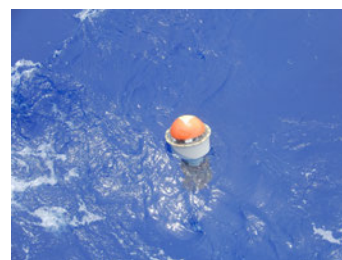




Mirai Cruise Report

MR18-06 leg 1



South east (off Chile) and central Pacific

Dec. 11, 2018 - Jan. 12, 2019

Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)

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IV. Notice on Using

I. Cruise Information

1. **Cruise ID**
MR18-06 leg 1
2. **Name of Vessel**
R/V *Mirai*
3. **Title of Project**
East/central Pacific International Campaign (EPIC)
4. **Title of Cruise**
MR18-06 R/V *Mirai*
5. **Ports of Departure/call/arrival/**
Departure: Shimizu, Japan
Arrival: Valparaiso, Chile
6. **Research Area**
South east (off Chile) and central Pacific

7. **Research Map**

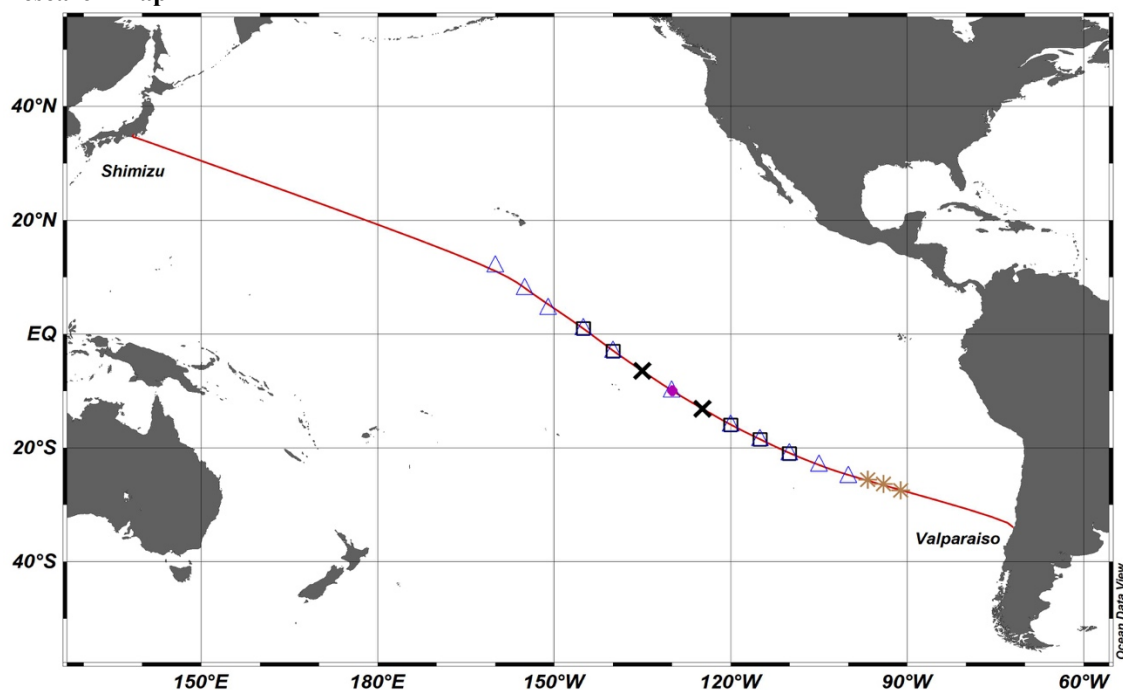


Fig. 7.1 Cruise track planned for the 1st leg of MR18-06. The symbols indicate planned deployment points of each buoy as follows: triangles: core ARGO float, crosses: ARGO float (Deep APEX), solid circle: ARGO float (Deep NINJA), asterisks: drifting buoy with CO₂ sensor, and squares: drifting buoy with hydrophone.

II. Researchers

1. Chief Scientist

Akihiko Murata (RCGC/JAMSTEC)

2. List of Participants

Name	Affiliation	Position
Masayuki Obayashi	JAMSTEC	Senior Scientist
Ryo Oyama	NME	Technical Staff
Masanori Murakami	NME	Technical Staff
Masanori Enoki	MWJ	Technical Staff
Atsushi Ono	MWJ	Technical Staff
Hiroshi Hoshino	MWJ	Technical Staff

JAMSTEC: Japan Agency for Marine Science and Technology

NME: Nippon Marine Enterprises, Ltd

MWJ: Marine Works Japan, Ltd

III. Observation

1. Cruise Narrative

The MR18-06 cruise by the R/V *Mirai* was conducted for the following two themes, which were selected from 17 proposals based on the report created in the JAMSTEC long-term cruise planning workshop: “An explorative study on connectivity between poor nutrients environment in the South-East Pacific gyre and ecosystem” and “Research into the world only-one subduction zone in the active ridge: Chile triple junction”. For these themes, biological, oceanographic, geologic and geophysical surveys were made in the area off Chile and the central and southeastern Pacific Ocean.

The first leg of MR18-06 was done for the period from 11 December, 2018 through 12 January, 2019. We started underway observations such as gas aerosol, marine weather, geophysics and bio-geochemistry soon after departure from the Shimizu Port, Japan. In addition to these observations, we deployed various types of buoys along the cruise track: 14 ARGO floats (Core ARGO and Deep ARGO), 5 drifting buoys with hydrophone, and 2 drifting buoys with CO₂ sensor. One of the drifting buoys with CO₂ sensor was cancelled.

We experienced no serious malfunctions of the observation devices during the cruise. On the way to Valparaiso, Chile, we entered the EEZ of U.S.A., where no permission for ocean observation was taken.

For the EEZ, we stopped the observations or removed the data obtained in the area. We terminated the observations around 00:00 on 10 January (UTC) when we entered the Chilean EEZ.

2. Cruise Track and Log

The cruise track and log of MR18-06Leg1 are shown in Figure 2.1 and Table 2.1 respectively.

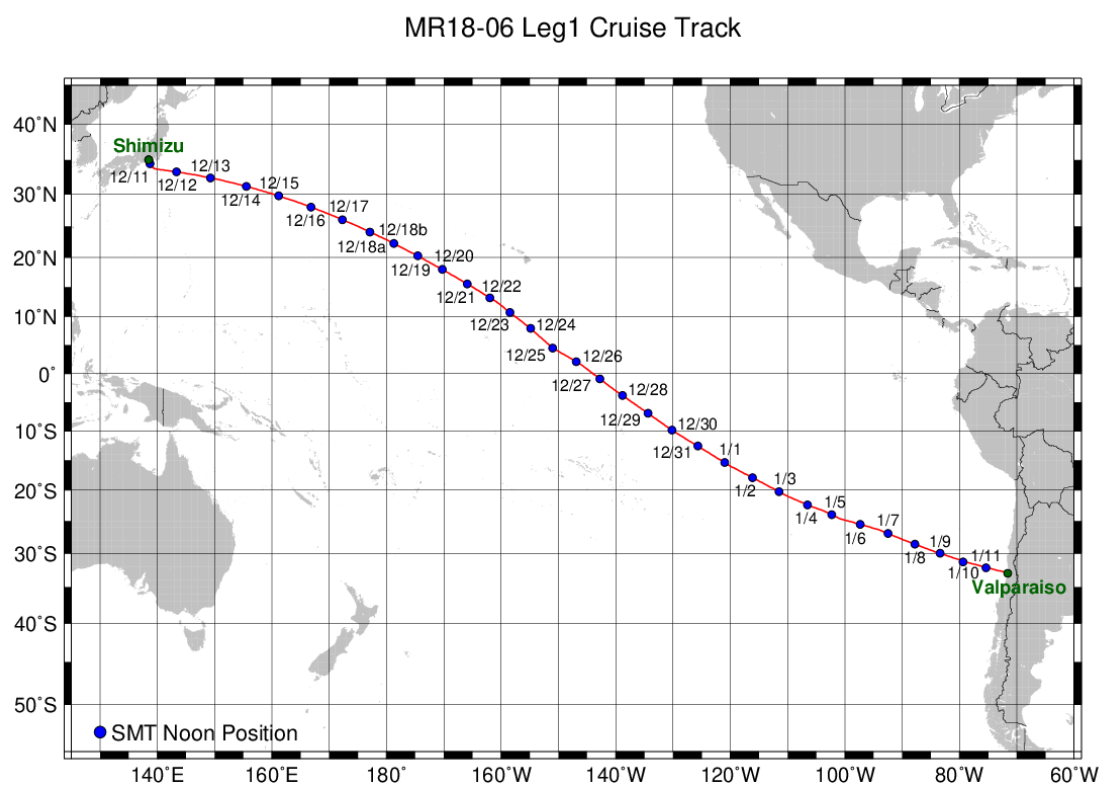


Figure 2.1 Cruise track of MR18-06 Leg1.

Table 2.1 Log of MR18-06 Leg1.

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Lat.	Lon.	
12.10	22:00	12.11	7:00	35-02.34N	138-30.59E	Departure from Shimizu
12.11	0:35		9:35	35-00.05N	138-36.59E	Sea water pump start
	1:51		10:51	34-43.90N	138-39.12E	MBES observation start
	2:51		11:51	34-31.24N	138-42.30E	EPCS observation start
	21:18	12.12	6:18	33-27.83N	142-01.72E	Doppler Rader Start
12.14	13:00	12.14	22:00	-	-	Time adjustment +1 hour (SMT=UTC+10h)
	21:58	12.15	7:58	29-58.98N	160-17.28E	Calibration for magnetometer #01
	22:32		8:32	29-58.52N	160-17.83E	XCTD #01
	12:00		22:00	-	-	Time adjustment +1 hour (SMT=UTC+11h)
12.16	6:57	12.16	17:57	27-31.00N	168-41.51E	XCTD #02
12.18	11:00	12.18a	22:00	-	-	Time adjustment +1 hour (SMT=UTC+12h)
	16:54	12.18b	4:54	22-50.90N	179-59.95E	Crossing the International Date Line (SMT=UTC-12h)
12.20	13:45	12.20	1:45	18-58.00N	172-09.40W	U.S. EEZ In
12.21	22:25	12.21	10:25	15-41.00N	166-10.70W	U.S. EEZ Out
12.22	10:00		22:00	-	-	Time adjustment +1 hour (SMT=UTC-11h)
12.23	6:57	12.22	19:57	12-25.84N	160-43.09W	ARGO Float (APEX) deploymentment #Stn.1
	7:05		20:05	12-25.85N	160-42.51W	Calibration for magnetometer #02
12.24	21:56	12.24	10:56	8-01.2N	155-00.23W	ARGO Float (APEX) deploymentment #Stn.2
12.25	22:23	12.25	11:23	4-34.32N	151-04.84W	ARGO Float (APEX) deploymentment #Stn.3
12.26	9:00		22:00	-	-	Time adjustment +1 hour (SMT=UTC-10h)
12.27	1:50	12.26	15:50	1-42.40N	146-12.67W	ARGO Float (APEX) deploymentment #Stn.4
	2:00		16:00	1-42.17N	146-12.32W	Drifting Buoys with Hydrophone deploymentment #Stn.4
12.28	8:00	12.27	22:00	-	-	Time adjustment +1 hour (SMT=UTC-9h)
	16:57	12.28	7:57	3-19.67S	139-32.10W	ARGO Float (APEX) deploymentment #Stn.5
	17:06		8:06	3-19.71S	139-32.04W	Drifting Buoys with Hydrophone deploymentment #Stn.5
12.29	17:58	12.29	8:58	6-32.76S	134-55.18W	ARGO Float (Deep APEX) deploymentment #Stn.6
12.30	7:00		22:00	-	-	Time adjustment +1 hour (SMT=UTC-8h)
	20:57	12.30	12:57	9-57.76S	130-02.7W	ARGO Float (APEX) deploymentment #Stn.7
	21:05		13:05	9-57.85S	130-02.42W	ARGO Float (Deep NINJA) deploymentment #Stn.7
12.31	22:58	12.31	14:58	12-56.35S	125-06.10W	ARGO Float (APEX) deploymentment #Stn.8
	23:05		15:05	12-56.66S	125-05.47W	Calibration for magnetometer #03
1.2	0:22	1.1	16:22	15-55.69S	120-07.61W	ARGO Float (APEX) deploymentment #Stn.9
	0:26		16:26	15-55.79S	120-07.49W	Drifting Buoys with Hydrophone deploymentment #Stn.9
1.3	1:53	1.2	17:53	18-31.30S	114-57.20W	ARGO Float (APEX) deploymentment #Stn.10
	1:57		17:57	18-31.32S	114-56.93W	Drifting Buoys with Hydrophone deploymentment #Stn.10
	6:00		22:00	-	-	Time adjustment +1 hour (SMT=UTC-7h)
1.4	2:25	1.3	19:25	20-59.85S	109-59.46W	ARGO Float (APEX) deploymentment #Stn.11
	2:29		19:29	20-59.91S	109-59.29W	Drifting Buoys with Hydrophone deploymentment #Stn.11
1.5	0:56	1.4	17:56	22-47.08S	105-32.03W	ARGO Float (APEX) deploymentment #Stn.12
	5:00		22:00	-	-	Time adjustment +1 hour (SMT=UTC-6h)
1.6	1:55	1.5	19:55	24-39.23S	100-47.41W	ARGO Float (APEX) deploymentment #Stn.13
	19:25	1.6	13:25	25-35.42S	97-01.95W	Drifting Buoys with CO2 sensor deploymentment #Stn.14
	4:00		22:00	-	-	Time adjustment +1 hour (SMT=UTC-5h)
1.7	12:57	1.7	7:57	26-39.62S	93-18.07W	Drifting Buoys with CO2 sensor deploymentment #Stn.15
	19:01		14:01	27-06.00S	92-05.25W	Calibration for magnetometer #04
	19:30		14:30	27-06.10S	92-04.81W	XCTD #03
1.9	3:00	1.8	22:00	-	-	Time adjustment +1 hour (SMT=UTC-4h)
						Doppler Rader finish
1.10	0:00	1.9	20:00	30-28.89S	81-45.16W	MBES observation finish
						EPCS observation finish
						Sea water pump finish
						Chile EEZ In
1.11	2:00	1.10	22:00	-	-	Time adjustment +1 hour (SMT=UTC-3h)
1.12	11:00	1.12	8:00	33-00.254S	71-34.86W	Arrival at Valparaiso

3. Underway Observation

3.1 Swath Bathymetry

(1) Personnel

<i>Akihiko MURATA</i>	<i>JAMSTEC: Principal investigator</i>
<i>Ryo OYAMA</i>	<i>Nippon Marine Enterprises LTD. (NME)</i>
<i>Masanori MURAKAMI</i>	<i>NME</i>
<i>Takehito HATTORI</i>	<i>MIRAI crew</i>

(2) Objectives

The objective of Multi-Beam Echo Sounding system (MBES) is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global data sets.

(3) Apparatus

The "SEABEAM 3012" on R/V MIRAI was used for bathymetry mapping during this cruise. To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data to get the sea surface (6.62m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from XCTD and Argo float data by the equation in Del Grosso (1974).

Table 3.1.1 SEABEAM 3012 System configuration and performance

Frequency:	12 kHz
Transmit beam width:	2.0 degree
Transmit power:	4 kW
Transmit pulse length:	2 to 20 msec.
Receive beam width:	1.6 degree
Depth range:	50 to 11,000 m
Number of beams:	301 beams (Spacing mode: Equi-angle)
Beam spacing:	1.5 % of water depth (Spacing mode: Equi-distance)
Swath width:	60 to 150 degrees
Depth accuracy:	< 1 % of water depth (average across the swath)

(4) Preliminary Results

The results will be published after primary processing.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.

<http://www.godac.jamstec.go.jp/darwin/e>

(6) Remarks

1. The following period, data acquisitions were stopped for cruising in the EEZ of the foreign countries.

13:30UTC 20 Dec. 2018 - 22:30UTC 21 Dec. 2018

00:00UTC 10 Jan. 2019 - 12 Jan. 2019 (Arrival at Valparaiso)

3.2 Surface Meteorological Observations

(1) Personnel

<i>Akihiko MURATA</i>	<i>JAMSTEC: Principal investigator</i>
<i>Ryo OYAMA</i>	<i>Nippon Marine Enterprises LTD. (NME)</i>
<i>Masanori MURAKAMI</i>	<i>NME</i>
<i>Takehito HATTORI</i>	<i>MIRAI crew</i>

(2) Objectives

Surface meteorological parameters are observed as a basic dataset of the meteorology. These parameters provide the temporal variation of the meteorological condition surrounding the ship.

(3) Apparatus

Surface meteorological parameters were observed throughout the MR18-06 Leg1 cruise. During this cruise, we used two systems for the observation.

i. *MIRAI Surface Meteorological observation (SMet) system*

Instruments of SMet system are listed in Table 3.2.1 and measured parameters are listed in Table 3.2.2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-seconds averaged data.

ii. *Shipboard Oceanographic and Atmospheric Radiation (SOAR) measurement system*

SOAR system designed by BNL (Brookhaven National Laboratory, USA) consists of major six parts.

- a) Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation.
- b) Analog meteorological data sampling with CR1000 logger manufactured by Campbell Inc. Canada – wind, pressure, and rainfall (by a capacitive rain gauge) measurement.
- c) Digital meteorological data sampling from individual sensors - air temperature, relative humidity and rainfall (by optical rain gauge (ORG)) measurement.
- d) Photosynthetically Available Radiation (PAR) and Ultraviolet Irradiance (UV) sensor manufactured by Biospherical Instruments Inc (USA) – PAR and UV measurement
- e) Scientific Computer System (SCS) developed by NOAA (National Oceanic and Atmospheric Administration, USA) – centralized data acquisition and logging of all data sets.

SCS recorded PRP, air temperature, relative humidity, CR1000, ORG and PAR data. SCS composed Event data (JamMet) from these data and ship's navigation data every 6 seconds. Instruments and their locations are listed in Table 3.2.3 and measured parameters are listed in Table 3.2.4.

For the quality control as post processing, we checked the following sensors, before and after the cruise.

i. Young Rain gauge (SMet and SOAR)

Inspect of the linearity of output value from the rain gauge sensor to change Input value

by adding fixed quantity of test water.

- ii. Barometer (SMet and SOAR)
Comparison with the portable barometer value, PTB220, VAISALA
- iii. Thermometer (air temperature and relative humidity) (SMet and SOAR)
Comparison with the portable thermometer value, HM70, VAISALA

(4) Preliminary results

Figure 3.2.1 shows the time series of the following parameters;

Wind (SOAR)
Air temperature (SMet)
Relative humidity (SMet)
Precipitation (SOAR, ORG)
Short wave radiation (SOAR)
Long wave radiation (SOAR)
Barometric Pressure (SMet)
Sea surface temperature (SMet)
Significant wave height (SMet)

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.

<http://www.godac.jamstec.go.jp/darwin/e>

(6) Remarks

1. The following periods, SST data of SMET was available.
00:35UTC 11 Dec. 2018 - 00:00UTC 10 Jan. 2019
2. The following period, data acquisitions were stopped for cruising in the EEZ of the foreign countries.
13:45UTC 20 Dec. 2018 - 22:25UTC 21 Dec. 2018
00:00UTC 10 Jan. 2019 - 12 Jan. 2019 (Arrival at Valparaíso)
3. The following time, increasing of SMet capacitive rain gauge data were invalid due to transmitting for MF/HF radio.
22:35UTC - 23:40UTC 15 Dec. 2018
4. PAR data was not acquired in this cruise, due to the system maintenance.
5. FRSR data was not available in this cruise, due to the system trouble.
6. The following periods, long wave radiation (PIR) data of SOAR was invalid due to mechanical trouble.
22:17UTC 30 Dec. 2018 - 00:21UTC 31 Dec. 2018
01:49UTC 01 Jan. 2019 - 08:00UTC 01 Jan. 2019
22:33UTC 04 Jan. 2019 - 00:33UTC 05 Jan. 2019

Table 3.2.1 Instruments and installation locations of MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KS-5900	Koshin Denki, Japan	foremast (25 m)
Tair/RH	HMP155	Vaisala, Finland	compass deck (21 m)
with aspirated radiation shield	43408 Gill	R.M. Young, USA	starboard side and port side
Thermometer: SST	RFN2-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	Model-370	Setra System, USA	captain deck (13 m)
Rain gauge	50202	R. M. Young, USA	weather observation room
Optical rain gauge	ORG-815DS	Osi, USA	compass deck (19 m)
Radiometer (short wave)	MS-802	Eko Seiki, Japan	compass deck (19 m)
Radiometer (long wave)	MS-202	Eko Seiki, Japan	radar mast (28 m)
Wave height meter	WM-2	Tsurumi-seiki, Japan	radar mast (28 m)
			bow (10 m)

Table 3.2.2 Parameters of MIRAI Surface Meteorological observation system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 Ship's speed	knot	Mirai log
4 Ship's heading	degree	Mirai gyro
5 Relative wind speed	m/s	6sec./10min. averaged
6 Relative wind direction	degree	6sec./10min. averaged
7 True wind speed	m/s	6sec./10min. averaged
8 True wind direction	degree	6sec./10min. averaged
9 Barometric pressure	hPa	adjusted to sea surface level 6sec. averaged
10 Air temperature (starboard side)	degC	6sec. averaged
11 Air temperature (port side)	degC	6sec. averaged
12 Dewpoint temperature (starboard side)	degC	6sec. averaged
13 Dewpoint temperature (port side)	degC	6sec. averaged
14 Relative humidity (starboard side)	%	6sec. averaged
15 Relative humidity (port side)	%	6sec. averaged
16 Sea surface temperature	degC	6sec. averaged
17 Rain rate (optical rain gauge)	mm/hr	hourly accumulation
18 Rain rate (capacitive rain gauge)	mm/hr	hourly accumulation
19 Down welling shortwave radiation	W/m ²	6sec. averaged
20 Down welling infra-red radiation	W/m ²	6sec. averaged
21 Significant wave height (bow)	m	hourly
22 Significant wave height (aft)	m	hourly
23 Significant wave period (bow)	second	hourly
24 Significant wave period (aft)	second	hourly

Table 3.2.3 Instruments and installation locations of SOAR system

Sensors (Meteorological)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Barometer	PTB210	Vaisala, Finland	foremast (23 m)
with pressure port	61002 Gill	R.M. Young, USA	foremast (24 m)
Rain gauge	50202	R.M. Young, USA	foremast (23 m)
Tair/RH	HMP155	Vaisala, Finland	foremast (24 m)
with aspirated radiation shield	43408 Gill	R.M. Young, USA	foremast (24 m)
Optical rain gauge	ORG-815DR	Osi, USA	foremast (25 m)
Sensors (PRP)	Type	Manufacturer	Location (altitude from surface)
Radiometer (short wave)	PSP	Epply Labs, USA	foremast (25 m)
Radiometer (long wave)	PIR	Epply Labs, USA	foremast (25 m)
Fast rotating shadowband radiometer		Yankee, USA	foremast (25 m)
Sensor (PAR&UV)	Type	Manufacturer	Location (altitude from surface)
PAR&UV sensor	PUV-510	Biospherical Instrum ents Inc., USA	Navigation deck (18m)

Table 3.2.4 Parameters of SOAR system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 SOG	knot	
4 COG	degree	
5 Relative wind speed	m/s	
6 Relative wind direction	degree	
7 Barometric pressure	hPa	
8 Air temperature	degC	
9 Relative humidity	%	
10 Rain rate (optical rain gauge)	mm/hr	
11 Precipitation (capacitive rain gauge)	mm/hr	reset at 50 mm
12 Down welling shortwave radiation	W/m ²	
13 Down welling infra-red radiation	W/m ²	
14 Defuse irradiance	W/m ²	
15 PAR	microE/cm ² /sec	
16 UV	microW/cm ² /nm	

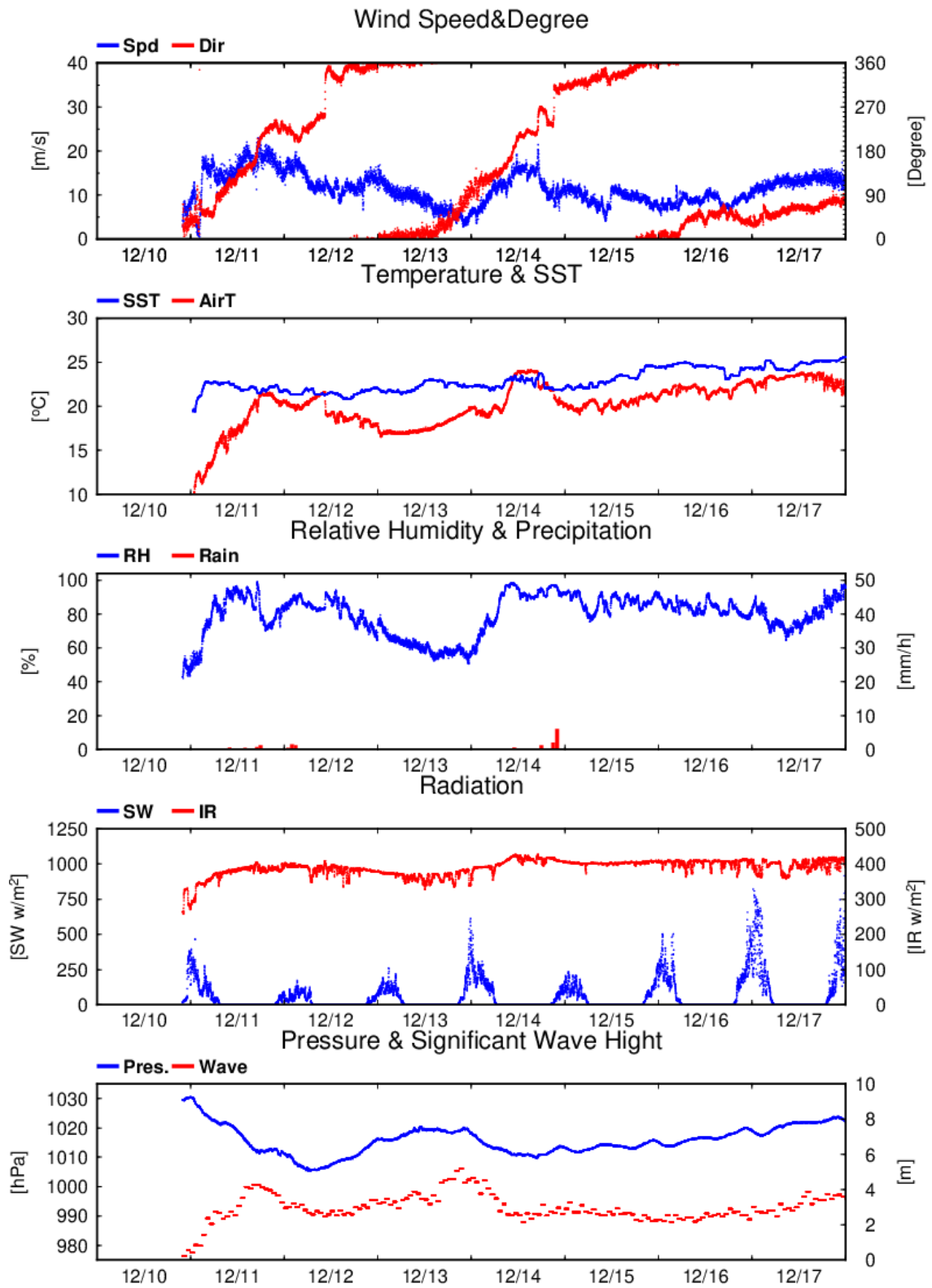


Fig. 3.2.1 Time series of surface meteorological parameters during the cruise

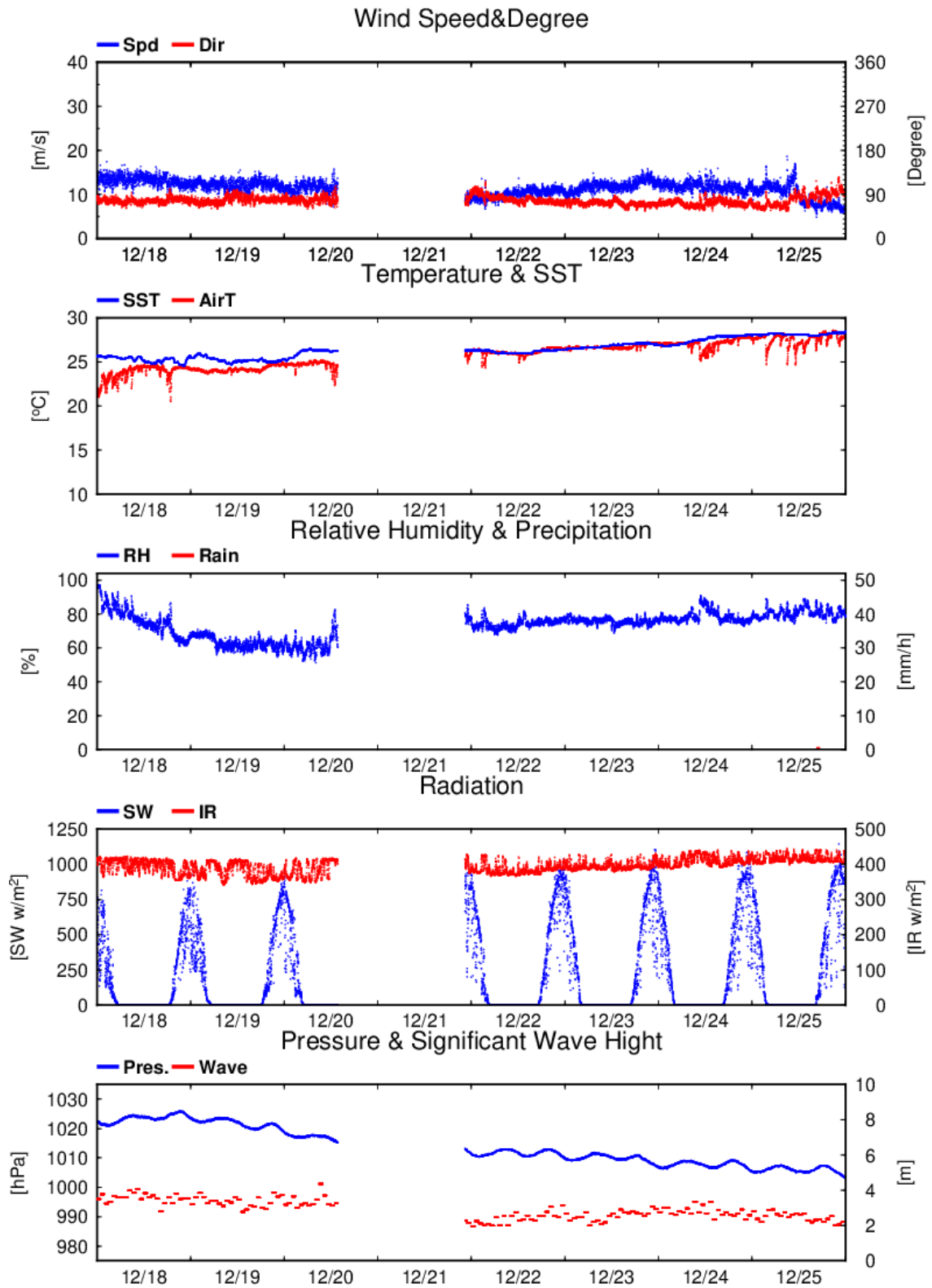


Fig. 3.2.1 (Continued)

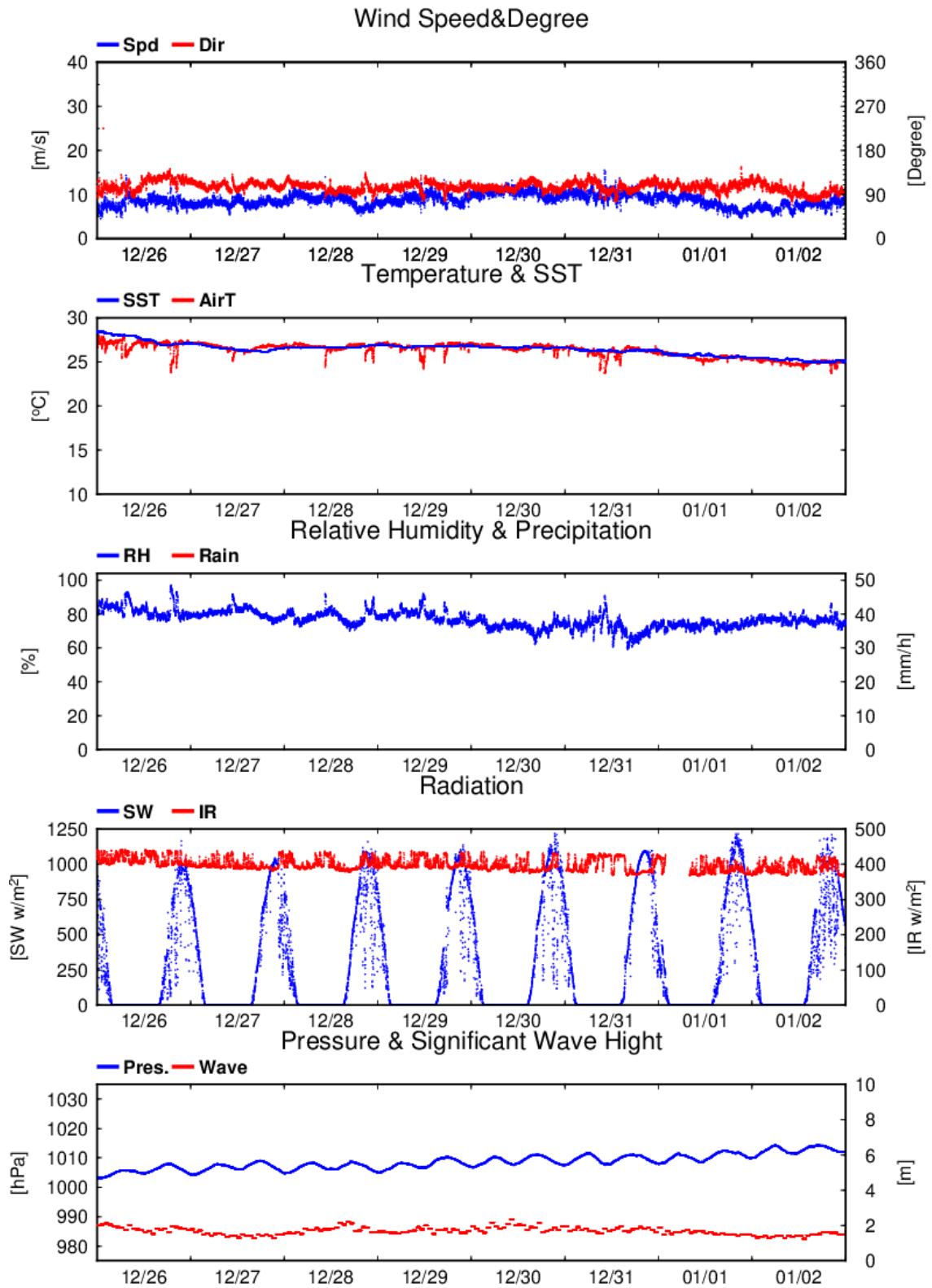


Fig. 3.2.1 (Continued)

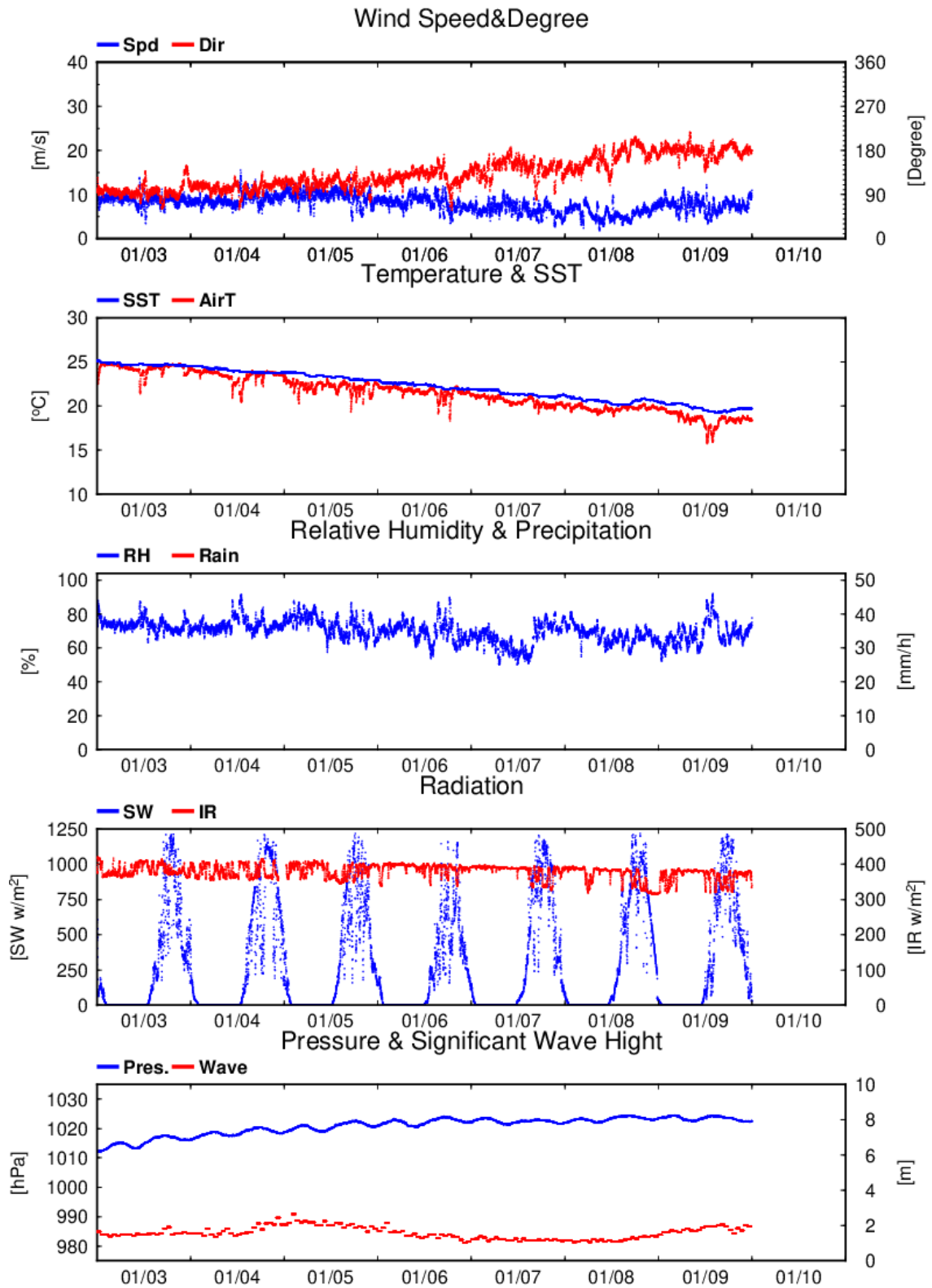


Fig. 3.2.1 (Continued)

3.3 Thermo-Salinograph and Related Measurements

(1) Personnel

Akihiko Murata (JAMSTEC): Principal Investigator

Hiroshi Hoshino (MWJ): Operation leader

(2) Objective

Our purpose is to obtain temperature, salinity, dissolved oxygen, fluorescence, and total dissolved gas pressure data continuously in near-sea surface water.

(3) Parameters

Temperature

Salinity

Dissolved oxygen

Fluorescence

Turbidity

Total dissolved gas pressure

(4) Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co. Ltd.) has five sensors and automatically measures temperature, salinity, dissolved oxygen, fluorescence, turbidity and total dissolved gas pressure in near-sea surface water every one minute. This system is located in the “sea surface monitoring laboratory” and connected to shipboard LAN-system. Measured data, time, and location of the ship were stored in a data management PC. Sea water was continuously pumped up to the laboratory from an intake placed at the approximately 4.5 m below the sea surface and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was adjusted to $10 \text{ dm}^3 \text{ min}^{-1}$.

a. Instruments

Software

SeaMoni Ver.1.1.0.0

Sensors

Specifications of the each sensor in this system are listed below.

Temperature and Conductivity sensor

Model: SBE-45, SEA-BIRD ELECTRONICS, INC.

Serial number: 4552788-0264

Measurement range: Temperature -5°C - $+35^\circ\text{C}$

Conductivity 0 S m^{-1} - 7 S m^{-1}

Initial accuracy: Temperature 0.002°C

Conductivity 0.0003 S m^{-1}

Typical stability (per month): Temperature 0.0002°C

Conductivity 0.0003 S m^{-1}

Resolution: Temperature 0.0001°C

Conductivity 0.00001 S m^{-1}

Bottom of ship thermometer

Model: SBE 38, SEA-BIRD ELECTRONICS, INC.

Serial number: 3852788-0457

Measurement range: -5°C - $+35^\circ\text{C}$

Initial accuracy: $\pm 0.001^\circ\text{C}$

Typical stability (per 6 month): 0.001°C

Resolution:	0.00025 °C
Dissolved oxygen sensor	
Model:	RINKO II, JFE ADVANTECH CO. LTD.
Serial number:	13
Measuring range:	0 mg L ⁻¹ - 20 mg L ⁻¹
Resolution:	0.001 mg L ⁻¹ - 0.004 mg L ⁻¹ (25 °C)
Accuracy:	Saturation ± 2 % F.S. (non-linear) (1 atm, 25 °C)
Fluorescence & Turbidity sensor	
Model:	C3, TURNER DESIGNS
Serial number:	2300384
Measuring range:	Chlorophyll in vivo 0 µg L ⁻¹ – 500 µg L ⁻¹
Minimum Detection Limit:	Chlorophyll in vivo 0.03 µg L ⁻¹
Measuring range:	Turbidity 0 NTU - 1500 NTU
Minimum Detection Limit:	Turbidity 0.05 NTU
Total dissolved gas pressure sensor	
Model:	HGTD-Pro, PRO OCEANUS
Serial number:	37-394-10
Temperature range:	-2 °C - 50 °C
Resolution:	0.0001 %
Accuracy:	0.01 % (Temperature Compensated)
Sensor Drift:	0.02 % per year max (0.001 % typical)

(5) Observation log

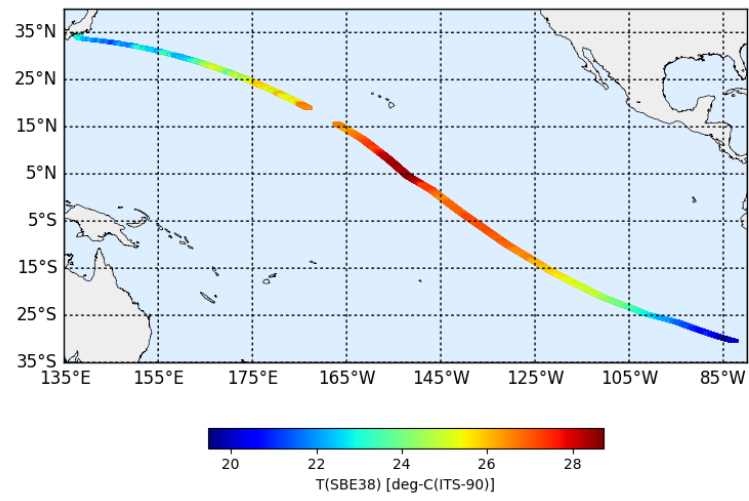
Periods of measurement, maintenance, and problems during this cruise are listed in Table 3.3-1.

Table 3.3-1 Events list of the Sea surface water monitoring during MR18-06 Leg1

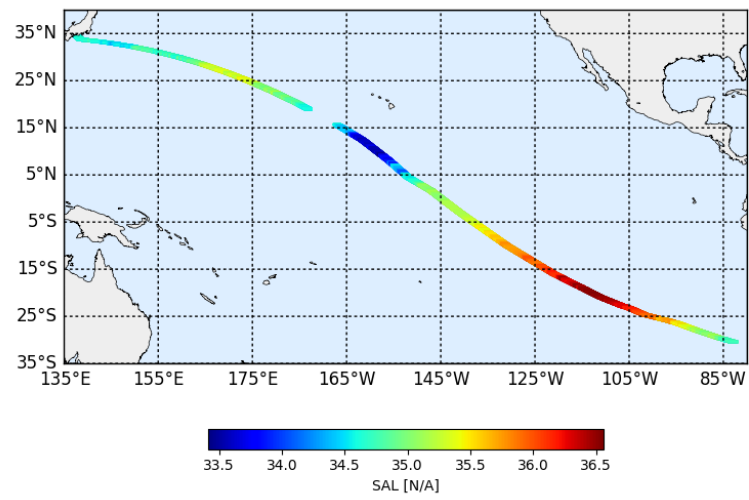
System Date [UTC]	System Time [UTC]	Events	Remarks
2018/12/11	02:51	All the measurements started and data was available.	Start
2018/12/12	10:00-10:17	Adjust flow rate	Turbidity and gas pressure data were affected.
2018/12/14	00:21-00:30	Adjust flow rate	Gas pressure data were affected.
2018/12/20	13:45	All the measurements stopped.	USA EEZ in
2018/12/21	22:26	All the measurements started.	USA EEZ out
2018/12/29	18:43-18:55	Adjust flow rate	Gas pressure data were affected.
2019/01/02	21:18-21:28	Filter Cleaning	All data except for SBE38 were affected
2019/01/05	23:24-23:32	Adjust flow rate	Gas pressure data were affected.
2019/01/09	00:06	All the measurements stopped.	Chile EEZ in

We took the surface water samples from this system once a day to compare sensor data with bottle data of salinity and dissolved oxygen. The results are shown in fig. 3.3-2. All the salinity samples were analyzed by the Model 8400B “AUTOSAL” manufactured by Guildline Instruments Ltd., and dissolve oxygen samples were analyzed by Winkler method.

(a)



(b)



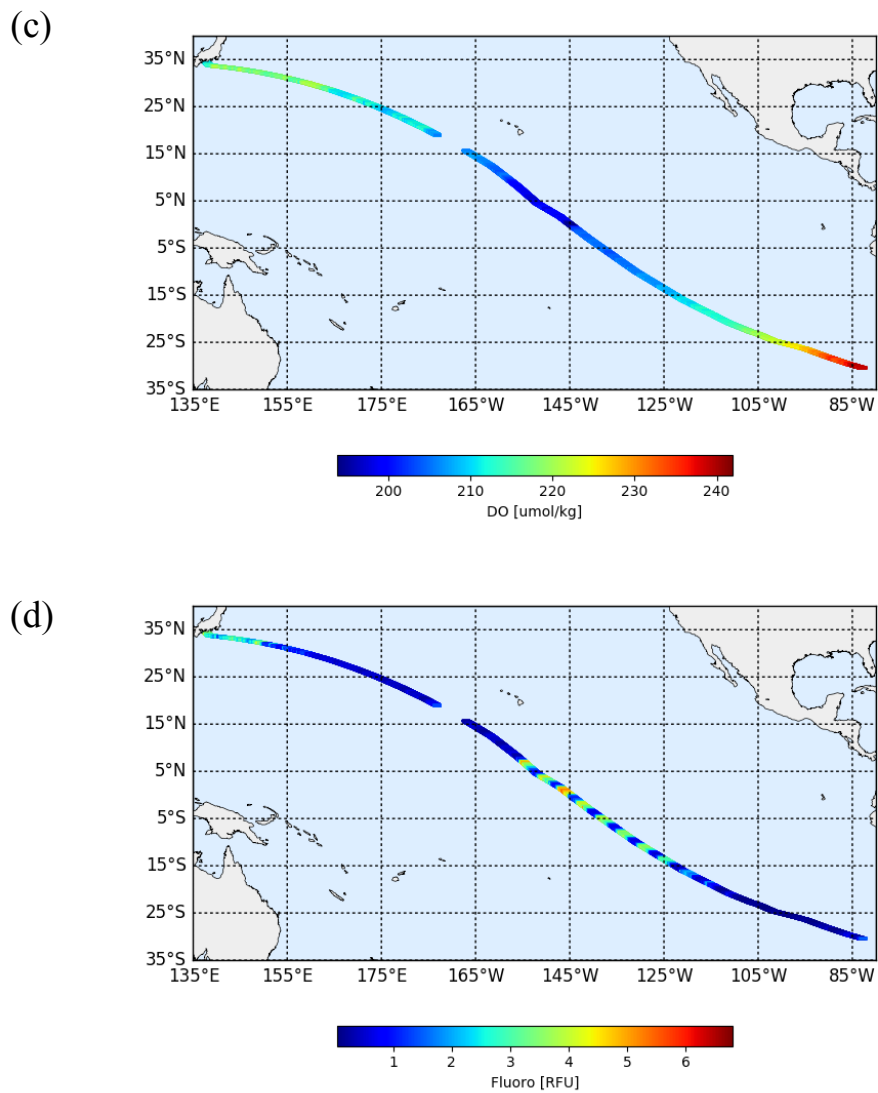


Figure 3.3-1 Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen, and (d) fluorescence in MR18-06 Leg1 cruise.

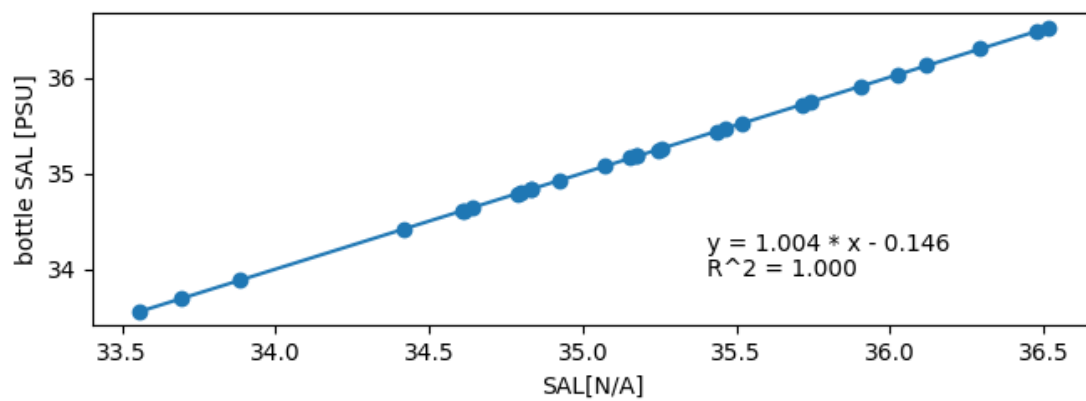


Figure 3.3-2-1 Correlation of salinity between sensor data and bottle data.

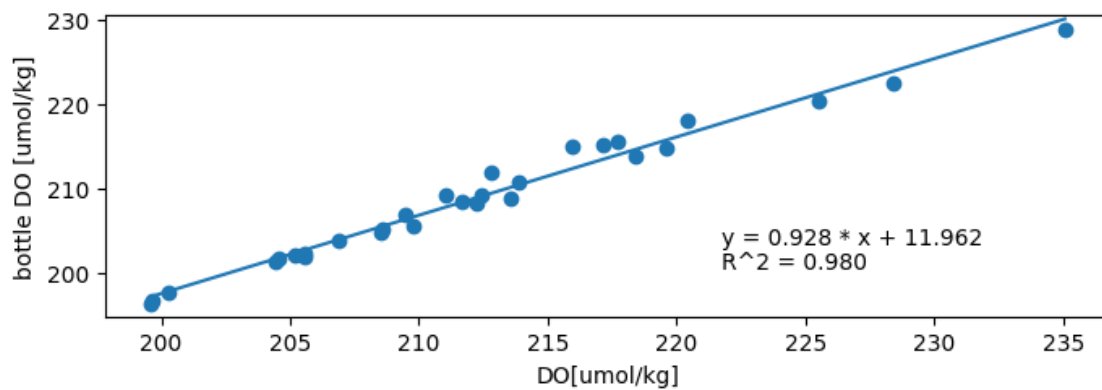


Figure 3.3-2-2 Correlation of dissolved oxygen between sensor data and bottle data.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.

<http://www.godac.jamstec.go.jp/darwin/e>

3.4 pCO₂

(1) Personnel

<i>Akihiko Murata (JAMSTEC)</i>	<i>on board</i>
<i>Masanori Enoki (MWJ)</i>	<i>on board</i>
<i>Atsushi Ono (MWJ)</i>	<i>on board</i>
<i>Hiroshi Hoshino (MWJ)</i>	<i>on board</i>

(2) Objective

Concentrations of CO₂ in the atmosphere are now increasing at a rate of about 2.0 ppmv y⁻¹ owing to human activities such as burning of fossil fuels, deforestation, and cement production. It is an urgent task to estimate as accurately as possible the absorption capacity of the oceans against the increased atmospheric CO₂, and to clarify the mechanism of the CO₂ absorption, because the magnitude of the anticipated global warming depends on the levels of CO₂ in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities.

In this cruise, we measured pCO₂ (partial pressure of CO₂) in the atmosphere and surface seawater continuously along cruise tracks in the Pacific in order to quantify how much CO₂ is absorbed in the region.

(3) Apparatus

Concentrations of CO₂ in the atmosphere and the sea surface were measured continuously during the cruise using an automated system with a non-dispersive infrared (NDIR) analyzer (Li-COR LI-7000). The automated system (Nippon ANS) was operated by about one and a half hour cycle. In one cycle, standard gasses, marine air and an air in a headspace of an equilibrator were analyzed subsequently. The nominal concentrations of the standard gas were 270, 330, 390 and 420 ppmv. The standard gases will be calibrated after the cruise.

The marine air taken from the bow was introduced into the NDIR by passing through a mass flow controller, which controlled the air flow rate at about 0.6 – 0.8 L/min, and a cooling unit

A fixed volume of the marine air taken from the bow was equilibrated with a stream of seawater that flowed at a rate of 4.0–5.0 L/min in the equilibrator. The air in the equilibrator was circulated with a pump at 0.7–0.8L/min in a closed loop passing through the cooling unit as used for marine air sample.

(4) Results

Concentrations of CO₂ (xCO₂) of marine air and surface seawater are shown in Fig. 3.4.1, together with SST.

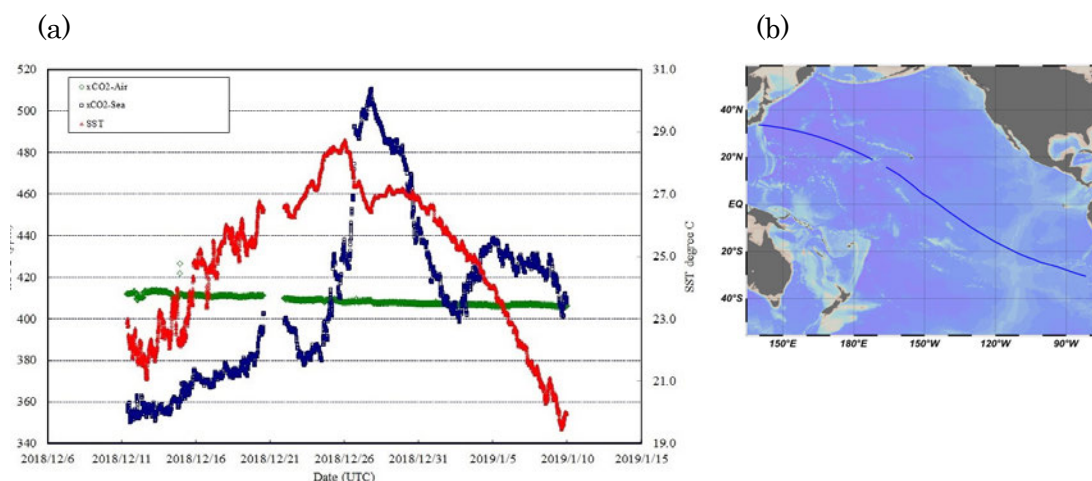


Fig. 3.4.1. (a) preliminary results of concentrations of CO₂ (xCO₂) in atmosphere (green) and surface seawater (blue), and SST (red) observed along the cruise track of the leg 1 of MR18-06 (b).

3.5 DIC

(1) Personnel

Akihiko Murata (JAMSTEC)

Masanori Enoki (MWJ)

Atsushi Ono (MWJ)

Hiroshi Hoshino (MWJ)

(2) Objective

It is doubtless that the ocean moderates global warming by absorbing ~30% of anthropogenic CO₂ emitted into the atmosphere. However, increases of anthropogenic CO₂ in the ocean cause another CO₂ problem called as ocean acidification. Since it is predicted that ocean acidification gives a large influence on ocean biology, especially on calcifying organisms, it is an important task to evaluate progression of ocean acidification.

In the first leg of MR18-06 cruise, we measured dissolved inorganic carbon (DIC) in the surface seawater continuously along the cruise track. The data for DIC are used to calculate saturation state of calcium carbonate (DIC), which is one of good indicators of ocean acidification, together with data for underway pCO₂ (section 3.4)

(3) Apparatus

Measurement of DIC was made with automated DIC analyzer (Nippon ANS, Inc., Japan). The system comprises of a seawater dispensing system, a CO₂ extraction system and a coulometer (Model 3000A, Nippon ANS, Inc., Japan). Specification of the system is as follows:

Seawater collected from the seawater inlet at 4.5 m deep is transferred into a DURAN[®] glass bottle of nominal 250 ml after overflowing seawater of 3 time volume of the bottle. The seawater sample is kept at 20°C by a constant temperature bath until measurement. Then the seawater sample is dispensed from the glass bottle into a pipette of about 15 ml volume. The pipette is also kept at 20 °C by a water jacket, in which water from a water bath set at 20°C is circulated. CO₂ dissolved in a seawater sample is extracted in a stripping chamber of the CO₂ extraction system by adding phosphoric acid (~ 10 % v/v) of about 2 ml. The stripping chamber is approx. 25 cm long and has a fine frit at the bottom. The acid is added to the stripping chamber from the bottom of the chamber by pressurizing an acid bottle for a given time to push out the right amount of acid. The pressurizing is made with nitrogen gas (99.9999 %). After the acid is transferred to the stripping chamber, a seawater sample kept in a pipette is introduced to the stripping chamber by the same method as in adding an acid. The seawater reacted with phosphoric acid is stripped of CO₂ by bubbling the nitrogen gas through a fine frit at the bottom of the stripping chamber. The CO₂ stripped in the chamber is carried by the nitrogen gas (flow rates is 140 ml min⁻¹) to the coulometer through a dehydrating module. The module consists of two electric dehumidifiers (kept at ~4°C) and a chemical desiccant (Mg(ClO₄)₂).

The measurement sequence such as 1.5% CO₂ gas in N₂ base, system blank (phosphoric acid blank), seawater samples (6) is repeated automatically by PC control.

(4) Results

Distributions of surface seawater DIC along the cruise track are shown in Fig. 3.5.1, together with those of salinity. Data around 170°W are removed because the area belongs to the exclusive economic zone (EEZ) of U.S.A. Surface seawater DIC showed relatively low values in the subtropical and tropical regions in the northern hemisphere, and being minima around 10°N. Then the values increased sharply just north of the equator. From 150°W to 120°W, surface seawater DIC remained ~2030 μmol kg⁻¹. East of 120°W, values of surface seawater DIC were in excess of 2050 μmol kg⁻¹. A series of changes in surface seawater DIC were well correlated with those of surface seawater salinity, although there found some local anomalies from the tendency.

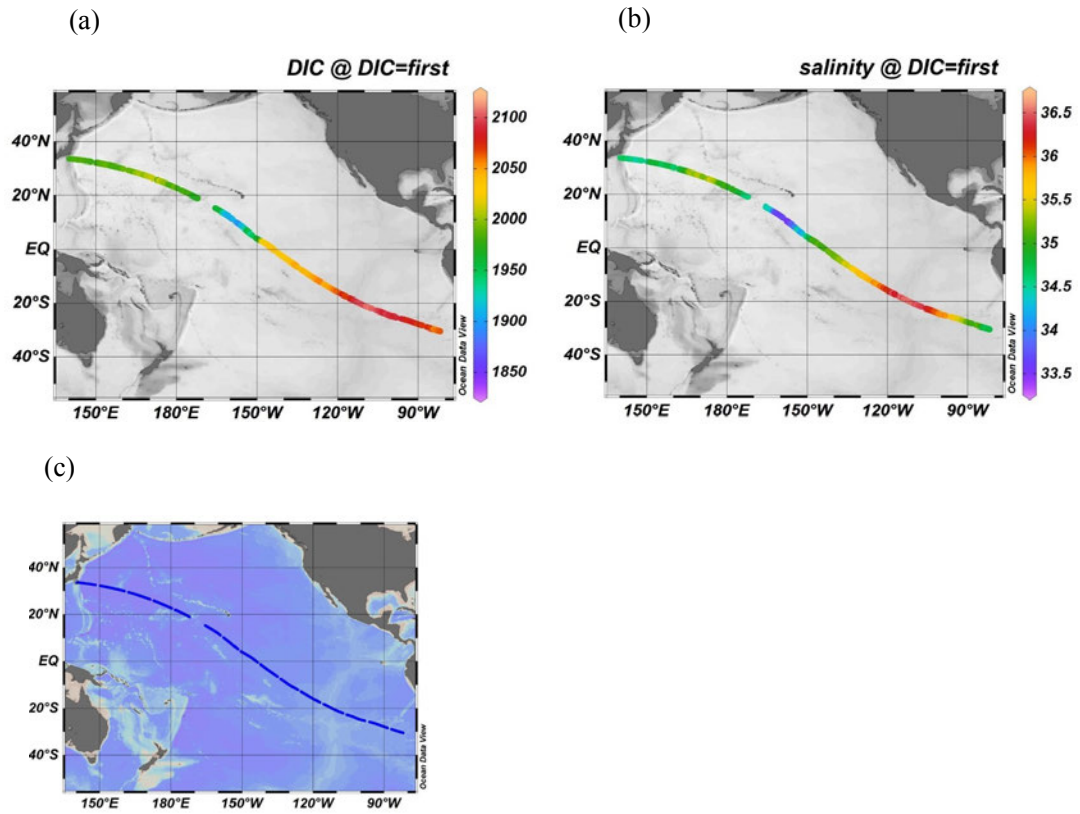


Fig. 3.5.1 Distributions of surface seawater DIC and surface seawater salinity along the cruise track. (a) surface seawater DIC, (b) surface seawater salinity and (c) cruise track.

3.6 Shipboard ADCP

(1) Personnel

<i>Akihiko MURATA</i>	<i>JAMSTEC: Principal investigator</i>
<i>Ryo OYAMA</i>	<i>Nippon Marine Enterprises LTD. (NME)</i>
<i>Masanori MURAKAMI</i>	<i>NME</i>
<i>Takehito HATTORI</i>	<i>MIRAI crew</i>

(2) Objective

To obtain continuous measurement data of the current profile along the ship's track.

(3) Apparatus

Upper ocean current measurements were made in this cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation, the instrument was configured for water-tracking mode. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made to get the calibration data for evaluating transducer misalignment angle in the shallow water. The system consists of following components;

1. R/V MIRAI has installed the Ocean Surveyor for vessel-mount ADCP (frequency 76.8 kHz; Teledyne RD Instruments, USA). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel.
2. For heading source, we use ship's gyro compass (Tokyo Keiki, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System (Phins, Ixblue, France) which provide high-precision heading, attitude information, pitch and roll. They are stored in ".N2R" data files with a time stamp.
3. Differential GNSS system (StarPack-D, Fugro, Netherlands) providing precise ship's position.
4. We used VmDas software version 1.49(TRDI) for data acquisition.
5. To synchronize time stamp of ping with Computer time, the clock of the logging computer is adjusted to GPS time server continuously by the application software.
6. Fresh water is charged in the sea chest to prevent bio fouling at transducer face.
7. The sound speed at the transducer does affect the vertical bin mapping and vertical velocity measurement, and that is calculated from temperature, salinity (constant value; 35.0 PSU) and depth (6.5 m; transducer depth) by equation in Medwin (1975).

Data was configured for "8 m" layer intervals starting about 23m below sea surface, and recorded every ping as raw ensemble data (.ENR). Additionally, 10 seconds averaged data were recorded as short-term average (.STA). 300 seconds averaged data were long-term average (.LTA), respectively.

(4) Parameters

Major parameters for the measurement, Direct Command, are shown in Table 3.6.1.

Table 3.6.1 Major parameters

Bottom-Track Commands	
BP = 001	Pings per Ensemble (almost less than 1,300m depth)
Environmental Sensor Commands	
EA = 04500	Heading Alignment (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH = 00000	Heading (1/100 deg)
ES = 35	Salinity (0-40 pp thousand)

EX = 00000	Coordinate Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 10200010	Sensor Source (C; D; H; P; R; S; T; U)
	C (1): Sound velocity calculates using ED, ES, ET (temp.)
	D (0): Manual ED
	H (2): External synchro
	P (0), R (0): Manual EP, ER (0 degree)
	S (0): Manual ES
	T (1): Internal transducer sensor
	U (0): Manual EU
EV = 0	Heading Bias(1/100 deg)
Water-Track Commands	
WA = 255	False Target Threshold (Max) (0-255 count)
WC = 120	Low Correlation Threshold (0-255)
WD = 111 100 000	Data Out (V; C; A; PG; St; Vsum; Vsum^2; #G; P0)
WE = 1000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WN = 100	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS = 800	Depth Cell Size (cm)
WV = 0390	Mode 1 Ambiguity Velocity (cm/s radial)

(5) Preliminary results

Horizontal velocity along the ship's track is presented in Fig.3.6.1. In vertical direction, the data are averaged from 35 to 100m.

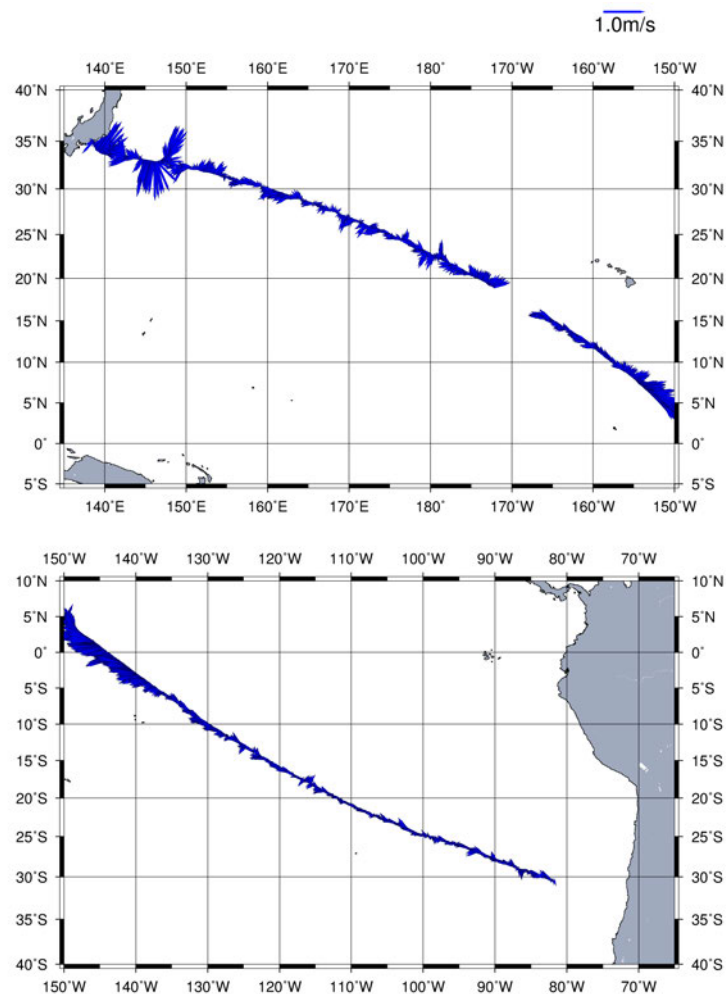


Fig.3.6.1 Horizontal Velocity along the ship's track. (15min. Average / Layer: 35-100m)

(6) Data Archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.

<http://www.godac.jamstec.go.jp/darwin/e>

(7) Remarks

1. The following period, data acquisitions were stopped for cruising in the EEZ of the foreign countries.

13:30UTC 20 Dec. 2018 - 22:30UTC 21 Dec. 2018

00:00UTC 10 Jan. 2019 - 12 Jan. 2019 (Arrival at Valparaiso)

3.7 XCTD

(1) Personnel

<i>Akihiko MURATA</i>	<i>JAMSTEC: Principal investigator</i>
<i>Ryo OYAMA</i>	<i>Nippon Marine Enterprises LTD. (NME)</i>
<i>Masanori MURAKAMI</i>	<i>NME</i>
<i>Takehito HATTORI</i>	<i>MIRAI crew</i>

(2) Objective

To obtain vertical profiles of sea water temperature and salinity (calculated by the function of temperature, pressure (depth), and conductivity).

(3) Apparatus

We observed the vertical profiles of the sea water temperature and conductivity measured by XCTD-1 manufactured by Tsurumi-Seiki Co. (TSK). The signal was converted by MK-150N(TSK) and was recorded by AL-12B software (Ver.1.1.4, TSK). We launched 3 probes by using the automatic launcher. The summary of XCTD observation log is shown in Table 3.7.1.

The range and accuracy of parameters measured by the XCTD (eXpendable Conductivity, Temperature & Depth profiler) are as follows;

Parameter	Range	Accuracy
Conductivity	0 ~ 60 [mS/cm]	+/- 0.03 [mS/cm]
Temperature	-2 ~ 35 [deg-C]	+/- 0.02 [deg-C]
Depth	0 ~ 1000 [m]	5 [m] or 2 [%] (either of them is major)

Table 3.7.1 XCTD observation log

No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [deg]	Longitude [deg]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N	Probe Type
1	2018/12/14	22:33	29-58.5255N	160-17.8297E	5739	22.164	34.629	17121088	XCTD-1
2	2018/12/16	06:56	27-31.0019N	168-14.5107E	5919	25.240	35.256	17121094	XCTD-1
3	2019/01/07	19:30	27-06.1044S	92-04.8118W	3752	21.370	35.376	18086031	XCTD-1

SST: Sea Surface Temperature [deg-C] measured by TSG (Thermo Salino Graph).

SSS: Sea Surface Salinity [PSU] measured by TSG.

(4) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.

<http://www.godac.jamstec.go.jp/darwin/e>

3.8 C-band Weather Radar

(1) Personnel

<i>Fumikazu Taketani (JAMSTEC)</i>	<i>not on board</i>
<i>Masaki Katsumata (JAMSTEC)</i>	<i>not on board</i>
<i>Biao Geng (JAMSTEC)</i>	<i>not on board</i>

(2) Objective

The objective of weather radar observations is to investigate the structures and evolutions of precipitating systems over the tropical ocean.

(3) Radar specifications

The C-band weather radar on board the R/V Mirai was used. Basic specifications of the radar are as follows:

Frequency:	5370 MHz (C-band)
Polarimetry:	Horizontal and vertical (simultaneously transmitted and received)
Transmitter:	Solid-state transmitter
Pulse Configuration:	Using pulse-compression
Output Power:	6 kW (H) + 6 kW (V)
Antenna Diameter:	4 meter
Beam Width:	1.0 degrees
Inertial Navigation Unit:	PHINS (IXBLUE S.A.S)

(4) Available radar variables

Radar variables, which were converted from the power and phase of the backscattered signal at vertically- and horizontally-polarized channels, were as follows:

Radar reflectivity:	Z
Doppler velocity:	V_r
Spectrum width of Doppler velocity:	SW
Differential reflectivity:	Z_{DR}
Differential propagation phase:	Φ_{DP}
Specific differential phase:	K_{DP}
Co-polar correlation coefficients:	ρ_{HV}

(5) Operational methodology

The antenna was controlled to point the commanded ground-relative direction, by controlling the azimuth and elevation to cancel the ship attitude (roll, pitch and yaw) detected by the laser gyro. The Doppler velocity was also corrected by subtracting the ship movement in beam direction.

For the maintenance, internal signals of the radar were checked and calibrated at the beginning and the end of the cruise. Meanwhile, the following parameters were checked daily; (1) frequency, (2) mean output power, (3) pulse width, and (4) PRF (pulse repetition frequency).

During the cruise, the radar was operated as in Table 3.8-1. A dual PRF mode was used for a volume scan. For RHI, vertical point, and surveillance PPI scans, a single PRF mode was used.

(6) Data and preliminary results

The C-band weather radar observations were conducted through the cruise, except in the EEZs and territorial waters without permission, and in the area where the operations were prohibited by Japanese license.

The obtained data will be analyzed after the cruise.

(7) Data archive

All data from the C-band weather radar observations during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

Table 3.8-1 Parameters for scans.

	Survei-llance PPI Scan	Volume Scan						RHI Scan	Vertical Point Scan
Repeated Cycle (min.)	30	6						12	
Times in One Cycle	1	1						3	3
Pulse Width (long / short, in microsec)	200 / 2	64 / 1		32 / 1		32 / 1		32 / 1	32 / 1
Scan Speed (deg/sec)	18	18		24		36		9	36
PRF(s) (Hz)	400	dual PRF (ray alternative)						1250	2000
		667	833	938	1250	1333	2000		
Pulses / Ray	16	26	33	27	34	37	55	32	64
Ray Spacing (deg.)	0.7	0.7		0.7		1.0		0.2	1.0
Azimuth (deg)	Full Circle							Option	Full Circle
Bin Spacing (m)	150								
Max. Range (km)	300	150		100		60		100	60
Elevation Angle(s) (deg.)	0.5	0.5		1.0, 1.8, 2.6, 3.4, 4.2, 5.1, 6.2, 7.6, 9.7, 12.2, 15.2		18.7, 23.0, 27.9, 33.5, 40.0		0.0~60.0	90

3.9 Ceilometer

(1) Personnel

<i>Akihiko MURATA</i>	<i>JAMSTEC: Principal investigator</i>
<i>Ryo OYAMA</i>	<i>Nippon Marine Enterprises LTD. (NME)</i>
<i>Masanori MURAKAMI</i>	<i>NME</i>
<i>Takehito HATTORI</i>	<i>MIRAI crew</i>

(2) Objectives

The information of cloud base height and the liquid water amount around cloud base is important to understand the process on formation of the cloud. As one of the methods to measure them, the ceilometer observation was carried out.

(3) Apparatus

Cloud base height and backscatter profile were observed by ceilometer (CL51, VAISALA, Finland) throughout the MR18-06 Leg1 cruise. Measured parameters and major specifications for the measurement configuration are shown in Table 3.9.1 and Table 3.9.2 respectively. On the archive dataset, cloud base height and backscatter profile are recorded with the resolution of 10 m.

Table 3.9.1 Measured parameters
Parameters

1. Cloud base height [m]
2. Backscatter profile, sensitivity and range normalized at 10 m resolution
3. Estimated cloud amount [oktas] and height [m]; Sky Condition Algorithm

Table 3.9.2 Major specifications for the measurement configuration

Property	Description / Value
Laser source	Indium Gallium Arsenide (InGaAs) Diode
Transmitting center wavelength	910±10 nm at 25 degC
Transmitting average power	19.5 mW
Repetition rate	6.5 kHz
Detector	Silicon avalanche photodiode (APD)
Responsibility at 905 nm	65 A/W
Cloud detection range	0 ~ 13 km
Measurement range	0 ~ 15 km
Resolution	10 meter in full range
Sampling rate	36 sec.
Sky Condition	Cloudiness in oktas (0 ~ 9)
	0 Sky Clear
	1 Few
	3 Scattered
	5-7 Broken
	8 Overcast
	9 Vertical Visibility

(4) Preliminary results

Figure 3.9.1 shows the time series of cloud-base heights derived from the ceilometer during this cruise.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of

JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.

<http://www.godac.jamstec.go.jp/darwin/e>

(6) Remarks

1. Window cleaning

14:01UTC 15 Dec. 2018

21:46UTC 22 Dec. 2018

21:05UTC 30 Dec. 2018

16:10UTC 06 Jan. 2019

2. The following period, data acquisitions were stopped for cruising in the EEZ of the foreign countries.

13:45UTC 20 Dec. 2018 - 22:25UTC 21 Dec. 2018

00:00UTC 10 Jan. 2019 - 12 Jan. 2019 (Arrival at Valparaiso)

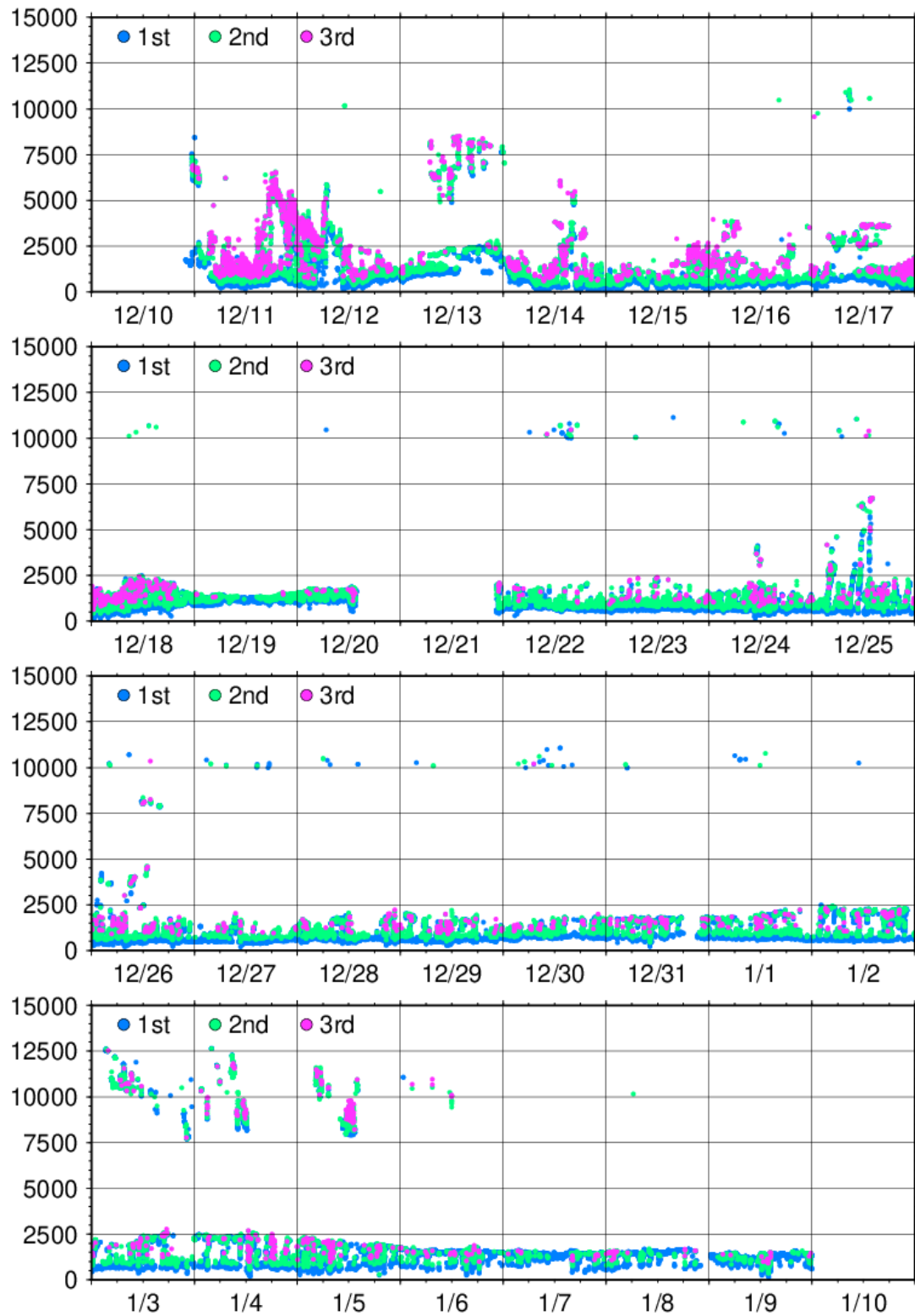


Figure 3.9.1 Time series of cloud base height during this cruise

3.10 Micro Rain Radar

(1) Personnel

Fumikazu Taketani (JAMSTEC)

not on board

Masaki Katsumata (JAMSTEC)

not on board

(2) Objectives

The micro rain radar (MRR) is a compact vertically-pointing Doppler radar, to detect vertical profiles of rain drop size distribution. The objective of this observation is to understand detailed vertical structure of the precipitating systems.

(3) Instruments and Methods

The MRR-2 (METEK GmbH) was utilized. The specifications are in Table 3.10-1. The antenna unit was installed at the starboard side of the anti-rolling systems (see Fig. 3.10-1), and wired to the junction box and laptop PC inside the vessel.

The data was averaged and stored every one minute. The vertical profile of each parameter was obtained every 100 meters in range distance (i.e. height) up to 3100 meters, i.e. well beyond the melting layer. The recorded parameters were; Drop size distribution, radar reflectivity, path-integrated attenuation, rain rate, liquid water content and fall velocity.

Fig. 3.10-1: Photo of the antenna unit of MRR



Table 3.10-1: Specifications of the MRR-2.

Transmitter power	50 mW
Operating mode	FM-CW
Frequency	24.230 GHz (modulation 1.5 to 15 MHz)
3dB beam width	1.5 degrees
Spurious emission	< -80 dBm / MHz
Antenna Diameter	600 mm
Gain	40.1 dBi

(4) Preliminary Results

The data have been obtained all through the cruise, except EEZs without permission. The further analyses will be after the cruise.

(5) Data Archive

All data obtained during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

(6) Acknowledgment

The operations are supported by Japan Aerospace Exploration Agency (JAXA) Precipitation Measurement Mission (PMM).

3.11 Disdrometers

(1) Personnel

<i>Fumikazu Taketani (JAMSTEC)</i>	<i>not on board</i>
<i>Masaki Katsumata (JAMSTEC)</i>	<i>not on board</i>

(2) Objectives

The disdrometer can continuously obtain size distribution of raindrops. The objective of this observation is (a) to reveal microphysical characteristics of the rainfall, depends on the type, temporal stage, etc. of the precipitating clouds, (b) to retrieve the coefficient to convert radar reflectivity (especially from C-band radar in Section 3.8) to the rainfall amount, and (c) to validate the algorithms and the products of the satellite-borne precipitation radars; TRMM/PR and GPM/DPR.

(3) Instrumentations and Methods

Two “Laser Precipitation Monitor (LPM)” (Adolf Thies GmbH & Co) are utilized. It is an optical disdrometer. The instrument consists of the transmitter unit which emit the infrared laser, and the receiver unit which detects the intensity of the laser come thru the certain path length in the air. When a precipitating particle fall thru the laser, the received intensity of the laser is reduced. The receiver unit detect the magnitude and the duration of the reduction and then convert them onto particle size and fall speed. The sampling volume, i.e. the size of the laser beam “sheet”, is 20 mm (W) x 228 mm (D) x 0.75 mm (H).

The number of particles are categorized by the detected size and fall speed and counted every minutes. The categories are shown in Table 3.11-1.

The LPMs are installed on the top (roof) of the anti-rolling system, as shown in Fig. 3.11-1. One is installed at the corner at the bow side and the starboard side, while the other at the corner at the bow and the port side. This is to select the data from upwind side.

(4) Preliminary Results

The data have been obtained all through the cruise, except territorial waters without permission. The further analyses for the rainfall amount, drop-size-distribution parameters, etc., will be carried out after the cruise.s

(5) Data Archive

All data obtained during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

(6) Acknowledgment

The operations are supported by Japan Aerospace Exploration Agency (JAXA) Precipitation Measurement Mission (PMM).



Fig. 3.11-1: The location of the LPM sensors, on the panorama photo looking down toward the bow (from a tower for the radome of the C-band radar). Red broken circle shows the location of LPM sensors.

Table 3.11-1: Categories of the particle size and the fall speed.

Particle Size		
Class	Diameter [mm]	Class width [mm]
1	≥ 0.125	0.125
2	≥ 0.250	0.125
3	≥ 0.375	0.125
4	≥ 0.500	0.250
5	≥ 0.750	0.250
6	≥ 1.000	0.250
7	≥ 1.250	0.250
8	≥ 1.500	0.250
9	≥ 1.750	0.250
10	≥ 2.000	0.500
11	≥ 2.500	0.500
12	≥ 3.000	0.500
13	≥ 3.500	0.500
14	≥ 4.000	0.500
15	≥ 4.500	0.500
16	≥ 5.000	0.500
17	≥ 5.500	0.500
18	≥ 6.000	0.500
19	≥ 6.500	0.500
20	≥ 7.000	0.500
21	≥ 7.500	0.500
22	≥ 8.000	unlimited

Fall Speed		
Class	Speed [m/s]	Class width [m/s]
1	≥ 0.000	0.200
2	≥ 0.200	0.200
3	≥ 0.400	0.200
4	≥ 0.600	0.200
5	≥ 0.800	0.200
6	≥ 1.000	0.400
7	≥ 1.400	0.400
8	≥ 1.800	0.400
9	≥ 2.200	0.400
10	≥ 2.600	0.400
11	≥ 3.000	0.800
12	≥ 3.400	0.800
13	≥ 4.200	0.800
14	≥ 5.000	0.800
15	≥ 5.800	0.800
16	≥ 6.600	0.800
17	≥ 7.400	0.800
18	≥ 8.200	0.800
19	≥ 9.000	1.000
20	≥ 10.000	10.000

3.12 Rain Water Sampling

(1) Personnel

Fumikazu Taketani (JAMSTEC) *not on board*
Yugo Kanaya (JAMSTEC) *not on board*
Kazuhiko Matsumoto (JAMSTEC) *not on board*

(2) Objectives

To obtain the information of nutrient input from atmosphere to Ocean surface, we collected rainfall.

(3) Instrumentations and Methods

Rain Water Sampling is installed on the compass deck. Rain water was collected by plastic infundibulum. There are 24 bottles in the sampler. The sampling was carried out every 8 hours from 11th December 0:00. Sampled rain water was stored to refrigeration room. These sampling logs are listed in Table 3.12-1. All samples are going to be analyzed in laboratory.

(4) Data Archive

All data obtained during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

Table 3.12-1: Logs of rain water sampling

ID	UTC	Rain water
MR1804Leg1-RS-001	12/11 0:00-6:00	Non
MR1804Leg1-RS-002	12/11 6:00-11:59	Sampled
MR1804Leg1-RS-003	12/11 12:00-17:59	Sampled
MR1804Leg1-RS-004	12/11 18:00-23:39	Non
MR1804Leg1-RS-005	12/12 0:00-6:00	Sampled
MR1804Leg1-RS-006	12/12 6:00-11:59	Sampled
MR1804Leg1-RS-007	12/12 12:00-17:59	Non
MR1804Leg1-RS-008	12/12 18:00-23:39	Sampled
MR1804Leg1-RS-009	12/13 0:00-6:00	Non
MR1804Leg1-RS-010	12/13 6:00-11:59	Non
MR1804Leg1-RS-011	12/13 12:00-17:59	Non
MR1804Leg1-RS-012	12/13 18:00-23:39	Non
MR1804Leg1-RS-013	12/14 0:00-6:00	Non
MR1804Leg1-RS-014	12/14 6:00-11:59	Sampled
MR1804Leg1-RS-015	12/14 12:00-17:59	Sampled
MR1804Leg1-RS-016	12/14 18:00-23:39	Sampled
MR1804Leg1-RS-017	12/15 0:00-6:00	Sampled
MR1804Leg1-RS-018	12/15 6:00-11:59	Non
MR1804Leg1-RS-019	12/15 12:00-17:59	Non
MR1804Leg1-RS-020	12/15 18:00-23:39	Sampled
MR1804Leg1-RS-021	12/16 0:00-6:00	Sampled

3.13 Tropospheric Gas and Particles Observation in the Marine Atmosphere

(1) Personnel

<i>Fumikazu Taketani (JAMSTEC)</i>	<i>not on board</i>
<i>Yugo Kanaya (JAMSTEC)</i>	<i>not on board</i>
<i>Takuma Miyakawa (JAMSTEC)</i>	<i>not on board</i>
<i>Zhu Chunmao (JAMSTEC)</i>	<i>not on board</i>
<i>Kaori Kawana (JAMSTEC)</i>	<i>not on board</i>

(2) Objectives

- To investigate roles of aerosols in the marine atmosphere in relation to climate change
- To investigate processes of biogeochemical cycles between the atmosphere and the ocean.

(3) Instrumentations and Methods

Black carbon (BC): Number and mass BC concentration were measured by an instrument based on laser-induced incandescence, single particle soot photometer (SP2) (model D, Droplet Measurement Technologies). The laser-induced incandescence technique based on intracavity Nd:YVO4 laser operating at 1064 nm were used for detection of single particles of BC.

Fluorescent property: Fluorescent properties of aerosol particles were measured by a single particle fluorescence sensor, Waveband Integrated bioaerosol sensor (WIBS4) (WIBS-4A, Droplet Measurement Technologies). Two pulsed xenon lamps emitting UV light (280 nm and 370 nm) were used for excitation. Fluorescence emitted from a single particle within 310–400 nm and 420–650 nm wavelength windows was recorded

For SP2 and WIBS4, the ambient air was commonly sampled from the compass deck by a 3-m-long conductive tube through the dryer to dry up the particles, and then introduced to each instrument installed at the environmental research room.

Ambient air sampling: Ambient air samplings were carried out by air samplers installed at compass deck. Ambient particles were collected on the quartz filter (size: 8" × 10") using a high-volume air sampler (HVS, 120SL, KIMOTO operated at flow rate of 740L/min. To avoid collecting particles emitted from the funnel of the own vessel, the sampling period was controlled automatically by using a "wind-direction selection system". These sampling logs are listed in Table 3.13-1. All samples are going to be analyzed in laboratory.

CO and O3: Ambient air was continuously sampled on the compass deck and drawn through ~20-m-long Teflon tubes connected to CO analyzer (Model 48C, Thermo Fisher Scientific) and a UV photometric ozone analyzer (Model 49C, Thermo Fisher Scientific). The data will be used for characterizing air mass origins.

(4) Data Archive

All data obtained during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

Table 3.13-1: Logs of Ambient particles sampling

ID	Date/Time sampling(UTC)				latitude			longitude		
	yyyy	mm	dd	start (hh:mm)	deg	min	N-S	deg	min	E-W
MR1806Leg1-HV-001	2018	12	10	22:12	35	1.8893	N	138	30.1828	E
MR1806Leg1-HV-002	2018	12	12	1:58	33	20.33	N	143	5.79	E
MR1806Leg1-HV-003	2018	12	13	1:58	32	28.33	N	149	2.71	E
MR1806Leg1-HV-004	2018	12	14	1:56	31	14.93	N	155	14.9	E
MR1806Leg1-HV-005	2018	12	15	1:49	29	44.53	N	161	6.9	E

3.14 Aerosol Optical Characteristics

(1) Personnel

Fumikazu Taketani (JAMSTEC) *not on board*

Kazuma Aoki (University of Toyama) *not on board*

Sky radiometer operation was supported by Nippon Marine Enterprises, Ltd.

(2) Objectives

Objective of this observation is to study distribution and optical characteristics of marine aerosols by using a ship-borne sky radiometer (POM-01 MK-III: PREDE Co. Ltd., Japan). Furthermore, collections of the data for calibration and validation to the remote sensing data were performed simultaneously.

(3) Instrumentations and Methods

The sky radiometer measures the direct solar irradiance and the solar aureole radiance distribution with seven interference filters (0.315, 0.4, 0.5, 0.675, 0.87, 0.94, and 1.02 μm). Analysis of these data was performed by SKYRAD.pack version 4.2 developed by Nakajima et al. 1996.

(4) Parameters

- Aerosol optical thickness at five wavelengths (400, 500, 675, 870 and 1020 nm)
- Ångström exponent
- Single scattering albedo at five wavelengths
- Size distribution of volume (0.01 μm – 20 μm)
- # GPS provides the position with longitude and latitude and heading direction of the vessel, and azimuth and elevation angle of the sun. Horizon sensor provides rolling and pitching angles.

(5) Data Archive

Aerosol optical data are to be archived at University of Toyama (K.Aoki, SKYNET/SKY: <http://skyrad.sci.u-toyama.ac.jp/>) after the quality check and will be submitted to JAMSTEC.

(6) Acknowledgment

The operations are supported by Japan Aerospace Exploration Agency (JAXA) RA6 by GCOM-C.

3.15 Lidar

(1) Personnel

<i>Fumikazu Taketani (JAMSTEC)</i>	<i>not on board</i>
<i>Masaki Katsumata (JAMSTEC)</i>	<i>not on board</i>
<i>Kyoko Taniguchi (JAMSTEC)</i>	<i>not on board</i>
<i>Ryo Oyama (NME)</i>	<i>on board</i>
<i>Masanori Murakami (NME)</i>	<i>on board</i>

(2) Objective

The objective of this observation is to capture the vertical distribution of clouds, aerosols, and water vapor in high spatio-temporal resolution.

(3) Instrumentations and Methods

The Mirai Lidar system transmits a 10-Hz pulse laser in three wavelengths: 1064nm, 532nm, 355nm. For cloud and aerosol observation, the system detects Mie scattering at these wavelengths. The separate detections of parallel and perpendicular components at 532 nm and 355 nm obtain additional characteristics of the targets. The system also detects Raman water vapor signals at 660 nm and 408nm, Raman nitrogen signals at 607 nm and 387nm at nighttime. Based on the signal ratio of Raman water vapor to Raman nitrogen, the system offers water vapor mixing ratio profiles.

(4) Results

The lidar system observed the lower atmosphere throughout the cruise, except on EEZs and territorial waters without permission. All data will be reviewed after the cruise to maintain data quality.

(5) Data Archive

All data obtained during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

3.16 GNSS Precipitable Water

(1) Personnel

<i>Fumikazu Taketani (JAMSTEC)</i>	<i>not on board</i>
<i>Masaki Katsumata (JAMSTEC)</i>	<i>not on board</i>
<i>Mikiko Fujita (JAMSTEC)</i>	<i>not on board</i>

(2) Objective

Getting the GNSS satellite data to estimate the total column integrated water vapor content of the atmosphere.

(3) Method

The GNSS satellite data was archived to the receiver (Trimble NetR9) with 5 sec interval. The GNSS antenna (Margrin) was set on the roof of aft wheel house. The observations were carried out all thru the cruise.

(4) Results

We will calculate the total column integrated water from observed GNSS satellite data after the cruise.

(5) Data archive

Raw data is recorded as T02 format and stream data every 5 seconds. These raw datasets are available from Mikiko Fujita of JAMSTEC. Corrected data will be submitted to JAMSTEC Marine-Earth Data and Information Department and will be archived there.

3.17 Sea Surface Gravity

(1) Personnel

Akihiko MURATA *JAMSTEC: Principal investigator*
Ryo OYAMA *Nippon Marine Enterprises LTD. (NME)*
Masanori MURAKAMI *NME*
Takehito HATTORI *MIRAI crew*

(2) Objective

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data during this cruise.

(3) Apparatus

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during the cruise. To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (Scintrex gravity meter CG-5), at Shimizu and Valparaiso port as the reference points. The parameters for gravity calculation are as follows;

Relative Gravity [CU: Counter Unit]
[mGal] = (coefl: 0.9946) * [CU]

(4) Preliminary Results

Absolute gravity table is shown in Table 3.17.1

Table 3.17.1 Absolute gravity table of the MR18-06Leg1 cruise

No.	Date & Time (UTC)	Port	Absolute Gravity	Sea Level [mGal]	Ship Draft [cm]	Gravity at Sensor * [mGal]	S-116 Gravity [mGal]
#1	10-Dec-18 20:50 12010.42	Shimizu	979729.06	184	658	979729.91	
#2	13-Jan-19 18:51	Valparaiso	979619.32	294	625	979620.44	11903.97

* Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.2654

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.

<http://www.godac.jamstec.go.jp/darwin/e>

(6) Remarks

1. The following period, data acquisitions were stopped for cruising in the EEZ of the foreign countries.

13:45UTC 20 Dec. 2018 - 22:25UTC 21 Dec. 2018

00:00UTC 10 Jan. 2019 - 12 Jan. 2019 (Arrival at Valparaiso)

3.18 Sea Surface Magnetic Field

(1) Personnel

Akihiko MURATA *JAMSTEC: Principal investigator*
Ryo OYAMA *Nippon Marine Enterprises LTD. (NME)*
Masanori MURAKAMI *NME*
Takehito HATTORI *MIRAI crew*

(2) Objective

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during this cruise.

(3) Apparatus

A shipboard three-component magnetometer system (SFG2018, Tierra Tecnica) is equipped on-board R/V MIRAI. Three-axes flux-gate sensors with ring-cored coils are fixed on the fore mast. Outputs from the sensors are digitized by a 20-bit A/D converter (1 nT/LSB), and sampled at 8 times per second. Yaw (heading), Pitch and Roll are measured by the Inertial Navigation System (INS) for controlling attitude of a Doppler radar. Ship's position (Differential GNSS), speed over ground and gyro data are taken from LAN every second.

The relation between a magnetic-field vector observed on-board, $\mathbf{H}_{ob}$, (in the ship's fixed coordinate system) and the geomagnetic field vector, $\mathbf{F}$, (in the Earth's fixed coordinate system) is expressed as:

$$\mathbf{H}_{ob} = \tilde{\mathbf{A}} \tilde{\mathbf{R}} \tilde{\mathbf{P}} \tilde{\mathbf{Y}} \mathbf{F} + \mathbf{H}_p \quad (a)$$

where $\tilde{\mathbf{R}}$, $\tilde{\mathbf{P}}$ and $\tilde{\mathbf{Y}}$ are the matrices of rotation due to roll, pitch and heading of a ship, respectively. $\tilde{\mathbf{A}}$ is a 3 x 3 matrix which represents magnetic susceptibility of the ship, and $\mathbf{H}_p$ is a magnetic field vector produced by a permanent magnetic moment of the ship's body. Rearrangement of Eq. (a) makes

$$\tilde{\mathbf{B}} \mathbf{H}_{ob} + \mathbf{H}_{bp} = \tilde{\mathbf{R}} \tilde{\mathbf{P}} \tilde{\mathbf{Y}} \mathbf{F} \quad (b)$$

where $\tilde{\mathbf{B}} = \tilde{\mathbf{A}}^{-1}$, and $\mathbf{H}_{bp} = -\tilde{\mathbf{B}} \mathbf{H}_p$. The magnetic field, $\mathbf{F}$, can be obtained by measuring $\tilde{\mathbf{R}}$, $\tilde{\mathbf{P}}$, $\tilde{\mathbf{Y}}$ and $\mathbf{H}_{ob}$, if $\tilde{\mathbf{B}}$ and $\mathbf{H}_{bp}$ are known. Twelve constants in $\tilde{\mathbf{B}}$ and $\mathbf{H}_{bp}$ can be determined by measuring variation of $\mathbf{H}_{ob}$ with $\tilde{\mathbf{R}}$, $\tilde{\mathbf{P}}$, and $\tilde{\mathbf{Y}}$ at a place where the geomagnetic field, $\mathbf{F}$, is known.

(4) Preliminary Results

The results will be published after the primary processing.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.

<http://www.godac.jamstec.go.jp/darwin/e>

(6) Remarks

1. The following period, calibration data were collected.

21:58UTC 14 Dec. 2018 - 22:33UTC 14 Dec. 2018 (29-58.92N, 160-17.35E)

07:05UTC 23 Dec. 2018 - 07:45UTC 23 Dec. 2018 (12-26.04N, 160-42.97W)

23:05UTC 31 Dec. 2018 - 23:35UTC 31 Dec. 2018 (12-56.56S, 125-05.55W)

19:01UTC 07 Jan. 2019 - 19:28UTC 07 Jan. 2019 (27-06.00S, 92-05.25W)

2. The following period, data acquisitions were stopped for cruising in the EEZ of the foreign countries.

13:45UTC 20 Dec. 2018 - 22:25UTC 21 Dec. 2018

00:00UTC 10 Jan. 2019 - 12 Jan. 2019 (Arrival at Valparaiso)

4. Floats and Drifters

4.1 Argo Floats

(1) Personnel

<i>Shuhei Masuda (JAMSTEC)</i>	<i>Principal Investigator (not on board)</i>
<i>Shigeki Hosoda (JAMSTEC)</i>	<i>not on board</i>
<i>Mizue Hirano (JAMSTEC)</i>	<i>not on board</i>
<i>Masanori Enoki (MWJ)</i>	<i>on board</i>

(2) Objective

The objective of this study is to clarify the mechanisms of climate and oceanic environment variability for understanding changes of earth system through estimations of heat and material transports, and to improve climate forecasts of, by sustainably monitoring in the global ocean. To achieve the objective, automatically long-term measurements of physical parameters are carried out to deploy Argo floats in the eastern South Pacific Ocean where the spatial density of Argo floats tends to be sparse due to a lack of deployment opportunities by ship cruise. The Argo floats contribute to construct and maintain the global Argo observing system in collaboration with lots of countries. The Argo floats will detect detailed spatial and temporal changes of physical environment, as well as long-term climate change signals by analyzing globally covered Argo floats.

Also, the aim of deep Argo float deployment (one Deep NINJA and two Deep APEXs) is to clarify changes of deep ocean environment below 4000 m depth, contributing to the deep Argo observing system which started to construct since 2015. Recent climate change reports (e.g., IPCC AR5) documented that the deep ocean plays an important role of the global warming to accumulate huge heat from atmosphere, however, detailed mechanisms are still unknown because of less amount of observation. Since deep Argo float can obtain frequent temperature and salinity profiles with fine vertical resolution, accurate climate variability in the deeper ocean associated with circulation and water mass will be captured in collaboration with other deep Argo floats in the framework of the deep Argo observing system. Since some technical issues on deep Argo floats are investigated at this time, the deployed deep Argo floats will certainly contribute to improve the issues with accurate ship observation.

The deep Argo and Argo float data will also apply to the ESTOC, which is 4D-VAR data assimilation system to estimate state of global ocean for climate changes, to investigate whole mechanism of long-term changes in the ocean.

(3) Parameters

- Water temperature, salinity and pressure.

(4) Methods

i. Argo profiling float

We launched APEX float manufactured by Teledyne Webb Research. This float equips SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc. The float drifts at a depth of 1000 dbar (called the parking depth) during waiting measurement, then goes upward from a depth of 2000 dbar to the sea surface every 10 days. During the ascent, physical values are measured every 2 dbar in advance following depth table. During surfacing for approximately half an hour, the float sends all measured data to the land via the Iridium RUDICS telecommunication system. The lifetime of floats is expected to be about four~seven years. The status of float and its launching information is shown in Table 4. 1.

Table 4. 1 Status of floats and their launches

Float Type	APEX float manufactured by Teledyne Webb Research.
CTD sensor	SBE41 manufactured by Sea-Bird Electronics Inc.
Cycle	every 10 day (approximately 30minutes at the sea surface)
Iridium transmit type	Router-Based Unrestricted Digital Internetworking Connectivity Solutions (RUDICS)
Target Parking Pressure	1000 dbar

Sampling layers 2dbar interval from 2000 dbar to surface (approximately 1000 levels)

Launches Float S/N	WMOID	Date and Time of Launch (UTC)	Location of Launch		Type of Float
8514	5905835	2018/12/23 6:57	12.4307[N]	160.7182[W]	APEX
8513	5905836	2018/12/24 21:56	8.02[N]	155.0038[W]	APEX
8515	5905837	2018/12/25 22:23	4.5722[N]	151.0807[W]	APEX
8523	5905838	2018/12/27 1:50	1.7067[N]	146.2112[W]	APEX
8520	5905839	2018/12/28 16:57	3.3278[S]	139.535[W]	APEX
8516	5905840	2018/12/30 20:57	9.9627[S]	130.0462[W]	APEX
8517	5905841	2019/1/2 0:22	15.9282[S]	120.1268[W]	APEX
8518	3902388	2019/1/3 1:53	18.5217[S]	114.9533[W]	APEX
8519	3902389	2019/1/4 2:25	20.9975[S]	109.991[W]	APEX
8521	3902390	2019/1/5 0:56	22.7847[S]	105.5338[W]	APEX
8522		2019/1/6 1:55	24.6538[S]	100.7902[W]	APEX

ii. Deep NINJA

We also launched Deep float (Deep NINJA) manufactured by The Tsurumi-Seiki Co., Ltd. This float equips SBE41cp CTD for deep sensor manufactured by Sea-Bird Electronics Inc. The float drifts at a depth of 2000 dbar (called the parking depth) during waiting measurement, then goes upward from a depth of 4000 dbar to the sea surface every 10 days. During the ascent, physical values are measured at decided depths in advance following depth table. During surfacing for approximately half an hour, the float sends the all measured data to the land via the Iridium SBD telecommunication service. The float lifetime is expected to be about four years. The status of float and its launching information is shown in Table 4.2.

Table 4. 2 Status of floats and their launch of Deep Float (Deep NINJA)

Float Type	Deep NINJA float manufactured by The Tsurumi-Seiki Co., Ltd..
CTD sensor	SBE41 deep manufactured by Sea-Bird Electronics Inc.
Cycle	every 10 day (approximately 30minutes at the sea surface)
Iridium transmit type	Short Burst Data (SBD)
Target Parking Pressure	2000 dbar
Sampling layers	5dbar interval from 4000 dbar to surface (approximately 800 levels)

Float S/N	WMOID	Date and Time of Launch (UTC)	Location of Launch		Type of Float
d00027	5905846	2018/12/30 21:05	9.9642[S]	130.007[W]	Deep NINJA

iii. Deep APEX

In this cruise, we launched other two deep floats (Deep APEX) manufactured by Teledyne Webb Research. This float equips SBE61 CTD for deep observation manufactured by Sea-Bird Electronics Inc. The float drifts at a depth of 2000 dbar (called the parking depth) during waiting measurement, then goes upward from a depth of 6000 dbar to the sea surface every 10 days. During the ascent, physical values are measured at fixed depths in advance following a depth table. During surfacing for approximately half an hour, the float sends the all measured data to the land via the Iridium RUDICS telecommunication service. The lifetime of Deep APEXs will be about four years. The status of float and its launching information is shown in Table 4. 3.

Table 4. 3 Status of floats and their launches of Deep Floats (Deep APEX)

Float Type	Deep APEX float manufactured by Teledyne Webb Research.
CTD sensor	SBE61 manufactured by Sea-Bird Electronics Inc.
Cycle	every 10 day (approximately 30minutes at the sea surface)
Iridium transmit type	Router-Based Unrestricted Digital Internetworking Connectivity Solutions (RUDICS)

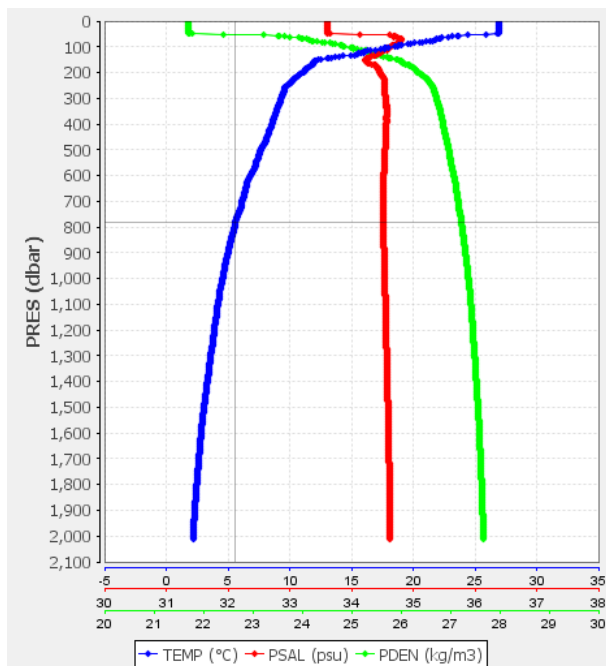
Target Parking Pressure	2000 dbar
Sampling layers	2dbar interval from 6000 dbar to surface. (approximately 3000 levels in maximum)

Launches

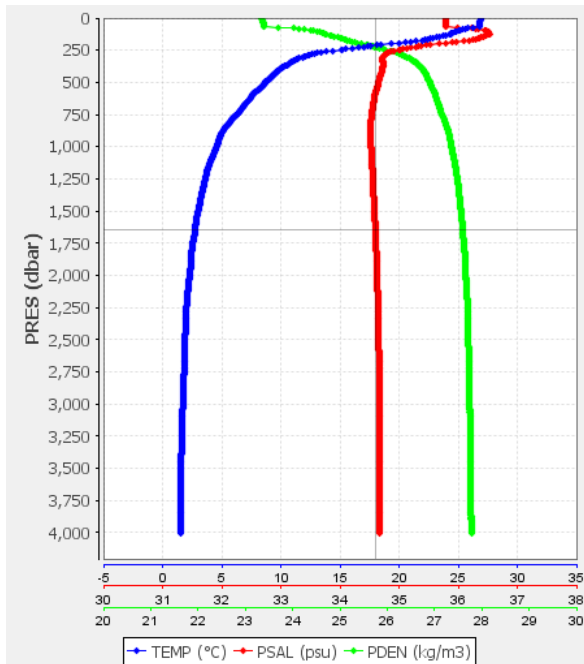
Float S/N	WMOID	Date and Time of Launch (UTC)	Location of Launch		Type of Float
00041	5905842	2018/12/29 17:58	6.546[S]	134.9197[W]	Deep APEX
00042	5905843	2018/12/31 22:58	12.9392[S]	125.1017[W]	Deep APEX

(5) Data archive

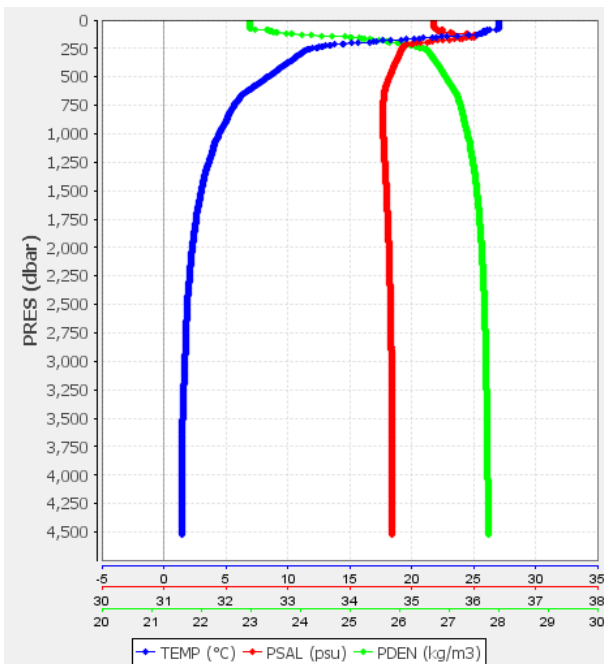
The Argo float data will be provided to meteorological organizations, research institutes, and universities, conducting the real-time quality control within 24 hours following the procedure decided by Argo data management team. Then the delayed mode quality control will be conducted within 6 months ~ 1 year, to satisfy their data accuracy for climate research use. Those quality controlled data of Argo and deep Argo floats are freely available via internet and utilized for not only research use but also weather forecasts and any other variable uses through internet from Global Data Assembly Center (GDAC: <http://www.usgoda.gov/argo/argo.html>, <http://www.coriolis.eu.org/>) and Global Telecommunication System (GTS).



S/N: 8514
WMO ID: 5905835
DATE: 2018/12/23 09:58:17
LOCATION: 12.444[N] 160.747[W]
Float of Type: APEX



S/N: 27
WMO ID: 5905846
DATE: 2019/01/01 00:44
LOCATION: 9.963[S] 130.138[W]
Float of Type: Deep NINJA



S/N: 0041
WMO ID: 5905842
DATE: 2019/01/01 12:02:40
LOCATION: 6.562 [S] 135.014 [W]
Float of Type: Deep APEX

Fig. 4.5. Vertical profiles of first measurements on launched Argo float and deep Argo floats.
(Blue:Temperature(degC) Red:Salinity(psu) Green:Density)

4.2 Drifting Buoys with Hydrophone

(1) Personnel

Masayuki Obayashi (JAMSTEC)

(2) Objective

There are two huge mantle plumes from the base of the mantle below the South Pacific and Africa. The South Pacific plume is considered to be associated with hot spot volcanoes and massive eruptions 120 millions years ago that produced Ontong Java plateau, the most voluminous Large Igneous Province on the oceanic region. Because Mantle plumes carry mass and heat from the core-mantle boundary to the surface, they can influence the global heat budget of the earth and mantle cooling through earth's history. Imaging the detail of the mantle plume is the key to understand the mantle dynamics. To obtain a robust seismic image, we shall obtain seismic data from regions of the Pacific Ocean that have never been sampled before, by using a new type of seismological instrument: drifting buoy with hydrophone. Under an international project collaborated among Japan, France, United States and China, we plan to deploy more than 40 drifting buoys with hydrophone. As part of this project, we deployed drifting buoys in the South Pacific during the 1st leg of MR18-06 cruise.

(3) Apparatus

The drifting hydrophone buoy was constructed by OSEAN Corporation. This buoy is an autonomous robotic seismic float equipped a hydrophone to measure water pressure change converted from seismic P-wave at seafloor. The buoy drifts passively at 1,500 – 2,000 m depth until an earthquake signal is detected. If this is identified as a strong P wave, the buoy ascends at speed of 10 cm/s for transmission of the recorded waveform within time window of a hundred seconds before and after the P wave arrival as well as its global positioning system (GPS) coordinates at the surface. After transmitting the data via satellite links, the buoy descends at speed of 5 cm/s to monitor earthquake signals at 2,000 – 3,000 m depth again. The specification of drifting hydrophone buoy is as Table 4.2.1.

Table 4.2.1 Specification of drifting hydrophone buoy

Items	Specification
Size	Diameter: 630 mm, Height: 1310 mm
Weight	65 kg
Depth Rating	2000 m
Positioning	GPS
Battery	Primary lithium battery
Acoustic range	0.1 – 10 Hz
Full scale sound pressure level	180 dB ref 1 μ m
Resolution	24 bits

(4) Results

We injected 5 drifting hydrophone buoys into the South Pacific. We deployed them during the cruise of R/V *Mirai* (leg 1 of MR18-06) (Figs. 4.2.1), and started data acquisition through a satellite communication system.

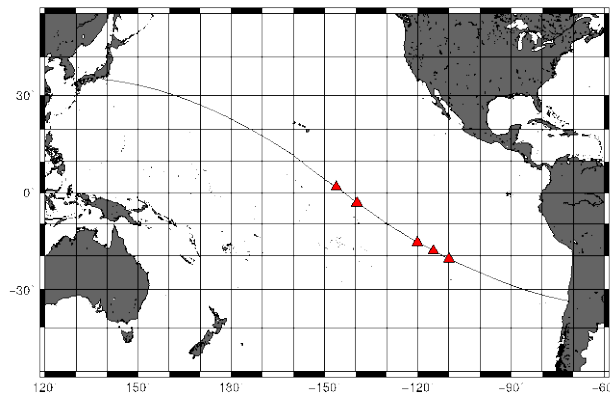


Fig. 4.2.1. Positions (triangles) of drifting hydrophone buoys injected during the R/V *Mirai* cruise.

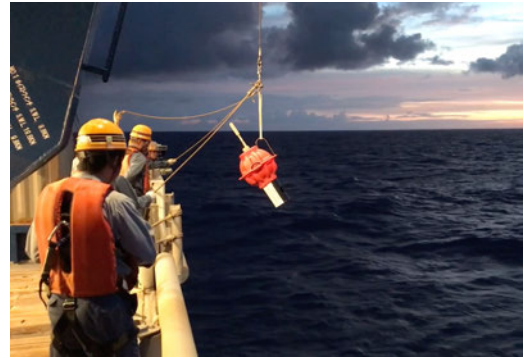


Fig. 4.2.2. Drifting hydrophone buoy deployed from the R/V *Mirai* using it's A frame.

4.3 Drifting Buoys with CO₂ Sensor

(1) Personnel

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(2) Objective

It is said that the ocean takes up approx. 30% of CO₂ emitted into the atmosphere by human activities such as fossil fuel burning, deforestation, cement production, etc. Thus accurate estimation of CO₂ uptake by the ocean is an important task in predicting global warming and related climate changes, because the ocean tends to moderate the warming by absorbing anthropogenic CO₂ from the atmosphere. Calculation of air-sea fluxes of CO₂ is one of straightforward methods to estimate the CO₂ uptake. Data for surface seawater partial pressure of CO₂ (pCO₂) are necessary for the calculation. Surface seawater pCO₂ data covering the world ocean have been collected by such an international activity as Surface Ocean Carbon Dioxide Atlas (SOCAT). However, in spite of the long-term effort over 40 years, a large data gap is still found in the Southern Hemisphere oceans, especially in the South Pacific. This is because the ocean is far away from pCO₂ observations-leading countries, i.e., difficult to do observations by research vessels due to high cost, and because there scarcely exist regular lines of cargo ships, along which pCO₂ observations have been conducted. Drifting buoys with pCO₂ sensor are free from the limitation. Therefore we deployed drifting buoys in the South Pacific during the 1st leg of MR18-06 cruise.

(3) Apparatus

The drifting pCO₂ buoy was constructed by NiGK Corporation. The specification of drifting CO₂ buoy is as Table 4.3.1.

Table 4.3.1 Specification of drifting buoy with CO₂ sensor

Items	Specification
Size	Diameter: 315 mm (max.), Height: 575 mm
Weight	8.6 kg
Pressure proof	5 m
Positioning	GPS
Battery	Primary lithium battery
CO ₂ range	150 – 1000 ppm
CO ₂ resolution	< 1 ppm
Accuracy	< 1.5%

(4) Results

We injected 2 drifting CO₂ buoys into the South Pacific, where a large data gap exists. We deployed them during the cruise of R/V *Mirai* (leg 1 of MR18-06) (Table 4.3.2 and Fig. 4.3.1), and started data acquisition through a satellite communication system.

Table 4.3.2 Deployment of drifting buoys with CO₂ sensor

S/N	ARGOS ID	Date (UTC)	Time (UTC)	Longitude	Latitude
18019	160856	6 January, 2019	19:25	97°02'W	25°35'S
18020	132482	7 January, 2019	12:57	93°18'W	26°40'S

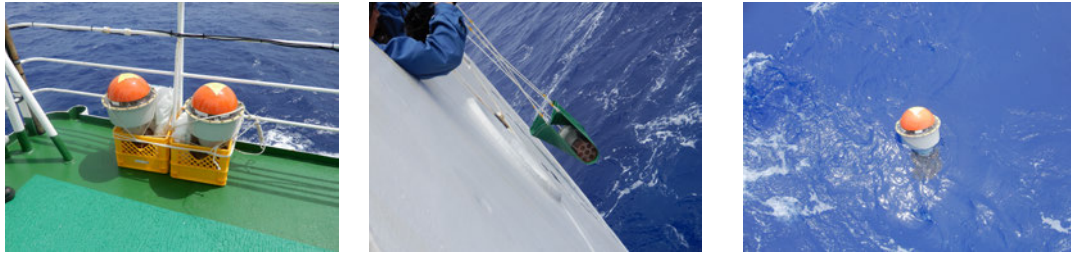


Fig. 4.3.1 (a) checking of GPS response, (b) deployment of the buoy with a sheet, and (c) a buoy on the sea surface.

IV. Notice on Using

This cruise report is a preliminary documentation as of the end of cruise.

This report is not necessarily corrected even if there is any inaccurate description (i.e. taxonomic classifications). This report is subject to be revised without notice. Some data on this report may be raw or unprocessed. If you are going to use or refer the data on this report, it is recommended to ask the Chief Scientist for latest status.

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