Eddy covariance measurements of trace gases and energy fluxes from an urban district of Mexico City

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Introduction

In the MCMA-2003 field study we demonstrated the feasibility of the micrometeorological techniques to measure fluxes of CO_2 (Velasco et al., 2005a) and VOCs (Velasco et al., 2005b) in an urban environment. Micrometeorological techniques, such as eddy covariance (EC) are ideal because the flux measurements include all major and minor emission sources from a determined area, hence, they are a valuable tool for evaluating and improving emission inventories.

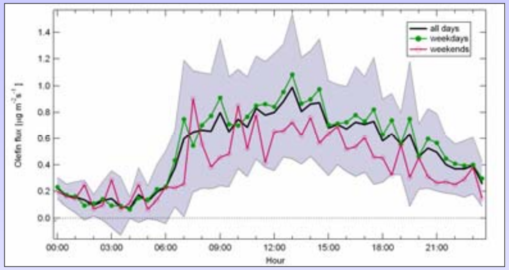
One of our objectives for 2006 was to verify the representativeness of the 2003 flux measurements in terms of the magnitude, composition, and overall distribution of urban emissions. We deployed a new flux system in a busy district surrounded by congested avenues close to the center of the city (SIMAT site) during 25 days of March 2006 as part of the MILAGRO campaign.

For this study we extended the number of species using diverse instruments coupled with different micrometeorological methods. This poster presents preliminary results of fluxes calculated by the eddy covariance technique (fluxes of olefins, CO_2, and energy), and their associated ambient concentrations.

References

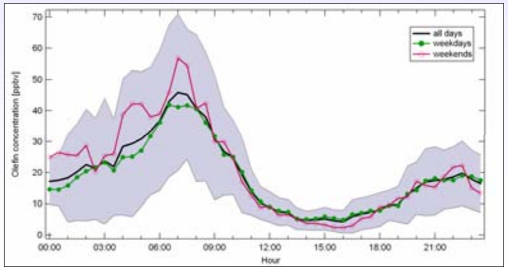
• Velasco et al., 2005a. Measurements of CO_2 fluxes from the Mexico City urban landscape. Atmos. Environ. 39, 7433-7446.
• Velasco et al., 2005b. Measurements of urban VOC fluxes. Geophysical Research Letters, 32, doi:10.1029/2005GL023356.

Olefins



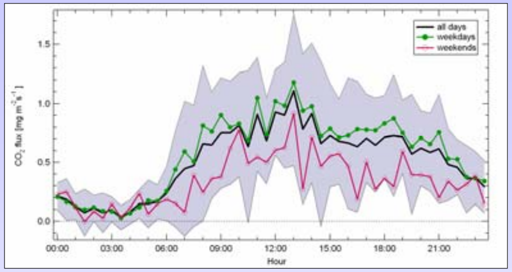
Olefin fluxes ranged from essentially zero to 1.5 µg m^{-2} s^{-1}, with an average of 0.51 µg m^{-2} s^{-1}, 42% higher than the average observed in 2003. The diurnal pattern was constant during the entire study, but on average, weekday fluxes were 36% higher than on weekends.

Average diurnal pattern of olefin fluxes (top graph) and ambient concentrations (bottom graph) for the 25-days study, and for weekdays and weekends. The grey shadow represents ±1 standard deviation from the total average. The olefins were measured by a Fast Isoprene Sensor calibrated with a propylene standard.



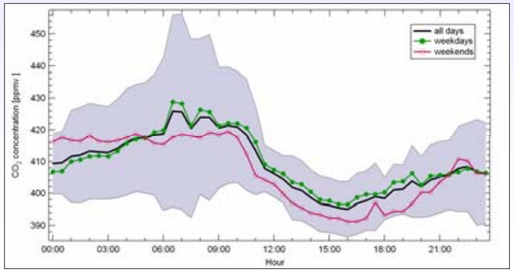
The olefin concentrations showed a clear diurnal pattern similar to other pollutants emitted by mobile sources, such as NO_x and CO. The highest concentrations occurred constantly between 7:00 and 8:00 am. The evolution of the boundary layer and the atmospheric photochemistry reduced olefin mixing ratios to near zero in the afternoons.

CO_2



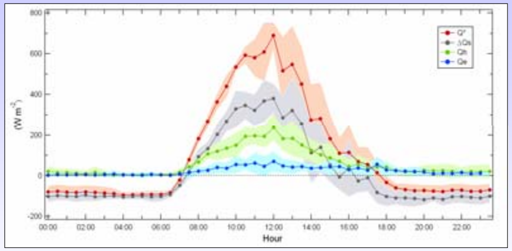
The monitored urban site showed to be a net source of CO_2, with a diurnal average of 0.51 mg m^{-2} s^{-1}, 24% higher than the average measured in 2003. The effects of reduced traffic on weekends produced a reduction of 39% for the average diurnal weekend flux compared to weekdays.

Average diurnal pattern of CO_2 fluxes (top graph) and ambient concentrations (bottom graph) for the 25-days study, and for weekdays and weekends. The grey shadow represents ±1 standard deviation from the total average. The CO_2 was measured by an open-path infrared gas analyzer (IRGA) model OP-2.



The CO_2 concentrations showed a similar diurnal pattern to what would be expected for typical pollutants emitted by mobile sources. The diurnal mean was 409 ppm, 5% higher than the observed mean in 2003. The highest concentrations occurred between 6:00 and 9:00 am with an average of 423 ppm.

Energy balance



Average energy balance diurnal pattern from March 21 to 29, 2006. The shaded areas indicate the ±1 standard deviation ranges. The sensible (Qh) and latent (Qe) heats were measured by eddy covariance, the net radiation (Q) by a net radiometer, and the storage heat (ΔQs) was obtained as the residual of the measured energy components (ΔQs = Q* - (Qh + Qe)).*

This figure shows the energy balance for 9 days with clear, sunny mornings and cloudy afternoons with scattered showers. During the daytime (Q^* >0) ΔQs contributed 50% to Q^*, Qh 37% and Qe 13%. The Bowen ratio ($\beta = Qh/Qe$) showed large values, with a diurnal average of 2.9. Large β are typical for urban sites. Using the long and short wave radiation measurements from the net radiometer, we calculated an albedo (α) of 0.115 and a surface emissivity (ε) of 0.757

Summary

• The implementation of a flux tower at the SIMAT site was successful.

• Clear anthropogenic signatures of concentrations and fluxes were observed.

• The diurnal patterns of both, concentrations and fluxes of olefins and CO_2 were similar to those observed in 2003, but with higher magnitudes. These differences were due to the different characteristics of the monitored site rather than an increment of the emissions in a period of 3 years.

• Valuable turbulent data and energy fluxes were obtained.

• The energy balance distribution and radiative parameters observed are similar to distributions and parameters reported for other urban sites.

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