inter.noise
HAMBURG 2016

# Spectral Noise Measurements supply Instantaneous Traffic information for Multidisciplinary Mobility projects

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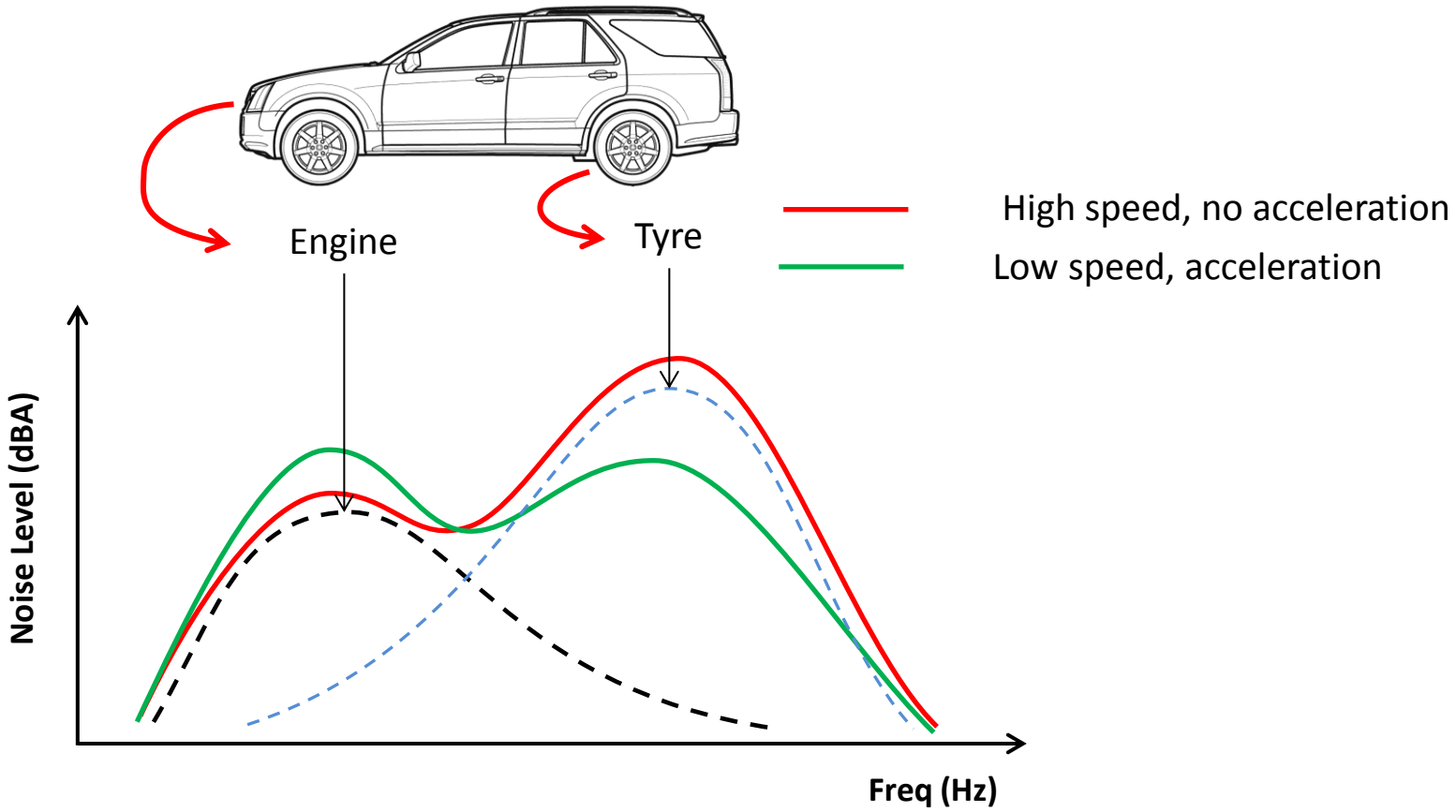
Bert De Coensel and Luc int Panis

# Spatial and temporal variability in noise and air pollution

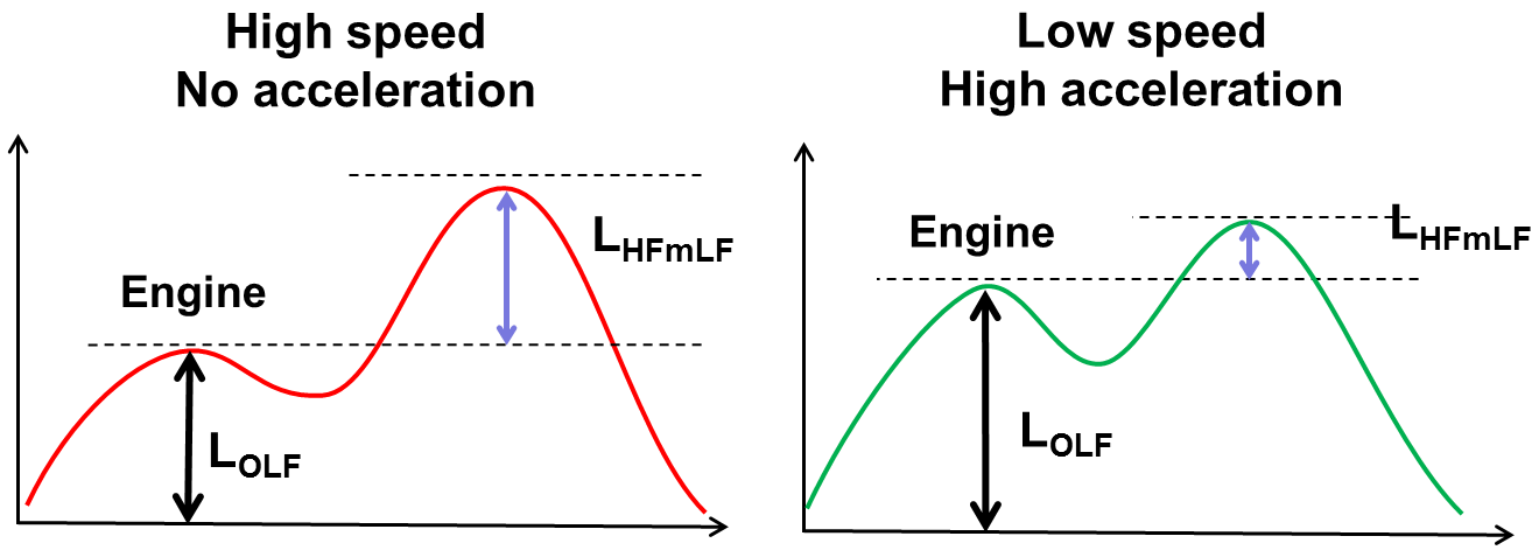



**Did you imagine the matching sound ???**

# How can noise assess traffic dynamics?



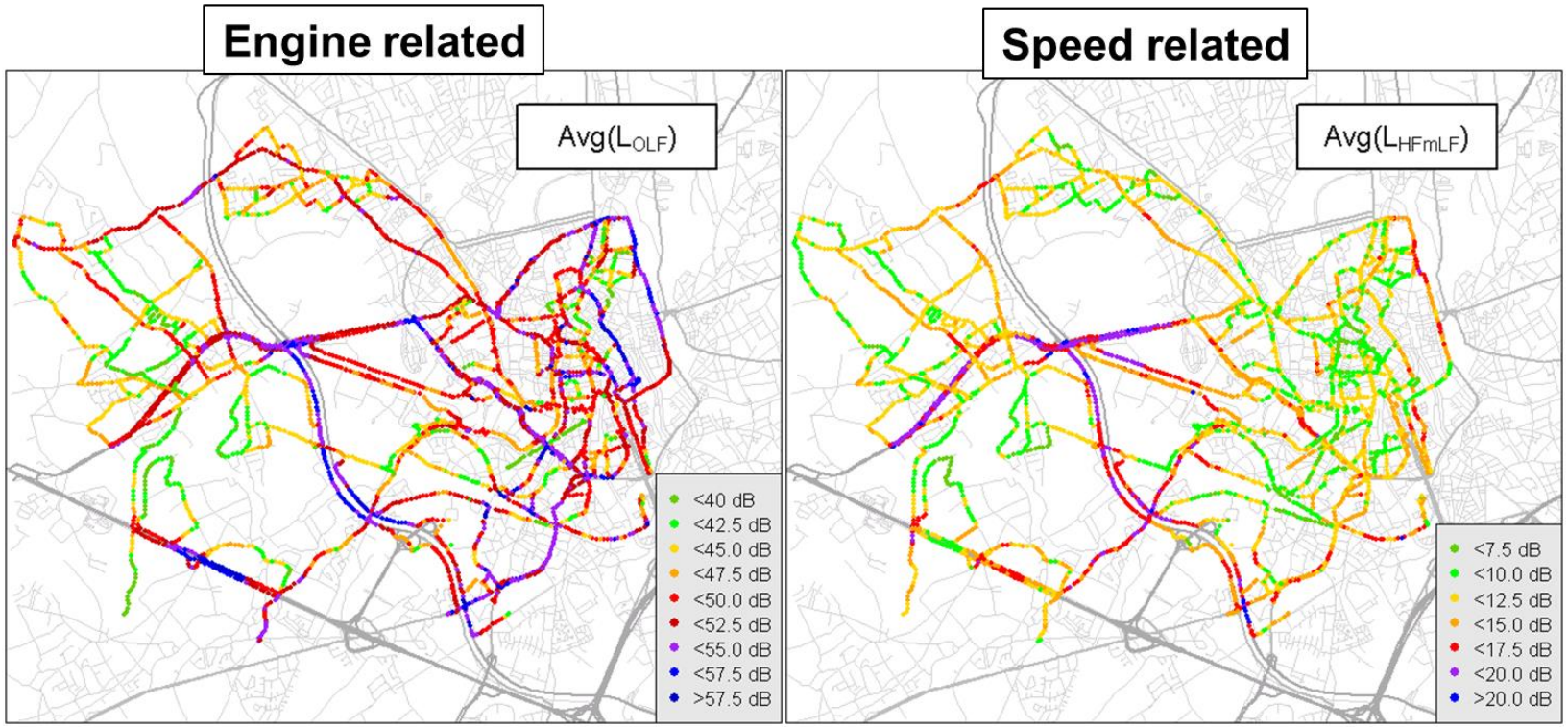
# How can noise assess traffic dynamics?




Dekoninck, Luc, Dick Botteldooren, and Luc Int Panis.
"An Instantaneous Spatiotemporal Model to Predict a Bicyclist's Black Carbon Exposure Based on Mobile Noise Measurements."
ATMOSPHERIC ENVIRONMENT 79 (2013): 623–631.

# Mobile noise mapping to capture spatial resolution






**10 second temporal resolution at average speed of 18 km/h**

**==**

**spatial resolution of 50 m along the road network**

# Linking traffic dynamics to bicyclist's Black Carbon exposure

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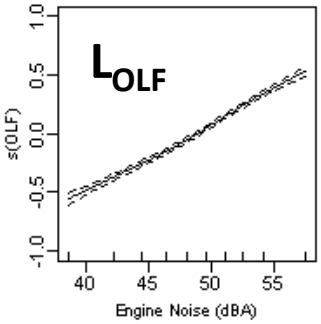
**Tune into Bkg level**

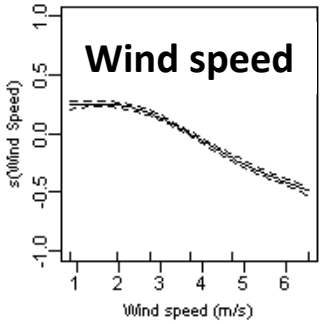
$$BC_{total} = BC_{bgk*} + BC_{local}$$

$$\log(BC_{local}) =$$

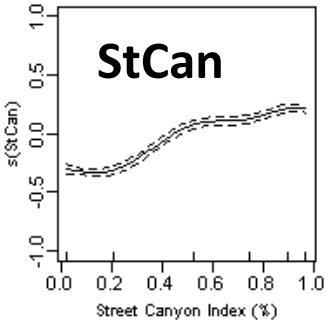
**gam model**



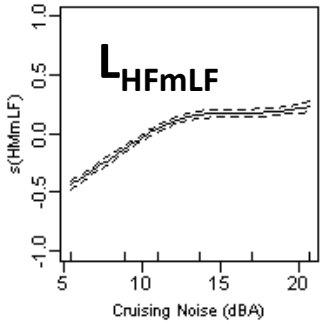

Linear relation with Engine Noise




More wind Lower exposure

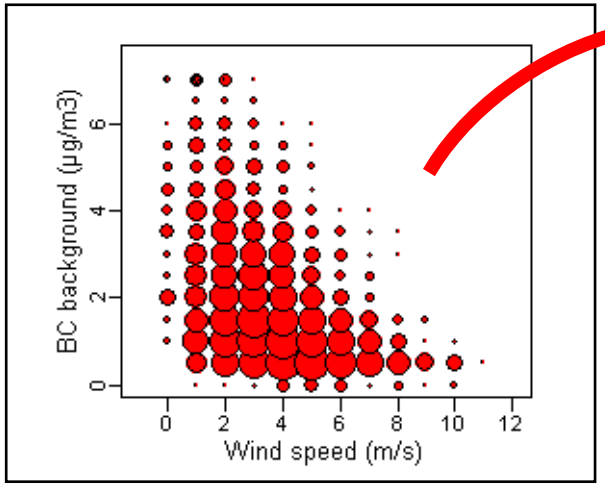



Narrow Street Canyon Higher exposure

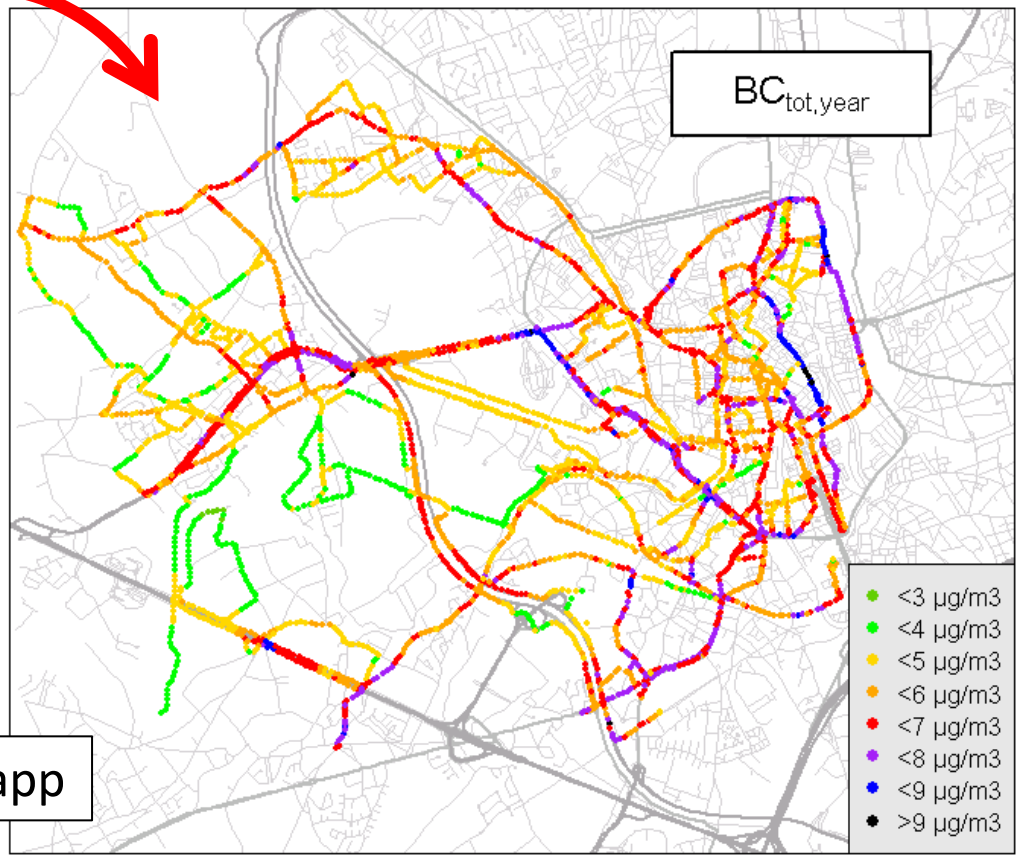



Exposure saturates with traffic speed

# City wide mobile noise mapping




Apply instantaneous model




Meteorological bias resolved

Only four passages required to quantify traffic

Cost layer for bicycle exposure app

Dekoninck, Luc, Dick Botteldooren, and Luc Int Panis.
"Using city-wide mobile noise assessments to estimate annual exposure to Black Carbon.",
*Environment international* 83 (2015): 192-201.

# Benefits of quantifying traffic through spectral noise assessments

- Increase local variability
- Enables spatiotemporal modelling
- **Disentangles meteorological and traffic effects**

- Improves Land-Use modelling
- Route sensitive and activity specific
  Personal exposure assessment possible

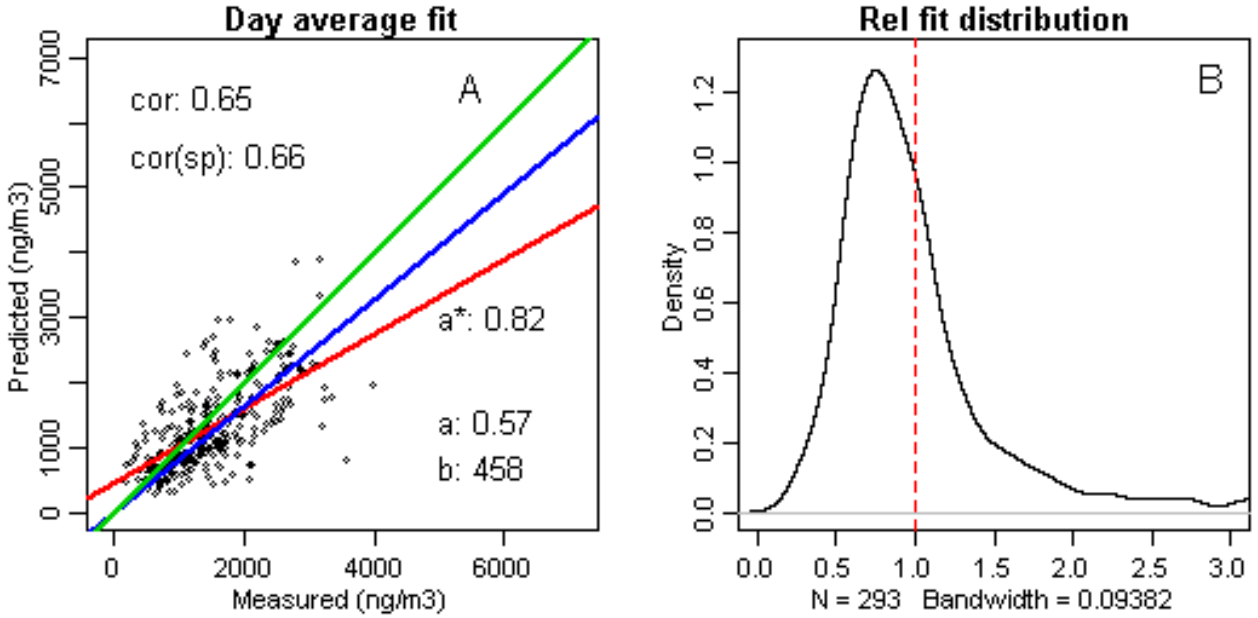
# PhD topic:
## Predict Personal exposure to BC

- Mobile bike and in-vehicle exposure
- Extrapolate to Flemish region
  using noise maps as a proxy

- Activity Specific and Route sensitive models
  - Bike, Car, Indoor (home and work)
  - Instantaneous ‘micro’ Land-Use Regression (µLUR)
  - Non-linear modeling (generalized additive model)
- External validation (VITO measurement campaign)

# PhD:

## Personal exposure to BC




293 person-days, summer and winter

No information of external campaign was used in the activity specific models

# Variability in space and time for noise/air pollution

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**Spatial information**

**City wide spectral mobile noise measurements**

**Temporal information**

**Can we do something similar at fixed (dwelling) locations ?**

# Pilot:

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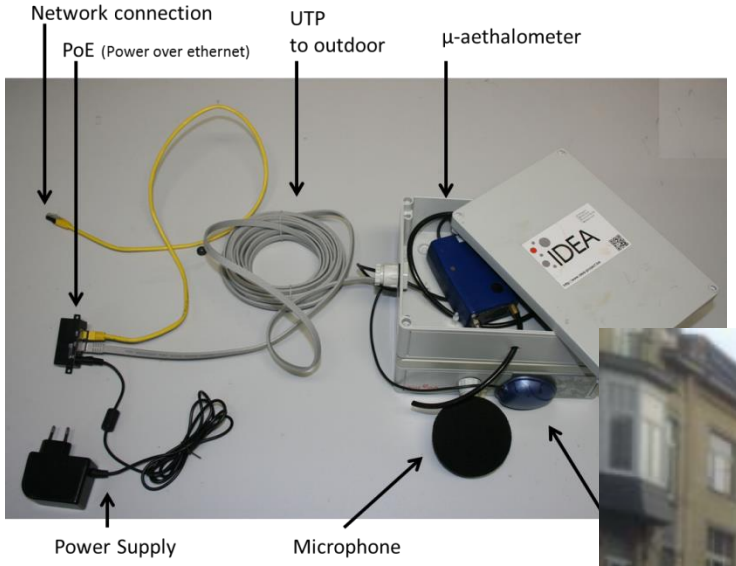
## Exposure at facade in busy street



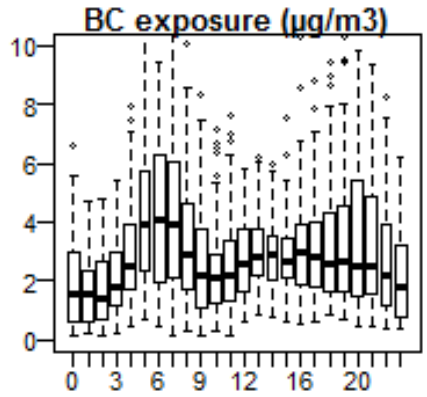

Busses
Street Canyon


Six weeks
Easter holiday
Large traffic variation
Large meteo variation
Large bkg variation

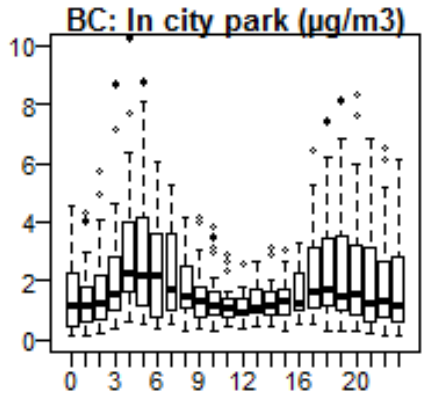
# Pilot (cont.):

## Exposure at facade

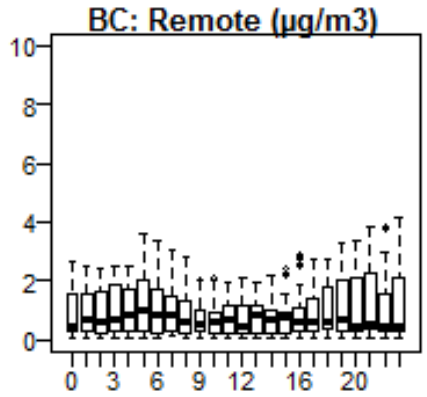
Dwelling

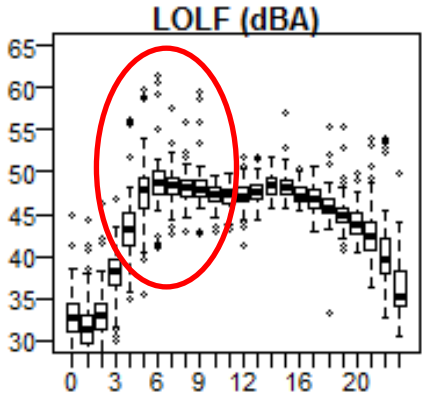


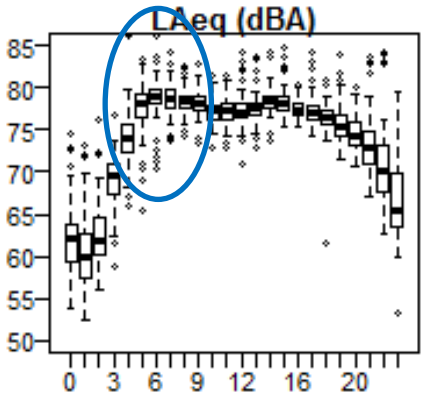

In-city bkg

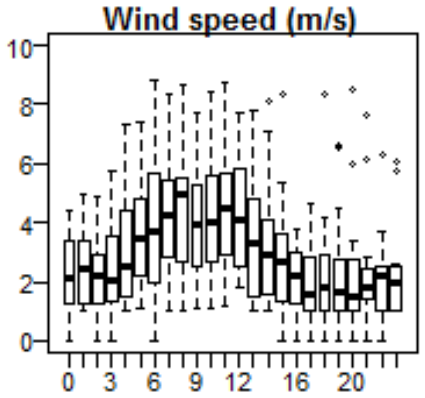



remote bkg



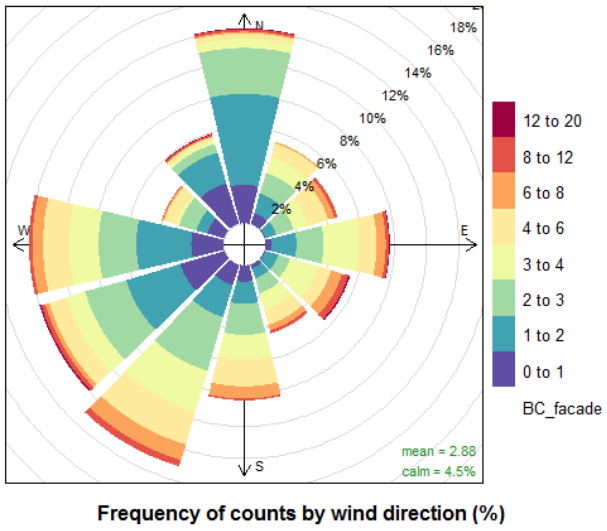



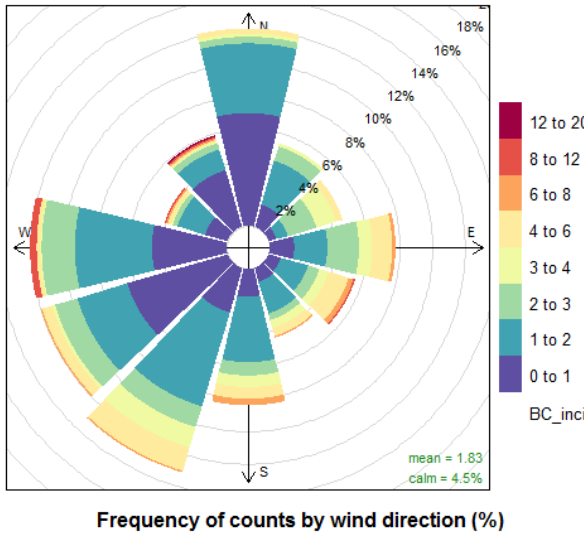
# Pilot (cont.):

## BC exposure by wind direction



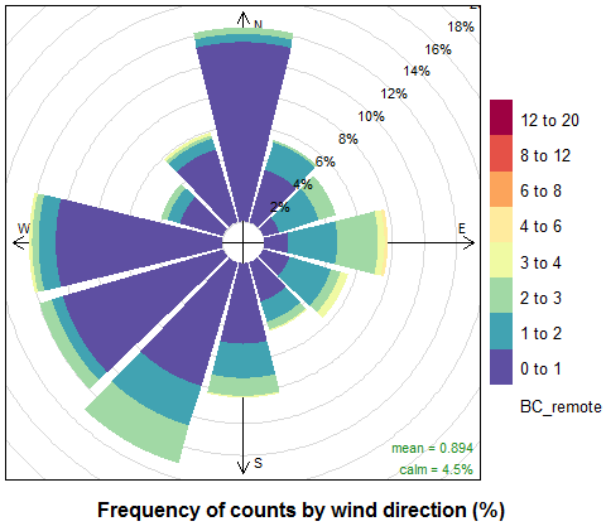

Frequency of counts by wind direction (%)

**Dwelling**
All wind directions
high exposure




Frequency of counts by wind direction (%)

**In-city background**
Selected wind directions
high exposure
Short episodes of high exposure




Frequency of counts by wind direction (%)

**Remote background**
Eastern wind directions
high exposure
Stable atmosphere!!

# Pilot (cont.):

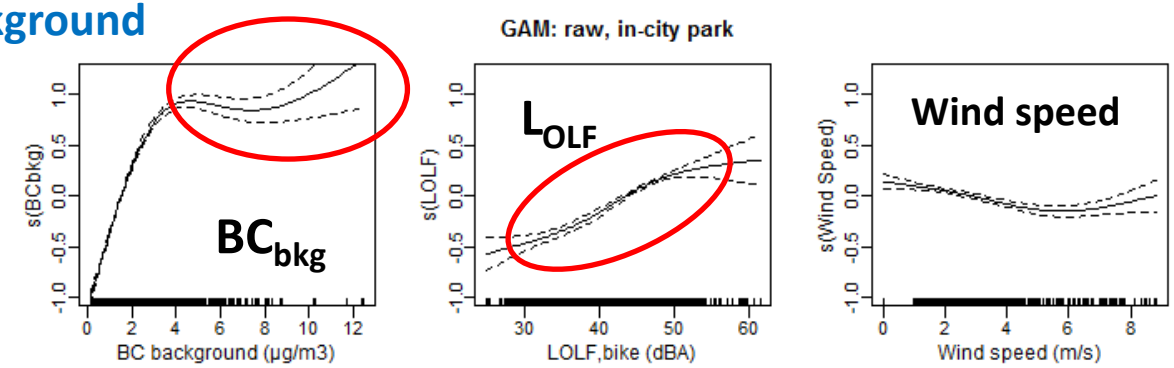
## Overview of the models

| | | | | | F-values | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Background station | Noise parameter | Deviance explained | AIC | Intercept (ng/m3) | log(BCbkg) | Wind speed | Tempera-ture | Noise parameter | # samples |
| Remote background | LOLF,bike | 28.8% | 5290 | 1432 | 17 | 62 | 58 | 218 | 1961 |
| Remote background | LAeq | 28.6% | 5299 | 1432 | 16 | 62 | 57 | 71 | 1961 |
| Remote background | LA50 | 28.3% | 5307 | 1432 | 16 | 60 | 59 | 72 | 1961 |
| Remote background | LA05 | 28.2% | 5310 | 1429 | 17 | 61 | 61 | 66 | 1961 |
| Remote background | LA95 | 26.9% | 5345 | 1430 | 18 | 60 | 64 | 54 | 1961 |
| Near major city | LOLF,bike | 26.2% | 5 | | | | | | |
| Near major city | LA50 | 25.9% | 5 | | | | | | |
| Near major city | LAeq | 25.8% | 5 | | | | | | |
| Remote background | LOLF,eq | 25.1% | 5 | | | | | | |
| Near major city | LA95 | 24.8% | 5725 | 1110 | 77 | 12 | 17 | 96 | 1961 |
| Near major city | LA05 | 23.1% | 5769 | 1106 | 77 | 17 | 22 | 81 | 1961 |
| Near major city | LOLF,eq | 22.8% | 5778 | 1110 | 72 | 4 | 26 | 78 | 1961 |
| In-city park | LOLF,eq | 21.2% | 5359 | 1238 | 49 | 14 | 26 | 49 | 1961 |
| In-city park | LOLF,bike | 20.6% | 5370 | 1237 | 56 | 23 | 20 | 131 | 1961 |
| In-city park | LAeq | 20.6% | 5371 | 1236 | 56 | 23 | 23 | 130 | 1961 |
| In-city park | LA50 | 20.6% | 5371 | 1237 | 55 | 23 | 22 | 130 | 1961 |
| In-city park | LA95 | 20.6% | 5375 | 1238 | 51 | 21 | 18 | 43 | 1961 |
| In-city park | LA05 | 20.0% | 5389 | 1233 | 55 | 21 | 26 | 39 | 1961 |

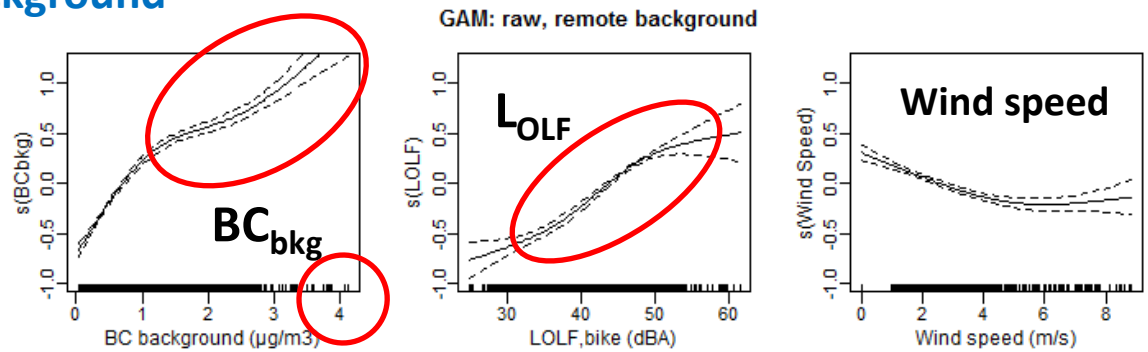
$L_{OLF,bike}$ does not conserves acoustical energy
Best predictor of Black Carbon in the experiment

# Pilot (cont.):
# BC exposure GAM models ($L_{OLF}$)

## In-city background



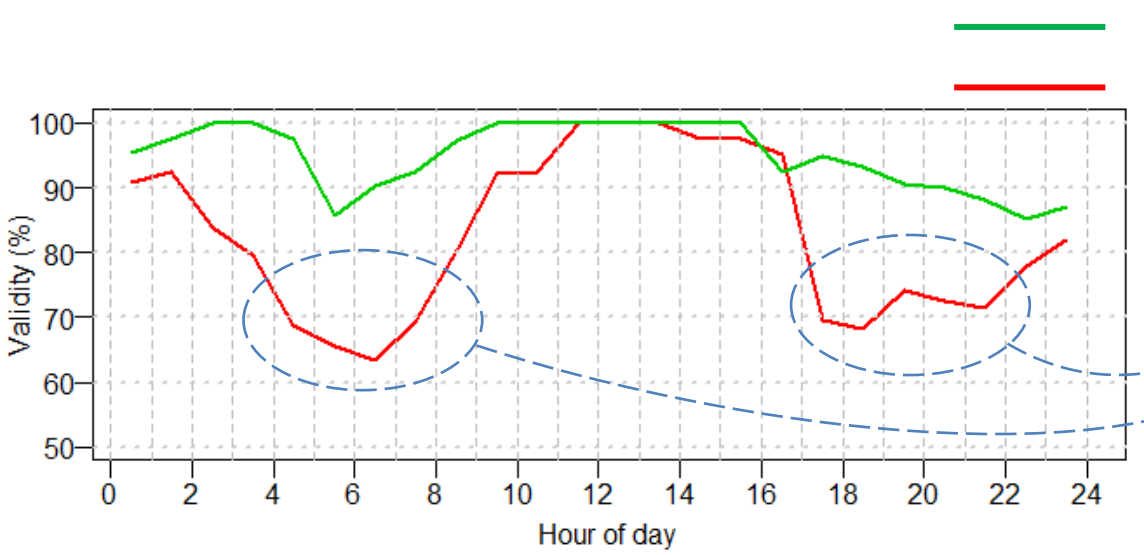

## Remote background



# Pilot (cont.):

## Diurnal pattern in model quality…

Count of 15min episodes
showing correlation between background and dwelling




For 30% of the episodes during rush hour at low wind speed,
the in-city background is **not correlating** with dwelling exposure

**The nearby major road disturbs the in-city background location**

# Overview

## spectral noise…

**Spatial information**

⇩

**City wide**
**spectral mobile**
**noise measurements**

**Temporal information**

⇩

**Longterm**
**multiple dwellings**
**spectral noise measurements**

⇩

**Spatiotemporal models**
**with extreme resolution**

**Future:**
Extend to
multi-dwelling models

# Conclusion

- Spectral noise measurements capture traffic densities and traffic dynamics
- Improves spatial and temporal resolution of traffic
- Simple metrics on standard noise measurements !!!
- Multidisciplinary advantages !!!
  - Enables **disentanglement** of traffic and meteorological effects in air pollution exposure
  - Activity specific and Route sensitive models (µLURs in PhD)
- Future applications:
  - Advances in noise mapping, annoyance evaluations, quality of life, personal exposure for epidemiologists and beyond…