London CO_2 fluxes and the urban water balance

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Introduction

CO_2 may now be regarded as a pollutant. Accurate monitoring and modelling of the anthropogenic contribution to CO_2 levels is important for assessing the impact and success of **low carbon policies**. How big is the **anthropogenic influence on CO_2** in London? Can we forecast the impacts of **CO_2 mitigation**?

Improved understanding and modelling of the Urban Water Balance (UWB) is required to aid the implementation and planning of **sustainable water policies**. How can urban water balance modelling be used to mitigate the impacts of future climate change on **drinking water supply**, **garden irrigation** and **urban runoff**?

CO_2 Monitoring

KCL have a range of CO_2 monitoring capabilities:

- Ongoing continuous monitoring using calibrated Licor 840 analysers
- Flux measurements using an open-path Licor 7500 analyser and sonic anemometer
- CO_2 vertical profiling, using a Licor 840 analyser
- CO_2 dispersion monitoring using two open-path FTIR spectrometers.

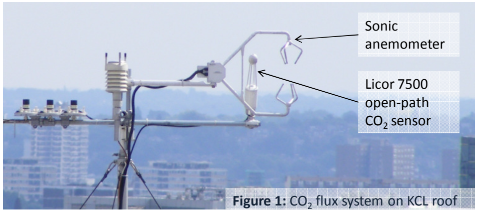

Figure 1: CO_2 flux system on KCL roof

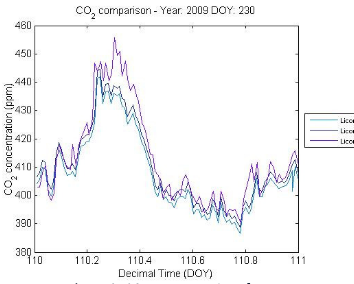

Figure 2: CO_2 concentrations from three different sensors

Can trends in **diurnal/weekly CO_2 concentrations** be attributed to anthropogenic activities?
Does **urban vegetation** have an effect on levels of CO_2?

Open-path Fourier transform infrared (OP-FTIR) spectroscopy can yield path integrated CO_2 concentrations. Knowledge of path concentrations has the potential to improve our understanding of CO_2 dispersion and the interaction between roadside pollution and the wider environment.

How does **building geometry** affect CO_2 concentration at street level?
How might changes in **vehicle fleet** affect CO_2 on different scales?

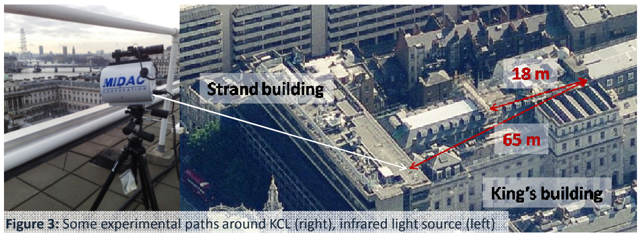

Figure 3: Some experimental paths around KCL (right), infrared light source (left)

CO_2 Flux

The Eddy Covariance system operated on rooftops in central London (Gouvea et al. 2009) allows for the estimation of the turbulent flux of CO_2. The following criteria are applied to the fluxes in the post processing procedure for quality control – exclude periods with:

- Rain observed by auto weather station/rain gauge
- CO_2 concentrations (Licor 7500) < 0 mmol
- Diagnostics value (Licor 7500) > 253
- CO_2 standard deviations (Licor 7500) > 1.72 µmol

The resulting fluxes (based on 15 min averages) still show some extreme values (Fig. 4) which might turn out to be artefacts of severe conditions in urban pollution. But to guarantee data quality these situations need further investigation.

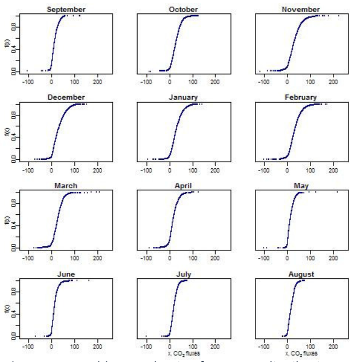

Figure 4: Monthly cumulutaive frequency distributions of CO_2 flux [µmol m^{-2} s^{-1}] for September 2008 – August 2009

CO_2 flux climatology enables comparison of monthly mean daily cycle (Fig. 5):

- Mean daily cycle less pronounced in spring/summer
- Smaller standard deviations in spring/summer
- Weekdays > weekends
- Standard deviations of weekdays > weekends
- Weekends-weekdays difference larger in autumn/winter

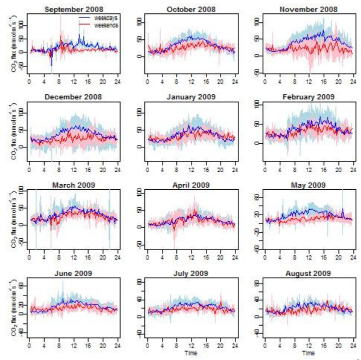

Figure 5: Monthly mean daily cycle of CO_2 flux [µmol m^{-2} s^{-1}] separated for weekends and weekdays, std shaded.

Urban Water Balance

The monitoring and modelling of the UWB is important for the investigation of the influence of urban areas on the water cycle, the effectiveness of water management techniques (e.g. **rain water collection** and **grey water recycling**) and potential urban climate change mitigation (e.g. **green roofs** and **urban vegetation/trees**).

The UWB is modelled (Eq. 1) using a mass balance approach (Grimmond et al. 1986) applied to the transfer of water (mm) through a specified area or catchment (Fig. 1). Particular attention needs to be taken to consider scale when modelling the UWB, the framework applied is a bottom up approach starting with microscale unit blocks (Fig 2a) based on land use type, these blocks are combined to form local scale clusters (Fig. 2b). The local scale clusters are combined (Fig. 2c) for the entire urban area (Mitchell et al. 2001). The UWB model can be linked to surface energy based models and parameterizations (e.g. LUMPS, UCM) due to a link to the surface energy balance by the evaporation term, *E*.

$$P + I + F = E + R + \Delta S + \Delta A$$

Precipitation + Piped Water Supply + Anthropogenic Water Release =
Evapotranspiration + Runoff + Net Change in Storage + Net Moisture Advection

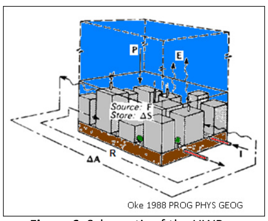

Figure 6: Schematic of the UWB.

The UWB model will be applied across greater London using utility and meteorological measurements to either directly simulate or parameterize the terms of the balance equation. The combined LUMPS-UWB model will then be used to assess the effects of the aforementioned management techniques and urban climate change mitigation.

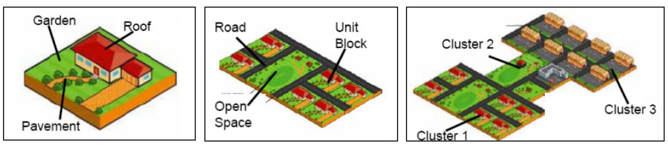

Figure 7: Application of scale in a bottom up approach to modelling the UWB (Mitchell *et al.* 2001)

References

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