Swiss TPH
Swiss Tropical and Public Health Institute
Schweizerisches Tropen- und Public Health-Institut
Institut Tropical et de Santé Publique Suisse

Department of Epidemiology and Public Health/
Environmental Exposures and Health Unit

Characterizing Vertical Air Pollution Gradients in the Urban Environment

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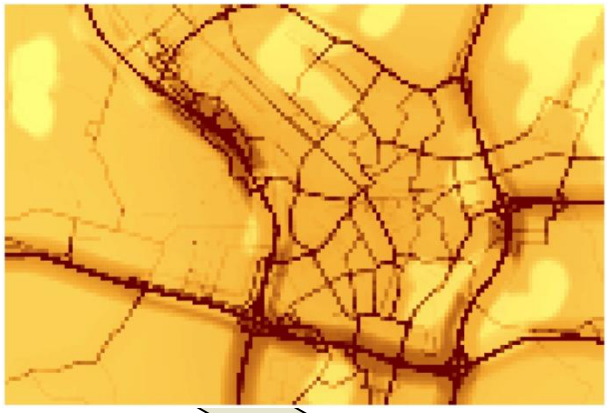
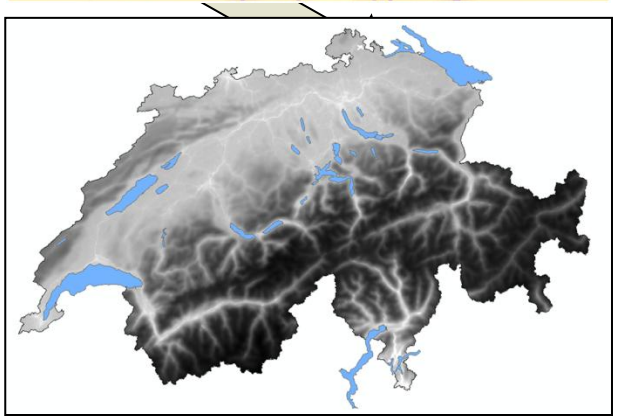
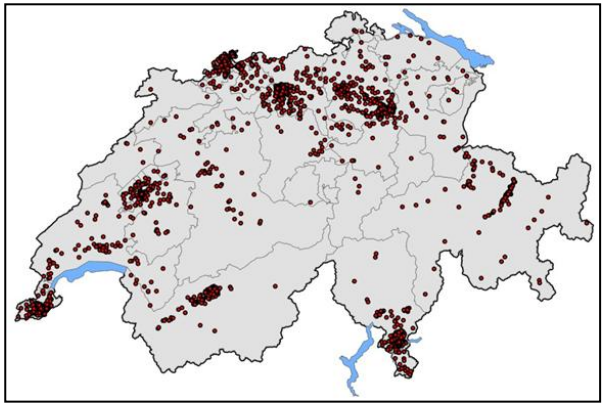
A few measurement sites can serve to obtain high resolution concentration maps and exposure estimates

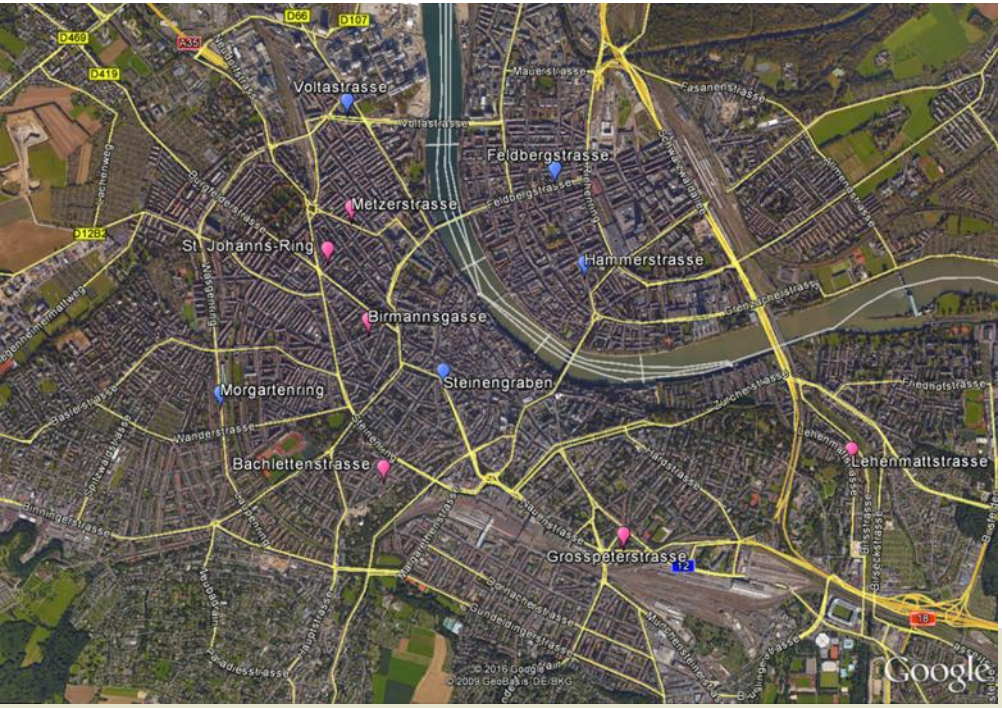






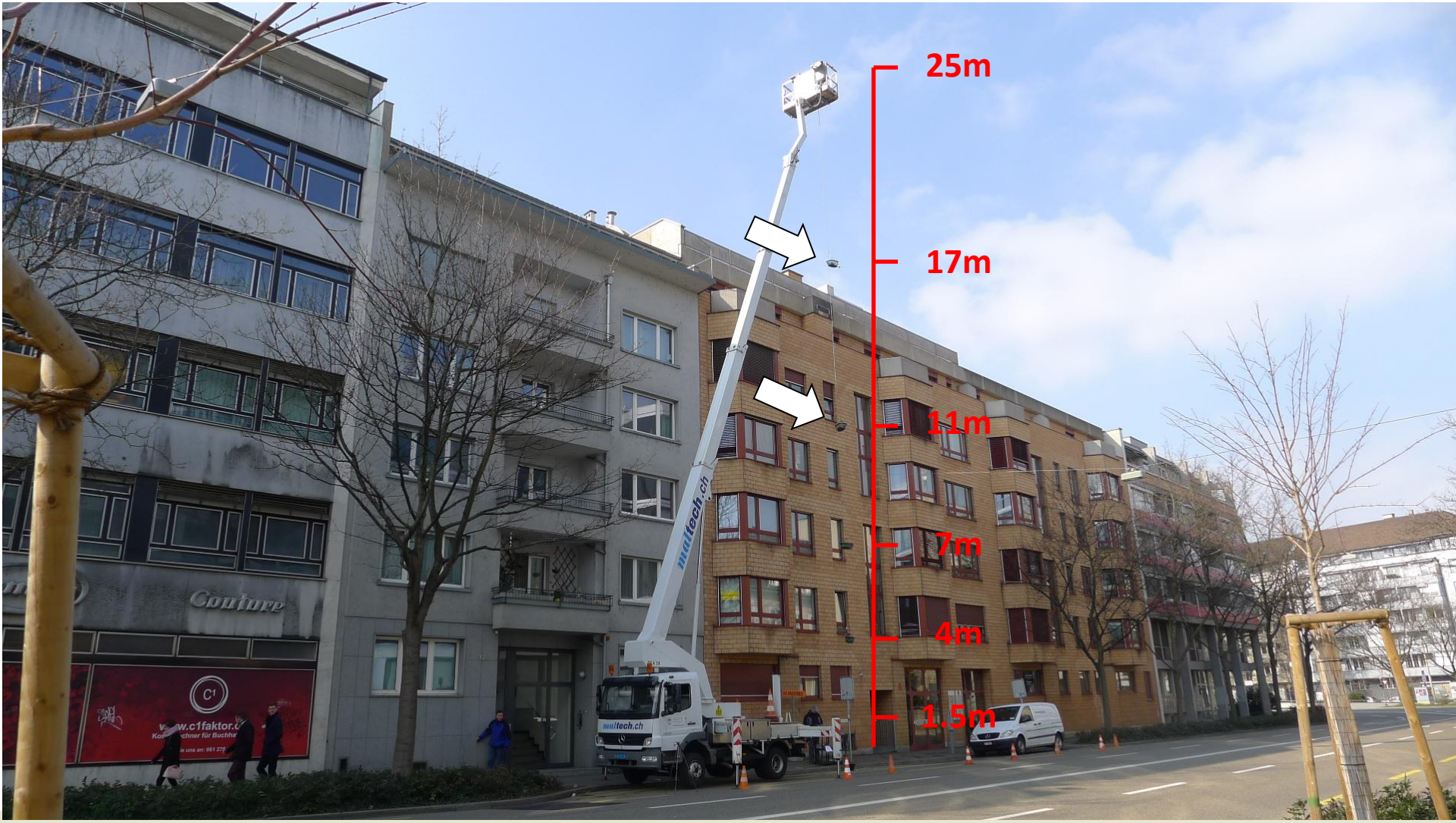
But: if 2 people have the same pixel value on this map: do you have the same residential exposures?

Research question:
Are people living at higher floors differently exposed to air pollution (& noise)?



Study design:

- 11 Streets with different traffic intensity and street configuration in Basel Stadt
- Pollutants:
  - Ultrafine particle count
  - Black carbon
  - Noise
  - Particle size distribution
  - PM2.5
- 30 minute real-time sample
- 2 seasons (summer / winter)
- Up to 6 different heights: (1.5, 4, 7, 11, 17 and 25m)


25m
17m
11m
7m
4m
1.5m
multech.ch
multech.ch

BASKET 3, 7M
13
miniDiSC
BASKET 5, 17M
12
miniDiSC
Model 30
pulsar

Setup of baskets and sampling heights

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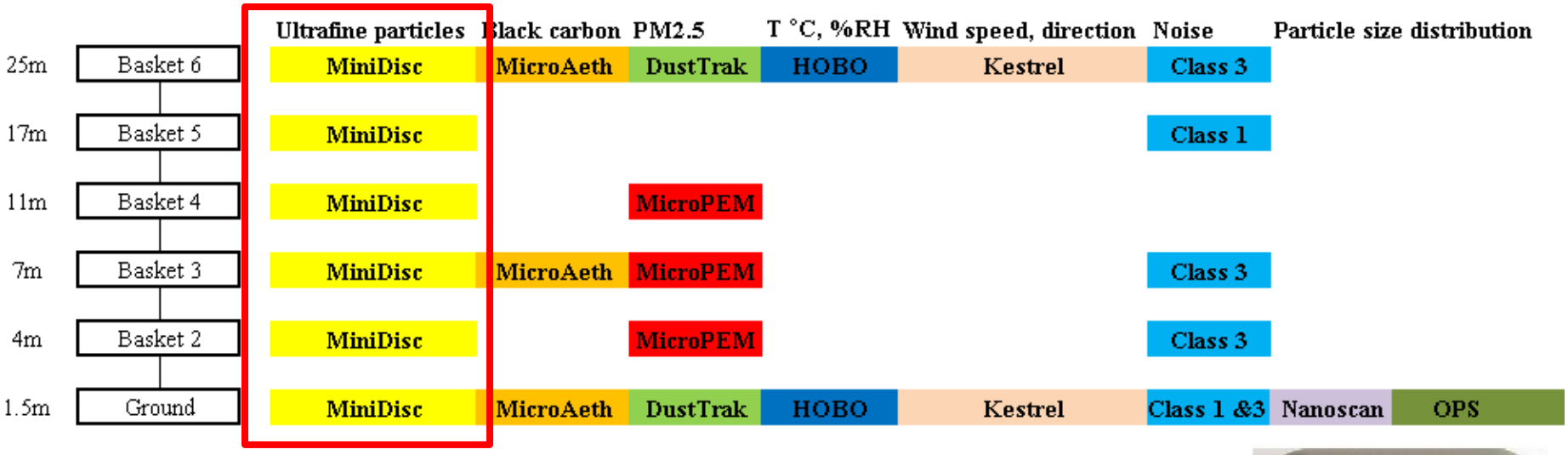

- Miniature Diffusion Size Classifier (MiniDiSC) (Fachhochschule Nordwestschweiz, Switzerland) (Fierz et al., 2011)
- Particles in the size range of 10 to 300 nm
- Flow rate of 1.0 l/min.
- Raw data were collected at 1 second logging intervals

Grosspeterstrasse, Basel
- 896 cars + 52 trucks during 30 minutes
- 19m wide, rooflines 23m tall

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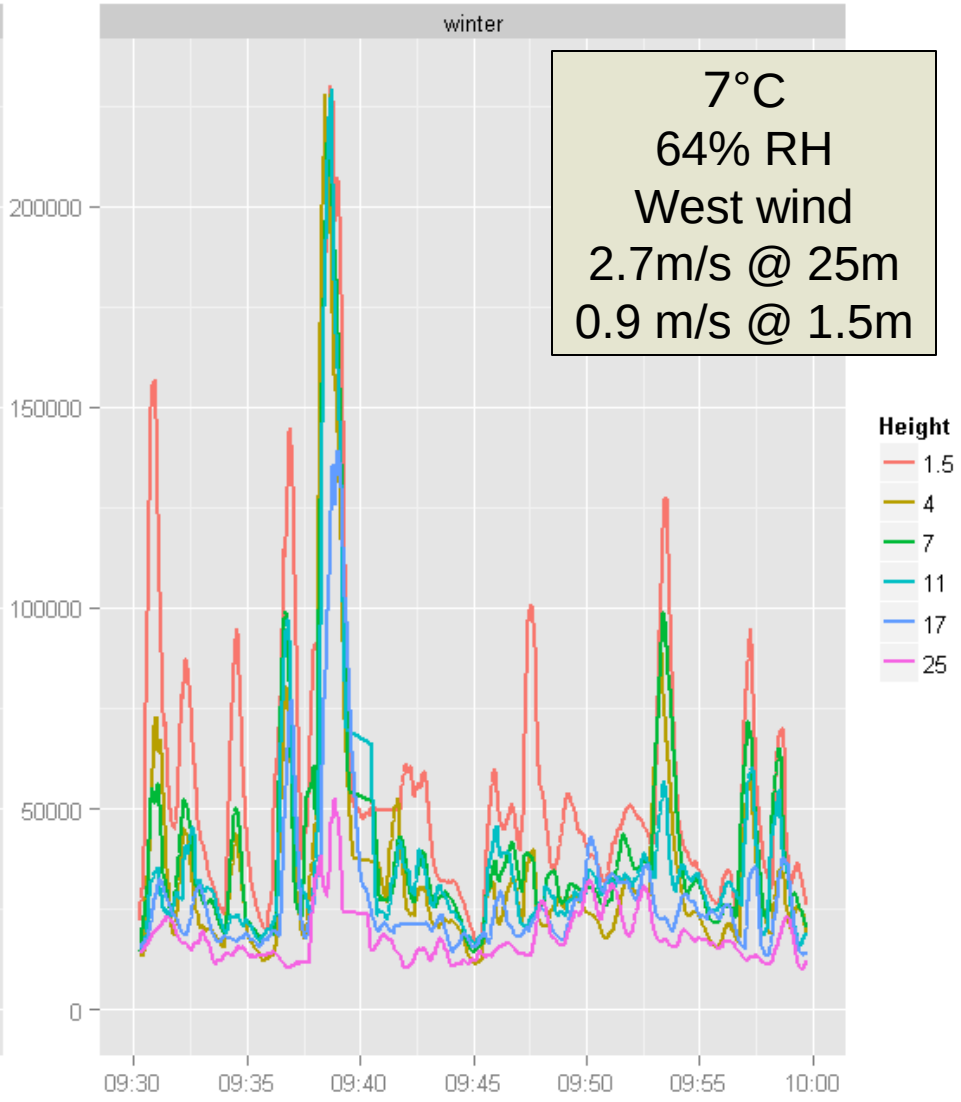
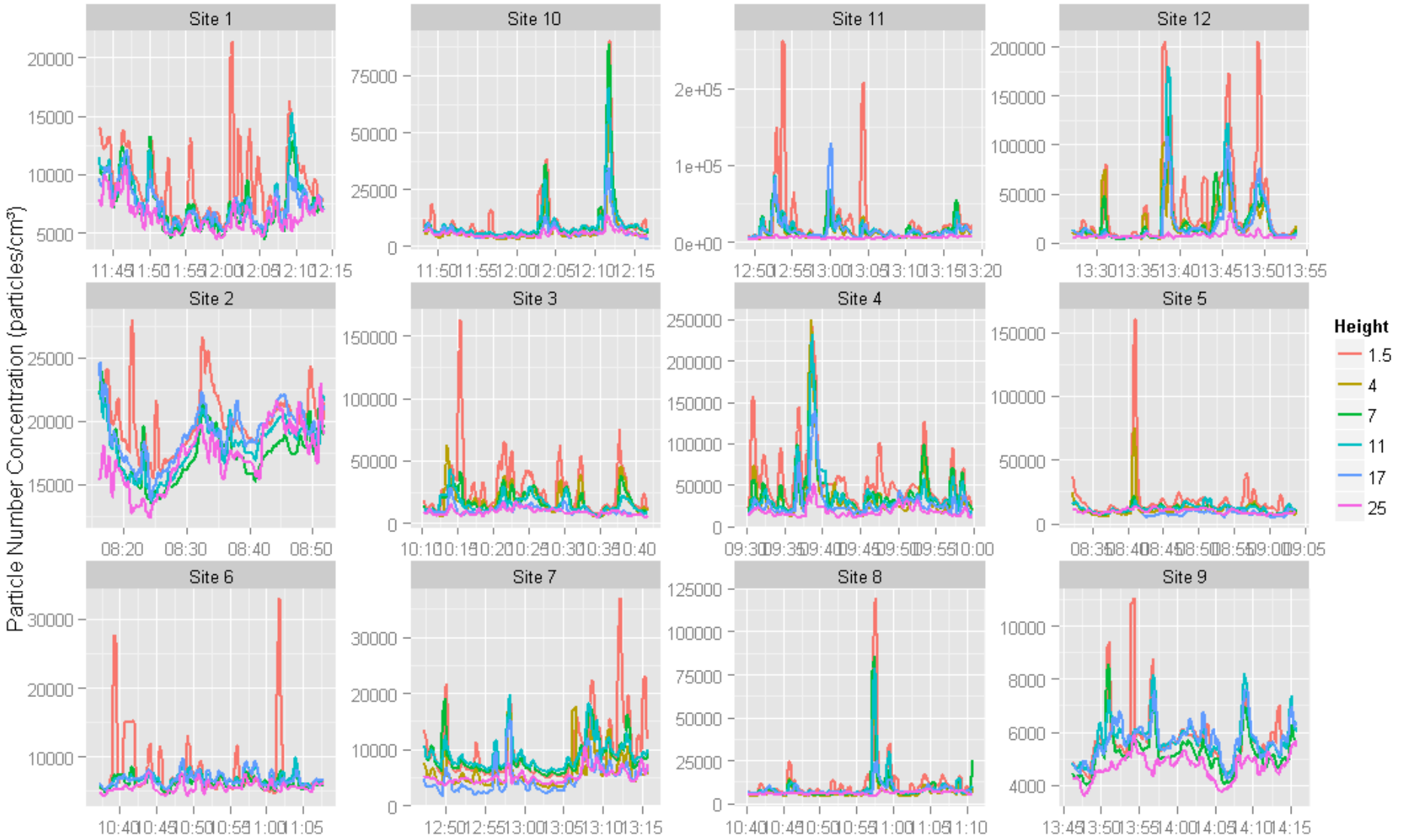


7°C
64% RH
West wind
2.7m/s @ 25m
0.9 m/s @ 1.5m

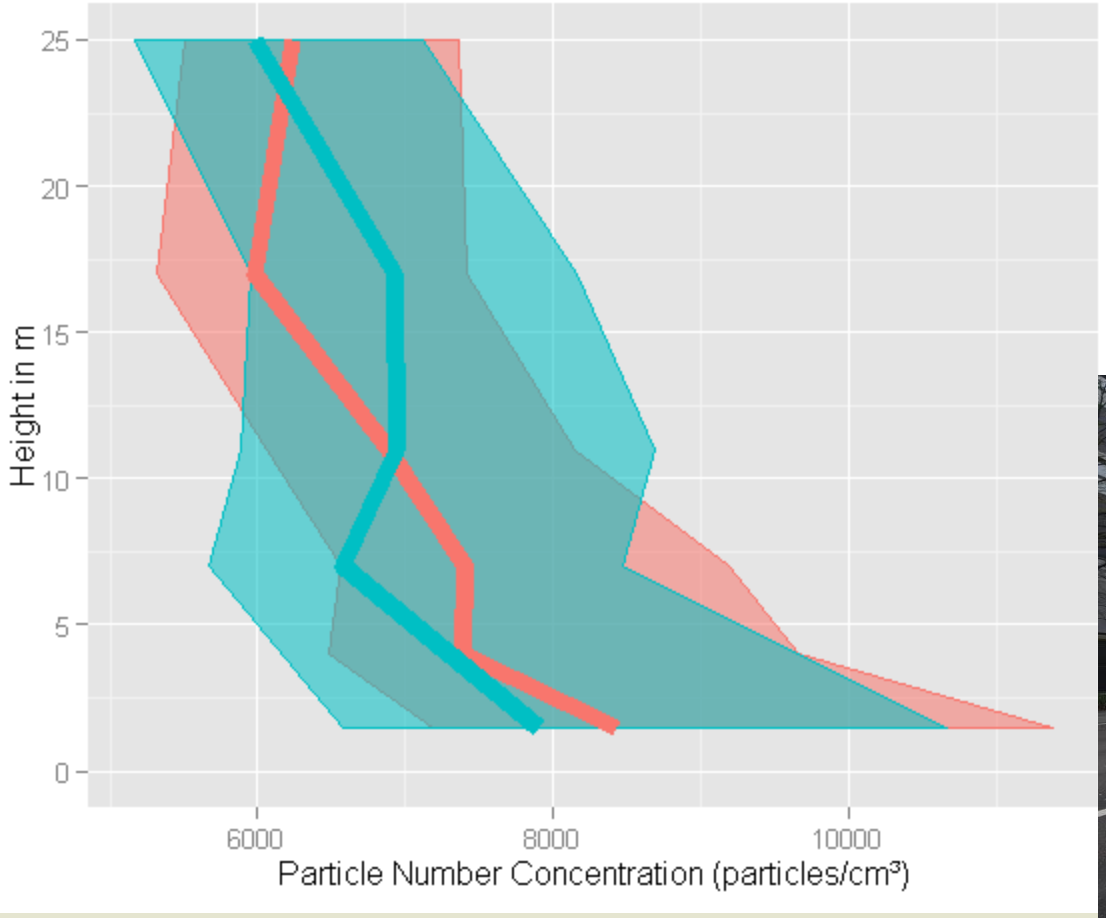
The pattern is similar at all sites:

- Peaks occur mainly at the lower heights
- Lowest concentrations generally occur at 25m

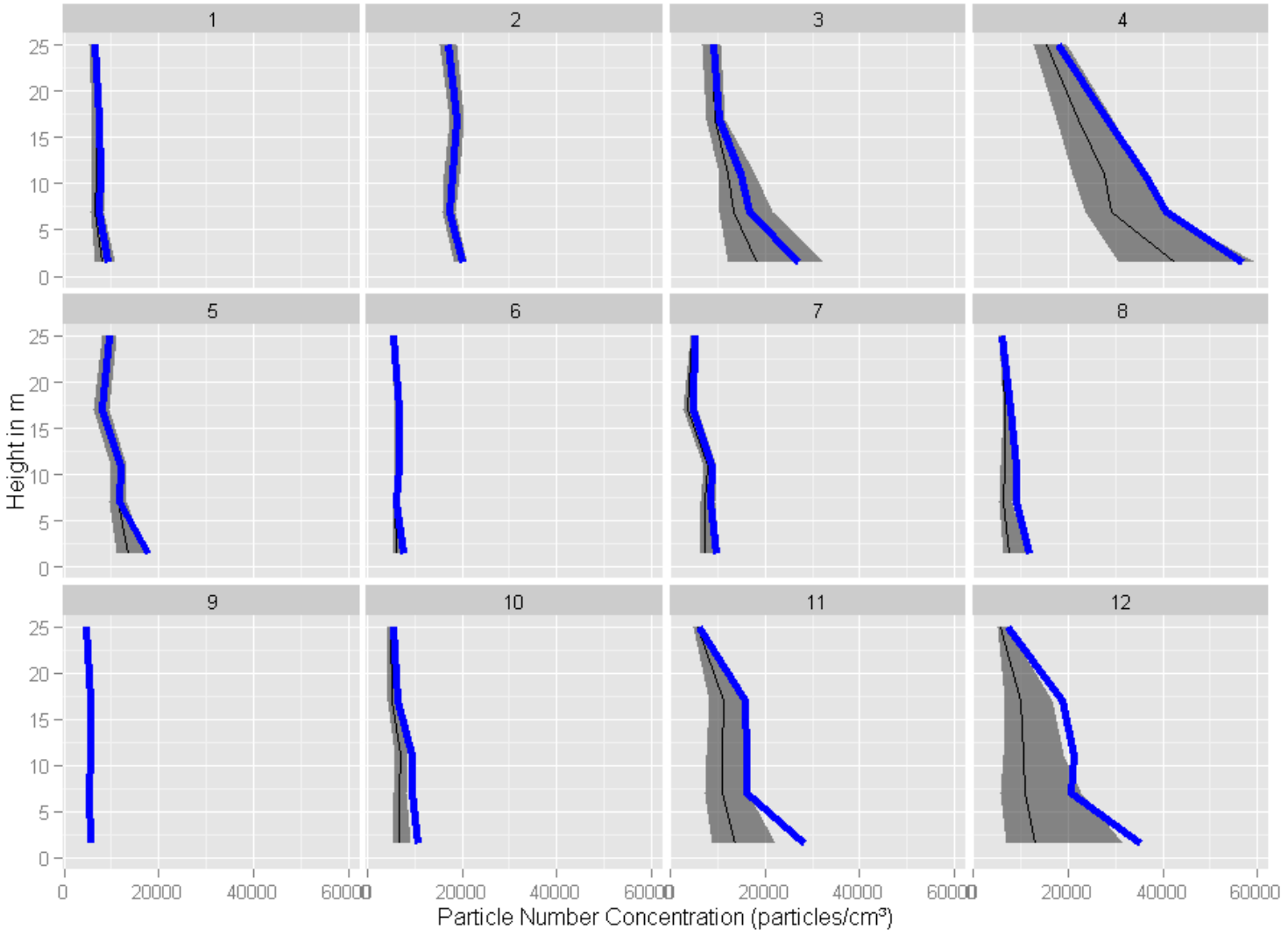


There is a non-linear decrease with height in Particle Number Concentration in both summer and winter.

Median concentration and interquartile range by height (m)

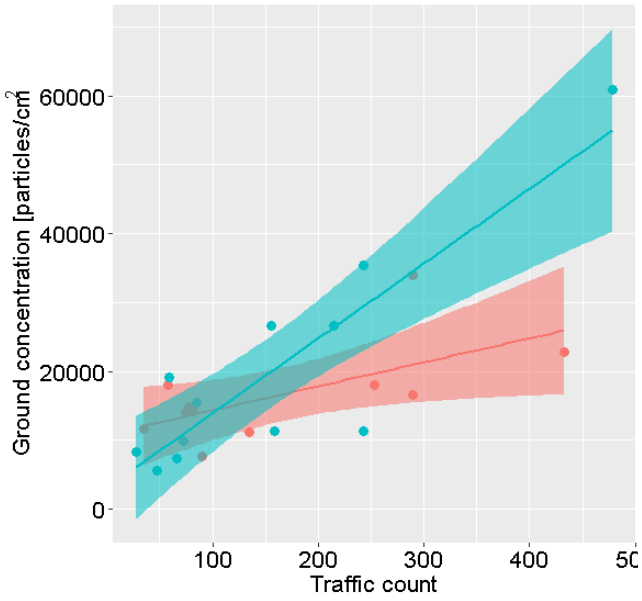


There is a steeper decrease in very busy streets
The mean decreases steeper than the median, because of peaks

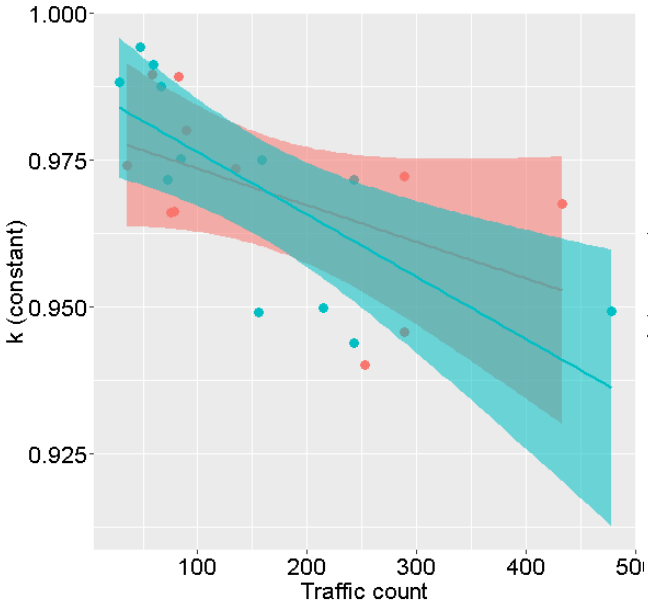


We can describe the relation between height and concentration:

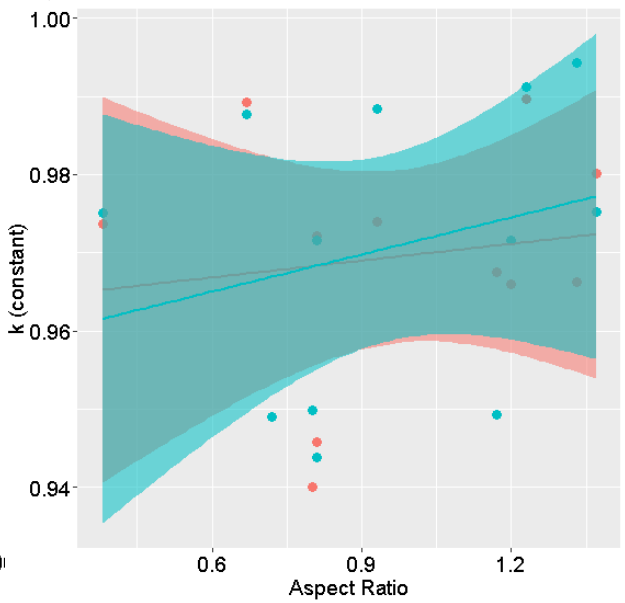
$$Concentration_h = Concentration_{ground} \times e^{-k\,h}$$



More traffic →
higher ground concentration



More traffic →
More decay with height (k)



Higher Aspect Ratio →
Less decay with height (k)

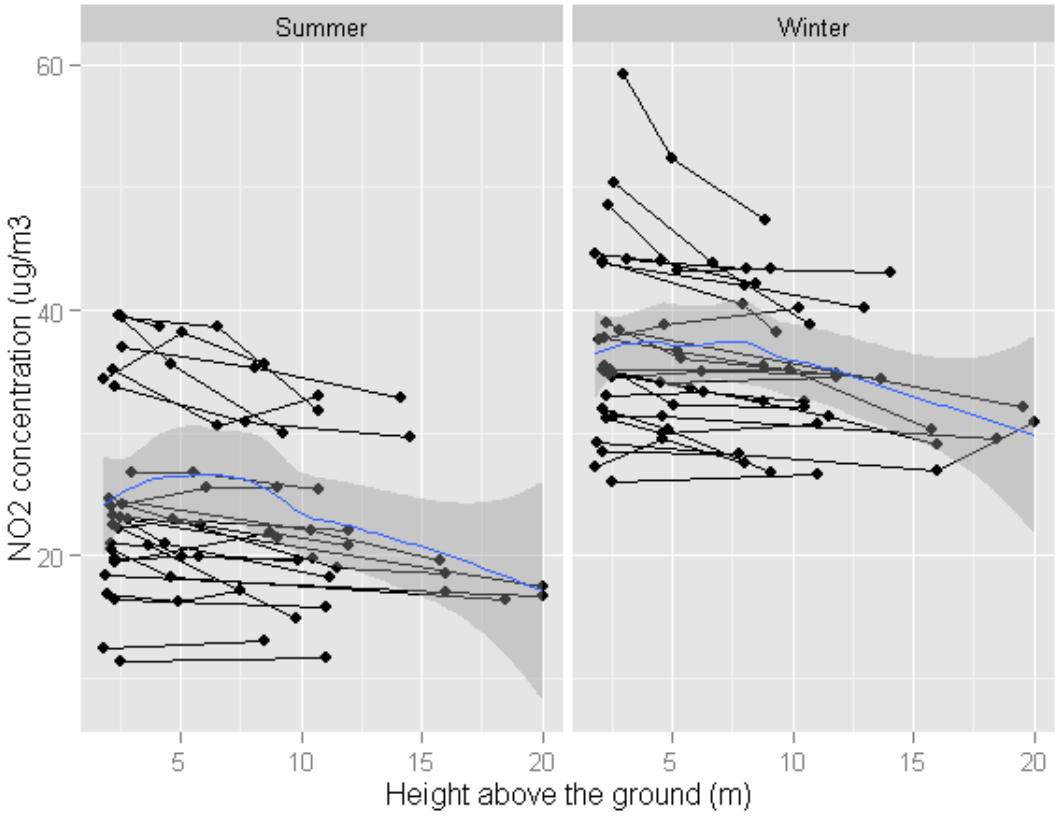
We see a similar pattern for noise

Vertical gradients matter on the long term also!

- Two-week NO_2 measurements at 26 places in Basel, summer and winter

- NO_2 Concentration decreases with increasing height (non-linear)

- NO_2 decreases more with height if the concentration was high at ground level



Thanks to:
Mark Davey
Alex Ineichen
Danyal Odabasi
Benjamin Flückiger
Ming-Yi Tsai

And all the bucket truck drivers of Maltech AG

Conclusions:

- There is room for improvement in air pollution exposure characterization, especially in cities with a lot of high-rise.
- Exposure is especially overestimated for people living at height along busy streets.
- Digital data on building height and floor of residence is increasingly available. Let's use it!

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Street canyons limit vertical air exchange

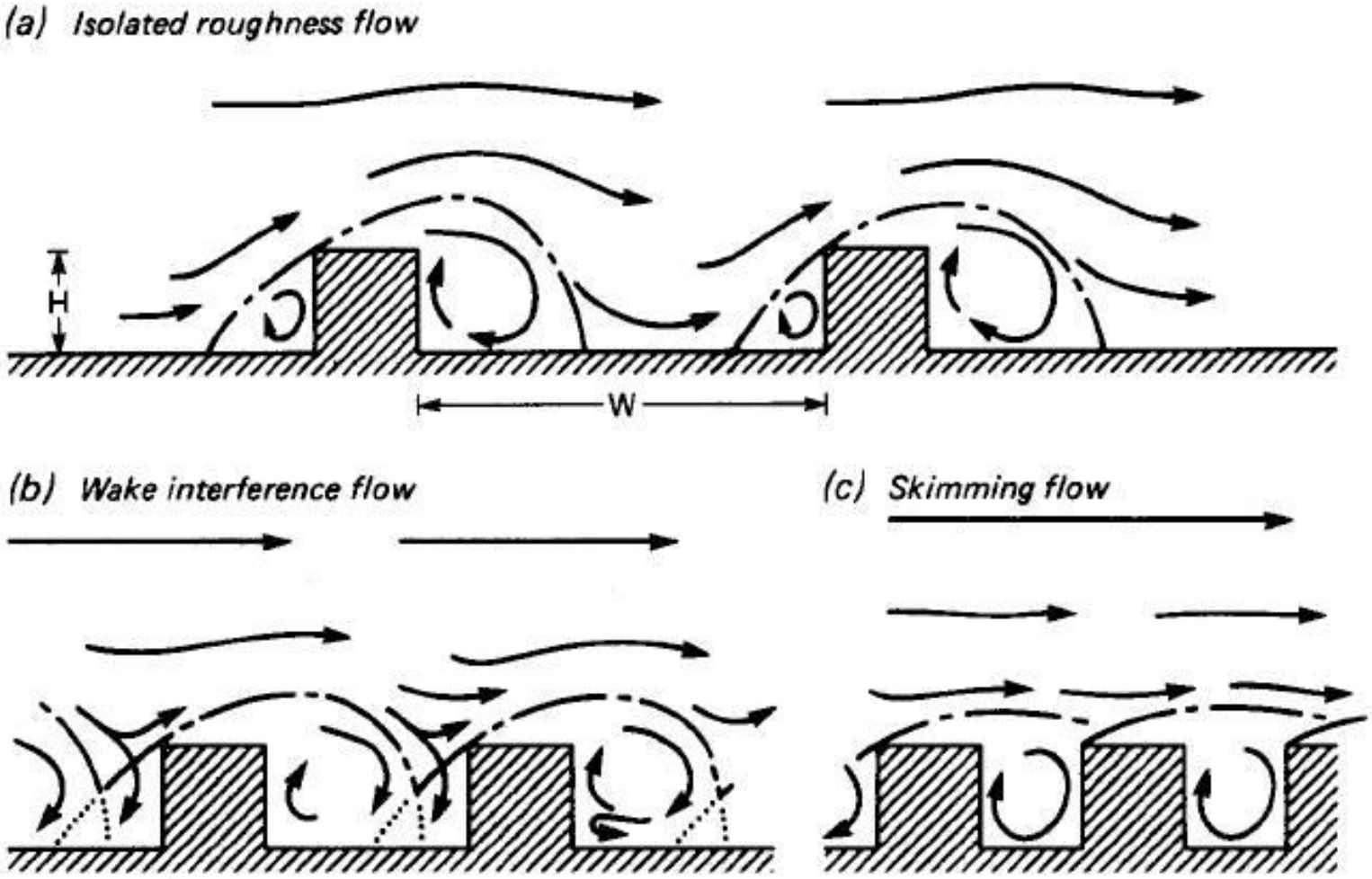
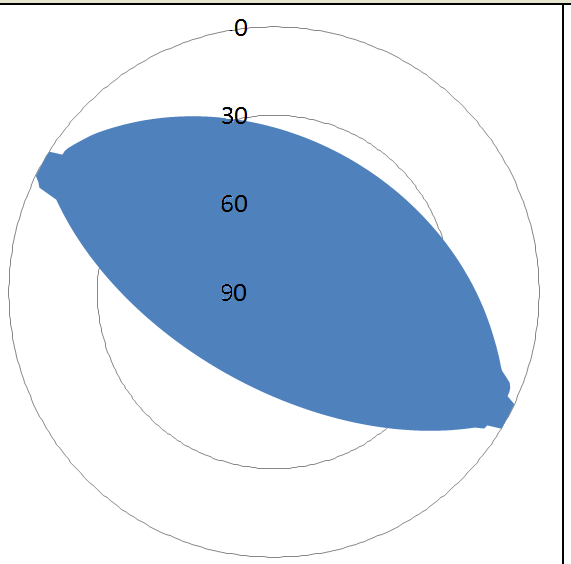
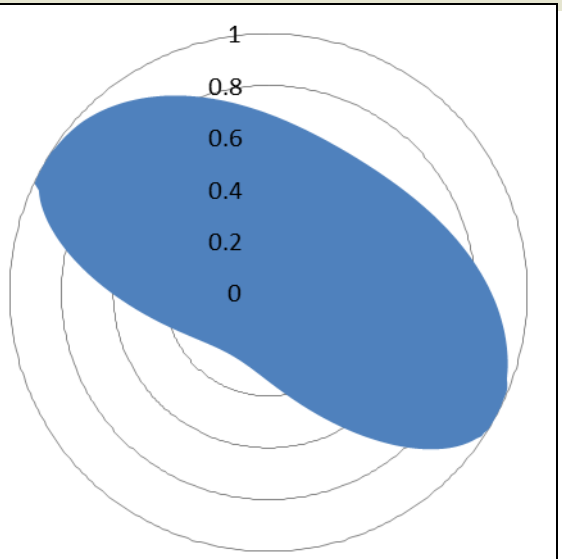


Fig. 1. The flow regimes associated with air flow over building arrays of increasing H/W.

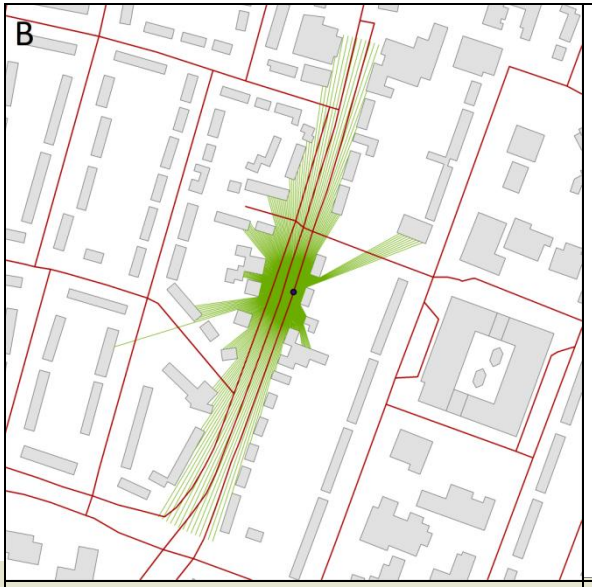
Maximum Aspect Ratio = 0.67



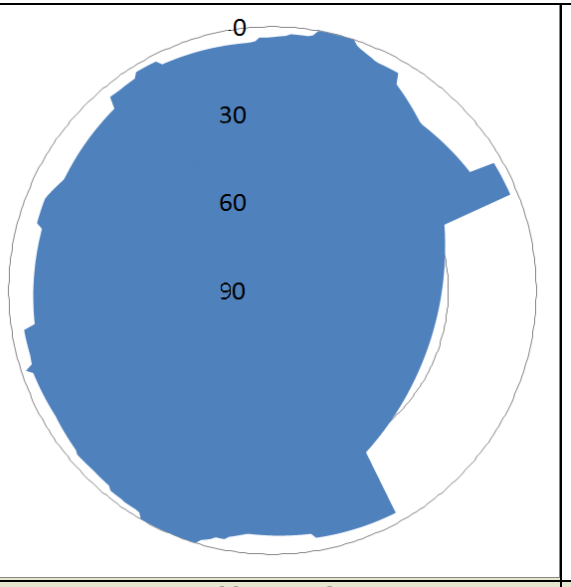
Mean Building Angle = 33.6°
Median Building Angle = 35.1°



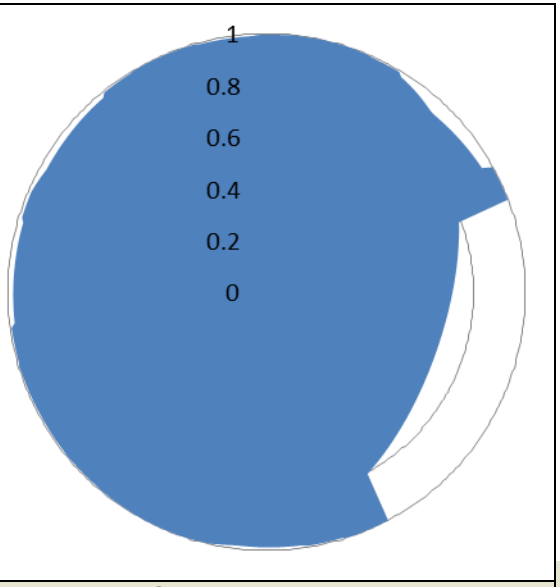
SkyView Factor = 0.66



Maximum Aspect Ratio = 0.21



Mean Building Angle = 11.2°
Median Building Angle = 6.2°



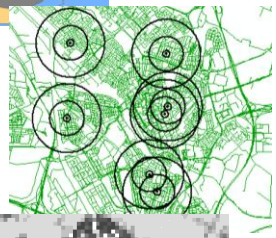
SkyView Factor = 0.93

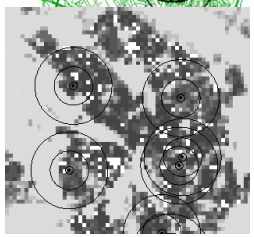
Information about the SkyView Factor is also available for Basel Stadt

A land use regression model connects measured concentrations with environmental predictors

Concentration NO_2 ($\mu g/m^3$) = X_1 +

X_2 * industrial land use in a 2000m buffer +

X_3 *  traffic load in a 50m buffer +

X_4 *  population in a 1000m buffer +