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R/V Mirai Cruise Report
MR14-01

January 09 – February 13, 2014

Tropical Ocean Climate Study (TOCS)

Edited by

Iwao Ueki

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

Contents

1. General information

1. 1. Cruise ID
MR14-01

1. 2. Name of vessel
R/V MIRAI
Captain: Kan Matsuura

1. 3. Title of the cruise
Tropical Ocean Climate Study/Operation of TRITON Buoy

1. 4. Research area
Tropical Eastern Indian Ocean

***** Remarks *****

This cruise report is a preliminary documentation as of the end of the cruise. This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information. Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.

2. Introduction and observation summary

2. 1. Overview

The warm water pool located at the eastern Indian Ocean and the western equatorial Pacific Ocean has the highest sea surface temperature in the ocean all over the world. Therefore interaction between the ocean and atmosphere in that region becomes important for climate variability such as Dipole mode in the Indian Ocean and ENSO (El Niño/Southern Oscillation) in the Pacific Ocean. This cruise is conducted for understanding the process of warm water convergence and divergence, and interaction processes in the eastern tropical Indian Ocean. For that purpose, we carried out deployment and recovery of the TRITON (TRIangle Trans Ocean buoy Network) buoys as the main mission. The TRITON buoys have advantage of analysis for long- term variability in the warm water pool. We also carried out other observations, such as ADCP moorings, CTD measurements and meteorological observation, for understanding the Ocean and atmospheric conditions.

We also tried to conduct emergency recovery of an ADCP mooring in the Philippine Sea (7˚N 127˚ 46' E) with a towed sweep-line. Although a part of mooring was tangled with the towed sweep-line, we could not recover the mooring because of high tension on the line. Note that there is no observation except the activities for the emergency recovery of the ADCP mooring within the Republic of the Philippines' EEZ.

Oceanic and atmospheric conditions in the tropical Indian and Pacific Ocean showed almost same as climatological mean state. All of indices associated with ENSO and IOD indicate a normal condition. MJO (Madden-Julian Oscillation) index also indicates there is no MJO signal in Indian Ocean.

Major Climate forecasts, such as JAMSTEC, JMA, NOAA and so on, says El Niño will start evolving in late boreal spring and reach its height in the latter half of 2014.

2. 2. Observation summary

m-TRITON buoy deployment:	3 sites.
m-TRITON buoy recovery:	4 sites
ADCP buoy deployment:	1 sites
ADCP buoy recovery:	2 sites
CTD including water sampling:	8 casts
UnderwayCTD:	18 casts
XCTD:	3 launches
Surface meteorology:	continuous
Shipboard ADCP measurement:	continuous
Geophysics measurement:	continuous
Surface temperature and salinity measurements by intake method	continuous
pCO_2 measurements	continuous

*** Other specially designed observations have been carried out successfully.

3. Period, ports of call, cruise log and cruise track

3.1 Period

09th January 2014 – 13th February 2014

3.2 Ports of call

Sekinehama, Japan (Departure: 09th January 2014)
Hachinohe, Japan (Arrival: 10th January 2014)
Hachinohe, Japan (Departure: 10th January 2014)
Koror, Republic of Palau (Arrival: 13th February 2014)

3.3 Cruise Log

SMT	UTC	Event
Jan. 09th (Thu.) 2014		
08:00	23:00 (-1day)	Departure from Sekinehama
		[Ship Mean Time (SMT)=UTC+9h]
10:30	01:30	Safety guidance
15:20	06:20	Arrival at Hachinohe
Jan. 10th (Fri.) 2014		
13:20	04:20	Departure from Hachinohe
15:00	06:00	Surface sea water sampling start
16:45	07:45	Konpira ceremony
Jan. 11th (Sat.) 2014		
13:15	04:15	Emergency drill
15:00	06:00	Observation Meeting
22:23 – 23:44	13:23 – 14:44	CTD dC01M01 (2000m)
23:48	14:48	Deployment of ARGO float (#1)
23:55 – 00:11	14:55 – 15:11	Underway CTD dU001C1 (500m) (#1)
Jan. 12th (Sun.) 2014		
00:26	15:26	Start of Cesium magnetometer observation (#1)
Jan. 13th (Mon.) 2014		
15:36	06:36	End of Cesium magnetometer observation
Jan. 15th (Wen.) 2014		
11:00	02:00	Stop continuous observations because R/V MIRAI entered into Taiwan EEZ
11:00	02:00	Surface sea water sampling stop
22:00	13:00	Time adjustment -1h (SMT=UTC+8h)
Jan. 23th (Thu.) 2014		
22:00	14:00	Time adjustment -1h (SMT=UTC+7h)

SMT	UTC	Event
Jan. 24th (Fri.) 2014		
07:20	00:20	Exit from Indonesian EEZ
08:00	0100	Start continuous observations because R/V MIRAI exited from Indonesian EEZ
22:00	15:00	Time adjustment -1h (SMT=UTC+6h)
23:12	17:12	Arrival at ADCP buoy (EQ90E) station
Jan. 25th (Sat.) 2014		
08:06 – 10:08	02:06 – 04:08	Recovery of ADCP buoy (EQ90E, #1)
11:19 – 12:34	05:19 – 06:34	CTD dC02M01 (1000m) (#2)
13:13 – 15:02	07:13 – 09:02	Deployment of ADCP buoy (EQ90E, #1) (Fixed Position: 05-02.0108S, 156-01.5378E)
16:10 – 16:24	10:10 – 10:24	Checking of ATLAS buoy
16:26	10:26	XCTD observation X-01 (#1)
16:30	10:30	Departure from ADCP buoy (EQ90E) station
18:59 – 19:07	12:59 – 13:07	Underway CTD dU002C1 (500m) (#2)
Jan. 26th (Sun.) 2014		
03:24	21:24 (-1day)	Arrival at m-TRITON buoy TR#18 station
08:28 – 13:54	02:28 – 07:54	Recovery of m-TRITON buoy TR#18 (#1) TR#18 was not recoveried because over a standard value of tension
17:10 – 17:26	11:10 – 11:26	Underway CTD dU003C1 (500m) (#3)
17:27 – 17:56	11:27 – 11:56	Figure-8 turn for Three-component magnetometer calibration (0-57.82S, 89-59.98E, #1)
Jan. 27th (Mon.) 2014		
08:22	12:49	Deployment of m-TRITON buoy TR#18 (#2) (Fixed Position: 01-36.4097S, 090-04.8466E)
15:35 – 15:58	09:35 – 09:58	Checking of m-TRITON buoy TR#18
16:57 – 18:11	10:57 – 12:11	CTD dC03M01 1000m (#3)
18:12	12:12	Departure from m-TRITON buoy TR#18 station
Jan. 29th (Wen.) 2014		
04:54	22:54 (-1day)	Arrival at m-TRITON buoy TR#97 station
05:58 – 07:11	23:58 – 01:11	CTD dC04M01 1000m (#4)
08:18 – 12:15	02:18 – 06:15	Recovery of m-TRITON buoy TR#97 (#3)
12:24	06:24	Departure from m-TRITON buoy TR#97 station
13:31 – 13:47	07:31 – 07:47	Underway CTD dU004C1 (500m) (#4)
15:59 – 16:15	09:59 – 10:15	Underway CTD dU005C1 (500m) (#5)
18:26 – 18:41	12:26 – 12:41	Underway CTD dU006C1 (500m) (#6)

SMT	UTC	Event
Jan. 30th (Thu.) 2014		
01:24	19:24	Arrival at m-TRITON buoy TR#17 station
08:15 – 11:55	02:15 – 05:55	Deployment of m-TRITON buoy TR#17 (#4)
		(Fixed Position: 05-02.1182S, 094-58.6098E)
13:33 – 14:19	07:33 – 08:19	CTD dC05M01 1000m (#5)
15:02 – 15:47	09:02 – 09:47	CTD dC06M01 1000m (#6)
15:47 – 16:29	09:47 – 10:29	Checking of m-TRITON buoy TR#17
19:15 – 19:26	13:15 – 13:26	Underway CTD dU007C1 (500m) (#7)
Jan. 31th (Fri.) 2014		
08:05 – 11:53	02:05 – 05:53	Recovery of m-TRITON buoy TR#17 (#5)
12:00	06:00	Departure from m-TRITON buoy TR#17
15:03 – 15:21	09:03 – 09:21	Underway CTD dU008C1 (500m) (#8)
17:38 – 17:53	11:38 – 11:53	Underway CTD dU009C1 (500m) (#9)
20:07 – 20:25	14:07– 14:25	Underway CTD dU010C1 (500m) (#10)
22:52	17:52	XCTD observation X-02 (#2)
Feb. 1st (Sat.) 2014		
01:30	19:30 (-1day)	XCTD observation X-03 (#3)
04:42	22:42 (-1day)	Arrival at m-TRITON buoy TR#19 station
08:14 – 11:40	02:14 – 05:40	Deployment of m-TRITON buoy TR#19(#6)
		(Fixed Position: 08-03.9706, 095-07.4339E)
13:28 – 14:14	07:28 – 08:14	CTD dC07M01 1000m (#7)
14:14 – 14:30	08:14 – 14:30	Checking of m-TRITON buoy TR#19 (recovery buoy)
15:10 – 15:53	09:10 – 09:53	CTD dC08M01 1000m (#8)
15:53 – 16:30	09:53 – 10:30	Checking of m-TRITON buoy TR#19 (Deployment buoy)
16:41 – 17:09	10:41 – 11:09	Figure-8 turn for Three-component magnetometer calibration
		(8-02.05S, 95-07.10E, #2)
Feb. 2nd (Sun.) 2014		
08:05	02:08	Recovery of m-TRITON buoy TR#19 (#7)
12:12	06:12	Departure from m-TRITON buoy TR#19 station
14:05 – 14:20	08:05 – 08:20	Underway CTD dU011C1 (500m) (#11)
16:10 – 16:25	10:10 – 10:25	Underway CTD dU012C1 (500m) (#12)
18:16 – 18:30	12:16 – 18:30	Underway CTD dU013C1 (500m) (#13)
20:25 – 20:39	14:25 – 14:39	Underway CTD dU014C1 (500m) (#14)
22:36 – 22:50	16:36 – 16:50	Underway CTD dU015C1 (500m) (#15)
Feb. 3rd (Mon.) 2014		
00:50 – 01:05	18:50 – 17:05 (-1day)	Underway CTD dU016C1 (500m) (#16)
03:04 – 03:19	21:04 – 03:19 (-1day)	Underway CTD dU017C1 (500m) (#17)
05:23 – 05:38	23:23 – 23:38 (-1day)	Underway CTD dU018C1 (500m) (#18)
08:45	02:45	Surface sea water sampling stop
09:00	03:00	Stop continuous observations because R/V MIRAI entered
		into Indonesian EEZ
22:00	16:00	Time adjustment +1h (SMT=UTC+7h)

SMT	UTC	Event
Feb. 5st (Wen.) 2014		
22:00	15:00	Time adjustment +1h (SMT=UTC+8h)
Feb. 7th (Fri.) 2014		
22:00	16:00	Time adjustment +1h (SMT=UTC+9h)
Feb. 10th (Mon.) 2014		
19:45	10:45	Entered into Philippine EEZ
22:48	13:48	Arrival at ADCP buoy (7N127E) station
Feb. 11th (The.) 2014		
06:00 – 20:40	21:00 – 11:40	Recovery of ADCP buoy (7N127E, #2) We performed minesweeping, but was not able to recovery the ADCP buoy
20:42	11:42	Departure from ADCP buoy (7N127E) station
Feb. 13th (Thu.) 2014		
11:00	02:00	Arrival at Koror (Anchoring)
Feb. 14th (Fri.) 2014		
08:30	23:30 (-1day)	Shifted to commercial port

3.4 Cruise track

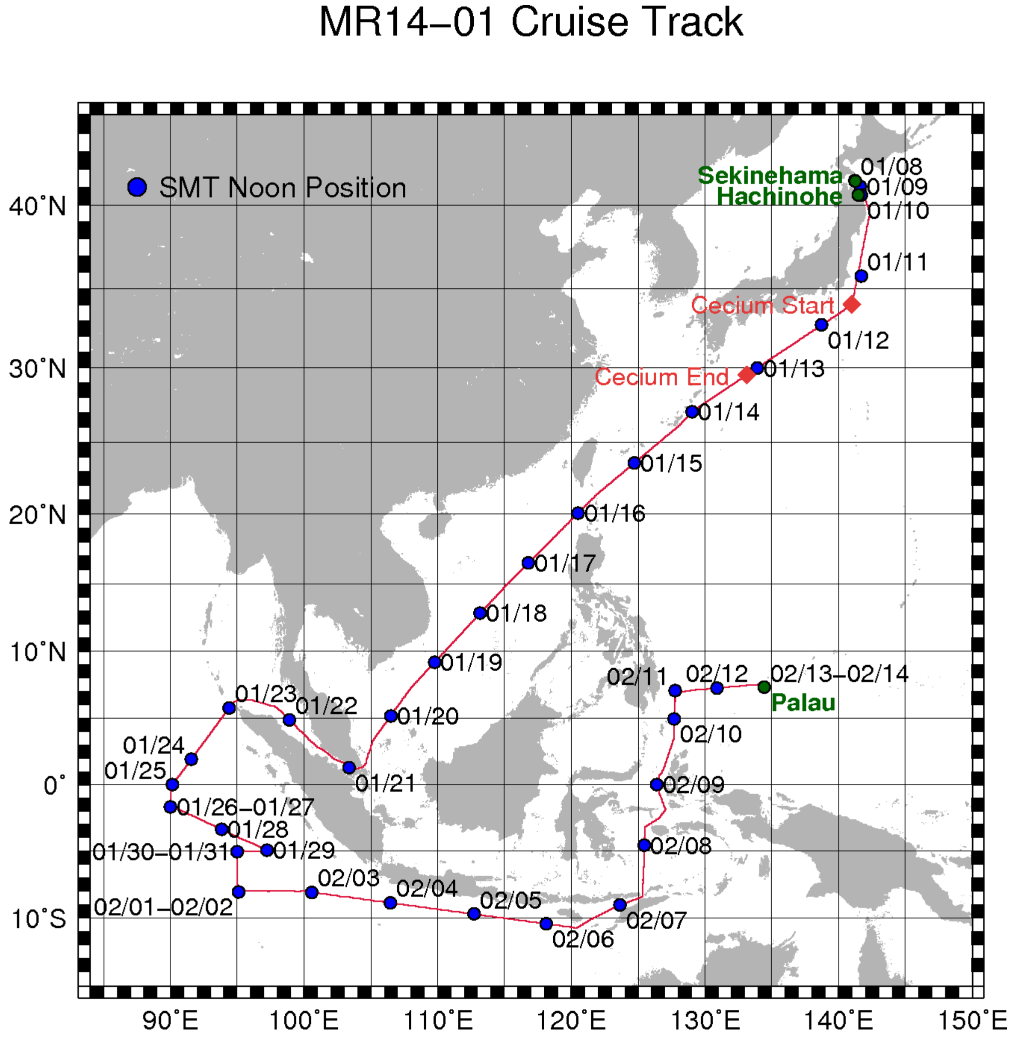


Fig 3.4 MR14-01 Cruise track and noon positions

4. Research themes and science party

4. 1. Title of Proposal of main mission

Tropical Ocean Climate Study/Operation of TRITON Buoy

4. 2. Principal Investigators of main mission

Kentaro ando (Tropical Ocean Climate Study)
Program Director,
Research Institute for Global Change,
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
2-15, Natsushima-cho, Yokosuka, Kanagawa 237-0061, JAPAN

Yasuhisa Ishihara (Operation of TRITON Buoy)
Group leader
Marine Technology Center,
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
2-15, Natsushima-cho, Yokosuka, Kanagawa 237-0061, JAPAN

4. 3. Chief Scientist

Iwao Ueki
Researcher
Research Institute for Global Change,
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
2-15, Natsushima-cho, Yokosuka, Kanagawa 237-0061, JAPAN

4. 4. Research Themes of Sub-missions and Principal Investigators (PIs)

(1) Study on ocean general circulation and heat/freshwater transport and their variability in the western North Pacific Ocean using Argo floats (PI: Toshio Suga, RIGC/JAMSTEC)
(2) Temporal and spatial distribution of optical characteristics of clouds and aerosols on oceans (PI: Nobuo Sugimoto, National Institute for Environmental Studies)
(3) Tropospheric aerosol and gas observations (PI: Yugo Kanaya, RIGC/JAMSTEC)
(4) Variability of oceanic carbon cycle on IOD events (PI: Akihiko Murata, RIGC/JAMSTEC)
(5) Observations of CO2 column averaged volume mixing ratios over the Indian Ocean and the tropical Pacific Ocean using a ship-borne compact system for a simple estimation of the carbon flux with GOSAT data (PI: Kei Shiomi, JAXA EORC)
(6) Optical characteristics of aerosols on oceans observed by shipboard skyradiometer (PI: Kazuma Aoki, Toyama University)
(7) Standardization of geophysical data and application to ocean floor dynamics (PI: Takeshi Matsumoto, Ryukyu University)

5. Participants list

5.1 R/V MIRAI scientists and technical staffs

Name	Affiliation	Occupation	Onboard section
Iwao Ueki	JAMSTEC	Chief Scientist	Sekinehama – Koror
Yukio Takahashi	JAMSTEC	Scientist	Sekinehama – Koror
Shinya Okumura	Global Ocean Development Inc.	Technical Staff	Sekinehama – Koror
Koichi Inagaki	Global Ocean Development Inc.	Technical Staff	Sekinehama – Koror
Hiroshi Matsunaga	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror
Tomoyuki Takamori	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror
Tatsuya Tanaka	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror
Akira Watanabe	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Sekinehama
Rei Ito	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror
Takatoshi Kiyokawa	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror
Masaki Yamada	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror
Tomonori Watai	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror
Elena Hayashi	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror
Atsushi Ono	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror
Shinichiro Yokogawa	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror
Yuta Iibuchi	Marine Works Japan Ltd.	Technical Staff	Sekinehama – Koror

5.2 R/V MIRAI crew members

Name	Rank or rating
Kan Matsuura	Master
Haruhiko Inoue	Chief Officer
Takeshi Isohi	1st Officer
Takahiro Noguchi	2nd Officer
Hiroki Kobayashi	3rd Officer
Minoru Maruta	Chief engineer
Hiroyuki Tohen	1st Engineer
Naoto Miyazaki	2nd Engineer
Wataru Okuma	3rd engineer
Toshitaka Oki	Jr. 3rd Engineer
Ryo Kimura	Technical Officer
Kazuyoshi Kudo	Boatswain
Tsuyoshi Sato	Able Seaman
Takeharu Aisaka	Able Seaman
Masashige Okada	Able Seaman
Hiromu Hirokawa	Able Seaman
Shuji Komata	Able Seaman
Hideaki Tamotsu	Able Seaman
Shohei Uehara	Able Seaman
Tomohiro Shimada	Able Seaman

Ryosuke Hiratsuka	Able Seaman
Akira Chishima	Able Seaman
Yoshihiro Sugimoto	No.1 Oiler
Toshiyuki Furuki	Oiler
Kazumi Yamashita	Oiler
Keisuke Yoshida	Oiler
Kazuya Ando	Wiper
Hitoshi Ota	Chief Steward
Tamotsu Uemura	Cook
Yukio Chiba	Cook
Shigenori Yamaguchi	Cook
Shohei Maruyama	Steward

6. General observations

6.1 Meteorological measurements

6.1.1 Surface meteorological observations

(1) Personnel

Iwao Ueki	(JAMSTEC) Principal Investigator
Shinya Okumura	(GODI)
Koichi Inagaki	(GODI)
Ryo Kimura	(MIRAI Crew)

(2) Objective

Surface meteorological parameters are observed as a basic dataset of the meteorology. These parameters bring us the information about the temporal variation of the meteorological condition surrounding the ship.

(3) Instruments and Methods

Surface meteorological parameters were observed throughout the MR14-01 cruise. We used two systems for the observation, during this cruise.

1) MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table.6.1.1-1 and measured parameters are listed in Table.6.1.1-2. 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.

2) Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

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

a) Portable Radiation Package (PRP) designed by BNL - short and long wave downward radiation.
b) Zeno Meteorological (Zeno/Met) system designed by BNL - wind, air temperature, relative humidity, pressure, and rainfall measurement.
c) Photosynthetically Available Radiation (PAR) sensor manufactured by Biospherical Instruments Inc. (USA) - PAR measurement.
d) 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, while Zeno/Met data every 10 seconds. Instruments and their locations are listed in Table.6.1.1-3 and measured parameters are listed in Table.6.1.1-4.

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

a) 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.
b) Barometer (SMet and SOAR)
   Comparison with the portable barometer value, PTB220CASE, VAISALA.
c) Thermometer (air temperature and relative humidity) (SMet and SOAR)
   Comparison with the portable thermometer value, HMP41/45, VAISALA.

(4) Preliminary results

Figure 6.1.1-1 show the time series of the following parameters;

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

(5) Data archives

These meteorological data was submitted to the Data Management Group DMG of JAMSTEC and will be opened to public via web site of "Data Research for Whole Cruise Information in JAMSTEC".

(6) Remarks

1) SST (Sea Surface Temperature) data were available in the following periods.
06:00UTC 10 Jan. 2014 - 02:00UTC 15 Jan. 2014
01:00UTC 24 Jan. 2014 - 02:45UTC 03 Feb. 2014

2) At the following time, increasing of SMet capacitive rain gauge data were invalid due to transmitting for MF/HF radio.
00:35UTC 19 Jan. 2014
01:22UTC 19 Jan. 2014

3) Cleaning of optical rain gauge.
05:05UTC 12 Jan. 2014
07:35UTC 24 Jan. 2014
02:51UTC 30 Jan. 2014

4) The following time, increasing of SMet capacitive rain gauge data were invalid due to transmitting for VHF radio.
17:47UTC 21 Jan. 2014

5) In the following period, FRSR data acquisition was suspended to prevent damage to the shadow-band from freezing.
23:00UTC 08 Jan. 2014 - 02:03UTC 11 Jan. 2014

6) At the following period, air temperature, dew-point temperature and relative humidity data of SMet include invalid data.
01:13UTC 15 Jan. 2014 - 01:40UTC 15 Jan. 2014 (the port side)
06:11UTC 15 Jan. 2014 - 06:12UTC 15 Jan. 2014 (the port side)
05:47UTC 17 Jan. 2014 - 07:45UTC 17 Jan. 2014 (the port side)

7) At the following period, air temperature and relative humidity data of SOAR was invalid due to sensor trouble.

09:22UTC 30 Jan. 2014
01:41UTC 01 Feb. 2014 - 01:46UTC 01 Feb. 2014
09:39UTC 01 Feb. 2014 - 09:40UTC 01 Feb. 2014
18:36UTC 01 Feb. 2014 - 01:41UTC 02 Feb. 2014
19:59UTC 02 Feb. 2014 - 20:07UTC 02 Feb. 2014
20:09UTC 02 Feb. 2014
20:11UTC 02 Feb. 2014
01:02UTC 03 Feb. 2014
22:19UTC 03 Feb. 2014 - 22:24UTC 03 Feb. 2014
20:51UTC 04 Feb. 2014
00:57UTC 05 Feb. 2014 - 01:01UTC 05 Feb. 2014
02:20UTC 05 Feb. 2014
23:43UTC 06 Feb. 2014 - 00:00UTC 13 Feb. 2014

Table.6.1.1-1 Instruments and installations of MIRAI Surface Meteorological observation system

Sensors	Type	Manufacture	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24m)
Tair/RH	HMP155	Vaisala, Finland	compass deck (21m)
with 43408 Gill aspirated radiation shield		R. M. Young, USA	starboard and port side
Thermometer (SST)	RFN1-0	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	Eiko Seiki, Japan	radar mast (28 m)
Radiometer (long wave)	MS-202	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	WM-2	Tsurumi-seiki, Japan	bow (10 m)
			port side stern (8 m)

Table.6.1.1-2 Parameters of MIRAI Surface Meteorological observation system

Parameter		Units	Remarks
1	Latitude	degree	
2	Longitude	degree	
3	Ship's speed	knot	MIRAI log, DS-30 Furuno
4	Ship's heading	degree	MIRAI gyro, TG6000, Tokimec
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)	degC	6sec. averaged
11	Air temperature (port side)	degC	6sec. averaged
12	Dewpoint temperature (starboard)	degC	6sec. averaged
13	Dewpoint temperature (side)	degC	6sec. averaged
14	Relative humidity (starboard)	%	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.6.1.1-3 Instruments and installation locations of SOAR system

Sensors (Zeno/Met)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Tair/RH	HMP155	Vaisala, Finland	foremast (23 m)
with 43408 Gill aspirated radiation shield		R.M. Young, USA	
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)
Optical rain gauge	ORG-815DA	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 Instru ments Inc., USA	Navigation deck (18m)

Table.6.1.1-4 Parameters of SOAR system

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

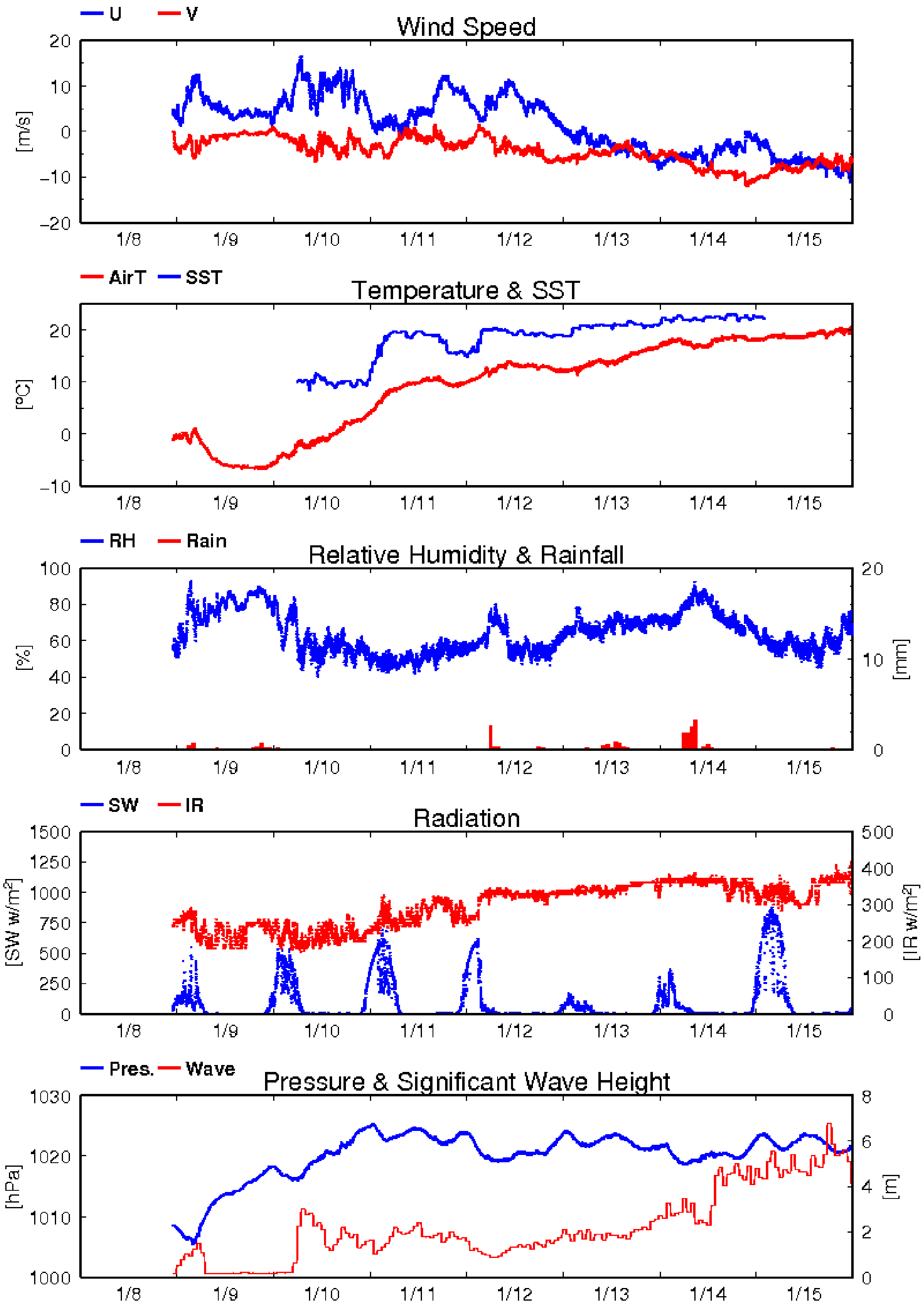


Fig.6.1.1-1 Time series of surface meteorological parameters during the MR14-01

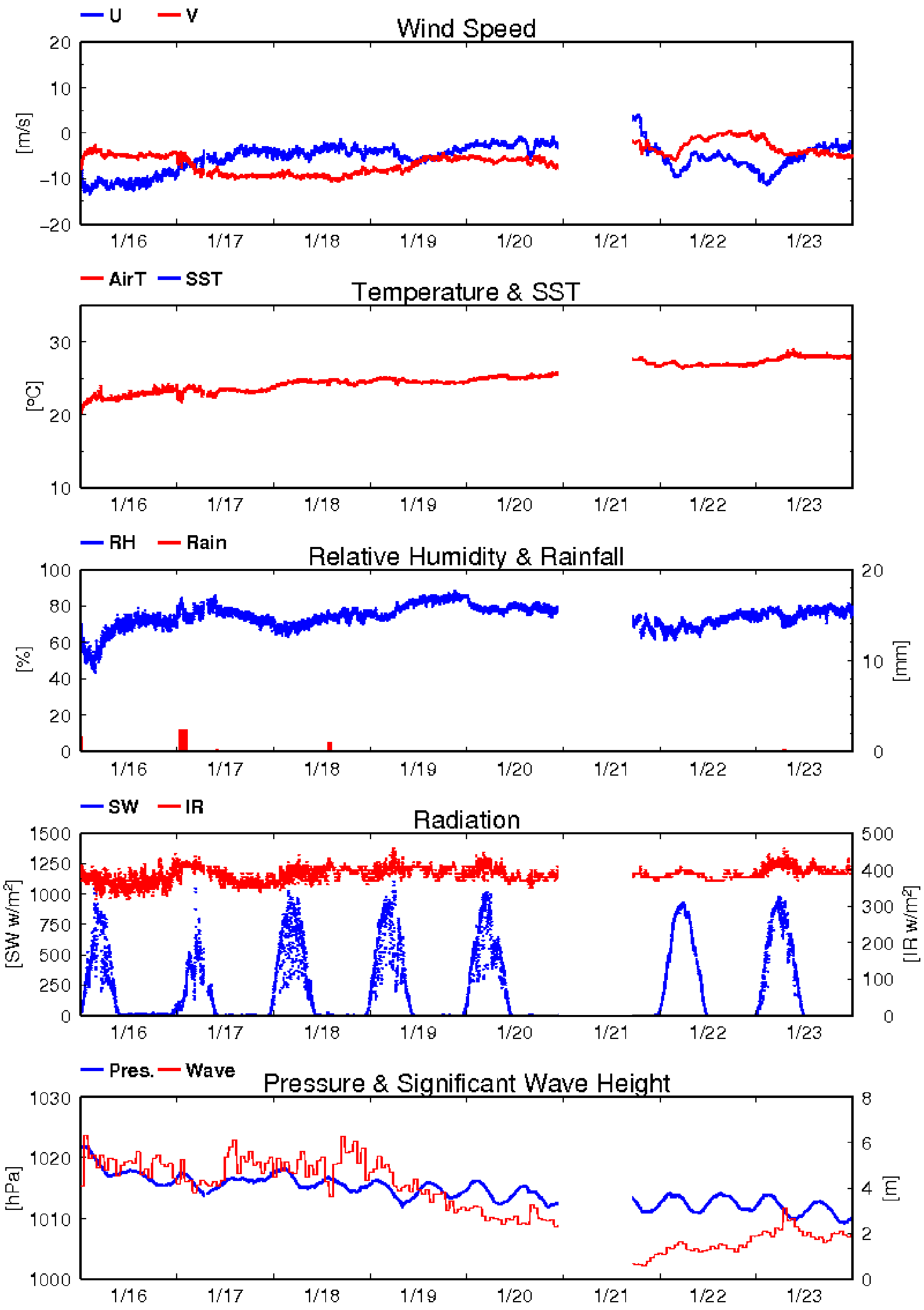


Fig.6.1.1-1 (Continued)

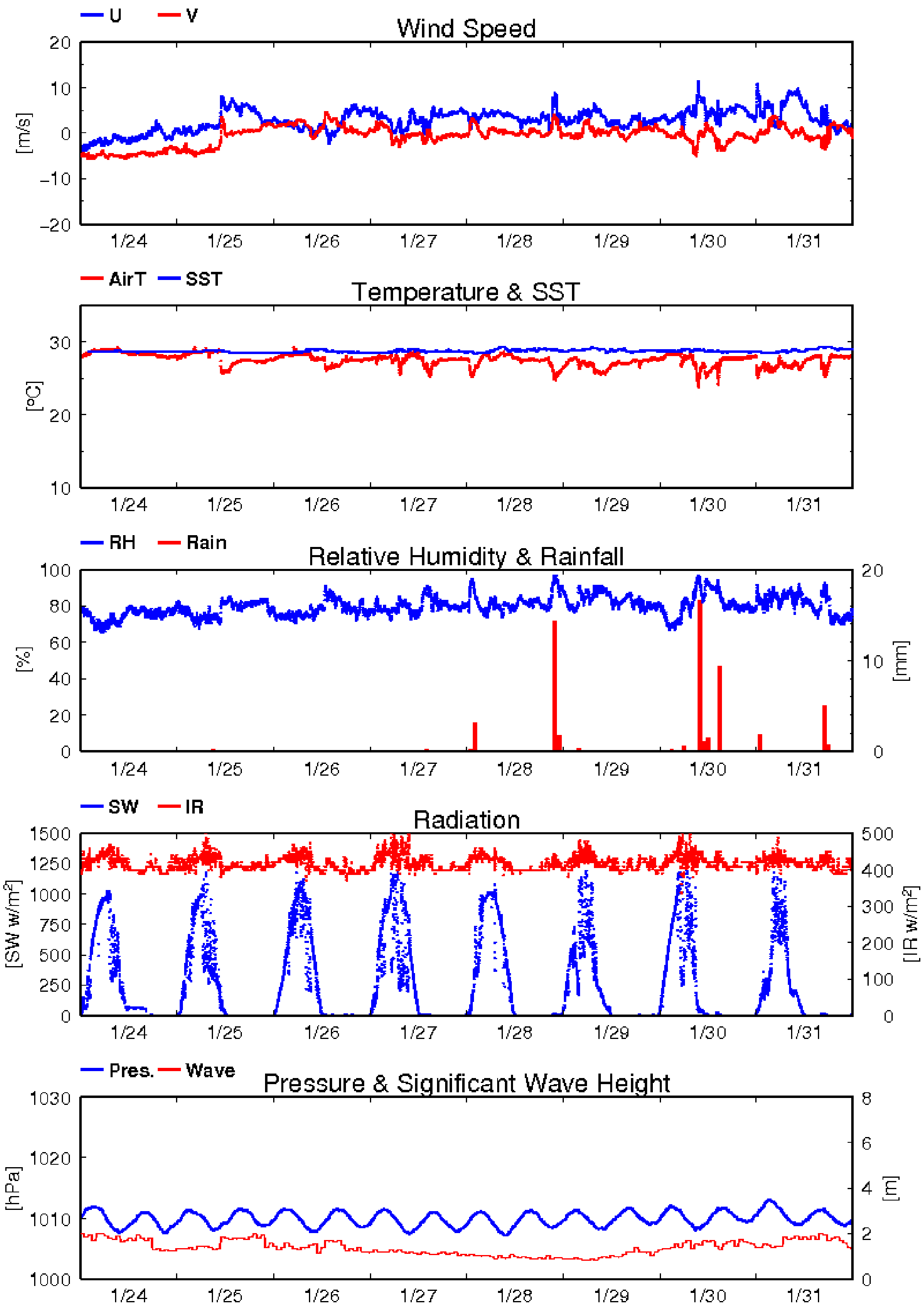


Fig.6.1.1-1 (Continued)

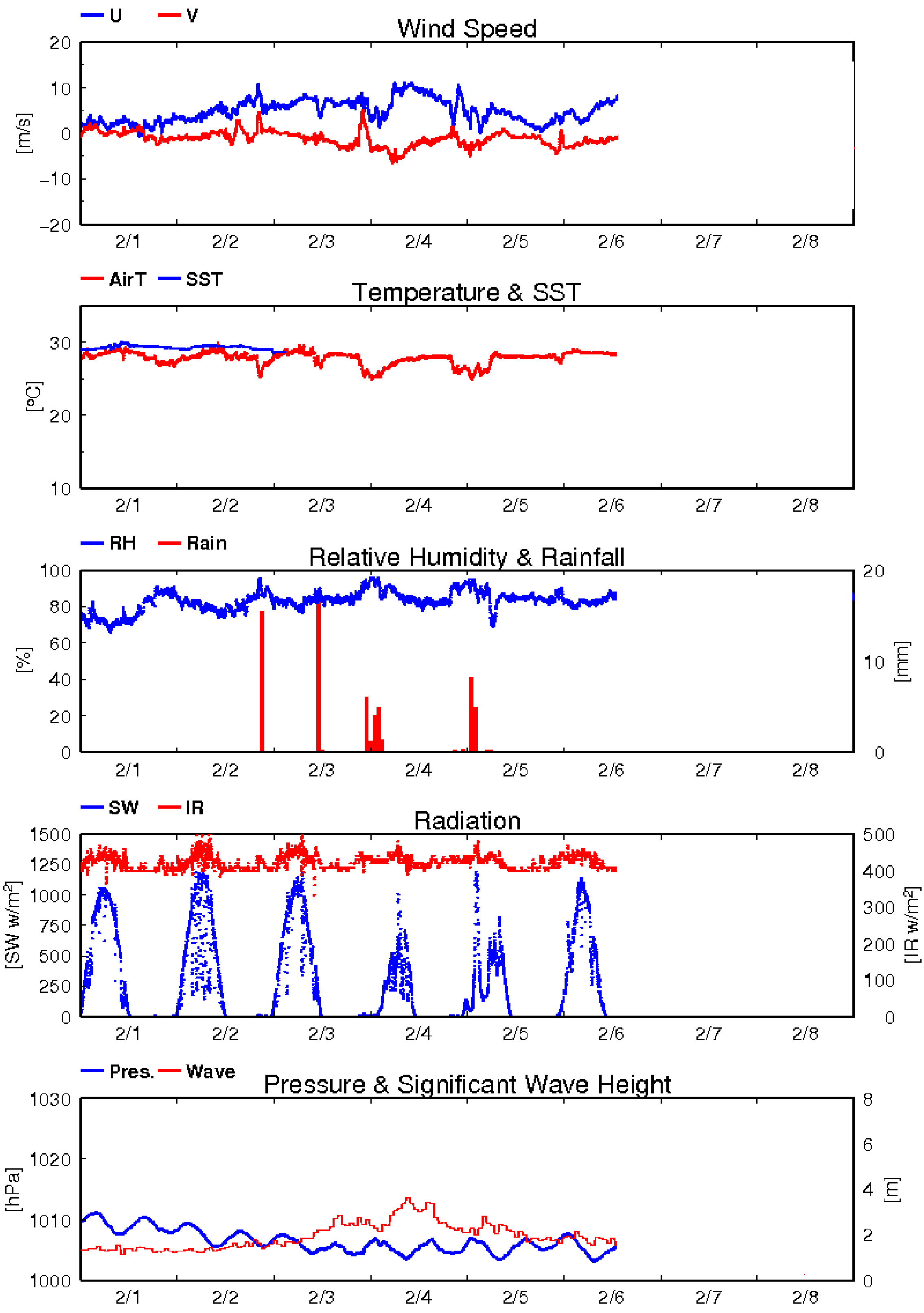


Fig.6.1.1-1 (Continued)

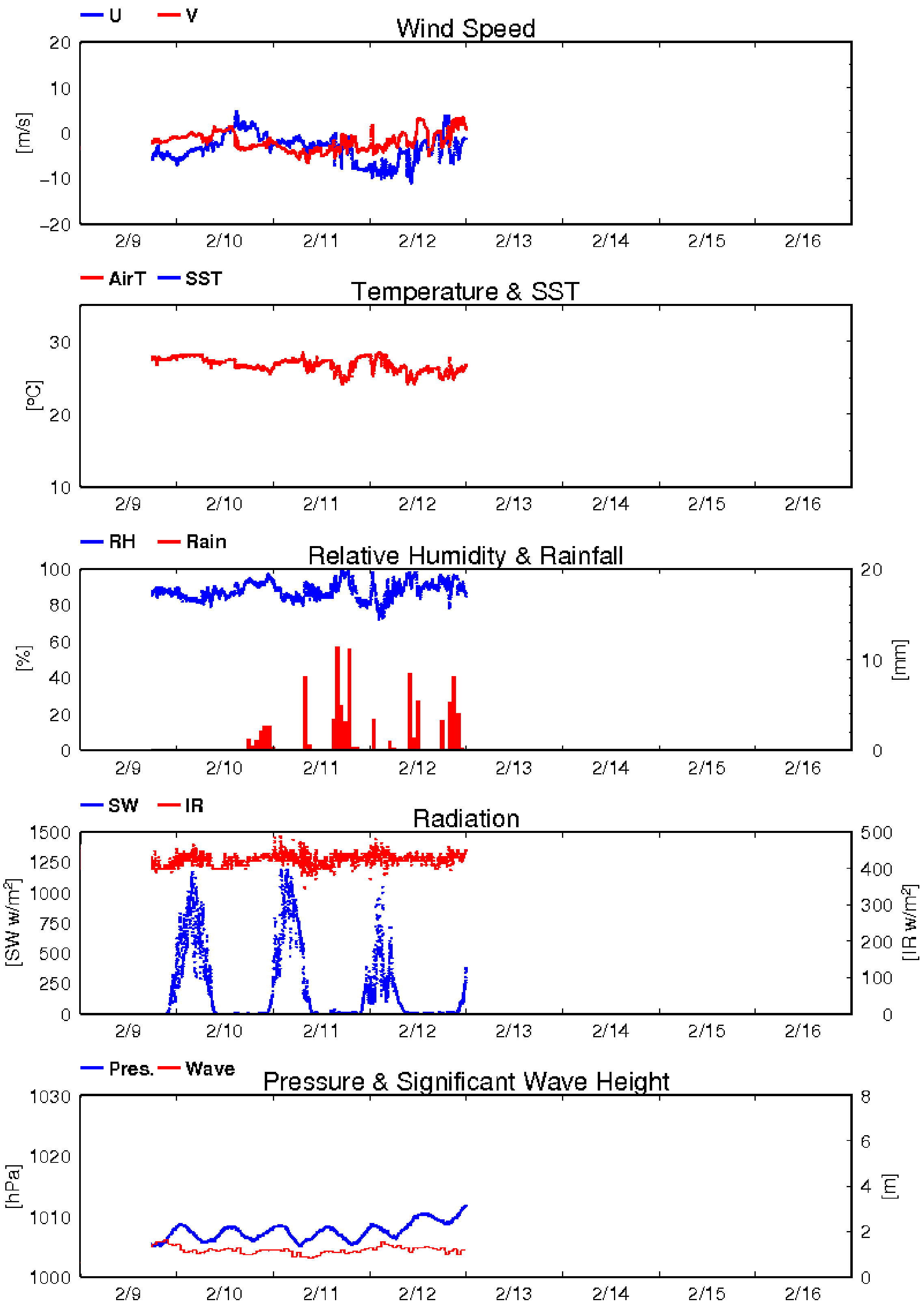


Fig.6.1.1-1 (Continued)

6.1.2 Ceilometer

(1) Personnel

Iwao Ueki	(JAMSTEC) *Principal Investigator
Shinya Okumura	(Global Ocean Development Inc., GODI)
Koichi Inagaki	(GODI)
Ryo Kimura	(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.

(3) Paramters

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) throughout the MR14-01 cruise.

Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode Laser
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)
Measurement range:	0 ~ 15 km
	0 ~ 13 km (Cloud detection)
Resolution:	10 meter in full range
Sampling rate:	36 sec
Sky Condition	0, 1, 3, 5, 7, 8 oktas (9: Vertical Visibility)
	(0: Sky Clear, 1:Few, 3:Scattered, 5-7: Broken, 8: Overcast)

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

(5) Preliminary results

Fig.6.1.2-1 shows the time series plot of the lowest, second and third cloud base height during the cruise.

(6) Data archives

The raw data obtained during this cruise will be submitted to the Data Management Group of JAMSTEC and will be opened to public via web site of "Data Research for Whole Cruise Information in JAMSTEC".

(7) Remarks

1) Window Cleaning

05:05UTC 11 Jan. 2014

05:08UTC 12 Jan. 2014

07:33UTC 24 Jan. 2014

02:50UTC 30 Jan. 2014

2) The following period, data acquisition was suspended in the territorial waters and EEZ.
02:00UTC 15 Jan. 2014 - 01:00UTC 24 Jan. 2014

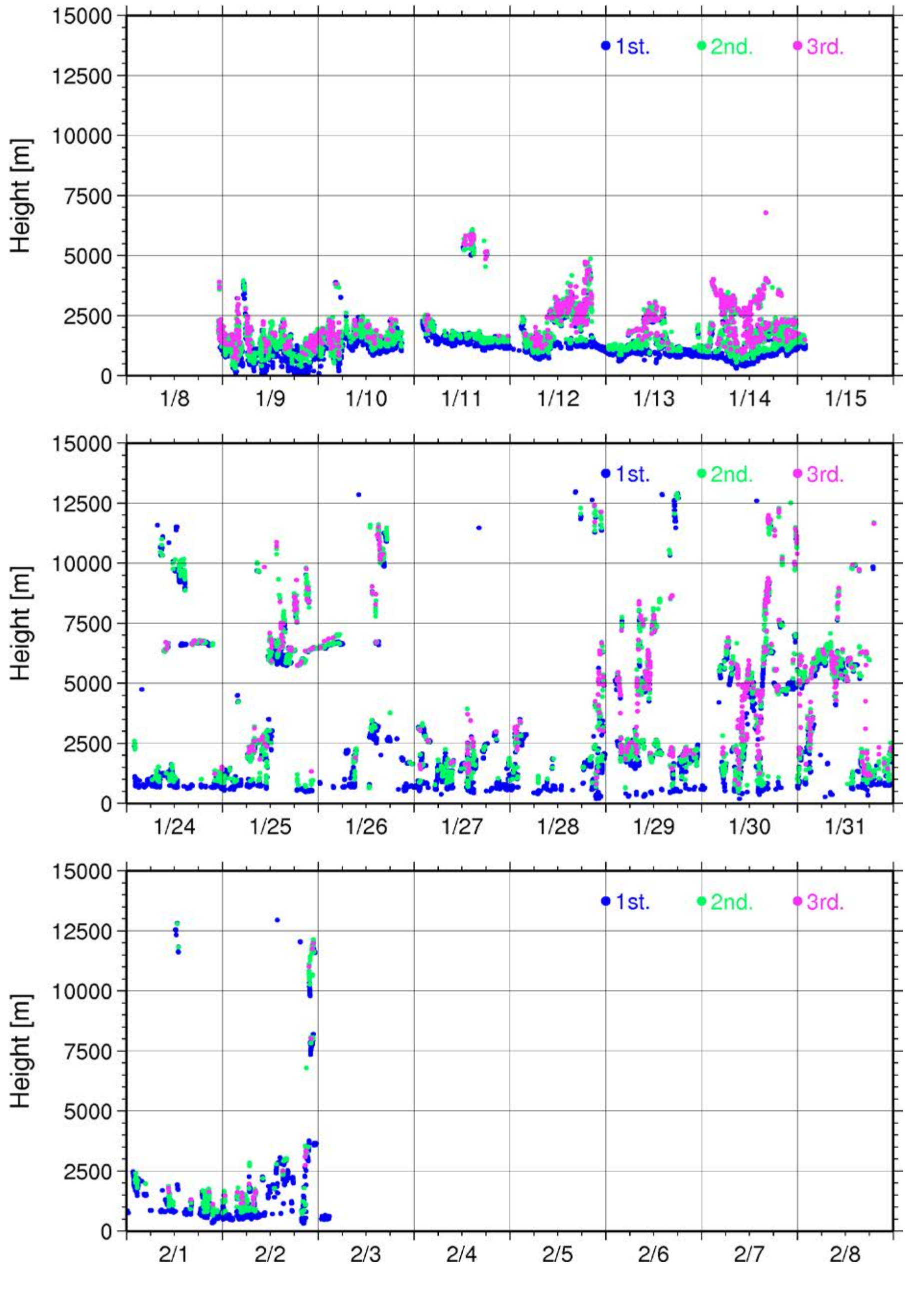


Fig. 6.1.2-1 First (Blue), 2nd (Green) and 3rd (Red) lowest cloud base height during the cruise.

6. 2 CTD/UnderwayCTD/XCTD

6. 2. 1 CTD

(1) Personnel

Iwao Ueki	(JAMSTEC) Principal investigator
Rei Ito	(MWJ)
Tatsuya Tanaka	(MWJ)

(2) Objective

Investigation of oceanic structure and water sampling.

(3) Parameters

Temperature (Primary and Secondary)
Conductivity (Primary and Secondary)
Pressure
Dissolved Oxygen (Primary and Secondary)

(4) Instruments and Methods

CTD/Carousel Water Sampling System, which is a 36-position Carousel water sampler (CWS) with Sea-Bird Electronics, Inc. CTD (SBE9plus), was used during this cruise. 12-litter Niskin Bottles were used for sampling seawater. The sensors attached on the CTD were temperature (Primary and Secondary), conductivity (Primary and Secondary), pressure and dissolved oxygen （Primary and Secondary）. Salinity was calculated by measured values of pressure, conductivity and temperature. The CTD/CWS was deployed from starboard on working deck.

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.22.5) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled during the up cast by sending fire commands from the personal computer. We usually stop for 30 seconds to stabilize then fire.

8 casts of CTD measurements were conducted (Table 6.2.1-1).

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.22.5a) and SEASOFT were as follows:

(The process in order)

DATCNV: Convert the binary raw data to engineering unit data. DATCNV also extracts bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 3.0 seconds, and the offset was set to 0.0 seconds.

BOTTLESUM: Create a summary of the bottle data. The data were averaged over 3.0 seconds.

ALIGNCTD: Convert the time-sequence of sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Dissolved oxygen data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensor and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 5 seconds advancing dissolved oxygen sensor output (dissolved oxygen voltage) relative to the temperature data.

WILDEDIT: Mark extreme outliers in the data files. The first pass of WILDEDIT obtained an accurate estimate of the true standard deviation of the data. The data were read in blocks of 1000 scans. Data greater than 10 standard deviations were flagged. The second pass computed a standard deviation over the same 1000 scans excluding the flagged values. Values greater than 20 standard deviations were marked bad. This process was applied to pressure, depth, temperature, conductivity and dissolved oxygen voltage.

CELLTM: Remove conductivity cell thermal mass effects from the measured conductivity. Typical values used were thermal anomaly amplitude alpha = 0.03 and the time constant 1/beta = 7.0.

FILTER: Perform a low pass filter on pressure with a time constant of 0.15 second. In order to produce zero phase lag (no time shift) the filter runs forward first then backward

SECTIONU (original module of SECTION):
Select a time span of data based on scan number in order to reduce a file size. The minimum number was set to be the starting time when the CTD package was beneath the sea-surface after activation of the pump. The maximum number of was set to be the end time when the package came up from the surface.

LOOPEDIT: Mark scans where the CTD was moving less than the minimum velocity of 0.0 m/s (traveling backwards due to ship roll).

DERIVE: Compute dissolved oxygen (SBE43).

BINAVG: Average the data into 1-dbar pressure bins.

BOTTOMCUT (original module):
Bottom cut deletes discontinuous scan bottom data if it’s created by BINAVG.

DERIVE: Compute salinity, potential temperature, and sigma-theta.

SPLIT: Separate the data from an input .cnv file into down cast and up cast files.

Configuration file

MR1401A.xmlcon:C01M01 - C03M01

MR1401B.xmlcon:C04M01 – C06M02C

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:

SBE9plus (S/N 09P21746-0575, Sea-Bird Electronics, Inc.)

Pressure sensor: Digiquartz pressure sensor (S/N 79492)

Calibrated Date: 21 Jul. 2013

Temperature sensors:

Primary: SBE03Plus (S/N 03P2453, Sea-Bird Electronics, Inc.)

Calibrated Date: 12 Nov. 2013

Secondary: SBE03Plus (S/N 03P2730, Sea-Bird Electronics, Inc.)

Calibrated Date: 28 Nov. 2013

Conductivity sensors:

Primary: SBE04C (S/N 043036, Sea-Bird Electronics, Inc.)

Calibrated Date: 13 Nov. 2013

Secondary: SBE04C (S/N 042240, Sea-Bird Electronics, Inc.)

Calibrated Date: 13 Nov. 2013

Dissolved Oxygen sensors:

Primary: SBE43 (S/N 432036, Sea-Bird Electronics, Inc.)

Calibrated Date: 21 Aug. 2013

Secondary-1: SBE43 (S/N 430394, Sea-Bird Electronics, Inc.)

Calibrated Date: 23 Aug. 2013

Secondary-2: SBE43 (S/N 430205, Sea-Bird Electronics, Inc.)

Calibrated Date: 08 Nov.. 2013

Deck unit:

SBE11plus (S/N 11P9833-0344, Sea-Bird Electronics, Inc.)

Carousel water sampler:

SBE32 (S/N 3227443-0391, Sea-Bird Electronics, Inc.)

(5) Preliminary Results

During this cruise, 8 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 6.2.1.

Vertical profile (down cast) of primary temperature, salinity and dissolved oxygen with pressure are shown in Figure 6.2.1-1 - 6.2.1-2.

(6) Remarks

Since There was large difference between down- and up- cast for the secondary dissolved oxygen sensor (Secondary-1) , thus replased by the other sensor (Secondary-2) from station C04M01.

(7) Data archive

All raw and processed data will be quality controled by the Data Management Group of JAMSTEC and be opened to public via web site of "Data Research for Whole Cruise Information in JAMSTEC".

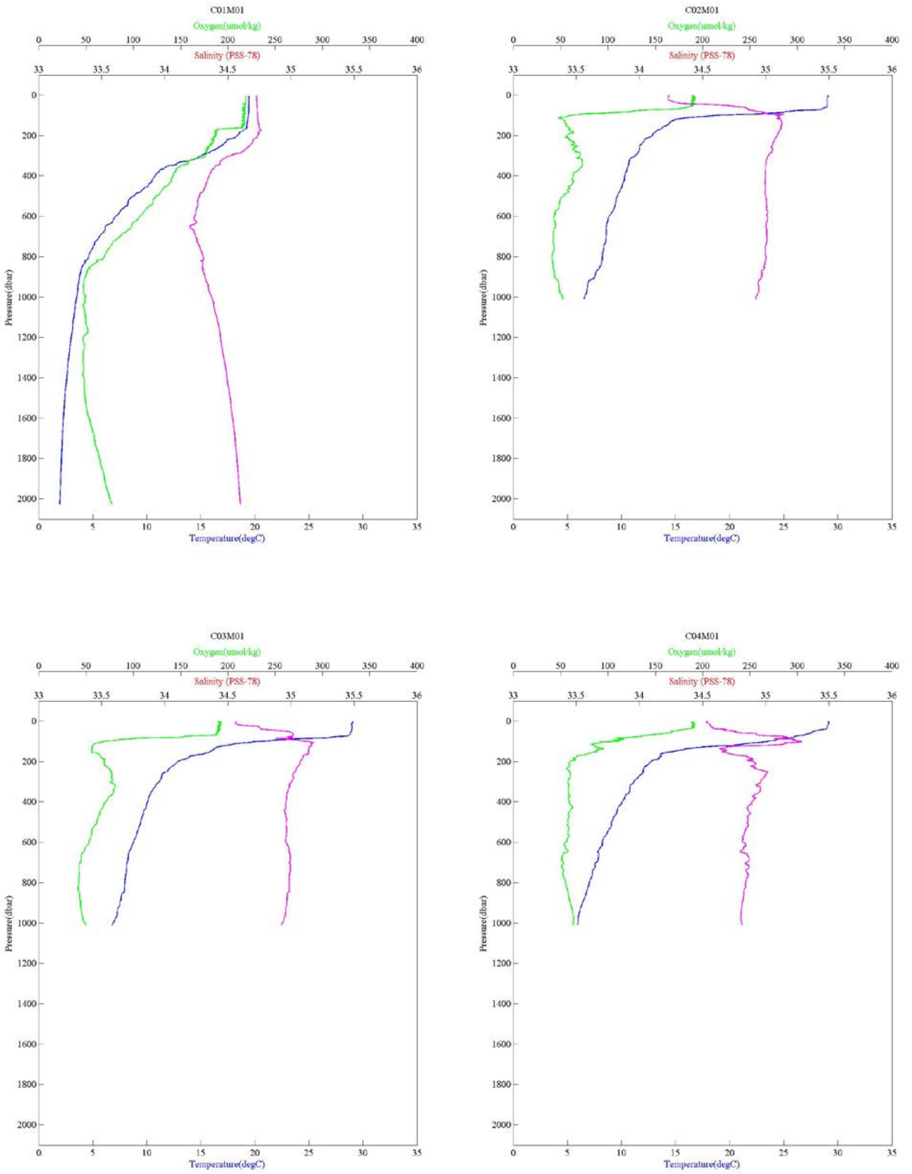


Figure 6.2.1-1 CTD profile (C01M01, C02M01, C03M01 and C04M01)

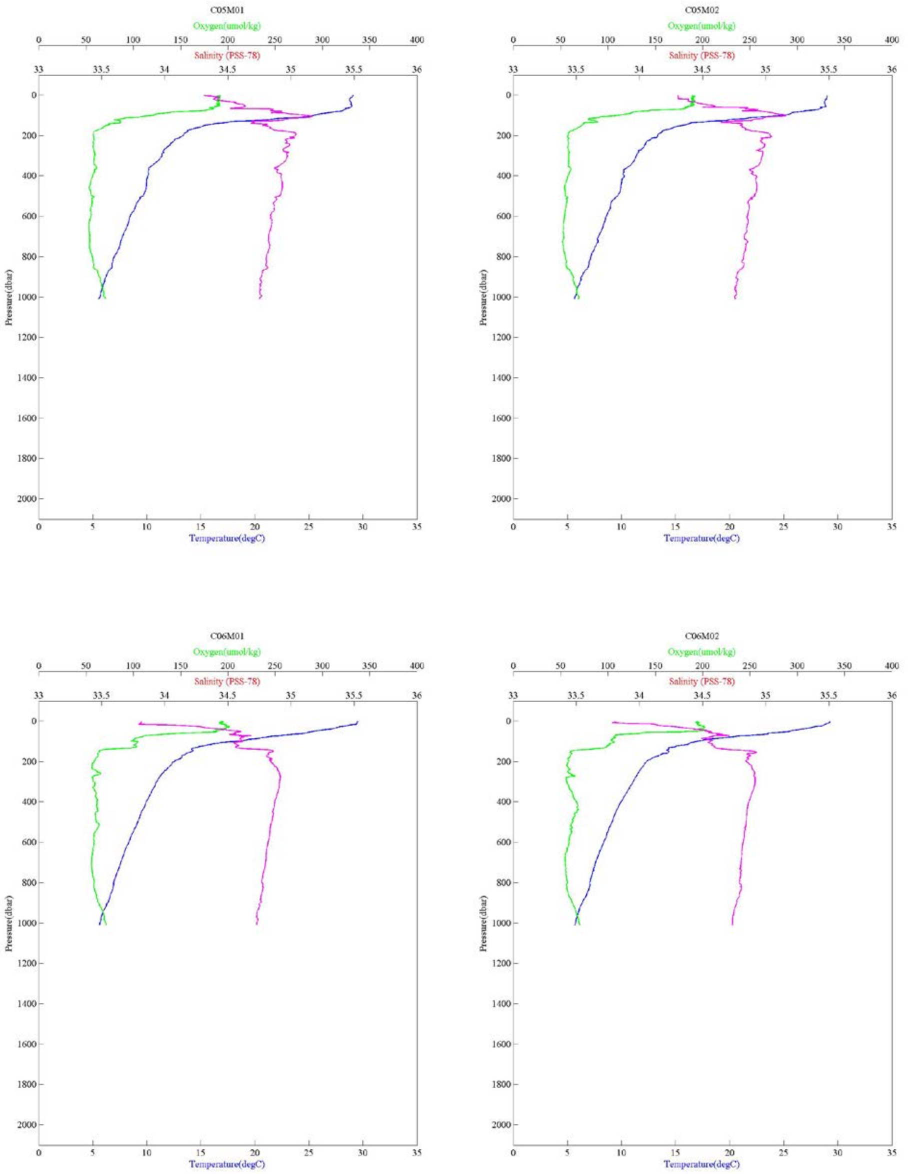


Figure 6.2.1-2 CTD profile (C05M01, C05M02, C06M01 and C06M02)

Table 6.2.1 MR14-01 Cast table

MR14-01 CTD cast table

Stnnbr	Castno.	Date (UTC)	Time (UTC)		Bottom Position		Depth	Wire Out	HT Above Bottom	Max Depth	Max Pressure	CTD Filename	Remark
		(mmddyy)	Start	End	Latitude	Longitude							
C01	1	011114	13:28	14:41	34-01.12N	141-00.70E	4040.0	2064.6	-	2000.9	2025.0	C01M01	Deployment Argo float
C02	1	012514	05:25	06:32	00-00.00N	090-08.31E	4082.0	1002.9	-	1002.0	1010.0	C02M01	Recovery and Deployment ADCP
C03	1	012714	11:03	12:08	01-35.48S	090-01.69E	4700.0	1001.4	-	1002.0	1010.0	C03M01	Deployment m-TRITON 18
C04	1	012914	00:03	01:07	04-54.54S	097-15.36E	5054.0	1001.8	-	1001.0	1009.0	C04M01	Recovery m-TRITON 97
C05	2	013014	07:39	08:17	04-55.37S	094-56.34E	5012.0	1000.7	-	1001.0	1009.0	C05M02	Recovery m-TRITON 17
C05	1	013014	09:06	09:44	04-59.48S	094-57.92E	5013.0	1003.4	-	1001.0	1009.0	C05M01	Deployment m-TRITON 17
C06	2	020114	07:34	08:11	07-56.91S	095-04.24E	5131.0	1002.5	-	1001.9	1010.0	C06M02	Recovery m-TRITON 19
C06	1	020114	09:15	09:50	08-01.90S	095-08.56E	5252.0	1000.9	-	1000.9	1009.0	C06M01	Deployment m-TRITON 19

6. 2. 2. UnderwayCTD

(1) Personnel

Iwao Ueki	(JAMSTEC) Principal Investigator
Hiroshi Matsunaga	(MWJ)
Tomoyuki Takamori	(MWJ)
Tatsuya Tanaka	(MWJ)
Rei Ito	(MWJ)

(2) Objective

Investigation of oceanic structure.

(3) Methods

The UnderwayCTD system, manufactured by Oceanscience, is utilized in this cruise. The system consists of the probe unit and on-deck unit with the winch and the rewinder. After spooling the line for certain length onto the probe unit (in "tail spool" part), the probe unit is released from the vessels into the ocean, and then measure temperature, conductivity and pressure during its free-fall with speed of roughly 4 m/s in the ocean. The probe unit is physically connected to the winch on the vessel by line. Releasing the line from the tail spool ensure the probe unit to be fall without physical forcing by the movement of the vessel. After the probe unit reaches the deepest layer for observation, it is recovered by using the winch on the vessel.

The observed data are stored in the memory within the probe unit. The dataset can be downloaded into PCs via Bluetooth communication on the deck. The specifications of the sensors are in Table 6.2.2-1.

The UCTD system used in this cruise can observe temperature, conductivity and pressure from surface to 1000 m depth with 16 Hz sampling rate. During the profiling, the vessel can be cruised (straight line recommended). The manufacturer recommends the maximum speed of the vessel during the profiling as in Table 6.2.2-2. In this cruise, we examine various cruising speed up to 12 knot and confirm there are no apparent problem for the examined speeds.

Table 6.2.2-1: Specification of the sensors of the UCTD system

Parameter	Accuracy	Resolution	Range
Temperature (deg.C)	0.004	0.002	-5 to 43
Conductivity (S/m)	0.0003	0.0005	0 to 9
Pressure (dbar)	1.0	0.5	0 to 2000

Table 6.2.2-2: Maximum speed of the vessel during profile, recommended by the manufacturer.

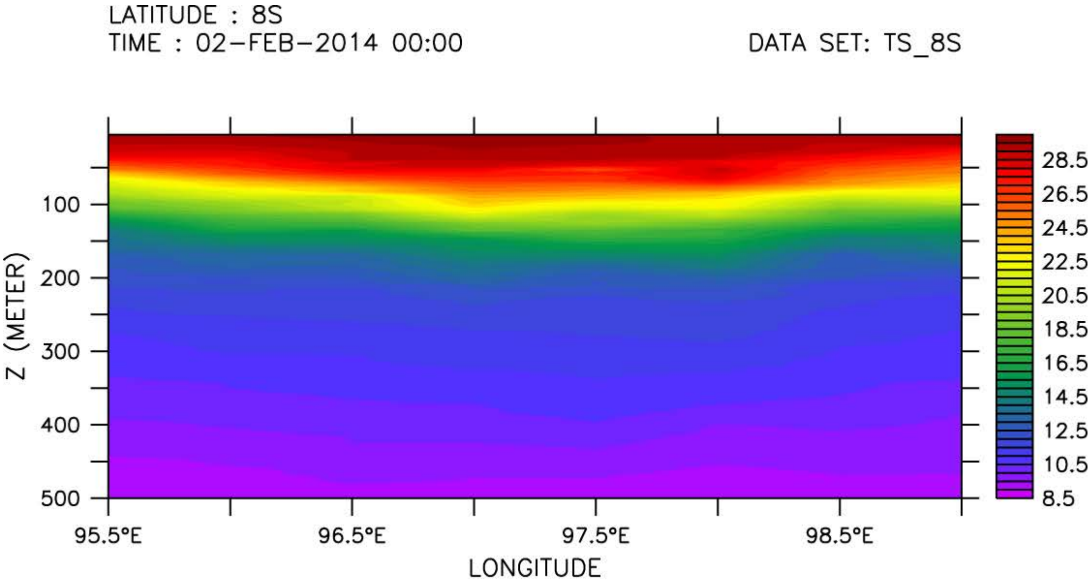
Max. depth to profile	Max Speed (knot)
0 to 350 m	13
350 to 400 m	12
400 to 450 m	11
450 to 500 m	10
500 to 550 m	8
550 to 600 m	6
600 to 650 m	4
650 to 1000 m	2

(4) Preliminary results

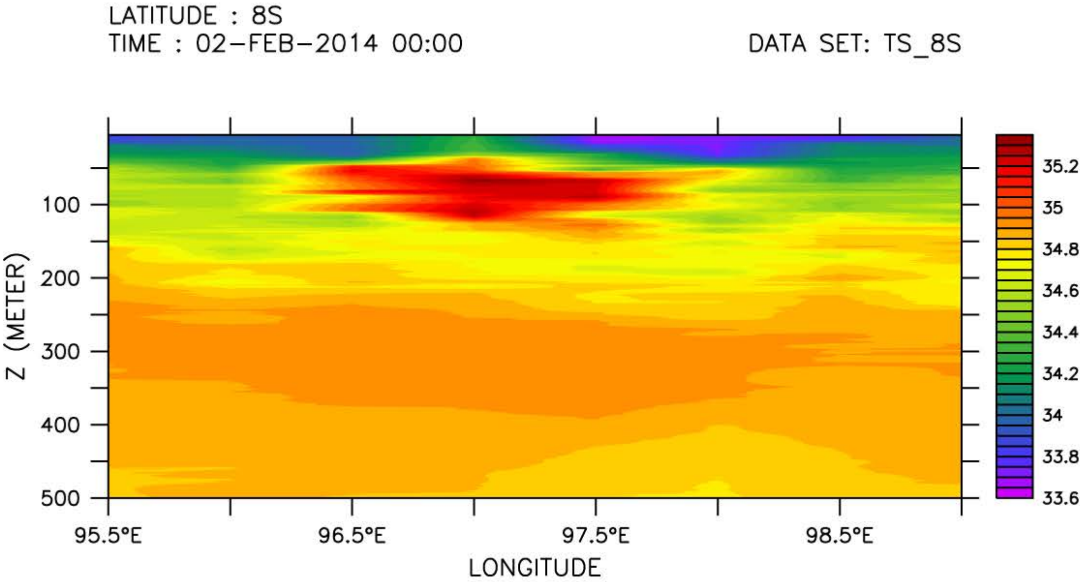
We conducted 18 casts as listed in Table 6.2.2-3. The longitude-depth section along 8˚S for temperature and salinity is displayed in Fig. 6.2.2-1.

Table 6.2.2-3: List of UnderwayCTD observations.

Stn No.	Date and time	Latitude	Lohgitude
U001	11 Jan. 14:55	34˚01.83"N	141˚01.07"E
U002	25 Jan. 12:59	00˚30.00"S	089˚59.99"E
U003	26 Jan. 11:10	01˚00.88"S	090˚00.00"E
U004	29 Jan. 07:31	04˚59.88"S	097˚00.33"E
U005	29 Jan. 09:59	04˚59.97"S	096˚30.44"E
U006	29 Jan. 12:26	05˚00.00"S	096˚00.31"E
U007	30 Jan. 13:15	04˚56.78"S	095˚29.85"E
U008	31 Jan. 09:03	05˚29.64"S	095˚00.03"E
U009	31 Jan. 11:38	05˚59.54"S	094˚59.96"E
U010	31 Jan. 14:07	06˚29.56"S	095˚00.00"E
U011	02 Feb. 08:05	07˚59.96"S	095˚29.54"E
U012	02 Feb. 10:10	08˚00.01"S	095˚59.71"E
U013	02 Feb. 12:16	08˚00.01"S	096˚29.72"E
U014	02 Feb. 14:25	07˚59.98"S	096˚59.63"E
U015	02 Feb. 16:36	07˚59.98"S	097˚29.56"E
U016	02 Feb. 18:50	08˚00.03"S	097˚59.51"E
U017	02 Feb. 21:04	07˚59.98"S	098˚29.65"E
U018	02 Feb. 23:23	08˚00.00"S	098˚59.66"E



Temp.



Sal.

Fig. 6.2.2-1: The longitude-depth section along 8˚S for temperature (upper) and salinity (lower).

(5) Data archive

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

6. 2. 3. XCTD

(1) Personnel

Iwao Ueki	(JAMSTEC)	Principal Investigator
Shinya Okumura	(GODI)	
Koichi Inagaki	(GODI)	
Ryo Kimura	(Mirai Crew)	

(2) Objective

Investigation of oceanic structure.

(3) Methods

We observed the vertical profiles of the sea water temperature and salinity measured by XCTD-1 (manufactured by Tsurumi-Seiki Co.). The signal was converted by MK-150N (Tsurumi-Seiki Co.) and was recorded by AL-12B software (Ver.1.1.4). The specifications of the measured parameters are as in Table 6. 2. 3-1.

Table 6. 2. 3-1: The range and accuracy of parameters measured by XCTD-1.

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

(4) Preliminary results

We launched 3probes by using automatic launcher as listed in Table 6.2.3-2. The vertical profile of temperature, conductivity and salinity is displayed in Fig. 6.2.3-1 and Fig. 6.2.3-2.

Table 6. 2. 3-2: List of XCTD observations.

No.	Date	Time	Latitude [dd-mm.mmmm]	Longitude [ddd-mm.mmmm]	SST [deg-C]	SSS [PSU]	Probe S/N
X-01	2014/01/25	10:26	00-03.8499N	090-10.8336E	29.222	34.249	13093854
X-02	2014/01/31	16:52	07-00.0334S	094-59.9994E	29.549	34.195	13093855
X-03	2014/01/31	19:30	07-30.0043S	095-00.0231E	29.474	34.041	13093856

SST (sea surface temperature) and SSS (sea surface salinity) at each launch are obtained by TSG (Section 6.4).

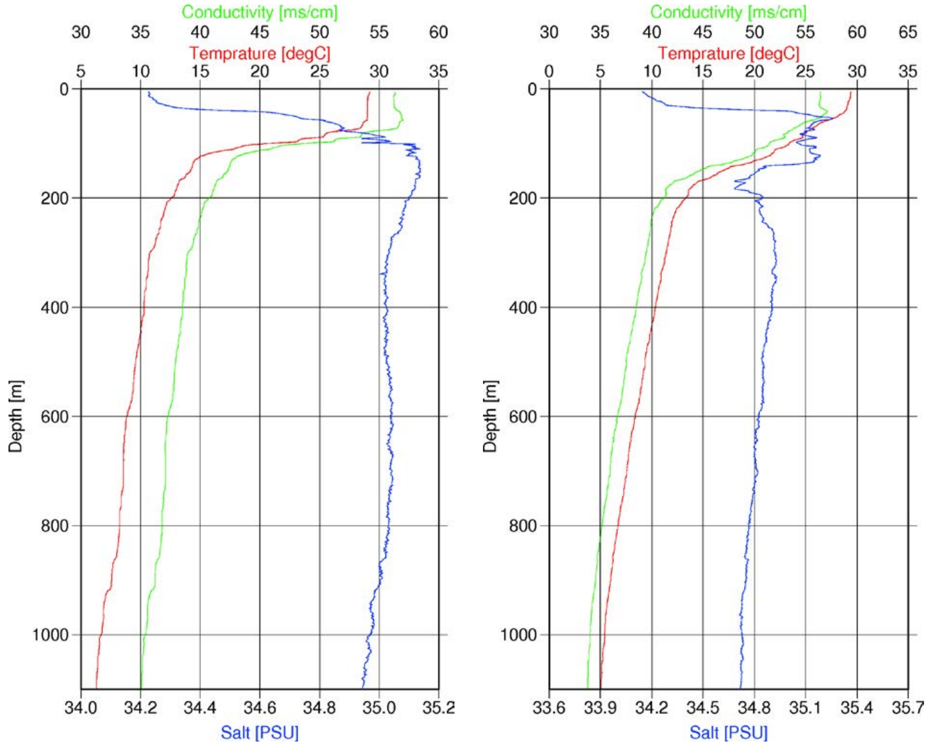


Fig.6.2.3-1: Vertical profile of temperature, conductivity and salinity by X-01(left) and X-02(right).

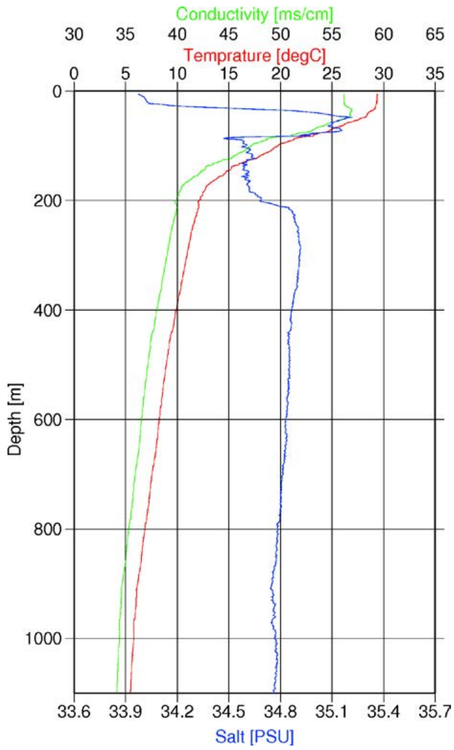


Fig.6. 2. 3-2: Vertical profile of temperature, conductivity and salinity by X-03.

(5) Data archive

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

6.3 Water sampling

6.3.1. Salinity

(1) Personnel

Iwao Ueki (JAMSTEC) Principal Investigator

Tatsuya Tanaka (MWJ)

(2) Objective

To measure bottle salinity obtained by CTD casts and the continuous sea surface water monitoring system (TSG).

(3) Method

a. Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles and TSG. The salinity sample bottle of the 250ml brown glass with GL32 screw cap was used for collecting the sample seawater. Each bottle was rinsed 3 times with the sample seawater, and was filled with sample seawater to the bottle shoulder. All of sample bottles were sealed with a plastic cone and a screw cap because we took into consideration the possibility of storage for about a month. The cone was rinsed 3 times with the sample seawater before its use. Each bottle was stored for more than 12 hours in the laboratory before the salinity measurement.

Types and numbers (n) of samples are shown in Table 6.3.1-1.

Table 6.3.1-1 Types and numbers (n) of samples

Types	N
Samples for CTD	14
Samples for TSG	16
Total	30

b. Instruments and Method

The salinity measurement was carried out on R/V MIRAI during the cruise of MR14-01 using the salinometer (Model 8400B "AUTOSAL" ; Guildline Instruments Ltd.: S/N 62556) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.).

One pair of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.) were used. One thermometer monitored the ambient temperature and the other monitored the bath temperature of the salinometer.

The specifications of the AUTOSAL salinometer and thermometer are shown as follows ;

Salinometer (Model 8400B “AUTOSAL”; Guildline Instruments Ltd.)

Measurement Range: 0.005 to 42 (PSU)

Accuracy: Better than ±0.002 (PSU) over 24 hours without re-standardization

Maximum Resolution: Better than ±0.0002 (PSU) at 35 (PSU)

Thermometer (Model 9540; Guildline Instruments Ltd.)

Measurement Range: -40 to +180 deg C

Resolution: 0.001

Limits of error ±deg C: 0.01 (24 hours @ 23 deg C ±1 deg C)

Repeatability: ±2 least significant digits

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 22.5 deg C to 24.5 deg C, while the bath temperature was very stable and varied within +/- 0.002 deg C on rare occasion.

The measurement for each sample was done with a double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 10 seconds after filling the cell with the sample and it took about 10 seconds to collect 31 readings by the personal computer. Data were taken for the sixth and seventh filling of the cell. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for the practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. In the case of the double conductivity ratio of eighth filling did not satisfy the criteria above, we measured a ninth or tenth filling of the cell and calculated the bottle salinity. The conductivity cell was cleaned with detergent after the measurement of the day.

(4) Results

a. Standard Seawater (SSW)

The specifications of SSW used in this cruise are shown as follows ;

Batch:	P154
Conductivity Ratio:	0.99990
Salinity:	34.996
Use by:	20/Oct./2014

Standardization control of the salinometer S/N 62556 was set to 690 at 21st January and all measurements were carried out at this setting. The value of STANDBY was 24+5197~5198 and that of ZERO was 0.0+0000~0.0-0001. 11 bottles of SSW were measured.

Fig.6.3.1-1 shows the time series of the double conductivity ratio of SSW batch P154 before correction. The average of the double conductivity ratio was 1.99983 and the standard deviation was 0.00003, which is equivalent to 0.0006 in salinity.

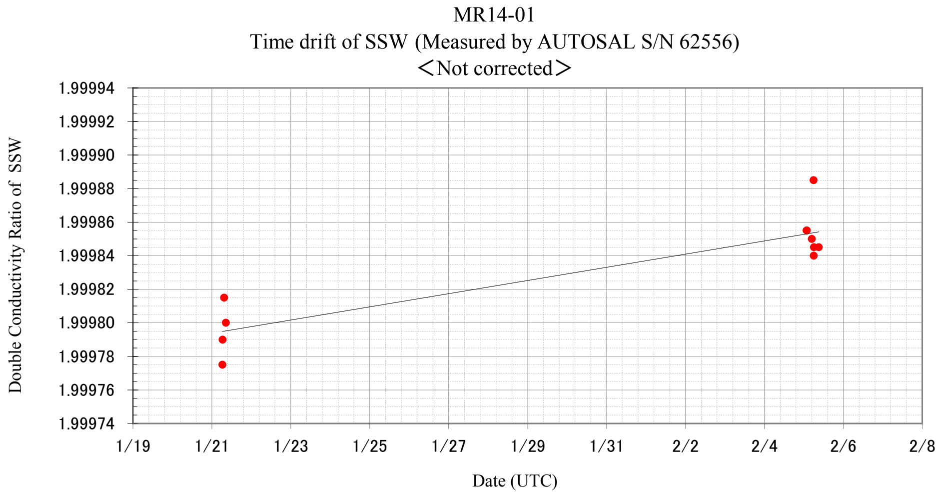


Fig. 6.3.1-1 Time series of double conductivity ratio for the Standard Seawater batch P154 (before correction)

Fig.6.3.1-2 shows the time series of the double conductivity ratio of SSW batch P154 after correction. The average of the double conductivity ratio was 1.99980 and the standard deviation was 0.00002, which is equivalent to 0.0003 in salinity.

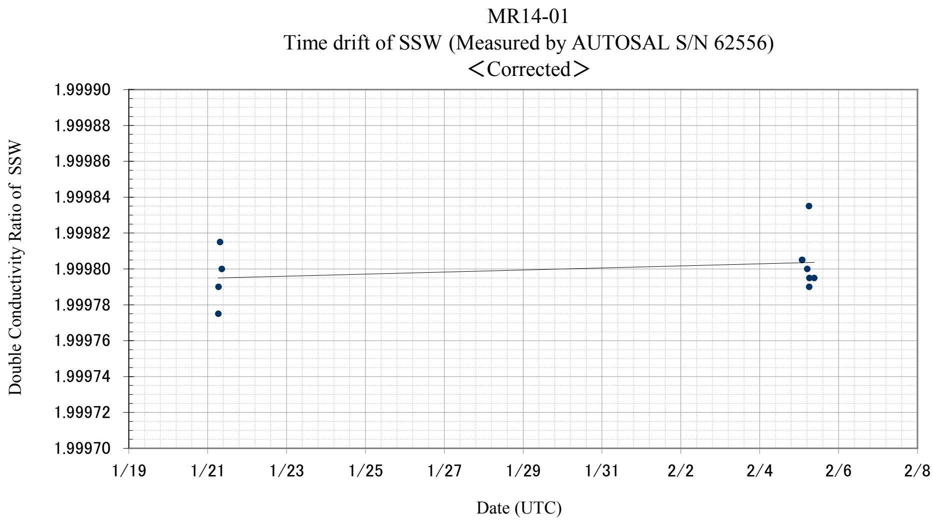


Fig.6.3.1-2 Time series of double conductivity ratio for the Standard Seawater batch P154 (after correction)

b. Sub-Standard Seawater

Sub-standard seawater was made from surface sea water filtered by a pore size of 0.22 micrometer and stored in a 20 liter container made of polyethylene and stirred for at least 24 hours before measuring. It was measured about every 6 samples in order to check for the possible sudden drifts of the salinometer.

c. Replicate Samples

We estimated the precision of this method using 7 pairs of replicate samples taken from the same Niskin bottle. Fig.6.3.2 shows the histogram of the absolute difference between each pair of the replicate samples. The average and the standard deviation of absolute difference among 7 pairs of replicate samples were 0.0003 and 0.0003 in salinity, respectively.

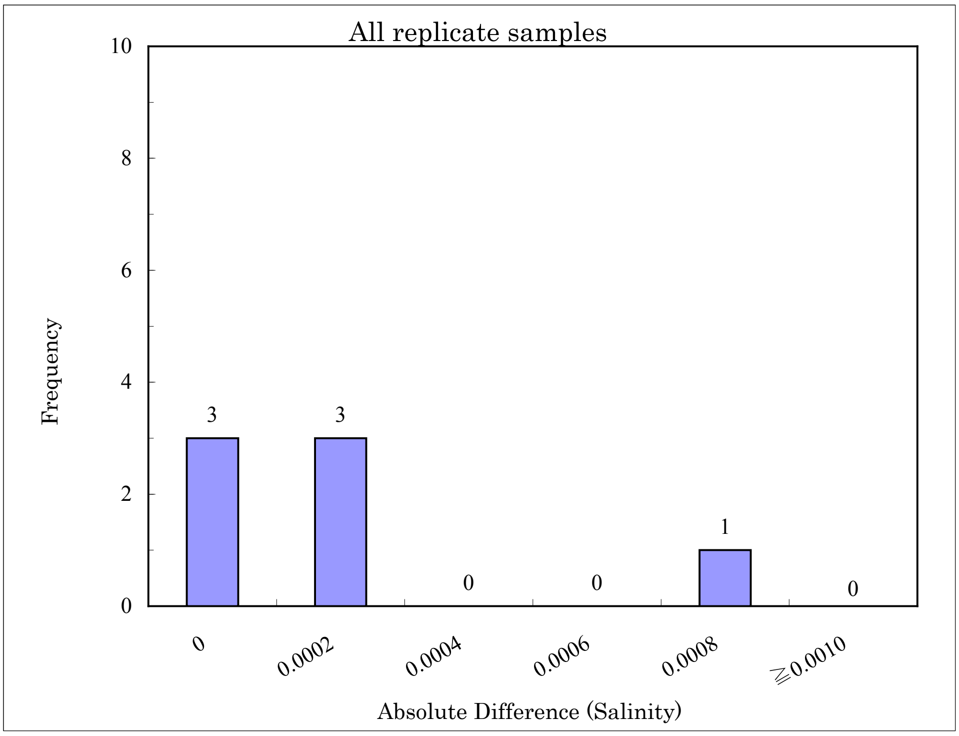


Fig.6.3.2 Histogram of the absolute difference between replicate samples

(5) Data archive

All raw data submitted to the Data Management Group of JAMSTEC and will be opened to public via web site of "Data Research for Whole Cruise Information in JAMSTEC".

(6) Reference

Aoyama, M. T. Joyce, T. Kawano and Y. Takatsuki : Standard seawater comparison up to P129. *Deep-Sea Research*, **49**, 1103-1114, 2002.

UNESCO : Tenth report of the Joint Panel on Oceanographic Tables and Standards., *UNESCO Tech. Papers in Mar. Sci.*, **36**, 25 pp., 1981

6. 4. Continuous monitoring of surface seawater

6. 4. 1 Underway surface water monitoring

(1) Personnel

Iwao UEKI (JAMSTEC): Principal Investigator

Akihiko MURATA (JAMSTEC)

Shinichiro YOKOGAWA (Marine Works Japan Co. Ltd): Operation Leader

Yuta IIBUCHI (Marine Works Japan Co. Ltd)

(2) Objective

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

(3) Parameters

Temperature (surface water)

Salinity (surface water)

Dissolved oxygen (surface water)

Fluorescence (surface water)

(4) Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co. Ltd.) has five sensors and automatically measures temperature, salinity, dissolved oxygen and fluorescence 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:

Temperature and Conductivity sensor

Model:	SBE-45, SEA-BIRD ELECTRONICS, INC.
Serial number:	4563325-0362
Measurement range:	Temperature -5 to +35 ^oC
	Conductivity 0 to 7 S m^{-1}

Initial accuracy: Temperature 0.002 °C
Conductivity 0.0003 S m^{-1}
Typical stability (per month): Temperature 0.0002 °C
Conductivity 0.0003 S m^{-1}
Resolution: Temperatures 0.0001 °C
Conductivity 0.00001 S m^{-1}

Ship bottom mounted thermometer

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

Fluorometer

Model:	C3, TURNER DESIGNS
Serial number:	2300123

b. Measurements

Periods of measurement, maintenance, and problems during MR14-01 are listed in Table 6.4.1-1.

Table 6.4.1-1 Events list of the Sea surface water monitoring during MR14-01

System Date [UTC]	System Time [UTC]	Events	Remarks
2014/01/10	06:51	All the measurements started and data was available.	Cruise start
2014/01/15	02:00	All the measurements stopped.	
2014/01/24	01:00	All the measurements started and data was available.	
2014/02/03	02:43	All the measurements stopped.	Cruise end

(5) Preliminary Result

We took the surface water samples once a day to compare sensor data with bottle data of salinity, dissolved oxygen and fluorescence. The results are shown in Fig. 6.4.1 ~ 2. All the salinity samples were analyzed by the Guideline 8400B "AUTOSAL" (see 6.3.1), and dissolve oxygen samples were analyzed by Winkler method.

(6) Data archive

All raw data submitted to the Data Management Group of JAMSTEC and will be opened to public via web site of "Data Research for Whole Cruise Information in JAMSTEC".

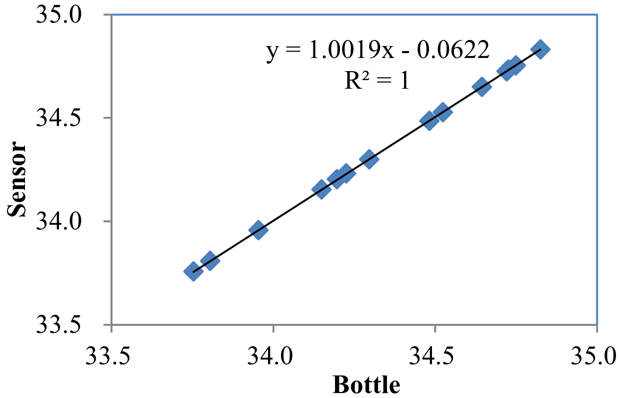


Fig 6.4.1-1 Correlation of salinity between sensor data and bottle data.

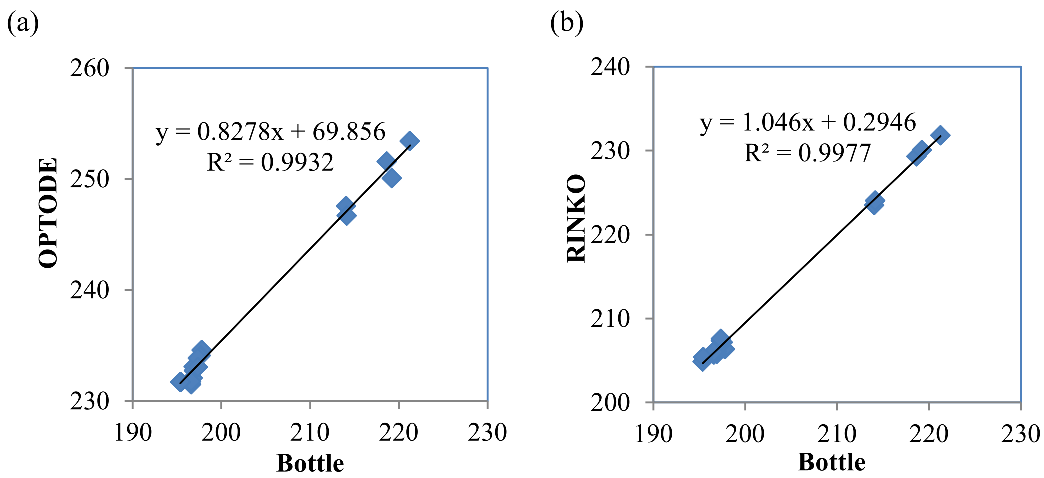


Fig 6.4.1-2 Correlation of dissolved oxygen between sensor data and bottle data.
(a: OPTODE, b: RINKO)

6. 4. 2. pCO_2 measurement

(1) Personnel

Akihiko Murata (JAMSTEC) Principal Investigator

Vedula Sarma (NIO)

Hiroshi Uchida (JAMSTEC)

Toshiro Saino (JAMSTEC)

Atsushi Ono (MWJ)

(2) Objective

Concentrations of CO_2 in the atmosphere are now increasing at a rate of about 2.0 ppmv yr^{-1} due to human activities such as burning of fossil fuels, deforestation, and cement production. The ocean is said to alleviate global warming by taking up CO_2 emitted into the atmosphere. However, it is well known that the El Niño and La Niña phenomena modulate CO_2 sinks and sources condition in the ocean, especially in the eastern tropical Pacific. Relationships between the phenomena and CO_2 budgets in the region have been well surveyed so far. By contrast, investigations of impacts of Indian Ocean Dipole (IOD), which is one of typical ocean climate variations of months to decade time-scale as well as the El Niño and La Niña phenomena, on CO_2 budgets in regional and basin scales. Thus we were aimed at surveying impacts of IOD on CO_2 sinks and source condition in the eastern part of the Indian Ocean.

(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 nominal concentrations of the standard gas were 250, 330, 360 and 420 ppmv. The standard gases will be calibrated after the cruise.

The marine air taken from the bow was introduced into the NDIR by passing through a mass flow controller, which controlled the air flow rate at about 0.6 – 0.8 L/min, 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. 6. 4.2-2 , together with SST.

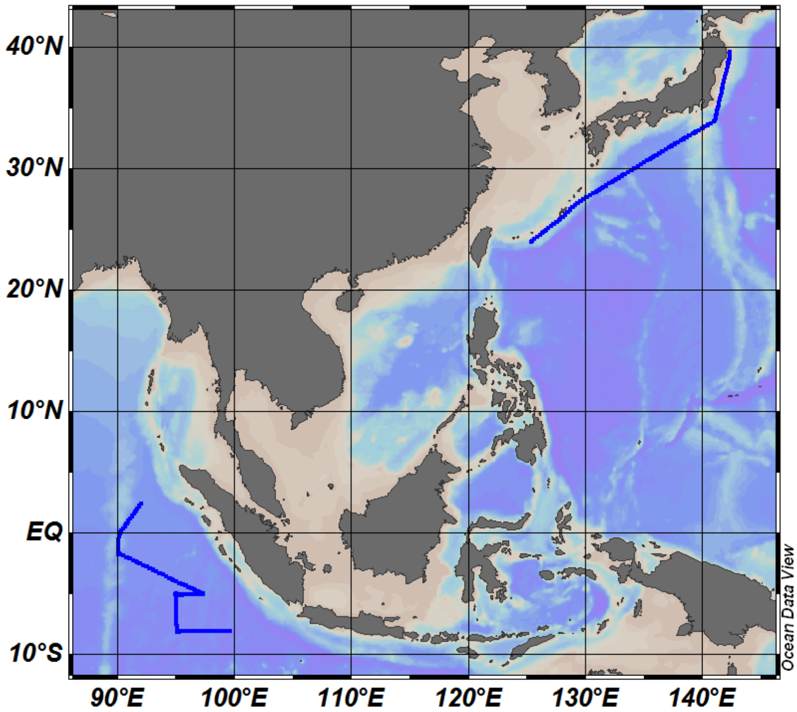


Fig. 6.4.2-1. Cruise track of the R/V Mirai , where atmospheric and surface seawater pCO_2 were measured.

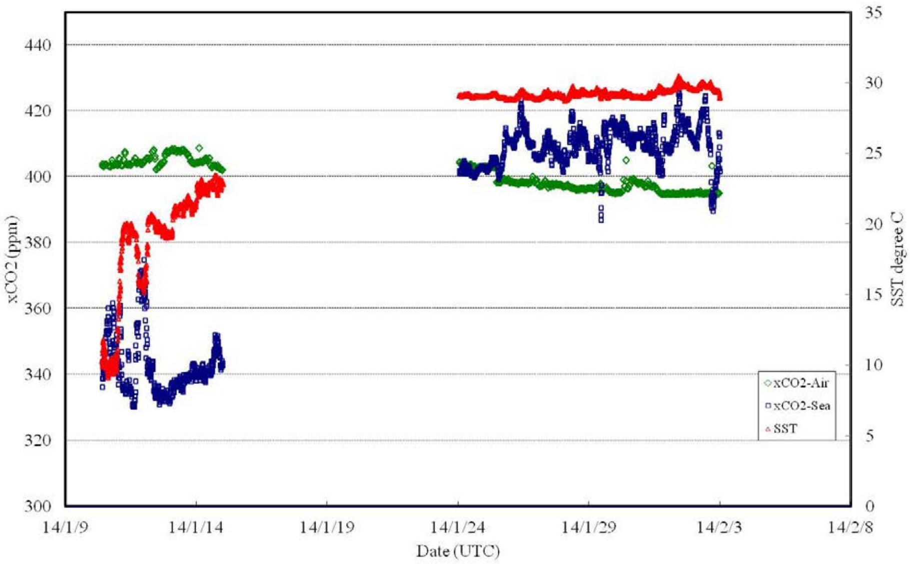


Fig. 6. 4. 2-2. Preliminary results of concentrations of CO_2 (xCO_2) in atmosphere (green) and surface seawater (blue), and SST (red) observed during MR14-01.

6.5 Shipboard ADCP

(1) Personnel

Iwao Ueki	(JAMSTEC) Principal Investigator
Shynya Okumura	(GODI)
Koichi Inagaki	(GODI)
Ryo Kimura	(MIRAI Crew)

(2) Objective

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

(3) Methods

Upper ocean current measurements were made in MR14-01 cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation the instrument was configured for water-tracking mode. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made to get the calibration data for evaluating transducer misalignment angle in the shallow water. The system consists of following components;

1. R/V MIRAI has installed the Ocean Surveyor for vessel-mount ADCP (frequency 76.8 kHz; Teledyne RD Instruments, USA). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel.
2. For heading source, we use ship's gyro compass (Tokimec, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System which provide high-precision heading and attitude data (pitch and roll) are stored in ".N2R" data file with a time stamp.
3. DGPS system (Trimble SPS751 & StarFixXP) providing precise ship's position.
4. We used VmDas software version 1.46.5 (TRDI) for data acquisition.
5. To synchronize time stamp of ping with GPS time, the clock of the logging computer is adjusted to GPS time every 1 minute
6. Fresh water is charged in the sea chest to prevent biofouling at transducer face.
7. 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 23-m below sea surface. Data was recorded every ping 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 6.5-1.

(4) Preliminary results

Fig.6.5-1 and Fig.6.5-2 show the current profile along the ship's track.

(5) Data archive

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

Table 6.5-1 Major parameters

Bottom-Track Commands	
BP = 001	Pings per Ensemble (almost less than 1000m depth)
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)

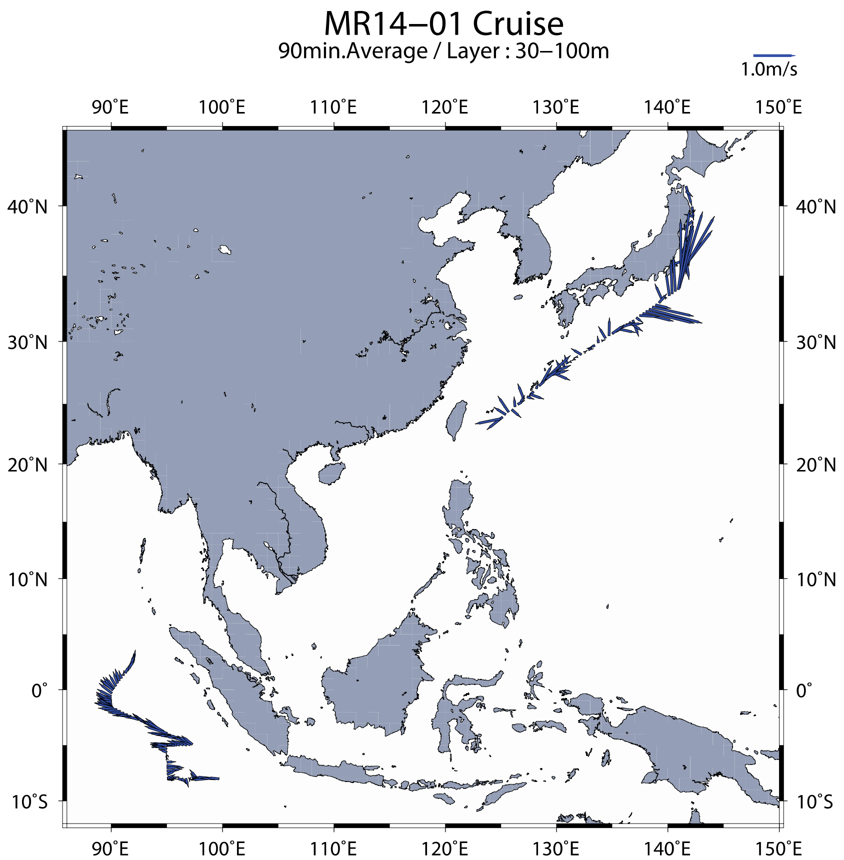


Fig 6.5-1. Current profile along the ship's track. (Whole Cruise)

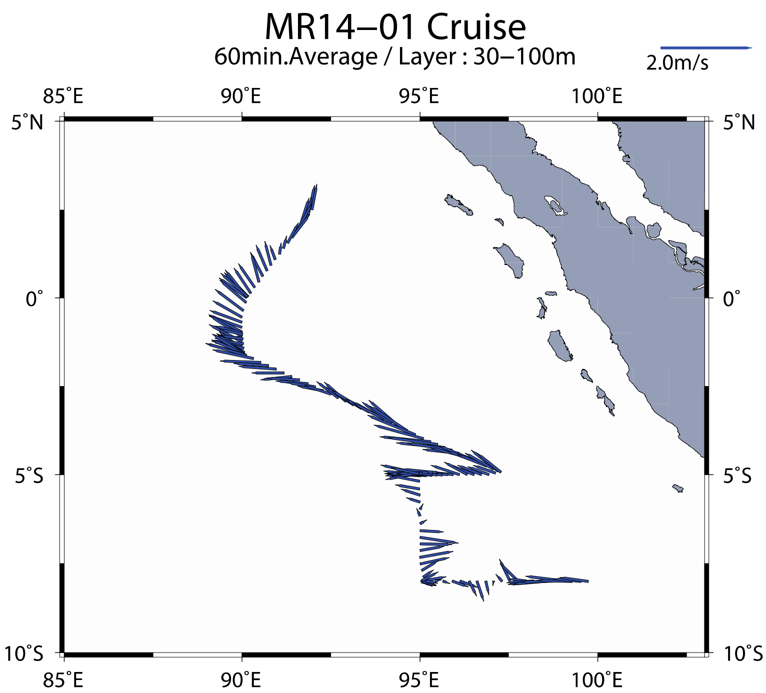


Fig 6.5-2. Current profile along the ship's track. (The Indian Ocean)

6.6 Underway geophysics

6.6.1. Sea surface gravity

(1) Personnel

Takeshi Matsumoto	(University of the Ryukyus, Not on-board) Principal Investigator
Iwao Ueki	(JAMSTEC)
Shinya Okumura	(GODI)
Koichi Inagaki	(GODI)
Ryo Kimura	(MIRAI Crew)

(2) Introduction

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface.

(3) Parameters

Relative Gravity [CU: Counter Unit]

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

(4) Data Acquisition

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) in the MR14-01 cruise.

We measured gravity to convert the relative gravity to absolute one, using portable gravity meter (Scintrex gravity meter CG-5) at Sekinehama as the reference point.

(5) Preliminary Results

Absolute gravity shown in Table 6.6.1-1

(6) Data Archives

Surface gravity data obtained during this cruise was submitted to the Data Management Group in JAMSTEC, and will be opened to public via web site of "Data Research for Whole Cruise Information in JAMSTEC".

(7) Remarks

1) Following periods, data acquisition was suspended in the territorial waters and EEZ.

02:00UTC 15 Jan. 2014 - 01:00UTC 24 Jan. 2014

2) The following period, Time and Navigation data was invalid. Due to we maintained Navigation System.

06:20UTC 09 Jan. 2014 - 04:20UTC 10 Jan. 2014

Table 6.6.1-1 Absolute gravity table

No	Date	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at Sensor *[1] [mGal]	L&R*[2] Gravity [mGal]
#1	Jan/06	06:45	Sekinehama	980,371.95	259	630	980,372.97	12,663.24
#2	Mar/24	07:32	Sekinehama	980,371.92	310	600	980,373.03	12,666.28

*[1]: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.222

*[2]: LaCoste and Romberg air-sea gravity meter S-116

6.6.2 Sea surface magnetic field

1) Three-component magnetometer

(1) Personnel

Takeshi Matsumoto	(University of the Ryukyus, Not on-board) Principal Investigator
Iwao Ueki	(JAMSTEC)
Shinya Okumura	(GODI)
Koichi Inagaki	(GODI)
Ryo Kimura	(MIRAI Crew)

(2) Introduction

Measurement of magnetic force on the ocean is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. Thus, we measured geomagnetic field using a three-component magnetometer in the MR14-01 cruise.

(3) Principle of shipboard 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 that 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 $\mathbf{H}bp = -\tilde{\mathbf{R}}\ \mathbf{H}p$. 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.

(4) 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.

(5) Data Archives

These data obtained in this cruise was submitted to the Data Management Group of JAMSTEC, and will be opened to public via “R/V MIRAI Data Web Page”.

(6) Remarks

1) Observation was carried out from 8th January to 15th January and 21th January to 3rd February.

2) For calibration of the ship’s magnetic effect, we made a “figure-eight” turn (a pair of clockwise and

anti-clockwise rotation) three times as follows;

11:27UTC - 11:56UTC 26 Jan. 2014 around 00-58S, 090-00E

10:41UTC - 11:09UTC 01 Feb. 2014 around 08-02S, 095-07E

3) The following period, data acquisition was suspended in territorial waters and EEZ.

02:00UTC 15 Jan. 2014 - 01:00UTC 24 Jan. 2014

4) The following period, Time and Navigation data was invalid. Because of we maintained Navigation System.

06:20UTC 09 Jan. 2014 - 04:20UTC 10 Jan. 2014

2) Cesium magnetometer

(1) Personnel

Takeshi Matsumoto	(University of the Ryukyus, Not on-board) Principal Investigator
Iwao Ueki	(JAMSTEC)
Shinya Okumura	(GODI)
Koichi Inagaki	(GODI)
Ryo Kimura	(MIRAI Crew)

(2) 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.

(3) Data Period

11th Jan. 2014, 15:14 - 13st Jan. 2014, 06:37 UTC

(4) 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.
The system configuration of MIRAI cesium magnetometer system is shown as below.

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

(5) Data Archive

Total magnetic force data obtained during this cruise was submitted to the Data Management Group of JAMSTEC, and will be opened to public via web site of "Data Research for Whole Cruise Information in JAMSTEC".

6.6.3. Swath Bathymetry

(1) Personnel

Takeshi Matsumoto	(University of the Ryukyus, Not on-board) Principal Investigator
Iwao Ueki	(JAMSTEC)
Shinya Okumura	(GODI)
Koichi Inagaki	(GODI)
Ryo Kimura	(MIRAI Crew)

(2) Introduction

R/V MIRAI is equipped with a Multi narrow Beam Echo Sounding system (MBES). 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.

(3) Data Acquisition

The "SEABEAM 3012 Upgrade Model" on R/V MIRAI was used for bathymetry mapping during the MR14-01 cruise from 09 January to 03 February 2014, except territorial waters and EEZ.

To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data to get the sea surface (6.62m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from CTD, XCTD and Argo float data by the equation in Del Grosso (1974) during the cruise.

The system configuration and performance for SEABEAM 3012 Upgrade Model (12 kHz system) is listed below.

Frequency:	12 kHz
Transmit beam width:	1.6 degree
Transmit power:	20 kW
Transmit pulse length:	2 to 20 msec.
Receive beam width:	1.8 degree
Depth range:	100 to 11,000 m
Beam spacing:	0.5 degree athwart ship
Swath width:	150 degree (max)
	120 degree to 4,500 m
	100 degree to 6,000 m
	90 degree to 11,000 m
Depth accuracy:	Within < 0.5% of depth or ±1m, whichever is greater, over the entire swath. (Nadir beam has greater accuracy; typically within < 0.2% of depth or ±1m, whichever is greater)

(4) Preliminary Results

The results will be published after primary processing.

(5) Data Archives

Bathymetric data obtained during this cruise was submitted to the Data Management Group of JAMSTEC, and will be opened to public via web site of “Data Research for Whole Cruise Information in JAMSTEC”.

7. Special observation

7.1 TRITON moorings

7.1.1 TRITON mooring operation

(1) Personnel

Iwao Ueki	(JAMSTEC) Principal Investigator
Yukio Takahashi	(JAMSTEC)
Akira Watanabe	(MWJ)
Hiroshi Matsunaga	(MWJ)
Takatoshi Kiyokawa	(MWJ)
Masaki Yamada	(MWJ)
Tomoyuki Takamori	(MWJ)
Tatsuya Tanaka	(MWJ)
Rei Ito	(MWJ)
Shinichiro Yokogawa	(MWJ)
Tomonori Watai	(MWJ)
Erena Hayashi	(MWJ)
Atsushi Ono	(MWJ)
Yuta iibuchi	(MWJ)

(2) Objectives

The large-scale air-sea interaction over the warmest sea surface temperature region in the western tropical Pacific Ocean called warm pool that affects the global atmosphere and causes El Nino phenomena. The formation mechanism of the warm pool and the air-sea interaction over the warm pool has not been well understood. Therefore long term data sets of temperature, salinity, currents and meteorological elements have been required at fixed locations. The TRITON program aims to obtain the basic data to improve the predictions of El Nino and variations of Asia-Australian Monsoon system.

TRITON buoy (included m-TRITON buoy) array is integrated with the existing TAO (Tropical Atmosphere Ocean) array, which is presently operated by the Pacific Marine Environmental Laboratory/National Oceanic and Atmospheric Administration of the United States. TRITON is a component of international research program of CLIVAR (Climate Variability and Predictability), which is a major component of World Climate Research Program sponsored by the World Meteorological Organization, the International Council of Scientific Unions, and the Intergovernmental Oceanographic Commission of UNESCO. TRITON will also contribute to the development of GOOS (Global Ocean Observing System) and GCOS (Global Climate Observing

System).

Three m-TRITON buoys have been successfully recovered and three m-TRITON buoys deployed during this cruise (MR14-01).

(3) Measured parameters

The TRITON/m-TRITON buoy observes oceanic parameters and meteorological parameters as follows:

Meteorological parameters:	wind speed/direction, air temperature, relative humidity, shortwave radiation, precipitation
Oceanic parameters:	water temperature and depth at 1m, 10m, 20m, 40m, 60m, 80m, 100m, 120m, 140m, 200m, 300m, 500m, conductivity at 1m, 10m, 20m, 40m, 100m, currents at 10m

*TRITON and m-TRITON observes same oceanic parameters and meteorological parameters.

Details of the instruments used on the TRITON/m-TRITON buoy are summarized as follows:

Oceanic sensors

1) CTD (Conductivity-Temperature-Depth meter, Sea Bird Electronics Inc.)

SBE-37 IM Micro CAT

A/D cycles to average :	4
Sampling interval :	600sec
Measurement range, Temperature :	-5～+35 deg-C
Measurement range, Conductivity :	0～+7 S/m
Measurement range, Pressure :	0～full scale range

2) TD (Temperature and Depth meter, Sea Bird Electronics Inc.)

SBE-39 IM

Sampling interval :	600sec
Measurement range, Temperature :	-5～+35 deg-C
Measurement range, Pressure :	0～full scale range

3) CRN (Current meter, Nortek AS)

Aquadopp IM400

Sampling interval :	1200sec
Sensor frequency :	2MHz
Velocity Range:	±5m/s

Meteorological sensors

1) Precipitation (JAMSTEC)

MODEL Y50203

Sampling interval : 600sec

2) Relative humidity/air temperature (JAMSTEC)

MODEL MP103A

Sampling interval : 600sec

3) Shortwave radiation (JAMSTEC)

MODEL EPSP

Sampling interval : 600sec

4) Wind speed/direction (JAMSTEC)

MODEL Y85000

Sampling interval : 600sec

*Meteorological sensors were assembled that used A/D (Analougue/Digital) conversion PCB (Print Cycle Board) made from MARITEC (Marine Technology Center)/JAMSTEC

Data logger and ARGOS transmitter

1) Data logger

Meteorological sensors are controlled by I/O RS485.

GPS and Inductive modem are controlled by RS232C.

2) ARGOS transmitter

The data in the interval of 10 minute are being transmitted through ARGOS transmitter.

(4) Results

Locations of deployment and recovery are as follow:

Locations of Recovery

Nominal location	5S, 95E(m-TRITON)
ID number at JAMSTEC	17505
ARGOS PTT number	16C34BE
ARGOS backup PTT number	29791
Deployed date (UTC)	13 Jun. 2012
Recovered date (UTC)	31 Jan. 2014
Exact location	04 - 56.93S, 94 - 58.51E
Depth	5,023 m

Nominal location	1.5S,90E(m-TRITON)
ID number at JAMSTEC	18506
ARGOS PTT number	3E052AD
ARGOS backup PTT number	29792
Deployed date (UTC)	09 Jun. 2012
Recovered date	This buoy wasn’t recovered.
Exact location	01 - 39.34S, 89 - 59.74 E
Depth	4,700 m

Nominal location	8S, 95E(m-TRITON)
ID number at JAMSTEC	19503
ARGOS PTT number	3E052BE
ARGOS backup PTT number	96773
Deployed date (UTC)	15 Jun. 2012
Recovered date (UTC)	02 Feb. 2014
Exact location	07 - 59.97S, 95 - 02.39E
Depth	5,243 m

Nominal location	5S, 97.25E(m-TRITON)
ID number at JAMSTEC	97501
ARGOS PTT number	16C34C7
ARGOS backup PTT number	30830
Deployed date (UTC)	12 Jun. 2012
Recovered date (UTC)	29 Jan. 2014
Exact location	04 - 57.55S, 97 - 17.13E
Depth	4,988 m

Locations of Deployment

Nominal location	5S,95E(m-TRITON)
ID number at JAMSTEC	17506
ARGOS PTT number	29EB779
ARGOS backup PTT number	30829
Deployed date (UTC)	30 Jan. 2014
Exact location	05 - 02.12S, 94 - 58.61E
Depth	5,012 m

Nominal location	1.5S,90E(m-TRITON)
ID number at JAMSTEC	18507
ARGOS PTT number	9EB84D4
ARGOS backup PTT number	24742
Deployed date (UTC)	27 Jan. 2014
Exact location	01 - 36.41S, 90 - 04.85E
Depth	4,715 m

Nominal location	8S,95E(m-TRITON)
ID number at JAMSTEC	19504
ARGOS PTT number	29EB75F
ARGOS backup PTT number	13066
Deployed date (UTC)	01 Feb. 2014
Exact location	08 - 03.97S, 95 - 07.43E
Depth	5,261 m

(5) Data archive

The data in the interval of 10 minutes were transmitted via ARGOS satellite data-transmission system in real time. These data will be archived and be opened to public via “TRITON Web Page”.

7. 1. 2. JAMSTEC original CTD sensor

1) Personnel

Yukio Takahashi (JAMSTEC) Principal Investigator

2) Objectives

(1)Sensors following Jamstec developed is deployed in m-Triton buoy to evaluated the long-term stability. In addition, in order to evaluate the pressure dependence of the water temperature sensor and verification of calibration results by the CTD casting.

①Practical version CTD sensor which is developed by the JAMSTEC

②A conductivity sensor aimed at low drift of the conductivity

(2)Marine anti-biofouling effect of JES10-CTIM deployed at the depth of 21m on KY12-08 voyage is evaluated.

3) Underwater sensors practical version

Two underwater sensors practical version were deployed in m-Triton buoy, on MR14-01 voyage. These are planned to evaluate the drift characteristics.

(1) JES10-CTDIM SN004 (depth of 501m, position 5S95E)

This sensor is a CTD sensor equipped with a conductivity cell of platinum black electrodes developed in Jamstec. Photo 7.1.2-1 is the conductivity cell. Photo 7.1.2-2 is a CTD sensor equipped with this conductivity cell. A SUS316 cylindrical tube of 62mmφ is used for the pressure container to reduce the cost.

(2) JES10-TDIM SN001 (depth of 501m, position 1.5S90E)

This sensor is a TD sensor using the same pressure container as JES10-CTDIM SN004.

Photo 7.1.2-1 Conductivity cell

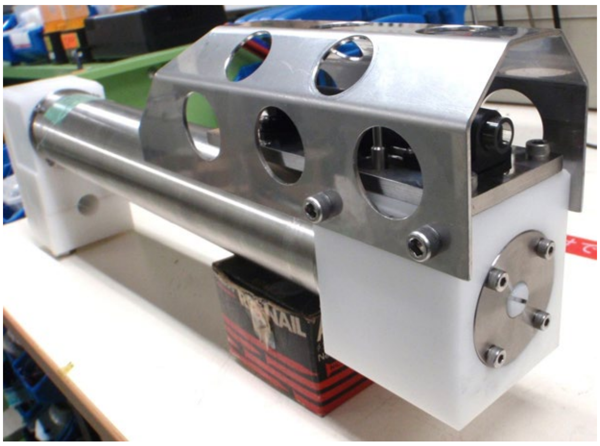


Photo 7.1.2-2 JES10-CTDIM

4) CTD casting

The validity of the calibration and the pressure dependence of the temperature were evaluated by attaching a SBE37 and JES10 sensors in the vicinity of 9Plus sensor. And some thermistor probes filled up using several kinds of resin were also examined. The CTD flame with 9Plus sensor was stopped for 5 minutes at each depth of 1000m, 750m, 500m, 300m and 100m, these measurements were compared with the 9Plus. Photo 7.1.2-3 shows the CTD flame.

Table 7.1.2-1, -2, -3, -4, and -5 show the results of the two measurements (JES10-CTDIM & SBE37).

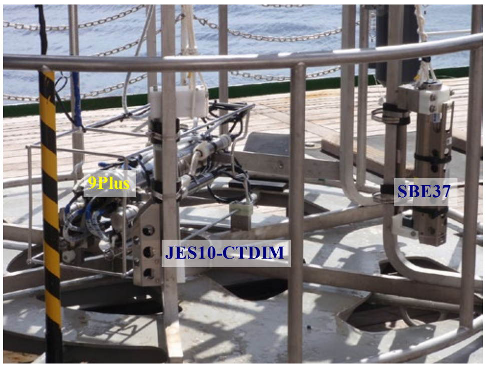


Photo 7.1.2-3 CTD flame

Table 7.1.2-1 Results of 9Plus

Depth	Temp.(degC)	Cond.(S/m)	Press (dbar)
1000m	6.7575	3.5439	1009.01
	0.00057	0.00004	0.251
750m	8.1029	3.6637	755.36
	0.00143	0.00015	0.206
500m	9.4224	3.7735	503.53
	0.00067	0.00006	0.231
300m	11.0258	3.9198	301.91
	0.00134	0.00013	0.205
100m	19.7829	4.7935	101.24
	0.01693	0.00162	0.352

(upper: average, lower: standard deviation)

Table 7.1.2-2 Results of JES10-CTDIM

Depth	Temp.(degC)	Cond.(S/m)	Press.(dbar)
1000m	6.7580	3.5456	1008.91
	0.00076	0.00013	0.317
750m	8.1029	3.6654	755.44
	0.00165	0.00011	0.218
500m	9.4216	3.7752	503.52
	0.00065	0.00006	0.303
300m	11.0249	3.9215	302.00
	0.00465	0.00054	0.224
100m	19.7799	4.7949	101.03
	0.00913	0.00118	0.315

Table 7.1.2-3 Difference between JES10&9Plus

Depth	Temp.(degC)	Cond.(S/m)	Press (dbar)
1000m	0.0005	0.0017	-0.10
750m	0.0000	0.0017	0.07
500m	-0.0008	0.0017	-0.01
300m	-0.0009	0.0017	0.08
100m	-0.0030	0.0014	-0.21

Table 7.1.2-4 Results of SBE37

Depth	Temp.(degC)	Cond.(S/m)	Press.(dbar)
1000m	6.7595	3.5489	1013.40
	0.00084	0.00093	0.392
750m	8.1033	3.6593	756.34
	0.00196	0.00102	0.251
500m	9.4224	3.7698	503.23
	0.00079	0.00112	0.230
300m	11.0258	3.9165	300.93
	0.00634	0.00086	0.362
100m	19.7811	4.7524	93.31
	0.01276	0.01818	0.184

Table 7.1.2-5 Difference between SBE37&9Plus

Depth	Temp.(degC)	Cond.(S/m)	Press (dbar)
1000m	0.0020	0.0050	4.40
750m	0.0004	-0.0044	0.97
500m	0.0000	-0.0037	-0.30
300m	0.0000	-0.0032	-0.98
100m	-0.0018	-0.0411	-7.93

5) Conductivity sensor of new conductivity processing system

Aiming a low drift of conductivity, conductivity new processing of AD conversion system has been developed. The conventional system has a RC oscillator circuit whose oscillation frequency is variable by the conductivity. In this manner, the drift of the conductivity is determined by the drift characteristics of the capacitor and fixed resistor that determines the frequency of the RC oscillator circuit.

In the AD conversion system, a low-frequency constant current drives the reference resistor and the conductivity cell, and voltage signals of these elements are AD converted. The resistance of the conductivity cell is calculated from the reference resistor and voltage amplitude ratio of the two signals. In this manner, the drift of conductivity is determined by the only drift characteristics of the reference resistor. Photo 7.1.2-4 is a conductivity-sensor equipped with this circuit board that has been developed. JES10-aC SN002 conductivity sensor was deployed depth of 501m, position 8S95E.

Photo 7.1.2-4 JES10-aC SN002 and the circuit board

6) Evaluation of marine anti-biofouling

On MR11-06 voyage, JES10-CTIM SN003 sensor with a new anti-biofouling device was deployed, position 5S97.25E at the depth of 21m. On behalf of the TBTO so far, plates of BeCu are attached to both ends of the conductivity cell. Photo 7.1.3-5 is a conductivity cell with BeCu plates. Photo 7.1.3-6 shows the biofouling state conductivity cell inside the entrance of recovered JES10-CTIM. Figure 7.1.3-1 shows the measurement results of this sensor and 20mCTD (SBE37).

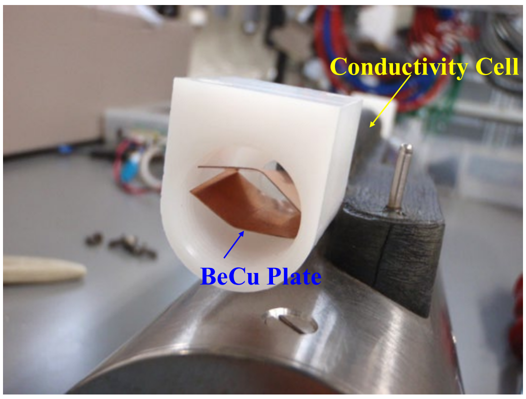


Photo 5 Conductivity cell with BeCu plates

Photo 6 Biofouling state of recovered JES10

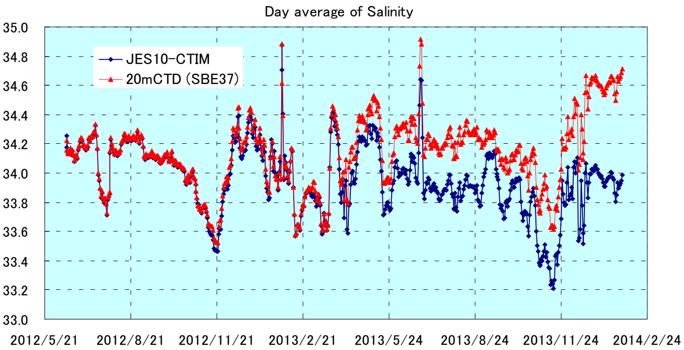


Figure 7.1.3-1 Day average of salinity

7. 2. ADCP subsurface moorings

(1) Personnel

Iwao Ueki	(JAMSTEC) Principal Investigator
Akira Watanabe	(MWJ)
Hiroshi Matsunaga	(MWJ)
Takatoshi Kiyokawa	(MWJ)
Masaki Yamada	(MWJ)
Tomoyuki Takamori	(MWJ)
Tatsuya Tanaka	(MWJ)
Rei Ito	(MWJ)
Shinichiro Yokogawa	(MWJ)
Tomonori Watai	(MWJ)
Erena Hayashi	(MWJ)
Atsushi Ono	(MWJ)
Yuta iibuchi	(MWJ)

(2) Objectives

The purpose of this ADCP observation is to get knowledge of physical process underlying the dynamics of oceanic circulation in the eastern equatorial Indian Ocean. Sub-surface currents are observed by using ADCP moorings at 90°E right on the equator. In this cruise (MR14-01), we deployed as well as recovered sub-surface ADCP moorings at 0°S, 90°E.

We also tried to conduct emergency recovery of an ADCP mooring in the Phillipine Sea (7˚N 127˚ 46' E) with a towed sweep-line. Although we try to recover the mooring during previous cruise, it did not rise to the surface after release an anchor and acoustic equipment indicated the mooring was still be there. We consider the mooring might be tangled with something near the seafloor.

(3) Parameters

Current profiles

Echo intensity

Pressure, Temperature and Conductivity

(4) Method

Two instruments are mounted at the top float of the mooring. One is ADCP (Acoustic Doppler Current Profiler) to observe upper-ocean currents from subsurface down to around 400m depths. The second instrument mounted below the float is CTD, which observes pressure, temperature and salinity for correction of sound speed and depth variability. Details of the instruments and their parameters are described as follows:

1) Current meters

WorkHorse ADCP 75 kHz (Teledyne RD Instruments, Inc.)

Distance to first bin :	7.04 m
Pings per ensemble :	27
Time per ping :	6.66 seconds
Number of depth cells :	60
Bin length :	8.00 m
Sampling Interval :	3600 seconds

Recovered ADCP

Serial Number : 1248 (Mooring No.120608-0090E)

Deployed ADCP

Serial Number : 13123 (Mooring No.140125-0090E)

2) CTD

SBE-37 (Sea Bird Electronics Inc.)

Sampling Interval : 1800 seconds

Recovered CTD

Serial Number : 1388 (Mooring No.120608-0090E)

Deployed CTD

Serial Number : 1775 (Mooring No.140125-0090E)

3) Other instrument

Acoustic Releaser (BENTHOS,Inc.)

Recovered Acoustic Releaser

Serial Number : 600 (Mooring No.120608-0090E)

Serial Number : 937 (Mooring No.120608-0090E)

Deployed Acoustic Releaser

Serial Number : 955 (Mooring No.140125-0090E)

Serial Number : 961 (Mooring No.140125-0090E)

Transponder (BENTHOS,Inc.)

Deployed Transponder

Serial Number : 67491 (Mooring No.140125-0090E)

(5) Deployment

Deployment of the ADCP mooring at 0°N, 90°E was planned to mount the ADCP at about 400m depths. During the deployment, we monitored the depth of the acoustic releaser after dropped the anchor.

The position of the mooring (No.140125-0090E)

Date: 25 Jan. 2014 Lat: 00-00.1688S Long: 90-08.7603E Depth: 4,085m

(6) Recovery

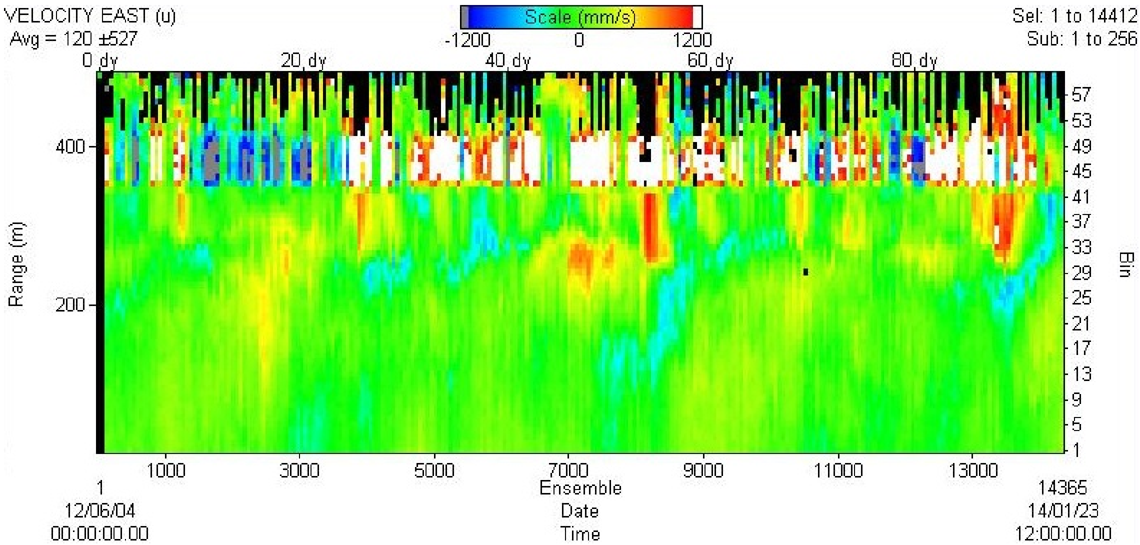
We recovered one ADCP mooring which was deployed on 08 Jun. 2012 (KY12-08 cruise). After the recovery, we uploaded ADCP and CTD data into a computer, then raw data were converted into ASCII code.

Results were shown in the figures in the following pages. Fig.7.2-1 shows the ADCP velocity data (zonal and meridional component / Eq-90E). Fig.7.2-2 shows CTD pressure, temperature and salinity data (Eq-90E).

For the mooring deployed near Mindanao Is. (7˚N 127˚ 46' E), we tried to recover by a towed sweep-line operation. Although a part of mooring was tangled with the towed sweep-line, we could not recover the mooring because of high tension on the line.

(7) Data Archives

The quality controled data will be submitted to the Data Management Group of JAMSTEC, and opened to public via JAMSTEC web site.



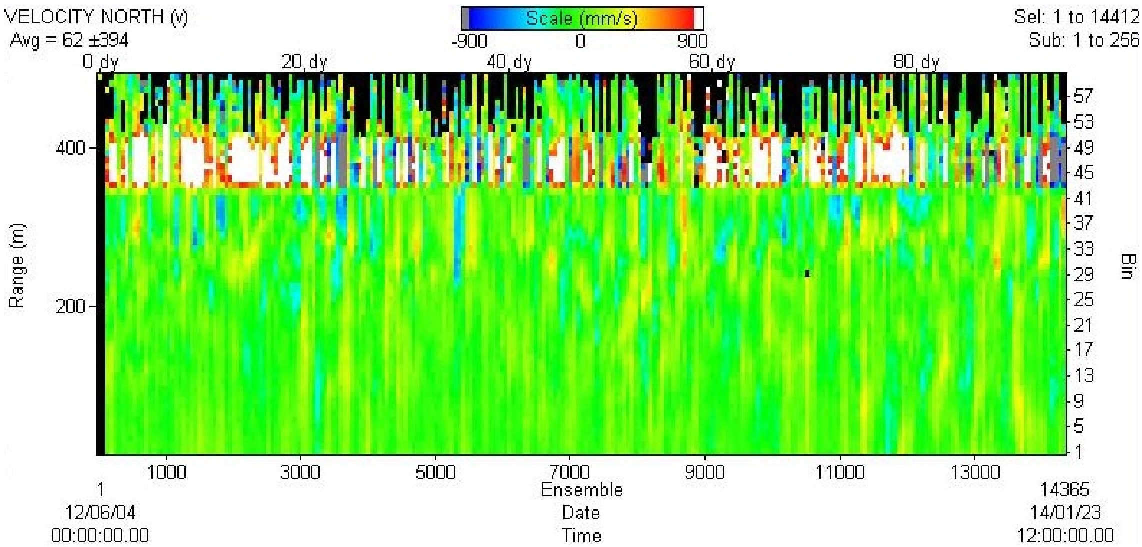


Fig.7.2-1 Time-depth sections of observed zonal (upper) and meridional (lower) currents obtained from ADCP mooring at Eq-90E. (2012/06/04-2014/01/25)

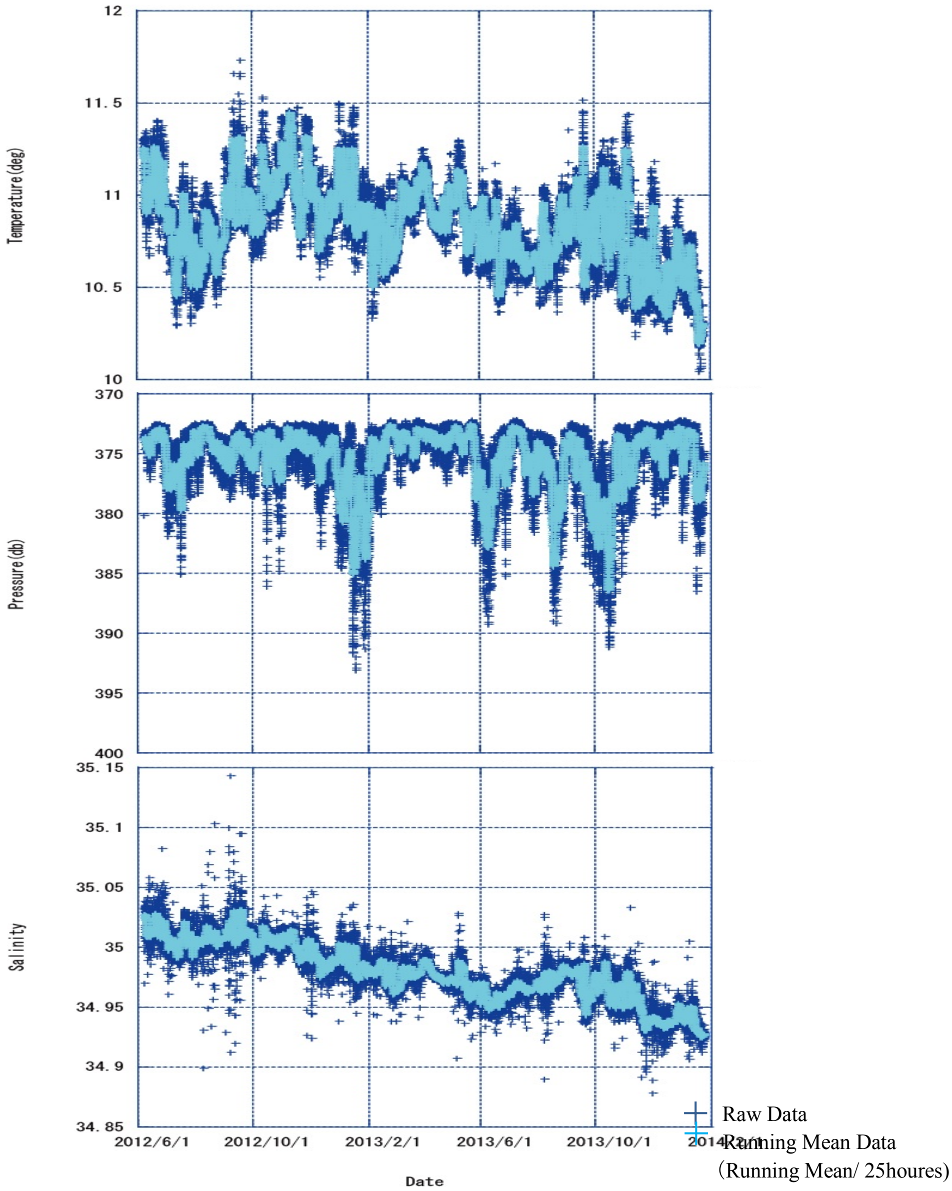


Fig.7.2-2 Time-series of the observed temperature (upper), pressure (middle) and salinity (lower) obtained from CTD at Eq-90E. The dark-blue curve indicates the raw data, while the light-blue curve shows the filtered data from 25 hours running-mean. (2012/06/04-2014/01/25)

7. 3. Argo floats

(1) Personnel

Toshio Suga	(JAMSTEC/RIGC, not on board) Principal Investigator
Shigeki Hosoda	(JAMSTEC/RIGC, not on board)
Kanako Sato	(JAMSTEC/RIGC, not on board)
Mizue Hirano	(JAMSTEC/RIGC, not on board)
Tomoyuki Takamori(MWJ)	

(2) Objectives

The objective of deployment is to clarify the structure and temporal/spatial variability of water masses in the North Pacific such as North Pacific Subtropical Mode Water in the subtropical North Pacific.

The profiling floats launched in this cruise measure vertical profiles of temperature and salinity automatically every 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, and pressure

(4) Methods

1) Profiling float deployment

We launched an Arvor float manufactured by nke. These floats equip an SBE41cp CTD sensor manufactured by Sea-Bird Electronics Inc.

The floats 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. They stay at the sea surface for approximately nine hours, transmitting the CTD data to the land via the ARGOS system, and then return to the parking depth by decreasing volume. The status of floats and their launches are shown in Table 7.3-1.

Table 7.3-1 Status of floats and their launches float (2000dbar)

Float Type	Arvor float manufactured by nke.
CTD sensor	SBE41cp manufactured by Sea-Bird Electronics Inc.
Cycle	10 days (approximately 9 hours at the sea surface)
ARGOS transmit interval	30 sec
Target Parking Pressure	1000 dbar
Sampling layers	115 (2000,1950,1900,1850,1800,1750,1700,1650,1600,1550,1500, 1450, 1400, 1350, 1300, 1250, 1200, 1150, 1100, 1050, 1000, 980, 960, 940, 920, 900, 880, 860, 840, 820, 800, 780, 760, 740, 720, 700, 680, 660, 640, 620, 600, 580, 560, 540, 520, 500, 490, 480, 470, 460, 450, 440, 430, 420, 410, 400, 390, 380, 370, 360, 350, 340, 330, 320, 310, 300, 290, 280, 270, 260, 250, 240, 230, 220,210, 200, 195, 190, 185, 180, 175, 170, 165, 160, 155, 150, 145, 140, 135, 130, 125, 120, 115, 110, 105, 100, 95, 90, 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30, 25, 20, 15, 10, 4 or surface dbar)

Launches

Float S/N	ARGOS ID	Date and Time of Reset (UTC)	Date and Time of Launch(UTC)	Location of Launch	CTD St. No.
OIN-13JAP-ARL-43	123603	2014/01/11 13：37	2014/01/11 14：48	34-01.92N 141-01.09E	C01

(5) Data archive

The real-time data are 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.

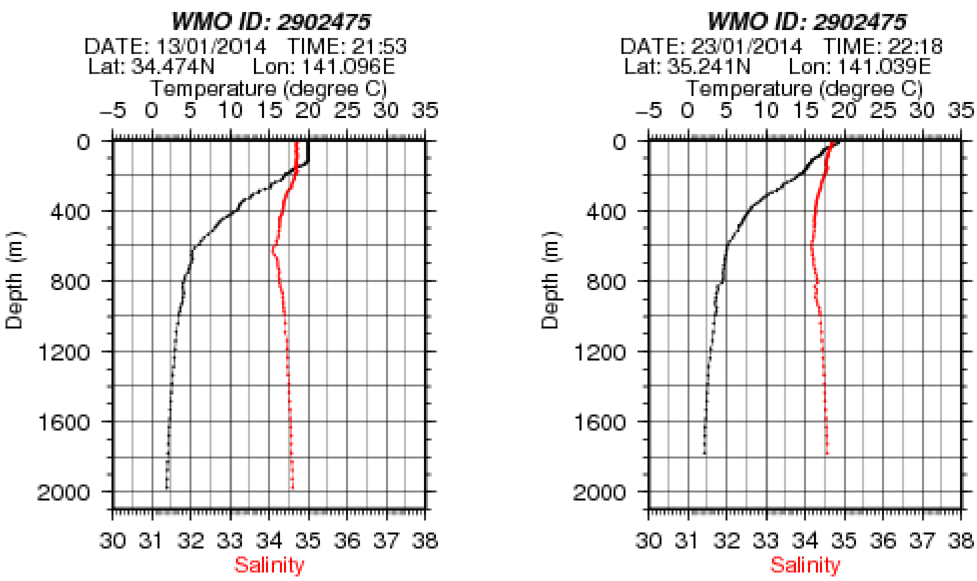


Fig. 7.3-1 The profile of the float launched during MR14-01.

7. 4. Tropospheric aerosol and gas observations

(1) Personnel

Yugo Kanaya	(JAMSTEC RIGC, not on board) Principal Investigator
Fumikazu Taketani	(JAMSTEC RIGC, not on board)
Takuma Miyakawa	(JAMSTEC RIGC, not on board)
Hisahiro Takashima	(JAMSTEC RIGC, not on board)
Xiaole Pan	(JAMSTEC RIGC, not on board)
Yuichi Komazaki	(JAMSTEC RIGC, not on board)

Operation was supported by Global Ocean Development Inc.

(2) Objective

To clarify transport processes of atmospheric pollutants from the Asian continent to the ocean

To investigate processes of biogeochemical cycles between the atmosphere and the ocean

To advance validation of satellite observations of atmospheric composition

(3) Parameters

1) Black carbon mass concentrations and size distribution

2) Ozone and carbon monoxide mixing ratios

3) Aerosol composition (trace metals, water-soluble ions, carbonaceous etc)

(4) Instruments and Methods

1) CO, O_3, and black carbon (BC)

Carbon monoxide (CO) and ozone (O_3) measurements were also continuously conducted during the cruise. For CO and O_3 measurements, 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) in the Research Information Center.

BC was measured by an instrument based on laser-induced incandescence (SP2, Droplet Measurement Technologies). Ambient air was sampled from the flying bridge by a 3-m-long conductive tube and then introduced to the instrument.

2) 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 for three separate periods. The filter samples obtained during the cruise are subject to chemical analysis of aerosol composition, including water-soluble ions and trace metals.

(5) Observation log

The shipboard measurements and sampling were conducted in the open sea.

(6) Data archives

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

7.5. Lidar observations of clouds and aerosols

(1) Personnel

Nobuo Sugimoto	(NIES, not on board) Principal Investigator
Ichiro Matsui	(NIES, not on board)
Atsushi Shimizu	(NIES, not on board)
Tomoaki Nishizawa	(NIES, not on board)

Operation was supported by Global Ocean Development Inc.

(2) Objective

Objectives of the observations in this cruise is to study distribution and optical characteristics of ice/water clouds and marine aerosols using a two-wavelength polarization Mie-scattering lidar.

(3) Description of instruments deployed

Vertical profiles of aerosols and clouds are measured with a two-wavelength polarization Mie-scattering lidar. The lidar employs a Nd:YAG laser as a light source which generates the fundamental output at 1064nm and the second harmonic at 532nm. Transmitted laser energy is typically 30mJ per pulse at both of 1064 and 532nm. The pulse repetition rate is 10Hz. The receiver telescope has a diameter of 20 cm. The receiver has three detection channels to receive the lidar signals at 1064 nm and the parallel and perpendicular polarization components at 532nm. An analog-mode avalanche photo diode (APD) is used as a detector for 1064nm, and photomultiplier tubes (PMTs) are used for 532 nm. The detected signals are recorded with a transient recorder and stored on a hard disk with a computer. The lidar system was installed in a container with a glass window on the roof, and the lidar was operated continuously regardless of weather. Every 10 minutes vertical profiles of four channels (532 parallel, 532 perpendicular, 1064, 532 near range) are recorded.

(4) Preliminary results

The two wavelength polarization Mie-scattering lidar worked well and succeeded in getting the lidar data during the whole observation period. Quicklook figures of time-height sections of measured data are depicted in Fig. 7.5-1. Left panel shows an existence of mixing layer near the sea surface, blow 1 km altitude. Moderate backscatter, with lower depolarization ratio, continues during whole day, which implies surface was covered by spherical particles like sulfate or organic carbons. In the same figure, multiple cloud layer can be recognized. Around 6 km altitude, there was a strong scattering layer. Simultaneously another cloud layer between 10-12 km was confirmed. In right panel, on January 28, geometrically thick cirrus cloud spreads between 12-16 km. Further analysis will be conducted after numerical data is obtained from shipborne lidar PC.

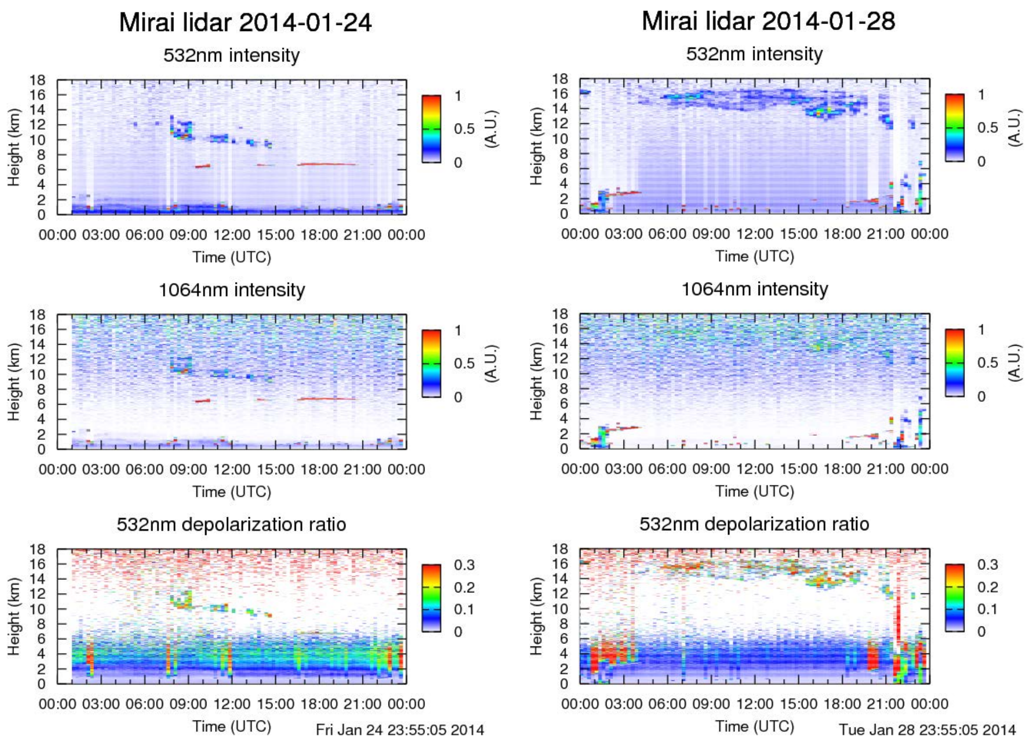


Fig.7.5-1 Time-height sections of backscatter intensities at 532nm /1064nm and total depolarization ratio at 532nm measured on January 24 (left) and January 28 (right), 2014.

(5) Data archives

1) Raw data

temporal resolution 10min / vertical resolution 6 m (up to 18 km)

data period (UTC): January 10, 2014 ~ January 31, 2014

Backscatter intensities at 532 nm/1064 nm, depolarization ratio at 532 nm

2) Processed data (plan)

cloud base height, apparent cloud top height, phase of clouds (ice/water), cloud fraction

boundary layer height (aerosol layer upper boundary height), backscatter coefficient of aerosols, particle depolarization ratio of aerosols

* Data policy and Citation

Contact NIES lidar team (nsugimot/i-matsui/shimizua/nisizawa@nies.go.jp) to utilize lidar data for productive use.

These data obtained in this cruise will also be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via JAMSTEC web site.

7. 6. Aerosol optical characteristics measured by Shipborne Sky radiometer

(1) Personnel

Kazuma Aoki (University of Toyama, not onboard) Principal Investigator

Tadahiro Hayasaka (Tohoku University, not onboard)

Sky radiometer operation was supported by Global Ocean Development Inc.

(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.

7. 7. Observations of CO_2 column averaged volume mixing ratios over the Indian Ocean and the tropical Pacific Ocean using a ship-borne compact system for a simple estimation of the carbon flux with GOSAT data

(1) Personnel

Kei Shiomi (JAXA EORC, not onboard) Principal Investigator

Shuji Kawakami (JAXA EORC, not onboard)

Operation was supported by Global Ocean Development Inc.

(2) Objective

Greenhouse gases Observing SATellite (GOSAT) was launched on 23 January 2009 in order to monitor the global distributions of atmospheric greenhouse gas concentrations: column-averaged dry-air mole fractions of carbon dioxide (CO2) and methane (CH4). A network of ground-based high-resolution Fourier transform spectrometers provides essential validation data for GOSAT. Vertical CO2 profiles obtained during ascents and descents of commercial airliners equipped with the in-situ CO2 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.

Fig. 7.7.-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

(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 (Fig.7.7-1) 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 is detected. The measurements of the solar spectra were performed during solar zenith angles of <80°.

(4) Analysis method

The CO_2 absorption spectrum at the 1.6 μm band measured with the OSA is shown in Fig. 7.7-2. 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. 7.7-3 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.

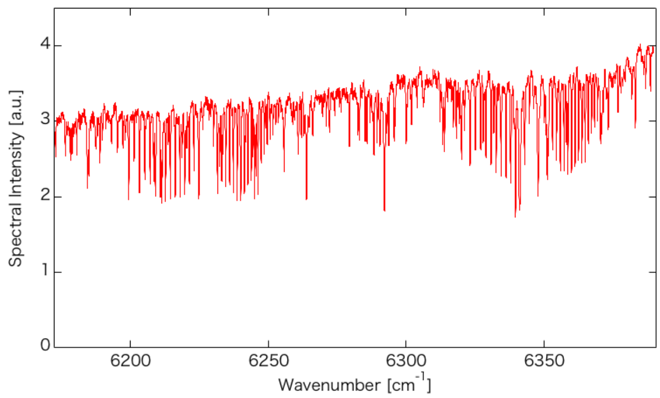


Fig. 7.7-2. 1.6 μm CO_2 absorption spectrum measured with the OSA.

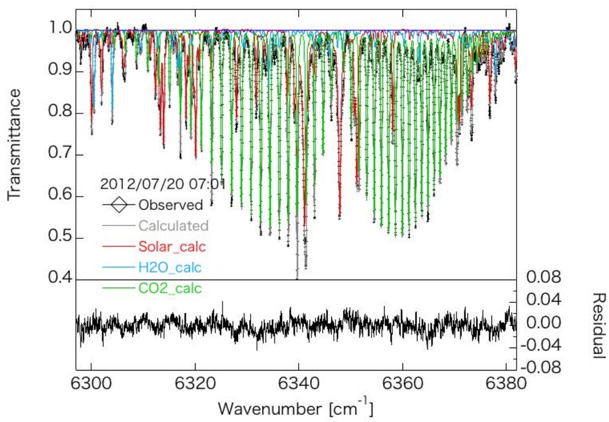


Fig. 7.7-3. Spectral fit performed for the 6297–6382 cm^{-1} region using an OSA spectrum. Open diamonds denote the measured spectrum, and the solid line denotes the spectrum calculated from the retrieval result. The residual between the measured and calculated spectra is also shown.

(5) Preliminary results

The observations were made from January 9 to February 3, 2014 continuously in daytime (excluding the EEZs of other countries) (Table 7.7-1 and Fig. 7.7-4).

Table 7.7-1. Period of CO_2 observations

CO_2 observations		
Date	Start Time(JST)	End Time(JST)
2014/01/09	10:35	14:14
2014/01/10	8:44	15:23
2014/01/11	7:51	15:48
2014/01/12	7:46	11:58
2014/01/12	7:46	11:58
2014/01/14	8:48	11:35
2014/01/15	8:47	11:00
2014/01/24	10:27	18:43
2014/01/25	10:18	19:44
2014/01/26	12:01	20:32
2014/01/27	9:53	21:01
2014/01/28	11:07	20:24
2014/01/29	9:28	17:05
2014/01/30	9:30	18:03
2014/01/31	10:17	16:46
2014/02/01	9:26	20:10
2014/02/02	9:27	20:18
2014/02/03	9:12	12:00

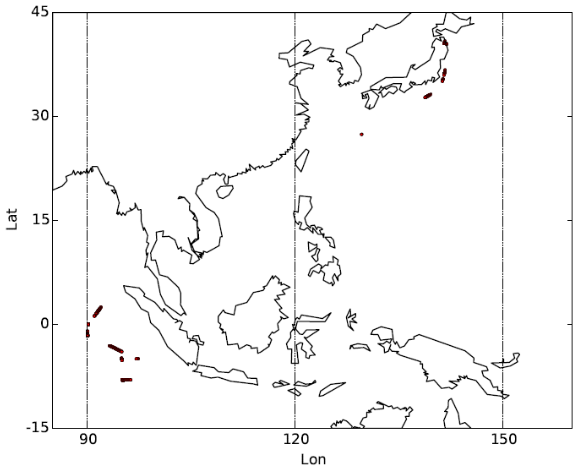


Fig. 7.7-4 Locations of CO_2 observations

(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 the Data Management Group of JAMSTEC, and will be opened to the public via JAMSTEC web site.