KING'S College LONDON

Environmental Research Group
Air Quality Monitoring | Air Quality Modelling
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METHODS TO ISOLATE TRAFFIC-LED CO_2 EMISSIONS

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BACKGROUND

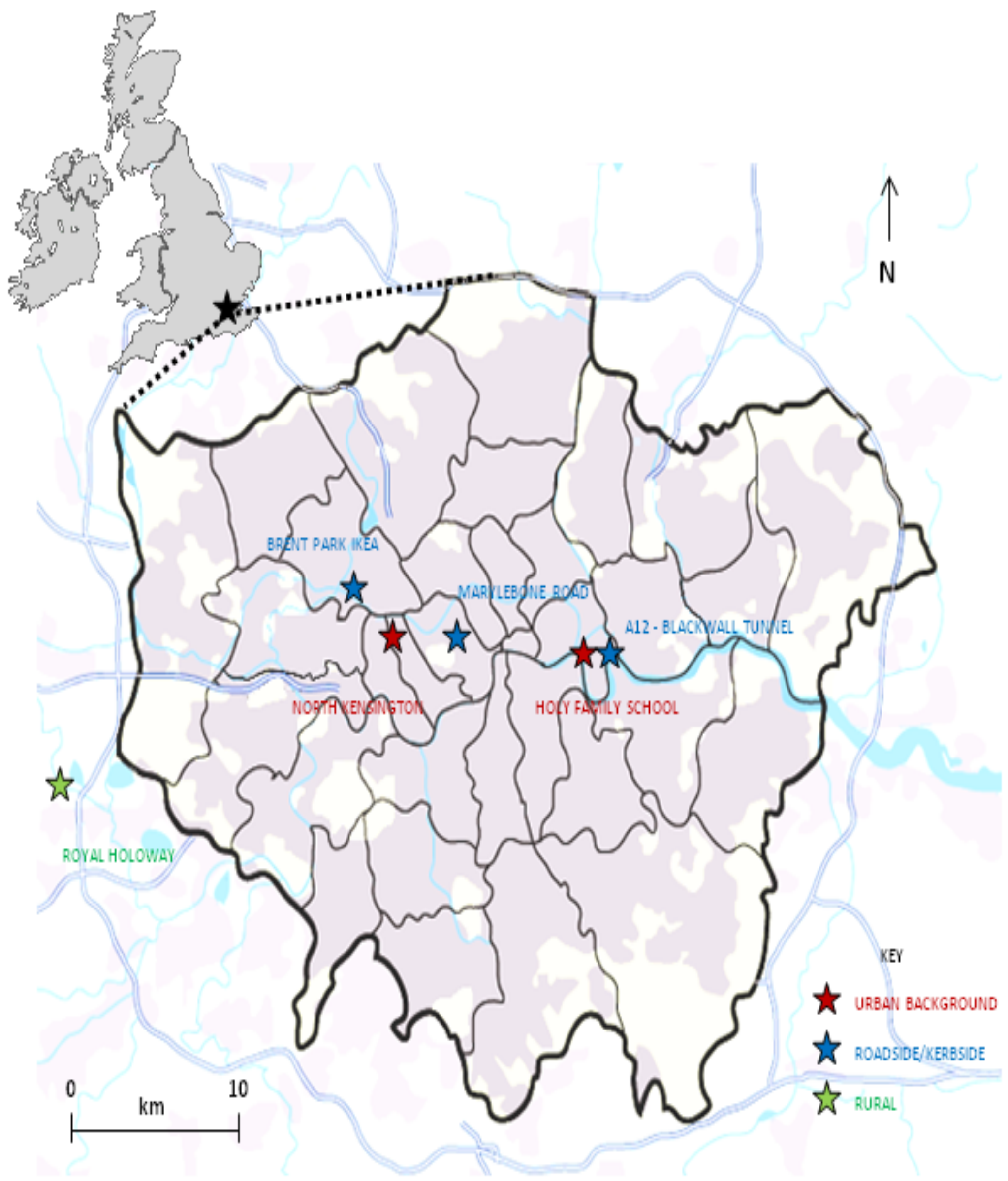
Urban areas are major sources of CO_2 emissions which, in turn, affect the global carbon cycle. Approximately 9% of the UK's CO_2 emissions are thought to originate from within the Greater London Area, estimated at 44 million tonnes of CO_2 [1]. Of this, 22% is attributable to ground level transport with over three quarters from road transport [2].

Current emissions estimates rely heavily on data input from models, which lack validation through comparison with monitoring measurements. We have therefore implemented a fixed, long-term continuous CO_2 monitoring network at ground level across Greater London with the aim of quantifying vehicle exhaust emissions and trends.

METHODS

To account for the trans-boundary nature and multiple source characteristics of CO_2, the monitoring network was designed to comprise of a combination of roadside, urban background and rural monitoring sites at locations existent on the London Air Quality Network (figure 1). Monitoring commenced in July 2010. CO_2 is measured with absolute, non dispersive infrared (IR) analysers (LI-820: Licor ®).

FIGURE 1 Urban CO_2 monitoring network in London



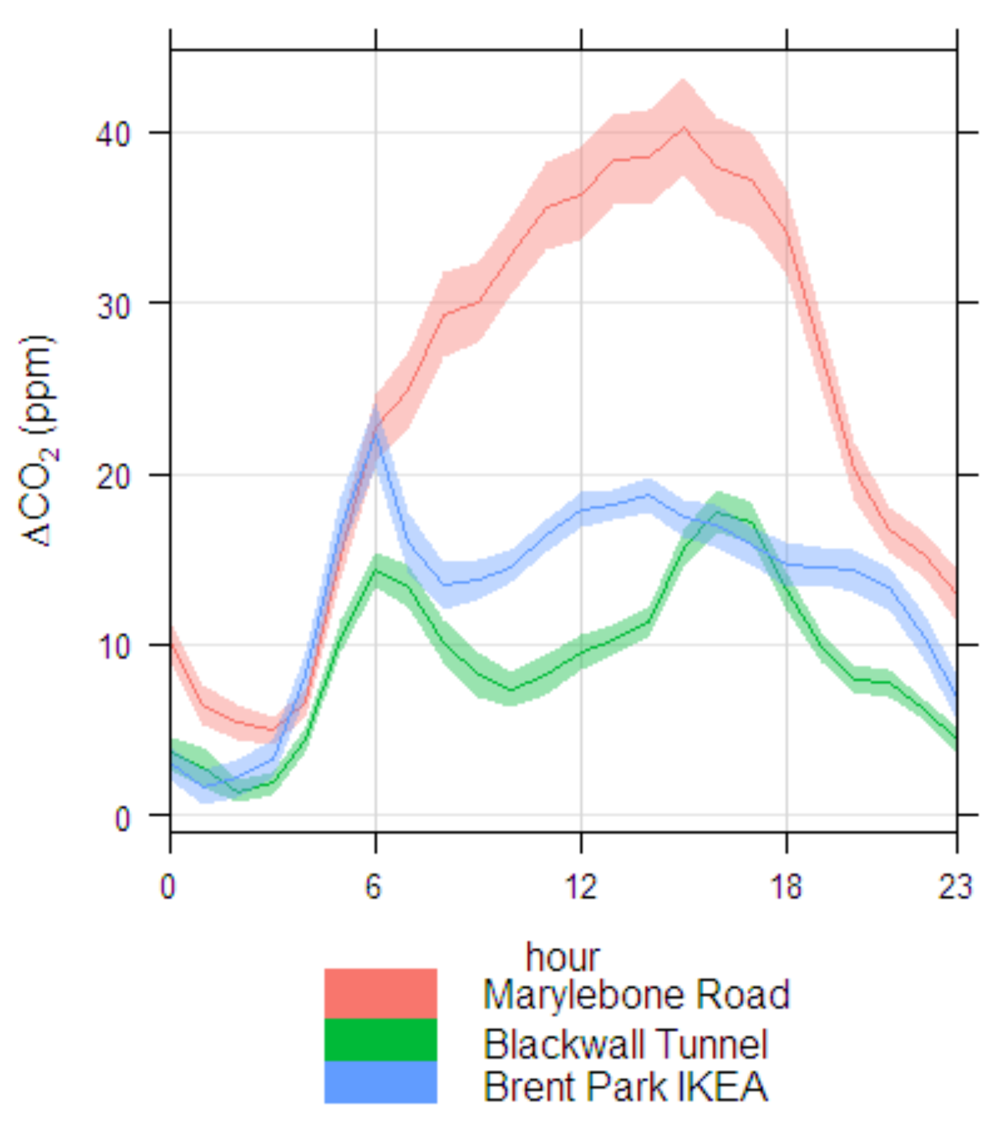
- ➢The network includes three roadside sites on A roads in London: the A501 Marylebone Road in central London, the A406 north circular road at Brent Park IKEA and the A12 at Blackwall Tunnel.
- ➢There are two urban background sites in school grounds in the boroughs of Kensington and Tower Hamlets.

- ❖As both CO_2 and NO_X are produced during the engine combustion process, NO_X can be utilised as a 'tracer' for traffic-related CO_2.
- ❖However, NO_X and CO_2 first require the separation of local influences from the regional source loading.
- ❖This source apportionment was carried out through the creation of a 'roadside increment' (ΔNO_X and ΔCO_2) advocated by Lenschow [3].
- ❖Traffic-led CO_2 emissions are then isolated by analysis of the relationship of local CO_2 with local NO_X ($\Delta NO_X/\Delta CO_2$).

RESULTS

Thermal mixing is the principal factor governing CO_2 dispersion and therefore drives the relationship with NO_X (figure 2). To account for this we used the Monin-Obukhov length stability parameter (L) - a term that can be applied qualitatively to describe the effects of buoyancy or vertical motion of air parcels, particularly in the lower tenth of the atmosphere.

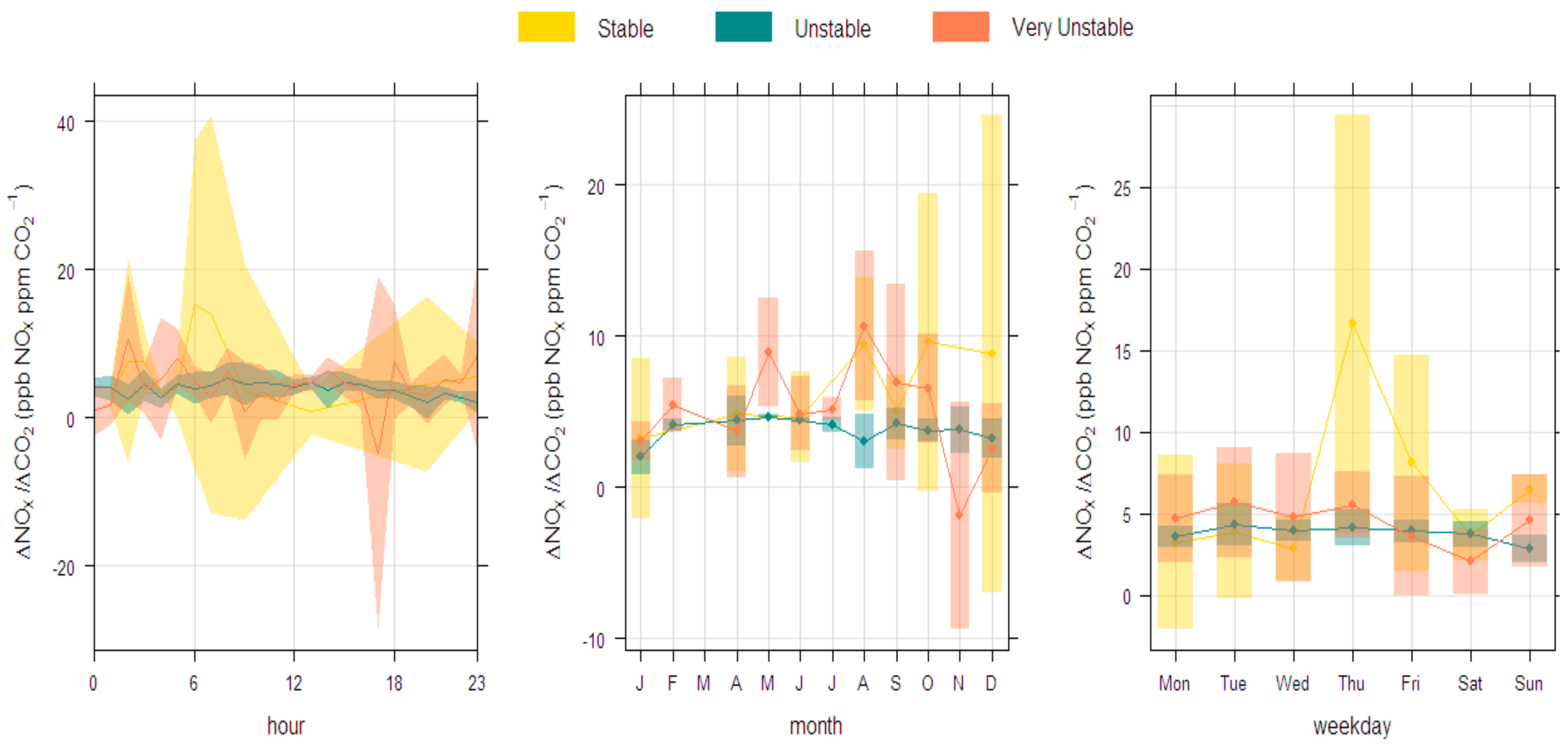
FIGURE 2 Diurnal variation in the roadside CO_2 increment (ΔCO_2)



- ➢The morning increase in CO_2 is driven by rush hour traffic at the roadside.
- ➢This occurrence coincides with the growth of the boundary layer, convective mixing and entrainment of air less concentrated in CO_2 from above that cause the relative drop in CO_2 at the Blackwall Tunnel and Brent Park IKEA sites
- ➢There is a continued rise in CO_2 at Marylebone Road due to its position within a street canyon – where locally stagnant air concentrates pollutants near ground level.

Figure 3 shows the effects of each stability classification on the variation of $\Delta NO_X/\Delta CO_2$ at Marylebone Road. Under unstable stratification, consistent $\Delta NO_X/\Delta CO_2$ ratios occur that indicate uniform emissions of both NO_X and CO_2. Therefore the CO_2 emissions encountered here are predominantly those from traffic sources. These emissions were further constrained by filtering for selected wind speeds (< 5 $m \cdot s^{-1}$) and wind directions that characterise the flow of air from the road to the monitoring station.

FIGURE 3 Temporal variation in $\Delta NO_X/\Delta CO_2$ with stability at Marylebone Road from July 2010 to August 2011.



DISCUSSION

Analysis revealed two distinct behaviours of roadside CO_2 in comparison to roadside NO_X across the three sites. At Marylebone road there is proportionally more CO_2 to NO_X (mean of 4.6 ppb NO_X ppm $CO_2{}^{-1}$) than at Brent Park IKEA and Blackwall Tunnel (mean of 5.6 ppb NO_X ppm $CO_2{}^{-1}$).

This difference might be indicative of the dominant engine type of vehicle fleets at each site. The Brent Park IKEA and Blackwall Tunnel sites lie on arterial A roads where there are an increased number of diesel-powered heavy goods vehicles that produce less CO_2 with respect to NO_X compared to the predominantly petrol car and bus fleet encountered along the Marylebone road.

In the long term, this methodology will be used for the analysis of observable CO_2 emissions control scenarios, long-term emissions trends and elucidation of emissions models and inventories.

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