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R/V Mirai Cruise Report
MR10-02

April 6, 2010 – May 3, 2010

Tropical Western Pacific Ocean

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

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Note:

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

1. Cruise name and code

Title of the cruise: Tropical Ocean Climate Study

Cruise code: MR10-02

Ship: R/V Mirai (Captain: Yasushi Ishioka)

Main Title of proposal:	Tropical Ocean Climate Study
Main Title of proposal:	Operation of TRITON buoy

2. Introduction and observation summary

2.1 Introduction

The purpose of this cruise is to observe ocean and atmosphere in the western tropical Pacific Ocean for better understanding of climate variability involving the ENSO (El Nino/Southern Oscillation) phenomenon. Particularly, warm water pool (WWP) in the western tropical Pacific is characterized by the highest sea surface temperature in the world, and plays a major role in driving global atmospheric circulation. Zonal migration of the WWP in the western Pacific is associated with El Nino and La Nina, which cause drastic climate changes in the world such as found during 1997-98 El Nino and 1999 La Nina. However, this atmospheric and oceanic system is so complicated that scientific knowledge is still limited.

In order to understand the mechanism of the atmospheric and oceanic system, its high quality data for long period is required. Considering this background, we developed the TRITON (TRIangle Trans-Ocean buoy Network) buoys and m-TRITON (small size TRITON), and have deployed them in the western equatorial Pacific and Indian Ocean since 1998 cooperating with USA and Indonesia. The major mission of this cruise is to maintain the network of TRITON buoys along 130E and 138E lines in the western equatorial Pacific. In this cruise, several atmospheric compositions, aerosol, rain and water vapor sampling, atmospheric turbulence measurements and general meteorological observations are also conducted during the cruise.

2.2 Overview

1) Ship

R/V Mirai

Captain Yasushi Ishioka

2) Cruise code

MR10-02

3) Project names

Main projects

3-1) Tropical Ocean Climate Study

3-2) Operation of TRITON buoys

Public offering projects

3-3) Lidar observations of clouds and aerosols (Lidar observations of optical characteristics and vertical distribution of aerosols and clouds

3-4) Sampling of rainfall, atmospheric vapor, and seawaters (Water sampling for building water isotopologue map over the Ocean)

3-5) Sky radiometer (Maritime aerosol optical properties from measurement of Ship-borne sky radiometer)

3-6) Milimeter wave radar and Infrared radiometer (Distribution and configuration of

Clouds in various oceans)

3-7) Air-sea surface eddy flux measurement (On-board continuous air-sea eddy flux measurement)

3-8) Kuroshio air-sea interaction observations (Observational research on air-sea interaction in the Kuroshio-Oyashio Extension region)

3-9) Argo float launching (Study of ocean circulation and heat and freshwater transport and their variability, and experimental comprehensive study of physical, chemical, and biochemical processes in the western North Pacific by the deployment of Argo floats and using Argo data)

3-10) Geophysical surveys (Standardising the marine geophysics data and its application to the ocean floor geodynamics studies)

4) Undertaking institution

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

BPPT (Agency for the Assessment and Application of Technology, Indonesia)

NIES (National Institute for Environmental Studies, Japan)

University of Toyama (Japan)

Chiba University (Japan) with Tohoku University (Japan)

Okayama University (Japan) with Kobe University (Japan)

Ryukyu University (Japan)

5) Chief scientist

Kentaro Ando (JAMSTEC)

6) Period

April 6th, 2010 - May 3rd, 2010 (Guam, USA)

7) Number of Research participants

Two scientists, one engineers, and twenty-five technical staffs from three Japanese institutions and companies

One scientist and one security officer from Indonesian government

Two engineers from US government

2.3 Observation summary

TRITON mooring recoveries and re-deployments: 6 moorings were deployed and recovered

JKEO and KEO: Visual check to J-KEO and repair to KEO

CTD (Conductivity, Temperature and Depth) and water sampling:	11 casts
XCTD:	81 casts
Sonde:	22 launchings

Current measurements by shipboard ADCP:	continuous
General Surface meteorology:	continuous
Lidar, rain sampling, turbulences, aerosol etc.:	continuous
Geophysical bottom survey:	continuours

Regarding TRITON buoy maintenance work, we recovered and re-installed nine buoys at 130E and 137/138E lines during this cruise without any big trouble. The so-called “Iron mask” meteorological tower has been used on the buoy at 8N130E, and the tower was not vandalized heavily in comparison with the past buoys with normal tower at this site.

During this cruise, we conducted 11 CTD casts for various purposes. For TRTION sensor check, CTD casts were conducted down to 1000m depth near the recovered buoy for the purpose to compare with TRITON salinity sensors which are installed from surface to the depth of 750m.

2.4 Observed Oceanic and Atmospheric Conditions

The cruise was conducted just in the termination period of 2009/10 El Nino. During the cruise, Sea surface temperature (SST) in the western Pacific was higher than normal, already suggesting the termination period of El Nino. The highest SST anomalies near the equator in the central Pacific in April 14th moved to west at the end of April (see bottom right), and at the same time the negative SST anomaly started to appear (Figure 2.4-1) in the eastern tropical Pacific, indicating the beginning of 2010 La Nina. The westward surface wind in the western Pacific was stronger than normal, causing the cooler SST area in 5N-10N in the northern hemisphere.

In the western Pacific, from the El Nino phase to La Nina phase, TRITON buoy array captured the westward expansion of warm water (Figure 2.4-2). In January 2010, SST indicates below 29.0 degree-C in the west of 138E, but SST in the TRITON are gradually increase, and reaches more than 29.5 degree-C in May 2010 except for north of 8N. After the cruise, TRITON buoys along 156E in the southern hemisphere indicates rather high SST more than 30.3 degree-C. It is clearly shown that before and after the cruise, the oceanic and atmospheric conditions have suddenly changed.

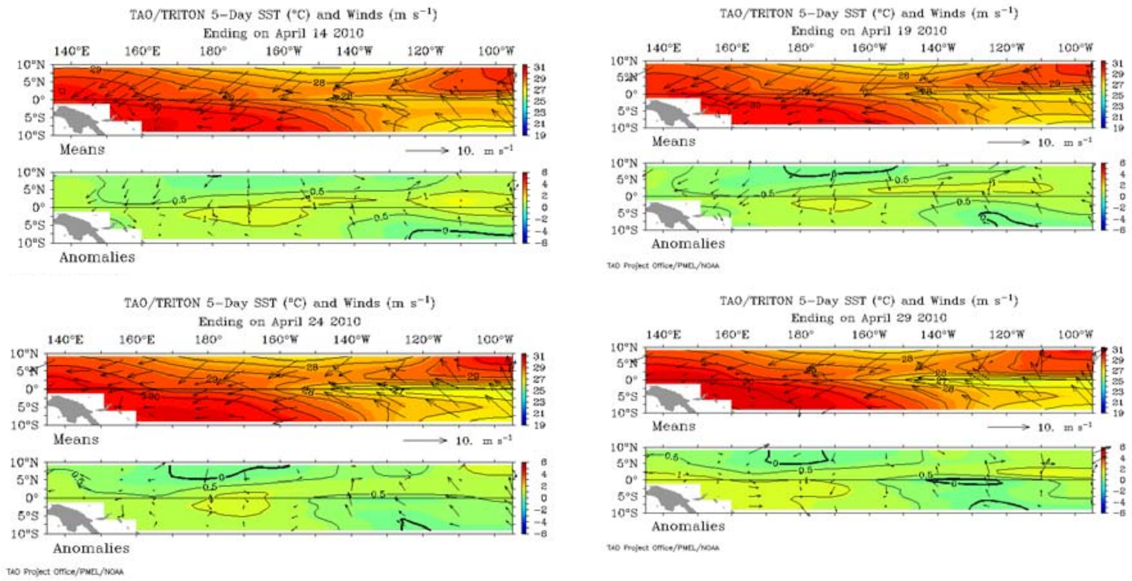


Figure 2.4-1 5-days average and anomaly of SST and surface wind ending on April 14 (left-top), April 19 (right-top), April 24 (left-bottom), and April 29 (right-bottom) from PMEL TAO/TRITON web site.

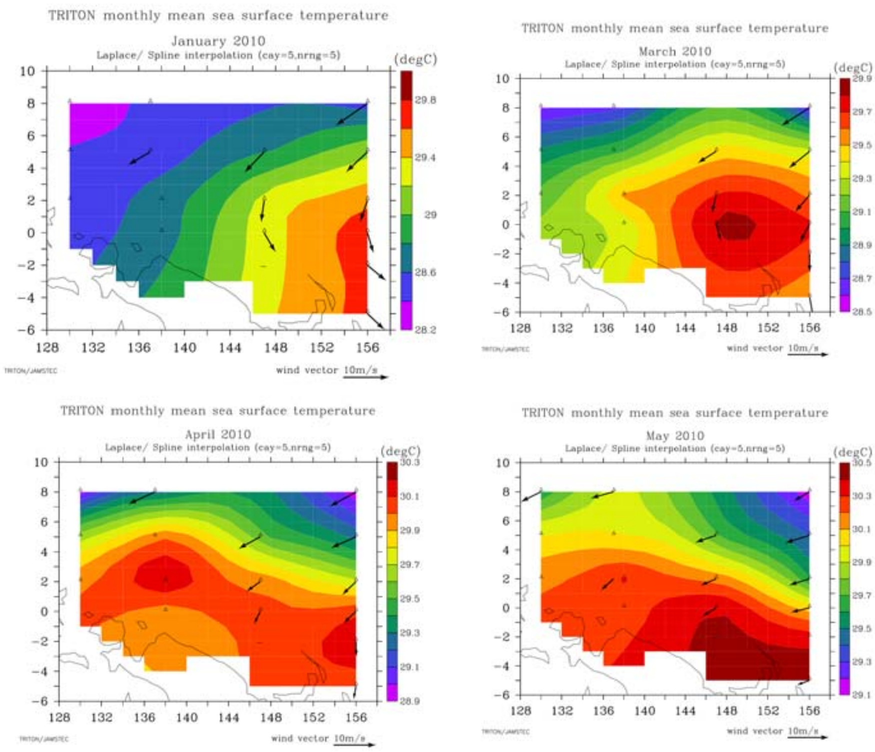


Figure 2.4-2 Monthly average of SST and surface wind in Jan 2010 (left-top), March 2010 (right-top), April 2010 (left-bottom), and May 2010 (right-bottom) from TRITON data.

3. Ports of call, cruise log and cruise track

3.1 Ports of call

Sekinehama (Japan) April 6th,2010

Hachinohe (Japan) April 7th, 2010

Koror (Palau) April 17th, 2010

Guam (USA) May 3rd, 2010

3.2 Cruise Log

SMT	UTC	Event
Apr. 06 (Tue) 2010		
15:50	06:50	Departure from Sekinehama, Japan
Apr. 07 (Wed) 2010		
08:10	23:10	Arrival to Hachinohe port, Japan
15:30	06:30	Departure from Hachinohe, Japan, Start continuous observation
16:20	07:20	Start surface ocean condition
16:45	07:45	Konpira Ceremony
Apr. 08 (Thu) 2010		
09:00	00:00	Lecture on the safety and comfortable life in Mirai
10:30	01:30	Meeting on the observation of this cruise
13:15	04:15	Boat drill
15:00	05:00	Look and Check J-KEO (38-02.74N, 146-29.01E)
15:22 – 16:11	06:22 – 07:11	CTD#1 (1000m) at J-KEO site
15:44	06:44	XCTD#1 at J-KEO site
16:18	07:18	Radio Sonde#1 at J-KEO site
19:21	10:21	XCTD#2 (37-30N, 146-14E)
19:30	10:30	Radio Sonde#2 (37-30N, 146-14E)
22:05	13:05	XCTD#3 (37-01N,146-04E)
22:16	13:16	Radio Sonde#3 (36-58N, 146-04E)
23:33	14:33	XCTD#4 (36-45N ,146-00E)
23:43	14:43	Radio Sonde#4 (36-43N, 145-59E)
Apr. 09 (Fri) 2010		
01:07	16:07	XCTD#5 (36-30N ,145-54E)
01:14	16:14	Radio Sonde#5 (36-29N, 145-55E)
02:39	17:39	XCTD#6 (36-15N,145-49 E)
02:48	17:48	Radio Sonde#6 (36.13N, 145-49E)
04:07	19:07	XCTD#7 (36-00N,145-44 E)
04:15	19:15	Radio Sonde#7 (35-58N, 145-44E)
05:31	20:31	XCTD#8 (35-45N, 145-40E)

05:40	20:40	Radio Sonde#8 (35-43N, 145-39E)
06:51	21:51	XCTD#9 (35-32N,145-35 E)
06:57	21:57	Radio Sonde#9 (35-28N, 145-34E)
08:08	23:08	XCTD#10 (35-16N,145-30 E)
08:10	23:10	Radio Sonde#10 (35-14N, 145-30E)
09:27	00:27	XCTD#11 (35-01N,145-25 E)
09:28	00:28	Radio Sonde#11 (34-59N, 145-25E)
10:46	01:46	XCTD#12 (34-45N,145-20 E)
10:47	01:47	Radio Sonde#12 (34-44N, 145-20E)
12:05	03:05	XCTD#13 (34-30N, 145-15E)
12:06	03:06	Radio Sonde#13 (34-29N, 145-15E)
13:25	04:25	XCTD#14 (34-16N,145-11 E)
13:33	04:33	Radio Sonde#14 (34-13N, 145-10E)
14:48	05:48	XCTD#15 (34-00N,145-06 E)
14:50	05:50	Radio Sonde#15 (33-59N, 145-09E)
15:30	06:30	Meeting on KEO on-deck repairing operation
17:39	08:39	XCTD#16 (33-30N,144-55 E)
17:40	08:40	Radio Sonde#16 (33-29N, 144-55E)
20:27	11:27	XCTD#17 (33-00N, 144-46E)
20:35	11:35	Radio Sonde#17 (32-59N, 144-45E)
Apr. 10 (Sat) 2010		
03:00	18:00	Sonde#18 at KEO site
05:58-12:00	20:58-03:00	Repairing KEO on-deck operation
05:44	20:44	Sonde#19 at KEO site
09:01	00:01	Sonde#20 at KEO site
12:07	03:07	Sonde#21 at KEO site
13:00 – 13:45	04:00 – 04:45	CTD#2 (1000m) at KEO site
13:15	04:15	XCTD#18 at KEO site
14:00	05:00	Look and Check KEO
14:58	05:58	Sonde#22 (32-09N, 144-27E)
Apr. 11 (Sun) 2010 – Apr. 12(Mon) 2010		
	Cruising to TRITON #10 deployment site	
Apr. 13 (Tue) 2010		
08:30 – 09:16	23:30 – 00:16	Test cast CTD#3 (1000m) (17-18N, 139-52 E)
Apr. 14 (Wed) 2010		
	Cruising to TRITON #10 deployment site	
Apr. 15 (Thu) 2010		
08:13 – 10:30	23:13 – 01:30	Deployment of TRITON #10 (8N, 137E)
12:58 – 13:45	03:58 – 04:45	CTD#4 (1000m) at TRITON #10 deployment site
15:28 – 16:15	06:28 – 07:15	CTD#5 (1000m) at TRITON #10 recovery site

15:44	06:44	XCTD#20 at TRITON #10 recovery site
16:22	07:22	Deployment of Argo Float#1 at TRITON #10 recovery site
Apr. 16 (Fri) 2010		
08:05 – 11:21	23:05 – 02:21	Recovery of TRITON buoy#10 (8N, 137E)
13:04 – 13:50	04:04 – 04:50	T-MAP (MSP)#1 (500m) at TRITON #10 recovery site
21:00	12:00	Stop continuous observation
Apr. 17 (Sat) 2010		
06:30	21:30	Stop surface ocean condition
09:00	00:00	Arrival to Koror port, Palau
13:00	04:00	Meeting on the observation in Indonesia EEZ
14:00	05:00	Departure from Koror port, Palau
14:30	05:30	Lecture on the safety and comfortable life in Mirai
16:00	07:00	Start surface ocean condition
16:00	07:00	Start continuous observation
Apr. 18 (Sun) 2010		
12:47 – 15:11	03:47 – 06:11	Deployment of TRITON #11 (5N, 137E)
16:07 – 16:50	07:07 – 07:50	CTD#5 (1000m) at TRITON #11 deployment site
16:23	07:23	XCTD#20 at TRITON #11 deployment site
16:48 – 17:27	07:48 – 08:27	T-MAP (MSP)#2 (500m) at TRITON #11 deployment site
18:42 – 19:26	09:42 – 10:26	CTD#6 (1000m) at TRITON #11 recovery site
18:55	09:55	XCTD#21 at TRITON #11 recovery site
Apr. 19 (Mon) 2010		
08:07 – 11:48	23:07 – 02:48	Recovery of TRITON buoy#11 (5N, 137E)
16:38	07:38	XCTD#22 (04-00N, 137-30E)
22:01	13:01	XCTD#23 (03-00N, 137-48E)
Apr. 20 (Tue) 2010		
08:13 – 10:43	23:13 – 01:43	Deployment of TRITON #12 (2N, 138E)
13:01 – 13:43	04:01 – 04:43	CTD#7 (1000m) at TRITON #12 deployment site
13:16	04:16	XCTD#24 at TRITON #12 deployment site
13:45 – 14:33	04:45 – 05:33	T-MAP (MSP)#3 (400m) at TRITON #12 deployment site
15:09 – 15:53	06:09 – 06:53	CTD#8 (1000m) at TRITON #12 recovery site
15:25	06:25	XCTD#25 at TRITON #12 recovery site
18:00 – 18:26	09:00 – 09:26	Calibration of 3-componet magnetic field
Apr. 21 (Wed) 2010		
08:06 – 11:41	23:06 – 02:41	Recovery of TRITON buoy#12 (2N, 138E)
15:39	06:39	XCTD#26 (01-30N, 137-58E)
19:11	10:11	XCTD#27 (01-00N, 137-57E)

20:56	11:56	XCTD#28 (00-45N, 137-56E)
22:38	13:38	XCTD#29 (00-30N, 137-55E)
Apr. 22 (Thu) 2010		
00:20	15:20	XCTD#30 (00-15N, 137-54E)
05:28 – 06:10	20:28 – 21:10	CTD#9 (1000m) at TRITON #13 recovery site
05:43	20:43	XCTD#31 at TRITON #13 recovery site
08:04 – 10:29	23:04 – 01:29	Deployment of TRITON #13 (EQ, 138E)
11:12	02:12	XCTD#32 at TRITON #13 deployment site
13:03 – 16:43	04:03 – 07:43	Recovery of TRITON #13 (EQ, 138E)
17:03 – 17:38	08:03 – 08:38	T-MAP (MSP)#4 (400m) at TRITON #13 recovery site
18:47	09:47	XCTD#33 (00-15S, 137-54E)
19:51	10:51	XCTD#34 (00-30S, 137-56E)
20:54	11:54	XCTD#35 (00-45S, 137-58E)
22:00	13:00	XCTD#36 (01-00S, 137-59E)
23:02	14:02	XCTD#37 (01-12S, 138-00E)
Apr. 23 (Fri) 2010		
00:13	15:13	XCTD#38 (01-00S, 137-50E)
01:24	16:24	XCTD#39 (00-48S, 137-40E)
02:34	17:34	XCTD#40 (00-36S, 137-30E)
03:44	18:44	XCTD#41 (00-24S, 137-19E)
04:51	19:51	XCTD#42 (00-12S, 137-10E)
05:59	20:59	XCTD#43 (00-00S, 137-00E)
08:05	23:05	XCTD#44 (00-00N, 136-31E)
10:10	01:10	XCTD#45 (00-00S, 136-01E)
12:13	03:13	XCTD#46 (00-00S, 135-31E)
13:00 – 13:46	04:00 – 04:46	CTD#10 (1000m) (00-00N, 135-20E)
13:17	04:17	XCTD#47 (00-00N, 135-20E)
15:12	06:12	XCTD#48 (00-15N, 135-10E)
16:31	07:31	XCTD#49 (00-29N, 134-59E)
17:49	08:49	XCTD#50 (00-45N, 134-48E)
19:10	10:10	XCTD#51 (01-00N, 134-37E)
20:26	11:26	XCTD#52 (01-14N, 134-25E)
21:34	12:34	XCTD#53 (01-14N, 134-10E)
23:04	14:04	XCTD#54 (01-03N, 133-54E)
Apr. 24 (Sat) 2010		
00:48	15:48	XCTD#55 (00-45N, 133-34E)
02:23	17:23	XCTD#56 (00-30N, 133-17E)
04:04	19:04	XCTD#57 (00-15N, 132-58E)
05:57 – 06:42	20:57 – 21:42	CTD#11 (1000m) (00-01N, 132-39E)
06:13	21:13	XCTD#57 (00-01N, 132-39E)

08:28	23:28	XCTD#58 (00-00N, 132-15E)
09:43	00:43	XCTD#59 (00-14N, 132-06E)
10:59	01:59	XCTD#60 (00-29N, 131-56E)
12:17	03:17	XCTD#61 (00-44N, 131-47E)
13:34	04:34	XCTD#62 (00-59N, 131-38E)
15:12	06:12	XCTD#63 (01-20N, 131-25E)
16:32	07:32	XCTD#64 (01-20N, 131-07E)
18:09	09:09	XCTD#65 (01-05N, 130-51E)
19:40	10:40	XCTD#66 (00-50N, 130-36E)
21:26	12:26	XCTD#67 (00-52N, 130-18E)
22:47	13:47	XCTD#68 (00-55N, 130-00E)
Apr. 25 (Sun) 2010		
00:35	15:35	XCTD#69 (01-15N, 129-59E)
01:50	16:50	XCTD#70 (01-30N, 129-58E)
03:06	18:06	XCTD#71 (01-45N, 129-57E)
05:55 – 06:39	20:55 – 21:39	CTD#12 (1000m) at TRITON #16 recovery site
06:10	21:10	XCTD#72 at TRITON #16 recovery site
08:03 – 11:38	23:03 – 02:38	Recovery of TRITON buoy#16 (2N, 130E)
12:30 - 14:30	03:30 – 05:30	Sea bottom survey by MNB (2N, 130E)
Apr. 26 (Mon) 2010		
08:11 – 10:21	23:11 – 01:21	Deployment of TRITON #16 (2N, 130E)
13:02 – 14:33	04:02 – 05:02	CTD/JES10-TD# (1000m) at TRITON #16 deployment site
13:37	04:37	XCTD#73 at TRITON #16 deployment site
14:33 – 15:23	05:33 – 06:23	T-MAP (MSP)#5 (500m) at TRITON #16 deployment site
20:49	11:49	XCTD#74 (03-00N, 130-08E)
Apr. 27 (Tue) 2010		
01:44	16:44	XCTD#75 (04-00N, 130-07E)
06:29	21:29	XCTD#76 (05-00N, 130-07E)
12:39	03:39	XCTD#77 (06-00N, 130-09E)
18:51	09:51	XCTD#78 (07-00N, 130-06E)
Apr. 28 (Wed) 2010		
08:10 – 11:03	23:10 – 02:03	Deployment of TRITON #14 (8N, 130E)
12:59 – 13:33	03:59 – 04:33	CTD#14 (1000m) at TRITON #14 deployment site
13:15	04:15	XCTD#79 at TRITON #14 deployment site
13:48 – 14:36	04:48 – 05:36	T-MAP (MSP)#6 (500m) at TRITON #14 deployment site
15:32 – 16:19	06:32 – 07:19	CTD#15 (1000m) at TRITON #14 recovery site
16:22	07:22	XCTD#80 at TRITON #14 recovery site

16:55 - 19:50	07:55 – 10:50	Sea bottom survey by MNB (8N, 130E)
Apr. 29 (Thu) 2010		
07:54 – 11:37	22:54 – 02:37	Recovery of TRITON buoy#14 (8N, 130E)
	SMT is adjusted to Guam time (UTC+10hr)	
Apr. 30 (Fri) 2010 – May 1 (Sat) 2010		
	Cruising to Apra port, Guam, USA	
May 2 (Sun) 2010		
09:57 – 11:12	23:57 – 01:12	CTD#16 (1000m) (12-39N, 142-00E)
11:18	01:18	Deployment of Argo Float#2 (12-39N, 142-00E)
13:00	03:00	Stop surface ocean condition
13:00	03:00	Stop continuous observation
May 3 (Mon) 2010		
09:50	23:50	Arrival to Apra port, Guam, USA

3.3 Cruise track

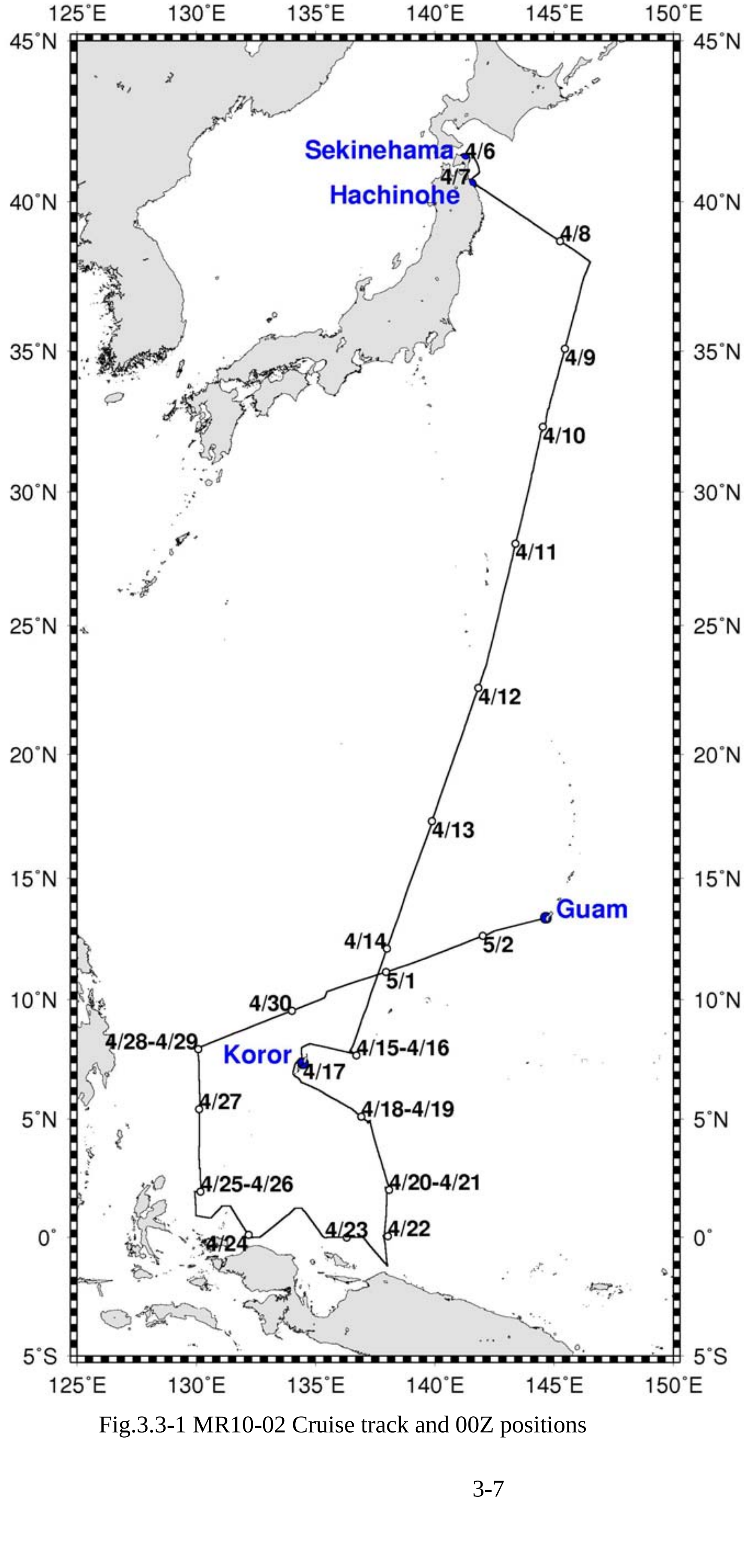


Fig.3.3-1 MR10-02 Cruise track and 00Z positions

4. Chief scientist, Science Party, and participants list

4.1 Chief Scientist

Chief Scientist

Kentaro Ando
Research Scientist
Research Institute for Global Change (RIGC),
Japan Agency for Marine-Earth Science and Technology
(JAMSTEC) 2-15, Natsushima-cho, Yokosuka, 237-0061, Japan

Co-chief Scientist (from Palau to Guam)

Fadli Syamsudin
Scientist
BPPT (Agency for the Assessment and Application of Technology)
Jl. M.H. Thamrin 8, Jakarta 10340

4.2 Science Party

4.2.1. Tropical Ocean Climate Study

Kentaro Ando
Iskhaq Iskandar
Keisuke Mizuno (not on board)
Yukio Masumoto (not on board)
Yuji Kashino (not on board)
Iwao Ueki (not on board)
Takuya Hasegawa (not on board)
Miki Fujita (not on board)

As an international collaborative project under IA between JAMSTEC and BPPT, Fadli Syamusdin and Winarno from BPPT joined the party

4.2.2. TRITON operation program

Yasuhisa Ishihara (not on board)
Tatsuya Fukuda
Shoichiro Baba (not on board)
Takashi Murashima (not on board)

Masayuki Yamaguchi (not on board)

Hiroshi Matsunaga (not on board)

4.2.3 Lidar observations of clouds and aerosols

Nobuo Sugimoto (National Institute for Environmental Studies, not on board)

Ichiro Matsui (National Institute for Environmental Studies, not on board)

Atsushi Shimizu (National Institute for Environmental Studies, not on board)

Tomoaki Nishizawa (National Institute for Environmental Studies, not on board)

4.2,4 Sampling of rainfall, atmospheric vapor, and seawaters

Naoyuki Kurita (JAMSTEC, not on board)

4.2.5 Sky radiometer

Kazuma Aoki (University of Toyama, not on board)

Tadahiro Hayasaka (Tohoku University, not on board)

4.2.6 Milimeter wave radar and Infrared radiometer

Toshiaki Takano (Chiba University, not on board)
Shunsuke Moriya(Chiba University, not on board)
Daichi Nishino(Chiba University, not on board)
Shinji Nakayama (Chiba University, not on board)
Hajime Okamoto (Tohoku University, ot on board)

4.2.7 Air-sea surface eddy flux measurement

Osamu Tsukamoto (Okayama University, not on board)

Fumiyoshi Kondo (University of Tokyo, not on board)

Hiroshi Ishida (Kobe University, not on board)

4.2.8 Kuroshio air-sea interaction observations

Yoshimi Kawai (JAMSTEC, not on board)

Meghan Cronin (NOAA/PMEL, not on board)

Keith Ronnholm (NOAA/PMEL)

J. Michael Strick (NOAA/PMEL)

Akira Nagano (JAMSTEC, not on board)

Hiroyuki Tomita (JAMSTEC, not on board)

4.2.9 Argo

Toshio Suga (JAMSTEC, not on board)

Shigeki Hosoda (JAMSTEC, not on board)

Kanako Sato (JAMSTEC, not on board)

Mizue Hirano (JAMSTEC, not on board)

4.2.10 Geophysical survey

Takeshi Matsumoto (Ryukyu Univ., not on board)

4.3. R/V MIRAI on board scientist and technical staff

Kentaro Ando	JAMSTEC
Tatsuya Fukuda	JAMSTEC
Nishino Daichi	University of Chiba
Mike Strick	NOAA/PMEL
Keith Ronnholm	NOAA/PMEL
Fadli Syamusdin	BPPT
Toru Idai	MWJ
Tomoyuki Takamori	MWJ
Keisuke Matsumoto	MWJ
Akira Watanabe	MWJ
Hiroki Ushiromura	MWJ
Shinsuke Toyoda	MWJ
Yasuhiro Arii	MWJ
Misato Kuwahara	MWJ
Ai Takano	MWJ
Yukihiko Nakano	MWJ
Kei Suminaga	MWJ
Tetsuya Nagahama	MWJ
Katsuhisa Maeno	GODI
Ryo Kimura	GODI
Haris Djoko Nugraha	Indonesian Navy

JAMSTEC: Japan Agency for Marine-Earth Science and Technology

GODI: Global Ocean Development Inc.

MWJ: Marine Works Japan Ltd.

BPPT: Agency for the Assessment and Application of Technology of Indonesia

5. Observations

5.1 Atmospheric Measurements
5.1.1 Surface Meteorological Observations
5.1.1.1 General Meteorological Observations

(1) Personnel

Kentaro Ando	(JAMSTEC) : Principal Investigator
Katsuhisa Maeno	(Global Ocean Development Inc., GODI)
Ryo Kimura	(GODI)
Wataru Tokunaga	(Mirai Crew)

(2) Objectives

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

(3) Methods

Surface meteorological parameters were observed throughout the MR10-02 cruise. During this cruise, we used three systems for the observation; MIRAI Surface Meteorological observation (SMet) system, Shipboard Oceanographic, and Atmospheric Radiation (SOAR) system

i. MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table.5.1.1.1-1 and measured parameters are listed in Table.5.1.1.1-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-second averaged data.

ii. Shipboard Oceanographic and Atmospheric Radiation (SOAR) measurement systems

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

a) Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation.
b) Zeno Meteorological (Zeno/Met) system designed by BNL – wind, air temperature, relative humidity, pressure, and rainfall measurement.
c) Scientific Computer System (SCS) developed by NOAA (National Oceanic and Atmospheric Administration, USA) – centralized data acquisition and logging of all data sets.

SCS recorded PRP data every 6 seconds, while Zeno/Met data every 10 seconds. Instruments and their locations are listed in Table.5.1.1.1-3 and measured parameters are listed in Table.5.1.1.1-4.

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

i. Young Rain gauge (SMet and SOAR)

Inspect of the linearity of output value from the rain gauge sensor to change Input value by adding fixed quantity of test water.

ii. Barometer (SMet and SOAR)

Comparison with the portable barometer value, PTB220CASE, VAISALA.

iii. Thermometer (air temperature and relative humidity) (SMet and SOAR)

Comparison with the portable thermometer value, HMP41/45, VAISALA.

(4) Preliminary results

Figure 5.1.1-1 shows the time series of the following parameters;

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

(5) Data archives

These meteorological data will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC just after the cruise.

(6) Remarks

i. SST (Sea Surface Temperature) data was available in the following periods.

07:19UTC 06th Apr. 2010 to 12:30UTC 16th Apr. 2010
12:00UTC 17th Apr. 2010 to 03:00UTC 02nd May 2010

ii. Following periods, data acquisition was suspended in the territorial waters.

12:30UTC 16th Apr. 2010 - 12:00UTC 17th Apr. 2010 (Palau)
11:00UTC 02nd May. 2010 - 23:50UTC 02nd May. 2010 (Guam, U.S.A.)

Table.5.1.1-1 Instruments and installation locations of MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	compass deck (21 m) starboard side and port side
Thermometer: SST	RFN1-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	Model-370	Setra System, USA	captain deck (13 m) weather observation room
Rain gauge	50202	R. M. Young, USA	compass deck (19 m)
Optical rain gauge	ORG-815DR	Osi, USA	compass deck (19 m)
Radiometer (short wave)	MS-801	Eiko Seiki, Japan	radar mast (28 m)
Radiometer (long wave)	MS-200	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10 m)

Table.5.1.1-2 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, TG-6000, Tokimec
5 Relative wind speed	m/s	6sec./10min. averaged
6 Relative wind direction	degree	6sec./10min. averaged
7 True wind speed	m/s	6sec./10min. averaged
8 True wind direction	degree	6sec./10min. averaged
9 Barometric pressure	hPa	adjusted to sea surface level 6sec. averaged
10 Air temperature (starboard side)	degC	6sec. averaged
11 Air temperature (port side)	degC	6sec. averaged
12 Dewpoint temperature (starboard side)	degC	6sec. averaged
13 Dewpoint temperature (port side)	degC	6sec. averaged
14 Relative humidity (starboard side)	%	6sec. averaged
15 Relative humidity (port side)	%	6sec. averaged
16 Sea surface temperature	degC	6sec. averaged
17 Rain rate (optical rain gauge)	mm/hr	hourly accumulation
18 Rain rate (capacitive rain gauge)	mm/hr	hourly accumulation
19 Down welling shortwave radiation	W/m2	6sec. averaged
20 Down welling infra-red radiation	W/m2	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.5.1.1-3 Instruments and installation locations of SOAR system

Sensors (Zeno/Met)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	foremast (23 m)
Barometer	61202V	R.M. Young, USA	
with 61002 Gill pressure port		R.M. Young, USA	foremast (23 m)
Rain gauge	50202	R.M. Young, USA	foremast (24 m)
Optical rain gauge	ORG-815DA	Osi, USA	foremast (24 m)

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

Table.5.1.1-4 Parameters of SOAR system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 SOG	knot	
4 COG	degree	
5 Relative wind speed	m/s	
6 Relative wind direction	degree	
7 Barometric pressure	hPa	
8 Air temperature	degC	
9 Relative humidity	%	
10 Rain rate (optical rain gauge)	mm/hr	
11 Precipitation (capacitive rain gauge)	mm	reset at 50 mm
12 Down welling shortwave radiation	W/m2	
13 Down welling infra-red radiation	W/m2	
14 Defuse irradiance	W/m2	

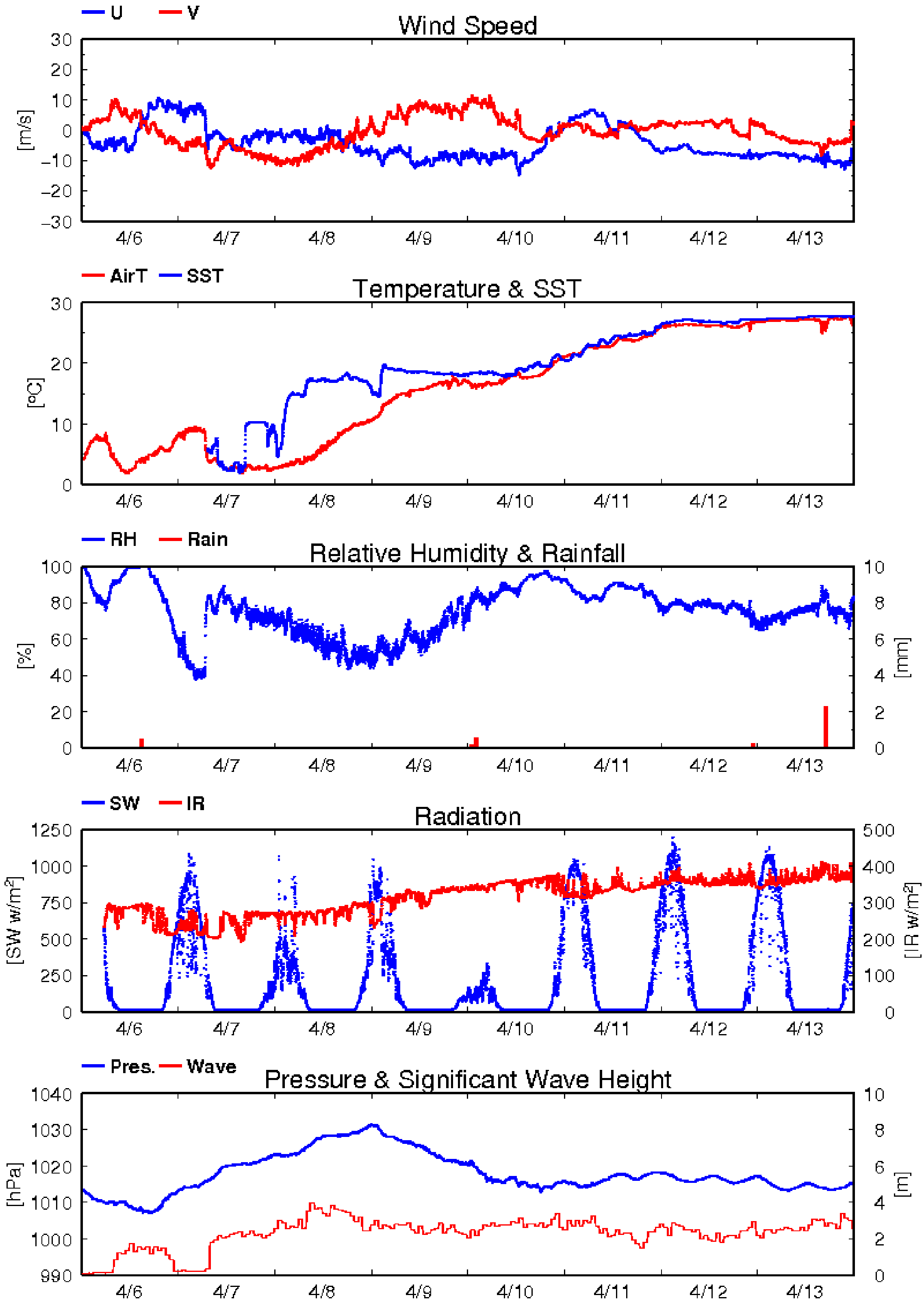


Fig.5.1.1-1 Time series of surface meteorological parameters during the cruise

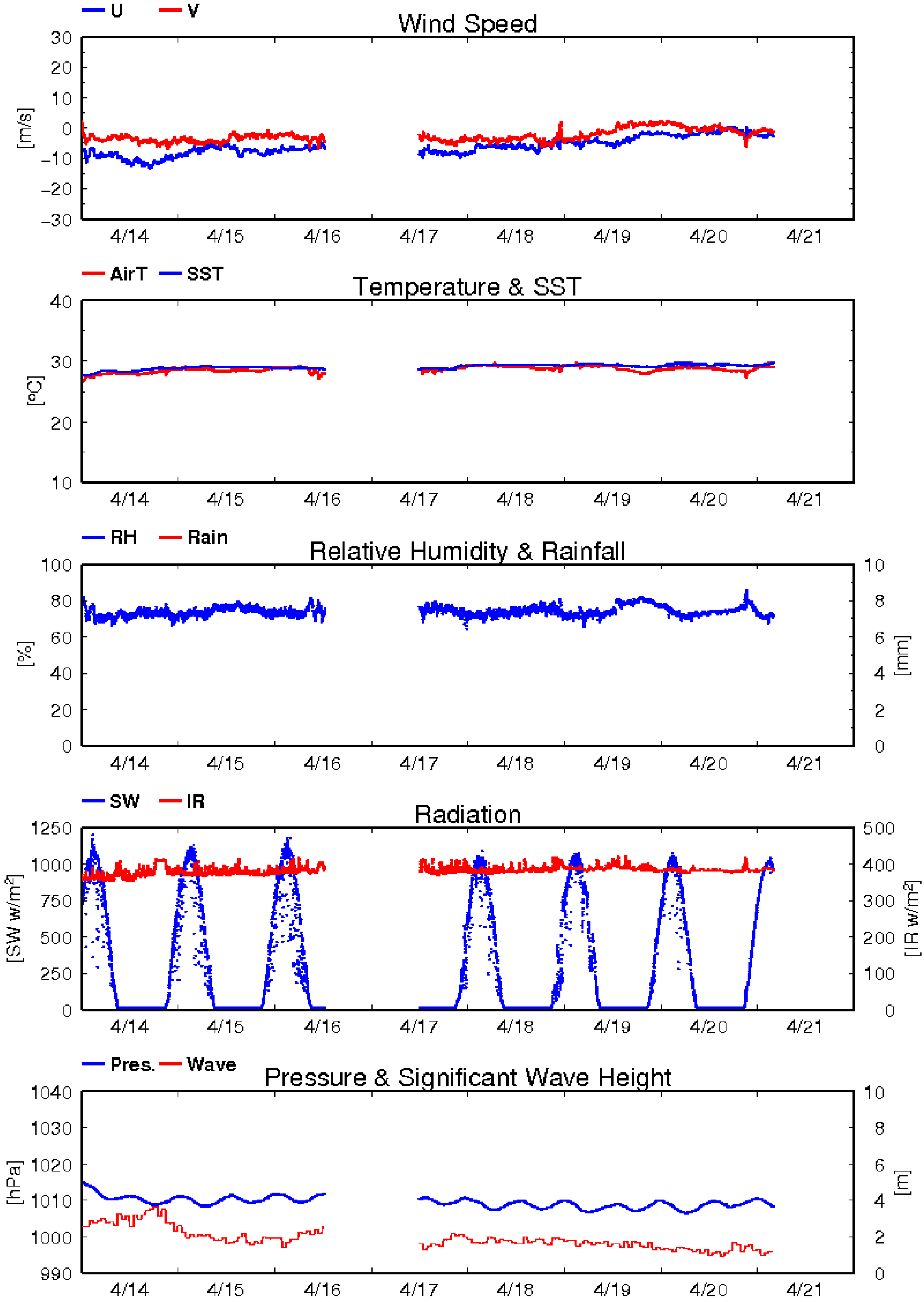


Fig. 5.1.1-1 (Continued)

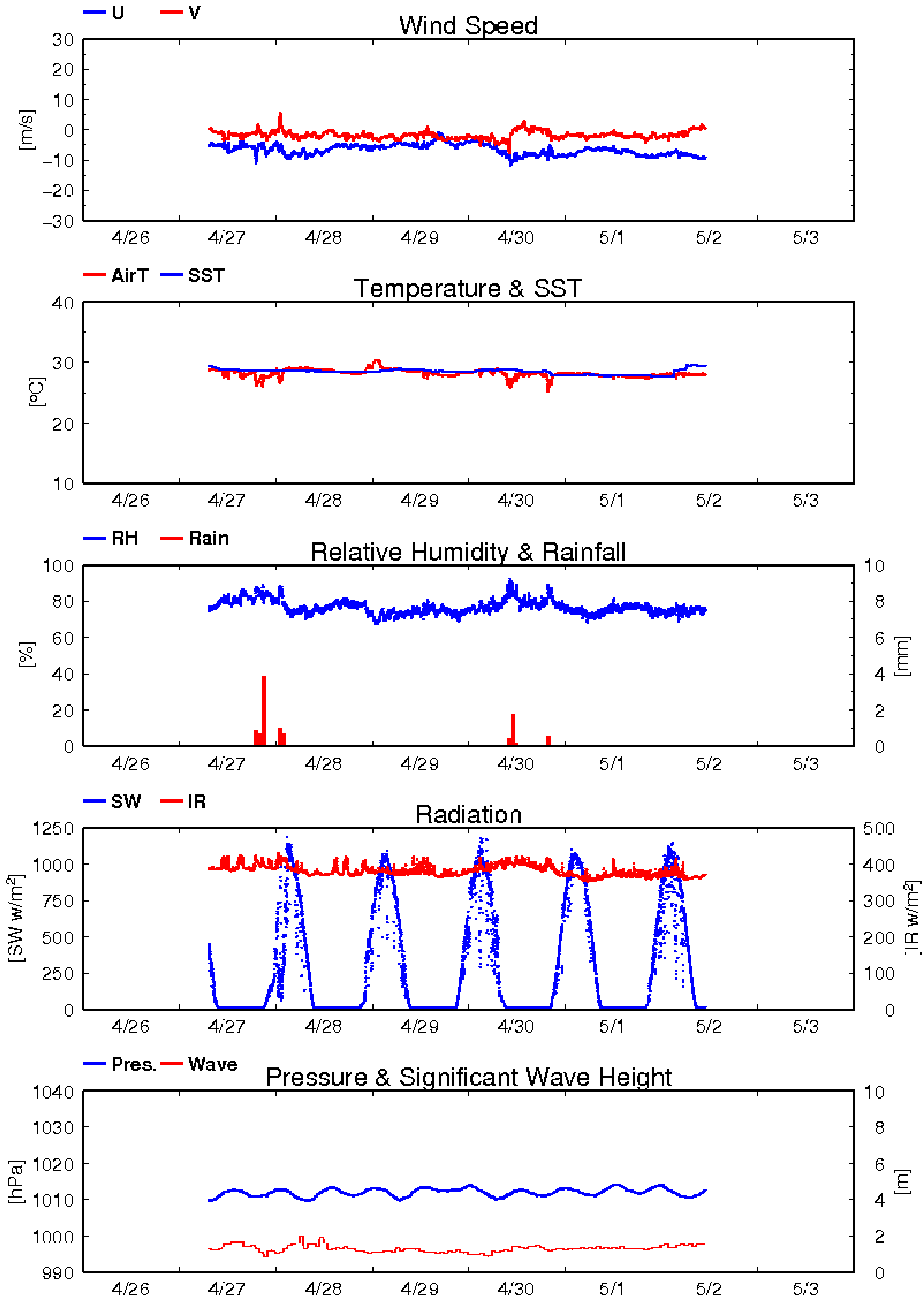


Fig. 5.1.1-1 (Continued)

5.1.1.2 Ceilometer

(1) Personnel

Kentaro Ando	(JAMSTEC): Principal Investigator (not on-board)
Katsuhisa Maeno	(Global Ocean Development Inc., GODI)
Ryo Kimura	(GODI)
Wataru Tokunaga	(MIRAI Crew)

(2) Objectives

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

(3) Paramters

1. Cloud base height [m].
2. Backscatter profile, sensitivity and range normalized at 30 m resolution.
3. Estimated cloud amount [oktas] and height [m]; Sky Condition Algorithm.

(4) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR10-02 cruise.

Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode
Transmitting wavelength:	905±5 nm at 25 degC
Transmitting average power:	8.9 mW
Repetition rate:	5.57 kHz
Detector:	Silicon avalanche photodiode (APD)
	Responsibility at 905 nm: 65 A/W
Measurement range:	0 ~ 7.5 km
Resolution:	50 ft in full range
Sampling rate:	60 sec
Sky Condition	0, 1, 3, 5, 7, 8 oktas (9: Vertical Visibility)
	(0: Sky Clear, 1:Few, 3:Scattered, 5-7: Broken, 8: Overcast)

On the archive dataset, cloud base height and backscatter profile are recorded with the resolution of 30 m (100 ft).

(5) Preliminary results

Fig.5.1.1.2-1 shows the time series of the lowest, second and third cloud base height during the cruise.

(6) Data archives

The raw data obtained during this cruise will be submitted to the Data Integration and Analysis Group (DIAG) in JAMSTEC.

(7) Remarks

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

   12:30UTC 16th Apr. 2010 to 12:00UTC 17th Apr. 2010 (Palau)

   11:00UTC 02nd May. 2010 - 23:50UTC 02nd May. 2010 (Guam, U.S.A.)

2) Window cleaning;

   00:31UTC 06th Apr. 2010

   04:59UTC 12th Apr. 2010

   01:17UTC 20th Apr. 2010

   00:07UTC 01st May. 2010

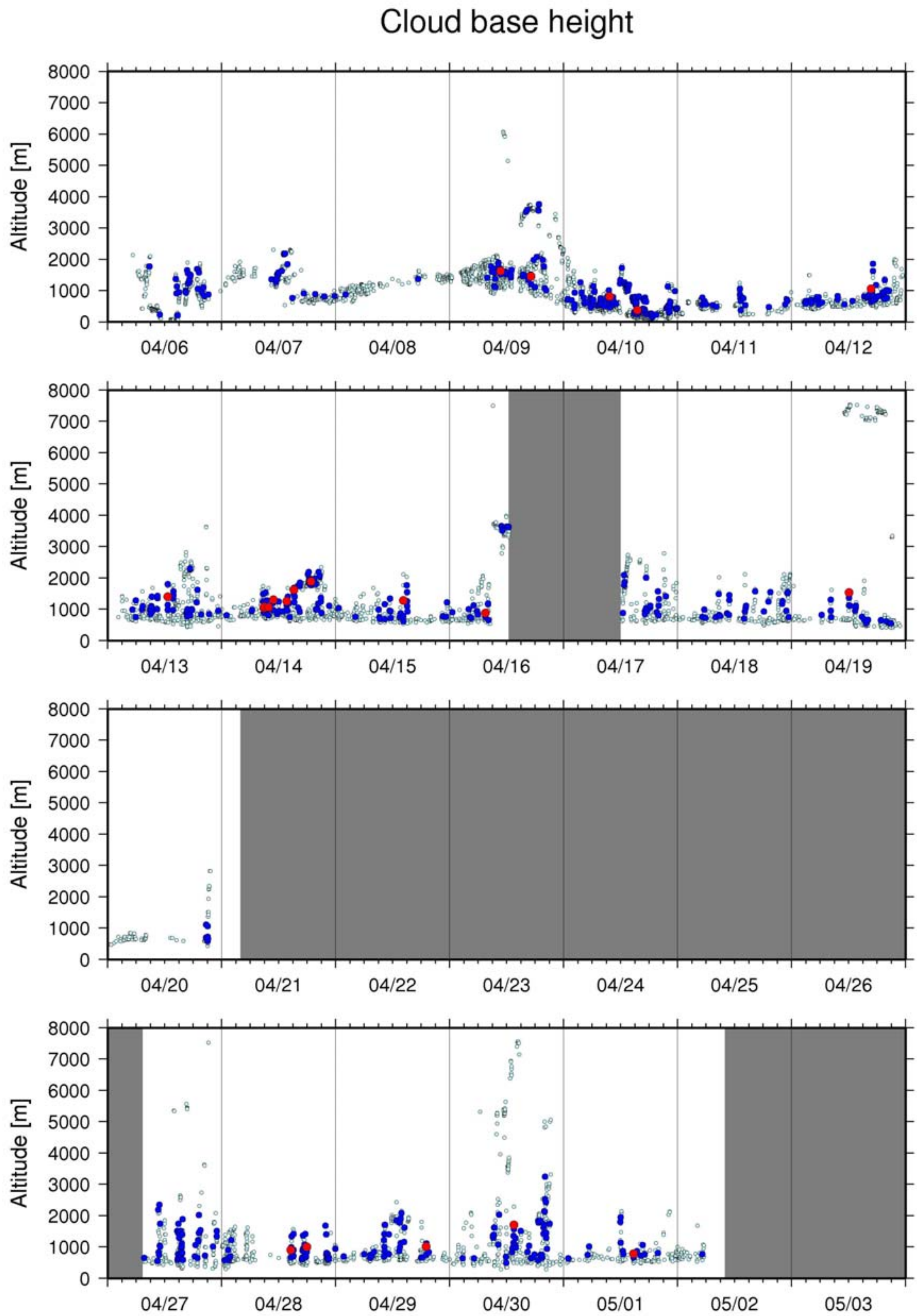


Fig.5.1.1.2-1 Lowest (light-blue), 2nd(blue) and 3rd(red) cloud base height during the cruise

5.1.1.3 GPS Meteorology

(1) Personnel

Mikiko Fujita	(JAMSTEC)	Principal Investigator (not on board)
Katsuhisa Maeno	(GODI)	
Ryo Kimura	(GODI)	
Wataru Tokunaga	(Mirai Crew)	

(2) Objective

Getting the GPS and GLONASS satellite data to derived estimates of the total column integrated water vapor content of the atmosphere.

(3) Method

The GPS and GLONASS satellite data was archived to the receiver (Trimble NetR8) with 5 sec interval. The antenna (GNSS Choke Ring Antenna) was set on the deck at the part of stern. This observation was carried out from April 06 to May 04, 2010.

(4) Results

We will calculate the total column integrated water from observed satellite data later.

(5) Data archive

Raw data is recorded as RINEX format every 5 seconds during the observation. These raw datasets is available from M. Fujita of JAMSTEC.

5.1.2 Lidar observations of clouds and aerosols

(1) Personnel

Nobuo Sugimoto, Ichiro Matsui, Atsushi Shimizu, Tomoaki Nishizawa (National Institute for Environmental Studies, not on board)

Lidar operation was supported by Global Ocean Development Inc and Daichi Nishino (Chiba University).

(2) Objectives

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

(3) Measured parameters

- Vertical profiles of backscattering coefficient at 532 nm
- Vertical profiles of backscattering coefficient at 1064 nm
- Depolarization ratio at 532 nm

(4) Method

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

(5) Results

As lidar data has not been brought to NIES, an example of lidar observation result is shown in Figure 5.1.2-1. Although data duration is one day, multi-layered structure of the atmosphere is depicted. Cirrus clouds appear between 10 – 15 km altitude continuously, and middle layer clouds are detected around 8 km. In the boundary layer aerosols are observed near the beginning of the day, and sometimes cumulus are seen below 1 km. Both of depolarization ratio of 532 nm which represents shape of scatterers and backscatter intensity of 1064 nm sensitive to larger particles are recorded simultaneously.

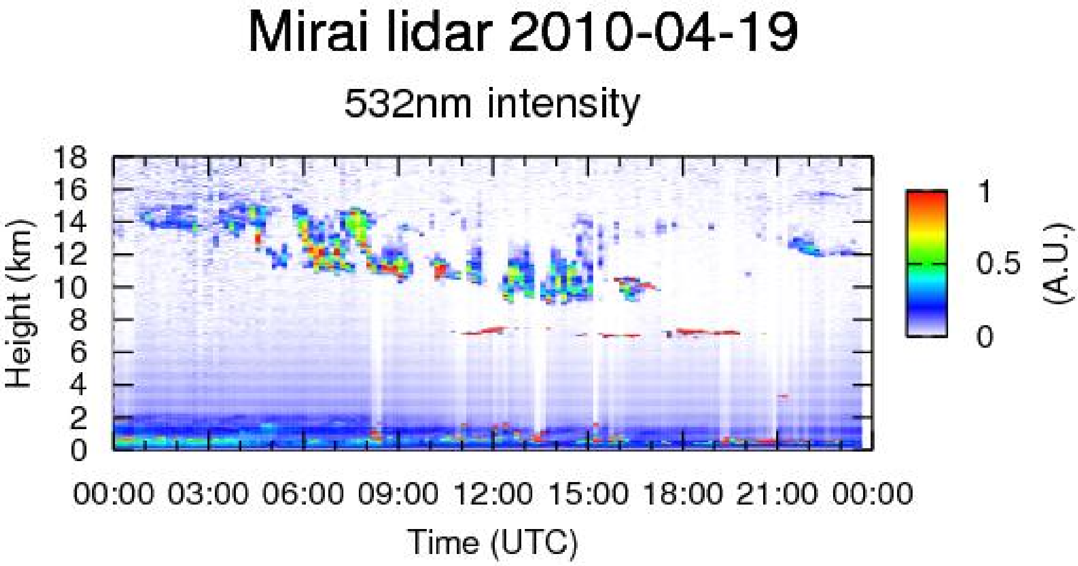


Figure 5.1.2-1: Time-height section of backscatter intensity of 532 nm on April 19, 2010.

(6) Data archive

- raw data

  lidar signal at 532 nm

  lidar signal at 1064 nm

  depolarization ratio at 532 nm

  temporal resolution 10min/ vertical resolution 6 m

  data period (UTC): April 7 – May 2, 2010

- processed data (plan)

  cloud base height, apparent cloud top height

  phase of clouds (ice/water)

  cloud fraction

  boundary layer height (aerosol layer upper boundary height)

  backscatter coefficient of aerosols

particle depolarization ratio of aerosols

(7) Data policy and Citation

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

5.1.3 Sampling of rainfall, atmospheric vapor, and seawaters

(1) Personnel

Naoyuki Kurita (JAMSTEC) Principal Investigator（not on-board）

Operator

Ryo Kimura (Global Ocean Development Inc.: GODI)

(2) Objective

It is well known that the variability of stable water isotopes (HDO and $H_2^{18}O$) is closely related with the moisture origin and hydrological processes during the transportation from the source region to deposition site. Thus, water isotope tracer is recognized as the powerful tool to study of the hydrological cycles in the atmosphere. However, oceanic region is one of sparse region of the isotope data, it is necessary to fill the data to identify the moisture sources by using the isotope tracer. In this study, to fill this sparse observation area, intense water isotopes observation was conducted along the cruise track of MR10-02.

(3) Method

Following observation was carried out throughout this cruise.

- Atmospheric moisture sampling:

  Water vapor was sampled from the height about 20m above the sea level. The air was drawn at rate of 1.6-4.5L/min through a plastic tube attached to top of the compass deck. The flow rate is regulated according to the water vapor content to collect the sample amount 10-30ml. The water vapor was trapped in a glass trap submerged into an ethanol cooled to 100 degree C by radiator, and then they are collected every 12 hour during the cruise. After collection, water in the trap was subsequently thawed and poured into the 6ml glass bottle.

- Rainwater sampling

  Rainwater samples gathered in rain collector were collected just after precipitation events have ended. The collected sample was then transferred into glass bottle (6ml) immediately after the measurement of precipitation amount.

- Surface seawater sampling

  Seawater sample taken by the pump from 4m depth were collected in glass bottle (6ml) around the noon at the local time.

(4) Results

Sampling of water vapor for isotope analysis is summarized in Table 5.1.3-1 (50 samples). The detail of rainfall sampling (10 samples) is summarized in Table 5.1.3-2. Described rainfall amount is calculated from the collected amount of precipitation. Sampling of surface seawater taken by pump from 4m depths is summarized in Table 5.1.3-3 (24 samples).

(5) Data archive

Isotopes (HDO, $H_2^{18}O$) analysis will be done at RIGC/JAMSTEC, and then analyzed isotopes data will be submitted to JAMSTEC Data Integration and Analysis Group (DIAG).

Table 5.1.3-1 Summary of water vapor sampling for isotope analysis

Sample	Date	Time (UT)	Date	Time (UT)	Lon	Lat	Total (m^3)	MASS (ml)
V-1	4.6	08:00	4.6	22:03	141-32.0E	40-34.8N	3.68	19.0
V-2	4.6	22:13	4.7	08:00	141-46.4E	40-31.8N	3.36	7.9
V-3	4.7	08:21	4.7	22:01	144-50.5E	38-55.4N	3.30	10.5
V-4	4.7	22:03	4.8	10:03	146-15.5E	37-32.5N	2.89	9.2
V-5	4.8	10:06	4.8	22:08	145-33.8E	35-25.8N	2.89	9.8
V-6	4.8	22:12	4.9	10:00	144-50.5E	33-14.8N	2.87	16.2
V-7	4.9	10:04	4.9	22:01	144-33.6E	32-21.0N	2.86	22.5
V-8	4.9	22:08	4.10	10:23	144-12.2E	31-10.3N	2.93	32.0
V-9	4.10	10:27	4.10	22:00	143-30.7E	28-32.1N	2.34	32.5
V-10	4.10	22:05	4.11	10:02	142-46.5E	25-49.9N	2.00	33.0
V-11	4.11	10:07	4.11	22:05	141-57.9E	22-58.5N	1.57	29.5
V-12	4.11	22:08	4.12	10:01	140-58.9E	20-20.9N	1.41	27.8
V-13	4.12	10:05	4.12	22:00	139-57.5E	17-33.1N	1.43	27.5
V-14	4.12	22:04	4.13	10:00	139-06.5E	15-13.6N	1.43	27.5
V-15	4.13	10:03	4.13	22:00	138-08.6E	12-32.1N	1.43	28.2
V-16	4.13	22:04	4.14	10:00	137-13.4E	09-56.0N	1.36	27.0
V-17	4.14	10:04	4.14	22:00	136-26.2E	07-48.3N	1.25	25.5
V-18	4.14	22:05	4.15	10:00	136-34.2E	07-37.0N	1.25	26.5
V-19	4.15	10:05	4.15	22:00	136-41.8E	07-39.0N	1.25	26.0
V-20	4.15	22:01	4.16	10:10	135-34.9E	07-59.0N	1.27	27.8
V-21	4.17	12:00	4.17	22:00	136-33.4E	05-23.5N	1.03	27.8
V-22	4.17	22:03	4.18	10:00	137-14.7E	04-52.9N	1.25	27.5
V-23	4.18	10:01	4.18	22:04	137-15.1E	04-51.7N	1.27	27.0
V-24	4.18	22:09	4.19	10:06	137-39.0E	03-31.2N	1.21	25.9
V-25	4.19	10:11	4.19	22:00	138-02.3E	02-00.0N	1.21	25.7
V-26	4.19	22:03	4.20	10:00	137-57.3E	02-04.7N	1.22	26.0
V-27	4.20	10:03	4.20	22:00	138-03.3E	02-03.8N	1.22	25.2
V-28	4.20	22:04	4.21	10:00	137-57.6E	01-01.1N	1.22	25.9
V-29	4.21	10:02	4.21	22:00	137-59.7E	00-02.5N	1.22	25.5
V-30	4.21	22:03	4.22	10:00	137-55.3E	00-18.7S	1.21	26.3
V-31	4.22	10:03	4.22	22:00	136-45.2E	00-00.1N	1.21	25.0
V-32	4.22	22:02	4.23	12:57	134-05.6E	01-11.8N	1.51	32.5
V-33	4.23	12:58	4.23	22:00	132-35.0E	00-00.4N	0.92	18.0
V-34	4.23	22:02	4.24	10:00	130-42.2E	00-55.2N	1.21	26.0
V-35	4.24	10:02	4.24	22:03	129-55.6E	01-56.5N	1.22	24.5
V-36	4.24	22:06	4.25	10:00	130-13.6E	00-56.8N	1.21	25.7
V-37	4.25	10:03	4.25	22:00	130-10.4E	01-54.3N	1.22	24.2
V-38	4.25	22:02	4.26	10:00	130-10.4E	02-37.5N	1.21	26.1

V-39	4.26	10:02	4.26	22:00	130-07.4E	05-04.9N	1.22	24.0
V-40	4.26	22:02	4.27	10:00	130-06.4E	07-02.1N	1.21	25.9
V-41	4.27	10:04	4.27	22:00	130-05.5E	07-55.4N	1.21	25.2
V-42	4.27	22:03	4.28	10:00	130-05.1E	08-01.9N	1.21	26.0
V-43	4.28	10:03	4.28	22:00	130-01.6E	07-59.3N	1.18	24.0
V-44	4.28	22:03	4.29	10:00	131-27.9E	08-32.8N	1.18	22.5
V-45	4.29	10:03	4.29	21:00	133-28.9E	09-20.4N	1.09	20.2
V-46	4.29	21:03	4.30	09:24	135-28.4E	10-19.9N	1.22	26.0
V-47	4.30	09:27	4.30	21:04	137-28.1E	10-59.8N	1.15	22.8
V-48	4.30	21:08	5.1	09:00	139-32.4E	11-41.5N	1.17	24.0
V-49	5.1	09:03	5.1	21:00	141-38.4E	12-30.3N	1.14	22.2
V-50	5.1	21:03	5.2	09:00	143-16.9E	13-08.9N	1.18	24.0

Table 5.1.3-2 Summary of precipitation sampling for isotope analysis.

	Date	Time (UT)	Lon	Lat	Date	Time (UT)	Lon	Lat	Rain (mm)
R-1	4.07	00:00	142-34.5E	40-07.1N	4.07	11:44	142-34.5E	40-07.1N	0.8
R-2	4.07	11:44	142-34.5E	40-07.1N	4.10	04:28	144-32.3E	32-20.7N	0.8
R-3	4.10	04:28	144-32.3E	32-20.7N	4.13	21:41	138-10.4E	12-37.0N	2.6
R-4	4.17	12:00	134-23.4E	06-33.0N	4.23	21:26	132-39.1E	00-00.6N	8.6
R-5	4.23	21:26	132-39.1E	00-00.6N	4.24	23:27	129-55.5E	01-56.7N	1.9
R-6	4.24	23:27	129-55.5E	01-56.7N	4.26	21:15	130-07.5E	04-57.5N	9.2
R-7	4.26	21:15	130-07.5E	04-57.5N	4.27	00:37	130-07.3E	05-31.2N	0.8
R-8	4.27	00:37	130-07.3E	05-31.2N	4.27	22:51	130-04.9E	07-55.6N	9.4
R-9	4.27	22:51	130-04.9E	07-55.6N	4.28	12:57	130-02.4E	08-01.7N	2.7
R-10	4.28	12:57	130-02.4E	08-01.7N	5.01	00:18	138-00.3E	11-09.8N	3.1

Table 5.1.3-3 Summary of water vapor sampling for isotope analysis

Sampling No.		Date	Time (UTC)	Position LON	LAT
MR10-02 O-	1	8-Apr	03:00	145-53.7E	38-23.2N
MR10-02 O-	2	9-Apr	03:01	145-15.8E	34-30.7N
MR10-02 O-	3	10-Apr	03:10	144-31.0E	32-19.7N
MR10-02 O-	4	11-Apr	03:00	143-12.7E	27-26.0N
MR10-02 O-	5	12-Apr	03:01	141-34.3E	21-55.8N
MR10-02 O-	6	13-Apr	03:00	139-43.4E	16-49.8N
MR10-02 O-	7	14-Apr	03:00	137-45.2E	11-27.0N
MR10-02 O-	8	15-Apr	03:00	136-30.1E	07-52.1N
MR10-02 O-	9	16-Apr	03:00	136-40.0E	07-42.1N
MR10-02 O-	10	18-Apr	03:00	137-11.8E	04-53.6N
MR10-02 O-	11	19-Apr	03:00	137-11.8E	04-53.6N

MR10-02 O-	12	20-Apr	03:00	138-04.4E	01-59.8N
MR10-02 O-	13	21-Apr	03:00	137-59.5E	02-02.4N
MR10-02 O-	14	22-Apr	03:00	137-57.1E	00-01.8N
MR10-02 O-	15	23-Apr	03:00	135-32.9E	00-00.0N
MR10-02 O-	16	24-Apr	03:00	131-48.3E	00-41.9N
MR10-02 O-	17	25-Apr	03:00	130-00.7E	01-55.7N
MR10-02 O-	18	26-Apr	03:00	130-11.6E	01-55.9N
MR10-02 O-	19	27-Apr	03:00	130-08.8E	05-53.6N
MR10-02 O-	20	28-Apr	03:00	130-04.3E	07-56.5N
MR10-02 O-	21	29-Apr	03:00	130-04.9E	07-59.8N
MR10-02 O-	22	30-Apr	02:00	134-03.4E	09-33.9N
MR10-02 O-	23	1-May	02:00	138-17.7E	11-15.7N
MR10-02 O-	24	2-May	02:00	142-06.1E	12-40.1N

5.1.4 Sky radiometer

(1) Personnel

Kazuma Aoki (University of Toyama) Principal Investigator / not onboard
Tadahiro Hayasaka (Tohoku University) Co-worker / not onboard

(2) Objective

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

(3) Methods

Sky radiometer is measuring the direct solar irradiance and the solar aureole radiance distribution, has seven interference filters (0.34, 0.4, 0.5, 0.675, 0.87, 0.94, and 1.02 µm). Analysis of these data is performed by SKYRAD.pack version 4.2 developed by Nakajima *et al*. 1996.

(4) Preliminary results

Data obtained in this cruise will be analyzed at University of Toyama.

@ Measured 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 sun. Horizon sensor provides rolling and pitching angles.

(5) Data archives

Measurements of aerosol optical data are not archived so soon and developed, examined, arranged and finally provided as available data after certain duration. All data will archived at University of Toyama (K.Aoki, SKYNET/SKY: http://skyrad.sci.u-toyama.ac.jp/) after the quality check and submitted to JAMSTEC.

5.1.5 Millimeter Wave Radar and Infrared Radiometer

5.1.5.1 Millimeter Wave Radar: FALCON-I (operated by T.Takano et al., Chiba Univ.)

(1) Personnel

TAKANO Toshiaki (Chiba University): Principal Investigator, Associate Prof.
MORIYA Shusuke (Chiba University): Student, Master Course 2nd gr.
NISHINO Daichi (Chiba University): Student, Master Course 1st gr.
NAKAYAMA Shinji (Chiba University): Student, Master Course 1st gr.

(2) Objective

Main objective for the 95GHz cloud radar named FALCON-I is to detect vertical structure of cloud and precipitation and Doppler spectra of the observed targets. Combinational use of the radar, lidar, and infrared radiometer is recognized to be a powerful tool to study vertical distribution of cloud microphysics, i.e., particle size and liquid/ice water content (LWC/IWC).

(3) Observations and products

Observation with FALCON-I was done continuously with 15 sec repetition cycle. Basic output from data is cloud occurrence, radar reflectivity factor, and Doppler spectra. Sensitivity of FALCON-I is about -32 dBZ and its spacial resolution is about 15m at 5 km height.

In order to derive reliable cloud amount and cloud occurrence, we need to have radar and lidar for the same record. Radar / lidar retrieval algorithm has been developed in Tohoku University. The algorithm is applied to water cloud in low level and also cirrus cloud in high altitude. In order to analyze the radar data, it is first necessary to calibrate the signal to convert the received power to radar reflectivity factor, which is proportional to backscattering coefficient in the frequency of interest. Then we can interpolate radar and lidar data to match the same time and vertical resolution. Finally we can apply radar/lidar algorithm to infer cloud microphysics.

(4) Results

The time height cross-sections of radar reflectivity power obtained on April 10 and 30, 2010, during MR10-02 cruise are shown in Fig.5.1.5.1-1. The location of MIRAI was 32N, 144E on

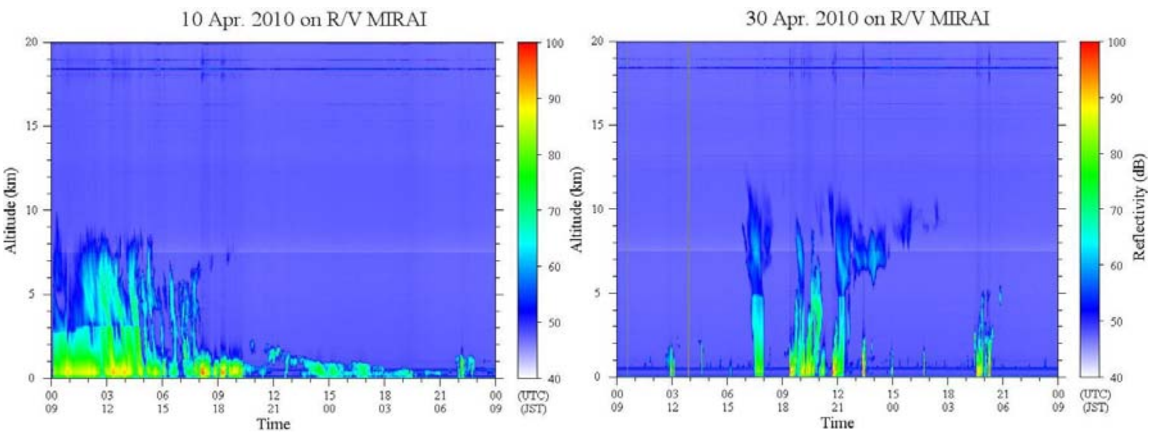


Fig 5.1.5.1-1. Time height cross section of radar reflectivity power in arbitral unit of dB on April 10 and 30, 2010 and the latitudes of MIRAI was 32N and 9N. We can recognize that the heights of the melting layers and cloud tops are higher in the lower latitude.

April 10 and 9N, 134E on April 30. We can recognize that the heights of the melting layers and cloud tops are higher in the lower latitude.

Fig.5.1.5.1-2. shows an expanded time height cross-sections of radar reflectivity power obtained on April 30, 2010 for 2 hours from 6:40. Fig.5.1.5.1-3. shows Doppler spectra at every 20 minutes. Because we measure phase shifts of received signal for Doppler measurement, 2nπ phase

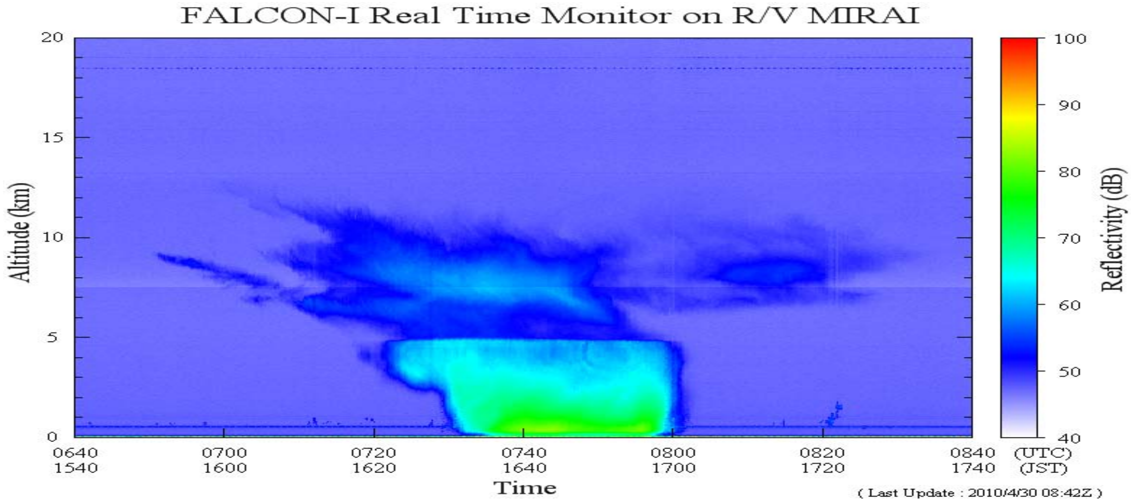


Fig 5.1.5.1-2. Expanded time height cross section of radar reflectivity power in arbitral unit in dB on April 30, 2010 for 2 hours from 6:40. We can see the melting layer around 5 km in height.

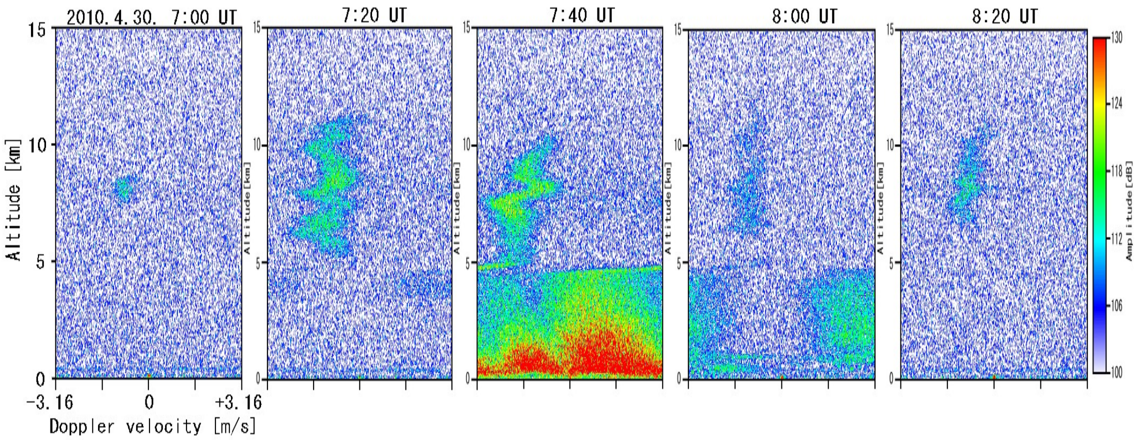


Fig 5.1.5.1-3. Doppler spectra of clouds and rain at every 20 minutes. Clouds above 5 km have velocities of around 1 m/s downward. At the melting layer about 5 km raindrops are accelerated and falling in wide velocity range up to 9 m/s.

ambiguities remain in spectra. We can realize raindrops at 7:40 has suddenly accelerated in the melting layer about 5 km in height and falling in wide velocity range between 3 m/s and 9 m/s downward.

(5) Data archive

The data archive server will be set inside Chiba University and the original data and the results of the analyses will be available from us.

(6) Remarks

The cloud radar is successfully operated for 24 hours during the cruise.

5.1.5.2 **Infrared radiometer** (by H.Okamoto et al., Kyushu Univ., Tohoku Univ.)

(1) Personnel

OKAMOTO Hajime (Kyushu University , Tohoku University)

(2) Objective

The infrared radiometer (hereafter IR) is used to derive the temperature of the cloud base and emissivity of the thin ice clouds. Main objectives are to study clouds and climate system in tropics by the combination of IR with active sensors such as lidar and 95GHz cloud radar with Doppler function. From these integrated approach, it is expected to extend our knowledge of clouds and climate system. We also improved a part of our instrument for the protection of precipitation.

Special emphasis is made to retrieve cloud microphysics in upper part of clouds, including sub-visual clouds that are recognized to be a key component for the exchange of water amount between troposphere and stratosphere. Since June 2006, spaceborn radar and lidar systems, CloudSat and CALIPSO are providing vertical and global distribution of clouds and aerosols. One important aim is to observe the same clouds and aerosols by the observational systems on R/V Mirai. Combination of space-based and ship based observations should provide the unique opportunity to study the complete system of theses clouds and aerosols in relation to its environments. These data will be also used to develop the retrieval algorithms for the new satellite mission, EarthCARE, that will currently be launched in 2013 and will carry Doppler CPR, high spectral resolution lidar, and imager.

(3) Method

IR instrument directly provides broadband infrared temperature (9.6-10.5μm).

General specifications of IR system (KT 19II, HEITRONICS)

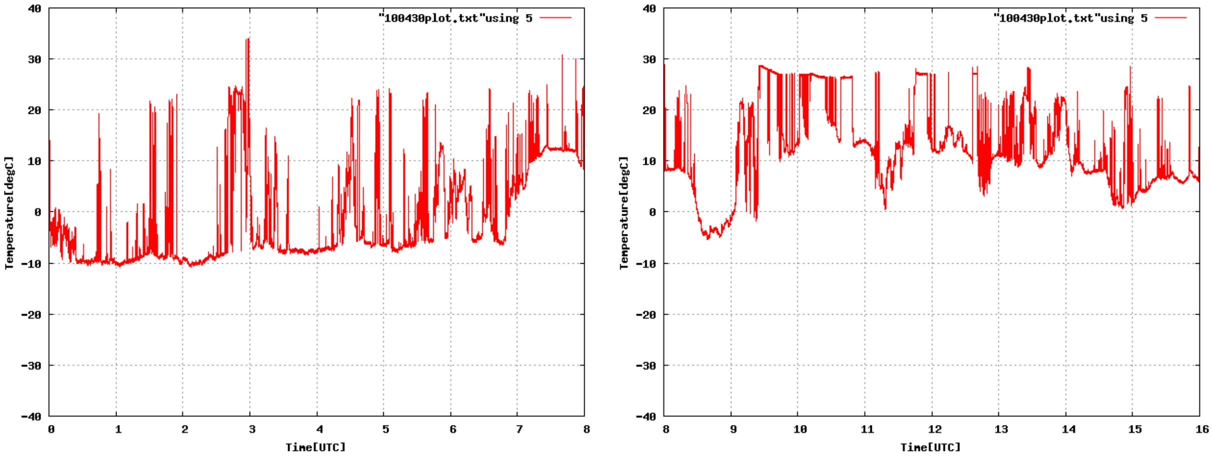
Temperature range	-100 to 100^{o}C
Accuracy	0.5 ^{o}C
Mode	24hours
Time resolution	1 min.
Field of view	Less than 1^{o} (will be estimated later)
Spectral region	9.6-10.5μm

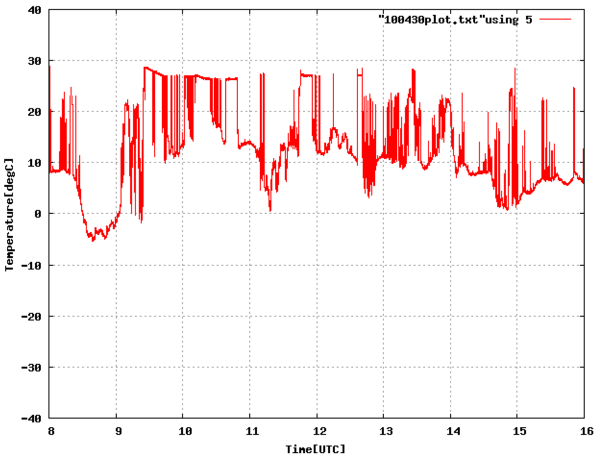
This is converted to the broadband radiance around the wavelength region. This is further combined with the lidar and/or radar for the retrieval of cloud microphysics such as optical thickness at visible wavelength, effective particle size. The applicability of the retrieval technique of the synergetic use of radar/IR or lidar/IR is so far limited to ice clouds. It is also worth to mention that the water cloud bottom can be accurately detected by the instrument. The information is very useful to identify the existence of water particles in clouds. The microphysics of clouds from these techniques will be compared with other retrieval technique such as radar/lidar one or radar with multi-parameter.

When the rain is observed by the rain sensor installed in the IR observing system, the radiometer is automatically rotated and stops at the downward position in order to prevent from the rain drops attached on the lens surface.

(4) Results

Fig. 5.1.5.2-1 displays the temperature measured by IRT on April 30 , 2010. The horizontal line denotes the hours (UTC) and vertical axis is the temperature. The location is 9.33°N and 134.04° E. Relatively high temperature of above 10°C corresponds to the temperature of water cloud bottom. One of the key features of infrared temperature in the low latitude region is that there is very strong contribution of water vapor and the infrared temperature is almost determined by both of the emission due to clouds as well as water vapor. The temperature below -5 °C actually in good correspondence to the occurrence of ice clouds detected by the radar and lidar.





(a) upper left panel
(b) upper right panel
(c) lower panel

Fig 5.1.5.2-1 Temperature measured with the IRT in April 30, 2010, during MR10-02. (a) 0 to 8:00 (UTC), (b) 8 to 16:00 (UTC) and (c) 16:00-24:00 (UTC). Location was 9.33°N and 134.04° E.

(5) Data archive

The data archive server is set inside Kyushu University and the original data and the results of the analyses will be available from us.

(6) Remarks

Basically the IRT is operated for 24 hours. The automatic rain protection system works very fine except for some periods where the rain-protection system worked in clear sky condition after the somewhat strong precipitation events. There were no data in such periods (usually for about a few hours).

5.1.6 Air-sea surface eddy flux measurement

(1) Personnel

Osamu Tsukamoto (Okayama University) Principal Investigator * not on board
Fumiyoshi Kondo (University of Tokyo) * not on board
Hiroshi Ishida (Kobe University) * not on board
Satoshi Okumura (Global Ocean Development Inc. (GODI))

(2) Objective

To better understand the air-sea interaction, accurate measurements of surface heat and fresh water budgets are necessary as well as momentum exchange through the sea surface. In addition, the evaluation of surface flux of carbon dioxide is also indispensable for the study of global warming. Sea surface turbulent fluxes of momentum, sensible heat, latent heat, and carbon dioxide were measured by using the eddy correlation method that is thought to be most accurate and free from assumptions. These surface heat flux data are combined with radiation fluxes and water temperature profiles to derive the surface energy budget.

(3) Instruments and Methods

The surface turbulent flux measurement system (Fig. 5.1.6-1) consists of turbulence instruments (Kaijo Co., Ltd.) and ship motion sensors (Kanto Aircraft Instrument Co., Ltd.). The turbulence sensors include a three-dimensional sonic anemometer-thermometer (Kaijo, DA-600) and an infrared hygrometer (LICOR, LI-7500). The sonic anemometer measures three-dimensional wind components relative to the ship. The ship motion sensors include a two-axis inclinometer (Applied Geomechanics, MD-900-T), a three-axis accelerometer (Applied Signal Inc., QA-700-020), and a three-axis rate gyro (Systron Donner, QRS-0050-100). LI7500 is a CO_2/H_2O turbulence sensor that measures turbulent signals of carbon dioxide and water vapor simultaneously. These signals are sampled at 10 Hz by a PC-based data logging system (Labview, National Instruments Co., Ltd.). By obtaining the ship speed and heading information through the Mirai network system it yields the absolute wind components relative to the ground. Combining wind data with the turbulence data, turbulent fluxes and statistics are calculated in a real-time basis. These data are also saved in digital files every 0.1 second for raw data and every 1 minute for statistic data.

(4) Observation log

The observation was carried out throughout this cruise.

(5) Data Policy and citation

All data are archived at Okayama University, and will be open to public after quality checks and corrections. Corrected data will be submitted to JAMSTEC Marine-Earth Data and Information Department.

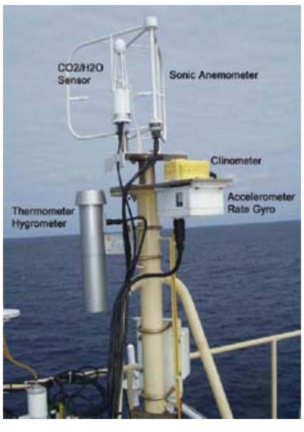


Fig. 5.1.6-1 Turbulent flux measurement system on the top deck of the foremast.

5.2 CTD/XCTD
5.2.1 CTD measurements

(1) Personnel

Kentaro Ando	(JAMSTEC): Principal investigator
Shinsuke Toyoda	(MWJ): Operation leader
Yukihiko Nakano	(MWJ)
Hiroki Ushiromura	(MWJ)

(2) Objective

Oceanic structure measurements and water sampling

(3) Parameters

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

(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) /CWS were 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, dissolved oxygen and altimeter. 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.7.20c) 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.

17 casts of CTD measurements were conducted (table 5.2.1-1).

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.18d) and SEASOFT were as follows:

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

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

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

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

C01M01, C02M01: MR1002a.con

CTD test cast: MR1002b.con

C03M01 - C09M02: MR1002c.con

C10M01 - : MR1002d.con

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:

SBE9plus:C01M01, C02M01, C03M01 - :

S/N 09P9833-0357, Sea-Bird Electronics, Inc.

Pressure sensor: Digiquartz pressure sensor (S/N 42423)

Calibrated Date: 24 Jul. 2009

CTD test cast:

S/N 09P27443-0677, Sea-Bird Electronics, Inc.

Pressure sensor: Digiquartz pressure sensor (S/N 79511)

Calibrated Date: 24 Jul. 2009

Temperature sensors:

Primary: C01M01 - C03M01:

SBE03-04/F (S/N 031525, Sea-Bird Electronics, Inc.)

Calibrated Date: 05 Feb. 2010

C03M02 - :

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

Calibrated Date: 02 Mar. 2010

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

Calibrated Date: 05 Feb. 2010

Conductivity sensors:

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

Calibrated Date: 29 Jan. 2010

Secondary: C01M01 - C09M02:

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

Calibrated Date: 29 Jan. 2010

C10M01 - :

SBE04C (S/N 042435, Sea-Bird Electronics, Inc.)

Calibrated Date: 13 Jun. 2009

Dissolved Oxygen sensors:

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

Calibrated Date: 13 Jun. 2009

Altimeter:

Benthos PSA-916T (S/N 1100, Teledyne Benthos, Inc.)

Carousel water sampler:

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

Deck unit: SBE11plus (S/N 11P7030-0272, Sea-Bird Electronics, Inc.)

(5) Preliminary Results

During this cruise, 17 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 5.2.1-1.

In this cruise, several unknown noises were found during observation. In the down cast of Stn.C01, noise appeared in the data from primary set. In the cast of Stn.C02, noise appeared in the data from primary set again. Then after this cast, we changed 9plus from S/N 0357 to S/N 0677. In the test cast of CTD, primary temperature data shifted. Then, we changed 9plus from S/N 0677 to S/N 0357. Again, in the cast of Stn.C03 cast1, primary temperature data shifted, so we changed primary temperature sensor from S/N 031525 to S/N 03P2730.

Because of this failure, we recomputed dissolved oxygen, primary salinity, primary potential temperature and primary sigma-theta of CTD test cast and Stn.C03 cast1, by the set of primary conductivity and secondary temperature. Those were stored at the column of primary processed data position in the processed datasets.

For the further test, after the cast of Stn.09 we changed secondary conductivity sensor (S/N 041206 - S/N 042435), but there was no significant differences in the test.

Vertical profile (down cast) of primary temperature, salinity and dissolved oxygen with pressure are shown in Figure 5.2.1-1 - 5.2.1-3, without Stn.06 - Stn.09

(6) Data archive

All raw and processed data files were submitted to Data Management Office (DMO). JAMSTEC will be opened to public via “R/V MIRAI Data Web Page” in the JAMSTEC home page.

Table 5.2.1-1 CTD Casttable

Stnnbr	Castno	Date(UTC) (mmddyy)	Time(UTC) Start	Time(UTC) End	BottomPosition Latitude	BottomPosition Longitude	Depth	Wire Out	Max Depth	Max Pressure	CTD Filename	Remark
C01	1	040810	06:27	07:08	38-02.39N	146-30.62E	5409.0	1005.1	1001.4	1011.4	C01M01	J-KEO buoy site down cast: Noise affected secondary data.
C02	1	041010	04:04	04:42	32-20.69N	144-32.23E	5642.0	1003.8	1000.4	1011.9	C02M01	KEO buoy site Noise affected secondary data.
TEST	1	041210	23:36	00:13	17-18.94N	139-52.65E	4851.0	1006.7	1002.5	1011.0	100412	changed 9plus (S/N0357 - S/N0677) Primary temperature data observed sift.
C03	1	041510	04:03	04:41	07-51.95N	136-28.54E	3351.0	1010.9	1001.2	1009.3	C03M01	TRITON buoy deployment changed 9plus (S/N0677 - S/N0357) down cast: Primary temperature data observed sift.
C03	2	041510	06:33	07:12	07-39.45N	136-40.36E	3170.0	1017.7	1000.4	1008.0	C03M02	TRITON buoy recovery changed primary temperature sensor (S/N031525 - S/N03P2730)
C04	1	041810	07:11	07:47	04-57.17N	137-16.41E	4163.0	1011.7	1001.3	1009.4	C04M01	TRITON buoy deployment
C04	2	041810	09:46	10:23	04-53.03N	137-14.71E	3867.0	1022.7	1001.7	1009.6	C04M02	TRITON buoy recovery
C05	1	042010	04:05	04:40	02-00.53N	138-05.50E	4294.0	1005.8	1000.6	1009.2	C05M01	TRITON buoy deployment
C05	2	042010	06:14	06:50	02-03.94N	138-02.41E	4333.0	1008.4	1001.6	1009.5	C05M02	TRITON buoy recovery
C06	1	042110	20:32	21:07	00-01.77N	137-54.34E	4349.0	1007.7	1000.8	1008.7	C06M01	TRITON buoy recovery
C07	1	042310	04:05	04:44	00-00.16N	135-20.25E	4866.0	1004.5	999.9	1007.9	C07M01	
C08	1	042310	21:01	21:39	00-00.60N	132-39.12E	4835.0	1009.7	1002.2	1009.3	C08M01	
C09	1	042410	21:00	21:36	01-55.86N	129-56.35E	4427.0	1010.6	1002.1	1009.9	C09M01	TRITON buoy recovery
C09	2	042610	04:27	05:29	01-55.64N	130-11.29E	4376.0	1005.8	1000.4	1008.0	C09M02	TRITON buoy deployment
C10	1	042810	04:03	04:40	07-57.72N	130-04.54E	5591.0	1005.8	1001.1	1008.9	C10M01	TRITON buoy deployment changed secondary conductivity sensor (S/N041206 - S/N042435)
C10	2	042810	06:37	07:16	07-59.21N	130-00.57E	5713.0	1001.6	1000.8	1008.4	C10M02	TRITON buoy recovery
C11	1	050210	00:02	01:10	12-38.75N	141-59.83E	2913.0	2015.2	2000.6	2022.1	C11M01	ARGO float deployment

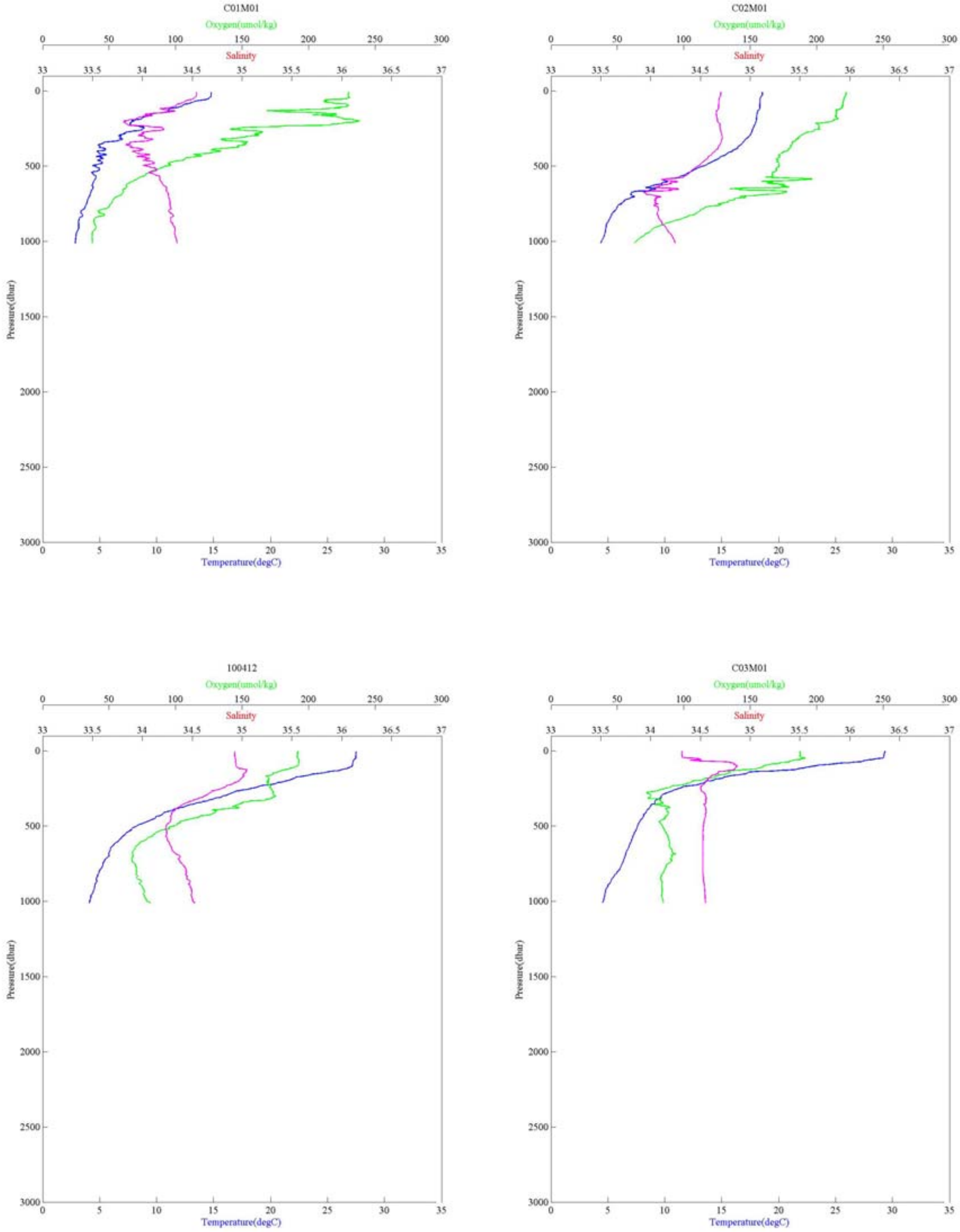


Figure 5.2.1-1 CTD profile (C01M01, C02M01, CTD test (100412) and C03M01)

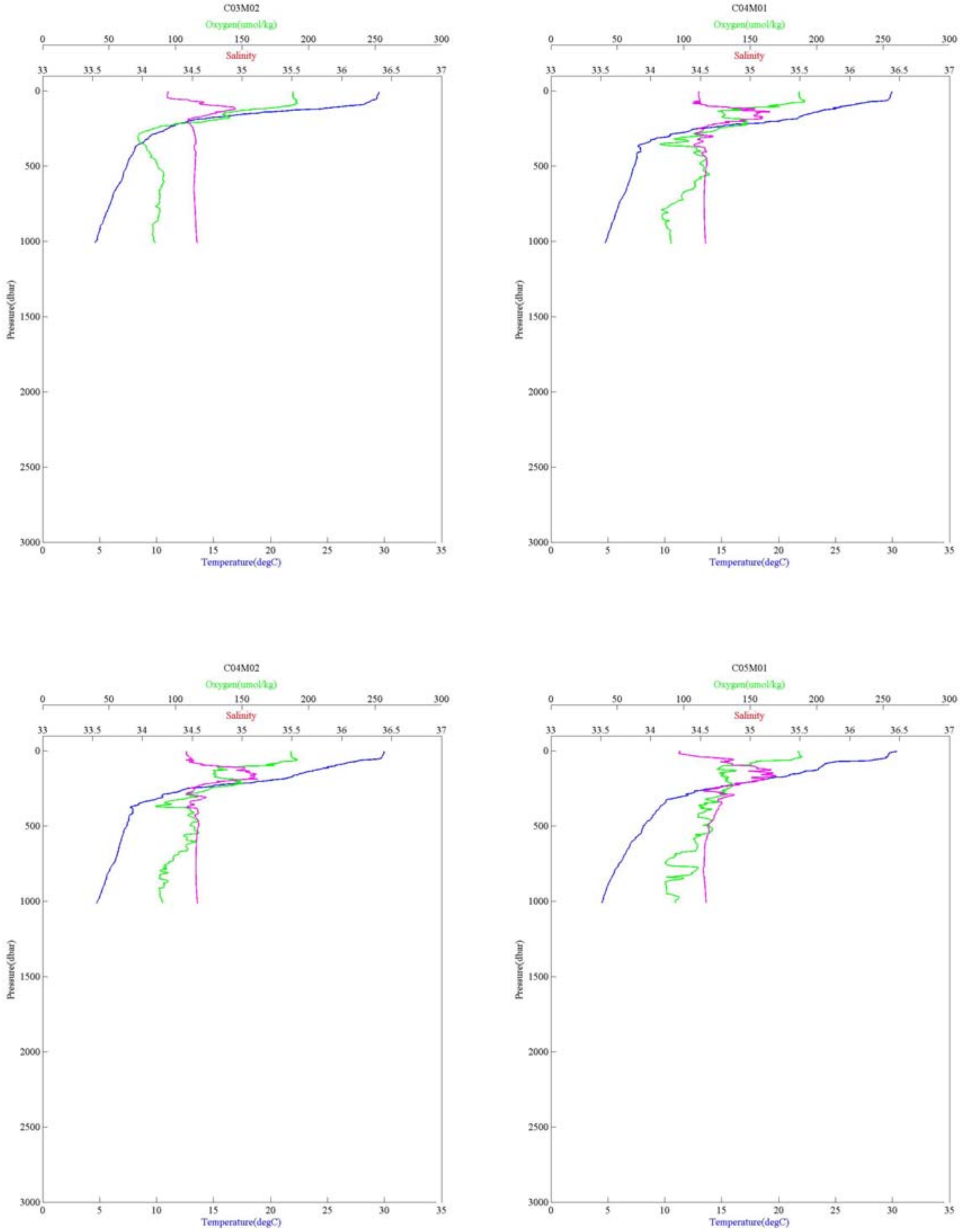


Figure 5.2.1-2 CTD profile (C03M02, C04M01, C04M01 and C05M01)

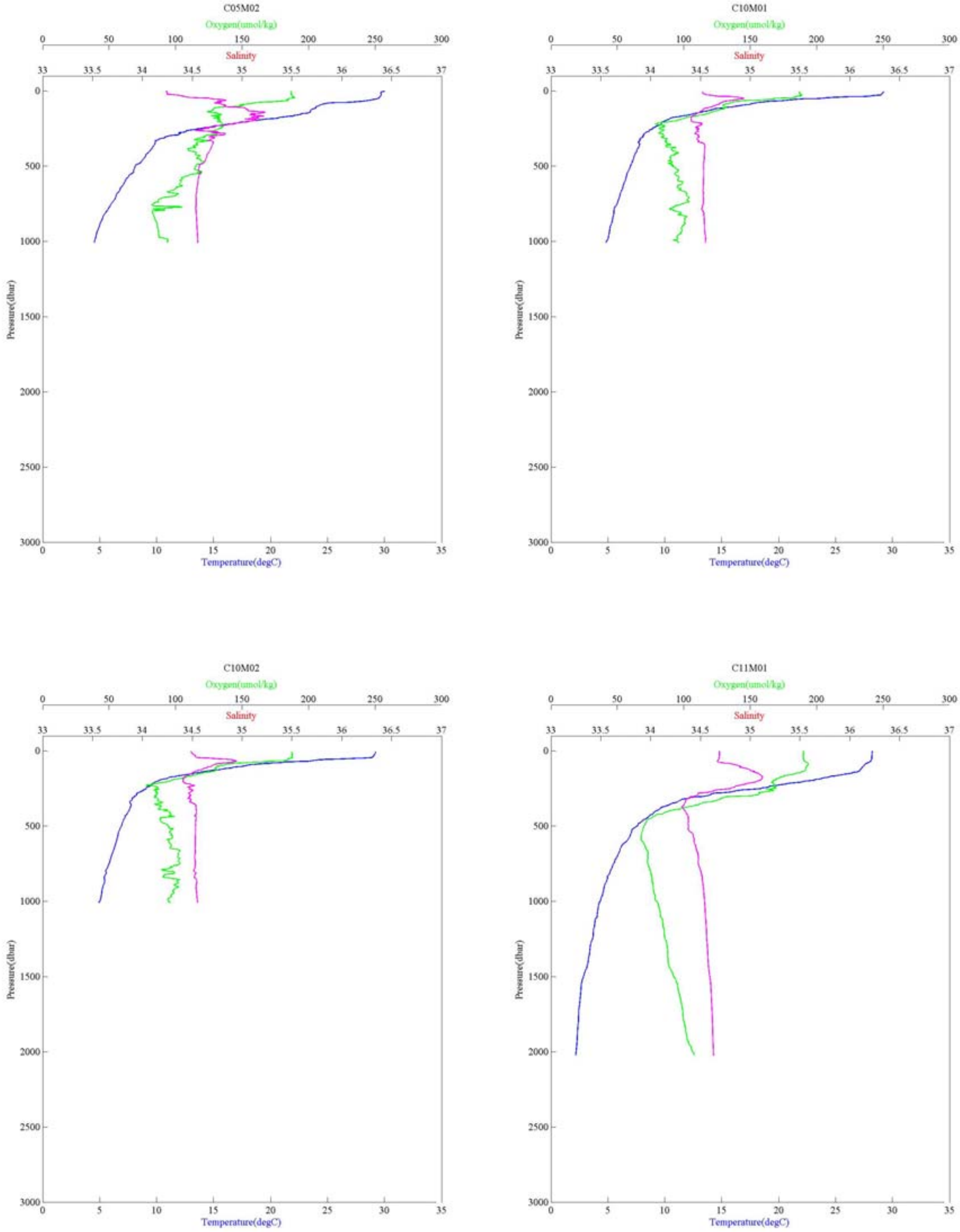


Figure 5.2.1-3 CTD profile (C05M02, C10M01, C10M02 and C11M01)

5.2.2 CTD inter-comparison with TRITON data

(1) Personnel

Kentaro Ando	(JAMSTEC): Principal Investigator
Keisuke Matsumoto	(MWJ): Operation Leader
Shinsuke Toyoda	(MWJ): Technical staff
Akira Watanabe	(MWJ): Technical staff

(2) Objectives

TRITON CTD data validation

(3) Measured parameters

・Temperature
・Conductivity
・Pressure

(4) Methods

TRITON buoy underwater sensors (SBE 37) are equipped along a wire cable of the buoy below sea surface. We used the same CTD (SBE 9/11Plus) system with general CTD observation on R/V MIRAI for this inter-comparison. We conducted 1 CTD cast at each TRITON buoy site immediately before recovery and after deployment. R/V MIRAI was kept the distance from the TRITON buoy within about 2 nm.

TRITON buoy data was sampled every 1 hour for ARGOS satellites transmission. We compared CTD observation by R/V MIRAI data with TRITON buoy data using the 1 hour averaged value.

As our temperature sensors are expected to be more stable than conductivity sensors, conductivity data and salinity data are selected at the same value of temperature data. Then, we calculate difference of salinity from conductivity between the shipboard CTD data on R/V MIRAI and the TRITON buoy data for each deployment and recovery of buoys.

Sites at comparison

Observation No.	Latitude	Longitude	Condition
10009	8N	137E	After Deployment
11009	5N	137E	After Deployment
12011	2N	138E	After Deploymant
14008	8N	130E	After Deploymant
10008	8N	137E	Before Recover
11008	5N	137E	Before Recover
12010	2N	138E	Before Recover
14007	8N	130E	Before Recover

(5) Results

Most of temperature, conductivity and salinity data from TRITON buoy showed good agreement with CTD cast data in T-S diagrams. See the Figures 5.2.2-1(a)(b).

To evaluate the performance of the conductivity sensors on TRITON buoy, the data from had deployed buoy and shipboard CTD data at the same location were analyzed.

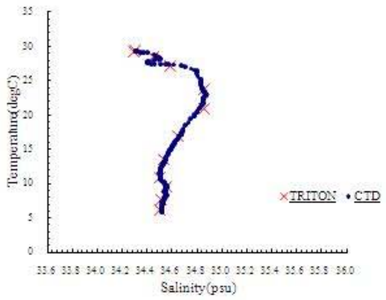
The estimations were calculated as deployed buoy data minus shipboard CTD (9plus) data. The salinity differences are from -0.138 to 0.091 for all depths. Below 300db, salinity differences are from -0.014 to 0.033 (See the Figures 5.2.2-2 (a) and Table 5.2.2-1 (a)). The absolute average of all salinity differences was 0.022 with absolute standard deviation of 0.026.

The estimations were calculated as recovered buoy data minus shipboard CTD (9Plus) data. The salinity differences are from –3.186 to 0.171 for all depths. Below 300db, salinity differences are from 0.001 to 0.102 (See the Figures 5.2.2-2(b) and Table 5.2.2-1 (b)). The absolute average of salinity differences was 0.104 with absolute standard deviation of 0.457.

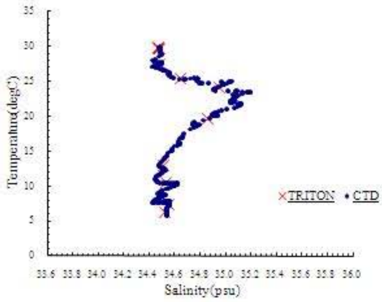
The estimations of time-drift were calculated as recovered buoy data minus deployed buoy data. The difference of salinity over 1 year had the variation ranging from 0.000 to 3.183, for all depths. Below 300db, the difference of salinity over 1 year had the variation ranging from 0.000 to 0.092 (See the figures 5.2.2-2(c)). The absolute average of salinity differences was 0.094 with absolute standard deviation of 0.457.

(6) Data archive

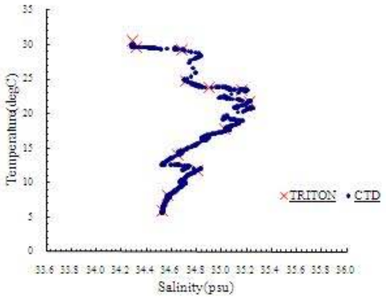
All raw and processed CTD data files were submitted to JAMSTEC TOCS group of the Ocean Observation and Research Department. All original data will be stored at JAMSTEC Mutsu brunch. (See section 5)



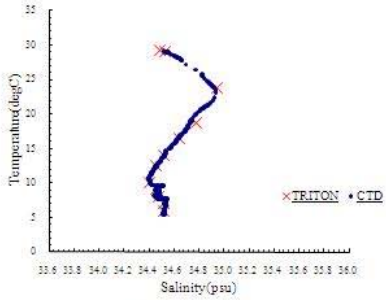
Observation No. 10009 after Deployment



Observation No. 11009 after Deployment

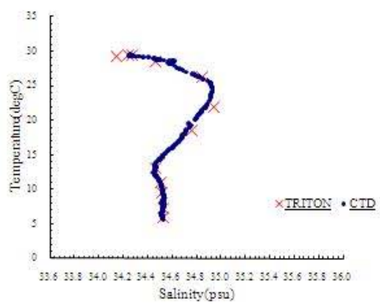


Observation No. 12011 after Deployment

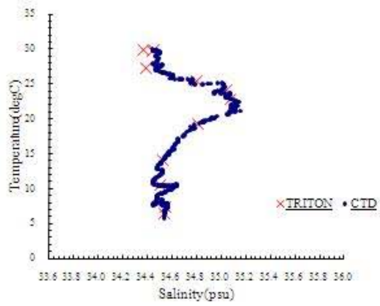


Observation No. 14008 after Deployment

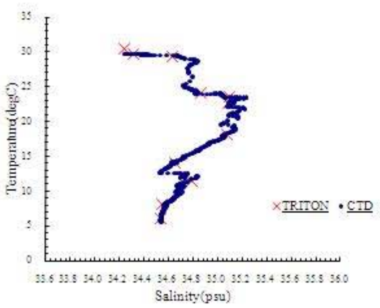
Fig.5.2.2.-1(a) T-S diagram of TRITON buoys data and shipboard CTD data



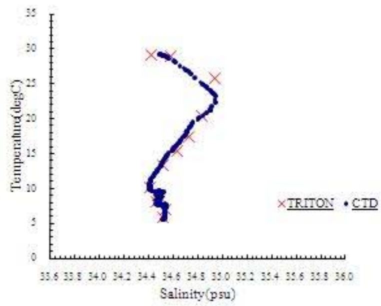
Observation No. 10008 Before Recovery



Observation No. 11008 Before Recovery



Observation No. 12010 Before Recovery



Observation No. 14007 Before Recovery

Fig.5.2.2.-1(b) T-S diagram of TRITON buoys data and shipboard CTD data

Table 5.2.2.-1(a) Data differences between TRITON buoys data and CTD data after deployment

Observation No.	Pressure (db)	Temperature (degC)	Conductivety (S/m)	Salinity (psu)
10009	1.5	0.01	-0.001	-0.019
10009	25.0	0.00	-0.003	-0.017
10009	50.0	0.01	-0.004	-0.031
10009	75.0	0.00	-0.014	-0.093
10009	100.0	-0.05	-0.004	0.017
10009	125.0	0.12	0.018	0.052
10009	150.0	-0.07	-0.010	-0.014
10009	200.0	-0.02	-0.003	-0.012
10009	250.0	-0.06	-0.005	0.003
10009	299.0	-0.16	-0.013	-0.004
10009	500.0	0.00	0.003	-0.012
10009	745.7	-0.04	-0.003	-0.014
11009	1.5	0.01	-0.001	-0.014
11009	25.0	0.00	-0.003	-0.014
11009	50.0	0.00	-0.002	-0.012
11009	75.0	0.01	0.003	0.020
11009	100.0	0.04	-0.015	-0.138
11009	125.0	-0.05	-0.002	0.023
11009	150.0	-0.01	-0.002	-0.009
11009	200.0	-0.12	-0.014	-0.018
11009	250.0	0.03	0.006	0.034
11009	297.6	0.00	0.004	0.033
11009	500.0	0.00	0.000	-0.011
11009	737.9	0.16	0.013	-0.009
12011	1.5	0.30	0.031	-0.001
12011	25.0	0.00	-0.008	-0.056
12011	50.0	0.02	0.000	-0.015
12011	75.0	-0.06	-0.007	-0.010
12011	100.0	0.00	0.004	0.031
12011	125.0	0.00	0.012	0.091
12011	150.0	0.08	0.010	0.010
12011	200.0	0.05	0.004	-0.004
12011	250.0	0.01	0.002	0.007
12011	297.6	0.01	0.000	-0.006
12011	500.0	0.00	0.001	0.006
12011	740.7	0.00	-0.002	-0.006
14008	1.5	0.04	0.000	-0.030
14008	25.0	0.00	-0.004	-0.027
14008	50.0	-0.04	-0.002	0.022
14008	75.0	0.02	0.008	0.043
14008	100.0	0.03	0.005	0.015
14008	125.0	-0.01	-0.001	-0.001
14008	150.0	0.01	0.000	-0.009
14008	200.0	0.01	0.001	-0.002
14008	250.0	-0.01	-0.001	-0.008
14008	296.3	0.00	0.000	0.002
14008	500.0	0.01	0.000	-0.011
14008	723.0	0.10	0.008	-0.008

(red) bad data

Table 5.2.2.-1(b) Data differences between TRITON buoys data and ship board CTD data before recovery

Observation No.	Pressure (db)	Temperature (degC)	Conductivety (S/m)	Salinity (psu)
10008	1.5	0.02	-0.001	-0.015
10008	25.0	0.00	0.004	0.029
10008	50.0	0.00	-0.032	-0.218
10008	75.0	0.02	-0.016	-0.122
10008	100.0	0.04	0.006	0.018
10008	125.0	-0.08	0.000	0.062
10008	150.0	0.01	0.006	0.044
10008	200.0	-0.01	-0.001	-0.004
10008	250.0	0.00	0.001	0.006
10008	300.2	0.01	0.000	-0.011
10008	500.0	0.00	-0.001	-0.001
10008	745.3	0.01	0.001	0.002
11008	1.5	0.00	-0.011	-0.070
11008	25.0	0.01	0.003	0.013
11008	50.0	0.01	-0.007	-0.053
11008	75.0	-0.03	-0.016	-0.095
11008	100.0	0.09	0.015	0.046
11008	125.0	-0.04	0.002	0.051
11008	150.0	0.03	0.003	0.001
11008	200.0	0.04	0.008	0.034
11008	250.0	0.14	0.015	0.016
11008	297.7	0.00	-0.010	-0.102
11008	500.0	0.00	-0.001	-0.011
11008	717.4	0.10	0.008	0.002
12010	1.5	0.74	0.077	-0.003
12010	25.0	0.00	0.010	0.067
12010	50.0	-0.01	-0.008	-0.045
12010	75.0	-0.29	-0.473	-3.186
12010	100.0	-0.02	0.003	0.037
12010	125.0	0.00	0.005	0.037
12010	150.0	-0.02	-0.007	-0.037
12010	200.0	0.00	0.002	0.013
12010	250.0	0.03	0.003	-0.003
12010	299.8	0.10	0.014	0.038
12010	500.0	0.00	-0.002	-0.018
12010	744.5	0.01	0.000	-0.002
14007	1.5	0.00	-0.013	-0.083
14007	25.0	0.01	0.007	0.048
14007	50.0	-0.07	0.016	0.171
14007	75.0	-0.09	-0.010	-0.010
14007	100.0	-0.05	0.000	0.040
14007	125.0	0.14	0.021	0.071
14007	150.0	0.01	0.003	0.015
14007	200.0	0.00	0.000	-0.003
14007	250.0	0.00	0.001	0.010
14007	299.6	0.04	0.003	-0.002
14007	500.0	0.00	0.000	-0.001
14007	731.8	0.00	-0.001	-0.012

bad data

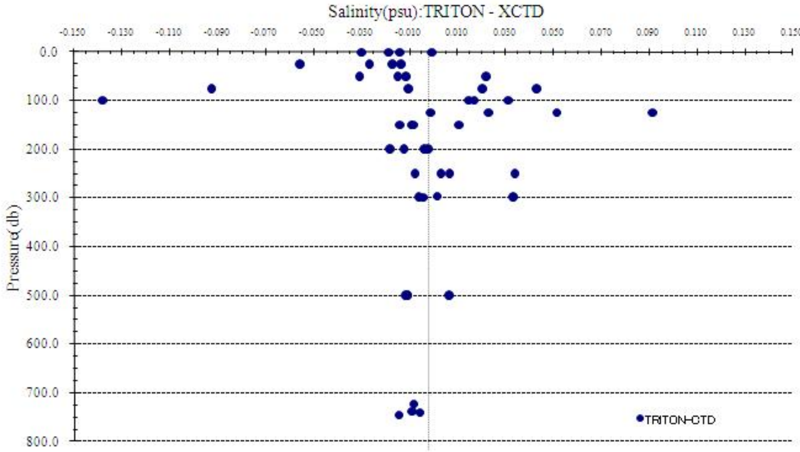


Fig.5.2.2.-2 (a) Salinity differences between TRITON buoys data and shipboard CTD data after deployment

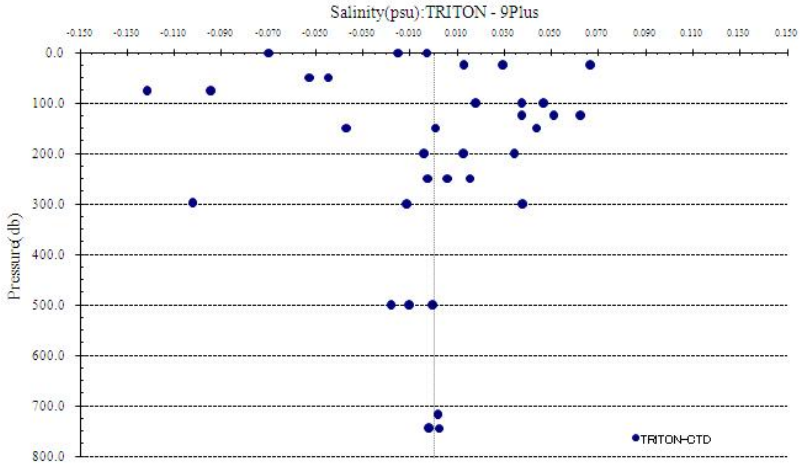


Fig.5.2.2.-2 (b) Salinity differences between TRITON buoys data and shipboard CTD data before recovery

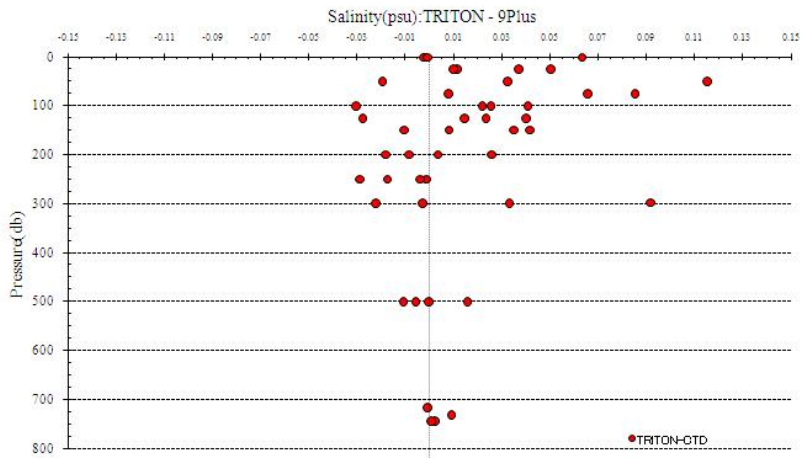


Fig.5.2.2.-2 (c) Salinity differences between deployment data and recovery data for 1year Observation No.10,11,12,14

5.2.3 XCTD

(1) Personnel

Kentaro Ando	(JAMSTEC): Principal Investigator
Katsuhisa Maeno	(Global Ocean Development Inc.: GODI)
Ryo Kimura	(GODI)
Wataru Tokunaga	(MIRAI Crew)

(2) Objectives

Measurements of oceanic structure.

(3) Parameters

According to the manufacturer's nominal specifications, the range and accuracy of parameters measured by the XCTD (eXpendable Conductivity, Temperature & Depth profiler) are as follows;

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

(4) Methods

We observed the vertical profiles of the sea water temperature and salinity measured by XCTD-1 manufactured by Tsurumi-Seiki Co.. The signal was converted by MK-130, Tsurumi-Seiki Co. and was recorded by MK-130 software (Ver.3.07) provided by Tsurumi-Seiki Co.. We launched 82 probes (X01-X81) by using automatic launcher. The summary of XCTD observations and launching log were shown in Table 5.2.3-1. SST (Sea Surface Temperature) and SSS (Sea Surface Salinity) in the table were got from EPCS at launching.

(5) Preliminary results

Position map of XCTD observations was shown in Fig.5.2.3-1.

(6) Data archive

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

Table 5.2.3-1 Summary of XCTD observation and launching log

No.	Station No.	Date	Time	Latitude	Longitude	Max Depth [m]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
X19	TR10REC	2010/04/15	06:44	07-39.37N	136-40.42E	1029	3174	29.490	34.254	09116375
X20	TR11DEP	2010/04/18	07:23	04-57.11N	137-16.39E	1032	4145	29.298	34.477	09116381
X21	TR11REC	2010/04/18	09:55	04-52.92N	137-14.72E	1032	3875	29.939	34.435	09116378
X22	1	2010/04/19	07:38	04-00.00N	137-30.69E	1032	4487	30.215	34.404	09116376
X23	2	2010/04/19	13:01	03-00.02N	137-48.36E	1032	4349	30.003	34.259	09116377
X24	TR12DEP	2010/04/20	04:15	02-00.51N	138-05.49E	1032	4292	30.353	34.273	09116385
X25	TR12REC	2010/04/20	06:25	02-03.91N	138-02.43E	1031	4330	30.304	34.220	09116384
X26	3	2010/04/21	06:38	01-29.96N	137-58.63E	1031	4364	30.444	34.352	09116389
X27	4	2010/04/21	10:10	01-00.00N	137-57.61E	1032	4333	30.295	34.353	09116379
X28	5	2010/04/21	11:56	00-45.00N	137-56.56E	1032	3690	30.140	34.294	09116386
X29	6	2010/04/21	13:39	00-29.97N	137-55.28E	1032	4005	30.519	34.363	09116383
X30	7	2010/04/21	15:20	00-14.79N	137-53.87E	1032	4021	30.135	34.403	09116382
X31-1	TR13REC	2010/04/21	20:43	00-01.81N	137-54.38E	268	4348	29.934	34.384	09116380
X31-2	TR13REC	2010/04/21	20:48	00-01.78N	137-54.35E	140	4347	29.943	34.386	09116388
X32	TR13DEP	2010/04/22	02:12	00-03.63N	138-02.17E	1032	4175	30.105	34.410	09116387
X33	8	2010/04/22	09:47	00-14.99S	137-54.81E	1032	4525	30.224	34.375	09116391
X34	9	2010/04/22	10:50	00-29.97S	137-56.22E	1031	4442	30.401	32.515	09116392
X35	10	2010/04/22	11:54	00-44.99S	137-57.58E	1031	4202	30.264	33.543	09116395
X36	11	2010/04/22	13:00	00-59.99S	137-58.98E	1032	3979	30.119	33.493	09116393
X37	12	2010/04/22	14:02	01-12.00S	138-00.05E	1032	2290	30.026	32.878	09116394
X38	13	2010/04/22	15:12	01-00.00S	137-50.08E	1031	2295	30.131	33.479	09116406
X39	14	2010/04/22	16:23	00-48.01S	137-39.83E	1032	3241	30.186	33.490	09116390
X40	15	2010/04/22	17:34	00-36.00S	137-29.49E	1032	4454	29.940	33.526	09116397
X41	16	2010/04/22	18:43	00-24.00S	137-19.21E	1032	4702	30.018	33.665	09116398
X42	17	2010/04/22	19:50	00-12.00S	137-09.71E	1032	4805	29.989	34.251	09116402
X43	18	2010/04/22	20:58	00-00.00N	137-00.04E	1032	4438	29.936	34.262	09116396
X44	19	2010/04/22	23:05	00-00.01N	136-30.01E	1032	4716	30.325	33.900	09116403
X45	20	2010/04/23	01:10	00-00.33N	136-00.00E	1032	5044	29.994	33.830	09116408
X46	21	2010/04/23	03:13	00-00.02S	135-29.98E	1032	4818	30.618	33.617	09116400
X47	22	2010/04/23	04:16	00-00.13N	135-20.28E	1032	4868	30.167	34.138	09116399
X48	23	2010/04/23	06:11	00-15.00N	135-09.70E	1028	5049	30.629	34.241	09116401
X49	24	2010/04/23	07:30	00-30.00N	135-58.80E	1030	5048	30.514	34.321	09116404
X50	25	2010/04/23	08:49	00-44.99N	134-47.98E	1032	4498	30.269	34.318	09116407
X51	26	2010/04/23	10:09	01-00.00N	134-36.99E	1032	2415	30.248	34.315	09116410
X52	27	2010/04/23	11:26	01-13.80N	134-25.14E	1032	4270	30.332	34.314	09116405
X53	28	2010/04/23	12:34	01-14.13N	134-09.60E	1032	4136	30.148	34.237	10027018
X54	29	2010/04/23	14:04	00-59.45N	133-53.84E	1032	3846	30.296	34.059	10027019
X55	30	2010/04/23	15:47	00-44.67N	133-34.23E	1031	4030	30.251	33.934	10027012
X56	31	2010/04/23	17:22	00-30.00N	133-16.72E	1032	3743	30.371	33.941	10027021
X57	32	2010/04/23	19:04	00-15.01N	132-58.20E	1030	3779	30.205	33.685	09116409
X58	33	2010/04/23	21:13	00-00.64N	132-39.18E	1032	4834	30.101	33.561	10027022

No.	Station No.	Date	Time	Latitude	Longitude	Max Depth [m]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
X59	34	2010/04/23	23:28	00-00.00S	132-15.04E	1032	4524	30.107	33.793	10027024
X60	35	2010/04/24	00:43	00-15.00N	132-05.48E	1031	3949	29.999	33.981	10027014
X61	36	2010/04/24	01:59	00-30.10N	131-55.74E	1031	3654	30.031	33.962	10027013
X62	37	2010/04/24	03:17	00-45.00N	131-46.32E	1032	3550	30.054	34.054	10027016
X63	38	2010/04/24	04:34	01-00.00N	131-37.22E	1032	3778	30.197	34.055	10027020
X64	39	2010/04/24	06:12	01-19.89N	131-24.50E	1031	3327	30.215	33.974	10027015
X65	40	2010/04/24	07:31	01-19.80N	131-06.00E	1031	3782	30.245	34.164	10027017
X66	41	2010/04/24	09:08	01-04.46N	130-51.01E	1032	3662	30.018	34.091	10027026
X67	42	2010/04/24	10:40	00-49.72N	130-35.96E	1032	4319	29.992	34.040	10027028
X68	43	2010/04/24	12:16	00-52.09N	130-18.00E	1031	4197	30.043	34.076	10027025
X69	44	2010/04/24	13:47	00-54.94N	130-00.02E	1032	2818	29.768	33.943	10027023
X70	45	2010/04/24	15:34	01-14.99N	129-58.69E	1032	3382	29.689	33.982	10027027
X71	46	2010/04/24	16:50	01-30.00N	129-57.99E	1031	4128	29.732	34.027	10027034
X72	47	2010/04/24	18:06	01-45.00N	129-56.91E	1031	3543	29.568	34.103	10027035
X73	TR16REC	2010/04/24	21:10	01-55.93N	129-56.41E	1031	4422	29.582	34.195	10027033
X74	TR16DEP	2010/04/26	04:36	01-55.65N	130-11.31E	472	4371	30.081	34.154	10027029
X75	48	2010/04/26	11:49	03-00.00N	130-07.65E	1032	3379	30.433	34.444	10027030
X76	49	2010/04/26	16:43	03-59.99N	130-07.41E	1031	4745	30.014	34.095	10027031
X77	50	2010/04/26	21:29	05-00.00N	130-07.45E	1032	4851	29.795	34.463	10027032
X78	51	2010/04/27	03:38	06-00.00N	130-08.51E	1032	5537	29.839	34.484	10027036
X79	52	2010/04/27	09:50	07-00.00N	130-06.41E	1032	5572	29.552	34.249	10027037
X80	TR14DEP	2010/04/28	04:14	07-57.69N	130-04.59E	466	5604	29.177	34.513	10027038
X81	TR14REC	2010/04/28	07:21	07-59.46N	130-00.55E	1032	5708	29.198	34.498	10027039

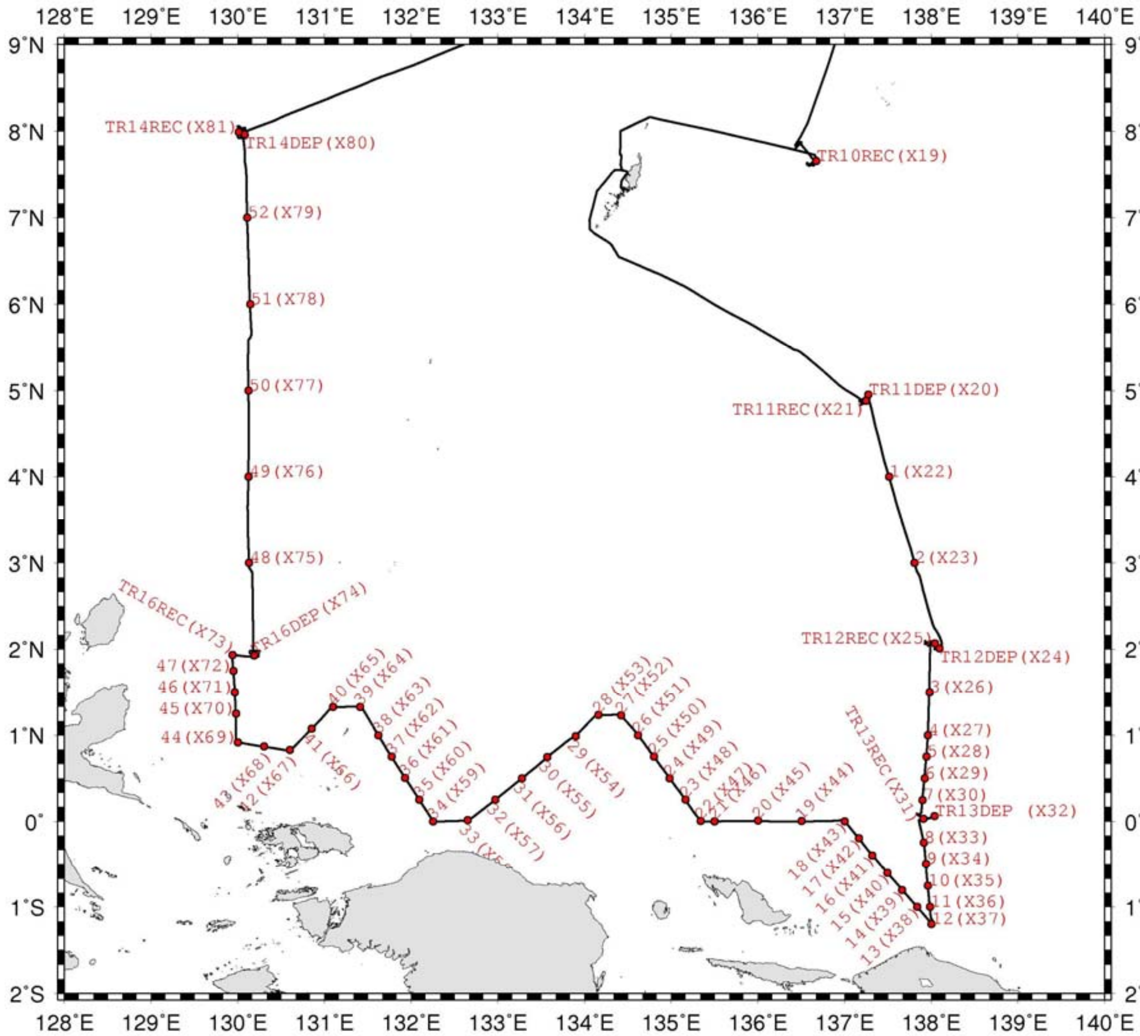


Fig.5.2.3-1 Position map of XCTD observations (Tropical region).

5.3 Microstructure Profiler（MSP）

(1) Personnel

Kentaro Ando (JAMSTEC): Principal Investigator
Katsuhisa Maeno (Global Ocean Development Inc.: GODI)
Ryo Kimura (GODI)
Wataru Tokunaga (MIRAI Crew)

(2) Outlines

The western equatorial Pacific is called “Water Mass Crossroad” (Fine et al., 1994) because of complicated ocean structure due to various water masses from the northern and southern Pacific oceans. Small structure associated with ocean mixing such as interleaving was sometimes observed. Because this mixing effect is not fully implemented in the ocean general circulation model presently, it should be evaluated by in-situ observation. Considering this background, JAMSTEC started collaboration research with IPRC of Univ. of Hawaii since 2007, The past observations revealed interesting fine structures with vertical scale of order 10m and horizontal scale of order 100km. For better understanding of ocean fine structures involving this phenomenon, we observe ocean turbulence using a Turbulence Ocean Microstructure Acquisition Profiles, TurboMAP-L, developed by JFE Advantech Co.,Ltd. during this cruise.

(3) Parameters

Using the TurboMAP-L, we measured following parameters:

Table 5.3-1 Parameters used in the measurements

Parameter	Type	Range	Accuracy	Sample Rate
$\partial u/\partial z$	Shear probe	0～10 /s	5%	512Hz
$T+\partial T/\partial z$	EPO-7 thermistor	−5～45℃	±0.01℃	512Hz
T	Platinum wire thermometer	−5～45℃	±0.01℃	64Hz
Conductivity	Inductive Cell	0～70mS	±0.01mS	64Hz
Depth	Semiconductor strain gauge	0～1000m	±0.2%	64Hz
x- acceleration	Solid-state fixed mass	±2G	±1%	256Hz
y- acceleration	Solid-state fixed mass	±2G	±1%	256Hz
z- acceleration	Solid-state fixed mass	±2G	±1%	64Hz
Chlorophyll	Fluorescence	0～100 μg/Lm	0.5 μg/L or ±1%	256Hz
Turbidity	Backscatter	0～100ppm	1ppm or ±2%	256Hz
$\partial u/\partial z$	Shear probe	0～10 /s	5%	512Hz

We use following twin shear probes for measuring current shear:

Primary: S/N 685

Secondary: S/N 686

(4) Observation stations

Table 5.3-2 Observation stations during MR10-02

No.	Station ID	Date	Observation Start			Max Depth	
			Time	Longitude	Latitude	Time	Depth (m)
1	TR10	2010/04/16	04:05	07-43.0231N	136-39.4577E	04:29	604
2	TR11	2010/04/18	07:54	04-57.4558N	137-16.3824E	08:08	396
3	TR12	2010/04/20	04:52	02-00.6251N	138-05.3329E	05:08	496
4	TR13	2010/04/22	08:04	00-00.7695N	137-51.4700E	08:20	483
5	TR16	2010/04/26	05:42	01-55.5655N	130-11.2748E	05:58	540
6	TR14	2010/04/28	04:49	07-57.9894N	130-04.5697E	05:09	675

(5) Operation and data processing

We operated the TurboMAP-L by a crane which is usually used for foods supply and installed in the middle of ship. We lowered it at the starboard of R/V Mirai. Measurement depth was 500m because our interest is ocean turbulence around thermocline. Table 5.3-1 shows the weight of sinker internal sensor unit and the average rate of descent. In the station TR11 and TR13, we have added weight of 300g.

Data acquisition and processing were carried out using PC in the Atmospheric Gas Observation Room of R/V Mirai. Data processing software was TMTool ver.3.04C provided by JFE Advantech Co.,Ltd.

Table 5.3-3

No.	1	2	3	4	5	6
Station ID	TR10	TR11	TR12	TR13	TR16	TR14
Weight (g)	1300	1600	1600	1900	1900	1900
Average rate of descent (m/s)	0.44	0.50	0.54	0.60	0.61	0.61

(6) Preliminary results

Fig.5.3-1 to Fig.5.3-4 show current shear in each station except the EEZ of Indonesia.

(7) Data archives

The raw data obtained during this cruise will be submitted to the Data Integration and Analysis Group (DIAG) in JAMSTEC.

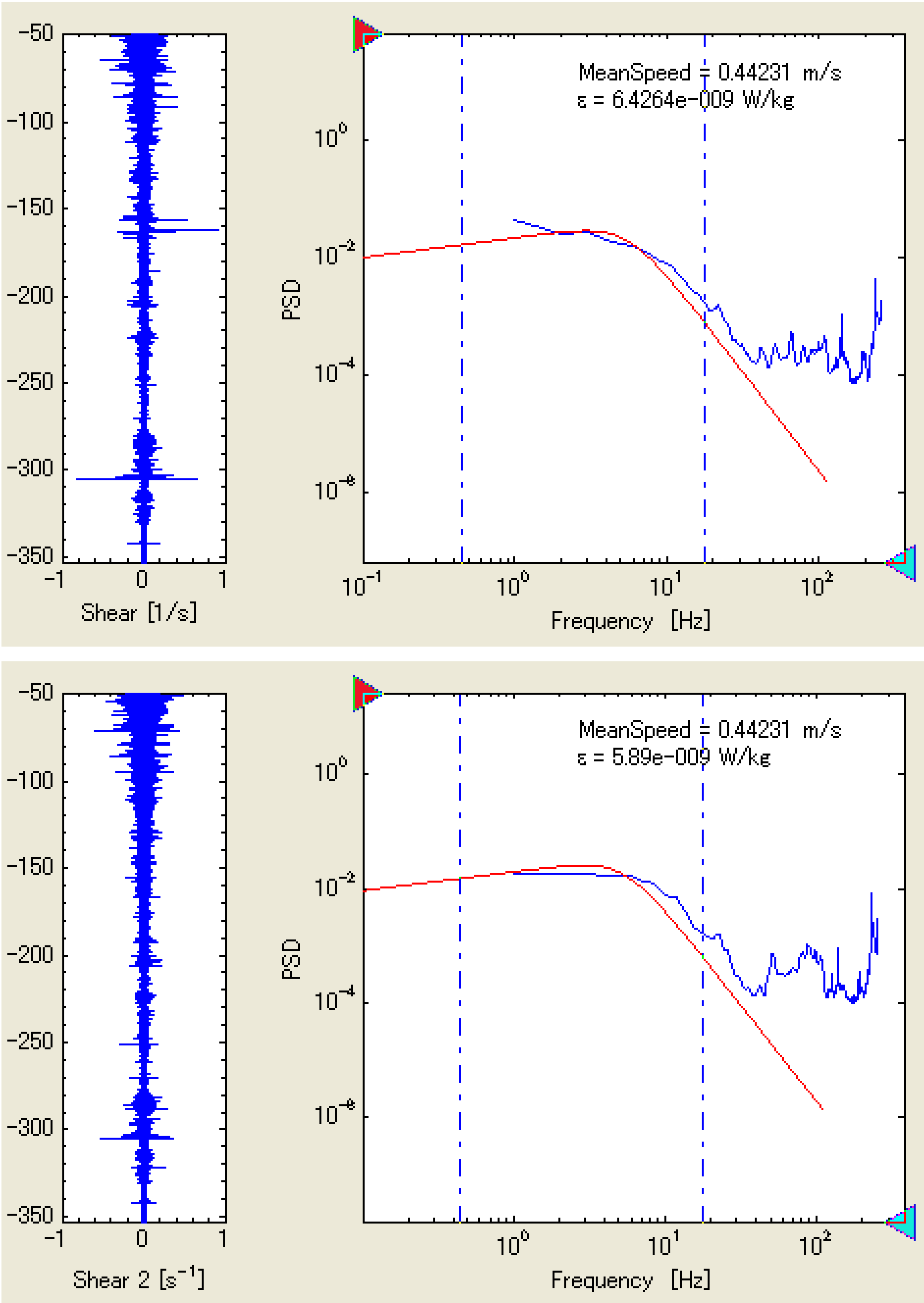


Fig.5.3-1 Profile of primary (upper) and secondary (lower) current shear in the station of TRITON No.10.

The left-hand graph shows vertical profile of the shear data (50 – 350m depth).

The right-hand graph shows the power spectrum of the data (blue) and fit a Nasmyth universal spectrum to the data (red).

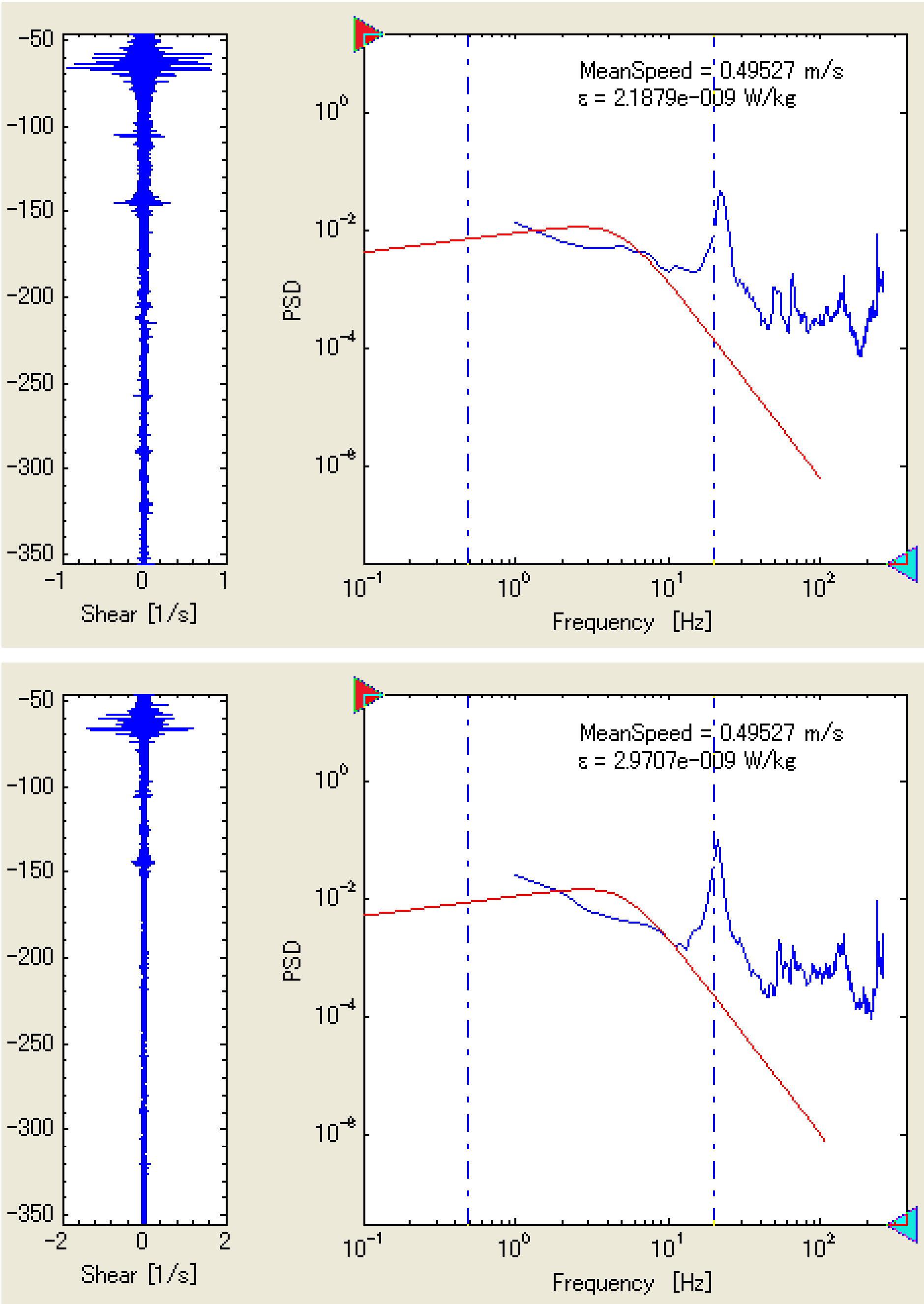


Fig.5.3-2 Profile of primary (upper) and secondary (lower) current shear in the station of TRITON No.11.

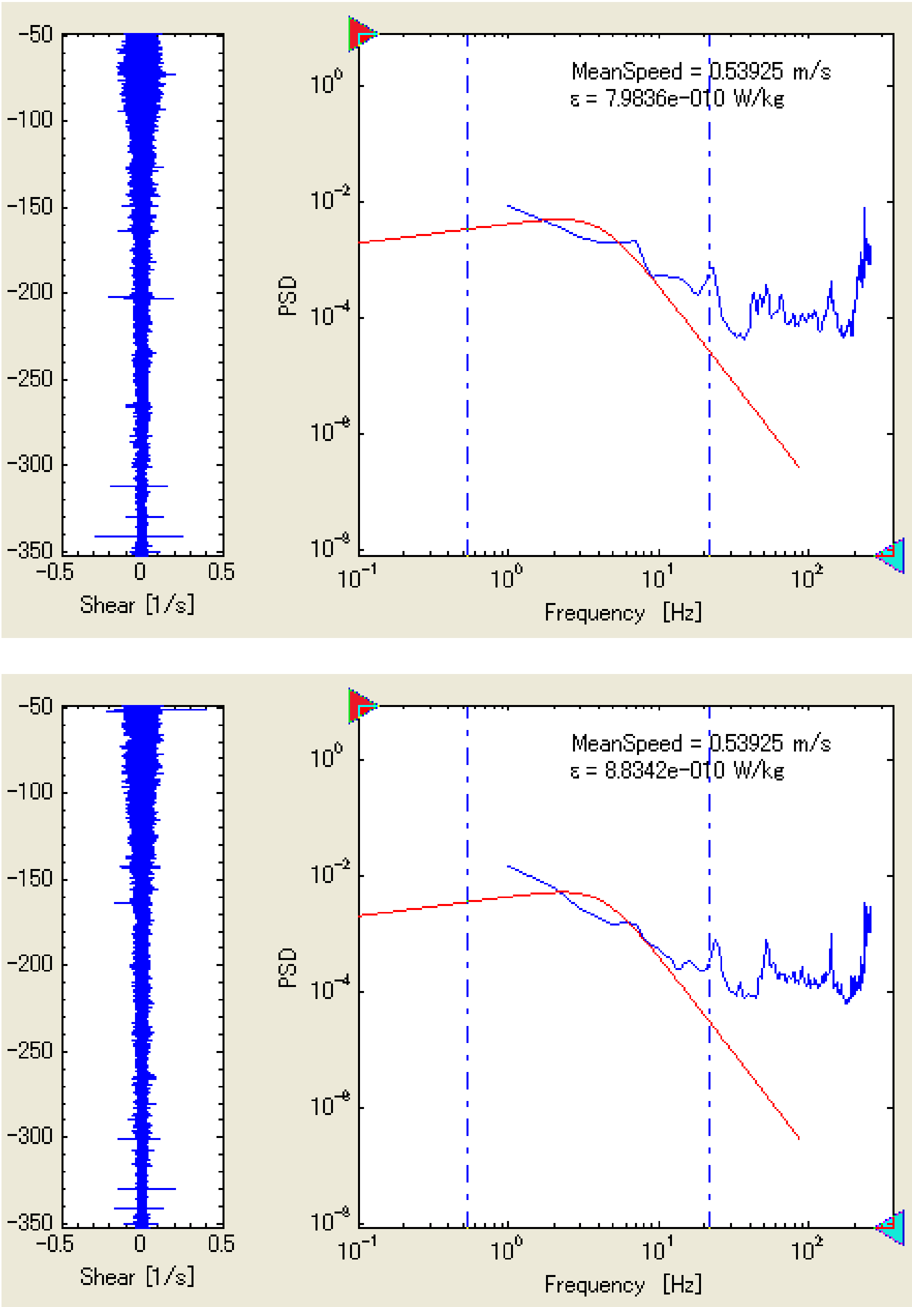


Fig.5.3-3 Profile of primary (upper) and secondary (lower) current shear in the station of TRITON No.12.

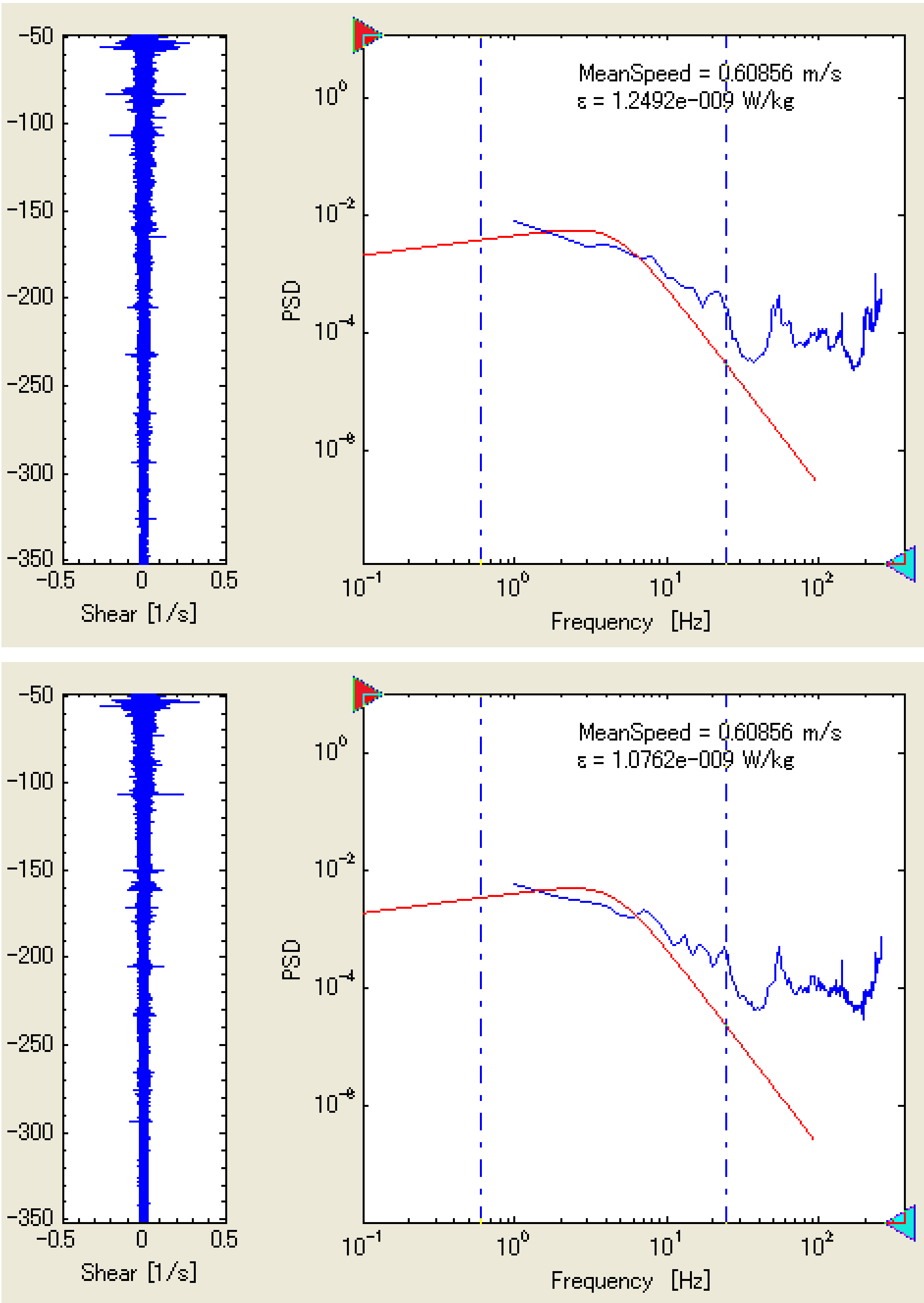


Fig.5.3-4 Profile of primary (upper) and secondary (lower) current shear in the station of TRITON No.14.

5.4 Water sampling
5.4.1 Salinity

Kentaro Ando	(JAMSTEC)：Principal Investigator
Hiroki Ushiromura	(MWJ)：Operation Leader
Shinsuke Toyoda	(MWJ)

(1) Objectives

To measure bottle salinity obtained by CTD casts and EPCS.

(2) Method

a. Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles and EPCS. The salinity sample bottle of the 250ml brown grass bottle with screw cap was used for collecting the sample water. Each bottle was rinsed three times with the sample water, and was filled with sample water to the bottle shoulder. The salinity sample bottles for EPCS were sealed with a plastic insert thimble and a screw cap because we took into consideration the possibility of storage for about a month. The thimble was rinsed 3 times with the sample water before use. The bottle was stored for more than 21 hours in the laboratory before the salinity measurement.

The kind and number of samples taken are shown as follows；

Table 5.4.1-1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD	40
Samples for EPCS	33
Total	73

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR10-02 using the salinometer (Model 8400B “AUTOSAL”； Guildline Instruments Ltd.: S/N 62556) 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 AUTOSAL salinometer and thermometer are shown as follows；

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

Measurement Range	:	0.005 to 42 (PSU)
Accuracy	:	Better than ±0.002 (PSU) over 24 hours without re-standardization
Maximum Resolution	:	Better than ±0.0002 (PSU) at 35 (PSU)

Thermometer (Model 9540 ; Guildline Instruments Ltd.)

Measurement Range	:	-40 to +180 deg C
Resolution	:	0.001
Limits of error ±deg C	:	0.01 (24 hours @ 23 deg C ±1 deg C)
Repeatability	:	±2 least significant digits

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 22 deg C to 24 deg C, while the bath temperature was very stable and varied within +/- 0.003 deg C on rare occasion.

The measurement for each sample was done with the double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 10 seconds after filling the cell with the sample and it took about 15 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell after rinsing 5 times. 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 practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. In the case of the double conductivity ratio of eighth filling did not satisfy the criteria above, we measured a ninth filling of the cell and calculated the bottle salinity above. The measurement was conducted in about 3 - 7 hours per day and the cell was cleaned with soap after the measurement of the day.

(3)Result

a. Standard Seawater

Standardization control of the salinometer was set to 624 and all measurements were done at this setting. The value of STANDBY was 24+5473 +/- 0001 and that of ZERO was 0.0+0002 +/- 0001. The conductivity ratio of IAPSO Standard Seawater batch P151 was 0.99997 (the double conductivity ratio was 1.99994) and was used as the standard for salinity.

We measured 12 bottles of P151.

Fig.5.4.1-1 shows the history of the double conductivity ratio of the Standard Seawater batch P151 before correction. The average of the double conductivity ratio was 1.99994 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

Fig.5.4.1-2 shows the history of the double conductivity ratio of the Standard Seawater batch P151 after correction. The average of the double conductivity ratio after correction was 1.99994 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	:	P151
conductivity ratio	:	0.99997
salinity	:	34.999
Use by	:	20th-May-2012
preparation date	:	20th-May-2009

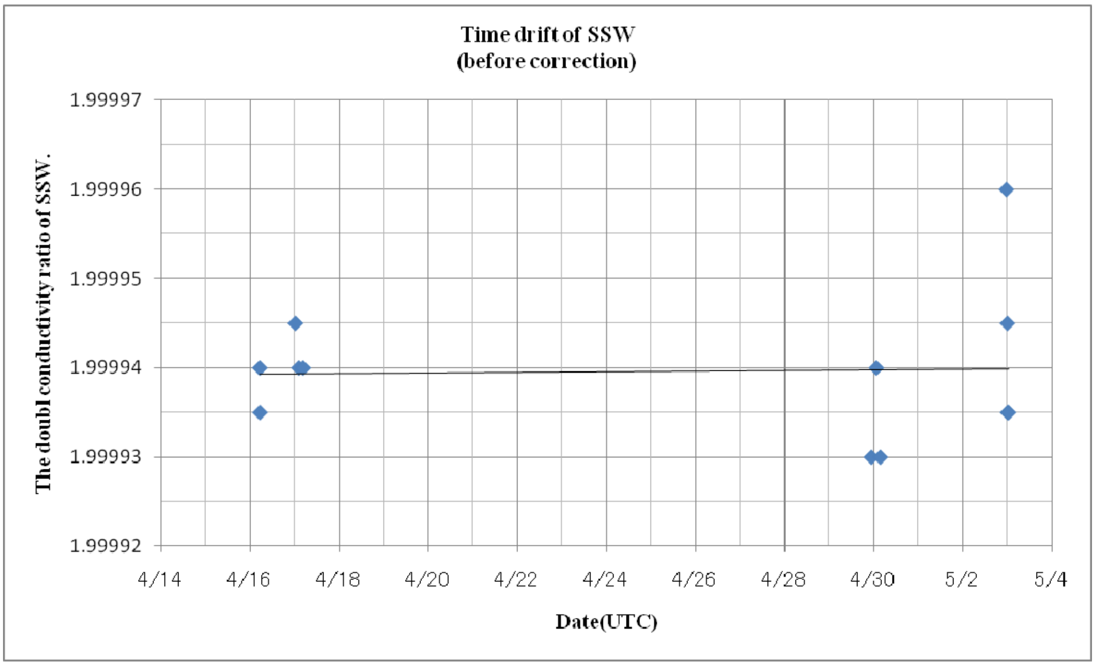


Fig. 5.4.1-1 The history of the double conductivity ratio for the Standard Seawater batch P151 (before correction)

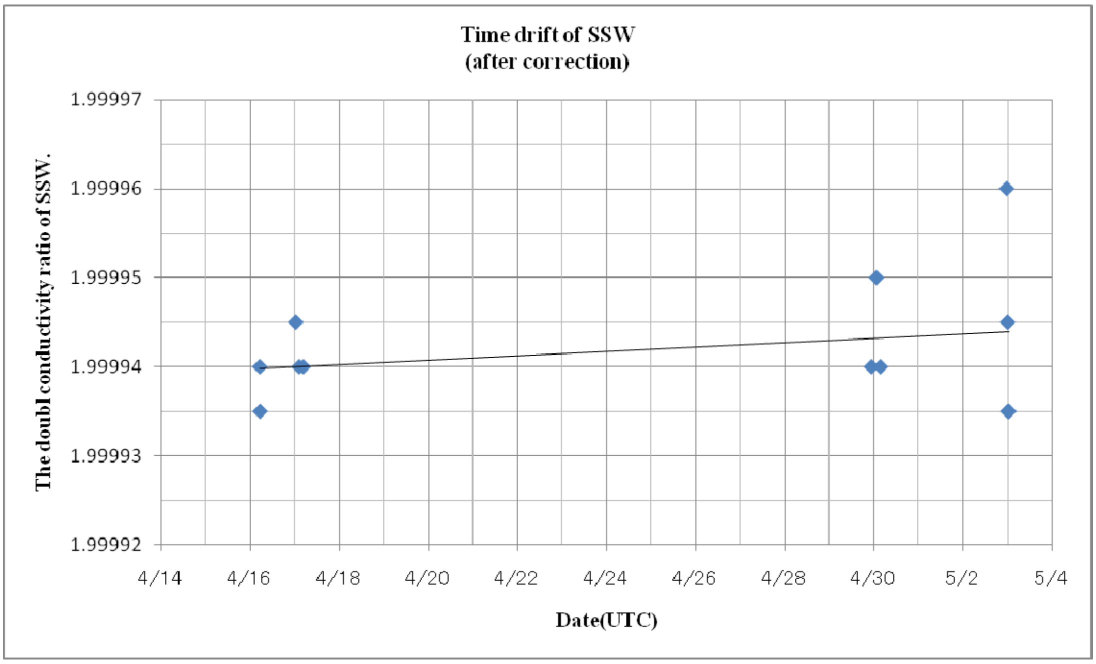


Fig. 5.4.1-2 The history of the double conductivity ratio for the Standard Seawater batch P151 (after correction)

b. Sub-Standard Seawater

Sub-standard seawater was made from deep-sea water filtered by a pore size of 0.45 micrometer and stored in a 20-liter container made of polyethylene and stirred for at least 24 hours before measuring. It was measured about every 6 samples in order to check for the possible sudden drifts of the salinometer.

c. Replicate Samples

We estimated the precision of this method using 20 pairs of replicate samples taken from the same Niskin bottle. The average and the standard deviation of absolute deference among 20 pairs of replicate samples were 0.0005 and 0.0005 in salinity, respectively.

(4) Data archive

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

(5) 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

5.5 Shipboard ADCP

(1) Personnel

Kentaro Ando	(JAMSTEC) :Principal Investigator
Katsuhisa Maeno	(Global Ocean Development Inc.: GODI)
Ryo Kimura	(GODI)
Wataru Tokunaga	(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 MR10-02 cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation the instrument was configured for water-tracking mode. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made to get the calibration data for evaluating transducer misalignment angle. The system consists of following components;

1) R/V MIRAI has installed the Ocean Surveyor for vessel-mount (acoustic frequency 75 kHz; Teledyne RD Instruments). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel
2) For heading source, we use ship's gyro compass (Tokimec, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System (INS) which provide high-precision heading, attitude information, pitch and roll, are stored in ".N2R" data files with a time stamp.
3) DGPS system (Trimble SPS751 & StarFixXP) providing position fixes.
4) We used VmDas version 1.4.2 (TRD Instruments) for data acquisition.
5) To synchronize time stamp of ping with GPS time, the clock of the logging computer is adjusted to GPS time every 1 minute
6) We have placed ethylene glycol into the fresh water to prevent freezing in the sea chest.
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 the surface. Every ping was recorded as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds averaged data were recorded as short term average (.STA) and long term average (.LTA) data, respectively. Major parameters for the measurement (Direct Command) are shown in Table 5.5-1.

(4) Preliminary results

Fig.5.5-1 shows vector plot of surface (50-100m) water current in MR10-02 cruise except the EEZ of Indonesia. In this cruise, the data quality was not in good condition. When cruising speed is faster than 12 knot, current profile deeper than 250m was bad. The reason of this phenomenon is not cleared, but some problem might be occurred on a transducer system. Paying attention for using shipboard ADCP data is highly recommended to check the status data (correlation, echo amplitude and error velocity).

(5) Data archive

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

Table 5.5-1 Set-up parameters

Bottom-Track Commands	
BP = 001	Pings per Ensemble (almost less than 1000m depth)
Environmental Sensor Commands	
EA = +04500	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH = 00000	Heading (1/100 deg)
ES = 35	Salinity (0-40 pp thousand)
EX = 00000	Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 10200010	Sensor Source (C; D; H; P; R; S; T; U)
	C (1): Sound velocity calculates using ED, ES, ET (temp.)
	D (0): Manual ED
	H (2): External synchro
	P (0), R (0): Manual EP, ER (0 degree)
	S (0): Manual ES
	T (1): Internal transducer sensor
	U (0): Manual EU
Timing Commands	
TE = 00:00:02.00	Time per Ensemble (hrs:min:sec.sec/100)
TP = 00:02.00	Time per Ping (min:sec.sec/100)
Water-Track Commands	
WA = 255	False Target Threshold (Max) (0-255 count)
WB = 1	Mode 1 Bandwidth Control (0=Wid, 1=Med, 2=Nar)
WC = 120	Low Correlation Threshold (0-255)
WD = 111 100 000	Data Out (V; C; A; PG; St; Vsum; Vsum^2;#G;P0)
WE = 1000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WG = 001	Percent Good Minimum (0-100%)
WI = 0	Clip Data Past Bottom (0 = OFF, 1 = ON)
WJ = 1	Rcvr Gain Select (0 = Low, 1 = High)
WM = 1	Profiling Mode (1-8)
WN = 40	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS= 1600	Depth Cell Size (cm)
WT = 000	Transmit Length (cm) [0 = Bin Length]
WV = 0390	Mode 1 Ambiguity Velocity (cm/s radial)

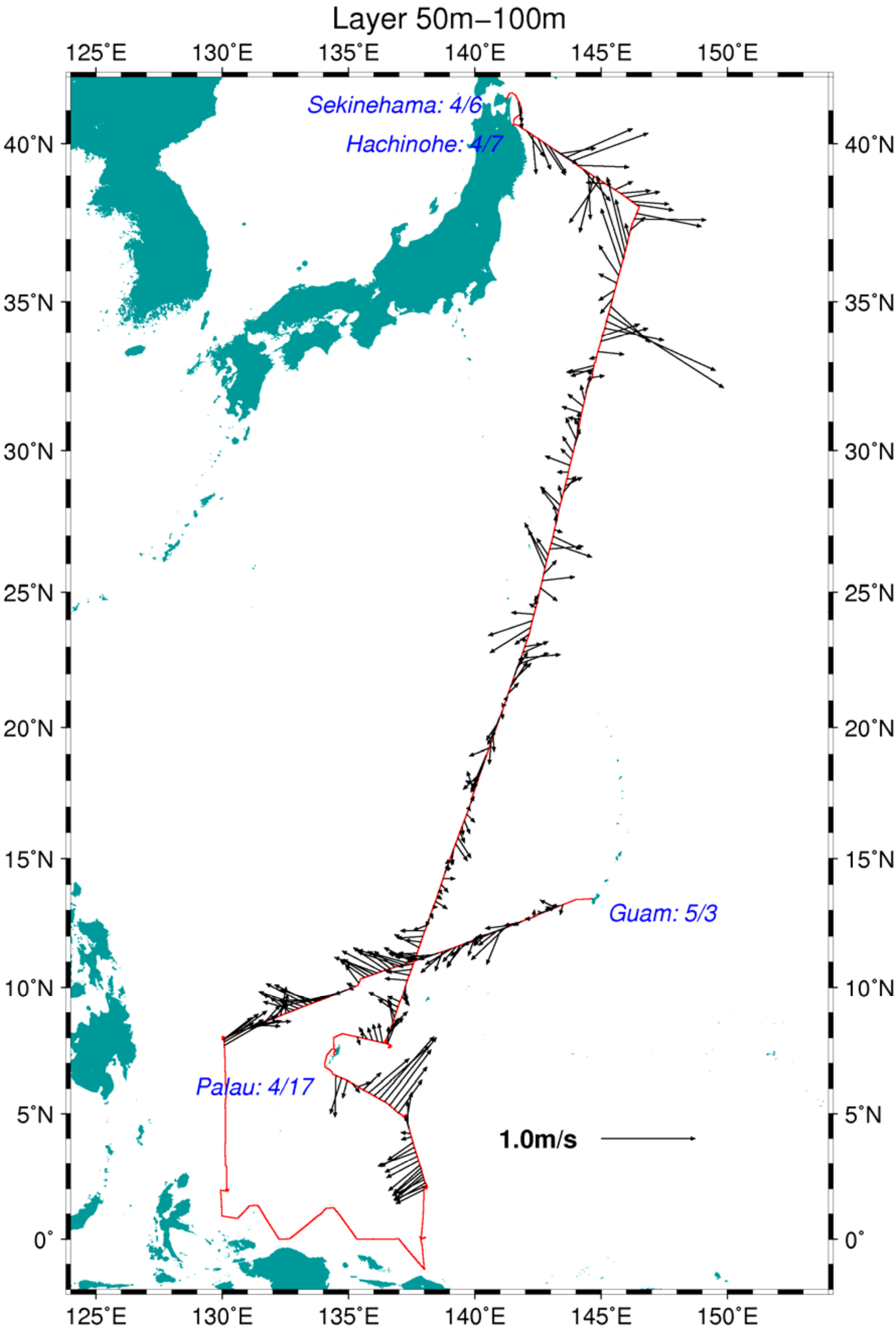


Fig 5.5-1 Vector plot of surface (50-100m) water current in this cruise.

5.6 TRITON buoys

(1) Personnel

Kentaro Ando	(JAMSTEC): Principal Investigator
Tatsuya Fukuda	(JAMSTEC): Technical Investigator
Keisuke Matsumoto	(MWJ): Operation Leader
Akira Watanabe	(MWJ): Technical Staff
Tetsuya Nagahama	(MWJ): Technical Staff
Toru Idai	(MWJ): Technical Staff
Kei Suminaga	(MWJ): Technical Staff
Tomoyuki Takamori	(MWJ): Technical Staff
Shinsuke Toyoda	(MWJ): Technical Staff
Hiroki Ushiromura	(MWJ): Technical Staff
Yukihiko Nakano	(MWJ): Technical Staff
Yasuhiro Arii	(MWJ): Technical Staff
Misato Kuwahara	(MWJ): Technical Staff
Ai Takano	(MWJ): Technical Staff

(2) Objectives

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

TRITON buoy 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).

Six TRITON buoys have been recovered and six TRITON buoys have been deployed successfully during this R/V MIRAI cruise (MR10-02).

(3) Measured parameters

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

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

(4) Instrument

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 : 1800sec
Average interval : 120sec

3) Meteorological sensors

Precipitation

R.M.YOUNG COMPANY MODEL50202/50203

Atmospheric pressure

PAROPSCIENTIFIC.Inc. DIGIQUARTZ FLOATING BAROMETER 6000SERIES

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

Woods Hole Institution ASIMET

Sampling interval : 60sec
Data analysis : 600sec averaged

(5) Locations of TRITON buoys deployment

Nominal location	8N, 137E
ID number at JAMSTEC	10009
Number of surface float	T10
ARGOS PTT number	29759
ARGOS backup PTT number	07861
Deployed date	15 Apr. 2010
Exact location	07 - 51.95N, 136 - 29.43Ｅ
Depth	3,354 m

Nominal location	5N, 137E
ID number at JAMSTEC	11009
Number of surface float	T11
ARGOS PTT number	29767
ARGOS backup PTT number	07864
Deployed date	18 Apr. 2010
Exact location	04 - 56.55N, 137 - 17.87Ｅ
Depth	4,130 m

Nominal location	2N, 138E
ID number at JAMSTEC	12011
Number of surface float	T14
ARGOS PTT number	29719
ARGOS backup PTT number	07878
Deployed date	20 Apr. 2010
Exact location	01 - 59.96N, 138 - 05.74E
Depth	4,317m

Nominal location	EQ, 138E
ID number at JAMSTEC	13011
Number of surface float	T18
ARGOS PTT number	29636
ARGOS backup PTT number	07881
Deployed date	22 Apr. 2010
Exact location	00 - 04.33N, 138 - 02.84E
Depth	4,206 m

Nominal location	8N, 130E
ID number at JAMSTEC	14008
Number of surface float	T26
ARGOS PTT number	29641
ARGOS backup PTT number	11593
Deployed date	28 Apr. 2010
Exact location	07 - 55.28N, 130 - 03.48E
Depth	5,641 m

Nominal location	2N, 130E
ID number at JAMSTEC	16009
Number of surface float	T23
ARGOS PTT number	None
ARGOS backup PTT number	29738, 29708
Deployed date	26 Apr. 2010
Exact location	01 - 57.03N, 130 - 11.51E
Depth	4,372 m

(6) Locations of TRITON buoys recovery

Nominal location	8N, 137E
ID number at JAMSTEC	10008
Number of surface float	T02
ARGOS PTT number	27399
ARGOS backup PTT number	29696
Deployed date	17 Apr. 2009

Recovered date	16 Apr. 2010
Exact location	07 - 39.04N, 136 - 41.97E
Depth	3,164 m

Nominal location	5N, 137E
ID number at JAMSTEC	11008
Number of surface float	T05
ARGOS PTT number	27394
ARGOS backup PTT number	29697
Deployed date	19 Apr. 2009
Recovered date	19 Apr. 2010
Exact location	04 - 51.43N, 137 - 15.07E
Depth	4,097 m

Nominal location	2N, 138E
ID number at JAMSTEC	12010
Number of surface float	T08
ARGOS PTT number	27389
ARGOS backup PTT number	24245
Deployed date	23 Apr. 2009
Recovered date	21 Apr. 2010
Exact location	02 - 04.00N, 138 - 03.73E
Depth	4,342 m

Nominal location	EQ, 138E
ID number at JAMSTEC	13010
Number of surface float	T03
ARGOS PTT number	27401
ARGOS backup PTT number	24246
Deployed date	25 Apr. 2009
Recovered date	22 Apr. 2010
Exact location	00 - 02.04N, 137 - 53.02E
Depth	4,359 m

Nominal location	8N, 130E
ID number at JAMSTEC	14007
Number of surface float	T04
ARGOS PTT number	28377
ARGOS backup PTT number	29710
Deployed date	22 Feb. 2009
Recovered date	29 Apr. 2010
Exact location	07 - 58.98N, 130 - 01.07E
Depth	5,720 m

Nominal location	2N, 130E
ID number at JAMSTEC	16008
Number of surface float	T13
ARGOS PTT number	None
ARGOS backup PTT number	29692,29694
Deployed date	25 Feb. 2009
Recovered date	25 Apr. 2010
Exact location	01 - 56.39N, 129 - 56.05 E
Depth	4,428 m

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

(7) Details of deployment

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

Deployed TRITON buoys

Observation No.	Location.	Details.
10009	8N-137E	Deploy with full spec and 1 optional unit. JES10-CT : 25m
11009	5N-137E	Deploy with full spec and 1 optional unit. SBE37 (CT) : 175m
12011	2N-138E	Deploy with full spec and 1 optional unit. SBE37 (CT) : 175m
13011	EQ-138E	Deploy with full spec and 2 optional units. SBE37 (CT) : 175m Camera system : with TRITON tower
14008	8N-130E	Deploy with full spec. This tower devised a countermeasure to vandalism deeds. So this buoy used the Ultrasonic WND sensor.
16009	2N-130E	Deploy with full spec and 2 optional units. SBE37 (CT) : 175m Camera system : with TRITON tower

(7) 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 The JAMSTEC Mutsu Institute for Oceanography.

TRITON Homepage : http://www.jamstec.go.jp/jamstec/triton

5.7. Ocean Surface Layer monitoring
5.7.1 EPCS

1) Personnel

Kentaro ANDO(JAMSTEC): Principal Investigator

Misato KUWAHARA (Marine Works Japan Co. Ltd.): Operation Leader

Ai TAKANO(Marine Works Japan Co. Ltd.)

2) Objective

Measurements of temperature, salinity and dissolved oxygen of the sea surface water in the Western Tropical Pacific Ocean.

3) Instruments and methods

The *Continuous Sea Surface Water Monitoring System* (Nippon Kaiyo Co. Ltd.) that equips three sensors of 1) salinity, 2) temperatures (two sensors) and 3) dissolved oxygen can continuously measure their values in near-sea surface water. Salinity is calculated by conductivity on the basis of PSS78. Specifications of these sensors are listed below.

This system is settled in the “*sea surface monitoring laboratory*” on R/V MIRAI, and near-surface water was continuously pumped up to the system through a vinyl-chloride pipe. The flow rate for the system is manually controlled by several valves with its value of 12 L min^{-1}. Flow rate is monitored with respective flow meter. The system is connected to shipboard LAN-system, and measured data is stored in a hard disk of PC every 1-minute with time (UTC) and position of the ship.

a) Temperature and Conductivity sensor

Model: SBE-21, SEA-BIRD ELECTRONICS, INC.

Serial number: 2126391-3126

Measurement range: Temperature -5 to +35 , Conductivity 0 to 7 S m^{-1}

Resolution: Temperatures 0.001 , Conductivity 0.0001 S m^{-1}

Stability: Temperature 0.01 6 months^{-1}, Conductivity 0.001 S m^{-1} month^{-1}

b) Bottom of ship thermometer

Model: SBE 3S, SEA-BIRD ELECTRONICS, INC.

Serial number: 032607

Measurement range: -5 to +35

Resolution: ±0.001

Stability: 0.002 year^{-1}

c) Dissolved oxygen sensor

Model: 2127A, Hach Ultra Analytics Japan, INC.

Serial number: 61230

Measurement range: 0 to 14 ppm

Accuracy: ±1% in ±5 of correction temperature

Stability: 5% month^{-1}

The monitoring period (UTC) during this cruise are listed below.

Start: 2010/04/07 8:39

Stop: 2010/05/02 2:59

4) Preliminary Result

Preliminary data of temperature, salinity and dissolved oxygen at sea surface are shown in Fig.5.7.1-1. The surface water was sampled once a day to compare with sensor data. The results are shown in Fig.5.7.1-2. All the salinity samples were analyzed by the Guideline 8400B "AUTOSAL".

5) Data archive

The data were stored on a CD-R, which will be submitted to JAMSTEC Data Management Office (DMO), and will be opened to public via "R/V MIRAI Data Web Page" in JAMSTEC homepage.

6) Remarks

We can't get data during 2010/4/8 6:01～2010/4/8 6:14,because of PC soft error.

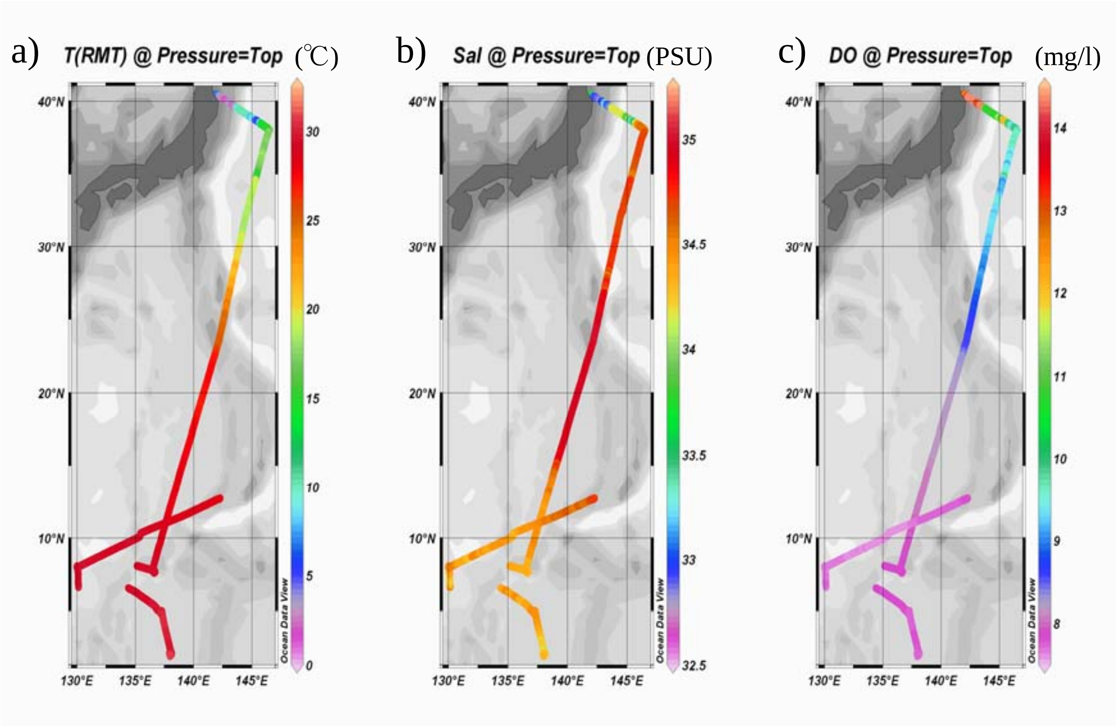


Fig.5.7.1-1 Spatial and temporal distribution of (a) temperature, (b) salinity and (c) dissolved oxygen in MR10-02 cruise.

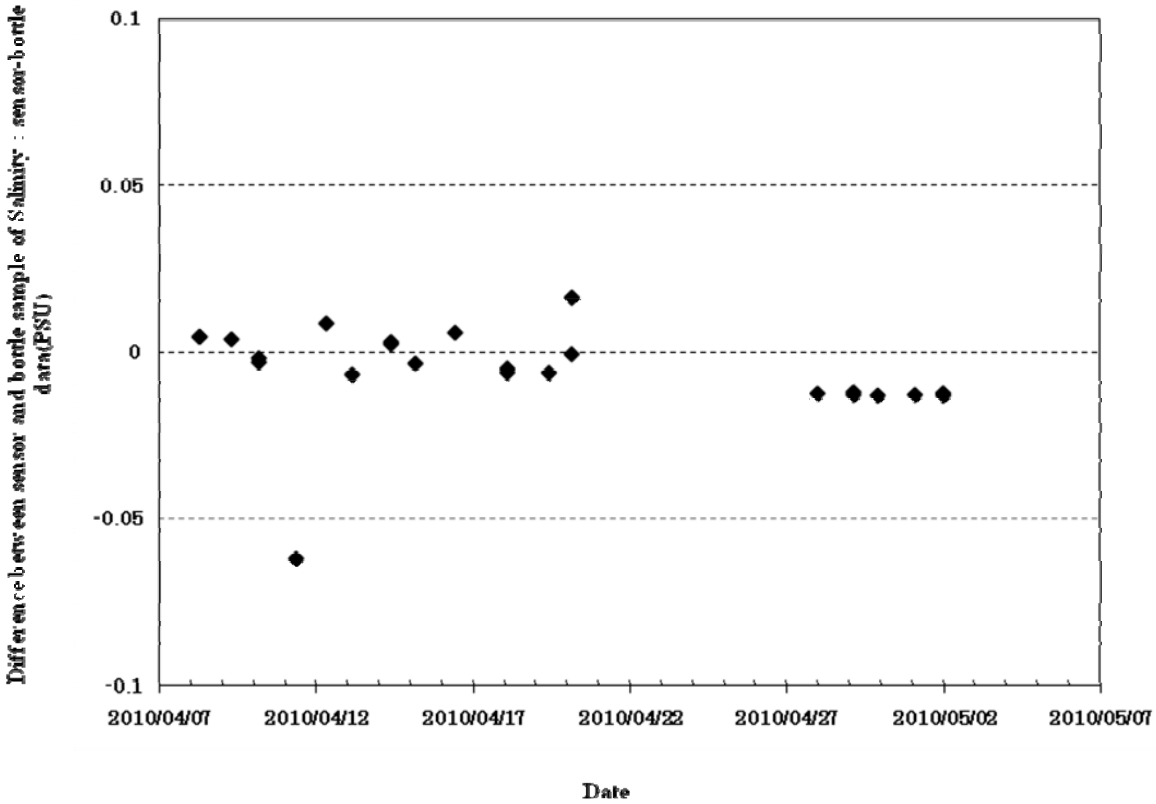


Fig.5.7.1-2 Difference of salinity between sensor data and bottle data. The mean difference is 0.0103 psu.

5.7.2 pCO_2

Yoshimi KAWAI (JAMSTEC) *not on board
Yasuhiro ARII (MWJ)

(1) Objectives

Concentrations of CO_2 in the atmosphere are now increasing at a rate of 1.5 ppmv y^{-1} owing to human activities such as burning of fossil fuels, deforestation, and cement production. It is an urgent task to estimate as accurately as possible the absorption capacity of the oceans against the increased atmospheric CO_2, and to clarify the mechanism of the CO_2 absorption, because the magnitude of the anticipated global warming depends on the levels of CO_2 in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities. We report on board measurements of pCO_2 during MR10-02 cruise.

(2) Methods, Apparatus and Performance

Concentrations of CO_2 in the atmosphere and the sea surface were measured continuously during the cruise using an automated system with a non-dispersive infrared gas analyzer (NDIR; MLT 3T-IR).

The automated system was operated by one and a half hour cycle. In one cycle, standard gasses, marine air and equilibrated air with surface seawater within the equilibrator were analyzed subsequently. The concentrations of the standard gas were 299.84, 349.83, 399.93 and 449.96 ppm.

To measure marine air concentrations (mol fraction) of CO_2 in dry air (xCO_2-air), marine air sampled from the bow of the ship (approx.30m above the sea level) was introduced into the NDIR by passing through a mass flow controller which controls the air flow rate at about 0.5 L/min, a cooling unit, a perma-pure dryer (GL Sciences Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

To measure surface seawater concentrations of CO_2 in dry air (xCO_2-sea), marine air equilibrated with a stream of seawater within the equilibrator was circulated with a pump at 0.7-0.8L/min in a closed loop passing through two cooling units, a perma-pure dryer (GL Science Inc.) and a desiccant holder containing $Mg(ClO_4)_2$. The seawater taken by a pump from the intake placed at the approx. 4.5m below the sea surface flowed at a rate of 5-6L/min in the equilibrator. After that, the equilibrated air was introduced into the NDIR.

(3) Preliminary results

Concentrations of CO_2 (xCO_2) of marine air and surface seawater are shown in Fig. 5.7.2-1.

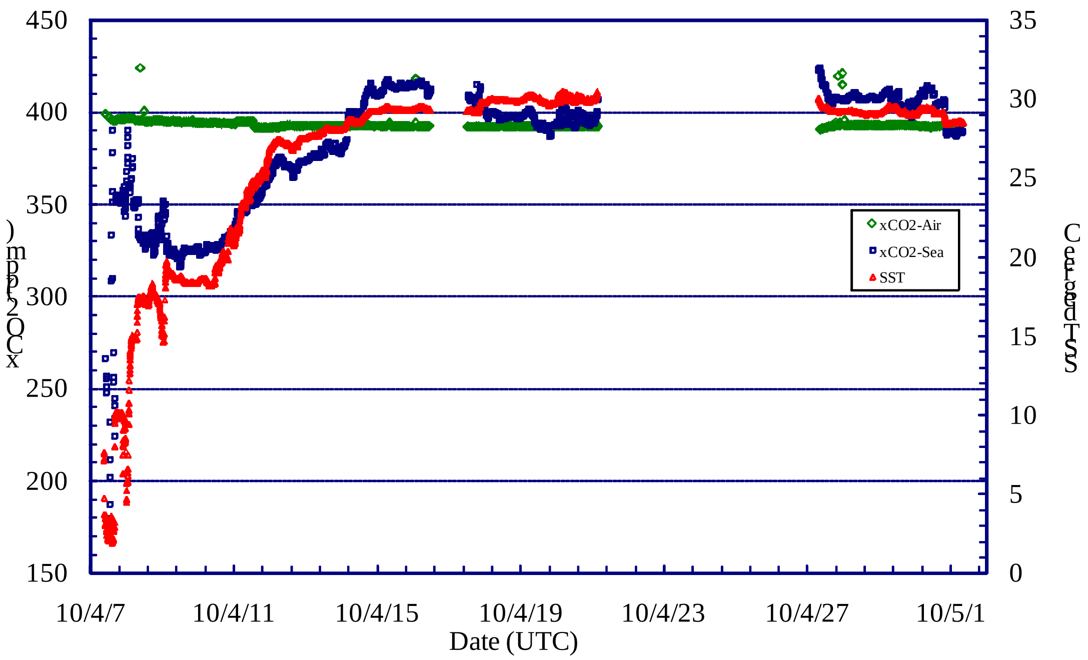


Figure 5.7.2-1 Temporal changes of concentrations of CO_2 (xCO_2) in atmosphere (green) and surface seawater (blue), and SST (red).

(4) Data Archive

All data will be submitted to the Data Management Office (DMO), JAMSTEC and will be opened to public via “R/V MIRAI Data Web Page” in JAMSTEC home page.

(5) Reference

Dickson, A. G., Sabine, C. L. & Christian, J. R. (2007), Guide to best practices for ocean CO_2 measurements; PICES Special Publication 3.

5.8 JKEO, KEO, and Kuroshio air-sea interaction observations

5.8.1 KEO repair work

(1) Personnel

Keith Ronnholm	(NOAA/PMEL)	
J. Michael Strick	(NOAA/PMEL)	
Kentaro Ando	(JAMSTEC)	
Not on board:		
Yoshimi Kawai	(JAMSTEC)	Principal Investigator
Meghan Cronin	(NOAA/PMEL)	

(2) Objective

The KEO buoy, which has been moored in the south of the Kuroshio Extension since 5 September 2009 by NOAA/PMEL collaborating with JAMSTEC, was damaged in the late September due to the passage of a typhoon (T0914 Choi-wan). After the damage, the transmission of most of data stopped. Hence we repaired the KEO buoy and revealed the reason of the trouble in this cruise.

(3) Methods

We took the surface buoy on board, swapped Atlas tube and sensors, added battery to pCO2, removed Flex system and depleted batteries, redeployed on existing mooring line and anchor. After the buoy got on deck and secured, the buoy was detached from the nilspin. The nilspin was lowered on a working line with the top of the nilspin 1 or 2 m below the surface. The Mirai held positions while attached to the KEO anchor. Tensions were continuously monitored and were generally in the 400 kg range. A JAMSTEC employee was assigned to be at the ready with deckset and the release code.

Site: 32° 20.3 N 144° 35.1 E (Figure 5.8.1-1)
First line attached to buoy: 9 April 2010 at 21:05 GMT
Buoy on deck: 22:45
Inductive loop testing done at: 23:11
Work on buoy tower and well: 23:30 to 02:30 - 3 hours.
Location at buoy redeployment at exactly 03:00 GMT 10 April - 32° 19.80' N, 144° 31.27 E
Total ops time: 5.5 hours. starting with small boat launch
Location at flyby: 05:00 GMT - 32° 20.444' N, 144° 31.541 E
Weather at flyby: shown in Table 5.8.1-1

(4) Results

The status of the currently deployed instruments and recovered ones are summarized in Tables 5.8.1-2 and 5.8.1-3.

Flex:

During the buoy recovery, the lifting line knocked the Atlas Gill off of the mast, but it remained dangling by its communications cable. Attempts to communicate with the Flex system were unsuccessful using the RF modem.

Once the buoy was on deck and secured, communications with the Flex system were attempted via directly plugging into the faceplate with no success. While the topsection remained attached to the nilspin, an IMM was connected to the inductive cable at the faceplate end, and communications with the inductive subsurface sensors was attempted, without success. The buoy was detached from the nilspin and the IMM was connected directly to the top socket, with a separate seawater return. Again we could not inductively communicate with subsurface sensors.

Once the lid was removed, extensive corrosion and rust on the Flex faceplate circuit board made it obvious why we had no comms with Flex. The completely drained Flex batteries were an unanticipated occurrence. During a phone call to PMEL, it was decide to install the new battery on the pCO2 system, and pull the Flex system and sensors. All Flex sensors and Flex box were removed from the buoy tower and well, and a spare FLEX faceplate was installed to replace the damaged one.

PCO2:

A second battery for the pCO2 system was installed to provide sufficient power until the expected Feb 2011 recovery. To accomplish this, the red frame was removed, span gas and pCO2 cabling disconnected, the span gas lid removed and the complete pCO2 electronics canister removed. The micarta plate was removed and the new CO2 battery installed. All three depleted Flex battery packs were also removed. The pCO2 system reassembly was straightforward. Stacy's equilibrator pipe was not damaged, barnacles were removed and the float was sliding smoothly. The pCO2 was put in DEP mode and newspaper holding up the equilibrator was removed after the buoy was lifted from the deck for redeployment. Stacy reported that the system was running well.

Atlas:

The prior Atlas system was removed and the new tube (733) and sensors were installed without issues. After the decision to remove the Flex system, the tube was reconfigured to accept rain (which was planned to be only on Flex). The new tube produced good data when observed with Tweezers, however, there was no data from the Atlas SST module. It appeared to be in place and connected.

Subsurface comment:

There was no fishing gear on the buoy or bridle. The bridle had a thick growth of barnacles, but there were very few on the buoy hull. Fishing line (perhaps 5 m or so) was visible on the wire just below the 6.1 m DVS. The 10m SBE37 was only mounted on the wire by its inductive fitting, so it was hanging at an angle. It had slid down to the level of the 14.25 m Sontek. Only

3 fairings remained on the wire above the Sontek. The 14 m Sontek and 16m Aquadopp were in and out of the water and seemed to be mounted securely.

(5) Data archives

The meteorological and oceanic data obtained at the KEO buoy are released through the Internet (http://www.pmel.noaa.gov/keo/).

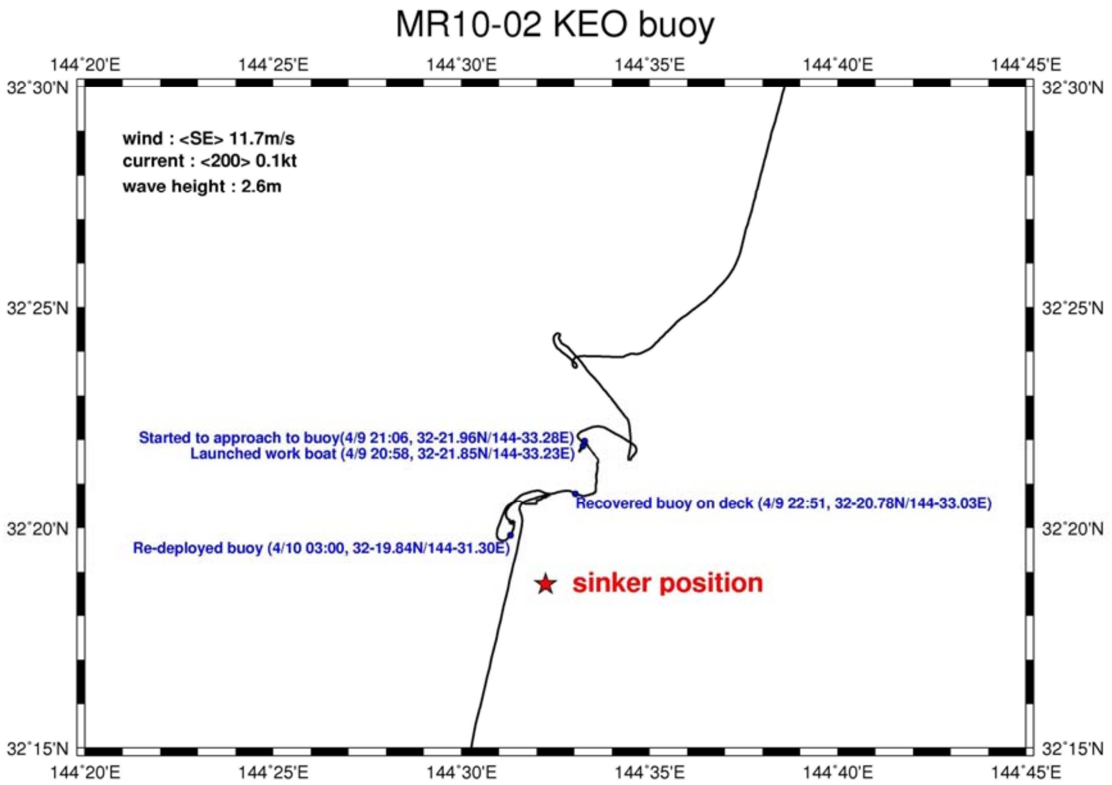


Figure 5.8.1-1 Locations of the KEO buoy and the ship track during the repair operations.

Table 5.8.1-1 Weather at flyby

	Buoy	Ship
AT	17.5 °C	16.5°C
Wind Speed	10.4 m/s (20.2 knts)	11.3 (22.0 knts)
Wind Direction	137	130
RH	80.6	85
SST		18.60 °C
Swell		2.5 – 3 m
Depth		5653 m

Table 5.8.1-2 Status of the currently deployed instruments and equipment.

Site	Mooring ID	Sensor type	Serial No	Comments
32° N 144° E	KE007B	Tube	733	New
		ATRH	133373	New
		Rain	1173-4	New
		RMYoung wind	34359	New
		SWR	31623	remain from KEOO7A
		LWR	33340	remain from KEOO7A
		Flex Druck	2153676	remain from KE007A – dummy plug on cable (no Flex box)
		Bridle inst		remain from KEOO7A
		Subsurface wire inst		Remain from KEOO7A

Table 5.8.1-3 Status of the recovered instruments and equipment.

Site	Mooring ID	Sensor type	Serial No	Comments
32° N 144° E	KE007B	Tube	684	logic battery - 1.43V when connected to motherboard, 2.41V when disconnected
		ATRH	133386	tested ok after recovery
		Rain	1557	FFFF in test after recovery, water inside top funnel shell
		Atlas Gill wind	51415	No comms in test after recovery
		FLEX box	06	tested fine after recovery
		Faceplate		circuit board severely rusted and corroded
		Flex ATRH	133374	tested ok after recovery
		Flex Rain	1643	tested ok after recovery
		Flex Gill	8170013	not tested (out after Choi-wan typhoon)
		Flex Vaisala	C471007	not tested (data showed AT RH drift during deployment)
		Flex SWR	32432	not tested
		Flex LWR	33341	not tested
		Flex GPS/Iridium can	0003	formerly marked with KEO 2

5.8.2 J-KEO-KEO monitoring line observations
5.8.2.1 XCTD

(1) Personnel

Katsuhisa Maeno	(GODI)	
Ryo Kimura	(GODI)	
Keith Ronnholm	(NOAA/PMEL)	
J. Michael Strick	(NOAA/PMEL)	
Not on board:		
Yoshimi Kawai	(JAMSTEC)	Principal Investigator
Akira Nagano	(JAMSTEC)	
Meghan Cronin	(NOAA/PMEL)	

(2) Objectives

Investigation of oceanic structure around the Kuroshio Extension for air-sea interaction research.

(3) Parameters

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

Parameter	Range	Accuracy
Conductivity	0~60 mS	+/- 0.03 mS/cm
Temperature	-2~35 °C	+/- 0.02 °C
Depth	0~1000 m	5 m or 2 % at depth, whichever is greater

(4) Methods

We observed the vertical profiles of the sea water temperature and salinity by using the XCTD-1 manufactured by Tsurumi-Seiki Co. The signal was converted by MK 130, Tsurumi-Seiki Co. and was recorded by MK-130 software (version 3.07) made by Tsurumi-Seiki Co.

We dropped 18 probes between the JKEO and KEO sites across the Kuroshio Extension by using automatic launcher and hand launcher. The summary of the XCTD observation and launching log is shown in Tables 5.8.2-1 and Figure 5.8.2-1.

(5) Preliminary results

Vertical temperature and salinity sections are shown in Figures. 5.8.2-2 and 5.8.2-3.

(6) Data archives

These XCTD data will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC just after the cruise.

Table 5.8.2-1 Summary of the XCTD observation and launching log

	Date and Time (UTC)		Lat. (N) and Long. (E)				
Station Name	YYYY/MM/DD	hh:mm	Deg.	Min.	Deg.	Min.	Depth (m)
JKEO	2010/04/08	06:43	38	02.43	146	30.65	5409
E01	2010/04/08	10:21	37	30.00	146	14.40	5532
E02	2010/04/08	13:05	36	59.98	146	04.45	5459
E03	2010/04/08	14:33	36	45.01	145	59.81	5469
E04	2010/04/08	16:06	36	30.00	145	55.04	5473
E05	2010/04/08	17:39	36	15.00	145	49.82	5570
E06	2010/04/08	19:07	35	59.99	145	44.89	5702
E07	2010/04/08	20:30	35	45.00	145	40.02	5822
E08	2010/04/08	21:51	35	29.99	145	35.17	5844
E09	2010/04/08	23:08	35	14.99	145	30.16	5894
E10	2010/04/08	00:27	34	59.99	145	25.40	5875
E11	2010/04/09	01:46	34	45.01	145	20.65	5811
E12	2010/04/09	03:05	34	30.00	145	15.53	5842
E13	2010/04/09	04:25	34	14.99	145	10.87	5797
E14	2010/04/09	05:48	34	00.00	145	05.82	5713
E15	2010/04/09	08:38	33	30.00	144	55.84	5705
E16	2010/04/09	11:26	33	00.01	144	46.41	5629
KEO	2010/04/10	14:16	32	26.69	144	32.19	5644

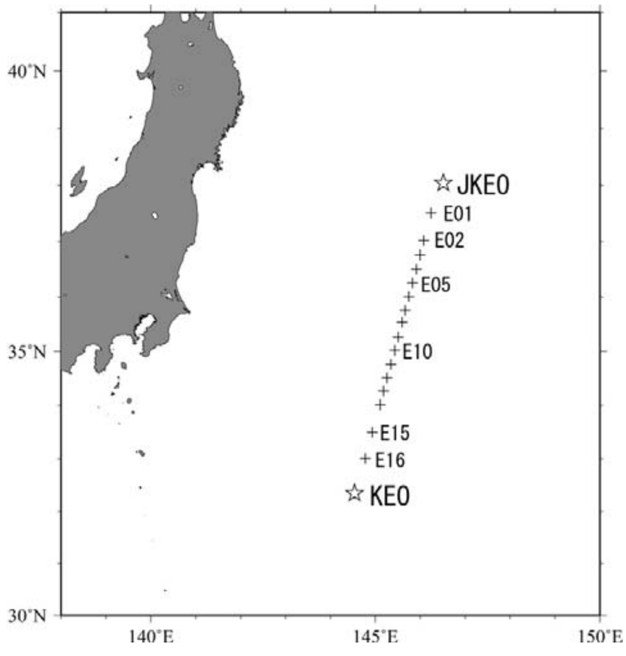


Figure 5.8.2-1 Positions of the XCTD observations

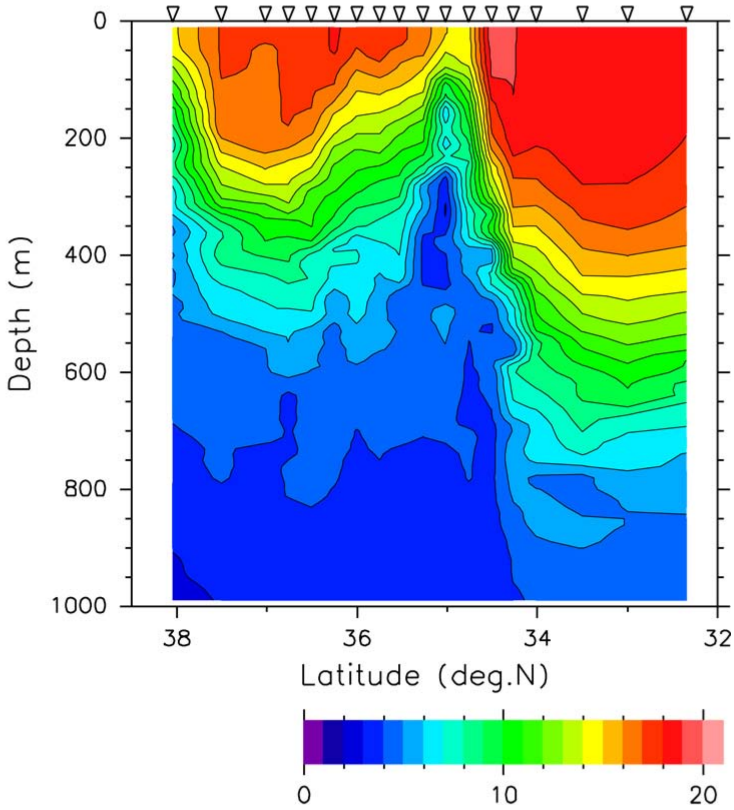


Figure 5.8.2-2 Potential temperature along the ship track (°C).

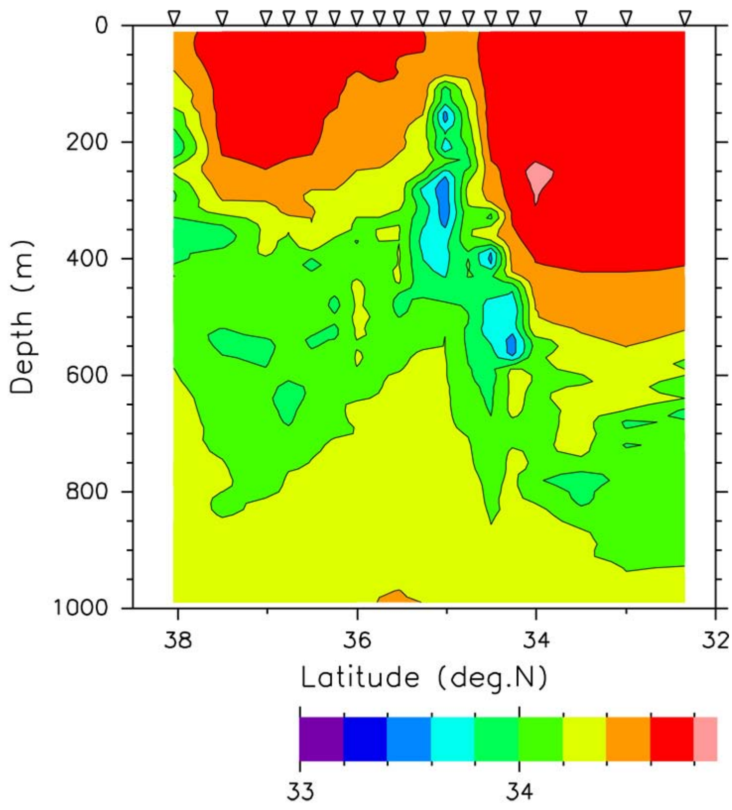


Figure 5.8.2-3 Salinity along the ship track (psu).

5.8.2.2 Sonde

(1) Personnel

Katsuhisa Maeno	(GODI)	
Ryo Kimura	(GODI)	
Keith Ronnholm	(NOAA/PMEL)	
J. Michael Strick	(NOAA/PMEL)	
Not on board:		
Yoshimi Kawai	(JAMSTEC)	Principal Investigator
Hiroyuki Tomita	(JAMSTEC)	
Meghan Cronin	(NOAA/PMEL)	

(2) Objective

Investigation of atmospheric vertical structure of pressure, temperature, relative humidity, wind direction, and wind speed responding to the ocean temperature front of the Kuroshio Extension.

(3) Parameters

According to the manufacturer, the range and accuracy of parameters measured by the radiosonde sensor (RS92-SGPD) are as follows;

Parameter	Range	Accuracy
Pressure	3~1080 hPa	+/- 1 hPa (1080-100 hPa), +/- 0.6 hPa (100-3 hPa)
Temperature	-90~60 °C	+/- 0.5 °C
Humidity	0~100 %	5 %

(4) Method

Atmospheric sounding by radiosonde was carried out between the JKEO and KEO sites in the northwestern Pacific Ocean. In total, 22 soundings were carried out (Table 5.8.2-2). The main system consists of processor (Vaisala, DigiCORA III), GPS antenna (GA20), UHF antenna (RB21), ground check kit (GC25), balloon launcher (ASAP), and GPS radiosonde sensor (RS92-SGPD).

(5) Preliminary results

Latitude-height cross sections of air temperature, specific humidity, zonal and meridional wind speeds along the ship track are shown in Figure.5.8.2-4.

(6) Data archive

All the sounding data were sent to the world meteorological community by Global Telecommunication System (GTS) through the Japan Meteorological Agency, immediately after each observation. Raw data are recorded in ASCII format every 2 seconds during ascent. These raw data will be submitted to the Data Integration and Analysis Group (DIAG) of

JAMSTEC just after the cruise.

Table 5.8.2-2 Radiosonde launch log between the JKEO and KEO sites.

Sounding No.	Station No.	Launching				Maximum		Duration (sec)
		Date (UTC)	Time	Lon	Lat	Altitude	hPa	
RS001	JKEO	2010/04/08	07:17:06	146.5100	38.0387	13558	149.6	3868
RS002	E01	2010/04/08	10:29:34	146.2540	37.5335	11508	205.9	3100
RS003	E02	2010/04/08	13:15:24	146.0910	37.0521	11115	219.9	2774
RS004	E03	2010/04/08	14:42:44	146.0080	36.7827	11054	223.3	2796
RS005	E04	2010/04/08	16:13:32	145.9280	36.5500	10168	257.2	2796
RS006	E05	2010/04/08	17:47:21	145.8440	36.2922	10412	249.3	2774
RS007	E06	2010/04/08	19:14:25	145.7680	36.0549	10636	242.5	2782
RS008	E07	2010/04/08	20:39:52	145.6830	35.7993	10644	243.6	2782
RS009	E08	2010/04/08	21:56:54	145.6020	35.5464	10054	267.6	2790
RS010	E09	2010/04/08	23:09:38	145.5100	35.2740	10363	256.7	2802
RS011	E10	2010/04/09	00:28:25	145.4390	35.0419	10118	267.5	2784
RS012	E11	2010/04/09	01:47:11	145.3570	34.7716	10515	252.8	2774
RS013	E12	2010/04/09	03:05:49	145.2730	34.5389	11598	214.2	2790
RS014	E13	2010/04/09	04:32:17	145.1870	34.2873	10073	271.3	2780
RS015	E14	2010/04/09	05:49:06	145.1180	34.0481	11154	230.7	2794
RS016	E15	2010/04/09	08:39:56	144.9450	33.5433	17564	81.5	4304
RS017	E16	2010/04/09	11:34:15	144.7940	33.0464	16691	94.4	4286
RS018	KEO	2010/04/09	17:59:08	144.5770	32.3992	19527	58.9	4276
RS019	KEO	2010/04/09	20:42:59	144.5640	32.3707	17880	77.5	4292
RS020	KEO	2010/04/10	00:00:54	144.5300	32.3470	15530	114.7	3664
RS021	KEO	2010/04/10	03:06:41	144.5230	32.3329	19923	55.5	4762
RS022	KEO	2010/04/10	05:57:37	144.4900	32.1832	22811	35.3	5570

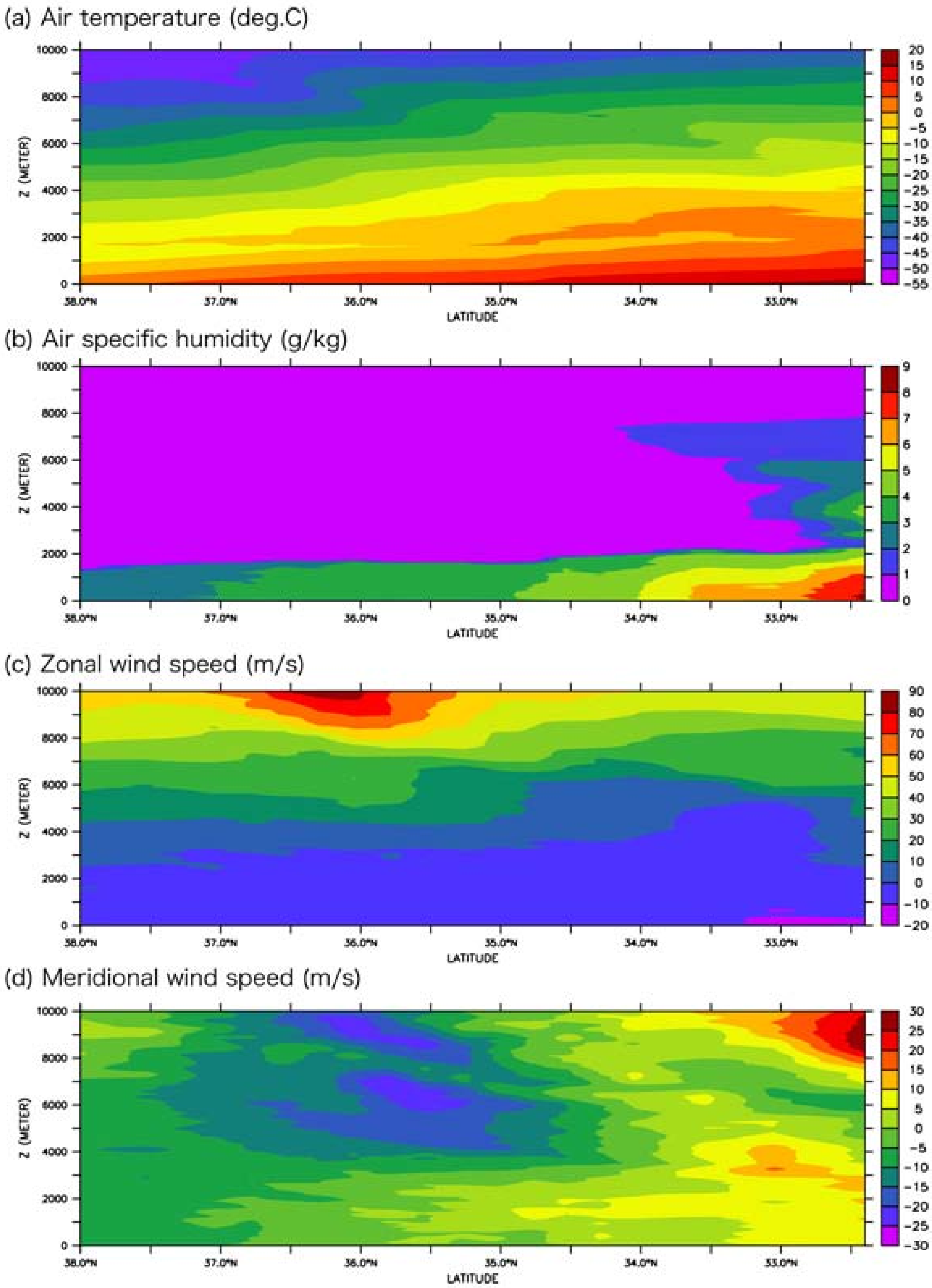


Figure 5.8.2-4 Latitude-height cross sections of air temperature, specific humidity, zonal and meridional wind speeds along the ship track.

5.9Argo floats

(1) Personnel

Toshio Suga	*(JAMSTEC/RIGC): Principal Investigator (not on board)*
Shigeki Hosoda	*(JAMSTEC/RIGC): not on board*
Kanako Sato	*(JAMSTEC/RIGC): not on board*
Mizue Hirano	*(JAMSTEC/RIGC): not on board*
Hroki Ushiromura	*(MWJ): Technical Staff (Operation Leader)*
Toru Idai	*(MWJ): Technical Staff*

(2) Objectives

The objective of deployment is to construct the Argo float array in the global ocean and to clarify the structure and temporal/spatial variability of water masses such as Subtropical Mode Water and North Pacific Intermediate Water in the North Pacific.

The profiling floats launched in this cruise automatically measure vertical profiles of temperature and salinity in the upper ocean every ten days. The data from the floats will enable us to understand the phenomenon mentioned above with finer temporal and spatial scales than in previous studies.

(3) Parameters

・water temperature, salinity, and pressure

(4) Methods

i. Profiling float deployment

We launched a Provor float assembled by NKE Electronics. This float equip the SBE41CP CTD sensor manufactured by Sea-Bird Electronics Inc.

The float usually drift at 1000 dbar (called "parking pressure"), then down to 2000 dbar and ascend up to the sea surface by changing the float volume and the buoyancy in a cycle. The float measures temperature, salinity, and pressure in the ascending time. After the surfacing, the float transmits the observed data using the ARGOS system while staying at the sea surface for several hours. The status of the float and its launch are shown in Table 5.9.

Table 5.9-1 Status of floats and their launches

Float Type	**Provor floats manufactured by NKE Electronics.**
CTD sensor	**SBE41CP manufactured by Sea-Bird Electronics Inc.**
Cycle	**10 days (approximately 9 hours at the sea surface)**
ARGOS transmit interval	**30 sec**
Target Parking Pressure	**1000 dbar**
Sampling layers	**115 (2000,1950,1900,1850,1800,1750,1700,1650,1600,1550,1500,1450,1400,1350,1300, 1250,1200,1150,1100,1050,1000,980,960,940,920,900,880,860,840,820,800,780,760,740, 720,700,680,660,640,620,600,580,560,540,520,500,490,480,470,460,450,440,430,420, 410,400,390,380,370,360,350,340,330,320, 10,300,290,280,270,260,250,240,230,220, 210,200,195,190,185,180,175,170,165,160,155,150,145,140,135,130,125,120,115,110,**

	105,100,95,90,85,80,75,70,65,60,55,50,45,40,35,30,25,20,15,10,4 or surf, dbar

Launches

Float S/N	**ARGOS ID**	**Date and Time of Reset (UTC)**	**Date and Time of Launch(UTC)**	**Location of Launch**	**CTD St. No.**
09015	**97910**	**2010/05/02 00:23**	**2010/05/02 01:18**	**12-38.96N 141-59.72E**	**C11M01**

(5) Data archive

The observed data are automatically sent within 24 hours to Japan Meteorological Agency. After quality controls, the data are delivered to Global Data Assembly Center (GDAC: http://www.usgodae.org/argo/argo.html, http://www.coriolis.eu.org/) and Global Telecommunication System (GTS). All obtained data are opened to public and utilized for research analyses and forecasts of ocean conditions.

5.10 Geophysical Survey

5.10.1. Sea surface gravity

(1) Personnel

Takeshi Matsumoto (University of the Ryukyus) : Principal Investigator (Not on-board)
Katsuhisa Maeno (Global Ocean Development Inc., GODI)
Ryo Kimura (GODI)
Wataru Tokunaga (MIRAI Crew)

(2) Introduction

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

(3) Parameters

Relative Gravity [CU: Counter Unit]
[mGal] = (coef1: 0.9946) * [CU]

(4) Data Acquisition

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during the MR10-02 cruise from 6th April 2010 to 3rd May 2010.

To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (Scintrex gravity meter CG-3M), at Sekinehama as the reference point.

(5) Preliminary Results

Absolute gravity shown in Tabel 5.10.1-1

(6) Data Archives

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

(7) Remarks

1) Following periods, data acquisition was suspended in the territorial waters.
   12:30UTC 16th Apr. 2010 to 12:00UTC 17th Apr. 2010 (Palau)
   11:00UTC 02nd May. 2010 to 23:50UTC 02nd May. 2010 (Guam, U.S.A.)

Table 5.10.1-1

No	Date	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at Sensor *[1] [mGal]	L&R*[2] Gravity [mGal]
#1	Apr/5	06:26	Sekinehama	980,371.93	310	655	980,372.94	12,635.71
#2	**/**	**:**	*****	***,***.**	***	***	***,***.**	**,***.**

*[1]: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.0431

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

5.10.2 Sea surface three-component magnetometer

(1) Personnel

Takeshi Matsumoto (University of the Ryukyus) : Principal Investigator (Not on-board)
Katsuhisa Maeno (Global Ocean Development Inc., GODI)
Ryo Kimura (GODI)
Wataru Tokunaga (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 the three-component magnetometer from Sekinehama on 6th April 2010 to Guam on 3rd May 2010.

(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:

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

where $\widetilde{\mathbf{R}}$, $\widetilde{\mathbf{P}}$ and $\widetilde{\mathbf{Y}}$ are the matrices of rotation due to roll, pitch and heading of a ship, respectively. $\widetilde{\mathbf{A}}$ 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

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

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

(4) Instruments on R/V MIRAI

A shipboard three-component magnetometer system (Tierra Tecnica SFG1214) is equipped on-board R/V MIRAI. Three-axes flux-gate sensors with ring-cored coils are fixed on the fore mast. Outputs from the sensors are digitized by a 20-bit A/D converter (1 nT/LSB), and sampled at 8 times per second. Ship's heading, pitch, and roll are measured by the Inertial Navigation System (INS) for controlling attitude of a Doppler radar. Ship's position (GPS) and speed data are taken from LAN every second.

(5) Data Archives

These data obtained in this cruise will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC.

(6) Remarks

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

   12:30UTC 16th Apr. 2010 to 12:00UTC 17th Apr. 2010 (Palau)

   11:00UTC 02nd May. 2010 to 23:50UTC 02nd May. 2010 (Guam, U.S.A.)

2) 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.

   09:00UTC 20th Apr. 2010 to 09:26UTC 20th Apr. 2010 around at 02-05N, 137-59E

5.10.3. Swath Bathymetry

(1) Personnel

Takeshi Matsumoto	(University of the Ryukyus)	: Principal Investigator (Not on-board)
Katsuhisa Maeno	(Global Ocean Development Inc., GODI)	
Ryo Kimura	(GODI)	
Wataru Tokunaga	(MIRAI Crew)	

(2) Introduction

R/V MIRAI is equipped with a Multi narrow Beam Echo Sounding system (MBES), SEABEAM 2112 (SeaBeam Instruments Inc.). 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 2100" on R/V MIRAI was used for bathymetry mapping during the MR10-02 cruise from 7th April 2010 to 2nd May 2010.

To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data to get the sea surface (6.2m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from CTD and XCTD data by the equation in Del Grosso (1974) during the cruise.

Table 5.10.3-1 shows system configuration and performance of SEABEAM 2112.004 system.

Table 5.10.3-1 System configuration and performance

SEABEAM 2112 (12 kHz system)	
Frequency:	12 kHz
Transmit beam width:	2 degree
Transmit power:	20 kW
Transmit pulse length:	3 to 20 msec.
Depth range:	100 to 11,000 m
Beam spacing:	1 degree athwart ship
Swath width:	150 degree (max)
	120 degree to 4,500 m
	100 degree to 6,000 m
	90 degree to 11,000 m
Depth accuracy:	Within < 0.5% of depth or +/-1m,
	whichever is greater, over the entire swath.
	(Nadir beam has greater accuracy;
	typically within < 0.2% of depth or +/-1m, whichever is greater)

(4) Preliminary Results

The results will be published after primary processing.

(5) Data Archives

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

(6) Remarks

1) Following periods, data acquisition was suspended in the territorial waters of Palau.
   12:30UTC 16th Apr. 2010 to 12:00UTC 17th Apr. 2010