TRAFFIC
Human exposure to air pollution during daily journeys in London

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Human exposure to air pollution

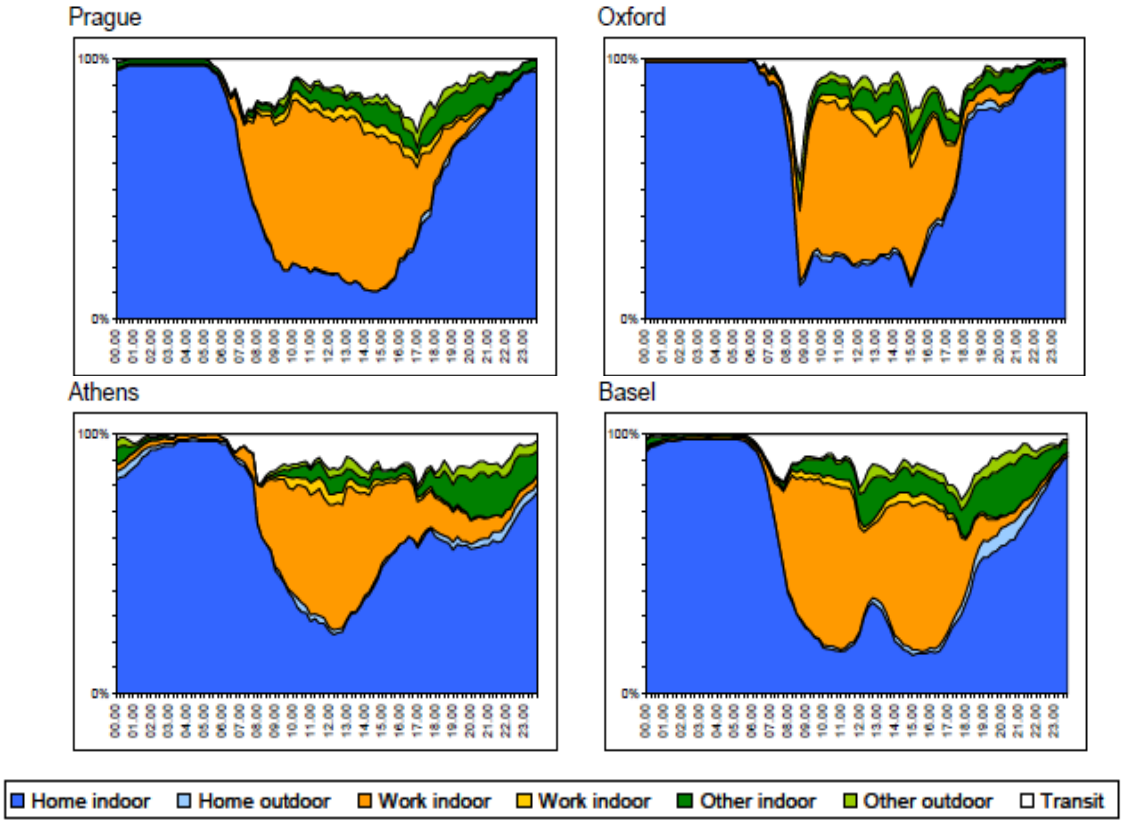
In order to detect and quantify the health effects of air pollution, both:

- the **magnitude of concentration** and
- the **length of exposure**

are necessary.

Daily exposure - microenvironments

People spend time in different microenvironments depending on the day hour



$$E = \sum_j E_j = \frac{1}{T}\left(\sum_j \bar{C}_j t_j\right)$$

Air Pollution Exposure in European Cities: the EXPOLIS study (1994-1998)

Air pollution exposure models

- Land use regression: the pollution concentration at a given site is estimated based on surrounding land use and traffic characteristics, limited accuracy for areas with variant tropography
- Line dispersion: solve Gaussian plume equations, need for extensive cross validation with monitoring data and estimate errors have been reported
- Integrated emission – meteorological: simulate complex pollutants' pathways allowing the potential of precise health effect estimates
- Hybrid: personal exposure calculations plus one of the above

"Hybrid" models may well overcome the problem of achieving population representative samples while understanding the role of exposure variation at the individual level (Jerrett et al., *J Expo Anal Env Epid*, 2005).

"Traffic Pollution and Health in London" f*unded by NERC/MRC*

Description of hybrid exposure model for London

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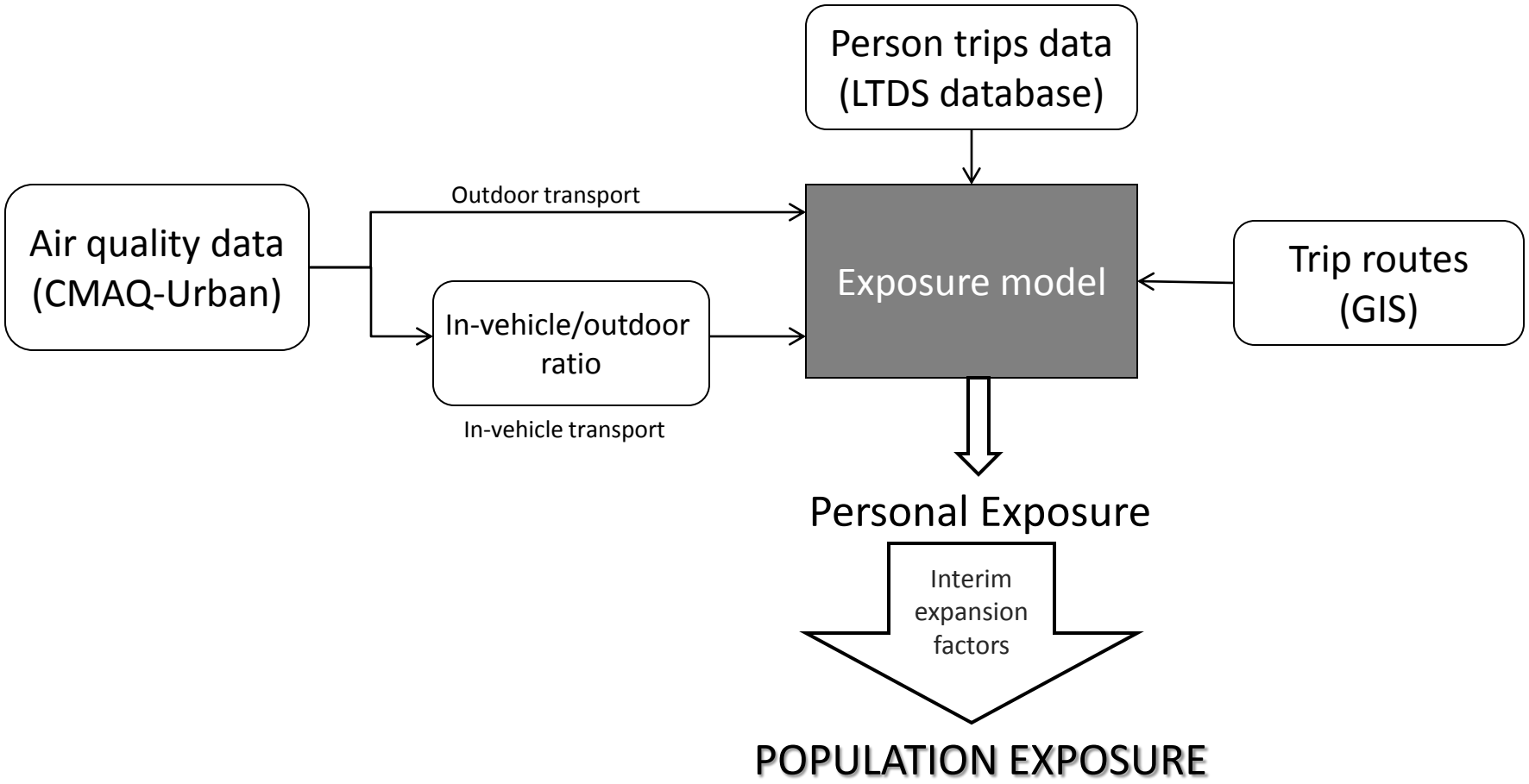
Model flowchart



Person Trips data

London Travel Demand Survey (LTDS) conducted by TfL for 2005-2010

(37310 Households, 87912 Persons, 208205 Trips, 339689 *Trip* Stages)

Transport modes

walk/cycle (168618 routes)

car/motorcycle/van/coach/taxi (98577 routes)

bus (38409 routes)

train – National rail & London overground (11213 routes)

underground (22442 routes)

boat/other (430 routes)

Significant parameters for the trip simulation

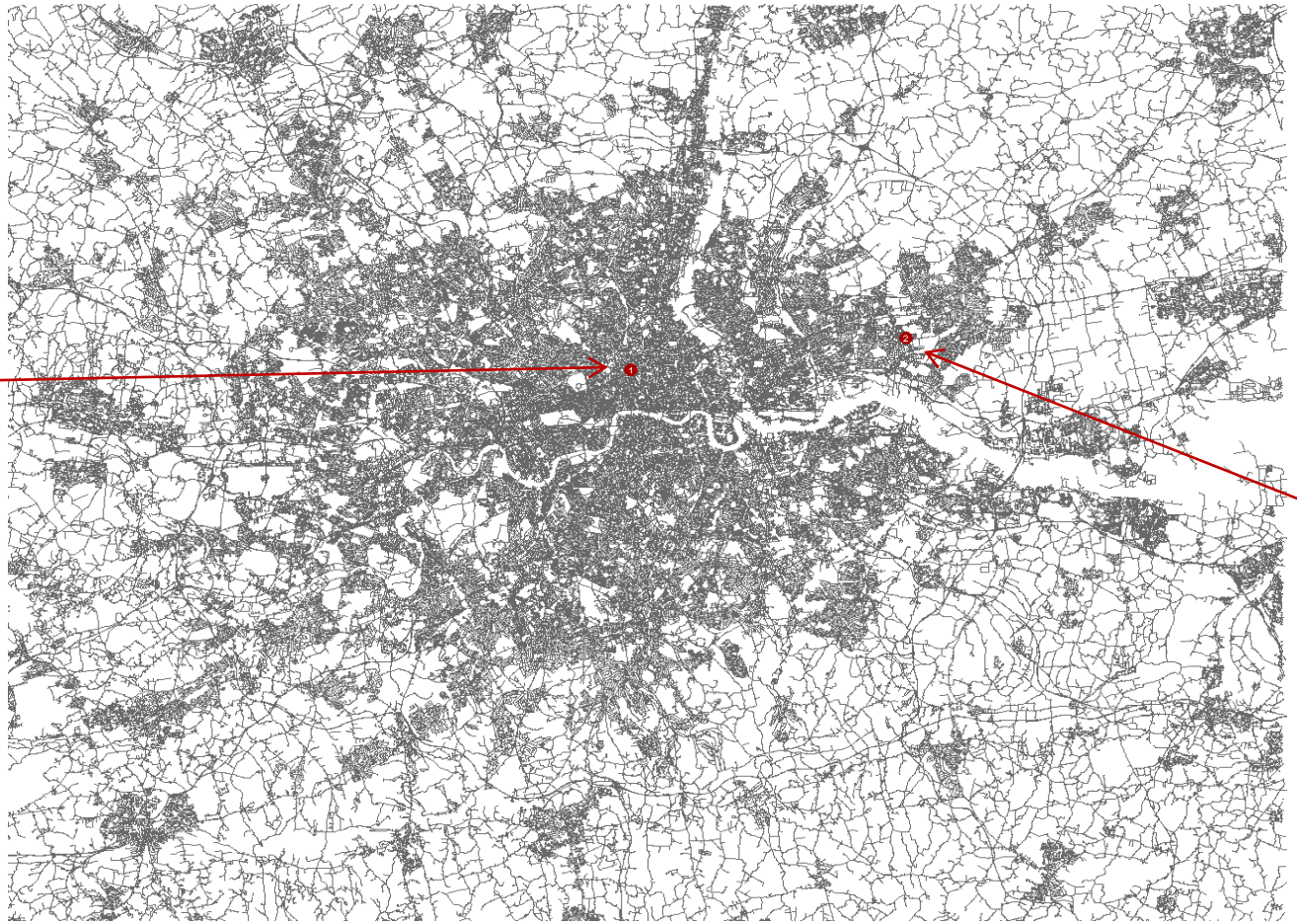
Person	no of trips made
Trip	no of stages per trip, trip start/end time
Stage	origin easting/northing, destination easting/northing, mode of transport, duration of trip stage, distance of trip stage

Trip routes

Transportation network: ITN road network *(rail, tube and bus networks to be included)*

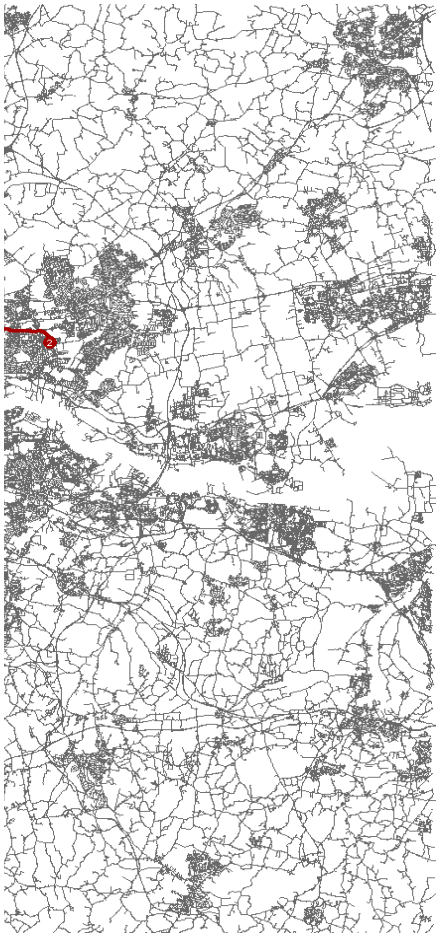
ArcGIS 10.1 or pgRouting

Trip routes



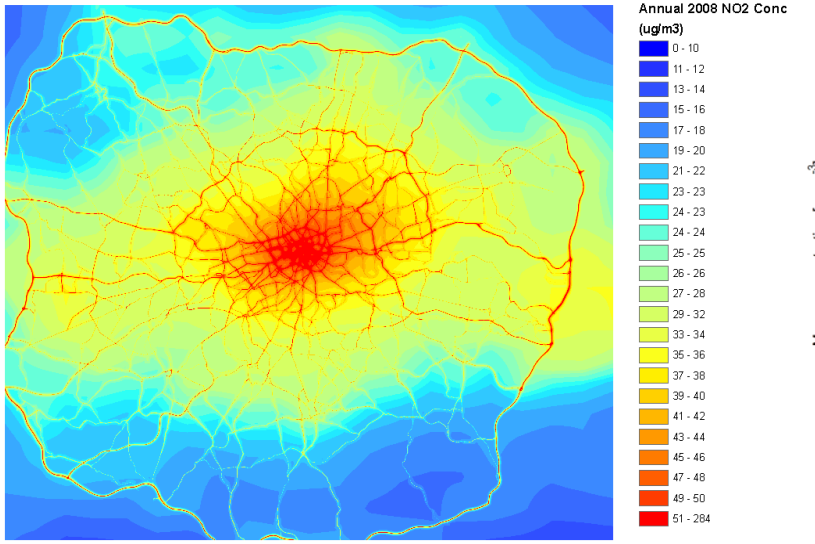
Trip routes

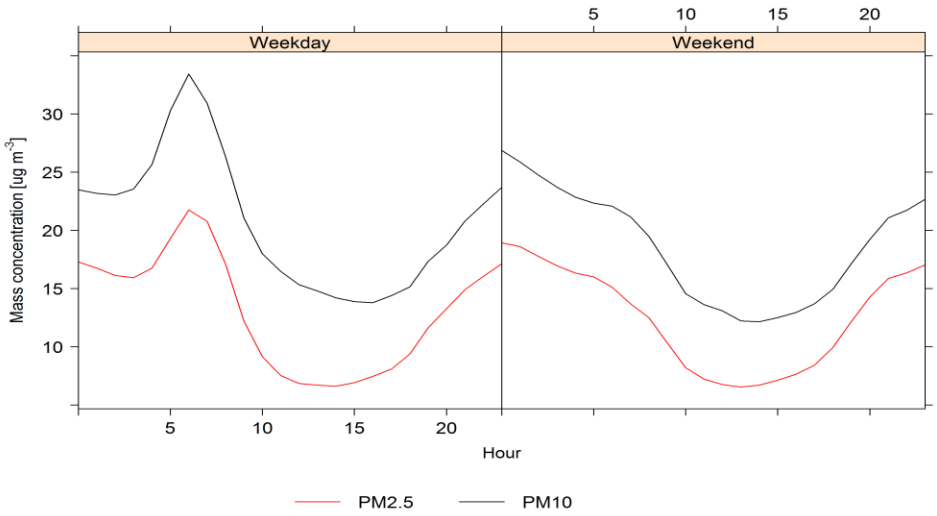
ObjectID	RoadLabel	Attr_Length(m)	Cumul_Length(m)	x (deg)	y (deg)
1		23.104633	23.104633	-0.10197	51.53693
2		13.079037	36.183671	-0.10206	51.53704
3	THEBERTON STREET	61.032778	97.216449	-0.10171	51.53704
4	UPPER STREET	24.698178	121.914627	-0.1012	51.53714
5	GASKIN STREET	68.352029	190.266657	-0.10068	51.53713
6	GASKIN STREET	84.070967	274.337624	-0.09968	51.53686
7	ESSEX ROAD	40.804411	315.142036	-0.09899	51.53679
8	ESSEX ROAD	32.15794	347.299976	-0.09867	51.53705
9	ESSEX ROAD	64.699031	411.999008	-0.09825	51.5374
10	ESSEX ROAD	33.600595	445.599603	-0.09782	51.53775
11	ESSEX ROAD	30.232432	475.832036	-0.09755	51.53798
12	ESSEX ROAD	10	485.832036	-0.09738	51.53813
13	ESSEX ROAD	15.811388	501.643424	-0.09726	51.53822
14	ESSEX ROAD	29.209372	530.852797	-0.09706	51.53838
15	ESSEX ROAD	106.233985	637.086783	-0.0964	51.53884
16	ESSEX ROAD	93.35137	730.438153	-0.09537	51.53945
17	ESSEX ROAD	15.957985	746.396139	-0.0948	51.53979
18	ESSEX ROAD	47.124844	793.520984	-0.09451	51.54002
19	ESSEX ROAD	46.622402	840.143386	-0.094	51.54023
20	ESSEX ROAD	17.918815	858.062202	-0.09369	51.54046
21	ESSEX ROAD	77.64115	935.703353	-0.09315	51.54073
22	ESSEX ROAD	41.987566	977.690919	-0.09245	51.54104
23	ESSEX ROAD	76.404839	1054.095759	-0.09176	51.54135
24	ESSEX ROAD	28.449465	1082.545225	-0.09116	51.54163
25	ESSEX ROAD	95.557652	1178.102877	-0.09049	51.54199
26	ESSEX ROAD	15.728954	1193.831832	-0.08993	51.54236
27	ESSEX ROAD	22.561028	1216.39286	-0.08974	51.54249
28	ESSEX ROAD	75.927603	1292.320464	-0.08927	51.54282



Air quality data

Outdoor transport: CMAQ-urban (horizontal resolution: 20m x 20m)





Forest lane, **Stratford** (51.54˚, 0.02˚) *April 2006*

In-vehicle transport: The correlation between in-vehicle and outdoor concentration depends on the air exchange rates and deposition rate of the pollutant (Liu & Frey, 2011).

Impacts of trip parameters on personal exposure

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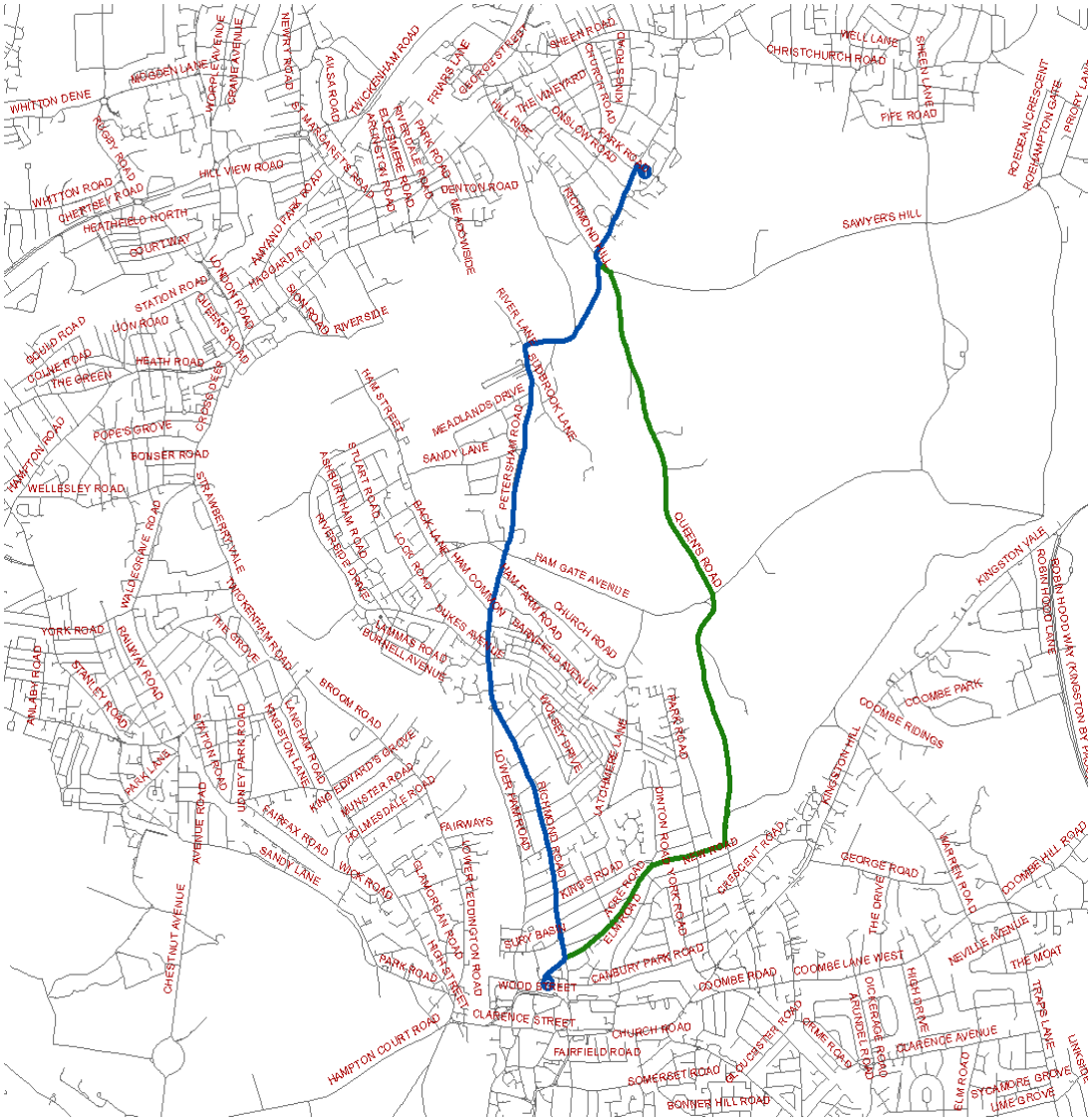
Traversing routes

through a green space?



Transport mode:

Cycle

Origin and destination:

(1) Park road northwest of Richmond Park

(2) Kingston train station

Trip time:

7:10 – 7:32

Vehicle speed:

9mph

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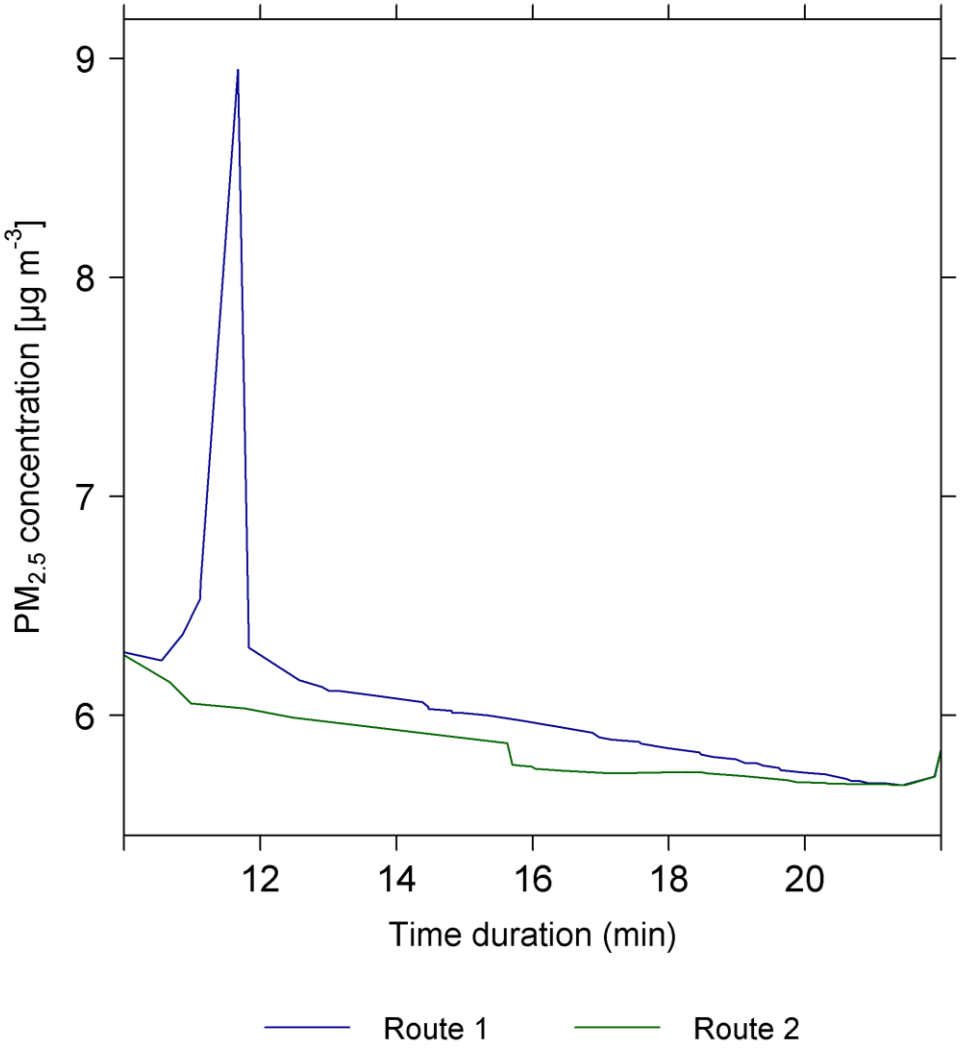
Traversing routes



Total inhaled mass (µg)

Route 1: 6.9

Route 2: 6.4

7.5% less exposure along Route 2

Inhaled mass =

ventilation rate (breathing frequency *x* tidal volume per breath) *x*
pollutant concentration *x*
exposure time

ventilation rate (cycling) = 3 m^3 h^{-1}*

**ICRP (1994)*

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Travelling hours

avoid rush hours?

Transport mode:

Motorcycle

Origin and destination:

(1) Rainham road North, Dagenham

(2) Essex Road, Islington

Trip time:

7:00 – 7:45

Vehicle speed:

20mph

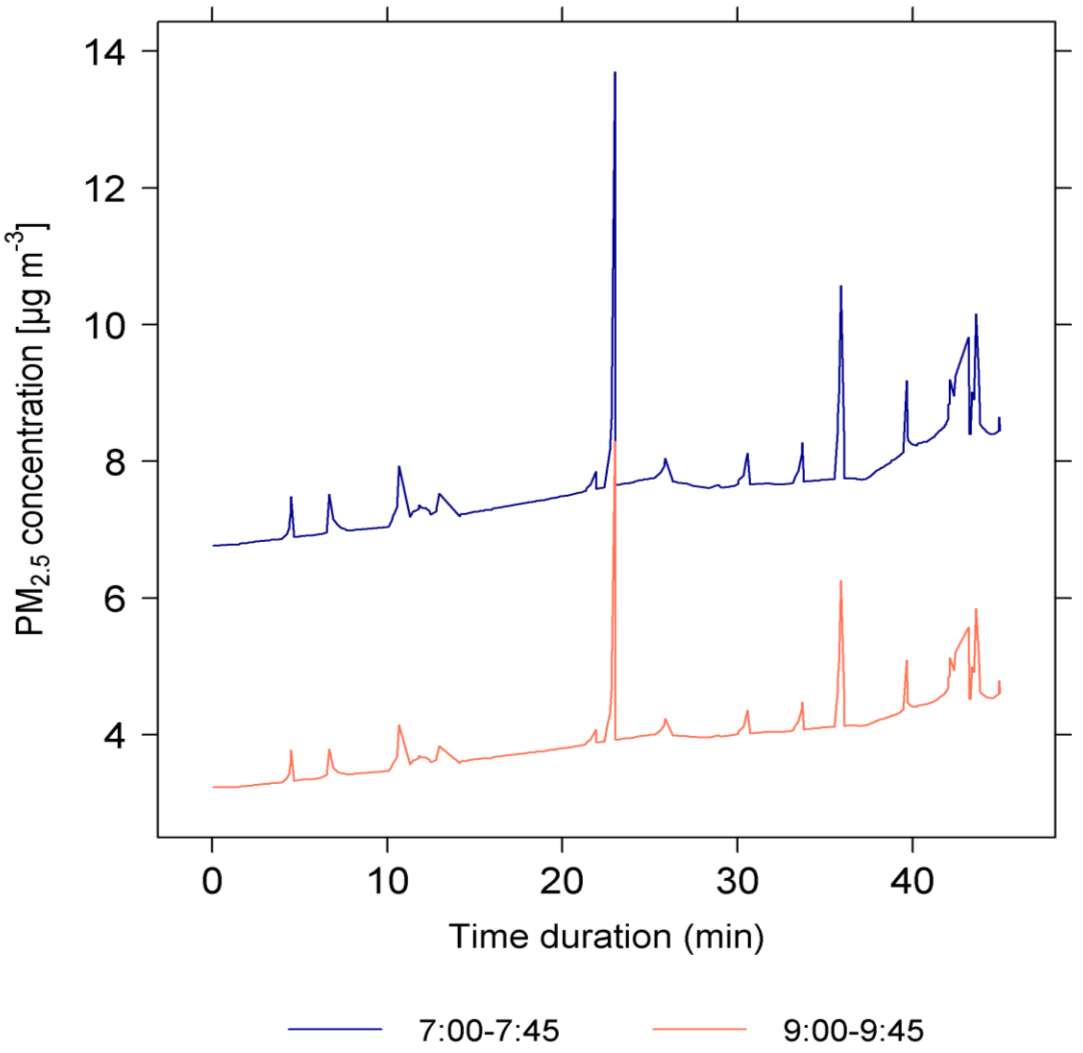
Travelling hours

Transport mode:
Motorcycle

Trip time:
7:00 – 7:45 (blue)
9:00 – 9:45 (coral)

Vehicle speed:
20mph

- Decrease in exposure by up to 50% for travelling in non-rush hours
- Total inhaled mass for trip time 9:00 – 9:45 is half the calculated mass for trip 7:00 – 7:45 (1.59 vs. 3.09 µg)



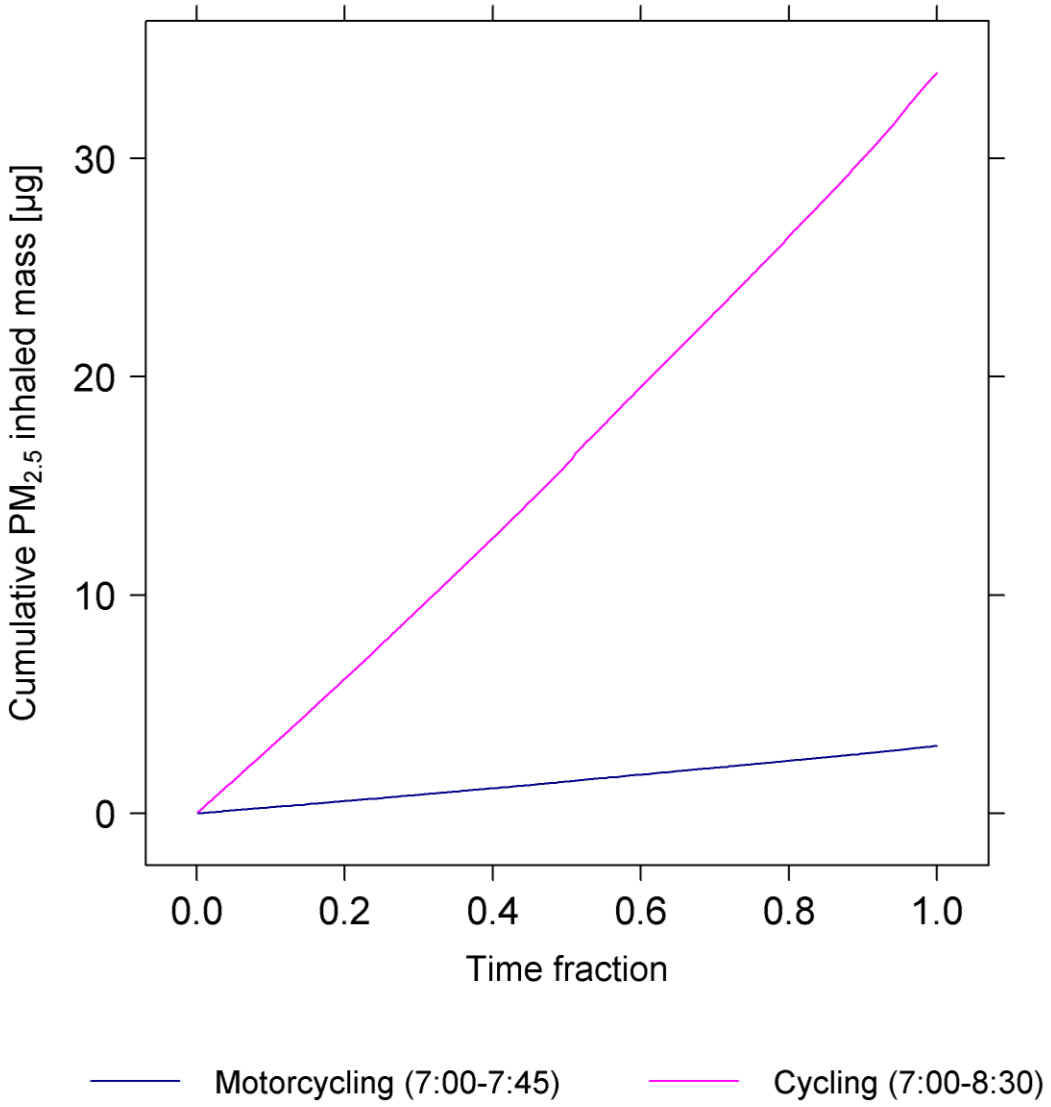
ventilation rate (motorcycling) = 0.5 m^3 h^{-1}*

**ICRP (1994)*

Transport modes

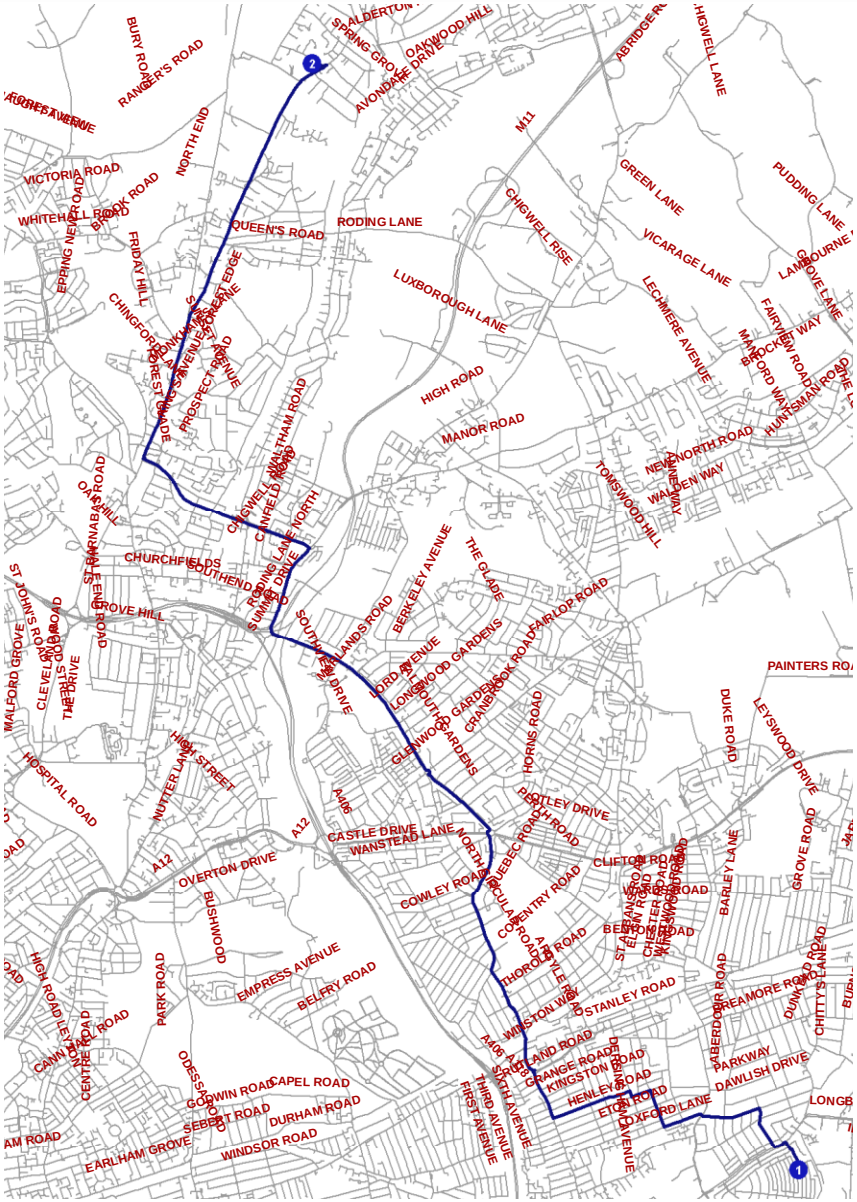
Personal activity level

Transport mode	
Motorcycle	Cycle
Trip time	
7:00 – 7:45	7:00 – 8:30
Vehicle speed	
20mph	9mph
Ventilation rate	
0.5 m^3 h^{-1}	3 m^3 h^{-1}



- The inhaled dose received by the cyclist during the entire trip is 10 times higher than the respective dose during motorcycling

In-vehicle transport



Transport mode:

Car

Origin and destination:

(1) Southwold Dr, Barking

(2) High Road, Loughton

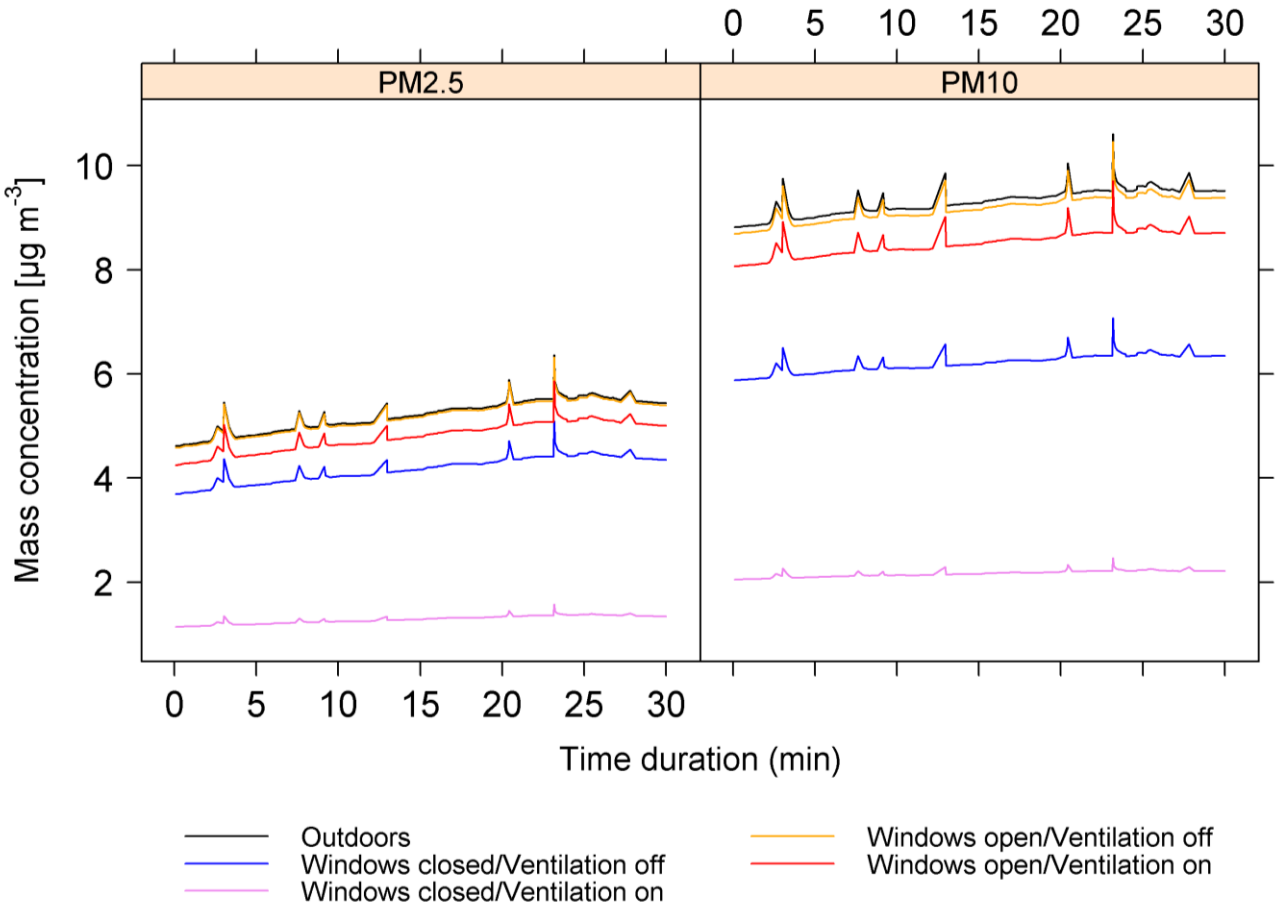
Trip time:

8:10 – 8:40

Vehicle speed:

20mph

In-vehicle transport



- In-car exposure is similar to the outdoor exposure when the windows are fully open
- Decrease in the in-car exposure by 10% when the air conditioning system is on
- Significant reduction (up to 78%) in the in-car exposure when the windows are closed and the air conditioning system is on

Conclusions

Main factors affecting air pollution exposure whilst travelling in London are detected

- the selection of green traversing routes leads to reduced exposure levels
- the exposure depends on travelling hours and with the aid of the model the advantage of travelling in non rush-hour periods can be determined
- the respiratory dose is influenced by the transport mode and level of physical activity – increased inhaled dose during cycling comparing to less active transport modes
- the in-vehicle transport may aid to significantly reduced particle exposure under specific operational conditions (windows, air conditioning system)

Points for discussion

- How do the factors affecting **personal exposure** whilst travelling in London impact on **population exposure**?
- How much do the in-the-city journeys contribute to people daily exposure? How are these daily exposure calculations compared to traditional exposure estimates? **Exposure misclassification**
- What are the health effects from exposure to traffic-related air pollution for various groups of people (separated by age, gender, socio-economic status)? **Epidemiological studies**
- Based on the answers to the above points, how **traffic and transport policies** could be improved?

Thank you!

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