R/V Mirai Cruise Report
MR06-05
(Leg 2)

November 28 – December 13, 2006
MISMO cruise
In collaboration with
Tropical Ocean Climate Study

Edited by
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Hideaki Hase

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


TRITON
JAMSTEC

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Tropical Ocean Climate Study
MR06-05 (Leg 2)
Ship: R/V MIRAI
Captain: Masaharu Akamine

2. Introduction and observation summary

2.1. Introduction

The Madden-Julian oscillation (MJO), that is a dominant eastward propagating intraseasonal oscillation in the Tropics, is a key issue to be solved, as it influences not only the tropical atmospheric and oceanic variations but also the global climate. Since the MJO is a phenomenon coupled with deep cumulus convections, it is manifested over the warm pool region from the eastern Indian Ocean through the western Pacific Ocean. However, past major field experiments conducted in the Indian Ocean were devoted to study the summer monsoon, and there are few data especially in the boreal fall-winter season.

On the one hand, recent studies using reanalysis and satellite data revealed various aspects of the large-scale MJO structure. However, current general circulation models still fail to simulate the "slow" eastward propagation and underestimate the strength of the intraseasonal variability. It is believed that this deficiency is mainly due to the insufficient cumulus parameterization. Therefore, it requires that fine-scale observation data is invaluable to promote our knowledge on the mechanism of the MJO.

Based on the fact mentioned above, we at JAMSTEC have planned to conduct the intensive observation using the R/V Mirai to capture the detailed features from the ocean surface to the entire troposphere in the period from late October through November when the onset of convection in the MJO is often observed. We have named this project as MISMO (Mirai Indian Ocean cruise for the Study of the MJO-convection Onset).

During the Leg-2 of MISMO cruise, surface meteorological measurement, atmospheric sounding by radiosonde, CTD casting, and ADCP current measurement as well as Doppler radar observation were carried out as a main mission. In addition, deployment of TRITON/m-TRITON buoys, turbulent flux measurement, Mie-scattering LIDAR, vertical-pointing cloud radar, and other many observations were conducted.

We would like to introduce the web site for MISMO project. On the web site at "http://www.jamstec.go.jp/iorgc/mismo/", details on not only the Mirai cruise but also the relevant observations conducted as part of the MISMO project can be found.

2.2. Overview

2.2.1. Ship

R/V MIRAI
Captain Masaharu Akamine

2.2.2. Cruise code

MR06-05 Leg 2

2.2.3. Project name

Tropical Ocean Climate Study

2.2.4. Undertaking institution

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
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2.2.5. Chief Scientist

Yoshifumi Kuroda (JAMSTEC)

2.2.6. Period

November 28th, 2006 (Male, Maldives) – December 13th, 2006 (Singapore)

2.2.7. Research Participants

Total 29 scientists and technical staffs participated from 6 different institutions and companies.

2.3. Observation summary

TRITON buoy deployment:	2 sites
TRITON buoy recovery:	2 sites
m-TRITON buoy deployment:	1 site
ADCP buoy deployment:	1 site
ADCP buoy recovery	3 sites
CTD including water sampling:	7 casts
XCTD:	2 launches
Radio sonde:	52 launches
Surface meteorology:	continuous
Shipboard ADCP measurement:	continuous
Surface temperature and salinity measurements by intake method	continuous

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

2.4 Observed oceanic and atmospheric conditions

A zonal Dipole Mode phenomenon in the tropical Indian Ocean has developed since the end of July 2006 and was in the mature phase in November 2006. Associated with this event, easterly winds prevailed until mid November. The data from two m-TRITON buoys (0,79E and 0,82E) in the MISMO mooring array indicated that the thermocline was shallower than climatology, and it deepened toward west reversed to the climatology. It may indicate warm water migration from east to west. The temperature in the surface layer was warmer than climatology. The shipboard ADCP data during Leg 1 indicated that the westward currents dominated in the surface layer, but reversed eastward currents intensified subsurface layer. In mid November, a MJO system reached to the MISMO region, then the easterly winds was weakened and convective clouds developed. During Leg 2, westerly winds observed, and the convective system moved also eastward as R/V Mirai moved. On the ship, the cloud convective system highly developed on December 4. When the ship steamed from 1.5S90E to 5S95E, we observed strong boreal winter monsoon winds about 15m/s. Then, the convective system seemed to be calmed down, and it was calm weather continued since December 8th. The ship board ADCP data during Leg 2 indicated that the eastward currents were well developed along the equator without strong westerly winds along the equator. Thus, we infer that the east ward currents was induced by ocean interior dynamics rather than surface winds forcing. At the 5S, 95E TRITON buoy site, the sea surface temperature was lower than climatology, and it may be due to that the cooled pole of Dipole Mode well developed and there was large excursion of upwelling water from Sumatra coast. The eastward currents along the equator may contribute some part to the termination of this Dipole Mode event.

Thus, during Leg 1, we observed from the preconditioning stage to the onset of one MJO under the mature phase of the Dipole Mode event. During Leg 2, we observed from developing stage to termination stage of the MJO. The obtained data shall enable us to analyze the ocean and atmosphere changes associated with the MJO and Dipole Mode event, and its hidden interaction processes between them.

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

3.1. Period

November 28 - December 13, 2006

3.2. Ports of call

Male, Maldives	(Departure; November 28, 2006)
Singapore	(Arrival; December 13, 2006)

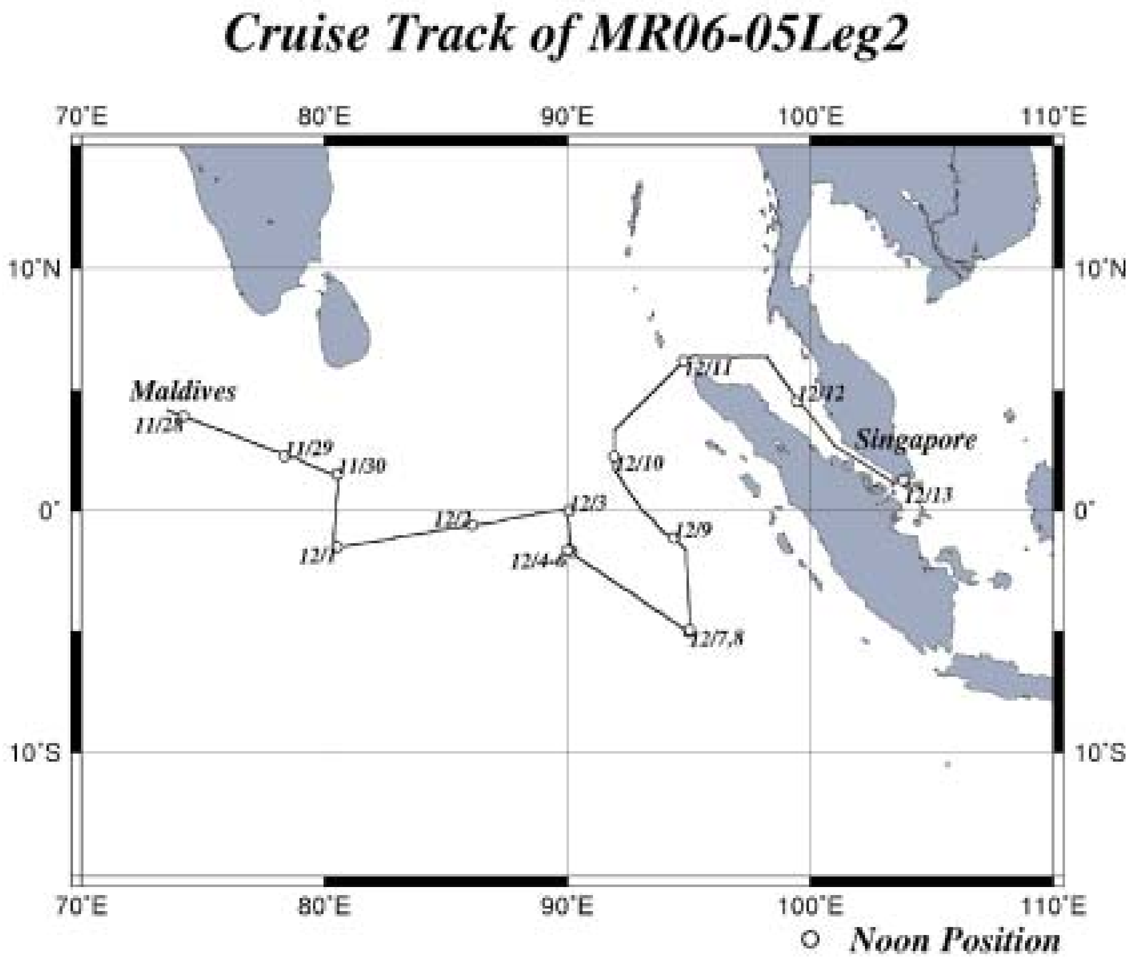
3.3. Cruise log

SMT (Ship Mean Time)	UTC	Event
Nov. 28 (Tue.)		
08:40	03:40	Departure from Male, Maldives (SMT = UTC + 5.0) Start Leg-2 of MR06-05 cruise
10:00	05:00	Safety guidance for participants
10:28	05:28	Meeting for observation
13:15	08:15	Boat drill
16:45	11:45	Konpira-san ceremony
Nov. 29 (Wed.)		
04:00	23:00	Starting of continuous monitoring of surface sea water, and shipboard observations including Doppler radar (because of no permission for observation into Maldives EEZ)
05:00	00:00	Radio sonde launch R01 (2.7689 N, 77.2023 E)
11:00	06:00	R02 (2.3553 N, 78.3355 E)
17:00	12:00	R03 (2.1126 N, 78.9847 E)
23:00	18:00	R04 (1.8082 N, 79.6186 E) Cruise to (1.5 N, 80.5 E)
Nov. 30 (Thu.)		
05:00	00:00	R05 (1.5734 N, 80.2008 E)
07:26-10:12	02:26-05:12	Recovery of ADCP mooring at 1.5N, 80.5E (4543 m, 01-30.0 N, 080-23.8 E)
10:56-14:09	05:56-09:09	CTD C01 (4536 m, 01-32.39 N, 080-31.80 E)
11:00	06:00	R06 (1.4763 N, 80.3915 E)
17:00	12:00	R07 (1.2649 N, 80.5428 E)
23:00	18:00	R08 (0.0603 N, 80.4398 E)
Dec. 01 (Fri.)		
05:00	00:00	R09 (1.1390 S, 80.3697 E)
07:25-10:28	02:25-05:28	Recovery of ADCP mooring at 1.5S, 80.5E (4867 m, 01-30.0 S, 080-20.7 E)
11:00	06:00	R10 (1.4924 S, 80.3487 E)
11:26-13:12	06:26-08:12	CTD C02 (4840 m, 01-30.08 S, 080-31.26 E)
17:00	12:00	R11 (1.4021 S, 81.2029 E)
22:00	16:00	Adjust SMT to UTC + 6.0
Dec. 02 (Sat.)		
00:00	18:00	R12 (1.1618 S, 82.7742 E)
06:00	00:00	R13 (0.8819 S, 84.3633 E)

07:59-08:06	01:59-02:06	Sampling of sea surface water (00-45.49 S, 085-04.52 E)
12:00	06:00	R14 (0.6589 S, 85.8589 E)
15:57-16:02	09:57-10:02	Sampling of sea surface water (00-27.02 S, 087-07.09 E)
18:00	12:00	R15 (0.3958 S, 87.3532 E)
		Cruise to (0 N, 90 E)
Dec. 03 (Sun.)		
00:00	18:00	R16 (0.1571 S, 88.5857 E)
06:00	00:00	R17 (0.0253 N, 89.7314 E)
06:30	00:30	Confirmation of ATLAS buoy vandalism (take a photograph)
07:31-10:24	01:31-04:24	Recovery of ADCP mooring on equator at 90 E
11:04-13:07	05:04-07:07	Deployment of ADCP mooring on equator at 90 E (4410 m, 00-00.37 N, 090-03.78 E)
12:00	06:00	R18 (0.0203 N, 90.0883 E)
14:24-17:26	08:24-11:26	CTD C03 (4403 m, 00-03.20 N, 089-55.30 E)
18:00	12:00	R19 (0.0513 N, 89.9256 E)
Dec. 04 (Mon.)		
00:00	18:00	R20 (0.8967 S, 90.0770 E)
06:00	00:00	R21 (1.7315 S, 90.0454 E)
07:45-11:26	01:45-05:26	Deployment of m-TRITON at 1.5S, 90E (4714 m, 01-42.98 S, 090-08.78 E)
12:00	06:00	R22 (1.7170 S, 90.1427 E)
12:56-13:35	06:56-07:35	CTD C04 (4715 m, 01-41.33 S, 090-10.36 E)
18:00	12:00	R23 (1.6548 S, 90.0083 E)
Dec. 05 (Tue.)		
00:00	18:00	R24 (1.6439 S, 90.0923 E)
06:00	00:00	R25 (1.5971 S, 90.1162 E)
08:15-11:01	02:15-05:01	Deployment of TRITON at 1.5S, 90E (4712 m, 01-35.63 S, 090-05.41 E)
09:00	03:00	R26 (1.5550 S, 90.1203 E)
11:24	05:24	XCTD X001 (4702 m, 01-35.11 S, 090-06.03 E)
12:00	06:00	R27 (1.5861 S, 90.0911 E)
12:56-16:01	06:56-10:01	CTD C05 (4694 m, 01-38.33 S, 090-00.46 E)
15:00	09:00	R28 (1.6433 S, 90.0111 E)
18:00	12:00	R29 (1.6425 S, 90.0281 E)
21:00	15:00	R30 (1.6599 S, 90.0259 E)
Dec. 06 (Wed.)		
00:00	18:00	R31 (1.6896 S, 90.0075 E)
03:00	21:00	R32 (1.6909 S, 90.0082 E)
06:00	00:00	R33 (1.6692 S, 90.0106 E)
08:21-12:13	02:21-06:13	Recovery of TRITON at 1.5S, 90E
09:00	03:00	R34 (1.6537 S, 89.9896 E)
12:00	06:00	R35 (1.6532 S, 90.0006 E)
18:00	12:00	R36 (2.3699 S, 91.0605 E)
Dec. 07 (Thu.)		
00:00	18:00	R37 (3.2484 S, 92.3659 E)
06:00	00:00	R38 (4.1504 S, 93.6640 E)

10:30	04:30	Commemorative Photo at upper deck
12:00	06:00	R39 (5.0165 S, 94.9506 E)
13:09-15:54	07:09-09:54	Deployment of TRITON at 5S, 95E (5012 m, 05-01.56 S, 094-59.74 E)
16:31	10:31	XCTD X002 (5011 m, 05-01.17 S, 094-59.67 E)
16:35-17:30	10:35-11:30	CTD C06 (5007 m, 04-57.98 S, 094-59.25 E)
18:00	12:00	R40 (4.9664 S, 94.9886 E)
Dec. 08 (Fri.)		
00:00	18:00	R41 (4.9703 S, 95.0218 E)
06:00	00:00	R42 (4.9476 S, 95.0094 E)
08:19-12:29	02:19-06:29	Recovery of TRITON at 5S, 95E
12:00	06:00	R43 (4.9396 S, 95.0136 E)
12:55-16:04	06:55-10:04	CTD C07 (5001 m, 04-56.20 S, 095-01.75 E)
16:11	10:11	Launch of ARGO float (04-56.55 S, 095-01.71 E)
18:00	12:00	R44 (4.7703 S, 95.0239 E)
Dec. 09 (Sat.)		
00:00	18:00	R45 (3.5281 S, 94.9713 E)
06:00	00:00	R46 (2.2763 S, 94.9015 E)
12:00	06:00	R47 (1.2478 S, 94.4875 E)
18:00	12:00	R48 (0.5542 S, 93.6362 E)
22:00	15:00	Adjust SMT to UTC + 7.0
Dec. 10 (Sun.)		
01:00	18:00	R49 (0.2354 N, 92.9164 E)
07:00	00:00	R50 (1.1855 N, 92.2602 E)
13:00	06:00	R51 (2.3275 N, 91.9164 E)
13:15	06:15	Pirates station drill
19:00	12:00	R52 (3.2849 N, 91.9159 E)
19:00	12:00	Stop of continuous monitoring of surface sea water, and shipboard observations (because of enter into Indonesian and Tai land EEZs)
19:00	12:00	Social gathering
22:00	14:00	Adjust SMT to UTC + 8.0
Dec. 11 (Mon.)		
13:00	05:00	On-board seminar Cruise to Singapore
Dec. 12 (Tue.)		
06:00	22:00	Restart of continuous monitoring of surface sea water, and shipboard observations
18:00	10:00	Finish of continuous monitoring of surface sea water, and shipboard observations Cruise to Singapore
Dec. 13 (Wed.)		
13:00	05:00	Arrival to Singapore

3.4 Cruise Track



4. Chief scientist

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Group leader
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5. Participants List

5.1 On Board Scientists / Engineers / Technical Staffs / Observers

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5.2 M/V MIRAI crewmembers

Master	Akamine, Masaharu
Chief Officer	Kita, Yujiro
1st Officer	Sasaki, Daisuke
2nd Officer	Hikichi, Tomoo
3rd Officer	Fukaura, Nobuo
Chief Engineer	Higashi, Koichi
1st Engineer	Masuno, Koji
2nd Engineer	Minami, Kaoru
3rd Engineer	Tohken, Hiroyuki
Chief Radio Officer	Sagawa, Kazuo
Boatswain	Omote, Kunihiko
Able Seaman	Yamauchi, Keiji
Able Seaman	Suzuki, Yukiharu
Able Seaman	Honzo, Toshiharu
Able Seaman	Matsumoto, Shozo
Able Seaman	Kuwahara, Yosuke
Able Seaman	Sato, Tsuyoshi
Able Seaman	Okada, Masashige
Able Seaman	Komata, Shuji
Able Seaman	Aisaka, Takeharu
Able Seaman	Yabugami, Atsuhiro
No.1 Oiler	Honda, Sadanori
Oiler	Kinoshita, Shigeaki
Oiler	Sugimoto, Yoshihiro
Oiler	Yamashita, Kazumi
Oiler	Tanaka, Toshimitsu
Oiler	Taniguchi, Daisuke
Chief Steward	Ota, Hitoshi
Steward	Hiraishi, Hatsuji
Steward	Sugimoto, Kitoshi
Steward	Hamabe, Tatsuya
Steward	Uemura, Tamotsu
Steward	Sasaki, Wataru

6.1 Meteorology and atmospheric observation

6.1.1 Surface meteorological observation

(1) Personnel

Kunio Yoneyama	(JAMSTEC):	Principal Investigator (not onboard)
Souichiro Sueyoshi	(GODI)	
Norio Nagahama	(GODI)	
Ryo Ohyama	(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

The surface meteorological parameters were observed throughout MR06-05 Leg2 cruise.

At this cruise, we used 2 systems for the surface meteorological observation.

1. Mirai surface meteorological observation system
2. Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

(3-1) Mirai surface meteorological observation system

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

Table 6.1.1-1: Instruments and their installation locations of Mirai meteorological system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24m)
Thermometer	HMP45A	Vaisala, Finland	compass deck (21m)
	with 43408 Gill aspirated radiation shield (R.M. Young)		
	RFN1-0	Koshin Denki, Japan	4th deck(-1m, inlet -5m) SST
Barometer	Model-370	Setra System, USA	weather observation room captain deck (13m)
Rain gauge	50202	R. M. Young, USA	compass deck (19m)
Optical rain gauge	ORG-815DR	Osi, USA	compass deck (19m)
Radiometer (short wave)	MS-801	Eiko Seiki, Japan	radar mast (28m)
Radiometer (long wave)	MS-202	Eiko Seiki, Japan	radar mast (28m)
Wave height meter	MW-2	Tsurumi-seiki, Japan	bow (10m)

Table 6.1.1-2: Parameters of Mirai meteorological observation system

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

(3-2) Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

SOAR system, designed by BNL (Brookhaven National Laboratory, USA), is consisted of 3 parts.

1. Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation
2. Zeno meteorological system designed by BNL – wind, air temperature, relative humidity, pressure and rainfall measurement
3. Scientific Computer System (SCS) designed by NOAA (National Oceanographic 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 6.1.1-3 and measured parameters are listed in Table 6.1.1-4

Table 6.1.1-3: Instruments and their installation locations of SOAR system

Sensors	Type	Manufacturer	Location (altitude from surface)
Zeno/Met			
Anemometer	05106	R.M. Young, USA	foremast (25m)
Tair/RH	HMP45A	Vaisala, Finland	foremast (24m)
	with 43408 Gill aspirated radiation shield (R.M. Young)		
Barometer	61201	R.M. Young, USA	foremast (24m)
	with 61002 Gill pressure port (R.M. Young)		
Rain gauge	50202	R. M. Young, USA	foremast (24m)
Optical rain gauge	ORG-815DA	Osi, USA	foremast (24m)
PRP			
Radiometer (short wave)	PSP	Eppley, USA	foremast (25m)
Radiometer (long wave)	PIR	Eppley, USA	foremast (25m)
Fast rotating shadowband radiometer		Yankee, USA	foremast (25m)

Table 6.1.1-4: Parameters of SOAR system

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

(4) Preliminary results

Figure 6.1.1-1 shows the time series of the following parameters during the stationary observation period; Wind (SOAR), air temperature (SOAR), relative humidity (SOAR), precipitation (SOAR), short/long wave radiation (SOAR), pressure (SOAR). 60 minutes accumulated precipitation data from SOAR optical rain gauge was converted to the rainfall intensity.

(5) Data archives

These raw data will be submitted to the Marine-Earth Data and Information Department (MEDID) of JAMSTEC just after the cruise.

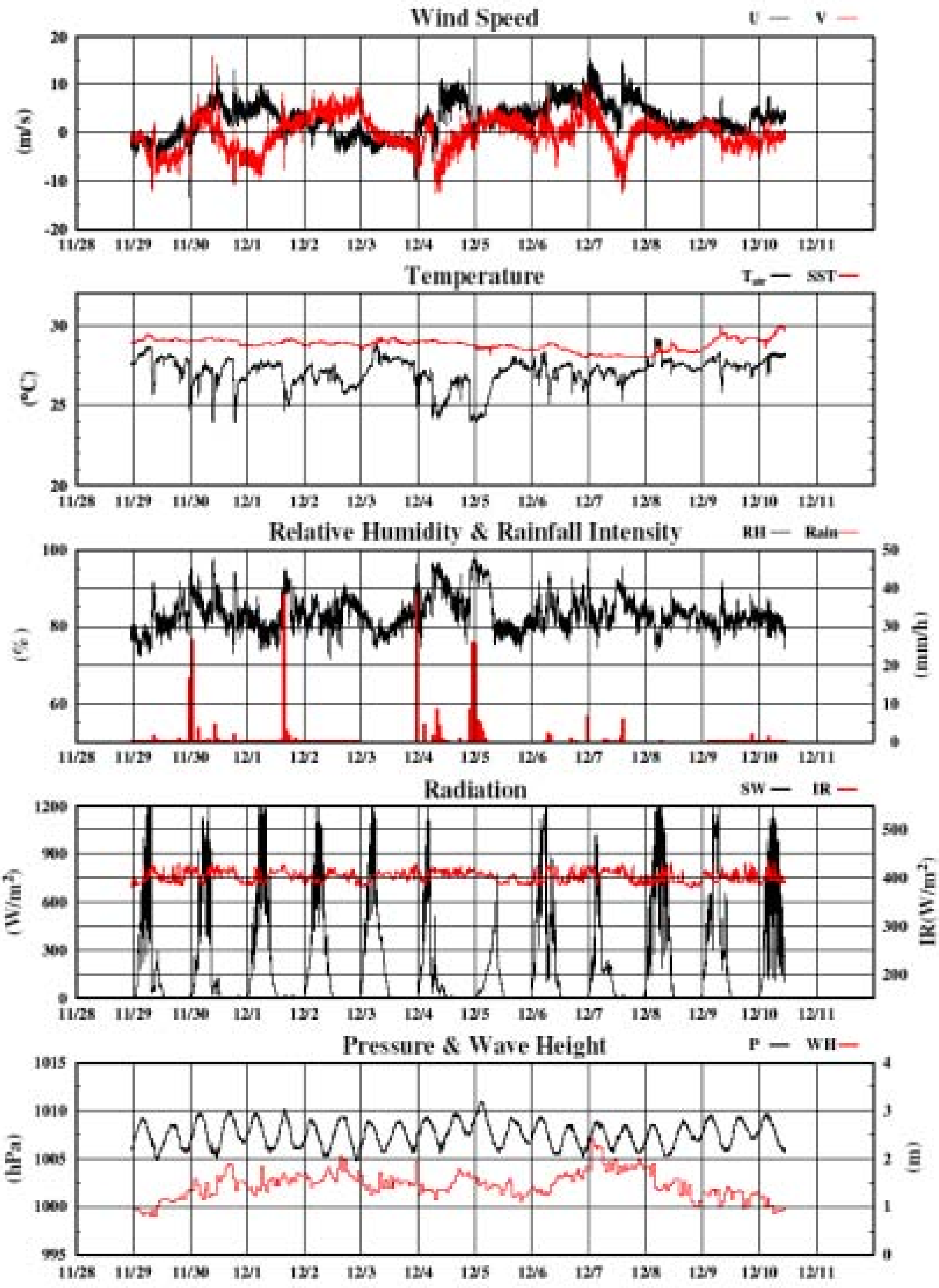


Figure 6.1.1-1: Time series of surface meteorological parameters during the stationary observation.

6.1.2 Ceilometer

(1) Personnel

Kunio Yoneyama (JAMSTEC): Principal Investigator (not onboard)
Souichiro Sueyoshi (GODI)
Norio Nagahama (GODI)
Ryo Ohyama (GODI)

(2) Objective

The information of the cloud base height is important to understand the processes on the exchange of water and energy between the atmospheric boundary layer and the layer above, and horizontal / vertical distribution of the cloud. As one of the methods to measure them, the ceilometer observation was carried out.

(3) Methods

We measured cloud base height and backscatter profile using CT-25K (VAISALA, Finland) ceilometer throughout MR06-05 Leg2 cruise.

Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode
Transmitting wave length:	905±5 nm at 25 deg-C
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

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) Preliminary results

Fig. 6.1.2-1 shows the first, second and third lowest cloud base height which the ceilometer detected during the stationary observation.

(5) Data archives

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

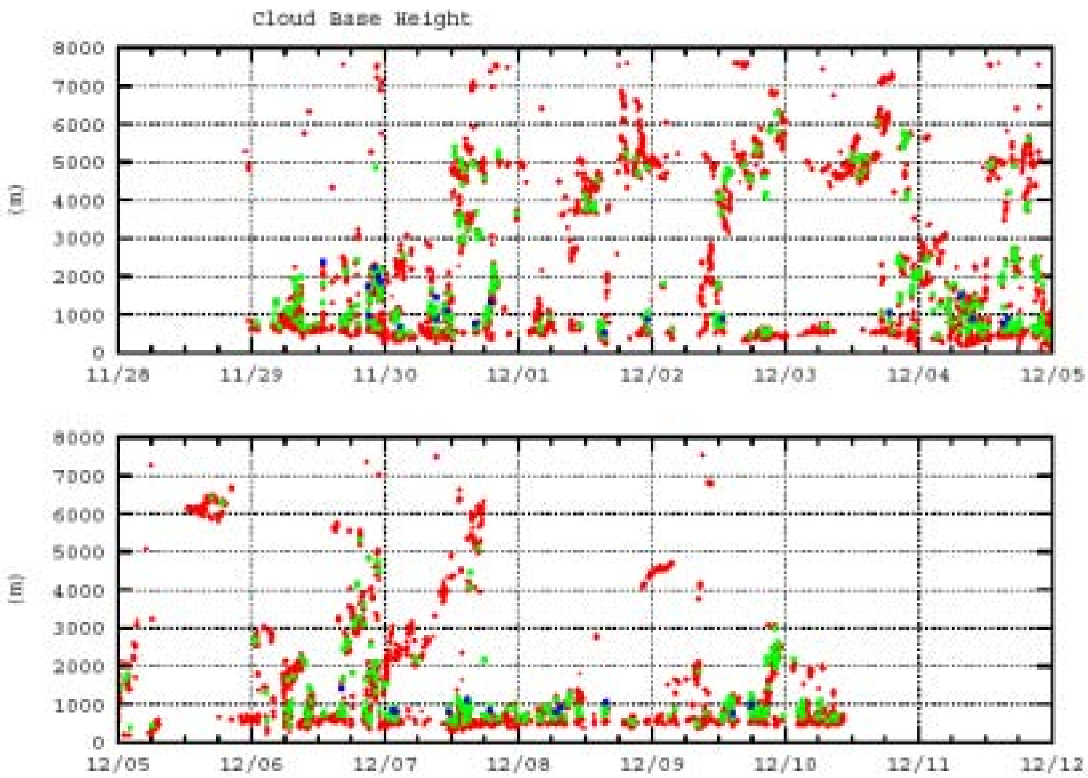


Figure 6.1.2-1 1st (red), 2nd (green) and 3rd (blue) lowest cloud base height during the cruise.

6.2 CTD/XCTD observations
6.2.1. CTD

Personnel	Hideaki Hase	(JAMSTEC): Principal Investigator
	Satoshi Ozawa	(MWJ): Operation leader
	Akinori Murata	(MWJ)

(1) Objective

Investigation of oceanic structure and water sampling.

(2) Overview of the equipment and observation

CTD/Carousel water sampling system (CTD system), which is 36-position Carousel Water Sampler (SBE 32) with SBE 9plus (Sea-Bird Electronics Inc) attached with sensors, was used during this cruise. 12-litter Niskin bottles were used for sampling seawater. The CTD system was deployed from starboard on working deck. During this cruise, 7 CTD observations were carried out (see Table 6.2.1-1). Sampling layers were shown in Table 6.2.1-2.

(3) List of sensors and equipments

Under water unit:	SBE, Inc., SBE 9plus, S/N 0357
Temperature sensor:	SBE, Inc., SBE 03-04/F, S/N 031359
Conductivity sensor:	SBE, Inc., SBE 04C, S/N 042854
Oxygen sensor:	SBE, Inc., SBE 43, S/N 430330
Pump:	SBE, Inc., SBE 5T, S/N 053118
Altimeter:	Benthos, Inc, PSA-916T, S/N 1157
Fluorometer:	Seapoint Sensors, Inc, Clorophyll, S/N 2579
Deck unit:	SBE, Inc., SBE 11plus, S/N 11P9833-0308
Carousel Water Sampler:	SBE, Inc., SBE 32, S/N 3227443-0278
Water sample bottle:	General Oceanics, Inc., 12-litre Niskin-X

(4) Data processing

The SEASOFT-Win32 (Ver. 5.27b) was used for processing the CTD data. Descriptions and settings of the parameters for the SEASOFT were written as follows.

DATCNV converted the raw data to scan number, pressure, depth, time elapsed, temperature, conductivity, oxygen voltage, altitude, desent rate, modulo error count and pump status. DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 3.0 seconds, and the offset was set to 0.0 seconds.

ROSSUM created a summary of the bottle data. The bottle position, date, time were output as the first two columns. Scannumber, pressure, depth, temperature, conductivity, oxygen voltage, fluorometer, altimter and descent rate were over 3.0 seconds. And Oxygen, Salinity, sigma-theta and potential temperature were computed.

ALIGNCTD converted the time-sequence of oxygen sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. For a SBE 9plus CTD with the ducted temperature and conductivity sensors and a 3000 rpm pump, the typical net advance of the conductivity relative to the temperature is 0.073 seconds. So, the SBE 11plus deck unit S/N 11P9833-0308 was set to advance the primary conductivity for 1.73 scans (1.75/24 = 0.073 seconds). Oxygen data are also systematically delayed with respect to depth mainly because of the long time constant of the oxygen sensor and of an additional delay from the transit time of water in the pumped plumbing line. This delay was compensated by 6 seconds advancing oxygen sensor output (oxygen voltage) relative to the pressure.

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

CELLTM used a recursive filter to remove conductivity cell thermal mass effects from the measured conductivity. Typical values used were thermal anomaly amplitude alpha = 0.03 and the time constant 1/beta = 7.0.

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

WFILTER performed a median filter on fluorometer with a window size of 49.

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

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

DERIVE was used to compute oxygen.

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

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

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

(5) Preliminary Results

Date, time and locations of the CTD casts are listed in Table 6.2.1-1. Vertical profile of temperature salinity and oxygen with pressure are shown in Figure 6.2.1-1, 6.2.1-2.

(6) Data archive

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

Table 6.2.1-1 CTD Casttable

Stnnbr	Castno	Date(UTC)	Time(UTC)		StartPosition		Depth	Wire Out	HT Above Bottom	Max Depth	Max Pressure	CTD Filename
		(mmddyy)	Start	End	Latitude	Longitude						
C01	1	113006	6:09	9:09	01-32.39N	080-31.80E	4537	4504.7	37.1	4489.9	4563.2	C01M01
C02	1	120106	6:35	8:12	01-30.08S	080-31.26E	4845	2012.6	-	2000.2	2021.4	C02M01
C03	1	120306	8:31	11:26	00-03.20N	089-55.30E	4409	4390.9	25.7	4376	4446.2	C03M01
C04	1	120406	7:02	7:34	01-41.33S	090-10.36E	4715	505.3	-	500.2	503.4	C04M01
C05	1	120506	7:02	10:01	01-38.33S	090-00.46E	4692	4687.8	22.8	4661.2	4739.3	C05M01
C06	1	120706	11:03	11:30	04-57.98S	094-59.25E	5005	807.2	-	800.9	806.7	C06M01
C07	1	120806	7:01	10:04	04-56.20S	095-01.75E	5001	4989.1	15.3	4974.3	5060.8	C07M01

Table 6.2.1-2 Sampling layler

Stn : C01		Stn : C02		Stn : C03		Stn : C04		Stn : C05		Stn : C07	
Niskin No.	Depth [m]	Niskin No.	Depth [m]	Niskin No.	Depth [m]	Niskin No.	Depth [m]	Niskin No.	Depth [m]	Niskin No.	Depth [m]
1	Bottom	1	2000	1	Bottom	1	500	1	Bottom	1	Bottom
2	4000	2	700	2	4000	2	-	2	4000	2	4000
3	3000	3	10	3	3000	3	-	3	3000	3	3000
4	2000	4	2000	4	2000	4	300	4	2000	4	2000
5	1800	5	1800	5	1800	5	-	5	1800	5	1800
6	1600	6	1600	6	1600	6	-	6	1600	6	1600
7	1400	7	1400	7	1400	7	200	7	1400	7	1400
8	1200	8	1200	8	1200	8	-	8	1200	8	1200
9	1000	9	1000	9	1000	9	-	9	1000	9	1000
10	900	10	900	10	900	10	140	10	900	10	900
11	800	11	800	11	800	11	-	11	800	11	800
12	700	12	700	12	700	12	-	12	700	12	700
13	600	13	600	13	600	13	120	13	600	13	600
14	500	14	500	14	500	14	-	14	500	14	500
15	400	15	400	15	400	15	-	15	400	15	400
16	350	16	350	16	350	16	100	16	350	16	350
17	300	17	300	17	300	17	-	17	300	17	300
18	275	18	275	18	275	18	-	18	275	18	275
19	250	19	250	19	250	19	80	19	250	19	250
20	225	20	225	20	225	20	-	20	225	20	225
21	200	21	200	21	200	21	-	21	200	21	200
22	175	22	175	22	175	22	60	22	175	22	175
23	150	23	150	23	150	23	-	23	150	23	150
24	125	24	125	24	125	24	-	24	125	24	125
25	100	25	100	25	100	25	40	25	100	25	100
26	75	26	75	26	75	26	-	26	75	26	75
27	50	27	50	27	50	27	-	27	50	27	50
28	30	28	30	28	30	28	20	28	30	28	30
29	10	29	10	29	10	29	-	29	10	29	10
30	10	30	10	30	10	30	-	30	10	30	10
31	200	31	175	31	150	31	10	31	160	31	150
32	150	32	125	32	100	32	-	32	110	32	100
33	100	33	75	33	50	33	-	33	60	33	50
34	710	34	100	34	800	34	-	34	700	34	600
35	115	35	700	35	150	35	-	35	175	35	150
36	3000	36	100	36	Bottom	36	-	36	1000	36	700

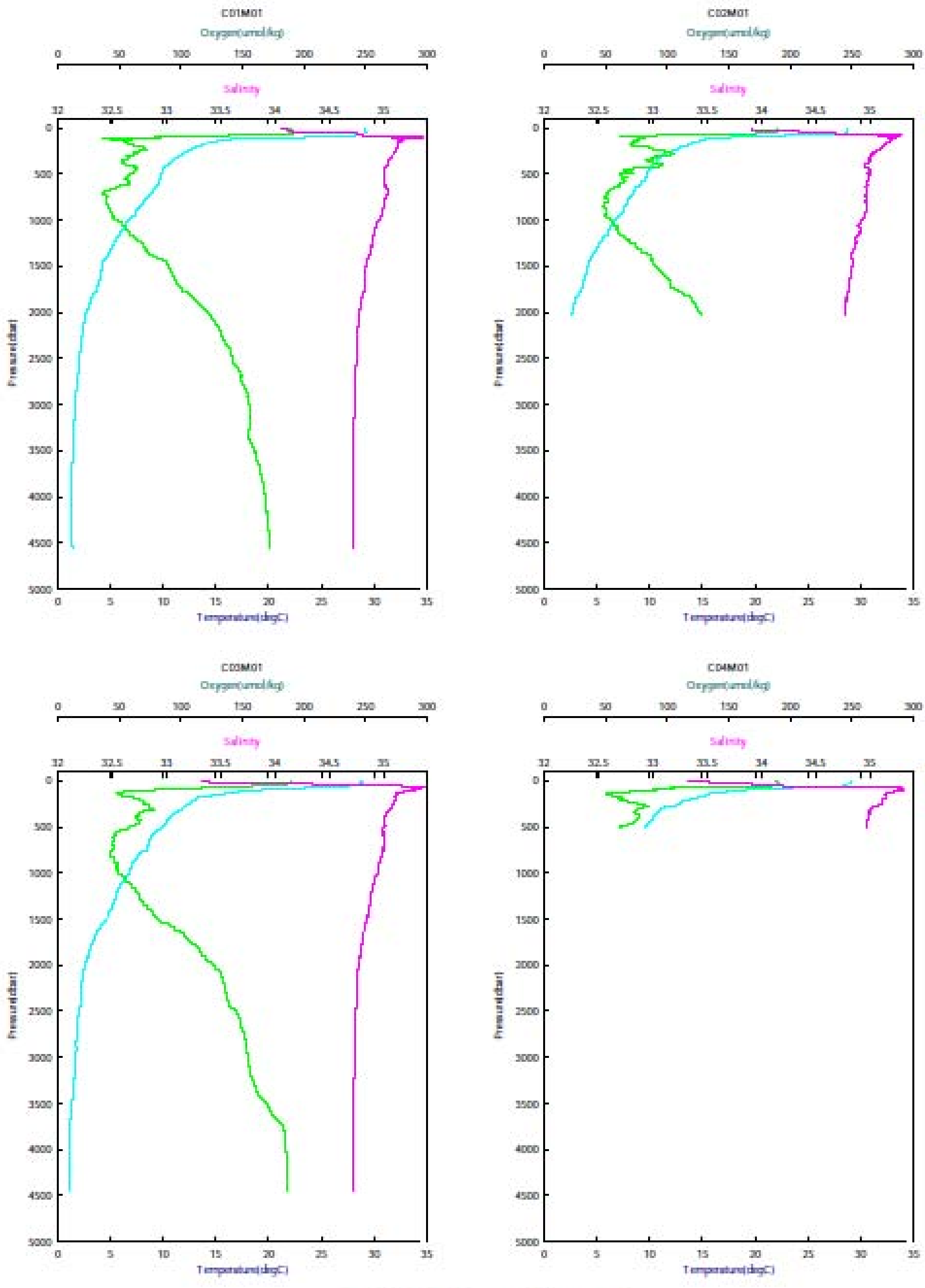


Fig6.2.1-1 CTD profile(C05-C07)

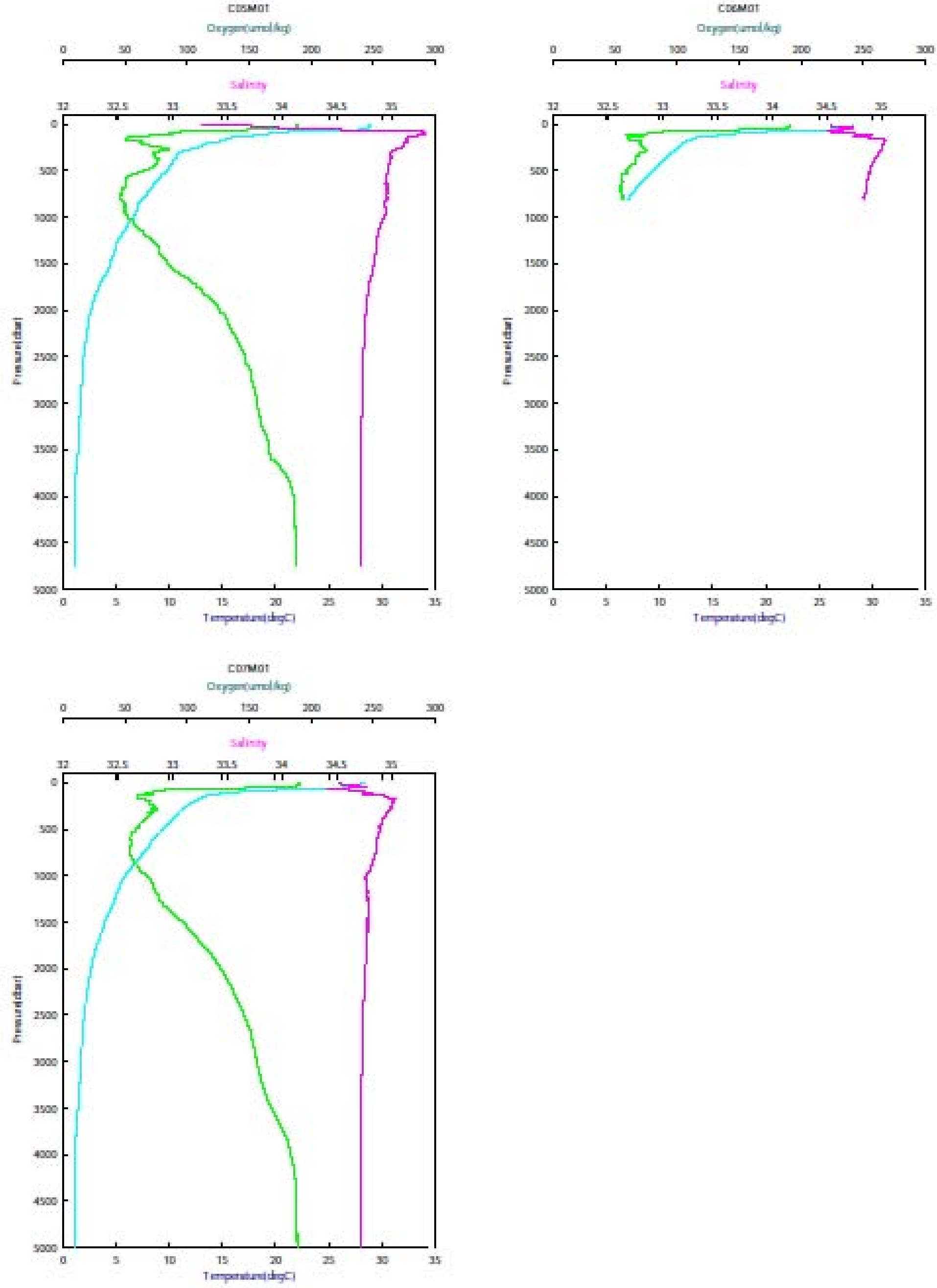


Fig6.2.1-2 CTD profile(C05-C07)

6.2.2 XCTD

Yoshihumi Kuroda (JAMSTEC) : Principal Investigator
Hideaki Hase (JAMSTEC)
Souichiro Sueyoshi (Global Ocean Development Inc.)
Norio Nagahama (GODI)
Ryo Ohyama (GODI)

(1) Objectives

Comparing to the data from TRITON buoy, the XCTD (eXpendable Conductivity, Temperature & Depth profiler) observation was carried out within 2 miles from TRITON buoy.

(2) Parameters

According to the manufacturer's information, the range and accuracy of parameters measured by the XCTD are as follows;

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

(3) Methods

We observed the vertical profiles of the sea water temperature and salinity measured by the XCTD-1 manufactured by Tsurumi-Seiki Co.. The signal was converted by MK-100, Tsurumi-Seiki Co. and was recorded by WinXCTD software (version 1.07) made by Tsurumi-Seiki Co..

We dropped 2 probes (X001-X002) by using automatic launcher. The summary of XCTD observation and launching log were shown in Table 6.2.2-1.

(4) Preliminary results

Vertical profile of temperature, salinity and conductivity were shown in the following Fig. 6.2.2-1.

(5) Data archives

XCTD data obtained in this cruise will be submitted to the JAMSTEC Marine-Earth Data and Information Department (MEDID) and will be available via "R/V MIRAI Data Web Page" in JAMSTEC home page.

Table 6.2.2-1 Summary of XCTD observation and launching log

Station No.	Launc Time (UTC)		Finish time	Launch Position		Measured Depth	Water Depth	Surface Temp.	Surface Salinity	Probe
	date	time		Latitude	Longitude					S/N
001	12/5	05:24:04	05:29	01-35.12N	90-06.03E	1035	4702	28.550	32.962	5022150
002	12/7	10:36:59	10:42	05-01.18S	94-59.67E	1035	4011	28.047	34.517	5022149

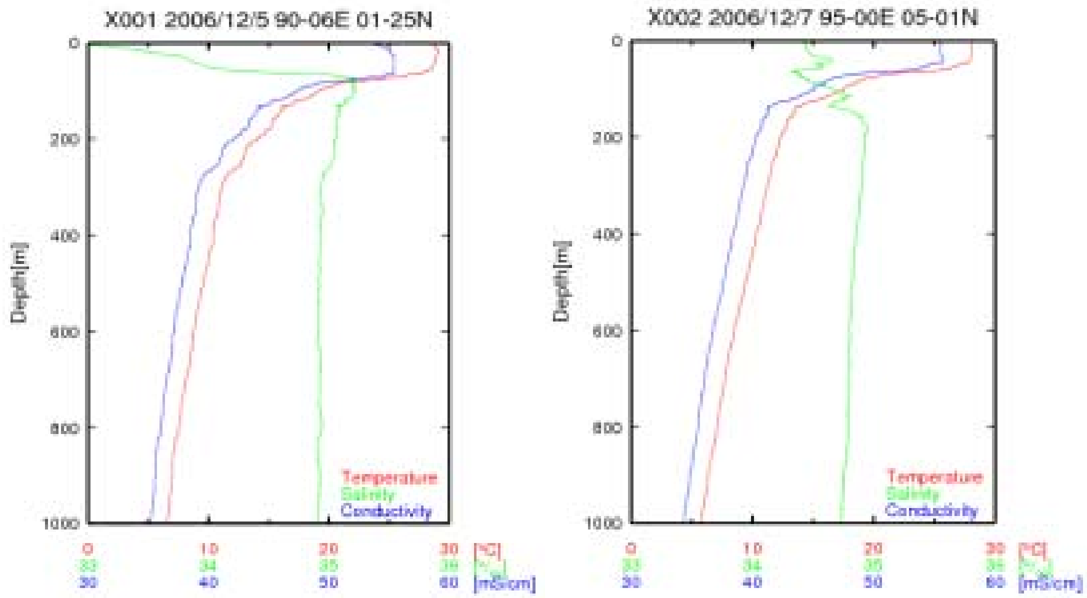


Fig 6.2.2-1 Profile of temperature, salinity and conductivity at each Station

6.3 Validation of CTD cast data

6.3.1 Salinity measurement of sampled seawater

(1) Personnel

Akinori Murata (MWJ) ： Operation Leader
Satoshi Ozawa

(2) Objectives

To measure bottle salinity obtained by CTD casts and EPCS.

(3) Method

(3-1) Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles and EPCS. The 250ml brown glass bottle was used to collect the sample water. The sample bottle was sealed with a plastic insert thimble and a screw cap. Each bottle was rinsed three times with the sample water, and was filled with sample water to the bottle shoulder. Its cap and thimble were also thoroughly rinsed. The bottle was stored more than 24 hours in 'AUTOSAL ROOM' before the salinity measurement.

(3-2) Instruments and Methods

The salinity analysis was carried out on R/V MIRAI during the cruise of MR06-05 Leg2 using the salinometer (Model 8400B "AUTOSAL"； Guildline Instruments Ltd.: S/N 62827), with additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). We also used two precision digital thermometers (Model 9540； Guildline Instruments Ltd.). One thermometer monitored an ambient temperature and the other monitored a bath temperature.

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

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

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

Thermometer (Model 9540； Guildline Instruments Ltd.)

Measurement Range	：	-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 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. An ambient temperature varied from approximately 24.1 deg C to 24.7 deg C, while a bath temperature is very stable and varied within +/- 0.004 deg C on rare occasion. We measured sub-standard seawater and confirmed that the salinometer was stable before the routine measurement of the day. The measurement for each sample was done with a double conductivity ratio that is defined as median of 31 times reading of the salinometer. Data collection was started in 5 seconds after filling sample to the cell and it took about 15 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell after five times rinse of the cell. In case the difference between the double conductivity ratio of these two fillings is smaller than 0.00002, the average value of these double conductivity ratio was used to calculate the bottle salinity with the algorithm for practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, we measured eighth filling of the cell. In case the double conductivity ratio of eighth filling did not satisfy the criteria above, we measured ninth filling of the cell.

The kind and number of samples are shown as follows；

Table 6.3.1-1: Kind and number of samples

Kind of samples	Number of samples
Samples for CTD	38
Samples for EPCS	12
Total	50

(3-3) Standard Seawater

Standardization control was set to 393 and all the measurements were done by this setting. We used IAPSO Standard Seawater (SSW) batch P145 as the standard for salinity. And we measured the SSW in order to correct the measured salinity at the measurement of a day. We measured 6 bottles in total.

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

Standard seawater (SSW)

batch	：	P145
conductivity ratio	：	0.99981
salinity	：	34.993
preparation date	：	15-Jul.-2004

(3-4) Sub-Standard Seawater

We also used sub-standard seawater which was obtained from 2,500m depth in MR06-02 cruise filtered by Millipore filter (pore size of 0.45 μm), which was stored in a 20 liter polyethylene container and stirred for at least 24 hours before measuring. It was measured every about six samples in order to check the drift of the salinometer. During the whole measurements, there was no detectable sudden drift of the salinometer.

(4) Results

(4-1) Standard Seawater

The average and standard deviation of SSW were respectively 34.9925 and 0.0002 in salinity.

(4-2) Replicate Samples

We took 14 pairs of replicate samples. The average and the standard deviation of the absolute difference of replicate samples were respectively 0.0002 and 0.0002 in salinity.

(5) Data Archive

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

(6) Remarks

Reference

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

・UNESCO : Tenth report of the Joint Panel on Oceanographic Tables and Standards. *UNESCO Technical Papers in Marine Science*, 36, 25 pp., 1981

6.4 Continuous monitoring of surface seawater

(1) Personnel

Yoshifumi Kuroda	(JAMSTEC): Principal Investigator
Hideaki Hase	(JAMSTEC)
Ayako Fujii	(Tokyo Institute of Technology)
Yuichi Sonoyama	(MWJ): Operation leader
Hideki Yamamoto	(MWJ): Technical Staff
Minoru Kamata	(MWJ): Technical Staff

(2) Objective

Measurement of temperature, salinity, dissolved oxygen and fluorescence in the sea surface water.

(3) Methods

The *Continuous Sea Surface Water Monitoring System* (Nippon Kaiyo Co. Ltd.) has five kind of sensors and can automatically measure salinity, temperature (two systems), dissolved oxygen and fluorescence in near-sea surface water continuously, every 1-minute. Salinity is calculated by conductivity on the basis of PSS78. This system is located in the "*sea surface monitoring laboratory*" on R/V MIRAI. This system is connected to shipboard LAN-system. Measured data is stored in a hard disk of PC every 1-minute together with time and position of ship, and displayed in the data management PC machine.

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

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

a) Temperature and Conductivity sensor

SEACAT THERMOSALINOGRAPH

Model: SBE-21, SEA-BIRD ELECTRONICS, INC.
Serial number: 2126391-3126
Measurement range: Temperature -5 to +35℃, Conductivity 0 to 6.5 S m-1
Accuracy: Temperature 0.01℃ 6month-1,Conductivity 0.001 S m-1 month-1
Resolution: Temperatures 0.001℃, Conductivity 0.0001 S m-1

b) Bottom of ship thermometer

Model: SBE 3S, SEA-BIRD ELECTRONICS, INC.
Serial number: 032607
Measurement range: -5 to +35℃
Resolution: ±0.001℃
Stability: 0.002℃ year-1

c) Dissolved oxygen sensor

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

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

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

The monitoring periods (UTC) during this cruise are listed below.
Start : 2006/11/28 23:00 Stop : 2006/12/10 11:00
Start : 2006/12/11 22:00 Stop : 2006/12/12 10:00

(4) Preliminary Result

Preliminary data of temperature (Bottom of ship thermometer), salinity, dissolved oxygen, fluorescence at sea surface between this cruise are shown in Fig.6.4-1~4. We took the surface water samples to compare sensor data wih bottle data of salinity and dissolved oxygen for one-time per day, and measured. They are shown in Fig.6.4-5~7. All the salinity samples were analyzed by the Guildline 8400B, dissolve oxygen samples were analyzed by the KIMOTO DOT-01.

(5) Date archive

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

(6) Remarks

We did not collect the data in the EEZ of Republic of Moldives from 4:00-28-November to 23:00-28-November 2006, and of the United States of Indonesia from 11:00-10-December to 22:00-11-December 2006.

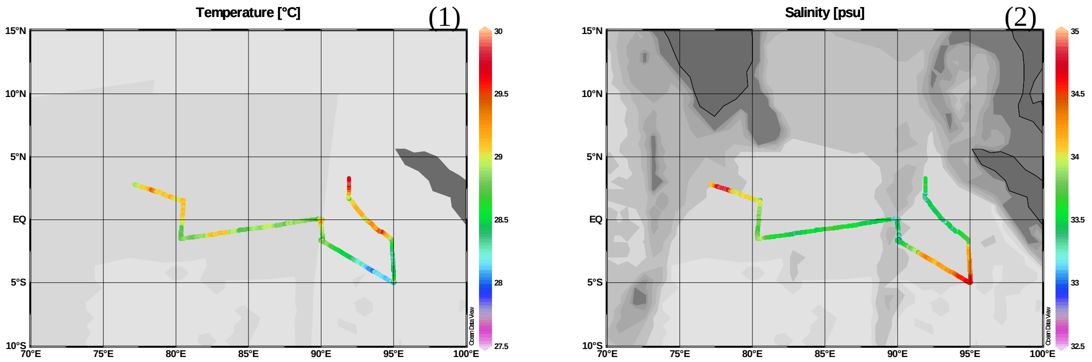


Fig.6.4-1,2 Spatial and temporal distribution of temperature (left) and Salinity.

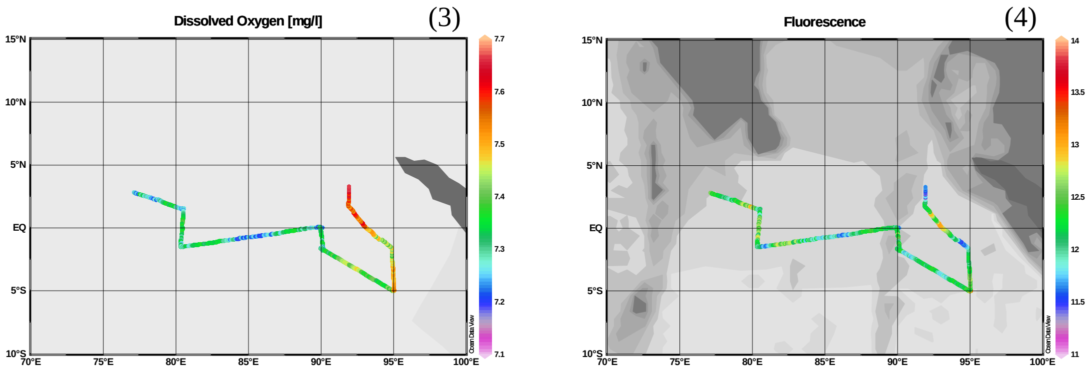


Fig.6.4-3,4 Spatial and temporal distribution of dissolved oxygen (left) and fluorescence.

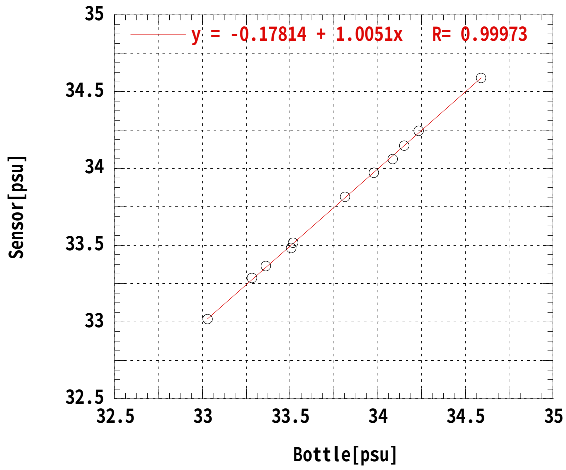


Fig.6.4-5 Comparison between salinity sensor and bottle data

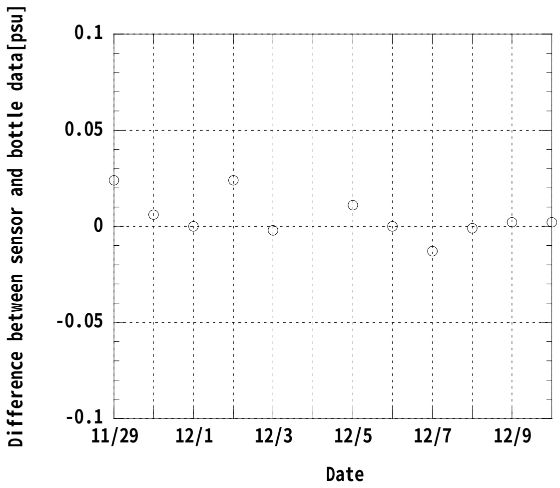


Fig.6.4-6 Difference in value between salinity sensor and bottle data

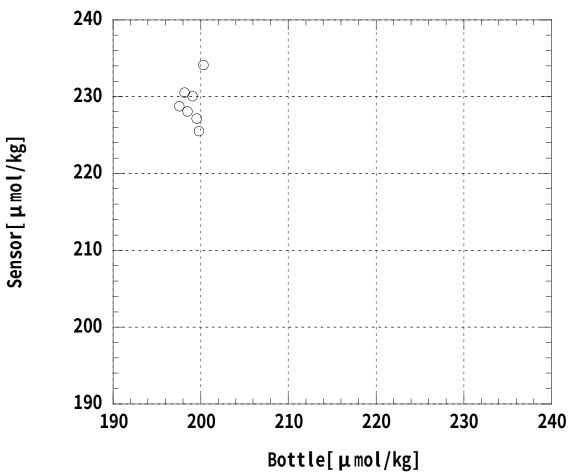


Fig.6.4-7 Comparison between dissolved oxygen sensor and bottle data

6.5 Shipboard ADCP

(1) Personnel

Yoshifumi Kuroda	(JAMSTEC): Principal Investigator
Souichiro Sueyoshi	(GODI)
Norio Nagahama	(GODI)
Ryo Oyama	(GODI)

(2) Objective

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

(3) Methods

Upper ocean current measurements were made throughout MR06-05 Leg2 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;

ⅰ) 75 kHz Broadband (coded-pulse) profiler with 4-beam Doppler sonar operating (RD Instruments, USA), mounted with beams pointing 30 degrees from the vertical and 45 degrees azimuth from the keel;

ⅱ) the Ship's main gyro compass (Tokimec, Japan), continuously providing ship's heading measurements to the ADCP;

ⅲ) a GPS navigation receiver (Trimble 4000DS) providing position fixes;

ⅳ) a personal computer running data acquisition software (VmDas version 1.4.0, RD Instruments, USA). The clock of the logging PC are adjusted to GPS time every 10 minutes.

ⅴ) high-precision attitude information, heading, pitch and roll, are also stored in N2R data files with a time stamp.

The ADCP was configured for 16 m processing bin and 8 m blanking distance. 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). 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. Major parameters for the measurement (Direct Command) are shown bellow;

Bottom-Track Commands

BP = 001	Pings per Ensemble

Environmental Sensor Commands

EA = +00000	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +0001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH = 00000	Heading (1/100 deg)
ES = 35	Salinity (0-40 pp thousand)
EX = 00000	Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 1020001	Sensor Source (C;D;H;P;R;S;T) C(1): Sound velocity calculate using ED, ES, ET(temp.) D(0): Manual ED H(2): External synchro

	P(0), R(0): Manual EP, ER (0 degree)
	S(0): Manual ES
	T(1): Internal transducer sensor
Timing Commands	
TE = 00:00:02.00	Time per Ensemble (hrs:min:sec.sec/100)
TP = 00:02.00	Time per Ping (min:sec.sec/100)
Water-Track Commands	
WA = 255	False Target Threshold (Max) (0-255 counts)
WB = 1	Mode 1 Bandwidth Control (0=Wid,1=Med,2=Nar)
WC = 064	Low Correlation Threshold (0-255)
WD = 111 111 111	Data Out (V;C;A PG;St;Vsum Vsum^2;#G;P0)
WE = 5000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WG = 001	Percent Good Minimum (0-100%)
WI = 0	Clip Data Past Bottom (0=OFF,1=ON)
WJ = 1	Rcvr Gain Select (0=Low,1=High)
WM = 1	Profiling Mode (1-8)
WN = 040	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS = 1600	Depth Cell Size (cm)
WT = 000	Transmit Length (cm) [0 = Bin Length]
WV = 999	Mode 1 Ambiguity Velocity (cm/s radial)

(4) Preliminary results

Fig. 6.5-1 to Fig. 6.5-3 were showed water current vector along the ship track. The data were processed LTA data using CODAS (Common Oceanographic Data Access System) software, developed at the University of Hawaii.

(5) Data archive

These data obtained in this cruise will be submitted to the Marine-Earth Data and Information Department（MEDID）of JAMSTEC, and will be opened to the public via “R/V Mirai Data Web Page” in JAMSTEC home page.

(6) Remarks

1. Because the temperature sensor of transducer had failure, calculated sound velocity had bad value. Therefore, bad ADCP data is contained on following period.
   5 December 23:25 – 7 December 04:35 (UTC)
2. Following period, we changed sound velocity to fixed value using direct command (EZ0020001 and ECxxxx) in definition file.
   EC1542 (m/s) : 7 December 04:43 – 11 December 10:00 (UTC)
   EC1541 (m/s) : 11 December 22:08 – 12 December 10:00 (UTC)
3. ADCP observation stopped in the following period due to communication trouble between deck unit and transducer.
   28 November 23:00 – 29 November 05:40 (UTC)

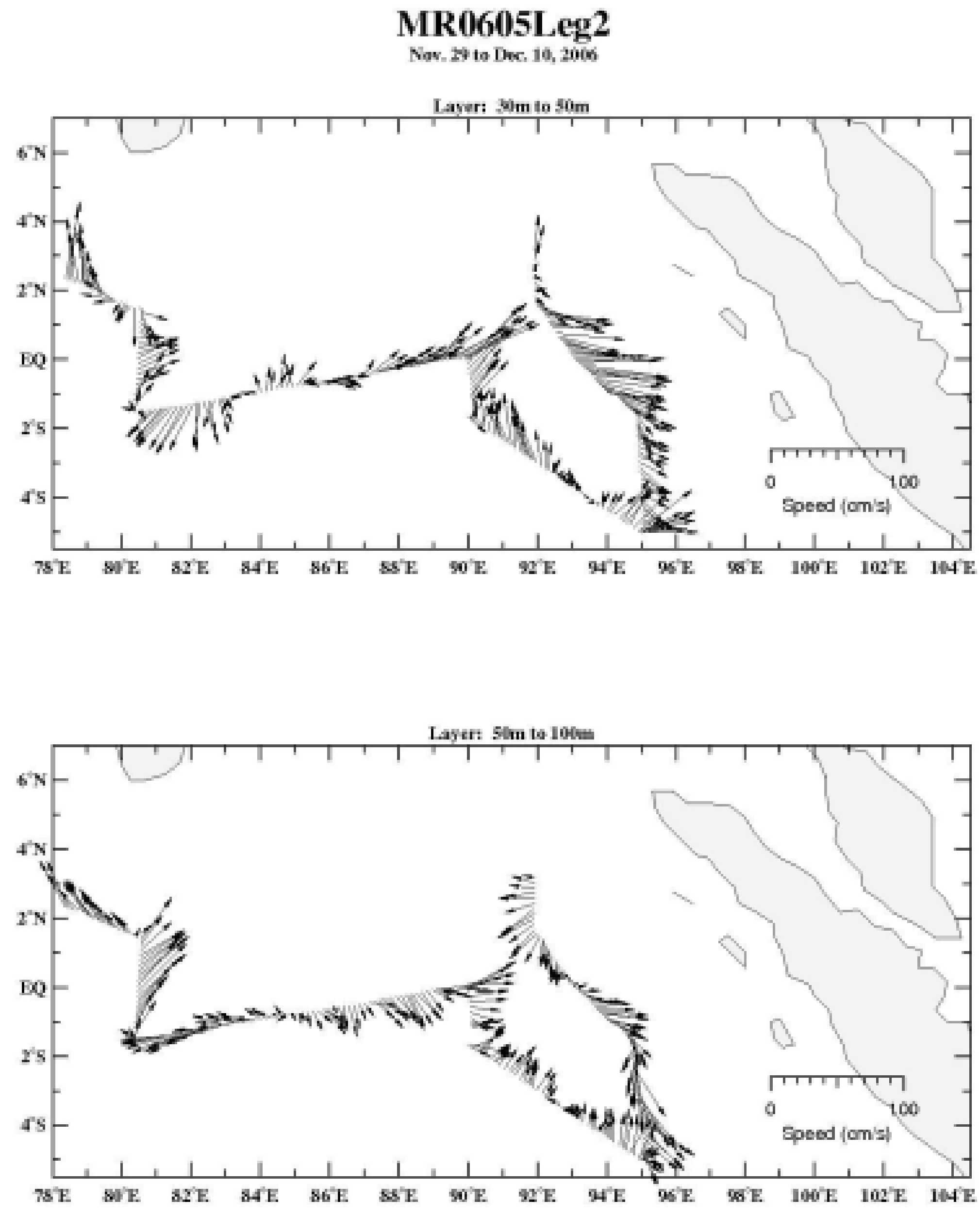


Fig. 6.5-1 Water current vector. (Water depth layer: 30 m to 50 m and 50 m to 100 m)

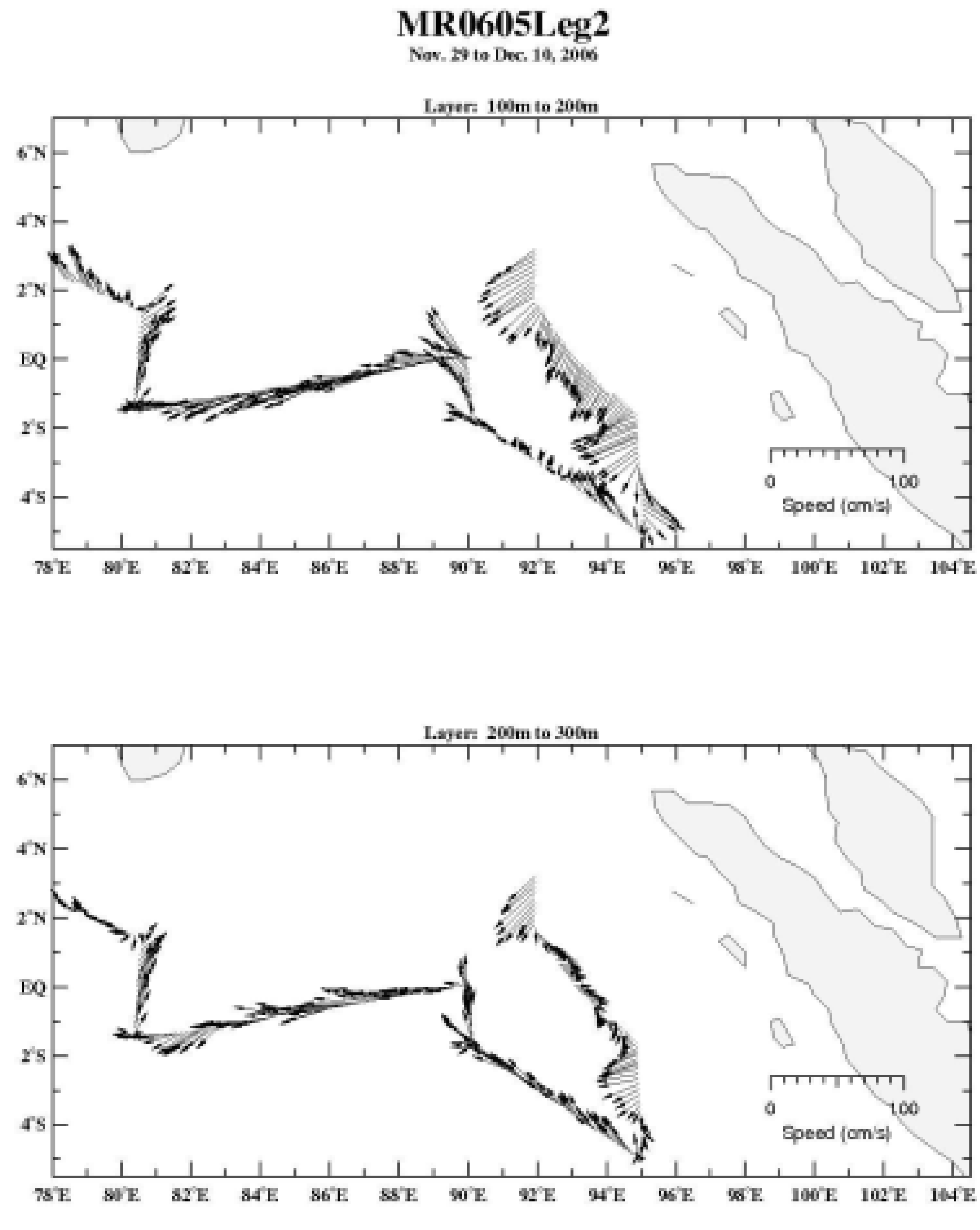


Fig. 6.5-2 Water current vector. (Water depth layer: 100 m to 200 m and 200 m to 300 m)

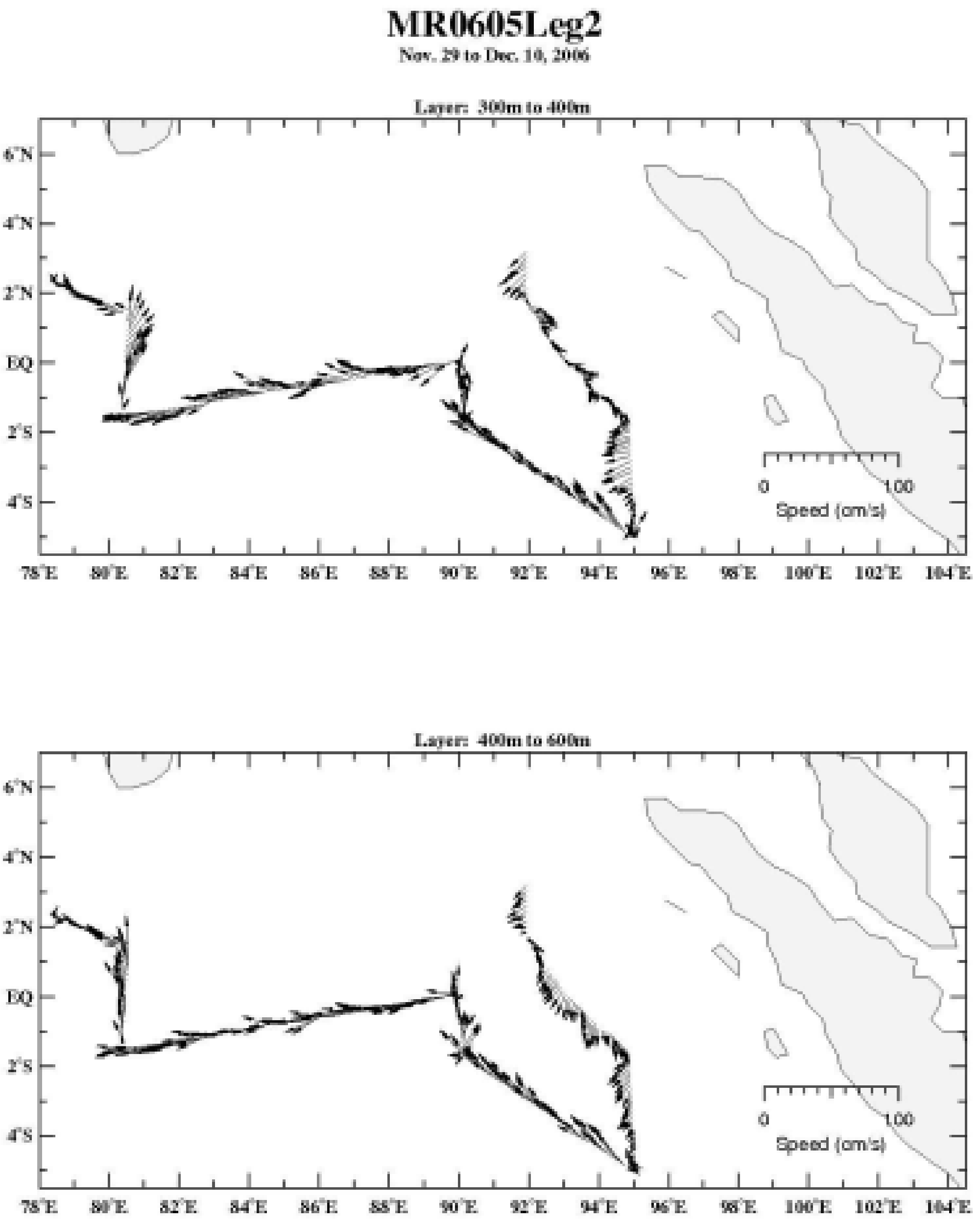


Fig. 6.5-3 Water current vector. (Water depth layer: 300 m to 400 m and 400 m to 600 m)

6.6 Underway geophysics
6.6.1 Sea Surface Gravity

Takeshi Matsumoto (University of the Ryukyus) :Principal investigator (Not on-board)
Souichiro Sueyoshi (Global Ocean Development Inc.)
Norio Nagahama (GODI)
Ryo Ohyama (GODI)

(1) Introduction

The distribution of local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface during the MR06-05 leg2 cruise from Male, Maldives on 28th November 2006 to Singapore on 13th December 2006.

(2) Parameters

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

(3) Data Acquisition

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

(4) Preliminary Results

Absolute gravity shown in Table 6.6.1-1

Table 6.6.1-1

No.	Date	U.T.C.	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at Sensor *[1] [mGal]	L&R *[2] Gravity [mGal]
----	Oct./3	03:33	Sekinehama	980371.95	227	635	980372.70	12712.31

*[1]: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.0431
*[2]: LaCoste and Romberg air-sea gravity meter S-116

(5) Data Archives

Gravity data obtained during this cruise will be submitted to the JAMSTEC Marine-Earth Data and Information Department (MEDID), and archived there.

6.6.2 Sea Surface Three-Component Magnetic Field

Takeshi Matsumoto	(University of the Ryukyus) :Principal investigator (Not on-board)
Souichiro Sueyoshi	(Global Ocean Development Inc.)
Norio Nagahama	(GODI)
Ryo Ohyama	(GODI)

(1) Introduction

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during the MR06-K05 leg2 cruise from Male, Maldives on 28 November 2006 to Singapore on 13 December 2006.

(2) Parameters

Three-component magnetic force [nT]
Ship's attitude [1/100 deg]

(3) Method of Data Acquisition

A sensor of three-component fluxgate magnetometer is set on the top of foremast. Sampling is controlled by 1pps (pulse per second) standard clock of GPS signals. Navigation information, 8 Hz three-component of magnetic force, and VRU (Vertical Reference Unit) data are recorded every one second.

For calibration of the ship's magnetic effect, we made a running like a "figure-eight" turn (a pair of clockwise and anti-clockwise rotation). This calibration carried out as below.

7 December 2006, 12:15 to 12:35 about at 04-58S, 95-02E

(4) Preliminary Results

The results will be published after primary processing.

(5) Data Archives

Magnetic force data obtained during this cruise will be submitted to the JAMSTEC Marine-Earth Data and Information Department (MEDID), and archived there.

(6) Remarks

No data : 3 Dec 2006 07:21 – 08:35UTC, due to the logging software trouble

6.6.3 Swath Bathymetry

Takeshi Matsumoto	(University of the Ryukyus)	:Principal investigator (Not on-board)
Souichiro Sueyoshi	(Global Ocean Development Inc.)	
Norio Nagahama	(GODI)	
Ryo Ohyama	(GODI)	

(1) Introduction

R/V MIRAI is equipped with a Multi Narrow Beam Echo Sounding system (MNBES), SEABEAM 2112.004 (SeaBeam Instruments Inc.).

The objective is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global datasets. In addition, we need to confirm the depth at the location of deployment of TRITON buoys and ADCP mooring buoys in order to design these mooring systems.

(2) Data Acquisition

The "SEABEAM 2100" on R/V MIRAI was used for bathymetry mapping during the this cruise from Male, Maldives on 28th November 2006 to Singapore on 13th December except for the territorial waters of foreign countries.

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

Table 6.6.3-1 listed system configuration and performance of SEABEAM 2112.004 system and SBP subsystem.

Table 6.6.3-1 System configuration and performance

SEABEAM 2112.004 (12kHz system)

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

(3) Preliminary Results

The results will be published after primary processing.

(4) Data Archives

Bathymetric data obtained during this cruise will be submitted to the JAMSTEC Marine-Earth Data and Information Department, and archived there.

6.7 Satellite image acquisition

6.7.1 NOAA/HRPT

Yoshifumi Kuroda (JAMSTEC): Principal Investigator
Souichiro Sueyoshi (GODI)
Norio Nagahama (GODI)
Ryo Ohyama (GODI)

(1) Objectives

It is our objectives to collect data of cloud image and sea surface temperature in a high spatial resolution mode from the Advance Very High Resolution Radiometer (AVHRR) on the NOAA polar orbiting satellites. Infrared (ch. 4) image provides cloud system information for atmospheric observation.

(2) Method

We receive the down link High Resolution Picture Transmission (HRPT) signal from NOAA satellites. We processed the HRPT signal with the in-flight calibration and computed the sea surface temperature by the Multi-Channel Sea Surface Temperature (MCSST) method. A daily composite map of MCSST data is processed for each day on the R/V MIRAI for the area, where the R/V MIRAI located.

We received and processed NOAA data throughout MR06-05 Leg2 cruise.

(3) Preliminary results

Fig. 6.7.1-1 shows sea surface temperature about eastern Indian Ocean. There were composite maps of MCSST data during the cruise.

(4) Data archives

These raw data will be submitted to the Marine-Earth Data and Information Department (MEDID) of JAMSTEC just after the cruise.

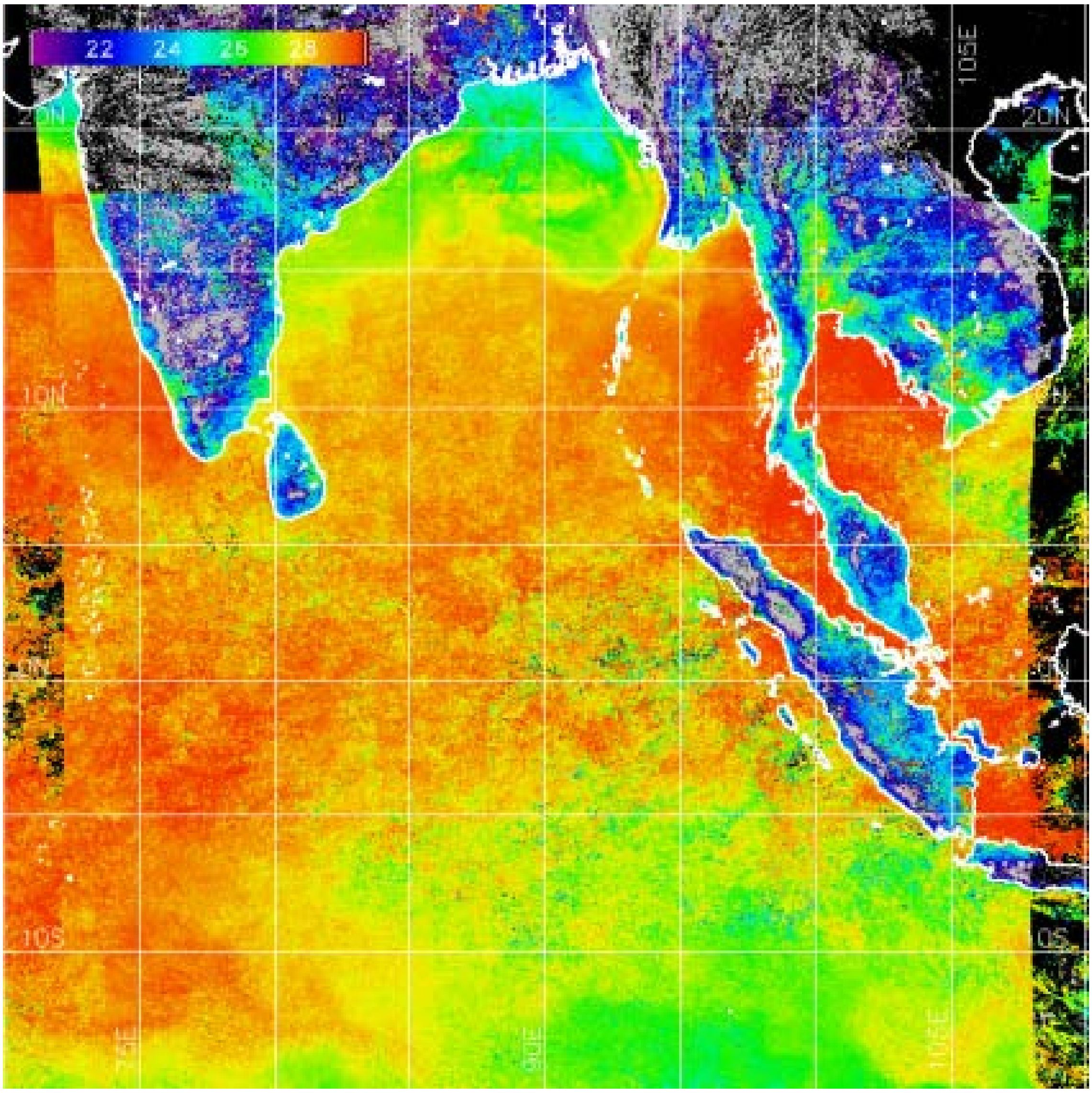


Fig. 6.7.1-1 MCSST composite image, from 28th November to 12th December 2006.

7 Special Observation
7.1 TRITON moorings
7.1.1 TRITON Mooring Operation

(1) Personnel

Yoshifumi Kuroda	(JAMSTEC): Principal Investigator
Hideaki Hase	(JAMSTEC): Principal Investigator
Tomohide Noguchi	(MWJ): Operation Leader
Keisuke Matsumoto	(MWJ): Technical Leader
Koichi Takao	(MWJ): Technical Staff
Nobuyuki Saito	(MWJ): Technical Staff
Hideki Yamamoto	(MWJ): Technical Staff
Satoshi Ozawa	(MWJ): Technical Staff
Toru Idai	(MWJ): Technical Staff
Masaki Furuhata	(MWJ): Technical Staff
Minoru Kamata	(MWJ): Technical Staff
Yuichi Sonoyama	(MWJ): Technical Staff
Akinori Murata	(MWJ): Technical Staff
Masaki Yamada	(MWJ): Technical Staff
Masatomo Hisazumi	(MWJ): Technical Staff

(2) Objectives

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

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

Two TRITON buoys have been successfully recovered and deployed during this R/V MIRAI cruise (MR06-05 Leg2).

(3) Measured parameters

Meteorological parameters:	wind speed, direction, atmospheric pressure, air temperature, relative humidity, radiation, precipitation.
Oceanic parameters:	water temperature and conductivity at 1.5m, 25m, 50m, 75m, 100m, 125m, 150m, 200m, 300m, 500m 750m, depth at 300m and 750m, currents at 10m.

(4) Instrument

1) CTD and CT

SBE-37 IM MicroCAT

A/D cycles to average : 4

Sampling interval : 600sec

Measurement range, Temperature : -5～+35 deg-C

Measurement range, Conductivity : 0～+7 S/m

Measurement range, Pressure : 0～full scale range

2) CRN(Current meter)

SonTek Argonaut ADCM

Sensor frequency : 1500kHz

Sampling interval : 1200sec

Average interval : 120sec

3) Meteorological sensors

Precipitation

R.M.YOUNG COMPANY MODEL50202/50203

Atmospheric pressure

PAROPSCIENTIFIC.Inc. DIGIQUARTZ FLOATING BAROMETER 6000SERIES

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

Woods Hole Institution ASIMET

Sampling interval : 60sec

Data analysis : 600sec averaged

(5) Locations of TRITON buoys deployment

Nominal location	5S, 95E
ID number at JAMSTEC	17005
Number on surface float	T08
ARGOS PTT number	20275
ARGOS backup PTT number	13066
Deployed date	07 Dec. 2006
Exact location	05 - 01.57S, 94 - 59.75 E
Depth	5,012 m

Nominal location	1.5S, 90E
ID number at JAMSTEC	18006
Number on surface float	T14
ARGOS PTT number	23510
ARGOS backup PTT number	13067
Deployed date	05 Dec. 2006
Exact location	01 - 35.63S, 90 - 05.42 E
Depth	4,712 m

(6) TRITON recovered

Nominal location	5S, 95E
ID number at JAMSTEC	17004
Number on surface float	T24
ARGOS PTT number	20384
ARGOS backup PTT number	24233

Deployed date	14 Aug. 2005
Recovered date	08 Dec. 2006
Exact location	04 - 56.92S, 94 - 58.40 E
Depth	5,009m

Nominal location	1.5S, 90E
ID number at JAMSTEC	18005
Number on surface float	T25
ARGOS PTT number	20439
ARGOS backup PTT number	24240
Deployed date	10 Aug. 2005
Recovered date	06 Dec. 2006
Exact location	01 - 39.42S, 89 - 58.85 E
Depth	4,693m

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

(6) Details of deployed

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

Deployed TRITON buoys

Observation No.	Location.	Details.
17005	5S-95E	Deploy with Ultrasonic waves WND, HRH, precipitation sensor on the tower and ten CT sensor, two CTD sensor, one current meter.
18006	1.5S-90E	Deploy with full spec.

(7) Data archive

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

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

7.1.2 Inter-comparison between shipboard CTD and TRITON data

(1) Personnel

Yoshifumi Kuroda	(JAMSTEC): Principal Investigator
Hideaki Hase	(JAMSTEC): Principal Investigator
Keisuke Matsumoto	(MWJ): Operation Leader
Satoshi Ozawa	(MWJ): Technical staff
Akinori Murata	(MWJ): Technical staff

(2) Objectives

TRITON CTD data validation

(3) Measured parameters

・Temperature
・Conductivity
・Pressure

(4) Methods

TRITON buoy underwater sensors are equipped along a wire cable of the buoy below sea surface. We used the same CTD (SBE 9/11Plus) system with general CTD observation (See section 5) on R/V MIRAI for this intercomparison. We conducted 1 CTD cast at each TRITON buoy site before recovery, conducted 1 CTD cast at each TRITON buoy site after deployment. The cast was performed immediately after the deployment and before recovery. R/V MIRAI was kept the distance from the TRITON buoy within about 2 nm.

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

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

Compared site

Observation No.	Latitude	Longitude	Condition
17005	5S	95E	After Deployment
18006	1.5S	90E	After Deployment
17004	5S	95E	Before Recover
18005	1.5S	90E	Before Recover

(5) Results

Most of temperature, conductivity and salinity data from TRITON buoy showed good agreement with CTD cast data in T-S diagrams. See the Figures 7.1.2-1(a)(b).

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

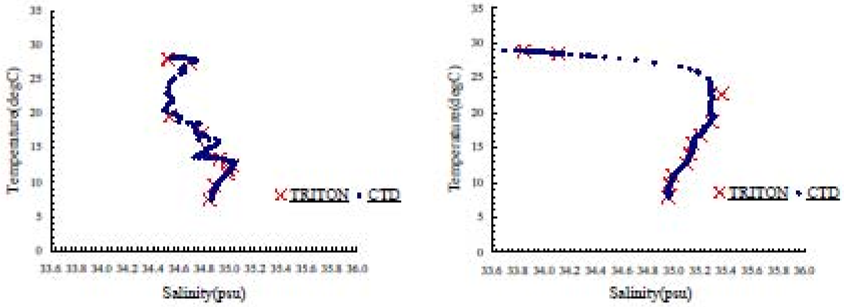
The estimations were calculated as deployed buoy data minus shipboard CTD data. The salinity differences are from –0.563 to 0.363 for all depths. Below 300db, salinity differences are from –0.019 to –0.000 (See the Figures 7.1.2-2 (a) and Table 7.1.2-1 (a)). The absolute average of all salinity differences was 0.067 with absolute standard deviation of 0.133.

The estimations were calculated as recovered buoy data minus shipboard CTD (9Plus) data. The salinity differences are from –2.713 to 0.160 for all depths. Below 300db, salinity differences are from –0.003 to 0.009 (See the Figures 7.1.2-2(b) and Table 7.1.2-1 (b)). The absolute average of salinity differences was 0.249 with absolute standard deviation of 0.715.

The estimations of time-drift were calculated as recovered buoy data minus deployed buoy data. The difference of salinity over 1 year had the variation ranging from –2.838 to 0.360, for all depths. Below 300db, the difference of salinity over 1 year had the variation ranging from –0.004 to 0.002 (See the figures 7.1.2-2(c)). The absolute average of salinity differences was 0.295 with absolute standard deviation of 0.731.

(6) Data archive

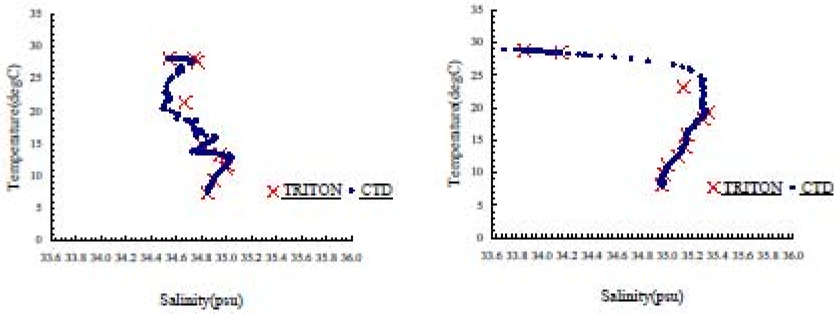
All raw and processed CTD data files were copied on 3.5 inch magnetic optical disks and submitted to JAMSTEC TOCS group of the Ocean Observation and Research Department. All original data will be stored at JAMSTEC Mutsu brunch. (See section 5)



Observation No. 17005 after Deployment

Observation No. 18006 after Deployment

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



Observation No. 17004 Before Recovery

Observation No. 18005 Before Recovery

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

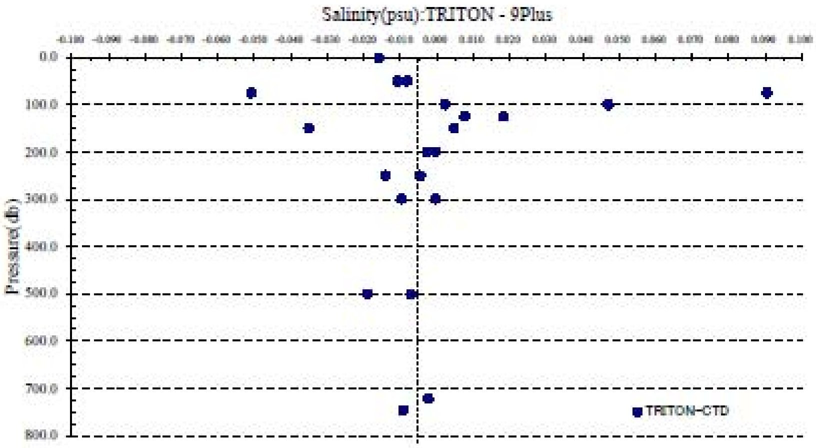


Fig.7.1.2.-2 (a) Salinity differences between TRITON buoys data and shipboard CTD data after deployment

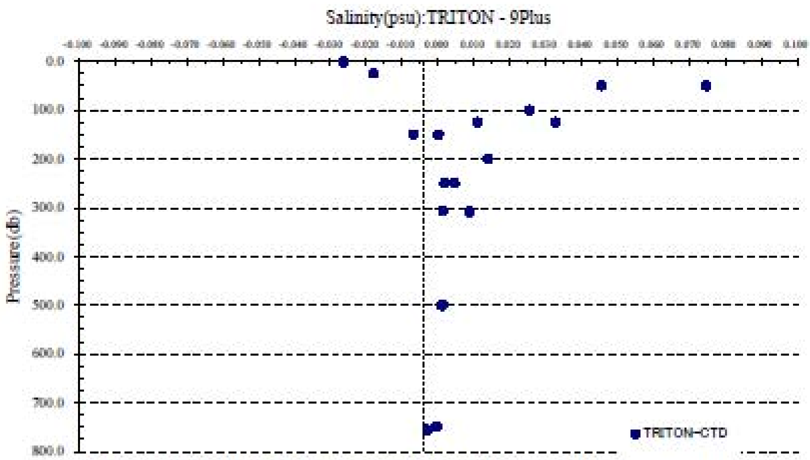


Fig.7.1.2.-2 (b) Salinity differences between TRITON buoys data and shipboard CTD data before recovery

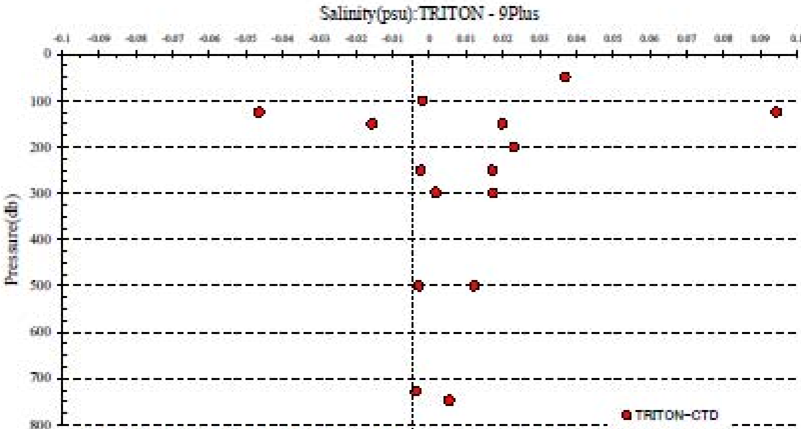


Fig.7.1.2.-2 (c) Salinity differences between deployment data and recovery data for 1year
Observation No.17,18

Table 7.1.2.-1(a) Data differences between TRITON buoys data and ship board CTD data after deployment

Observation No.	Pressure (db)	Temperature (degC)	Conductivety (S/m)	Salinity (psu)
17005	1.5	-0.07	-0.009	-0.016
17005	25.0	0.02	-0.023	-0.170
17005	50.0	-0.07	-0.009	-0.011
17005	75.0	0.00	-0.007	-0.051
17005	100.0	0.02	0.007	0.047
17005	125.0	-0.05	-0.003	0.018
17005	150.0	0.00	-0.004	-0.035
17005	200.0	0.00	0.000	-0.003
17005	250.0	-0.01	-0.002	-0.014
17005	299.6	0.00	0.000	0.000
17005	500.0	0.00	-0.001	-0.019
17005	746.8	0.00	-0.002	-0.009
18006	1.5	-0.41	-0.123	-0.563
18006	25.0	0.00	0.053	0.363
18006	50.0	0.00	-0.001	-0.008
18006	75.0	0.05	0.016	0.091
18006	100.0	0.04	0.004	0.002
18006	125.0	0.02	0.003	0.008
18006	150.0	-0.08	-0.007	0.005
18006	200.0	-0.04	-0.004	0.000
18006	250.0	0.01	0.000	-0.005
18006	299.4	0.00	-0.001	-0.010
18006	500.0	0.00	0.000	-0.007
18006	722.2	0.00	-0.001	-0.002

(Red) Bad data

Table 7.1.2.-1(b) Data differences between TRITON buoys data and ship board CTD data before recovery

Observation No.	Pressure (db)	Temperature (degC)	Conductivety (S/m)	Salinity (psu)
17004	1.5	0.01	-0.004	-0.026
17004	25.0	0.00	0.015	0.105
17004	50.0	-0.02	0.005	0.046
17004	75.0	-0.03	0.017	0.160
17004	100.0	-0.02	-0.315	-2.713
17004	125.0	0.04	0.005	0.011
17004	150.0	0.00	-0.001	-0.007
17004	200.0	-0.01	-0.250	-2.404
17004	250.0	0.00	0.000	0.005
17004	308.8	0.00	0.001	0.009
17004	500.0	0.00	0.000	0.001
17004	750.1	0.00	0.000	0.000
18005	1.5	-0.29	-0.053	-0.164
18005	25.0	0.00	-0.002	-0.018
18005	50.0	0.00	0.011	0.075
18005	75.0	-0.03	-0.023	-0.152
18005	100.0	0.02	0.005	0.026
18005	125.0	-0.03	0.001	0.033
18005	150.0	0.00	0.000	0.000
18005	200.0	0.01	0.003	0.014
18005	250.0	0.01	0.001	0.002
18005	306.9	0.02	0.002	0.002
18005	500.0	-0.01	-0.001	0.001
18005	755.2	0.12	0.010	-0.003

7.2 ADCP subsurface mooring

(1) Personnel

Yukio Masumoto	(JAMSTEC): Principal Investigator (not on board)
Kentaro Ando	(JAMSTEC): not on board
Hideaki Hase	(JAMSTEC): On board Investigator
Iwao Ueki	(JAMSTEC): not on board
Tomohide Noguchi	(MWJ): Operation leader
Koichi Takao	(MWJ): Technical staff
Satoshi Ozawa	(MWJ): Technical staff
Keisuke Matsumoto	(MWJ): Technical staff
Akinori Murata	(MWJ): Technical staff
Toru Idai	(MWJ): Technical staff

(2) Objectives

The purpose is to get the knowledge of physical process in the eastern equatorial Indian Ocean. Sub-surface currents were observed by using ADCP moorings along the equator. In this cruise (MR06-05), we deployed one sub-surface ADCP mooring at EQ-90E and recovered three ADCP moorings at EQ-90E/ 1.5N-80.5E/ 1.5S-80.5E.

(3) Parameters

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

(4) Methods

Two instruments are mounted at the top float of the mooring. One is ADCP (Acoustic Doppler Current Profiler) to observe upper ocean layer currents from subsurface down to around 350m depths. The other is CTD to observe pressure, temperature and salinity for correction of sound speed and depth variability. Details of the instruments and their parameters are as follows:

1) ADCP

◆Self-Contained Broadband ADCP 150 kHz (RD Instruments)
Distance to first bin : 8 m
Pings per ensemble : 27
Time per ping : 6.66 seconds
Bin length : 8.00 m
Sampling Interval : 3600 seconds
Recovered ADCP

- Serial Number : 1224 (Mooring No.061024-1.5N80.5E)
- Serial Number : 1225 (Mooring No.061026-1.5S80.5E)

◆Self-Contained Work Horse Long Ranger ADCP 75 kHz (RD Instruments)
Distance to first bin : 8 m

Pings per ensemble : 27
Time per ping : 6.66 seconds
Bin length : 8.00 m
Sampling Interval : 3600 seconds

Deployed ADCP

- Serial Number : 1248 (Mooring No.061203-0090E)

Recovered ADCP

- Serial Number : 1647 (Mooring No.050808-0090E)

2) CTD

◆SBE-16 (Sea Bird Electronics Inc.)
Sampling Interval : 1800 seconds
Recovered CTD

- Serial Number : 1275 (Mooring No.061024-1.5N80.5E)
- Serial Number : 1278 (Mooring No.061026-1.5S80.5E)

◆SBE-37 (Sea Bird Electronics Inc.)
Sampling Interval : 1800 seconds
Deployed CTD

- Serial Number : 1775 (Mooring No.061203-0090E)

Recovered CTD

- Serial Number : 1388 (Mooring No.050808-0090E)

3) Other instrument

◆Acoustic Releaser (BENTHOS,Inc.)
Deployed Acoustic Releaser

- Serial Number : 955 (Mooring No.061203-0090E)
- Serial Number : 663 (Mooring No.061203-0090E)

Recovered Acoustic Releaser

- Serial Number : 632 (Mooring No.061024-1.5N80.5E)
- Serial Number : 693 (Mooring No.061024-1.5N80.5E)
- Serial Number : 954 (Mooring No.061026-1.5S80.5E)
- Serial Number : 717 (Mooring No.061026-1.5S80.5E)
- Serial Number : 960 (Mooring No.050808-0090E)
- Serial Number : 961 (Mooring No.050808-0090E)

(5) Deployment

The ADCP mooring deployed at EQ-90E was planned to play the ADCP at about 400m depths. After we dropped the anchor, we monitored the depth of the acoustic releaser.

- The position of the mooring No. 061203-0090E
  Date: 03 Dec. 2006　Lat: 00-00.37N　Long: 90-03.79E　Depth: 4410m

(6) Recovery

We recovered three ADCP moorings. One was deployed on 8 Aug.2005 (MR05-03 Leg2), the other was deployed on 24 Oct. 2006 (MR06-05 Leg1) and the other was deployed on 26 Oct. 2006 (MR06-05 Leg1). After the recovery, we uploaded ADCP and CTD data into a computer, then raw data were converted into ASCII code. But the ADCP data recovered at 1.5N-80.5E was missing owing to the poor connection between batteries.

Results were shown in the figures in the following pages.

Fig.7.2-1 shows CTD pressure, temperature and salinity data (1.5N-80.5E).
Fig.7.2-2 shows the ADCP velocity data (zonal and meridional component / 1.5S-80.5E).
Fig.7.2-3 shows CTD pressure, temperature and salinity data (1.5S-80.5E).
Fig.7.2-4 shows the ADCP velocity data (zonal and meridional component / EQ-90E).
Fig.7.2-5 shows CTD pressure, temperature and salinity data (EQ-90E).

(7) Data archive

The velocity data will be reconstructed using CTD depth data. The all data will be archived by the member of TOCS project at JAMSTEC.

All data will be submitted to DMO at JAMSTEC within 3 years after each recovery.

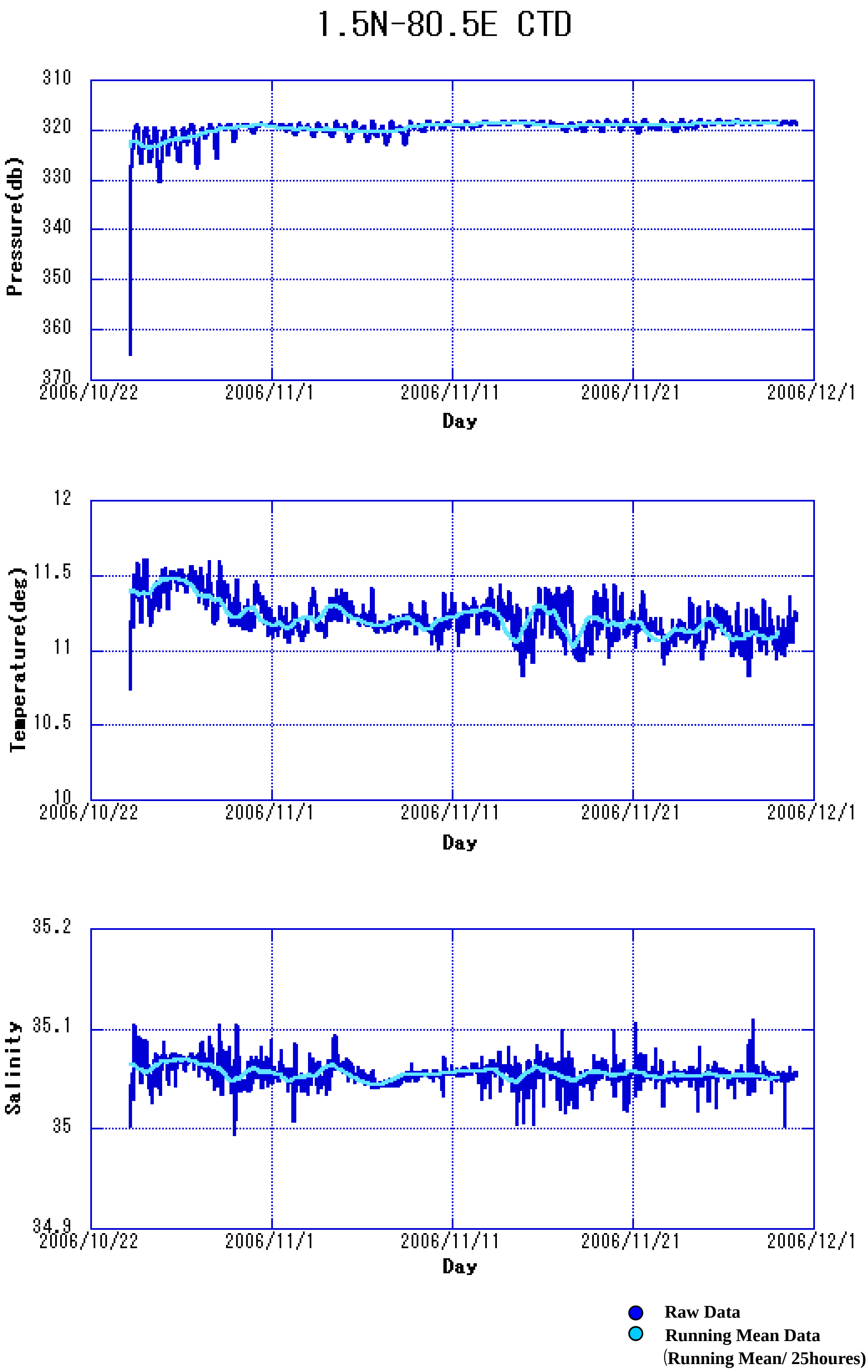


Fig.7.2-1 Time Series of pressure, temperature, salinity of obtained with CTD of 1.5N-80.5E mooring (2006/10/24-2006/11/30)

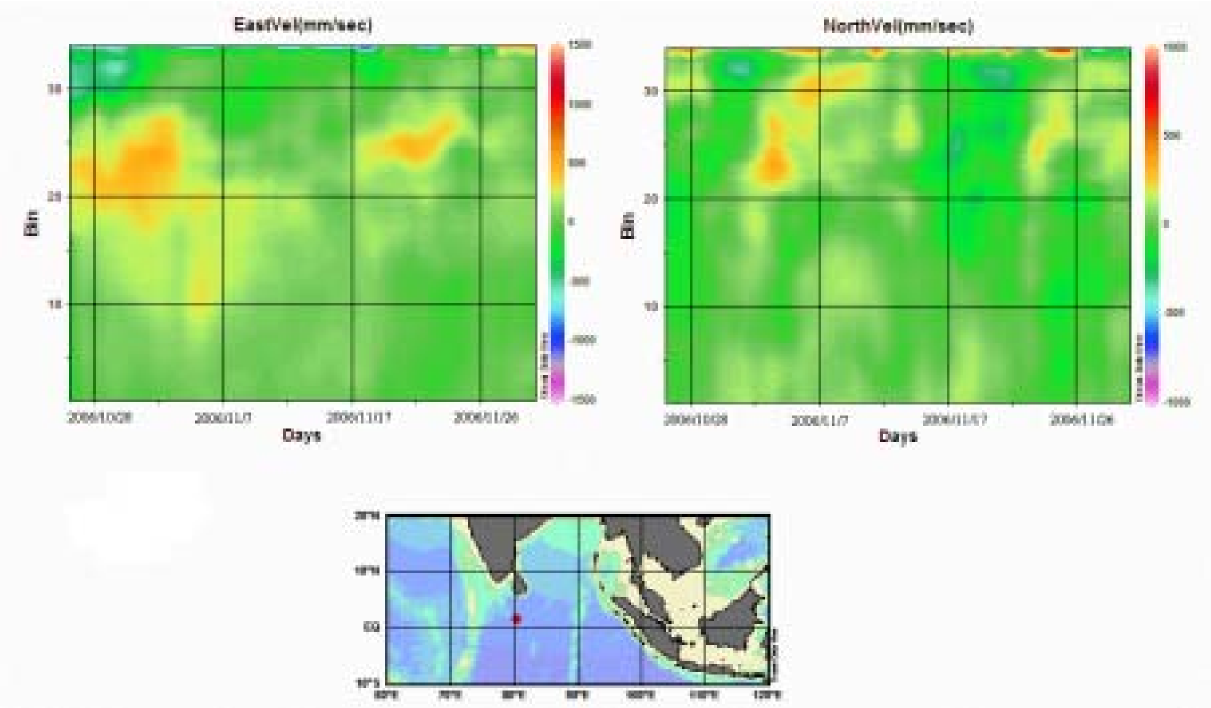


Fig.7.2-2 Time Series of zonal and meridional velocities of 1.5S-80.5E mooring
(2006/10/26-2006/12/1)

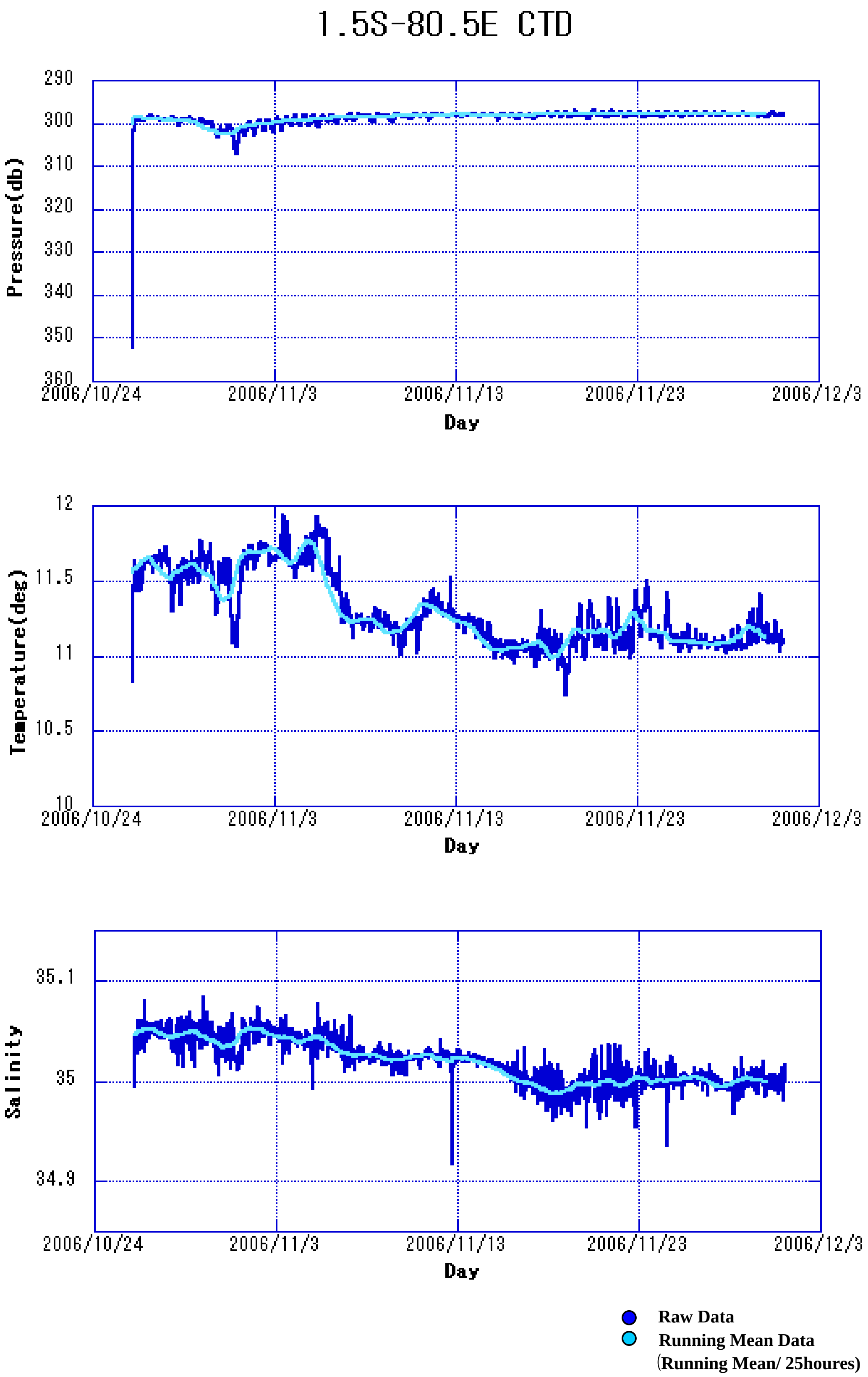


Fig.7.2-3 Time Series of pressure, temperature, salinity of obtained with CTD of 1.5S-80.5E mooring (2006/10/26-2006/12/1)

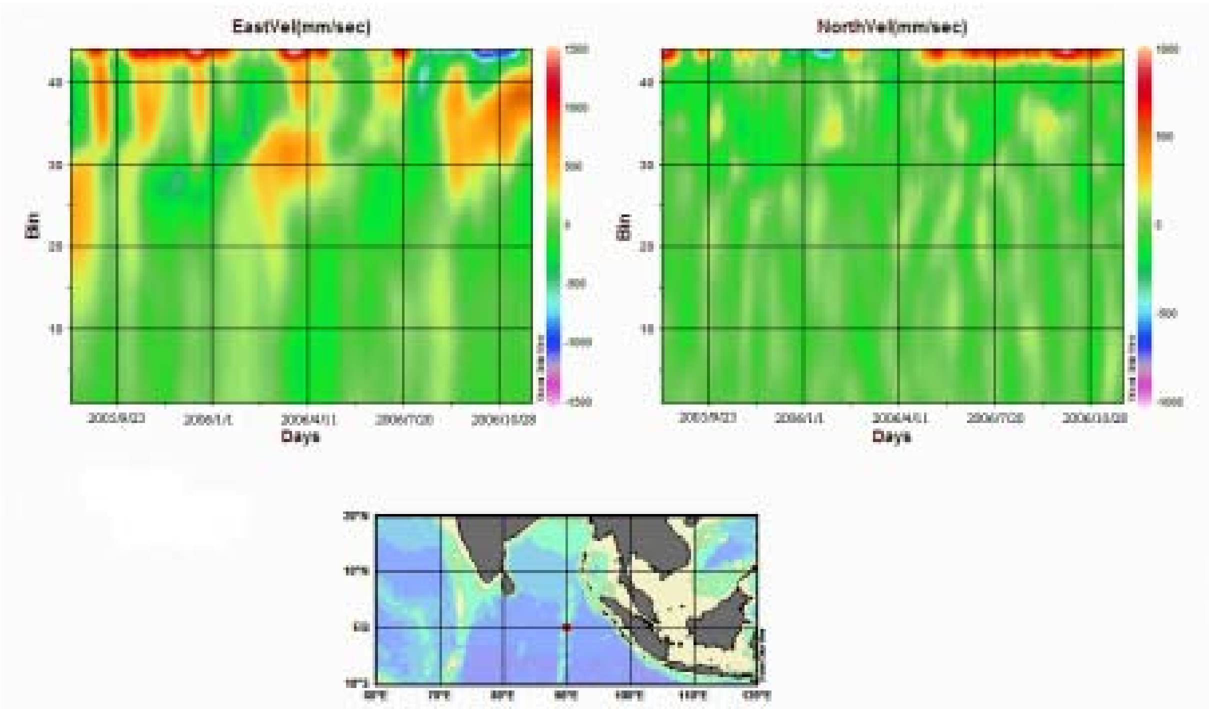


Fig.7.2-4 Time Series of zonal and meridional velocities of EQ-90E mooring (2005/8/9-2006/12/3)

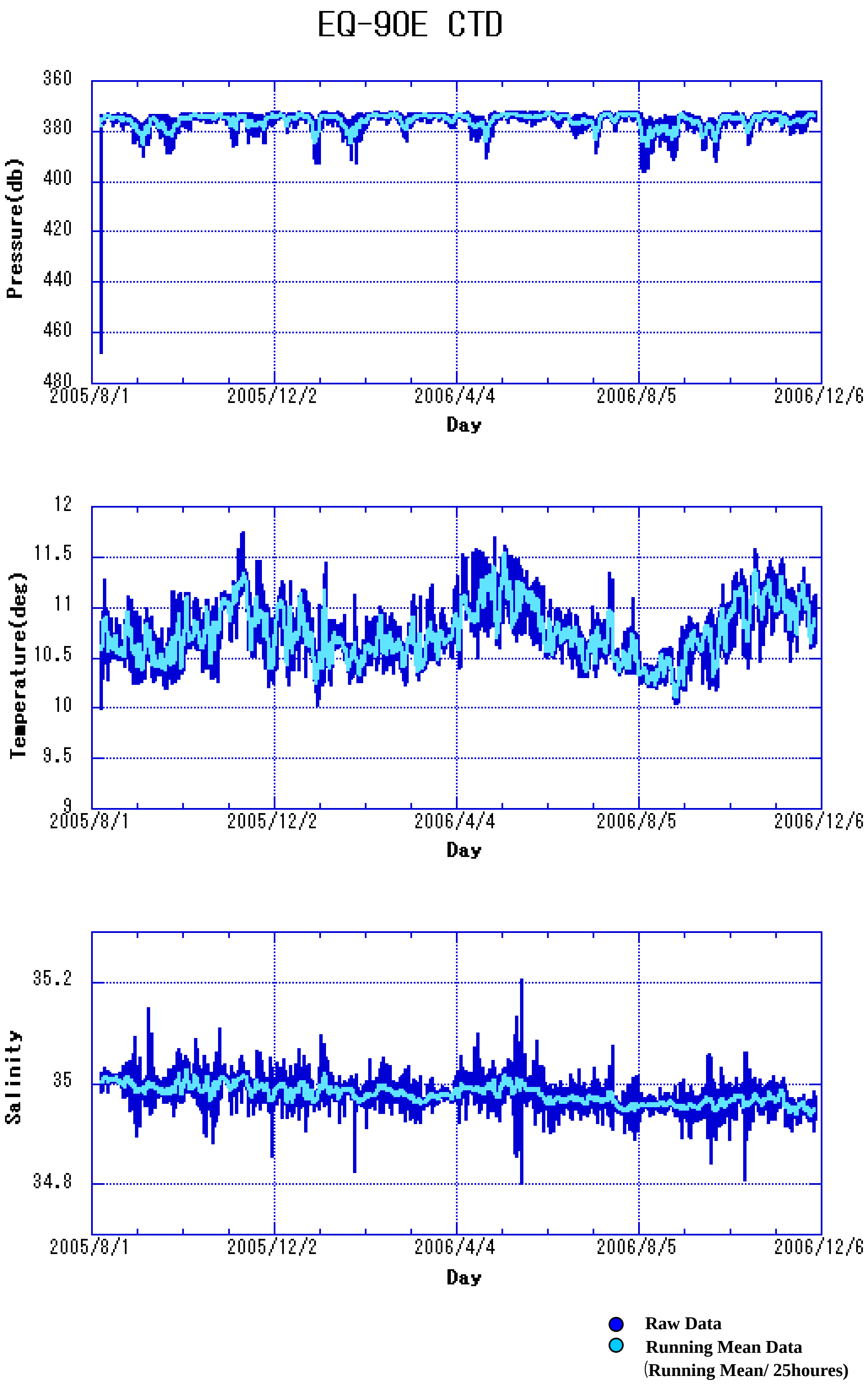


Fig.7.2-5 Time Series of pressure, temperature, salinity of obtained with CTD of EQ-90E mooring (2005/8/8-2006/12/3)

7.3 m-TRITON mooring operation

(1) Personnel

Keisuke Mizuno	(JAMSTEC): Principal Investigator (Not on board)
Yoshifumi Kuroda	(JAMSTEC): Engineer (On-board Principal Investigator)
Hideaki Hase	(JAMSTEC): Oceanographer
Koichi Takao	(MWJ): Technical Staff
Keisuke Matsumoto	(MWJ): Technical Staff
Tomohide Noguchi	(MWJ): Technical Staff
Toru Idai	(MWJ): Technical Staff
Masaki Furuhata	(MWJ): Technical Staff
Masaki Yamada	(MWJ): Technical Staff

(2) Objective

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has developed new oceanic observation buoy which called m-TRITON buoy, for the purpose to understand the characteristics of the atmospheric and oceanic variability in the eastern Indian Ocean and to compose the Indian Ocean buoy array in the international effort.

The m-TRITON buoy was deployed at 1.5S-90E in this cruise to compare the data with TRITON buoy at same area.

(3) Method

The m-TRITON buoy observes oceanic parameters and meteorological parameters as follows:

Meteorological parameters:	wind speed, direction, air temperature, relative humidity, shortwave radiation, precipitation.
Oceanic parameters:	water temperature and conductivity

Details of the instruments used on the m-TRITON buoy is summarized as follows:

<u>Oceanic sensors</u>

1) CTD (Conductivity-Temperature-Depth meter, Sea Bird Electronics Inc.)

SBE-37 IM Micro CAT

A/D cycles to average :	4
Sampling interval :	600sec
Measurement range, Temperature :	-5～+35 deg-C
Measurement range, Conductivity :	0～+7 S/m

Measurement range, Pressure : 0～full scale range

2) TD (Temperature and Depth meter, Sea Bird Electronics Inc.)

SBE-39 IM

Sampling interval : 600sec

Measurement range, Temperature : -5～+35 deg-C

Measurement range, Pressure : 0～full scale range

Meteorological sensors

1) Precipitation (R.M.Young Co.)

MODEL50202/50203

Sampling interval : 600sec

2) Relative humidity/air temperature (Rotronic Co.)

MODEL MP101A

Sampling interval : 600sec

3) Shortwave radiation (Eppley Co.)

MODEL PSP

Sampling interval : 600sec

4) Wind speed/direction (R.M.Young Co.)

MODEL 05106

Sampling interval : 600sec

*Meteorological sensors were assembled that used A/D (Analougue/Digital) conversion PCB (Print Cycle Board) made from MARITEC(Marine Technology Center)/JAMSTEC

Data logger and ARGOS transmitter

1) Data logger

I/O: RS485 has controlled of meteorological sensors.

RS232C has controlled of compass , GPS and Inductive modem.

2) ARGOS transmitter

Hourly averaged data are being transmitted through ARGOS transmitter.

(4) Results

The location of deployment is as follow:

The location of deployment

Nominal location 1.5S, 90E

ID number at JAMSTEC 18501

ARGOS PTT number	24770
ARGOS backup PTT number	24742
Deployed date (UTC)	04 Dec. 2006
Exact location	01 - 42.98N, 90 - 08.78E
Depth	4760 m

(5) Data archive

Hourly averaged data were transmitted via ARGOS satellite data-transmission system in real time. These data will be archived at the JAMSTEC Yokosuka Headquarters. And the data will be distributed world wide through internet from the JAMSTEC web site (http://www.jamstec.go.jp/).

7.4 ARGO profiling float deployment

(1) Personnel

Nobuyuki Shikama	(JAMSTEC): Principal Investigator (not on board)
Mizue Hirano	(JAMSTEC): not on board
Tomohide Noguchi	(MWJ): Technical Staff
Masatomo Hisazumi	(MWJ): Technical Staff

(2) Objectives

The objective of deployment is to clarify the structure and temporal/spatial variability of water masses in the eastern Indian Ocean.

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

(3) Parameters

・water temperature, salinity, and pressure

(4) Methods

・Profiling float deployment

We launched one APEX float of JAMSTEC. This float equips an SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc.

The floats usually drift at a depth of 1500 dbar (called the parking depth), rising up to the sea surface every ten days by increasing their volume and thus changing the buoyancy. During the ascent, they measure temperature, salinity, and pressure. They stay at the sea surface for approximately twelve hours, transmitting their positions and the CTD data to the land via the ARGOS system, and then return to the parking depth by decreasing volume. The details and the launch place of float are shown below.

≪Information about float≫

Float Type	：APEX floats manufactured by Webb Research Ltd.
CTD sensor	：SBE41 manufactured by Sea-Bird Electronics Inc.
ARGOS PTT ID	：66078
Target Parking Pressure	：1500dbr

≪Information about launch≫

Date and Time of Reset	：2006/12/08 07:02(UTC)
Date and Time of Launch	：2006/12/08 10:11(UTC)
Location of Launch	：Lat: 04-56.55S　Long: 095-01.71E

(5) Data archive

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

7.5 Doppler radar and radiosonde observation

7.5.1 Doppler radar observation

(1) Personnel

Ryuichi SHIROOKA	(JAMSTEC)	Principal Investigator
Hiroyuki YAMADA	(JAMSTEC)	
Ayako SEIKI	(JAMSTEC)	
Tomoki MIYAKAWA	(JAMSTEC/University of Tokyo)	
Souichiro SUEYOSHI	(GODI)	
Norio NAGAHAMA	(GODI)	
Ryo OHYAMA	(GODI)	

(2) Objective

The Doppler radar is operated to obtain detailed spatial and temporal distribution of rainfall amount, and structure of precipitating cloud systems.

(3) Methods

The hardware specification of this shipboard Doppler radar (RC-52B, manufactured by Mitsubishi Electric Co. Ltd., Japan) is:

Frequency:	5290 MHz
Beam Width:	better than 1.5 degree
Output Power:	250 kW (Peak Power)
Signal Processor:	RVP-7 (Sigmet Inc., USA)
Inertial Navigation Unit:	PHINS (IXSEA SAS, France)
Application Software:	IRIS/Open (Sigment Inc., USA)

The observation is performed continuously from 2300UTC, 28 November 2006, to 0830 UTC, 10 December 2006. During the observation period, the “surveillance” PPI (Plan Position Indicator) at one elevation angle with Intensity mode (300 km range for reflectivity) had been obtained every 30 minutes. The “volume scan” (consists of PPIs for 21 elevations) with Doppler-mode (160 km range for reflectivity and Doppler velocity) had been obtained every 10 minutes. In addition, RHI (Range Height Indicator) scans were operated to obtain detailed vertical cross sections with Doppler mode. The Doppler velocity in the volume scans is unfolded automatically by dual-PRF unfolding algorithm.

(4) Preliminary Results

The surveillance PPI reflectivity every 24 hours are shown in Fig. 7.5.1-1

(5) Data Archive

The inventory information of the Doppler radar data will be submitted to JAMSTEC DMD. The original data will be archived at and available from R. Shirooka of JAMSTEC.

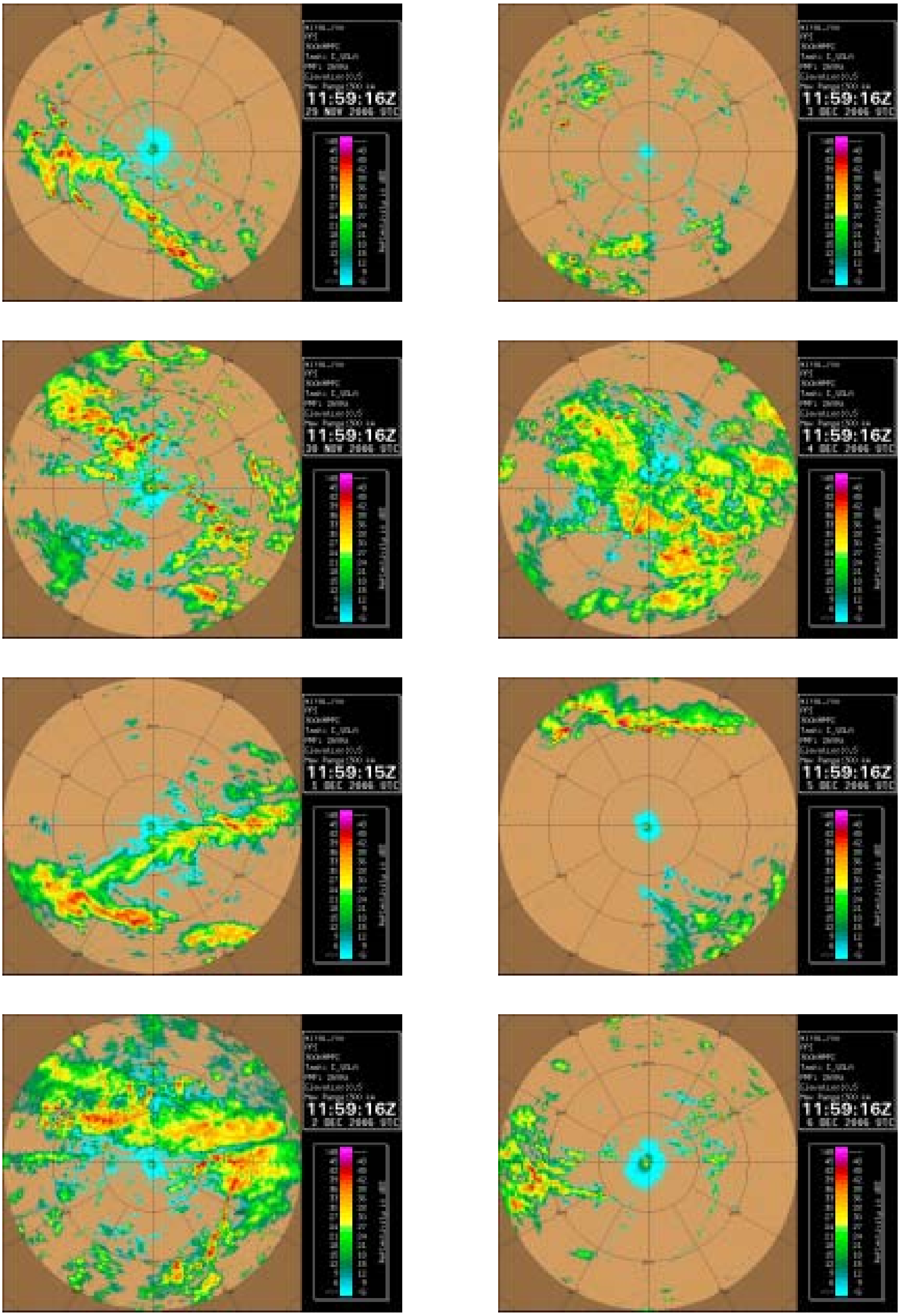


Fig. 7.5.1-1 Doppler radar reflectivity 300km in radius during MR06-05 Leg2.

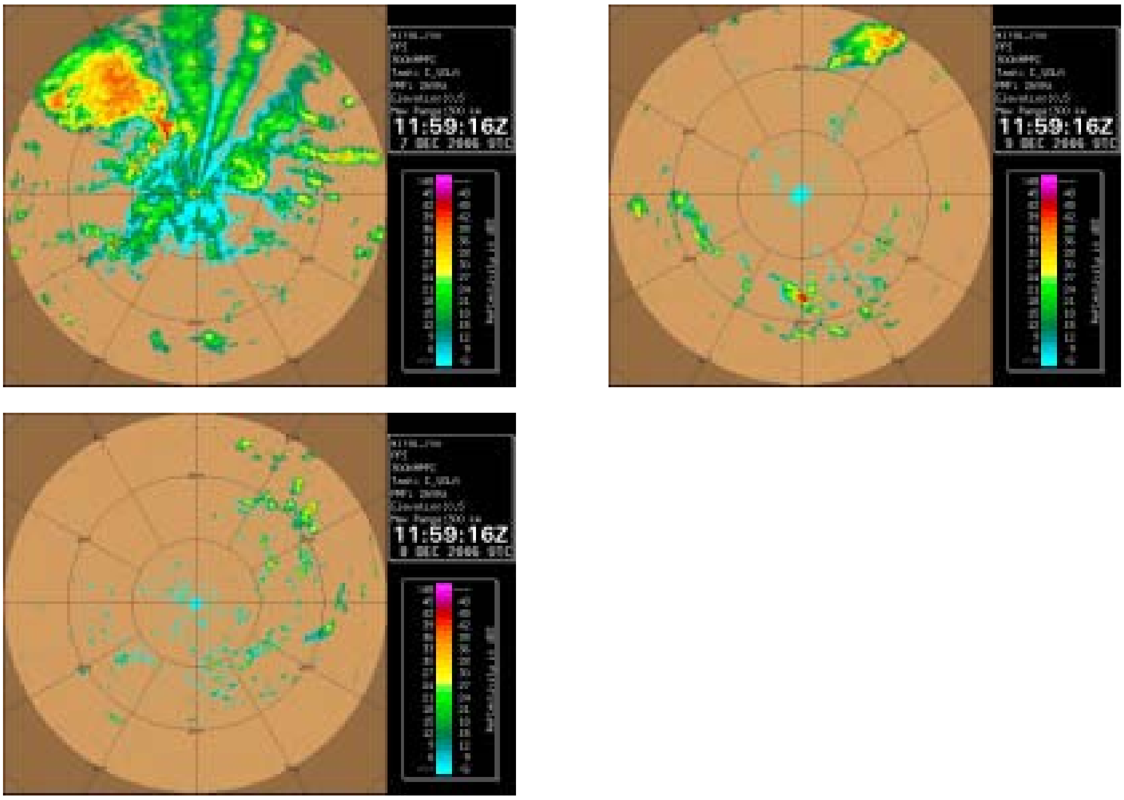


Fig. 7.5.1-1 (continued)

7.5.2 Radiosonde observation

(1) Personnel

Ryuichi SHIROOKA	(JAMSTEC)	Principal Investigator
Hiroyuki YAMADA	(JAMSTEC)	
Ayako SEIKI	(JAMSTEC)	
Tomoki MIYAKAWA	(JAMSTEC/University of Tokyo)	
Souichiro SUEYOSHI	(GODI)	
Norio NAGAHAMA	(GODI)	
Ryo OHYAMA	(GODI)	

(2) Objective

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

(3) Method

Atmospheric sounding by radiosonde was carried out every 6 hours from November 29, 2006 through December 10, 2006. In total, 52 soundings were carried out (Table 7.5.2-1). The main system consists of processor (Vaisala, DigiCORA III), GPS antenna (GA20), UHF antenna (RB21), balloon launcher (ASAP), and GPS radiosonde sensor (RS92-SGP).

(4) Results

Figure 7.5.2-1 shows vertical profiles of temperature and dew point temperature on the thermodynamic chart with wind profiles.

(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 Data Management Office. Corrected and projected onto every 5hPa level datasets are also available from R. Shirooka of JAMSTEC.

Table 7.5.2-1 Radiosonde launch log.

Date & Time	Position		Surface Data					Max. height		Cloud	
YYMMDDHH	degN	degE	hPa	degC	%	deg	m/s	m	hPa	Amount / Type	
06112900	2.7689	77.2023	1006.4	27.7	79	83	3.1	22901	34.3	1	Unknown
06112906	2.3553	78.3355	1008.5	28.7	77	10	3.6	23075	33.5	8	Cu, Ac, As
06112912	2.1126	78.9847	1006.1	28.1	78	28	5.0	21919	40.1	5	Cu, Cb, As, Ci
06112918	1.8082	79.6186	1008.7	27.7	80	0	4.0	24424	27.0	4	Cu, Sc
06113000	1.5734	80.2008	1006.3	27.8	85	98	4.7	24026	28.6	8	Unknown
06113006	1.4763	80.3915	1009.5	27.5	85	237	6.2	25259	23.7	8	Cu, Cb, Ac, As
06113012	1.2649	80.5428	1006.3	26.8	89	270	11.2	20042	54.8	10	Cu, Cb
06113018	0.0603	80.4398	1009.7	28.0	82	338	3.3	18198	75.4	10	Cu, As, Sc
06120100	-1.1390	80.3697	1007.2	26.8	84	327	6.5	23132	33.1	7	Cu, As, Sc
06120106	-1.4924	80.3487	1008.9	28.3	76	316	11.4	26546	19.5	8	Cu, Ac
06120112	-1.4021	81.2029	1006.1	27.6	80	289	4.8	21359	44.0	10	Cu, Ac, As, Sc
06120118	-1.1618	82.7742	1008.9	25.2	91	204	2.5	5152	547.7	10	As
06120200	-0.8819	84.3633	1006.7	26.7	86	231	4.2	25944	21.2	9	Cu, Ac, Sc
06120206	-0.6589	85.8589	1008.2	26.6	86	200	4.5	25662	22.2	9	Cu, Cb, Ac, As, Ns
06120212	-0.3958	87.3532	1006.7	27.3	85	202	6.0	20187	53.4	10	Cu, Ac, As
06120218	-0.1571	88.5857	1009.5	26.0	89	158	5.7	21278	44.8	10	Cu, As, Sc
06120300	0.0253	89.7314	1006.3	26.4	85	179	5.1	24143	28.2	8	Cu, Ac, Ns
06120306	0.0203	90.0883	1008.4	29.1	75	87	2.6	25853	21.6	7	Cu, Ac
06120312	0.0513	89.9256	1006.6	28.1	77	59	2.9	23565	30.9	10	Cu, Ac, As
06120318	-0.8967	90.0770	1008.5	27.6	86	23	3.2	23761	30.0	9	Cu, Cb, Ac
06120400	-1.7315	90.0454	1007.9	24.5	94	32	2.6	21154	45.7	10	Ns
06120406	-1.7170	90.1427	1008.8	27.3	84	242	3.7	22347	37.7	9	Cu, Cb, As
06120412	-1.6548	90.0083	1007.6	25.3	90	302	9.3	19804	57.3	10	Ns
06120418	-1.6439	90.0923	1009.6	26.9	83	293	9.1	22124	39.1	10	Cb, As
06120500	-1.5971	90.1162	1008.9	24.3	98	346	1.8	4978	558.7	10	Ns
06120503	-1.5550	90.1203	1010.9	24.4	94	242	6.2	22191	38.7	10	Ns
06120506	-1.5861	90.0911	1008.5	25.4	94	239	5.3	23453	31.5	10	Cu, As, Sc
06120509	-1.6433	90.0111	1006.6	27.0	77	214	5.5	24670	25.7	8	Cu, Ac
06120512	-1.6425	90.0281	1006.3	27.3	78	240	5.9	22984	33.8	5	Ac, As
06120515	-1.6599	90.0259	1008.9	27.5	80	228	5.2	23327	32.1	9	Ac, As
06120518	-1.6896	90.0075	1008.8	27.8	76	217	4.9	23877	29.3	4	Ac
06120521	-1.6909	90.0082	1007.3	27.5	81	255	3.5	23989	28.7	4	Cu, Ac

06120600	-1.6692	90.0106	1006.8	27.3	82	254	3.1	25275	23.6	2	Cu, Ac
06120603	-1.6537	89.9896	1009.2	27.2	84	301	5.4	24067	28.8	6	Cu, Ac
06120606	-1.6532	90.0006	1008.6	28.5	79	271	5.7	21359	44.2	4	Cu, Cb, Ci
06120612	-2.3699	91.0605	1005.9	27.6	82	279	7.8	23922	28.9	3	Cu, Cb, Cc, Cs
06120618	-3.2484	92.3659	1008.1	27.0	88	279	7.4	22670	35.5	5	Cb, As
06120700	-4.1504	93.6640	1007.3	25.9	91	249	11.8	23198	32.5	10	Ns
06120706	-5.0165	94.9506	1008.6	27.4	83	252	6.2	22866	34.4	10	Cu, Sc, Ns
06120712	-4.9664	94.9886	1007.0	27.1	88	340	8.1	21748	41.1	10	Cu, Sc, Ns
06120718	-4.9703	95.0218	1007.8	27.0	87	268	10.7	23912	29.0	3	Cu, Ac
06120800	-4.9476	95.0094	1006.8	27.4	85	249	6.9	24819	25.2	4	Cu, Ac, Ci
06120806	-4.9396	95.0136	1007.6	29.4	74	270	3.4	25596	22.4	3	Cu, Ci
06120812	-4.7703	95.0239	1006.1	27.8	82	325	2.7	23294	32.0	5	Cu, Sc, Ci
06120818	-3.5281	94.9713	1008.5	27.5	83	313	1.7	20679	49.3	1	Cu, Ac
06120900	-2.2763	94.9015	1007.6	27.4	84	215	2.7	24407	26.9	5	Cu, Cb, As
06120906	-1.2478	94.4875	1008.5	28.0	80	270	2.4	23420	31.5	3	Cu, Cb, Ci, Cs
06120912	-0.5542	93.6362	1006.6	27.7	81	303	2.8	24580	26.1	5	Cu, As, Sc, Ci
06120918	0.2354	92.9164	1008.8	27.5	83	320	2.2	24249	27.7	2	Cu, Ac
06121000	1.1855	92.2602	1008.0	27.6	82	333	5.6	24931	24.8	4	Cu, Cb, Cs
06121006	2.3275	91.9164	1008.7	28.5	80	295	4.1	24287	27.3	4	Cu, Ac, Ci
06121012	3.2849	91.9159	1006.2	28.1	80	287	4.9	22396	37.1	4	Cu, Cs, Ci

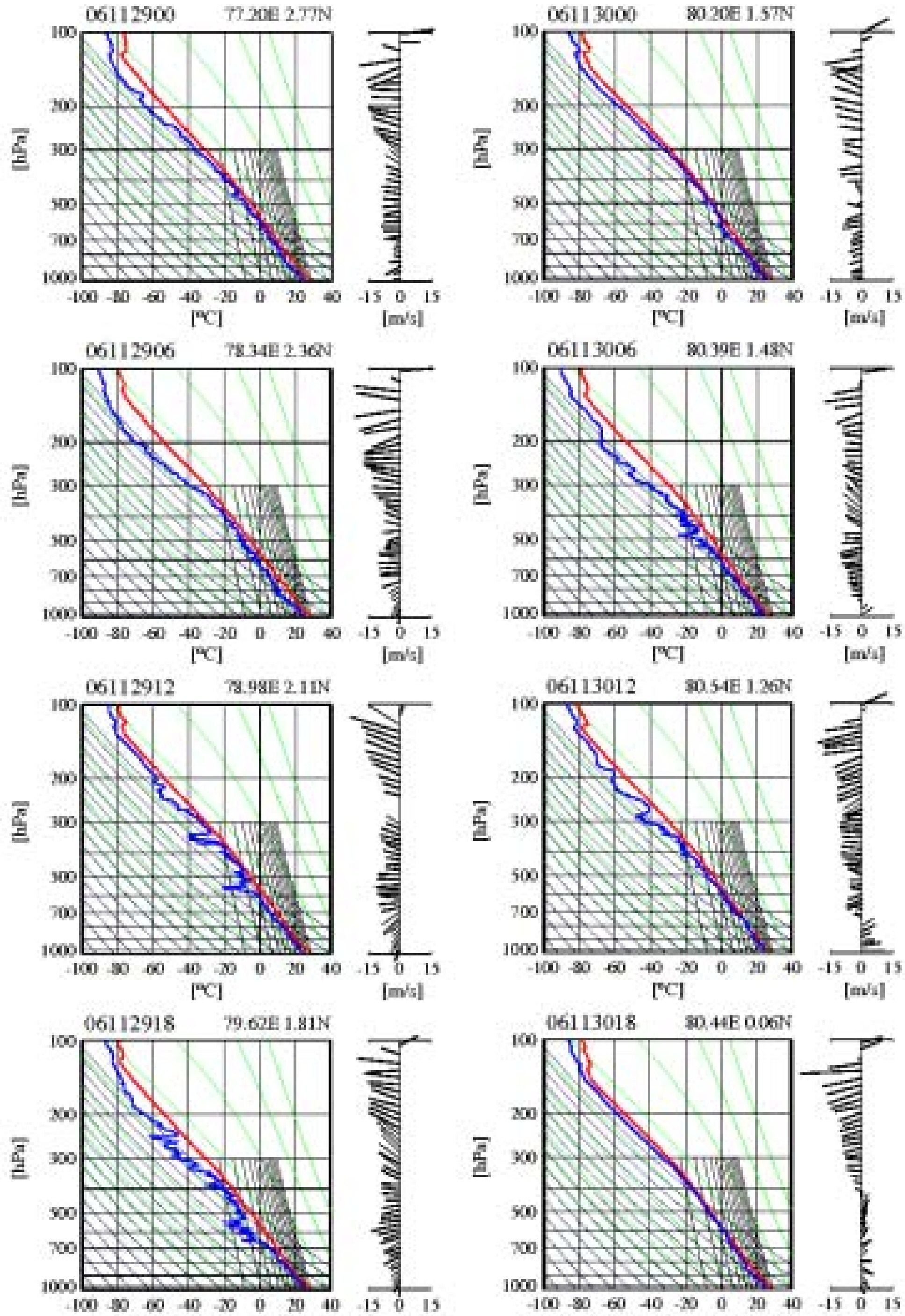


Fig. 7.5.2-1 Thermodynamic chart during MR06-05 Leg2.

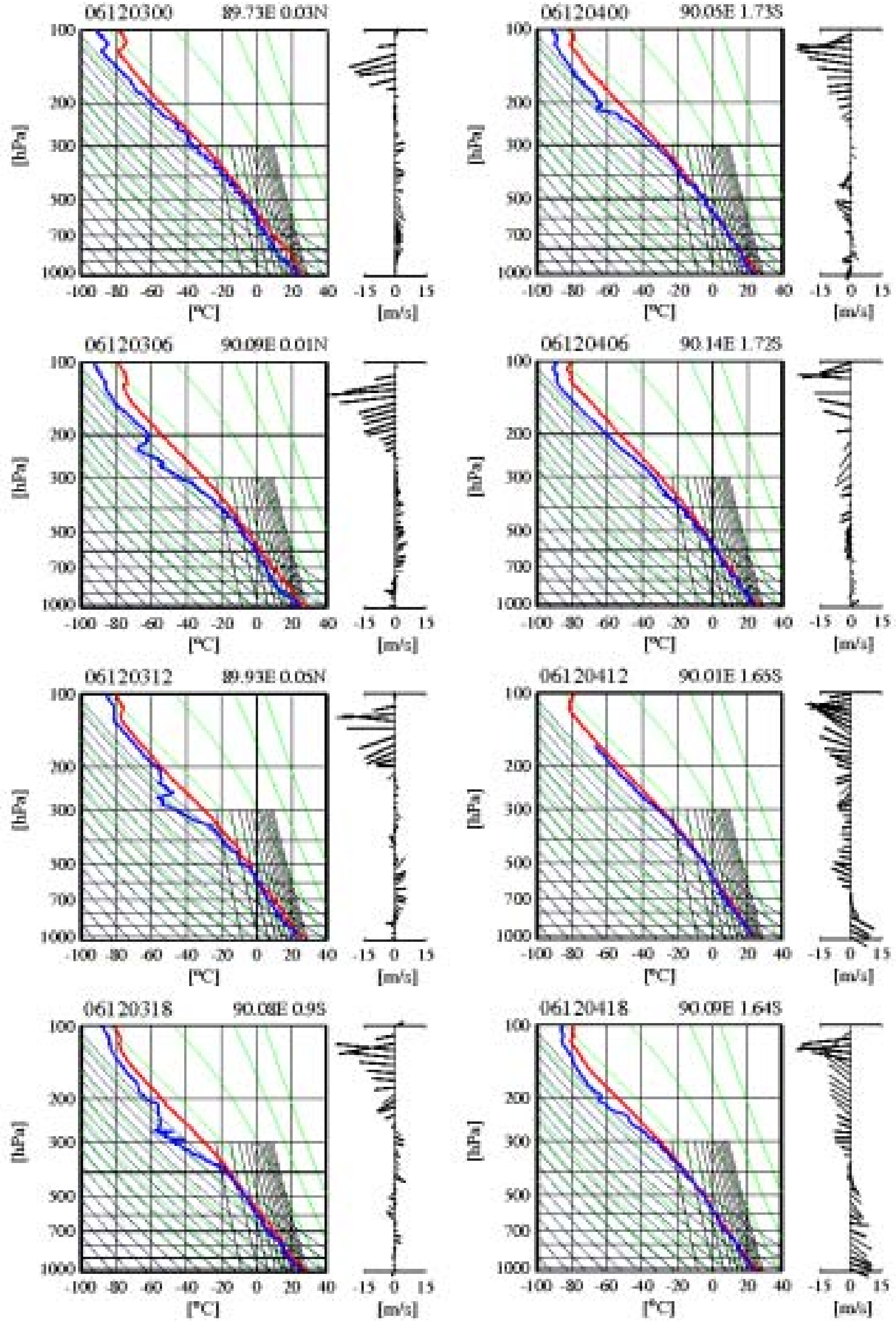


Fig. 7.5.2-1 (continued)

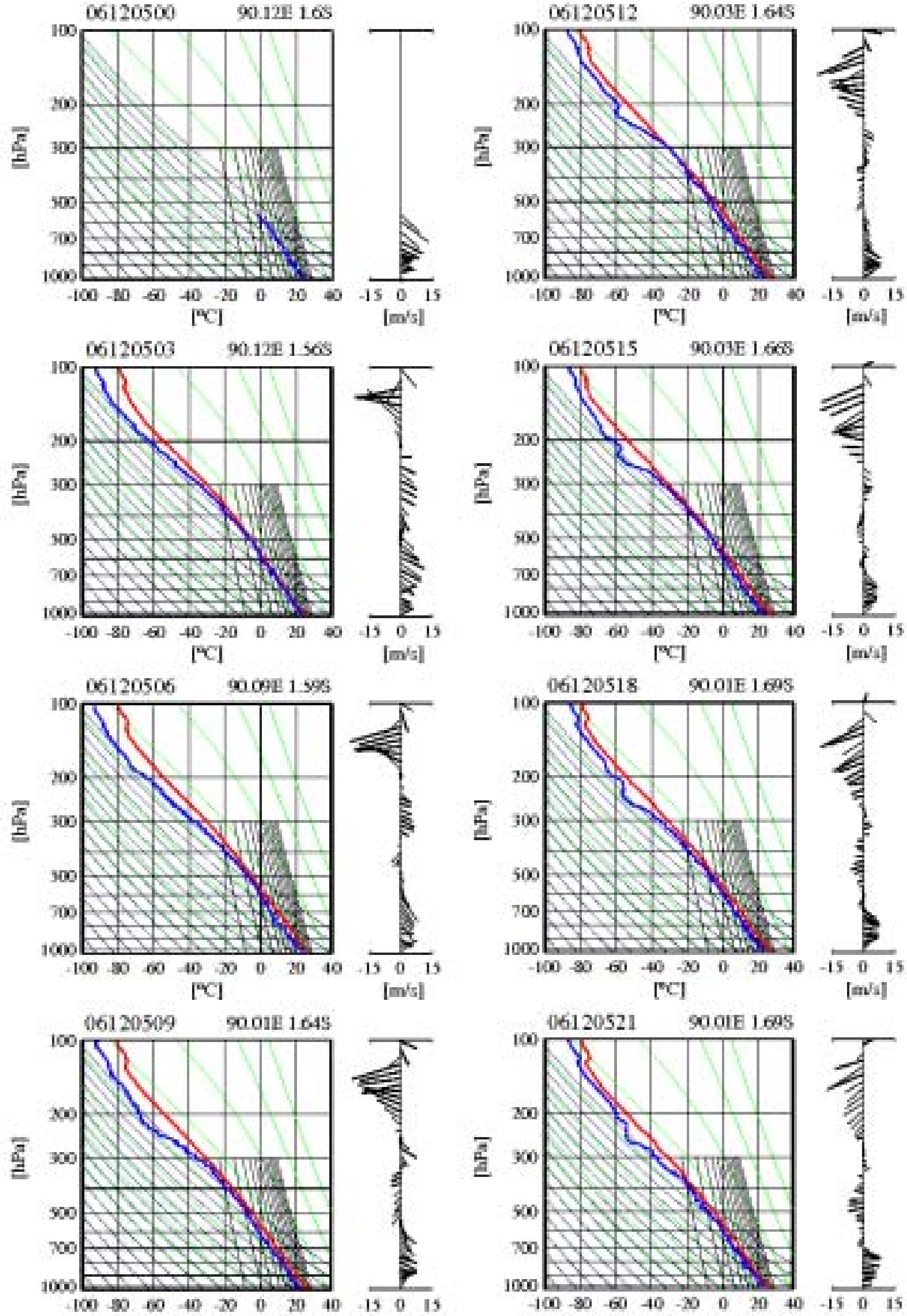


Fig. 7.5.2-1 (continued)

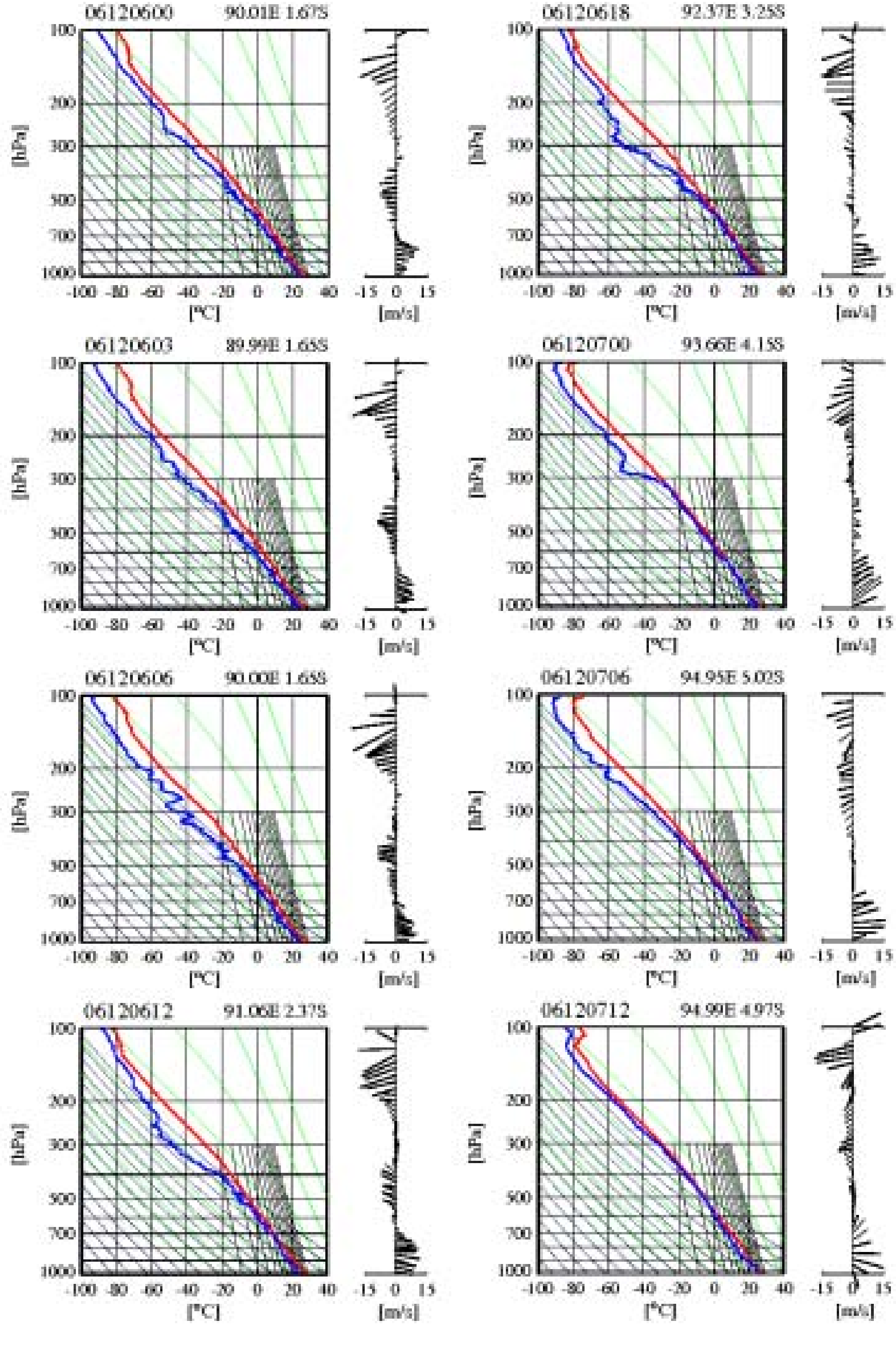


Fig. 7.5.2-1 (continued)

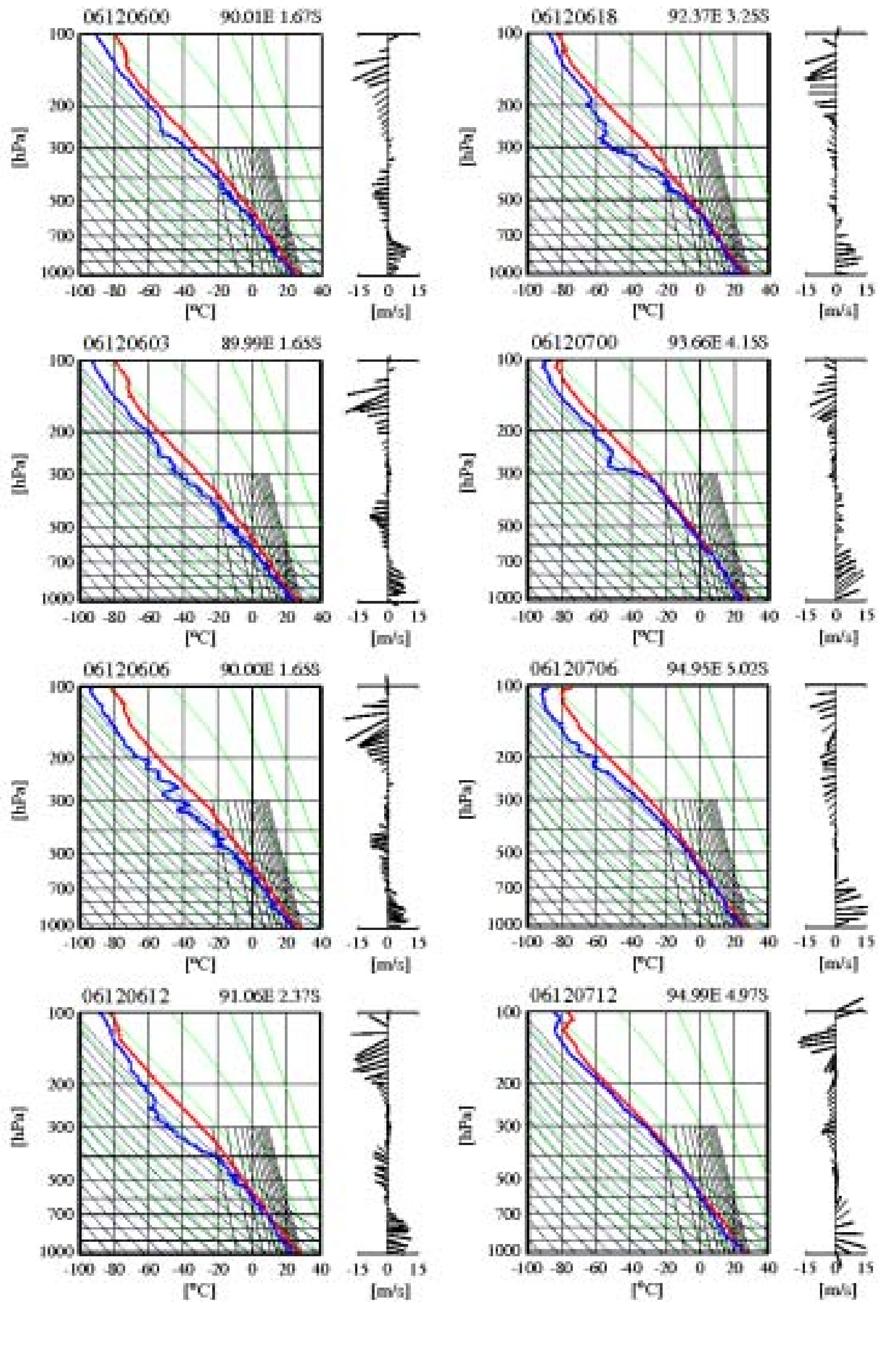


Fig. 7.5.2-1 (continued)

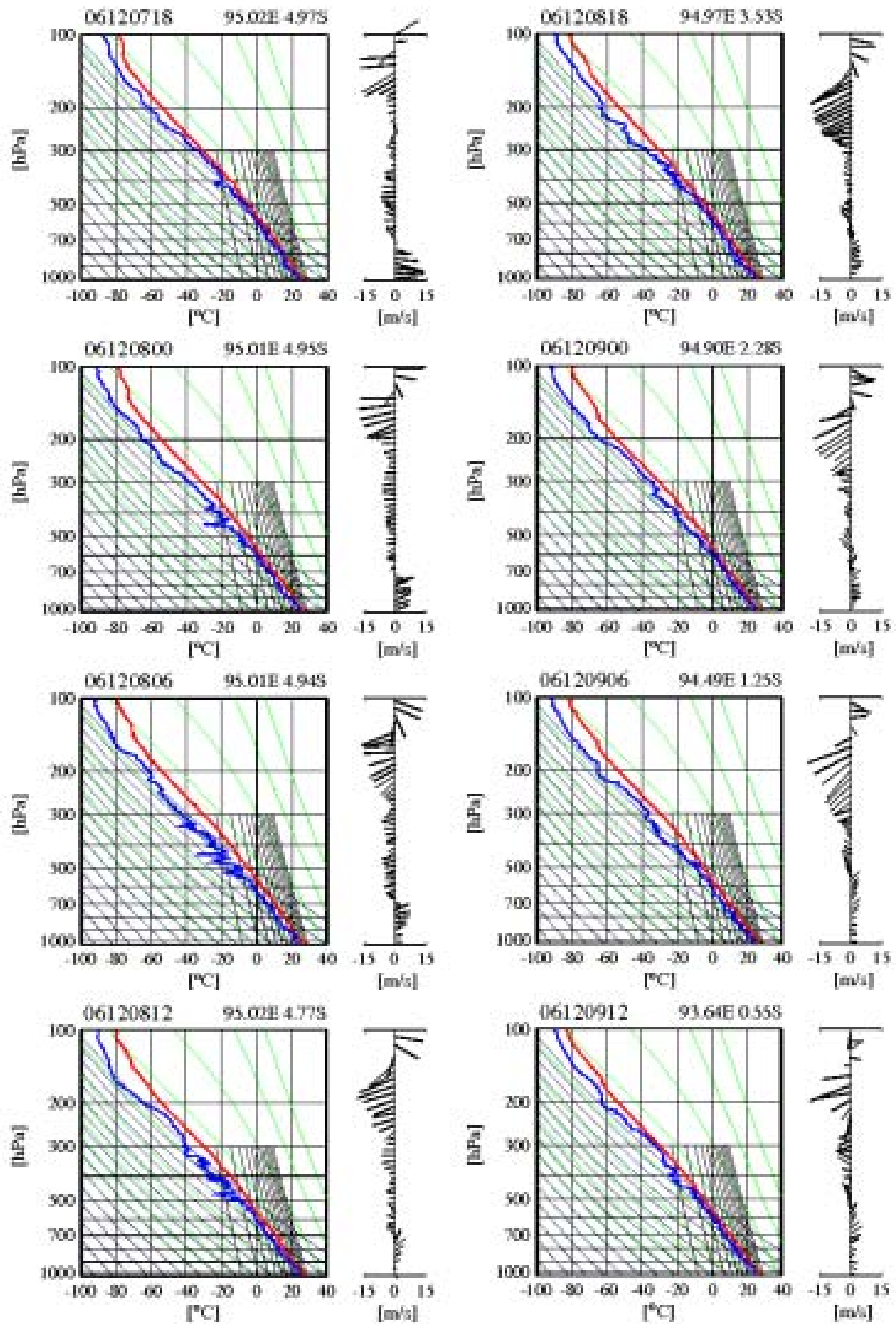


Fig. 7.5.2-1 (continued)

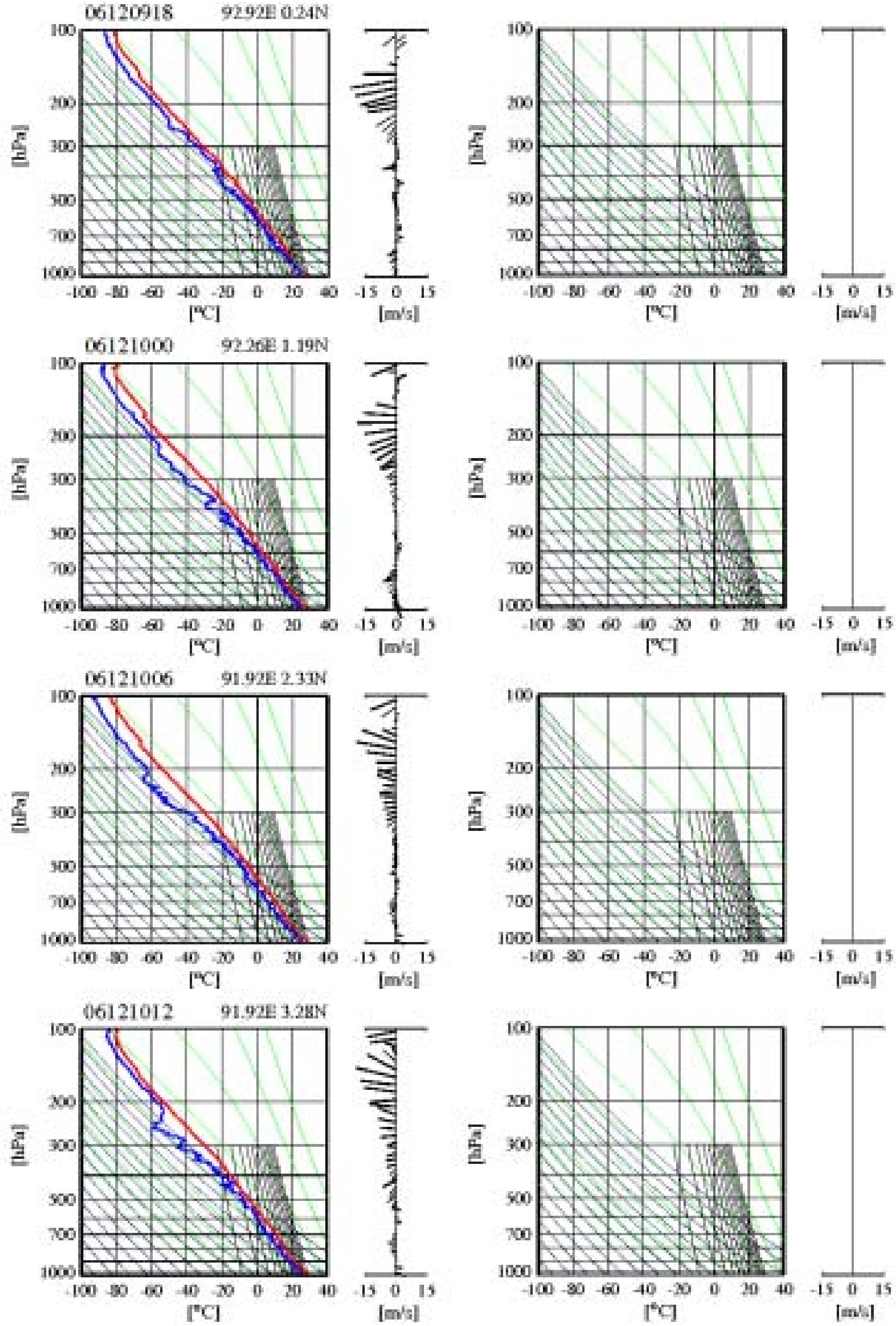


Fig. 7.5.2-1 (continued)

7.6 Lidar observations of clouds and aerosols

(1) Personnel

Nobuo Sugimoto, Ichiro Matsui, Atsushi Shimizu (National Institute for Environmental Studies, not on board), lidar operation was supported by Mr. Kinoshita (Chiba University).

(2) Objectives

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

(3) Measured parameters

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

(4) Method

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

(5) Results

Full lidar raw data is still under data processing and analysis. So we show here only sample vertical profiles of backscattering intensity, Figure 1 shows an atmospheric structure revealed by lidar on December 1, 2006. There were two cloud layers around 8 km and 12.5 km. Similar profiles are obtained every 15 minutes, and three dimensional structure of atmospheric scatterers (clouds and aerosols) are revealed in whole troposphere.

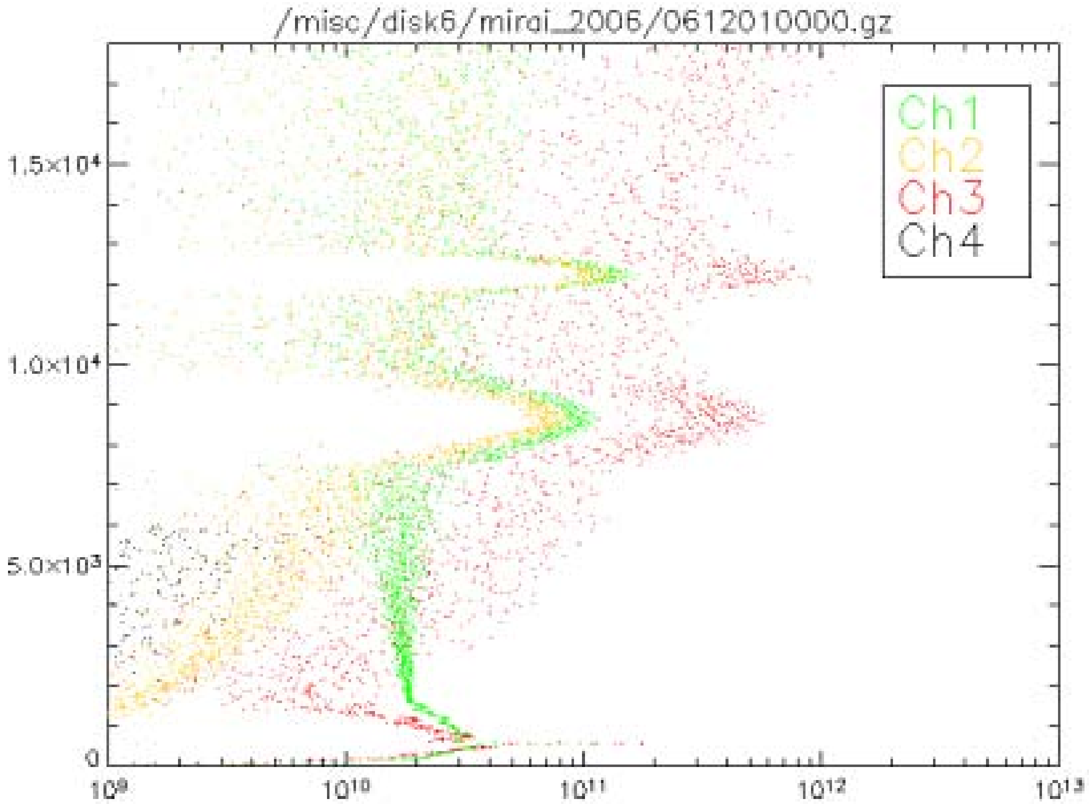


Figure 1: Vertical profiles of backscattering intensity at 532 nm parallel (green), 532 nm perpendicular (yellow), 1064 nm (red) on December 1, 2006. Black indicates signal from near field telescope (532nm).

(6) 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 : November 28 2006 – December 13, 2006

- 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

7.7 Rain and Water Vapor sampling for Stable Isotope Measurement

(1) Personnel

Naoyuki Kurita (JAMSTEC) Principal Investigator
Kimpei Ichiyanagi (JAMSTEC)
Mayumi Horikawa (Nagoya University)

(2) Objective

Stable isotopes in water (HDO and $H_2^{18}O$) are powerful tool to study of the moisture origin of precipitation associated with MJO. Sampling of rainwater and atmospheric moisture was performed for stable isotope analyses throughout the MR06-05 Leg2 cruise from Maldives on November 28, 2006 to Singapole on December 13, 2006.

(3) Method

Following observation was carried out throughout this cruise

- Atmospheric moisture sampling:

  Water vapor was sampled at the two heights above sea level, namely foremast and mainmast height. The cryogenic method that air was drawn at the 3L/min for about 6 hour from the intake point through a glass trap cooled by radiator around -100℃ was used for water vapor sampling

- Measurement of the mixing ratio at the sampling levels.

  The 10 min average of air temperature and relative humidity (Vaisala Co. Ltd., HMP45) was measured at the air intake point. The mixing ratio of each level was determined in each level using temerature and relative humidity.

- Rainwater sampling

  Precipitation sampling was collected every 3 hours with auto-precipitation sampler developed by JAMSTEC (Masinax Co., Ltd. , MAS-UK150-1). All precipitation during the period falls through a funnel and pooled in the rain collector, then 10 ml of the water is mechanically transferred to an airtight sample container.

(4) Results

The sampling coordinates and meteorological condition for all water vapor samples are summarized in Table 7.7-1 for foremast (49 samples) and Table 7.7-2 for mainmast (49 samples). The rainfall samples data (24 samples) is summarized in Table 7.7-3. It includes the sampling coordination and rainfall amount. As for the meteorological data, temporal variation of temperature, relative humidity, and mixing ratio are shown in Figure 7.7-1.

(5) Data archive

These raw data obtained during this cruise will be submitted to JAMSTEC Data Management Office. Analyzed stable isotope data (HDO and $H_2^{18}O$) are also available from N. Kurita of JAMSTEC.

Table 7.7-1 Summary of all water vapor data collected at the foremast height.

No	Date	Time UTC	Latitude N	Longitude E	Log Speed	Temp. ℃	RH %	Mixing ratio g/Kg	Sample g
1	20061129	0:00	2.525	77.855	11.43	28.8	0.71	17.703	22.5
2	20061129	6:00	2.212	78.718	7.93	28.1	0.76	18.349	22.9
3	20061129	12:00	1.908	79.378	6.83	28.1	0.77	18.544	23.4
4	20061129	18:00	1.664	79.973	6.16	27.5	0.8	18.772	23.9
5	20061130	0:00	1.5	80.38	3.08	26.8	0.83	18.607	23.4
6	20061130	6:00	1.47	80.538	5.4	27.2	0.81	18.539	23.7
7	20061130	12:00	0.52	80.495	12.18	27.6	0.79	18.602	24.4
8	20061130	18:00	-0.674	80.415	11.95	26.4	0.8	17.494	21.8
9	20061201	0:00	-1.057	80.386	7.74	27.2	0.78	17.778	22.7
10	20061201	6:00	-1.467	80.77	10.32	28.3	0.73	17.656	22.4
11	20061201	12:00	-1.241	82.237	15.92	26.6	0.82	18.029	24.2
12	20061201	18:00	-0.971	83.778	16.34	26.6	0.8	17.67	21.3
13	20061202	0:00	-0.832	84.638	15.93	27.2	0.78	17.952	22.7
14	20061202	6:00	-0.493	86.791	14.9	27.8	0.75	17.89	22.3
15	20061202	12:00	-0.23	88.12	12.61	26.8	0.8	17.774	24
16	20061202	18:00	-0.026	89.288	11.76	26.3	0.81	17.702	22
17	20061203	0:00	0.022	90.032	3.92	27.9	0.75	17.839	22.7
18	20061203	6:00	0.036	89.969	2.53	28.5	0.72	17.909	22.5
19	20061203	12:00	-0.516	90.033	10.43	28	0.76	18.301	23.5
20	20061203	18:00	-1.502	90.109	9.91	27.4	0.81	18.681	23.6
21	20061204	0:00	-1.697	90.167	3.34	27.1	0.8	18.224	23.3
22	20061204	6:00	-1.667	90.08	3.89	25.2	0.88	17.927	22.4
23	20061204	12:00	-1.635	90.073	1.34	26.5	0.82	18.012	23.1
24	20061204	18:00	-1.608	90.094	0.79	26.1	0.83	17.834	23.3
25	20061205	0:00	-1.576	90.112	1.53	24.6	0.9	17.594	22.1
26	20061205	6:00	-1.64	90.021	1.45	27.7	0.74	17.457	23.3
27	20061205	12:00	-1.662	90.023	1.45	27.7	0.75	17.548	22
28	20061205	18:00	-1.68	90.01	0.83	27.6	0.75	17.619	22.1
29	20061206	0:00	-1.654	89.995	1.3	28.7	0.73	18.261	23.2
30	20061206	6:00	-2.038	90.579	14.82	27.7	0.79	18.623	23.5
31	20061206	12:00	-2.907	91.865	15.86	27.6	0.78	18.268	22.7
32	20061206	18:00	-3.785	93.161	15.88	26.9	0.82	18.341	23.4
33	20061207	0:00	-4.666	94.457	14.56	28	0.76	18.218	23.2
34	20061207	6:00	-5.009	95.004	2.03	27.6	0.78	18.34	23.4

35	20061207	12:00	-4.968	95.027	2.81	27	0.83	18.716	23.9
36	20061207	18:00	-4.956	95.031	0.82	27.4	0.79	18.322	22.9
37	20061208	0:00	-4.943	94.991	1.94	29.3	0.72	18.478	23.7
38	20061208	6:00	-4.895	95.028	3.57	29.8	0.7	18.605	23.1
39	20061208	12:00	-3.964	95.002	12.42	27.7	0.79	18.599	24.8
40	20061208	18:00	-2.726	94.927	12.52	27.4	0.78	18.178	21.5
41	20061209	0:00	-1.592	94.745	12.06	28.8	0.73	18.297	23.1
42	20061209	6:00	-0.838	93.961	11.33	28.7	0.73	18.277	22.1
43	20061209	12:00	-0.081	93.214	11.05	28	0.76	18.082	23.5
44	20061209	18:00	0.831	92.513	11.79	27.7	0.77	18.237	23.9
45	20061210	0:00	1.841	91.973	12.55	29	0.73	18.629	22.4
46	20061210	6:00	2.954	91.922	9.85	28.9	0.73	18.598	23.4

Table 7.7-2 same as Table 7.7-1 but mainmast height

No	Date	Time UTC	Latitude N	Longitude E	Log Speed	Temp. ℃	RH %	Mixing ratio g/Kg	Sample g
1	20061129	0:00	2.522	77.864	11.47	28.2	0.73	17.658	21.7
2	20061129	6:00	2.211	78.72	7.92	27.7	0.77	18.193	23.6
3	20061129	12:00	1.902	79.391	6.8	27.8	0.78	18.466	23.3
4	20061129	18:00	1.659	79.984	6.13	27.2	0.82	18.695	23.6
5	20061130	0:00	1.5	80.384	3.22	26.4	0.85	18.442	22.8
6	20061130	6:00	1.459	80.539	5.45	26.6	0.83	18.334	23.4
7	20061130	12:00	0.512	80.493	12.17	27.3	0.8	18.476	23.2
8	20061130	18:00	-0.67	80.416	11.86	26.1	0.8	17.236	22.7
9	20061201	0:00	-1.451	80.355	3.3	27.4	0.77	17.794	21.9
10	20061201	6:00	-1.47	80.749	10.24	27.6	0.75	17.45	22.2
11	20061201	12:00	-1.242	82.23	15.92	26.3	0.83	17.997	25
12	20061201	18:00	-0.965	83.809	16.35	26.3	0.81	17.594	21.7
13	20061202	0:00	-0.728	85.287	15.53	27.1	0.79	17.998	22.2
14	20061202	6:00	-0.492	86.792	14.89	27	0.78	17.681	22.6
15	20061202	12:00	-0.231	88.118	12.61	26.5	0.81	17.71	22.9
16	20061202	18:00	-0.026	89.287	11.67	26	0.83	17.585	22.9
17	20061203	0:00	0.019	90.048	3.67	27.6	0.76	17.811	22.1
18	20061203	6:00	0.036	89.971	2.36	29.5	0.69	18.077	22.5
19	20061203	12:00	-0.513	90.032	10.43	27.7	0.78	18.28	24.4
20	20061203	18:00	-1.516	90.109	9.77	27	0.82	18.595	23.7
21	20061204	0:00	-1.696	90.17	3.23	26.6	0.82	18.121	22.1

22	20061204	6:00	-1.667	90.081	3.87	24.7	0.9	17.677	23
23	20061204	12:00	-1.635	90.073	1.35	26	0.83	17.76	22.8
24	20061204	18:00	-1.608	90.094	0.78	25.7	0.85	17.657	23.1
25	20061205	0:00	-1.577	90.111	1.62	24.3	0.91	17.53	22
26	20061205	6:00	-1.641	90.019	1.37	26.7	0.78	17.254	21.7
27	20061205	12:00	-1.66	90.023	1.44	27.3	0.76	17.357	21.8
28	20061205	18:00	-1.68	90.01	0.9	27.3	0.76	17.446	22.7
29	20061206	0:00	-1.654	89.995	1.21	27	0.8	18.088	22.1
30	20061206	6:00	-2.02	90.552	14.48	27	0.81	18.41	23.3
31	20061206	12:00	-2.904	91.861	15.86	27.2	0.79	17.938	23.3
32	20061206	18:00	-3.803	93.188	15.88	26.4	0.83	18.039	23.3
33	20061207	0:00	-4.67	94.462	14.74	27.1	0.78	17.8	21.7
34	20061207	6:00	-5.01	95.004	2.04	27	0.8	18.105	22.7
35	20061207	12:00	-4.968	95.026	2.78	26.5	0.84	18.483	24.3
36	20061207	18:00	-4.955	95.03	0.92	27	0.8	18.138	22.5
37	20061208	0:00	-4.943	94.991	1.86	27.6	0.78	18.297	22.7
38	20061208	6:00	-4.901	95.028	3.33	27.7	0.79	18.557	23
39	20061208	12:00	-4.006	95.003	12.41	27.4	0.8	18.622	24.2
40	20061208	18:00	-2.745	94.929	12.52	27.1	0.8	18.139	23.2
41	20061209	0:00	-1.588	94.748	12.06	27.9	0.77	18.263	21.8
42	20061209	6:00	-0.84	93.965	11.34	27.7	0.77	18.217	23
43	20061209	12:00	-0.068	93.202	11.05	27.4	0.78	18.024	23.7
44	20061209	18:00	0.847	92.502	11.8	27.3	0.79	18.195	24.1
45	20061210	0:00	1.841	91.969	12.56	28	0.77	18.534	21.7
46	20061210	6:00	2.937	91.921	9.78	28.2	0.76	18.561	23.4

Table 7.7-3 Summary of all precipitation data

No	Rainfall Start					Rainfall Stop					rainfall
	Year	date	time	Lon	Lat	Year	date	time	lon	lat	mm
1	2006	1129	7:00	2.228	78.608	2006	1129	9:00	2.196	78.871	0.4
2	2006	1129	18:00	1.733	79.802	2006	1130	0:00	1.515	80.353	17.7
3	2006	1130	0:00	1.515	80.353	2006	1130	3:00	1.491	80.393	2.7
4	2006	1130	2:00	1.495	80.397	2006	1130	3:00	1.491	80.393	2.6
5	2006	1130	8:00	1.536	80.527	2006	1130	10:00	1.285	80.544	44.8
6	2006	1130	10:00	1.285	80.544	2006	1130	12:00	0.895	80.534	0.4
7	2006	1130	17:00	-0.085	80.476	2006	1130	18:00	-0.288	80.456	1.5

8	2006	1201	13:00	-1.291	81.956	2006	1201	17:00	-1.09	82.964	14
9	2006	1201	19:00	-1.016	83.499	2006	1201	20:00	-0.977	83.768	0.3
10	2006	1203	21:00	-1.729	90.133	2006	1204	0:00	-1.689	90.208	29.6
11	2006	1204	5:00	-1.698	90.172	2006	1204	7:00	-1.672	90.152	2.6
12	2006	1204	6:00	-1.689	90.172	2006	1204	9:00	-1.652	89.981	11.2
13	2006	1204	8:00	-1.656	90.045	2006	1204	12:00	-1.642	90.053	3.6
14	2006	1204	11:00	-1.652	90.036	2006	1204	18:00	-1.611	90.077	1.1
15	2006	1204	17:00	-1.613	90.069	2006	1205	0:00	-1.584	90.13	47.8
16	2006	1204	23:00	-1.588	90.123	2006	1205	3:00	-1.581	90.099	16.8
17	2006	1205	2:00	-1.562	90.117	2006	1205	3:00	-1.581	90.099	0.2
18	2006	1206	4:00	-1.653	90	2006	1206	7:00	-1.894	90.369	4.5
19	2006	1206	15:00	-3.074	92.106	2006	1206	18:00	-3.497	92.768	1.4
20	2006	1206	17:00	-3.342	92.552	2006	1206	23:00	-4.225	93.836	5.4
21	2006	1207	6:00	-5.014	95.018	2006	1207	8:00	-5.023	94.998	0.2
22	2006	1207	12:00	-4.966	95.006	2006	1207	14:00	-4.968	95.044	4.6
23	2006	1209	19:00	0.664	92.618	2006	1209	20:00	0.824	92.508	0.2
24	2006	1210	16:00	4.376	92.951	2006	1210	19:00	4.941	93.522	1.3

* Rainfall amount in each sampling period is calculated from SOJ data.

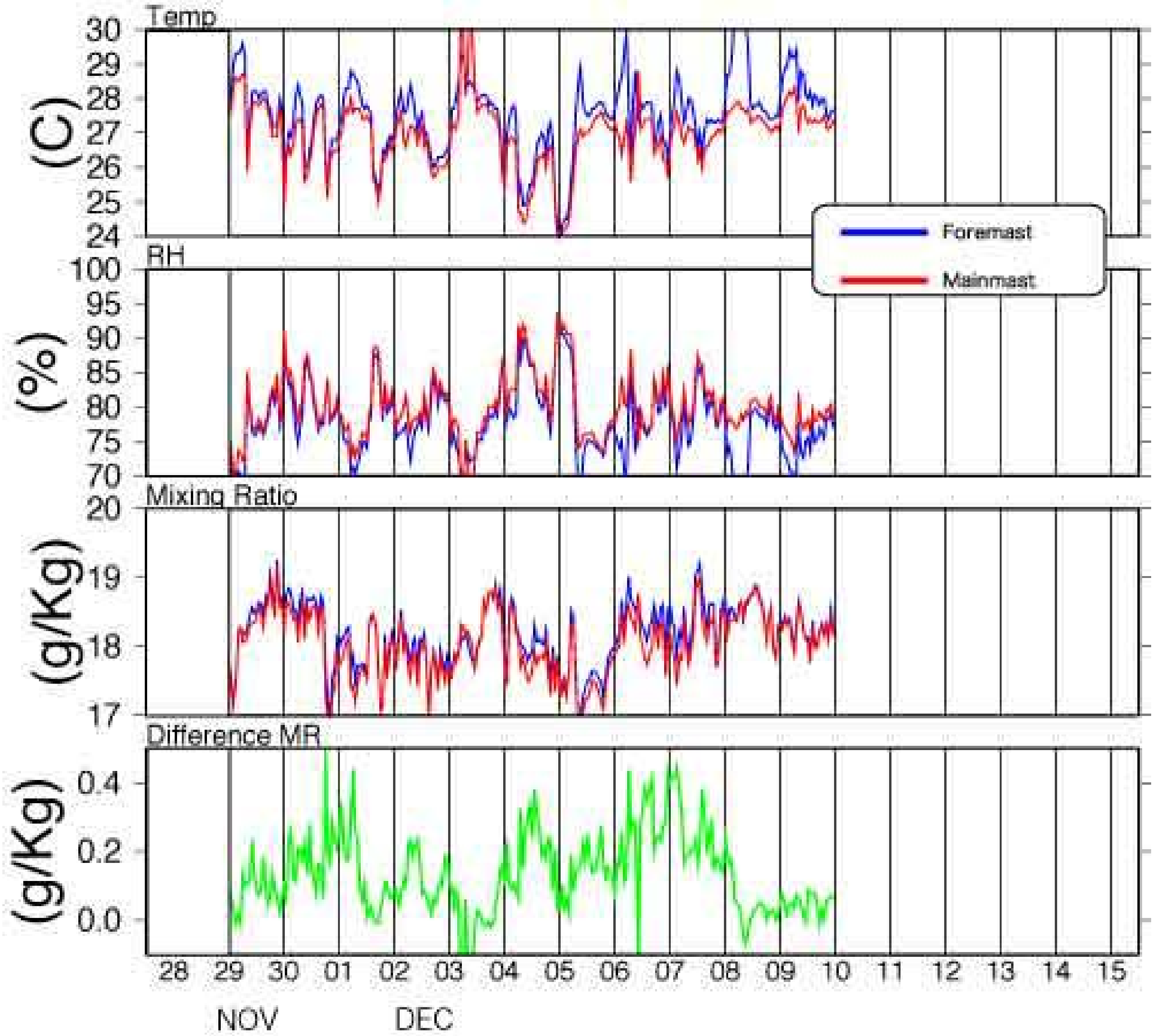


Fig. 7.7-1 Temporal variation of (a) temperature (degK), (b) relative humidity (%), (c) mixing ratio (g/Kg), and (d) difference of mixing ratio between foremast and mainmast height from Maldives to Singapole.

7.8 Aerosol optical characteristics measured by Ship-borne Sky radiometer

(1) Personnel

Principal Investigator :

Kazuma Aoki (University of Toyama) Associate Professor / not onboard

Co-workers:

Tatsuo Endoh (Tottori University of Environmental Studies) Professor / not onboard

Tamio Takamura (CEReS, Chiba University) Professor / not onboard

Teruyuki Nakajima (CCSR, The University of Tokyo) Professor / not onboard

Nobuo Sugimoto (NIES) Chief Research Scientist / not onboard

Operation was supported by Global Ocean Development Inc. (GODI).

(2) Objective

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

(3) Methods

Sky radiometer is measuring the direct solar irradiance and the solar aureole radiance distribution, has seven interference filters. Analysis of these data is performed by SKYRAD.pack version 4.2 developed by Nakajima *et al*. 1996.

(4) Results

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

@ Measured parameters

- Aerosol optical thickness at 5 wavelengths (400, 500, 675, 870 and 1020 nm)
- Ångström exponent
- Single scattering albedo at 5 wavelengths
- Size distribution of volume (0.01 μm – 20 μm)

GPS provides the position with longitude and latitude and heading direction of the vessel, and azimuth and elevation angle of sun. Horizon sensor provides rolling and pitching angles.

(5) Data Archives

Measurements of aerosol optical data are not archived so soon and developed, examined, arranged and finally provided as available data after a certain duration. All data will archived at University of Toyama (K.Aoki, SKYNET/SKY: http://skyrad.sci.u-toyama.ac.jp/) and Chiba University (T.Takamura, SKYNET) after the quality check and submitted to JAMSTEC within 3-year.

7.9 The production-consumption mechanisms and sea-air flux of greenhouse gases

1. Personnel

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2. Sampling

Sampling of Tokyo Institute of Technology (Yoshida Laboratory) for seawater and ambient air are listed in Table 1, Table 2and Table 3.

3. Nitrous oxide and related substances

Ayako FUJII, Narin BOONTANON, Kohei KAWANO, Osamu YOSHIDA, Shuichi Watanabe and Naohiro YOSHIDA
Tokyo Institute of Technology Group (Yoshida Laboratory)

3.1. Introduction

Recently considerable attention has been focused on emission of biogenic trace gases from ecosystems, since the gases contain a significant amount of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Isotopic signatures of these gases are well recognized to provide constraints for relative source strength and information on reaction dynamics concerning their formation and biological pathways. Nitrous oxide is a very effective heat-trapping gas in the atmosphere because it absorbs outgoing radiant heat in infrared wavelengths that are not captured by the other major greenhouse gases, such as water vapor and CO_2. The annual input of N_2O into the atmosphere is estimated to be about 16.4 Tg N_2O-N yr^{-1}, and the oceans are believed to contribute more than 17% of the total annual input (IPCC, 2001).

N_2O is produced by the biological processes of nitrification and denitrification (Dore et al., 1998; Knowles et al., 1981; Rysgaard et al., 1993; Svensson, 1998; Ueda et al., 1993). Depending on the redox conditions, N_2O is produced from inorganic nitrogenous compounds (NH_3 or NO_3^-), with subsequently different isotopic fractionation factors. The isotopic signatures of N_2O confer constraints on the relative source strength, and the reaction dynamics of N_2O biological production pathways are currently under investigation. Furthermore, isotopomers of N_2O contain more easily interpretable biogeochemical information as to their sources than obtained from conventional bulk ^{15}N and ^{18}O measurements (Yoshida and Toyoda, 2000).

3.2 Materials and methods

Samples were collected in MR06-05 leg 2 research expedition on the R/V Mirai from November 28, 2006 to December 13, 2006. The production-consumption mechanisms of dissolved N_2O in Indian Ocean was investigated by collecting vertical seawater samples (5 stations), dissolved oxygen (DO) (5stations), dissolved oxygen (DO) (5stations), chlorophyll a (Chl.a) (5stations), particulate organic matter (POM) (5 stations), on-board incubation experiments (5 stations). The sea-air fluxes (sampling sea surface water and ambient water) (7 stations). And then, the sea-air flux of N2O in Indian Ocean was investigated by collecting sea surface water and ambient water.

3.2.1 N_2O concentration and isotope analyses

Water samplings were carried out at the indicated depths using a CTD water sampler. For N_2O analyses, water samples were introduced into 225 ml glass vial and then sterilized with mercury chloride (1 ml saturated $HgCl_2$ solution per vial). The vial was then sealed with a butyl-rubber septum and an aluminum cap, taking care to avoid bubble formation, and then brought back to the laboratory and stored at 4˚C until the analyses were conducted. Dissolved N_2O concentrations and its isotopic compositions will be measured by using GC/C/IRMS.

3.2.2 DO

Samples were collected and measured at stations with CTD observation. The data are showed in Fig.1.

3.2.3 Nutrients

Samples for nutrients (NH_4^+, NO_3^-, NO_2^-) were collected into 100ml PP bottle and stored at -20˚C. They will be measured by using Auto Analyzer.

3.2.4 Chlorophyll a (Chl.a)

Samples for Chlorophyll a (Chl.a) were collected. Sea waters are filtrated (500ml to 1000ml) and stored into 9ml vials satisfied with Dimetylformamid, and stored at -20˚C. They will be measured by using fluorophotometer. These data will be used for calibration with value of fluorescence sensor.

3.2.5 POM

Samples for POM were collected at the depth at the depth of Chlorophyll a (Chl.a) concentration maximum and that depth plus 50m and 100m each. After the filtration, the filter were treated with 0.05N hydrochloric acid, washed with Milli-Q water and then dried at 60˚C for 48 hrs and stored. They will be measured by

3.2.6 On-board incubation experiment (Fujii)

The water samples for on-board incubation experiments were collected at Surface layer (10m) and Oxygen minimum layer which expected for the highest N_2O production. Water samples were introduced into 225 ml glass vial sealed with a butyl rubber septum and an aluminum cap. After 2days and 5days at in situ temperature, the sample was then sterilized with mercury chloride and stored at 4˚C until the analyses were conducted. Dissolved N_2O concentrations and its isotopic compositions will be measured by using GC/C/IRMS.

3.3 Expected results

N_2O concentration of sea surface water affects the sea-air flux directly. And there is a possible that N2O gases are carried at the place seawater is transporting from deep layer to surface layer like upwelling zone. However, the pathway of N_2O production and consumption mechanisms is also still unresolved. So it is very important to understand vertical profiles of N2O.Usually N_2O production in surface layer is predominantly carried out nitrification, but denitrification also occurs in the case of oxygen concentration is low (Maribeb and Laura, 2004). In deeper layer during the settling particles or fecal pellets which may produce from phytoplankton or zooplankton, either directly or indirectly. In such pattern, N_2O could be produced through in situ biological processes of settling particles in subsurface layer and the maxima concentrations could be observed. Consequently, the isotopic measurement of these gases becomes a useful parameter for determining the origin and production pathway of N_2O under investigation. at least three factors could be control the N_2O concentration and its isotopic compositions in these study areas are:

(i) The isotopic compositions of dissolved N_2O were governed through the gas exchange with the atmospheric N_2O in the surface layer.

(ii) The well mixing of N_2O in the deeper part may occur due to the transportation from upper layer or the transportation of N_2O from the other area by the occurrence of ocean current.

(iii) The isotopic and compositions of surface and oxygen minimum layer N_2O could provide an information of N_2O production mechanisms, and could be estimate for those N_2O production-consumption rate.

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4. Methane

Methane concentration and stable isotopic distribution as indicators of biogenic methane dynamics in Indian Ocean

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4.1. Introduction

Atmospheric methane (CH_4) is a trace gas playing an important role in the global carbon cycle as a greenhouse gas. Its concentration has increased by about 1050 ppbv from 700 ppbv since the pre-industrial era (IPCC, 1995). In order to understand the current global methane cycle, it is necessary to quantify its sources and sinks. At present, there remain large uncertainties in the estimated methane fluxes from sources to sinks. The ocean’s source strength for atmospheric methane should be examined in more detail, even though it might be a relatively minor source, previously reported to be 0.005 to 3% of the total input to the atmosphere (Cicerone and Oremland, 1988; Bange et al., 1994).

To estimate an accurate amount of the methane exchange from the ocean to the atmosphere, it is necessary to explore widely and vertically. Distribution of dissolved methane in surface waters from diverse locations in the world ocean is often reported as a characteristic subsurface maximum representing a supersaturation of several folds (Yoshida et al., 2004). Although the origin of the subsurface methane maximum is not clear, some suggestions include advection and/or diffusion from local anoxic environment nearby sources in shelf sediments, and in situ production by methanogenic bacteria, presumably in association with suspended particulate materials (Karl and Tilbrook, 1994). These bacteria are thought to probable live in the anaerobic microenvironments supplied by organic particles or guts of zooplankton (Alldredge and Cohen, 1987).

So, this study investigates in detail profile of methane concentration and stable isotopic distribution in the water column in the central Indian Ocean as open ocean to clarify methane dynamics and estimate the flux of methane to the atmosphere. A better understanding of the CH4 budget, and how it is changing with time, is needed to predict more accurately the future role of CH4 in climate change.

4.2. Materials and methods

Seawater samples are taken by CTD-CAROUSEL system attached Niskin samplers of 12 L at 29 layers and surface layer taken by plastic bucket. Each sample was carefully subsampled into 30, 125, 600 mL glass vials to avoid air contamination for analysis of methane concentration, carbon isotope ratio, and hydrogen isotope ratio respectively. The seawater samples were poisoned by 20 µL (30 and 125 mL vials) or 100 µL (600 mL vial) of mercuric chloride solution (Tilbrook and Karl, 1995; Watanabe et al., 1995), and were closed with rubber and aluminum caps. These were stored in a dark and cool place until we got to land, where we conducted gas chromatographic analysis of methane concentration and mass spectrometric analysis of carbon and hydrogen isotopic composition at the laboratory.

The analytical method briefly described here: The system consists of a purge and trap unit, a desiccant unit, rotary valves, a gas chromatograph equipped with a flame ionization detector for concentration of methane, GC/C/IRMS for carbon isotope ratio of methane, GC/TC/IRMS for hydrogen isotope ratio of methane, and data acquisition units. The entire volume of seawater in each glass vial was processed all at once to avoid contamination and loss of methane. Precision obtained from replicate determinations of methane concentration was estimated to be better than 5% for the usual concentration of methane in seawater.

4.3. Expected results

Subsurface maximum concentrations of methane (>3 nmol kg^{-1}) were expected to be observed in the central Indian Ocean. A commonly-encountered distribution in the upper ocean with a methane peak within the pycnocline (e.g., Ward et al., 1987; Owens et al., 1991; Watanabe et al., 1995). Karl and Tilbrook (1994) suggested the suboxic conditions would further aid the development of microenvironments within particles in which methane could be produced. The organic particles are accumulated in the pycnocline, and methane produced in the micro reducing environment by methanogenic bacteria. Moreover, in situ microbial methane production in the guts of zooplankton can be expected (e.g., Owens et al., 1991; de Angelis and Lee, 1994; Oudot et al., 2002). Watanabe et al. (1995) pointed out that the diffusive flux of methane from subsurface maxima to air-sea interface is sufficient to account for its emission flux to the atmosphere. In the mixed layer above its boundary, the methane is formed and discharged to the atmosphere in part, in the below its boundary, methane diffused to the bottom vertically. By using concentration and isotopic composition of methane and hydrographic parameters for vertical water samples, it is possible to clarify its dynamics such as production and/or consumption in the water column.

Kelley and Jeffrey (2002) observed in the equatorial upwelling region of 10 and 20% supersaturated methane. In this study, in situ methane production result in the property distributions and large methane flux in the Indian Ocean can be expected.

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Table 1 The sampling position with CTD observation (seawater and ambient air)

No.	Latitude	Longitude
1	1.32.33 N	80.31.77 E
2	1.20.20 S	80.31.21 E
3	0.03.15 N	89.55.42 E
4	1.38.42 S	90.00.52 E
5	4.56.21 S	95.01.83 E

Table 2 The sampling position (sea surface water and ambient air)

No.	Latitude	Longitude
1	0.45.40 S	85.04.69 E
2	0.26.96 S	87.07.21 E

Table 3 Sampling items

No.	Items
1	N_2O/CH_4 Flux
2	DO
3	N_2O concentration and isotope(Fujii)
4	N_2O concentration (NOK)
5	CH_4 concentration
6	CH_4 isotope (delta^{13}C)
7	CH_4 isotope (delta D)
8	Nutrients
9	Chl.a
10	POM
11	Incubation 1 (NOK)
12	Incubation 2 (Fujii)

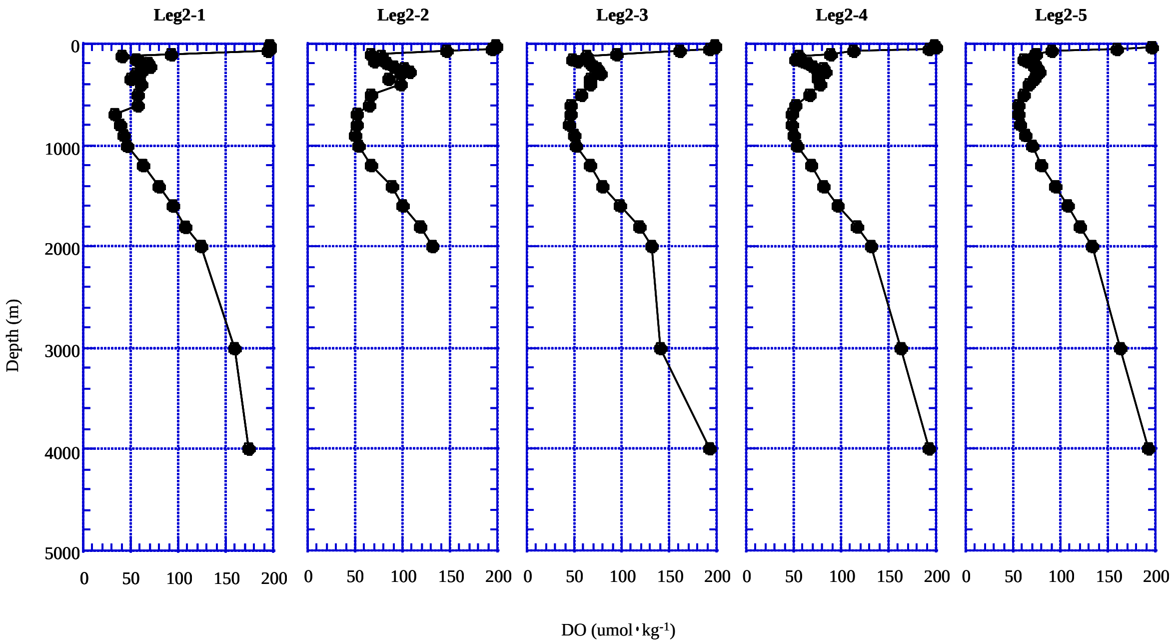

Fig.1 Data of Dissolved Oxygen (DO)

7.10 Infrared radiometer

(1) Personnel

Hajime Okamoto (CAOS, Tohoku University): Principal Investigator
Naoki Mashiko (CAOS, Tohoku University): Student (Master 1)
Kaori Sato ((CAOS, Tohoku University): Student, Doctor Course 1
Nobuo Sugimoto (National Institute for Environmental Studies)
Ichiro Matsui (National Institute for Environmental Studies)

(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.

(3) Method

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

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

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

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.

(4) 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.

(5) Remarks

During MR-06-05 leg.2 cruise, observation wasn't done because IR was out of order.

95GHz cloud profiling radar

(1) Personnel

Hajime Okamoto (CAOS, Tohoku University): Principal Investigator
Naoki Mashiko (CAOS, Tohoku University): Student, Master course 1
Kaori Sato ((CAOS, Tohoku University): Student, Doctor Course 1
Toshiaki Takano (Chiba University)
Yoshinori Kinoshita (Chiba University): Student, Master course 1
Shinichi Yokote (Chiba University): Student, Master course 1
Nobuo Sugimoto (National Institute for Environmental Studies)
Ichiro Matsui (National Institute for Environmental Studies)

(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 09-December during MR-06-05 leg.2 cruise. Vertical extent is 20km. It is seen that there are several convective activities which often reach 15km.

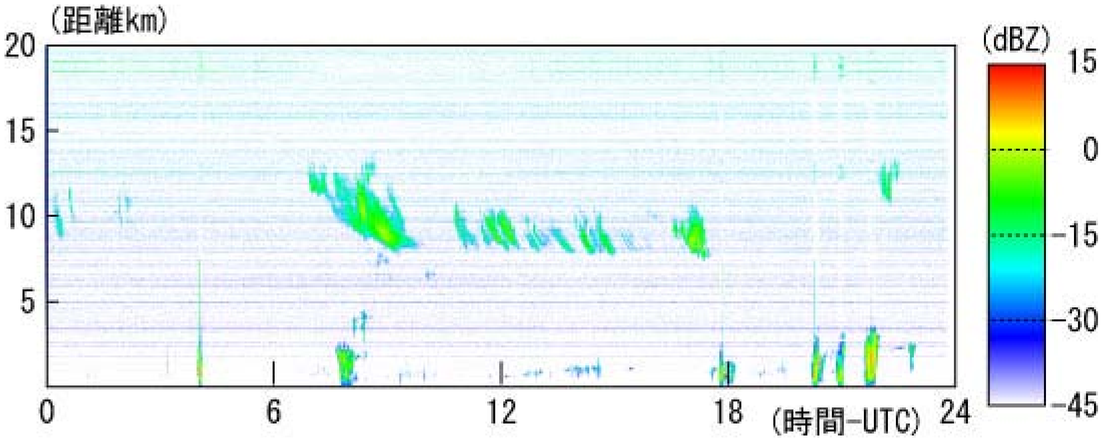

Fig. 1 Time height cross section of radar reflectivity factor in dBZe in 09-December during MR06-05 leg. 2 cruise.

(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.

7.11 GPS Meteorology

(1) Personnel

Mikiko Fujita	(JAMSTEC)	Principal Investigator
Souichiro SUEYOSHI	(GODI)	
Norio NAGAHAMA	(GODI)	
Ryo OHYAMA	(GODI)	

(2) Objective

Getting the GPS satellite data to derived estimates of 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 November 29, 2006 through December 12, 2006.

(4) Results

The time series of the total column integrated water vapor at November 29, 2006, which was calculated from GPS satellite data using the TRACK utility in the GAMIT analysis software, is shown in Fig. 7.11-1. They include the specific humidity (SH). The time-longitude cross sections of convective activity estimating by METEOSAT satellite data are shown in Fig. 7.11-2.

(5) Data archive

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

(6) Remarks

The significant increment with water vapor was observed around 0600Z 29 December (in Fig. 7.11-1) due to some convective system over the Indian Ocean (Fig. 7.11-2). Before through the convection, precipitable water vapor increased drastically.

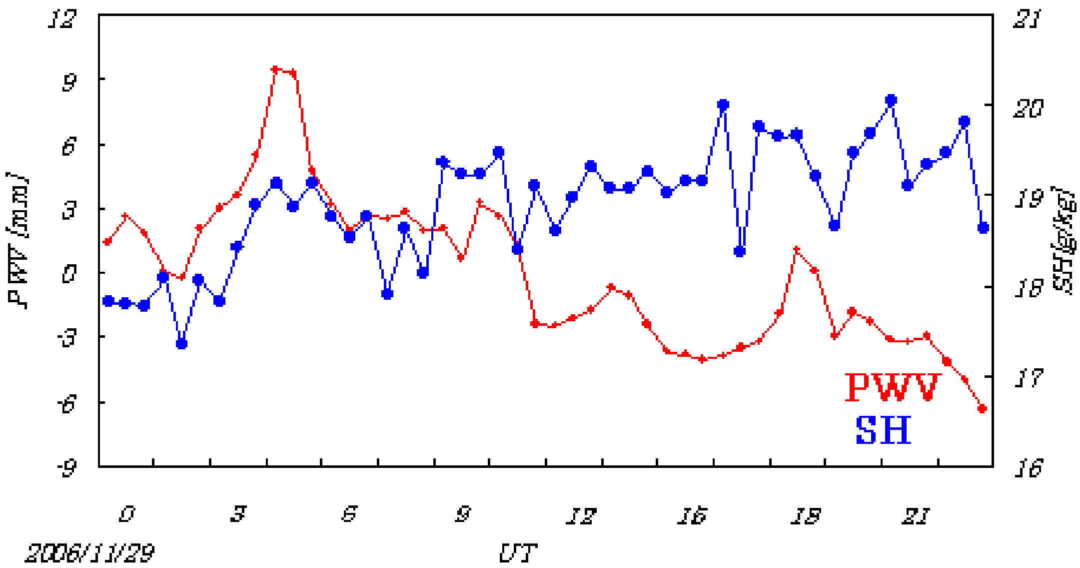

Fig. 7.11-1 The time series of the precipitable water vapor (PWV, shown by deviation from diurnal average) and surface specific humidity (SH).

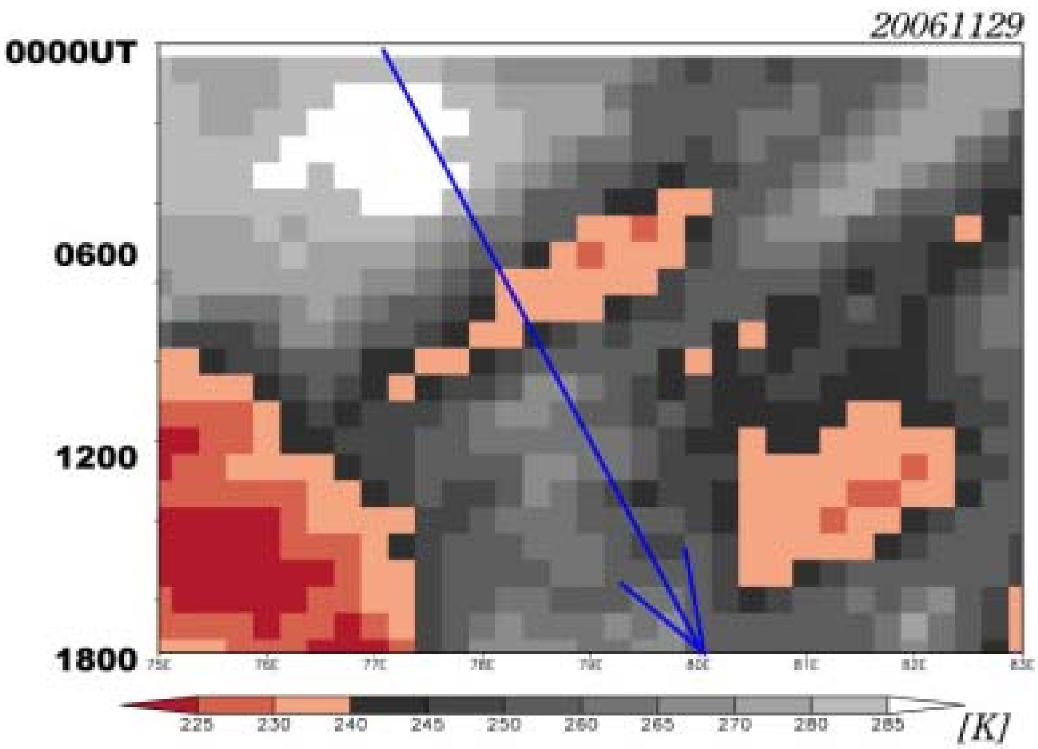

Fig. 7.11-2 The time-longitude cross sections of convective activity around the Maldives estimating by METEOSAT satellite (copyright 2006 EUMETSAT) data in 29 November 2006. The blue line indicates the track of R/V Mirai.