Underway pCO₂ System Description
Laboratory: LDEO

Name/Vintage: Rapid-Response (SeaSoar) pCO₂ System, designed and built by Dave Chipman in 1997
Reference: general operating principle described in Wanninkhof and Thoning (1992) and Feely et al. (1998)

Where installed: Used on RVIB Nathaniel B. Palmer during 1997 JGOFS Southern Ocean (AESOPS) cruise with LDEO pumping SeaSoar (used with surface seawater line when not being used with SeaSoar).

Location of Data: Contact Taro Takahashi (taka@ldeo.columbia.edu) for LDEO data

Analyzer: LI-COR 6251 or 6252 (analog output) infrared (IR) analyzer

Method of analysis: Differential analyses relative to nitrogen zero gas Measures dried equilibrated gas.

Drying method: The samples and standard gases pass through a Perma Pure (Nafion) dryer before reaching the analyzer. The counter flow drying gas in the Perma Pure tube is nitrogen, part of which is subsequently used as the equilibration gas.

Equilibrator (setup, size, flows): Equilibrator fabricated using a modified 2.5" by 8" Liquicel Contactor (tubular microporous membrane exchanger) Water flow rate: up to 10 L/min. Equilibration gas flow rate: up to 220 ml/min.

Standards (number, concentrations, frequency): Four standards are used with approximate concentrations of 110 ppm, 236 ppm, 360 and 456 ppm. All four standards are run approximately once every 15 minutes.

Source of calibration and accuracy: The standards come uncalibrated from various sources (usually Scott-Marin) and are calibrated in the laboratory at Lamont against primary standards traceable to WMO scale. Accuracy normally believed to be within +/- 0.1%. (less certain below 240 ppm).

Standard consumption: Less than 1 tank a year for standards.

Operating cycle: Optimum cycle length not determined- for testing purposes, four standard gases, followed by approximately 13 minutes of analysis of equilibrated gas (10 readings averaged to give single value every 2.1 seconds).
The reference outflow of the IR analyzer is used to sweep the chopper space prior to being vented to the atmosphere.

Parameters recorded/frequency : Raw data are recorded at the time each IR analysis is completed. Each data file contains all the data for a single day (approx. 2.5 MB)

Raw data file contains:
YEAR_DAY: calculated from computer date
TIME: computer "TIMER" reading (seconds since midnight)
IR_VOLTS: analyzer voltage CO₂ channel
IR_CONC: concentration determined from 2nd order polynomial fit of preceding standards
PROVISIONAL pCO₂ (based on IR_CONC, PRESSURE, EQ_TEMP)
POTENTIAL pCO₂ (calculated to a constant temperature, either 20° C or $–1.8^{o}$ C)
EQ_TEMP: temperature determined from an empirical polynomial function determined from laboratory calibration for RTD in equilibrator
EQ_PRESSURE: pressure at gas outlet of equilibrator
GAS_FLOW: Flow (ml/min) from the voltage output of the gas flow meter on the analyzer sample out vent

IR_TEMP: from temperature sensor in IR analyzer
(other parameters are merged from ship's data collection system afterwards)

Hardware details

Temperature measurements: Platinum resistance thermometer (100O RTD) positioned in water-inlet passage of equilibrator, calibrated against a NIST-calibrated calorimeter thermometer

Pressure measurements: Setra model 270 pressure transducer (800-1100 mbar) connected to equilibration gas outlet passage of equilibrator (which runs 1-2 mbar above ambient laboratory pressure)

Operating software: Compiled PowerBASIC program written by Dave Chipman. Separate initialization text file allows changes to operating cycle, replacement of standard gases, etc. to be made without need to modify and recompile operating software, although source code is available.

Computer interface boards and sensors read:

Boards: Omega 1000-series A/D signal-conditioning modules used for all readings and valve/solenoid control

Sensors: voltage LI-COR CO_2 channel (0-5 V)
voltage LI-COR temperature (0-5 V)
voltage Setra pressure transducer (0-5 V)
resistance, constant current 100O RTD probe in equilibrator
voltage Aalborg gas flow meter

Approximate Size and Footprint
Box with valves and LI-COR: 21" wide by 12" deep by 28" high
Equilibrator: 3" diameter by 10 " long.
Computer: any laptop with one serial port

"Unique" Hardware or operating principles worth highlighting:
Equilibration rate constant of Liquicel < 5 sec. Seawater drains under pressure, not gravity. 50 micron filter required in seawater line upstream of Liquicel equilibrator.

What improvements would you incorporate in this system?
Modify 50-micron water filter to allow in-place backflushing. Develop cleaning system for Liquicel equilibrators (subject to biofouling).