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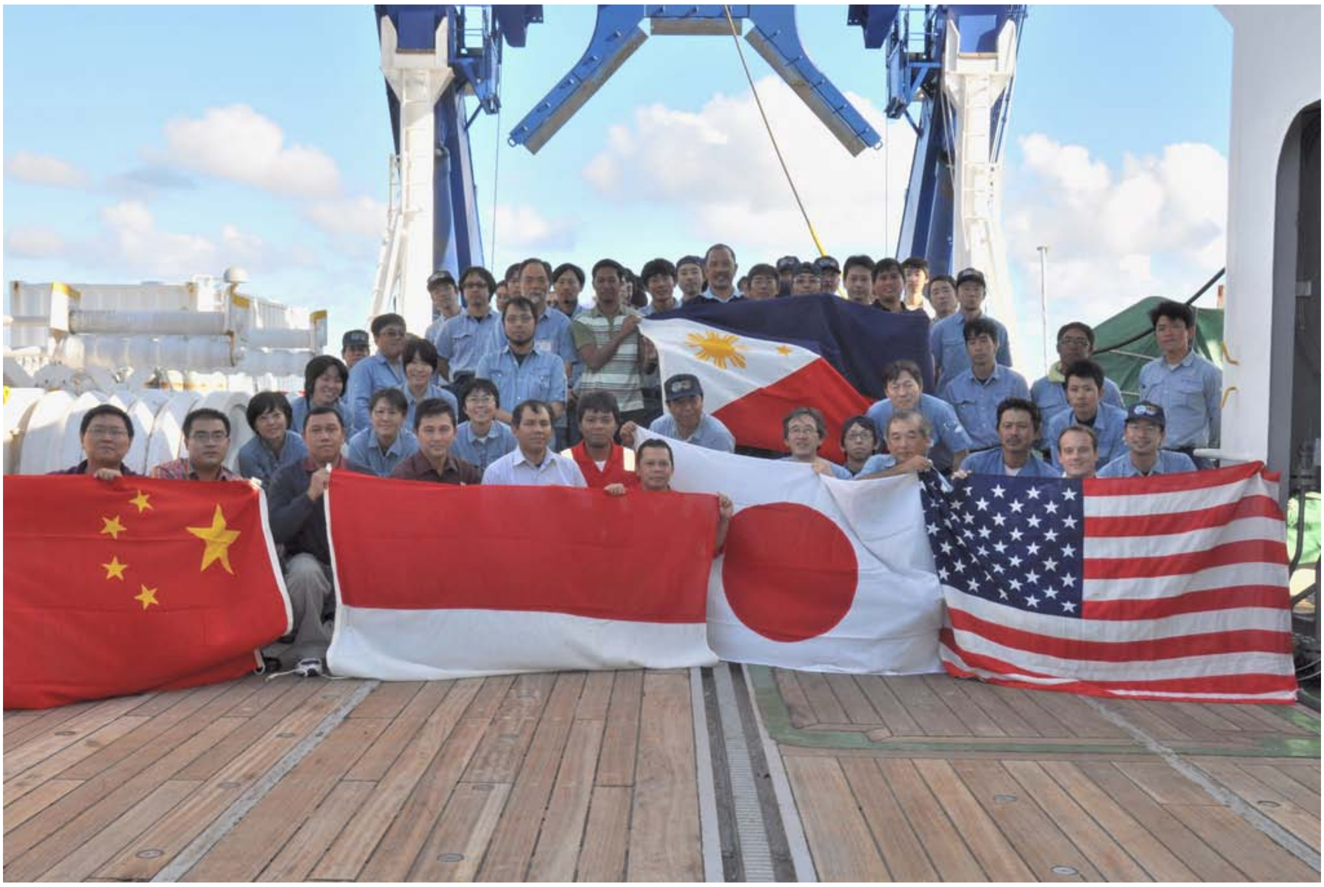
R/V Mirai Cruise Report
MR11-06

August 13, 2011 – September 20, 2011
Tropical Ocean Climate Study (TOCS)

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 scientist 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

Tropical Ocean Climate Study

MR11-06

Ship: R/V Mirai

Captain: Yasushi Ishioka

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) phenomena. 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 is associated with El Nino and La Nina which cause drastic climate changes in the world such as 1997-98 El Nino and 1999 La Nina. However, this atmospheric and oceanic system is so complicated that we still do not have enough knowledge about it.

In order to understand the mechanism of the atmospheric and oceanic system, its high quality data for long period is needed. Considering this background, we developed the TRITON (TRIangle Trans-Ocean buoy Network) buoys and have deployed them in the western equatorial Pacific and Indian Ocean since 1998 cooperating with USA, Indonesia, and India. The major mission of this cruise is to maintain the network of TRITON buoys along 130E and 137-138E lines in the western equatorial Pacific.

During this cruise, we observe the low-latitude western boundary currents of the Pacific collaborating with China under the NPOCE (North Pacific Ocean Circulation and Climate Experiment) project, which was recently endorsed by CLIVAR. For this purpose, two subsurface Acoustic Doppler Current Profiler (ADCP) buoys are deployed east of Mindanao Island of Philippines. Additionally, CTD observations with a lowered ADCP are conducted in the western boundary region of the equatorial Pacific where is in the Indonesian EEZ and Philippine EEZ/territorial waters. Because of this background, three Indonesians, three Filipinos, and two Chinese participate in this cruise.

We have been observed ocean fine structure in order to understand ocean mixing effect on tropical ocean climate since MR07-07 leg 1 collaborating with International Pacific Research Center (IPRC) of USA. For this purpose, we conducted CTD observations with a LADCP along 137E-138E, 2N, 130E, and 7N lines. Additionally, ocean turbulence observation was conducted using a turbulence microstructure profiler, Turbo-Map during this cruise.

Before we arrived at TRITON buoy area, we repair the K-TRITON buoy deployed in the Kuroshio Extension region because data from meteorological sensors of this buoy is abnormal, and communication of the underwater sensors and wave height meter are stopped. In the Kuroshio Extension region, we also conduct XCTD, Radiosonde, and Doppler radar observations.

. During this cruise, 12 Agro floats and 30 surface drifters are deployed because of contribution to the global observational network. Among of them, 10 Argo floats and all drifters are prepared by University of Hawaii and National Oceanic and Atmospheric Administration (NOAA, USA), respectively.

Except for above, automatic continuous oceanic, meteorological and geophysical observations are also conducted along ship track during this cruise as usual. In particular, a cesium magnetometer was towed west of Mariana Islands on the way to the equatorial region, and east of Philippines on the way to Singapore.

Finally, it is noted that two Indonesian engineers participate in this cruise for training of buoy operation because two TRITON buoys in the Indonesian EEZ will be maintained by Indonesia in the future.

2.2 Overview

1) Ship

R/V Mirai

Captain Yasushi Ishioka

2) Cruise code

MR11-06

3) Project name

Tropical Ocean Climate Study (TOCS)

4) Undertaking institution

This cruise was jointly conducted by following two institutes:

Japan: Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
2-15, Natsushima-cho, Yokosuka, 237-0061, Japan

Indonesia: Badan Pengkajian Dan Penerapan Teknologi (BPPT)
Jl.M.H.Thamrin 8, Jakarta, 10340, Indonesia

5) Chief scientist

Chief Scientist (Japan)

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

Co-chief Scientist (Indonesia)

Lukijanto, Badan Pengkajian Dan Penerapan Teknologi (BPPT)

6) Period

August 13, 2011 (Sekinehama, Japan) – August 14 and 15, 2011 (Hachinohe, Japan)
– September 20, 2011 (Singapore, Republic of Singapore)

7) Research participants

Three scientists, two engineers, one research engineering staff, and seventeen marine technicians from Japan

One scientist from USA

Two scientists from China

Two scientists, two engineers and one security officer from Indonesia

One scientist and two navy officers from Philippines

2.3 Observation summary

TRITON buoy recovery and re-installation:	6 moorings were deployed and 5 moorings were recovered.
K-TRITON buoy:	It was successfully repaired.
Subsurface ADCP moorings:	2 moorings were deployed.
CTD (Conductivity, Temperature and Depth) and water sampling:	51 casts
XCTD:	33 casts
Ocean turbulence observation	34 casts
Launch of Argo floats	
Provor type (Japan)	2 floats
SOLO II type (USA)	10 floats
Launch of surface drifters	30 drifters
Radiosonde	23 casts
Rain, water vapor and surface water sampling for isotope analysis	19 casts for rain, 60 casts for water vapor, and 31 cast for surface water
Current measurements by shipboard ADCP:	continuous (*1)
Sea surface temperature, salinity, and dissolved oxygen, measurements by intake method:	continuous (*1)
Surface meteorology:	continuous (*1)
Doppler radar observation:	continuous (*2)
Water vapor observation:	continuous (*1)
Underway geophysics observations	continuous (*1)
Towing a cesium magnetometer	continuous, two times

*1) We stopped these continuous observations after 14 September near the northern tip of Luzon Island, Philippines. (That is, we did not conduct observation in the South China Sea.)

*2) This observation was conducted only in the Kuroshio Extension region.

We successfully recovered and re-installed six TRITON buoys at 130E and 137-138E lines during this cruise without any troubles. We find some damages and distortions in the recovered buoys. Particularly it is noted that flashers and camera were stolen, and its theft activity was recorded by the camera at the TRITON buoy #16 (2N, 130E).

In spite of steep topography and strong current near the Philippine coast, we successfully deployed two subsurface ADCP buoys east of Mindanao. These buoys will be recovered in December 2012 using R/V Mirai.

During this cruise, we conducted shallow CTD casts with a LADCP until 500m or 800m depth and ocean turbulence observation using Turbo-Map every 30nm along 137-138E and 2N lines. Along 130E and 7N, measurement depth of CTD/LADCP observations extended to 1000m because we would also like to focus the circulation below 500m depth: there are the Antarctic Intermediate Water and subsurface Mindanao Undercurrent below this depth in this region. Ocean turbulence observations were conducted south of 6N in this region.

We successfully got all CTD and LADCP data, however, there are troubles in the ocean turbulence observations. Three FP07 temperature sensors of the Turbo-Map troubled during this cruise. Finally, no FP07 sensor was available after the cast at 3N, 130E and data from this sensor cannot be used then. As same as MR10-07 cruise, measurement depth of the ocean turbulence observation did not reached 500m depth at the many casts because of strong undercurrents in the equatorial region,

We deployed 12 Argo floats. Two Provor type Argo floats were deployed at 36N, 145-45E, and 25N, 142-18E under the JAMSTEC Argo project. Other 10 floats were US floats and deployed between 18N and 9N, where is focused area by the US OKMC (Origin of Kuroshio and Mindanao Currents) project. These floats were new SOLO II type developed by Scripps Institute of Oceanography.

We also deployed 30 surface drifters collaborating with the NOAA. 12 drifters were deployed east of Japan because of the research of drift of the tsunami debris, which were produced by tsunami attacked Tohoku area of Japan on 11 March 2011. Other 18 drifters were deployed in the equatorial region.

Because large air-sea interaction seems to occur in the Kuroshio Extension region as same as the tropics, JAMSTEC and PMEL/NOAA(USA) deployed surface moorings, K-TRITON and KEO buoys, in this region. For the research of this air-sea interaction, XCTD, radiosonde and Doppler radar observations were conducted during this cruise in the Kuroshio Extension region. Furthermore, because some sensors of the K-TRITON buoy did not work well, we repaired it on 16 August.

With regard to automatic continuous meteorological, oceanographic and geophysical observations, all observations were carried out well. Because of political reason, we did not conduct these observations in the South China Sea.

Thus, we conducted all planed observations on schedule in this cruise.

2.4 Observed oceanic and atmospheric conditions

In 2011 boreal summer, atmosphere and ocean in the tropical Pacific was under normal condition. Japan Meteorological Agency forecasted that this condition will continue until autumn.

Because of this condition, sea surface temperature (SST) anomaly was lower than 1℃ in the whole Pacific (Figure. 2-1).

In spite of many rainy days during this cruise, sea state during observations was good and suitable for buoy maintenance work. It is noted that lower salinity water than 34.0 PSU was observed north of 3N along 137-138E and 7N along 130E (Figure 2-2).

During this cruise, clouds associating with the Maddan Julian Oscillation were in the eastern Indian Ocean.

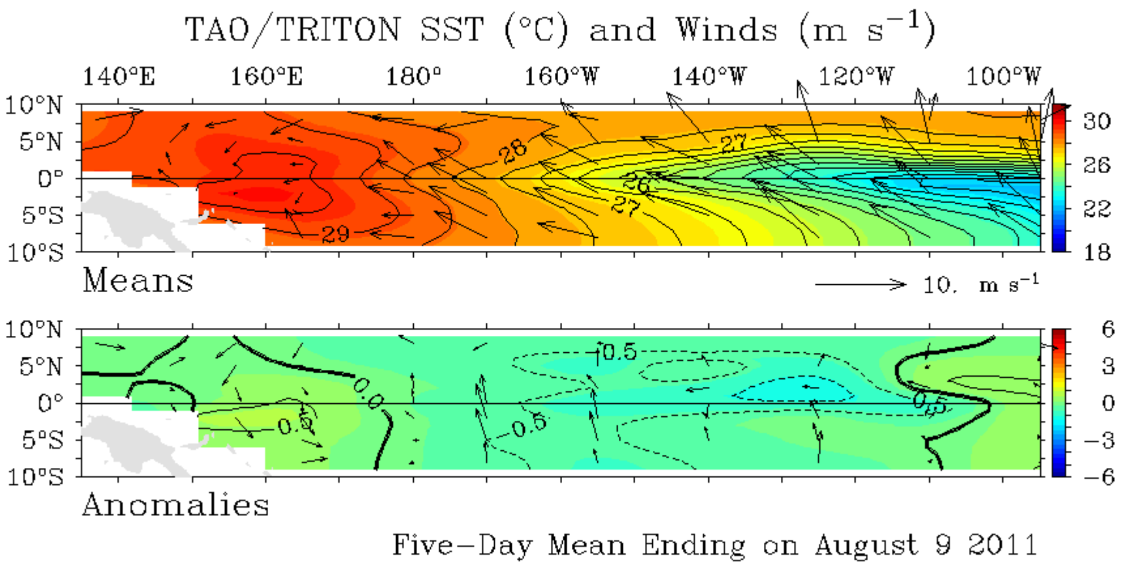


Figure 2-1. Maps of five –day mean ending sea surface temperature and winds (upper panel), and their anomaly (lower panel) obtained from TAO/TRITON buoy array on 9 August 2011.

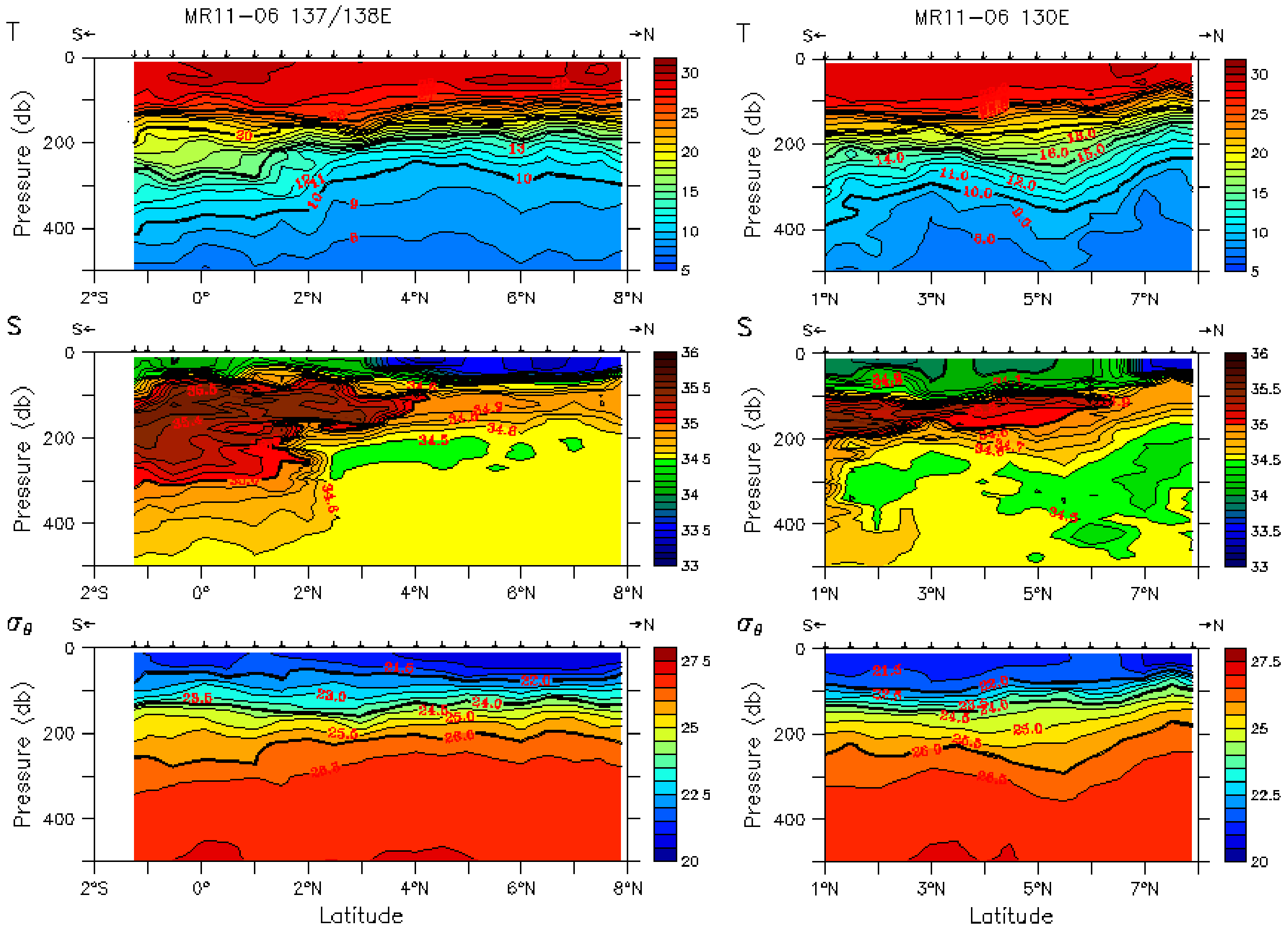


Figure 2-2. Temperature, salinity and potential density sections along 137-138E line (left) and 130E (right).

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

3.1 Period

13 August, 2011 – 20 September, 2011

3.2 Ports of call

Sekinehama, Japan (Departure: 13 August)

Hachinohe, Japan (Arrival: 14 August, Departure: 15 August)

Sekinehama, Japan (Arrival: 20 September)

3.3 Cruise Log

SMT	UTC	Event
Aug. 13 (Sat.) 2011		
16:00	07:00	Departure from Sekinehama and start underway observations
		[Ship Mean Time (SMT)=UTC+9h]
Aug. 14 (Sun.)		
09:00	00:00	Arrival at Hachinohe
Aug. 15 (Mon.)		
06:00	21:00 (-1 day)	Departure from Hachinohe
08:00	23:00	Start pumping intake surface water
12:24	03:24	Surface drifter deployment at 39-45.00N, 143-00.03E
14:24	05:24	Surface drifter deployment at 39-30.01N, 143-30.03E
16:09	07:09	Surface drifter deployment at 39-14.98N, 143-30.03E
17:11 to 20:43	08:11 to 11:43	CTD cable maintenance "FreeFall"
21:56	12:56	Surface drifter deployment at 38-59.96N, 144-30.08E
23:46	14:46	Surface drifter deployment at 38-44.98N, 144-59.99E
Aug. 16 (Tue.)		
01:40	16:40 (-1 day)	Surface drifter deployment at 38-29.99N, 144-59.99E
03:34	18:34	Surface drifter deployment at 38-14.99N, 146-00.03E
06:10 to 06:40	21:10 to 21:40	Interrogate to acoustic transponder
07:58 to 11:46	22:58 to 02:46	Maintenance work for K-TRITON Buoy
09:45	00:45	Start the Doppler radar observation
11:50	02:50	Surface drifter deployment at 38-05.09N, 146-22.80E
11:59	02:59	Radiosonde observation at JKEO site (RS01)
12:03	03:03	XCTD observation at JKEO site (X01)
14:01	05:01	Radiosonde observation at E01 (RS02)
14:01	05:01	Surface drifter deployment at 37-46.06N, 146-19.53E

14:06	05:06	XCTD observation at E01 (X02)
15:30	06:30	Radiosonde observation at E02 (RS03)
15:31	06:31	Surface drifter deployment at 37-30.25N, 146-14.89E
15:34	06:34	XCTD observation at E02 (X03)
16:59	07:59	Radiosonde observation at E03 (RS04)
16:59	07:59	Surface drifter deployment at 37-15.21N, 146-09.72E
17:06	08:06	XCTD observation at E03 (X04)
18:30	09:30	Radiosonde observation at E04 (RS05)
18:30	09:30	Surface drifter deployment at 37-00.16N, 146-04.56E
18:35	09:35	XCTD observation at E04 (X05)
20:00	11:00	Radiosonde observation at E05 (RS06)
20:05	11:05	XCTD observation at E05 (X06)
21:30	12:30	Radiosonde observation at E06 (RS07)
20:34	11:34	XCTD observation at E06 (X07)
23:00	14:00	Radiosonde observation at E07 (RS08)
23:04	14:04	XCTD observation at E07 (X08)
Aug. 17 (Wed.)		
00:28 to 01:41	15:28 to 16:41 (-1 day)	CTD/CWS cast at E08 (C01)
01:40	16:41	Radiosonde observation at E08 (RS09)
01:47	16:47	Argo float deployment at 36-00.01N, 145-45.75E
01:49	16:49	XCTD observation at E08 (X09)
03:30	18:30	Radiosonde observation at E09 (RS10)
03:35	18:35	XCTD observation at E09 (X10)
05:00	20:00	Radiosonde observation at E10 (RS11)
05:03	20:03	XCTD observation at E10 (X11)
06:31	21:31	XCTD observation at E11 (X12)
06:35	21:35	Radiosonde observation at E11 (RS12)
08:00	23:00	Radio sonde observation at E12 (RS13)
08:05	23:05 (-1 day)	XCTD observation at E12 (X13)
09:30	00:30	Radiosonde observation at E13 (RS14)
09:34	00:34	XCTD observation at E13 (X14)
10:59	01:59	Radiosonde observation at E14 (RS15)
11:03	02:03	XCTD observation at E14 (X15)
12:31	03:31	Radiosonde observation at E15 (RS16)
12:36	03:36	XCTD observation at E15 (X16)
14:05	05:05	XCTD observation at E16 (X17)
14:21	05:21	Radiosonde observation at E16 (RS17)
15:30	06:30	Radiosonde observation at E17 (RS18)
15:35	06:35	XCTD observation at E18 (X19)

17:00	08:00	Radiosonde observation at E18 (RS19)
17:04	08:04	XCTD observation at E18 (X19)
18:30	09:30	Radiosonde observation at E19 (RS20)
18:35	09:35	XCTD observation at E19 (X20)
20:00	11:00	Radiosonde observation at E20 (RS21)
20:04	11:04	XCTD observation at E20 (X21)
21:29	12:29	Radiosonde observation at E21 (RS22)
21:33	12:33	XCTD observation at E21 (X22)
23:00	14:00	Visual Check of KEO buoy
23:29	14:29	Radiosonde observation at KEO site (RS23)
23:32	14:32	XCTD observation at KEO site (X23)
Aug. 18 (Thu.)		
01:00	16:00 (-1 day)	Finish Doppler Radar observation
Aug. 19 (Fri.)		
09:12 to 10:27	00:12 to 01:27 (-1 day)	CTD/CWS cast (C02)
10:32	01:32	Argo float deployment at 25-00.10N, 142-17.89E
14:30 to 14:51	05:30 to 05:51	Start towing Cesium magnetometer
Aug. 20 (Sat.)		
18:53 to 19:07	09:53 to 10:07	End of towing Cesium magnetometer
19:09	10:09	Argo float deployment at 18-00.10N, 139-29.95E
Aug. 21 (Sun.)		
00:21	15:21 (-1 day)	Argo float deployment at 16-59.96N, 139-39.94E
05:27	20:27	Argo float deployment at 15-59.92N, 139-19.97E
05:28	20:28 (-1 day)	Surface drifter deployment at 15-59.90N, 139-19.96E
10:15	01:15	Argo float deployment at 15-00.06N, 139-00.00E
10:17	01:17	Surface drifter deployment at 15-00.01N, 138-59.98E
15:09	06:09	Argo float deployment at 13-59.92N, 138-40.03E
15:10	06:10	Surface drifter deployment at 13-59.89N, 138-40.06E
20:07	11:07	Argo float deployment at 13-00.07N, 138-20.01E
20:08	11:08	Surface drifter deployment at 13-00.06N, 138-20.01E
Aug. 22 (Mon.)		
01:35	16:35 (-1 day)	Argo float deployment at 12-00.09N, 138-00.05E
01:37	16:37	Surface drifter deployment at 12-00.08N, 138-00.04E
07:01	22:01	Argo float deployment at 11-00.11N, 137-40.09E
07:02	22:02 (-1 day)	Surface drifter deployment at 11-00.09N, 137-40.09E
11:55	02:55	Argo float deployment at 10-00.00N, 137-19.96E
11:55	02:55	Surface drifter deployment at 09-59.98N, 137-19.97E
16:36	07:36	Argo float deployment at 09-00.02N, 136-59.97E
16:36	07:36	Surface drifter deployment at 08-59.99N, 136-59.97E

Aug. 23 (Tue.)

05:30 to 06:46	20:30 to 21:46 (-1 day)	CTD/CWS cast around the recovering buoy (C03)
07:59 to 11:15	22:59 to 02:15	Recovery of TRITON buoy #10
15:54 to 16:20	06:54 to 07:20	Figure-8 turn for calibration of Three-comp. magnetometer

Aug. 24 (Wed.)

08:11 to 10:31	23:11 to 01:31 (-1 day)	Deployment of TRITON buoy #10
10:51 to 11:01	01:51 to 02:01	Acoustic ranging and positioning (Fixed point: 7-52.0035N, 136-29.5952E, Depth: 3,355 m)
11:23	02:23	XCTD observation around the deployed buoy (X24)
11:55	02:55	Surface drifter deployment at 07-52.36N, 136-30.43E
14:11	05:11	XCTD observation at 7-30N (X25)
16:18	07:18	Surface drifter deployment at 07-00.02N, 136-44.01E
16:19	07:19	XCTD observation at 7-00N (X26)
18:27	09:27	XCTD observation at 6-30N (X27)
20:35	11:35	Surface drifter deployment at 06-00.01N, 136-58.07E
20:36	11:36	XCTD observation at 6-00N (X28)
23:13	14:13	XCTD observation at 5-30N (X29)

Aug. 25 (Thu.)

08:10 to 10:57	23:10 to 01:57	Deployment of TRITON buoy #11
11:16 to 11:30	02:16 to 02:30	Acoustic ranging and positioning (Fixed point: 4-51.5768N, 137-16.0319E, Depth: 4,110 m)
11:37	02:37	XCTD observation around the deployed buoy (X30)
13:24 to 13:53	04:24 to 04:53	CTD/CWS cast at 04-30N, 137-25E (C05)
13:58 to 14:47	04:58 to 05:47	MSP observation at 04-30N, 137-25E
17:06 to 17:37	08:06 to 08:37	CTD/CWS cast at 04-00N, 137-35E (C06)
17:43 to 18:29	08:43 to 09:29	MSP observation at 04-00N, 137-35E
18:31		Surface drifter deployment at 04-00.03N, 137-36.21E

Aug. 26 (Fri.)

05:28 to 06:07	20:28 to 21:07 (-1 day)	CTD/CWS cast around the recovering buoy (C04)
06:10 to 06:49	21:10 to 21:49	MSP observation around the recovery buoy
07:57 to 11:02	22:57 to 02:02	Recovery of TRITON buoy #11
11:08	02:08	Surface drifter deployment at 04-58.26N, 137-22.08E
13:17 to 13:55	04:17 to 04:55	MSP re-observation at 04-30N, 137-25E
16:11 to 16:46	07:11 to 07:46	MSP re-observation at 04-00N, 137-35E
18:57 to 19:27	09:57 to 10:27	CTD/CWS cast (C07)
19:32 to 20:09	10:32 to 11:09	MSP observation at 03-30N, 137-45E

Aug. 27 (Sat.)

05:29 to 06:09	20:29 to 21:09 (-1 day)	CTD/CWS cast around the recovering buoy (C10)
06:13 to 06:56	21:13 to 21:56	MSP observation around the recovering buoy
07:57 to 11:36	22:57 to 02:36	Recovery of TRITON buoy #12
13:51 to 14:21	04:51 to 05:21	CTD/CWS cast at 02-30N, 138-05E (C09)
14:25 to 15:02	05:25 to 06:02	MSP observation at 02-30N, 138-05E
17:33 to 18:03	08:33 to 09:03	CTD/CWS cast at 03-00N, 137-55E (C08)
18:09 to 18:51	09:09 to 09:51	MSP observation at 03-00N, 137-55E
18:58	09:58	Surface drifter deployment at 02-58.96N, 137-56.37E
Aug. 28 (Sun.)		
08:08 to 10:39	23:08 to 01:39	Deployment of TRITON buoy #12
11:03 to 11:12	02:03 to 02:12	Acoustic ranging and positioning (Fixed point: 1-59.9876N, 138-05.9833E, Depth: 4,320 m)
11:31 to 12:12	02:31 to 03:12	MSP observation around the deployed buoy
12:13	03:13	Surface drifter deployment at 01-59.20N, 138-05.21E
12:18	03:18	XCTD observation around the deployed buoy (X31)
14:52 to 15:23	05:52 to 06:23	CTD/CWS cast at 01-30N, 138-00E (C11)
15:29 to 16:09	06:29 to 07:09	MSP observation at 01-30N, 138-00E
18:30 to 19:01	09:30 to 10:01	CTD/CWS cast at 01-00N, 138-00E (C12)
19:06 to 19:44	10:06 to 10:44	MSP observation at 01-00N, 138-00E
19:46	10:46	Surface drifter deployment at 01-00.42N, 137-59.46E
Aug. 29 (Mon.)		
05:28 to 05:59	20:28 to 20:59 (-1 day)	CTD/CWS cast at 01-15S, 138-00E (C17)
06:10 to 06:59	21:10 to 21:59	MSP observation at 01-15S, 138-00E
08:11 to 08:39	23:11 to 23:39	CTD/CWS cast at 01-00S, 138-00E (C16)
08:46 to 09:22	23:46 to 00:22 (-1 day)	MSP observation at 01-00S, 138-00E
09:24	00:24	Surface drifter deployment at 00-59.34S, 137-58.21E
11:36 to 12:07	02:36 to 03:07	CTD/CWS cast at 00-30S, 138-00E (C15)
12:33 to 13:17	03:33 to 04:17	MSP observation at 00-30S, 138-00E
17:26 to 17:58	08:26 to 08:58	CTD/CWS cast at 00-30N, 138-00E (C13)
18:06 to 18:43	09:06 to 09:43	MSP observation at 00-30N, 138-00E
21:06 to 23:06	12:06 to 14:06	SBP survey around TRITON buoy site (#13B)
Aug. 30 (Tue.)		
08:08 to 10:31	23:08 to 01:31	Deployment of TRITON buoy #13
10:58 to 11:08	01:58 to 02:08	Acoustic ranging and positioning (Fixed point: 0-04.3108N, 138-02.8480E, Depth: 4,206 m)
11:27 to 12:08	02:27 to 03:08	CTD/CWS cast around the deployed buoy (C14)
12:13 to 12:53	03:13 to 03:53	MSP observation around the deployed buoy

13:05 to 14:25	04:05 to 05:25	SBP survey around TRITON buoy site (#13A)
15:43	06:43	Surface drifter deployment at 00-05.32N, 138-03.82E
Aug. 31 (Wed.)		
05:30 to 06:00	20:30 to 21:00 (-1 day)	CTD/CWS cast at 02-00N, 137-00E (C18)
06:05 to 06:42	21:05 to 21:42	MSP observation at 02-00N, 137-00E
10:57 to 11:26	01:57 to 02:26	CTD/CWS cast at 02-00N, 136-00E (C19)
11:31 to 12:12	02:31 to 03:12	MSP observation at 02-00N, 136-00E
16:26 to 16:55	07:26 to 07:55	CTD/CWS cast at 02-00N, 135-00E (C20)
16:59 to 17:37	07:59 to 08:37	MSP observation at 02-00N, 135-00E
21:47 to 22:17	12:47 to 13:17	CTD/CWS cast at 02-00N, 134-00E (C21)
22:21 to 22:55	13:21 to 14:55	MSP observation at 02-00N, 134-00E
Sep. 1 (Thu.)		
03:26 to 03:56	18:26 to 18:56 (-1 day)	CTD/CWS cast at 02-00N, 133-00E (C22)
03:59 to 04:33	18:59 to 19:33	MSP observation at 02-00N, 133-00E
08:45 to 09:16	23:45 to 00:16	CTD/CWS cast at 02-00N, 132-00E (C23)
09:20 to 09:59	00:20 to 00:59	MSP observation at 02-00N, 132-00E
14:16 to 14:45	05:16 to 05:45	CTD/CWS cast at 02-00N, 131-00E (C24)
14:49 to 15:30	05:49 to 06:30	MSP observation at 02-00N, 131-00E
18:58 to 20:05	09:58 to 11:05	CTD/CWS cast around the recovering buoy (C25)
20:09 to 20:44	11:09 to 11:44	MSP observation around the recovering buoy
Sep. 2 (Fri.)		
05:29 to 06:00	20:29 to 21:00 (-1 day)	CTD/CWS cast at 02-00N, 129-00E (C26)
06:03 to 06:44	21:03 to 21:44	MSP observation at 02-00N, 129-00E
12:37 to 13:42	03:37 to 04:42	CTD/CWS cast at 01-00N, 130-00E (C27)
13:46 to 14:24	04:46 to 05:24	MSP observation at 01-00N, 130-00E
16:29 to 17:35	07:29 to 08:35	CTD/CWS cast at 01-30N, 130-00E (C28)
17:39 to 18:10	08:39 to 09:10	MSP observation at 01-30N, 130-00E
20:18 to 21:55	11:18 to 12:55	SBP survey around TRITON buoy site (#16A)
21:55 to 22:27	12:55 to 13:27	Figure-8 turn for calibration of Three-comp. magnetometer
Sep. 3 (Sat.)		
07:56 to 11:20	22:56 to 02:20	Recovery of TRITON buoy #16
13:48 to 14:52	04:48 to 05:52	CTD/CWS cast at 02-30N, 130-00E (C29)
14:56 to 15:30	05:56 to 06:30	MSP observation at 02-30N, 130-00E
18:46 to 20:20	09:46 to 11:20	SBP survey around TRITON buoy site (#16B)
Sep. 4 (Sun.)		
08:08 to 10:57	23:08 to 01:57	Deployment of TRITON buoy #16
11:22 to 11:34	02:22 to 02:34	Acoustic ranging and positioning (Fixed point: 01-57.1776N,

		130-11.3800E, Depth: 4,371 m)
11:41	02:41	XCTD observation around the deployed buoy (X32)
15:56 to 17:06	06:56 to 08:06	CTD/CWS cast at 03-00N, 130-00E (C30)
17:51 to 18:27	08:51 to 09:27	MSP observation at 03-00N, 130-00E
Sep. 5 (Mon.)		
05:23 to 06:28	20:23 to 21:28 (-1 day)	CTD/CWS cast at 03-30N, 130-00E (C31)
06:34 to 07:07	21:34 to 22:07	MSP observation at 03-30N, 130-00E
09:24 to 10:35	00:24 to 01:35	CTD/CWS cast at 04-00N, 130-00E (C32)
10:39 to 11:16	01:39 to 02:16	MSP observation at 04-00N, 130-00E
13:35 to 14:42	04:35 to 05:42	CTD/CWS cast at 04-30N, 130-00E (C33)
14:45 to 15:20	05:42 to 06:20	MSP observation at 04-30N, 130-00E
17:42 to 18:49	08:42 to 09:49	CTD/CWS cast at 05-00N, 130-00E (C34)
18:53 to 19:34	09:53 to 10:34	MSP observation at 05-00N, 130-00E
Sep. 6 (Tue.)		
05:26 to 06:33	20:26 to 21:33 (-1 day)	CTD/CWS cast at 05-30N, 130-00E (C35)
06:37 to 07:17	21:37 to 22:17	MSP observation at 05-30N, 130-00E
09:39 to 10:45	00:39 to 01:45	CTD/CWS cast at 06-00N, 130-00E (C36)
10:49 to 11:31	01:49 to 02:31	MSP observation at 06-00N, 130-00E
13:53 to 14:57	04:53 to 05:57	CTD/CWS cast at 06-30N, 130-00E (C37)
17:09 to 18:15	08:09 to 09:15	CTD/CWS cast at 07-00N, 130-00E (C38)
Sep. 7 (Wed.)		
08:12 to 10:48	23:12 to 01:48	Deployment of TRITON buoy #14
11:18 to 11:28	02:18 to 02:28	Acoustic ranging and positioning (Fixed point: 07-58.8682N, 130-02.6963E, Depth: 5,726 m)
11:39	02:39	XCTD observation around the deployed buoy (X33)
13:02 to 14:06	04:02 to 05:06	CTD/CWS cast at buoy recovered point (C40)
15:57 to 17:02	06:57 to 08:02	CTD/CWS cast at 07-30N, 130-00E (C39)
Sep. 8 (Thu.)		
07:55 to 11:45	22:55 to 02:45	Recovery of TRITON buoy #14
18:08 to 19:14	09:08 to 10:14	CTD/CWS cast at 07-00N, 130-00E (C41)
Sep. 9 (Fri.)		
05:58 to 07:02	20:58 to 22:02 (-1 day)	CTD/CWS cast at 07-00N, 129-00E (C42)
09:30 to 10:33	00:30 to 01:33	CTD/CWS cast at 07-00N, 128-30E (C43)
12:58 to 14:02	03:58 to 05:02	CTD/CWS cast at 07-00N, 128-00E (C44)
15:14 to 16:18	06:14 to 07:18	CTD/CWS cast at 07-00N, 127-45E (C45)
17:31 to 18:37	08:31 to 09:37	CTD/CWS cast at 07-00N, 127-30E (C46)

Sep. 10 (Sat.)		
07:58 to 10:16	22:58 to 01:16	Deployment of ADCP buoy (7N128E)
11:02 to 11:13	02:02 to 02:13	Acoustic ranging and positioning (Fixed point: 07-00.0618N, 127-46.1167E, Depth: 5,833 m)
13:36 to 14:40	04:36 to 05:40	CTD/CWS cast at 07-00N, 127-15E (C47)
15:50 to 16:55	06:50 to 07:55	CTD/CWS cast at 07-00N, 127-00E (C48)
Sep. 11 (Sun.)		
07:56 to 09:52	22:56 to 00:52	Deployment of ADCP buoy (7N127E)
10:33 to 10:44	01:33 to 01:44	Acoustic ranging and positioning (Fixed point: 07-00.8853N, 126-54.9715E, Depth: 4,826 m)
13:05 to 14:04	04:05 to 05:04	CTD/CWS cast at 07-00N, 126-30E (C51)
14:50 to 15:54	05:50 to 06:54	CTD/CWS cast at 07-00N, 126-36E (C50)
17:11 to 18:21	08:11 to 09:21	CTD/CWS cast at 07-00N, 126-48E (C49)
Sep. 12 (Mon.)		
08:00 to 08:13	23:00 to 23:18 (-1day)	Start towing Cesium magnetometer
22:00	14:00	Time adjustment -1h (SMT=UTC+8h)
Sep. 14 (Wed.)		
13:02 to 13:17	04:02 to 04:17	End of towing Cesium magnetometer
13:30	05:30	Stop pumping intake surface water
14:00	06:00	Finish underway observations
Sep. 20 (Tue.)		
10:00	02:00	Arrival at Singapore port and completion of MR11-06 cruise

3.4 Cruise track

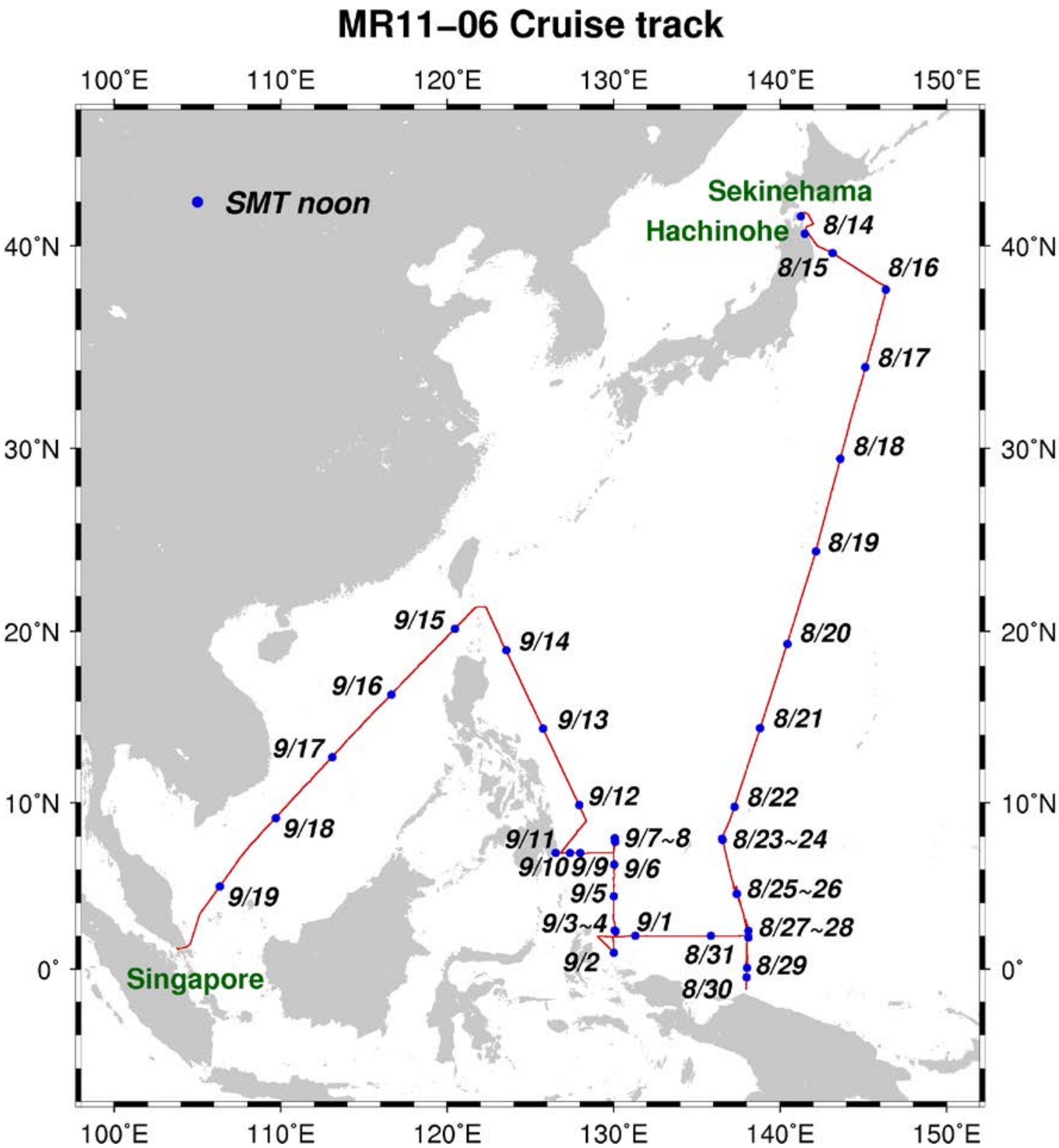


Fig 3.4-1 MR11-06 Cruise track with noon positions

4. Chief scientist

Chief Scientist

Yuji Kashino
Senior 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 (Indonesia)

Lukijanto
Badan Pengkajian Dan Penerapan Teknologi (BPPT)

5. Participants list

5.1 R/V MIRAI scientists and technical staffs

Name	Affiliation	Occupation
Yuji Kashino	JAMSTEC[*1)], Japan	Senior Research Scientist (Chief scientist)
Masayuki Yamaguchi	JAMSTEC, Japan	Engineer
Yukio Takahashi	JAMSTEC, Japan	Engineer
Kyoko Taniguchi	JAMSTEC, Japan	Technical Assistant
Ichiro Matsui	NIES[*2)], Japan	Senior Scientist
Fumiaki Nakaura	Chiba University, Japan	University Student
Saulo Soares	IPRC[*3)], University of Hawaii, USA	Graduate Student
Li Yao	IOCAS[*4)], Republic of China	Scientist
Chuanji Wei	IOCAS, Republic of China	Scientist
Valeriano Borja	NFRDI[*5)], Republic of Philippines	Scientist
Joval Gines	Philippine Navy, Republic of Philippines	Ensign
Ronald Allan Tapawan	Philippine Navy, Republic of Philippines	Electronic Technician 3rd class
Lukijanto	BPPT[*6)], Republic of Indonesia	Scientist (Co-chief Scientist)
Gentio Harsono	Bogor Agricultural Univ., Republic of Indonesia	Scientist
Arnold Danari	BPPT, Republic of Indonesia	Engineer
Jonathan Meiky Davis Rori	BPPT, Republic of Indonesia	Engineer
Edhi Prasetya	Ministry of Defense, Republic of Indonesia	Lieutenant colonel (Security Officer)
Tomohide Noguchi	Marine Works Japan Ltd., Japan	Technical Staff
Takeo Matsumoto	Marine Works Japan Ltd., Japan	Technical Staff
Kenichi Katayama	Marine Works Japan Ltd., Japan	Technical Staff
Keisuke Matsumoto	Marine Works Japan Ltd., Japan	Technical Staff
Tatsuya Tanaka	Marine Works Japan Ltd., Japan	Technical Staff
Akira Watanabe	Marine Works Japan Ltd., Japan	Technical Staff
Tamami Ueno	Marine Works Japan Ltd., Japan	Technical Staff
Masaki Yamada	Marine Works Japan Ltd., Japan	Technical Staff
Kai Fukuda	Marine Works Japan Ltd., Japan	Technical Staff
Masahiro Orui	Marine Works Japan Ltd., Japan	Technical Staff

Katsunori Sagishima	Marine Works Japan Ltd., Japan	Technical Staff
Misato Kuwahara	Marine Works Japan Ltd., Japan	Technical Staff
Yasushi Hashimoto	Marine Works Japan Ltd., Japan	Technical Staff
Sayaka Kawamura	Marine Works Japan Ltd., Japan	Technical Staff
Kei Suminaga	Marine Works Japan Ltd., Japan	Technical Staff
Satoshi Okumura	Global Ocean Development Inc., Japan	Technical Staff
Kazuho Yoshida	Global Ocean Development Inc., Japan	Technical Staff

*1) Japan Agency for Marine-Earth Science and Technology

*2) National Institute for Environmental Science

*3) International Pacific Research Center

*4) Institute of Oceanology, Chinese Academy of Sciences

*5) National Fisheries Research and Development Institute

*6) Badan Pengkajian Dan Penerapan Teknologi

5.2 R/V MIRAI crew members

Name	Rank or rating
Yasushi Ishioka	Master
Haruhiko Inoue	Chief Officer
Hajime Matsuo	1st Officer
Yoshihary Tsutsumi	Jr.1st Officer
Nobuo Fukaura	2nd Officer
Haruka Wakui	3rd Officer
Hiroyuki Suzuki	Chief Engineer
Hiroyuki Tohken	2nd Engineer
Toshio Kiuchi	2nd Engineer
Yusuke Kimoto	3rd Engineer
Wataru Tokunaga	Technical Officer
Kazuyoshi Kudo	Able Seaman
Tsuyoshi Sato	Able Seaman
Takeharu Aisaka	Able Seaman
Tsuyoshi Monzawa	Able Seaman
Masashige Okada	Able Seaman
Shuji Komata	Able Seaman
Hideaki Tamotsu	Ordinary Seaman
Ginta Ogaki	Ordinary Seaman
Masaya Tanikawa	Ordinary Seaman
Shohei Uehara	Ordinary Seaman
Tomohiro Shimada	Ordinary Seaman
Sadanori Honda	No.1 Oiler
Yoshihiro Sugimoto	Oiler
Daisuke Taniguchi	Oiler
Keisuke Yoshida	Ordinary Oiler
Shintaro Abe	Ordinary Oiler
Yuichiro Tani	Ordinary Oiler
Hitoshi Ota	Chief Steward
Tamotsu Uemura	Cook
Sakae Hoshikuma	Cook
Masao Hosoya	Cook
Yoshiteru Hiramatsu	Cook
Shohei Maruyama	Steward

6. General observations

6.1 Meteorological measurements

6.1.1 Surface meteorological observations

(1) Personnel

Yuji Kashino	(JAMSTEC): Principal Investigator
Satoshi Okumura	(Global Ocean Development Inc., GODI)
Kazuho Yoshida	(GODI)
Wataru Tokunaga	(MIRAI Crew)

(2) Objectives

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

(3) Methods

Surface meteorological parameters were observed throughout the MR11-06 cruise. During this cruise, we used two systems for the observation.

1. MIRAI Surface Meteorological observation (SMet) system
2. Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

1. MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table.6.1.1-1 and measured parameters are listed in Table.6.1.1-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-second averaged data.

2. Shipboard Oceanographic and Atmospheric Radiation (SOAR) measurement system

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

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

SCS recorded PRP data every 6 seconds, while Zeno/Met data every 10 seconds. Instruments and their locations are listed in Table.6.1.1-3 and measured parameters are listed in Table.6.1.1-4.

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

1. 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.

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

(4) Preliminary results

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

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

(5) Data archives

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

(6) Remarks

1. Data acquisition was suspended in the South China Sea from 06:00UTC on 14 September to the end of this cruise.

2. The following periods, SMet true wind velocity and direction data were not available, because the update of speed and course over ground was suspended due to the network server error.

   15 Aug. 2011: 15:08:30UTC
   22 Aug. 2011: 10:43:15UTC - 12:03:00 UTC (intermittently)
   24 Aug. 2011: 04:38:25UTC, 14:01:40 UTC, 18:19:30 UTC,
   19:36:45UTC, 19:38:25 UTC, 19:54:00 UTC,
   19:55:35UTC - 19:56:05UTC (intermittently)
   25 Aug. 2011: 02:06:50UTC - 24:00:00UTC (intermittently)
   26 Aug. 2011: 00:00:00UTC - 09:42:10UTC (intermittently)
   27 Aug. 2011: 01:54:05UTC, 23:23:15UTC
   04 Sep. 2011: 21:07:50UTC - 21:07:55UTC
   07 Sep. 2011: 09:31:30UTC, 09:38:15UTC, 09:47:45UTC, 09:49:40UTC

3. SST (Sea Surface Temperature) data was available in the following period.
   23:00UTC 14 Aug. 2011 - 05:28UTC 14 Sep. 2011

4. SMet rain gauge data was not available in the following period, interfered by MF/HF radio transmission.
   23:20UTC 10 Sep. 2011

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

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	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-202	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10 m)

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

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 Ship's speed	knot	Mirai log, DS-30 Furuno
4 Ship's heading	degree	Mirai gyro, 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.6.1.1-3 Instruments and installation locations of SOAR system

Sensors (Zeno/Met)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Tair/RH	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.6.1.1-4 Parameters of SOAR system

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

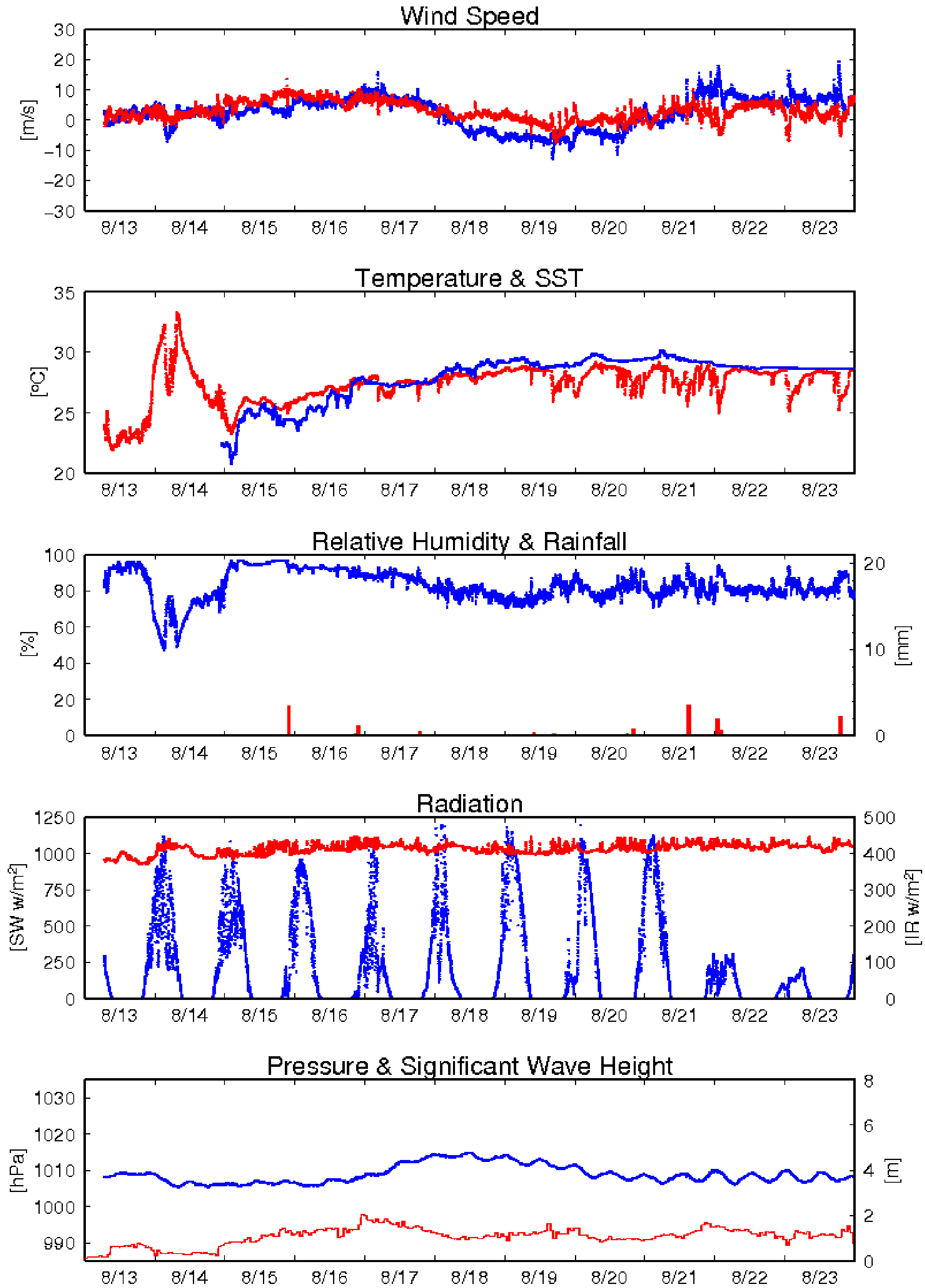


Fig.6.1.1-1 Time series of surface meteorological parameters during the MR11-06 cruise

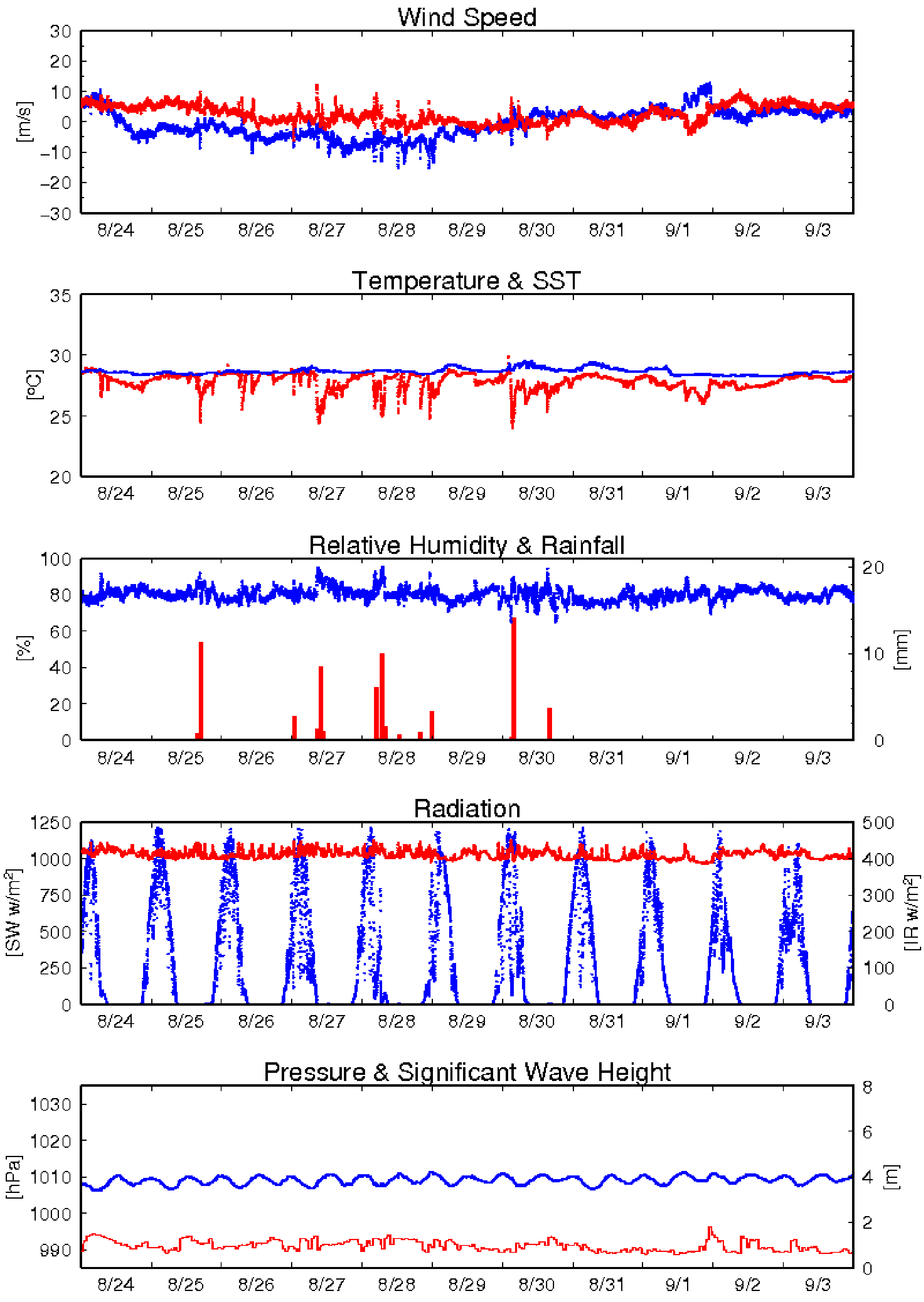


Fig. 6.1.1-1 (Continued)

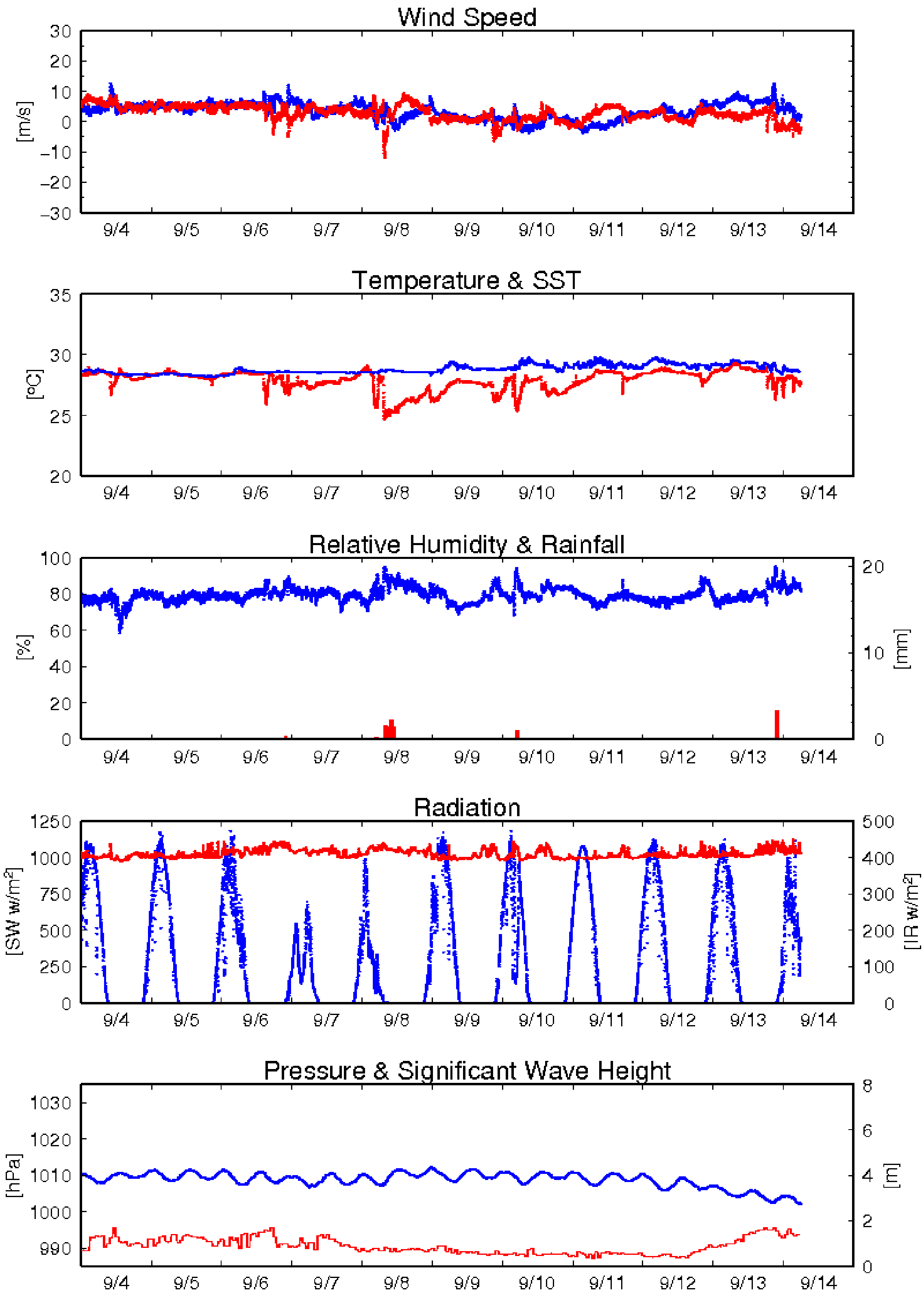


Fig. 6.1.1-1 (Continued)

6.1.2 Ceilometer

(1) Personnel

Yuji Kashino	(JAMSTEC): Principal Investigator
Satoshi Okumura	(Global Ocean Development Inc., GODI)
Kazuho Yoshida	(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) Parameters

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 MR11-06 cruise.

Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode
Transmitting wavelength:	905±5 mm 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.6.1.2-1 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 Management Group (DMG) in JAMSTEC.

(7) Remarks

1. Data acquisition was suspended in the South China Sea from 06:00 on 14 September to the end of this cruise.

2. Window cleaning;

   05:02UTC 13 Aug. 2011

   00:30UTC 26 Aug. 2011

   00:42UTC 03 Sep. 2011

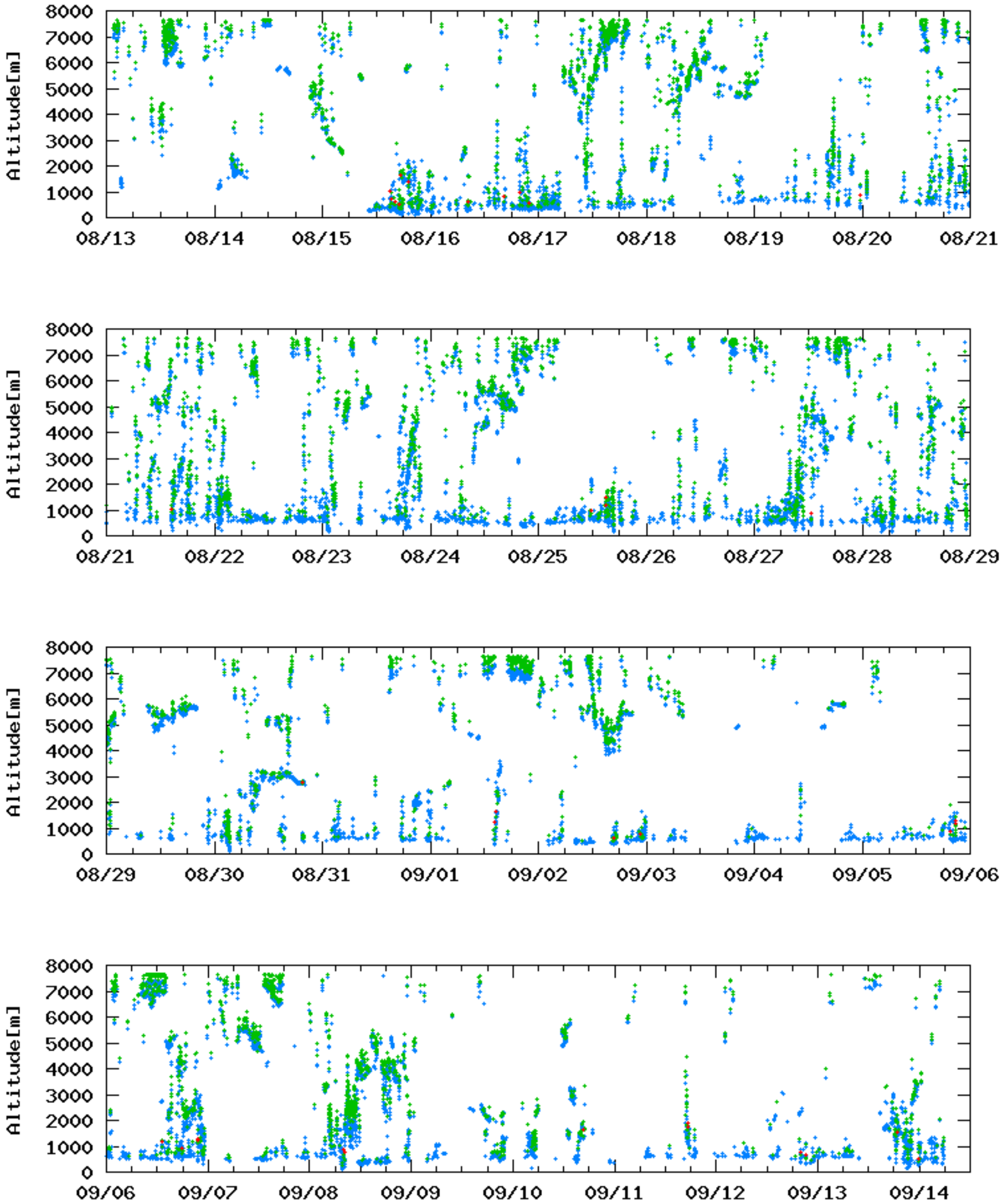


Fig. 6.1.2-1 Lowest, 2nd and 3rd cloud base height in the MR11-06 cruise

6.2 CTD/XCTD

6.2.1 CTD

(1) Personnel

Yuji Kashino	(JAMSTEC): Principal investigator
Tatsuya Tanaka	(MWJ): Operation leader
Tamami Ueno	(MWJ)
Kenichi Katayama	(MWJ)
Tomohide Noguchi	(MWJ)
Masahiro Orui	(MWJ)
Sayaka Kawamura	(MWJ)
Yasushi Hashimoto	(MWJ)
Kei Suminaga	(MWJ)

(2) Objective

Investigation of oceanic structure and water sampling.

(3) Parameters

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

(4) Instruments and Methods

CTD/Carousel Water Sampling System, which is a 36-position Carousel water sampler (CWS) with Sea-Bird Electronics, Inc. CTD (SBE9plus), was used during this cruise. 12-litter Niskin Bottles were used for sampling seawater. The sensors attached on the CTD were temperature (Primary and Secondary), conductivity (Primary and Secondary), pressure, dissolved oxygen (Primary) 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.7.20g) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled during the up cast by sending fire commands from the personal computer. We usually stop for 30 seconds at each layer to stabilize then fire.

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

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

(The process in order)

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

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

ALIGNCTD: Convert the time-sequence of sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Dissolved oxygen data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensor and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 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 dissolved oxygen voltage and decent rate.
*For LADCP (time bin) data, WILDEDIT was not processed.

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 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).
*For LADCP (time bin) data, LOOPEDIT was not processed.

DERIVE: Compute dissolved oxygen (SBE43).

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

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: MR1106A.con (before Stn.C02) and MR1106B.con (after Stn.C03)

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:

SBE9plus (S/N 09P27443-0677, Sea-Bird Electronics, Inc.)

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

Calibrated Date: 11 May 2011

Temperature sensors:

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

Calibrated Date: 02 Mar. 2011

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

Calibrated Date: 16 Sep. 2010

Conductivity sensors:

Primary: SBE04-04/0 (S/N 041172, Sea-Bird Electronics, Inc.)

Calibrated Date: 02 Mar. 2011

Secondary: SBE04-02/0 (S/N 041088, Sea-Bird Electronics, Inc.)

Calibrated Date: 02 Mar. 2011

Dissolved Oxygen sensors:

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

Calibrated Date: 20 May 2011

Altimeter:

Benthos PSA-916T (S/N 1157, Teledyne Benthos, Inc.)

Carousel water sampler:

SBE32 (S/N 3221746-0278, Sea-Bird Electronics, Inc.)

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

(5) Preliminary Results

During this cruise, 51 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 6.2.1-1.

In the down cast of Stn.S18cast 1 (filename: C18M01), spike was observed in the conductivity (Secondary). This spike was removed and corrected by interpolation method.

Vertical profile (down cast) of primary temperature, salinity and dissolved oxygen with pressure are shown in Figure 6.2.1-1 to 6.2.1-13.

Vertical profile of the difference between dissolved oxygen sensor and bottle are shown in Figure 6.2.1-14. Distribution of dissolved oxygen sensor and bottle are shown in Figure 6.2.1-15.

(6) Data archive

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

6.2.1-1 MR11-06 CTD Casttable

Stnnbr	Castno	Date(UTC) (mmddyy)	Time(UTC) Start	End	BottomPosition Latitude	Longitude	Depth	Wire Out	HT Above Bottom	Max Depth	Max Pressure	CTD Filename	Remark
C01	1	081611	15:33	16:39	36-00.12N	145-45.58E	5704.0	2003.1	-	2002.0	2026.9	C01M01	ARGO,SAL
C02	1	081911	00:18	01:25	25-00.07N	142-18.02E	2178.0	2001.1	-	2001.3	2024.3	C02M01	ARGO,SAL
C03	1	082211	20:36	21:42	07-52.96N	136-29.95E	3349.0	997.9	-	1000.9	1009.2	C03M01	R-T10,LADCP,SAL,JES10
C05	1	082511	04:28	04:50	04-29.88N	137-25.12E	4698.0	497.6	-	500.9	504.2	C05M01	LADCP,SAL
C06	1	082511	08:11	08:32	03-59.84N	137-35.23E	4749.0	498.9	-	500.8	504.3	C06M01	LADCP,SAL
C04	1	082511	20:33	21:04	04-57.90N	137-22.12E	4175.0	799.8	-	801.4	807.5	C04M01	R-T11,LADCP,SAL
C07	1	082611	10:02	10:24	03-29.71N	137-45.16E	4433.0	506.6	-	502.6	506.2	C07M01	LADCP,SAL
C10	1	082611	20:34	21:06	02-00.94N	138-06.48E	4184.0	797.5	-	800.3	806.2	C10M01	R-T12,LADCP,SAL
C09	1	082711	04:56	05:18	02-29.99N	138-05.18E	4096.0	497.4	-	501.5	505.4	C09M01	LADCP,SAL
C08	1	082711	08:39	09:00	02-59.89N	137-55.25E	4536.0	500.9	-	500.8	504.4	C08M01	LADCP,SAL
C11	1	082811	05:57	06:20	01-30.16N	137-59.84E	4372.0	502.3	-	502.5	506.3	C11M01	LADCP,SAL
C12	1	082811	09:35	09:58	01-00.20N	137-59.77E	4277.0	499.0	-	501.7	505.3	C12M01	LADCP,SAL
C17	1	082811	20:33	20:56	01-14.84S	137-59.69E	1931.0	503.4	-	503.2	506.9	C17M01	LADCP,SAL
C16	1	082811	23:16	23:37	00-59.82S	137-59.62E	4034.0	499.6	-	502.0	505.4	C16M01	LADCP,SAL
C15	1	082911	02:41	03:04	00-29.94S	138-00.12E	4471.0	499.2	-	501.1	504.5	C15M01	LADCP,SAL
C13	1	082911	08:31	08:54	00-30.02N	137-59.93E	3935.0	500.7	-	502.5	505.9	C13M01	LADCP,SAL
C14	1	083011	02:33	03:05	00-04.28N	138-00.89E	4134.0	801.1	-	801.3	807.3	C14M01	D-T13,LADCP,SAL
C18	1	083011	20:35	20:58	01-59.95N	137-00.01E	4112.0	500.0	-	502.3	505.9	C18M01	LADCP,SAL
C19	1	083111	02:02	02:23	01-59.99N	136-00.07E	4166.0	499.8	-	502.6	505.5	C19M01	LADCP,SAL
C20	1	083111	07:30	07:53	02-00.00N	135-00.02E	4404.0	499.2	-	500.6	504.1	C20M01	LADCP,SAL
C21	1	083111	12:53	13:15	02-00.00N	134-00.01E	4602.0	500.3	-	501.3	504.7	C21M01	LADCP,SAL
C22	1	083111	18:31	18:52	01-59.98N	132-59.99E	3593.0	499.6	-	503.0	506.4	C22M01	LADCP,SAL
C23	1	083111	23:51	00:13	02-00.09N	132-00.17E	3992.0	500.3	-	500.4	504.3	C23M01	LADCP,SAL
C24	1	090111	05:21	05:42	02-00.12N	131-00.06E	3963.0	496.1	-	501.3	503.5	C24M01	LADCP,SAL

C25	1	090111	10:03	11:02	01-58.55N	130-11.59E	4376.0	999.4	-	1001.4	1009.3	C25M01	R-T16,LADCP,SAL,DO
C26	1	090111	20:34	20:56	01-59.94N	128-59.97E	1776.0	498.5	-	500.6	504.0	C26M01	LADCP,SAL
C27	1	090211	03:43	04:39	00-59.99N	130-00.03E	3017.0	1002.2	-	1001.8	1009.8	C27M01	LADCP,SAL,DO
C28	1	090211	07:34	08:33	01-29.66N	129-59.66E	4109.0	1005.1	-	1001.1	1009.0	C28M01	LADCP,SAL,DO
C29	1	090311	04:53	05:49	02-30.03N	129-59.99E	4021.0	1000.1	-	999.9	1007.8	C29M01	LADCP,SAL,DO
C30	1	090411	07:02	08:04	03-00.05N	129-59.91E	3050.0	999.6	-	1000.9	1008.8	C30M01	LADCP,SAL,DO
C31	1	090411	20:28	21:25	03-29.87N	129-59.93E	4521.0	999.8	-	1000.8	1008.2	C31M01	LADCP,SAL,DO
C32	1	090511	00:30	01:32	03-59.78N	129-59.84E	4715.0	999.8	-	1001.1	1008.9	C32M01	LADCP,SAL,DO
C33	1	090511	04:40	05:39	04-29.74N	130-00.07E	4805.0	998.5	-	1001.7	1009.5	C33M01	LADCP,SAL,DO
C34	1	090511	08:47	09:46	04-59.67N	130-00.26E	5040.0	999.6	-	1000.7	1008.8	C34M01	LADCP,SAL,DO
C35	1	090511	20:31	21:30	05-29.93N	130-00.33E	5487.0	1000.5	-	1001.1	1009.1	C35M01	LADCP,SAL,DO
C36	1	090611	00:44	01:42	05-59.90N	130-00.78E	5497.0	1019.1	-	1001.3	1009.4	C36M01	LADCP,SAL,DO
C37	1	090611	04:57	05:54	06-29.85N	130-00.36E	5554.0	1004.9	-	1000.8	1008.5	C37M01	LADCP,SAL,DO
C38	1	090611	08:15	09:13	07-00.03N	130-00.10E	5558.0	1002.9	-	1001.1	1009.4	C38M01	LADCP,SAL,DO
C40	1	090711	04:07	05:03	07-54.31N	130-04.00E	5588.0	1000.7	-	1000.8	1008.9	C40M01	R-T14,LADCP,SAL,DO
C39	1	090711	07:02	07:59	07-29.99N	130-00.19E	5545.0	1000.0	-	1001.3	1009.3	C39M01	LADCP,SAL,DO
C41	1	090811	09:13	10:11	07-00.07N	129-30.36E	5371.0	1001.2	-	1002.1	1010.6	C41M01	LADCP,SAL,DO
C42	1	090811	21:03	22:00	06-59.95N	129-00.12E	5087.0	1001.2	-	1000.3	1008.8	C42M01	LADCP,SAL,DO
C43	1	090911	00:36	01:30	07-00.02N	128-30.15E	5631.0	1000.3	-	1002.2	1010.1	C43M01	LADCP,SAL,DO
C44	1	090911	04:04	04:59	07-00.18N	127-59.61E	4990.0	999.6	-	1001.4	1009.3	C44M01	LADCP,SAL,DO
C45	1	090911	06:19	07:16	07-00.00N	127-45.06E	5807.0	1002.7	-	1001.4	1009.8	C45M01	LADCP,SAL,DO
C46	1	090911	08:36	09:34	06-59.93N	127-30.04E	7233.0	1000.1	-	1001.2	1009.1	C46M01	LADCP,SAL,DO
C47	1	091011	04:41	05:37	06-59.81N	127-14.96E	8215.0	1003.3	-	1001.5	1009.7	C47M01	LADCP,SAL,DO
C48	1	091011	06:55	07:52	06-59.52N	126-59.84E	5583.0	1012.1	-	1000.5	1008.7	C48M01	LADCP,SAL,DO
C51	1	091111	04:10	05:01	07-00.04N	126-30.04E	844.0	801.7	-	802.6	808.5	C51M01	LADCP,SAL,DO
C50	1	091111	05:55	06:52	06-59.85N	126-35.67E	2227.0	1007.1	-	1000.5	1008.8	C50M01	LADCP,SAL,DO
C49	1	091111	08:16	09:16	06-59.52N	126-47.92E	4300.0	1024.2	-	1001.0	1009.1	C49M01	LADCP,SAL,DO

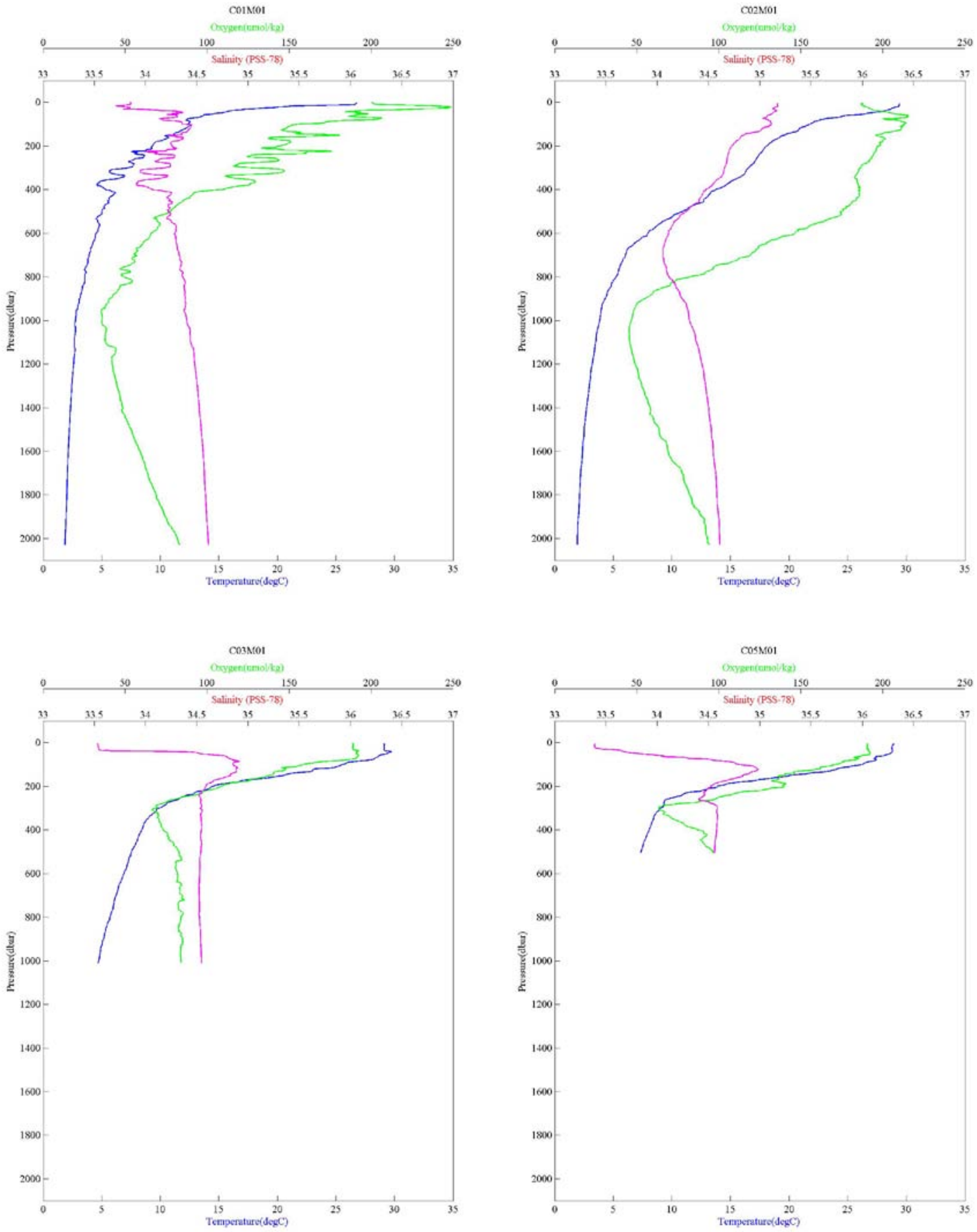


Figure 6.2.1-1 CTD profile (C01M01, C02M01, C03M01 and C05M01)

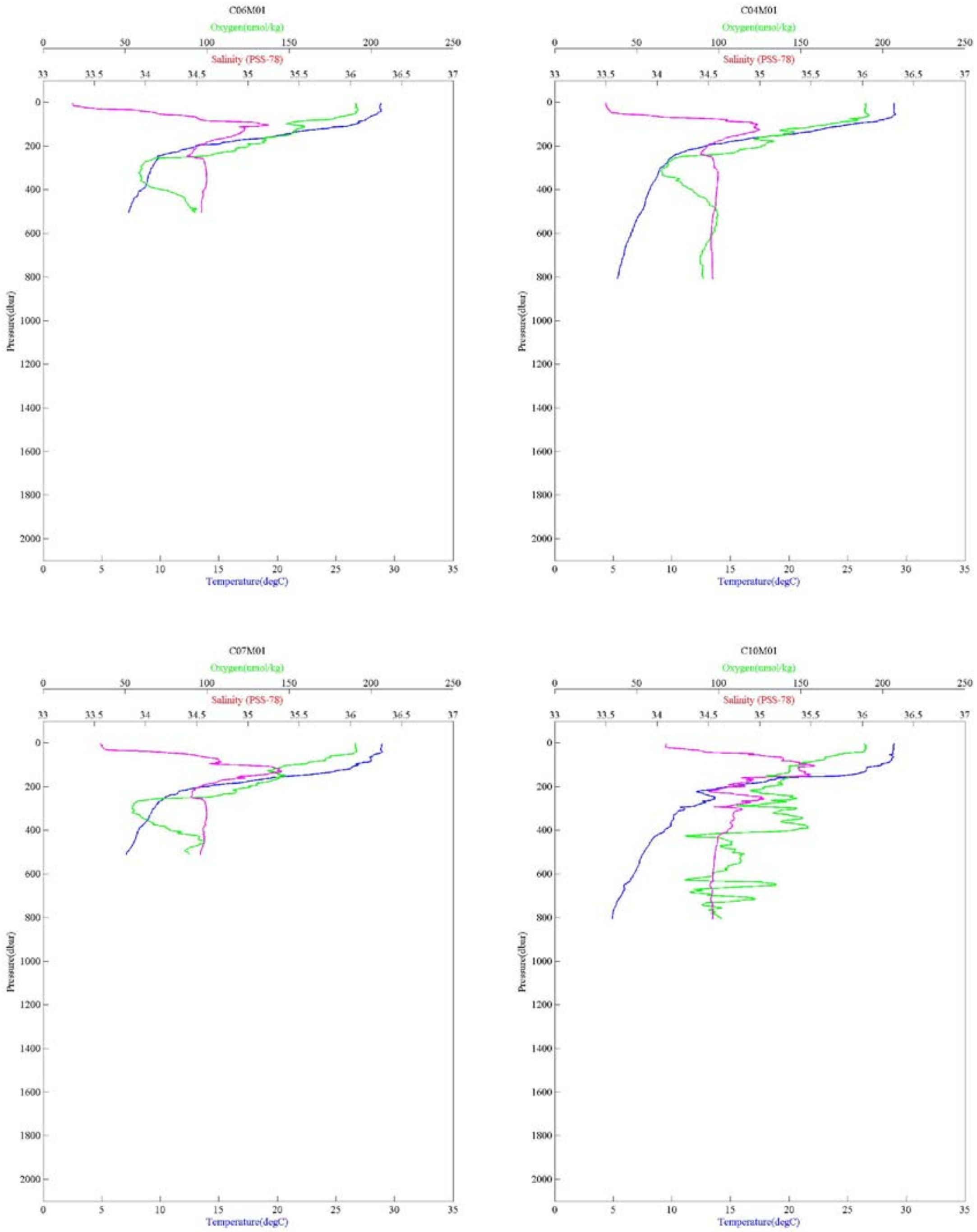


Figure 6.2.1-2 CTD profile (C06M01, C04M01, C07M01 and C10M01)

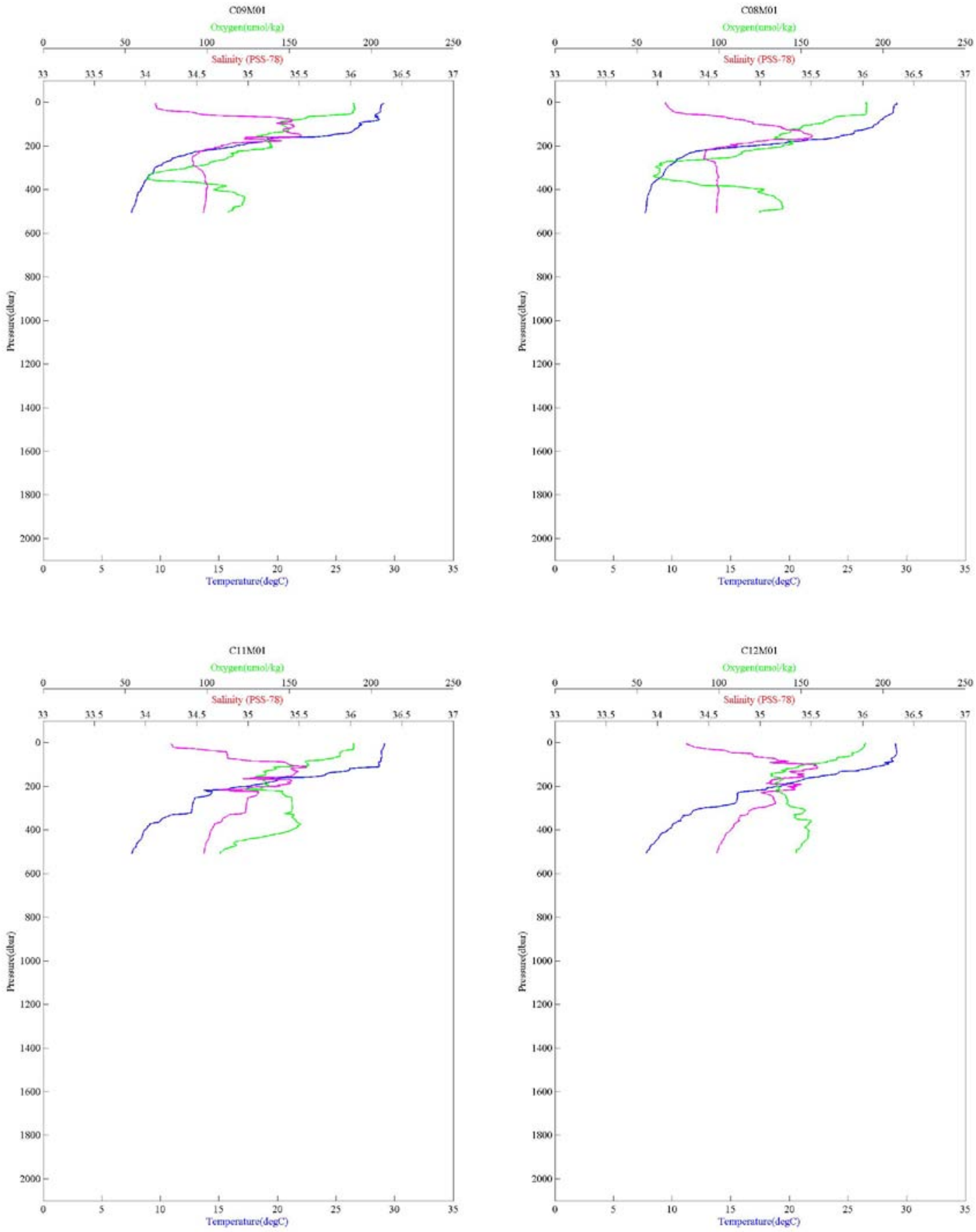


Figure 6.2.1-3 CTD profile (C09M01, C08M01, C11M01 and C12M01)

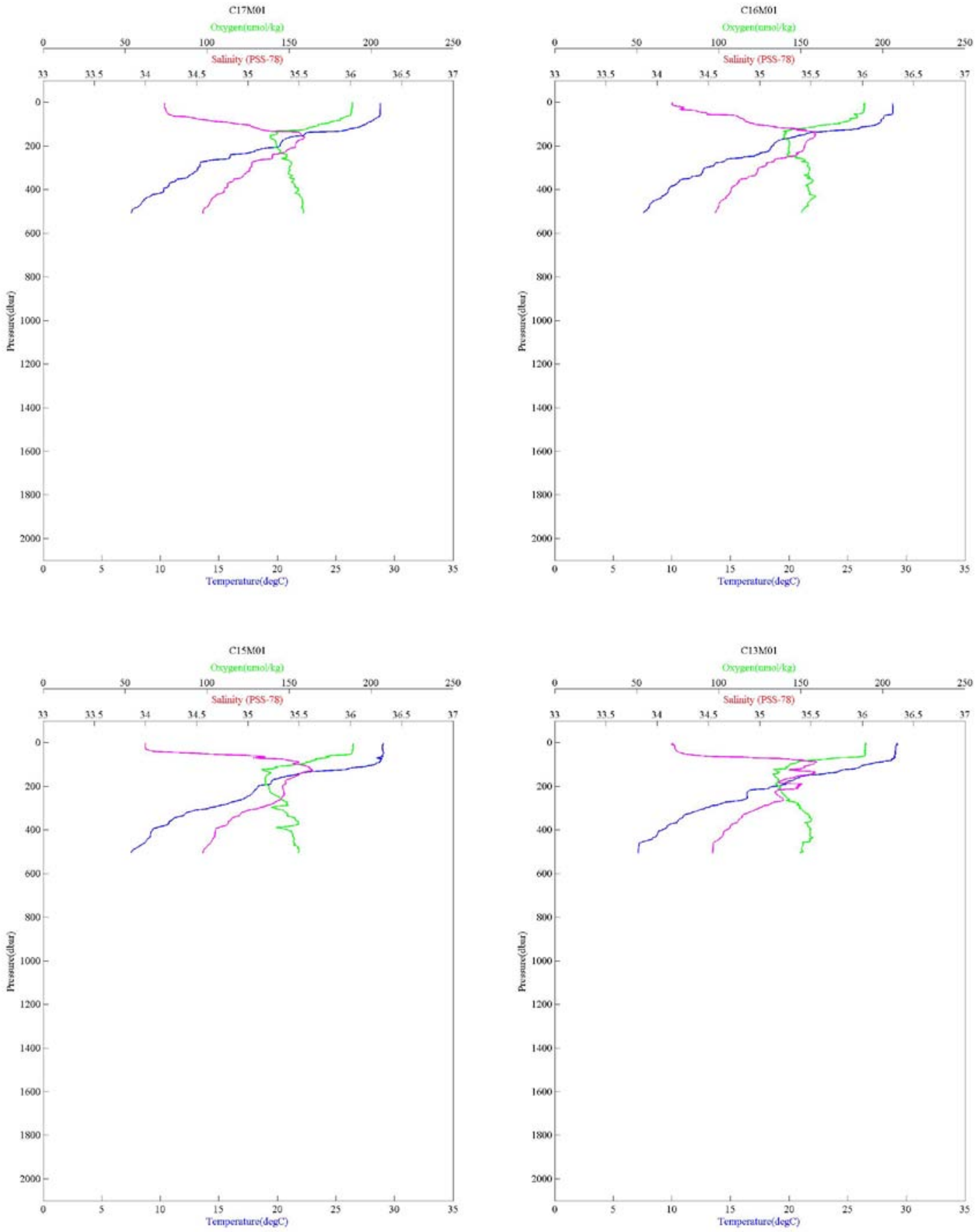


Figure 6.2.1-4 CTD profile (C17M01, C16M01, C15M01 and C13M01)

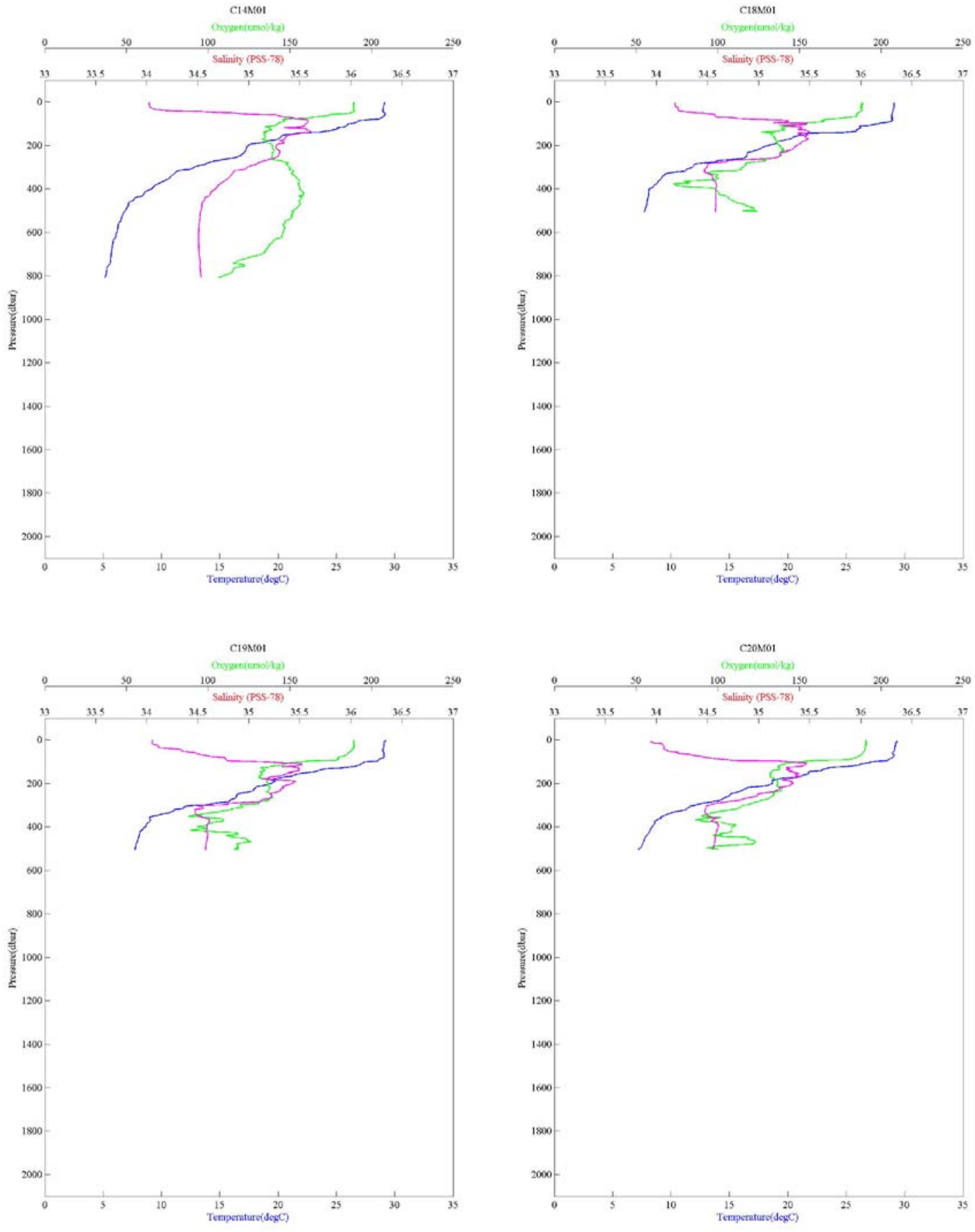


Figure 6.2.1-5 CTD profile (C14M01, C18M01, C19M01 and C20M01)

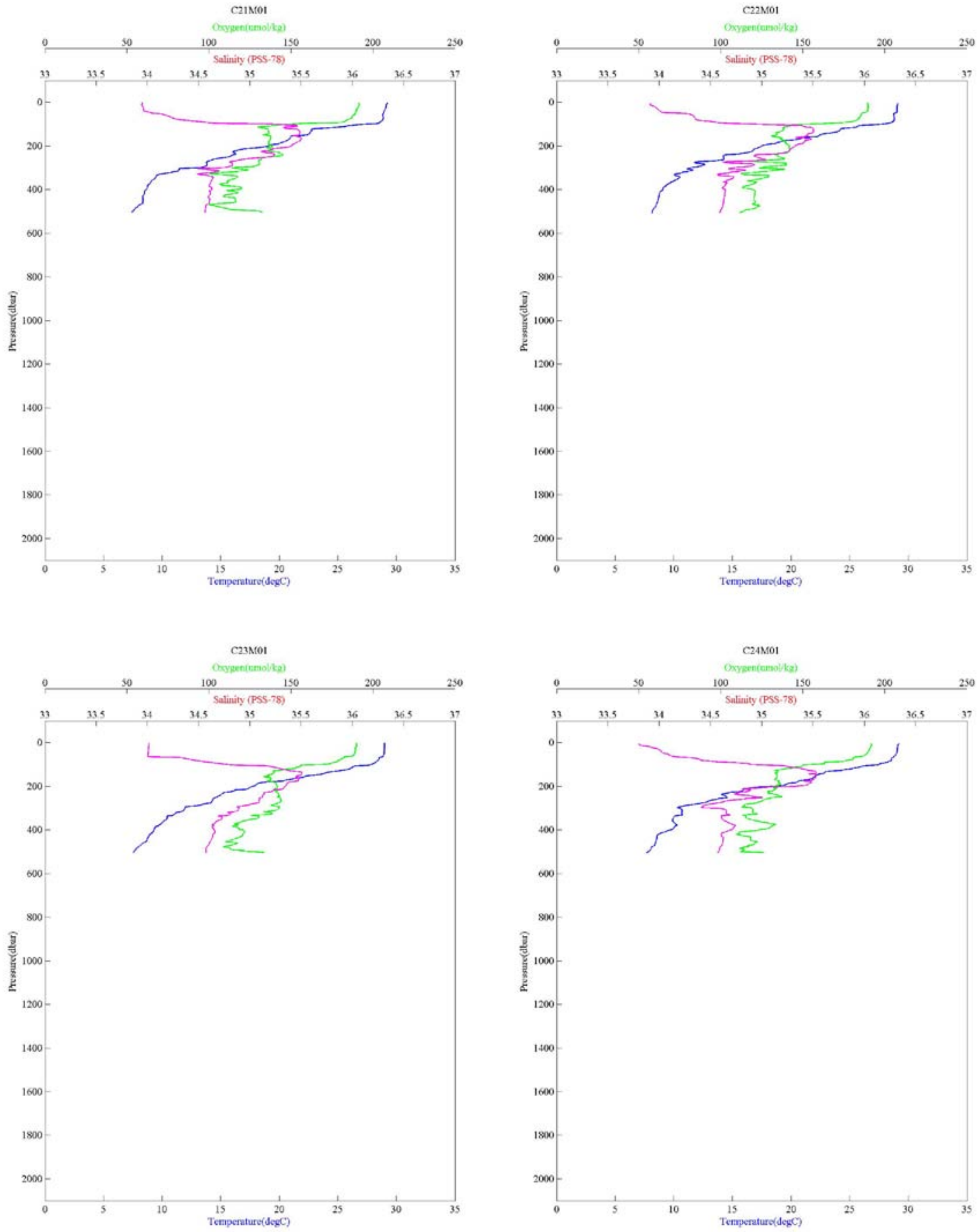


Figure 6.2.1-6 CTD profile (C21M01, C22M01, C23M01 and C24M01)

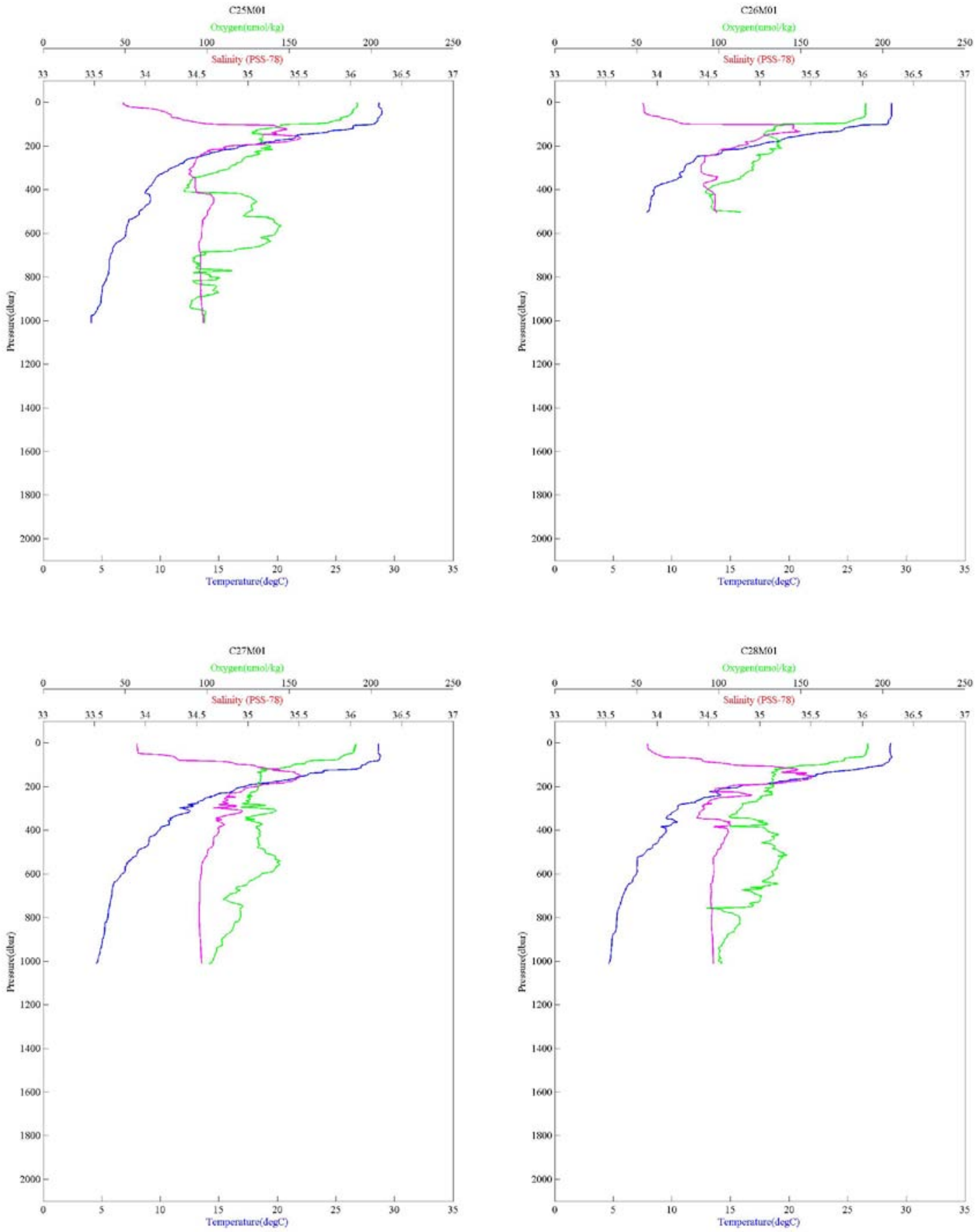


Figure 6.2.1-7 CTD profile (C25M01, C26M01, C27M01 and C28M01)

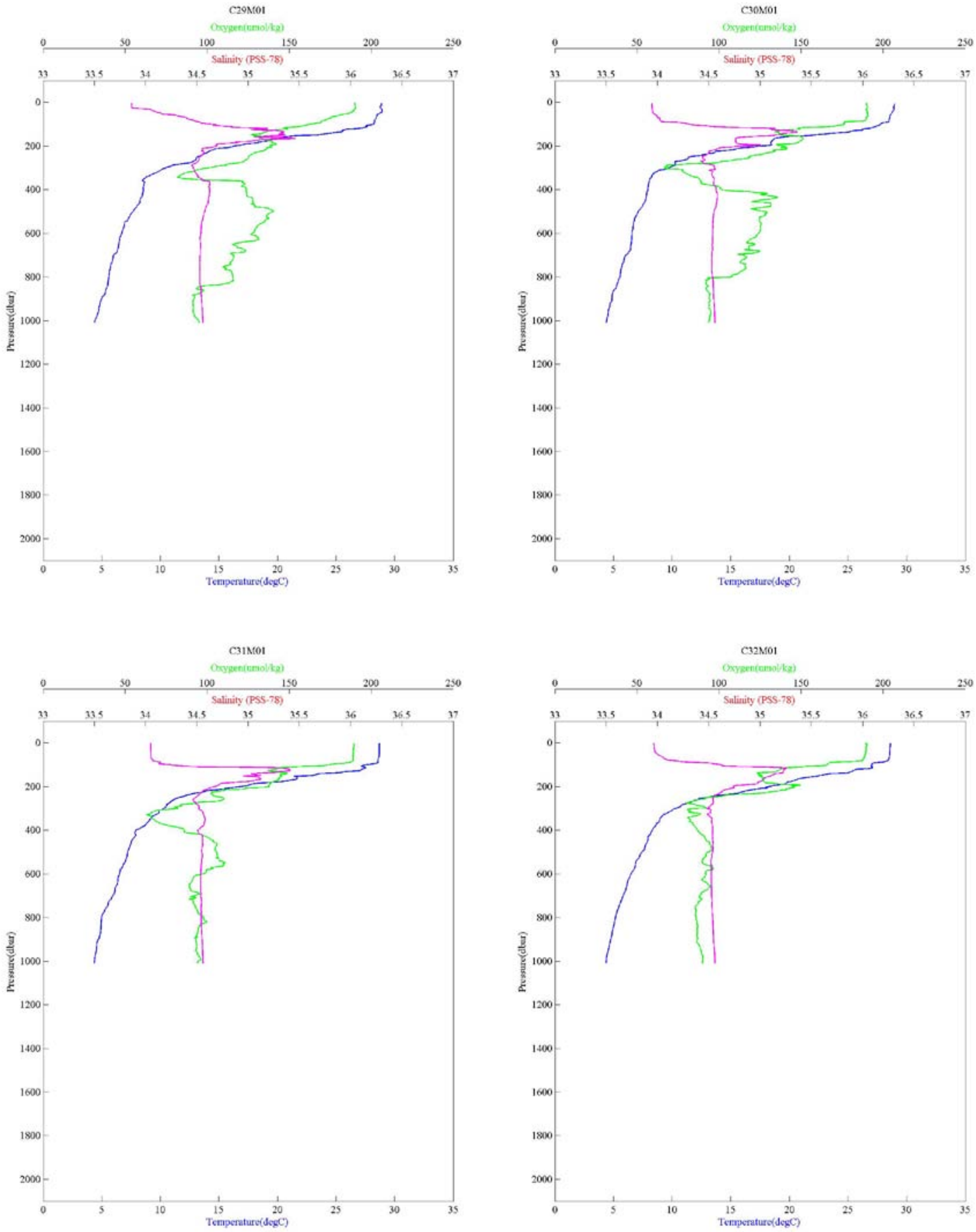


Figure 6.2.1-8 CTD profile (C29M01, C30M01, C31M01 and C32M01)

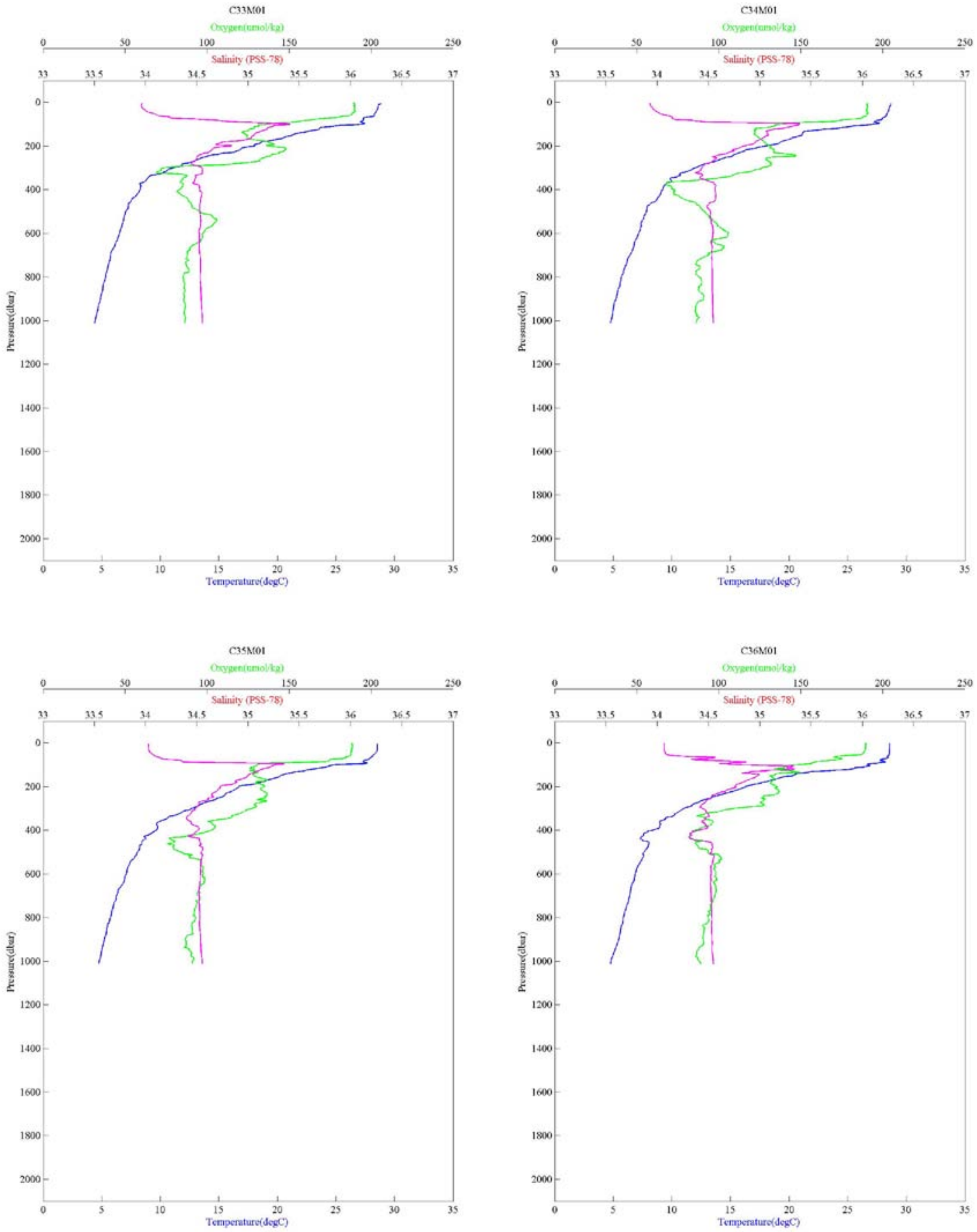


Figure 6.2.1-9 CTD profile (C33M01, C34M01, C35M01 and C36M01)

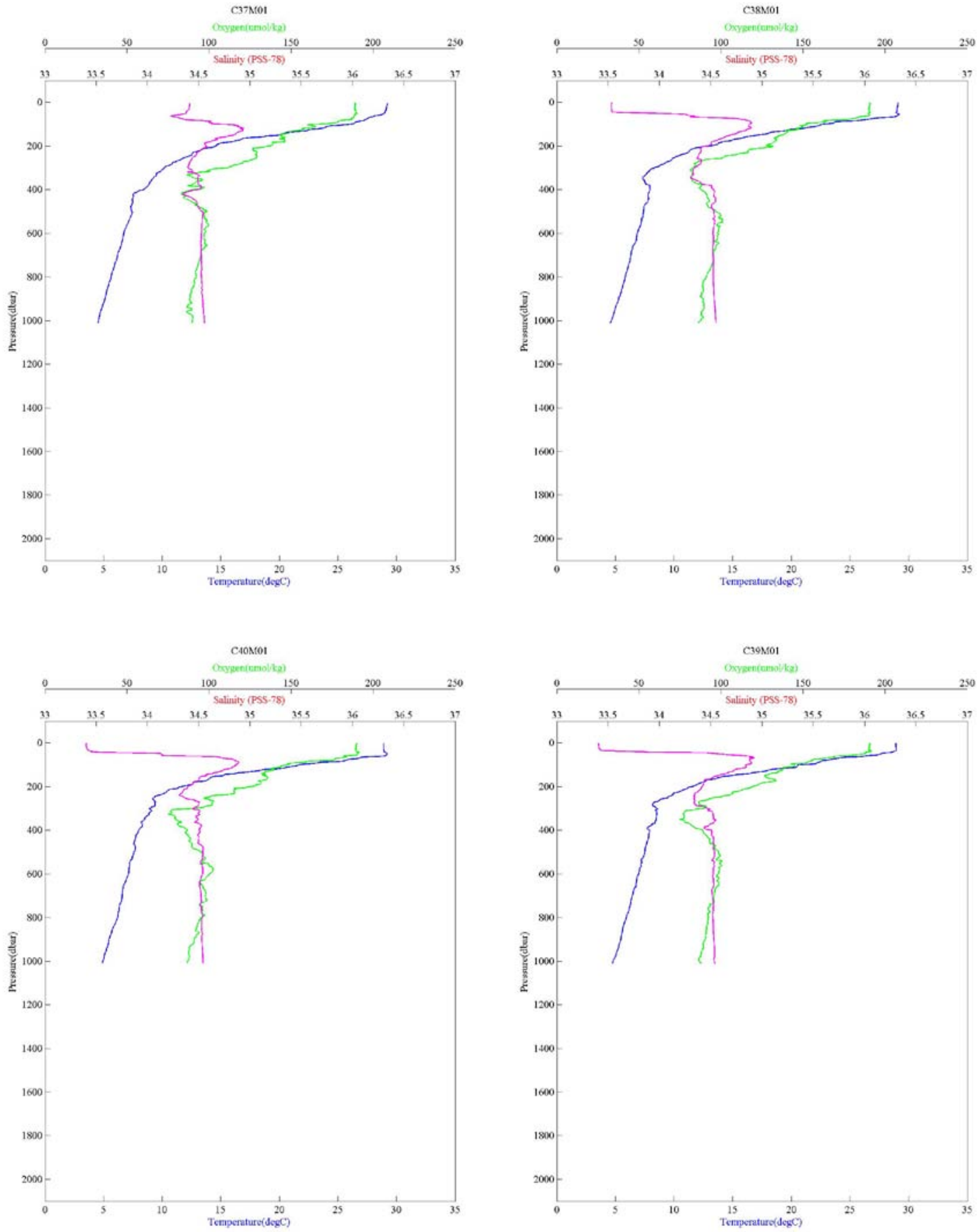


Figure 6.2.1-10 CTD profile (C37M01, C38M01, C40M01 and C39M01)

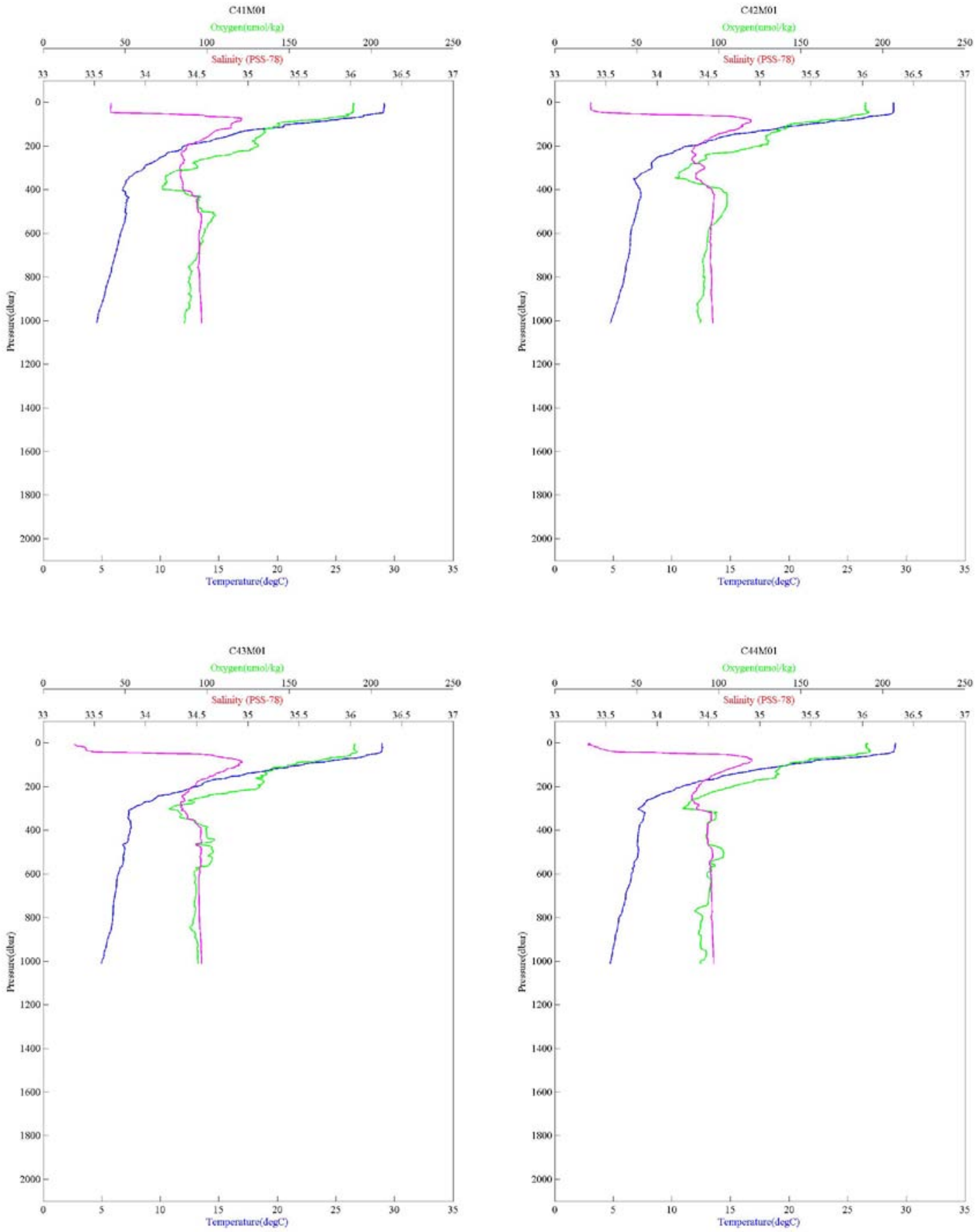


Figure 6.2.1-11 CTD profile (C41M01, C42M01, C43M01 and C44M01)

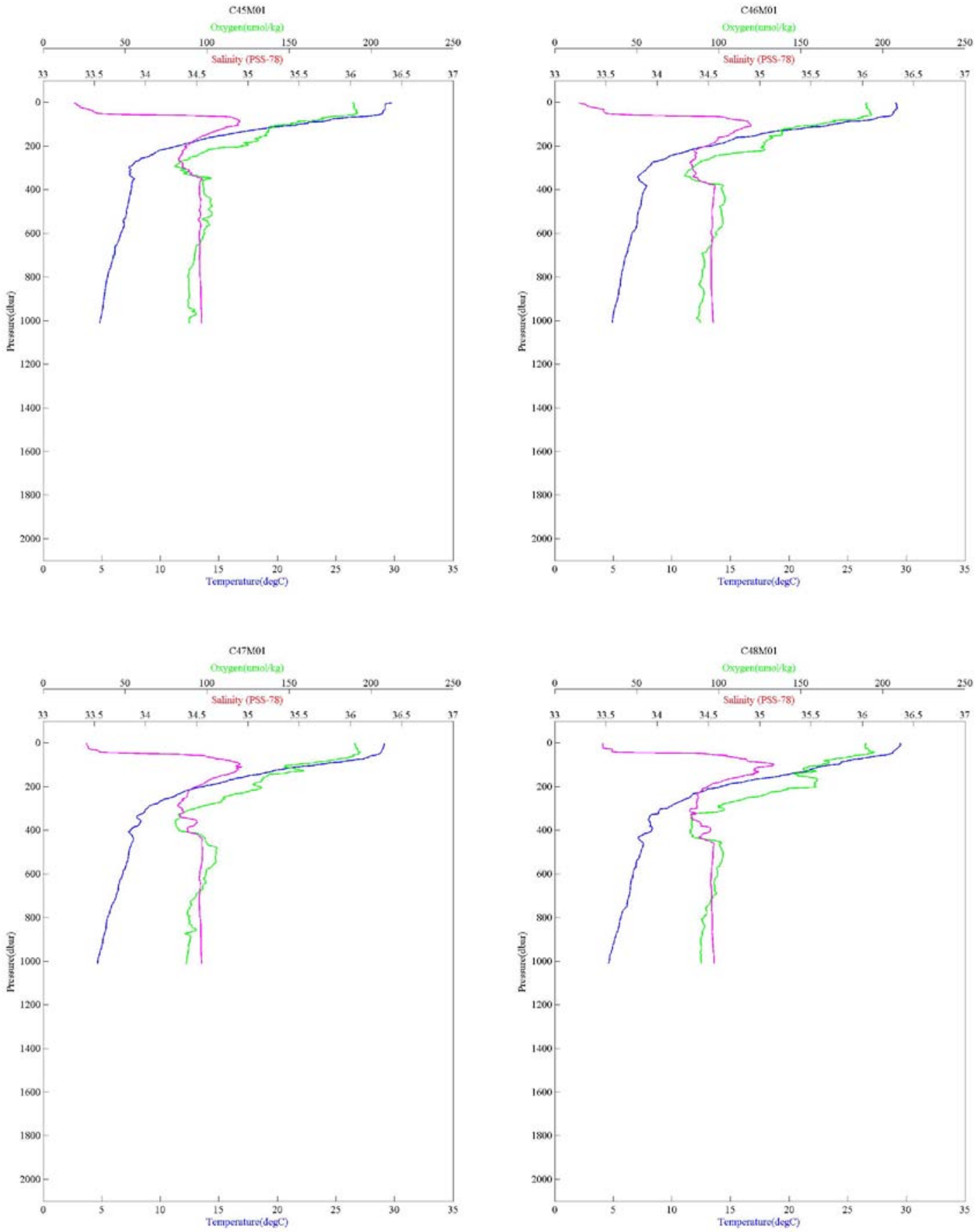


Figure 6.2.1-12 CTD profile (C45M01, C46M01, C47M01 and C48M01)

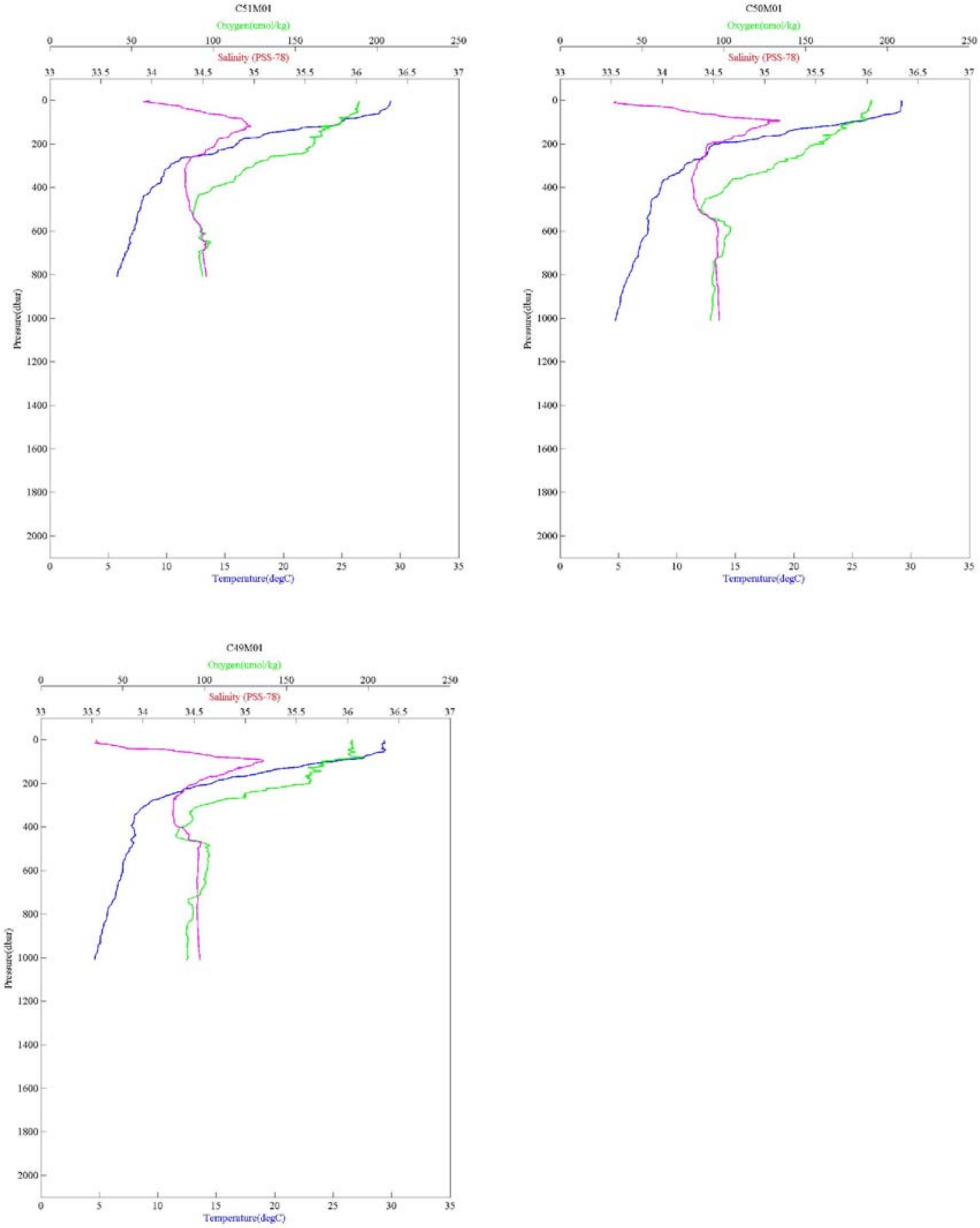


Figure 6.2.1-13 CTD profile (C51M01, C50M01 and C49M01)

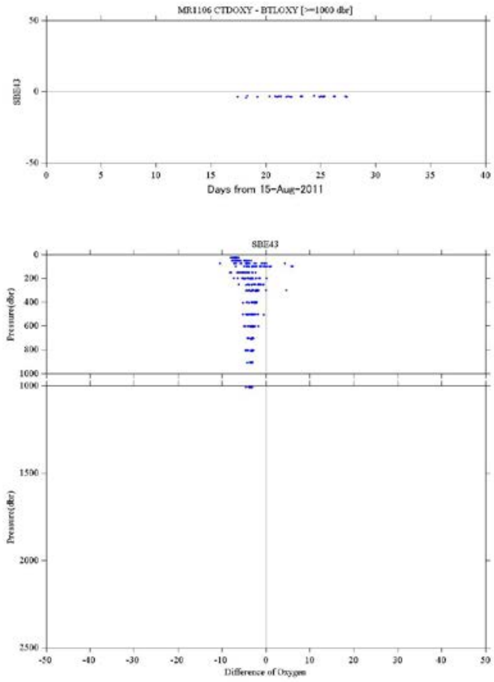


Figure 6.2.1-14 Vertical profile of the difference between dissolved oxygen sensor and bottle

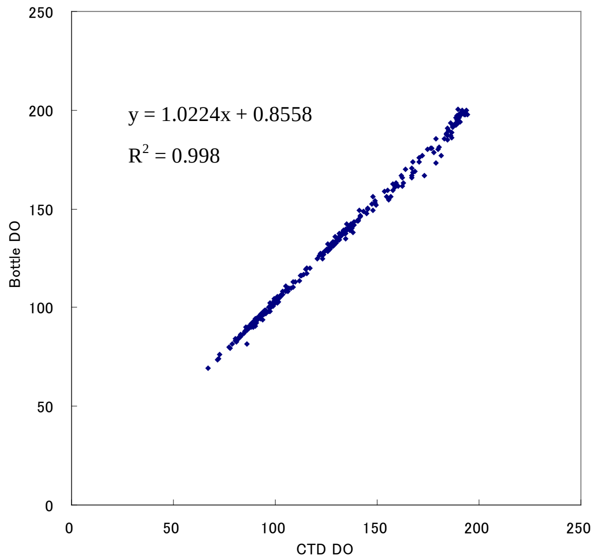


Figure 6.2.1-15 Distribution of dissolved oxygen sensor and bottle

6.2.2 XCTD

(1) Personnel

Yuji Kashino	(JAMSTEC): Principal Investigator
Kyoko Taniguchi	(JAMSTEC)
Satoshi Okumura	(Global Ocean Development Inc., GODI)
Kazuho Yoshida	(GODI)
Wataru Tokunaga	(MIRAI Crew)

Not on board:

Yoshimi Kawai	(JAMSTEC): Principal Investigator
Akira Nagano	(JAMSTEC)

(2) Objectives

To investigate vertical structure of temperature and salinity around Kuroshio Extension and tropical region of western Pacific Ocean.

(3) Parameters

Parameters of XCTD (eXpendable Conductivity, Temperature & Depth profiler; Tsurumi-Seiki Co, Japan) 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 (XCTD-1)	5 m or 2 % at depth, whichever is greater

(4) Methods

We observed vertical profile of temperature and salinity with XCTD system made by Tsurumi-Seiki Co., which consisted MK-150N converter and AL-12B software (version 1.1.4) for operation of the automatic launcher and data recording. We dropped 23 XCTD-1 probes between JKEO and KEO sites across Kuroshio Extension and 10 probes in tropical region of western Pacific Ocean. The summary of the XCTD observation is shown in Tables 6.2.2-1.

(5) Preliminary results

Position map of XCTD observations, vertical sections of temperature and salinity are shown in Figures. 6.2.2-1 and 6.2.2-4.

(6) Data archives

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

Table 6.2.2-1 Summary of the XCTD observation

Station Name	Date and Time (UTC)		Lat. (N) and Long. (E)				Depth (m)
	YYYY/MM/DD	hh:mm	Deg.	Min.	Deg.	Min.	
JKEO	2011/08/16	03:02	38	5.7566	146	23.6359	5461
E01	2011/08/16	05:05	37	45.7167	146	18.8021	5536
E02	2011/08/16	06:34	37	29.9899	146	14.2304	5538
E03	2011/08/16	08:06	37	14.8261	146	8.9288	5588
E04	2011/08/16	09:35	36	59.8193	146	3.8366	5468
E05	2011/08/16	11:04	36	45.0127	145	59.3422	5470
E06	2011/08/16	12:35	36	29.736	145	54.1171	5482
E07	2011/08/16	14:04	36	14.8144	145	48.7774	5567
E08	2011/08/16	16:49	35	59.902	145	45.6989	5717
E09	2011/08/16	18:34	35	44.6132	145	40.3933	5823
E10	2011/08/16	20:03	35	30.0684	145	35.4401	5840
E11	2011/08/16	21:30	35	15.2533	145	29.8717	5915
E12	2011/08/16	23:05	35	0.7078	145	24.3849	5857
E13	2011/08/17	00:34	34	45.3167	145	19.4093	5816
E14	2011/08/17	02:03	34	30.0772	145	14.6396	5824
E15	2011/08/17	03:35	34	15.0162	145	8.8886	5770
E16	2011/08/17	05:04	34	0.2025	145	4.0824	5754
E17	2011/08/17	06:35	33	45.2316	144	59.5792	5756
E18	2011/08/17	08:04	33	30.0194	144	54.6958	5708
E19	2011/08/17	09:35	33	15.1428	144	49.0935	5732
E20	2011/08/17	11:04	32	59.8934	144	44.0523	5654
E21	2011/08/17	12:33	32	44.7282	144	39.2012	5213
KEO	2011/08/17	14:32	32	26.7796	144	32.4086	5756
TR10	2011/08/24	02:23	7	52.2870	136	30.3012	3351
7-30N	2011/08/24	05:11	7	29.9036	136	37.0058	2518
7-00N	2011/08/24	07:18	6	59.9719	136	44.0186	4914
6-30N	2011/08/24	09:26	6	29.9794	136	51.0044	4585
6-00N	2011/08/24	11:36	5	59.9675	136	58.0820	4425
5-30N	2011/08/24	14:13	5	30.0084	137	5.0128	4618
TR11	2011/08/25	02:37	4	51.5742	137	15.3843	4099
TR12	2011/08/28	03:18	1	59.2743	138	5.3538	4303
TR16	2011/09/04	02:41	1	58.5845	130	10.8269	4381
TR14	2011/09/07	02:39	7	59.4212	130	3.6272	5718

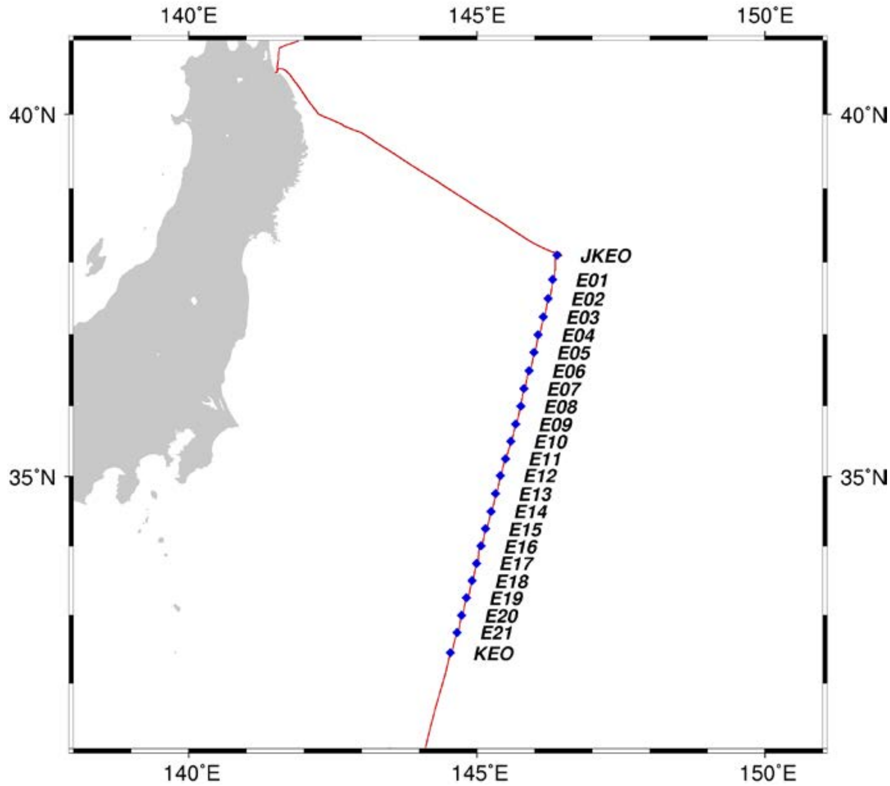


Figure 6.2.2-1 Positions of the XCTD observations from JKEO to KEO sites (eastern to Japan)

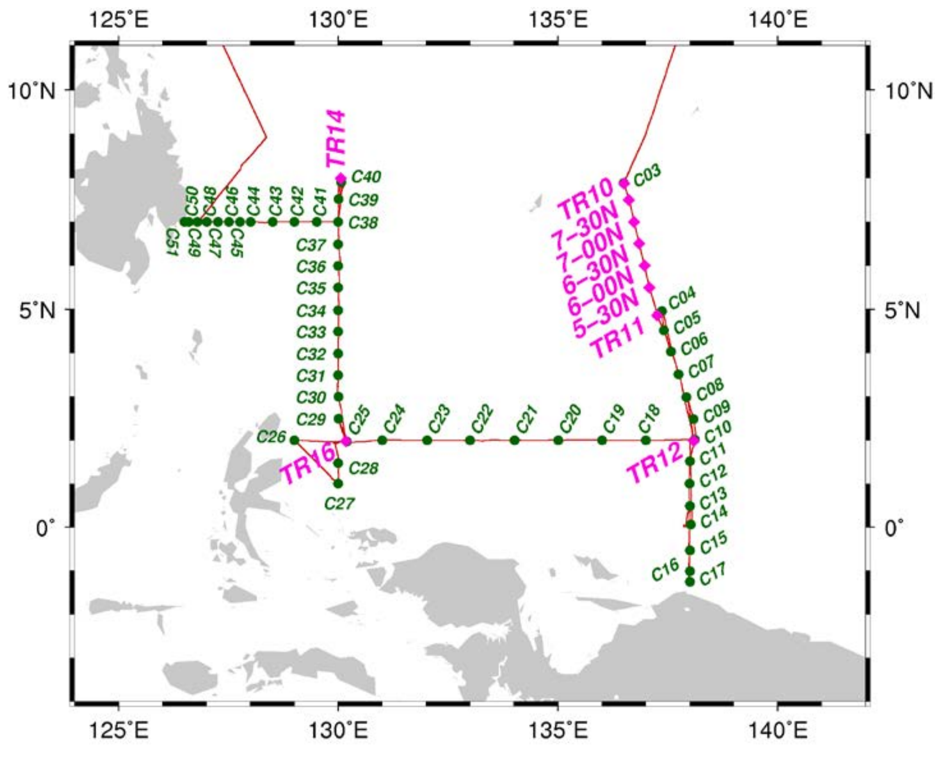


Figure 6.2.2-2 Positions of the XCTD observations from TR10 to TR14
(tropical region of western Pacific Ocean. Pink: XCTD, Green: CTD)

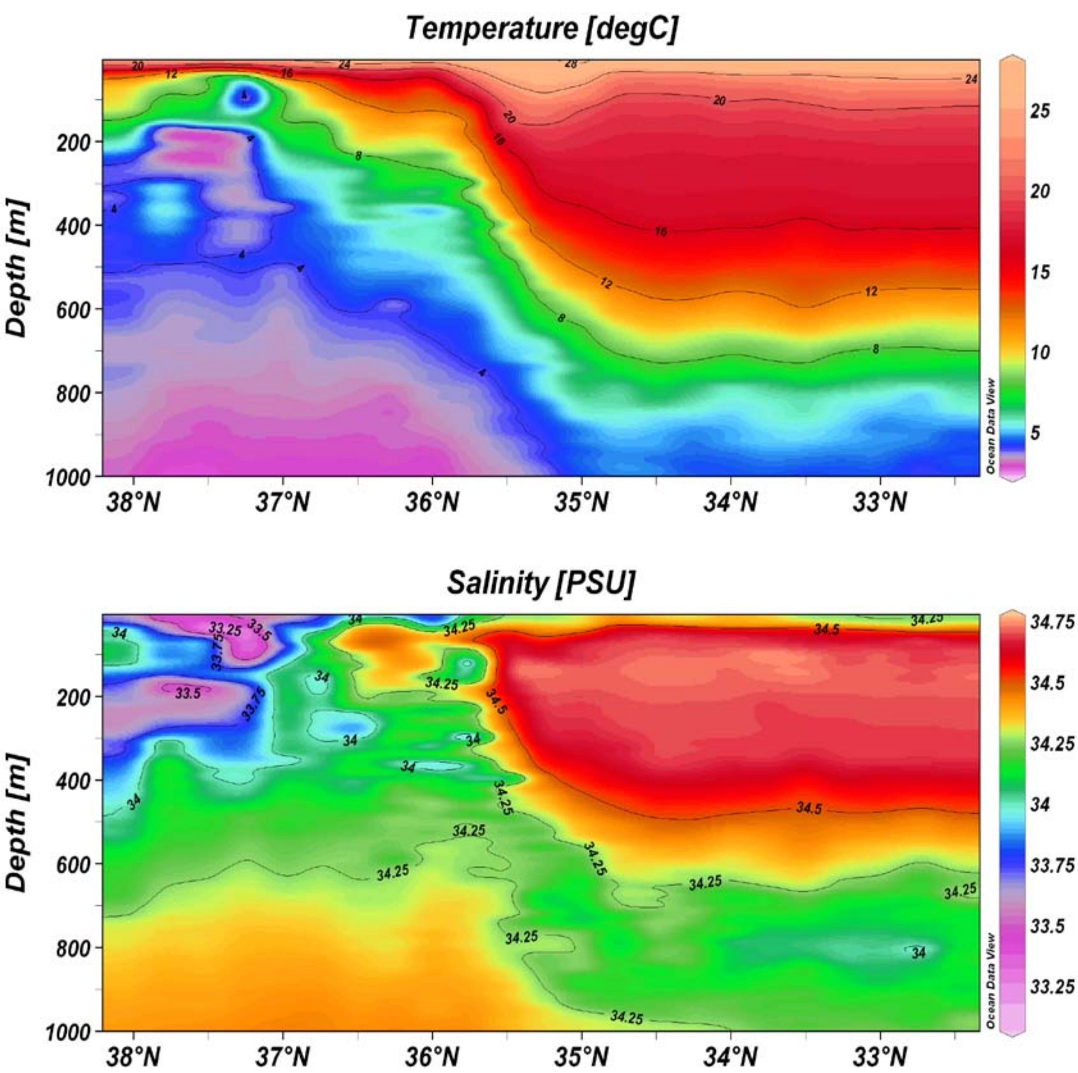


Figure 6.2.2-3 Vertical section from JKEO to KEO sites (eastern to Japan)
(upper: temperature, lower: salinity).

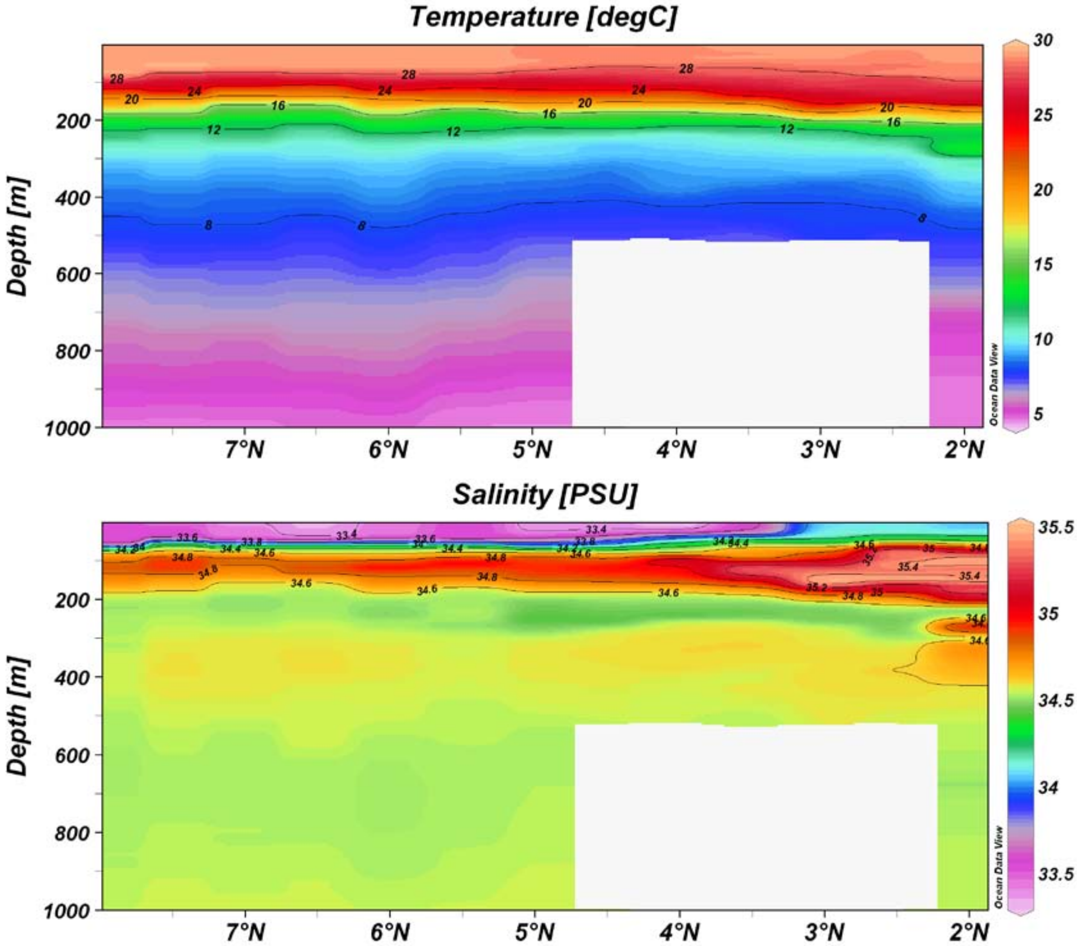


Figure 6.2.2-4 Vertical section from TR10 to TR12 (8N137E to 2N138E), interpolated CTD data from 4.5N to 2.5N (upper: temperature, lower: salinity).

6.3 Water sampling

6.3.1 Salinity

(1) Personnel

Yuji Kashino	(JAMSTEC)	: Principal Investigator
Tamami Ueno	(MWJ)	: Technical Staff (Operation Leader)
Tatsuya Tanaka	(MWJ)	: Technical Staff

(2) Objective

To measure bottle salinity obtained by CTD casts and The Continuous Sea Surface Water Monitoring System (TSG).

(3) Method

a. Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles and TSG. The salinity sample bottle of the 250ml brown glass with screw cap was used collecting the sample seawater. Each bottle was rinsed three times with the sample seawater, and was filled with sample seawater to the bottle shoulder. In this cruise, each bottle sealed with a plastic insert cap and a screw cap because we took into consideration the possibility of storage for about two weeks. These caps were rinsed three times with the sample seawater before its use. Each bottle was stored for more than 12 hours in the laboratory before the salinity measurement.

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

Table 6.3.1-1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD	109
Samples for TSG	34
Total	145

b. Instruments and Method

The salinity measurement was carried out on R/V MIRAI during the cruise of MR11-06 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. One thermometer monitored the ambient temperature and the other monitored the bath temperature of the salinometer.

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

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

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

Thermometer (Model 9540 ; Guildline Instruments Ltd.)

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

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 22 deg C to 25 deg C, while the bath temperature was very stable and varied within +/- 0.002 deg C on rare occasion. The measurement for each sample was done with a double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 10 seconds after filling the cell with the sample and it took about 15 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for the practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. In the case of the double conductivity ratio of eighth filling did not satisfy the criteria, we measured a ninth filling of the cell and calculated the bottle salinity. The measurement was conducted in about 5 hours per day and the cell was cleaned with soap after the measurement of the day.

(4) Preliminary Results

a. Standard Seawater

Standardization control of the salinometer was set to 752 from 21th August to 4th September. During this period, the value of STANDBY was 24+5571 +/- 0001 and that of ZERO was 0.0±0000. Because of changing cell electrical joint at 5th September, the salinometer standardization control was set again to 754. After the day, the value of STANDBY was 24+5572 +/- 0001 and that of ZERO was 0.0±0000.

In this cruise, the conductivity ratio of IAPSO Standard Seawater batch P153 was 0.99979 (the double conductivity ratio was 1.99958) and was used as the standard for salinity.

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

Batch	:	P153
Conductivity Ratio	:	0.99979
Salinity	:	34.992
Use By	:	08th March 2014

Fig.6.3.1-1 shows the time series of the double conductivity ratio of the Standard Seawater during first period. Figure (a) shows before correction. The average of the double conductivity ratio was 1.99955 and the standard deviation was 0.00001, which is equivalent to 0.0003 in

salinity. Figure (b) shows after correction. The average of the double conductivity ratio was 1.99958 and the standard deviation was 0.00001, which is equivalent to 0.0001 in salinity.

Fig.6.3.1-2 shows the time series of the double conductivity ratio of the Standard Seawater during second period. Figure (a) shows before correction. The average of the double conductivity ratio was 1.99956 and the standard deviation was 0.00001, which is equivalent to 0.0003 in salinity. Figure (b) shows after correction. The average of the double conductivity ratio was 1.99958 and the standard deviation was 0.00001, which is equivalent to 0.0003 in salinity.

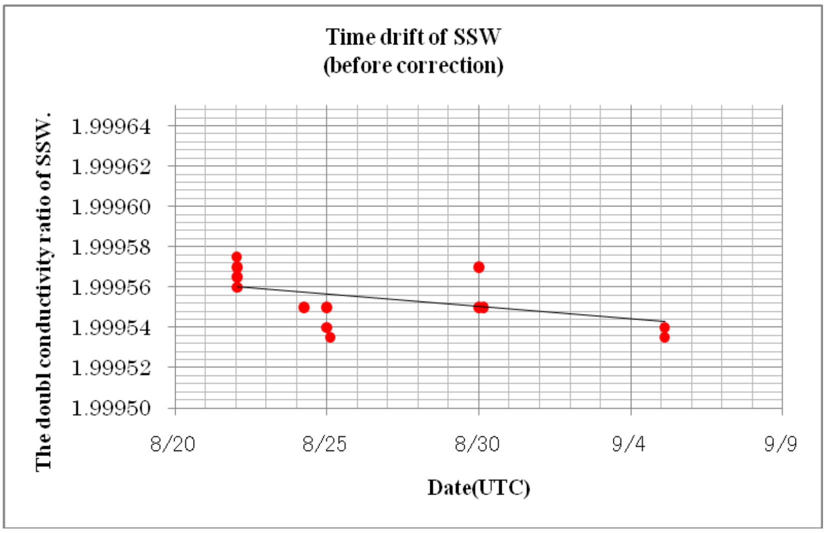


Fig. 6.3.1-1(a) Time series of double conductivity ratio for the Standard Seawater during 1st period. (before correction)

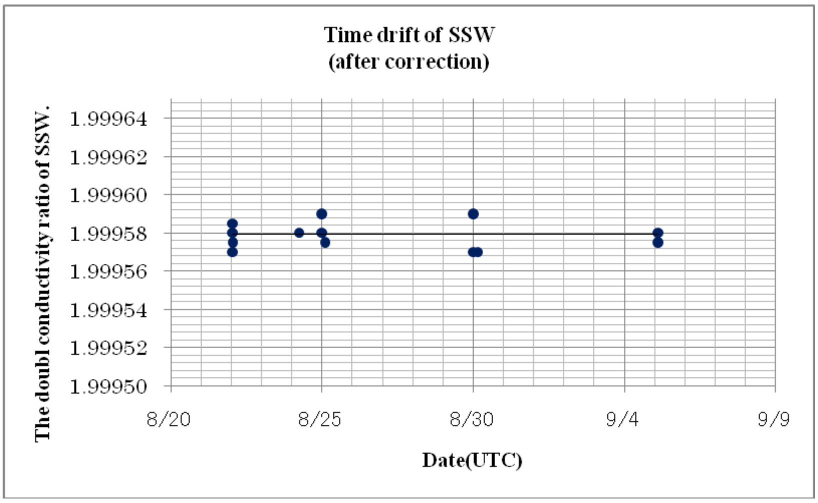


Fig.6.3.1-1(b) Time series of double conductivity ratio for the Standard Seawater during 1st period. (after correction)

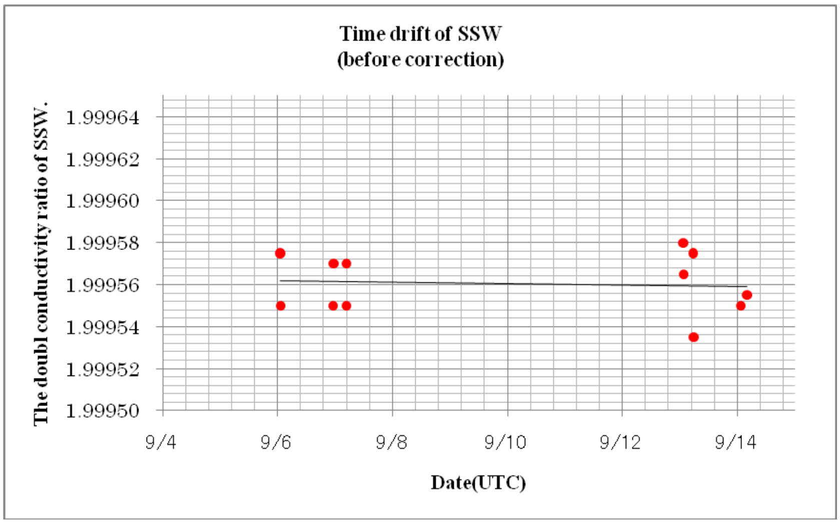


Fig. 6.3.1-2(a) Time series of double conductivity ratio for the Standard Seawater during 2nd period. (before correction)

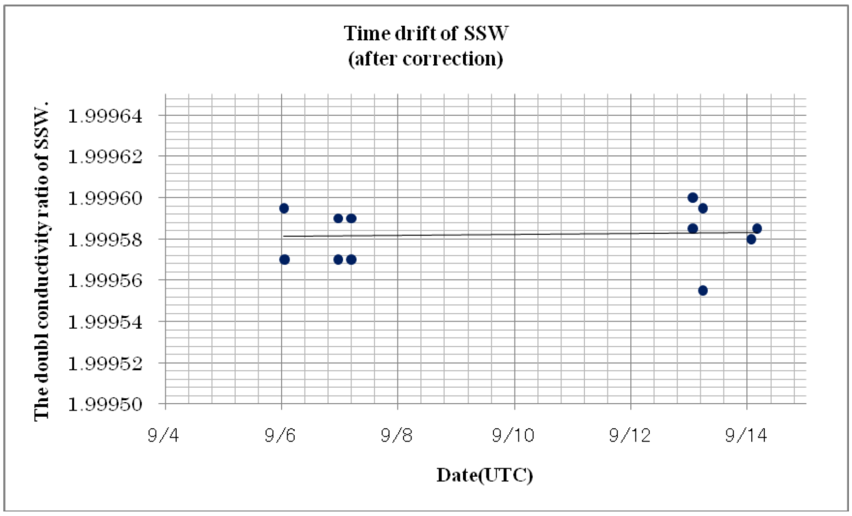


Fig. 6.3.1-2(b) Time series of double conductivity ratio for the Standard Seawater during 2nd period. (after correction)

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 51 pairs of replicate samples taken from the same Niskin bottle. Fig.6.3.1-3 shows the histogram of the absolute difference between each pair of the replicate samples.The average and the standard deviation of absolute difference among 51 pairs of replicate samples were 0.0004 and 0.0003 in salinity, respectively.

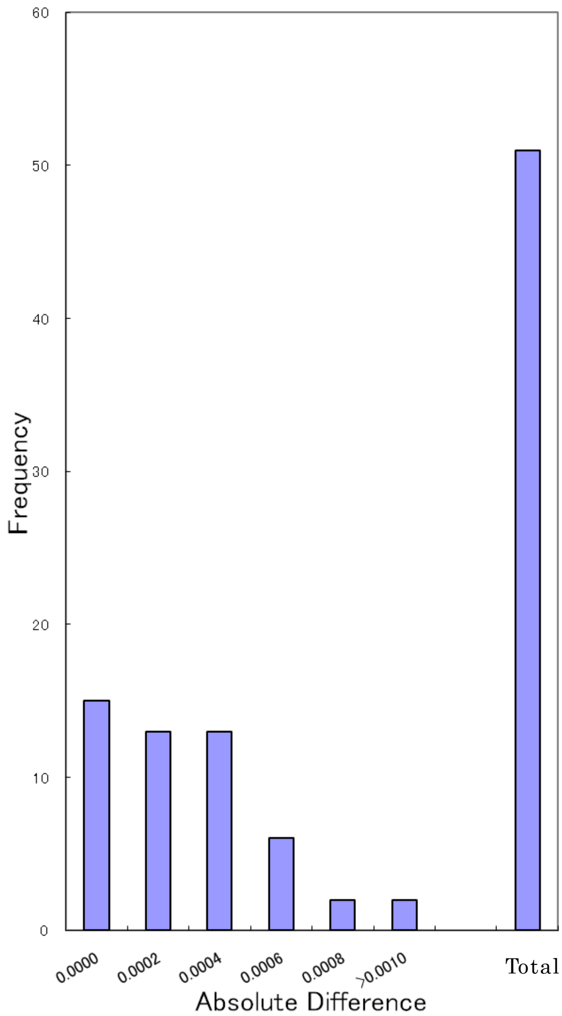


Fig.6.3.1-3 The histogram of the double conductivity ratio for the absolute difference of replicate samples

(5) Data archive

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

(6) Reference

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

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

6.3.2 Dissolved oxygen

(1) Personnel

Yuji KASHINO (JAMSTEC): Principal Investigator
Katsunori SAGISHIMA (MWJ): Operation Leader
Misato KUWAHARA (MWJ)

(2) Objectives

Determination of dissolved oxygen in seawater by Winkler titration.

(3) Parameter

Dissolved Oxygen

(4) Instruments and Methods

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

a. Instruments

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

b. Reagents

Pickling Reagent I: Manganese chloride solution (3 mol dm^{-3})
Pickling Reagent II: Sodium hydroxide (8 mol dm^{-3}) / sodium iodide solution (4 mol dm^{-3})
Sulfuric acid solution (5 mol dm^{-3})
Sodium thiosulfate (0.025 mol dm^{-3})
Potassium iodide (0.001667 mol dm^{-3})
CSK standard of potassium iodide:
Lot EPJ3885, Wako Pure Chemical Industries Ltd., 0.0100N

c. Sampling

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

d. Sample measurement

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

e. Standardization and determination of the blank

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

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

Table 6.3.2-1 shows results of the standardization and the blank determination during this cruise.

Data	KIO_3 ID	$Na_2S_2O_3$	DOT-01X(No.7)		DOT-01X(No.8)		Stations
			E.P.	Blank	E.P.	Blank	
2011/08/18	20110523-02-01	20110602-23	3.943	-0.005	3.945	-0.003	
2011/08/18	CSK	20110602-23	3.943	-0.005	3.944	-0.003	
2011/09/01	20110523-02-03	20110602-23	3.947	-0.003	3.948	0.002	25, 27, 28
2011/09/03	20110523-02-04	20110602-23	3.945	-0.005	3.949	0.002	29, 30, 31, 32, 33, 34, 35, 36, 37, 38
2011/09/07	20110523-02-05	20110602-23	3.949	0.000	3.951	0.004	40, 39, 41, 42, 43, 44, 45, 46, 47, 48, 51, 50, 49
2011/09/13	20110523-02-06	20110602-23	3.949	-0.003	3.949	0.003	

f. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. Total amount of the replicate sample pairs of good measurement was78. The standard deviation of the replicate measurement was 0.07 μmol kg^{-1} that was calculated by a procedure in Guide to best practices for ocean CO_2 measurements Chapter4 SOP23 Ver.3.0 (2007). Results of replicate samples were shown in Table 6.3.2-2 and this diagram shown in Fig. 6.3.2-1.

Table 6.3.2-2 Results of the replicate samples

Layer	Number of replicate sample pairs	Oxygen concentration (μmol kg^{-1}) Standard Deviation.
1000m>=	54	0.07
>1000m	24	0.07
All	78	0.07

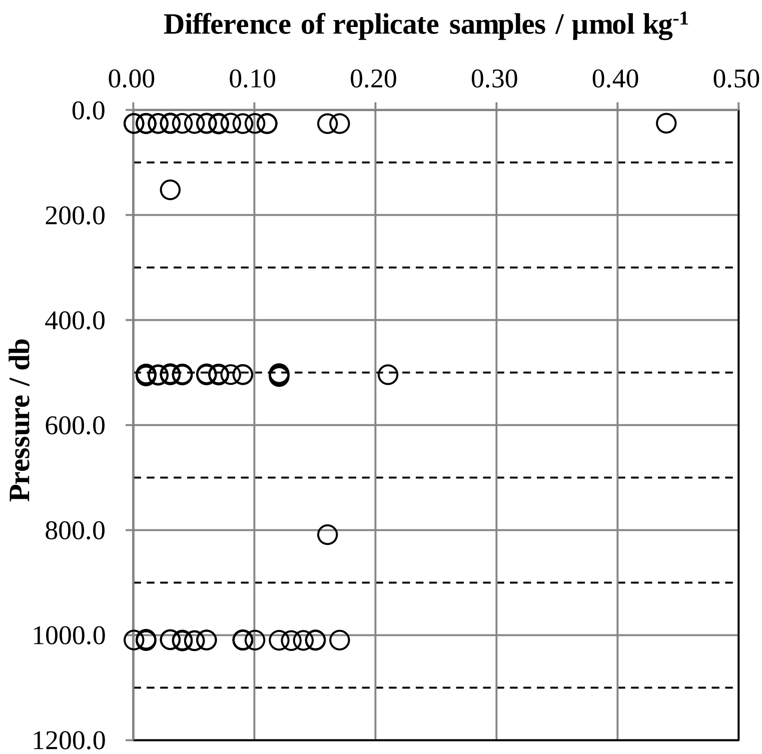


Fig. 6.3.2-1 Difference of replicate samples against pressure

(5) Data archive

All data will be submitted to Chief Scientist.

(6) References

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

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

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

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

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

6.4 Continuous monitoring of surface seawater

6.4.1 Temperature, salinity and dissolved oxygen

1) Personnel

Yuji Kashino (JAMSTEC): Principal Investigator
Katsunori Sagishama(MWJ): Operation Leader
Misato Kuwahara (MWJ)

2) Objective

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

3) Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co. Ltd.) has four sensors and automatically measures salinity, temperature and dissolved oxygen in near-sea surface water every one minute. This system is located in the "*sea surface monitoring laboratory*" and connected to shipboard LAN-system. Measured data, time, and location of the ship were stored in a data management PC. The near-surface water was continuously pumped up to the laboratory from about 4 m water depth and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was adjusted to be 3 dm^3 min^{-1}. Specifications of the each sensor in this system are listed below.

a. Instruments

Software

Seamoni-kun Ver.1.20

Sensors

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

Temperature and Conductivity sensor

Model:	SBE-45, SEA-BIRD ELECTRONICS, INC.
Serial number:	4563325-0362
Measurement range:	Temperature -5 to +35 ^oC
	Conductivity 0 to 7 S m^{-1}
Initial accuracy:	Temperature 0.002 ^oC
	Conductivity 0.0003 S m^{-1}

Typical stability (per month): Temperature 0.0002 °C
Conductivity 0.0003 S m^{-1}

Resolution: Temperatures 0.0001 °C
Conductivity 0.00001 S m^{-1}

Bottom of ship thermometer

Model:	SBE 38, SEA-BIRD ELECTRONICS, INC.
Serial number:	3852788-0457
Measurement range:	-5 to +35 °C
Initial accuracy:	±0.001 °C
Typical stability (per 6 month):	0.001 °C
Resolution:	0.00025 °C

Dissolved oxygen sensor

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

4) Measurements

Periods of measurement, maintenance, and problems during MR11-06 are listed in Table 6.4.1-1.

Table 6.4.1-1 Events list of the surface seawater monitoring during MR11-06

System Date [UTC]	System Time [UTC]	Events	Remarks
2011/08/15	1:00	All the measurements started and data was available.	Cruise started.
2011/08/15	2:03	All the measurements stopped for check logging data.	
2011/08/15	2:06	All of the measurements started and data was available.	
2011/08/15	03:33	Data was lost from 2011/08/15 2:24 to 3:33 due to handling error.	
2011/09/14	05:29	All the measurements stopped.	

5) Preliminary Result

We took the surface water samples to compare sensor data with bottle data of salinity and dissolved oxygen. The results are shown in Fig.6.4.1-1~2. All the salinity samples were analyzed by the Guideline 8400B “AUTOSAL”, and dissolve oxygen samples were analyzed by Winkler method. Preliminary data of temperature, salinity, and dissolved oxygen at sea surface are shown in Fig.6.4.1-3.

6) Data archive

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

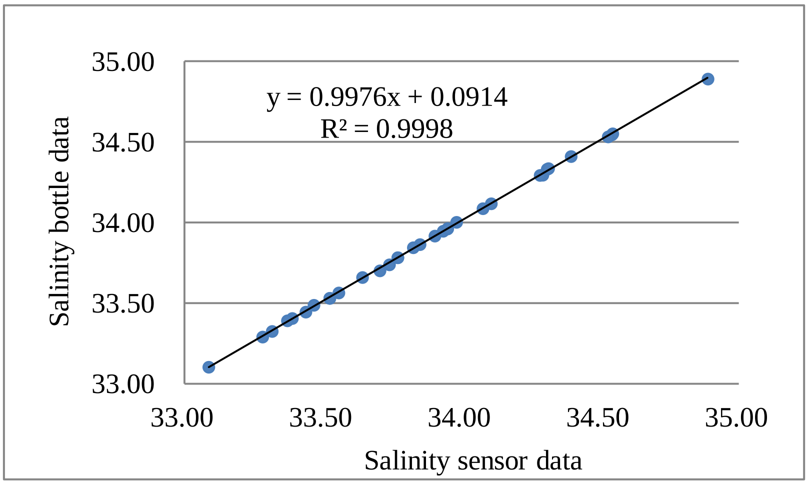


Fig.6.4.1-1 Correlation of salinity between sensor data and bottle data.

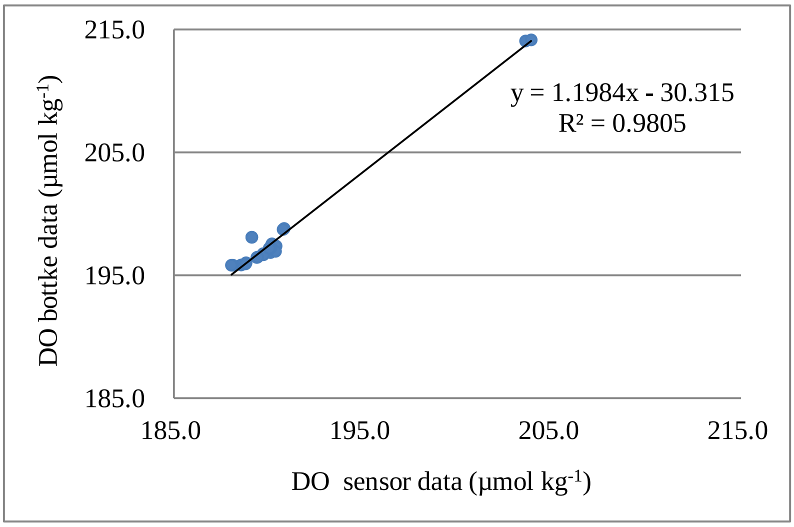


Fig.6.4.1-2 Correlation of dissolved oxygen between sensor data and bottle data.

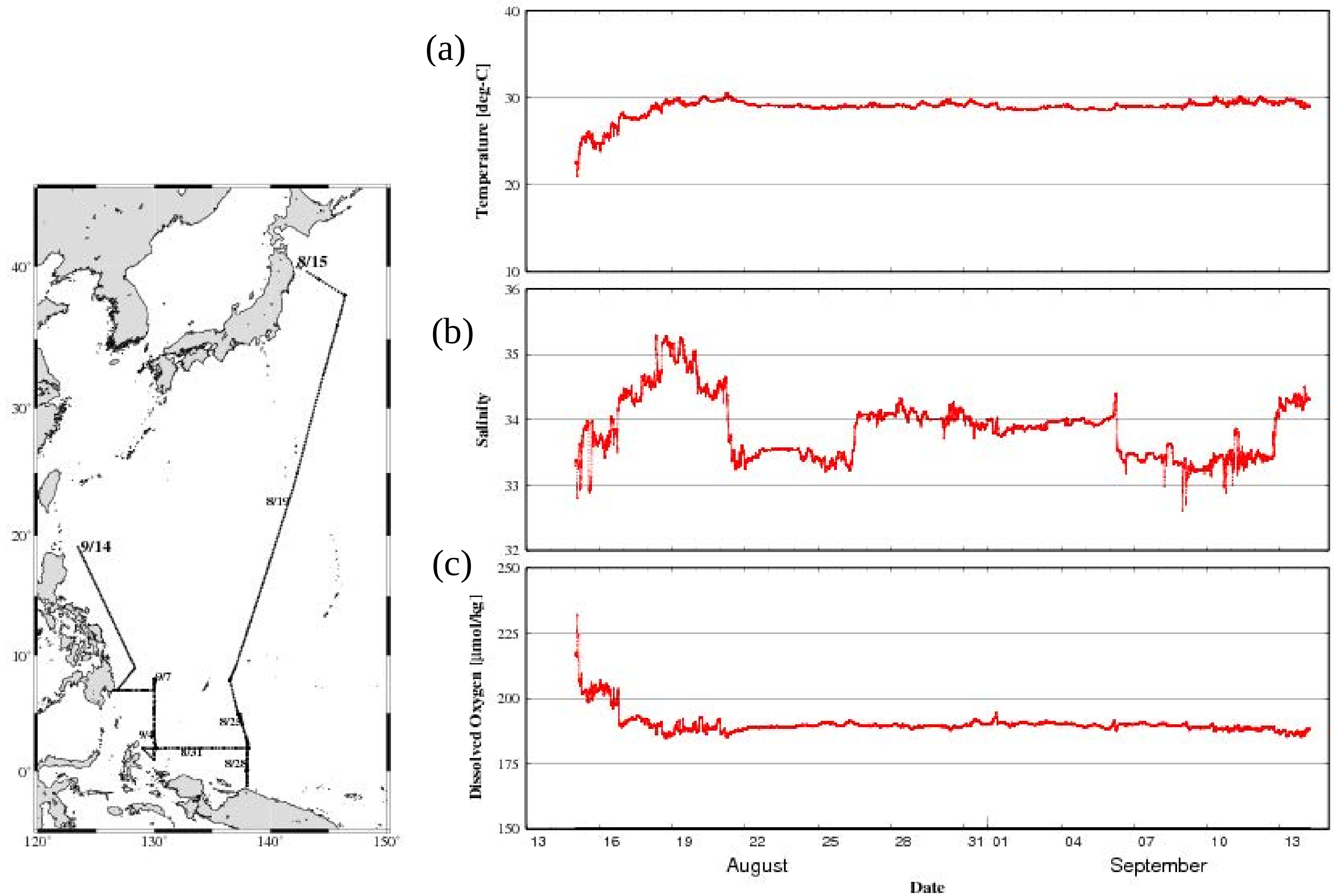


Fig.6.4.1-3 Spatial and temporal distribution of (a) temperature (b) salinity (c) dissolved oxygen in MR11-06 cruise

6.5 Shipboard ADCP

(1) Personnel

Yuji KASHINO	(JAMSTEC): Principal Investigator
Satoshi Okumura	(Global Ocean Development Inc., GODI)
Kazuho Yoshida	(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 MR11-06 cruise with the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation the instrument was configured for water-tracking mode. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made to get the calibration data for evaluating transducer misalignment angle in the shallow water. The system consists of following components;

1. R/V MIRAI has installed the Ocean Surveyor for vessel-mount ADCP (frequency 75 kHz; Teledyne RD Instruments, USA). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel
2. For heading source, we use ship's gyro compass (Tokimec, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System which provide high-precision heading, attitude information, pitch and roll, stored in ".N2R" data files with time stamp.
3. DGPS system (Trimble SPS751 & StarFixXP) providing precise ship's position.
4. We used VmDas software version 1.4.6 (TRDI) for data acquisition.
5. To synchronize time stamp of ping with GPS time, the clock of the logging computer is adjusted to GPS time every 1 minute
6. Fresh water is charged in the sea chest to prevent biofouling at transducer face.
7. The sound speed at the transducer, does affect the vertical bin mapping and vertical velocity measurement, were calculated from temperature, salinity (constant value; 35.0 psu) and depth (6.5 m; transducer depth) by equation in Medwin (1975).

Data was configured for 16-m intervals starting 23-m below sea surface. Data was recorded every ping as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds averaged data were recorded as short-term average (.STA) and long-term average (.LTA) data, respectively. Major parameters for the measurement, Direct Command, are shown in Table 6.5-1.

(4) Preliminary results

Fig.6.5-1 shows surface current profile along the ship's track, averaged three depth cells from the top, 23 to 71m with 1 hour average.

Data acquisition was suspended in the South China Sea from 06:00 on 14 September to the end of this cruise.

(5) Data archive

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

Table 6.5-1 Major parameters

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

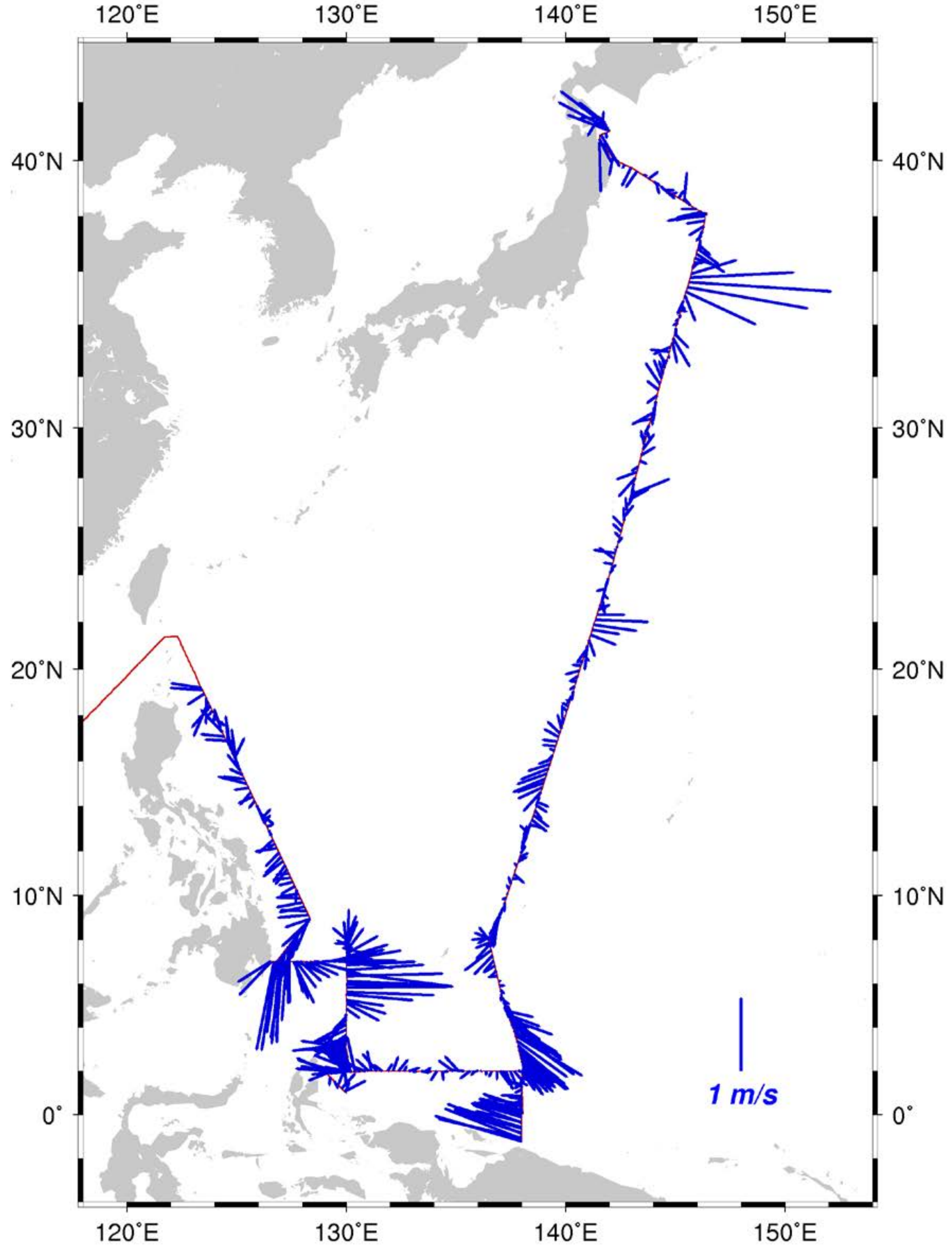


Fig 6.5-1. Current profile along the ship’s track, from 23m to 71m, averaged every 1 hour

6.6 Underway geophysics

6.6.1. Sea surface gravity

(1) Personnel

Takeshi Matsumoto	(University of the Ryukyus)	: Principal Investigator (Not on-board)
Satoshi Okumura	(Global Ocean Development Inc., GODI)	
Kazuho Yoshida	(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) in the MR11-01 cruise.

To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (Scintrex gravity meter CG-5), at Sekinehama before departure, and will measure after MR11-08, as the reference point.

(5) Preliminary Results

Absolute gravity will be calculated on February 2012, going back to Sekinehama port.

(6) Data Archives

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

(7) Remarks

Data acquisition was suspended in the South China Sea from 06:00 on 14 September to the end of this cruise.

6.6.2 Sea surface magnetic field

1) Three-component magnetometer

(1) Personnel

Takeshi Matsumoto (University of the Ryukyus): Principal Investigator (Not on-board)
Satoshi Okumura (Global Ocean Development Inc., GODI)
Kazuho Yoshida (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 a three-component magnetometer in the MR11-06 cruise.

(3) Principle of ship-board geomagnetic vector measurement

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

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

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

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

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

(4) Instruments on R/V MIRAI

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

(5) Data Archives

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

(6) Remarks

1. Stop collecting data just before entering the South China Sea on 14 September.

2. Navigation, time, depth data were Not Available during following periods (UTC), due to the trouble of data providing server.
   8/22 10:43:15 to 12:03:00, intermittently
   8/24 04:38:25 to 19:56:05, intermittently
   8/25 02:06:50 to 23:59:35, intermittently
   8/26 00:00:10 to 09:42:10, intermittently
   8/27 01:54:05, 23:23:15
   9/4 21:07:50 to 21:07:55, continuously
   9/7 09:31:30, 09:38:15, 09:47:45, 09:49:40

3. For calibration of the ship's magnetic effect, we made a "figure-eight" turn (a pair of clockwise and anti-clockwise rotation) three times (UTC) as follows;
   8/23 06:54 to 07:20
   9/2 12:58 to 13:27

2) Cesium magnetometer

(1) Personnel

Takeshi Matsumoto	(University of the Ryukyus): Principal Investigator (Not on-board)
Satoshi Okumura	(Global Ocean Development Inc., GODI)
Kazuho Yoshida	(GODI)
Wataru Tokunaga	(MIRAI Crew)

(2) Introduction

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

(3) Data Period (UTC)

2011/08/19 05:41 to 8/20 09:53

09/11 23:12 to 9/14 05:02

(4) Specification

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

Table 6.6.2-1 shows system configuration of MIRAI cesium magnetometer system.

Table 6.6.2-1 System configuration of MIRAI cesium magnetometer system.

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

(5) Data Archive

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

6.6.3. Swath Bathymetry

1) Multi narrow beam echo sounding system

(1) Personnel

Takeshi Matsumoto	(University of the Ryukyus)	: Principal Investigator (Not on-board)
Satoshi Okumura	(Global Ocean Development Inc., GODI)	
Kazuho Yoshida	(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 in the MR11-01 cruise.

To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) measuring sound velocity directly in surface intake water (6.2m). Also sound velocity profiles in water column were calculated using temperature and salinity profiles from CTD, XCTD and Argo float data by the equation in Del Grosso (1974). Table 6.6.3-1 shows system configuration and performance of SEABEAM 2112.004 system.

Table 6.6.3-1 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 Management Group (DMG) in JAMSTEC, and will be archived there.

2) Sub-bottom profiler

Masayuki Yamaguchi	(JAMSTEC): Principal Investigator
Satoshi Okumura	(Global Ocean Development Inc., GODI)
Kazuho Yoshida	(GODI)
Wataru Tokunaga	(MIRAI Crew)

(1) Personnel

Yamaguchi	(JAMSTEC): Principal Investigator
Satoshi Okumura	(Global Ocean Development Inc., GODI)
Kazuho Yoshida	(GODI)
Wataru Tokunaga	(MIRAI Crew)

(2) Introduction

Site survey was conducted around mooring point for investigate bottom condition with Sub-Bottom Profiler (SBP) which is add-on system of multi-beam echo sounder, SEABEAM 2112. SBP collected vertical information of 'sub-bottom' sediments as much as 75m below the sea floor, although depth penetration varies with bottom compositions.

(3) Methods

Sub-bottom profiler gives us vertical information of sediments types, geophysical activity and geomorphic trending in near-real time. This system has projector array with 60 units, which make 5-degree beam, and shared hydrophone array with the bathymetric system for high resolution.

Table 6.6.3-1 System configuration and performance

Sub-bottom profiler	
Frequency:	4 kHz centered, Frequency modulated Chirp
Transmit beam width:	5-degree for fore/aft, 45-degree athwartship
Received beam width:	5-degree
Transmit pulse duration:	5, 25, 50, or 100msec
Depth range:	50 to 11,000 m
Accuracy:	tens-of-centimeters range under most conditions
	Depends on sediment type, depth and environmental conditions

(4) Preliminary Results

Fig. 6.6.3-1 shows vertical sedimentary profiles below surface along ship's track around planned mooring position of TRITON No.16 (A). Appearance around the sea floor is not implicating hard rock features.

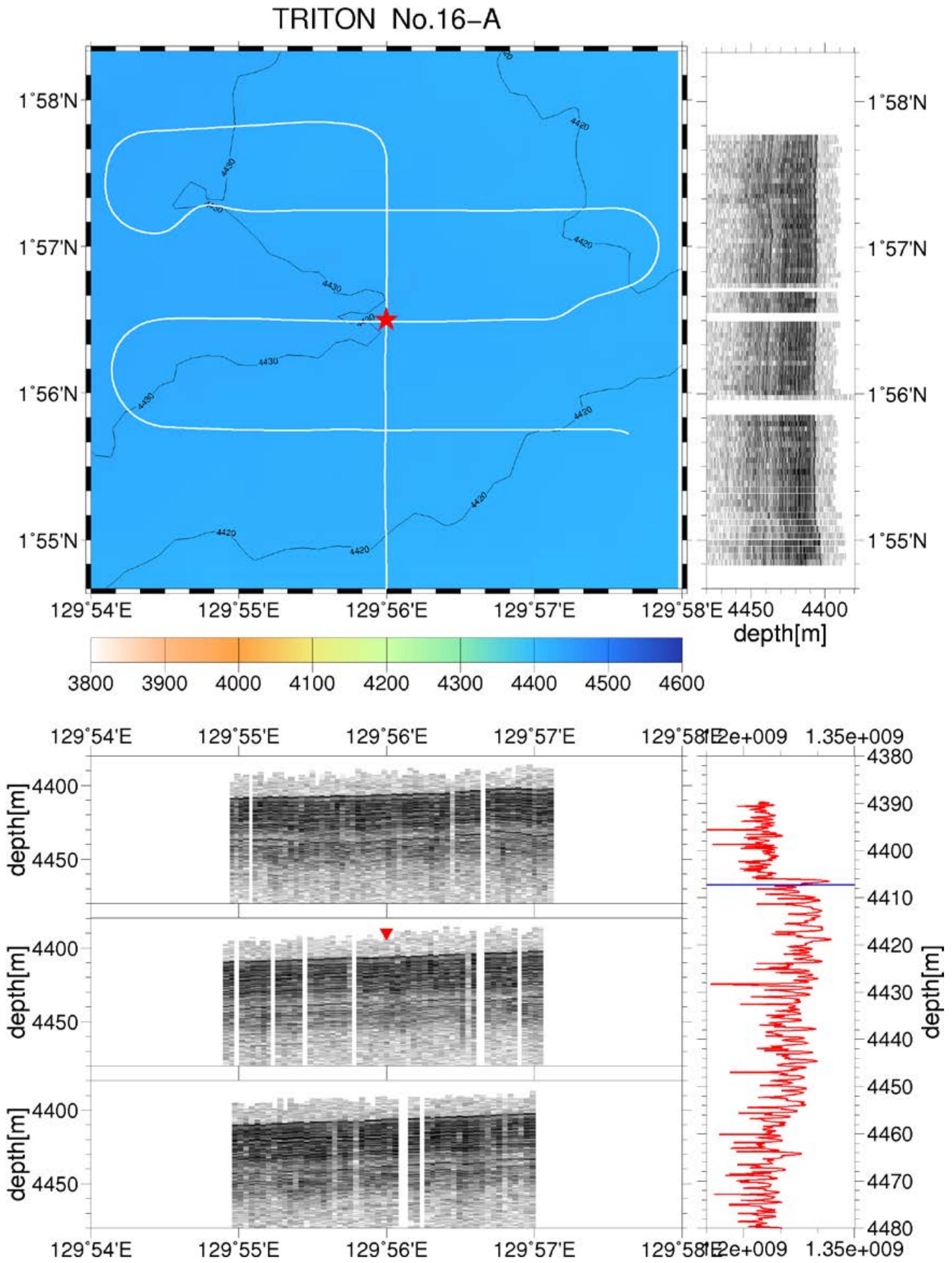


Fig. 6.6.3-1 SPB cross sections along the ship's track, and vertical profile at planned position.

(5) Data Archives

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

7. Special observations

7.1 TRITON buoys

7.1.1 Operation of the TRITON buoys

(1) Personnel

Yuji Kashino	(JAMSTEC): Principal Investigator
Keisuke Matsumoto	(MWJ): Operation Leader
Akira Watanabe	(MWJ): Technical Staff
Masaki Yamada	(MWJ): Technical Staff
Kai Fukuda	(MWJ): Technical Staff
Tomohide Noguchi	(MWJ): Technical Staff
Kenichi Katayama	(MWJ): Technical Staff
Tatsuya Tanaka	(MWJ): Technical Staff
Tamami Ueno	(MWJ): Technical Staff
Kei Suminaga	(MWJ): Technical Staff
Katsunori Sagishima	(MWJ): Technical Staff
Misato Kuwahara	(MWJ): Technical Staff
Masahiro Orui	(MWJ): Technical Staff
Yasushi Hashimoto	(MWJ): Technical Staff
Sayaka Kawamura	(MWJ): Technical Staff

(2) Objectives

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

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

Five TRITON buoys have been successfully recovered and six TRITON buoys deployed during this R/V MIRAI cruise (MR11-06).

(3) Measured parameters

Meteorological parameters:	wind speed, direction, atmospheric pressure, air temperature, relative humidity, 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 : 1200sec
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	10010
Number on surface float	T24
ARGOS PTT number	28151
ARGOS backup PTT number	7860
Deployed date	24 Aug. 2011
Exact location	07-52.00N, 136-29.60E
Depth	3,355 m

Nominal location	5N, 137E
ID number at JAMSTEC	11010
Number on surface float	T25
ARGOS PTT number	27958
ARGOS backup PTT number	24234
Deployed date	25 Aug. 2011
Exact location	04-51.58N, 137-16.03E
Depth	4,110 m

Nominal location	2N, 138E
ID number at JAMSTEC	12012
Number on surface float	T27
ARGOS PTT number	28149
ARGOS backup PTT number	24238

Deployed date	28 Aug. 2011
Exact location	01-59.99N, 138-05.98 E
Depth	4,320 m

Nominal location	EQ, 138E
ID number at JAMSTEC	13012
Number on surface float	T12
ARGOS PTT number	29768
ARGOS backup PTT number	7881
Deployed date	30 Aug. 2011
Exact location	00-04.31N, 138-02.85 E
Depth	4,206 m

Nominal location	2N, 130E
ID number at JAMSTEC	16010
Number on surface float	T13
ARGOS PTT number	None
ARGOS backup PTT number	27406, 27409
Deployed date	04 Sep. 2011
Exact location	01-57.18N, 130-11.38 E
Depth	4,371 m

Nominal location	8N, 130E
ID number at JAMSTEC	14009
Number on surface float	T28
ARGOS PTT number	29874
ARGOS backup PTT number	27410
Deployed date	07 Sep. 2011
Exact location	07-58.87N, 130-02.70 E
Depth	5,726m

(6) TRITON recovered

Nominal location	8N, 137E
ID number at JAMSTEC	10009
Number on surface float	T10
ARGOS PTT number	29759
ARGOS backup PTT number	7861
Deployed date	15 Apr. 2010
Recovered date	22 Aug. 2011
Exact location	07-51.95N, 136-29.43E
Depth	3,354 m

Nominal location	5N, 137E
ID number at JAMSTEC	11009
Number on surface float	T11
ARGOS PTT number	29767

ARGOS backup PTT number	7864
Deployed date	18 Apr. 2010
Recovered date	25 Aug. 2011
Exact location	04-56.55N, 137-17.87E
Depth	4,130 m

Nominal location	2N, 138E
ID number at JAMSTEC	12011
Number on surface float	T14
ARGOS PTT number	29719
ARGOS backup PTT number	7878
Deployed date	20 Apr. 2010
Recovered date	26 Aug. 2011
Exact location	01-59.96N, 138-05.74E
Depth	4,317 m

Nominal location	2N, 130E
ID number at JAMSTEC	16009
Number on surface float	T23
ARGOS PTT number	None
ARGOS backup PTT number	29708, 29738
Deployed date	26 Apr. 2010
Recovered date	02 Sep. 2011
Exact location	01-57.03N, 130-11.51E
Depth	4,372 m

Nominal location	8N, 130E
ID number at JAMSTEC	14008
Number on surface float	T26
ARGOS PTT number	29641
ARGOS backup PTT number	11593
Deployed date	28 Apr. 2010
Recovered date	07 Sep. 2011
Exact location	07-55.28N, 130-03.48E
Depth	5,641m

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

(7) Details of deployed

We had deployed six TRITON buoys, described them details in the Table 7.1.1-1.

Table 7.1.1. Deployment TRITON buoys

Observation No.	Location	Details
10010	8N137E	Deploy with full spec and 1 optional unit. JES10-CTIM : 26m
11010	5N137E	Deploy with full spec and 1 optional unit. SBE37 (CT) : 175m
12012	2N138E	Deploy with full spec and 2 optional unit. JES10-CTDIM: 751m SBE37 (CT): 175m
13012	EQ138E	Deploy with full spec and 1 optional unit. SBE37 (CT): 175m Camera system : with TRITON tower
16010	2N130E	Deploy with full spec and 1 optional unit. SBE37 (CT): 175m Two camera systems : with TRITON tower
14009	8N130E	Deploy with full spec. 750mCTD sensor is JES10-CTDIM. SBE37 (CTD) is deployed for backup sensor at 751m.

(8) Data archive

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

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

7.1.2 Inter-comparison between shipboard CTD and TRITON transmitted data

(1) Personnel

Yuji Kashino	(JAMSTEC): Principal Investigator
Keisuke Matsumoto	(MWJ): Technical Staff
Tatsuya Tanaka	(MWJ): Technical Staff
Akira Watanabe	(MWJ): Technical Staff
Tamami Ueno	(MWJ): Technical Staff

(2) Objectives

TRITON CTD data validation.

(3) Measured parameters

- ・Temperature
- ・Conductivity
- ・Pressure

(4) Methods

TRITON buoy underwater sensors 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 (See section 6.2.1) on R/V MIRAI for this intercomparison. We conducted 1 CTD cast at each TRITON buoy site before recovery, conducted 1 CTD or XCTD cast at each TRITON buoy site after deployment. The cast was performed immediately after the deployment and before recovery. R/V MIRAI was kept the distance from the TRITON buoy within 2 nm.

TRITON buoy data was sampled every 1 hour except for transmission to the ship. 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 (X)CTD data on R/V MIRAI and the TRITON buoy data for each deployment and recovery of buoys.

XCTD has large differences from TRITON data, therefore we did not compare the each data. Some recovered TRITON buoys could not compare the data, because No.10, 14 buoys had no data by vandalism on underwater cable, and No.13 buoy had recovered already at R/V YOKOSUKA.

Compared site

Observation No.	Latitude	Longitude	Condition
13012	EQ	138E	After Deployment
11009	5N	137E	Before Recover
12011	2N	138E	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 7.1.2-1(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.

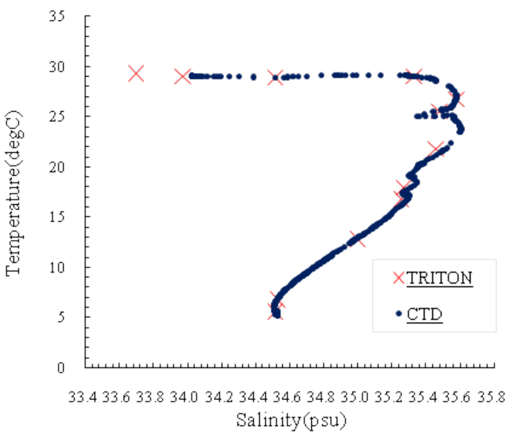
The estimation was calculated as deployed buoy data minus shipboard CTD (9Plus) data. The salinity differences are from –0.3259 to 0.0375for all depths. Below 300db, salinity differences are from –0.0098 to 0.0148 (See the Figures 7.1.2-2 (a)). The average of salinity differences was -0.0455with standard deviation of 0.0997.

The estimation was calculated as recovered buoy data minus shipboard CTD (9Plus) data. The salinity differences are from –0.2915 to 0.2652 for all depths. Below 300db, salinity differences are from -0.0774 to 0.0860 (See the Figures 7.1.2-2(b)). The average of salinity differences was 0.0202 with standard deviation of 0.1374.

The estimation of time-drift was calculated as recovered buoy data minus deployed buoy data. The salinity changes for 1 year are from –0.3054to 0.2811, for all depths. Below 300db, salinity changes for 1 year are from -0.0950 to 0.0717 (See the figures 7.1.2-2(c)). The average of salinity differences was -0.0255 with standard deviation of 0.1475.

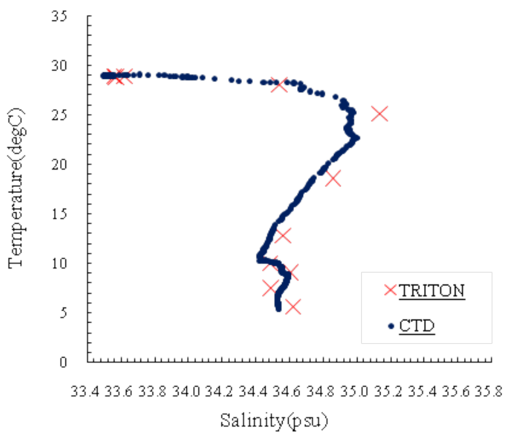
(6) Data archive

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.

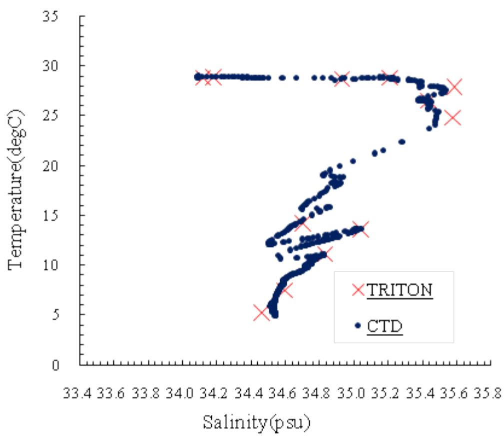


Observation No. 13012 after deployment

Fig.7.1.2.-1(a) T-S diagram of TRITON buoys data and shipboard CTD data



Observation No. 11009 before recovery



Observation No. 12011 before recovery

Fig.7.1.2.-1(b) T-S diagram of TRITON buoys data and shipboard CTD data

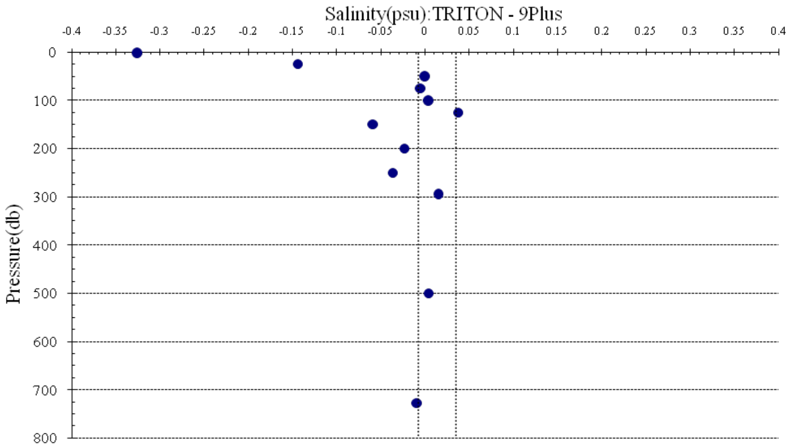


Fig.7.1.2.-2 (a) Salinity differences between TRITON buoys data and shipboard CTD data after deployment

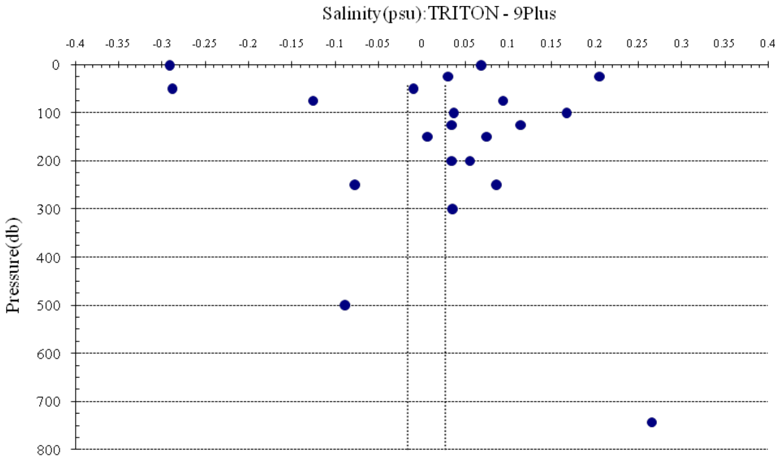


Fig.7.1.2.-2 (b) Salinity differences between TRITON buoys data and shipboard CTD data before recovery

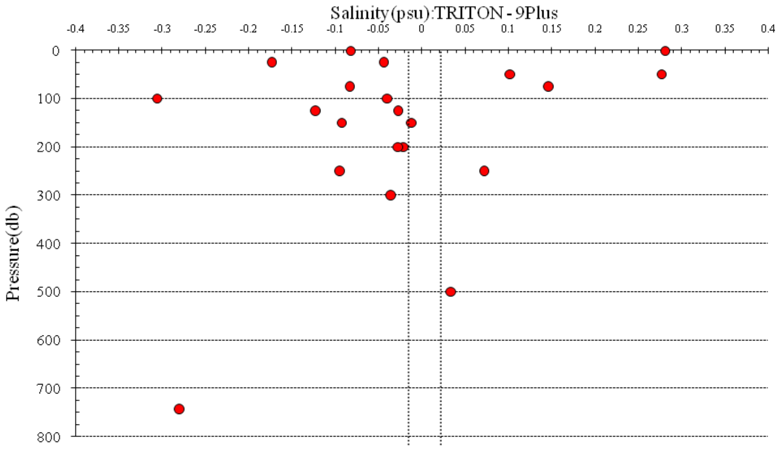


Fig.7.1.2.-2 (c) Salinity differences between deployment data and recovery data for 1year

7.1.3 Inter-comparison between air temperature and Iron-Mask internal temperature

(1) Personnel

Takeo Matsumoto (MWJ): Principal investigator (as a JICA expert)

(2) Objectives

m-TRITON's Iron-Mask data validation.

(3) Measured parameters and Period

- Temperature
- 18 Aug. 2011~30 Aug. 2011

(4) Methods

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has developed new oceanic observation buoy which is called m-TRITON buoy, for the purpose to understand the characteristics of the atmospheric and oceanic variability in the eastern Indian Ocean and to compose the Indian Ocean buoy array in the international effort. We had deployed some buoys since 2007, but their buoys have damaged by vandalism. On the other, the IRON-MASK has been using at TRITON buoy since 2006. The IRON-MASK have lessen the damage at TRITON buoy.

I have considered anti vandalism for m-TRITON, had designed new sensor pole for m-TRITON similar IRON-MASK of TRITON buoy. The Iron-Mask was characterized by rise the temperature of internal Iron-Mask at the TRITON buoy. Therefore we made certain of this characteristic.

The temperature sensor (JAMMET HRH-TH502) is equipped internal Iron-Mask. We used the temperature sensor (ASIMET-HRH) for this inter-comparison.

Photo 7.1.3-1

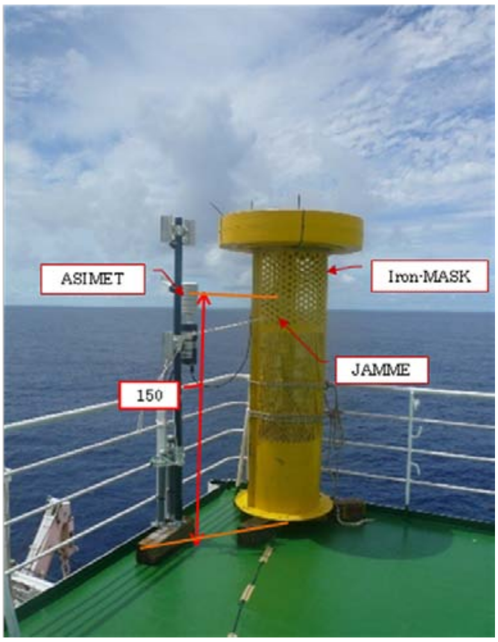
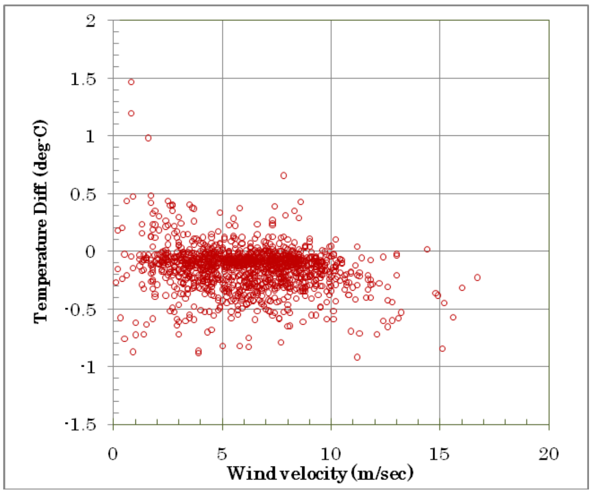
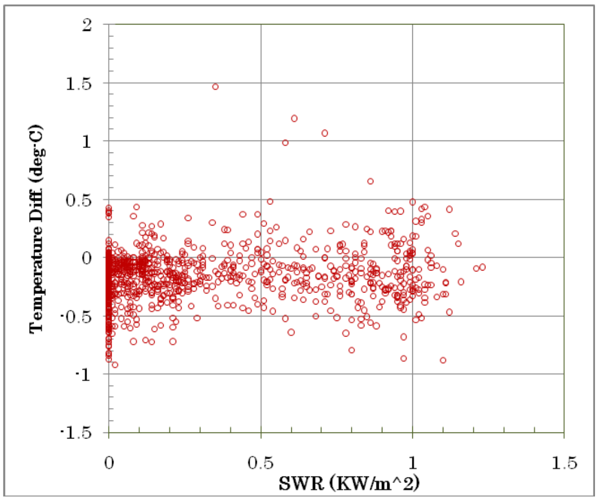


Photo 7.1.3-2

(5) Results

The estimation was calculated as ASIMET data minus JAMMET data. The temperature differences are from –1.5 to 0.9 deg-C. The average of temperature differences was 0.15 deg-C with standard deviation of 0.17 deg-C. We will evidence by inspection with another meteorological data.





7.1.4 JAMSTEC original CTD sensor

(1) Personnel

Yukio Takahashi (JAMSTEC): Engineer

(2) Background

SBE37 (Sea-Bird Electronics, Inc.) have been used to all the CTD sensors in TRITON buoys. Low cost and long-term deployment forward will be required in TRITON buoy. JAMSTEC has developed CTD sensor for buoy system form several years ago. The first target is low cost and the performance equal to SBE37. The next target is characteristic of the ultra-low drift sensing. On MR11-06, CTD sensors of the first target have been deployed to evaluate the performance.

JAMSTEC also has developed anti-biofouling. Several devices have been evaluated to be minimized a sea pollution to replace TBT (Tri Butyl Tin).

(3) CTD sensor

Temperature and pressure circuits have a high resolution using 24 bit Σ-Δ ADC. Conductivity also has a high resolution using RC oscillator with an ultra high stability resistors and condensers. The initial accuracies are 0.002°(temperature), 0.0003 S/m (conductivity), 0.1 %FS (pressure). The conductivity cell has a high response time by short-length cell (30mm). Photo 7.1.4-1 is a CTD sensor with an inductive modem
(JES10-CTDIM). Two CTD sensors have attached at the depth of 750m, and location of 2N,138E, 8N,130E to evaluate the drift characteristic.

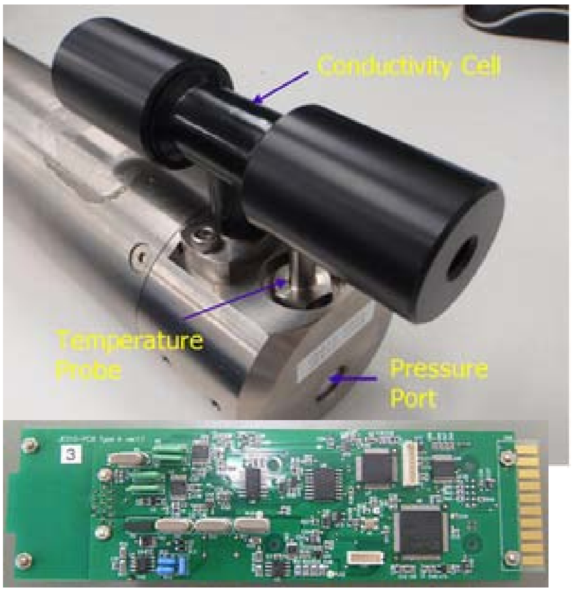


Photo 7.1.4-1


Photo 7.1.4-2

(4)Anti-biofouling

Several devices have been developed for a cover of sensor heads and a conductivity cell.

C sensor (JES10-C) that was deployed to evaluate an anti-fouling cover at 26m, 8N,137E on MR10-02, was recovered. We have the painting material silicon type on tne plastic cover. Photo 2 is recovered JES10-C. Figure 7.1.4-1 is the instrument frequency. The effect of the cover will be evaluated later.

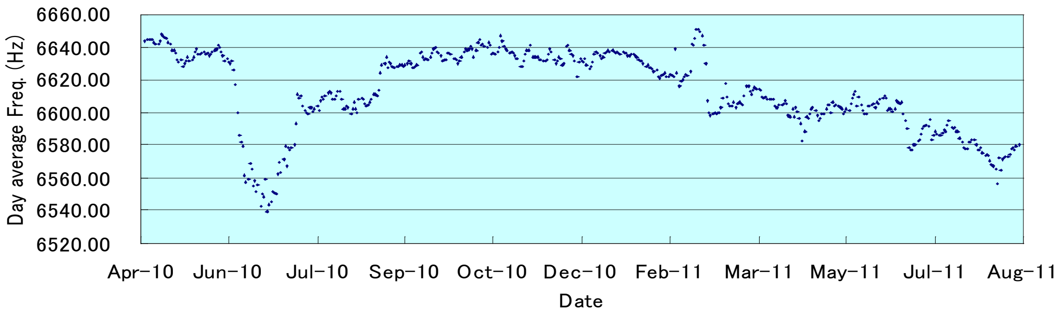


Figure 7.1.4-.1 Frequency drift

On MR11-06, a CT sensor (JES10-CTIM) with anti-biofouling device of BeCu. The device can prevent a biological growth in the conductivity cell by a resolution of Be and Cu ions to sea. These devices are attached at the both sides of the conductivity cell to evaluate the effect of the anti-biofouling during deployment (Photo 7.1.4-3). This CT sensor has been attached at the depth of 26m, and location of 8N,137E.

Photo 7.1.4-3

7.1.5 On board training program for SATREPS[*1)] project

(1) Personnel

Arnold Danari	(BPPT)	: engineer
Jonathan Meiky Davis Rori	(BPPT)	: engineer
Takeo Matsumoto	(MWJ)	: engineer (as a JICA expert)
Masayuki Yamaguchi	(JAMSTEC)	: engineer (as a JICA expert)

(2) Objectives

Indonesia-Japan technical cooperation project for climate variability study[*2)] is promoting as one of SATREPS projects supported by JICA and JST.

Concerning the meteorological and oceanographic observation in this project, JAMSTEC engages in technology transfer to Indonesian party (BPPT) about buoy operation.

On board training in this cruise is carried out as follow.

(3) Program

1) Observation of buoy operation
   a) On-deck repair of the K-TRITON buoy
   b) Recovery and deployment operation of the TRITON buoy
   c) Ship handling during recovery and deployment operation
   d) Preparation work of mooring materials and sensors
   e) CTD casting and monitoring
   f) Deployment operation of ADCP
2) System operation
   a) Communication with met. & underwater sensors
   b) Buoy system (met. & underwater sensor) setting procedure
3) On-the-job training
   a) Setting of mooring materials of the TRITON buoy
   b) Attaching / Detaching underwater sensors to / from wire rope
   c) Cleaning of met. & underwater sensors
4) Other activities
   a) Tour on board for oceanographic observational equipments and ship facilities.
   b) Lecture / discussion / exercise about buoy operation.
      (incl. specification of m-TRITON and operation by R/V Baruna Jaya IV)
   c) Water sampling for calibration of salinity and dissolved oxygen.

※ Detail schedule is shown on following table.

*1) Science and Technology Research Partnership for Sustainable Development

*2) Technical Cooperation Project for Climate Variability Study and Societal Application through Indonesia-Japan "Maritime Continent COE" -Radar-Buoy Network Optimization for Rainfall Prediction (research representative : Manabu Yamanaka (JAMSTEC))

Date	Activity = Observation, Lecture or OJT
16 Aug.	On deck repair of K-TRITON buoy
19 Aug.	CTD cast. & data processing CTD cast seawater sampling [OJT] Preparation of mooring materials for TRITON No.10
20 Aug.	Under water sensors
21 Aug.	Meteorological sensors 
22 Aug.	How to recover the TRITON buoy [Lecture]
23 Aug.	TRITON No.10 recovery How to deploy the TRITON buoy [Lecture]
24 Aug.	TRITON No.10 deployment
25 Aug.	TRITON No.11 deployment (bridge)
26 Aug.	TRITON No.11 recovery (bridge) Cleaning of the meteorological sensors [OJT]
27 Aug.	TRITON No.12 recovery Cleaning of the underwater sensors [OJT] Preparation work for TRITON No.12
28 Aug.	TRITON No.12 deployment Advanced attaching the underwater sensors of TRITON No.13 [OJT] 
29 Aug.	CTD cast seawater sampling [OJT] Buoy system (met. & underwater sensor) setting procedure
30 Aug.	TRITON No.13 deployment Attaching the underwater sensors of TRITON No.13 [OJT] m-TRITON buoy operation by BARUNA_JAYA IV [self-study]
31 Aug.	Preparation of the mooring materials of TRITON No.14 & 16
2 Sept.	Preparation of packing of the sensors for oversea transport [OJT] <discussion> m-TRITON buoy operation by R/V BARUNA_JAYA IV
3 Sept.	TRITON No.16 recovery Detaching and cleaning of the underwater sensors [OJT]
4 Sept.	TRITON No.16 deployment Preparation work for TRITON No.14
6 Sept.	<EXERCISE> The roll of c/o, bos'n and marine technician leader Check on the eve of deployment
7 Sept.	TRITON No.14 deployment Attaching of underwater sensors
8 Sept.	TRITON No.14 recovery
9 Sept.	Ship positioning during buoy operation under wind and current condition [Lecture] Specification of m-TRITON buoy [Lecture]
10 Sept.	ADCP deployment 
12 Sept.	<SELF STUDY>
13 Sept.	Document preparation of field record sheets for SATREPS buoy operation
14 Sept.	
15 Sept.	Communication with meteorological sensors
17 Sept.	[CRUISE SEMINAR]

7.2 Repair of K-TRITON buoy

(1) Personnel

Kyoko Taniguchi	(JAMSTEC)	
Keisuke Matsumoto	(MWJ)	
Tomohide Noguchi	(MWJ)	
Akira Watanabe	(MWJ)	
Masaki Yamada	(MWJ)	
Katsunori Sagishima	(MWJ)	
Kai Fukuda	(MWJ)	
Not on board:		
Yoshimi Kawai	(JAMSTEC)	Principal Investigator
Akira Nagano	(JAMSTEC)	
Takuji Waseda	(Tokyo University)	

(2) Objective

The K-TRITON buoy has been moored in the Kuroshio Extension since 23 February 2011 by JAMSTEC. The anemometer and thermo-hydrometer data started recording fixed values, and longwave radiation sensor stopped transmitting data. In addition to the weather sensors, the data transmission of subsurface sensors, except the 1m CT sensor, has problems, and no data was transmitted last a few months. Also, the wave height meter system has no communication after few days of deployment. To improve the situation, the repair works on the K-TRITON buoy was operated

(3) Methods

Prior to on deck the buoy, some fairings along the upper wire rope was removed. Once the buoy got on deck and secured, the buoy was detached from the mooring line. After the buoy is on board, replacement of anemometer and thermo-hydrometer, reconnection of long wave radiation sensor, and restarting the wave height meter system were operated. The buoy was redeployed on existing mooring line and anchor. The R/V MIRAI held positions while attached to the K-TRITON anchor. Tensions were continuously monitored and were generally in the 500 kg range.

Site: 38° 05.0921' N, 146°22.8075' E (Figure7.2-1)

First line attached to buoy: 15August 2011 at 23:04 GMT

Buoy on deck: 16 August 2011 at 0:36 GMT

Maintenance operation: 23:30 to 02:30 - 3 hours.

Location at buoy redeployment at 2:46 GMT 16 August - 38° 05.1687' N, 146°24.0682' E

Total ops time: 3 hours 50 minutes starting with a small boat launch

(4) Results

Weather sensors:

The communications with the logger system were established prior to any swapping operation to confirm the replaced sensors have no problems on communication with the logger system of the buoy.

Thermo-Hydrometer:

After disconnecting the thermo-hydrometer from the communication cable, replacement sensor was connected to the cable. With the confirmation of communication with the logger system, old sensor was removed, and the replacement was attached securely to the sensor tower of the buoy. Prior to the replacement, all connectors were cleaned.

Anemometer:

During the buoy recovery, the lifting line knocked the anemometer off, and the upper parts was lost into the ocean.

Once the buoy was on deck securely, the replacement sensor was mounted on the sensor tower after removing the damaged anemometer. The cleaned connector was connected to the logger system, and a good status of communication was confirmed.

Longwave Radiation Sensor:

The long wave radiation sensor was disconnected once and reconnected. As other sensors, the connectors were cleaned before the reconnection. This reconnection process dissolved the communication problems, and the logger system started recording the longwave radiation observations.

Wave Height Meter:

The switch box lid of the wave height mater held water drops inside, although the lid was not loose. Obvious corrosion in the switch box was observed. The switch board was unglued and slightly lifted by moving the switch sticks. Three times attempts of the restart was ended with no indication of success. Further close examination of the system was found no visible damages.

Subsurface sensors:

Fishing line with a 20cm diameter buoy was tangled on the 10m Aquadopp, especially at the upper part of the sensor. By winching up the mooring line, the fish gear was eliminated completely. The clamp has held the sensor securely without an effect of the fishing gear. The 15m SBE 37 was covered alga lightly while it seemed to be mounted securely.

Wire rope:

Once the buoy was on deck and secured, buoy was detached from the mooring line below. At the detachment process, the wire coating just below the top socket was found to be rubbed. From the close examination, the damage was only the wire coating and not reached to the center wire, and it was determined not to be crucial to cause a drift of buoy by continuous mooring with a proper repair. The damaged part was repaired with a fusible tape and protected with a wire braided hose.

Metal parts:

On the deck, upper metal parts placing between the buoy and the wire socket were examined. The examination was found no severe worn out was found on any parts; only the second upper shack was slightly worn down. Although the degree of worn down should cause no problem in the normal circumstances, the shackle was replaced with new one to take a caution for one more year ofmooring.

(5) Data archives

The meteorological and oceanic data obtained at the K-TRITON buoy are released through the Internet (http://www.jamstec.go.jp/iorgc/ocorp/ktsfg/data/jkeo/JKEOdata.htm).

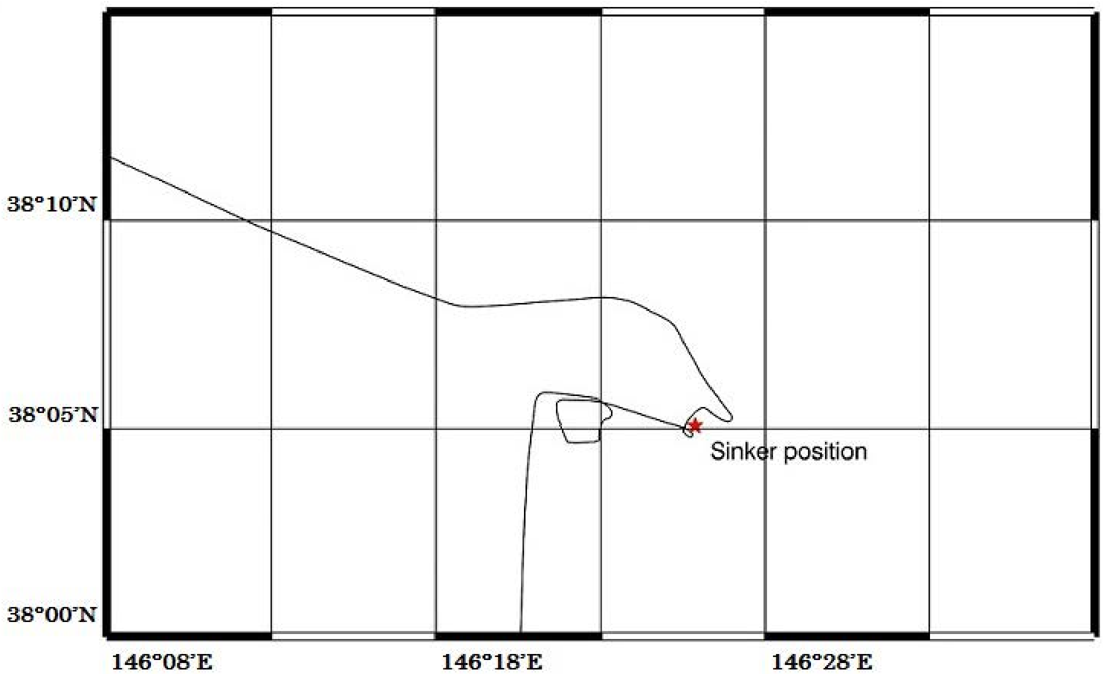


Figure7.2-1 Locations of the KEO buoy and the ship track during the repair operations.

7.3 Subsurface ADCP moorings

(1) Personnel

Yuji Kashino (JAMSTEC): Principal Investigator

Tomohide Noguchi (MWJ): Operation leader

(2) Objectives

The purpose of this ADCP observation is to get knowledge of physical process underlying the dynamics of oceanic circulation in the western equatorial Pacific Ocean. We have been observing subsurface currents using ADCP moorings along the equator region. In this cruise (MR11-06), we deployed two subsurface ADCP moorings at 7N-127E and 7N-128E.

Components of this mooring are depicted in Figure 3-7-1 and Figure 3-7-2.

(3) Parameters

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

(4) Instruments

1) Current meters

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

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

RCM9 (AANDERAA INSTRUMENTS)

Temperature Range : Low
Sampling Interval : 3600 seconds

3-D Acoustic Current Meter (Falmouth Scientific Inc.)

Sampling Interval : 3600 seconds
Average Interval : 30 seconds
On time : 30 seconds

AQUADOPP Deep Water Current Meter (NORTEK AS)

Sampling Interval : 3600 seconds

Average Interval : 30 seconds

2) CTD

SBE-16 (Sea Bird Electronics Inc.)

Sampling Interval : 1800 seconds

3) Other instrument

Acoustic Releaser (BENTHOS,Inc.)

Transponder (BENTHOS,Inc.)

(5) Deployment

Deployment of the ADCP mooring at 7N-127E and 7N-128E was planned to mount the ADCP at about 400m depths. During the deployment, we monitored the depth of the acoustic releaser after dropped the anchor.

The position of the mooring No. 110911-7N127E

Date: 11 Sep. 2011 Lat: 7-00.89N Long: 126N-54.98E D epth: 4,826m

The position of the mooring No. 110910-7N128E

Date: 10 Sep. 2011 Lat: 7-00.61N Long: 127N-46.12E D epth: 5,833m

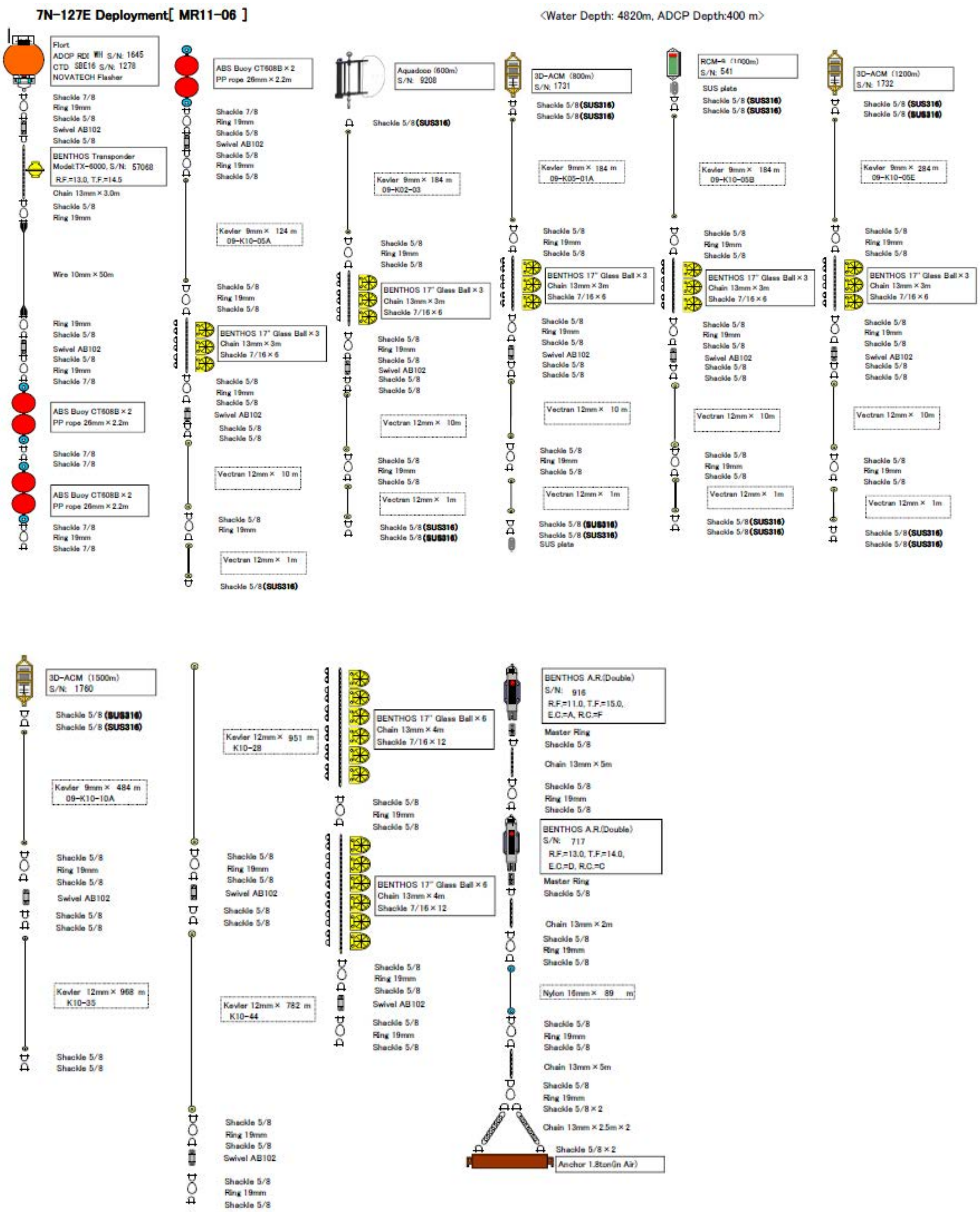


Fig.7-3-1 Mooring diagram of Deploy mooring (7N127E)

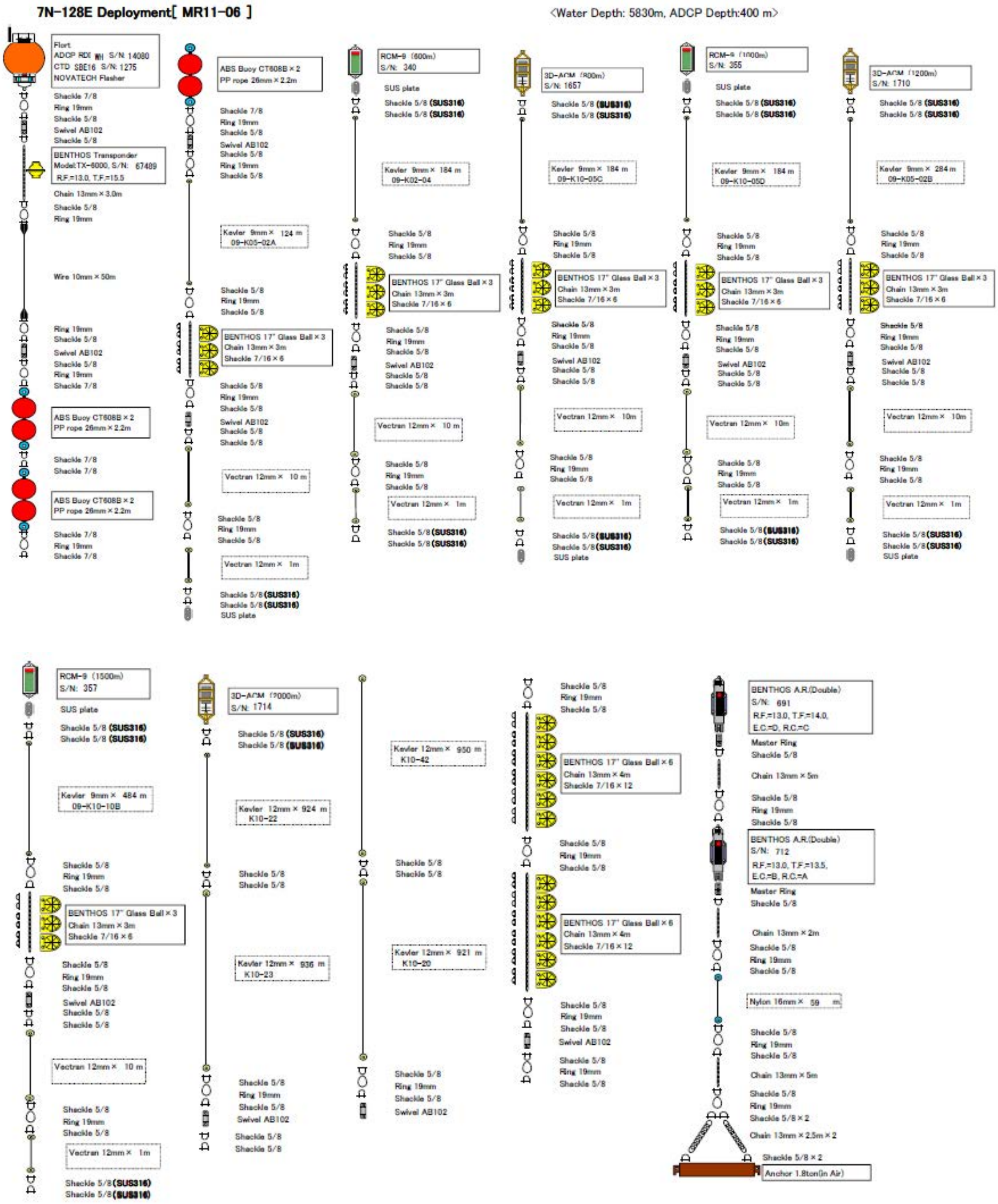


Fig.7-3-2 Mooring diagram of Deploy mooring (7N128E)

7.4 Current profile observations using a high frequency lowered acoustic Doppler current profiler

Personnel Saulo Soares (University of Hawaii)
Li Yao (IOCAS)
Wei Chuanjie (IOCAS)

(1) Objective

To measure the small vertical scale (SVS) velocity structure in the tropics.

(2) Overview of instrument and operation

In order to measure the velocity structure at fine vertical scales a high frequency ADCP was used in lowered mode (LADCP). The instrument was a Teledyne RDI Workhorse Sentinel 600kHz ADCP rated for 1000m depth. The instrument was attached to the frame of the CTD system using a steel collar sealed around the instrument by three bolts on each side, with the collar attached to the rosette frame by two u-bolts on two mounting points. A rope was tied to the top end of the instrument to minimize vertical slippage and for added safety (see Figure 7.4-1). The instrument was tested at 8N 136.5E (CTD station 03) and deployed on CTD stations C04-C51 in the tropics, performing well throughout its use.

Fig 7.4-1 Mounting of LADCP on CTD System (photo: S. Soares)

The instrument is self-contained with an internal battery pack. The health of the battery is monitored by the recorded voltage count. The relationship between the actual battery voltage and the recorded voltage count is obscure and appears to vary with the instrument and environmental conditions. Taking a direct measurement of the state of the battery requires opening up the instrument. Direct measurements of the battery voltage were taken before and after the deployment and compared to the recorded voltage count:

	Battery Voltage (V)	Voltage Count (VC)	ratio (V/VC)
Before	44.60	152	0.29
After	39.80	136	0.29

implying an almost constant relationship of V~=0.29VC. RDI recommends the battery be changed when V gets below 30V.

(3) Setup and Parameter settings

At all stations the LADCP was controlled at deploy and recover stages by a Linux PC using the python script **ladcp600.py** (written by Eric Firing, University of Hawai`i) The commands sent to the instrument at setup were contained in **ladcp600.cmd**. The instrument was set up to have a relatively small bin depth (2m) and a fast ping rate (every 0.25 sec). The full list of commands sent to the instrument were:

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

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

To add flexibility, the instrument could also be controlled at deploy and recover stages by the RDI software (**BBTalk**) installed on the JAMSTEC Windows PC with the same list of commands as above. BBTalk was used three times for downloading the data off the instrument's recorder, when difficulties occurred in using the Linux software for that purpose.

(4) Data processing

An initial sampling of the data was made using the following scripts to check that the instrument was performing correctly

scanbb	integrity check
plot_PTCV.py	plot pressure, temperature, voltage and current counts
plot_vel.py	plot velocity from all 4 beams

The principal onboard data processing was performed using the Lamont Doherty Earth Observatory (LDEO, Columbia University) LADCP software package version IX_6beta (available at ftp://ftp/ldeo.columbia.edu/pub/ant/LADCP). The package is based on a number of matlab scripts. The package performs an inverse of the LADCP data, incorporating CTD (for depth) and GPS data, to provide a vertical profile of the horizontal components of velocity, U and V (eastward and northward, respectively), that is a best fit to specified constraints. The down- and up-casts are solved separately, as well as the full cast inverse. The package also calculates U and V from the vertical shear of velocity.

The software is run using the matlab script **process_cast.m** with the configuration file **set_cast_params.m.** Frequent CTD data are required. Files of 1 second averaged CTD data were prepared for each station. Accurate time keeping is also required, particularly between the CTD and GPS data. To ensure this, the CTD data records also included the GPS position. The LDEO software allows the ship's ADCP data (SADCP) to be included in the inverse calculation. The SADCP data were not included in this case so as to provide an independent check on the functioning of the LADCP.

On-station SADCP velocity profiles were produced by averaging the five-minute averaged profiles (mr1007002_000000.LTA and mr1007004_000000.LTA produced using VmDAS) over the period of the CTD/LADCP cast. Care was taken to ensure the average did not contain any spurious data from periods when the ship was maneuvering.

(5) Preliminary results

An example of the on-board processed data is presented in Figure 7.4-2 and 7.4-3. Figure 7.4-2 compares the full cast inverse, up- and down-cast inverse, and the shear solutions for the zonal (U) and meridional (V) components of the velocity vector with the corresponding SADCP profile for Station C07_01. There is a very good correspondence between the general structure of all velocity profiles. While the large vertical scale flow is in a good agreement with the SADCP data (gray line), the LADCP solutions show a lot of smaller scale structure, not resolved by the SADCP. Especially noticeable are the features within and bellow the core (maximum) of the North Equatorial Counter Current (NECC) between the depths of 100 and 250 m visible in both U and V.

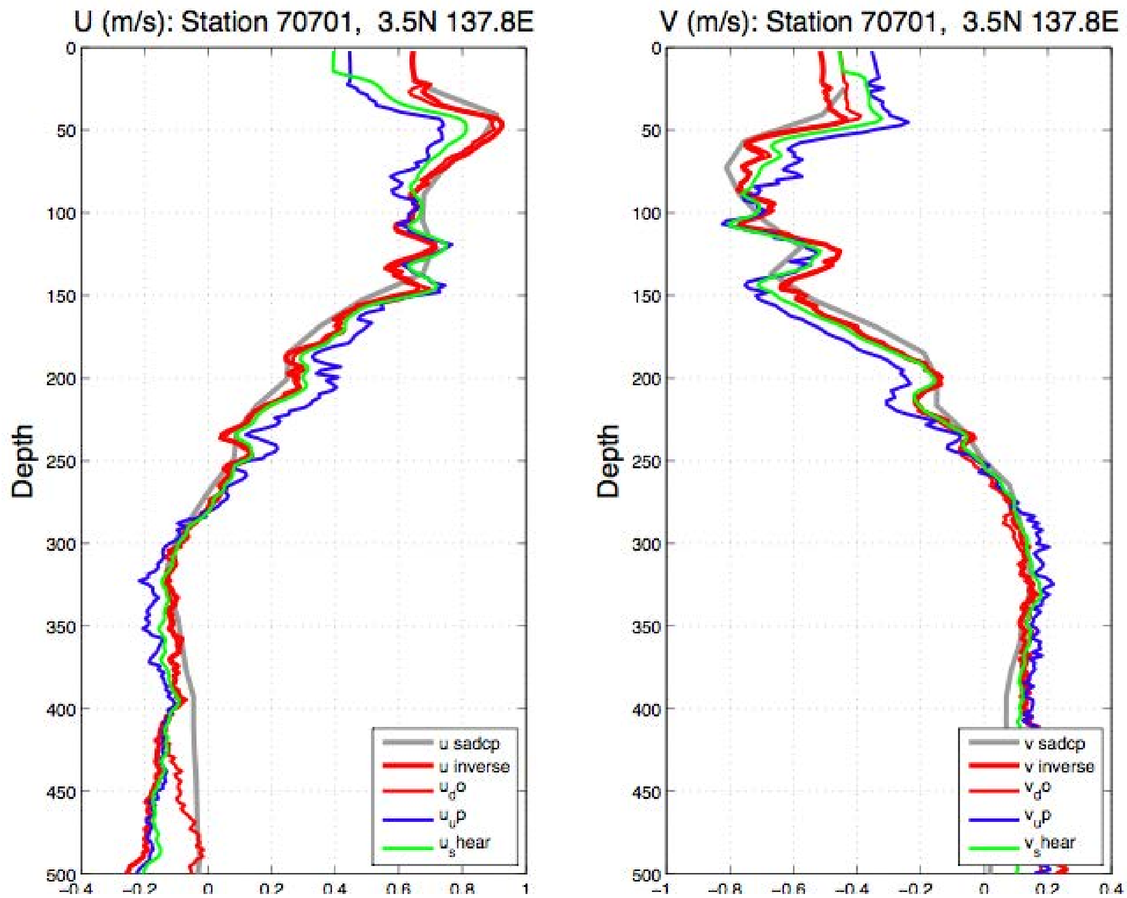


Figure 7.4-2 CTD Station C07M01: Vertical profiles of U and V calculated by a number of methods using LADCP data. Full cast inverse (u inverse), downcast only inverse (u_do), up-cast only inverse (u_up) and shear solution (u_shear). Also shown are the profiles using SADCP data (u sadcp).

These small vertical scale structures are often associated with small vertical scale anomalies in salinity profiles. As an example, the down- and up-cast inverse solutions for U and V are compared with salinity over a portion of the CTD Station C09_01 profile in Figure 7.4-3. The fact that a number of the same small scale features are evident in both the down- and up- cast profiles of both U and V, confirms the ability of the instrument to measure small vertical scale features in velocity. There is a strong correspondence between the small-scale features in V and salinity and to a smaller extent between U and salinity as well (e.g., slightly above and below the 200 m depth), although the exact relationship will depend on the time evolution of the fields.

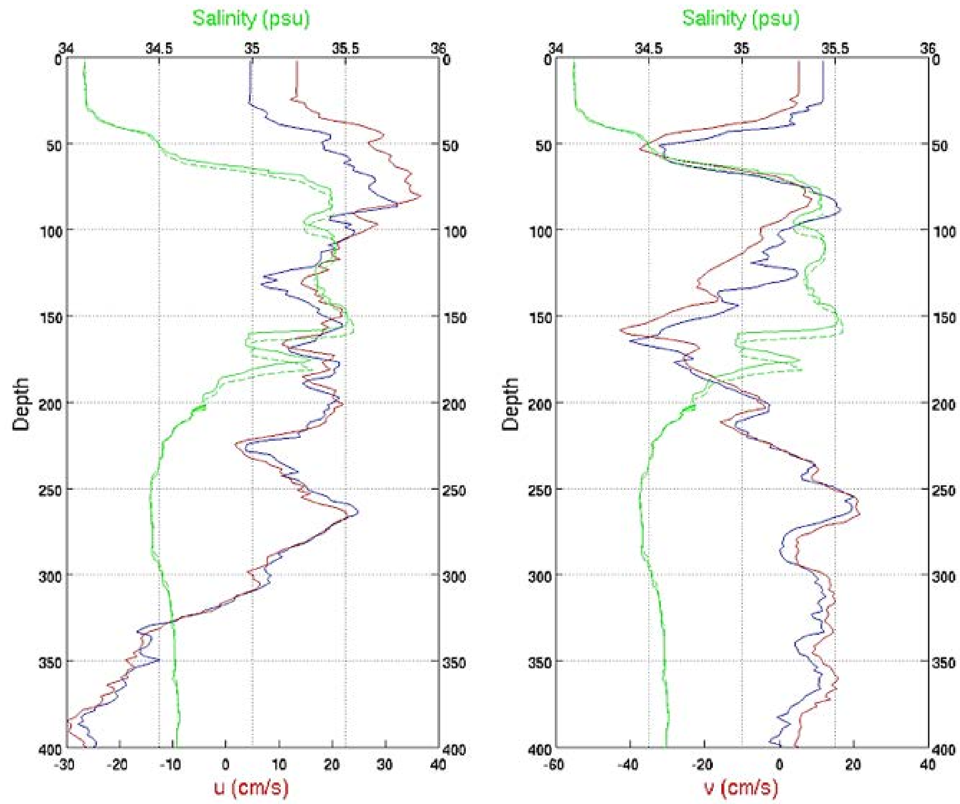


Figure 7.4-3 CTD Station C09M01: Vertical profile of the downcast (green full line) and up-cast (green dashed line) salinity overlain with downcast (red) and up-cast (blue) horizontal velocity components (zonal left panel; meridional right panel). Note the correspondence of salinity with the small vertical scale meridional velocity features.

The measurements at individual stations are combined to produce latitudinal and longitudinal sections of the velocity fields. Figures 7.4-4, 7.4-5, 7.4-6 and 7.4-7 show the zonal and meridional components of the velocity vector as a function of latitude and depth at 138E and 130E correspondingly. Figures 7.4-8, 7.4-9, 7.4-10 and 7.4-11 show the zonal and meridional components of the velocity vector as a function of longitude and depth at 2N and 7N correspondingly. All plots show the abundance of features with vertical scales 30 – 60 m. The intensity of such features seems to be independent of latitude. Many SVS features clearly extend over several stations and/or show remarkable spatial correlation. This is particularly evident in contour plots of meridional velocity along latitudinal sections of 138E and 130E, as well as in the longitudinal section along 2N. Similar scales are also evident in the zonal velocity of the 7N longitudinal section. The origin of these features is the subject of an ongoing observational and theoretical investigation. A comparison with the turbulence energy dissipation rate profiles obtained on this cruise using a microstructure profiles (MSP) suggests that these features may account for a significant fraction of the overall dissipation in the thermocline, but further analysis is necessary to quantify their role.

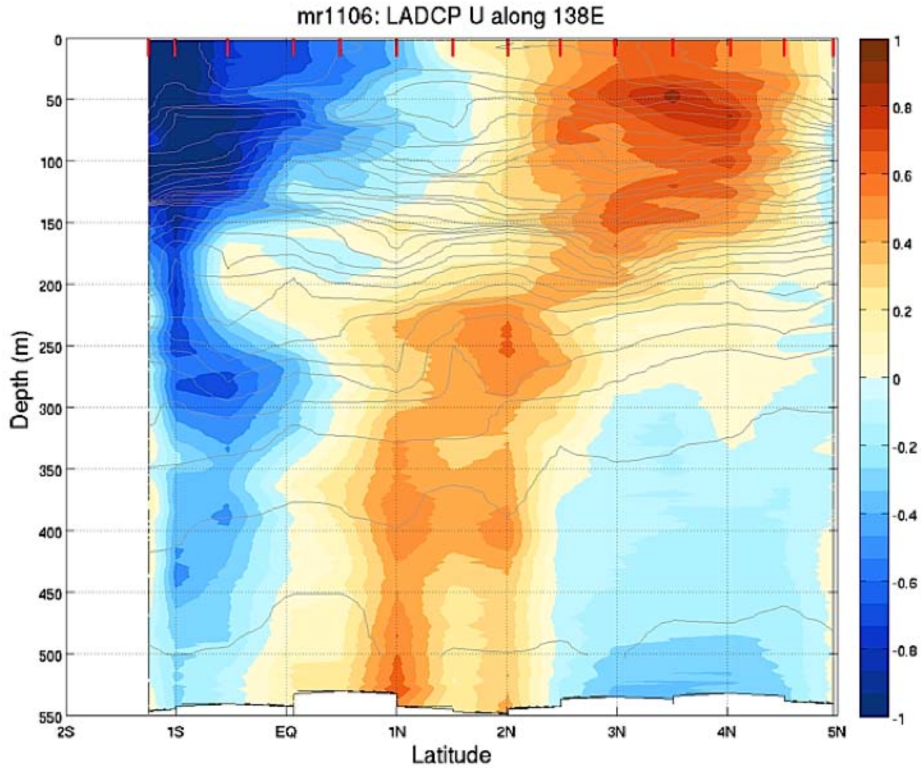


Figure 7.4-4. Latitudinal section of the zonal component of velocity at 138E.

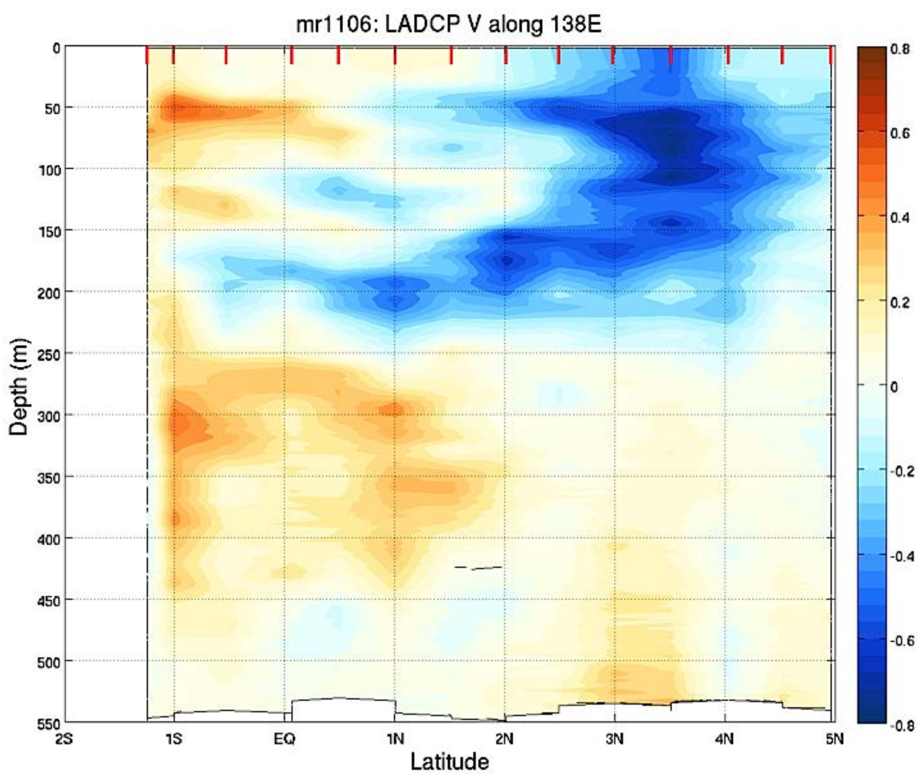


Figure 7.4-5. Latitudinal section of the meridional component of velocity at 138E

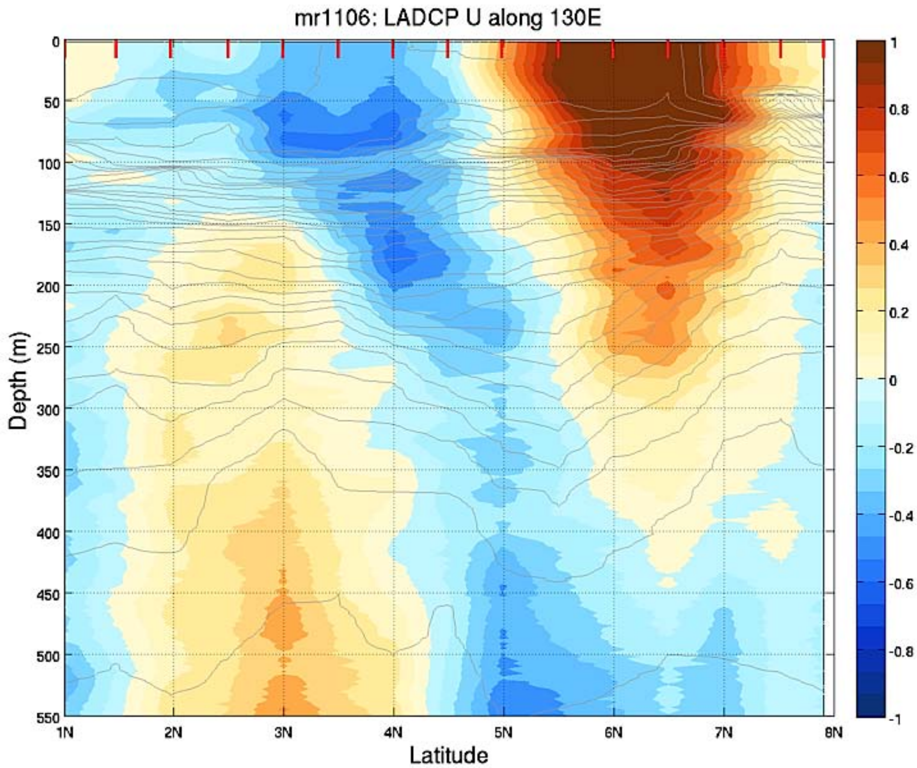


Figure 7.4-6. Latitudinal section of the zonal component of velocity at 130E.

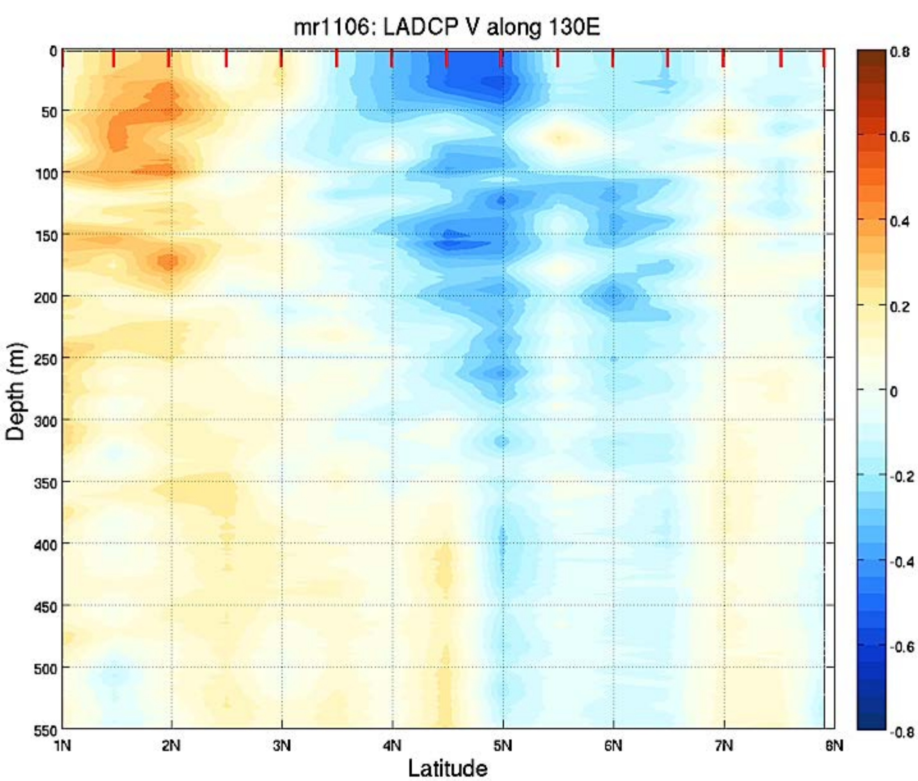


Figure 7.4-7. Latitudinal section of the meridional component of velocity at 130E.

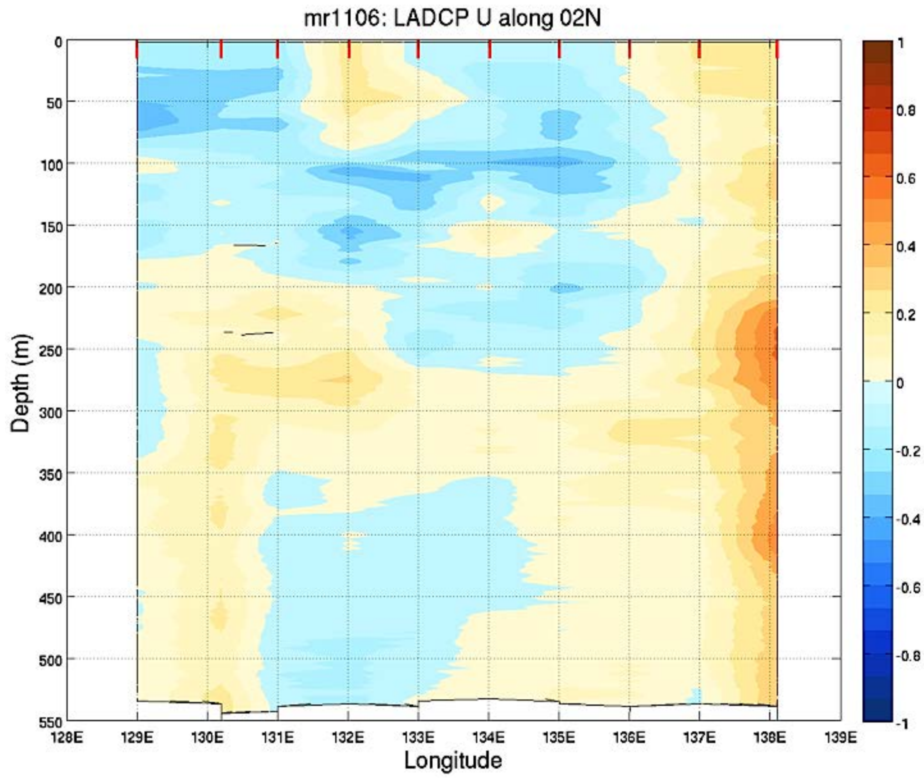


Figure 7.4-8. Longitudinal section of the zonal component of velocity at 2N.

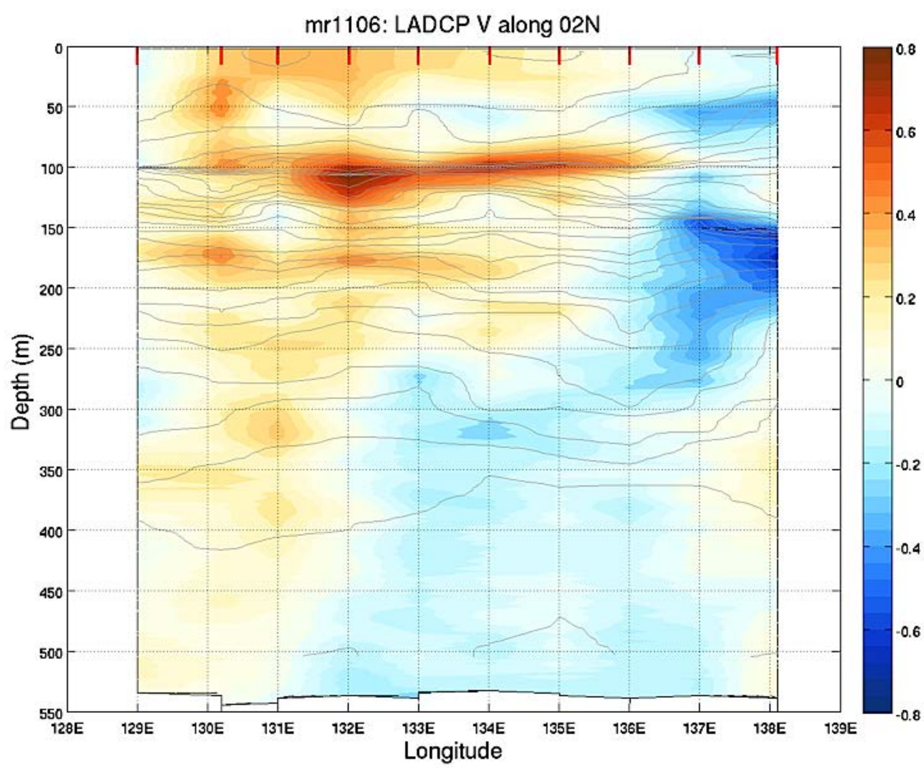


Figure 7.4-9. Longitudinal section of the meridional component of velocity at 2N.

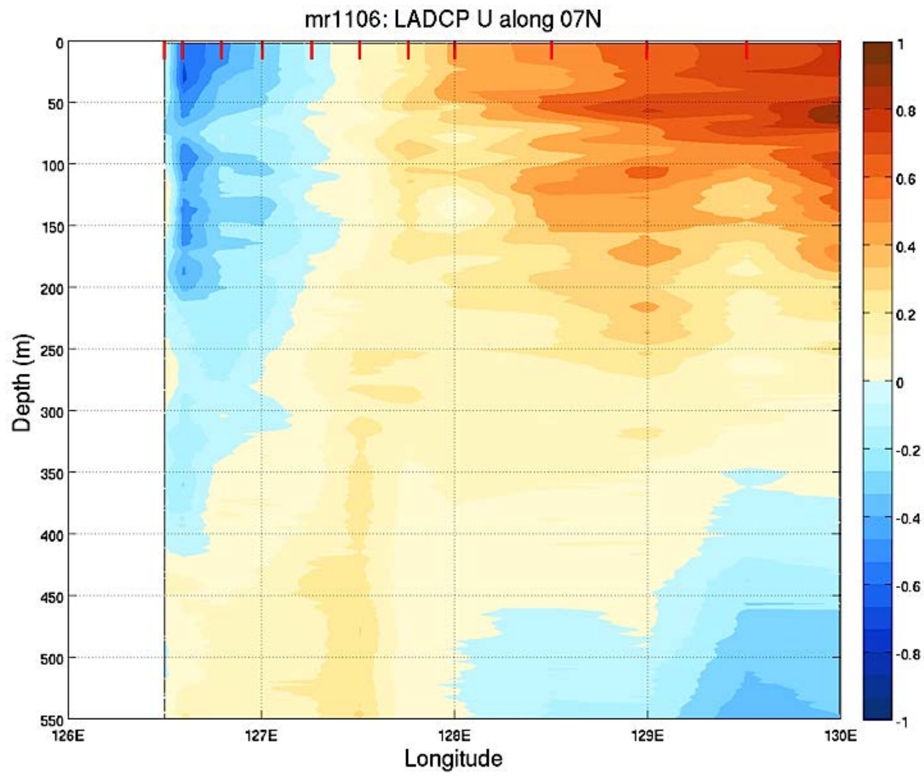


Figure 7.4-10. Longitudinal section of the zonal component of velocity at 7N.

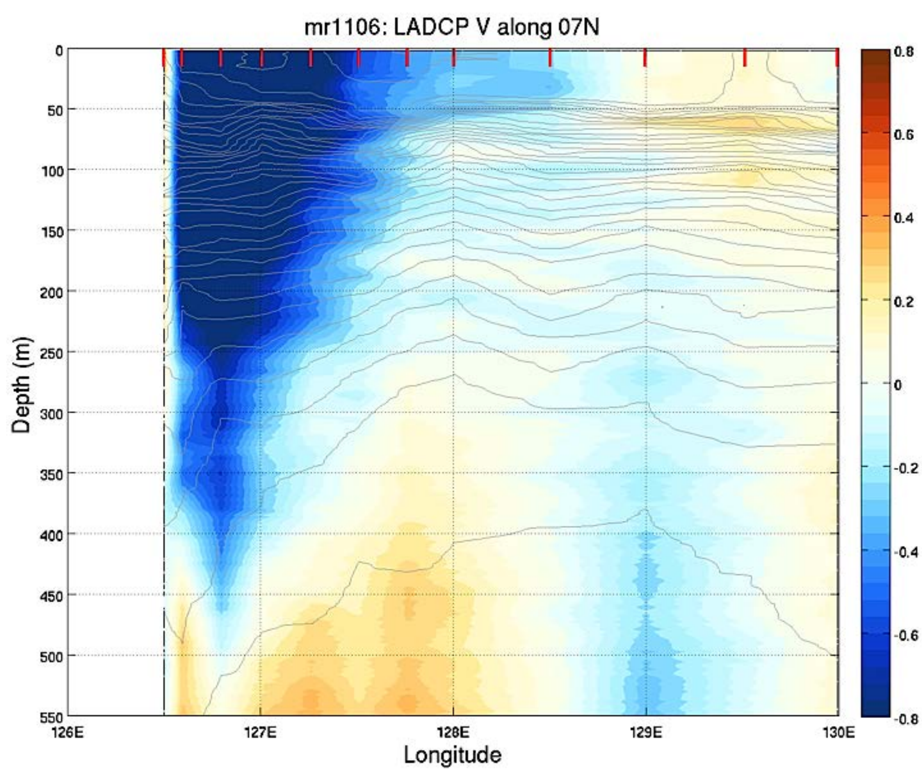


Figure 7.4-11. Longitudinal section of the meridional component of velocity at 7N.

7.5 Observation of ocean turbulence

Personnel Yuji Kashino (RIGC, JAMSTEC)
Satoshi Okumura (Global Ocean Development Inc.)
Kazuho Yoshida (Global Ocean Development Inc.)
Wataru Tokunaga (Mirai crew, Global Ocean Development Inc.)

(1) Introduction

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, and observations using lowered acoustic Doppler current profiler (LADCP) with high frequency were carried out during MR07-07 Leg 1, MR08-03, MR09-04 and MR10-07. These 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, Turbo Map-L, developed by JFE Advantech Co Ltd. during this cruise.

(2) Measurement parameters

Using the Turbo Map-L, we measured following parameters:

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 sensor and twin shear probes:

FP07 sensor

Cast No. 1- 5 SN:192

Cast No. 6-34 SN:193 *)

*) FP07 sensor did not work well at cast 28-34.

Shear Ch1 sensor

All casts: SN:686

Shear Ch2 sensor

All casts: SN:687

At the first cast (TR11), FP07 sensor (S/N181) did not work well. Therefore, we exchanged the sensor (S/N192) and conducted the second cast. (We did not show information of the first cast in the following table.) The same trouble occurred at cast #8 (TR12), and also exchanged the FP07 sensor (S/N193) and conducted second cast. Because this FP07 sensor (S/N193) was the last sensor, we could not exchange when the same trouble occurred again at the cast at 3N, 130E. Therefore, data from FP07 after this cast is not available.

Because shear probes worked well during this cruise, we did not exchange it.

(3) Observation stations.

Cast No.	Station ID	Date	Observation Start			Max Depth		File Name (.BIN)
			Time	Latitude	Longitude	Time	Depth(m)	
1	TR11	2011/08/25	21:11	4-57.89N	137-22.23E	21:28	609	mr11-06-4
2	4.5N137E	2011/08/26	04:18	4-30.04N	137-25.12E	04:32	548	mr11-06-5
3	4N137E	2011/08/26	07:12	3-59.97N	137-35.13E	07:27	404	mr11-06-6
4	3.5N138E	2011/08/26	10:33	3-29.62N	137-45.31E	10:48	409	mr11-06-7
5	TR12	2011/08/26	21:14	2-01.07N	138-06.53E	21:28	477	mr11-06-8
6	2.5N138E	2011/08/27	05:26	2-30.00N	138-05.30E	05:37	351	mr11-06-9
7	3N138E	2011/08/27	09:09	2-59.82E	137-55.46E	09:24	490	mr11-06-10
8	TR12	2011/08/28	02:32	1-59.17N	138-04.90E	02:46	510	mr11-06-11
9	1.5N138E	2011/08/28	06:30	1-30.33N	137-59.71E	06:44	462	mr11-06-12
10	1N138E	2011/08/28	10:07	1-00.34N	137-59.67E	10:21	354	mr11-06-13
11	1.5S138E	2011/08/28	21:11	1-14.81N	137-59.56E	21:25	507	mr11-06-14
12	1S138E	2011/08/28	23:47	0-59.75S	137-59.34E	8/29 0:01	535	mr11-06-15
13	0.5S138E	2011/08/29	03:35	0-29.78S	137-59.76E	03:53	518	mr11-06-16
14	0.5N138E	2011/08/29	09:09	0-30.10N	137-59.73E	09:22	471	mr11-06-17
15	TR13	2011/08/30	03:14	0-04.38N	138-00.70E	03:29	510	mr11-06-18
16	2N137E	2011/08/30	21:06	1-59.94N	137-00.09E	21:20	553	mr11-06-19

17	2N136E	2011/08/31	02:32	2-00.04N	136-00.12E	02:49	630	mr11-06-20
18	2N135E	2011/08/31	08:00	2-00.01N	135-00.04E	08:16	592	mr11-06-21
19	2N134E	2011/08/31	13:23	2-00.01N	134-00.00E	13:38	554	mr11-06-22
20	2N133E	2011/08/31	19:00	2-00.02N	133-00.03E	19:15	563	mr11-06-24
21	2N132E	2011/09/01	00:21	2-00.22N	132-00.31E	00:35	523	mr11-06-25
22	2N131E	2011/09/01	05:50	2-00.32N	131-00.10E	00:06	572	mr11-06-26
23	TR16	2011/09/01	11:10	1-58.68N	130-11.58E	11:29	630	mr11-06-27
24	2N129E	2011/09/01	21:04	1-59.89N	129-00.01E	21:21	635	mr11-06-28
25	1N130E	2011/09/02	04:47	0-59.98N	130-00.13E	05:04	600	mr11-06-29
26	1.5N130E	2011/09/02	08:40	1-29.85N	129-59.76E	08:55	576	mr11-06-30
27	2.5N130E	2011/09/03	05:57	2-30.13N	130-00.02E	06:12	573	mr11-06-31
28	3N130E	2011/09/04	08:52	3-00.52N	129-59.66E	09:06	412	mr11-06-32
29	3.5N130E	2011/09/04	21:35	3-29.96N	129-59.93E	21:50	542	mr11-06-33
30	4N130E	2011/09/05	01:41	3-59.70N	129-59.77E	01:55	509	mr11-06-34
31	5.5N130E	2011/09/05	05:46	4-29.46N	130-00.17E	06:01	542	mr11-06-35
32	5N130E	2011/09/05	09:53	4-59.31N	130-00.46E	10:07	484	mr11-06-36
33	5.5N130E	2011/09/05	21:38	5-29.81N	130-00.90E	21:52	438	mr11-06-37
34	6N130E	2011/09/06	01:51	5-59.63N	130-01.84E	02:04	403	mr11-06-38

(4) Operation and data processing

We operated the Turbo Map-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 (see below).

Figure 7-5-1. Observation using Turbo Map-L.

Measurement depth was 500m because our interest is ocean turbulence around thermocline. However, we could not measure until 500m depth at many casts because Turbo-Map was drifted by strong undercurrents.

Decent rate of the Turbo Map-L was 0.5 – 0.7 m s^{-1}.

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

5) Results

Figure 7-5-2 shows the section of logarithm of energy dissipation rate (epsilon) along 137-138E, 2N and 130E are shown. Compared with salinity section (Figure 2-2), there are following tendencies:

a) High epsilon was generally seen below the high salinity water exceeding 35 PSU (150-200m).
b) High epsilon was also seen south of 2N along 138E line, where is also saline water exceeding 35 PSU.

Theses results suggest that ocean mixing is active around high salinity water exceeding 35 PSU (South Pacific Tropical Water).

a)

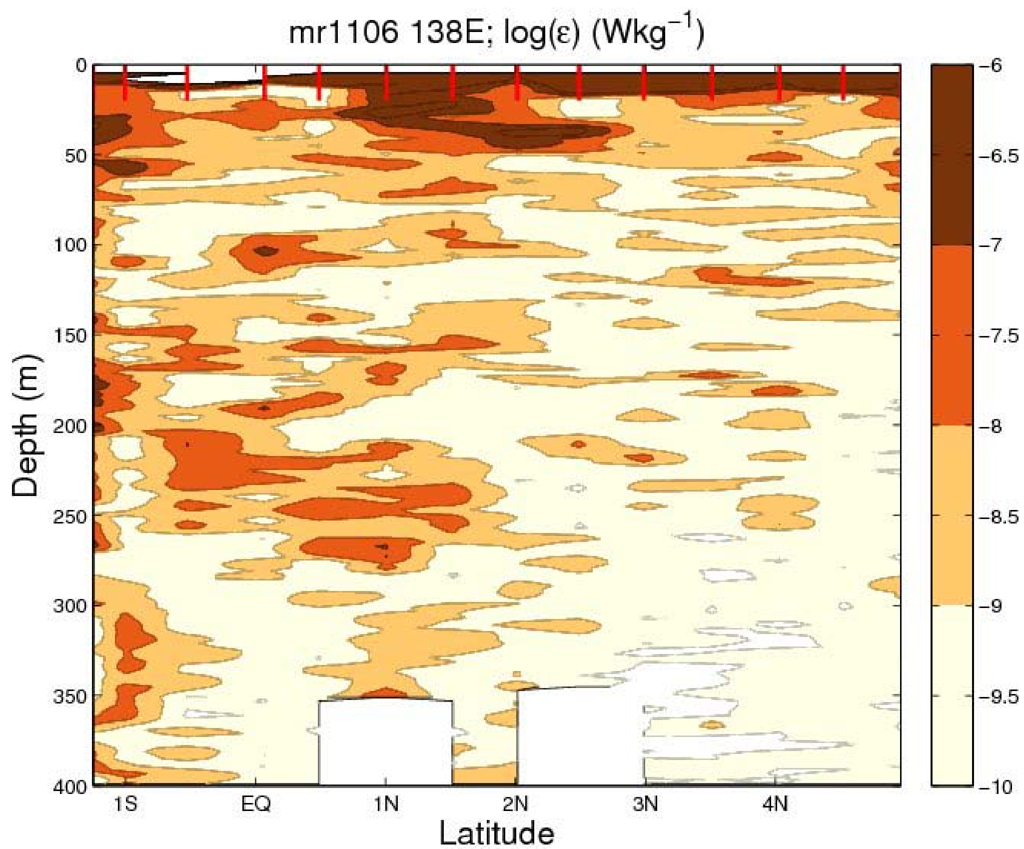
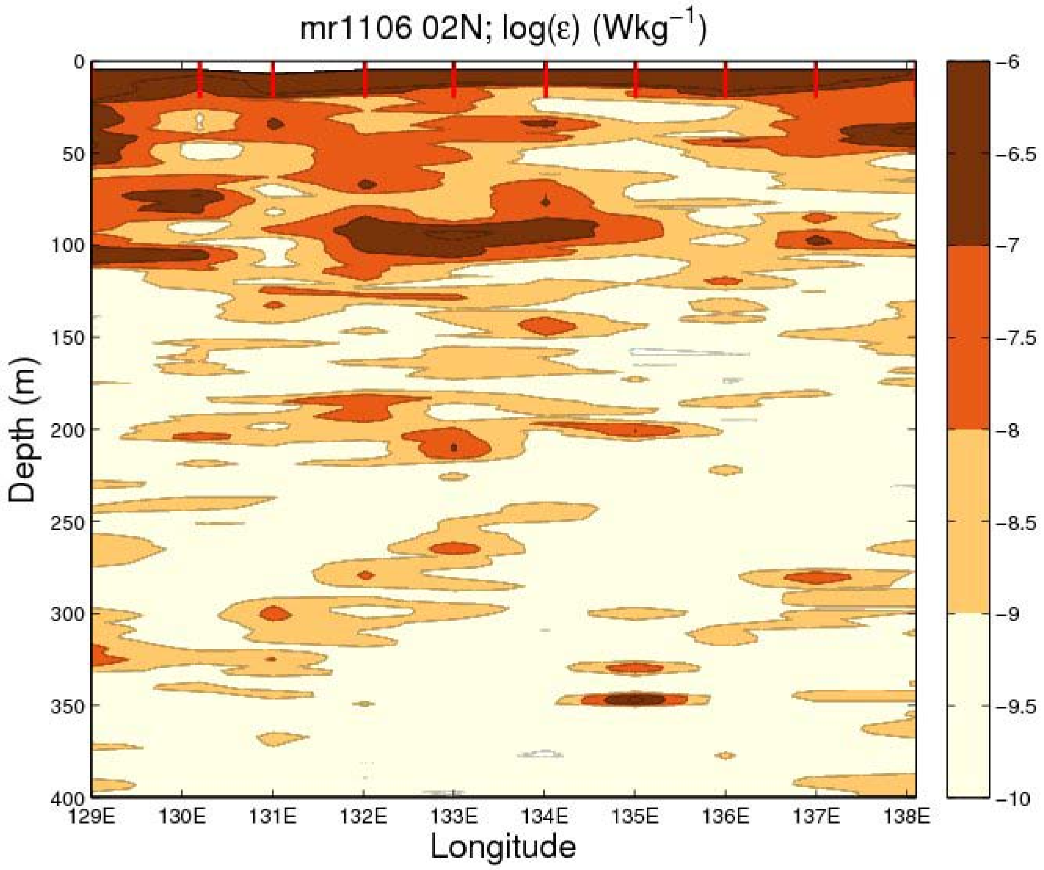


Figure 7-5-2. a) Vertical section of logarithm of energy dissipation rate alogn 137-138E during MR11-06 cruise.

b)



c)

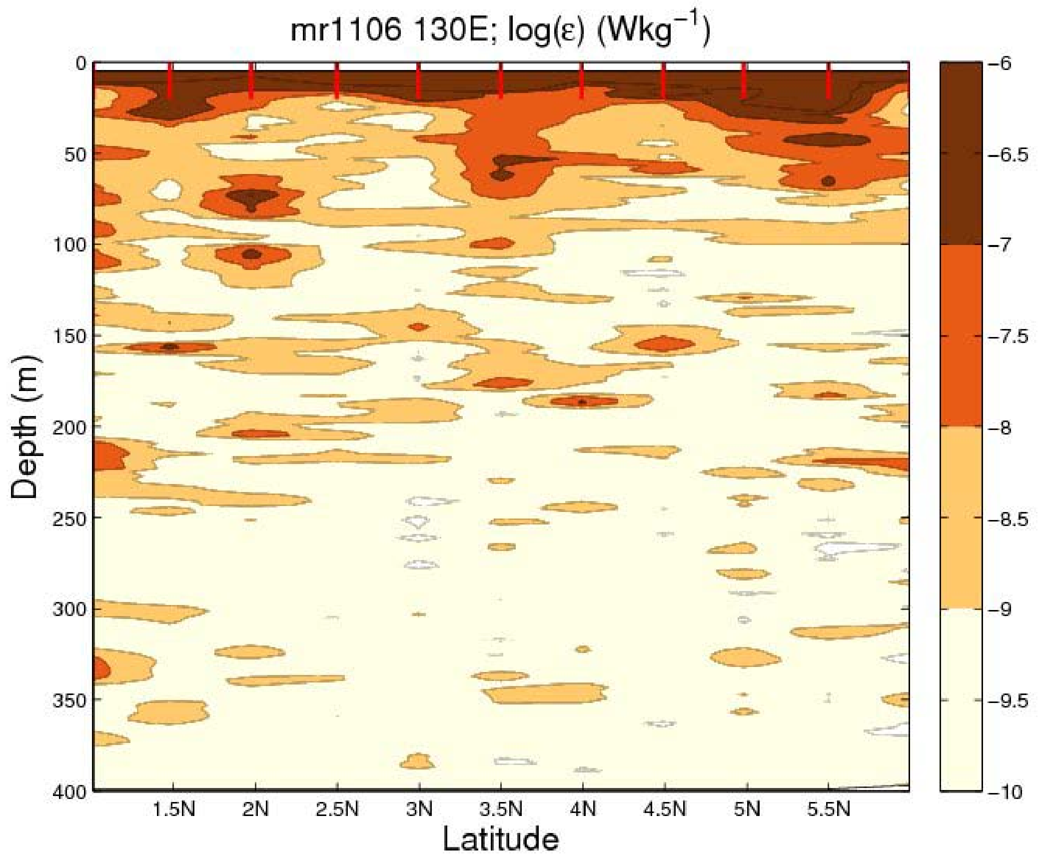


Figure 7-5-2. b) and c). Same as a) but for along 2N and 130E line.

7.6 Profiling floats for JAMSTEC Argo Project

(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*
Kenichi Katayama	*(MWJ): Technical Staff (Operation Leader)*

(2) Objectives

The objective of deployment is to clarify the structure and temporal/spatial variability of water masses in the North Pacific such as North Pacific Subtropical Mode Water and North Pacific Intermediate Water and their formation mechanism. To achieve the objective, profiling floats are launched to measure vertical profiles of temperature and salinity automatically every ten days. As the vertical resolution of the profiles is very fine, the structure and variability of the water mass can be displayed well. Therefore, the profile data from the floats will enable us to understand the variability and the formation mechanism of the water mass.

(3) Parameters

・water temperature, salinity, and pressure

(4) Methods

i. Profiling float deployment

We launched two Provor floats manufactured by NKE Electronics. Each float equips an SBE41CP CTD sensor manufactured by Sea-Bird Electronics Inc.

The floats usually drift at a depth of 1000 dbar (called the parking depth), diving to a depth of 2000 dbar and rising up to the sea surface by decreasing and increasing their volume and thus changing the buoyancy in ten-day cycles. During the ascent, they measure temperature, salinity, and pressure. They stay at the sea surface for approximately nine hours, transmitting the CTD data to the land via the ARGOS system, and then return to the parking depth by decreasing volume. The status of floats and their launches are shown in Table 7.6-1.

Table 7.6-1 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.
09023	97918	2011/08/16 15：20	2011/08/16 16：47	36－00.01 [N] 145－45.75 [E]	C01
09028	97923	2011/08/19 00：27	2011/08/19 01：32	25－00.01 [N] 142－17.89 [E]	C02

(5) Data archive

The real-time data are provided to meteorological organizations, research institutes, and universities via Global Data Assembly Center (GDAC: http://www.usgodae.org/argo/argo.html, http://www.coriolis.eu.org/) and Global Telecommunication System (GTS), and utilized for analysis and forecasts of sea conditions and the climates.

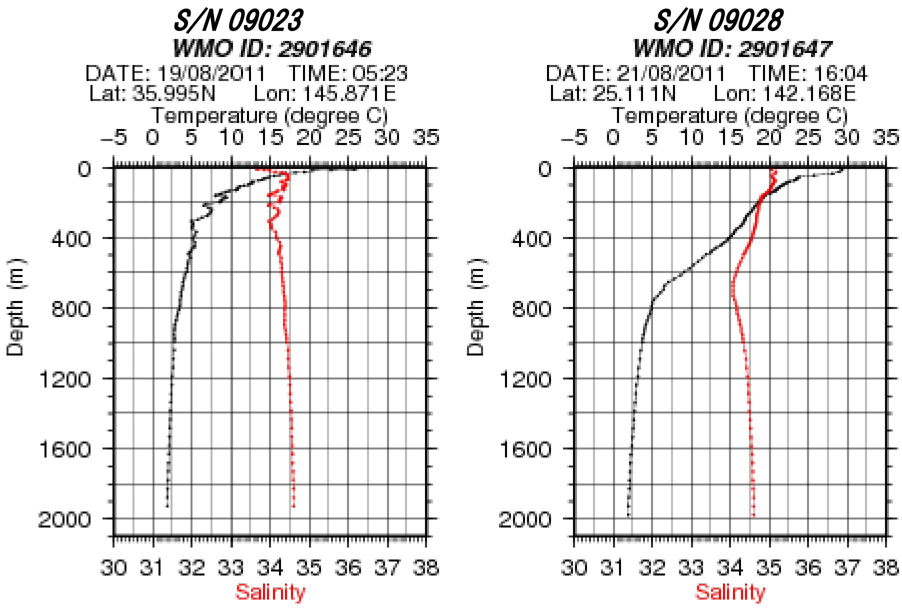


Fig. 7.6.1. The profile of each float launched during MR11-06.

7.7 OKMC SOLO-II profiling floats

(1) Personnel

Dan Rudnick	***(Scripps Institution of Oceanography): Principal Investigator of OKMC (not on board)***
Bo Qiu	***(University of Hawaii): co-PI of OKMC (not on board)***
Derek Vana	***(Scripps Institution of Oceanography): Technical staff (not on board)***

(2) Objectives

The objective of deploying the 10 SOLO-II is to clarify the structure and temporal/spatial variability of water masses in the Philippine Seas in the western North Pacific Ocean. The float deployment complements other on-going, in-situ measurements in the region as part of the US Origin of Kuroshio and Mindanao Currents (OKMC) project funded by the Office of Naval Research. The SOLO-II profiling float data will be combined with other available measurements from the OKMC project and other sources to synergetically determine the circulation pattern and variability in the western North Pacific Ocean.

(3) Parameters

Water temperature, salinity, and pressure from surface down to 2,000 dbar.

(4) Methods

i. Profiling float deployment

We launched ten (10) SOLO-II floats manufactured by Scripps Institution of Oceanography. T hese floats are equipped with SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc to measure the temperature, salinity and pressure from surface to 2,000 dbar. The floats drift at the depth of 1,000 dbar (known as the parking depth), diving to the depth of 2,000 dbar before their profiling ascending. The measured T/S/p data are sent to the Argo data center via the Iridium transmitting system in real time; for data transmission, the floats stay at the sea surface for only a few minutes. The repeat cycle of the float measurements is every 5 days and the floats are expected to take a total of about 300 profiles for ~4 years. The status of floats and their launches are shown in Table 7.7-1.

Table 7.7-1 Status of floats and their launches

Float Type	**SOLO-II floats manufactured by Scripps Institution of Oceanography**
CTD sensor	**SBE41-cp manufactured by Sea-Bird Electronics Inc.**
Repeat Cycle	**5 days (a few minutes at the sea surface)**
Target Parking Pressure	**1,000 dbar**
Sampling layers	**1-dbar between surface and 10-dbar, 2-dbar from 10 to 2,000 dbar**

Launches

Float S/N	Date and Time of Launch(UTC)	Location of Launch	CTD St. No.
8033	2011/08/20 10:08	18-00.10N; 139-59.94E	(None)
8028	2011/08/20 15:20	16-59.96N; 139-39.94E	(None)
8029	2011/08/20 20:27	15-59.92N; 139.19.96E	(None)
8026	2011/08/21 01:15	15-00.06N; 138-59.99E	(None)
8032	2011/08/21 06:09	13-59.91N; 138-40.03E	(None)
8034	2011/08/21 11:07	13-00.07N: 138-20.00E	(None)
8030	2011/08/21 16:35	12-00.08N; 138-00.05E	(None)
8027	2011/08/21 22:01	11-00.10N; 137-40.08E	(None)
8025	2011/08/22 02:54	10-00.00N; 137-19.96E	(None)
8031	2011/08/22 07:35	09-00.01N; 136-59.97E	(None)

(5) Data archive

The real-time data are provided to meteorological organizations, research institutes, and universities via Global Data Assembly Center (GDAC: http://www.usgodae.org/argo/argo.html, http://www.coriolis.eu.org/) and Global Telecommunication System (GTS), and utilized for analysis and forecasts of the ocean conditions and the climates.

7.8 Global Drifter Program – SVP Drifting Buoys

(1) Personnel

Rick Lumpkin (National Oceanographic Atmospheric Administration / Global Drifter Program): Principal Investigator of GDP (not on board)
Shaun Dolk (National Oceanographic Atmospheric Administration / Global Drifter Program): (not on board)

(2) Objectives

The objective of deploying the 30 drifting buoys is to compliment the current global array of drifting buoys. The western equatorial region and east of Japan is of great value, as there are few deployment opportunities in this region. As a result, the data collected from these instruments will significantly affect the current dataset of historical drifters in the area.

(3) Parameters

Sea surface temperature and ocean current velocities.

(4) Methods

i. Profiling float deployment

We launched thirty (30) drifting buoys manufactured by Pacific Gyre Inc. These drifters are equipped with thermistor sensors to measure the temperature at the surface of the ocean. The drifters float at the surface, following upper ocean surface currents. The measured temperature and location data are sent to the Drifter Data Assembly Center via the ARGOS transmitting system for data processing and quality control procedures. The drifters are expected to transmit for 450 days, while maintaining a drogue presence for 300 days. The status of drifters and their launches are shown in Table 7.8-1.

Table 7.8-1 Status of drifters and their launches

Drifter Type	**Surface Velocity Profiler (SVP) Type drifter Manufactured by Pacific Gyre Inc.**

Launches

Drifter S/N	Date	Time (UTC)	Latitude	Longitude
37650	Aug 15, 2011	03:23	39-45.00 N	143-00.06 E
38629	Aug 15, 2011	05:16	39-30.01 N	143-30.02 E
38630	Aug 15, 2011	07:08	39-14.98 N	144-00.02 E
37644	Aug 15, 2011	12:56	38-59.98 N	144-30.03 E
38625	Aug 15, 2011	14:46	38-44.97 N	145-00.01 E
37647	Aug 15, 2011	16:40	38-29.99 N	145-30.03 E
37657	Aug 15, 2011	18:34	38-14.98 N	146-00.02 E
37267	Aug 16, 2011	02:50	38-05.22 N	146-24.14 E
37124	Aug 16, 2011	05:00	37-46.06 N	146-19.52 E
37090	Aug 16, 2011	06:30	37-30.24 N	146-14.89 E
37040	Aug 16, 2011	07:59	37-15.19 N	146-09.73 E
37042	Aug 16, 2011	09:29	37-00.15N	146-04.56 E
37291	Aug 20, 2011	20:28	15-59.90 N	139 19.96 E
37265	Aug 21, 2011	01:17	15-00.00N	138 59.98 E
37294	Aug 21, 2011	06:10	13-59.89 N	138 40.05 E
37268	Aug 21, 2011	11:08	13-00.05 N	138 20.00 E
37266	Aug 21, 2011	16:36	12-00.08 N	138 00.03 E
37223	Aug 21, 2011	22:01	11-00.08 N	137 40.08 E
37269	Aug 22, 2011	02:55	09-59.98 N	137 19.96 E
37292	Aug 24, 2011	07:36	08-59.99 N	136 59.97 E
36729	Aug 24, 2011	03:25	07-52.41 N	136 30.21 E
36730	Aug 24, 2011	07:18	07-00.02 N	136 44.00 E
36753	Aug 24, 2011	11:35	06-00.01 N	136 58.06 E
36741	Aug 25, 2011	09:31	04-00.03 N	137 36.20 E
37264	Aug 26, 2011	02:08	04-58.25 N	137 22.07 E
37257	Aug 27, 2011	09:57	02-58.95 N	137 56.36 E
37020	Aug 28, 2011	03:13	01-59.20 N	138 05.21 E
37263	Aug 28, 2011	10:46	01-00.41 N	137 59.45 E
37039	Aug 29, 2011	12:25	00-59.33 S	137 58.20 E
36755	Aug 30, 2011	06:43	00-05.32 N	138 03.82 E

(5) Data archive

The real time data are provided via DAC Data Products, which you can access at (http://www.aoml.noaa.gov/phod/dac/meds.html). The quality controlled data are provided to oceanographic organizations, research institutes, and universities via Drifter Data Assembly Center (http://www.aoml.noaa.gov/phod/dac/dirall.html) and Global Telecommunication System (GTS), and utilized for analysis and forecasts of the ocean conditions and the climates.

-

7.9 Radiosonde observation

(1) Personnel

Satoshi Okumura	(GODI)	
Kazuho Yoshida	(GODI)	
Tokunaga	(MIRAI Crew)	
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 radiosondes were performed between the JKEO and KEO sites in the northwestern Pacific Ocean. In total, 23 soundings were obtained. 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).

The observation points and the launching logs are summarized in Figure 7.9-1 and Table 7.9-1.

(5) Preliminary results

Latitude-height cross sections of air temperature and mixing ratio along the ship track are shown in Figure.7.9-2, -3. Also, an emagram for each observation is shown in Figure 7.9-4.

(6) Data archive

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.

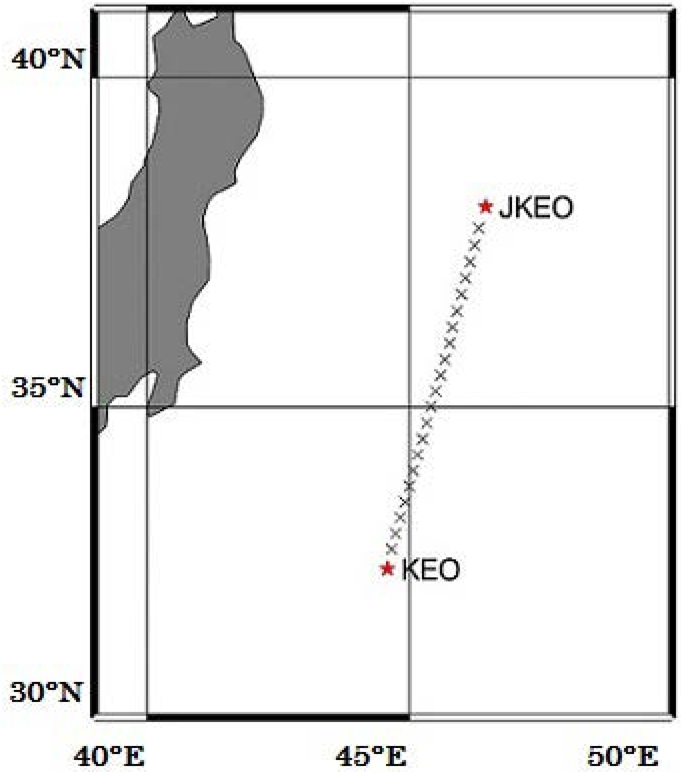


Figure 7.9-1 Radiosonde observation points.

Table 7.9-1 Radiosonde launch log between the JKEO and KEO sites.

Sounding No.	Station No.	Launching				Maximum		Duration
		Date (UTC)	Time	Lon	Lat	Altitude	hPa	(sec)
RS001	JKEO	2011/8/16	3:00:00	146.401	38.0859	12292	205.0	3724
RS002	E01	2011/8/16	5:00:00	146.350	37.8214	12033	213.8	3728
RS003	E02	2011/8/16	6:30:00	146.277	37.5471	13934	158.8	3694
RS004	E03	2011/8/16	8:00:00	146.188	37.2928	11575	229.2	3726
RS005	E04	2011/8/16	9:30:00	146.104	37.0450	14732	139.4	3690
RS006	E05	2011/8/16	11:00:00	146.019	36.7900	13547	169.3	3704
RS007	E06	2011/8/16	12:30:00	145.937	36.5300	12575	197.3	3716
RS008	E07	2011/8/16	14:00:00	145.847	36.2913	12964	185.6	3706
RS009	E08	2011/8/16	15:30:00	145.761	36.0018	14628	141.5	4318
RS010	E09	2011/8/16	18:30:00	145.699	35.7801	13101	181.5	3724
RS011	E10	2011/8/16	20:00:00	145.616	35.5421	13100	181.6	3702
RS012	E11	2011/8/16	21:30:00	145.521	35.2913	12743	191.9	3702
RS013	E12	2011/8/16	23:00:00	145.433	35.0498	12779	191.0	3724
RS014	E13	2011/8/17	0:30:00	145.357	34.8012	13891	160.5	3702
RS015	E14	2011/8/17	2:00:00	145.277	34.5570	12883	187.7	3698
RS016	E15	2011/8/17	3:30:00	145.188	34.2937	13542	169.4	3684
RS017	E16	2011/8/17	5:00:00	145.065	33.9921	7497	405.4	1582
RS018	E17	2011/8/17	6:30:00	145.026	33.8218	12901	187.6	3722
RS019	E18	2011/8/17	8:00:00	149.943	33.5526	13022	184.0	3704
RS020	E19	2011/8/17	9:30:00	141.862	33.2895	13011	184.2	3714
RS021	E20	2011/8/17	11:00:00	144.764	33.0336	14070	155.6	3694
RS022	E21	2011/8/17	12:30:00	144.688	32.7877	12382	203.1	3724
RS023	KEO	2011/8/17	14:30:00	144.571	32.4755	13695	164.9	3714

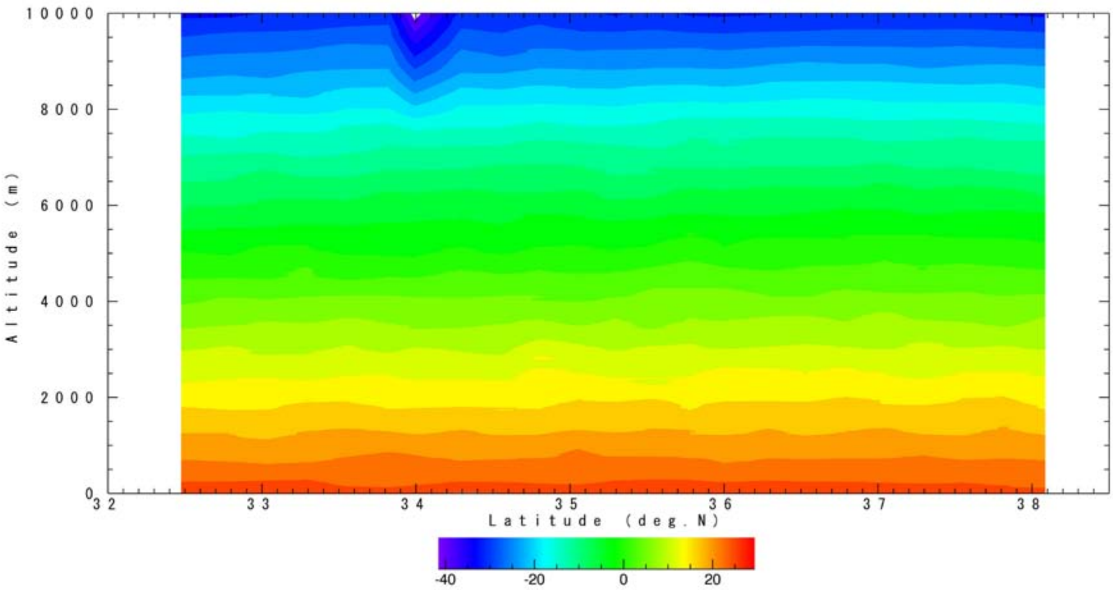


Figure 7.9-2 Latitude-height cross sections of air temperature along the ship track.

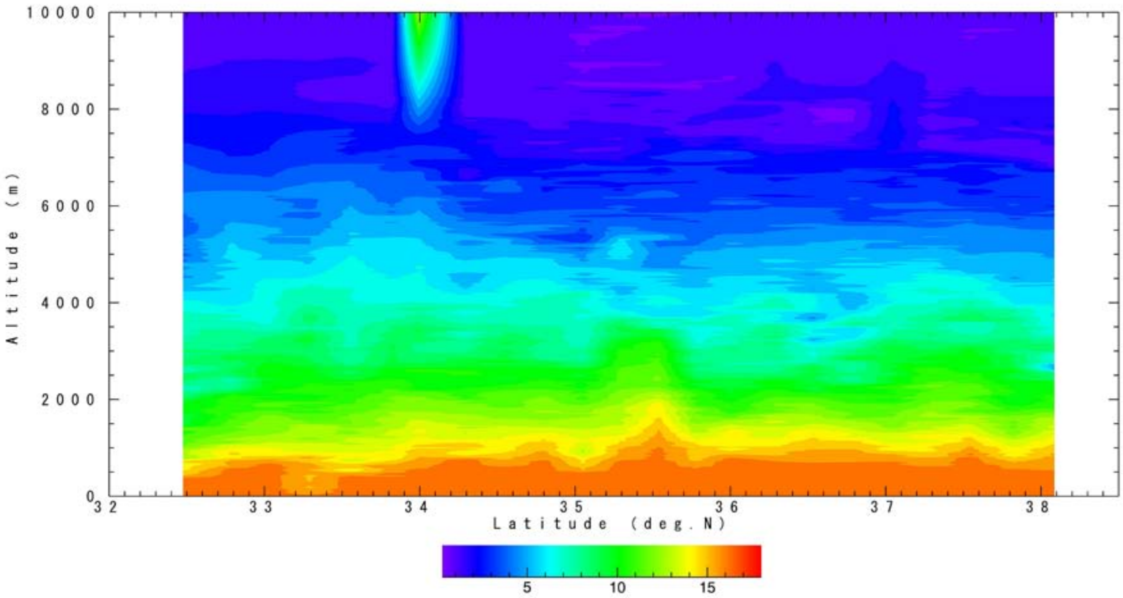
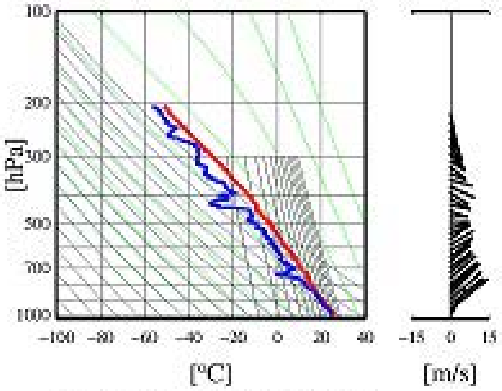
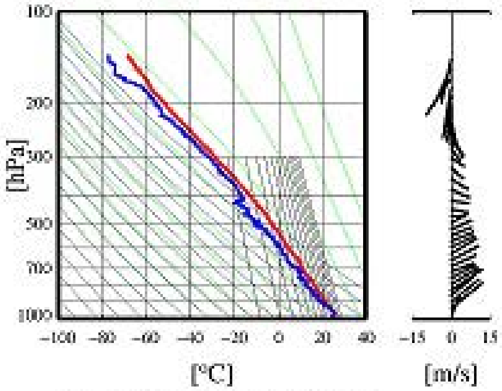


Figure 7.9-3 Latitude-height cross sections of mixing ratio (g/kg) along the ship track.

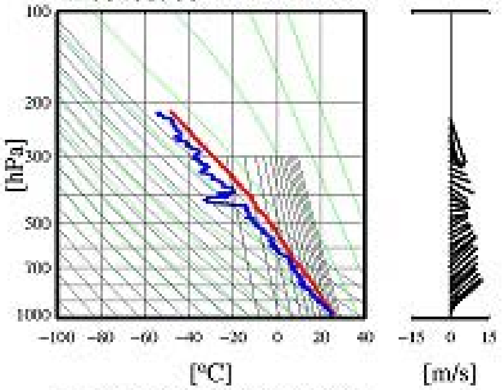
1108160300 146.40E 38.09N



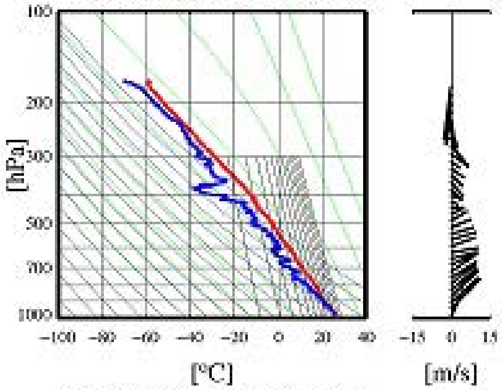
1108160930 146.10E 37.04N



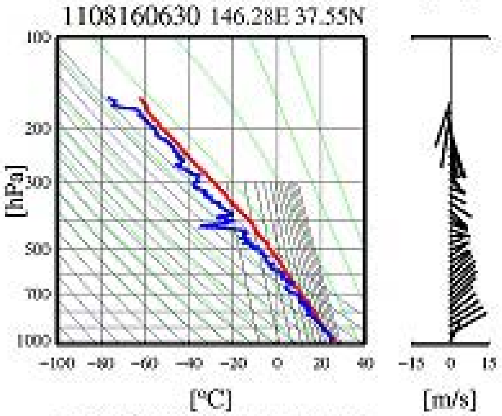
1108160500 146.35E 37.82N



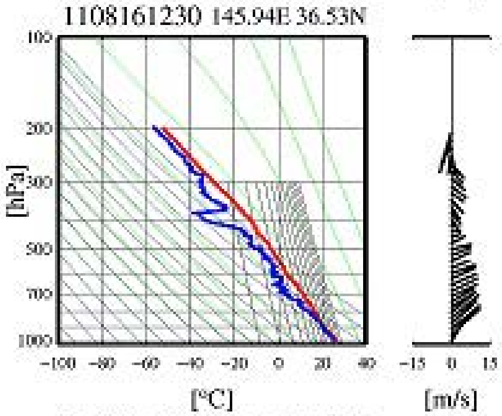
1108161100 146.02E 36.79N



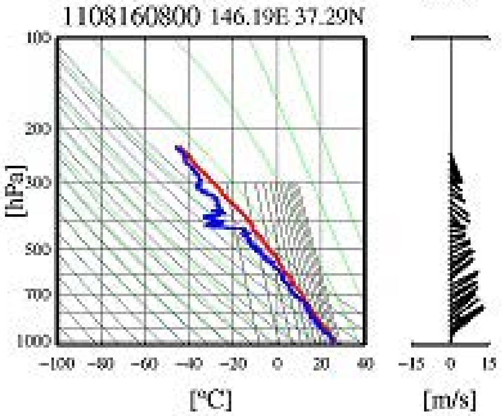
1108160630 146.28E 37.55N



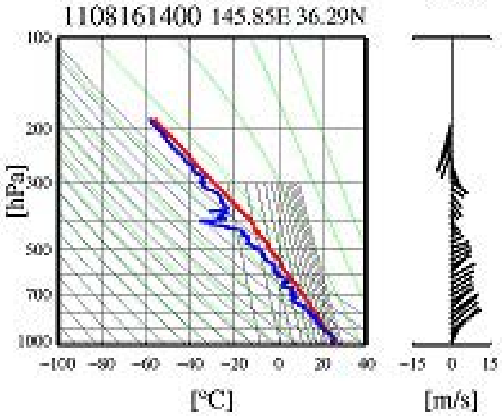
1108161230 145.94E 36.53N

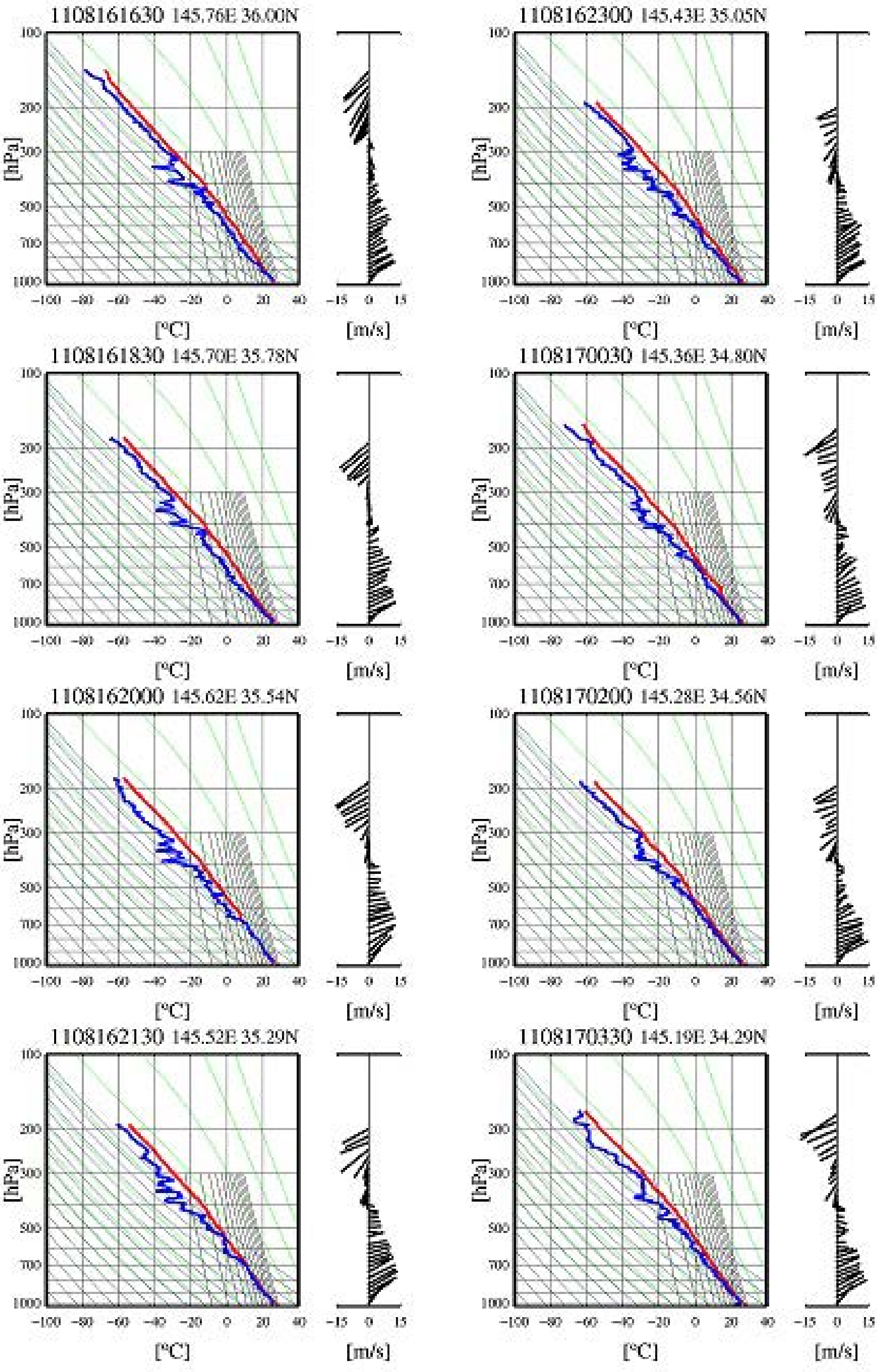


1108160800 146.19E 37.29N



1108161400 145.85E 36.29N




1108161630 145.76E 36.00N
1108162300 145.43E 35.05N
1108161830 145.70E 35.78N
1108170030 145.36E 34.80N
1108162000 145.62E 35.54N
1108170200 145.28E 34.56N
1108162130 145.52E 35.29N
1108170330 145.19E 34.29N
[hPa]
100
200
300
500
700
1000
-100 -80 -60 -40 -20 0 20 40
[°C]
-15 0 15
[m/s]

FiFf

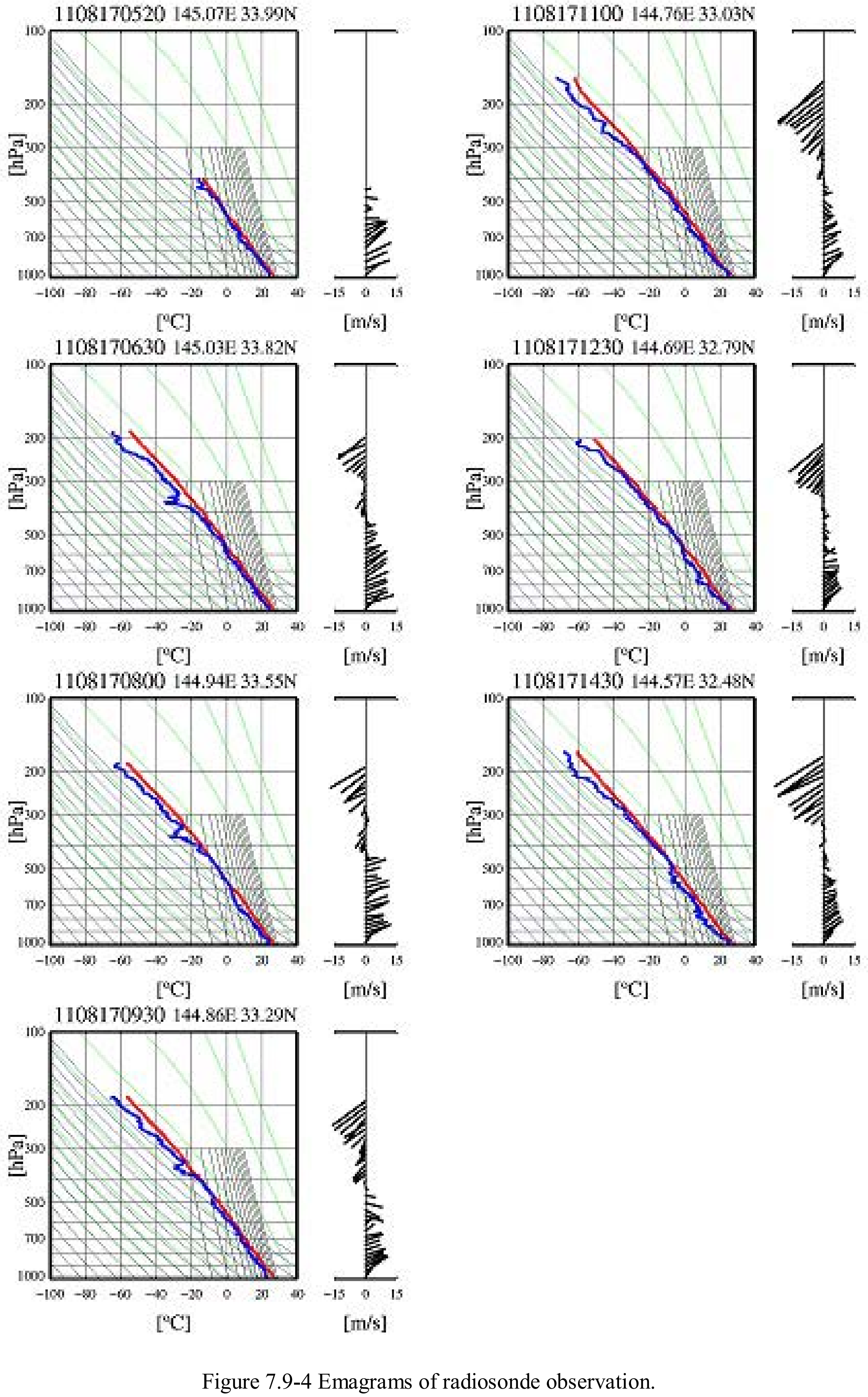


Figure 7.9-4 Emagrams of radiosonde observation.

7.10 Doppler rader observation

(1) Personnel

Kyoko Taniguchi	(JAMSTEC)	
Satoshi Okumura	(GODI)	
Kazuho Yoshida	(GODI)	
Wataru Tokunaga	(MIRAI Crew)	
Not on board:		
Yoshimi Kawai	(JAMSTEC)	Principal Investigator
Hiroyuki Tomita	(JAMSTEC)	
Meghan Cronin	(NOAA/PMEL)	

(2) Objective

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

(3) Methods

R/V MIRAI installed the ship-board Doppler radar RC-52B (Mitsubishi Electric Co., JAPAN). Its specifications are as follows;

Frequency	5290MHz (C-band)
Beam Width	less than 1.5 degrees
Transmit Power	250kW (Peak Power)
Signal Processor	RVP-7 (VAISALA Inc. Sigmet Product Line, U.S.A.)
Internal Navigation Unit (INU)	PHINS (Ixsea SAS, France)
Application Software	IRIS/ Open (VAISALA Inc. Sigmet Product Line, U.S.A.)

Measured parameters are Radar reflectivity factor (dBZ) and Doppler velocity (m/s), which is corrected with ship's speed and course over ground provided from INU. High-precision attitude and heading information detected by INU are used for control of the antenna to correct azimuth and elevation angles against roll, pitch and yaw of the ship.

Prior to the operation, the transmitter's four parameters (transmitted frequency, mean transmitted power, pulse width, and pulse repetition frequency (PRF)) were checked and the receiver calibration was performed. The same procedure was carried out at the end of the observation as well.

The Doppler radar was operated between JKEO and KEO sites on August 16-17, 2011. During the period, the volume scan consisting of 21 PPI (Plan Position indicator) scans with different elevation angles from 0.5 to 40.0 degrees was conducted every 10 minutes. A dual PRF mode with the maximum range of 160 km was used for the volume scan. Meanwhile, a surveillance PPI scan was performed every 30 minutes in a single PRF mode with the maximum range of 300 km at 0.5 degree of elevation angle. The detail information for the observation mode is listed in Table 7.10-1.

(4) Data archives

The Doppler Radar data will be submitted to the Data Management Group (DMG) of JAMSTEC just after the cruise.

Table 7.10-1 Parameters for the observation mode

	Surveillance PPI	Volume Scan
Pulse Width	2.0 (microsec)	0.5 (microsec)
Scan Speed	18 (deg/sec)	18 (deg/sec)
PRF	260 (Hz)	900/720 (Hz)
Sweep Integration	32 samples	50 samples
Ray Spacing	1.0 (deg)	1.0 (deg)
Bin Spacing	250 (m)	250 (m)
Elevation Angle	0.5	0.5, 1.0, 1.8, 2.6, 3.4, 4.2, 5.0, 5.8, 6.7, 7.7, 8.9, 10.3, 12.3, 14.5, 17.1, 20.0, 23.3, 27.0, 31.0, 35.4, 40.0
Azimuth	Full Circle	Full Circle
Range	300 (km)	160 (km)

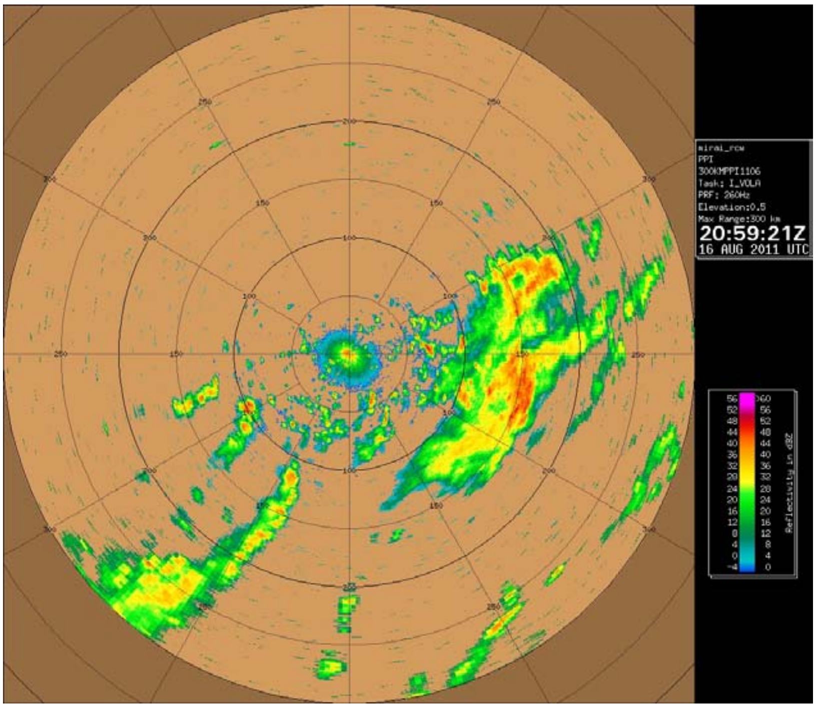


Figure 7.10-1 The surveillance PPI scan (elevation angle: 0.5 degree, range: 300km) at 2059 UTC, August 16, 2011.

7.11 Lidar observations of clouds and aerosols

(1) Personnel

Ichiro Matsui (on board), Nobuo Sugimoto, Atsushi Shimizu, Tomoaki Nishizawa (National Institute for Environmental Studies), lidar operation was supported by Global Ocean Development Inc.

(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 polarization Mie lidar and a high-spectral resolution lidar (HSRL).

(3) Measured parameters

<u>Mie lidar</u>

Vertical profiles of backscatter coefficient at 532nm
Vertical profiles of backscatter coefficient at 1064nm
Vertical profiles of depolarization ratio at 532nm

<u>HSRL</u>

Vertical profiles of extinction coefficient at 532nm
Vertical profiles of backscatter coefficient at 532nm
Vertical profiles of backscatter coefficient at 1064nm
Vertical profiles of depolarization ratio at 532nm
Vertical profiles of depolarization ratio at 1064nm
Vertical profiles of water vapor concentration

(4) Method

<u>Mie lidar</u>

Vertical profiles of aerosols and clouds are measured with a two-wavelength polarization Mie lidar. The lidar employs a Nd:YAG laser as a light source which generates the fundamental output at 1064nm and the second harmonic at 532nm. Transmitted laser energy is typically 30mJ per pulse at both of 1064 and 532nm. The pulse repetition rate is 10Hz. The receiver telescope has a diameter of 20 cm. The receiver has three detection channels to receive the lidar signals at 1064 nm and the parallel and perpendicular polarization components at 532nm. An analog-mode avalanche photo diode (APD) is used as a detector for 1064nm, and photomultiplier tubes (PMTs) are used for 532 nm. The detected signals are recorded with a transient recorder and stored on a hard disk with a computer. The lidar system was installed in a container which has a glass window on the roof, and the lidar was operated continuously regardless of weather. Every 15 minutes vertical profiles of four channels (532 parallel, 532 perpendicular, 1064, 532 near range) are recorded.

HSRL

Vertical profiles of aerosols, clouds, and water vapor are measured with a HSRL. The lidar employs an injection-seeded Nd:YAG laser at 532 and 1064nm in narrower line width than the laser used in the Mie lidar. Transmitted laser energy is more than 100mJ per pulse at both of 1064 and 532nm. The pulse repetition rate is 10Hz. The receiver telescope has a diameter of 30 cm. The receiver has six detection channels: parallel and perpendicular polarization components of lidar signals at 532 and 1064nm, Raman scatter signals at 660nm for water vapor detection, and Rayleigh scatter signals at 532nm using a HSRL technique. APDs are used for 1064nm channels, and PMTs are used for 532 and 660nm. 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 1 minute profiles of six channels are recorded.

(5) Results

Temporal and vertical distributions of 532nm lidar signals measured with the two wavelength polarization Mie lidar from Aug. 14 to Sep. 12 are depicted in Fig. 7.11-1. The figure shows that the lidar can detect maritime aerosols in the planetary boundary layer (PBL) formed below 1km, water clouds formed at the top of the PBL, ice clouds in the upper layer and rain falling from clouds, indicating that appropriate lidar measurements could be conducted. Especially, it should be noted that the lidar could detect ice clouds (cirrus) up to very high altitude of 15km since optical and microphysical properties and distributions of cirrus are key parameters for evaluating climate change.

Unfortunately, an optical component of the transmitter system of the HSRL broke on 19 Aug and observation by the HSRL was turned off. An example of a vertical profile of 532nm signals measured on 18 Aug is depicted in Fig. 7-11.2. The parallel and perpendicular polarization signals were so strong at 5km that clouds (ice clouds) existed there. On the other hand, the signals measured by using the HSRL technique rather decreased in the clouds. The HSRL technique used in this system blocks light scattered by particles (i.e., clouds and aerosols) and transmits light scattered by molecules (i.e., Rayleigh backscatter signals) using an iodine absorption filter and the laser with narrow line width. Thus, this result indicates that the HSRL system worked well. The broken optical component cannot be fixed in this cruise unfortunately, however, we will change the broken optical component to new one and will be able to restart the HSRL measurements in the next cruise (i.e., MR11-07).

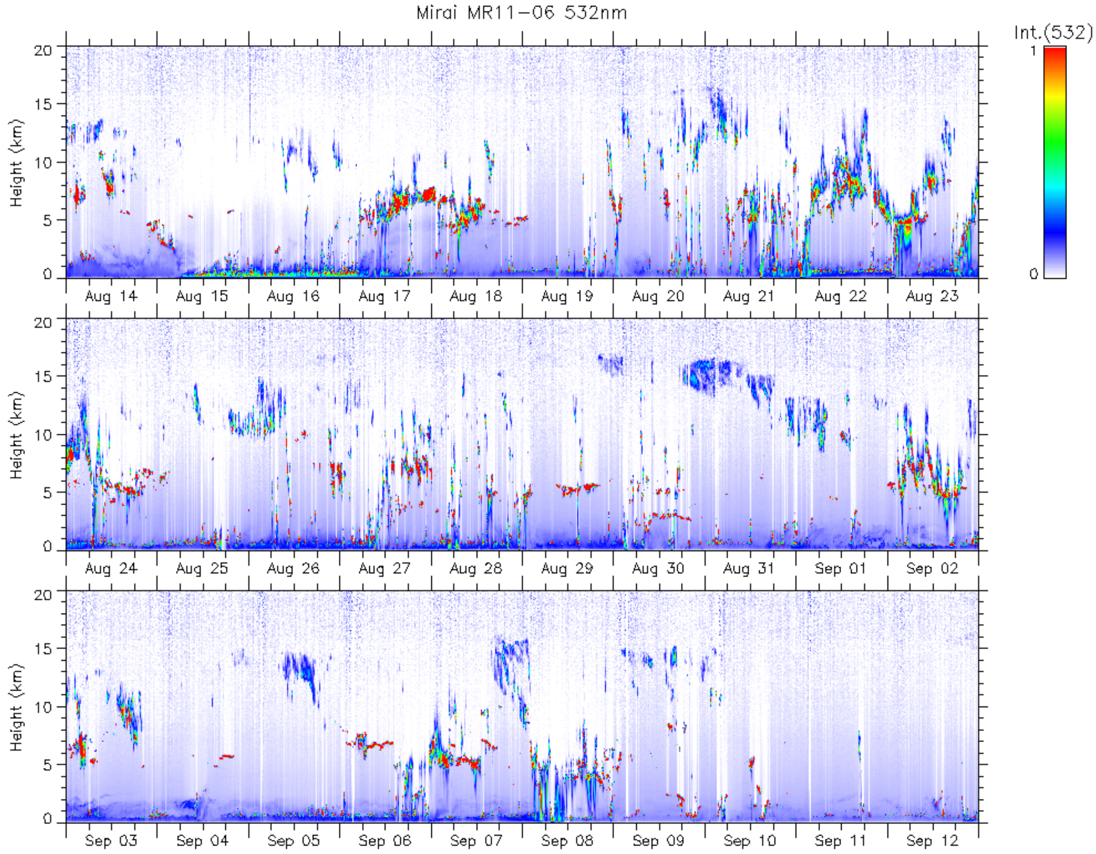


Figure 7.11-1: Time-height sections of backscatter intensity at 532 nm from 14 August 2011 to 12 September 2011.

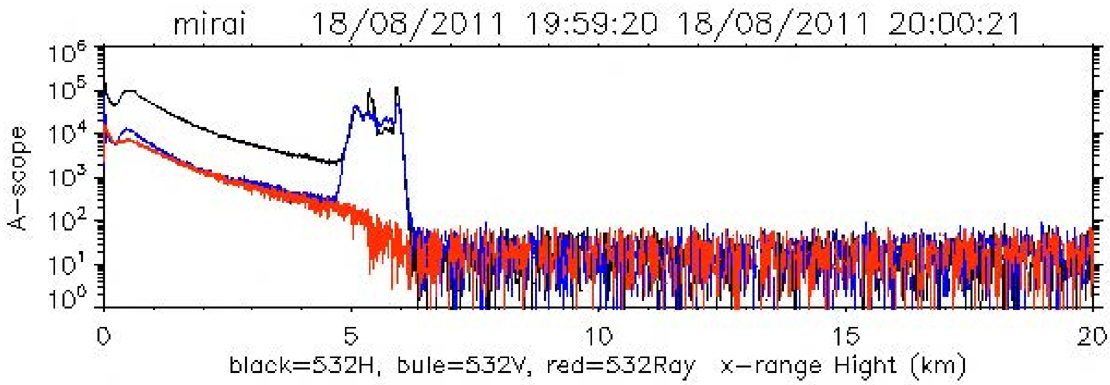


Figure 7.11-2: Vertical profiles of (blue) perpendicular and (black) parallel backscatter intensities and (red) Rayleigh backscatter intensity at 532nm on 18 Aug, 2011.

(6) Data archive

<u>Mie lidar</u>

- 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): August, 14, 2011 - September 14, 2011
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
HSRL
- raw data (plan)
lidar signal at 532 nm
lidar signal at 1064 nm
depolarization ratio at 532 nm
depolarization ratio at 1064 nm
Rayleigh backscatter signal at 532nm
Raman backscatter signal at 660nm
temporal resolution 1min/ vertical resolution 3.75 m
data period (UTC): August, 18, 2011 - August 19, 2011 (Only test data)
processed data (plan)
extinction coefficient at 532nm
backscatter coefficient at 532nm
backscatter coefficient at 1064nm
depolarization ratio at 532nm
depolarization ratio at 1064nm
water vapor concentration

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

7.12 Millimeter Wave Radar and Lidar

(1) Personnel

TAKANO Toshiaki (Chiba University): Principal Investigator, Associate Prof.
NISHINO Daichi (Chiba University): Student, Master Course 2nd gr.
OHKURA Tetsuya (Chiba University): Student, Master Course 1st gr.
NAKAURA Fumiaki (Chiba University): Undergraduate Student, 4th gr.
NISHIZAWA Tomoaki (NIES):
MATSUI Ichiro (NIES):
SUGIMOTO Nobuo (NIES):
OKAMOTO Hajime (Kyushu University):

(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 and lidar 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 10 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 by H.Okamoto, Kyushu 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

An example of the time height cross-sections of radar reflectivity power obtained on 2. Sept. 2011, during MR11-06 cruise are shown in Fig.7.12-1. The location of MIRAI was 0N, 130E.

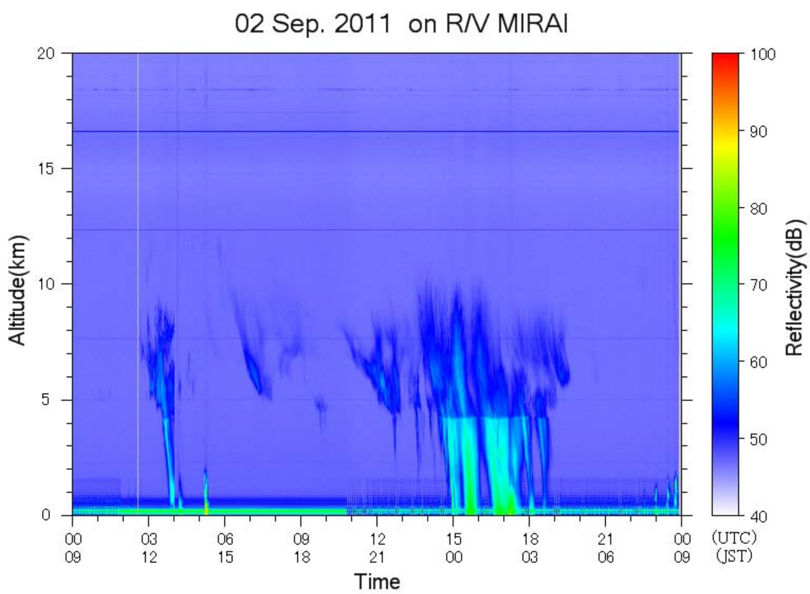


Fig 7.12-1. Time height cross section of radar reflectivity power in arbitral unit of dB on 2. Sept., 2011. The location of MIRAI was 0N, 130E. We can recognize that the heights of the melting layers.

(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 FALCON-I was successfully operated for 24 hours during the cruise from 13. Aug. until 5. Sept. 2011. A signal generator for the local oscillator of the radar system was out of order on 5. Sept. and was fixed on 22. during the call on Singapore.

The High Spectral Resolution Lidar was tested on fundamental characteristics and not operated for observations of atmosphere during the cruise.

7.13 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. 7.13-1) 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.

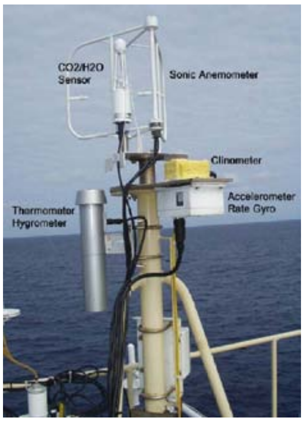


Fig. 7.13-1 Turbulent flux measurement system on the top deck of the foremast.

7.14 Aerosol optical characteristics measured by Ship-borne Sky radiometer

Kazuma Aoki (University of Toyama) Principal Investigator / not onboard
Tadahiro Hayasaka (Tohoku University) Co-worker / not onboard
Masataka Shiobara (NIPR) Co-worker / not onboard
Sky radiometer operation was supported by Global Ocean Development Inc.

(1) 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.

(2) Methods and Instruments

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.

@ 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.

(3) Preliminary results

This study is not onboard. Data obtained in this cruise will be analyzed at University of Toyama.

(4) 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.

7.15 Rain, water vapor and surface water sampling

(1) Personnel

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

Operator

Kazuho Yoshida (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 MR11-06.

(3) Method

Following observation was carried out throughout this cruise.

- Atmospheric moisture sampling:

Ambient air sampling was conducted using both latest laser based water vapor isotope analyzer (WVIA) and conventional cryogenic cold trap method. We used different air-sampling tube lines for each sampling. Both air-sampling lines connected at the middle level (20m above the sea level) of the mast at the compass deck to the laboratory. Air was drawn by external pump at a flow rate of 2 Lmin-1 for laser instrument and 1.5Lmin-1 for cold trap method. As for laser based measurement, every 50 minutes, the 3-way valve in the instrument automatically switched from ambient inlet to WVISS reference air, and then reference air with a H2O mixing ratio of 10000 ppmv was introduced to the WVIA during 10 minutes. After finishing reference gas measurement, the valve switches back to ambient inlet and ambient air sampling is resumed. The WVIA can measure HDO and H218O in the water vapor every second.

As for collection of vapor samples in cold trap, sampled air was passed through a glass trap in an ethanol bath, which was thermoelectrically cooled to -100 degree C. It is collected every 12 hour during the cruise. Amount of cold-trapped vapor was between 20 and 30g. After collection, water in the trap was subsequently thawed and poured into the 6ml glass bottle.

- Rainwater sampling

Rainwater samples gathered in rain/snow 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) Water samples for isotope analysis

Sampling of water vapor for isotope analysis is summarized in Table 7.15-1 (60 samples). The detail of rainfall sampling (19 samples) is summarized in Table 7.15-2. 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 7.15-3 (31 samples).

(5) Data archive

The isotopic data of water vapor can obtain from the laser based water vapor isotope analyzer on board. The archived raw observed data was submitted to JAMSTEC Data Integration and Analysis Group (DIAG) after the cruise immediately. As for collected water samples, isotopes (HDO, $H_2{}^{18}O$) analysis will be done at RIGC/JAMSTEC, and then analyzed isotopes data will be submitted to JAMSTEC DIAG.

Table 7.15-1 Summary of water vapor sampling for isotope analysis

Sample	Date	Time (UT)	Date	Time (UT)	Lon	Lat	T.M. (m^3)	Sam. (ml)	H2O ppm
V-1	8.13	3:36	8.14	0:01	141-30.0E	40-33.3N	2.00	36.0	22400
V-2	8.14	20:35	8.15	12:01	144-15.1E	39-07.7N	1.34	26.5	24610
V-3	8.15	12:08	8.16	0:05	146-23.9E	38-04.7E	1.07	24.0	27913
V-4	8.16	0:08	8.16	12:48	145-52.9E	36-27.6N	1.12	26.2	29111
V-5	8.16	12:51	8.17	9:45	144-48.4E	33-12.8N	1.41	32.5	28684
V-6	8.17	9:52	8.18	0:07	143-53.6E	30-21.0N	1.27	28.2	27633
V-7	8.18	0:10	8.18	12:00	143-04.0E	27-38.3N	1.05	22.0	26074
V-8	8.18	12:02	8.19	0:15	142-18.0E	24-59.9N	1.08	23.4	26963
V-9	8.19	0:17	8.19	12:20	141-33.8E	22-42.5N	1.07	22.3	25936
V-10	8.19	12:22	8.20	0:34	140-40.5E	20-03.0N	1.08	22.8	26272
V-11	8.20	0:37	8.20	12:00	139-53.0E	17-38.6N	1.02	22.4	27329
V-12	8.20	12:03	8.21	0:02	139-53.0E	15-14.6N	1.07	22.6	26285
V-13	8.21	0:05	8.21	12:00	139-04.8E	12-50.7N	1.06	23.5	27589
V-14	8.21	12:04	8.22	00:02	137-31.7E	10-35.4N	1.07	23.5	27331
V-15	8.22	00:07	8.22	12:00	136-47.0E	8-31.0N	1.05	23.8	28207
V-16	8.22	12:04	8.23	00:44	136-28.6E	7-51.6N	1.14	23.0	25107
V-17	8.23	00:47	8.23	12:00	136-29.8E	7-51.8N	1.01	21.5	26491
V-18	8.23	12:03	8.24	0:54	136-30.5E	7-52.3N	1.15	25.0	27053
V-19	8.24	00:56	8.24	12:01	136-59.2E	5-55.2N	0.99	20.2	25392
V-20	8.24	12:04	8.25	0:47	137-14.4E	4-53.4N	1.14	23.0	25107
V-21	8.25	00:49	8.25	14:30	137-34.3E	4-34.3N	1.22	27.8	28357
V-22	8.25	14:31	8.26	0:03	137-21.8E	4-57.2N	0.85	17.6	25767
V-23	8.26	00:06	8.26	12:08	137-48.7E	3-17.9N	1.08	24.5	28230
V-24	8.26	12:10	8.27	0:18	138-07.3E	1-59.5N	1.06	22.2	26063

V-25	8.27	00:22	8.27	12:00	137-59.0E	02-44.3N	1.02	22.8	27817
V-26	8.27	12:02	8.28	0:11	138-03.2E	2-00.5N	1.08	22.2	25580
V-27	8.28	00:14	8.28	12:00	137-59.3E	0-43.7N	1.05	23.8	28207
V-28	8.28	12:02	8.29	9:47	137-58.3E	0-54.8S	1.14	23.5	25653
V-29	8.29	00:55	8.29	12:15	137-52.1E	0-03.0N	1.03	24.0	28997
V-30	8.29	12:17	8.30	0:09	138-01.8E	0-04.5N	1.07	22.2	25819
V-31	8.30	00:11	8.30	12:00	138-01.3E	1-22.3N	1.05	22.2	26311
V-32	8.30	12:03	8.31	0:39	136-17.6E	2-00.1N	1.13	22.0	24228
V-33	8.31	00:42	8.31	12:01	134-10.4E	2-00.1N	1.00	22.0	27378
V-34	8.31	12:09	9.1	0:09	132-00.2E	2-00.1N	1.07	20.0	23261
V-35	9.1	00:12	9.1	12:00	130-10.7E	01-58.9N	1.05	22.2	26311
V-36	9.1	12:02	9.2	0:18	129-26.4E	01-33.8N	1.10	21.8	24663
V-37	9.2	00:20	9.2	12:10	129-57.8E	01-57.1N	1.04	22.2	26564
V-38	9.2	12:13	9.3	0:03	130-11.8E	01-57.9N	1.06	22.5	26415
V-39	9.3	00:06	9.3	12:00	130-11.4E	01-57.9N	1.06	24.0	28176
V-40	9.3	12:02	9.4	0:09	130-11.7E	01-59.2N	0.88	22.8	32242
V-41	9.4	00:12	9.4	12:08	129-59.4E	03-15.5N	1.06	23.8	27941
V-42	9.4	12:10	9.5	0:02	130-00.1E	03-56.2N	1.06	20.3	23832
V-43	9.5	00:04	9.5	12:00	130-01.1E	05-03.3N	1.06	24.0	28176
V-44	9.5	12:02	9.6	0:01	130-06.7E	05-52.8N	1.07	22.0	25587
V-45	9.6	00:03	9.6	12:00	130-00.6E	07-20.4N	1.06	24.0	28176
V-46	9.6	12:02	9.7	0:14	130-03.8E	08-01.2N	1.09	22.2	25346
V-47	9.7	00:17	9.7	12:02	13-08.0E	07-50.7N	1.05	22.8	27022
V-48	9.7	12:05	9.8	0:45	130-04.5E	07-56.2N	1.14	24.0	26199
V-49	9.8	00:49	9.8	12:00	129-23.2E	07-00.19N	1.00	20.1	25013
V-50	9.8	12:02	9.9	0:03	128-34.6E	07-00.1E	1.08	21.6	24889
V-51	9.9	00:05	9.9	12:00	127-45.8E	06-59.4N	1.06	22.0	25828
V-52	9.9	12:02	9.10	0:03	127-47.5E	06-59.1N	1.07	20.3	23610
V-53	9.10	00:05	9.10	12:00	126-54.2E	06-59.9N	1.06	22.2	26063
V-54	9.10	12:05	9.11	0:00	126-55.0E	07-01.2N	1.07	21.2	24656
V-55	9.11	00:03	9.11	12:00	127-06.7E	07-21.9N	1.07	23.6	27448
V-56	9.11	12:03	9.12	0:04	128-16.6E	09-07.1N	1.07	22.0	25587
V-57	9.12	00:06	9.12	12:00	127-13.E	11-20.5N	1.07	22.3	25936
V-58	9.12	12:02	9.13	0:01	126-01.4E	13-49.9N	1.17	23.9	25421
V-59	9.13	01:04	9.13	13:00	124-55.0E	16-06.9N	1.07	24.2	28145
V-60	9.13	13:02	9.14	5:30	123-25.0E	19-09.2N	1.38	32.0	28857

Table 7.15-2 Summary of precipitation sampling for isotope analysis.

	Date	Time (UT)	Lon	Lat	Date	Time (UT)	Lon	Lat	Rain (mm)	R/S
R-1	8.13	07:00	141-14.4E	41-22.0N	8.16	02:26	146-24.0E	38-05.4N	4.6	R
R-2	8.16	02:26	146-24.0E	38-05.4N	8.16	22:57	145-25.1E	35-01.0N	1.6	R
R-3	8.16	22:57	145-25.1E	35-01.0N	8.17	21:30	144-04.9E	30-57.3N	2.9	R
R-4	8.17	21:30	144-04.9E	30-57.3N	8.19	20:30	140-58.4E	20-56.6N	1.6	R
R-5	8.19	20:30	140-58.4E	20-56.6N	8.21	22:35	137-40.0E	10-59.8N	10.0	R
R-6	8.21	22:35	137-40.0E	10-59.8N	8.23	00:50	136-27.5E	7-51.5N	6.7	R
R-7	8.23	00:50	136-27.5E	7-51.5N	8.24	00:19	136-31.5E	7-52.8N	2.5	R
R-8	8.24	00:19	136-31.5E	7-52.8N	8.25	22:48	137-21.1E	4-57.6N	16.5	R
R-9	8.25	22:48	137-21.1E	4-57.6N	8.27	02:56	138-08.7E	2-03.3N	3.1	R
R-10	8.27	02:56	138-08.7E	2-03.3N	8.27	21:35	138-01.5E	2-01.6N	10.6	R
R-11	8.27	21:35	138-01.5E	2-01.6N	8.28	08:40	137-59.7E	1-09.9N	20.1	R
R-12	8.28	08:40	137-59.7E	1-09.9N	8.29	05:56	137-59.3E	0-06.1S	7.7	R
R-13	8.29	05:56	137-59.3E	0-06.1S	8.30	05:37	138-03.8E	0-05.6N	17.0	R
R-14	8.30	05:37	138-03.8E	0-05.6N	8.31	01:41	138-02.5E	02:00.1N	3.4	R
R-15	8.31	01:41	138-02.5E	02:00.1N	9.07	00:13	130-03.8E	8-01.2N	2.4	R
R-16	9.07	00:13	130-03.8E	8-01.2N	9.08	07:00	129-56.2E	6-59.8N	0.2	R
R-17	9.08	07:00	129-56.2E	6-59.8N	9.08	21:49	129-00.1E	6-59.9N	7.6	R
R-18	9.08	21:49	129-00.1E	6-59.9N	9.10	07:56	126-59.7E	6-59.0N	2.0	R
R-19	9.10	07:56	126-59.7E	6-59.0N	9.13	22:31	124-02.5E	17-54.2N	8.0	R

Table 7.15-3 Summary of sea surface water sampling for isotope analysis

Sampling No.		Date	Time (UTC)	Position LON	Position LAT
MR11-06 O-	1	8.15	03:05	142-55.3E	39-46.3N
MR11-06 O-	2	8.16	03:12	146-22.0E	38-05.6N
MR11-06 O-	3	8.17	03:05	145-11.5E	34-13.4N
MR11-06 O-	4	8.18	03:05	143-41.3E	29-40.0N
MR11-06 O-	5	8.19	03:05	142-12.3E	24-41.0N
MR11-06 O-	6	8.20	03:03	140-20.7E	19-30.3N
MR11-06 O-	7	8.21	03:07	138-52.4E	14-36.8N
MR11-06 O-	8	8.22	03:05	137-19.4E	9-58.6N
MR11-06 O-	9	8.23	03:04	136-30.5E	7-51.5N
MR11-06 O-	10	8.24	03:04	136-30.2E	7-52.2N
MR11-06 O-	11	8.25	03:00	137-17.2E	4-47.2N
MR11-06 O-	12	8.26	03:01	137-22.6E	4-46.7N
MR11-06 O-	13	8.27	03:05	138-08.4E	2-05.4N
MR11-06 O-	14	8.28	04:28	138-03.8E	1-47.6N
MR11-06 O-	15	8.29	03:03	138-00.0E	0-29.9S

MR11-06 O-	16	8.30	03:02	138-00.8E	0-04.3S
MR11-06 O-	17	8.31	03:00	136-00.3E	2-00.1N
MR11-06 O-	18	9.1	03:02	131-31.3E	2-00.1N
MR11-06 O-	19	9.2	03:01	129-54.4E	1-05.1N
MR11-06 O-	20	9.3	03:01	130-09.1E	2-08.2N
MR11-06 O-	21	9.4	03:03	130-09.9E	2-03.3N
MR11-06 O-	22	9.5	03:05	129-59.9E	4-10.5N
MR11-06 O-	23	9.6	03:13	130-02.8E	6-08.1N
MR11-06 O-	24	9.7	03:05	130-05.1E	7-57.1N
MR11-06 O-	25	9.8	03:23	130-05.8E	7-49.4N
MR11-06 O-	26	9.9	03:04	128-09.9E	6-59.7N
MR11-06 O-	27	9.10	03:00	127-37.0E	7-00.0N
MR11-06 O-	28	9.11	03:02	126-37.1E	6-59.9N
MR11-06 O-	29	9.12	03:01	128-00.6E	9-40.9N
MR11-06 O-	30	9.13	04:02	125-44.8E	14-24.4N
MR11-06 O-	31	9.14	04:00	123-32.3E	18-55.3N

7.16 Tropospheric aerosol and gas observations by MAX-DOAS and auxiliary techniques

(1) Personnel

Hisahiro TAKASHIMA (PI, JAMSTEC/RIGC, not on board)
Fumikazu TAKETANI (JAMSTEC/RIGC, not on board)
Hitoshi IRIE (JAMSTEC/RIGC, not on board)
Yugo KANAYA (JAMSTEC/RIGC, not on board)

(2) Objectives

- To quantify typical background values of atmospheric aerosol and gas over the ocean
- To clarify transport processes from source over Asia to the ocean (and also clarify the gas emission from the ocean (including organic gas))
- To validate satellite measurements (as well as chemical transport model)

(3) Methods

(3-1) MAX-DOAS

Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) is a passive remote sensing technique designed for atmospheric aerosol and gas profile measurements using scattered visible and ultraviolet (UV) solar radiation at several elevation angles. Our MAX-DOAS instrument for R/V *Mirai* consists of two main parts: an outdoor telescope unit and an indoor spectrometer (Acton SP-2358 with Princeton Instruments PIXIS-400B). These two parts are connected by a 14-m bundle cable that consists of 12 cores with 100-mm radii. On the roof top of the anti-rolling system of R/V *Mirai*, the telescope unit was installed on a gimbal mount, which compensates for the pitch and roll of the ship. A sensor measuring pitch and roll of the telescope unit (10Hz) is used together to measure an offset of elevation angle due to incomplete compensation by the active-type gimbal. The line of sight was in directions of the starboard and portside of the vessel.

The MAX-DOAS system records spectra of scattered solar radiation every 0.2-0.4 second. Measurements were made at several elevation angles of 0, 1.5, 3, 5, 10, 20, 30, 70, 110, 150, 160, 170, 175, 177 and 178.5 degrees using a movable mirror, which repeated the same sequence of elevation angles every 30-min. The UV/visible spectra range was changed every minute (284-423 nm and 391-528 nm).

For the spectral analysis, spectra data were selected with a criterion for the elevation angle to be within ±0.2° of the target. For those spectra, DOAS spectral fitting was performed to quantify the slant column density (SCD), defined as the concentration integrated along the light path, for each elevation angle. In this analysis, SCDs of NO_2 (and other gases) and O_4 (O_2-O_2, collision complex of oxygen) were obtained together. Next, O_4 SCDs were converted to the aerosol optical depth (AOD) and the vertical profile of aerosol extinction coefficient (AEC) at a wavelength of 476 nm using an optimal estimation inversion method with a radiative transfer model. Using derived aerosol information, another inversion is performed to retrieve the tropospheric vertical column/profile of NO_2 and other gases.

(3-2) CO, O_3, and aerosol size distribution

Carbon monoxide (CO) and ozone (O_3) measurements were also continually conducted during the cruise. For CO and O_3 measurements, ambient air was continually sampled on the compass deck and drawn through ~20-m-long Teflon tubes connected to gas filter correlation CO analyzer (Model 48C, Thermo Fisher Scientific) and UV photometric based ozone analyzer (Model 49C, Thermo Fisher Scientific) in the *Research Information Center*. Aerosol size distribution measurements by optical particle counter (KR-12A, Rion) were not conducted due to instrument problems during the cruise.

(4) Preliminary results

These data for the whole cruise period will be analyzed.

(5) Data archives

The data will be submitted to the Marine-Earth Data and Information Department (MEDID) of JAMSTEC after the full analysis of the raw spectrum data is completed, which will be <2 years after the end of the cruise.