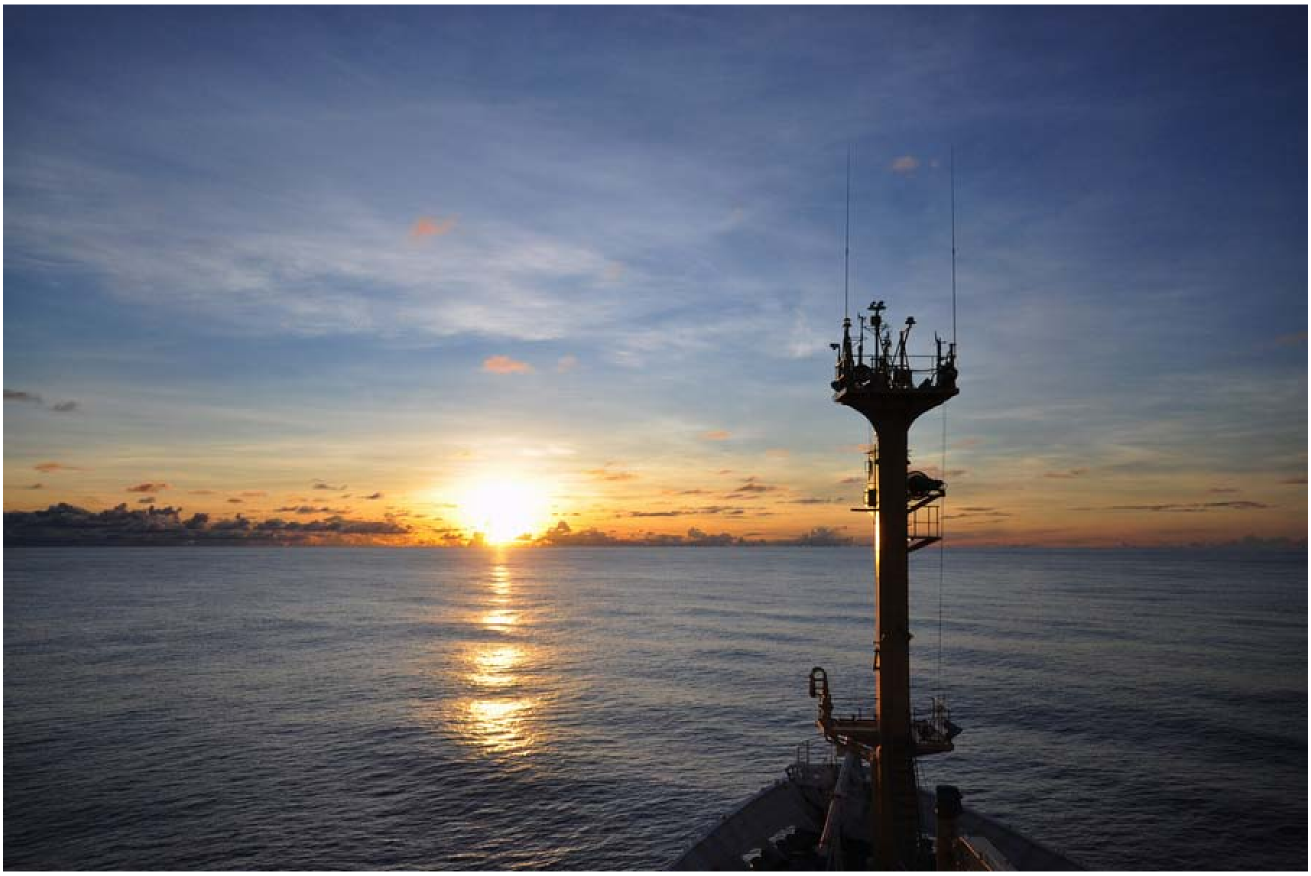
doi : 10.17596/0003144

# R/V Mirai Cruise Report
# MR11-01

*December 31, 2010 – February 6, 2011*
*Tropical Ocean Climate Study (TOCS)*



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

# Table of contents

**Note:**

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

# 1. Cruise name and code

Tropical Ocean Climatology Study

MR11-01

Ship: R/V Mirai

Captain: Takao Nakayama

## 2. Introduction and observation summary

### 2.1 Introduction

The purpose of this cruise is to observe ocean and atmosphere in the eastern equatorial Indian Ocean for better understanding of climate variability involving the Indian Ocean Dipole mode (IOD) event. The IOD event is thought to largely affect climate in the East Asia involving Japan, however, its feature and mechanism have not been understood because the IOD event was just found in 1999.

In order to observe the IOD event, we have been developing the TRITON (TRIangle Trans-Ocean buoy Network) buoys in the eastern equatorial Indian Ocean since 2001 at 5S, 90E (#17) and 1.5S 90E (#18). A new station of the TRITON buoy, 8S, 95E (#19), was added to the observation network in the equatorial Indian Ocean in 2009. After 2007, small size TRITON buoys, named as “m-TRITON” buoy, have been replaced for old type of the TRITON buoy because of easy operation. Additionally, subsurface Acoustic Doppler Current Profiler (ADCP) buoys at the equator, 90E are maintained to obtain time-series data of equatorial ocean currents in the Indian Ocean. Main mission of this cruise is maintenance of these buoys.

A prototype of the Southern Ocean buoy, which has been developing for future observation under the rough and cold sea state conditions in the South Pacific Ocean, was deployed near the Cape Erimo of Hokkaido during MR10-07. We recover this buoy before we arrive at Sekinehama. In order to observe its recovery operation, fifteen persons from JAMSTEC participate from Yokohama.

Except for above, automatic continuous oceanic, meteorological and geophysical observations are also conducted along ship track during this cruise as usual. One Argo float is deployed at 5S, 95E.

### 2.2 Overview

**1) Ship**

R/V Mirai

Captain Takao Nakayama

**2) Cruise code**

MR11-01

**3) Project name**

Tropical Ocean Climate Study (TOCS)

**4) Undertaking institution**

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

2-15, Natsushima-cho, Yokosuka, 237-0061, Japan

**5) Chief scientist**

Yuji Kashino (JAMSTEC)

**6) Period**

December 31, 2010 (Koror, Republic of Palau) – February 2-3, 2011 (Yokohama, Japan) – February 6, 2011 (Sekinehama, Japan)

**7) Research participants**

One scientist and three engineers of JAMSTEC

(Two of engineers were on board from Yokohama to Sekinehama.)

Twelve Marine technicians from Marine works Japan. Ltd. and Global Ocean Development Inc. (Japan)

(Three of them were changed when R/V Mirai arrived at Yokohama.

Fifteen persons from JAMSTEC were on board from Yokohama to Sekinehama for observing the operation work of the Southern Ocean Buoy.

## 2.3 Observation summary

TRITON/m-TRITON mooring recovery and re-installation

3 moorings were deployed and recovered

Three m-TRITON buoys were recovered and two m-TRITON buoys were deployed.

One TRITON buoy was deployed.

Prototype of the Southern Ocean buoy: It was successfully recovered.

Subsurface ADCP mooring recovery and re-installation:

one moorings were deployed and recovered

CTD (Conductivity, Temperature and Depth) and water sampling: 6 casts

Launch of Argo floats 1 float

Rain, water vapor and surface water sampling for isotope analysis

3 casts for rain, 32 casts for water vapor, and 16 cast for surface water

Current measurements by shipboard ADCP: continuous

Sea surface temperature, salinity, and dissolved oxygen

measurements by intake method: continuous

Surface meteorology: continuous

Clouds and aerosol observations continuous

Underway geophysics observations continuous

We successfully recovered and re-installed all TRITON/m-TRITON buoys during this cruise. However, we found some damages which were probably due to vandalism in all recovered buoys.

We installed the new conductivity and temperature sensors developed by Marine Technology Center of JAMSTEC in m-TRITON buoys #18 (85S95E) at 500m depth. We also had a plan of installation of this sensor in m-TRITON buoy #18 (1.5N9E) at 20m depth, however, we gave it up because of the sensor trouble. We successfully recovered the new sensors at m-TRITON buoys #17 (5S90E) and #18 at 100m depth.

We also recovered and re-installed an ADCP buoys at 0N90E with no trouble. Data from the recovered ADCP was successfully acquired. Note that location of the deployment point was shifted to the east about 5 nautical miles because we found that the submarine cable was located near the location of the ADCP buoy.

Although CTD casts were conducted only six times, its accuracy was as quite good as it satisfied WOCE requirement (0.002 PSU). Accuracy of Autosal salinity was further good (0.0002 PSU).

We successfully recovered the Southern Ocean buoy near the Cape Erimo of Hokkaido because of good sea and atmospheric condition for recovery work. (Sea state was not often good in the area of north Japan because of strong northwesterly monsoon during boreal winter season.)

With regard to automatic continuous meteorological, oceanographic and geophysical observations, all observations were carried out well.

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

## 2.4 Observed oceanic and atmospheric conditions

In 2010 boreal autumn, atmosphere and ocean in the tropical Indian Ocean was changed to condition of weak negative IOD event (Figure 2-1). Although this event terminated in December 2010, sea surface temperature in the equatorial Indian Ocean was not high (28.5℃).

During cruise period, atmospheric convection was active because of the Madden Julian Oscillation which arrived at the tropical Indian Ocean (Figure 2-2). Because of this phenomenon, weather during MR11-01 was almost cloudy or rainy.

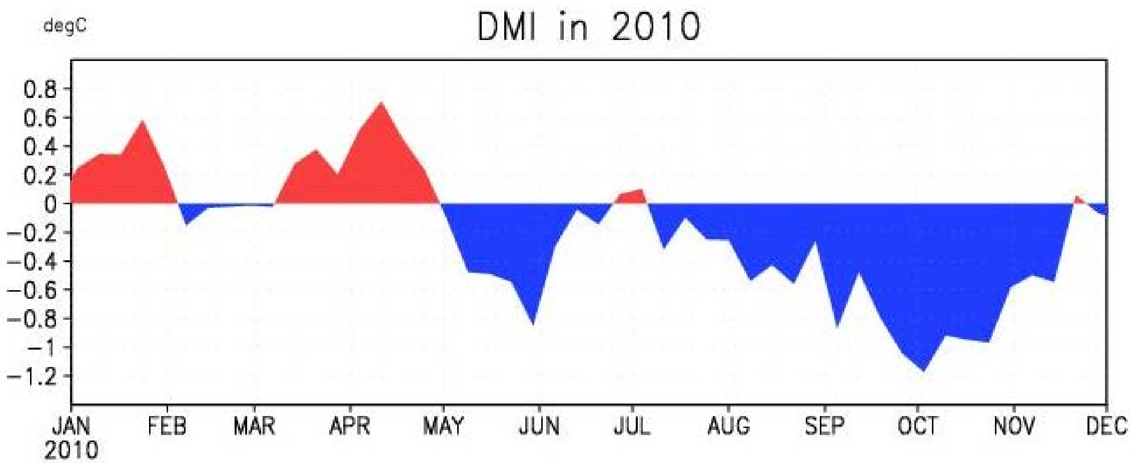



Figure 2-1. Time series of the Dipole Mode Index in 2010.

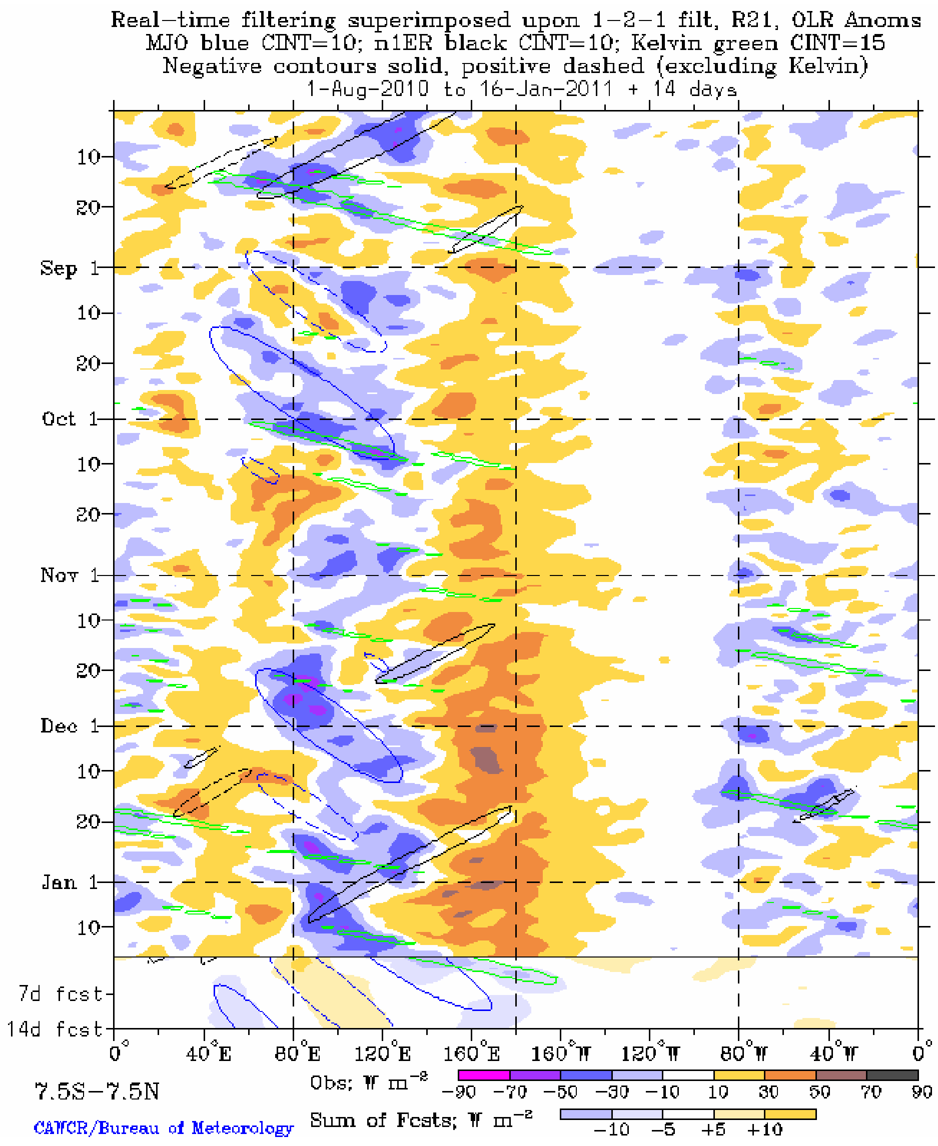



Figure 2-2. Outgoing radiation anomaly between 7.5S – 7.5N by CAWCR.

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

## 3.1 Period

31st December, 2010 – 06th February, 2011

## 3.2 Ports of call

Marakal, Republic of Palau (Departure: 31 December, 2010)

Yokohama, Japan (Arrival: 2 February, Departure: 3 February, 2011)

Sekinehama, Japan (Arrival: 6 February)

## 3.3 Cruise Log

| SMT | UTC | Event |
|---|---|---|
| Dec. 31 (Fri.) 2010 | | |
| 16:00 | 07:00 | Departure from Palau<br>[Ship Mean Time (SMT)=UTC+9h] |
| Jan. 04 (Tue.) | | |
| 22:00 | 14:00 | Time adjustment -1h (SMT=UTC+8h) |
| Jan. 07 (Fri.) | | |
| 22:00 | 15:00 | Time adjustment -1h (SMT=UTC+7h) |
| Jan. 09 (Sun.) | | |
| 17:48 | 10:48 | XCTD measurement for sound velocity profile |
| 18:00 | 11:00 | Start underway observations |
| 22:00 | 16:00 | Time adjustment -1h (SMT=UTC+6h) |
| Jan. 11 (Tue.) | | |
| 08:11 to 11:39 | 02:11 to 05:39 | Deployment of TRITON buoy (TR#19) |
| 12:17 to 12:46 | 06:17 to 06:46 | Acoustic Ranging and SSBL calibration for fixing a settled sinker position (Fixed point: 08-04.0489S, 95-07.3975E, Depth: 5,261m) |
| 13:12 to 13:59 | 07:12 to 07:59 | CTD/Water sampling (1,000 m) around the deployed buoy |
| 14:10 | 08:10 | Visual checking of deployed buoy |
| 14:57 to 15:42 | 08:57 to 09:42 | CTD/Water sampling (1,000 m) around the recovering buoy |
| 15:58 | 09:58 | Visual checking of recovering buoy |
| 16:20 to 16:47 | 10:20 to 10:47 | Figure-8 turn for calibration of Three-comp. Magnetometer |
| 19:27 | 13:27 | Confirm receiving signals from deployed buoy |
| Jan. 12 (Wed.) | | |
| 06:57 | 00:57 | Send enable command to acoustic releaser |
| 07:56 to 12:02 | 01:56 to 06:02 | Recovery of TRITON buoy (TR#19) |
| 12:06 | 06:06 | Departure from TR#19 station |

| SMT | UTC | Event |
|---|---|---|
| Jan. 13 (Thu.) | | |
| 03:42 | 21:42 (-1day) | Arrival at TR#17 station |
| 08:14 to 11:36 | 02:14 – 05:36 | Deployment of TRITON buoy (TR#17) |
| 12:10 to 12:28 | 06:10-06:28 | Acoustic ranging and positioning (Fixed point: 5-01.9680S, 94-58.5992E, Depth: 5,014 m) |
| 13:00 to 13:46 | 07:00 to 07:46 | CTD/Water sampling (1,000 m) around the deployed buoy |
| 15:00 to 16:15 | 09:00 to 10:15 | CTD/Water sampling (2,000 m) around the recovering buoy |
| 17:30 to 18:20 | 11:30 to 12:20 | Confirm receiving signals from deployed buoy |
| Jan. 14 (Fri.) | | |
| 06:56 | 00:56 | Send enable command to acoustic releaser |
| 07:45 to 11:18 | 01:45 to 05:18 | Recovery of TRITON buoy (TR#17) |
| 12:25 | 06:25 | ARGO Float deployment |
| 13:00 | 07:00 | Departure from TR#17 station |
| Jan. 15 (Sat.) | | |
| 14:48 | 08:48 | Arrival at TR#18 station |
| 14:59 to 15:41 | 08:59 to 09:41 | CTD/Water sampling (1,000 m) at the buoy deploying point |
| Jan. 16 (Sun.) | | |
| 08:07 to 11:05 | 02:14 to 05:36 | Deployment of TRITON buoy (TR#18) |
| 11:32 to 11:38 | 05:32 to 05:38 | Acoustic ranging and positioning (Fixed point: 1-36.1759S, 90-04.4374E, Depth: 4,716 m) |
| 12:56 to 13:43 | 06:56 to 07:43 | CTD/Water sampling (1,000 m) around the deployed buoy |
| 14:00 | 08:00 | Visual checking of deployed buoy |
| 21:00 to 21:10 | 15:00 to 15:10 | Confirm receiving signals from deployed buoy |
| Jan. 17 (Mon.) | | |
| 06:52 | 00:52 | Send enable command to acoustic releaser |
| 07:56 to 10:57 | 01:56 to 04:57 | Recovery of TRITON buoy (TR#18) |
| 11:00 | 05:00 | Departure from TR#18 station |
| 17:46 | 11:46 | XCTD measurement for sound velocity profile |
| 18:35 | 12:35 | Start topographical survey |
| Jan. 18 (Tue.) | | |
| 04:00 | 22:00 (-1day) | End of topographic survey |
| 06:00 | 00:00 | Arrival at ADCP mooring station |
| 06:53 | 00:53 | Send enable command to acoustic releaser |
| 06:55 | 00:55 | Send release command to acoustic releaser |
| 08:13 to 10:05 | 02:13 to 04:05 | Recovery of ADCP buoy |
| 10:54 to 11:23 | 04:54 to 06:23 | Figure-8 turn for calibration of Three-comp. Magnetometer |
| 12:59 to 14:32 | 06:59 to 08:32 | Deployment of ADCP buoy |
| 14:53 to 15:03 | 08:53 to 09:03 | Acoustic ranging and positioning (Fixed point: 0-00.0743N, 90-08.6753E, Depth: 4,085 m) |

| SMT | UTC | Event |
|---|---|---|
| 22:40 to 23:00 | 16:40 to 17:00 | Visual checking of ATLAS buoy at 1-35.303N, 90-05.201E |
| 23:52 | 17:52 | Start topographical survey |
| Jan. 19 (Wed.) | | |
| 03:06 | 21:06 (-1day) | End of topographic survey |
| 11:00 | 05:00 | Suspend underway observations for entering Indonesian EEZ |
| 22:00 | 15:00 | Time adjustment +1h (SMT=UTC+7h) |
| Jan. 21 (Fri.) | | |
| 22:00 | 14:00 | Time adjustment +1h (SMT=UTC+8h) |
| Jan. 28 (Fri.) | | |
| 08:00 | 00:00 | Restart underway observations |
| 08:30 to 11:55 | 00:30 to 03:55 | CTD Cable FF for maintenance |
| 12:00 | 04:00 | Departure from FF station |
| Jan. 29 (Sat.) | | |
| 22:00 | 13:00 | Time adjustment +1h (SMT=UTC+9h) |
| Feb. 01 (Tue.) | | |
| 15:30 | 06:30 | Suspend pumping intake surface water |
| Feb. 02 (Wed.) | | |
| 08:10 | 23:10 (-1day) | Port call at Yokohama |
| Feb. 03 (Thu..) | | |
| 15:50 | 06:50 | Departure from Yokohama |
| 18:00 | 09:00 | Restart pumping intake surface water |
| Feb. 05 (Sat..) | | |
| 03:54 | 18:54 (-1day) | Arrival at Southern Ocean Buoy staton |
| 06:55 | 21:55 (-1day) | Send enable command to acoustic releaser |
| 08:00 to 10:06 | 23:00 to 01:06 | Recovery of Southern Ocean Buoy |
| 10:45 to 11:13 | 01:45 to 02:13 | Figure-8 turn for calibration of Three-comp. Magnetometer |
| 11:18 | 02:18 | Departure from Buoy station |
| Feb. 06 (Sun.) | | |
| 09:00 | 00:00 | Arrival at Seinehama and completion of MR11-01 cruise |

## 3.4 Cruise track

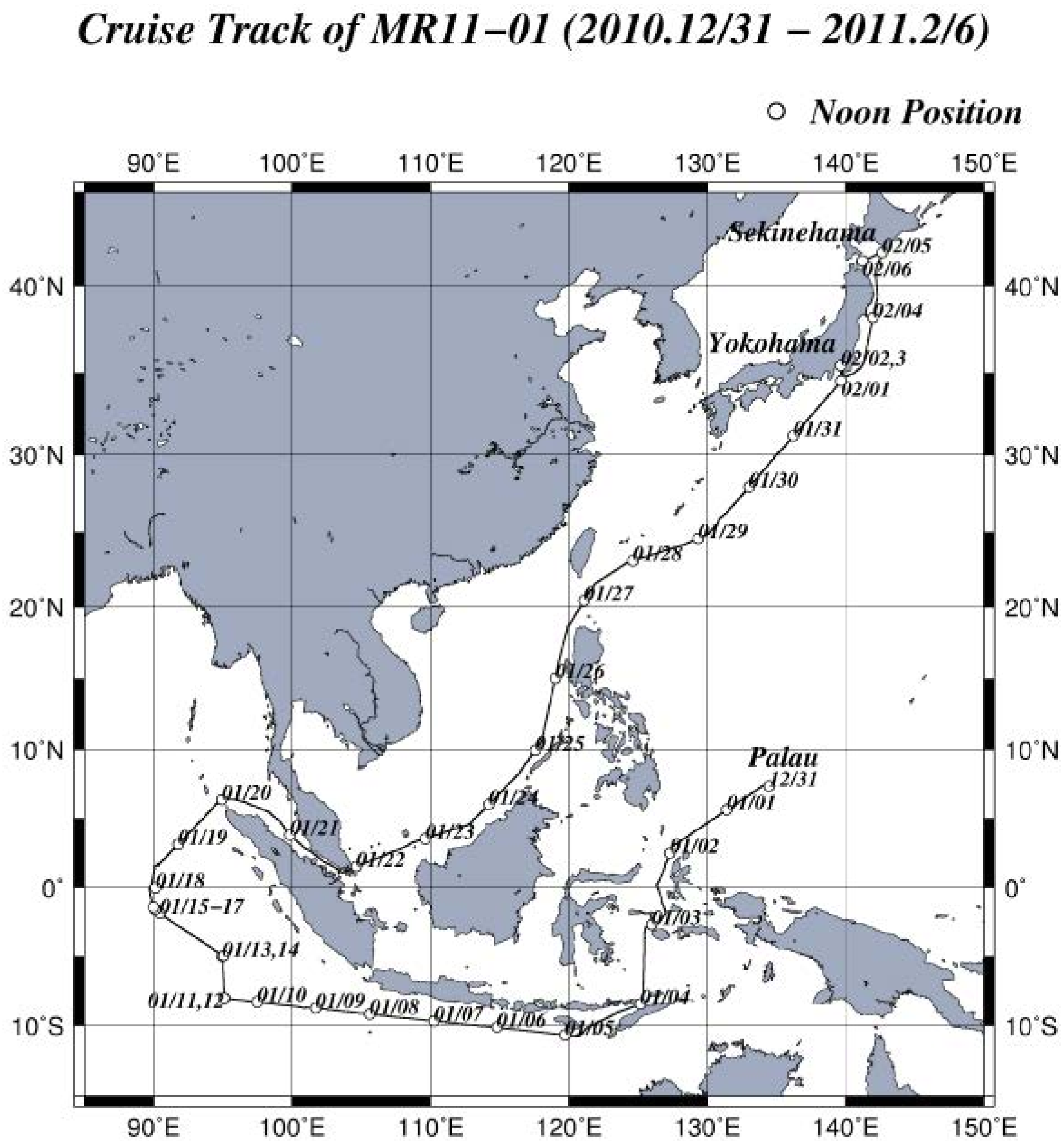



Fig 3.4 MR11-01 Cruise track and noon positions

## 4. Chief scientist

Chief Scientist

Yuji Kashino

Senior Research Scientist

Research Institute for Global Change (RIGC),

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

2-15, Natsushima-cho, Yokosuka, 237-0061, Japan

# 5. Participants list

## 5.1 R/V MIRAI scientists and technical staffs

| Name | Affiliation | Occupation | Onboard section |
|---|---|---|---|
| Yuji Kashino | JAMSTEC | Chief Scientist | Koror - Sekinehama |
| Yutaka Ota | JAMSTEC | Engineer | Koror - Sekinehama |
| Shoichiro Baba | JAMSTEC | Engineer | Yokohama - Sekinehama |
| Tatsuya Fukuda | JAMSTEC | Engineer | Yokohama - Sekinehama |
| Hiromichi Igarashi | JAMSTEC | Engineer | Yokohama - Sekinehama |
| Li-Feng Lu | JAMSTEC | Scientist | Yokohama - Sekinehama |
| Hidenori Aiki | JAMSTEC | Senior Scienitst | Yokohama - Sekinehama |
| Yoshiki Fukutomi | JAMSTEC | Senior Scienitst | Yokohama - Sekinehama |
| Ami Yamada | JAMSTEC | Engineer | Yokohama - Sekinehama |
| Asuka Shiomi | JAMSTEC | Engineer | Yokohama - Sekinehama |
| Mari Inada | JAMSTEC | Engineer | Yokohama - Sekinehama |
| Shumon Saizen | JAMSTEC | Administrative staff | Yokohama - Sekinehama |
| Shinichiro Ohki | JAMSTEC | Engineer | Yokohama - Sekinehama |
| Yoko Irie | JAMSTEC | Administrative staff | Yokohama - Sekinehama |
| Kazumi Nakano | JAMSTEC | Administrative staff | Yokohama - Sekinehama |
| Kazuki Komatsu | JAMSTEC | Administrative staff | Yokohama - Sekinehama |
| Tomoyuki Futamura | JAMSTEC | Administrative staff | Yokohama - Sekinehama |
| Yuki Furukawa | JAMSTEC | Engineer | Yokohama - Sekinehama |
| Ken Yatsu | JAMSTEC | Engineer | Yokohama - Sekinehama |
| Kenichi Katayama | Marine Works Japan Ltd | Technical Staff | Koror - Sekinehama |
| Naoko Miyamoto | Marine Works Japan Ltd | Technical Staff | Koror - Sekinehama |
| Tomoyuki Takamori | Marine Works Japan Ltd | Technical Staff | Koror - Yokohama |
| Keisuke Matsumoto | Marine Works Japan Ltd | Technical Staff | Koror - Sekinehama |
| Akira Watanabe | Marine Works Japan Ltd | Technical Staff | Koror - Yokohama |
| Tamami Ueno | Marine Works Japan Ltd | Technical Staff | Koror - Sekinehama |
| Masaki Yamada | Marine Works Japan Ltd | Technical Staff | Koror - Sekinehama |
| Takeo Matsumoto | Marine Works Japan Ltd | Technical Staff | Koror - Yokohama |
| Ai Takano | Marine Works Japan Ltd | Technical Staff | Koror - Sekinehama |
| Masakazu Ishikawa | Marine Works Japan Ltd | Technical Staff | Koror - Sekinehama |
| Fujio Kobayashi | Marine Works Japan Ltd | Technical Staff | Yokohama - Sekinehama |
| Tomohide Noguchi | Marine Works Japan Ltd | Technical Staff | Yokohama - Sekinehama |
| Tatsuya Tanaka | Marine Works Japan Ltd | Technical Staff | Yokohama - Sekinehama |
| Satoshi Okumura | Global Ocean Development Inc | Technical Staff | Koror - Sekinehama |
| Katsuhisa Maeno | Global Ocean Development Inc | Technical Staff | Koror - Sekinehama |

## 5.2 R/V MIRAI crew members

| Name | Rank or rating |
|---|---|
| Takao Nakayama | Master |
| Takeshi Isohi | Chief Officer |
| Norichika Watanabe | 1st Officer |
| Hajime Matsuo | 2nd Officer |
| Haruka Wakui | 3rd Officer |
| Yoichi Furukawa | Chief Engineer |
| Katsunori Kajiyama | 1st Engineer |
| Hiroyuki Tohken | 2nd Engineer |
| Keisuke Nakamura | 3rd Engineer |
| Yusuke Kimoto | Jr.3rd Engineer |
| Ryo Ohyama | Technical Officer |
| Yosuke Kuwahara | Boatswain |
| Takeharu Aisaka | Able Seaman |
| Tsuyoshi Monzawa | Able Seaman |
| Masashige Okada | Able Seaman |
| Yoshihiro Hatanaka | Able Seaman |
| Shuji Komata | Able Seaman |
| Hideyuki Okubo | Ordinary Seaman |
| Ginta Ogaki | Ordinary Seaman |
| Shohei Uehara | Ordinary Seaman |
| Kazunari Mitsunaga | Ordinary Seaman |
| Tomohiro Shimada | Ordinary Seaman |
| Sadanori Honda | No.1 Oiler |
| Toshimi Yoshikawa | Oiler |
| Yoshihiro Sugimoto | Oiler |
| Kazumi Yamashita | Oiler |
| Daisuke Taniguchi | Oiler |
| Shintaro Abe | Ordinary Oiler |
| Hitoshi Ota | Chief Steward |
| Tamotsu Uemura | Cook |
| Sakae Hoshikuma | Cook |
| Michihiro Mori | Cook |
| Masao Hosoya | Cook |
| Shohei Maruyama | Steward |

# 6. General observations

## 6.1 Meteorological measurements

### 6.1.1 Surface meteorological observations


| | |
|---|---|
| Yuji Kashino | (JAMSTEC): Principal Investigator |
| Satoshi Okumura | (Global Ocean Development Inc., GODI) |
| Katsuhisa Maeno | (GODI) |
| Ryo Ohyama | (MIRAI Crew) |


(1) Objectives

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

(2) Methods

Surface meteorological parameters were observed throughout the MR11-01 cruise. During this cruise, we used three systems for the observation.

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

1. MIRAI Surface Meteorological observation (SMet) system

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

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

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

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

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

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

1. Young Rain gauge (SMet and SOAR)

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

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

(3) Preliminary results

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

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

(4) Data archives

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

(5) Remarks

1. Significant wave height data was not available in the following period.
   11:00 UTC 09 Jan. - 05:00 UTC 19 Jan. 2011
2. SST (Sea Surface Temperature) data was available in the following periods.
   11:00UTC 09 Jan. - 05:00UTC 19 Jan. 2011
   00:00UTC 28 Jan. - 06:27UTC 01 Feb. 2011
   09:10UTC 03 Feb. - 04:59UTC 05 Feb. 2011
3. SMet rain gauge data was NOT available in the following period, interfered by MF/HF radio transmission.
   04:25 UTC 15 Jan. 2011
4. SMet optical rain gauge lens cleaning
   05:23UTC 27 Jan. 2011
   05:25UTC 01 Feb. 2011
5. The upwelling radiometer (long wave) data was not available due to sensor maintenance in the following period.
   04:15 - 05:30UTC 02 Feb. 2011
6. Data acquisition was stopped due to the PC trouble in the following period.
   23:19 - 23:42UTC 10 Jan. 2011

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

| Sensors | Type | Manufacturer | Location (altitude from surface) |
|---|---|---|---|
| Anemometer | KE-500 | Koshin Denki, Japan | foremast (24 m) |
| Tair/RH | HMP45A | Vaisala, Finland | |
| with 43408 Gill aspirated radiation shield | | R.M. Young, USA | compass deck (21 m)<br>starboard side and port side |
| Thermometer: SST | RFN1-0 | Koshin Denki, Japan | 4th deck (-1m, inlet -5m) |

| | | | |
|---|---|---|---|
| Barometer | Model-370 | Setra System, USA | captain deck (13 m)<br>weather observation room |
| Rain gauge | 50202 | R. M. Young, USA | compass deck (19 m) |
| Optical rain gauge | ORG-815DR | Osi, USA | compass deck (19 m) |
| Radiometer (short wave) | MS-801 | Eiko Seiki, Japan | radar mast (28 m) |
| Radiometer (long wave) | MS-200 | Eiko Seiki, Japan | radar mast (28 m) |
| Wave height meter | MW-2 | Tsurumi-seiki, Japan | bow (10 m) |

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

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

Table.6.1.1-3 Instruments and installation locations of SOAR system

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

| | | | |
|---|---|---|---|
| Optical rain gauge | ORG-815DA | Osi, USA | foremast (24 m) |

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

Table.6.1.1-4 Parameters of SOAR system

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

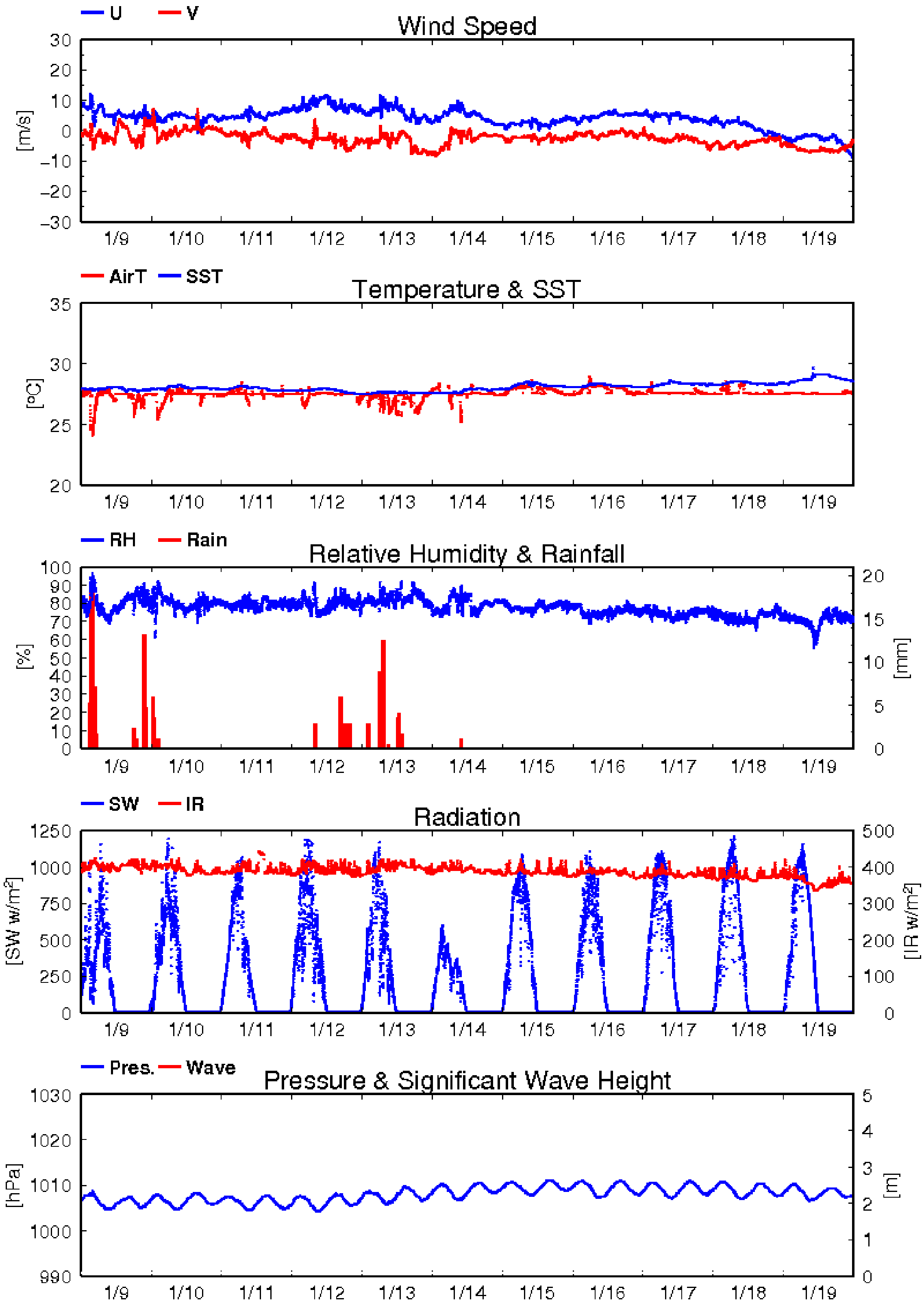



Fig.6.1.1-1 Time series of surface meteorological parameters during the MR11-01 cruise

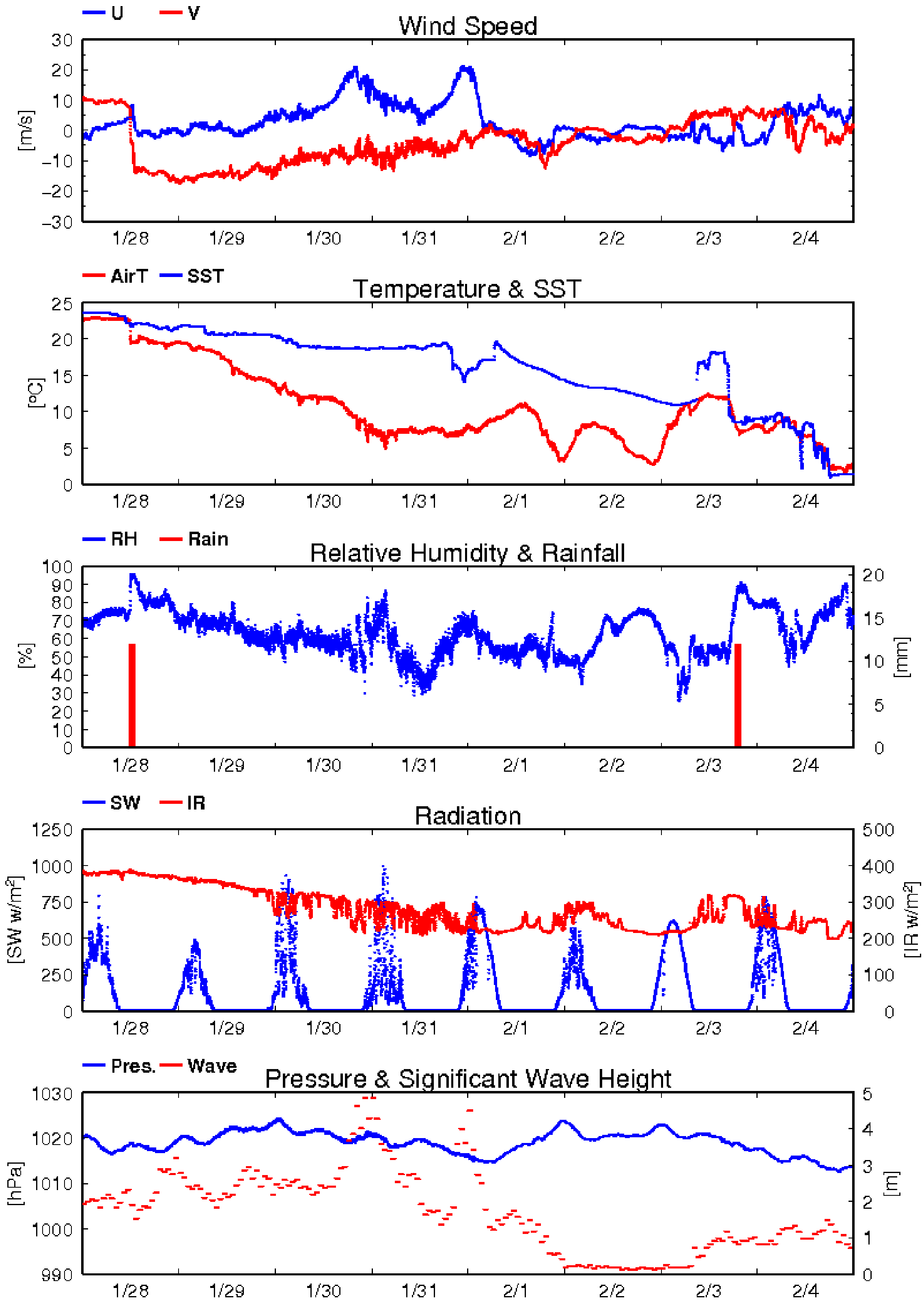



Fig. 6.1.1-1 (Continued)

### 6.1.2 Ceilometer

Yuji Kashino (JAMSTEC): Principal Investigator
Satoshi Okumura (Global Ocean Development Inc., GODI)
Katsuhisa Maeno (GODI)
Ryo Ohyama (MIRAI Crew)

(1) Objectives

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

(2) Parameters

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

(3) Methods

We measured cloud base height and backscatter profile using ceilometer (CT-25K, VAISALA, Finland) throughout the MR11-01 cruise.

Major parameters for the measurement configuration are as follows;

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

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

(4) Preliminary results

Fig.6.1.2-1 shows the time series of the lowest, second and third cloud base height during the cruise.

(5) Data archives

The raw data obtained during this cruise will be submitted to the Data Management Group

(DMG) in JAMSTEC.

(6) Remarks

1. Window cleaning;

02:20UTC 08 Jan. 2011

05:22UTC 27 Jan. 2011

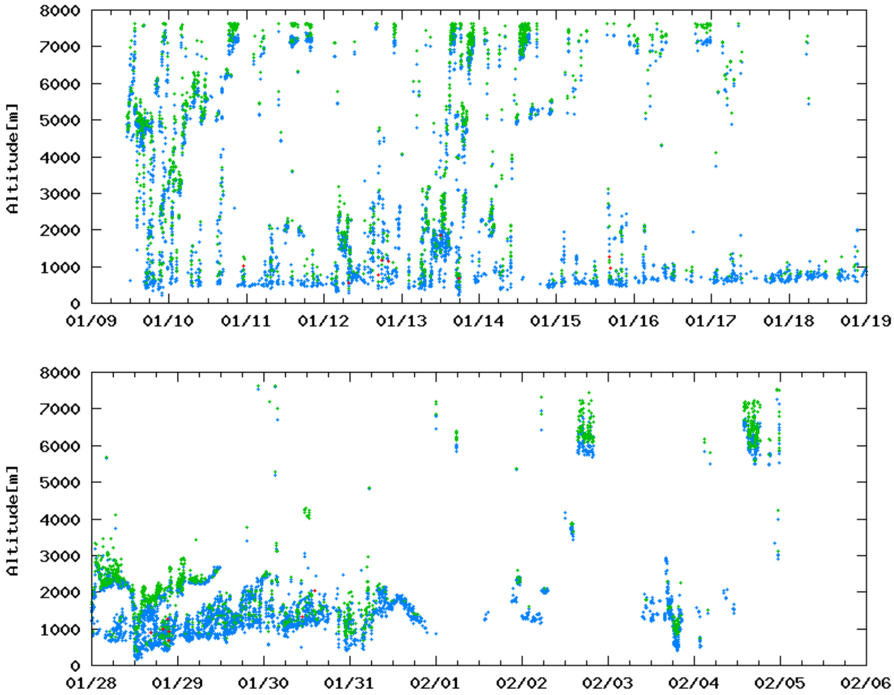



Fig. 6.1.2-1 Lowest, 2nd and 3rd cloud base height in the MR11-01 cruise

## 6.2 CTD

(1) Personnel

| | |
|---|---|
| Yuji Kashino | (JAMSTEC): Principal investigator |
| Naoko Miyamoto | (MWJ): Operation leader |
| Tamami Ueno | (MWJ) |

(2) Objective

Investigation of oceanic structure and water sampling.

(3) Parameters

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

(4) Instruments and Methods

CTD/Carousel Water Sampling System, which is a 36-position Carousel water sampler (CWS) with Sea-Bird Electronics, Inc. CTD (SBE9plus), was used during this cruise. 12-litter Niskin Bottles were used for sampling seawater. The sensors attached on the CTD were temperature (Primary and Secondary), conductivity (Primary and Secondary), pressure, dissolved oxygen (Primary). Salinity was calculated by measured values of pressure, conductivity and temperature. The CTD/CWS was deployed from starboard on working deck.

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.20g) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled at 1,000 or 2,000m by sending fire commands from the personal computer to check Salinity data. We usually stop for 30 seconds to stabilize then fire.

6 casts of CTD measurements were conducted (Table 6.2-1).

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

(The process in order)

DATCNV: Convert the binary raw data to engineering unit data. DATCNV also extracts bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 3.0 seconds, and the offset was set to 0.0 second. Tau Correction and hysteresis correction for oxygen of “Miscellaneous” tab were applied.

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

ALIGNCTD: Convert the time-sequence of sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Dissolved oxygen data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensor and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 3 seconds advancing dissolved oxygen sensor output (dissolved oxygen voltage) relative to the temperature data.

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

CELLTM: Remove conductivity cell thermal mass effects from the measured conductivity. Typical values used were thermal anomaly amplitude alpha = 0.03 and the time constant 1/beta = 7.0.

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

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

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

DERIVE: Compute dissolved oxygen (SBE43).

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

DERIVE: Compute salinity, potential temperature, and sigma-theta.

SPLIT: Separate the data from an input .cnv file into down cast and up cast files.

Configuration file: MR1101A.con

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:

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

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

Calibrated Date: 07 Jul. 2010

Temperature sensors:

Primary: SBE03-04/F (S/N 031464, Sea-Bird Electronics, Inc.)

Calibrated Date: 20 Jul. 2010

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

Calibrated Date: 17 Sep. 2010

Conductivity sensors:

Primary: SBE04-04/0 (S/N 042854, Sea-Bird Electronics, Inc.)

Calibrated Date: 09 Jun. 2010

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

Calibrated Date: 28 Jan. 2010

Dissolved Oxygen sensors:

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

Calibrated Date: 08 Sep. 2010

Carousel water sampler:

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

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

(5) Preliminary Results

During this cruise, 6 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 6.2-1.

Vertical profile (down cast) of primary temperature, salinity and dissolved oxygen with pressure are shown in Figure 6.2-1 - 6.2-2.

(6) Data archive

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

6.2-1 MR11-01 CTD Cast table

| Station number | Cast No. | Date(UTC) (mmddyy) | Time(UTC) Start | End | BottomPosition Latitude | Longitude | Depth (m) | Wire Out(m) | Max. Depth(m) | Max. Pressure(db) | CTD Filename | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C01 | 1 | 011111 | 07:18 | 07:56 | 08-03.75S | 095-08.47E | 5266.0 | 1002.0 | 1001.9 | 1010.0 | C01M01 | No.19 dep. |
| | 2 | 011111 | 09:03 | 09:39 | 08-03.05S | 095-04.42E | 5250.0 | 999.4 | 1000.9 | 1009.0 | C01M02 | No.19 rec. |
| C02 | 1 | 011311 | 07:05 | 07:44 | 05-01.78S | 095-00.16E | 5007.0 | 998.5 | 1001.0 | 1009.2 | C02M01 | No.17 dep. |
| | 2 | 011311 | 09:05 | 10:12 | 04-58.15S | 095-02.21E | 5002.0 | 2001.2 | 2001.1 | 2021.9 | C02M02 | No.17 rec. / ARGO |
| C03 | 1 | 011511 | 09:01 | 09:38 | 01-41.76S | 090-01.81E | 4711.0 | 998.5 | 1000.0 | 1008.0 | C03M01 | No.18 rec. |
| | 2 | 011611 | 07:00 | 07:39 | 01-36.30S | 090-07.24E | 4673.0 | 999.4 | 1001.0 | 1009.0 | C03M02 | No.18 dep. |

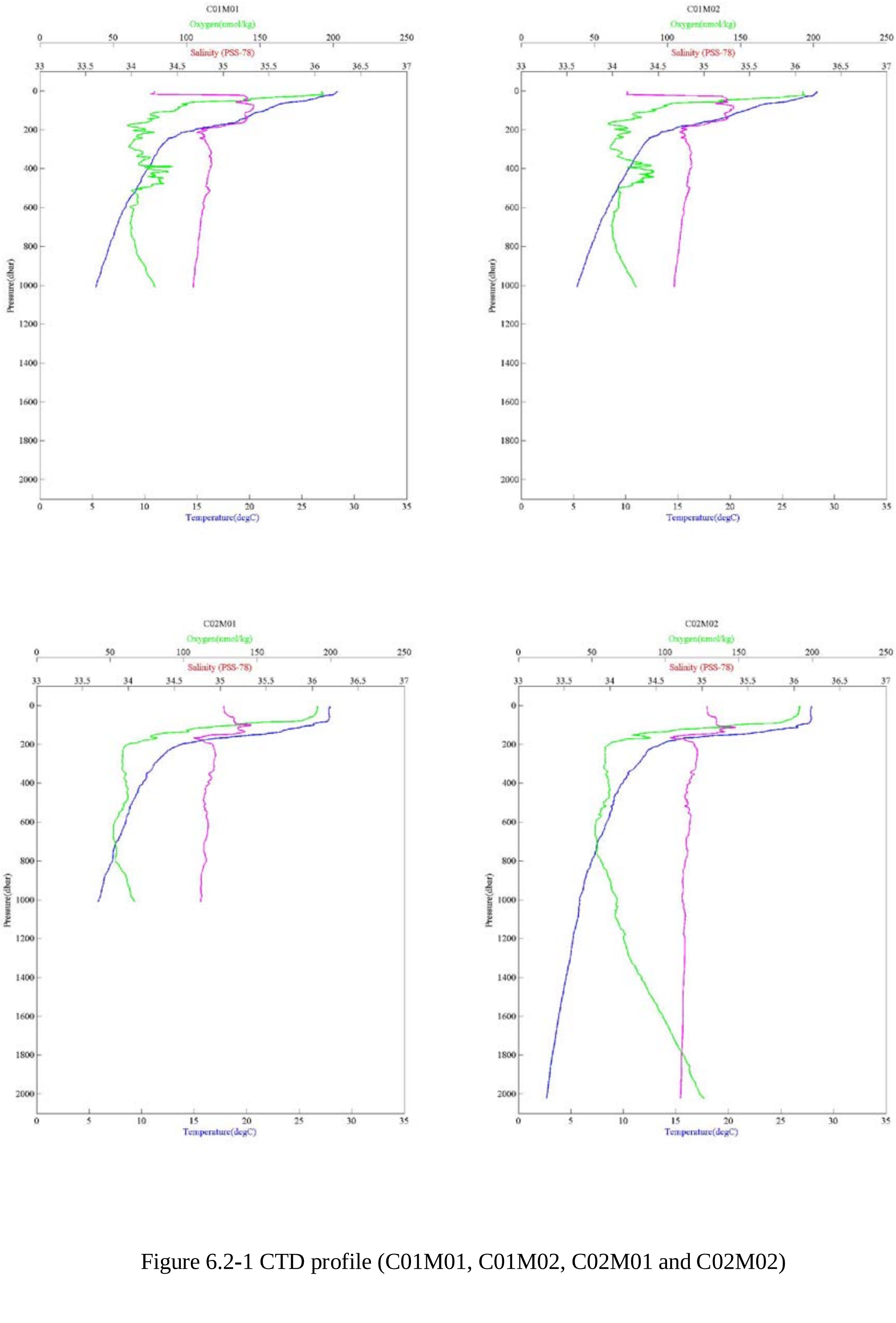



Figure 6.2-1 CTD profile (C01M01, C01M02, C02M01 and C02M02)

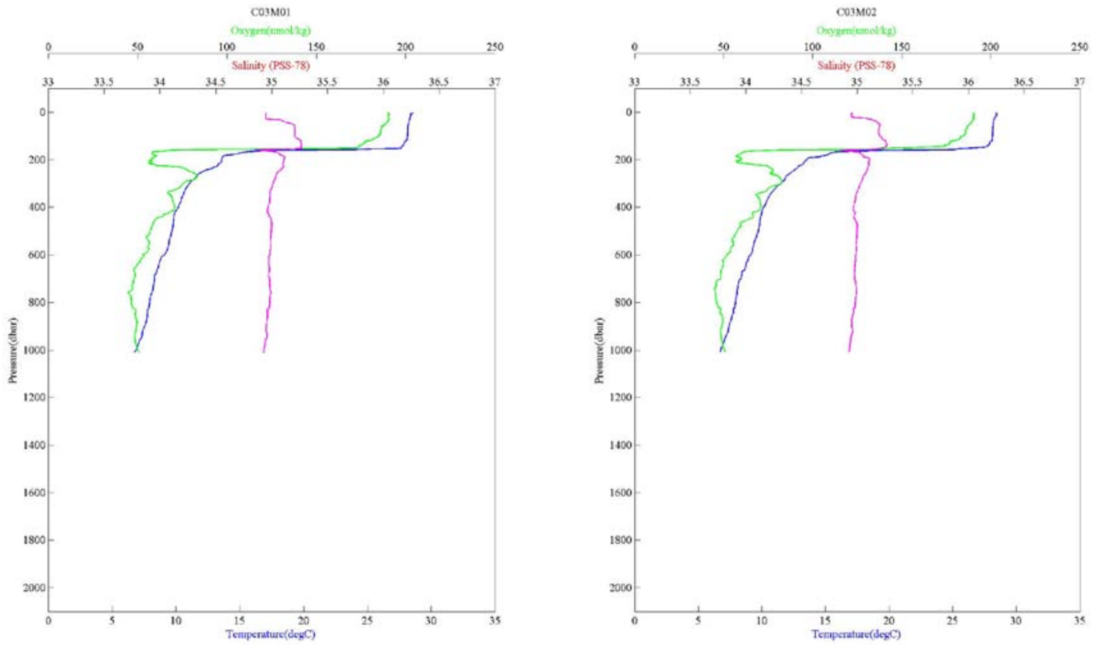



Figure 6.2-2 CTD profile (C03M01, C03M02)

## 6.3 Water sampling

### 6.3.1 Salinity

(1) Personnel

Yuji Kashino (JAMSTEC) : Principal Investigator
Tamami Ueno (MWJ) : Technical Staff (Operation Leader)
Naoko Miyamoto (MWJ) : Technical Staff

(2) Objective

To provide a calibration for the measurement of salinity of bottle water collected on the CTD casts and The Continuous Sea Surface Water Monitoring System (TSG).

(3) Method

a. Salinity Sample Collection

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

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

Table 6.3.1-1 Kind and number of samples

| Kind of Samples | Number of Samples |
|---|---|
| Samples for CTD | 24 |
| Samples for TSG | 22 |
| Total | 46 |

b. Instruments and Method

The salinity measurement was carried out on R/V MIRAI during the cruise of MR11-01 using the salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.: S/N 62556) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). A pair of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.) were used. One thermometer monitored the ambient temperature and the other monitored the bath temperature of the salinometer.

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

Salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.)
Measurement Range : 0.005 to 42 (PSU)
Accuracy : Better than ±0.002 (PSU) over 24 hours without re-standardization
Maximum Resolution : Better than ±0.0002 (PSU) at 35 (PSU)

Thermometer (Model 9540 ; Guildline Instruments Ltd.)

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

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 21 deg C to 24 deg C, while the bath temperature was very stable and varied within +/- 0.002 deg C on rare occasion. The measurement for each sample was done with a double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 10 seconds after filling the cell with the sample and it took about 15 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for the practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. In the case of the double conductivity ratio of eighth filling did not satisfy the criteria, we measured a ninth filling of the cell and calculated the bottle salinity. The measurement was conducted in about 4 hours per day and the cell was cleaned with soap after the measurement of the day.

(4) Preliminary Results

a. Standard Seawater

Standardization control of the salinometer was set to 777 and all measurements were done at this setting. The value of STANDBY was 24+5589 +/- 0001 and that of ZERO was 0.0±0000. The conductivity ratio of IAPSO Standard Seawater batch P152 was 0.99981 (the double conductivity ratio was 1.99962) and was used as the standard for salinity. 12 bottles of P152 were measured.

Fig.6.3.1-1 shows the history of the double conductivity ratio of the Standard Seawater batch P152 before correction. The average of the double conductivity ratio was 1.99960 and the standard deviation was 0.00002, which is equivalent to 0.0005 in salinity.

Fig.6.3.1-2 shows the history of the double conductivity ratio of the Standard Seawater batch P152 after correction. The average of the double conductivity ratio after correction was 1.99962 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

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

| | | |
|---|---|---|
| Batch | : | P152 |
| Conductivity Ratio | : | 0.99981 |
| Salinity | : | 34.993 |
| Use By | : | $05^{th}$ May 2013 |

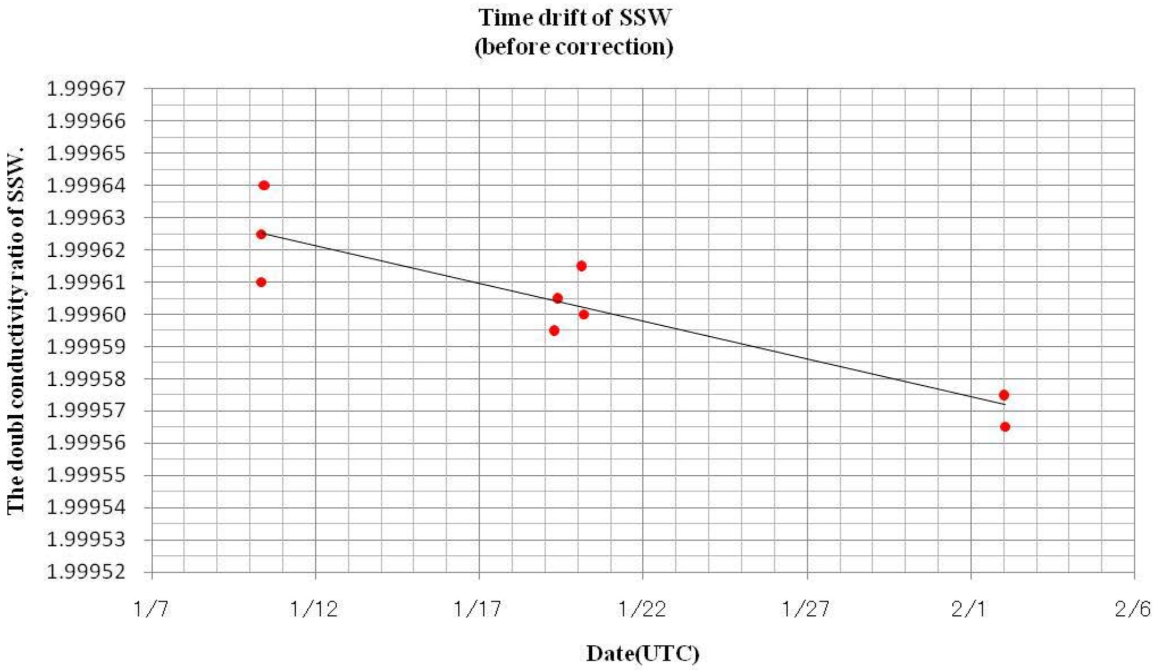



Fig. 6.3.1-1 History of double conductivity ratio for the Standard Seawater batch P152
(before correction)

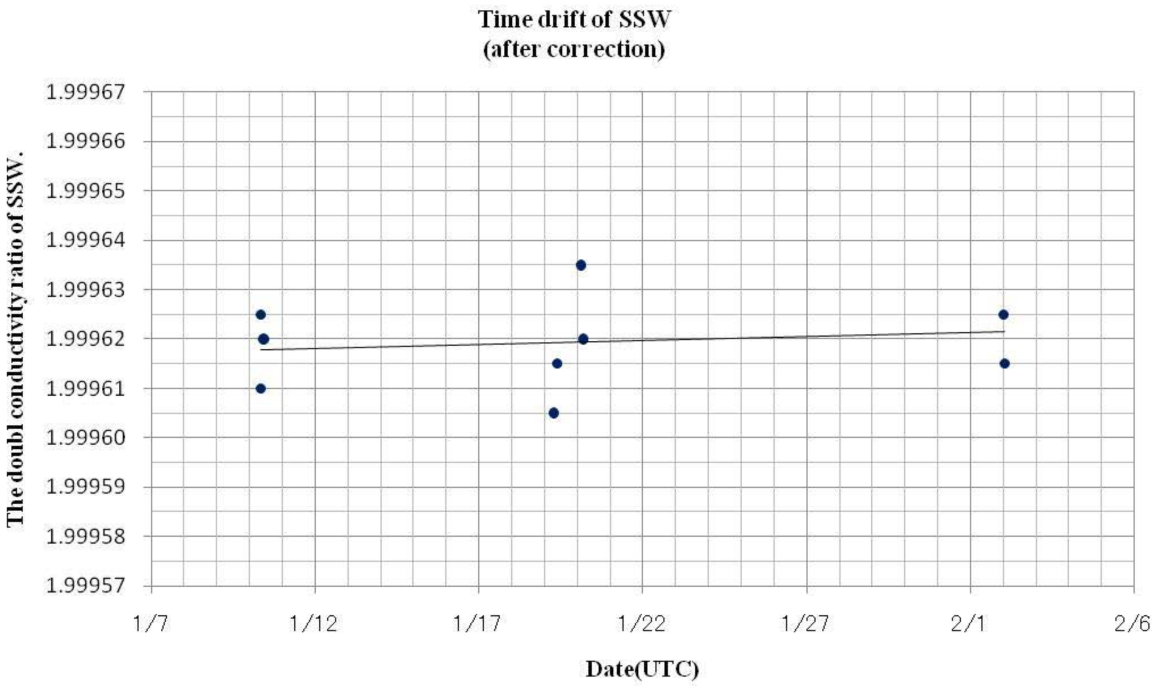



Fig. 6.3.1-2 History of double conductivity ratio for the Standard Seawater batch P152
(after correction)

b. Sub-Standard Seawater

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

c. Replicate Samples

We estimated the precision of this method using 12 pairs of replicate samples taken from the same Niskin bottle. The average and the standard deviation of absolute difference among 12 pairs of replicate samples were 0.0002 and 0.0002 in salinity, respectively.

(5) Data archive

These raw datasets will be submitted to JAMSTEC Data Management Office (DMO) and corrected datasets are available from Mirai Web site at http://www.jamstec.go.jp/mirai/.

(6) Reference


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

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

## 6.4 Continuous monitoring of surface seawater

### 6.4.1 Temperature, salinity, dissolved oxygen

1. Personnel

Yuji Kashino (JAMSTEC): Principal Investigator

Ai Takano (MWJ)

2. Objective

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

3. Instruments and Methods

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

a. Instruments

Software

Seamoni-kun Ver.1.10

Sensors

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

Temperature and Conductivity sensor

| | |
|---|---|
| Model: | SBE-45, SEA-BIRD ELECTRONICS, INC. |
| Serial number: | 4552788-0264 |
| Measurement range: | Temperature -5 to +35 $^oC$ |
| | Conductivity 0 to 7 S $m^{-1}$ |
| Initial accuracy: | Temperature 0.002 $^oC$ |
| | Conductivity 0.0003 S $m^{-1}$ |
| Typical stability (per month): | Temperature 0.0002 $^oC$ |

| | |
|---|---|
| | Conductivity 0.0003 S $m^{-1}$ |
| Resolution: | Temperatures 0.0001 $^oC$ |
| | Conductivity 0.00001 S $m^{-1}$ |

Bottom of ship thermometer

| | |
|---|---|
| Model: | SBE 38, SEA-BIRD ELECTRONICS, INC. |
| Serial number: | 3857820-0540 |
| Measurement range: | -5 to +35 $^oC$ |
| Initial accuracy: | ±0.001 $^oC$ |
| Typical stability (per 6 month): | 0.001 $^oC$ |
| Resolution: | 0.00025 $^oC$ |

Dissolved oxygen sensor

| | |
|---|---|
| Model: | OPTODE 3835, AANDERAA Instruments. |
| Serial number: | 985 |
| Measuring range: | 0 - 500 μmol $dm^{-3}$ |
| Resolution: | <1 μmol $dm^{-3}$ |
| Accuracy: | <8 μmol $dm^{-3}$ or 5% whichever is greater |
| Settling time: | <25 s |

4. Measurements

Periods of measurement, maintenance, and problems during MR11-01 are listed in Table 6.4.1-1.

Table 6.4.1-1 Events list of the surface seawater monitoring during MR11-01

| System Date [UTC] | System Time [UTC] | Events | Remarks |
|---|---|---|---|
| 2011/1/9 | 11:00 | All the measurements started and data was available. | Cruise started. |
| 2011/1/19 | 05:04 | All the measurements stopped. | |
| 2011/1/27 | 23:52 | All of the measurements started and data was available. | |
| 2011/2/1 | 06:28 | All the measurements stopped. | |
| 2011/2/3 | 10:02 | All of the measurements started and data was available. | |
| 2011/2/4 | 06:37 | All the measurements stopped. | Cruise finished |

5. Preliminary Result

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

6. Data archive

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

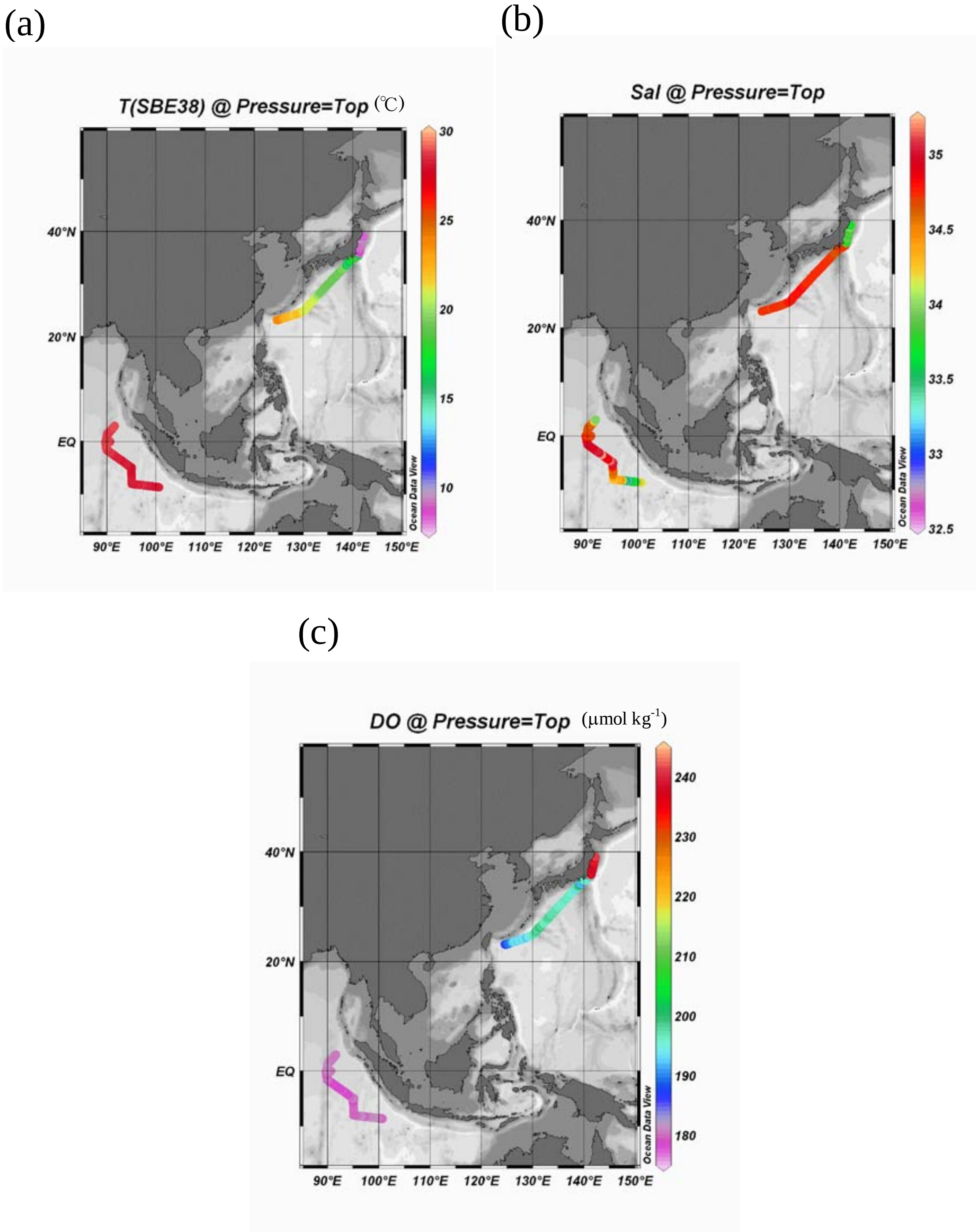



Fig.6.4.1-1 Spatial and temporal distribution of (a) temperature (b) salinity (c) dissolved oxygen in MR11-01 cruise.

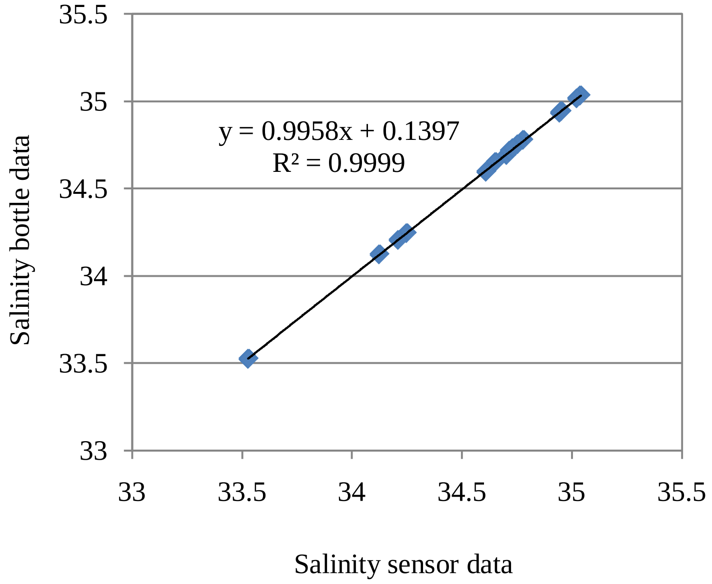



Fig.6.4.1-2 Correlation of salinity between sensor data and bottle data.

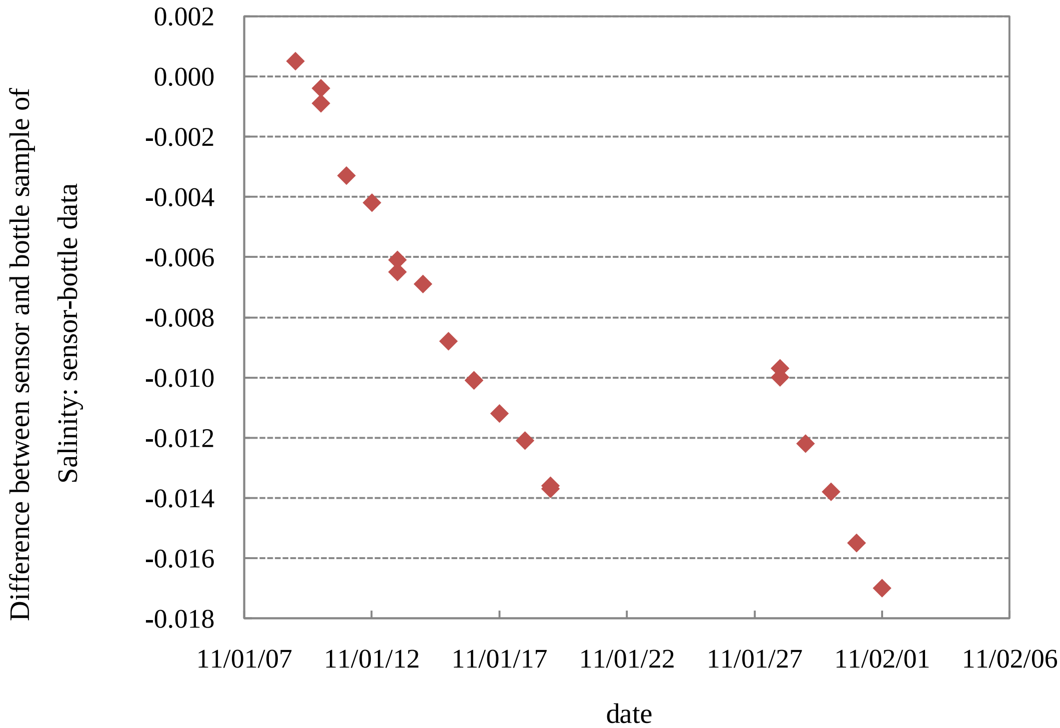



Fig.6.4.1-3 Difference of salinity between sensor data and bottle data.

## 6.5 Shipboard ADCP

(1) Personnel

| | |
|---|---|
| Yuji KASHINO | (JAMSTEC): Principal Investigator |
| Satoshi Okumura | (Global Ocean Development Inc., GODI) |
| Katsuhisa Maeno | (GODI) |
| Ryo Ohyama | (MIRAI Crew) |

(2) Objective

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

(3) Methods

Upper ocean current measurements were made in MR11-01 cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation the instrument was configured for water-tracking mode. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made to get the calibration data for evaluating transducer misalignment angle in the shallow water. The system consists of following components;

1. R/V MIRAI has installed the Ocean Surveyor for vessel-mount ADCP (frequency 75 kHz; Teledyne RD Instruments, USA). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel
2. For heading source, we use ship's gyro compass (Tokimec, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System which provide high-precision heading, attitude information, pitch and roll, are stored in ".N2R" data files with a time stamp.
3. DGPS system (Trimble SPS751 & StarFixXP) providing precise ship's position.
4. We used VmDas software version 1.4.2 (TRDI) for data acquisition.
5. To synchronize time stamp of ping with GPS time, the clock of the logging computer is adjusted to GPS time every 1 minute
6. Fresh water is charged in the sea chest to prevent biofouling at transducer face.
7. The sound speed at the transducer does affect the vertical bin mapping and vertical velocity measurement, is calculated from temperature, salinity (constant value; 35.0 psu) and depth (6.5 m; transducer depth) by equation in Medwin (1975).

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

(4) Preliminary results

Fig.6.5-1 shows the current profile along the ship's track.

(5) Data archive

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

Table 6.5-1 Major parameters

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

| | |
|---|---|
| WN = 40 | Number of depth cells (1-128) |
| WP = 00001 | Pings per Ensemble (0-16384) |
| WS= 1600 | Depth Cell Size (cm) |
| WT = 000 | Transmit Length (cm) [0 = Bin Length] |
| WV = 0390 | Mode 1 Ambiguity Velocity (cm/s radial) |

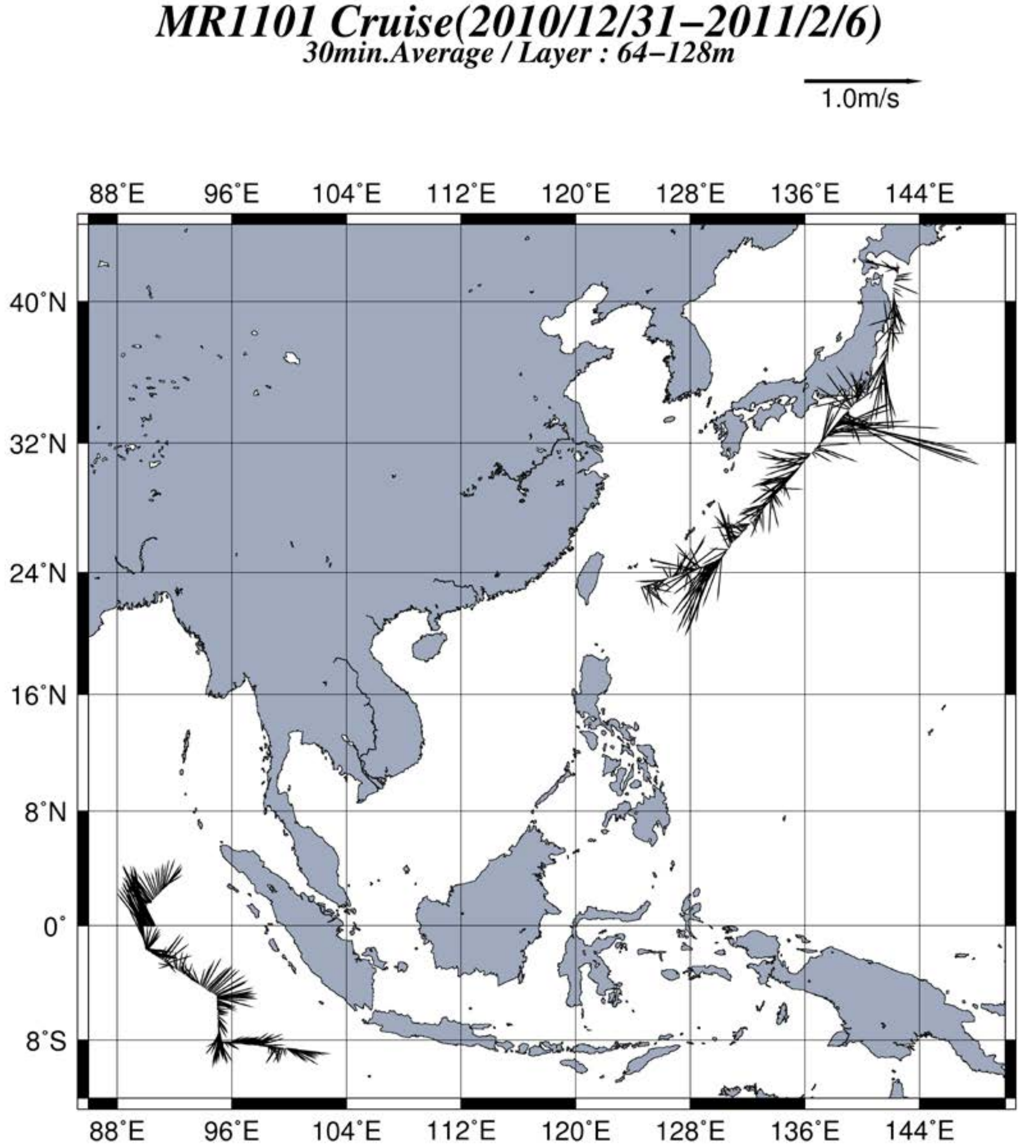



Fig 6.5-1. Current profile along the ship’s track.

## 6.6 Underway geophysics

### 6.6.1. Sea surface gravity

(1) Personnel

| | | |
|---|---|---|
| Takeshi Matsumoto | (University of the Ryukyus) | : Principal Investigator (Not on-board) |
| Satoshi Okumura | (Global Ocean Development Inc., GODI) | |
| Katsuhisa Maeno | (GODI) | |
| Ryo Ohyama | (MIRAI Crew) | |

(2) Introduction

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

(3) Parameters

Relative Gravity [CU: Counter Unit]

[mGal] = (coef1: 0.9946) * [CU]

(4) Data Acquisition

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) in the MR11-01 cruise.

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

(5) Preliminary Results

Absolute gravity shown in Table 6.6.1-1

(6) Data Archives

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

(7) Remarks

1. Following periods, data acquisition was suspended in the territorial waters and EEZ.
   07:00UTC 31st Dec. 2010 - 11:00UTC 09th Jan. 2011 (Palau and Indonesia)
   05:00UTC 19th Jan. - 23:59UTC 27th Jan. 2011 (Indonesia, Singapore, Malaysia, Brunei and Philippine)

Table 6.6.1-1

| No | Date | UTC | Port | Absolute Gravity [mGal] | Sea Level [cm] | Draft [cm] | Gravity at Sensor *[1] [mGal] | L&R*[2] Gravity [mGal] |
|---|---|---|---|---|---|---|---|---|
| #1 | Nov/23 | 20:56 | Sekinehama | 980,371.92 | 224 | 630 | 980,372.66 | 12,654.69 |
| #2 | Feb/06 | 07:56 | Sekinehama | 980,371.92 | 222 | 630 | 980,372.65 | 12,655.63 |

*[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

### 6.6.2 Sea surface magnetic field

(1) Personnel

| | |
|---|---|
| Takeshi Matsumoto | (University of the Ryukyus): Principal Investigator (Not on-board) |
| Satoshi Okumura | (Global Ocean Development Inc., GODI) |
| Katsuhisa Maeno | (GODI) |
| Ryo Ohyama | (MIRAI Crew) |

(2) Introduction

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer in the MR11-01 cruise.

(3) Principle of ship-board geomagnetic vector measurement

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

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

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

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

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

(4) Instruments on R/V MIRAI

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

(5) Data Archives

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

(6) Remarks

1. Following periods, data acquisition was suspended in the territorial waters and exclusive economic zone of other countries.

   07:00UTC 31st Dec. 2010 - 11:00UTC 09th Jan. 2011 (Palau and Indonesia)

   05:00UTC 19th Jan. - 23:59UTC 27th Jan. 2011 (Indonesia, Singapore, Malaysia, Brunei and Philippine)

2. For calibration of the ship's magnetic effect, we made a "figure-eight" turn (a pair of clockwise and anti-clockwise rotation) three times as follows;

   10:20-10:47UTC 11 Jan. 2011 around 08-05.4S, 095-03.2E

   04:53-05:22UTC 18 Jan. 2011 around 00-02.6S, 090-05.4E

   01:45-02:13UTC 05 Feb. 2011 around 42-53.4N, 142-32.5E

### 6.6.3. Swath bathymetry

(1) Personnel

| | |
|---|---|
| Takeshi Matsumoto | (University of the Ryukyus): Principal Investigator (Not on-board) |
| Satoshi Okumura | (Global Ocean Development Inc., GODI) |
| Katsuhisa Maeno | (GODI) |
| Ryo Ohyama | (MIRAI Crew) |

(2) Introduction

R/V MIRAI is equipped with a Multi narrow Beam Echo Sounding system (MBES), SEABEAM 2112 (SeaBeam Instruments Inc.). The objective of MBES is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global datasets.

(3) Data Acquisition

The "SEABEAM 2100" on R/V MIRAI was used for bathymetry mapping in the MR11-01 cruise.

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

Table 6.6.3-1 System configuration and performance

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

(4) Preliminary Results

The results will be published after primary processing.

(5) Data Archives

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

# 7. Special Observations

## 7.1 TRITON/m-TRITON buoys

### 7.1.1 Operation of the TRITON/m-TRITON buoys

(1) Personnel

| | |
|---|---|
| Yuji Kashino | (JAMSTEC): Principal Investigator |
| Keisuke Matsumoto | (MWJ): Operation Leader |
| Akira Watanabe | (MWJ): Technical Staff |
| Takeo Matsumoto | (MWJ): Technical Staff |
| Masaki Yamada | (MWJ): Technical Staff |
| Kenichi Katayama | (MWJ): Technical Staff |
| Naoko Miyamoto | (MWJ): Technical Staff |
| Tomoyuki Takamori | (MWJ): Technical Staff |
| Tamami Ueno | (MWJ): Technical Staff |
| Ai Takano | (MWJ): Technical Staff |
| Masakazu Ishikawa | (MWJ): Technical Staff |

(2) Objectives

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

TRITON buoy (included m-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).

Three m-TRITON buoys have been successfully recovered and two m-TRITON buoys and one TRITON buoy deployed during this cruise (MR11-01).

(3) Measured parameters

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

Meteorological parameters: wind speed/direction, air temperature, relative humidity, shortwave radiation, precipitation, Barometer(Only deployment buoy)

Oceanic parameters: water temperature and depth at 1m, 10m, 20m, 40m, 60m, 80m, 100m, 120m, 140m, 200m, 300m, 500m, conductivity at 1m, 10m, 20m, 40m, 100m, currents at 10m

*TRITON and m-TRITON observes same oceanic parameters and meteorological parameters.

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

Oceanic sensors

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) CTD (Conductivity-Temperature and Depth meter, JAMSTEC)

JES10-CTIM

| | |
|---|---|
| Sampling interval : | 600sec |
| Measurement range, Temperature : | -5～+35 deg-C |
| Measurement range, Conductivity : | 0～+7 S/m |
| Measurement range, Pressure : | 0～full scale range |

3) 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 |

4) CRN (Current meter, Teledyne RD Instruments,Inc)

Doppler Volume Sampler

| | |
|---|---|
| Sampling interval : | 600sec |
| Sensor frequency : | 2400kHz |
| Velocity Range: | ±6m/s |

5) CRN(Current meter,Argonaut)

SonTek Acoustic Doppler Current Meter

| | |
|---|---|
| Sensor frequency : | 1500kHz |
| Sampling interval : | 1200sec |
| Average interval : | 120sec |

Meteorological sensors

1) Precipitation (JAMSTEC)

MODEL50203

| | |
|---|---|
| Sampling interval : | 600sec |

2) Relative humidity/air temperature (JAMSTEC)

MODEL MP101A, 103A

| | |
|---|---|
| Sampling interval : | 600sec |

3) Shortwave radiation (JAMSTEC)

MODEL EPSP

| | |
|---|---|
| Sampling interval : | 600sec |

4) Wind speed/direction (JAMSTEC)

MODEL Y85000

| | |
|---|---|
| Sampling interval : | 600sec |

5) Baromater (JAMSTEC)

MODEL DP4000

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

Meteorological sensors are controlled by I/O RS485.

GPS and Inductive modem are controlled by RS232C.

2) ARGOS transmitter

The data in the interval of 10 minute are being transmitted through ARGOS transmitter.

(4) Results

Locations of deployment and recovery are as follow:

Locations of Recovery

| | |
|---|---|
| Nominal location | 5S, 95E(m-TRITON) |
| ID number at JAMSTEC | 17503 |
| ARGOS PTT number | 29040 |
| ARGOS backup PTT number | 27406 |
| Deployed date (UTC) | 11 Nov. 2009 |
| Recovered date (UTC) | 14 Jan. 2011 |
| Exact location | 04 - 56.91S, 94 - 58.35E |
| Depth | 5,005 m |

| | |
|---|---|
| Nominal location | 1.5S,90E(m-TRITON) |
| ID number at JAMSTEC | 18504 |
| ARGOS PTT number | 3E052BE |
| ARGOS backup PTT number | 29792 |
| Deployed date (UTC) | 09 Nov. 2009 |
| Recovered date (UTC) | 17 Jan. 2011 |
| Exact location | 01 - 39.59S, 89 - 59.69Ｅ |
| Depth | 4,688 m |

| | |
|---|---|
| Nominal location | 8S, 95E(m-TRITON) |
| ID number at JAMSTEC | 19501 |
| ARGOS PTT number | 3E052AD |
| ARGOS backup PTT number | 29791 |
| Deployed date (UTC) | 14 Nov. 2009 |
| Recovered date (UTC) | 12 Jan. 2011 |
| Exact location | 07 - 59.97S, 95 - 02.60E |
| Depth | 5,207 m |

Locations of Deployment

| | |
|---|---|
| Nominal location | 5S,95E(TRITON) |
| ID number at JAMSTEC | 17504 |
| ARGOS PTT number | 27400 |
| ARGOS backup PTT number | 24246 |
| Deployed date (UTC) | 13 Jan. 2011 |
| Exact location | 05 - 01.97S, 94 - 58.60E |
| Depth | 5,014 m |

| | |
|---|---|
| Nominal location | 1.5S,90E(m-TRITON) |
| ID number at JAMSTEC | 18505 |
| ARGOS PTT number | 9EB84D4 |
| ARGOS backup PTT number | 27411 |
| Deployed date (UTC) | 16 Jan. 2011 |
| Exact location | 01 - 36.18S, 90 - 04.44E |
| Depth | 4,716 m |

| | |
|---|---|
| Nominal location | 8S,95E(m-TRITON) |
| ID number at JAMSTEC | 19502 |
| ARGOS PTT number | 29EB779 |
| ARGOS backup PTT number | 24742 |
| Deployed date (UTC) | 11 Jan. 2011 |
| Exact location | 08 - 04.05S, 95 - 07.40E |
| Depth | 5,261 m |

(5) Data archive

The data in the interval of 10 minutes 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/ ).

## 7.2 Recovery of the Southern Ocean buoy

(1) Personnel

| | |
|---|---|
| Shoichiro Baba | (JAMSTEC): Engineer |
| Tatsuya Fukuda | (JAMSTEC): Engineer |
| Yutaka Ohta | (JAMSTEC): Engineer |
| Kenichi Katayama | (MWJ): Technical staff |
| Keisuke Matsumoto | (MWJ): Technical staff |
| Tomohide Noguchi | (MWJ): Technical staff |
| Masaki Yamada | (MWJ): Technical staff |
| Fujio Kobayashi | (MWJ): Technical staff |
| Shinya Tanaka | (MWJ): Technical staff |

(2) Objective

A Prototype of southern ocean buoy was deployed for about 2(two) month in Hokkaido coast to verify the performance in winter season.

(3) Measured parameters

Meteorological parameters: Wind speed/direction, Atmospheric pressure, Air temperature, Relative humidity, Short wave radiation, Precipitation

Oceanic parameters: water temperature at 2m, Current profiler below 2.5m

Engineering parameters: Monitoring camera for the wind direction velocimetry with ~~the ice suppression~~ heater, Monitoring camera for the deck of the buoy, Monitoring camera for the dome cover, Iridium camera for the dome cover in real time communication, Overtopping waves measurement, Nilometer at 1.4m in 3 sets, Tension meter at the end of the center pole, Attitude measurement

(4) Instrument

1) Meteorological sensors

Wind speed/direction, air temperature, relative humidity, atmospheric pressure, precipitation
Vaisala Weather Transmitter WXT520
Sampling interval: 600s

Atmospheric pressure
JAMMET BAR & model DP4000
Sampling interval: 600s

Air temperature, relative humidity
JAMMET HRH & model MP103A
Sampling interval: 600s

Short Wave Radiation
JAMMET SWR & model EPSP
Sampling interval: 600s

Precipitation

JAMMET RAN & model Y50202

Sampling interval: 600s

2) Underwater sensor

Water temperature

JES10 (form JAMSTEC): Sampling interval 600sec

3) Engineering sensors

Monitoring cameras 3 sets

TAMAYA TECHNICS INC. KADEC21-EYE II: Shooting interval: 1 hour

Iridium camera

Nissin-technica inc. UART-camera for outside: Shooting interval: 24h

Overtopping waves measure

KENEK CO., LTD. CHT5-100JAMS: Sampling interval: 600s, Sampling time: 60s

Measurement range: 0-1000mm

Nilometer

RIGO CO., LTD. RMD N5225: Sampling interval: 600s, Sampling time: 60s

Measurement range: 0-5m

Tension meter

Unipulse Corporation LT-50KNG79: Sampling interval: 600s, Sampling time: 60s

Measurement range: 0-50kN

Attitude Measurement

Silicon Sensing Systems Japan, Ltd. AMU-1802-BR

Sampling interval: 7 days, Sampling time: 8hours

Measurement range roll: ±180deg

Measurement range pitch : ±85deg

Measurement range angle velocity: ±180 deg/s

Measurement range accelerated velocity: ±2G

Workhorse ADCP 300kHz

Hydro Systems Development. Inc.

Layer: 8m, Sampling interval: 600s, Maximum measuring range: 154m

Compass

PNI Corporation TCM3: Sampling interval: 600s

(5) Location of recovery

Nominal location 41° 50’N,142° 40’E

ID number at JAMSTEC Nantaiyo

| | |
|---|---|
| ARGOS PTT number | 96773 |
| Deployed date | 24 Nov. 2010 |
| Recovered date | 5 Feb. 2011 |
| Exact location | 41°50.1522N, 142°39.7641’E |
| Depth | 796m |

## 7.3 Subsurface ADCP mooring

(1) Personnel

| | |
|---|---|
| Yuji Kashino | (JAMSTEC): Principal Investigator |
| Akira Watanabe | (MWJ): Operation leader |
| Tomoyuki Takamori | (MWJ): Technical staff |
| Kenichi Katayama | (MWJ): Technical staff |
| Keisuke Matsumoto | (MWJ): Technical staff |
| Tamami Ueno | (MWJ): Technical staff |
| Takeo Matsumoto | (MWJ): Technical staff |
| Masaki Yamada | (MWJ): Technical staff |

(2) Objective

The purpose of this ADCP observation is to get knowledge of physical process underlying the dynamics of oceanic circulation in the eastern equatorial Indian Ocean. Sub-surface currents are observed by using ADCP moorings at 0°S, 90°E. In this cruise (MR11-01), we deployed as well as recovered sub-surface ADCP moorings at 0°S, 90°E.

(3) Parameters

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

(4) Method

Two instruments are mounted at the top float of the mooring. One is ADCP (Acoustic Doppler Current Profiler) to observe upper-ocean currents from subsurface down to around 400m depths. The second instrument mounted below the float is CTD, which observes pressure, temperature and salinity for correction of sound speed and depth variability. Details of the instruments and their parameters are described as follows:

1) ADCP

Work Horse Long Ranger ADCP 75 kHz (Teledyne RD Instruments, Inc.)

Distance to first bin: 15.5 m
Pings per ensemble: 27
Time per ping: 6.66 seconds
Bin length: 8.00m

Sampling interval: 3600 seconds

*Deployed ADCP*

- Serial Number : 13123 (Mooring No.110118-0090E)

*Recovered ADCP*

- Serial Number : 1248 (Mooring No.091108-0090E)

2) CTD

SBE-37 (Sea Bird Electronics Inc.)

Sampling Interval: 1800 seconds

*Deployed ADCP*

- Serial Number : 1775 (Mooring No.110118-0090E)

*Recovered CTD*

- Serial Number : 1338 (Mooring No.091108-0090E)

3) Other instrument

(a)Acoustic Releaser (BENTHOS,Inc.)

*Deployed Acoustic Releaser*

- Serial Number: 677 (Mooring No.110118-0090E)
- Serial Number: 689 (Mooring No.110118-0090E)

*Recovered Acoustic Releaser*

- Serial Number: 664 (Mooring No.091108-0090E)
- Serial Number: 956 (Mooring No.091108-0090E)

(b) Transponder (BENTHOS,Inc.)

*Deployed Transponder*

- Serial Number : 57114 (Mooring No.110118-0090E)

*Recovered Transponder*

- Serial Number : 67489 (Mooring No.091108-0090E)

(5) Deployment

Deployment of the ADCP mooring at 0°S, 90°E was planned to mount the ADCP at about 400m depth. After dropping the anchor, we monitored the depth of the acoustic releaser.

- The position of the mooring No.110118-0090E

  Date: 18 Jan. 2011 Lat: 00° 00.0743' N Long: 90° 08.6753' E Depth: 4,085m

(6) Recovery

We recovered one ADCP mooring which was deployed on 8 Nov. 2009 (KY09-09 cruise). We uploaded ADCP and CTD data into a computer. The raw data, then, were converted into ASCII code. Figure 7.3 show results from the mooring.

(7) Data archive

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

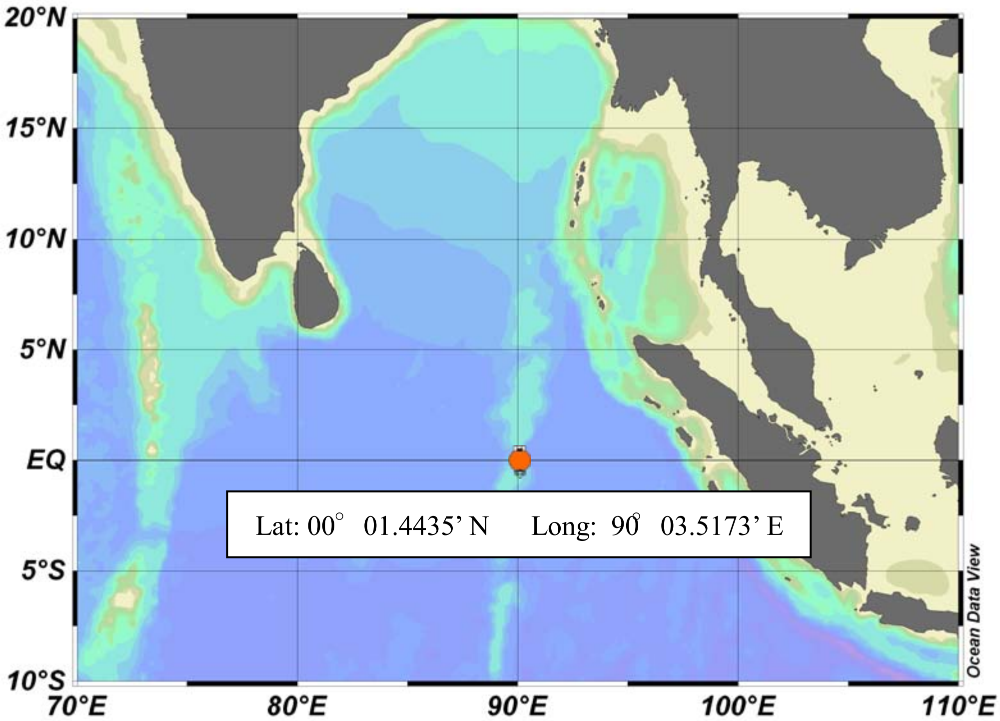



Fig.7.3-1 Mooring position of recovered subsurface ADCP

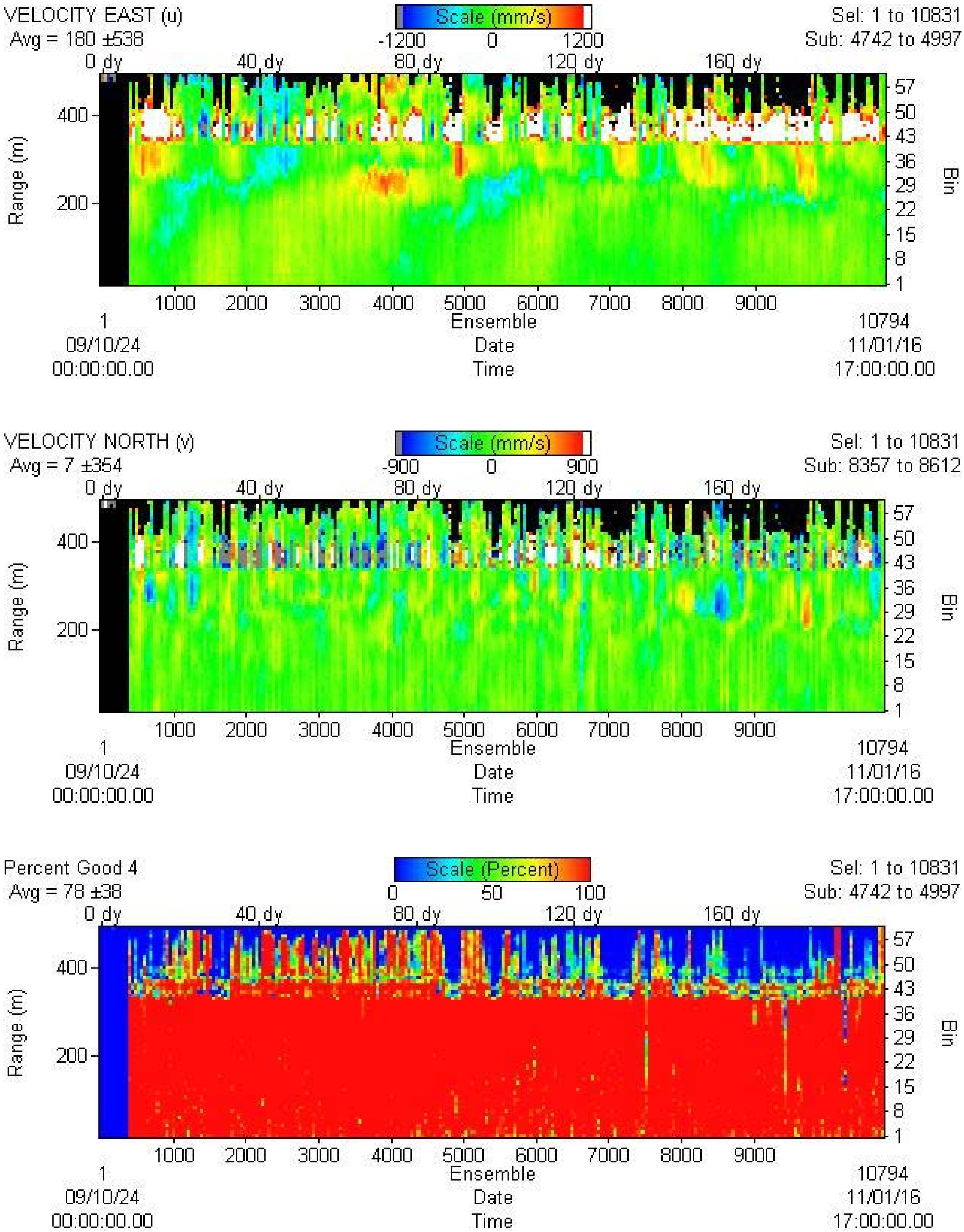



Fig.7.3-2 Time-depth sections of observed zonal (*top panel*) and meridional (*middle panel*) currents obtained from ADCP mooring at (0°S, 90°E).Percent good(*bottom panel*) shows percent of available data in each ensemble.

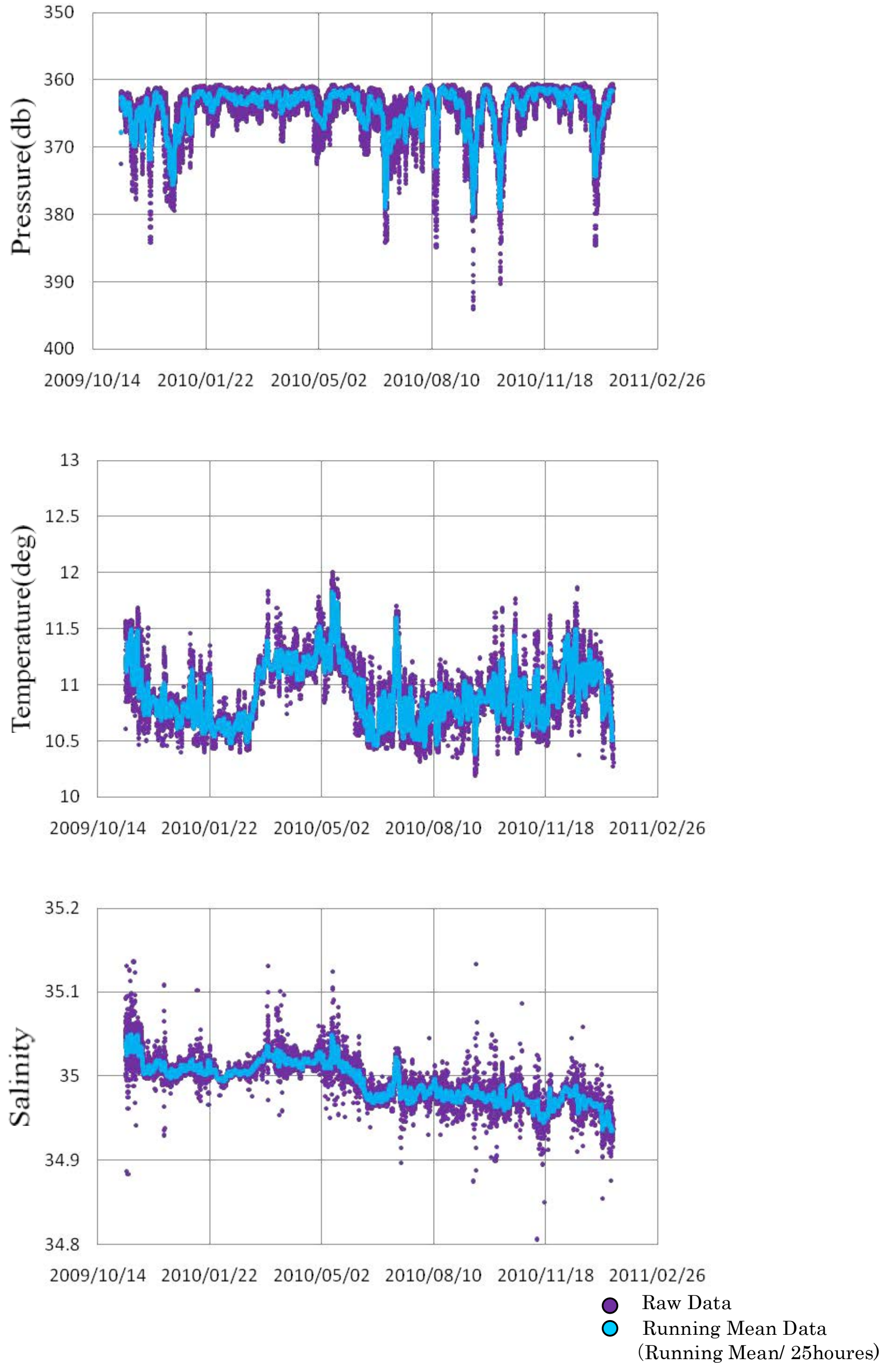



Fig.7.3-3.Time-series of the observed pressure (*top panel*), temperature (*middle panel*) and salinity (*bottom panel*) obtained from CTD at (0°S, 90°E). The *purple* curve indicates the raw data, while the *light-blue* curve shows the filtered data from 25 hours running-mean.

## 7.4 Argo float

### (1) Personnel

| | |
|---|---|
| *Toshio Suga* | *(JAMSTEC/RIGC): Principal Investigator (not on board)* |
| *Shigeki Hosoda* | *(JAMSTEC/RIGC): not on board* |
| *Kanako Sato* | *(JAMSTEC/RIGC): not on board* |
| *Mizue Hirano* | *(JAMSTEC/RIGC): not on board* |
| *Tamami Ueno* | *(MWJ): Technical Staff (Operation Leader)* |
| *Naoko Miyamoto* | *(MWJ): Technical Staff* |

### (2) Objectives

The objective of deployment is to clarify the structure and temporal/spatial variability of water masses in the equatorial Indian Ocean. To achieve the objective, profiling floats are launched in the region with less number of active floats to measure vertical profiles of temperature and salinity automatically every 10 days. The data from the floats as well as other active floats in this area will enable us to understand the variability of water masses.

### (3) Parameters

・water temperature, salinity, and pressure

### (4) Methods

#### i. Profiling float deployment

We launched an APEX float manufactured by Webb Research Ltd. These floats equip an SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc. to measure temperature, salinity and pressure from surface to 1500 dbar. The floats usually drift at a depth of 1000 dbar (called the parking depth), diving to a depth of 1525 dbar. During the ascent to the surface by increasing the volume of the float in order to increase its buoyancy, the float measures sea water temperature, salinity, and pressure. To send the measured data to the Argo data center via the ARGOS transmitting system in real time, the float stays at the sea surface for enough time, approximately 10 hours. Finally, the float returns to the parking depth by decreasing its volume. This cycle of the float moving repeats every 10 days for 3 or 4 years. The status of floats and their launches are shown in Table 7.4.1.

**Table 7.4.1 Status of floats and their launches**
**Float(1525dbar)**

| | |
|---|---|
| **Float Type** | **APEX floats manufactured by Webb Research Ltd.** |
| **CTD sensor** | **SBE41 manufactured by Sea-Bird Electronics Inc.** |
| **Cycle** | **10 days (approximately 9 hours at the sea surface)** |
| **ARGOS transmit interval** | **30 sec** |
| **Target Parking Pressure** | **1000 dbar** |
| **Sampling layers** | **105 (1500, 1450, 1400, 1350, 1300, 1250, 1200, 1150, 1100, 1050, 1000, 980, 960, 940, 920, 900, 880, 860, 840, 820, 800, 780, 760, 740, 720, 700, 680, 660, 640, 620, 600, 580, 560, 540, 520, 500, 490, 480, 470, 460, 450, 440, 430, 420, 410, 400, 390, 380, 370, 360, 350, 340, 330, 320, 310, 300, 290, 280, 270, 260, 250, 240,** |

| | |
|---|---|
| | **230, 220,210, 200, 195, 190, 185, 180, 175, 170, 165, 160, 155, 150, 145, 140, 135, 130, 125, 120, 115, 110, 105, 100, 95, 90, 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30, 25, 20, 15, 10, 4 or surface dbar)** |

**Launches**

| Float S/N | ARGOS ID | Date and Time of Reset (UTC) | Date and Time of Launch(UTC) | Location of Launch | CTD St. No. |
|---|---|---|---|---|---|
| **5213** | **70357** | **2011/01/14 05:17** | **2011/01/14 06:55** | **4-58.05S 95-02.14E** | **C02M02** |

**(5) Data archive**

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

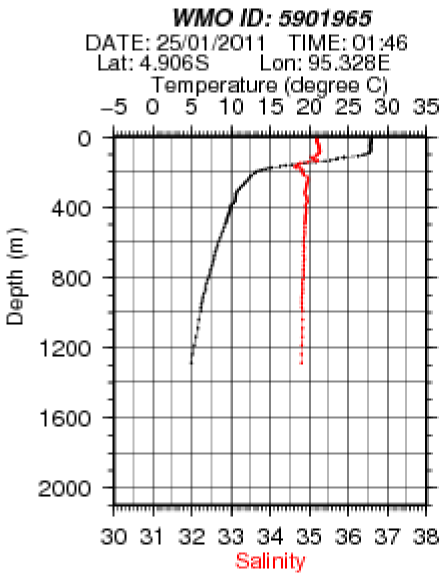



**Fig. 7.4.1. The profile of each float launched during MR11-01.**

## 7.5 Surface atmospheric turbulent flux measurement

(1) Personnel

| | | | |
|---|---|---|---|
| Osamu Tsukamoto | (Okayama University) | Principal Investigator | * not on board |
| Fumiyoshi Kondo | (University of Tokyo) | | * not on board |
| Hiroshi Ishida | (Kobe University) | | * not on board |

(2) Objective

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

(3) Instruments and Methods

The surface turbulent flux measurement system (Fig. 7.5-1) consists of turbulence instruments (Kaijo Co., Ltd.) and ship motion sensors (Kanto Aircraft Instrument Co., Ltd.). The turbulence sensors include a three-dimensional sonic anemometer-thermometer (Kaijo, DA-600) and an infrared hygrometer (LICOR, LI-7500). The sonic anemometer measures three-dimensional wind components relative to the ship. The ship motion sensors include a two-axis inclinometer (Applied Geomechanics, MD-900-T), a three-axis accelerometer (Applied Signal Inc., QA-700-020), and a three-axis rate gyro (Systron Donner, QRS-0050-100). LI7500 is a $CO_2/H_2O$ turbulence sensor that measures turbulent signals of carbon dioxide and water vapor simultaneously. These signals are sampled at 10 Hz by a PC-based data logging system (Labview, National Instruments Co., Ltd.). By obtaining the ship speed and heading information through the Mirai network system it yields the absolute wind components relative to the ground. Combining wind data with the turbulence data, turbulent fluxes and statistics are calculated in a real-time basis. These data are also saved in digital files every 0.1 second for raw data and every 1 minute for statistic data.

(4) Observation log

The observation was carried out throughout this cruise.

(5) Data Policy and citation

All data are archived at Okayama University, and will be open to public after quality checks and corrections. Corrected data will be submitted to JAMSTEC Data Management Group (DMG).

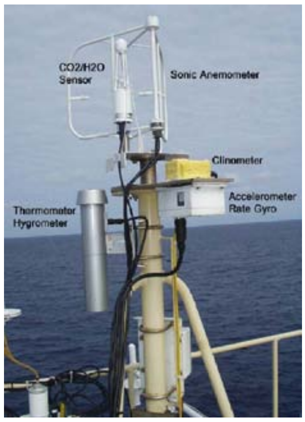



Fig. 7.5-1 Turbulent flux measurement system on the top deck of the foremast.

## 7.6 Aerosol optical characteristics measured by Shipborne Sky radiometer

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

(1) Objective

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

(2) Methods and Instruments

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

@ Measured parameters

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

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

(3) Preliminary results

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

(4) Data archives

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

## 7.7 Lidar observations of clouds and aerosols

(1) Personnel

Nobuo Sugimoto, Ichiro Matsui, Atsushi Shimizu, Tomoaki Nishizawa (National Institute for Environmental Studies, not on board), lidar operation was supported by Global Ocean Development Inc.

(2) Objectives

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

(3) Measured parameters

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

(4) Method

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

(5) Results

As lidar data has not been brought to NIES, a quick-look of lidar observation on February 3, 2011 is shown in Figure 7.7-1. Although data duration is one day, layered structure of the atmosphere is clearly depicted. Lower clouds were located around 2 km altitude, and there was aerosol layer below the cloud layer.

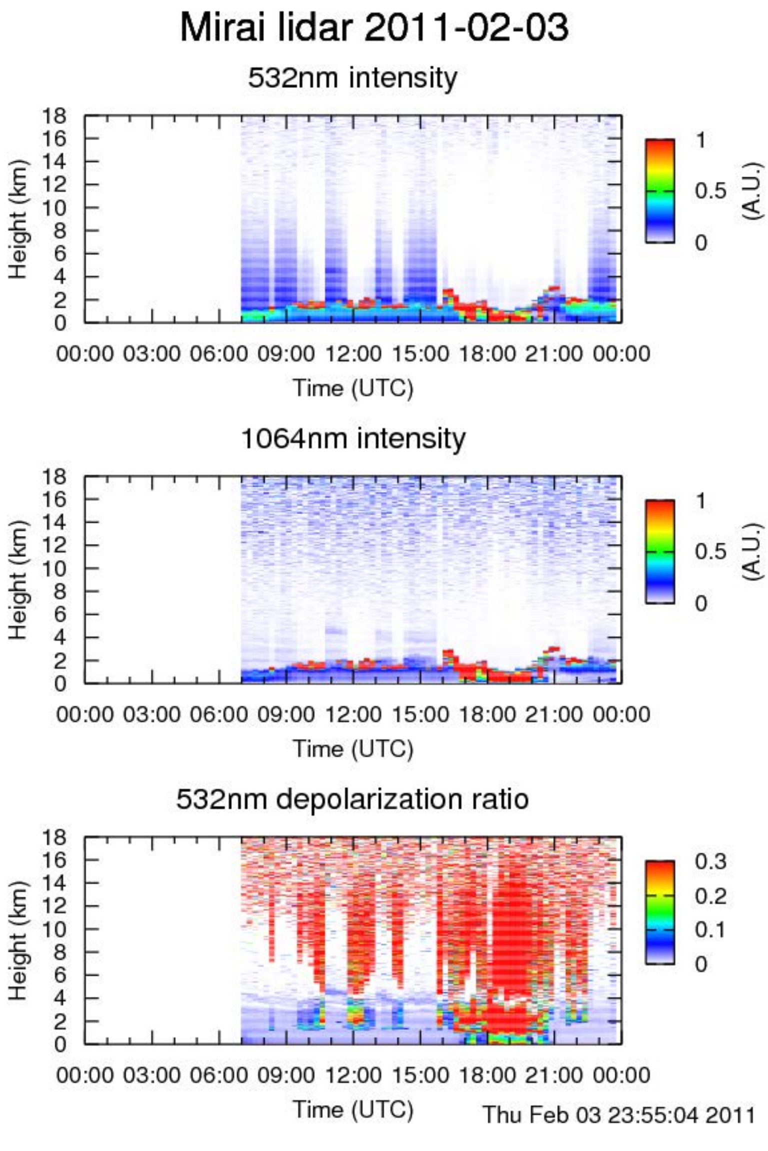



Figure 7.7-1: Time-height sections of (top) backscatter intensity at 532 nm, (middle) backscatter intensity at 1064 nm, and (bottom) volume depolarization ratio at 532 nm on February 3, 2011.

(6) Data archive

- raw data
  - lidar signal at 532 nm
  - lidar signal at 1064 nm
  - depolarization ratio at 532 nm
  - temporal resolution 10min/ vertical resolution 6 m
  - data period (UTC): December 31, 2010 - February 6, 2011
- processed data (plan)
  - cloud base height, apparent cloud top height
  - phase of clouds (ice/water)
  - cloud fraction
  - boundary layer height (aerosol layer upper boundary height)
  - backscatter coefficient of aerosols
  - particle depolarization ratio of aerosols

(7) Data policy and Citation

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

## 7.8 Rain, water vapor and surface water sampling

(1) Personnel

Naoyuki Kurita (JAMSTEC) Principal Investigator（not on-board）
Satoshi Okumura (Global Ocean Development Inc.) Operator
Maeno Katsuhisa (GODI) Operator

(2) Objective

It is well known that the variability of stable water isotopes (HDO and $H_2^{18}O$) is closely related with the moisture origin and hydrological processes during the transportation from the source region to deposition site. Thus, water isotope tracer is recognized as the powerful tool to study of the hydrological cycles in the atmosphere. However, oceanic region is one of sparse region of the isotope data, it is necessary to fill the data to identify the moisture sources by using the isotope tracer. In this study, to fill this sparse observation area, intense water isotopes observation was conducted along the cruise track of MR11-01.

(3) Method

Following observation was carried out throughout this cruise.

- Atmospheric moisture sampling:

  Water vapor was sampled from the height about 20m above the sea level. The air was drawn at rate of 1.5-3.0L/min through a plastic tube attached to top of the compass deck. The flow rate is regulated according to the water vapor content to collect the sample amount 4-20ml. The water vapor was trapped in a glass trap submerged into an ethanol cooled to 100 degree C by radiator, and then they are collected every 12 or 24 hour during the cruise. After collection, water in the trap was subsequently thawed and poured into the 6ml glass bottle.

- Rainwater sampling

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

- Surface seawater sampling

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

(4) Results

Sampling of water vapor for isotope analysis is summarized in Table 7.8-1 (32 samples). The detail of rainfall sampling (3 samples) is summarized in Table 7.8-2. Described rainfall amount is calculated from the collected amount of precipitation. Sampling of surface seawater taken by pump from 4m depths is summarized in Table 7.8-3 (16 samples).

(5) Data archive

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

Table 7.8-1 Summary of water vapor sampling for isotope analysis

| Sample | Date | Time (UT) | Date | Time (UT) | Lon | Lat | T.M. ($m^3$) | Sam. (ml) | H2O ppm |
|---|---|---|---|---|---|---|---|---|---|
| V-1 | 1.9 | 11:05 | 1.10 | 1:49 | 98-02.0E | 8-22.0S | 1.34 | 24.5 | 22753 |
| V-2 | 1.10 | 1:52 | 1.10 | 12:00 | 96-24.1E | 8-11.9S | 0.92 | 16.9 | 22860 |
| V-3 | 1.10 | 12:02 | 1.11 | 0:00 | 95-15.0E | 8-00.6S | 1.09 | 19.5 | 22263 |
| V-4 | 1.11 | 0:02 | 1.11 | 12:00 | 95-06.8E | 8-05.9S | 1.09 | 19.5 | 22263 |
| V-5 | 1.11 | 12:03 | 1.12 | 0:00 | 95-04.0E | 8-03.6S | 1.09 | 19.0 | 21692 |
| V-6 | 1.12 | 0:01 | 1.12 | 12:02 | 95-03.5E | 6-45.9S | 1.10 | 20.0 | 22626 |
| V-7 | 1.12 | 12:05 | 1.13 | 0:00 | 95-03.3E | 5-03.3S | 1.08 | 18.0 | 20741 |
| V-8 | 1.13 | 0:01 | 1.13 | 12:00 | 94-59.3E | 5-01.4S | 1.09 | 19.0 | 21692 |
| V-9 | 1.13 | 12:01 | 1.14 | 0:00 | 95-02.0E | 4-57.5S | 1.09 | 19.5 | 22263 |
| V-10 | 1.14 | 0:01 | 1.14 | 12:00 | 94-03.8E | 4-20.0S | 1.09 | 19.5 | 22263 |
| V-11 | 1.14 | 12:02 | 1.15 | 0:00 | 91-38.8E | 2-43.8S | 1.09 | 19.5 | 22263 |
| V-12 | 1.15 | 0:01 | 1.15 | 12:00 | 90--4.1E | 1-36.4S | 1.09 | 20.0 | 22834 |
| V-13 | 1.15 | 12:02 | 1.16 | 0:00 | 90-10.1E | 1-36.4S | 1.09 | 19.5 | 22263 |
| V-14 | 1.16 | 0:01 | 1.16 | 12:00 | 90-08.0E | 1-36.2S | 1.09 | 18.5 | 21121 |
| V-15 | 1.16 | 12:02 | 1.17 | 0:00 | 90-00.5E | 1-40.0S | 1.08 | 18.5 | 21317 |
| V-16 | 1.17 | 0:01 | 1.17 | 12:26 | 89-38.9E | 0-03.2S | 1.13 | 20.0 | 22026 |
| V-17 | 1.17 | 12:28 | 1.18 | 0:00 | 90-02.9E | 0-01.6S | 1.05 | 18.0 | 21333 |
| V-18 | 1.18 | 0:02 | 1.18 | 12:00 | 89-52.9E | 0-23.5N | 1.09 | 19.0 | 21692 |
| V-19 | 1.18 | 12:04 | 1.18 | 21:28 | 90-29.0E | 1-47.3N | 0.85 | 14.0 | 20497 |
| V-20 | 1.18 | 21:31 | 1.19 | 4:55 | 91-36.9E | 2-58.8N | 0.68 | 11.5 | 21046 |
| V-21 | 1.28 | 0:05 | 1.28 | 12:00 | 126-15.7E | 23-34.6N | 1.42 | 18.0 | 15775 |
| V-22 | 1.28 | 12:01 | 1.29 | 0:40 | 128-46.5E | 24-21.0N | 1.51 | 17.5 | 14422 |
| V-23 | 1.29 | 0:44 | 1.29 | 12:00 | 130-40.7E | 25-29.9N | 1.34 | 11.0 | 10216 |
| V-24 | 1.29 | 12:02 | 1.30 | 0:00 | 132-32.4E | 27-25.7N | 1.43 | 8.0 | 6962 |
| V-25 | 1.30 | 0:02 | 1.30 | 12:00 | 134-14.3E | 29-09.9N | 1.79 | 8.0 | 5562 |
| V-26 | 1.30 | 12:03 | 1.31 | 0:00 | 135-50.0E | 30-45.5N | 1.79 | 7.5 | 5214 |
| V-27 | 1.31 | 00:01 | 1.31 | 12:00 | 137-32.5E | 32-25.9N | 1.79 | 6.0 | 4171 |
| V-28 | 1.31 | 12:01 | 2.1 | 0:15 | 139-16.6E | 34-06.8N | 2.22 | 6.5 | 3644 |
| V-29 | 2.1 | 0:17 | 2.1 | 23:00 | 139-38.8E | 35-27.1N | 3.41 | 12.5 | 4562 |
| V-30 | 2.3 | 7:00 | 2.4 | 0:31 | 141-48.9E | 37-35.8N | 2.62 | 12.2 | 5795 |
| V-31 | 2.4 | 0:34 | 2.5 | 0:15 | 142-39.6E | 41-49.8N | 3.53 | 14.0 | 4935 |
| V-32 | 2.5 | 0:17 | 2.5 | 12:00 | 141-18.7E | 41-29.1N | 1.75 | 3.8 | 2702 |

Table 7.8-2 Summary of precipitation sampling for isotope analysis.

| | **Date** | **Time (UT)** | **Lon** | **Lat** | **Date** | **Time (UT)** | **Lon** | **Lat** | **Rain (mm)** | R/S |
|---|---|---|---|---|---|---|---|---|---|---|
| R-1 | 1.09 | 11:08 | 100-39.9E | 8-41.5S | 1.09 | 23:14 | 98-30.0E | 8-25.0S | 3.4 | R |
| R-2 | 1.09 | 23:14 | 98-30.0E | 8-25.0S | 1.13 | 23:44 | 95-02.0E | 4-57.0S | 2.2 | R |
| R-3 | 1.28 | 00:05 | 126-15.7E | 23-34.6N | 1.28 | 21:55 | 128-17.5E | 24-10.2N | 3.2 | R |

Table 7.8-3 Summary of sea surface water sampling for isotope analysis

| Sampling No. | | Date | Time | Position | |
|---|---|---|---|---|---|
| | | | (UTC) | LON | LAT |
| MR11-01 O- | 1 | 1.10 | 04:59 | 97-29.3E | 8-19.1S |
| MR11-01 O- | 2 | 1.11 | 05:57 | 95-07.0E | 8-03.4S |
| MR11-01 O- | 3 | 1.12 | 06:00 | 95-05.4E | 8-04.3S |
| MR11-01 O- | 4 | 1.13 | 06:01 | 94-58.5E | 05-02.8S |
| MR11-01 O- | 5 | 1.14 | 06:01 | 95-03.5E | 04-58.0S |
| MR11-01 O- | 6 | 1.15 | 06:00 | 90-25.8E | 01-54.5S |
| MR11-01 O- | 7 | 1.16 | 06:00 | 90-05.5E | 01-35.6S |
| MR11-01 O- | 8 | 1.17 | 06:00 | 89-58.2E | 01-25.7S |
| MR11-01 O- | 9 | 1.18 | 06:00 | 90-06.6E | 00-02.1S |
| MR11-01 O- | 10 | 1.28 | 04:20 | 124-41.7E | 23-07.1N |
| MR11-01 O- | 11 | 1.29 | 04:00 | 129-20.5E | 24-34.5N |
| MR11-01 O- | 12 | 1.30 | 03:00 | 133-01.1E | 27-55.4N |
| MR11-01 O- | 13 | 1.31 | 03:05 | 136-15.3E | 31-10.3N |
| MR11-01 O- | 14 | 2.1 | 03:00 | 139-40.9E | 34-30.0N |
| MR11-01 O- | 15 | 2.4 | 03:00 | 141-58.3E | 38-13.1N |
| MR11-01 O- | 16 | 2.5 | 03:00 | 142-23.6E | 41-51.1N |

## 7.9 Observation of atmospheric gas and aerosols by MAX-DOAS methods

(1) Personnel

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

(2) Objectives

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

(3) Methods

Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) is a passive remote sensing technique using scattered visible and ultraviolet (UV) solar radiation at several elevation angles. The MAX-DOAS system used in this study records spectra of scattered solar radiation every 0.2-0.4 second. Measurements were made at several elevation angles of 0, 3, 4, 5, 10, 20, 30, 70, 110, 150, 160, 170, 175, 176 and 177 degrees using a movable mirror, which repeated the same sequence of elevation angles every 30-min. The UV/visible spectra range was changed every min (284-423 nm and 391-528 nm). On the roof top of the anti-rolling system of R/V *Mirai*, the telescope unit was installed on a gimbal mount, which compensates for the pitch and roll of the ship. A sensor measuring pitch and roll of the telescope unit (10Hz) is used together to measure an offset of elevation angle due to incomplete compensation by the gimbal. The line of sight was in directions of the starboard and portside of the ship.

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

(4) Preliminary results

These data for the whole cruise period will be analyzed.

(5) Data archives

The data will be submitted to the Data Management Group (DMG) of JAMSTEC after the full analysis of the raw spectrum data is completed, which will be <2 years after the end of the cruise.