Partitioning of Biogenic and Anthropogenic CO₂ Signals using CO Tracer Technique

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Abstract
The poster reports a CO:CO₂ ratio technique in the estimation and quantification of biogenic CO₂ (CO₂Excess) and anthropogenic CO₂ (CO₂An) signals in an urban setting following continuous dry mixing ratio measurements of carbon dioxide (CO₂) and carbon monoxide (CO) using a wavelength-scanned cavity Ring-Down spectroscopic (CRDS) technology. The measurements were carried out in different days during the spring, summer and winter of 2017 and 2018 at a height 15 m above the ground. The CO:CO₂ correlation ratios (β) values were evaluated using regression analysis after subtracting the region’s background concentration based on a 5th percentile background subtraction technique. For the year 2017, β values (ppb/ppm⁻¹) of 9.7 ± 0.4, 5.3 ± 0.4, and 2.0 ± 0.2 were obtained for the winter, spring and summer seasons, respectively. In 2018, a similar trend in the β values was observed where values of 8.7 ± 0.5, 7.4 ± 0.7, and 2.6 ± 0.5 measured in winter, spring, and summer seasons, respectively. Correlation values (r²) of 0.9, 0.8 and 0.6 were obtained for winter, spring and summer seasons respectively, indicating the strong biospheric CO₂ exchange during summertime. This strong biospheric signal is brought about by the strong photosynthetic activity in the summertime as opposed to the dominant respiratory carbon fluxes that dominates the winter season.

Introduction
The three contributors to the overall atmospheric CO₂ signal (CO₂Tot) are, background CO₂ (CO₂Bg), anthropogenic CO₂ (CO₂An), and the biospheric CO₂ (CO₂Bio).

Techniques and Methods

Study site and Cavity Ring-Down Spectroscopic Technique:-

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Figure 1: Map of the location and surroundings of the study site (35.1828°N, 85.5016°W)

Figure 2: The schematic diagram of Cavity ring-down spectroscopy set-up and the associated components in the laboratory

The basic instrumentation of CRDS consists a laser, a high optical cavity setting following continuous dry mixing ratio measurements of carbon dioxide (CO₂) and carbon monoxide (CO) using a wavelength-scanned cavity Ring-Down spectroscopy (CRDS) technique.

The poster reports a CO:CO₂ ratio technique in the estimation and quantification of biogenic CO₂ (CO₂Excess) and anthropogenic CO₂ (CO₂An) signals in an urban setting following continuous dry mixing ratio measurements of carbon dioxide (CO₂) and carbon monoxide (CO) using a wavelength-scanned cavity Ring-Down spectroscopic (CRDS) technology. The measurements were carried out in different days during the spring, summer and winter of 2017 and 2018 at a height 15 m above the ground. The CO:CO₂ correlation ratios (β) values were evaluated using regression analysis after subtracting the region’s background concentration based on a 5th percentile background subtraction technique. For the year 2017, β values (ppb/ppm⁻¹) of 9.7 ± 0.4, 5.3 ± 0.4, and 2.0 ± 0.2 were obtained for the winter, spring and summer seasons, respectively. In 2018, a similar trend in the β values was observed where values of 8.7 ± 0.5, 7.4 ± 0.7, and 2.6 ± 0.5 measured in winter, spring, and summer seasons, respectively. Correlation values (r²) of 0.9, 0.8 and 0.6 were obtained for winter, spring and summer seasons respectively, indicating the strong biospheric CO₂ exchange during summertime. This strong biospheric signal is brought about by the strong photosynthetic activity in the summertime as opposed to the dominant respiratory carbon fluxes that dominates the winter season.

The three contributors to the overall atmospheric CO₂ signal (CO₂Tot) are, background CO₂ (CO₂Bg), anthropogenic CO₂ (CO₂An), and the biospheric CO₂ (CO₂Bio).

CO₂Tot = CO₂Bg + CO₂An + CO₂Bio

It can be assumed that the greatest source of CO in Cookeville region is fossil fuel burning and therefore anthropogenic CO (COAn) can be calculated as,

COAn = β(CO₂Bio - CO₂Bg)

Assuming that CO and CO are co-emitted by anthropogenic sources at a given ratio, β, then the CO₂An can be derived from CO₂ as follows,

CO₂An = β(CO₂Tot - CO₂Bg - CO₂An)

By combining equation 4-1,

CO₂Bio = CO₂Tot - CO₂An

The highest β values were generally associated with afternoon hours between 4 p.m. and 7 p.m.

Correlations between CO₂ and CO were higher during the evenings irrespective of the season. This is an indication of vehicle emissions during the afternoon rush-hour traffic.

Night time β values were comparatively lower

Table 1: Observed β values and their r² values.

<table>
<thead>
<tr>
<th>Season</th>
<th>Period</th>
<th>Observed β value</th>
<th>r²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>Morning</td>
<td>8.0 ± 0.7 ppm⁻¹</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Midday</td>
<td>7.0 ± 0.5 ppm⁻¹</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Afternoon</td>
<td>6.0 ± 0.3 ppm⁻¹</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Night</td>
<td>5.0 ± 0.2 ppm⁻¹</td>
<td>0.7</td>
</tr>
<tr>
<td>Summer</td>
<td>Morning</td>
<td>9.0 ± 0.9 ppm⁻¹</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Midday</td>
<td>8.0 ± 0.7 ppm⁻¹</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Afternoon</td>
<td>7.0 ± 0.5 ppm⁻¹</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Night</td>
<td>6.0 ± 0.3 ppm⁻¹</td>
<td>0.7</td>
</tr>
<tr>
<td>Winter</td>
<td>Morning</td>
<td>10.0 ± 1.1 ppm⁻¹</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Midday</td>
<td>9.0 ± 0.9 ppm⁻¹</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Afternoon</td>
<td>8.0 ± 0.7 ppm⁻¹</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Night</td>
<td>7.0 ± 0.5 ppm⁻¹</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Conclusions and Future Directions

During the winters, when the biospheric CO₂ fluxes are close to zero, mostly correlated (r² > 0.9) anthropogenic β values were observed.

This study demonstrates the potential of a CO-based technique over ¹⁴C0₂-based method in quantifying CO₂An.

Selected References


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