Development of a New N₂O/CO Cavity Ring-Down Spectrometer for Sub-ppb Ambient Gas Monitoring

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Results and Discussion

Introduction

With a global warming potential of nearly 300, N₂O is a critically important greenhouse gas, contributing about 5% of the US total GHG emissions. Agriculture soil management practices are the dominant source of anthropogenic N₂O emissions, contributing nearly 75% of US N₂O emissions. In urban areas, vehicle tailpipe emissions and waste water treatment plants are significant sources of N₂O. We report here a new mid-infrared laser-based cavity ring-down spectrometer (Picarro G5310) that was recently developed to measure sub-ppb ambient concentrations of two key greenhouse gas species, N₂O and CO, simultaneously. It combines a quantum cascade laser with a proprietary 3-mirror optical cavity. The new optical analyzer was set up to monitor N₂O and CO, along with CO₂ and CH₄, in ambient air obtained from a 10 meter tower in Santa Clara, California. Evidence of contributions from traffic and a nearby sewage treatment facility were expected in the measurement data.

Cavity Ring-Down Spectroscopy

Cavity ring-down spectroscopy (CRDS) is a time-based absorption technique employing a high-finesse optical cavity to deliver effect path-lengths in the order of several kilometers. Combined with precise temperature, pressure, and wavelength control, CRDS offers high sensitivity, precision, and low-drift measurements. The G5310 further extends this performance via the use of a quantum-cascade laser (QCL) operating in the mid-infrared, a region of the spectrum offering significantly higher sensitivity for nitrous oxide and its than relevant absorption features at shorter wavelengths in the near-infrared.

Analyzer – Specifications and Test Results

<table>
<thead>
<tr>
<th>Specification</th>
<th>N₂O</th>
<th>CO</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision (1σ: 5 sec)</td>
<td>0.2</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Measurement range</td>
<td>1-1,500 ppb</td>
<td>1-1,500 ppb</td>
<td>0-3%</td>
</tr>
<tr>
<td>Drift (24 hrs)</td>
<td>&lt;0.1 ppb</td>
<td>&lt;0.1 ppb</td>
<td>&lt;0.1 ppb</td>
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Experimental Set-up

The experiment was located at the Picarro facility in Santa Clara, California. The G5310 analyzer was connected to a sampling point at a height of approximately 50 meters, with a sample line length of approximately 40 meters. Sample line material was a fluorinated polymer and the air sample was collected at a flow rate of 240 sccm, without drying.

Conclusions

Performance test data obtained during development of the G5310 validates the analyzer for long-term background measurements of N₂O and CO. Precision and drift characteristics make the G5330 the ideal choice for measurement network deployment, where frequency of calibration is critical to efficient operations, and long-term measurement precision is vital. In addition, the analyzer has been shown to have the necessary dynamic range to provide essential monitoring capabilities in urban environments. The CO₂ measurement based on ¹³CO₂ further extends the range of potential monitoring applications.

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- Contact Graham Leggett (gleggett@picarro.com)
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