Urban CO$_2$ Emissions from the Los Angeles Basin: Assessing chemistry and dynamics using the suite of tracers measured aboard the CalNex WP-3 Aircraft

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Goals for studying CO$_2$ and other GHGs in CalNEX

• *Use of CO$_2$ as the primary metric of combustion influence*

• *Test ideas of how to measure changes in total emissions over time (treaty verification)*

• *Use CO$_2$ as a model validation tool*
Background

$\text{CO}_2$, CO, $\text{CH}_4$ concentrations:

Mt. Wilson vs from the P-3
Uniformity an artifact of an aged mix of sources?
Mean Vertical Distributions of $\Delta$CO$_2$ on 10 flight days over Los Angeles
ΔCH₄/ΔCO₂ = 8 ± 0.8

Slope = 9.68 +/- 0.13

TCCON

ΔN₂O/ΔCO₂ = 0.5 ± 0.3

Slope = 0.0967 +/- 0.0017

stratosphere?
Figure 20. Column CO$_2$ over Los Angeles from the Total Carbon Column Observation Network (TCCON) for five days in March, 2008. Three of the four days show strong diurnal variation associated with urban emissions while the March 27 data show much smaller variations due to the air originated from the Mojave Desert. Note that there is no data recorded at night, and the solid vertical lines represent the time between 7 PM and 7 AM. (Source: Wunch et al. 2009)
Locations of urban measurement sites in the Salt Lake Valley. Photos show placement & locale.
Variation of background air entering the SLC Valley

Data from Britt Stephens

CO$_2$ (ppm)
SLC CO$_2$ (Vulcan emissions in tonne C/hr)
Observed and Modeled CO$_2$ concentrations, Salt Lake City (Downtown)

Date (October, 2006)

Downtown

- Observed
- Model, 4 km
- Model 1.3 km + UCM
Obs. vs model CO$_2$ at 3 sites in Salt Lake City, Oct. 2006, from hi-resolution model (1.3 km, urban canopy). Hourly points in gray and 8-hour averages in red. Line is SMA fit to 8-hour data.
<table>
<thead>
<tr>
<th>Model Configuration</th>
<th>Site</th>
<th>SMA Slope (±95% CI)</th>
<th>Scaling Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Resolution / UCM</td>
<td>Downtown</td>
<td>0.57 (0.11)</td>
<td>1.76 (0.44)</td>
</tr>
<tr>
<td></td>
<td>Neighborhood</td>
<td>0.54 (0.09)</td>
<td>1.84 (0.27)</td>
</tr>
<tr>
<td></td>
<td>Junior High</td>
<td>0.54 (0.10)</td>
<td>1.86 (0.28)</td>
</tr>
</tbody>
</table>

**How could the inventory be so far off??**
The effect of inhomogeneous spatial distribution of emissions on aggregated source models.
Figure 19. (a-d) Vertical distributions of CO₂ (ppm) over Salt Lake City according to the high-resolution model on October 12, 2006, at 7 am, 3, 4, and 5 pm MST (left to right). (e) Location of the north-south transect for the vertical model runs, relative to total Vulcan emissions (kt C) for one week in October. (e) Observed and simulated surface CO₂ at the Downtown site on October 12, 2006. The four hour that were modeled in the vertical are highlighted. (g-h) CO₂ enhancements above background, integrated through the vertical column (g) for three afternoon hours and (h) for a morning hour versus the average of the afternoon hours.
Figure 19. (a-d) Vertical distributions of CO$_2$ (ppm) over Salt Lake City according to the high-resolution model on October 12, 2006, at 7 am, 3, 4, and 5 pm MST (left to right). (e) Location of the north-south transect for the vertical model runs, relative to total Vulcan emissions (kt C) for one week in October. (f) Observed and simulated surface CO$_2$ at the Downtown site on October 12, 2006. The four hour that were modeled in the vertical are highlighted. (g-h) CO$_2$ enhancements above background, integrated through the vertical column (g) for three afternoon hours and (h) for a morning hour versus the average of the afternoon hours.
Summary of results

• CO$_2$ is an excellent tracer of combustion influence in Los Angeles, with overwhelming dominance of fossil fuels and an aged mix of basin-wide sources.
• Methane emission rates are large.
• Total column measurements are most likely to provide independent verification of emission rates.
• Detailed modeling of CO$_2$ or other long-lived emissions in urban areas requires a priori knowledge of source spatial and temporal distributions, not usually available. Less important in Los Angeles than in most other cities.
Obs. vs model CO$_2$ at 3 sites in Salt Lake City, Oct. 2006. Top row: model and obs. from hi-resolution model (1.3 km, urban canopy). Bottom: 4 km baseline model. Hourly points in gray and 8-hour averages in red. Lines are SMA fits to 8-hour data.