

Explorer of the Seas METADATA - 2006

Class of Data: Surface ocean carbon dioxide concentrations

Dataset Identifier: Explorer of the Seas

Two Files: Explorer\_2006\_NS  
Explorer\_2006\_EW

Statement of how to cite dataset:

Explorer website: [http://www.aoml.noaa.gov/ocd/gcc/explorer\\_cruisetracks.php](http://www.aoml.noaa.gov/ocd/gcc/explorer_cruisetracks.php)

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Measurement platform identifier: Explorer of the Seas

Cruise Information:

Weekly cruises to Bermuda or through the Caribbean departing from Miami, Florida or Bayonne, New Jersey.

Project Information:

This project represents a collaboration between Royal Caribbean International, the University of Miami's Rosenstiel School of Marine and Atmospheric Science, the National Oceanic and Atmospheric Administration, the National Science Foundation, the Office of Naval Research, and the National Aeronautics and Space Administration.

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Timestamp for initial submission of dataset: 8/03/07

Timestamp for the most recent update of dataset: 8/03/07

Timestamp period the dataset refers to: 1/16/2006 - 12/24/2006

Geographic area the dataset refers to:

16 N to 44 N  
62 W to 90 W

Eastern Cruise Track:

Day 1 - Miami, Florida (25.8 N/80.7 W)  
Day 3 - San Juan, Puerto Rico (18.5 N/66.1 W)  
Day 4 - Philipsburg, St. Maarten (18.0 N/63.0 W)  
Day 5 - Charlotte Amalie, St. Thomas (18.3 N/64.9 W)  
Day 7 - Nassau, Bahamas (25.1 N/77.3 W)  
Day 8 - Miami, Florida (25.8 N/80.7 W)

Western Cruise Track:

Day 1 - Miami, Florida (25.8 N/80.7 W)  
Day 3 - Belize City, Belize (17.4 N/88.1 W)  
Day 4 - Costa Maya, Mexico (18.7 N/87.7 W)  
Day 5 - Cozumel, Mexico (20.5 N/87.0 W)  
Day 6 - George Town, Grand Cayman (19.3 N/81.4 W)  
Day 8 - Miami, Florida (25.8 N/80.7 W)

Change in Western Cruise Track for EX0651W:

Day 1 - Miami, Florida (25.8 N/80.7 W)  
Day 3 - Cozumel, Mexico (20.5 N/87.0 W)  
Day 5 - Grand Cayman, Cayman Islands (19.3 N/81.4 W)  
Day 6 - Montego Bay, Jamaica (18.5 N/77.9 W)  
Day 8 - Miami, Florida (25.8 N/80.2 W)

Northern Cruise Track:

Day 1 - Bayonne, New Jersey (40.7 N/74.1 W)  
Day 3 - Kings Wharf, Bermuda (32.3 N/64.8 W)  
Day 6 - Bayonne, New Jersey (40.7 N/74.1 W)

Change in Northern Cruise Track for EX0620W:

Day 1 - Miami, Florida (25.8 N/80.7 W)  
Day 3 - Bayonne, New Jersey (40.7 N/74.1 W)  
Day 5 - Kings Wharf, Bermuda (32.3 N/64.8 W)  
Day 8 - Bayonne, New Jersey (40.7 N/74.1 W)

Southern Cruise Track:

Day 1 - Bayonne, New Jersey (40.7 N/74.1 W)  
Day 4 - Charlotte Amalie, St. Thomas (18.3 N/64.9 W)  
Day 5 - Philipsburg, St. Maarten (18.0 N/63.0 W)  
Day 6 - San Juan, Puerto Rico (18.5 N/66.1 W)  
Day 7 - Labadee, Hispaniola (19.8 N/72.3 W)  
Day 10 - Bayonne, New Jersey (40.7 N/74.1 W)

List of variables included in this dataset:

COLUMN	HEADER	EXPLANATION
1.	Group_Ship:	AOML_Explorer for all Explorer of the Seas data.
2.	Cruise:	Cruise Name (For example, EX0546W: EX = Explorer of the Seas, 05 = 2006, 46 = 46th weekly cruise, and W = western track).
3.	JD_GMT:	Decimal year day.
4.	Date_DDMMYYYY:	The date format has been changed to comply with the IOCCP recommendations.
5.	TIME_HH:MM:SS:	GMT time. NOTE: local time = GMT - 4 hr or GMT - 5 hr.
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 latitudes).
8.	xCO2eq_ppm:	Mole fraction of CO2 (dry) in the headspace equilibrator at equilibrator temperature (Teq) in parts per million.
9.	xCO2a_ppm:	Mole fraction of CO2 in air in parts per million. This field is not measured on the Explorer of the Seas - all data initialized to -9.
10.	Pres_Equil_hPa:	Barometric pressure in the lab in hectopascals (1 hectopascal = 1 millibar).
11.	Pres_sealevel_hPa:	Barometric pressure from ship's barometer, corrected to sea level in hectopascals (1 hectopascal = 1 millibar).
12.	EqTemp_C:	Temperature in equilibrator water in degrees centigade. Temperature in equilibrator measured with a calibrated thermistor.
13.	SST(TSG)_C:	Temperature from the ship's thermosalinograph in degrees centigrade.
14.	Sal(TSG)_Permil:	Salinity from the ship's thermosalinograph on the Practical Salinity Scale.
15.	Water_flow_l/min:	Water flow through equilibrator in liters per minute.
16.	Gasflow_IR_ml/min:	Gas flow through the Licor infrared analyzer before the flow is stopped in milliliters per minute.
17.	Temp_IR_C:	Temperature of the Licor infrared analyzer sample cell in degrees centigrade.
18.	Pres_IR_hPa:	Pressure in the Licor infrared analyzer in hectopascals.

NOTE: There is no pressure sensor in the Licor but since it is vented to atmosphere prior to measurement, this value is the same as the pressure in the lab (number 10 above). (1 hectopascal = 1 millibar).

19. Ship\_heading\_true\_degree: Ship's heading from ship's navigation system in degrees with 0 = North and 90 = East.
20. Ship\_speed\_knot: Ship's speed from ship's navigation system in knots.
21. Wind\_dir\_rel\_degree: Wind direction relative to the ship from ship's navigation system in degrees with 0 = from the bow and 90 = from starboard.
22. Wind\_speed\_rel\_m/s: Wind speed relative to the ship from ship's navigation system in meters per second.
23. fCO2W@SST\_uatm: Fugacity of CO2 in sea water in microatmospheres calculated as outlined below.
24. Qcflag\_water: Quality control flag for sea water xCO2 and fCO2 values with 2 = good value, 3 = questionable value, 4 = bad value, and 9 = no measurement taken.
25. fCO2a\_uatm: Fugacity of CO2 in air in microatmospheres. This field is not measured on the Explorer of the Seas - all data initialized to -9.
26. Qcflag\_air: Quality control flag for air xCO2 and fCO2. Since no air values were taken, all values are initialized to 9.
27. dfCO2\_uatm: Sea water fCO2 - air fCO2 in microatmospheres. This uses the average air value for the current hour. This field is not measured on the Explorer of the Seas - all data initialized to -9.
28. Fluoro\_ug/l: Reading from the fluorometer in micrograms per liter.
29. Wind\_speed\_true\_m/s: True wind speed in meters per second.
30. Wind\_dir\_true\_degree: True wind direction in degrees were 0 = North and 90 = East.
31. Air\_Temp\_C: Outside air temperature from ship's computer system in degrees centigrade.
32. Oxygen: Units not known at this time.

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

Group\_Ship  
Cruise  
JD\_GMT  
DATE\_DDMMYYYY  
TIME\_HH:MM:SS  
Lat\_dec\_degree

Long\_dec\_degree  
xCO2eq\_ppm  
Pres\_Equil\_hPa  
EqTemp\_C  
Water\_flow\_l/min  
Gasflow\_IR\_ml/min  
Temp\_IR\_C  
Pres\_IR\_hPa  
fCO2W@SST\_uatm  
QCflag\_water

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

Pres\_sealevel\_hPa  
SST(TSG)\_C  
Sal(TSG)\_Permil  
Ship\_heading\_true\_degree  
Ship\_speed\_knot  
Wind\_dir\_rel\_degree  
Wind\_speed\_rel\_m/s  
Fluoro\_ug/l  
Wind\_speed\_true\_m/s  
Wind\_dir\_true\_degree  
Air\_Temp\_C  
Oxygen

Narrative description of system design:

#### CO2 ANALYTICAL SYSTEM:

The concentration of carbon dioxide (CO<sub>2</sub>) in surface ocean water is determined by measuring the concentration of CO<sub>2</sub> in gas that is in contact with the water. Surface water is pumped over 200 m through 7/8" Teflon tubing from an inlet in the ship's bow to the equilibration chamber. Water comes from the bow intake 2 m below the water line and the TSG is located close to the inlet. Since the sea surface temperature is high and the ship is well air-conditioned, the T<sub>eq</sub> is on average about 0.4 °C 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<sub>2</sub>) partition between the water and the headspace. At equilibrium, the ratio of CO<sub>2</sub> in the water and in the headspace is influenced most by temperature, and that relationship is known. By measuring the concentration of CO<sub>2</sub> in the headspace and the temperature in the chamber, the partial pressure (or fugacity) of CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> molecule. The LI-COR detector passes IR radiation through two 6" cells. The reference cell is flushed with a gas of known CO<sub>2</sub> 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<sub>2</sub> (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<sub>2</sub> are analyzed once an hour instead of the headspace gas.

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

Method of Analysis: Differential analyses relative to a reference gas which is close to the CO<sub>2</sub> concentration of the middle standard. Measures dried equilibrator headspace gas. Gas flow is stopped prior to IR readings.

Drying Method: The equilibrator headspace sample gas first goes through an air filter and a thermoelectric refrigerator (~6-10 °C). The sample and standard gases pass through a Perma Pure (Nafion) dryer and a short column of magnesium perchlorate before reaching the analyzer. The counter flow in the Perma Pure tube is the reference gas.

Equilibrator (setup, size, flows): The equilibrator was fabricated using a filter housing (ColeParmer, U-010509-00) with ~0.5 L water reservoir and ~0.8 L gaseous headspace. Water flow rate is ~1.5 L/min. Headspace recirculation rate is ~80 ml/min.

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<sub>2</sub> in surface seawater and water saturated air in order to determine the fCO<sub>2</sub>. For ambient air and equilibrator headspace, the fCO<sub>2a</sub> (or fCO<sub>2eq</sub>) is calculated assuming 100% water vapor content:

$$fCO_{2eq} = xCO_{2eq}(P-pH_{2O}) \exp(B_{11}+2d_{12}) P/RT$$

where fCO<sub>2eq</sub> is the fugacity in the equilibrator, pH<sub>2O</sub> 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<sup>3</sup>·atm·deg<sup>-1</sup>·mol<sup>-1</sup>). The exponential term is the fugacity correction where B<sub>11</sub> is the second virial coefficient of pure CO<sub>2</sub>

$$B_{11} = -1636.75 + 12.0408T - 0.032795T^2 + 3.16528E-5 T^3$$

and d<sub>12</sub> = 57.7 - 0.118 T is the correction for an air-CO<sub>2</sub> mixture in units of cm<sup>3</sup>·mol<sup>-1</sup> (Weiss, 1974).

The calculation for the fugacity at SST involves a temperature correction term for the increase of fCO<sub>2</sub> due to heating of the water from passing through the

pump and through 5 cm ID PVC tubing within the ship. The water in the equilibrator is typically 0.4 °C cooler than sea surface temperature. The empirical temperature correction from equilibrator temperature to SST is:

$$fCO_2(SST) = fCO_2(eq) \text{ Exp } (-0.0423 (T_{eq}-SST))$$

where SST is sea surface temperature and  $T_{eq}$  is the equilibrator temperature in degrees °C.

Sampling Cycle:

The system runs on an hourly cycle during which 3 standard gases, a reference gas and 20 surface water samples (from the equilibrator head space) are analyzed on the following schedule:

Mins. after hour =====	Sample =====
0:00	Low Standard
2:10	Mid Standard
4:25	High Standard
6:40	Reference
8:55	Water
11:28	Water
14:01	Water
16:34	Water
19:07	Water
21:40	Water
24:13	Water
26:46	Water
29:19	Water
31:52	Water
34:25	Water
36:58	Water
39:31	Water
42:04	Water
44:37	Water
47:10	Water
49:43	Water
52:16	Water
54:49	Water
57:22	Water

NOTES ON DATA:

Columns have a default value of -9 in case of instrument malfunction, erroneous readings or missing data. Furthermore, if a suspicious  $xCO_2$  value, pressure or temperature value is encountered, the  $fCO_2$  is not calculated.

Analytical Instrument Manufacturer/Model:

The Explorer of the Seas system was built by Dave Chipman in 2000. The analyzer is a LI-COR 6252 (analog output) infrared analyzer.

Standard Gases and Reference Gas: The three standard gases come from CMDL in Boulder and are directly traceable to the WMO scale. The reference gas is a non-calibrated gas from a commercial company. While individual data points above 420 or below 300 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 ocean laboratory of the Explorer of the Seas. 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 xCO<sub>2</sub>eq measurements are believed accurate to 0.1 ppm. The fCO<sub>2</sub>@SST measurements are believed to be precise to 0.2 ppm.

List of calibration gases used:

The standards used on the cruise are:

STANDARD	TANK #	CONCENTRATION	VENDOR
STD1	CA02040	319.82	CMDL
STD2	CA02030	377.14	CMDL
STD3	CA02020	458.04	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:

Thermosalinograph information can be found at <http://www.rsmas.miami.edu/rccl/facilities.html>.

Units:

All xCO<sub>2</sub> values are reported in parts per million (ppm) and fCO<sub>2</sub> 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 pCO<sub>2</sub> 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 fCO<sub>2</sub> in the Eastern Equatorial Pacific on NOAA ships BALDRIGE and DISCOVERER, NOAA data report ERL AOML-30, 52 pp.,

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- Wanninkhof, R. and K. Thoning (1993). Measurement of fugacity of CO<sub>2</sub> 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 CO<sub>2</sub> in seawater. *Nature* 300: 511-513.

Comments related to the individual legs:

Explorer of the Seas Naming Convention: EX06NNT where EX is the ship abbreviation, 06 is the year, NN is the number of the cruise which will be a number between 1 and 52, and T is the cruise track which will be either W for the west track, E for the east track, N for the north track or S for the south track.

For all legs, due to the slow response time of the system, the first 10 minutes of data for each hour for the entire leg was removed. This slow response time is not fully understood. On certain legs the response time was worse and up to 40 minutes of data was removed.

For all legs, the first hour of data after leaving port is removed.

EX0603W: Due to rough seas, no data logged January 18 starting at 11:00. No water flow on January 19. Chip opened the pinch clamp but still there wasn't any water flow. He ran fresh water thru the lines and the flow rate returned to 2.68 l/m.

EX0604E: The pCO<sub>2</sub> data is questionable due to water flow problems throughout the cruise. On January 24, the flow rate dropped. Don Cucchiara ran fresh water thru the system for about 10 minutes. After flushing the system, there was a flow rate above 2.0 but when the system was returned to seawater, the flow rate completely dropped and the system shut off. When the ship left port, the flow rate was around 1.2 l/m. There was still not much flow from the showerhead; however, there was water flow in the small equilibrator chamber. On January 28, there was no water flow thru the system at all. Don flushed the system again with fresh water while the ship was in port. The flow reading was around 2.0 but there were leaks coming from the small equilibrator seals and the T clamp above the small equilibrator. Don lowered the water flow and tightened the T clamp and the leaking stopped. However, when the system was switched back to seawater there was still no flow. Don flushed the system again with fresh water and this time the system worked when switched back to seawater. On January 29, Bob Castle took apart the shower head and found it partially blocked by small bits of marine shells. He cleaned out the showerhead and tested the system with fresh water. When the ship left port, the water flow was very good with sufficient spray inside the large equilibrator.

EX0607W: Air temperature sensor was not working throughout the cruise. Barometric pressure sensor was not working throughout the cruise. Replaced all zeros and unchanging barometric pressure values in Pres\_sealevel\_hPa

with -9.

EX0608E: There is no Air\_Temp\_C data for this cruise.

EX0609W: There is no Pres\_sealevel\_hPa and Air\_Temp\_C data for this cruise.

EX0611W: System down on the following days: JD 73.543 to 73.875, JD 76.418 to 76.499 and JD 77.468 to 77.499. On March 15, 2006, Don replaced the reference gas and flushed the system with fresh water.

EX0612E: Removed the following suspect data: 81.140 to 81.208 and 82.977 to 83.083.

EX0615W: Removed the following suspect data: JD 102.305 to 102.458.

EX0616E: An air compressor line from the electrical closet to the pCO2 instrument area was installed. Once the line is connected, the system will use compressed air with a dehumidifier instead of the drying gas from the CO2 cylinders and there will no longer be a reference gas.

Removed the following questionable data: JD 109.066 to 109.196 and JD 110.937 to 110.957.

EX0618E: May 1, 2006 - no water flow thru the system Monday morning. Chip flushed the system with fresh water and the flow returned to normal. He also replaced the CO2 tank.

Due to hardware system failure the following questionable data was removed: JD 123.876 to 123.916, 123.965 to 124.042, and 124.291 to 124.333. Chip rebooted the system and restarted data collection.

EX0620N: May 14, 2006 - Water flow problems - After the pump came on line There was very little flow coming out of the showerhead. Don flushed the line with fresh water for 20 minutes and the flow rate returned to normal. He switched the system back to seawater but after an hour the flow rate was below the cutoff point and the system shut off.

May 15, 2006 - Monday morning Don flushed the system for 30 minutes with fresh water. The flow rate returned to normal. He switched the system back to seawater and the flow rate remained normal.

May 19, 2006 - Water flow problems - after flushing the system with fresh water for 30 minutes, the flow rate returned to normal.

EX0623S: Removed the following suspect data: JD 161.806 to JD 161.833. At the very beginning and end of the cruise, there is a larger than normal discrepancy between the SST and the equilibrator temperature (greater than 1 degree). This discrepancy, which is not present in the Caribbean, is most likely due to the cool North Atlantic water being warmed in the water line before it reaches the equilibrator.

EX0625S: From JD 168.024 to JD 168.107, there is a larger than normal discrepancy between the SST and the equilibrator temperature (greater than 1 degree). This discrepancy, which is not present in the Caribbean, is most likely due to the cool North Atlantic water being warmed in the water line before it reaches the equilibrator.

On Monday, 6/19/06, Chip changed the CO2 cylinder.

Low water flow on Monday, 6/20/06 and Sunday, 6/25/06. Chip flushed the system with fresh water both times and the flow rate returned to normal.

EX0626N: Monday, June 26, 2006, the water flow was very low. Chip flushed the system and the flow rate returned to normal.

EX0627S: Removed the following data due to low gas flow in the water sample phase: 186.024 to 187.999.

EX0631S: System down on 8/04/06 from 13:00 to 15:00 and on 8/05/06 from 21:00 to 22:00.

Removed the following data due to low gas flow: JD 211.079 to 211.083, 214.098 to 214.110, 214.232 to 214.249 and 217.515 to 217.541.

There was a change in itinerary due to tropical storm Chris - the ship had a port stop in Nassau, Bahamas rather than port stops in San Juan, Puerto Rico and Labadee, Hispaniola:

Day 1 - Bayonne, New Jersey (40.7 N/74.1 W)  
Day 4 - Charlotte Amalie, St. Thomas (18.3 N/64.9 W)  
Day 5 - Philipsburg, St. Maarten (18.0 N/63.0 W)  
Day 7 - Nassau, Bahamas (25.1 N/77.3 W)  
Day 10 - Bayonne, New Jersey (40.7 N/74.1 W)

EX0632N: System down on 8/10/06 from 03:00 to 04:00 and from 10:00 to 17:00. Merged missing latitude and longitude for JD 222.861 (6/14/07). No oxygen data.

EX0633S: There were problems with the system throughout the cruise. The hardware failure light kept coming on and the system had to be restarted several times.

EX0635S: The system was down on 8/26/06.

EX0636N: On 9/6/06, water flow was low; Chip flushed the system with fresh water. On 9/8/06, Bob Castle replaced the computer, reinstalled PCAnywhere and restarted the software.

EX0638N: Intermittent water flow problems throughout the cruise.

EX0643S: Water flow problems beginning on 10/28/06 at 13:11 and ending on 10/29/06 at 6:59 - questionable data was removed.

EX0645S: Kevin Sullivan: Replaced the reference gas cylinder with compressed, dry gas generated from a PermaPure (HD-2000) pure gas generator. The ship's compressed gas @ ~65 psi feeds the heatless drier. The compressed gas cylinder (CO2 in air for now) is the secondary gas in case the pure air generator malfunctions. An automated switch (Bioswitch) will switch to the backup tank if the pressure falls below 15 psi. The output of the flow controller goes to the PermaPure drier and through the needle valve to "Reference" gas input to VIC1. The Licor was changed to absolute mode, with a soda lime trap inline with chopper motor space and reference cell.

EX0646E: Sunday, November 19, 2006: No gas flow throughout the cruise.

The tube leading into the equilibrator was clogged with salt. There was two inches of salt blocking the tube which Bob cleaned out with tab water.

Bob also installed a second Aalborg flow meter set up to read only the drying gas (ref) output. It was reading about 311 while he was there. From now on, read the reference gas flow off the new flow meter bypassing the switch that was used to switch between the ref and sample gas readings. Sample and standard flows are read as usual.

EX0647W: Due to a leak in the system, the following questionable data was removed: JD 324.808 to JD 325.000 and JD 329.807 to JD 329.958.

Don adjusted the sample gas flow on November 21, 2006. He adjusted the headspace pump valve to get the flow up to around 100.

EX0648E: Due to a leak in the system, the following questionable data was removed: JD 331.870 to JD 331.917 and JD 335.890 to JD 335.917.

EX0649W: Due to a leak in the system, the following questionable data was removed: JD 338.866 to 338.932.

EX0650E: December 10, 2006 - The sample gas flow was too high (over 200). Don adjusted the black valve and got the flow back to around 100.

Due to a leak in the system, the following questionable data was removed: JD 349.890 - 349.917.

EX0651W: Due to a leak in the system, the following questionable data was removed: JD 352.870 to JD 352.958.

December 17, 2006 - Due to a medical emergency, there was a change in the cruise track:

- Day 1 - Miami, Florida (25.8 N/80.2 W)
- Day 3 - Cozumel, Mexico (20.5 N/87.0 W)
- Day 5 - Grand Cayman, Cayman Islands (19.3 N/81.4 W)
- Day 6 - Montego Bay, Jamaica (18.5 N/77.9 W)
- Day 8 - Miami, Florida (25.8 N/80.2 W)

