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Personal air pollution exposure assessment of rural and urban residents in greater Beijing area

Improving personal exposure metrics

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Introduction

Global burden of non-communicable disease

Limitations of epidemiological research

AIRLESS project

Novel monitoring methodological framework

1. Performance of the personal air quality monitor
2. Mobile air pollution network
3. Time-activity-location model

Personal exposure measurements

Preliminary health outcomes

Future work

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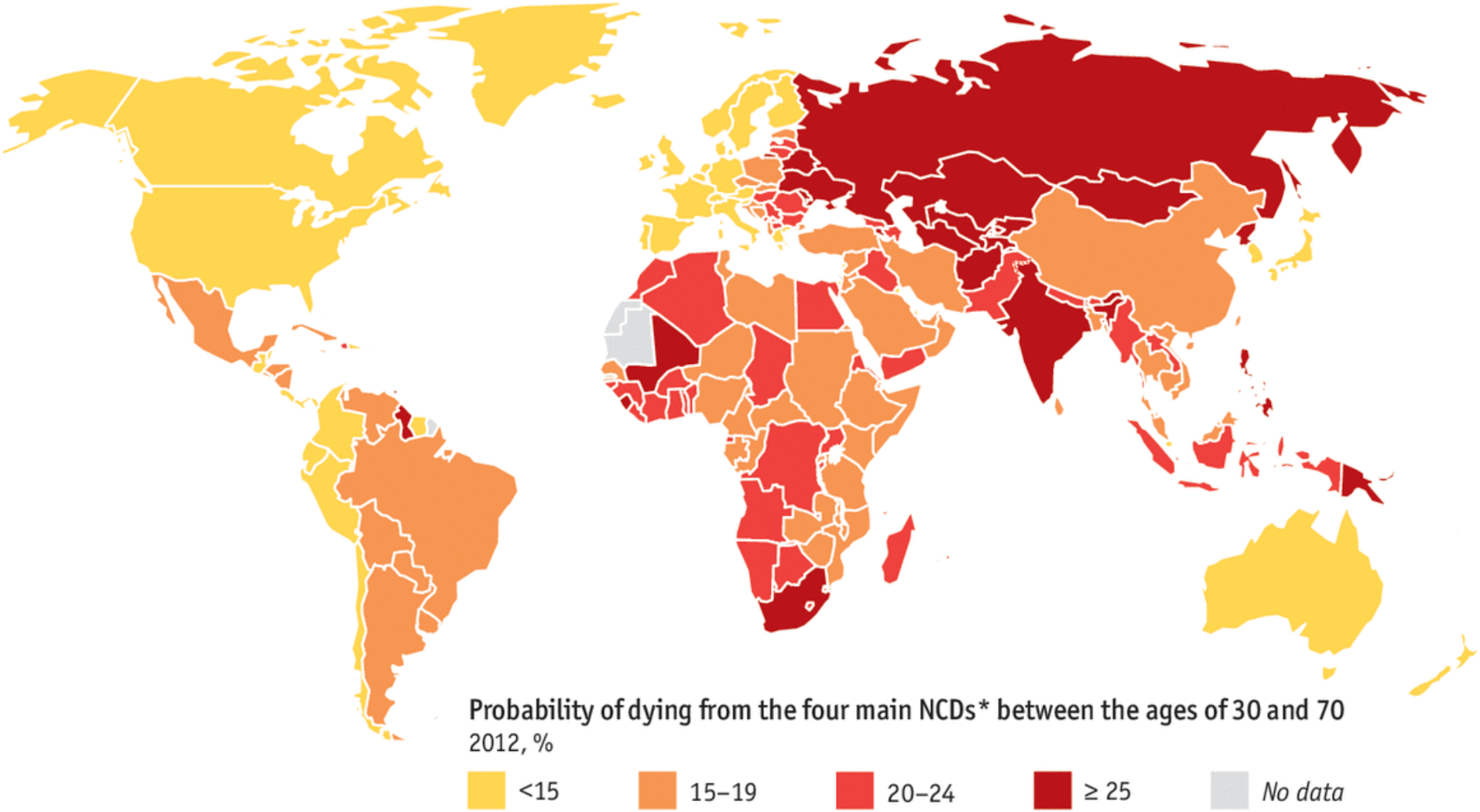
The world is changing …



Source: WHO

*Non-communicable diseases: cardiovascular diseases, cancer, chronic respiratory diseases and diabetes

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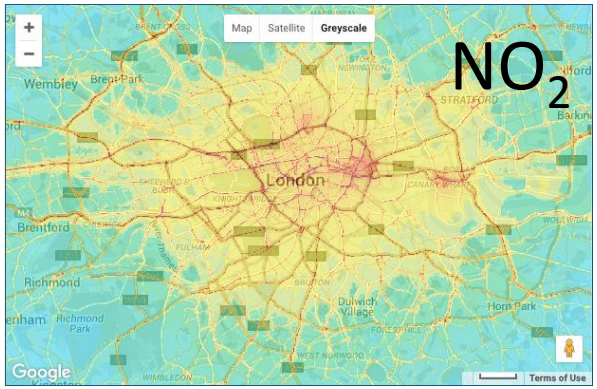
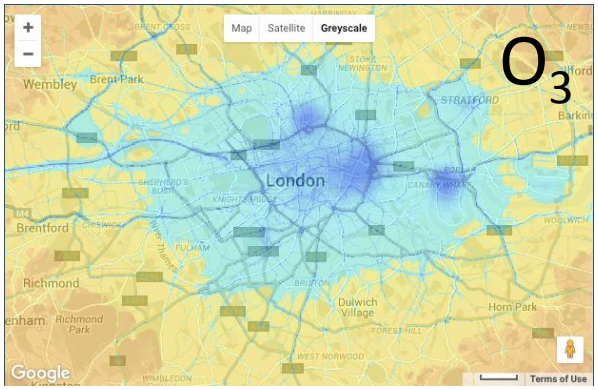
A shift in the burden of disease in counties with high rates of infectious disease

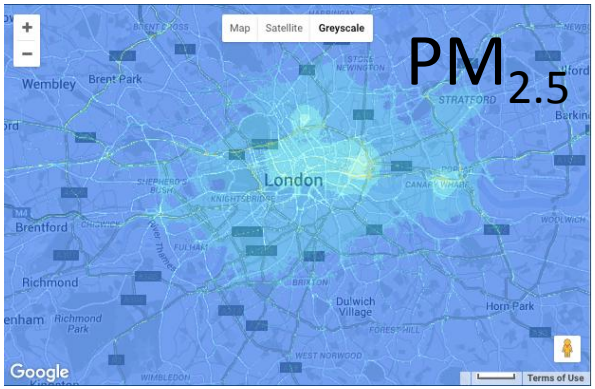
Health effects of air pollution: Time for reassessment?

1) Issues related to methodological bias – aggregated exposure metrics and health outcomes
2) Lack of monitoring infrastructure in rural settings
3) **Concerns about confounding/ multi-collinearity**

- Similar emission sources (traffic), dispersion processes
  $\Rightarrow$ correlation (NO_2, PM)
- O_3 titration in high pollution areas…
  $\Rightarrow$ anti-correlation







Modelled annual averages based on measurements made in 2010

$\Rightarrow$ Cannot distinguish causal links

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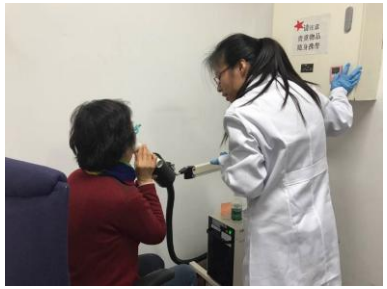
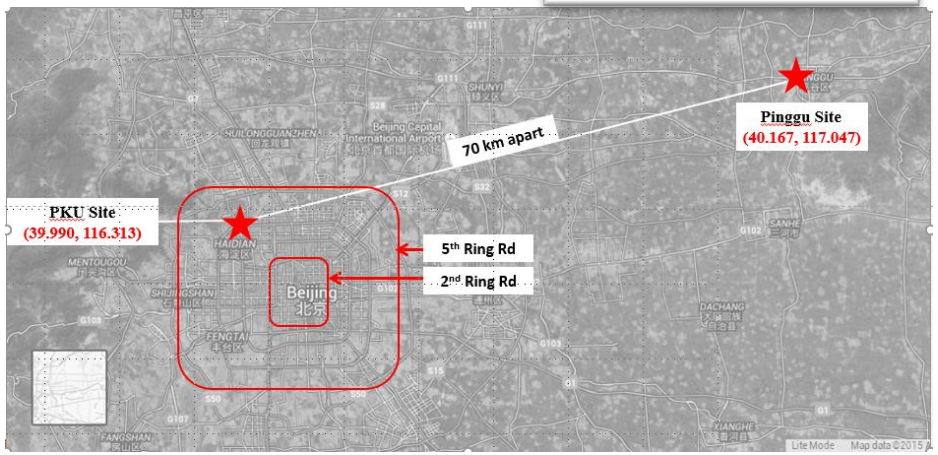
The AIRLESS project

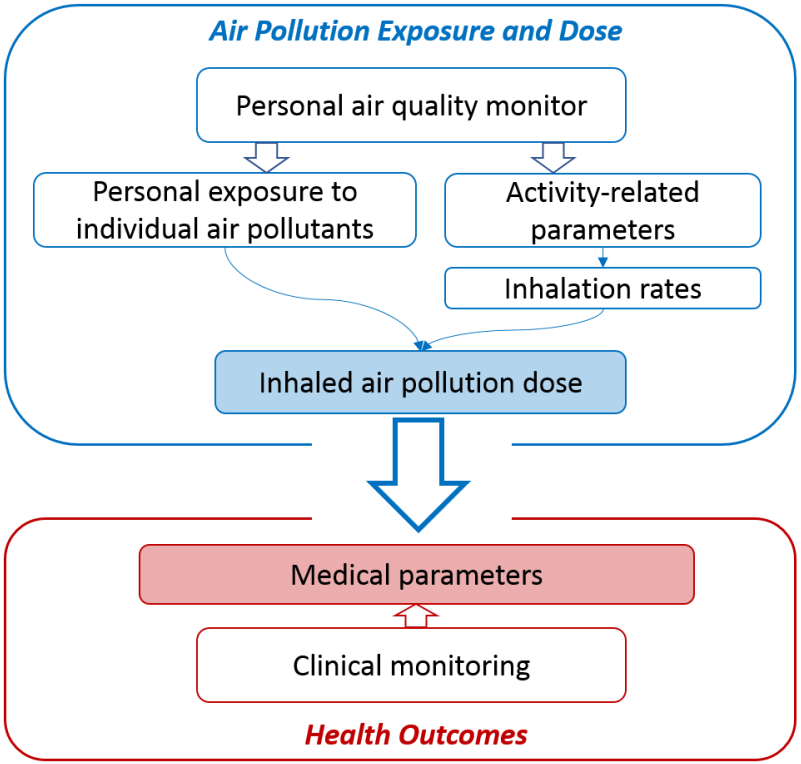
Personal exposure measurements at high spatial and temporal resolution + detailed medical outcomes ⇒ *underlying mechanisms of chronic disease*

urban cohort



rural cohort





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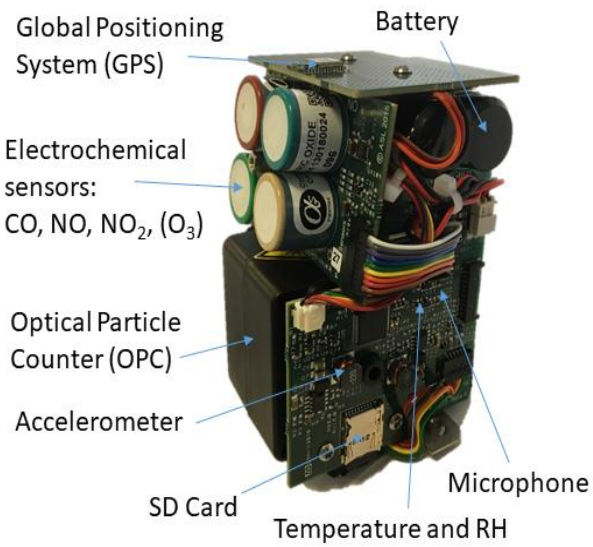
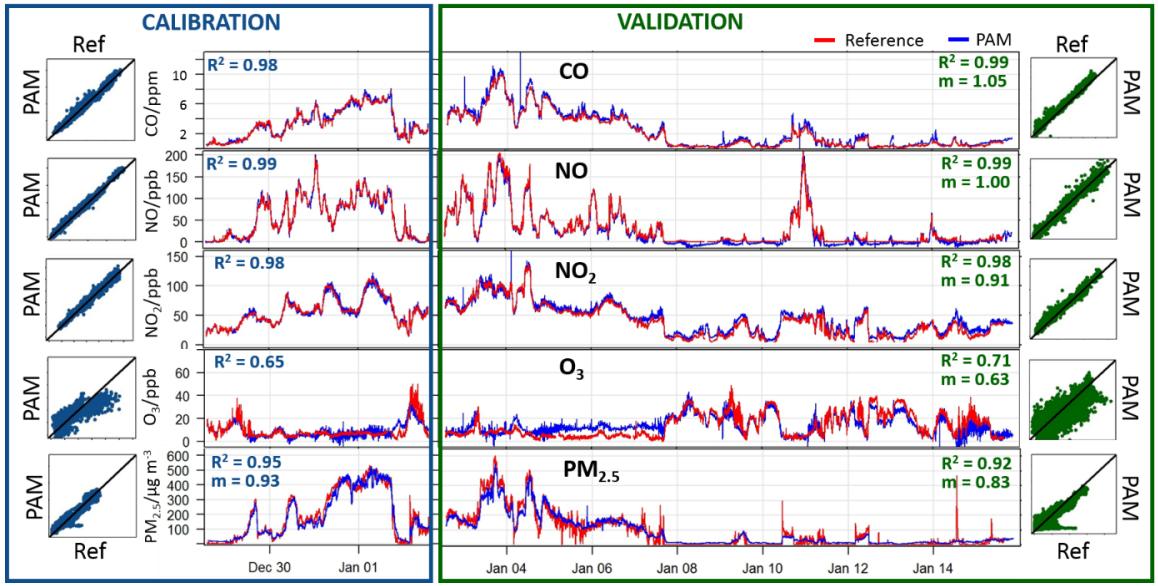
Highly portable sensor platforms

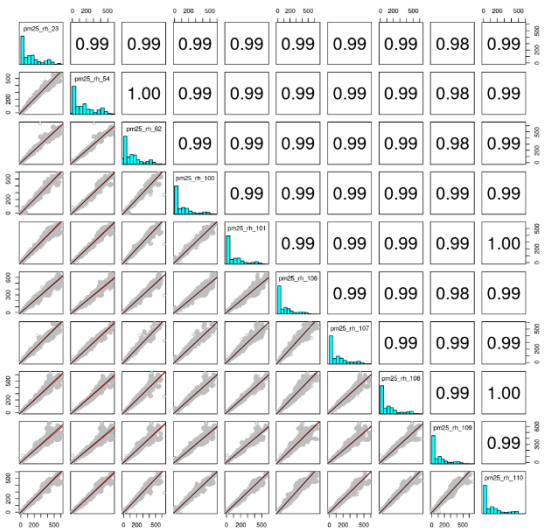
PAM: To capture the personal exposure to air pollution of an individual



[dimensions 12.5 cm x 9 cm x 8 cm; weight 400 g; resolution 1 min]



Outdoor co-location of 60 PAMs with the reference instrument on the roof of PKU. Time-series of pollutants measured with the PAM and reference instruments.



Reproducibility between 10 PM sensors

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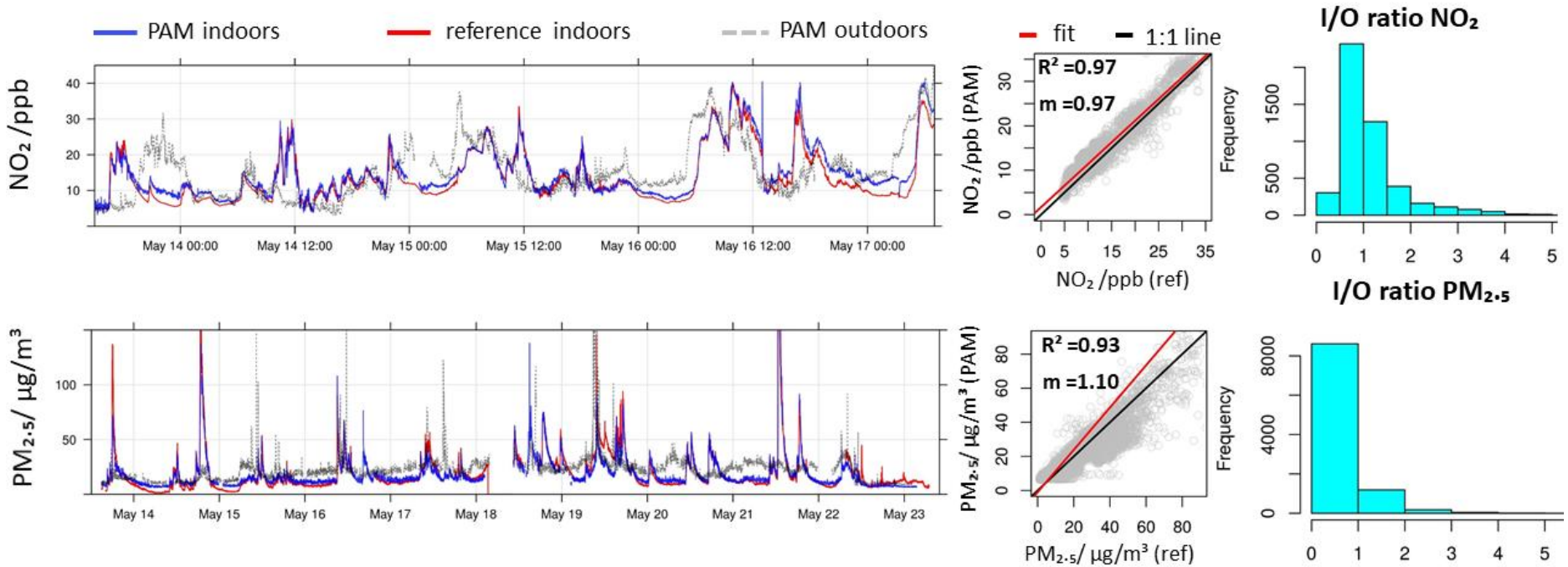
But do they work indoors ?

Excellent agreement with commercial portable instruments



Indoor co-location of a PAM (blue) with portable commercial instrumentation (red) in an urban flat in China during the non-heating season. A second PAM was deployed outdoors (grey).

NO_2 reference: cavity attenuated phase shift spectroscopy (CAPS), University of York
$PM_{2.5}$ reference: spectrometer (GRIMM 1.108), NERC

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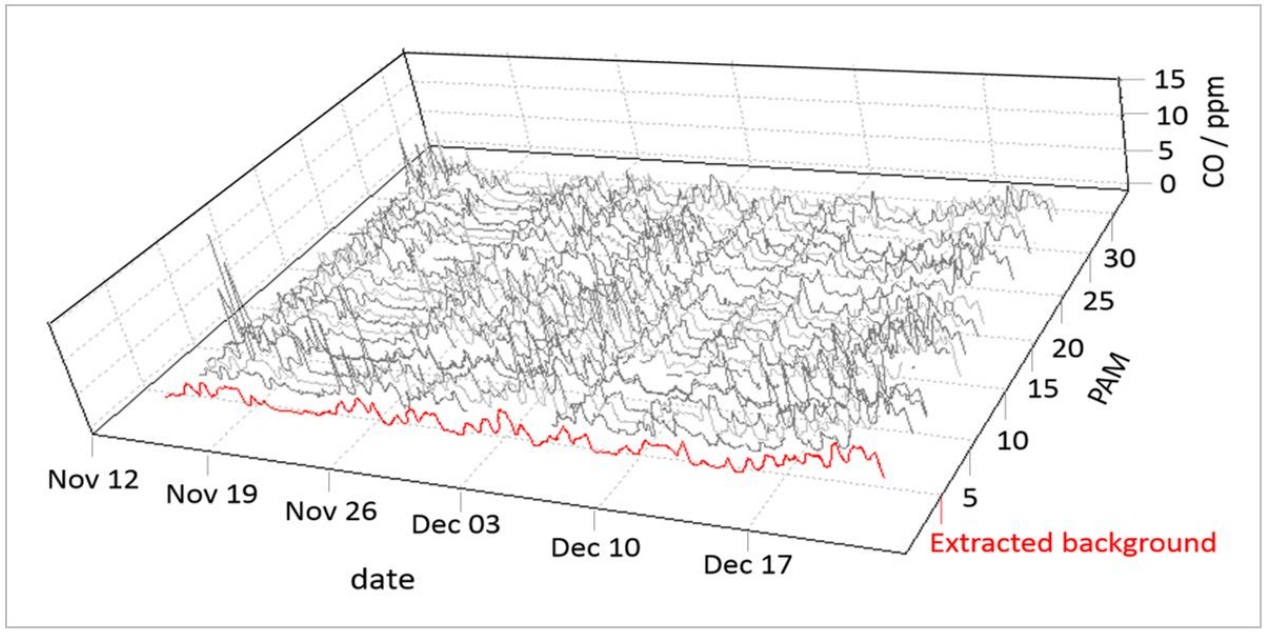
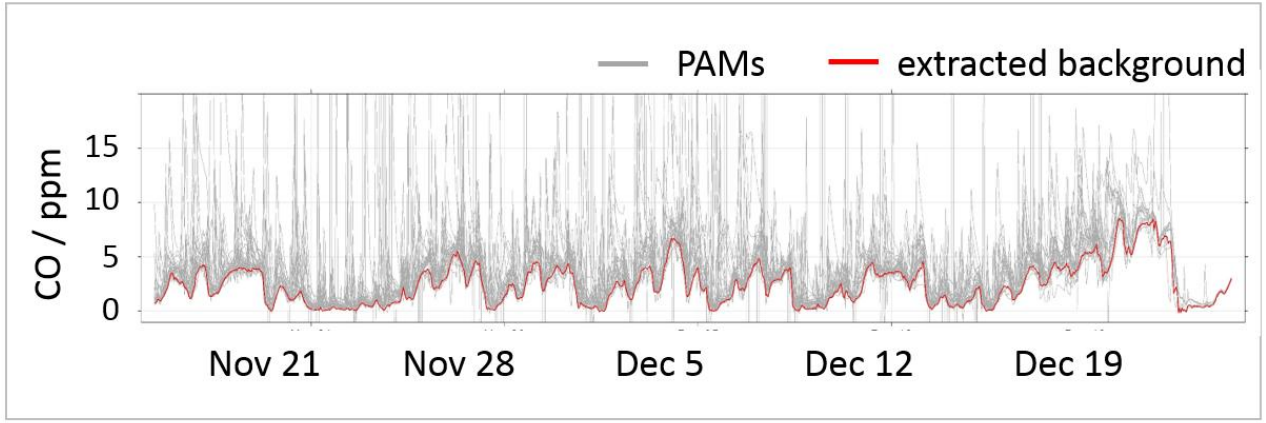
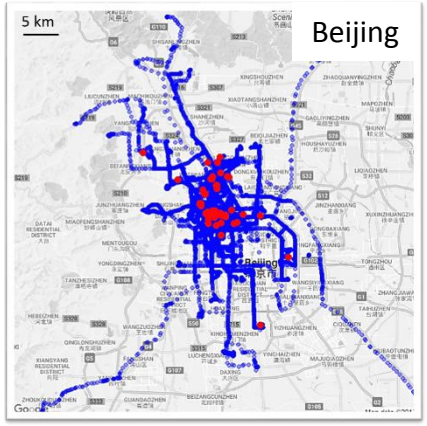
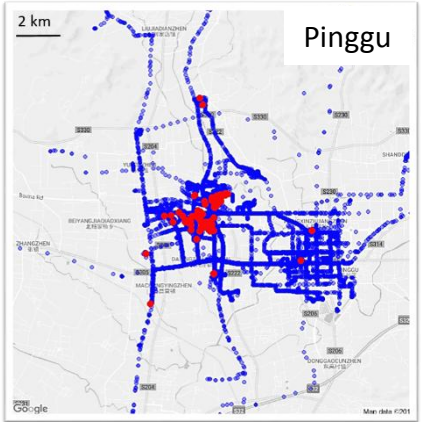
Mobile air pollution monitoring networks

3D presentation of CO concentrations measured by the urban sensor network (grey)



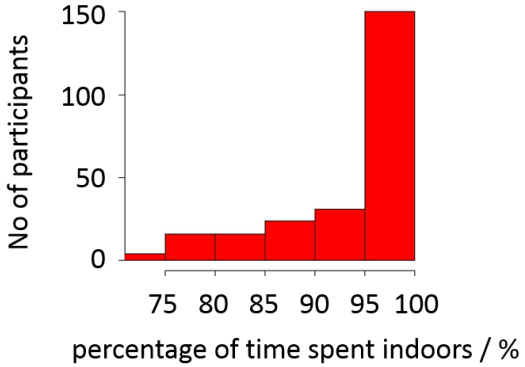




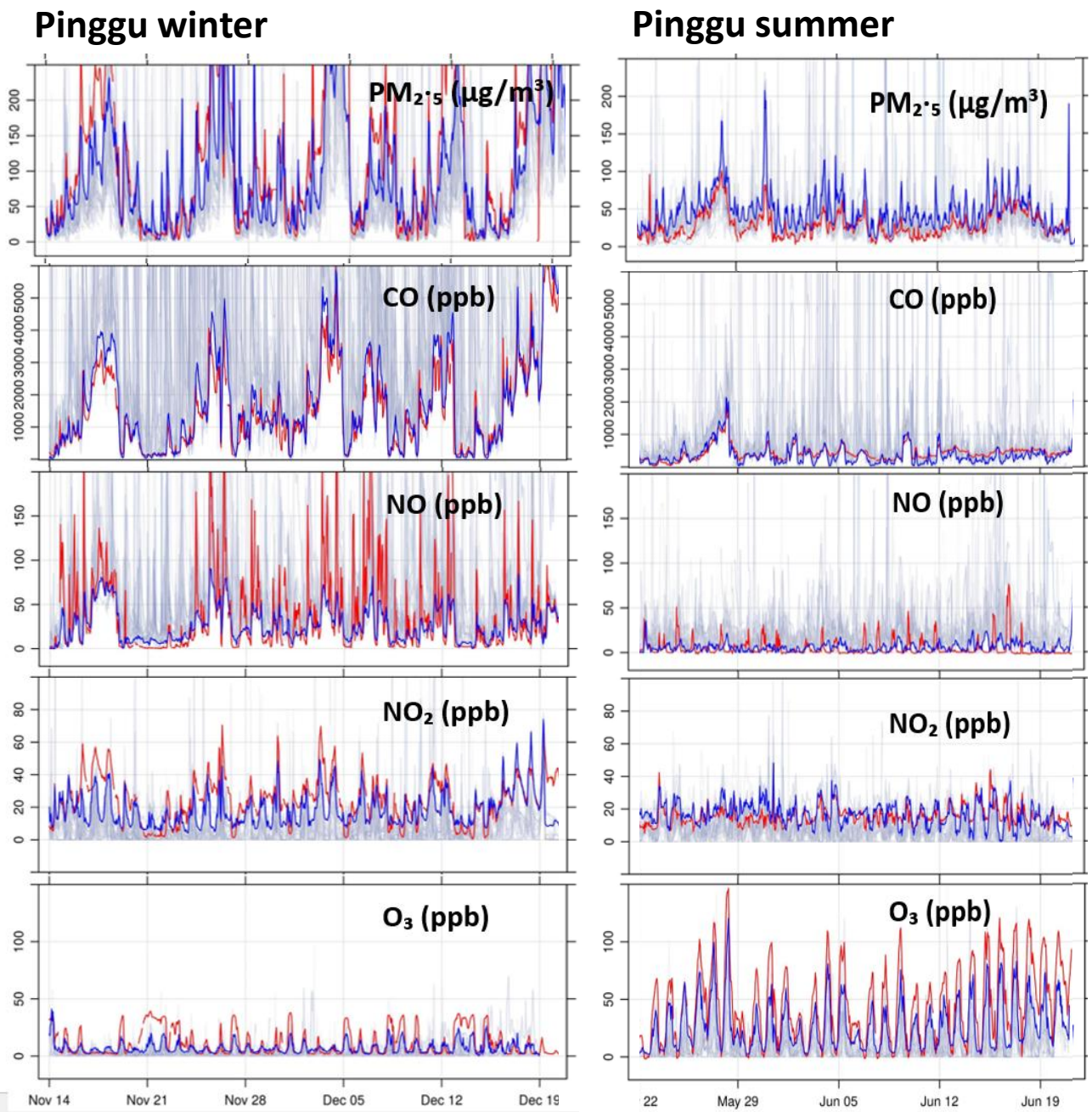


home location of participant

visited locations during participation



Mobile air pollution monitoring networks



- **Real-time validation of the PAM performance during daily life across seasons and settings**
- **Capture the heterogeneity of personal exposure in high spatial and temporal resolution in under-researched rural locations**

Extracted background

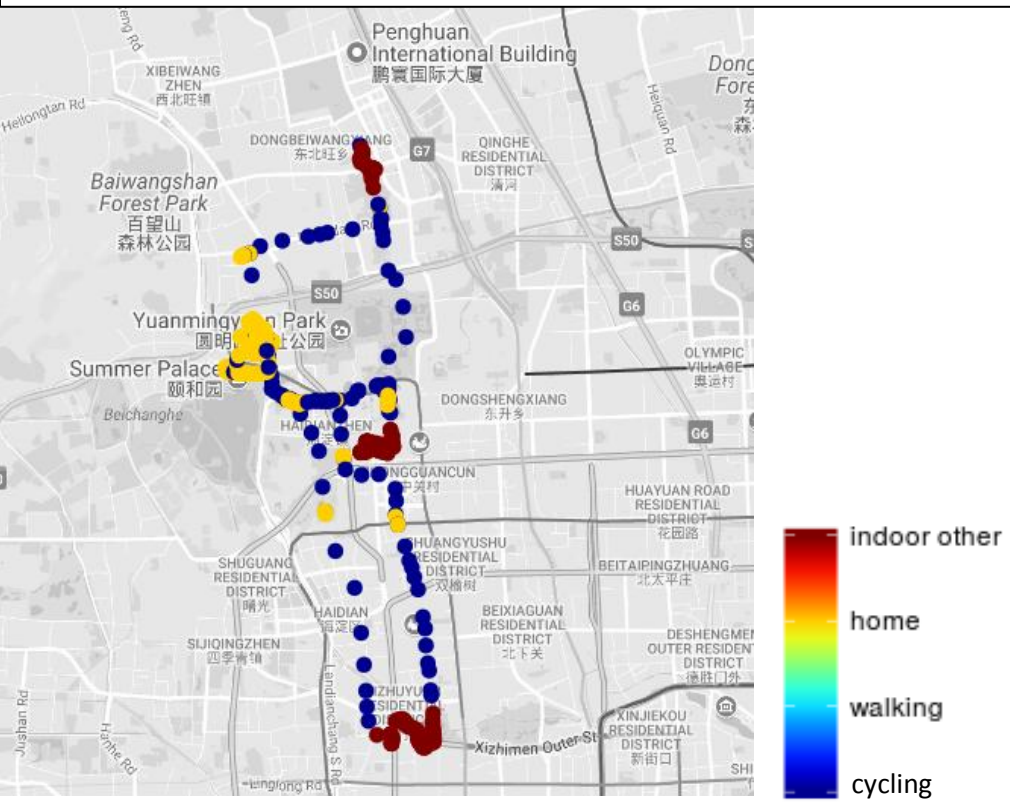
reference

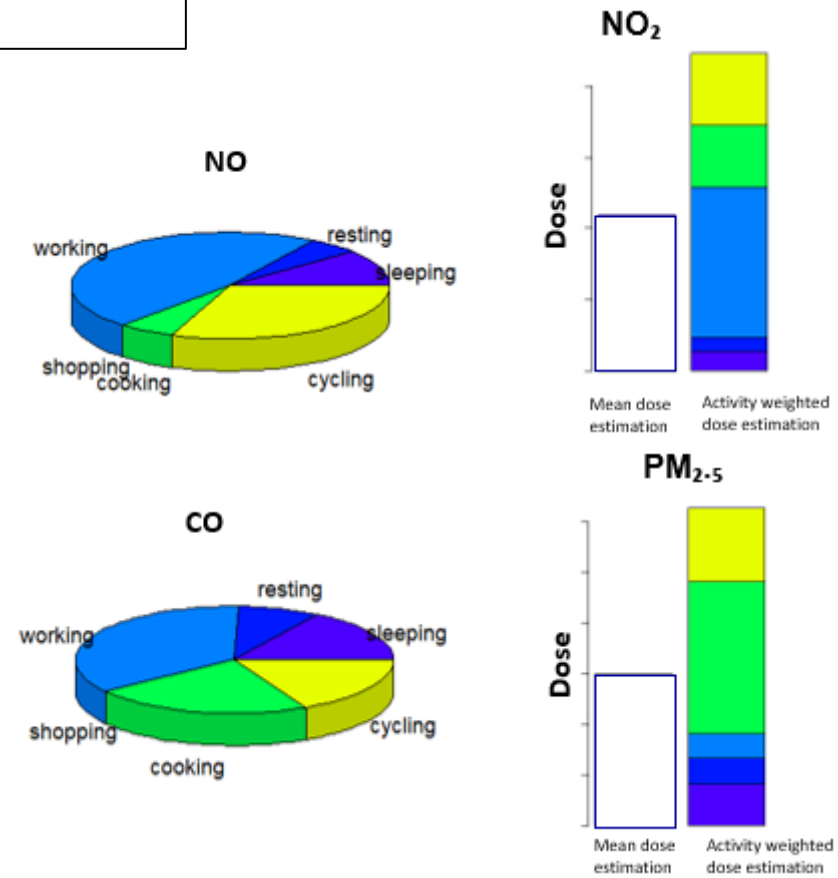
All PAMs

Automated time-activity model

PAM enables:

- **Assignment of exposure levels to different activities**
- **Capture of exposure during commuting**
- **Activity-weighted exposure**





Map of visited places of case participant, coloured by location category (motorised travel, walking, home, indoor other).

Comparison between dose estimations using a generic inhalation rate (white bars) and using activity-dependent inhalation rates (coloured bars)

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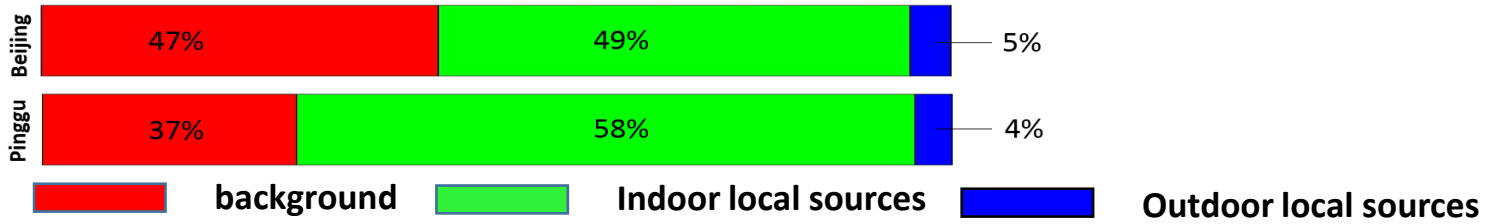
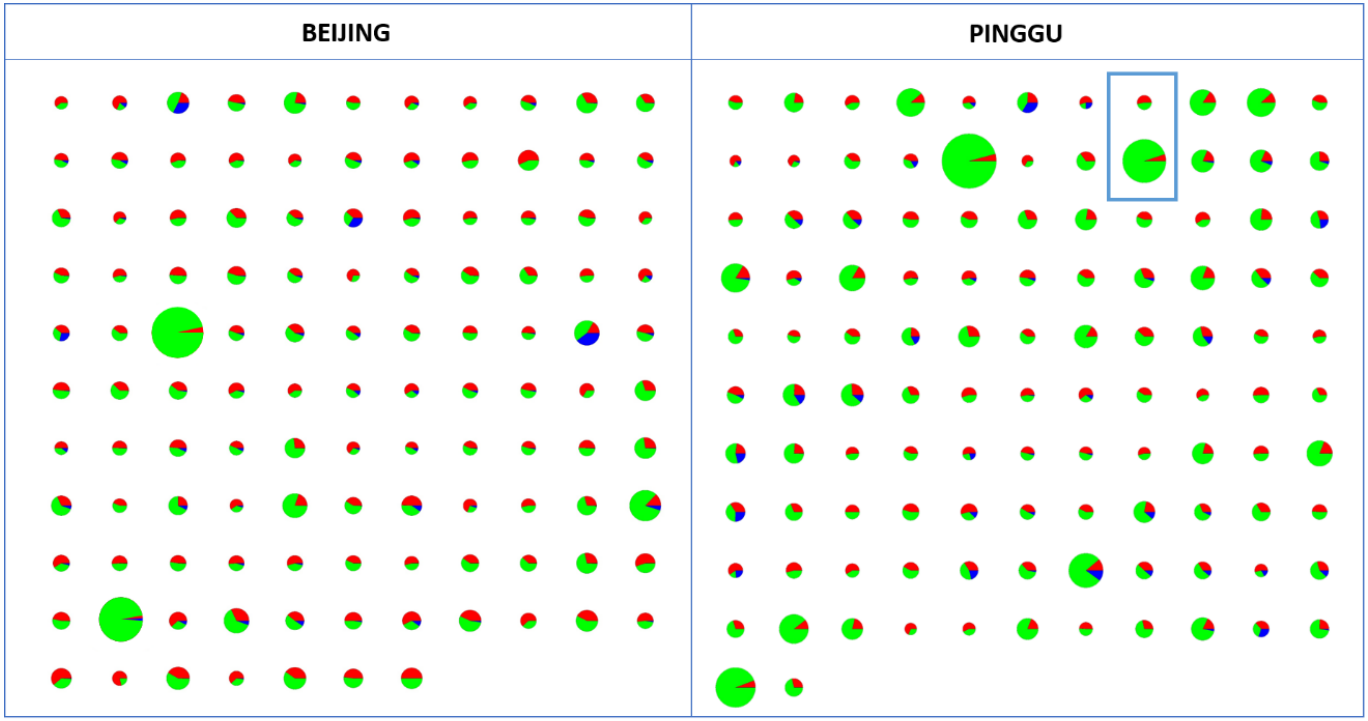
Variability of personal exposure to air pollution



Mean overall CO exposure of all participants



Pie area ∝ total exposure

Indoor exposure is a significant part of total personal exposure.

Novel sensing technologies can revolutionise health studies

Overall CO exposure of each individual in the Beijing and Pinggu cohort. The area of the pie is proportional to their total exposure over the whole participation time. The colours indicate the contribution from background pollution levels (red), indoor (green) and outdoor (blue) emission sources in the surroundings

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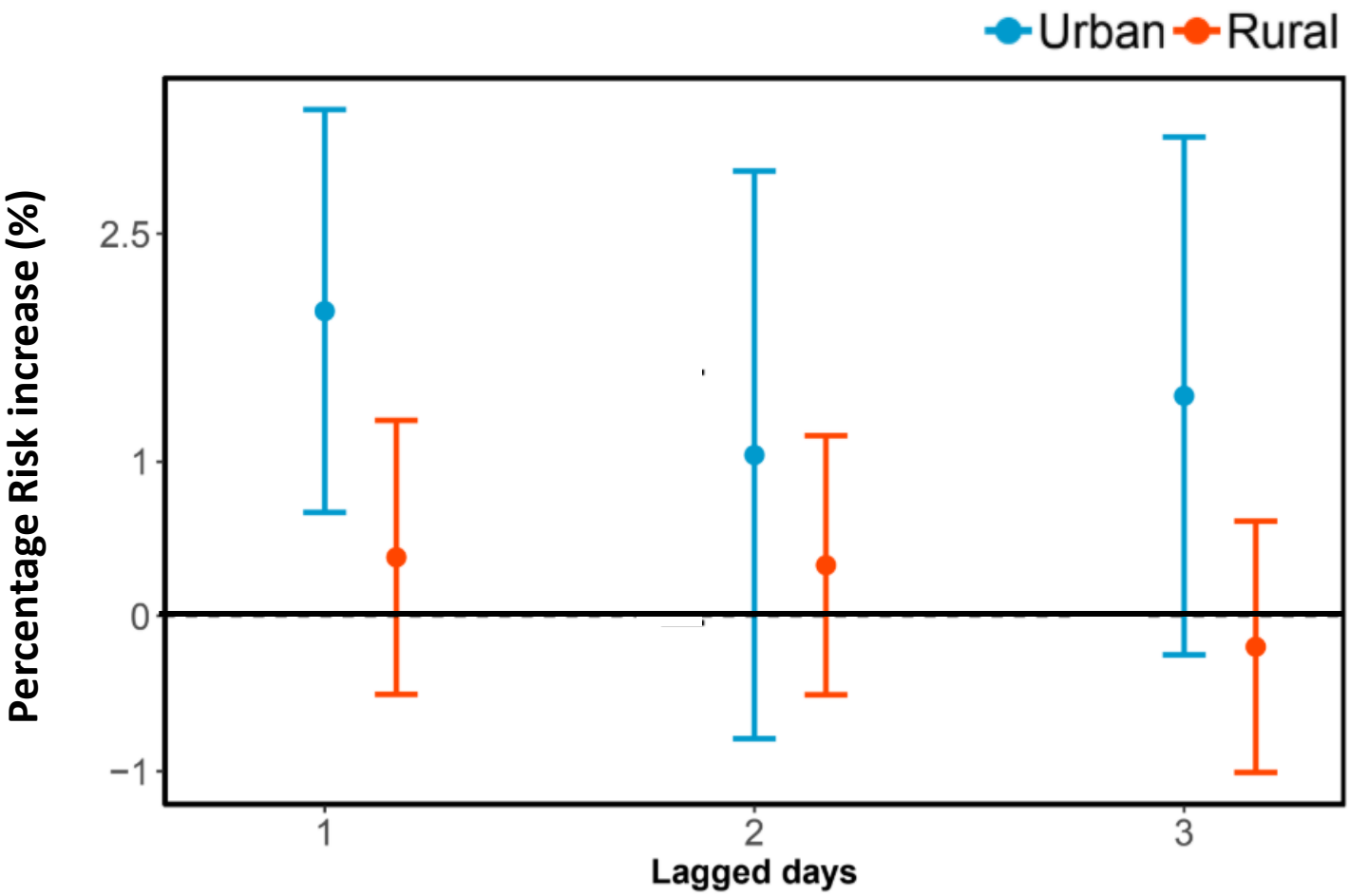
Distinct health outcomes between cohorts



Monocytes (a type of white blood cell used as a biomarker for inflammatory response) ~ personal exposure to $PM_{2.5}$

Urban residents had acute health responses associated with personal exposure to $PM_{2.5}$

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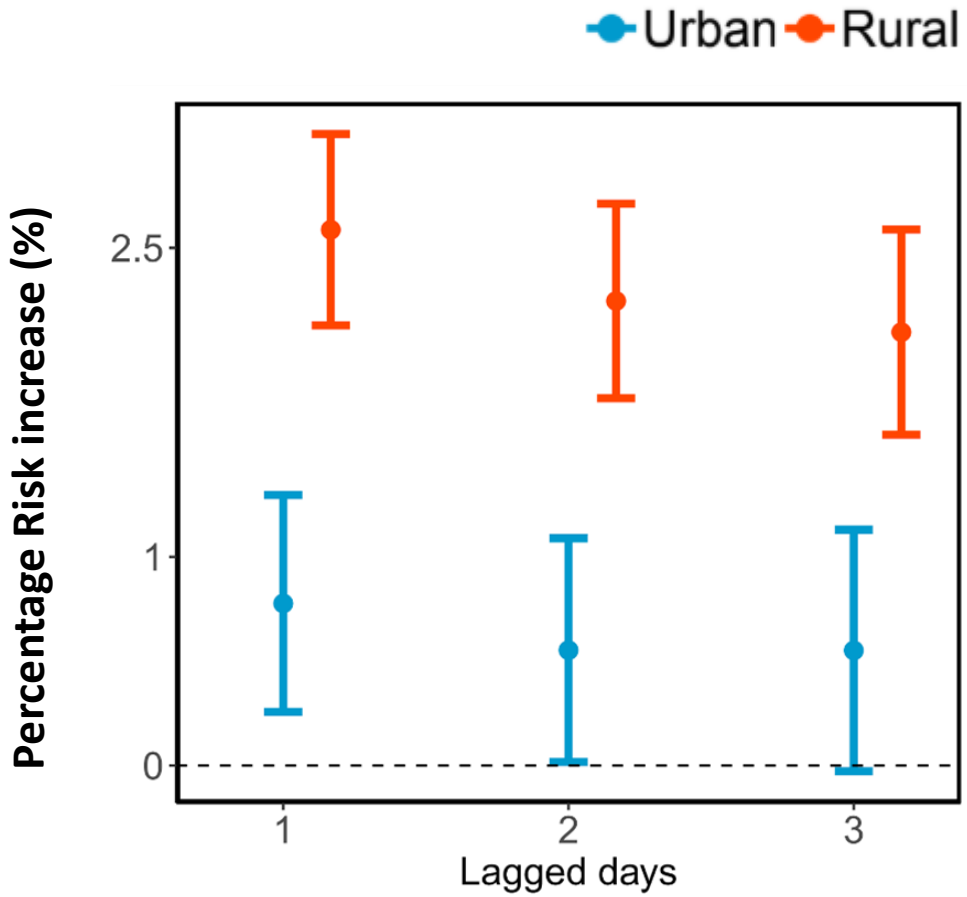
graph: Yiqun Han

…which could not be captured when using outdoor measurements as metrics of exposure



Monocytes (a type of white blood cell used as a biomarker for inflammatory response) ~ **outdoor** $PM_{2.5}$ from fixed monitoring station

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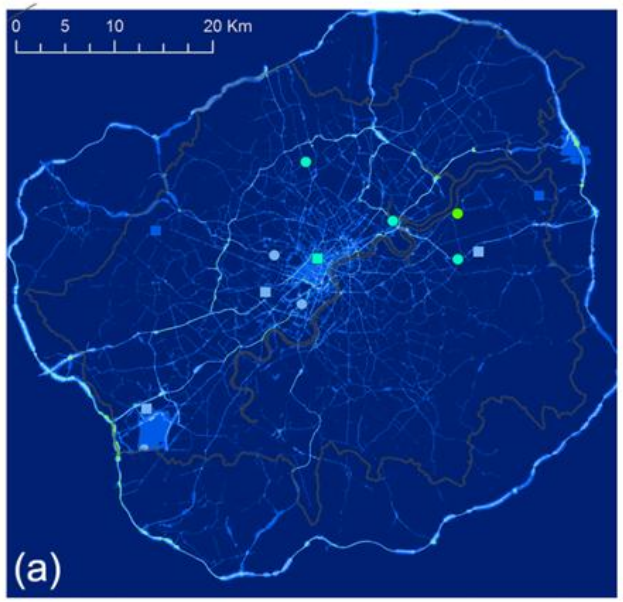
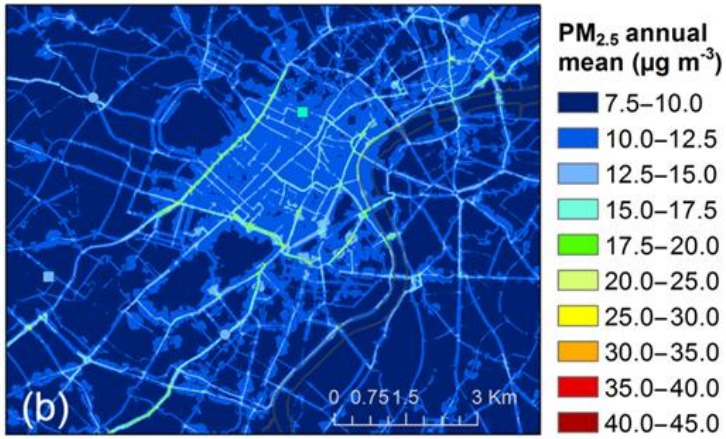
graph: Yiqun Han

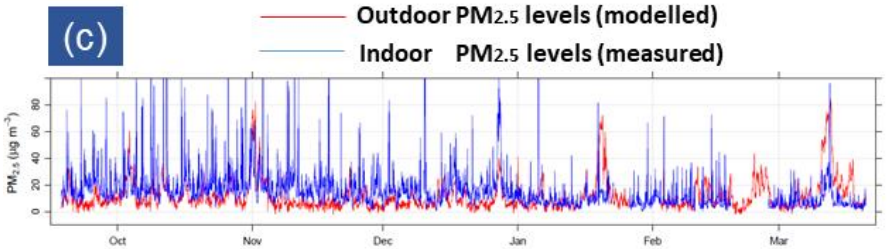
Future work

WP3: Outdoor dispersion modelling

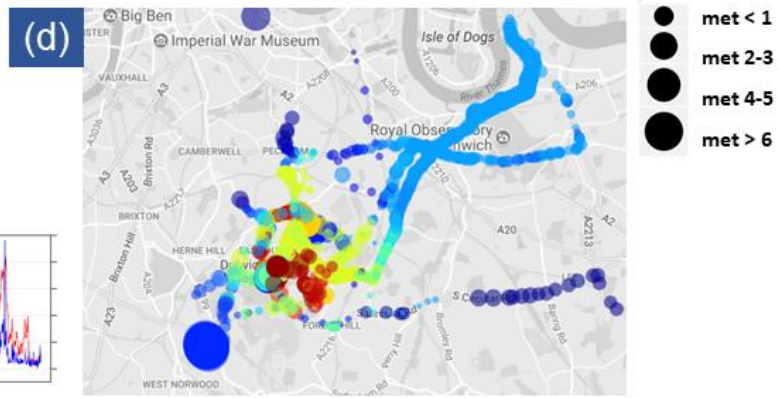




WP4: Indoor air pollution modelling



WP5: Time-activity profiling



An illustrative example of the proposed methodology to develop a modelling tool to estimate personal exposure to air pollution at high spatial and temporal resolution in large-scale studies.

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Summary

Novel sensing technologies can improve personal exposure metrics by increasing coverage in pollutant species, space, time, microenvironments and geographical settings.

Mobile air pollution networks can validate sensor performance in real-time and input for outdoor and indoor models.

Automated time-activity-location classifications can integrate inhalation rates in personal exposure estimates.

Together with detailed medical outcomes to investigate the underlying mechanisms of air pollution impacts on health revolutionising epidemiological evidence.

Future work involves the development of an open-source, extendable and validated methodological framework to estimate air pollution exposure at the individual level across seasons and geographical locations

Thank you!
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- **All participants** from Pinggu and Peking University

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Appendix

Mobile air pollution monitoring networks