Estimating Personal Exposure to Air Pollution on the Journey to and from School using GPS, GIS & Mobile Phone Technology

Duncan Whyatt
Lancaster Environment Centre
Lancaster University

d.whyatt@lancaster.ac.uk

Colin Pooley, Paul Coulton, Marion Moser, Gemma Davies, Will Bamford

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

LANCASTER UNIVERSITY

Background

- Medical evidence shows air pollution causes premature deaths and reduced life expectancy
  - Fine and ultra-fine particles considered particularly problematic
- The effects of air pollution depend on the age and general health of the person exposed, the concentration of the pollutants, the duration of exposure and the level of activity being undertaken
- Children considered to be particularly at risk

Previous Studies

- Have tended to focus on chronic exposure assessment, hence time-varying factors have been ignored
  - Static location (postcode or geographic coordinate)
  - Static pollution (annual mean concentration or surrogate, e.g., distance to nearest heavily-trafficked road)
- "It would seem worthwhile to try and take some account of both time-activity patterns and temporal patterns of pollution in exposure assessment…" [Briggs, 2005]
- Recent progress in personal exposure assessment: DAPPLE (monitoring), STEMS (modelling)

This Study

- Explores alternative methods of deriving estimates of personal exposure to air pollution
- Uses GPS technology to capture the positions of children on their journeys to and from school
- Uses a mobile-phone based application to capture children's perceptions of the environment en route
- Uses a dispersion model (ADMS Roads) to generate sub-hourly pollution surfaces at high spatial resolution
- Uses GIS techniques to integrate quantitative & qualitative data in space and time

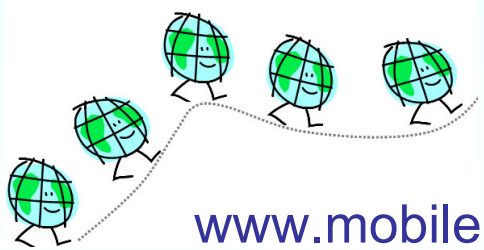
Methodology

- 30 school children + reserves (aged 12-13 years)
  - Opted into the study (with parental consent)
  - Supported by the school
- Each provided with GPS unit and mobile phone running a customised application ("GeoBlog")
  - 4 x 1 week survey periods
- Follow-up interviews after each survey period



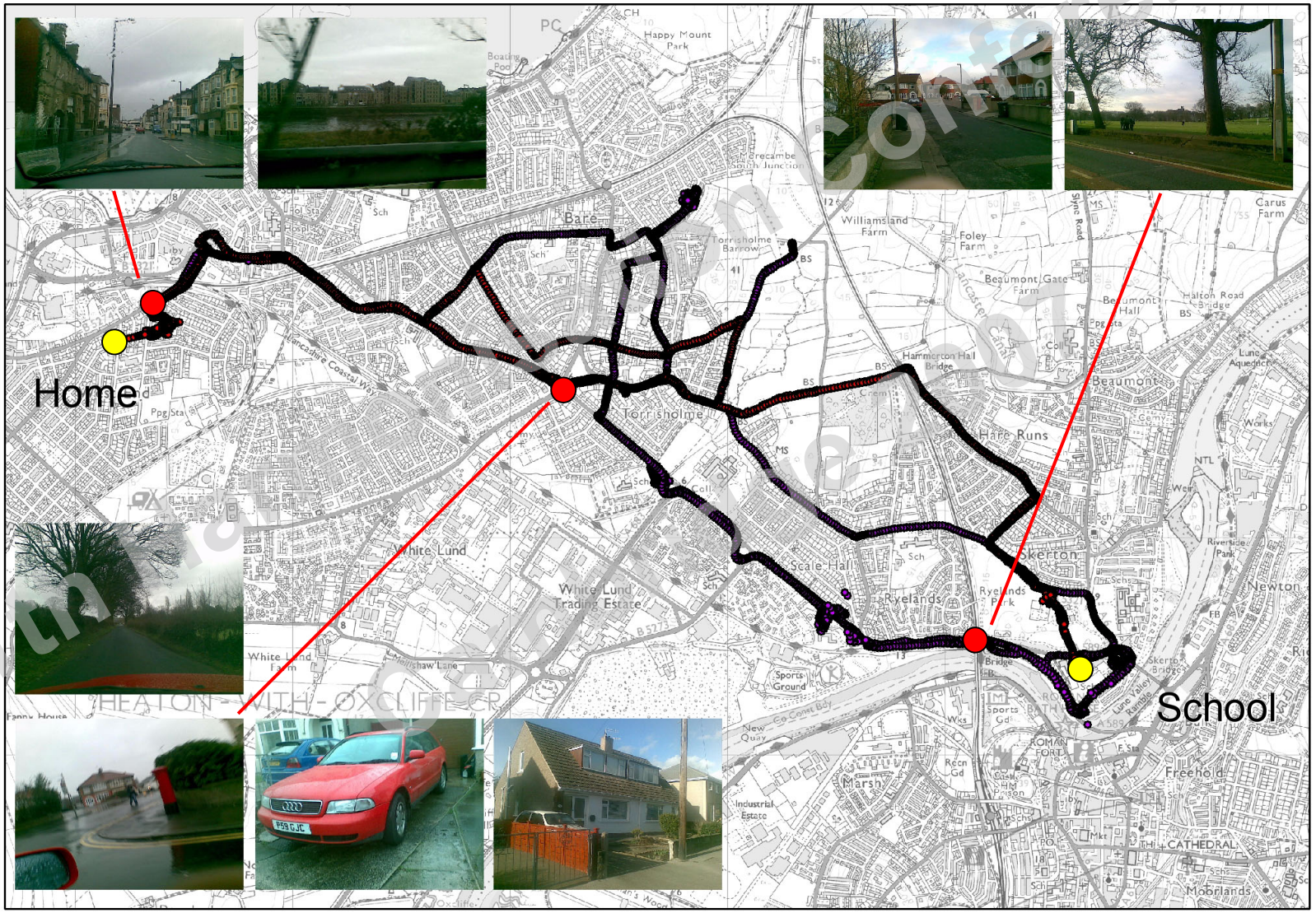

GeoBlog Application

- Java application running on Nokia 5500 phone
- Position of user captured and stored at 1 second intervals using GPS
- User blog entries (text and photos) are time and place-stamped
- Daily symptoms list also accessed via mobile phone interface

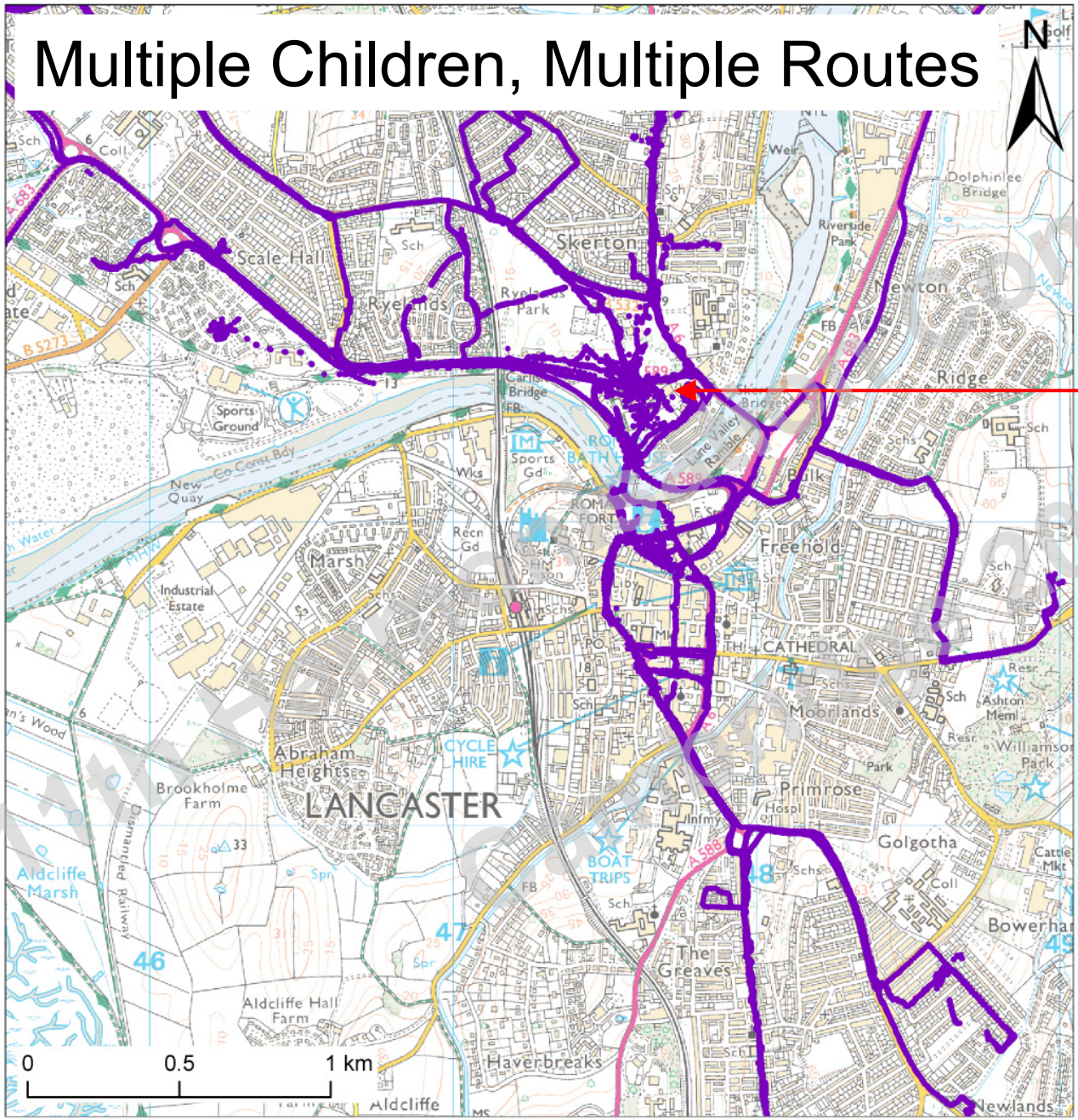


www.mobileradicals.com

Sample Geoblog (Adam)



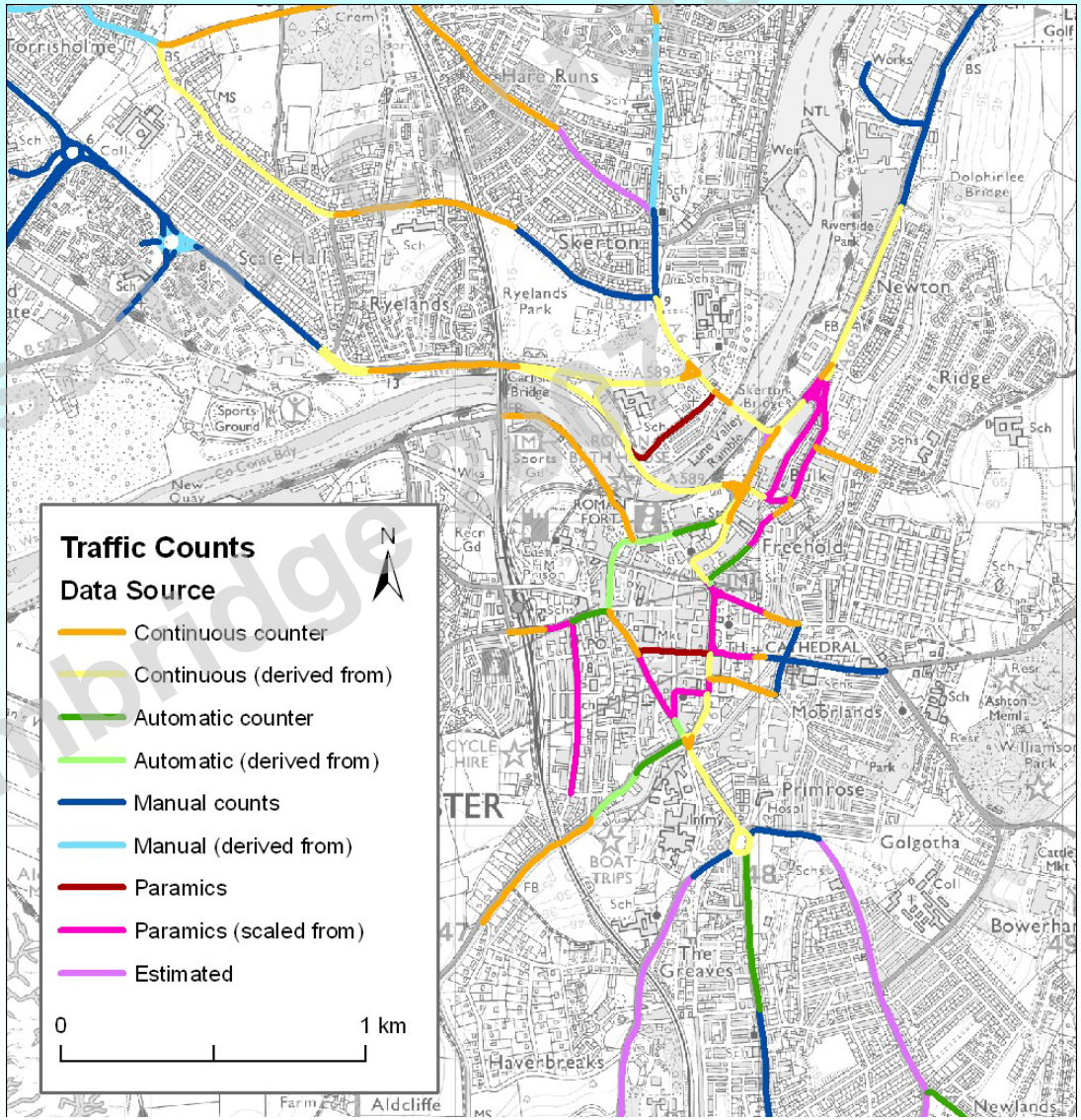
Multiple Children, Multiple Routes

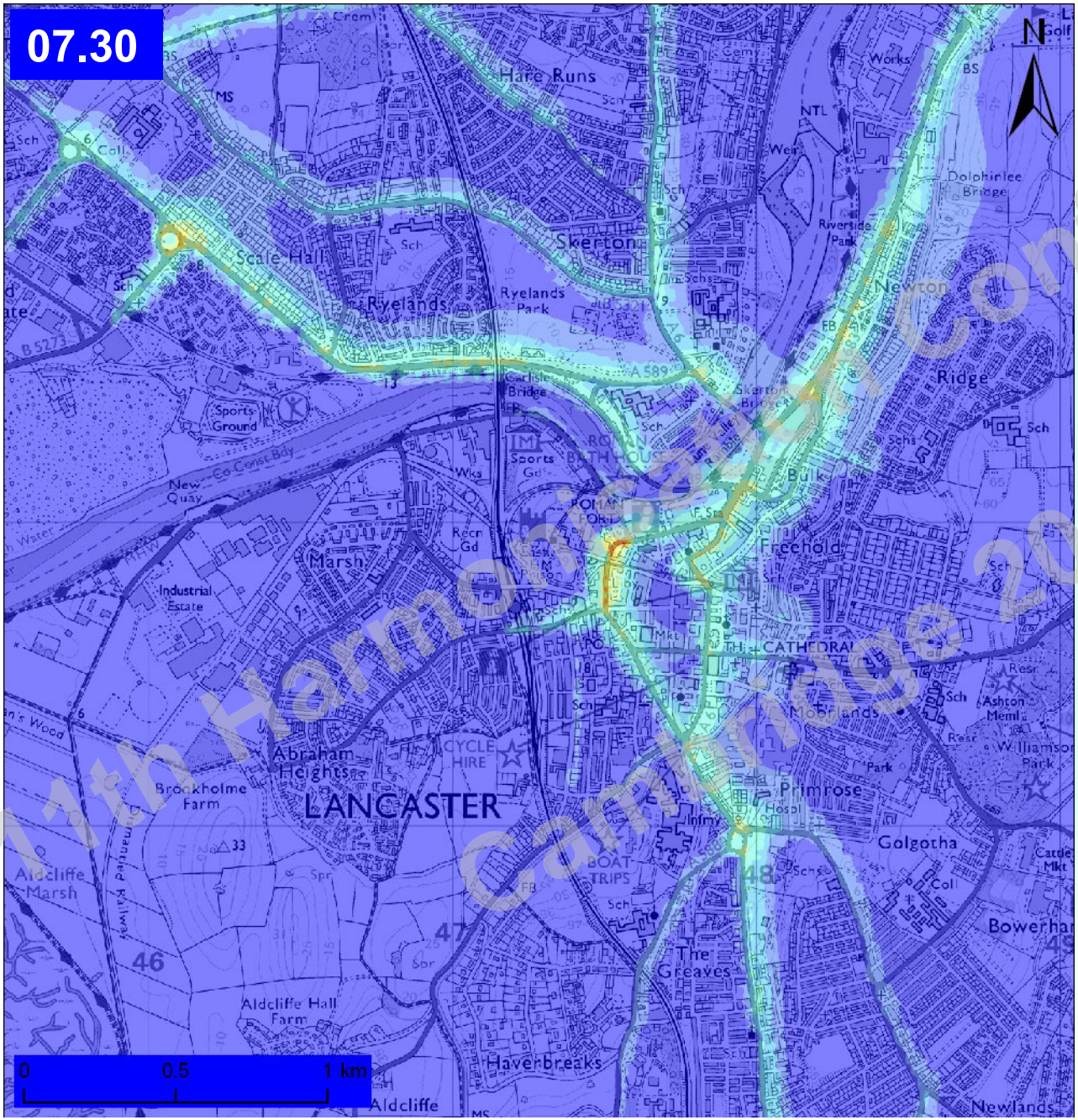


GPS-derived location based on 1 second sampling rate

Dispersion Modelling: Roads Database

- Developed for 15 min time-slices
- Using combination of continuous, automatic and manual traffic count data
- Plus some infilling using estimates from the PARAMICS traffic simulation model



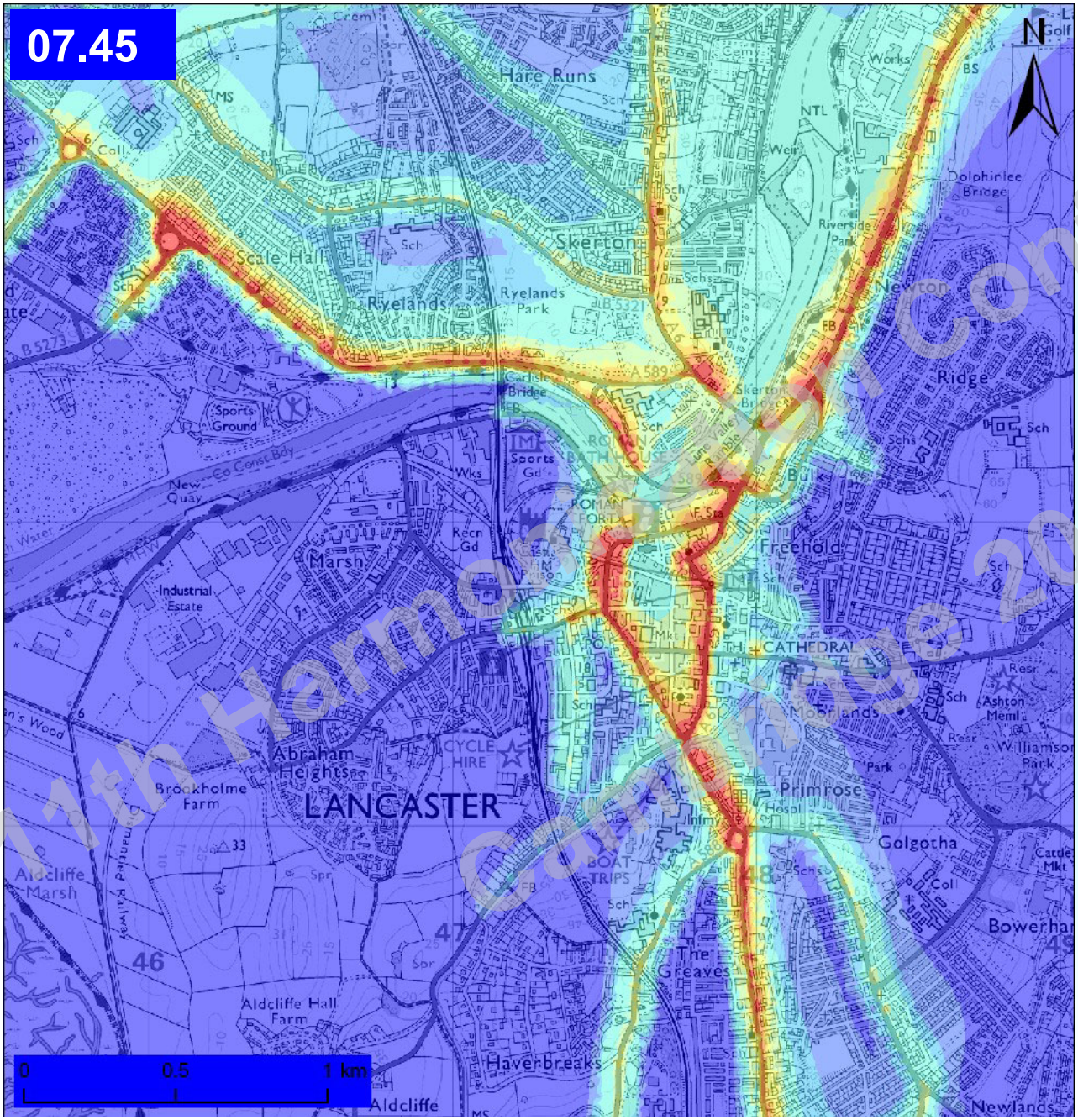


$PM_{2.5}$ µg/m³

- < 10.75
- 10.75 - 10.85
- 10.85 - 11.05
- 11.05 - 11.70
- 11.70 - 12.35
- 12.35 - 13.00
- 13.00 - 13.65
- 16.65 - 14.95
- > 14.95

●●●●●●● Participant's Route

$PM_{2.5} = PM_{10} \times 0.65$

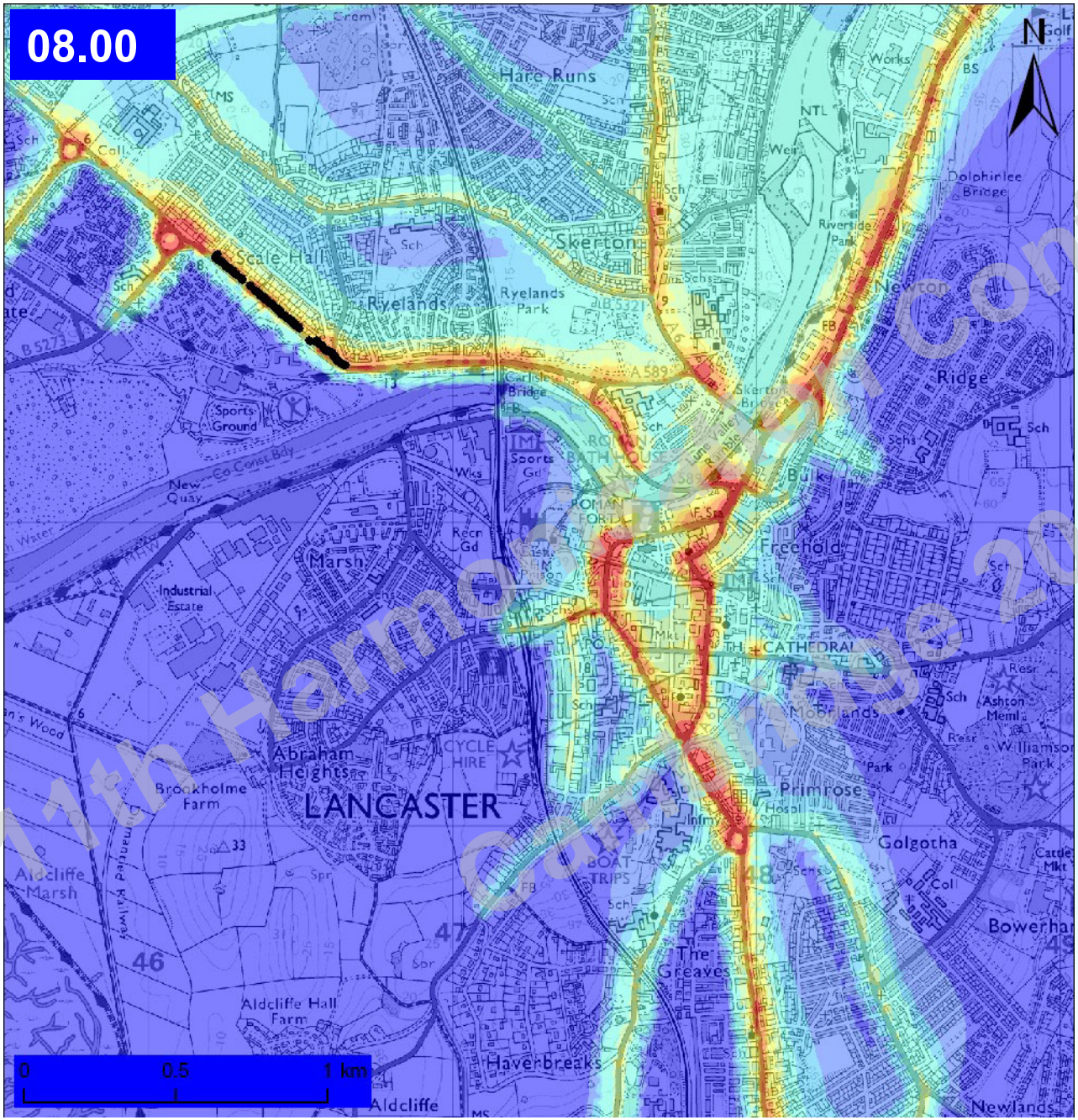


$PM_{2.5}$ µg/m³

- < 10.75
- 10.75 - 10.85
- 10.85 - 11.05
- 11.05 - 11.70
- 11.70 - 12.35
- 12.35 - 13.00
- 13.00 - 13.65
- 16.65 - 14.95
- > 14.95

●●●●●●● Participant's Route

$PM_{2.5} = PM_{10} \times 0.65$

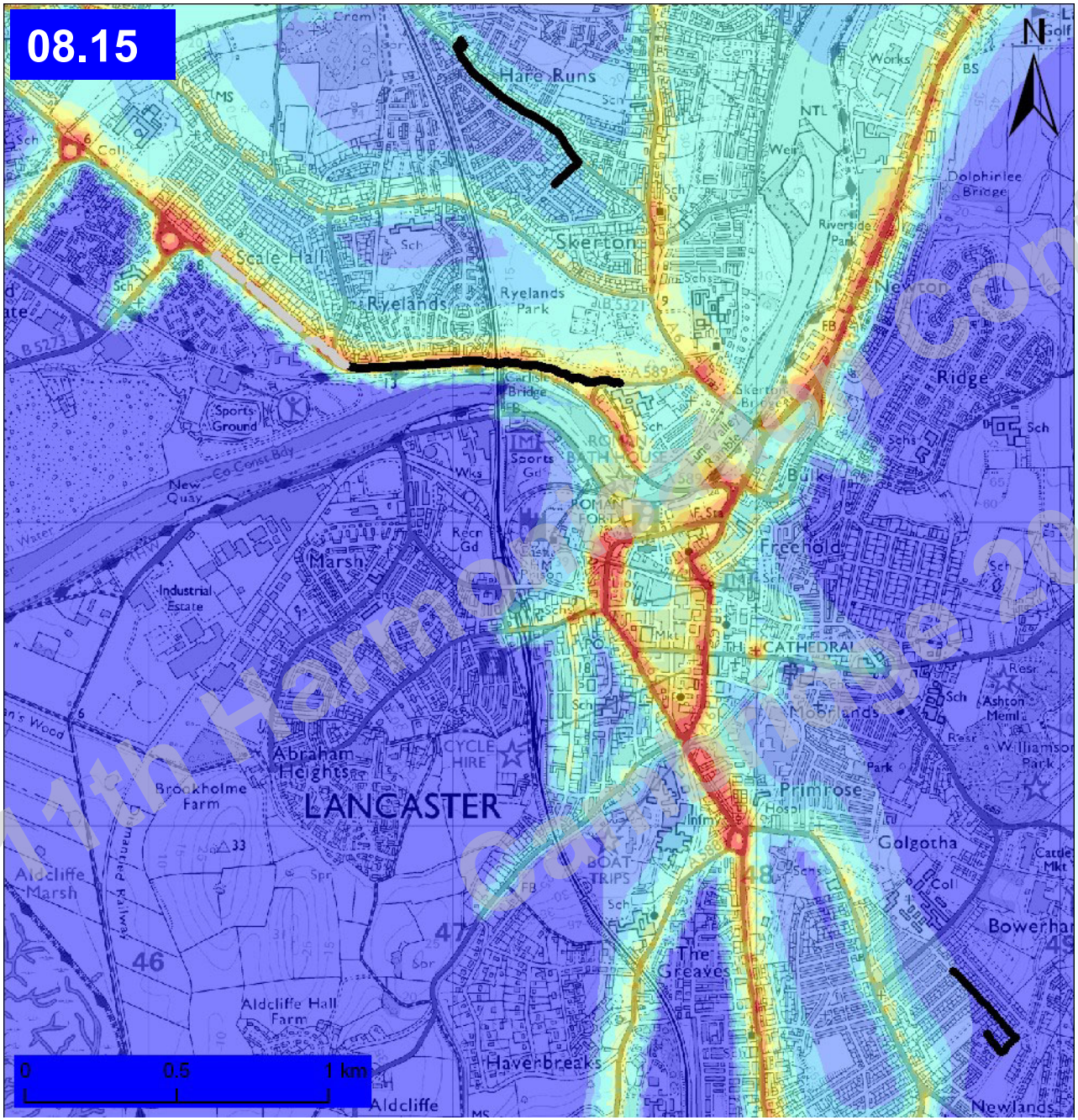


$PM_{2.5}$ µg/m³

- < 10.75
- 10.75 - 10.85
- 10.85 - 11.05
- 11.05 - 11.70
- 11.70 - 12.35
- 12.35 - 13.00
- 13.00 - 13.65
- 16.65 - 14.95
- > 14.95

●●●●●●● Participant's Route

$PM_{2.5} = PM_{10} \times 0.65$

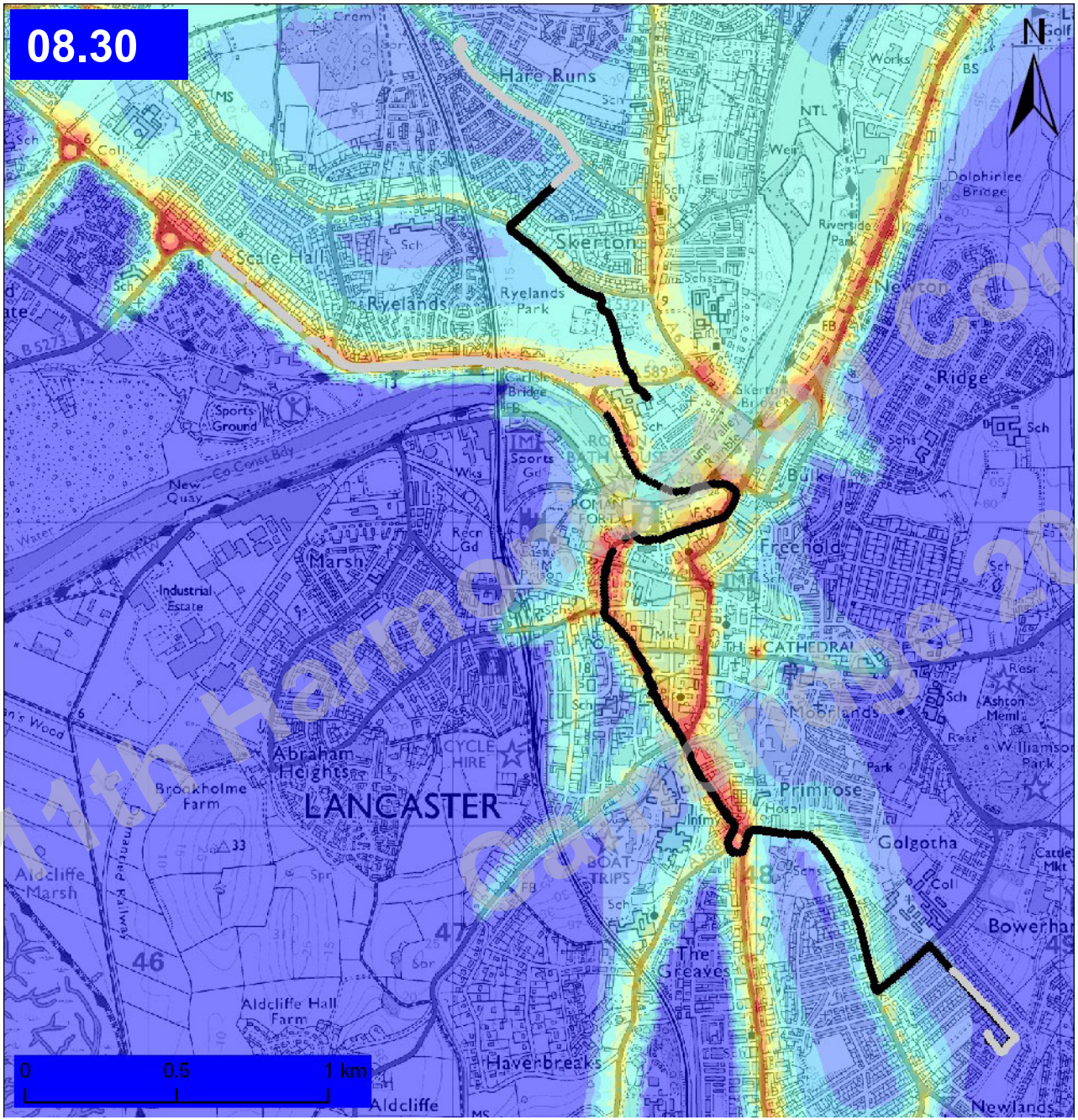


$PM_{2.5}$ µg/m³

- < 10.75
- 10.75 - 10.85
- 10.85 - 11.05
- 11.05 - 11.70
- 11.70 - 12.35
- 12.35 - 13.00
- 13.00 - 13.65
- 16.65 - 14.95
- > 14.95

Participant's Route

$PM_{2.5} = PM_{10} \times 0.65$



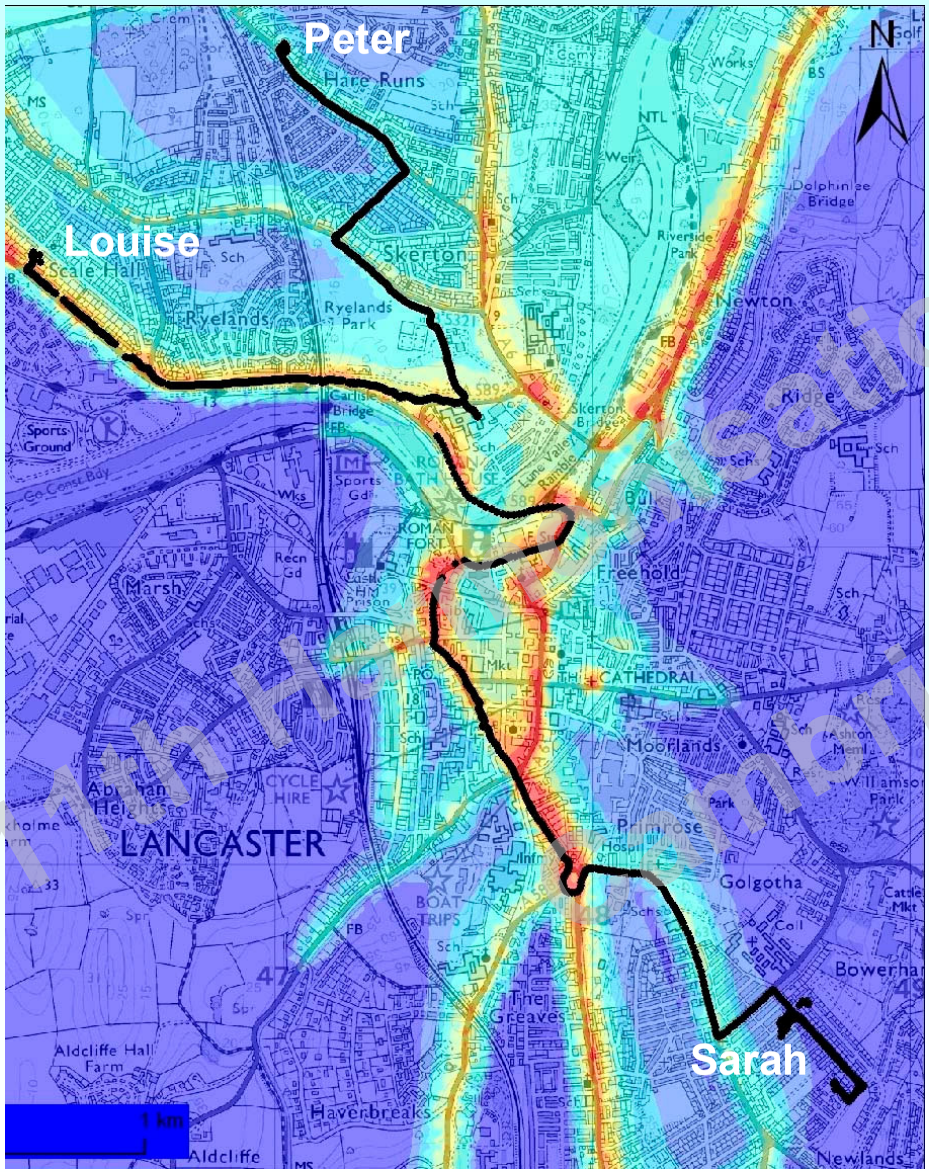
$PM_{2.5}$ µg/m³

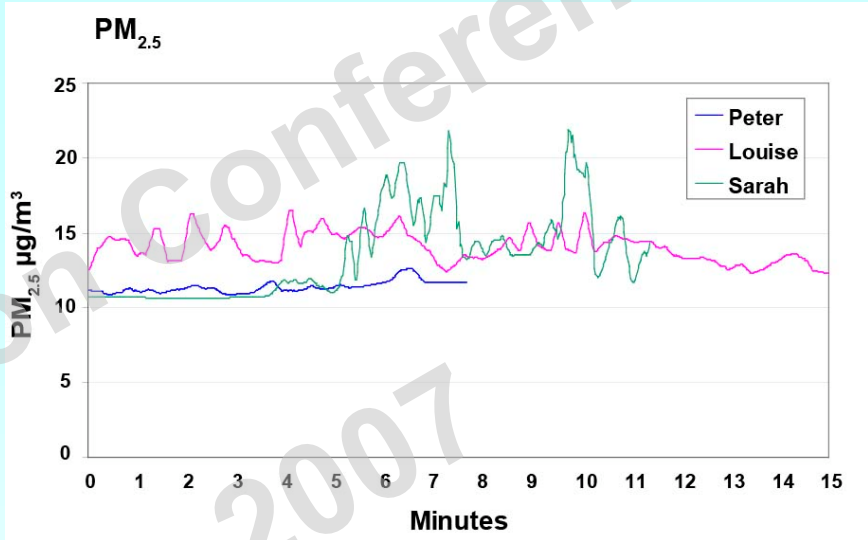
< 10.75
10.75 - 10.85
10.85 - 11.05
11.05 - 11.70
11.70 - 12.35
12.35 - 13.00
13.00 - 13.65
16.65 - 14.95
> 14.95

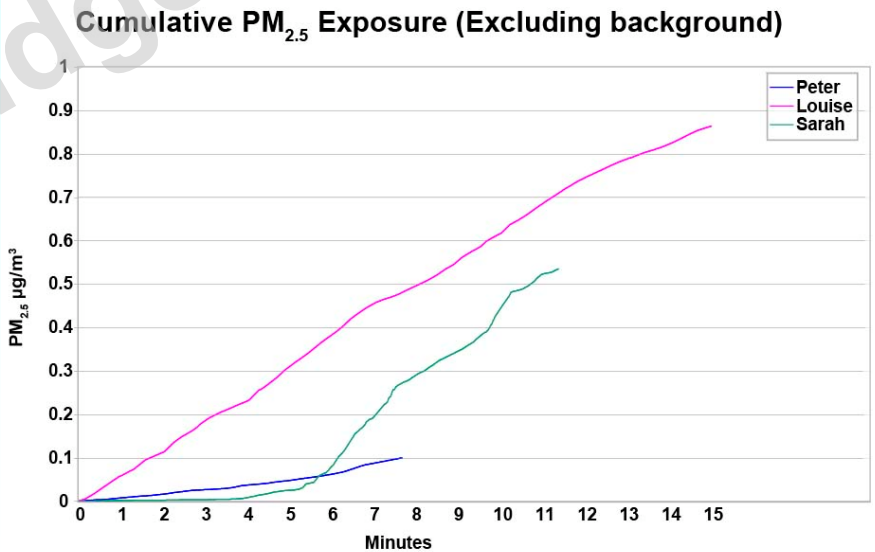
●●●●●● Participant's Route

$PM_{2.5} = PM_{10} \times 0.65$

Individual Exposure Assessment ($PM_{2.5}$)

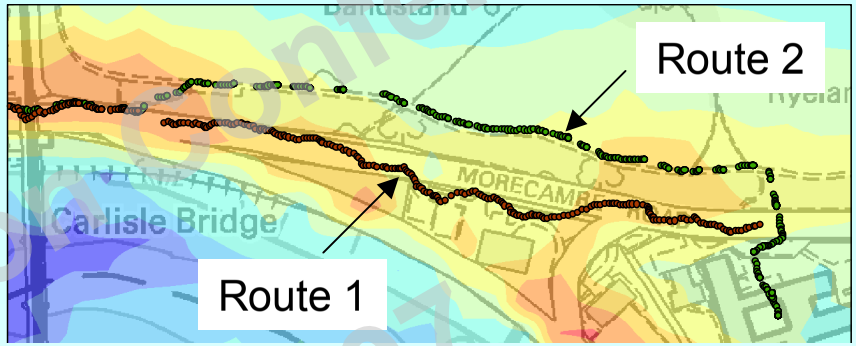






Personal Exposure Reduction?

- Louise sometimes deviates from the road side to walk through the park
- Her exposure is reduced as a consequence
- Interview reveals why she varies her route this way



- Royal Commission: UK Government should promote the concept of exposure reduction. "Carefully choosing your route has a dramatic effect." [Colville, 2007]

Summary

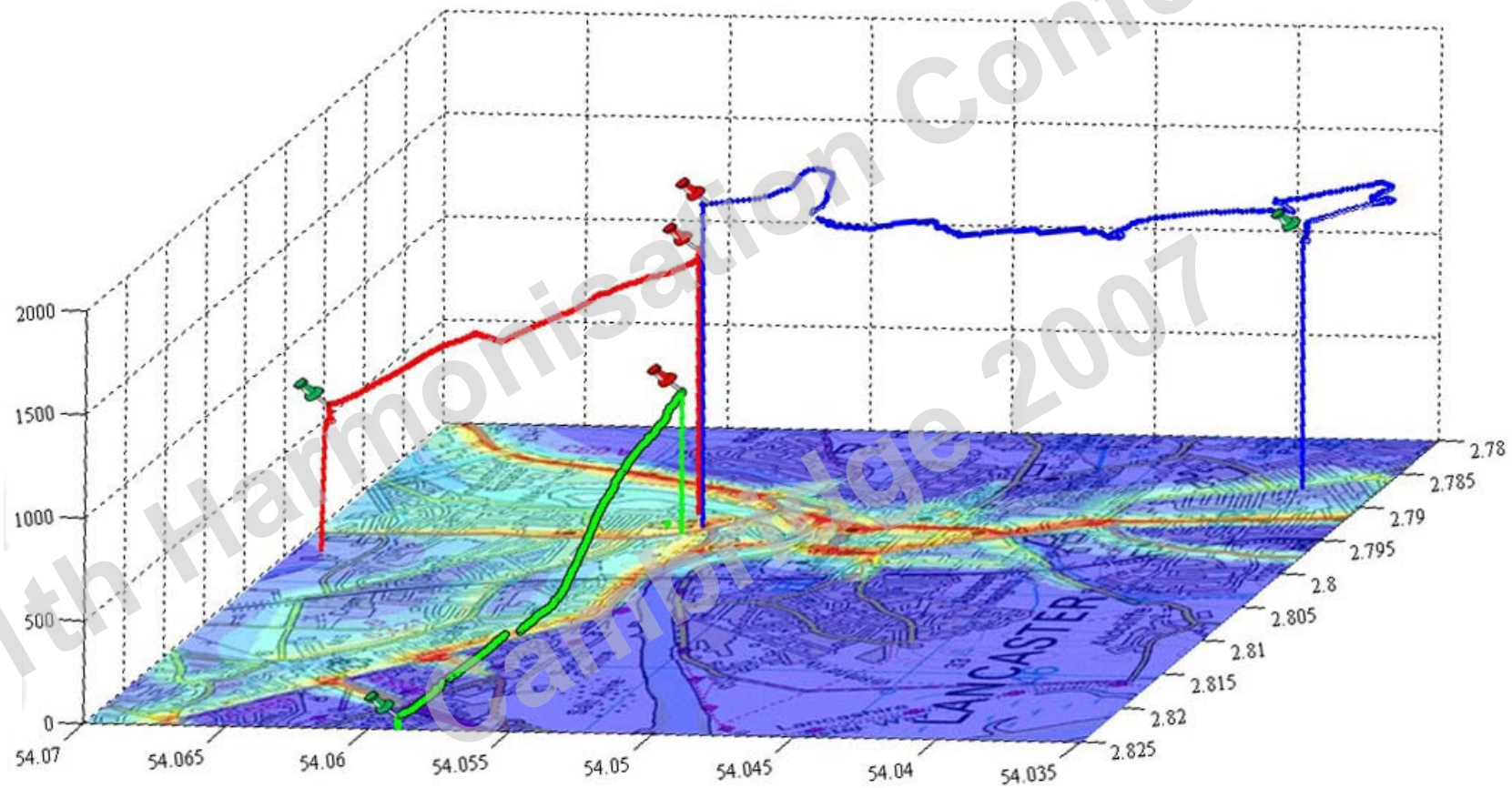
- Integrating individual route data with modelled pollution surfaces enables us to generate very detailed estimates of personal exposure

- The approach clearly has some advantages over real-time exposure monitoring

  - Inexpensive
  - Large sample size
  - Flexible (e.g., determine optimal low exposure routes)

- But validation (in space and time) remains problematic…

- Exposure reduction clearly requires an understanding of <u>both</u> pollution levels <u>and</u> personal behaviour in space and time





We would like to acknowledge the ESRC for funding this project, Lancaster City and Lancashire County Council for the provision of data and the staff and pupils of the school participating in this study