

**Dataset Expocode** 09AR20141205

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**Dataset** **Funding Info:** Data collection was funded by the Integrated Marine Observing System (IMOS) - IMOS is supported by the Australian Government through the National Collaborative.  
**Initial Submission (yyyymmdd):** 20160201  
**Revised Submission (yyyymmdd):**

**Campaign/Cruise** **Expocode:** 09AR20141205  
**Campaign/Cruise Name:** Integrated Marine Observing System (IMOS)  
**Campaign/Cruise Info:** AA1415V02  
**Platform Type:**  
**CO2 Instrument Type:** Equilibrator-IR or CRDS or GC  
**Survey Type:** Ship Of Opportunity Program(SOOP)  
**Vessel Name:** Aurora Australis  
**Vessel Owner:** P&O Maritime Services  
**Vessel Code:** 09AR

**Coverage** **Start Date (yyyymmdd):** 20141205  
**End Date (yyyymmdd):** 20150124  
**Westernmost Longitude:** 109.5 E  
**Easternmost Longitude:** 147.4 E  
**Northernmost Latitude:** 43.5 S  
**Southernmost Latitude:** 67.2 S  
**Port of Call:** Hobart, Australia  
**Port of Call:** Casey Station, Antarctica.

**Variable** **Name:** Group/ship  
**Unit:**  
**Description:** CSIRO/ ship name.

**Variable** **Name:** CruiseID  
**Unit:**  
**Description:** Cruise designation.

**Variable** **Name:** JD\_GMT  
**Unit:** ddd.hhhh  
**Description:** UTC

**Variable** **Name:** Date  
**Unit:** yyyymmdd  
**Description:** Observation date UTC

**Variable** **Name:** Time  
**Unit:** HH:MM:SS

**Description:** observation time UTC

**Variable**

**Name:** Lat

**Unit:** degree

**Description:** latitude (decimal degrees).

**Variable**

**Name:** Long

**Unit:** degree

**Description:** longitude (decimal degrees).

**Variable**

**Name:** xCO2EQ\_PPM

**Unit:** ppm

**Description:** mole fraction of CO<sub>2</sub> (dry) in the equilibrator head space at equilibrator temperature

**Variable**

**Name:** xCO2ATM\_PPM

**Unit:** ppm

**Description:** mole fraction CO<sub>2</sub> (dry) in air, interpolated

**Variable**

**Name:** xCO2ATM\_PPM\_INTERPOLATED

**Unit:** ppm

**Description:** mole fraction CO<sub>2</sub> for air interpolated in time between good air measurements

**Variable**

**Name:** Press\_Equil

**Unit:** hPa

**Description:** pressure in equilibrator

**Variable**

**Name:** Press\_ATM

**Unit:** hPa

**Description:** barometric pressure at sea level

**Variable**

**Name:** TEQ

**Unit:** degree celsius

**Description:** equilibrator seawater temperature

**Variable**

**Name:** SST

**Unit:** degree celcius

**Description:** sea surface temperature

**Variable**

**Name:** SAL

**Unit:**

**Description:** sea surface salinity

**Variable**

**Name:** fCO2SW\_UATM

**Unit:**

**Description:** fugacity of carbon dioxide at surface water salinity and temperature and 100% humidity

**Variable**

**Name:** fCO2ATM\_UATM\_INTERPOLATED

**Unit:** microatmosphere

**Description:** fugacity of CO<sub>2</sub> in the atmosphere from xCO<sub>2</sub>ATM\_PPM at sea surface salinity and temperature and 100% humidity

**Variable**

**Name:** DfCO2\_UATM

**Unit:** microatmosphere

**Description:** sea water fCO<sub>2</sub> minus interpolated air fCO<sub>2</sub>

**Variable**

**Name:** LICOR\_flow

**Unit:** millilitre per minute

**Description:** gas flow to LICOR NDIR

**Variable**

**Name:** H2O\_flow

**Unit:** litre per minute

**Description:** seawater flow to equilibrator

**Variable**

**Name:** WindSpd\_True

**Unit:** knot

**Description:** wind speed, true

**Variable**

**Name:** WindDirn\_True

**Unit:** degree

**Description:** wind direction, True , 0 degree is N, 90 is E

**Variable**

**Name:** Type

**Unit:**

**Description:** Measurement type (EQU=equilibrator; ATM=air)

**Variable**

**Name:** WOCE\_QC\_FLAG

**Unit:**

**Description:** WOCE quality control flag (2=good, 3=questionable).

**Variable**

**Name:** SUBFLAG

**Unit:**

**Description:** Quality control sublag for questionable data as defined in Pierrot et al 2009

**Sea Surface Temperature**

**Location:** Approximately 150mm inboard from the intake.

**Manufacturer:** Sea-Bird Electronics

**Model:** SBE-38 sn: 0395.

**Accuracy:** 0.005 (°C if units not given)

**Precision:** 0.001 (°C if units not given)

**Calibration:** CSIRO NATA calibration facility, Hobart, September 2014.

**Comments:** Sensor maintain by the Australian Antarctic Division.

**Sea Surface Salinity**

**Location:** Next and inline with water supply to the fCO2 system.

**Manufacturer:** Sea-Bird Electronics

**Model:** SBE-45 sn: 0368

**Accuracy:** ± 0.01

**Precision:** .003

**Calibration:** Pre-season calibration made on the 26 May 2014, at CSIRO Hobart.

**Comments:**

**Atmospheric Pressure**

**Location:** Mounted ~16m above sea level on the bridge deck outside the Meteorological lab on the port side with a velocity head.

**Normalized to Sea Level:** yes

**Manufacturer:** Vaisala

**Model:** PTB220 sn: A3920002.

**Accuracy:** 0.15 (hPa if units not given)

**Precision:** 0.01 (hPa if units not given)

**Calibration:** September 2014. Sensor maintain by the Australian Antarctic Division.

**Comments:**

**Atmospheric CO2**

**Measured/Frequency:** A set of 5 records every 3-4 hours

**Intake Location:** Mounted ~16m above sea level on the bridge deck outside the Met lab on the port side.

**Drying Method:**

**Atmospheric CO2 Accuracy:** ± 0.2 ppm at 350 ppm

**Atmospheric CO2 Precision:** 0.01 ppm

## **Aqueous CO2 Equilibrator Design**

**System Manufacturer:**

**Intake Depth:** 4 m.

**Intake Location:** The intake is located in the propeller shaft tunnel approximately 4m below the waterline and 10m forward of the stern gland on the port side of the vessel.

**Equilibration Type:** Weiss style shower equilibrator with water jacket, General Oceanics.

**Equilibrator Volume (L):** 1.2 L

**Headspace Gas Flow Rate (ml/min):** 70 - 150 ml/min

**Equilibrator Water Flow Rate (L/min):** 2.3 L/min

**Equilibrator Vented:** Yes

**Equilibration Comments:** Equilibrator with water jacket and vented through a smaller equilibrator.

**Drying Method:** Thermoelectric condenser (2-5 °C), and Perma Pure (Nafion dryers). Dried to <2 H2O mmol/mol.

## **Aqueous CO2 Sensor Details**

**Measurement Method:** CO2 mole fraction in dry air (non-dispersive infrared gas analyser), stopped flow.

**Method details:** see Pierrot et al., 2009

**Manufacturer:** LI-COR

**Model:** LI-7000 sn: IRG4-0910

**Measured CO2 Values:** xCO2(dry)

**Measurement Frequency:** Every 80 sec, except during calibration routines

**Aqueous CO2 Accuracy:** 2 ppm

**Aqueous CO2 Precision:** 0.01 ppm

**Sensor Calibrations:** The LI-COR analyser is calibrated using four reference standards measured every 3-4 hours. The instrument zero and span are set daily using the low and high reference standards.

**Calibration of Calibration Gases:** CO2-in-air reference gases were manufactured and calibrated by CSIRO, Melbourne

**Number Non-Zero Gas Standards:** 3

**Calibration Gases:**

Std 1 CA06898: 0 ppm 04 Jun 2008, Std 2 CA01610: 299.41 ppm 17 Aug 2004, Std 3 CA01669: 353.00 ppm 17 Aug 2004, Std 4 CA01673: 402.15 ppm 23 Aug 2004. Reference standards were calibrated on WMO-X2007 mole fraction scale for CO2-in-air at CSIRO Ocean and Atmosphere, Melbourne. Uncertainty = ± 0.05 ppm.

**Comparison to Other CO2 Analyses:**

**Comments:**

**Method Reference:**

Pierrot D., C. Neill, K. Sullivan, R. Castle, R. Wanninkhof, H. Luger, T. Johannessen, A. Olsen, R. A. Feely, C. E. Cosca (2009). Recommendations for autonomous underway pCO2 measuring systems and data-reduction routines. Deep-Sea Research II, 56, 512-522.

## **Equilibrator Temperature Sensor**

**Location:** Probe 60 mm below water line inside the equilibrator.

**Manufacturer:** Fluke Hart Scientific.

**Model:** 1521 sn: A66752 paired with probe 5610-9 sn: B072714.

**Accuracy:** 0.025 (°C if units not given)

**Precision:** 0.001 (°C if units not given)

**Calibration:** The meter and paired probe were calibrated as a system on the 30 Aug 2013 in a NATA facility at CSIRO, Hobart.

**Comments:****Equilibrator  
Pressure Sensor****Location:** Attached to equilibrator headspace.**Manufacturer:** Setra**Model:** 239 sn: 2223344.**Accuracy:** 0.052 (hPa if units not given)**Precision:** 0.01 (hPa if units not given)**Calibration:** Factory calibration.**Comments:** The equilibrator pressure is the differential pressure reading from the Setra-239 attached to the equilibrator headspace added to a pressure reading made using a GE Druck RPT350 sensor located at the outlet of the LI-COR 6252 analyser when the analyser is vented to laboratory air for a measurement.**Additional  
Information****Suggested QC flag from Data Provider:** NA**Additional Comments:** Processing comments: The ship's underway sea surface temperature, and meteorological data were collected and calibrated by the Australian Antarctic Division Data Centre. The salinity values used on this cruise, correspond to a thermosalinograph installed next in-line with the water supply of the fCO<sub>2</sub> system and calibrated and maintained by CSIRO. All data prior to 05/12/2014 14:48 was excluded. This is the starting point of the cruise outside the Derwent River. A software upgrade on 13/12/2014 23:58 caused a problem with the file header and Dry Druck pressure readings until 20/12/2014 02:16. The Dry Druck missing values were calculated from the Li-cor internal pressure sensor readings plus the average difference offset of 0.3. The labview software had several problems with formatting and recording the data in the correct columns. Cell spaces were not maintained in some occasions where part of the data was missing. E.g. record 09/12/2014 04:37 was missing the values from the infrared sensor and the rest of the data was shifted and recorded in the wrong places. All the formatting issues were resolved and some of the records had to be excluded. While the ship was in heavy ice, there was insufficient seawater flowing to the fCO<sub>2</sub> system and/or the salinity becomes unreliable during the time periods listed below. This data was flagged as 'bad' and excluded for calculations. 11/12/2014 23:42 to 12/12/2014 10:44, 21/12/2014 11:47 to 20:52, 23/12/2014 17:06 to 24/12/2014 20:48, 27/12/2014 05:07 to 17:43, 29/12/2014 12:15 to 30/12/2014 02:33, 30/12/2014 06:52 to 15:45, 30/12/2014 17:36 to 22:59, 01/01/2015 13:37 to 04/01/2015 06:08, 06/01/2015 08:17 to 11:54, 07/01/2015 21:47 to 22:52, 08/01/2015 00:07 to 00:56, 08/01/2015 07:47 to 09/01/2015 03:29, 11/01/2015 07:15 to 10:24, and 11/01/2015 12:30 to 14:02. There was insufficient seawater flowing to the fCO<sub>2</sub> system during the times listed below. These data was flagged as 'bad' and excluded for calculations. 18/01/2015 15:27 to 23:23, and 22/01/2015 02:02 to 03:39. All data after 25/01/2015 00:41 was excluded. This is the end point of the cruise outside the Derwent River. EQU Observations: 47795, QCed: 87% good 13% bad (including pre/post-cruise and insufficient seawater flow to the fCO<sub>2</sub> system in heavy ice). ATM Observations: 1550, QCed: 81% good 19% bad.**Citation for this Dataset:**Tilbrook, B., C. Neill and J. Akl. 2014. Integrated Marine Observing System (IMOS) sea surface and atmospheric fCO<sub>2</sub> measurements in the Southern Ocean onboard R/V Aurora Australis in Dec 2014 -Jan 2015.**Other References for this Dataset:**