Novel System for Continuous Measurements of Dissolved Gases in Liquids

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Introduction

Measurements of dissolved gases are critical in studying a variety of phenomena, including underwater greenhouse gas generation, air-surface exchange, and pollution migration. These studies typically involve obtaining water samples from streams, lakes, or ocean water and transporting them to a laboratory, where they are degased. The gases obtained are then generally measured using conventional gas chromatography and isotope ratio mass spectrometry for concentrations and isotope ratios, respectively. This conventional, off-line methodology is time consuming, significantly limits the number of the samples that can be measured and thus severely inhibits detailed spatial and temporal mapping of gas concentrations and isotope ratios.

Here we describe the testing of a comprehensive commercial membrane-based gas extraction unit that interfaces directly to LGR's gas analyzers to continuously measure concentrations of dissolved gases in real time.

This new tool (model 915-9600) can replace head-space equilibration and allow new research opportunities, including (but not limited to):

- **Measuring CH_4, CO_2 (and other gases) seepages from ocean floor**
- **Monitoring water quality in lakes, oceans, fish-farms, etc.**
- **Monitoring dissolved gases in lakes and rivers**
- **Providing quality control for waste water treatment plants**

Deployment in the Arctic in 2013

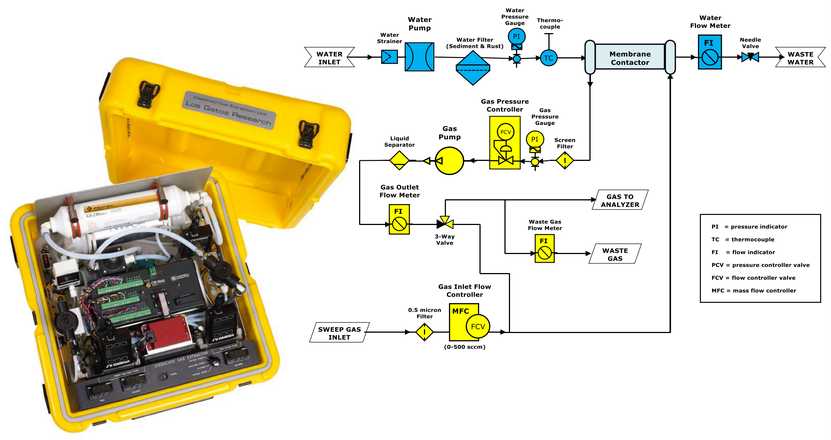
A beta-prototype DGEU was successfully deployed at Toolik Lake, Alaska in 2013 (see last year's 2013 AGU B52B-02: "High Resolution CH_4 Emissions and Dissolved CH_4 Measurements Elucidate Surface Gas Exchange Processes in Toolik Lake, Arctic Alaska," T. Del Sontro; S. Sollberger; G.W. Kling; G.R. Shaver; W. Eugster).

Demonstration at AGU 2014

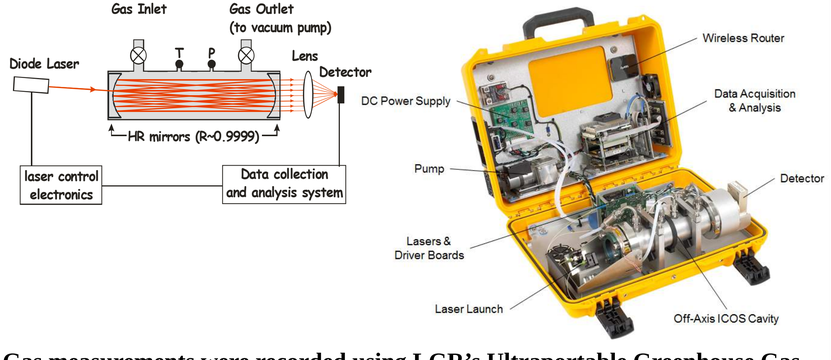
The Dissolved Gas Extraction Unit, together with LGR's Ultraportable Greenhouse Gas Analyzer (911-0011), is presently in operation this week at Exhibit Booth #1905.

Dissolved Gas Extraction Unit

The schematic diagram of the Dissolved Gas Extraction Unit (model 915-9600) is shown below. The internal components of the DGEU allow control of the pressure and flow rates of the sampled liquid and gases. During operation, the DGEU requires 45 watts of electrical power.



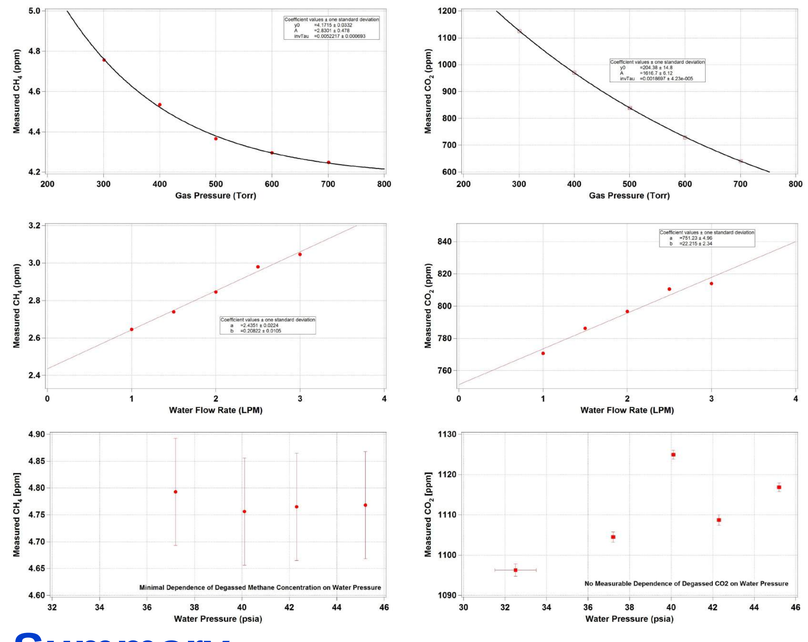
Dissolved Gas Extraction Unit (45 W, 16 kg) controls the pressure and flow rates of sampled liquid (30-45 psia, 1-2 L/min) and sweep gas (0.15-1 L/min).



Gas measurements were recorded using LGR's Ultraportable Greenhouse Gas Analyzer (model 915-0011). (left) Schematic diagram of the optical layout of LGR's patented (Off-axis ICOS) cavity enhanced laser absorption measurement strategy (www.LGRinc.com). (right) LGR's Ultraportable Greenhouse Gas Analyzer (15 kg, 70 W) used to record measurements of CH_4 and CO_2 in water.

Performance

The DGEU controls water and gas flow rates and pressures so the user can select the optimal operating parameters. For evaluation of performance, the DGEU sampled liquid water from a 190-L tank filled with local (Mountain View, CA) tap water. The water and sweep gas pressure and flow rates were varied using the DGEU internal controls over the full operating conditions to determine the dependence on water pressure (which flows inside the membrane), gas pressure (which flows outside the membrane), and flow rates on gas concentrations out of the DGEU. The output gas from the DGEU, which is the dissolved gas in the water, was sampled by LGR's UGGA to determine CH_4 and CO_2 concentrations. All parameters were recorded on the DGEU by the included (Campbell CR1000) data logger. These plots indicate the expected dependence on (top) gas pressure, (center) water flow rate, and (bottom) water pressure.



Summary

By accurately controlling the water flow rate through the DGEU, gas pressure on the outside of the membrane, and water pressure on the inside of the membrane, the DGEU (with separate LGR gas analyzer) can generate precise and reproducible measurements of dissolved gas concentrations. Moreover, by measuring the gas flow rates in and out of the DGEU, the gas-phase concentrations (e.g., units of ppm) may be converted into dissolved gas concentrations (e.g., units of nM).