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R/V Mirai Cruise Report
MR16-08

November 27 – December 24, 2016
Tropical Ocean Climate Study (TOCS)

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

Contents

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 (e-mail: dmo@jamstec.go.jp).

1. General information

1.1. Cruise ID

MR16-08

1.2. Name of vessel

R/V Mirai

1.3. Title of cruise

Tropical Ocean Climate Study (TOCS) in the Pacific Ocean/Operation of Triangle trans-ocean buoy network (TRITON) buoys

1.4. Research area

The western tropical Pacific Ocean

2. Overview and observation summary

2.1. Overview

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

Oceanic and atmospheric conditions in the tropical Pacific Ocean showed La Niña features. Sea surface temperatures remained below-average over the central and eastern equatorial Pacific during October 2016. Major Climate forecasts, such as JAMSTEC, JMA, NOAA and so on, says La Niña conditions will continue until the end of the year.

2.2. Observation summary

TRITON buoy deployment (including a Philippine sea mooring):	3 sites.
TRITON buoy recovery:	8 sites
ADCP buoy deployment:	1 sites
ADCP buoy recovery:	1 sites
Surface drifter installation	2 installed
CTD including water sampling:	14 casts
UnderwayCTD:	51 casts
XCTD:	3 launched
Radio sonde:	54 launched
Surface meteorology:	continuous
Doppler radar observation:	continuous
Shipboard ADCP measurement:	continuous
Geophysics measurement:	continuous
Surface temperature, salinity and dissolved oxygen measurements by intake method	continuous

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

3. Cruise Information

3.1. Period

November 27 – December 24, 2016

3.2. Ports of call

Shimizu, Japan	(Departure: November 27 2016)
Suva, Republic of Fiji	(Arrival: December 24 2016)

3.3. Cruise log

SMT	UTC	Event
Nov. 27th (Sun.) 2016		
11:00	02:00	Safety guidance
16:00	07:00	Departure from Shimizu
		[Ship Mean Time (SMT)=UTC+9h]
		Start of surface sea water sampling
		Start of continuous observations
Nov. 28th (Mon.) 2016		
13:15	04:15	Emergency drill
14:24	05:24	Doppler ladar observation start
15:00	06:00	Observation Meeting
16:45	07:45	Konpira ceremony
Dec. 01st (Thu.) 2016		
09:00	00:00	Test cast for UCTD
20:30	11:30	Radio Sonde01
Dec. 02nd (Fri.) 2016		
08:05	23:05 (-1day)	UCTD01 (13˚ 0.0’N, 136˚ 30.1’E)
09:12	00:12	UCTD02 (13˚ 0.0’N, 136˚ 40.1’E)
10:18	01:18	UCTD03 (13˚ 0.0’N, 136˚ 50.1’E)
10:45	01:45	Surface drifter installation
12:33	03:33	CTD01 (12˚ 59.9’N, 137˚ 00.0’E, 500m)
14:28	05:28	UCTD04 (13˚ 0.0’N, 137˚ 10.1’E)
14:55	05:55	Surfce drifter installation
15:43	06:43	UCTD05 (13˚ 0.0’N, 137˚ 20.0’E)

SMT	UTC	Event
Dec. 02nd (Fri.) 2016 (continued)		
16:49	07:49	UCTD06 (13˚ 0.0’N, 137˚ 30.1’E)
20:30	11:30	Radio Sonde02
Dec. 03rd (Sat.) 2016		
07:50 – 13:41	22:50 (-1day) – 13:41	
		Deployment of the Philippine Sea mooring
		(12˚ 52.83’N, 136˚ 55.48’E, 5216 m)
15:18	06:18	CTD02 (12˚ 54.0’N, 136˚ 53.7’E, 5240 m)
20:30	11:30	Radio Sonde03
23:52	14:52	UCTD07 (11˚ 59.9’N, 137˚ 0.0’E)
Dec. 04th (Sun.) 2016		
07:56	22:56 (-1day)	UCTD08 (11˚ 0.0’N,137˚ 0.0’E)
12:53	03:53	UCTD09 (10˚ 0.0’N, 137˚ 0.0’E)
17:49	08:49	UCTD10 (8˚ 59.9’N, 137˚ 0.0’E)
20:30	11:30	Radio Sonde04
Dec. 05th (Mon.) 2016		
08:10 – 11:44	23:10 (-1day) – 02:44	
		Deployment of TRITON mooring (TR#10)
		(7˚ 52.0’N, 136˚ 30.0’E, 3349 m)
12:24	03:24	UCTD11 (7˚ 52.3’N, 136˚ 29.4’E)
12:51	03:51	UCTD11 (Retry: 7˚ 50.1’N, 136˚ 28.3’E)
14:40	05:40	Recovery of Wave Glider (07˚ 40.7’N, 136˚ 43.1’E)
16:00	07:00	CTD03(7˚ 40.1’N, 136˚ 42.9’E, 3141 m)
20:30	11:30	Radio Sonde05
Dec. 06th (Tue.) 2016		
08:00 – 11:49	23:00 (-1day) – 02:49	
		Recovery of TRITON mooring (TR#10)
		(7˚ 39.1’N, 136˚ 42.0’E, 3170 m)
15:26	06:26	UCTD12 (7˚ 0.0’N, 137˚ 0.0E)
20:30	11:30	Radio Sonde06
20:32	11:32	UCTD13 (6˚ 1.1’N, 136˚ 59.2’E)

SMT	UTC	Event
Dec. 07th (Wed.) 2016		
05:59	20:59 (-1day)	CTD04 (4˚ 52.3’N, 137˚ 17.3’E, 1000 m)
07:55 – 12:16	22:55 (-1 day) – 03:16	
		Recovery of TRITON mooring (TR#11)
		(4˚ 51.7’N, 137˚ 17.2’E, 4100 m)
13:30	04:30	CTD05 (4˚ 51.4’N, 137˚ 16.0’E, 4080 m)
17:58 – 19:30	08:30 – 10:30	Sampling of oceanic sea skaters
20:30	11:30	Radio Sonde07
Dec. 08th (Thu.) 2016		
08:27	23:27 (-1day)	CTD06 (2˚ 01.8’N, 138˚ 07.5’E, 1000 m)
09:25 – 14:29	00:25 – 05:29	Recovery of TRITON mooring (TR#12)
		(2˚ 04.1’S, 138˚ 03.9’E, 4340 m)
17:59 – 19:00	08:59 – 10:00	Sampling of oceanic sea skaters
Dec. 09th (Fri.) 2016		
20:30	11:30	Radio Sonde08
Dec. 10th (Sat.) 2016		
08:30	23:30 (-1day)	Radio Sonde09
09:44	00:44	CTD07 (0˚ 03.4’N, 147˚ 01.8’E, 1001 m)
12:30 – 16:28	03:30 – 07:28	Recovery of TRITON mooring (TR#09)
		(0˚ 03.6’N, 147˚ 01.1’E, 4470 m)
20:30	11:30	Radio Sonde10
21:08	12:08	XCTD01 (1˚ 00.0’N, 147˚ 00.0’E)
22:00	13:00	Time adjustment +1h (SMT=UTC+10h)
Dec. 11th (Sun.) 2016		
00:30	14:30 (-1day)	Radio Sonde11
03:30	17:30 (-1day)	Radio Sonde12
05:59	19:59 (-1day)	CTD08 (2˚ 05.5’N, 146˚ 56.9’E, 1003 m)
07:55 – 11:40	21:55 (-1day) – 01:40	
		Recovery of TRITON mooting (TR#08)
		(2˚ 04.6’N, 146˚ 57.0’E, 4520 m)
09:30	23:30 (-1day)	Radio Sonde13
21:30	11:30	Radio Sonde14

SMT	UTC	Event
Dec. 12th (Mon.) 2016		
09:30	23:30 (-1day)	Radio Sonde15
21:30	11:30	Radio Sonde16
Dec. 13th (Tue.) 2016		
07:59	21:59	CTD09 (2˚ 01.4’N, 156˚ 01.0’E, 1003 m)
08:55 – 12:10	22:55 (-1day) – 02:10	
		Recovery of TRITON mooting (TR#03)
		(2˚ 02.3’N, 156˚ 01.9’E, 2580 m)
09:30	23:30 (-1day)	Radio Sonde17
13:28	03:28	CTD10 (2˚ 02.3’N, 156˚ 01.1’E, 2568 m)
18:40	08:40	Radio Sonde18
20:17	10:17	XCTD02 (1˚ 00.0’N, 156˚ 59.8’E)
21:30	11:30	Radio Sonde19
Dec. 14th (Wed.) 2016		
00:30	14:30 (-1day)	Radio Sonde20
08:00 – 11:07	22:00 (-1day) – 01:07	
		Deployment of TRITON mooring (TR#04)
		(0˚ 01.0’S, 155˚ 57.6’E, 1942 m)
09:30	23:30 (-1day)	Radio Sonde21
12:57	02:57	CTD11 (0˚ 01.6’S, 155˚ 58.9’E, 1001 m)
15:00	05:00	CTD12 (0˚ 00.5’N, 156˚ 03.6’E, 1937 m)
21:30	11:30	Radio Sonde22
Dec. 15th (Thu.) 2016		
07:55 – 11:15	21:55 (-1day) – 01:15	
		Recovery of TRITON mooting (TR#04)
		(0˚ 00.9’N, 156˚ 03.3’E, 1950 m)
09:30	23:30 (-1day)	Radio Sonde23
13:07	03:07	Wave Glider installation (0˚ 01.9’S, 155˚ 59.3’E)
21:30	11:30	Radio Sonde24
22:00	15:00	Time adjustment +1h (SMT=UTC+11h)

SMT	UTC	Event
Dec. 16th (Fri.) 2016		
07:55 – 09:34	20:55 – 22:34 (-1 day)	
		Recovery of ADCP mooring
		(0˚ 02.1’S, 156˚ 08.0’E, 1950 m)
10:30	23:30 (-1day)	Radio Sonde25
12:30 – 13:52	01:30 – 02:52	Deployment of ADCP mooring
		(0˚ 02.3’S, 156˚ 08.07E, 1950 m)
15:05	04:05	Recovery of Wave Glider (0˚ 01.1’S, 156˚ 03.3’E)
20:44	09:44	XCTD03 (1˚ 00.0’S, 156˚ 00.0’E)
22:30	11:30	Radio Sonde26
Dec. 17th (Sat.) 2016		
04:30	17:30 (-1day)	Radio Sonde27
05:58	18:58 (-1 day)	CTD13 (2˚ 02.0’S, 155˚ 58.7’E, 1001 m)
07:58 – 11:50	20:58 (-1day) – 00:15	
		Recovery of TRITON mooting (TR#05)
		(2˚ 01.0’S, 155˚ 57.5’E, 1750 m)
10:30	23:30 (-1day)	Radio Sonde28
13:00	02:00	CTD14 (2˚ 01.1’S, 155˚ 57.5’E, 1738 m)
16:30	05:30	Radio Sonde29
17:35	06:35	UCTD14 (2˚ 19.2’S, 156˚ 30.0’E)
20:20	09:20	UCTD15 (2˚ 36.0’S, 157˚ 00.1’E)
22:30	11:30	Radio Sonde30
23:24	12:24	UCTD16 (2˚ 52.7’S, 157˚ 30.0’E)
Dec. 18th (Sun.) 2016		
02:10	15:10 (-1 day)	UCTD17 (3˚ 09.6’S, 158˚ 00.0’E)
04:30	17:30 (-1day)	Radio Sonde31
05:15	18:15 (-1 day)	UCTD18 (3˚ 26.5’S, 158˚ 30.1’E)
08:10	21:15 (-1 day)	UCTD19 (3˚ 43.2’S, 159˚ 00.0’E)
10:30	23:30 (-1day)	Radio Sonde32
11:10	00:10	UCTD20 (4˚ 00.0’S, 159˚ 30.3’E)
14:35	03:35	UCTD21 (4˚ 24.7’S, 160˚ 00.0’E)
16:30	05:30	Radio Sonde33

SMT	UTC	Event
Dec. 18th (Sun.) 2016 (continued)		
17:50	06:50	UCTD22 (4˚ 49.4’S, 160˚ 30.0’E)
21:05	10:05	UCTD23 (5˚ 14.1’S, 161˚ 00.0’E)
22:30	11:30	Radio Sonde34
Dec. 19th (Mon.) 2016		
00:25	13:25 (-1 day)	UCTD24 (5˚ 38.6’S, 161˚ 30.0’E)
03:35	16:35 (-1 day)	UCTD25 (6˚ 03.4’S, 162˚ 00.1’E)
04:30	17:30 (-1day)	Radio Sonde35
06:55	19:55 (-1 day)	UCTD26 (6˚ 28.2’S, 162˚ 30.1’E)
10:04	23:04 (-1 day)	UCTD27 (6˚ 52.5’S, 163˚ 00.0’E)
10:30	23:30 (-1day)	Radio Sonde36
13:20	02:20	UCTD28 (7˚ 17.2’S, 163˚ 30.0’E)
16:30	05:30	Radio Sonde37
16:50	05:50	UCTD29 (7˚ 41.4’S, 164˚ 00.0’E)
20:10	09:10	UCTD30 (8˚ 06.1’S, 164˚ 30.0’E)
22:30	11:30	Radio Sonde38
23:20	12:20	UCTD31 (8˚ 30.7’S, 165˚ 00.0’E)
Dec. 20th (Tue.) 2016		
02:30	15:30 (-1 day)	UCTD32 (8˚ 55.8’S, 165˚ 30.0’E)
04:30	17:30 (-1day)	Radio Sonde39
06:12	19:12 (-1 day)	UCTD33 (9˚ 21.0’S, 166˚ 00.1’E)
07:30	20:30 (-1day)	Radio Sonde40
09:28	22:28 (-1 day)	UCTD34 (9˚ 46.1’S, 166˚ 30.1’E)
10:30	23:30 (-1day)	Radio Sonde41
12:40	01:40	UCTD35 (10˚ 11.1’S, 167˚ 00.0’E)
13:30	02:30	Radio Sonde42
16:30	05:30	Radio Sonde43
16:54	05:54	UCTD36 (10˚ 36.2’S, 167˚ 30.0’E)
19:30	08:30	Radio Sonde44
20:15	09:15	UCTD37 (11˚ 01.1’S, 168˚ 00.0’E)
22:00	11:00	Time adjustment +1h (SMT=UTC+12h)
23:30	11:30	Radio Sonde45

SMT	UTC	Event
Dec. 21st (Wed.) 2016		
00:30	12:30 (-1 day)	UCTD38 (11˚ 26.1'S, 168˚ 30.0'E)
03:50	15:30 (-1 day)	UCTD39 (11˚ 51.0'S, 169˚ 00.0'E)
05:30	17:30 (-1day)	Radio Sonde46
07:29	19:29 (-1 day)	UCTD40 (12˚ 16.0'S, 169˚ 30.1'E)
10:48	22:48 (-1 day)	UCTD41(12˚ 40.8'S, 170˚ 00.0'E)
11:30	23:30 (-1day)	Radio Sonde47
16:00	04:00	UCTD42 (13˚ 05.6S, 170˚ 30.0'E)
17:30	05:30	Radio Sonde48
22:00	10:00	UCTD43 (13˚ 30.4'S, 171˚ 00.0'E)
23:30	11:30	Radio Sonde49
Dec. 22nd (Thu.) 2016		
04:00	16:00	UCTD44 (13˚ 55.1'S, 171˚ 30.0'E)
05:30	17:30 (-1day)	Radio Sonde50
07:24	19:24 (-1 day)	UCTD45 (14˚ 19.8'S, 172˚ 00.1'E)
10:37	22:37 (-1 day)	UCTD46 (14˚ 44.5'S, 172˚ 30.0'E)
11:30	23:30 (-1day)	Radio Sonde51
14:04	02:04	UCTD47 (15˚ 09.1'S, 173˚ 00.0'E)
17:30	05:30	Radio Sonde52
17:41	05:41	UCTD48 (15˚ 33.5'S, 173˚ 30.0'E)
20:56	08:56	UCTD49 (15˚ 58.0'S, 174˚ 00.0'E)
22:00	10:00	Time adjustment +1h (SMT=UTC+13h)
Dec. 23rd (Fri.) 2016		
00:30	11:30 (-1day)	Radio Sonde53
01:18	12:18 (-1 day)	UCTD50 (16˚ 22.5'S, 174˚ 30.0'E)
04:23	15:23 (-1 day)	UCTD51 (16˚ 46.9'S, 175˚ 00.0'E)
09:00	20:00	Stop of surface sea water sampling
12:30	23:30 (-1day)	Radio Sonde54
16:00	03:00	Stop of continuous observations
Dec. 24th (Sat.) 2016		
10:00	21:00	Arrival at Suva (Anchoring)
23:00	09:00??	Shifted to commercial port

3.4. Cruise track

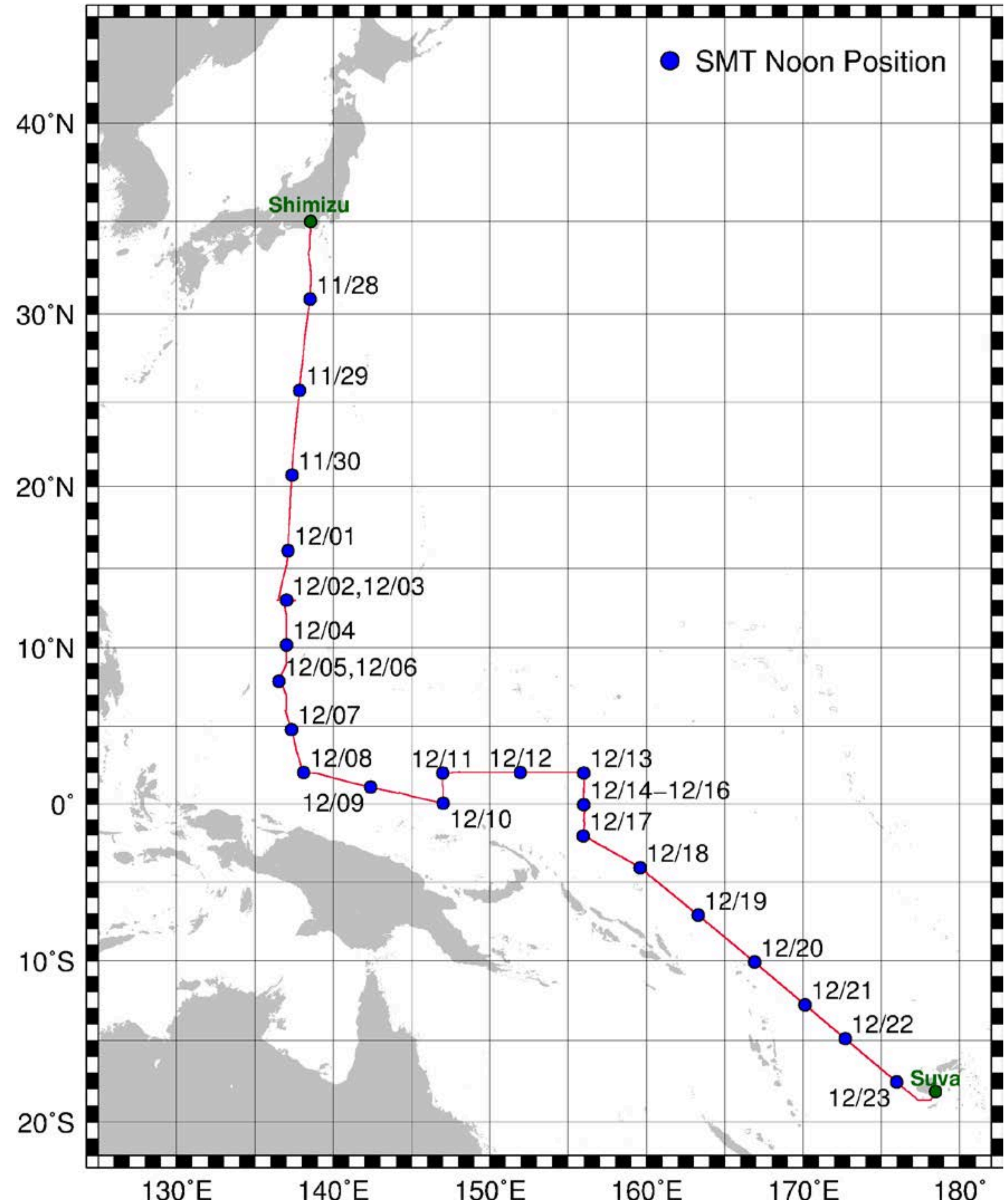


Fig. 3-1: MR16-08 cruise track

4. Research themes and science party

4.1. Chief scientist

Iwao Ueki

Deputy Group Leader,

Ocean-Atmosphere Interaction Research Group

Research Institute for Global Change,

JAMSTEC

4.2. Main missions

Tropical Ocean Climate Study (TOCS) in the Pacific Ocean

Principal Investigator (PI): Iwao Ueki

Operation of Triangle trans-ocean buoy network (TRITON) buoys

PI: Yasuhisa Ishihara

Group Leader,

Long-Term Observation Technology Gloup,

Marine Technology Development Department,

JAMSTEC

4.3. Applied missions

Physiological and ecological studies on the relationship between the distribution and environmental tolerance by oceanic sea skaters, *Halobates* inhabiting tropical Pacific Ocean, and several environmental factors

PI: Tetsuo Harada

Professor,

Laboratory of Environmental Physiology,

Graduate School of Integrated Sciences and Arts of Human,

Kochi University

Ship-borne measurements of aerosols in the marine atmosphere: Investigation of potential influence of marine aerosol particles on the climate

PI: Fumikazu Taketani

Reseacher,

Department of Environmental Geochemical Cycle Research, JAMSTEC

Study on vertical measurement by in-situ pH/pCO2 sensor

PI: Kiminori Shitashima

Associate Professor,

Tokyo University of Marine Science and Technology

Aerosol optical characteristics measured by Ship-borne Sky radiometer

PI: Kazuma Aoki

Professor,

Depart of Earth Science,

University of Toyama

5. Participants list

5.1. R/V Mirai scientists and technical staffs

Name		Affiliation	Occupation	Onboard section
Iwao	Ueki	JAMSTEC	Chief Scientist	Shimizu - Suva
Geng	Biao	JAMSTEC	Scientist	Shimizu - Suva
Akira	Nagano	JAMSTEC	Scientist	Shimizu - Suva
Kyoko	Taniguchi	JAMSTEC	Technical Staff	Shimizu - Suva
Yukio	Takahashi	JAMSTEC	Engineer	Shimizu - Suva
Tetsuo	Harada	Kochi University	Professor	Shimizu - Suva
Takahiro	Furuki	Kochi University	Student	Shimizu - Suva
Hiroki	Fujita	Kochi University	Student	Shimizu - Suva
Kiminori	Shitashima	Tokyo University of Marine Science and Technology	Professor	Shimizu - Suva
Kazuh	Yoshida	Nippon Marine Enterprises, Ltd.	Technical Staff	Shimizu - Suva
Koichi	Inagaki	Nippon Marine Enterprises, Ltd.	Technical Staff	Shimizu - Suva
Hiroki	Ushiromura	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Hiroshi	Matsunaga	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Kenichi	Katayama	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Akira	Watanabe	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Sonoka	Tanihara	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Keisuke	Takeda	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Rio	Kobayashi	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Takayuki	Hashimukai	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Kai	Fukuda	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Emi	Deguchi	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Hiroshi	Hoshino	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva
Masahiro	Orui	Marine Works Japan Ltd.	Technical Staff	Shimizu - Suva

5.2. R/V Mirai crew member

Name		Rank or rating
Toshihisa	Akutagawa	Master
Takaaki	Shishikura	Chief Officer
Hiroyuki	Kato	1st Officer
Tomoyuki	Takahashi	2nd Officer
Akihiro	Nunome	3rd Officer
Yoichi	Furukawa	Chief Engineer
Yu	Watanabe	1st Engineer
Daisuke	Gibu	2nd Engineer
Akihiro	Demura	3rd Engineer
Masanori	Murakami	Chief Radio Operator
Yosuke	Kuwahara	Boatswain
Kazuyoshi	Kudo	Quarter Master
Tsuyoshi	Sato	Quarter Master
Takeharu	Aisaka	Quarter Master
Masashige	Okada	Quarter Master
Shuji	Komata	Quarter Master
Masaya	Tanikawa	Quarter Master
Hideyuki	Okubo	Sailor
Tetsuya	Sakamoto	Sailor
Yasunobu	Kawabe	Sailor
Shinya	Kojima	Sailor
Kazumi	Yamashita	No.1 Oiler
Fumihito	Kaizuka	Oiler
Toshiyuki	Furuki	Oiler
Keisuke	Yoshida	Oiler
Ryo	Sato	Oiler
Kazuya	Ando	Assistant Oiler
Kazuhiro	Hirayama	Chief Steward
Sakae	Hoshikuma	Steward
Toshiyuki	Asano	Steward
Yoshitaka	Yamamoto	Steward
Mizuki	Nakano	Steward

6. Misson observations

6.1. TRITON and Philippine Sea moorings

6.1.1. TRITON mooring operation

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Akira Nagano	(JAMSTEC)
Yukio Takahashi	(JAMSTEC)
Akira Watanabe	(MWJ) Operation Leader
Hiroki Ushiromura	(MWJ)
Hiroshi Matsunaga	(MWJ)
Kenichi Katayama	(MWJ)
Takayuki Hashimukai	(MWJ)
Hiroshi Hoshino	(MWJ)
Kai Fukuda	(MWJ)
Masahiro Orui	(MWJ)
Emi Deguchi	(MWJ)
Sonoka Tanihara	(MWJ)
Keisuke Takeda	(MWJ)
Rio Kobayashi	(MWJ)

(2) Objectives

The large-scale air-sea interaction over the warmest sea surface temperature region in the western tropical Pacific Ocean called warm pool that affects the global atmosphere and causes El Niño 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 Niño 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).

Eight TRITON buoys have been recovered and two TRITON buoys have been deployed during this R/V MIRAI cruise (MR16-08).

(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 (Deployment):
water temperature and conductivity at 1.5m, 25m,
50m, 75m, 100m, 125m, 150m, 200m, 300m, 500m,
pressure at 300m and 500m,
currents at 10m.

Oceanic parameters(Recovery) :
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:

<u>Oceanic sensors</u>

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.

<u>Meteorological sensors</u>

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, and Wind speed/direction

Woods Hole Institution ASIMET

Sampling interval :	600sec.

(5) Locations of TRITON buoys deployment

Nominal location :	EQ, 156E
ID number at JAMSTEC :	04018
Number on surface float :	T01
ARGOS PTT number :	28320
ARGOS backup PTT number :	29694
Deployed date :	14 Dec. 2016
Exact location :	00°00.96' S, 155°57.57' E
Depth :	1,942 m

Nominal location :	8N, 137E
ID number at JAMSTEC :	10013
Number on surface float :	T22

ARGOS PTT number :	27400
ARGOS backup PTT number :	30832
Deployed date :	05 Dec. 2016
Exact location :	07°52.03' N, 136°30.03' E
Depth :	3,349 m

(6) Locations of TRITON buoys recovered

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
Recovered date:	13 Dec. 2016
Exact location :	02°02.33' N, 156°01.22' E
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
Recovered date:	15 Dec. 2016
Exact location :	00°01.05' N, 156°02.53' E
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
Recovered date:	17 Dec. 2016
Exact location :	02°01.03' S, 155°57.47' E
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
Recovered date:	11 Dec. 2016
Exact location :	02°04.58' N, 146°56.98' E
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
Recovered date:	10 Dec. 2016
Exact location :	00°03.58' N, 147°00.65' E
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
Recovered date:	06 Dec. 2016
Exact location :	07°39.10' N, 136°41.96' E
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
Recovered date:	07 Dec. 2016
Exact location :	04°51.65' N, 137°16.18' E
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
Recovered date:	08 Dec. 2016
Exact location :	02°04.05' N, 138°03.88' E
Depth :	4,333 m

*Dates are UTC and represent anchor drop times for deployments and acoustic releaser on deck time for recoveries, respectively.

(7) Details of deployed

We had deployed two TRITON moorings. The specifications are describrd in Table 6.1.1-1.

Table 6.1.1-1: Specifications of the deployed TRITON moorings

Observation No.	Nominal location	Specifications
04018	EQ156E	Deploy with full spec and 2 optional unit. SBE37 (CT) :175m SBE37(CTD): 501m
10013	8N137E	Deploy with full spec. SBE37 (CT) :175m JES10-CTD IM: 301m

(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

6.1.2. Philippine Sea mooring operation

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Akira Nagano	(JAMSTEC)
Yukio Takahashi	(JAMSTEC)
Akira Watanabe	(MWJ) Operation Leader
Hiroki Ushiromura	(MWJ)
Hiroshi Matsunaga	(MWJ)
Kenichi Katayama	(MWJ)
Takayuki Hashimukai	(MWJ)
Hiroshi Hoshino	(MWJ)
Kai Fukuda	(MWJ)
Masahiro Orui	(MWJ)
Emi Deguchi	(MWJ)
Sonoka Tanihara	(MWJ)
Keisuke Takeda	(MWJ)
Rio Kobayashi	(MWJ)

(2) Objectives

Ocean and atmosphere variations in the northern periphery of the North Pacific tropical warm pool, east of the Philippines, is considered to play important roles in large-scale atmosphere and ocean variabilities such as El Niño and the Southern Oscillation and Pacific Decadal Oscillation. The variation of the upper ocean structure in this region is strongly affected by the sea-surface heat and freshwater fluxes and upwelling from the base of the mixed layer. Therefore, high-frequency time series of temperature, salinity, current velocity, and meteorological elements at a fixed point are required. In this cruise, a moored buoy (K-TRITON) was deployed at the nominal location of 13˚N, 137˚E to collect oceanic and atmospheric high-frequency time series data.

(3) Measured parameters

The Philippine Sea mooring observes oceanic parameters and meteorological parameters as follow:

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

Oceanic parameters : water temperature and conductivity at 1m, 10m, 20m, 40m, 60m, 80m, 90m, 100m, 110m, 120m, 150m, 180m, 200m, 300m
depth at 1m, 10m, 40m, 80m, 100m, 120m, 150m, 180m, 300m,
dissolved oxygen at 80m, 100m, 150m,
CO_2 and pH at 1m,
currents at 1m.

(4) Instrument

Details of the instruments used on the Philippine Sea mooring are summarized as follow:

<u>Oceanic sensors</u>

1) CTD and CT

SBE-37 IM MicroCAT(Sea-Bird Electronics, Inc.)

Sampling interval : 600sec.

2) CRN(Current meter)

WORKHORSE-ADCP Sentinel(TELEDYNE RD INSTRUMENTS, Inc.)

Sensor frequency :	300 kHz
Depth cell size:	4.00 m
Number of depth cell:	30
Png per ensemble:	30
Time per ping:	2 sec.
Time per ensemble:	20 min.

3) Dissolved oxygen

MODEL Riniko I(JFE Advantech Inc.)

Sampling interval: 600sec.

4) CO_2 and pH

pH-CO_2 hybrid sensor HCST (JAMSTEC)

Sampling interval: 1sec. (pH), 1h. (CO_2)

Meteorological sensors

1) Precipitation

R.M.YOUNG COMPANY MODEL50202/50203

Sampling interval : 600sec.

2) Atmospheric pressure and Relative humidity/air temperature(JAMSTEC)

MODEL Rotronics: MP103A, GE: RPS8100

Sampling interval : 600sec.

3) Wind speed/direction (JAMSTEC)

MODEL Y85000

Sampling interval : 600sec.

4) Shortwave radiation (JAMSTEC)

MODEL EPSP

Sampling interval : 600sec.

5) Longwave radiation (ASIMET)

MODEL EPIR

Sampling interval : 600sec.

(5) Locations of Philippine Sea mooring deployment

Nominal location : 13˚N, 137˚E

ID number at JAMSTEC : 40501

Number on surface float : K03

Iridium number : 300434061416080

ARGOS backup PTT number : 28160

Deployed date : 03 Dec. 2016

Exact location : 12°52.83' N, 136°55.42' E

Depth : 5,216 m

6.1.3 JES10 experiments

(1) Personnel

Yukio Takahashi (JAMSTEC) PI

(2) Objectives

Sensors (JES10) following Jamstec developed are deployed in Triton buoy for observation and to evaluated the long-term stability. In addition, in order to evaluate the verification of calibration results by the CTD casting.

(3) CTD casting

Four sensors developed by Jamstec (JES10-CTDIM 3 units, and JES10-Pro), and SBE37 (Sea-Bird Electronics, Inc.) to be attached to the frame of the CTD (SBE9plus) Water Sampling System, were carried out CTD casting (position: 13N137E for JES10, EQ156E for SBE37). JES10-Pro was developed for profile measurement. The CTD flame with 9Plus sensor was stopped for 5 minutes at each depth of 500m, 300m and 200m, these measurements were compared with the 9plus. Photo 6.1.3-1 shows the CTD flame. The results of comparing these CTD data (Temperature, Conductivity, Salinity) with 9plus data are shown in Table 6.1.3-1 – 6.1.3-6.

Photo 6.1.3-1

Table 6.1.3-1 Results of 9plus (13N137E)

Depth(m)	Temp.(degC)	Cond.(S/m)	Salinity
500	7.7185	3.56625	34.4451
	0.0048	0.00049	0.0005
300	10.9091	3.84889	34.4009
	0.0082	0.00077	0.0004
200	16.0486	4.36424	34.6447
	0.0073	0.00077	0.0007

(upper: average, lower: standard deviation)

Table 6.1.3-2 Difference(av.) JES10-CTDIM SN004

Depth(m)	Temp.(degC)	Cond.(S/m)	Salinity
500	0.0048	-0.00059	-0.0112
300	-0.0041	-0.00115	-0.0078
200	-0.0025	-0.00088	-0.0058

Table 6.1.3-3 Difference (av.) JES10-CTDIM SN007

Depth(m)	Temp.(degC)	Cond.(S/m)	Salinity
500	0.0027	-0.00213	-0.0258
300	-0.0041	-0.00244	-0.0206
200	-0.0065	-0.00303	-0.0214

Table 6.1.3-4 Difference (av.) JES10-Pro

Depth(m)	Temp.(degC)	Cond.(S/m)	Salinity
500	0.0041	-0.00050	-0.0096
300	-0.0061	-0.00121	-0.0065
200	-0.0067	-0.00113	-0.0044

Table 6.1.3-5 Results of 9plus (EQ156E)

Depth(m)	Temp.(degC)	Cond.(S/m)	Salinity
1000	4.7705	3.33008	34.5410
	0.0006	0.00005	0.0001
500	8.0717	3.61242	34.5935
	0.0010	0.00010	0.0001

Table 6.1.3-6 Difference (av.) SBE37

Depth(m)	Temp.(degC)	Cond.(S/m)	Salinity
1000	0.0047	0.00556	0.0560
500	0.0014	−0.00236	−0.0266

(4) Deployment of developed sensors

Two JES10-CTDIM sensors were established in the following TRITON buoy.

- JES10-CTDIM SN004: EQ156E at 500m (with real time communication)
- JES10-CTDIM SN007: 8N137E at 301m (no real time communication)

Photo 6.1.3-2 JES10-CTDIM SN004

Photo 6.1.3-3 JES10-CTDIM SN007

6.2. Surface drifter observation

(1) Personnel

Akira Nagano	(JAMSTEC) PI
Iwao Ueki	(JAMSTEC)
Hiroki Ushiromura	(MWJ)
Hiroshi Matsunaga	(MWJ)

(2) Objective

The objective of the deployment of the surface drifters is to examine from a Lagrangian viewpoint the modification of sea surface water from above and below the mixed layer. The drifter observations supplement the Eulerian observation by the moored buoy at the nominal location of 37˚N, 137˚E, east of the Philippines.

(3) Parameters

Temperature and salinity of sea surface water

(4) Method

Two Surface Velocity Program Salinity (SVP-S) drifters were deployed at points west and east of the buoy mooring site, east of the Philippines. These drifters were manufactured by Pacific Gyre (Oceanside, CA USA) and are equipped with SeaBird SBE 37 sensors to measure temperature and salinity of the sea surface water and GPS system to track location of the drifters. External appearance of a SVP-S drifter is shown in Fig. 6.2-1. Surface float is made of ABS plastic and its diameter is 35 cm. Surface float and holy sock drogue (diameter is 122 cm) is connected with impregnated steel wire rope. The centers of the drogues are set to be located at a depth of 15 m. The measured data are collected in Argos data system (www.argos-system.org) by the Iridium satellite phone network and are sent by e-mail. The drifters are expected to transmit data for 1 to 2 years.

Fig. 6.2-1: External appearance of SVP-S drifter.

(5) Preliminary results

Locations and times of deployments are listed in Table 6.2.1.

Table. 6.2-1: Locations and times of SVP-S drifters.

Drifter S/N	Date	Time (UTC)	Latitude	Longitude
CIJ-SVPS-0001	Dec 2, 2016	01:43	13˚ 00.0054’ N	136˚ 53.0319’ E
CIJ-SVPS-0002	Dec 2, 2016	05:53	12˚ 59.9749’ N	137˚ 12.9661’ E

6.3. ADCP subsurface mooring

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Hiroki Ushiromura	(MWJ) Operation leader
Hiroshi Matsunaga	(MWJ)
Kenichi Katayama	(MWJ)
Takayuki Hashimukai	(MWJ)
Hiroshi Hoshino	(MWJ)
Akira Watanabe	(MWJ)
Kai Fukuda	(MWJ)
Masahiro Orui	(MWJ)
Emi Deguchi	(MWJ)
Sonoka Tanihara	(MWJ)
Keisuke Takeda	(MWJ)
Rio Kobayashi	(MWJ)

(2) Objectives

The purpose of the ADCP subsurface mooring is to get knowledge of physical process underlying the dynamics of the equatorial current structure and associated processes in the western Pacific Ocean. We have been observing subsurface currents using ADCP moorings along the equator. In this cruise (MR16-08), we recovered the mooring at Eq-156E and deployed another mooring at the same site.

(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 observed parameters by them are listed 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 : 7176 (Mooring No. 141229-EQ156E)

Deployed ADCP

Serial Number : 1248 (Mooring No. 161216-EQ156E)

2) CTD

SBE-16 (Sea Bird Electronics Inc.)

Sampling Interval : 1800 seconds

Recovered CTD

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

Deployed CTD

Serial Number : 1288 (Mooring No. 161216-EQ156E)

3) Other instrument

(a) Acoustic Releaser (BENTHOS,Inc.)

Recovered Acoustic Releaser

Serial Number : 600 (Mooring No. 141229-EQ156E)

Serial Number : 937 (Mooring No. 141229-EQ156E)

Deployed Acoustic Releaser

Serial Number : 632 (Mooring No. 161216-EQ156E)

Serial Number : 666 (Mooring No. 161216-EQ156E)

(b) Transponder (BENTHOS,Inc.)

Recovered Transponder

Serial Number : 56413 (Mooring No. 141229-EQ156E)

Deployed Transponder

Serial Number : 57069 (Mooring No. 161216-EQ156E)

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

Recovered Transponder

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

Deployed Transponder

Serial Number : Z03-088 (Mooring No. 161216-EQ156E)

(5) Deployment

Deployment of the ADCP subsurface mooring at Eq-156E were planned to install the ADCP at about 400 m depths. During the deployment, we monitored the depth of the acoustic releaser after dropped the anchor.

The position of the mooring (#161216-EQ156E) are listed as below.

Date: 16 Dec. 2016 Lat: 00-02.26S Long: 156-07.98E Depth: 1,950m

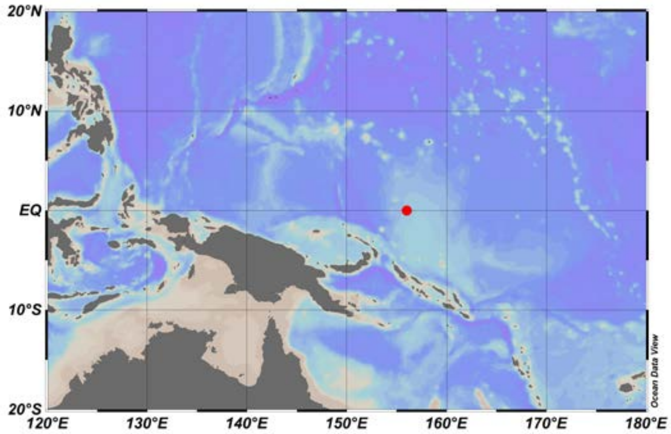
(6) Recovery

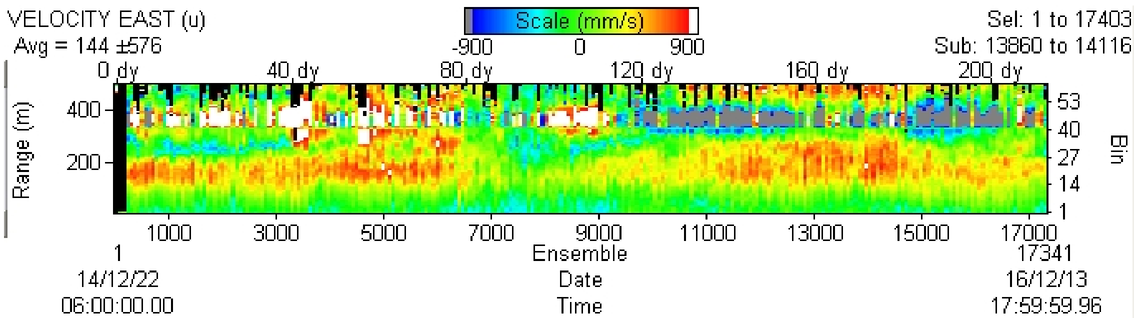
We recovered an ADCP subsurface mooring, which was deployed on 29 Dec 2014 (MR14-06). The current variability acquired by the mooring is shown in Fig. 6.3-1 and 6.3-2.

(7) Data archive

All data will be disseminated from the following web page.

http://www.jamstec.go.jp/rigc/j/tcvrp/ipocvrt/adcp_data.html





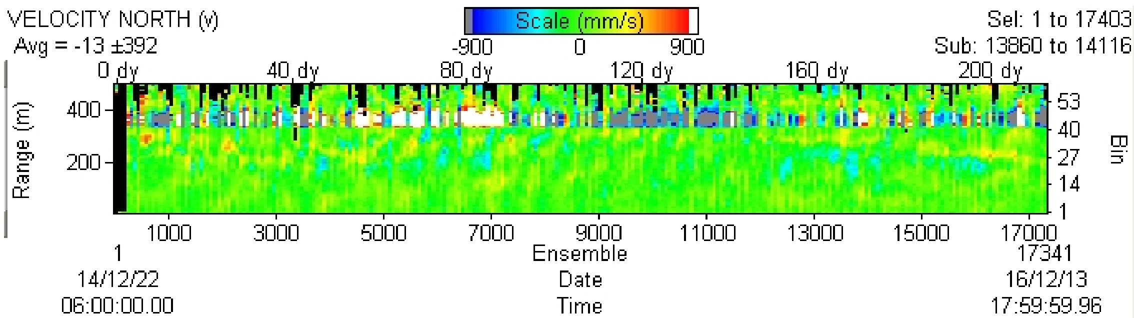


Fig.6.3-1 Time-depth sections of observed zonal (*top panel*) and meridional (*bottom panel*) currents obtained from ADCP mooring at Eq-156E (2014/12/29 - 2016/12/16).

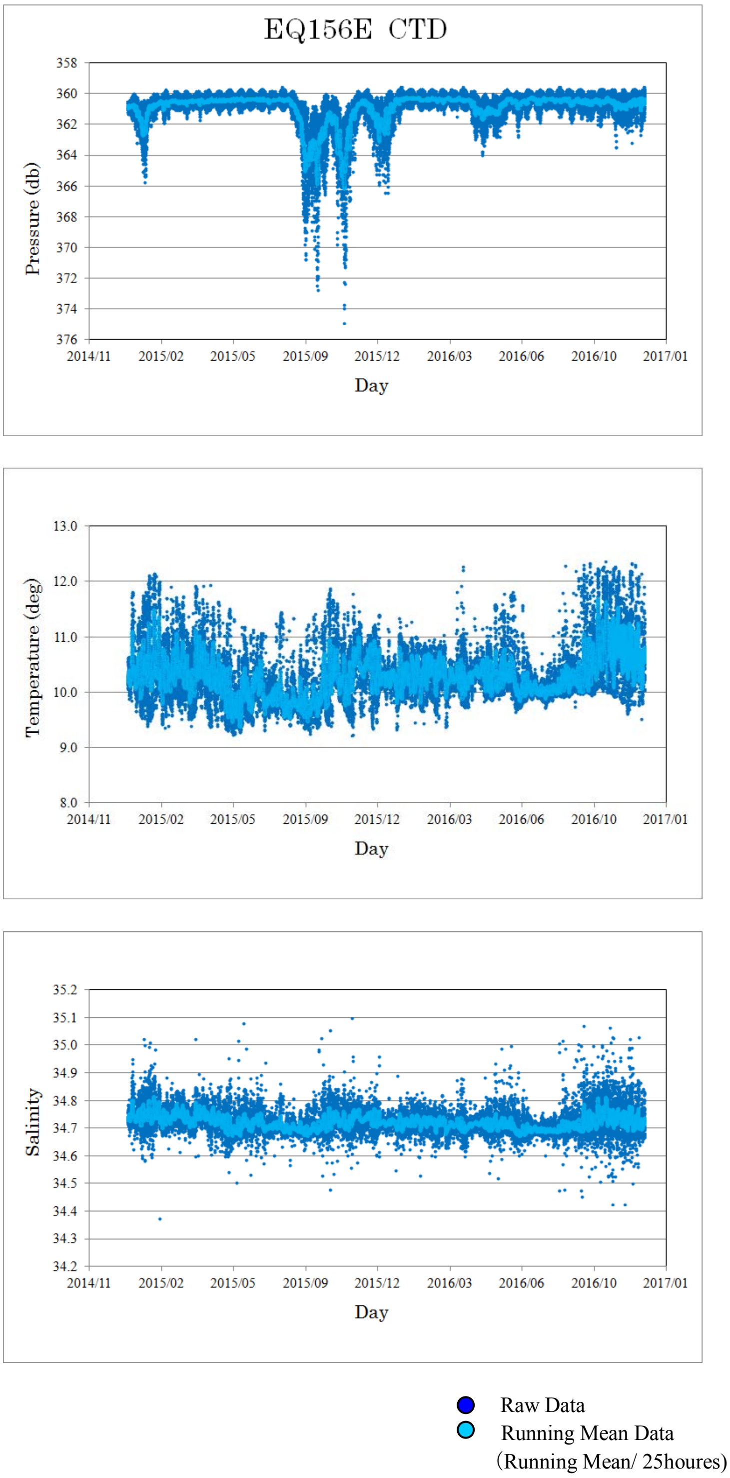


Fig.6.3-2 Time-series of the observed pressure (*top panel*), temperature (*middle panel*) and salinity (*bottom panel*) obtained from CTD at Eq-156E. The *dark-blue* curve indicates the raw data, while the *light-blue* curve shows the filtered data from 25-hours running mean (2014/12/29 - 2016/12/16).

6.4. Wave Glider experiment

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Makito Yokota	(JAMSTEC) not on board
Tatsuya Fukuda	(JAMSTEC) not on board
Yosaku Maeda	(JAMSTEC) not on board
Hiroshi Matsunaga	(MWJ)
Nobuhiro Fujii	(MWJ) not on board

(2) Objectives

The purpose of the Wave Glider operation is to conduct air-sea flux observation in the tropical Ocean, especially warm pool region. In this cruise (MR16-08), we recovered the mooring at Eq-156E and deployed another mooring at the same site.

(3) Parameters

- Meteorological parameters: Air temperature, relative humidity, barometric pressure longwave radiation, shortwave radiation, wind
- Upper ocean parameters: sea surfece temperature, temperature profile until 10 m depth, and pressure temperature and conductivity at underwater glider depth (approximately at 6 m depth).

(4) Instrumentation

Wave Glider is an autonomous surface behicle, which utilize both wave energy for propulsion and solar power for supporting on-board computing, communications and sensor payloads. It can travel tens of thousands of miles, collect data in the most demanding conditions, and deliver this data in real time. The Wave Glider consists of two-part architecture; surface float and underwater glider with umbilical cable (Fig. 6.4.-1). As payloads, we install three types of meteorological sensor units; the Weather Station, Weather Transmitter, and JAMMET (Fig. 6.4.-2). The observed parameters are air temperature, relative humidity, barometric pressure longwave radiation, shortwave radiation, and wind. Underwater sensors for temperature, conductivity and pressure and thermistor chain for temperature profile within 10 m depth are also installed (Fig. 6.4.-3). The acquired data are recorded on logger system and transmitted to land station via iridium satellite communication system.

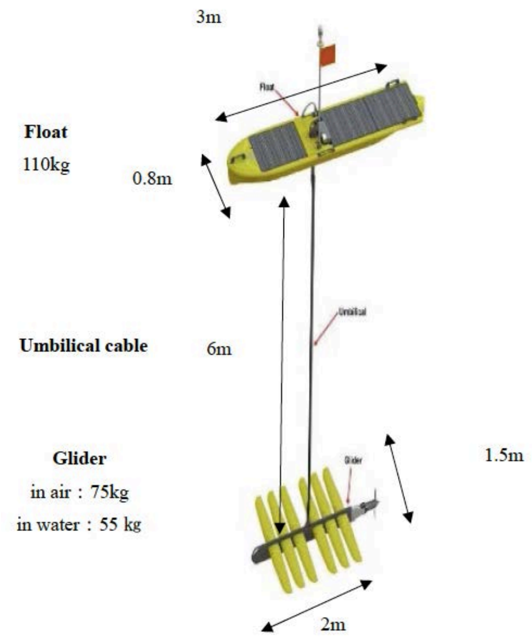


Fig. 6.4.-1 Wave Glider SV3 configuration

Fig. 6.4.-2 Meteolorogical sensor units Fig. 6.4.-3 Thermistor chane and CTD sensor

(5) Field experiments

We conducted field experiments for confirmation of operational performance and data quality around 2 TRITON sites at 8˚N 137˚E and 0˚ 156˚E. First of all we try to check a performance of the Wave Glider operation arround TRITON mooring at 8˚N 137˚E. We set the operation route as a circle of 2.5 nautical miles radius centered at the TRITON mooring. We recovered the Wave Glider on 05 December 2016 (Fig. 6.4.-4). The second field experiment for observed data quality check was conducted around TRITON mooring at 0˚ 156˚E. We reinstalled meteolorogical and underwater sensors and conducted the experiment on 15-16 December 2016 (Fig. 6.4.-5).

Fig. 6.4.-4 Recovery of Wave Glider on 05 December 2016

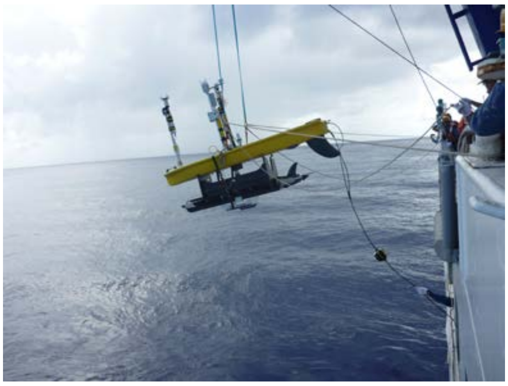


Fig. 6.4.-5 Deployment of Wave Glider with thermistor chane on 15 December 2016

(6) Preliminary Results

Although several damage for meteolorogical sensors were shown, the field experiments were favorably conducted. Results of data comparison between the Wave Glider and TRITON mooring around 0˚ 156˚E are shown in Fig. 6.4.-6. As shown in these figures, observed variables with both platform are consistent, which demonstrate effectiveness of the meteolorogical observation by the Wave Glider. In terms of the observations for the upper ocean elements, the thermistor chane was also able to capture detailed temperature profiles with less impact for cruising (Fig. 6. 4.-7).

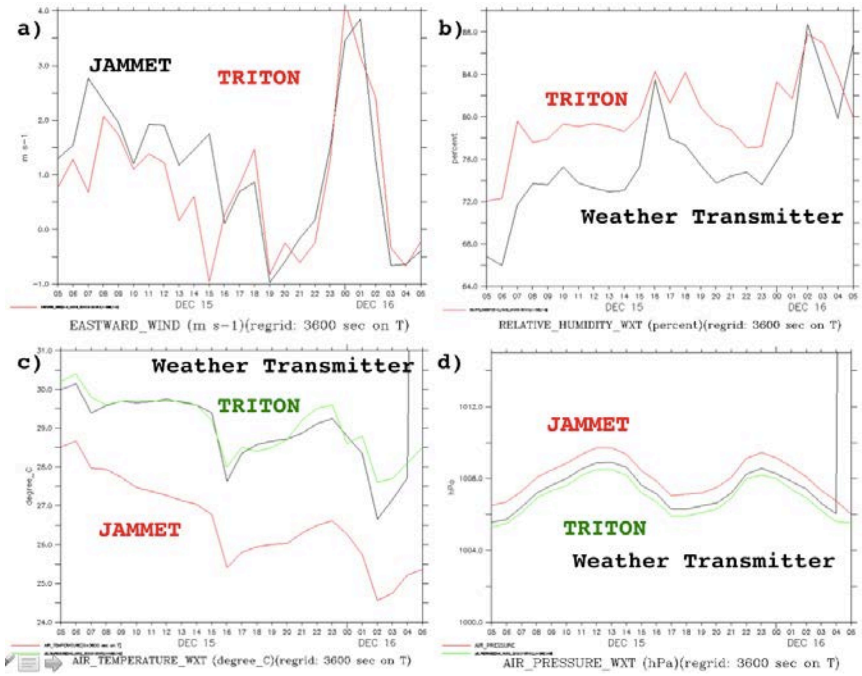


Fig. 6.4.-6 Data comparison between the Wave Glider and TRITONmooring around 0˚ 156˚E for a) zonal wind, b) relative humidity, c) air temparature, and d) barometric pressure.

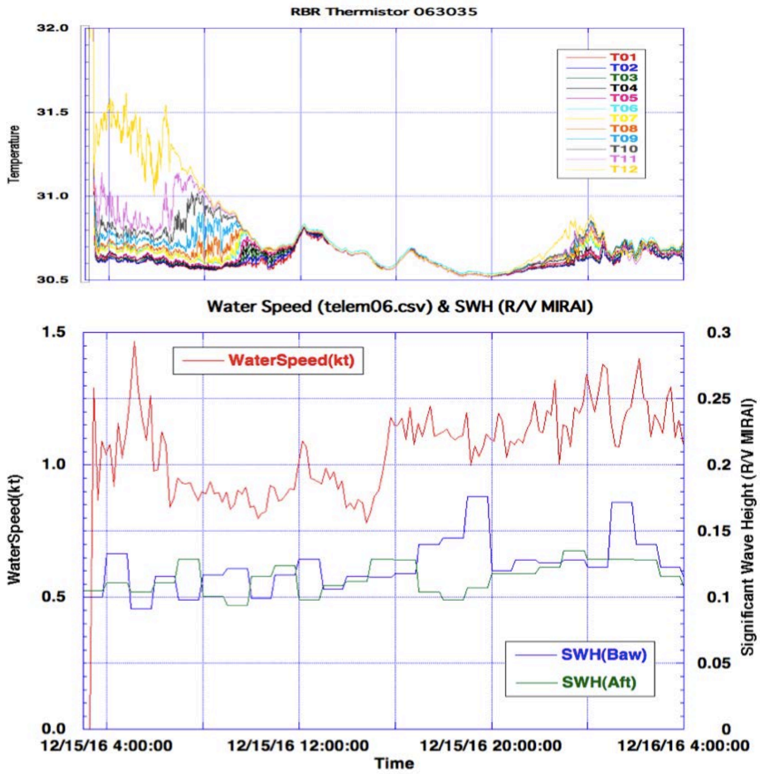


Fig. 6.4.-7 Time series of upper ocean temperature above 10 m (upper) and water speed of the Wave Glider with significant wave height observed by R/V MIRAI.

6.5. Lidar observations of clouds, aerosols and water vapor

(1) Personal

Masaki Katsumata	(JAMSTEC) PI, not on board
Kyoko Taniguchi	(JAMSTEC)
Biao GENG	(JAMSTEC)
Tomoaki Nishizawa	(NIES) not on board
Atsushi Shimizu	(NIES) not on board

(2) Objective

To capture distributions of cloud, aerosol and water vapor in high temporal and special resolutions.

(3) Instrumentation

The lidar system on R/V Mirai transmits 10Hz pulse laser at 1064 nm, 532nm, and 355nm, and detects backscattered signals at the same wavelengths (Mie signal) continuously up to 21km height. The system splits signals at 532 nm and 355nm into parallel and perpendicular components. These Mie signals indicate vertical distribution of cloud and aerosol. The parallel and perpendicular components provide the depolarization ratio, an indicator of particle roundness. The combination of these parameters provides the information about the clouds and aerosols, including amounts and types.

The system also detects Raman signals at 387nm and 607nm for nitrogen and 660 nm for water vapor. The Raman signals indicate vertical distribution of nitrogen and water vapor molecules. The 660nm and 607nm signals share a 532nm laser as a light source. The ratio of the Raman signals is a proportion to the water vapor mixing ratio, a mass ratio of water vapor and dry air. The observations at 607nm and 660nm are only available at nighttime (from sunset to sunrise).

The system reserves a period of 23:56-00:00 UTC for daily maintenance. Instead of observations, the system obtains the background noise data for calibration. Necessary care such as observation window cleaning also take place in the period.

(4) Observation period

29 November 2016 – 22 December 2016 in UTC

* All data are subject to review.

(5) Preliminary Results

Figure 6.4-1 is preliminary results of backscattering intensities at 355 nm, 532 nm and 1064 nm obtained between 12:00 and 18:00 on 18 December 2016 UTC. Each wavelength similarly captures clouds from 14:30 to 16:00 UTC at 0.5km altitude and precipitation after 17:00 UTC as a strong scattering (white parts in Fig. 6.5-1). Contrary, a layer of high aerosol appears differently (blue to green parts in Fig. 6.5-1). The difference among three wavelengths suggests properties of the aerosol such as a particle size.

Figure 6.5-2 is preliminary results of Raman scattering photon counting at 387nm, 607nm, and 660nm on the same day. The clouds from 14:30 to 16:00 UTC lower the range of the valid data altitude by high signal attenuation. The rain reduces the photon counting in all wavelength, as seen after 17:00 UTC.

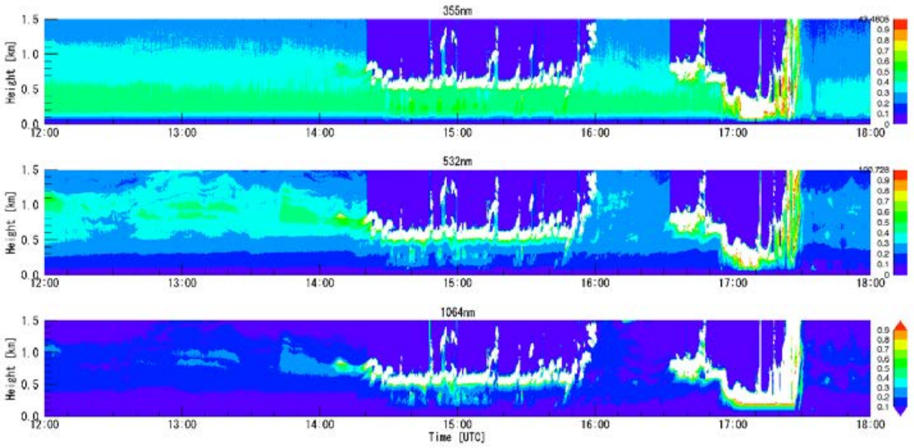


Fig 6.5-1. Backscattering intensities at 355nm, 532nm and 1064nm obtained between 12:00 and 18:00 on 18 December 2016 UTC.

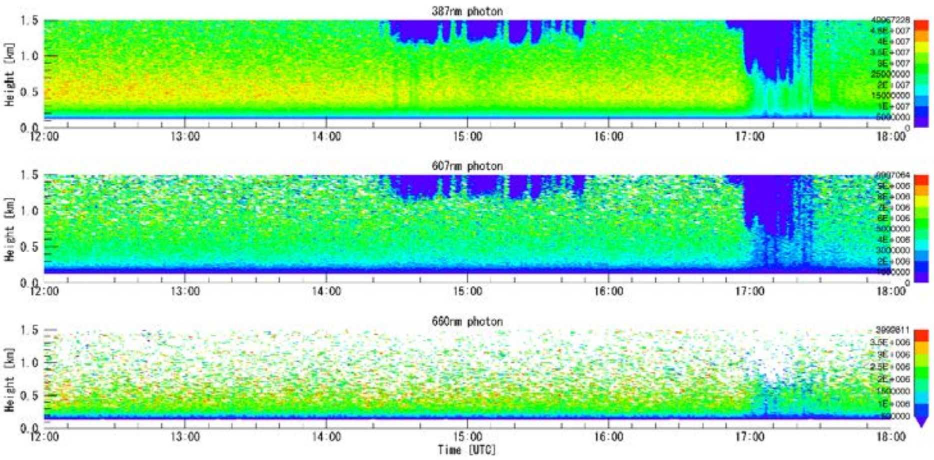


Fig 6.5-2. Raman scattering photon counting of 387nm, 607nm, and 660nm obtained between 12:00 and 18:00 on 18 December 2016 UTC.

6.6. Radio sonde observation

(1) Personnel

Masaki KATSUMATA	(JAMSTEC) PI, not on board
Biao GENG	(JAMSTEC)
Kyoko TANIGUCHI	(JAMSTEC)
Kazuho YOSHIDA	(NME) Operation Leader
Koichi INAGAKI	(NME)

(2) Objectives

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

(3) Operational methodology

The Vaisala GPS radiosonde sensor (RS41-SGP) was launched with the balloon (TA-200). The on-board radiosonde system consists of sounding processing system (SPS-311), ground check device (RI41), processing and recording software (MW41), GPS antenna (GA20), UHF antenna (RB21), and automatic balloon launcher (ASAP). In addition, the pressure sensor (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. 1 to Dec. 23, 2016. During this period, 54 radiosonde equipped balloons have been launched (Table 6.6-1). Figure 6.6-1 shows some results of the radiosonde observations. Detailed analyses of the data observed by the radiosonde will be performed after the cruise.

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 datasets will be submitted to the JAMSTEC Data Management Group.

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

ID	SN	Date	Latitude	Longitude	Psfc	Tsfc	RHsfc	WD	Wsp	SST	Max height		
		YYMMDDHH	deg	deg	hPa	degC	%	deg	m/s	degC	hPa	m	Duration
RS001	M3540039	2016120112	14.537	136.852	1011.0	28.5	73	69	10.6	28.9	23.5	25252.8	6299
RS002	M3540038	2016120212	12.811	137.055	1009.1	28.7	82	70	10.0	29.0	23.0	25390.4	5734
RS003	M3540031	2016120312	12.741	136.893	1009.2	28.8	78	74	11.5	29.0	28.7	23983.8	5508
RS004	M3540033	2016120412	8.783	136.919	1006.6	28.5	85	87	3.3	29.5	42.8	21515.7	4955
RS005	M3540056	2016120512	7.656	136.748	1006.4	27.5	85	44	3.5	29.7	26.9	24396.0	5751
RS006	M3530709	2016120612	6.075	137.013	1005.9	27.3	87	181	7.7	29.9	27.1	24353.1	5797
RS007	M3540026	2016120712	4.538	137.352	1006.6	27.3	84	252	11.3	29.9	40.7	21814.3	5533
RS008	M3540027	2016120912	0.716	144.100	1005.3	29.1	78	241	4.3	30.1	20.7	26092.0	6382
RS009	M3540060	2016121000	0.112	146.761	1006.5	29.5	75	202	4.3	30.4	24.0	25144.0	5889
RS010	M3540032	2016121012	0.766	147.010	1005.2	29.6	77	260	4.2	30.4	27.2	24364.1	5703
RS011	M3540058	2016121015	1.338	146.981	1004.9	29.3	76	193	2.0	30.3	21.0	25937.0	6104
RS012	M3530719	2016121018	1.828	146.962	1003.3	28.9	82	191	3.9	30.2	21.7	25753.1	5937
RS013	M3540091	2016121100	2.063	146.952	1005.9	29.6	75	159	3.2	30.3	13.6	28765.2	6689
RS014	M3540059	2016121112	2.058	148.866	1006.1	28.7	79	13	4.1	31.0	29.4	23856.2	5502
RS015	M3540055	2016121200	2.056	151.327	1006.9	29.5	75	46	3.8	30.3	21.4	25834.1	6218
RS016	M3530712	2016121212	2.053	153.807	1007.5	29.6	76	54	4.2	30.4	25.1	24832.4	5839
RS017	M3530760	2016121300	2.027	156.014	1007.3	29.4	77	5	5.0	30.6	14.4	28377.2	7139
RS018	M3540057	2016121309	1.472	156.013	1005.3	29.5	74	11	7.3	30.7	31.7	23328.6	5699
RS019	M3540029	2016121312	0.912	155.990	1006.3	29.7	76	10	7.7	30.6	33.7	22996.6	5499
RS020	M3310397	2016121315	0.590	155.988	1004.7	29.2	76	6	8.8	30.6	31.2	23442.7	5413
RS021	M3310457	2016121400	-0.064	155.935	1006.6	29.3	75	142	5.2	30.6	10.3	30602.1	6481
RS022	M3310394	2016121412	-0.030	156.114	1005.6	29.1	77	46	2.4	30.5	31.0	23503.5	5048
RS023	M3540030	2016121500	0.007	156.036	1006.0	29.7	74	14	1.6	30.6	13.5	28802.5	6732
RS024	M3540022	2016121512	-0.072	156.069	1006.2	28.7	80	347	5.7	30.7	24.5	25009.0	5842
RS025	M3310391	2016121600	-0.030	156.128	1005.5	29.0	80	2	2.0	30.7	21.5	25828.2	5833
RS026	M3310393	2016121612	-1.166	156.019	1006.1	28.6	78	300	7.4	30.5	25.4	24763.1	6028
RS027	M3540021	2016121618	-1.945	155.985	1002.9	28.8	81	296	7.6	30.5	26.9	24364.2	5914
RS028	M3530708	2016121700	-2.012	155.955	1005.8	28.1	81	246	9.8	30.5	10.9	30282.2	6532
RS029	M3540049	2016121706	-2.166	156.217	1002.6	28.7	85	278	9.9	30.5	29.2	23847.9	5386
RS030	M3540048	2016121712	-2.750	157.273	1007.0	25.0	94	260	14.6	30.2	50.6	20528.0	5197
RS031	M3530762	2016121718	-3.340	158.307	1003.3	28.4	79	283	9.7	30.3	356.5	8443.4	2019
RS032	M3540043	2016121800	-3.890	159.291	1005.3	28.6	78	266	10.4	30.1	20.1	26310.2	6167
RS033	M3540044	2016121806	-4.598	160.203	1002.0	28.7	82	300	7.1	30.6	36.0	22572.6	4736
RS034	M3540047	2016121812	-5.331	161.116	1004.5	28.5	82	345	3.5	30.0	30.9	23569.2	5608
RS035	M3540042	2016121818	-6.105	162.055	1002.3	27.4	91	321	8.8	30.0	27.8	24190.0	5823
RS036	M3540046	2016121900	-6.875	162.995	1003.0	29.1	80	333	5.6	30.0	23.9	25137.8	5613
RS037	M3540040	2016121906	-7.627	163.912	1001.2	28.5	81	348	2.5	30.2	26.3	24541.9	5916
RS038	M3540041	2016121912	-8.338	164.788	1004.3	27.8	85	13	4.0	29.6	27.2	24365.9	5440
RS039	M3540037	2016121918	-9.096	165.701	1002.4	26.7	83	74	0.6	29.3	23.1	25358.3	5994
RS040	M3530710	2016121921	-9.438	166.115	1004.8	25.9	94	64	5.7	29.5	26.0	24679.8	5553
RS041	M2750059	2016122000	-9.825	166.569	1004.6	25.6	95	125	5.7	29.4	305.2	9619.9	2405
RS042	M2750159	2016122003	-10.208	167.026	1004.7	25.3	92	207	2.8	29.5	28.4	24099.0	7747
RS043	M2750118	2016122006	-10.539	167.423	1003.8	27.2	83	260	1.2	29.6	27.3	24326.7	4991
RS044	M2750083	2016122009	-10.847	167.793	1004.8	28.2	79	342	0.7	29.6	15.0	28221.1	6393
RS045	M2750091	2016122012	-11.247	168.273	1005.9	28.4	83	326	3.0	30.2	34.1	22969.8	5450
RS046	M2750075	2016122018	-11.982	169.156	1004.6	28.3	78	239	2.9	29.8	23.0	25401.0	6073
RS047	M2750355	2016122100	-12.703	170.028	1005.7	28.7	77	322	2.0	30.0	42.7	21560.6	4834
RS048	M2750157	2016122106	-13.168	170.583	1004.9	29.1	76	233	4.7	29.9	36.0	22591.9	5483
RS049	M2750160	2016122112	-13.572	171.070	1007.3	27.4	87	152	5.3	29.5	49.7	20632.6	4831
RS050	M2750158	2016122118	-14.019	171.621	1005.5	27.7	82	131	2.8	29.5	37.2	22387.1	5525
RS051	M2750227	2016122200	-14.777	172.542	1005.9	27.9	78	73	1.5	29.0	43.9	21360.2	4931
RS052	M2750096	2016122206	-15.475	173.400	1004.7	28.1	73	200	2.1	29.1	12.0	29648.8	7011
RS053	M2750223	2016122212	-16.213	174.302	1007.2	27.2	80	190	2.8	28.4	50.0	20568.2	4829
RS054	M2750078	2016122300	-17.562	175.966	1007.5	26.6	78	163	5.1	28.1	33.9	22959.8	5241

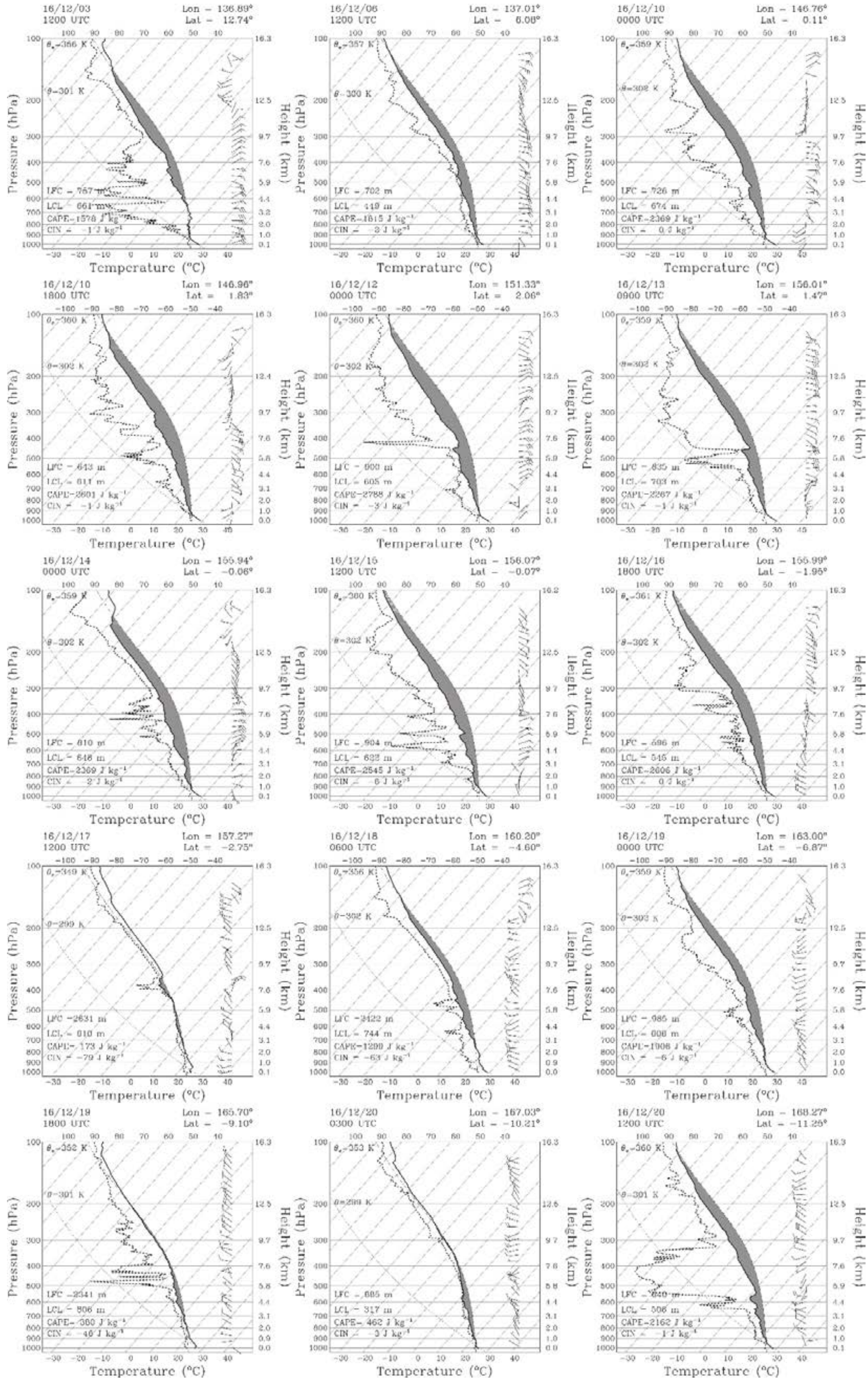


Figure 6.6-1. Skew-T log-p diagrams of the radiosonde observations.

6.7. Doppler radar observation

(1) Personnel

Masaki Katsumata	(JAMSTEC) PI, not on board
Biao Geng	(JAMSTEC)
Kyoko Taniguchi	(JAMSTEC)
Kazuho Yoshida	(NME) Operation Leader
Koichi Inagaki	(NME)

(2) Objective

The objective of Doppler radar observations in this cruise is to investigate the structure and evolution of precipitating systems over the tropical ocean, especially those developing in association with the intertropical convergence zone (ITCZ), the south pacific convergence zone (SPCZ), and the Madden-Julian Oscillation (MJO).

(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
INU (Inertial Navigation Unit):	PHINS (IXBLUE 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 INU. 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) peak output power, (3) pulse width, and (4) PRF (pulse repetition frequency).

The operational mode of the radar during the cruise is shown in Tables 6.6-1. A dual PRF mode is used for a volume scan. For a RHI, vertical point, and surveillance PPI scans, a single PRF mode is used.

(6) Data

The Doppler radar observations were conducted from Nov. 28 to Dec. 23, 2016. During this period, precipitating systems, such as isolated cumulonimbus, mesoscale convective system, narrow rainband, etc., have been observed by the Doppler radar. Figures 6.6-1 and 6.6-2 show horizontal distributions of reflectivity observed by the Doppler radar around the ITCZ and the SPCZ, respectively. 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.

6.8. disdrometer observation

(1) Personnel

Masaki Katsumata	(JAMSTEC) PI, not on board
Biao Geng	(JAMSTEC)
Kyoko Taniguchi	(JAMSTEC)

(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

Three different types of disdrometers are utilized to obtain better reasonable and accurate value on the moving vessel. Two of them 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. The other one, 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 two disdrometers (Parsivel and LPM), 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.

(4-1) 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 6.8-1.

(4-2) "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 6.8-2.

(4-3) Micro rain radar

The MRR-2 (METEK GmbH) was utilized. The specifications are in Table 6.8-3. 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 Nov. 27 to Dec. 23. 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.

(7) Acknowledgment

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

Table 6.8-1: Categories of the size and the fall speed for LPM.

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

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

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

Particle Size			Fall Speed		
Class	Average Diameter [mm]	Class spread [mm]	Class	Average Speed [m/s]	Class Spread [m/s]
1	0.062	0.125	1	0.050	0.100
2	0.187	0.125	2	0.150	0.100
3	0.312	0.125	3	0.250	0.100
4	0.437	0.125	4	0.350	0.100
5	0.562	0.125	5	0.450	0.100
6	0.687	0.125	6	0.550	0.100
7	0.812	0.125	7	0.650	0.100
8	0.937	0.125	8	0.750	0.100
9	1.062	0.125	9	0.850	0.100
10	1.187	0.125	10	0.950	0.100
11	1.375	0.250	11	1.100	0.200
12	1.625	0.250	12	1.300	0.200
13	1.875	0.250	13	1.500	0.200
14	2.125	0.250	14	1.700	0.200
15	2.375	0.250	15	1.900	0.200
16	2.750	0.500	16	2.200	0.400
17	3.250	0.500	17	2.600	0.400
18	3.750	0.500	18	3.000	0.400
19	4.250	0.500	19	3.400	0.400
20	4.750	0.500	20	3.800	0.400
21	5.500	1.000	21	4.400	0.800
22	6.500	1.000	22	5.200	0.800
23	7.500	1.000	23	6.000	0.800
24	8.500	1.000	24	6.800	0.800
25	9.500	1.000	25	7.600	0.800
26	11.000	2.000	26	8.800	1.600
27	13.000	2.000	27	10.400	1.600
28	15.000	2.000	28	12.000	1.600
29	17.000	2.000	29	13.600	1.600
30	19.000	2.000	30	15.200	1.600
31	21.500	3.000	31	17.600	3.200
32	24.500	3.000	32	20.800	3.200

Table 6.8-3: 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. GNSS precipitable water

(1) Personnel

Masaki Katsumata	(JAMSTEC) PI, not on board
Mikiko Fujita	(JAMSTEC) not on board
Biao Geng	(JAMSTEC)
Kyoko Taniguchi	(JAMSTEC)
Kazuho Yoshida	(NME) Operation Leader
Koichi Inagaki	(NME)

(2) Objective

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

(3) Method

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

(4) Results

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

(5) Data archive

Raw data is recorded as T02 format and stream data every 5 seconds. These raw datasets are available from Mikiko Fujita of JAMSTEC. Corrected data will be submitted to the JAMSTEC Data Management Group and will be archived there.

6.10. Aerosol optical characteristics measured by Ship-borne Sky radiometer

(1) Personnel

Kazuma Aoki (University of Toyama) PI, not onboard

Tadahiro Hayasaka (Tohoku University), not onboard

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

(2) Objective

Objective of this observation is to study distribution and optical characteristics of marine aerosols by using a ship-borne sky radiometer (POM-01 MK-III: 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 (0.315, 0.4, 0.5, 0.675, 0.87, 0.94, and 1.02 μm). Analysis of these data was performed by SKYRAD.pack version 4.2 developed by Nakajima *et al.* 1996.

(5) Data archives

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

6.11. Tropospheric gas and particles observation

(1) Personnel

Fumikazu Taketani	(JAMSTEC) PI, not on board
Yugo Kanaya	(JAMSTEC), not on board
Takuma Miyakawa	(JAMSTEC), not on board
Hisahiro Takashima	(JAMSTEC/Fukuoka Univ.), not on board
Yutaka Tobo	(NIPR), not on board
Yuichi Komazaki	(JAMSTEC), not on board
Hitoshi Matsui	(Nagoya Univ./JAMSTEC), not on board

* Operation was supported by Nippon Marine Enterprises. Ltd.

(2) Objectives

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

(3) Parameters

- Fluorescent particles
- Particle size distribution
- Composition of ambient particles
- Aerosol extinction coefficient (AEC)
- Surface ozone (O3), and carbon monoxide (CO) mixing ratios

(4) Instruments and methods

(4-1) Online aerosol observations:

(4-1-1) Particle size distribution

The size distribution of particles was measured by a scanning mobility particle sizer (SMPS) (comprising a 3080 Electrostatic Classifier with 3081 differential mobility analyzer (DMA), a condensation particle counter (CPC) model 3010, TSI).

(4-1-2) Fluorescent particles

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

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

(4-2) Ambient air sampling

Ambient air samplings were carried out by air samplers installed at compass deck. Ambient particles were collected on the quartz filter (ϕ =110mm) along cruise track to analyze their composition using a high-volume air sampler (HVS, HV-525PM, SIBATA) operated at flow rate of 500 L/min. To avoid collecting particles emitted from the funnel of the own vessel, the sampling period was controlled automatically by using a "wind-direction selection system". Coarse and fine particles separated at the diameter of 2.5 μm were collected on quartz and Teflon filters, respectively. All samples are going to be analyzed in laboratory.

(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 telescope unit was updated before the cruise; only one-axis scan for elevation angle was attained, while capability of azimuth scan was not employed. The line of sight was in the directions of the portside of the vessel and the scanned elevation angles were 1.5, 3, 5, 10, 20, and 30, 90 degrees in the 30-min cycle. The roll motion of the ship was measured to autonomously compensate additional motion of the prism, employed for scanning the elevation angle.

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) Data archives

These data obtained in this cruise will be submitted to the JAMSTEC Data Management Group, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site (http://www.godac.jamstec.go.jp/darwin/e).

6.12. Study on vertical measurement by in-situ pH/pCO_2 sensor

(1) Personnel

Kiminori Shitashima (Tokyo University of Marine Science and Technology) PI

(2) Objectives

The measurement of pH in the marine system is important because this parameter related to the chemical equilibrium conditions of the seawater and the biological and chemical processes occurring in the sea. In particular, the pH of seawater is reflected in the exchange of CO_2 between the atmosphere and the ocean, and oceanic carbon cycles. In order to characterize the oceanic CO_2 system, at least two of the parameters, pH, pCO_2, alkalinity and total CO_2 have to be measured. The measurement of pH and pCO_2 is comparatively easy in these four parameters. Furthermore, a change of pH and pCO_2 in seawater should preferably be observed continually in a long term and a wide area (vertically and horizontally) to monitor air-sea CO_2 exchange and oceanic carbon cycle concerning the global warming. Unfortunately, the onboard measurement of pH and pCO_2 in seawater is not convenient for the long term and continuous observations. In-situ measurement with a sensor is the most suitable for such observations, but a marketed in-situ pH sensor using a glass electrode cannot detect a detailed pH change because precision is extremely low and response time is too long. In addition, in the pCO_2 measurement, it is limited to only a measurement at the marine surface under the present conditions. The purpose of this study is to develop new type of high performance pH/pCO_2 sensor for in situ measurement in the deep sea, and apply it to chemical oceanography.

(3) Method

1) In-situ pH/pCO_2 sensor

The in-situ pH sensor employs an Ion Sensitive Field Effect Transistor (ISFET) as a pH electrode, and the Chloride ion selective electrode (Cl-ISE) as a reference electrode. The ISFET is a semiconductor made of p-type Si coated with SiO_2 and Si_3N_4 that can measure H^+ ion concentration in aqueous phase. New ISFET-pH electrode specialized for oceanographic use was developed by CRIEPI. The Cl-ISE is a pellet made of several chlorides having a response to the chloride ion, a major element in seawater. The electric potential of the Cl-ISE is stable in the seawater, since it has no inner electrolyte solution. Therefore, The in-situ pH sensor has a quick response (within a few second), high accuracy (±0.005pH) and pressure-resistant performance. The pCO_2 sensor was devised to incorporate the above-mentioned newly developed in-situ pH sensor to measure the in-situ pCO_2 in seawater. The principle of pCO_2 measurement is as follows. Both the ISFET-pH electrode and the Cl-ISE of the pH sensor are sealed in a unit with a gas permeable membrane whose inside is filled with inner electrolyte solution with 1.5 % of NaCl. The pH sensor can detect pCO_2 change as inner solution pH change caused by permeation of carbon dioxide gas species through the membrane. An amorphous Teflon membrane (Teflon AF™) manufactured by DuPont was used as the gas permeable membrane. The in-situ response time of the pCO_2 sensor was less than 60 seconds. The diode on ISFET can measure the temperature of seawater simultaneously and the in situ pH data can be calibrated using this temperature data. ISFET and Cl-ISE are connected to pH converter circuit in the pressure housing through the underwater cable connector. The pressure housing includes pH converter circuit, A/D converter, data logger RS-232C interface and Li ion battery. Before and after the observation, the pH sensor was calibrated using two different standard buffer solutions, 2-aminopyridine (AMP; pH 6.7866) and 2-amino-2-hydroxymethil-1,3-propanediol (TRIS; pH 8.0893) described by Dickson and Goyet, for the correction of electrical drift of pH data. The measured pH and temperature data are stored in the data logger. After finish of the pH measurement, these data are transferred from the data logger into a personal computer (PC) connected with RS-232C cable, and the in situ pH is calculated using calibration data of AMP and TRIS in a PC. Since the calibration of in-situ pCO_2 measurements was not conducted in our field application reported here, only raw data (arbitrary unit) from the pCO_2 sensor output were obtained. Raw data showing small digit readings indicates pH depression of the inner solution, which reflects an increase in partial pressure of CO_2 in seawater. Two sets of the in-situ pH/pCO_2 sensors were installed to the CTD-RMS, and in-situ data of pH and pCO_2 ware measured every 1 second and/or 2 seconds during descent and ascent of the CTD-RMS.

2) On-board analysis

2-1) pH

Sub-samples for the pH measurement were aliquoted from 12L-Niskin X bottles, mounted on the CTD carousel, by transferring the collected seawaters into 100 mL dry plastic bottles after ~100% overflow of the samples with no air bubbles, in order to avoid any exchange of CO_2 with the atmosphere during the sub-sampling. For the pH measurement, the sample was transferred to a specially designed glass cylindrical cell with overflow. The cell has a double structure, the inner ~20 mL space for sample seawater and a surrounding space where thermostated water (by using a constant temperature circulator) is circulated to hold the temperature of the inner seawater sample at 24.9±0.1°C. Below the cell was a magnetic stirrer. The pH measurement was conducted using a PHM93 Reference pH Meter (Radiometer Copenhagen) within a day after sampling. A combined pH electrode (Radiometer, GK2401C) and a temperature sensor (Radiometer, T901) were tightly inserted into the inner space of the pH cell through two tapered joints. The pH measurement was therefore conducted in a completely closed environment with a constant temperature of 24.9±0.1°C.

Analysis time of each seawater sample is 10 minutes. Prior to analysis, the pH meter and the electrode were calibrated against two standards, pH=7.000 buffer solution (S11M004, Radiometer) and pH=4.005 buffer solution (S11M002, Radiometer) for IUPAC/NIST pH scale (NBS). Two buffer solutions: TRIS (Artificial Seawater (2-Amino-2-hydroxymethyl-1,3-propanediol), Lot. WEK8350, Wako pure chemical industries, 287-77321) and AMP (Artificial Seawater (2-Aminopyridine), Lot. WEK8351, Wako pure chemical industries, 284-77321) were used for calibration of seawater pH scale (SWS). For the SWS, the e.m.f. values (mV) of the pH electrode were measured for the two buffers both at the beginning and the end of each series of measurements (usually 20 to 30 samples at each station). The e.m.f. values (mV) of the unknown seawater samples were converted to pH(X) values according to the equations in the manual SOP 6 (Determination of the pH of sea water using a glass/reference electrode cell, August 30, 1996). The RSD of duplicate or triplicate analyses for surface seawater samples was less than 0.005.

2-2) Total alkalinity (TA)

Sub-samples for the TA measurement were aliquoted from 12L-Niskin X bottles, mounted on the CTD carousel, by transferring the collected seawaters into 250 mL dry plastic bottles after ~100% overflow of the samples. The volume-determined sample (50 mL) was transferred to a 100 mL glass beaker for open-cell titration. The beaker was putted in thermostated water bath (by using a constant temperature circulator) to hold the temperature of the inner seawater sample at 24.9±0.1°C. Below the beaker was a magnetic stirrer. A Total Alkalinity titration analyzer ATT-05, Kimoto Electric Co. Ltd, was used for titration. A combined pH electrode (Radiometer, GK2401C), a temperature sensor (ATT-05) and a Teflon tube connected to a titrant were inserted in the beaker. The titrant was 0.1N HCl solution (Wako N/10 Hydrochloric Acid, 083-01115, Lot. WEL4206, Wako Pure Chemical Industries, Ltd.), and was also set in the thermostated water bath.

Analysis time of each seawater sample is about 15 minutes. The basic calibrations were performed at the beginning and at the end of the cruise using the international reference material for oceanic CO_2 measurements (Batch 141 bottled on June 13, 2014) prepared by Dr. A.G. Dickson. Surface seawater collected at station BD02 at 10 m depth was used as the working standard, which was measured at the beginning and the end of each series of measurements. The precision was estimated to be less than ±2 μmol/kg from replicate analyses of the working standard. The final TA values were corrected by using the authorized TA value of 2222.61 μmol/kg of the international reference material.

2-3) Total dissolved inorganic carbon (TCO_2)

The TCO_2 concentration in seawater samples was determined by using the NDIR detector (LI-COR Inc.). Samples for TCO_2 analysis were drawn from the Niskin sampler into 125 mL glass vial bottles after an overflow of about 100 mL of the seawater. The samples were immediately poisoned with 50 μl of 50% saturated $HgCl_2$ in order to restrict biological alteration prior to sealing the bottles. Seawater was introduced manually into the thermostated (25ºC±0.1ºC) measuring pipette with a volume of ~30 mL by a pressurized headspace CO_2-free air that had been passed through the soda-lime scrubber. The measured volume was then transferred to the extraction vessel. The seawater sample in the extraction vessel was acidified with 1.0 mL of 3.8% phosphoric acid and the CO_2 was extracted from the sample by bubbling with the CO_2-free air. After passing through the Ag_2SO_4 scrubber, polywool and $Mg(ClO_4)_2$ scrubber to remove sea salts and water vapor, the evolved CO_2 gas was continuously induced to the NDIR detector. The precision of the TCO_2 measurement was tested by analyzing CRMs (batch 141) at the beginning of the measurement of samples every day.

(4) Data archive

All data will be archived at Tokyo University of Marine Science and Technology after checking of data quality and submitted to the JAMSTEC Data Management Group within 3 years.

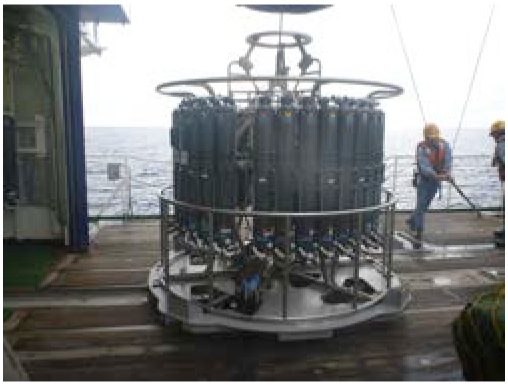


Fig. 6.12-1 In-situ pH/pCO_2/ORP sensor

6. 13. Study on distribution, temperature tolerance and environmental factors of the oceanic sea skaters, Halobates (Heteroptera: Gerridae) inhabiting 02º-08ºN 137-138ºE in the western tropical Pacific Ocean

(1) Personnel

Tetsuo Harada	(Kochi University) PI
Hiroki Fujita	(Kochi University)
Takahiro Furuki	(Kochi University)

(2) Objectives

This study during this scientific cruise, MR16-08 aims, first, to examine the relationship between the population density of the oceanic sea skaters of *Halobates* (Heteroptera: Gerridae) inhabiting the tropical Pacific Ocean of 2ºN-8ºN, 137ºE-138ºE and meteorological factors (for example precipitation and atmospheric temperature) in November and December 2016. This study aims, second, to examine whether sea skaters, living in the tropical Pacific Ocean, show a temperature acclimation effect on temperature tolerance. The oceanic sea skaters inhabiting tropical oceans live under very stable surface water temperature at 28ºC (rainy case) and 30º-31ºC (fine) through the year. Thirty two or three degree is only one or two degree above usual surface water temperature, although this high temperature would be possible in the near future because of the global warming. The third purpose is to examine a heat shock by a high water temperature of 32-33ºC on the lower temperature tolerance. The fourth aim of this study is to examine, as a preliminary data, ultra violet radiation value (μW/cm^2) at 8:00 and at 12:30 every day on the deck of R/V MIRAI during the cruise of MR16-08 by R/V MIRAI.

(3) Materials and method

Samplings

Samplings were performed in three days of 5th, 7th and 8th December 2016 to 14th in the area of 5S-7ºS, 101ºE-103ºE with a Neuston NET (6 m long and with diameter of 1.3 m.). The Neuston NET was trailed for 15 mm x 3 or 6 times as one set-trial on the sea surface. Three 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 x 3-6 times at night for the all 3 set-trials with the ship speed of 2.0 knot to the sea water. 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.

Cool Coma Experiments

Twelve or thirteen adults and/or 5th and 4th instars larvae specimens were moved from the cube aquaria in which those specimen had been kept, to the two machines as Low Temperature

Thermostatic Water Bathes (Thomas: T22LA) (55cm × 40cm × 35cm). The specimen had been acclimated at 25 ± 0.1, 28 ± 0.1 or 31 ± 0.1ºC for 8 hours or 24 hours. Temperature was gradually decreased (1 ºC per 3-5 min) by 1℃ every 15 min by the automatic cooling/heating system of the water bathes till the cool temperature comas occur in all the experimental specimens.

Temperature at which Cool Coma occurs was recorded (Cool Coma Temperature [CCT]: The temperature when ventral surface of the body was caught by sea water film and the ability to skate was lost, or when abnormal postures on the sea-water were observed - for example, one leg sank into the water, the body was upside down, or the mid-leg moved behind and attached to hind leg)

Temperature acclimation experiments

Adults of *Halobates germanus* which were collected in Station 1 in this study were used for the temperature acclimation experiment (Experiments 1-6). Rearing temperature on water surface in the laboratory was kept at 29±1ºC. All specimens were acclimated at 25±0.1ºC, 28±0.1ºC or 31±0.1ºC for 10 hours. The cool coma experiments were performed for the adult specimens in the machines under the three temperature conditions.

Heat shock experiments

Some of specimens of *H. germanus and H. micans* which were collected at Station 1 mostly were used for the heat shock experiments (Experiments 7, 8). Rearing temperature on water surface in the laboratory was kept at 29±1ºC. As a heat shock, water temperature was set for 12 hours into 32.5±1.0ºC by controlling air conditioning system in the laboratory. After the heat shock and the recovering hours of 24 or 76, the cool coma experiments were performed for the adult specimens in the machines where they has acclimated to 28±0.1ºC or 31±0.1ºC for 24 hours

Ultra violet radiation measurement

Ultra violet radiation was measured around at 8:00 and 12:00 every day during the MR16-08 cruise by R/V MIRAI. The measurement was performed at the height of 150 cm in the open space of the deck of MIRAI.

(4) Results

Distribution

The samplings of *Halobates* (Table 1) inhabiting tropical stations in the eastern Pacific Ocean showed that 586 individuals in total (15 min x 7 times) of two species of *Halobates germanus and H. micans* were collected at the 2 stations at 04º36'-37'N 137˚19-20'E (Station A) and 01˚59'N 02º00' 138˚46'E (Station B). The population densities of the Station A and B were about 129598 individuals / km^2 and 15746 individuals / km^2, respectively (Table 6.13-2). Exclusively *H. germanus* seems to occupy this area. The number of individuals collected for 15min were greatly different between the Station A (Maximum number: 218) and B (Minimum number: 9). At the Stations 1 and 2, 189 and 19 larvae were collected, respectively, and 12 exuviae (wasted skin at molting) were caught in total. Reproductive and growth activity might be very active at the two stations (Table 6.13-3).

Ultra violet measurement

In the tropical area, the UV radiation was ranged from 90 $\mu W/cm^2$ in the heavy rain to about 4500$\mu W/cm^2$ in the fine weather (Table 6.13-4). The data will be compared to the value on the water surfaces in the flesh water habitats of Gerridae insect.

(5) Acknowledgement

We would like to thank Dr. Iwao UEKI (Chief Scientist of the cruise: MR16-04¥8, Senior Scientist, Japan Agency for Marine-Earth Science and Technology: JAMSTEC) for his permission of doing this study during the cruise boarding 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. Toshihisa AKUTAGAWA) and all the scientists and the engineers from MWJ and NME in this cruise. We would like to give special thanks to them.

(6) Reference

Harada T, Furuki T, Ohoka W, Umamoto N, Nakajo M and Katagiri C (2016) The first finding of six instars of larvae in Heteroptera and the negative correlation between precipitation and number of individuals collected in sea skaters of *Halobates* (Heteroptera: Gerridae). *Insects* 7: 73; doi: 10.3390/insects70440073

Table 6.13-1: Number of oceanic sea skaters, *Halobates* collected at locations in the tropical Pacific Ocean in December 7th, 2016 - December 8th 2016 during the science cruise, MR16-08 (N: Total number of individuals collected; H.g.*: Halobates germanus*, *H.m.: H. micans*, *H.s.: H. sericeus*; Stat: Station number; WT: Water temperature (℃); AT: Air temp.; L: N of larvae; A: N of adults, E: N of exuviae; EG: number of eggs (on some substrates like as polystyrene form); Date: sampling date; Sampling was performed for 15min. Sa: salinity (‰); 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 (ug/L) No other species of oceanic sea skaters were collected in this area.

Latitude	Longitude	N	L	A		H.g.	H.m.	H.s.	EG	E	Stat	WT	AT	WS	W	CS	Sa	CD	TD	Date	S x(1.3m²)	Ch	OD
				F	M																		
04° 36'N	137° 20'E	104	35	32	37	97	7	0	0	1	St.1-1	29.6	28.0	7.7	Cloudy	0.7	32/33.9	95	18:00-15	Dec. 07	-	-	-
04° 36'N	137° 20'E	115	54	28	33	111	4	0	0	0	St.1-2	29.6	27.8	7.6	Cloudy	0.8	32/33.9	89	18:24-39	Dec. 07	920.0	-	-
04° 37'N	137° 20'E	218	70	73	75	213	5	0	0	4	St.1-3	29.6	28.1	7.2	Cloudy	0.7	32/33.9	89	18:46-19:01	Dec. 07	768.0	-	-
04° 37'N	137° 19'E	101	30	37	34	99	2	0	0	4	St.1-4	29.6	28.0	6.3	Cloudy	0.7	32	83	19:07-22	Dec. 07	707.0	-	-
01° 59'N	138° 46'E	20	10	4	6	19	1	0	0	2	St.2-1	28.2	24.9	6.8	Rainy	0.6	32	184	17:59-18:14	Dec. 08	817.0	-	-
02° 00'N	138° 46'E	9	4	3	2	9	0	0	0	1	St.2-2	28.2	24.7	6.6	Rainy	0.6	32/33.6	182	18:20-35	Dec. 08	819.0	-	-
02° 00'N	138° 46'E	19	5	2	7	18	1	0	0	0	St.2-3	28.2	25.0	8.1	Rainy	0.6	32/33.6	192	18:14-56	Dec. 08	709.0	-	-

Table 6.13-2: Population density of oceanic sea skaters, *Halobates* collected in a tropical Pacific Oceans. Samplings during the cruise, MR16-08. *H.m: Halobates micans: H.g.: H. germanus; H.s.: H. sericeus; H.p.: H. princeps; H.*sp; Density: individual number/km²

A 04º36-37'N 137˚19-20'E (Station 1)

	Total		H.m.	H.g.	H.s.	H.p.	H.sumatraensis	AS
	Nymphs	Adults						
Number	189	349	18	520	0	0	0	0.0041513
Density	45527.9	84070.0	4336.0	125262.0	0.0	0.0	0.0	–

B 01˚59'N-02º00'N 138˚46'E (Stations 2)

	Total		H.m.	H.g.	H.s.	H.p.	H.sumatraensis	AS
	Nymphs	Adults						
Number	19	29	2	46	0	0	0	0.0030485
Density	6232.6	9512.9	656.1	15089.4	0.0	0.0	0.0	–

Table 6.13-3A: Components of instars of larvae and adults of oceanic sea skaters, *Halobates germanus* sampled at Stations located in 2º N - 4.5ºN, 137º E - 138º E in the tropical Pacific Ocean during the science cruise, MR16-08.

Halobates germanus

	Larvae					Adult	
	1st	2nd	3rd	4th	5th	F	M
St.1-1	2	5	10	9	8	29	34
St.1-2	1	3	20	16	11	29	33
St.1-3	7(2*)	16	9	13	22	73	74
St.1-4	1	3	6	11	8	37	33
St.2-1	1(1*)	0	3	3	3	3	6
St.2-2	0	1	0	1	2	3	2
St.2-3	0	0	1	0	4	7	6
Total	12(3*)	28	49	53	58	181	188

Table 6.13-3B: Components of instars of larvae and adults of oceanic sea skaters, *Halobates micans* sampled at Stations located in 2º N - 4.5 º S, 137 º E - 138 º E in the tropical Pacific Ocean during the science cruise, MR16-08.

Halobates micans

	Larvae					Adult	
	1st	2nd	3rd	4th	5th	F	M
St.1-1	0	0	0	0	1	3	3
St.1-2	0	0	1	0	2	1	0
St.1-3	0	0	0	0	3	1	1
St.1-4	0	0	0	0	1	0	1
St.2-1	0	0	0	0	0	1	0
St.2-2	0	0	0	0	0	0	0
St.2-3	0	0	0	0	0	0	1
Total	0	0	1	0	7	6	6

Table 6.13-4: Ultra violet value measured on the deck of R/V MIRAI during MR16-08 cruise. The value was measured at the height of 150 cm and sensor was directed to upper (vertical) direction.

Date (year/month/day)	Time of day	Ultra Violet radiation (μW/cm^2)	Place (latitude, longitude)		Weather
2016 November 27	07:57	124	35°02'N	138°30'E	rainy (a little)
2016 November 27	12:28	534	35°02'N	138°30'E	cloudy
2016 November 28	07:50	240	31°59'N	138°31'E	cloudy
2016 November 28	12:27	963	30°57'N	138°24'E	cloudy (fine)
2016 November 29	07:48	330	26°27'N	137°55'E	cloudy
2016 November 29	12:30	1450	25°35'N	137°50'E	fine
2016 November 30	07:50	204	21°30'N	137°24'E	cloudy
2016 November 30	12:26	1960	20°36'N	137°20'E	cloudy/fine
2016 December 01	07:52	413	16°42'N	137°07'E	fine (in the shade)
2016 December 01	12:36	2100	15°57'N	137°05'E	fine
2016 December 02	07:48	500	13°00'N	136°27'E	fine
2016 December 02	12:23	2850	12°59'N	137°00'E	fine
2016 December 03	07:43	465	12°54'N	136°49'E	cloudy (fine)
2016 December 03	12:20	2430	12°53'N	136°54'E	fine
2016 December 04	07:45	487	11°01'N	137°00'E	cloudy (fne)
2016 December 04	12:20	3200	10°06'N	136°59'E	fine
2016 December 05	12:19	952	07°52'N	136°29'E	cloudy
2016 December 06	07:46	463	07°38'N	136°41'E	cloudy (fine)
2016 December 06	12:24	1460	07°35'N	136°46'E	cloudy (fine)
2016 December 07	07:48	375	04°52'N	137°17'E	cloudy
2016 December 07	12:20	162	04°41'N	137°19'E	heavy rain
2016 December 08	07:45	684	02:07'N	138°03'E	cloudy
2016 December 08	13:27	90	02°01'N	138°05'E	heavy rain
2016 December 09	07:49	812	01°18'N	142°19'E	fine (cloudy)
2016 December 09	11:50	3520	01°06'N	142°19'E	fine
2016 December 10	07:44	940	00°07'N	146°42'E	fine
2016 December 10	12:16	3390	00°03'N	147°01'E	fine
2016 December 11	07:50	460	02°04'N	146°57'E	fine (shade)
2016 December 11	12:20	4280	02°00'N	147°03'E	fine (super)
2016 December 12	07:48	560	02°03'N	151°94'E	fine
2016 December 12	12:23	4360	02°03'N	152°00'E	fine
2016 December 13	07:45	702	02°01'N	156°00'E	fine
2016 December 13	12:20	1100-4200	02°01'N	155°58'E	cloudy-fine
2016 December 14	09:49	1670	00°02'S	155°56'E	cloudy (fine)
2016 December 14	12:29	1765-2130	00°01'S	155°59'E	cloudy (fine)
2016 December 15	08:15-45	140-710	00°01'S	156°02'E	fine (cloudy)
2016 December 15	12:30-50	2320-3800	00°01'S	155°59'E	fine (cloudy)
2016 December 16	08:29	670	00°02'S	156°07'E	cloudy (rainy)
2016 December 16	12:26	610	00°01'S	156°10'E	fine
2016 December 17	08:17	507	02°00'S	155°58'E	fine (shade)
2016 December 17	12:33	920-1170	02°01'S	155°57'E	cloudy
2016 December 18	07:52	520-635	03°41'S	158°56'E	cloudy
2016 December 18	12:33	920-1170	04°08'S	159°40'E	fine (cloudy)
2016 December 19	07:52	550	06°34'S	162°38'E	fine-cloudy (shade)
2016 December 19	12:28	5200	07°10'S	163°22'E	fine (super)
2016 December 20	08:15	107	09°36'S	166°18'E	rainy
2016 December 20	12:24	197	10°10'S	166°58'E	rainy

7. General observations

7.1. Meteorological observations

7.1.1. Surface meteorological observation

(1) Personnel

Iwao Ueki (JAMSTEC) PI
Kazuho Yoshida (NME)
Koichi Inagaki (NME)
Masanori Murakami (MIRAI Crew)

(2) Objective

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

(3) Instruments and Methods

Surface meteorological parameters were observed during the cruise. We used two systems for the observation as follows;

1) 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.

2) 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, PTB220, VAISALA.

iii) Thermometer (air temperature and relative humidity) (SMet and SOAR)
Comparison with the portable thermometer value, HM70, 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 data obtained in this cruise will be submitted to the JAMSTEC Data Management Group, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site (http://www.godac.jamstec.go.jp/darwin/e).

(6) Remarks

1) The following periods, Sea Surface Temperature of SMet data was available.

07:44UTC 27 Nov. 2016 - 20:00UTC 22 Dec. 2016

2) The following times, increasing of SMet capacitive rain gauge data was invalid due to transmitting for MF/HF radio.

04:21UTC 15 Dec. 2016
20:21UTC 22 Dec. 2016

3) The following periods, PRP data acquisition was suspended due to maintenance.

00:30UTC 09 Dec. 2016 – 00:42UTC 09 Dec. 2016

01:21UTC 10 Dec. 2016 – 01:37UTC 10 Dec. 2016

03:37UTC 13 Dec. 2016 – 04:36UTC 13 Dec. 2016

06:24UTC 13 Dec. 2016 – 06:51UTC 13 Dec. 2016

4) The following periods, logging interval of PRP was longer than normal due to system trouble.

23:12UTC 07 Dec. 2016 – 23:23UTC 07 Dec. 2016

00:27UTC 09 Dec. 2016 – 00:30UTC 09 Dec. 2016

03:39UTC 09 Dec. 2016 – 03:48UTC 09 Dec. 2016

23:34UTC 09 Dec. 2016 – 23:59UTC 09 Dec. 2016

00:15UTC 10 Dec. 2016 – 01:21UTC 10 Dec. 2016

05:32UTC 13 Dec. 2016 – 06:24UTC 13 Dec. 2016

5) The following periods, FRSR data acquisition was stopped due to the motor unit trouble.

00:42UTC 09 Dec. 2016 - 04:36UTC 13 Dec. 2016

06:51UTC 13 Dec. 2016 – 03:00UTC 23 Dec. 2016

6) The following periods, True Wind data of SMet and JamMet was invalid or unreliable due to gyro’s failure.

17:20UTC 19 Dec. 2016 - 17:25UTC 19 Dec. 2016 (invalid)

17:25UTC 19 Dec. 2016 - 18:00UTC 19 Dec. 2016 (low reliable)

7) The following periods, Wave data was invalid due to software trouble.

06:55UTC 21 Dec. 2016 - 13:55UTC 21 Dec. 2016

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, TOKYO-KEIKI
5	Relative wind speed	m/s	6sec./10min. averaged
6	Relative wind direction	degree	6sec./10min. averaged
7	True wind speed	m/s	6sec./10min. averaged
8	True wind direction	degree	6sec./10min. averaged
9	Barometric pressure	hPa	adjusted to sea surface level 6sec. averaged
10	Air temperature (starboard)	degC	6sec. averaged
11	Air temperature (port side)	degC	6sec. averaged
12	Dewpoint temperature (starboard)	degC	6sec. averaged
13	Dewpoint temperature (port 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 (JamMet)

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

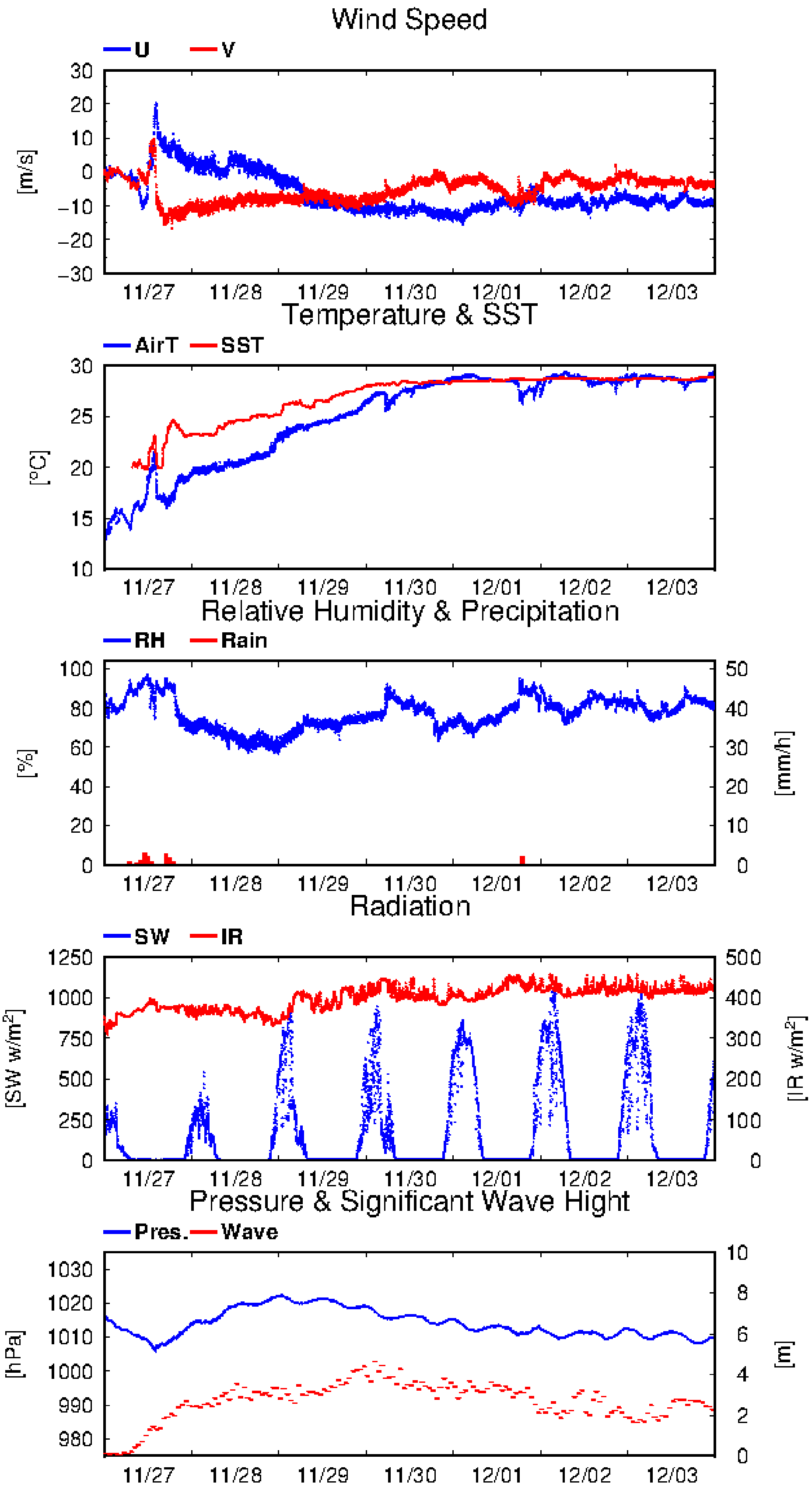


Fig.7.1.1-1 Time series of surface meteorological parameters during the MR16-08

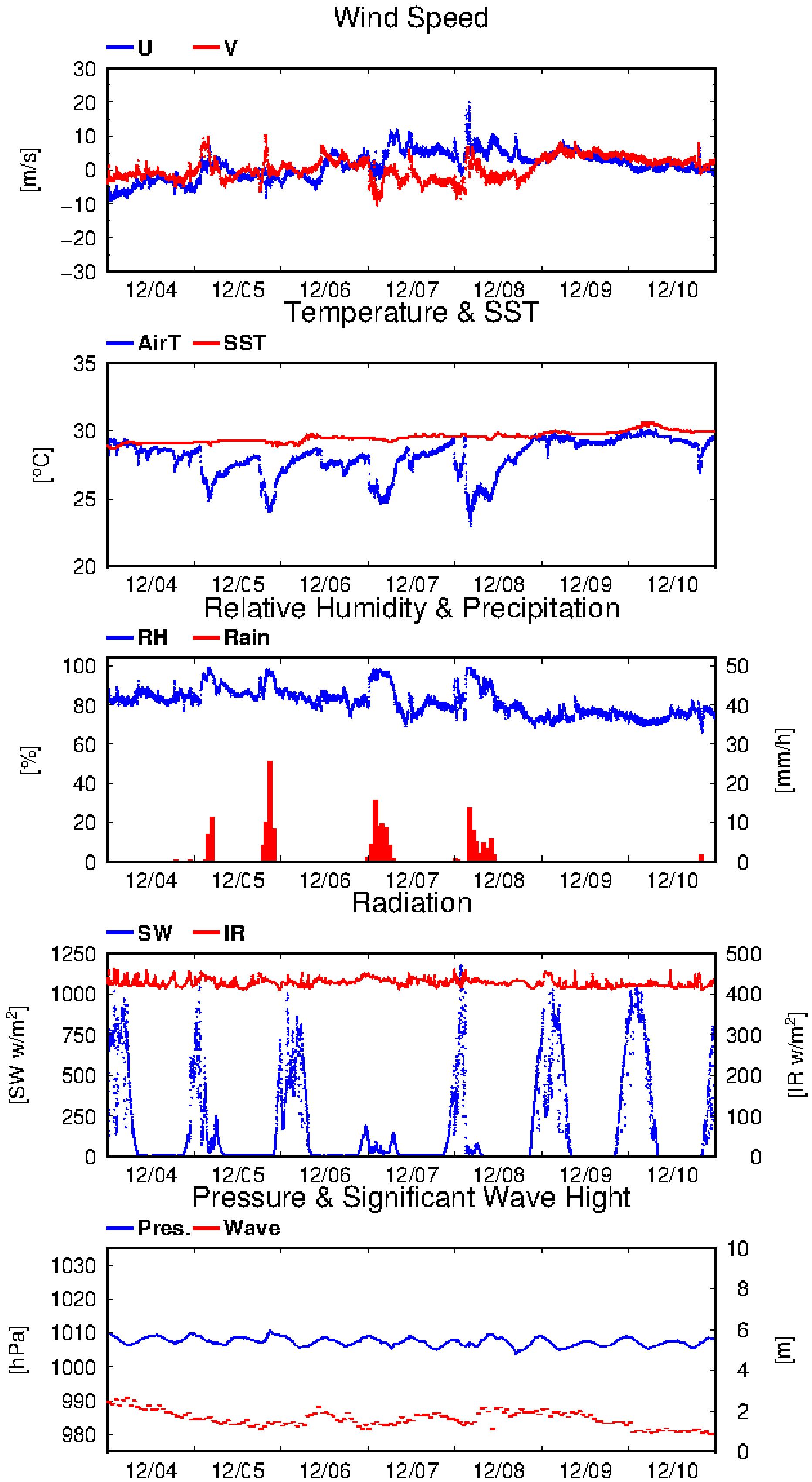


Fig.7.1.1-1 (Continued)

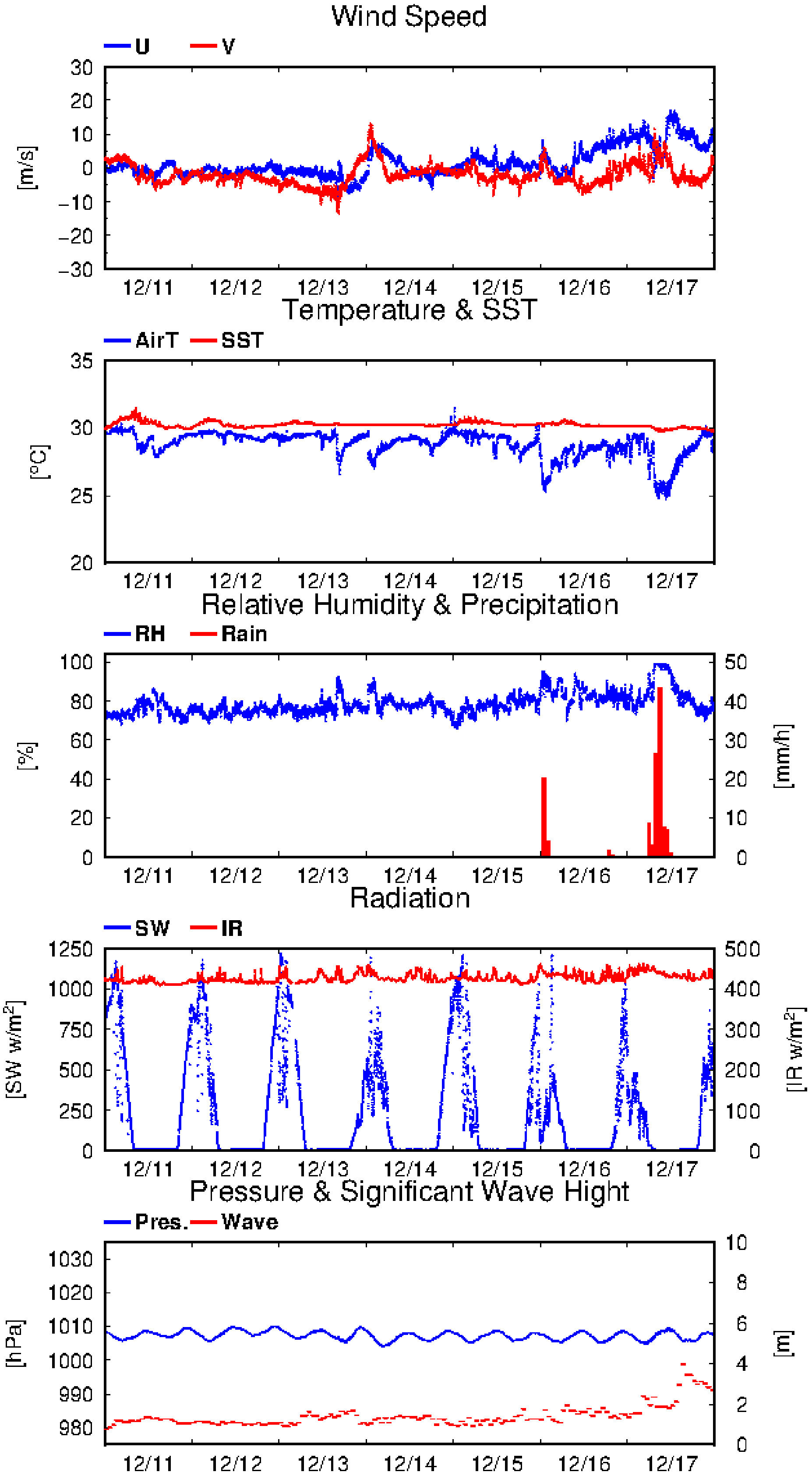


Fig.7.1.1-1 (Continued)

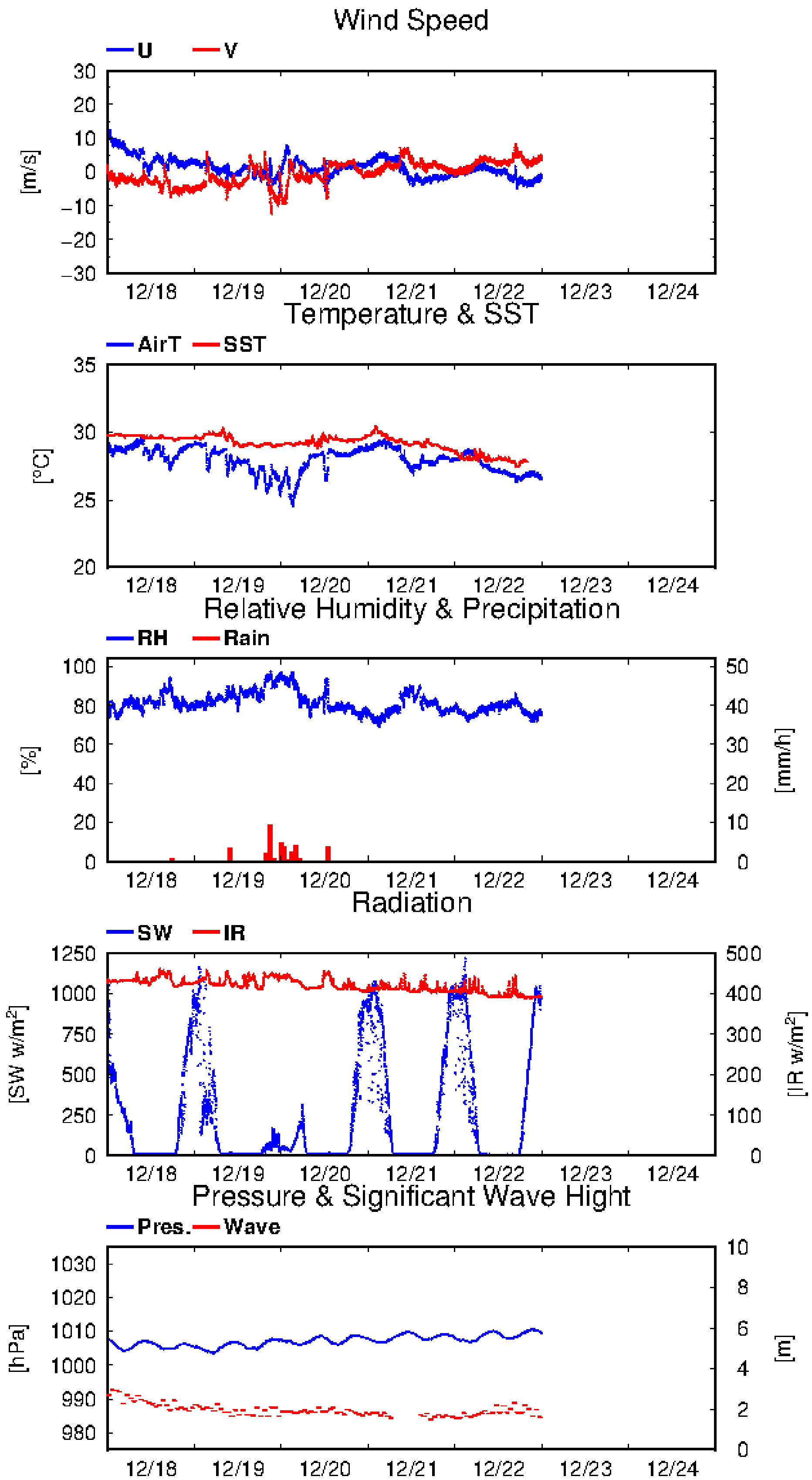


Fig.7.1.1-1 (Continued)

7.1.2. Ceilometer

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Kazuho Yoshida	(NME)
Koichi Inagaki	(NME)
Masanori Murakami	(MIRAI Crew)

(2) Objectives

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

(3) Paramters

- Cloud base height [m].
- Backscatter profile, sensitivity and range normalized at 10 m resolution.
- 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 this cruise.

Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode Laser
Transmitting center wavelength:	910±10 nm at 25 degC
Transmitting average power:	19.5 mW
Repetition rate:	6.5 kHz
Detector:	Silicon avalanche photodiode (APD)
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 this cruise.

(6) Data archives

These data obtained in this cruise will be submitted to the JAMSTEC Data Management Group, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site (http://www.godac.jamstec.go.jp/darwin/e).

(7) Remarks

1) Window Cleaning;

01:43UTC 29 Nov. 2016

05:44UTC 04 Dec. 2016

03:57UTC 11 Dec. 2016

04:27UTC 19 Dec. 2016

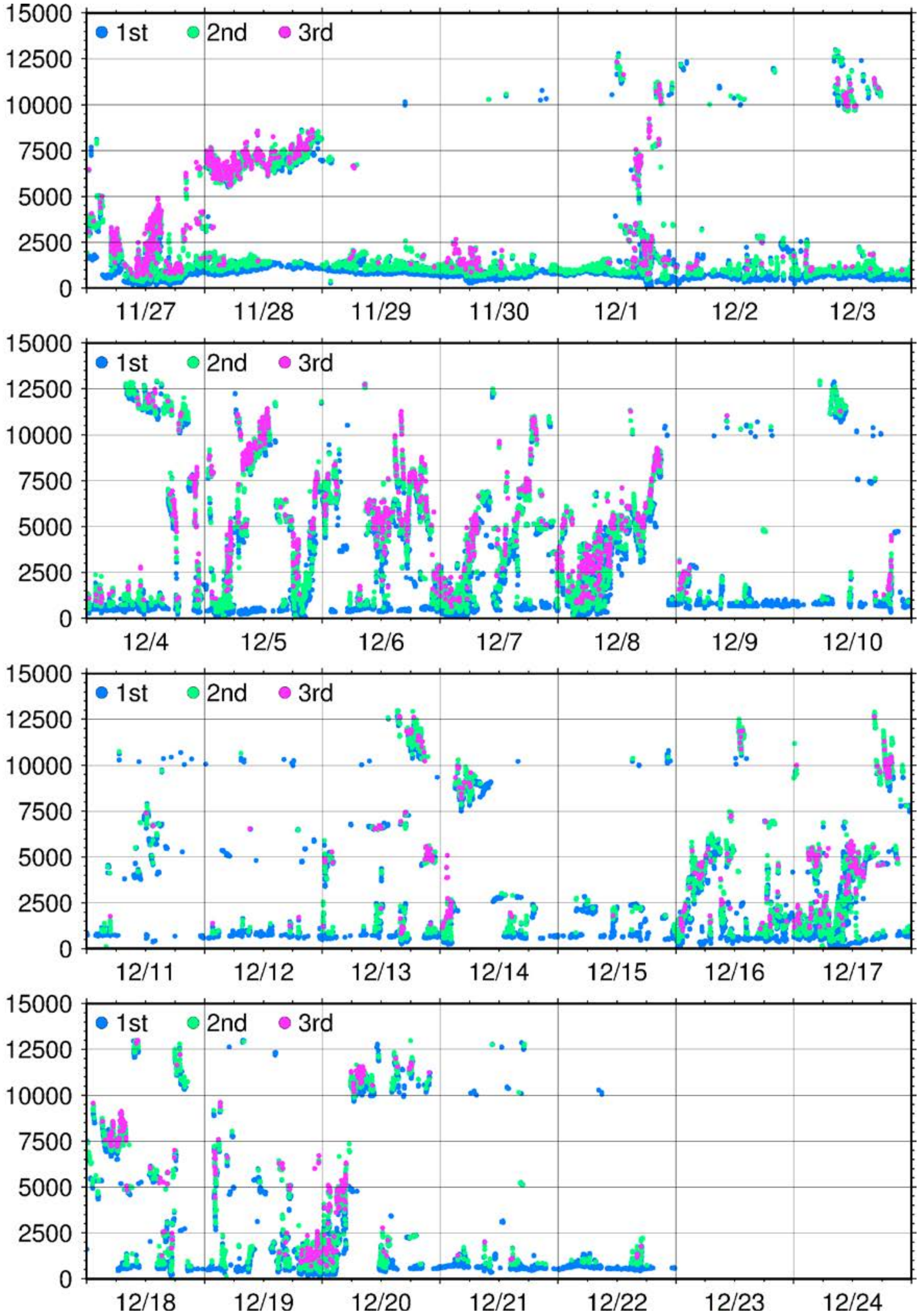


Fig. 7.1.2-1 First (Blue), 2nd (Green) and 3rd (Red) cloud base height (MR16-08)

7.2. Ocean observations

7.2.1. CTD

(1) Personnel

Iwao Ueki	(JAMSTEC): PI
Sonoka Tanihara	(MWJ): Operation leader
Kenichi Katayama	(MWJ)

(2) Objective

Investigation of ocean structure with water sampling.

(3) Parameters

Temperature (Primary and Secondary)

Conductivity (Primary and Secondary)

Pressure

Dissolved Oxygen (Primary and Secondary)

(4) Instruments and Methods

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

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.23.2) 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.

14 casts of CTD measurements were conducted (Table 7.2.1-1).

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.

TCORP (original module): Corrected the pressure sensitivity of the primary temperature (SBE3) sensor.
031359: -1.8386e-007 (degC/dbar)
031524: -2.5868e-007 (degC/dbar)

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 6 seconds advancing dissolved oxygen sensor output (dissolved oxygen voltage) relative to the temperature data.

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

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

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

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

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

DERIVE: Compute dissolved oxygen (SBE43).

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

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

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

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

Configuration file

MR1608A.xmlcon

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:

SBE9plus

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

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

Calibrated Date: 13 Apr 2016

Temperature sensors:

Primary: SBE03-04/F (S/N 031359, Sea-Bird Electronics, Inc.)

Calibrated Date: 01 Jun 2016

Secondary: SBE03 (S/N 031524, Sea-Bird Electronics, Inc.)

Calibrated Date: 04 Aug 2016

Conductivity sensors:

Primary: SBE04-04/0 (S/N 041206, Sea-Bird Electronics, Inc.)

Calibrated Date: 04 Aug 2016

Secondary: SBE04-04/0 (S/N 041203, Sea-Bird Electronics, Inc.)

Calibrated Date: 04 Aug 2016

Dissolved Oxygen sensors:

Primary: SBE43 (S/N 432211, Sea-Bird Electronics, Inc.)

Calibrated Date: 10 May 2016

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

Calibrated Date: 06 Aug 2016

Carousel water sampler:

SBE32 (S/N 3254451-0826, Sea-Bird Electronics, Inc.)

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

(5) Preliminary Results

During this cruise, 14 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 7.2.1-1.

Vertical profile (down cast) of primary temperature, salinity and dissolved oxygen with pressure are shown in Figure 7.2.1-1 - 7.2.1-4.

(6) Remarks

Station C01M01 and C11M01 ware observation for comparison of CTD and JES10-profiler.

(7) Data archive

All raw and processed data files will be submitted to the JAMSTEC Data Management Group.

Table 7.2.1-1 MR16-08 Cast table

MR16-08 CTD casttable													
Stnnbr	Castno	Date(UTC) (mmddyy)	Time(UTC) Start	End	BottomPosition Latitude	Longitude	Depth	Wire Out	HT Above	Max Depth	Max Pressure	CTD Filename	Remark
C01	1	120216	03:39	04:17	12-59.99N	136-59.93E	4941.0	500.4	-	503.5	507.0	C01M01	Jes-10 cast
C02	1	120316	06:24	09:54	12-54.19N	136-53.56E	5269.0	5244.9	9.5	5240.0	5336.0	C02M01	Deployment point of TRITON No.40
C03	1	120516	07:09	09:31	07-40.09N	136-42.91E	3162.0	3141.7	9.4	3140.5	3182.0	C03M01	Recovery point of TRITON No.10
C04	1	120616	21:04	21:39	04-52.32N	137-17.37E	4061.0	1002.0	-	1002.0	1010.0	C04M01	Recovery point of TRITON No.11
C05	1	120716	04:35	07:23	04-51.17N	137-16.27E	4096.0	4094.3	9.6	4079.3	4142.0	C05M01	Near recovery point of TRITON No.11
C06	1	120716	23:32	00:10	02-01.70N	138-07.47E	4192.0	1000.6	-	1000.0	1008.0	C06M01	Recovery point of TRITON No.12
C07	1	121016	00:49	01:52	00-03.32N	147-01.87E	4483.0	999.4	-	1001.0	1009.0	C07M01	Recovery point of TRITON No.9
C08	1	121016	20:03	20:39	02-05.53N	146-56.90E	4491.0	1002.9	-	1003.0	1011.0	C08M01	Recovery point of TRITON No.8
C09	1	121216	22:03	22:39	02-01.40N	156-00.87E	2586.0	1003.1	-	1003.0	1011.0	C09M01	Recovery point of TRITON No.3
C10	1	121316	03:32	05:25	02-02.37N	156-00.99E	2582.0	2572.0	7.8	2567.8	2598.0	C10M01	Near recovery point of TRITON No.3
C11	1	121416	03:02	03:47	00-01.62S	155-58.98E	1946.0	1000.6	-	1001.0	1009.0	C11M01	Deployment point of TRITON No.4 Jes-10 cast
C12	1	121416	05:10	06:47	00-00.43N	156-03.59E	1952.0	1939.4	10.2	1937.2	1957.0	C12M01	Recovery point of TRITON No.4
C13	1	121616	19:03	19:39	02-01.98S	155-58.85E	1754.0	1004.0	-	1001.0	1009.0	C13M01	Recovery point of TRITON No.5
C14	1	121716	02:02	03:31	02-01.23S	155-57.63E	1752.0	1746.4	-	1738.0	1755.0	C14M01	Near recovery point of TRITON No.5

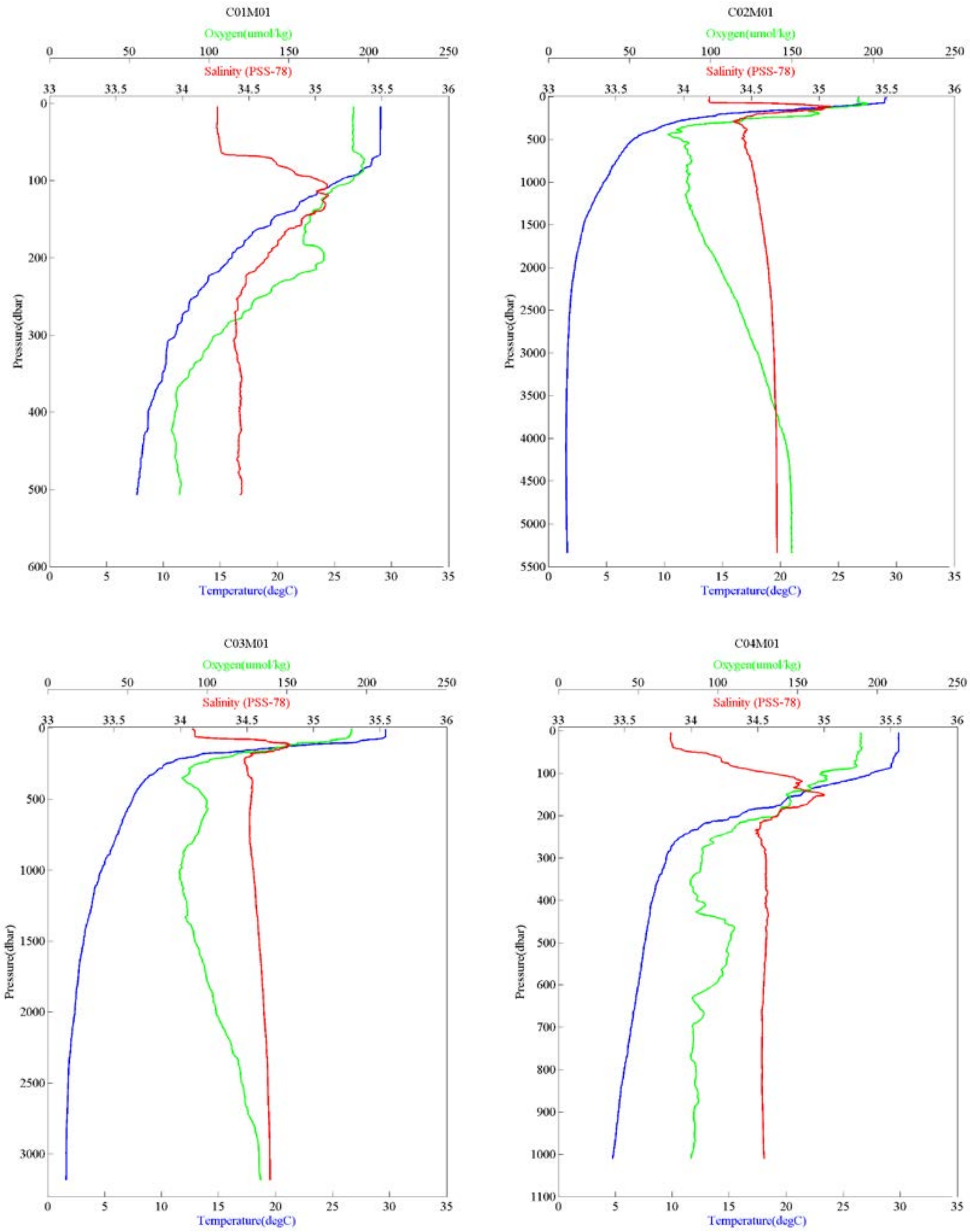


Figure 7.2.1-1 CTD profile (C01M01, C02M01, C03M01 and C04M01)

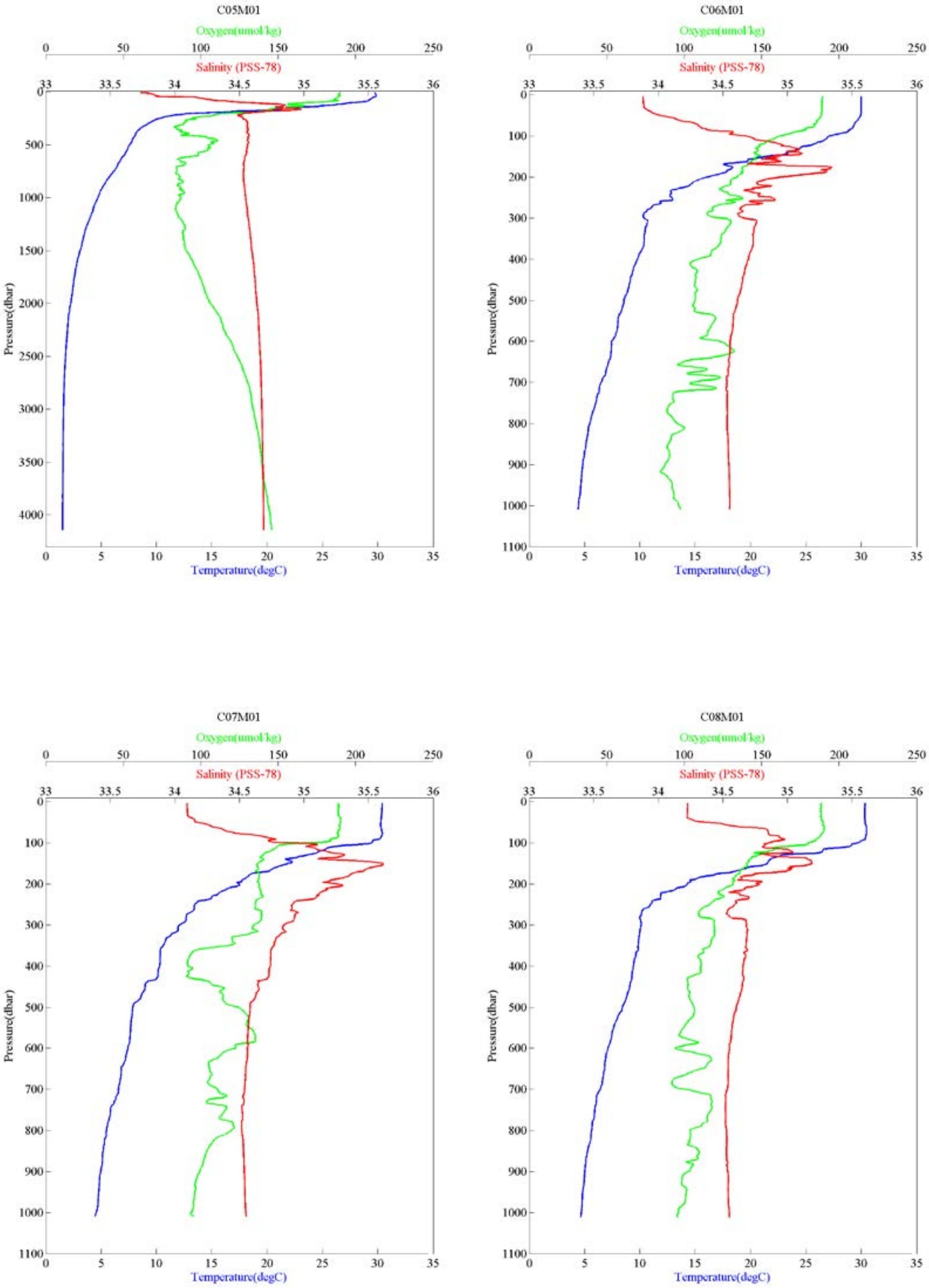


Figure 7.2.1-2 CTD profile (C05M01, C06M01, C07M01 and C08M01)

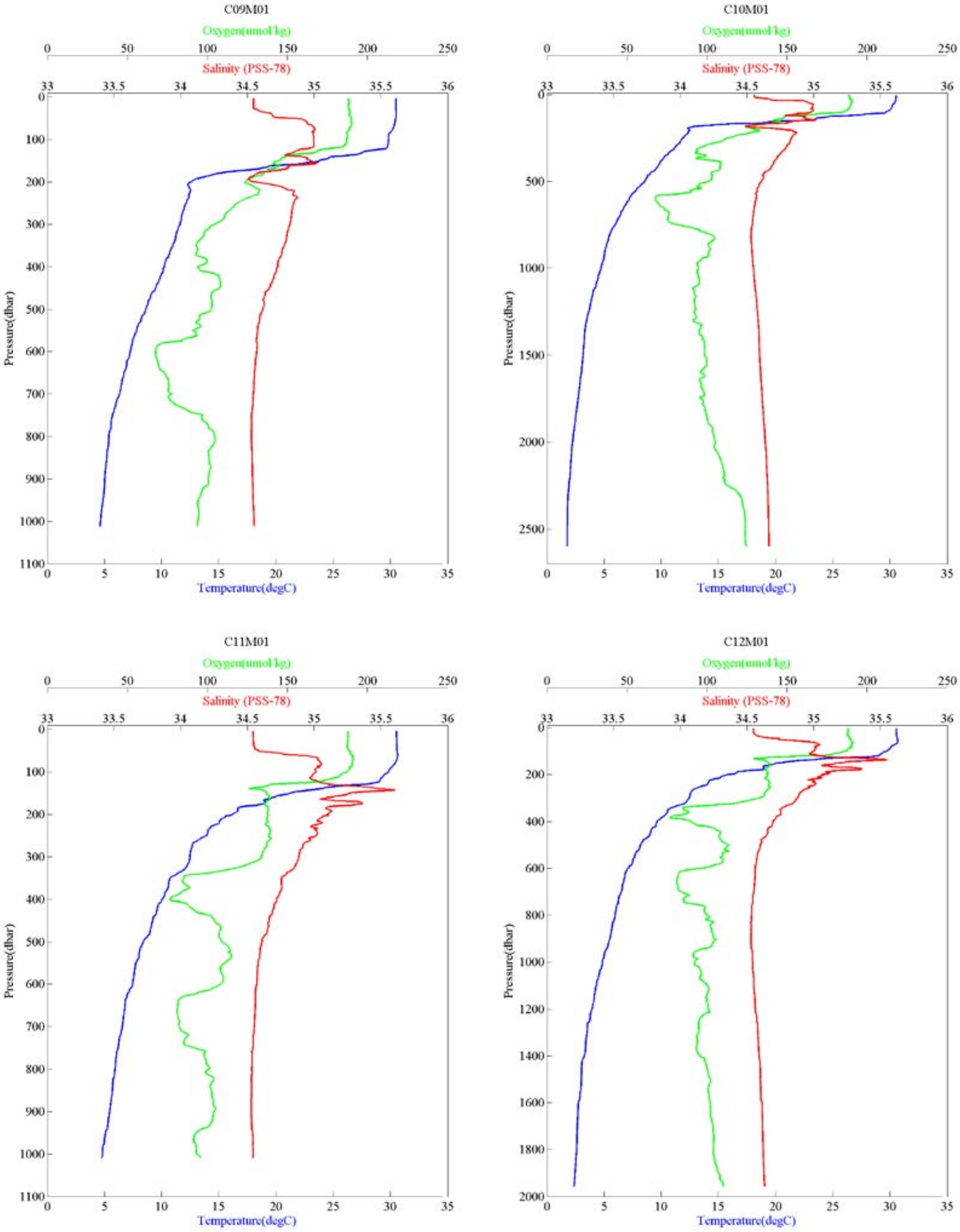


Figure 7.2.1-3 CTD profile (C09M01, C10M01, C11M01 and C12M01)

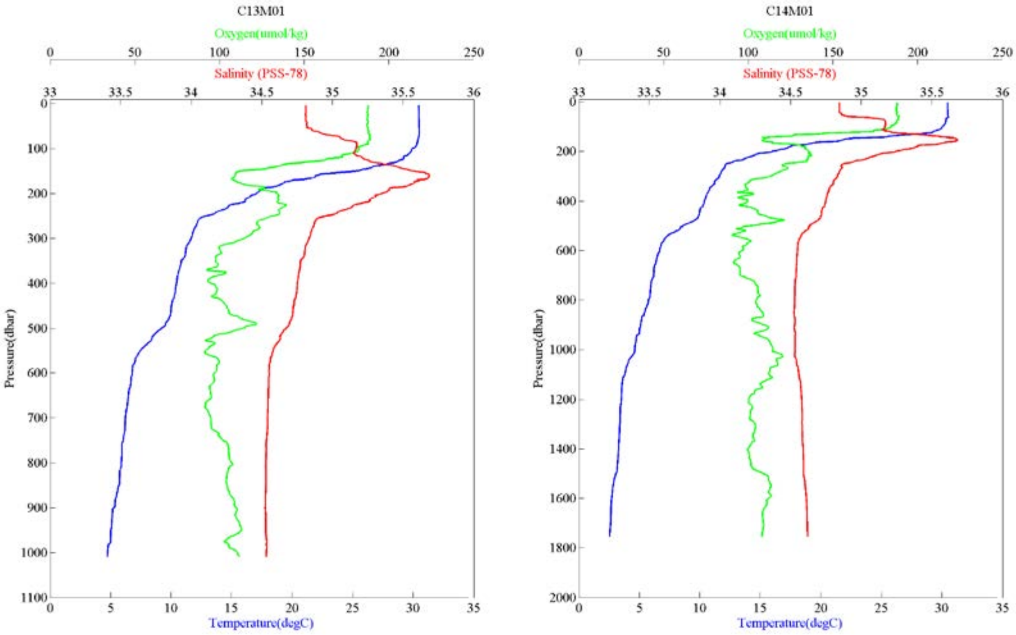


Figure 7.2.1-4 CTD profile (C13M01 and C14M01)

7.2.2. LADCP

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Kenichi Katayama	(MWJ): Operation leader
Sonoka Tanihara	(MWJ)

(2) Objectives

To obtain horizontal current velocity in high vertical resolution.

(3) Methods

In order to measure the velocity structure at fine vertical scales a high frequency ADCP was used in lowered mode (LADCP). The instrument was a Teledyne RDI Workhorse Sentinel 600kHz ADCP rated for 1000m depth.

The instrument was attached to the frame of the CTD system using a steel collar sealed around the instrument by three bolts on each side, with the collar attached to the rosette frame by two u-bolts on two mounting points (see Figure 7.2.2-1).

The instrument was deployed at CTD casts below 1000m depth those were the TRITON-buoy mooring points, performing well throughout its use. The instrument was self-contained with an internal battery pack. The health of the battery was monitored by the recorded voltage count.

Figure 7.2.2-1:Mounting of LADCP on CTD System

The instrument was controlled at deploy and recover stages by the RDI software (BBTalk) installed on the Windows PC. The commands sent to the instrument at setup were contained in ladcp600.txt. The instrument was set up to have a relatively small bin depth (2m) and a fast ping rate (every 0.25 sec).

The full list of commands sent to the instrument were:

CR1	# Retrieve parameter (default)
TC2	# Ensemble per burst
WP1	# Pings per ensemble
TE 00:00:00.00	# Time per ensemble (time between data collection cycles)
TP 00:00.25	# Time between pings in mm:ss
WN25	# Number of Depth cells
WS0200	# Depth cell size (in cm)
WF0088	# Blank after transit (recommended setting for 600kHz)
WB0	# Mode 1 bandwidth control (default - wide)
WV250	# Ambiguity velocity (in cm/s)
EZ0111101	# Sensor source (speed of sound excluded)
EX00000	# Beam coordinates
CF11101	# Data flow control parameters

(see the RDI Workhorse "Commands and Data Output Format" document for details)

(4) Preliminary results

During the cruise, 8 profiles were obtained in total. All the data has to be converted and quality-controlled before the analyses. The further analyses will be in near future.

(5) Data archive

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

7.2.3. Water sampling

7.2.3.1. Salinity

(1) Personnel

Iwao Ueki (JAMSTEC) PI

Kenichi Katayama (MWJ) Operation Leader

(2) Objective

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

(3) Method

1) Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles and TSG. The salinity sample bottle of the 250ml brown glass bottle with screw cap was used for collecting the sample water. Each bottle was rinsed 3 times with the sample water, and was filled with sample water to the bottle shoulder. All of sample bottle 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.

The kind and number of samples taken are shown in Table 7.2.3.1-1.

Table 7.2.3.1-1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD	26
Samples for TSG	25
Total	51

2) Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR16-08 using the salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.: S/N 62827) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). A pair of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.) were used. The thermometer monitored the ambient temperature and the other monitored a bath temperature.

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 23 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 5 seconds after filling the cell with the sample and it took about 10 seconds to collect 31 readings by a 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. The measurement was conducted in about 4 hours per day and the cell was cleaned with soap after the measurement of the day.

(4) Results

1) Standard Seawater

Standardization control of the salinometer was set to 483 and all measurements were done at this setting. The value of STANDBY was 24+5414~5418 and that of ZERO was 0.0+0000~0001. The conductivity ratio of IAPSO Standard Seawater batch P157 was 0.99985 (double conductivity ratio was 1.99970) and was used as the standard for salinity. 10 bottles of P157 were measured.

Fig.7.2.3.1-1 shows the time series of the double conductivity ratio of the Standard Seawater batch P157. The average of the double conductivity ratio was 1.99967 and the standard deviation was 0.00002 which is equivalent to 0.0004 in salinity.

Fig.7.2.3.1-2 shows the time series of the double conductivity ratio of the Standard Seawater batch P157 after correction. The average of the double conductivity ratio after correction was 1.99970 and the standard deviation was 0.00001, which is equivalent to 0.0001 in salinity.

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

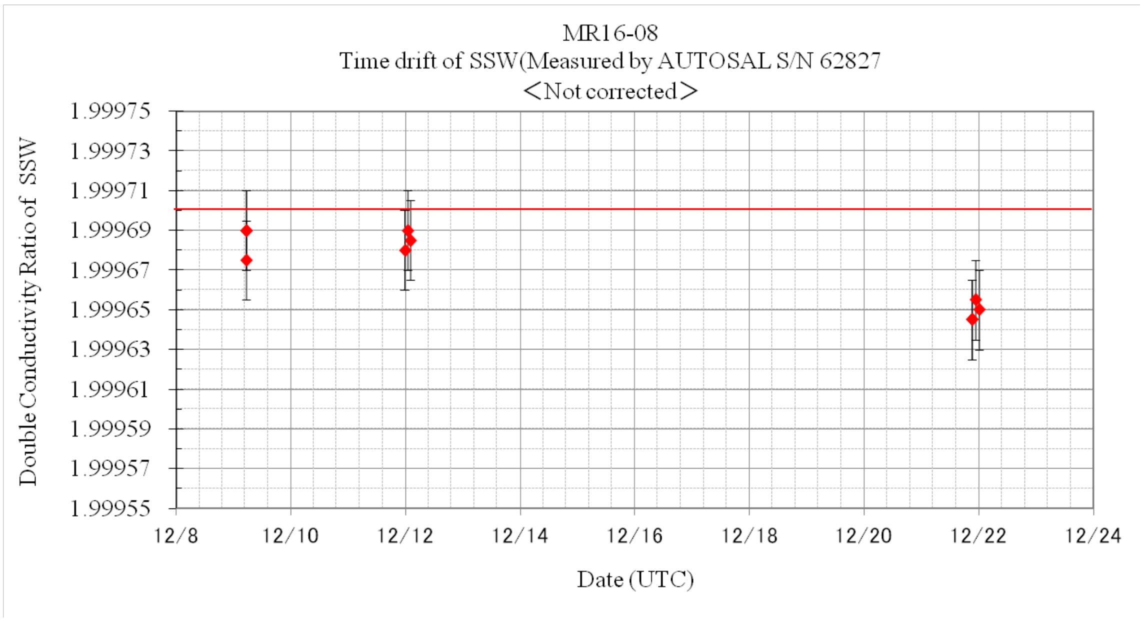


Fig. 7.2.3.1-1: Time series of double conductivity ratio for the Standard Seawater batch P157 (before correction)

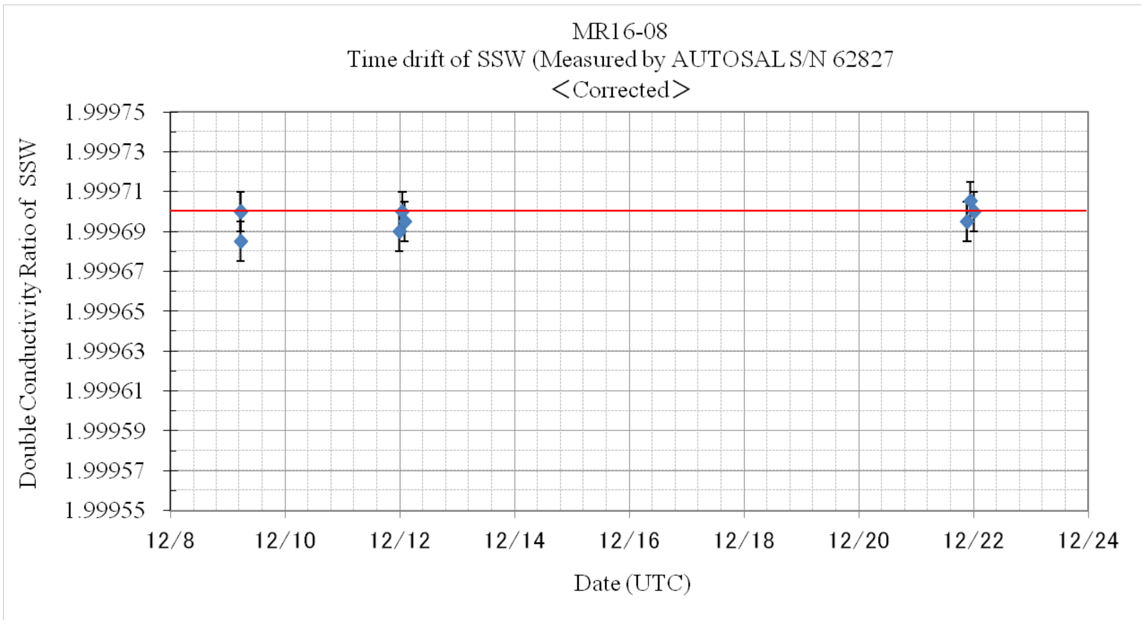


Fig. 7.2.3.1-2: Time series of double conductivity ratio for the Standard Seawater batch P157 (after correction)

2) Sub-Standard Seawater

Sub-standard seawater was made from Surface-sea water filtered by a pore size of 0.22 micrometer and stored in a 20 liters 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.

3) Replicate Samples

We estimated the precision of this method using 13 pairs of replicate samples taken from the same Niskin bottle. The average and the standard deviation of absolute difference among 13 pairs of replicate samples were 0.0002 and 0.0002 in salinity, respectively.

(5) Data archive

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

(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

7.2.3.2. Dissolved Oxygen

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Masahiro Orui	(MWJ) Operation Leader
Hiroshi HOSHINO	(MWJ)

(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).

1) 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

2) 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 KPG6393, Wako Pure Chemical Industries Ltd., 0.0100N

3) 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 1 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.

4) 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 the titration apparatus. Dissolved oxygen concentration (μmol 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.

5) 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 130º 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 1 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 (1 cm^3) and II (1 cm^3) was assumed to be 7.6 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

1) Standardization and determination of the blank

Table 7.2.3.2-1 shows results of the standardization and the blank determination during this cruise.

Table 7.2.4.3-1 Results of the standardization and the blank determinations during cruise.

Date	KIO3 ID	$Na_2S_2O_3$	DOT-01X(No.8)		Stations
			E.P.(ml)	Blank(ml)	
2016/11/29	K1605B01	T1606E	3.962	0.003	
2016/12/02	K1605B02	T1606E	3.964	0.003	C02,C03,C05
2016/12/09	K1605B03	T1606E	3.964	0.006	C07,C10,C12
2016/12/16	K1605B04	T1606E	3.962	0.005	C14

2) Repeatability of sample measurement

Replicate samples were taken at every CTD casts. Total amount of the replicate sample pairs of good measurement was 14. The standard deviation of the replicate measurement was 0.13 μmol 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. 7.2.3.2-1.

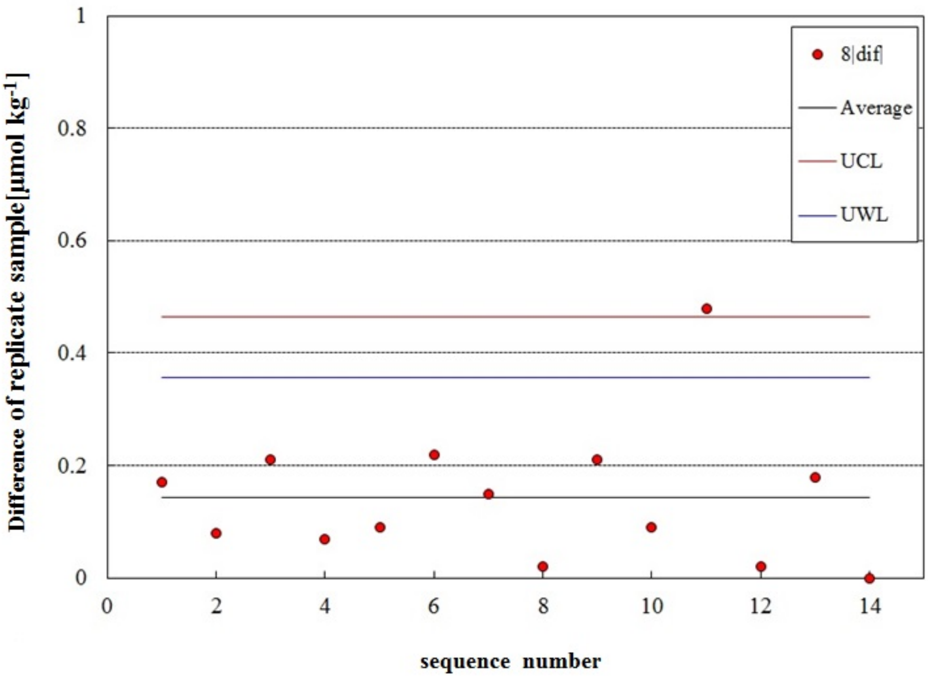


Fig. 7.2.3.2-1 Differences of replicate samples against sequence number

(6) Data archives

These data obtained in this cruise will be submitted to the JAMSTEC Data Management Group, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site (http://www.godac.jamstec.go.jp/darwin/e).

(7) 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. XCTD

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Kazuho Yoshida	(NME)
Koichi Inagaki	(NME)
Masanori Murakami	(MIRAI Crew)

(2) Objectives

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

(3) Parameters

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

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

(4) Methods

We observed the vertical profiles of the sea water temperature and conductivity measured by XCTD system. We launched 3 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 7.2.2-1.

(5) Preliminary results

Fig. 7.2.2-1 and Fig 7.2.2-2 shows the vertical profile of temperature, conductivity and salinity.

(6) Data archive

These data obtained in this cruise will be submitted to the JAMSTEC Data Management Group, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site
(http://www.godac.jamstec.go.jp/darwin/e).

Table 7.2.2-1 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	XCTD-01	2016/12/10	12:08	0-59.9854N	147-00.0127E	4520	30.368	34.243	16071480
2	XCTD-02	2016/12/13	10:18	0-59.9986N	155-59.7554E	2264	30.577	34.576	16071481
3	XCTD-03	2016/12/16	09:44	1-00.0080S	156-00.0016E	2084	30.603	34.268	16071482

Depth: The depth of water [m]

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

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

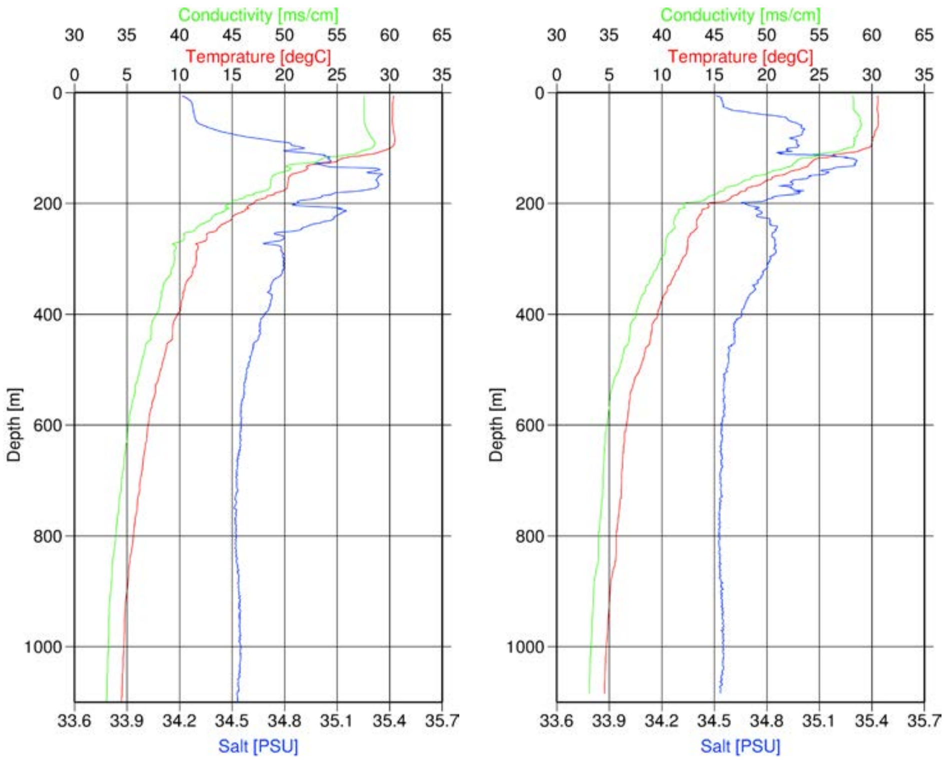


Fig. 7.2.2-1 Vertical profile of temperature, conductivity and salinity by No.1(left) and No.2(right).

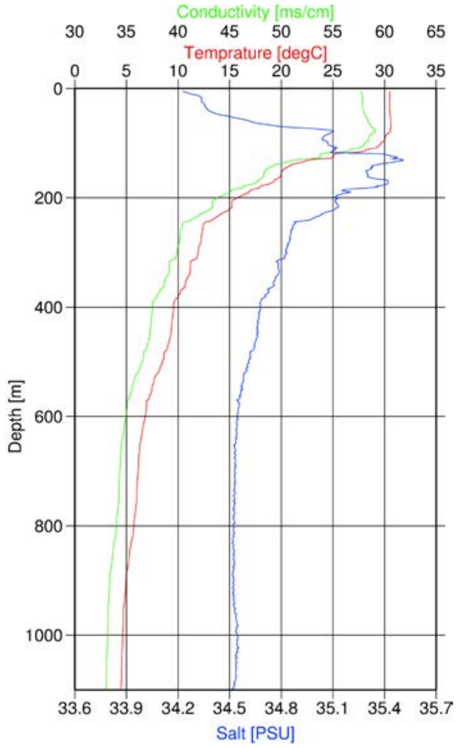


Fig. 7.2.2-2 Vertical profile of temperature, conductivity and salinity by No.3.

7.2.5. UnderwayCTD

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Akira Nagano	(JAMSTEC)
Keisuke Takeda	(MWJ) Operation Leader
Hiroshi Matsunaga	(MWJ)
Emi Deguchi	(MWJ)
Sonoka Tanihara	(MWJ)
Rio Kobayashi	(MWJ)

(2) Objectives

The objective is to investigate upper ocean structures in the western tropical regions of the North and South Pacific.

(3) Methods

The UCTD system manufactured by Oceanscience, is used in this cruise. The system consists of the probe unit and on-deck unit with the winch and the rewinder. After spooling the line for certain length onto the probe unit (in "tail spool" part), the probe unit is released from the vessel into ocean with connection to winch on the vessel by line, and then measure temperature, conductivity, and pressure during its free-fall with speed of about 4 m/s in the ocean, while the vessel traveling with speed of about 8 knot. After the probe unit reaches the deepest layer for observation, it is recovered by the winch.

The UCTD system used in this cruise observed temperature, conductivity (salinity), and pressure from the sea surface to a level exceeding 500 dbar with 16 Hz sampling rate.

The observed data were stored in the memory within the probe unit, and after recovery, downloaded into a PC via Bluetooth communication. The accuracy, resolution, and range of the UCTD observation are listed in Table 7.2.5-1.

Table 7.2.5-1: The accuracy, resolution, and range of the UCTD observation.

Parameter	Accuracy	Resolution	Range
Temperature (˚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

(4) Preliminary results

We obtained temperature and salinity profiles down to a level of about 500 dbar at 52 stations (Table 7.2.5-2). Sections of potential temperature and salinity based on the UCTD and CTD observations are shown in Figs. 7.2.5-1, 2 and 3. The hydrographic structures of the upper layer along the lines are mostly characterized by saline North Pacific tropical water (NPTW) and South Pacific tropical water (SPTW), which are derived from northern and southern hemispheres, respectively, and by overlying fresh sea surface water.

At the zonal line of 13˚N (U01-U06), the NPTW characterized by salinity higher than 35.0 stays beneath the mixed layer fresh water. Around the moored buoy east of the Philippines, salinity of the NPTW is particularly high. At the meridional line from 13˚N, 137˚E to 13˚N, 138˚E (C02-C04), the main thermocline (indicated by approximately 12-28˚C) shoals toward a latitude of approximately 7˚N, the thermocline ridge separating the North Equatorial Current and Countercurrent. The surface mixed layer water becomes fresher southward. The northern edge of the SPTW is identified at 5˚N as high salinity signal of over 35.0. At the southeastward line to Fiji (C13-U51), the SPTW is close to its formation region, so that the thickness is great and the salinity high.

These upper water mass structures are considered to be resulted from the ocean-atmosphere interaction in the tropical and subtropical regions. Accordingly, the hydrographic data are expected to include valuable information about the ocean-atmosphere interaction.

(5) Data archive

These data obtained in this cruise will be submitted to the JAMSTEC Data Management Group, and will be opened to the public via “Data Research System for Whole Cruise

Information in JAMSTEC (DARWIN)" in JAMSTEC web site (http://www.godac.jamstec.go.jp/darwin/e).

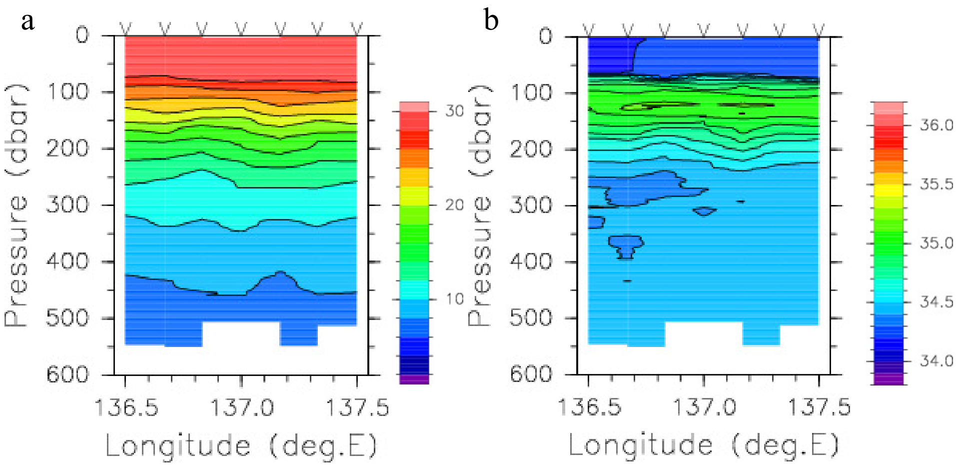


Fig. 7.2.5-1 Sections of (a) potential temperature and (b) salinity at zonal line along 13˚N (U01-U06). Contour intervals in (a) and (b) are 2˚C and 0.1 (psu), respectively. Inverted triangles indicate UCTD and CTD stations.

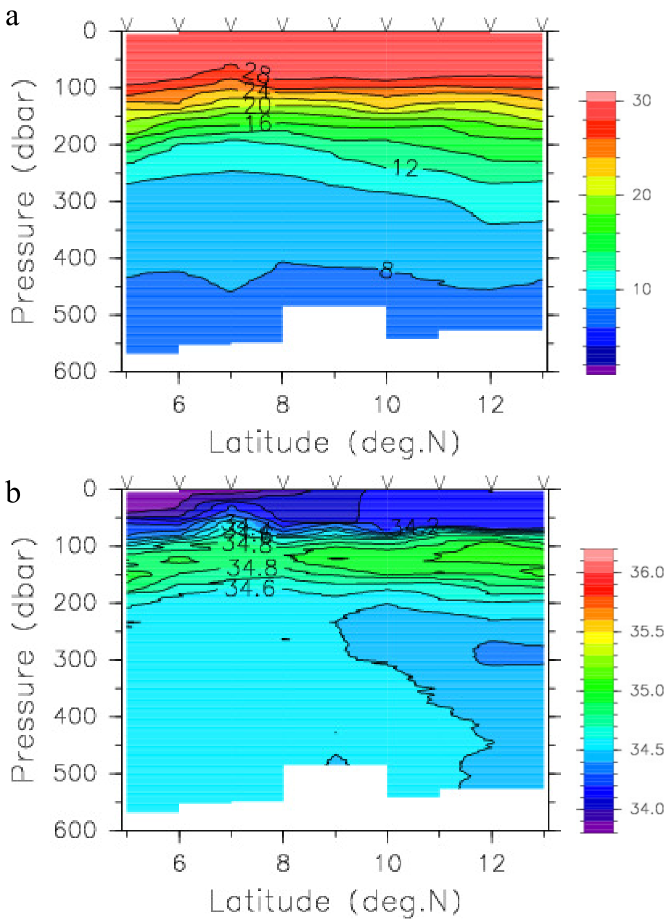


Fig. 7.2.5-2 Same as Fig. 7.2.5-1, but for meridional line along 137˚E (C2-C4).

a

b

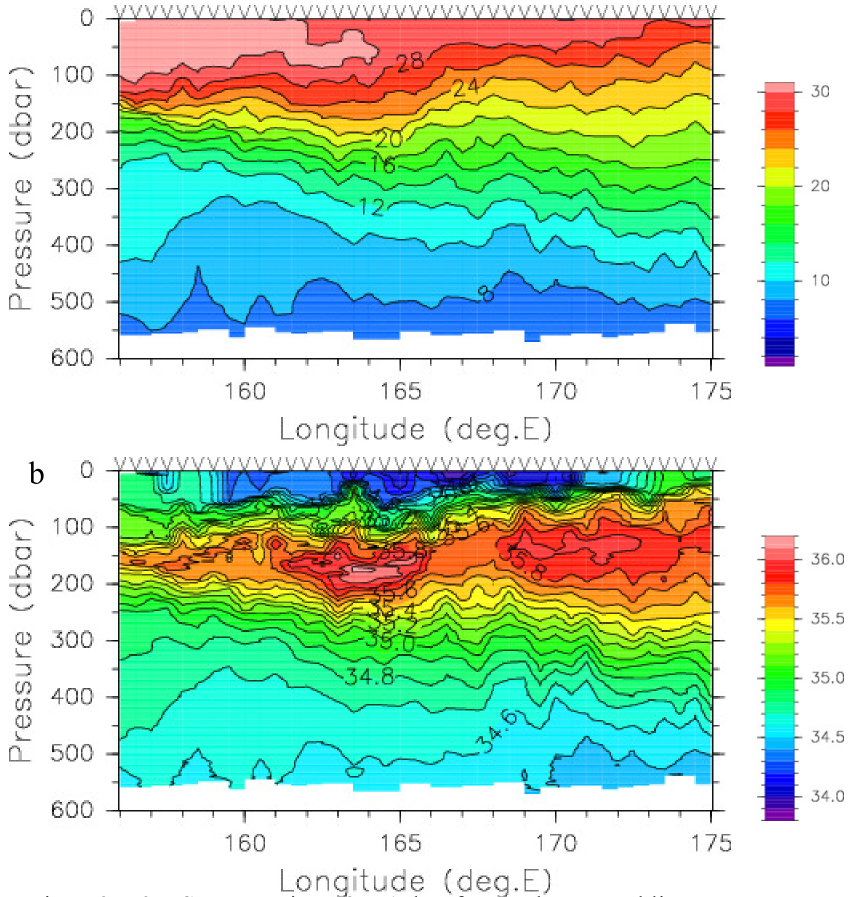


Fig. 7.2.5-3 Same as Fig. 7.2.5-1, but for southeastward line to Fiji (C13-U51).

Table 7.2.5-2: List of the UCTD observation.

Station	Cast Nonmmber	Date (UTC)	Time (UTC)	Lat		Lon		Depth (m)	Wavehight (m)	Shipspeed (Kt)		Depth to go (m)	Probe S/N
										Tow	Recovery		
U01	1	2016.12.1	23:06	13 - 0.02	N	136 - 30.07	E	5445.0	2.8	8	8	550	236
U02	1	2016.12.2	0:11	12 - 60.00	N	136 - 40.07	E	4620.0	2.9	8	8	550	236
U03	1	2016.12.2	1:17	12 - 59.99	N	136 - 50.07	E	5340.0	3.0	8	8	550	236
U04	1	2016.12.2	5:28	12 - 59.99	N	137 - 10.05	E	4889.0	2.7	8	8	550	236
U05	1	2016.12.2	6:43	13 - 0.01	N	137 - 20.04	E	4824.0	2.6	8	8	550	236
U06	1	2016.12.2	7:49	12 - 60.00	N	137 - 30.14	E	4760.0	2.6	10	8	550	236
U07	1	2016.12.3	14:52	11 - 59.94	N	136 - 59.99	E	5298.0	2.7	8	8	550	236
U08	1	2016.12.3	22:56	10 - 59.97	N	137 - 0.02	E	4939.0	2.6	8	8	550	236
U09	1	2016.21.4	3:53	9 - 59.97	N	136 - 60.00	E	5067.0	2.5	8	8	550	236
U10	1	2016.21.4	8:49	8 - 59.94	N	136 - 60.00	E	3620.0	1.9	8	8	550	236
U11	1	2016.12.5	3:24	7 - 52.25	N	136 - 29.39	E	3352.0	1.8	8	8	550	236
U11	2	2016.12.5	3:51	7 - 50.05	N	136 - 28.30	E	3356.0	1.7	8	8	550	257
U12	1	2016.12.6	6:24	7 - 0.00	N	137 - 0.02	E	4256.0	1.8	8	8	550	236
U13	1	2016.12.6	11:32	6 - 1.11	N	136 - 59.16	E	4236.0	1.5	8	8	550	236
U14	1	2016.12.17	6:36	2 - 19.15	S	156 - 30.04	E	1673.0	2.2	8	8	550	236
U15	1	2016.12.17	9:25	2 - 35.99	S	157 - 0.05	E	1695.0	1.6	8	8	550	236
U16	1	2016.12.17	12:23	2 - 52.74	S	157 - 30.04	E	1729.0	1.6	8	8	550	236
U17	1	2016.12.17	15:11	3 - 9.59	S	158 - 0.01	E	1838.0	2.5	8	8	550	236
U18	1	2016.12.17	18:19	3 - 26.48	S	158 - 30.06	E	1883.0	2.3	8	8	550	236
U19	1	2016.12.17	21:13	3 - 43.20	S	159 - 0.03	E	1820.0	2.2	8	8	550	236
U20	1	2016.12.18	0:16	4 - 0.03	S	159 - 30.03	E	1850.0	2.3	8	8	550	236
U21	1	2016.12.18	3:34	4 - 24.73	S	160 - 0.04	E	1951.0	2.2	8	8	550	236
U22	1	2016.12.18	6:54	4 - 49.36	S	160 - 30.03	E	1795.0	2.0	8	8	550	236
U23	1	2016.12.18	10:07	5 - 14.08	S	161 - 0.02	E	1816.0	1.9	8	8	550	236
U24	1	2016.12.18	13:24	5 - 38.64	S	161 - 30.03	E	2623.0	1.7	8	8	550	236
U25	1	2016.12.18	16:37	6 - 3.35	S	162 - 0.05	E	2934.0	1.8	8	8	550	236
U26	1	2016.12.18	19:54	6 - 28.16	S	162 - 30.07	E	3358.0	1.9	8	8	550	236
U27	1	2016.12.18	23:04	6 - 52.52	S	163 - 0.03	E	3515.0	2.2	8	8	550	236
U28	1	2016.12.19	2:17	7 - 17.22	S	163 - 30.02	E	2209.0	2.0	8	8	550	236
U29	1	2016.12.19	5:50	7 - 41.74	S	164 - 0.03	E	3634.0	1.9	8	8	550	236
U30	1	2016.12.19	9:05	8 - 6.12	S	164 - 30.03	E	3583.0	1.9	8	8	550	236
U31	1	2016.12.19	12:18	8 - 30.71	S	165 - 0.02	E	3878.0	2.0	8	8	550	236
U32	1	2016.12.19	15:30	8 - 55.79	S	165 - 30.02	E	4055.0	2.0	8	8	550	236
U33	1	2016.12.19	19:12	9 - 20.97	S	166 - 0.06	E	2734.0	1.8	8	8	550	236
U34	1	2016.12.19	22:29	9 - 46.08	S	166 - 30.08	E	1316.0	1.9	8	8	550	236
U35	1	2016.12.20	1:42	10 - 11.06	S	167 - 0.04	E	2137.0	2.4	8	8	550	236
U36	1	2016.12.20	5:55	10 - 36.20	S	167 - 30.02	E	2081.0	1.8	8	8	550	236
U37	1	2016.12.20	9:16	11 - 1.08	S	168 - 0.02	E	1530.0	2.1	8	8	550	236
U38	1	2016.12.20	12:30	11 - 26.11	S	168 - 30.03	E	3420.0	2.0	8	8	550	236
U39	1	2016.12.20	15:49	11 - 51.01	S	169 - 0.02	E	3275.0	2.1	8	8	550	236
U40	1	2016.12.20	19:29	12 - 15.92	S	169 - 30.06	E	3025.0	1.7	8	8	550	236
U41	1	2016.12.20	22:47	12 - 40.84	S	170 - 0.03	E	3385.0	1.7	8	8	550	236
U42	1	2016.12.21	4:00	13 - 5.60	S	170 - 30.04	E	3343.0	1.9	8	8	550	236
U43	1	2016.12.21	10:01	13 - 30.35	S	171 - 0.01	E	3368.0	1.6	6	6	550	236
U44	1	2016.12.21	16:00	13 - 55.07	S	171 - 30.04	E	4060.0	1.8	8	8	550	236
U45	1	2016.12.21	19:24	14 - 19.83	S	172 - 0.05	E	3342.0	1.5	8	8	550	236
U46	1	2016.12.21	22:37	14 - 44.54	S	172 - 30.03	E	3644.0	1.6	8	8	550	236
U47	1	2016.12.22	2:04	15 - 9.06	S	173 - 0.03	E	3341.0	1.9	8	8	550	236
U48	1	2016.12.22	5:41	15 - 33.49	S	173 - 30.03	E	2873.0	1.8	8	8	550	236
U49	1	2016.12.22	8:56	15 - 58.00	S	174 - 0.02	E	2661.0	2.0	8	8	550	236
U50	1	2016.12.22	12:18	16 - 22.52	S	174 - 30.03	E	2680.0	2.3	8	8	550	236
U51	1	2016.12.22	15:23	16 - 46.93	S	175 - 0.04	E	2499.0	2.2	8	8	550	236

7.2.6. Shipboard ADCP

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Kazuho Yoshida	(NME)
Koichi Inagaki	(NME)
Masanori Murakami	(MIRAI Crew)

(2) Objective

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

(3) Methods

Upper ocean current measurements were made in MR16-08 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 gyrocompass (TOKYO KEIKI, 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) Differential GNSS system (Multi-Fix, Fugro, Netherlands) providing precise ship's position.
4) We used VmDas version 1.46.5 (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 bio fouling at transducer face.
7) The sound speed at the transducer does affect the vertical bin mapping and vertical velocity measurement, is calculated from temperature, salinity (constant value; 35.0 psu) and depth

(6.5 m; transducer depth) by equation in Medwin (1975).

Data was configured for 16 m intervals starting 23 m below sea surface. 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 7.2.6-1.

(4) Preliminary results

Fig.7.2.6-1 shows the surface current vector along the ship's track.

(5) Data archive

These data obtained in this cruise will be submitted to the JAMSTEC Data Management Group, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site (http://www.godac.jamstec.go.jp/darwin/e).

(6) Remarks

1) The following period, heading data of a ship's gyrocompass was invalid due to its failure.

17:20UTC – 17:47UTC, 19 Dec. 2016

Table 7.2.5-1 Major parameters

Environmental Sensor Commands

EA	=	+04500	Heading Alignment (1/100 deg)
EB	=	+00000	Heading Bias (1/100 deg)
ED	=	00065	Transducer Depth (0 - 65535 dm)
EF	=	+001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH	=	00000	Heading (1/100 deg)
ES	=	35	Salinity (0-40 pp thousand)
EX	=	00000	Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ	=	10200010	Sensor Source (C; D; H; P; R; S; T; U)

C (1): Sound velocity calculates using ED, ES, ET (temp.)

D (0): Manual ED

H (2): External synchro

P (0), R (0): Manual EP, ER (0 degree)

S (0): Manual ES

T (1): Internal transducer sensor

U (0): Manual EU

Timing Commands

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

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

Water-Track Commands

WA= 255 False Target Threshold (Max) (0-255 count)

WB = 1 Mode 1 Bandwidth Control (0=Wid, 1=Med, 2=Nar)

WC = 120 Low Correlation Threshold (0-255)

WD = 111 100 000 Data Out (V; C; A; PG; St; Vsum; Vsum^2;#G;P0)

WE= 1000 Error Velocity Threshold (0-5000 mm/s)

WF= 0800 Blank After Transmit (cm)

WG = 001 Percent Good Minimum (0-100%)

WI = 0 Clip Data Past Bottom (0 = OFF, 1 = ON)

WJ = 1 Rcvr Gain Select (0 = Low, 1 = High)

WM = 1 Profiling Mode (1-8)

WN = 40 Number of depth cells (1-128)

WP=	00001	Pings per Ensemble (0-16384)
WS=	1600	Depth Cell Size (cm)
WT=	000	Transmit Length (cm) [0 = Bin Length]
WV	=	0390 Mode 1 Ambiguity Velocity (cm/s radial)

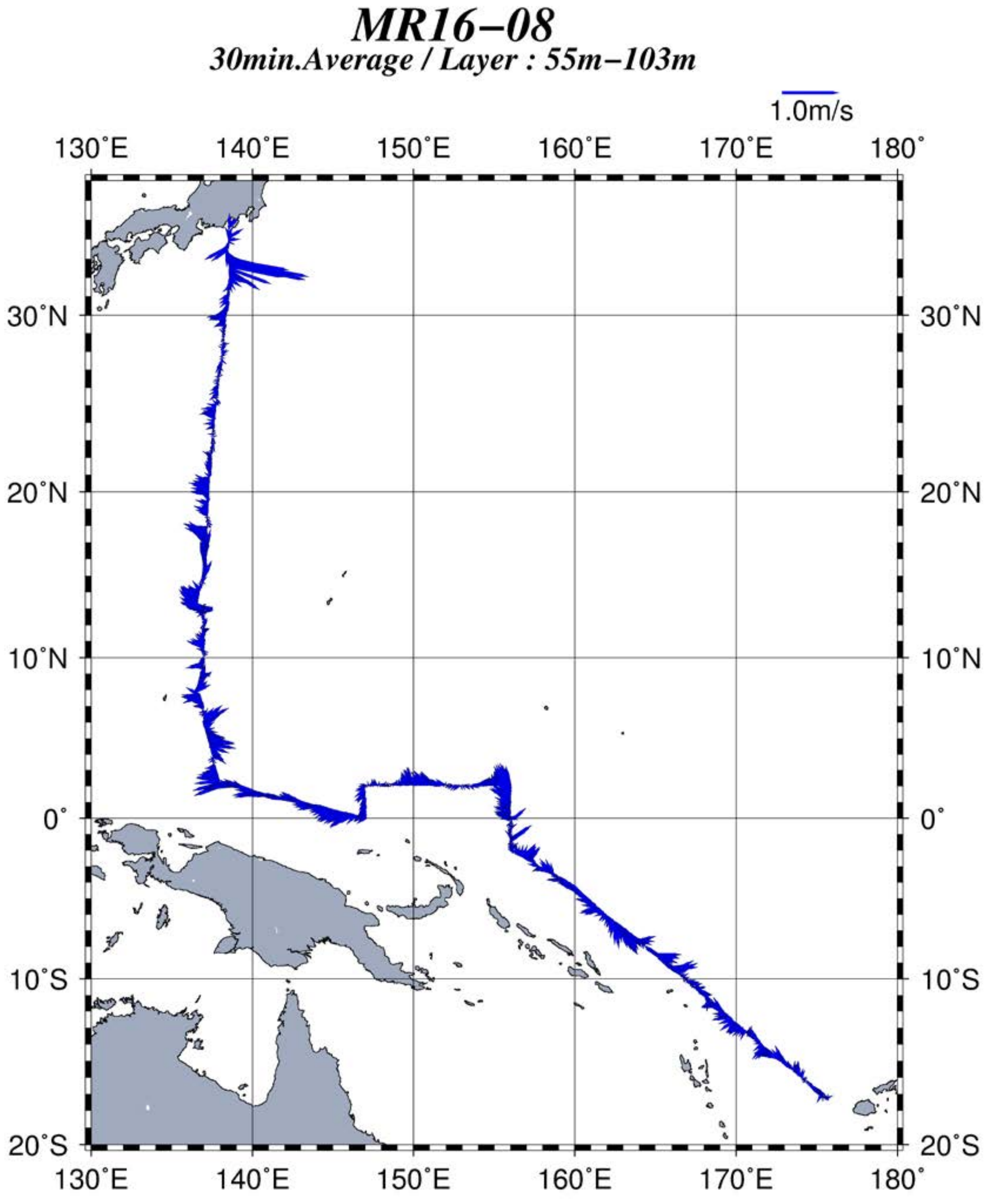


Fig 7.2.6-1. Surface current vector along the ship's track.

7.2.7. Underway surface water monitoring

7.2.7.1. TSG

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Hiroshi Hoshino	(MWJ) Operation Leader
Masahiro Orui	(MWJ)

(2) Objective

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

(3) Parameters

- Temperature (surface water)
- Salinity (surface water)
- Dissolved oxygen (surface water)
- Fluorescence (surface water)
- Turbidity (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, fluorescence and turbidity 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 8.5 L min^{-1}.

1) 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:	4557820-0319
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:	3852788-0457
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:	1915
Measuring range:	0 - 500 μmol L^{-1}
Resolution:	< 1 μmol L^{-1}
Accuracy:	< 8 μmol L^{-1} or 5 % whichever is greater
Settling time:	< 25 s

Dissolved oxygen sensor

Model:	RINKO II, ARO-CAR/CAD
Serial number:	13
Measuring range:	0 - 20 mg L^{-1}
Resolution:	0.001 – 0.004 mg L^{-1} (25 ^{o}C)
Accuracy:	Saturation ± 2% F.S.
	(non-linear) (1 atm, 25 ^{o}C)

Fluorescence and Turbidity

Model: C3, TURNER DESIGNS

Serial number: 2300384

(5) Station list or Observation log

Periods of measurement, maintenance, and problems during MR16-08 are listed in Table 7.2.6.1-1. Spatial and temporal distribution of temperature, salinity, dissolved oxygen, and fluorescence are shown in Fig 7.2.7.1-1.

Table 7.2.7.1-1 Events list of the Sea surface water monitoring during MR16-08

System Date [UTC]	System Time [UTC]	Events	Remarks
2016/11/27	08:32	All the measurements started and data were available.	
2016/11/29	00:08	Seawater supplying only for the C3 sensor stopped for repairing seawater leakage.	Fluorescence and turbidity were unreliable.
2016/11/29	01:57	Seawater supplying for C3 sensor restarted.	Fluorescence and turbidity were available.
2016/12/08	09:25	All the measurements stopped.	Filter cleaning.
2016/12/08	11:24	All the measurements started.	
2016/12/22	20:01	All the measurements stopped.	

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. 7.2.6.1-2 and Fig. 7.2.6.1-3. 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 JAMSTEC Data Management Group, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site
(http://www.godac.jamstec.go.jp/darwin/e).

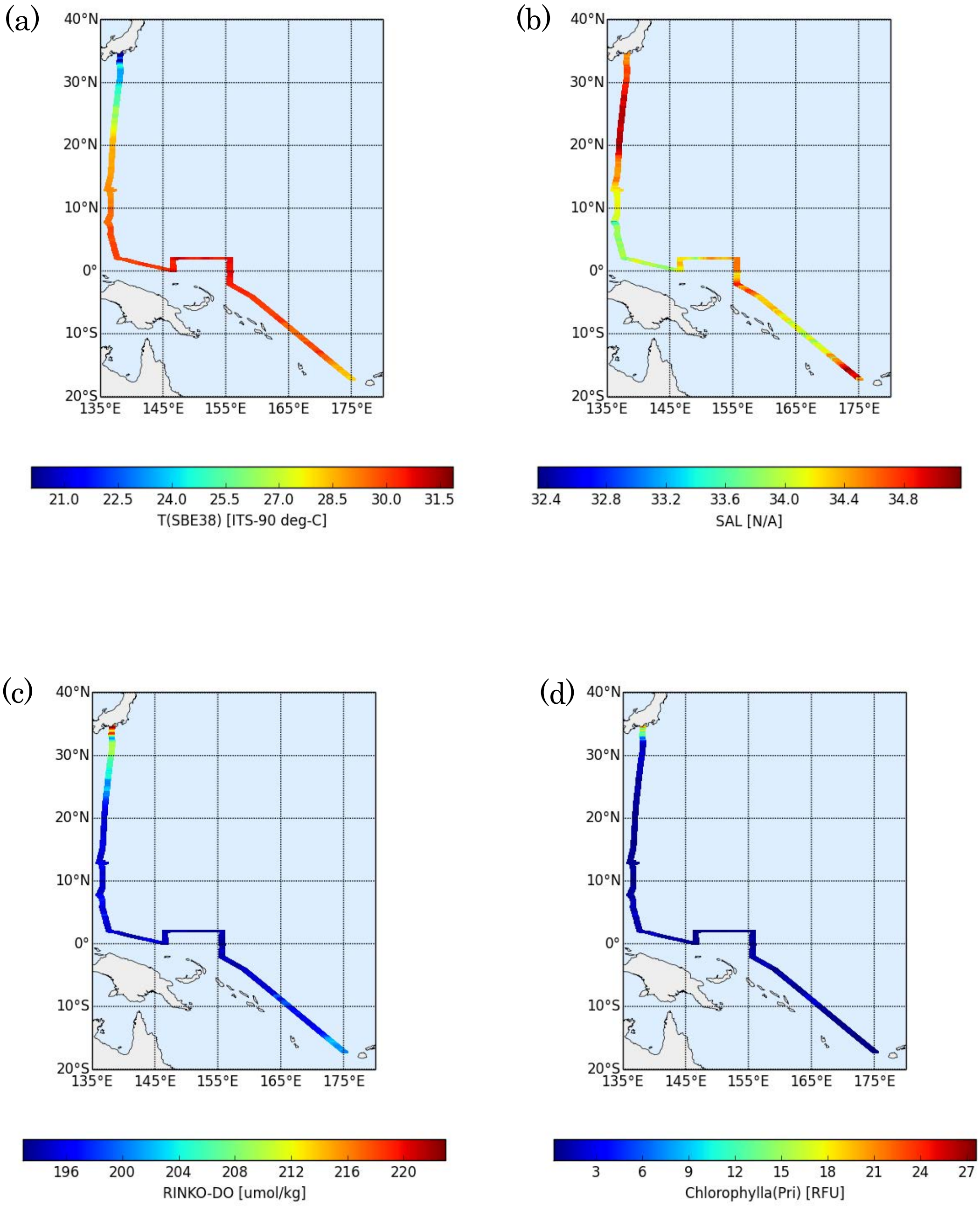


Fig 7.2.7.1-1 Spatial and temporal distribution of (a) temperature, (b) salinity, and (c) dissolved oxygen and (d) fluorescence in MR16-08 cruise.

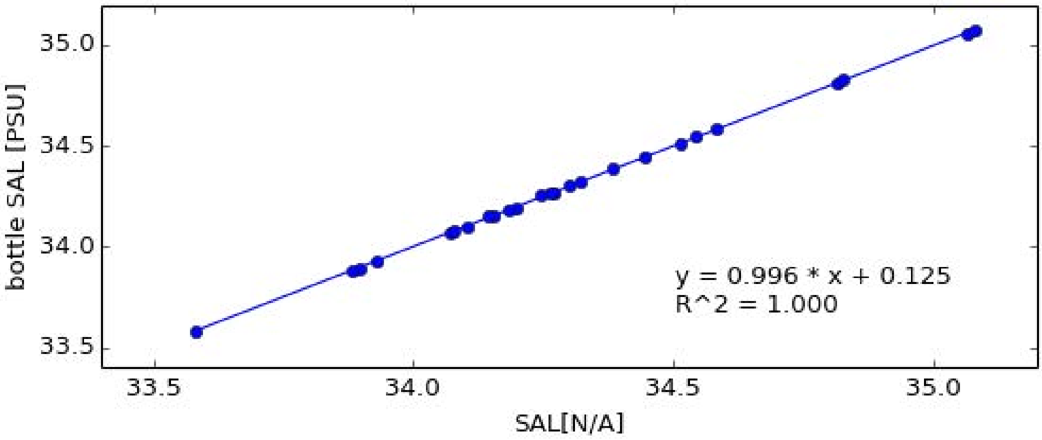
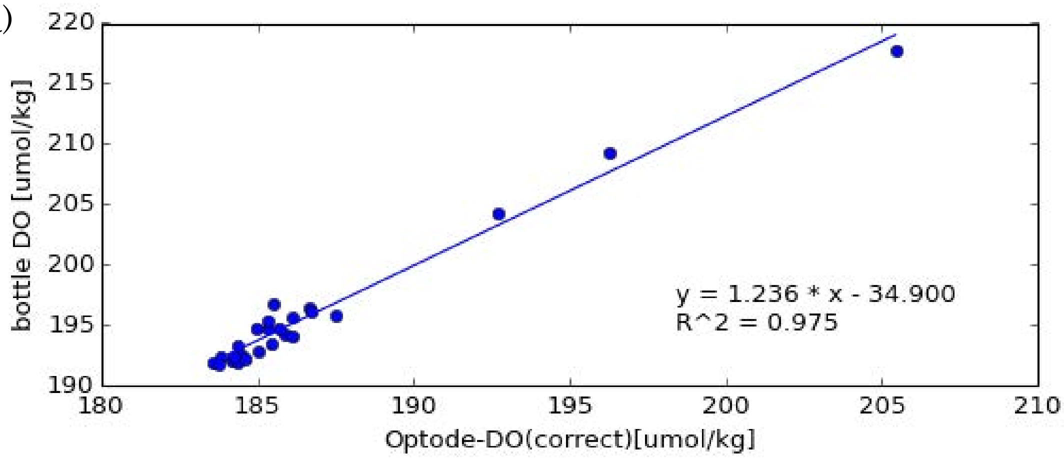


Fig 7.2.7.1-2 Correlation of salinity between sensor data and bottle data in MR16-08 cruise.

(a)



(b)

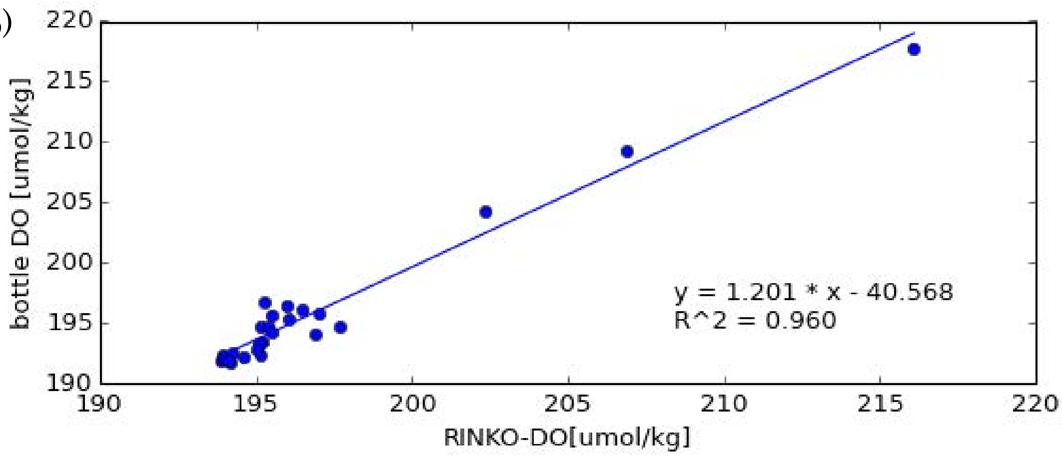


Fig 7.2.6.1-3 Correlation of dissolved oxygen between sensor data and bottle datain MR16-08 cruise.

(a: OPTODE, b: RINKO)

7.3. Geophysical surveys

7.3.1. Sea surface gravity

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Kazuho Yoshida	(NME)
Koichi Inagaki	(NME)
Masanori Murakami	(MIRAI Crew)

(2) Introduction

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface during the MR16-08 cruise.

(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 Shimizu and Suva as the reference point.

(5) Data Archives

These data obtained in this cruise will be submitted to the JAMSTEC Data Management Group, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site (http://www.godac.jamstec.go.jp/darwin/e).

(6) Remarks

1) The following periods, depth data was not available.

22:59UTC 05 Dec. 2016 - 23:27UTC 05 Dec. 2016

21:47UTC 06 Dec. 2016 - 23:31UTC 06 Dec. 2016

00:31UTC 08 Dec. 2016 - 01:12UTC 08 Dec. 2016

02:20UTC 10 Dec. 2016 - 04:24UTC 10 Dec. 2016

20:50UTC 10 Dec. 2016 - 22:25UTC 10 Dec. 2016

22:53UTC 12 Dec. 2016 - 23:44UTC 12 Dec. 2016

21:58UTC 14 Dec. 2016 - 22:25UTC 14 Dec. 2016

19:45UTC 15 Dec. 2016 - 20:24UTC 15 Dec. 2016

19:57UTC 16 Dec. 2016 - 21:34UTC 16 Dec. 2016

2) The following periods, heading data of a ship's gyro compass was invalid or unreliable due to gyro's failure.

17:20UTC 19 Dec. 2016 – 17:25UTC 19 Dec. 2016 (invalid)

17:25UTC 19 Dec. 2016 – 18:00UTC 19 Dec. 2016 (low reliable)

Table 7.3.1-1

No.	Date	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Ship Draft [cm]	Gravity at Sensor * [mGal]	S-116 Gravity [mGal]
#1	25-Nov-16	06:18	Shimizu	979729.626	127.5	645	979730.18	12014.81

[*1]: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.2223
[*2]: L&R = LaCoste and Romberg air-sea gravity meter S-116

7.3.2. Sea surface three component magnetic field

(1) Personnel

Iwao Ueki (JAMSTEC) PI

Kazuho Yoshida (NME)

Koichi Inagaki (NME)

Masanori Murakami (MIRAI Crew)

(2) Introduction

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during the MR16-08 cruise.

(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:

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

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

Rearrangement of Eq. (a) makes

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

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

(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 (Differential GNSS), speed over ground, and gyro data are taken from LAN every second.

(5) Data Archives

These data obtained in this cruise will be submitted to the JAMSTEC Data Management Group, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site
(http://www.godac.jamstec.go.jp/darwin/e).

(6) Remarks

1) 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.

20:50 - 21:13 01 Dec. 2016 around13-01N, 136-30E

08:00 - 08:25 14 Dec. 2016 around 00-01S, 156-06E

17:00 - 17:23 22 Dec. 2016 around 16-59S, 175-15E

2) The following periods, speed over ground data was not available.

14:31:43UTC 28 Nov. 2016 - 14:32:55UTC 28 Nov. 2016

23:22:14UTC 09 Dec. 2016 - 23:22:54UTC 09 Dec. 2016

23:50:43UTC 09 Dec. 2016 - 23:50:51UTC 09 Dec. 2016

21:31:01UTC 10 Dec. 2016

3) The following periods, depth data was not available.

22:58UTC 05 Dec. 2016 - 23:27UTC 05 Dec. 2016

21:47UTC 06 Dec. 2016 - 23:31UTC 06 Dec. 2016

00:31UTC 08 Dec. 2016 - 01:12UTC 08 Dec. 2016

02:20UTC 10 Dec. 2016 - 04:24UTC 10 Dec. 2016

20:50UTC 10 Dec. 2016 - 22:25UTC 10 Dec. 2016

22:53UTC 12 Dec. 2016 - 23:44UTC 12 Dec. 2016

21:58UTC 14 Dec. 2016 - 22:25UTC 14 Dec. 2016

19:45UTC 15 Dec. 2016 - 20:24UTC 15 Dec. 2016

19:57UTC 16 Dec. 2016 - 21:34UTC 16 Dec. 2016

4) The following periods, heading data of a ship’s gyrocompass was invalid or unreliable due to gyro’s failure.

17:20UTC 19 Dec. 2016 – 17:25UTC 19 Dec. 2016 (invalid)

17:25UTC 19 Dec. 2016 – 18:00UTC 19 Dec. 2016 (low reliable)

7.3.3. Swath bathymetry

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Kazuho Yoshida	(NME)
Koichi Inagaki	(NME)
Masanori Murakami	(MIRAI Crew)

(2) Introduction

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

(3) Data Acquisition

The "SEABEAM 3012" on R/V MIRAI was used for bathymetry mapping during the MR16-08 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 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

These data obtained in this cruise will be submitted to the JAMSTEC Data Management Group, and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site (http://www.godac.jamstec.go.jp/darwin/e).

(6) Remarks

1) The following period, data acquisition was suspended due to operating ANS system.

22:58UTC 05 Dec. 2016 - 23:27UTC 05 Dec. 2016
21:47UTC 06 Dec. 2016 - 23:31UTC 06 Dec. 2016
00:31UTC 08 Dec. 2016 - 01:12UTC 08 Dec. 2016
02:20UTC 10 Dec. 2016 - 04:24UTC 10 Dec. 2016
20:50UTC 10 Dec. 2016 - 22:25UTC 10 Dec. 2016
22:53UTC 12 Dec. 2016 - 23:44UTC 12 Dec. 2016
21:58UTC 14 Dec. 2016 - 22:25UTC 14 Dec. 2016
19:45UTC 15 Dec. 2016 - 20:24UTC 15 Dec. 2016
19:57UTC 16 Dec. 2016 - 21:34UTC 16 Dec. 2016

8. Acknowledgement

First of all, I would like to express great thank to Captain Akutagawa and all of the crew of R/V MIRAI. The all of observation activities were conducted under the cooperation with marine technicians of MWJ and NME. Their efforts were crucially important for our scientific activities. I hope all of scientists joining this cruise will acquire fruitful results. Finally I appreciate all of people, who have been involved this cruise.