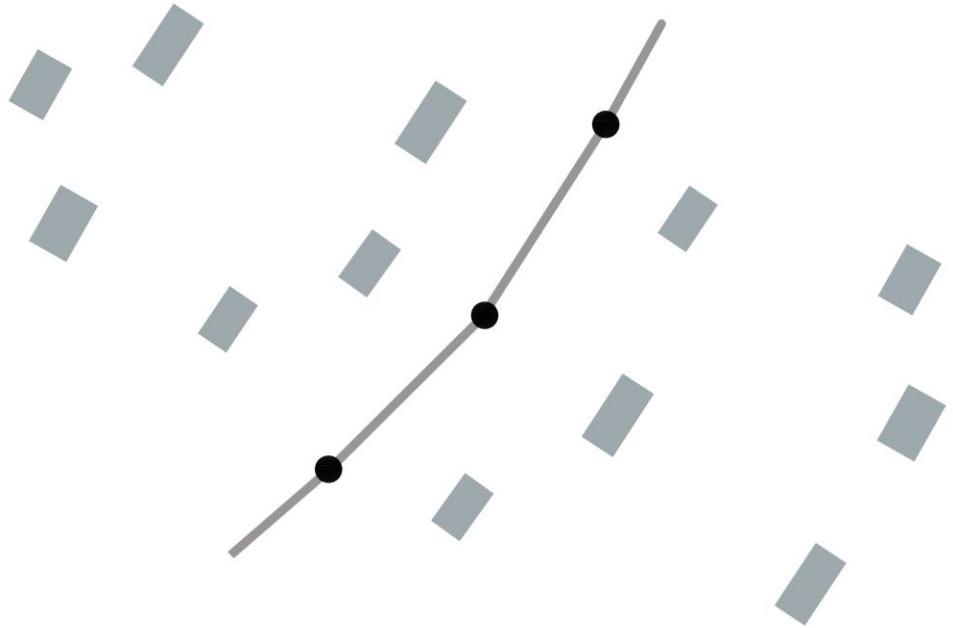
Why a new method?

- Many routes through different types of built environment
- High level of detail needed to expose differences in shelter along a route
- Integrate aspects of urban canyon method in Isovist
- Expanded with vegetational shelter (tree density) as a separate factor

Shelter

Metrics

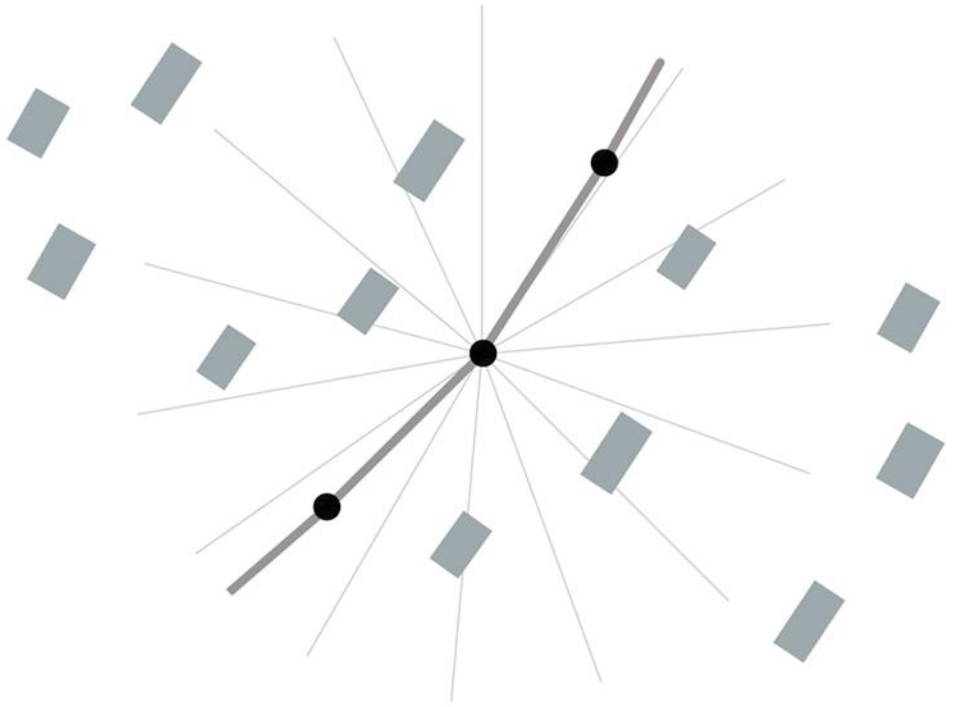
- Sampled over the bicycle road network
- Within fixed distance of each other
- Contain elevation value
- Vegetational shelter: tree density



Shelter

Metrics

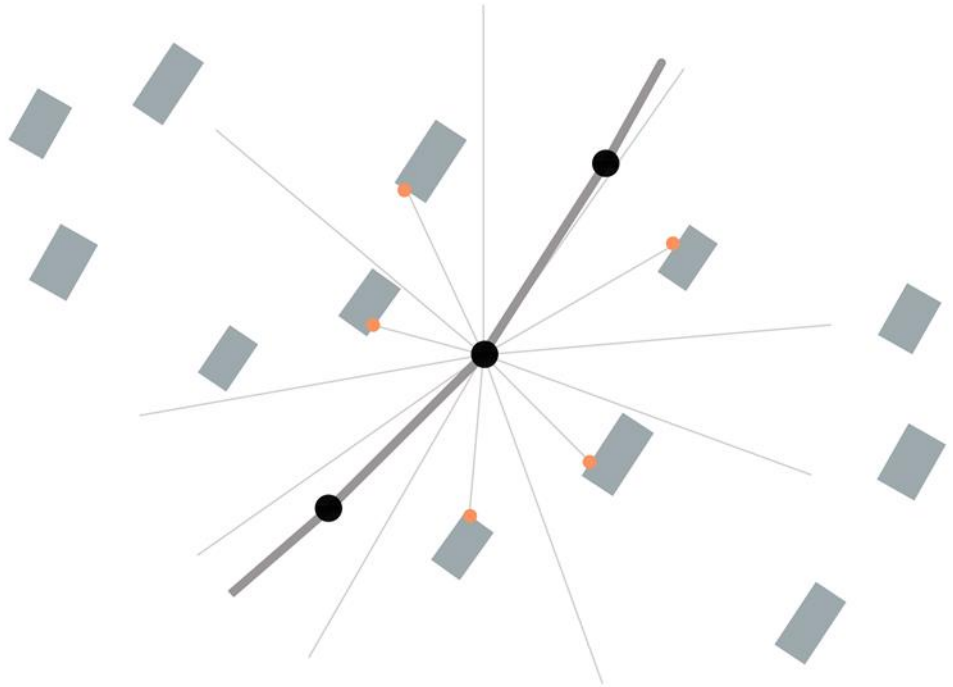
- Rays every 10 degrees



Shelter

Metrics

- Find buildings intersecting with ray



Shelter

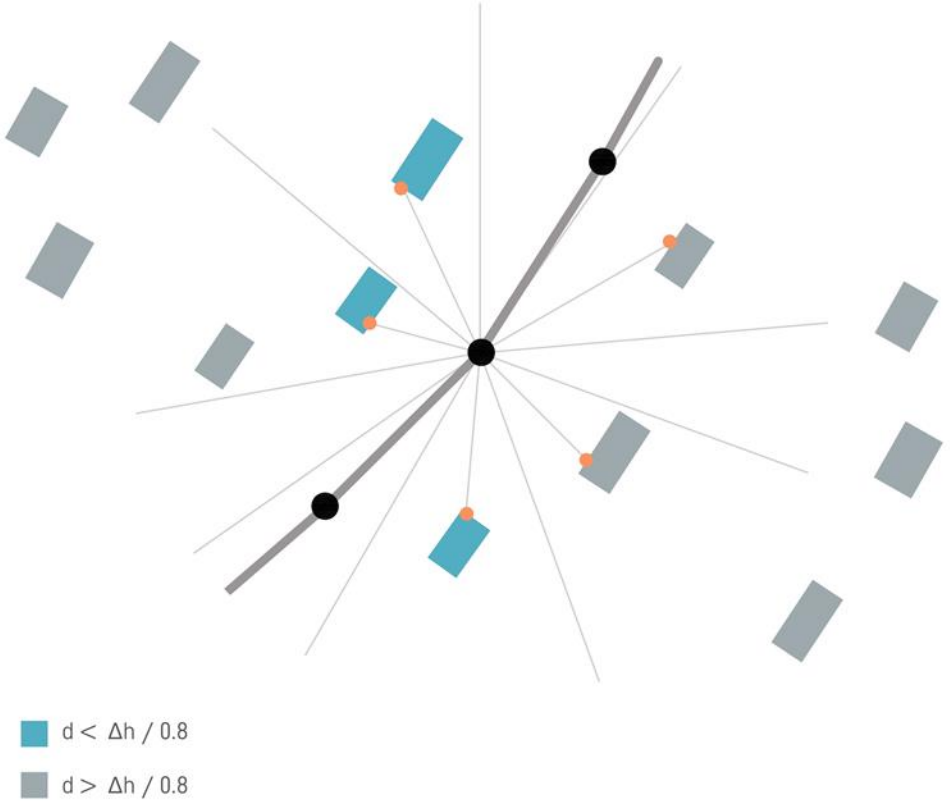
Metrics

- Buildings stored as set of segments
- Both rays and segments stored in parametric form:
  point(x,y)+direction(x,y)*t
- When ray and segment intersect: (x,y) component will be equal

Shelter

Metrics

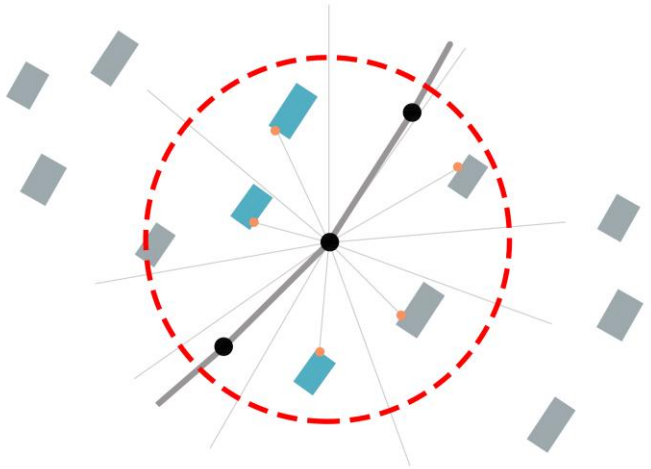
- Closest intersecting building
- Should provide at least minimum shelter: **distance < Δh/0.8**



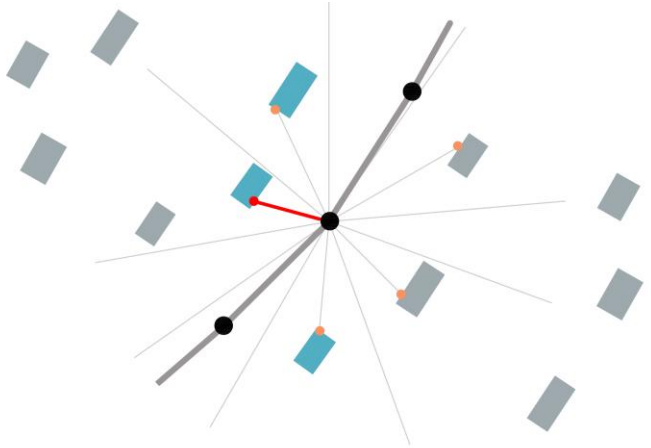
Shelter

Metrics

- Mean shelter = $\frac{\sum_1^n \frac{Height\ object - Height\ sample\ point}{Distance\ to\ object + Height\ delta}}{Number\ of\ rays}$



- Maximum shelter = $\max \frac{Height\ object - Height\ sample\ point}{Distance\ to\ object + Height\ delta}$

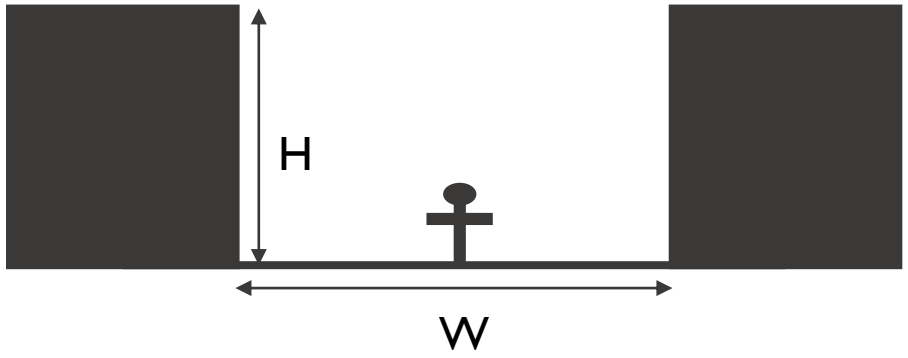


Shelter

Why two factors?

Closed urban canyon:

- High mean building shelter



Shelter

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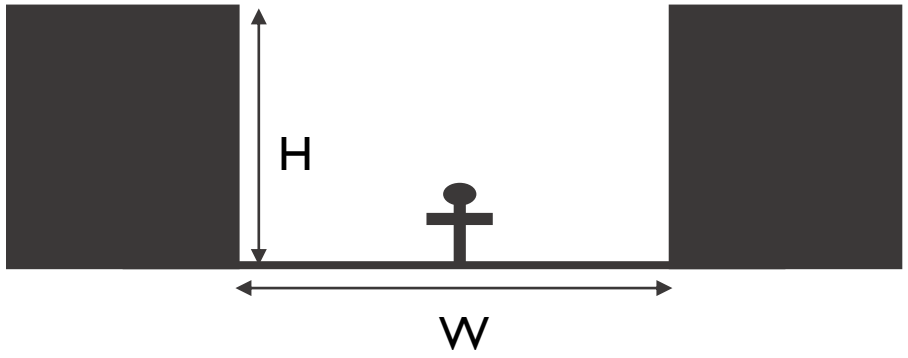

Open urban canyon:

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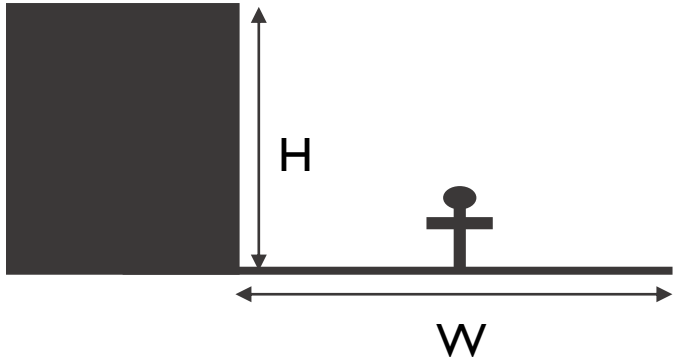

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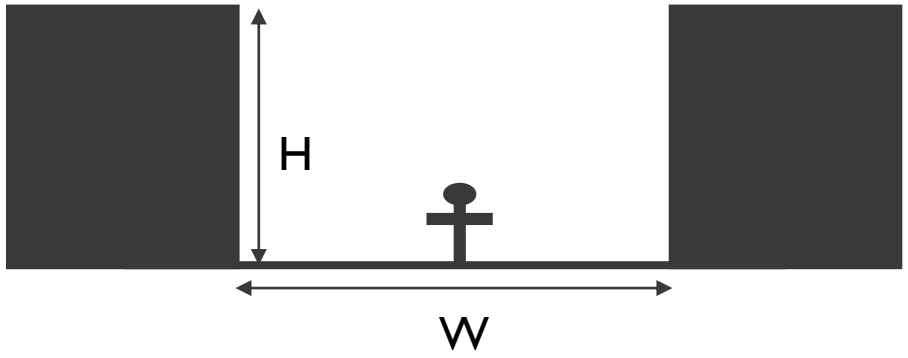

Open urban canyon:

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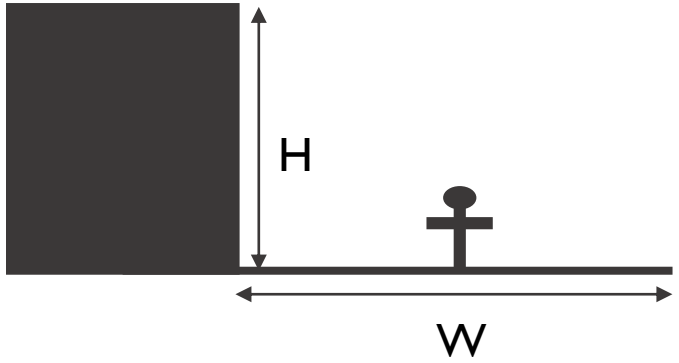
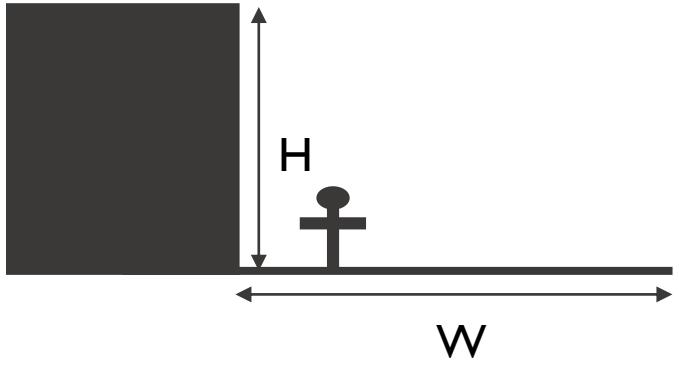


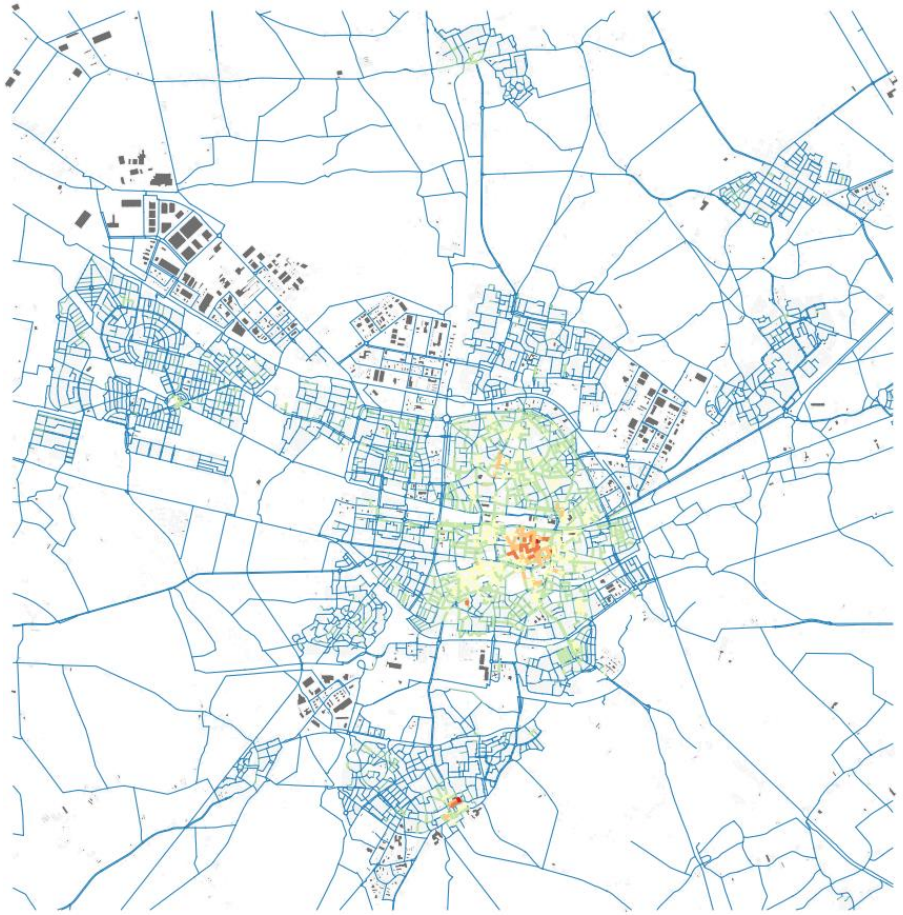
Close to building

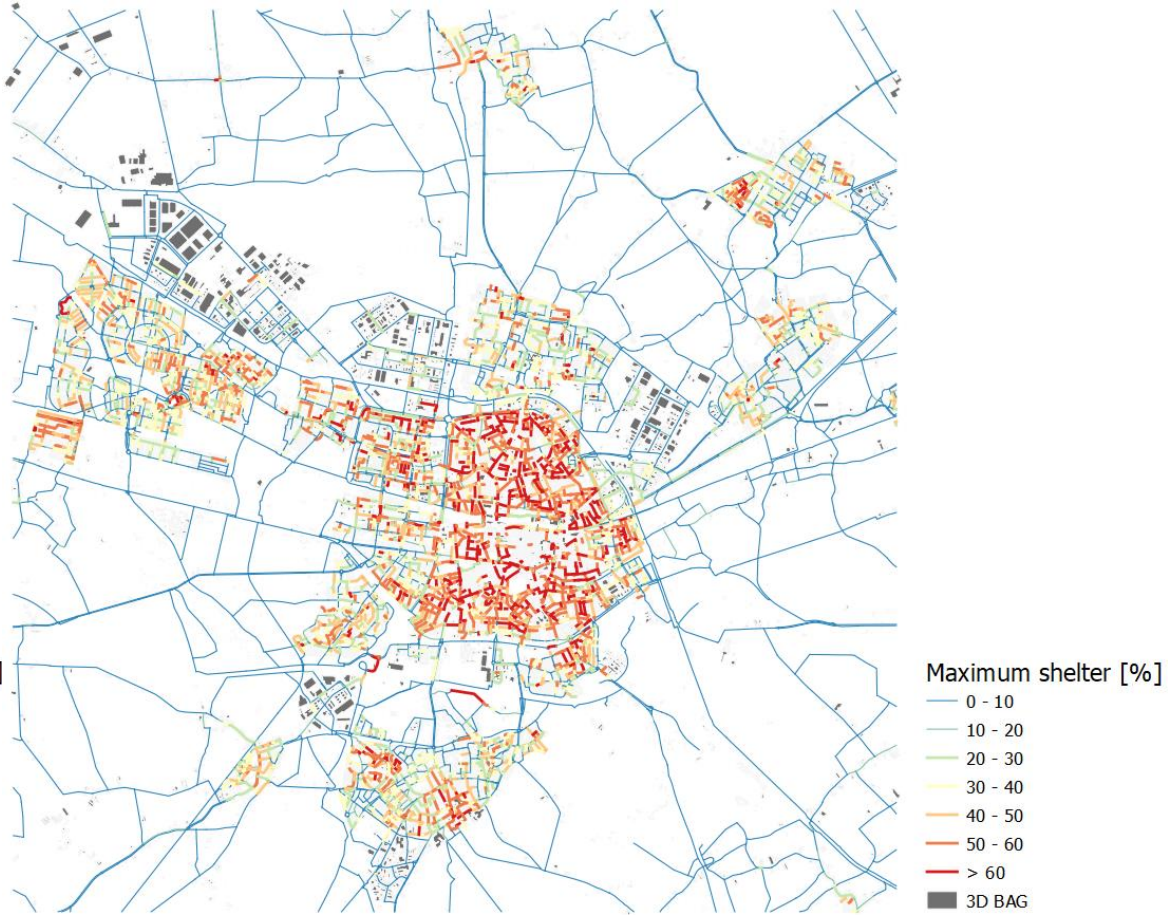
- Low mean building shelter
- Substantial shelter from building → Maximum shelter as measure



Shelter

Distribution over study area



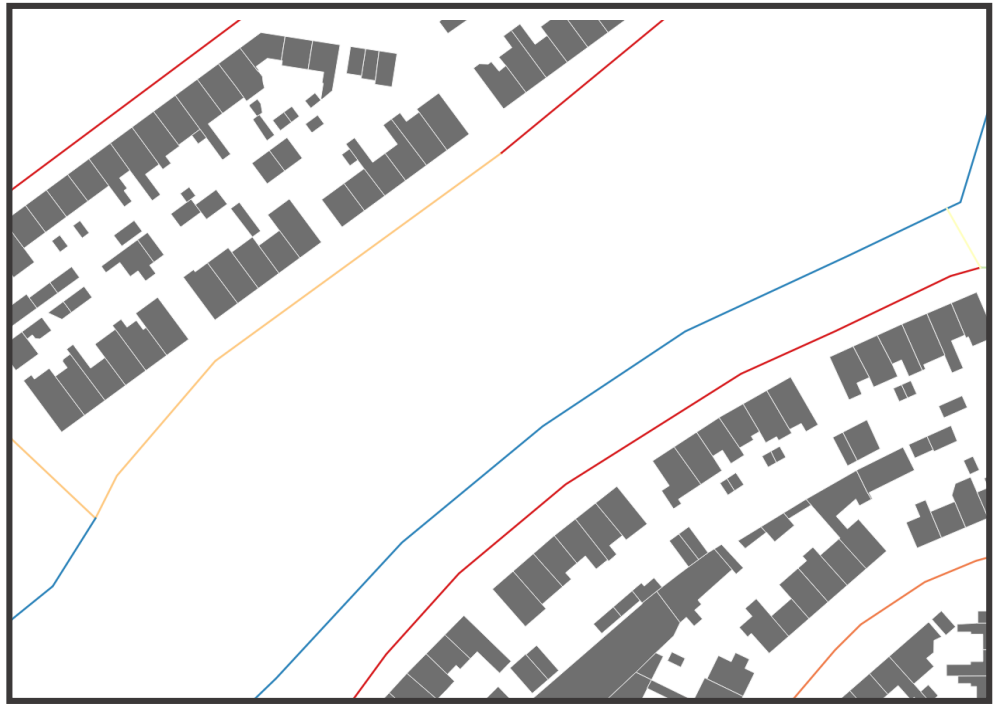


Shelter

Mean vs. maximum building shelter

Mean building shelter

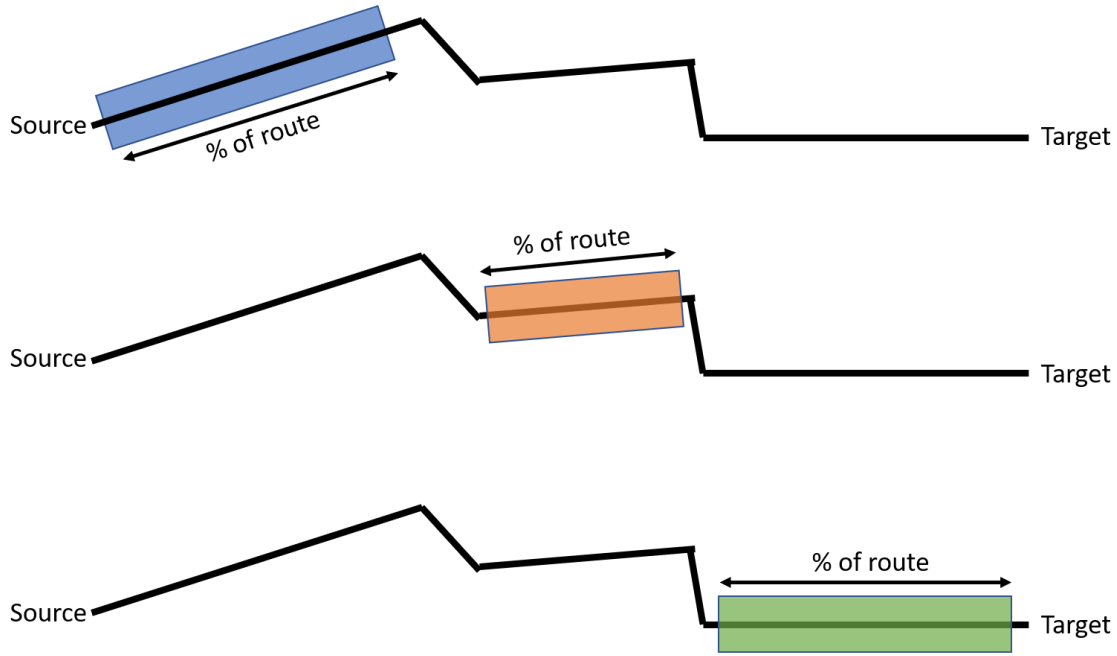
Maximum building shelter



Shelter

Aggregation on route-level

- Mean building shelter > 25%
- Maximum building shelter > 50%
- Tree density > 50%



3. Results

Results

Regression models

Route:

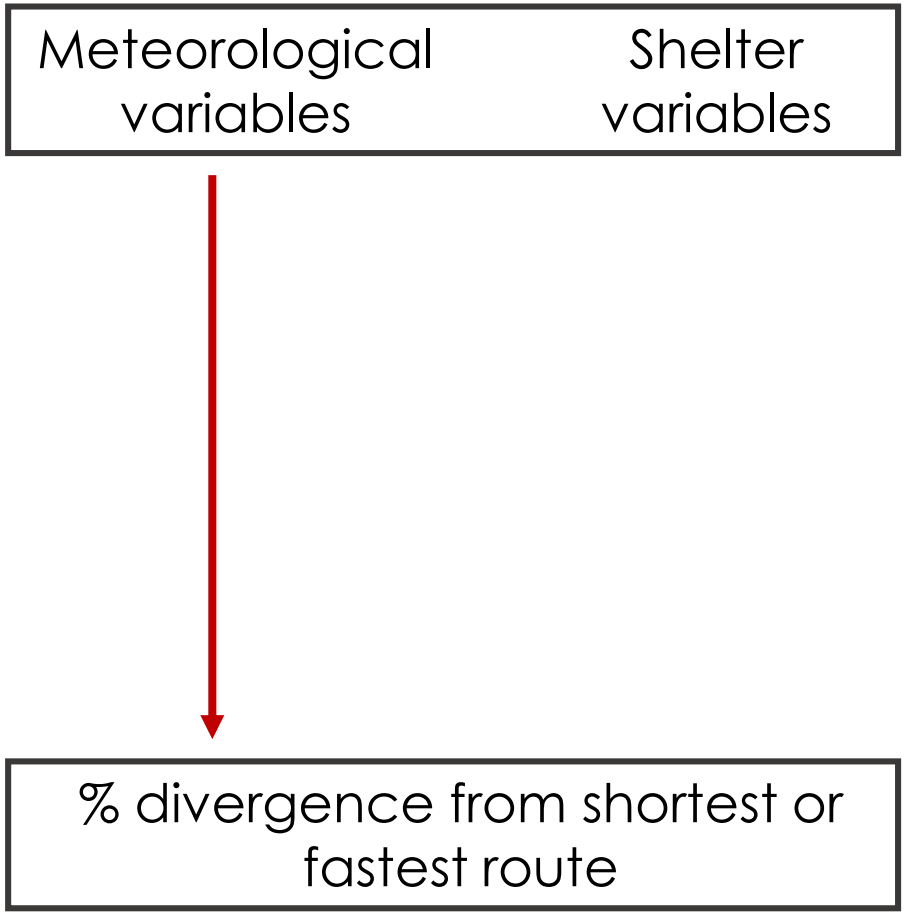
Meteorological variables	Shelter variables

% divergence from shortest or fastest route

Results

Regression models

Route:



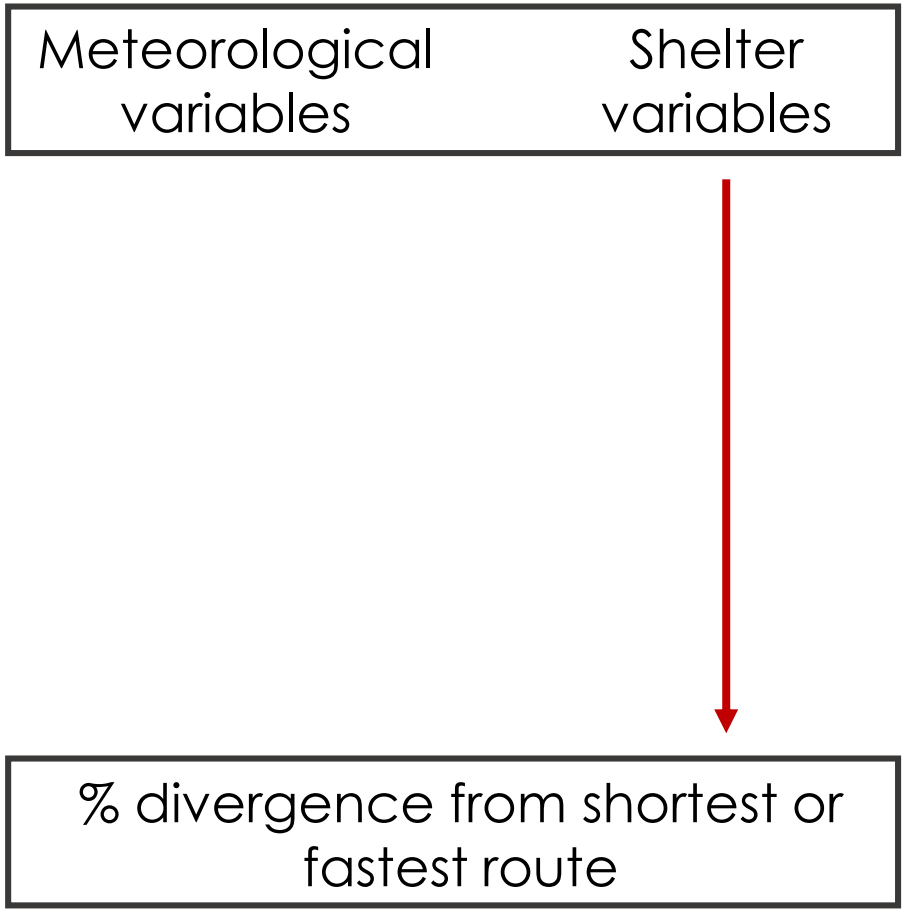
Model 1:

- Meteorological factors

Results

Regression models

Route:



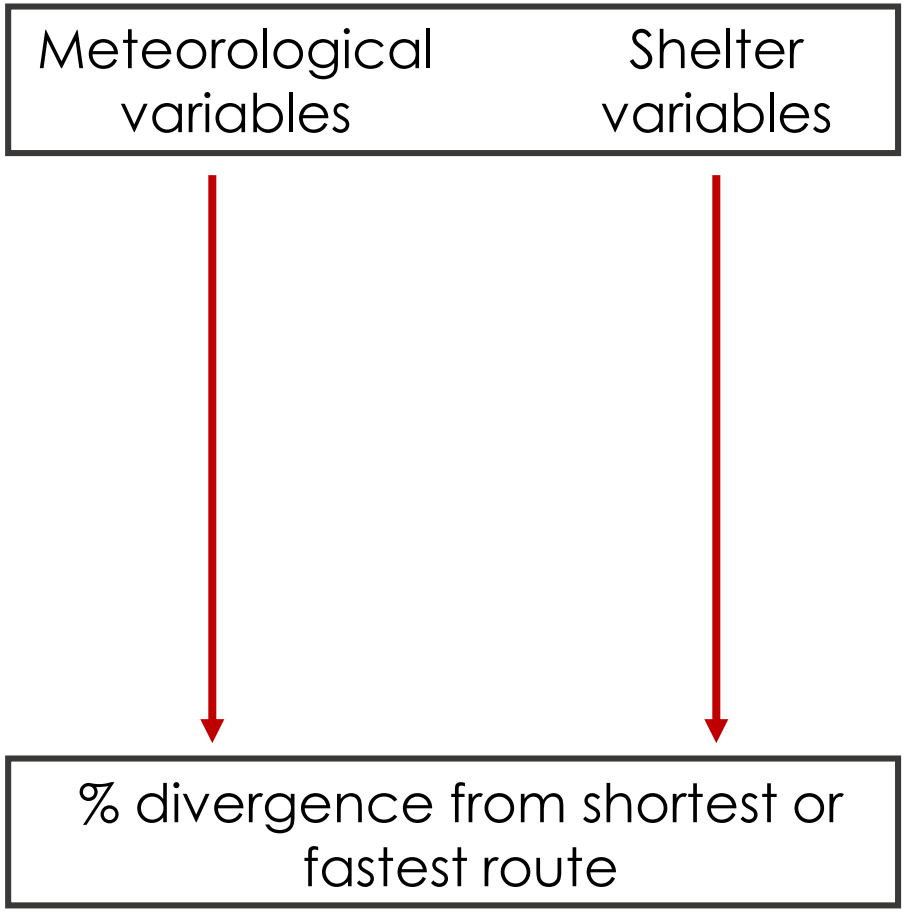
Model 2:

- Shelter factors

Results

Regression models

Route:



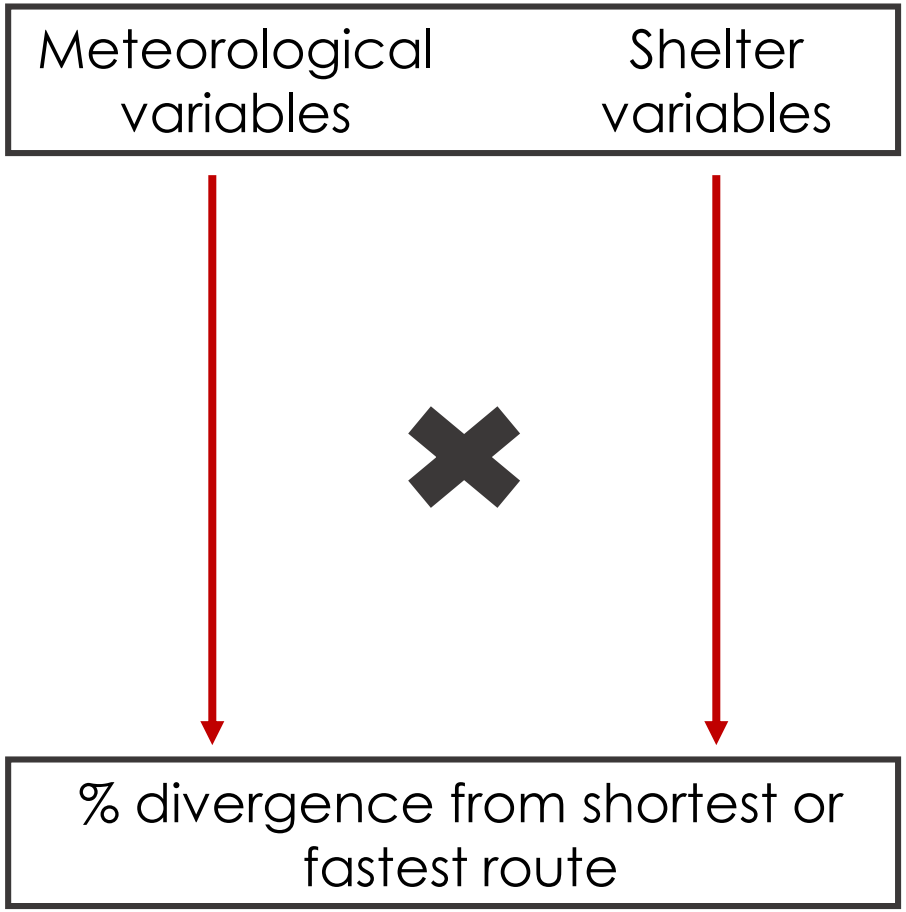
Model 3:

- Meteorological factors
- Shelter factors

Results

Regression models

Route:



Model 4:

- Interactions between meteorological and shelter factors

Results

Regression models

Route: Meteorological variables

% difference between observed and shortest/fastest route

- Mean building shelter
- Maximum building shelter
- Vegetational shelter

Model 5:

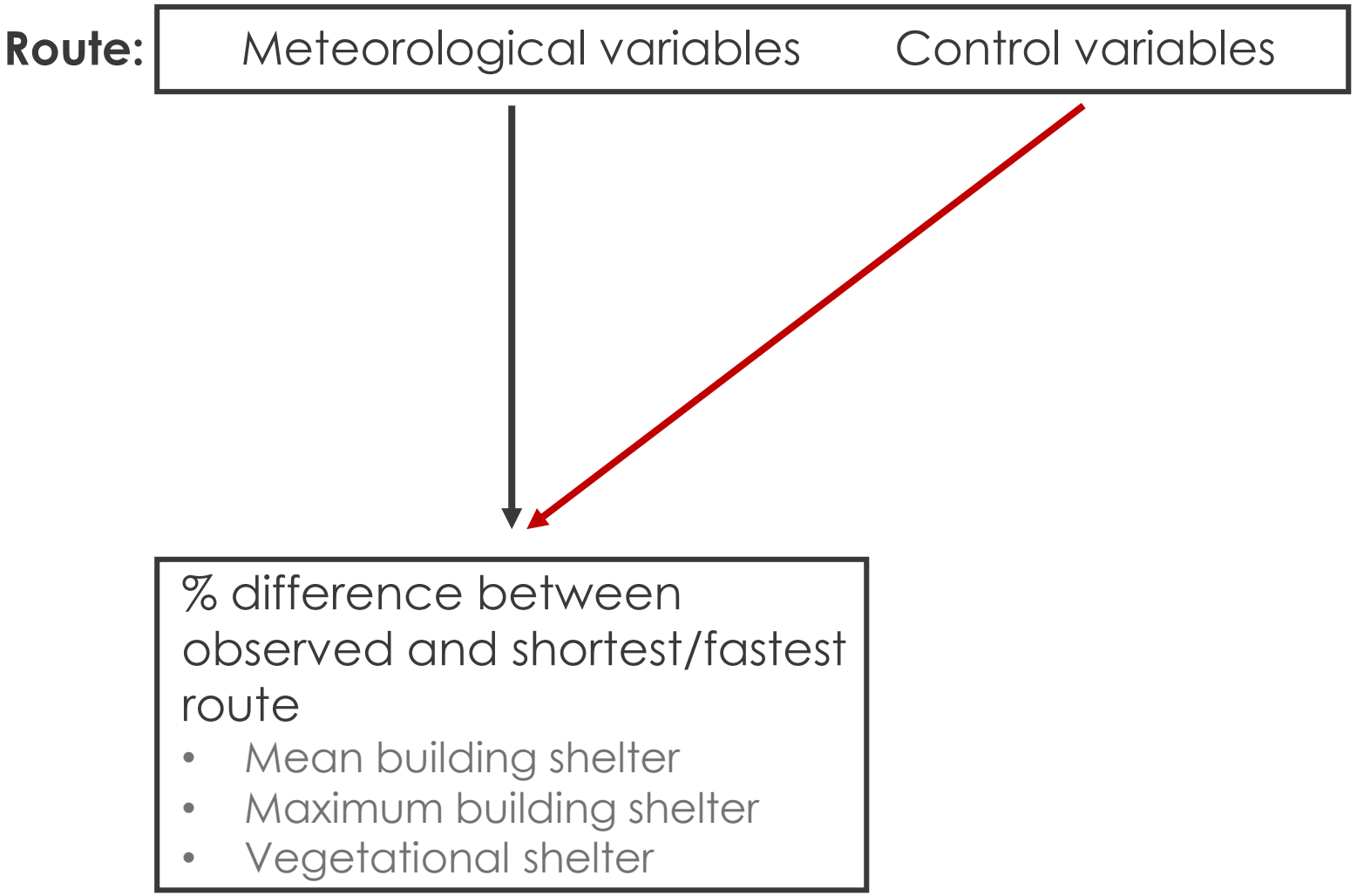
- Adaptation of route choice to shelter factors

Results

Regression models

Create context:

- Individual characteristics
- Infrastructural characteristics
- Environmental characteristics

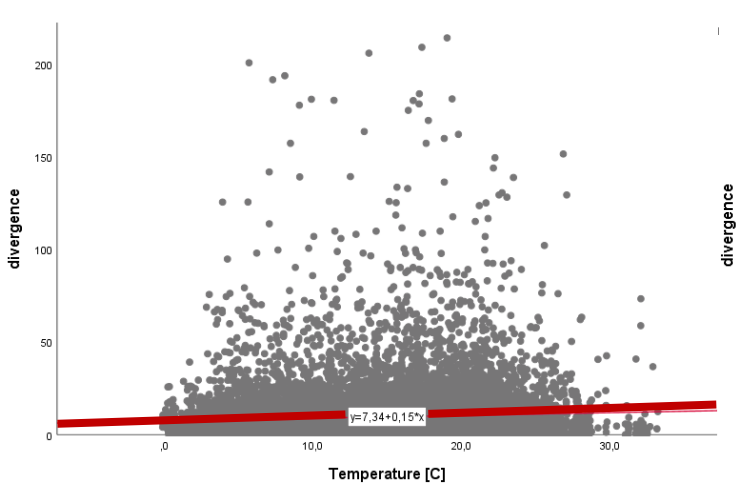


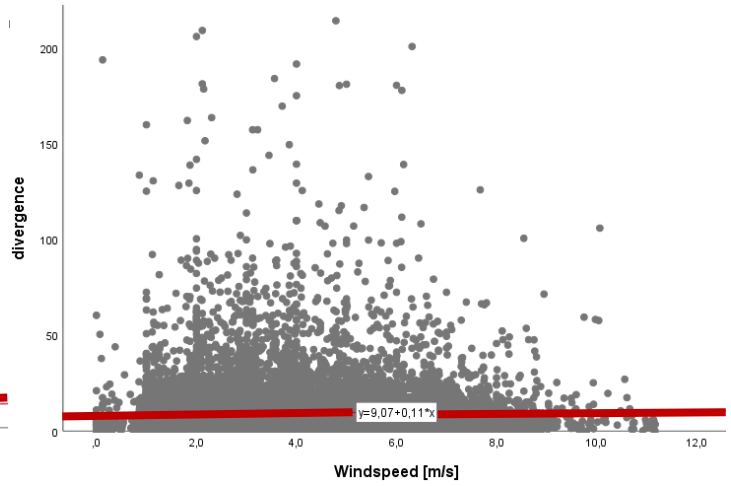
Results

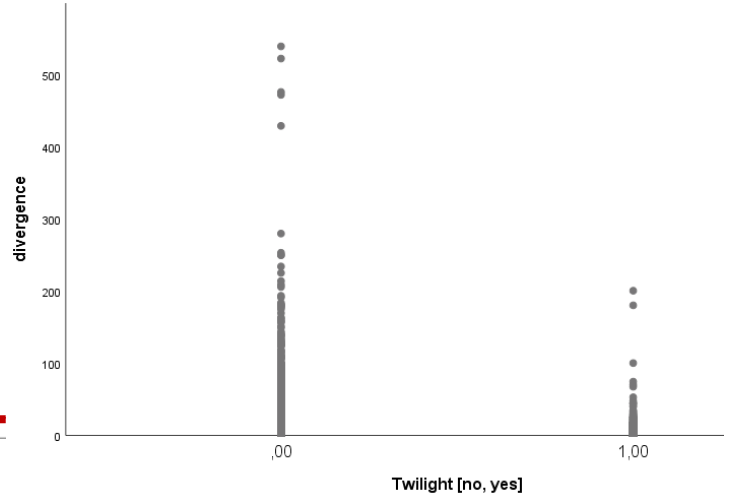
Influence of weather

Model 1:

- Moderate effects of **temperature**, **windspeed**, and **cycling during twilight**
- No significant effects for fog, precipitation, solar radiation, wind direction, and cycling without daylight
- Barely any routes with ice or snow measurements





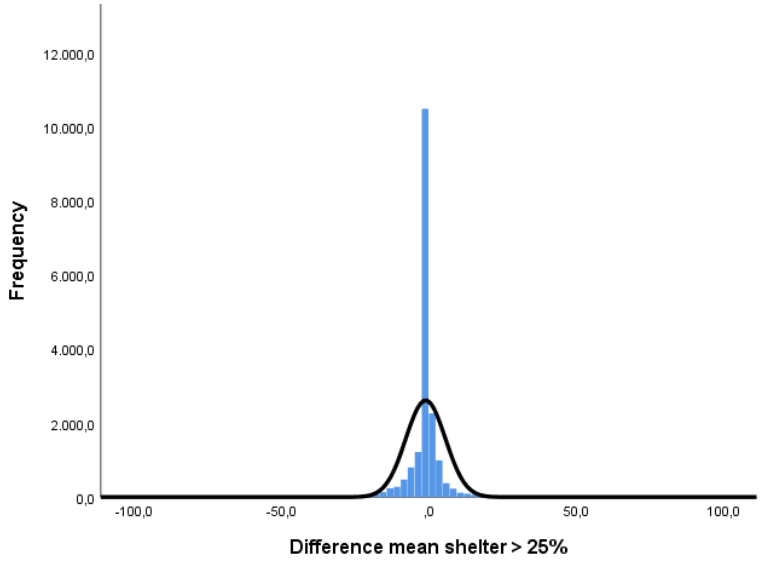


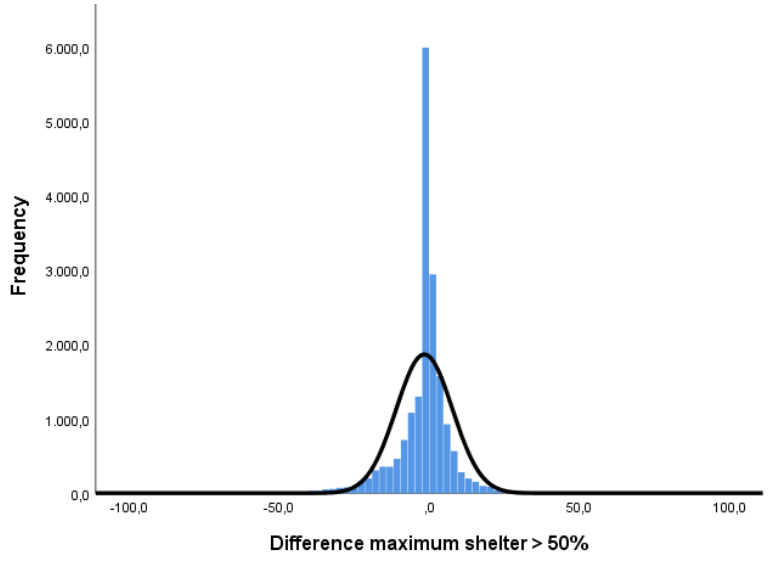
Results

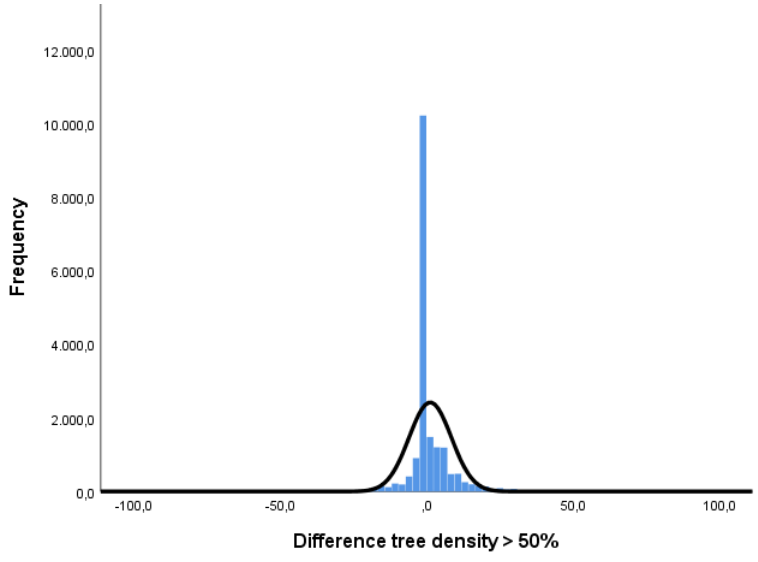
Influence of built environment shelter

Model 2:

- Divergence **negatively** influenced by building and vegetational shelter
- Cyclists seek for lower degrees of built environment shelter when diverging
- Effects are limited: little variation between observed and shortest/fastest routes
- No clear indication which factor is a better descriptor of building shelter







Results

Influence of built environment shelter

Model 3:

- The effects of meteorological and shelter variables do not change

Model 4:

- **No substantial** interaction effects between meteorological and shelter variables
- Shelter variables do not explain the effect of weather on route choice

Model 5:

- For three shelter variables: limited influence of **temperature** and **windspeed**
- Building shelter mainly explained by infrastructural characteristics
- Tree density mainly explained by environmental characteristics

4. Conclusions

Conclusions

Main findings

Shelter by the built environment **cannot** be considered as an explanatory factor for cyclist route choice in different weather conditions

Conclusions

Main findings

Shelter by the built environment **cannot** be considered as an explanatory factor for cyclist route choice in different weather conditions

- Utilitarian cyclists are moderately influenced by weather conditions
- Strong preference for shortest/fastest route
- No divergence to obtain more building or vegetational shelter
- Cyclists did not adapt route choice to degree of shelter based on weather conditions

Conclusions

Discussion

- No mitigation of weather conditions through built environment shelter
- Minimization of travel distance/time as strategy to minimize exposure to weather
- Policies should focus on fast travelling
- Mainly based on routes through urban areas
- **Boundary problem:** majority of routes through city

Conclusions

Future work

- Qualitative research on perception of shelter
- Application on larger study area
- Integrated weather conditions
- Different approach vegetational shelter

Thank you!

References

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