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MIRAI MR14-06 Leg1 Cruise Report

Tropical ocean climate study in the Indian and Pacific Ocean/Study of structure and formation process of the Ontong Java Plateau/Operation of Triton buoy

Nov. 4, 2014-Dec. 18, 2014

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

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1. Cruise Information

●Cruise code: MR14-06 Leg1

●Vessel: R/V MIRAI

●Cruise title: Tropical ocean climate study in the Indian and Pacific Ocean/Study of structure and formation process of the Ontong Java Plateau/Operation of Triton buoy

●Chief Scientist: Daisuke Suetsugu

Director, Department of Deep Earth Structure and Dynamics Research

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

●Representative of the Science Party:

Daisuke Suetsugu (Japan Agency for Marine-Earth Science and Technology)

Yugo Kanaya (Japan Agency for Marine-Earth Science and Technology)

Kazuma Aoki (Toyama University)

Masaki Katsumata (Japan Agency for Marine-Earth Science and Technology)

Takeshi Matsumoto (Ryukyu University)

Toshio Suga (Japan Agency for Marine-Earth Science and Technology)

Takeshi Hanyu (Japan Agency for Marine-Earth Science and Technology)

Shuji Kawakami (Japan Aerospace Exploration Agency)

●Research titles

*Study of structure and formation process of the Ontong Java Plateau (D. Suetsugu)

*Applied research of MIRAI brand-new shipboard weather radar: Validation and utilization of dual-polarization information for global deployment (M. Katsumata)

*Global distribution of drop size distribution of precipitating particles over pure-oceanic background (M. Katsumata)

*The study of the ocean circulation and the transport of heat and fresh water in the Pacific Ocean using by Argo floats (T. Suga)

*Advanced continuous measurements of aerosols in the marine atmosphere: Elucidation of the roles in the Earth system (Y. Kanaya)

*Search for the basement rocks of Ontong Java Plateau (T. Hanyu)

*Shipboard CO_2 observations over the tropical Indo-Pacific Ocean for a simple estimation of the carbon flux between the ocean and the atmosphere from GOSAT data (S. Kawakami)

*Aerosol optical characteristics measured by Ship-borne Sky radiometer (K. Aoki)

*Standardisation of marine geophysical data and its application to geodynamics studies (T. Matsumoto)

● Cruise period: Nov. 4, 2014~Dec. 18, 2014

● Ports of departure: Sekinehama, Japan; Port of arrival: Chuuk Island, Federated States of Micronesia

● Research area: 10°S-10°N, 150°E-175°E, The Pacific Ocean in and around the Ontong Java Plateau

● Research Map

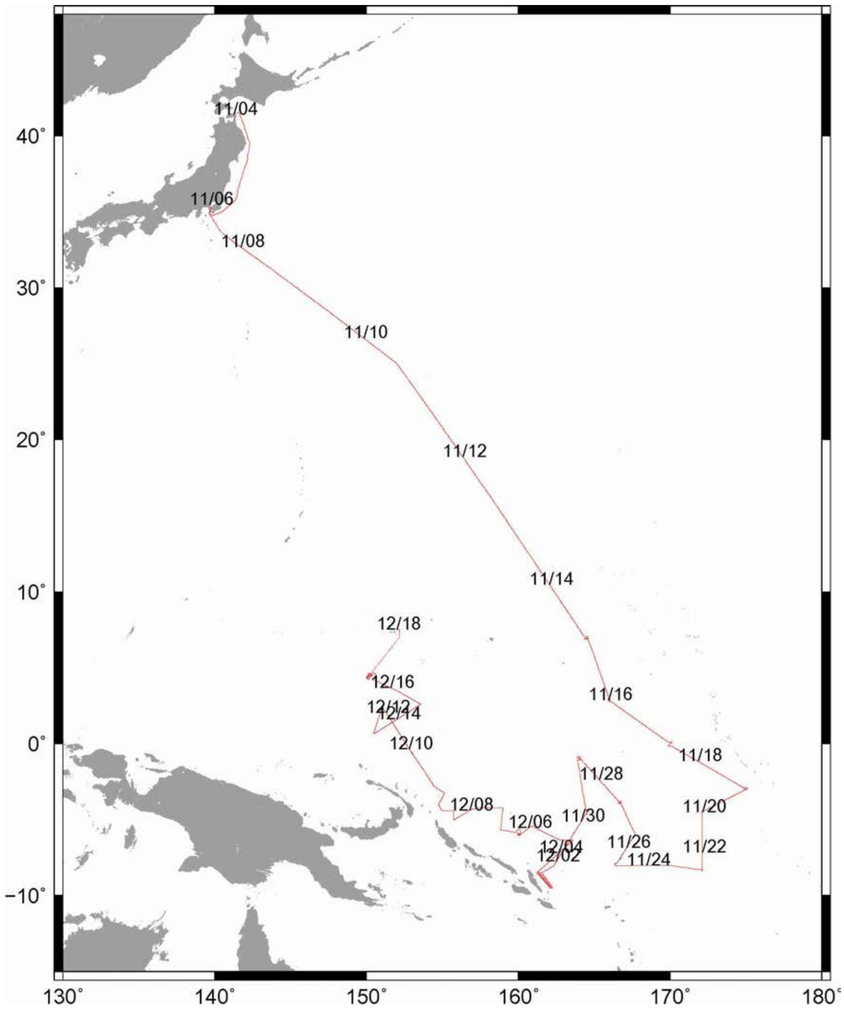

Fig. 1-1 Cruise track

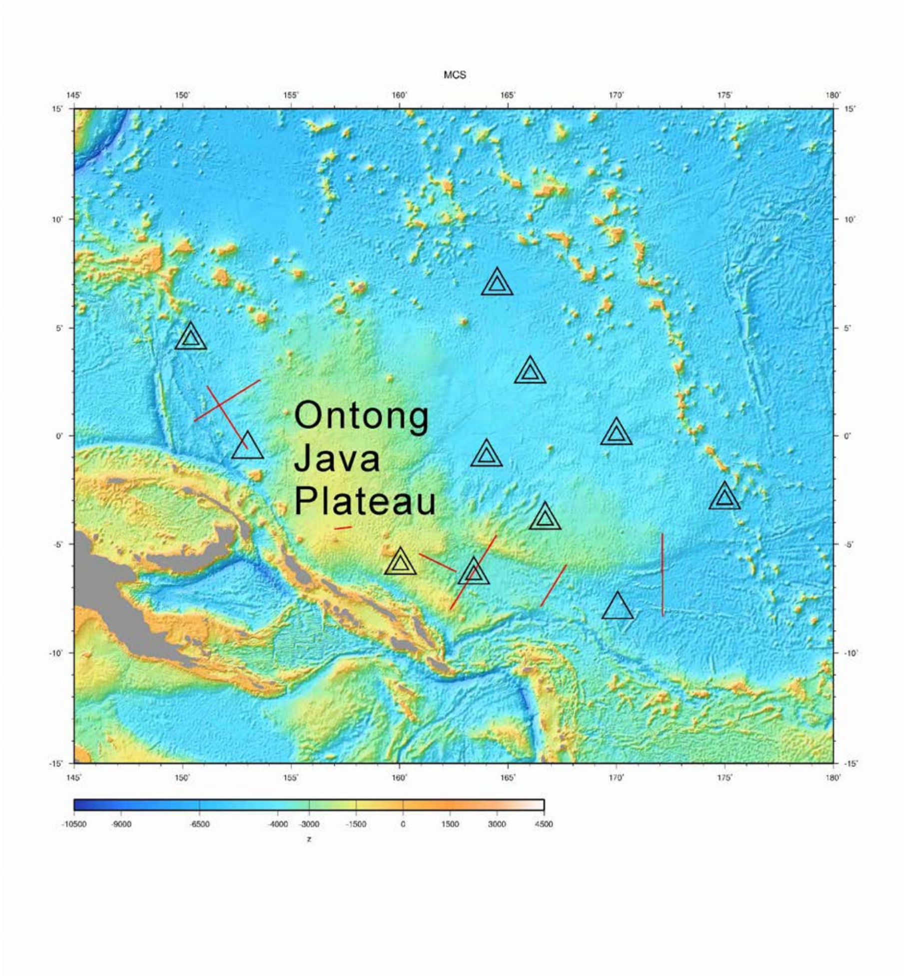

Fig. 1-2 Observation area. Triangle: Location of Ocean Bottom Seismograph (OBS); Double triangle: Location of OBS and Ocean Bottom Electromagnetometer (OBEM); Red line: MCS survey line

2. Background, purpose, and summary of the research cruise

The Ontong Java Plateau (OJP) is the most voluminous Large Igneous Province on the oceanic region of the Earth, which was emplaced at 120 million years ago by massive eruptions. The volcanic eruption gave major environmental impacts, such as global climate change. However, the cause of the eruption remains to be controversial due to a lack of the underground structure beneath the OJP. One of the main missions of the project is to determine the underground structure beneath the OJP with an unprecedented accuracy.

For the purpose, we planned to deploy 23 ocean bottom seismographs (OBS) and 20 ocean bottom electromagnetometers (OBEM) on the seafloor in and around the OJP during the Leg1 and Leg2 of the MR14-06 cruise for determination of crust and upper mantle structure beneath the OJP. In the Leg1, we deployed 11 OBS and 9 OBEM among all. The OBS and OBEM can continuously record an electromagnetic field and ground motions due to natural earthquakes. The data are stored in the ocean bottom instruments, which are planned to be recovered in 2016. The data will be used to determine three-dimensional seismic and electrical conductivity structure, respectively. We also conducted active-source high-resolution multichannel seismic reflection survey, multi-beam echo sounding survey, sea-bottom reflectivity survey, gravity and magnetic surveys to study detailed shallow crustal and seafloor structure, which should provide valuable information on the origin of the OJP and the evolution process. A detailed survey was conducted near young seamounts and subduction zone to find exposed basements.

Another main mission of the R/V MIRAI MR14-06 cruise is to observe oceanographic and atmospheric conditions in the tropical western Pacific to achieve a better understanding of air-sea interaction over this region and its related climate change. To achieve this purpose, we will also perform the following researches along the cruise track: Observation of aerosols and trace gases in the atmosphere, which is important for global climate change, to analyze transport from the Asian continent to the ocean environment along the winter monsoon; observation of precipitating clouds in ambient atmospheric and oceanic situations to better estimate precipitation amount by utilizing ship-borne and satellite-borne radars; acquisition of the validation data over sea for Greenhouse gases Observing SATellite (GOSAT) using an automated compact instrument; installation of ARGO profiling floats to obtain vertical profiles of sea temperatures and conductivity.

3. List of participants

Principal Investigator: Dr. Daisuke Suetsugu

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Table 3-1. Science party

Name	Affiliation	Appointment
Daisuke Suetsugu	Department of Deep Earth Structure and Dynamics Research, JAMSTEC	Director, scientist
Hiroko Sugioka	Department of Deep Earth Structure and Dynamics Research, JAMSTEC	Scientist
Noriko Tada	Department of Deep Earth Structure and Dynamics Research, JAMSTEC	Research scientist
Hiroshi, Ichihara	Department of Deep Earth Structure and Dynamics Research, JAMSTEC	Research scientist
Takehi Isse	Earthquake Research Institute, the University of Tokyo	Scientist
Shoka Shimizu	Department of Deep Earth Structure and Dynamics Research, JAMSTEC	Research student
Shungo Oshitani	MWJ	Technical Staff
Tatsuya Tanaka	MWJ	Technical Staff
Tomonori Watai	MWJ	Technical Staff
Masahiro Orui	MWJ	Technical Staff
Wataru Tokunaga	GODI.	Technical Staff
Miki Morioka	GODI.	Technical Staff
Koichi Inagaki	GODI.	Technical Staff
Makoto Ito	NME.	Technical Staff
Yuta Watarai	NME.	Technical Staff
Naoto Noguchi	NME.	Technical Staff
Ryo Miura	NME.	Technical Staff
Akie Suzuki	NME.	Technical Staff
Haruhiro Shibata	NME.	Technical Staff

JAMSTEC: Japan Agency for Marine-Earth Science and Technology

GODI: Global Ocean Development Inc.

MWJ: Marine Work Japan Ltd.
NME: Nippon Marine Enterprises Inc.

4. Deployment of ocean bottom seismograph (BBOBS)

(1) Personnel

Daisuke Suetsugu (PI, JAMSTEC)
Hiroko Sugioka (JAMSTEC)
Takehi Isse (Earthquake Research Institute, the University of Tokyo)
Wataru Tokunaga (Global Ocean Development, Ltd.)
Miki Morioka (Global Ocean Development, Ltd.)
Koichi Inagaki (Global Ocean Development, Ltd.)

(2) Objectives

We deployed eleven OBSs to determine seismic structure of the crust and mantle beneath the OJP region and its vicinity.

(3) Instruments and method

The OBS system used in the present study had been developed as a new portable broadband ocean bottom instruments, under the Ocean Hemisphere network Project in 1996-2001 (Fukao et al., 2001). We have practiced more than 150 long-term OBS experiments since 1999.

An OBS unit is deployed by free-fall and recovered by a self-pop-up system, designed to rise from the seafloor after receipt of an acoustic command. The OBS with a three-component CMG-3T broadband sensor (Guralp Systems Ltd.) senses ground motions at periods from 0.02 to 360 s with a sampling rate of 100 Hz at 24-bit resolution. All of the seismic instrument components including the sensor, data logger (LS-9100; Hakusan Ltd.), transponder (SI-2; Kaiyodenshi Ltd.) and batteries (Li cells) are packed into a 65-cm diameter titanium alloy pressure housing, which allows for a maximum operating depth of 6000 m. The system runs for as long as 1.5 years to ensure long-term seismic observations. The principal specifications are summarized in Table 4.1. The deployed OBSs (see Photo 4-1) have been already recording (the observation period of 630 days). The information of each station is listed in Table 4.2.

Locations of the deployed OBS (and OBEM) are listed in Table 5.3 and Fig. 5.1. Bathymetry maps of the OBSs (and OBEMSs) stations are shown in Fig. 5.2.

Table 4.1 Specification of the OBS

Outside	
Size	1 m x 1 m x 0.7 m (Width x Depth x Height)
Weight in air	250 kg (with anchor), 160 kg (without anchor)
Pressure case	Sphere shaped titanium alloy pressure housing (Diameter=65 cm, Buoyancy=70 kg)
Releasing mechanism	Forced electric corrosion of two thin titanium plates (Thickness=0.4 mm) (Mitsuya Ltd.)
Recovery control	Acoustic transponder system with recorder communication (SI-2, Kaiyodenshi Ltd.)
Recovery aids	Radio beacon (160 MHz band) and Xenon flasher with the pressure switch (Novatech Ltd.)
Inside	
Sensor	CMG-3T for ocean bottom seismograph (Guralp System Ltd.) on the active leveling gimbal unit (Katsujima Ltd.) Period: 360 s ~ 50 Hz Sensitivity: 1500 V/m/s Gimbal works up to 20 degree in tilting
Recorder	LS-9100 series (Hakusan Ltd.) (a) LS-9100-T3H (with TCXO of crystal oscillator) (b) LS-9100-A4H (with CSAC of atomic clock) A/D: 24 bit (0~5V) delta-sigma ADC Sampling: 100 Hz sampling Data format: Win format compression (1 day-long file) Data media: SD memory cards of 64 GB; Set up 2 cards in mirroring modes for redundancy
Clock precision	TCXO: < ±1 ppm/year CSAC: < ± 0.0003 ppm/month
Power supply	DD-size lithium cells (Exium SC-DD01ST, 3.9V, 30 Ah) D-size lithium cells (Electrochem 3B-35ST, 3.9V, 15 Ah) Sensor: 14 parallels (4 series (DD-size) =14.4V, 420 Ah) Recorder: 10 parallels (3 series (DD-size) =10.9V, 300 Ah) Gimbal: 2 parallel (2 series (DD-size) + 2 series (D-size); 7.2 V, 45 Ah) Backup clock: 4 parallels (for CSAC, DD-size, 3.6 V, 120 Ah);

	8 parallels (for TCXO, DD-size, 3.6 V, 240 Ah)
Power consumption	Sensor: 360 mW Recorder: 140 mW (TCXO); 188 mW (CSAC) Gimbal: 14 mW Backup clock: 40 mW

Table 4.2 Information of deployed OBS

Site	Clock type	Tx code	Radio freq. [MHz]	S/N of Seismograph	Gimbal controller	Date of deployment (LT)	Date ended of recoding (UT)
O4	CSAC	813	159.200	T35594	SISEI312	2014/12/16	2016/09/06
O5	TCXO	539	159.300	T3H79	SISEI307’	2014/12/09	2016/08/31
O15	TCXO	537	159.250	T3H55	SISEI308	2014/12/06	20146/08/27
O16	CSAC	810	159.350	T36786	SISEI308	2014/12/04	2016/08/25
O17	TCXO	504	159.150	T3D25	SISEI307’	2014/11/28	2016/08/19
O18	TCXO	502	159.300	T3C08	SISEI307’	2014/11/27	2016/08/18
O19	CSAC	812	159.300	T3D15	SISEI308	2014/11/24	2016/08/15
O20	CSAC	802	159.200	T3C05	SISEI308	2014/11/19	2016/08/10
O21	TCXO	515	159.300	T33854	SISEI310	2014/11/17	2016/08/09
O22	CSAC	816	159.150	T3M66	SISEI312	2014/11/16	2016/08/07
O23	TCXO	513	159.250	T3D14	SISEI308	2014/11/15	2016/08/06

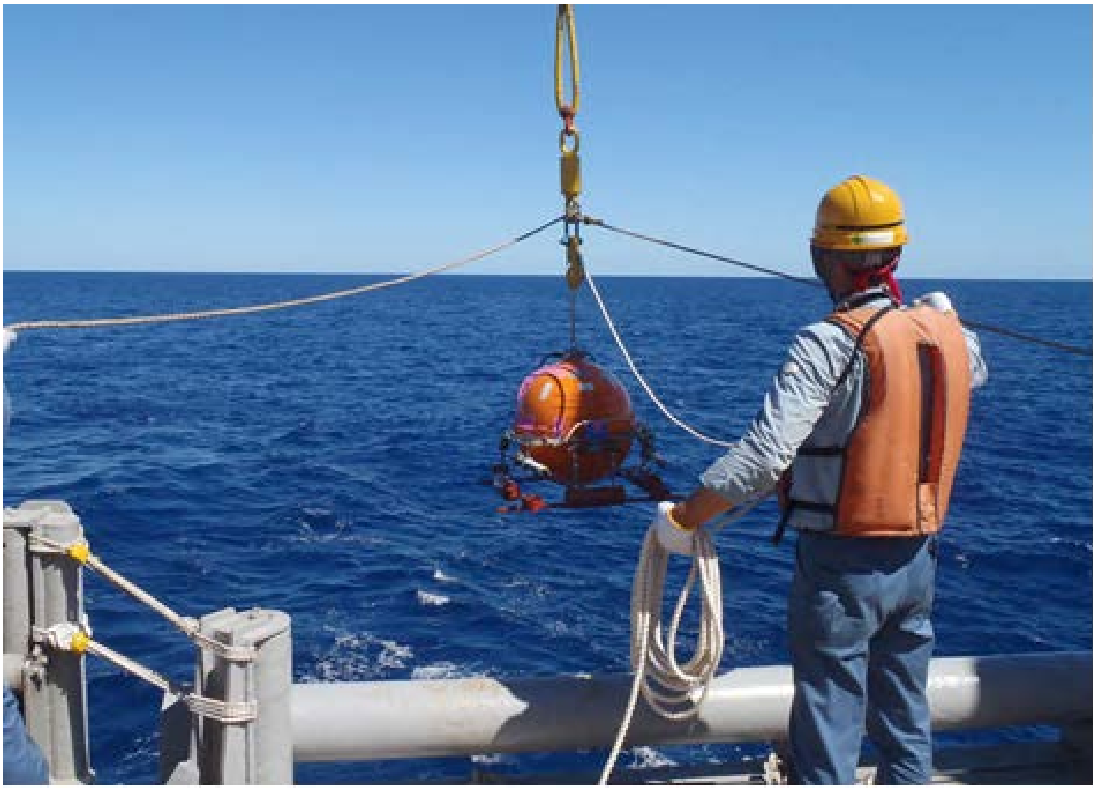


Photo 4-1 The OBS launching at the stern.

5. Deployment of ocean bottom electromagnetometers (OBEMs)

(1) Personnel

Daisuke Suetsugu (PI, JAMSTEC)
Noriko Tada (JAMSTEC)
Hiroshi Ichihara (JAMSTEC)
Wataru Tokunaga (Global Ocean Development, Ltd.)
Miki Morioka (Global Ocean Development, Ltd.)
Koichi Inagaki (Global Ocean Development, Ltd.)

(2) Objectives

We deployed nine OBEM to investigate electrical conductivity structure of the crust and mantle beneath the OJP and its vicinity.

(3) Instruments and method

The OBEM system can measure time variations of three components of magnetic field, horizontal electric field, the instrumental tilts, and temperature. The resolutions are 0.01 nT for fluxgate magnetometer, 0.305 μV using 16 bit A/D converter or 0.01μV using 24 bit A/D converter for voltmeter, 0.00026 degrees for tiltmeter, and 0.01 °C for thermometer. We used two types of OBEM; two-glass sphere type (Type A) and one-glass sphere type (Type B). Type A has two pressure-resistant 17-inch glass spheres; one contains the electromagnetometer and the other contains an acoustic transponder and a Lithium battery pack (Photo 5-1). Type B consists of one pressure-resistant 17-inch glass sphere, a sensor unit in titanium pressure housing, an acoustic transponder unit, and an electrode arm unit with arm holding mechanism which folds electrode arms when OBEM is in surfacing (Photo 5-2, Kasaya et al., 2006; Kasaya and Goto, 2009). The glass sphere involves a data logger and a lithium battery pack. Each OBEM has four pipes for attaching five Filloux-type silver-silver chloride electrodes (Filloux, 1987) made by Clover Tech. A radio beacon and a flash light are also mounted on the OBEM.

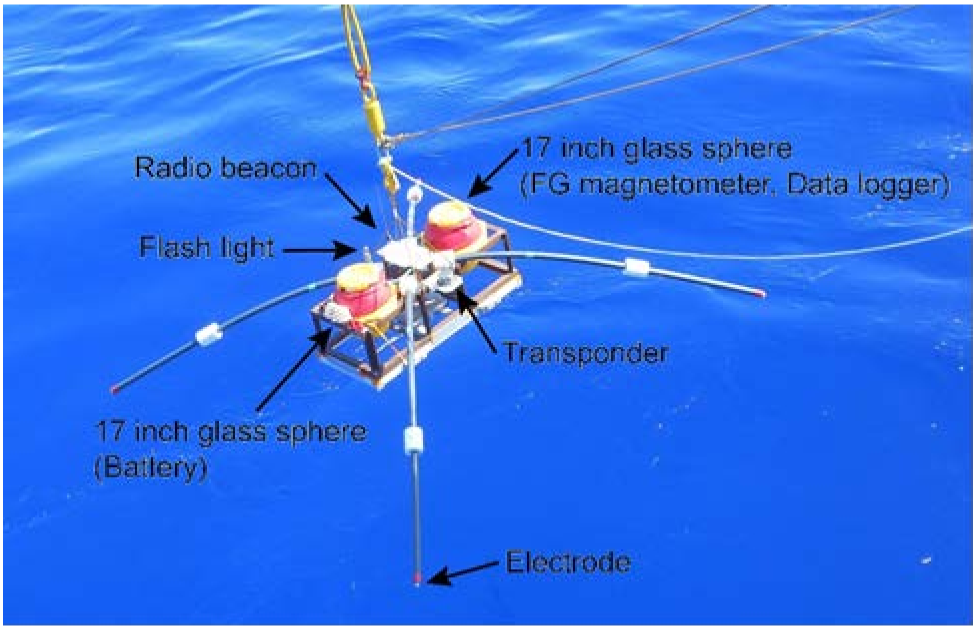


Photo 5-1. Two-glass sphere type OBEM (Type A)

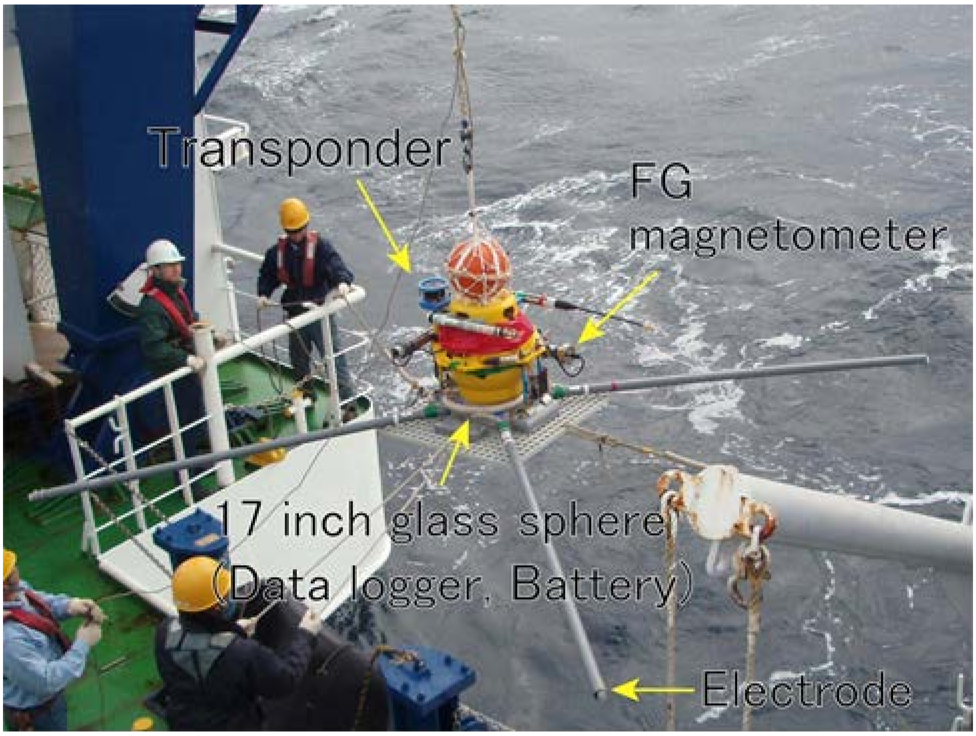


Photo 5-2. One-glass sphere type OBEM (Type B)

We deployed nine OBEMs in this cruise. We first mapped the bathymetry in the vicinity of planned position using SeaBeam system and searched flat seafloor for the final deployment point. The OBEMs were launched from deck using the A-frame, and sunk by their own weights.

The operations were quick and smooth. We confirmed that the OBEMs were successfully settled on the seafloor by measuring acoustic signals. Then, the settled positions were determined by measurements of the slant ranges at least three positions surrounding the launched point for each OBEM. The information that will be needed for the recovery and the data analysis are listed in Table 5-1. We used SSBL system equipped with R/V Mirai at the site O20 to measure slant ranges and determine the settled position

The clocks of the OBEM were synchronized to UTC time before deployment by using a laptop PC using USB or RS232C communication. The laptop PC was synchronized by using GPS unit. Sampling schedules were also set before the OBEMs were deployed (Table 5-2).

Locations of the deployed OBEMs (and OBSs) are listed in Table 5.3 and Fig. 5.1. Bathymetry maps of the OBEMs (and OBSs) stations are shown in Fig. 5.2.

Table 5-1. Specification of OBEMs

Site ID	OBEM ID	A/D of Electric Field	Acoustic system*	Frequency (Tx, ship side)	Frequency (Rx, ship side)	Release command	Beacon Freq. [MHz]	Dipole length [m] NS	EW
O4	ERI15	24 bit	K	9.494kHz	13.500kHz	4E-1	159.250	5.400	5.385
O15	JM106	24 bit	K	9.494kHz	13.500kHz	4E-1	159.150	4.445	4.445
O16	VTM1	24 bit	K	9.036kHz	13.501kHz	5A-1	159.200	5.395	5.395
O17	JM7	24 bit	K	10.000 kHz	13.500 kHz	3C-1	159.300	5.395	5.385
O18	JM4	16 bit	K	11.029 kHz	13.501 kHz	1A-1	159.150	5.395	5.40
O20	JM2	16 bit	K	11.029 kHz	13.501 kHz	1C-1	159.300	5.405	5.405
O21	JM8	24 bit	N	9.6~10.9 kHz	10.240 kHz	3-B	159.150	5.40	5.40
O22	JM1	16 bit	N	9.6~10.9 kHz	10.240 kHz	3-H	159.200	5.42	5.41
O23	JM6	24 bit	K	10.563 kHz	13.500 kHz	2C-1	159.300	5.40	5.41

*K: Kaiyo Denshi, N: Nichiyu Giken

Table 5-2. Sampling Schedules of OBEMs

Site ID	Obs start time1	Obs end time1	Sampling Rate1	Obs start time2	Obs end time2	Sampling Rate2
O4	2015-01-31 14:59:00	2015-03-31 14:58:00	10 s	2015-03-31 14:59:00	-	60 s
O15	2015-01-31 14:59:00	2015-03-31 14:58:00	10 s	2015-03-31 14:59:00	-	60 s
O16	2015-01-31 14:59:00	2015-03-31 14:58:00	10 s	2015-03-31 14:59:00	-	60 s
O17	2015-01-31 14:59:00	2015-03-31 14:58:00	10 s	2015-03-31 14:59:00	-	60 s
O18	2015-01-31 14:59:00	-	60 s	-	-	-
O20	2015-01-31 14:59:00	-	60 s	-	-	-
O21	2015-01-31 14:59:00	2015-03-31 14:58:00	10 s	2015-03-31 14:59:00	-	60 s
O22	2015-01-31 14:59:00	-	60 s	-	-	-

Table 5-3 Locations of deployed BBOBS and OBEM

Date of deployment (2014)	St. code	BBOBS			OBEM		
		latitude	longitude	depth	latitude	longitude	depth
Nov. 15	O23	06-57.265N	164-29.796E	5117m	06-57.178N	164-29.766E	5116m
Nov. 16	O22	02-52.264N	166-01.581E	4309m	02-52.166N	166-01.683E	4308m
Nov. 17	O21	00-01.552N	170-00.278E	4458m	00-01.405N	170-00.169E	4459m
Nov. 19	O20	02-56.745S	174-59.442E	5077m	02-56.737S	174-59.424E	5078m
Nov. 23	O19	08-00.729S	170-03.190E	4860m	—	—	—
Nov. 27	O18	03-53.272S	166-42.490E	3441m	03-53.275S	166-42.609E	3440m
Nov. 28	O17	00-59.112S	164-00.514E	4435m	00-59.193S	164-00.402E	4434m
Dec. 4	O16	06-25.040S	163-25.009E	3558m	06-25.080S	163-25.047E	3559m
Dec. 6	O15	05-57.891S	160-02.448E	1813m	05-57.881S	160-02.399E	1813m
Dec. 9	O5	00-36.928S	153-00.113E	4337m	—	—	—
Dec. 16	O4	04-27.000N	150-22.978E	3987m	04-26.961N	150-23.058E	3986m

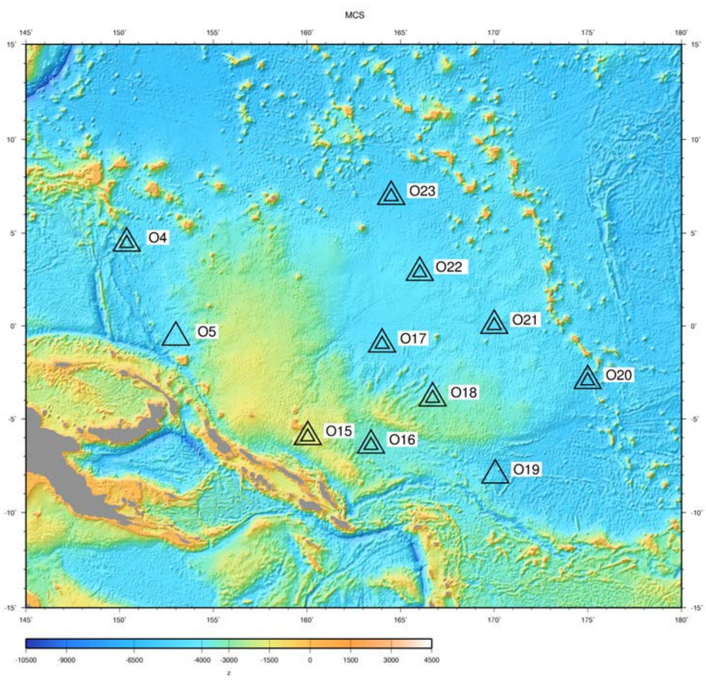


Fig. 5-1 Deployed OBS and OBEM stations. Triangles: OBS stations; Double triangles; OBS and OBEM stations

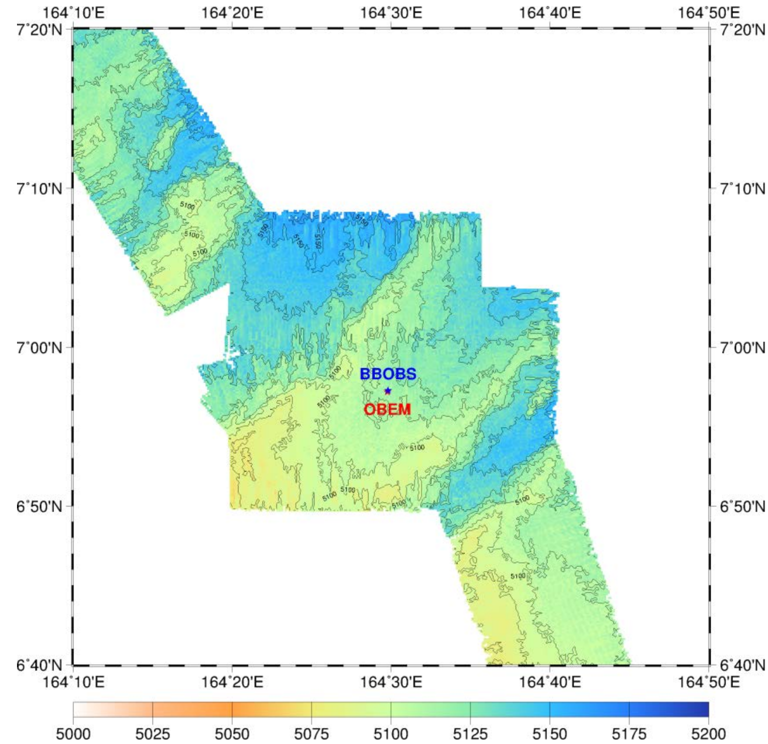


Fig. 5.2a Bathymetry at the O23 station.

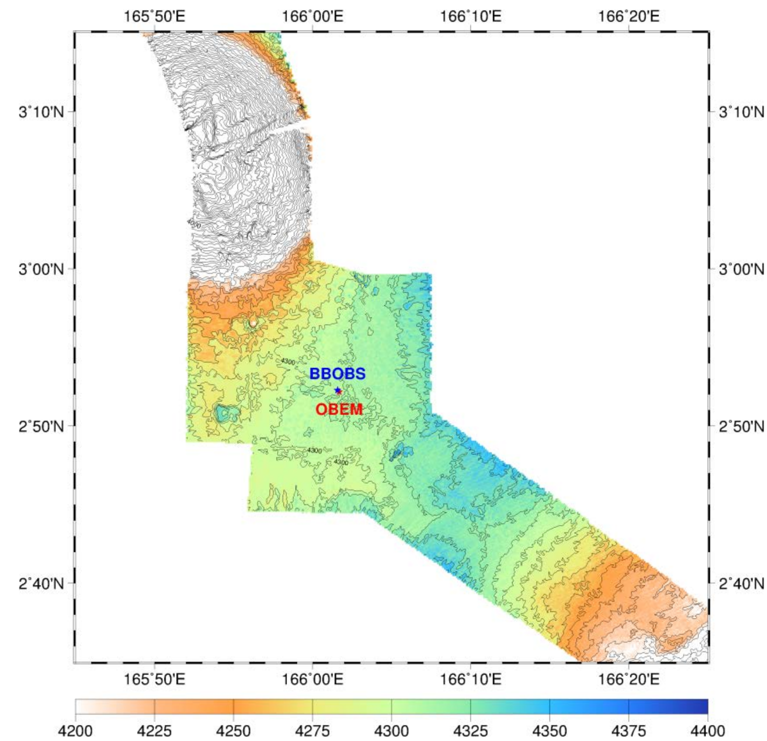


Fig. 5.2b Bathymetry at the O22 station.

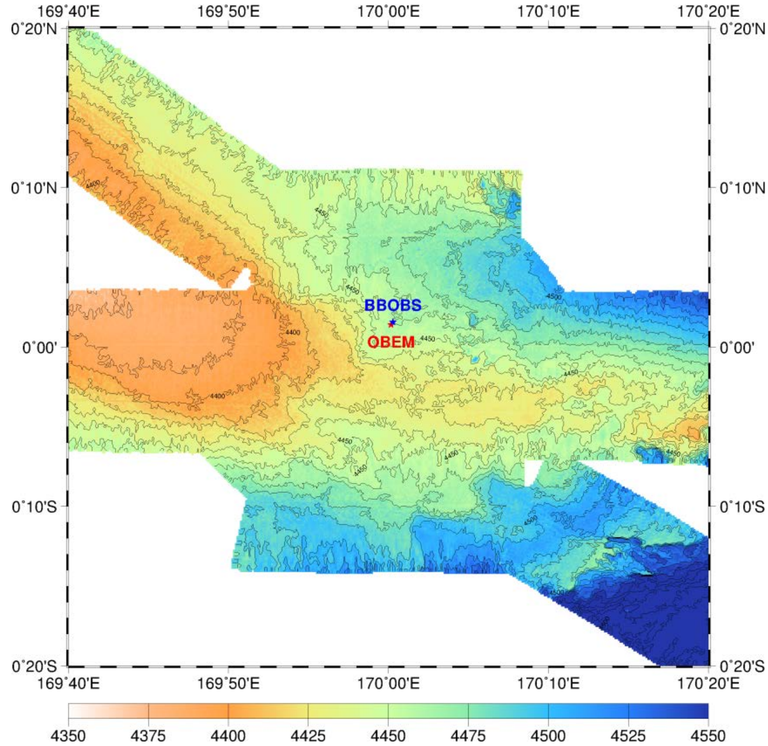


Fig. 5.2c Bathymetry at the O21 station

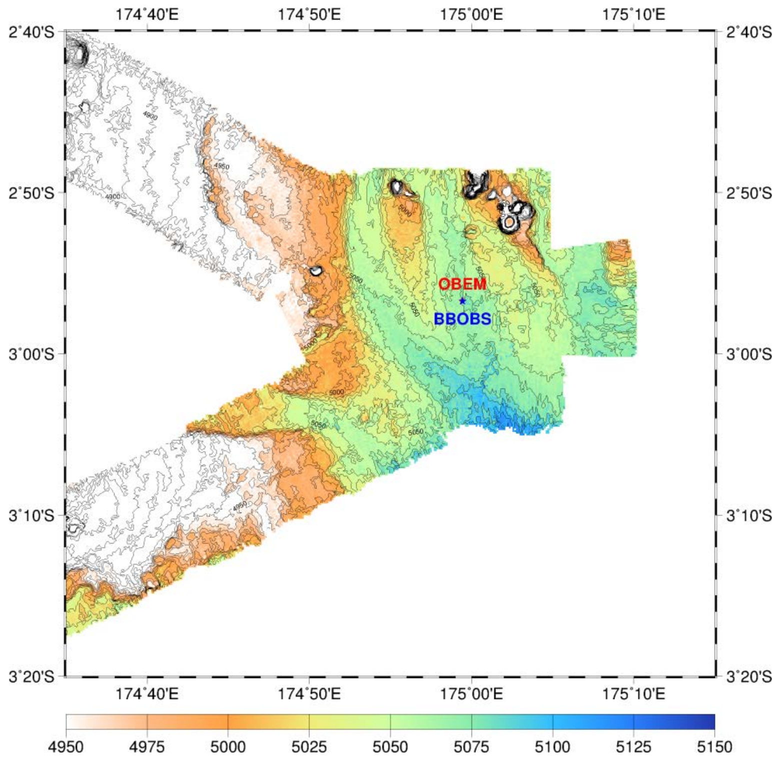


Fig. 5.2d Bathymetry at the O20 station

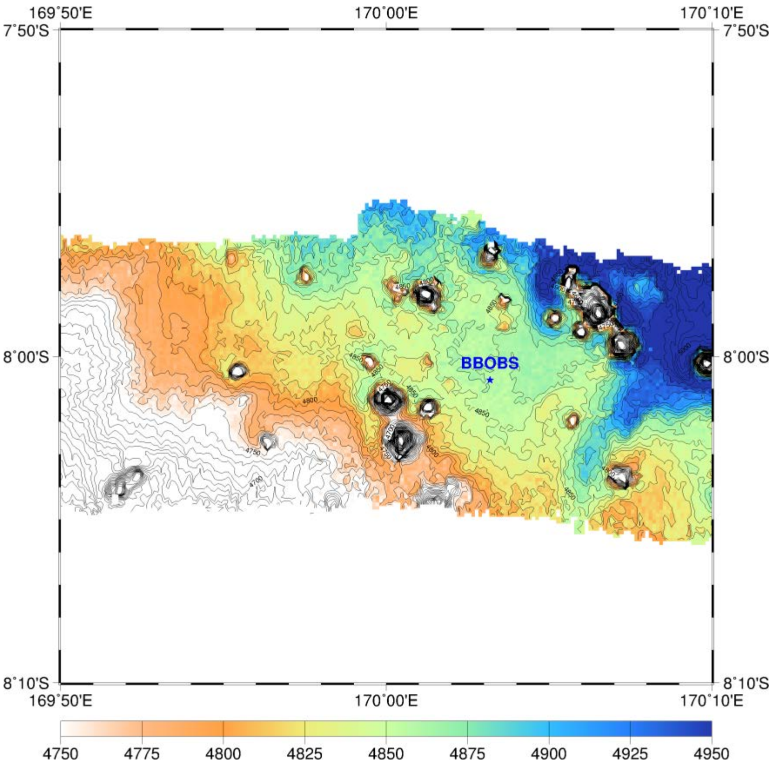


Fig. 5.2e Bathymetry at the O19 station

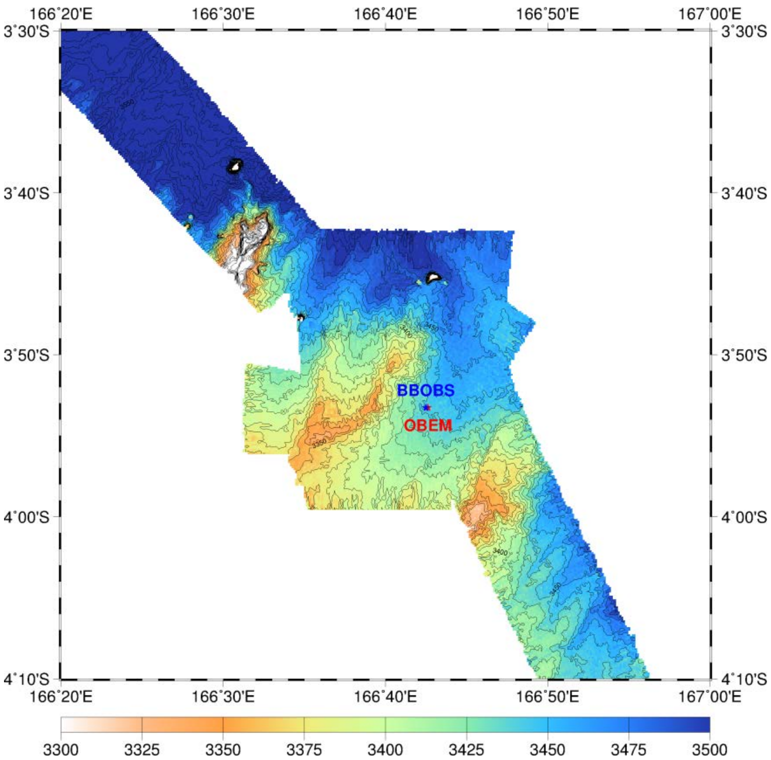


Fig. 5-2f Bathymetry at the O18 station

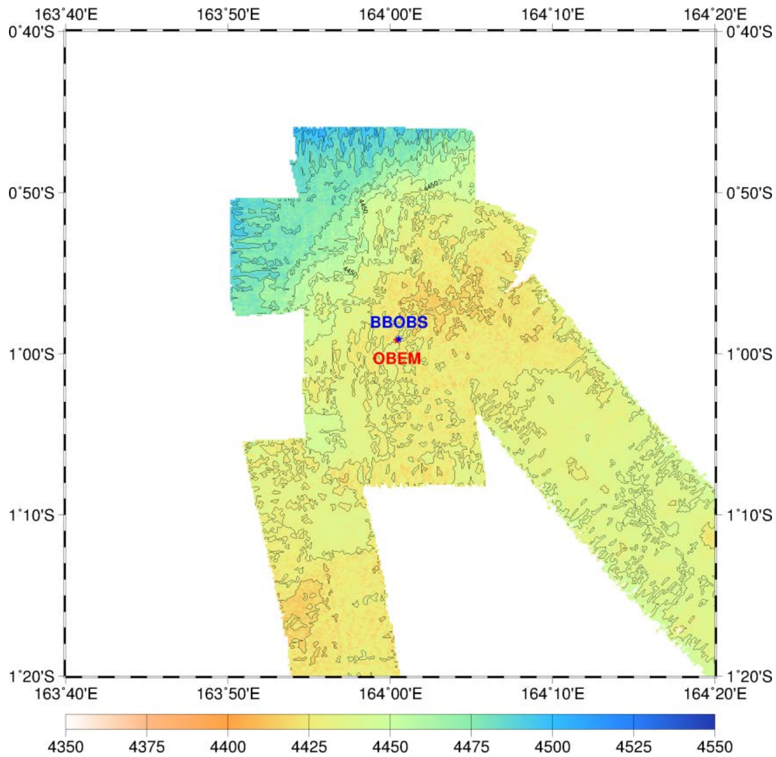


Fig. 5.2g Bathymetry at the O17 station

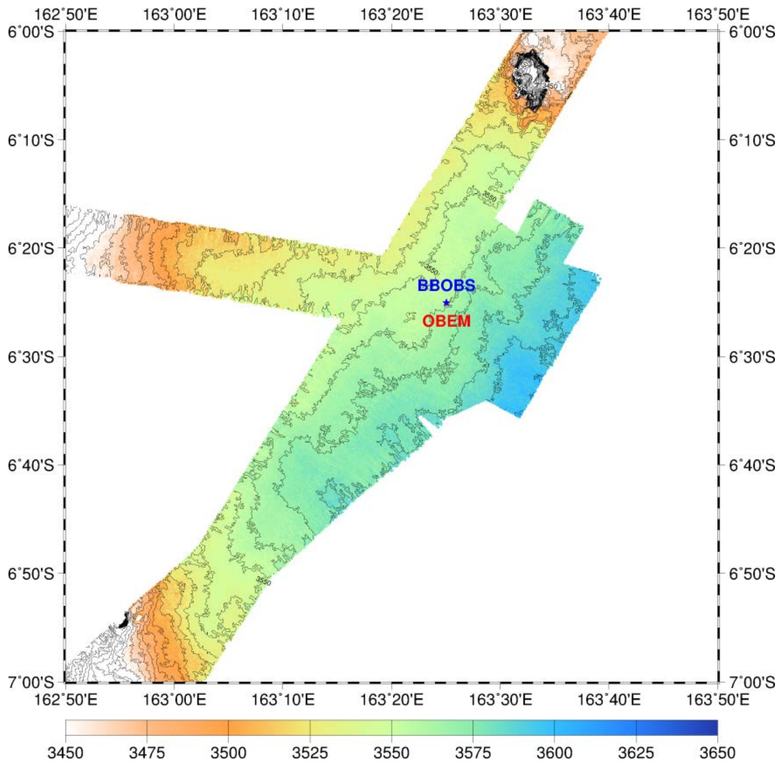


Fig. 5.2h Bathymetry at the O16 station

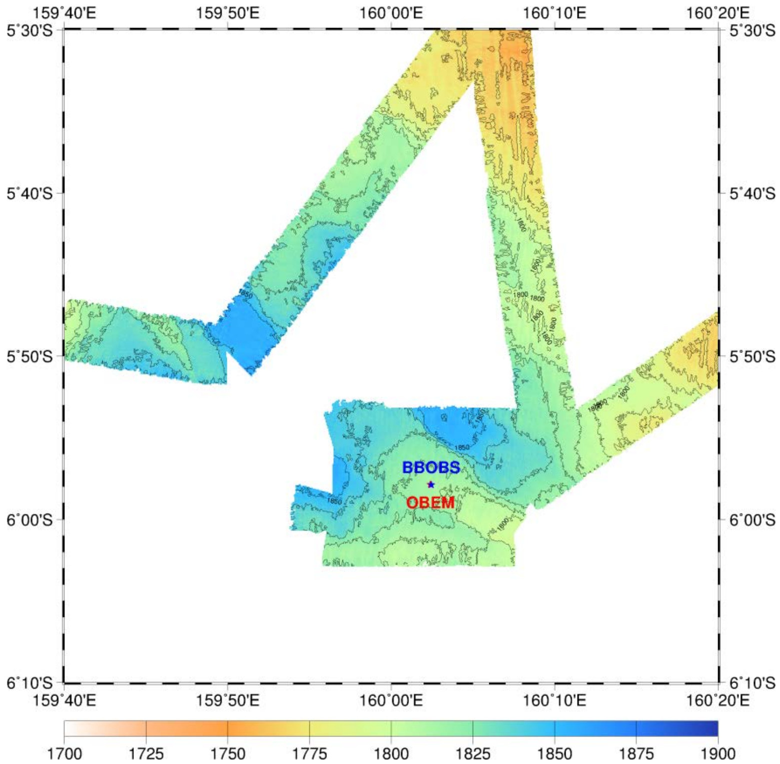


Fig. 5.2i Bathymetry at the O15 station

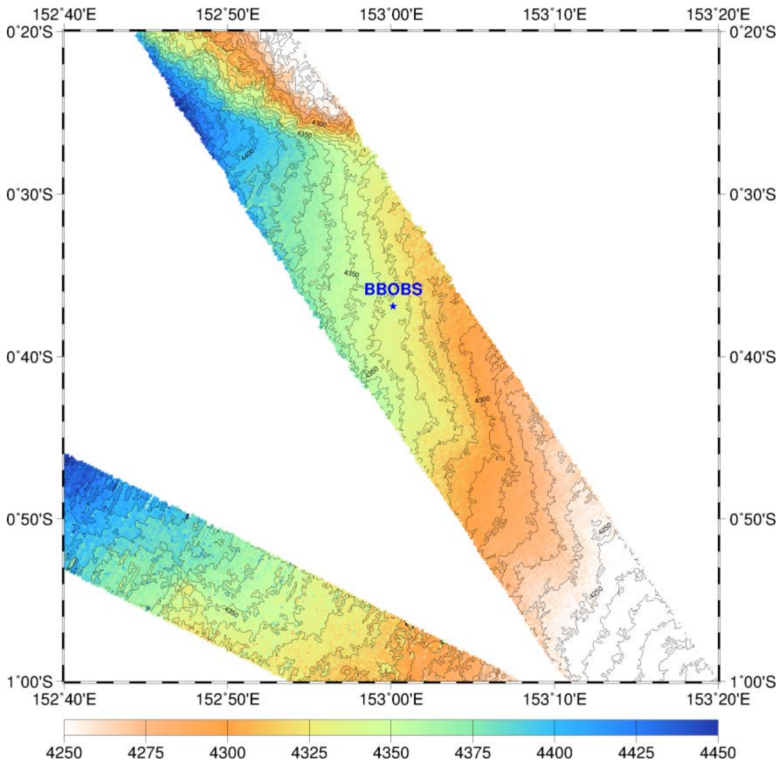


Fig. 5.2j Bathymetry at the O05 station

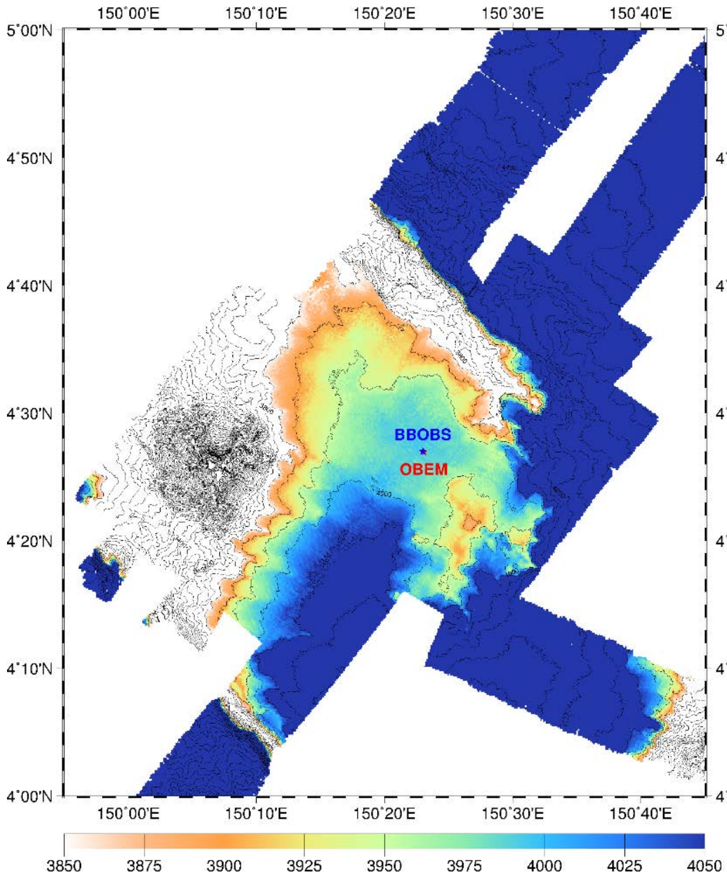


Fig. 5.2k Bathymetry at the O04 station

6. High resolution multichannel seismic reflection survey for crustal structure of the Ontong Java Plateau

Daisuke Suetsugu (PI, JAMSTEC)
Masao Nakanishi (Chiba Universsity, not onboard)
Makoto Ito (NME.)
Yuta Watari (NME.)
Naoto Noguchi (NME.)
Ryo Miura (NME.)
Akie Suzuki (NME.)
Haruhiro Shibata (NME.)

6-1. Purpose

We performed high resolution multichannel seismic reflection (MCS) survey to determine shallow crustal structure in the OJP area, since it should bears a key to understand an evolution process of the OJP. Depending on the evolution process, seismic signatures such as fault and rift could remain in the crust of the OJP, which should be imaged by the MCS survey.

6-2. Instruments

The MCS system is composed of a cluster air-gun array and a streamer cable with a tail buoy at the end. The MCS system was towed with a speed of 3-4 knots. Specification of the instrument is shown in Table 6-1. We also towed a Cesium magnetometer of to obtain a magnetic signature along the survey lines.

Table 6-1. Specification of the MCS system

<table>
<tr><td colspan="7">Source: cluster airgun array</td></tr>
<tr><td colspan="2">Air volume: 380 inch^3 of total volume (40 inch^3×2 + 150 inch^3×2)</td><td>Air pressure: 2000psi</td><td colspan="2">Shot interval: 37.5m</td><td colspan="2">Airgun depth: 3m</td></tr>
<tr><td colspan="7">Streamer cable</td></tr>
<tr><td>L1</td><td>Channel: 168</td><td colspan="2">Cable length: 1341m</td><td colspan="2">Cable depth: 4m</td><td>Hydrophone interval: 6.25m</td></tr>
<tr><td>L2, L4, L5, L6, L8</td><td>Channel: 160</td><td colspan="2">Cable length: 1290~1200m</td><td colspan="2">Cable depth: 4m</td><td>Hydrophone interval: 6.25m</td></tr>
<tr><td>L7</td><td>Channel: 144</td><td colspan="2">Cable length: 1150m</td><td colspan="2">Cable depth: 4m</td><td>Hydrophone interval: 6.25m</td></tr>
</table>

Note: L3 line was cancelled due to failure of the streamer cable.

6-3. Survey lines

The MCS survey was conducted along four lines in the Ellice and Stewart basins near the eastern salient of the OJP, 1 line at a small seamount near the Nuugurigia atoll, and two lines in the Lyra basin near a western rim of the OJP. The lines are listed in Table 6-2 and shown in Fig. 6-1. Seismic structure will be determined by a detailed data processing after the MR14-06 cruise.

Table 6-2 Lists of pMCS survey lines

Survey line	Date (UTC)	Start points (latitude, longitude)	End points (latitude, longitude)	Length (nm)
L1	Nov. 19-23	04-30.32S, 172-06.73E	08-20.20S, 172-07.00E	229
L2	Nov. 24-26	07-52.05S, 166-30.22E	05-56.85S, 167-41.58E	135
L3	Cancelled			
L4	Nov. 29-Dec. 2,	04-35.47S, 164-28.27E	08-00.08S, 162-20.96E	240
L5	Dec. 4-5	06-16.26S, 162-36.53E	05-25.96S, 160-53.93E	114
L6	Dec. 7	04-11.92S, 157-48.58E	04-18.00S, 156-59.91E	49
L7	Dec. 9-12	00-40.96N,150-31.93E	02-35.54N, 153-34.33E	215
L8	Dec. 12-15	00-37.49S, 153-00.33E	02-19.19N, 151-07.55E	209

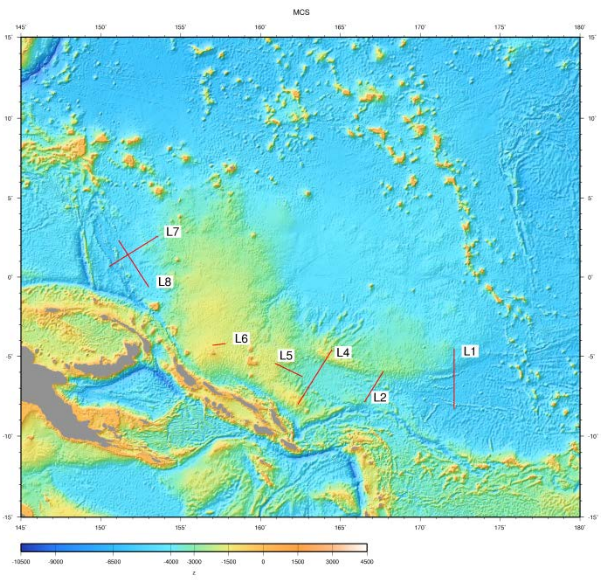


Figure 6-1 Survey lines of pMCS measufements

7. Search for basement rocks of the Ontong Java Plateau

(1)Personnel

Takeshi Hanyu (PI, JAMSTEC, not onboard)
Shoka Shimizu (JAMSTEC)
Wataru Tokunaga (GODI)
Miki Morioka (GODI)
Koichi Inagaki (GODI)

(2) Objectives

Since the Ontong Java Plateau (OJP) sits largely under the ocean, rock sampling has been thus far restricted. A surface of the OJP is largely covered with thick sediments, which also make it difficult to sample rocks. We need to search potential sites where basement rocks are exposed for successful sampling that will provide a key to elucidate an origin of the OJP. During the MR14-06 cruise, we have searched for feasible sites of the rock sampling with underway geophysical survey. We plan to sample rocks with a dredge in 2016 at the sites where rocks are likely to be exposed at the seafloor.

(3) Observation sites and methods

We have performed multi narrow beam echo sounding system, sub-bottom profiler, towing cesium magnetometer, ship-board three-component magnetometer, and gravity meter at four sites: Off the east coast of the Malaita island; flanks of three submarine volcanoes on the OJP, whose the top is an atoll (the Ontong Java atoll, the Cartrete atoll, and the Nuguria atoll). The Malaita sites are a convergence zone of the OJP and the North Solomon trench. It is selected for the survey, since a previous study of an MCS survey (Phinney et al., 2004, Tectonophysics, 389, 221-246) suggests that there is places where a sediment is very thin or nil, which may be a suitable site for sampling igneous rocks with a dredge.

The three submarine volcanoes are selected because we found that a flank of another submarine volcanoes (Nuugurigia), similar to the three volcanoes, has a small cones where igneous rocks are exposed. It leads us to an idea that the three atolls have volcanic cones on their flanks, which are potential sites of exposed rocks.

(4) Preliminary results: bathymetry of the survey areas

We obtained detailed bathymetry, sub-bottom structure, and magnetic data along the survey lines shown in Fig. 7-1-1.

Off east coast of the Malaita island, we found two ridges and basins between the ridges. The ridges have steep cliffs, where Phinney (2004) suggested an OJP igneous rock mat be exposed. The cliffs are potential sites for future sampling with a dredge.

Bathymetry along survey line of the flanks of the Ontong Java atoll is relatively smooth and we could not find volcanic cones.

The magnetic, gravity, and sub bottom profiling data will be carefully analyzed after the cruise.

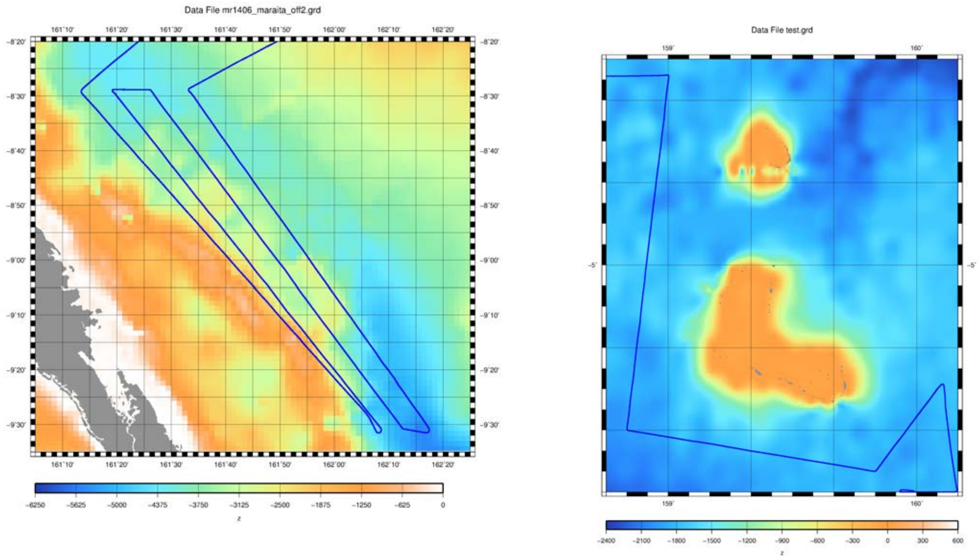


Fig. 7-1-1 Survey line near the Malaita island.(left) and around the Ontong Java atoll (right)

8. General observations

8.1. Meteorological measurements

8.1.1 Surface Meteorological Observations

(1) Personnel

Daisuke Suetsugu	(JAMSTEC)	: Principal Investigator
Wataru Tokunaga	(Global Ocean Development Inc. GODI)	
Koichi Inagaki	(GODI)	
Miki Morioka	(GODI)	
Masanori Murakami	(MIRAI Crew)	

(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) Methods

Surface meteorological parameters were observed during the MR14-06 Leg1 cruise from 4th November 2014 to 17th December 2014, without territorial waters on Independent State of Papua New Guinea and Federated States of Micronesia. In this cruise, we used two systems for the observation.

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

Instruments of SMet system are listed in Table 8.1.1-1 and measured parameters are listed in Table 8.1.1-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-second averaged data.

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

SOAR system designed by BNL (Brookhaven National Laboratory, USA) consists of major five 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 ORG (optical rain gauge)) measurement.
d) Photosynthetically Available Radiation (PAR) sensor manufactured by Biospherical Instruments Inc. (USA) - PAR 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 data every 6 seconds, CR1000 data every 10 seconds, air temperature and relative humidity data every 2 seconds and ORG data every 5 seconds. SCS composed Event data (JamMet) from these data and ship's navigation data. Instruments and their locations are listed in Table 8.1.1-3 and measured parameters are listed in Table 8.1.1-4.

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, HMP41/45, VAISALA

(4) Preliminary results

Fig. 8.1.1-1 shows the time series of the following parameters;

Wind (SMet)
Air temperature (SMet)
Relative humidity (SMet)
Precipitation (SOAR, rain gauge)
Short/long wave radiation (SOAR)
Pressure (SMet)
Sea surface temperature (SMet)
Significant wave height (SMet)

(5) Data archives

These meteorological data will be submitted to the Data Management Group (DMG) of JAMSTEC just after the cruise.

(6) Remarks (Times in UTC)

i) The following periods, Sea surface temperature of SMet data was available.
   08:57 07 Nov. 2014 - 05:30 17 Dec. 2014

ii) The following time, increasing of SMet capacitive rain gauge data were invalid due to transmitting for VHF or MF/HF radio.
   07:24 07 Nov. 2014
   04:42 12 Nov. 2014

iii) The following period, downwelling radiometer (short wave) was invalid.
   26 Nov. 2014 - 17 Dec. 2014

iv) SOAR true wind direction and speed were invalid due to fail relative direction of anemometer during this cruise.

v) The following period, PAR data was invalid due to maintenance.
13:31 09 Nov. 2014 - 13:36 09 Nov. 2014

Table 8.1.1-1 Instruments and installation locations of
MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	compass deck (21 m)
			starboard side and port side
	with 43408 Gill aspirated radiation shield		R.M. Young, USA
Thermometer: SST	RFN2-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	Model-370	Setra System, USA	captain deck (13 m)
			weather observation room
Rain gauge	50202	R. M. Young, USA	compass deck (19 m)
Optical rain gauge	ORG-815DS	Osi, USA	compass deck (19 m)
Radiometer (short wave)	MS-802	Eko Seiki, Japan	radar mast (28 m)
Radiometer (long wave)	MS-202	Eko Seiki, Japan	radar mast (28 m)
Wave height meter	WM-2	Tsurumi-seiki, Japan	bow (10 m)
			port side stern (8 m)

Table 8.1.1-2 Parameters of MIRAI Surface Meteorological observation system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 Ship's speed	knot	Log, (DS-30, Furuno)
4 Ship's heading	degree	Gyro, (TG-6000, TOKYO-KEIKI)
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 8.1.1-3 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	61302V	R.M. Young, USA	foremast (23 m)
	with 61002 Gill pressure port		R.M. Young, USA
Rain gauge	50202	R.M. Young, USA	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	foremast (23 m)
	with 43408 Gill aspirated radiation shield		R.M. Young, USA
Optical rain gauge	ORG-815DR	Osi, USA	foremast (24 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)	Type	Manufacturer	Location (altitude from surface)
PAR sensor	PUV-510	Biospherical Instruments Inc., USA	Navigation deck (18 m)

Table 8.1.1-4 Parameters of SOAR system (JamMet)

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

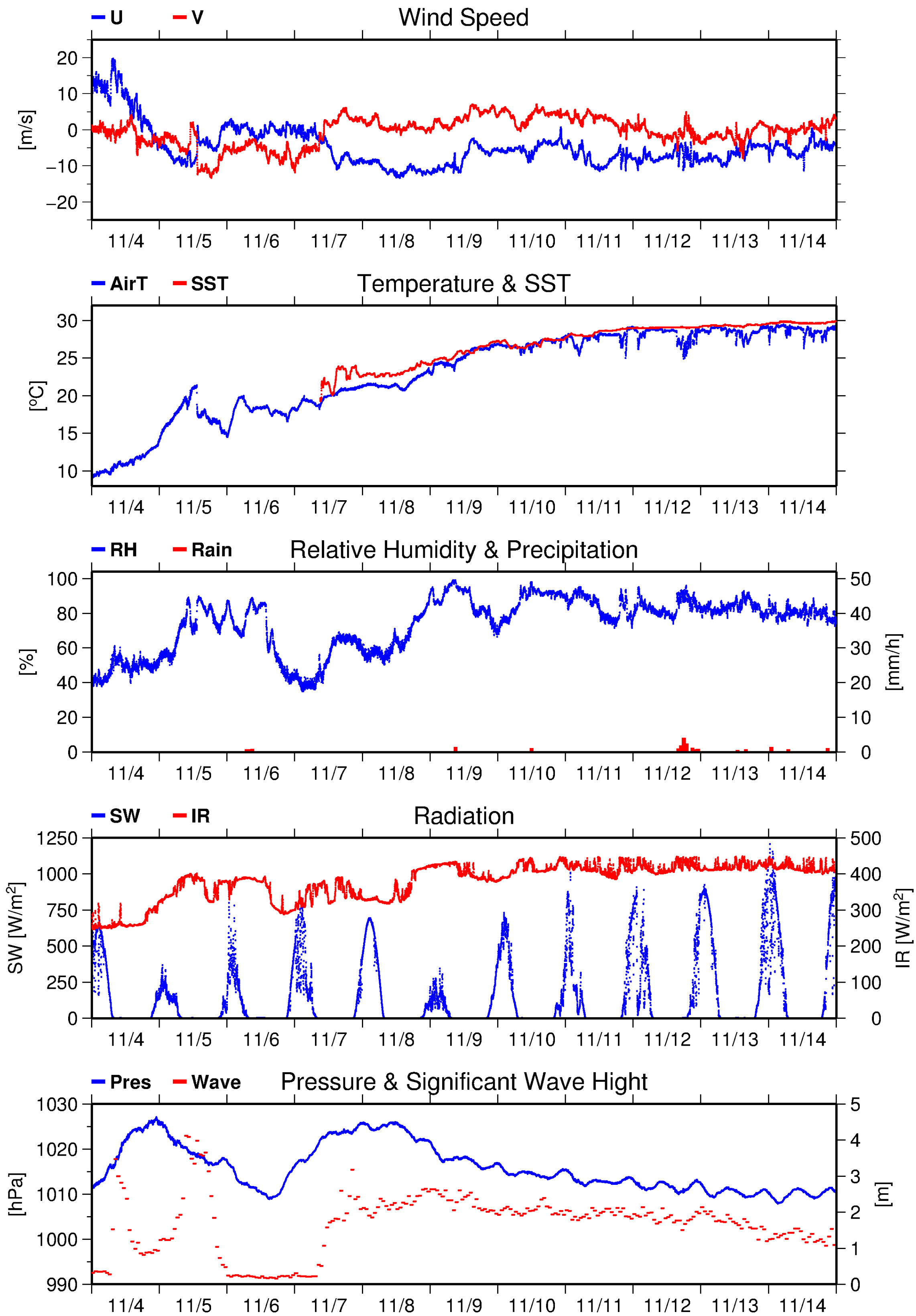


Fig. 8.1.1-1 Time series of surface meteorological parameters during the MR14-06 Leg1 cruise

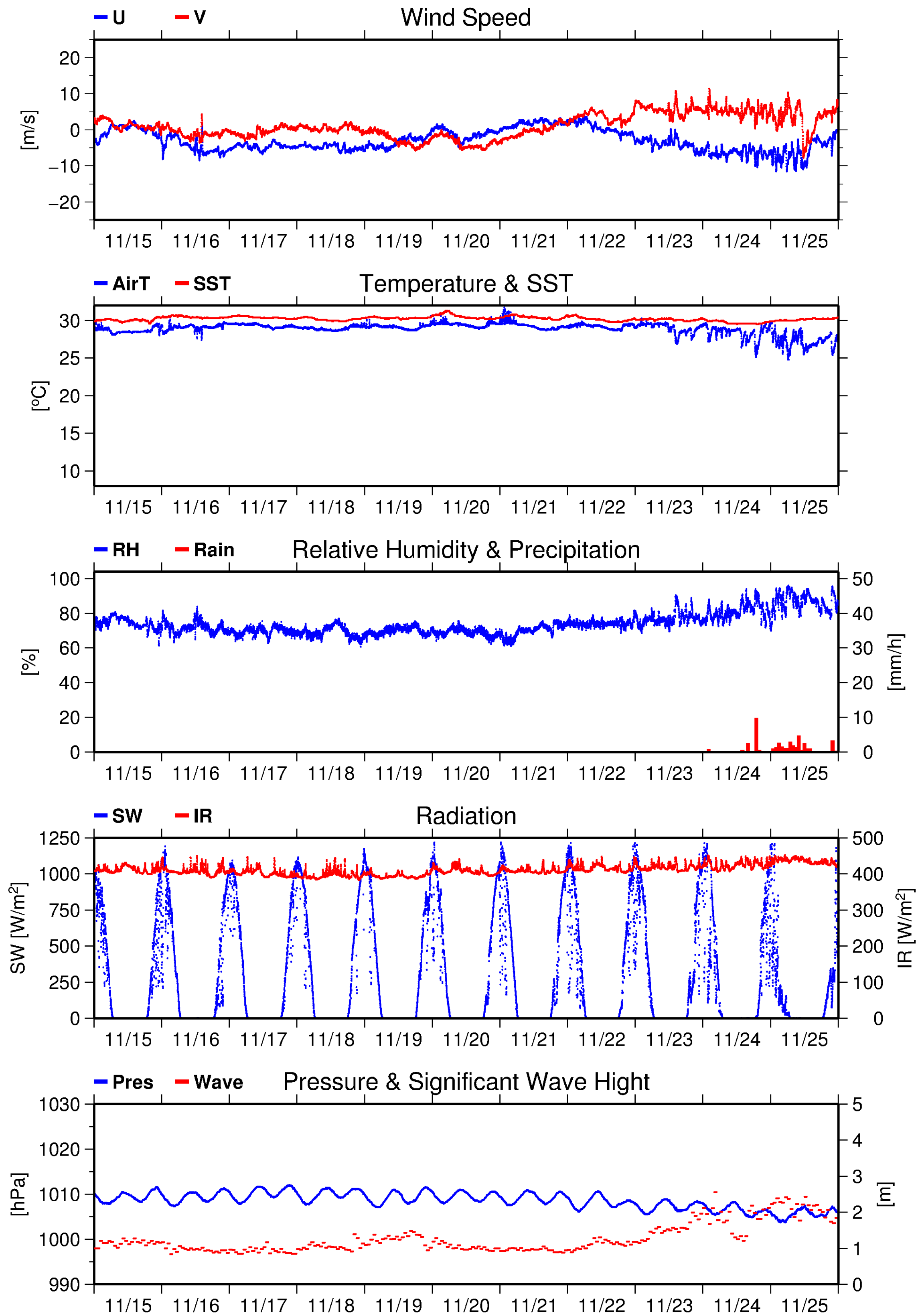


Fig. 8.1.1-1 (Continued)

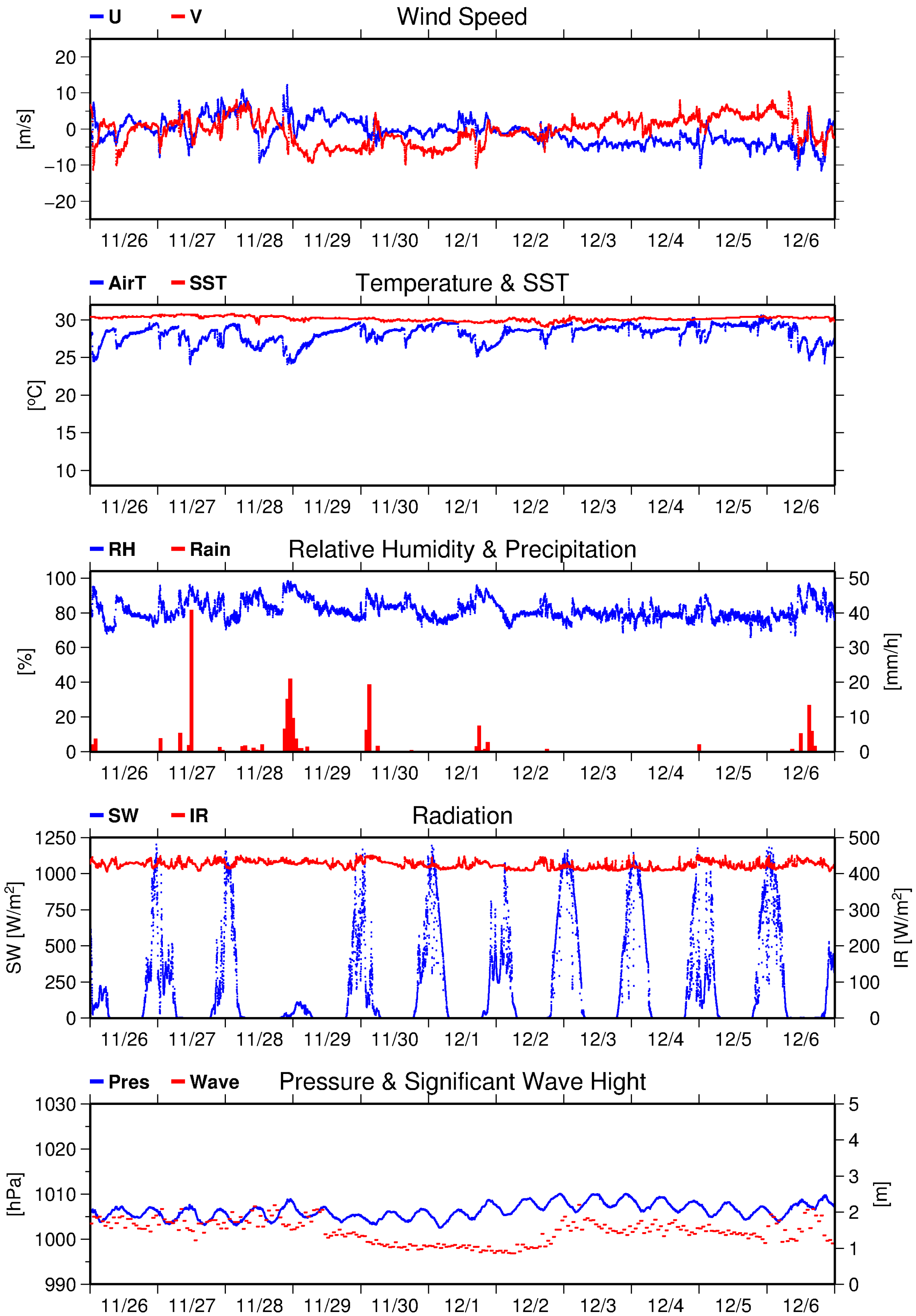
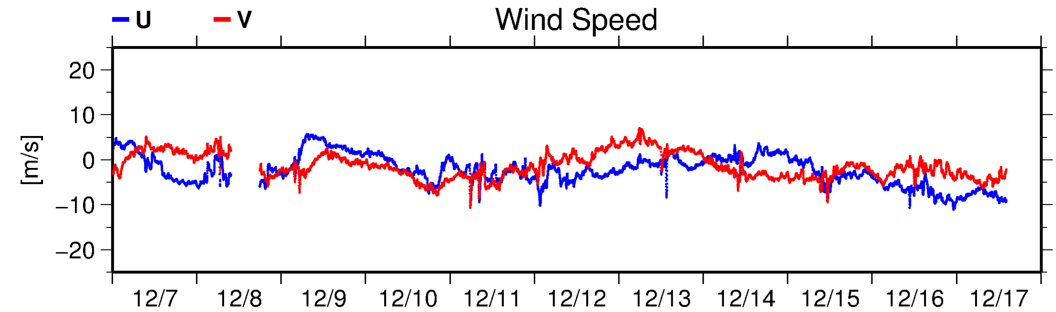
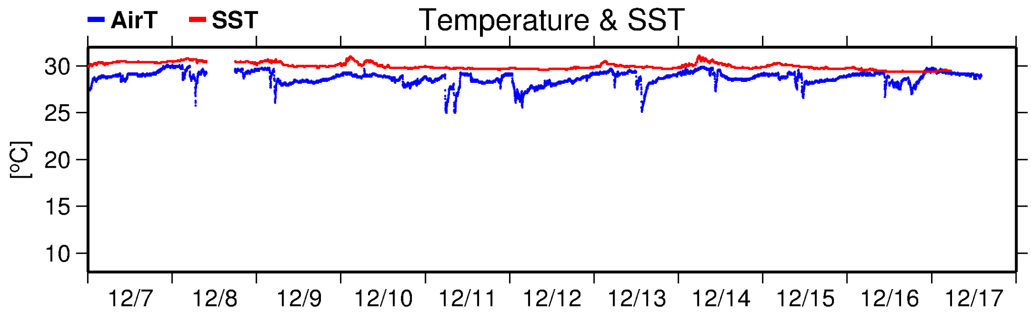
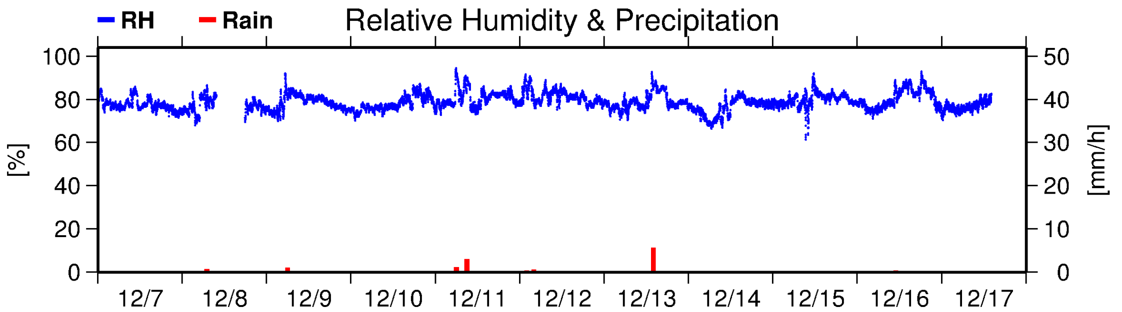
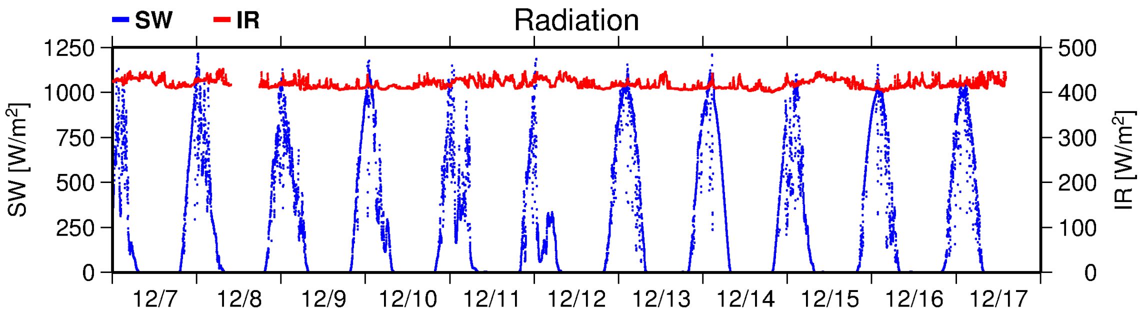


Fig. 8.1.1-1 (Continued)


U
V
Wind Speed
[m/s]
20
10
0
−10
−20
12/7
12/8
12/9
12/10
12/11
12/12
12/13
12/14
12/15
12/16
12/17


AirT
SST
Temperature & SST
[ºC]
30
25
20
15
10
12/7
12/8
12/9
12/10
12/11
12/12
12/13
12/14
12/15
12/16
12/17


RH
Rain
Relative Humidity & Precipitation
[%]
[mm/h]
100
80
60
40
20
0
50
40
30
20
10
0
12/7
12/8
12/9
12/10
12/11
12/12
12/13
12/14
12/15
12/16
12/17


SW
IR
Radiation
SW [W/m2]
IR [W/m2]
1250
1000
750
500
250
0
500
400
300
200
100
0
12/7
12/8
12/9
12/10
12/11
12/12
12/13
12/14
12/15
12/16
12/17

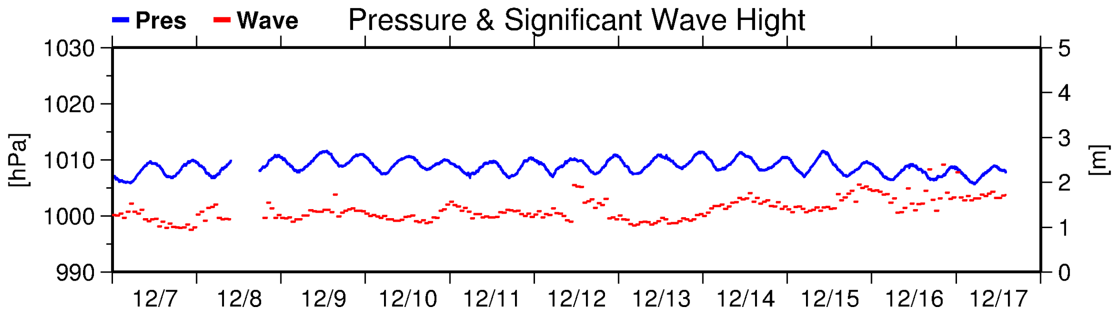

Pres
Wave
Pressure & Significant Wave Hight
[hPa]
[m]
1030
1020
1010
1000
990
5
4
3
2
1
0
12/7
12/8
12/9
12/10
12/11
12/12
12/13
12/14
12/15
12/16
12/17

Fig. 8.1.1-1 (Continued)

8.1.2 Ceilometer observation

(1) Personnel

Daisuke Suetsugu	(JAMSTEC)	: Principal Investigat
Wataru Tokunaga	(Global Ocean Development Inc., GODI)	
Koichi Inagaki	(GODI)	
Miki Morioka	(GODI)	
Masanori Murakami	(MIRAI Crew)	

(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 during this cruise without territorial waters on Independent State of Papua New Guinea and Federated States of Micronesia.

(3) 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.

(4) Methods

We measured cloud base height and backscatter profile using ceilometer (CL51, VAISALA, Finland). Major parameters for the measurement configuration are shown in Table 8.1.2-1;

Table 8.1.2-1 Major parameters

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 octas (0 ~ 9) (0:Sky Clear, 1:Few, 3:Scattered, 5-7:Broken, 8:Overcast, 9:Vertical Visibility)

On the archive dataset, cloud base height and backscatter profile are recorded with the resolution of 10 m (33 ft).

(5) Preliminary results

Fig.8.1.2-1 shows the time series of 1st, 2nd and 3rd lowest cloud base height during the cruise.

(6) Data archives

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

(7) Remarks (Times in UTC)

i) The following time, the window was cleaned.
04:41UTC 04 Nov. 2014
22:07UTC 09 Nov. 2014
19:22UTC 16 Nov. 2014
23:00UTC 24 Nov. 2014
21:27UTC 02 Dec. 2014
19:54UTC 09 Dec. 2014
20:36UTC 15 Dec. 2014

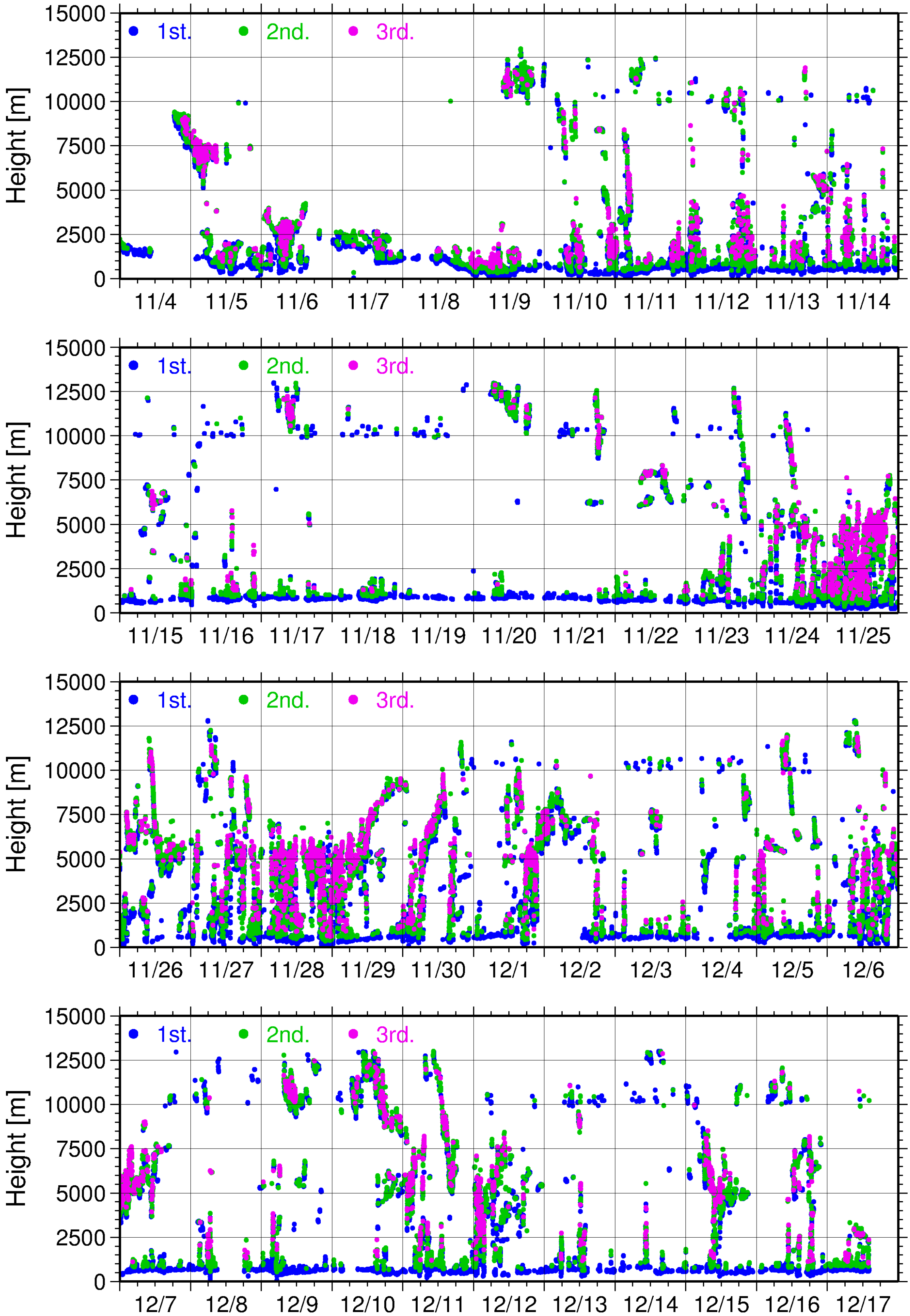


Fig. 8.1.2-1 1st, 2nd and 3rd lowest cloud base height during this cruise.

8.1.3. Aerosol optical characteristics measured by ship-borne sky radiometer

(1) **Personnel**

Kazuma Aoki (PI, University of Toyama, not onboard)

Tadahiro Hayasaka (Tohoku University, not onboard)

(2) Objective

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

(3) 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.

(4) Instruments and Methods

The sky radiometer measures the direct solar irradiance and the solar aureole radiance distribution with seven interference filters (0.34, 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.

(5) Data archives

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.

8.1.4 Tropospheric gas and particle observation in the marine atmosphere

(1) Personnel

Yugo Kanaya (DEGCR/JAMSTEC, not onboard)
Fumikazu Taketani (DEGCR/JAMSTEC, not onboard)
Takuma Miyakawa (DEGCR/JAMSTEC, not onboard)
Hisahiro Takashima (DEGCR/JAMSTEC, not onboard)
Yuichi Komazaki (DEGCR/JAMSTEC, not onboard)
Maki Noguchi (RCGC/JAMSTEC, not onboard)
Operation was supported by GODI.

(2) Objective

- 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) Parameter

- Black carbon(BC) particles
- Composition of ambient particles
- Aerosol optical depth (AOD) and Aerosol extinction coefficient (AEC)
- Surface ozone(O3), and carbon monoxide(CO) mixing ratios

(4) Description of instruments deployed

(4-1) Online aerosol observations of black carbon (BC)

BC particles were measured by an instrument based on laser-induced incandescence (SP2, Droplet Measurement Technologies). For SP2, ambient air was commonly sampled from the flying bridge by a 3-m-long conductive tube through the Diffusion Dryer(model TSI) to dry up the particles, and then introduced to each instrument. The laser-induced incandescence technique based on intracavity Nd:YVO4 laser operating at 1064 nm were used for detection of single particles of BC.

(4-2) Ambient air sampling by high-volume air sampler

Ambient aerosol particles were collected along cruise track using a high-volume air sampler (HV-525PM, SIBATA) located on the flying bridge operated at a flow rate of 500 L min-1. 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”. Coarse and fine particles separated at the diameter of 2.5 μm were collected on quartz filters. The filter samples obtained during the cruise are subject to chemical analysis of aerosol composition, including water-soluble ions and trace metals.

(4-3) MAX-DOAS

Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS), a passive remote sensing technique measuring spectra of scattered visible and ultraviolet (UV) solar radiation, was used for atmospheric aerosol and gas profile measurements. Our MAX-DOAS instrument consists of two main parts: an outdoor telescope unit and an indoor spectrometer

(Acton SP-2358 with Princeton Instruments PIXIS-400B), connected to each other by a 14-m bundle optical fiber cable. The line of sight was in the directions of the portside of the vessel and the measurements were made at several elevation angles of 1.5, 3, 5, 10, 20, 30, 90 degrees using a movable prism, which repeated the same sequence of elevation angles every ~15-min.For the selected spectra recorded with elevation angles with good accuracy, DOAS spectral fitting was performed to quantify the slant column density (SCD) of NO_2 (and other gases) and O_4 (O_2-O_2, collision complex of oxygen) for each elevation angle. Then, the O_4 SCDs were converted to the aerosol optical depth (AOD) and the vertical profile of aerosol extinction coefficient (AEC) using an optimal estimation inversion method with a radiative transfer model. Using derived aerosol information, retrievals of the tropospheric vertical column/profile of NO_2 and other gases were made.

(4-4) CO and O_3

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

(5) Observation log

The shipboard measurements and sampling were conducted in the open sea

(6) Preliminary results

N/A (All the data analysis is to be conducted.)

(7) Data archive

The data files will be submitted to JAMSTEC Data Management Group (DMG), after the full analysis is completed, which will be <2 years after the end of the cruise.

8.1.5 Disdrometers

(1) Personnel

Masaki Katsumata (PI, JAMSTEC, not onboard)

(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 to the rainfall amount, and (c) to validate the algorithms and the product of the satellite-borne precipitation radars; TRMM/PR and GPM/DPR.

Parameters

Number and size of precipitating particles

Methods

Four different types of disdrometers are utilized to obtain better reasonable and accurate value on the moving vessel. Three of the disdrometers and one optical rain gauge are installed in one place, the starboard side on the roof of the anti-rolling system of R/V Mirai, as in Photo 8.1.5-1. One of the disdrometers named "micro rain radar" is installed at the starboard side of the anti-rolling systems (see Photo 8.1.5-2).

The details of the sensors are described below. All the sensors archive data every one minute.

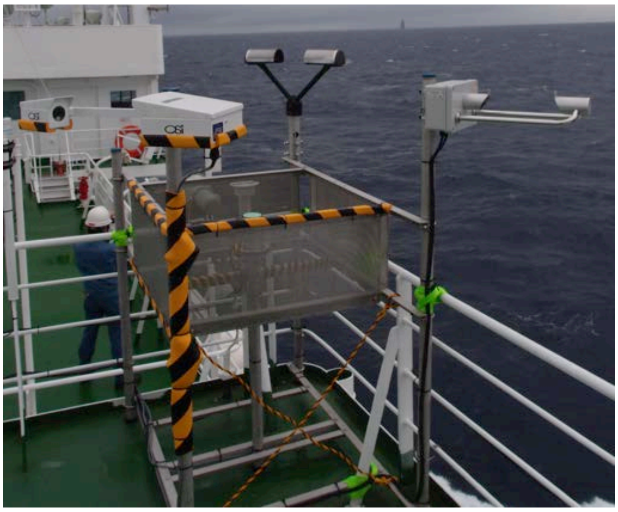


Photo 8.1.5-1: The three disdrometers (Parsivel, LPM and Joss-Waldvogel disdrometer) and an optical rain gauge, installed on the roof of the anti-rolling tank.

Photo 8.1.5-2: The micro rain radar, installed on the starboard side of the anti-rolling tank.

(3-1) Joss-Waldvogel type disdrometer

The “Joss-Waldvogel-type” disdrometer system (RD-80, Disdromet Inc.) (hereafter JW) equipped a microphone on the top of the sensor unit. When a raindrop hit the microphone, the magnitude of induced sound is converted to the size of raindrops. The logging program “DISDRODATA” determines the size as one of the 20 categories as in Table 8.1.5-1, and accumulates the number of raindrops at each category. The rainfall amount could be also retrieved from the obtained drop size distribution. The number of raindrops in each category, and converted rainfall amount, are recorded every one minute.

(3-2) Laser Precipitation Monitor (LPM) optical disdrometer

The “Laser Precipitation Monitor (LPM)” (Adolf Thies GmbH & Co) 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 8.1.5-2.

(3-3) “Parsivel” optical disdrometer

The “Parsivel” (OTT Hydromet GmbH) is another optical disdrometer. The principle is same as the LPM. The sampling volume, i.e. the size of the laser beam “sheet”, is 30 mm (W) x 180 mm (D). The categories are shown in Table 8.1.5-3.

(3-4) Optical rain gauge

The optical rain gauge, which detect scintillation of the laser by falling raindrops, is installed beside the above three disdrometers to measure the exact rainfall. The ORG-815DR (Optical Scientific Inc.) is utilized with the controlling and recording software (manufactured by Sankosha Co.).

(3-5) Micro rain radar

The MRR-2 (METEK GmbH) was utilized. The specifications are in Table 8.1.5-4. The antenna unit was installed at the starboard side of the anti-rolling systems (see Fig. 8.1.5-2), 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 200 meters in range distance (i.e. height) up to 6200 meters, i.e. well beyond the melting layer. The drop size distribution is recorded, as well as radar reflectivity, path-integrated attenuation, rain rate, liquid water content and fall velocity.

Preliminary Results

The data were obtained continuously thru the cruise from Nov. 4 to Dec.18. The further analyses will be done after the cruise.

Data Archive

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

Acknowledgment

The optical rain gauge is kindly provided by National Institute for Information and Communication Technology (NICT). The operations are supported by Japan Aerospace Exploration Agency (JAXA) Precipitation Measurement Mission (PMM).

Table 8.1.5-1: Category number and corresponding size of the raindrop for JW disdrometer.

Category	Corresponding size range [mm]		
1	0.313	-	0.405
2	0.405	-	0.505
3	0.505	-	0.696
4	0.696	-	0.715
5	0.715	-	0.827
6	0.827	-	0.999
7	0.999	-	1.232
8	1.232	-	1.429
9	1.429	-	1.582
10	1.582	-	1.748
11	1.748	-	2.077
12	2.077	-	2.441
13	2.441	-	2.727
14	2.727	-	3.011
15	3.011	-	3.385
16	3.385	-	3.704
17	3.704	-	4.127
18	4.127	-	4.573
19	4.573	-	5.145
20	5.145	or larger	

Table 8.1.5-2: Categories of the size and the fall speed for LPM.

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

Table 8.1.5-3: Categories of the size and the fall speed for Parsivel.

Particle Size		
Class	Average Diameter [mm]	Class spread [mm]
1	0.062	0.125
2	0.187	0.125
3	0.312	0.125
4	0.437	0.125
5	0.562	0.125
6	0.687	0.125
7	0.812	0.125
8	0.937	0.125
9	1.062	0.125
10	1.187	0.125
11	1.375	0.250
12	1.625	0.250
13	1.875	0.250
14	2.125	0.250
15	2.375	0.250
16	2.750	0.500
17	3.250	0.500
18	3.750	0.500
19	4.250	0.500
20	4.750	0.500
21	5.500	1.000
22	6.500	1.000
23	7.500	1.000
24	8.500	1.000
25	9.500	1.000
26	11.000	2.000
27	13.000	2.000
28	15.000	2.000
29	17.000	2.000
30	19.000	2.000
31	21.500	3.000
32	24.500	3.000

Fall Speed		
Class	Average Speed [m/s]	Class Spread [m/s]
1	0.050	0.100
2	0.150	0.100
3	0.250	0.100
4	0.350	0.100
5	0.450	0.100
6	0.550	0.100
7	0.650	0.100
8	0.750	0.100
9	0.850	0.100
10	0.950	0.100
11	1.100	0.200
12	1.300	0.200
13	1.500	0.200
14	1.700	0.200
15	1.900	0.200
16	2.200	0.400
17	2.600	0.400
18	3.000	0.400
19	3.400	0.400
20	3.800	0.400
21	4.400	0.800
22	5.200	0.800
23	6.000	0.800
24	6.800	0.800
25	7.600	0.800
26	8.800	1.600
27	10.400	1.600
28	12.000	1.600
29	13.600	1.600
30	15.200	1.600
31	17.600	3.200
32	20.800	3.200

Table 8.1.5-4: 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

8.1.6 C-band Weather Radar

(1) Personnel

Masaki Katsumata (PI, JAMSTEC, not onboard)
Biao GENG (JAMSTEC, not onboard)
Wataru TOKUNAGA (Operation leader, GODI)
Koichi INAGAKI (GODI)
Miki MORIOKA (GODI)

(2) Objective

The objective of the C-band weather radar observation in this cruise is to evaluate the performance of the radar, and to develop the better strategy of the radar observation, as well as to capture the structure of precipitating systems and their temporal and spatial evolution over the tropical area.

(3) Parameters

Power and phase of the backscattered signal at vertically- and horizontally-polarized channels, which can be converted to: Radar reflectivity, Doppler velocity, spectrum width of Doppler velocity, differential reflectivity (ZDR), differential propagation phase (ϕ_{DP}), specific differential phase (KDP), co-polar correlation coefficients (ρ_{HV}), etc.

(4) Method

The C-band weather radar on board R/V Mirai is used. The basic specification of the radar is 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
Laser Gyro:	PHINS (Ixsea S.A.S.)

The antenna is 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 is also corrected by subtracting the ship motion in beam direction.

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

During the cruise, the radar was operated typically by repeating a volume scan with 18 PPIs (Plan Position Indicators) every 6-minute. A dual PRF mode with the maximum range of, typically 100 km, is used for the volume scan. Meanwhile, a surveillance PPI scan is performed every 30 minutes in a single PRF mode with the maximum range of 300 km. The scan strategy is kept same thru the cruise, as in Table 8.1.6-1, to provide the same data quality to highlight the temporal variation of the precipitating systems.

Table 8.1.6-1 Parameters for scans

	Surveillance PPI	Volume Scan					
Repeated Cycle (min.)	30	6					
Pulse Width (long / short, in microsec)	200 / 2	64 / 1		32 / 1		32 / 1	
Scan Speed (deg/sec)	36	18		24		36	
PRF(s) (Hz)	400	dual PRF (ray alternative)					
		667	833	938	1250	1333	2000
Pulses / Ray	8	26	33	27	34	37	55
Ray Spacing (deg.)	0.7	0.7		0.7		1.0	
Azimuth	Full Circle						
Bin Spacing (m)	150						
Max. Range (km)	300	150		100		60	
Elevation Angle(s) (deg.)	0.5	0.5		1.0, 1.7, 2.4, 3.1, 3.8, 4.6, 5.6, 6.7, 8.2, 10.3, 12.8, 15.8		19.4, 23.6, 28.4, 33.7, 40.0	

(5) Preliminary results

The radar was operated continuously from Nov. 7 to Dec.18 during the cruise. The analyses will be performed after the cruise.

(6) Data archive

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

8.1.7 Shipboard CO_2 observations over the tropical Indo-Pacific Ocean for a simple estimation of the carbon flux between the ocean and the atmosphere from GOSAT data

(1) Personnel

Shuji Kawakami (PI, EORC/JAXA)
Kei Shiomi (EORC/JAXA)

(2) Objectives

Greenhouse gases Observing SATellite (GOSAT) was launched on 23 January 2009 in order to observe the global distributions of atmospheric greenhouse gas concentrations: column-averaged dry-air mole fractions of carbon dioxide (CO_2) and methane (CH_4). A network of ground-based high-resolution Fourier transform spectrometers provides essential validation data for GOSAT. Vertical CO_2 profiles obtained during ascents and descents of commercial airliners equipped with the in-situ CO_2 measuring instrument are also used for the GOSAT validation. Because such validation data are obtained mainly over land, there are very few data available for the validation of the over-sea GOSAT products. The objectives of our research are to acquire the validation data over the Indian Ocean and the tropical Pacific Ocean using an automated compact instrument, to compare the acquired data with the over-sea GOSAT products, and to develop a simple estimation of the carbon flux between the ocean and the atmosphere from GOSAT data.

(3) Description of instruments deployed

The column-averaged dry-air mole fractions of CO_2 and CH_4 can be estimated from absorption by atmospheric CO_2 and CH_4 that is observed in a solar spectrum. An optical spectrum analyzer (OSA, Yokogawa M&I co., AQ6370) was used for measuring the solar absorption spectra in the near-infrared spectral region. A solar tracker (PREDE co., ltd.) and a small telescope (Photo 8.1.7-1) collected the sunlight into the optical fiber that was connected to the OSA. The solar tracker searches the sun every one minute until the sunlight with a defined intensity. The measurements of the solar spectra were performed during solar zenith angles less than 80°.

Photo 8.1.7-1 Solar tracker and telescope. The sunlight collected into optical fiber was introduced into the OSA that was installed in an observation room in the MIRAI.

(4) Analysis method

The CO_2 absorption spectrum at the 1.6 μm band measured with the OSA is shown in Fig. 8.1.7-1. The absorption spectrum can be simulated based on radiative transfer theory using assumed atmospheric profiles of pressure, temperature, and trace gas concentrations. The column abundance of CO_2 (CH_4) was retrieved by adjusting the assumed CO_2 (CH_4) profile to minimize the differences between the measured and simulated spectra. Fig. 8.1.7-2 shows an example of spectral fit performed for the spectral region with the CO_2 absorption lines. The column-averaged dry-air mole fraction of CO_2 (CH_4) was obtained by taking the ratio of the CO_2 (CH_4) column to the dry-air column.

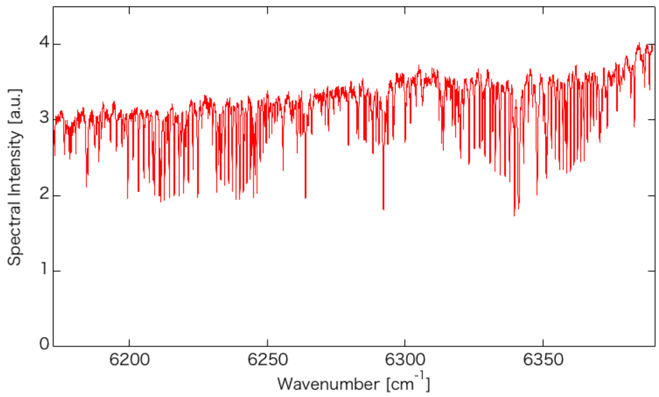


Fig. 8.1.7-1. 1.6 μm CO_2 absorption spectrum measured with the OSA.

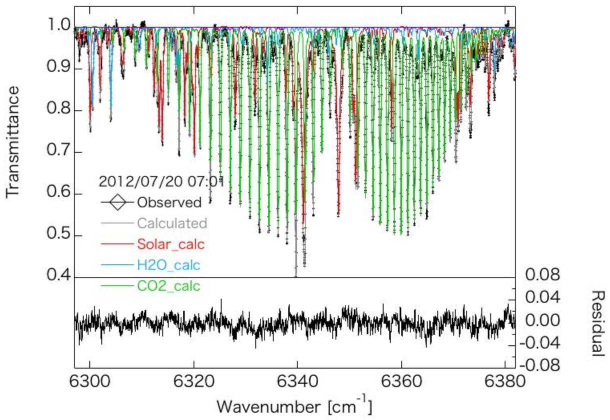


Fig. 8.1.7-2. Spectral fit performed for the 6297–6382 cm^{-1} region using an OSA spectrum. Open diamonds denote the measured spectrum, and the solid line denotes the spectrum calculated from the retrieval result. The residual between the measured and calculated spectra is also shown as an example.

(5) Preliminary results

The observations were made from November 4 to December 16, 2014 continuously in daytime, including data obtained in the high seas (Table 8.1.7-1 and Fig. 8.1.7-3).

CO_2 observations			CO_2 observations		
Date	Start Time(JST)	End Time(JST)	Date	Start Time(JST)	End Time(JST)
2014/11/04	7:16	15:21	2014/11/26	4:17	14:41
2014/11/05	7:30	7:31	2014/11/27	4:17	15:01
2014/11/07	7:07	12:49	2014/11/28	5:47	12:45
2014/11/08	6:56	16:12	2014/11/28	5:47	12:45
2014/11/08	6:56	16:12	2014/11/30	4:29	13:07
2014/11/10	8:28	14:17	2014/12/01	5:06	15:31
2014/11/11	8:48	14:50	2014/12/02	7:02	14:13
2014/11/12	5:45	15:09	2014/12/03	4:35	15:16
2014/11/13	6:38	15:00	2014/12/04	4:32	15:17
2014/11/14	5:53	14:55	2014/12/05	4:33	14:23
2014/11/15	4:40	15:17	2014/12/06	4:46	15:04
2014/11/16	4:30	15:05	2014/12/7	6:49	13:29
2014/11/17	4:19	14:18	2014/12/8	4:59	13:01
2014/11/18	6:10	14:40	2014/12/9	5:14	15:51
2014/11/19	3:44	14:31	2014/12/10	5:24	15:56
2014/11/20	3:53	14:27	2014/12/11	5:46	14:37
2014/11/21	3:54	14:45	2014/12/12	5:34	9:37
2014/11/22	3:51	15:10	2014/12/13	5:40	15:53
2014/11/23	4:03	14:50	2014/12/14	5:33	15:42
2014/11/24	4:01	15:00	2014/12/15	5:30	13:15
2014/11/25	5:23	11:44	2014/12/16	5:51	16:20

Table 8.1.7-1 Period of CO_2 observations

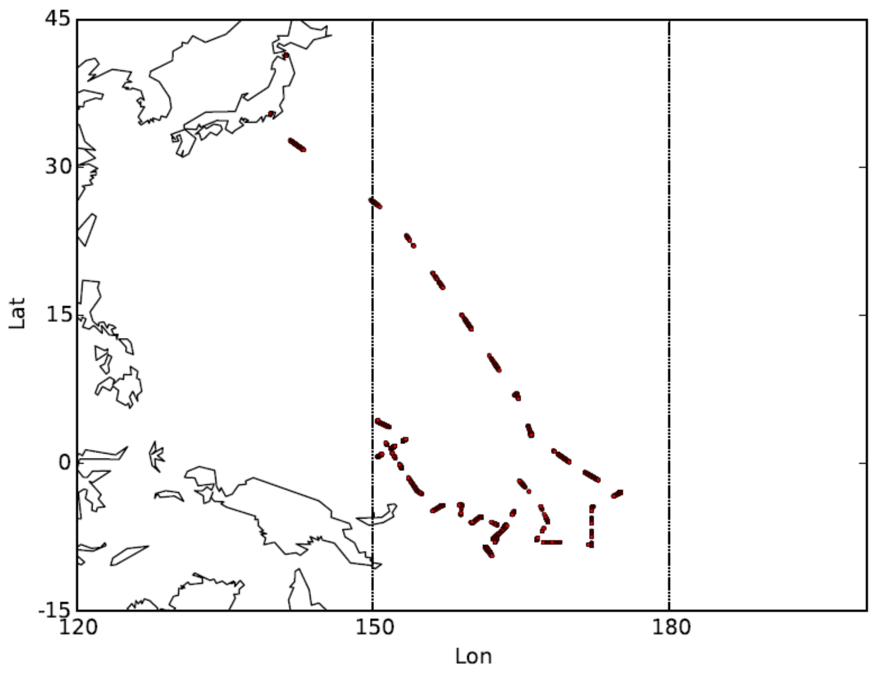


Fig. 8.1.7-3 Locations of CO_2 observations

(6) Data archive

The column-averaged dry-air mole fractions of CO_2 and CH_4 retrieved from the OSA spectra will be submitted to JAMSTEC Data Management Group (DMG).

8.1.8 Satellite image acquisition

(1) Personnel

Masaki Katsumata (JAMSTEC) : Principal Investigator (Not-onbord)
Wataru Tokunaga (Global Ocean Development Inc., GODI)
Koichi Inagaki (GODI)
Miki Morioka (GODI)
Masanori Murakami (MIRAI Crew)

(2) Objectives

The objectives are to collect cloud data in a high spatial resolution mode from the Advance Very High Resolution Radiometer (AVHRR) on the NOAA and MetOp polar orbiting satellites, and to verify the data from Doppler radar on board.

(3) Methods

We received the down link High Resolution Picture Transmission (HRPT) signal from satellites, which passed over the area around the R/V MIRAI. We processed the HRPT signal with the in-flight calibration and computed the brightness temperature. A cloud image map around the R/V MIRAI was made from the data for each pass of satellites.

We received and processed polar orbiting satellites data throughout MR14-06 Leg1 cruise from 07 November to 17 December 2014.

(4) Data archives

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

8.2 Continuous monitoring of surface seawater

8.2.1 Temperature, salinity and dissolved oxygen

1. Personnel

   Daisuke Suetsugu (PI, JAMSTEC)
   Shungo Oshitani (MWJ)
   Tatsuya Tanaka (MWJ)
   Tomonori Watai (MWJ)
   Masahiro Orui (MWJ)

2. Objective

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

3. Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co. Ltd.) has four sensors and automatically measures temperature, salinity and dissolved oxygen 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. The near-surface water was continuously pumped up to the laboratory from about 4.5 m water depth and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was adjusted to be 5 dm^3 min^{-1}.

a. Instruments

Software

Seamoni-kun Ver.1.50

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:	4563325-0362
Measurement range:	Temperature -5 to +35 ^{o}C
	Conductivity 0 to 7 S m^{-1}
Initial accuracy:	Temperature 0.002 ^{o}C

	Conductivity 0.0003 S m^{-1}
Typical stability (per month):	Temperature 0.0002 ^{o}C
	Conductivity 0.0003 S m^{-1}
Resolution:	Temperatures 0.0001 ^{o}C
	Conductivity 0.00001 S m^{-1}

Bottom of ship thermometer

Model:	SBE 38, SEA-BIRD ELECTRONICS, INC.
Serial number:	3857820-0540
Measurement range:	-5 to +35 ^{o}C
Initial accuracy:	±0.001 ^{o}C
Typical stability (per 6 month):	0.001 ^{o}C
Resolution:	0.00025 ^{o}C

Dissolved oxygen sensor

Model:	OPTODE 3835, AANDERAA Instruments.
Serial number:	1519
Measuring range:	0 - 500 μmol dm^{-3}
Resolution:	< 1 μmol dm^{-3}
Accuracy:	< 8 μmol dm^{-3} or 5 % whichever is greater
Settling time:	< 25 s

Dissolved oxygen sensor

Model:	RINKO II, ARO-CAR/CAD
Serial number:	13
Measuring range:	0 - 540 μmol dm^{-3}
Resolution:	< 0.1 μmol dm^{-3}
or 0.1 % of reading whichever is greater	
Accuracy:	< 1 μmol dm^{-3}
or 5 % of reading whichever is greater	

b. Measurements

Periods of measurement, maintenance, and problems during MR14-06_leg1 are listed in Table 8.2.1-1.

Table 8.2.1-1 Events list of the Sea surface water monitoring during MR14-06_leg1

System Date [UTC]	System Time [UTC]	Events	Remarks
2014/11/7	10:40	All the measurements started and data was available.	Cruise start
2014/11/21	2:52	OPTODE was drifted	
2014/11/21	4:41	OPTODE was drifted	
2014/11/21	6:14	OPTODE was drifted	
2014/11/24	23:41	OPTODE correspondence stopped	Check OPTODE
2014/11/24	23:42	OPTODE correspondence started	
2014/11/24	23:49	OPTODE correspondence stopped	Check OPTODE
2014/11/24	23:50	OPTODE correspondence started	
2014/11/25	2:11	OPTODE correspondence stopped	Check OPTODE
2014/11/25	2:22	OPTODE correspondence started	
2014/11/25	5:08	All the measurements stopped.	
2014/11/25	5:51	All the measurements started and data was available.	
2014/12/17	5:36	All the measurements stopped.	Cruise end

4. Preliminary Result

We took the surface water samples to compare sensor data with bottle data of salinity. The results are shown in Fig.8.2.1-1. All the salinity samples were analyzed by the Guideline 8400B "AUTOSAL". Preliminary data of temperature, salinity, and dissolved oxygen at sea surface are shown in Fig.8.2.1-2.

We checked the data of OPTODE sensor. Then we found drift of this sensor. The doubtful data of OPTODE are listed in Table 8.2.1-2.

Table 8.2.1-2 List of the doubtful data of OPTODE during MR14-06_leg1

System Date [UTC]	System Time [UTC]	Events
2014/11/21	01:00	The doubtful data of OPTODE are started
2014/11/21	09:30	The doubtful data of OPTODE are finished
2014/11/24	23:30	The doubtful data of OPTODE are started
2014/11/25	00:00	The doubtful data of OPTODE are finished
2014/11/25	01:50	The doubtful data of OPTODE are started
2014/11/25	06:50	The doubtful data of OPTODE are finished

5. Data archive

These data obtained in this cruise will be submitted to the Data Management Office (DMO) of JAMSTEC, and will be opened to the public via Data Research for Whole Cruise Information in JAMSTEC.

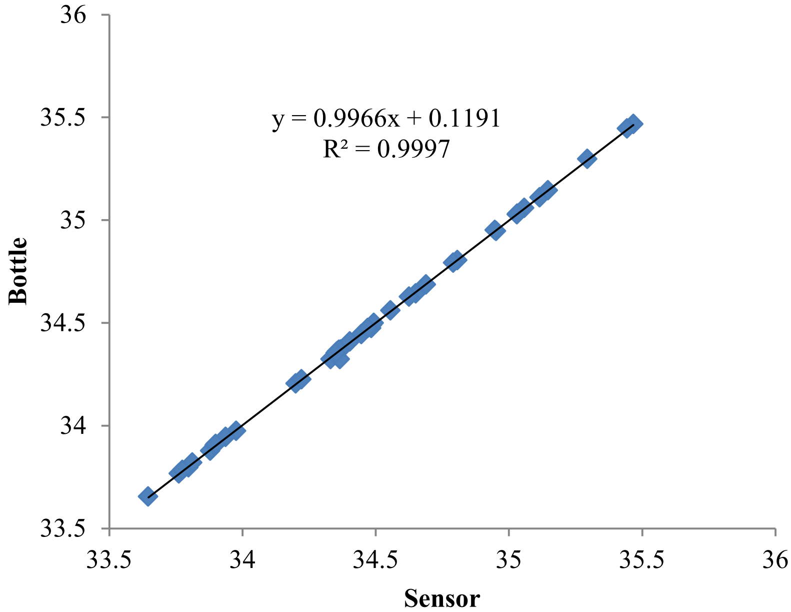
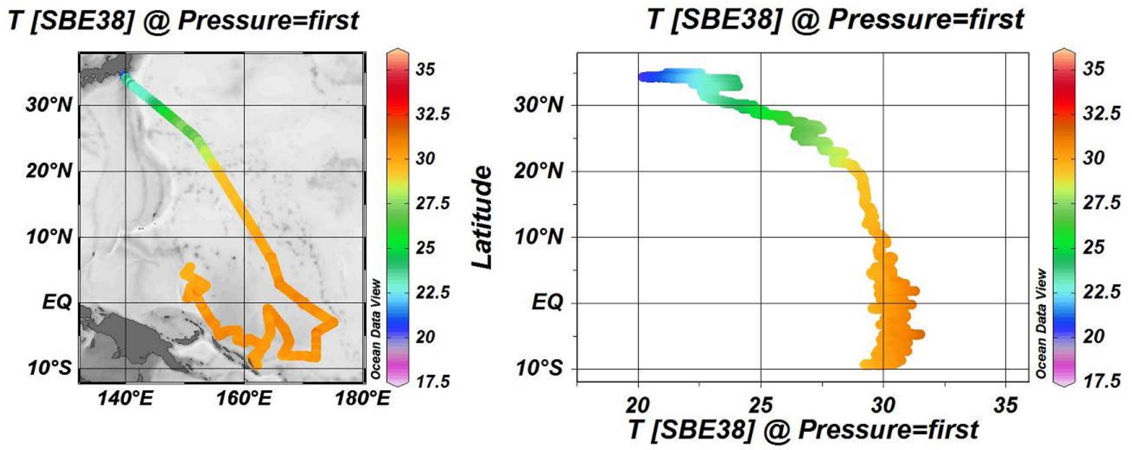
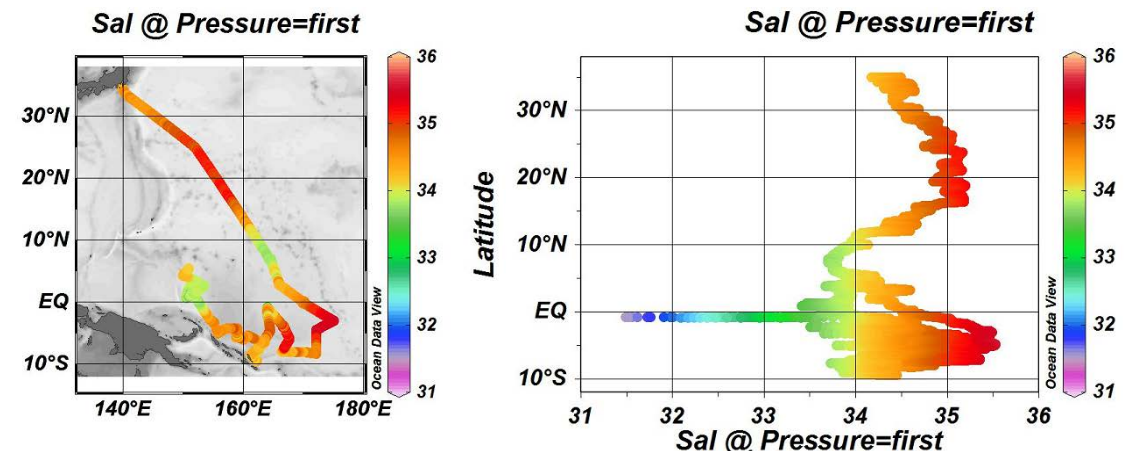


Fig 8.2.1-1 Correlation of salinity between sensor data and bottle data.

(a) Temperature



(b) Salinity



(c) Dissolved oxygen

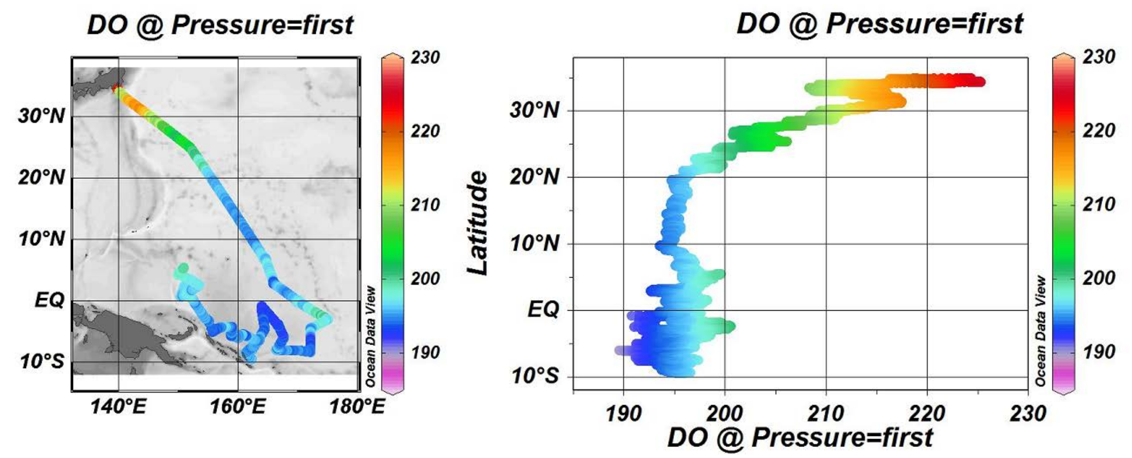


Fig.8.2.1 -2 Spatial and temporal distribution of (a) temperature by SBE38 (b) salinity (c) dissolved oxygen in MR14-06_leg1 cruise.

8.2.2 Underway pCO2

(1) Personnel

Akihiko Murata (JAMSTEC, not onboard)
Tomonori Watai (MWJ)

(2) Objectives

Concentrations of CO_2 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 CO_2, and to clarify the mechanism of the CO_2 absorption, because the magnitude of the anticipated global warming depends on the levels of CO_2 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 were aimed at quantifying how much anthropogenic CO_2 absorbed in the surface ocean in the subtropical region of North Pacific. For the purpose, we measured pCO_2 (partial pressure of CO_2) in the atmosphere and surface seawater.

(3) Apparatus

Concentrations of CO_2 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 calibrated concentrations of the standard gas were 269.06, 330.21, 359.34 and 419.29 ppmv. To check drifts of gas concentrations, the standard gases are calibrated again after the cruise.

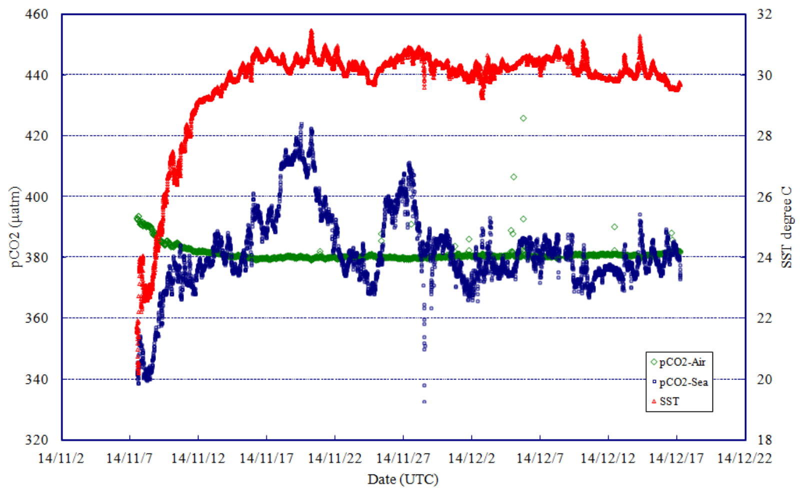
The marine air taken from the bow was introduced into the NDIR by passing through a mass flow controller, which controlled the air flow rate at about 0.6 – 0.8 L/min, a cooling unit, a perma-pure dryer (GL Sciences Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

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 two cooling units, a perma-pure dryer (GL Science Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

(4) Results

Concentrations of CO_2 (xCO_2) of marine air and surface seawater are shown in Fig. 8.2.2-1a, together with SST. Figure 8.2.2-1b shows the cruise track, along which pCO_2 was measured.

(a)



(b)

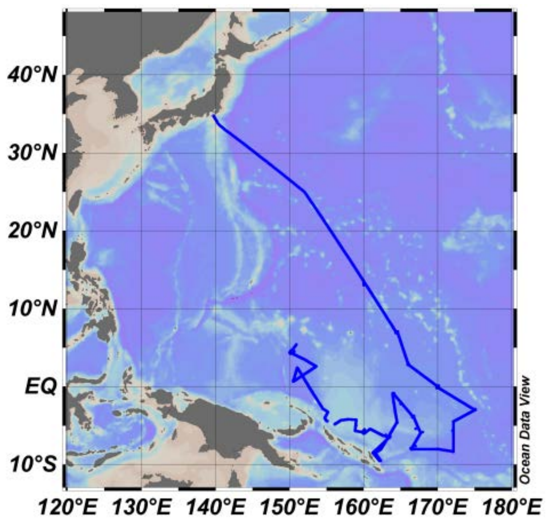


Fig. 8.2.2-1 Distributions of (a) CO_2 (ppmv) in marine air and in surface sweater, and SST. The cruise track along which CO_2 was measured is shown in (b).

8.3 Shipboard ADCP

(1) Personnel

Daisuke Suetsugu	(JAMSTEC)	: Principal Investigator
Wataru Tokunaga	(Global Ocean Development Inc., GODI)	
Koichi Inagaki	(GODI)	
Miki Morioka	(GODI)	
Masanori Murakami	(MIRAI Crew)	

(2) Objectives

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

(3) Methods

Upper ocean current measurements were made in the MR14-06 Leg1 cruises using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system, without territorial waters at Independent State of Papua New Guinea and Federated States of Micronesia, and EEZ at Republic of the Marshall Islands, Republic of Kiribati, Solomon Islands and Republic of Nauru 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 vessel-mount ADCP (acoustic frequency 76.8 kHz "Ocean Surveyor", Teledyne RD Instruments). 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 sources, ship's gyro compass (TOKYO KEIKI, Japan) continuously providing heading to the ADCP system directory, and Inertial Navigation System (PHINS, IXBLUE) which provide high-precision heading and attitude information are stored in ".N2R" data files.
3) Positioning system (GARMIN: GPS 19x HVS) providing position fixes.
4) Data acquisition system using the VmDas version 1.4.6.5 (TRDI)
5) To synchronize time stamp of pinging with GPS time, the clock of the logging computer is adjusted to GPS time every 1 minutes.

6) The sound speed at the transducer does affect the vertical bin mapping and vertical velocity measurement, 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 16 m intervals starting about 15 m below the surface. Every ping was recorded as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds averaged data were recorded as short term average (.STA) and long term average (.LTA) data, respectively. Major parameters for the measurement (Direct Command) are shown in Table 8.4-1.

(4) Preliminary results

Fig.8.4-1 shows surface current profile along the ship's track at research area, averaged three depth layer from No.3 to No.5, about from 47 m to 95 m with 60 minutes averaged.

(5) Data archive

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 JAMSTEC home page.

Table 8.4-1 Major parameters

Bottom-Track Commands

BP = 001	Pings per Ensemble (almost less than 1300m depth)
	05:17UTC 04 Nov. 2014 – 23:16UTC 05 Nov. 2014
	05:43UTC 07 Nov. 2014 – 11:18UTC 07 Nov. 2014
	00:05UTC 11 Nov. 2014 – 05:24UTC 11 Nov. 2014

Environmental Sensor Commands

EA = +04500	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (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	Coord 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

Timing Commands

TE = 00:00:02.00	Time per Ensemble (hrs:min:sec.sec/100)
TP = 00:02.00	Time per Ping (min:sec.sec/100)

Water-Track Commands

WA = 255	False Target Threshold (Max) (0-255 count)
WB = 1	Mode 1 Bandwidth Control (0=Wid, 1=Med, 2=Nar)
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)
WG = 001	Percent Good Minimum (0-100%)
WI = 0	Clip Data Past Bottom (0 = OFF, 1 = ON)
WJ = 1	Rcvr Gain Select (0 = Low, 1 = High)
WM = 1	Profiling Mode (1-8)
WN = 40	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS= 1600	Depth Cell Size (cm)
WT = 000	Transmit Length (cm) [0 = Bin Length]
WV = 0390	Mode 1 Ambiguity Velocity (cm/s radial)

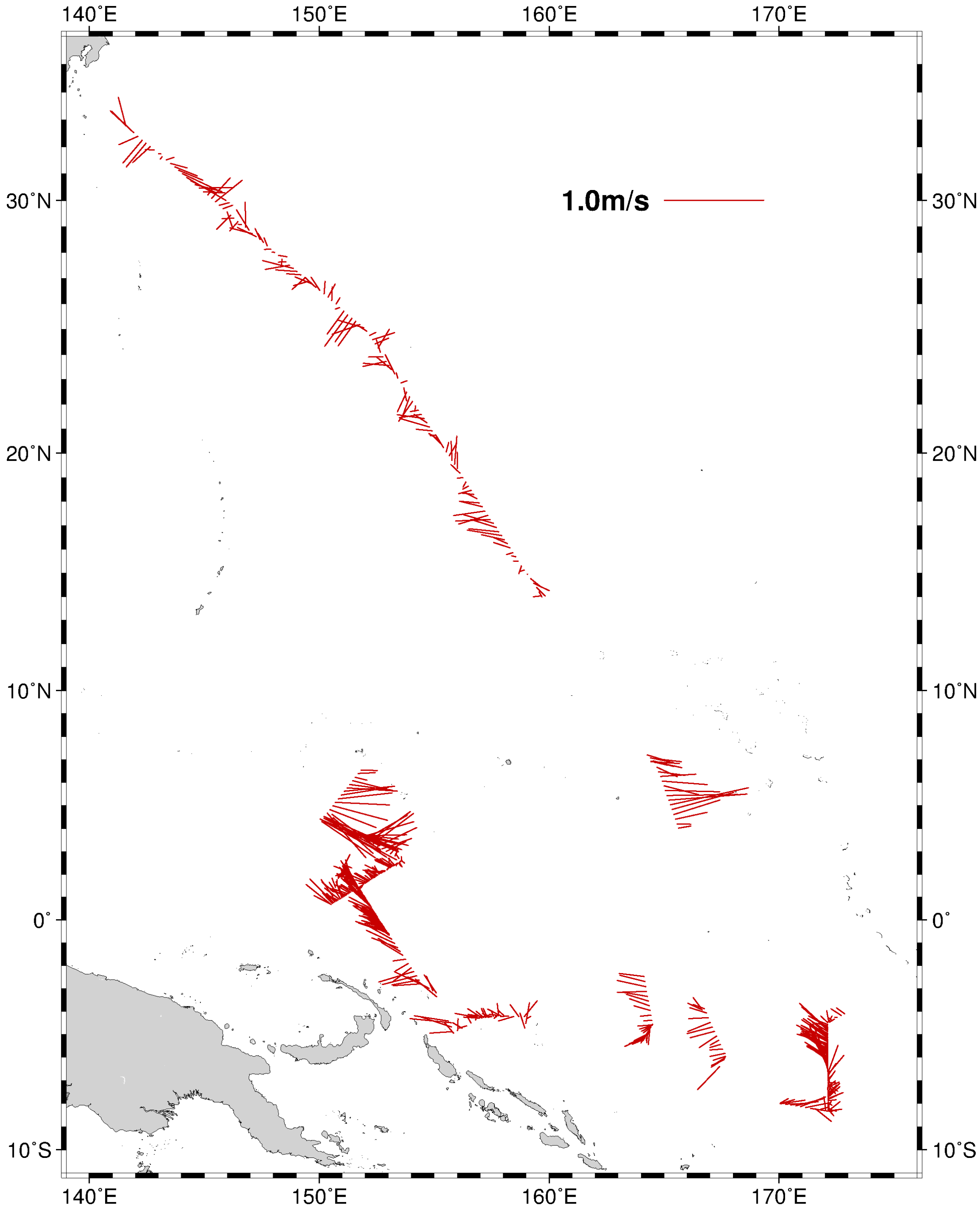


Fig 2.6-1 Current profile along the ship's track at research area, about 47 m to 95 m depth,
averaged every 60 minutes.

8.4 Argo floats

(1) Personnel

Toshio Suga	(PI, JAMSTEC/RCGC, not onboard)
Shigeki Hosoda	(JAMSTEC/ RCGC, not onboard)
Kanako Sato	(JAMSTEC/ RCGC, not onboard)
Mizue Hirano	(JAMSTEC/ RCGC, not onboard)
Shuhei Masuda	(JAMSTEC/ RCGC), not onboard)
Shungo Oshitani	(MWJ): Technical Staff (Operation Leader)

(2) Objectives

The objective of deployment is to clarify the structure and temporal/spatial variability in the North Pacific Ocean, especially water masses such as the Sub Tropical Mode Water (STMW). The deployment to this area where Argo float density tends to be sparse also contribute to the international Argo program to construct the global Argo array.
The profiling floats launched in this cruise measure vertical profiles of temperature and salinity automatically every five or ten days. As the vertical resolution of the profiles is very fine, the structure and variability of the water mass can be displayed well. Therefore, the profile data from the floats will enable us to understand the variability and the formation mechanism of the water mass.

(3) Parameters

・water temperature, salinity, pressure, and dissolved oxygen

(4) Methods

i. Profiling float deployment

We launched Navis float manufactured by Sea Bird Electronics Inc. This float equip SBE41cp CTD sensor manufactured by Sea-Bird Electronics Inc. as Argo float.
The float usually drift at a depth of 1000 dbar (called the parking depth), diving to a depth of 2000 dbar and rising up to the sea surface by decreasing and increasing their volume and thus changing the buoyancy in ten-day cycles. During the ascent, they measure temperature, salinity, and pressure. It stay at the sea surface for approximately thirty minutes, transmitting the CTD data to the land via the Iridium Rudics system, and then return to the parking depth by decreasing volume. The status of float and it launch is shown in Table 4.1.1.

Table 8.4-1 Status of floats and their launches

Float Type	**Navis float manufactured by Sea-Bird Electronics Inc.**
CTD sensor	**SBE41cp manufactured by Sea-Bird Electronics Inc.**
Cycle	**10 days (approximately 30minutes hours 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 layers)**

Launches

Float S/N	WMO ID	Date and Time of Launch(UTC)	Location of Launch	CTD St. No.
F0398	2902531	2014/11/10 12:40	24° 59.99' [N] 152° 00.00'[E]	N/A

(5) Data archive

The real-time data of the launched profiling float is provided to meteorological organizations, research institutes, and universities via Global Data Assembly Center (GDAC: http://www.usgodae.org/argo/argo.html, http://www.coriolis.eu.org/) and Global Telecommunication System (GTS), and utilized for analysis and forecasts of sea conditions. The real time data of S3A floats will also be provided and opened to the public as Argo equivalent floats following Argo data management procedure, although it is some delay due to some data management issues.

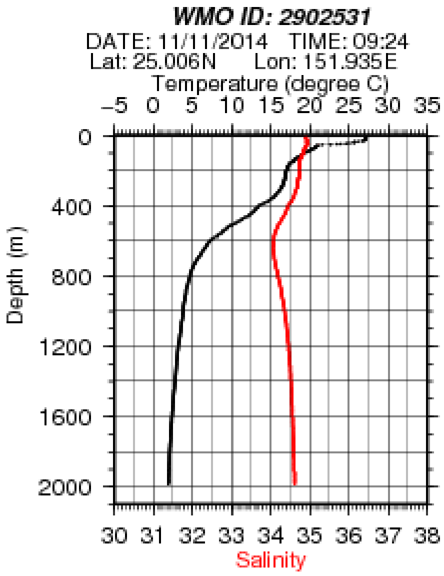


Fig. 8.4-1 First profile of temperature and salinity from the launched Argo float.

8.5 Underway geophysics

Personnel

Daisuke Suetsugu	(JAMSTEC)	: Principal Investigator
Shoka Shimizu	(JAMSTEC)	
Takeshi Hanyu	(JAMSTEC)	: Not on-board
Masao Nakanishi	(Chiba University)	: Not on-board
Takeshi Matsumoto	(University of the Ryukyus)	: Not on-board
Wataru Tokunaga	(Global Ocean Development Inc., GODI)	
Koichi Inagaki	(GODI)	
Miki Morioka	(GODI)	
Masanori Murakami	(MIRAI Crew)	

8.5.1 Sea surface gravity

(1) Introduction

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface during the MR14-06 Leg1 cruise without territorial waters on Independent State of Papua New Guinea and Federated States of Micronesia.

(2) Parameters

Relative Gravity [CU: Counter Unit]

[mGal] = (coef1: 0.9946) * [CU]

(3) Data Acquisition

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during this cruise. To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (Scintrex gravity meter CG-5), at Sekinehama as the reference point.

(4) Preliminary Results

Absolute gravity shown in Table 8.5.1-1

(5) Data Archives

Surface gravity data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

Table 8.5.1-1

No.	Date M/D	UTC	Port	Absolute Gravity [mGal]	Sea level [cm]	Draft [cm]	Gravity at Senor[*1] [mGal]	L&R[*2] [mGal]
#01	10/31	06:04	Sekinehama	980,371.95	275	640	980,373.04	12665.89
#02	11/6	23:24	Yokohama	-	243	665	-	12036.36
#03	12/18	05:28	Chuuk	-	230	625	-	-

[*1]: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.2223

[*2]: L&R = LaCoste and Romberg air-sea gravity meter S-116

8.5.2 Sea surface magnetic field

1) Three-component magnetometer

(1) Introduction

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 the MR14-06 Leg1 cruise without territorial waters on Independent State of Papua New Guinea and Federated States of Micronesia.

(2) Principle of ship-board geomagnetic vector measurement

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

$$\mathbf{H}ob = \tilde{\mathbf{A}}\ \tilde{\mathbf{R}}\ \tilde{\mathbf{P}}\ \tilde{\mathbf{Y}}\ \mathbf{F} + \mathbf{H}p \qquad \text{(a)}$$

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 **H**p is a magnetic field vector produced by a permanent magnetic moment of the ship's body. Rearrangement of Eq. (a) makes

$$\tilde{\mathbf{R}}\ \mathbf{H}ob + \mathbf{H}bp = \tilde{\mathbf{R}}\ \tilde{\mathbf{P}}\ \tilde{\mathbf{Y}}\ \mathbf{F} \qquad \text{(b)}$$

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

(3) Instruments on R/V MIRAI

A shipboard three-component magnetometer system (Tierra Tecnica SFG1214) 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. Ship's heading, pitch, and roll are measured by the Inertial Navigation System (INS) for controlling attitude of a Doppler radar. Ship's position (GPS) and speed data are taken from LAN every second.

(4) Data Archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC.

(5) Remarks

1) For calibration of the ship's magnetic effect, we made a "figure-eight" turn (a pair of clockwise and anti-clockwise rotation). This calibration was carried out as below.

01:11 – 01:47 15 Nov. 2014 around 06-57N, 164-30E
23:27 – 23:53 18 Nov. 2014 around 02-58S, 175-00E
11:44 – 12:09 27 Nov. 2014 around 03-53S, 166-43E
10:05 – 10:28 04 Dec. 2014 around 06-24S, 163-25E
12:36 – 12:59 09 Dec. 2014 around 00-37S, 152-59E

2) Cesium magnetometer

(1) Introduction

Measurement of total magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure.

(2) Data Period and Sensor Rotation

20:58 19 Nov. 2014 – 01:08 23 Nov. 2014	Rotation = 0 degrees
09:18 24 Nov. 2014 – 04:16 25 Nov. 2014	Rotation = 0 degrees
08:32 25 Nov. 2014 – 20:52 26 Nov. 2014	Rotation = +30 degrees
10:27 29 Nov. 2014 – 22:32 03 Dec. 2014	Rotation = 0 degrees
15:48 04 Dec. 2014 – 22:48 05 Dec. 2014	Rotation = +75 degrees
09:44 06 Dec. 2014 – 03:07 07 Dec. 2014	Rotation = 0 degrees
08:05 07 Dec. 2014 – 22:54 07 Dec. 2014	Rotation = -30 degrees
23:10 07 Dec. 2014 – 09:41 08 Dec. 2014	Rotation = 0 degrees
17:50 08 Dec. 2014 – 23:19 08 Dec. 2014	Rotation = 0 degrees
15:05 09 Dec. 2014 – 10:08 12 Dec. 2014	Rotation = +135 degrees

19:58 12 Dec. 2014 – 12:50 15 Dec. 2014 Rotation = +45 degrees

(3) Specification

We measured total geomagnetic field using a cesium marine magnetometer (Geometrics Inc., G-882) and recorded by G-882 data logger (Clovertech Co., Ver.1.0.0). The G-882 magnetometer uses an optically pumped Cesium-vapor atomic resonance system. The sensor fish towed 500 m behind the vessel to minimize the effects of the ship's magnetic field. Table 8.5.2-1 shows system configuration of MIRAI cesium magnetometer system.

Table 8.5.2-1 System configuration of MIRAI cesium magnetometer.

Dynamic operating range:		20,000 to 100,000 nT
Absolute accuracy:		<±2 nT throughout range
Setting:	Cycle rate;	0.1 sec
	Sensitivity;	0.001265 nT at a 0.1 second cycle rate
	Sampling rate;	1 sec

(4) Data Archive

Total magnetic force data obtained during this cruise was submitted to the Data Management Group (DMG) of JAMSTEC, and archived there.

8.5.3 Swath Bathymetry

(1) Introduction

R/V MIRAI is equipped with a Multi narrow Beam Echo Sounding system (MBES), SEABEAM 3012 (L3 Communications ELAC Nautik). The objective of MBES is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global datasets.

(2) Data Acquisition

The "SEABEAM 3012" on R/V MIRAI was used for bathymetry mapping during the MR14-06 Leg1 cruise without territorial waters on Independent State of Papua New Guinea and Federated States of Micronesia.

To get accurate sound velocity of water column for ray-path correction of acoustic beam, 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) during this cruise.

Table 8.5.3-1 shows system configuration and performance of SEABEAM 3012 system.

Table 8.5.3-1 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
Beam spacing:	Equi-Angle
Number of beams	301 beams
Swath width:	60 to 150 degree (max)
Depth accuracy:	< 1 % of water depth (average across the swath)

(3) Preliminary Results

The results will be published after primary processing.

(4) Data Archives

Bathymetric data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

8.5.4 Sub-bottom profiler

(1) Introduction

R/V MIRAI is equipped with a Sub-Bottom Profiler (SBP), Bathy2010 (SyQwest). The objective of SBP is collecting sub-bottom data along ship's track.

(2) Data Acquisition

Bathy2010 on R/V MIRAI was used for sub-bottom mapping during the 14 Nov. 2014 to 17 Dec. 2014 without territorial waters on Independent State of Papua New Guinea and Federated States of Micronesia. Table 8.5.4-1 shows system configuration and performance of Bathy2010 system.

Table 8.5.4-1 Bathy2010 System configuration and performance

Frequency:	3.5 KHz (FM sweep)
Transmit beam width:	23 degree
Transmit pulse length:	0.5 to 50 msec
Strata resolution:	Up to 8 cm with 300 m of bottom penetration according to bottom type
Depth resolution:	0.1 feet, 0.1 m
Depth accuracy:	±10 cm to 100 m, ± 0.3% to 6,000 m
Sound velocity:	1,500 m/s (fix)

(3) Data Archives

Sub-bottom data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC, and will be archived there.

9. Cruise log of MR14-06 leg1

Date, time(UTC)	Location	Activity/Event
Nov. 4 0:00 5:17 6:10		 Continuous observations (Meteorological, Gravity meter, Magnetometer, etc.) are started. ADCP is started. Departure from Sekinehama.
Nov. 5 23:15		 Arrival at Yokohama
Nov. 7 7:00 9:00 9:55 10:30 10:40 22:24		 Departure from Yokohama. Surface sea water sampling pump is started. MBES is started. TSG observation is started. Measurement of CO2 in air and water is started. Operation of Doppler radar is started.
Nov. 8 0:00~7:45 1:23		 Safety guidance and drill, observation meeting, Konpira ceremony. High volume air sampler is started.
Nov. 9 4:00~5:30		 Airgun test is completed.
Nov. 10 0:00~09:00 13:00	 24-5999N,152-0000E	 Maintenance of streamer cables is completed. ARGO is launched. Time adjustment +1 hour (SMT=UTC+10 hour)
Nov. 11		VRU has trouble. Relaced by another one. MBES is stopped from 04:24 to 04:46. MAX-DOAS is stopped from 04:24 to 05:20.
Nov. 12 03:30		 Seminar on the research of the Ontong Java Plateau; Guidance on crustal survey with the portable MCS
Nov. 13		Time adjustment +1 hour (SMT=UTC+11 hour)
Nov. 14 02:54 18:35 19:00 22:30 23:33 23:41	 07-07.76N,164-17.40E 06-57.203N,164-29.744E 06-57.216N,164-29.693E	 SBP is started. XCTD is launched. Arrival at the O23 area. MBES survey is started. MBES survey is completed. OBEM is launched. BBOBS is launched.
Nov. 15 00:41		 Settlement and status of BBOBS are

 03:11~03:47 02:06 02:10~03:20 03:30 22:41	 06-57.2649N,164-29.7958E,5108m 06-57.1780N,164-29.7663E,5103m	confirmed. Calibration of shipboard magnetometer Settlement of OBEM is confirmed. BBOBS is located. OBEM is located. Departure from the O23 area Arrival at the O22 area. MBES survey is started.
Nov. 16 01:46 02:38 02:45 03:36 04:38 04:40~05.59 06:00	 02-52.2113N,166-01.6144E 02-52.2746N,166-01.5286E 02-52.2644N,166-01.5806E,4317m 02-52.1660N,166-01.6832E,4322m	 MBES survey is completed. OBEM is launched. BBOBS is launched. Settlement and status of BBOBS are confirmed. Settlement of OBEM is confirmed. BBOBS is located. OBEM is located. Departure from the O22 area
Nov. 17 05:16 07:30 07:39 07:46 08:37 09:47 09:50~10:55 10:55~11:25 11:26 11:42~14:28	 00-01.38N,170-00.31E 00-01.36N,170-00.37E 00-01.5515N,170-00.2777,4464m 00-01.4053N,170-00.1694E,4466m	 Arrival at the O21 area. MBES survey is started. MBES survey is completed. OBEM is launched. BBOBS is launched. BBOBS is deployed. Settlement of OBEM is confirmed. BBOBS is located. OBEM is located. Status of BBOBS is checked. Departure from the O21 area MBES survey resumed.
Nov.18 17:28 21:42 21:48 21:56 22:22 22:55 23:27~23:53 00:14	 02-56.7606S,174-59.417E 02-56.7725S,174-59.4328E 02-57S, 174-59E	 Arrival at the O20 area. MBES survey is started. MBES survey is completed. OBEM is launched. BBOBS is launched. XCDT is launched. Settlement and status of BBOBS are confirmed. Calibration of shipboard magnetometer. Settlement of OBEM is confirmed.
Nov. 19 01:15~01:29 01:36 20:48 20:58~23:09 23:49	 02-56.7454S,174-59.4424E,5056m 02-56.7372S,174-59.4244E,5054m 02-56.7639S,174-59.4153E,5069m 04-30S, 172-07E 04-30.32S,172-06.73E	 BBOBS is located. OBEM is located. OBEM is located with SSBL. Departure from the O20 area Arrival at the L1 crustal survey line Preparation for survey with Cesium magnetometer and pMCS (tail buoy, airgun, streamer cable) pMCS survey is started (3.5kt).

Nov. 20 02:15 02:40		Airgun compressor is stopped Airgun compressor is resumed The pMCS survey is continued (3.5kt)
Nov. 21 22:30~23:00 23:09	 07-06S,172-07E	 The pMCS survey is continued (3.5kt) Meeting of shipboard scientists and technicians for revising pMCS lines. The Cesium magnetometer is stopped.
Nov. 22 00:20	 07-10S,172.07E	 The Cesium magnetometer is resumed. The pMCS survey is continued. (3.0~3.5kt)
Nov. 23 00:21 00:29~01:09 02:15~03:48 03:54 12:45 13:45 14:34 15:39 15:39~16:34 16:36	 08-20.20S,172-07.00E 08-00.7848S,170-03.1546E,4858m 08-00.7287S,170-03.1896E,4851m	 The pMCS streamer cable is cut off near the end of L1. The tail buoy and the buoy side of the cable are disconnected from the ship. The pMCS survey is completed. Recovery of the airgun, the cesium magnetometer, .and the ship side of the cable Recovery of the tail buoy and the buoy side of the cable. Departure from the L1 area Arrival at the O19 area. MBES survey is started. MBES survey is completed. BBOBS is launched. Settlement and status of BBOBS is confirmed. BBOBS is located. Departure from the O19 area.
Nov. 24 09:12 09:18~14:40 17:57	 07-54S, 166-29E 07-52.05S,166-30.22E	 Arrival at the L2 crustal survey line The Cesium magnetometer and pMCS (tail buoy, airgun, streamer cable) is launched. Three parts in the streamer cable are removed one by one to identify a malfunctioned part of the cable. The pMCS survey is started at a speed of 3.0 kt, though the problem has not been resolved.
Nov. 25 03:50 03:56	 07-31.6442S,166-42.8937E	 The pMCS survey is stopped on the L2 line. The Cesium magnetometer is recovered for adjustment.

04:20~06:52		A series of tests to identify a part of the streamer cable that causes the problem in data transmission is performed. The malfunctioned part is identified and removed.
08:32		The Cesium magnetometer is launched.
08:57	07-31.95S,166-42.73E	The pMCS survey is resumed on the L2 line.
Nov. 26		
19:11	05-56.85S,167-41.58E	The pMCS survey on the L2 line is completed.
19:20~20:52		Recovery of the airgun, the streamer cable, the tail buoy, and the cesium magnetometer
21:06		Departure from the L2 area
Nov. 27		
07:52		Arrival at O18 area and MBES survey is started.
10:02		MBES survey is suspended.
10:32	03-53.3216S,166-42.6098E	OBEM is launched.
10:39	03-53.4047S,166-42.4888E	BBOBS is launched.
11:21		Settlement and status of BBOBS are confirmed.
11:44~12:09		Calibration of shipboard magnetometer
12:23		Settlement of OBEM is confirmed.
12:23~13:16	03-53.2720S,166-42.4899E,3460m	BBOBS is located.
	03-53.2752S,166-42.6086E,3460m	OBEM is located.
13:18		MBES is resumed.
15:15		MBES is completed. Departure from the O18 area
Nov. 28		
09:00		Arrival at O17 area and MBES survey is started.
12:24		MBES survey is suspended.
12:31	00-59.1012S,164-00.4577E	OBEM is launched.
12:37	00-59.0906S,164-00.5459E	BBOBS is launched.
13:36		Settlement and status of BBOBS are confirmed.
14:23		Settlement of OBEM is confirmed.
14:24~15:21	00-59.1119S,164-00.5143E 4440m	BBOBS is located.
	00-59.1932S 164-00.4024E 4436m	OBEM is located.
15:30		MBES is resumed.
17:08		MBES is completed. Departure from the O17 area
Nov. 29		
10:18		Arrival at the L4 crustal survey line
10:27~12:30	04-37.0718S,164-32.1549E	A cesium magnetometer and pMCS (tail buoy, airgun, streamer cable) is launched.
13:19	04-35.47S,164-28.27E	The pMCS survey along the L4 line is started at a speed of 3.3~4.0 kt.
14:00	04-37.29S,164-27.20E	The survey is stopped due to crossing

		of the magnetometer cable and the airgun.
14:28	04-37.89S,164-26.89E	The survey is resumed.
Nov. 30		
13:30~15:30		Meeting on a structure beneath the L1 pMCS line.
		The survey on L4 is continued.
Dec. 1		The survey on L4 is continued.
Dec. 2		
04:30	08-00.08S,162-20.96E	The pMCS survey on the L4 line is completed.
04:40~05:53		Recovery of the airgun, the streamer cable, the tail buoy.
06:06		Departure from the L4 area.
10:35		The underway geophysical survey started off east coast of Malaita Island.
10:42	8-31.03S,161-34.82E	XCTD is launched.
Dec. 3		
08:00		MAX-DOAS is stopped.
07:28		XCTD is launched.
14:01		The underway geophysical survey (off east coast of Malaita) is completed.
22:32		The Cesium magnetometer is recovered.
Dec. 4		
04:28	06-34S,163-22E	Arrival at O16 area and MBES survey is started.
08:42	06-25S,163-25E	MBES survey is completed.
08:47	06-24.9854S,163-24.9287E,3555m	OBEM is launched.
08:55	06-25.0167S,163-25.0072E,3555m	BBOBS is launched.
09:37		Settlement and status of BBOBS are confirmed.
10:05~10:28	06-24.56S,163-25.02E	Calibration of shipboard magnetometer
10:38		Settlement of OBEM is confirmed.
10:38~11:41	06-25.0400S,163-25.0086E,3575m	BBOBS is located.
	06-25.0797S,163-25.0469E,3576m	OBEM is located.
11:48		Departure from the O16 area.
15:36		Arrival at the L5 crustal survey line.
15:48~17:21		A Cesium magnetometer and pMCS (tail buoy, airgun, streamer cable) is launched.
19:04	06-16.26S,162-36.50E	The pMCS survey along the L5 line is started at a speed of 4.0 kt.
Dec. 5		
21:27	05-25.96S,160-53.93E	The pMCS survey on the L5 line is completed.
21:32~22:48		Recovery of the airgun, the streamer cable, the tail buoy, and the Cesium magnetometer.
23:00		Departure from the L5 area.
Dec. 6		
03:04	05-58.00S,160:07.50E	Arrival at O15 area and MBES survey

		is started
06:00		MBES survey is stopped.
06:01	05-57.9846S,160-02.4266E	OBEM is launched.
06:06	05-57.9872S,160-02.4610E	BBOBS is launched.
06:28		Settlement and status of BBOBS are confirmed.
06:40		Settlement of OBEM is confirmed.
06:41~07:40	05-57.8913S,160-02.4481E,1837m	BBOBS is located.
	05-57.8812S,160-02.3992E,1835m	OBEM is located.
07:42		MBES survey is resumed.
09:44		Departure from the O15 area.
09:32	05-55.00S,160-07.50E	MBES survey is completed.
09:48		The Cesium magnetometer is launched.
12:18	05-30S,160-05E	Underway geophysical survey is started around the Ontong Java atoll (B lines).
Dec. 7		
02:52	04-15S,159-00E	Underway geophysical survey is completed for the B line.
03:07	04-13.94S,158-59.30E	The Cesium magnetometer is recovered.
08:00		Arrival at the L6 crustal survey area.
08:06~09:39		A Cesium magnetometer and pMCS (tail buoy, airgun, streamer cable) is launched.
10:28	04-11.92S,157-48.58E	The pMCS survey along the L6 line is started at a speed of 4.0 kt.
21:33	04-18.00S,156-59.91E	The pMCS survey on the L6 line is completed.
21:37~22:54		Recovery of the airgun, the streamer cable, the tail buoy, and the Cesium magnetometer.
23:00		Departure from the L6 area.
23:23	04-18.66S,156-54.64E	The Cesium magnetometer is adjusted and launched.
Dec. 8		
11:00		Time adjustment -1 hour (SMT = UTC + 10 hour)
23:21	02-50S,154-30E	The Cesium magnetometer is recovered.
Dec. 9		
11:18	00-37S,153-00E	Arrival at the O5/L8 area. MBES survey is started.
11:59		MBES survey is completed.
12:27	00-36.9845S,153-00.0272E	BBOBS is launched.
12:36~12:59	00-36.85S,152-59.51E	Calibration of shipboard magnetometer
13:16		Settlement and status of BBOBS is confirmed.
13:29~14:22	00-36.9275S,153-00.1128E,4339m	BBOBS is located.
15:05~16:12		A Cesium magnetometer and pMCS (tail buoy, airgun, streamer cable) is launched.

17:22	00-37.49S,153-00.33E	The pMCS survey along the L8 line is started at a speed of 3.0 kt.
Dec. 10 04:51 04:52~06:25 08:43	 00-08.86S,152-42.06E 00-10.57S,152-43.15E	 The pMCS survey is stopped on the L8 line. The malfunctioned part is identified and removed. The pMCS survey is resumed on the L8 line.
Dec. 11		The pMCS is continued on L8.
Dec. 12 05:02 05:05~10:12 10:24 19:54 19:58~21:31 22:20	 02:19.38N,151-07.40E 00-40.21N,150-27.30E 00-40.96N,150-31.93E	 The pMCS survey is completed on L8. Recovery of the airgun, the streamer cable, the tail buoy, and the Cesium magnetometer. During the recovery, malfunctioned parts of the active cable are identified and removed and stretch cables are added. Departure from the L8 area Arrival at the L7 crustal survey line. A Cesium magnetometer and pMCS (tail buoy, airgun, streamer cable) is launched. The pMCS survey along the L7 line is started at a speed of 4.0 kt.
Dec. 13 10:25 21:00		 MAX-DOAS is resumed. Disdrometer is stopped due to disk full. The pMCS survey is continued.
Dec. 14 12:30 13:00		 Survey speed is reduced to 3.0 kt. The pMCS survey is continued. Disdrometer is resumed.
Dec. 15 11:01 11:04~12:51 13:12	 02-35.54N,153-34.33E	 The pMCS survey on the L7 line is completed. Recovery of the airgun, the streamer cable, the tail buoy, and the Cesium magnetometer. Departure from the L7 area.
Dec. 16 06:32 11:06 11:10 11:17 12:04 12:24~12:44 13:07 13:08~14:12	 04-15.00N,150-25.00E 04-26.9833N,150-23.0112E 04-27.0324N,150-22.9174E 04-26.55N,150-23.55E 04-27.0003N 150-22.9776E 4008m 04-26.9613N 150-23.0580E 4006m	 Arrival at O4 area and MBES survey is started. MBES survey is stopped. OBEM is launched. BBOBS is launched. Settlement and status of BBOBS are confirmed. Calibration of shipboard magnetometer Settlement of OBEM is confirmed. BBOBS is located. OBEM is located.

14:51		MBES survey is resumed.
Dec. 17 00:59 05:29 08:01 05:30 13:01	 04-45.60N,150-23.50E	 MBES survey is completed. Departure from the O4 area. TSG observation is completed. High volume sampler is stopped. Continuous observations (Meteorological, geopygical, Gravity meter, Magneteo meter, MBES, SBP, Doppler radar etc) are completed. ADCP is stopped. Transit to Chuuk
Dec. 18 23:20	 07-26.7330N,151-50.3532E	 Arrival at Chuuk MR14-06 Leg1 is completed.