# Carbon dioxide & methane emission dynamics in central London (UK).

Centre for Ecology & Hydrology
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## Introduction

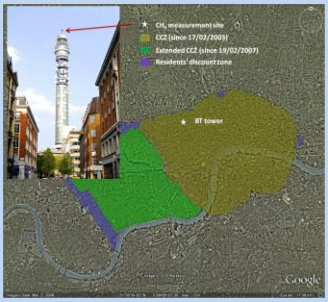


*Figure 1: Satellite image of central London and location of the BT tower within the congestion charging zone (CCZ).*

Continuous monitoring of carbon dioxide ($CO_2$) and methane ($CH_4$) fluxes in central London (UK) began in August 2011. Measurements are taken by eddy-covariance (EC) atop the British Telecom (BT) tower, at a height of 190 meters above street level (Fig. 1).

The EC system consists of a Gill R3-50 ultrasonic anemometer and a Picarro G2301-f $CO_2$, $CH_4$ & $H_2O$ analyser operating in high precision mode which provides water vapour corrected concentrations of $CO_2$ and $CH_4$. Flux corrections are applied offline to account for damping caused by low sampling rate. These are functions of atmospheric stability and are of the order of 15% - 20 %.

Based on analyses from previous measurement campaigns, the footprint entrains very densely populated, high traffic areas as well as traffic-calmed areas and the sources contributing the most to daytime fluxes measured at the BT tower are contained within a 5 km radius †.

The BT tower provides thus a valuable platform for the monitoring of air pollution and the tracking of the evolution of greenhouse gas emissions at the heart of a European megacity.

† *Helfter C., Famulari D., Phillips G.J., Barlow J.F., Wood C.R., Grimmond C.S.B., Nemitz E., 2011. Controls of carbon dioxide concentrations and fluxes above central London. Atmospheric Chemistry and Physics 11, 1913-1928.*

## Results

▪ Concentrations of $CO_2$ and $CH_4$ are in phase over the entire diurnal cycle and the diurnal trends are consistent with cycles of growth and shrinkage of the atmospheric boundary layer. Trends of $CO_2$ fluxes are consistent with diurnal traffic patterns within the tower flux footprint (Fig.2).

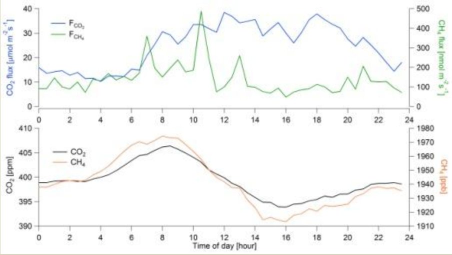


*Figure 2: Diurnal trends in carbon dioxide and methane concentrations and fluxes measured at the BT tower between January and August 2012.*

▪ $CH_4$ and $CO_2$ fluxes are strongly correlated throughout day and night; however, the ratio of $CH_4$ to $CO_2$ fluxes ($R_f$) exhibits a marked dependence on time of day (Fig. 3).

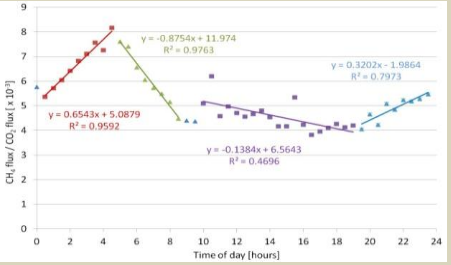


*Figure 3: Ratio of methane fluxes to carbon dioxide fluxes (R) measured between January and August 2012 as a function of time of day.*

▪ Night time trends for $R_f$ are thought to be traffic-driven; $CO_2$ emissions from traffic reach their minimum at around 03 - 04:00 GMT, whilst the $CH_4$ flux baseline (leaks from natural gas distribution network) remains constant.

▪ $R_f$ is nearly constant between 10:00 – 18:00 GMT (summer time slope is almost 0), suggesting an equilibration of sources of $CO_2$ and $CH_4$ during the day.

▪ Baseline $CH_4$ emissions (29 tons $CH_4$ $km^{-2}$ $yr^{-1}$) obtained by extrapolating the regression function between $CH_4$ and $CO_2$ fluxes (Fig. 4) for $F_{CO2}$ = 0 (i.e. $CH_4$ emissions from sources not contributing to $CO_2$ fluxes) are consistent with city centre values (Westminster and Camden: 28 tons $CH_4$ $km^{-2}$ $yr^{-1}$) reported by the UK National Atmospheric Emissions Inventory (NAEI).

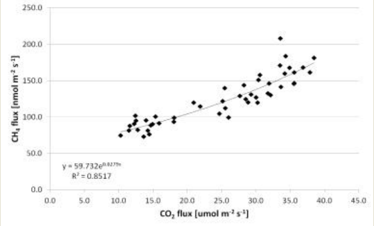


*Figure 4: $CH_4$ fluxes versus $CO_2$ fluxes (diurnal averages for January – August 2012).*

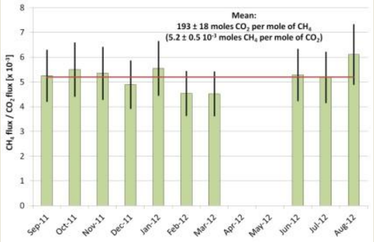


*Figure 5: Monthly values of the ratio of methane to carbon dioxide fluxes ($R_f$).*

▪ Little inter-monthly variation of $CH_4$ to $CO_2$ flux ratio (Fig. 5 – the mean annual ratio ($R_{annual}$) is 5.2 ± 0.5 mmol $CH_4$ per mole of $CO_2$).

▪ Emissions of $CH_4$ predicted on the basis of $R_{annual}$ and $CO_2$ inventory data for the two London boroughs contributing the most to fluxes measured at BT tower exceed inventory estimates of $CH_4$ by a factor of 2 to 3 (for Camden and Westminster, respectively).

## Conclusions

Methane emissions from central London exhibit diurnal patterns both for concentrations and fluxes. Fluxes are strongly correlated to those of carbon dioxide; although flux ratios exhibit diurnal cycles they are relatively constant on an annual basis. The baseline for methane fluxes is thought to result from leaks in the natural gas distribution network at a rate of 29 tons $km^{-2}$ $yr^{-1}$, which agrees with inventory data. However, a two- to three-fold difference was found between inventory and measured total fluxes, which could indicate an underestimation of $CH_4$ emissions from combustion sources by the inventory (e.g. road traffic, domestic and commercial heating). Central London methane emissions are estimated at 67 tons $km^{-2}$ $yr^{-1}$ and the global warming effect of $CO_2$ was found to be 25 times greater than that of $CH_4$ (100-year horizon).

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*The BT tower is part of the InGOS network of tall tower sites (http://www.ingos-infrastructure.eu/).*