Modelling Low Exposure Routes in Urban Micro-Environments

Duncan Whyatt & Gemma Davies

Lancaster Environment Centre

Lancaster University

d.whyatt@lancaster.ac.uk

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

The Lancaster Environment Centre

LANCASTER UNIVERSITY

Introduction

- GPS trails combined with modelled pollution surfaces to derive individual estimates of journey-time exposure
  - 30 school children (car, bus, cycle, walk)

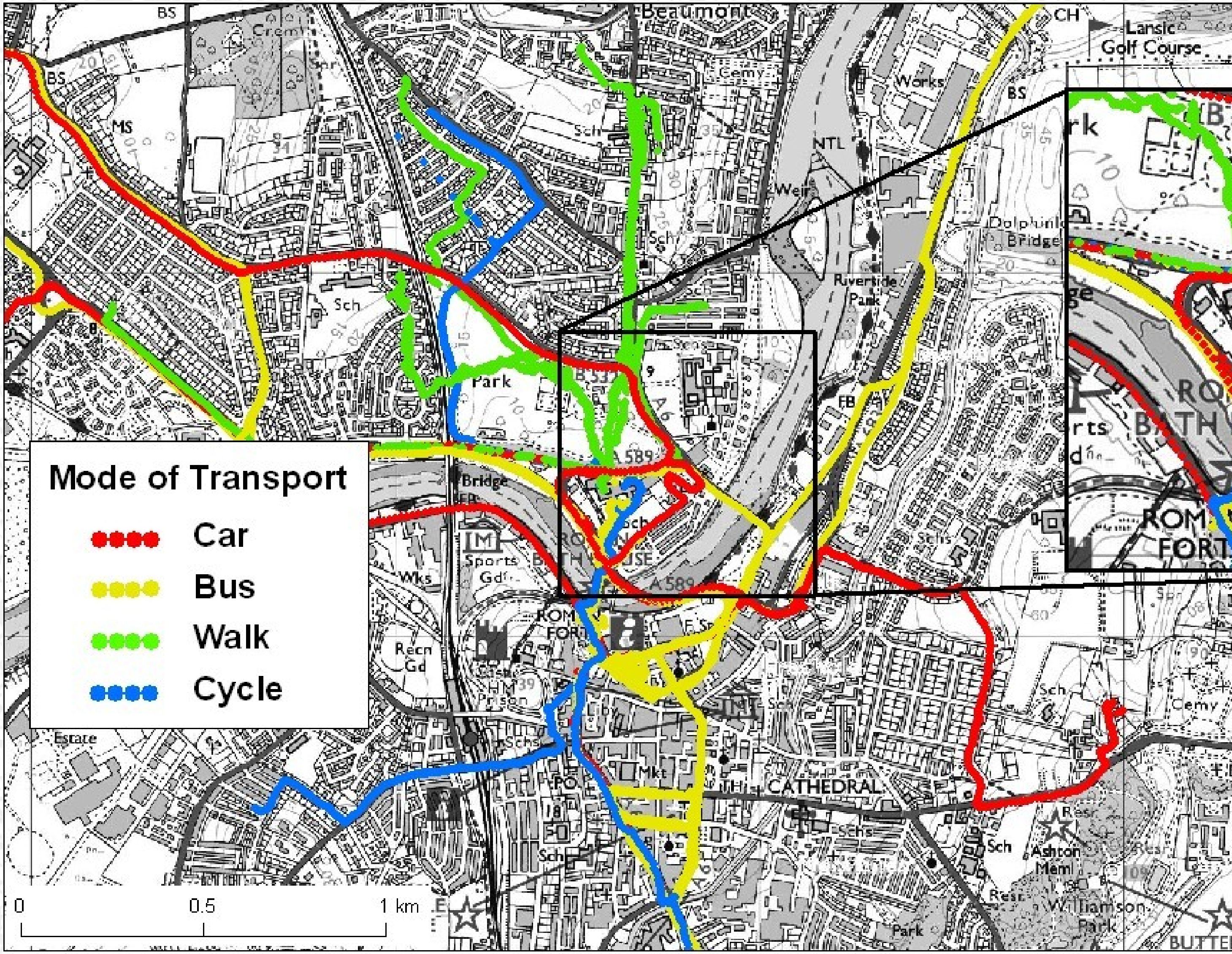
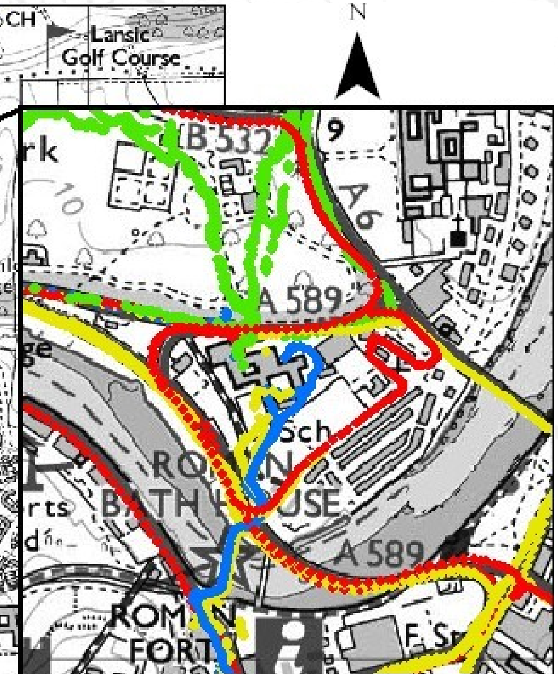
- Cheaper and more flexible than personal monitoring

- Methodology and initial results presented at HARMO11. Further results presented here

- Methodology extended to demonstrate benefits of using least-cost approaches in exposure studies

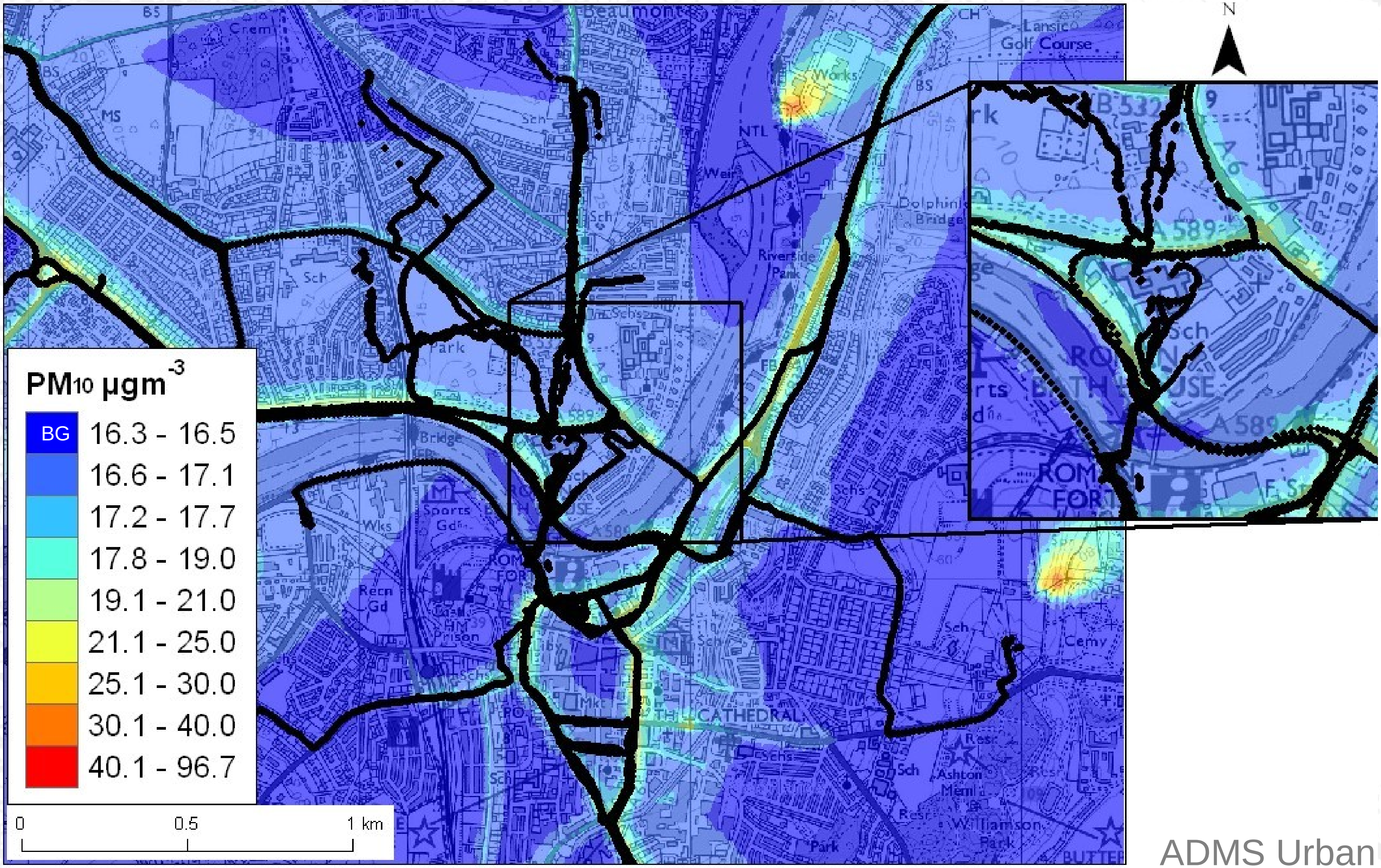
- Potential applications of latest eco-sensor phones also considered

Representative Routes

1-sec sampling

Integration with Modelled PM_{10} Surface



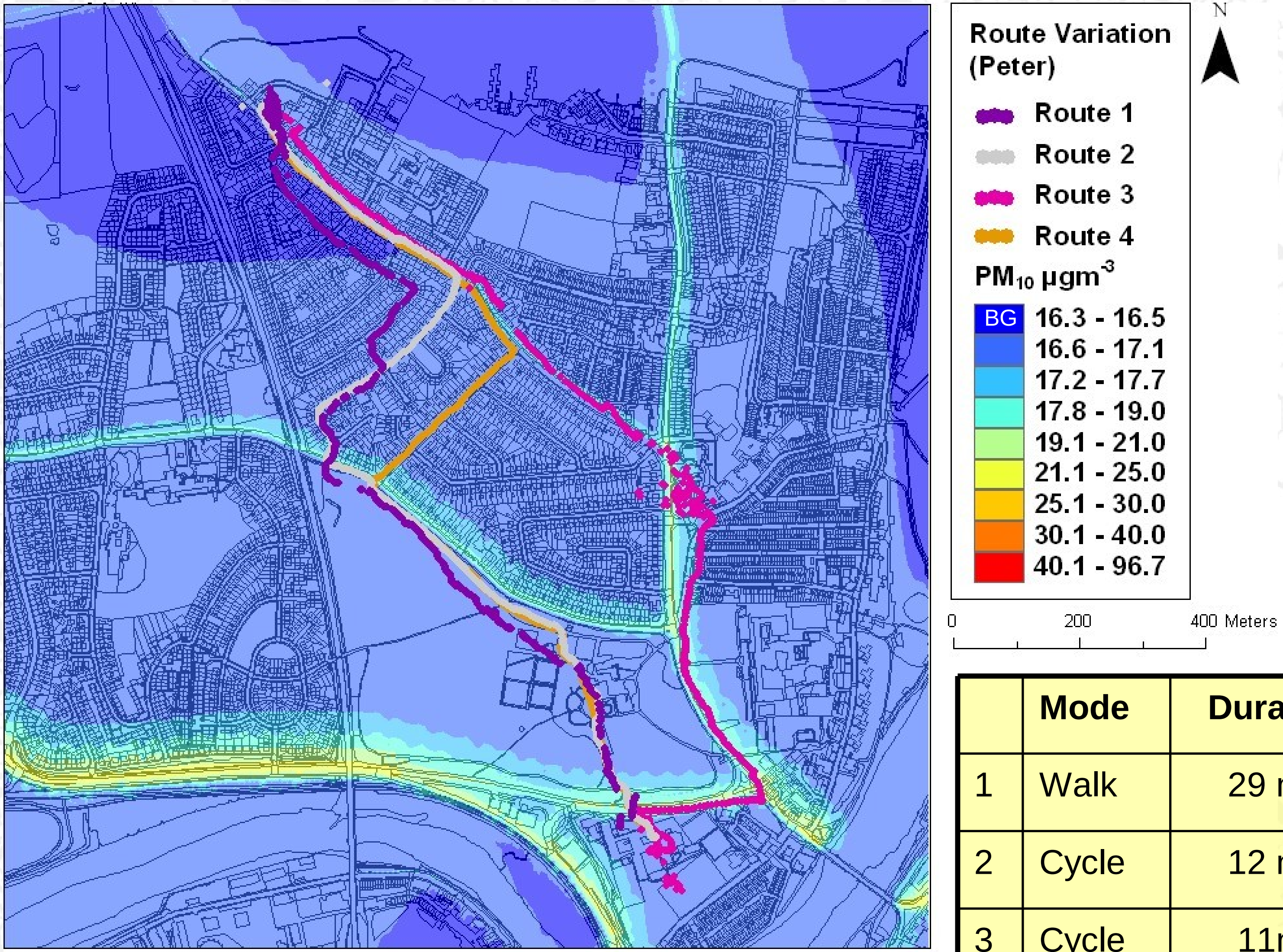
ADMS Urban

Summary of Representative Routes

Mode	Count	Min Duration	Max Duration	Mean Duration	Min JTE	Max JTE	Mean JTE
Car	12	8 mins	38 mins	17 mins	3 µg m^{-3}	11 µg m^{-3}	5 µg m^{-3}
Bus	19	10 mins	43 mins	22 mins	4 µg m^{-3}	14 µg m^{-3}	9 µg m^{-3}
Cycle	8	11 mins	22 mins	17 mins	2 µg m^{-3}	7 µg m^{-3}	4 µg m^{-3}
Walk	24	7 mins	27 mins	16 mins	3 µg m^{-3}	33 µg m^{-3}	6 µg m^{-3}

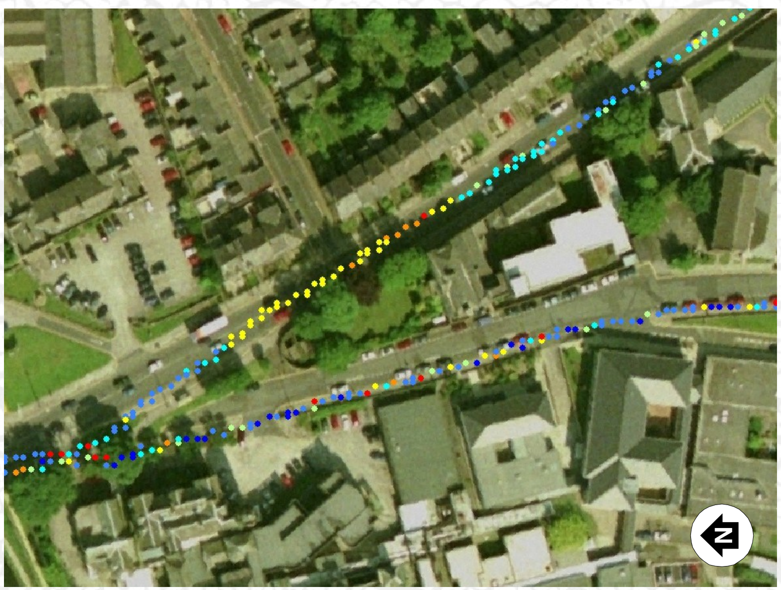
Assumptions (1) no indoor:outdoor correction to modelled values (2) no scaling to reflect activity levels (3) dominant SW wind direction

Route and Exposure Variation: Peter



	Mode	Duration	JTE
1	Walk	29 mins	8 $\mu g\ m^{-3}$
2	Cycle	12 mins	3 $\mu g\ m^{-3}$
3	Cycle	11mins	3 $\mu g\ m^{-3}$
4	Cycle	8 mins	2 $\mu g\ m^{-3}$

Validation (PM_{10}, 2nd October 2008)



SIDEPAK Personal Aerosol Monitor

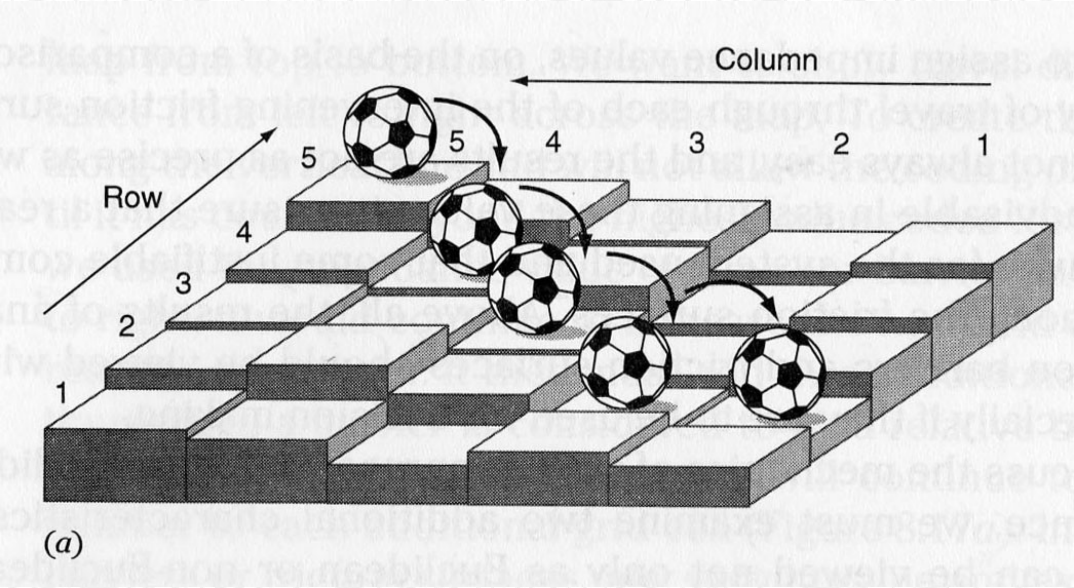
1-second sampling along selection of routes. Detail shows:

$PM_{10}\mu m^{-3}$
0 - 5
6 - 18
19 - 30
31 - 55
56 - 100
101 - 150
> 151

a) Roundabout
b) Cycle path and road side
c) Major and minor road

Least Cost Paths

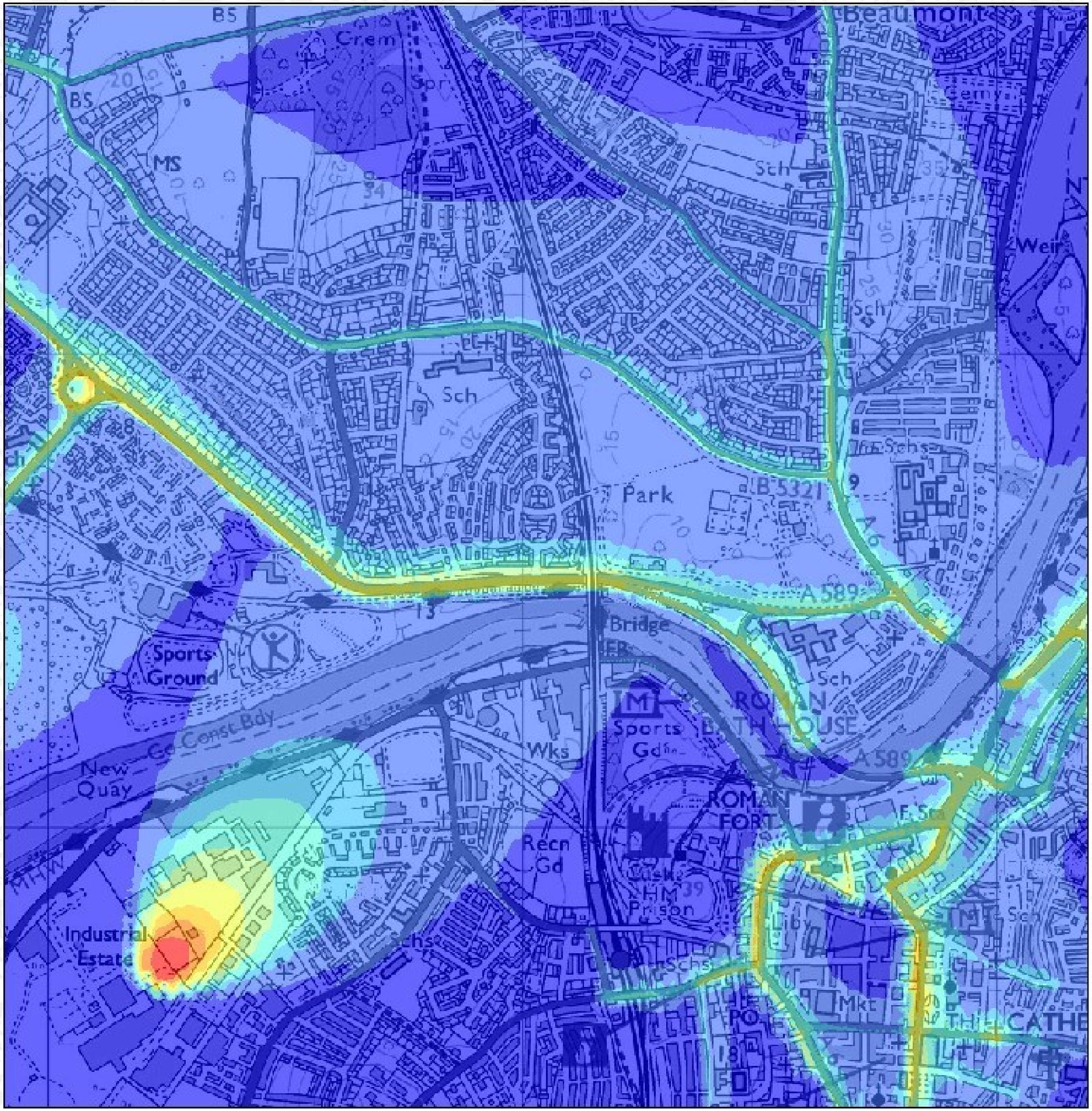
- *The path between two locations that costs the least to traverse, where cost is a function of time, distance, or some other criteria defined by the user…* (ESRI, 2008)

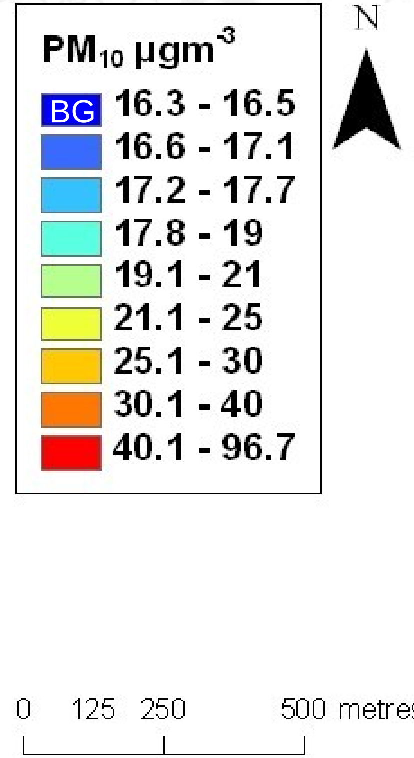


- Widely used in hydrological modelling, e.g., water down a hill side.

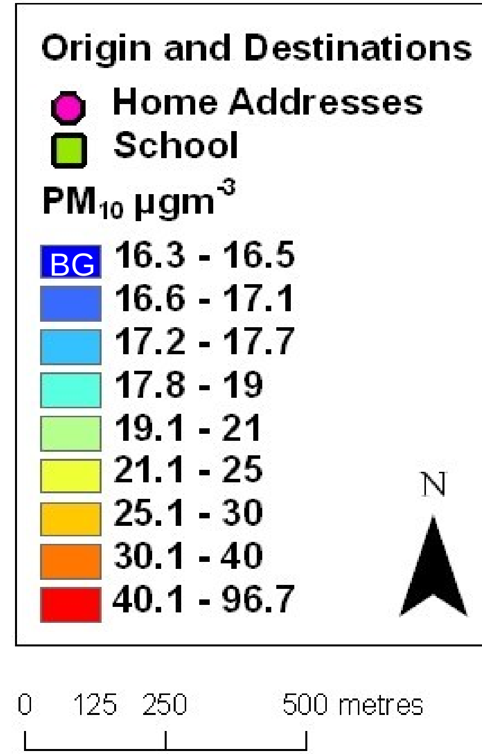
Least Cost Assumptions

- Based on <u>friction surfaces</u> and <u>barriers</u>
  - Friction surface imposes costs on ‘ease of movement’ from origin to destination
  - Barriers prevent or deflect movement (absolute barriers, relative barriers)
- Cost-distance surface represents distance from school modified by friction surface (air pollution) and absolute barriers (rivers, buildings, private land)
- Least-cost path across cost-distance surface computed from school to home addresses for a selection of children walking or cycling to school





Friction Surface: Modelled PM_{10}



Friction Surface: Modelled PM_{10}

Origin and Destinations

- Home Addresses
- School

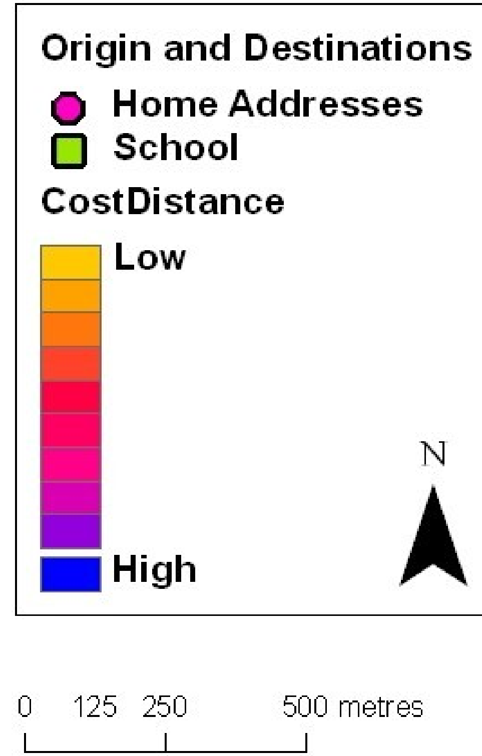
PM_{10} μgm^{-3}

- BG 16.3 - 16.5
- 16.6 - 17.1
- 17.2 - 17.7
- 17.8 - 19
- 19.1 - 21
- 21.1 - 25
- 25.1 - 30
- 30.1 - 40
- 40.1 - 96.7

N

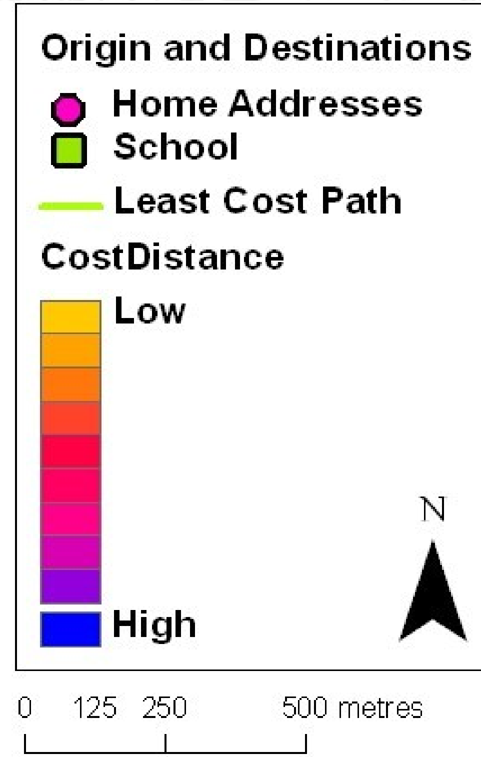
0 125 250 500 metres

Absolute Barriers:
Rivers, Buildings...

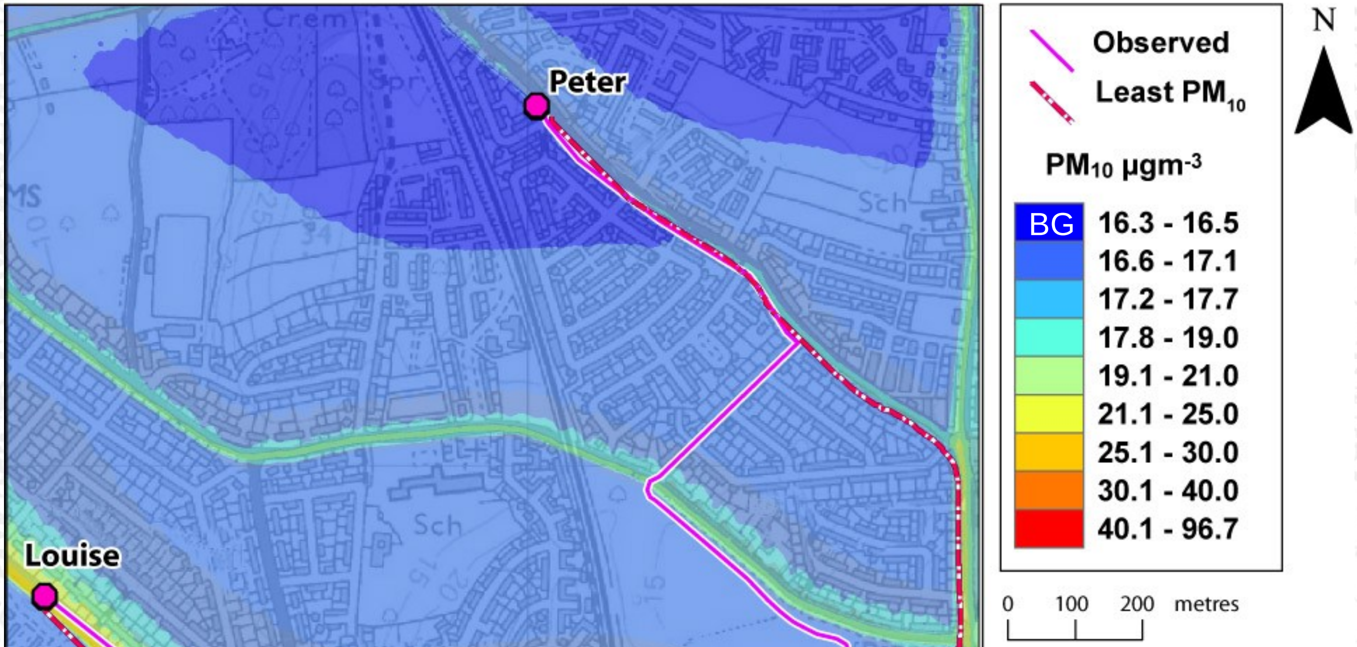


Cost-Distance Surface

Cost-Distance Surface & Least-Cost Paths



Comparison: Least-Cost v Actual Routes



	Duration	Actual	Least Cost
Claire	15 mins	4.2 $\mu g\ m^{-3}$	3.6 $\mu g\ m^{-3}$
Ella	20 mins	5.8 $\mu g\ m^{-3}$	5.6 $\mu g\ m^{-3}$
Jessica	17 mins	5.3 $\mu g\ m^{-3}$	3.5 $\mu g\ m^{-3}$
Louise	21 mins	7.3 $\mu g\ m^{-3}$	5.6 $\mu g\ m^{-3}$
Peter	20 mins	5.5 $\mu g\ m^{-3}$	5.0 $\mu g\ m^{-3}$
Vernon	10 mins	2.9 $\mu g\ m^{-3}$	2.3 $\mu g\ m^{-3}$

New Developments in Environmental Monitoring

- Everyday mobile devices could soon incorporate sensors for environmental monitoring
  - Nokia Eco Sensor Concept (PM, CO, O_3, heart-rate)

- Coupled with this is the upsurge in GPS enabled mobile technology and location-based social networking
  - Nokia expects to sell 35 million GPS enabled phones worldwide in 2008

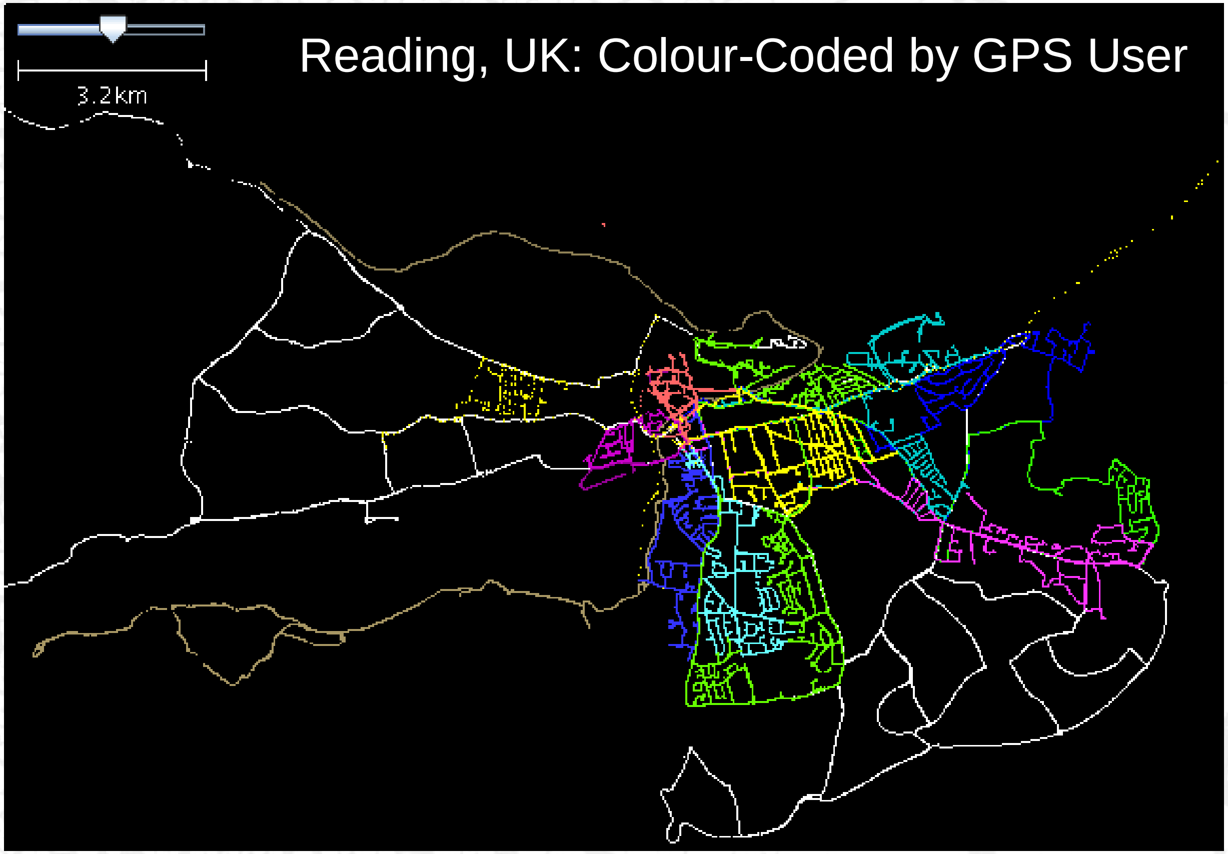
- Convergence suggests a future in which there is widespread collection & sharing of location-based environmental data by the general public in real time
  - EU 2008 eParticipation programme

- Could inform the real-time route selection of the individual (Colvile)

NOKIA
Connecting People

- Or be combined and used in broader applications
  - cf. OpenStreetMap project
  - http://www.openstreetmap.org/

- Could potentially map pollution levels for <u>every</u> street in a town or city



Conclusions and Future Work

- Main approach needs refining (indoor:outdoor, activity levels, PM_{10} → $PM_{2.5}$) and further validation
- More detailed data on air quality required - perhaps from eco-sensor type phones and mass participation events?
- Least-cost approach provides viable low-exposure alternatives to current routes. Likely adoption controlled by other factors?
  - Child's independence, Parental pressure…
- Sustainable urban futures? Radical re-design of urban infrastructure? Or education to increase awareness of low-exposure alternatives?


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