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R/V *MIRAI*
MR04-07 Cruise Report

17 November 2004 – 10 December 2004

－Study of biogeochemical cycles－

Chemical environment and its changes in the ocean

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

Contents

A. Cruise narrative

A-1. Introduction

The main purpose of this cruise is to evaluate the transport and alternation of seawater and the spacial change of the CO_2 aboundances and its related materials. We will measure the profiles of tempurature, salinity, dissolved oxygen, nutrients and other chemical propeties to detect the green house effect. In addition, the relation between the primary production and the formation of biogenic gases are available to achieve a better understanding of carbon cycles over this region and its related climate change. Then, primary productivity, optical properties and biologocal properties (phytoplankton, zooplankton and bacteria) will be measured also.

The other purposes of this cruise are as follows;

a. to observe surface meteorological and hydrological parameters as a basic dataset of the meteorology and oceanography.
b. to observe sea bottom topography, gravity and magnetic fields along the cruise track in order to understand the dynamics of ocean plate and the accompanying geophysical activities.
c. to obtain data on global distribution and optical characteristics of aerosols and clouds for climate change and for studying the feasibility of the satellite observations.
d. to observe aerosols and their chemical properties to understand the effect for phytoplankton.
e. to observe concentration of cloud droplets.
f. to deploy Argo floats for global ocean observation.

A-2. Cruise summary

A-2-1. Cruise name and code

Study of biogeochemical cycles－Chemical environment and its changes in the ocean
Vessel: R/V MIRAI
Cruise code: MR04-07

A-2-2. Period, ports of call and chief scientist

Period

17 November 2004 – 10 December 2004 (Sekinehama – Chuuk)

Ports of call

1) Sekinehama, Japan (17 Nov. 2004)
2) Hachinohe, Japan (18 Nov. 2004)
3) Chuuk, Federated States of Micronesia (10 Dec. 2004)

Chief scientist

Shuichi Watanabe
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Mutsu Institute for Oceanography (MIO)
690 Kitasekine, Sekine, Mutsu, Aomori 035-0022, Japan

A-2-3. Cruise log

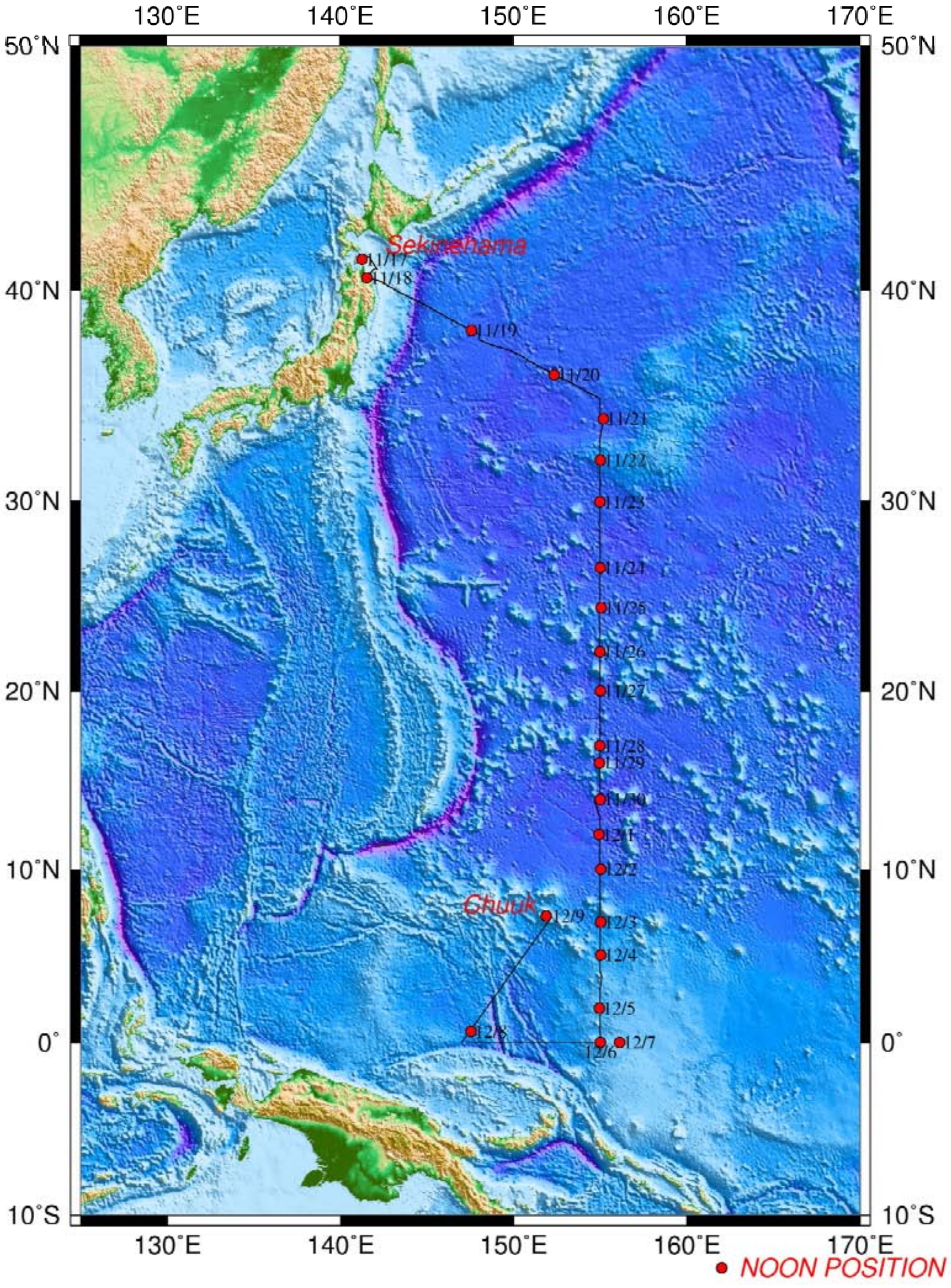
Start Time	Date	Start Time	Station	Position(Start)		Events
(U.T.C.)		(L.S.T.)		Lat.	Lon.	
	2004/11/17	15:10				Departure from Sekinehama
	2004/11/18	8:30				Arrival at Hachinohe
	2004/11/18	15:10				Departure from Hachinohe
13:06	2004/11/20	23:06	1	35-00.19N	154-59.99E	Arrival at Stn.1
		23:53	1	35-00.19N	154-59.99E	CTD(Deep Cast)
	2004/11/21	0:00	1	35-00.52N	154-59-94E	Sea Surface Sampling
	2004/11/21	0:05	1	35-00.54N	154-59.93E	Plankton Net
23:06	2004/11/21	9:06	2	34-00.20N	155-00.40E	Arrival at Stn.2
		9:48	2	34-00.68N	115-02.40E	CTD with Niskin by Rosette(Shallow Cast 1)
		9:50	2	34-00.72N	155-02.60E	OPC observation
		10:40	2	34-01.30N	155-05.71E	Optical Freefall
		11:15	2	34-02.47N	155-07.30E	CTD with Niskin by Rosette(Shallow Cast 2)
		11:17	2	34-02.49N	155-07.41E	Sea Surface Sampling
		11:18	2	34-02.50N	155-07.50E	Plankton Net
		11:54	2	34-03.17N	155-09.73E	In-situ High Volume Filtration
		17:46	2	33-59.91N	155-00.31E	CTD with Niskin by Rosette(Deep Cast)
16:30	2004/11/22	2:30	3	32-59.96N	154-59.91E	Arrival at Stn.3
		2:32	3	32-59.96N	154-59.91E	CTD with Niskin by Rosette(Deep Cast)
		2:40	3	32-59.77N	154-59.79E	Sea Surface Sampling
		2:44	3	32-59.75N	154-59.78E	Plankton Net
22:04	2004/11/22	8:04	4	32-41.22N	154-59.82E	Arrival at Stn.4
		8:04	4	32-41.22N	154-59.82E	Tethered Ballon Observatuon(1000m)
		12:54	4	32-00.07N	154-59.95E	CTD with Niskin by Rosette(Deep Cast)
		13:00	4	32-00.09N	154-59.91E	OPC observation
		13:02	4	32-00.09N	154-59.93E	Sea Surface Sampling
		13:02	4	32-00.09N	154-59.93E	Plankton Net
		14:56	4	32-00.07N	154-59.81E	Plankton Net
10:24	2004/11/22	20:24	5	31-00.00N	155-00.22E	Arrival at Stn.5
		20:29	5	31-00.01N	155-00.20E	CTD with Niskin by Rosette(Deep Cast)
		20:35	5	31-00.00N	155-00.22E	Sea Surface Sampling
		20:36	5	30-59.98N	155-00.24E	Plankton Net
18:42	2004/11/23	4:42	6	30-00.01N	154-59.92E	Arrival at Stn.6
		4:44	6	30-00.01N	154-59.92E	CTD with Niskin by Rosette(Deep Cast)
		9:36	6	29-59.35N	154-59.52E	OPC observation
		10:09	6	29-59.20N	154-59.71E	Optical Freefall
		11:15	6	29-59.02N	154-59.27E	CTD with Niskin by Rosette(Shallow Cast 2)
		11:17	6	29-59.01N	154-59.25E	Sea Surface Sampling
		11:20	6	29-59.00N	154-59.23E	Plankton Net
		13:07	6	29-42.07N	154.59-75E	Tethered Ballon Observatuon(1000m)
6:36	2004/11/23	16:36	7	29-00.01N	154-59.88E	Arrival at Stn.7
		16:36	7	29-00.01N	154-59.88E	CTD with Niskin by Rosette(Deep Cast)
		16:43	7	29-00.01N	154-59.69E	Sea Surface Sampling
17:01	2004/11/24	3:01	8	27-30.11N	154-59.98E	Arrival at Stn.8
		3:04	8	27-30.11N	154-59.98E	CTD with Niskin by Rosette(Deep Cast)
		3:10	8	27-30.13N	154-59.86E	Sea Surface Sampling
		3:10	8	27-30.13N	154-59.86E	Plankton Net
		6:14	8	27-30.74N	154-59.79E	OPC observation
4:27	2004/11/24	14:27	9	26-00.08N	154-59.91E	Arrival at Stn.9
		14:29	9	26-00.08N	154-59.91E	CTD with Niskin by Rosette(Deep Cast)
		14:36	9	26-00.19N	154-59.75E	Sea Surface Sampling
		14:36	9	26-00.19N	154-59.75E	Plankton Net
20:05	2004/11/25	6:05	10	24-29.95N	155-00.13E	Arrival at Stn.10
		9:40	10	24-29.42N	155-01.93E	CTD with Niskin by Rosette(Shallow Cast 1)
		10:24	10	24-29.48N	155-02.32E	Optical Freefall
		11:00	10	24-29.39N	155-02.90E	CTD with Niskin by Rosette(Shallow Cast 2)
		11:01	10	24-29.42N	155-02.92E	Sea Surface Sampling
		11:01	10	24-29.42N	155-02.92E	Plankton Net
		11:02	10	24-29.42N	155-02.95E	OPC observation

Start Time	Date	Start Time	Station	Position(Start)		Events
(U.T.C.)		(L.S.T.)		Lat.	Lon.	
		13:00	10	24-30.76N	154-56.71E	In-situ High Valume Filtration
		17:32	10	24-29.94N	154-59.76E	CTD with Niskin by Rosette(Deep Cast)
		21:45	10	24-29.25 N	154-58.15 E	ARGO Float
17:35	2004/11/26	3:35	11	22-59.98N	154-59.97E	Arrival at Stn.11
		3:37	11	22-59.98N	154-59.97E	CTD with Niskin by Rosette(Deep Cast)
		3:43	11	22-59.96N	154-59.87E	Sea Surface Sampling
		3:43	11	22-59.96N	154-59.87E	Plankton Net
		8:26	11	22.59.91N	154-58.12E	OPC observation
4:43	2004/11/26	14:43	12	21-29.97N	155-00.11E	Arrival at Stn.12
		14:45	12	21-29.97N	155-00.11E	CTD with Niskin by Rosette(Deep Cast)
		14:52	12	21-30.05N	155-00.02E	Sea Surface Sampling
		14:52	12	21-30.05N	155-00.02E	Plankton Net
20:00	2004/11/27	6:00	13	20-00.01N	155-00.09E	Arrival at Stn.13
		6:02	13	20-00.04N	155-00.09E	CTD with Niskin by Rosette(Deep Cast)
		10:53	13	20-01.68N	155-00.32E	Optical Freefall
		11:14	13	20-01.78N	155-01.00E	OPC observation
		12:30	13	19.59.92N	155-00.03E	CTD with Niskin by Rosette(Shallow Cast 2)
		12:30	13	19.59.92N	155-00.03E	Sea Surface Sampling
		12:30	13	19.59.92N	155-00.03E	Plankton Net
7:30	2004/11/27	17:30	14	19-00.07N	154-59.86E	Arrival at Stn.14
		17:32	14	19-00.07N	154-59.86E	CTD with Niskin by Rosette(Deep Cast)
		17:39	14	19-00.12N	154-59.68E	Sea Surface Sampling
		17:49	14	19-00-17N	154-59.61E	Plankton Net
15:59	2004/11/28	1:59	15	17-59.96N	154-59.78E	Arrival at Stn.15
		2:01	15	17-59.96N	154-59.78E	CTD with Niskin by Rosette(Deep Cast)
		2:07	15	18-00.03N	154-59.71E	Sea Surface Sampling
		2:23	15	18-00.11N	154-59.65E	Plankton Net
0:54	2004/11/28	10:54	16	17-00.02N	154-59.97E	Arrival at Stn.16
		15:54	16	16-59.99N	154-59.97E	OPC observation
		17:59	16	17-00.05N	154-59.87E	CTD with Niskin by Rosette(Deep Cast)
		18:05	16	17-00.13N	154-59.83E	Sea Surface Sampling
		18:05	16	17-00.13N	154-59.83E	Plankton Net
		22:04	16	17-01.77N	154-59.31E	ARGO Float
20:27	2004/11/29	6:27	17	15-59.76N	154-59.95E	Arrival at Stn.17
		6:29	17	15-59.76N	154-59.95E	CTD with Niskin by Rosette(Deep Cast)
		10:29	17	16-01.35N	154-59.60E	Optical Freefall
		11:11	17	16-01.72N	154-58.76E	OPC observation
		13:02	17	16-00.06N	154-59.98E	CTD with Niskin by Rosette(Shallow Cast 2)
		13:02	17	16-00.06N	154-59.98E	Sea Surface Sampling
		13:02	17	16-00.06N	154-59.98E	Plankton Net
8:05	2004/11/29	18:05	18	15-00.07N	154-59.97E	Arrival at Stn.18
		18:07	18	15-00.07N	154.59.97E	CTD with Niskin by Rosette(Deep Cast)
		18:12	18	15-00.13N	154-59.91E	Sea Surface Sampling
		18:12	18	15-00.13N	154-59.91E	Plankton Net
16:15	2004/11/30	2:15	19	13-59.98N	154-59.95E	Arrival at Stn.19
		2:18	19	13-59.98N	154-59.95E	CTD with Niskin by Rosette(Deep Cast)
		2:24	19	14-00.02N	154-59.88E	Sea Surface Sampling
		2:24	19	14-00.02N	154-59.88E	Plankton Net
		7:57	19	13-59.38N	154-59.57E	In-situ High Valume Filtration
		14:22	19	13-59.98N	155-00.15E	CTD with Niskin by Rosette(Shallow Cast 1)
		14.25	19	14-00.01N	155-00.12E	Sea Surface Sampling
		14:52	19	14-00.30N	154-59.71E	ARGO Float
		15:02	19	14-00.14N	154-58.68E	Tethered Ballon Observatuon(1000m)
		16:44	19	13-57.49N	154-41.43E	OPC observation
11:18	2004/11/30	21:18	20	13-00.50N	154-59.97E	Arrival at Stn.20
		21:24	20	13-00.05N	154-59.97E	CTD with Niskin by Rosette(Deep Cast)
		21:30	20	13-00.08N	154-59.83E	Sea Surface Sampling
		21:30	20	13-00.08N	154-59.83E	Plankton Net
19:45	2004/12/1	5:45	21	12-00.00N	154-59.96E	Arrival at Stn.21
		5:47	21	12-00.00N	154-59.96E	CTD with Niskin by Rosette(Deep Cast)
		10:12	21	12-01.31N	154-58.75E	Optical Freefall

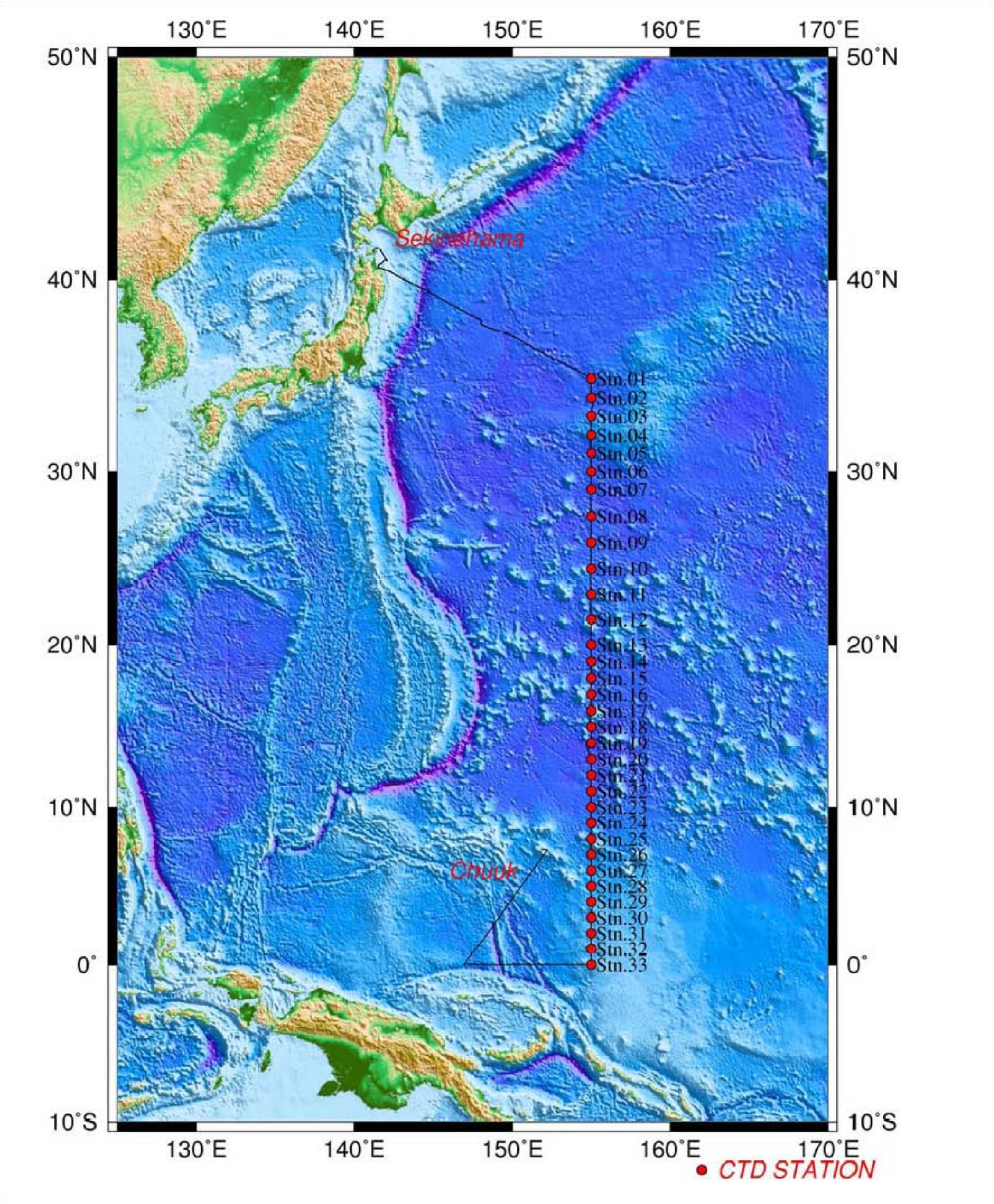
Start Time	Date	Start Time	Station	Position(Start)		Events
(U.T.C.)		(L.S.T.)		Lat.	Lon.	
		10:53	21	12-01.35N	154-58.42E	OPC observation
		13:01	21	12-00.07N	154-59.82E	CTD with Niskin by Rosette(Shallow Cast 2)
		13:01	21	12-00.07N	154-59.82E	Sea Surface Sampling
		13:01	21	12-00.07N	154-59.82E	Plankton Net
7:39	2004/12/1	17:39	22	11-00.01N	155-00.12E	Arrival at Stn.22
		17:41	22	11-00.01N	155-00.12E	CTD with Niskin by Rosette(Deep Cast)
		17:46	22	11-00.02N	155-00.03E	Sea Surface Sampling
		17:46	22	11-00.02N	155-00.03E	Plankton Net
		21:46	22	11-01.22N	154-58.58E	ARGO Float
16:11	2004/12/2	2:11	23	10-00.03N	154-59.93E	Arrival at Stn.23
		2:13	23	10-00.03N	154-59.93E	CTD with Niskin by Rosette(Deep Cast)
		2:19	23	10-00.06N	154-59.85E	Sea Surface Sampling
		2:19	23	10-00.06N	154-59.85E	Plankton Net
		6:23	23	10-00.12N	154-59.84E	In-situ High Valume Filtration
		13:01	23	10-00.12N	154-59.96E	CTD with Niskin by Rosette(Shallow Cast 1)
		13:57	23	10-01.24N	154-59.13E	OPC observation
8:34	2004/12/2	18:34	24	9-00.00N	155-00.07E	Arrival at Stn.24
		18:37	24	9-00.00N	155-00.07E	CTD with Niskin by Rosette(Deep Cast)
		18:42	24	9-00.10N	155-00.07E	Sea Surface Sampling
		18:42	24	9-00.10N	155-00.07E	Plankton Net
16:48	2004/12/3	2:48	25	8-00.00N	155-00.12E	Arrival at Stn.25
		2:50	25	8-00.00N	155-00.12E	CTD with Niskin by Rosette(Deep Cast)
		2:55	25	8-00.03N	155-00.17E	Sea Surface Sampling
		2:55	25	8-00.03N	155-00.17E	Plankton Net
		5:52	25	8-01.25N	155-00.78E	ARGO Float
0:12	2004/12/3	10:12	26	7-00.00N	155-00.14E	Arrival at Stn.26
		10:14	26	7-00.00N	155-00.14E	Optical Freefall
		10:30	26	6-59.88N	155-00.39E	Sea Surface Sampling
		10:30	26	6-59.88N	155-00.39E	Plankton Net
		10:32	26	6-59.86N	155-00.31E	CTD with Niskin by Rosette(Shallow Cast 2)
		11:37	26	7-00.40N	155-01.36E	OPC observation
		13:17	26	6-45.53N	155-02.72E	Tethered Ballon Observatuon(1000m)
		15:28	26	7-00.18N	155-00.23E	CTD with Niskin by Rosette(Deep Cast)
12:54	2004/12/3	22:54	27	5-59.99N	155-00.16E	Arrival at Stn.27
		23:00	27	5-59.99N	155-00.16E	CTD with Niskin by Rosette(Deep Cast)
		23:08	27	5-59.99N	155-00.27E	Sea Surface Sampling
		23:08	27	5-59.99N	155-00.27E	Plankton Net
20:08	2004/12/4	6:08	28	5-05.04N	155-10.09E	Arrival at Stn.28
		6:11	28	5-05.04N	155-10.09E	CTD with Niskin by Rosette(Deep Cast)
		6:18	28	5-05.07N	155-00.19E	Sea Surface Sampling
		6:18	28	5-05.07N	155-00.19E	Plankton Net
		9:25	28	5-05.38N	155-00.70E	OPC observation
		9:41	28	5-05.43N	155-00.68E	In-situ High Valume Filtration
		15:35	28	5-05.00N	155-00.01E	CTD with Niskin by Rosette(Shallow Cast 1)
10:00	2004/12/4	20:00	29	4-05.02N	154-59.94E	Arrival at Stn.29
		20:05	29	4-05.02N	154-59.94E	CTD with Niskin by Rosette(Deep Cast)
		20:10	29	4-04.98N	154-59.98E	Sea Surface Sampling
		20:10	29	4-04.98N	154-59.98E	Plankton Net
17:12	2004/12/5	3:12	30	2-59.96N	154-59.97E	Arrival at Stn.30
		3:14	30	2-59.96N	154-59.97E	CTD with Niskin by Rosette(Deep Cast)
		3:19	30	2-59.95N	154-59.99E	Sea Surface Sampling
		3:19	30	2-59.95N	154-59.99E	Plankton Net
		5:35	30	2-59.56N	154-59.97E	ARGO Float
23:36	2004/12/5	9:36	31	1-59.85N	154-59.82E	Arrival at Stn.31
		10:03	31	2-00.02N	154-59.75E	OPC observation
		10:15	31	1-59.98N	154-59.86E	Optical Freefall
		10:32	31	2-00.21N	154-59.73E	CTD with Niskin by Rosette(Shallow Cast 2)
		10:33	31	2-00.20N	154-59.72E	Sea Surface Sampling
		10:33	31	2-00.20N	154-59.72E	Plankton Net
		13:03	31	2-00.07N	154-59.99E	CTD with Niskin by Rosette(Deep Cast)
9:29	2004/12/5	19:29	32	00-59.96N	155-00.06E	Arrival at Stn.32

Start Time	Date	Start Time	Station	Position(Start)		Events
(U.T.C.)		(L.S.T.)		Lat.	Lon.	
		19:31	32	00-59.96N	155-00.06E	CTD with Niskin by Rosette(Deep Cast)
		19:36	32	00-59.93N	155-00.10E	Sea Surface Sampling
		19:36	32	00-59.93N	155-00.10E	Plankton Net
17:27	2004/12/6	3:27	33	00-00.00N	155-00.02E	Arrival at Stn.33
		3:29	33	00-00.00N	155-00.02E	CTD with Niskin by Rosette(Deep Cast)
		6:24	33	00-00.12S	155-00.33E	In-situ High Valume Filtration
		11:23	33	00-00.02S	155-00.11E	CTD with Niskin by Rosette(Shallow Cast 1)
		13:01	33	00-00.04N	155-00.07E	Optical Freefall 1st
		13:03	33	00-00.06N	155.00.04E	Optical Freefall 2nd
		13:18	33	00-00.12N	155-00.03E	CTD with Niskin by Rosette(Shallow Cast 2)
		13:19	33	00-00.11N	155-00.06E	Sea Surface Sampling
		13:19	33	00-00.11N	155-00.06E	Plankton Net
		14:15	33	00-00.14S	155-00.40E	OPC observation
	2004/12/8	8:05		00-00.29S	147-02.26E	Repaire for TRITON
	2004/12/10	9:20				Arrival at Chuuk

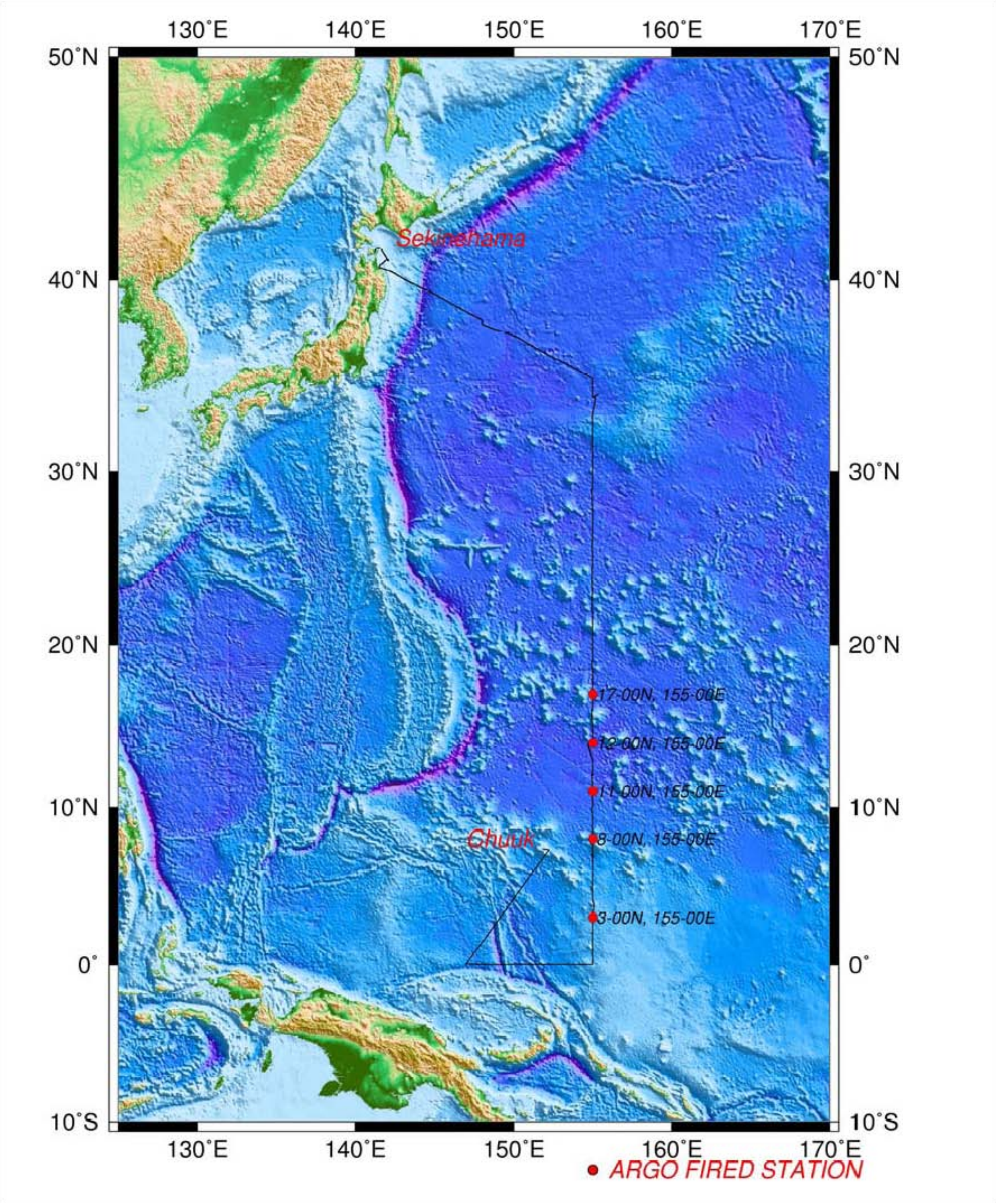
A-2-4. Cruise Track



A-2-4-1. Noon Position



A-2-4-2. CTD cast station



A-2-4-3. Argofloot fired station

A-2-5. List of participants

A-2-5-1. R/V MIRAI Scientists & Technicians

No.	Name	Affiliation
1	Shuichi WATANABE	JAMSTEC
2	Kazuhiko MATSUMOTO	JAMSTEC
3	Masahide WAKITA	JAMSTEC
4	Kazuhiko MIURA	Tokyo University of Science
5	Taichi SATO	Tokyo University of Science
6	Koichi YOSHIDA	Tokyo University of Science
7	Hiroki YUASA	Tokyo University of Science
8	Satoshi KITAJIMA	University of Tokyo
9	Kanako SUGAI	University of Tokyo
10	Takahiro NAKANISHI	National Institute of Radiological Sciences

No.	Name	Affiliation
11	Akifumi SHIMAMOTO	Kansai Environmental Engineering Center Co., LTD
12	Yuichi SAKUMA	Kansai Environmental Engineering Center Co., LTD
13	Kenichi FUTABA	Chiba University
14	Kenichiro SATO	Marine Works Japan Ltd. (MWJ)
15	Fujio KOBAYASHI	MWJ
16	Hiroshi MATSUNAGA	MWJ
17	Kenichi KATAYAMA	MWJ
18	Tomoyuki TAKAMORI	MWJ
19	Fuma MATSUNAGA	MWJ
20	Hideki YAMAMOTO	MWJ
21	Fuyuki SHIBATA	MWJ

No.	Name	Affiliation
22	Katsunori SAGISHIMA	MWJ
23	Mikio KITADA	MWJ
24	Ai YASUDA	MWJ
25	Taeko OHAMA	MWJ
26	Minoru KAMATA	MWJ
27	Takayoshi SEIKE	MWJ
28	Yuichi SONOYAMA	MWJ
29	Junko HAMANAKA	MWJ
30	Takuhei SHIOZAKI	MWJ
31	Masanori ENOKI	MWJ
32	Kimiko NISHIJIMA	MWJ

No.	Name	Affiliation
33	Ayumi TAKEUCHI	MWJ
34	Ayako YAMAMOTO	MWJ
35	Maiko KOMURE	MWJ
36	Ryo OYAMA	Global Ocean Development Inc. (GODI)
37	Norio NAGAHAMA	GODI
38	Ryo KIMURA	GODI

A-2-5-2. R/V MIRAI Crew members

No.	Name	Rank
1	Masaharu AKAMINE	Master
2	Yujiro KITA	Chief Officer
3	Haruhiko INOUE	1st Officer
4	Takeshi ISOHI	2nd Officer
5	Takeyuki FUKAZAWA	3rd Officer
6	Tokuro KOBAYASHI	Jr.1st Officer
7	Nobuo FUKAURA	Jr.3rd Officer
8	Koichi HIGASHI	Chief Engineer
9	Toshiyuki IGATA	1st Engineer
10	Koji MASUNO	2nd Engineer
11	Takashi OMICHI	3rd Engineer
12	Keiichirou SHISHIDO	C.R.Officer
13	Naoto MORIOKA	2nd.R.Officer
14	Kenetsu ISHIKAWA	Boatswain
15	Yasuyuki YAMAMOTO	Able Seaman
16	Kenichi TORAO	Able Seaman
17	Keiji YAMAUCHI	Able Seaman
18	Kunihiko OMOTE	Able Seaman
19	Yukiharu SUZUKI	Able Seaman
20	Masaru SUZUKI	Able Seaman
21	Kazuyoshi KUDO	Able Seaman
22	Tsuyoshi SATO	Able Seaman
23	Takeharu AISAKA	Able Seaman
24	Shuji KOMATA	Able Seaman
25	Sadanori HONDA	No.1 Oiler
26	Yukitoshi HORIUCHI	Oiler
27	Toshimi YOSHIKAWA	Oiler
28	Takashi MIYAZAKI	Oiler
29	Toshio MATSUO	Oiler
30	Nobuo BOSHITA	Oiler
31	Daisuke TANIGUCHI	Oiler
32	Yasutaka KURITA	Chief Steward
33	Hatsuji HIRAISHI	Cook
34	Kitoshi SUGIMOTO	Cook
35	Ryoji TAKESAKO	Cook
36	Motohisa SAKAI	Cook
37	Kozo UEMURA	Cook
38	Hiroyuki YOSHIZAWA	Cook

B. Meteorology and atmospheric observation

B-1. Meteorological Observation

B-1-1. Surface Meteorological Observation

Norio Nagahama (Global Ocean Development Inc.)
Ryo Kimura (GODI)
Ryo Oyama (GODI)
Kunio Yoneyama (JAMSTEC) Principal Investigator / Not on-board:

Objectives

The 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.

Methods

The surface meteorological parameters were observed throughout the MR04-07 cruise from the departure of Sekinehama on 17 November 2004 to arrival of Chuuk on 10 Desember 2004. At this cruise, we used two systems for the surface meteorological 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 B-1-1-1 and measured parameters are listed in Table B-1-1-2. Data was collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set has 6-second averaged.

2) Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

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

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

SCS recorded PRP data every 6 seconds, Zeno/Met data every 10 seconds. Instruments and their locations are listed in TableB-1-1-3 and measured parameters are listed in Table B-1-1-4.

We have carried out inspecting and comparing about following three sensors, before and after the cruise.

a) Young Rain gauge (SMet and SOAR)
    Inspecting the linearity of output value from the rain gauge sensor to change input value by adding fixed quantity of test water.
b) Barometer (SMet and SOAR)
    Comparing with the portable barometer value, PTB220CASE, VAISALA.
c) Thermometer (air temperature and relative humidity) (SMet and SOAR)
    Comparing with the portable thermometer value, HMP41/45, VAISALA.

Preliminary results

Figures B-1-1-1 show the time series of the following parameters; Wind (SOAR), air temperature (SOAR), relative humidity (SOAR), precipitation (SOAR), short/long wave radiation (SOAR), pressure (SOAR), sea surface temperature (SMet) and significant wave height (SMet).

Data archives

The raw data obtained during this cruise will be submitted to JAMSTEC Data Management Division. Corrected data sets will also be available from K. Yoneyama of JAMSTEC.

Remarks

PRP data was stopped during the period below, due to the sensor maintenance.
Nov 22 2004 23:52UTC - Nov 23 2004 00:16UTC

We used the calibraiton coefficents of the another PIR to calculate long wave radiation.
After next calibration, we will recalculate later.

Table B.1-1 Instruments and installations of MIRAI Surface Meteorological 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	F-451	Yokogawa, Japan	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 B.1-2 Parameters of MIRAI Surface Meteorological observation system

	Parmeter	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/m^2	6sec. averaged
20	Down welling infra-red radiation	W/m^2	6sec. averaged
21	Significant wave height (bow)	m	hourly
22	Significant wave height (aft)	m	hourly
23	Significant wave period (bow)	second	hourly
24	Significant wave period (aft)	second	hourly

Table B.1-3 Instrument 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 (24 m)
Barometer	61201	R.M. Young, USA	
with 61002 Gill pressure port		R.M. Young, USA	foremast (24 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(FRSR)		Yankee, USA	foremast (25 m)

Table B.1-4 Parameters of SOAR system

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

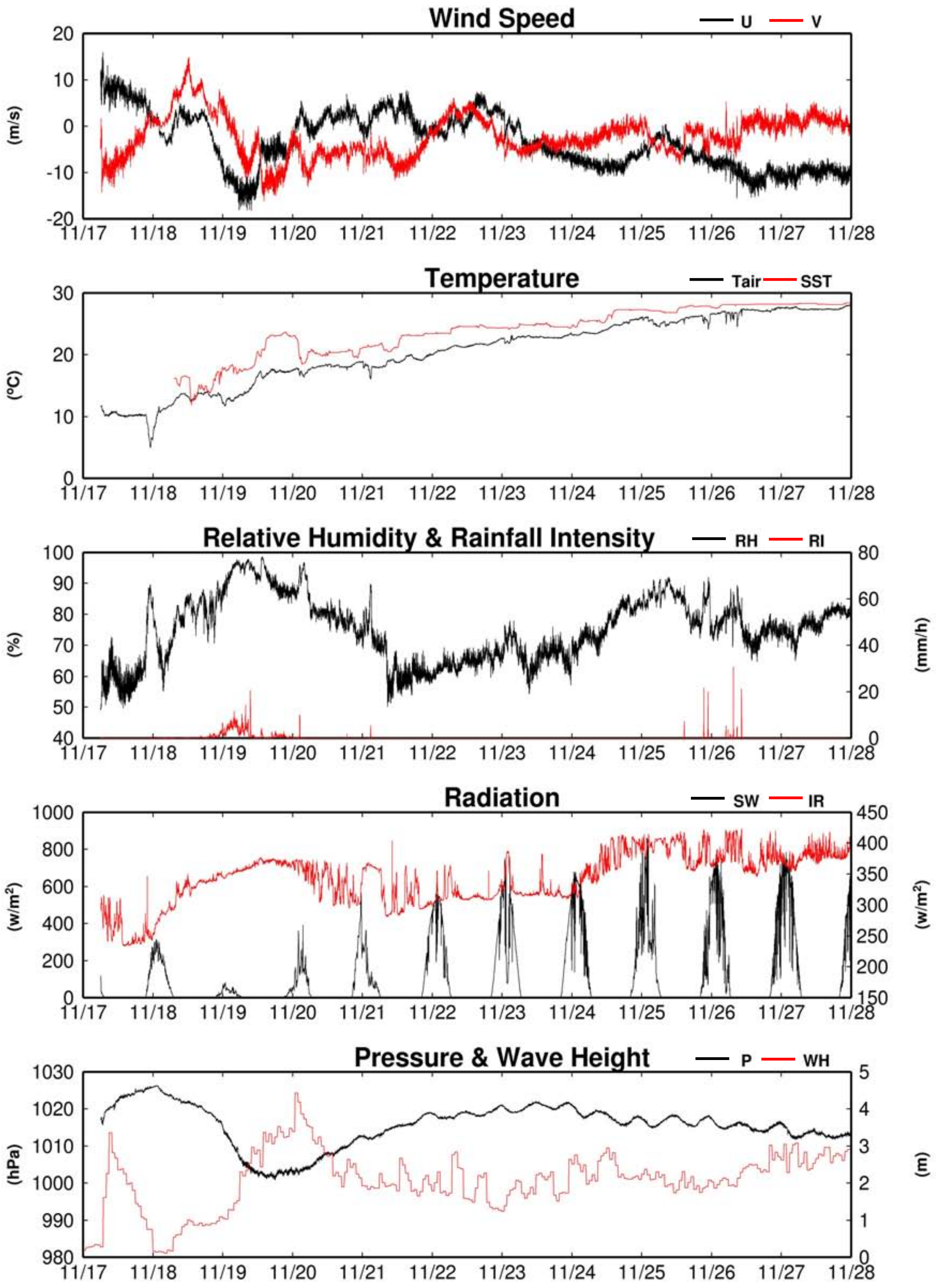


Fig.B.1-1 Time series of surface meteorological parameters during the cruise

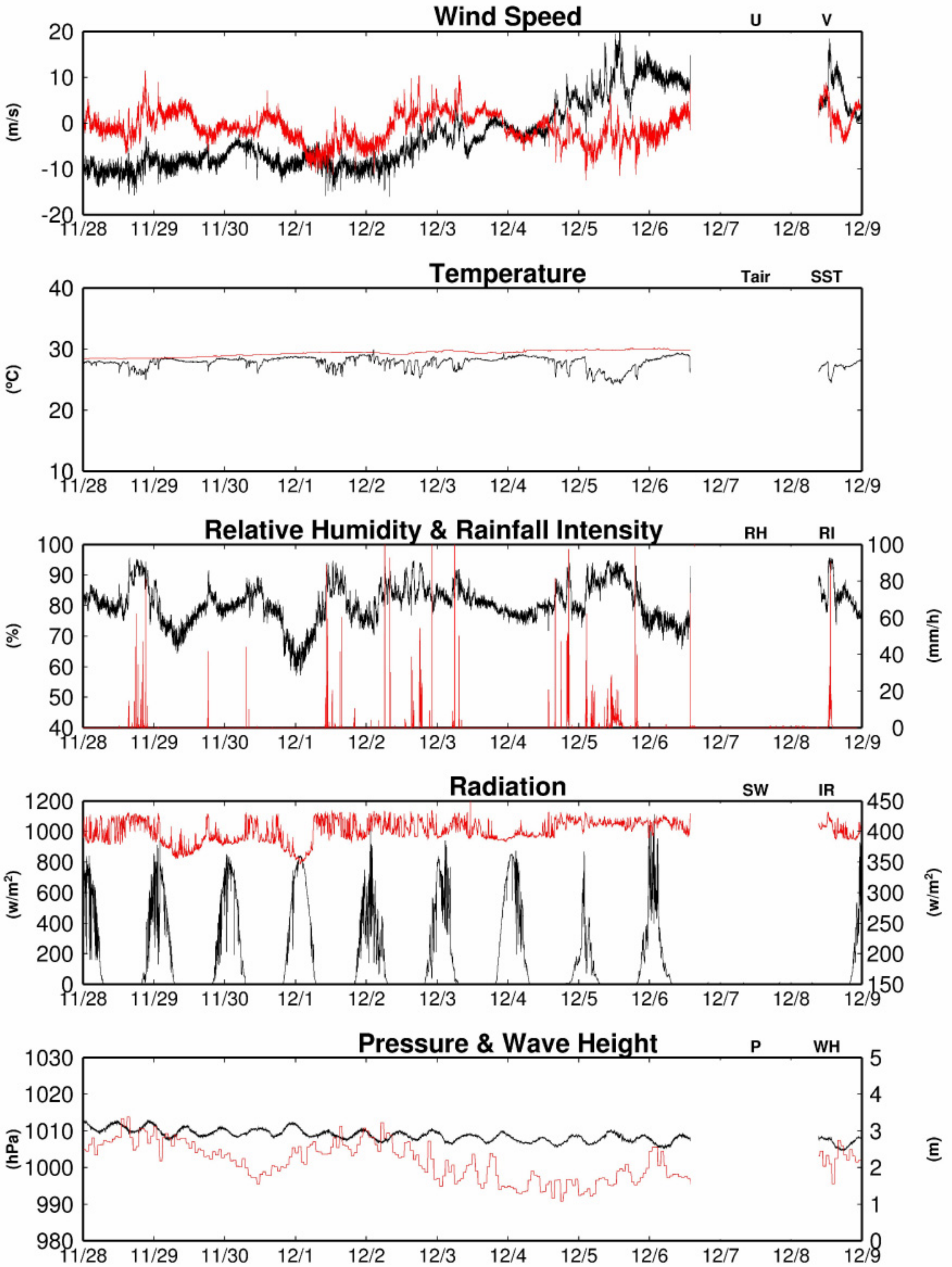


Fig.B.1-1 Continue

B-1-2. Ceilometer Observation

Norio Nagahama (Global Ocean Development Inc.)
Ryo Kimura (GODI)
Ryo Ohyama (GODI)
Not on-board:
Kunio Yoneyama (JAMSTEC) Principal Investigator

(1) 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.

(2) 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.

(3) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR04-07 cruise from the departure of Sekinehama on 17 November 2004 to arrival of Chuuk on 10 December 2004.

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).

(4) Preliminary results

The figure B-1-2-1 shows the time series of the first, second and third lowest cloud base height.

(5) Data archives

The raw data obtained during this cruise will be submitted to JAMSTEC Data Management Division.

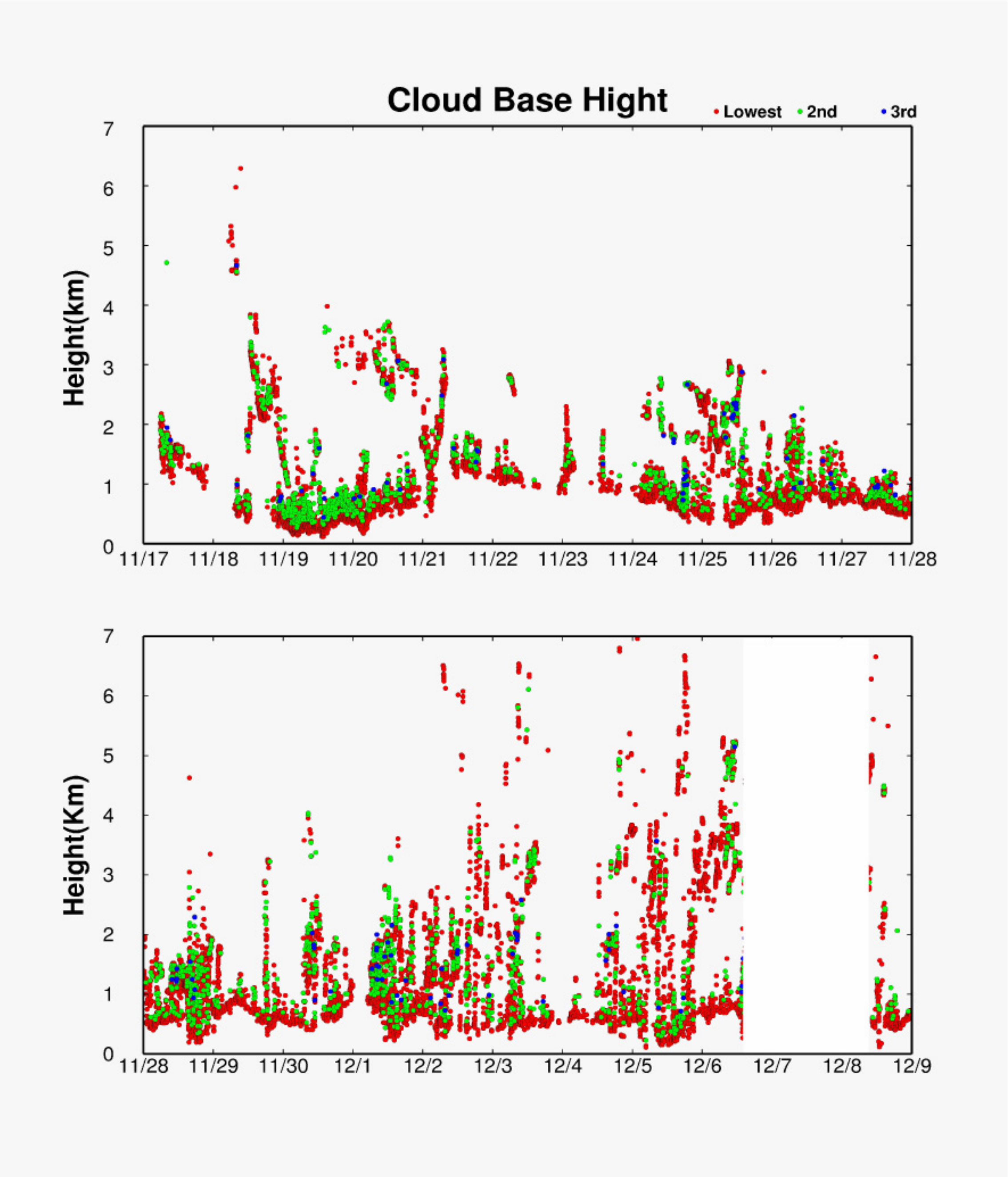


Figure B-1-2-1 1st, 2nd and 3rd lowest cloud base height during the cruise.

B-1-3. Surface atmospheric turbulent flux measurement

(1) Personnel

On-shore scientists
Osamu Tsukamoto (Okayama University)
Hiroshi Ishida (Kobe University)

(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) Methods

The surface turbulent flux measurement system consists of turbulence instruments (Kaijo Co., Ltd.) and ship motion sensors (Kanto Aircraft Instrument Co., Ltd.). Details of each sensor are as follows. All sensors are equipped at 25 m height from sea surface.

Sensor	Type / Manufacturer
Three-dimensional sonic anemometer-thermometer	Kaijo, DA-600
Infrared hygrometer	LICOR, LI-7500
Two-axis inclinometer	Applied Geomechanics, MD-900-T
Three-axis accelerometer	Applied Signal Inc., QA-700-020
Three-axis rate gyro	Systron Donner, QRS-0050-100

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.

(4) Calibration

All sensors were calibrated at the manufacturer (Kaijo Co. Ltd.,) in April 2003.

After the cruise, these data will be compared with surface meteorological data obtained by another system (SOAR) to exclude unreliable data.

(5) Preliminary results

Data will be processed after the cruise at Okayama University

(6) Data Archive

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 Data Management Division.

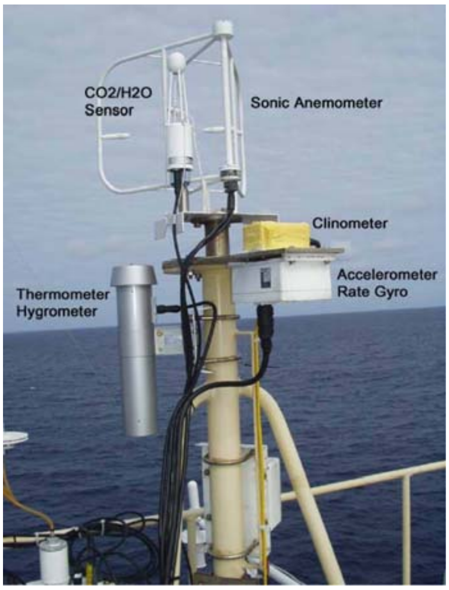


Fig.B.1.3 Turbulent flux measurement system on the top deck of the foremast

B-2 Physical properties of atmospheric aerosols

Personnels

Kazuhiko Miura , Taichi Sato, Hiroki Yuasa, Kouichi Yoshida
(Department of Physics, Science University of Tokyo)

Objectives

In order to know the effect of aerosols on climate change, it is necessary to investigate the physical properties of marine aerosols, that is, concentration, size distribution, horizontal distribution, vertical distribution, thermodynamic property, optical property, and so on.

Main purposes of our observation are as follows:

(a) Measuring the entire size distribution with three instruments
(b) Obtaining the residence time of aerosols with radon and thoron measurements
(c) Investigation of the mixing condition of individual particles with TEM/EDX analysis
(d) Measuring the thermodynamic properties as a function of relative humidity
(e) Estimation of refractive index by simultaneous observation with kytoon and lidar
(f) Estimation of generation flux of sea salt particles from the vertical profile near the surface measured along the foremast or with multi-joint crane

Measured parameters

- size distribution
  - scanning mobility particle sizer : 3936N25 (3085 + 3025A), TSI Inc. (44<d<168nm)
  - optical particle counters (OPCs) : KC18 and KC01, Rion Co. Ltd.
    (d>100, 150, 200, 250, 300, 500, 1000, 2000, 5000 nm)
- total concentration of particles
  - condensation nuclei counter (CNC) : 3022A, TSI Inc.
- radon daughter concentration
  - radon daughter monitor : ES-7269, JREC Co. Ltd.
- particle concentration profile with kytoon system
  - kytoon : 10 m^3 in volume
  - CNC : 3087, TSI Inc.
  - OPC (d>300, 500, 700, 1000, 2000, 5000 nm) : KR12, Rion Co. Ltd.
- shape and elemental composition of aerosols
  - sampling : cascade impactor : Model I-1L, PIXE Int. Corp.
    carbon-covered nitrocellulose film supported on an electron microscopic grid
  - analysis : an energy dispersive X-ray spectrometer : Kevex Sigma

Methods

The size distributions from 4.4 nm to 5000 nm in diameter were measured with two systems consisting of a scanning mobility particle sizer (SMPS; 3936N or 3936L, TSI Inc.) and optical particle counters (OPCs; KC01D, KC18, RION Co. Ltd.). One system consisting of a SMPS and two OPCs was used to measure the size distribution in dry condition and the other consisting of a TDMA and OPCs was used to measure that in wet condition. We also measured radon daughter concentration with radon daughter monitor (ES-7269, JREC Co. Ltd.) to estimate the lifetime of aerosols.

Kytoon (about 10 m^3 in volume), which loaded an OPC (RION Co., KR12) or a CPC (TSI 3087) with radiosonde, was ascended and descended up to about 800 m in maximum on the working deck (Table B-2-1). Aerosol particles larger than 0.15, 0.25, 0.35, 0.5, 1.0, and 2.5 μm in radius were counted with the KR12 every 22 s and temperature and relative humidity were measured every two seconds. In order to estimate the refractive index, we calculate backscattering coefficients and compare that obtained with Mie scattering lidar operated by NIES group.

Vertical profiles near the surface were measured to obtain sea salt flux. Measuring box containing the KR12 and CPC3007 was ascended and descended up to 12 m in height from the deck along the foremast (Table B-2-2). Measuring was performed for 1 min at every 3 m. In order to avoid the effect of ship body, the box was suspended from 2 to 10 m in height from the sea surface by the multi-joint crane (Table B-2-3).

Aerosol particles were collected directly on a carbon-covered nitrocellulose grid with two impactors for 10 min at the highest level with kytoon and on the compass deck at the same time (Table B-2-4). The electron micrograph will be obtained using a scanning electron microscope (Hitachi Co., H-9000). The elemental compositions in individual particles larger than 0.1 μm in radius will be analyzed with an energy dispersive X-ray spectrometer (Kevex Sigma).

Primary results

Example of vertical profile of aerosol particles measured with the KR12 by the kytoon system on 30 November is shown in Fig. B-2-1. Profile shows decreasing of the concentration with height. Degree of the decreasing is dependent on particle size.

Example of vertical profiles of aerosol particles near surface measured with the KR12 along the foremast and by the multi-joint crane on 30 November is shown in Fig. B-2-2. Two profiles are almost similar.

Fig. B-2-3 shows the example of vertical profile of total particles measured with the CPC by the kytoon system on 30 November. However the profile is effected by the exhaust of the funnel, the concentration shows almost constant value. Latitudinal dependence of the total concentration shows small value at the south of 25 N.

The further analyses are in future work.

Data archive

The original data will be archived at Department of Physics, Tokyo University of Science (Contact Kazuhiko Miura).

Table B-2-1 Measuring list of the number concentration profile with OPC and CNC on the kytoon.

No.	date (JST)	start time	stop time	max. length (m)	size range (diameter)	latitude	longitude	remarks
1	2004.11.22	7:19	7:50	800	> 0.3,0.5,0.7,1,2,5 um	33-00N	155-00E	running
2	2004.11.22	7:57	8:25	800	total	33-00N	155-00E	running
3	2004.11.23	12:16	12:50	800	> 0.3,0.5,0.7,1,2,5 um	29-50N	155-00E	running
4	2004.11.23	12:53	13:17	800	total	29-50N	155-00E	running
5	2004.11.30	14:01	14:33	800	> 0.3,0.5,0.7,1,2,5 um	14-00N	155-00E	running
6	2004.11.30	14:33	15:01	800	total	14-00N	155-00E	running
7	2004.12.3	12:21	12:44	700	> 0.3,0.5,0.7,1,2,5 um	07-00N	155-00E	running
8	2004.12.3	12:49	13:14	750	total	07-00N	155-00E	running

Table B-2-2 Measuring list of the number concentration profile with OPC and CNC along the fore-mast.

No.	date (JST)	start time	stop time	height (m)	size range (diameter)	latitude	longitude	remarks
1	2004.11.21	8:52	9:01	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	34-00N	155-00E	St.2
2	2004.11.22	12:03	12:12	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	32-00N	155-00E	St.4
3	2004.11.23	8:37	8:47	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	30-00N	155-00E	St.6
4	2004.11.24	5:15	5:24	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	27-30N	155-00E	St.8
5	2004.11.25	10:03	10:12	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	24-30N	155-00E	St.10
6	2004.11.26	7:26	7:35	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	23-00N	155-00E	St. 11
7	2004.11.27	10:14	10:23	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	20-00N	155-00E	St. 13
8	2004.11.28	15:18	15:27	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	17-00N	155-00E	St.16
9	2004.11.29	10:12	10:21	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	16-00N	155-00E	St.17
10	2004.11.30	16:08	16:17	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	14-00N	155-00E	St.19
11	2004.12.1	9:52	10:01	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	12-00N	155-00E	St.21
12	2004.12.2	12:57	13:06	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	10-00N	155-00E	St.23
13	2004.12.3	10:37	10:46	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	07-00N	155-00E	St.26
14	2004.12.4	8:25	8:33	3, 6, 9, 12	total, > 0.3,0.5,0.7,1,2,5 um	05-05N	155-00E	St.28

Table B-2-3 Measuring list of the number concentration profile with OPC and CNC by the multi-joint crane.

No.	date (JST)	start time	stop time	height (m)	size range (diameter)	latitude	longitude	remarks
1	2004.11.21	8:11	8:24	2, 6, 10	total, > 0.3,0.5,0.7,1,2,5 um	34-00N	155-00E	St.2
2	2004.11.22	11:34	11:46	2, 6, 10	total	32-00N	155-00E	St.4
3	2004.11.23	8:07	8:19	2, 6, 10	total, > 0.3,0.5,0.7,1,2,5 um	30-00N	155-00E	St.6
4	2004.11.24	7:00	7:12	2, 6, 10	total, > 0.3,0.5,0.7,1,2,5 um	27-30N	155-00E	St.8
5	2004.11.25	10:36	10:47	2, 6, 10	total, > 0.3,0.5,0.7,1,2,5 um	24-30N	155-00E	St.10
6	2004.11.26	7:02	7:14	2, 6, 10	total, > 0.3,0.5,0.7,1,2,5 um	23-00N	155-00E	St.11
7	2004.11.27	9:32	9:43	6, 8, 10	total, > 0.3,0.5,0.7,1,2,5 um	20-00N	155-00E	St.13
8	2004.11.28	14:55	15:07	4, 7, 10	total, > 0.3,0.5,0.7,1,2,5 um	17-00N	155-00E	St.16
9	2004.11.29	9:46	9:58	4, 7, 10	total, > 0.3,0.5,0.7,1,2,5 um	16-00N	155-00E	St.17
10	2004.11.30	15:45	15:57	2, 6, 10	total, > 0.3,0.5,0.7,1,2,5 um	14-00N	155-00E	St.19
11	2004.12.1	9:30	9:41	4, 7, 10	total, > 0.3,0.5,0.7,1,2,5 um	12-00N	155-00E	St.21
12	2004.12.2	12:32	12:44	4, 7, 10	total, > 0.3,0.5,0.7,1,2,5 um	10-00N	155-00E	St.23
13	2004.12.3	10:06	10:18	2, 6, 10	total, > 0.3,0.5,0.7,1,2,5 um	07-00N	155-00E	St.26
14	2004.12.4	7:58	8:09	2, 6, 10	total, > 0.3,0.5,0.7,1,2,5 um	05-05N	155-00E	St.28

Table B-2-4 sampling list of aerosols with impactor.

sampling volume 1 l/min normal and nitron

No.	date(JST)	start time	stop time	latitude(N)	longitude(E)	place	remarks
1	2004.11.15	11:07	11:12	41-21	141-14	Sekinehama	
2	2004.11.17	15:46	15:51	41-27	141-19	compass	running
3	2004.11.18	16:17	16:22	40-31	141-48	compass	running
4	2004.11.19	8:01	8:06	38-31	146-48	compass	running
5	2004.11.20	8:02	8:07	36-26	151-40	compass	running
6	2004.11.21	9:31	9:36	34-01	155-05	compass	Stn.2
7	2004.11.22	9:40	9:45	32-33	154-59	compass	running
8	2004.11.22	9:40	9:45	32-33	154-59	500m	running
9	2004.11.23	13:35	13:40	29-27	155-00	compass	running
10	2004.11.23	13:35	13:40	29-27	155-00	800m	running
11	2004.11.24	9:03	9:08	27-03	155-00	compass	Stn.8
12	2004.11.25	8:56	9:01	24-29	155-02	compass	Stn.10
13	2004.11.26	13:57	14:02	21-30	155-00	compass	Stn.12
14	2004.11.27	17:01	17:06	19-00	155-00	compass	Stn.14
15	2004.11.28	15:20	15:25	17-00	155-00	compass	Stn.16
16	2004.11.29	17:06	17:11	15-00	155-00	compass	Stn.18
17	2004.11.30	15:17	15:22	13-56	154-44	compass	running
18	2004.11.30	15:17	15:22	13-56	154-44	800→ 700m	running
19	2004.12.1	11:59	12:04	12-00	155-00	compass	Stn.21
20	2004.12.2	13:01	13:06	10-01	154-59	compass	Stn.23
21	2004.12.3	13:30	13:35	6-55	154-57	compass	running
22	2004.12.3	13:30	13:35	6-55	154-57	500m	running
23	2004.12.4	8:26	8:31	5-05	155-01	compass	Stn.28
24	2004.12.5	15:22	15:27	1-44	155-00	compass	running
25	2004.12.5	20:17	20:22	1-00	155-00	compass	Stn.32
26	2004.12.6	7:30	7:35	0-00	155-00	compass	Stn.33
27	2004.12.6	13:17	13:22	0-00	155-00	compass	Stn.33

Table B-2-5 Seawater sampling (500cc)

No.	date(JST)	start time	stop time	latitude(N)	longitude(E)	place	remarks
1	2004.11.21	11:00		34-00	155-00	surface	stn.2
2	2004.11.23	11:00		30-00	155-00	surface	stn. 6
3	2004.11.27	12:30		20-00	155-00	surface	stn. 13
4	2004.12.2	2:00		10-00	155-00	surface	stn. 23
5	2004.12.6	14:00		00-00	155-00	surface	stn. 33

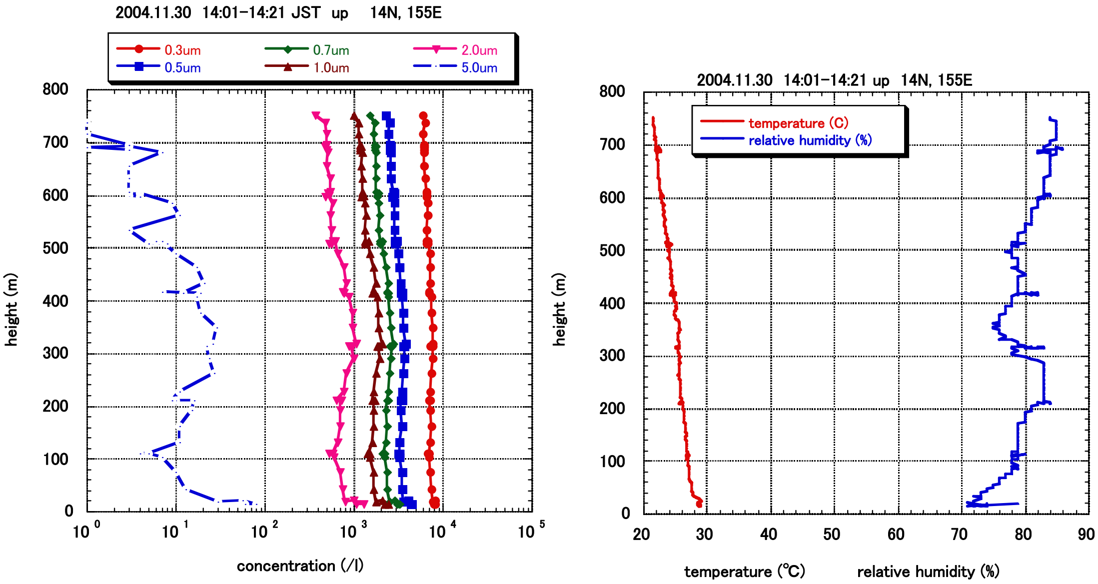


Fig. B-2-1 Vertical profile of aerosol concentration measured with the OPC KR12 by kytoon system.

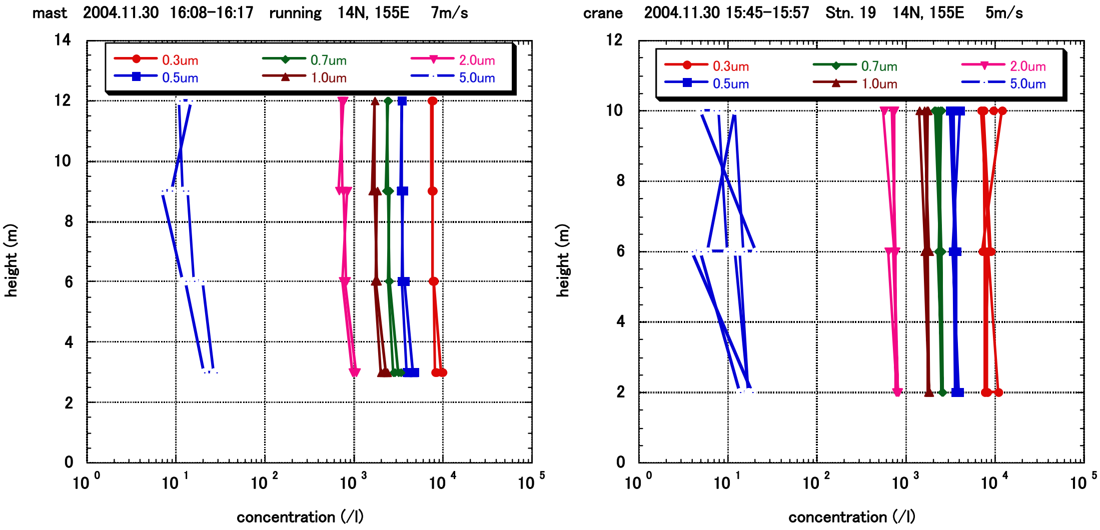


Fig. B-2-2 Vertical profile of aerosol concentration near the surface measured with the OPC KR12 by foremast and multi-joint crane.

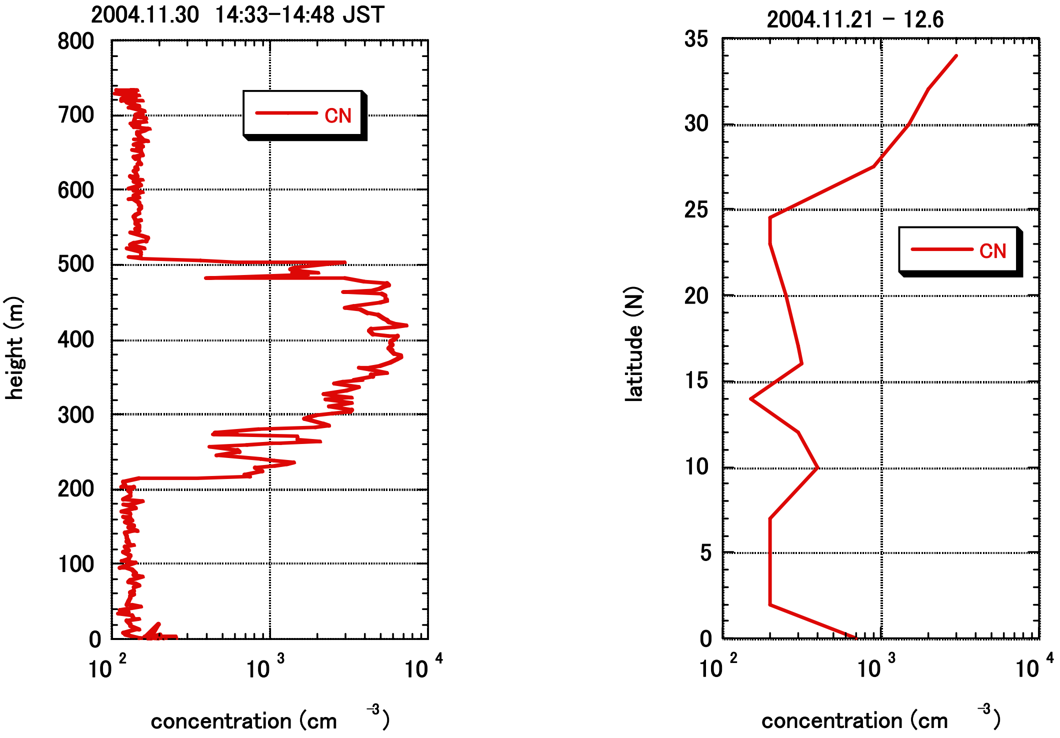


Fig. B-2-3 Total concentration measured with the CPC.

Left : Vertical profile by the kytoon system, right : latitudinal dependence.

B-3. Long range transport of Atmospheric pollutants to western Pacific

Personnel

Shungo Kato, Mayo Watari, Yoshizumi Kajii (Tokyo Metropolitan University),
Hiroki Yuasa, Kazuhiko Miura (Tokyo University of Science)

Objectives

Asia is one of the most populated areas in the world and its industrial developing would cause serious air pollution. East Asia including China is large industrial area and South East Asia is known as an intensive biomass burning area. It is not only local city pollution, but also regional (or even global) issue. The polluted air emitted in Asia is transported to the Pacific by westerly wind. The actual atmospheric measurements in the Pacific are only limited, since the ideal measurement sites are available only some islands; Ogasawara, Okinawa, etc. Therefore the measurements on ships on the western Pacific are quite important, and they would contribute to elucidate the situation of the long-range transport of polluted air from Asia. Also, some gases emitted from the ocean like DMS would affect the global or regional atmospheric chemistry. Our knowledge about the interactions between gas and surface ocean is not enough and more measurements on the ocean are required.

Method

Atmospheric concentration of Carbon monoxide (CO), Ozone (O_3), Sulfur dioxide (SO_2), Volatile Organic Compounds (VOC, including hydrocarbons, halocarbons, DMS) were measured.

CO was measured by an IR-Gas filter correlation analyzer (Thermo Environmental Instruments, Model 48C). O_3 was measured by an UV absorption analyzer (Dylec, Model 1150). SO_2 was measured by an UV-Fluorescence analyzer (Thermo Environmental Instruments, Model 43C Trace Level). These gases were analyzed continuously on the ship and minutely averaged data was logged by personal computers. The detection limits were estimated 10 ppbv, 1.0 ppbv, 0.1 ppbv for CO, O_3, SO_2, respectively. Zero gas was automatically injected for 15 minutes every hour for CO and SO_2. The air was taken through a 1/4 PFA tube from the right side of the compass deck for these gas measurements. The air for volatile organic compounds measurements was sampled into Silcosteel canisters (Restek) using a membrane pump. Total 24 canisters were sampled as listed in Table B-3-1. They will be analyzed by Pre-concentrator (Entech7000) and GC-FID (Hewlett Packard, HP6890)/ GC-MS (Hewlett Packard, HP5793) in the laboratory in Tokyo Metropolitan University.

Table B-3-1 sampling list of gases with canister.

sampling volume 3 l/min or 6 l/min

No.	date(JST)	start time	stop time	latitude(N)	longitude(E)	place	remarks
1	2004.11.17	15:47	15:48	41-27	141-20	compas	running
2	2004.11.18	15:17	15:18	40-31	141-48	compas	running
3	2004.11.19	9:02	9:03	38-37	146-48	compas	running
4	2004.11.20	8:04	8:05	36-27	151-39	compas	running
5	2004.11.21	9:39	9:40	34-01	155-05	compas	stn.2
6	2004.11.22	8:40	8:41	32-33	154-60	compas	running
7	2004.11.23	13:28	13:29	29-27	155-00	compas	running
8	2004.11.24	9:04	9:05	27-02	155-00	compas	running
9	2004.11.25	8:58	8:59	24-30	155	compas	stn.10
10	2004.11.26	14:00	14:01	21-30	155-00	compas	stn.12
11	2004.11.27	17:03	17:04	19-00	154-59	compas	stn.14
12	2004.11.28	15:21	15:22	17-00	154-59	compas	stn.16
13	2004.11.29	17:07	17:08	15-00	155-00	compas	stn.18
14	2004.11.30	15:17	15:18	13-58	154-44	compas	running
15	2004.12.1	12:00	12:01	12-00	154-59	compas	stn.21
16	2004.12.2	13:04	13:05	10-01	154-59	compas	stn.23
17	2004.12.3	13:27	13:28	06-54	154-57	compas	running
18	2004.12.4	8:28	8:29	05-05	155-00	compas	stn.28
19	2004.12.5	15:25	15:26	01-44	154-59	compas	running
20	2004.12.5	20:17	20:18	00-59	155-00	compas	stn.32
21	2004.12.6	7:32	7:33	00-00	155-00	compas	stn.33
22	2004.12.6	13:19	13:20	00-00	154-59	compas	stn.33

B-4. The observation of Clouds and Raining from FM-CW 95GHz Radar

Personnal :

Toshiaki Takano (Chiba University Associste Professer)
Yohei Kawamura (Chiba University Technical officer)
Ken-ichi Akita (Chiba University Graduate student)
Hiroshi Kubo (Chiba University Graduate student)
Ken-ichi Futaba (Chiba University Undergraduate student) On board

Objective :

Objectives of the observation during this cruise are to study mechanism of clouds and rainning and to study reflection of electromagnetic wave from aerial particles.

Methods :

Vertical profiles of clouds and raining were measured by FM-CW 95GHz Radar. The Radar use 95GHz electromagnetic wave on FM-CW mode. The advantage of FM-CW mode is using small power about 500mW. And 95GHz wave can observe vertical profile of thick clouds.

The system have two signal generator. The one creates signal wave, the other creates FM wave. The waves are mixed and sent to a parabola antenna of transmitter. The other parabola anttena of receiver can receive the reflection of sending wave from aerial particles. The received signal send to an A/D converter board in an observation PC. The digital date of the reflection wave were used Fourier transform by FFT program and stored on a hard disk in a processing PC.

Results :

Figure B-4-1 shows quick-look time-height indications of FM-CW 95GHz signal on this cruise.

Data archive :

The quick-look data is exhibited on Shimakura Laboratory’s http server at Chiba University now.

All data will be archived at Chiba University, and submitted to JAMSTEC within 3-years.

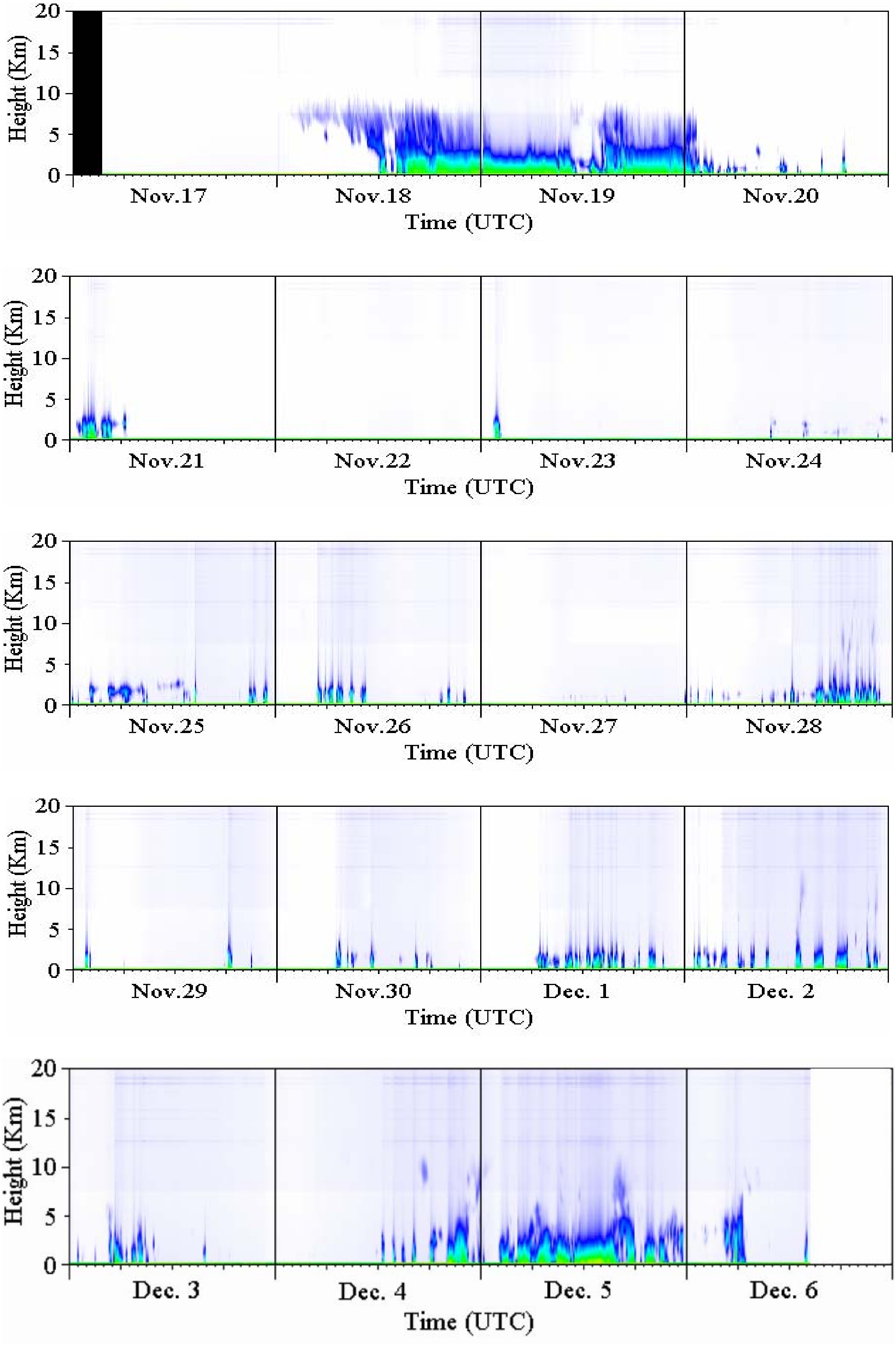


Fig. B-4-1 : Quick-Look Data at FM-CW 95GHz Radar

C. Hydrography

C-1. Underway Measurements

C-1-1. Navigation and Bathymetry

C-1-1-1. Navigation

(1) Personal

Norio Nagahama	(Global Ocean Development Inc. GODI.)
Ryo Kimura	(GODI)
Ryo Ohyama	(GODI)

(2) Method

Ship’s position was measured by navigation system, made by Sena Co. Ltd, Japan. The system has two 12-channel GPS receivers (Leica MX9400N). GPS antennas located at Navigation deck, offset to starboard and portside, respectively. We switched them to choose better state of receiving when the number of GPS satellites decreased or HDOP increased. But the system sometimes lost the position while the receiving status became worse. The system also integrates gyro heading (Tokimec TG-6000), log speed (Furuno DS-30) and other navigation devices data on HP workstation. The workstation keeps accurate time using GPS Time server (Datum Tymserv2100) via NTP(Network Time Protocol). Navigation data was recorded as “SOJ” data every 60 seconds. The periods of losing the position are described in “Readme” file attached to SOJ data.

(3) Apparatus & Performance

Doppler Sonar (Furuno DS-30)

Frequency:	440 kHz
Number of beams:	3 beams
Range:	Fore-aft –10 to +40 knots
	Port-stbd –9.99 to +9.99 knots
Accuracy (ground tracking):	+/– 0.4 % or 0.01 m/sec, whichever is greater
Accuracy (water tracking):	+/– 1 % or 0.1 knot, whichever is greater.

Gyrocompass (TokimecTG-6000)

Settling time:	within 2 hours
Settling point error:	Less than +/– 0.3 deg.
RMS value of the differences:	Less than 0.1 deg.
Follow-up speed:	360 deg. /15 sec.
Band of speed error correction:	0-50 knot / Latitude 0-70 deg.

(4) Data archives

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

(5) Remarks

SOJ data was not update, due to data output trouble of Navigation System. The periods are as follows:

03/December/2004 22:23 - 22:35 [UTC]

C-1-1-2. Bathymetry

(1) Personal

Shuichi Watanebe	(JAMSTEC)
Norio Nagahama	(Global Ocean Development Inc. GODI.)
Ryo Kimura	(GODI)
Ryo Ohyama	(GODI)
Not on-board: Toshiya Fujiwara	(JAMSTEC) : Principal Investigator

(2) Introduction

R/V MIRAI equipped a Multi Narrow Beam Echo Sounding system (MNBES), SEABEAM 2112.004 (SeaBeam Instruments Inc.). The main objective of MNBES survey is collecting continuous bathymetry data along ship’s track to make a contribution to geological and geophysical investigations and global datasets.

(3) Data Acquisition

The “SEABEAM 2100” on R/V MIRAI was used for bathymetry mapping during MR04-07 cruise from 18 November 2004 to 10 December 2004. For primary data quality management, applying proper sound velocity profile is the most important. Sound velocity profiles were calculated using temperature data and salinity data from CTD and XBT (in the case of XBT, salinity used SOJ data from EPCS) by the equation in Mackenzie (1981). Variations of sound velocity at transducer face have a large influence on depth, especially side beams, so that this system has Surface Sound Velocimeter, which measuring sound velocity in the surface intake water continuously. Obvious bad data was flagged automatically by real-time data screening function of the system.

Table C-1-1-2 listed system configuration and performance of SEABEAM 2112.004 .

(4) Preliminary Results

Fig.C-1-1-2 shown results of bathymetric survey along cruise track.

(5) Data Archives

Data obtained during this cruise will be submitted to the JAMSTEC Data Management

Division, and archived there.

(6) Remarks

The periods of incorrect ship's position data are follows:

04/December/2004 22:23:06 - 22:34:54 [UTC]

Table C-1-1-2 System configuration and performance

SEABEAM 2112.004 (12kHz 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)

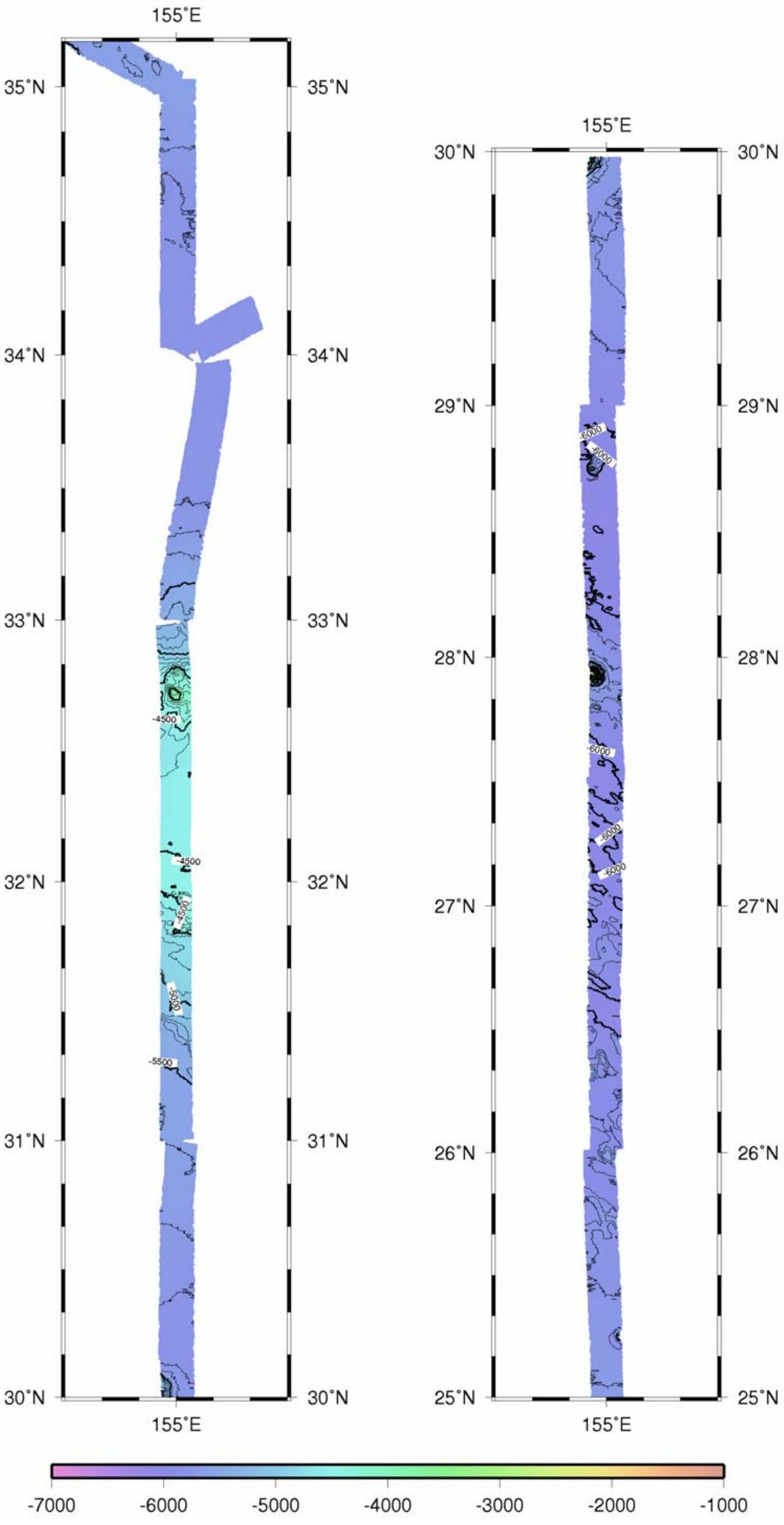


Fig. C-1-1-2 The map of bathymetry along cruise track (35N to Equator)

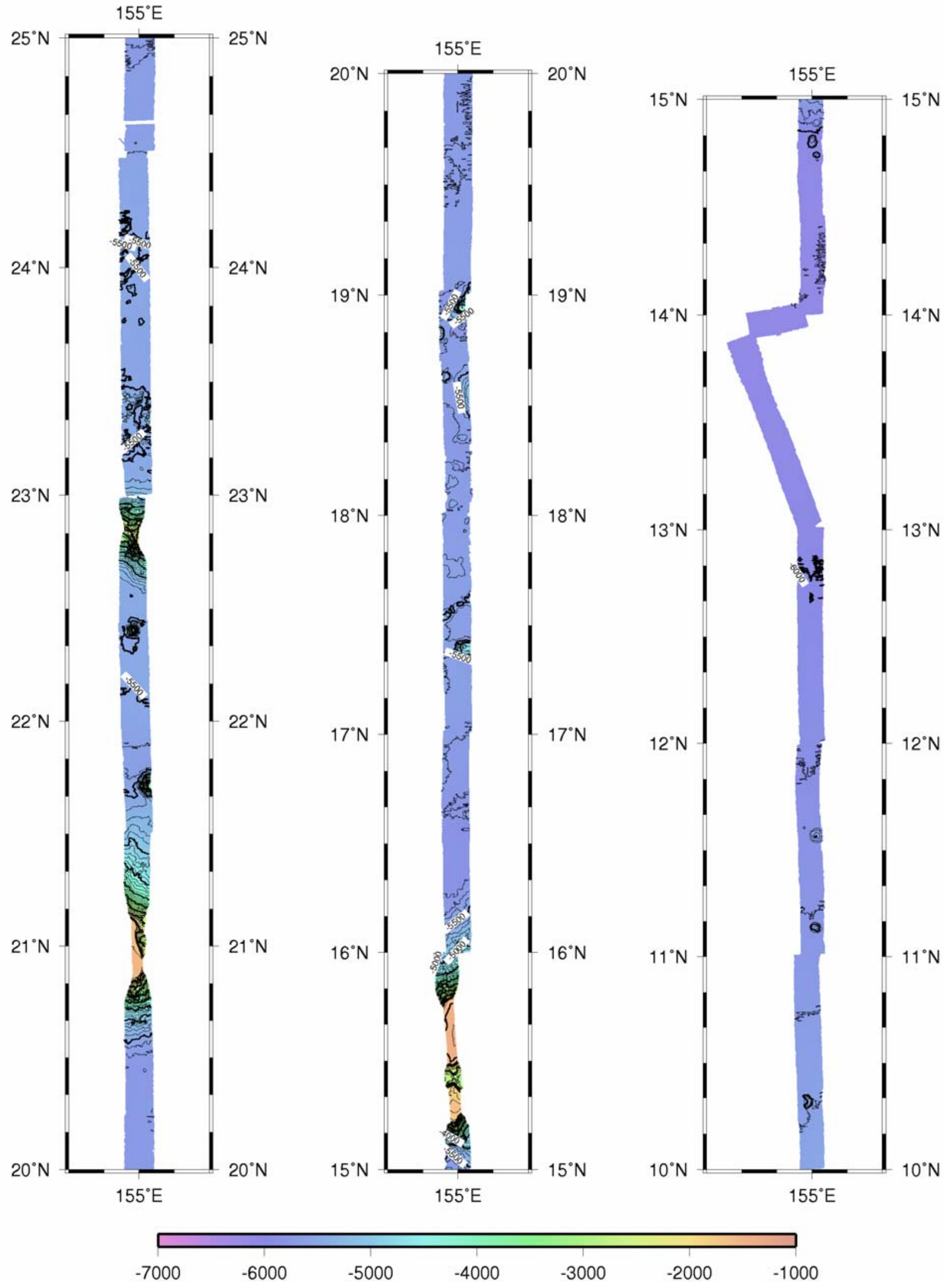


Fig. C-1-1-2 Continued

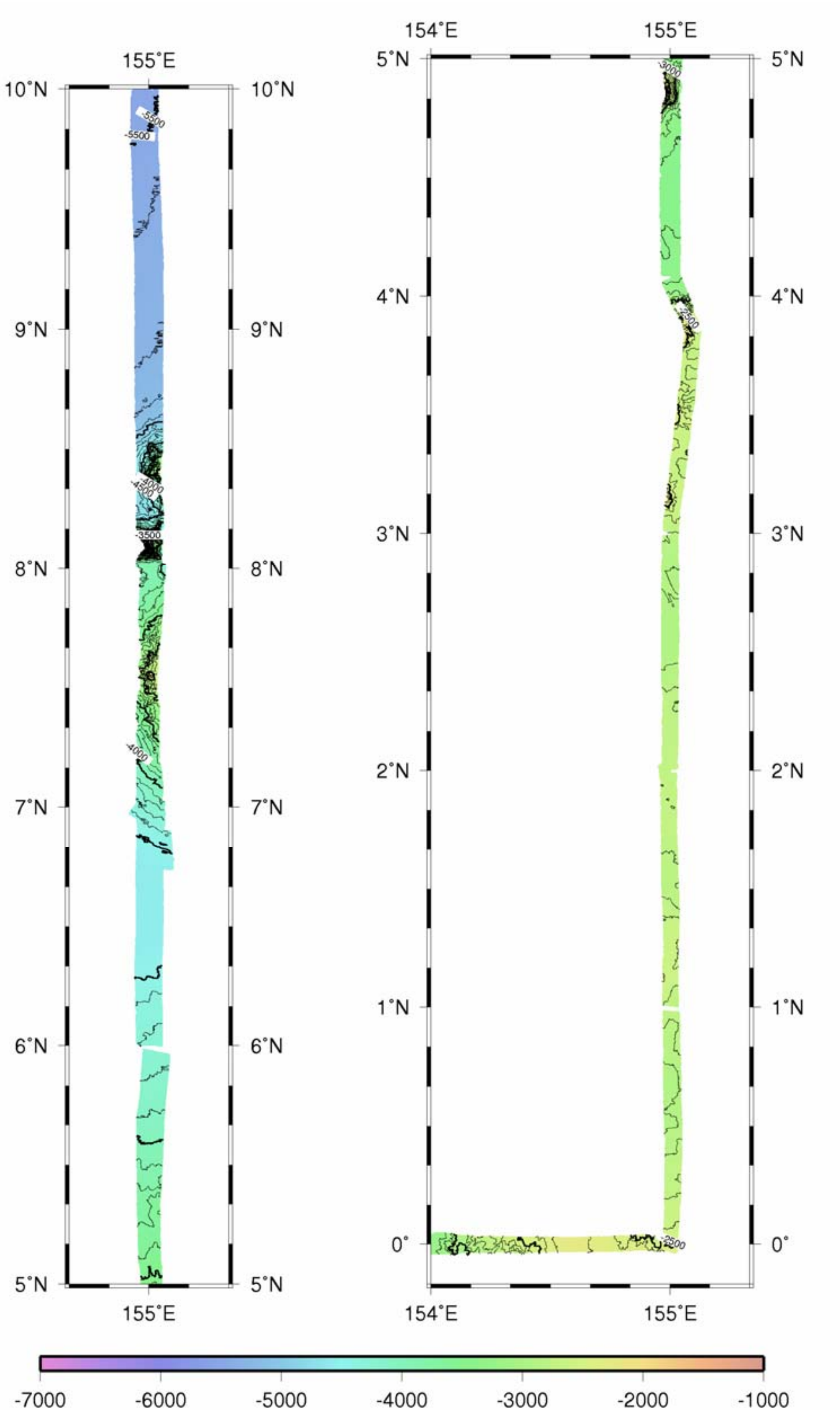


Fig. C-1-1-2 Continued

C-1-2. Shipboard ADCP observation

(1) Personnel

Shuichi Watanebe	(JAMSTEC)
Norio Nagahama	(Global Ocean Development Inc. GODI.)
Ryo Kimura	(GODI)
Ryo Ohyama	(GODI)

(2) Objective

Current velocity of each depth cell [m/s]
Echo intensity of each depth cell [dB]

(3) Methods

Upper ocean current measurements were made throughout MR04-07 cruise (Departure from Sekinehama on 17 November 2004 to the arrival at Chuuk on 10 December) except for the territorial waters of the Federated States of Micronesia, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system that is permanently installed on the R/V Mirai. The system consists of following components;

1) a 75 kHz Broadband (coded-pulse) profiler with 4-beam Doppler sonar operating at 75 KHz (RD Instruments, USA), mounted with beams pointing 30 degrees from the vertical and 45 degrees azimuth from the keel;
2) the Ship's main gyro compass (Tokimec, Japan), continuously providing ship's heading measurements to the ADCP;
3) a GPS navigation receiver (Leica MX9400) providing position fixes;
4) an IBM-compatible personal computer running data acquisition software (VmDas version 1.3 ; RD Instruments, USA). The clock of the logging PC are adjusted to GPS time every 10 minutes.

The ADCP was configured for 8-m processing bin, a 8-m blanking interval. The sound speed is calculated from temperature (thermistor near the transducer head), salinity (constant value; 35.0 psu) and depth (6.5 m; transducer depth) by equation in Medwin (1975). The transducer depth was 6.5 m; 100 velocity measurements were made at 8-m intervals starting 23m below the surface. Every ping was recorded as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds average data were recorded as short term average (.STA) and long term average (.LTA) data., respectively. Major parameters for the measurement (Direct Command) are as follows:

Bottom-Track Commands

BP = 001	Pings per Ensemble

Environmental Sensor Commands

EA = +00000	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +0001	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 = 1020001	Sensor Source (C;D;H;P;R;S;T) C(1): Sound velocity calculate 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

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 counts)
WB = 1	Mode 1 Bandwidth Control (0=Wid,1=Med,2=Nar)
WC = 064	Low Correlation Threshold (0-255)
WD = 111 111 111	Data Out (V;C;A PG;St;Vsum Vsum^2;#G;P0)
WE = 5000	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 = 100	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS = 0800	Depth Cell Size (cm)
WT = 000	Transmit Length (cm) [0 = Bin Length]
WV = 999	Mode 1 Ambiguity Velocity (cm/s radial)

The periods of bottom track mode and water mode track are as follows;

Water Track : from the 09:52UTC 18 November to 17:35UTC December
Bottom Track : from 15:12UTC 17 November to 09:49UTC 18 November

(4) Preliminary results

Fig. C.1.2-1 shows time series of water current profile on the 155E Line. The data was processed to 60-minutes, in the each depth data using CODAS (Common Oceanographic Data Access System), developed at the University of Hawaii.

(5) Data archive

These data obtained in this cruise will be submitted to the JAMSTEC DMD (Data Management Division).

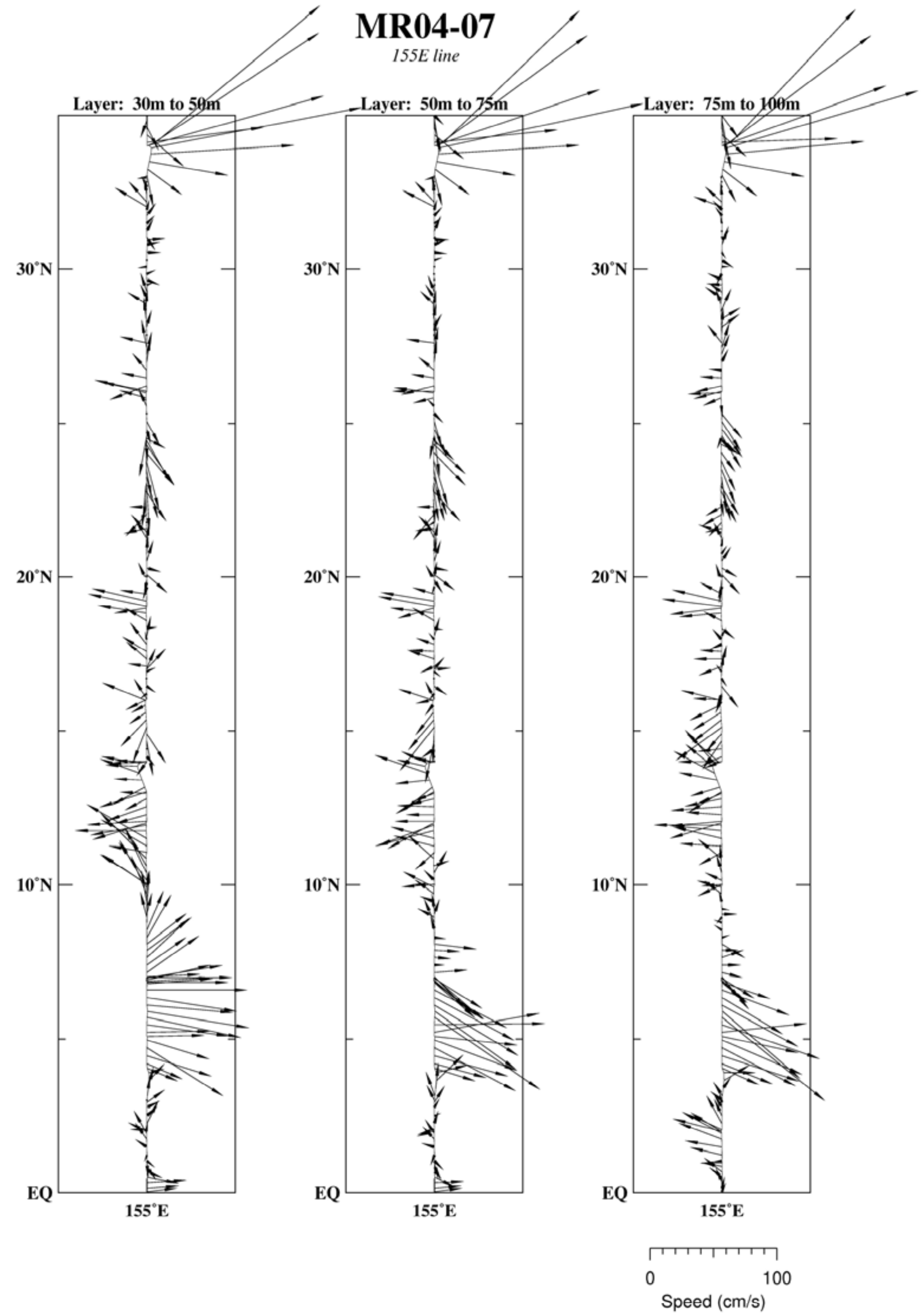


Fig.C.1.2-1: The water current profile during the observation on the 155E Line. The vector represents the horizontal current (northbound for up). The arrow length represents absolute current speed.

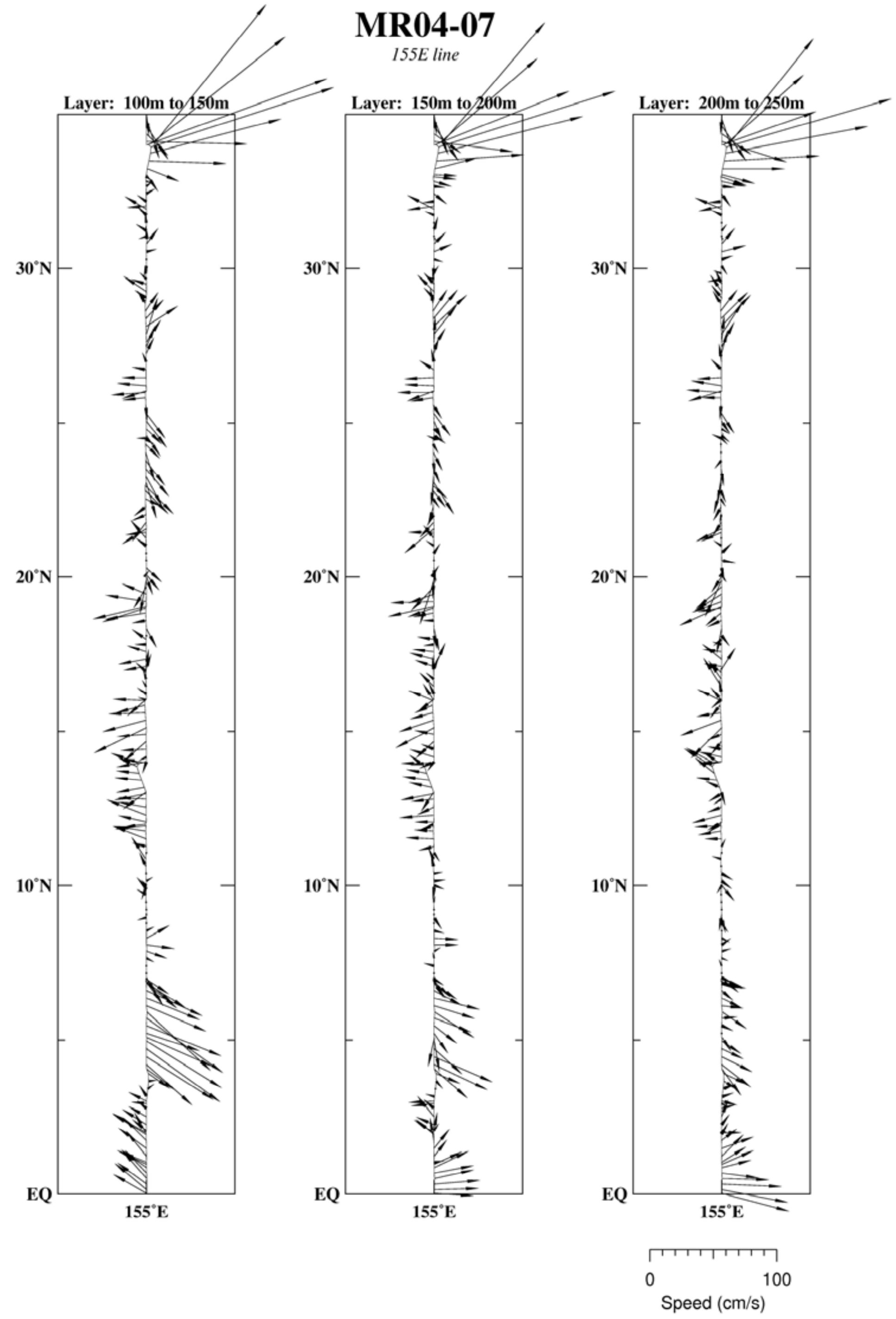


Fig.C.1.2-1: Continued

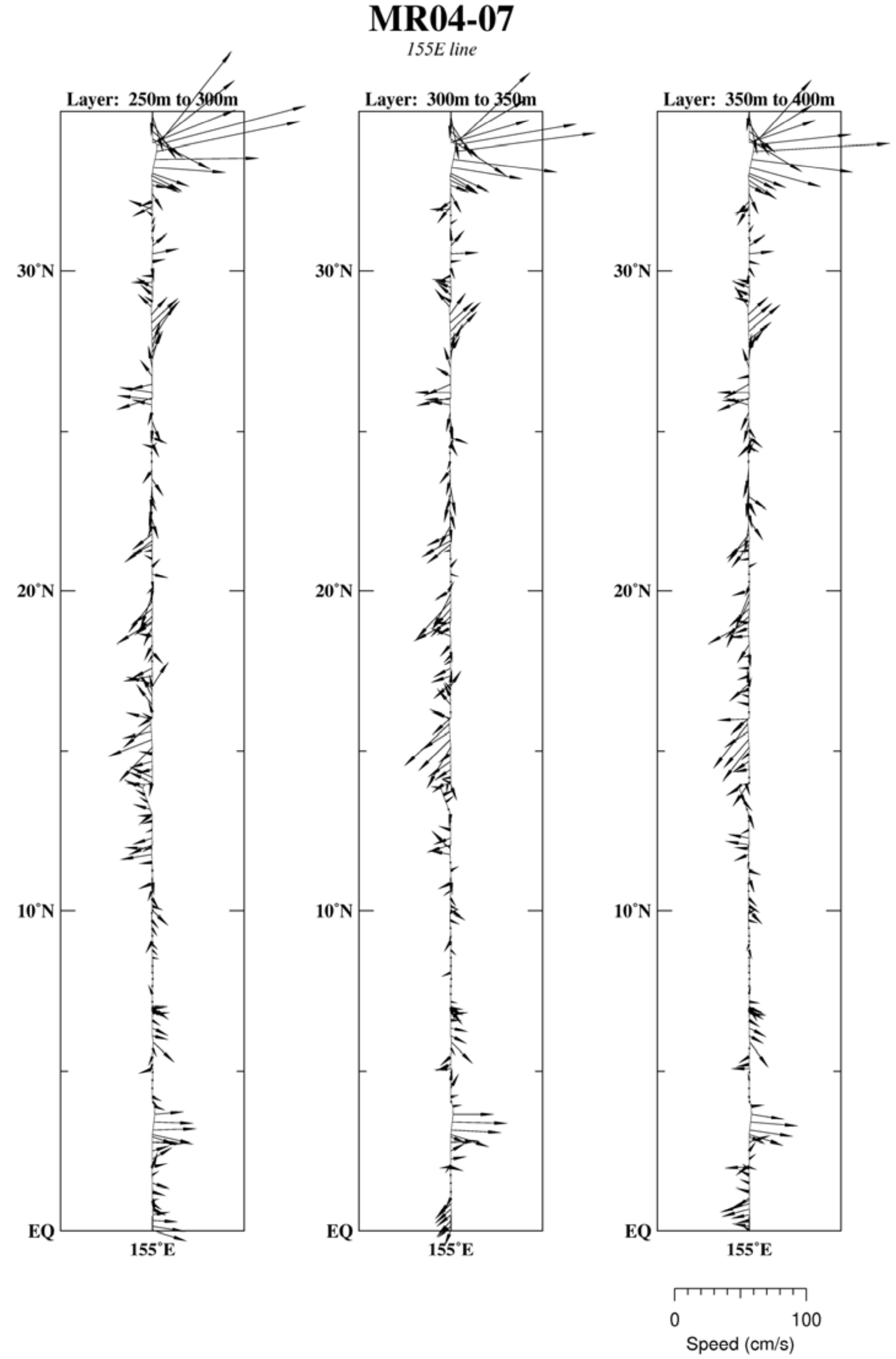


Fig.C.1.2-1: Continued

C-1-3. Sea surface monitoring

Takayoshi SEIKE, Kimiko NISHIJIMA (Marine Works Japan Co. Ltd.)

Objective

To measure salinity, temperature, dissolved oxygen, and fluorescence of near-sea surface water.

Methods

The *Continuous Sea Surface Water Monitoring System* (Nippon Kaiyo Co. Ltd.) has six kind of sensors and can automatically measure salinity, temperature, dissolved oxygen, fluorescence and particle size of plankton in near-sea surface water continuously, every 1-minute. This system is located in the “*sea surface monitoring laboratory*” on R/V MIRAI. This system is connected to shipboard LAN-system. Measured data is stored in a hard disk of PC every 1-minute together with time and position of ship, and displayed in the data management PC machine.

Near-surface water was continuously pumped up to the laboratory and flowed into the *Continuous Sea Surface Water Monitoring System* through a vinyl-chloride pipe. The flow rate for the system is controlled by several valves and was 12L/min except with fluorometer (about 0.3L/min). The flow rate is measured with two flow meters.

Specification of the each sensor in this system of listed below.

a) Temperature and Salinity sensor

SEACAT THERMOSALINOGRAPH
Model: SBE-21, SEA-BIRD ELECTRONICS, INC.
Serial number: 2126391-2641
Measurement range: Temperature -5 to +35℃, Salinity0 to 6.5 S m-1
Accuracy: Temperature 0.01 ℃ 6month-1, Salinity0.001 S m-1 month-1
Resolution: Temperatures 0.001℃, Salinity0.0001 S m-1

b) Bottom of ship thermometer

Model: SBE 3S, SEA-BIRD ELECTRONICS, INC.
Serial number: 032175
Measurement range: -5 to +35℃
Resolution: ±0.001℃
Stability: 0.002 ℃ year-1

c) Dissolved oxygen sensor

Model: 2127A, HACH ULTRA ANALYTICS JAPAN, INC.
Serial number: 44733
Measurement range: 0 to 14 ppm
Accuracy: ±1% at 5 ℃ of correction range
Stability: 1% month-1

d) Fluorometer

Model: 10-AU-005, TURNER DESIGNS
Serial number: 5562 FRXX
Detection limit: 5 ppt or less for chlorophyll a
Stability: 0.5% month-1 of full scale

e) Particle Size sensor

Model: P-05, Nippon Kaiyo LTD.
Serial number: P5024
Measurement range: 0.2681 mm to 6.666 mm
Accuracy: ±10% of range
Reproducibility: ±5%
Stability: 5% week-1

f) Flow meter

Model: EMARG2W, Aichi Watch Electronics LTD.
Serial number: 8672
Measurement range: 0 to 30 l min-1
Accuracy: ±1%
Stability: ±1% day-1

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

18-Nov.-’04 08:40 to 6-Dec.-’04 08:20

Preliminary Result

Preliminary data of temperature (Bottom of ship thermometer), salinity, dissolved oxygen, fluorescence at sea surface between this cruise are shown in Figs1.-4. These figures were drawn using Ocean Data View (R. Schlitzer, http://www.awi-bremerhaven.de/GEO/ODV, 2002).

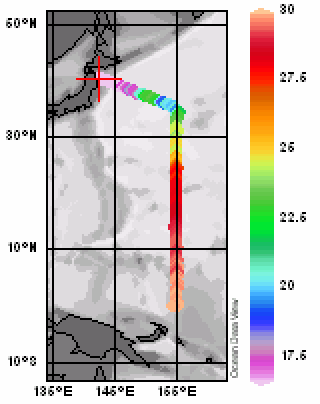


Fig.1 Contour line of Temperature.

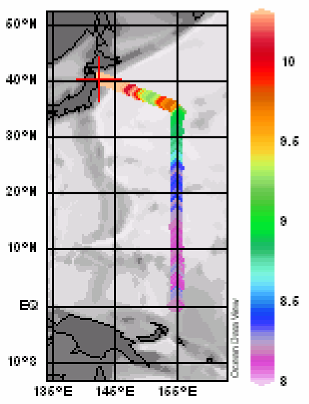


Fig.3 Contour line of dissolved oxygen.

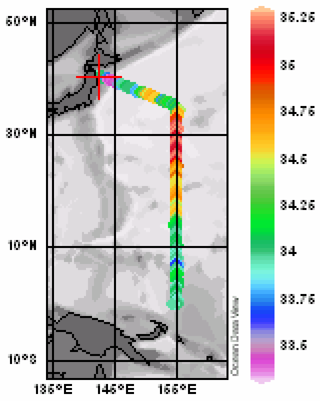


Fig.2 Contour line of salinity.

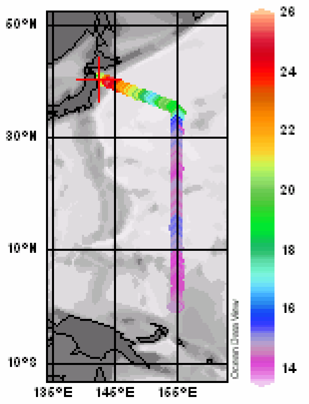


Fig.4 Contour line of fluorescence.

Date archive

The data were stored on a magnetic optical disk, which will be submitted to the Data Management Office (DMO) JAMSTEC, and will be opened to public via “R/V MIRAI Data Web Page” in JAMSTEC homepage.

C-1-4. Partial Pressure of CO_2 (pCO_2) Measurement and Underway Total Dissolved Inorganic Carbon Measurement

Minoru KAMATA (MWJ)
Fuyuki SHIBATA (MWJ)

Objective

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; alkalinity, total dissolved inorganic carbon (TDIC), pH and pCO_2 (Partial pressure of CO_2). When more than two of the four parameters are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994). We here report on board measurements of pCO_2 and underway TDIC during MR04-07 cruise.

Measured Parameters

Partial pressure of CO_2 in the atmosphere and surface seawater

Total dissolved inorganic carbon in the surface seawater

Apparatus and performance

pCO_2

Concentrations of CO_2 in the atmosphere and the sea surface were measured continuously during the cruise using an automated system with a non-dispersive infrared (NDIR) analyzer (BINOS^{TM}). The automated system was operated by on one and a half hour cycle. In one cycle, standard gasses, marine air and an air in a headspace of an equilibrator were analyzed subsequently. The concentrations of the standard gas were 270.08, 330.16, 359.10 and 409.23 ppm. The standard gases will be recalibrated after the cruise.

The marine air taken from the bow was introduced into the NDIR by passing through a mass flow controller which controlled the air flow rate at about 0.5 L/min, a cooling unit, a perma-pure dryer (GL Sciences Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

A fixed volume of the marine air taken from the bow was equilibrated with a stream of seawater that flowed at a rate of 5-6L/min in the equilibrator. The air in the equilibrator was circulated with a pump at 0.7-0.8L/min in a closed loop passing through two cooling units, a perma-pure dryer (GL Science Inc.) and a desiccant holder containing $Mg(ClO_4)_2$.

TDIC

Surface seawater was continuously collected by a pump from bottom of this ship (depth of 4.5m). The TDIC of the introduced surface seawater was constantly measured by a coulometer that was set to analyze surface seawater specifically. The coulometric measurement is same as described in C-2-5.

After the samples were measured, the calibration factor (slope) was calculated by measuring series of sodium carbonate solutions (0~2.5mM) and this calibration factor was applied to all of the data acquired throughout the cruise. By measuring of RM(batch BGL; JAMSTEC) every time the cell was filled with fresh anode and cathode solutions, the slope was calibrated with the counts of this outcome. The set of cell solutions was changed in every three days.

Preliminary results

pCO_2

Figure C-1-4-1 is showing the results of measuring the CO_2 concentration (xCO_2) of ambient air samples and the seawater samples.

TDIC

Figure C-1-4-2 is showing the results of measuring the TDIC concentration of surface seawater samples. During the cruise, 14 bottles of RM was analyzed in order to calibrate the slope of the calibration factor. The standard deviation of the absolute differences of duplicate measurements was 1.1 μmol/kg (n=14).

Data Archive

All data was submitted to JAMSTEC Data Management Office (DMO) and is currently under its control.

Reference

DOE (1994), *Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water*; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74.

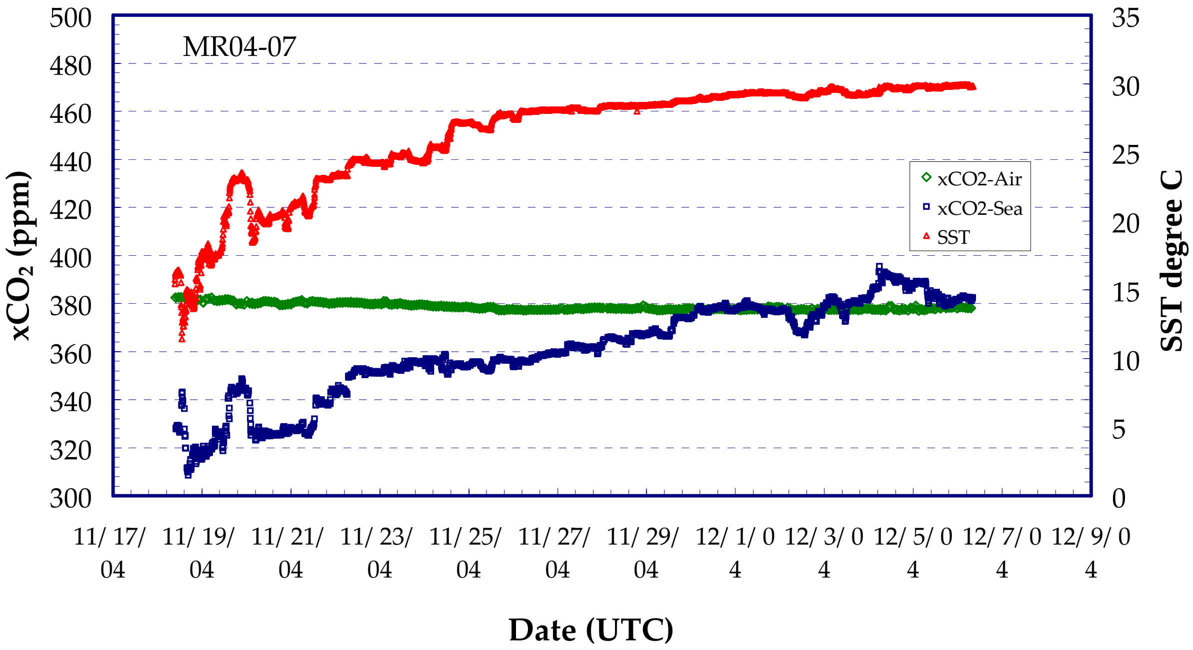


Figure C-1-4-1. Concentrations of CO_2 (xCO_2) in atmosphere (green) and surface seawater (blue), and SST (red).

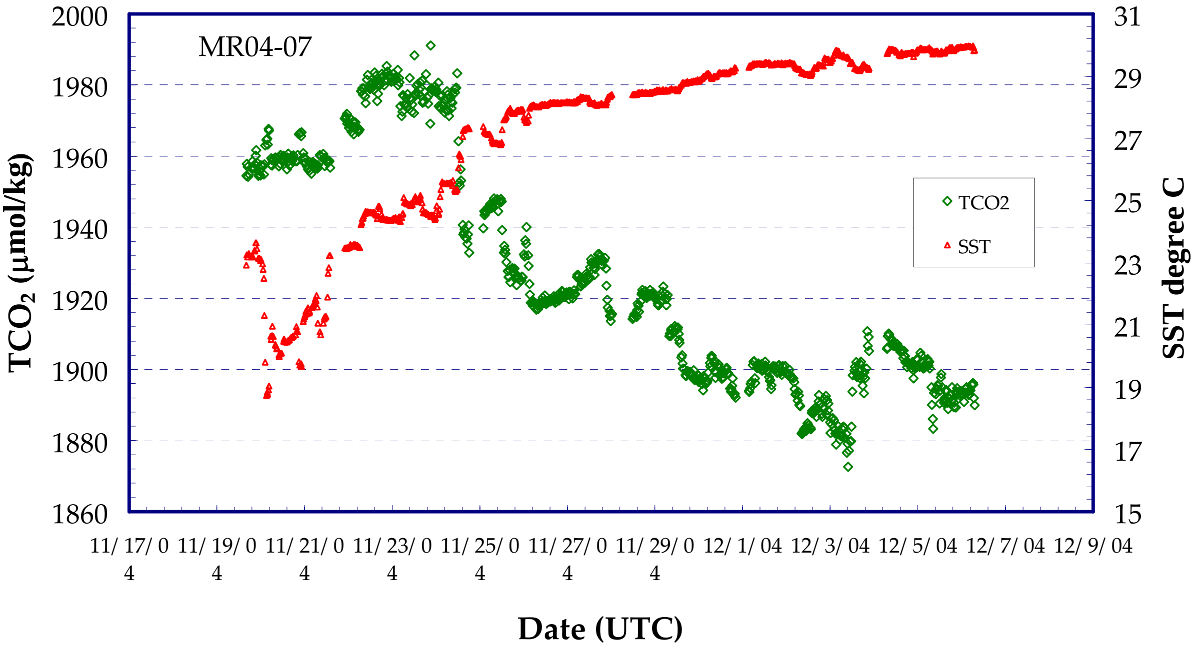


Figure C-1-4-2 TDIC concentration (blue) in surface seawater and SST (red) in this cruise

C-1-5. Nutrients

1. Personnel

Junko Hamanaka, Ayumi Takeuchi, Kenichiro Sato (MWJ)
Shuichi Watanabe (JAMSTEC)

2. Objective

Phytoplankton requires nutrient elements for growth, chiefly nitrogen, phosphorus, and silicon. The data of nutrients in surface seawater is important for investigation of phytoplankton productivity.

3. Measured parameters

Nitrate+ Nitrite, Nitrite, Phosphate, Silicate

4. Inventory information for the sampling

Date: November 18 to December 6, 2004

5. Methods or Apparatus & Performance

The nutrients monitoring system was performed on BRAN+LUEBBE continuous monitoring system Model TRAACS-800 (4 channels). This system was located at the surface seawater laboratory for monitoring in R/V Mirai. Seawater at depth of 4.5 m was continuously pumped up to the laboratory and introduced direct to monitoring system with narrow tube. The standard and base solutions of nutrients were measured each 8 hours. To get more accurate data, we corrected the monitoring data by the reference materials of nutrients (KANSO), which were measured by this system each 3-5 days. The methods are as follows.

Nitrate + Nitrite: Nitrate in the seawater was reduced to nitrite by reduction tube (Cd-Cu tube), and the nitrite reduced was determined by the nitrite method as shown below. The flow cell was 3 cm length type.

Nitrite: Nitrite was determined by diazotizing with sulfanilamide by coupling with N-1-naphthyl-ethylendiamine (NED) to form a colored azo compound, and by being measured the absorbance of 550 nm using 3 cm length flow cell in the system.

Phosphate: Phosphate was determined by complexion with molybdate, by reducing with ascorbic acid to form a colored complex, and by being measured the absorbance of 800 nm using 5 cm length flow cell in the system.

Silicate: Silicate was determined by complexion with molybdate, by reducing with ascorbic acid to form a colored complex, and by being measured the absorbance of 800 nm using 3 cm length flow cell in the system.

6. Preliminary Result

The outline of surface nutrients profile is shown in Figure C-1-5.

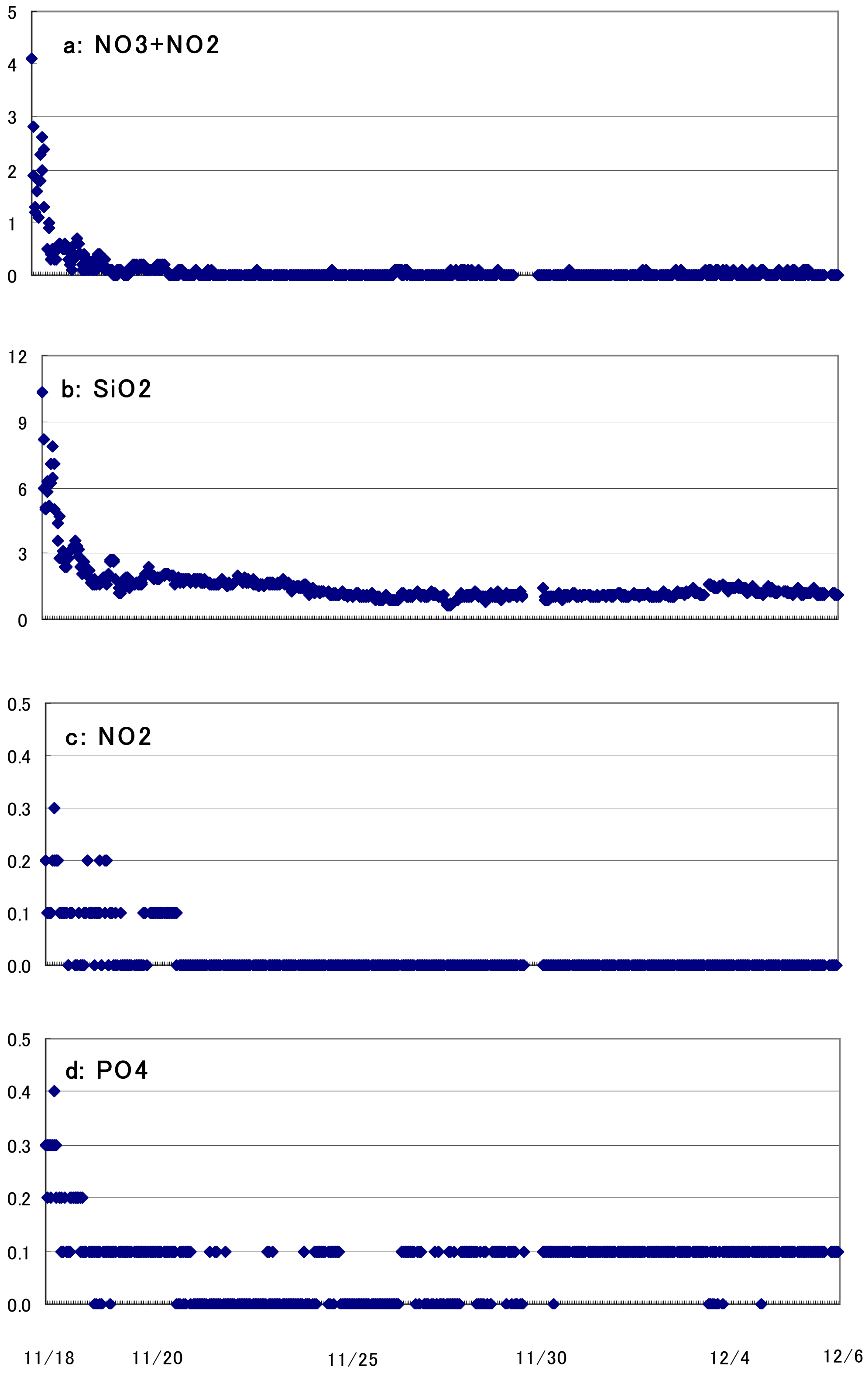


Figure C-1-5. Profiles of (a) Nitrate + Nitrite, (b) Silicate, (c) Nitrite and (d) Phosphate (unit: µM) in surface seawater.

C-2. Hydrographic Measurements

C-2-1. CTDO-Sampler

Personal

Hiroshi Matsunaga	(MWJ)
Tomoyuki Takamori	(MWJ)
Fuma Matsunaga	(MWJ)

(1) Objective

Investigation of oceanic structure and water sampling of each layer.

(2) Methods

2-1:Overview of the equipment

The CTD system, SBE 911plus system (Sea-Bird Electronics, Inc., USA), is a real time data system with the CTD data transmitted from a SBE 9plus underwater unit via a conducting cable to the SBE 11plus deck unit. The SBE 11plus deck unit is a rack-mountable interface which supplies DC power to the underwater unit, decodes the serial data stream, formats the data under microprocessor control, and passes the data to a companion computer. The serial data from the underwater unit is sent to the deck unit in RS-232 NRZ format using a 34560 Hz carrier-modulated differential-phase-shift-keying (DPSK) telemetry link. The deck unit decodes the serial data and sends them to a personal computer (Hewlett Packard Vectra VL, Intel(r) Celeron(tm), Microsoft Windows98 2nd edition) to display, at the same time, to storage in a disk file using SBE SEASOFT software.

The SBE 911pus system acquires data from primary, secondary and auxiliary sensors in the form of binary numbers corresponding to the frequency or voltage outputs from those sensors at 24 samples per second. The calculations required to convert from raw data to engineering units of the parameters are performed by the SBE SEASOFT in real-time. The same calculations can be carried out after the observation using data stored in a disk file.

The SBE 911plus system controls the 36-position SBE 32 Carousel Water Sampler. The Carousel accepts 12-litre water sample bottles. Bottles were fired through the RS-232C modem connector on the back of the SBE 11plus deck unit while acquiring real time data. The 12-litre Niskin-X water sample bottle (General Oceanics, Inc., USA) is equipped externally with two stainless steel springs. The external springs are ideal for applications such as the trace metal analysis because the inside of the sampler is free from contaminants from springs.

2-2:Details of sensors

The system used in this cruise is summarized as follows:

Under water unit:

SBE, Inc., SBE 9plus, S/N 79492

Temperature sensor:

SBE, Inc., SBE 3-04/F, S/N 031259 (primary)

SBE, Inc., SBE 3Plus, S/N 03P2730 (secondary)

Conductivity sensor:

SBE, Inc., SBE 04-04/0, S/N 041203(primary)

SBE, Inc., SBE 04-04/0, S/N 041202(primary)

SBE, Inc., SBE 04-04/0, S/N 041206 (secondary)

Oxygen sensor:

SBE, Inc., SBE 43, S/N 430394 (primary)

SBE, Inc., SBE 43, S/N 430205 (secondary)

Pump:

SBE, Inc., SBE 5T, S/N 053118 (primary)

SBE, Inc., SBE 5T, S/N 050984 (secondary)

Altimeter:

Datasonics Inc., PSA-900D, S/N 396

Deep Ocean Standards Thermometer:

SBE, Inc., SBE 35, S/N 3533904-0045

Deck unit:

SBE, Inc., SBE 11plus, S/N 11P8010-0308

Carousel Water Sampler:

SBE, Inc., SBE 32, S/N 3227443-0391

Fluorometer:

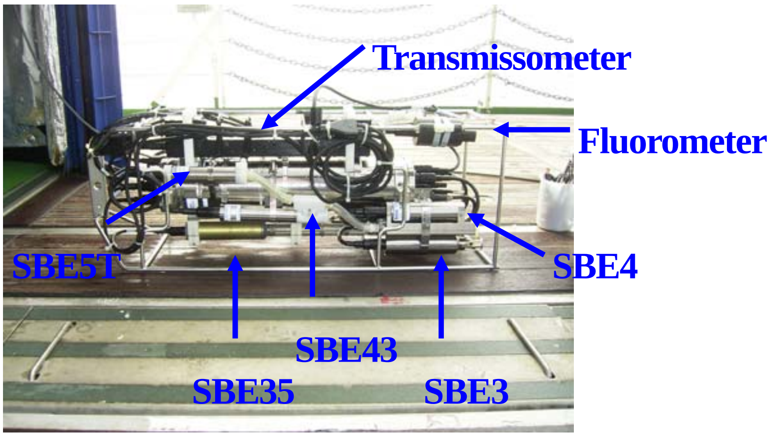
Seapoint sensors, Inc., S/N 2579

Transmissometer:

Wetlabs,Inc., S/N CST-207RD

Water sample bottle:

General Oceanics, Inc., 12-litre Niskin-X



2-3:Data collection and processing

2-3-1: Data collection

CTD measurements were made using a SBE 9plus CTD equipped with two pumped temperature-conductivity (TC) sensors. The TC pairs were monitored to check drift and shifts by examining the differences between the two pairs. The SBE 9plus CTD (sampling rate of 24 Hz) was mounted horizontally in a 36-position carousel frame. Auxiliary sensors included altimeter, dissolved oxygen sensors, fluorometer, Transmissometer and Deep Ocean Standards Thermometer.

The package was lowered into the water from the starboard side and held 10 m beneath the surface for about one minute in order to activate the pump. After the pump was activated the package was lifted to the surface and lowered at a rate of 0.5 m/s to 100 m then the package was stopped in order to operate the heave compensator of the crane. The package was lowered again at a rate of 1.0-1.2 m/s to the bottom. The position of the package relative to the bottom was monitored by the altimeter reading. Also the bottom depth was monitored by the SEABEAM multibeam sounder on board. For the up cast, the package was lifted at a rate of 1.0-1.2 m/s except for bottle firing stops. At each bottle firing stops, the bottle was fired after waiting 30 seconds and the package was stayed 7 seconds in order to sample temperature by the Deep Ocean Standards Thermometer. At 100 m from the surface, the package was stopped in order to stop the heave compensator of the crane.

The SBE 11plus deck unit received the data signal from the CTD. Digitized data were forwarded to a personal computer running the SEASAVE module of the SEASOFT acquisition and processing software, version 5.27b.

2-3-2: Data processing

The following are the SEASOFT-Win32 (Ver. 5.27b) processing module sequence and specifications used in the reduction of CTD data in this cruise.

DATCNV converted the raw data to scan number, pressure, depth, temperatures, conductivities, oxygen voltage, and desent rate, altitude, fluorescence, transmission. DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 4.4 seconds, and the offset was set to 0.0 seconds.

ROSSUM created a summary of the bottle data. The bottle position, date, time were output as the first two columns. Scan number, pressure, depth, temperatures, conductivities, oxygen voltage, and altitude, fluorescence, transmission were averaged over 4.4 seconds.

ALIGNCTD converted the time-sequence of oxygen sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. For a SBE 9plus CTD with the ducted temperature and conductivity sensors and a 3000 rpm pump, the typical net advance of the conductivity relative to the temperature is 0.073 seconds. So, the SBE 11plus deck unit was set to advance the conductivity for 1.73 scans (1.75/24 = 0.073 seconds). Oxygen data are also systematically delayed with respect to depth mainly because of the long time constant of the oxygen sensor and of an additional delay from the transit time of water in the pumped plumbing line. This delay was compensated by 6 seconds advancing oxygen sensor output (oxygen voltage) relative to the pressure.

WILDEDIT marked 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, temperatures, conductivities, oxygen voltage and altimeter, fluorescence, transmission outputs.

CELLTM used a recursive filter to 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 performed a low pass filter on pressure with a time constant of 0.15 seconds. In order to produce zero phase lag (no time shift) the filter runs forward first then backwards.

WFILTER performed a median filter to remove spikes in the fluorescence and transmission data.. A median value was determined from a window of 49 scans.

SECTION selected 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. (Data to check the CTD pressure drift were prepared before SECTION.)

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

DERIVE was used to compute oxygen.

BINAVG averaged the data into 1 dbar pressure bins. The center value of the first bin was set equal to the bin size. The bin minimum and maximum values are the center value plus and minus half the bin size. Scans with pressures greater than the minimum and less than or equal to the maximum were averaged. Scans were interpolated so that a data record exists every dbar.

DERIVE was re-used to compute salinity, potential temperature, and sigma-theta.

SPLIT was used to split data into the down cast and the up cast.

2-3-3:Data collection problems

After at station 1(second cast), secondary conductivity sensor was replaced from S/N01202 to S/N 1206 because of sensor trouble.

Miss trip of carousel No.2 was found out from results of analyses (D.O., Nut) at the Station. 9.

Miss trip of carousel No.7 was found out from results of analyses (D.O., Nut) at the Station. 23 (second cast).

(3) calibration

3-1:Pressure

The Paroscientific series 4000 Digiquartz high pressure transducer (Paroscientific, Inc., USA) uses a quartz crystal resonator whose frequency of oscillation varies with pressure induced stress with 0.01 per million of resolution over the absolute pressure range of 0 to 15,000 psia (0 to 10,332 dbar). Also, a quartz crystal temperature signal is used to compensate for a wide range of temperature changes at the time of an observation. The pressure sensor (MODEL 415K-187) has a nominal accuracy of 0.015 % FS (1.5 dbar), typical stability of 0.0015 % FS/month (0.15 dbar/month) and resolution of 0.001 % FS (0.1 dbar).

Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA. The following coefficients were used in the SEASOFT:

S/N 79492 25-May-04
c1 = -6.570680+004
c2 = -1.758329e-001
c3 = 2.042500e-002
d1 = 2.714600e-002
d2 = 0
t1 = 2.992375e+001
t2 = -2.638690e-004
t3 = 3.921320e-006
t4 = 1.359470e-009
t5 = 4.497040e-012

Pressure coefficients are first formulated into

$$c = c1 + c2 * U + c3 * U^2$$
$$d = d1 + d2 * U$$
$$t0 = t1 + t2 * U + t3 * U^2 + t4 * U^3 + t5 * U^4$$

where U is temperature in degrees Celsius. The pressure temperature, U, is determined according to

U (degC) = M * (12 bit pressure temperature compensation word) – B

The following coefficients were used in SEASOFT:

M = 1.28490e-002

B = -8.38803e+000

(in the underwater unit system configuration sheet dated on May 24, 1994)

Finally, pressure is computed as

P (psi) = c * [1 – (t0^2 / t^2)] * {1 – d * [1 – (t0^2 / t^2)]}

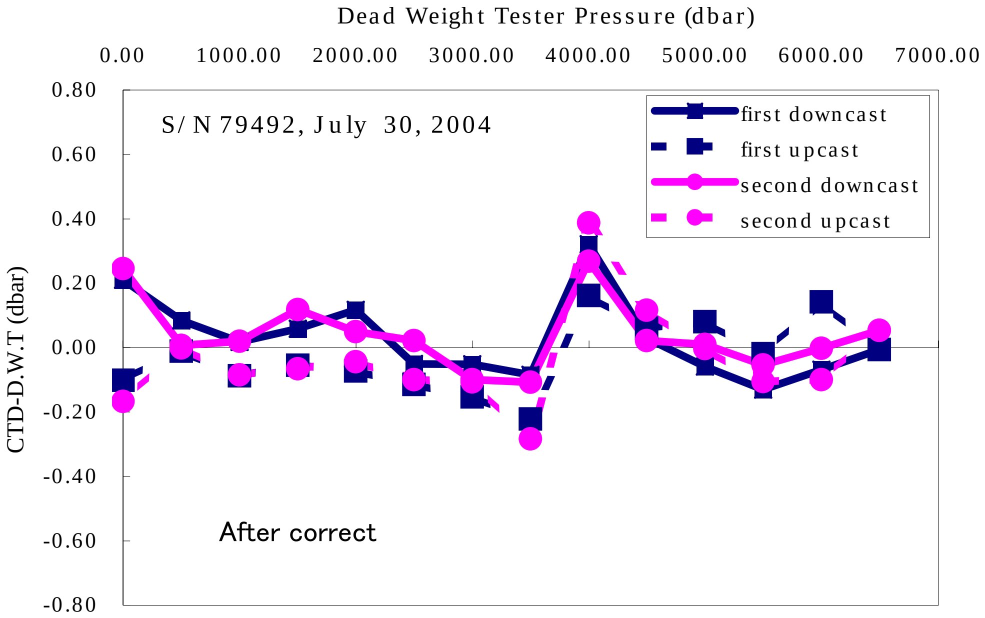
where t is pressure period (microsec). Since the pressure sensor measures the absolute value, it inherently includes atmospheric pressure (about 14.7 psi). SEASOFT subtracts 14.7 psi from computed pressure above automatically.

Pressure sensor calibrations against a dead-weight piston gauge are performed at Marine Works Japan Ltd. in Yokosuka, Kanagawa, JAPAN, usually once in a year in order to monitor sensor time drift and linearity. The pressure sensor drift is known to be primarily an offset drift at all pressures rather than a change of span slope. (show Figure.C-2-1-1, 2) The pressure sensor hysterisis is typically 0.2 dbar. The following coefficients for the sensor drift correction were also used in SEASOFT through the software module SEACON:

S/N 79492 30-July-04
slope = 0.9999004
offset = 0.9452709

The drift-corrected pressure is computed as

Drift-corrected pressure (dbar) = slope * (computed pressure in dbar) + offset



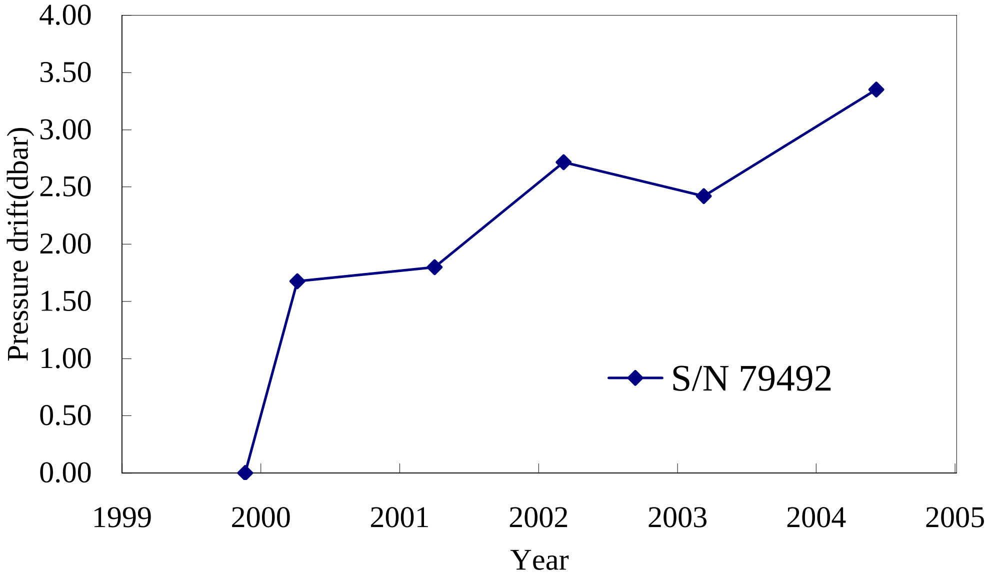


Figure C-2-1-1 (upper): The residual pressures between the Dead Weight Tester and the CTD.

Figure C-2-1-2 (lower): Drift (offset) of the pressure sensor measured by the Dead Weight Tester.

3-2: Temperature

The temperature sensing element is a glass-coated thermistor bead in a stainless steel tube, providing a pressure-free measurement at depths up to 10,500m . The sensor output frequency ranges from approximately 5 to 13 kHz corresponding to temperature from –5 to 35 degC. The output frequency is inversely proportional to the square root of the thermistor resistance, which controls the output of a patented Wien Bridge circuit. The thermistor resistance is exponentially related to temperature. The SBE 3F thermometer has a nominal accuracy of 0.001 degC, typical stability of 0.0002 degC/month and resolution of 0.0002 degC at 24 samples per second.

Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA. (Show Figure.C-2-1-3, 4,) The following coefficients were used in SEASOFT:

S/N 031359 (primary) 24-Jun-04

g = 4.37590961e-003
h = 6.40637221e-004
i = 2.25887775e-005
j = 2.10346460e-006
f0 = 1000.000

S/N 032730 (secondary) 23-Sep-04

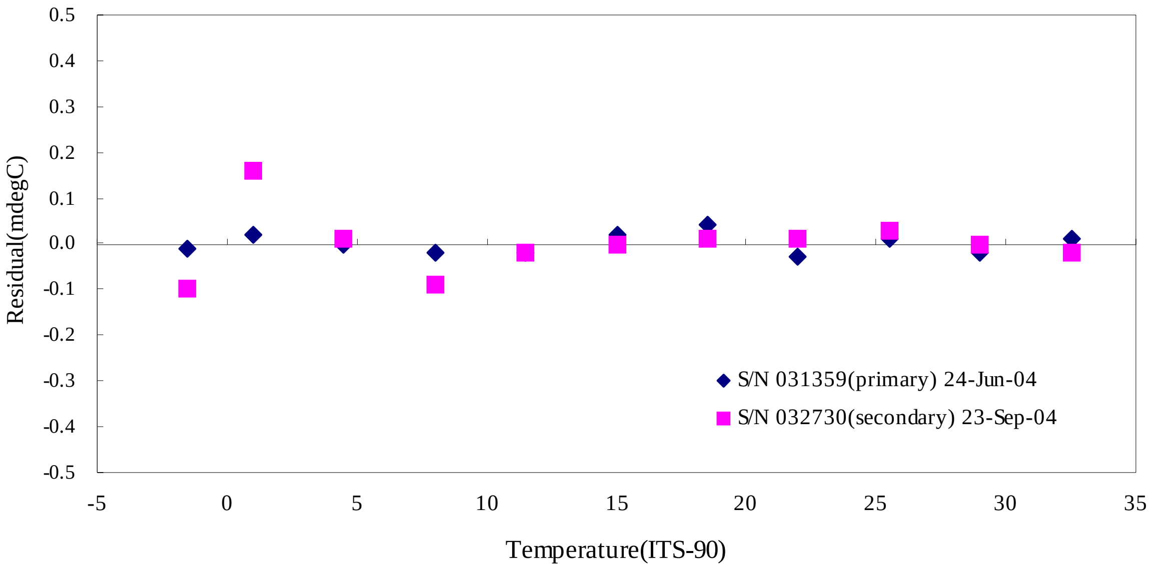
g = 4.33730364e-003
h = 6.45450863e-004
i = 2.32695074e-005
j = 2.19351095e-006
f0 = 1000.000

Temperature (ITS-90) is computed according to

Temperature (ITS-90) =

$$1 / \{g + h * [\ln(f0 / f)] + i * [\ln^2(f0 / f)] + j * [\ln^3(f0 / f)]\} – 273.15$$

where f is the instrument frequency (kHz).



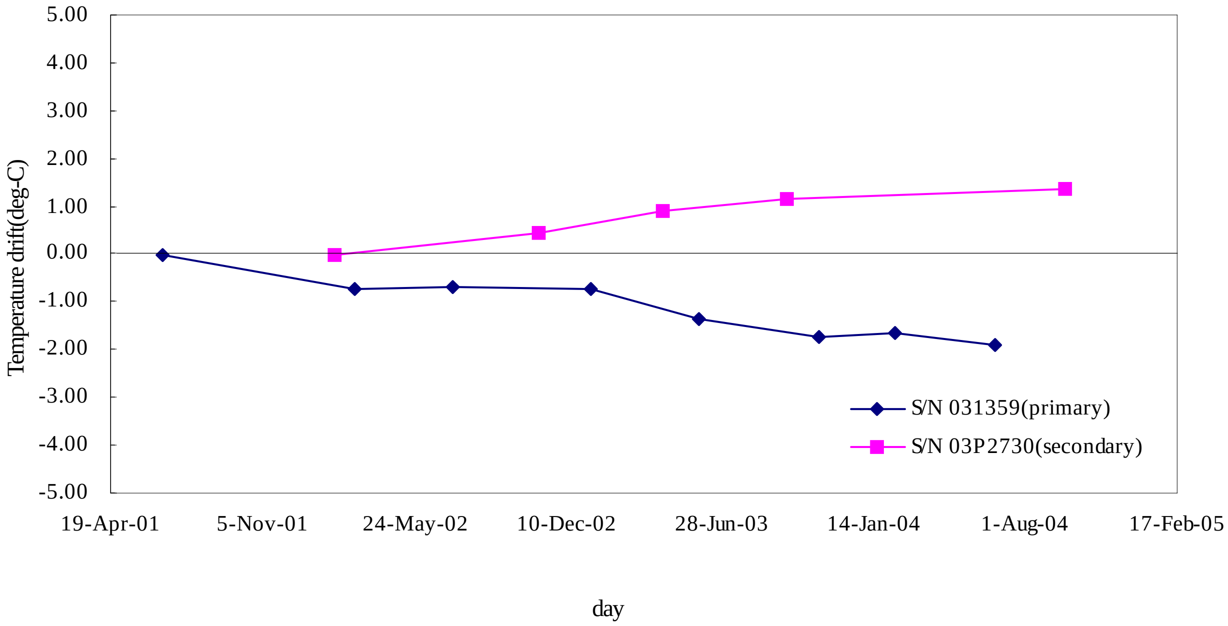


Figure C-2-1-3 (upper): Residual temperature between bath and instrument temperature .
Figure C-2-1-4 (lower): Drift of the temperature sensors based on laboratory calibrations.

3-3: Conductivity (SBE 4)

The flow-through conductivity sensing element is a glass tube (cell) with three platinum electrodes to provide in-situ measurements at depths up to 10,500 meters. The impedance between the center and the end electrodes is determined by the cell geometry and the specific conductance of the fluid within the cell. The conductivity cell composes a Wien Bridge circuit with other electric elements of which frequency output is approximately 3 to 12 kHz corresponding to conductivity of the fluid of 0 to 7 S/m. The conductivity cell SBE 4 has a nominal accuracy of 0.0003 S/m, typical stability of 0.0003 S/m/month and resolution of 0.00004 S/m at 24 samples per second.

Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA. The following coefficients were used in SEASOFT:

S/N 041206 (primary) 30-Apr-04
g = -4.05242086e+000
h = 4.93532786e-001
i = 7.26654890e-005
j = 2.32093798e-005
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)

S/N 0412062(secondary) 20-Aug-04
g = -3.94385153e+000
h = 4.39403806e-001
i = -6.85808976e-005
j = 2.4937625e-005
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)

S/N 041206 (secondary) 24-Jun-04
g = -4.29078852e+000
h = 5.03688092e-001
i = 5.32362768e-005
j = 2.37479049e-005
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)

Conductivity of a fluid in the cell is expressed as:

$$C\ (S/m) = (g + h * f^2 + i * f^3 + j * f^4) / [10\ (1 + CTcor * t + CPcor * p)]$$

where f is the instrument frequency (kHz), t is the water temperature (degC) and p is the water pressure (dbar). The value of conductivity at salinity of 35, temperature of 15 degC (IPTS-68) and pressure of 0 dbar is 4.2914 S/m.

3-4: Deep Ocean Standards Thermometer

The SBE 35 is an accurate, ocean-range temperature sensor that can be standardized against Triple Point of Water and Gallium Melt Point cells and is also capable of measuring temperature in the ocean to depths of 6,800 m. The SBE 35 communicates via a standard RS-232 interface at 300 baud, 8 bits, no parity. The SBE 35 can be used with the SBE 32 Carousel Water Sampler and SBE 911plus CTD system. The SBE 35 makes a temperature measurement each time a bottle fire confirmation is received, and stores the value in EEPROM. Calibration coefficients stored in EEPROM allow the SBE 35 to transmit data in engineering units. Commands can be sent to SBE 35 to provide status display, data acquisition setup, data retrieval, and diagnostic test.

Following the methodology used for standards-grade platinum resistance thermometers (SPRT), the calibration of the SBE 35 is accomplished in two steps. The first step is to characterize and capture the non-linear resistance vs temperature response of the sensor. The SBE 35 calibrations are performed at SBE, Inc., in a low-gradient temperature bath and against ITS-90 certified SPRTs maintained at Sea-Bird's primary temperature metrology laboratory. The second step is frequent certification of the sensor by measurements in thermodynamic fixed-point cells. Triple point of water (TPW) and gallium melt point (GaMP) cells are appropriate for the SBE 35. Like SPRTs, the slow time drift of the SBE 35 is adjusted by a slope and offset correction to the basic non-linear calibration equation.

Initial Accuracy : 0.001 degC
Typical Stabiltity (per year) : 0.001 degC
Resolution : 0.000025 degC

Pre-cruise sensor calibrations were performed at SBE, Inc. in Bellevue, Washington, USA. The following coefficients were stored in EEPROM:

S/N 0045 27- Sep- 02 (1st step: linearization)
a0 = 5.84093815e-03
a1 = -1.65529280e-03
a2 = 2.37944937e-04
a3 = -1.32611385e-05
a4 = 2.83355203e-07

Temperature (ITS-90) is computed according to

Temperature (ITS-90) =

$$1 / \{a0 + a1 * [\ln(n)] + a2 * [\ln^2(n)] + a3 * [\ln^3(n)] + a4 * [\ln^4(n)]\} - 273.15$$

where n is the instrument output.

S/N 0045 31- Mar- 04 (2nd step: fixed point calibration)
Slope = 1.000009
Offset = -0.000772

The SBE 35 has a time constant of 0.5 seconds. The time required per sample = 1.1 * NCYCLES + 2.7 seconds. The 1.1 seconds is total time per an acquisition cycle. NCYCLES is the number of acquisition cycles per sample. The 2.7 seconds is required for converting the measured values to temperature and storing average in EEPROM. RMS temperature noise for an SBE 35 in a Triple Point of Water cell is typically expressed as 82 / sqrt(NCYCLES) in micro K. In this cruise NCYCLES was set to 4 (acquisition time was

4.4 seconds) and the RMS noise was 0.000041 degrees C.

3-5: Oxygen (SBE 43)

The SBE 43 oxygen sensor uses a Clark polarographic element to provide in-situ measurements at depths up to 7,000 meters. Calibration stability is improved by an order of magnitude and pressure hysterisis is largely eliminated in the upper ocean (1000 m). Continuous polarization eliminates the wait-time for stabilization after power-up. Signal resolution is increased by on-board temperature compensation. This Sensor is also included in the path of pumped sea water. The oxygen sensor determines the dissolved oxygen concentration by counting the number of oxygen molecules per second (flux) that diffuse through a membrane, where the permeability of the membrane to oxygen is a function of temperature and ambient pressure. Computation of dissolved oxygen in engineering units is done in SEASOFT software through almost the same way as for the case of the SBE 13. The range for dissolved oxygen is 120 % of surface saturation in all natural waters; nominal accuracy is 2 % of saturation; typical stability is 2 % per 1000 hours.

The following coefficients were used in SEASOFT:

S/N 430394 (primary) 28- Apr- 04p

Soc = 0.3441
Boc = 0.0000
TCor = 0.0017
PCor = 1.350e-04
Offset = -0.5148
tau = 0

S/N 430205 (secondary) 21-Sep-04p

Soc = 0.3933
Boc = 0.0000
TCor = 0.0004
PCor = 1.350e-04
Offset = -0.4839
tau = 0

Oxygen (ml/l) is computed as

$$\text{Oxygen (ml/l)} = [\text{Soc} * \{(v + \text{offset}) + (\text{tau} * doc/dt)\} + \text{Boc} * \exp(-0.03 * t)] * \exp(\text{TCor} * t + \text{PCor} * p) * \text{Oxsat}(t, s)$$

$$\text{Oxsat}(t, s) = \exp[A1 + A2 * (100 / t) + A3 * \ln(t / 100) + A4 * (t / 100) + s * (B1 + B2 * (t / 100) + B3 * (t / 100) * (t / 100))]$$

where p is pressure in dbar, t is absolute temperature and s is salinity in psu. Oxsat is oxygen saturation value minus the volume of oxygen gas (STP) absorbed from humidity-saturated air. Its coefficients are as follows.

A1 = -173.4292
A2 = 249.6339
A3 = 143.3483
A4 = -21.8482

B1 = -0.033096
B2 = -0.00170

3-6: Altimeter

The Benthos PSA-900 Programmable Sonar Altimeter (Benthos, Inc., USA) determines the distance of the target from the unit in almost the same way as the Benthos 2110. PSA-900 also uses the nominal speed of sound of 1500 m/s. But, PSA-900 compensates for sound velocity errors due to temperature. In a PSA-900 operating at a 350 microsecond pulse at 200 kHz, the jitter of the detectors can be as small as 5 microseconds or approximately 0.4 centimeters total distance. Since the total travel time is divided by two, the jitter error is 0.25 centimeters. The unit (PSA-900D) is rated to a depth of 6,000 meters.

The following scale factors were used in SEASOFT:

S/N 0396
FSVolt * 300 / FSRange = 5
Offset = 0.0

3-7: Fluorometer

The Seapoint Chlorophyll Fluorometer (Seapoint sensors, Inc., USA) is a high-performance, low power instrument to provide in-situ measurements of chlorophyll-a at depths up to 6,000 meters. The instrument uses modulated blue LED lamps and a blue excitation filter to excite chlorophyll-a. The fluorescent light emitted by the chlorophyll-a passes through a red emission filter and is detected by a silicon photodiode. The low level signal is then processed using synchronous demodulation circuitry which generates an output voltage proportional to chlorophyll-a concentration.

Minimum Detectable Level : 0.02 μ g/l
Sensitivity/range : gain = 30x, sensitivity,V/ μ g/l = 1.0, Range, μ g/l = 5

The following coefficients were used in SEASOFT through the software module SEACON as user defined polynomial:

S/N 2579
Concentration = (V*30/gain) + offset
where
Gain setting :30X 0-5 ug/l
Offset :0.0

3-7 Transmissometer

The C-Star Transmissometer (WET Labs, Inc., USA) measures light transmittance at a single wavelength over a known path. In general, losses of light propagating through water can be attributed to two primary causes: scattering and absorption. By projecting a collimated beam of light through the water and placing a focused

receiver at a known distance away, one can quantify these losses. The ratio of light gathered by the receiver to the amount originating at the source is known as the beam transmittance. Suspended particles, phytoplankton, bacteria and dissolved organic matter contribute to the losses sensed by the instrument. Thus, the instrument provides information both for an indication of the total concentrations of matter in the water as well as for a value of the water clarity.
Sensitivity : 1.25mv

The following coefficients were used in SEASOFT through the software module SEACON:

S/N CST-207RD March 19, 1998

M = 19.6415
B = -1.3945
Path length (m) = 0.25

The beam transmittance (Tr) iscomputed as

Tr (%) = M * voltage + B

(4) Preliminary Results

Date, time and locations of the CTD casts are listed in SUM (station summary) file. In total 48 CTD casts were carried out. Vertical section of temperature, salinity, dissolved oxygen are shown in following chapter. Uncorrected CTD data are used (Show C-2-1)

Table C-2-1 CTD Cast table

STNNBR	CASTNO	Date(UTC)	Time(UTC)		Start Position		Depth	WIRE OUT	HT ABOVE BOTTOM	Max Depth	Max Pressure	CTD data file name	Sample	Remarks
		yyyy/mm/dd	Start	End	Latitude	Longitude								
001	1	2004/11/20										001M01		Because of trouble,cancellation
001	2	2004/11/20	13:53	18:33	35-00.48	154-59.93	5679.0	5656.4	8.1	5651.5	5769.4	001M02	Deep	
002	1	2004/11/20-21	23:50	0:30	34-00.70	155-02.55	5841.0	303.9	-	303.0	306.0	002M01	Shallow1	
002	2	2004/11/21	1:17	1:49	34-02.49	155-07.42	5829.0	199.0	-	198.0	200.0	002M02	Shallow2	
002	3	2004/11/21	7:48	12:11	33-59.90	155-00.43	5854.0	5931.0	6.7	5825.0	5947.4	002M03	Deep	
003	1	2004/11/21	16:34	20:40	32-59.94	154-59.90	5327.0	5360.2	8.7	5311.4	5416.6	003M01	Deep	
004	1	2004/11/22	2:56	6:18	32-00.07	154-59.94	4472.0	4451.6	10.4	4453.7	4532.9	004M01	Deep	
005	1	2004/11/22	10:31	14:35	31-00.01	155-00.22	5589.0	5565.0	10.7	5563.8	5676.3	005M01	Deep	
006	1	2004/11/22	18:46	23:00	30-00.00	154-59.91	5659.0	5644.1	9.9	5631.4	5745.0	006M01	Deep	
006	2	2004/11/23	1:18	1:48	29-59.01	154-59.26	5616.0	199.1	-	200.6	201.1	006M02	Shallow2	
007	1	2004/11/23	6:39	10:48	29-00.02	154-59.85	5945.0	5911.6	57.0	5878.0	6000.2	007M01	Deep	
008	1	2004/11/23	17:06	21:31	27-30.12	154-59.93	6062.0	5891.9	173.1	5870.7	5990.7	008M01	Deep	
009	1	2004/11/24	4:31	8:31	26-00.08	154-59.89	5693.0	5793.7	13.1	5748.8	5864.9	009M01	Deep	
010	1	2004/11/24-25	23:42	0:14	24-29.43	155-01.96	5588.0	297.5	-	298.9	300.9	010M01	Shallow1	
010	2	2004/11/25	1:02	1:30	24-29.41	155-02.92	5588.0	197.5	-	200.6	202.0	010M02	Shallow2	
010	3	2004/11/25	7:34	11:37	24-29.93	154-59.75	5586.0	5604.0	10.3	5567.7	5676.8	010M03	Deep	
011	1	2004/11/25	17:39	21:39	22-59.98	154-59.93	5134.0	5090.6	10.6	5061.0	5155.0	011M01	Deep	
012	1	2004/11/26	4:47	8:18	21-29.97	155-00.09	5143.0	5128.6	9.5	5117.3	5210.5	012M01	Deep	
013	1	2004/11/26-27	20:04	0:26	20-00.08	155-00.09	5709.0	5739.4	9.2	5701.9	5813.7	013M01	Deep	
013	2	2004/11/27	2:32	2:58	19-59.95	155-00.02	5710.0	194.5	-	198.7	200.7	013M02	Shallow2	
014	1	2004/11/27	7:34	11:30	19-00.09	154-59.81	5638.0	5685.0	10.3	5650.2	5761.8	014M01	Deep	

Table C-2-1 CTD Cast table

STNNBR	CASTNO	Date(UTC)	Time(UTC)		Start Position		Depth	WIRE OUT	HT ABOVE BOTTOM	Max Depth	Max Pressure	CTD data file name	Sample	Remarks
		yyyy/mm/dd	Start	End	Latitude	Longitude								
015	1	2004/11/27	16:04	20:32	17-59.97	154-59.76	5660.0	5673.0	11.7	5644.0	5755.0	015M01	Deep	
016	1	2004/11/28	8:02	11:54	17-00.06	154-59.86	5690.0	5667.2	8.9	5666.7	5776.6	016M01	Deep	
017	1	2004/11/28-29	20:31	0:20	15-59.78	154-59.96	4942.0	4964.2	10.8	4942.1	5028.8	017M01	Deep	
017	2	2004/11/29	3:03	3:25	16-00.10	154-59.94	4968.0	198.0	-	199.0	200.1	017M02	Shallow2	
018	1	2004/11/29	8:09	11:57	15-00.07	154-59.96	5617.0	5622.3	9.2	5599.5	5707.4	018M01	Deep	
019	1	2004/11/29	16:20	21:02	13-59.97	154-59.94	6072.0	5916.0	169.0	5881.0	5999.5	019M01	Deep	
019	2	2004/11/30	4:24	4:47	14-00.01N	155-00.12E	6067.0	298.2	-	298.3	301.2	019M02	Shallow1	
020	1	2004/11/30	11:26	15:31	13-00.05N	154-59.96E	6040.0	5889.7	-	5881.7	5999.5	020M01	Deep	
021	1	2004/11/30-12/1	19:49	0:07	12-00.02N	154-59.89E	5905.0	5912.0	10.7	5879.8	5996.5	021M01	Deep	
021	2	2004/12/1	3:03	3:24	12-00.09N	154-59.75E	5907.0	203.7	-	200.5	200.9	021M02	Shallow2	
022	1	2004/12/1	7:43	11:41	11-00.08N	155-00.11E	5751.0	5753.5	9.3	5730.8	5842.4	022M01	Deep	
023	1	2004/12/1	16:15	20:11	10-00.03N	154-59.91E	5525.0	5495.6	11.8	5493.8	5595.9	023M01	Deep	
023	2	2004/12/2	3:02	3:24	10-00.16N	154-59.92E	5518.0	313.3	-	300.9	303.4	023M02	Shallow1	
024	1	2004/12/2	8:38	12:18	09-00.00N	155-00.06E	5329.0	5319.9	8.5	5297.1	5394.5	024M01	Deep	
025	1	2004/12/2	16:51	19:45	08-00.00N	155-00.12E	3864.0	3887.0	10.5	3842.7	3901.2	025M01	Deep	
026	1	2004/12/3	0:34	0:59	06-59.87N	155-00.35E	4270.0	197.8	-	200.8	202.2	026M01	Shallow2	
026	2	2004/12/3	5:30	8:35	07-00.18N	155-00.24E	4250.0	4256.3	9.3	4220.0	4285.2	026M02	Deep	
027	1	2004/12/3	13:04	16:14	05-59.98N	155-00.17E	4264.0	4278.8	11.1	4246.1	4313.2	027M01	Deep	
028	1	2004/12/3	20:12	22:51	05-05.04N	155-00.11E	3516.0	3500.5	10.9	3492.0	3540.0	028M01	Deep	
028	2	2004/12/4	5:36	5:57	05-04.98N	155-00.02E	3522.0	301.5	-	300.0	301.7	028M02	Shallow1	
029	1	2004/12/4	10:07	12:37	04-05.00N	154-59.96E	3334.0	3225.5	8.9	3368.4	3323.8	029M01	Deep	
030	1	2004/12/4	17:15	19:30	02-59.95N	154-59.98E	2805.0	2807.0	9.8	2792.0	2827.0	030M01	Deep	

Table C-2-1 CTD Cast table

STNNBR	CASTNO	Date(UTC)	Time(UTC)		Start Position		Depth	WIRE	HT ABOVE	Max	Max	CTD data	Sample	Remarks
		yyyy/mm/dd	Start	End	Latitude	Longitude		OUT	BOTTOM	Depth	Pressure	file name		
031	1	2004/12/5	0:34	0:58	02-00.19N	154-59.70E	2750.0	-	-	198.7	201.6	031M01	Shallow2	
031	2	2004/12/5	3:05	5:22	02-00.07N	154-59.98E	2746.0	2741.6	10.6	2734.6	2768.0	031M02	Deep	
032	1	2004/12/5	9:33	11:42	00-59.96N	155-00.06E	2743.0	2734.5	10.9	2728.4	2760.1	032M01	Deep	
033	1	2004/12/5	17:31	19:40	00-00.00N	155-00.02E	2520.0	2507.0	11.2	2502.4	2531.3	033M01	Deep	
033	2	2004/12/6	1:24	1:52	00-00.05S	155-00.14E	2521.0	301.0	-	300.9	303.8	033M02	Shallow1	
033	3	2004/12/6	3:19	3:45	00-00.10N	155-00.07E	2517.0	205.0	-	202.3	203.8	033M03	Shallow2	

4-1:Pressure

The CTD pressure sensor drift in the period of this cruise is estimated from the pressure readings on the ship deck. For best results the Paroscientific sensor has to be powered for at least 10 minutes before the operation and carefully temperature equilibrated. However, CTD system was powered only several minutes before the operation at most of stations. In order to get the calibration data for the pre- and post-cast pressure sensor drift, the CTD deck pressure is averaged over first and last two minutes, respectively. Then the atmospheric pressure deviation from a standard atmospheric pressure (14.7 psi) is subtracted from the CTD pressure. The atmospheric pressure was measured at the captain deck (20 m high from the base line) and averaged over one minute for a meteorological data.

The CTD pressure sensor drift is estimated from the deck pressure obtained above. An average of the pre- and the post-casts data over the whole period of this cruise gave an estimation of –0.67 dbar and the root-mean-square difference of 0.12 dbar. (show Figure.C-2-1-5) And the pre-cruise calibration (July 2004) shows that residual pressure between the Dead Weight Tester and the drift corrected CTD data at 0 dbar was –0.12 dbar. As the result, pressure sensor drift from the pre-cruise calibration is less than 1.0 dbar. So the post-cruise calibration is not deemed necessary for this pressure sensor.

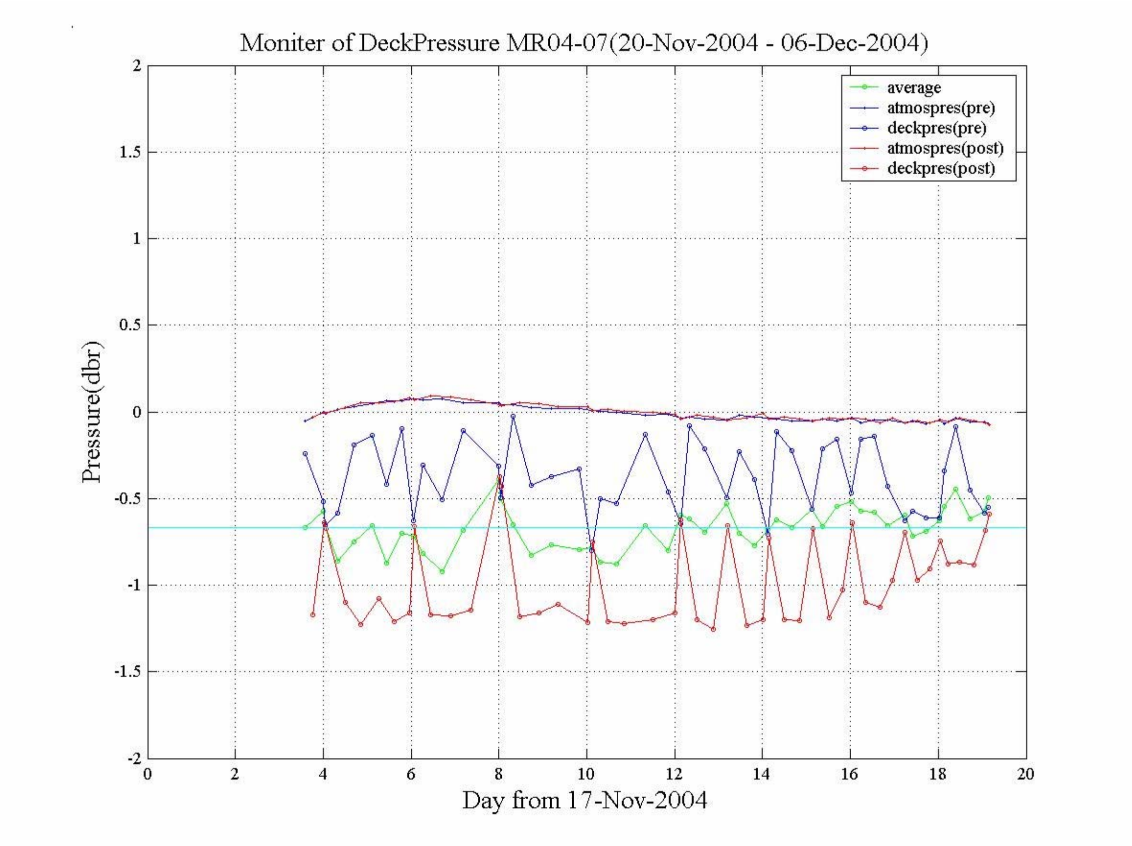
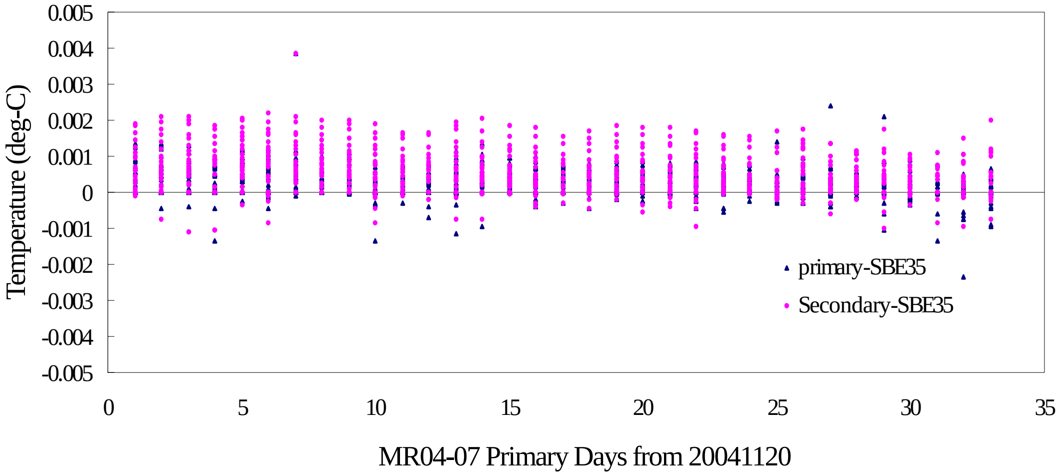


Figure C.2-1-5: Time series of the CTD deck pressure from 17 Nov.2004 to 06 Dec.2004

4.2 Temperature

CTD temperature compared between SBE3 and SBE35 data. Result was Fig C2-1-1-6.



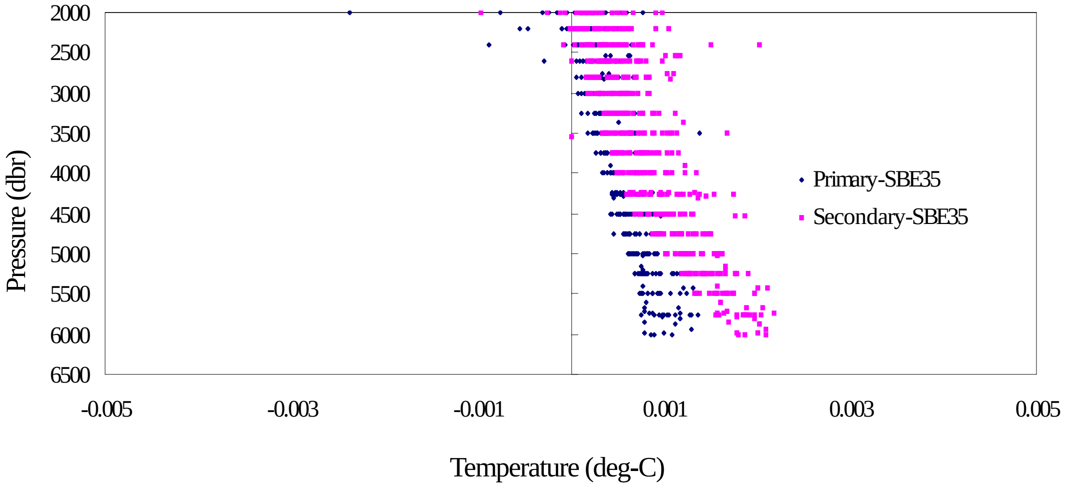


Figure C-2-1-6: Comparison between SBE3 and SBE35 deeper than 2,000dbr.

5 Further calibration

CTD temperature is going to be corrected using SBE35 data. The CTD salinity and dissolved oxygen are going to be calibrated using in-situ salinity and dissolved oxygen data.

C-2-2. Bottle Salinity Measurement

(1) Personnel

Fujio Kobayashi(MWJ)：Operation Leader
Kenichi Katayama (MWJ)

(2) Objective

1. To measure bottle salinity obtained by CTD casts, bucket sampling, and EPCS
2. To calibrate CTD salinity in the way of comparing with bottle salinity

(3) Instrument and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR04-07 using two salinometers (Model 8400B “AUTOSAL”； Guildline Instruments Ltd.: S/N 62556 and 62827) with additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). We also used two pairs of precision digital thermometers (Model 9540； Guildline Instruments Ltd.). One thermometer monitored an ambient temperature and the other monitored a bath temperature.

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

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

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

Thermometer (Model 9540； Guildline Instruments Ltd.)

Measurement Range	:	-180 to +240 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 same as Aoyama *et al.* (2003). The salinometer was operated in the air-conditioned ship's laboratory ‘AUTOSAL ROOM’ at a bath temperature of 24 deg C, very stable and varied within 24 deg C +/- 0.002 deg C on rare occasion.

The measurement for each sample was done with a double conductivity ratio that is defined as median of 31 times reading of the salinometer. Data collection was started in 5 seconds after filling sample to the cell and it took about 10 seconds to collect 31 readings by a personal computer. In case the difference between the double conductivity ratio measured for each sample is smaller than 0.00002, the average value of these double conductivity ratio was used to calculate the bottle salinity with the algorithm for practical salinity scale, 1978 (UNESCO, 1981). If this condition isn’t satisfied within 5 times in a series of measurement for each sample, we will consider the sample as the bad sample.

(3-1) Standardization

The salinometer was standardized at the beginning of the sequence of measurements using IAPSO Standard Seawater (SSW). Because of the good stability of the salinometer, standardize of the salinometer was performed only twice, the Standardize Dial was adjusted at the time. 82 bottles of SSW were measured in total (4 bad bottles were included). The average of the double conductivity ratio for each salinometer was 1.999737 and 1.999734. The standard deviation was 0.000009 and 0.000010, respectively. The value is used for the calibration (linear compensation) of the measured salinity.

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

Standard seawater (SSW)

batch	:	P144
conductivity ratio	:	0.99987
salinity	:	34.995
preparation date	:	23-Sep.-2003

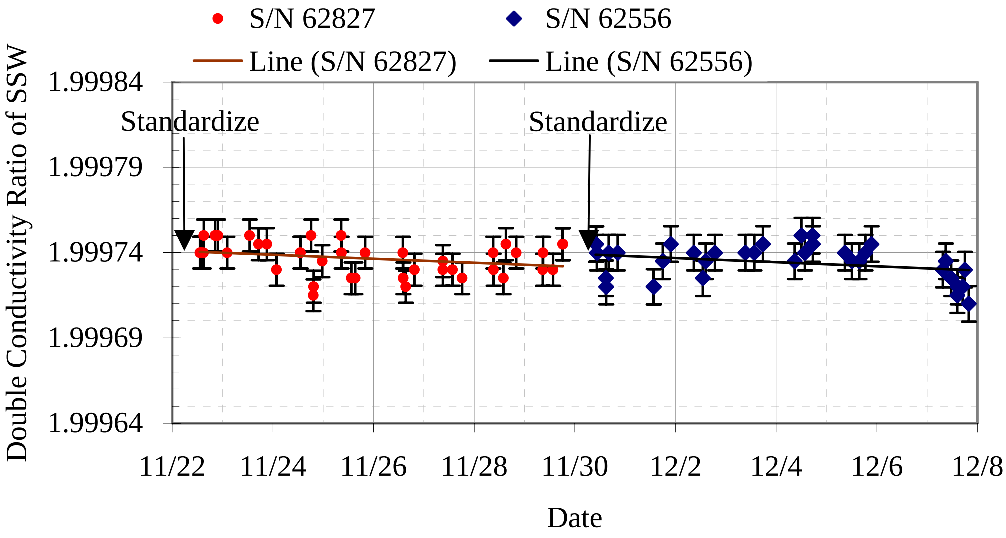


Fig. C.2.2-1 : The history of double conductivity ratio of SSW (P144)

(3-2) Sub-Standard Seawater

We also used sub-standard seawater (SUB) that was sampled and filtered by Millipore filter (pore size: 0.45μm), which was stored in a 20 liters polyethylene container. It was measured every about 6 samples in order to check the drift of the AUTOSAL. During the whole measurements, there was no detectable sudden drift of the salinometer.

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

Sub standard seawater (SUB)

sampling cruise ID : MR03-K04 Leg1
sampling depth : 3,250dbar
filtration date : 21-Aug.-2003

sampling cruise ID : MR03-K04 Leg1
sampling depth : 3,250dbar
re-filtration date : 7-Oct.-2004

sampling cruise ID : MR03-K01
sampling depth : 2,000m
filtration date : 27-Feb.-2003

sampling cruise ID : MR03-ENG
sampling depth : 5,000dbar
filtration date : 6-July-2003

(3-3) Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X (Teflon coating and non-coating) bottle, bucket, and the EPCS. The salinity sample bottle of the 250ml brown grass bottle with screw cap was used to collect the sample water. Each bottle was rinsed three times with the sample water, and was filled with sample water to the bottle shoulder. Its cap was also thoroughly rinsed. The bottle was stored more than 24 hours in 'AUTOSAL ROOM' before the salinity measurement.

The kind and number of samples are shown as follows ;

Table C.2.2-1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD	1,400
Samples for EPCS	18
Total	1,418

(4) Preliminary Results

(4-1) Replicate and Duplicate Samples

We estimated the precision of this method using 178 pairs of replicate samples taken from the same Niskin bottle. Fig.C.2.2-2 shows the histogram of absolute difference between replicate samples. There were 6 questionable measurements in replicate samples. These might be the cause of insufficient seal of the sample bottles or mistake in sampling. Excluding shallow pairs (< 1,000db) and these questionable measurements, the average and the standard deviation of absolute deference among 172 pairs of replicate samples were 0.00016 (M) and 0.00014 (σ), respectively. According to 3σ method ($M + 3\sigma$), the precision of this measurement would be 0.0006 in salinity.

20 pairs of duplicate samples were collected from the different bottles in the same depth to check leak of water bottle, misfire, and miss-trip of CTD with water sampling system. The average and the standard deviation of absolute difference between each pair of replicate and duplicate samples were obtained. The results of replicate and duplicate samples are shown as Table C.2.2-2.

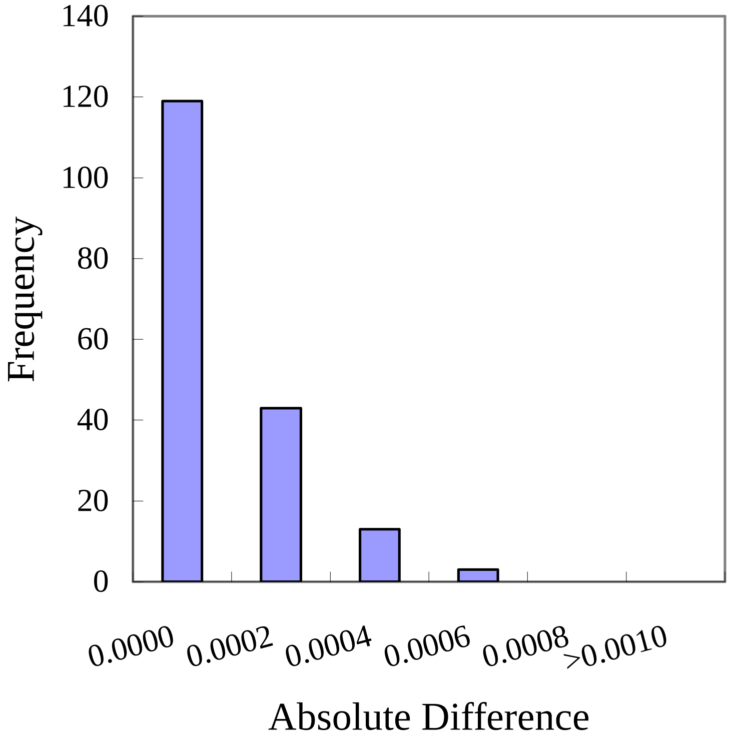


Fig. C.2.2-1 Frequency distribution for replicate samples

Table C.2.2-2 Results of replicate and duplicate samples

Kind of Samples	Number of Samples	Average	Standard deviation
Replicate	172	0.00016	0.00014
Duplicate	20	0.00028	0.00025

(4-2) Comparison between CTD salinity and bottle salinity

The average and standard deviation of difference between CTD salinity and bottle salinity is shown as Table C.2.2-3. Notice that bad data (difference > 0.02 in salinity) and considerably miss-tripped data were excluded.

Table 2.2.2-3 Difference between CTD salinity and bottle salinity

Kind of samples	Number of samples	Average	Standard deviation
Primary sensor (all data)	1,354	0.0020	0.0028
Secondary sensor (all data)	1,312	-0.0054	0.0030
Primary sensor (below 1,000db)	782	0.0020	0.0010
Secondary sensor (below 1,000db)	755	-0.0061	0.0010

(5) Data Archive

All raw and processed salinity data were submitted to Principal Investigator according to the data management policy of JAMSTEC.

(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 Technical Papers in Marine Science*, 36, 25 pp., 1981

C-2-3. Bottle Oxygen

Takayoshi SEIKE (Marine Works Japan Co. Ltd.)
Kimiko NISHIJIMA (Marine Works Japan Co. Ltd.)

(1) Objectives

Determination of dissolved oxygen in seawater by Winkler titration.

(2) Methods

Reagents:

Pickling Reagent I: Manganous chloride solution (3M)
Pickling Reagent II: Sodium hydroxide (8M) / sodium iodide solution (4M)
Sulfuric acid solution (5M)
Sodium thiosulfate (0.025M)
Potassium iodate (0.001667M)

Instruments:

Burette for sodium thiosulfate;
APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel
Burette for potassium iodate;
APB-410 manufactured by Kyoto Electronic Co. Ltd. / 20 cm^3 of titration vessel
Detector and Software; Automatic photometric titrator manufactured by Kimoto Electronic Co. Ltd.

Sampling

Following procedure is based on the WHP Operations and Methods (Dickson, 1996).

Seawater samples were collected with Niskin bottle attached to the CTD-system. Seawater for oxygen measurement was transferred from Niskin sampler bottle 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, 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.

Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. A magnetic stirrer bar and 1 cm^3 sulfuric acid solution 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 two sets of the titration apparatus (DOT-1 and DOT-2). Dissolved oxygen concentration ($\mu mol\ kg^{-1}$) was calculated by sample temperature during seawater sampling, salinity of the sample, and titrated volume of sodium thiosulfate solution without the blank.

Standardization and determination of the blank

Concentration of sodium thiosulfate titrant (ca. 0.025M) 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 (0.001667M). 10 cm^3 of the standard potassium iodate solution was added to a flask using a 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 sodium thiosulfate titrated gave the morality of sodium thiosulfate titrant.

The blank from the presence of redox species apart from oxygen in the reagents was determined as follows. 1 cm^3 of the standard potassium iodate solution was added to a flask 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 were added into the flask in order. Just after titration of the first potassium iodate, a further 1 cm^3 of standard potassium iodate was added and titrated. The blank was determined by difference between the first and second titrated volumes of the sodium thiosulfate. The oxygen in the pickling reagents I (0.5 cm^3) and II (0.5 cm^3) were assumed to be 3.8×10^{-8} mol (Dickson, 1996).

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

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

Date	KIO_3	DOT-01			DOT-02		
		$Na_2S_2O_3$	E.P.	Blank	$Na_2S_2O_3$	E.P.	Blank
2004/11/20	040723-092	20041119-1	3.960	-0.008	20041119-2	3.965	-0.009
2004/11/20	040723-092	20041119-1	3.963	-0.008	20041119-2	3.968	-0.009
2004/11/21	040723-093	20041119-1	3.959	-0.008	20041119-2	3.965	-0.008
2004/11/22	040723-094	20041119-1	3.958	-0.007	20041119-2	3.964	-0.005
2004/11/22	040723-094	20041119-3	3.960	-0.006	20041119-4	3.965	-0.008
2004/11/23	040723-095	20041119-3	3.960	-0.006	20041119-4	3.965	-0.007
2004/11/25	040723-096	20041119-3	ー	ー	20041119-4	3.964	-0.007
2004/11/25	040723-096	20041119-5	3.962	-0.007	20041123-1	3.970	-0.006
2004/11/26	040723-097	20041119-5	3.959	-0.008	20041123-1	3.969	-0.007
2004/11/26	CSK	20041119-5	3.953	ー	20041123-1	3.964	ー
2004/11/27	040723-098	20041119-5	3.960	-0.009	20041123-1	3.972	-0.008
2004/11/27	040723-098	20041123-2	3.967	-0.008	20041123-3	3.973	-0.007
2004/11/29	040723-099	20041123-2	3.965	-0.008	20041123-3	3.971	-0.008
2004/11/30	040723-100	20041123-2	3.968	-0.008	20041123-3	3.973	-0.006
2004/11/30	040723-100	20041123-4	3.967	-0.007	20041123-5	3.970	-0.006
2004/12/01	040723-101	20041123-4	3.968	-0.007	20041123-5	3.970	-0.007
2004/12/02	040723-102	20041123-4	3.970	-0.005	20041123-5	3.970	-0.006
2004/12/02	040723-102	20041128-1	3.961	-0.006	20041128-2	3.964	-0.006
2004/12/03	040723-103	20041128-1	3.955	-0.006	20041128-2	3.962	-0.006
2004/12/04	040723-104	20041128-1	3.959	-0.006	20041128-2	3.963	-0.006
2004/12/04	040723-107	20041128-1	3.958	ー	20041128-2	3.962	ー
2004/12/04	040723-107	20041128-3	3.961	-0.006	20041128-4	3.963	-0.008
2004/12/05	040723-108	20041128-3	3.961	-0.006	20041128-4	3.963	-0.007
2004/12/06	040723-109	20041128-3	3.960	-0.007	20041128-4	3.962	-0.007
2004/12/06	040723-109	20041128-3	3.949	ー	20041128-4	3.952	ー

(3) Reproducibility of sample measurement

Replicate samples were taken at every CTD cast; usually these were 5 - 10 % of seawater samples of each cast during this cruise. Results of the replicate samples were shown in Table 2 and this histogram shown in Fig.1. The standard deviation was calculated by a procedure (SOP23) in DOE (1994).

Table 2 Results of the replicate sample measurements

Number of replicate sample pairs	Oxygen concentration (μmol/kg)
	Standard Deviation.
113	0.07

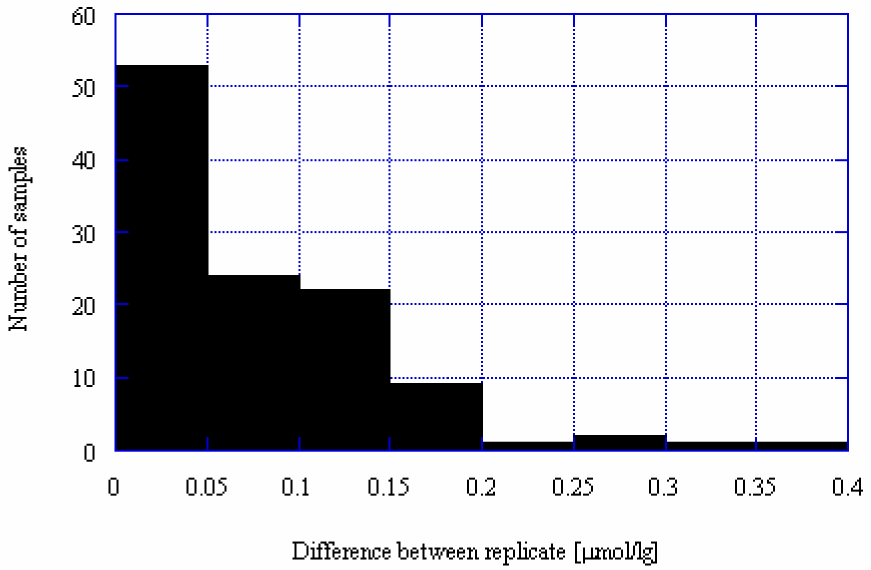


Fig.1 Results of the replicate sample measurements

(4) Preliminary results

During this cruise we measured oxygen concentration in 1,696 seawater samples at 33 stations.

References:

Dickson, A. (1996) Dissolved Oxygen, in WHP Operations and Methods, Woods Hole, pp1-13.

DOE (1994) Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2. A.G. Dickson and C. Goyet (eds), ORNL/CDIAC-74.

Emerson, S, S. Mecking and J.Abell (2001) The biological pump in the subtropical North Pacific Ocean: nutrient sources, redfield ratios, and recent changes. *Global Biogeochem. Cycles*, 15, 535-554.

Watanabe, Y. W., T. Ono, A. Shimamoto, T. Sugimoto, M. Wakita and S. Watanabe (2001) Probability of a reduction in the formation rate of subsurface water in the North Pacific during the 1980s and 1990s. *Geophys. Res. Letts.*, 28, 3298-3292.

C-2-4. Nutrients

1. Personnel

Junko HAMANAKA, Ayumi TAKEUCHI, Kenichiro SATO (MWJ)
Shuichi WATANABE (JAMSTEC)

2. Objectives

The vertical and horizontal distributions of the nutrients are one of the most important factors on the primary production. During this cruise nutrient measurements will give us the important information on the mechanism of the primary production or seawater circulation.

3. Methods or Apparatus & Performance

Nutrient analysis was performed on two BRAN+LUEBBE TRAACS 800 systems that have 4-channel analyzing systems for nitrate, nitrite, silicate and phosphate. The systems of analysis were improved which proposed for nutrients of seawater by BRAN+LUEBBE. The new systems are shown in Figures C-2-1 - 4.

The laboratory temperature was maintained between 25-27 deg C.

a. Measured Parameters

Nitrite: Nitrite was determined by diazotizing with sulfanilamide and coupling with N-1-naphthyl-ethylenediamine (NED) to form a colored azo dye that was measured absorbance of 550 nm using 5 cm length cell.

Nitrate: Nitrate in seawater is reduced to nitrite by reduction tube (Cd - Cu tube), and the nitrite determined by the method described above, but the flow cell used in nitrate analysis was 3 cm length cell. Nitrite initially present in the sample is corrected.

Silicate: The standard AAII molybdate-ascorbic acid method was used. The silicomolybdate produced is measured absorbance of 630 nm using a 3 cm length cell.

Phosphate: The method by Murphy and Riley (1962) was used with separate additions of ascorbic acid and mixed molybdate-sulfuric acid-tartrate. The phospho-molybdate produced is measured absorbance of 880 nm using a 5 cm length cell.

Nutrients reported in micromoles per kilogram were converted from micromoles per liter by dividing by density calculated at sample temperature.

b. Nutrients Standard

Silicate standard solution, the silicate primary standard, is obtained from Kanto

Chemical CO., Inc. This standard solution is 1000 mg per litter with 0.5 M KOH and prepared for ICP analysis. Primary standard for nitrate (KNO_3), nitrite ($NaNO_2$) and phosphate (KH_2PO_4) obtained from Wako Pure Chemical Industries, Ltd.

c. Sampling Procedures

Samples were drawn into two of virgin 10 ml polyacrylates vials that were rinsed three times before sampling without sample drawing tubes. Sets of 5 different concentrations of the shipboard standards were analyzed at beginning, halfway and end of each group of analysis. The standard solutions of highest concentration were measured every 12–13 samples and were used to evaluate precision of nutrients analysis during the cruise. We also used three concentrations of reference material for nutrients in seawater, RMNS (KANSO Co., Ltd., lots AS, AT and AU), for all runs to secure traceability on nutrient analysis throughout the cruise.

d. Low Nutrients Sea Water (LNSW)

Low nutrients seawater was collected in January 2002 at equatorial Pacific and filtered with 0.45 μm pore size membrane filter (Millipore HA), which was used for the shipboard standard solution.

4. Preliminary Results

Analytical precisions of nitrate, nitrite, silicate, and phosphate were less than 0.19% (55 μM), 0.21% (1.2 μM), 0.18% (172 μM) and 0.24% (3.7μM), respectively. Results of RMNS analysis are shown in Table C-2-4.1.

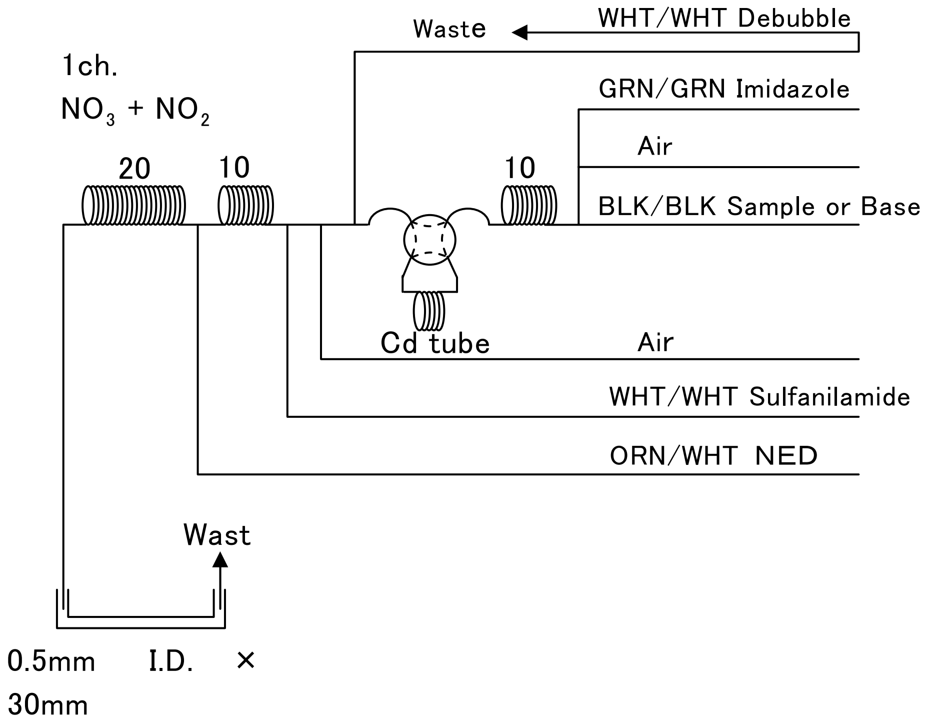


Figure C-2-4.1 1ch. (NO_3+NO_2) Flow diagram.

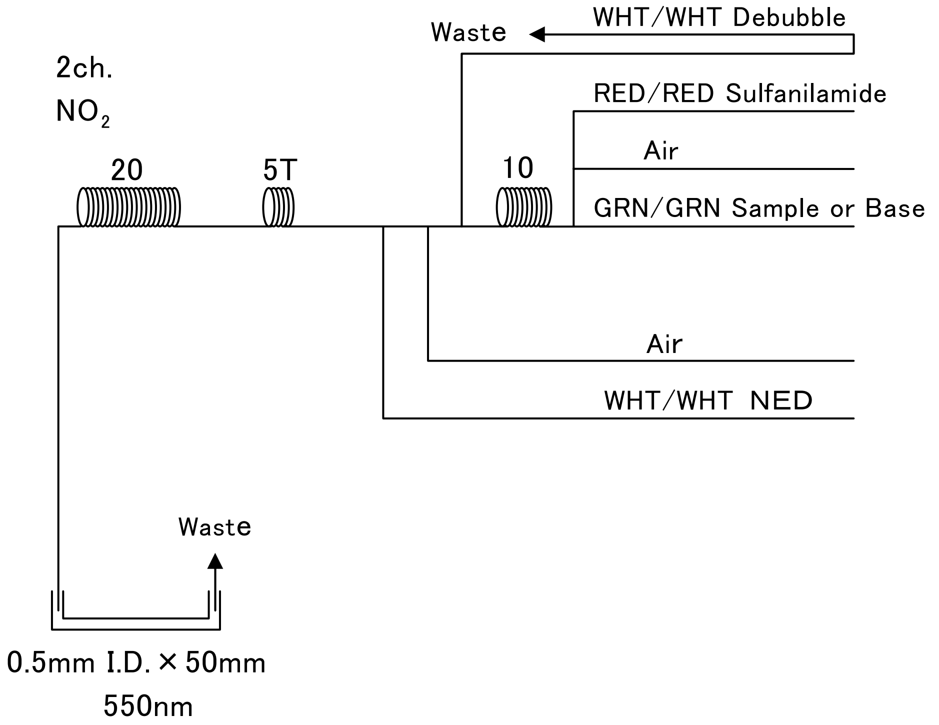


Figure C-2-4.2 2ch. (NO_2) Flow diagram.

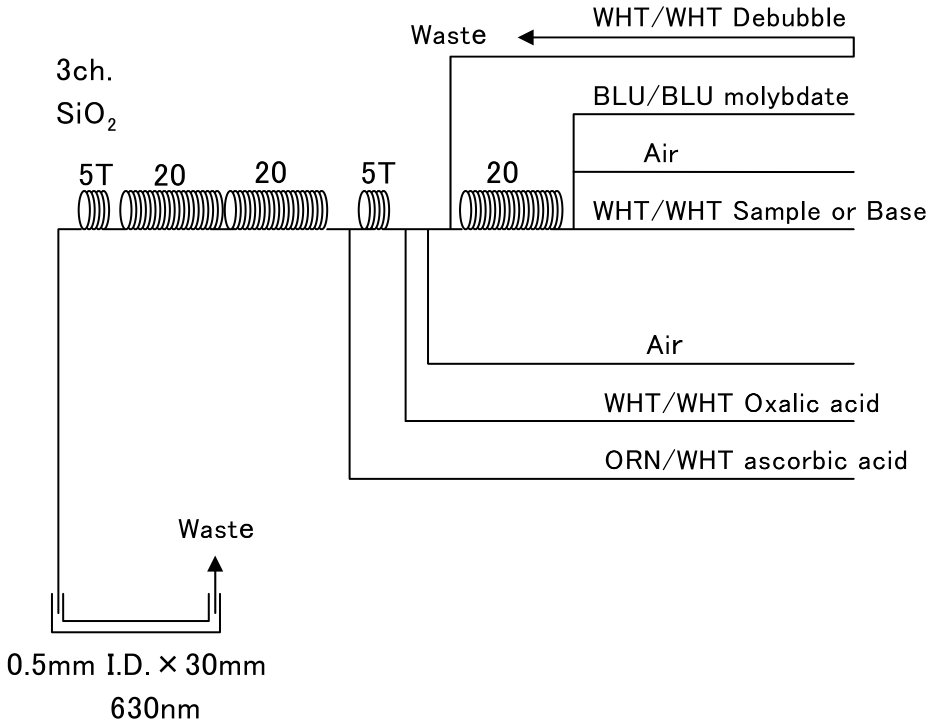


Figure C-2-4.3 3ch. (SiO_2) Flow diagram.

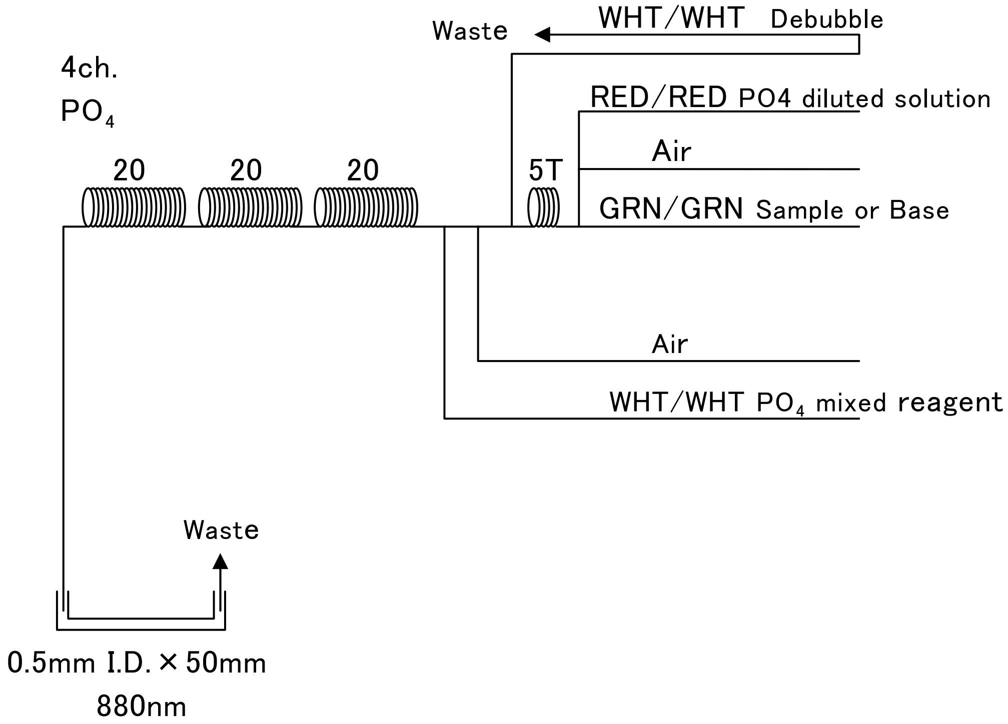


Figure C-2-4.4 4ch. (PO_4) Flow diagram.

Table C-2-4.1 Summary of RMNS concentrations

μmol/kg

		NO_3	NO_2	SiO_2	PO_4
RM-AS	avg	0.10	0.01	1.65	0.07
	stdev	0.02	0.00	0.05	0.01
	n=	33	33	33	33
RM-AT	avg	7.46	0.01	18.32	0.58
	stdev	0.03	0.00	0.08	0.01
	n=	33	33	33	33
RM-AU	avg	29.98	0.01	68.09	2.18
	stdev	0.06	0.00	0.18	0.01
	n=	66	66	66	66

C-2-5. Total Dissolved Inorganic Carbon Measurement

(1) Personnel
Minoru KAMATA (MWJ)
Fuyuki SHIBATA (MWJ)

(2) Objective

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; alkalinity, total dissolved inorganic carbon, pH and pCO_2. If two of these four are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994). We here report on board measurements of total dissolved inorganic carbon (TDIC) during MR04-07 cruise.

(3) Measured Parameters

Total dissolved inorganic carbon

(4) Apparatus and performance

(4)-1 Seawater sampling

Seawater samples were collected by CTD-CMS mounted a 12L Niskin bottles at 33 stations. Seawater was sampled in a 250ml glass bottle that was previously soaked in 5% non-phosphoric acid detergent (pH13) solution for at least 3 hours and was cleaned by fresh water and Milli-Q deionized water for 3 times each. A sampling tube was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for two times volume of bottle with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the glass bottles were removed to the laboratory to be analyzed. Prior to the analysis, 3ml of the sample (1% of the bottle volume) was removed from the glass bottle in order to make a headspace. The samples were then poisoned with 100μl of over saturated solution of mercury chloride within one hour from the sampling point. After poisoning, the samples were sealed using a grease (Apiezon M grease) and a stopper-clip. The samples were stored in a refrigerator at approximately 5℃ until analyzed.

(4)-2 Seawater analysis

We used two similar analysis systems for total dissolved inorganic carbon measurement (system A and system B). Their system was connected a Model 5012 coulometer (Carbon Dioxide Coulometer, UIC Inc.), an automated sampling and CO_2 extraction system controlled by a computer (JANS, Inc.). The concentration of TDIC in seawater was measured as follows.

The sampling cycle was composed of 3 measuring factors; 70ml of standard CO_2 gas (2% CO_2 - N_2 gas), 2ml of 8%-phosphoric acid solution and 6 seawater samples. The standard CO_2 gas was measured to confirm the constancy of the calibration factor during a run and phosphoric acid was measured for acid blank correction.

The temperature of samples were controlled at 20℃ by a thermostatic water bath before analysis. From the glass bottle, approximately 20ml(system A), 28ml (system B) of seawater was measured in a receptacle and was mixed with 2ml of 10%-phosphoric acid. The carbon dioxide gas evolving from the chemical reaction was purged by nitrogen gas (carbon dioxide free) for 10min. (system A) or 12 min. (system B) at the flow rate of 130-140ml/min. and was absorbed into an electrolyte solution. In the electrolyte solution, acids forming from the reaction between the solution and the absorbed carbon dioxide were titrated with hydrogen ions in the coulometer and the counts of the titration were stored in the computer.

After the samples were measured, the calibration factor (slope) was calculated by measuring series of sodium carbonate solutions (0~2.5mM) and this calibration factor was applied to all of the data acquired throughout the cruise. By measuring Certified Reference Material (CRM batch 60; 1991.24μmol/kg, batch 65; 1993.68μmol/kg: Scripps Institution of Oceanography) at the start of every run series, the slope was calibrated with the counts of this outcome. We also carried out a reference material (system A: KRM batch G, system B: QRM batch Q10) measurement during every run as well as CRM measurements. QRM was prepared in JAMSTEC by a similar procedure of CRM preparation. KRM was created by KANSO. A set of cell solution was changed after approximately 80 seawater samples were measured.

(5) Preliminary results

During the cruise, 1214 samples were analyzed for TDIC. A replicate analysis was made on every nineth seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure C-2-5). The average of the differences was 1.5 μmol/kg (n=124). The standard deviation was 1.3 μmol/kg that indicates that the analysis was accurate enough according to DOE (1994). CRM (batch 60) measurement results that the average was 1993.9 μmol/kg (n=10:system A) and 1993.7 μmol/kg (n=7:system B), the standard deviation was 0.9 μmol/kg and 0.5 μmol/kg respectively.

(6) Data Archive

All data will be submitted to JAMSTEC Data Management Office (DMO) and is currently under its control.

Reference

DOE (1994), Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74

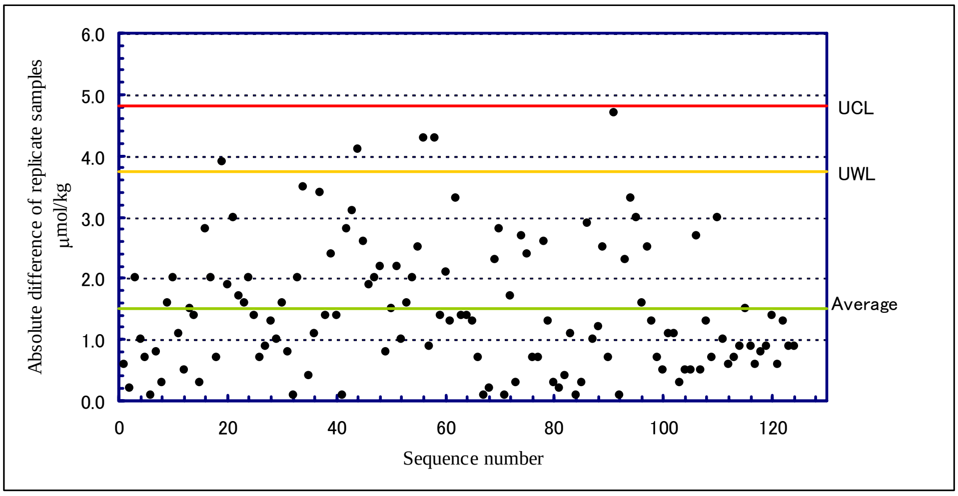


Figure C-5-2 Absolute difference of replicate measurements

C-2-6. Total alkalinity and pH measurement

(1) Personnel

Mikio Kitada (MWJ)
Taeko OHAMA (MWJ)

(2) Objective

Since the global warming is becoming an issue world-widely, studies on the green house gas such as CO_2 are drawing high attention. Because the ocean plays an important roll in buffering the increase of atmospheric CO_2, studies on the exchange of CO_2 between the atmosphere and the sea becomes highly important. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Unfortunately, the concentrations of the individual species of CO_2 system in solution cannot be measured directly. There are, however, four parameters that could be measured; alkalinity, total dissolved inorganic carbon, pH and pCO_2. If two of these four are measured, the concentration of CO_2 system in the water could be estimated (DOE, 1994). We here report on board measurements of total alkalinity (TA) and pH during MR04-04 cruise.

(3) Measured Parameters

Total alkalinity
pH

(4) Apparatus and performance

(4)-1 Seawater sampling

Seawater samples were collected by 12L Niskin bottles at 41 stations. Seawater was sampled in a 125ml glass bottle that was previously soaked in 5% non-phosphoric acid detergent (pH13) solution for at least 2 hours and was cleaned by fresh water and Milli-Q deionized water for 3 times each. A sampling tube was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 10 seconds. After collecting the samples on the deck, the glass bottles were removed to the lab to be analyzed. The samples were stored in a refrigerator at approximately 5℃ until analyzed.

(4)-2 Seawater analysis

(4)-2-1 Total alkalinity

Measurement of TA was made using a titration systems (Nippon ANS, Inc.). The systems comprise of a water dispensing unit, an auto-burette (Metrohm) and a pH meter (Thermo Orion), which are automatically controlled by a PC. The concentration of TA was measured as follows.

A seawater of approx. 40 ml is transferred from a sample bottle (brosilicate glass bottle; 130 ml) into a water-jacketed (25 ºC), and is introduced into a water-jacketed (25 ºC) titration cell. The seawaters are titrated by a acid titrant, which was 0.05 M HCl in 0.65 M NaCl in this cruise.

Calibration of the acid titrant was made by measuring TA of 6 solutions of Na_2CO_3 in 0.7 M NaCl solutions. The computed TAs were approx. 0, 500, 1000, 1500, 2000 and 2500 μmol kg^{-1}. The measured values of TA (calculated by assuming 0.05 M) should be a linear function of the TA contributed by the Na_2CO_3. The line was fitted by the method of least squares. Theoretically, the slope should be unity. If the measured slope is not equal to one, the acid normality should be adjusted by dividing initial normality by the slope, and the whole set of calculations is repeated until the slope = 1.

Calculation of TA was made based on a modified Gran approach.

Certified Reference Material (CRM batch 60 and 65: Scripps Institution of Oceanography) were measured at the end of every run series to calibrate measurement values. Before and halfway and after the samples were measured, We also carried out a reference material (Q10) measurement during every run as well as CRM measurements.

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(4)-2-2 pH

pH(-log[H^+]) of the seawater was measured potentiometrically in the closed cell at the temperature 25 ℃ (pH_{25}). The cell with liquid junction or 'salt bridge' (saturated solution of KCl) was applied.

Ag, AgCl| solution of KCl || test solution |H+ -glass –electrode.

The e.m.f. of the glass / reference electrode cell was measured with a pH / Ion meter (Radiometer PHM95). Separate glass (Radiometer PHG201) and reference (Radiometer REF201) electrodes were used. In order not to have seawater sample exchange CO_2 with the atmosphere during pH measurement, closed glass container with water jacket was used. The temperature during pH measurement was monitored with temperature sensor (Radiometer T901) and controlled to 25℃ within ±0.1℃.

To calibrate the electrodes the TRIS (pH=8.0936 pH unit at 25℃, Delvalls and Dickson, 1998) and AMP (pH=6.786 pH unit at 25℃, Dickson and Goyet, 1996) in the synthetic seawater (S=35 PSU) (Total hydrogen scale) were applied.

pH_{sws} of seawater sample (pH_{samp}) is calculated from the expression

$$pH_{samp} = pH_{TRIS} + (E_{TRIS} - E_{samp}) / ER$$

where electrode response "ER" is calculated as follows:

$$ER = (E_{AMP} - E_{TRIS}) / (pH_{TRIS} - pH_{AMP})$$

ER value should be equal to the ideal Nernst value as follows:

$$ER = RT\ LN(10) / F = 59.16\ mV / pH\ unit\ at\ 25℃$$

(5) Preliminary results

(5)-1 Total alkalinity

A duplicate analysis was made on every 12th seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure C-2-6-1). The average of the difference was 1.5 μmol/kg (n=123 pairs). The standard deviation was 1.4 μmol/kg which indicates that the analysis was accurate enough according to DOE (1994).

(5)-2 pH

A duplicate analysis was made on every 9th seawater sample and the difference between each pair of analyses was plotted on a range control chart (see Figure C-2-6-2). The average of the difference was 0.001 pH unit (n=120 pairs). The standard deviation was 0.002 pH unit, which indicates that the analysis was accurate enough according to DOE (1994).

(6) Data Archive

All data will be submitted to JAMSTEC Data Management Office (DMO) and is currently under its control.

Reference

DOE (1994), Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2, A. G. Dickson & C. Goyet, Eds., ORNS/CDIAC-74

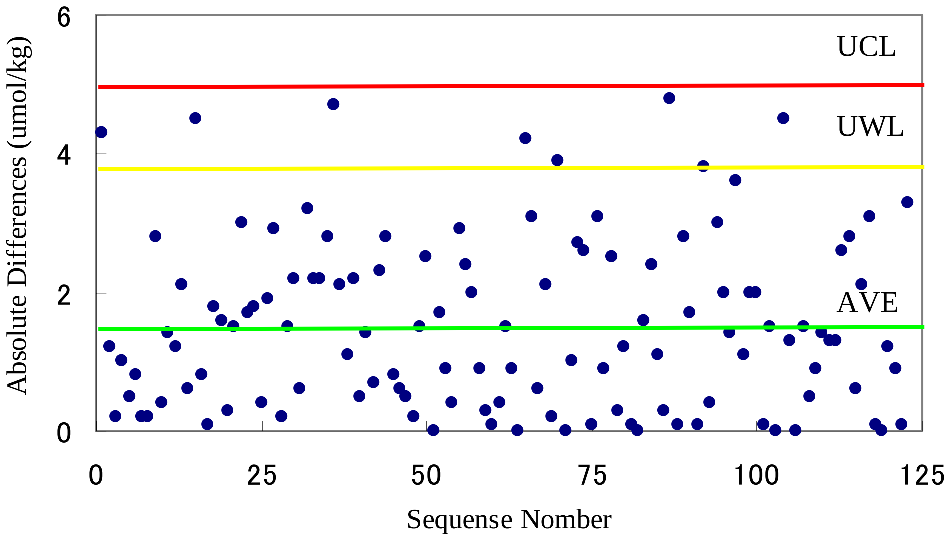

Figure C-2-6-1 Absolute differences of replicate measurements of TA

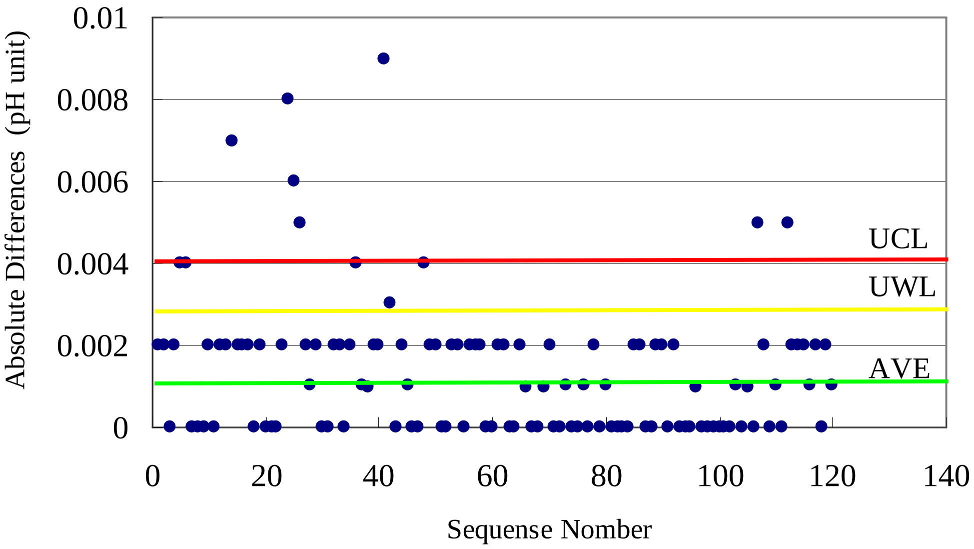

Figure C-2-6-2 Absolute differences of replicate measurements of pH

C-2-7. Chlorofluorocarbons

Shuichi WATANABE[1)], Katsunori SAGISHIMA[2)], Hideki YAMAMOTO[2)]
1) Japan Agency for Marine-Earth Science and Technology
2) Marine Works Japan Co. Ltd

(1) Objectives

Chlorofluorocarbons (CFCs) are the artificially formed gas. CFC-11 (CCl_3F), CFC-12 (CCl_2F_2) , CFC-113 ($C_2Cl_3F_3$) are useful chemical tracers to clarify the water movement. We determined dissolved CFC-11, CFC-12, CFC-113 concentrations in seawater on board.

(2) Apparatus

Dissolved CFCs concentrations in seawater were determined with an electron capture detector - gas chromatograph (ECD-GC) attached the purge and trapping system.

Table C-3-2-1 Instruments and analytical conditions

Instruments	
Gas Chromatograph:	GC-14B (Shimadzu Ltd.)
Detector:	ECD-14 (Shimadzu Ltd)
Column:	
Pre column:	Plot Fused Silica (i. d.: 0.53mm, length: 7m, tick: 6.0μm)
Main column:	Pola BOND – Q (i. d.: 0.53mm, length: 9m, tick: 6.0μm) & Plot Fused Silica (i.d.:0.53mm, length: 30m, tick 0.25μm)
Temperature	
Oven:	95 deg-C
Detector:	250 deg-C
Trapping & desorbing:	-45 deg-C & 130 deg-C
Gas flow rate	
Carrier gas:	17 ml/min
Detector Make UP:	20 ml/min
Column Purge:	30 ml/min
Sample purge:	190 - 200 ml/min

(3) Procedures

(3-1) Sampling

Seawater samples for CFCs measurement were collected from 12 litter Niskin bottles to N2 purged 300ml glass bottle with specially ordered Swagelok unions. Two times bottle volumes of seawater sample were overflowed to minimize contamination with atmospheric CFCs.

Air samples for CFCs measurement were collected to 100ml glass cylinder at the navigation deck on R/V “MIRAI”.

(3-2) Analysis

The CFCs analytical system was modified from the original design of Bullister and Weiss (1988). Sample volume was 50ml. The trap used to hold CFCs consists of a length of 1/8 in. o.d. SS tubing packed with 3 cm of Porapak® type T (80/100 mesh) and 5 cm of Res-Sil ™ C. Trapping and desorbing temperature were - 45 deg-C and 130 deg –C, respectively. The trapped gas was transformed to GC system directly. Analytical conditions were bellow.

(4) Performance

The standard gases used in this cruise will be calibrated to SIO scale standard gases after the cruise, and then the data will be corrected.

(5) Results

We did the analysis of 33 casts in this cruise. .Preliminaly results was shown in fig C-2-7-1.

(6) Data archive

All data will be submitted to JAMSTEC Data Management Office (DMO) and under its control.

(7) Reference

Bullister, J.L and Weiss R.F. 1988. Determination of CCl_3F and CCl_2F_2 in seawater and air. Deep Sea Research, 35, 839-853.

C-2-8. Chlorophyll *a* Measurements of size-fractionated phytoplankton

1. Personnel

Masanori Enoki (MWJ) : Operation Leader

2. Objective

Phytoplankton are existed various species and size in the ocean. Phytoplankton species are roughly characterized by the cell size. The object of this study is to investigate the vertical distribution of phytoplankton by using the size-fractionated filtration method in the Western North Pacific Ocean.

3. Methods

Seawater samples were collected 1 liter at 11 layers(Shallowcast) and 0.5 liter at 5 layer(Deepcast) from surface to 200m using Niskin bottles, except for the surface water, which was taken by the bucket. At after sampling, Shallowcast samples were gently vacuum-filtrated (<15cmHg) through the three types of 47mm-diameter nuclepore filters (pore size of 10.0μm, 3.0μm and 1.0μm) and the 25mm-diameter Whatman GF/F filter (pore size of about 0.7μm) .Deepcast samples ware gently vacuum-filtrated (<15cmHg) through 25mm-diameter Whatman GF/F filter. Phytoplankton pigments on the filters were immediately extracted in a polypropylene tube with 7 mL of N,N-dimethylformamide after filtration. Then, the extracted samples were stored at –20℃ under the dark condition for extraction of chlorophyll *a*. Over 24 hours, fluorescence of the samples were measured by using Turner Design fluorometer (10-AU-005), which was previously calibrated against a pure chlorophyll *a* (Sigma chemical Co.). We selected the fluorometric “Non-acidification” method. Analytical condition of this method are indicated in Table 1.

4. Data archives

The processed data file of Chlorophyll *a* was copied onto CD-ROM and submitted to Chief Scientist.

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

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

C-2-9. The Measurement of marine phytoplankton pigments by HPLC

1. Personnel

Yuichi SONOYAMA (Marine Works Japan Ltd.) : Operation Leader

2. Objective

The chemotaxonomic assessment of phytoplankton populations present in natural seawater requires good biochemical markers and very efficient analytical tools. A high-performance liquid chromatographic (HPLC) mesurement has been shown to be a conclusive method for separating and quantifying photosynthetic pigments in natural seawater.

In this cruise, we mesured the marine phytoplankton pigments by HPLC method to investigate the marine phytoplankton community structure at section of 155E in the Westurn-North Pacific Ocean.

3. Methods & Performance

Seawater were collected at 12 depths from surface to 200m using Niskin bottles, except for the surface water, which was taken by a bucket. The water sample (3~5L) were gently vaccum-filtrated (<15 cmHg) through and phytoplankton cells in the water were collected on the 47 mm-diameter Whatman GF/F filter (pore size: c.a. 0.7 μm). To remove the remaining seawater of the sample filters, we vacuumized the filters in freezer (-20 deg C) for 1 hour. After that, phytoplankton pigments on a filter was extracted in a glass tube with 4 mL of N,N-dimethylformamide (HPLC-grade), stored in freezer (-20 deg C) over 24 hours.

Extracts were filtered through 25 mm-diameter polypropylene syringe (pore size: 0.2 μm) to remove cell and filter debris. They are measured by HPLC method which was modified the method of Zapata *et al* (2000).

3.1 HPLC System

HPLC System was a Waters modular system (high dwell volume) including a Waters 600 S controller, a Waters 616 pump (low-pressure mixing system), a Waters 717 Plus autosampler (2400 μl loop) and a Waters 996 photodiodearray detector (2.4 nm optical resolution).

3.2 Stationary phase

Analytical separations were performed using a YMC C_8 column (150×4.6 mm). The column was thermostatted at 25 deg C by column heater box.

3.3 Mobile phases

Eluent A was a mixture of methanol : acetonitrile : aqueous pyridine solution (0.25M pyridine) (50 : 25 : 25 v : v: : v) while eluent B was acetonitrile : acetone (80 : 20 v: : v). Organic solvents employed to prepare mobile phases were HPLC-grade.

3.4 Standard Solutions

The HPLC system is calibrated with the following commercially pigment standards (Table 1). We selected Chlorophyll *a*, Chlorophyll *b* (Sigma) and other 19 pigments (VKI). Concentrations of pigment standards were determined using its extinction coefficient of substance by spectroometer.

3.5 Pigment detection and identification

Chlorophylls and carotenoids were detected by photodiode array spectroscopy (350~720nm). We calculated sample's pigment cocentrations from peak area by three identification methods.

First , Chlorophyllide *a*, Pheophorbide *a*, Divinyl Chlorophyll *a* and Chlorophyll *a* were identified at 664.0 nm of wavelength.

Second, Chlorophyll *b* was identified at 457.2 nm of wavelength.

Third, other pigments were identified at 460.0 nm of wavelength.

4. Data archives

The processed data file of pigments was copied onto CD-ROM and submitted to the Chief Scientist.

Refference：

Zapata M, Rodriguez F, Garrido JL (2000) Separation of chlorophylls and carotenoids from marine phytoplankton : a new HPLC method using a reversed phase C8 column and pyridine-containing mobile phases. Mar. Ecol Prog Ser 195：29-45

Table.1 Peak identification table of the pigments.

No.	Pigment	Retension Time (min.)	Wavelength (max：nm)	Extinction Coefficient (l/g/cm)
1	Chlorophyll C3	8.515	452.5	346
2	Chlorophyllide *a*	10.633	664.5	127
3	Chlorophyll C2	11.957	447	374
4	Peridinin	14.695	474.5	132.5
5	Pheophorbide *a*	17.100	665.5	74.2
6	19'-butanoyloxyfucoxanthin	17.817	446	160
7	Fucoxanthin	18.823	449.5	160
8	Neoxanthin	19.440	437	224.3
9	Prasinoxanthin	20.482	454.5	160
10	19'-hexanoyloxyfucoxanthin	21.145	446	160
11	Violaxanthin	21.217	440	255
12	Diadinoxanthin	23.445	446.5	262
13	Alloxanthin	25.483	452.5	262
14	Myxoxanthophyll	25.538	449.5	125.3
15	Diatoxanthin	26.140	452	262
16	Zeaxanthin	26.715	450.5	254
17	Lutein	26.807	445	255
18	Chlorophyll *b*	30.270	457.2	51.23
19	Echinenone	30.712	463	215.2
20	Divinyl Chlorophyll *a*	31.295	664	87.67
21	Chlorophyll *a*	31.638	664	88.74
22	Alpha-carotene	34.300	447.5	270
23	Beta-carotene	34.423	452	262

C-2-10.　Primary productivity

Personnel

Ai YASUDA 1), Takuhei SHIOZAKI 1)

1)　Marine Works Japan LTD

(1) Objective

The objective of this study is to known the mechanism of primary production at the open sea on the each station.

(2) Mehtods of Apparatus and Performance

Simulated in-situ incubation

Bottles for incubation and filters

Bottles for incubation are ca. 1 liter Nalgen polycarbonate bottles with screw caps. Grass fiber filters (Whatman GF/F 25mm) pre-combusted with temperature 450 degree C for at least 4 hours, were used for a filtration.

Simulated in-situ incubation

We took two transparent samples from 7 layers took from the surface and six predefined depth by a bucket and Niskin bottles at St. 2, 6, 10, 13, 17, 21, 26, 31 and 33. These depths corresponded to nominal specific optical depths i.e. 50%, 25%, 10%, 5%, 2.5% and 1% light intensity relative to the surface irradiance, PAR, as determined from the optical profiles.

All samples were spiked with 0.2 mmoles/mL of $NaH^{13}CO_3$ solution (1 mL per 1 bottle). After spike, bottles were placed into incubators by neutral density filters corresponding to nominal light levels at the depth at which samples were taken. All samples were incubated in a bath on the deck for 24 hours.

At the end of the incubation period, samples were filtered through Grass fiber filters (Whatman GF/F 25mm). GF/F filters were kept to freeze till analyse. After that, filters were dried on the oven of 45 degree C at least 20 hours.

Measurement

After the filtration, all samples were measured by a mass spectrometer ANCA-SL system at MIRAI.

C-2-11. Phytoplankton abundances

(1) Personnel

Kazuhiko Matsumoto (JAMSTEC)

(2) Objectives

The main objective of this study is to estimate phytoplankton abundance and distribution in the north-western Pacific. We measured phytoplankton abundances with two kinds of methods: microscopy for large size phytoplankton and flowcytometry for picophytoplankton.

(3) Materials and Methods

1) Microscopy

Water samples were placed in 500 ml plastic bottle and fixed with neutral buffered formalin solution (3% final concentration). The measurements will be scheduled after cruise.

2) Flowcytometry

2)-1 Equipment

The flowcytometry system used in this research was BRYTE HS system Bio-Rad Laboratories Inc. System specification were follows:

Light source: 75W Xenon arc lamp
Excitation wavelength: 350-650 nm
Detector: high-performance PMT
Analyzed volume: 75 µl
Flow rate: 10 µl min^{-1}
Sheath fluid: Milli-Q water
Filter block: B2 as excitation filter block, OR1 as fluorescence separator block
B2 and OR1 have ability as follows:

B2:	Excitation filter	390-490 nm
	Beam-splitter	510 nm
	Emission filter	515-720 nm
OR1:	Emission filter 1	565-605 nm
	Beam-splitter	600 nm
	Emission filter 2	>615 nm

2)-2 Sampling

Water samples were immediately filtered with 10 µm filter which mounted with filter holder, and placed in 50 ml poly-carbonate bottle. The sample was fixed with glutaraldehyde (1% final concentration).

2)-3 Measurements

Sea water samples were pre-filtered through a 10 µm mesh plankton net and fixed with 1%

(final concentration) glutaraldehyde and stored in the dark at 4°C. Flow cytometry (FCM) data using the flow cytometer were acquired on board within 24 hours after fixation of the sample. Phytoplankton cell number and cell size were estimated by the forward light scatter signal. Milli-Q® water was used as a sheath fluid. Acquired data were stored in list mode and analyzed by WinBryte™ software. Phytoplankton are classified into three picophytoplankton groups (*Prochlorococcus*, *Synechococcus* and picoeukaryotes) by flow cytometric signals of scatter and fluorescence. *Synechococcus* is discriminated by the orange fluorescence, while *Prochlorococcus* and picoeukaryotes are recognized by the red fluorescence without the orange fluorescence, and *Prochlorococcus* is distinguished from picoeukaryotes by their much smaller scatter and weak fluorescence. Counts of *Prochlorococcus* populations with dim fluorescence are treated as multiplying the cell number in the right part of the distributions by two. The data analysis will be scheduled in land after cruise.

C-2-12. Polysaccharides and TEP measurement

(1) Personnel

Kazuhiko Matsumoto (JAMSTEC)

(2) Objectives

The sinking of biogenic particles plays an important role in carbon cycling in the ocean. Phytoplankton generates large amounts of extracellular polysaccharides. The particles were produced from polysaccharides, and that the formation of polysaccharide aggregation is a pathway to convert dissolved into particulate organic carbon. The extracellular polysaccharide particles, described as transparent exopolymer particles (TEP) support the formation of large particle aggregates. Furthermore, TEP promote the sedimentation of particles, and, because their carbon content is high, their direct contribution to fluxes of carbon into deep water is significant. The objective in this study is to be measured the abundance of polysaccharides and TEP in the euphotic layer.

(3) Materials and Methods

(a) Polysaccharides

A spectrophotometric method is described for the determination of dissolved mono- and polysaccharides in seawater (Hung et al., 2001). It is based upon the well known alkaline ferricyanide reaction with the reagent 2,4,6-tripyridyl-s-triazine (TPTZ), followed by spectrophotometric analysis (Myklestad et al., 1997). Samples were corrected into glass vials after the filtration through precombusted GF/F filters and stored at -30°C until the subsequent analysis.

(b) TEP

For estimation of TEP concentrations, samples were filtered through 0.4μm Nuclepore filters. Sample filters are stored at -80°C until the subsequent analysis. TEP will be quantified by the colorimetric alcian blue staining method of Passow and Alldredge (1995).

C-2-13. Physiological Ecology of Planktonic Cyanobacteria in the Western Subtropical and Tropical North Pacific

Personnel: Satoshi Kitajima, Kanako Sugai, Shigenobu Takeda, and Ken Furuya
(Department of Aquatic Bioscience, Graduate School of Agricultural and Life Sciences
The University of Tokyo)

Cyanobacteria are taxonomically, physiologically and ecologically diverse, and dominant phytoplankters in the subtropical and tropical ocean. Spatial distribution of planktonic cyanobacteria has been well studied in the western subtropical and tropical Pacific Ocean, and their importance in nitrogen fixation is repeatedly emphasized. However, most studies have been focused on distribution ecology and our knowledge on their physiological ecology is still fragmentary. We investigated nitrogen fixation activity of both filamentous and unicellular cyanobacteria and light adaptation of phycoerythrin-containing unicellular cyanobacteria during the MR04-07 cruise.

1. Distribution of diazotrophs, and its rate of nitrogen fixation

Objective

Recently, some new diazotrophs, such as unicellular cyanobacteria or proteobacteria have been found in the subtropical and tropical ocean. The findings invoke re-evaluation of marine nitrogen fixation in warm waters. Nitrogen fixation is controlled by environmental factors such as availability of nutrients and iron. Among them, iron is critical to activity of nitrogenase that is a key enzyme system of nitrogen fixation, and iron bioavailability is considered to be the most important in nitrogen fixation in the open ocean. Recent evidence indicates airborne supply of iron as dust determines the magnitude of nitrogen fixation. During the MR04-07 cruise we measured the nitrogen fixation rate by acetylene reduction assay, distribution of diazotrophs, and iron concentration on the 155^{o}E line.

Sampling and Analysis

3000 mL of seawater were collected by a CTD Teflon coated Niskin-X sampler from layers of 100 (surface), 50, 25, 10 and 1% of surface light intensity at Stn. 2, 4(only surface layer), 6, 10, 13, 17, 21, 26, 31, and 33. The seawater was poured into three-1000 mL PET bottle, then placed in an on-deck incubator under natural sunlight with running near surface water pumped up from a 5 m depth. Nitrogen fixation was measure during daytime and nighttime separately. Samples were spiked with 10% acetylene and return to the incubator. Subsampling was done at 0, 12, 24 hours after the acetylene addition to measure ethylene production using a gas chromatograph (GC-14B, Shimadzu). The ethylene production was converted to an amount of fixed nitrogen with a ratio of C_2H_2: N_2 = 1:4. After the sampling, seawater left in the bottle was fixed with 1% formalin for later microscopic examination.

Along with the nitrogen fixation measurements, following determination and sample preparation were made; total iron concentration, ^{15}N: ^{14}N ratio of the surface layer, flow cytometric count of unicellular cyanobacteria (at Stns 2, 6, 10,and 13), algal pigments by HPLC.

Horizontal hauls of a plankton net, and seawater sampling from 6 to 9 layers were made for geographic distribution of *Trichodesmium* and *R. intracellularis* associated with diatoms. The plankton net samplings were microscopically observed during the cruise.

Future works

Samples and specimens prepared during the cruise will be analyzed and examined. for flow cytometry fixed with 1% glutaradehyde and those for HPLC and ^{15}N: ^{14}N ratio prepared by a gentle filtration (< 18 mmHg) of particles on GF/F filters were immediately frozen and transferred to land laboratory. Analysis of these samples will be conducted. Samples taken with plankton net and fixed seawater samples will be also brought back to land laboratory to make further study.

2. Photo-adaptation of *Synechococcus* on the 155° E line

Objective

Phycoerythrin (PE) is a major light-harvesting pigment of marine *Synechococcus*. PE of *Synechococcus* in general contains two chromophores, phycourobilin (PUB) and phycoerythrobilin (PEB). Relative composition of PUB and PEB determines optical property of PE and is considered to be crucial in light adaptation of *Synechococcus*. However, little is known for functions of PE in light adaptation of the *Synechococcus* largely owing to unavailability of a convenient method to quantify PE until quite recent. We examined vertical distribution of PE and relative composition of PEB and PUB using a newly developed method to understand latitudinal distribution of PE and its chromophore composition.

Methods

Measurements were made using samples taken by routine casts of a CTD-carousel at Stns. 2, 6, 10, 13, 17, 21, 26, 31, and 33. Seawater samples collected from 10 depths between 0 and 200 m depth were immediately filtered onto a 0.4-μm Nuclepore filter with a gentle suction (< 18 mmHg). Cells on the filter were re-suspended in 4 mL of 50% glycerol and allowed for dark acclimation for 10 min. Fluorescence of PE in the suspension was measured with a fluorometer (TD-700, Turner Designed). PE concentration was determined from the fluorescence intensity using the equation by Imamura (*in prep.*). The glycerol-treated samples were also subjected to fluorometry for relative composition of PUB and PEB using a spectrofluorometer (RF-5300, Shimadzu). Excitation spectrum was swept from 400 to 565 nm at emission of 570 nm. Peaks at 495 and 545 nm were attributed to PUB and PEB, respectively. Samples for flow cytometric determination of *Synechococcus* were prepared as described above.

Future work

Sample analysis and data interpretation are in progress.

C-3. Optical measurements

(1) Personnel

Kazuhiko Matsumoto (JAMSTEC)

(2) Objectives

The objectives of this measurement are to estimate *in-situ* bio-optical parameters in the north-western Pacific. We referred *in-situ* optical data to decide sampling depth for the measurements of primary productivity.

(3) Materials and Methods

The instrument system is the SeaWiFS Profiling Multichannel Radiometer (SPMR). The SPMR is deployed in a freefall mode through the water column while measuring the following physical and optical parameters. The profiler carries a 13-channel irradiance sensor (Ed) and a 13-channel radiance sensor (Lu), as well as instrument tilt. This instrument suite is used for the derivation of the penetration of visible and ultra–violet light in the ocean, and for the determination of the vertical distribution of apparent optical properties. The profiler was deployed to a depth of 200m. The reference was mounted on the compass deck and was never shadowed by any ship structures. The profiler fell at an average rate of 1ms^{-1} with tilts of less than 5 degrees.

The profiler data were processed with Satlantic's Prosoft software version 6.0. Data from each casts were corrected for recent instrument calibration, and then binned at 1m intervals. PAR (Photosynthetically available radiation) data was determined optical depth for the *in-situ* and simulated *in-situ* primary productivity measurement.

C-4. Argo float

(1) Personnel

Nobie Shikama	(FORSGC): Principal Investigator (not on board)
Eitarou Oka	(FORSGC): not on board
Mizue Hirano	(FORSGC): not on board
Tomoyuki Takamori	(MWJ)
Hiroshi Matsunaga	(MWJ)

(2) Objectives

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

The profiling floats launched in this cruise obtain vertical profiles of temperature and salinity automatically every ten days. The data from the floats will enable us to understand the phenomenon mentioned above with time/spatial scales much smaller than those in the previous studies.

(3) Parameters

・water temperature, salinity, and pressure

(4) Methods

1) Profiling float deployment

We launched 6 APEX floats of FORSGC. These floats equip an SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc.

The floats usually drift at depth of 2000 or 1500 dbar (called the parking depth), rising up to the sea surface every ten days by increasing their volume and thus changing the buoyancy. During the ascent, they measure temperature, salinity, and pressure. They stay at the sea surface for approximately nine hours, transmitting their positions and 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 C-4-1.

(6) Data archive

All data acquired by the FORSGC floats through the ARGOS system is stored at FORSGC. The real-time data are provided to meteorological organizations via Global Telecommunication System (GTS) and utilized for analysis and forecasts of sea conditions.

Table C-4-1 Status of floats and their launches

Float (FORSGC)

Float Type	APEX floats manufactured by Webb Research Ltd.
CTD sensor	SBE41 manufactured by Sea-Bird Electronics Inc.
Cycle	10 days (approximately 9 hours at the sea surface)
ARGOS transmit interval	30 sec
Target Parking Pressure	2000 or 1500 dbar
Sampling layers	71 (2000, 1900, 1800, 1700, 1600, 1500, 1400, 1300, 1250, 1200, 1150, 1100, 1050, 1000, 975, 950, 925, 900, 875, 850, 825, 800, 780, 760, 740, 720, 700, 680, 660, 640, 620, 600, 580, 560, 540, 520, 500, 480, 460, 440, 420, 400, 380, 360, 340, 320, 300, 280, 260, 240, 220, 200, 190, 180, 170, 160, 150, 140, 130, 120, 110, 100, 90, 80, 70, 60, 50, 40, 30, 20, 10 [dbar])

Launches

Owner	Type	S/N	ARGOS PTT ID	Date and Time of Reset (UTC)	Date and Time of Launch (UTC)	Location of Launch
FORSGC	APEX	1093	21330	10:10, Nov. 25	11:45, Nov. 25	24-29.25 N, 154-58.15 E
FORSGC	APEX	1095	21389	10:17, Nov. 28	12:04, Nov. 28	17-01.77 N, 154-59.31 E
FORSGC	APEX	1332	28373	03:30, Nov. 30	04:52, Nov. 30	14-00.30 N, 154-59.71 E
FORSGC	APEX	937	25294	09:20, Dec. 01	11:46, Dec. 01	11-01.22 N, 154-58.58 E
FORSGC	APEX	1082	20816	17:08, Dec. 02	19:52, Dec. 02	08-01.25 N, 155-00.78 E
FORSGC	APEX	1074	20573	17:08, Dec. 04	19:35, Dec. 04	02-59.56 N, 154-59.97 E

C-5. Study of carbon cycle in the surface ocean by using radionuclides

Personnel:

Takahiro Nakanishi (National Institute of Radiological Sciences)
Akifumi Shimamoto (The General Environmental Technos Co., Ltd)
Yuichi Sakuma (The General Environmental Technos Co., Ltd)

Objective:

The ocean plays an important role in carbon cycle in the earth’s surface, because about 2/7 of CO_2 emitted into the atmosphere by human activity is eventually to be absorbed into the ocean. The CO_2 absorbed is converted to an organic matter through photosynthesis of phytoplankton. While a part of the organic matter sinks to the depths as particles, its majority decomposes to become inorganic carbon again. These processes are influenced by not only biological processes but also chemical and physical processes. Most of the processes are mutually related, so that any single process does not determine the material balance of carbon in the ocean.

This research aims at evaluating the parameters in the above processes and clarifying a mutual relationship among them quantitatively and synthetically. This study utilizes several natural radionuclides; phosphor isotopes (^{32}P, ^{33}P), thorium isotopes (^{228}Th, ^{230}Th, ^{234}Th), radium isotopes (^{226}Ra, ^{228}Ra) and radioactive beryllium (^{7}Be). The various parameters obtained by the data analysis of these radionuclides are applied to dissolved/particle nutrients, carbonate species, particulate organic carbon, and dissolved oxygen etc. Eventually the carbon cycle in surface water will be clarified synthetically.

Methods:

This study requires large volume of seawater samples (~ several m3) because we will measure extremely low concentration of radionuclides in different chemical/physical forms such as dissolved form, small particles, large particles and plankton. In situ large-volume system we developed consists of dual filtration lines: one for relatively small volume filtration (~hundreds liters) and the other for large volume filtration (several m^3). Each line has two kinds of filters and an adsorbent. The main line has a prefilter with pore size of 70 µm and a filter with pore size of 1 µm; beneath the filters there are a pair of adsorbent (Fe-impregnated filter cartridge) and a flow meter. Another line has a prefilter (a filter cartridge with 1-µm pore size), a pair of adsorbent (Mn-impregnated filter cartridge), and a flow meter.

The whole system was performed at 5 stations: Stns.10, 19, 23, 28 and 33. About 5 - 11 m^3 of seawater could be filtered for 2 - 4 hrs of operation and more than 90% of the water went through the main line. Seawater was sampled for determining recovery of total dissolved phosphorous and ^{226}Ra.

D. Geological and Geophysical Observation

D-1. Sea surface gravity

(1) Personal

Shuichi Watanabe	(JAMSTEC)
Norio Nagahama	(Global Ocean Development Inc.)
Ryo Kimura	(GODI)
Ryo Ohyama	(GODI)
Not on-board: Toshiya Fujiwara	(JAMSTEC): Principal Investigator

(2) Introduction

The difference of local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface during the MR04-07 cruise from 17 November 2004 to 10 December 2004, except for the territorial waters of the Federated States of Micronesia.

(3) Parameters

Relative Gravity [mGal]

(4) Data Acquisition

We have measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (LaCosat and Romberg Gravity Meters, Inc.) during this cruise. To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (Scintrex gravity meter CG-3M), at Sekinehama Port as reference points.

(5) Preliminary Results

Absolute gravity will be calculated after the MR04-08 cruise, because of Chuuk is not exists on gravity reference point.

(6) Data Archives

Gravity data obtained during this cruise will be submitted to the JAMSTEC Data Management Division, and archived there.

(7) Remarks

SOJ data were not updated, due to Navigation System trouble. The periods are as follows;

03/December/2004 22:23:00 – 22:35:30

D-2. Sea Surface three-component magnetic field

(1) Personal

Shuichi Watanabe	(JAMSTEC)
Norio Nagahama	(Global Ocean Development Inc.)
Ryo Kimura	(GODI)
Ryo Ohyama	(GODI)
Not on-board: Toshiya Fujiwara	(JAMSTEC): Principal investigator

(2) Introduction

Measurements of magnetic force on the sea are 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 throughout the MR04-07 cruise (departure from Sekinehama on 17 November 2004 to the arrival at Chuuk on 10 December), except for the territorial waters of the Federated States of Micronesia.

(3) Principle of ship-board geomagnetic vector measurement

The relation between a magnetic-field vector observed on-board, $\mathbf{H}\mathrm{ob}$, (in the ship's fixed coordinate system) and the geomagnetic field vector, $\mathbf{F}$, (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 yaw of a ship, respectively. $\tilde{\mathbf{A}}$ is a 3 x 3 matrix which represents magnetic susceptibility of the ship, and $\mathbf{H}\mathrm{p}$ is a magnetic field vector produced by a permanent magnetic moment of the ship's body. Rearrangement of eq. (a) makes

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

where $\tilde{\mathbf{B}}=\tilde{\mathbf{A}}^{-1}$, and $\mathbf{H}\mathrm{bp}=-\tilde{\mathbf{B}}\mathbf{H}\mathrm{p}$. The magnetic field, $\mathbf{F}$, can be obtained by measuring $\tilde{\mathbf{R}}$, $\tilde{\mathbf{P}}$, $\tilde{\mathbf{Y}}$ and $\mathbf{H}\mathrm{ob}$, if $\tilde{\mathbf{B}}$ and $\mathbf{H}\mathrm{bp}$ are known. Twelve constants in $\tilde{\mathbf{B}}$ and $\mathbf{H}\mathrm{bp}$ can be determined by measuring variation of $\mathbf{H}\mathrm{ob}$ with $\tilde{\mathbf{R}}$, $\tilde{\mathbf{P}}$ and $\tilde{\mathbf{Y}}$ at a place where the geomagnetic field, $\mathbf{F}$, 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 of 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 utilizing a ring-laser gyro installed for controlling attitude of a Doppler radar. Ship's position (D-GPS) and speed data are taken from LAN every second.

(5) Data Archives

Magnetic force data obtained during this cruise will be submitted to the JAMSTEC Data Management Division, and archived there.

(6) Remarks

a) For calibration of the ship’s magnetic effect, we made a running like a “Figure of 8” (a pair of clockwise and anti-clockwise rotation). The periods are follows;

17/November/2004	10:39 – 11:08
05/December/2004	01:10 – 01:33

b) Magnetic data were not collected about several reasons. The periods are follows;

- Operation trouble:

26/Nobember/2004	10:17:05 – 10:17:20

- Logging PC trouble:

01/December/2004	18:01:59 – 19:44:42

c) Ship’s position data were not updated, due to Navigation System trouble. The periods are as follows;

03/December/2004	22:23:00 – 22:35:33

d) The periods of loosing position are follows;

17/November/2004	23:29:39 – 23:29:45, 23:29:55 – 23:30:01
21/November/2004	20:21:31 – 20:21:37
22/November/2004	03:52:00 – 03:52:06, 04:40:09 – 04:40:15, 12:02:01 – 12:02:07, 12:20:59 – 12:21:05, 13:29:49 – 13:29:55, 21:14:48 – 21:14:54, 22:11:18 – 22:11:24, 22:13:46 – 22:13:52, 22:26:34 – 22:26:40
25/November/2004	21:20:51 – 21:20:57
27/November/2004	07:50:30 – 07:50:36
29/November/2004	09:40:43 – 09:40:49, 17:02:26 – 17:02:32
30/November/2004	00:49:55 – 00:50:01, 01:24:38 – 01:24:44, 01:43:58 – 01:44:04, 02:18:14 – 02:18:20, 03:32:31 – 03:32:37, 11:40:39 – 11:40:45, 13:08:39 – 13:08:45
01/ December/2004	17:00:46 – 17:00:52
02/ December/2004	18:54:25 – 18:54:31
03/ December/2004	20:30:05 – 20:30:11, 23:37:18 – 23:37:24
04/ December/2004	10:49:06 – 10:49:12, 11:12:15 – 11:12:21, 11:23:28 – 11:23:34, 11:55:42 – 11:55:48, 18:07:21 – 18:07:27, 18:44:51 – 18:44:57, 23:48:55 – 23:49:01, 23:49:13 – 23:49:21
05/ December/2004	03:46:16 – 03:46:22, 09:49:27 – 09:49:33, 09:53:05 – 09:53:11, 10:06:57 – 10:07:03, 10:47:32 – 10:47:38, 18:14:26 – 18:14:32

E. TRITON repair

(1) Personnel

Shuji Watanabe	(JAMSTEC): Principal Investigator
Hiroshi Matsunaga	(MWJ): Operation leader
Fuma Matsunaga	(MWJ): Technical staff

(2) Objectives

The TRITON buoy (ID number at JAMSTEC:09006) has been stopped to transmit ARGOS transmitter data since 22 Nov 2004. This one was deployed at 15 Nov 2003 during R/V KAIYO cruise (KY03-12). During this R/V MIRAI cruise (MR04-07), this one has successfully attached ARGOS transmitter (showed Fig.1).

(3) Instrument

ARGOS Transmitter

Transmission interval : 80seconds

Transmission time schedule : 22hours after 26hours sleep

(4) Locations of TRITON Buoy Deployment

Nominal location	EQ, 147E
ID number at JAMSTEC	09006
Number on surface float	T26
ARGOS PTT number	20275
ARGOS backup PTT number	24232
Deployed date	15 Nov. 2003
Exact location	00 - 01.68S, 146 - 59.73E
Depth	4566 m

(5) Location of TRITON Buoy After Repair

ARGOS PTT number (Attached)	24245
Attached date	08 Dec. 2004

(6) 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

fig.1 Attached ARGOS transmitter