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R/V MIRAI Cruise Report
MR08-02

Tropical Western Pacific Ocean

May 26 - June 30, 2008

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

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1. Introduction

Since the huge amount of heat released from active convections developed over the tropical western Pacific Ocean drives the atmospheric circulation, this area is thought to be a heat engine of the globe. Therefore, it is important to study the convective activity over this area in studying the global climate. In particular, large-scale cloud systems accompanied with the Madden-Julian oscillation (MJO), Asian monsoon, and tropical depressions (or cyclones) are the major precipitating systems which are often observed in the boreal summer season.

To study the mechanism of development and maintenance of these cloud systems, we conducted the atmospheric and oceanic observations at the fixed point at 12N, 135E for three weeks. During the stationary observation period, we conducted surface meteorological measurement, atmospheric sounding by radiosonde, Doppler radar observation, CTD casting, and ADCP current measurement as a main mission. In addition, turbulent flux measurement, Mie-scattering LIDAR, vertical-pointing cloud radar, rain and water vapor sampling, and other many observations were intensively conducted. Furthermore, before arrival to the stationary site, we deployed Argo-type floats along 130.1E line from 20N to 5E.

This cruise report summarizes the observation items and preliminary results. In the first four sections, basic information such as cruise track, on board personnel list are described. Details of each observation are described in Section 5. Every atmospheric and oceanic profiles obtained by radiosonde and CTD are also attached in Appendices.

***** Remarks *****

This cruise report is a preliminary documentation as of the end of the cruise. It may not be corrected even if changes on content are found after publication. It may also be changed without notice. Data on the cruise report may be raw or not processed. Please ask the Chief Scientist for the latest information.

2. Cruise Summary

2.1 Ship

Name	Research Vessel MIRAI
L x B x D	128.6m x 19.0m x 13.2m
Gross Tonnage	8,687 tons
Call Sign	JNSR
Home Port	Mutsu, Aomori Prefecture, Japan

2.2 Cruise Code

MR08-02

2.3 Project Name (Main mission)

Observational Study on Air-Sea Interaction in the Tropical Western Pacific Ocean

2.4 Undertaking Institute

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

2.5 Chief Scientist

Kunio Yoneyama
Institute of Observational Research for Global Change (IORGC) / JAMSTEC

2.6 Periods and Ports of Call

2008	May 26	departed Sekinehama, Japan
	May 27	called at Hachinohe, Japan
	June 30	arrived at Guam, U.S.A.

2.7 Research Themes of Sub-missions and Principal Investigators (PIs)

(1) Study on the internal structure of precipitation system and its interaction with environment over the tropical western Pacific Ocean
PI : Taro Shinoda (Nagoya University)

(2) Study on lifecycle of clouds over the tropical western Pacific Ocean using cloud radar and lidar
PI : Hajime Okamoto (Tohoku University)

(3) Continuous observations of clouds and aerosols using two-wavelength polarization lidar
PI : Nobuo Sugimoto (National Institute for Environmental Studies)

(4) Rain and water vapor sampling for stable isotope measurement
PI : Naoyuki Kurita (JAMSTEC)

(5) Continuous measurements of air-sea surface eddy fluxes
PI : Osamu Tsukamoto (Okayama University)

(6) N_2 fixation activity and phytoplankton dynamics in the subtropical and tropical North Pacific
PI : Ken Furuya (The University of Tokyo)

(7) Distribution and ecology of three species of oceanic sea skaters inhabiting tropical area around equator in the Pacific Ocean and their responses to environmental factors
PI : Tetsuo Harada (Kochi University)

(8) Standardization of geophysical data and study on its application to the sea plate dynamics
PI : Takeshi Matsumoto (University of the Ryukyus)

(9) Tectonic evolution of the Pacific Plate
PI : Masao Nakanishi (Chiba University)

2.8 Observation Summary

5.3-GHz Doppler radar	continuously	from May 29 to June 29
GPS Radiosonde	209 times	from June 02 to June 28
Ceilometer	continuously	from May 26 to June 29
Surface Meteorology	continuously	from May 26 to June 29
GPS Meteorology	continuously	from May 26 to June 29
CTD and water sampling	99 times	from June 02 to June 27
ADCP	continuously	from May 27 to June 29
Sea surface water monitoring	continuously	from May 27 to June 29
Mie-scattering LIDAR	continuously	from May 26 to June 29
95-GHz cloud profiling radar	continuously	from May 26 to June 29
Infrared radiometer	continuously	from May 26 to June 29
Rain and water vapor sampling	continuously	from May 26 to June 29
Turbulent flux	continuously	from May 26 to June 29
Gravity/Magnetic force	continuously	from May 26 to June 29
Topography	continuously	from May 26 to June 29
Sea skater sampling	27 times	from June 01 to June 27
Argo float deployment	5 times	from June 01 to June 04

2.9 Overview

In order to investigate the atmospheric and oceanic conditions in the tropical western Pacific Ocean in the boreal summer season, the intensive observations. First, we deployed 5 Argo floats along 130.1E line from 20N to 5N. Then, we conducted the observations at a fixed site at 12N, 135E from June 6 through June 27 (22 days).

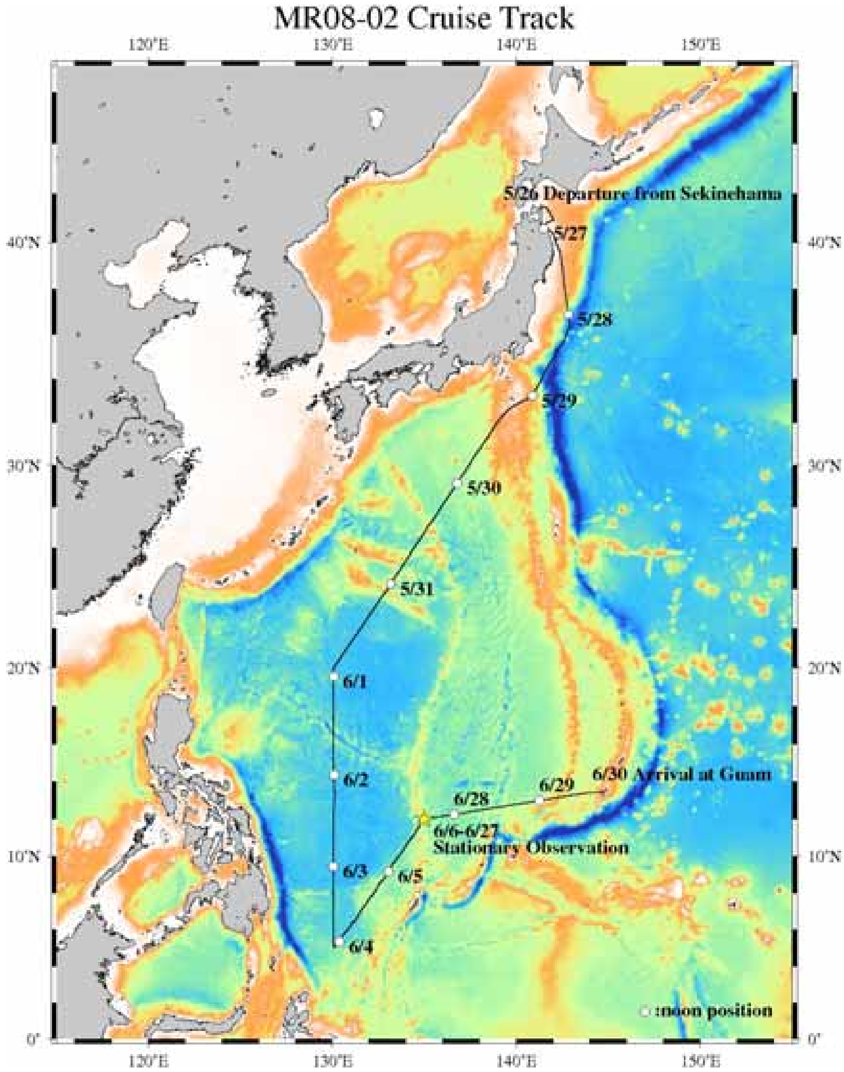
During the first half of observation period, so-called trade winds (easterlies) were prevailed in the lower troposphere. This period corresponded to the convectively inactive phase of intraseasonal variability, and only shallow cumulus clouds can develop. On the other hand, deep convections much developed in the latter half of stationary observation. In particular, tropical cyclone developed just south-west of the Mirai on June 19. This shift of convective activity from inactive to active can be confirmed by the time series of Doppler radar echo area (see Fig. 5.2-1). In corresponding to this feature, atmospheric instability index CAPE (convective available potential energy) clearly shows the gradual increase in the first half of observation period, while it decreases during the latter half (see Fig. 5.1-2). This feature suggest that it might be due to the fact that energy stored was used for development of convections. As for the oceanic features, a significant feature during the stationary observation period was the change of ocean surface current from strong westward current to weak one (see Fig. 5.18-1), which might reflect the meander or change of the North Equatorial Current. Details on this mechanism and relationship to the atmospheric disturbances such as tropical cyclone should be studied further.

2.10 Acknowledgments

We would like to express our sincere thanks to Captain M. Akamine and his crew for their skillful ship operation. Thanks are extended to the technical staff of Global Ocean Development Inc. and Marine Works Japan, Ltd. for their continuous support to conduct the observations.

3. Cruise Track and Log

3.1 Cruise Track



3.2 Cruise Log

Date	SMT / UTC	Events	
May 26	16:00 / 07:00	Departure from Sekinehama (mother port of *Mirai*)	
27	08:30 / 23:30	Calling at Hachinohe, Japan	
	14:30 / 05:30	Departure from Hachinohe, Japan	
28	12:45 / 03:45	(36-20N, 142-55E)	CTD cable free-fall
29	16:00 / 0700	Starting Doppler radar observation	
Jun. 01	07:02 / 22:02	(19-59N, 130-06E)	Argo float deployment (Argos type)
	10:00 / 01:00	(19-16N, 130-05E)	Massive seawater collection using pump
	19:12 / 10:12	(17-22N, 130-05E)	Sea skater collection (#001)
	22:12 / 13:12	(16-59N, 130-05E)	Argo float deployment (Argos type)
02	08:30 / 23:30	(14-28N, 130-06E)	Radiosonde (#001)
	10:46 / 01:46	(13-59N, 130-06E)	CTD (#001; 2000m)
	11:30 / 02:30	(13-59N, 130-06E)	Radiosonde (#002)
	12:08 / 03:08	(13-59N, 130-06E)	Argo float deployment (Iridium type)
	14:30 / 05:30	(13-28N, 130-07E)	Radiosonde (#003)
	17:42 / 08:42	(12-40N, 130-06E)	Radiosonde (#004)
	19:00 / 10:00	(12-22N, 130-05E)	Sea skater collection (#002)
	20:30 / 11:30	(12-13N, 130-05E)	Radiosonde (#005)
	23:29 / 14:29	(11-28N, 130-06E)	Radiosonde (#006)

03	01:30 / 16:30	(11-00N, 130-05E)	CTD (#002; 2000m)
	02:31 / 17:30	(11-00N, 130-05E)	Radiosonde (#007)
	02:50 / 17:50	(11-00N, 130-05E)	Argo float deployment (Iridium type)
	05:30 / 20:30	(10-19N, 130-04E)	Radiosonde (#008)
	08:25 / 23:25	(09-35N, 130-04E)	Radiosonde (#009)
	11:31 / 02:31	(08-48N, 130-04E)	Radiosonde (#010)
	14:30 / 05:30	(08-04N, 130-03E)	Radiosonde (#011)
	15:00 / 06:00	(08-00N, 130-00E)	TRITON buoy inspection
	17:25 / 08:25	(07-29N, 130-03E)	Radiosonde (#012)
	19:00 / 10:00	(07-07N, 130-04E)	Sea skater collection (#003)
	20:30 / 11:30	(07-00N, 130-04E)	Radiosonde (#013)
	23:36 / 14:30	(06-15N, 130-05E)	Radiosonde (#014)
04	02:31 / 17:31	(05-31N, 130-04E)	Radiosonde (#015)
	04:33 / 19:33	(05-02N, 130-05E)	Sea skater collection (#004)
	05:30 / 20:30	(05-00N, 130-06E)	Radiosonde (#016)
	05:45 / 20:45	(05-00N, 130-06E)	CTD (#003; 2000m)
	07:06 / 22:06	(05-00N, 130-06E)	Argo float deployment (Iridium type)
	08:30 / 23:30	(05-16N, 130-18E)	Radiosonde (#017)
	11:31 / 02:31	(05-52N, 130-45E)	Radiosonde (#018)
	14:45 / 05:45	(06-26N, 132-11E)	Radiosonde (#019) No data due to failure
	17:31 / 08:31	(06-58N, 131-32E)	Radiosonde (#020)
	19:00 / 10:00	(07-16N, 131-42E)	Sea skater collection (#005)
	20:30 / 11:30	(07-20N, 131-49E)	Radiosonde (#021)
	23:31 / 14:31	(07-50N, 132-09E)	Radiosonde (#022)
05	02:31 / 17:31	(08-20N, 132-28E)	Radiosonde (#023)
	04:27 / 19:27	(08-38N, 132-39E)	Sea skater collection (#006)
	05:30 / 20:30	(08-36N, 132-42E)	Radiosonde (#024)
	08:29 / 23:29	(09-04N, 133.00E)	Radiosonde (#025)
	11:30 / 02:30	(09-38N, 133.20E)	Radiosonde (#026)
	14:30 / 05:30	(10-11N, 133.46E)	Radiosonde (#027)
	17:30 / 08:30	(10-44N, 134-08E)	Radiosonde (#028)
	19:00 / 10:00	(11-00N, 134-18E)	Sea skater collection (#007)
	20:30 / 11:30	(11-01N, 134-21E)	Radiosonde (#029)
	23:31 / 14:31	(11-31N, 134-41E)	Radiosonde (#030)
06	02:29 / 17:29	(11-59N, 134-59E)	Radiosonde (#031)
	02:33 / 17:33	(11-59N, 134-59E)	CTD (#004; 500m)
	05:30 / 20:30	(12-00N, 134-59E)	Radiosonde (#032)
	08:36 / 23:36	(12-00N, 134-59E)	Radiosonde (#033)
	08:36 / 23:36	(12-00N, 134-59E)	CTD (#005; 500m)
	09:20 / 00:20		Starting Seasnake SST measurement
	10:58 / 01:58	(12-00N, 134-59E)	Light intensity (#001; 200m)
	11:30 / 02:30	(12-00N, 134-59E)	Radiosonde (#034)
	12:32 / 03:32	(12-00N, 134-59E)	Pump seawater collection (#001)
	14:30 / 05:30	(12-00N, 134-59E)	Radiosonde (#035)
	14:32 / 05:32	(12-00N, 134-59E)	CTD (#006; 1000m)
	17:30 / 08:30	(11-59N, 135-00E)	Radiosonde (#036)
	18:48 / 09:48	(12-00N, 134-57E)	Sea skater collection (#008)
	20:33 / 11:33	(11-59N, 135-00E)	Radiosonde (#037)
	20:33 / 11:33	(12-00N, 134-59E)	CTD (#007; 500m)
	23:31 / 14:31	(11-59N, 135-00E)	Radiosonde (#038)
07	02:38 / 17:38	(11-59N, 134-59E)	Radiosonde (#039)
	02:41 / 17:41	(11-59N, 134-59E)	CTD (#008; 500m)
	05:30 / 20:30	(11-59N, 134-59E)	Radiosonde (#040)
	05:33 / 20:33	(12-00N, 134-59E)	CTD (#009; 500m)
	08:30 / 23:30	(11-59N, 134-59E)	Radiosonde (#041)
	08:32 / 23:32	(12-00N, 134.59E))	CTD (#010; 500m)
	10:53 / 01:53	(12-00N, 135-00E)	Light intensity (#002; 200m)
	11:30 / 02:30	(12-00N, 135-00E)	Radiosonde (#042)
	11:32 / 02:32	(12-00N, 134-59E)	CTD (#011; 500m)
	14:30 / 05:30	(11-59N, 134-59E)	Radiosonde (#043)
	14:33 / 05:33	(12-00N, 134-59E)	CTD (#012, 1000m)
	17:26 / 08:26	(11-59N, 135-00E)	Radiosonde (#044)
	17:29 / 08:29	(12-00N, 134-59E)	CTD (#013, 500m)
	20:25 / 11:25	(11-59N, 134-59E)	Radiosonde (#045)
	20:29 / 11:29	(12-00N, 134-59E)	CTD (#014, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#046)
	23:29 / 14:29	(11-59N, 134-59E)	CTD (#015, 500m)
08	02:30 / 17:30	(11-59N, 134-59E)	Radiosonde (#047)
	02:32 / 17:32	(11-59N, 134-59E)	CTD (#016, 500m)
	05:25 / 20:25	(11-59N, 134-59E)	Radiosonde (#048)
	08:25 / 23:25	(11-59N, 134-59E)	Radiosonde (#049)
	08:25 / 23:28	(11-59N, 134-59E)	CTD (#017, 500m)
	10:49 / 01:49	(12-00N, 135-00E)	Light intensity (#003; 200m)

	11:25 / 02:25	(12-00N, 134-59E)	Radiosonde (#050)
	12:31 / 03:31	(12-01N, 135-00E)	Pump seawater collection (#002)
	14:25 / 05:25	(12-00N, 134-59E)	Radiosonde (#051)
	14:30 / 05:30	(12-00N, 134-59E)	CTD (#018, 1000m)
	17:25 / 08:25	(12-01N, 135-00E)	Radiosonde (#052)
	18:51 / 09:51	(11-59N, 134-58E)	Sea skater collection (#009)
	20:25 / 11:25	(12-00N, 135-00E)	Radiosonde (#053)
	20:28 / 11:28	(12-00N, 134-59E)	CTD (#019, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#054)
09	02:25 / 17:25	(11-59N, 134-59E)	Radiosoned (#055)
	02:30 / 17:30	(11-59N, 134-59E)	CTD (#020, 500m)
	05:25 / 20:25	(11-59N, 134-59E)	Radiosonde (#056)
	05:29 / 20:29	(11-59N, 134-59E)	CTD (#021, 500m)
	08:25 / 23:25	(11-59N, 135-00E)	Radiosonde (#057)
	08:28 / 23:28	(12-00N, 135-00E)	CTD (#022, 500m)
	10:47 / 01:47	(12-00N, 135-00E)	Light intensity (#004, 200m)
	11:25 / 02:15	(11-59N, 134-59E)	Radiosonde (#058)
	11:28 / 02:28	(11-59N, 134-59E)	CTD (#023, 500m)
	14:25 / 05:25	(11-59N, 135-00E)	Radiosonde (#059)
	14:29 / 05:29	(12-00N, 134-59E)	CTD (#024, 1000m)
	17:25 / 08:25	(11-59N, 134-59E)	Radiosonde (#060)
	17:30 / 08:30	(12-00N, 134-59E)	CTD (#025, 500m)
	20:25 / 11:25	(12-00N, 135-00E)	Radiosonde (#061)
	20:28 / 11:28	(12-00N, 134-59E)	CTD (#026, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#062)
	23:29 / 14:29	(11-59N, 134-59E)	CTD (#027, 500m)
10	02:25 / 17:25	(11-59N, 134-59E)	Radiosonde (#063)
	02:30 / 17:30	(11-59N, 134-59E)	CTD (#028, 500m)
	05:25 / 20:25	(11-59N, 134-59E)	Radiosonde (#064)
	08:25 / 23:25	(11-59N, 135-00E)	Radiosonde (#065)
	08:27 / 23:27	(11-59N, 134-59E)	CTD (#029, 500m)
	10:50 / 01:50	(12-00N, 135-00E)	Light intensity (#005, 200m)
	11:25 / 02:25	(12-00N, 134-59E)	Radiosonde (#066)
	12:32 / 03:32	(12-00N, 135-00E)	Pump seawater collection (#003)
	14:26 / 05:26	(11-59N, 134-59E)	Radiosonde (#067)
	14:30 / 05:30	(12-00N, 134-59E)	CTD (#030, 1000m)
	17:25 / 08:25	(12-01N, 135-00E)	Radiosonde (#068)
	18:48 / 09:48	(12-00N, 134-58E)	Sea skater collection (#010)
	20:25 / 11:25	(11-59N, 134-59E)	Radiosonde (#069)
	20:30 / 11:30	(11-59N, 134-59E)	CTD (#031, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#070)
11	02:25 / 17:25	(11-59N, 135-00E)	Radiosonde (#071)
	02:29 / 17:29	(12-00N, 135-00E)	CTD (#032, 500m)
	05:25 / 20:25	(12-00N, 134-59E)	Radiosonde (#072)
	08:25 / 23:25	(11-59N, 135-00E)	Radiosonde (#073)
	08:28 / 23:28	(12-00N, 134-59E)	CTD (#033, 500m)
	10:47 / 01:47	(12-00N, 135-00E)	Light intensity (#006, 200m)
	11:25 / 02:25	(12-00N, 134-59E)	Radiosonde (#074)
	14:27 / 05:27	(12-00N, 134-59E)	Radiosonde (#075)
	14:29 / 05:29	(12-00N, 134-59E)	CTD (#034, 1000m)
	17:25 / 08:25	(11-59N, 134-59E)	Radiosonde (#076)
	18:48 / 09:48	(12-00N, 134-58E)	Sea skater collection (#011)
	20:25 / 11:25	(11-59N, 134-59E)	Radiosonde (#077)
	20:28 / 11:28	(12-00N, 134-59E)	CTD (#035, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#078)
12	02:25 / 17:25	(11-59N, 135-00E)	Radiosonde (#079)
	02:30 / 17:30	(11-59N, 135-00E)	CTD (#036, 500m)
	05:25 / 20:25	(11-59N, 134-59E)	Radiosonde (#080)
	08:25 / 23:25	(11-59N, 135-00E)	Radiosonde (#081)
	08:28 / 23:28	(11-59N, 134-59E)	CTD (#037, 500m)
	10:46 / 01:46	(11-59N, 135-00E)	Light intensity (#007, 200m)
	11:25 / 02:25	(11-59N, 134-59E)	Radiosonde (#082)
	12:30 / 03:30	(12-01N, 134-59E)	Pump seawater collection (#004)
	14:25 / 05:25	(11-59N, 134-59E)	Radiosonde (#083)
	14:28 / 05:28	(12-00N, 134-59E)	CTD (#038, 1000m)
	17:25 / 08:25	(11-59N, 135-00E)	Radiosonde (#084)
	18:48 / 09:48	(12-00N, 134-58E)	Sea skater collection (#012)
	20:25 / 11:25	(12-00N, 134-59E)	Radiosonde (#085)
	20:29 / 11:29	(12-00N, 134-59E)	CTD (#039, 500m)
	23:26 / 14:26	(12-00N, 134-59E)	Radiosonde (#086)
13	02:25 / 17:25	(11-59N, 134-59E)	Radiosonde (#087)
	02:29 / 17:29	(11-59N, 134-59E)	CTD (#040, 500m)
	05:25 / 20:25	(11-59N, 135-00E)	Radiosonde (#088)

	08:26 / 23:26	(11-59N, 135-00E)	Radiosonde (#089)
	08:28 / 23:28	(11-59N, 134-59E)	CTD (#041, 500m)
	10:49 / 01:49	(12-00N, 135-00E)	Light intensity (#008, 200m)
	11:25 / 02:25	(12-00N, 134-59E)	Radiosonde (#090)
	14:25 / 05:25	(11-59N, 135-00E)	Radiosonde (#091)
	14:29 / 05:29	(12-00N, 134-59E)	CTD (#042, 1000m)
	17:25 / 08:25	(11-59N, 134-59E)	Radiosonde (#092)
	18:49 / 09:49	(12-00N, 134-58E)	Sea skater collection (#013)
	20:25 / 11:25	(11-59N, 135-00E)	Radiosonde (#093)
	20:28 / 11:28	(11-59N, 134-59E)	CTD (#043, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#094)
14	02:25 / 17:25	(11-59N, 135-00E)	Radiosonde (#095)
	02:28 / 17:28	(11-59N, 134-59E)	CTD (#044, 500m)
	05:25 / 20:25	(11-59N, 135-00E)	Radiosonde (#096)
	08:25 / 23:25	(12-00N, 135-00E)	Radiosonde (#097)
	08:28 / 23:28	(12-00N, 134-59E)	CTD (#045, 500m)
	10:47 / 01:47	(11-59N, 135-00E)	Light intensity (#009, 200m)
	11:20 / 02:20	(12-00N, 134-59E)	Radiosonde (#098)
	12:30 / 03:30	(12-00N, 134-59E)	Pump seawater collection (#005)
	14:25 / 05:25	(12-00N, 135-00E)	Radiosonde (#099)
	14:27 / 05:27	(12-00N, 134-59E)	CTD (#046, 1000m)
	17:25 / 08:25	(11-59N, 134-59E)	Radiosonde (#100)
	18:46 / 09:46	(12-00N, 134-58E)	Sea skater collection (#014)
	20:26 / 11:26	(11-59N, 134-59E)	Radiosonde (#101)
	20:29 / 11:29	(12-00N, 134-59E)	CTD (#047, 500m)
	23:25 / 14:25	(12-00N, 135-00E)	Radiosonde (#102)
15	02:25 / 17:25	(12-00N, 135-00E)	Radiosonde (#103)
	02:28 / 17:28	(12-00N, 134-59E)	CTD (#048, 500m)
	05:25 / 20:25	(11-59N, 134-59E)	Radiosonde (#104)
	08:25 / 23:25	(11-59N, 135-00E)	Radiosonde (#105)
	08:27 / 23:27	(12-00N, 134-59E)	CTD (#049, 500m)
	10:47 / 01:47	(12-00N, 135-00E)	Light intensity (#010, 200m)
	11:25 / 02:25	(11-59N, 134-59E)	Radiosonde (#106)
	14:25 / 05:25	(11-59N, 134-59E)	Radiosonde (#107)
	14:28 / 05:28	(12-00N, 134-59E)	CTD (#050, 1000m)
	17:25 / 08:25	(11-59N, 135-00E)	Radiosonde (#108)
	18:47 / 09:47	(11-59N, 134-58E)	Sea skater collection (#015)
	20:25 / 11:25	(11-59N, 134-59E)	Radiosonde (#109)
	20:29 / 11:29	(11-59N, 134-59E)	CTD (#051, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#110)
16	02:25 / 17:25	(11-59N, 135-00E)	Radiosonde (#111)
	02:29 / 17:29	(12-00N, 134-59E)	CTD (#052, 500m)
	05:44 / 20:44	(11-59N, 135-00E)	Radiosonde (#112)
	08:25 / 23:25	(11-59N, 134-59E)	Radiosonde (#113)
	08:28 / 23:28	(12-00N, 134-59E)	CTD (#053, 500m)
	10:51 / 01:51	(11-59N, 134-59E)	Light intensity (#011, 200m)
	11:25 / 02:25	(12-00N, 135-00E)	Radiosonde (#114)
	12:30 / 03:30	(12-00N, 134-59E)	Pump seawater collection (#006)
	14:26 / 05:26	(11-59N, 135-00E)	Radiosonde (#115)
	14:29 / 05:29	(12-00N, 134-59E)	CTD (#054, 1000m)
	17:25 / 08:25	(11-59N, 135-00E)	Radiosonde (#116)
	18:46 / 09:46	(12-00N, 134-58E)	Sea skater collection (#016)
	20:25 / 11:25	(11-59N, 134-59E)	Radiosonde (#117)
	20:29 / 11:29	(11-59N, 134-59E)	CTD (#055, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#118)
17	02:25 / 17:25	(12-00N, 135-00E)	Radiosonde (#119)
	02:29 / 17:29	(12-00N, 134-59E)	CTD (#056, 500m)
	05:25 / 20:25	(12-00N, 134-59E)	Radiosonde (#120)
	08:25 / 23:25	(11-59N, 135-00E)	Radiosonde (#121)
	08:29 / 23:29	(11-59N, 134-59E)	CTD (#057, 500m)
	10:47 / 01:47	(11-59N, 135-00E)	Light intensity (#012, 200m)
	11:25 / 02:25	(12-00N, 135-00E)	Radiosonde (#122)
	14:25 / 05:25	(11-59N, 135-00E)	Radiosonde (#123)
	14:28 / 05:28	(11-59N, 134-59E)	CTD (#058, 1000m)
	17:25 / 08:25	(11-59N, 135-00E)	Radiosonde (#124)
	18:48 / 09:48	(12-00N, 134-59E)	Sea skater collection (#017)
	20:25 / 11:25	(12-00N, 134-59E)	Radiosonde (#125)
	20:32 / 11:32	(12-00N, 134-59E)	CTD (#059, 500m)
	23:31 / 14:31	(11-59N, 134-59E)	Radiosonde (#126)
18	02:25 / 17:25	(12-00N, 135-00E)	Radiosonde (#127)
	02:29 / 17:29	(12-00N, 134-59E)	CTD (#060, 500m)
	05:26 / 20:26	(11-59N, 134-59E)	Radiosonde (#128)
	08:19 / 23:19	(12-01N, 134-59E)	Radiosonde (#129)

	08:29 / 23:29	(12-01N, 134-59E)	CTD (#061, 500m)
	10:50 / 01:50	(12-00N, 135-00E)	Light intensity (#013, 200m)
	11:25 / 02:25	(12-00N, 134-59E)	Radiosonde (#130)
	12:30 / 03:30	(12-00N, 135-00E)	Pump seawater collection (#007)
	14:25 / 05:25	(11-59N, 134-59E)	Radiosonde (#131)
	14:29 / 05:29	(12-00N, 134-59E)	CTD (#062, 1000m)
	17:16 / 08:16	(12-00N, 135-00E)	Radiosonde (#132)
	18:51 / 09:51	(12-01N, 134-58E)	Sea skater collection (#018)
	20:18 / 11:18	(12-00N, 134-59E)	Radiosonde (#133)
	20:28 / 11:28	(12-00N, 134-59E)	CTD (#063, 500m)
	23:25 / 14:25	(11-59N, 134-58E)	Radiosonde (#134)
19	02:21 / 17:21	(12-00N, 134-59E)	Radiosonde (#135)
	02:29 / 17:29	(12-00N, 134-59E)	CTD (#064, 500m)
	05:25 / 20:25	(11-59N, 134-59E)	Radiosonde (#136)
	08:24 / 23:24	(12-00N, 134-59E)	Radiosonde (#137)
	08:28 / 23:28	(12-00N, 135-00E)	CTD (#065, 500m)
	10:47 / 01:47	(12-00N, 135-00E)	Light intensity (#014, 200m)
	11:41 / 02:41	(11-59N, 135-00E)	Radiosonde (#138)
	14:21 / 05:21	(12-00N, 135-00E)	Radiosonde (#139)
	14:28 / 05:28	(12-00N, 135-00E)	CTD (#066, 1000m)
	17:25 / 08:25	(11-59N, 135-00E)	Radiosonde (#140)
	18:46 / 09:46	(12-01N, 135-00E)	Sea skater collection (#019)
	20:25 / 11:25	(12-00N, 134-59E)	Radiosonde (#141)
	20:29 / 11:29	(12-00N, 134-59E)	CTD (#067, 500m)
	23:26 / 14:26	(11-59N, 134-59E)	Radiosonde (#142)
20	02:25 / 17:25	(11-59N, 134-59E)	Radiosonde (#143)
	02:32 / 17:32	(11-59N, 134-59E)	CTD (#068, 500m)
	05:27 / 20:27	(11-59N, 134-59E)	Radiosonde (#144)
	08:26 / 23:26	(12-00N, 134-59E)	Radiosonde (#145)
	08:29 / 23:29	(11-59N, 134-59E)	CTD (#069, 500m)
	10:49 / 01:49	(11-59N, 134-59E)	Light intensity (#015, 200m)
	11:25 / 02:25	(11-59N, 134-59E)	Radiosonde (#146)
	14:25 / 05:25	(12-00N, 134-58E)	Radiosonde (#147)
	14:28 / 05:28	(12-00N, 134-58E)	CTD (#070, 1000m)
	17:25 / 08:25	(12-00N, 134-56E)	Radiosonde (#148)
	18:47 / 09:47	(12-01N, 135-00E)	Sea skater collection (#020)
	20:25 / 11:25	(12-00N, 134-58E)	Radiosonde (#149)
	20:30 / 11:30	(12-00N, 134-58E)	CTD (#071, 500m)
	23:25 / 14:25	(11-59N, 134-57E)	Radiosonde (#150)
21	02:25 / 17:25	(12-00N, 134-59E)	Radiosonde (#151)
	02:31 / 17:31	(12-00N, 134-59E)	CTD (#072, 500m)
	05:25 / 20:25	(11-59N, 134-59E)	Radiosonde (#152)
	08:50 / 23:50	(11-59N, 135-01E)	Radiosonde (#153)
	08:53 / 23:53	(11-59N, 135-01E)	CTD (#073, 500m)
	10:49 / 01:49	(12-00N, 135-00E)	Light intensity (#016, 200m)
	11:25 / 02:25	(12-00N, 135-00E)	Radiosonde (#154)
	14:25 / 05:25	(12-00N, 135-00E)	Radiosonde (#155)
	14:30 / 05:30	(12-00N, 135-00E)	CTD (#074, 1000m)
	15:30 / 06:30		End of Seasnake SST measurement
	17:25 / 08:25	(11-59N, 134-59E)	Radiosonde (#156)
	18:50 / 09:50	(12-00N, 134-59E)	Sea skater collection (#021)
	20:34 / 11:34	(11-59N, 135-00E)	Radiosonde (#157)
	20:36 / 11:36	(11-59N, 135-00E)	CTD (#075, 500m)
	23:25 / 14:25	(12-00N, 135-00E)	Radiosonde (#158)
22	02:29 / 17:29	(12-00N, 135-00E)	Radiosonde (#159)
	02:35 / 17:35	(12-00N, 135-00E)	CTD (#076, 500m)
	05:25 / 20:25	(11-59N, 134-59E)	Radiosonde (#160)
	08:25 / 23:25	(12-00N, 135-00E)	Radiosonde (#161)
	08:30 / 23:30	(11-59N, 135-00E)	CTD (#077, 500m)
	10:45 / 01:45	(12-00N, 135-00E)	Light intensity (#017, 200m)
	11:26 / 02:26	(12-00N, 135-00E)	Radiosonde (#162)
	12:25 / 03:25	(12-00N, 134-59E)	Pump seawater collection (#008)
	14:25 / 05:25	(12-00N, 134-59E)	Radiosonde (#163)
	14:28 / 05:28	(12-00N, 134-59E)	CTD (#078, 1000m)
	17:35 / 08:35	(12-00N, 134-59E)	Radiosonde (#164)
	18:47 / 09:47	(11-59N, 135-02E)	Sea skater collection (#022)
	20:25 / 11:25	(12-00N, 134-59E)	Radiosonde (#165)
	20:29 / 11:29	(11-59N, 134-59E)	CTD (#079, 500m)
	23:25 / 14:25	(11-59N, 134-59E)	Radiosonde (#166)
23	02:26 / 17:26	(11-59N, 134-59E)	Radiosonde (#167)
	02:29 / 17:29	(11-59N, 134-59E)	CTD (#080, 500m)
	05:25 / 20:25	(12-00N, 134-59E)	Radiosonde (#168)
	08:25 / 23:25	(11-59N, 134-59E)	Radiosonde (#169)

	08:29 / 23:29	(11-59N, 134-59E)	CTD (#081, 500m)
	10:46 / 01:46	(12-00N, 134-59E)	Light intensity (#018, 200m)
	11:26 / 02:26	(11-59N, 134-59E)	Radiosonde (#170)
	14:25 / 05:25	(12-00N, 134-59E)	Radiosonde (#171)
	14:28 / 05:28	(12-00N, 134-59E)	CTD (#082, 1000m)
	17:25 / 08:25	(12-00N, 134-59E)	Radiosonde (#172)
	18:46 / 09:46	(12-02N, 135-01E)	Sea skater collection (#023)
	20:26 / 11:26	(11-59N, 134-59E)	Radiosonde (#173)
	20:29 / 11:29	(11-59N, 135-00E)	CTD (#083, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#174)
24	02:25 / 17:25	(11-59N, 135-00E)	Radiosonde (#175)
	02:29 / 17:29	(11-59N, 135-00E)	CTD (#084, 500m)
	05:25 / 20:25	(11-59N, 135-00E)	Radiosonde (#176)
	08:26 / 23:26	(11-59N, 135-00E)	Radiosonde (#177)
	08:28 / 23:28	(11-59N, 135-00E)	CTD (#085, 500m)
	10:45 / 01:45	(12-00N, 135-00E)	Light intensity (#019, 200m)
	11:25 / 02:25	(12-00N, 135-00E)	Radiosonde (#178)
	14:27 / 05:27	(12-00N, 134-59E)	Radiosonde (#179)
	14:29 / 05:29	(12-00N, 134-59E)	CTD (#086, 1000m)
	17:22 / 08:22	(11-59N, 134-59E)	Radiosonde (#180)
	18:48 / 09:48	(11-58N, 134-57E)	Sea skater collection (#024)
	20:25 / 11:25	(11-59N, 135-00E)	Radiosonde (#181)
	20:30 / 11:30	(11-59N, 135-00E)	CTD (#087, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#182)
25	02:25 / 17:25	(11-59N, 134-59E)	Radiosonde (#183)
	02:29 / 17:29	(11-59N, 134-59E)	CTD (#088, 500m)
	05:25 / 20:25	(11-59N, 135-00E)	Radiosonde (#184)
	08:25 / 23:25	(11-59N, 134-59E)	Radiosonde (#185)
	08:28 / 23:28	(12-00N, 134-59E)	CTD (#089, 500m)
	10:45 / 01:45	(12-00N, 135-00E)	Light intensity (#020, 200m)
	11:26 / 02:26	(12-00N, 134-59E)	Radiosonde (#186)
	14:25 / 05:25	(12-00N, 134-59E)	Radiosonde (#187)
	14:29 / 05:29	(12-00N, 134-59E)	CTD (#090, 1000m)
	17:25 / 08:25	(12-00N, 135-00E)	Radiosonde (#188)
	18:46 / 09:46	(11-58N, 134-57E)	Sea skater collection (#025)
	20:26 / 11:26	(12-00N, 135-00E)	Radiosonde (#189)
	20:28 / 11:28	(12-00N, 135-00E)	CTD (#091, 500m)
	23:25 / 14:25	(11-59N, 135-00E)	Radiosonde (#190)
26	02:25 / 17:25	(11-59N, 135-00E)	Radiosonde (#191)
	02:29 / 17:29	(12-00N, 135-00E)	CTD (#092, 500m)
	05:25 / 20:25	(11-59N, 134-59E)	Radiosonde (#192)
	08:25 / 23:25	(12-00N, 135-00E)	Radiosonde (#193)
	08:27 / 23:27	(12-00N, 135-00E)	CTD (#093, 500m)
	10:45 / 01:45	(12-00N, 135-00E)	Light intensity (#021, 200m)
	11:22 / 02:22	(12-00N, 134-59E)	Radiosonde (#194)
	14:25 / 05:25	(12-00N, 134-59E)	Radiosonde (#195)
	14:27 / 05:27	(12-00N, 134-59E)	CTD (#094, 1000m)
	17:25 / 08:25	(11-59N, 134-59E)	Radiosonde (#196)
	18:45 / 09:45	(12-02N, 135-00E)	Sea skater collection (#026)
	20:32 / 11:32	(12-00N, 135-00E)	Radiosonde (#197)
	20:36 / 11:36	(12-00N, 135-00E)	CTD (#095, 500m)
	23:28 / 14:28	(11-58N, 134-59E)	Radiosonde (#198)
27	02:26 / 17:26	(11-59N, 134-59E)	Radiosonde (#199)
	02:29 / 17:29	(11-59N, 135-00E)	CTD (#096, 500m)
	05:25 / 20:25	(11-59N, 134-59E)	Radiosonde (#200)
	08:25 / 23:25	(11-59N, 134-59E)	Radiosonde (#201)
	08:27 / 23:27	(11-59N, 134-59E)	CTD (#097, 500m)
	11:25 / 02:25	(11-59N, 135-00E)	Radiosonde (#202)
	14:25 / 05:25	(11-59N, 135-00E)	Radiosonde (#203)
	14:27 / 05:27	(11-59N, 134-59E)	CTD (#098, 1000m)
	17:25 / 08:25	(12-00N, 134-59E)	Radiosonde (#204)
	18:45 / 09:45	(12-02N, 134-58E)	Sea skater collection (#027)
	20:25 / 11:25	(11-59N, 134-59E)	Radiosonde (#205)
	20:27 / 11:27	(12-00N, 134-59E)	CTD (#099, 500m)
	23:26 / 14:26	(11-59N, 134-59E)	Radiosonde (#206)
28	02:25 / 17:25	(12-03N, 135-30E)	Radiosonde (#207)
	05:25 / 20:25	(12-08N, 136-00E)	Radiosonde (#208)
	08:25 / 23:25	(12-13N, 136-31E)	Radiosonde (#209)
	22:00 / 13:00	Time Adjustment (22:00 SMT → 23:00 SMT)	
29	16:00 / 06:00	End of observation	
30	10:20 / 00:20	Arrival at Guam, U.S.A.	

4. List of Participants

4.1 Participants on board

Name	Affiliation	Theme No.*
Kunio Yoneyama	JAMSTEC	M
Biao Geng	JAMSTEC	M
Yoshiaki Miyamoto	JAMSTEC	M
Tomohito Hioki	Nagoya University	1
Junichi Watanabe	Chiba University	2
Mayumi Horikawa	Nagoya University	4
Satoshi Kitajima	The University of Tokyo	6
Takuhei Shiozaki	The University of Tokyo	6
Takako Masuda	The University of Tokyo	6
Taketoshi Kodama	The University of Tokyo	6
Takato Matsui	Hokkaido University	6
Tetsuo Harada	Kochi University	7
Shiho Takenaka	Kochi University	7
Chihiro Katagiri	Hokkaido University	7
Souichiro Sueyoshi	Global Ocean Development Inc. (GODI)	T
Shinya Okumura	GODI	T
Wataru Tokunaga	GODI	T
Harumi Ota	GODI	T
Tomoyuki Takamori	Marine Works Japan Ltd. (MWJ)	T
Hirokatsu Uno	MWJ	T
Fujio Kobayashi	MWJ	T
Yuichi Sonoyama	MWJ	T
Yoshiko Ishikawa	MWJ	T
Miyo Ikeda	MWJ	T
Shoko Tatamisashi	MWJ	T
Hiroki Ushiromura	MWJ	T
Tomonori Watai	MWJ	T
Akira Watanabe	MWJ	T

* Theme number (1-9) corresponds to that shown in Section 2.7.
M means Main mission, while T means Technical staff.

4.2 Participants not on board

Name	Affiliation	Theme No.
Naoki Sato	JAMSTEC	M
Mikiko Fujita	JAMSTEC	M
Taroh Shinoda	Nagoya University	1
Hajime Okamoto	Tohoku University	2
Toshiaki Takano	Chiba University	2
Nobuo Sugimoto	National Institute for Environmental Studies (NIES)	3
Ichiro Matsui	NIES	3
Atsushi Shimizu	NIES	3
Naoyuki Kurita	JAMSTEC	4
Osamu Tsukamoto	Okayama University	5
Fumiyoshi Kondo	Okayama University	5
Hiroshi Ishida	Kobe University	5
Ken Furuya	The University of Tokyo	7
Takeshi Matsumoto	University of the Ryukyus	8
Masao Nakanishi	Chiba University	9

4.3 Ship Crew

Masaharu Akamine	Master
Haruhiko Inoue	Chief Officer
Yooshimichi Nagai	First Officer
Nobuo Fukaura	Second Officer
Noriyuki Hatachi	Third Officer
Mitsunobu Asanuma	Jr. Third Officer
Hiroyuki Doi	Chief Engineer
Koji Masuno	First Engineer
Kaoru Minami	Second Engineer
Toshio Kiuchi	Third Engineer
Shuji Nakabayashi	Chief Radio Officer
Hisao Oguni	Boatswain
Yosuke Kuwahara	Able Seaman
Takeharu Aisaka	Able Seaman
Tsuyoshi Monzawa	Able Seaman
Masashige Okada	Able Seaman
Shuji Komata	Able Seaman
Keita Nishimura	Ordinary Seaman
Hideaki Tamotsu	Ordinary Seaman
Hideyuki Okubo	Ordinary Seaman
Yusuke Asano	Ordinary Seaman
Ginta Ogaki	Ordinary Seaman
Sadanori Honda	No. 1 Oiler
Toshimi Yoshikawa	Oiler
Hiroki Sato	Oiler
Yoshihiro Sugimoto	Oiler
Kazumi Yamashita	Oiler
Daisuke Taniguchi	Oiler
Yasuhiro Kitahara	Oiler
Hitoshi Ota	Chief Steward
Hatsuji Hiraishi	Cook
Tamotsu Uemura	Cook
Masao Hosoya	Cook
Kozo Uemura	Cook
Yoshiteru Hiramatsu	Cook

5. Summary of the Observations

5.1 GPS Radiosonde

(1) Personnel

Kunio Yoneyama	(JAMSTEC)	Principal Investigator
Biao Geng	(JAMSTEC)	
Yoshiaki Miyamoto	(JAMSTEC)	
Souichiro Sueyoshi	(GODI)	Operation Leader
Shinya Okumura	(GODI)	
Wataru Tokunaga	(GODI)	
Harumi Ota	(GODI)	
Tomohito Hioki	(Nagoya University)	
Taro Shinoda	(Nagoya University)	* not on board

(2) Objective

Atmospheric soundings of temperature, humidity, and wind speed/direction.

(3) Method

Atmospheric sounding by radiosonde was carried out every 3 hours from 0000Z June 2, 2008 through 0000Z June 28, 2008. In total, 209 soundings were carried out (Table 5.1-1) and one trial conducted as sounding No. 19 was failed to launch. Thus, data were taken for 208 soundings. The main system consists of processor (Vaisala, DigiCORA III), GPS antenna (GA20), UHF antenna (RB21), ground check kit (GC25), balloon launcher (ASAP), and GPS radiosonde sensor (RS92-SGP).

(4) Results

Time-height cross sections of equivalent potential temperature, relative humidity, zonal and meridional wind components are shown in Fig.5.1-1, respectively. Several basic parameters are calculated from sounding data (Fig. 5.1-2). They include convective available potential energy (CAPE), convective inhibition (CIN), lifted condensation level (LCL), 1000-700 hPa layer-mean zonal and meridional wind components, and total precipitable water vapor (TPW). In Appendix-B, vertical profiles of temperature and dew point temperature on the thermodynamic chart with wind profiles are also attached.

(5) Data archive

Data were sent to the world meteorological community via Global Telecommunication System through the Japan Meteorological Agency, immediately after the each observation. Raw data is recorded as ASCII format every 2 seconds during ascent. These raw datasets will be submitted to JAMSTEC Marine-Earth Data and Information Department and corrected datasets are available from Mirai Web site at http://www.jamstec.go.jp/cruisedata/mirai/e/.

Table 5.1-1 Radiosonde launch log. Surface values and maximum height.

ID	Date	Long.	Lat.	Pres	Tair	RH	WD	Wsp	Max height		Cloud	
	YYYYMMDDHH	deg	deg	hPa	degC	%	deg	m/s	hPa	m	Amount	Type
RS001	2008060200	14.563	130.103	1008.7	28.9	76	184	6.1	33.9	23028	7	Cu,Cb,Ci,Cs,Cc
RS002	2008060203	14.000	130.010	1008.8	28.8	77	183	4.9	26.0	24729	6	Cu,Ci,Cs,Cc
RS003	2008060206	13.519	130.103	1007.7	28.8	76	174	3.8	24.1	25184	6	Cu,Cc,Cs
RS004	2008060209	12.707	130.108	1007.4	28.9	76	106	4.3	34.6	22890	3	Cu,Cb,Ci
RS005	2008060212	12.293	130.101	1009.6	28.8	77	99	5.5	27.9	24275	4	unknown
RS006	2008060215	11.547	130.101	1010.4	28.7	79	91	5.1	26.9	24494	-	unknown
RS007	2008060218	11.002	130.095	1008.5	28.5	80	69	5.6	29.3	23946	-	unknown
RS008	2008060221	10.401	130.086	1008.5	28.6	78	96	7.2	74.1	18240	2	Cu,Cb
RS009	2008060300	9.649	130.076	1009.0	28.5	80	66	6.7	27.7	24300	5	Cu,Cb,St
RS010	2008060303	8.875	130.078	1009.1	29.1	76	71	7.4	28.1	24204	3	Cb,Cu,Cs
RS011	2008060306	8.149	130.062	1007.2	28.8	80	89	8.0	33.6	23072	9	Cu,Cb
RS012	2008060309	7.580	130.067	1006.2	28.0	77	67	5.9	44.1	21250	9	As,Cu,Sc
RS013	2008060312	7.086	130.099	1008.4	28.1	82	117	7.0	40.1	21941	9	As,Ns
RS014	2008060315	6.336	130.088	1007.9	28.1	76	88	7.4	29.9	23812	6	unknown
RS015	2008060318	5.599	130.081	1006.6	28.4	76	100	7.9	30.1	23747	7	unknown
RS016	2008060321	5.019	130.102	1007.8	28.6	76	67	7.2	597.7	4434	-	unknown
RS017	2008060400	5.244	130.277	1007.4	28.9	76	81	6.2	28.3	24169	1	Cu,Ci
RS018	2008060403	5.847	130.707	1007.3	29.1	74	100	6.3	43.3	21481	3	Cu,Ci,Cs
RS019	2008060406	6.427	131.192	1005.0	29.0	74	84	5.0	-	-	-	not measured
RS020	2008060409	6.954	131.521	1004.8	28.8	76	82	6.9	35.1	22765	6	Cs,Ci,As,Ns,Cb,Cu,Sc
RS021	2008060412	7.306	131.767	1006.1	28.6	78	90	7.7	23.4	25424	5	unknown
RS022	2008060415	7.833	132.122	1006.5	28.7	78	94	7.5	27.1	24473	1	Cu,Sc
RS023	2008060418	8.299	132.462	1005.3	28.3	83	111	5.9	26.5	24574	4	Cu
RS024	2008060421	8.620	132.693	1005.5	27.3	82	90	6.3	29.0	23975	8	Cu,Cb,Ac,Sc
RS025	2008060500	9.102	133.002	1007.1	28.8	80	69	8.2	24.4	25121	1	Cu,Cb
RS026	2008060503	9.621	133.319	1006.7	29.0	76	83	7.2	24.2	25168	3	Cu,Ci
RS027	2008060506	10.152	133.731	1005.3	29.1	73	67	7.9	938.7	624	2	Cu
RS028	2008060509	10.718	134.106	1005.3	29.0	72	71	7.6	25.3	24876	2	Cu,Ci,Ac
RS029	2008060512	11.011	134.343	1007.0	28.6	74	77	6.7	31.7	23449	5	Cu,Ci
RS030	2008060515	11.503	134.657	1007.2	28.5	74	97	7.8	27.8	24311	1	Cu
RS031	2008060518	11.992	134.985	1006.8	28.4	74	103	7.1	40.5	21877	-	unknown
RS032	2008060521	12.015	134.989	1007.1	28.2	78	108	5.7	29.1	23969	8	Cu,Cb,Ci
RS033	2008060600	12.027	134.990	1008.2	28.5	73	93	6.3	27.2	24416	1	Cu
RS034	2008060603	12.004	134.994	1008.0	28.8	69	95	6.8	23.0	25503	3	Cu,Cs,Ci
RS035	2008060606	12.009	134.989	1006.8	28.9	73	70	5.8	28.1	24196	3	Cu,Cs
RS036	2008060609	12.031	134.994	1007.0	28.8	75	73	7.2	26.0	24709	8	Cs,Ci,As,Cu
RS037	2008060612	12.000	134.993	1008.1	28.8	75	61	8.6	30.7	23643	-	unknown
RS038	2008060615	12.051	135.018	1008.3	28.3	81	76	7.8	38.7	22190	1	Cu
RS039	2008060618	11.997	134.998	1007.5	29.1	78	66	6.8	27.2	24414	-	unknown
RS040	2008060621	12.000	134.992	1008.1	28.3	79	69	6.5	37.8	22353	2	Cu,Cb,Ci
RS041	2008060700	11.996	135.011	1009.0	28.8	76	69	7.6	27.9	24259	2	Cu,Ci
RS042	2008060703	12.000	135.002	1008.9	28.8	77	76	5.6	32.0	23364	3	Cu,Cs
RS043	2008060706	12.002	135.004	1007.7	29.1	73	68	5.7	40.5	21930	4	Cu,Cs,Cb
RS044	2008060709	11.964	134.997	1008.0	29.0	72	63	6.1	27.8	24291	7	Cb,Cu,As,Cc,Ci
RS045	2008060712	12.010	134.994	1009.0	28.0	80	43	6.3	31.3	23541	-	unknown
RS046	2008060715	12.025	134.997	1009.1	28.3	78	61	8.0	39.9	22012	-	unknown
RS047	2008060718	12.001	134.999	1008.2	28.3	76	67	7.8	21.8	25852	-	unknown
RS048	2008060721	12.016	134.996	1008.5	28.1	79	67	7.0	30.0	23807	4	Cu,Ci
RS049	2008060800	12.010	135.001	1008.9	28.7	74	82	8.9	33.9	23018	2	Cu,Ci
RS050	2008060803	12.003	134.995	1008.4	28.8	76	76	8.3	26.2	24688	2	Cu,Ci,Cs
RS051	2008060806	12.032	134.997	1007.4	28.3	78	77	4.6	25.2	24912	1	Cu
RS052	2008060809	12.074	135.013	1007.6	28.6	79	57	5.2	33.3	23139	5	Cu,Cb
RS053	2008060812	12.000	134.995	1009.0	27.0	85	64	4.1	23.3	25471	-	unknown
RS054	2008060815	12.022	135.008	1008.9	27.1	81	74	6.9	29.9	23863	-	unknown
RS055	2008060818	12.005	135.021	1007.5	28.4	77	88	8.6	32.1	23380	-	unknown
RS056	2008060821	12.005	134.996	1007.8	28.1	78	98	7.9	36.2	22648	8	Cu,Cb,Sc
RS057	2008060900	12.014	135.010	1008.9	28.5	77	86	8.6	32.1	23390	2	Cu,Cb,Ac
RS058	2008060903	12.003	134.996	1008.1	28.8	70	96	7.3	28.1	24237	1	Cu
RS059	2008060906	12.017	135.008	1006.8	28.8	71	81	7.6	66.3	18932	2	Cu
RS060	2008060909	12.012	135.002	1006.6	28.9	73	68	7.0	29.0	24000	4	Cu
RS061	2008060912	12.046	135.003	1007.5	28.8	73	83	10.3	29.9	23832	-	Cu
RS062	2008060915	12.020	135.007	1008.1	28.7	79	80	6.8	26.5	24640	-	unknown
RS063	2008060918	12.015	135.008	1007.1	28.6	74	86	7.8	25.8	24803	-	unknown
RS064	2008060921	12.027	135.013	1007.2	28.2	76	73	5.9	33.8	23079	1-	Cu
RS065	2008061000	12.018	135.015	1008.4	28.6	75	64	6.1	25.0	25013	1-	Cu
RS066	2008061003	12.004	134.997	1007.9	28.7	77	75	5.1	24.0	25271	2	Cu
RS067	2008061006	12.007	134.997	1006.6	28.9	75	73	5.1	24.2	25226	4	Cu,As
RS068	2008061009	12.063	135.005	1008.6	28.8	73	96	4.9	44.2	21380	8	Ci,Cb,Cu,Cs
RS069	2008061012	11.996	134.996	1008.7	28.5	79	74	2.9	31.5	23535	-	Cu
RS070	2008061015	12.027	135.005	1009.0	28.4	79	74	4.4	38.7	22221	4	Cu
RS071	2008061018	12.034	135.001	1007.7	28.1	80	63	4.5	41.4	21771	-	unkown
RS072	2008061021	12.038	134.993	1008.3	27.8	77	91	3.6	28.3	24191	10	Cu,Cb,Sc

RS073	2008061100	12.019	135.004	1009.6	28.4	76	73	3.9	27.1	24477	9	Cu,Cb,Sc
RS074	2008061103	12.003	134.997	1008.7	28.8	74	98	5.0	29.6	23942	9	Cu,Cb,Sc
RS075	2008061106	12.028	135.009	1007.1	29.0	72	68	3.8	27.6	24370	8	Cu,As
RS076	2008061109	12.055	135.003	1006.9	27.4	86	75	5.0	37.1	22442	10-	Cs,As,Cu,Cb,Ns
RS077	2008061112	12.001	125.005	1008.6	28.5	76	56	3.7	50.2	20607	8	Cu,Ci,Cs
RS078	2008061115	12.027	135.005	1008.8	28.2	80	78	3.9	28.2	24231	6	Cu,Ci,Cs
RS079	2008061118	12.027	135.003	1007.4	28.2	77	77	5.7	29.6	23888	-	unknown
RS080	2008061121	12.019	135.004	1007.5	28.0	78	89	4.7	37.9	22340	10-	Ac,Cu,Cb,Sc
RS081	2008061200	12.016	135.008	1008.2	28.3	78	70	4.4	21.5	25983	9	Ac,Cu,Ci,Cb
RS082	2008061203	12.002	134.998	1008.7	26.0	73	74	4.8	26.9	24539	3	Cu,Ac,Ci
RS083	2008061206	12.009	135.000	1006.3	28.8	72	51	3.0	43.0	21552	3	Cu
RS084	2008061209	12.034	134.984	1005.7	28.7	74	44	6.5	27.0	24489	6	Cs,Ci,Cc,Cu
RS085	2008061212	12.000	135.001	1007.3	28.7	78	45	7.8	34.8	22892	4	Cu
RS086	2008061215	12.039	134.991	1008.1	28.7	76	64	5.8	30.8	23663	4	Cu,Cc,Cb
RS087	2008061218	12.004	135.002	1007.1	28.5	77	88	4.2	99.4	16576	2	Cu
RS088	2008061221	12.018	135.005	1007.4	28.2	78	79	3.9	31.8	23458	9	Ac,Cb,Cu
RS089	2008061300	12.022	135.000	1009.0	28.7	76	83	2.7	26.7	24588	4	Ac,Cu,Ci
RS090	2008061303	12.001	134.997	1008.7	28.9	74	37	3.8	29.0	24073	2	Cu,Ci
RS091	2008061306	12.015	134.988	1006.9	29.0	71	47	4.0	26.7	24585	4	Cu,Cb,Cs,Ci
RS092	2008061309	12.043	135.004	1007.0	28.8	78	75	5.0	29.5	23951	8	Ci,Cu,As
RS093	2008061312	11.998	135.003	1008.2	29.0	78	63	5.0	28.0	24281	5	Cu
RS094	2008061315	12.039	135.003	1008.2	28.6	79	51	4.0	28.9	24087	5	Cu,Cg,Cs
RS095	2008061318	12.004	135.000	1007.1	28.2	83	61	3.8	27.2	24462	1	Cu
RS096	2008061321	12.033	134.992	1006.9	27.9	82	14	3.7	31.5	23535	1	Cu,Sc,Ci
RS097	2008061400	12.017	134.994	1008.5	28.3	75	18	6.0	26.2	24713	7	Cb,Cu
RS098	2008061403	12.001	134.998	1007.6	28.9	75	47	6.2	31.3	23588	6	Cu,Cb,Ci,Cs,As,Sc
RS099	2008061406	12.002	134.996	1006.7	27.9	79	53	6.7	28.4	24186	7	Cu,Cb,Sc,Ci
RS100	2008061409	12.040	135.004	1006.5	27.0	87	99	6.2	232.8	11415	10	Ns,Cu,Cb,Ac
RS101	2008061412	12.000	134.998	1007.5	28.2	81	67	4.6	35.4	22792	10	Cu,Sc
RS102	2008061415	12.029	134.998	1007.5	28.4	81	59	6.3	36.9	22544	10	Cu,As,Sc
RS103	2008061418	12.021	134.995	1006.2	28.4	80	47	4.7	27.0	24494	10	unkown
RS104	2008061421	12.037	134.988	1006.4	27.1	83	35	3.9	27.7	24327	7	Cb,Ci,Cu,Sc
RS105	2008061500	12.028	135.013	1007.5	28.8	81	63	3.8	24.8	25057	5	Cu,Cb,Sc
RS106	2008061503	12.002	134.997	1006.4	29.0	77	83	8.3	87.5	17323	6	Cu,Sc,Ci,Cb
RS107	2008061506	12.022	135.005	1005.1	29.1	76	80	8.8	24.4	25134	4	Cu,Cb
RS108	2008061509	12.036	135.017	1004.9	28.7	80	78	5.0	26.1	24716	5	Cu,Ci,Cs
RS109	2008061512	11.996	134.996	1006.5	28.7	82	107	5.1	35.4	22792	7	Cb,Cu,Ci,Cs
RS110	2008061515	12.029	135.004	1007.2	28.7	76	85	7.3	26.6	24639	5	Cu,Cs
RS111	2008061518	12.020	135.011	1006.0	28.7	77	79	5.7	31.3	23562	5	Cu
RS112	2008061521	11.995	135.002	1006.2	28.5	77	74	5.1	30.6	23692	7	Ci,As,Cu
RS113	2008061600	12.030	135.019	1007.7	28.6	79	71	4.2	30.2	23821	7	Cb,Cu,As,Ci
RS114	2008061603	12.002	134.997	1007.6	26.8	83	35	5.7	24.5	25134	6	Cu,Cs,Cc,As
RS115	2008061606	12.007	134.995	1005.7	28.2	81	60	5.0	27.0	24514	5	Cu,As,Cs
RS116	2008061609	12.030	135.007	1005.8	28.7	77	92	4.6	26.0	24735	9	Sc,Cu,Cb,Ci
RS117	2008061612	12.000	134.998	1006.9	28.7	78	76	7.8	31.8	23479	3	Ci,Sc
RS118	2008061615	12.029	135.013	1007.8	28.5	77	85	5.6	30.8	23695	4	Cu,Ci
RS119	2008061618	12.017	135.008	1006.6	28.3	81	64	4.7	28.5	24170	3	Cu
RS120	2008061621	12.034	135.010	1006.5	28.4	78	71	5.3	26.2	24722	7	Cu,Ci,Cb
RS121	2008061700	12.032	135.023	1007.8	28.5	80	52	5.7	31.7	23504	5	Cu,Ci
RS122	2008061703	12.003	135.000	1007.5	28.8	78	68	8.0	27.7	24355	4	Cu,Cs,Ci
RS123	2008061706	12.025	135.002	1006.3	28.3	78	81	8.5	29.7	23884	5	Cu,Cb,Cs
RS124	2008061709	12.019	135.011	1006.0	28.1	79	93	7.8	28.4	24177	2	Cb,Cu,Ci
RS125	2008061712	12.007	134.994	1007.3	27.7	76	88	7.3	35.6	22747	1	Cb,Cu
RS126	2008061715	12.021	135.004	1007.2	26.8	88	103	9.4	35.6	22742	4	Cu,Cb
RS127	2008061718	12.029	135.013	1005.4	28.1	81	85	8.7	27.2	24460	3	Cu,Cb
RS128	2008061721	12.017	135.025	1005.7	27.5	84	85	11.0	28.6	24152	5	Cb,Cu,Ci
RS129	2008061800	12.043	135.006	1007.2	26.8	87	122	11.2	25.3	24937	10-	Cb,Cu,Cs
RS130	2008061803	12.009	135.000	1006.6	28.7	78	92	10.0	25.9	24807	6	Cu,Ac,Sc
RS131	2008061806	12.008	135.002	1005.3	27.4	81	93	7.6	27.8	24348	10-	Cu,Ac,Sc
RS132	2008061809	12.017	135.019	1004.8	27.4	87	115	10.1	43.6	21464	10	Sc,Cu,Cb
RS133	2008061812	12.005	135.000	1006.3	27.8	84	110	10.4	33.2	23204	3	Sc,Cu,Ci
RS134	2008061815	12.004	135.012	1007.0	27.8	83	124	9.7	30.1	23830	8	Ac,Cu
RS135	2008061818	12.005	135.020	1005.3	28.0	83	124	10.0	33.1	23200	4	Cu,Cs
RS136	2008061821	12.010	135.035	1004.4	28.0	82	115	8.8	35.6	22745	10-	Cu,Ci,Cs,As,Ac
RS137	2008061900	12.015	135.019	1005.9	27.3	86	136	6.7	32.0	23432	7	Cu,As,Cb,Ci,Cc
RS138	2008061903	12.001	135.001	1005.4	28.5	81	132	5.4	23.5	25428	6	Cu,Cb,Sc,Cs
RS139	2008061906	12.016	135.029	1004.4	28.7	77	161	7.4	19.6	26609	7	Cu,Cg,As,Ci,Cs,Cc
RS140	2008061909	11.989	135.037	1004.3	28.7	76	179	4.7	24.8	25076	2	Cu,Ci,Cc,Cb
RS141	2008061912	12.000	135.002	1006.5	28.6	76	174	5.3	34.8	22893	7	Sc,Ac
RS142	2008061915	11.997	134.998	1005.9	25.8	90	163	6.3	32.0	23444	8	Ns
RS143	2008061918	11.982	135.010	1005.0	28.0	74	196	6.9	27.5	24395	5	Cu,Sc
RS144	2008061921	11.990	135.003	1004.9	27.5	84	188	5.6	22.9	25573	8	Cu,Cb,Ci,As,Ac
RS145	2008062000	12.000	135.001	1006.4	27.7	83	191	7.7	29.3	24002	6	Cu,Cs,Cc,As,Ac
RS146	2008062003	11.992	134.998	1006.6	27.9	82	210	8.6	27.7	24355	9	Cu,Cb,As
RS147	2008062006	11.977	134.968	1005.1	27.0	80	242	9.8	24.8	25078	8	Cu,Cg,Cb.As,Ac,Sc
RS148	2008062009	11.992	134.951	1004.5	27.9	79	220	10.7	28.3	24191	9	Sc,Cb,Cu
RS149	2008062012	12.000	134.986	1005.6	28.0	77	244	7.1	33.5	23158	7	Sc,Cu

RS150	2008062015	11.969	134.950	1006.6	28.2	78	225	7.1	30.3	23784	10	Sc,Cu
RS151	2008062018	11.989	134.998	1005.5	28.3	79	208	1.9	36.4	22614	10	Sc,Cu
RS152	2008062021	11.989	135.021	1005.1	26.6	84	123	1.2	33.7	23118	10	Cb,Cu
RS153	2008062100	11.992	135.028	1006.2	26.0	91	174	2.9	55.3	20076	10	Cb
RS154	2008062103	12.002	135.006	1007.4	26.1	87	175	9.5	546.2	5418	10	Cb,Cu
RS155	2008062106	11.990	135.014	1005.2	25.0	85	188	6.7	44.8	21327	10	Cu,Cb,As
RS156	2008082109	11.999	135.958	1006.3	25.4	86	167	7.9	547.2	5133	10	Ns,Sc
RS157	2008082112	11.999	135.000	1007.6	26.5	82	108	7.5	56.2	19937	-	unknown
RS158	2008082115	12.005	135.045	1006.7	27.1	80	172	6.2	45.6	21215	10	Ns,Sc
RS159	2008082118	12.001	135.018	1006.5	27.5	80	245	3.0	75.6	18145	10	Ns
RS160	2008082121	11.999	135.023	1006.9	28.3	73	219	1.7	42.0	21717	10	Cu,Sc,Ac,Cs
RS161	2008062200	11.997	135.018	1007.6	27.0	82	343	4.9	66.8	18890	10	Cu,Sc
RS162	2008062203	11.999	135.007	1007.5	27.1	83	279	5.2	26.9	24562	10	Cu,As
RS163	2008062206	11.991	134.998	1006.2	27.4	81	298	3.9	28.8	24090	10-	As,Cs,Cu
RS164	2008062209	12.000	134.999	1006.8	27.7	79	265	4.9	35.2	22816	9	Sc,Cu
RS165	2008062212	12.000	135.000	1007.2	27.4	79	204	4.3	38.3	22313	10	Sc,Cu
RS166	2008062215	11.983	135.004	1007.3	27.5	81	165	6.6	28.3	24211	10	Sc
RS167	2008062218	11.990	135.017	1006.9	27.8	80	154	4.1	39.1	22159	9	Ac
RS168	2008062221	11.984	135.019	1007.0	26.2	87	188	7.3	27.7	24329	9	Cu,Cb,As,Ac
RS169	2008062300	12.002	134.993	1007.7	27.7	79	155	3.8	34.6	22954	5	Cu,Cc,Ci,Cs,Ac,As
RS170	2008062303	12.003	134.999	1007.3	28.4	72	179	2.0	25.6	24853	7	Cu,Ac,Sc
RS171	2008062306	11.997	135.017	1006.6	28.8	72	170	3.0	27.0	24517	8	Cu,Ac,Cs
RS172	2008062309	12.006	135.004	1007.3	28.4	76	189	2.9	35.0	22869	7	Ci,Cu,Cb,Sc
RS173	2008062312	12.001	135.001	1008.7	28.4	77	133	2.9	39.0	21193	1	Sc
RS174	2008062315	11.987	135.003	1008.8	28.2	76	108	2.5	26.8	24577	6	Cu,As
RS175	2008062318	11.979	134.987	1007.6	28.0	81	79	1.9	25.3	24914	7	Ac,Ci
RS176	2008062321	11.980	134.991	1008.8	27.6	77	326	1.2	27.5	24411	8	As,Ac,Cu,Cb
RS177	2008062400	11.991	134.994	1009.5	26.1	80	109	2.6	27.4	24458	9	As,Ac,Cu,Cb
RS178	2008062403	12.000	135.000	1009.4	27.5	76	40	1.7	24.6	25113	6	Cs,Sc,Cu
RS179	2008062406	12.013	135.012	1007.8	28.0	77	35	3.1	20.9	26202	6	Cg,Cb,As,Ac,Cc
RS180	2008062409	11.993	135.011	1008.0	28.2	79	44	2.8	37.9	22348	3	Ac,Cu,Cb
RS181	2008062412	11.999	135.000	1009.3	28.5	79	3	3.3	28.3	24247	-	unknown
RS182	2008062415	12.012	134.996	1009.4	28.4	75	44	4.4	37.0	22517	4	Cu,Ci
RS183	2008062418	12.015	135.009	1008.2	28.5	74	40	4.4	27.9	24318	3	Cu
RS184	2008062421	12.012	135.001	1009.0	28.3	76	45	4.2	28.6	24157	5	Cu,As,Cb,Ci,Cc,Ac
RS185	2008062500	12.017	134.997	1009.7	28.3	77	44	4.9	22.0	25874	1	Cu,As,Ci
RS186	2008062503	12.002	134.996	1008.9	28.7	75	69	4.2	23.9	25333	4	Cu,Cg,As,Ac,Ci
RS187	2008062506	11.994	135.020	1007.6	29.1	73	72	5.0	26.7	24590	5	Cu,Cb,Ci
RS188	2008062509	12.002	135.001	1007.6	27.5	84	42	5.4	28.8	24116	8	Cb,Cu,Ci
RS189	2008062512	12.001	134.999	1009.1	28.3	76	56	5.2	32.2	23404	-	unknown
RS190	2008062515	11.997	135.010	1009.2	28.1	80	85	6.7	28.1	24285	3	Cu,Sc
RS191	2008062518	12.025	135.009	1007.6	28.2	79	122	7.7	43.5	21508	3	Cu,Cb,Ci
RS192	2008062521	12.016	135.008	1008.0	28.0	80	139	6.0	38.5	22283	6	Cu,Cb,As,Cc,Ci
RS193	2008062600	12.016	135.007	1009.1	28.4	74	145	7.7	22.6	25678	7	As,Cu,Cb
RS194	2008062603	12.004	134.997	1009.1	27.1	86	103	6.7	22.3	25777	10-	Cu,Cb
RS195	2008062606	12.013	135.013	1007.9	28.7	75	157	7.4	24.9	25084	9	Cu,Cb
RS196	2008062609	12.011	135.003	1008.2	28.1	79	112	2.3	28.3	24219	8	Cb,Cu,Ac,Sc
RS197	2008062612	12.000	135.000	1009.5	25.6	87	252	4.6	615.6	4223	10	Cb
RS198	2008062615	12.003	134.989	1010.3	25.7	85	82	0.1	40.2	22014	7	unknown
RS199	2008062618	11.979	135.015	1009.0	25.6	89	163	1.9	35.8	22718	9	Ac,Sc
RS200	2008062621	11.994	135.024	1009.3	26.8	83	133	5.7	35.8	22699	7	Cb,Cu,Ci,Ac.Cs.Cc
RS201	2008062700	11.990	134.996	1009.5	27.5	73	108	7.8	27.5	24417	9	Cu,Ac,Ci,Cs
RS202	2008062703	12.003	134.997	1008.5	28.0	78	91	6.3	33.0	23246	6	Cu,Cs
RS203	2008062706	11.984	134.998	1007.6	27.8	81	107	7.8	31.0	23661	9	Cu,Cs,Ac
RS204	2008062709	12.015	135.004	1007.7	28.3	76	110	7.4	70.5	18575	7	Ci,Cc,Cu,Cb
RS205	2008062712	12.003	134.997	1008.8	28.4	76	100	5.9	32.5	23356	1-	Cu,Cb
RS206	2008062715	11.992	134.995	1009.3	28.2	79	109	2.5	28.8	24112	-	unknown
RS207	2008062718	12.079	135.486	1008.4	27.9	76	128	5.3	32.5	23320	3	Cu,Cb
RS208	2008062721	12.153	135.990	1008.9	27.8	81	125	4.8	28.6	24171	7	Cb,Cu,Ci
RS209	2008062800	12.233	136.498	1010.0	28.7	76	92	5.6	27.9	24321	4	Cb,Cu,As,Ci

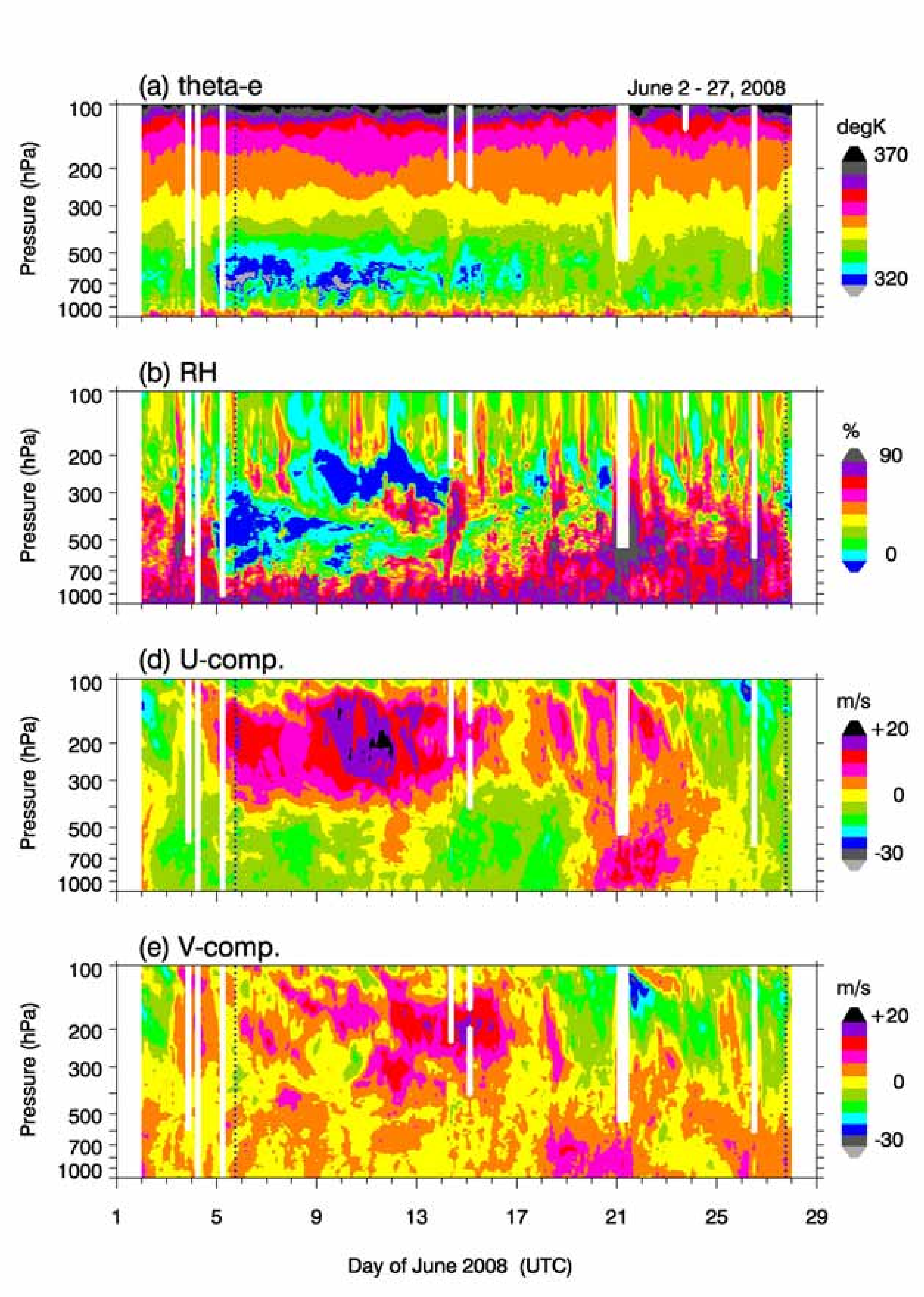


Fig. 5.1-1. Time-height cross sections of (a) equivalent potential temperature (degK), (b) relative humidity (%), (c) zonal wind component (m/s), and (d) meridional wind component (m/s).Blue dotted line indicates the period of stationary observation at 12N, 135E.

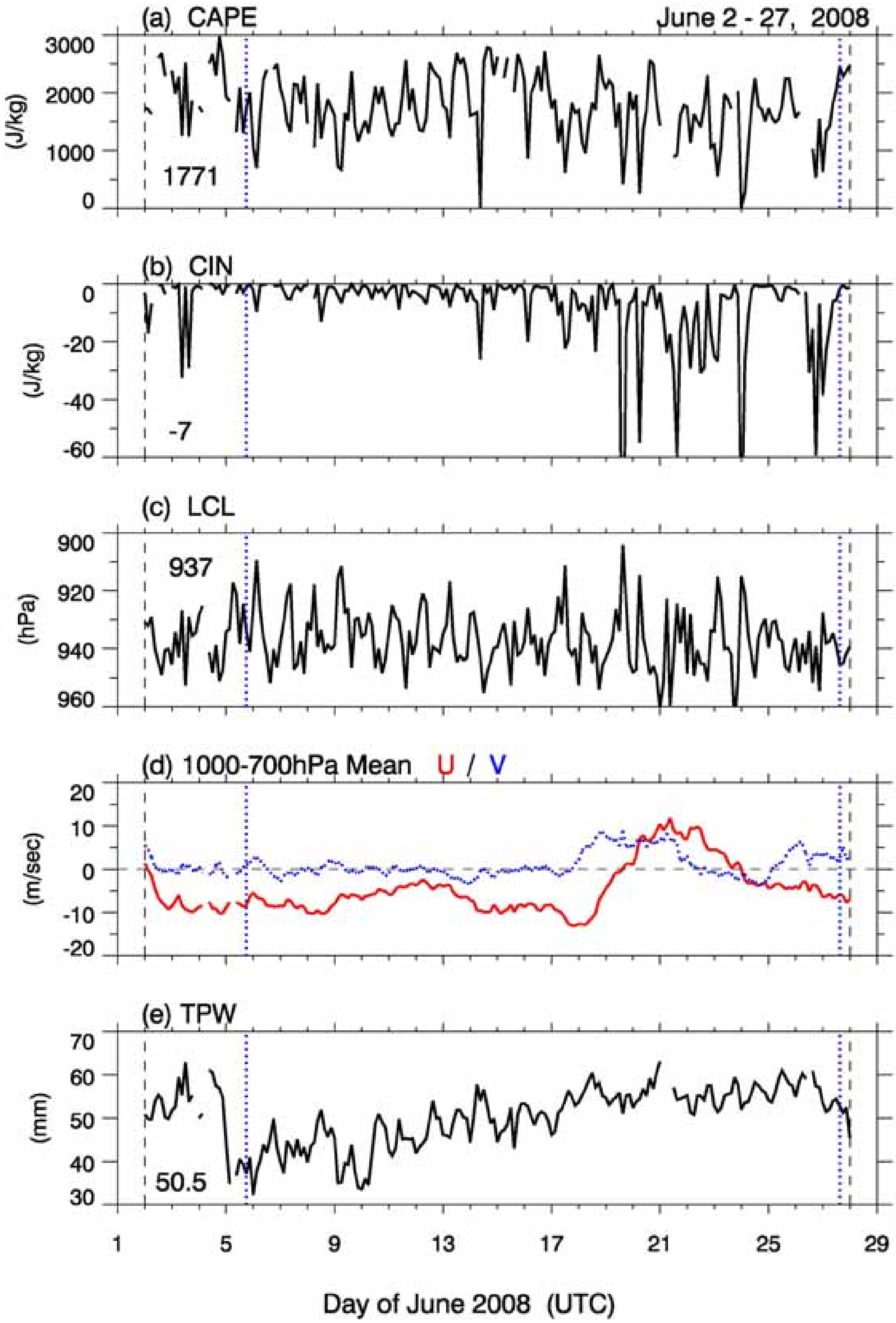


Fig. 5.1-2. Time series of (a) convective available potential energy, (b) convective inhibition, (c) lifted condensation level, and (d) 1000-700 hPa layer-mean zonal (red) and meridional (blue) wind components, and (e) total precipitable water vapor. Numbers on panel are the averages over the whole 26-day period.

5.2 Doppler Radar

(1) Personnel

Biao Geng	(JAMSTEC)	Principal Investigator
Kunio Yoneyama	(JAMSTEC)	
Souichiro Sueyoshi	(GODI)	Operation Leader
Shinya Okumura	(GODI)	
Wataru Tokunaga	(GODI)	
Harumi Ota	(GODI)	

(2) Objective

The objective of the Doppler radar observation in this cruise is to investigate three dimensional rainfall and kinematic structures of precipitation systems and their temporal and special variations around the Western Pacific Ocean.

(3) Method

The Doppler radar on board of MIRAI is used. The specification of the radar is:

Frequency:	5290 MHz
Beam Width:	less than 1.5 degrees
Output Power:	250 kW (Peak Power)
Signal Processor:	RVP-7 (Sigment Inc., USA)
Inertial Navigation Unit:	PHINS (Ixsea S.A.S., France)
Application Software:	IRIS/Open (Sigment Inc., USA)

Parameters of the radar are checked and calibrated at the beginning and the end of the intensive observation. Meanwhile, daily checking is performed for (1) frequency, (2) mean output power, (3) pulse width, and (4) PRF (pulse repetition frequency).

During the cruise, the volume scan consisting of 21 PPIs (Plan Position Indicator) is conducted every 10 minutes. A dual PRF mode with the maximum range of 160 km is used for the volume scan. Meanwhile, a surveillance PPI scan is performed every 30 minutes in a single PRF mode with the maximum range of 300 km. At the same time, RHI (Range Height Indicator) scans of the dual PRF mode are also operated whenever detailed vertical structures are necessary in certain azimuth directions. Detailed information for each observational mode is listed in Table 5.2-1. The Doppler radar observation is from May. 29 to Jun. 28, 2008.

(4) Preliminary results

Shown in Fig. 5.2-1 is the variation of radar echo areas obtained from surveillance PPI scans during the cruise. Various kinds of precipitation systems have been observed by the Doppler radar. On the way to the target area around (12N, 135E), the internal structure of Typhoon 0805 is observed (Fig. 5.2-2). During the first week of the intensive observation (from Jun. 6 to Jun. 13), distinct diurnal variation of precipitation without the apparent effect of large scale disturbances is observed (Figs. 5.2-1 and 5.2-3). The peak of the diurnal variation appears at about 1700 UTC (0200 LST). In the latter half of the cruise, the intensive observational area is influenced by large scale disturbances including Typhoon 0806. Larger echo areas, which indicate the appearance of strong precipitation systems, are observed from Jun. 20 to Jun. 22 (Fig. 5.2-1). During this period, many mesoscale convective systems have developed around the observational area. Figure 5.2-4 shows the horizontal and vertical structures of a mesoscale convective system observed by the Doppler radar at 2010 UTC, Jun. 20, 2008. It appears that the Doppler radar observation has provided useful data for studying the structure and development of various kinds of precipitation systems evolved around the target area.

(5) Data archive

All data of the Doppler radar observation during this cruise will be submitted to the JAMSTEC Marine-Earth Data and Information Department.

Table 5.2-1 Parameters for each observational mode

	Surveillance PPI	Volume Scan	RHI
Pulse Width	2 (microsec)	0.5 (microsec)	0.5 (microsec)
Scan Speed	18 (deg/sec)	18 (deg/sec)	Automatically determined
PRF	260 (Hz)	900/720 (Hz)	900/720 (Hz)
Sweep Integration	32 samples	40 samples	32 samples
Ray Spacing	1.0 (deg)	1.0 (deg)	0.2 (deg)
Bin Spacing	250 (m)	250 (m)	150 (m)
Elevation Angle	0.5	0.5, 1.0, 1.8, 2.6, 3.4, 4.2, 5.0, 5.8, 6.7, 7.7, 8.9, 10.3, 12.3, 14.5, 17.1, 20.0, 23.3, 27.0, 31.0, 35.4, 40.0	0.0 to 65.0
Azimuth	Full Circle	Full Circle	Optional
Range	300 (km)	160 (km)	160 (km)

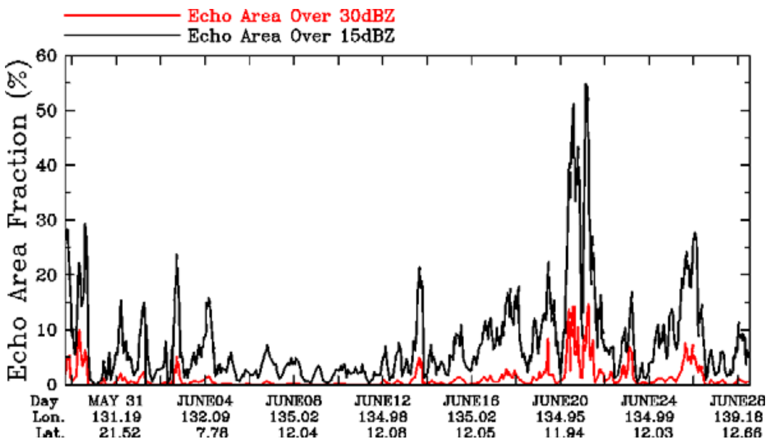


Fig. 5.2-1. Variation of radar echo areas obtained from surveillance PPI scans. The indicated value is the ratio of the echo area to the radar coverage area with a radius of 200 km.

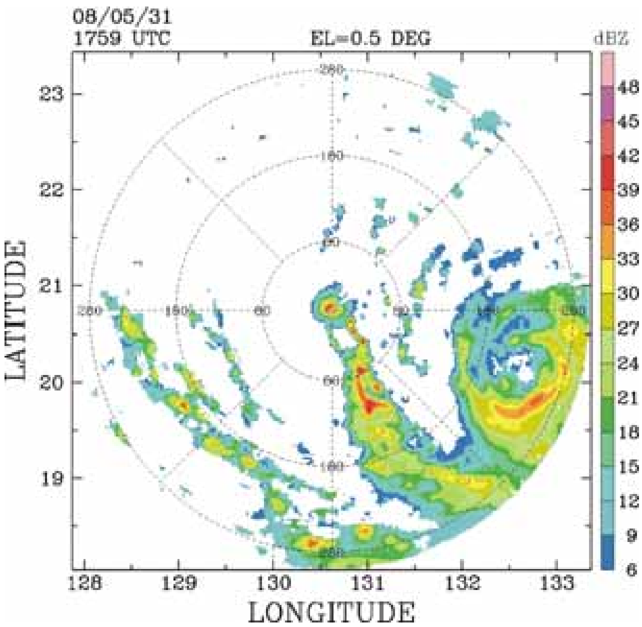


Fig. 5.2-2. Horizontal distribution of Typhoon 0805 obtained from the surveillance PPI scan at 1759 UTC, May 31, 2008.

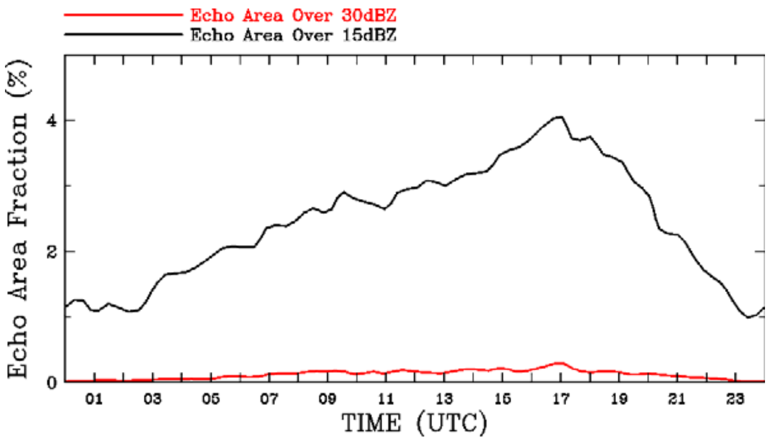


Fig. 5.2-3. Diurnal variation of radar echo areas obtained from surveillance PPI scans. The indicated value is the ratio of the echo area to the radar coverage area with a radius of 200 km.

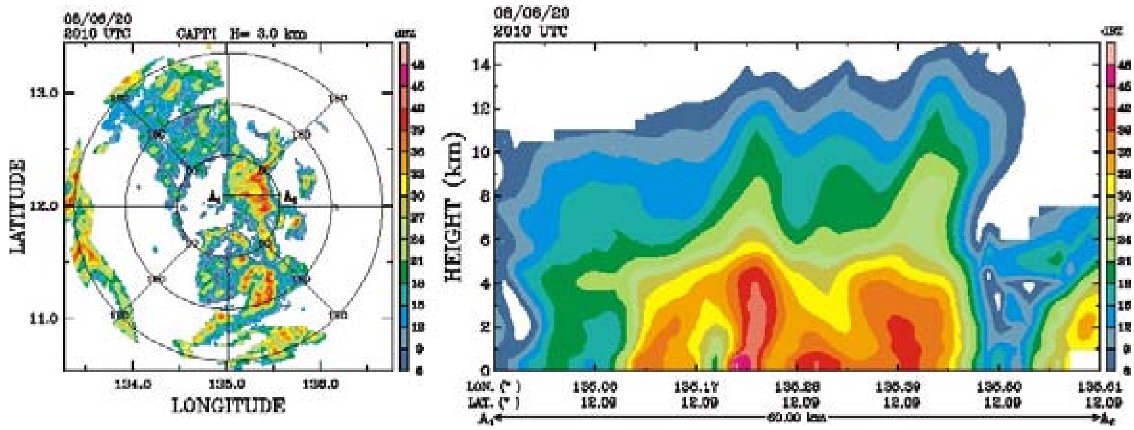


Fig. 5.2-4. Horizontal (left) and vertical (right) distributions of a mesoscale convective system obtained from the volume scan at 2010 UTC, June 20, 2008.

5.3 95GHz cloud profiling radar

(1) Personnel

Hajime Okamoto	(CAOS, Tohoku University)	Principal Investigator	* not on board
Ryo Yoshida	(CAOS, Tohoku University)		* not on board
Kaori Sato	(CAOS, Tohoku University)		* not on board
Toshiaki Takano	(Chiba University)		* not on board
Junichi Watanabe	(Chiba University)		
Nobuo Sugimoto	(National Institute for Environmental Studies)		* not on board
Ichiro Matsui	(National Institute for Environmental Studies)		* not on board

(2) Objective

Main objective for the 95GHz cloud radar is to detect vertical structure of cloud and precipitation in the observed region. Combinational use of the radar and lidar is recognized to be a powerful tool to study vertical distribution of cloud microphysics, i.e., particle size and liquid/ice water content (LWC/IWC).

(3) Method

Basic output from data is cloud occurrence, radar reflectivity factor and cloud microphysics. In order to derive reliable cloud amount and cloud occurrence, we need to have radar and lidar for the same record.

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

(4) Results

The time height cross-section of radar reflectivity factor obtained in June 3, 2008 is shown in Fig. 5.3-1. Vertical extent is 20km. It is seen that there are three relatively strong convective activities.

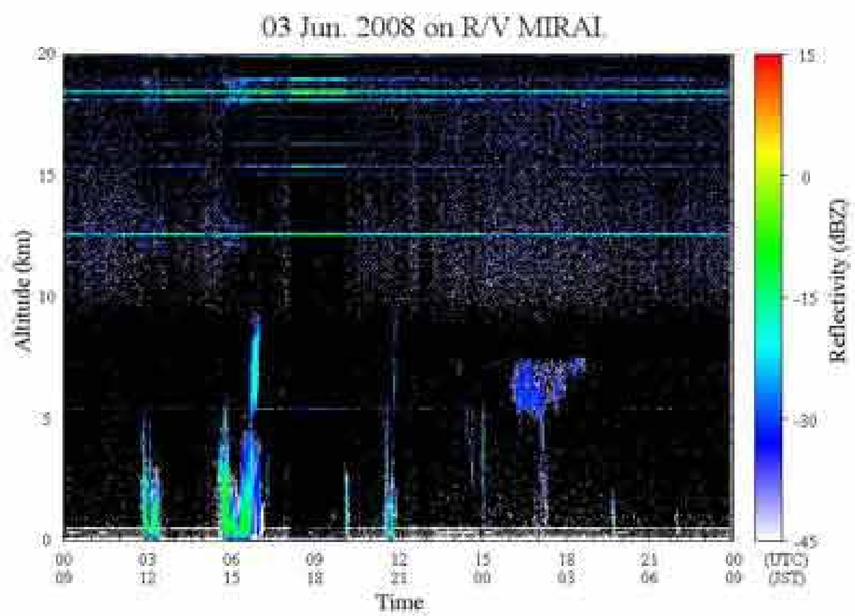


Fig. 5.3-1. Time-height cross section of radar reflectivity factor in dBZe in June 3, 2008.

(5) Data archive

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

(6) Remarks

The cloud radar is successfully operated for 24 hours.

5.4 Lidar observations of clouds and aerosols

(1) Personnel

Nobuo Sugimoto	(National Institute for Environmental Studies)	Principal Investigator *not on board
Ichiro Matsui	(National Institute for Environmental Studies)	* not on board
Atsushi Shimizu	(National Institute for Environmental Studies)	* not on board
Junichi Watanabe	(Chiba University)	

(2) Objective

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

(3) Method

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

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

(4) Results

Data obtained during this cruise has not been analyzed yet.

(5) Data archive

- raw data
  - lidar signal at 532 nm
  - lidar signal at 1064 nm
  - depolarization ratio at 532 nm
  - temporal resolution 10 sec/ vertical resolution 6 m
  - data period : May 27, 2008 – June 29, 2008 (UTC)
- processed data
  - cloud base height, apparent cloud top height
  - phase of clouds (ice/water)
  - cloud fraction
  - boundary layer height (aerosol layer upper boundary height)
  - backscatter coefficient of aerosols
  - particle depolarization ratio of aerosols

All data will be archived at NIES and then will be submitted to JAMSTEC Marine-Earth Data and Information Department.

5.5 Ceilometer observation

(1) Personnel

Kunio Yoneyama	(JAMSTEC)	Principal Investigator
Biao Geng	(JAMSTEC)	
Souichiro Sueyoshi	(GODI)	Operation Leader
Shinya Okumura	(GODI)	
Wataru Tokunaga	(GODI)	
Harumi Ota	(GODI)	

(2) Objective

Ceilometer was used to detect the cloud base height which is important to understand the processes on formation of cloud. It also provides the information of horizontal / vertical distribution of the cloud.

(3) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout MR08-02 from the departure of Sekinehama on May 26 to one day before the arrival at Guam on June 29, 2008.

Major specifications of the measurement system are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode
Transmitting wave length:	905±5 nm at 25℃
Transmitting average power:	8.9 mW
Repetition rate:	5.57kHz
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
Measured parameters	Cloud base height [m]
	Backscatter profile, sensitivity, and range at 30m resolution
	Sky condition with 0, 1, 3, 5, 7, 8 [oktas]
	0: sky clear, 1:few, 3:scattered, 5-7: broken, 8: overcast

On the archived dataset, three cloud base height and backscatter profile are recorded with the resolution of 30 m (100 ft.). If the apparent cloud base height could not be determined, vertical visibility and the height of detected highest signal are calculated instead of the cloud base height.

(4) Results

Figure 5.5-1 shows the first, second and third lowest cloud base height which the ceilometer detected during the stationary observation.

(5) Data archive

Data obtained during this cruise will be submitted to and archived by the Marine-Earth Data and Information Department of JAMSTEC.

(6) Remarks

Window was cleaned at 0037 UTC on 26 May and at 0153 UTC on June 4, 2008.

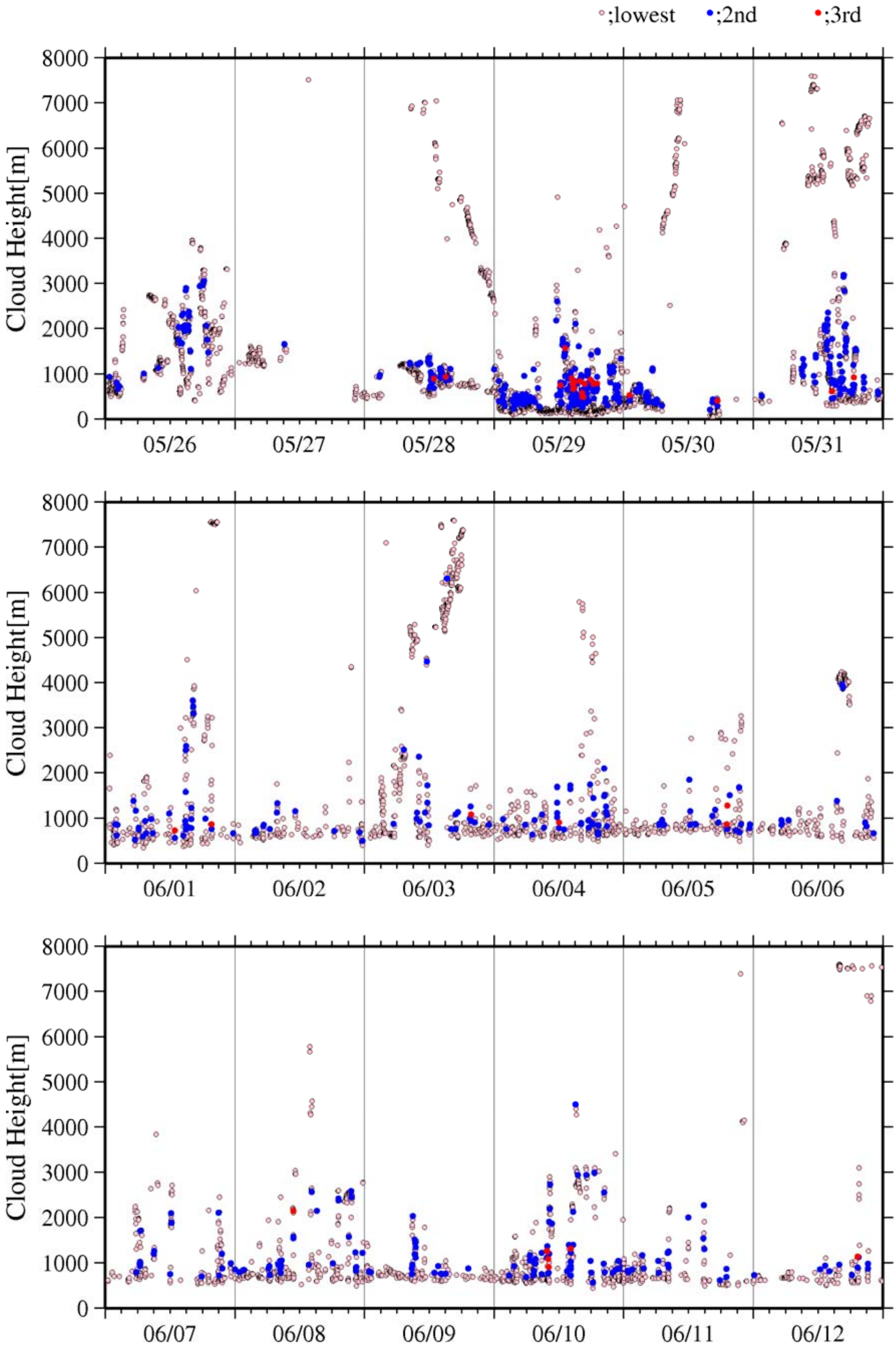


Fig. 5.5-1. First, 2nd and 3rd lowest cloud base height during the cruise.

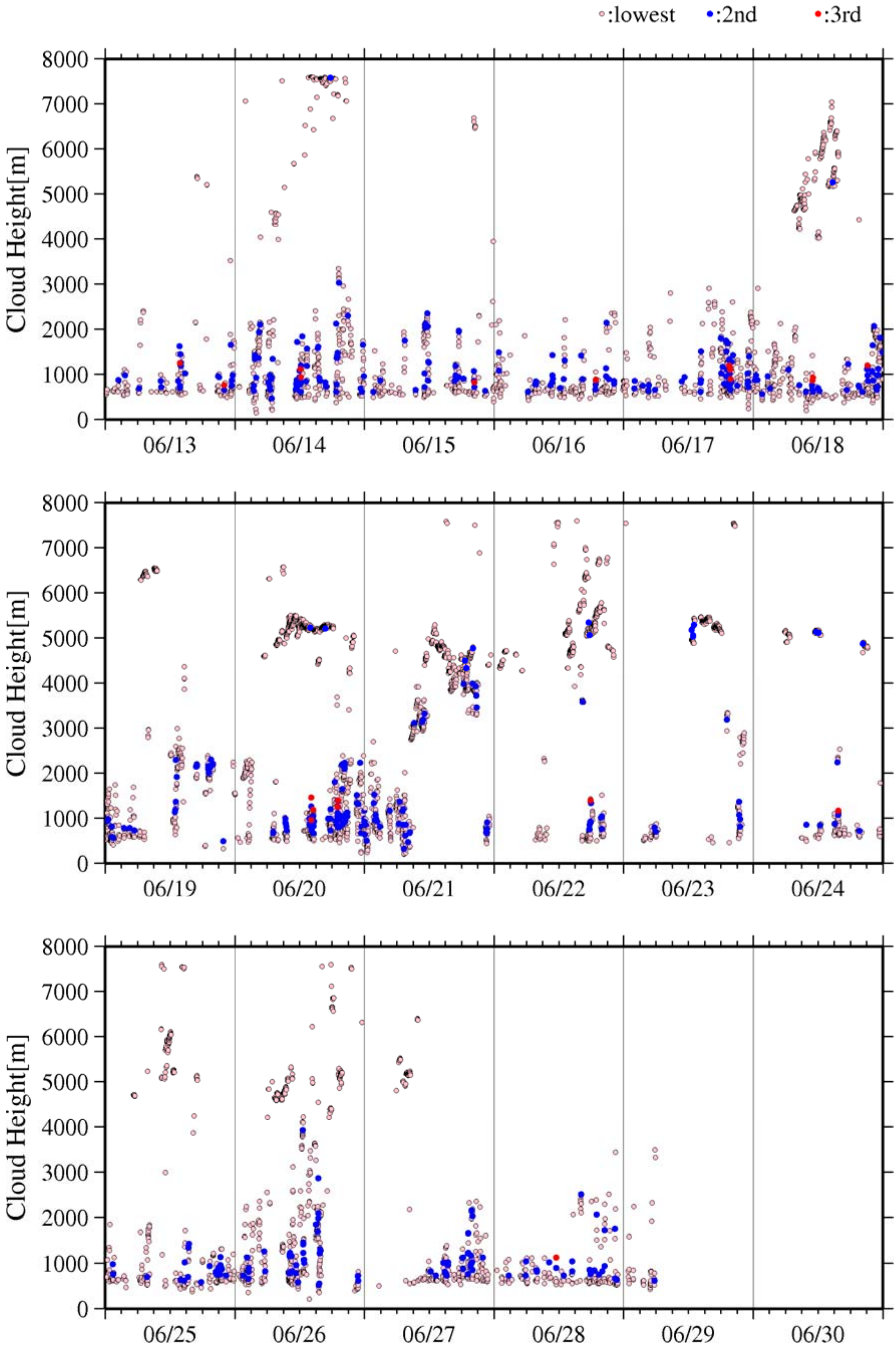


Fig. 5.5-1. (Continued)

5.6 GPS Meteorology

(1) Personnel

Mikiko Fujita	(JAMSTEC)	Principal Investigator	* not on board
Kunio Yoneyama	(JAMSTEC)		
Biao Geng	(JAMSTEC)		
Souichiro Sueyoshi	(GODI)		
Shinya Okumura	(GODI)		
Wataru Tokunaga	(GODI)		
Harumi Ota	(GODI)		

(2) Objective

Getting the GPS satellite data to estimate the total column integrated water vapor content of the atmosphere.

(3) Method

The GPS satellite data was archived to the receiver (Ashtech Xstream) with 5 sec interval. The GPS antenna (Margrin) was set on the deck at the part of stern. This observation was carried out from 0700Z May 26, 2008 through 0600Z June 29, 2008.

(4) Results

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

(5) Data archive

Raw data is recorded as RINEX format every 5 seconds during ascent. These raw datasets are available from M. Fujita of JAMSTEC. Corrected data will be submitted to JAMSTEC Marine-Earth Data and Information Department and will be archived there.

5.7 Rain and Water Vapor Sampling for Stable Isotope Measurement

(1) Personnel

Naoyuki Kurita (JAMSTEC) Principal Investigator * not on board
Mayumi Horikawa (Nagoya University)

(2) Objective

Stable isotopes in water (HDO and $H_2{}^{18}O$) are powerful tool to study the moisture origin of precipitation associated with disturbances in tropical and sub-tropical regions. Sampling of atmospheric moisture, rainwater and surface seawater was performed for stable isotope analyses throughout the MR08-02 cruise from Sekinehama, Japan on May 26, 2008 to Guam, U.S.A. on June 29, 2008.

(3) Methods

Following observations were carried out throughout this cruise.

- Atmospheric moisture sampling:

  Water vapor was sampled from the height about 20m above the sea level. The air was drawn at rate of 2.8-3L/min through a plastic tube attached to top of the compass deck. The water vapor was trapped in a glass trap submerged into an ethanol cooled to 100 degree C by radiator, and then they are collected every 3 to 6 hour during the cruise. After collection, water in the trap was subsequently thawed and poured into the 6ml glass bottle.

- Rainwater sampling

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

- Surface seawater sampling

  Seawater sample taken by the pump from 4m depth were collected in glass bottle (6ml) at 6 o’clock UTC every day. The surface water taken by bucket from the deck was also sampled in case the bucket water sampling has carried out.

(4) Results

Sampling of water vapor for isotope analysis is summarized in Table 5.7-1 (152 samples). The detail of rainfall sampling (59 samples) is summarized in Table 5.7-2. Described rainfall amount is calculated from the collected amount of precipitation. Sampling of surface seawater is summarized in Table 5.7-3 (55 samples).

(5) Data archive

Isotopes (HDO, $H_2{}^{18}O$) analysis will be done at IORGC/JAMSTEC, and then analyzed isotopes data will be submitted to JAMSTEC Data Management Office.

Table 5.7-1 Summary of water vapor sampling for isotope analysis.

	Start		End				Sample	Moisture density
No.	Date	UTC	Date	UTC	Latitude	Longitude	[g]	[g/m^3]
1	2008/5/26	12:10	2008/5/26	23:54	40-33N	141-30E	15.0	7.14
2	2008/5/26	23:54	2008/5/27	06:07	40-35N	141-35E	6.3	5.73
3	2008/5/27	06:13	2008/5/27	12:04	39-20N	142-26E	6.3	6.00
4	2008/5/27	12:08	2008/5/28	00:22	36-49N	142-50E	16.0	7.31
5	2008/5/28	00:25	2008/5/28	06:04	36-21N	142-55E	8.0	7.84
6	2008/5/28	06:10	2008/5/28	12:09	35-29N	142-24E	8.0	7.48
7	2008/5/28	12:14	2008/5/28	23:54	33-16N	140-53E	22.0	10.53
8	2008/5/28	23:59	2008/5/29	06:00	32-39N	139-40E	15.0	13.89
9	2008/5/29	06:13	2008/5/29	12:25	31-24N	138-31E	19.0	16.96
10	2008/5/29	12:30	2008/5/29	23:57	29-09N	136-48E	35.0	18.04
11	2008/5/30	00:03	2008/5/30	06:04	27-53N	135-51E	19.0	17.76
12	2008/5/30	06:06	2008/5/30	12:02	26-36N	134-54E	21.0	19.63
13	2008/5/30	12:10	2008/5/30	17:58	25-22N	133-59E	22.0	21.15
14	2008/5/30	18:02	2008/5/30	23:57	24-15N	133-11E	23.0	21.90
15	2008/5/31	00:02	2008/5/31	06:02	23-04N	132-19E	22.0	20.56
16	2008/5/31	06:07	2008/5/31	12:09	21-54N	131-28E	23.0	21.30
17	2008/5/31	12:13	2008/5/31	18:03	20-43N	130-36E	14.0	20.00
18	2008/5/31	18:05	2008/5/31	23:55	19-32N	130-05E	14.0	20.00
19	2008/5/31	23:57	2008/6/1	05:59	18-20N	130-05E	24.0	22.22
20	2008/6/1	06:01	2008/6/1	12:03	17-12N	130-04E	24.0	22.22
21	2008/6/1	12:07	2008/6/1	18:10	15-47N	130-05E	14.0	19.18
22	2008/6/1	18:12	2008/6/1	23:55	14-23N	130-07E	13.5	19.85
23	2008/6/1	23:58	2008/6/2	02:56	13-59N	130-06E	10.0	18.52
24	2008/6/2	03:00	2008/6/2	06:05	13-20N	130-07E	10.0	17.86
25	2008/6/2	06:08	2008/6/2	08:58	12-36N	130-06E	9.5	18.63
26	2008/6/2	09:02	2008/6/2	12:03	12-05N	130-05E	10.0	18.52
27	2008/6/2	12:06	2008/6/2	18:01	10-58N	130-05E	22.0	20.75
28	2008/6/2	18:05	2008/6/2	21:05	10-11N	130-04E	9.5	17.59
29	2008/6/2	21:07	2008/6/2	23:50	9-29N	130-05E	9.0	18.37
30	2008/6/2	23:56	2008/6/3	02:56	8-42N	130-05E	9.8	18.49
31	2008/6/3	03:00	2008/6/3	05:55	7-59N	130-04E	9.5	17.92
32	2008/6/3	05:59	2008/6/3	09:01	7-21N	130-04E	9.7	17.64
33	2008/6/3	09:04	2008/6/3	12:19	6-49N	130-04E	11.0	18.64
34	2008/6/3	12:22	2008/6/3	18:02	5-24N	130-05E	20.0	19.61
35	2008/6/3	18:06	2008/6/3	21:31	5-00N	130-06E	11.0	18.03
36	2008/6/3	21:35	2008/6/4	00:02	5-21N	130-23E	8.0	18.18
37	2008/6/4	00:06	2008/6/4	05:59	6-26N	131-13E	22.0	20.95
38	2008/6/4	06:04	2008/6/4	11:59	7-25N	131-52E	20.0	20.20
39	2008/6/4	12:07	2008/6/4	18:18	8-27N	132-32E	22.0	21.15
40	2008/6/4	18:22	2008/6/5	00:02	9-10N	130-04E	20.0	21.05
41	2008/6/5	00:07	2008/6/5	06:00	10-16N	130-50E	20.0	20.41
42	2008/6/5	06:04	2008/6/5	12:03	11-05N	134-25E	19.8	19.80
43	2008/6/5	12:07	2008/6/5	18:16	12-00N	135-00E	20.0	19.42
44	2008/6/5	18:20	2008/6/6	00:07	12-00N	135-00E	19.0	19.59
45	2008/6/6	00:12	2008/6/6	06:02	12-00N	135-00E	19.0	19.59
46	2008/6/6	06:05	2008/6/6	11:59	12-00N	135-00E	20.0	20.20
47	2008/6/6	12:03	2008/6/6	18:06	12-00N	135-00E	22.0	21.57

48	2008/6/6	18:12	2008/6/7	00:08	12-00N	135-00E	20.5		20.50
49	2008/6/7	00:12	2008/6/7	06:01	12-00N	135-00E	20.0		20.62
50	2008/6/7	06:05	2008/6/7	12:00	12-00N	135-00E	20.0		20.00
51	2008/6/7	12:04	2008/6/7	18:06	12-00N	135-00E	20.0		19.80
52	2008/6/7	18:09	2008/6/8	00:00	12-00N	135-00E	20.0		20.41
53	2008/6/8	00:03	2008/6/8	05:58	12-01N	135-00E	20.0		20.20
54	2008/6/8	06:04	2008/6/8	12:03	12-00N	135-00E	21.0		20.79
55	2008/6/8	12:08	2008/6/8	18:09	12-00N	134-59E	20.0		19.80
56	2008/6/8	18:14	2008/6/9	00:03	12-00N	135-00E	20.0		20.62
57	2008/6/9	00:07	2008/6/9	05:59	12-00N	135-00E	20.0		20.41
58	2008/6/9	06:06	2008/6/9	12:00	12-00N	135-00E	20.0		20.20
59	2008/6/9	12:06	2008/6/9	23:58	12-00N	135-00E	38.0		20.99
60	2008/6/10	00:02	2008/6/10	05:56	12-00N	135-00E	20.0		20.20
61	2008/6/10	06:01	2008/6/10	11:59	12-00N	135-00E	20.5		20.50
62	2008/6/10	12:05	2008/6/10	17:59	12-00N	135-00E	20.0		20.20
63	2008/6/10	18:03	2008/6/11	00:00	12-00N	135-00E	20.0		20.00
64	2008/6/11	00:09	2008/6/11	05:58	12-00N	135-00E	20.0		20.41
65	2008/6/11	06:05	2008/6/11	11:58	12-00N	135-00E	20.0		20.20
66	2008/6/11	12:04	2008/6/11	18:23	12-02N	135-00E	22.0		20.75
67	2008/6/11	18:26	2008/6/11	23:58	12-00N	135-00E	18.3		19.68
68	2008/6/12	00:02	2008/6/12	05:58	12-00N	135-00E	20.0		20.20
69	2008/6/12	06:07	2008/6/12	11:57	12-00N	135-00E	20.0		20.41
70	2008/6/12	11:59	2008/6/12	18:01	12-00N	135-00E	21.5		21.29
71	2008/6/12	18:05	2008/6/13	00:01	12-00N	135-00E	20.0		20.00
72	2008/6/13	00:06	2008/6/13	05:59	12-00N	135-00E	20.0		20.41
73	2008/6/13	06:03	2008/6/13	12:01	12-00N	135-00E	20.5		20.50
74	2008/6/13	12:04	2008/6/13	18:01	12-00N	135-00E	21.5		21.50
75	2008/6/13	18:06	2008/6/13	23:59	12-00N	135-00E	20.5		20.71
76	2008/6/14	00:07	2008/6/14	02:57	12-03N	134-59E	8.5		17.71
77	2008/6/14	03:01	2008/6/14	06:00	12-00N	135-00E	9.8		18.15
78	2008/6/14	06:03	2008/6/14	09:02	12-02N	135-01E	9.8		18.49
79	2008/6/14	09:06	2008/6/14	11:59	12-00N	135-00E	9.2		18.04
80	2008/6/14	12:03	2008/6/14	18:00	12-00N	135-00E	23.8		22.24
81	2008/6/14	18:04	2008/6/14	23:58	12-00N	135-00E	20.5		20.71
82	2008/6/15	00:03	2008/6/15	06:00	12-00N	135-00E	22.0		22.00
83	2008/6/15	06:06	2008/6/15	11:59	12-00N	135-00E	21.5		21.94
84	2008/6/15	12:03	2008/6/15	18:00	12-00N	135-00E	21.0		21.00
85	2008/6/15	18:04	2008/6/15	23:58	12-00N	135-00E	20.5		20.71
86	2008/6/16	00:03	2008/6/16	03:02	12-03N	134-59E	9.0		18.00
87	2008/6/16	03:05	2008/6/16	06:02	12-00N	135-00E	10.0		18.87
88	2008/6/16	06:07	2008/6/16	09:00	12-02N	135-02E	9.8		18.85
89	2008/6/16	09:05	2008/6/16	12:00	12-00N	135-00E	9.7		18.65
90	2008/6/16	12:05	2008/6/16	18:03	12-00N	135-00E	22.0		21.78
91	2008/6/16	18:07	2008/6/16	23:58	12-00N	135-00E	20.3		20.71
92	2008/6/17	00:01	2008/6/17	06:00	12-00N	135-00E	20.8		20.80
93	2008/6/17	06:05	2008/6/17	11:59	12-00N	134-59E	20.0		20.20
94	2008/6/17	12:03	2008/6/17	18:01	12-00N	135-00E	21.7		21.70
95	2008/6/17	18:03	2008/6/18	00:01	12-02N	135-00E	20.5		20.50
96	2008/6/18	00:05	2008/6/18	03:06	12-02N	135-02E	9.3		18.24
97	2008/6/18	03:08	2008/6/18	06:01	12-00N	135-00E	9.3		17.88
98	2008/6/18	06:04	2008/6/18	09:01	12-03N	135-03E	10.0		18.87

99	2008/6/18	09:06	2008/6/18	11:58	12-00N	135-00E	9.3	18.24
100	2008/6/18	12:01	2008/6/18	15:07	12-01N	135-01E	10.8	19.29
101	2008/6/18	15:12	2008/6/18	17:59	12-00N	135-00E	9.2	18.40
102	2008/6/18	18:02	2008/6/19	00:04	12-00N	135-00E	23.8	22.04
103	2008/6/19	00:06	2008/6/19	02:59	12-00N	135-02E	10.0	19.23
104	2008/6/19	03:03	2008/6/19	06:01	12-00N	135-00E	10.0	18.87
105	2008/6/19	06:04	2008/6/19	08:59	11-58N	135-02E	9.0	18.37
106	2008/6/19	09:02	2008/6/19	12:12	12-00N	135-00E	10.5	18.42
107	2008/6/19	12:15	2008/6/19	15:00	11-58N	135-02E	8.0	17.39
108	2008/6/19	15:04	2008/6/19	18:02	12-00N	135-00E	9.5	17.92
109	2008/6/19	18:05	2008/6/20	00:01	12-00N	135-00E	21.0	21.21
110	2008/6/20	00:05	2008/6/20	03:05	11-57N	135-00E	9.0	18.00
111	2008/6/20	03:07	2008/6/20	06:00	12-00N	134-59E	8.5	16.35
112	2008/6/20	06:05	2008/6/20	12:01	12-00N	134-59E	20.0	20.00
113	2008/6/20	12:03	2008/6/20	18:40	11-59N	135-03E	21.0	18.92
114	2008/6/20	18:44	2008/6/21	00:03	12-00N	135-02E	17.8	20.00
115	2008/6/21	00:05	2008/6/21	03:00	11-58N	135-02E	9.0	17.31
116	2008/6/21	03:03	2008/6/21	06:05	12-00N	135-00E	9.5	17.27
117	2008/6/21	06:10	2008/6/21	08:59	11-59N	134-58E	9.5	18.63
118	2008/6/21	09:02	2008/6/21	11:59	12-00N	135-00E	9.5	17.92
119	2008/6/21	12:02	2008/6/21	14:59	12-01N	135-03E	9.2	17.36
120	2008/6/21	15:02	2008/6/21	18:02	12-00N	135-00E	9.3	17.22
121	2008/6/21	18:06	2008/6/22	00:01	12-00N	135-00E	19.0	19.00
122	2008/6/22	00:06	2008/6/22	06:01	12-00N	135-00E	20.5	20.71
123	2008/6/22	06:07	2008/6/22	11:59	12-00N	135-00E	20.0	20.41
124	2008/6/22	12:02	2008/6/22	18:10	12-00N	135-00E	21.3	20.68
125	2008/6/22	18:13	2008/6/23	00:00	12-00N	135-00E	20.0	20.62
126	2008/6/23	00:05	2008/6/23	06:03	12-00N	135-00E	19.8	19.80
127	2008/6/23	06:07	2008/6/23	11:58	12-00N	135-00E	19.5	19.90
128	2008/6/23	12:03	2008/6/23	18:15	11-59N	135-00E	21.5	20.67
129	2008/6/23	18:18	2008/6/23	23:59	12-00N	135-00E	18.0	18.95
130	2008/6/24	00:03	2008/6/24	05:59	12-00N	135-00E	19.5	19.70
131	2008/6/24	06:02	2008/6/24	11:59	12-00N	135-00E	20.5	20.50
132	2008/6/24	12:03	2008/6/24	23:59	12-00N	135-00E	36.0	20.45
133	2008/6/25	00:02	2008/6/25	06:01	12-00N	134-59E	20.0	20.00
134	2008/6/25	06:04	2008/6/25	12:01	12-00N	135-00E	20.0	20.00
135	2008/6/25	12:04	2008/6/25	17:59	12-00N	135-00E	20.0	20.20
136	2008/6/25	18:02	2008/6/25	23:59	12-00N	135-00E	20.5	20.50
137	2008/6/26	00:03	2008/6/26	03:01	12-01N	135-01E	9.7	19.40
138	2008/6/26	03:04	2008/6/26	06:00	12-00N	135-00E	9.3	17.55
139	2008/6/26	06:02	2008/6/26	09:00	12-01N	135-01E	9.3	17.55
140	2008/6/26	09:03	2008/6/26	12:01	12-00N	135-00E	9.2	17.36
141	2008/6/26	12:06	2008/6/26	15:01	11-58N	135-00E	8.6	16.54
142	2008/6/26	15:05	2008/6/26	18:00	12-00N	135-00E	9.0	16.98
143	2008/6/26	18:04	2008/6/27	00:02	12-00N	135-00E	20.0	20.00
144	2008/6/27	00:07	2008/6/27	05:59	12-00N	135-00E	19.8	20.20
145	2008/6/27	06:03	2008/6/27	11:59	12-00N	135-00E	20.0	20.20
146	2008/6/27	12:02	2008/6/27	18:23	12-05N	135-40E	21.7	20.28
147	2008/6/27	18:26	2008/6/28	00:00	12-14N	136-37E	18.3	19.47
148	2008/6/28	00:04	2008/6/28	06:00	12-26N	137-45E	20.2	20.20
149	2008/6/28	06:07	2008/6/28	12:28	12-37N	138-55E	22.0	20.75

150	2008/6/28	12:31	2008/6/28	18:12	12-47N	139-54E	20.0	20.83
151	2008/6/28	18:15	2008/6/29	00:01	12-56N	140-56E	20.0	20.62
152	2008/6/29	00:04	2008/6/29	05:58	13-06N	141-54E	20.3	20.51

Table 5.7-2 Summary of precipitation sampling for isotope analysis.

	Sampling				Rainfall
No.	Date	UTC	Latitude	Longitude	[mm]
1	2008/5/27	00:05	40-33N	141-30E	0.7
2	2008/5/29	06:30	32-32N	139-31E	5.0
3	2008/5/30	00:18	29-03N	136-44E	10.0
4	2008/6/1	08:40	17-40N	130-05E	0.5
5	2008/6/1	23:48	14-24N	130-07E	0.2
6	2008/6/3	05:42	8-02N	130-04E	0.2
7	2008/6/3	07:58	7-36N	130-04E	6.7
8	2008/6/3	23:50	5-19N	130-22E	0.6
9	2008/6/4	23:51	9-08N	133-03E	5.0
10	2008/6/5	23:20	12-00N	135-00E	0.3
11	2008/6/7	00:20	12-00N	135-00E	0.1
12	2008/6/7	13:30	12-07N	134-59E	2.4
13	2008/6/8	06:32	12-03N	134-59E	0.6
14	2008/6/8	12:41	12-03N	135-02E	4.6
15	2008/6/8	19:17	12-05N	135-01E	0.4
16	2008/6/8	22:47	12-04N	135-03E	0.4
17	2008/6/12	19:47	12-05N	135-02E	1.1
18	2008/6/14	03:59	12-00N	135-00E	7.7
19	2008/6/14	04:37	12-01N	134-59E	1.9
20	2008/6/14	06:45	12-03N	135-00E	0.2
21	2008/6/14	07:18	12-06N	135-00E	2.5
22	2008/6/14	08:54	12-02N	135-01E	0.1
23	2008/6/14	15:54	12-09N	134-59E	0.8
24	2008/6/14	20:33	12-00N	135-00E	6.5
25	2008/6/14	21:42	12-06N	135-02E	10.2
26	2008/6/15	00:15	12-01N	135-00E	0.1
27	2008/6/15	22:52	12-04N	135-03E	1.9
28	2008/6/16	00:15	12-01N	135-00E	8.0
29	2008/6/16	00:59	12-03N	135-03E	2.3
30	2008/6/16	01:57	12-00N	135-00E	9.1
31	2008/6/16	03:06	12-03N	134-59E	0.3
32	2008/6/16	13:53	12-04N	135-02E	0.1
33	2008/6/16	17:40	12-00N	134-59E	0.9
34	2008/6/17	20:44	12-01N	135-00E	0.8
35	2008/6/18	04:05	12-01N	135-00E	0.6
36	2008/6/19	00:21	12-00N	135-01E	1.0
37	2008/6/19	02:10	12-00N	135-00E	0.7
38	2008/6/19	13:55	11-59N	134-58E	0.1
39	2008/6/19	14:42	11-59N	135-01E	0.6
40	2008/6/20	20:48	11-58N	135-01E	2.8
41	2008/6/21	00:10	12-00N	135-02E	4.5
42	2008/6/21	01:37	12-00N	135-01E	21.9
43	2008/6/21	03:09	11-57N	135-02E	7.8

44	2008/6/21	05:17	12-00N	135-00E	7.8
45	2008/6/21	07:10	12-00N	134-57E	0.1
46	2008/6/21	08:29	12-00N	135-00E	5.1
47	2008/6/21	09:35	12-00N	134-58E	0.5
48	2008/6/21	12:10	12-00N	135-00E	0.1
49	2008/6/22	06:20	12-01N	135-01E	0.3
50	2008/6/24	17:30	12-00N	135-00E	0.3
51	2008/6/26	03:35	12-02N	135-02E	1.1
52	2008/6/26	06:10	12-00N	135-00E	0.1
53	2008/6/26	12:25	12-00N	135-00E	15.1
54	2008/6/26	14:20	11-59N	134-59E	13.5
55	2008/6/26	20:42	11-59N	135-00E	3.2
56	2008/6/27	19:40	12-08N	135-54E	3.6
57	2008/6/27	20:59	12-10N	136-06E	1.5
58	2008/6/27	23:28	12-13N	136-32E	2.3
59	2008/6/29	00:13	12-56N	140-59E	0.2

Table 5.7-3 Summary of surface seawater sampling for isotope analysis.

	Sampling			
No.	Date	UTC	Latitude	Longitude
1	2008/5/28	06:35	36-21N	142-55E
2	2008/5/29	06:43	32-31N	139-30E
3	2008/5/30	06:17	27-50N	135-49E
4	2008/5/31	06:31	22-58N	132-15E
5	2008/6/1	06:20	18-14N	130-05E
6	2008/6/2	02:13	13-59N	130-06E
7	2008/6/2	06:31	13-13N	130-07E
8	2008/6/2	16:50	11-00N	130-05E
9	2008/6/3	06:24	7-56N	130-04E
10	2008/6/3	21:10	5-00N	130-06E
11	2008/6/4	06:33	6-34N	131-18E
12	2008/6/5	06:24	10-21N	133-53E
13	2008/6/5	23:50	12-00N	135-00E
14	2008/6/6	06:31	12-00N	135-00E
15	2008/6/6	23:50	12-00N	135-00E
16	2008/6/7	06:17	12-00N	135-00E
17	2008/6/7	23:45	12-00N	135-00E
18	2008/6/8	06:49	12-04N	135-00E
19	2008/6/8	23:45	12-00N	135-00E
20	2008/6/9	06:23	12-01N	134-59E
21	2008/6/9	23:42	12-00N	135-00E
22	2008/6/10	06:13	12-00N	135-00E
23	2008/6/10	23:45	12-00N	135-00E
24	2008/6/11	06:29	12-02N	135-00E
25	2008/6/11	23:43	12-00N	135-00E
26	2008/6/12	06:23	12-02N	134-59E
27	2008/6/12	23:45	12-00N	135-00E
28	2008/6/13	06:25	12-01N	135-00E
29	2008/6/13	23:43	12-00N	135-00E
30	2008/6/14	06:30	12-02N	135-00E

31	2008/6/14	23:45	12-00N	135-00E
32	2008/6/15	06:32	12-02N	135-00E
33	2008/6/15	23:42	12-00N	135-00E
34	2008/6/16	06:24	12-01N	135-00E
35	2008/6/16	23:45	12-00N	135-00E
36	2008/6/17	06:32	12-01N	135-01E
37	2008/6/17	23:45	12-02N	135-00E
38	2008/6/18	06:22	12-00N	135-00E
39	2008/6/18	23:45	12-00N	135-00E
40	2008/6/19	06:20	12-00N	135-01E
41	2008/6/19	23:45	12-00N	135-00E
42	2008/6/20	06:28	11-59N	134-59E
43	2008/6/21	00:10	12-00N	135-02E
44	2008/6/21	06:46	12-00N	134-59E
45	2008/6/21	23:45	12-00N	135-00E
46	2008/6/22	06:32	12-01N	135-01E
47	2008/6/22	23:45	12-00N	135-00E
48	2008/6/23	06:28	12-01N	135-00E
49	2008/6/23	23:43	12-00N	135-00E
50	2008/6/24	06:42	12-00N	135-00E
51	2008/6/24	23:43	12-00N	135-00E
52	2008/6/25	06:28	12-00N	135-00E
53	2008/6/25	23:42	12-00N	135-00E
54	2008/6/26	06:43	12-01N	135-01E
55	2008/6/27	06:47	12-01N	135-01E

5.8 Infrared radiometer

(1) Personnel

Hajime Okamoto	(CAOS, Tohoku University)	Principal Investigator	* not on board
Ryo Yoshida	(CAOS, Tohoku University)		* not on board
Kaori Sato	(CAOS, Tohoku University)		* not on board
Toshiaki Takano	(Chiba University)		* not on board
Junichi Watanabe	(Chiba University)		
Nobuo Sugimoto	(National Institute for Environmental Studies)		* not on board
Ichiro Matsui	(National Institute for Environmental Studies)		* not on board

(2) Objective

The infrared radiometer (hereafter IR) is used to derive the temperature of the cloud base and emissivity of the thin ice clouds. Main objectives are to use study clouds and climate system in tropics by the combination of IR with active sensors such as lidar and 95GHz cloud radar. From these integrated approach, it is expected to extend our knowledge of clouds and climate system. Special emphasis is made to retrieve cloud microphysics in upper part of clouds, including sub-visual clouds that are recognized to be a key component for the exchange of water amount between troposphere and stratosphere. Since June 2006, spaceborn radar and lidar systems, CloudSat and CALIPSO are providing vertical and global distribution of clouds and aerosols. One important aim is to observe the same clouds and aerosols by the observational systems on R/V Mirai. Combination of space-based and ship based observations should provide the unique opportunity to study the complete system of theses clouds and aerosols in relation to its environments. We also added the new function for the protection of precipitation.

(3) Method

IR instrument directly provides broadband infrared temperature (9.6-10.5 µm).
General specifications of IR system (KT 19II, HEITRONICS) are as follows.

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

This is converted to broadband radiance around the wavelength region. This is further combined with the lidar or radar for the retrieval of cloud microphysics such as optical thickness at visible wavelength, effective particle size. The applicability of the retrieval technique of the synergetic use of radar/IR or lidar/IR is so far limited to ice clouds. The microphysics of clouds from these techniques will be compared with other retrieval technique such as radar/lidar one or radar with multi-parameter. When the rain is observed by the rain sensor installed in the IR observing system, the radiometer is automatically rotated and stops at the downward position in order to prevent from the rain drops attached on the lens surface.

(4) Results

Figure 5.8-1 displays the temperature measured by IRT on June 3, 2008. The horizontal line denotes the hours (UTC) and vertical axis is the temperature. The location is 5.40^{o}N and 30.36^{o} E.

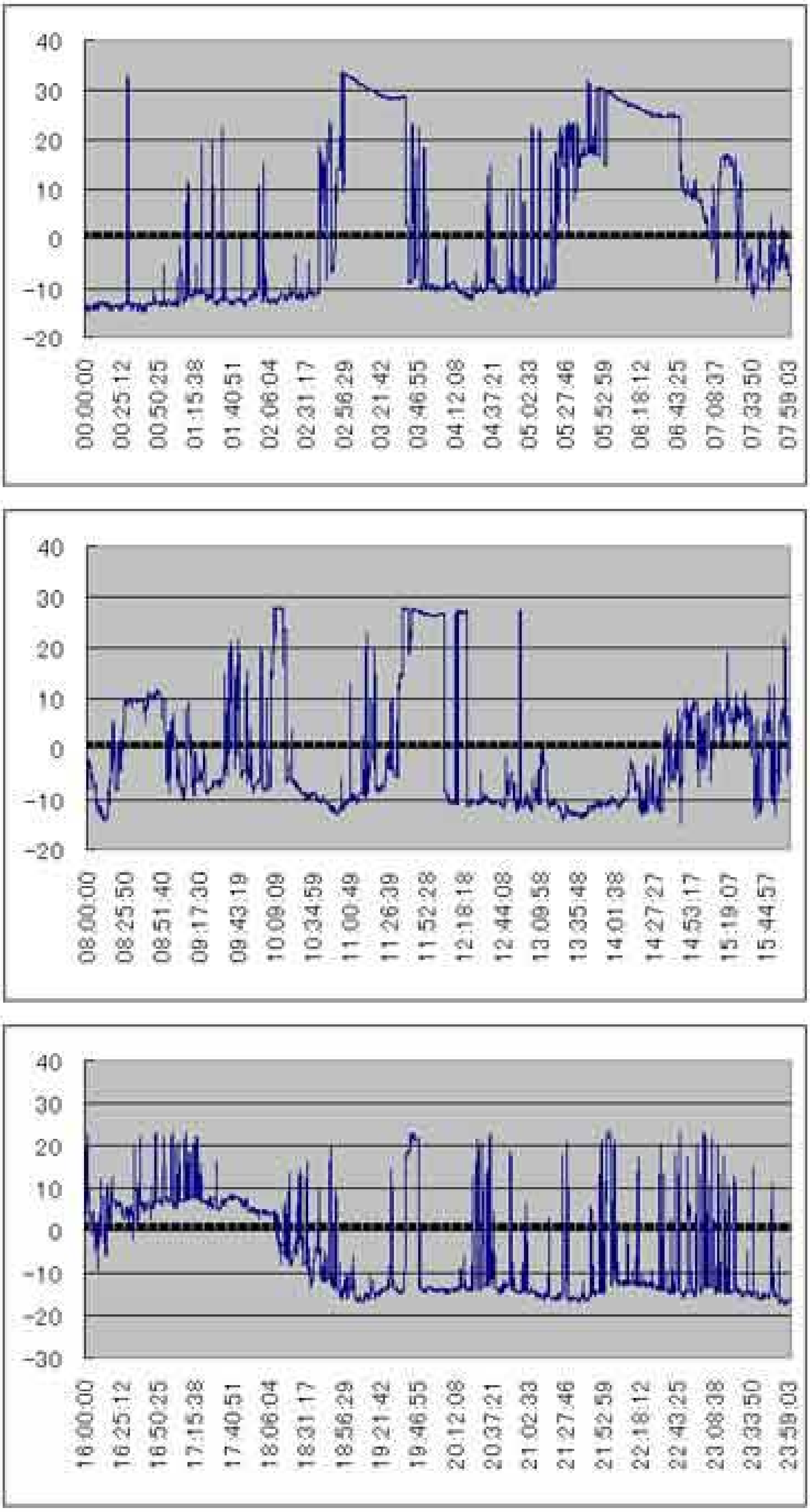


Fig. 5.8-1.Temperature measured by the IRT on June 3, 2008. (a) From 0000 to 0800 UTC, (b) 0800 to 1600 UTC and (c) 1600 to 0000 UTC.

(5) Data archive

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

(6) Remarks

Basically the IRT is operated for 24 hours. The automatic rain protection system works very fine.

5.9 Surface Meteorological Observation

(1) Personnel

Kunio Yoneyama	(JAMSTEC)	Principal Investigator
Biao Geng	(JAMSTEC)	
Souichiro Sueyoshi	(GODI)	Operation Leader
Shinya Okumura	(GODI)	
Wataru Tokunaga	(GODI)	
Harumi Ota	(GODI)	

(2) Objective

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

(3) Methods

Surface meteorological parameters were observed throughout the MR08-02 cruise. During this cruise, we used the following three systems for the observation.

a. MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table 5.9-1 and measured parameters are listed in Table 5.9-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-second averaged data.

b. Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

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

1) Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation.
2) Zeno Meteorological (Zeno/Met) system designed by BNL – wind, air temperature, relative humidity, pressure, and rainfall measurement.
3) 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 Table 5.9-3 and measured parameters are listed in Table 5.9-4.

c. SeaSnake Skin Sea Surface Temperature (SSST)

To measure the skin sea surface temperature (SSST), the SeaSnake SSST-meter which is the floating thermistor designed by BNL was installed at the bow (5m extension). In this cruise, SSST was observed using two thermistors (107 Campbell, USA). We converted sensor output voltage to SSST by using Steinhart-Hart equation led by the calibration data. Each coefficient is as below.

Sensor	a	b	c
NT02-1 Sensor:	9.123407e-04	-1.978120e-04	-1.074893e-07
NT02-2 Sensor:	9.710250e-04	-1.904110e-04	-1.255215e-07
NT03-1 Sensor:	5.846428E-04	-2.404745E-04	3.795453E-11
NT03-2 Sensor:	1.020894E-03	-1.831682E-04	-1.463220E-07

$y = a + b * x + c * x^3$,
$x = \log (1 / ((Vref / V - 1) * R2 - R1))$
$T = 1 / y - 273.15$
Vref = 2500[mV], R1=249000[Ω], R2=1000[Ω]
T: Temperature [degC], V: Sensor output voltage [mV]

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

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

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

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

(4) Results

Figures 5.9-1 shows the time series of the following parameters;

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

Figure 5.9-2 shows the time series of skin sea surface temperature compared to sea surface temperature (EPCS). SSST was plotted using the data from NT02-1 and NT03-1 thermistors.

(5) Data archives

These raw data will be submitted to the JAMSTEC Marine-Earth Data and Information Department just after the cruise. Corrected data sets will be available from K. Yoneyama of JAMSTEC.

(6) Remarks

a. We did not collect FRSR (Fast Rotating data all through this cruise.
b. SST data are available in the following periods.
   06:33UTC 27 May 2008 – 06:00UTC 29 June 2008
c. SSST sensor unit was replaced due to thermistor trouble. Each sensor unit was used as follows:
   NT02: 00:18UTC 02 Jun. 2008 – 00:53UTC 08 Jun. 2008
   NT03: 01:07UTC 08 Jun. 2008 – 06:30UTC 21 Jun. 2008

Table 5.9-1 Instruments and installations of MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	compass deck (21 m) starboard side and port side
Thermometer: SST	RFN1-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	AP370	Koshin Denki, 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-200	Eiko Seiki, Japan	radar mast (28 m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10 m)

Table 5.9-2 Parameters of MIRAI Surface Meteorological observation system

Parameter		Units	Remarks
1	Latitude	degree	
2	Longitude	degree	
3	Ship's speed	knot	Mirai log, DS-30 Furuno
4	Ship's heading	degree	Mirai gyro, TG-6000, Tokimec
5	Relative wind speed	m/s	6sec./10min. averaged
6	Relative wind direction	degree	6sec./10min. averaged
7	True wind speed	m/s	6sec./10min. averaged
8	True wind direction	degree	6sec./10min. averaged
9	Barometric pressure	hPa	adjusted to sea surface level 6sec. averaged
10	Air temperature (starboard side)	degC	6sec. averaged
11	Air temperature (port side)	degC	6sec. averaged
12	Dewpoint temperature (starboard side)	degC	6sec. averaged
13	Dewpoint temperature (port side)	degC	6sec. averaged
14	Relative humidity (starboard side)	%	6sec. averaged
15	Relative humidity (port side)	%	6sec. averaged
16	Sea surface temperature	degC	6sec. averaged
17	Rain rate (optical rain gauge)	mm/hr	hourly accumulation
18	Rain rate (capacitive rain gauge)	mm/hr	hourly accumulation
19	Down welling shortwave radiation	W/m2	6sec. averaged
20	Down welling infra-red radiation	W/m2	6sec. averaged
21	Significant wave height (bow)	m	hourly
22	Significant wave height (aft)	m	hourly
23	Significant wave period (bow)	second	hourly
24	Significant wave period (aft)	second	hourly

Table 5.9-3 Instruments and installation locations of SOAR system

Sensors (Zeno/Met)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	foremast (25 m)
Tair/RH	HMP45A	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	foremast (23 m)
Barometer	61202V	R.M. Young, USA	
with 61002 Gill pressure port		R.M. Young, USA	foremast (22 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 (24 m)
Radiometer (long wave)	PIR	Epply Labs, USA	foremast (24m)

Table 5.9-4 Parameters of SOAR system

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

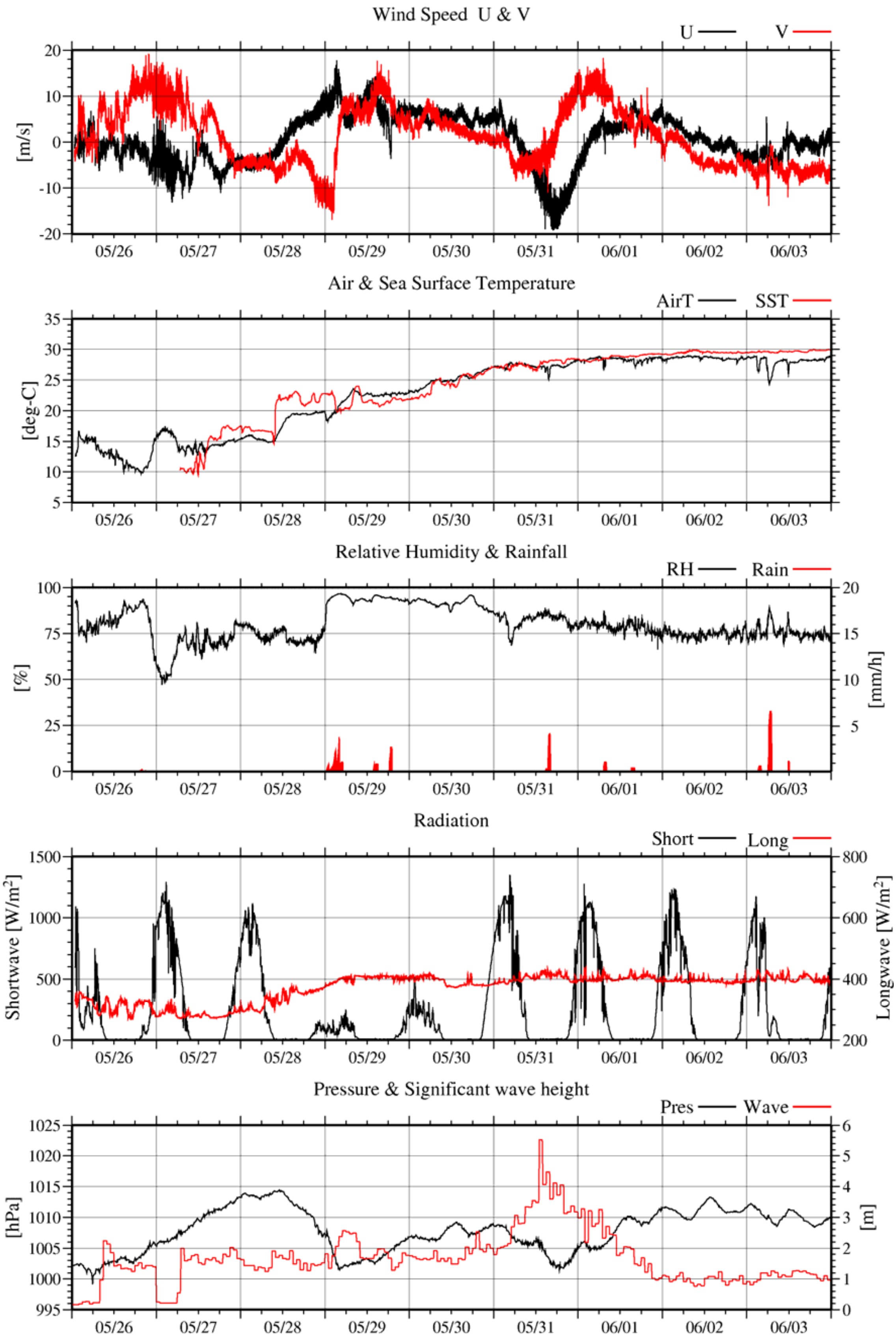


Fig. 5.9-1. Time series of surface meteorological parameters during the MR08-02 cruise

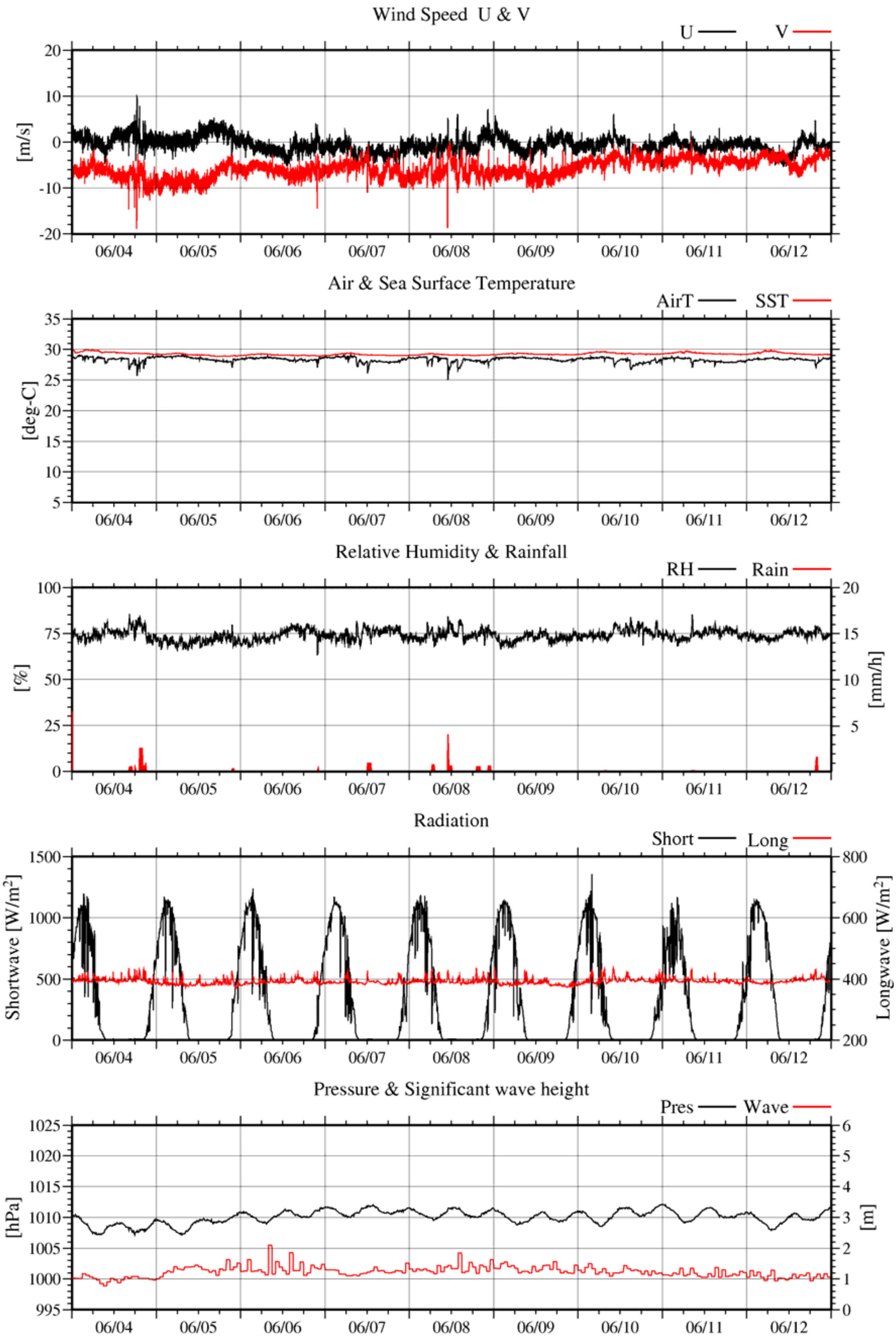


Fig. 5.9-1. (Continued)

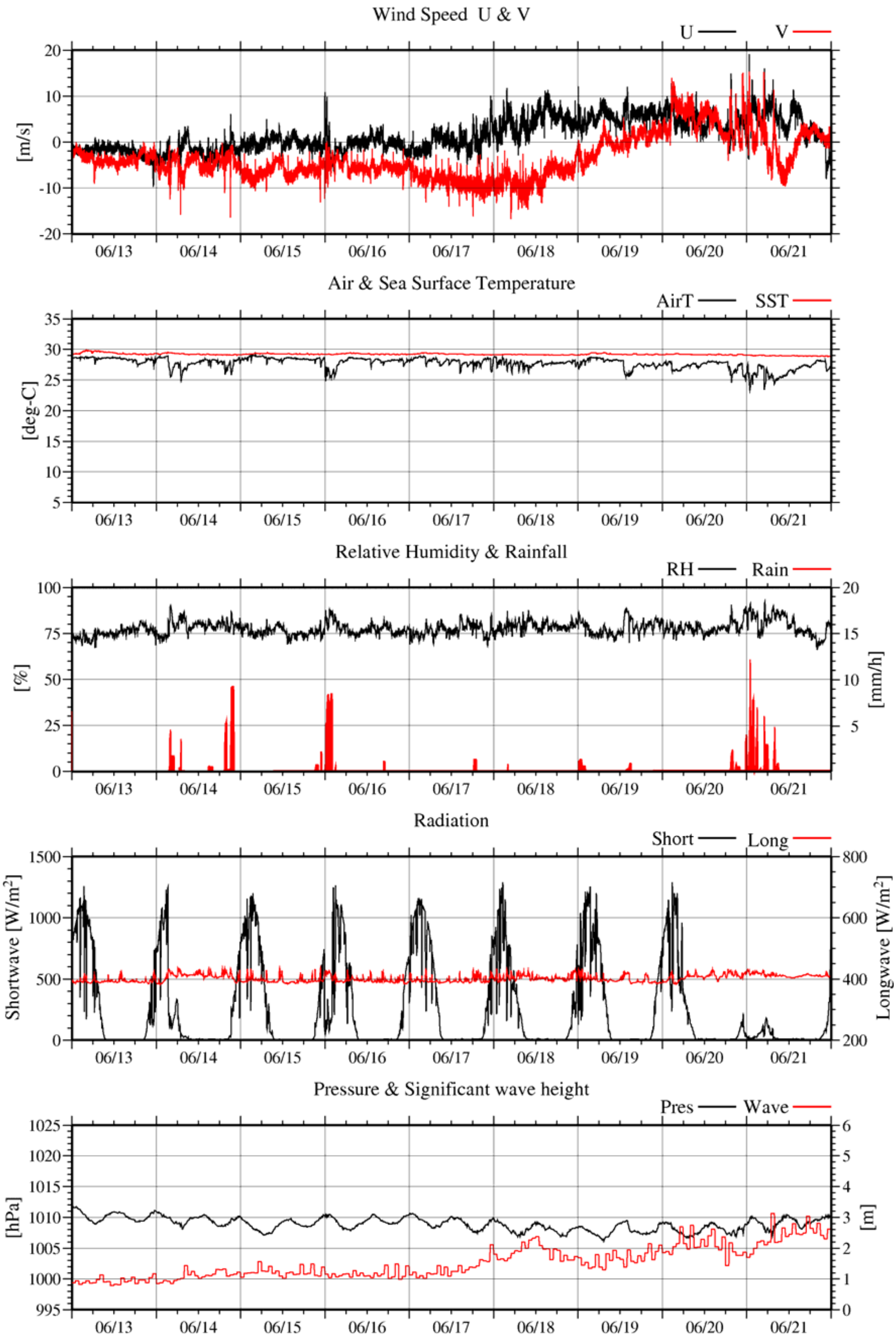


Fig. 5.9-1. (Continued)

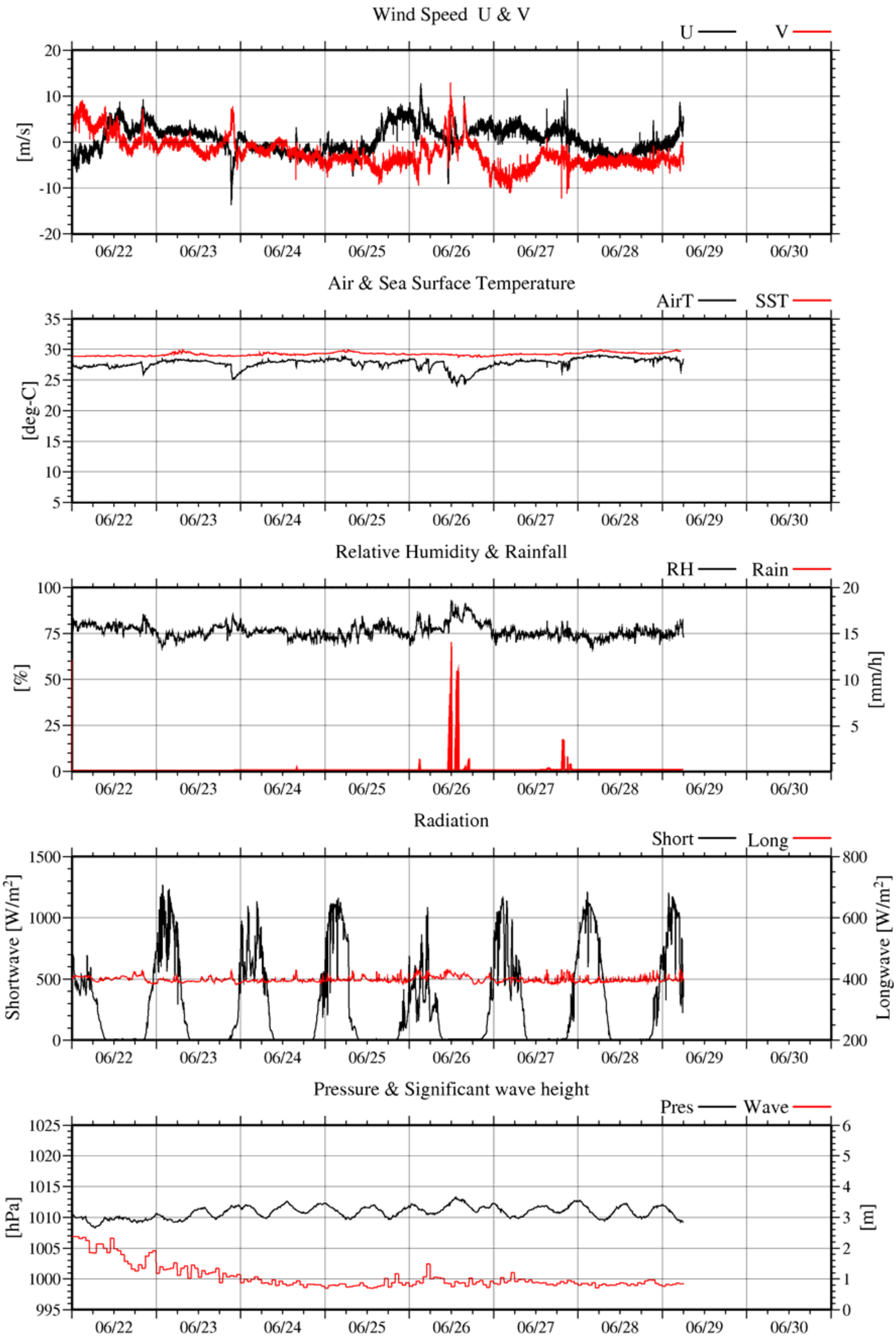


Fig. 5.9-1. (Continued)

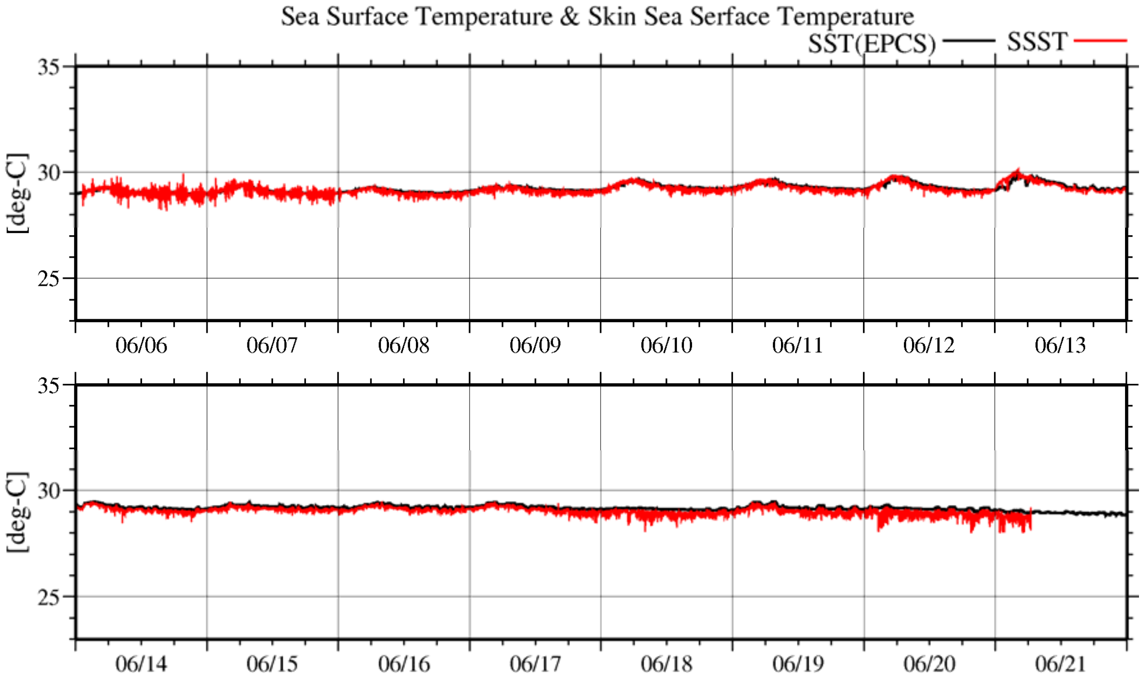


Fig. 5.9-2. Time series of sea surface temperature during the MR08-02 cruise

5.10 Air-sea surface eddy flux measurement

(1) Personnel

Osamu Tsukamoto	(Okayama University)	Principal Investigator	* not on board
Fumiyoshi Kondo	(Okayama University)		* not on board
Hiroshi Ishida	(Kobe University)		* not on board
Souichiro Sueyoshi	(GODI)		
Shinya Okumura	(GODI)		
Wataru Tokunaga	(GODI)		
Harumi Ota	(GODI)		

(2) Objective

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

(3) Methods

The surface turbulent flux measurement system (Fig. 5.10-1) consists of turbulence instruments (Kaijo Co., Ltd.) and ship motion sensors (Kanto Aircraft Instrument Co., Ltd.). The turbulence sensors include a three-dimensional sonic anemometer-thermometer (Kaijo, DA-600) and an infrared hygrometer (LICOR, LI-7500). The sonic anemometer measures three-dimensional wind components relative to the ship. The ship motion sensors include a two-axis inclinometer (Applied Geomechanics, MD-900-T), a three-axis accelerometer (Applied Signal Inc., QA-700-020), and a three-axis rate gyro (Systron Donner, QRS-0050-100). LI7500 is a CO2/H2O turbulence sensor that measures turbulent signals of carbon dioxide and water vapor simultaneously.These signals are sampled at 10 Hz by a PC-based data logging system (Labview, National Instruments Co., Ltd.). By obtaining the ship speed and heading information through the Mirai network system it yields the absolute wind components relative to the ground. Combining wind data with the turbulence data, turbulent fluxes and statistics are calculated in a real-time basis. These data are also saved in digital files every 0.1 second for raw data and every 1 minute for statistic data.

(4) Results

Data will be processed after the cruise at OkayamaUniversity.

(5) Data Archives

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

Fig. 5.10-1 Turbulent flux measurement system on the top deck of the foremast.

5.11 Continuous monitoring of surface seawater

(1) Personnel

Kunio Yoneyama	(JAMSTEC)	Principal Investigator
Yoshiko Ishikawa	(MWJ)	Operation Leader
Tomonori Watai	(MWJ)	

(2) Objective

Measurements of temperature, salinity, dissolved oxygen and fluorescence of the sea surface water in the western tropical Pacific Ocean.

(3) Methods

The *Continuous Sea Surface Water Monitoring System* (Nippon Kaiyo Co. Ltd.) that equips five sensors of 1) salinity, 2) temperatures (two sensors), 3) dissolved oxygen and 4) fluorescence can continuously measure their values in near-sea surface water. Salinity is calculated by conductivity on the basis of PSS78. Specifications of these sensors are listed below.

This system is settled in the "*sea surface monitoring laboratory*" on R/V MIRAI, and near-surface water was continuously pumped up to the system through a vinyl-chloride pipe. The flow rate for the system is manually controlled by several valves with its value of 12 L min^{-1} except for the fluorometer (about 0.5 L min^{-1}). Each flow rate is monitored with respective flow meter. The system is connected to shipboard LAN-system, and measured data is stored in a hard disk of PC every 1-minute together with time (UTC) and position of the ship.

a. Temperature and Conductivity sensor

Model:	SBE-21, SEA-BIRD ELECTRONICS, INC.
Serial number:	2118859-2641
Measurement range:	Temperature -5 to +35℃, Conductivity 0 to 7 S m^{-1}
Resolution:	Temperatures 0.001℃, Conductivity 0.0001 S m^{-1}
Stability:	Temperature 0.01℃ 6 $months^{-1}$, Conductivity 0.001 S m^{-1} $month^{-1}$

b. Bottom of ship thermometer

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

c. Dissolved oxygen sensor

Model:	2127A, Hach Ultara Analytics Japan, INC.
Serial number:	61230
Measurement range:	0 to 14 ppm
Accuracy:	±1% in ±5℃ of correction temperature
Stability:	5% $month^{-1}$

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

Start : 2008/05/27 07:32 Stop : 2008/06/29 05:15

(4) Results

Preliminary data of temperature, salinity, dissolved oxygen, fluorescence at sea surface are shown in Fig.5.11-1. We took the surface water samples once a day to compare sensor data with bottle data of salinity and dissolved oxygen. The results are shown in Figs.5.11-2, and 3. All the salinity samples were analyzed by the Guildline 8400B “AUTOSAL”, and dissolve oxygen samples by Winkler method.

(5) Data archive

The data were stored on a CD-R, which will be submitted to the Marine-Earth Data and Information Department of JAMSTEC, and will be opened to public via R/V MIRAI Data Web site at http://www.jamstec.go.jp/cruisedata/mirai/e/.

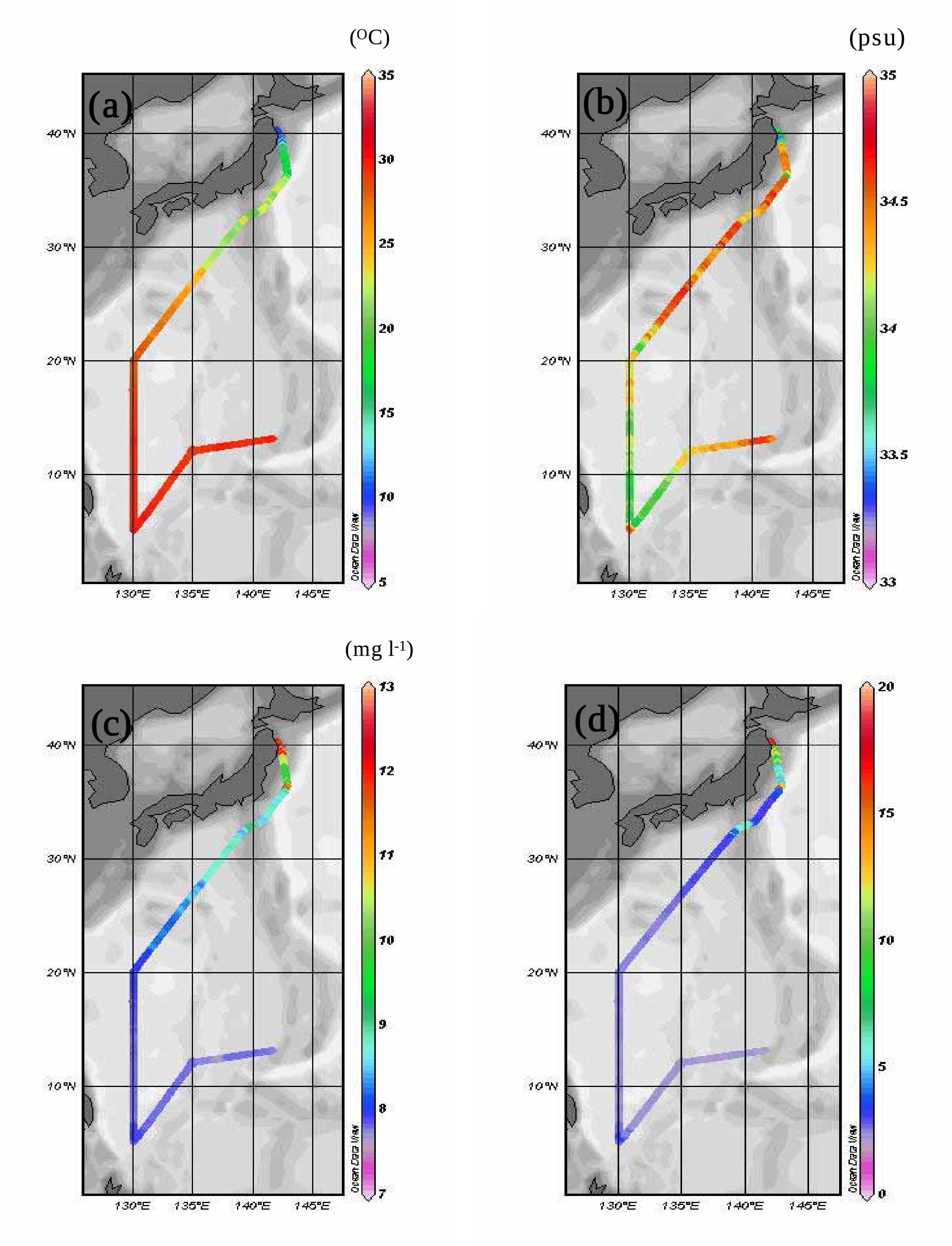


Fig.5.11-1. Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen and (d) fluorescence. Fluorescence is relative value.

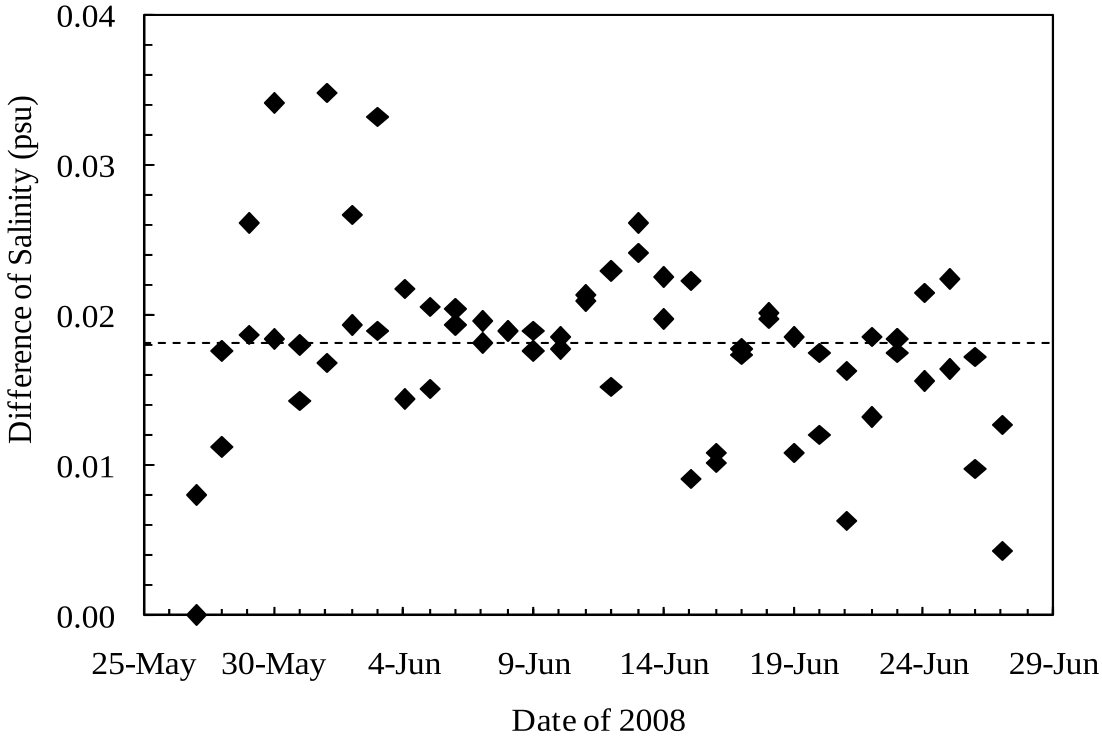


Fig.5.11-2. Difference of salinity between sensor data and bottle data. The mean difference is 0.0181psu.

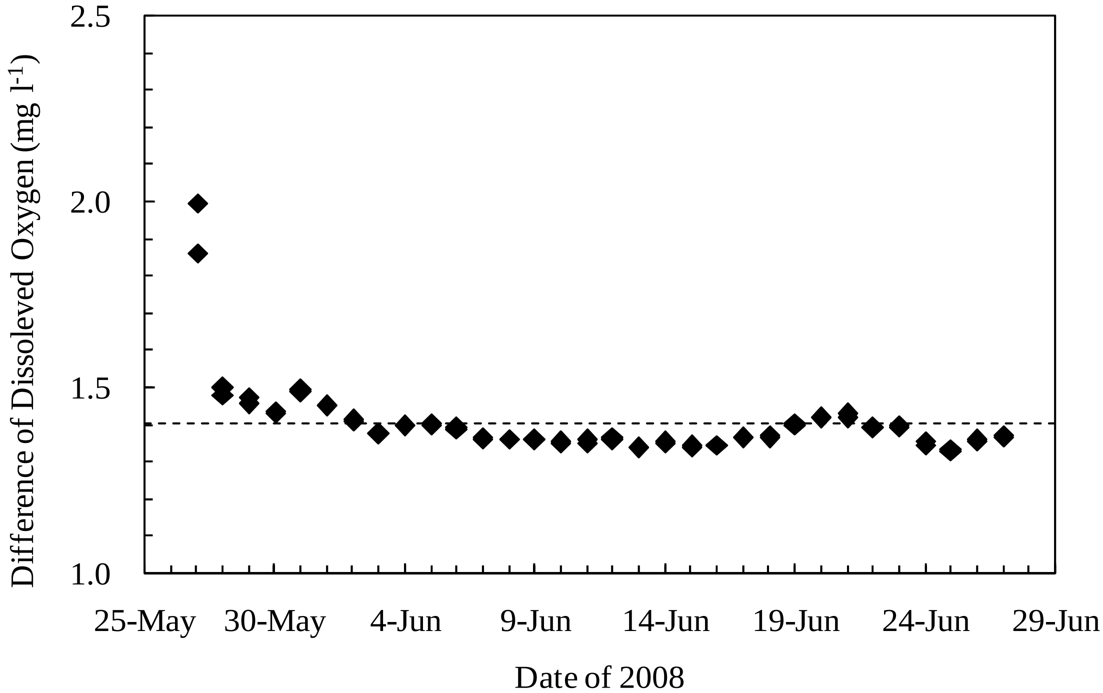


Fig.5.11-3. Difference of dissolved oxygen between sensor data and bottle data. The mean difference is 1.4026 mg l^{-1}.

5.12 CTDO Sampler

(1) Personnel

Kunio Yoneyama	(JAMSTEC)	Principal Investigator
Tomoyuki Takamori	(MWJ)	Operation Leader
Hirokatsu Uno	(MWJ)	
Akira Watanabe	(MWJ)	
Fujio Kobayashi	(MWJ)	
Hiroki Ushiromura	(MWJ)	

(2) Objective

Investigation of oceanic structure and water sampling.

(3) Methods

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 911plus system controls the 36-position SBE 32 Carousel Water Sampler. The Carousel accepts 12-litre Niskin-X water sample bottles (General Oceanics, Inc., USA). Bottles were fired through the RS-232C modem connector on the back of the SBE 11plus deck unit while acquiring real time data.

The CTD raw data were acquired on real time by using the Seasave –Win32(ver.5.27b) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled during up –cast by sending a command from the personal computer.

The CTD raw data was processed using SBE Data Processing-Win32 (ver.5.27b).

Data processing procedures and used utilities SBE Data Processing-Win32 of were as follows:

DATCNV: DATCNV converted the raw data .DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition.
- Sorce of Scan Range = Bottle Log(BL)file
- Offset = 0.0
- Duration = 3.0

ROSSUM: ROSSUM created a summary of the bottle data

ALIGNCTD: 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.
- Advance Primary Oxygen Voltage = 6.0 sec

WILDEDIT: WILDEDIT marked extreme outliers in the data files
- Std deviation for pass 1= 10
- Std deviation for pass 2= 20
- Scan per block= 1000
- Keep data within this distance of mean= 0
- Exclude Scan Marked Bad = Check

CELLTM: CELLTM removed conductivity cell thermal mass effects from measured conductivity.
- Primary Alpha = 0.03 1/beta = 7.0
- Secondary Alpha = 0.03 1/beta = 7.0

FILTER: FILTER performed a low pass filter on pressure with a time constant of 0.15 seconds.

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

SECTION: SECTION removed the unnecessary data.

LOOPEDIT: LOOPEDIT marked scan with ‘badflag’, if the CTD velocity is less than 0 m/s.
- Minimum Velocity Type = Fixed Minimum Velocity
- Minimum CTD Velocity [m/sec] = 0.0
- Exclude Scan Marked Bad = Check

DETIVE: DERIVE was used to compute oxygen.

BINAVG: BINAVG calculate the averaged data in every 1 dbr.

DERIVE:	DERIVE was re-used to compute salinity, sigma-theta and potential temperature.
SPLIT:	SPLIT was used to split data into the down cast and the up cast.

The system used in this cruise is summarized as follows:

Under water unit:	SBE,Inc. SBE9plus S/N 09P27443-0677
Deck unit:	SBE,Inc. SBE11plus S/N 11P7030-0272
Carousel Water Sampler	SBE,Inc. SBE32 S/N 3227443-0391
Water Sample bottle	General Oceanics,Inc. 12-litre Niskin-X

Primary sensors

Temperature sensor:	SBE,Inc. SBE03-04/F S/N 031359
Conductivity sensor:	SBE,Inc. SBE04C S/N 043036
Oxygen sensor:	SBE,Inc. SBE43 S/N430394
Pump:	SBE,Inc. SBE5T S/N054595

Secondary sensors

Temperature sensor:	SBE,Inc. SBE03Plus S/N 03P4421
Conductivity sensor:	SBE,Inc. SBE04-04/0 S/N 041206
Oxygen sensor:	SBE,Inc. SBE43 S/N430949
Pump:	SBE,Inc. SBE5T S/N054598

Option sensor

Fluorescence sensor	Seapoint.Inc. S/N2579

(4) Results

Total in 99 casts of CTD measurements have been carried out (Table 5.12.1). Time-depth cross sections of temperature, salinity, dissolved oxygen, and fluorescence during intensive observation are shown in Fig.5.12-1.

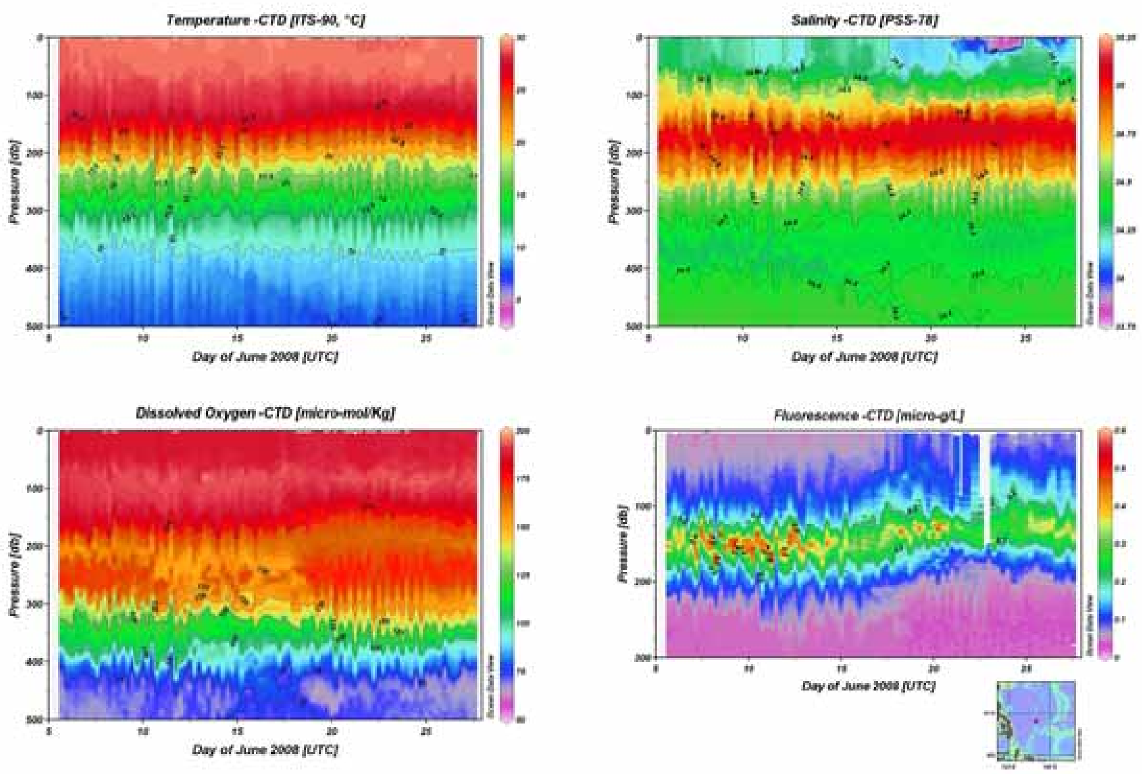


Fig.5.12-1. Time-depth cross section of temperature, salinity, dissolved oxygen, and fluorescence.

(5) Data archive

Data will be submitted to the Marine-Earth Data and Information Department of JAMSTEC, and will be opened to public via R/V MIRAI Data Web site at http://www.jamstec.go.jp/cruisedata/mirai/e/.

(6) Remarks

The CTD salinity data was calibrated using salinity of sampled water below 1000dbr measured by AUTOSAL. The CTD salinity was calibrated as follow:

Offset = Btl_CTDsal – Btl_AUTOSAL
CTDsal_cal = CTDsal_raw - Offset

where

CTDsal_cal : calibrated salinity
CTDsal_raw : CTD salinity
Offset: calibration coefficient
Btl_CTDsal : CTD salinity when fired during up-cast
Btl_AUTOSAL : salinity measured by AUTOSAL

Offset of the Primary CTDsal_raw was 0.007(psu) and Offset of the secondary CTDsal_raw was 0.000(psu). The results of the calibration are summarized in Fig. 5.12-2.

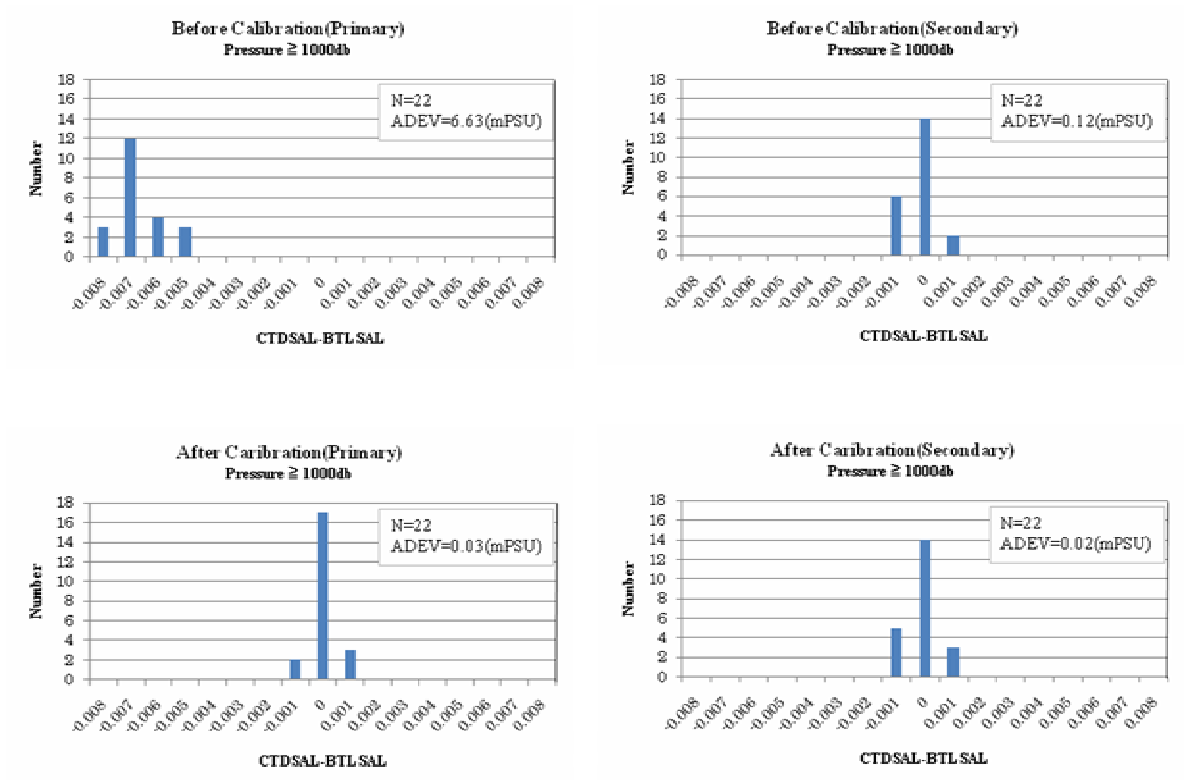


Fig.5.12-2. Difference between the CTD salinity and bottle salinity. Upper histograms show the difference before the calibration, Lower histograms show the difference after the calibration. The left figure is result of the primary sensor and the right figure is result of the Secondary senor. And N is the number of the data, ADEV is the mean absolute deviation .

Table 5.12.1 CTD cast table

CWS: Carousel Water Sampler

Station	Cast	File name	Date (UTC)	Start time	End time	Latitude (N)	Longitude (E)	Wire Out (m)	Depth (MNB)	Max.Press (db)	NOTE
P1	001	P1M001	02/06/2008	1:52	3:05	13-59.97	130-06.08	2000.5	5686	2000.8	
P2	001	P2M001	02/06/2008	16:36	17:43	10-59.98	130-05.90	2001.2	5897	2001.0	
P3	001	P3M001	03/06/2008	20:51	21:58	04-59.90	130-06.04	1998.9	4870	2009.0	
P4	001	P4M001	05/06/2008	17:38	17:58	11-59.90	134-59.64	507.6	4615	501.5	
P4	002	P4M002	05/06/2008	23:41	0:16	11-59.99	134-59.95	500.5	4618	500.7	
P4	003	P4M003	06/06/2008	5:37	6:18	12-00.11	134-59.93	1008.9	4610	1002.5	
P4	004	P4M004	06/06/2008	11:38	12:01	11-59.98	134-59.98	502.2	4609	501.2	
P4	005	P4M005	06/06/2008	17:46	18:19	11-59.69	134-59.55	508.9	4617	503.4	
P4	006	P4M006	06/06/2008	20:38	21:07	11-59.98	134-59.79	502.2	4616	501.2	
P4	007	P4M007	06/06/2008	23:37	0:20	11-59.98	134-59.88	499.0	4612	499.1	
P4	008	P4M008	07/06/2008	2:38	3:07	12-00.03	135-00.02	506.0	4609	504.5	
P4	009	P4M009	07/06/2008	5:40	6:34	12-00.02	134-59.91	1019.4	4608	1010.6	
P4	010	P4M010	07/06/2008	8:34	9:08	12-00.00	134-59.94	504.0	4611	504.5	
P4	011	P4M011	07/06/2008	11:36	12:16	12-00.01	134-59.86	506.7	4621	505.1	
P4	012	P4M012	07/06/2008	14:34	15:04	11-59.94	134-59.93	506.6	4611	505.4	
P4	013	P4M013	07/06/2008	17:39	18:11	11-59.95	134-59.81	511.1	4615	508.9	
P4	014	P4M014	07/06/2008	23:33	0:02	11-59.90	134-59.79	504.4	4614	504.6	
P4	015	P4M015	08/06/2008	5:34	6:15	12-00.67	134-59.79	1056.8	4619	1009.9	
P4	016	P4M016	08/06/2008	11:33	11:55	12-00.06	134-59.91	504.5	4611	505.0	
P4	017	P4M017	08/06/2008	17:35	18:07	11-59.75	134-59.77	506.7	4620	507.8	
P4	018	P4M018	08/06/2008	20:34	21:02	11-59.68	134-59.46	505.8	4617	505.3	
P4	019	P4M019	08/06/2008	23:33	0:08	11-59.93	135-00.14	506.0	4594	506.2	
P4	020	P4M020	09/06/2008	2:32	3:00	11-59.88	134-59.83	504.2	4614	504.3	
P4	021	P4M021	09/06/2008	5:33	6:26	11-59.95	135-00.01	1038.8	4606	1010.2	
P4	022	P4M022	09/06/2008	8:35	9:11	12-00.03	134-59.80	512.4	4620	504.4	
P4	023	P4M023	09/06/2008	11:33	12:07	12-00.12	135-00.07	503.6	4610	504.7	
P4	024	P4M024	09/06/2008	14:33	15:05	11-59.82	134-59.94	504.0	4611	504.9	
P4	025	P4M025	09/06/2008	17:37	18:12	11-59.86	134-59.97	504.4	4613	506.2	
P4	026	P4M026	09/06/2008	23:32	0:03	11-59.88	134-59.90	509.1	4612	504.5	
P4	027	P4M027	10/06/2008	5:35	6:13	12-00.08	134-59.88	1033.7	4619	1010.3	
P4	028	P4M028	10/06/2008	11:34	11:56	11-59.84	134-59.79	503.1	4617	504.0	
P4	029	P4M029	10/06/2008	17:34	17:55	12-00.04	135-00.08	504.4	4610	503.7	
P4	030	P4M030	10/06/2008	23:32	0:08	11-59.95	135-00.02	509.1	4603	507.7	
P4	031	P4M031	11/06/2008	5:34	6:17	12-00.17	134-59.90	1067.2	4612	1011.9	
P4	032	P4M032	11/06/2008	11:33	12:09	12-00.05	135-00.01	507.1	4609	505.2	
P4	033	P4M033	11/06/2008	17:35	17:56	11-59.96	135-00.05	502.2	4603	504.3	
P4	034	P4M034	11/06/2008	23:32	0:02	11-59.85	134-59.95	505.1	4611	505.3	
P4	035	P4M035	12/06/2008	5:33	6:14	11-59.98	134-59.80	1045.3	4617	1009.1	
P4	036	P4M036	12/06/2008	11:34	11:54	12-00.02	134-59.91	505.3	4616	505.3	
P4	037	P4M037	12/06/2008	17:34	17:53	11-59.94	134-59.88	503.6	4617	504.2	
P4	038	P4M038	12/06/2008	23:33	0:08	11-59.92	135-00.02	508.2	4607	509.0	
P4	039	P4M039	13/06/2008	5:34	6:14	12-00.03	134-59.97	1014.8	4615	1008.9	
P4	040	P4M040	13/06/2008	11:32	12:10	11-59.73	135-00.00	507.8	4608	509.8	
P4	041	P4M041	13/06/2008	17:34	17:53	11-59.87	135-00.01	502.0	4610	504.3	
P4	042	P4M042	13/06/2008	23:33	0:06	11-59.99	134-59.96	510.6	4616	505.6	
P4	043	P4M043	14/06/2008	5:32	6:11	12-00.02	134-59.93	1027.1	4618	1009.9	
P4	044	P4M044	14/06/2008	11:32	11:58	11-59.99	134-59.85	503.1	4617	505.0	
P4	045	P4M045	14/06/2008	17:33	17:53	12-00.00	134-59.92	503.1	4610	504.1	
P4	046	P4M046	14/06/2008	23:32	0:05	11-59.93	134-59.98	506.7	4605	505.1	
P4	047	P4M047	15/06/2008	5:32	6:10	11-59.94	134-59.82	1014.8	4613	1010.7	
P4	048	P4M048	15/06/2008	11:33	12:12	11-59.83	134-59.85	503.6	4612	505.2	
P4	049	P4M049	15/06/2008	17:34	17:52	11-59.98	134-59.94	506.6	4612	505.2	
P4	050	P4M050	15/06/2008	23:33	N/A	11-59.95	134-59.96	508.6	4613	505.4	CWS fired 35 positions except #9 (#6 was overlapped).
P4	050	P4M050a	15/06/2008	N/A	0:02	N/A	N/A	N/A	N/A	N/A	System re-started at 5db for sampling position #9.
P4	051	P4M051	16/06/2008	5:33	6:09	11-59.93	135-00.01	1014.1	4606	1010.2	
P4	052	P4M052	16/06/2008	11:33	11:53	11-59.87	134-59.88	504.9	4613	505.0	
P4	053	P4M053	16/06/2008	17:33	17:52	11-59.99	134-59.98	504.9	4615	504.1	
P4	054	P4M054	16/06/2008	23:35	0:09	11-59.91	134-59.92	502.9	4611	504.5	
P4	055	P4M055	17/06/2008	5:33	6:09	11-59.79	134-59.98	1007.3	4609	1009.7	
P4	056	P4M056	17/06/2008	11:38	12:17	12-00.01	134-59.57	509.3	4622	506.6	
P4	057	P4M057	17/06/2008	17:35	17:54	12-00.18	134-59.86	504.2	4615	505.0	
P4	058	P4M058	17/06/2008	23:34	0:02	12-01.62	134-59.73	502.0	4604	504.2	
P4	059	P4M059	18/06/2008	5:34	0:15	11-59.75	134-59.90	1028.9	4613	1010.3	
P4	060	P4M060	18/06/2008	11:33	11:53	12-00.12	134-59.49	505.3	4625	505.2	
P4	061	P4M061	18/06/2008	17:34	17:53	11-59.96	134-59.56	502.2	4618	504.0	
P4	062	P4M062	18/06/2008	23:33	0:08	12-00.01	134-59.96	513.3	4593	505.0	
P4	063	P4M063	19/06/2008	5:33	6:12	12-00.01	135-00.28	1020.3	4575	1009.6	
P4	064	P4M064	19/06/2008	11:33	12:13	11-59.99	134-59.81	-	4601	506.9	
P4	065	P4M065	19/06/2008	17:37	17:56	11-59.93	134-59.73	502.7	4599	504.8	
P4	066	P4M066	19/06/2008	23:34	0:07	11-59.95	134-59.78	503.6	4604	503.4	
P4	067	P4M067	20/06/2008	5:33	6:13	12-00.18	134-58.90	1008.2	4597	1009.6	
P4	068	P4M068	20/06/2008	11:34	11:57	12-00.10	134-58.96	506.0	4604	504.3	
P4	069	P4M069	20/06/2008	17:36	17:55	12-00.10	134-59.91	502.9	4616	504.2	
P4	070	P4M070	20/06/2008	23:59	0:37	11-59.50	135-01.70	508.2	4133	505.1	

Table 5.12.1 (Continued)

Station	Cast	File name	Date (UTC)	Start time	End time	Latitude (N)	Longitude (E)	Wire Out (m)	Depth (MNB)	Max.Press (db)	NOTE
P4	071	P4M071	21/06/2008	5:35	6:17	11-59.97	135-00.13	1034.8	4607	1008.8	
P4	072	P4M072	21/06/2008	11:40	12:20	11-59.95	135-00.09	-	4607	504.4	
P4	073	P4M073	21/06/2008	17:41	18:01	12-00.11	135-00.06	504.4	4613	504.4	
P4	074	P4M074	21/06/2008	23:36	23:39	11-59.90	135-00.13	N/A	4610	N/A	System re-start at 110dbar. (Fluorescence was abnormal.)
P4	074	P4M074a	21/06/2008	23:40	0:12	N/A	N/A	505.6	N/A	503.4	
P4	075	P4M075	22/06/2008	5:32	6:11	12-00.08	134-59.94	1008.6	4611	1009.3	
P4	076	P4M076	22/06/2008	11:33	11:52	12-00.02	134-59.95	508.8	4617	503.5	
P4	077	P4M077	22/06/2008	17:34	17:54	11-59.91	134-59.93	501.4	4610	503.9	
P4	078	P4M078	22/06/2008	23:34	0:09	11-59.91	134-59.87	502.0	4615	504.8	
P4	079	P4M079	23/06/2008	5:32	6:13	12-00.09	134-59.93	1014.6	4609	1009.9	
P4	080	P4M080	23/06/2008	11:33	12:09	11-59.96	134-59.99	510.4	4610	505.8	
P4	081	P4M081	23/06/2008	17:34	17:54	11-59.86	135-00.13	503.8	4600	503.9	
P4	082	P4M082	23/06/2008	23:33	0:02	11-59.83	135-00.04	502.7	4612	505.2	
P4	083	P4M083	24/06/2008	5:33	6:11	12-00.08	134-59.99	1006.9	4611	1009.8	
P4	084	P4M084	24/06/2008	11:34	11:52	11-59.84	135-00.06	503.6	4608	504.4	
P4	085	P4M085	24/06/2008	17:34	17:53	11-59.75	134-59.86	503.1	4629	504.5	
P4	086	P4M086	24/06/2008	23:33	0:07	11-59.95	134-59.87	504.4	4613	504.8	
P4	087	P4M087	25/06/2008	5:33	6:08	12-00.02	134-59.76	1018.8	4617	1009.5	
P4	088	P4M088	25/06/2008	11:32	12:07	12-00.05	135-00.04	509.1	4608	504.8	
P4	089	P4M089	25/06/2008	17:34	17:53	11-59.96	135-00.03	506.4	4604	504.5	
P4	090	P4M090	25/06/2008	23:32	0:03	11-59.99	134-59.99	507.5	4606	504.0	
P4	091	P4M091	26/06/2008	5:31	6:09	12-00.06	134-59.89	1022.7	4612	1010.3	
P4	092	P4M092	26/06/2008	11:40	12:05	12-00.14	135-00.19	511.9	4604	504.6	
P4	093	P4M093	26/06/2008	17:34	17:53	11-59.84	134-59.98	503.1	4613	504.2	
P4	094	P4M094	26/06/2008	23:32	23:51	11-59.84	134-59.93	503.6	4615	505.2	
P4	095	P4M095	27/06/2008	5:32	6:10	11-59.90	134-59.92	1006.2	4610	1009.6	
P4	096	P4M096	27/06/2008	11:31	11:49	11-59.97	134-59.80	503.4	4619	504.2	

5.13 Salinity of Sampled Water

(1) Personnel

Kunio Yoneyama	(JAMSTEC)	Principal Investigator
Fujio Kobayashi	(MWJ)	Operation Leader
Hiroki Ushiromura	(MWJ)	

(2) Objective

To provide a calibration for the measurement of salinity of bottle water collected on the CTD casts and EPCS.

(3) Methods

a. Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles and EPCS. The salinity sample bottle of the 250ml brown glass bottle with screw cap was used for collecting the sample water. Each bottle was rinsed three times with the sample water, and was filled with sample water to the bottle shoulder. The sample bottle was sealed with a plastic insert thimble and a screw cap； the thimble being thoroughly rinsed before use. The bottle was stored for more than 18 hours in the laboratory before the salinity measurement.

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

Table 5.13-1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD	65
Samples for EPCS	64
Total	129

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR08-02 using the salinometer (Model 8400B “AUTOSAL”； Guildline Instruments Ltd.: S/N 62827) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). A pair of precision digital thermometers (Model 9540； Guildline Instruments Ltd.) were used. The thermometer monitored the ambient temperature and the other monitored a bath temperature.

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

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

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

Thermometer (Model 9540； Guildline Instruments Ltd.)

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

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 20 deg C to 24 deg C, while the bath temperature was very stable and varied within +/- 0.002 deg C on rare occasion. The measurement for each sample was done with a double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 5 seconds after filling the cell with the sample and it took about 15 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for the practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. The measurement was conducted in about 7 hours per day and the cell was cleaned with soap after the measurement of the day.

(4) Results

a. Standard Seawater

Standardization control of the salinometer was set to 456 and all measurements were done at this setting. The value of STANDBY was 5393 +/- 0001 and that of ZERO was 0.0+0000 or 0.0+0001. The conductivity ratio of IAPSO Standard Seawater batch P149 was 0.99984 (double conductivity ratio was 1.99968) and was used as the standard for salinity. 22 bottles of P149 were measured.

Figure 5.14-1 shows the history of the double conductivity ratio of the Standard Seawater batch P149. The average of the double conductivity ratio was 1.99970 and the standard deviation was 0.00002, which is equivalent to 0.0004 in salinity.

Figure 5.14-2 shows the history of the double conductivity ratio of the Standard Seawater batch P149 after correction. The average of the double conductivity ratio after correction was 1.99968 and the standard deviation was 0.00002, which is equivalent to 0.0003 in salinity.

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

batch	：	P149
conductivity ratio	：	0.99984
salinity	：	34.994
preparation date	：	5-October-2007

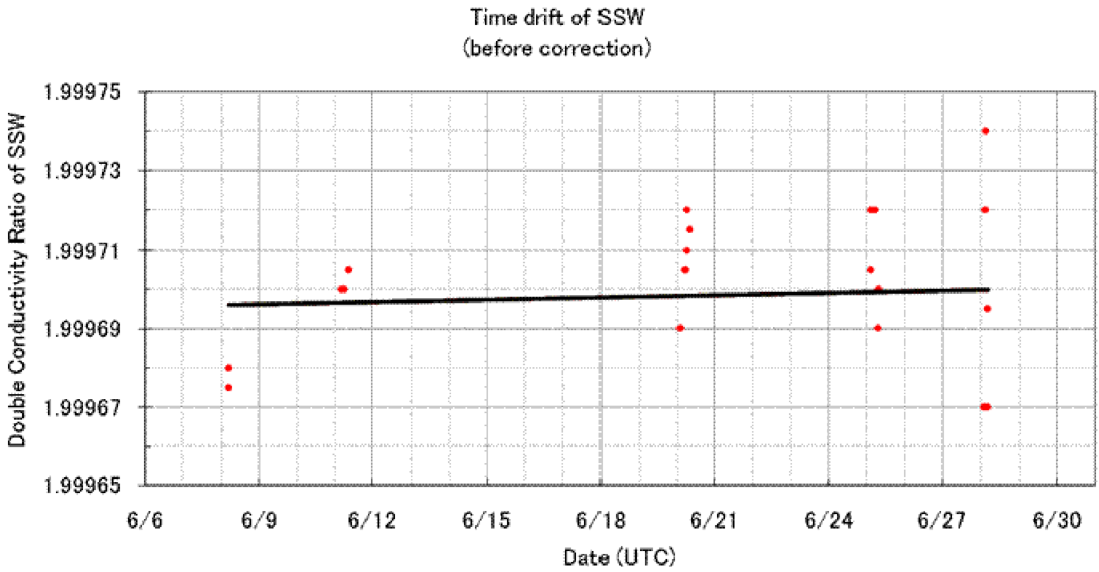


Fig. 5.13-1. History of double conductivity ratio for the Standard Seawater batch P149 (before correction)

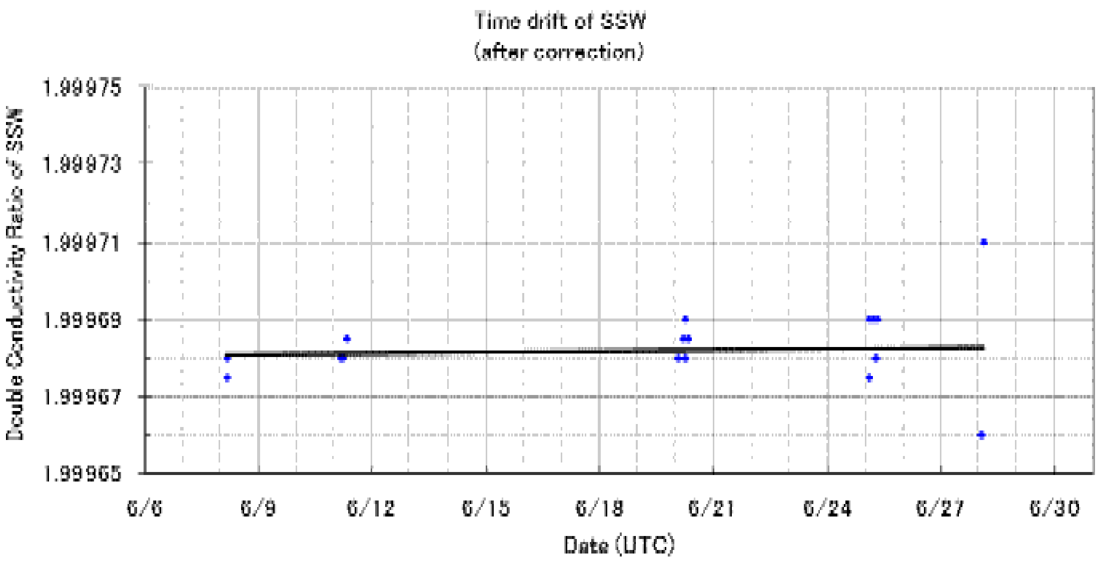


Fig. 5.13-2. History of double conductivity ratio for the Standard Seawater batch P149 (after correction)

b. Sub-Standard Seawater

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

c. Replicate Samples

We estimated the precision of this method using 22 pairs of replicate samples taken from the same Niskin bottle. The average and the standard deviation of absolute difference among 22 pairs of replicate samples were 0.0002 and 0.0004 in salinity, respectively.

(5) Data archive

These raw datasets will be submitted to JAMSTEC Marine-Earth Data and Information Department and corrected datasets are available from Mirai Web site at http://www.jamstec.go.jp/cruisedata/mirai/e/.

(6) References

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

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

5.14 Dissolved Oxygen of Sampled Water

(1) Personnel

Kunio Yoneyama	(JAMSTEC)	Principal Investigator
Miyo IKEDA	(MWJ)	Operation leader

(2) Objective

Determination of dissolved oxygen in seawater by Winkler titration.

(3) Methods

a. 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)

b. Instruments

Burette for sodium thiosulfate;

APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel

Burette for potassium iodate;

APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel

Detector and Software;

Automatic photometric titrator (DOT-01) manufactured by Kimoto Electronic Co. Ltd.

c. 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. We collected samples from 2 Niskin bottles at 1cast/day. 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 and II) of 0.5 cm^3 each were added immediately into the sample flask and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

d. Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. 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 one set of the titration apparatus. Dissolved oxygen concentration (μmol kg^{-1}) was calculated by sample temperature during seawater sampling, salinity of the sample, and titrated volume of sodium thiosulfate solution without the blank.

e. 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^{o}C. 1.7835g 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. Firstry, 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. Secondary, 2 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. The blank was determined by difference between the first and second titrated volumes of the sodium thiosulfate.

Table 5.14-1 shows results of the standardization and the blank determination during this cruise.

Table 5.14-1 Results of the standardization and the blank determinations during this cruise.

Date	KIO_3		$Na_2S_2O_3$				Samples
(UTC)	M	Bottle No.	Bottle No.	E.P.	blank	M	Cast No.
2008/05/28	0.001670	20070912-19-01	20070613-41-01	3.971	0.000	0.0252	-
2008/06/06		20070912-19-02	20070613-41-01	3.970	0.000	0.0252	003,009,015,021 027,031,035,039
2008/06/14		20070912-19-03	20070613-41-01	3.971	0.000	0.0252	043,047,051,055 059,063,067
2008/06/21		20070912-19-05	20070613-41-01	3.968	-0.001	0.0252	071,075,079,083, 087,091,095
2008/06/27		20070912-19-06	20070613-41-01	3.970	-0.001	0.0252	-

f. Reproducibility of sample measurement

Replicate samples were taken at every day(1day/cast). Results of replicate samples are shown in Table 5.14-2 and Fig.5.14-1. The standard deviation was calculated by a procedure in Guide to best practices for ocean CO2 measurements Chapter4 SOP23 Ver.3.0 (2007).

Table 5.14-2 Results of the replicate sample measurements

Number of replicate sample pairs	Oxygen concentration (μmol/kg) Standard Deviation.
22	0.08

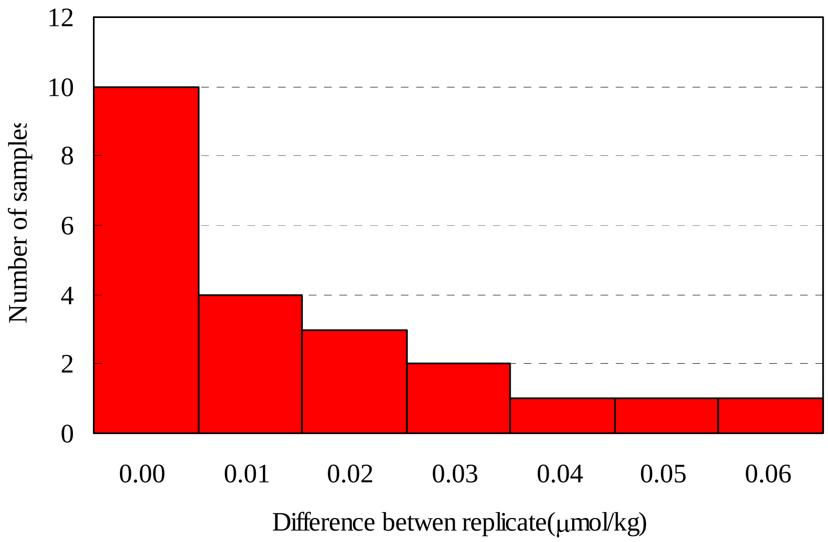


Fig 5.14-1 Results of the replicate sample measurements

(4) Preliminary Result

During this cruise, we measured oxygen concentration in 65 seawater samples at 22 casts of “P4” station. Result of the sample measurements were shown in Table 5.15-3.

Table 5.14-3. Result of the sample measurements

Date	Cast No.	Niskin #2	Niskin #18-1	Niskin#18-2
2008/6/6	003	80.64	80.37	80.27
2008/6/7	009	85.05	85.34	85.11
2008/6/8	015	86.26	86.27	86.26
2008/6/9	021	85.81	86.21	86.22
2008/6/10	027	82.79	82.81	82.77
2008/6/11	031	82.70	82.52	82.37
2008/6/12	035	81.94	81.64	81.65
2008/6/13	039	82.76	82.77	82.57
2008/6/14	043	82.63	82.71	82.69
2008/6/15	047	84.41	84.46	84.28
2008/6/16	051	81.00	80.61	80.54
2008/6/17	055	86.14	86.21	86.18
2008/6/18	059	82.35(1)	-	-
2008/6/18	059	82.33(2)	-	-
2008/6/19	063	84.68	84.70	84.71
2008/6/20	067	85.66	85.64	85.40
2008/6/21	071	83.54	83.53	83.40
2008/6/22	075	84.24	84.20	84.09
2008/6/23	079	75.71	75.67	75.60
2008/6/24	083	76.59	76.54	76.68
2008/6/25	087	76.49	76.52	76.51
2008/6/26	091	79.91	76.90	76.74
2008/6/27	095	76.10	76.14	76.02

*Cast 059 Niskin #18 was not sampled because Niskin did not close. Instead of #18, we collected replicate samples from #2.

(5) Data archive

All data will be submitted to JAMSTEC Marine-Earth Data and Information Department.

(6) References

Dickson 1996: Determination of dissolved oxygen in sea water by Winkler titration.

Dickson et al. 2007: Guide to best practice for ocean CO2 measurements.

Culberson 1991: WHP Operations and Methods July-1991 “Dissolved Oxygen”.

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

KIMOTO electric Co. Ltd.: Automatic photometric titrator DOT-01 Instruction manual.

5.15 N_2 fixation activity and phytoplankton dynamics in the subtropical and tropical North Pacific

(1) Personnel

Ken Furuya	(The University of Tokyo)	Principal Investigator	* not on board
Satoshi Kitajima	(The University of Tokyo)	Operation Leader	
Takuhei Shiozaki	(The University of Tokyo)		
Takako Masuda	(The University of Tokyo)		
Taketoshi Kodama	(The University of Tokyo)		
Takato Matsui	(Hokkaido University)		
Yuichi Sonoyama	(MWJ)		
Shoko Tatamisashi	(MWJ)		

(2) Objectives

Importance of nanoplanktonic cyanobacteria in N_2 fixation has become recognized in the subtropical and tropical ocean. However, our knowledge on temporal and spatial distributions of N_2 fixation was still fragmentary. In this cruise, we measured carbon and nitrogen uptakes including N_2 fixation activity, nutrients concentration, and distribution of phytoplankton to accumulate the data on the temporal and spatial distribution of N_2 fixation and its correlation with nutrient and phytoplankton dynamics in the subtropical and tropical western North Pacific.

(3) Methods

a. Temporal variations of nutrients, N_2 fixation and phytoplankton assemblages at the Station P4

Samples for nutrients, *nifH* gene, phytoplankton abundance and pigments analysis were collected every day from June 6 to 26 by a bucket and Niskin samplers upto 500 m depth. In addition, samples for DON, DOP, chlorophyll *a*, ^{15}N and ^{13}C assimilation experiments were collected every two days. The depth profiles of light intensity were obtained by INF-300 (Biospherical Instruments) for determination of the depth for the sampling. Along with the water samples, surface hauls of a plankton net (20–µm mesh) were also made every day to survey some plankters. Samples were observed by a stereomicroscope on board.

Aliquots of the samples for nutrients and chlorophyll *a* concentration were analyzed by a supersensitive colorimetric system and a fluorometer on board, respectively. For DON and DOP measurements seawater that passed through a GF/F filter were frozen immediately until analysis on land. Subsamples for phytoplankton abundance were fixed by 1% glutarualdehyde and frozen immediately or by 0.6% Lugol solution for later analysis on land. Subsamples for pigments analysis and *nifH* gene abundance were filtered by a GF/F and Supor filter, respectively, and frozen immediately until later analysis on land.

N_2 fixation and primary production were determined using a dual isotopic technique (^{13}C-^{15}N). Duplicate samples were poured into 4 L polycarbonate bottles and spiked with 0.2 mM of $H^{13}CO_3^-$ and 2 ml of $^{15}N_2$. For nitrate assimilation and nitrification experiments, duplicate samples were respectively collected 2 L polycarbonate bottles and spike with 10 nM of $^{15}NO_3^-$ and with 10 nM of $^{15}NH_4^+$. Then, samples were placed in the on-deck incubator under the light corresponding to the sampling depth. Incubations were terminated by filtration onto precombusted GF/F filters with low vacuum pressure (< 200 mmHg). After filtration, filters were stored in a freezer. For the nitrification experiments, filtrates were also collected to be determined the amount of $^{15}NO_3^-$ formed in $^{15}NH_4^+$ enriched samples during the incubation. The filtrates were recovered in glass bottles and poisoned with 0.2 ml saturated $HgCl_2$.

N_2 fixation activity was also monitored by the acetylene reduction assay every day. The activity was determined for whole water and that passed through 10 µm mesh taken at the surface. Each three 560 mL of samples were poured into 1200 mL PET bottle. Samples were spiked with 10% acetylene and incubated in an on-deck incubator under natural sunlight with running near surface water pumped up from the bottom of the ship for a day. Subsamplings of headspace were done several times during the incubation by a gas chromatograph (GC-17A, Shimadzu). Produced ethylene during the incubation will be converted to an amount of fixed nitrogen based on the results of $^{15}N_2$ uptakes experiment as above. After the measurement, seawater left in the bottles was fixed for the microscopic observation on land.

b. Growth response of phytoplankton to artificial enrichment of nutrients and dissolved iron

1) Nutrient enrichment experiments

Sampling was conducted at the Stn. P4 on June 6, 10, 14, 18 and 22. Seawater samples were collected from a depth of 10 m using a trace-metal clean pump sampling system. Samples were filtrated by 1µm in-line cartridge filter and poured into 4-L polycarbonate bottles. For <1 µm size-fractionated sub-samples, nutrients (N and P) were added alone to final concentrations of 100 nM of nitrogen (NO_3^-, NH_4^+, Urea), or 10nM of PO_4^-. Samples without addition were prepared as controls for each treatment to distinguish enclosure effects from effects of treatment. All enrichment was done in triplicate. Samples were incubated in flowing seawater on-deck incubations with light attenuated to 50 % of sea surface light intensity by neutral density screen. Subsamples were taken every day for nutrients concentrations, pico- and nanoplankton cell densities and algal pigments concentration upto three days after enrichment. Samples for nutrients and algal pigments concentration were measured by supersensitive colorimetric methods, and high performance liquid chromatography (HPLC). Samples for pico- and nanoplankton cell densities were fixed by 1% of glutarualdehyde, frozen by liquid nitrogen, and stored in freezer until analysis by flow cytometry on land.

2) Iron enrichment experiments

Seawater samples were collected from a depth of 10 m using a trace-metal clean pump sampling system on June 8, 12, and 16. Samples were filtrated by 10 µm in-line cartridge filter, and poured into 2-L polycarbonate bottles. Following five treatments were employed: (1) 1 nM of Fe^{3+} addition, (2) 10 nM of PO_4^{3-} addition, (3) 1 nM of Fe^{3+} and 10 nM PO_4^{3-} additions, (4) 1 nM of Fe^{3+} and 100 nM of NO_3^- additions, and (5) a control treatment with no additions. All enrichment was done in triplicate. Samples were incubated in flowing seawater on-deck incubations with light attenuated to 50 % of sea surface light intensity by neutral density screen. Subsamples for dissolved iron concentration, nutrients concentration, numerical and DNA abundance of plankton, and N_2 fixation activity were taken just after the sampling (initial) and at 1, 3, and 5 days after the treatment. Nutrients concentration and N_2 fixation activity was determined on board by using high sensitive colorimetric method and acetylene reduction assay, respectively. Subsample for numerical abundance of plankton was fixed 1% of glutarualdehyde, and were frozen by liquid nitrogen and stored in freezer until analysis on land by flow cytometry. Subsamples for DNA abundance of plankton were filtrated onto 0.2 µm Supor membrane filter, and stored in freezer until analysis on land by quantitative polymerase chain reaction.

c. Spacial distribution of nutrients and phytoplankton assemblages on the surface water

All samples were collected using the seawater pumped from the bottom of the ship during cruising from Hachinohe to the station P4. We measured nutrients concentration for nitrate plus nitrite, soluble reactive phosphorus and ammonium by supersensitive colorimetric methods. Temperature, salinity, and *in vivo* Chlorophyll *a* concentration were also monitored by a micro-CTD (Ocean Seven 301, Idronaut) attaching a fluorometer (Minitrack).

Along with these hydrographic observations, samples for pigment analysis by HPLC, flow cytometry and microscopic observations of phytoplankton were also taken to reveal phytoplankton community structures. These samples will be analyzed on land.

We also obtained the samples for nutrients concentration, N_2 fixation activity, primary productivity, nitrate assimilation, and phytoplankton abundances using a bucket at the five stations on 130.1^{o}E (19.3, 17, 14, 11, and 5^{o}N). These samples will be analyzed as written in above.

(4) Preliminary Result

Since all the data will be calibrated or measured on land, there is no result to be reported up to date.

(5) Data archive

All the data obtained during and after the cruise will be submitted to the JAMSTEC Marine-Earth Data and Information Department within two years after the cruise.

5.16 Distribution and heat-tolerance of the oceanic sea skaters of *Halobates* (Heteroptera: Gerridae) inhabiting tropical area of western Pacific Ocean and oceanic dynamics

(1) Personnel

Tetsuo Harada	(Kochi University)	Principal Investigator
Shiho Takenaka	(Kochi University)	
Chihiro Katagiri	(Hokkaido University)	

(2) Objectives

Many great voyages were launched to explore the oceans and what lies beyond, because they have always held a great fascination to us. A great variety of marine organisms were collected and describe during these voyages, but insects appear to have received little attention (Andersen and Chen, 2004). Although they are the most abundant animals on land, insects are relatively rare in marine environments (Cheng 1976). However, a few thousand insect species belonging to more than 20 orders are considered to be marine (Cheng and Frank 1993; Cheng 2003). The majority of marine insects belong to the Coleoptera, Hemiptera, and Diptera, and they can be found in various marine habitats. However, the only insects to live in the open ocean are members of the genus *Halobates*, commonly known as sea-skaters. They belong to the family Gerridae (Heteroptera), which comprises the common pond-skaters or water-striders. Unlike most of its freshwater relatives, the genus Halobates is almost exclusively marine. Adults are small, measuring only about 0.5 cm in body length, but they have rather long legs and may have a leg span of 1.5 cm or more. They are totally wingless at all stages of their life cycle and are confined to the air-sea interface, being an integral member of the pleuston community (Cheng 1975). One may wonder how much tiny insects have managed to live in the open sea, battling waves and storms. In life, sea-skaters appear silvery. On calm days ocean-going scientists have probably seen them as shiny spiders skating over the sea surface. It is not known whether ancient mariners ever saw them, and no mention of their presence has been found in the logs of Christopher Columbus’ (1451-1506) sips or other sips that sailed to and from the New World (Andersen and Cheng 2004).

Forty-six species of *Halobates* are now known (Andersen and Cheng 2004). Five are oceanic and are widely distributed in the Pacific, Atlantic and the Indian Oceans. The remaining species occur in nearshore areas of the tropical seas associated with mangrove or other marine plants. Many are endemic to islands or island groups (Cheng 1989a).

The only insects that inhabit the open sea area are five species of sea skaters: *Halobates micans, H. sericeus, H. germanus, H. splendens*,and *H. sobrinus* (Cheng 1985). Three species, *Halobates sericeus*, *H. micans* and *H. germanus* inhabit tropical and temperate areas of the Pacific Ocean in the northern hemisphere, including The Kuroshio Current and the East China Sea (Andersen and Polhemus 1976; Cheng 1985). *Halobates sericeus, H. micans and H germanus* are reported from latitudes of 13ºN-40ºN, 0ºN-35ºNand 0ºN-37ºN, respectively, in the Pacific Ocean (Miyamoto and Senta 1960; Andersen and Polhemus 1976; Ikawa et al. 2002). However, this information was collected on different cruises and in different times of the years. There have been two ecological studies based on samples collected in a specific area in a particular season during the four cruises of R/V HAKUHO-MARU: KH-02-01, KH-06-02, TANSEI-MARU: KT-07-19, and R/V MIRAI: MR-06-05-Leg 3.

During one cruise, KH-02-01, one sea skater species, *Halobates sericeus*, was collected at 18 locations in the East China Sea area (27°10' N- 33°24' N, 124º57' E - 129º30' E) (Harada 2005), and *H. micans* and/or *H. germanus* at only 8 locations in the area south of 29° 47'N, where water temperatures were more than 25℃. At three locations, where the water temperature was less than 23℃, neither *H. micans* nor *H. germanus* were caught.

14˚30'*Halobates micans* were caught at 6 of 7 locations, while *H.germanus* and *H. sericeus* were caught at only 3 and 1 location(s), respectively (Harada et al., unpublished). However, at 15˚00'N or northern area, *H. germanus* were caught at 14 of 19 locations, whereas *H. micans* and *H. cericeus* were caught at only 8 and 6 locations, respectively (Harada et al. 2006).

In the cruise, MR-06-05-Leg 3, larvae of both *H. micans* and *H. germanus* were very abundant at 6º N, whereas adults of *H. germanus* alone were completely dominant at 2ºN on the longitudinal line of 130ºE. On the longitudinal line of 138ºE, larvae and adults of *H. micans* alone were dominant at points of 5º and 8ºN, while adults of *H. germanus* were abundant between 0º and 2ºN. At the two stations of St. 37 (6ºN, 130ºE) and St. 52 (5ºN, 138ºE), relatively great number of larvae of *H. sericeus* were collected. This species has been known to be distributed in the northern area of the Pacific Ocean. At St. 52 (6ºN, 138ºE), it was heavily raining around the ship while trailed.

In the cruise, KT-07-19 on the northern edge of Kuroshio Current, *H. sericeus* was mainly collected in the northern-eastern area of 135º-140ºE, 34º-35ºN whereas *H. germanus and H. micans* were mainly collected in the relatively southern-western area of 131º-133ºE., 31º-33ºN. Only *H. sericeus* can be transferred by the Kuroshio Current onto the relatively northern-eastern area and to do reproduce at least in the summer season.

All samplings of *Halobates* have been performed at different geographical positions in any cruise in the Pacific Ocean so far. However, there has been no information on the dynamics in species and individual compositions due to oceanic and atmosphere dynamics in a fixed position in the Ocean. This study aims, first, to perform continuous samplings for 20 days at a fixed position located in the relatively low latitude (12°N) of the Western Pacific Ocean and examine dynamics of the species composition and reproductive and growth activity and compare these data to sea current dynamics and weather dynamics.

Fresh water species in Gerridae seem to have temperature tolerance from -3℃ to 42℃(Harada, 2003), because water temperature in fresh water in ponds and river highly changes daily and seasonally. However, water temperatures in the ocean are relatively stable and only range from 24℃ to 30℃ in the center of Kuroshio current in southern front of western Japan. Adults of *Halobates germanus* showed semi-heat-paralysis (SHP: static posture with no or low frequency to skate on water surface), when they were exposed to temp. higher than 32℃ (Harada unpublished, data in the TANSEIMARU cruise: KT-05-27).

In contrast to the temperate ocean, water temperature In the tropical ocean area, is more stable around 30℃. Therefore, the tropical species of *H. micans* is hypothesized to have lower tolerances to temperature changes than the temperate species, *H. cericeus*. This hypothesis was true in the laboratory experiment during the cruise of KH-06-02-Leg 5 When the water temperature increased stepwise 1℃ every 1 hour, heat-paralysis occurred at 29 to >35℃ (increase by 1 to >7℃). Three of four specimens in *Halobates sericeus* were not paralyzed even at 35℃ and resistant to temperature change, while only one of nine in *H. micans.* and only four of twelve in *H. germanus* were not paralyzed at 35℃. On average, *H. sericeus, H germanus and H. micans* were paralyzed at >35.6℃ (SD: 0.89), >32.9℃(SD: 2.17) and >31.6℃ (SD: 2.60) on average, respectively.

The 0-10ºN latitude-area in the Pacific Ocean has very complicated dynamic systems of ocean and atmosphere. Because of such complicated system, water/air temperatures and water conductivity (salinity) can be in dynamic change temporally and spatially. Sea skaters inhabiting this area of the Pacific Ocean show relatively high tolerance to temperature changes (heat tolerance)(Harada et al. 2007: the cruise report of MR-06-05-Leg 3). However, no such experiments have been performed on the sea skaters inhabiting a fixed position in the Ocean to examine how the tolerance to environmental stress as temperature change is affected by temporal changes in weather and (sea) current dynamics. This study aims, second, to examine the tolerance to high temperature is tested with the Temperature Paralysis Experiment on the adults and larvae of *Halobates* collected in a fixed position (135°E, 12°N) to discuss the relationship between the heat tolerance and changes in such oceanic dynamics during three weeks.

(3) Methods

a. Samplings

Samplings were performed in 1st – 27th June, 2008 with an ORI NET (6 m long and with diameter of 1.5 m.)(Photos 5.16-1, 2). ORI net was trailed for 15min on the sea surface at 8 stations ranged 5º to 17 ºN and 130º or 135ºE in the western Pacific Ocean on the right side of R/V MIRAI (8687t) which is owned by JAMSTEC. The trailing was performed for 15min mostly at night with the ship speed of 2.5 knot to the sea water (Table 5.16-1). It was repeated twice in each station. At St 8, such samplings were performed from 19:00 every day in 8-27 June. Surface area which was swept by ORI NET was expressed as value of flow-meter x diameter of the ORI NET based on the data obtained in the quite same samplings in MR-06-05-Leg 3 (41900.4 m^2 on average for 45 min-trailing)

b. Laboratory experiment

Sea skaters trapped in the pants (white flaxen bag)**(**Photo 5.16-3) located and fixed at the end of ORI net were paralyzed with the physical shock due to the trailing of the ORI net. Such paralyzed sea skaters were transferred on the surface of paper towel and to respire (Photo 5.16-4). Then, the paralysis of some ones was discontinued within 20min. When sea skaters were trapped in the jelly of jelly fishes, the jelly was removed from the body of sea skaters very carefully by hand for the recovering out of the paralysis.

All the adults and 5th instars which recovered out of the paralysis were moved on the sea water in the aquaria set in the laboratory for the Heat-Paralysis Experiments. Many hite cube aquaria with 30cm × 30cm × 40cm) were used in the laboratory of the ship for the rearing of the adults and larvae which were recovered out of the paralysis due to the trailing. Each aquarium contained ten to twenty adults or larvae of *Halobates*. Both the room temperature and sea water temperature in the aquaria were kept at 29±2℃. More than 12 hours after the collection, sea skaters were kept in the aquaria before the heat-paralysis experiment. Air was supplied to the sea water for the rearing and heat paralysis experiment in aquaria to prevent the increase of water surface viscosity due to bacterial activity. Without air supplying system, bodies of sea skaters would be caught by the water film several hours later and could not be kept long in the aquaria. All the individuals of *Halobates* kept in the aquaria were fed on mainly adult flies, *Lucillia illustris* or shrimps before the heat-paralysis experiments. The transparent aquarium as the experimental arena has sea water with the same temperature (mostly 28 or 29 ℃) as that of the aquarium to keep sea skaters. 2 to 12 individuals at adult or larval stage were moved to the transparent aquarium. Temperature was stepwise increased by 1℃ every 1 hour till the high temperature paralysis occurring in all the experimental specimens.

Temperature was very precisely controlled by handy on-off-switching to keep in ±0.3℃ of the current water temperature. Handy-stirring with wooden stick and supplying a cool sea water of 10℃ with a syringe were effective to keep the precise controlling of the current temperature. Sea skaters on the water surface of the aquarium were recorded with Digital Handy Video Camera (SONY) from above position for the last fifteen or 30min of each 1hour under the current temperature. Temperature at which Semi High Temperature Paralysis (SHTP: no or little movement on the water surface: Photo 5.16-5) and High Temperature Paralysis (HTP: ventral surface of the body was caught by sea water film and no ability to skate any more) were recorded.

(4) Results

a. Distribution

On the longitudinal line of 130ºE, larvae of both *H. micans* and *H. germanus* were very abundant at 5-12º N, whereas adults of *H. sericeus* alone were dominant at 17º N. At St 3-6 located relatively low latitude area, all the three described species*, H. micans, H. germanus* and *H. sericeus* and un-described *H. sp.* were collected. At a fixed St 8, *H. micans* was dominant through the sampling period of 20 days, whereas *H. sericeus* was collected mainly in the latter half of the period. Higher number of *Halobates* (593) was collected in the first half of the sampling period at St 8 than that (427) in the second half.

b. Laboratory experiment (Table 5.16-2)

Temp. for semi heat paralysis (TSHP), temp. for heat paralysis (THP) and gap temp. for heat paralysis (GTHP) were ranged 26 ºC to 39 ºC, 26 ºC to 40 ºC, and 0.5 ºC to 11:5 ºC, respectively. Both of GTHP (Mean ±SD: 7.83±1.86 ºC, n=32) and THP (35.03±1.80 ºC, n=32) during the first half of sampling period at St 8 was significantly higher than those (5.10±2.05 ºC, n=63; 34.03±2.02 ºC, n=63) during the second half (Mann-Whitney U-test, GTPH: z=-5.47, P<0.001 ; THP: z=-2.72, P=0.007).

c. Additional analysis

Comparison of the data on field samplings in this study should be done to the sampling data in the area of 0-8 degree north in the Pacific Ocean at the cruise, MR-06-05-Leg 3 as well as those in the area of 12-17 degree north in the Pacific Ocean at the cruise, KH-06-02-Leg 5, those in the area of 30-35 degree north along the Kuroshio Current at the cruise, KT-07-19 and in the tropical area around equator in the Indian Ocean at the cruise, KH-07-04-Leg 1.

Heat tolerance of the adults of *H. micans* inhabiting the tropical Pacific Ocean should be compared to that of those in the tropical Indian Ocean. The relationship of the extent of the heat tolerance to the ocean dynamics including several currents in the Pacific and Indian Ocean and also to the biological productivity by phyto-planktons and zoo-planktons should be analyzed in the near future.

The video camera data will be analyzed very soon after the cruise to examine the frequency and speed of skating and their responses to the temperature differences.

(5) Discussions

a. Distribution and ocean dynamics

Based on this study and another study during other two cruise, MR-06-05-Leg 3 and KH-06-02, *Halobates micans* seems to, predominantly, inhabit the area of 12ºN and 135-138ºE in the Pacific Ocean ,. while higher number of *H. germanus* was collected than that of *H. micans* at 12ºN and 130E in this study. On the line of 12ºN, area of 130ºE is nearer to the current NEC than that of 135E. *H. germanus* is possible to be transferred from eastern area on the NEC. *Halobates cericeus* was dominantly collected at the station of 17ºN, 130ºE which is also very near to the NEC, The NEC is also possible to transfer this species (Syamsudin and Lukijanto 2007: Figure 7 in the voyage summary of MR-06-05-Leg 3)..

Higher number of individuals were collected in the first half of sampling period at St 8 (12ºN, 135ºE) than that in the second half. Frequent rain fall on the surface of sea in the latter half of the period can kill the sea skaters by decreasing osmotic pressure of the haemolymph and the number of individuals could be diminished after the rainfall.

Individuals of *Halobates sp* were collected at St.3-6(5-8ºN, 130ºE) in this study, is possible to be one of *H. sobrinus* and *H. splendens* both of which have been reported to be distributed limitedly in the eastern region of the Pacific Ocean, or *new" oceanic species"*in *Halobates*. Size is similar to *H. micans*, while the body shape and color was very similar to another H. sp which was much bigger than the H. sp (Harada et al. 2007). Only three species of *H..micans, H. germanus and H. sericeus* have been known in the western Pacific Ocean (Chen 1985). However, the two H. sp are possible to be described as new species in the future. In such case, the number of species of oceanic *Halobates* becomes "5". This question is remained to be solved in the near future.

b. Heat paralysis

Heat-paralysis can be used as the index to show a resistance to the temperature changes. Average GTHP (7.83ºC)and THP (35.03ºC) of *Halobates micans* (adults and 5^{th} instars) collected in the first half of the sampling period at St 8 were significantly higher than that of the second half (5.10ºC, 34.03

ºC). There is one possible reason for the difference in GTHP and THP. Based on the Doppler Radar Data on rain fall, GTHP (Mean ±SD: 4.78±0.81, n=18) and THP (33.78±0.81, n=18) of adults and 5th instars of *H. micans* collected in June 21 and 22 when there were much amount of clouds around the fixed station were significantly lower than those (6.31±2.51, n=77; 34.51±2.16, n=77) of *H. micans* collected in the other days when it was relatively clear at the fixed station. The first is that the frequent rain fall leads to the lower osmotic pressure of the haemolymph of sea skaters which means severe physiological damage and causes the lower tolerance to the heat stress. It would be also possible that the current, NEC has southern position in the first half of the sampling period (Yoneyama, 2008: the cruise report of MR-08-02), and the individuals collected in the first half are possible to be transferred on the southern edge of the current from eastern and formerly northern area. Because such individuals might experience dynamic changes in ambient temperature, those are possible to have higher resistance to the heat stress than the "domestic" individuals collected in the latter half.

(6) Data archive

All the data obtained during the cruise will be submitted to the JAMSTEC Marine-Earth Data and Information Department within two years after the cruise.

(7) Acknowledgments

We would like to thank Dr. Kunio YONEYAMA (Head Scientist of the cruise: MR-08-02) for the permission to do this study during the cruise on the R/V MIRAI, for his warm suggestion on ocean dynamics, and encouragement and help throughout this cruise. The samplings and the experimental study were also possible due to supports from all of the crew (Captain: Dr. Masaharu AKAMINE) and all the scientists and the engineers from GODI and MWJ in this cruise. We would like to give special thanks to them.

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Table 5.16-1. Number of Halobates collected at 8 locations in the western region of the Pacific Ocean from June 1, 2008 to June 27, 2008. (N:Total number of individuals collected; H.m.: Halobates micans; H.g.: Halobates germanus; H.s.: Halobates sericeus; H.sp.: H. sobrinus, H. splendens or new Halobates species; Stat: Station number; WT: Water temperature (℃); AT: Air temp.; L: N of larvae; A: N of adults, EG:N of eggs; E: N of exuviae; Date: sampling date.)

Latitude	Longitude	N	L	A	*H.m.*	*H.g.*	*H.s.*	*H.sp*	EG	E	Stat	WT	AT	Time	Duration (min)	Date
17°21’N	130°04’E	44	6	38	6	0	38	0	0	0	St. 1	28.6	29.5	19:17 -	45	June 1
12°21’N	130°05’E	367	335	32	127	239	1	0	0	2	St. 2	29.7	29.5	19:01 -	45	June 2
07°06’N	130°04’E	583	534	49	>121	>47	>15	>85	0	6	St. 3	29.6	28.8	19:06 -	45	June 3
05°00’N	130°06’E	225	135	90	>6	>87	>1	>1	0	5	St. 4	29.7	28.3	04:35 -	45	June 4
07°17’N	131°43’E	80	67	13	>6	>5	>6	>1	0	1	St. 5	29.3	28.3	19:00 -	45	June 5
08°37’N	132°40’E	60	33	27	48	9	2	1	0	0	St. 6	28.9	27.6	04:30 -	45	June 6
11°00’N	134°18’E	130	113	17	129	1	0	0	0	1	St.7	28.9	28.6	19:01 -	45	June 7
12°00’N	135°57’E	21	17	4	20	0	1	0	48	0	St. 8	29.0	29.2	18:51 -	45	June 8
11°59’N	134°57’E	8	5	3	8	0	0	0	0	0	St. 8-1	28.9	29.0	18:52 -	45	June 9
12°00’N	134°59’E	24	20	4	24	0	0	0	0	0	St.8-2	29.2	28.8	19:00 -	45	June 10
12°00’N	134°59’E	67	62	5	12	0	55	0	3	1	St. 8-3	29.2	29.0	18:51 -	45	June 11
12°00’N	134°59’E	128	111	17	99	0	29	0	>1000	5	St. 8-4	29.3	29.3	18:50 -	45	June 12
12°00’N	134°59’E	132	117	15	124	0	8	0	0	10	St. 8-5	29.2	28.8	18:50 -	45	June 13
12°00’N	134°58’E	41	31	10	33	0	8	2	0	1	St. 8-6	29.0	28.3	18:58 -	45	June 14
11°59’N	134°58’E	83	73	10	64	0	19	0	0	10	St. 8-7	28.9	27.5	19.05 -	45	June 15
11°59’N	134°58’E	44	37	7	26	0	18	0	2	2	St. 8-8	29.0	29.0	18:49 -	45	June 16
11°59’N	134°59’E	47	35	12	38	0	9	0	0	2	St. 8-9	29.0	28.8	19:04 -	45	June 17
12°00’N	134°59’E	37	30	7	30	0	7	0	0	0	St. 8-10	29.3	27.6	18:54 -	45	June 18
12°00’N	135°00’E	56	37	19	40	1	15	0	>600	0	St. 8-11	29.0	28.8	18:48 -	45	June 19
12°01’N	134°59’E	38	21	17	34	0	4	0	0	1	St. 8-12	28.9	28.6	18:50 -	45	June 20
11°59’N	134°59’E	40	30	10	37	1	2	0	0	0	St. 8-13	28.7	26.1	18:53 -	45	June 21
11°59’N	135°01’E	99	55	44	89	0	10	0	0	0	St. 8-14	28.6	28.6	18:50 -	45	June 22
12°01’N	135°00’E	42	32	10	42	0	0	0	0	0	St. 8-15	29.2	29.1	18:49 -	45	June 23
11°59’N	134°57’E	37	23	14	31	2	4	0	0	2	St. 8-16	29.1	28.9	18:50 -	45	June 24
11°58’N	134°58’E	17	16	1	16	0	1	0	0	0	St. 8-17	28.8	28.5	18:50 -	45	June 25
12°01’N	134°59’E	10	4	6	9	0	1	0	0	2	St. 8-18	28.9	27.6	18:48 -	45	June 26
12°01’N	134°58’E	51	44	7	49	0	2	0	0	1	St. 8-19	28.9	28.5	18:48 -	45	June 27
Total		2511	2023	488	>1268	>392	>256	>90	>1653	52						

Table 5.16-2. Results of "heat-paralysis" experiments performed on larvae and adults of Halobates micans (H.m.), H.germanus(H.g.), H. sericeus(H.s.) and another Halobates species (H.sp.; H. sobrinus, H. splendens or new species) . TA: temp. at which specimen adapted, TSHP: temp. at which semi-heat-paralysis occurred; THP: temp. at which heat-paralysis occurred ; GTHP: gap temp. for heat paralysis (from base temp.); "Date and Time of day" when experiments were performed.

St.No.	Latitude(N)	Exp.No.	TA	TSHP	THP	GTHP	Species	Stage (sex)	Date	Time of day
St 1	17˚21'N	1	26.5	29	30	3.5	H.s.	Adult (male)	Jun. 2	09:00~
St 1	17˚21'N	1	26.5	29	31	4.5	H.s.	Adult (male)	Jun. 2	09:00~
St 1	17˚21'N	1	26.5	31	31	4.5	H.s.	Adult (female)	Jun. 2	09:00~
St 1	17˚21'N	1	26.5	31	31	4.5	H.s.	Adult (female)	Jun. 2	09:00~
St 1	17˚21'N	1	26.5	31	31	4.5	H.s.	Adult (female)	Jun. 2	09:00~
St 1	17˚21'N	1	26.5	31	32	5.5	H.s.	Adult (male)	Jun. 2	09:00~
St 1	17˚21'N	1	26.5	31	33	6.5	H.s.	Adult (male)	Jun. 2	09:00~
St 1	17˚21'N	1	26.5	31	36	9.5	H.s.	Adult (male)	Jun. 2	09:00~
St 2	12˚21'N	2	26.5	28	31	4.5	H.g.	Adult (male)	Jun. 3	08:00~
St 2	12˚21'N	2	26.5	28	31	4.5	H.g.	Adult (female)	Jun. 3	08:00~
St 3	07˚06'N	3	27.5	28	29	1.5	H.m.	5th instar	Jun. 4	09:00~
St 3	07˚06'N	3	27.5	28	29	1.5	H.m.	5th instar	Jun. 4	09:00~
St 3	07˚06'N	3	27.5	28	31	3.5	H.m.	5th instar	Jun. 4	09:00~
St 3	07˚06'N	3	27.5	29	31	3.5	H.m.	5th instar	Jun. 4	09:00~
St 3	07˚06'N	3	27.5	29	31	3.5	H.m.	5th instar	Jun. 4	09:00~
St 3	07˚06'N	3	27.5	28	31	3.5	H.g.	Adult (female)	Jun. 4	09:00~
St 3	07˚06'N	3	27.5	29	31	3.5	H.g.	Adult (female)	Jun. 4	09:00~
St 3	07˚06'N	3	27.5	30	31	3.5	H.g.	Adult (male)	Jun. 4	09:00~
St 3	07˚06'N	3	27.5	30	32	4.5	H.m.	5th instar	Jun. 4	09:00~
St 3	07˚06'N	3	27.5	29	33	5.5	H.m.	5th instar	Jun. 4	09:00~
St 6	08˚37'N	4	26.5	27	28	1.5	H.m.	Adult (male)	Jun. 5	09:00~
St 6	08˚37'N	4	26.5	27	32	5.5	H.m.	Adult (male)	Jun. 5	09:00~
St 6	08˚37'N	4	26.5	28	32	5.5	H.m.	Adult (male)	Jun. 5	09:00~
St 6	08˚37'N	4	26.5	27	35	8.5	H.m.	Adult (female)	Jun. 5	09:00~
St 6	08˚37'N	4	26.5	32	35	8.5	H.m.	Adult (female)	Jun. 5	09:00~
St 6	08˚37'N	4	26.5	32	35	8.5	H.m.	Adult (male)	Jun. 5	09:00~
St 6	08˚37'N	4	26.5	33	35	8.5	H.m.	Adult (female)	Jun. 5	09:00~
St 6	08˚37'N	4	26.5	33	35	8.5	H.m.	Adult (male)	Jun. 5	09:00~
St 6	08˚37'N	4	26.5	34	35	8.5	H.m.	Adult (male)	Jun. 5	09:00~
St 6	08˚37'N	4	26.5	35	35	8.5	H.m.	Adult (female)	Jun. 5	09:00~
St 4	05˚00'N	5	26.0	27	27	1.0	H.g.	Adult (female)	Jun. 6	07:00~
St 4	05˚00'N	5	26.0	28	28	2.0	H.g.	Adult (male)	Jun. 6	07:00~
St 4	05˚00'N	5	26.0	30	30	4.0	H.g.	Adult (male)	Jun. 6	07:00~
St 4	05˚00'N	5	26.0	27	30	4.0	H.g.	Adult (female)	Jun. 6	07:00~
St 4	05˚00'N	5	26.0	28	31	5.0	H.g.	Adult (female)	Jun. 6	07:00~
St 4	05˚00'N	5	26.0	29	31	5.0	H.g.	Adult (female)	Jun. 6	07:00~
St 4	05˚00'N	5	26.0	31	31	5.0	H.g.	Adult (female)	Jun. 6	07:00~
St 4	05˚00'N	5	26.0	30	31	5.0	H.g.	Adult (male)	Jun. 6	07:00~
St 4	05˚00'N	5	26.0	31	31	5.0	H.g.	Adult (male)	Jun. 6	07:00~
St 4	05˚00'N	5	26.0	31	31	5.0	H.g.	Adult (male)	Jun. 6	07:00~
St 4	05˚00'N	6	27.0	30	32	5.0	H.g.	Adult (male)	Jun. 7	07:00~
St 4	05˚00'N	6	27.0	32	35	8.0	H.g.	Adult (male)	Jun. 7	07:00~
St 4	05˚00'N	6	27.0	32	35	8.0	H.g.	Adult (male)	Jun. 7	07:00~
St 4	05˚00'N	6	27.0	31	37	10.0	H.g.	Adult (female)	Jun. 7	07:00~
St 4	05˚00'N	6	27.0	32	37	10.0	H.g.	Adult (female)	Jun. 7	07:00~
St 4	05˚00'N	6	27.0	34	37	10.0	H.g.	Adult (female)	Jun. 7	07:00~
St 4	05˚00'N	6	27.0	32	37	10.0	H.g.	Adult (male)	Jun. 7	07:00~
St 4	05˚00'N	6	27.0	35	38	11.0	H.g.	Adult (female)	Jun. 7	07:00~
St 4	05˚00'N	6	27.0	30	32	5.0	H.g.	Adult (male)	Jun. 7	07:00~

Table 5.16-2. (Continued)

St.No.	Latitude(N)	Exp.No.	TA	TSHP	THP	GTHP	Species	Stage (sex)	Date	Time of day
St 3	07˚17’N	7	25.5	26	26	0.5	H.g.	Adult (male)	Jun. 8	07:00~
St 3	07˚17’N	7	25.5	26	28	2.5	H.sp	5th instar	Jun. 8	07:00~
St 3	07˚17’N	7	25.5	27	28	2.5	H.sp	5th instar	Jun. 8	07:00~
St 3	07˚17’N	7	25.5	26	32	6.5	H.sp	5th instar	Jun. 8	07:00~
St 3	07˚17’N	7	25.5	26	32	6.5	H.g.	Adult (female)	Jun. 8	07:00~
St 3	07˚17’N	7	25.5	26	32	6.5	H.sp	Adult (male)	Jun. 8	07:00~
St 3	07˚17’N	8	29.5	30	30	0.5	H.sp	5th instar	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	31	32	2.5	H.g.	Adult (male)	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	32	34	4.5	H.m	5th instar	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	31	36	6.5	H.sp	5th instar	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	31	36	6.5	H.g.	Adult (male)	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	35	36	6.5	H.g.	Adult (male)	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	32	36	6.5	H.sp	5th instar	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	33	36	6.5	H.sp	Adult (female)	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	36	36	6.5	H.sp	5th instar	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	36	37	7.5	H.sp	5th instar	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	37	38	8.5	H.sp	5th instar	Jun. 9	07:00~
St 3	07˚17’N	8	29.5	36	40	10.5	H.g.	Adult (male)	Jun. 9	07:00~
St 3	07˚17’N	9	25.5	28	32	6.5	H.sp	5th instar	Jun. 10	07:00~
St 6	08˚37’N	9	26.5	30	32	5.5	H.m.	Adult (female)	Jun. 10	07:00~
St 6	08˚37’N	9	26.5	30	32	5.5	H.g.	Adult (female)	Jun. 10	07:00~
St 8-1,2	12˚00’N	10	27.0	32	32	5.0	H.m.	Adult (male)	Jun. 11	07:00~
St 8-1,2	12˚00’N	10	27.0	32	34	7.0	H.m	5th instar	Jun. 11	07:00~
St 8-1,2	12˚00’N	10	27.0	33	34	7.0	H.m	5th instar	Jun. 11	07:00~
St 8-1,2	12˚00’N	10	27.0	33	34	7.0	H.m.	Adult (male)	Jun. 11	07:00~
St 8-1,2	12˚00’N	10	27.0	34	35	8.0	H.m.	5th instar	Jun. 11	07:00~
St 8-1,2	12˚00’N	10	27.0	34	35	8.0	H.m	Adult (male)	Jun. 11	07:00~
St 8-1,2	12˚00’N	10	27.0	31	36	9.0	H.m.	Adult (female)	Jun. 11	07:00~
St 8-3	12˚00’N	11	27.5	32	33	5.5	H.s.	Adult (male)	Jun. 12	07:00~
St 8-3	12˚00’N	11	27.5	33	33	5.5	H.m.	5th instar	Jun. 12	07:00~
St 8-3	12˚00’N	11	27.5	32	33	5.5	H.m.	4th instar	Jun. 12	07:00~
St 8-3	12˚00’N	11	27.5	32	34	6.5	H.s.	Adult (female)	Jun. 12	07:00~
St 8-3	12˚00’N	11	27.5	32	35	7.5	H.m.	3rd instar	Jun. 12	07:00~
St 8-3	12˚00’N	11	27.0	32	35	7.5	H.m.	4th instar	Jun. 12	07:00~
St 8-3	12˚00’N	11	27.0	34	35	7.5	H.m.	3rd instar	Jun. 12	07:00~
St 3	07˚17’N	12	27.0	33	35	8.0	H.m.	Adult (female)	Jun. 13	07:00~
St 8-4	12˚00’N	12	26.5	35	36	9.5	H.m.	5th instar	Jun. 13	07:00~
St 8-4	12˚00’N	12	26.5	28	36	9.5	H.m.	5th instar	Jun. 13	07:00~
St 8-4	12˚00’N	12	26.5	29	36	9.5	H.m.	3rd instar	Jun. 13	07:00~
St 8-4	12˚00’N	12	26.5	34	36	9.5	H.m.	4th instar	Jun. 13	07:00~
St 8-4	12˚00’N	12	26.5	33	37	10.5	H.s.	Adult (female)	Jun. 13	07:00~
St 8-5	12˚00’N	13	27.5	34	34	6.5	H.s.	Adult (male)	Jun. 14	07:00~
St 8-5	12˚00’N	13	27.5	34	34	6.5	H.s.	Adult (male)	Jun. 14	07:00~
St 8-5	12˚00’N	13	27.5	33	34	6.5	H.m	5th instar	Jun. 14	07:00~
St 8-5	12˚00’N	13	27.5	33	34	6.5	H.m.	Adult (female)	Jun. 14	07:00~
St 8-5	12˚00’N	13	27.5	34	35	7.5	H.m.	5th instar	Jun. 14	07:00~
St 8-5	12˚00’N	13	27.5	35	36	8.5	H.m.	2nd instar	Jun. 14	07:00~
St 8-5	12˚00’N	13	27.5	35	37	9.5	H.m.	Adult (male)	Jun. 14	07:00~
St 8-5	12˚00’N	13	27.5	36	39	11.5	H.m.	Adult (female)	Jun. 14	07:00~
St 2	12˚21’N	14	27.0	33	33	6.0	H.m.	Adult (male)	Jun. 15	07:00~
St 7	11˚00’N	14	27.5	36	36	8.5	H.m.	Adult (female)	Jun. 15	07:00~
St 8-5	12˚00’N	14	27.5	31	36	8.5	H.s.	Adult (male)	Jun. 15	07:00~
St 8-7	12˚00’N	15	27.5	30	30	2.5	H.m.	5th instar	Jun. 16	07:00~

Table 5.16-2. (Continued)

St.No.	Latitude(N)	Exp.No.	TA	TSHP	THP	GTHP	Species	Stage (sex)	Date	Time of day
St 8-7	12˚00'N	15	27.5	30	34	6.5	H.m.	Adult (male)	Jun. 16	07:00~
St 8-7	12˚00'N	15	27.5	30	34	6.5	H.m.	Adult (male)	Jun. 16	07:00~
St 8-7	12˚00'N	15	27.5	31	34	6.5	H.m.	Adult (female)	Jun. 16	07:00~
St 8-7	12˚00'N	15	27.5	34	35	7.5	H.m.	Adult (male)	Jun. 16	07:00~
St 8-8	12˚00'N	16	26.5	33	35	8.5	H.m.	5th instar	Jun. 17	07:00~
St 8-8	12˚00'N	16	26.5	35	35	8.5	H.m.	5th instar	Jun. 17	07:00~
St 8-8	12˚00'N	16	26.5	30	35	8.5	H.s.	Adult (male)	Jun. 17	07:00~
St 8-8	12˚00'N	16	26.5	34	36	9.5	H.m.	5th instar	Jun. 17	07:00~
St 8-8	12˚00'N	16	26.5	30	36	9.5	H.m.	4th instar	Jun. 17	07:00~
St 8-8	12˚00'N	16	26.5	36	36	9.5	H.m.	5th instar	Jun. 17	07:00~
St 8-8 or 9	12˚00'N	17	27.5	30	36	8.5	H.m.	Adult (male)	Jun. 18	07:00~
St 8-8 or 9	12˚00'N	17	27.5	36	37	9.5	H.m.	Adult (male)	Jun. 18	07:00~
St 8-9	12˚00'N	17	27.5	36	37	9.5	H.m.	Adult (female)	Jun.18	07:00~
St 8-9	12˚00'N	17	27.5	37	39	11.5	H.m.	Adult (female)	Jun. 18	07:00~
St 8-10	12˚00'N	18	29.0	32	32	3.0	H.s.	Adult (male)	Jun. 19	07:00~
St 8-10	12˚00'N	18	29.0	32	32	3.0	H.s.	Adult (female)	Jun. 19	07:00~
St 8-10	12˚00'N	18	29.0	32	33	4.0	H.m.	4th instar	Jun. 19	07:00~
St 8-10	12˚00'N	18	29.0	33	38	9.0	H.m.	5th instar	Jun. 19	07:00~
St 8-10	12˚00'N	18	29.0	33	38	9.0	H.m.	4th instar	Jun. 19	07:00~
St 8-11	12˚00'N	19	29.0	29	32	3.0	H.m.	5th instar	Jun. 20	07:00~
St 8-11	12˚00'N	19	29.0	30	32	3.0	H.m.	5th instar	Jun. 20	07:00~
St 8-11	12˚00'N	19	29.0	32	34	5.0	H.m.	4th instar	Jun. 20	07:00~
St 8-11	12˚00'N	19	29.0	33	35	6.0	H.m.	5th instar	Jun. 20	07:00~
St 8-11	12˚00'N	19	29.0	33	35	6.0	H.m.	4th instar	Jun. 20	07:00~
St 8-12	12˚00'N	20	29.0	32	32	3.0	H.m.	Adult (female)	Jun. 21	07:00~
St 8-12	12˚00'N	20	29.0	33	33	4.0	H.m.	Adult (male)	Jun. 21	07:00~
St 8-12	12˚00'N	20	29.0	33	33	4.0	H.m.	Adult (female)	Jun. 21	07:00~
St 8-12	12˚00'N	20	29.0	33	33	4.0	H.m.	Adult (female)	Jun. 21	07:00~
St 8-12	12˚00'N	20	29.0	34	34	5.0	H.m.	Adult (male)	Jun. 21	07:00~
St 8-12	12˚00'N	20	29.0	36	36	7.0	H.m.	Adult (female)	Jun. 21	07:00~
St 8-12	12˚00'N	20	29.0	37	38	9.0	H.m.	Adult (female)	Jun. 21	07:00~
St 8-12	12˚00'N	20	29.0	38	38	9.0	H.m.	Adult (female)	Jun. 21	07:00~
St 8-12	12˚00'N	20	29.0	39	39	10.0	H.m.	Adult (female)	Jun. 21	07:00~
St 8-12	12˚00'N	20	29.0	35	39	10.0	H.m.	Adult (male)	Jun. 21	07:00~
St 8-13	12˚00'N	21	29.0	30	33	4.0	H.m.	5th instar	Jun. 22	07:00~
St 8-13	12˚00'N	21	29.0	33	33	4.0	H.m.	Adult (female)	Jun. 22	07:00~
St 8-13	12˚00'N	21	29.0	33	34	5.0	H.m.	5th instar	Jun. 22	07:00~
St 8-13	12˚00'N	21	29.0	33	34	5.0	H.m.	Adult (female)	Jun. 22	07:00~
St 8-13	12˚00'N	21	29.0	33	34	5.0	H.m.	Adult (male)	Jun. 22	07:00~
St 8-13	12˚00'N	21	29.0	33	33	4.0	H.m.	5th instar	Jun. 22	07:00~
St 8-14	12˚00'N	22	29.0	32	32	3.0	H.m.	Adult (male)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	33	33	4.0	H.m.	Adult (female)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	33	33	4.0	H.m.	Adult (male)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	34	34	5.0	H.m.	Adult (female)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	34	34	5.0	H.m.	Adult (female)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	34	34	5.0	H.m.	Adult (female)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	33	34	5.0	H.m.	Adult (male)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	34	34	5.0	H.m.	Adult (female)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	33	34	5.0	H.m.	Adult (male)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	35	35	6.0	H.m.	Adult (male)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	35	35	6.0	H.m.	Adult (male)	Jun. 23	07:00~
St 8-14	12˚00'N	22	29.0	35	35	6.0	H.m.	Adult (female)	Jun. 23	07:00~
St 8-15	12˚00'N	23	29.0	30	34	5.0	H.m.	5th instar	Jun. 24	07:00~

Table 5.16-2. (Continued)

St.No.	Latitude(N)	Exp.No.	TA	TSHP	THP	GTHP	Species	Stage (sex)	Date	Time of day
St 8-15	12˚00’N	23	29.0	32	34	5.0	H.m.	5th instar	Jun. 24	07:00~
St 8-15	12˚00’N	23	29.0	34	34	5.0	H.m.	Adult (female)	Jun. 24	07:00~
St 8-15	12˚00’N	23	29.0	32	34	5.0	H.m.	5th instar	Jun. 24	07:00~
St 8-15	12˚00’N	23	29.0	34	34	5.0	H.m.	5th instar	Jun. 24	07:00~
St 8-15	12˚00’N	23	29.0	34	36	7.0	H.m.	Adult (male)	Jun. 24	07:00~
St 8-15	12˚00’N	23	29.0	34	36	7.0	H.m.	Adult (male)	Jun. 24	07:00~
St 8-15	12˚00’N	21	29.0	34	36	7.0	H.m.	Adult (male)	Jun. 24	07:00~
St 8-15	12˚00’N	21	29.0	34	36	7.0	H.m.	Adult (male)	Jun. 24	07:00~
St 8-16	12˚00’N	24	29.0	31	32	3.0	H.m.	Adult (male)	Jun. 25	07:00~
St 8-16	12˚00’N	24	29.0	32	32	3.0	H.m.	Adult (male)	Jun. 25	07:00~
St 8-16	12˚00’N	24	29.0	32	32	3.0	H.m.	Adult (male)	Jun. 25	07:00~
St 8-16	12˚00’N	24	29.0	34	34	5.0	H.s.	Adult (female)	Jun. 25	07:00~
St 8-16	12˚00’N	24	29.0	34	34	5.0	H.s.	Adult (male)	Jun. 25	07:00~
St 8-16	12˚00’N	24	29.0	32	34	5.0	H.m.	4th instar	Jun. 25	07:00~
St 8-16	12˚00’N	24	29.0	34	34	5.0	H.s.	Adult (female)	Jun. 25	07:00~
St 8-16	12˚00’N	24	29.0	34	34	5.0	H.s.	Adult (female)	Jun. 25	07:00~
St 8-16	12˚00’N	24	29.0	34	35	6.0	H.m.	Adult (male)	Jun. 25	07:00~
St 8-17	12˚00’N	25	28.0	33	34	6.0	H.m.	4th instar	Jun. 26	07:00~
St 8-17	12˚00’N	25	28.0	30	34	6.0	H.m.	5th instar	Jun. 26	07:00~
St 8-17	12˚00’N	25	28.0	34	34	6.0	H.m.	3rd inatar	Jun. 26	07:00~
St 8-17	12˚00’N	25	28.0	34	34	6.0	H.m.	5th inatar	Jun. 26	07:00~
St 8-17	12˚00’N	25	28.0	34	34	6.0	H.m.	4th inatar	Jun. 26	07:00~
St 8-17	12˚00’N	25	28.0	34	34	6.0	H.m.	4th inatar	Jun. 26	07:00~
St 8-17	12˚00’N	25	28.0	34	35	7.0	H.m.	5th inatar	Jun. 26	07:00~
St 8-17	12˚00’N	25	28.0	34	35	7.0	H.m.	5th inatar	Jun. 26	07:00~
St 8-18	12˚00’N	26	29.0	33	33	4.0	H.m.	5th instar	Jun. 27	07:00~
St 8-18	12˚00’N	26	29.0	30	34	5.0	H.m.	Adult (male)	Jun. 27	07:00~
St 8-18	12˚00’N	26	29.0	34	34	5.0	H.m.	Adult (female)	Jun. 27	07:00~
St 8-18	12˚00’N	26	29.0	34	35	6.0	H.m.	Adult (male)	Jun. 27	07:00~
St 8-18	12˚00’N	26	29.0	36	36	7.0	H.m.	5th instar	Jun. 27	07:00~
St 8-18	12˚00’N	26	29.0	35	36	7.0	H.m.	Adult (female)	Jun. 27	07:00~
St 8-18	12˚00’N	26	29.0	36	37	8.0	H.m.	Adult (female)	Jun. 27	07:00~
St 8-19	12˚00’N	27	29.0	30	30	1.0	H.m.	Adult (female)	Jun. 27	07:00~
St 8-19	12˚00’N	24	29.0	30	30	1.0	H.m.	Adult (female)	Jun. 27	07:00~
St 8-19	12˚00’N	24	29.0	31	31	2.0	H.m.	4th instar	Jun. 27	07:00~
St 8-19	12˚00’N	24	29.0	31	31	2.0	H.m.	5th instar	Jun. 27	07:00~
St 8-19	12˚00’N	27	29.0	31	31	2.0	H.m.	Adult (female)	Jun. 27	07:00~
St 8-19	12˚00’N	27	29.0	31	31	2.0	H.m.	5th instar	Jun. 27	07:00~
St 8-19	12˚00’N	27	29.0	31	31	2.0	H.m.	Adult (female)	Jun. 27	07:00~
St 8-19	12˚00’N	27	29.0	31	31	2.0	H.m.	3rd instar	Jun. 27	07:00~
St 8-19	12˚00’N	27	29.0	31	31	2.0	H.m.	4th instar	Jun. 27	07:00~
St 8-19	12˚00’N	27	29.0	31	32	3.0	H.m.	2nd instar	Jun. 27	07:00~
St 8-19	12˚00’N	27	29.0	32	32	3.0	H.s.	Adult (male)	Jun. 27	07:00~
St 8-19	12˚00’N	27	29.0	31	33	4.0	H.m.	1st instar	Jun. 27	07:00~

Photo 5.16-1. ORI net trailed on the surface of the western Pacific Ocean on the right side of R/V MIRAI at night with the ship speed of 2.5 knot to the sea water. The net is 6 m long and with diameter of 1.5 m.

Photo 5.16-2. ORI net trailed on the surface of the western Pacific Ocean on the right side of R/V MIRAI during daytime with a ship speed of 2.5 knot to the sea water.

Photo 5.16-3. After the trailing of ORI net, the white bag so called "Pants" is being removed from the transparent cylinder united with the end of the net, sea skaters trapped in the Pants transferred to the transparent round-shaped aquarium.

Photo 5.16-4. Sea skaters trapped in the pants were paralyzed with the physical shock due to the trailing of the ORI net. However, if such paralyzed sea skaters were transferred on the surface of paper towel and able to respire, the paralysis of some ones can be cancelled. When sea skaters were trapped in the jelly of jelly fishes, the jelly should be removed from the body of sea skaters very carefully by hand for the recovering out of the paralysis.

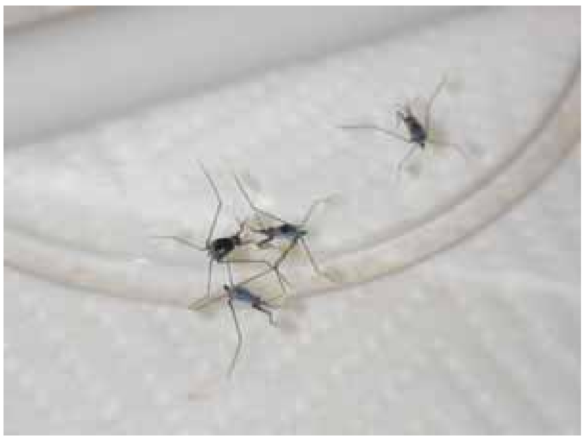


Photo 5.16-5: Four adults (three males, one female) are all in Semi-Paralysis due to heat, because they are floating on the sea water without any movement.

5.17 Argo-type Floats

(1) Personnel

Naoki Sato	(JAMSTEC)	Principal Investigator	* not on board
Biao Geng	(JAMSTEC)		
Tomoyuki Takamori	(MWJ)	Technical Staff	
Hiroki Ushiromura	(MWJ)	Technical Staff	
Hiroyuki Nakajima	(MWJ)	Technical Staff	* not on board

(2) Objective

The objective is to measure the vertical profiles of sea-water temperature and salinity and to investigate tropical air-sea interaction.

(3) Method

Five Argo-type floats were deployed from 20^{o}N to 5^{o}N along 130^{o}E (see Table 5.18.1). They measure the vertical profiles of sea-water temperature and salinity above 500db every day. Three of the five floats use the Iridium system to send observed data. The other 2 floats use the Argos system.

(4) Results

The vertical profiles of sea-water temperature and salinity measured at 4.986°N, 130.058°E on June 4, 2008 are shown in Fig.5.17.1. Potential density was calculated from temperature and salinity. Figure 5.17.2 illustrates the depth-time section of daily sea-water temperature observed near 5°N, 130°E. The intraseasonal variability of the surface and subsurface layers was obtained by these measurements.

(5) Data archive

The real-time data are provided officially via the Web site of Global Data Assembly Center (GDAC: http://www.usgodae.org/argo/argo.html, http://www.coriolis.eu.org/) in netCDF format The Argo group in JAMTEC (http://www.jamstec.go.jp/ARGO/J-ARGO/) also provide the real-time quality controlled data in ASCII format.

Table 5.17.1 Deployments of the floats

Date (YYY/MM/DD)	Time (UTC)	Latitude	Longitude	Type
2008/05/31	22:03	19^{o}59.92'N	130^{o}06.17'E	Argos
2008/06/01	13:12	16^{o}59.81'N	130^{o}05.78'E	Argos
2008/06/02	03:08	13^{o}59.98'N	130^{o}06.41'E	Iridium
2008/06/02	17:50	11^{o}00.00'N	130^{o}05.63'E	Iridium
2008/06/03	22:06	05^{o}00.60'N	130^{o}06.58'E	Iridium

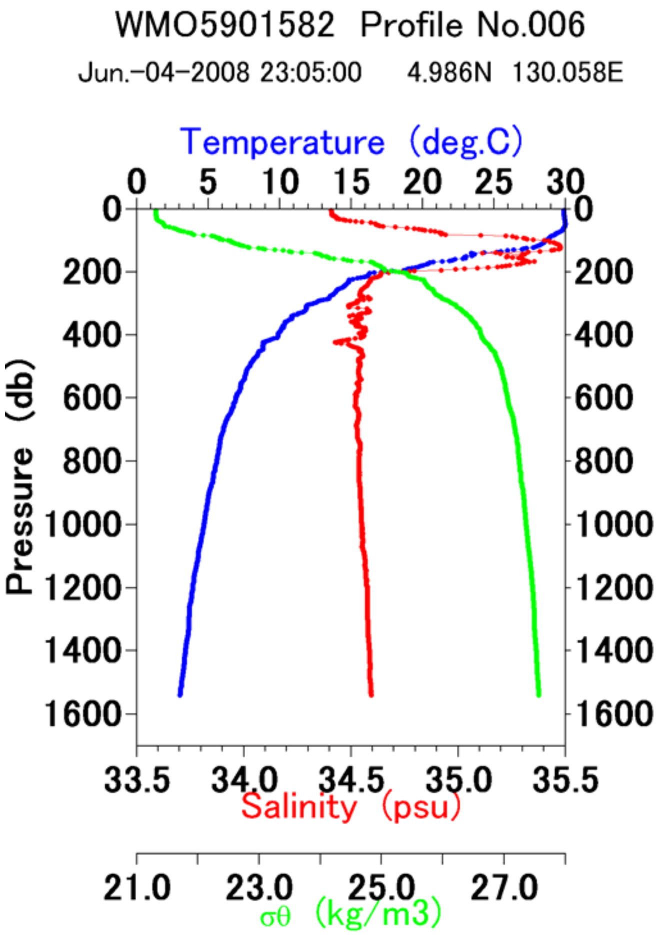


Fig. 5.17.1. Vertical profiles of sea-water temperature (blue), salinity (red), and potential density (green) measured at 4.986°N, 130.058°E on June 4, 2008.

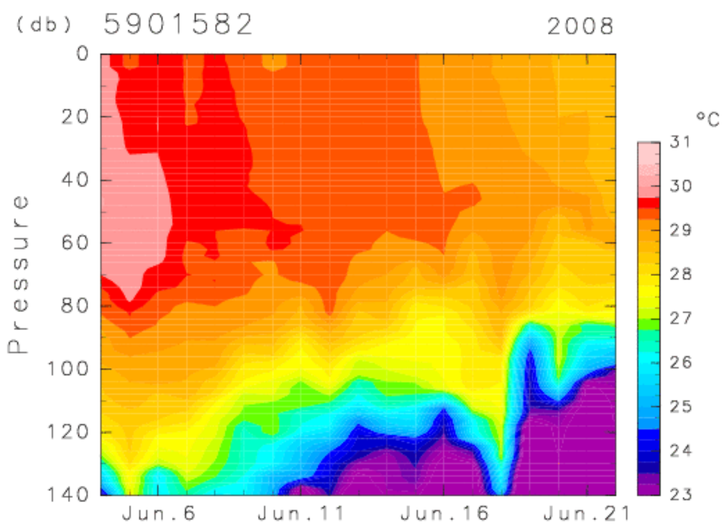


Fig. 5.17.2. Time-depth cross section of sea-water temperature observed near 5°N, 130°E.

5.18 Shipboard ADCP

(1) Personnel

Kunio Yoneyama	(JAMSTEC)	Principal Investigator
Souichiro Sueyoshi	(GODI)	Operation Leader
Shinya Okumura	(GODI)	
Wataru Tokunaga	(GODI)	
Harumi Ota	(GODI)	

(2) Objective

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

(3) Methods

Upper ocean current measurements were made throughout the cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system that is permanently installed on the R/V Mirai. For most of its operation, the instrument was configured for water-tracking mode recording. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made in shallower water region to get the calibration data for evaluating transducer misalignment angle. The system consists of following components ;

1) R/V MIRAI has installed the Ocean Surveyor (acoustic frequency 75 kHz) for vessel-mount made by Teledyne RD Instruments. It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel.
2) For heading source, we use Inertial Navigation System (INS) for Doppler Rader. Additionally high-precision attitude information from INS, pitch and roll, are stored in N2R data files with a time stamp. And also, ship's main gyro compass (Tokimec, Japan), continuously providing ship's heading to the ADCP.
3) GPS navigation receiver (Trimble DS4000) provides position fixes.
4) We used VmDas version 1.4.2 (RD Instruments) for data acquisition.
5) The clock of the logging computer is adjusted to GPS time every 1 minute.
6) We have placed ethylene glycol into the fresh water well to prevent freezing in the sea chest.
7) The sound speed at the transducer is calculated from temperature, salinity (constant value; 35.0 psu) and depth (6.5 m; transducer depth) by equation in Medwin (1975). The speed of sound dose affect the vertical bin placement and vertical velocity measurement.

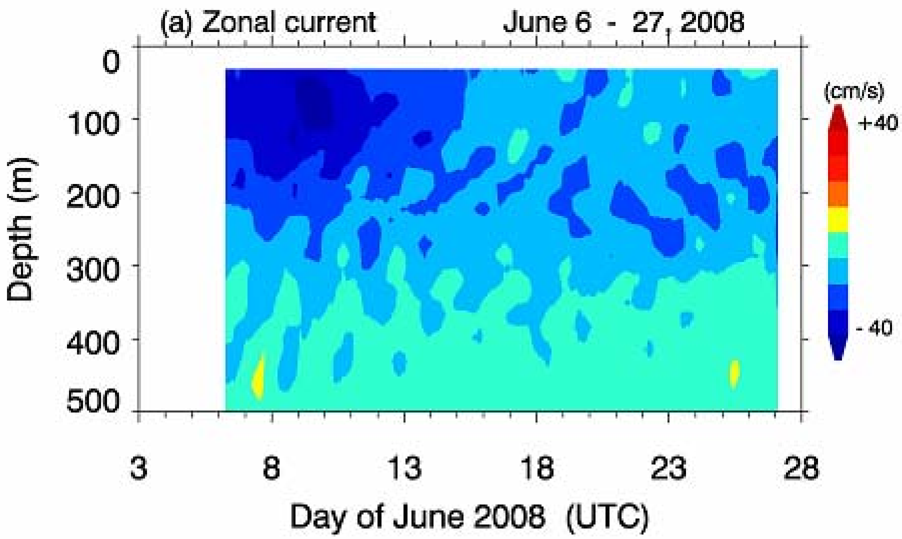
The ADCP was configured for 16 m processing bin and 8 m blanking distance. Data was made at 16-m intervals starting 31-m below the surface. Every ping was recorded as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds averaged data were recorded as short term average (.STA) and long term average (.LTA) data, respectively.

(4) Results

Figure 5.18-1 shows time series of ocean current profile as zonal and meridional components during the stationary observation period. This figure is plotted after applying 25-h running mean onto the 300-second averaged data.

(5) Data archive

All data will be submitted to the Marine-Earth Data and Information Department of JAMSTEC, and will be opened to the public at http://www.jamstec.go.jp/cruisedata/mirai/e/ .



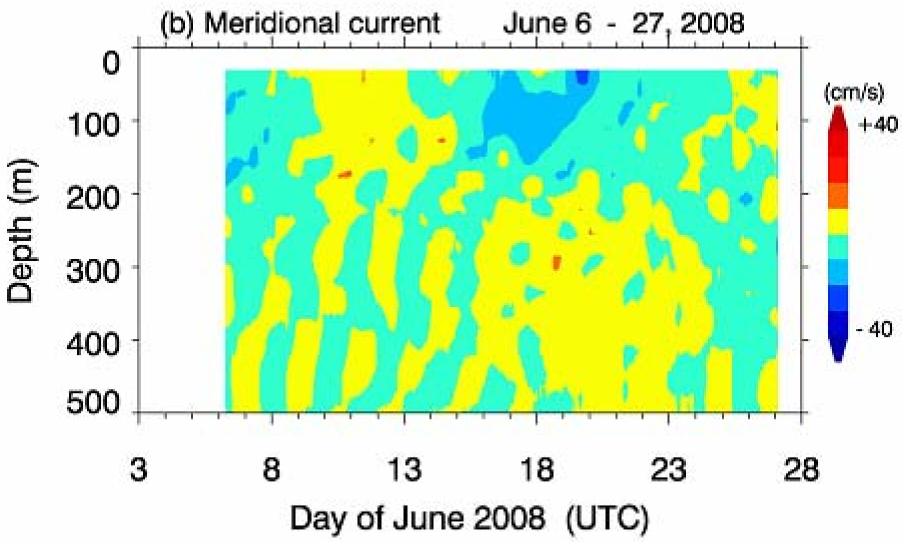


Fig. 5.18-1. Time-depth cross section of (a) zonal and (b) meridional ocean current components.

5.19 Underway Geophysics

(1) Personnel

Takeshi Matsumoto	(University of the Ryukyus)	Principal Investigator	for Theme-1	* not on board
Masao Nakanishi	(Chiba University)	Principal Investigator	for Theme-2	* not on board
Souichiro Sueyoshi	(GODI)	Operation Leader		
Shinya Okumura	(GODI)			
Wataru Tokunaga	(GODI)			
Harumi Ota	(GODI)			

(2) Objectives

The spatial and temporal variation of parameters as / below the sea bottom are basic data for the many fields of geophysics. During this cruise, we observed gravity, magnetic field at sea surface and topography along ship's track for the following two themes.

Theme-1: Standardization of geophysical data and study on its application to the sea plate dynamics

Theme-2: Tectonic evolution of the Pacific Plate

(3) Methods

a. Gravity

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during this cruise from May 27 to June 29, 2008, except for the territorial waters of U.S.A. To convert the relative gravity to absolute one, we measured gravity using portable gravity meter (Scintrex gravity meter CG-3M), at Sekinehama as the reference point. Absolute gravity is shown in Table 5.22-1.

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

Table 5.22-1. Absolute gravity.

Date (UTC)	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at Sensor *1 [mGal]	L&R *2 Gravity [mGal]
May 26 06:16	Sekinehama	980371.94	261	615	980372.78	12642.60

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

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

b. Three-components magnetic force

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 (GPS) and speed data are taken from LAN every second. Geomagnetic field was measured during this cruise from May 27 to June 29, 2008, except for the territorial waters of U.S.A.

Principle of ship-board geomagnetic vector measurement is as follows.

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

$$\mathbf{H}ob = \mathbf{A\ R\ P\ Y\ F} + \mathbf{H}p \quad (1)$$

where **R**, **R** and **Y** are the matrices of rotation due to roll, pitch and heading of a ship, respectively. **A** is a 3 x 3 matrix which represents magnetic susceptibility of the ship, and **H**p is a magnetic field vector produced by a permanent magnetic moment of the ship's body. Rearrangement of Eq. (1) makes

$$\mathbf{B\ H}ob + \mathbf{H}bp = \mathbf{R\ P\ Y\ F} \quad (2)$$

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

c. Topography

The "SEABEAM 2112" on R/V MIRAI was used for bathymetry mapping during the MR08-02 cruise from May 27 to June 29, 2008, except for the territorial waters of U.S.A. and the stationary observation period. Basic information on SEABEAM2112 is listed in Table 5.22-2.

To get accurate sound velocity of water column for ray-path correction of acoustic multi-beam, we used Surface Sound Velocimeter (SSV) data to get the sea surface (6.2m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from CTD and Argo-float data by the equation in Mackenzie (1981) during the cruise.

Table 5.22-2. System configuration and performance of SEABEAM2112

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:	Better than within < 0.5% of depth or +/-1m, over the entire swath. (Nadir beam has high accuracy; typically within < 0.2% of depth or +/-1m.)

(4) Results

Data were just only collected during the cruise and no data analysis was performed yet.

(5) Data archive

All data will be submitted to JAMSTEC Marine-Earth Data and Information Department and will be archived there.

(6) Remarks

a. For calibration of the ship's magnetic effect, we made a cruising along the figure "eight" (a pair of clockwise and anticlockwise rotation) at 01:37 - 02:02 on June 27, 2008.
b. We did not collect topographic data at 12N, 135E during the stationary observation period.