Sensing opportunities: Answering Urban Climate questions with citizen science and opportunistic sensing

Lunch Lecture Climate Action Plan

Arjan Droste, 14 Sept

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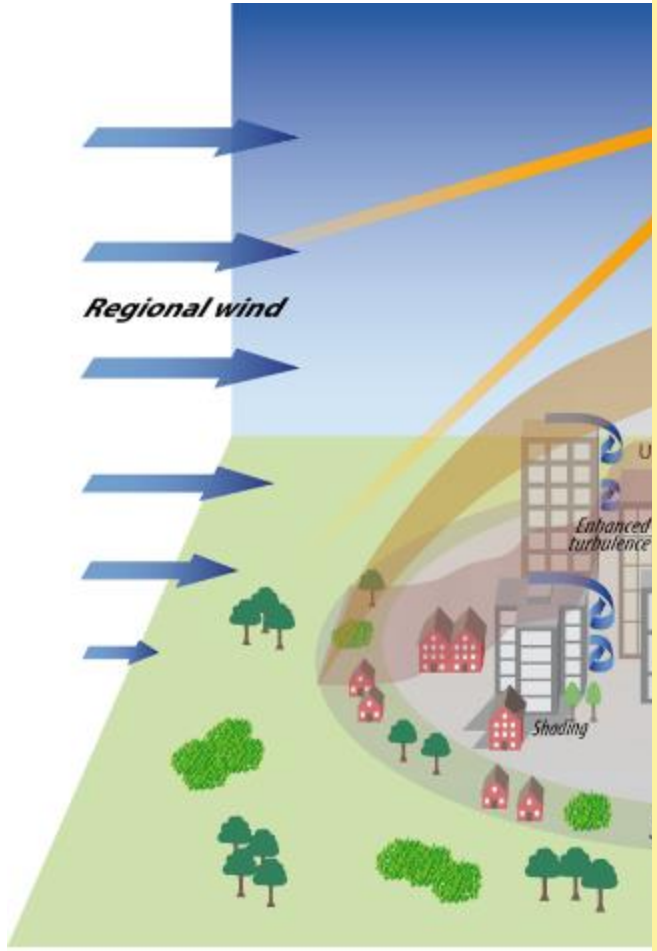
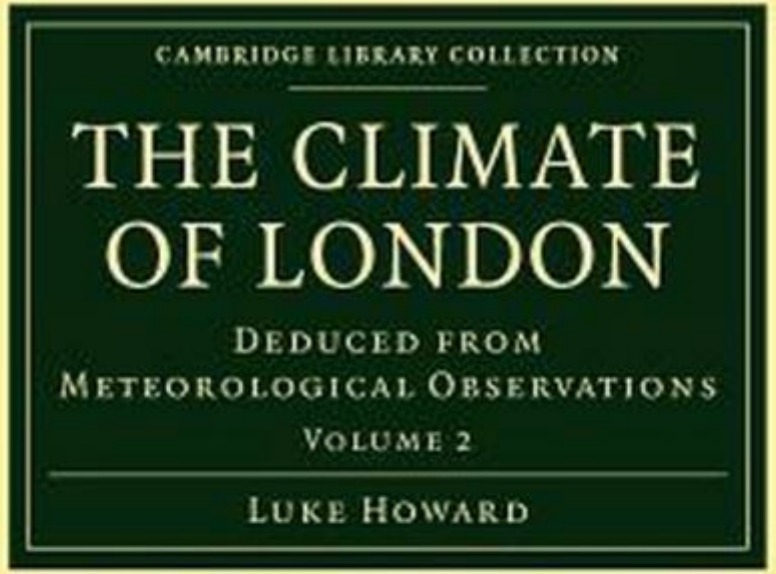
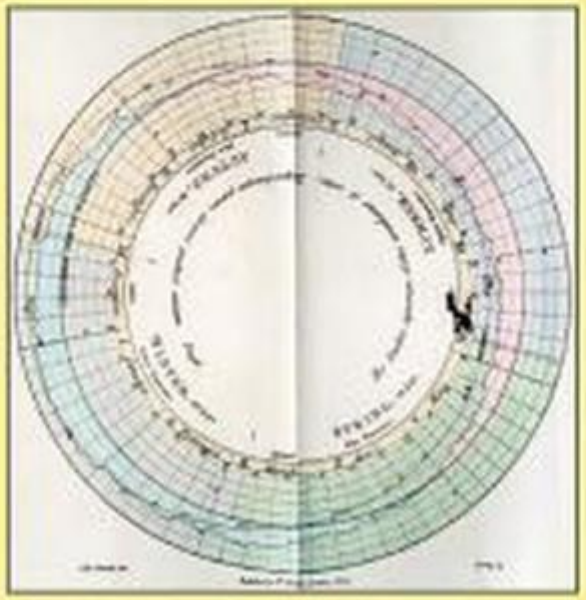
The Urban (Micro)Climate

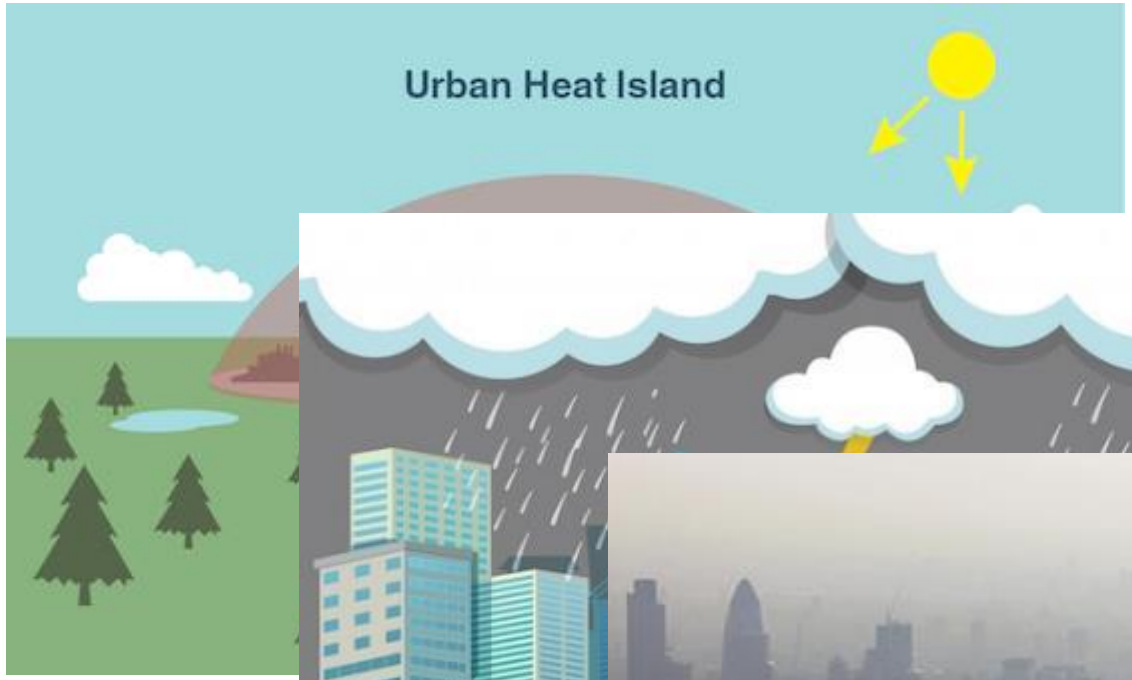
- **How a city interacts with local and larger scale weather**
- **Those interactions lead to questions at various scales and from various viewpoints**
- **Scientific, societal, practical, …**

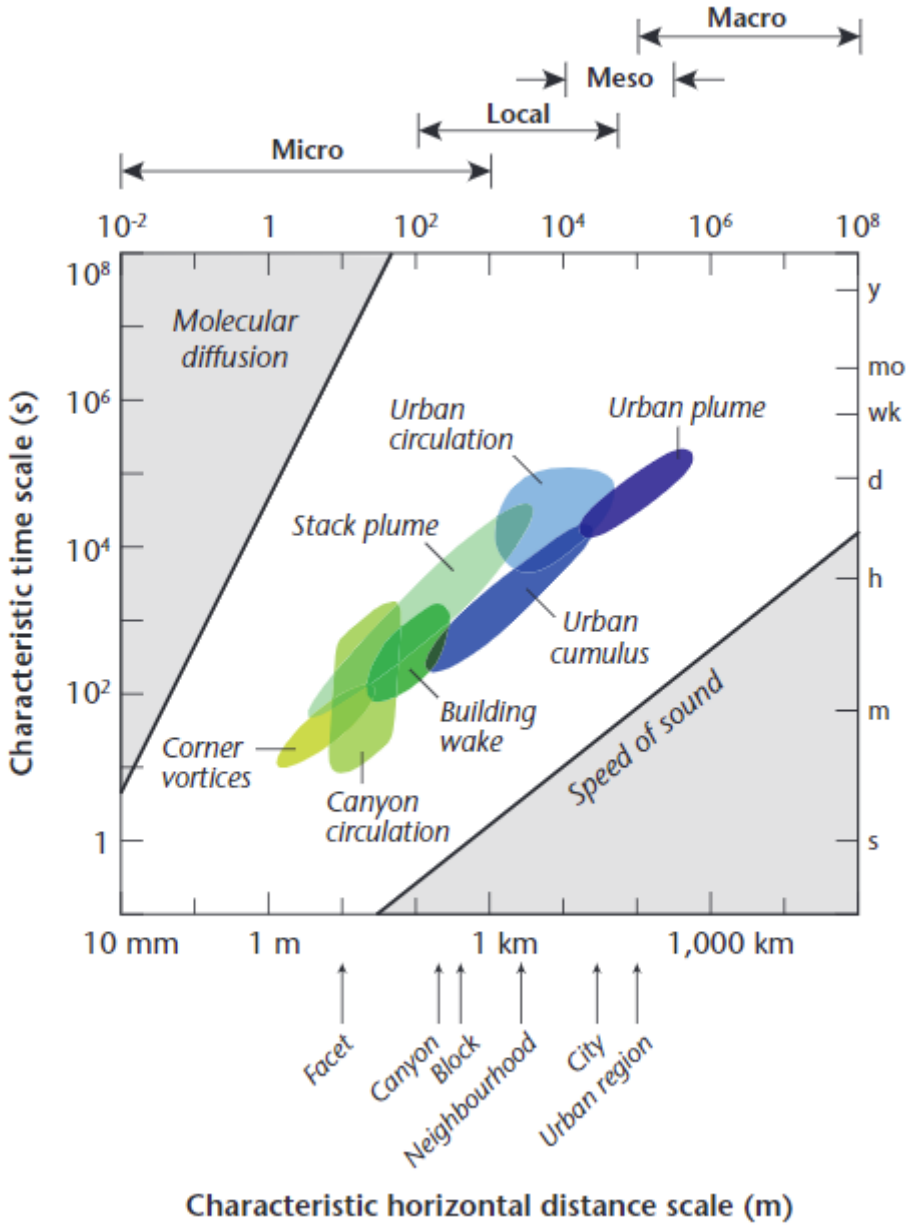






Urban climate issues




Macro
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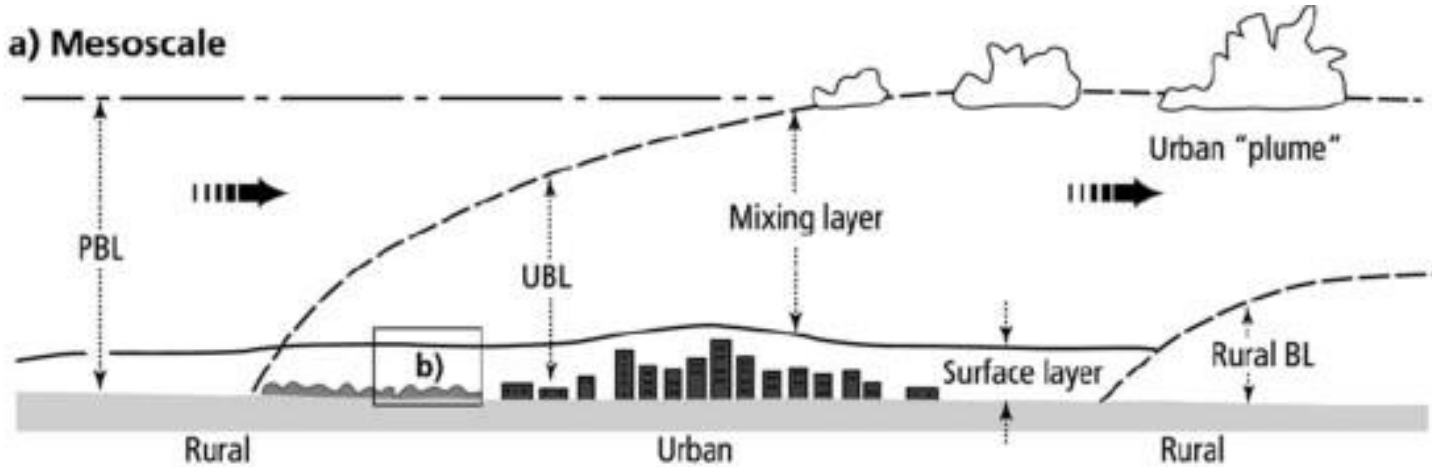
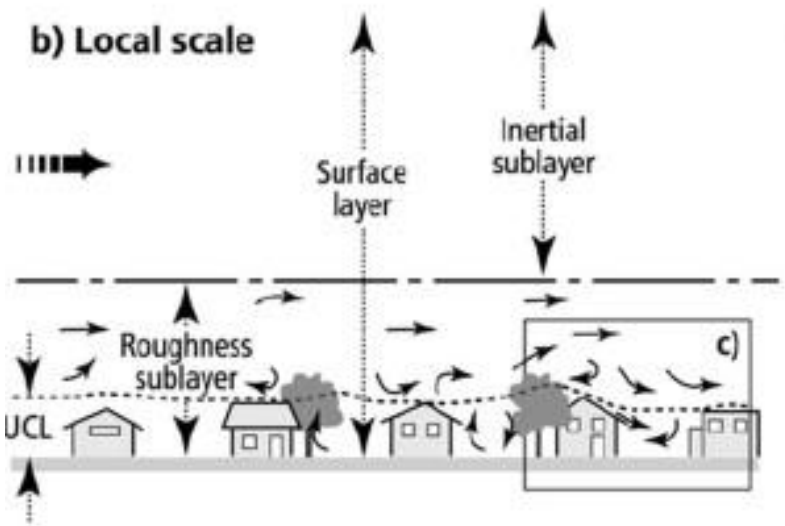
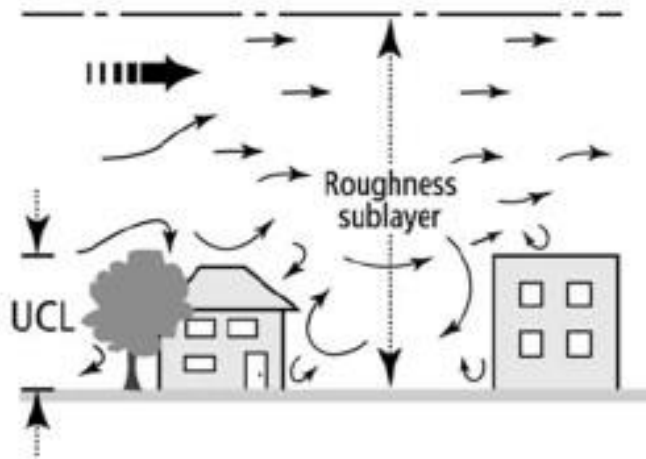
Molecular diffusion
Urban circulation
Urban plume
Stack plume
Urban cumulus
Building wake
Corner vortices
Canyon circulation
Speed of sound
Characteristic time scale (s)
10 mm
1 m
1 km
1,000 km
Facet
Canyon
Block
Neighbourhood
City
Urban region
Characteristic horizontal distance scale (m)


a) Mesoscale
Urban "plume"
Mixing layer
PBL
UBL
b)
Surface layer
Rural BL
Rural
Urban
Rural


b) Local scale
Surface layer
Inertial sublayer
Roughness sublayer
UCL
c)


c) Microscale
Roughness sublayer
UCL

Scale Dependency

- **What is your question?**
- **Where do you go research it?**
- **Where will your solution be?**

"Is my home sensitive to heat stress?"

Local (<100m)

Neighbourhood (~100m)

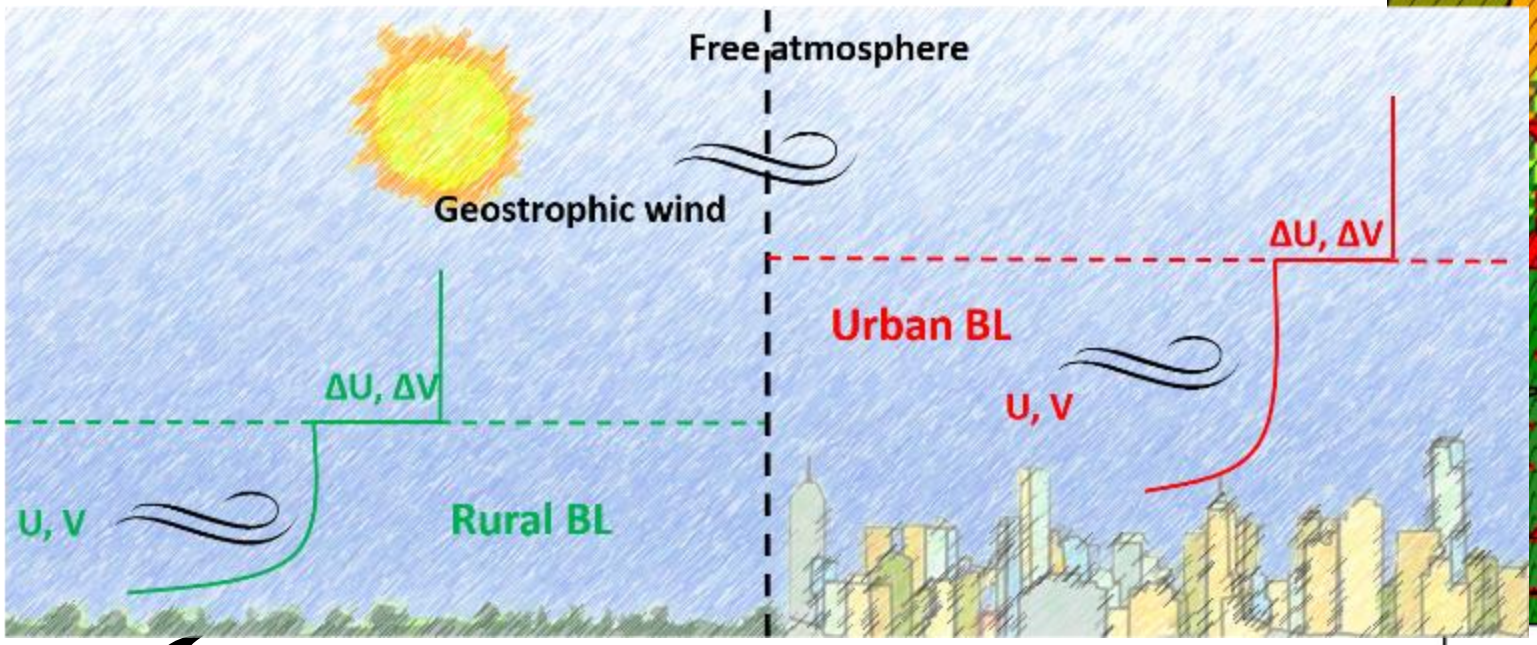
"What is a safe and clean route to work?"

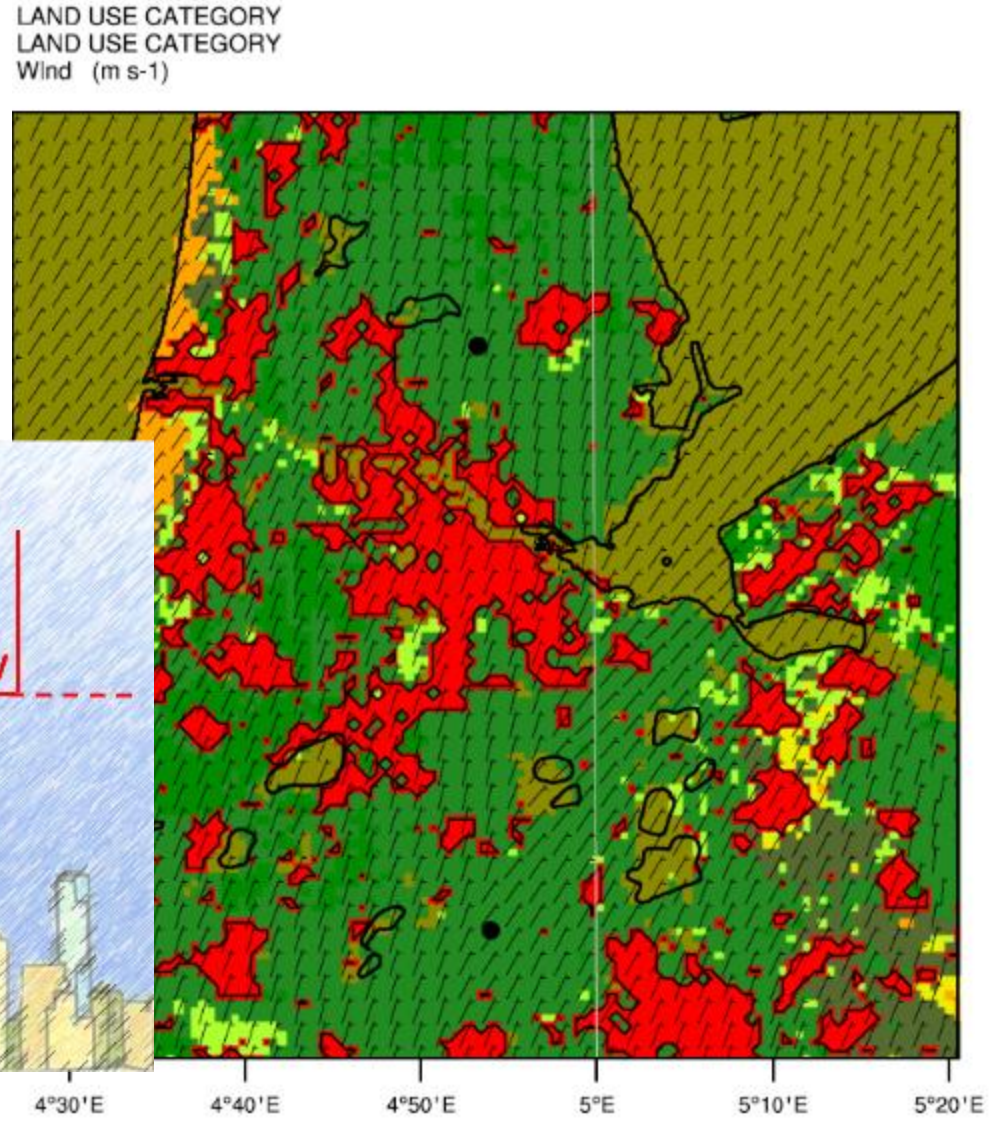
City (~km)

"Where do we experience most urban flooding?"

How do we represent a city?

- Modelling: land-use class “urban”





The TU campus: Urban or not?

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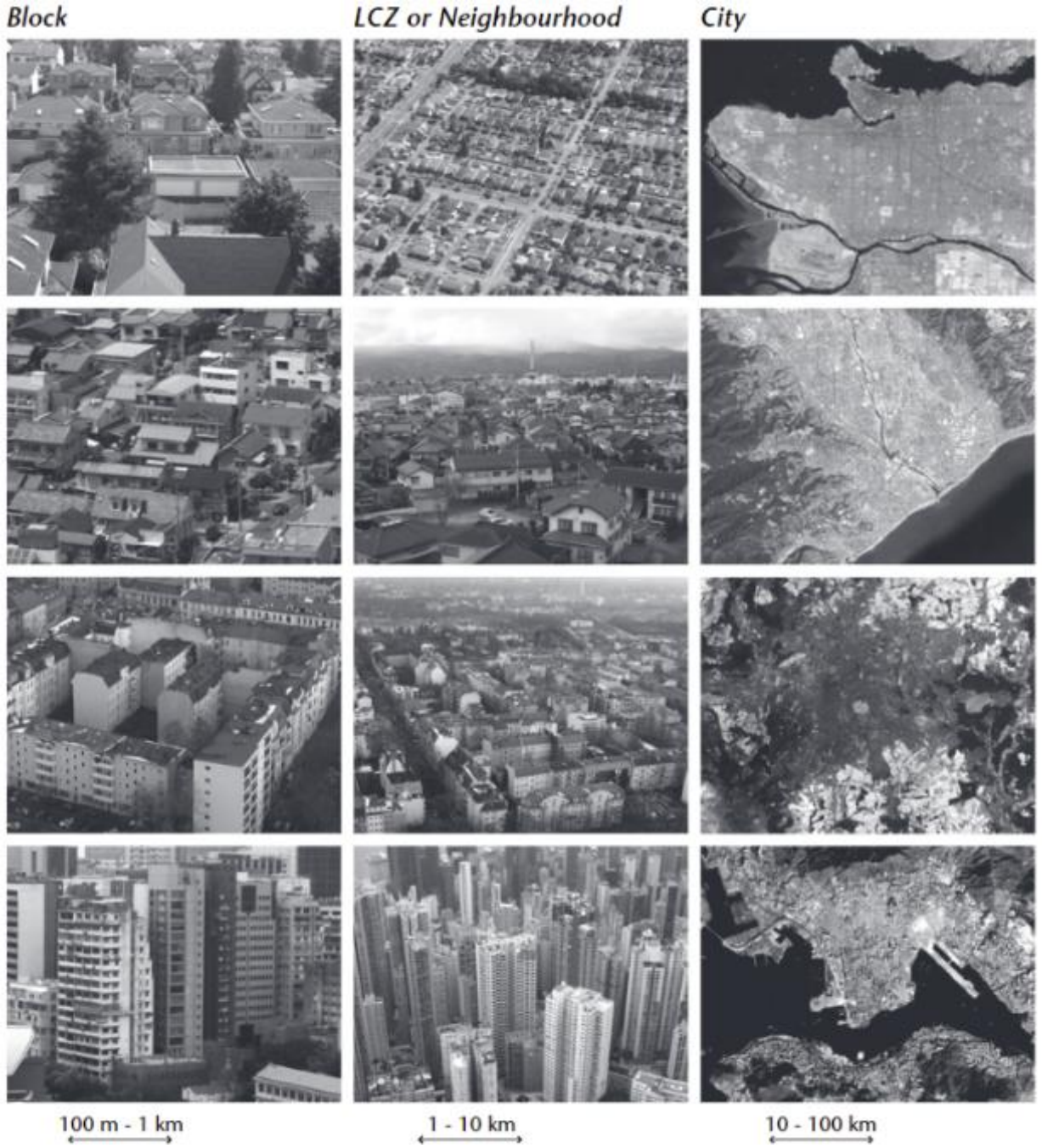
How do we represent a city?

- **Modelling: land-use class “urban”**
- **But no two cities are alike**
- **Suburban and city core are vastly different**

- **→ Scales!**



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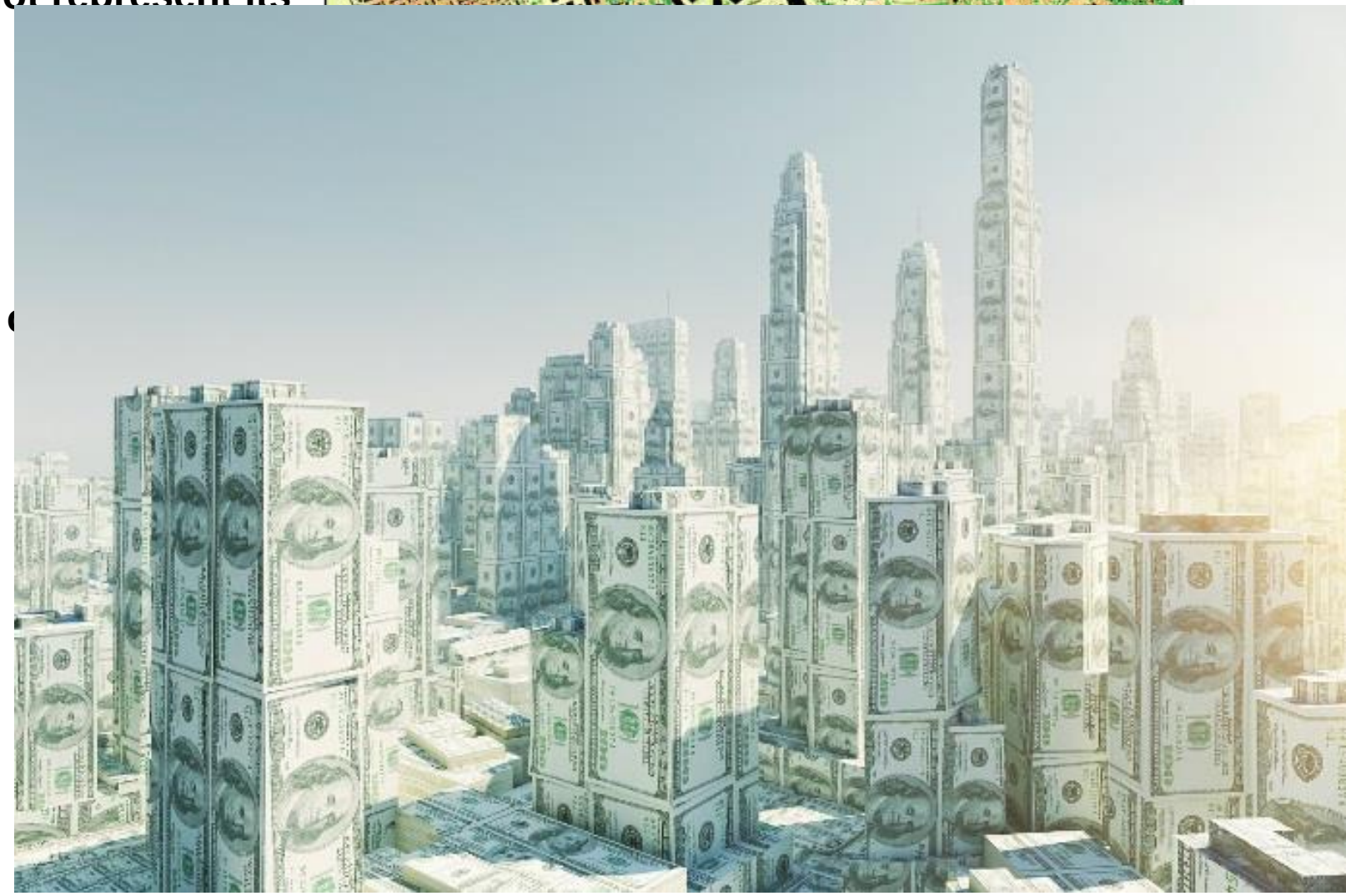
What about measuring?

- **Heterogeneity: one street does not represent its neighbour**
- **The issue of scale again**
- **Need many measurement points ‘capture’ a city**



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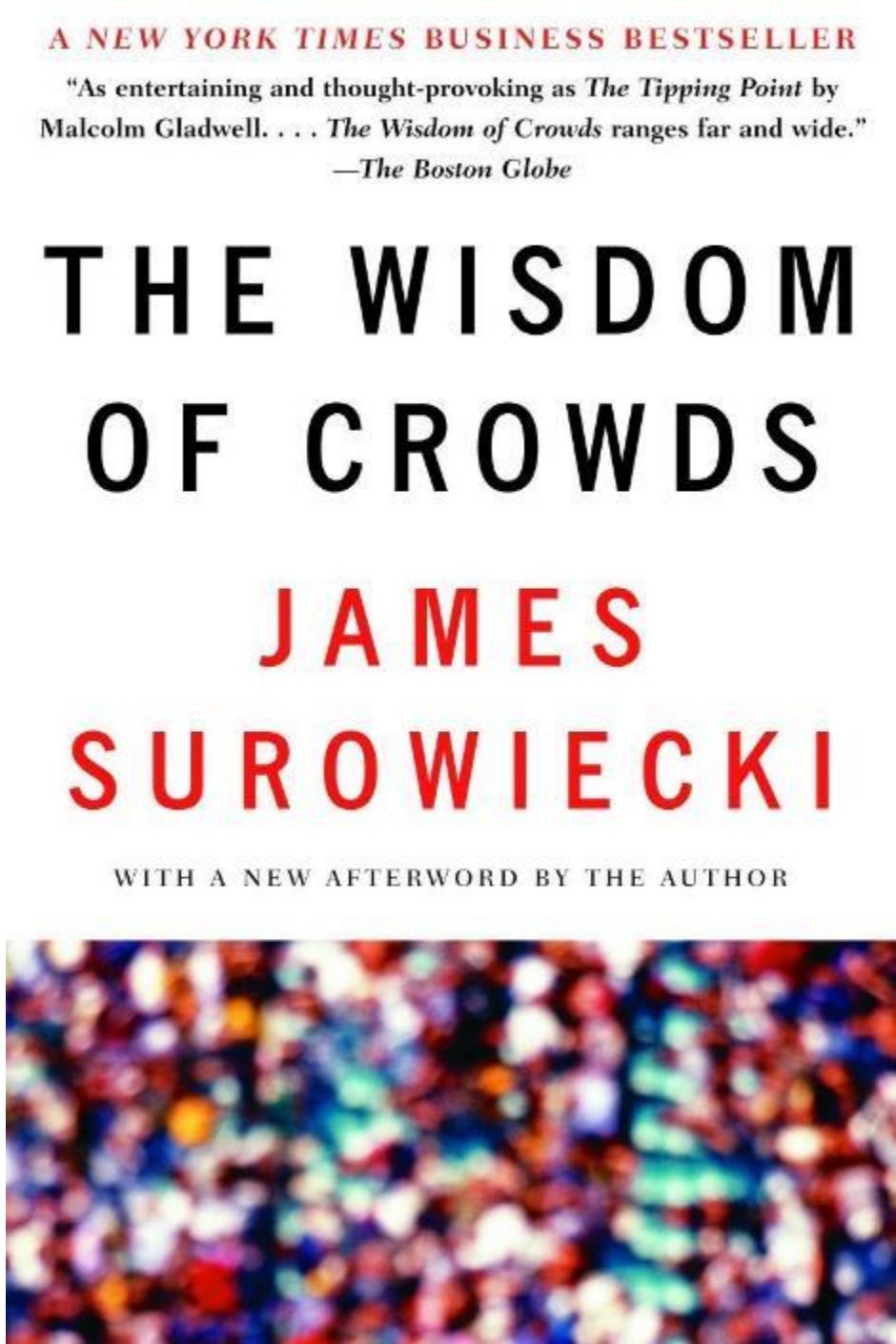
So what can we do? ..let ‘them’ do it!

- **People live in cities**
- **Where there are people, there are (smart) devices**
- **Creatively use mountains of data to get a signal!**

- **Crowdsourcing & Citizen Science**
- **Opportunistic Sensing**



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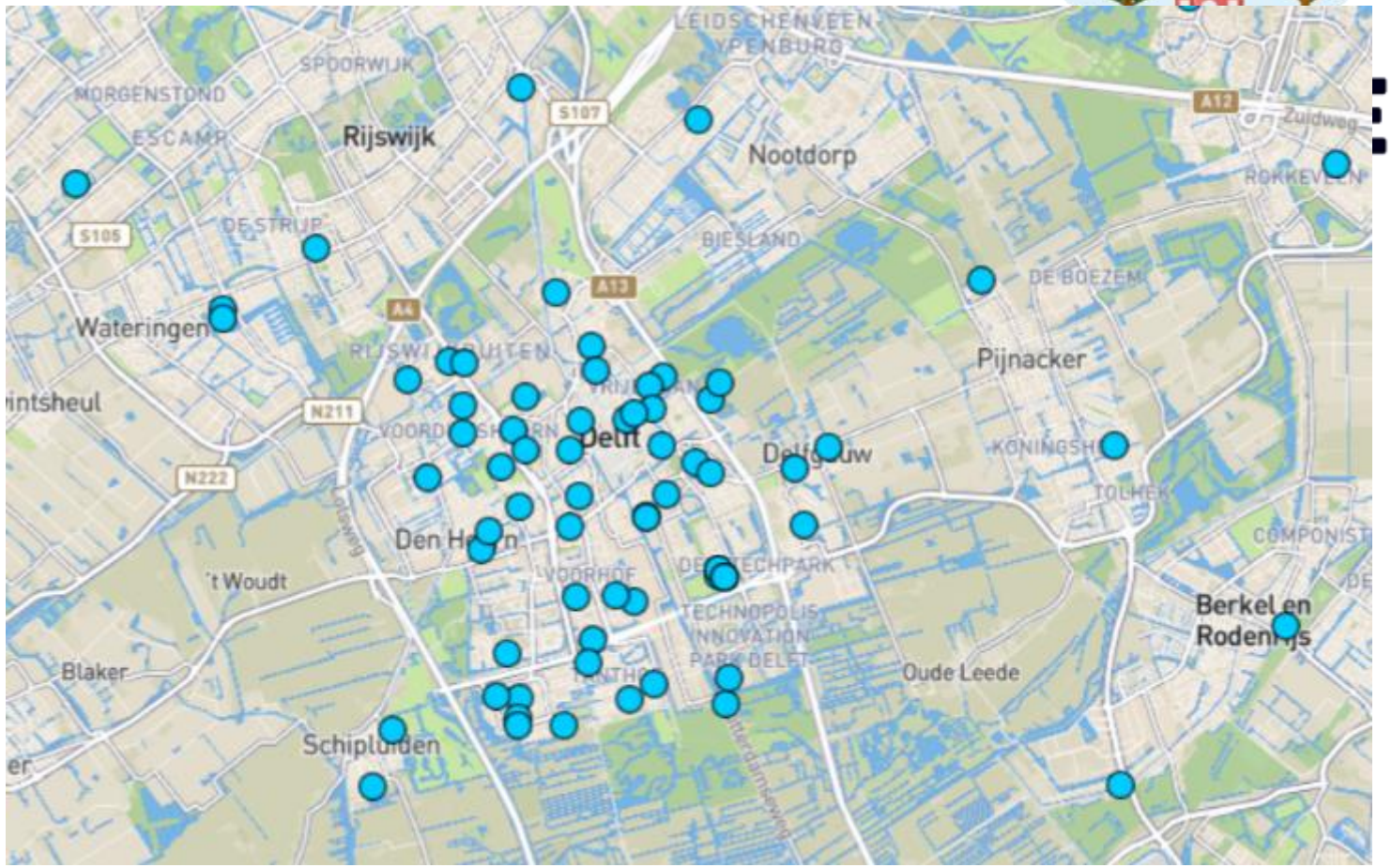
Crowdsourcing & Citizen Science

- **Let the citizen do your measurements**
- **Active involvement → Citizen Science**



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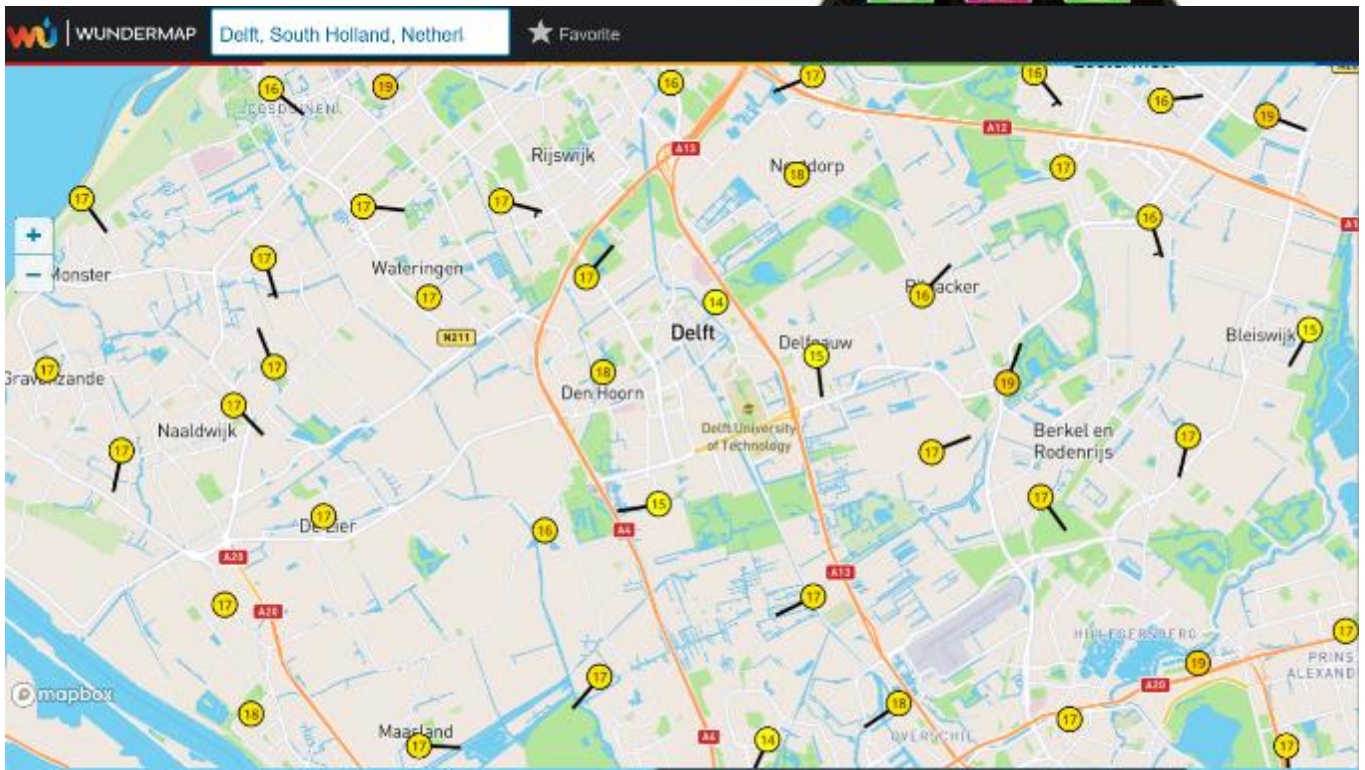
Crowdsourcing & Citizen Science

- **Let the citizen do your measurements**
- **Passive involvement → Crowdsourcing**

- **Urban wind from weather stations on balconies etc**
- **Weather amateur platforms:**
  Weather Underground; Netatmo

- **Pro: less work for the scientist**
- **Con: uncertainty in metadata, setup etc.**



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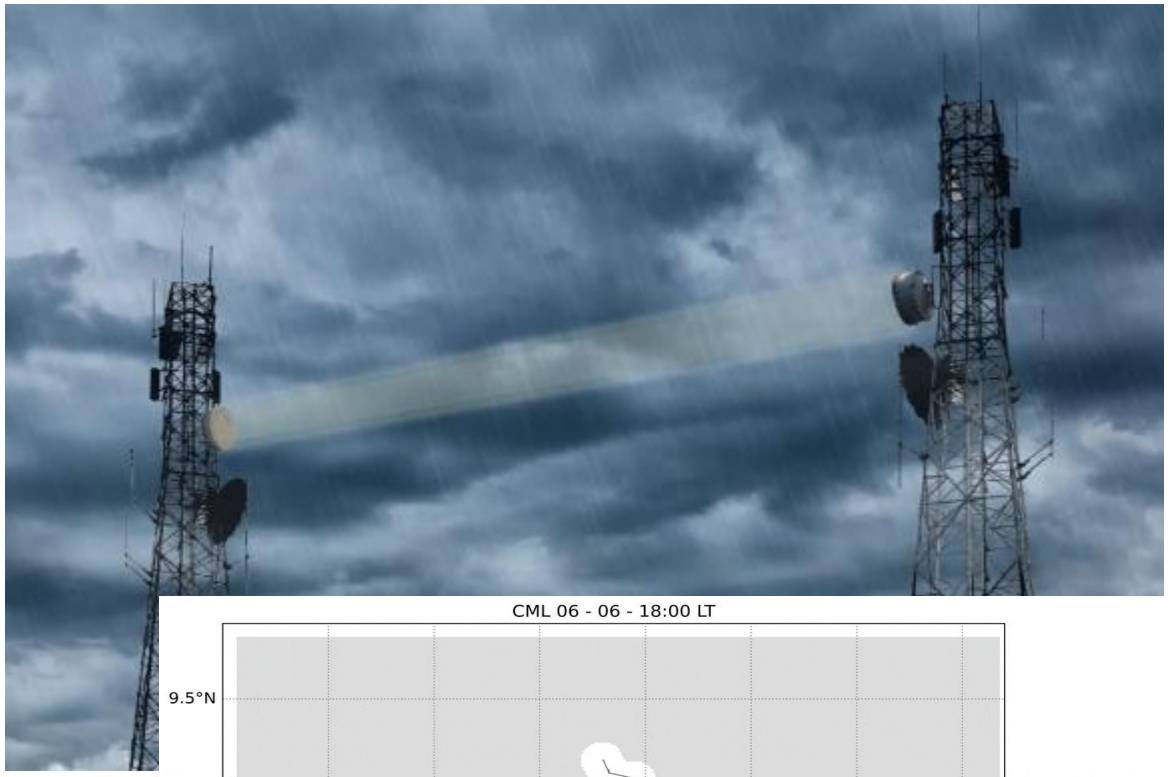
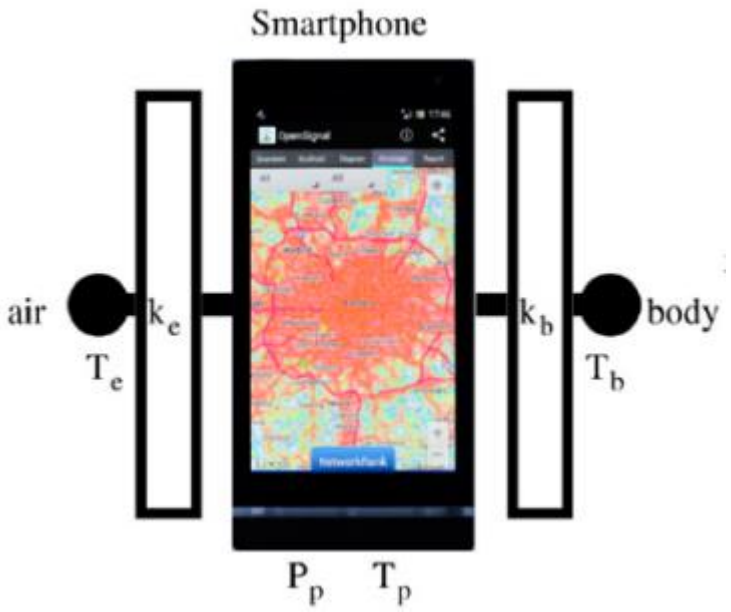
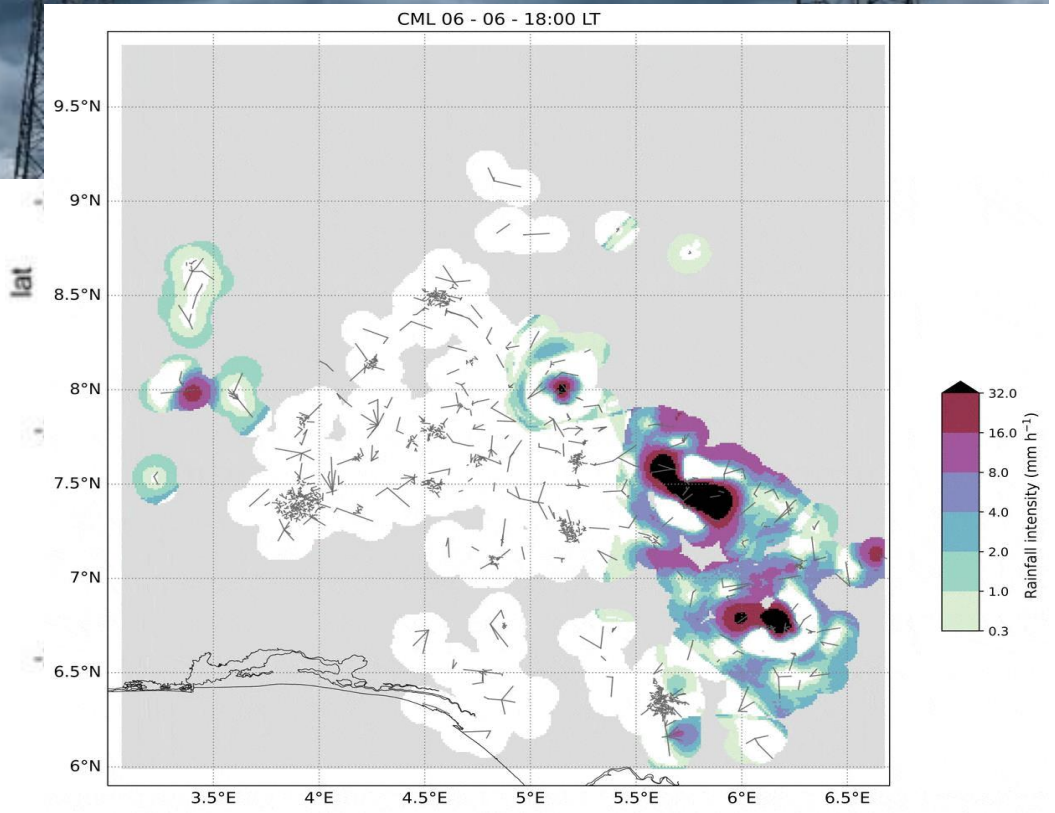
Opportunistic Sensing

- **Trawling large, seemingly irrelevant datasets for a signal**
- **Cellular Microwave Links (CML) to estimate rain**
- **Smartphone battery temperatures to estimate urban heat**







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Beware of errors!

- **Systematic and random biases**
- **Population bias…**
- **Incorrect Setup**
- **Time-sensitive**
- **Privacy sensitive…**
- **Unforeseen troubles**

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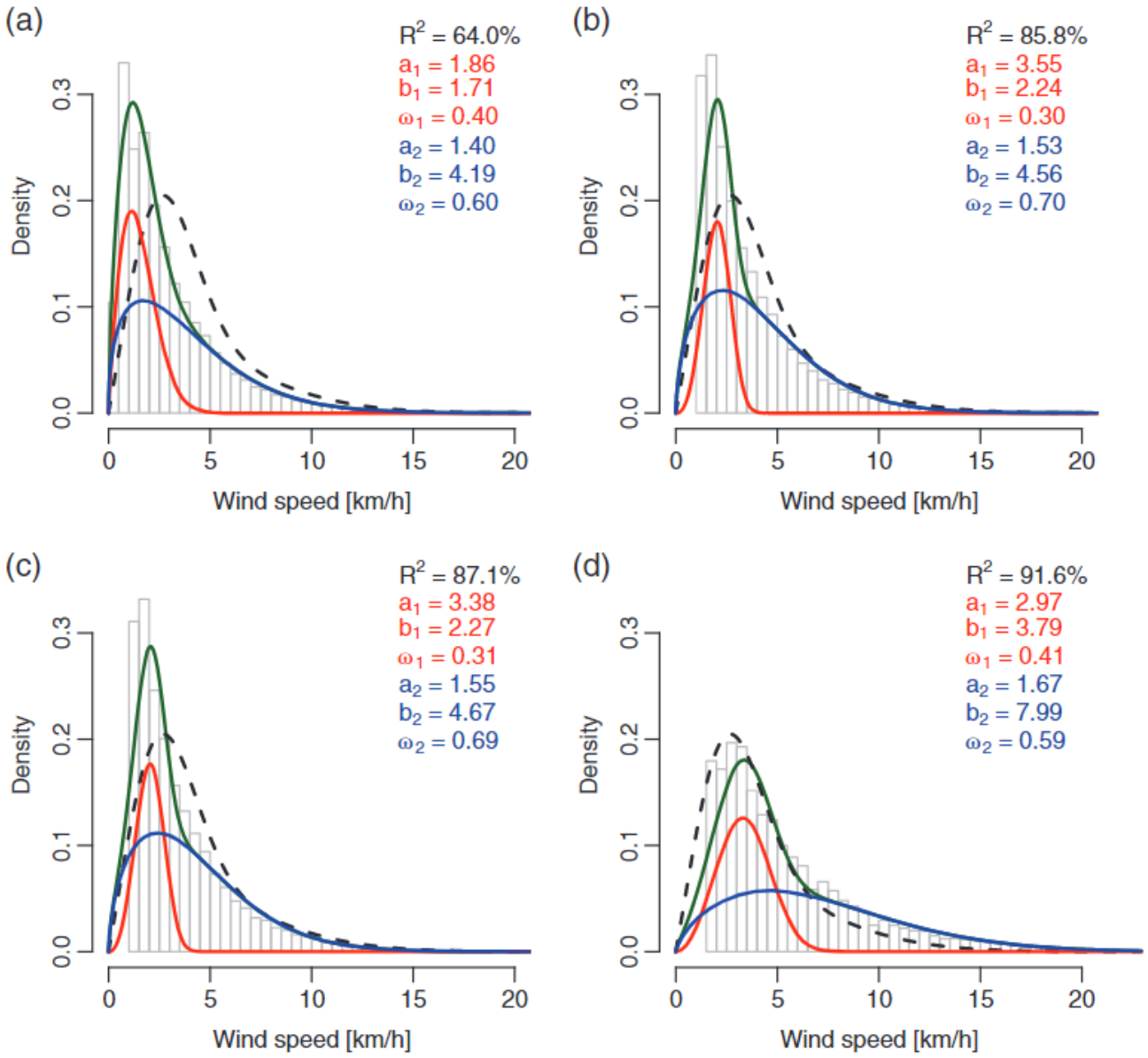
How to handle these data?

- **Quality-control procedures – based on statistics and as much prior knowledge as possible**
- **Physical impossibilities**
- **Can we identify systematic biases? And can we recognise these in the data to eliminate them?**
- **Data might not be valid under some circumstances**



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Combine strengths

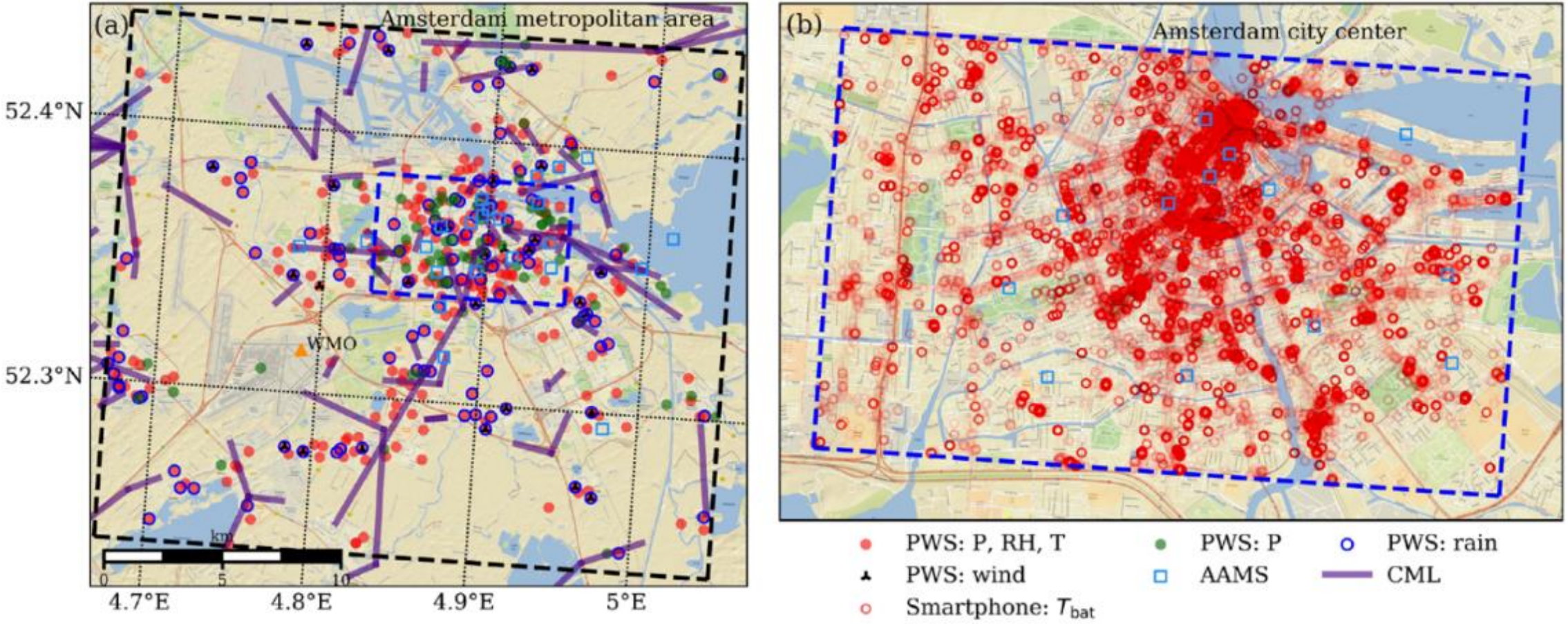
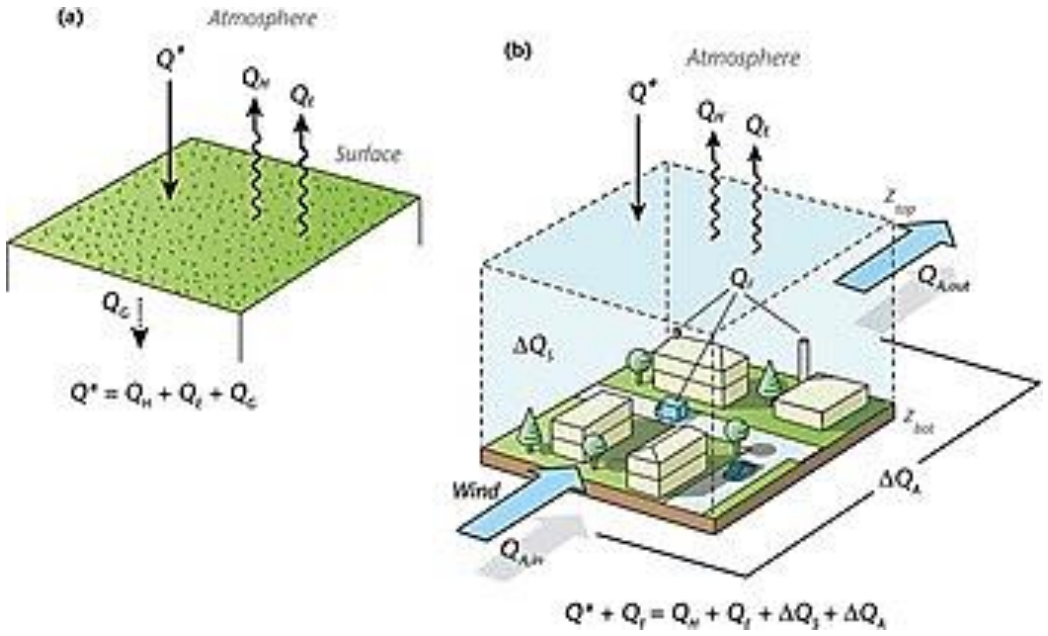


Fig. 1. Maps of (a) Amsterdam metropolitan area and city center with locations of all sensor networks: personal weather stations (PWSs), commercial microwave links (CMLs), and WMO station 06240 (Amsterdam airport) and (b) smartphone battery temperature readings and Amsterdam Atmospheric Monitoring Supersite (AAMS) stations.

Using the wisdom of the crowd:

- **Combine sources of data with each other (after careful quality control!!)**
- **Together with models, to improve understanding**
- **And design solutions and answer questions**
- **Across scales in space and time**



Thank you for your attention

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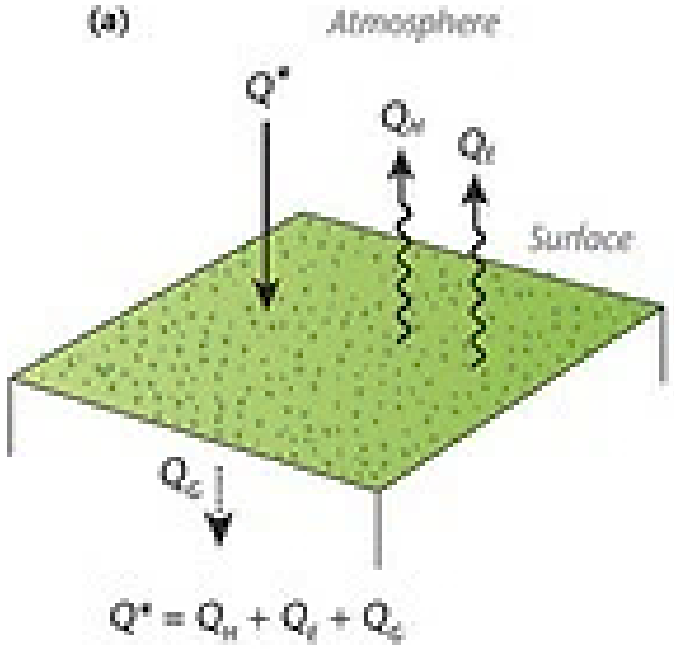
A crash course on boundary-layer meteorology

- The atmosphere interacts with the Earth's surface
- Exchanges of energy (heat), momentum (wind) and water (rain and evaporation)
- Solar energy (Q*) hits the surface and is distributed in 3 ways:
  - Heat up the air (sensible heat flux, QH)
  - Evaporate water (latent heat flux, QE)
  - Penetrate the soil (ground or storage heat flux, QG)
- This changes the lower part of the atmosphere – the boundary layer, where we live.



…and now we make it complicated

- Human influence:
  - Buildings (momentum exchange)
  - Energy consumption (heat exchange)
  - Hard surfaces (water & heat)

  - **Heterogeneity**
  - **Anthropogenic Heat Flux (QF)**