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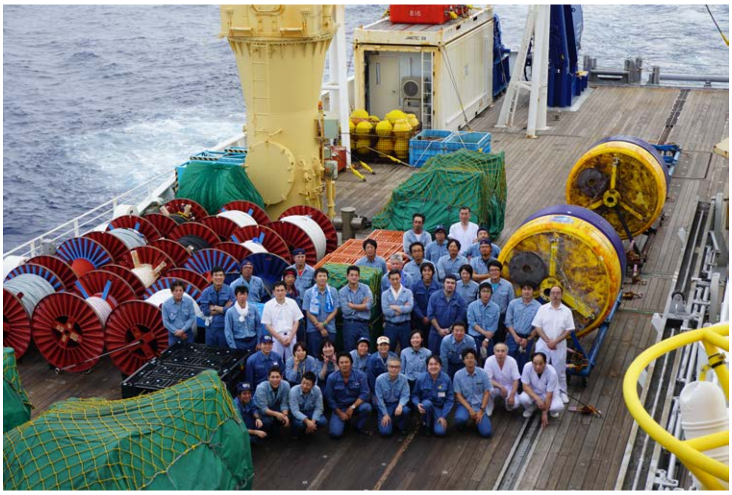
R/V Mirai Cruise Report
MR14-06 (leg 2&3)

December 20, 2014 – February 25, 2015

Tropical Western Pacific Ocean & Eastern Indian Ocean



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

Cruise Report ERRATA of the Nutrients part

page	Error	Correction
7-2-38	potassium nitrate CAS No. 7757-91-1	potassium nitrate CAS No. 7757-79-1

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Note:

This cruise report is a preliminary documentation as of the end of the cruise. It may not be revised even if new findings and others are derived from observation results after publication. It may also be changed without notice. Data on the cruise report may be raw or not processed. Please ask the chief scientists for the latest information before using this report. Users of data or results of this cruise are requested to submit their results to "JAMSTEC Data Management Group (DMG)", (e-mail: dmo@jamstec.go.jp).

1. General Information

1. 1. Cruise ID

MR14-06-leg2 and leg3

1. 2. Name of vessel

R/V MIRAI

1. 3. Title of the cruise (same as proposed title at application)

Tropical Ocean Climate Study in the Indian and Pacific Ocean/
Study of structure and formation process of the Ontong Java Plateau/
Operation of TRITON buoy

1. 4. Representatives of science party and thema

5- 1) Kentaro Ando (JAMSTEC):
Tropical Ocean Climate Study

5- 2) Yasuhisa Ishihara (JAMSTEC):
Operation of TRITON buoys

5- 3) Akihiko Murata (JAMSTEC):
Temporal and spatial variations of marine carbon cycle related to the Indian Dipole

5- 4) Masaki Katsumata (JAMSTEC):
Applied research of MIRAI brand-new shipboard weather radar: Validation and utilization of dual-polarization information for global deployment

5- 5) Masaki Katsumata (JAMSTEC):
Global distribution of drop size distribution of precipitating particles over pure-oceanic background

5- 6) Kazuma Aoki (Univ. of Toyama):
Aerosol optical characteristics measured by Ship-borne sky radiometer

5- 7) Takeshi Matsumoto (Univ. of the Ryukyus):
Standardization of marine geophysical data and its application to geodynamics studies

5- 8) Yugo Kanaya (JAMSTEC)
Advanced continuous measurements of aerosols in the marine atmosphere: Elucidation of the roles in the Earth system

5- 9) Shuji Kawakami (JAXA)
Shipboard CO2 observations over the tropical Indo-Pacific Ocean for a simple estimation of the carbon flux between the ocean and the atmosphere from GOSAT data

1. 5. Research area

Tropical Western Pacific Ocean and Tropical eastern Indian Ocean

2. Overview and observation summary

2. 1. Overview

Leg 2

Air-sea interaction and ocean circulation in the western Pacific Ocean is important to understand the ENSO and climate variations originated in the Pacific basin in particular in the Pacific warm pool. For these purposes, we have operated TRITON buoy network in the western Pacific as a part of TAO/TRITON. During the cruise, we carried out the deployments and recoveries of TRITON buoys as well as CTD measurements, ADCP moorings, XCTD, UCTD measurements. Several applied missions such as sampling of oceanic sea skaters.

Leg 3

Ocean-Atmosphere interaction in the warm water pool located at the eastern Indian Ocean is crucial for climate variability such as the Indian Ocean Dipole event (IOD). To understand and monitor of the upper ocean condition, we conduct mini-TRIangle Trans Ocean buoy Network (m-TRITON) moorings in the Indian Ocean as part of Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA). For that purpose, we carried out deployment and recovery of the m-TRITON moorings as the main mission. We also carried out other observations, such as ADCP moorings, CTD measurements with water sampling and meteorological observation, for understanding the Ocean and atmospheric conditions. In addition, we carried out several applied missions, which include CO_2, aerosols, and precipitation measurements

Oceanic and atmospheric conditions in the eastern tropical Indian 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.

2. 2. Observation Summary

Leg 2

TRITON mooring:	8 moorings were deployed 9 moorings recovered, and 1 buoy was possibly sunk on the sea floor.
BBOBS:	12 Deployments
OBEM deployment	11 Deployments
Sub-surface ADCP moorings:	1 mooring was deployed and recovered
CTD and water sampling:	12 casts
XCTD:	29 casts
UCTD:	3 cast
Sonde:	30 launchings
Sampling of oceanic sea skaters:	8 times
Current measurements by shipboard ADCP:	continuous
General Surface meteorology:	continuous
Lidar, rain sampling, turbulences, aerosol etc.:	continuous
Geophysical bottom survey:	continuous

Leg 3

m-TRITON buoy deployment	3 sites
m-TRITON buoy recovery	3 sites
ADCP buoy deployment	1 site

ADCP buoy Recovery	1 site
CTD including water sampling	9 casts
UnderwayCTD	21 launches
XCTD	1 launch
Shipboard ADCP measurement	continuous
Geophysics measurements	continuous
Surface temperature, salinity, and Chrolophyll measurements by intake method	continuous
CO_2 and pCO_2 measurements	continuous

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

3. Cruise Information

3. 1. Period

20th December 2014 – 19th January 2015 (Leg 2)
22nd January 2015 – 25th February 2015 (Leg 3)

3. 2. Ports of call

Chuuk, Federated States of Micronesia (Departure: 20th December 2014)
Koror, Republic of Palau (Arrival: 19th January 2015)
(Departure: 22nd January 2015)
Hachinohe, Japan (Arrival & Departure: 24th February 2015)
Sekinehama, Japan (Arrival: 25th February 2015)

3. 3. Cruise track

Leg 2

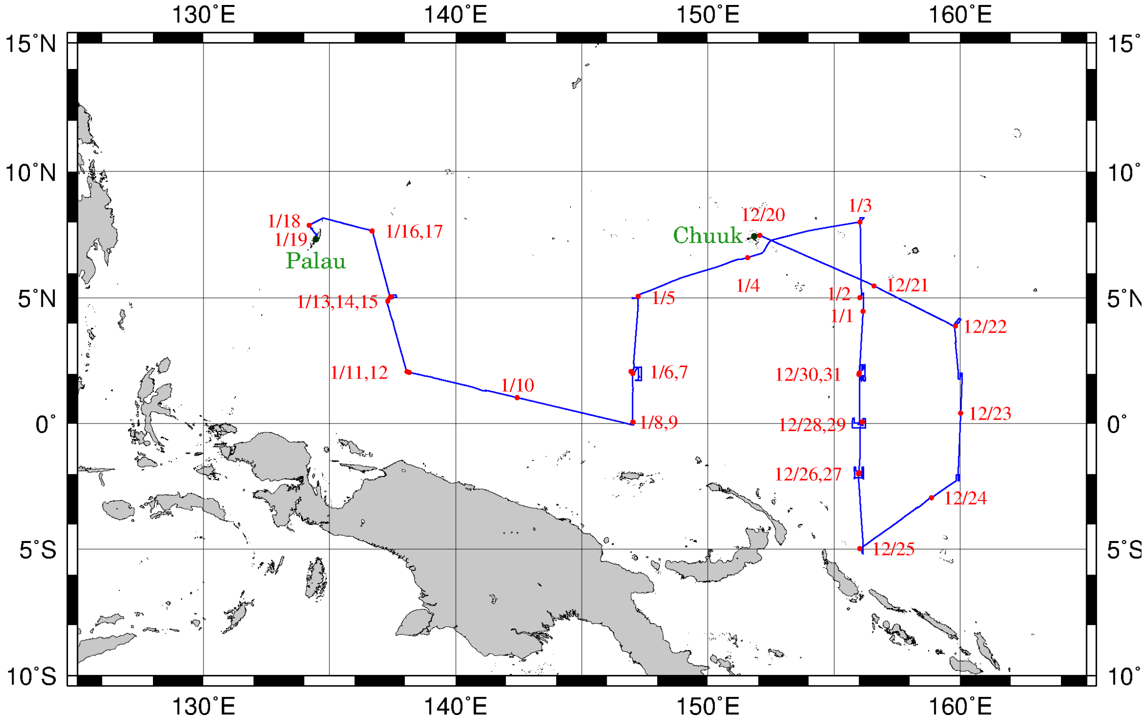


Fig 3-1. MR14-06 Leg 2 cruise track and noon positions from Chuuk to Palau.

Leg 3

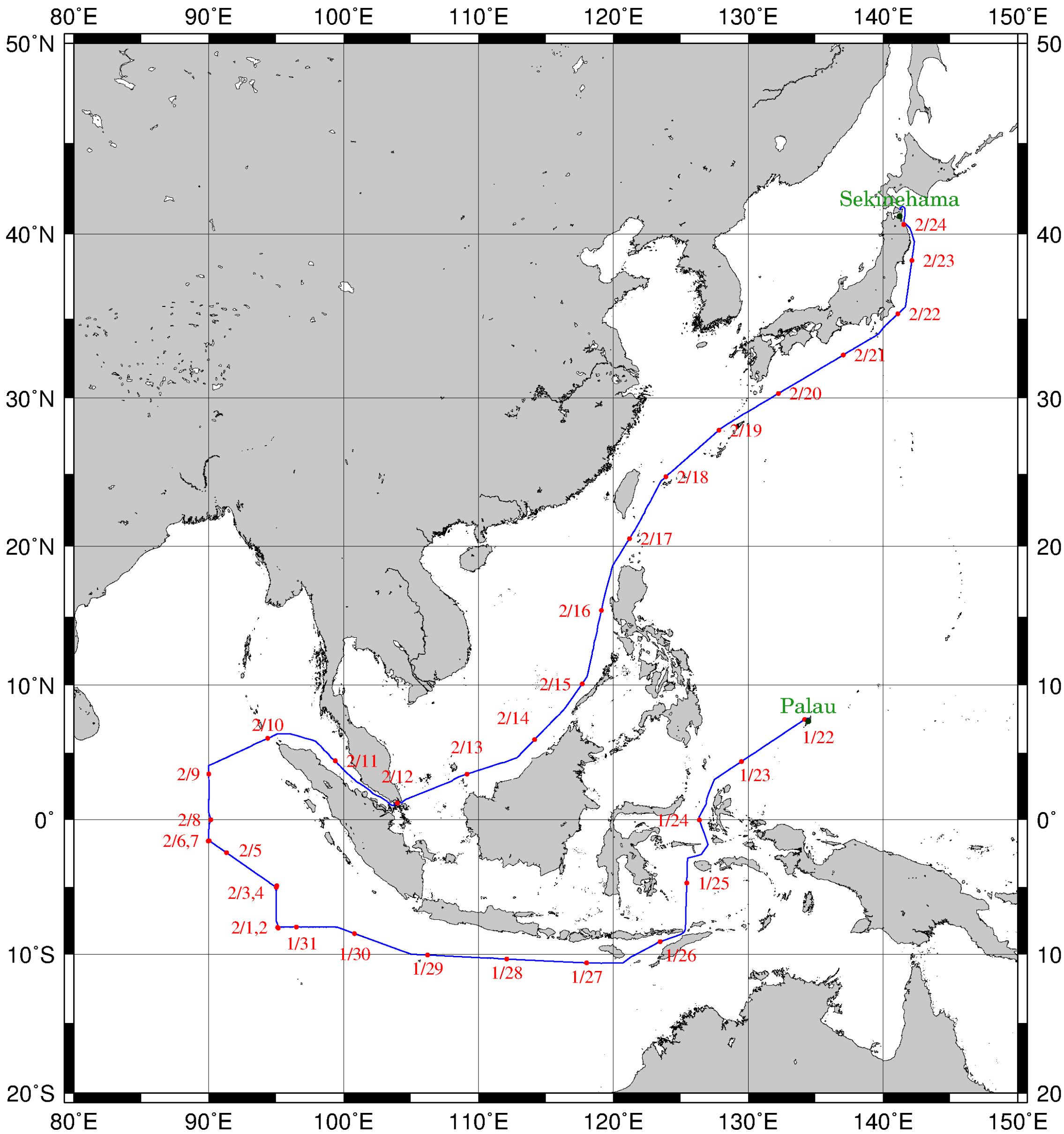


Fig 3-2. MR14-06 Leg 3 cruise track and noon positions from Palau to Sekinehama.

4. Research themes and science party

4. 1. Proposals of the main mission

Tropical Ocean Climate Study in the Indian and Pacific Ocean/
Study of structure and formation process of the Ontong Java Plateau/
Operation of TRITON buoy

4. 2. Principal investigators of the main mission

Kentaro Ando (Tropical Ocean Climate Study)
Group Leader,
Ocean-Atmosphere Interaction Research Group
Research Institute for Global Change,
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
2-15, Natsushima-cho, Yokosuka, Kanagawa 237-0061, JAPAN

Daisuke Suetsugu (Study of structure and formation process of the Ontong Java Plateau)
Director,
Department of Deep Earth Structure and Dynamics Research,
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,
Long-Term Observation Technology Gloup,
Marine Technology Development Department,
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
2-15, Natsushima-cho, Yokosuka, Kanagawa 237-0061, JAPAN

4. 3. Chief scientist

Leg 2

Dr. Kentaro Ando
Group Leader,
Ocean-Atmosphere Interaction Research Group
Research Institute for Global Change,
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
2-15, Natsushima-cho, Yokosuka, Kanagawa 237-0061, JAPAN

Leg 3

Dr. Iwao Ueki
Deputy Group Leader,
Ocean-Atmosphere Interaction Research Group
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 applied-missions and these principal investigators

(1) Temporal and spatial variations of marine carbon cycle related to the Indian Dipole (PI: Akihiko Murata, RCGC/JAMSTEC)
(2) Applied research of MIRAI brand-new shipboard weather radar: Validation and utilization of dual-polarization information for global deployment (PI: Masaki Katsumata, RCGC/JAMSTEC)
(3) Global distribution of drop size distribution of precipitating particles over pure-oceanic background (PI: Masaki Katsumata, RCGC/JAMSTEC)
(4) Aerosol optical characteristics measured by Ship-borne Sky radiometer (PI: Kazuma Aoki, University of Toyama)
(5) Standardisation of marine geophysical data and its application to geodynamics studies (PI: Takashi Matsumoto, University of the Ryukyus)
(6) Physiological and ecological studies on the relationship between the distribution and salinity & temperature hardiness, and environmental factors in the tropical oceanic sea skaters, *Halobates* (PI: Tetsuo Harada, Kochi University)
(7) Advanced continuous measurements of aerosols in the marine atmosphere: Elucidation of the roles in the Earth system (PI: Yugo Kanaya, RCGC/JAMSTEC)
(8) Shipboard CO_2 observations over the tropical Indo-Pacific Ocean for a simple estimation of the carbon flux between the ocean and the atmosphere from GOSAT data (PI: Shuji Kawakami, EORC/JAXA)

5. Participants list

5. 1. R/V Mirai scientists and technical staffs

Leg 2

Name	Affiliation	Occupation	Onboard section
Kentaro Ando	JAMSTEC	Chief Scientist	Chuuk - Koror
Yasuhisa Ishihara	JAMSTEC	Engineer	Chuuk - Koror
Biao Beng	JAMSTEC	Scientist	Chuuk-Koror
Kyoko Taniguchi	JAMSTEC	Scientist	Chuuk – Koror
Ichiro Matsui	NIES	Scientist	Chuuk - Koror
Tetsuo Harada	Kochi Univ.	Scientist	Chuuk – Koror
Noritomo Umamoto	Kochi Univ.	Scientist	Chuuk - Koror
Hiroko Sugioka	JAMSTEC	Scientist	Chuuk – Koror
Aki Ito (Kambe)	JAMSTEC	Scientist	Chuuk – Koror
Kiyoshi Baba	U. of Tokyo	Scientist	Chuuk - Koror
Shinya Okumura	GODI	Technical Staff	Chuuk – Koror
Kazuho Yoshida	GODI	Technical Staff	Chuuk - Koror
Yutaro Murakami	GODI	Technical Staff	Chuuk - Koror
Tomohide Noguchi	MWJ	Technical Staff	Chuuk - Koror
Kenichi Katayama	MWJ	Technical Staff	Chuuk - Koror
Takatoshi Kiyokawa	MWJ	Technical Staff	Chuuk - Koror
Akira Watanabe	MWJ	Technical Staff	Chuuk - Koror
Rei Ito	MWJ	Technical Staff	Chuuk - Koror
Sonoka Wakatsuki	MWJ	Technical Staff	Chuuk - Koror
Makito Yokota	MWJ	Technical Staff	Chuuk - Koror
Kai Fukuda	MWJ	Technical Staff	Chuuk - Koror
Emi Deguchi	MWJ	Technical Staff	Chuuk - Koror
Atsushi Ono	MWJ	Technical Staff	Chuuk - Koror
Tomomi Sono	MWJ	Technical Staff	Chuuk - Koror
Hideki Yamamoto	MWJ	Technical Staff	Chuuk - Koror
Keitaro Matsumoto	MWJ	Technical Staff	Chuuk - Koror
Haruka Tamada	MWJ	Technical Staff	Chuuk - Koror

Leg 3

Name	Affiliation	Occupation	Onboard section
Iwao Ueki	JAMSTEC	Chief Scientist	Koror – Sekinehama
Shoichiro Baba	JAMSTEC	Engineer	Koror-Sekinehama
Yukio Takahashi	JAMSTEC	Engineer	Koror – Sekinehama
Shinya Okumura	GODI	Technical Staff	Koror – Sekinehama
Miki Morioka	GODI	Technical Staff	Koror – Sekinehama
Tomohide Noguchi	MWJ	Technical Staff	Koror – Sekinehama
Tatsuya Tanaka	MWJ	Technical Staff	Koror – Sekinehama
Akira Watanabe	MWJ	Technical Staff	Koror – Sekinehama
Masaki Furuhata	MWJ	Technical Staff	Koror – Sekinehama
Masaki Yamada	MWJ	Technical Staff	Koror – Sekinehama
Shoko Tatamisashi	MWJ	Technical Staff	Koror – Sekinehama
Yoshiko Ishikawa	MWJ	Technical Staff	Koror – Sekinehama

Elena Hayashi	MWJ	Technical Staff	Koror – Sekinehama
Tomomi Sone	MWJ	Technical Staff	Koror – Sekinehama
Katsunori Sagishima	MWJ	Technical Staff	Koror – Sekinehama
Misato Kuwahara	MWJ	Technical Staff	Koror – Sekinehama
Masahiro Orui	MWJ	Technical Staff	Koror – Sekinehama

5. 2. R/V Mirai crew member

Leg 2

Name	Rank or rating
Kan Matsuura	Master
Haruhiko Inoue	Chief Officer
Takeshi Isohi	1st Officer
Toshihisa Akutagawa	Jr. 1st Officer
Hiroki Kobayashi	2nd Officer
Yukihiro Fukaya	3rd Officer
Shigeru Fujita	Chief engineer
Hiroyuki Tohken	1st Engineer
Jun Takahashi	2nd Engineer
Wataru Okuma	3rd engineer
Tomoaki Yanai	Jr. 3rd Engineer
Masanori Murakami	Technical Officer
Kazuyoshi Kudo	Boatswain
Tsuyoshi Sato	Able Seaman
Takeharu Aisaka	Able Seaman
Tsuyoshi Monzawa	Able Seaman
Masashige Okada	Able Seaman
Shuji Komata	Able Seaman
Kaito Murata	Able Seaman
Masaya Tanikawa	Able Seaman
Hideaki Tamotsu	Ordinary Seaman
Akiya Chishima	Ordinary Seaman
Tenki Yamashiro	Ordinary Seaman
Yoshihiro Sugimoto	No.1 Oiler
Toshiyuki Furuki	Oiler
Daisuke Taniguchi	Oiler
Keisuke Yoshida	Oiler
Shintaro Abe	Wiper
Kazuya Ando	Wiper
Ryotaro Baba	Chief Steward
Yukio Shige	Cook
Tamotsu Uemura	Cook
Yukio Chiba	Cook
Sakae Hoshikuma	Cook
Tsuneaki Yoshinaga	Cook
Takayoshi Deki	Cook

Leg 3

Name	Rank or rating
Kan Matsuura	Master
Haruhiko Inoue	Chief Officer
Nobuo Fukaura	2nd Officer
Hirokazu Sugawara	Jr. 2nd Officer
Akihiro Nunome	3rd Officer
Yoichi Furukawa	Chief engineer
Hiroyuki Tohken	1st Engineer
Wataru Okuma	2nd Engineer
Katsuyoshi Kodama	3rd engineer
Tomoaki Yanai	Jr. 3rd Engineer
Ryo Kimura	Technical Officer
Yosuke Kuwahara	Boatswain
Kazuyoshi Kudo	Able Seaman
Tsuyoshi Sato	Able Seaman
Tsuyoshi Minzawa	Able Seaman
Masashige Okada	Able Seaman
Masaya Tanikawa	Able Seaman
Hideyuki Okubo	Ordinary Seaman
Shohei Uehara	Ordinary Seaman
Tomohiro Shimada	Ordinary Seaman
Tetsuya Sakamoto	Ordinary Seaman
Tenki Yamashiro	Ordinary Seaman
Kazumi Yamashita	No.1 Oiler
Fumihito Kaizuka	Oiler
Toshiyuki Furuki	Oiler
Daisuke Taniguchi	Oiler
Kazuya Ando	Wiper
Hiromi Ikuta	Wiper
Hitoshi Ota	Chief Steward
Yukio Shige	Cook
Ryotaro Baba	Cook
Yukio Chiba	Cook
Shigenori Yamaguchi	Cook

6. Mission Observations

6. 1. TRITON and m-TRITON buoy

6. 1. 1. TRITON operation

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal Investigator
Yasuhisa Ishihara	(JAMSTEC) Principal Investigator
Akira Watanabe	(MWJ) Operation Leader
Tomohide Noguchi	(MWJ) Technical Staff
Kenichi Katayama	(MWJ) Technical Staff
Rei Ito	(MWJ): Technical Staff
Sonoka Wakatsuki	(MWJ): Technical Staff
Makito Yokota	(MWJ): Technical Staff
Kai Fukuda	(MWJ): Technical Staff
Takatoshi Kiyokawa	(MWJ): Technical Staff
Emi Deguchi	(MWJ): Technical Staff
Atsushi Ono	(MWJ): Technical Staff
Tomomi Sone	(MWJ): Technical Staff
Hideki Yamamoto	(MWJ): Technical Staff
Haruka Tamada	(MWJ): Technical Staff

(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 have 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 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).

Nine TRITON buoys have been recovered and eight TRITON buoys have been deployed during this R/V MIRAI cruise (MR14-06 Leg2).

(3) Measured parameters

The TRITON buoy observes oceanic parameters and meteorological parameters as follow:

Meteorological parameters : wind speed, direction,
atmospheric pressure,
air temperature, relative humidity,
shortwave radiation,
precipitation.

Oceanic parameters : water temperature and conductivity at 1.5m,
25m, 50m, 75m, 100m, 125m, 150m, 200m,
300m, 500m, 750m,
pressure at 300m and 750m,
currents at 10m.

(4) Instrument

Details of the instruments used on the TRITON buoy are summarized as follow:

Oceanic sensors

1) CTD and CT

SBE-37 IM MicroCAT

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) CRN(Current meter)

SonTek Argonaut ADCM

Sensor frequency : 1500kHz

Sampling interval : 1200sec

Average interval : 120sec

Meteorological sensors

1) Precipitation

R.M.YOUNG COMPANY MODEL50202/50203

Sampling interval : 600sec

2) Atmospheric pressure

PAROPSCIENTIFIC.Inc. DIGIQUARTZ FLOATING BAROMETER 6000SERIES

Sampling interval : 600sec

3) Relative humidity/air temperature, Shortwave radiation, Wind speed/direction

Woods Hole Institution ASIMET

Sampling interval : 600sec

(5) Locations of TRITON buoys deployment

Nominal location :	2N, 156E
ID number at JAMSTEC :	03017
Number on surface float :	T05
ARGOS PTT number :	29638
ARGOS backup PTT number :	27409
Deployed date :	30 Dec. 2014
Exact location :	02°02.33N, 156°01.22E
Depth :	2,573 m

Nominal location :	EQ, 156E
ID number at JAMSTEC :	04017
Number on surface float :	T09
ARGOS PTT number :	29641
ARGOS backup PTT number :	27410
Deployed date :	28 Dec. 2014
Exact location :	00°01.05N, 156°02.53E
Depth :	1,953 m

Nominal location : 2S, 156E

ID number at JAMSTEC : 05015
Number on surface float : T11
ARGOS PTT number : 27958
ARGOS backup PTT number : 29696
Deployed date : 26 Dec. 2014
Exact location : 02°01.03S, 155°57.47E
Depth : 1,751 m

Nominal location : 2N, 147E
ID number at JAMSTEC : 08014
Number on surface float : T16
ARGOS PTT number : 28149
ARGOS backup PTT number : 29698
Deployed date : 06 Jan. 2015
Exact location : 02°04.58N, 146°56.98E
Depth : 4,492 m

Nominal location : EQ, 147E
ID number at JAMSTEC : 09015
Number on surface float : T24
ARGOS PTT number : 29855
ARGOS backup PTT number : 29708
Deployed date : 08 Jan. 2015
Exact location : 00°03.58N, 147°00.65E
Depth : 4,474 m

Nominal location : 8N, 137E
ID number at JAMSTEC : 10012
Number on surface float : T25
ARGOS PTT number : 29636
ARGOS backup PTT number : 29710
Deployed date : 17 Jan. 2015
Exact location : 07°39.10N, 136°41.96E
Depth : 3,168 m

Nominal location : 5N, 137E
ID number at JAMSTEC : 11012
Number on surface float : T27
ARGOS PTT number : 29759
ARGOS backup PTT number : 29738
Deployed date : 13 Jan. 2015
Exact location : 04°51.91N, 137°16.22E
Depth : 4,107 m

Nominal location : 2N, 138E
ID number at JAMSTEC : 12014
Number on surface float : T28
ARGOS PTT number : 27275
ARGOS backup PTT number : 24715
Deployed date : 12 Jan. 2015
Exact location : 02°04.05N, 138°03.88E
Depth : 4,333 m

(6) Locations of TRITON buoys recovered

Nominal location :	5N, 156E
ID number at JAMSTEC :	02015
Number on surface float :	T01
ARGOS PTT number :	27388
ARGOS backup PTT number :	24234
Deployed date :	10 Mar. 2014
Recovered date :	02 Jan. 2015
Exact location :	04°58.45N, 156°02.04E
Depth :	3,600 m

Nominal location :	2N, 156E
ID number at JAMSTEC :	03016
Number on surface float :	T04
ARGOS PTT number :	27399
ARGOS backup PTT number :	24244
Deployed date :	08 Mar. 2014
Recovered date :	31 Dec. 2014
Exact location :	01°57.19N, 155°59.97E
Depth :	2,563 m

Nominal location :	EQ, 156E
ID number at JAMSTEC :	04016
Number on surface float :	T21
ARGOS PTT number :	27400
ARGOS backup PTT number :	24246, 24238
Deployed date :	03 Mar. 2014
Recovered date :	29 Dec. 2014
Exact location :	00°01.00S, 155°57.80E
Depth :	1,939 m

Nominal location :	2S, 156E
ID number at JAMSTEC :	05014
Number on surface float :	T15
ARGOS PTT number :	29765
ARGOS backup PTT number :	24239
Deployed date :	01 Mar. 2014
Recovered date :	27 Dec. 2014
Exact location :	01°59.00S, 156°01.99E
Depth :	1,757 m

Nominal location :	5S, 156E
ID number at JAMSTEC :	06014
Number on surface float :	T20
ARGOS PTT number :	30787
ARGOS backup PTT number :	24241
Deployed date :	27 Feb. 2014
Recovered date :	25 Dec. 2014
Exact location :	04°57.99S, 156°01.00E
Depth :	1,509 m

Nominal location : 2N, 147E
ID number at JAMSTEC : 08013
Number on surface float : T23
ARGOS PTT number : 29639
ARGOS backup PTT number : 24242
Deployed date : 21 Feb. 2014
Recovered date : 07 Jan. 2015
Exact location : 01°59.50N, 147°01.17E
Depth : 4,517 m

Nominal location : EQ, 147E
ID number at JAMSTEC : 09014
Number on surface float : T26
ARGOS PTT number : 27394
ARGOS backup PTT number : 24243
Deployed date : 22 Feb. 2014
Recovered date : 09 Jan. 2015
Exact location : 00°01.49S, 147°00.09E
Depth : 4,553 m

Nominal location : 8N, 137E
ID number at JAMSTEC : 10011
Number on surface float : T06
ARGOS PTT number : 27961
ARGOS backup PTT number : 27411
Deployed date : 09 Mar. 2013
Recovered date : 16 Jan. 2015
Exact location : 07°38.96N, 136°41.95E
Depth : 3,171 m

Nominal location : 5N, 137E
ID number at JAMSTEC : 11011
Number on surface float : T07
ARGOS PTT number : 27401
ARGOS backup PTT number : 29692
Deployed date : 07 Mar. 2013
Exact location : 04°56.43N, 137°18.10E
Depth : 4,131 m

*This buoy was missing. See 6.1.4 Search and recovery of 5N137E buoy.

Nominal location : 2N, 138E
ID number at JAMSTEC : 12013
Number on surface float : T14
ARGOS PTT number : 27389
ARGOS backup PTT number : 29694
Deployed date : 05 Mar. 2013
Recovered date : 11 Jan. 2015
Exact location : 02°03.93N, 138°03.83E
Depth : 4,322 m

*Dates are UTC and represent anchor drop times for deployments and release time for recoveries, respectively.

(7) Details of deployed

We had deployed eight TRITON buoys, described them details in the list. Deployment TRITON buoys

Observation No.	Location	Details
03017	2N156E	Deploy with full spec and 1 optional unit. SBE37 (CT) :175m
04017	EQ156E	Deploy with full spec and 1 optional unit. SBE37 (CT) :175m
05015	2S156E	Deploy with full spec.
08014	2N147E	Deploy with full spec and 1 optional unit. SBE37 (CT) :175m
09015	EQ147E	Deploy with full spec and 1 optional unit. SBE37 (CT) :175m
10012	8N137E	Deploy with full spec.
11012	5N137E	Deploy with full spec and 1 optional unit. SBE37 (CT) :175m
12014	2N138E	Deploy with full spec and 1 optional unit. SBE37 (CT) :175m

(8) Data archive

Hourly averaged data are transmitted through ARGOS satellite data transmission system in almost real time. The real time data are provided to meteorological organizations via Global Telecommunication System and utilized for daily weather forecast. The data will be also distributed world wide through Internet from JAMSTEC and PMEL home pages. All data will be archived at JAMSTEC Mutsu Institute.

TRITON Homepage : http://www.jamstec.go.jp/jamstec/TRITON/real_time/top.html

6. 1. 2. m-TRITON operation

(1) Personnel

Iwao Ueki	(JAMSTEC) Principal Investigator
Shoichiro Baba	(JAMSTEC) Principal Investigator
Akira Watanabe	(MWJ) Operation Leader
Tomohide Noguchi	(MWJ) Technical Staff
Tatsuya Tanaka	(MWJ) Technical Staff
Masaki Furuhata	(MWJ) Technical Staff
Masaki Yamada	(MWJ) Technical Staff
Shoko Tatamisashi	(MWJ) Technical Staff
Yoshiko Ishikawa	(MWJ) Technical Staff
Elena Hayashi	(MWJ) Technical Staff
Tomomi Sone	(MWJ) Technical Staff
Katsunori Sagishima	(MWJ) Technical Staff
Misato Kuwahara	(MWJ) Technical Staff
Masahiro Orui	(MWJ) Technical Staff

(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 recovered and three m-TRITON buoys deployed during this cruise (MR14-06 Leg3).

(3) Measured parameters

The 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.

(4) Instrument

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

Oceanic sensors

1) CTD (Conductivity-Temperature-Depth, 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 : 1800sec
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.

(5) Locations of m-TRITON buoys deployment

Nominal location : 5S95E
ID number at JAMSTEC : 17507

ARGOS PTT number :	171E68B(60600)
ARGOS backup PTT number :	29791
Deployed date :	03 Feb. 2015
Exact location :	04°57.05S, 94°58.44E
Depth :	5,009 m

Nominal location :	1.5S90E
ID number at JAMSTEC :	18508
ARGOS PTT number :	CFD07AD(139322)
ARGOS backup PTT number :	30830
Deployed date :	07 Feb. 2015
Exact location :	01°37.06S 89°59.02E
Depth :	4,694 m

Nominal location :	8S95E
ID number at JAMSTEC :	19505
ARGOS PTT number :	16C34C7(60588)
ARGOS backup PTT number :	27406
Deployed date :	01 Feb. 2015
Exact location :	08°00.03S, 95°02.41E
Depth :	5,209 m

(6) Locations of m-TRITON buoys recovered

Nominal location :	5S, 95E
ID number at JAMSTEC :	17506
ARGOS PTT number :	29EB779(45735)
ARGOS backup PTT number :	30829
Deployed date :	30 Jan. 2014
Recovered date :	04 Feb. 2015
Exact location :	05°02.12S, 94°58.61E
Depth :	5,012 m

Nominal location :	1.5S, 90E
ID number at JAMSTEC :	18507
ARGOS PTT number :	9EB84D4(96109)
ARGOS backup PTT number :	24742
Deployed date :	27 Jan. 2014
Recovered date :	06 Feb. 2015
Exact location :	01°36.41S, 90°04.85E
Depth :	4,715 m

*Topbuoy drifted from deployment position at 16 Jul 2014. Topbuoy and all sensors had been recovered at 03 Nov 2014. Under the snaped point was recovered in this cruise.

Nominal location :	8S, 95E
ID number at JAMSTEC :	19504
ARGOS PTT number :	29EB75F(45733)
ARGOS backup PTT number :	13066
Deployed date :	01 Feb. 2014
Recovered date :	02 Feb. 2015
Exact location :	08°03.97S, 95°07.43E
Depth :	5,261 m

*Dates are UTC and represent anchor drop times for deployments and release time for recoveries, respectively.

(7) Details of deployed

We had deployed three m-TRITON buoys, described them details in the list. Deployment m-TRITON buoys

Observation No.	Location	Details
17507	5S95E	Deploy with full spec.
18508	1.5S90E	Deploy with full spec and 1 optional unit. Security camera :with top buoy
19505	8S95E	Deploy with full spec and 1 optional unit. Security camera :with top buoy

(8) 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 at the JAMSTEC Yokosuka Headquarters. And the data will be distributed world wide through internet from the JAMSTEC web site (http://www.jamstec.go.jp/).

6. 1. 3. JES10 Profiler operation

(1) Personnel

Yukio Takahashi	(JAMSTEC) Engineer	- Not Onboad-
Kensuke Watari	(JAMSTEC) Engineer	- Not Onboad-

(2) Objective

JES10 Profiler is JAMSTEC original CTD sensor for the profiling float. This operation was conducted to evaluate the characteristics of the JES10 Profiler. The CTD castings were carried out to compare the SBE 9Plus and JES10 Profiler.

(3) CTD Casting

Figure 6.1.3-1 is the JES10 Profiler CTD sensor. Figure 6.1.3-2 is the CTD frame with JES10profiler. Table 6.1.3-1 is casting specification.

Fig6.1.3-1 JES10 profiler CTD sensor

Fig 6.1.3-2 CTD frame with JES10

Table 6.1.3-1 List of CTD casting for JES10 Profiler

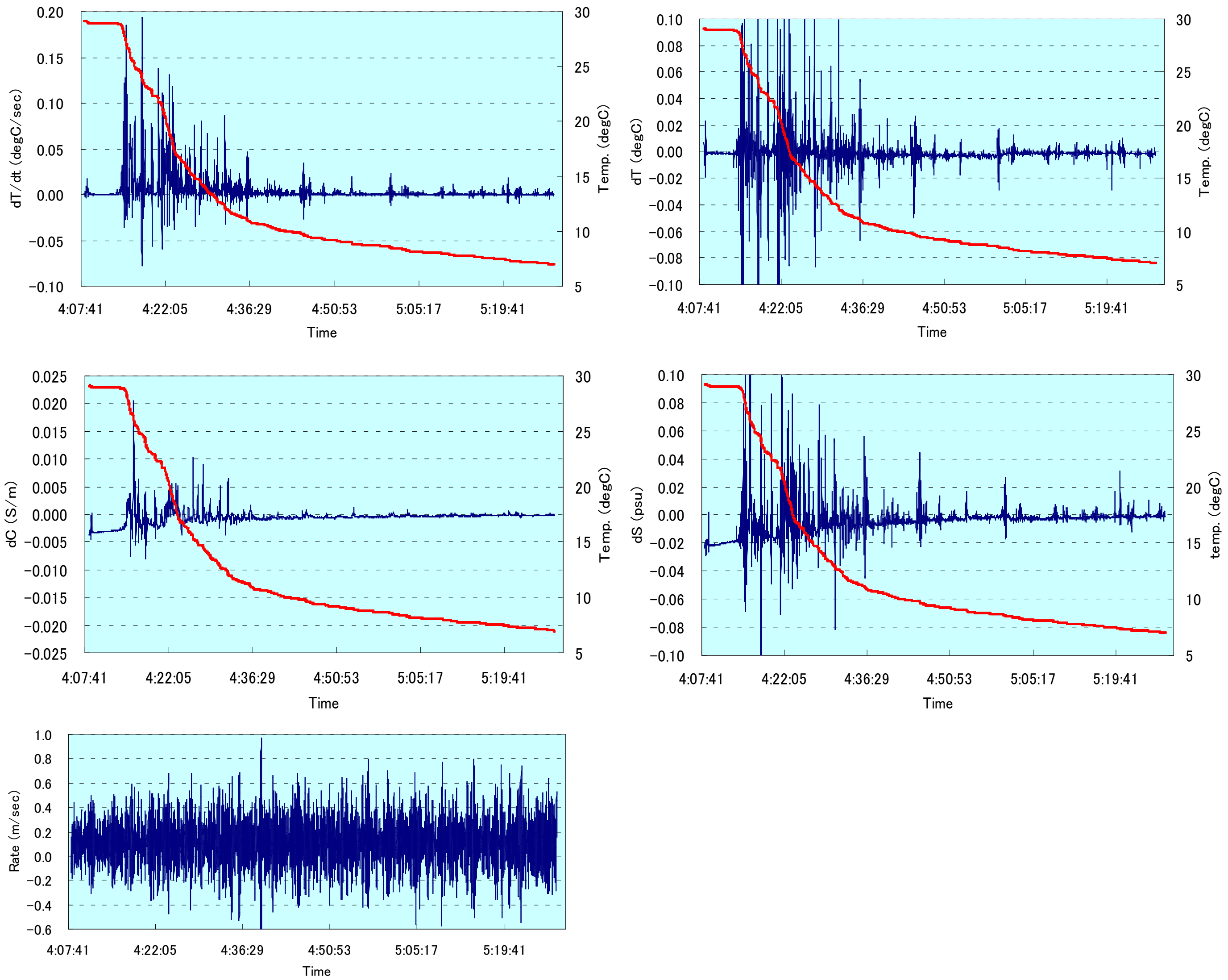
CTD casting	Position	Date	Rate (m/sec)	Max. Depth	Stop Depth(m) (for 5 min.)	JES10-Pro
Leg2-1	5S156E	Dec. 25 2014	Descent: 1.0 Ascent: 1.2	1000m	-	No pump
Leg2-2	2S156E	Dec. 26 2014	Descent: 1.0 Ascent: 1.2	1000m	-	No pump
Leg2-3	1S156E	Dec. 27 2014	Descent: 0.2 Ascent: 1.2 (0.1m/sec at depth of 100m to 150m)	1000m	1000, 750, 500, 300, 100 at ascent	No pump
Leg2-4	EQ156E	Dec. 28 2014	Descent: 1.0 Ascent: 1.2	1000m	-	with pump + TC duct
Leg2-5	5N137E	Jan. 14 2015	Descent: 0.1/0.2 Ascent: 1.2	550m	-	No pump
Leg2-6	7N136E	Jan. 17 2015	Descent: 0.1/0.2 (sea level to 550m) Ascent: 1.2	1000m	1000, 750, 500, 300, 100 at ascent	with pump + TC duct
Leg3-7	1.5S90E	Feb. 6 2015	Descent: 0.1 (sea level to 550m) Ascent: 1.2	1000m	1000, 750, 500, 300, 100 at ascent	with funnel

(4) Test results

JES10 profiler is the goal of following performance.

- The accuracy of profiling data of temperature and salinity: 0.005K and 0.01psu
- The vertical change of temperature: 0.05K/sec
- The time response of temperature and conductivity: 0.6 sec

Fig 6.1.3-1 is observation result in descent rate 0.1m/sec at 7N136E.The Jes10 Profiler with TC Duct which ensures that Temperature and Conductivity measurements are made on the same parcel of water, and Pump which ensures constant conductivity time response. Differences of temperature (dT), conductivity (dC) and salinity (dS) from the reference sensor, temperature change (dT/dt), Descent rate. These measurement results show spikes of salinity by TC Misalignment. From now on, it is scheduled to go to reduce the spikes of salinity by adjusting the conditions of the pump and sensor.



6. 1. 4. Search and bottom survey of 5N137E (Obs. No. 11011)buoy

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal Investigator
Yasuhisa Ishihara	(JAMSTEC) Principal Investigator

(2) Objectives

Observation number of 11011 TRITON buoy had deployed in 7 March 2013 at 5N137E. After fourteen month, in 13 May 2014, the buoy has suddenly started drift to the northeast and next day satellite transmission has completely stopped. According to the drifting track by Argos satellite, the buoy has shifted to the deeper area than original position.(Fig6-1.4-1) There was a possibility that the buoy had already been sunken. In this cruise, we tried to search and survey the mooring.

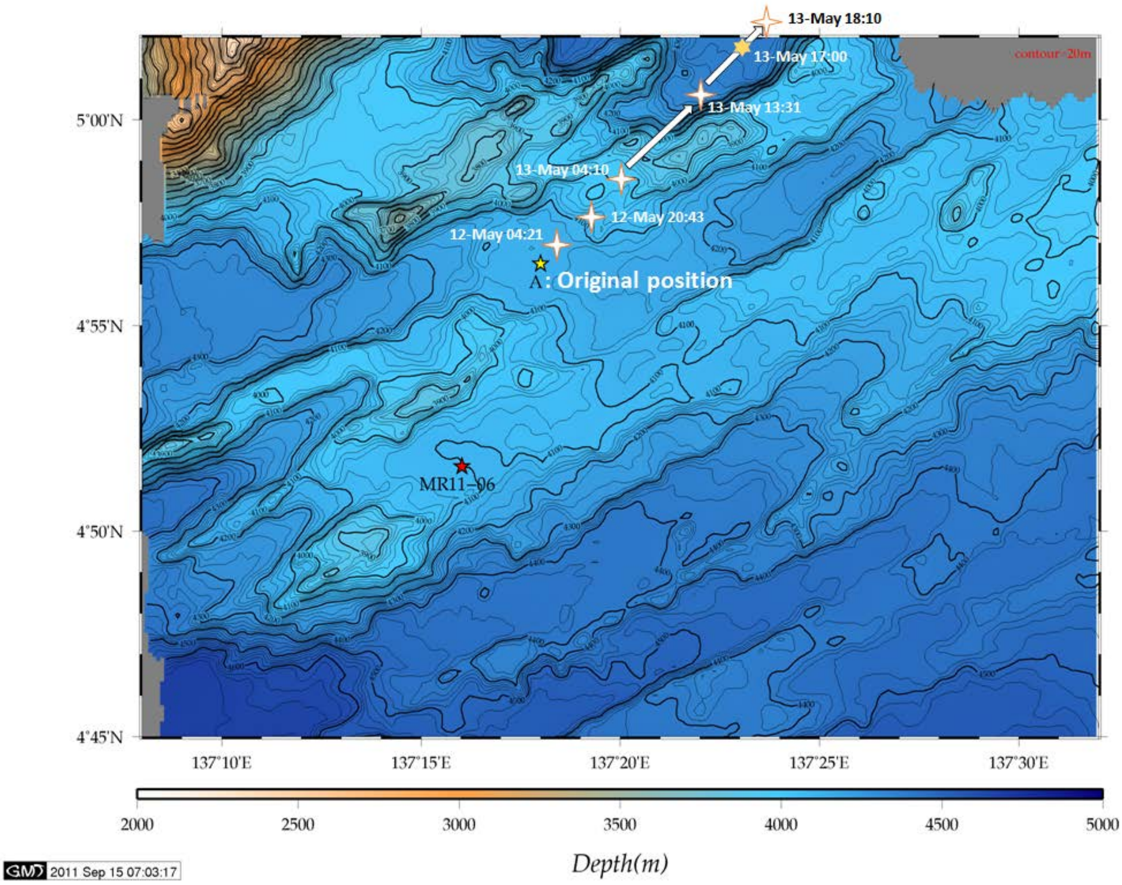


Fig6-1.4-1 Buoy drifting track and sea bottom map

(3) Mooring structure of No.11011 buoy

Fig6-1.4-2 shows mooring structure of the No.11011 buoy for rated depth of 4,130m. If this mooring system is shifted to the deep area, the system can't float. Because according to the result of calculation, total weight-in-water of this mooring (including the 4t anchor) is minus (–) 81kg .

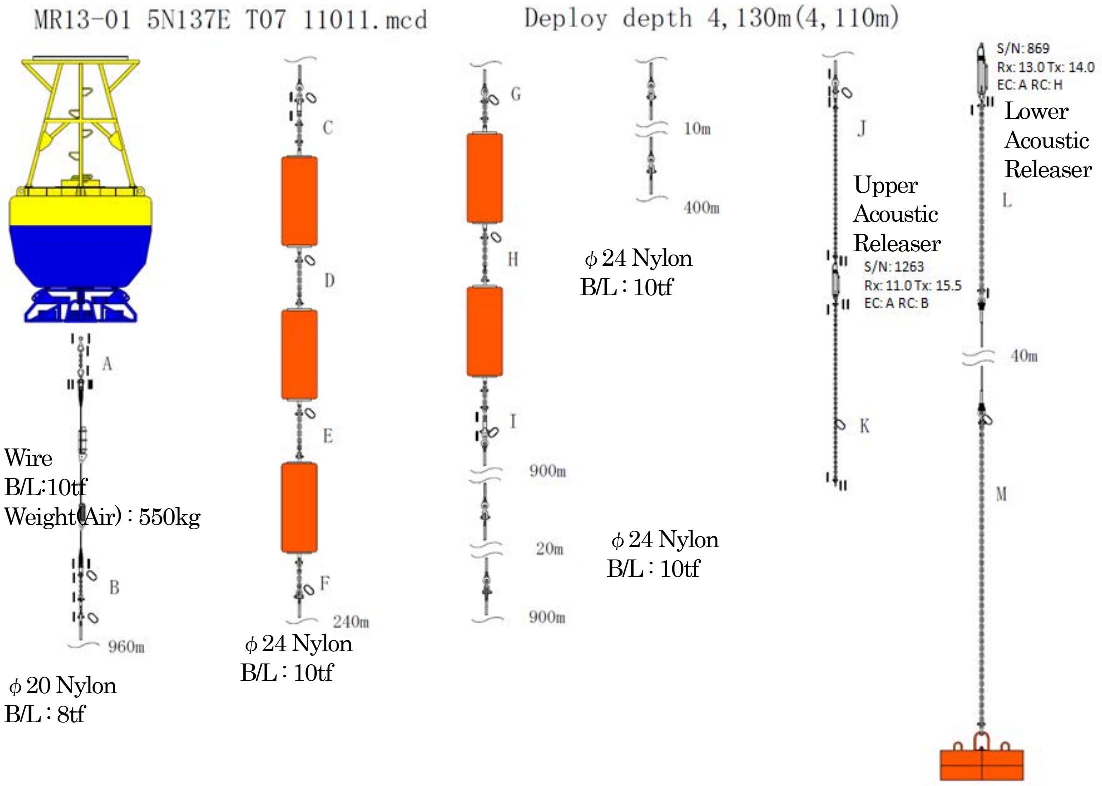


Fig6-1.4-2 Buoy drifting track and sea bottom map

(4) Instrumentation for search and bottom survey

Search the buoy

It was difficult to search the buoy visually, in this case, Acoustic Navigation System (ANS) was useful for search the bottom part of mooring line which is installed two sets of acoustic releasers (refer to the Table6-1.4-1&-2).

Table 6-4.1 -1 R/V "MIRAI" ANS specificaion

Item	Specification
Positioning	SSBL / LBL
Range of frequency	Tr : 5kHz – 16.5kHz Re : 10kHz – 16.5kHz
Max. range of slant	> 8000 m
Max number of target	4

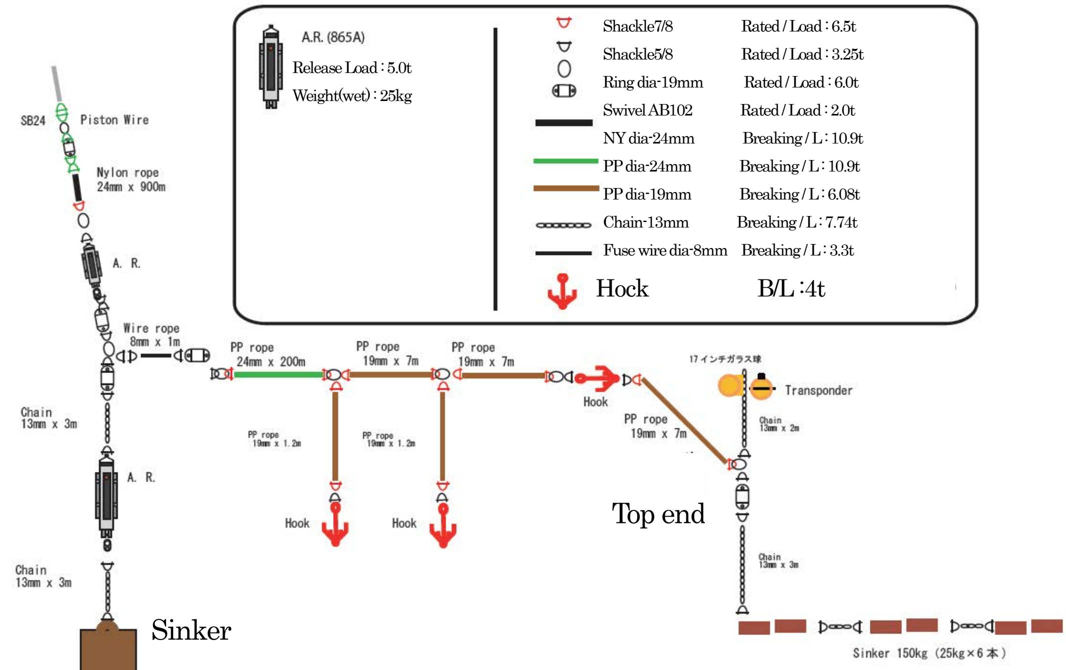
Table 6-4.1 -2 No.11011 buoy Acoustic releaser information

	Serial No	Receive	TrSSBLmit	Enable code	Release Code
Upper A/R	1263	11.0	15.5	A	B
Lower A/R	869	13.0	14.0	A	H

Bottom survey and Refloatation of a sunken buoy

Fig 6-4.1 -3 shows special gear for bottom survey and reflotaion of the buoy.

Fig 6-4.1 -3 Gear for



bottom 部 survey and reflotaion of the buoy

(2) Preliminary Results

Pre-inspection of ANS max. range of slant

We tried pre-inspection of ANS max. range of slant at the Eq-147E site. The depth of this site is 4,470m which is almost same depth as 5N137E target site. We used acoustic releasers those are installed in the Eq-147E buoy, before recovery. We have started to approach 5nm before the Eq-147E buoy. 4.8nm before we could contact both acoustic releasers.

ANS max. range of slant : 9950m (=√[4470^2 + [4.8*1852^2]])

Search the No.11011 buoy

According to the result of pre-inspection, Fig6-1.4-4 shows 3 way points(①―③) to search for 11011 buoy. Doted circle shows max. range of slant at each way point.

Date: 13-Jan.-2015
Sea condition was as below
Current : 60-deg at 2.5 kt
Wind : 14-28-deg at 3.6-5.2 m/s
Wave height : 3.5m
Maneuvering mode : Electric driven mode at FPP
5:15z Began to approach W.P ①
5:33z After transmit the enable code to both A/R (refer to Table 6-4.1 -2), we received the responses from the both .
6:06z Began to approach W.P. ②
6:22z according to the ANS calculation ,we canceled the W.P. ② then direct approach to the 5-02.4127N,137-23.846E
6:53z We found the both A/R at the 5-02.3817N,137-23.9003E.

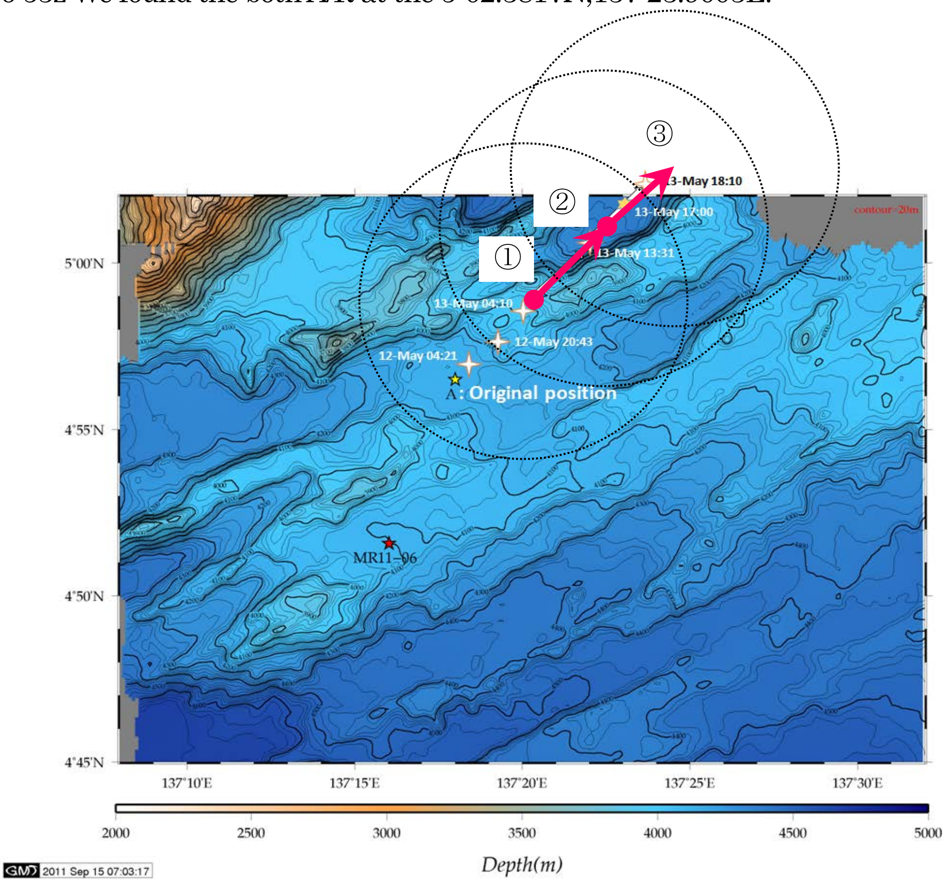


Fig6-1.4-4 3 way points(①―③) to search for 11011 buoy

Bottom survey and Refloatation of a sunken buoy

1) 13&14-Jan.-2015(First trial)

Sea condition was as below
Current : 95-deg at 2.4 kt
Wind : WNW at 3.4～5.4m/s
Wave height : 3m
Maneuvering mode : Diesel driven mode at CPP
Operation position : 2,500m upstream side from the both A/R for safety.
21:03z Enable command to both A/R and Re-position calibration again.
21:37z Release command to upper A/R , but both A/R were still fixed around the sea floor. It was difficult to decide if mooring system was sunken or midwater condition at this position. We tried to shift the position within 500m area from the target position.
22:41z We tried re-calibration at the closer area and we decided that mooring system was sunken. We canceled the normal recovery operation.
00:00z We started the bottom survey operation(Fig 6-1.4-5).

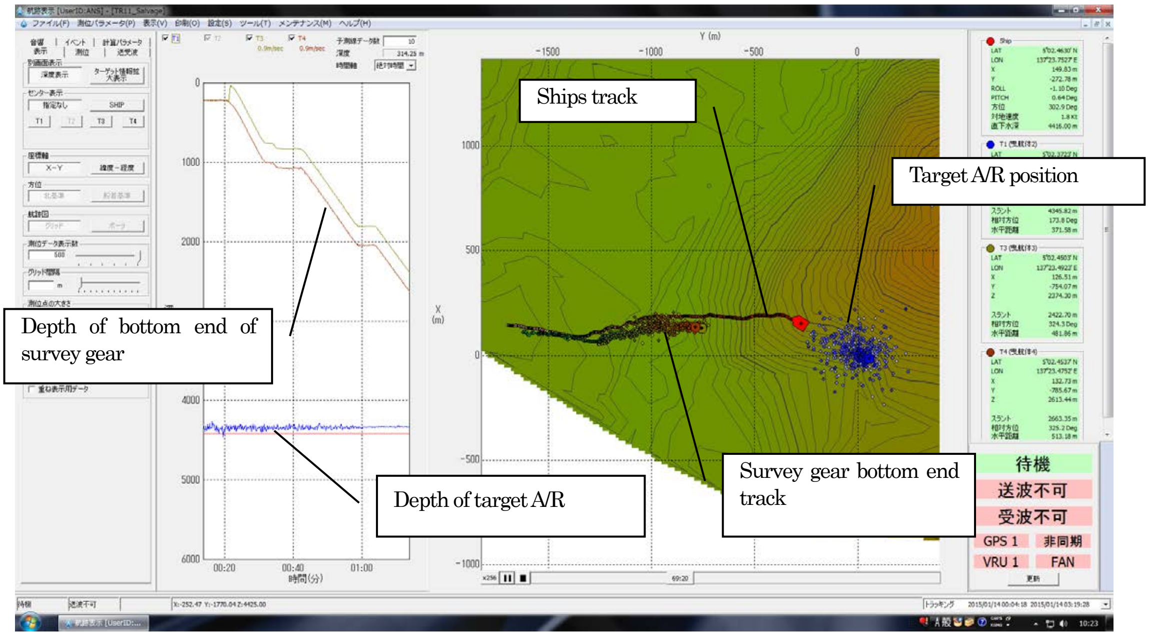


Fig6-1.4-5 Ship and bottom survey gear end track before touch down

02:07z Bottom survey gear was touched down to the sea floor at line tension 31kN.
02:16z We had started the towing of the bottom survey gear toward to the target position at line tension 33kN. (Fig 6-1.4-6)

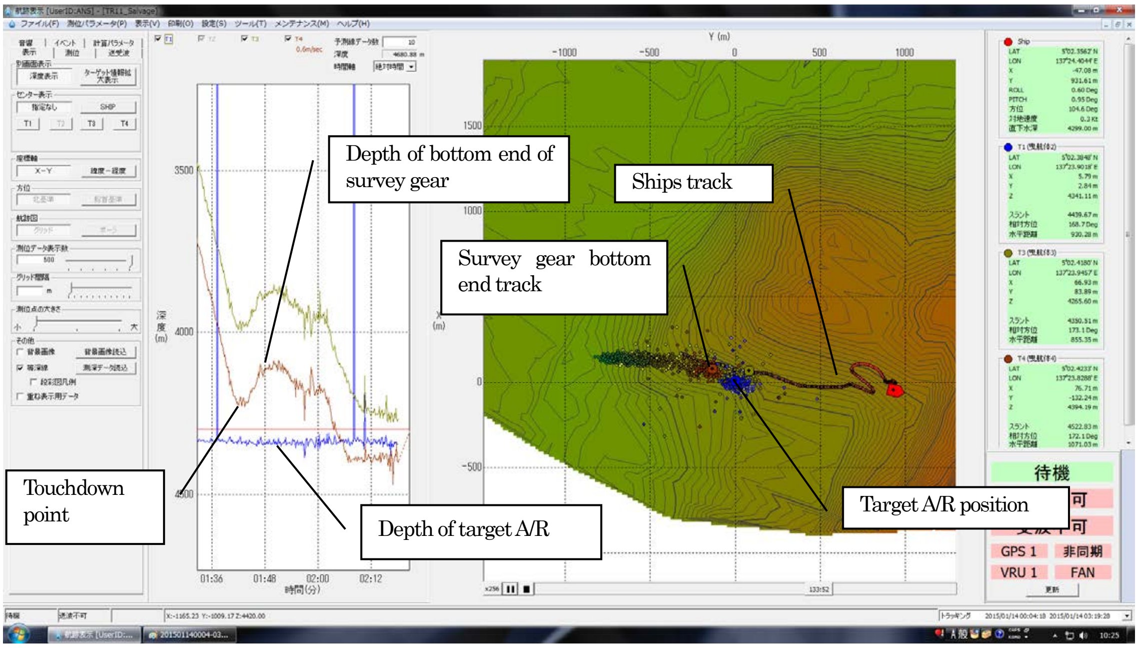


Fig6-1.4-6 Ship and bottom survey gear end track after touch down

02:48z We started the winding of the bottom survey gear at line tension 35kN. (Fig 6-1.4-7)
03:30z The current was too strong to be turning round with bottom survey gear, we decided to cancel the survey.
5:10z The bottom survey gear on deck.

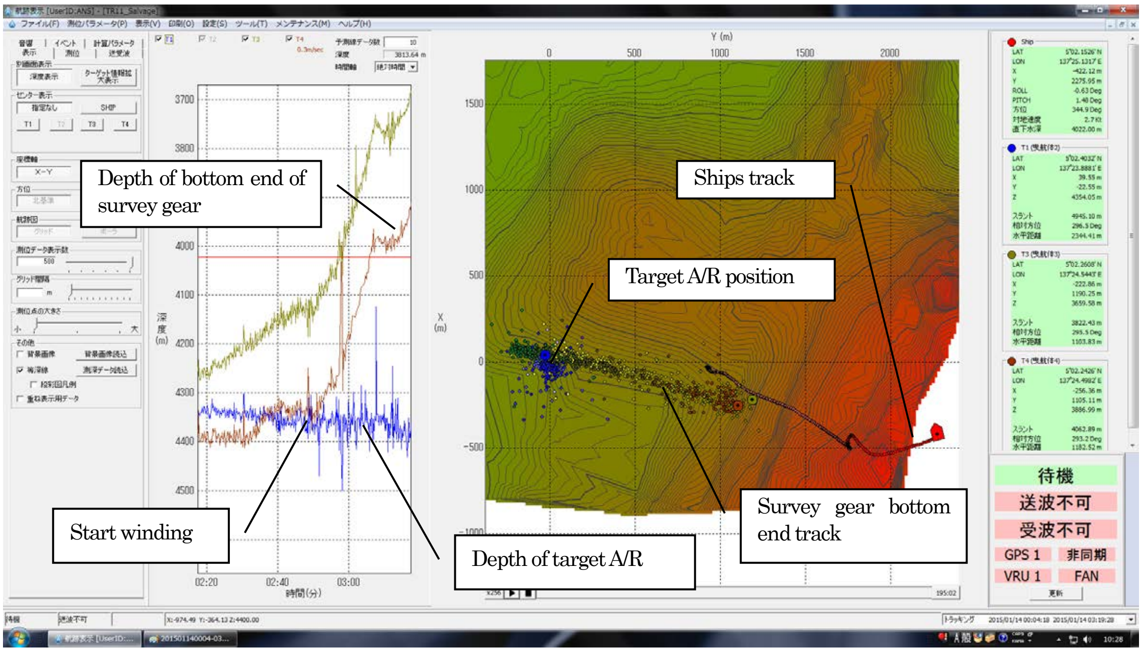


Fig6-1.4-7 Ship and bottom survey gear end track

2) 14&15-Jan.-2015(Second trial)
Sea condition was as below
Current : 98-deg at 1.8 kt
Wind : 270-deg at 5 m/s
Wave height : 2.5m
Maneuvering mode : Diesel driven mode at CPP

21:03z We started the bottom survey operation.
22:40z Bottom survey gear was touched down to the sea floor. We had started the towing of the bottom survey gear toward to the target position at line tension 32kN.
23:45z Line tension raised up to the 47kN, we started the winding.
23:48-53z Line tension was raised up to the 54kN then released to the 33kN. (Fig 6-1.4-8)

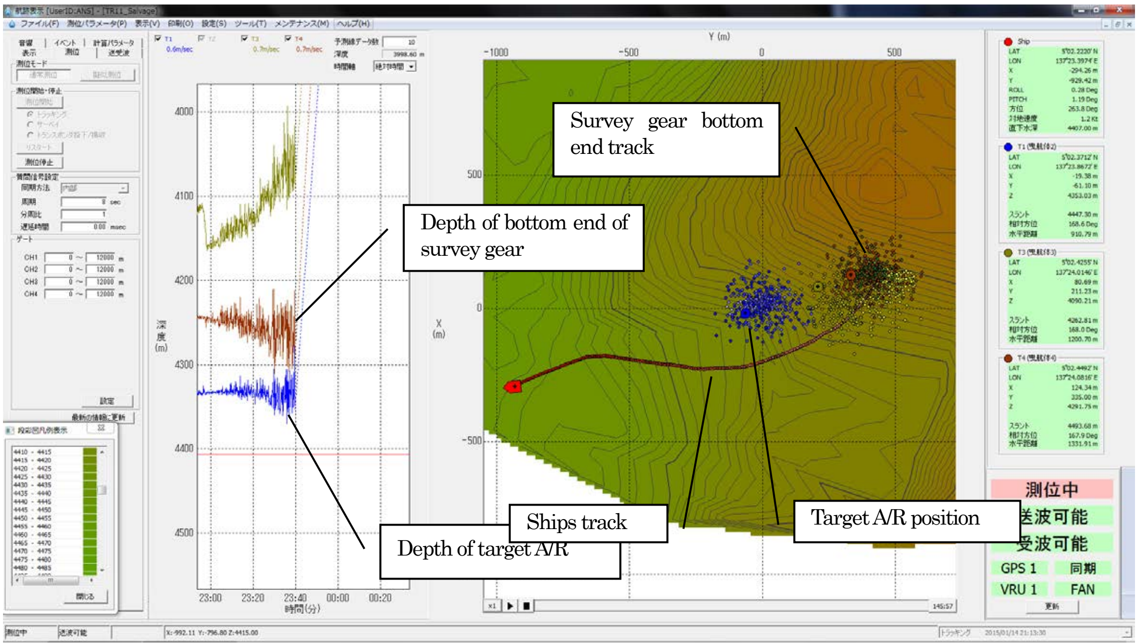


Fig6-1.4-8 Ship and bottom survey gear end track when line tension raised up

00:23z Bottom survey gear passed throw the target A/R position, started the winding.
00:33-42z Vessel was turning round. (Fig 6-1.4-9)

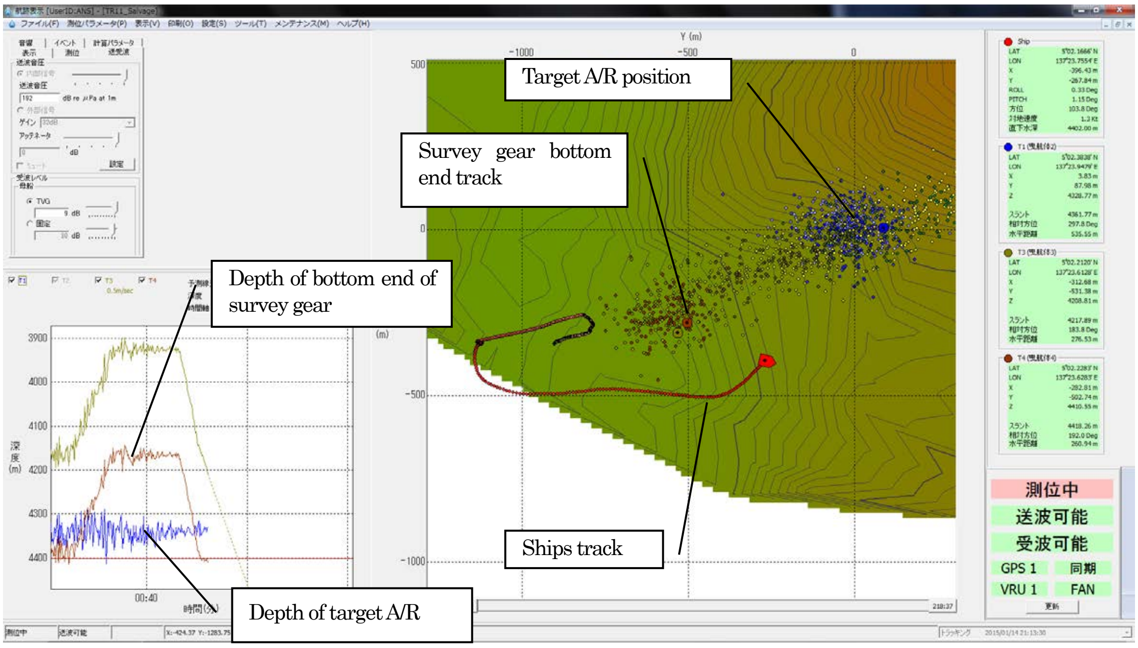


Fig6-1.4-9 Ship and bottom survey gear end track when turning round

00:45z We started to re-winding again.
00:52z Bottom survey gear was touched down to the sea floor again at line tension 31kN.
02:50z Line tension raised up to the 36kN by 1 minute.
03:08z We decided to cancel the survey. (Fig6-1.4-10)
05:11z The bottom survey gear on deck

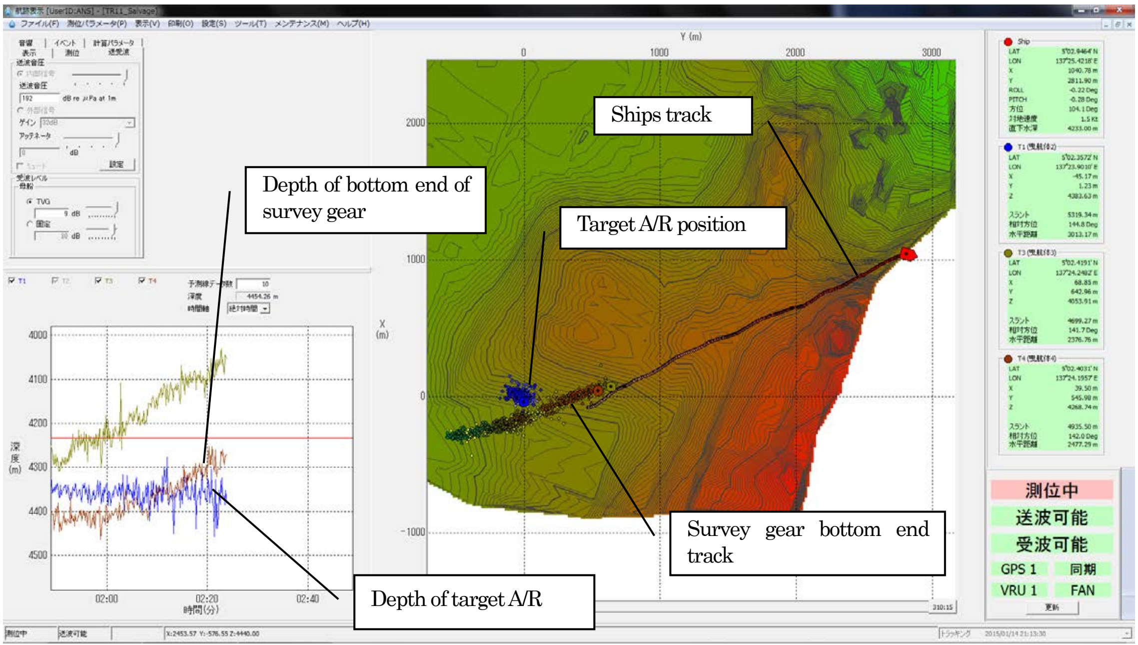
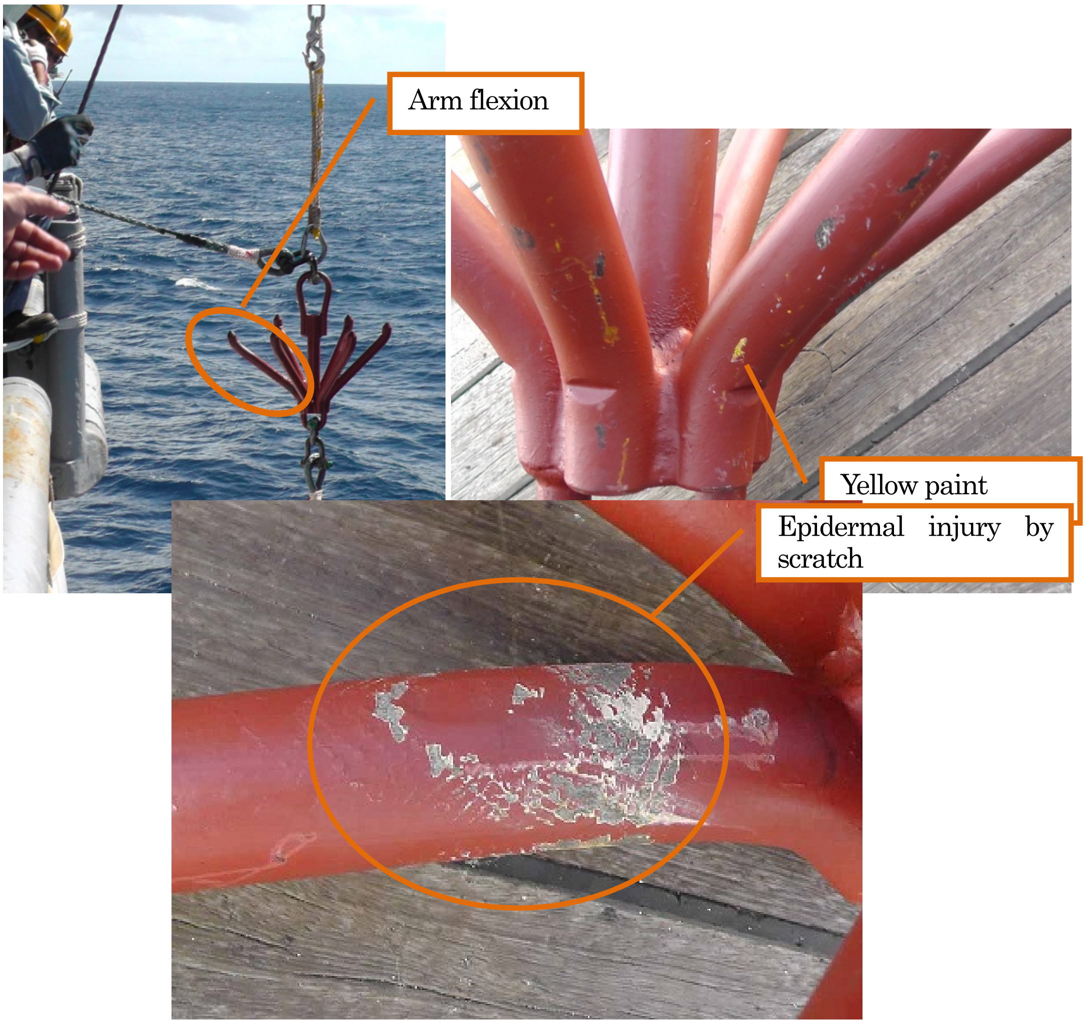


Fig6-1.4-10 Ship and bottom survey gear end track

We could not hung the No.11011 buoy, but after the survey gear on deck, Arm flexion, yellow paint stuck and epidermal injury are found. They seemed that arm flexion was caused by strong line tension and epidermal injury was scratched by some fiber rope. We could not decide weather yellow paint was scratched by sunken TRITON float or bottom survey gear end(Fig6-1.4-11).



Sub Bottom profiling

We tried sub bottom profiling for reference of sea floor condition(Fig6-1.4-12).

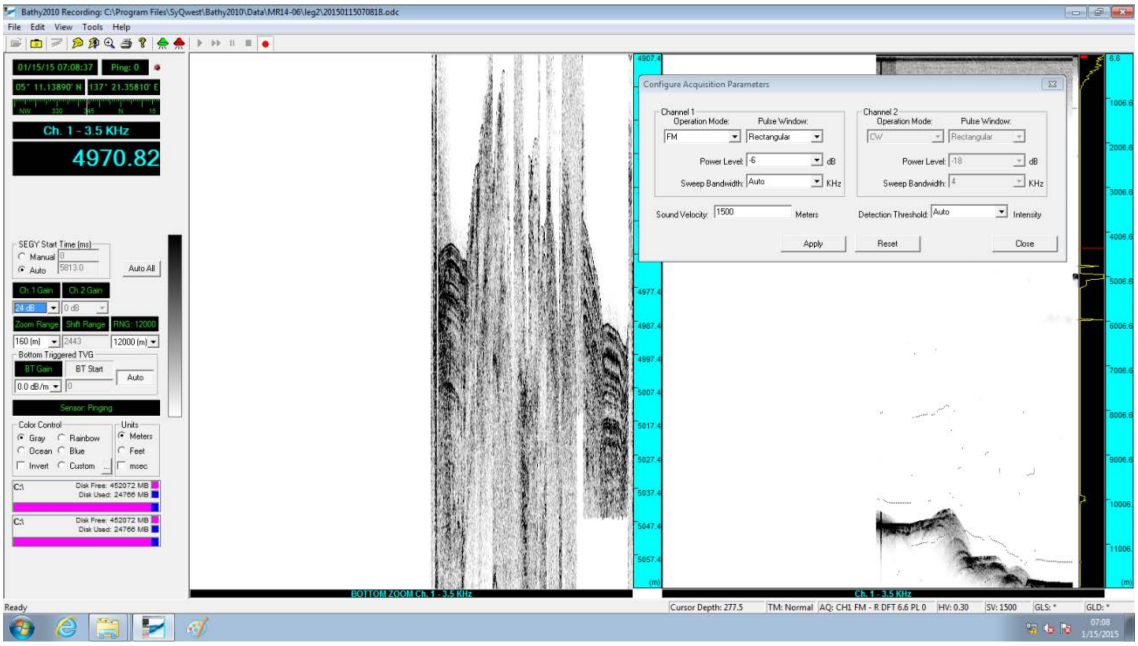


Fig6-1.4-12 Result of sub bottom profiling

6. 2. Subsurface ADCP moorings

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal investigator -Leg2-
Iwao Ueki	(JAMSTEC) Principal investigator -Leg3-
Tomohide Noguchi	(MWJ): Operation leader -Leg2,3-
Rei Ito	(MWJ) -Leg2-
Sonoka Wakatsuki	(MWJ) -Leg2-
Tomomi Sone	(MWJ) -Leg2,3-
Tatsuya Tanaka	(MWJ) -Leg3-
Akira Watanabe	(MWJ) -Leg3-
Shoko Tatamisashi	(MWJ) -Leg3-
Masahiro Orui	(MWJ) -Leg3-

(2) Objectives

The purpose of this ADCP observation is to get knowledge of physical process underlying the dynamics of oceanic circulation in the western equatorial Pacific Ocean and the eastern equatorial Indian Ocean. We have been observing subsurface currents using ADCP moorings along the equator. In this cruise (MR14-06), we recovered two subsurface ADCP moorings at Eq-156E and Eq-90E. And we deployed two subsurface ADCP moorings at Eq-156E and Eq-90E.

(3) Parameters

- Current profiles
- Echo intensity
- Pressure, Temperature and Conductivity

(4) Methods

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 as follows:

1) ADCP

Work horse 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 : 1645 (Mooring No. 140305-EQ156E)
- Serial Number : 13123 (Mooring No. 140125-EQ90E)

Deployed ADCP

- Serial Number : 7176 (Mooring No. 141229-EQ156E)
- Serial Number : 14080 (Mooring No. 150208-EQ90E)

2) CTD

SBE-16 (Sea Bird Electronics Inc.)

Sampling Interval : 1800 seconds

Recovered CTD

- Serial Number : 1288 (Mooring No. 140305-EQ156E)

Deployed CTD

- Serial Number : 1276 (Mooring No. 141229-EQ156E)

SBE-37 (Sea Bird Electronics Inc.)

Sampling Interval : 1800 seconds

Recovered CTD

- Serial Number : 2611 (Mooring No. 140125-EQ90E)

Deployed CTD

- Serial Number : 1388 (Mooring No. 150208-EQ90E)

3) Other instrument

(a) Acoustic Releaser (BENTHOS,Inc.)

Recovered Acoustic Releaser

- Serial Number : 960 (Mooring No. 140305-EQ156E)
- Serial Number : 677 (Mooring No. 140305-EQ156E)
- Serial Number : 955 (Mooring No. 140125-EQ90E)
- Serial Number : 961 (Mooring No. 140125-EQ90E)

Deployed Acoustic Releaser

- Serial Number : 600 (Mooring No. 141229-EQ156E)
- Serial Number : 937 (Mooring No. 141229-EQ156E)
- Serial Number : 630 (Mooring No. 150208-EQ90E)
- Serial Number : 717 (Mooring No. 150208-EQ90E)

(b) Transponder (BENTHOS,Inc.)

Recovered Transponder

- Serial Number : 61939 (Mooring No. 140305-EQ156E)
- Serial Number : 67491 (Mooring No. 140125-EQ90E)

Deployed Transponder

- Serial Number : 61939 (Mooring No. 141229-EQ156E)
- Serial Number : 46472 (Mooring No. 150208-EQ90E)

(c) ST-400A Xenon Flasher (MetOcean Data Systems)

Recovered Transponder

- Serial Number : Z03-090 (Mooring No. 140305-EQ156E)
- Serial Number : Z03-088 (Mooring No. 140125-EQ90E)

Deployed Transponder

- Serial Number : A02-057 (Mooring No. 141229-EQ156E)
- Serial Number : A02-056 (Mooring No. 150208-EQ90E)

(5) Deployment

Deployment of the ADCP mooring at Eq-156E and Eq-90E were 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. 141229-EQ156E
Date: 12 Dec. 2014 Lat: 00-02.14S Long: 156-07.99E Depth: 1,950m

The position of the mooring No. 150208-EQ90E
Date: 08 Feb. 2015 Lat: 00-00.28S Long: 90-08.66E Depth: 4,084m

(6) Recovery

We recovered two ADCP moorings. One was deployed on 25 Jan 2014 (MR14-01). And the another was deployed on 05 Mar 2014 (MR14-02). After the recovery, we uploaded CTD data into a computer, and then raw data were converted into ASCII code. However, ADCP recovered at Eq-156E and Eq-90E ran out of battery energy halfway. The results of mooring show in Figure 6.2-1 - 6.2-4.

(7) Data archive

All data will be opened at the following web page:.
http://www.jamstec.go.jp/rigc/j/tcvrp/ipocvrt/adcp_data.html

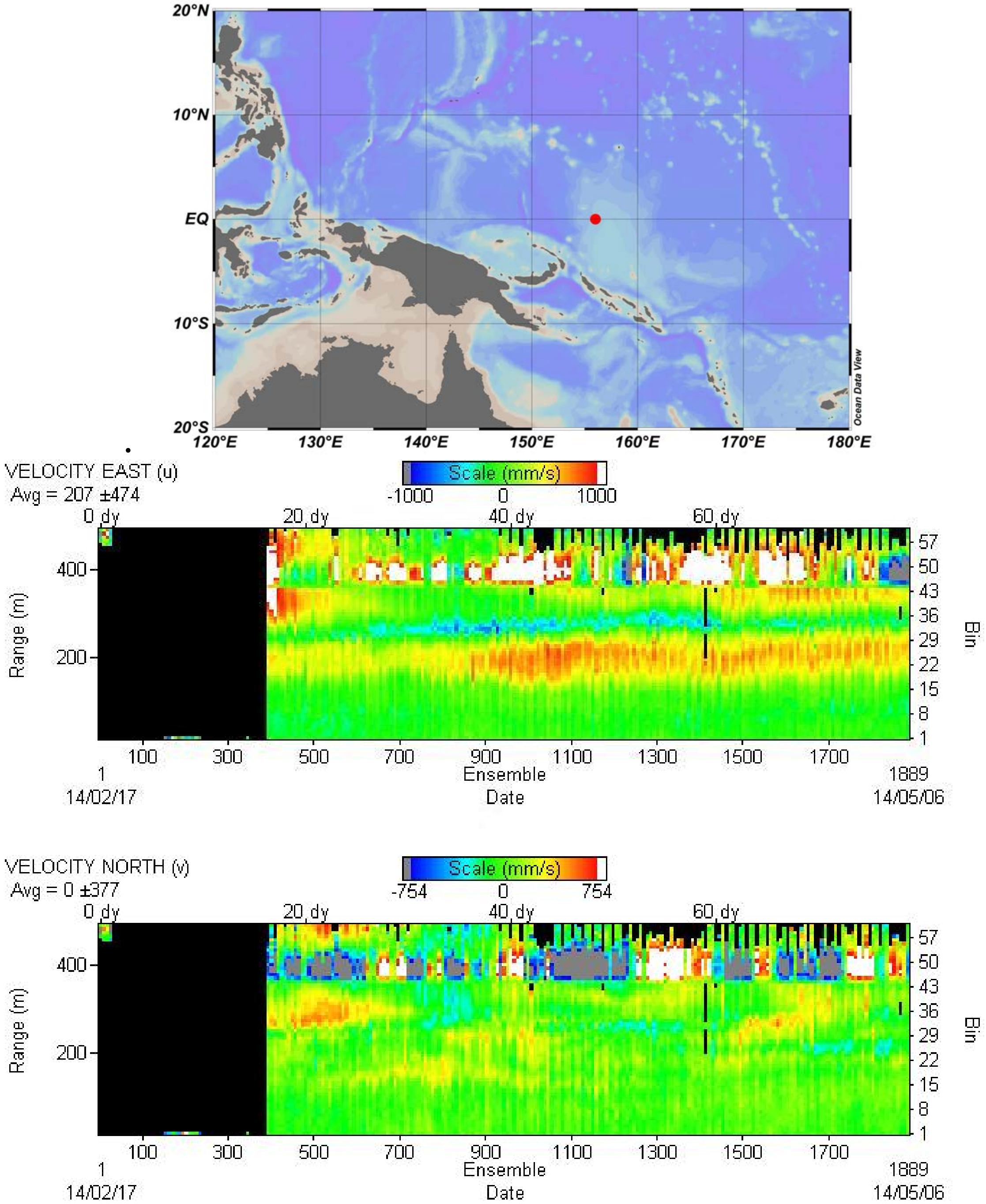


Fig.6.2-1 Time-depth sections of observed zonal (*top panel*) and meridional (*bottom panel*) currents obtained from ADCP mooring at Eq-156E. (2014/03/05 - 2014/05/06)

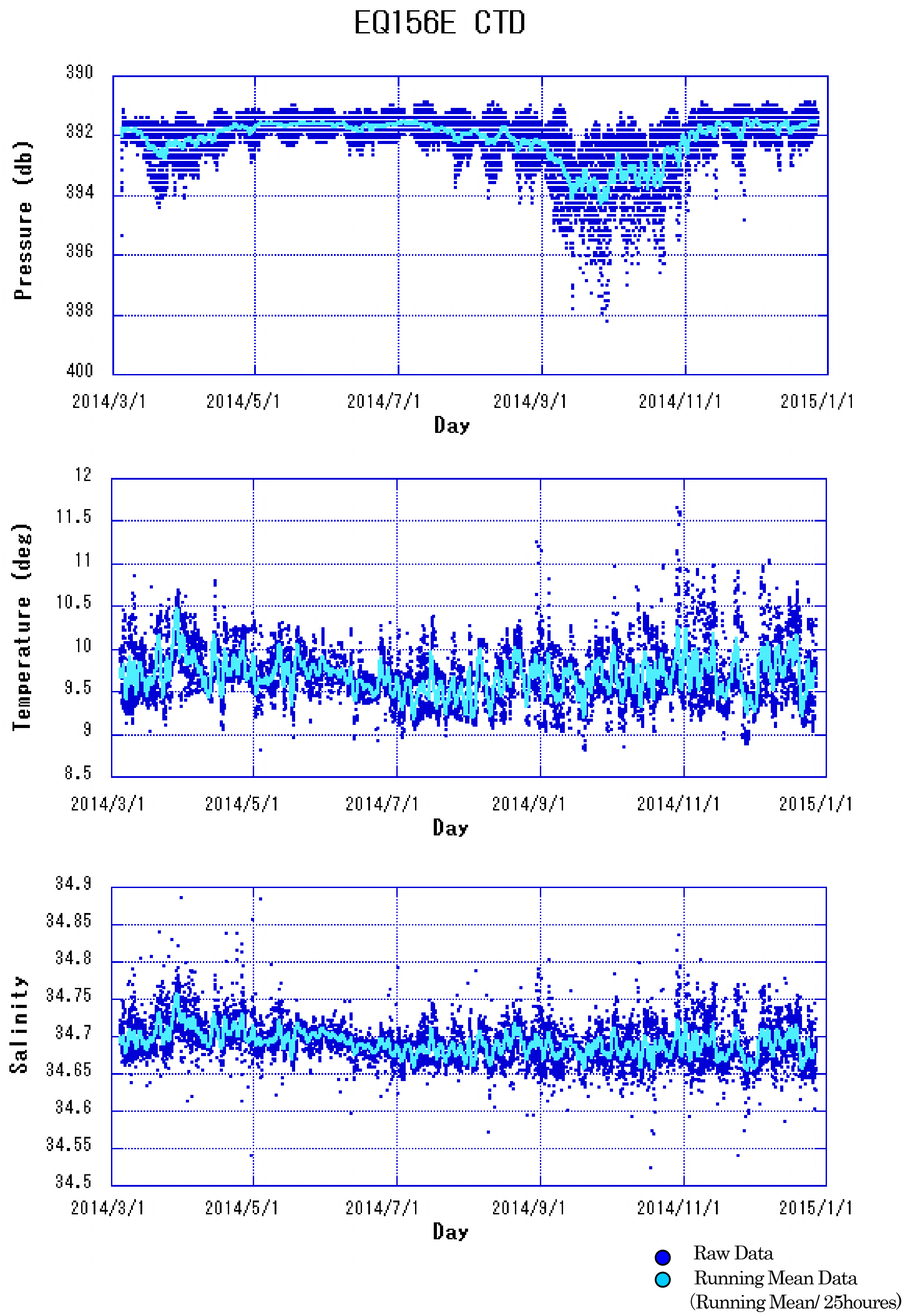


Fig.6.2-2 Time-series of the observed pressure (*top panel*), temperature (*middle panel*) and salinity (*bottom panel*) obtained from CTD at Eq-156E . The *dark-blue* curve indicates the raw data, while the *light-blue* curve shows the filtered data from 25 hours running-mean. (2014/03/05 - 2014/12/28)

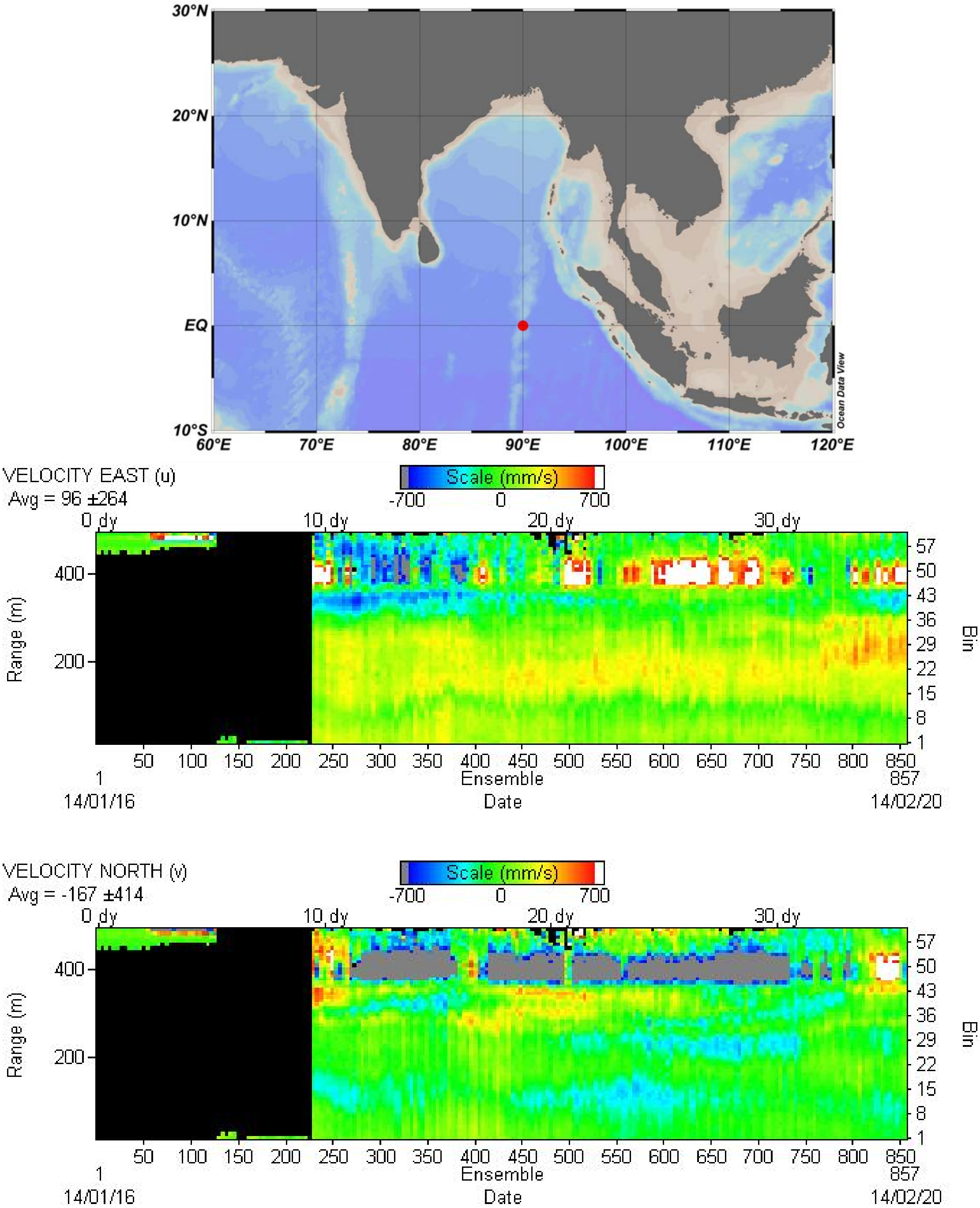


Fig.6.2-3 Time-depth sections of observed zonal (*top panel*) and meridional (*bottom panel*) currents obtained from ADCP mooring at Eq-90E. (2014/01/25 - 2014/02/20)

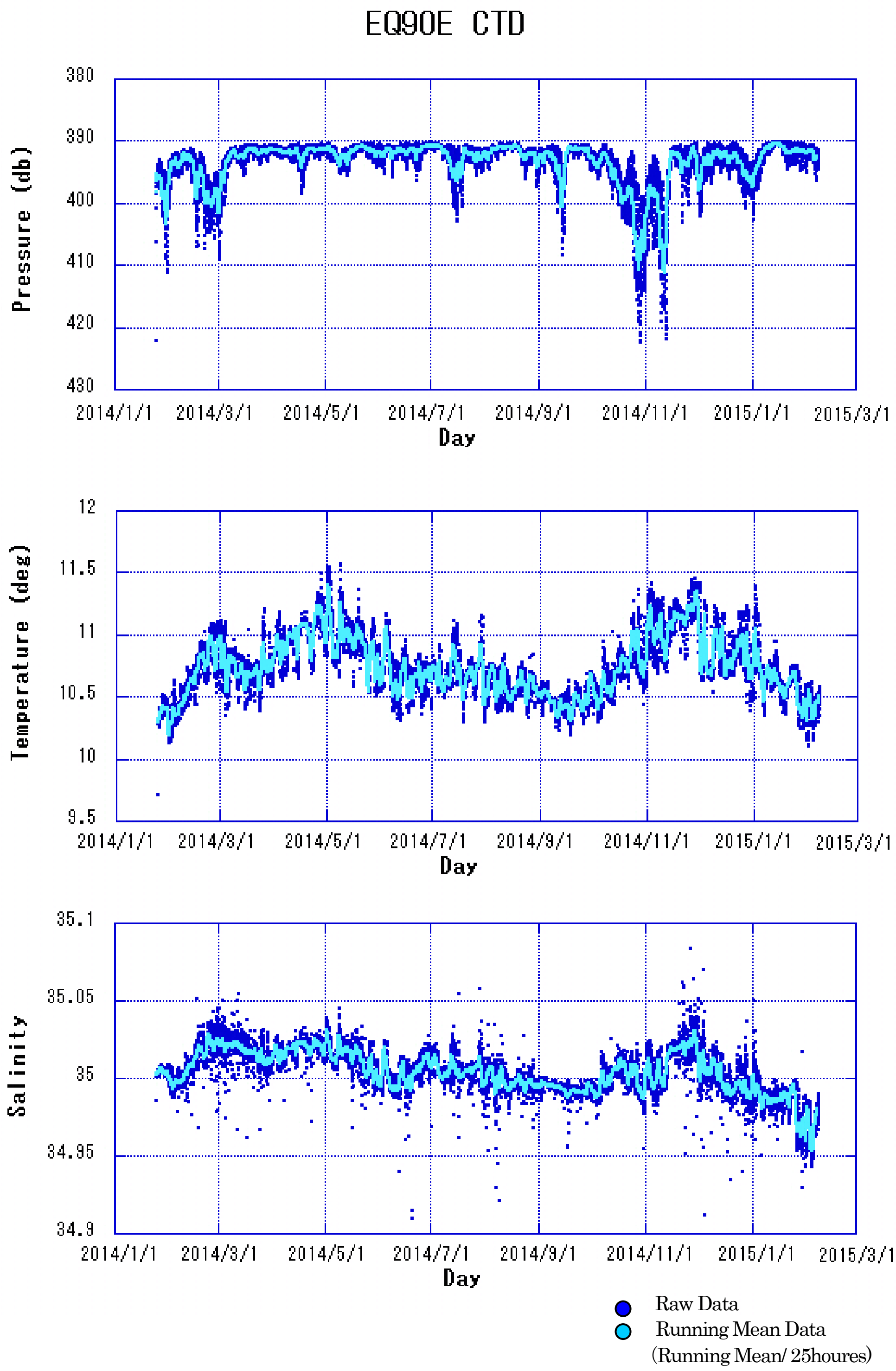


Fig.6.2-4 Time-series of the observed pressure (*top panel*), temperature (*middle panel*) and salinity (*bottom panel*) obtained from CTD at Eq-90E . The *dark-blue* curve indicates the raw data, while the *light-blue* curve shows the filtered data from 25 hours running-mean. (2014/01/25 - 2015/02/08)

6. 3. Broad Band Ocean Bottom Seismographs

(1) Personnel

Hiroko Sugioka	(JAMSTEC) Principal investigator	-Leg2-
Aki Ito	(JAMSTEC)	-Leg2-
Kiyoshi Baba	(ERI, University of Tokyo)	-Leg2-
Shinya Okumura	(GODI)	-Leg2-
Kazuho Yoshida	(GODI)	-Leg2-
Yutaro Murakami	(GODI)	-Leg2-

(2) Background and objectives

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

Under the project we planned to deploy 23 broadband ocean bottom seismographs (BBOBSs) and 20 ocean bottom electromagnetometers (OBEMs) on the seafloor in and around the OJP during the Leg1 and Leg2 of the MR14-06 cruise for determination of the crust and the upper mantle structure beneath the OJP region and its vicinity (Figure 6.4.1). We deployed 11 BBOBSs and 9 OBEMs in the previous cruise of Leg1, and 12 BBOBSs and 11 OBEMs in this cruise of Leg2. The BBOBS and OBEM can continuously record ground motions due to natural earthquakes and an electromagnetic field, whose data will be used to determine three-dimensional seismic and electrical conductivity structure, respectively. The data are stored in the ocean bottom instruments, which are planned to be recovered in 2016.

(3) Instrumentation

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

A BBOBS unit is deployed by free-fall and recovered by a self-pop-up system, designed to rise from the seafloor after receipt of an acoustic command. The BBOBS with a three-component CMG-3T broadband sensor (Guralp Systems Ltd.) senses ground motions at periods from 0.02 to 360 s with a sampling rate of 100 Hz at 24-bit resolution on a low power operating data logger (LS-9100; Hakusan Ltd.). All of the seismic instrument components including the sensor, the data logger, transponder (SI-2; Kaiyodenshi Ltd.) and batteries (Li cells) are packed into a 65-cm diameter titanium alloy pressure housing, which allows for a maximum operating depth of 6000 m. The system runs for as long as 1.5 years to ensure long-term seismic observations. The principal specifications are summarized in Table 6.3.1.

(4) Deployment work

In the Leg2, we deployed 12 BBOBSs at the stations of O1–3 and O6–14 just about in the central part of the array. We alternately distributed the BBOBS with two types of data logger in time accuracy (TCXO and CSAC) in order to complement in time correction. The deployment points were determined to flat seafloor near the planned points (Figures 6.4.2–13) after checking the bathymetry data taken by the multi-narrow echo sounding (MBES) system.

The BBOBSs were launched from the deck using A-frame crane at the stern (Photo 6.3.1). Two types in length of the anchor (1-m- or 2-m-long, Photo 6.3.2) make the BBOBS sink down to the sea bottom. The latter type works more effectively on coupling with the ground, which are equipped with the BBOBS deployed at the stations of O2, O6, O8, O11, O13 and O14. The settled positions at the bottom were determined by the echo ranging. The determined locations are listed in Table 6.4.3.

The BBOBS has been already recording by sending manually the starting command ("ad on") through the acoustic transmission on board. They are set uniformly the observation period of 630 days by the timer-controlled function. The setup information of the BBOBS for each station is listed in Tables 6.3.2.

(5) Recovery of the BBOBSs

The BBOBSs will be recovered in 2016 with R/V MIRAI. The data will be made available from data centers at JAMSTEC and Earthquake Research Institute (ERI) after a data priority period defined by JAMSTEC and ERI.

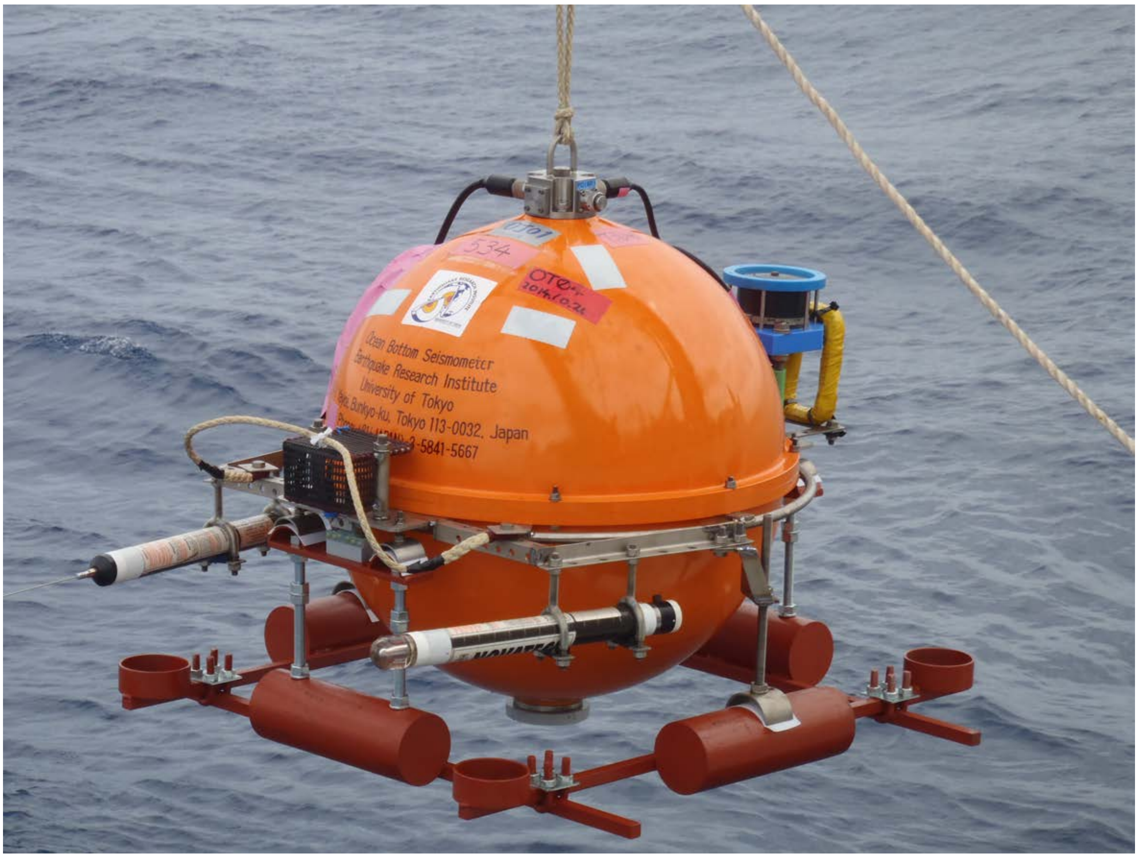
Table 6.3.1. Specifications of BBOBS.

Outside	
Size	(a) 1 m x 1 m x 0.7 m (with 1-m-long anchor) (b) 2 m x 2 m x 0.7 m (with 2-m-long anchor)
Weight in air	250 kg (with anchor), 160 kg (without anchor)
Pressure case	Sphere shaped titanium alloy pressure housing (Diameter=65 cm, Buoyancy=70 kg)
Releasing mechanism	Forced electric corrosion of two thin titanium plates (Thickness=0.4 mm) (Mitsuya Ltd.)
Recovery control	Acoustic transponder system with recorder communication (SI-2, Kaiyodenshi Ltd.)
Recovery aids	Radio beacon (160 MHz band) Xenon flasher with the pressure switch (Novatech Ltd.)
Inside	
Sensor	CMG-3T for ocean bottom seismograph (Guralp System Ltd.) on the active leveling gimbal unit (Katsujima Ltd.) Period: 360 s ~ 50 Hz Sensitivity: 1500 V/m/s Gimbal works up to 20 degree in tilting
Recorder	LS-9100 series (Hakusan Ltd.) (a) LS-9100-T3H (with TCXO of crystal oscillator) (b) LS-9100-A4H (with CSAC of atomic clock) A/D: 24 bit (0~5V) delta-sigma ADC Sampling: 100 Hz sampling Data format: Win format compression (1 day-long file) Data media: SD memory cards of 64 GB; Set up 2 cards in mirroring modes for redundancy
Clock precision	TCXO: < ±1 ppm/year CSAC: < ± 0.0003 ppm/month
Power supply	DD-size lithium cells (Exium SC-DD01ST, 3.9V, 30 Ah) D-size lithium cells (Electrochem 3B-35ST, 3.9V, 15 Ah) Sensor: 14 parallels (4 series (DD-size) =14.4V, 420 Ah) Recorder: 10 parallels (3 series (DD-size) =10.9V, 300 Ah) Gimbal: 2 parallel (2 series (DD-size) + 2 series (D-size); 7.2 V, 45 Ah) Backup clock: 4 parallels (for CSAC, DD-size, 3.6 V, 120 Ah); 8 parallels (for TCXO, DD-size, 3.6 V, 240 Ah)
Power consumption	Sensor: 360 mW Recorder: 140 mW (TCXO); 188 mW (CSAC) Gimbal: 14 mW Backup clock: 40 mW

Table 6.3.2. Setup information of deployed BBOBS.

Site	Clock type	Tx code	Radio Beacon frequency [MHz]	S/N of CMG-3T	F/W of Gimbal controller	Date of deployment (Local time)	Date ended of recoding (UTC)
O1	TCXO	534	159.150	T3U46	SISEI307	2015/01/05	2016/09/27
O2	CSAC	804	159.250	T36768	SISEI308	2015/01/07	2016/09/29
O3	TCXO	524	159.200	T3M57	SISEI312	2015/01/08	2016/10/01
O6	CSAC	809	159.350	T3E28	SISEI312	2014/12/25	2016/09/15
O7	TCXO	538	159.150	T3V33	SISEI307'	2014/12/27	2016/09/17
O8	CSAC	811	159.250	T3C11	SISEI308	2014/12/29	2016/09/20
O9	TCXO	537	159.250	T35351	SISEI308	2014/12/31	2016/09/22
O10	TCXO	523	159.200	T3F37	SISEI312	2015/01/02	2016/09/24
O11	CSAC	807	159.350	T3C10	SISEI308	2015/01/03	2016/09/25
O12	TCXO	517	159.250	T3V36	SISEI307'	2014/12/21	2016/09/12
O13	CSAC	800	159.300	T3X72	SISEI307	2014/12/23	2016/09/13
O14	CSAC	801	159.200	T3C12	SISEI308	2014/12/24	2016/09/14

Photo 6.3.1. BBOBS launching using A-frame crane at the stern.



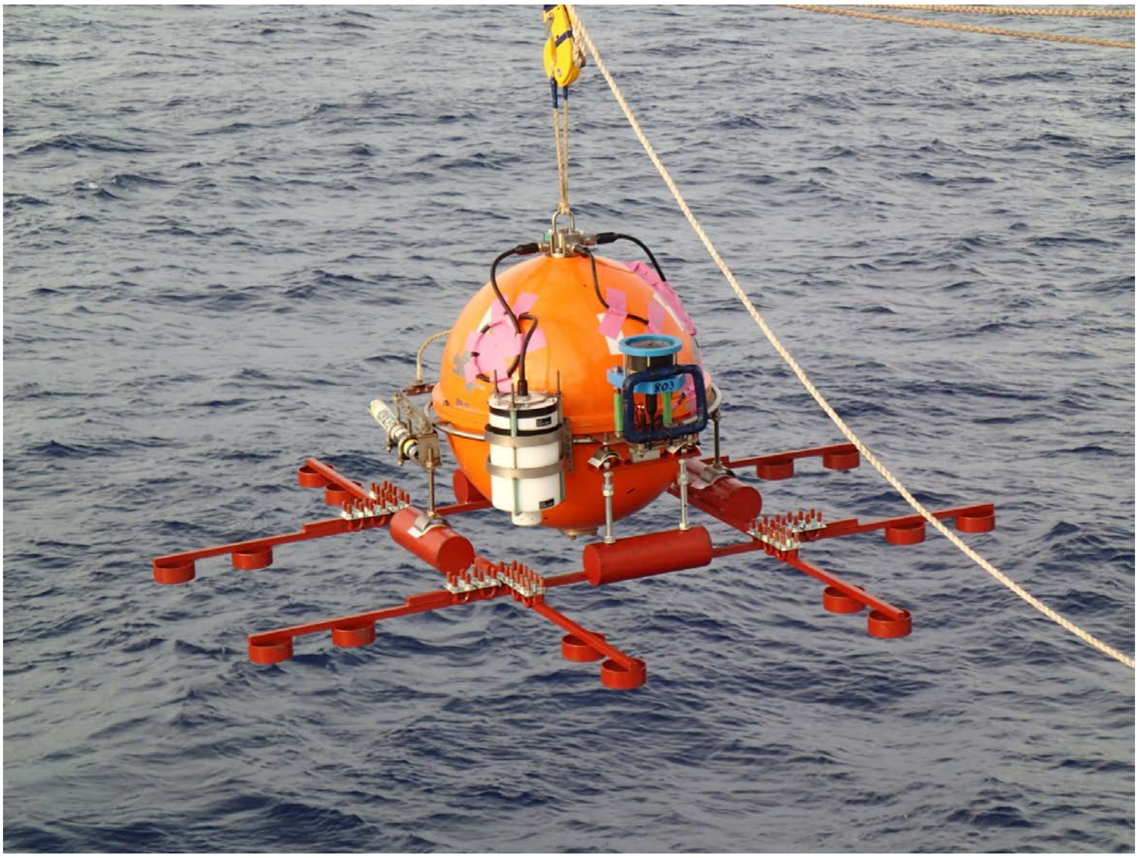


Photo 6.3.2. Two types sinker in length: 1-m-long (top) and 2-m-long (bottom)

6. 4. Ocean Bottom Electrtomagnetometers

(1) Personnel

Kiyoshi Baba	(ERI, University of Tokyo) Principal investigator	-Leg2-
Hiroko Sugioka	(JAMSTEC)	-Leg2-
Aki Ito	(JAMSTEC)	-Leg2-
Shinya Okumura	(GODI)	-Leg2-
Kazuho Yoshida	(GODI)	-Leg2-
Yutaro Murakami	(GODI)	-Leg2-

(2) Objectives

As a part of Ontong Java Plateau (OJP) Project (See Section 6.3), we started a seafloor electromagnetic (EM) survey using ocean bottom electromagnetometers (OBEMs). The natural EM field variation on the seafloor is measured by the OBEMs and the data are analyzed based on magnetotelluric (MT) method to estimate the electrical conductivity structure of the mantle beneath the survey area. Because electrical conductivity of the mantle materials is strongly dependent of temperature, volatiles such as water, and partial melt if it exist and interconnected, seafloor MT data are definitely useful to discuss the nature of the OJP. For this objective, total 20 OBEMs were deployed in the area shown in Fig. 6.4.1, during the cruises, MR14-06 legs 1 and 2. In this cruise (leg 2), 11 of them were successfully deployed at the same locations where BBOBSs were deployed (Section 6.3). The observation will start from February 1st, 2015 by timer and continue for more than 1.5 years until the battery power consumes. The recovery of them is planned in 2016 summer.

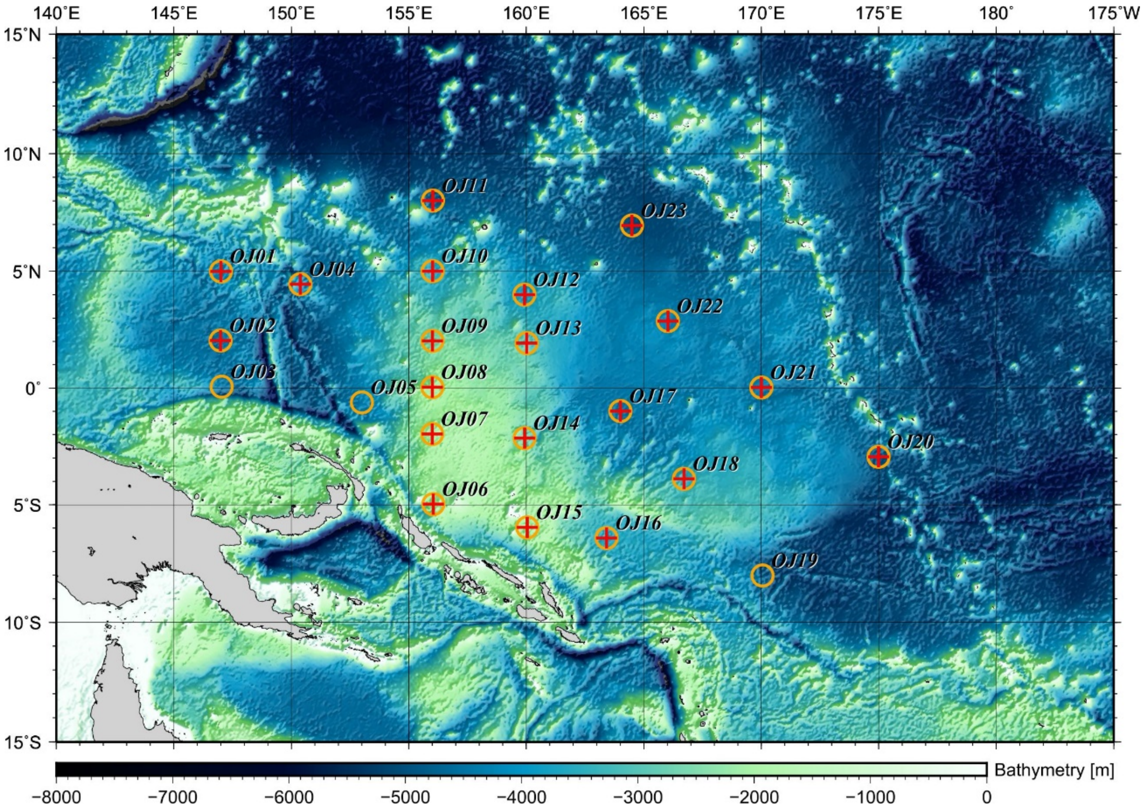
(3) Instrumentation

OBEMs can measure time variations of three components of magnetic field, horizontal electric field, instrumental tilts, and temperature. The resolutions are 0.01 nT for the flux-gate magnetometer, 0.305 μV with 16 bit A/D converter or 0.01 μV with 24 bit A/D converter for voltmeter (depending on the generation of the instrument), 0.00026 degrees for tiltmeter, and 0.01 °C for thermometer. The instrument consists of two pressure-resistant 17-inch glass sphere housings, four pipes that Ag-AgCl electrodes are attached on the tips for the electric field measurement, an acoustic transducer, an anchor release system based on burn wire, a flush light, a radio beacon, a recovery buoy, (these are mounted on titanium frame), and a concrete anchor (Photo 6.4.1). The flux-gate magnetic sensor and the data logger are equipped in a glass sphere and an acoustic transponder and battery packs are in the other sphere. Net weight is 190 kg in air and 30 kg in water including anchor and 100 kg in air and -22 kg in water without anchor. See Table 6.4.1 for specification of each OBEM.

(4) Deployment work

The OBEMs were set up on board. The clock of OBEM was synchronized to UTC using GPS. It will be compared again after the recovery to correct the time shift during the observation. Nine OBEMs are newer generations and they can change the sampling intervals during the observation by timer. The sampling interval was set to 10 seconds for the first two months and to 60 seconds from thence for these OBEMs. The sampling interval switching enables us to obtain the EM field variations in wider period range effectively. It is expected to increase the resolution of the electrical conductivity structure imaging especially for the shallower part by 10 seconds sampling data. The other old two OBEMs record the data every 60 seconds. The information of these setup parameters are listed in Table 6.4.2.

The seafloor topography in the vicinity of planned site locations was checked before the deployment. For the sites O12, O13, and O14, we mapped the bathymetry by onboard



multi-narrow echo sounding (MBES) system, SeaBeam3012. For the other sites, MBES data collected by past cruises were available. The deployment points were determined to flat seafloor near the planned points (Figs. 6.4.2–3, 5–13).

The OBEMs were launched from the deck using A-frame at the stern. They descended to the seafloor by their own weights. Just after the launch, the slant range between the OBEM and the ship was measured to confirm the descending. The descending speed was about 35~36 m/min. After they reached the seafloor, the settled positions were determined by measuring the slant ranges from triangle points about 0.4 nm away from the launched point. The determined position and are listed in Table 6.4.3.

(5) Bathymetry survey

The bathymetry mapping using SeaBeam3012 were also conducted in the areas surrounding the sites. Because the contrast in electrical conductivity between the sea water and crustal rocks is significant, rough seafloor topography distort the EM field on the seafloor. The collected bathymetry data will be used to model this effect on observed MT data. Figs. 6.4.2–6.4.13 show the bathymetry maps around the OBEM sites produced from the MBES data collected in this and past cruises.

(6) Recovery of the OBEMs

The OBEMs will be recovered in 2016 with R/V MIRAI. The data will be made available from the data center at JAMSTEC and ERI after a data priority period defined by JAMSTEC and ERI.

Figure 6.4.1. Seafloor seismic and electromagnetic observation array for OJP project, superimposed on bathymetric map. OJP is the bathymetric high in the center of the map. Circles

and crosses are the site location of BBOBSs and OBEMs, respectively.

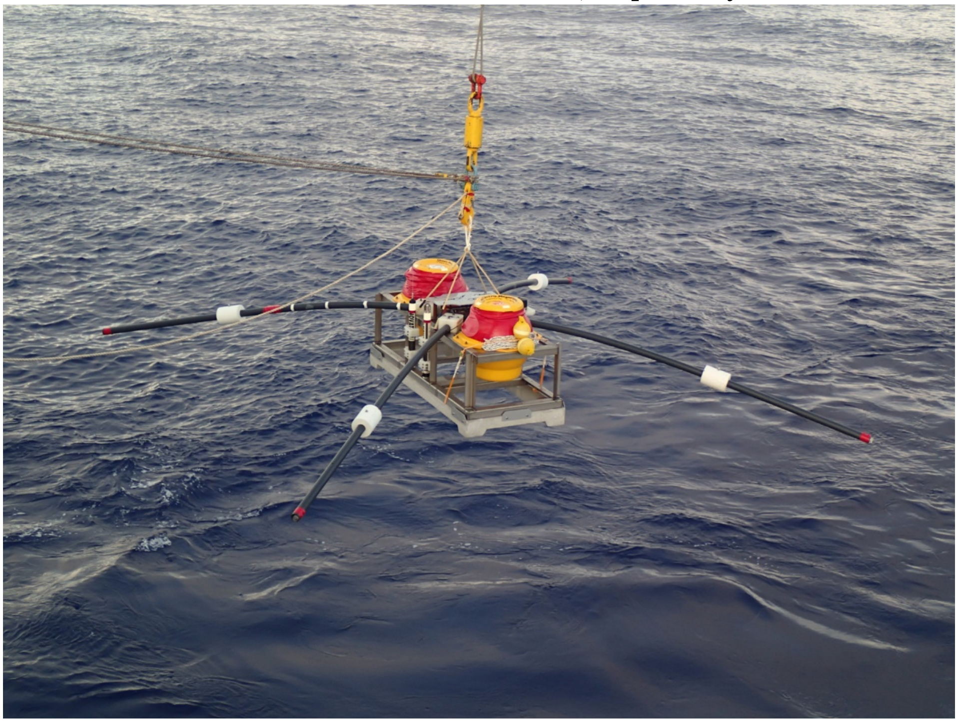


Photo. 6.4.1. OBEM launching at the stern.

Table 6.4.1. Specification of OBEMs.

Site	OBEM ID	Voltimeter		Acoustic system				Radio beacon frequency [MHz]
		A/D converter	Dipole length [m] (x, y)	Maker	Transmitting frequency [kHz]	Receiving Frequency [kHz]	Release command	
O01	TT8	16 bit, 2 channels	(5.400, 5.410)	N	9.600 ~ 10.900	10.240	3F	159.250
O02	TT4	24 bit, 4 channels	(5.405, 5.410)	K	9.494	13.500	4C-1	159.300
O06	ERI6	24 bit, 4 channels	(5.395, 5.405)	K	10.563	13.500	2D-1	159.200
O07	ERI7	24 bit, 4 channels	(5.415, 5.415)	K	10.563	13.500	2E-1	159.250
O08	ERI8	24 bit, 4 channels	(5.415, 5.405)	K	10.563	14.000	2F-2	159.300
O09	ERI5	24 bit, 4 channels	(5.405, 5.415)	K	10.563	14.000	2B-2	159.150
O10	ERI11	24 bit, 4 channels	(5.400, 5.415)	K	10.000	13.500	3D-1	159.250
O11	TT5	16 bit, 2 channels	(5.410, 5.405)	N	9.600 ~10.900	10.240	3C	159.300
O12	ERI12	24 bit, 4 channels	(5.395, 5.395)	K	10.000	13.500	3E-1	159.300
O13	ERI13	24 bit, 4 channels	(5.410, 5.390)	K	10.000	13.500	3F-1	159.150
O14	ERI14	24 bit, 4 channels	(5.410, 5.420)	K	9.494	13.500	4B-1	159.300

K: Kaiyo Denshi, N: Nichiu Giken, Transmitting/Receiving denotes ship's side.

Table 6.4.2. Setup parameters for OBEMs

Site	Clock set time (UTC)	Observation schedule (UTC)	Sampling int. [s]
O01	2015-01-03 04:39:00	2015-01-31 14:59 ~	60
O02	2015-01-05 00:20:00	2015-01-31 14:59 ~ 2015-03-31 14:58	10
		2015-03-31 14:59 ~	60
O06	2014-12-23 11:34:00	2015-01-31 14:59 ~ 2015-03-31 14:58	10
		2015-03-31 14:59 ~	60
O07	2014-12-24 23:48:00	2015-01-31 14:59 ~ 2015-03-31 14:58	10
		2015-03-31 14:59 ~	60
O08	2014-12-27 00:28:59	2015-01-31 14:59 ~ 2015-03-31 14:58	10
		2015-03-31 14:59 ~	60
O09	2014-12-29 00:10:00	2015-01-31 14:59 ~ 2015-03-31 14:58	10
		2015-03-31 14:59 ~	60
O10	2014-12-31 00:12:00	2015-01-31 14:59 ~ 2015-03-31 14:58	10
		2015-03-31 14:59 ~	60
O11	2015-01-02 04:51:29	2015-01-31 14:59 ~	60
O12	2014-12-21 05:21:59	2015-01-31 14:59 ~ 2015-03-31 14:58	10
		2015-03-31 14:59 ~	60
O13	2014-12-22 04:57:00	2015-01-31 14:59 ~ 2015-03-31 14:58	10
		2015-03-31 14:59 ~	60
O14	2014-12-23 05:05:00	2015-01-31 14:59 ~ 2015-03-31 14:58	10
		2015-03-31 14:59 ~	60

Table 6.4.3. Location of deployed BBOBSs and OBEMs.

Site	BBOBS				OBEM				Date of
	Latitude	Longitude	[a]Depth	[b]Depth	Latitude	Longitude	[a]Depth	[b]Depth	deployment
O01	04° 59.745' N	147° 00.301' E	4275 m	4275 m	04° 59.688' N	147° 00.192' E	4278 m	4279 m	05 Jan. 2015
O02	02° 02.281' N	146° 59.466' E	4480 m	4486 m	02° 02.219' N	146° 59.331' E	4478 m	4489 m	07 Jan. 2015
O03	00° 03.531' N	147° 02.114' E	4475 m	4486 m	N/A				08 Jan. 2015
O06	04° 58.377' S	156° 02.688' E	1494 m	1491 m	04° 58.367' S	156° 02.700' E	1493 m	1490 m	25 Dec. 2014
O07	01° 58.269' S	155° 59.828' E	1753 m	1743 m	01° 58.155' S	155° 59.828' E	1753 m	1743 m	27 Dec. 2014
O08	00° 02.173' N	156° 00.027' E	1969 m	1959 m	00° 02.156' N	156° 00.093' E	1969 m	1959 m	29 Dec. 2014
O09	02° 01.296' N	156° 00.443' E	2602 m	2583 m	02° 01.267' N	156° 00.452' E	2602 m	2583 m	31 Dec. 2014
O10	05° 00.560' N	156° 00.770' E	3622 m	3608 m	05° 00.496' N	156° 00.802' E	3620 m	3608 m	02 Jan. 2015
O11	08° 00.774' N	156° 01.468' E	4859 m	4875 m	08° 00.653' N	156° 01.340' E	4860 m	4876 m	03 Jan. 2015
O12	04° 00.098' N	159° 55.057' E	3759 m	3756 m	03° 59.793' N	159° 55.266' E	3760 m	3757 m	22 Dec. 2014
O13	01° 55.580' N	160° 00.984' E	2952 m	2948 m	01° 55.599' N	160° 01.112' E	2949 m	2949 m	23 Dec. 2014
O14	02° 08.865' S	159° 55.628' E	2495 m	2491 m	02° 08.835' S	159° 55.788' E	2493 m	2491 m	23 Dec. 2014

a: determined by slant range measurements at triangle points, b: value extracted from MBES data

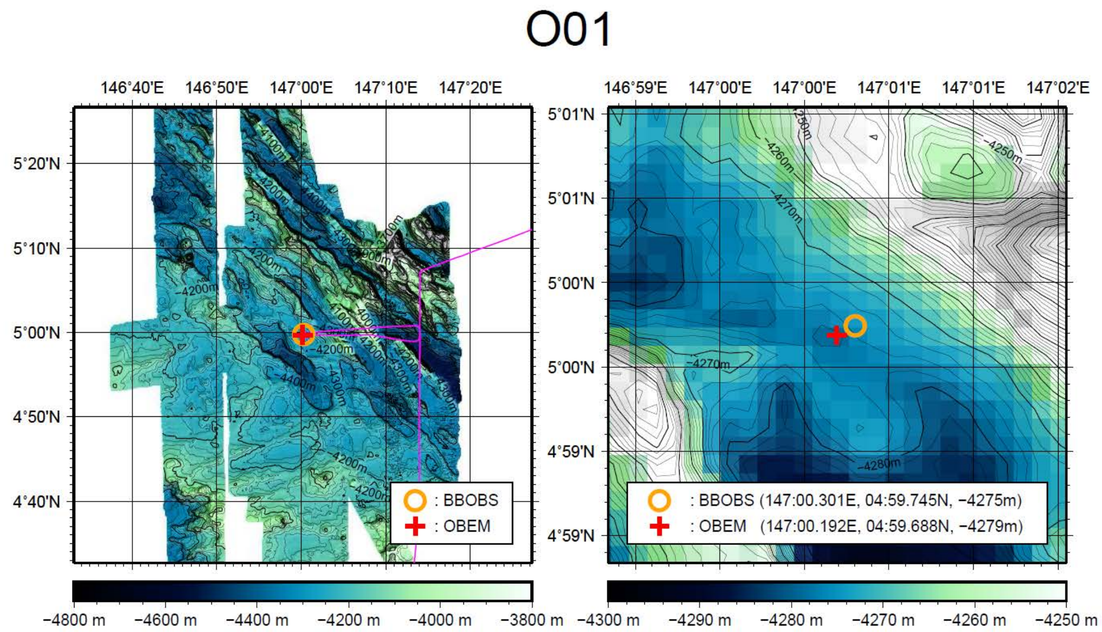


Figure 6.4.2. Bathymetry maps around the site O01 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

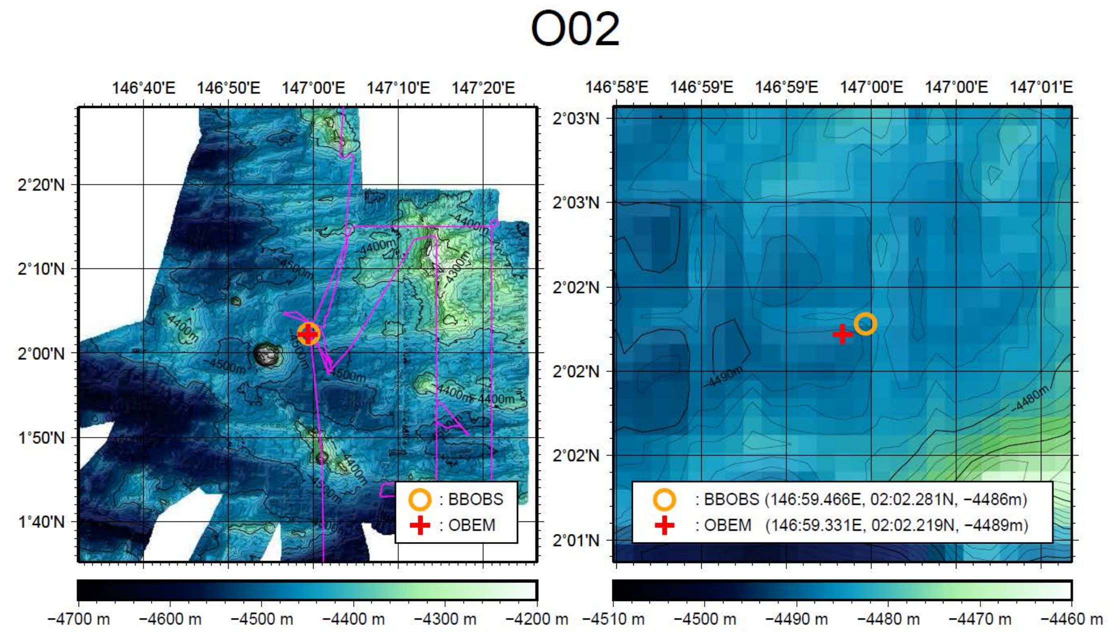


Figure 6.4.3. Bathymetry maps around the site O02 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

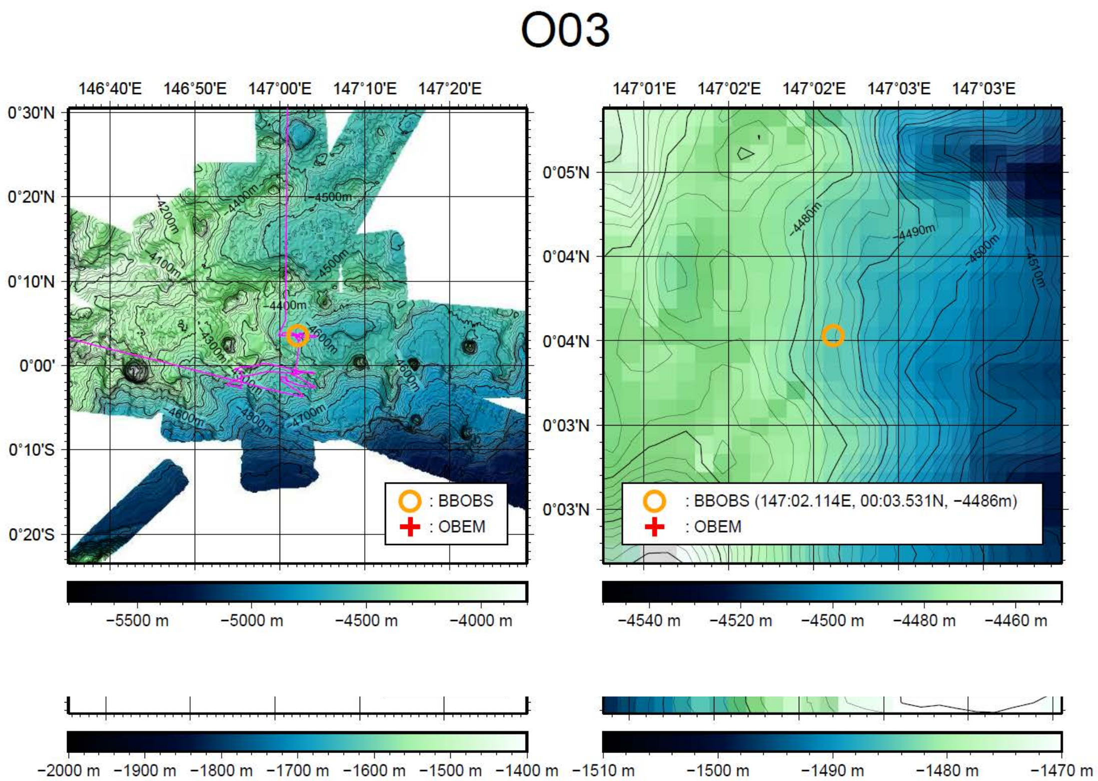


Figure 6.4.4. Bathymetry maps around the site O03 (left) and its magnification (right). Circle and lines indicate the BBOSS's position and the ship's track in this cruise. OBEM was not deployed at this site.

Figure 6.4.5. Bathymetry maps around the site O06 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

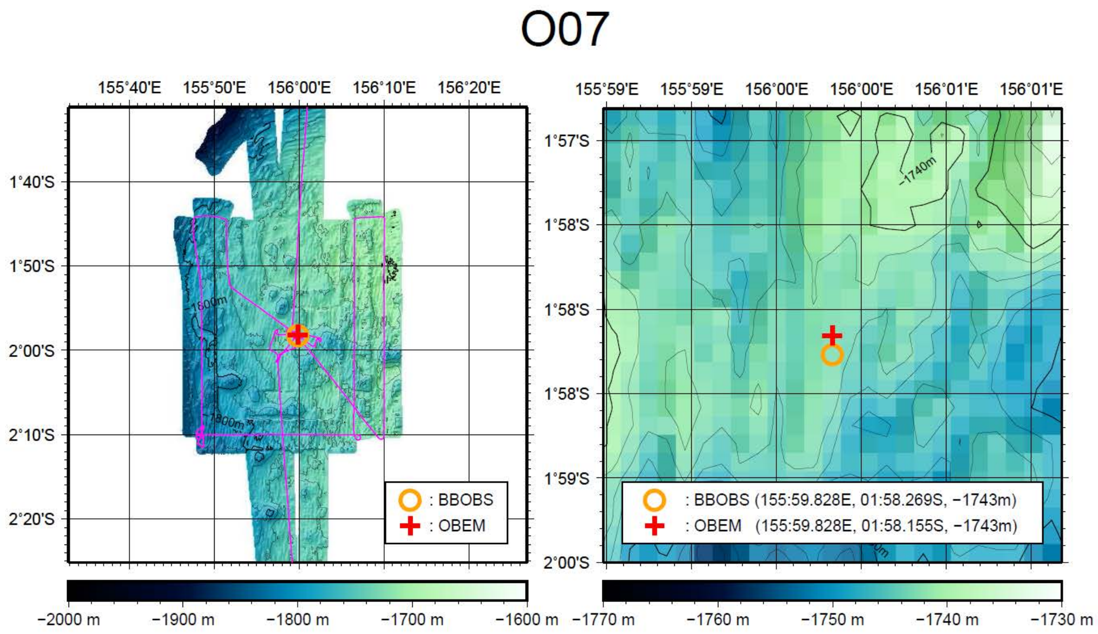


Figure 6.4.6. Bathymetry maps around the site O07 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

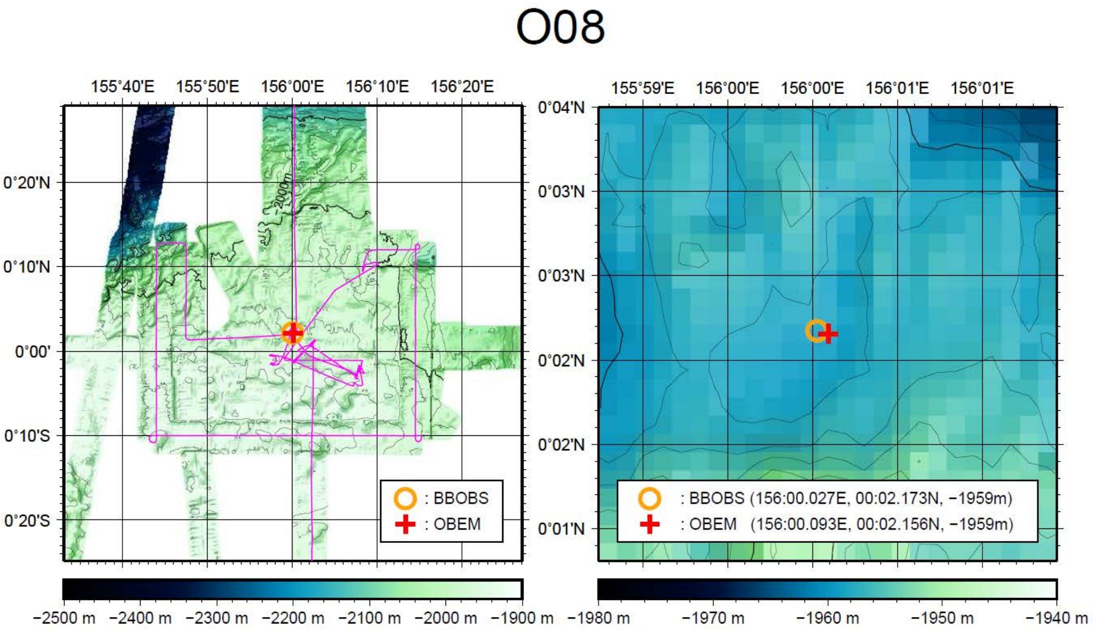


Figure 6.4.7. Bathymetry maps around the site O08 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

O09

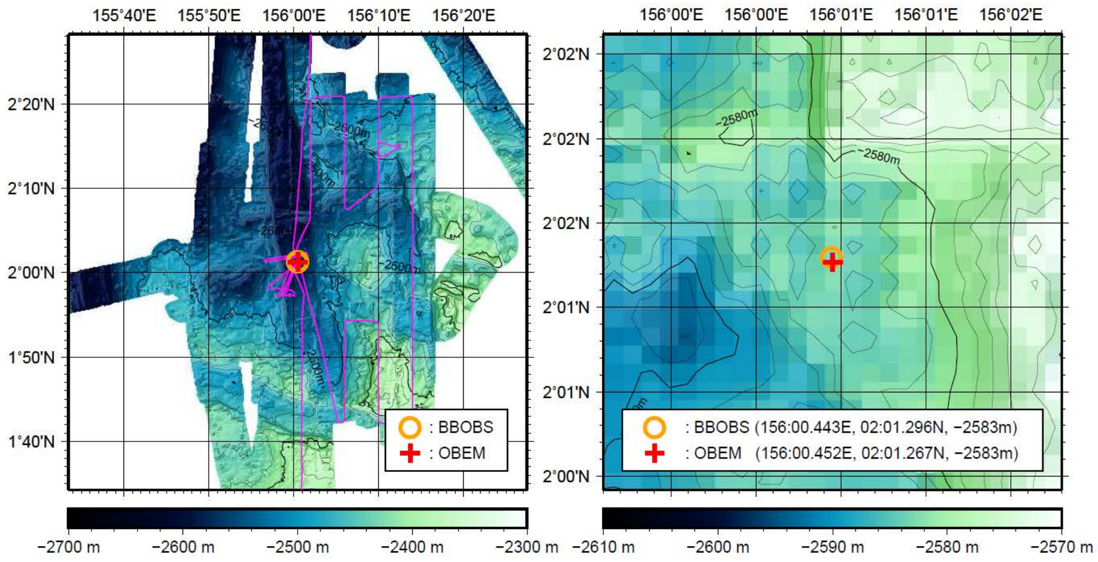


Figure 6.4.8. Bathymetry maps around the site O09 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

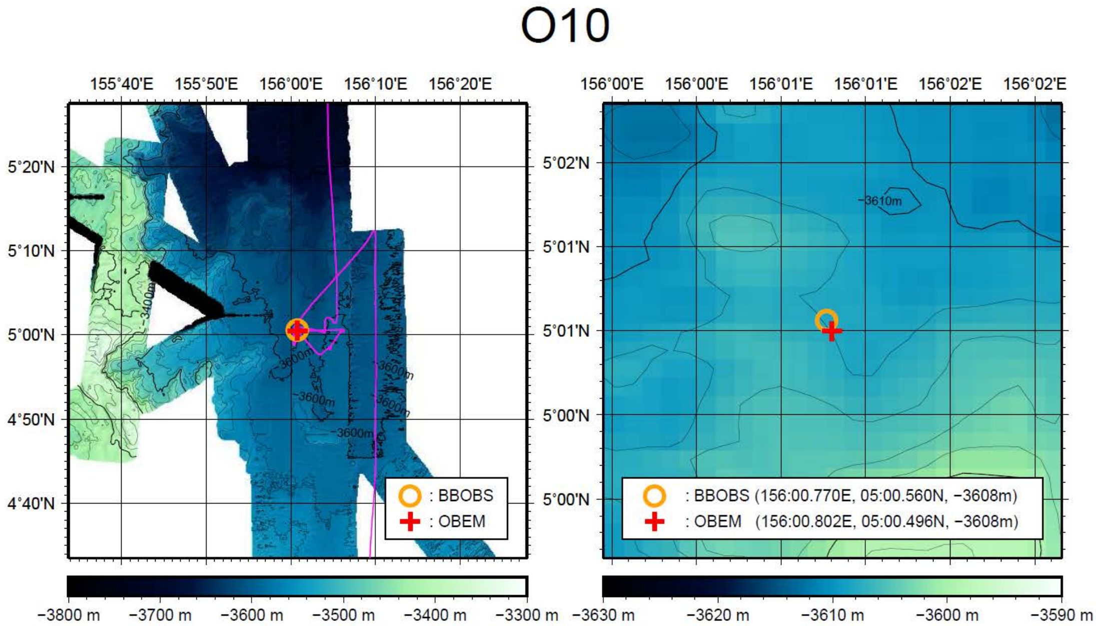


Figure 6.4.9. Bathymetry maps around the site O10 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

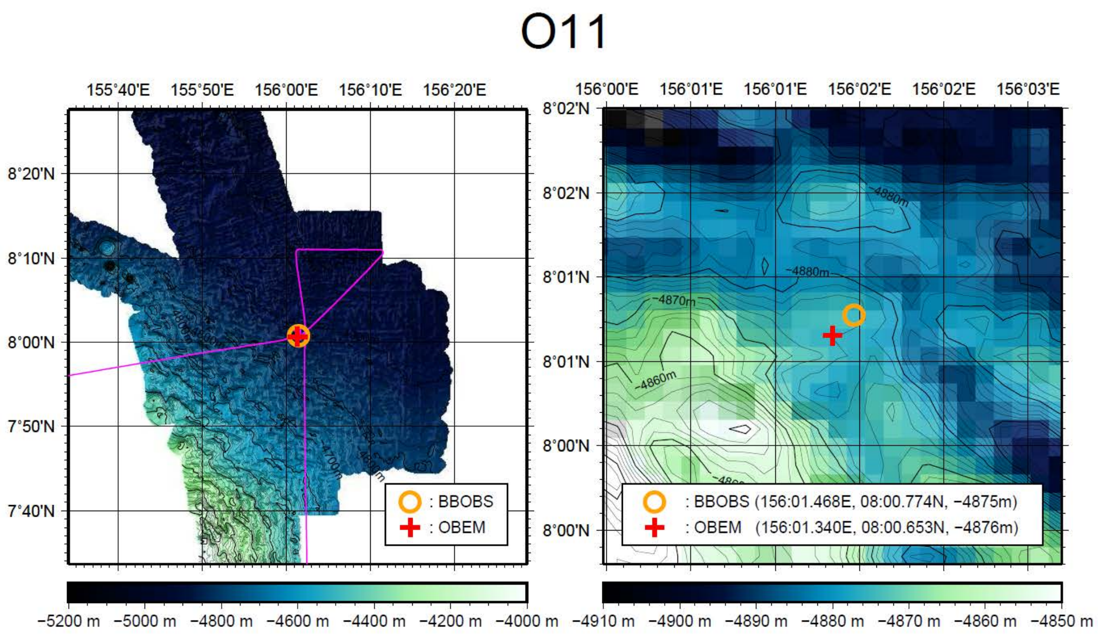


Figure 6.4.10. Bathymetry maps around the site O11 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

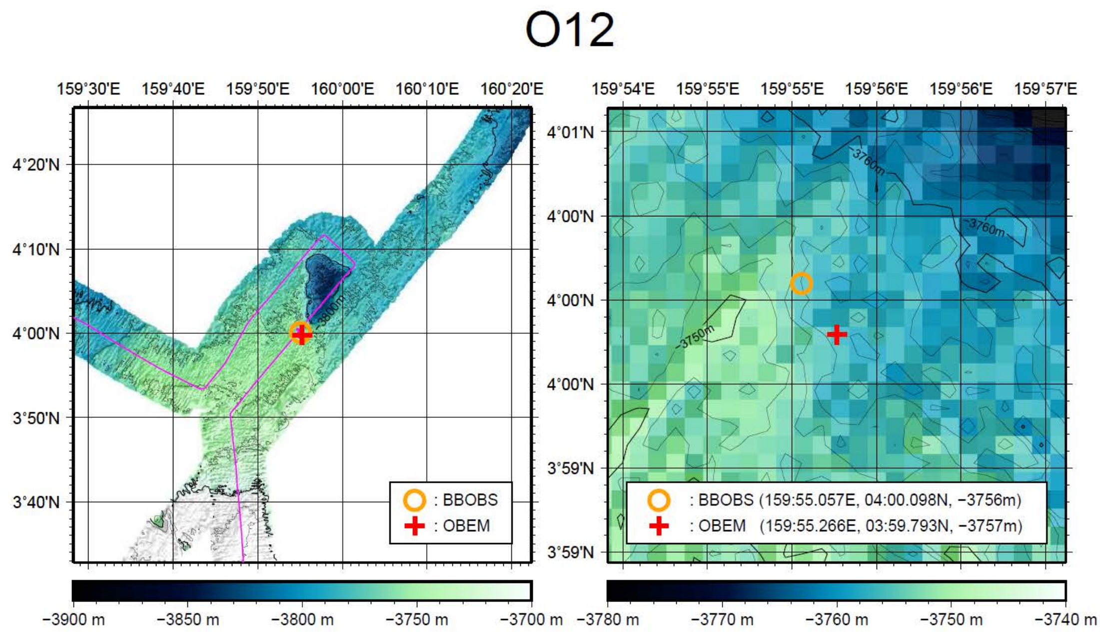


Figure 6.4.11. Bathymetry maps around the site O12 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

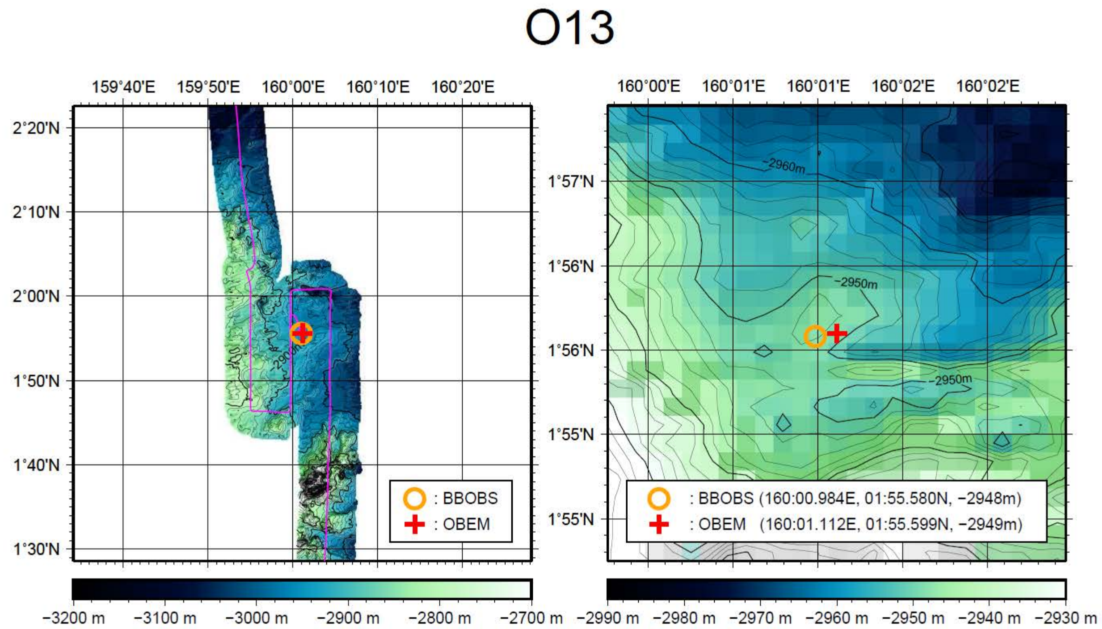


Figure 6.4.12. Bathymetry maps around the site O13 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

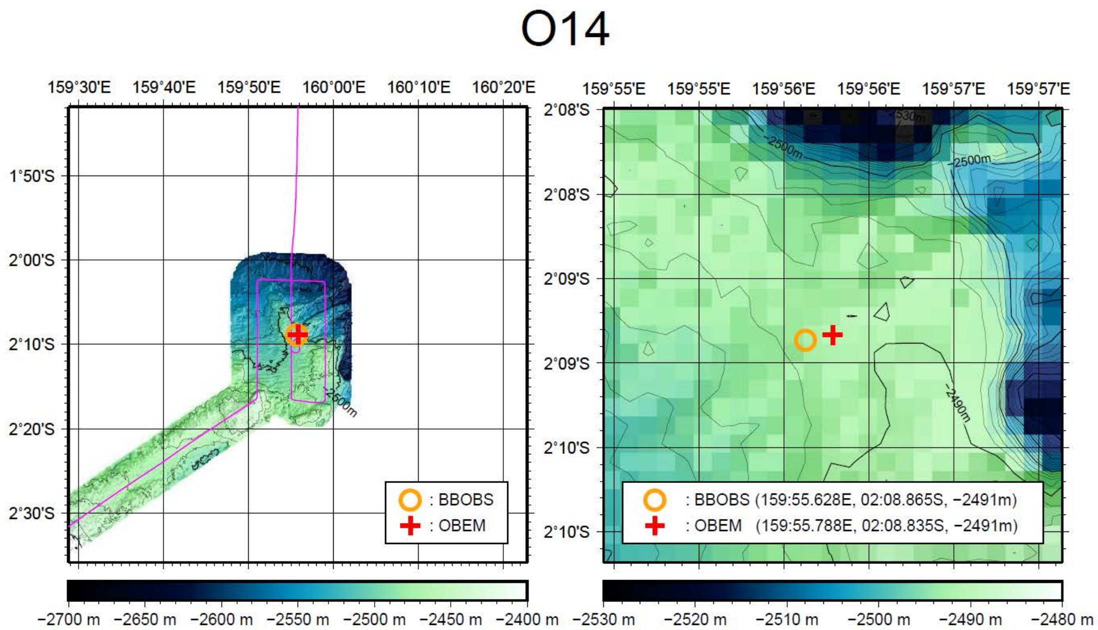


Figure 6.4.13. Bathymetry maps around the site O14 (left) and its magnification (right). Circle, cross, and lines indicate the BBOSS's position, OBEM's position, and the ship's track in this cruise.

6.5 Lidar observation of clouds, aerosols, and water vapor

(1) Personal

Masaki Katsumata	JAMSTEC	Principal Investigator	not on board
Ichiro Matsui	NIES		Leg2
Kyoko Taniguchi	JAMSTEC		Leg2
Biao Geng	JAMSTEC		Leg2
Nobuhiko Endo	JAMSTEC		not on board
Atsushi Shimizu	NIES		not on board
Tomoaki Nishizawa	NIES		not on board
Katsuhisa Maeno	GODI		Leg 3
Miki Morioka	GODI		Leg 3

(2) Objective

The lidar system in this cruise is introduced to obtain vertical distribution of cloud, aerosol and water vapor with high temporal resolution. As the first cruise to operate this lidar system, we in this cruise adjusted, optimized and evaluate the system

(3) Instrumentation

During the cruise, a lidar observation system has built in a radiosonde observation container on R/V Mirai. This lidar system transmits dual-wavelength laser, and provides 5-channel data: 1064 nm, 660 nm, depolarized 532 nm, and closer distance signals of 532 nm. The system specification is introduced below in 2 sections: transmitter, and detector and processor. Although a principle of lidar is well established, each system requires precise adjustments and adaptations prior to continuous operation.

Transmitter

The lidar system transmits Nd:YAG coaxial laser of 1064 nm and 532 nm with approximately 5 ns pulse duration. The laser diameter is approximately 28 mm after a beam expander stretches the laser diameter five times. The laser is sent into the atmosphere right above through a window on the ceiling of the radiosonde container with a repetition rate of 10 Hz. The timing of the laser transmission is recorded with a photodiode installed behind the direction changing mirror in front of laser transmitter for accurate estimation of vertical distributions.

Detector and Processor

The lidar system collects the scattered light with a 20cm-diameter telescope. From the collected signals, 1064 nm signals are extracted with a beamsplitter, then sends to the APD sensor. Similarly, 660 nm and 532 nm signals are also extracted. After the extraction, 532 nm signals are split into perpendicular and parallel components. Both 660 nm and 532 nm signals are counted with PMT sensors. Beside the telescope, a 5cm-diameter telescope collects closer distance signals of 532 nm.

The elastic scattering signals (1064 nm and 532 nm) are processed with an amplifier and A/D converters before recording. These data covers from 60 m to 24 km in altitude with vertical resolution of 6m. 660 nm signal corresponds to the Raman shift of water vapor (3652 cm-1) for a 532 nm light source. The Raman scattering data is recorded with a transient recorder, and its vertical resolution is 7.5 m. At 23:50-23:55 UTC, the system measures environmental noise, e.g. dark current, for calibration.

(4) Data Period (UTC)*

Leg2 10:40 31 December 2014 – 23:45 17 January 2015

Leg3 04:50 22 January 2015 - 01:35 23 January 2015

06:00 30 January 2015 – 10:55 9 February 2015

21:10 17 February 2015 –01:55 25 February 2015

*There are some gaps within the data periods

(5) Preliminary Results

Fig 6.5 1) and 2) shows preliminary results of 1064 nm and 532 nm data obtained on 17 January 2015, accordingly. On each plot, a layer of high aerosol known as PBL is captured below altitude of 1km layer. On the top of the layer, some clouds observed as strong backscatter signals in several times throughout the day. Also, distinct clouds at 6~7 km from 13:00~24:00 UTC are drawn. In addition, optically thin clouds are captured at 13 km and 16 km a few times, even though 1064 nm struggles with noise increasing with heights. Fig 6.5 3) is a preliminary result of 660 nm on the same day. The strong backscattering signals at the lower altitude indicate high content of water vapor. These data, especially 660 nm, requires farther processing.

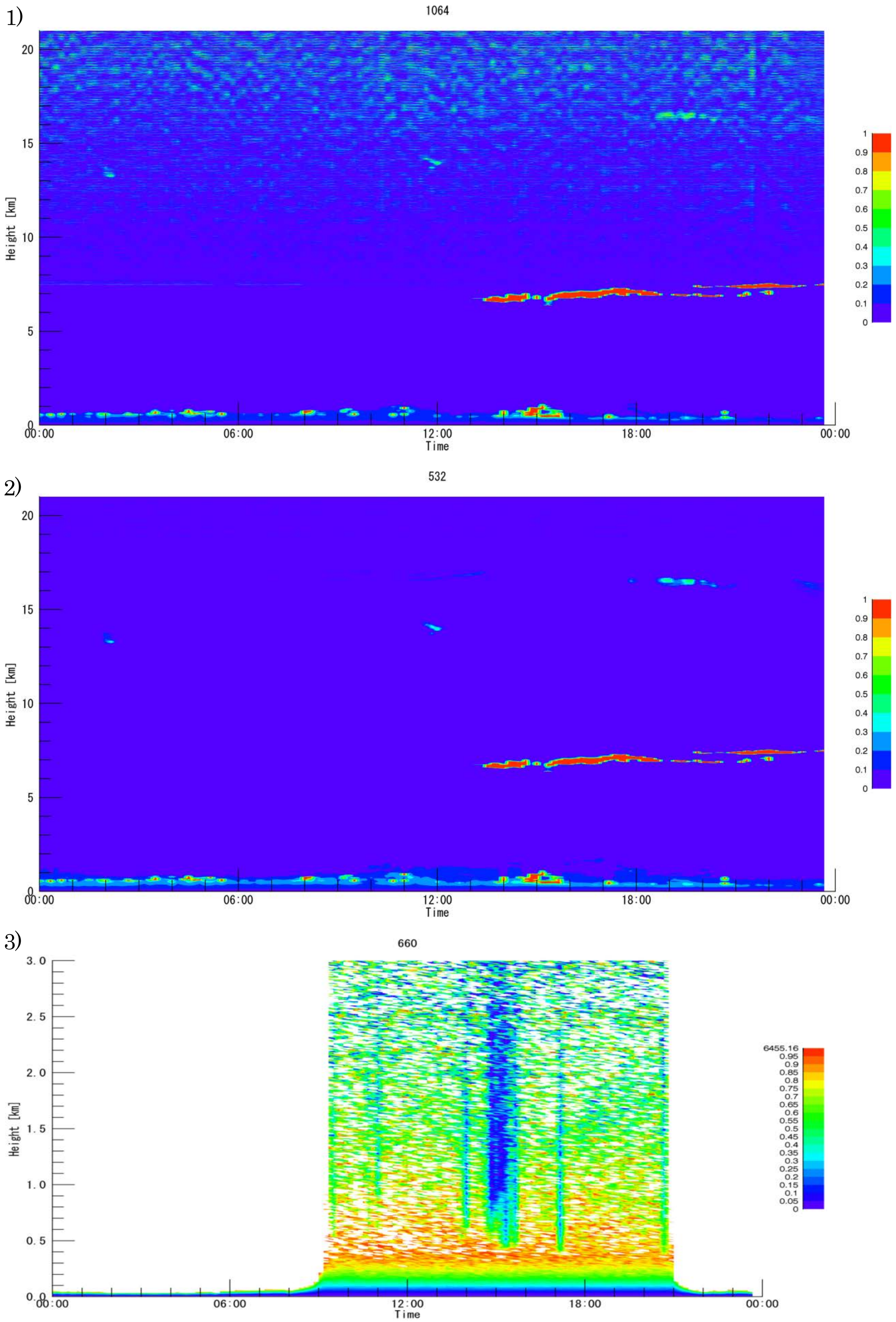


Fig6.5: Data obtained in 17 January, 2015 UTC at 1) 1064 nm, 2)532 nm and 3)660 nm.

6.6 Radiosonde observations

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	Principal Investigator (not on board)
Biao GENG	(JAMSTEC)	
Kyoko TANIGUCHI	(JAMSTEC)	
Ichiro MATSUI	(NIES)	
Shinya OKUMURA	(GODI)	Operation Leader
Kazuho YOSHIDA	(GODI)	
Yutaro MURAKAMI	(DODI)	

(2) Objectives

The objective of radiosonde observations is to obtain the atmospheric profile of temperature, humidity, and wind speed/direction, and their temporal variations over the tropical ocean.

(3) Operational methodology

The Vaisala GPS radiosonde sensor (RS92-SGPD) was launched with the balloons (Totex TA-200). The on-board radiosonde system consists of the processor (Vaisala, SPS-311), processing and recording software (DigiCORA III, ver.3.64), GPS antenna (GA20), UHF antenna (RB21), ground check kit (GC25), and automatic balloon launcher (ASAP). In addition, the pressure sensor (Vaisala PTB-330) was also utilized for ground check. In case the relative wind to the ship is not appropriate for using the automatic balloon launcher, the radiosonde equipped balloon was launched manually.

(4) Data

The radiosonde observations were conducted from Dec. 22, 2014 to Jan.17, 2015. During this period, 30 radiosonde equipped balloons have been launched (Table 6.6-1). The radiosonde observations were carried out when plenteous precipitating systems were near or over the ship (Fig. 6.6-1), as well as in fair weather conditions (Fig. 6.6-2). Detailed analyses of the data observed by the radiosonde will be performed after the cruise.

Most of the radiosonde data were sent to the world meteorological community via Global Telecommunication System (GTS) through the Japan Meteorological Agency, immediately after each observation. Raw data are recorded in Vaisala original binary format. The ASCII data are also available. These raw datasets will be submitted to JAMSTEC Data Integration and Analyses Group.

Table 6.6-1 Radiosonde launch log, with surface values and maximum height

ID	Date	Latitude	Longitude	Psfc	Tsfc	RHsfc	WD	Wsp	SST	Max height	
	YYYYMMDDHH	degN	degE	hPa	degC	%	deg	m/s	degC	hPa	m
RS001	2014122206	3.315	159.829	1003.2	26.9	87	129	9.2	29.865	75.2	18175
RS002	2014122212	2.118	159.920	1005.3	28.2	77	133	5.4	30.217	39.0	22046
RS003	2014122403	2.969	158.849	1002.2	26.7	86	277	6.2	30.802	26.9	24332
RS004	2014122406	−3.319	158.368	1002.4	27.7	85	275	4.2	30.399	28.5	23953
RS005	2014122600	−1.999	155.973	1004.4	28.4	73	358	7.3	30.458	23.3	25302
RS006	2014122800	−0.006	156.190	1006.3	27.7	77	173	0.8	30.590	27.5	24250
RS007	2014122803	−0.049	156.125	1004.0	27.4	88	43	7.4	30.556	40.1	21872
RS008	2014122809	0.174	156.156	1005.3	28.0	83	223	5.7	30.568	36.1	22528
RS009	2014123100	1.960	156.001	1004.6	27.4	87	112	6.5	30.295	20.9	25908
RS010	2015010200	4.984	156.084	1005.7	28.2	84	70	9.3	29.845	31.9	23315
RS011	2015010203	5.010	156.017	1003.6	27.7	88	51	6.9	29.766	56.9	19825
RS012	2015010205	5.005	156.065	1002.6	26.9	88	49	9.7	29.745	32.3	23169
RS013	2015010521	2.462	147.057	1003.5	27.7	83	288	5.2	29.667	27.0	24286
RS014	2015010600	2.053	147.012	1004.5	28.3	78	302	3.3	29.716	31.2	23420
RS015	2015010603	2.075	146.950	1002.7	27.0	85	354	5.2	29.742	32.5	23133
RS016	2015010605	1.964	147.036	1002.4	24.9	94	242	12.1	29.711	37.9	22169
RS017	2015010609	1.924	147.242	1002.6	26.7	87	48	1.3	29.710	32.7	23081
RS018	2015010703	2.020	147.009	1002.8	29.1	75	325	2.0	29.985	28.7	23849
RS019	2015011009	1.315	141.245	1004.2	27.0	84	356	3.3	29.679	48.8	20683
RS020	2015011306	4.961	137.315	1003.6	28.2	79	13	3.8	28.783	32.5	23131
RS021	2015011309	5.020	137.422	1004.9	25.7	91	59	5.9	28.762	43.6	21339
RS022	2015011312	5.078	137.487	1006.6	25.0	95	115	0.4	28.618	38.6	22086
RS023	2015011413	5.001	137.368	1005.7	26.8	92	248	6.5	28.486	24.8	24831
RS024	2015011416	4.996	137.380	1005.4	27.8	88	245	6.0	28.512	31.6	23291
RS025	2015011613	7.613	136.676	1007.3	28.1	78	219	4.2	28.939	32.8	23113
RS026	2015011616	7.633	136.701	1007.5	28.0	79	193	4.7	28.903	32.6	23138
RS027	2015011619	7.647	136.686	1005.8	27.9	79	192	8.2	28.901	38.8	22045
RS028	2015011700	7.642	136.695	1008.7	28.5	78	191	7.9	28.966	23.8	25082
RS029	2015011703	7.648	136.683	1008.1	28.5	75	187	6.5	29.077	24.5	24900
RS030	2015011706	7.665	136.621	1006.4	28.7	77	191	6.7	29.063	22.4	25437

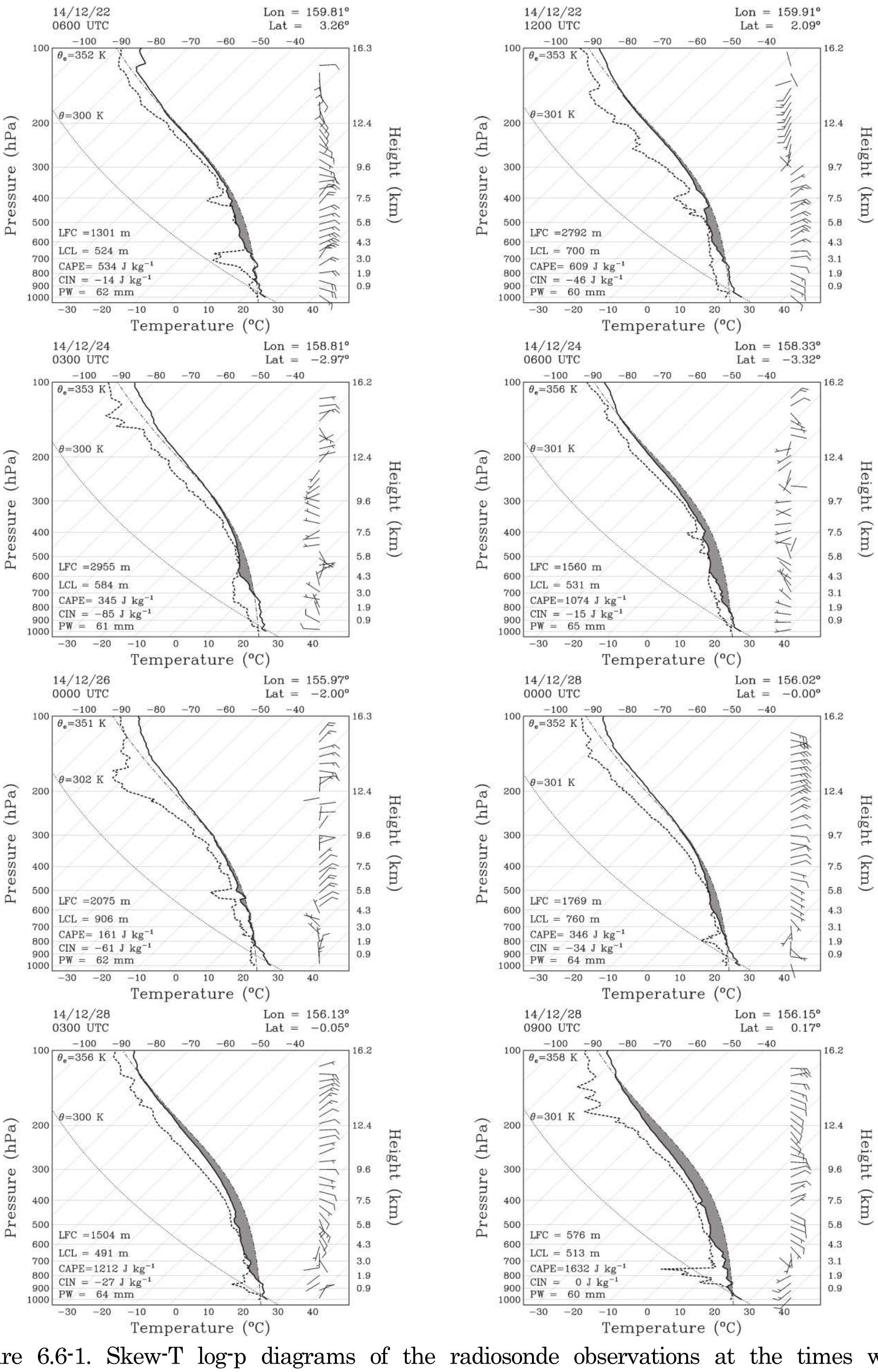


Figure 6.6-1. Skew-T log-p diagrams of the radiosonde observations at the times when precipitating systems were near or over the ship.

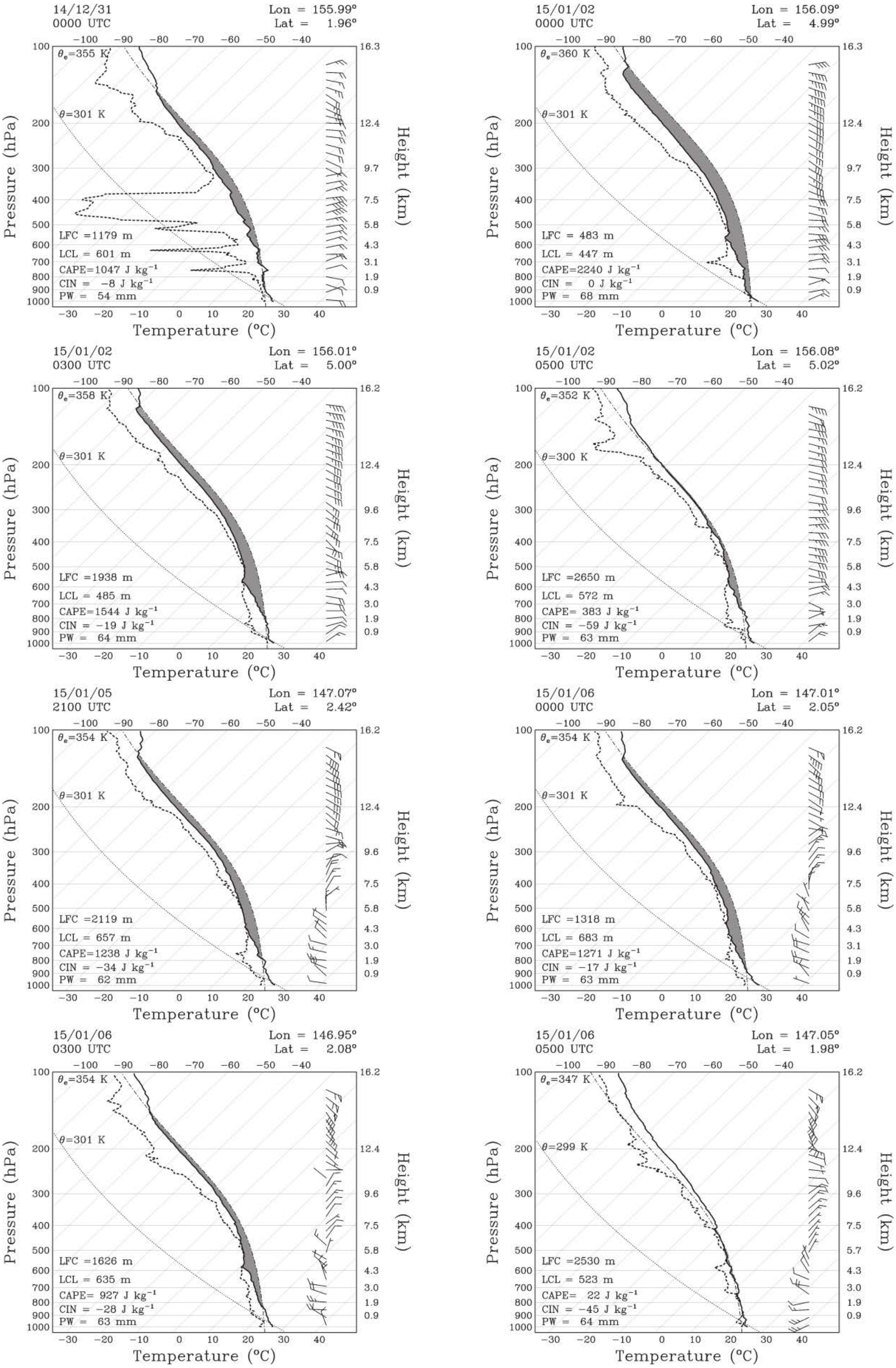


Figure 6.6-1. Continued.

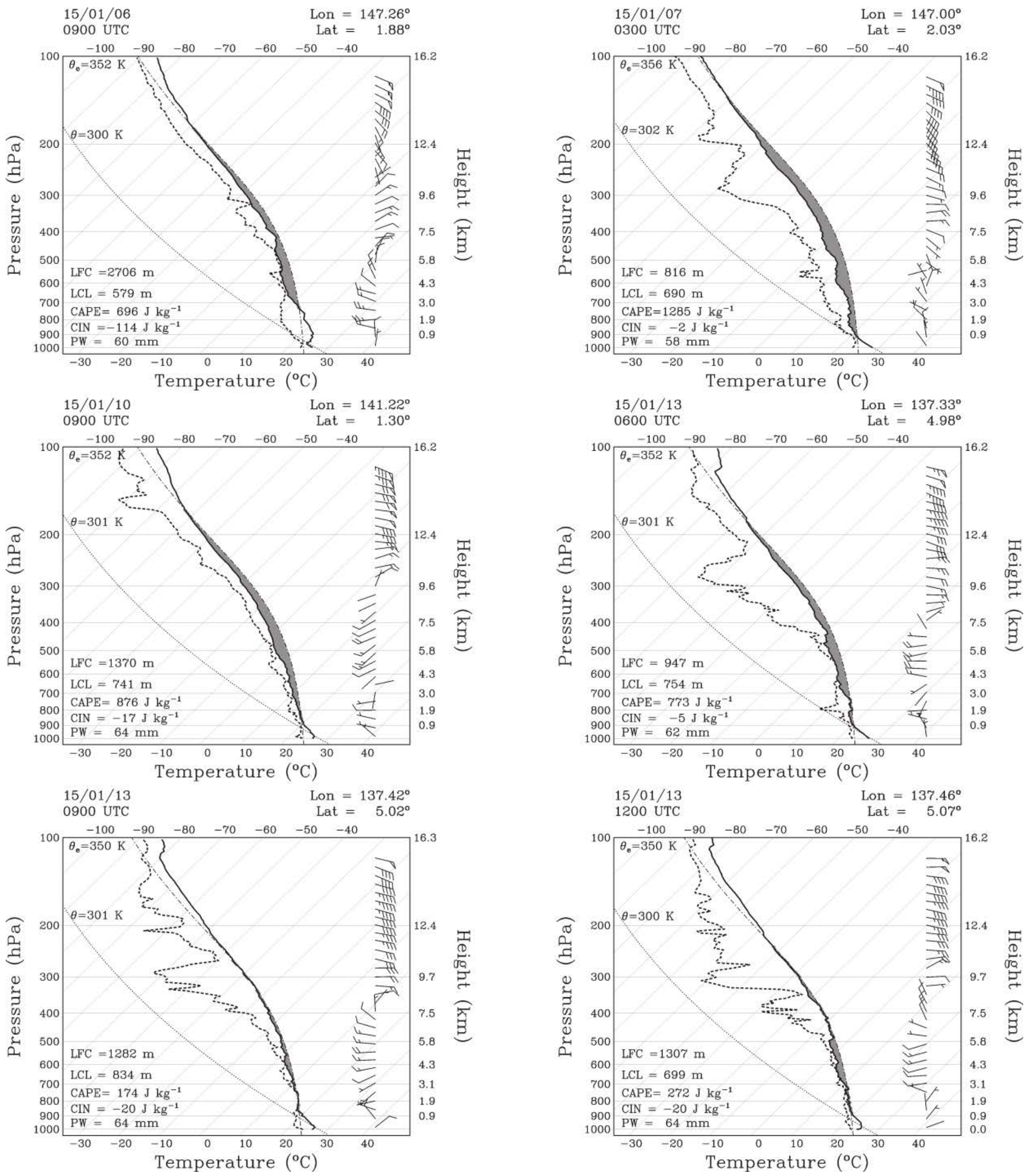


Figure 6.6-1. Continued.

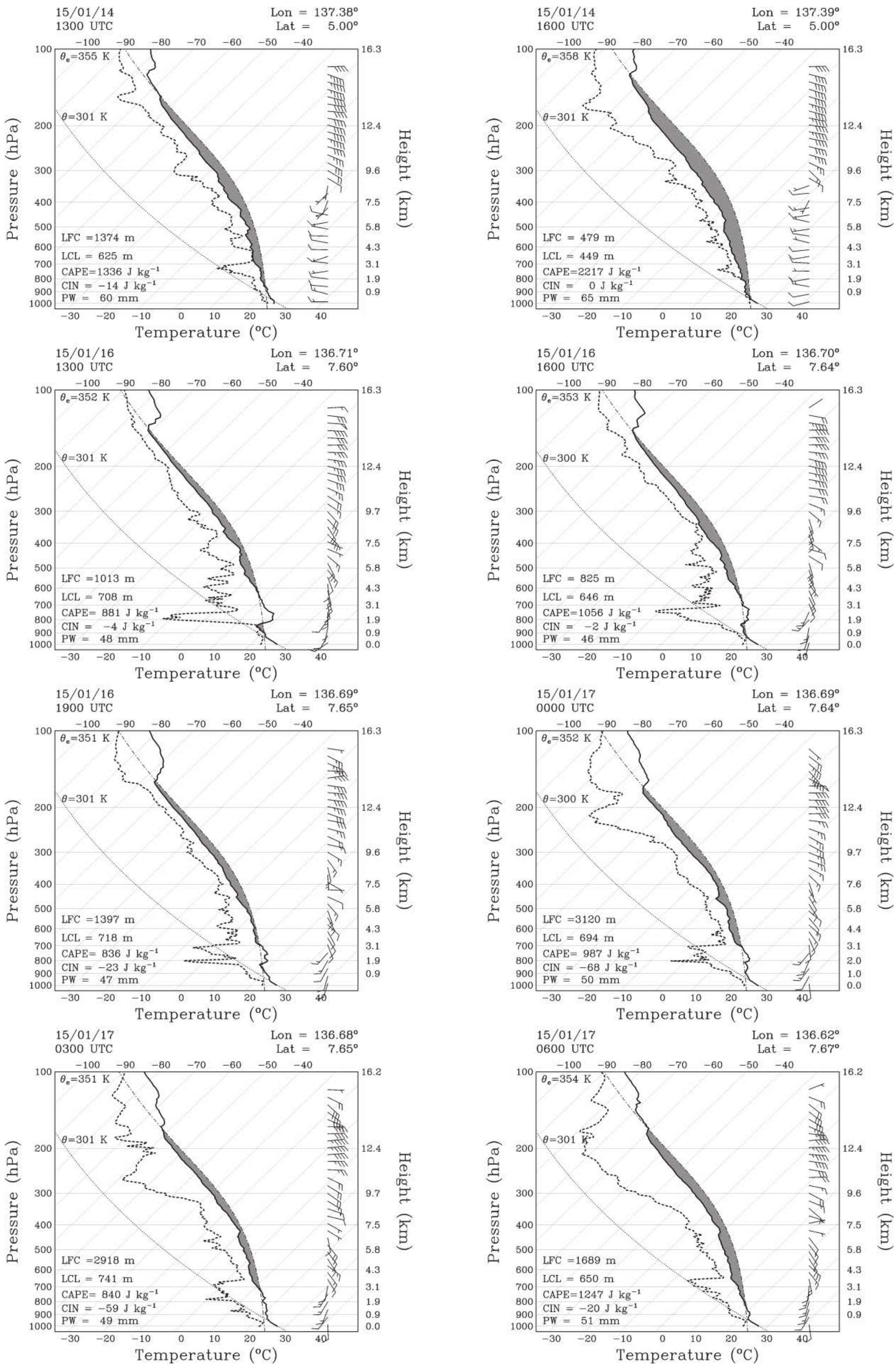


Figure 6.6-2. Skew-T log-p diagrams of the radiosonde observations in fair weather conditions.

6.7 Doppler radar observations

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	Principal Investigator (not on board)
Biao GENG	(JAMSTEC)	
Kyoko TANIGUCHI	(JAMSTEC)	
Ichiro MATSUI	(NIES)	
Shinya OKUMURA	(GODI)	Operation Leader of the Leg 2
Kazuho YOSHIDA	(GODI)	
Yutaro MURAKAMI	(DODI)	
Katsuhisa MAENO	(GODI)	Operation Leader of the Leg 3
Miki MORIOKA	(GODI)	

(2) Objective

The objective of Doppler radar observations in this cruise is to evaluate the performance of the newly installed radar, develop the better strategy of the radar observation, and investigate the structure and evolution of precipitating systems over the tropical ocean.

(3) Radar specifications

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

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

(4) Available radar variables

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

Radar reflectivity:	Z
Doppler velocity:	Vr
Spectrum width of Doppler velocity:	SW
Differential reflectivity:	ZDR
Differential propagation phase:	ΦDP
Specific differential phase:	KDP
Co-polar correlation coefficients:	ρHV

(5) Operational methodology

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

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

During the cruise, the radar was operated typically by repeating a volume scan with 18 PPIs (Plan Position Indicators) and several RHI (Range Height Indicator) scans every 6 minutes. A dual PRF mode with the maximum range of, typically 100 km, is used for the volume scan. For the RHI scan, a single PRF mode with the maximum range of 100 km is used. In addition, a surveillance PPI scan is performed every 30 minutes in a single PRF mode with the maximum range of 300 km. The scan strategy, as shown in Table 6.7-1, is kept same through the cruise to provide the same data quality to highlight the temporal variation of the precipitating systems.

Table 6.7-1 Parameters for scans

<table>
<tr><th></th><th>Surveillance PPI Scan</th><th colspan="6">Volume Scan</th><th>RHI Scan</th></tr>
<tr><td>Repeated Cycle (min.)</td><td>30</td><td colspan="7">6</td></tr>
<tr><td>Pulse Width (long / short, in microsec)</td><td>200 / 2</td><td colspan="2">64 / 1</td><td colspan="2">32 / 1</td><td colspan="2">32 / 1</td><td>32 / 1</td></tr>
<tr><td>Scan Speed (deg/sec)</td><td>36</td><td colspan="2">18</td><td colspan="2">24</td><td colspan="2">36</td><td>9</td></tr>
<tr><td rowspan="2">PRF(s) (Hz)</td><td rowspan="2">400</td><td colspan="6">dual PRF (ray alternative)</td><td rowspan="2">1250</td></tr>
<tr><td>667</td><td>833</td><td>938</td><td>1250</td><td>1333</td><td>2000</td></tr>
<tr><td>Pulses / Ray</td><td>8</td><td>26</td><td>33</td><td>27</td><td>34</td><td>37</td><td>55</td><td>32</td></tr>
<tr><td>Ray Spacing (deg.)</td><td>0.7</td><td colspan="2">0.7</td><td colspan="2">0.7</td><td colspan="2">1.0</td><td>0.2</td></tr>
<tr><td>Azimuth</td><td colspan="7">Full Circle</td><td>Option</td></tr>
<tr><td>Bin Spacing (m)</td><td colspan="8">150</td></tr>
<tr><td>Max. Range (km)</td><td>300</td><td colspan="2">150</td><td colspan="2">100</td><td colspan="2">60</td><td>100</td></tr>
<tr><td>Elevation Angle(s) (deg.)</td><td>0.5</td><td colspan="2">0.5</td><td colspan="2">1.0, 1.7, 2.4, 3.1, 3.8, 4.6, 5.6, 6.7, 8.2, 10.3, 12.8, 15.8</td><td colspan="2">19.4, 23.6, 28.4, 33.7, 40.0</td><td>0.0~ 45.0</td></tr>
</table>

(6) Data

The Doppler radar observations were conducted continuously from Dec. 20, 2014 to Jan.17, 2015, from Jan. 22 to 23, 2015, and from Jan. 30 to Feb. 9, 2015. During this period, precipitating systems, such as isolated cumulonimbus, mesoscale convective system, narrow rainband, etc., have been observed by the Doppler radar. Environments of these precipitating systems have also been observed by radiosondes during the Leg 2 of the cruise. Figure 6.7-1 shows horizontal distributions of reflectivity observed by the Doppler radar at the times when radiosonde equipped balloons were launched. Detailed analyses of the data observed by the Doppler radar will be performed after the cruise.

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

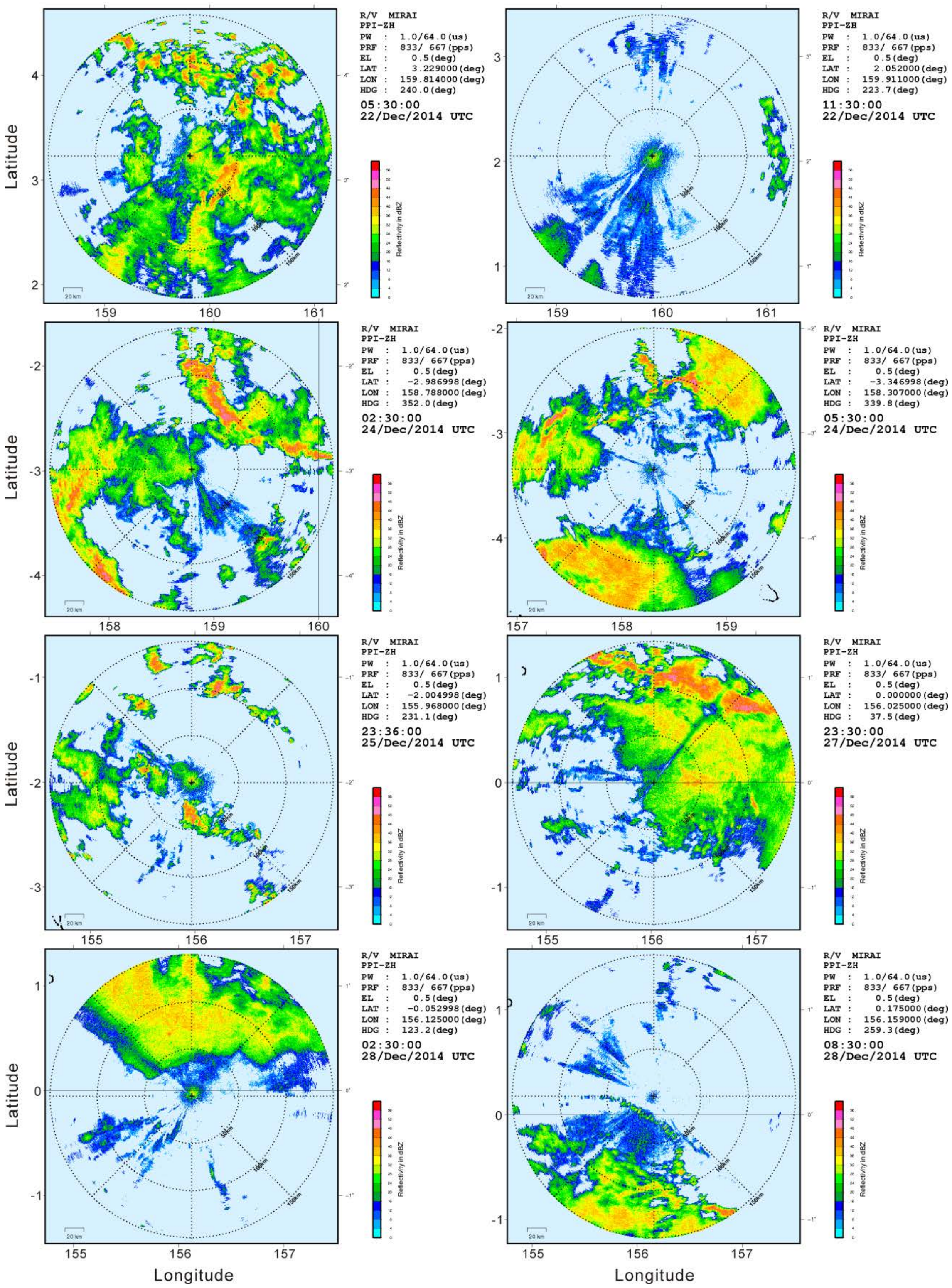


Figure 6.7-1. PPI plots of reflectivity at the times when radiosonde equipped balloons were launched.

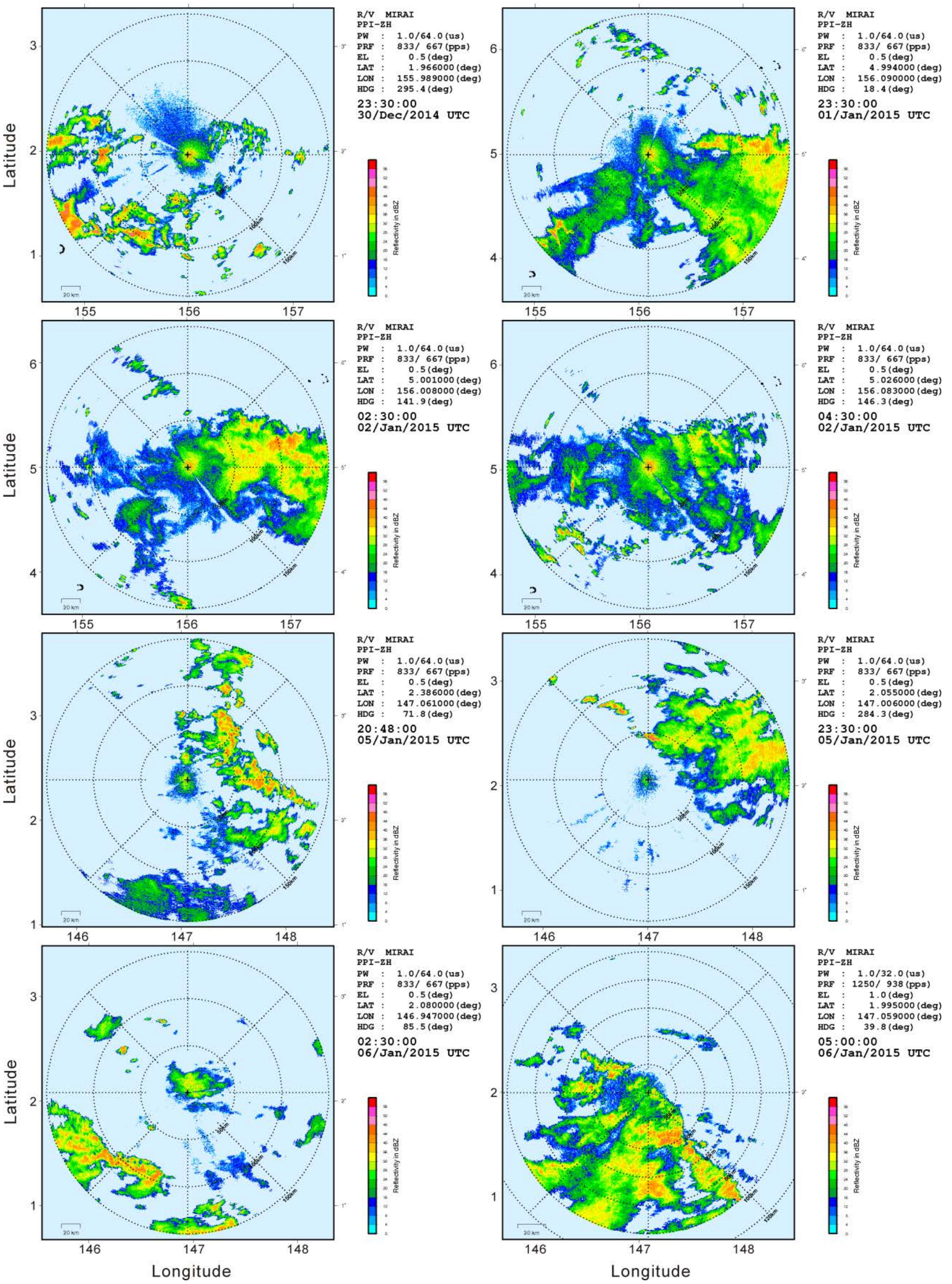


Figure 6.7-1. Continued.

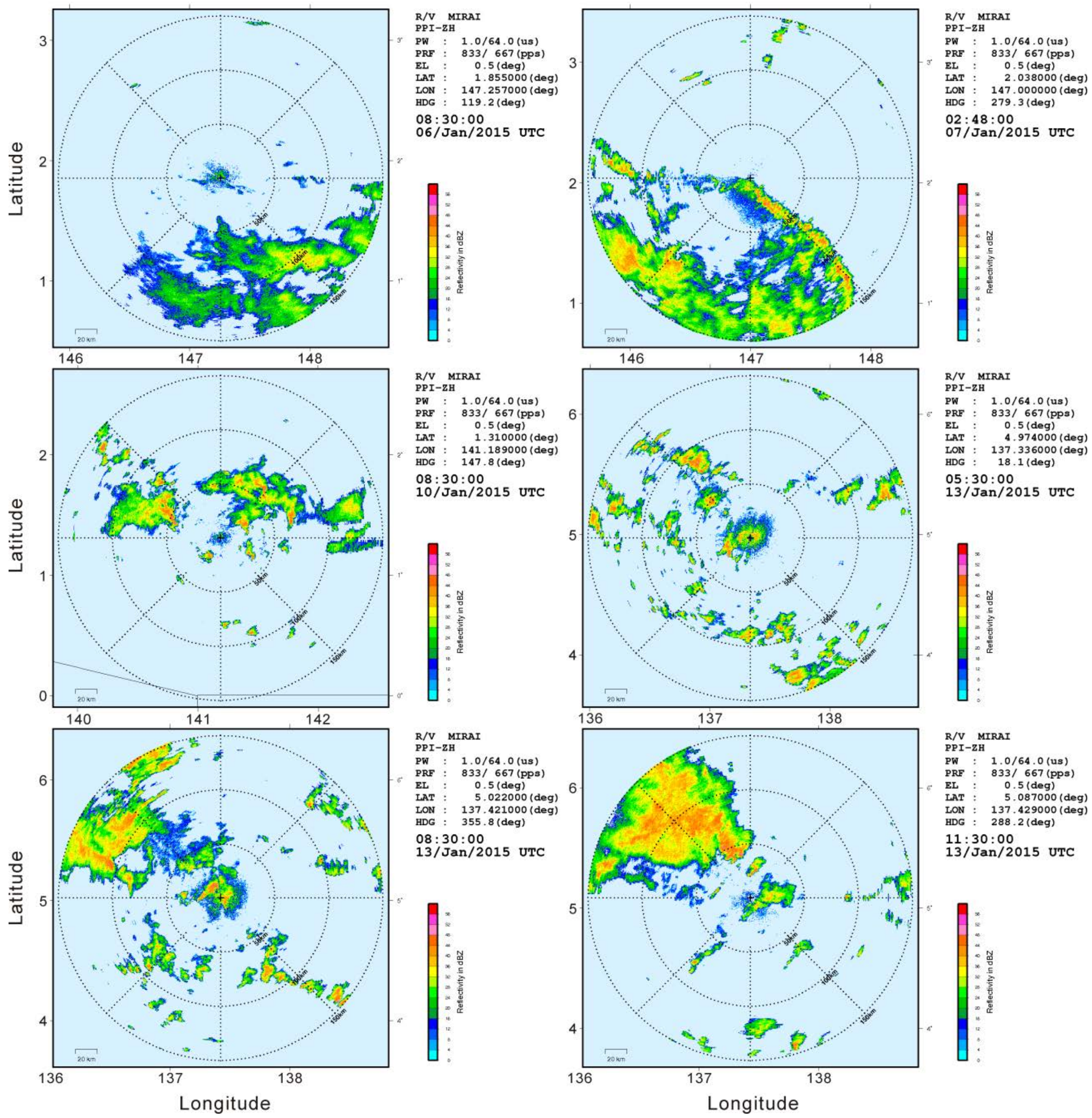


Figure 6.7-1. Continued.

6. 8. Disdrometers

(1) Personnel

Masaki Katsumata (JAMSTEC) Principal investigator

(2) Objectives

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

(3) Parameters

・Number and size of precipitating particles

(4) Methods

Four different types of disdrometers are utilized to obtain better reasonable and accurate value on the moving vessel. Three of the disdrometers and one optical rain gauge are installed in one place, the starboard side on the roof of the anti-rolling system of R/V Mirai, as in Fig. 6.8-1. One of the disdrometers named "micro rain radar" is installed at the starboard side of the anti-rolling systems (see Fig. 6.8-2).

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

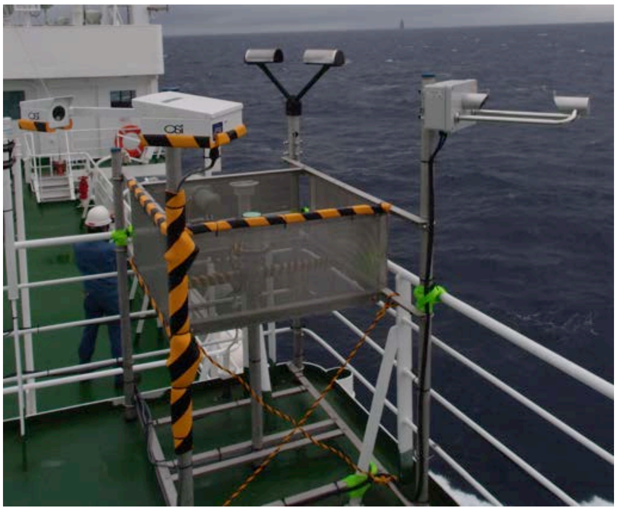


Fig. 6.8-1: The three disdrometers (Parsivel, LPM and Joss-Waldvogel disdrometer) and an optical rain gauge, installed on the roof of the anti-rolling tank.

Fig. 6.8-2: The micro rain radar, installed on the starboard side of the anti-rolling tank.

a. Joss-Waldvogel type disdrometer

The "Joss-Waldvogel-type" disdrometer system (RD-80, Disdromet Inc.) (hereafter JW) equipped a microphone on the top of the sensor unit. When a raindrop hit the microphone, the magnitude of induced sound is converted to the size of raindrops. The logging program "DISDRODATA" determines the size as one of the 20 categories as in Table 6.8-1, and accumulates the number of raindrops at each category. The rainfall amount could be also retrieved from the obtained drop size distribution. The number of raindrops in each category, and converted rainfall amount, are recorded every one minute.

b. Laser Precipitation Monitor (LPM) optical disdrometer

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

The number of particles are categorized by the detected size and fall speed and counted every minutes. The categories are shown in Table 6.8-2.

c. "Parsivel" optical disdrometer

The "Parsivel" (OTT Hydromet GmbH) is another optical disdrometer. The principle is same as the LPM. The sampling volume, i.e. the size of the laser beam "sheet", is 30 mm (W) x 180 mm (D). The categories are shown in Table 6.8-3.

d. Optical rain gauge

The optical rain gauge, which detect scintillation of the laser by falling raindrops, is installed beside the above three disdrometers to measure the exact rainfall. The ORG-6.8DR (Optical Scientific Inc.) is utilized with the controlling and recording software (manufactured by Sankosha Co.).

e. Micro rain radar

The MRR-2 (METEK GmbH) was utilized. The specifications are in Table 6.8-4. The antenna unit was installed at the starboard side of the anti-rolling systems (see Fig. 6.8-2), and wired to the junction box and laptop PC inside the vessel.

The data was averaged and stored every one minute. The vertical profile of each parameter was obtained every 200 meters in range distance (i.e. height) up to 6200 meters, i.e. well beyond the melting layer. The drop size distribution is recorded, as well as radar reflectivity, path-integrated attenuation, rain rate, liquid water content and fall velocity.

(5) Preliminary Results

The data were obtained continuously thru the cruise from Dec. 20 to Feb. 25, except the EEZs and territorial waters without permissions. The further analyses will be done after the cruise.

(6) Data archive

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

(7) Acknowledgment

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

Table 6.8-1: Category number and corresponding size of the raindrops for JW disdrometer.

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

Table 6.8-2: Categories of the size and the fall speed for LPM.

Particle Size			Fall Speed		
Class	Diameter [mm]	Class width [mm]	Class	Speed [m/s]	Class width [m/s]
1	≥ 0.125	0.125	1	≥ 0.000	0.200
2	≥ 0.250	0.125	2	≥ 0.200	0.200
3	≥ 0.375	0.125	3	≥ 0.400	0.200
4	≥ 0.500	0.250	4	≥ 0.600	0.200
5	≥ 0.750	0.250	5	≥ 0.800	0.200
6	≥ 1.000	0.250	6	≥ 1.000	0.400
7	≥ 1.250	0.250	7	≥ 1.400	0.400
8	≥ 1.500	0.250	8	≥ 1.800	0.400
9	≥ 1.750	0.250	9	≥ 2.200	0.400
10	≥ 2.000	0.500	10	≥ 2.600	0.400
11	≥ 2.500	0.500	11	≥ 3.000	0.800
12	≥ 3.000	0.500	12	≥ 3.400	0.800
13	≥ 3.500	0.500	13	≥ 4.200	0.800
14	≥ 4.000	0.500	14	≥ 5.000	0.800
15	≥ 4.500	0.500	15	≥ 5.800	0.800
16	≥ 5.000	0.500	16	≥ 6.600	0.800
17	≥ 5.500	0.500	17	≥ 7.400	0.800
18	≥ 6.000	0.500	18	≥ 8.200	0.800
19	≥ 6.500	0.500	19	≥ 9.000	1.000
20	≥ 7.000	0.500	20	≥ 10.000	10.000
21	≥ 7.500	0.500			
22	≥ 8.000	unlimited			

Table 6.8-3: Categories of the size and the fall speed for Parsivel.

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

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

Table 6.8-4: Specifications of the MRR-2.

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

6. 9. Aerosol optical characteristics measured by ship-borne sky radiometer

(1) Personnel

Kazuma Aoki (University of Toyama) Principal Investigator - Not Onboard -
Tadahiro Hayasaka (Tohoku University) Co-worker - Not Onboard -
Sky radiometer operation was supported by GODI.

(2) Objectives

Objective of this observation is to study distribution and optical characteristics of marine aerosols by using a ship-borne sky radiometer (POM-01 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 archive

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

6.10 Tropospheric gas and particle observation in the marine atmosphere

(1) Personnel
Yugo KANAYA (JAMSTEC DEGCR, not on board)
Fumikazu TAKETANI (JAMSTEC DEGCR, not on board)
Takuma MIYAKAWA (JAMSTEC DEGCR, not on board)
Hisahiro TAKASHIMA (JAMSTEC DEGCR, not on board)
Yuichi KOMAZAKI (JAMSTEC DEGCR, not on board)
Maki NOGUCHI (JAMSTEC RCGC, not on board)
Operation was supported by Global Ocean Development Inc.

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

(3) Parameter
- Black carbon(BC) particles
- Composition of ambient particles
- Aerosol optical depth (AOD) and Aerosol extinction coefficient (AEC)
- Surface ozone(O_3), and carbon monoxide(CO) mixing ratios

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

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

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

Ambient aerosol particles were collected along cruise track using a high-volume air sampler (HV-525PM, SIBATA) located on the flying bridge operated at a flow rate of 500 L min-1. To avoid collecting particles emitted from the funnel of the own vessel, the sampling period was controlled automatically by using a "wind-direction selection system". Coarse and fine particles separated at the diameter of 2.5 μm were collected on quartz filters. The filter samples obtained during the cruise are subject to chemical analysis of aerosol composition, including water-soluble ions and trace metals.

(4-3) MAX-DOAS

Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS), a passive remote sensing technique measuring spectra of scattered visible and ultraviolet (UV) solar radiation, was used for atmospheric aerosol and gas profile measurements. Our MAX-DOAS instrument consists of two main parts: an outdoor telescope unit and an indoor spectrometer (Acton SP-2358 with Princeton Instruments PIXIS-400B), connected to each other by a 14-m bundle optical fiber cable. The line of sight was in the directions of the portside of the vessel and the measurements were made at several elevation angles of 1.5, 3, 5, 10, 20, 30, 90 degrees using a movable prism, which repeated the same sequence of elevation angles every ~15-min.For the selected spectra recorded with elevation angles with good accuracy, DOAS spectral fitting was performed to quantify the slant column density (SCD) of NO2 (and other gases) and O4 (O2-O2, collision complex of oxygen) for each elevation angle. Then, the O4 SCDs were converted to the aerosol optical depth (AOD) and the vertical profile of aerosol extinction coefficient (AEC) using an optimal estimation inversion method with a radiative transfer model. Using derived aerosol information, retrievals of the tropospheric vertical column/profile of NO2 and other gases were made.

(4-4) CO and O3

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

(5) Observation log

The shipboard measurements and sampling were conducted in the open sea. Ambient air sampling by high-volume air sampler was carried out 10 times in the cruise.

(6) Preliminary results

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

(7) Data archive

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

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

(1) Personnel

Shuji Kawakami	(JAXA) Principal investigator	- Not Onboard -
Kei Shiomi	(JAXA)	- Not Onboard -

(2) Objectives

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

(3) Description of instruments deployed

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

Figure 6-12-1. Solar tracker and telescope. The sunlight collected into optical fiber was introduced into the OSA that was installed in an observation room in the MIRAI.

(4) Analysis method

The CO_2 absorption spectrum at the 1.6 μm band measured with the OSA is shown in Figure 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. Figure 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.

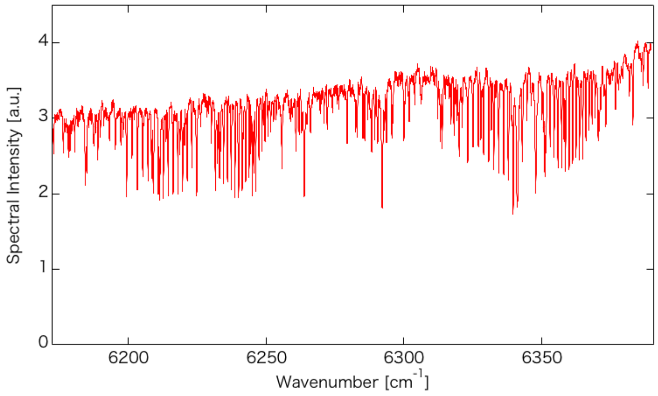


Figure 6-12-2. 1.6 μm CO_2 absorption spectrum measured with the OSA.

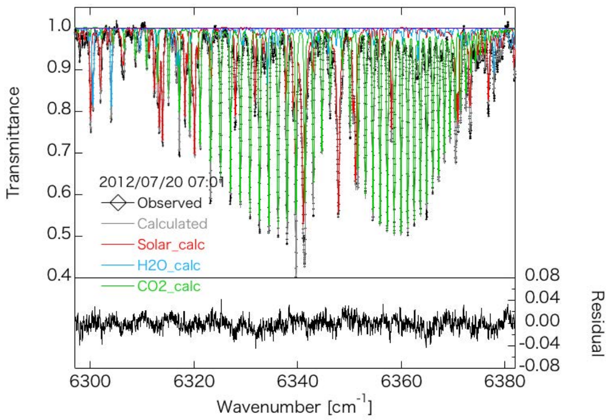


Figure 6-12-3. Spectral fit performed for the 6297–6382 cm^{-1} region using an OSA spectrum. Open diamonds denote the measured spectrum, and the solid line denotes the spectrum calculated from the retrieval result. The residual between the measured and calculated spectra is also shown as an example.

(5) Preliminary results

The observations were made from December 16, 2014 to January 18, 2015 (JST, Leg 2) and from January 22 to February 21, 2015 (JST, Leg 3), continuously in daytime, including data obtained in the high seas (Table 1 and Figure 4).

Table 6-12-1. Period of CO_2 observations

CO_2 observations (Leg 2)			CO_2 observations (Leg 3)		
Date	Start Time(JST)	End Time(JST)	Date	Start Time(JST)	End Time(JST)
2014/12/20	12:00	15:16	2015/1/22	14:08	17:03
2014/12/21	5:56	15:16	2015/1/30	15:28	19:55
2014/12/21	5:56	15:16	2015/1/31	9:22	18:33
2014/12/23	5:18	13:41	2015/2/1	10:31	18:47
2014/12/24	13:07	13:19	2015/2/2	9:28	20:21
2014/12/25	5:25	15:33	2015/2/3	9:37	20:20
2014/12/26	9:37	13:23	2015/2/4	9:35	20:05
2014/12/27	5:33	15:53	2015/2/5	11:43	20:15
2014/12/28	12:26	12:29	2015/2/6	17:56	18:16
2014/12/29	5:41	15:58	2015/2/7	9:53	20:31
2014/12/30	5:25	13:06	2015/2/8	9:57	18:23
2014/12/31	8:02	15:51	2015/2/18	8:48	17:44
2015/1/1	6:24	13:42	2015/2/19	7:56	17:19
2015/1/1	6:24	13:42	2015/2/20	11:43	15:37
2015/1/3	8:26	11:08	2015/2/21	8:16	13:39
2015/1/3	8:26	11:08			
2015/1/5	6:49	12:37			
2015/1/6	14:56	14:59			
2015/1/7	6:05	15:41			
2015/1/8	8:25	14:58			
2015/1/9	8:06	16:40			
2015/1/10	9:14	13:40			
2015/1/11	8:12	17:10			
2015/1/12	6:46	11:44			
2015/1/13	8:56	15:42			
2015/1/14	7:05	17:08			
2015/1/15	6:51	17:29			
2015/1/16	6:58	17:14			
2015/1/17	7:04	17:04			
2015/1/18	7:06	7:27			

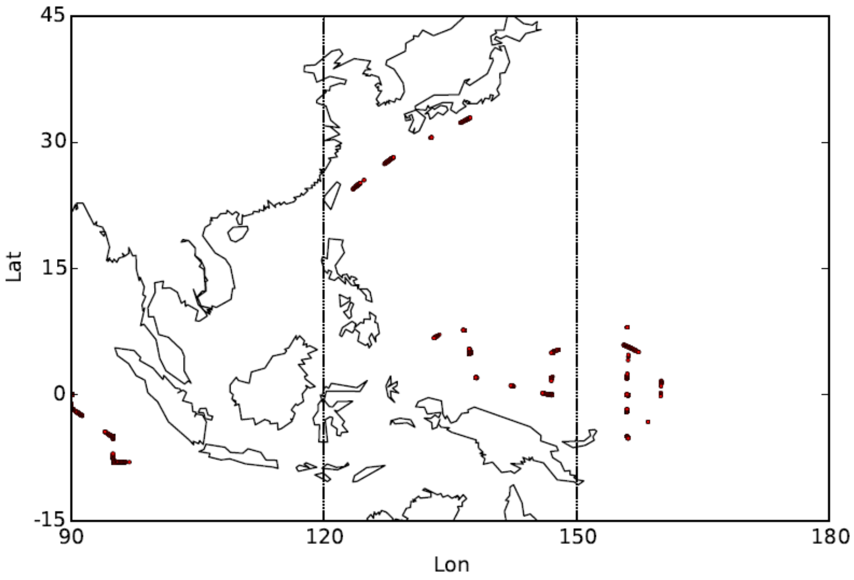


Figure 6-12-4. Locations of CO_2 observations

(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 JAMSTEC Data Management Group (DMG).

6. 12. Underway pCO_2 measurement

(1) Personnel

Akihiko Murata	(JAMSTEC) Principal investigator	- Not Onboard -
Yoshiko Ishikawa	(MWJ)	
Atsushi Ono	(MWJ)	

(2) Objectives

Concentrations of CO_2 in the atmosphere are now increasing at a rate of about 2.0 ppmv y^{-1} owing to human activities such as burning of fossil fuels, deforestation, and cement production. It is an urgent task to estimate as accurately as possible the absorption capacity of the oceans against the increased atmospheric CO_2, and to clarify the mechanism of the CO_2 absorption, because the magnitude of the anticipated global warming depends on the levels of CO_2 in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities.

In this cruise, we were aimed at quantifying how much anthropogenic CO_2 absorbed in the surface ocean in the subtropical regions of North Pacific and eastern Indian. For the purpose, we measured pCO_2 (partial pressure of CO_2) in the atmosphere and surface seawater.

(3) Apparatus

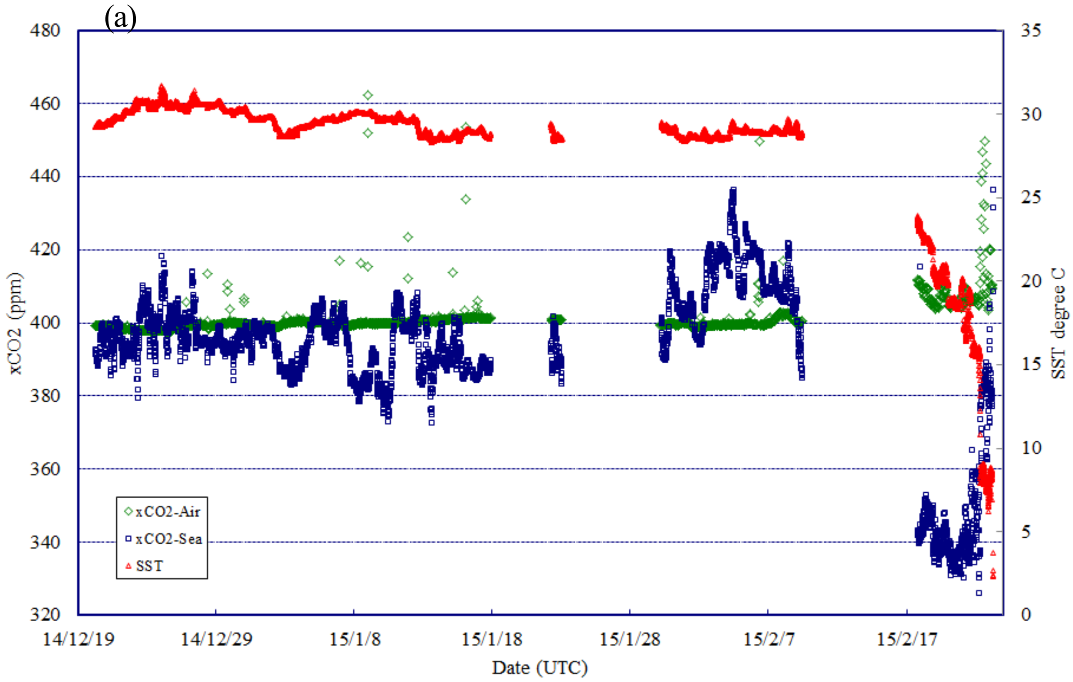
Concentrations of CO_2 in the atmosphere and the sea surface were measured continuously during the cruise using an automated system with a non-dispersive infrared (NDIR) analyzer (Li-COR LI-7000). The automated system (Nippon ANS) was operated by about one and a half hour cycle. In one cycle, standard gasses, marine air and an air in a headspace of an equilibrator were analyzed subsequently. The calibrated concentrations of the standard gas were 269.06, 330.21, 359.34 and 419.29 ppmv. To check drifts of gas concentrations, the standard gases are calibrated again after the cruise.

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

A fixed volume of the marine air taken from the bow was equilibrated with a stream of seawater that flowed at a rate of 4.0 – 5.0 L/min in the equilibrator. The air in the equilibrator was circulated with a pump at 0.7-0.8L/min in a closed loop passing through two cooling units, a perma-pure dryer (GL Science Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

(4) Results

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



(b)

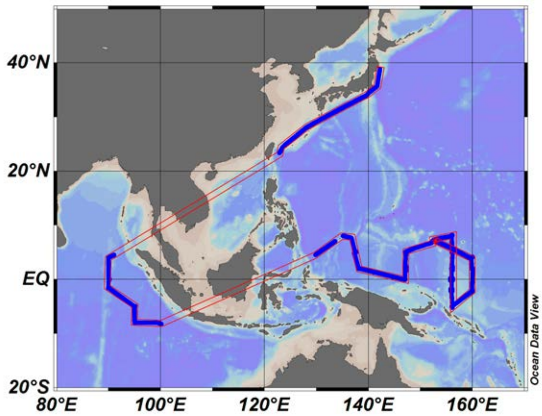


Figure 6-13-1. Distributions of (a) CO_2 (ppmv) in marine air and in surface sweater, and SST. The cruise track along which CO_2 was measured is shown in (b).

6.13 Distribution, Cool-Tolerance and Super Cooling Point of the Oceanic Sea Skaters of, *Halobates* (Heteroptera: Gerridae) Inhabiting tropical area of 10ºN-05ºS and 130ºE-160ºE in the Pacific Ocean

(1) Personnel

Tetsuo Harada (Kochi University) Principal Investigator
Noritomo Umamoto (Kochi University) Graduate Student

(2) Objectives

This study as this scientific cruise, MR14-06-Leg 2 aims, first, to examine the population density of the oceanic sea skaters of *Halobates* (Heteroptera: Gerridae) inhabiting the tropical pacific ocean of 5ºS-8ºN, 138ºE-157ºE in December 2014 and January 2015. This study aims, second, to examine whether sea skaters, living in the tropical Pacific Ocean show a significant positive correlation between cool tolerance and super cooling points (SCP) and also to examine some relationship of cool tolerance and SCP to several oceanic dynamism as several factors like as precipitation, waves, air temperature, chlorophyll conc. and dissolved oxygen conc. in surface water. This study tries to evaluate the SCP as an indicator of cool tolerance of *Halobates* due to the correlative analysis between the cool hardiness and SCP.

(3) Materials and methods

Samplings

Samplings were performed in 25th December 2014 to 17th January 2015 in the area of 5ºS-8ºN, 138ºE-157ºE with a Neuston NET (6 m long and with diameter of 1.3 m.) (Photo 1). The Neuston NET was trailed for 15 mm x 3 times as one set-trial on the sea surface. Ten set-trials have been performed in total from the starboard side of R/V MIRAI (8687t) which is owned by JAMSTEC (Japan Agency for Marine-Earth Science and Technology). The trailing was performed for 15min at night for 8 set-trials and in the daytime for 2 set-trials with the ship speed of 2.0 knot to the sea water (Photo 1). It was repeated 2 times in each station. Surface area which was swept by Neuston NET was evaluated as an expression of [flow-meter value x 1.3m of width of the Neuston NET.

Treatments of specimens after the samplings and before the experiments

Sea skaters trapped in the pants (grey plastic bottle) located and fixed at the end of Neuston NET (Photo 2) were paralyzed with the physical shock due to the trailing of the NET. Such paralyzed sea skaters were transferred on the surface of paper towel to respire. Then, the paralysis of some ones was discontinued within 20 min. When sea skaters were trapped in the jelly of jelly fishes, the jelly was removed from the body of sea skaters very carefully and quickly by hand for the recovering out of the paralysis.

Adults which recovered out of the paralysis were moved on the sea water in the aquaria set in the laboratory for the Cool Coma Experiments and measuring Super Cooling Points. Many white cube aquaria (30cm × 30cm × 40cm) were used in the laboratory of the ship for rearing of the adults which had been recovered out of the paralysis due to the trailing. Each aquarium contained ten to forty adults of *Halobates*. Both the room temperature and sea water temperature in the aquaria were kept at 29 ± 2. For 11-12 hours after the collection, sea skaters were kept in the aquaria before the Cool Coma Experiment. All the individuals of *Halobates* kept in the aquaria were fed on adult flies, *Lucillia illustris.* Foods were given and replaced to new ones every day and sea water in the aquaria was replaced by the new one at least two times at

8:00 and at 18:00 because of avoidance from water pollution due to the foods.

No foods were given for more than 12 hours before measuring SCP, because the contents of alimentary canal would be possible to become ice-nuclei substances. The transparent round-shaped aquarium as the experimental arena has sea water with the same temperature (mostly 28 or 30) as that of the aquarium where sea skaters had been kept. Twelve or thirteen adults or 5th instar larvae specimens were moved to the Low Temperature Thermostatic Water Bath (Thomas: T22LA) (55cm × 40cm × 35cm). Temperature was gradually decreased (1 ºC per 3-5 min) by 1 every 15 min by the automatic cooling system of the water bath till the cool temperature coma occurring in all the experimental specimens.

Temperature was very precisely controlled by automatic thermo-stat system of the water bath. Temperature at which Semi Cool Coma (Semi Cool Coma Temperature [SCCT]: extremely inhibited movement on the water surface more than 5 seconds) occurs and Temperature at which Cool Coma (Cool Coma Temperature [CCT]: ventral surface of the body was caught by sea water film and no ability to skate any more) occurs were recorded.

Determination of super cooling point (SCP)

Measurements of super cooling points and increasing temperature value at the moment of an exothermic event which has occurred in the body of the specimen (ITSCP: increased temperature at SCP) were performed for the adult specimen paralyzed by low temperature of the three species of oceanic sea skaters (*Halobates micans and H. germanus*) just after the cool coma experiment during this cruise.

Surface of each adult was dried with filter paper, and thermocouples which consist of nickel and bronze were attached to the abdominal surface of the thorax and connected to automatic temperature digital recorders (Digital Thermometer, Yokogawa Co, LTD, Model 10, Made in Japan). The thermocouple was completely fixed to be attached to the ventral surface of abdomen by a kind of Scotch tape. The specimen attached to thermocouples was placed into a compressed-Styrofoam box (5×5×3 cm^3) which was again set inside another insulating larger compressed Styrofoam to ensure that the cooling rate was about 1ºC/min for recording the SCP in the freezer in which temperature was -35ºC. The lowest temperature which reached before an exothermic event occurred due to release of latent heat was regarded as the SCP (Zhao and Kang, 2000). All tested specimen were killed by the body-freezing when SCP was determined.

(4) Results and discussion

Distribution

The samplings of *Halobates* (Table 1) inhabiting tropical stations around equator in the Pacific Ocean resulted in that 1-61 individuals of oceanic sea skaters were collected per one Neuston-net sampling for 15 min. Not the smallest species of *H. sericeus* but the two species of largest species as *H. micans* (Photo 2) and middle sized species of *H. germanus,* were collected in the area of 8ºN-7º38'S, 136º40'E-156ºE. The population density in this area was 3689.0 / 1 km^2 for *H. micans* and 17160.6 for *H. germanus*. On the station of 12ºN 135ºE during the cruise MR-13-03, the population density of *H. micans and H. germanus* was 9848.3 and 11688, respectively. In the area near to the islands, *H. germanus* might be more dominant than the *H. micans.* At the area of 8ºN-7º38'S, 136º40'E-156ºE, larvae were collected at 24 of 27 Neuston-net samplings for 15 min., Growth activity might be very active in this area.

Cool Coma Experiment and Measurement of Super Cooling Points

Cool-coma temperature (CCT), Semi cool-coma temperature (SCCT), gap temperature for cool coma (GTCC), super cooling point (SCP) and increased temperature at super cooling point (ITSCP) were ranged 5.0ºC to 20.0ºC, 15.0ºC to 26.0ºC, 4ºC to 15ºC, -19.3ºC to -5.6ºC and 0.7ºC to 11.2Cº, respectively.

The values of CCT, CCCT, GTCC, SCP and ITSCP were compared with those during the cruse, MR13-03. CCTs, SCCTs in this study were significantly lower than those during the cruise of MR13-03. GTCCs in this cruise were also larger than those at MR13-03. The area in this cruise has high precipitation through the year because of the islands nearby. The precipitation on the sea leads to the abrupt lower change in air temperature down to 25 Cº . The high tolerance to lower temperature shown in this study could be selected by such high temperature fluctuation in this sampling area.

(5) Additional analyisis

It will be analyzed how the data on field samplings in this study are related to environmental data as the oceanography data (for example, surface sea temperature and air temperature, chlorophyll contents and dissolved oxygen level) at sampling stations in the area of 8ºN-7º38'S, 136º40'E-156ºE during this cruise. This relationship can be compared to other similar analyses on the data collected in the area of 4ºS to 13ºS and 8ºN to 6ºS in the Indian Ocean at two cruises, KH-10-05-Leg 1 (Harada et al., 2010a) and KH-07-04-Leg1 (Harada et al., 2010b, 2011a), respectively and also in the area of 30º-35ºN along the Kuroshio Current at the cruises, KT-07-19, KT-08-23, KT-09-20 and the other R/V TANSEIMARU cruises held in the past (Harada et al., 2015).

ACKNOWLEDGEMENT

We would like to thank Dr. K. ANDO (Chief Scientist of the cruise: MR14-06 Leg 2, Senior Scientist, JAMSTEC: Japan Agency for Marine and Earth Sciences and Technology) for his permission of doing this study during the cruise on the R/V MIRAI, for his warm suggestion on this study, and encouragement and help throughout this cruise. The samplings and the experimental study were also possible due to supports from all of the crew (Captain: Mr. H. MATSUURA) and all the scientists and the engineers from MWJ and GODI in this cruise. We would like to give special thanks to them.

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Photo 1: a trailing scene of Neuston-NET

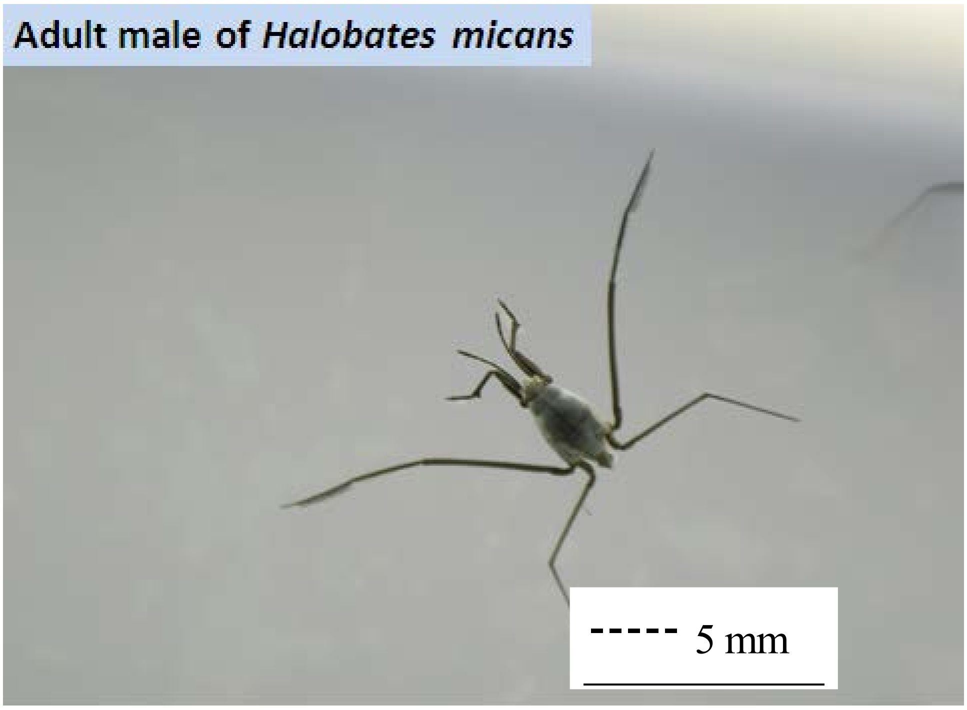


Photo 2: Adult male of *Halobates micans*.

Table 1-1: Number of oceanic sea skaters, *Halobates* collected at locations in the tropical pacific ocean in December 20th, 2014 - January 19th during the science cruise, MR14-06-Leg 2 (N: Total number of individuals collected; *H.s.: Halobates sericeus*;; Stat: Station number; WT: Water temperature (℃); AT: Air temp.; L: N of larvae; A: N of adults, E: N of exuviae; Date: sampling date; Sampling was performed for 45min. EG: eggs on some substrates like as polystyrene form thousands of eggs laid on the substrate. S: Surface area which was swept by Neuston NET was expressed as value of flow-meter x 1.3m of width of Neuston NET; WS: wind speed (m/s); W: weather; TD: Time of day; WS: Wind speed, CS: Current speed(m/s);CD: Current direction; F: female; M: male, S: salinity of sea surface (‰), Chla: Chlorophyll A (RFU); DO (dissolved oxygen: micro mol / kg)

Lat.	Lon.	N	L	A	EG	E		Stat	WT	AT	WS	W	CS	S	CD	TD	Date	S(x1.3 m^2)	Chla	DO
						F	M													
05°01'S	156°04'E	6	6	0	0	0	1	St.1-1	31.1	32.9	4.3	Cloudy	0.6	32	303	14:31~46	Dec 25	1597.5	1.40	197.36
05°00'S	156°04'E	8	7	0	1	0	0	St.1-2	31.1	32.9	4.6	Cloudy	0.7	32	295	14:55~15:10	Dec25	1579.5	1.45	197.61
05°00'S	156°05'E	3	3	0	0	0	1	St.1-3	31.1	32.9	3.8	Cloudy	0.7	32	299	15:17~32	Dec 25	1601.0	1.65	197.76
02°11'S	155°48'E	28	11	14	3	0	0	St.2-1	30.4	29.0	4.9	Fine	0.6	32	66	18:31~46	Dec 26	648.2	0.85	198.33
02°10'S	155°48'E	19	12	5	2	0	1	St.2-2	30.4	29.0	4.2	Fine	0.6	32	55	18:55~19:10	Dec 26	459.4	0.80	198.27
02°09'S	155°48'E	24	12	7	5	0	0	St.2-3	30.4	29.0	4.6	Cloudy	0.5	32	8	19:19-34	Dec 26	463.9	0.89	198.19
00°10'N	156°09'E	14	11	2	1	0	0	St.3-1	30.4	28.2	4.1	Fine	0.2	32	125	18:24~39	Dec 28	708.5	0.75	198.02
00°10'N	156°09' E	5	4	1	0	0	0	St.3-2	30.4	28.2	5.1	Fine	0.1	32	96	18:46~19:01	Dec 28	355.0	0.70	198.31
00°10'N	156°08' E	5	2	3	0	0	0	St.3-3	30.4	28.2	6.4	R/C	0.4	32	105	19:07-22	Dec 28	837.9	0.69	198.47
02°15'N	156°10' E	1	0	1	0	0	0	St.4-1	29.9	29.2	10.6	Fine	0.5	32	12	18:26~41	Dec 30	640.3	0.64	200.31
02°15'N	156°11' E	3	2	0	1	0	0	St.4-2	29.9	29.2	8.8	Fine	0.3	32	351	18:48~19:03	Dec 30	473.0	0.60	200.11
02°15'N	156°11' E	2	2	0	0	0	0	St.4-3	29.9	29.2	6.9	Fine	0.2	32	357	19:10-19:25	Dec 30	430.6	0.62	200.05
05°00'N	156°00' E	17	8	5	4	0	0	St.5-1	29.6	27.4	12.0	Rainy	1.1	32	86	13:09-24	Jan 02	369.2	1.21	200.82
05°00'N	156°01' E	15	9	5	1	0	0	St.5-2	29.6	27.4	13.1	Rainy	0.9	32	81	13:30~45	Jan 02	499.0	1.21	201.02
05°00'N	156°03' E	17	9	3	5	0	0	St.5-3	29.6	27.4	12.3	R/C	1.0	32	86	13:51-14:06	Jan 02	1472.0	1.17	200.87
01°51'N	147°16' E	11	0	4	7	0	0	St.6-1	29.5	27.5	1.8	Fine	0.6	32	77	18:54~19:09	Jan 06	1892.0	0.74	199.18
01°51'N	147°16' E	10	5	2	3	0	0	St.6-2	29.5	27.5	1.8	Fine	0.7	32	81	19:16~31	Jan 06	472.8	0.75	199.17
01°51'N	147°16' E	15	6	6	3	0	0	St.6-3	29.5	27.5	1.6	Fine	0.4	32	63	19: 36~51	Jan 06	736.2	0.73	199.15
00°02'N	146°55' E	35	5	13	17	0	0	St.7-1	30.0	29.4	7.6	F(R)	0.6	32	91	18:57-19:12	Jan 08	1045.0	3.16	200. 11
00°01'N	146°55' E	36	10	12	14	0	0	St.7-2	30.0	29.4	9.1	Fine	0.9	32	84	19:18~33	Jan 08	739.5	3.32	200.18
00°01'N	146°55' E	34	9	10	15	0	0	St.7-3	30.0	29.4	8.9	Fine	0.8	32	95	19: 39-54	Jan 08	642.0	3.43	200.09
02°02'N	138°02'E	48	2	24	22	0	0	St.8-1	29.8	29.9	3.5	Cloudy	1.1	31	246	18:26~41	Jan 11	847.0	0.54	203.06

02°01'N	138°02'E	42	0	20	22	0	0	St.8-2	29.8	29.9	4.6	Cloudy	1.0	31	243	18:47~19:02	Jan 11	757.8	0.53	202.80
02°01'N	138°03'E	21	2	17	2	0	0	St.8-3	29.8	29.9	0.8	Cloudy	1.0	31	248	19:07~22	Jan 11	564.5	0.56	202.58
05 °01'N	137°26'E	44	31	8	5	0	1	St.9-1	28.5	25.9	6.8	Rainy	2.9	32	70	18:39~54	Jan 13	700.5	0.53	203.04
05°02'N	137°28'E	30	18	8	4	0	3	St.9-2	28.5	25.9	3.6	Rainy	3.0	3	73	18:59~19:14	Jan 13	858.2	0.54	202. 65
05°02'N	137°30'E	61	35	16	10	0	0	St.9-3	28.5	25.9	1.0	Rainy	3.0	32	69	19:09-24	Jan 13	774.2	0.55	202.62

Table 1-2: Number of oceanic sea skaters, *Halobates* collected at locations in the tropical pacific ocean in December 20th, 2014 - January 19th during the science cruise, MR14-06-Leg 2 (N: Total number of individuals collected; *H.s.: Halobates sericeus*;; Stat: Station number; WT: Water temperature (℃); AT: Air temp.; L: N of larvae; A: N of adults, E: N of exuviae; Date: sampling date; Sampling was performed for 45min. EG: eggs on some substrates like as polystyrene form thousands of eggs laid on the substrate. S: Surface area which was swept by Neuston NET was expressed as value of flow-meter x 1.3m of width of Neuston NET; WS: wind speed (m/s); W: weather; TD: Time of day; WS: Wind speed, CS: Current speed(m/s)CD: Current direction; F: female; M: male, S: salinity of sea surface (‰), Chla: Chlorophyll A (RFU); DO (dissolved oxygen: micro mol / kg)

Lat.	Lon.	N	L	A	EG	E		Stat	WT	AT	WS	W	CS	S	CD	TD	Date	S (x1.3 m^2)	Chla	DO
					F	M														
07°38'N	136°41'E	26	15	7	4	0	0	St.10-1	28.9	28.8	5.4	Cloudy	0.1	32	148	18:30~45	Jan 16	720.5.0	0.62	201.23
07°37'N	136°41'E	28	20	6	2	0	2	St.10-2	28.9	28.8	4.9	Cloudy	0.2	32	193	18:50~19:05	Jan 16	528.0	0.64	201.16
07°37'N	136°40'E	21	12	6	3	0	0	St.10-3	28.9	28.8	4.4	Cloudy	0.2	32	176	19:10~25	Jan 16	710.0	0.68	201.15

7. General and supporting observations

7. 1. Meteorological measurements

7.1.1. Surface meteorological observations

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal Investigator	- Leg2 -
Iwao Ueki	(JAMSTEC) Principal Investigator	- Leg3 -
Shinya Okumura	(GODI)	- Leg2 -
Kazuho Yoshida	(GODI)	- Leg2 -
Yutaro Murakami	(GODI)	- Leg2 -
Katsuhisa Maeno	(GODI)	- Leg3 -
Miki Morioka	(GODI)	- Leg3 -
Masanori Murakami	(MIRAI Crew)	- Leg2 -
Ryo Kimura	(MIRAI Crew)	- Leg3 -

(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 MR14-06 Leg2 cruise from 20th December 2014 to 18th January 2015 and Leg3 cruise from 22th January 2015 to 25th February 2015, except for territorial waters of Federated States of Micronesia, the Republic of Palau and the Republic of Indonesia, and the South China sea.

We used two systems for the observation as follows;

i) MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table.7.1.1-1 and measured parameters are listed in Table.7.1.1-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-second averaged data.

ii) Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

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

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

SCS recorded PRP data every 6 seconds, CR1000 data every 10 seconds, air temperature and relative humidity data every 2 seconds and ORG data every 5 seconds. SCS composed Event data (JamMet) from these data and ship's navigation data. Instruments and their locations are listed in Table 7.1.1-3 and measured parameters are listed in Table 7.1.1-4.

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

i) Young Capacitive Rain gauge (SMet and SOAR)
Inspect of the linearity of output value from the rain gauge sensor to change Input value by adding fixed quantity of test water.

ii) Barometer (SMet and SOAR)
Comparison with the portable barometer value, PTB220CASE, VAISALA.

iii) Thermometer (air temperature and relative humidity) (SMet and SOAR)
Comparison with the portable thermometer value, HMP41/45, VAISALA.

(4) Preliminary results

Figure 7.1.1-1 show the time series of the following parameters;
Wind (SOAR)
Air temperature (SMet)
Relative humidity (SMet)
Precipitation (SOAR, capacitive rain gauge)
Short/long wave radiation (SOAR)
Pressure (SMet)
Sea surface temperature (SMet)
Significant wave height (SMet)

(5) Data archives

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

(6) Remarks

1. During the following periods, data acquisition was suspended.
   00:10UTC 20 Dec. 2014 - 03:00UTC 20 Dec. 2014
   (Federated States of Micronesia)
   23:00UTC 17 Jan. 2015 - 04:00UTC 22 Jan. 2015
   (Republic of Palau)
   10:12UTC 23 Jan. 2015 - 16:25UTC 26 Jan. 2015
   (Territorial water of Republic of Indonesia)
   11:22UTC 11 Feb. 2015 - 02:21UTC 13 Feb. 2015
   (Territorial and Archipelagic waters and South China sea)

2. The following period, SST (Sea Surface Temperature) data were available.
   04:16UTC 20 Dec. 2014 - 23:00UTC 17 Jan. 2015
   05:00UTC 22 Jan. 2015 - 01:30UTC 23 Jan. 2015
   05:00UTC 30 Jan. 2015 - 11:00UTC 09 Feb. 2015
   18:30UTC 17 Feb. 2015 - 06:29UTC 23 Feb. 2015

3. The following period, LOG and Gyro were lost due to the server error.
   [20 Dec. 2014] 04:12:30, 12:58:38
   [22 Dec. 2014] 03:13:42, 05:45:03
   [23 Dec. 2014] 00:33:53, 02:57:31, 08:25:33, 13:28:21
   [24 Dec. 2014] 03:12:35, 04:22:39, 11:38:47
   [25 Dec. 2014] 13:35:44
   [28 Dec. 2014] 01:41:37
   [29 Dec. 2014] 04:41:44
   [30 Dec. 2014] 00:57:21, 04:08:33, 07:14:26
   [31 Dec. 2014] 07:43:12, 20:33:40
   [02 Jan. 2015] 01:09:42, 13:06:01, 21:47:26
   [07 Jan. 2015] 05:26:13, 05:40:20, 13:13:11, 14:13:27
   [08 Jan. 2015] 13:24:21, 14:43:01, 15:57:54
   [09 Jan. 2015] 22:05:48
   [11 Jan. 2015] 10:11:39, 21:33:56
   [12 Jan. 2015] 20:18:54
   [14 Jan. 2015] 05:16:341, 5:05:58, 19:11:36
   [03 Feb. 2015] 06:58:15 - 07:00:34
   [04 Feb. 2015] 06:59:42, 07:19:31- 07:24:13, 12:00:36 - 12:02:24
   [09 Feb. 2015] 04:51:45
   [14 Feb. 2015] 11:20:02- 11:21:09, 11:34:27, 11:41:58, 11:54:29,
   12:11:30- 12:11:48, 12:30:55- 12:36:25,
   12:38:01 - 12:38:13, 12:39:31- 12:40:19
   [19 Feb. 2015] 14:24:12

4. The following time, increasing of SMet capacitive rain gauge data were invalid due to transmitting for MF/HF radio.
   05:44UTC 18 Feb. 2015
   05:52UTC 18 Feb. 2015

5. The following time, increasing of SMet capacitive rain gauge data were invalid due to transmitting for VHF radio.
   00:00UTC 26 Jan. 2015
   00:05UTC 26 Jan. 2015

Table.7.1.1-1 Instruments and installations of MIRAI
Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		(R.M. Young, USA)	compass deck (21 m) starboard and port side
Thermometer (SST)	RFN2-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	Model-370	Setra System, USA	captain deck (13 m) weather observation room
Capacitive 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.7.1.1-2 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.7.1.1-3 Instruments and installation locations of SOAR system

Sensors (Meteolorogical)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Barometer	PTB210	Vaisala, Finland	foremast (23 m)
with 61002 Gill pressure port, R.M. Young, USA			
Capacitive Rain gauge	50202	R.M. Young, USA	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	foremast (23 m)
with 43408 Gill aspirated radiation shield, R.M. Young, USA			
Optical rain gauge	ORG-815DR	Osi, USA	foremast (24 m)

Sensors (PRP)	Type	Manufacturer	Location (altitude from surface)
Radiometer (short wave)	PSP	Epply Labs, USA	foremast (25 m)
Radiometer (long wave)	PIR	Epply Labs, USA	foremast (25 m)
Fast rotating shadowband radiometer		Yankee, USA	foremast (25 m)

Sensor (PAR)	Type	Manufacturer	Location (altitude from surface)
PAR sensor	PUV-510	Biospherical Instruments Inc., USA	Navigation deck (18m)

Table.7.1.1-4 Parameters of SOAR system

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

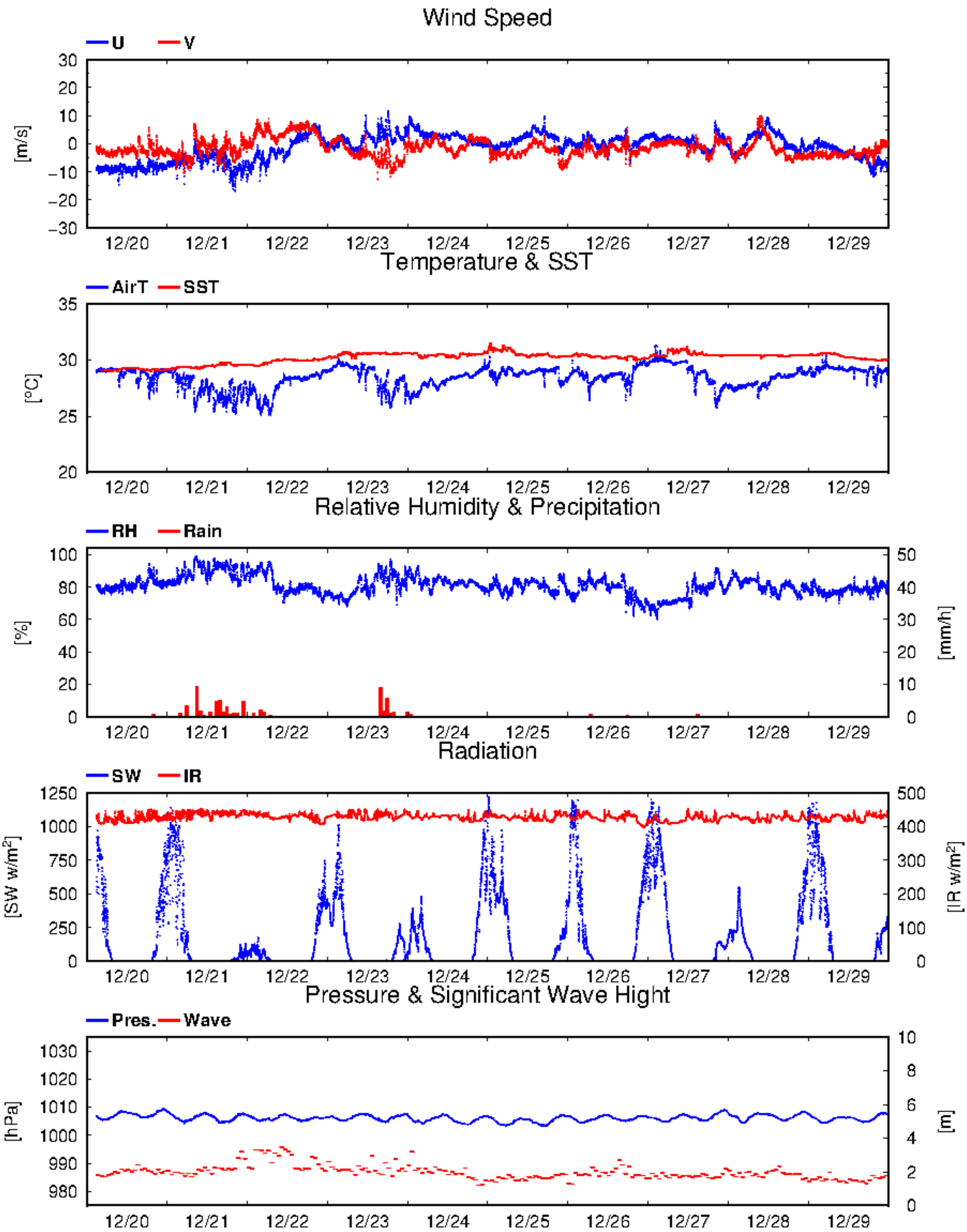


Fig.7.1.1-1 Time series of surface meteorological parameters during the MR14-06 Leg2

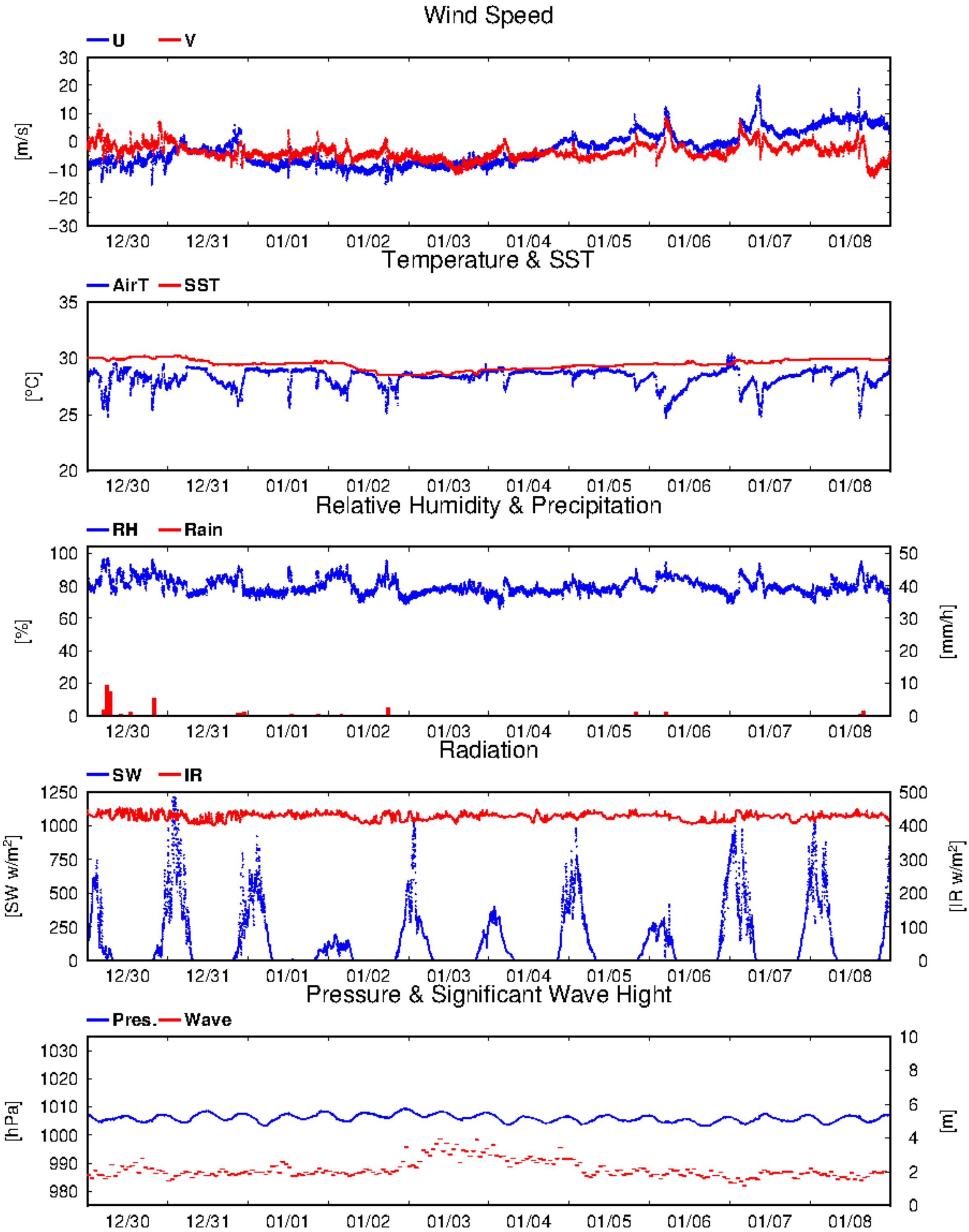


Fig.7.1.1-1 (Continued)

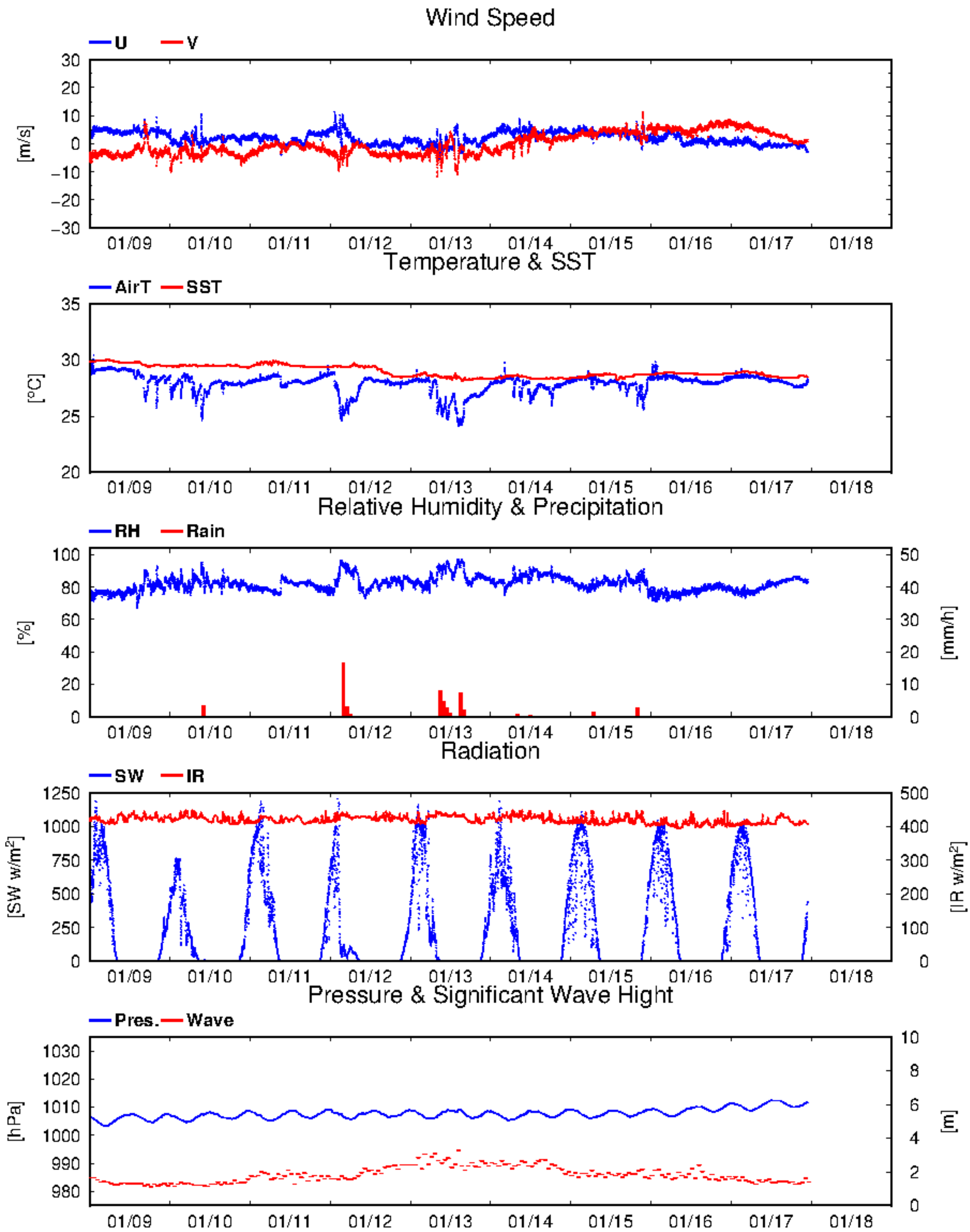


Fig.7.1.1-1 (Continued)

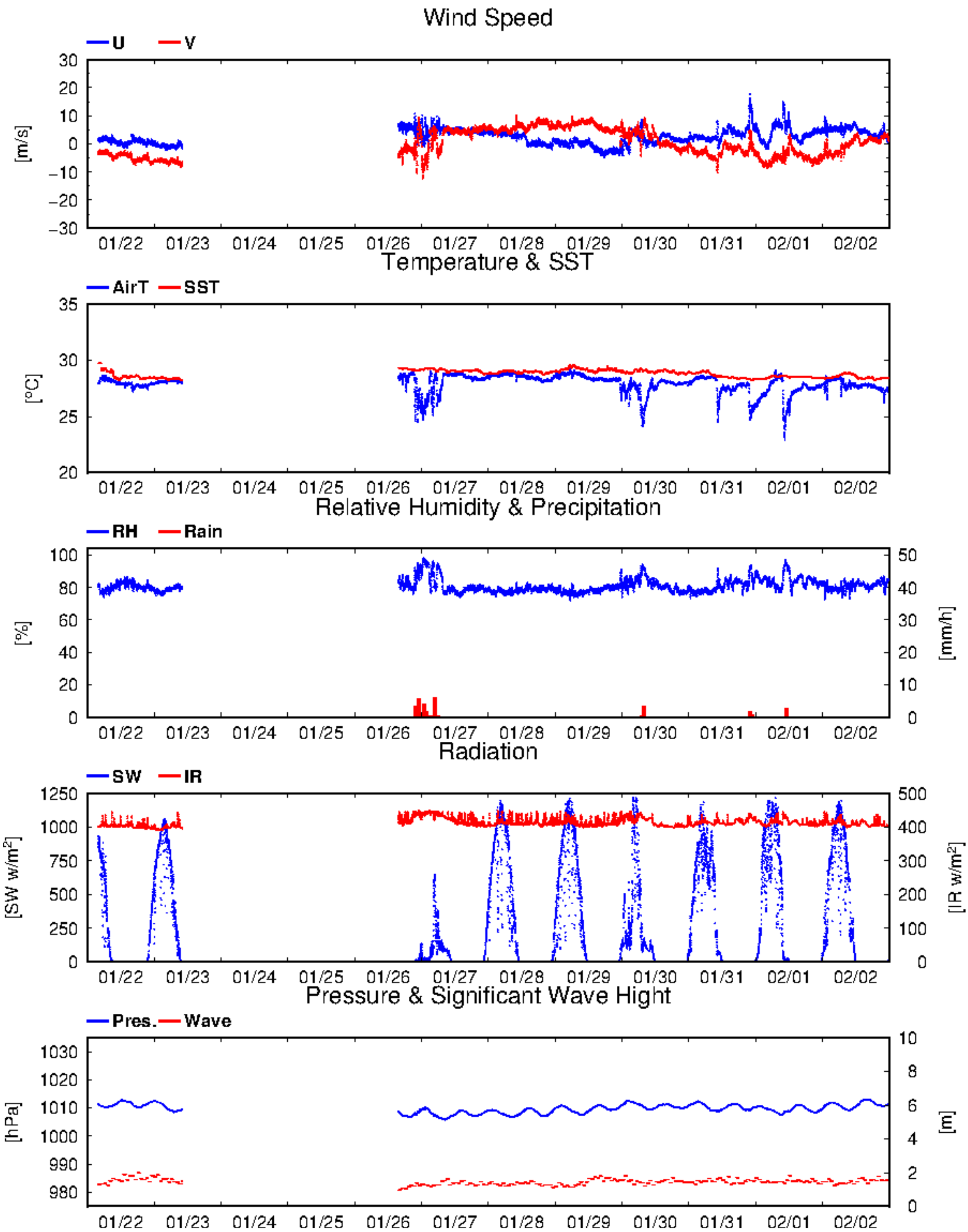


Fig.7.1.1-2 Time series of surface meteorological parameters during the MR14-06 Leg3

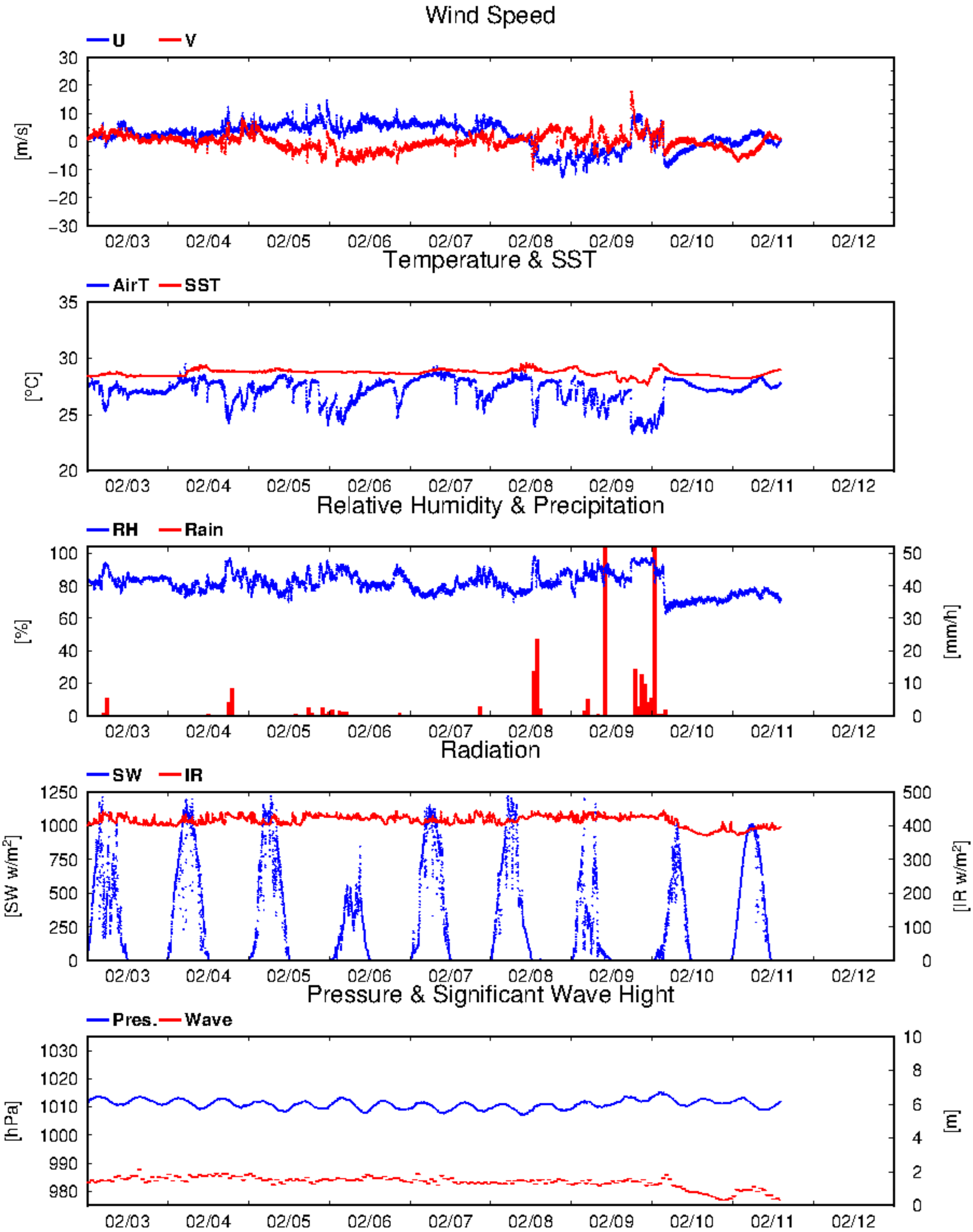


Fig.7.1.1-2 (Continued)

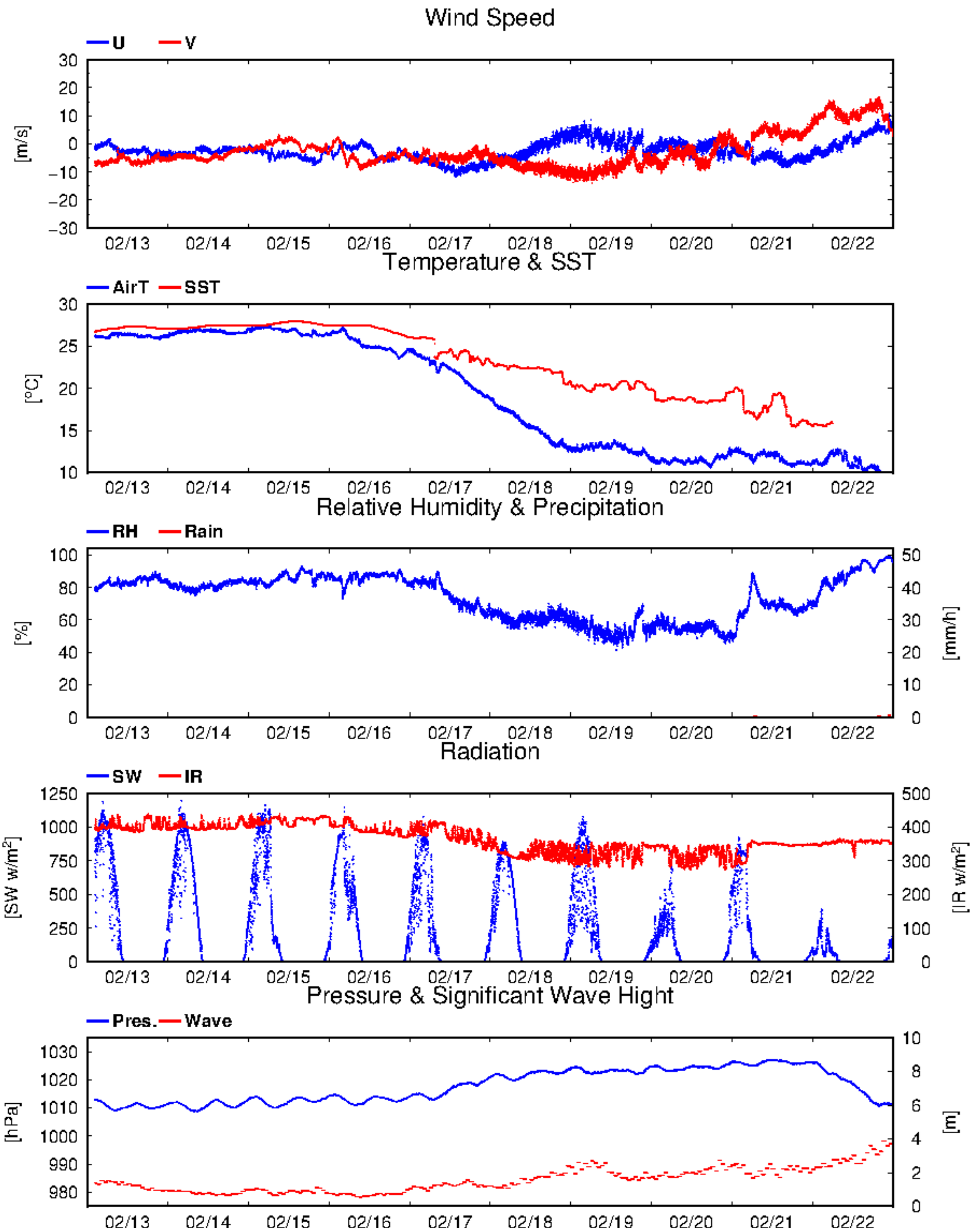


Fig.7.1.1-2 (Continued)

7.1.2. Ceilometer

(1) Personnel

Kentaro Andou	(JAMSTEC) *Principal Investigator	- Leg2 -
Iwao Ueki	(JAMSTEC) *Principal Investigator	- Leg3 -
Shinya Okumura	(Global Ocean Development Inc., GODI)	- Leg2 -
Kazuho Yoshida	(GODI)	- Leg2 -
Yutaro Murakami	(GODI)	- Leg2 -
Katsuhisa Maeno	(GODI)	- Leg3 -
Miki Morioka	(GODI)	- Leg3 -
Masanori Murakami	(MIRAI Crew)	- Leg2 -
Ryo Kimura	(MIRAI Crew)	- Leg3 -

(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) during MR14-06 Leg2 cruise from 20th December 2014 to 19th January 2015 and Leg3 cruise from 22th January 2015 to 25th February 2015, except for territorial waters of Federated States of Micronesia, the Republic of Palau and the Republic of Indonesia, and the South China sea.

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)
Cloud detection range: 0 ~ 13 km
Measurement range: 0 ~ 15 km
Resolution: 10 meter in full range
Sampling rate: 36 sec
Sky Condition: Cloudiness in octas (0 ~ 9)
(0: Sky Clear, 1-2:Few, 3:Scattered, 5-7: Broken, 8: Overcast, 9: Vertical Visibility)

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

(5) Preliminary results

Fig.7.1.2-1 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 (DMG) in JAMSTEC.

(7) Remarks

1. The following periods, data acquisition was suspended.
   00:10UTC 20 Dec. 2014 - 03:00UTC 20 Dec. 2014
   (Territorial water of Federated States of Micronesia)
   23:00UTC 17 Jan. 2015 - 00:00UTC 22 Jan. 2015
   (Territorial water of Republic of Palau)
   10:12UTC 23 Jan. 2015 - 16:25UTC 26 Jan. 2015
   (Territorial water of Republic of Indonesia)
   11:22UTC 11 Feb. 2015 - 2:21UTC 13 Feb. 2015
   (Territorial and Archipelagic waters and South China sea)
2. Window Cleaning;
   02:47UTC 31 Dec. 2014 - 02:52UTC 31 Dec. 2014
   04:36UTC 17 Jan. 2015
   02:13UTC 30 Jan. 2015
   23:41UTC 18 Feb. 2015

3-1. The following period, data acquisition were stopped due to transmitter trouble.
   05:42UTC 31 Jan. 2015 - 07:41UTC 03 Feb. 2015

3-2. The following period, data acquisition were stopped due to getting status messages.
   03:11UTC 30 Jan. 2015 - 03:14UTC 30 Jan. 2015
   04:12UTC 30 Jan. 2015 - 04:14UTC 30 Jan. 2015

3-3. During this cruise, It was occured that Transmitter experiers warning (Laser diode is too old). The measurement data was valid, but it was possible that some clouds were missed.

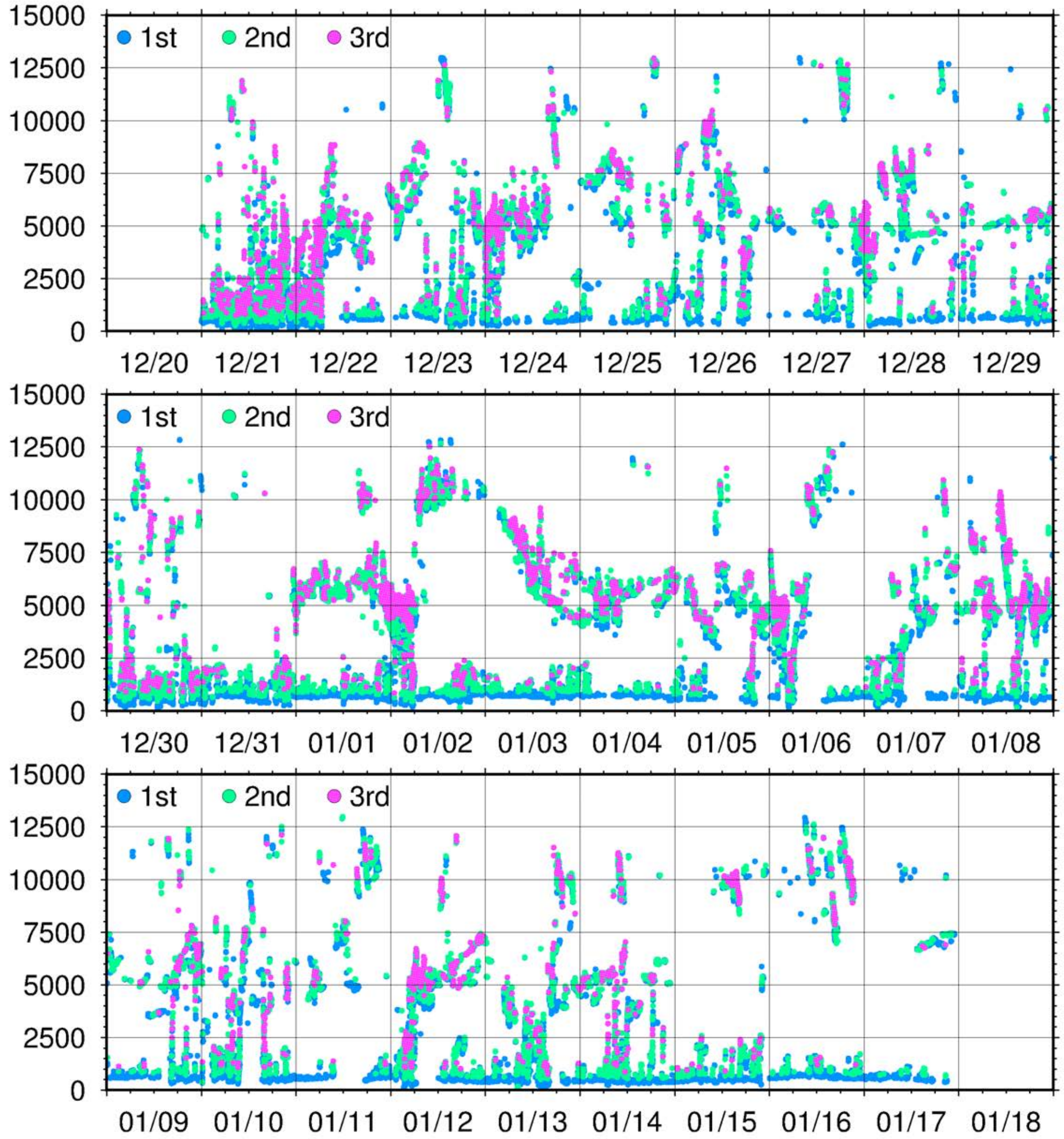


Fig. 7.1.2-1 First (Blue), 2nd (Green) and 3rd (Red) cloud base height (MR14-06 leg2)

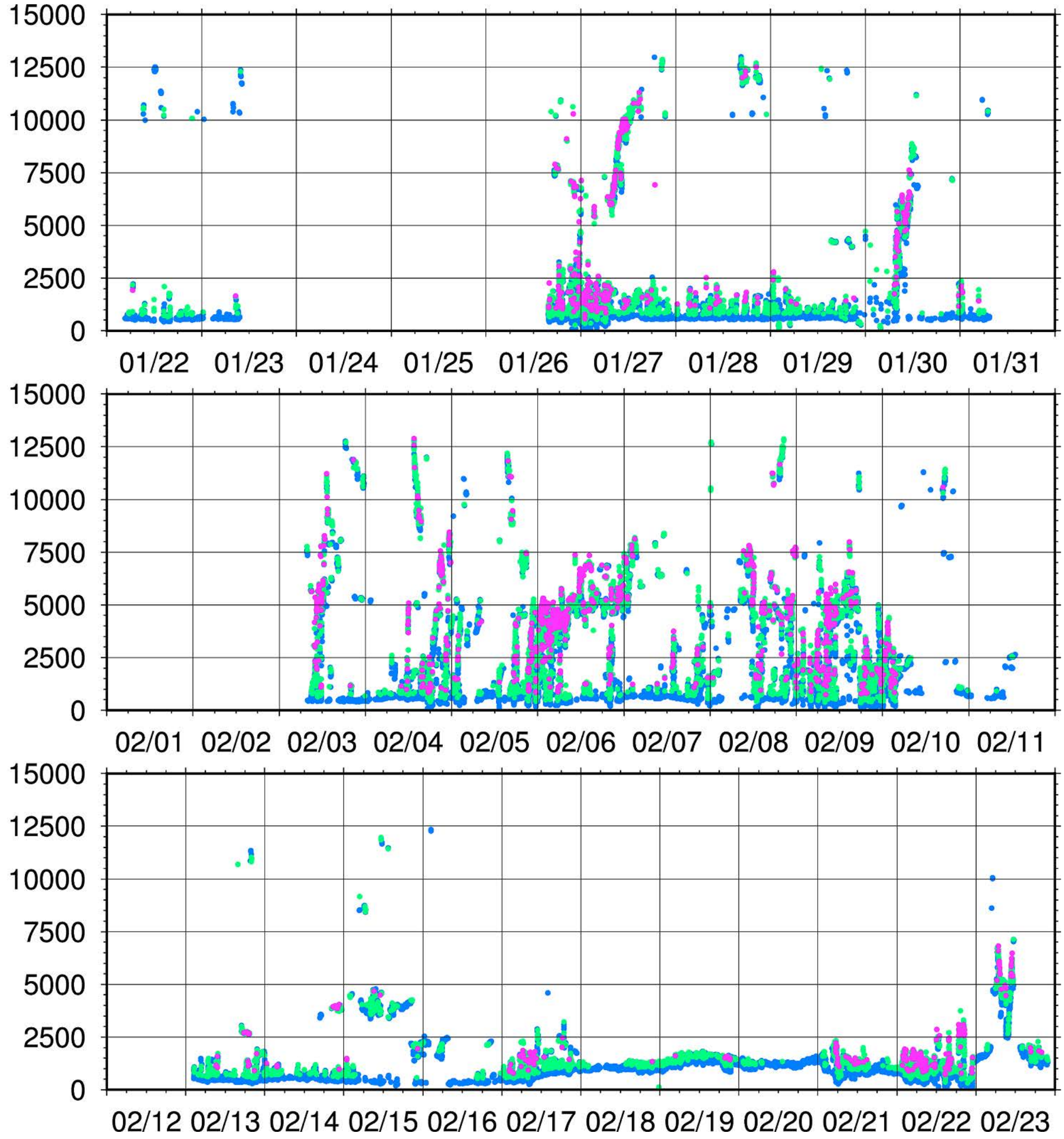


Fig. 7.1.2-2 First (Blue), 2nd (Green) and 3rd (Red) cloud base height (MR14-06 leg3)

7. 2. Ocean Observation

7.2.1. CTD

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal investigator	-Leg 2-
Iwao Ueki	(JAMSTEC) Principal investigator	-Leg 3-
Tatsuya Tanaka	(MWJ) Operation leader	-Leg 3-
Rei Ito	(MWJ) Operation leader	-Leg 2-
Katsunori Sagishima	(MWJ)	-Leg 3-
Sonoka Wakatsuki	(MWJ)	-Leg 2-

(2) Objective

Investigation of oceanic structure and water sampling.

1.

(3) Parameters

Temperature (Primary and Secondary)
Conductivity (Primary and Secondary)
Pressure
Dissolved Oxygen (Primary and Secondary)
Fluorescence (Leg3 only)

(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) in Leg2 and Leg3, and Fluorescence in Leg3. 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.7.23.2) 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.

CTD measurements of 15 casts in Leg2 and 9 casts in Leg3 (total 24 casts) were conducted (Table 7.2.1-1 in Leg2 and Table 7.2.1-2 in Leg3).

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.23.2) 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 3 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

WFILTER (Leg3 only): Perform a median filter to remove spikes in the fluorescence data. A median value was determined by 49 scans of the window.

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
MR1406A.xmlcon: Leg2
MR1406B.xmlcon: Leg3

Specifications of the sensors are listed below.
CTD: SBE911plus CTD system

Under water unit:
SBE9plus
S/N 09P38273-0786 (Sea-Bird Electronics, Inc.)

Pressure sensor: Digiquartz pressure sensor (S/N 94766)
Calibrated Date: 08 Apr. 2014
Temperature sensors:
Primary: SBE03-04/F (S/N 031359, Sea-Bird Electronics, Inc.)
Calibrated Date: 01 May 2014
Secondary: SBE03-04/F (S/N 031464, Sea-Bird Electronics, Inc.)
Calibrated Date: 02 May 2014
Conductivity sensors:
Primary: SBE04-04/0 (S/N 041203, Sea-Bird Electronics, Inc.)
Calibrated Date: 01 May 2014
Secondary: SBE04-04/0 (S/N 041172, Sea-Bird Electronics, Inc.)
Calibrated Date: 01 May 2014
Dissolved Oxygen sensors:
Primary: SBE43 (S/N 430330, Sea-Bird Electronics, Inc.)
Calibrated Date: 29 Apr. 2014
Secondary: SBE43 (S/N 432471, Sea-Bird Electronics, Inc.)
Calibrated Date: 10 Nov. 2012
Fluorescence (Leg3 only):
Chlorophyll Fluorometer (S/N 3618, Seapoint Sensors, Inc.)

Carousel water sampler:
SBE32 (S/N 3221746-0278, Sea-Bird Electronics, Inc.)

Deck unit: SBE11plus (S/N 11P54451-0872, Sea-Bird Electronics, Inc.)

(5) Preliminary Results

During this cruise, CTD observations of 15 casts in Leg2 and 9 casts in Leg3 (total 24 casts) were carried out. Date, time and locations of the CTD casts are listed in Table 7.2.1-1 and Table 7.2.1-2.

Vertical profiles (down cast) of primary temperature, primary salinity and primary dissolved oxygen with pressure in Leg2 are shown in Figure 7.2.1-1 - 7.2.1-3. Vertical profiles (down cast) of primary temperature, primary salinity, secondary dissolved oxygen and fluorescence with pressure in Leg3 are shown in Figure 7.2.1-4 - 7.2.1-5, and primary dissolved oxygen isn't shown in Leg3 because a vertical profile (down cast) of primary dissolved oxygen was distinctly different from a confirmed vertical profile (down cast) of secondary dissolved oxygen.

Vertical profiles and time series of differences between dissolved oxygen sensors (primary and secondary) and dissolved oxygen of water sampling in Leg3 are shown in Figure 7.2.1-6. The difference in primary sensor compared with the difference in secondary sensor represents a wide distribution at surface and below 250dbar in vertical profiles and represents a drift with time at surface and below 250dbar in time series.

(6) Remarks

Station J01, J02, J03 and J04 were observation for comparison CTD and JES10-profiler.

(7) Data archive

All raw and processed data files were copied onto HD provided by JAMSTEC DMO (Data Management Office); JAMSTEC will be opened to public via "R/V MIRAI Data Web Page" in the JAMSTEC home page.

Table 7.2.1-1 MR14-06 Leg2 Cast table

MR14-06 Leg.2 CTD casttable														
Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire	HT Above	Max	Max	CTD	Remark
		(mmddyy)	Start	End	Latitude	Longitude		Out	Bottom	Depth	Pressure	Filename	
C01	1	122414	21:40	22:22	04-58.41S	156-02.28E	1493.0	999.4	-	1001.0	1009.0	C01M01	Recovery point of TRITON No.6
C02	1	122614	03:09	03:49	01-59.07S	156-00.79E	1745.0	998.5	-	1001.0	1009.0	C02M01	Recovery point of TRITON No.5
J01	1	122714	03:19	05:38	01-57.57S	155-59.17E	1745.0	999.4	-	1001.0	1009.0	J01M01	JES10 cast
C03	1	122814	05:54	06:32	00-00.82S	155-59.10E	1947.0	998.5	-	1001.0	1009.0	C03M01	Recovery point of TRITON No.4
C04	1	123014	03:10	03:47	01-57.50N	155-58.45E	2545.0	998.3	-	1001.0	1009.0	C04M01	Recovery point of TRITON No.3
C05	1	010115	20:58	21:36	04-57.66N	156-03.39E	3599.0	1000.4	-	1001.0	1009.0	C05M01	Recovery point of TRITON No.2
C06	1	010615	04:02	04:41	01-57.84N	147-02.08E	4501.0	999.4	-	1001.0	1009.0	C06M01	Recovery point of TRITON No.8
C07	1	010815	04:24	05:02	00-00.89S	147-01.93E	4499.0	999.8	-	1001.0	1009.0	C07M01	Recovery point of TRITON No.9
C08	1	011115	00:01	00:37	02-01.02N	138-09.66E	4072.0	998.0	-	1001.0	1009.0	C08M01	Recovery point of TRITON No.12
C09	1	011315	08:36	09:14	05-01.59N	137-25.81E	4053.0	1023.8	-	1005.9	1014.0	C09M01	Recovery point of TRITON No.11
J02	1	011415	05:58	07:37	04-59.53N	137-30.68E	4036.0	548.3	-	552.2	556.0	J02M01	JES10 cast
J02	2	011415	07:40	08:40	04-59.16N	137-31.59E	4046.0	550.9	-	552.2	556.0	J02M02	JES10 cast
C10	1	011515	21:38	22:15	07-39.94N	136-42.90E	3167.0	1003.1	-	1002.9	1011.0	C10M01	Recovery point of TRITON No.10
J03	1	011715	04:07	06:24	07-40.32N	136-36.93E	2859.0	1010.1	-	1000.9	1009.0	J03M01	JES10 cast
J03	2	011715	06:27	07:26	07-41.24N	136-06.09E	2907.0	551.4	-	550.2	554.0	J03M02	JES10 cast

Table 7.2.1-2 MR14-06 Leg3 Cast table

MR14-06 Leg.3 CTD casttable														
Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire	HT Above	Max	Max	CTD	Remark
		(mmddyy)	Start	End	Latitude	Longitude		Out	Bottom	Depth	Pressure	Filename	
C11	1	013015	09:28	10:40	08-00.04S	099-30.09E	5444.0	994.5	-	993.0	1001.0	C11M01	UCTD Line
C12	1	020115	07:43	08:42	08-05.92S	095-09.48E	5256.0	992.5	-	993.0	1001.0	C12M01	Recovery point of m-TRITON No.19
C13	1	020115	09:48	10:24	08-00.62S	095-05.51E	5232.0	993.2	-	993.0	1001.0	C13M01	Deployment point of m-TRITON No.19
C14	1	020315	07:18	08:15	05-02.39S	095-01.11E	5001.0	999.3	-	994.1	1002.0	C14M01	Recovery point of m-TRITON No.17
C15	1	020315	09:04	09:39	04-57.80S	095-01.86E	4994.0	995.6	-	996.0	1004.0	C15M01	Deployment point of m-TRITON No.17
J04	1	020615	07:05	09:32	01-36.95S	089-58.83E	4682.0	990.6	-	993.1	1001.0	J04M01	JES10 cast
C16	1	020715	07:06	08:03	01-37.01S	089-56.88E	4676.0	994.3	-	995.1	1003.0	C16M01	Deployment point of m-TRITON No.18
C17	1	020815	09:43	10:38	00-01.90N	090-08.88E	4417.0	995.2	-	995.1	1003.0	C17M01	Recovery and Deployment point of ADCP
C18	1	020815	17:34	18:30	01-30.01N	090-00.08E	2303.0	990.8	-	995.1	1003.0	C18M01	UCTD Line

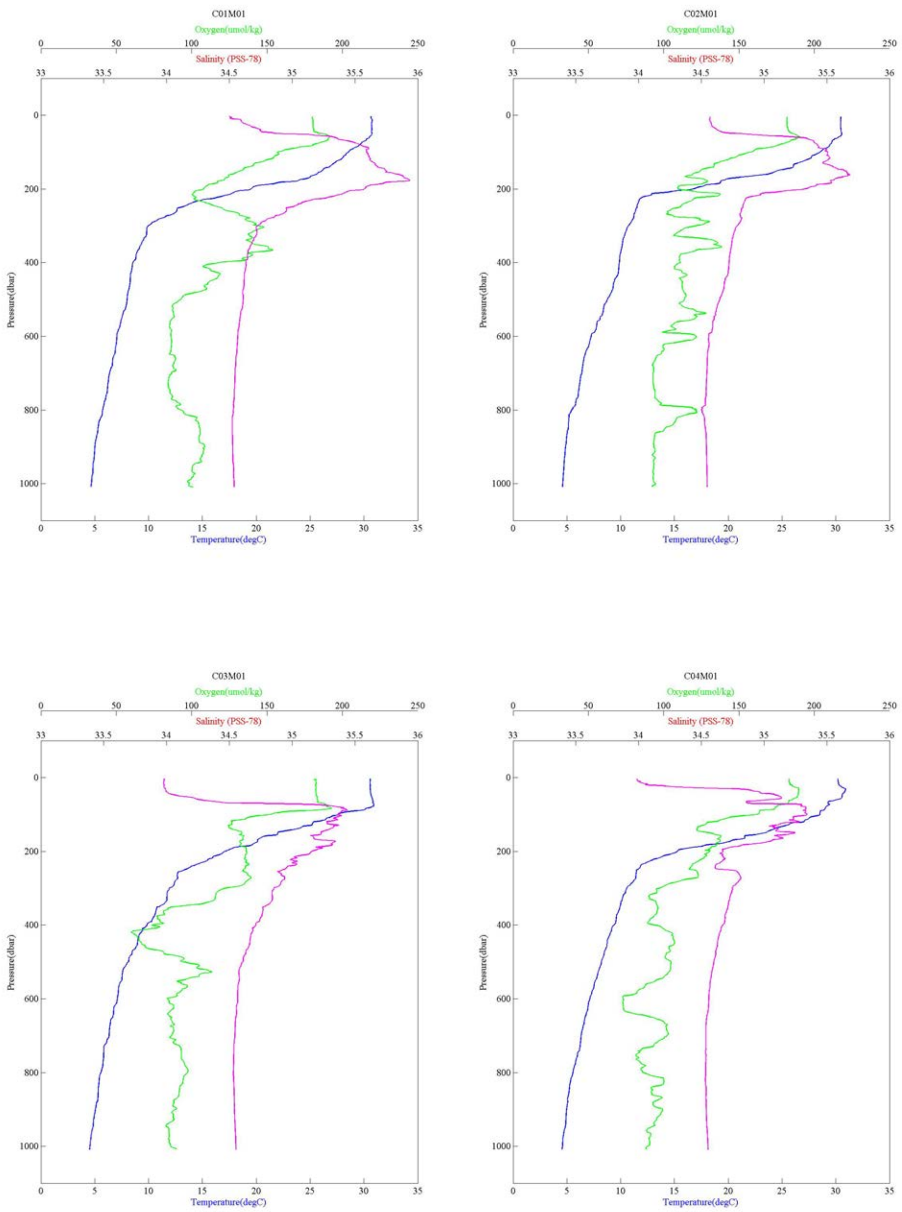


Figure 7.2.1-1 CTD profiles (C01M01, C02M01, C03M01 and C04M01 in Leg2)

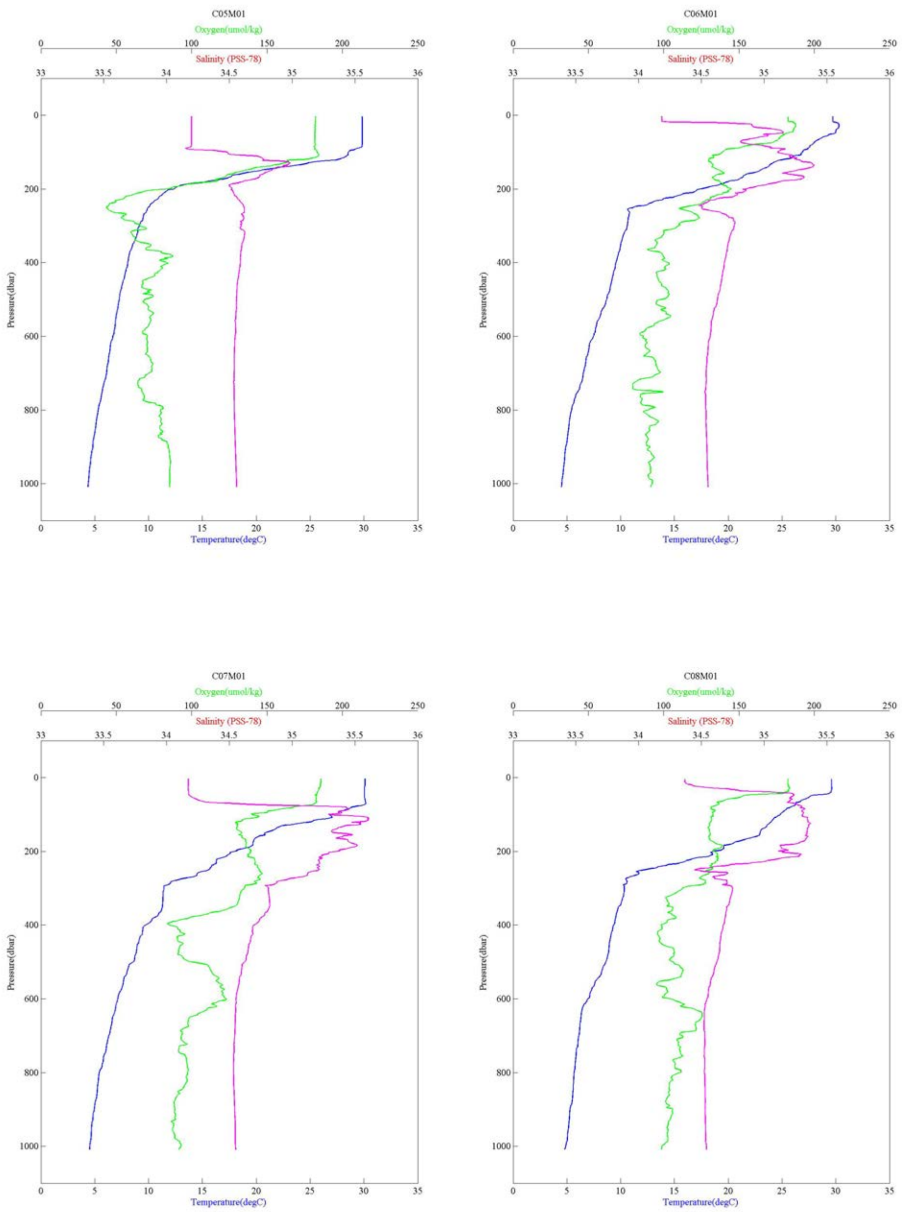


Figure 7.2.1-2 CTD profiles (C05M01, C06M01, C07M01 and C08M01 in Leg2)

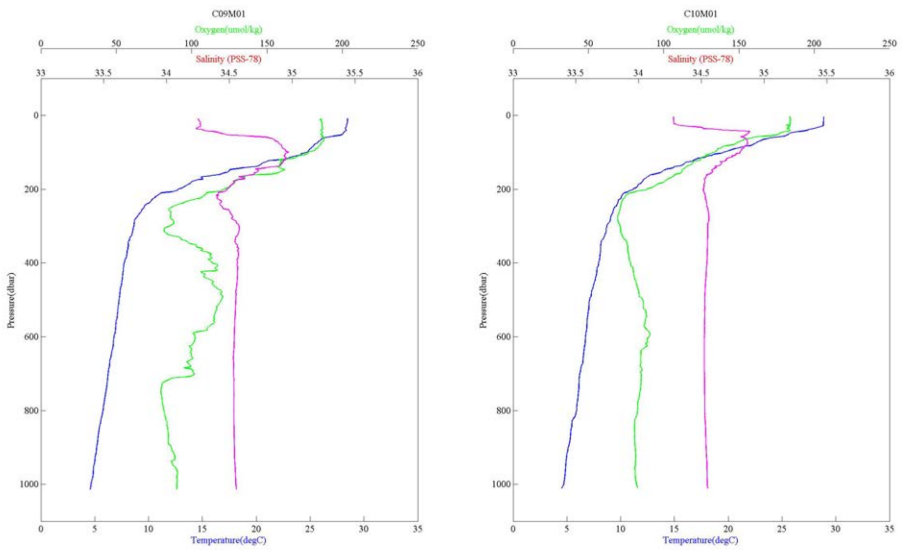


Figure 6.7.1-3 CTD profiles (C09M01 and C10M01 in Leg2)

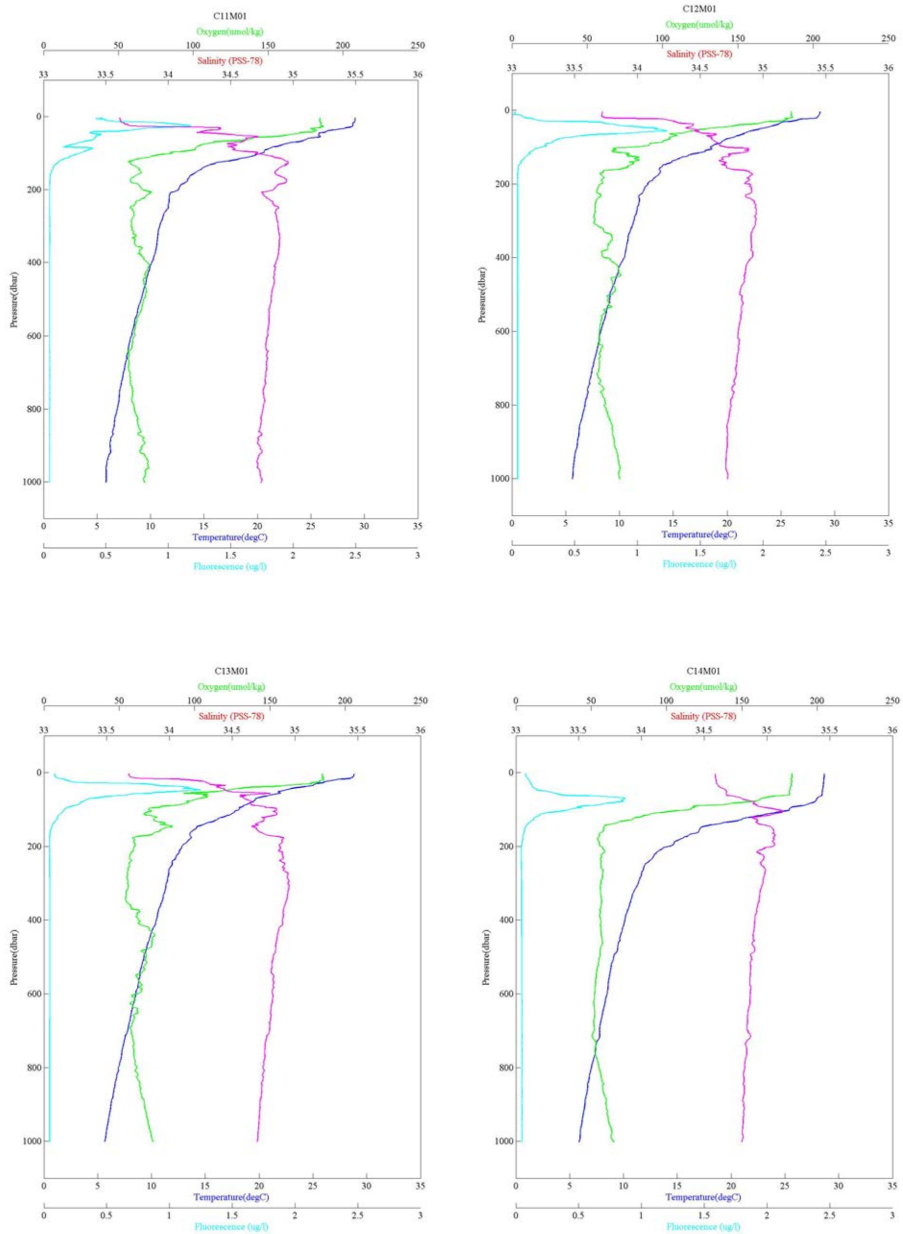


Figure 7.2.1-4 CTD profiles (C11M01, C12M01, C13M01 and C14M01 in Leg3)

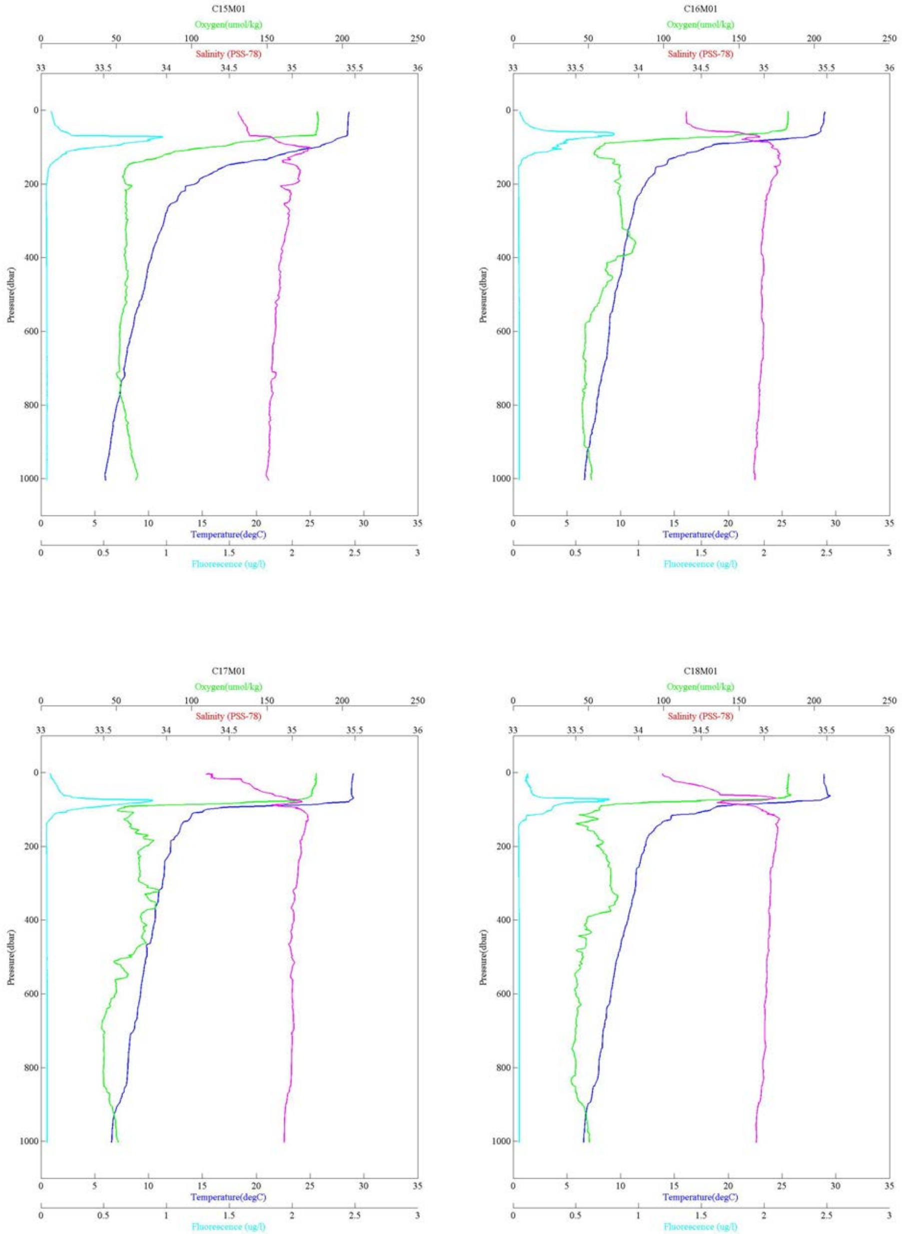


Figure 7.2.1-5 CTD profiles (C15M01, C16M01, C17M01 and C18M01 in Leg3)

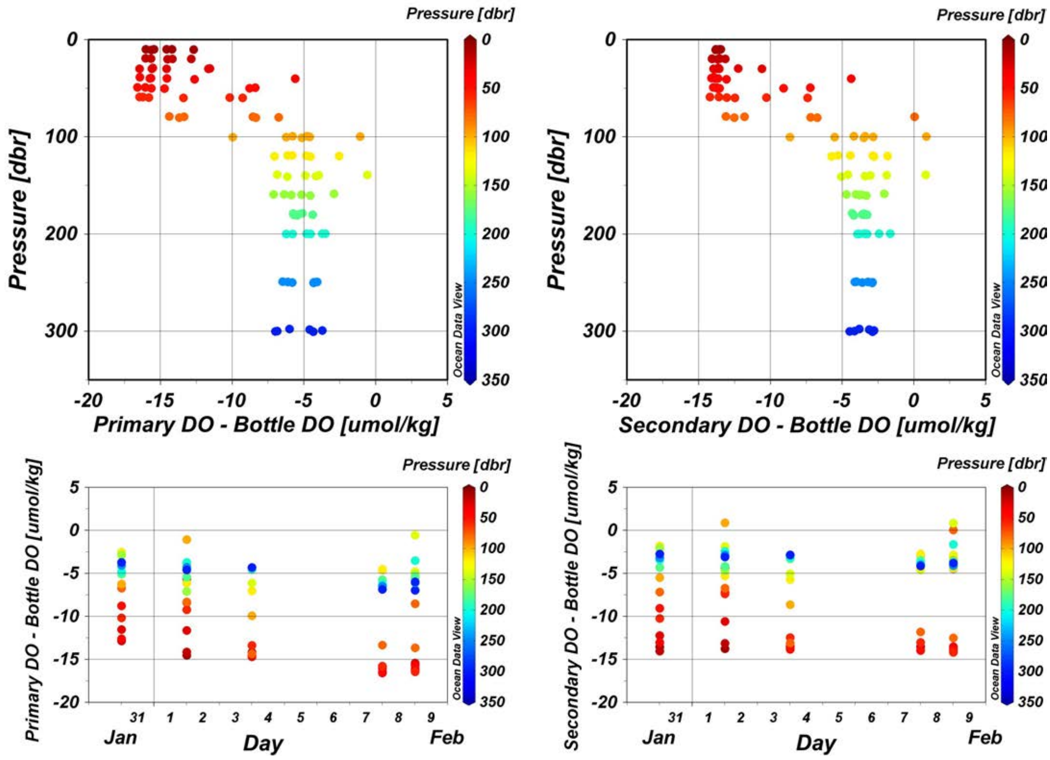


Figure 7.2.1-6 Vertical profiles (top panels) and time series (bottom panels) of differences between dissolved oxygen sensors and dissolved oxygen of water sampling in Leg3. Primary DO, Secondary DO and Bottle DO indicate primary dissolved oxygen sensor, secondary dissolved oxygen sensor and dissolved oxygen of water sampling, respectively.

7.2.2. XCTD

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal Investigator	-Leg 2-
Iwao Ueki	(JAMSTEC) Principal Investigator	-Leg 3-
Shinya Okumura	(GODI)	-Leg 2-
Kazuho Yoshida	(GODI)	-Leg 2-
Yutaro Murakami	(GODI)	-Leg 2-
Katsuhisa Maeno	(GODI)	-Leg 3-
Miki Morioka	(GODI)	-Leg 3-
Masanori Murakami	(MIRAI Crew)	-Leg 2-
Ryo Kimura	(MIRAI Crew)	-Leg 3-

(2) Objectives

Investigation of oceanic structure.

(3) Parameters

Parameters of XCTD-1 (eXpendable Conductivity, Temperature & Depth profiler; Tsurumi-Seiki Co.) are as follows;

Parameter	RangeAccuracy	
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 [%] (whichever is greater)

(4) Methods

We observed the vertical profiles of the sea water temperature and salinity measured by XCTD system. We launched 30 XCTD-1 probes by using the automatic launcher, MK-150N digital converter (Tsurumi-Seiki Co.) and AL-12B software (Ver.1.1.4; Tsurumi-Seiki Co.). The summary of XCTD observations were shown in Table 7.2.2.

(5) Preliminary results

Position map of XCTD observations was shown in Fig. 7.2.3-1. Vertical section of temperature and salinity were shown from Fig.7.2.3-2 to Fig.7.2.3-4.

(6) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V MIRAI Data Web Page" in JAMSTEC home page.

Table 7.2.2 Summary of XCTD observation and launching log

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [deg]	Longitude [deg]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
1	O12	2014/12/21	17:27	3-58.0607N	159-34.7015E	3766	29.787	33.838	14088916
2	XCTD-1	2014/12/22	06:42	2-59.9385N	159-49.8203E	3453	29.923	33.822	14088919
3	O13	2014/12/22	11:13	2-05.4918N	159-55.4221E	2844	30.193	33.993	14088918
4	XCTD-2	2014/12/22	23:24	1-00.0027N	160-02.5402E	2680	30.268	33.891	14088917
5	O14	2014/12/23	03:48	0-00.0076N	160-00.0149E	2836	30.7.2.0	33.794	14088903
6	XCTD-3	2014/12/23	08:08	1-00.1918S	159-57.5966E	2411	30.352	33.505	14088920
7	XCTD-4	2014/12/23	12:20	1-57.1579S	159-55.2600E	2600	30.738	34.548	14088921
8	TR06	2014/12/25	05:40	5-00.6536S	156-05.4594E	1459	31.051	34.631	14088923
9	XCTD-5	2014/12/25	12:21	4-00.0265S	156-05.7101E	1771	30.413	34.181	14088900
10	XCTD-6	2014/12/25	17:01	3-00.0067S	156-01.5703E	1809	30.661	34.596	14088922
11	TR05	2014/12/26	01:53	2-00.3397S	155-57.9558E	1747	30.587	34.589	14088892
12	XCTD-7	2014/12/27	10:23	1-00.0241S	156-01.987.2.E	207.2.	31.121	34.155	14088893
13	TR04	2014/12/28	00:47	0-00.5419N	156-02.2582E	1957	30.578	33.958	14088894
14	XCTD-8	2014/12/29	12:16	0-59.9951N	156-00.5383E	2252	30.390	33.967	14088897
15	TR03	2014/12/30	00:59	2-01.8154N	156-00.7252E	2589	30.176	34.007	14088895
16	XCTD-9	2014/12/31	11:51	3-00.0016N	156-03.837.2.E	2880	29.907	33.931	14088896
17	XCTD-10	2014/12/31	21:25	4-00.0004N	156-07.3513E	3466	29.7.2.9	34.085	14088899
18	XCTD-11	2015/01/02	09:31	6-00.0007N	156-03.8963E	4136	29.124	34.139	14088902
19	XCTD-12	2015/01/02	14:43	6-59.9998N	156-02.9800E	4420	28.715	34.120	14088901
20	TR01	2015/01/02	19:52	7-59.9973N	156-02.2213E	4878	28.695	34.057	14088898
21	TR08	2015/01/06	02:51	2-04.7704N	146-57.7.2.59E	4496	29.745	34.181	14088915
22	TR09	2015/01/08	01:31	0-03.4638N	147-01.8013E	4481	30.078	34.161	14088914
23	TR12	2015/01/12	03:54	2-03.7107N	138-03.1773E	4338	29.567	33.982	14088912
24	XCTD-13	2015/01/12	09:17	3-00.0024N	137-47.8271E	4454	29.685	34.120	14088913
25	XCTD-14	2015/01/12	14:24	4-00.0091N	137-31.8415E	4581	29.371	34.225	14088911
26	TR11	2015/01/13	03:59	4-52.8906N	137-17.4740E	4084	29.055	34.072	14088910
27	XCTD-15	2015/01/15	11:07	6-00.0170N	137-08.4548E	4565	28.885	34.187	14088908
28	XCTD-16	2015/01/15	16:10	6-59.9925N	136-52.1098E	4471	28.539	34.299	14088909
29	TR10	2015/01/17	02:32	7-38.9247N	136-40.6509E	3173	29.069	34.298	14088907
30	U15	2015/02/02	16:20	5-59.7245N	94-59.9887E	5115	28.619	34.361	14088904

Attached symbol and acronyms in Table XCTD observation log are as follows;

* : Observed by using the hand launcher, MK-130 digital converter and MK-130 software (ver.3.11)

Depth: The depth of water [m]

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

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

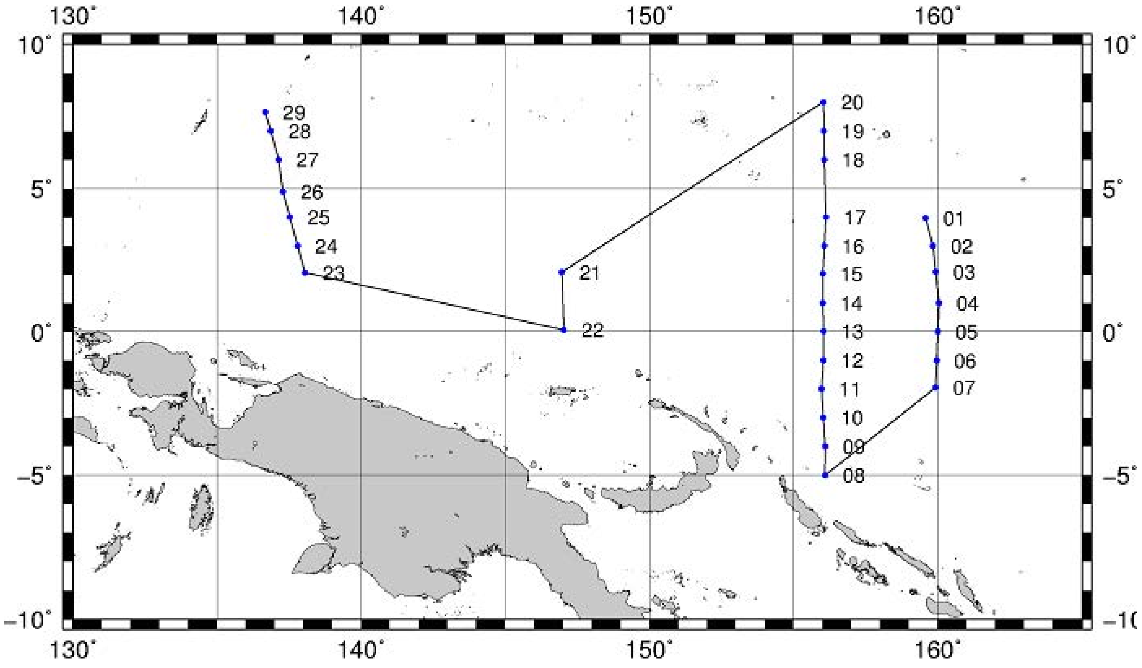
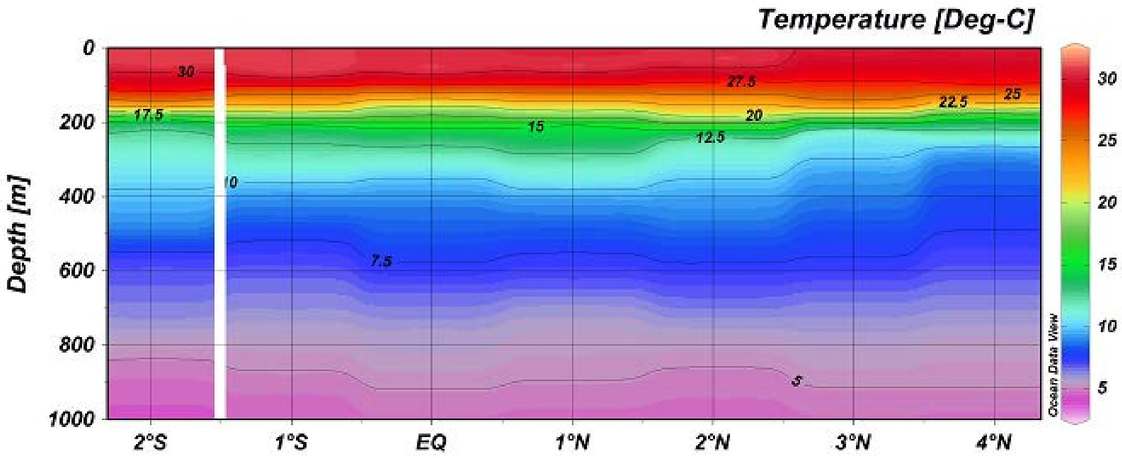


Fig. 7.2.3-1 Position map of XCTD observations.



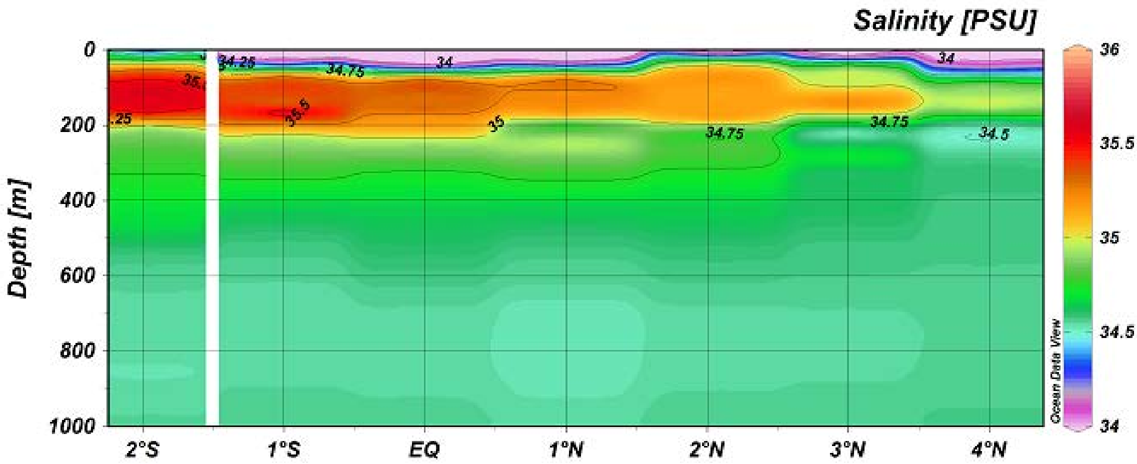


Fig. 7.2.3-2 Vertical section of temperature (upper) and salinity (lower)
from Station XCTD O-12 to XCTD-4 (No. 01 to No. 07)

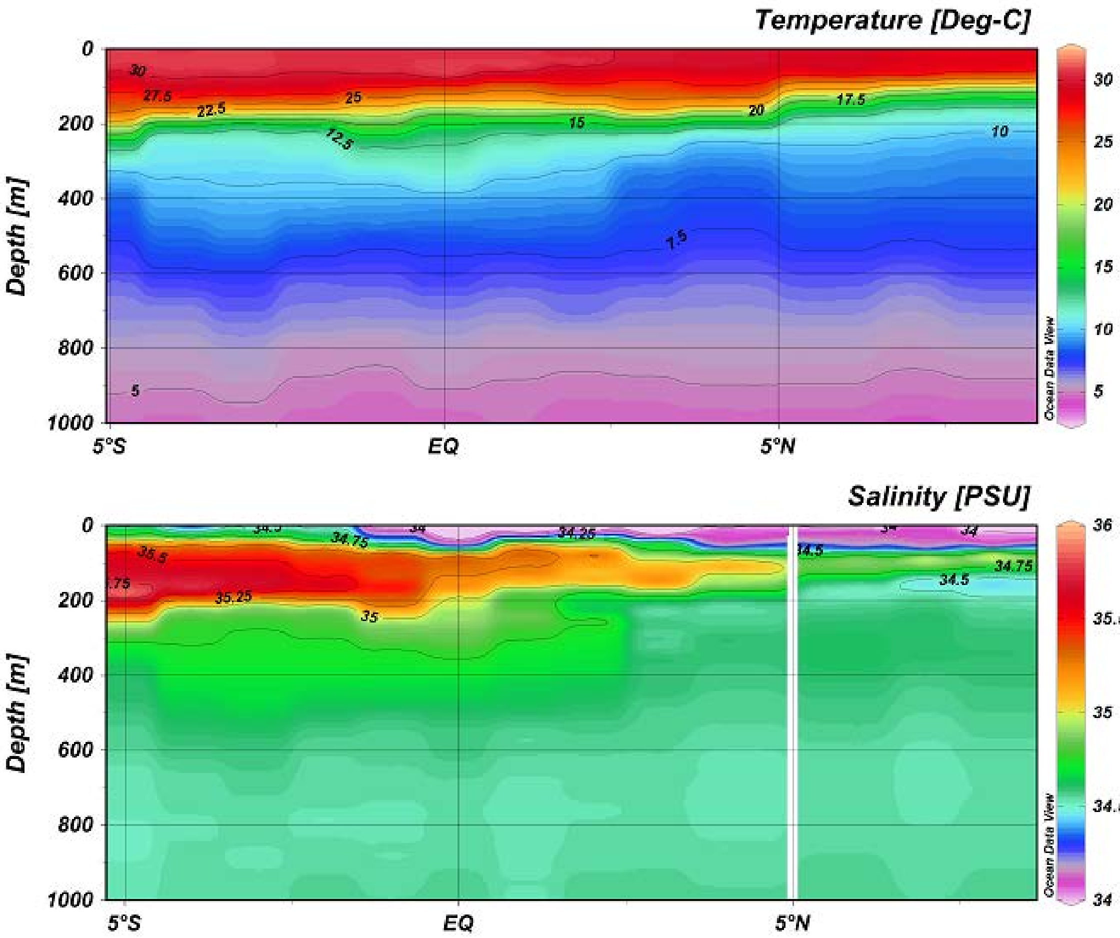


Fig. 7.2.3-3 Vertical section of temperature (upper) and salinity (lower)
from Station XCTD TR06 to TR01 (No. 08 to No. 20)

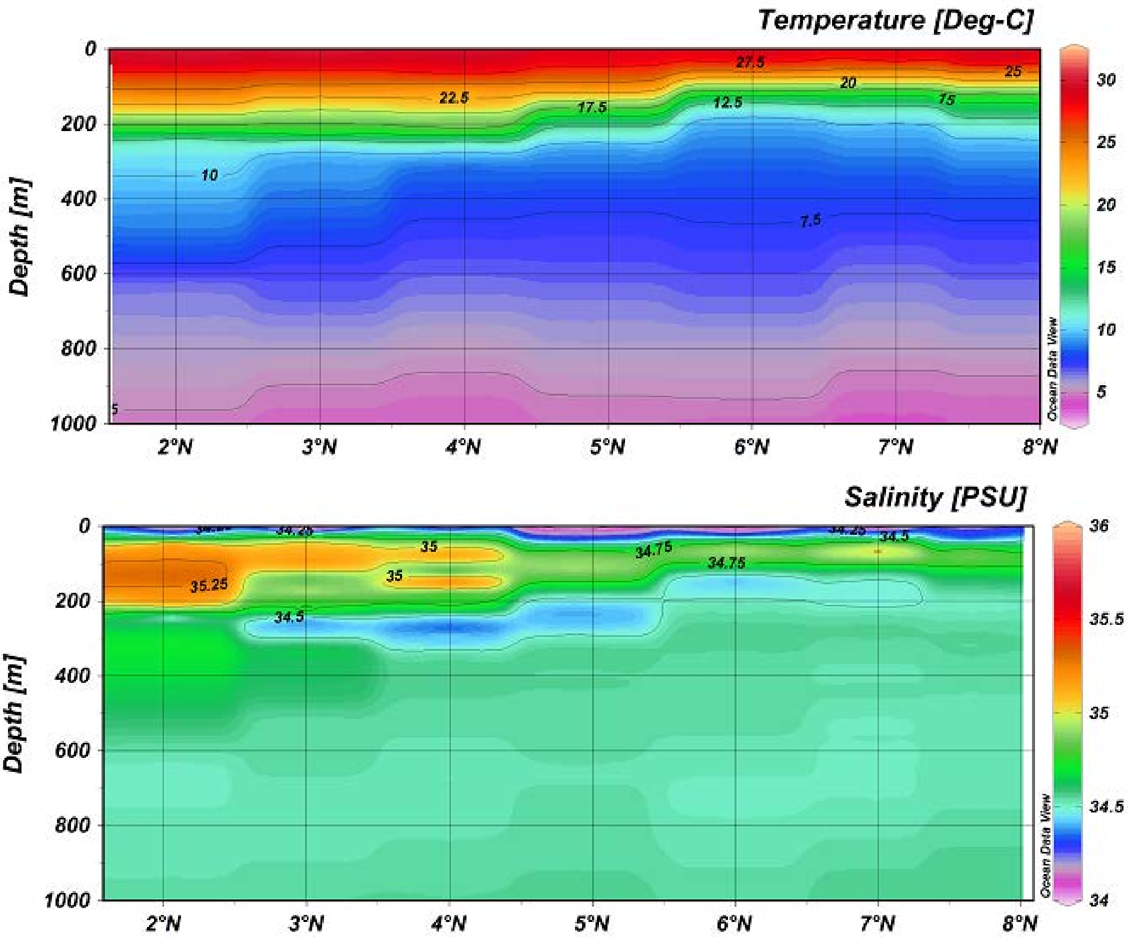


Fig. 7.2.3-4 Vertical section of temperature (upper) and salinity (lower) from Station XCTD TR12 to TR10 (No. 23 to No. 29)

7. 2. 3. Underway CTD

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal investigator	-Leg 2-
Kyoko Taniguchi	(JAMSTEC)	-Leg 2-
Iwao Ueki	(JAMSTEC) Principal investigator	-Leg 3-
Kenichi Katayama	(MWJ) Operation leader	-Leg 2-
Tomohide Noguchi	(MWJ) Operation leader	-Leg 2,3-
Tomomi Sone	(MWJ)	-Leg 2,3-
Katsunori Sagishima	(MWJ)	-Leg3-
Masahiro Orui	(MWJ)	-Leg3-

(2) Objective

The "Underway CTD" (UCTD) system measures vertical profiles of temperature, conductivity and pressure like traditional CTD system. The advantage of the UCTD system is to obtain good-quality CTD profiles from moving vessels with repeatable operation. In addition, the UCTD data are more accurate than those from XCTD because the sensor of the UCTD is basically same as that used in the traditional CTD system.

The purpose of UCTD observation in this cruise is to explore oceanic structure of temperature and salinity at the point of TRITON buoy deployment and the Indian ocean (8S line,95E line,90E line) .

(3) Methods

The UCTD system, manufactured by Oceanscience Group, was utilized in this cruise. The system consists of the probe unit and on-deck unit with the winch and the rewinder, as in Figure 7.2.3-1. After spooling the line for certain length onto the probe unit (in "tail spool" part), the probe unit is released from the vessels in to 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 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 listed in Table 7.2.3-1. 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 7.2.3-2.

Table 7.2.3-1: Specification of the sensors of the UCTD system in this cruise.

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 7.2.3-2: Maximum depth and speed of the vessel during profile.

Maximum depth to profile	Maximum ship 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

Figure 7.2.3-1: UCTD system installed and operated on R/V Mirai.

(4) Preliminary Results

During this cruise, 26 casts of UCTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 7.2.3-3.

Vertical profiles (down cast) of temperature, conductivity, salinity with descent rate are shown in Figure 7.2.3-2 - 7.2.3-4. Unfortunately, the data of u001c01 was uncollectable via Bluetooth communication due to the flood into the housing. Additionally, the cast of u008c01 was lost sensor probe body.

(5) Data archive

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

Table 7.2.3-3: List of UCTD stations during MR14-06 Leg2, Leg3 cruise

Station Number	Cast Number	Time Towed (UTC)	Position Towed		Depth to go (m)	Ship speed (knot)		S/N of sensor	Notes
			Lat. (deg-min)	Lon. (deg-min)		Tow	Recovery		
U01	1	Jan.12 03:54	02-03.71 N	138-03.18E	1000	2.0	2.0	145	Deployment point of T12. Data was uncollectable due to the flood into the housing.
U02	1	Jan.13 03:59	04-52.89 N	137-17.47E	1000	2.0	2.0	064	Deployment point of T11
U03	1	Jan.17 02:26	07-38.93 N	136-40.65E	1000	2.0	2.0	064	Deployment point of T10
U04	1	Jan.30 13:18	07-59.97 S	98-59.96 E	500	8.0	8.0	146	8S line
U05	1	Jan.30 15:56	08-00.00 S	98-29.98 E	500	8.0	8.0	146	8S line
U06	1	Jan.30 18:29	07-59.99 S	97-59.99 E	500	8.0	8.0	146	8S line
U07	1	Jan.30 21:12	07-59.99 S	97-29.99 E	500	8.0	8.0	146	8S line
U08	1	Jan.31 00:01	07-59.93 S	96-59.98 E	500	8.0	8.0	146	8S line Lost sensor probe
U08	2	Jan.31 00:26	07-59.99 S	96-57.19 E	500	8.0	8.0	064	8S line
U09	1	Jan.31 03:01	07-59.99 S	96-29.98 E	500	8.0	8.0	064	8S line
U10	1	Jan.31 05:40	07-59.99 S	95-59.98 E	500	8.0	8.0	064	8S line
U11	1	Jan.31 08:27	08-00.03 S	95-29.98 E	500	8.0	8.0	064	8S line
U12	1	Feb.02 08:49	07-30.00 S	94-59.98 E	500	8.0	8.0	064	95E line
U13	1	Feb.02	06-59.97	95-00.05	500	8.0	8.0	064	95E line

		11:19	S	E					
U14	1	Feb.02 13:52	06-30.00 S	94-59.97 E	500	8.0	8.0	064	95E line
U16	1	Feb.03 12:34	05-30.02 S	94-59.99 E	500	8.0	8.0	064	95E line
U17	1	Feb.07 11:16	00-59.99 S	90-00.00 E	500	8.0	8.0	064	90E line
U18	1	Feb.07 13:52	00-29.99 S	89-59.98 E	500	8.0	8.0	064	90E line
U19	1	Feb.08 12:55	00-30.01 N	90-00.00 E	500	8.0	8.0	064	90E line
U20	1	Feb.08 15:09	01-00.03 N	89-59.99 E	500	8.0	8.0	064	90E line
U21	1	Feb.08 20:40	02-00.01 N	90-00.05 E	500	8.0	8.0	064	90E line
U22	1	Feb.08 22:58	02-30.01 N	90-00.01 E	500	8.0	8.0	064	90E line
U23	1	Feb.09 01:14	03-00.01 N	89-59.99 E	500	8.0	8.0	064	90E line
U24	1	Feb.09 03:27	03-30.02 N	89-59.99 E	500	8.0	8.0	064	90E line Not logging data
U24	2	Feb.09 04:04	03-36.31 N	89-59.98 E	500	8.0	8.0	064	90E line
U25	1	Feb.09 05:46	04-00.03 N	90-00.00 E	500	8.0	8.0	064	90E line

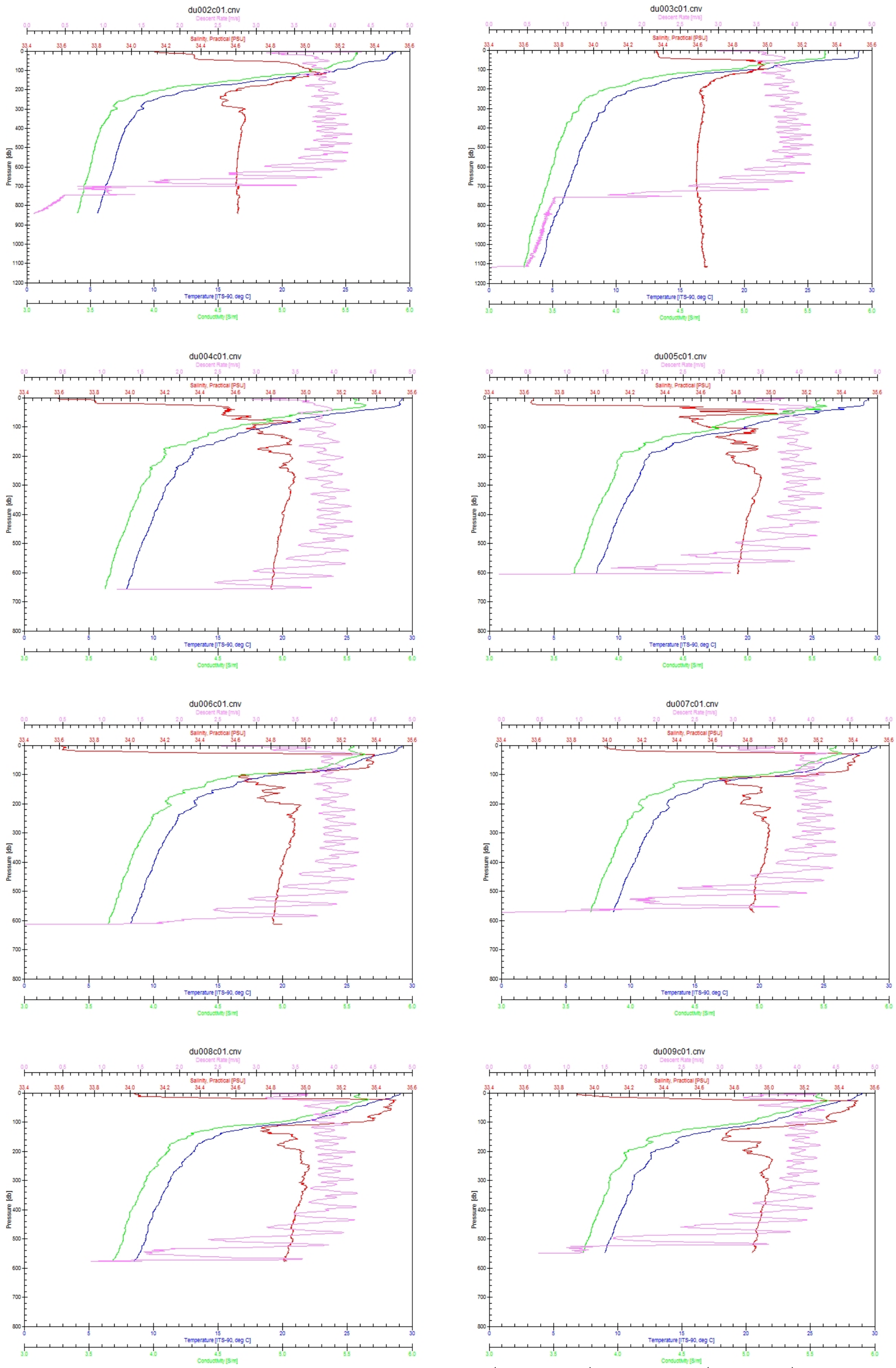


Figure 7.2.3-2: UCTD profiles of temperature (blue line), salinity (red line), conductivity (green line), and descent rate (purple line) at the station of u002c01 - u009c01.

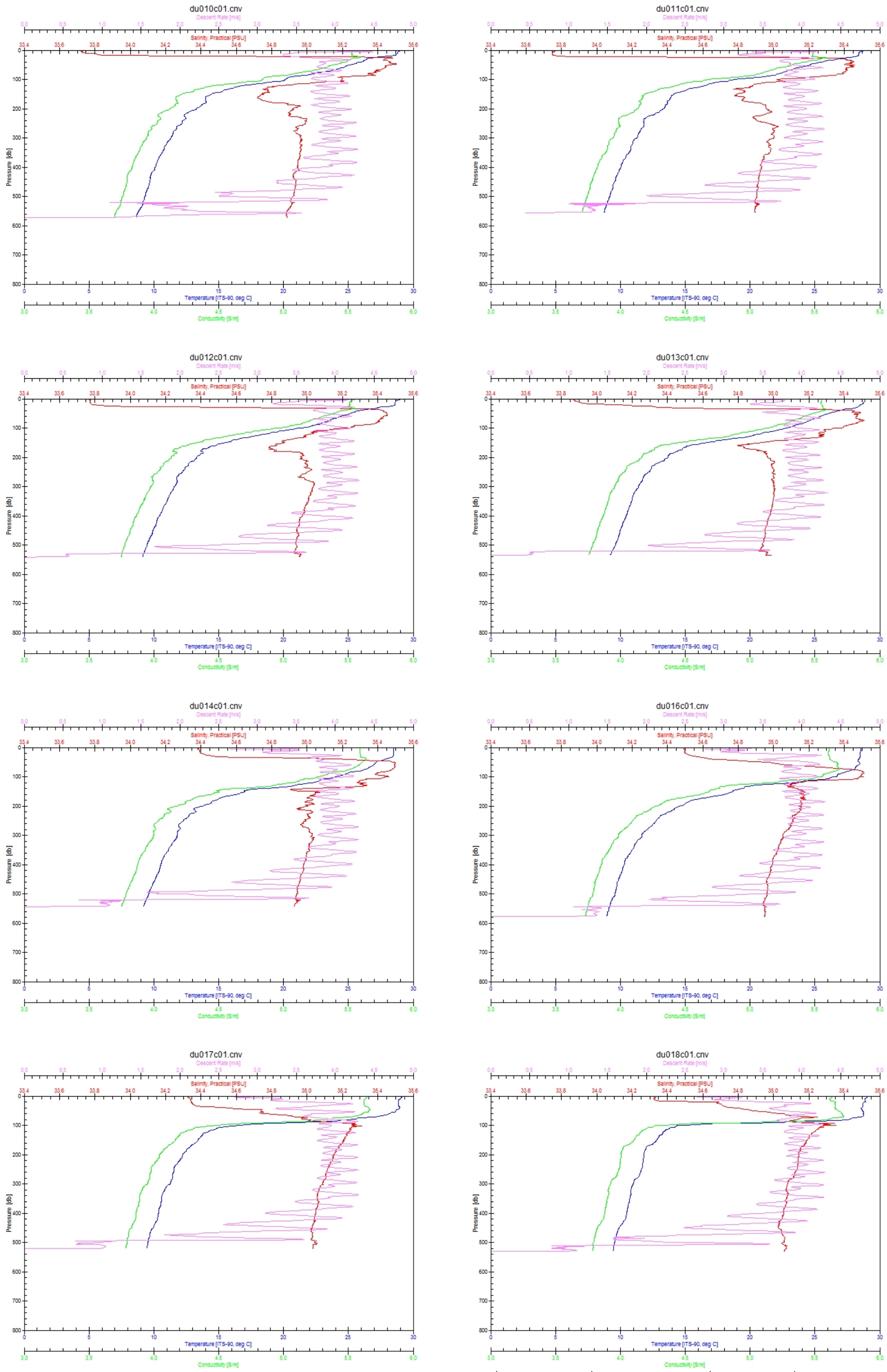


Figure 7.2.3-3: UCTD profiles of temperature (blue line), salinity (red line), conductivity (green line), and descent rate (purple line) at the station of u010c01 - u018c01

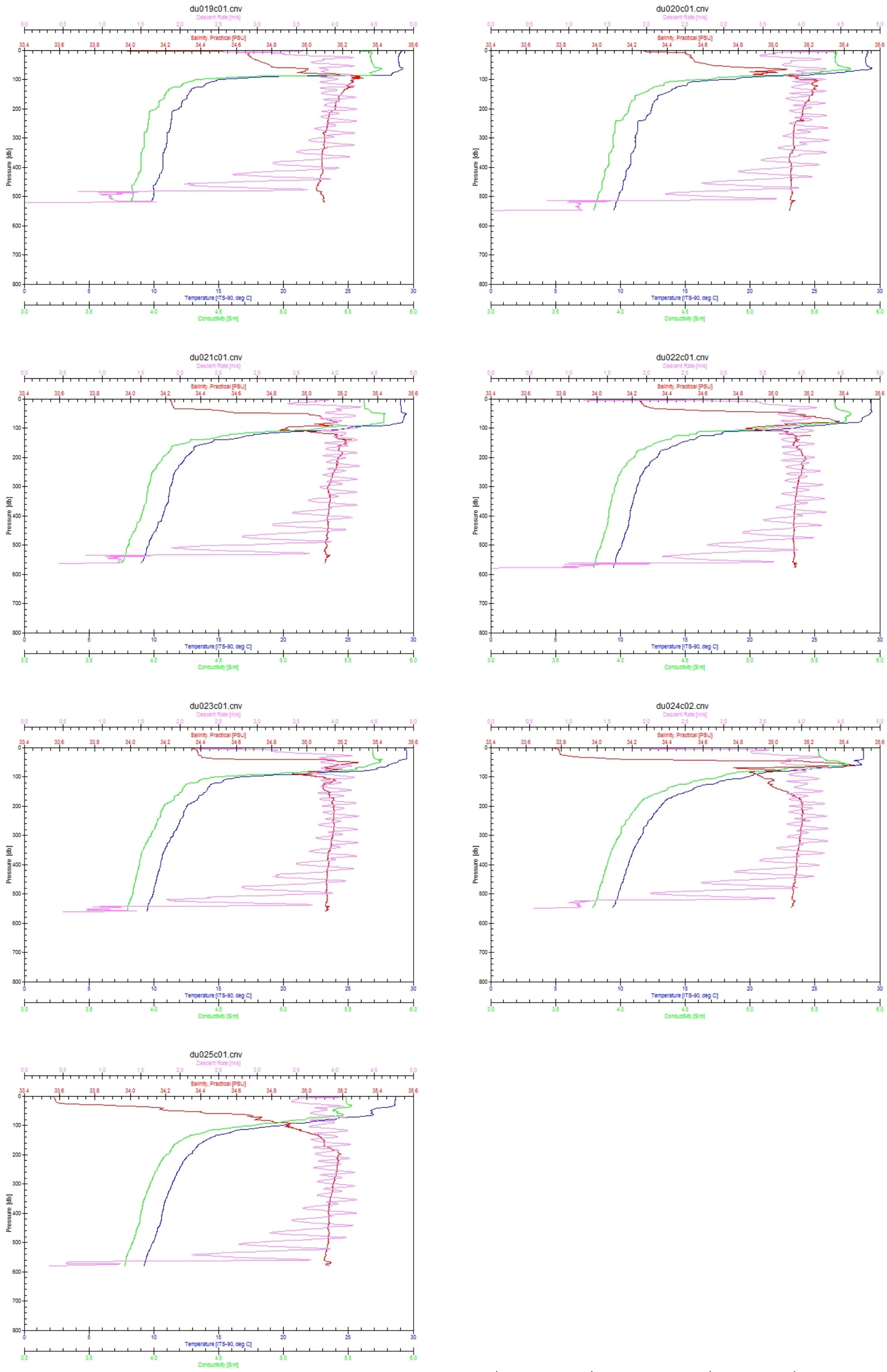


Figure 7.2.3-3: UCTD profiles of temperature (blue line), salinity (red line), conductivity (green line), and descent rate (purple line) at the station of u019c01 - u025c01

7. 2. 4. Water sampling
7.2.4.1. Salinity

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal Investigator	-Leg 2-
Iwao Ueki	(JAMSTEC) Principal investigator	-Leg 3-
Sonoka Wakatsuki	(MWJ) Operation Leader	-Leg 2-
Tatsuya Tanaka	(MWJ) Operation Leader	-Leg 3-
Rei Ito	(MWJ)	-Leg 2-

(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 in Leg2 and Leg3 are shown in Table 7.2.4.1-1 and Table 7.2.4.1-2, respectively.

Table 7.2.4.1-1 Types and numbers (n) of samples in Leg2

Types	N
Samples for CTD	30
Samples for JES10Profiler attached to CTD	10
Samples for TSG	28
Total	58

Table 7.2.4.1-2 Types and numbers (n) of samples in Leg3

Types	N
Samples for CTD	18
Samples for TSG	20
Total	38

b. Instruments and Method

The salinity measurement was carried out on R/V MIRAI during the this cruise 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 21 deg C to 25 deg C, while the bath temperature was very stable and varied within +/- 0.004 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 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:	P157
Conductivity Ratio:	0.99985
Salinity:	34.994
Use By:	15th May 2017

Standardization control of the salinometer S/N 62556 in Leg2 was set to 681 at 30th December and all measurements were carried out at this setting. The value of STANDBY was 24+5190~5191 and that of ZERO was 0.0-0001~0000. 6 bottles of SSW were measured.

Fig.7.2.4.1-1 shows the time series of the double conductivity ratio of SSW batch P157 before correction. The average of the double conductivity ratio was 1.99969 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.
Fig.7.2.4.1-2 shows the time series of the double conductivity ratio of SSW batch P157 after correction. The average of the double conductivity ratio was 1.99970 and the standard deviation was 0.00001, which is equivalent to 0.0001 in salinity.

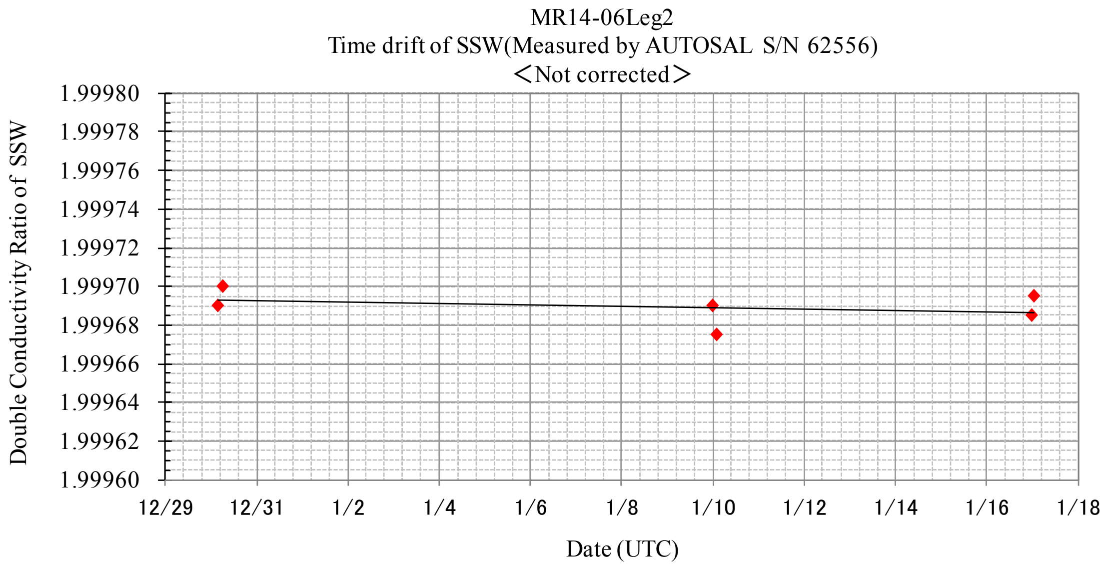


Fig.7.2.4.1-1 Time series of double conductivity ratio for the Standard Seawater batch P157 in Leg2 (before correction).

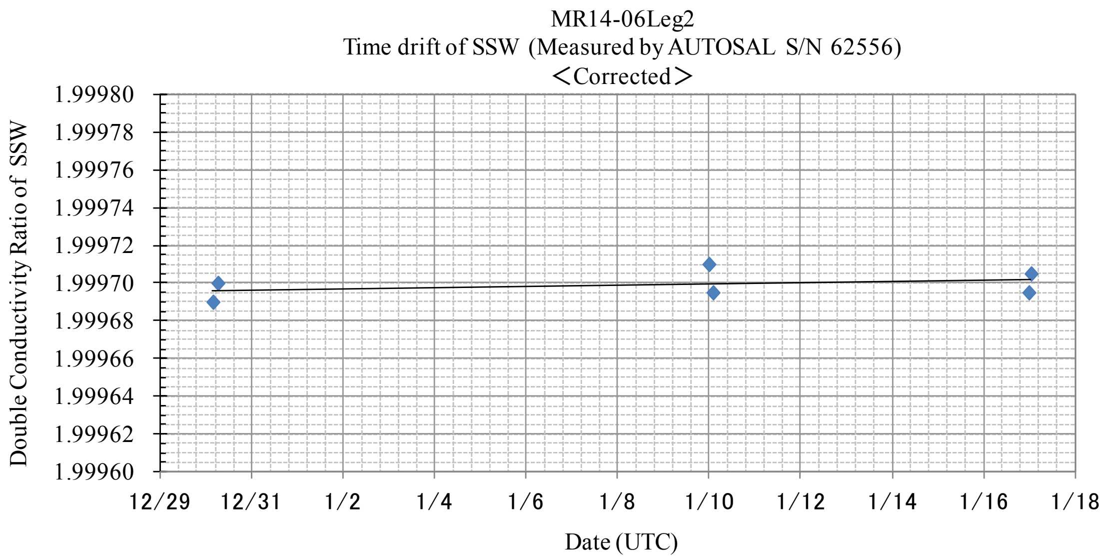


Fig.7.2.4.1-2 Time series of double conductivity ratio for the Standard Seawater batch P157 in Leg2. (after correction)

Standardization control of the salinometer S/N 62556 in Leg3 was set to 682 at 11th February and all measurements were carried out at this setting. The value of STANDBY was 24+5191~5192 and that of ZERO was 0.0-0001~0000. 6 bottles of SSW were measured.

Fig.7.2.4.1-3 shows the time series of the double conductivity ratio of SSW batch P157 before correction. The average of the double conductivity ratio was 1.99967 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

Fig.7.2.4.1-4 shows the time series of the double conductivity ratio of SSW batch P157 after correction. The average of the double conductivity ratio was 1.99970 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

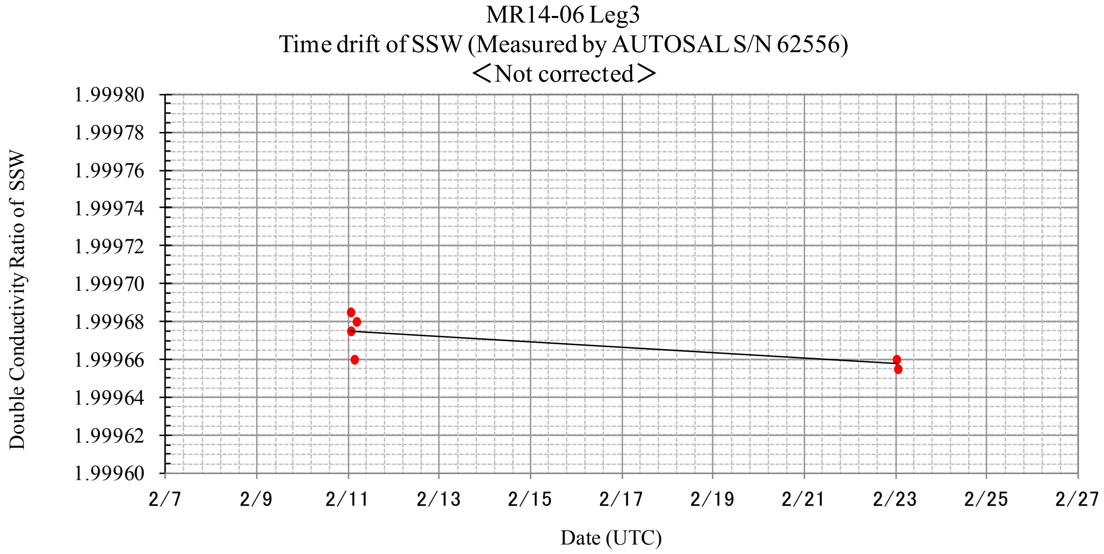


Fig.7.2.4.1-3 Time series of double conductivity ratio for the Standard Seawater batch P157 in Leg3 (before correction).

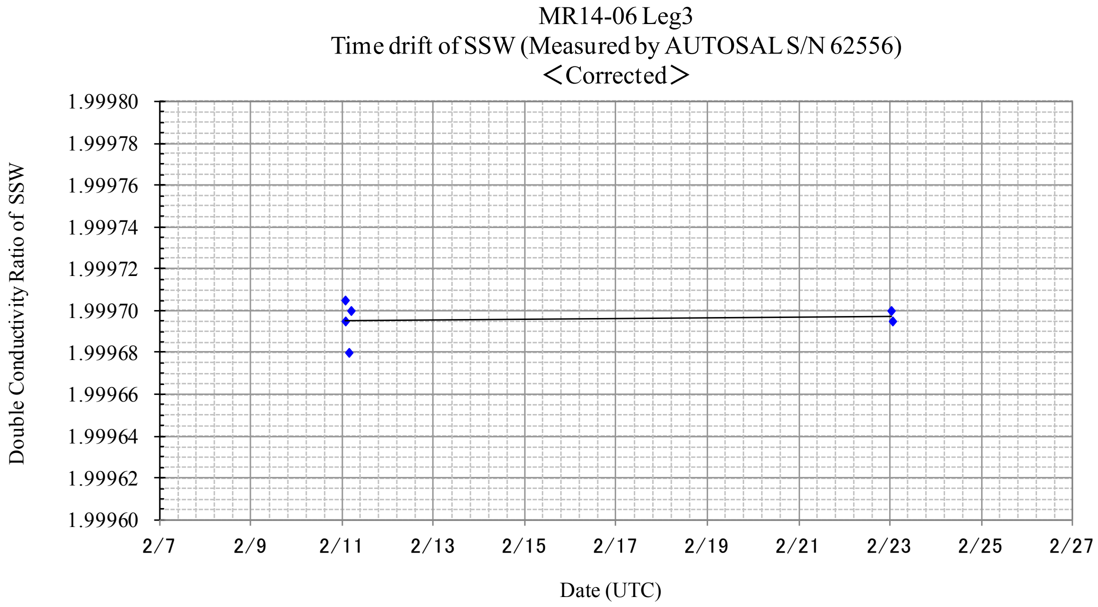


Fig.7.2.4.1-4 Time series of double conductivity ratio for the Standard Seawater batch P157 in Leg3 (after correction).

b. Sub-Standard Seawater

Sub-standard seawater was made from deep-sea water filtered by a pore size of 0.45 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 10 pairs of replicate samples taken from the same Niskin bottle in Leg2. Fig.7.2.4.1-5 shows the histogram of the absolute difference between each pair of the replicate samples. The average and the standard deviation of absolute difference among 10 pairs of replicate samples were 0.0003 and 0.0003 in salinity, respectively.

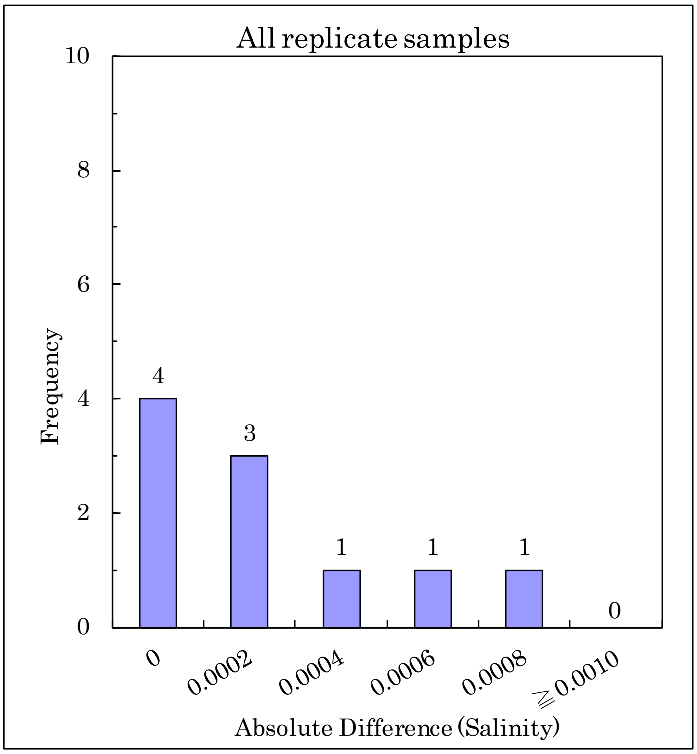


Fig.7.2.4.1-5 Histogram of the absolute difference between replicate samples in Leg2.

We estimated the precision of this method using 9 pairs of replicate samples taken from the same Niskin bottle in Leg3. Fig.7.2.4.1-6 shows the histogram of the absolute difference between each pair of the replicate samples. The average and the standard deviation of absolute difference among 9 pairs of replicate samples were 0.0004 and 0.0003 in salinity, respectively.

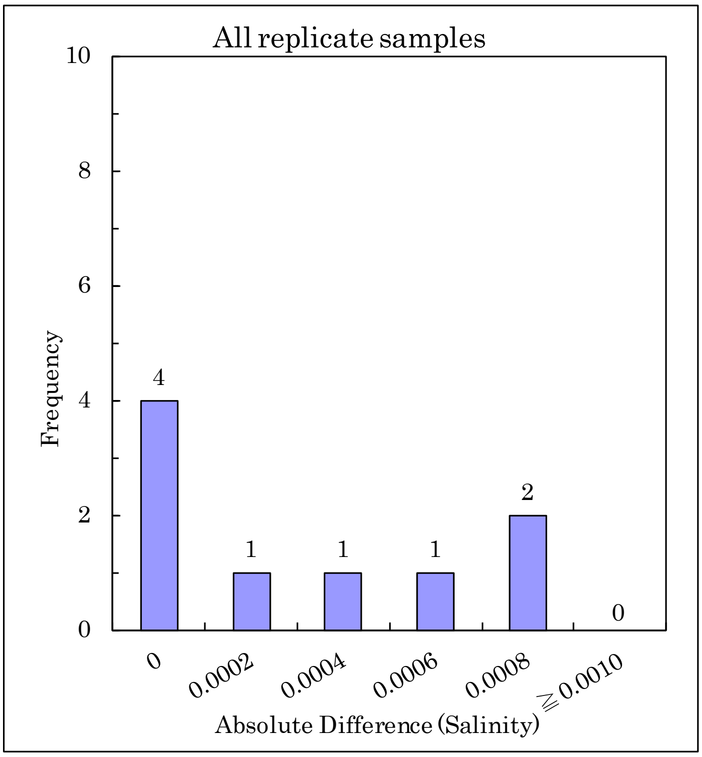


Fig.7.2.4.1.6 Histogram of the absolute difference between replicate samples in Leg3.

(5) Data archive

These raw datasets will be submitted to JAMSTEC DMO (Data Management Office).

(6) Reference

Aoyama, M. T. Joyce, T. Kawano and Y. Takatsuki: Standard seawater comparison up to P129. Deep-Sea Research, I, Vol. 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.

7. 2. 4. 2. Dissolved Oxygen

(1) Personnel

Iwao UEKI (JAMSTEC) Principal Investigator -Leg 3-
Misato KUWAHARA (MWJ) Operation Leader -Leg 3-
Masahiro ORUI (MWJ) -Leg 3-

(2) Objective

Determination of dissolved oxygen in seawater by Winkler titration.

(3) Parameters

Dissolved Oxygen

(4) Instruments and Methods

Following procedure is based on an analytical method, entitled by "Determination of dissolved oxygen in sea water by Winkler titration", in the WHP Operations and Methods (Dickson, 1996).

a. Instruments

Burette for sodium thiosulfate and potassium iodate;
APB-510 / APB-620 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel
Detector;
Automatic photometric titrator (DOT-01X) manufactured by Kimoto Electronic Co. Ltd.
Software;
DOT_Terminal Ver. 1.2.0

b. Reagents

Pickling Reagent I: Manganese chloride solution (3 mol dm^{-3})
Pickling Reagent II:
Sodium hydroxide (8 mol dm^{-3}) / sodium iodide solution (4 mol dm^{-3})
Sulfuric acid solution (5 mol dm^{-3})
Sodium thiosulfate (0.025 mol dm^{-3})
Potassium iodide (0.001667 mol dm^{-3})
CSK standard of potassium iodide:
Lot TLM1372, Wako Pure Chemical Industries Ltd., 0.0100N

c. Sampling

Seawater samples were collected with Niskin bottle attached to the CTD-system. Seawater for oxygen measurement was transferred from sampler to a volume calibrated flask (ca. 100 cm^3). Three times volume of the flask of seawater was overflowed. Temperature was measured by digital thermometer during the overflowing. Then two reagent solutions (Reagent I and II) of 0.5 cm^3 each were added immediately into the sample flask and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

d. Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. 1 cm^3 sulfuric acid solution and a magnetic stirrer bar were added into the sample flask and stirring began. Samples were titrated by sodium thiosulfate solution whose morality was determined by potassium iodate solution. Temperature of sodium thiosulfate during titration was recorded by a digital thermometer. During this cruise, we measured dissolved oxygen concentration using 2 sets of the titration apparatus. Dissolved oxygen concentration ($\mu mol\ kg^{-1}$) was calculated by sample temperature during seawater sampling, salinity of the bottle sampling, flask volume, and titrated volume of sodium thiosulfate solution without the blank.

e. Standardization and determination of the blank

Concentration of sodium thiosulfate titrant was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130° C. 1.7835 g potassium iodate weighed out accurately was dissolved in deionized water and diluted to final volume of 5 dm^3 in a calibrated volumetric flask (0.001667 mol dm^{-3}). 10 cm^3 of the standard potassium iodate solution was added to a flask using a volume-calibrated dispenser. Then 90 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the flask in order. Amount of titrated volume of sodium thiosulfate (usually 5 times measurements average) gave the morality of sodium thiosulfate titrant.

The oxygen in the pickling reagents I (0.5 cm^3) and II (0.5 cm^3) was assumed to be 3.8 x 10^{-8} mol (Murray *et al.*, 1968). The blank due to other than oxygen was determined as follows. 1 and 2 cm^3 of the standard potassium iodate solution were added to two flasks respectively using a calibrated dispenser. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I each were added into the flask in order. The blank was determined by difference between the first (1 cm^3 of KIO_3) titrated volume of the sodium thiosulfate and the second (2 cm^3 of KIO_3) one. The results of 3 times blank determinations were averaged.

(5) Observation log

a. Standardization and determination of the blank

Table 7.2.4.2-1 shows results of the standardization and the blank determination during this cruise.

Table 7.2.4.2-1 Results of the standardization and the blank determinations during cruise.

Date	KIO3 ID	$Na_2S_2O_3$	DOT-01X(No.7)		DOT-01X(No.8)		Stations
			E.P.(ml)	Blank(ml)	E.P.(ml)	Blank(ml)	
2015/01/23	K1404E07	T1406L	3.960	-0.001	3.960	0.001	
2015/01/29	K1404E08	T1406L	3.961	0.003	3.960	0.002	C11, C12, C14
2015/02/05	K1404E09	T1406L	3.959	0.000	3.959	0.002	C16, C17, C18

b. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. Total amount of the replicate sample pairs of good measurement was 10. The standard deviation of the replicate measurement was 0.08 $\mu mol\ kg^{-1}$ that was calculated by a procedure in Guide to best practices for ocean CO_2 measurements Chapter4 SOP23 Ver.3.0 (2007). Results of replicate samples diagram were shown in Figs. 7.2.4.2-1.

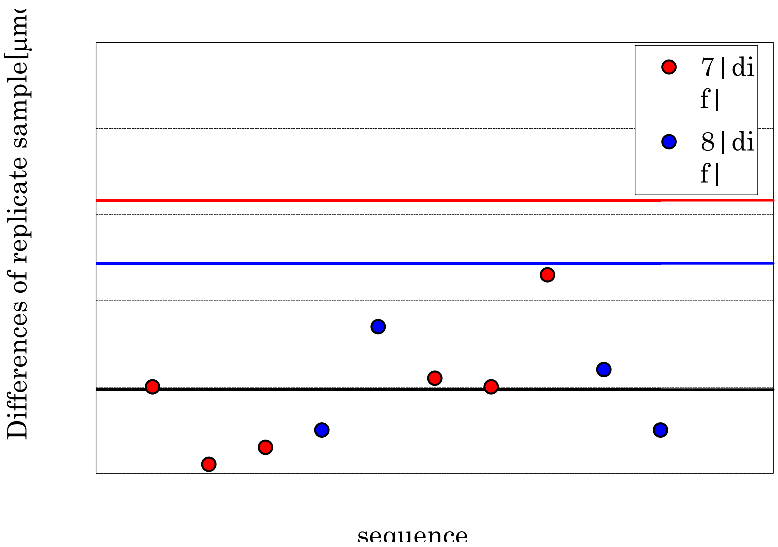


Fig. 7.2.4.2-1 Differences of replicate samples against sequence number

(6) Data archives

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

(7) References

Dickson, A.G., Determination of dissolved oxygen in sea water by Winkler titration. (1996)

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.), Guide to best practices for ocean CO2 measurements. (2007)

Culberson, C.H., WHP Operations and Methods July-1991 "Dissolved Oxygen", (1991)

Japan Meteorological Agency, Oceanographic research guidelines (Part 1) . (1999)

KIMOTO electric CO. LTD., Automatic photometric titrator DOT-01 Instruction manual

7. 2. 4. 3. Nutrients

(1) Personnel

Iwao UEKI	(JAMSTEC) Principal investigator	-Leg 3-
Elena HAYASHI	(MWJ) Operation leader	-Leg 3-
Yoshiko ISHIKAWA	(MWJ)	-Leg 3-
Tomomi SONE	(MWJ)	-Leg 3-

(2) Objectives

The objectives of nutrients analyses during the R/V Mirai MR14-06 cruise in East Indian Ocean is as follows:

- Describe the present status of nutrients concentration with excellent comparability.

(3) Parameters

The determinants are nitrate, nitrite, silicate and phosphate in the East Indian Ocean.

(4) Summary of nutrients analysis

We made 5 QuAAtro runs for the water columns sample at 6 casts during MR14-06. The total amount of layers of the seawater sample reached up to 180. We made basically duplicate measurement. The station locations for nutrients measurement is shown in Figure 7.2.4.3.1.

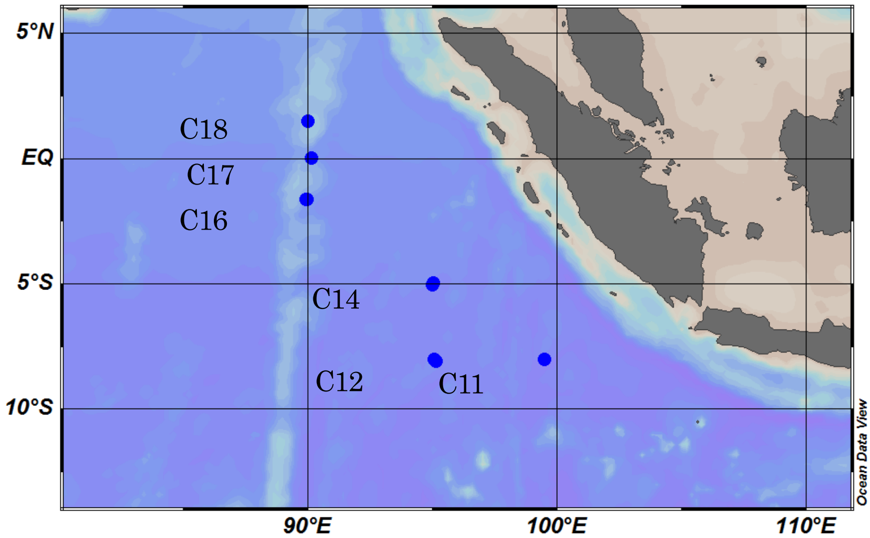


Figure 7.2.4.3.1. Sampling positions of nutrients sample.

(5) Instrument and Method

a. Analytical detail using QuAAtro 2-HR systems (BL-Tech)

Nitrate + nitrite and nitrite were analyzed according to the modification method of Grasshoff (1970). The sample nitrate was reduced to nitrite in a cadmium tube inside of which was coated with metallic copper. The sample streamed with its equivalent nitrite was treated with an acidic, sulfanilamide reagent and the nitrite forms nitrous acid which reacted with the sulfanilamide to produce a diazonium ion. N-1-Naphthylethylene-diamine added to the sample stream then coupled with the diazonium ion to produce a red, azo dye. With reduction of the nitrate to nitrite, both nitrate and nitrite reacted and were measured; without reduction, only nitrite reacted. Thus, for the nitrite analysis, no reduction was performed and the alkaline buffer was not necessary. Nitrate was computed by difference.

The silicate method was analogous to that described for phosphate. The method used was essentially that of Grasshoff et al. (1983), wherein silicomolybdic acid was first formed from the silicate in the sample and added molybdic acid; then the silicomolybdic acid was reduced to silicomolybdous acid, or "molybdenum blue" using ascorbic acid as the reductant. The analytical methods of the nutrients, nitrate, nitrite, silicate and phosphate, during this cruise were same as the methods used in (Kawano et al. 2009).

The phosphate analysis was a modification of the procedure of Murphy and Riley (1962). Molybdic acid was added to the seawater sample to form phosphomolybdic acid which was in turn reduced to phosphomolybdous acid using L-ascorbic acid as the reductant.

The details of modification of analytical methods used in this cruise are also compatible with the methods described in nutrients section in GO-SHIP repeat hydrography manual (Hydes et al., 2010). The flow diagrams and reagents for each parameter are shown in Figures 7.2.4.3.2. to 7.2.4.3.5.

b. Nitrate + Nitrite Reagents

Imidazole (buffer), 0.06 M (0.4 % w/v)

Dissolve 4 g imidazole, $C_3H_4N_2$, in ca. 1000 ml DIW; add 2 ml concentrated HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added.

Sulfanilamide, 0.06 M (1 % w/v) in 1.2M HCl

Dissolve 10 g sulfanilamide, 4-$NH_2C_6H_4SO_3H$, in 900 ml of DIW, add 100 ml concentrated HCl. After mixing, 2 ml Triton®X-100 (50 % solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride, 0.004 M (0.1 %f w/v)

Dissolve 1 g NED, $C_{10}H_7NHCH_2CH_2NH_2 \cdot 2HCl$, in 1000 ml of DIW and add 10 ml concentrated HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added. This reagent is stored in a dark bottle.

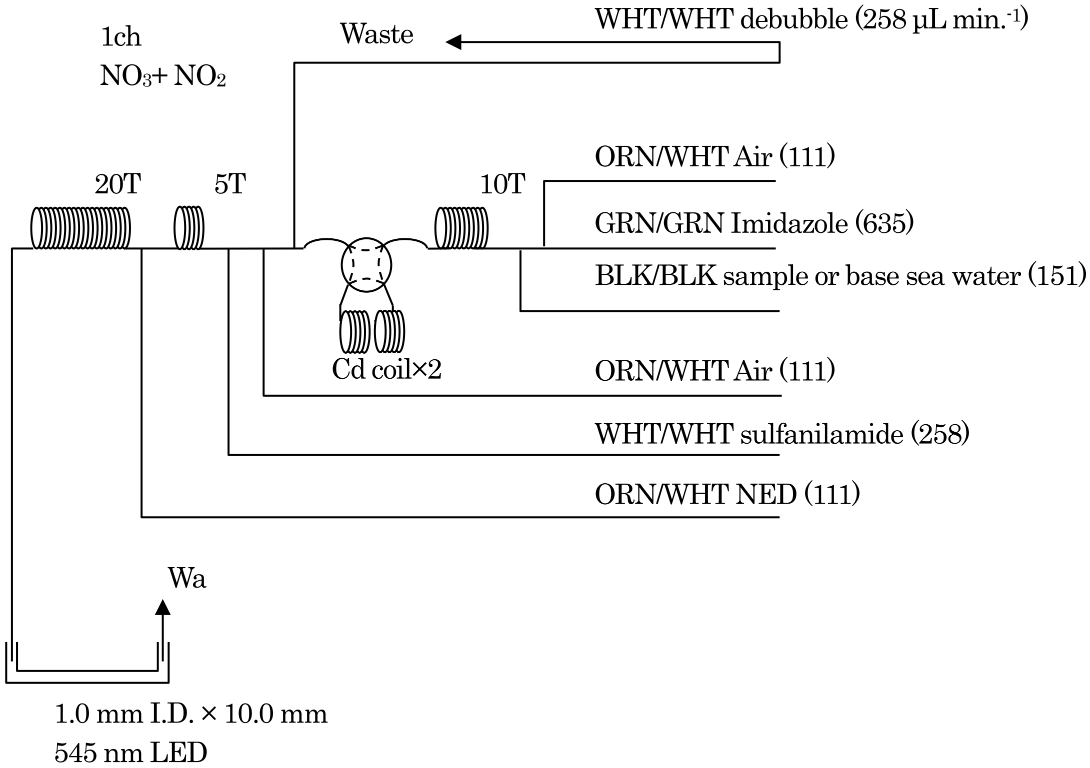


Figure 7.2.4.3.2.NO_3 + NO_2 (1ch.) Flow diagram.

c. Nitrite Reagents

Sulfanilamide, 0.06 M (1 % w/v) in 1.2 M HCl

Dissolve 10g sulfanilamide, 4-$NH_2C_6H_4SO_3H$, in 900 ml of DIW, add 100 ml concentrated HCl. After mixing, 2 ml Triton®X-100 (50 % solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride, 0.004 M (0.1 % w/v)

Dissolve 1 g NED, $C_{10}H_7NHCH_2CH_2NH_2 \cdot 2HCl$, in 1000 ml of DIW and add 10 ml concentrated HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added. This reagent is stored in a dark bottle.

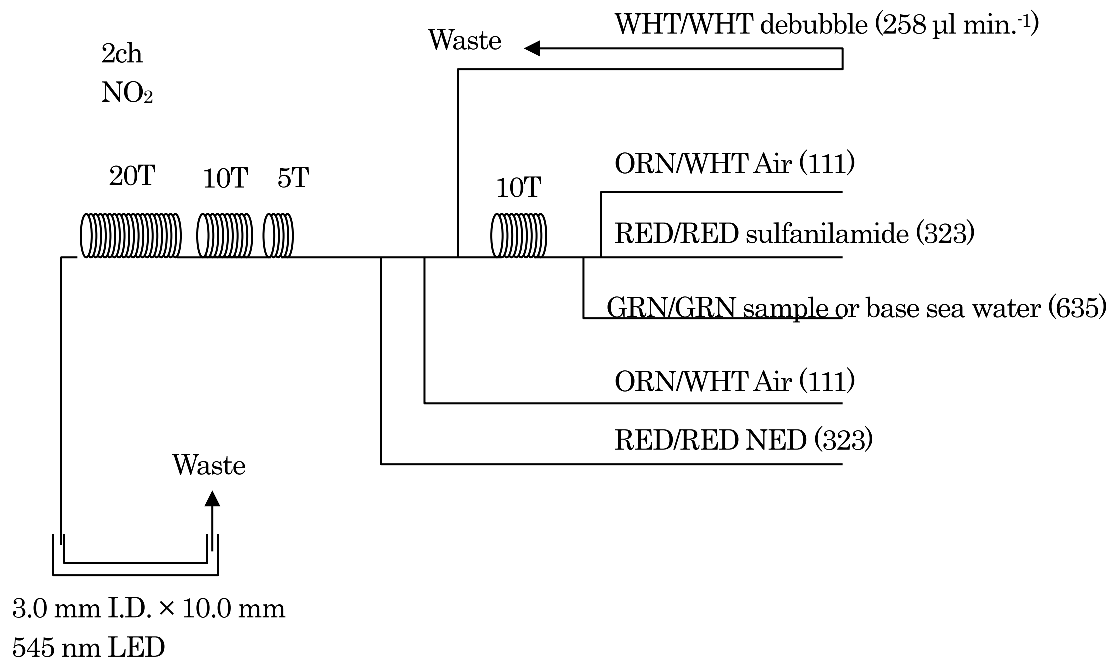


Figure7.2.4.3.3. NO_2 (2ch.) Flow diagram.

d. Silicate Reagents

Molybdic acid, 0.06 M (2 % w/v)

Dissolve 15 g disodium molybdate(VI) dihydrate, $Na_2M_oO_4 \cdot 2H_2O$, in 980 ml DIW, add 8 ml concentrated H_2SO_4. After mixing, 20 ml sodium dodecyl sulphate (15 % solution in water) is added.

Oxalic acid, 0.6 M (5 % w/v)

Dissolve 50 g oxalic acid anhydrous, HOOC: COOH, in 950 ml of DIW.

Ascorbic acid, 0.01M (3 % w/v)

Dissolve 2.5g L (+)-ascorbic acid, $C_6H_8O_6$, in 100 ml of DIW. Stored in a dark bottle and freshly prepared before every measurement.

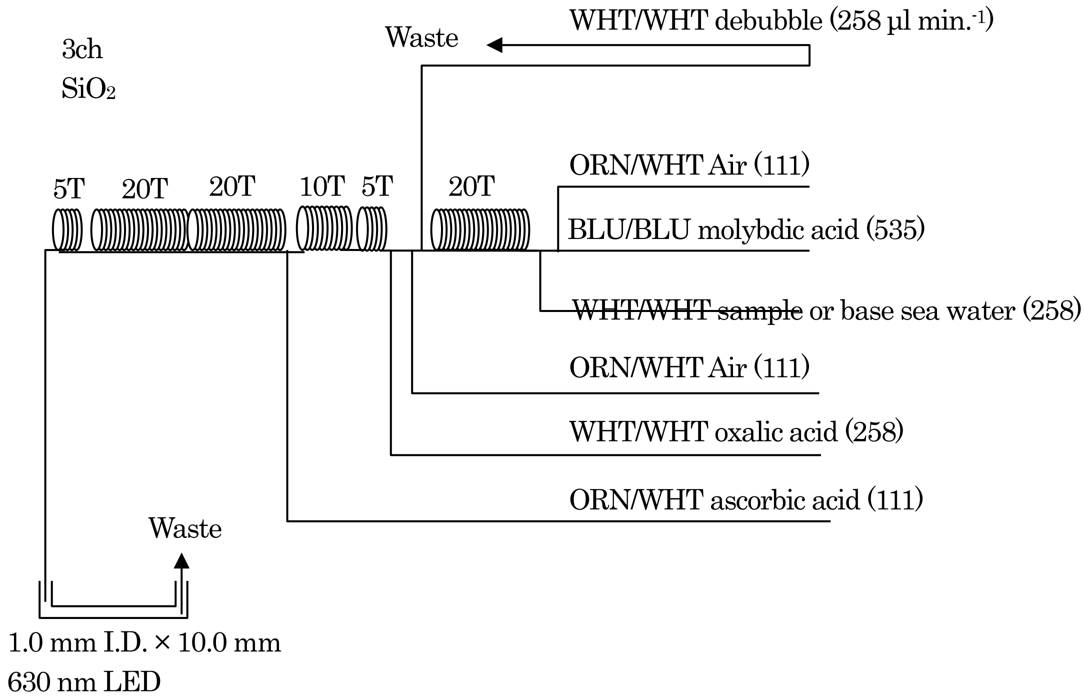


Figure7.2.4.3.4. SiO_2 (3ch.) Flow diagram.

e. Phosphate Reagents

Stock molybdate solution, 0.03M (0.8 % w/v)

Dissolve 8 g disodium molybdate(VI) dihydrate, $Na_2MoO_4 \cdot 2H_2O$, and 0.17 g antimony potassium tartrate, $C_8H_4K_2O_{12}Sb_2 \cdot 3H_2O$, in 950 ml of DIW and add 50 ml concentrated H_2SO_4.

Mixed Reagent

Dissolve 1.2 g L (+)-ascorbic acid, $C_6H_8O_6$, in 150 ml of stock molybdate solution. After mixing, 3 ml sodium dodecyl sulphate (15 % solution in water) is added. Stored in a dark bottle and freshly prepared before every measurement.

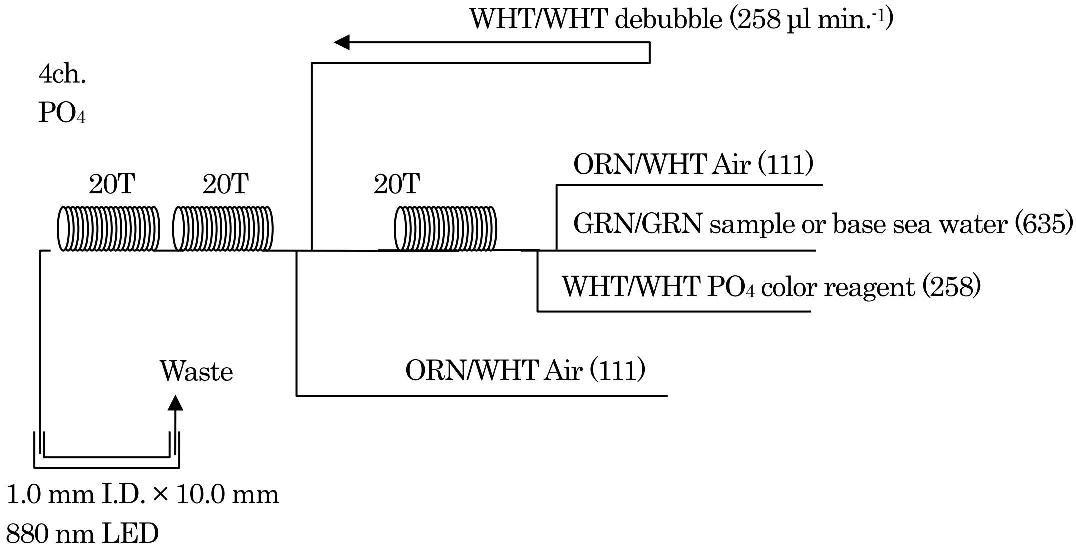


Figure7.2.4.3.5. PO_4 (4ch.) Flow diagram.

f. Sampling procedures

Sampling of nutrients followed that oxygen, salinity and trace gases. Samples were drawn into a virgin 10 ml polyacrylates vials without sample drawing tubes. These were rinsed three times before filling and vials were capped immediately after the drawing. The vials are put into water bath adjusted to ambient temperature, 21.5 ± 0.5 deg. C, in about 30 minutes before use to stabilize the temperature of samples.

No transfer was made and the vials were set an auto sampler tray directly. Samples were analyzed after collection basically within 24 hours. But C16 cast samples were measured 25 hours after the sampling.

g. Data processing

Raw data from QuAAtro were treated as follows:

- Check baseline shift.
- Check the shape of each peak and positions of peak values taken, and then change the positions of peak values taken if necessary.
- Carry-over correction and baseline drift correction were applied to peak heights of each samples followed by sensitivity correction.
- Baseline correction and sensitivity correction were done basically using liner regression.
- Load pressure and salinity from CTD data due to calculate density of seawater.
- Calibration curves to get nutrients concentration were assumed second order equations.

(6) Nutrients standards

a. Volumetric laboratory ware of in-house standards

All volumetric glass ware and polymethylpentene (PMP) ware used were gravimetrically calibrated. Plastic volumetric flasks were gravimetrically calibrated at the temperature of use within 0 to 4 K.

Volumetric flasks

Volumetric flasks of Class quality (Class A) are used because their nominal tolerances are 0.05 % or less over the size ranges likely to be used in this work. Class A flasks are made of borosilicate glass, and the standard solutions were transferred to plastic bottles as quickly as possible after they are made up to volume and well mixed in order to prevent excessive dissolution of silicate from the glass. PMP volumetric flasks were gravimetrically calibrated and used only within 0 to 4 K of the calibration temperature.

The computation of volume contained by glass flasks at various temperatures other than the calibration temperatures were done by using the coefficient of linear expansion of borosilicate crown glass.

Because of their larger temperature coefficients of cubical expansion and lack of tables constructed for these materials, the plastic volumetric flasks were gravimetrically calibrated over the temperature range of intended use and used at the temperature of calibration within 0 to 4 K. The weights obtained in the calibration weightings were corrected for the density of water and air buoyancy.

Pipettes and pipettors

All pipettes have nominal calibration tolerances of 0.1 % or better. These were gravimetrically calibrated in order to verify and improve upon this nominal tolerance.

b. Reagents, general considerations

Specifications

For nitrate standard, “potassium nitrate 99.995 suprapur®” provided by Merck, Lot. B0771365211, CAS No.: 7757-91-1, was used.

For nitrite standard, “sodium nitrite” provided by Wako, HLK7554,CAS No.: 7632-00-0, was used. And assay of nitrite was determined according JIS K8019 and assays of nitrite salts were 98.53 %. We use that value to adjust the weights taken.

For the silicate standard, we use “Silicon standard solution SiO_2 in NaOH 0.5 mol/l CertiPUR®” provided by Merck, CAS No.: 1310-73-2, of which lot number is HC382250 are used. The silicate concentration is certified by NIST-SRM3150 with the uncertainty of 0.5 %. HC382250 is certified as 1001 mg L-1, however, our direct comparison between two Merck standards and estimation based on RMNS gave us a factor of 973 mg L-1 for HC382250. We use this factor throughout MR14-06 to keep comparability for silicate concentration.

For phosphate standard, “potassium dihydrogen phosphate anhydrous 99.995 suprapur®” provided by Merck, Lot. B0691108204, CAS No.: 7778-77-0, was used.

Ultra pure water

Ultra pure water (Milli-Q) freshly drawn was used for preparation of reagent, standard solutions and for measurement of reagent and system blanks.

Low-nutrients seawater (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.20μm pore size membrane filter. This water is stored in 20 liter cubitainer with paper box. The concentrations of nutrient of this water were measured carefully in Oct 2014.

c. Concentrations of nutrients for A, B and C standards

Concentrations of nutrients for A, B and C standards are set as shown in Table 7.2.4.3.1. Then the actual concentration of nutrients in each fresh standard was calculated based on the ambient, solution temperature and determined factors of volumetric laboratory wares.

The calibration curves for each run were obtained using 5 levels, C-1, C-2, C-3, C-4 and C-5.

Table 7.2.4.3.1. Nominal concentrations of nutrients for A, B and C.

	A	B	C-1	C-2	C-3	C-4	C-5
NO_3 (μM)	22600	900	0	9	18	36	54
NO_2 (μM)	4000	20	0	0.2	0.4	0.8	1.2
SiO_2 (μM)	35000	2760	0.8	28	56	111	166
PO_4 (μM)	3000	60	0.1	0.7	1.3	2.5	3.7

Table 7.2.4.3.2. Working calibration standard recipes.

C Std.	B-1 Std.	B-2 Std.	DIW
C-1	0 ml	0 ml	60 ml
C-2	5 ml	5 ml	50 ml
C-3	10 ml	10 ml	30 ml
C-4	20 ml	20 ml	20 ml
C-5	30 ml	30 ml	0 ml

B-1 Std.: Mixture of nitrate, silicate and phosphate
B-2 Std.: Nitrite

d. Renewal of in-house standard solutions

In-house standard solutions as stated in paragraph c were renewed as shown in Table 7.2.4.3.3.

Table 7.2.4.3.3. Timing of renewal of in-house standards.

In-house standards	Renewal
A-1 Std. (NO_3)	maximum a month
A-2 Std. (NO_2)	maximum a month
A-3 Std. (SiO_2)	commercial prepared solution
A-4 Std. (PO_4)	maximum a month
B-1 Std. (mixture of NO_3, SiO_2, PO_4)	maximum 8 days
B-2 Std. (NO_2)	maximum 8 days
C Std. (mixture of B-1 and B-2.)	every 24 hours
D-1 Std. (3600 μM NO_3)	maximum 8 days
43 μM NO_3 (reduction estimation)	when C Std. renewed
47 μM NO_2 (reduction estimation)	when C Std. renewed

(7) Reference material of nutrients in seawater

To get the more accurate and high quality nutrients data to achieve the objectives stated above, huge numbers of the bottles of the reference material of nutrients in seawater (hereafter RMNS) are prepared (Aoyama et al., 2006, 2007, 2008, 2009). In the previous worldwide expeditions, such as WOCE cruises, the higher reproducibility and precision of nutrients measurements were required (Joyce and Corry, 1994). Since no standards were available for the measurement of nutrients in seawater at that time, the requirements were described in term of reproducibility. The required reproducibility was 1 %, 1 to 2 %, 1 to 3 % for nitrate, phosphate and silicate, respectively. Although nutrient data from the WOCE one-time survey was of unprecedented quality and coverage due to much care in sampling and measurements, the differences of nutrients concentration at crossover points are still found among the expeditions (Aoyama and Joyce, 1996, Mordy et al., 2000, Gouretski and Jancke, 2001). For instance, the mean offset of nitrate concentration at deep waters was 0.5 μmol kg^{-1} for 345 crossovers at world oceans, though the maximum was 1.7 μmol kg^{-1} (Gouretski and Jancke, 2001). At the 31 crossover points in the Pacific WHP one-time lines, the WOCE standard of reproducibility for nitrate of 1 % was fulfilled at about half of the crossover points and the maximum difference was 7 % at deeper layers below 1.6 deg. C in potential temperature (Aoyama and Joyce, 1996).

a. RMNS for this cruise

RMNS lots BY, BW and BV, which cover full range of nutrients concentrations in the East Indian Ocean are prepared. 8 sets of BY, BW and BV are prepared.

These RMNS assignment were completely done based on random number. The RMNS bottles were stored at a room in the ship, REAGENT STORE, where the temperature was maintained around 21.0 deg. C.

b. Assigned concentration for RMNSs

We assigned nutrients concentrations for RMNS lots BY, BW and BV as shown in Table 7.2.4.3.4.

Table 7.2.4.3.4 Assigned concentration of RMNSs.

unit: µmol kg^{-1}

	Nitrate	Nitrite	Silicate	Phosphate	Assigned year
BY	0.07	0.03	1.54	0.041	2014
BW	24.59	0.08	58.18	1.545	2014
BV	35.32	0.06	99.55	2.512	2014

(8) Quality control

a. Precision of nutrients analyses during the cruise

Precision of nutrients analyses during this cruise was evaluated based on the 5 measurements, which are measured every 7 to 8 samples, during a run at the concentration of C-5 std. Summary of precisions are shown as shown in Table 7.2.4.3.5.

Analytical precisions previously evaluated were 0.08 % for nitrate, 0.07 % for silicate and 0.10 % for phosphate in CLIVAR P21 revisited cruise of MR09-01 cruise in 2009, respectively. In this cruise, analytical precisions were 0.08% for nitrate, 0.10% for nitrite, 0.12% for silicate and 0.10% for phosphate in terms of median of precision, respectively. Then we can conclude that the analytical precisions for nitrate, nitrite, silicate and phosphate were maintained throughout this cruise.

Table 7.2.4.3.5 Summary of precision based on the replicate analyses.

	Nitrate CV %	Nitrite CV %	Silicate CV %	Phosphate CV %
Median	0.10	0.14	0.11	0.10
Mean	0.09	0.12	0.11	0.10
Maximum	0.11	0.16	0.16	0.17
Minimum	0.07	0.06	0.04	0.05
N	5	5	5	5

b. Carry over

We can also summarize the magnitudes of carry over throughout the cruise. These are small enough within acceptable levels as shown in Table 7.2.4.3.6.

Table 7.2.4.3.6. Summary of carry over throughout MR14-06

	Nitrate %	Nitrite %	Silicate %	Phosphate %
Median	0.24	0.14	0.24	0.23
Mean	0.24	0.12	0.23	0.23
Maximum	0.28	0.21	0.25	0.27
Minimum	0.19	0.04	0.20	0.19
N	5	5	5	5

(9) Problems/improvements occurred and solutions.

a. C16 cast measurement result

We used C16 cast remeasurement data as a final result. During measurement, NO_2 (2ch) and PO_4 (4ch) peak height out of charting windows, because lots of air bubbles have appeared into the flow lines. It also has found that 2ch baseline and peak chart noise high. Therefore, we adjusted line connection points not to make the space and changed some pump tubes. After that we measured C16 samples, again.

(10) Station list

The sampling station list for nutrients is shown in Table 7.2.4.3.7.

Table 7.2.4.3.7.List of stations

Station	Cast	Latitude	Longitude
C11	1	-8.0008	99.5016
C12	1	-8.0988	95.1581
C14	1	-5.0398	95.0186
C16	1	-1.6168	89.9481
C17	1	0.0317	90.1481
C18	1	1.5003	90.0014

(11) Data archive

These data obtained in this cruise will be submitted to the Data Integration and Analysis Group (DMG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC home page.

(12) References

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7. 2. 4. 4. Chlorophyll *a*

(1) Personnel

Iwao UEKI	(JAMSTEC) Principal Investigator	-Leg 3-
Misato KUWAHARA	(MWJ) Operation Leader	-Leg 3-
Masahiro ORUI	(MWJ)	-Leg 3-

(2) Objective

We measured total chlorophyll *a* in seawater by using the fluorometric method.

(3) Parameters

Total chlorophyll *a*

(4) Instruments and methods

We collected samples for chlorophyll *a* (chl-*a*) from 13 depths between the surface and 200 m depth with Niskin bottles attached to the CTD-system.

Water samples for total chl-*a* were vacuum-filtrated (<0.02MPa) through 25mm-diameter Whatman GF/F filter. Phytoplankton pigments retained on the filters were immediately extracted in a polypropylene tube with 7 ml of N,N-dimethylformamide. The tubes were stored at –20°C under the dark condition to extract chl-*a* for 24 hours or more.

Fluorescences of each sample were measured by Turner Design fluorometer (10-AU-005), which was calibrated against a pure chl-*a* (Sigma chemical Co.). We applied fluorometric determination for the samples of chl-*a*: "Non-acidification method" (Welschmeyer, 1994). Analytical conditions of this method were listed in Table 7.2.4.4-1.

(5) Results

Samples for total chl-*a* were collected at 6 casts. The numbers of samples for total chl-*a* were 84.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Office (DMO) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC home page.

(7) Reference

Welschmeyer, N. A. (1994): Fluorometric analysis of chlorophyll *a* in the presence of chlorophyll *b* and pheopigments. *Limnol. Oceanogr.*, 39, 1985–1992.

Table 7.2.4.4-1. Analytical conditions of non-acidification method for chlorophyll *a* with Turner Design fluorometer (10-AU-005).

	Non-acidification method
Excitation filter (nm)	436
Emission filter (nm)	680
Lamp	Blue F4T5,B2/BP

7.2.5. Shipboard ADCP

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal Investigator	- Leg2 -
Iwao Ueki	(JAMSTEC) Principal Investigator	- Leg3 -
Shinya Okumura	(GODI)	- Leg2 -
Kazuho Yoshida	(GODI)	- Leg2 -
Yutaro Murakami	(GODI)	- Leg2 -
Katsuhisa Maeno	(GODI)	- Leg3 -
Miki Morioka	(GODI)	- Leg3 -
Masanori Murakami	(MIRAI Crew)	- Leg2 -
Ryo Kimura	(MIRAI Crew)	- Leg3 -

(2) Objective

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

(3) Methods

Upper ocean current measurements were made in MR14-06Leg2, Leg3 cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation 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. The system consists of following components;

1) R/V MIRAI has installed the Ocean Surveyor for vessel-mount (acoustic frequency 76.8 kHz; Teledyne RD Instruments). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel
2) For heading source, we use ship's gyro compass (Tokimec, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System (INS) which provide high-precision heading, attitude information, pitch and roll, are stored in ".N2R" data files with a time stamp.
3) Positioning system (GARMIN: GPS 19x HVS) providing position fixes.
4) We used VmDas version 1.47.2 (TRD Instruments) 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 (7.2 m; transducer depth) by equation in Medwin (1975).

Data was configured for 16 m intervals starting 23 m below sea surface. Every ping was recorded as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds averaged data were recorded as short term average (.STA) and long term average (.LTA) data, respectively. Major parameters for the measurement (Direct Command) are shown in Table 7.2-1.

(4) Preliminary results

Fig.7.2-1 shows the surface current vector along the ship's track.

(5) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via JAMSTEC home page.

Table 7.2-1 Major parameters

Environmental Sensor Commands

EA	=	+04500	Heading Alignment (1/100 deg)
EB	=	+00000	Heading Bias (1/100 deg)
ED	=	0007.2	Transducer Depth (0 - 7.2535 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)

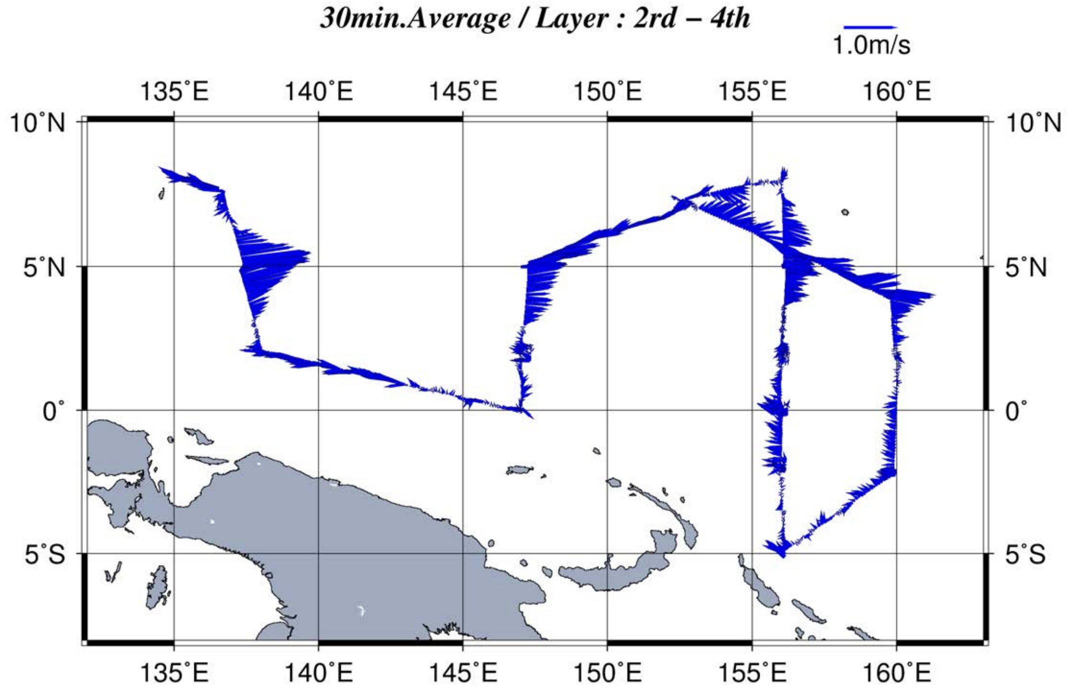


Fig 7.2-1. Surface current vector along the ship's track. (TRITON area)

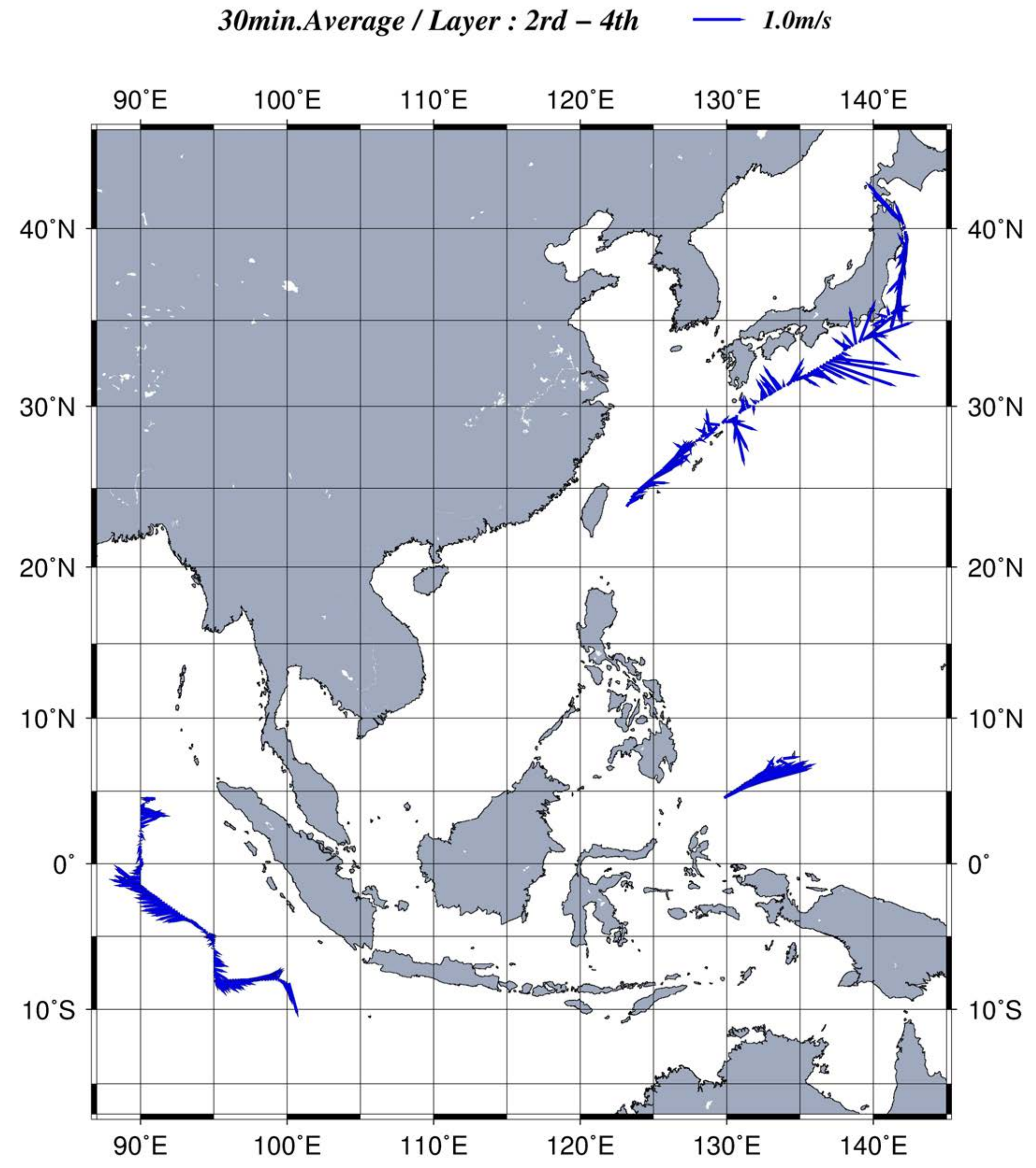


Fig 7.2-2. Surface current vector along the ship's track. (MR14-06 Leg3)

7.2.6. Ocean surface layer monitoring

7.2.6.1. TSG

(1) Objective

Kentaro Ando	(JAMSTEC)	Principal Investigator	- Leg2 -
Iwao Ueki	(JAMSTEC)	Principal Investigator	- Leg3 -
Akihiko Murata	(JAMSTEC)	Principal Investigator	- Leg2&3 -
Haruka Tamada	(MWJ)	Operation Leader	- Leg2 -
Hideki Yamamoto	(MWJ)		- Leg2 -
Keitaro Matsumoto	(MWJ)		- Leg2 -
Masahiro Orui	(MWJ)	Operation Leader	- Leg3 -
Katsunori Sagishima	(MWJ)		- Leg3 -
Misato Kuwahara	(MWJ)		- Leg3 -

(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 10 dm^3 min^{-1}.

a. Instruments

Software

Seamoni-kun Ver.1.50

Sensors

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

Temperature and Conductivity sensor

Model:	SBE-45, SEA-BIRD ELECTRONICS, INC.
Serial number:	4563325-0362
Measurement range:	Temperature -5 to +35 ^{o}C Conductivity 0 to 7 S m^{-1}
Initial accuracy:	Temperature 0.002 ^{o}C Conductivity 0.0003 S m^{-1}
Typical stability (per month):	Temperature 0.0002 ^{o}C Conductivity 0.0003 S m^{-1}
Resolution:	Temperatures 0.0001 ^{o}C Conductivity 0.00001 S m^{-1}

Bottom of ship thermometer

Model:	SBE38,SEA-BIRD ELECTRONICS,INC.
Serial number:	3857820-0540
Measurement range:	-5 to +35 ^{o}C
Initial accuracy:	±0.001 ^{o}C
Typical stability (per 6 month):	0.001 ^{o}C
Resolution:	0.00025 ^{o}C

Dissolved oxygen sensor

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

Dissolved oxygen sensor

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

Fluorometer

Model:	C3, TURNER DESIGNS
Serial number:	2300123

(5) Station list or Observation log

Periods of measurement, maintenance, and problems during MR14-06 Leg 2 and 3 are listed in Table 7.2.6.1-1.

Table 7.2.6.1-1 Events list of the Sea surface water monitoring during MR14-06

System Date [UTC]	System Time [UTC]	Events	Remarks
2014/12/20	05:49	All the measurements started and data was available.	Leg 2 start.
2015/01/08	04:25	All the measurements stopped.	Filter Cleaning.
2015/01/08	05:11	All the measurements started.	Logging restart.
2015/01/17	22:30	All the measurements stopped.	Leg 2 end.
2015/01/22	06:00	All the measurements started and data was available.	Leg 3 start.
2015/01/23	01:29	All the measurements stopped.	
2015/01/30	06:00	All the measurements started and data was available.	Logging restart.
2015/02/09	11:00	All the measurements stopped.	
2015/02/17	18:30	All the measurements started and data was available.	Logging restart.
2015/02/23	15:00	All the measurements stopped.	Leg 3 end.

We took the surface water samples once a day to compare sensor data with bottle data of salinity and dissolved oxygen. The results are shown in Fig. 7.2.6.1-3 ~ 6. All the salinity samples were analyzed by the Guideline 8400B "AUTOSAL" (see 7.2.4.1), and dissolve oxygen samples were analyzed by Winkler method.

(6) Data archive

These data obtained in this cruise will be submitted to the Data Management Office (DMO) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC home page.

We checked the data of each sensor. Then we found drift of data. The doubtful data are listed in Table 7.2.6.1-2.

Table 7.2.6.1-2 List of the doubtful data of OPTODEduring MR14-06

System Date [UTC]	System Time [UTC]	Events
12/20	05:28	The doubtful data of OPTODE are started
12/20	11:44	The doubtful data of OPTODE are finished
12/21	03:44	The doubtful data of OPTODE are started
12/21	08:43	The doubtful data of OPTODE are finished
12/24	12:21	The doubtful data of OPTODE are started
12/24	13:22	The doubtful data of OPTODE are finished
01/10	06:51	The doubtful data of OPTODE are started
01/10	08:15	The doubtful data of OPTODE are finished
01/10	08:55	The doubtful data of OPTODE are started
01/10	10:39	The doubtful data of OPTODE are finished
02/17	18:30	The doubtful data of OPTODE & RINKO are started
02/18	23:22	The doubtful data of Salinity are started
02/18	23:30	The doubtful data of Salinity are finished
02/18	00:00	The doubtful data of RINKO are finishd
02/18	01:00	The doubtful data of OPTODE are finished

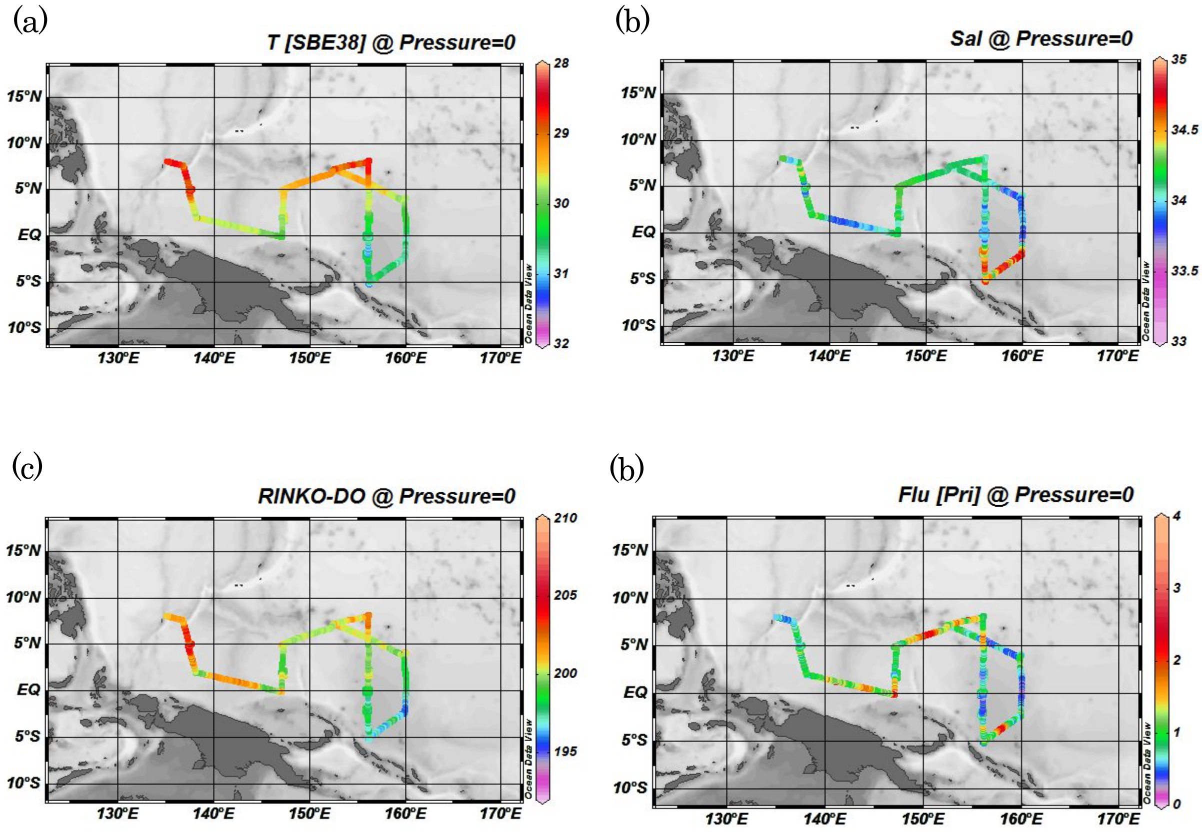


Fig 7.2.6.1-1 Spatial and temporal distribution of (a) temperature, (b) salinity, and (c) dissolved oxygen and (d) fluorescence in MR14-06leg2 cruise.

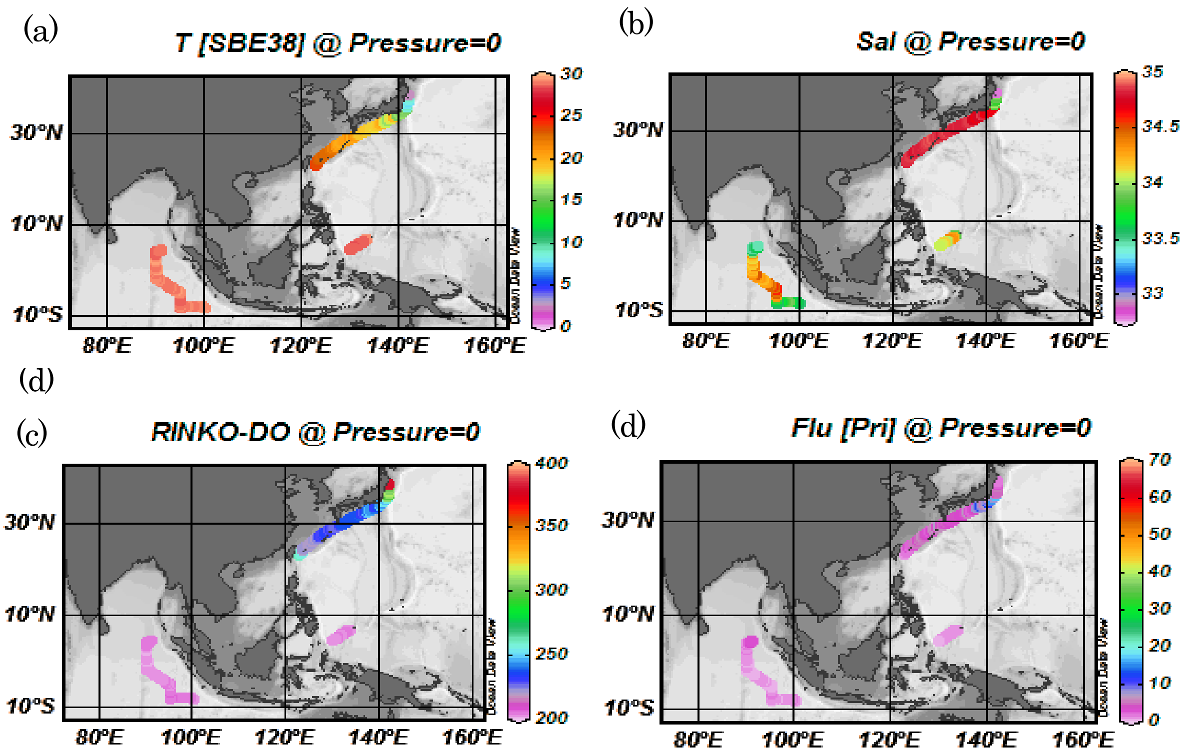


Fig 7.2.6.1-2 Spatial and temporal distribution of (a) temperature, (b) salinity, and (c) dissolved oxygen and (d) fluorescence in MR14-06leg3 cruise.

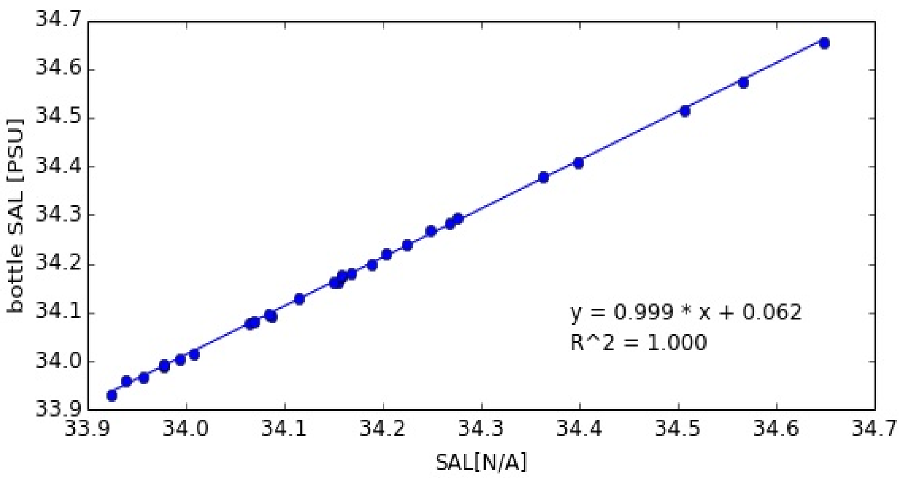


Fig 7.2.6.1-3 Correlation of salinity between sensor data and bottle data in MR14-06leg2 cruise.

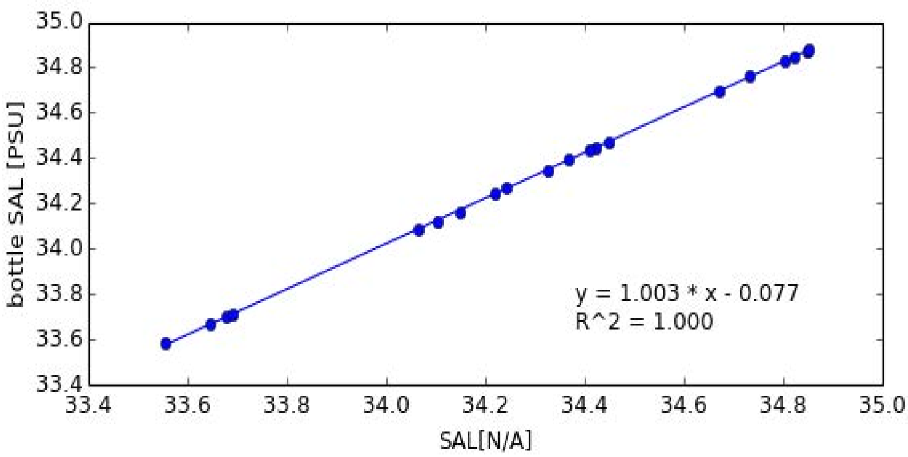


Fig 7.2.6.1-4 Correlation of salinity between sensor data and bottle data in MR14-06leg3 cruise.

(a)

(b)

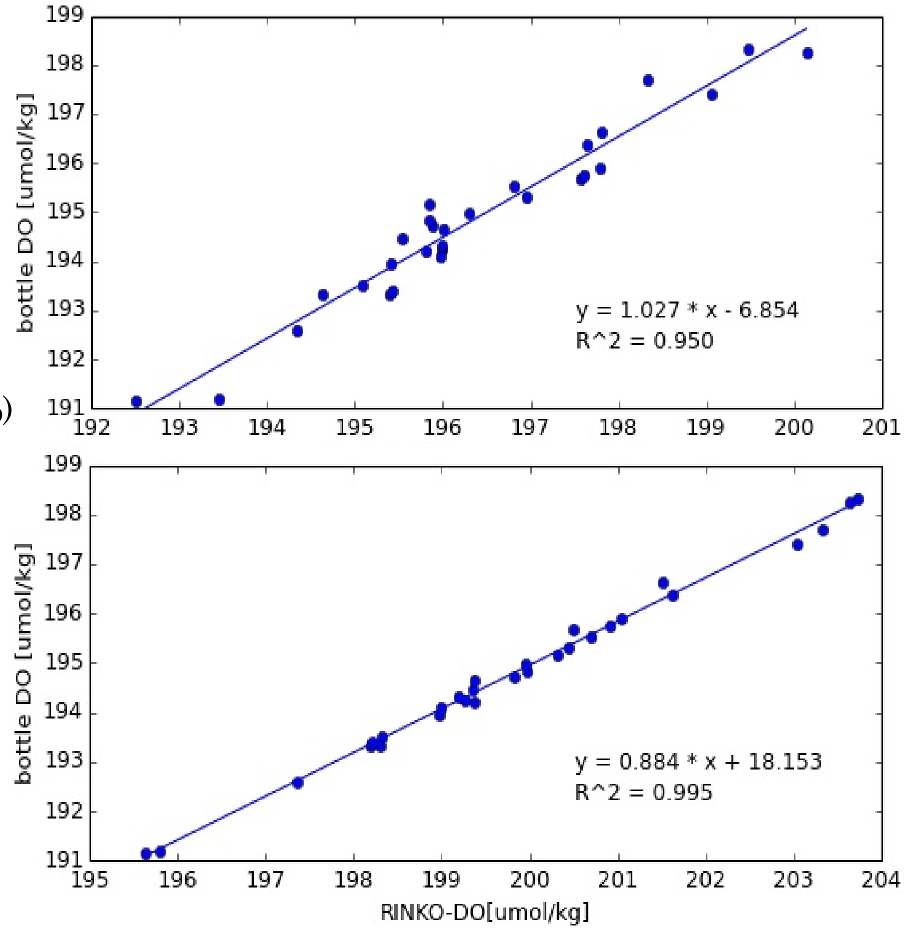
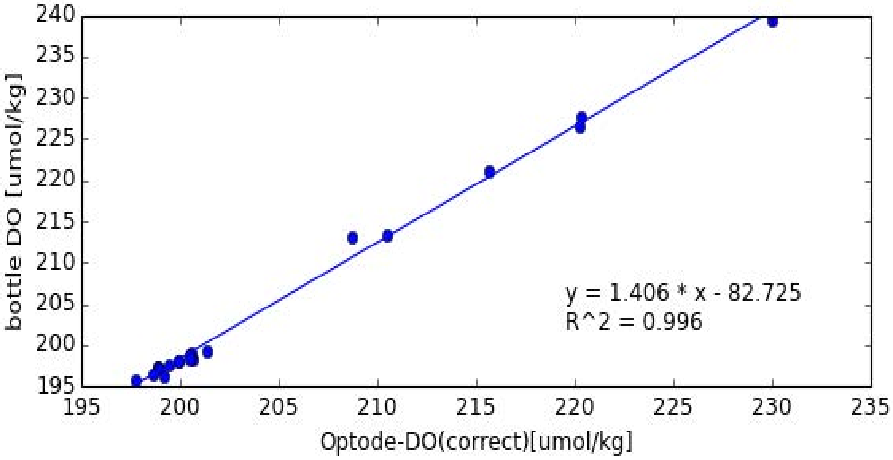

bottle DO [umol/kg]
y = 1.027 * x - 6.854
R^2 = 0.950
bottle DO [umol/kg]
y = 0.884 * x + 18.153
R^2 = 0.995
RINKO-DO[umol/kg]

Fig 7.2.

(a)



(b)

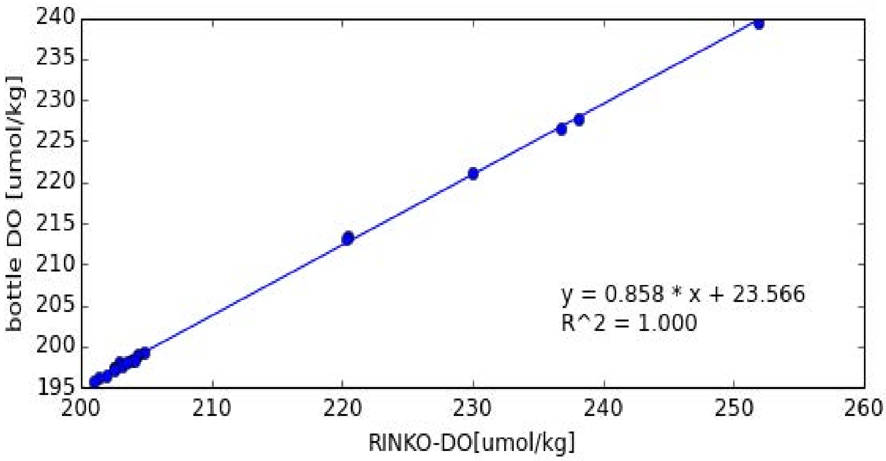


Fig 7.2.6.1-6 Correlation of dissolved oxygen between sensor data and bottle data in MR14-06leg3 cruise.(a: OPTODE, b: RINKO)

7. 3. Geophysical survey

7.3.1. Sea surface gravity

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal Investigator	-Leg2-
Daisuke Suetsugu	(JAMSTEC) Principal Investigator	-Leg2-
Iwao Ueki	(JAMSTEC) Principal Investigator	-Leg3-
Takeshi Hanyu	(JAMSTEC)	Not on-board
Masao Nakanishi	(Chiba University)	Not on-board
Takeshi Matsumoto	(University of the Ryukyus)	Not on-board
Shinya Okumura	(GODI)	-Leg2-
Kazuho Yoshida	(GODI)	-Leg2-
Yutaro Murakami	(GODI)	-Leg2-
Kastuhisa Maeno	(GODI)	-Leg3-
Miki Morioka	(GODI)	-Leg3-
Masanori Murakami	(MIRAI Crew) -Leg2-	
Ryo Kimura	(MIRAI Crew) -Leg3-	

(2) Objective

Sea surface gravity on cruise truck is observed as a basic dataset for geophysics and geodesy.

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

(5) Data archives

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

Table 7.3.1-1

No.	Date YY/MM/DD	UTC	Port	Absolute Gravity [mGal]	Sea level [cm]	Draft [cm]	Gravity at Senor[*1] [mGal]	L&R[*2] [mGal]
#01	14/10/31	06:04	Sekinehama	980,371.95	275	640	980,373.04	12665.89
#02	15/02/26	03:28	Sekinehama	980,371.94	298	625	980,373.07	12668.87

[*1]: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.2222

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

7.3.2. Sea surface magnetic field

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal Investigator	-Leg2-
Daisuke Suetsugu	(JAMSTEC) Principal Investigator	-Leg2-
Iwao Ueki	(JAMSTEC) Principal Investigator	-Leg3-
Takeshi Hanyu	(JAMSTEC)	Not on-board
Masao Nakanishi	(Chiba University)	Not on-board
Takeshi Matsumoto	(University of the Ryukyus)	Not on-board
Shinya Okumura	(GODI)	-Leg2-
Kazuho Yoshida	(GODI)	-Leg2-
Yutaro Murakami	(GODI)	-Leg2-
Kastuhisa Maeno	(GODI)	-Leg3-
Miki Morioka	(GODI)	-Leg3-
Masanori Murakami	(MIRAI Crew) -Leg2-	
Ryo Kimura	(MIRAI Crew) -Leg3-	

(2) Objective

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. For that purpose, we observed geomagnetic field along cruise track using a three-component magnetometer.

(3) Principle of ship-board geomagnetic vector measurement

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

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

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

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

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

(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 will be submitted to the Data Management Group (DMG) of JAMSTEC.

(6) Remarks

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

16:00UTC - 16:23UTC 22 Dec. 2014 around 01-56N, 160-01E

18:39UTC - 19:07UTC 24 Dec. 2014 around 04-58S, 156-03E
00:42UTC - 01:07UTC 03 Jan. 2015 around 08-01N, 156-01E

7.3.3. Swath Bathymetry

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal Investigator	-Leg2-
Daisuke Suetsugu	(JAMSTEC) Principal Investigator	-Leg2-
Iwao Ueki	(JAMSTEC) Principal Investigator	-Leg3-
Takeshi Hanyu	(JAMSTEC)	Not on-board
Masao Nakanishi	(Chiba University)	Not on-board
Takeshi Matsumoto	(University of the Ryukyus)	Not on-board
Shinya Okumura	(GODI)	-Leg2-
Kazuho Yoshida	(GODI)	-Leg2-
Yutaro Murakami	(GODI)	-Leg2-
Kastuhisa Maeno	(GODI)	-Leg3-
Miki Morioka	(GODI)	-Leg3-
Masanori Murakami	(MIRAI Crew) -Leg2-	
Ryo Kimura	(MIRAI Crew) -Leg3-	

(2) Objective

Swath bathymetry mapping was conducted to contribute to geological and geophysical study through making a global dataset.

(3) Data Acquisition

A Multi narrow Beam Echo Sounding system (MBES), SEABEAM 3012 (L3 Communications ELAC Nautik) on R/V MIRAI was used for bathymetry mapping during the MR14-06 Leg2 and Leg3 cruise.

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

Table 7.3.3-1 shows system configuration and performance of SEABEAM 3012 system.

Table 7.3.3-1 SEABEAM 3012 System configuration and performance

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

(4) Preliminary Results

The results will be published after primary processing.

(5) Data Archives

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

7.3.4. Sub-bottom profiler

(1) Personnel

Kentaro Ando	(JAMSTEC) Principal Investigator	-Leg2-
Daisuke Suetsugu	(JAMSTEC) Principal Investigator	-Leg2-
Takeshi Hanyu	(JAMSTEC)	Not on-board
Masao Nakanishi	(Chiba University)	Not on-board
Takeshi Matsumoto	(University of the Ryukyus)	Not on-board
Shinya Okumura	(GODI)	-Leg2-
Kazuho Yoshida	(GODI)	-Leg2-
Yutaro Murakami	(GODI)	-Leg2-
Masanori Murakami	(MIRAI Crew) -Leg2-	

(2) Objective

The objective of Sub-Bottom Profiler (SBP), Bathy2010 (SyQwest) is collecting sub-bottom data along cruise track.

(3) Data Acquisition

Bathy2010 on R/V MIRAI was used for the geological structure of the seabed. We carried out SBP survey at BBOBS/BBOBEM deployment stations and minesweeping area of TRITON No.11.

Table 7.3.4-1 shows system configuration and performance of Bathy2010 system.

Table 7.3.4-1 Bathy2010 System configuration and performance

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

(4) Data Archives

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

8. Cruise log

8.1. Leg 2

SMT (UTC+10)	UTC	Event
Dec. 20 (Sat)		
10:10	00:10	Departure from Chuuk, Federated States of Micronesia
18:00	08:00	Start continuous observations
Dec. 21 (Sun)		
		Heading to 4N160E site
Dec. 22 (Mon)		
03:27	17:27	Launching XCTD-1 (03-58.01N, 159-34.70E)
04:19	18:19	Starting Sea Beam Survey
08:00	22:00	Stop Sea Beam Survey
08:06	22:06	Deployment of OBEM-1 (4-00.019N, 159-55.02E)
08:13	22:13	Deployment of BBOBS-1 (4-00.03N, 159-55.09E)
11:14	01:14	Restart Sea Beam Survey
12:16	02:16	End Sea Beam Survey
15:30	05:30	Launching Radio Sonde-1 (03-13.72N, 159-48.84E)
16:42	06:42	Launching XCTD-2 (2-59.94N, 159-49.82E)
21:13	11:13	Launching XCTD-3 (2-05.49N, 159-55.42E)
21:28	11:28	Launching Radio Sonde-2 (2-03.15N, 159-54.83E)
21:45	11:45	Start Sea Beam survey
Dec. 23 (Tue)		
00:36	14:36	Stop Sea Beam survey
00:44	14:44	Deployment of OBEM-2 (1-55.67N, 160-00.91E)
00:55	14:55	Deployment of BBOBS-2 (1-55.59N, 160-00.92E)
03:48	17:48	Restart Sea Beam survey
05:45	19:45	End Sea beam survey
09:24	23:45	Launching XCTD-4 (1-00.00N, 160-02.54E)
13:49	03:49	Launching XCTD-5 (00-00.01N, 160-00.01E)
18:08	08:08	Launching XCTD-6 (1-00.19S, 159-57.60E)
22:22	12:22	Launching XCTD-7 (1-57.16S, 159-55.26E)
22:51	12:51	Start Sea Beam Survey
23:31	13:31	Stop Sea Beam Survey
23:54	13:54	Deployment of OBEM-3 (2-08.87N, 159-55.56E)
Dec. 24 (Wed)		
00:01	14:01	Deployment of BBOBS-3 (2-08.86N, 159-66.54E)
02:12	16:12	Restart Sea Beam Survey
06:10	20:10	End Sea Beam Survey
12:30	02:30	Radio Sonde-3 (02-59.10S, 158-47.29E)
15:30	05:30	Radio Sonde-4 (03-20.71S, 158-18.41E)
Dec. 25 (Thu)		
05:56	19:56	Deployment of OBEM-4 (4-58.39S, 156-02.68E)
06:03	20:03	Deployment of BBOBS-4 (4-58.44S, 156-02.72E)
07:34	21:34	Start CTD/water sampling (4-58.42S, 156-02.29E)
08:25	22:25	End CTD/water sampling
09:05	23:05	Start Recovery of TRITON No.6
12:31	02:31	End Recovery work of TRITON No.6

14:26	04:26	Start halobates sampling by plankton-net
15:34	05:34	End halobates sampling
15:40	05:40	XCTD-8 (5-00.65S, 156-05.46E)
16:39	06:39	Start Sea Beam Survey
18:34	08:34	End Sea Beam Survey
22:21	02:21	XCTD-9 (4-00.03S, 156-05.71E)
Dec. 26 (Fri)		
03:02	17:02	XCTD-10 (03-00.01S, 156-01.57E)
08:58	22:58	Start Deployment of TRITON No.5
09:31	23:31	Launching Radio Sonde-5 (2-00.27S, 155-58.08E)
11:13	01:13	End deployment of TRITON No.5
11:53	01:53	XCTD-11 (2-00.34S, 155-57.96E)
13:03	03:03	Start CTD/water sampling
13:52	03:52	End CTD/water sampling
15:05	05:05	Start Sea Beam survey
18:00	08:00	Stop Sea beam survey
18:28	08:28	Start halobates sampling
19:38	09:38	End halobates sampling
19:56	09:56	Re-start sea beam survey
Dec. 27 (Sat)		
02:22	14:22	End Sea beam survey
05:57	19:57	Deployment of OBEM-5 (1-58.29S, 155-59.77E)
06:05	20:05	Deployment of BBOBS-5 (1-58.29S, 155-59.75E)
08:00	22:00	Start Recovery of TRITON No.5
10:36	00:36	End recovery of TRITON No.5
13:05	03:05	Start CTD/water sampling
15:41	05:41	End CTD/water sampling
20:24	10:24	Launching XCTD-12 (1-00.02S, 156-01.99E)
Dec. 28 (Sun)		
08:19	22:18	Start deployment of TRITON No. 4
09:29	23:29	Launching of Radio Sonde-6 (0-00.03N, 156-01.48E)
10:13	00:13	End deployment of TRITON No.4
10:47	00:47	Launching XCTD-13 (0-00.54N, 156-02.26E)
12:30	02:30	Launching Radio Sonde-7 (0-03.25S, 156-07.51E)
13:23	03:23	Start deployment of sub-surface ADCP at 0-156E
14:51	04:51	End deployment of sub-surface ADCP at 0-156E
15:49	05:49	Start CTD/water sampling
16:35	06:35	End CTD/water sampling
16:36	06:36	Start Sea Beam survey
18:01	08:01	Resume Sea Beam Survey
18:23	08:23	Start halobates sampling
18:54	08:54	Launching Radio Sonde-8 (0-10.31N, 156-08.86E)
19:25	09:25	End halobates sampling
19:50	09:50	Re-start Sea Beam survey
Dec. 29 (Mon)		
04:30	18:30	End Sea Beam Survey
06:17	20:17	Deployment of OBEM-6 (0-02.21N, 156-00.01E)

06:24	20:24	Deployment of BBOBS-6 (0-02.22N, 156-00.00E)
07:57	21:57	Start Recovery of TRTION No.4 at 0-156E
10:42	00:42	End Recovery of TRITON No.4
13:05-14:00	03:05-4:00	Deployment of sub-surface ADCP at 0-156E
14:42	04:42	Start Measurement of deployed position of ADCP
15:23	05:23	End measurement of deployed position of ADCP
16:25	06:25	Start measurement of deployed position of OBS
17:15	07:15	End measurement of deployed position of OBS/OBEM
22:16	12:16	Launching XCTD-14
Dec. 30 (Tue)		
08:08	22:08	Start deployment of TRITON No.3 at 2N56E
10:23	00:23	End deployment of TRTION No.3
10:59	00:59	Launching XCTD-15 (2-01.82N, 156-00.73E)
13:04	03:04	Start CTD/water sampling
13:49	03:49	End CTD/water sampling
14:49	04:49	Start Sea Beam survey
18:10	08:10	End Sea Beam survey
18:25	08:25	Start Halobates sampling
19:28	09:28	End Halobates sampling
19:51	09:51	Re-start Sea Beam survey
Dec 31 (Wed)		
02:39	14:39	End Sea Beam survey
06:02	18:02	Deployment of OBEM-7 (2-01.31N, 156-00.42E)
06:08	18:08	Deployment of BBOBS-7 (2-01.31N, 156-00.45E)
08:01	20:01	Start deployment of TRITON No. 3
09:30	23:30	Launching Radio Sonde-9 (1-58.00N, 155-59.35E)
10:59	00:59	End deployment of TRITON
11:36	01:36	Start measurement of deployed position of OBS
12:37	02:37	End measurement of deployed position of OBS
21:51	11:51	Launching XCTD-16 (3-00.00N, 156-03.84E)
Jan. 1 (Thu)		
07:25	21:25	Launching XCTD-17 (4-00.08N, 156-07.35E)
15:00	05:00	Start Sea beam survey
19:25	09:25	End Sea Beam survey
Jan. 2 (Fri)		
06:04	20:04	Deployment of OBEM-8 (5-00.53N, 156-00.62E)
06:10	20:10	Deployment of BBOBS-8 (5-00.55N, 156-00.71E)
06:53-07:40	20:53-21:40	CTD/water sampling (4-57.66N, 156-03.04E)
08:07-11:05	22:07-01:05	Recovery of TRITON No.2 at 5N156E
09:30	23:30	Launching Radio Sonde-10 (4-59.65N, 156-05.39E)
11:48-12:55	01:48-02:55	Measurement of deployed position of OBS/OBEM
12:30	02:30	Launching Radio Sonde-11 (5-00.01N, 156-00.49E)
13:06-14:08	03:06-04:08	Sampling of Halobotes
14:29	04:29	Launching Radio Sonde-12 (05-01.46N, 156-05.08E)
19:32	09:32	Launching XCTD-18 (6-00.00N, 156-03.90E)
Jan. 3 (Sat)		
00:43	14:43	Launching XCTD-19 (07-00.00N, 156-02.98E)

05:53	19:53	Launching XCTD-20 (8-00.00N, 156-02.22E)
06:51-07:46	20:51-21:46	Sea Beam Survey
09:11	23:11	Deployment of OBEM-9
09:17	23:17	Deployment of BBOBS-9
10:42-11:06	00:42-01:06	Calibration of ship magnetrometer ("8" form routing)
11:30-12:40	01:30-02:40	Measurement of deployed position of OBEM and OBS
Jan. 4 (Sun)		
Heading to 5N147E site		
Jan. 5 (Mon)		
11:49-12:22	01:49-02:22	Sea Beam Survey around 5N147E
13:54	03:54	Deployment of OBEM-10 (4-59.69N, 147-00.19)
14:00	04:00	Deployment of BBOBS-10 (4-59.70N, 147-00.18E)
15:47-16:52	05:47-06:52	Measurement of deployed position of OBS/OBEM
18:05-19:46	08:05-09:46	Sea Beam Survey around 5N147E
Jan. 6 (Tue)		
06:51	20:51	Launching Radio Sonde-13 (2-23.43N, 147-04.04E)
09:08-12:13	23:08-02:13	Deployment of TRITON No.8
09:29	23:09	Launching Radio Sonde-14 (2-03.32N, 147-00.38E)
12:30	02:30	Launching Radio Sonde-15 (02-04-77N, 146-56.83E)
12:36-12:40	02:36-02:40	Measurement of deployed position of TRITON
12:51	02:51	Launching XCTD-21 (2-04.77N, 146-57.63E)
13:56-14:47	03:56-04:47	CTD/water sampling
14:57	04:57	Launching Radio Sonde-16 (01-59.32N, 147-03.22E)
16:35-18:22	06:35-08:22	Sea Beam Survey
18:31	08:31	Launching Radio Sonde-17 (1-51.23N, 147-15.55E)
18:53-19:54	08:53-09:54	Sampling of Halobates
20:32-03:40	10:32-17:40	Sea Beam Survey
Jan. 7 (Wed)		
06:04	20:04	Deployment of OBEM-11 (2-02.30N, 146-59.51E)
06:11	20:11	Deployment of BBOBS-11 (2-02.31N, 146-59.51E)
07:58-11:25	21:58-01:25	Recovery of TRITON No.8
12:46	02:46	Launching Radio Sonde-18 (02-02.28N, 147-00.09E)
13:06-14:03	03:06-04:03	Measurement of deployed position of OBS/OBEM
Jan. 8 (Thu)		
08:07-10:48	22:07-00:48	Deployment of TRITON No. 9 at 0-147E
11:14-11:17	01:14-01:17	Measurement of deployed site of the TRITON
11:31	01:31	Launching XCTD-22 (0-03.46N, 147-01.80E)
12:00	02:00	Deployment of BBOBS (00-03.60N, 147-02.03E)
12:54-13:43	02:54-03:43	Measurement of deployed position of BBOBS
14:18-15:04	04:18-05:04	CTD/water sampling
18:54-19:57	08:54-09:57	Sampling of Halobates
20:20-22:15	10:20-12:15	Test availability of ANS
Jan. 9 (Fri)		
08:03-11:45	22:03-01:45	Recovery of TRITON No.9 at 0-147E
Jan. 10 (Sat)		
18:31	08:31	Launching Radio Sonde-19 (1-18.48N, 141-11.39E)
Jan. 11 (Sun, SMT=UTC+9)		

08:55-09:40	23:55-00:40	CTD/water sampling (2-01.08N, 138-09.72E)
13:00-16:21	04:00-07:21	Recovery of TRITON No. 12 at 2N138E
18:27-19:27	09:27-10:27	Sampling of Halobates
Jan. 12 (Mon)		
09:08-11:47	00:08-02:47	Deployment of TRITON No. 12 at 2N138E
12:12-12:15	03:12-03:15	Measurement of deployed positon of TRITON No. 12
12:54	03:54	Launching XCTD (02-03.71N, 138-03.18E)
12:54	03:54	Launching UCTD (02-03.71N, 138-03.17E)
18:18	09:18	XCTD-24 (3.00-00N, 137-47.83E)
23:24	14:24	XCTD-25 (4-00.01N, 137-31.84E)
Jan. 13 (Tue)		
08:13-10:50	23:13-01:15	Deployment of TRITON No. 11 at 5N137E
11:20-11:32	02:20-02:32	Measurement of deployed position of TRITON No.11
12:59	03:59	Launching XCTD (04-52.89N, 137-16.22E)
12:59	03:59	Launching UCTD (4-52.89N, 137-17.47E)
14:33	05:33	Launching Radio Sonde-20 (4-58.62N, 137-20.31E)
14:31	04:31	Start searching lost TRITON No.11 by acoustic system
16:45	07:45	Determine the position of releasers of lost TRITON
17:20	08:20	Launching Radio Sonde-21 (5-01.22N, 137-25.00E)
17:30-18:17	08:30-09:17	CTD/ water sampling
18:27-19:26	09:27-10:26	Sampling of Halobates
20:21	11:21	Launching Radio Sonde-22 (5-04.81N, 137-26.36E)
20:45-23:47	11:45-14:47	Sea Beam survey
Jan. 14 (Wed)		
05:59	20:59	Recovery of TRITON No. 11
07:01	22:01	Determine the buoy to be landed
08:59	23:59	Start sea-bottom sweeping to recover TRITON No.11
14:12	05:12	End sea-bottom sweeping
14:52-17:43	05:52-08:43	CTD/JES-10 comparison
21:55	12:55	Launching Radio Sonde-23 (4-59.84N, 137-22.92E)
Jan. 15 (Thu)		
00:30	15:30	Launching Radio Sonde-24 (4-59.74N, 137-23.66E)
05:52	20:52	Start sea bottom sweeping to recover TRITON No.11
14:11	05:11	End sea bottom sweeping (failure to recovey)
15:05-15:16	06:05-06:16	Sub-bottom profiler
20:08	11:08	Launching XCTD-27 (6-00.02N, 137-08.45E)
Jan. 16 (Fri)		
01:10	16:10	Launching XCTD-28 (6-59.99N, 136-52.11E)
06:32-07:19	21:32-22:19	CTD/water sampling (7-39.95N, 136-42.91E)
08:04-11:02	23:04-02:02	Recovery of TRITON No.10 at 8N137E
18:29-19:28	09:29-10:28	Sampling of halobates
21:15	12:15	Launching Radio Sonde-25 (7-36.01N, 136-42.40E)
Jan. 17 (Sat)		
00:30	15:30	Launching Radio Sonde-26 (7-38.53N, 136-41.71E)
03:30	18:30	Launching Radio Sonde-27 (7-39.15N, 136-41.53E)
08:09-10:22	23:09-01:22	Deployment of TRITON No. 10 at 8N137E
08:30	23:30	Launching Radio Sonde-28 (7-38.60N, 136-41.73E)

10:42-10:44	01:42-01:44	Measurement of deployed position of TRITON No. 10
11:26	02:26	Launching XCTD-29 (7-38.92N, 136-40.65E)
11:27	02:27	Launching UCTD-3 (7-38.93N, 136-40.65E)
11:30	02:30	Launching Radio Sonde-29 (7-38.98N, 136-40.68E)
13:02-16:29	04:02-07:29	CTD/water sampling with JES-10 CTD
14:31	05:31	Launching Radio Sonde-30 (7-40.22N, 136-37.10E)
Jan. 18 (Sun)		
Heading to Palau		
Jan. 19 (Mon)		
Arrival to Palau (end of Leg-2)		

8.2. Leg 3

SMT (UTC+9)	UTC	Event
Jan. 22 (Thu)		
09:00	00:00	Departure from Koror, Republic of Palau
14:00	05:00	Start continuous observations
Jan. 23 (Fri)		
10:00	01:00	Stop continuous observations because R/V MIRAI entered into Indonesian EEZ Heading to 8S 99.5E site
Jan. 24 (Sat)		
22:00	13:00	Time adjustment -1h (SMT=UTC+8h)
Jan. 27 (Tue)		
22:00	14:00	Time adjustment -1h (SMT=UTC+7h)
Jan. 29 (Thu)		
22:00	15:00	Time adjustment -1h (SMT=UTC+6h)
Jan. 30 (Fri)		
12:00	06:00	Start continuous observations
15:23-16:42	09:23-10:42	CTD/water sampling (08-00.04S, 99-30.09E)
19:18	13:18	Launching UCTD (07-59.97S, 98-59.96E)
21:56	15:56	Launching UCTD (08-00.00S, 98-29.98E)
Jan. 31 (Sat)		
00:29	18:29 (-1day)	Launching UCTD (07-59.99S, 97-59.99E)
03:12	21:29 (-1day)	Launching UCTD (07-59.99S, 97-29.99E)
06:01	00:01	Launching UCTD (07-59.93S, 96-59.98E)
06:26	00:26	Relaunching UCTD (07-59.99S, 96-57.19E)
08:58	02:58	Launching UCTD (07-59.99S, 96-29.98E)
11:41	05:41	Launching UCTD (07-59.99S, 95-59.98E)
14:27	08:27	Launching UCTD (08-00.03S, 95-29.98E)
Feb. 01 (Sun)		
08:11-12:01	02:11-06:01	Deployment of m-TRITON No. 19 at 8S95E
13:37-14:43	07:37-08:43	CTD/water sampling (08-05.92S, 95-09.48E)
15:45-16:27	09:45-10:27	CTD/water sampling (08-00.62S, 95-05.51E)
Feb. 02 (Mon)		
07:55-11:35	01:55-05:35	Recovery of m-TRITON No. 19 at 8S95E
14:49	08:49	Launching UCTD (07-30.00S, 94-59.98E)

17:20	11:20	Launching UCTD (06-59.97S, 95-00.05E)
19:52	08:49	Launching UCTD (06-30.00S, 94-59.97E)
22:20	16:20	Launching XCTD (05-59.72S, 94-59.99E)
Feb. 03 (Tue)		
08:05-11:31	02:05-05:31	Deployment of m-TRITON No. 17 at 5S95E
13:13-14:50	07:13-08:50	CTD/water sampling (05-02.39S, 95-01.11E)
15:00-15:40	09:00-09:40	CTD/water sampling (04-57.80S, 95-01.86E)
18:34	12:34	Launching UCTD (05-30.02S, 94-59.99E)
Feb. 04 (Wed)		
07:58-11:20	01:58-05:20	Recovery of m-TRITON No. 17 at 5S95E Heading to 1.5S 90E site
Feb. 05 (Thu)		
15:45	09:45	Arrived at 1.5S90E
15:55-16:30	09:55-10:30	Confirmation of mooring position
Feb. 06 (Fri)		
07:58-09:15	07:58-09:15	Recovery of m-TRITON No. 18 at 1.5S90E
13:00-	07:00-	CTD/water sampling with JES10 (01-36.95S, 89-58.83E)
Feb. 07 (Sat)		
08:07-11:28	02:07-05:28	Deployment of m-TRITON No. 18 at 1.5S90E
13:00-14:05	07:00-08:05	CTD/water sampling (01-37.01S, 89-56.88E)
17:16	11:16	Launching UCTD (00-59.99S, 90-00.00E)
19:52	13:52	Launching UCTD (00-29.99S, 89-59.98E)
Feb. 08 (Sun)		
07:57-10:03	01:57-04:03	Recovery of ADCP at 0 90E
13:05-14:40	07:05-08:40	Deployment of ADCP at 0 90E
15:37-16:41	09:37-10:41	CTD/water sampling (00-01.90N, 90-08.88E)
18:55	12:55	Launching UCTD (00-30.01N, 90-00.00E)
21:09	15:09	Launching UCTD (01-00.03N, 89-59.99E)
23:27-24:32	17:27-18:32	CTD/water sampling (01-30.01N, 90-00.08E)
Feb. 09 (Mon)		
02:40	20:40 (-1day)	Launching UCTD (02-00.01N, 90-00.05E)
04:58	22:58 (-1day)	Launching UCTD (02-30.01N, 90-00.01E)
07:14	01:14	Launching UCTD (03-00.01N, 89-59.99E)
09:27	03:27	Launching UCTD (03-30.02N, 89-59.99E)
10:04	04:04	Relaunching UCTD (03-36.31N, 89-59.98E)
11:46	05:46	Launching UCTD (04-00.03N, 90-00.00E)
17:00	11:00	Stop continuous observations because R/V Mirai entered Indonesian EEZ
22:00	16:00	Time adjustment +1h (SMT=UTC+7h) Heading to Hachinohe, Japan
Feb. 10 (Tue)		
22:00	15:00	Time adjustment +1h (SMT=UTC+8h)
Feb. 17 (Tue)		
22:00	14:00	Time adjustment +1h (SMT=UTC+9h)
Feb. 24 (Tue)		
09:00	00:00	Arrived at Hachinohe, Japan
16:00	07:00	Departure from Hachinohe, Japan

		Heading to Sekinehama, Japan
Feb. 25 (Wed)		
09:00	00:00	Arrived at Sekinehama, Japan