

**Contact Person:**

Name: Castle, Robert  
Organization: NOAA/Atlantic Oceanographic & Meteorological Laboratory  
Address: 4301 Rickenbacker Causeway, Miami, FL 33149  
Phone: 305-361-4418  
Email: Robert.Castle@noaa.gov

**Investigator(s):**

Name: Wanninkhof, Rik  
Organization: NOAA/Atlantic Oceanographic & Meteorological Laboratory  
Address: 4301 Rickenbacker Causeway, Miami Fl, 33149  
Phone: 305-361-4379  
Email: Rik.Wanninkhof@noaa.gov

Name: Pierrot, Denis  
Organization: NOAA/Atlantic Oceanographic & Meteorological Laboratory  
Address: 4301 Rickenbacker Causeway, Miami Fl, 33149  
Phone: 305-361-4441  
Email: Denis.Pierrot@noaa.gov

**Dataset Information:**

Funding\_Info: NOAA Climate Program Office  
Initial\_Submission: 20140321  
Revised\_Submission: 20160131

**Cruise Information:**

Experiment Name: RB-13-05  
Experiment Type: Research Cruise  
Platform Type: Ship  
Co2 Instrument Type: Equilibrator-IR  
Cruise ID: 33RO20131020  
Cruise Info: NTAS, AOML\_SOOP\_CO2  
Geographical Region:  
Westernmost Longitude: -60.7  
Easternmost Longitude: -50.9  
Northernmost Latitude: 16.6  
Southernmost Latitude: 12.8  
Cruise Dates (YYYYMMDD)  
Start\_Date: 20131020  
End\_Date: 20131030  
Ports of Call:  
Bridgetown, Barbados  
Vessel Name: R/V Ronald H. Brown  
Vessel ID: 33RO  
Vessel Owner: NOAA

**Variables Information:**

Variable Name: xCO2\_EQU\_ppm

Description of Variable: Mole fraction of CO2 in the equilibrator headspace (dry) at equilibrator temperature (ppm)

Unit of Variable: ppm

Variable Name: xCO2\_ATM\_ppm

Description of Variable: Mole fraction of CO2 measured in dry outside air (ppm)

Unit of Variable: ppm

Variable Name: xCO2\_ATM\_interpolated\_ppm

Description of Variable: Mole fraction of CO2 in outside air associated with each water analysis. These values are interpolated between the bracketing averaged good xCO2\_ATM analyses (ppm)

Unit of Variable: ppm

Variable Name: PRES\_EQU\_hPa

Description of Variable: Barometric pressure in the equilibrator headspace (hPa)

Unit of Variable: hPa

Variable Name: PRES\_ATM@SSP\_hPa

Description of Variable: Barometric pressure measured outside, corrected to sea level (hPa)

Unit of Variable: hPa

Variable Name: TEMP\_EQU\_C

Description of Variable: Water temperature in equilibrator (°C)

Unit of Variable: Degree C

Variable Name: SST\_C

Description of Variable: Sea surface temperature (°C)

Unit of Variable: Degree C

Variable Name: SAL\_permil

Description of Variable: Sea surface salinity on Practical Salinity Scale (o/oo)

Unit of Variable: ppt

Variable Name: fCO2\_SW@SST\_uatm

Description of Variable: Fugacity of CO2 in sea water at SST and 100% humidity ( $\mu\text{atm}$ )

Unit of Variable:  $\mu\text{atm}$

Variable Name: fCO2\_ATM\_interpolated\_uatm

Description of Variable: Fugacity of CO2 in air corresponding to the interpolated xCO2 at SST and 100% humidity ( $\mu\text{atm}$ )

Unit of Variable:  $\mu\text{atm}$

Variable Name: dfCO2\_uatm

Description of Variable: Sea water fCO2 minus interpolated air fCO2 ( $\mu\text{atm}$ )

Unit of Variable:  $\mu\text{atm}$

Variable Name: WOCE\_QC\_FLAG

Description of Variable: Quality control flag for fCO2 values (2=good, 3=questionable)

Unit of Variable: None

Variable Name: QC\_SUBFLAG

Description of Variable: Quality control subflag for fCO2 values, provides explanation when QC flag=3

Unit of Variable: None

## Method Description:

### Equilibrator Design:

Depth of Seawater Intake: 5 meters

Location of Seawater Intake: Bow

Equilibrator Type: Spray head above dynamic pool, with thermal jacket

Equilibrator Volume: 0.95 L (0.4 L water, 0.55 L headspace)

Water Flow Rate: 1.5 - 2.0 L/min

Headspace Gas Flow Rate: 70 - 150 ml/min

Vented: Yes

Drying Method for CO<sub>2</sub> in Water:

Gas stream passes through a thermoelectric condenser (~5 °C) and then through a Perma Pure (Nafion) dryer before reaching the analyzer (90% dry).

Additional Information: Primary equilibrator is vented through a secondary equilibrator.

### CO<sub>2</sub> in Marine Air:

Measurement: Yes, 5 readings in a group every 3.5 hours

Location and Height: Bow tower ~10 m above the sea surface.

Drying Method:

Gas stream passes through a thermoelectric condenser (~5 °C) and then through a Perma Pure (Nafion) dryer before reaching the analyzer (90% dry).

### CO<sub>2</sub> Sensor:

Measurement Method: IR

Manufacturer: LI-COR

Model: 6262

Frequency: Every 140 seconds, except during calibration

Resolution Water: ± 0.01 µatm in fCO<sub>2</sub>\_SW

Uncertainty Water: ± 2 µatm in fCO<sub>2</sub>\_SW

Resolution Air: ± 0.01 µatm in fCO<sub>2</sub>\_ATM

Uncertainty Air: ± 0.5 µatm in fCO<sub>2</sub>\_ATM

Manufacturer of Calibration Gas:

Std 1: CA06709, 284.75 ppm, owned by ESRL, used every ~ 3.5 hours. Std 2: CA02813, 363.24 ppm, owned by ESRL, used every ~3.5 hours. Std 3: CA07921, 423.57 ppm, owned by ESRL, used every ~3.5 hours. Std 4: CA07931, 545.88 ppm, owned by ESRL, used every ~3.5 hours. Std 5: 0.00 ppm, owned by AOML, used every ~20.0 hours.

Number of Non Zero Gas Standards: 4

CO<sub>2</sub> Sensor Calibration:

The analyzer is calibrated every 3.5 hours using field standards that were calibrated with primary standards that are directly traceable to the WMO scale. Ultra-High Purity air (0.0 ppm CO<sub>2</sub>) and the high standard are used to zero and span the LI-COR analyzer.

Other Comments:

Instrument is located in an air-conditioned laboratory.

Method References:

Pierrot, D., C. Neil, K. Sullivan, R. Castle, R. Wanninkhof, H. Lueger, T. Johannessen, A. Olsen, R. A. Feely, and C. E. Cosca (2009), Recommendations for autonomous underway pCO<sub>2</sub> measuring systems and data reduction routines, Deep-Sea Res II, 56, 512-522.

Details Co<sub>2</sub> Sensing:

details of CO<sub>2</sub> sensing (not required)

Measured Co2 Params:

xco2(dry)

Sea Surface Temperature:

Location: Bow thruster room, before sea water pump, ~5 m below water line.

Manufacturer: Seabird

Model: SBE-21

Accuracy Degrees Celsius: 0.01

Precision Degrees Celsius: 0.001

Calibration: Factory calibration

Comments: Manufacturer's Resolution is taken as Precision; Maintained by ship.

Equilibrator Temperature:

Location: Inserted into equilibrator ~5 cm below water level

Manufacturer: Hart

Model: 1521

Accuracy Degrees Celsius: 0.025

Precision Degrees Celsius: 0.01

Calibration: Factory calibration

Comments: Resolution is taken as Precision.

Equilibrator Pressure:

Location: Attached to equilibrator headspace. Differential pressure reading from Setra 239 attached to the equilibrator headspace is added to the pressure reading from the LICOR, which is measured by an external Setra 270 connected to the exit of the analyzer.

Manufacturer: Setra

Model: 270

Accuracy hPa: 0.15

Precision hPa: 0.015

Calibration: Factory calibration

Comments:

Manufacturer's Resolution is taken as Precision.

Atmospheric Pressure:

Location: On bulkhead exterior on the port side of the radio room aft of the bridge at ~14 m above the sea surface.

Manufacturer: Vaisala

Model: PTB330

Accuracy:  $\pm 0.2$  hPa

Precision:  $\pm 0.08$  hPa

Calibration: Factory calibration

Normalized: yes

Comments: Manufacturer's resolution is taken as precision. Maintained by ship.

Sea Surface Salinity:

Location: Attached to underway system at sea water input.

Manufacturer: Seabird

Model: SBE 45

Accuracy:  $\pm 0.005$  o/oo

Precision: 0.0002 o/oo

Calibration: Factory calibration

Comments: Manufacturer's Resolution is taken as Precision

**Additional Information:**

(1.) It was determined that there was a 2.71 minute offset between the SST data record from the SBE-21 in the bow and the Hart 1571 temperature sensor in the equilibrator. The SST data were interpolated using this offset to determine the SST at the time of the equilibrator measurement. (2.) A total of 5324 measurements were taken with 5307 flagged as good, 10 flagged as questionable, and 7 flagged as bad. All measurements flagged as 4 (bad) have been removed from the final data file. Location: [http://www.aoml.noaa.gov/ocd/ocdweb/brown/brown\\_introduction.html](http://www.aoml.noaa.gov/ocd/ocdweb/brown/brown_introduction.html)

**Preliminary Quality Control:**

NA

**Form Type:**

underway