B51A-0922

HYDRA: A Programmable Portable Trace-Gas Measuring System

Sean Burns[1,2], Tony Delany[1], Jielun Sun[1], Gordon Maclean[1], Steve Oncley[1], Steve Semmer[1], and Russ Monson[2]

(1) National Center for Atmospheric Research, Boulder, Colorado (2) Department of Ecology and Evolutionary Biology, University of Colorado, Boulder

I. Introduction:

Measuring trace gases to understand and monitor the Earth has become an important (and common) task within the scientific community. A trace-gas measuring system (called "HYDRA") that can be easily moved and reconfigured to account for changes in scientific direction or focus has been developed at the NCAR Atmospheric Technology Division (ATD) for use in a wide variety of projects. The purpose of this poster is to present the physical characteristics of the HYDRA system and show results from a field project.

II. INSTRUMENTATION DETAILS:

HYDRA is a collection of tubing, manifolds, relays, mason jars, pumps, valves and a valve controller packaged in a portable box that delivers air from 18 different inlet locations to a sensor. Each inlet is equipped with a 1 micron Gelman-type filter that keeps dirt, dust and other small particles from entering the Hydra system. Mason jars are used as buffer volumes to mix and hold the incoming air sample. In order to create a sufficient pressure drop and draw the air sample into the buffer volumes, a suction manifold is attached to a Gast oilless rocking piston vacuum pump (model RAA). Though the Gast pump runs at ∼18 lpm, the actual flow rate of the sample air into the buffer volume is controlled by a valve (Omega engineering, model MFVB6) and monitored by a Dwyer Visi-Float Rotameter Flowmeter. With this configuration it is possible to independently control how quickly each buffer volume is flushed. Typical flow rates into the buffer volumes were on the order of 1-3 lpm. Schematics for the system are shown in two parts: the HYDRA sampling system (Fig. 1) and the sensor system (Fig. 2). The sensors used here are two LI-7000 CO_2/H_2O Gas Analyzers (LI-COR Biosciences Inc, 4308 Progressive Ave. Lincoln, Nebraska USA). Output from the LI-7000 are archived at 1 sample per second. The coordinator of the entire system is a computer-controlled Opto-22 microprocessor which energizes solid state optically-isolated relays that control the sampling pump and solenoid valves that control which inlet is sampled. If HYDRA is connected to a network, a C++ program allows for remote modification of sampling timing and strategy.

Figure 1: *Schematic of HYDRA sampling system.*

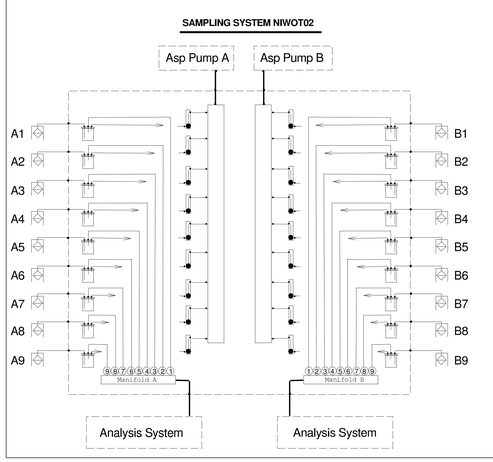
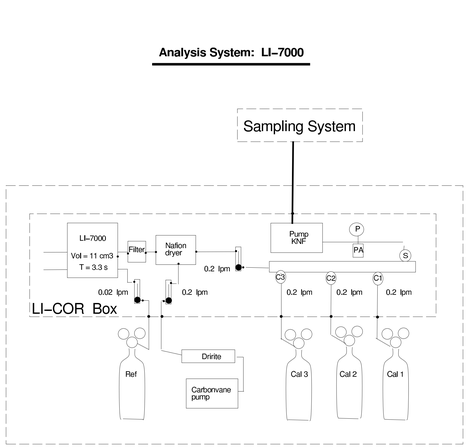
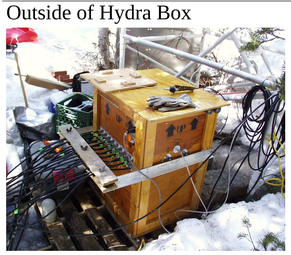


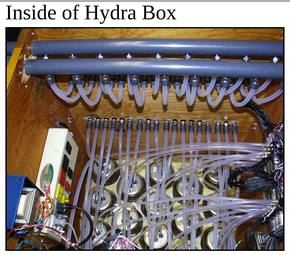
Figure 2: *Schematic of Analysis System (LI-COR 7000).*



Outside of Hydra Box

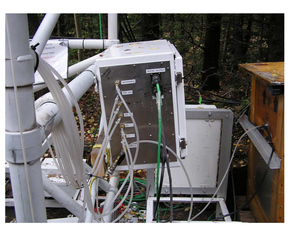


Inside of Hydra Box



Hydra Inlet

LI-COR Box



III. DATA PROCESSING:

The following items were considered when processing the HYDRA data: (1) flushing time of the tubing after a valve switch, (2) travel time of the air sample from the inlet to the HYDRA (only necessary if the pump is running continuously), (3) which calibration gases to use, and (4) interpolation of hourly calibration data to cover the time periods between calibrations.

For NIWOT02 (details below) three calibration gases of fixed CO_2 concentration were used. The lowest level gas (283.38 ppm) was deemed too different from the environmental CO_2 levels to be useful (Fig. 3), and was not used in the processing. Since only two calibration gases were being used a linear calibration was used to process the NIWOT02 data, i.e.,

$$CO_2 = A_1(CO_2)_{raw} + A_0, \quad (1)$$

where $(CO_2)_{raw}$ is the raw CO_2 concentration calculated by the LI-COR, and A_1 and A_0 are empirical constants determined from the calibration time periods. An example of the raw and calibrated data is shown in Fig. 3. A_1 and A_0 were linearly interpolated between hourly calibration periods. In order to ensure dead volumes were flushed, mean values are calculated from the final 20-seconds of each sampling period.

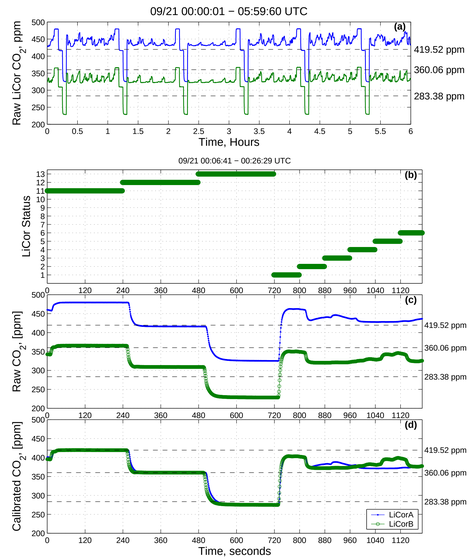


Figure 3: *Six-hour time series of (a) LI-7000 A and B raw data. Twenty-minute time series of (b) the hydra valve status, (c) LI-A and B raw data, and (d) LI-A and B calibrated data.*

IV. EXPERIMENTAL RESULTS:

In August-September of 2002, HYDRA was used to study CO_2 advective transport in a sub-alpine forest to the southeast of Niwot Ridge, Colorado. For NIWOT02, two model LI-7000 Gas Analyzers (one designated "LI-A" and the other "LI-B") running in parallel were used with the HYDRA to measure the CO_2 concentration at 18 inlet locations at various elevations spread over a 200x200 m section of the forest. As an empirical estimation of the measurement accuracy each LI-COR had an inlet co-located at 1-m near the HYDRA box. A comparison of LI-A and LI-B CO_2 from the co-located 1m inlets at indicate typical agreement of about ±0.3 ppm (Fig. 4). A composite of all the 1-m CO_2 data during September between 24:00-1:00 is shown in Fig. 5.

Figure 4: *Difference in CO_2 measured by LI-A and LI-B from 1-m co-located inlets during NIWOT02.*

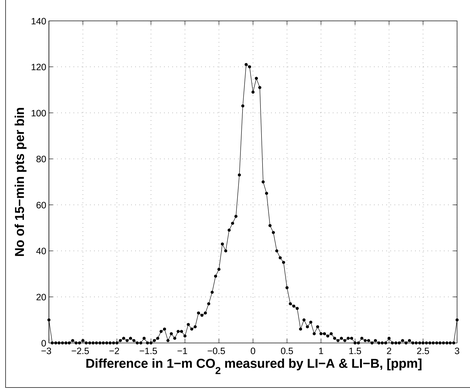


Figure 5: *Composite-contour of CO_2 measured at 1-m inlets by HYDRA between 24:00-1:00 MST.*