# P2.1 A Comparison Of $CO_2$ Fluxes At Two Sites Within The Urbanized Salt Lake Valley

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## 1. Introduction

Increasing $CO_2$ concentration in the atmosphere alters global and local climatology (Soloman et al. (2007)). Even though a large number of field studies have been conducted to understand sources and sinks of $CO_2$ emissions, very few of these studies have focused on urban areas. Christen et al. (2006) documented various urban $CO_2$ studies conducted at different cities around the world, and observed most of those sites acted as a net source of $CO_2$ throughout the day during the summer. In general, urbanization destroys natural $CO_2$ sinks (Walsh et al. (2004)) and replaces them with anthropogenic sources. As part of the Urban Trace-gas Emission Study (UTES), the Salt Lake Valley $CO_2$ flux experiment involved measuring $CO_2$ and energy fluxes from two different sites subjected to the same external forcings. One of the sites was located in a suburban residential neighborhood and the other was in a pre-urban area, located beyond regions that are currently under development. The results from presents study indicate that the residential neighborhood with significant vegetative cover acted as a $CO_2$ sink during a portion of the daylight hours during the summer. The pre-urban site however, acted as a source throughout the day. That is, in a naturally semi-arid region, the forest and vegetation planted in place of the natural grasses and shrubs sequesters substantially more $CO_2$ during the late summer. Also, due to the presence of the vegetative cover and irrigation, the suburban site had a significantly greater latent heat fluxes than the pre-urban site. The pre-urban site was largely dominated by the sensible heat flux during the convective period. All the data presented in this paper wer obtained during summer 2005.

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## 2. Sites and Instrumentation

The Salt Lake Valley is located in an intermountain basin situated in the western part of the United States. This metropolitan area is located south-east of the Great Salt Lake, with the Wasatch and Oquirrh mountain ranges to its eastern and western borders. The valley is about 1320 m above sea level and experiences semi arid climatic conditions.

The Salt Lake Valley experiment specifically focuses on two different sites, with their own unique land forms; a suburban residential area (Murray, UT), located at the center of the Salt Lake Valley, and a pre-urban site located on land owned by Kennecott Land (Kennecott) which resembles what much of the west side of the Salt Lake Valley looked like before it was developed. Both these sites are just 17 Km apart.

Figure 1 shows the Salt Lake Valley and the location of both experiment sites, Murray and Kennecott. The Murray residential site is located approximately 1 km west of a freeway (I-10) which runs across the valley, from north to south, while the Kenecott site is located at the south western part of the valley, close to the Oquirrh ranges. The Murray site is situated on relatively flat land, while the Kennecott site is located on gently sloping terrain.

Both sites have been in operation for approximately two years. The suburban site, Murray, is mostly residential in nature. The urban form around this site is consistent with any other residential neighborhood in the valley.

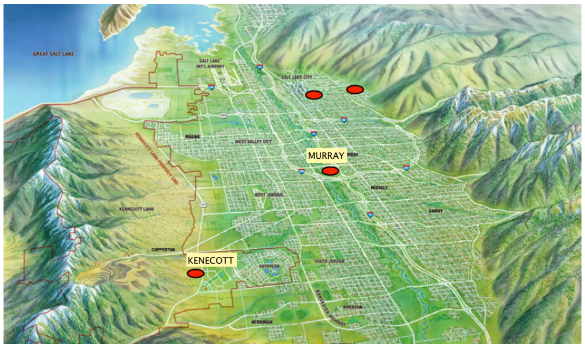


Figure 1: Topographic schematic of the Salt lake Valley showing the two measurement sites (Courtesy: Kennecott Land Corp.)

Table 1, illustrates the urban characteristics around Murray flux tower. The average building height around the site is 4.4 m and most of them are two-storied residential houses. The trees are deciduous in nature and most of them are non-native and manually planted. Around 56 $\%$ of the area around the tower (2 Km X 2 Km), is covered by vegetation. The area surrounding the Kenecott tower is covered with non-native sage and dormant grasses.

Table 1: Urban morphology characteristics of Murray site( from Quickbird imagery).

| | |
|---|---|
| Avg Bldg Ht | 4.4 m |
| Avg Tree Ht | 6.5 m |
| Plan Area Fraction Covered By Trees and Irrigated Grasses | 56% |
| Plan Area Fraction Covered By Roof Top | 13% |
| Leaf Area Index | 3.6 |

The data presented in this paper were obtained during the months of August and September 2005. The average temperature during this time period was about $28.6^oC$. The Kenecott site is 1576 m above sea level and the Murray site is 1306 m above sea level.

Table 2 lists all the instrumentation used for the field study. A 37 m tall communication tower, equipped with five Campbell Scientific CSAT3 sonic anemometers, mounted at different heights, was used for measuring wind characteristics at the Murray site. The site also used a LICOR 7000 infrared gas analyzer to measure carbon dioxide and water vapor concentrations. A 36 m long tube, 0.5 inches in diameter, fitted with a pump, was used to draw air from the top of the tower to the LICOR 7000, housed at the bottom of the tower. The rural site, Kenecott, had a 7 m tall aluminum tower, fitted with three Campbell Scientific CSAT3 sonic anemometers. The site used a LICOR 6260 infrared gas analyzer to measure carbon dioxide and water vapor concentrations. The site also had a CNR1 net radiation meter along with soil heat flux plates to measure the ground heat flux. Both the sites had a CR5000 datalogger. The Murray tower was also equipped with a NL100 network interface for internet connectivity.

## 3. Methodology

The data gathered from the two stations were converted to binary format and processed using Matlab software. The processed data were checked for irregularities and the erroneous data points were neglected. All data points higher than 15 $\%$ of the mean for that averaging period were omitted. In order to correct for topographical errors, a coordinate rotation technique was used as described by Wilzack et al. (2001). Also, a lag correction subroutine was employed (Fitzjarrald (1990)) to account for the delay between the velocity measurement and with the carbon dioxide measurement, recorded by the LICOR closed path gas analyzers. A 30 m long tube of 0.5 inch diameter was to used to draw air in to the LICOR at the Murray site and a similar tube, 7 m long was used at the Kenecott site.

The flow inside the tubes, attached to the gas analyzers was laminar, to avoid errors due to turbulent diffusion. To account for low frequency loses associated with tube attenuation, procedures described by Baldocchi (2001) were followed. The $CO_2$, sensible and latent heat fluxes were WPL corrected (Webb et al. (1980)) and Moores correction (Moore (1986)) was used to account for system response mismatch errors. The $CO_2$ sensors were calibrated for zero and span every 7-14 days manually.

For estimating fluxes, the instantaneous data were linearly detrended using five-minute windows and were averaged over a period of 30 minutes.

Table 2: Measurement equipment deployed during the observational period.

| | **Kenecott** | **Murray** |
|---|---|---|
| $CO_2$ & $H_2O$ Flx | LICOR 6260 (9 m) | LICOR 7000 (36 m) |
| Wind spd Wind Dir Momentum Sen. Ht. Flx | Cam. Sci CSAT3 (9,7 5 m AGL) | Cam Sci CSAT3 (36, 23.5, 17.1, 12.1, 6 m AGL) |
| Humidity | Cam. Sci HMP45C (9m) | - |
| Ground Ht. Flx | Cam. Sci HFP01SC | - |
| Net Radiation | Kipp & Zonen CNR1 | - |
| Soil Ht. Flx | Cam. Sci HFP01SC | - |

## 4. Results

Figure 2 shows 30 minute averaged $CO_2$ fluxes for the months of August and September 2005 for the Murray site. The plot shows a distinct diurnal pattern for both the months. The fluxes are positive during the evening and night and negative during the central part of the day. This pattern is due to the combined presence of trees and anthropogenic acitivities in the neighborhood. Photosynthesis is responsible for the negative fluxes during the daytime, whereas human and plant respiration and other anthropogenic activities contribute to the positive fluxes. A maximum flux of 6 $mol/m^2s$ occurs around 9 am in the morning, during the peak traffic hour when people commute to work.

Figure 3 shows 30 minute averaged $CO_2$ concentration for Murray for the months of August and September. The concentrations exhibit a similar pattern as the fluxes. The $CO_2$ concentration reaches a maximum approaching 410 ppm around 9 am in the morning and then drops rapidly to about 383 ppm during the mid day period.

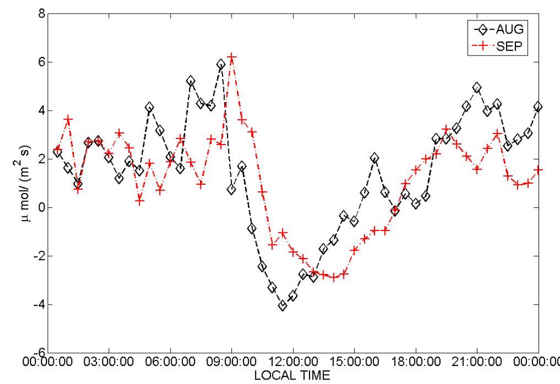


Figure 2: 30 minute averaged $CO_2$ fluxes for August and September 2005 for Murray, residential site.

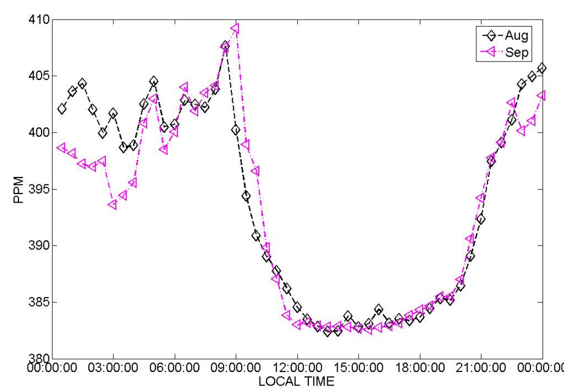


Figure 3: 30 minute averaged $CO_2$ concentrations for August and September 2005 for the Murray residential site.

Figure 4 shows half hour averaged diurnal variation of sensible and latent heat fluxes. The vegetative cover around the residential site plays an important role by not only squestering $CO_2$ but also by redistributing the energy fluxes. The plot reveals nearly equal contribution from both the sensible and latent heat fluxes for both the months. The heat fluxes have a peak value of 120

$W/m^2$. The sensible heat fluxes reach negative values during the nighttime and early morning hours, between 1900 to 0900.

It is interesting to note from Figure 2 and 4 that when the sensible heat flux becomes positive, around 9 am, there is a huge spike in the $CO_2$ flux. During the early morning period when the atmosphere is stable, the $CO_2$ from plant respiration and other anthropogenic activities accumulates in the lower part of the atmosphere. This build up breaks when the surface starts warming up and flushes out the accumulated $CO_2$, resulting in a spike.

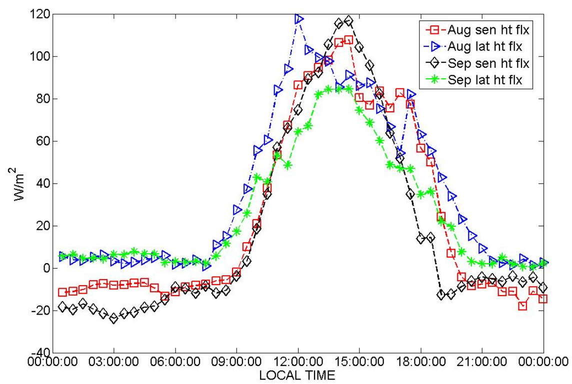


Figure 4: 30 minute averaged sensible and latent heat fluxes for August and September 2005 for Murray, residential site.

Figure 5 shows 30 minute averaged $CO_2$ flux from the pre-urban Kenencott site during September 2005. Overall, the $CO_2$ flux always stays positive throughout the day. The flux stays close to zero during the early morning and night time periods and peaks around 5-6 pm in the afternoon. The $CO_2$ flux pattern around the site is dictated by the traffic along the road that runs near the site as well as any local biological activity in the soil. The diurnal variation of the sensible and latent heat fluxes for Kenecott is shown in Figure 6. While the sensible heat flux reaches a peak value of $130\ w/m^2$, the contribution from the latent heat flux is significantly low due to lack of vegetation.

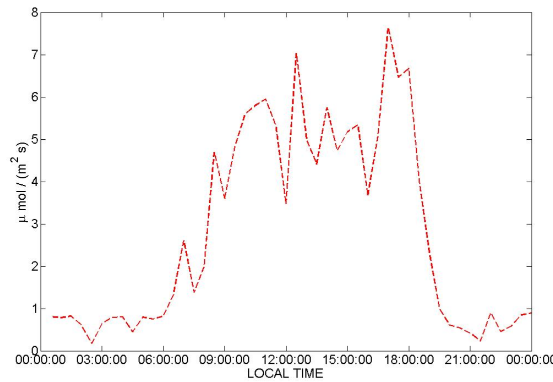


Figure 5: 30 minute averaged $CO_2$ fluxes for Kenecott, residential site.

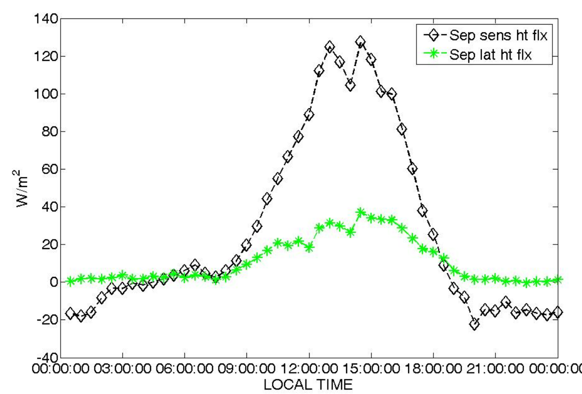


Figure 6: 30 minute averaged sensible and latent heat fluxes for August and September 2005 for Murray, residential site.

# 5. Conclusion

The results indicate the a potential impact of urbanization on the $CO_2$ cycle in Salt Lake Valley. The vegetative cover at the residential neighborhoods have significantly altered the diurnal variation of $CO_2$ fluxes. Apart from being $CO_2$ sinks, the irrigated surfaces have changed the energy balance by equally redistributing the energy between the sensible and latent heat fluxes. The $CO_2$ fluxes at the pre-urban site is mostly affected by vehicular traffic that passes through the site.

# References


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