R/V Ronald H. Brown METADATA - 1998

Class of Data: Surface ocean and atmospheric carbon dioxide concentrations

Dataset Identifier: R/V Ronald H. Brown

One File: RHB1998

Statement of how to cite dataset:

Ron Brown website: http://www.aoml.noaa.gov/ocd/gcc/rvbrown_data1998.php

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Measurement platform identifier: NOAA research vessel Ronald H. Brown (R104)

Cruise Information:

The Ron Brown conducted 4 major cruises in the north Atlantic and eastern Pacific for a total of 12 legs. Also included are data from 2 transit legs from the Atlantic to the Pacific.

Project Information:

The system was operated by personnel from AOML or PMEL (Pacific Marine Environmental Laboratory). The work was sponsored by the Underway pCO2 on Ships project of the NOAA climate program.

Scientist responsible for technical quality of dataset:

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Timestamp for initial submission of dataset: 09/03/08

Timestamp for the most recent update of dataset: 09/03/08

Timestamp period the dataset refers to: 1/8/1998 – 11/22/1998

Geographic area the dataset refers to:

10 S to 51 N
146 W to 10 W

1998 Cruises:

RB199801 – 24 North Leg 1
Miami, FL to Las Palmas, Canary Islands
January 8, 1998 to January 21, 1998
Chief Scientist – Gregg Thomas
Operator – Dana Greeley

RB199802 - 24 North Leg 2
Las Palmas, Canary Islands to Miami, FL
January 23, 1998 to February 24, 1998
Chief Scientist – Kitack Lee
Operator – Dana Greeley

RB199803 - Gasex98 Leg 1
Miami, FL to Lisbon, Portugal
May 11, 1998 to May 19, 1998
Chief Scientist – Jim Butler
Operator – Bob Castle

RB199804 - Gasex98 Leg 2
Lisbon, Portugal to Punta del Gado, Azores Islands
May 25, 1998 to June 26, 1998
Chief Scientist – Rik Wanninkhof
Operator – Bob Castle

RB199805 - Gasex98 Leg 3
Punta del Gado, Azores Islands to Miami, FL
June 28, 1998 to July 7, 1998
Chief Scientist – Shari Yvon-Lewis
Operator – Craig Neill

RB199806 - Transit98 Leg 1
Miami, FL to Panama Canal
July 12, 1998 to July 16, 1998
Chief Scientist – None
Operator – Jason Masters

RB199807 - Transit98 Leg 2
Panama Canal to Newport, OR
July 16, 1998 to July 27, 1998
Chief Scientist – None
Operator – Jason Masters

RB199808 - Vents98 Leg 1
Newport, OR to Victoria, BC, Canada
July 30, 1998 to August 15, 1998
Chief Scientist – Ed Baker
Operator – Dana Greeley

RB199810 - Vents98 Leg 3
Newport, OR to Victoria, BC, Canada
August 24, 1998 to September 20, 1998
Chief Scientist – Bob Embley
Operator – Jim Gendron

RB199811 - Vents98 Leg 4
Victoria, BC, Canada to Seattle, WA
September 23, 1998 to October 3, 1998
Chief Scientist – Hugh Milburn
Operator – Marilyn Roberts

RB199812 - TAO98 Leg 2
Seattle, WA to Panama Canal
October 15, 1998 to November 14, 1998
Chief Scientist – John Shanley
Operator – Esa Peltola

RB199813 - TAO98 Leg 2
Panama Canal to Charleston, SC
November 17, 1998 to November 22, 1998
Chief Scientist – None
Operator – Esa Peltola

List of variables included in this dataset:

COLUMN	HEADER	EXPLANATION
1.	GROUP/SHIP:	AOML_Brown for all underway data from the Ron Brown.
2.	CRUISE_DESIGNATION:	Cruise ID (e.g., RBYYYYnn where RB = Ron Brown, YYYY = the four digit year, and nn = the cruise number for that year).
3.	JD_GMT:	Decimal year day.
4.	DATE_DDMMYYYY:	GMT date. The date format has been changed to comply with the IOCCP recommendations.
5.	TIME_HH:MM:SS:	GMT time.
6.	LAT_DEC_DEGREE:	Latitude in decimal degrees (negative values are in the southern hemisphere).
7.	LONG_DEC_DEGREE:	Longitude in decimal degrees (negative values are in the western hemisphere).
8.	xCO2W_PPM:	Mole fraction of CO2 (dry) in the equilibrator headspace at equilibrator temperature (Teq) in parts per million.
9.	xCO2A_PPM:	Mole fraction of CO2 in air in parts per million.
10.	EqTEMP_C:	Temperature in equilibrator water in degrees centigade. Temperature in equilibrator measured with a calibrated thermistor.

11. PRES_EQUIL_hPa: Barometric pressure in the lab in hectopascals (1 hectopascal = 1 millibar).

12. SST(TSG)_C: Temperature from the ship's thermosalinograph in degrees centigrade.

13. SAL(TSG)_PERMIL: Salinity from the ship's thermosalinograph on the Practical Salinity Scale.

14. fCO2w,eq: Fugacity of CO2 in the equilibrator in microatmospheres calculated as outlined below.

15. fCO2W@SST_uatm: Fugacity of CO2 in sea water in microatmospheres calculated as outlined below.

16. fCO2A_uATM: Fugacity of CO2 in air in microatmospheres calculated as outlined below.

17. dfCO2_uatm: Sea water fCO2 - air fCO2 in microatmospheres. This uses the average air value for the current hour.

The following fields have been QC'ed by the CO2 group:

GROUP/SHIP
CRUISE_DESIGNATION
JD_GMT
DATE_DDMMYYYY
TIME_HH:MM:SS
LAT_DEC_DEGREE
LONG_DEC_DEGREE
xCO2W_PPM
xCO2A_PPM
EqTEMP_C
PRES_EQUIL_hPa
fCO2w,eq
fCO2W@SST_uatm
fCO2A_uATM
dfCO2_uatm

The following fields are from the ship's onboard systems and the quality of this data cannot be verified:

SST(TSG)_C
Sal(TSG)_Permil

Narrative description of system design:

CO2 ANALYTICAL SYSTEM:

The concentration of carbon dioxide (CO2) in surface ocean water is determined by measuring the concentration of CO2 in gas that is in contact with the water. Surface water is pumped ~ 100 m through 7/8" Teflon tubing from an inlet in the ship's bow to the equilibration chamber. Water comes from the bow intake ~4.2 m below the water line and the TSG is located close to the inlet. When the SST is below about 20 °C, friction in the pipes and from the pump cause heating and the Teq is higher than SST. When the SST is higher than about 25 °C, the ship's air conditioning cools the water and the Teq is lower than SST. The equilibration chamber has an enclosed volume of gas, or headspace, and a pool of seawater that continuously overflows to a drain. As the water flows through the chamber, the dissolved gases (like CO_2) partition between the water and the headspace. At equilibrium, the ratio of CO_2 in the water and in the headspace is influenced most by temperature, and that relationship is known. By measuring the concentration of CO_2 in the headspace and the temperature in the chamber, the partial pressure (or fugacity) of CO_2 in the surface water can be calculated.

INSTRUMENT DESCRIPTION

The general principle of instrumental design can be found in Wanninkhof and Thoning (1993), Ho et al. (1995), and Feely et al. (1998). The concentration of CO_2 in the headspace gas is measured using the adsorption of infrared (IR) radiation, which results from changes in the rotational and vibrational energy state of the CO_2 molecule. The LI-COR detector passes IR radiation through two 6" cells. The reference cell is flushed with a gas of known CO_2 concentration. The sample cell is flushed with the headspace gas. A vacuum-sealed, heated filament is the broadband IR source. The IR radiation alternates between the two cells via a chopping shutter disc. An optical filter selects an adsorption band specific for CO_2 (4.26 micron) to reach the detector. The solid state (lead selenide) detector is kept at -12 degrees °C for excellent stability and low signal noise (less than 0.2 ppm).

Several steps are taken to reduce interferences and to increase the accuracy of the measurements. After the equilibration chamber, the headspace travels through a drying trap to remove water vapor. During each analysis, the headspace gas is compared to a reference gas of known concentration. To improve the accuracy of the measurements, three different gaseous standards for CO_2 are analyzed once an hour instead of the headspace gas.

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

Method of Analysis: Differential analyses relative to the low standard. Measures dried equilibrator headspace gas. Gas flow is stopped prior to IR readings.

Drying Method: The equilibrator headspace sample gas first goes through a glass condenser cooled to ~ 5 °C. The sample and standard gases pass through a short column of magnesium perchlorate before reaching the analyzer.

Equilibrator (setup, size, flows): The equilibrator is based on a design by R. Weiss and was fabricated from a plexiglass housing with ~8 L water reservoir and ~16 L gaseous headspace. Water flow rate is ~11 L/min. Headspace recirculation rate is ~200 ml/min.

Additional sensors:

Thermistor mounted in the bottom of the equilibrator.
Setra Barometer Model 370
YSI Model 600R thermosalinograph with temperature, salinity, and dissolved oxygen sensors. This TSG is mounted in the Hydro lab sink near the equilibrator and the two are teed off the uncontaminated seawater feed. The dissolved oxygen measurements are not reported in the final data file.

Narrative statement identifying measurement method for each required parameter:

CALCULATIONS:

The mixing ratios of ambient air and equilibrated headspace air are calculated by fitting a second-order polynomial through the hourly averaged millivolt response of the detector versus mixing ratios of the standards. Mixing ratios of dried equilibrated headspace and air are converted to fugacity of CO_2 in surface seawater and water saturated air in order to determine the fCO_2.
For ambient air and equilibrator headspace, the fCO2a (or fCO2eq) is calculated assuming 100% water vapor content:

$$fCO2eq = xCO2eq(P-pH2O)\exp(B11+2*d12)P/RT$$

where fCO2eq is the fugacity in the equilibrator, pH2O is the water vapor pressure at the sea surface temperature, P is the atmospheric pressure (in atm), T is the SST or equilibrator temperature (in K) and R is the ideal gas constant (82.057 cm^3·atm·deg^-1·mol^-1). The exponential term is the fugacity correction where B11 is the second virial coefficient of pure CO2

$$B11 = -1636.75 + 12.0408T - 0.032795T^2 + 3.16528E-5\ T^3$$

and d12 = 57.7 - 0.118 T is the correction for an air-CO2 mixture in units of cm^3·mol^-1 (Weiss, 1974).

The calculation for the fugacity at SST involves a temperature correction term for the increase of fCO2 due to heating of the water from passing through the pump and through 5 cm ID PVC tubing within the ship. The empirical temperature correction from equilibrator temperature to SST is:

$$fCO2(SST) = fCO2(eq) / \mathrm{Exp}\ ((Teq-SST) * [0.03107 - 2.7851E-4 * Teq - 1.8391E-3 * \ln(fco2eq * 1.0E-6)])$$

where SST is sea surface temperature and Teq is the equilibrator temperature in degrees °C.

Sampling Cycle:
The system runs on an hourly cycle during which 3 standard gases, 3 air samples from the bow tower and 8 surface water samples (from the equilibrator head space) are analyzed on the following schedule:

Mins. after hour	Sample
4	Low Standard
8	Mid Standard
12	High Standard
16.5	Water
21	Water
25.5	Water
30	Water
34	Air
38	Air
42	Air
46.5	Water
51	Water
55.5	Water
60	Water

NOTES ON DATA:

Columns have a default value of -999.99 in case of instrument malfunction, erroneous readings or missing data. Furthermore, if a suspicious xCO2 value, pressure or temperature value is encountered, the fCO2 is not calculated.

Analytical Instrument Manufacturer/Model:

The Ron Brown system (version 2.5) was an in-house prototype built by Jason Masters, Mike Shoemaker, and Bob Castle in 1998. The analyzer is a LI-COR 6251 (analog output) infrared analyzer.

Standard Gases and Reference Gas: The three standard gases came from CMDL in Boulder and are directly traceable to the WMO scale. While individual data points above the high standard gas concentration or below the low standard gas concentration may not be accurate, the general trends should be indicative of the seawater chemistry.

Description of any additional environmental control:

The system is located in the Hydro Lab of the Ron Brown. The room is air-conditioned with little temperature fluctuation.

Resolution of measurement:

The resolution of the instrument is better than 0.1 ppm.

Estimated overall uncertainty of measurement:

The xCO2eq measurements are believed accurate to 0.1 ppm. The fCO2@SST measurements are believed to be precise to 0.2 ppm.

List of calibration gases used:

The standards used during the 1998 field season were:

STANDARD	TANK #	CONCENTRATION	VENDOR
Low	CC114999	275.63	CMDL
Low	CA03372	283.26	CMDL
Low,Mid	CC117904	297.74	CMDL
Low	CA01208	299.06	CMDL
Mid	CA02032	341.14	CMDL
Low,Mid,High	CC106641	360.62	CMDL
Mid,High	CC111795	408.35	CMDL
High	CA03065	523.44	CMDL

Traceability to an internationally recognized scale (including date/place of last calibration made):

All standards are obtained from NOAA/CMDL, now called the Global Monitoring Division of the Earth Research Laboratory and are directly traceable to WHO scale.

Uncertainty of assigned value of each calibration gas:

The uncertainty based on pre and post cruise calibrations is less than 0.05 ppm.

Pressure/Temperature/Salinity:

For information about the ship's thermosalinograph, contact Chief Survey Tech Jonathan Shannahoff at jonathan.shannahoff@noaa.gov.

Units:

All xCO2 values are reported in parts per million (ppm) and fCO2 values are reported in microatmospheres (uatm) assuming 100% humidity at the equilibrator temperature.

Bibliography:

DOE (1994). Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2. DOE.

Feely, R. A., R. Wanninkhof, H. B. Milburn, C. E. Cosca, M. Stapp and P. P. Murphy (1998). A new automated underway system for making high precision pCO2 measurements onboard research ships. Analytica Chim. Acta 377: 185-191.

Ho, D. T., R. Wanninkhof, J. Masters, R. A. Feely and C. E. Cosca (1997). Measurement of underway fCO2 in the Eastern Equatorial Pacific on NOAA ships BALDRIGE and DISCOVERER, NOAA data report ERL AOML-30, 52 pp., NTIS Springfield.

Wanninkhof, R. and K. Thoning (1993). Measurement of fugacity of CO2 in surface water using continuous and discrete sampling methods. Mar. Chem. 44(2-4): 189-205.

Weiss, R. F. (1970). The solubility of nitrogen, oxygen and argon in water and seawater. Deep-Sea Research 17: 721-735.

Weiss, R. F. (1974). Carbon dioxide in water and seawater: the solubility of a non-ideal gas. Mar. Chem. 2: 203-215.

Weiss, R. F., R. A. Jahnke and C. D. Keeling (1982). Seasonal effects of temperature and salinity on the partial pressure of CO2 in seawater. Nature 300: 511-513.

Comments related to all 1998 data:

1. xCO2 values outside the range of the standard gases (i.e. below the low standard or above the high standard) are not as accurate as values within the range. However, the general trends should be indicative of the seawater chemistry.
2. Data from the ship's computer system (SST and salinity) were merged into the underway system's data file with an approximate 3 minute delay factor. This is to account for the time it takes for sea water to travel from the bow intake to the equilibrator in the Hydro Lab.
3. Prior to this cruise, the operation of the Valco multi-port valve was changed in an attempt to reduce the number of mistrips that had been occurring about 1.5% of the time. Previously, the Valco reset to the home position after each measurement and then stepped to the correct position. For this cruise, the Valco was set to the following configuration:

Position 1	Water
Position 2	Air
Position 3	Water
Position 4	Std 1 (low)
Position 5	Std 2 (mid)
Position 6	Std 3 (high)

The valve was then stepped only at the end of each phase, or 6 times per hour. While this reduced the number of mistrips, the result when the valve failed to trip was that the valve would be in the wrong position for every succeeding phase until it was reset after the Std 3 phase.

4. Fluorometer data was added to the feed from the ship's computer system before the start of this cruise.
5. A separate power supply was added to the system to drive the equilibrator thermistor. The thermistor was recalibrated and a new equation for converting voltage to temperature was added to the program. Mercury thermometer measurements taken during the first cruise verify that the new equation is accurate.

Comments related to the individual legs:

RB199801: 1. The standard gases used on this leg were: low, 297.74 ppm; mid, 341.14 ppm; and high, 408.35 ppm.
2. There were 9 mistrips of the Valco valve resulting in 183 lost data measurements. When mistrips occur, low standard gas flows during the mid standard phase and mid standard gas flows during the high standard phase. To correct this, the low and mid standard voltage responses are moved to the appropriate positions and the high standard response is taken as the average of the previous and next hour’s response.

RB199802: 1. The standard gases used on this leg were: low, 297.74 ppm; mid, 341.14 ppm; and high, 408.35 ppm.
2. There were 33 mistrips resulting in 183 lost data measurements. Standard gas responses were corrected as in RB199801.

RB199803: 1. The standard gases used on this leg were: low, 297.74 ppm; mid, 360.62 ppm; and high, 408.35 ppm.
2. There were 8 mistrips resulting in 25 lost data measurements. Standard gas responses were corrected as in RB199801.
3. The system was down at the beginning of the leg while the program was modified to accept a new feed from the ship's computer system (SCS). It was started on May 10 at midnight.
4. The system was down on May 16 for 1-1/2 hours to recalibrate the YSI TSG.
5. The ship's salinity sensor began giving bad readings on May 16 at 1645 GMT. I used the good salinity values (prior to May 16) to derive a linear relationship between the SCS salinity and the YSI salinity. Starting on May 16 at 1959 SCS salinity readings were replaced with computed salinity using the equation SCS salinity = YSI salinity * 0.7656 + 8.336.
6. Also on May 16, we discovered a leak in the hose supplying uncontaminated sea water to the equilibrator which was allowing ambient lab air to get into the equilibrator. For this reason, there is more variability than normal in the fCO_2 values for this leg.
7. Some fCO_2 values must be considered questionable due to sharp changes in the fCO_2 level. They were not removed from the data set because no definitive reason to consider them bad could be found. They are listed below:

Date	Time	Year day
5/13	1120	133.4728
5/14	1229	134.5207
5/15	1159	135.4998
5/15	1646	135.6988
5/15	1716	135.7197
5/15	1730	135.7290
5/18	1955	138.8300

RB199804: 1. The standard gases used on this leg were: low, 275.63 ppm; mid, 297.74 ppm; and high, 360.62 ppm.
2. There were 12 mistrips resulting in 22 lost data measurements. Standard gas responses were corrected as in RB199801.
3. On May 29 some small air leaks in the system were discovered and repaired. Data prior to 2030 GMT shows higher variability than normal.
4. On May 30 from 2330 to 2400 GMT positive pressure in equilibrator caused headspace gas to back up into the Licor sample cell, resulting in bad readings.
5. On May 31 from 2115 to 2300 GMT the system was down to install a solenoid valve on the sample output of the Licor.
6. On June 3 from 1412 to 1825 the system was down to recalibrate the YSI TSG.
7. On June 9 from 545 to 625 the system was down to clean the equilibrator's shower head.
8. On June 12 from 1225 to 1312 the system was down to install a bounceless switch on the Valco valve.
9. On June 12 from 1430 to 1600 the system was down to recalibrate the YSI O2 sensor.
10. On June 17 from 1505 to 1930 the system was down to recalibrate the YSI O2 sensor.
11. On June 25 from 1315 to 1640 the system hung due to operator error.

RB199805: 1. The standard gases used on this leg were: low, 275.63 ppm; mid, 297.74 ppm; and high, 360.62 ppm. On July 5 at 1545 they were changed to 297.74, 360.62, and 408.35 respectively due to higher water values.
2. Gas flow in the water phase was low (but adequate) until June 30 @ 1100 GMT.
3. On July 3 from 0230 to 0330 the system was down due to a power failure.

RB199806: 1. The standard gases used on this leg were: low, 299.06 ppm; mid, 360.62 ppm; and high, 408.35 ppm.
2. The YSI TSG suffered from an apparent low water flow condition for this entire leg. Salinity values begin to degrade noticeably on YD 195.25 and temperature before that.
3. SCS salinity and temperature data was bad until YD 193.553 approximately the first 13 hours). I did a linear fit of equilibrator temperature to SCS temperature readings and derived SST by the following equation: SST = (EqT * 1.009079) - 0.331455 with R^2 = 0.989783. For SSS I did an eyeball check of YSI salinity vs SCS salinity for the period from 193.6 to 195 when there was a near constant offset between the two. I then replaced the SCS salinities up to YD 193.553 with computed salinities using the formula SSS = YSI sal - 0.07.
4. The Air Cadet that pumps air from the bow tower to the system went bad on YD 194.3 and was repaired on 195.7. In most cases I used the last of 3 air measurements during this time period.
5. Latitude and longitude values were recorded by the system with only 3 places of precision (e.g. -80.1, 9.97, etc). I merged SCS data provided by the ship into the data file to obtain better values.

RB199807: 1. The standard gases used on this leg were: low, 299.06 ppm; mid, 360.62 ppm; and high, 408.35 ppm. On July 23 at 0300 the high standard was changed to 523.44 ppm because of high xCO2 values in the surface water. At 0400 the mid standard was changed to 408.35 ppm. At 0200

the low standard was changed to 360.62 ppm. On July 24 at 1000 the standards were changed back to their original configuration.
2. For the last day of this leg (nearing Newport) large variations in surface water xCO_2 values were observed. I left these in the data file because of simultaneous large changes in SST and SSS.
3. Latitude and longitude values were recorded by the system with only 3 places of precision (e.g. -80.1, 9.97, etc). I merged SCS data provided by the ship into the data file to obtain better values.

RB199808: 1. The standard gases used on this leg were: low, 299.06 ppm; mid, 360.62 ppm; and high, 408.35 ppm.
2. For the first four hours low gas flow in the high standard phase (std 3) resulted in slightly depressed voltage readings due to inadequate flushing of the Licor's sample cell. Since the voltages in both air and water phases were at most only slightly higher than the mid standard gas, I have retained all of the original values without applying a correction.
3. On August 9 from 0030 through 0430, the ship conducted towing operations that caused stack gas to enter the intake during the air phase. All air values for this period have been removed.
4. The feed from the ship's computer system (SCS) gave only 3 significant digits in latitude and longitude for the first 224 rows in the data file.I 'fixed' this by interpolating values in both the latitude and longitude columns. This should be a fairly close approximation to the actual cruisetrack. If I can locate the original data from the ship, I will replace the interpolated values with the actual ones.

RB199810: 1. The standard gases used on this leg were: low, 299.06 ppm; mid, 360.62 ppm; and high, 408.35 ppm. On September 17 at 1700, the low standard was changed to 283.26 because the original tank was nearing empty.
2. The ship's salinity sensor began giving erratic readings starting on day 256 and continuing to the end of the cruise. I replaced these values (from year day 255.75 to the end) with salinity values I derived from the YSI salinity sensor attached to the system. I used data from the beginning of the cruise to day 255.75 to come up with a linear equation relating the two. The equation used was: SCS salinity = 0.907480 * YSI salinity + 2.861642 with $R^2 = 0.910347$.
3. The computer crashed on day 258.642 and the system was down for eight hours (until 258.972).
4. The feed from the ship's computer system (SCS) gave only 3 significant digits in latitude and longitude for the first 1114 rows in the data file. I 'fixed' this by interpolating values in both the latitude and longitude columns. This should be a fairly close approximation to the actual cruise track. If I can locate the original data from the ship, I will replace the interpolated values with the actual ones.

RB199811: 1. The standard gases used on this leg were: low, 283.26 ppm; mid, 360.62 ppm; and high, 408.35 ppm.
2. The ship's salinity sensor began giving erratic readings near the end of the previous leg. By the end of leg 3, the readings settled down. However, the offset between the YSI TSG attached to our system and the ship's TSG changed. For most of leg 3 the YSI gave readings about 0.15 higher than the ship's TSG. From near the end of leg 3 and for all of leg 4, the YSI read about 0.07 lower than the ship's TSG. I

have left the ship's salinity values as they were recorded and used them to compute fCO_2, etc for this leg.
3. Problems with the PC clock and the feed from the ship's computer system resulted in the loss of about 2-1/2 hour's worth of data at the beginning of leg 4 (from 267.014 through 267.109).
4. Starting on Oct. 1 the lat and lon from the ship's computer system included only 3 significant digits. I fixed this by interpolating latitude and longitude values.

RB199812: 1. The standard gases used on this leg were: low, 283.26 ppm; mid, 360.62 ppm; and high, 408.35 ppm. On November 1 at 1700 the standards were changed to 360.62, 408.35, and 523.44 respectively due to high xCO_2 values in the surface water. On November 8 at 2000 they were changed back to their original configuration.
2. Immediately after the first change, a drop in atmospheric CO_2 levels of approximately 1 ppm was observed. Air values gradually increased over the next few days until they were consistent with values observed before the tank change. I believe this was due to incomplete flushing of the regulator after changing tanks.
3. The Licor IR analyzer failed at the start of the cruise and was replaced with the spare. The first 26 hours of data were removed. All data in the file are from the replacement (good) Licor.

RB199813: 1. The standard gases used on this leg were: low, 283.26 ppm; mid, 360.62 ppm; and high, 408.35 ppm.
2. On November 21 at 0000 GMT, the ship's computer system was shut down for software work. For the remainder of the leg, I derived SST and salinity from the equilibrator temperature and the YSI salinity respectively. The equation used for temperature was SST = EqT * 1.016550 - 0.618679 with R^2 = 0.996014. The equation used for salinity was SSS = YSI salinity * 0.849961 + 5.162161 with R^2 = 0.942750.
3. Heightened pCO_2 air levels were observed when rounding the western tip of Cuba and when steaming up the east coast of the United States. I believe these were not caused by stack gases and have left them in the data set.