An Autonomous, Inexpensive, and Robust CO_2 Analyzer (AIRCOA)

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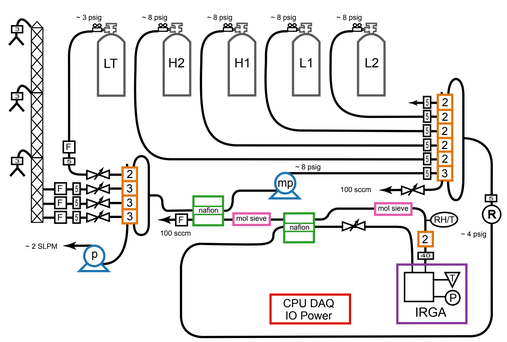
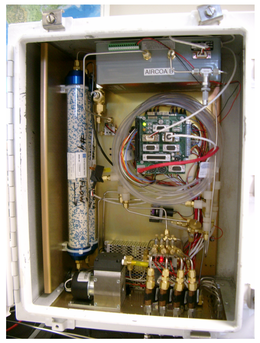
Overview: We present our design of a new autonomous, inexpensive, and robust CO_2 analyzer (AIRCOA), a description of our quality control procedures, and data examples from ongoing deployments (see companion poster). Our current AIRCOA units require less than $10K (USD) in components, show intercomparability better than 0.1 ppm during laboratory tests and 0.2 ppm in the field, and are designed to run autonomously for months at a time. We are working closely with other investigators developing and deploying similar single-cell IRGA based systems, as well as investigators deploying longer-established but more expensive technologies, in an effort to improve the intercomparability between independent observing networks.

Panel 1. AIRCOA design.





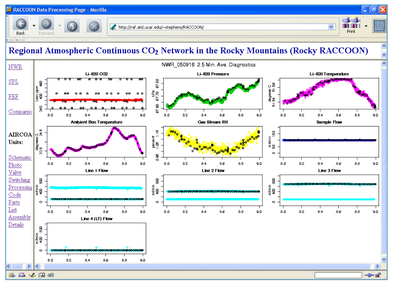
Components include rainshields and 3 um inlet filters (3), mass-flow meters (F), 5 um inline filters (5), manual needle valves, three-way (3) and two-way (2) solenoid valves and manifolds, Nafion driers, molecular sieve driers, a micropump (mp) and pump (p), high-pressure aluminum gas cylinders, two-stage pressure regulators, a single-stage pressure regulator (R), a humidity and temperature sensor (RH/T), a PC104 computer running Linux, PC104 relay and A/D boards, a power supply, and a LiCor 820 single-cell infrared gas analyzer (IRGA).

Panel 2. Potential sources of measurement error and AIRCOA solutions

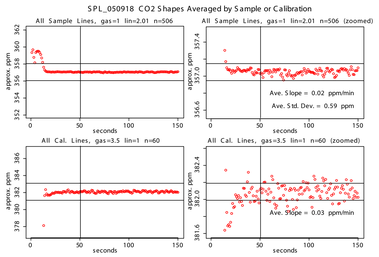
Measurement concern	Approach
Short-term IRGA noise	Average for 2 minutes to get better than 0.1 ppm precision
Drift in IRGA sensitivity	4-hourly 4-point calibrations and 30-minute 1-point calibrations
IRGA pressure sensitivity	Automated 4-hourly pressure sensitivity measurements
IRGA temperature sensitivity	30-minute 1-point calibrations, active temperature control in high temperature-variability deployments
Incomplete drying of air	Slow enough flow (100 sccm), two 96” Nafion driers, downstream humidity sensor to verify performance
Drying system altering CO_2	Continuous flows and pressures through Nafions and run surveillance gas through entire system
Incomplete flushing of cell and dead volumes	Fast enough flow (100 sccm), alternate calibration sequence low-to-high / high-to-low to look for effects
Leaks through fittings, solenoid valves, and pumps	Automated 8-hourly positive pressure leak-down and 4-hourly ambient pressure leak-up checks
Different pressure broadening with and without Ar	Use calibration gases made with real air
Fossil CO_2 in calibration gases and different field and lab ^{13}C sensitivities	Laboratory tests limit current effect to 0.05 ppm, long-term plans to use cylinders with natural CO_2
Regulator temperature effects	Laboratory oven tests suggest effect is negligible, though it could be regulator dependent
Whole-system diagnostics and comparability verification	Long-term surveillance tank analyzed every 8 hours, co-location with other programs, rotating cylinders, and laboratory comparisons

Panel 3. Near real-time data viewing and diagnostic checking

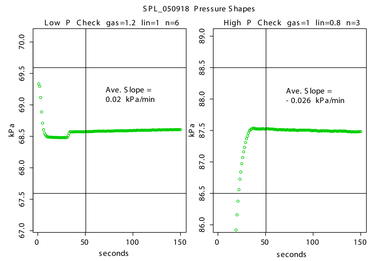
Web-based data display



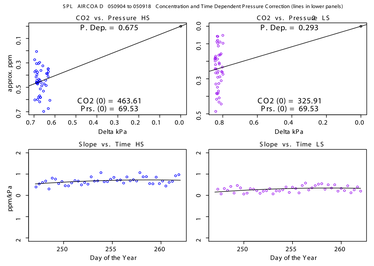
Averages over measurement cycle



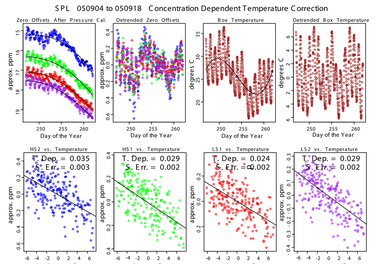
Leak checking pressure cycles



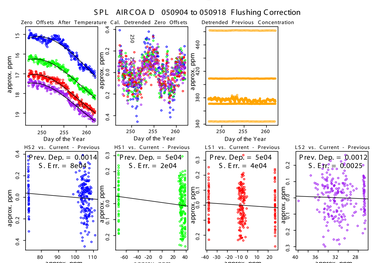
Empirical pressure correction



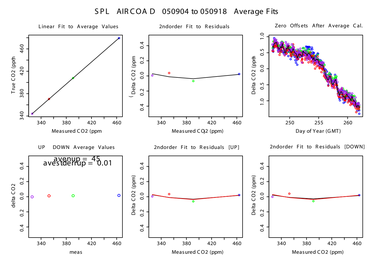
Empirical temperature correction



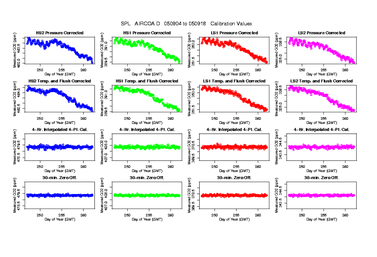
Empirical flushing correction



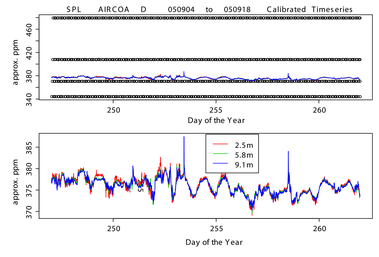
Average calibration curves



Calibration sequence

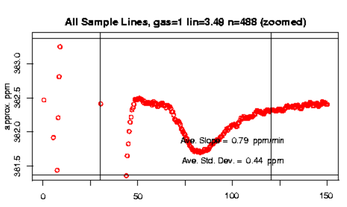


Resulting calibrated dataset

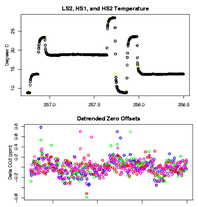


Panel 4. Systemmatic tests

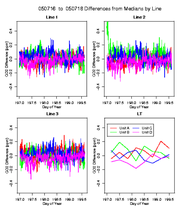
Nafion pressure change effect



Regulator temperature effect



Lab comparisons



Field surveillance measurements