

## For Using Data

Data Policy	JAMSTEC
Principal Investigator	Data Management Office
Use Constraints	See Terms and Conditions about constrain of use.
Data Citation	See Terms and Conditions about data citation.

## Quality level

Processed(DMO)-Qced

## Instrument

pCO<sub>2</sub> measurement system (MR10-07 - )

## Measurement System

Depth of sea water intake :	4.5m
Instrument :	pCO <sub>2</sub> measuring system
Method :	Non-dispersive infrared gas analyzer (NDIR)
Manufacturer :	Nihon ANS Ltd
Type :	LI-7000 (LI-COR)
Serial No. :	IRG4-0900
Equilibrator :	showerhead-type
Precision :	0.14 ppm
Reference Material	Standard gas (Taiyo Nippon Sanso Corporation)
/Calibration :	
Sea surface temperature/salinity :	Refer to details of "Underway Thermosalinograph"
Equilibrator temperature sensor :	Pt100 (THERMOTECHS Co. Ltd, Japan)

Sea-surface pCO<sub>2</sub> data analysis (aft. MR16-06)

We provide mole fraction of CO<sub>2</sub> (xCO<sub>2</sub>) of the sea-surface water as pCO<sub>2</sub> data of this cruise, given by equations following below. The calculation process of xCO<sub>2</sub> confirms to "Guideline of Ocean Observation" (Sasano and Nakaoka, 2015).

- 1) Temperature and salinity of the sea surface water and temperature of the equilibrator  
Temperature and salinity of the sea-surface water are obtained by SBE38 (or SBE45) set in the sea surface monitoring laboratory. Temperature sensor of the equilibrator is corrected using certified thermometer.
- 2) Calculation of pCO<sub>2</sub>

The equation for partial pressure of CO<sub>2</sub> is given by

$$[pCO_2] = [xCO_2] \times (P - [pH_2O]) \quad (1)$$

where xCO<sub>2</sub> (μmol mol<sup>-1</sup>) is the CO<sub>2</sub> mole fraction of dry gas sample measured by the analyzer, P (atm) is the atmospheric pressure (inside the equilibrator for sea water sample, or at the sea surface for atmospheric sample), and pH<sub>2</sub>O (atm) is the saturated vapor pressure. The equation of the pH<sub>2</sub>O of seawater is that of Weiss and Price (1980) given by

$$[pH_2O] = \exp (24.4543 - 67.4509 \times (100/T) - 4.8489 \times \ln(T/100) - 0.000544 \times S) \quad (2)$$

where T (= 273.15 + t, t in Celsius) is temperature (K), and S is salinity. To refer short diurnal or weekly variation, calculate pCO<sub>2</sub> using in-situ atmospheric pressure. For discussion of annual or decadal variation of pCO<sub>2</sub> considering the atmospheric pressure is one atm, divide [pCO<sub>2</sub>] of Eq. (1) by atmospheric pressure P.

### 3) Calculation of $p\text{CO}_2^{\text{eq}}$

With seawater temperature in the equilibrator  $T_{\text{eq}}$  (K) and salinity  $S$ , saturated vapor pressure in the equilibrator  $p\text{H}_2\text{O}^{\text{eq}}$  is given by Eq.(2). Then  $p\text{CO}_2^{\text{eq}}$ , partial pressure of  $\text{CO}_2$  in the equilibrator, can be obtained by Eq.(1), using  $x\text{CO}_2^{\text{eq}}$ , measured by NDIR, air pressure in equilibrator  $P_{\text{eq}}$  (or atmospheric pressure  $P$ ), and  $p\text{H}_2\text{O}^{\text{eq}}$ .

### 4) Temperature correction

To compensate for the temperature difference between the equilibrator and the sea surface, Takahashi et al. (1993) theoretically derived  $\Delta p\text{CO}_2 / \Delta t$  equation,

$$[p\text{CO}_2^{\text{sea}}] = [p\text{CO}_2^{\text{eq}}] \times \exp(0.0423 \times (T_{\text{sea}} - T_{\text{eq}})) \quad (3)$$

where  $p\text{CO}_2^{\text{eq}}$  is the partial pressure of  $\text{CO}_2$  of seawater in the equilibrator ( $\mu\text{atm}$ ) corrected by the vapor pressure,  $T_{\text{sea}}$  and  $T_{\text{eq}}$  are the seawater temperature (K) at the sea-surface and that in the equilibrator, respectively. If the temperature difference between the equilibrator and at the sea-surface is less than 0.05, it will be set at zero.

### 5) In-situ $x\text{CO}_2^{\text{sea}}$

Using  $p\text{CO}_2^{\text{sea}}$  from Eq.(3) and  $p\text{H}_2\text{O}^{\text{sea}}$ , which is calculated from Eq.(2) with sea surface temperature  $T_{\text{sea}}$ , salinity  $S$ , and atmospheric pressure  $P$ , in-situ  $x\text{CO}_2^{\text{sea}}$  can finally be obtained by Eq.(1).

### References

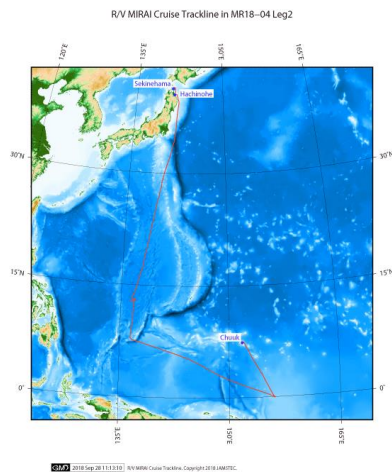
- Takahashi, T., J. Olafsson, J. G. Goddard, D. W. Chipman, and S. C. Sutherland (1993) Seasonal variation of  $\text{CO}_2$  and nutrients in the high-latitude surface oceans: A comparative study. *Global Biogeochemical Cycles*, 7(4), 843-878. doi:10.1029/93GB02263.
- Sasano, D. and S. Nakanoka (2015)  $p\text{CO}_2$ . In *The Oceanographic Society of Japan (Ed.) Underway, Guideline of Oceanographic Observation*.
- Weiss, R. F. and B. A. Price (1980) Nitrous oxide solubility in water and seawater. *Marine Chemistry*, 8, 347-359.

### Note

If you would like the raw data set, please contact DMO at "dmo@jamstec.go.jp".

## Related Information

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### MR18-04 Leg2

Ship Name:	MIRAI
Period:	2018/08/12 - 2018/09/06
Chief Scientist:	Masaki Katsumata(JAMSTEC)
Proposal:	The observational study to construct and extend the "western Pacific super site network"

## Format Description for pCO<sub>2</sub> FORMAT\_M

The file is in variable length, comma separated text file (csv) format.

The line starts with "#" is a comment line which contains version information and so on.

No.	Content	Unit	Remarks
1	Ship		Ship name
2	Cruise		Cruise ID
3	Serial No.		Serial No.
4	Date		year (YYYY) in UTC
5			month (MM) in UTC
6			day (DD) in UTC
7	Time		hour (hh) in UTC
8			minute (mm) in UTC
9	Latitude	degree	Positive in north
10	Longitude	degree	degree in eastward (0 - 360)
11	xCO <sub>2</sub> _Air	ppm	CO <sub>2</sub> mixing ratio in the air
12	F		Quality flag for xCO <sub>2</sub> _Air
13	xCO <sub>2</sub> _Sea	ppm	CO <sub>2</sub> mixing ratio in the sea surface water*
14	F		Quality flag for xCO <sub>2</sub> _Sea
15	Wind_Dir	degree	Wind direction : Positive in clockwise from the north
16	Wind_Spd	m/s	Wind speed
17	Atm_Prs	hPa	Barometric pressure
18	Atm_Tmp.	degree-C	Air temperature
19	SST	degree-C	Sea surface temperature
20	F		Quality flag for SST
21	SSS	PSU	Sea surface salinity
22	F		Quality flag for SSS
23	pH <sub>2</sub> O	hPa	Vapor pressure of in-situ sea water

\* Please refer to "Sea-surface pCO<sub>2</sub> data analysis".

### Definition of Quality Control Flags

- 2 - Good
- 3 - Questionable
- 4 - Bad
- 5 - Not reported
- 9 - No data