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R/V Mirai Cruise Report
MR20-01

February 23 – March 27, 2020

The Observational Study to Construct and to Extend
the "Western Pacific Super Site Network"

Edited by

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(JAMSTEC)

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 scientists for the latest information before using this report. Users of data or results of this cruise are requested to submit their results to JAMSTEC Data Management Group (e-mail: dmo@jamstec.go.jp).

1 General information

1.1. Cruise ID

MR20-01

1.2 Name of vessel

R/V Mirai

1.3 Title of cruise

The observational study to construct and to extend the "western Pacific super site network"

1.4 Research area

The western tropical Pacific Ocean

2 Overview and observation summary

2.1 Overview

The warm water pool located at the western equatorial Pacific Ocean has the highest sea surface temperature (SST) in the ocean all over the world. Therefore, the ocean and atmosphere interaction in this region is important for the climate variability in the Pacific Ocean such as El Niño/Southern Oscillation (ENSO). This cruise was conducted to understand the process of expansion and shrinkage of the warm water region, and the air-sea interaction in the western tropical Pacific Ocean. For these purposes, we performed deployment and recovery of the TRITON (TRIangle Trans Ocean buoy Network) and Philippine Sea buoys as the main mission. The buoy observations are advantageous for analyses of long- term variability in the warm water pool. In addition, we carried out other observations, such as by using acoustic Doppler current profiler (ADCP) moorings, conductivity-temperature-depth and dissolved oxygen concentration ($CTDO_2$) sensors, a lowered ADCP (LADCP), an underway CTD (UCTD), Wave Gliders, radiosondes, and other meteorological instruments.

Prior to and during the cruise, the ocean and atmosphere in the tropical Pacific Ocean was in the conditions of the transition phase from El Niño to La Niña, and, in the eastern edge of the warm pool, had varied vigorously in association with westward propagation of a warm SST anomaly.

2.2 Observation summary

TRITON buoy deployment (including Philippine Sea mooring):	3 sites
TRITON buoy recovery:	3 sites
ADCP buoy deployment:	1 sites
ADCP buoy recovery:	1 sites
Wave Glider	2 sites
$CTDO_2$/LADCP including RINKO profiler water sampling:	39 casts
Underway CTD:	26 casts
Radiosonde:	47 launched
Surface meteorology:	continuous
Doppler radar observation:	continuous
Shipboard ADCP measurement:	continuous
Geophysics measurement:	continuous
Surface temperature, salinity and dissolved oxygen measurements by intake method	continuous

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

3 Cruise Information

3.1 Chief scientist

Akira Nagano
Senior Scientist,
Ocean-Atmosphere Climate Research Group,
Research Institute for Global Change,
JAMSTEC

3.2 Period

February 23 – March 27, 2020

3.3 Ports of call

Koror, Republic of Palau (Departure: February 23, 2020)
Sekinehama, Japan (Arrival: March 27, 2020)

3.4 Cruise log

SMT	UTC	Event
Feb. 23rd (Sun) 2020		
		[Ship Mean Time (SMT)=UTC+9h]
10:00	01:00	Departure from Koror, Palau
11:00	02:00	Safety guidance
13:15	04:15	Emergency drill
15:00	06:00	Observation meeting
15:54	06:54	Start of sea surface water sampling
		Start of continuous observations
16:00	07:00	Pray to Kumbhira for secure cruise
16:30	07:30	Start of Doppler radar observation
Feb. 24th (Mon.) 2020		
08:24	23:24 (-1 day)	Start of MBES survey
Feb. 25th (Tue.) 2020		
03:20	18:20 (-1 day)	End of MBES survey
Feb. 26th (Wed.) 2020		
08:33-14:10	23:33(-1 day)-04:10	
		Deployment of the Philippine Sea mooring
		(12˚-53.68'N, 136˚-54.29'E, 5249m)
15:38-16:11	06:38-07:11	$CTDO_2$/LADCP (12˚-53.70'N, 136˚-54.11'E, 100 dbar)
		with JES10-mini and RINKO profiler
16:48-17:55	07:48-08:55	$CTDO_2$/LADCP (12˚-53.98'N, 136˚-52.90'E, 1000 dbar)
Feb. 27th (Thu.) 2020		
05:58	20:58 (-1 day)	$CTDO_2$/LADCP (13˚-06.56'N, 136˚-53.23'E, 2000 dbar)
		and water sampling
08:45-15:30	23:45 (-1 day)-06:30	
		Recovery of the Philippine Sea mooring
15:41	06:41	Installation of Argo float
Feb. 29th (Sat.) 2020		
09:40-13:13	00:40-04:13	Deployment of TRITON buoy
		(07˚-52.07'N,136˚-29.48'E, 3351m)
14:03-14:25	05:03-05:25	$CTDO_2$/LADCP (07˚-52.38'E, 136˚-29.24'E, 1000 dbar)
		with JES10-mini and RINKO profiler

14:40-15:25 05:40-06:25 $CTDO_2$/LADCP (07˚-52.50’N, 136˚-28.87’E, 1000 dbar)

Mar. 1st (Sun.) 2020

06:00-07:41 21:00-22:41 (-1 day)

$CTDO_2$/LADCP (07˚-38.59’E, 136˚-41.19’E, 2000 dbar)

and water sampling

08:21-12:56 23:21 (-1 day)-03:56

Recovery of TRITON buoy

13:02 03:02 Installation of Argo float

20:30 10:30 Radiosonde01

Mar. 2nd (Mon.) 2020

20:30 10:30 Radiosonde02

[Ship Mean Time (SMT)=UTC+10h]

Mar. 3rd (Tue.) 2020

21:30 10:30 Radiosonde03

Mar. 4th (Wed.) 2020

21:30 10:30 Radiosonde04

Mar. 6th (Fri.) 2020

08:35-11:16 22:36 (-1 day)-01:16

Deployment of TRITON buoy

(00˚-01.03’N,155˚-57.64’E, 1950 m)

13:08-13:27 03:08-03:27 $CTDO_2$/LADCP (00˚-00.69’N, 155˚-57.45’E, 110 dbar)

with JES10-mini and RINKO profiler

13:41-13:51 03:41-03:51 $CTDO_2$/LADCP (00˚-00.92’N, 155˚-56.91’E, 1000 dbar)

and water sampling

Mar. 7th (Sat.) 2020

06:02-07:08 20:02-21:08 (-1 day)

$CTDO_2$/LADCP (00˚-00.75’N, 156˚-01.90’E, 1000 dbar)

and water sampling

08:09-12:52 22:09 (-1 day)-02:52

Recovery of TRITON buoy

Mar. 8th (Sun.) 2020

08:19-10:10 22:19 (-1 day)-00:10

Recovery of ADCP mooring

13:12-14:36 03:12-04:36 Deployment of ADCP mooring

		(00˚-02.09'S,156˚-07.92'E, 1945 m)
15:45-16:07	05:45-06:07	UCTD freefall test
Mar. 9th (Mon.) 2020		
09:30	23:30 (-1 day)	Radiosonde05
12:02-12:09	02:02-02:09	Installation of Wave Glider 01
		(nominal location: EQ., 158˚E)
13:00	03:00	UCTD 01 (00˚-00.78'N, 158˚-07.74'E)
14:10	04:10	UCTD 02 (00˚-00.03'N, 158˚-18.09'E)
15:00	05:00	UCTD 03 (00˚-00.15'N, 158˚-27.77'E)
15:30	05:30	Radiosonde
16:00	06:00	UCTD 04 (00˚-00.13'S, 158˚-36.61'E)
17:00	07:00	UCTD 05 (00˚-00.01'N, 158˚-47.16'E)
18:00	08:00	UCTD 06 (00˚-00.04'N, 158˚-57.64'E)
19:00	09:00	UCTD 07 (00˚-00.01'S, 158˚-07.87'E)
20:00	10:00	UCTD 08 (00˚-00.02'N, 159˚-17.84'E)
21:00	11:00	UCTD 09 (00˚-00.10'S, 159˚-28.38'E)
21:30	11:30	Radiosonde
22:00	12:00	UCTD 10 (00˚-00.02'N, 159˚-36.49'E)
23:00	13:00	UCTD 11 (00˚-00.00'S, 159˚-46.48'E)
Mar. 10th (Tue.) 2020		
00:00	14:00 (-1 day)	UCTD 12 (00˚-00.02'S, 159˚-56.90'E)
01:00	15:00 (-1 day)	UCTD 13 (00˚-00.05'N, 160˚-07.55'E)
02:00	16:00 (-1 day)	UCTD 14 (00˚-00.01'N, 160˚-18.19'E)
03:00	17:00 (-1 day)	UCTD 15 (00˚-00.01'S, 160˚-29.04'E)
03:30	17:30 (-1 day)	Radiosonde
04:00	18:00 (-1 day)	UCTD 16 (00˚-00.06'S, 160˚-37.48'E)
05:00	19:00 (-1 day)	UCTD 17 (00˚-00.09'N, 160˚-48.10'E)
06:00	20:00 (-1 day)	UCTD 18 (00˚-00.02'S, 160˚-58.82'E)
07:00	21:00 (-1 day)	UCTD 19 (00˚-00.06'S, 161˚-09.48'E)
08:00	22:00 (-1 day)	UCTD 20 (00˚-00.12'S, 161˚-19.85'E)
09:00	23:00 (-1 day)	UCTD 21 (00˚-00.02'N, 161˚-30.43'E)
09:30	23:30 (-1 day)	Radiosonde
10:00	00:00	UCTD 22 (00˚-00.00'N, 161˚-39.86'E)
11:00	01:00	UCTD 23 (00˚-00.04'N, 161˚-50.38'E)

12:00	02:00	UCTD 24 (00˚-00.03’S, 162˚-00.83’E)
13:00	03:00	UCTD 25 (00˚-00.01’N, 162˚-11.31’E)
14:00	04:00	UCTD 26 (00˚-00.02’N, 162˚-21.73’E)
14:51-14:53	04:51-04:53	Installation of Wave Glider 02 (nominal location: EQ., 162˚30’E)
15:30	05:30	Radiosonde
21:30	11:30	Radiosonde

Mar. 11th (Wed.) 2020

06:30	20:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP (00˚-00.04’N, 160˚-59.98’E 500 dbar) and water sampling
08:34-08:49	22:34-22:49 (-1 day)	Installation of Sea Snake
09:30	23:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP (00˚-00.01’N, 160˚-59.98’E, 567 dbar)
12:30	02:30	Radiosonde/$CTDO_2$/LADCP (00˚-00.05’S, 161˚-00.07’E, 540 dbar)
15:30	05:30	Radiosonde/$CTDO_2$/LADCP (00˚-00.07’S, 161˚-00.11’E, 500 dbar)
18:30	08:30	Radiosonde/$CTDO_2$/LADCP (00˚-00.09’S, 161˚-00.07’E, 500 dbar) and water sampling
21:30	11:30	Radiosonde/$CTDO_2$/LADCP (00˚-00.03’S, 161˚-00.10’E 498 dbar)

Mar. 12th (Thu.) 2020

00:30	14:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP (00˚-00.04’S, 161˚-00.09’E, 500 dbar)
03:30	17:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP (00˚-00.05’S, 161˚-00.21’E, 500 dbar)
06:30	20:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP (00˚-00.24’S, 161˚-00.24’S, 500 dbar)
09:30	23:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP (00˚-00.25’S, 160˚-59.94’E, 500 dbar)
12:30	02:30	Radiosonde/$CTDO_2$/LADCP

		(00˚-00.01'S, 161˚-00.14'E, 500 dbar)
15:30	05:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.04'N, 160˚-59.99'E 500 dbar)
18:30	08:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.07'N, 161˚-00.09'E, 500 dbar)
		and water sampling
21:30	11:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.05'N, 160˚-59.99'E, 497 dbar)
Mar. 13th (Fri.) 2020		
00:30	14:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.04'N, 161˚-00.10'E 499 dbar)
03:30	17:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.20'N, 161˚-00.03'E, 500 dbar)
06:30	20:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.34'N, 160˚-59.92'E, 500 dbar)
09:30	23:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.13'S, 160˚-59.91'E, 500 dbar)
12:30	02:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.05'S, 161˚-00.03'E 500 dbar)
15:30	05:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.05'N, 161˚-00.42'E, 500 dbar)
18:30	08:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.19'N, 161˚-00.37'E, 500 dbar)
		and water sampling
21:30	11:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.22'S, 160˚-59.78'E, 500 dbar)
Mar. 14th (Sat.) 2020		
00:30	14:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.00'N, 161˚-00.05'E, 499 dbar)
03:30	17:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.32'N, 161˚-00.33'E, 500 dbar)
06:30	20:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.10'N, 161˚-00.12'E 500 dbar)
09:30	23:30 (-1 day)	Radiosonde/$CTDO_2$/LADCP

		(00˚-00.03'N, 161˚-00.13'E, 500 dbar)
12:30	02:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.00'N, 161˚-00.35'E 500 dbar)
13:59	03:59	Recovery of Sea Snake
15:30	05:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.05'N, 161˚-00.22'E, 500 dbar)
18:30	08:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.07'N, 161˚-00.16'E, 500 dbar)
		and water sampling
21:30	11:30	Radiosonde/$CTDO_2$/LADCP
		(00˚-00.14'S, 160˚-59.95'E, 500 dbar)

Mar. 15th (Sun.) 2020

08:51-09:20	22:51-23:20 (-1 day)	
		Recovery of Wave Glider 02

Mar. 16th (Mon.) 2020

08:52-09:16	22:52-23:16 (-1 day)	
		Recovery of Wave Glider 01
21:30	11:30	Radiosonde

Mar. 17th (Tue.) 2020

21:30	11:30	Radiosonde

Mar. 18th (Wed.) 2020

21:30	11:30	Radiosonde

[Ship Mean Time (SMT)=UTC+9h]

Mar. 19th (Thu.) 2020

08:54	23:54 (-1 day)	PAHs water sampling (14˚-19.41'N, 153˚-29.70'E)
20:04	11:04	PAHs water sampling (16˚-19.42'N, 152˚-35.63'E)
20:30	11:30	Radiosonde

Mar. 20th (Fri.) 2020

16:02	07:02	PAHs water sampling (19˚-40.83'N, 151˚-14.66'E)
20:30	11:30	Radiosonde

Mar. 21st (Sat.) 2020

15:58	06:58	PAHs water sampling (23˚-27.52'N, 149˚-41.55'E)

Mar. 22nd (Sun.) 2020

15:57	06:57	PAHs water sampling (27˚-30.46'N, 147˚-58.63'E)

Mar. 23rd (Mon.) 2020

16:01	07:01	PAHs water sampling (31˚-54.84’N, 146˚-02.28’E)

Mar. 24th (Tus.) 2020

13:00	04:00	End of Doppler radar observation

Mar. 25th (Wed.) 2020

08:57	23:57 (-1 day)	End of sea surface water sampling

Mar. 26th (Thu.) 2020

09:00	00:00	Arrival at Hachinohe, Japan
16:00	07:00	Departure from Hachinohe

Mar. 27th (Fri.) 2020

09:00	00:00	Arrival at Sekinehama

3.5 Cruise track

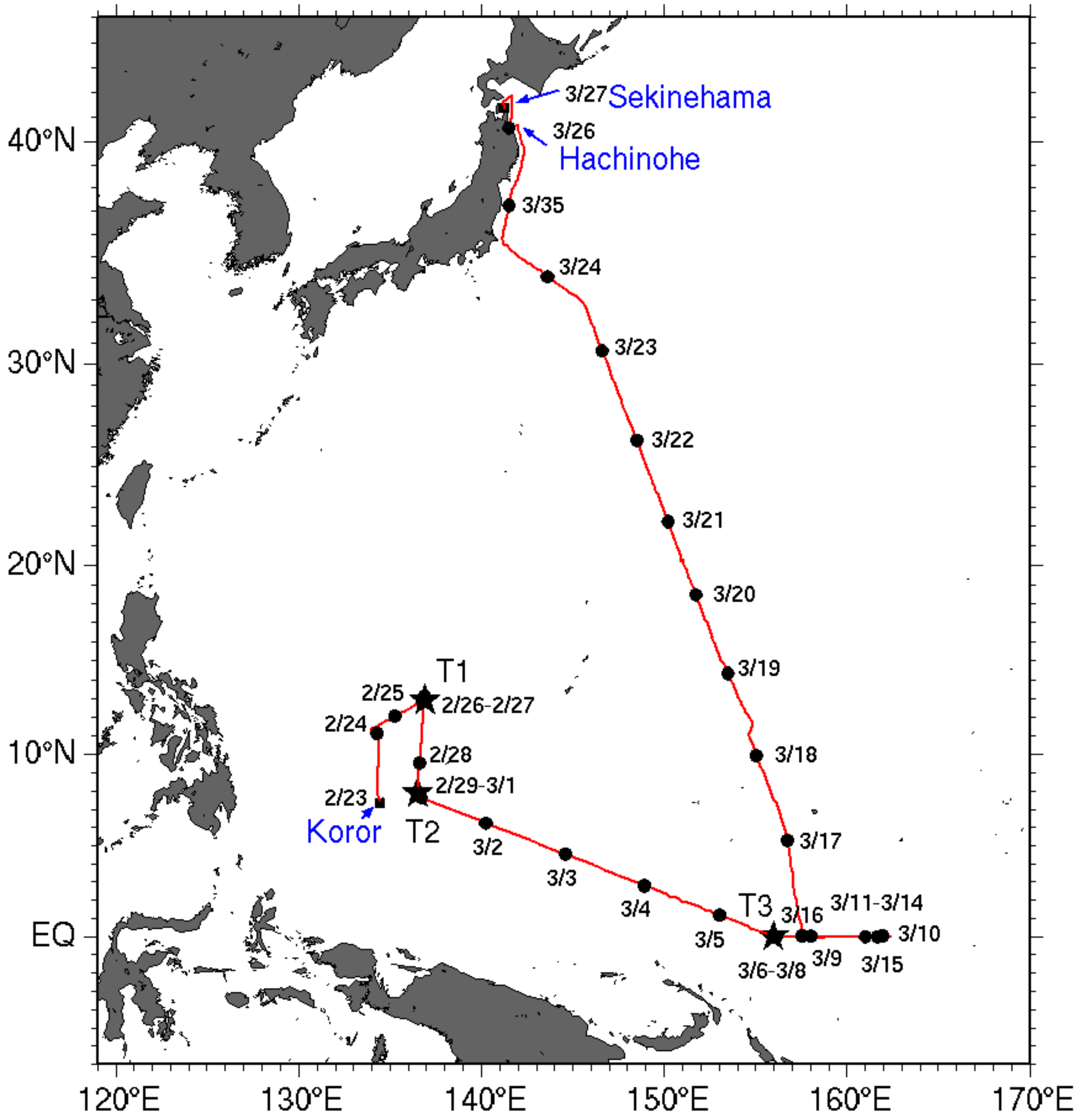

Fig. 3-1: MR20-01 cruise track (red line). Dots indicate UTC 00:00 positions of the R/V Mirai.

4 Participants list

4.1 R/V Mirai scientists and technical staffs

Name		Affiliation	Occupation	Onboard section
Akira	Nagano	JAMSTEC	Chief Scientist	Koror – Sekinehama
Biao	Geng	JAMSTEC	Scientist	Koror – Sekinehama
Kyoko	Taniguchi	JAMSTEC	Technical Staff	Koror – Sekinehama
Masahiro	Kaku	JAMSTEC	Engineer	Koror – Sekinehama
Masanori	Murakami	Nippon Marine Enterprises	Technical Staff	Koror – Sekinehama
Ryo	Oyama	Nippon Marine Enterprises	Technical Staff	Koror – Sekinehama
Yutaro	Murakami	Nippon Marine Enterprises	Technical Staff	Koror – Sekinehama
Hiroshi	Matsunaga	Marine Works Japan	Technical Staff	Koror – Sekinehama
Keisuke	Matsumoto	Marine Works Japan	Technical Staff	Koror – Sekinehama
Hiroki	Ushiromura	Marine Works Japan	Technical Staff	Koror – Sekinehama
Keisuke	Takeda	Marine Works Japan	Technical Staff	Koror – Sekinehama
Masaki	Yamada	Marine Works Japan	Technical Staff	Koror – Sekinehama
Hironori	Sato	Marine Works Japan	Technical Staff	Koror – Sekinehama
Tun	Htet Aung	Marine Works Japan	Technical Staff	Koror – Sekinehama

4.2 R/V Mirai crew member

Name		Rank
Akihisa	Tsuji	Master
Hiroyuki	Kato	Chief Officer
Kanto	Asaji	2nd Officer
Saito	Takata	Jr. 2nd Officer
Ryohei	Isejima	3rd Officer
Akihiro	Nunome	Jr. 3rd Officer
Kaneda	Kazuhiko	Chief Engineer
Jun	Takahashi	1st Engineer
Hiroki	Tanaka	2nd Engineer
Shintaro	Abe	3rd Engineer
Yoichi	Inoue	Chief Radio Operator
Kazuyoshi	Kudo	Boatswain
Shuji	Komata	Quarter Master
Hideaki	Tamotsu	Quarter Master
Hideyuki	Okubo	Quarter Master
Satoshi	Simpo	Quarter Master
Masaya	Tanikawa	Quarter Master
Takuya	Yajima	Sailor
Takuma	Tokunaga	Sailor
Keisuke	Isobe	Sailor
Noa	Sasaki	Sailor
Manato	Kimura	Sailor
Kazumi	Yamashita	No.1 Oiler
Daisuke	Taniguchi	Oiler
Toshiyuki	Furuki	Oiler
Kazuya	Ando	Oiler
Tsuyoshi	Uchiyama	Assistant Oiler
Yuta	Wakugawa	Assistant Oiler
Kiyotaka	Kosuji	Chief Steward
Yukio	Chiba	Steward
Toru	Wada	Steward
Norio	Takaku	Steward
Koki	Shinohara	Steward

5 Observations

5. 1 TRITON and Philippine Sea buoy moorings

(1) Personnel

Akira Nagano	(JAMSTEC): Chief Scientist
Masahiro Kaku	(JAMSTEC): Technical Scientist
Keisuke Matsumoto	(MWJ): Operation Leader
Masaki Yamada	(MWJ): Technical Leader
Hiroshi Matsunaga	(MWJ): Technical Staff
Hiroki Ushiromura	(MWJ): Technical Staff
Keisuke Takeda	(MWJ): Technical Staff
Hironori Sato	(MWJ): Technical Staff
Tun Htet Aung	(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 the warm pool, that affects the global atmosphere and causes El Niño phenomena. The formation mechanism of the warm pool and the air-sea interaction over the warm pool have not been well understood. Therefore, long term datasets 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 Niño and variations of Asia-Australian Monsoon system. The 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. The TRITON is a component of the international research program of CLIVAR (Climate Variability and Predictability), which is a major component of the World Climate Research Program sponsored by the World Meteorological Organization, the International Council of Scientific Unions, and the Intergovernmental Oceanographic Commission of UNESCO. The TRITON will also contribute to the development of the GOOS (Global Ocean Observing System) and GCOS (Global Climate Observing System).

Two TRITON buoys and a Philippine Sea buoy have been recovered, and the same type buoys have been deployed during this cruise.

(3) Measured parameters

The buoys observe oceanic parameters and meteorological parameters as follow:

Meteorological parameters:

Wind Speed, Direction,
Atmospheric Pressure,
Air Temperature, Relative Humidity,
Shortwave Radiation,
Precipitation.
Longwave Radiation (only Philippine sea)

Oceanic parameters (TRITON):

Water Temperature and Conductivity at
1.5 m, 25 m,50 m, 75 m, 100 m, 125 m, 150 m, 200 m, 300 m, and 500 m.
Depth at 300 m and 500 m.
Currents at 10 m.

Oceanic parameters (Philippine Sea):

Water Temperature and Conductivity at
1 m, 10 m, 20 m, 40 m, 60 m, 80 m, 90 m, 100 m, 110 m, 120 m, 180 m, 150 m, 200 m, and 300 m.
Depth at
1 m, 10 m, 40 m, 80 m, 100 m, 120 m, 180 m, 150 m, and 300 m.
Currents at 1 m
Dissolved Oxygen at 80 m (only recovered buoy), 100 m, and 150 m

(4) Instrument

Details of the instruments used on the TRITON buoys are summarized as follow:

Oceanic sensors

1) CTD and CT

SBE-37 IM MicroCAT

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

2) CRN (Current meter)

SonTek Argonaut ADCM

Sensor frequency:	1500 kHz

Sampling interval: 1200 sec.
Average interval: 120 sec.

Work Horse ADCP
Sensor frequency: 300 kHz
Sampling interval: 20 min.

<u>Meteorological sensors</u>

1) Precipitation
R.M. YOUNG COMPANY MODEL50202/50203
Sampling interval: 600 sec.

2) Atmospheric pressure
PAROPSCIENTIFIC. Inc. DIGIQUARTZ FLOATING BAROMETER 6000SERIES
Sampling interval: 600 sec.

3) Relative humidity/air temperature,
Shortwave radiation,
Longwave radiation,
Wind speed/direction
Woods Hole Institution ASIMET
Sampling interval: 600 sec.

(5) Locations of TRITON buoys and Philippine buoy deployment

Nominal location:	EQ, 156˚E
ID number at JAMSTEC:	04020
Number on surface float:	T11
ARGOS PTT number:	29641
ARGOS backup PTT number:	29694
Deployed date:	06 Mar. 2020
Exact location:	00°01.03' N, 155°57.64' E
Depth:	1,950 m

Nominal location: 8˚N, 137˚E

ID number at JAMSTEC:	10015
Number on surface float:	T24
ARGOS PTT number:	28320
ARGOS backup PTT number:	24715
Deployed date:	29 Feb. 2020
Exact location:	07°52.07' N, 136°29.48' E
Depth:	3,351 m

Nominal location:	13˚N, 137˚E
ID number at JAMSTEC:	40503
Number on surface float:	K03
Iridium ID number:	3004340603216270
ARGOS backup PTT number:	29738
Deployed date:	26 Feb. 2020
Exact location:	12°53.68' N, 136°5.29' E
Depth:	5,249 m

(6) Locations of the TRITON buoys and Philippine buoy recovered

Nominal location:	EQ, 156˚E
ID number at JAMSTEC:	04019
Number on surface float:	T04
ARGOS PTT number:	29765
ARGOS backup PTT number:	27409, 49730
Deployed date:	15 Aug. 2018
Recovered date:	07 Mar. 2020
Exact location:	00°00.97' N, 156°02.47' E
Depth:	1,953 m

Nominal location:	8˚N, 137˚E
ID number at JAMSTEC:	10014
Number on surface float:	T27
ARGOS PTT number:	27958
ARGOS backup PTT number:	27410, 49731
Deployed date:	22 Aug. 2018
Recovered date:	01 Mar. 2020
Exact location:	07°38.96' N, 136°42.01' E

Depth: 3,171 m

Nominal location: 13˚N, 137˚E
ID number at JAMSTEC: 40502
Number on surface float: J02
Iridium ID number: 300434060153300
ARGOS backup PTT number: 27411
Deployed date: 25 Aug. 2018
Recovered date: 27 Feb. 2020
Exact location: 13°06.90' N, 136°56.39' E
Depth: 5,327 m

*Dates are UTC and represent anchor drop times for deployments and acoustic releaser on deck time for recoveries, respectively.

(7) Details of deployed

Described the optional sensor in the list.

Deployment optional sensor

Observation No.	Location	Details
04020	EQ156E	Deploy with full spec and 2 optional units. SBE37 (CT) :175m
10015	8N137E	Deploy with full spec and 2 optional units. SBE37 (CT) :175m
40503	13N137E	Deploy with full spec

(8) Data archive

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

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

5.2 ADCP subsurface moorings

(1) Personnel

Iwao Ueki	(JAMSTEC): Principal investigator (Not onboard)
Akira Nagano	(JAMSTEC): Chief Scientist
Keisuke Takeda	(MWJ): Operation Leader
Hiroshi Matsunaga	(MWJ): Technical Staff
Keisuke Matsumoto	(MWJ): Technical Staff
Masaki Yamada	(MWJ): Technical Staff
Hiroki Ushiromura	(MWJ): Technical Staff
Hironori Sato	(MWJ): Technical Staff
Tun Htet Aung	(MWJ): Technical Staff

(2) Objectives

The purpose of this ADCP subsurface mooring is to obtain knowledge on the physical process underlying dynamics of the equatorial current structure and associated processes in western Pacific Ocean. We have been observing subsurface currents using ADCP moorings along the equator. In this cruise, we recovered the mooring at Eq-156˚E and deployed another mooring at the same site.

(3) Parameters

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

(4) Methods

Two instruments are mounted at the top float of the mooring. The first one is an ADCP (Acoustic Doppler Current Profiler). It observes upper-ocean currents from subsurface to around 400m depth. The second instrument is a CTD that is mounted on the bottom part of the float, and it observes pressure, temperature and salinity for sound speed correction and depth variability. Details of the instruments and their parameters are as follows:

1) ADCP

Work horse ADCP 75 kHz (Teledyne RD Instruments, Inc.)

Distance to first bin: 7.04 m

Pigs per ensemble:

Recover ADCP: 16

Deploy ADCP: 27

Time per ping: 6.66 seconds

Number of depth cells: 60

Bin length: 8.00 m

Sampling Interval: 3600 seconds

Recovered ADCP

- Serial Number: 7176 (Mooring No. 180817-EQ156E)

Deployed ADCP

- Serial Number: 1248 (Mooring No. 200308-EQ156E)

2) CTD

SBE-16 (Sea Bird Electronics Inc.)

Sampling Interval: 1800 seconds

Recovered CTD

- Serial Number: 1282(Mooring No. 180817-EQ156E)

Deployed CTD

- Serial Number: 1288 (Mooring No. 200308-EQ156E)

3) Other instruments

(a) Acoustic Releaser (BENTHOS,Inc.)

Recovered Acoustic Releaser

- Serial Number: 600 (Mooring No. 180817-EQ156E)
- Serial Number: 937 (Mooring No. 180817-EQ156E)

Deployed Acoustic Releaser

- Serial Number: 632 (Mooring No. 200308-EQ156E)
- Serial Number: 666 (Mooring No. 200308-EQ156E)

(b) Transponder (BENTHOS,Inc.)

Recovered Transponder

- Serial Number: 67491 (Mooring No. 180817-EQ156E)

Deployed Transponder

- Serial Number: 57089 (Mooring No. 200308-EQ156E)

(c) ST-400A Xenon Flasher (MetOcean Data Systems)

Recovered Flasher

- Serial Number: A02-066 (Mooring No. 180817-EQ156E)

Deployed Flasher

- Serial Number: Z03-088 (Mooring No. 200308-EQ156E)

(5) Deployment

Deployment of the ADCP mooring at Eq-156˚E was planned to mount the ADCP at about 400m depth. During the deployment, we monitored the depth of the acoustic releaser after dropped the anchor. The position of ADCP mooring show in Fig. 5.2-1.

The position of the mooring No. 200308-EQ156E

Date: 08 Mar. 2020 Lat: 00˚-02.09'S Long: 156˚-07.92'E Depth: 1,944m

(6) Recovery

We recovered one ADCP mooring which was deployed on 17th Aug 2018 (MR18-04 Leg2). We uploaded ADCP and CTD data to a computer, and then raw data was converted to ASCII code.

The results of mooring are shown in Figs. 5.2-2 and 5.2-3.

(7) Data archive

All data will be opened on the following web page:

http://www.jamstec.go.jp/rcgc/j/tcvrp/ipocvrt/adcp_data.html

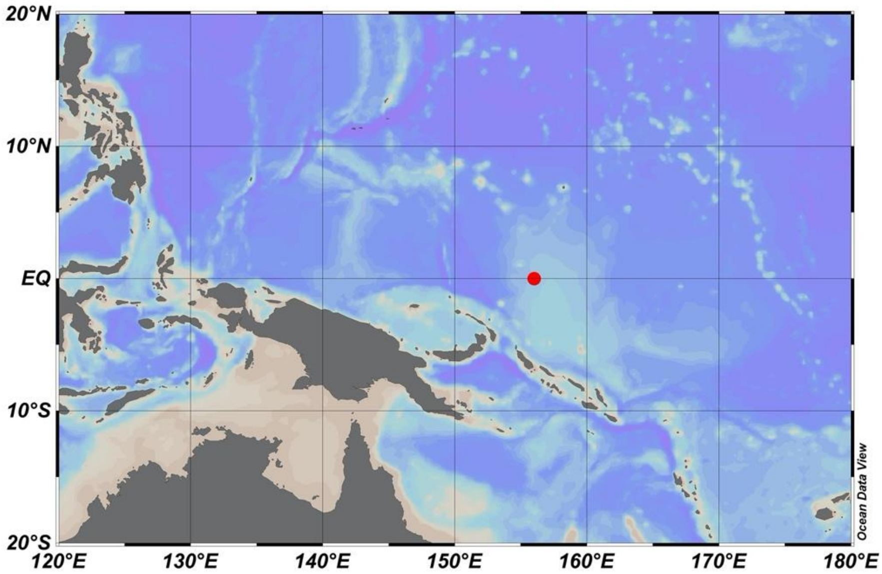

Fig.5.2-1 Position of ADCP mooring at Eq-156˚E

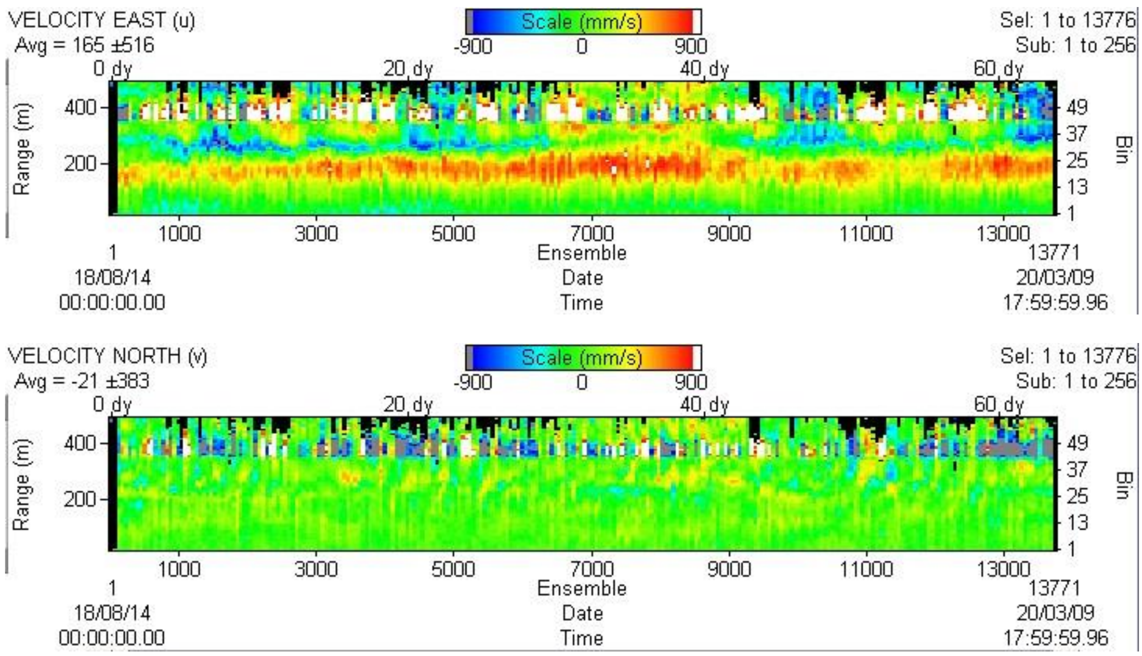

Fig.5.2-2 Time-depth sections of observed zonal (*top panel*) and meridional (*bottom panel*) currents obtained from ADCP mooring at Eq-156˚E (2018/08/17-2020/03/08)

Fig. 5.2-3 Time-series of the observed pressure (*top panel*), temperature (*middle panel*) and salinity (*bottom panel*) obtained from CTD at Eq-156˚E . (2018/08/17-2020/03/08)

5.3 Wave Glider observation

(1) Personnel

Akira Nagano	(JAMSTEC)	Principal Investigator
Kyoko Taniguchi	(JAMSTEC)	
Keisuke Takeda	(MWJ)	Operation leader
Hiroshi Matsunaga	(MWJ)	
Keisuke Matsumoto	(MWJ)	
Masaki Yamada	(MWJ)	
Tatsuya Fukuda	(JAMSTEC)	Not Onboard
Yasuhisa Ishihara	(JAMSTEC)	Not Onboard
Iwao Ueki	(JAMSTEC)	Not Onboard
Makito Yokota	(MWJ)	Not Onboard
Nobuhiro Fujii	(MWJ)	Not Onboard

(2) Background and Objectives

Although there are many global air-sea flux products mainly based on satellite observations, in situ observations by research vessels and mooring buoys are still essential. As a part of the TAO (Tropical Atmosphere and Ocean)/TRITON (Triangle trans-ocean buoy network) array, we are conducting air-sea flux observations in the western Pacific and eastern Indian oceans. Mooring observations have an advantage to acquire detailed direct measurement records at fixed points; however, they take relatively high cost to maintain many sites. Unmanned ocean surface vehicles, such as Wave Gliders and the Saildrones, have been sufficiently developed to use for air-sea flux observations. Using Wave Gliders, we conducted air-sea flux observations during the intensive observation period of this cruise.

(3) Instrumentation

A Wave Glider is an autonomous surface vehicle, which utilize both wave energy for propulsion and solar power for supporting on-board computing, communications, and sensor payloads. It can travel tens of thousands of miles, collect data in the most demanding conditions, and deliver these data to land in real time. The Wave Glider used in this cruise is a type consisting of two parts: surface float and underwater glider with umbilical cable (Fig. 5.3-1). As payloads, we installed three types of meteorological sensor units: the Weather Station, Weather Transmitter, and JAMMET (Fig. 5.3-2). The observed meteorological parameters are air temperature, relative humidity, barometric pressure, longwave radiation, shortwave radiation, wind, and rain fall amount. Underwater sensors were installed for measurements of temperature, conductivity, and pressure. A downward-looking ADCP was equipped to the bottom of the vehicle and measured currents in an upper 120 m depth layer. In addition, by a thermistor chain and CT and CTD sensors tied to the thermistor chain, temperature and salinity profiles was obtained down to a 11 m depth (Fig. 5.3-3). The acquired data are recorded on logger system and transmitted to land station via iridium satellite communication system.

We installed two Wave Gliders; SV3-248 and SV3-242, to observe behavior of surface meteorological and upper ocean variables associated with heat and momentum fluxes.

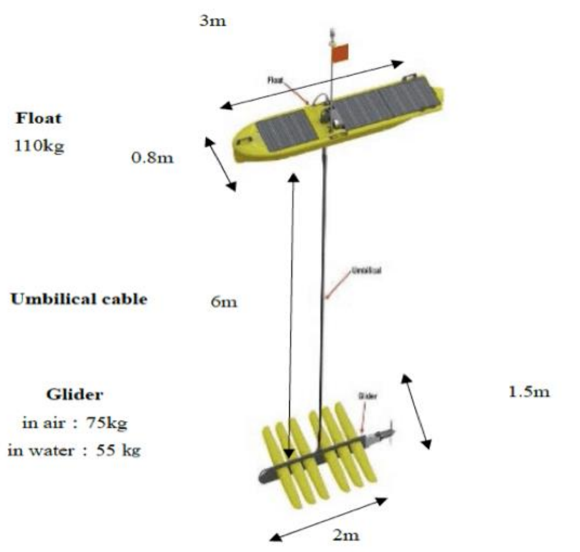

Fig. 5.3-1 Diagram of Wave Glider SV3 basic configuration

Fig. 5.3-2 Mereological sensors equipped to the float

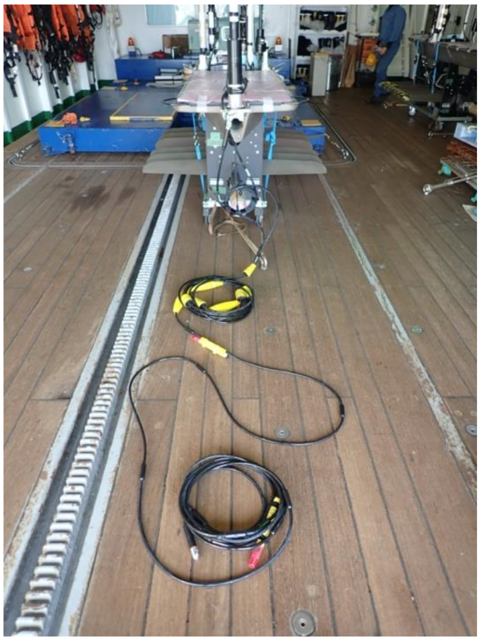

Fig. 5.3-3 Thermistor chain and tied CT/CTD sensors

(5) Observation

For the intensive observation period of this cruise, the two Wave Gliders were installed as satellite stations for the air-sea flux observation. The Wave Glider of SV3-248 has been installed at 0˚ 158˚E, where is corresponding to warmer side of SST front located around 0˚ 161˚E (Fig. 5.3-4), on March 9, 2020. Unfortunately, the Wave Glider SV3-248 rolled over and thereafter the JAMET wind sensors malfunctioned. Nevertheless, because we equipped several backup wind sensors (WXT and weather station), we obtained wind variation throughout the observation period. The other Wave Glider (SV3-252) was installed at 0˚ 162.5˚E, where is corresponding to colder side of SST front, on March 10 (Fig. 5.3-5). In cooperation with the intensive observation by the R/V Mirai at 0˚ 161˚E, the Wave Gliders conducted the air-sea flux observation as satellite stations from March 11 to 14. The Wave Gliders SV3-252 and SV3-248 were recovered on March 15 and 16, respectively.

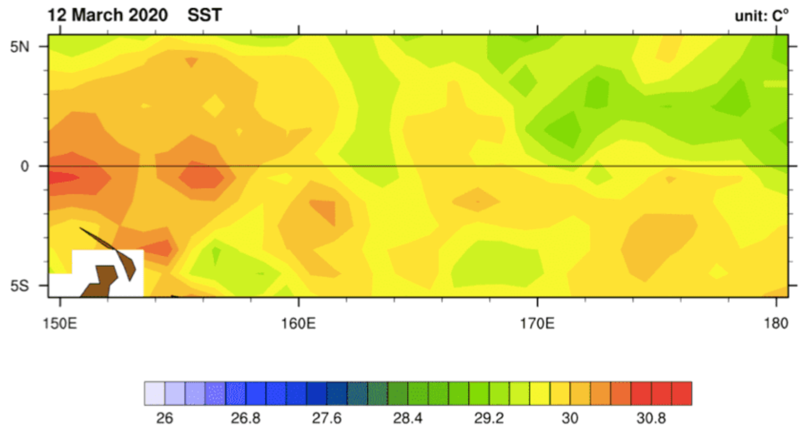

Fig. 5.3-4 SST distribution on March 12, 2020

Fig. 5.3-5 Wave Gilder operation

(6) Preliminary Results

We recognize that SV3-248 and SV3-252 are in locations of different oceanic conditions, warmer and colder sides of an SST front (Fig. 5.3.-6). A heavy rainfall in association with strong winds appeared on March 10 at the colder site. The diurnal SST and air temperature variations was amplified after the heavy rainfall. At the other site (warmer site), rainfall is less, and amplitudes of the diurnal variations in SST and air temperature were relatively small. A comprehensive analysis using the vessel-based observation will be conducted after the cruise.

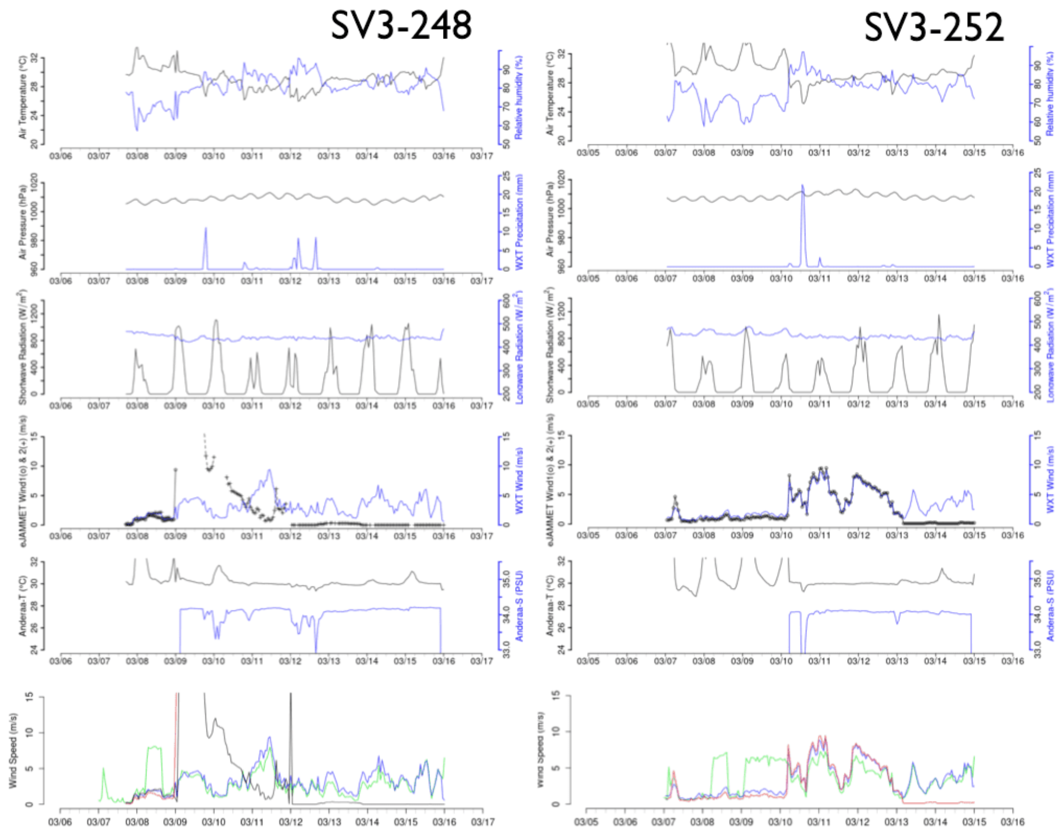

Fig. 5.3-6 Time series of meteorological variables collected by SV3-248 (left) and SV3-252 (right)

5.4 Argo float observation

(1) Personnel

Shigeki Hosoda (JAMSTEC) Principal Investigator (not on board)
Mizue Hirano (JAMSTEC) not on board
Keisuke Takeda (MWJ) Technical Staff

(2) Objective

The research objective is to clarify the mechanisms of climate and oceanic environment variability and to understand changes of the earth system through estimations of heat and material transports, improving the Argo observing system in the global ocean. In this cruise, two Argo floats are deployed to carry out automatically measurements of long-term temperature and salinity variations in the western equatorial Pacific Ocean where the warm pool is formed in the upper ocean. In the previous studies, the variability of the warm pool affects climate changes of the western North Pacific area including Japan through the air-sea interaction, however, the detailed mechanism of heat and freshwater content change is still unclear. The Argo floats expect to contribute to clarify the detailed mechanisms. Also, the data delivered from the Argo floats also contribute to improve accuracy of long-term forecasts of climate changes through data assimilation systems.

(3) Parameters

・Water temperature, salinity, and pressure.

(4) Method

We launched APEX Argo floats manufactured by Teledyne Webb Research. This float equips SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc. The floats drift at a depth of 1000 dbar (called the parking depth) during waiting measurement, then go upward from a depth of 2000 dbar to the sea surface every 10 days. The physical parameters are measured every 2 dbar from 2000 dbar after ends of drifting. When the floats are surfacing, they send all measured data with technical messages to land through the Iridium RUDICS telecommunication system within half an hour during surfacing. The lifetime of floats is expected to be about four-eight years. The status of floats and their launching information is shown in Table 5.4.1.

Table 5.4.1. Specifications of floats and their launching positions

Float Type	APEX float manufactured by Teledyne Webb Research.
CTD sensor	SBE41 manufactured by Sea-Bird Electronics Inc.
Cycle	10 day (or smaller time if necessary)
Iridium transmit type	Router-Based Unrestricted Digital Internetworking Connectivity Solutions (RUDICS)

Target Parking Pressure	1000 dbar
Sampling level	2dbar interval from 2000 dbar to surface (approximately 1000 levels)

Launching position

Float S/N	WMO ID	Date and Time of Launch (UTC)	Location of Launch		Station
8603	5905845	2020/02/27 06:41	13° 8.214N	136° 56.490E	T1
8610	5905856	2020/03/01 04:02	7° 40.638N	136° 42.222E	T2

(5) Data archive

The Argo float data will be provided with the real-time quality control within 24 hours following the procedure decided by Argo data management team. Then, the delayed mode quality control will be conducted within 6 months ~ 1 year to satisfy their data accuracy for climate research use. Those quality-controlled data are submitted to Global Data Assembly Center (GDAC: http://www.usgodae.org/argo/argo.html, http://www.coriolis.eu.org/), Global Telecommunication System (GTS), and are freely available via internet and utilized for not only research but also weather forecasts and any other variable use through internet.

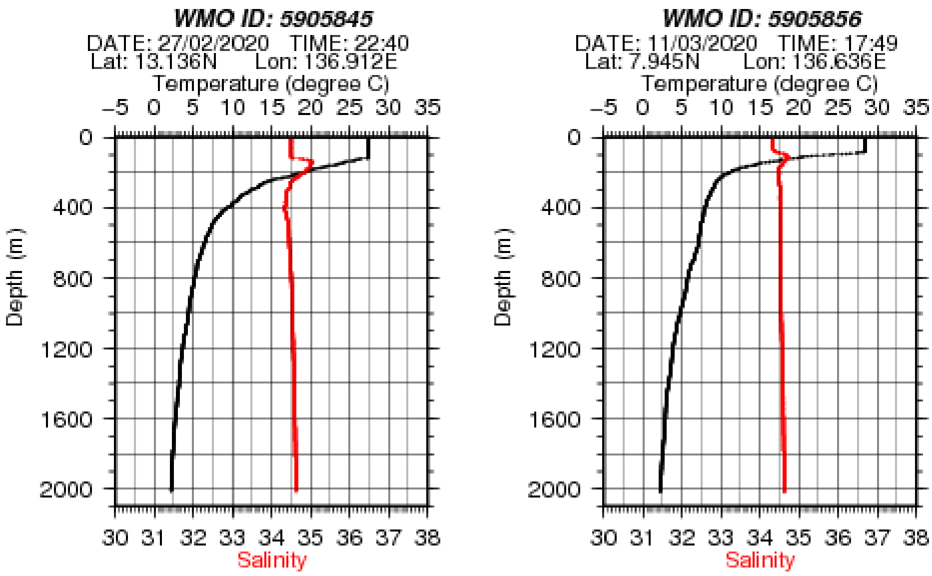

Fig. 5.4-1 Vertical temperature and salinity profiles of their first measurements for Argo floats (a: S/N 8603 and b: S/N 8610). Black and red lines show temperature and salinity profiles.

5.5 Lidar observation

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	Principle Investigator, not on board
Kyoko TANIGUCHI	(JAMSTEC)	
Masanori MURAKAMI	(NME)	Operation Leader
Ryo OYAMA	(NME)	
Yutaro MURAKAMI	(NME)	

(2) Objective

The objective of this observation is to capture the vertical distribution of clouds, aerosols, and water vapor in high spatiotemporal resolution.

(3) Methods

The Mirai Lidar system transmits a 10-Hz pulse laser in three wavelengths: 1064nm, 532nm, 355nm. For cloud and aerosol observation, the system detects Mie scattering at these wavelengths. The separate detections of polarization components at 532 nm and 355 nm obtain additional characteristics of the targets. The system also detects Raman water vapor signals at 660 nm and 408nm, Raman nitrogen signals at 607 nm and 387nm at nighttime. Based on the signal ratio of Raman water vapor to Raman nitrogen, the system offers water vapor mixing ratio profiles.

(4) Preliminary Results

The lidar system observed the lower atmosphere throughout the cruise, except on EEZs and territorial waters without permission. All data will be reviewed after the cruise to maintain data quality.

(5) Data Archive

All data obtained during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

5.6 Radiosonde observation

(1) Personnel

Akira NAGANO	(JAMSTEC)	Principal Investigator
Masaki KATSUMATA	(JAMSTEC)	(not on board)
Biao GENG	(JAMSTEC)	
Kyoko TANIGUCHI	(JAMSTEC)	
Masanori MURAKAMI	(NME)	Operation Leader
Ryo OYAMA	(NME)	
Yutaro MURAKAMI	(NME)	

(2) Objective

The objective of this observation is to obtain vertical profiles and temporal variations of air temperature, relative humidity, and wind speed/direction.

(3) Methods

Radiosonde provides atmospheric parameters as ascending the sky with a weather balloon. The obtained data is transmitted via radio to the receiver onboard.

The sensors in this cruise were Vaisala RS-41SGP. The sensor was prepared and calibrated with ground check device (Vaisala RI41) operated by Vaisala MW41 software. For calibration reference, observation value from a barometer (Vaisala PTB-330) near RI41 was applied. The sensor with a balloon (Totex TA-200) was launched from the shipboard balloon launcher. Foremast metrological observations (Section 5.12.1) were referred as the surface condition at launch. After launch, MW41 recorded and processed the sounding data, with a processor (Vaisala SPS-311), GPS antenna (GA20), and UHF antenna (RB21).

(4) Preliminary Results

During this cruise, radiosonde observation obtained 47 profiles, as listed in Table 5.6-1. Fig. 5.6-1 is emagrams of all radiosonde observations.

Fig. 6.6-2 shows the time-height cross sections of temperature anomaly, specific humidity anomaly, the zonal wind component, and the meridional wind component at stationary observation between 11/03/2020 and 14/03/2020. During the period, radiosonde was launched every three hours.

(5) Data Archive

Data were sent to the world meteorological community through the Japan Meteorological Agency, immediately after each observation. Raw data is available in ASCII format. These datasets will be submitted to JAMSTEC Data Management Group (DMG).

Table 5.6-1: Radiosonde launch log, with surface observations and maximum height.

ID	Date yyyymmdd	Launched Location		Surface Observation					Max Height	Cloud at Launch	
		Lat	Lon	P	T	RH	WD	WS			
		degN	degE	hPa	degC	%	deg	m/s	m	Amount	Type
RS001	2020030112	7.175	137.905	1008.0	27.9	77	65	9.5	23,988	3	As, Cu
RS002	2020030212	5.450	142.266	1006.9	28.6	89	26	5.3	25,144	7	Cu,As,Ns
RS003	2020030312	3.721	146.651	1007.3	29.7	78	28	4.0	24,592	5	Cu, Sc
RS004	2020030412	2.061	150.820	1006.7	27.9	84	359	5.6	21,477	9	Cs
RS005	2020030900	0.031	158.039	1007.7	29.9	73	23	5.4	25,463	4	Cu,Ci
RS006	2020030906	0.003	158.478	1004.0	29.9	74	49	4.9	25,111	3	Cu,Cs,Ci
RS007	2020030912	-0.002	159.481	1007.6	29.6	78	71	6.9	25,864	7	Sc,Cu,As
RS008	2020030918	0.000	160.494	1005.1	29.2	79	33	5.7	24,920	4	Cu,As,Ns
RS009	2020031000	0.000	161.505	1008.0	30.1	74	41	6.7	25,045	6	Cu,ci
RS010	2020031006	0.002	162.465	1005.5	26.9	94	19	11.2	21,374	9	Ns,Cu,As
RS011	2020031012	0.000	161.139	1009.9	25.9	97	82	8.6	5,839	10	unclear
RS012	2020031021	0.006	160.994	1008.6	28.1	82	16	7.7	26,492	10	Cu,As,Cc
RS013	2020031100	-0.001	160.998	1009.8	28.5	81	9	8.8	27,248	10	Sc,As
RS014	2020031103	-0.001	161.000	1007.6	28.8	80	1	12.2	24,635	9	Sc, St, Cu
RS015	2020031106	-0.001	161.002	1007.3	28.3	82	4	8.6	25,322	9	Cu,As,Ac
RS016	2020031109	-0.002	161.001	1009.1	28.7	77	11	8.3	23,550	unclear	unclear
RS017	2020031112	-0.001	161.001	1010.3	28.8	80	3	4.8	22,407	10	St,Sc
RS018	2020031115	0.000	161.001	1008.7	29.1	77	341	6.0	23,174	10	unclear
RS019	2020031118	-0.001	161.002	1008.1	26.4	88	355	8.9	16,319	unclear	unclear
RS020	2020031121	-0.005	161.002	1009.6	26.1	81	29	3.7	24,083	10	Cu,Sc,St
RS021	2020031200	0.000	161.000	1009.7	28.5	83	50	10.4	26,080	9	Sc,Cu,Ci,Cc
RS022	2020031203	0.002	161.001	1007.3	28.6	82	46	11.9	26,406	6	Cu, St, Sc, As
RS023	2020031206	0.004	161.003	1005.6	28.9	78	30	7.1	24,864	7	Cu, Ac, As
RS024	2020031209	0.003	161.001	1007.4	29.0	80	52	6.1	23,331	unclear	unclear
RS025	2020031212	0.004	161.001	1009.1	28.9	77	41	4.5	25,442	8	Cs,Ac,As
RS026	2020031215	0.003	161.001	1007.4	28.1	80	41	7.1	25,635	9	As,St,Sc
RS027	2020031218	0.003	161.002	1006.4	27.4	85	207	0.6	19,824	unclear	St
RS028	2020031221	0.003	161.002	1007.8	28.0	73	331	4.4	24,137	10	Cu,St,Sc
RS029	2020031300	-0.001	161.002	1008.8	27.9	84	112	4.2	26,552	9	Sc,As,Nb
RS030	2020031303	0.003	161.006	1005.7	28.2	76	112	2.2	27,287	9	Cu, St, Sc, Nb
RS031	2020031306	0.003	161.006	1003.7	28.5	80	57	2.8	25,215	8	Cu, Ac, As
RS032	2020031309	0.003	161.005	1005.6	28.9	77	30	4.3	21,829	unclear	unclear
RS033	2020031312	0.003	161.004	1007.3	28.9	77	159	1.1	25,533	8	St,Sc
RS034	2020031315	0.004	161.004	1005.4	28.8	77	89	2.5	24,880	10	As,Cs,Ac
RS035	2020031318	0.003	161.002	1004.3	27.8	86	353	3.6	24,132	unclear	St,Sc
RS036	2020031321	0.003	161.003	1005.6	28.3	82	5	4.2	24,189	10	Cu,St,Sc
RS037	2020031400	0.002	161.005	1006.3	29.1	78	12	5.3	25,824	7	Ac,Cc,Ns,Ci,Cu
RS038	2020031403	0.001	161.005	1004.1	29.2	76	15	5.2	26,474	8	Sc, St, Cu
RS039	2020031406	0.001	161.005	1002.9	30.8	78	24	5.7	25,927	8	Cu,Ac,As,Ns
RS040	2020031409	0.001	161.003	1004.8	29.4	77	45	5.8	23,668	unclear	unclear
RS041	2020031412	-0.002	161.002	1006.6	29.3	77	44	5.5	25,083	9	unclear
RS042	2020031512	-0.038	159.238	1008.2	29.6	77	142	5.6	25,604	4	unclear
RS043	2020031612	2.477	157.154	1010.0	29.4	75	134	5.0	25,244	4	unclear
RS044	2020031712	7.513	156.019	1010.8	26.3	94	91	13.0	22,392	10	unclear
RS045	2020031812	11.985	154.642	1012.2	27.7	77	71	11.7	23,813	unclear	unclear
RS046	2020031912	16.320	152.588	1014.9	26.7	79	58	11.6	22,520	unclear	unclear
RS047	2020032012	20.315	150.986	1016.4	25.6	81	81	5.5	23,988	unclear	unclear

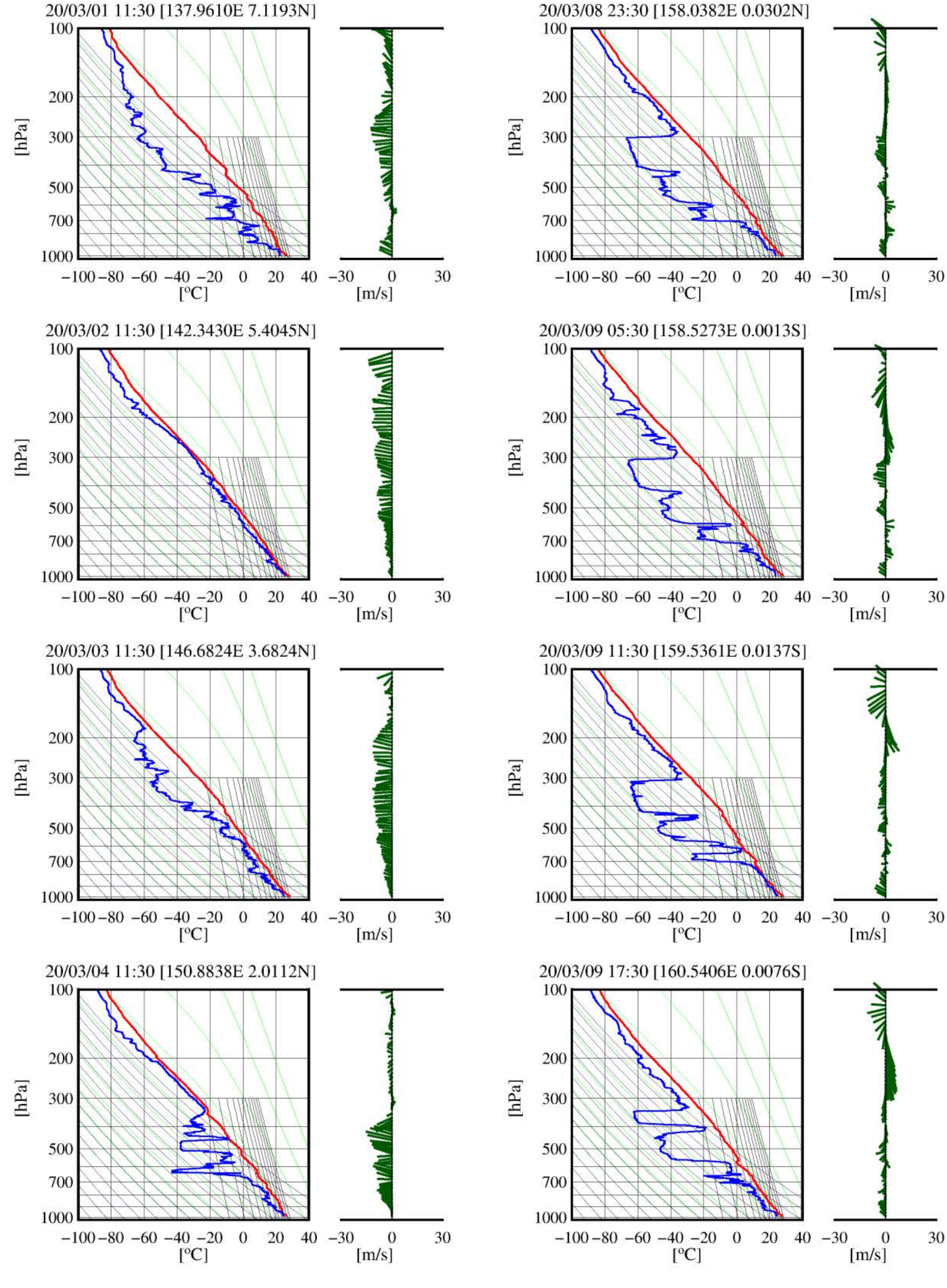

Fig. 5.6-1: Emagrams of radiosonde observations

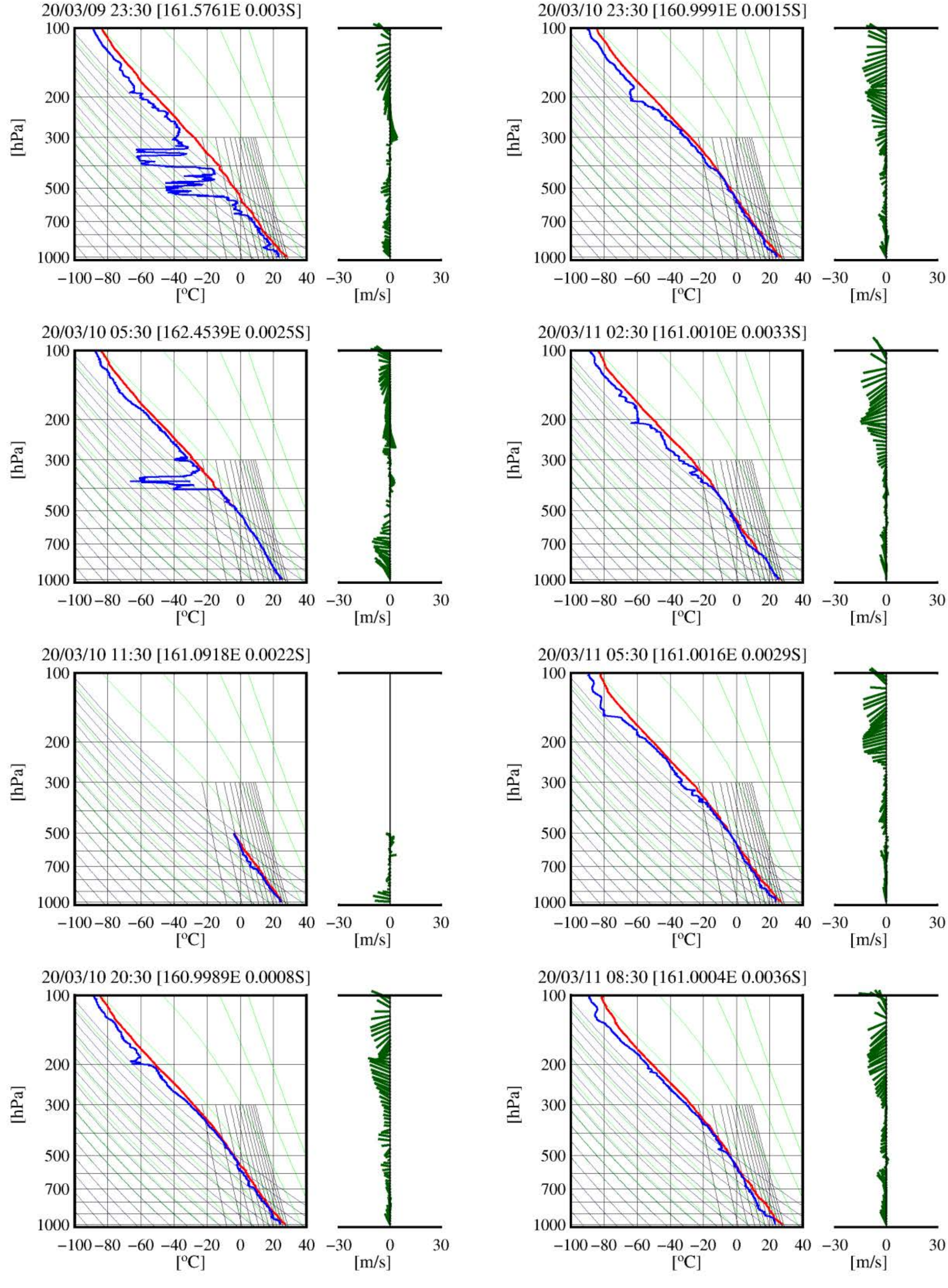

Fig. 5.6-1: Emagrams of radiosonde observations (continued)

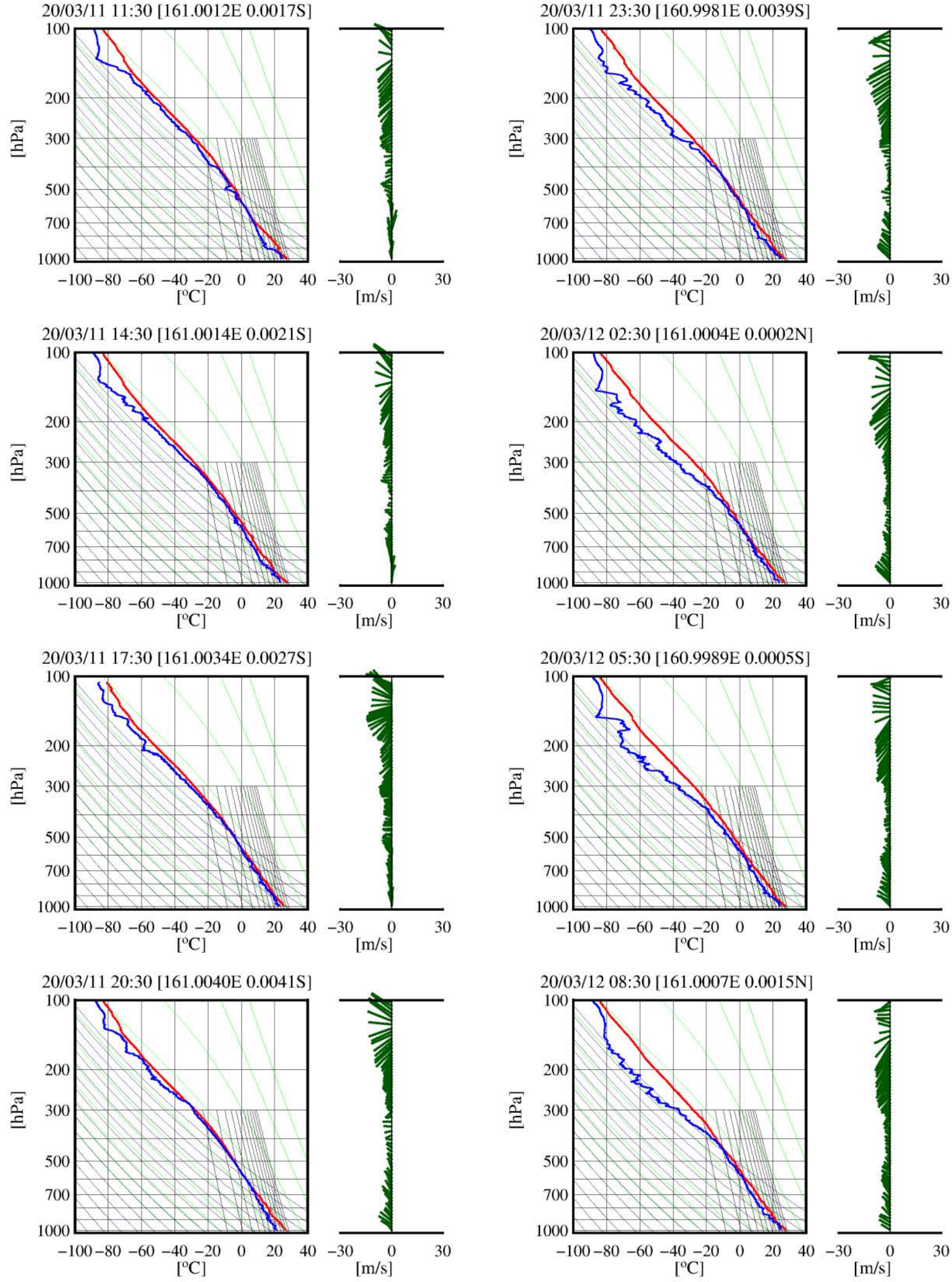

Fig. 5.6-1: Emagrams of radiosonde observations (continued)

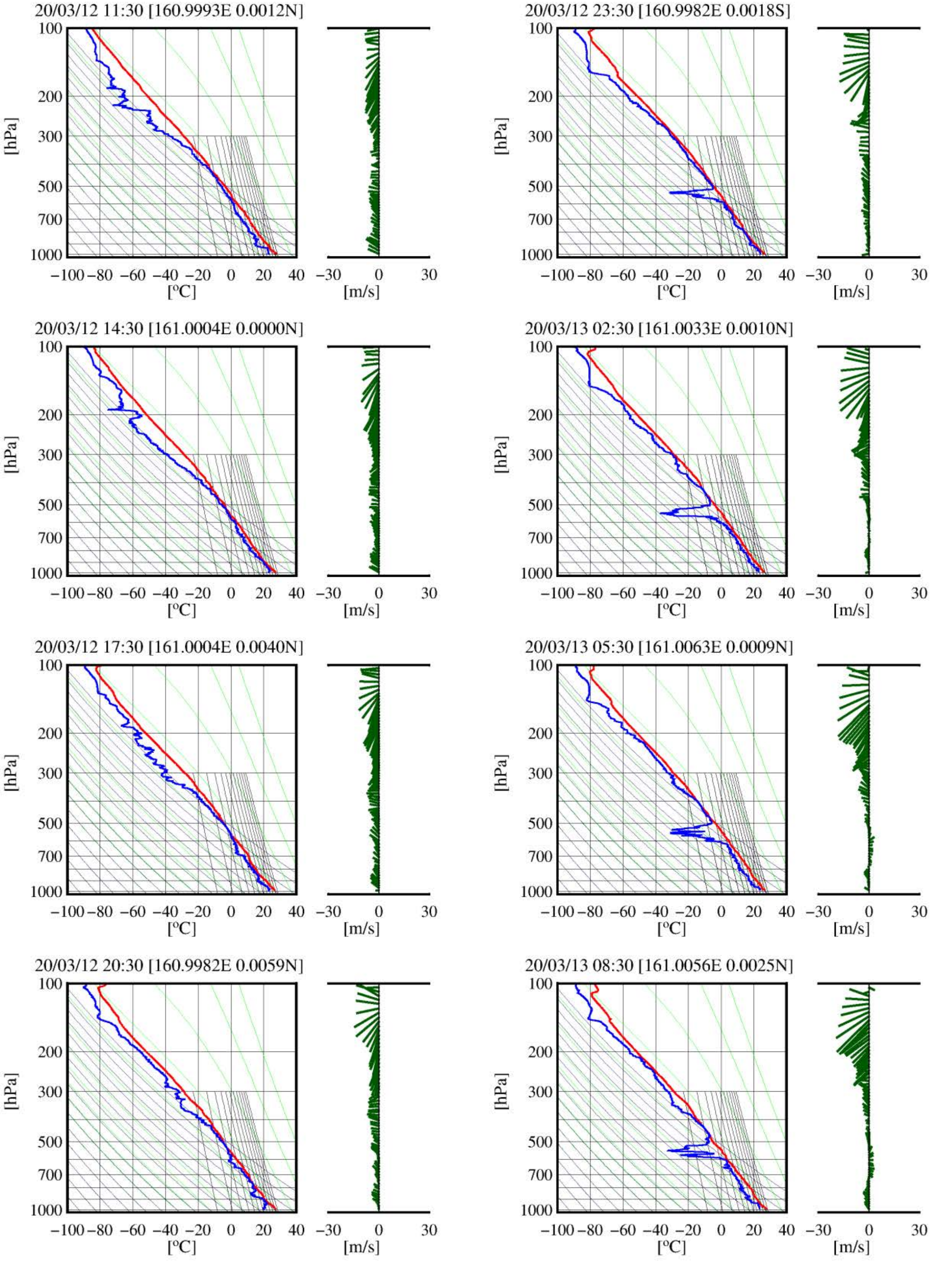

Fig. 5.6-1: Emagrams of radiosonde observations (continued)

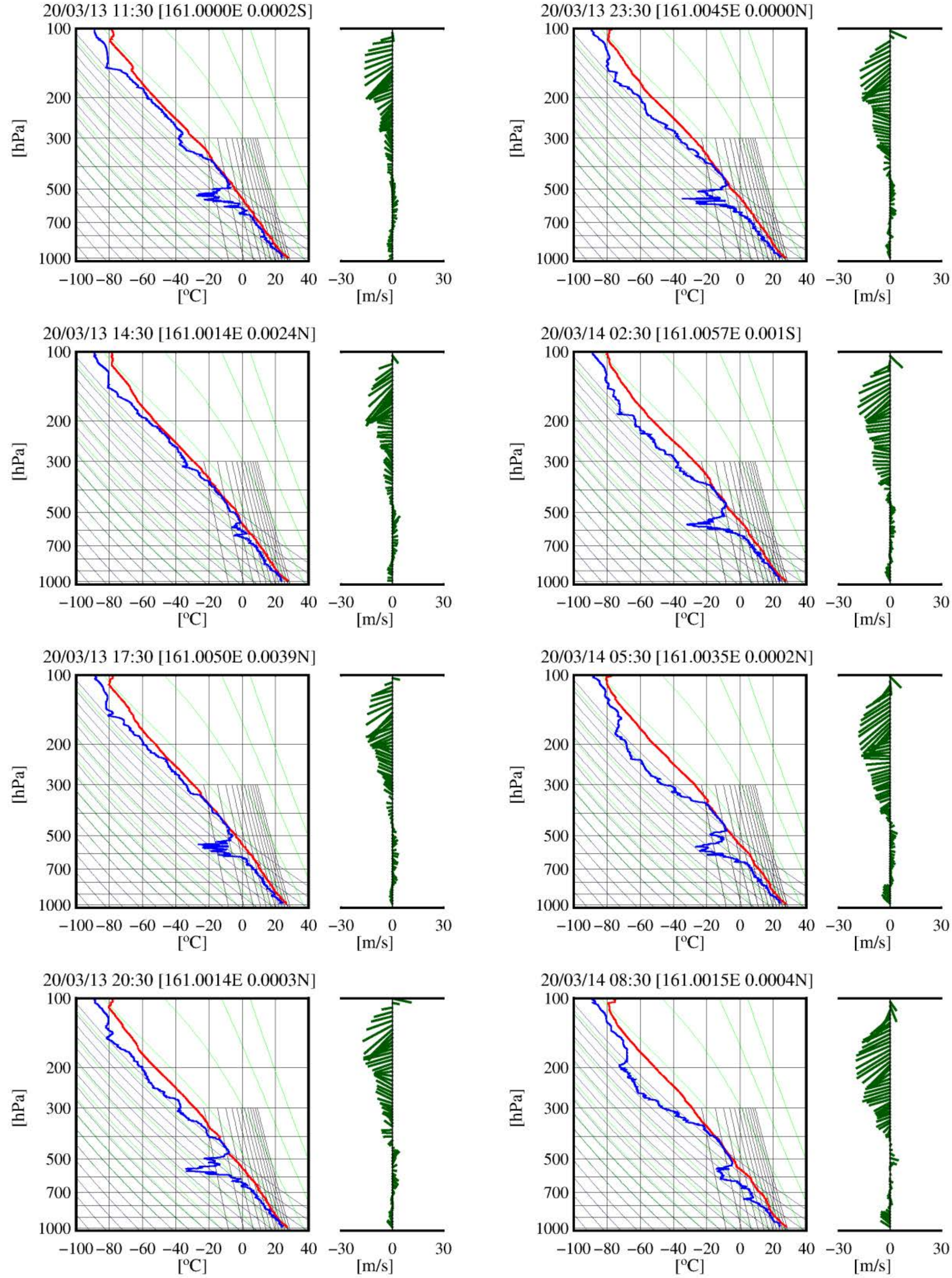

Fig. 5.6-1: Emagrams of radiosonde observations (continued)

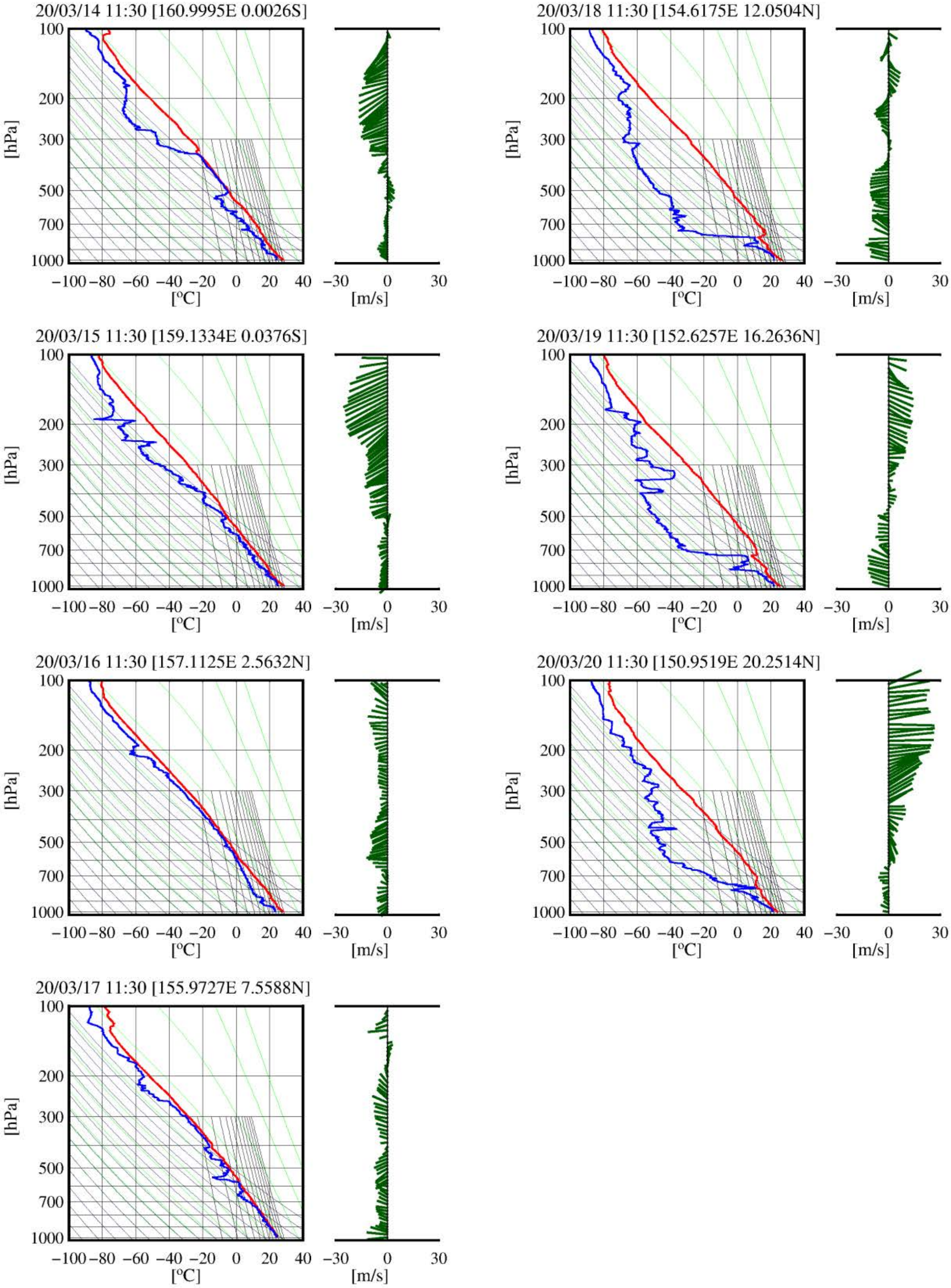

Fig. 5.6-1: Emagrams of radiosonde observations (continued)

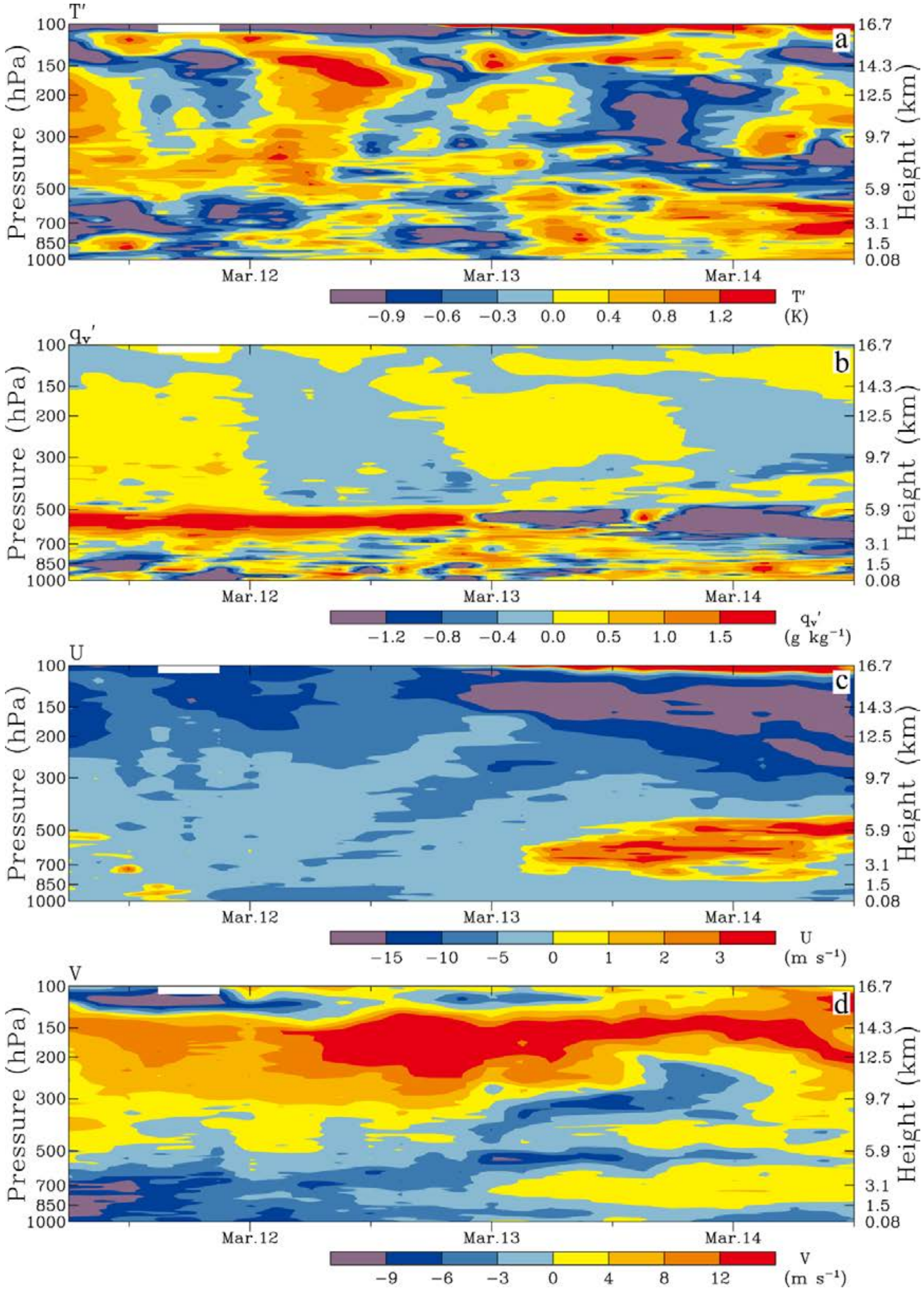

Fig. 5.6-2: Time-height sections of (a) temperature anomaly, (b) specific humidity anomaly, (c) the zonal wind component, and (d) the meridional wind component. An anomaly is defined as a deviation from the mean value of the period shown in the figure.

5.7 Doppler radar observation

(1) Personnel

Biao GENG	(JAMSTEC)	Principal Investigator
Masaki KATSUMATA	(JAMSTEC)	(not on board)
Masanori MURAKAMI	(NME)	Operation Leader
Ryo OYAMA	(NME)	
Yutaro MURAKAMI	(NME)	

(2) Objective

The objective of weather radar observations in this cruise is to investigate the structure and evolution of precipitating systems over the tropical ocean.

(3) Radar specifications

The C-band weather Doppler radar on board the R/V Mirai is used. Basic specifications of the radar are as follows:

Frequency:	5370 MHz (C-band)
Polarimetry:	Horizontal and vertical (simultaneously transmitted and received)
Transmitter:	Solid-state transmitter
Pulse Configuration:	Using pulse-compression
Output Power:	6 kW (H) + 6 kW (V)
Antenna Diameter:	4 meters
Beam Width:	1.0 degrees
Inertial Navigation Unit:	PHINS (IXBLUE SAS France)

(4) Available radar variables

Radar variables, which are converted from the power and phase of the backscattered signal at vertically- and horizontally-polarized channels, are as follows:

Radar reflectivity:	Z
Doppler velocity:	Vr
Spectrum width of Doppler velocity:	SW
Differential reflectivity:	ZDR
Differential propagation phase:	ΦDP
Specific differential phase:	KDP
Co-polar correlation coefficients:	ρHV

(5) Operational methodology

The antenna is controlled to point the commanded ground-relative direction, by controlling the azimuth and elevation to cancel the ship attitude (roll, pitch, and yaw) detected by the navigation unit. The Doppler velocity is also corrected by subtracting the ship movement in beam direction.

For the maintenance, internal signals of the radar are checked and calibrated at the beginning and the end of the cruise. Meanwhile, the following parameters are checked daily; (1) frequency, (2) mean output power, (3) pulse width, and (4) PRF (pulse repetition frequency).

During the cruise, the radar is operated in modes shown in Tables 5.7-1. A dual PRF mode is used for volume scans. For RHI, vertical point, and surveillance PPI scans, a single PRF mode is used.

(6) Data

The C-band weather radar observations were conducted from Feb. 23 to Mar. 24, 2020. During the period from Mar. 11 to 14, 2020, stationary observations were executed at (Equator, 161E). Figure 5.7-1 shows a time-height section of the areal coverage of radar echoes around the period when the stationary observations were conducted. During this period, various precipitating systems have been observed. These precipitation systems developed and evolved in time scales ranging from diurnal to several-day variations. Detailed analyses of the data observed by the weather radar will be performed after the cruise.

All data of the Doppler radar observations during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

Table 5.7-1 Scan modes of the Doppler radar

<table>
<tr><th></th><th>Surveillance PPI Scan</th><th colspan="6">Volume Scan</th><th>RHI Scan</th><th>Vertical Point Scan</th></tr>
<tr><td>Repeated Cycle (min.)</td><td>30</td><td colspan="6">6</td><td colspan="2">12</td></tr>
<tr><td>Times in One Cycle</td><td>1</td><td colspan="6">1</td><td>3</td><td>3</td></tr>
<tr><td rowspan="2">PRF(s) (Hz)</td><td rowspan="2">400</td><td colspan="6">dual PRF (ray alternative)</td><td rowspan="2">1250</td><td rowspan="2">2000</td></tr>
<tr><td>667</td><td>833</td><td>938</td><td>1250</td><td>1333</td><td>2000</td></tr>
<tr><td>Azimuth (deg)</td><td colspan="7">Full Circle</td><td>Option</td><td>Full Circle</td></tr>
<tr><td>Bin Spacing (m)</td><td colspan="9">150</td></tr>
<tr><td>Max. Range (km)</td><td>300</td><td colspan="2">150</td><td colspan="2">100</td><td colspan="2">60</td><td>100</td><td>60</td></tr>
<tr><td>Elevation Angle(s) (deg.)</td><td>0.5</td><td colspan="2">0.5</td><td colspan="2">1.0, 1.8, 2.6, 3.4, 4.2, 5.1, 6.2, 7.6, 9.7, 12.2, 15.2</td><td colspan="2">18.7, 23.0, 27.9, 33.5, 40.0</td><td>0.0~60.0</td><td>90</td></tr>
</table>

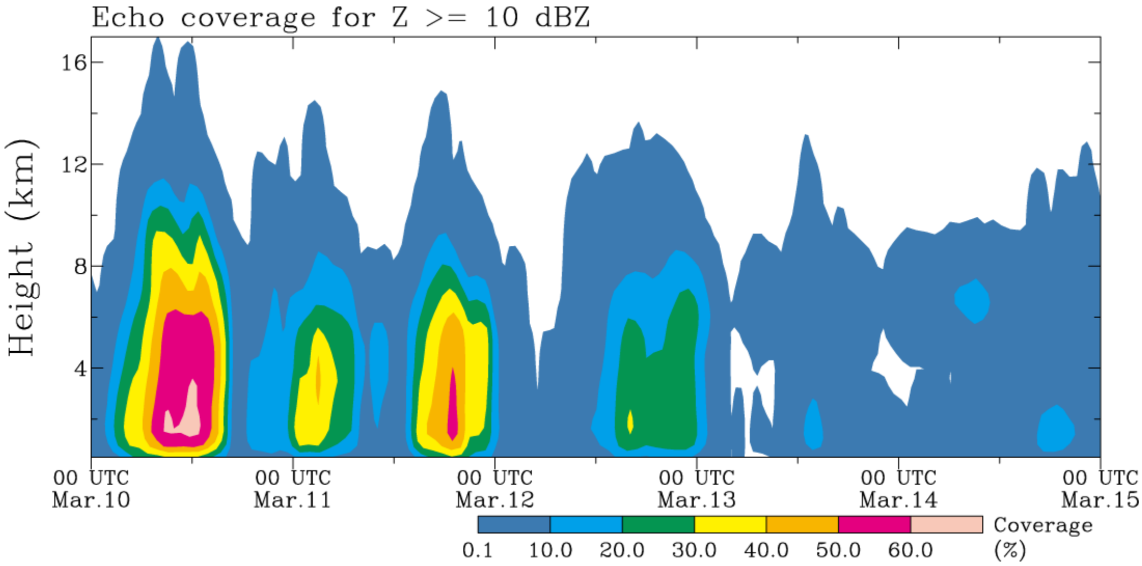

Fig. 5.7-1. Time-height section of the areal coverage of radar echoes within a radius of 100 km from the radar. Data from Mar. 10 to 15, 2020 are plotted.

5.8 Precipitation particles

5.8.1 Disdrometer

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	- Principal Investigator (*not on board)
Biao GENG	(JAMSTEC)	
Kyoko TANIGUCHI	(JAMSTEC)	

(2) Objectives

The disdrometer can continuously obtain size distribution of raindrops. The objective of this observation is (a) to reveal microphysical characteristics of the rainfall, depends on the type, temporal stage, etc. of the precipitating clouds, (b) to retrieve the coefficient to convert radar reflectivity (especially from C-band radar in Section 5.7) to the rainfall amount, and (c) to validate the algorithms and the products of the satellite-borne precipitation radars; TRMM/PR and GPM/DPR.

(3) Instrumentations and Methods

Two “Laser Precipitation Monitor (LPM)” (Adolf Thies GmbH & Co) are utilized. It is an optical disdrometer. The instrument consists of the transmitter unit which emit the infrared laser, and the receiver unit which detects the intensity of the laser come thru the certain path length in the air. When a precipitating particle fall thru the laser, the received intensity of the laser is reduced. The receiver unit detect the magnitude and the duration of the reduction and then convert them onto particle size and fall speed. The sampling volume, i.e. the size of the laser beam “sheet”, is 20 mm (W) x 228 mm (D) x 0.75 mm (H).

A number of particles are categorized by the detected size and fall speed and counted every minute. The categories are shown in Table 5.8.1-1.

The LPMs are installed on the top (roof) of the anti-rolling system, as shown in Fig. 5.8.1-1. Both are installed at the corner at the bow side and the starboard side. One (in aft) equipped the "wind protection element" to reduce the effect of the wind on the measurement, and to estimate the effectiveness of the "element" by comparing data from two sensors.

(4) Preliminary Results

The data have been obtained all through the cruise, except non-permitted territorial waters and EEZs. The further analyses for the rainfall amount, drop-size-distribution parameters, etc., will be carried out after the cruise.

(5) Data Archive

All data obtained during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

(6) Acknowledgment

The operations are supported by Japan Aerospace Exploration Agency (JAXA) Precipitation Measurement Mission (PMM).

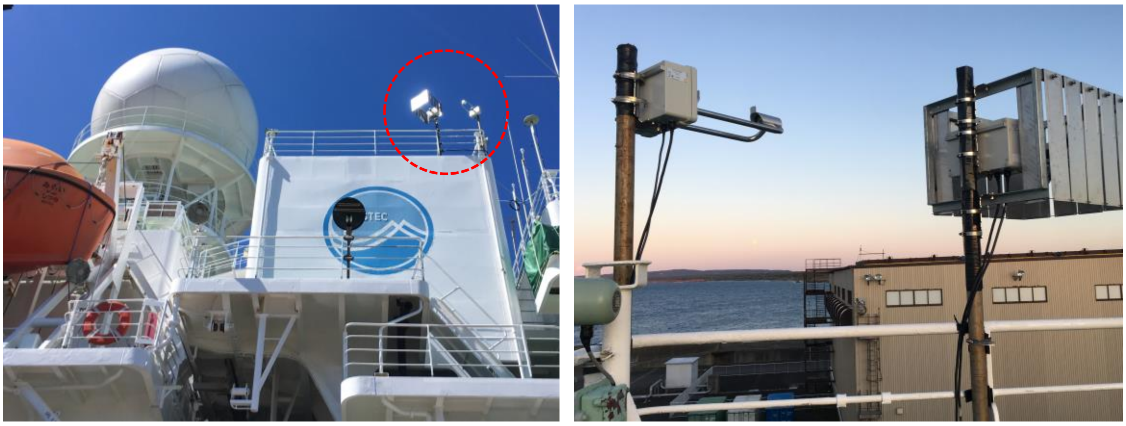

Fig. 5.8.1-1: Onboard LPM sensors. (Left) The location of the sensors, as designated by the red broken circle. (Right) The sensors. Right one (aft one) equipped wind protection element to reduce the effect of the wind, while left one (fore one) did not.

Table 5.8.1-1: Categories of the particle size and the fall speed.

Particle Size		
Class	Diameter [mm]	Class width [mm]
1	≥ 0.125	0.125
2	≥ 0.250	0.125
3	≥ 0.375	0.125
4	≥ 0.500	0.250
5	≥ 0.750	0.250
6	≥ 1.000	0.250
7	≥ 1.250	0.250
8	≥ 1.500	0.250
9	≥ 1.750	0.250
10	≥ 2.000	0.500
11	≥ 2.500	0.500
12	≥ 3.000	0.500
13	≥ 3.500	0.500
14	≥ 4.000	0.500
15	≥ 4.500	0.500
16	≥ 5.000	0.500
17	≥ 5.500	0.500
18	≥ 6.000	0.500
19	≥ 6.500	0.500
20	≥ 7.000	0.500
21	≥ 7.500	0.500
22	≥ 8.000	unlimited

Fall Speed		
Class	Speed [m/s]	Class width [m/s]
1	≥ 0.000	0.200
2	≥ 0.200	0.200
3	≥ 0.400	0.200
4	≥ 0.600	0.200
5	≥ 0.800	0.200
6	≥ 1.000	0.400
7	≥ 1.400	0.400
8	≥ 1.800	0.400
9	≥ 2.200	0.400
10	≥ 2.600	0.400
11	≥ 3.000	0.800
12	≥ 3.400	0.800
13	≥ 4.200	0.800
14	≥ 5.000	0.800
15	≥ 5.800	0.800
16	≥ 6.600	0.800
17	≥ 7.400	0.800
18	≥ 8.200	0.800
19	≥ 9.000	1.000
20	≥ 10.000	10.000

5.8.2 Micro rain radar

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	- Principal Investigator (*not on board)
Biao GENG	(JAMSTEC)	(*not on board)
Kyoko TANIGUCHI	(JAMSTEC)	(*not on board)

(2) Objectives

The micro rain radar (MRR) is a compact vertically-pointing Doppler radar, to detect vertical profiles of rain drop size distribution. The objective of this observation is to understand detailed vertical structure of the precipitating systems.

(3) Instruments and Methods

The MRR-2 (METEK GmbH) was utilized. The specifications are in Table 5.8.2-1. The antenna unit was installed at the starboard side of the anti-rolling systems (see Fig. 5.8.2-1), and wired to the junction box and laptop PC inside the vessel.

The data was averaged and stored every one minute. The vertical profile of each parameter was obtained every 100 meters in range distance (i.e. height) up to 3100 meters. The recorded parameters were; Drop size distribution, radar reflectivity, path-integrated attenuation, rain rate, liquid water content and fall velocity.

Fig. 5.8.2-1: Photo of the antenna unit of MRR

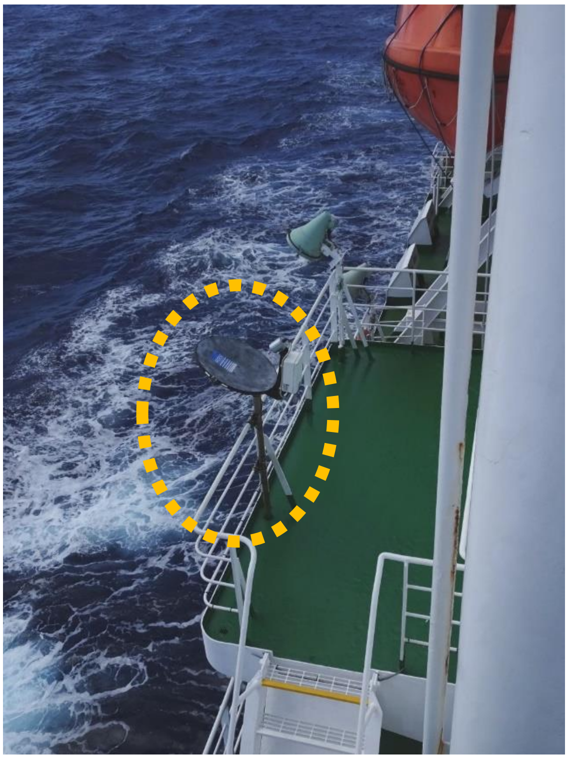

Table 5.8.2-1: Specifications of the MRR-2.

Transmitter power	50 mW
Operating mode	FM-CW
Frequency	24.230 GHz (modulation 1.5 to 15 MHz)
3dB beam width	1.5 degrees
Spurious emission	< -80 dBm / MHz
Antenna Diameter	600 mm
Gain	40.1 dBi

(4) Preliminary Results

The data have been obtained all through the cruise, except non-permitted territorial waters and EEZs. The further analyses will be after the cruise.

(5) Data Archive

All data obtained during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

(6) Acknowledgment

The operations are supported by Japan Aerospace Exploration Agency (JAXA) Precipitation Measurement Mission (PMM).

5.9 GNSS precipitable water

(7) Personnel

Masaki KATSUMATA	(JAMSTEC)	- Principal Investigator (*not on board)
Mikiko FUJITA	(JAMSTEC)	(*not on board)
Biao GENG	(JAMSTEC)	
Kyoko TANIGUCHI	(JAMSTEC)	

(8) Objectives

The objective is to obtain the GNSS satellite data to estimate the total column integrated water vapor content of the atmosphere.

(9) Instrumentations and Methods

The GNSS satellite data was archived to the receiver (Trimble NetR9) with 5 sec intervals. The GNSS antenna (Margrin) was set on the roof of aft wheel house. The observations were carried out all thru the cruise.

(10) Preliminary Results

The observations were conducted through the cruise, except in the EEZs and territorial waters without permission. We will calculate the total column integrated water from observed GNSS satellite data after the cruise.

(11) Data Archive

All data obtained during this cruise will be submitted to the JAMSTEC Data Management Group (DMG).

5.10 Aerosol optical characteristics measured by ship-borne sky radiometer

(1) Personnel

Kazuma Aoki (University of Toyama)	Principal Investigator (not onboard)
Katsumata Masaki (JAMSTEC)	not onboard
Fumikazu Taketani (JAMSTEC)	not onboard

Sky radiometer operation was supported by Nippon Marine Enterprises, Ltd.

(2) Objective

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

(3) 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 the sun. Horizon sensor provides rolling and pitching angles.

(4) Instruments and Methods

The sky radiometer measures the direct solar irradiance and the solar aureole radiance distribution with seven interference filters (0.315, 0.4, 0.5, 0.675, 0.87, 0.94, and 1.02 µm). Analysis of these data was performed by SKYRAD.pack version 4.2 developed by Nakajima *et al.* 1996.

(5) Data archives

Aerosol optical data are to be archived at University of Toyama (K. Aoki, SKYNET/SKY: http://skyrad.sci.u-toyama.ac.jp/) after the quality check and will be submitted to JAMSTEC.

5.11 Tropospheric gas and particles observation over the marine atmosphere

(1) Personnel

Yugo Kanaya	JAMSTEC	- not on board
Fumikazu Taketani	JAMSTEC	- not on board
Takuma Miyakawa	JAMSTEC	- not on board
Hisahiro Takashima	JAMSTEC/Fukuoka Univ.	- not on board
Chunmao Zhu	JAMSTEC	- not on board

Operation for all instruments was supported by Nippon Marine Enterprises, Ltd

(2) Objectives

• To investigate roles of aerosols in the marine atmosphere in relation to climate change

(3) Parameters

• Particle number concentration
• Aerosol extinction coefficient (AEC)
• Surface ozone (O_3), and carbon monoxide (CO) mixing ratios

(4) Instruments and methods

(4-1) Online aerosol observations:

(4-1-1) Particle number concentration

The number concentration of ament particles was measured by mixing condensation particle counter (MCPC) (Model 1720, Brechtel).

(4-1-2) Aerosol extinction coefficient (AEC)

Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS), a passive remote sensing technique measuring spectra of scattered visible and ultraviolet (UV) solar radiation, was used for atmospheric aerosol and gas profile measurements. Our MAX-DOAS instrument consists of two main parts: an outdoor telescope unit and an indoor spectrometer (Acton SP-2358 with Princeton Instruments PIXIS-400B), connected to each other by a 14-m bundle optical fiber cable. The line of sight was in the directions of the portside of the vessel and the scanned elevation angles were 1.5, 3, 5, 10, 20, 30, 90 degrees in the 30-min cycle. The roll motion of the ship was measured to autonomously compensate additional motion of the prism, employed for scanning the elevation angle. For the selected spectra recorded with elevation angles with good accuracy, DOAS spectral fitting was performed to quantify the slant column density (SCD) of NO_2 (and other gases) and O_4 (O_2-O_2, collision complex of oxygen) for each elevation angle. Then, the O_4 SCDs were converted to the aerosol optical depth (AOD) and the vertical profile of aerosol extinction coefficient (AEC) using an optimal estimation inversion method with a radiative transfer model. Using derived aerosol information, retrievals of the tropospheric vertical column/profile of NO_2 and other gases were made.

For MCPC instrument, the ambient air was commonly sampled from the compass deck by a 3-m-long conductive tube through the dryer to dry up the particles, and then introduced to the instrument installed at the environmental research room. MAXDOAS were installed at the deck above stabilizer of ship

(4-2) CO and O_3 observations:

Ambient air was continuously sampled on the compass deck and drawn through ~20-m-long Teflon tubes connected to a gas filter correlation CO analyzer (Model 48C, Thermo Fisher Scientific) and a UV photometric ozone analyzer (Model 205, 2B Tech), located in the Research Information Center. The data will be used for characterizing air mass origins.

(4-3) Rain sampling

Rain sample was corrected using a hand-made sampler. These sampling logs are listed in Table 5.11-1. To investigate the nutrients concentration in the rain, these samples are going to be analyzed in laboratory.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site. <http://www.godac.jamstec.go.jp/darwin/e>

Table 5.11-1

	date/time sampling(UTC)				latitude			longitude		
Bottle ID	yyyy	mm	dd	stop (hh:mm)	deg	min	N-S	deg	min	E-W
MR1406-R/S001										
MR2001-R001	2020	2	26	0:15	12	48.43	N	136	4746	E
MR2001-R002	2020	2	27	1:30	13	7.02	N	136	53.9	E
MR2001-R003	2020	3	1	0:40	7	39.49	N	136	42.59	E
MR2001-R004	2020	3	2	0:15	6	14.15	N	140	17.38	E
MR2001-R005	2020	3	3	0:40	4	28.65	N	144	43.24	E
MR2001-R006	2020	3	4	0:05	2	47.94	N	148	56.83	E
MR2001-R007	2020	3	5	0:10	1	9.98	N	153	4.13	E
MR2001-R008	2020	3	11	0:10	0	0.16	N	160	59.73	E
MR2001-R009	2020	3	12	0:05	0	0.08	S	160	59.67	E
MR2001-R010	2020	3	13	0:05	0	0.07	S	160	59.76	E
MR2001-R011	2020	3	16	0:15	0	7.83	N	157	31.33	E
MR2001-R012	2020	3	17	0:10	5	20.47	N	156	44.63	E
MR2001-R013	2020	3	18	0:10	9	57.81	N	155	2.15	E
MR2001-R014	2020	3	19	0:10	14	22.1	N	153	28.48	E
MR2001-R015	2020	3	20	0:15	18	31.63	N	151	42.15	E
MR2001-R016	2020	3	22	0:10	26	19.73	N	148	29.07	E
MR2001-R017	2020	3	23	6:00	31	45.11	N	146	6.64	E
MR2001-R018	2020	3	24	0:30	34	8.75	N	143	30.2	E
MR2001-R019	2020	3	25	1:20	37	29.68	N	141	35.57	E

5.12 Meteorological observations

5.12.1 Surface meteorological observations

(1) Personnel

Akira NAGANO	(JAMSTEC) * Principal Investigator
Masanori MURAKAMI	(Nippon Marine Enterprises Ltd., NME)
Ryo OYAMA	(NME)
Yutaro MURAKAMI	(NME)
Yoichi INOUE	(Mirai Crew)

(2) Objectives

Surface meteorological parameters are observed as a basic dataset of the meteorology. These parameters provide the temporal variation of the meteorological condition surrounding the ship.

(3) Methods

Surface meteorological parameters were observed during this cruise. During this cruise, we used two systems for the observation.

i) Mirai Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table 5.12.1-1 and measured parameters are listed in Table 5.12.1-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-seconds averaged data.

ii) Shipboard Oceanographic and Atmospheric Radiation (SOAR) measurement system

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

a) Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation.
b) Analog meteorological data sampling with CR1000 logger manufactured by Campbell Inc. Canada -wind, pressure, and rainfall (by a capacitive rain gauge) measurement.
c) Digital meteorological data sampling from individual sensors -air temperature, relative humidity and rainfall (by Optical Rain Gauge (ORG)) measurement.
d) Photosynthetically Available Radiation (PAR) and UltraViolet Irradiance (UV) sensor manufactured by Biospherical Instruments Inc., (USA) -PAR and UV measurement.
e) Scientific Computer System (SCS) developed by NOAA (National Oceanic and Atmospheric Administration, USA) -centralized data acquisition and logging of all data sets.
f) "SeaSnake" the floating thermistor designed by BNL -Skin Sea Surface Temperature (SSST) measurement.

SCS recorded PRP data every 6 seconds, CR1000 data every second, air temperature and relative humidity data every 2 seconds, ORG data every 6 seconds and PAR data every 6 seconds. SCS composed "Event data (JamMet_PARUV)" from these data and ship's navigation data. Instruments and their locations are listed in Table 5.12.1-3 and measured parameters are listed in Table 5.12.1-4.

"SeaSnake" has two thermistor probes and output voltage was converted to SSST by Steinhart-Hart equation with the following coefficients "a", "b" and "c", which were led from the calibration data.

Sensor	a	B	c
T06-005	8.74350E-04	-2.04952E-04	-8.29560E-08
T06-100	9.48760E-04	-1.93418E-04	-1.18144E-07

$y = a + b * x + c * x^3$
$x = \log (1 / ((V_{ref} / V - 1) * R_2 - R_1))$
$T = 1 / y - 273.15$

V_{ref} = 2500 [mV]
R_1 = 249000 [Ω]
R_2 = 1000 [Ω]
T: Temperature [degC]
V: Sensor output voltage [mV]

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

i. Capacitive rain gauge (SMet and SOAR)
Inspecting linearity of output value from the rain gauge sensor to change input value by adding fixed quantity of test water.
ii. Barometer (SMet and SOAR)
Comparing with the portable barometer value, PTB220, VAISALA.
iii. Thermometer (air temperature and relative humidity) (SMet and SOAR)
Comparing with the portable thermometer value, HM70/HMP75, VAISALA.
iv. "SeaSnake" SSST (SOAR)
"SeaSnake" thermistor probes were calibrated by the bath equipped with SBE-3 plus, Sea-Bird Electronics, Inc.

(4) Preliminary results

Figure 5.12.1-1 shows the time-series of the following parameters:

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

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.

http://www.godac.jamstec.go.jp/darwin/e

(6) Remarks

i) SST (Sea Surface Temperature) data was available in the following period.
06:54UTC 23 Feb. 2020 - 23:57UTC 24 Mar. 2020

ii) The following time, increasing of SMet capacitive rain gauge data were invalid due to transmitting MF/HF radio.
06:36UTC 21 Mar. 2020
06:42UTC 21 Mar. 2020

iii) FRSR data was not available in this cruise due to the system trouble.

iv) The following periods, SSST data were available.
22:41UTC 10 Mar. 2020 - 03:50UTC 14 Mar. 2020

Table 5.12.1-1 Instruments and installation locations of Mirai Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KS-5900	Koshin Denki, Japan	Foremast (25 m)
Tair/RH with aspirated radiation shield	HMP155 43408 Gill	Vaisala, Finland R.M. Young, U.S.A.	Compass deck (21 m) starboard and port side
Thermometer: SST	RFN2-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	Model-370	Setra System, U.S.A.	Captain deck (13 m) Weather observation room
Capacitive rain gauge	50202	R. M. Young, U.S.A.	Compass deck (19 m)
Optical rain gauge	ORG-815DR	Osi, USA	Compass deck (19 m)
Radiometer (short wave)	MS-802	Eko Seiki, Japan	Radar mast (28 m)
Radiometer (long wave)	MS-202	Eko Seiki, Japan	Radar mast (28 m)
Wave height meter	WM-2	Tsurumi-seiki, Japan	Bow (10 m) Stern (8m)

Table 5.12.1-2 Parameters of Mirai Surface Meteorological observation system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 Ship's speed	knot	Mirai log
4 Ship's heading	degree	Mirai gyro
5 Relative wind speed	m/s	6sec./10min. averaged
6 Relative wind direction	degree	6sec./10min. averaged
7 True wind speed	m/s	6sec./10min. averaged

8 True wind direction	degree	6sec./10min. averaged
9 Barometric pressure	hPa	adjusted to sea surface level 6sec. averaged
10 Air temperature (starboard)	degC	6sec. averaged
11 Air temperature (port)	degC	6sec. averaged
12 Dewpoint temperature (starboard)	degC	6sec. averaged
13 Dewpoint temperature (port)	degC	6sec. averaged
14 Relative humidity (starboard)	%	6sec. averaged
15 Relative humidity (port)	%	6sec. averaged
16 Sea surface temperature	degC	6sec. averaged
17 Precipitation intensity (optical rain gauge)	mm/hr	hourly accumulation
18 Precipitation (capacitive rain gauge)	mm/hr	hourly accumulation
19 Downwelling shortwave radiation	W/m^2	6sec. averaged
20 Downwelling infra-red radiation	W/m^2	6sec. averaged
21 Significant wave height (bow)	m	hourly
22 Significant wave height (stern)	m	hourly
23 Significant wave period (bow)	second	hourly
24 Significant wave period (stern)	second	hourly

Table 5.12.1-3 Instruments and installation locations of SOAR system

Sensors (Meteorological)	Type	Manufacturer	Location (altitude from surface)
Anemometer	05106	R.M. Young, USA	Foremast (25 m)
Barometer with pressure port	PTB210 61002 Gill	VAISALA, Finland R.M. Young, USA	Foremast (23 m)
Rain gauge	50202	R.M. Young, USA	Foremast (24 m)
Tair/RH with aspirated radiation shield	HMP155 43408 Gill	VAISALA, Finland R.M. Young, USA	Foremast (23 m)
Optical rain gauge	ORG-815DR	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 shadow-band radiometer		Yankee, USA	Foremast (25 m)

Sensor (PAR&UV)	Type	Manufacturer	Location (altitude from surface)

PAR&UV sensor	PUV-510	Biospherical Instrum ents Inc., USA	Navigation deck (18m)

Sensor (SeaSnake)	Type	Manufacturer	Location (altitude from surface)
Thermistor	107	Campbell Scientific, USA	Bow, 5m extension (0 m)

Table 5.12.1-4 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 Precipitation intensity (optical rain gauge)	mm/hr	
11 Precipitation (capacitive rain gauge)	mm/hr	reset at 50 mm
12 Down welling shortwave radiation	W/m^2	
13 Down welling infra-red radiation	W/m^2	
14 Defuse irradiance	W/m^2	
15 “SeaSnake” raw data	mV	
16 SSST (SeaSnake)	degC	
17 PAR	$microE/cm^2/sec$	
18 UV 305 nm	$microW/cm^2/nm$	
19 UV 320 nm	$microW/cm^2/nm$	
20 UV 340 nm	$microW/cm^2/nm$	
21 UV 380 nm	$microW/cm^2/nm$	

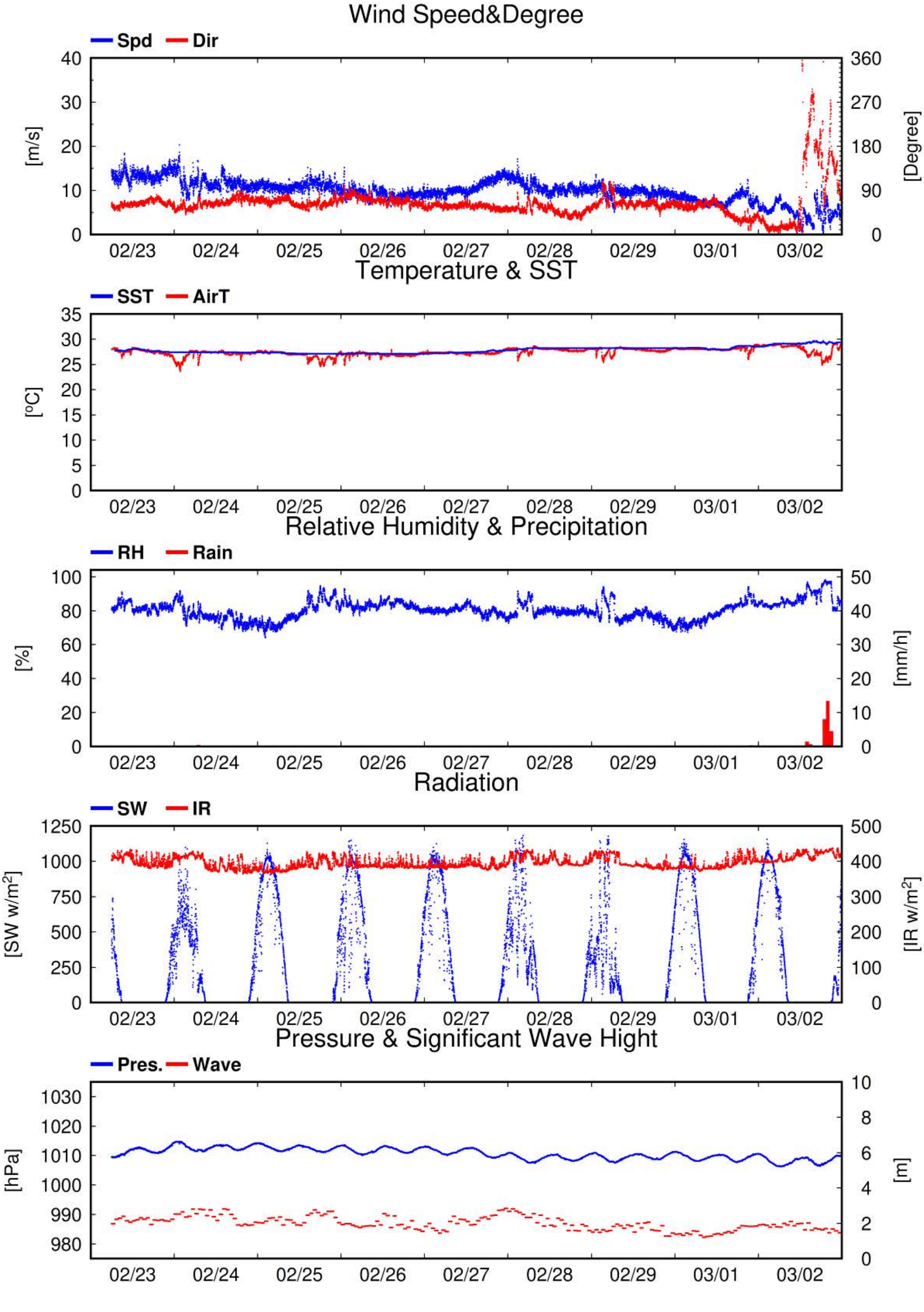

Fig. 5.12.1-1 Time series of surface meteorological parameters during the cruise

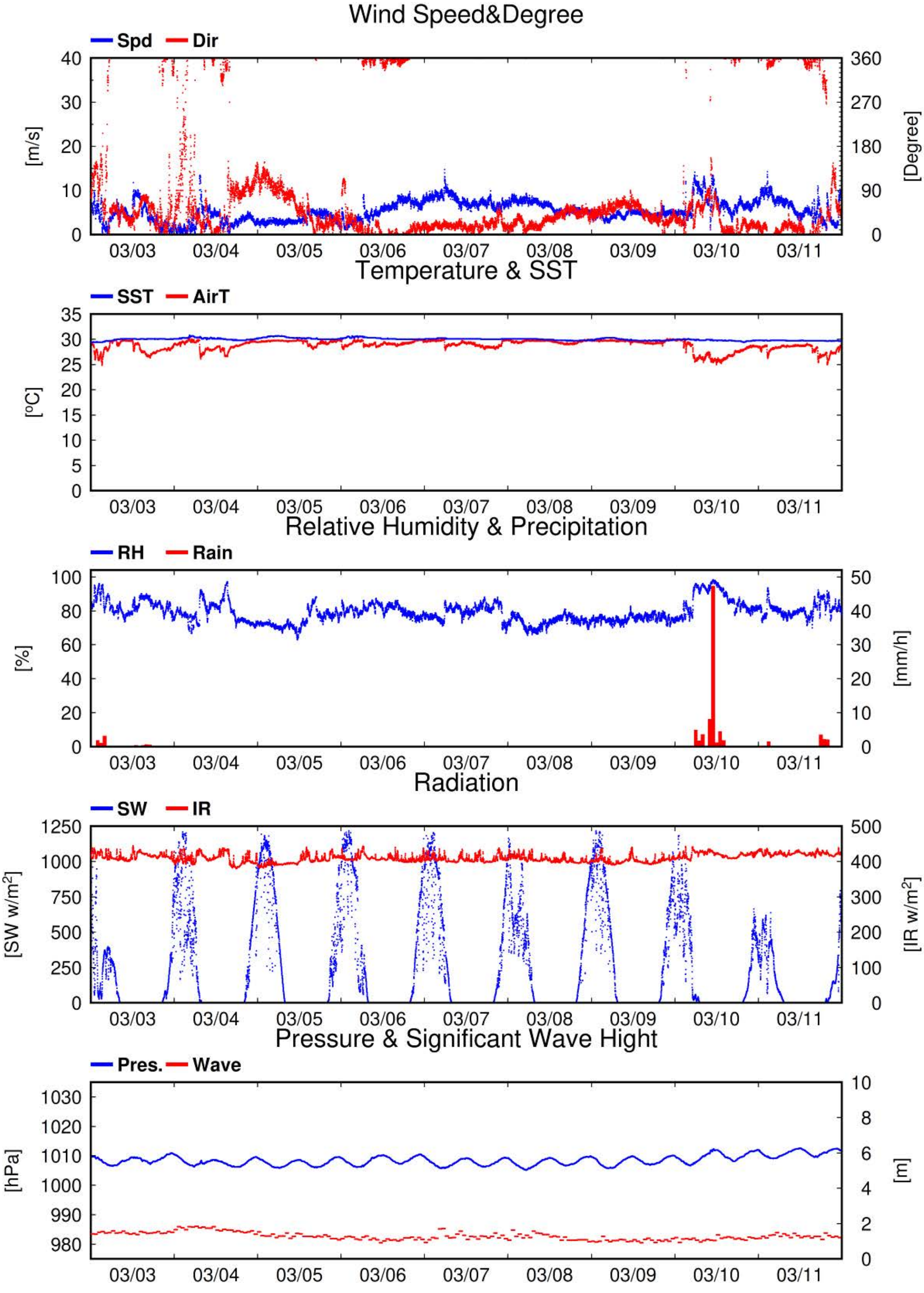

Fig. 5.12.1-1 (Continued)

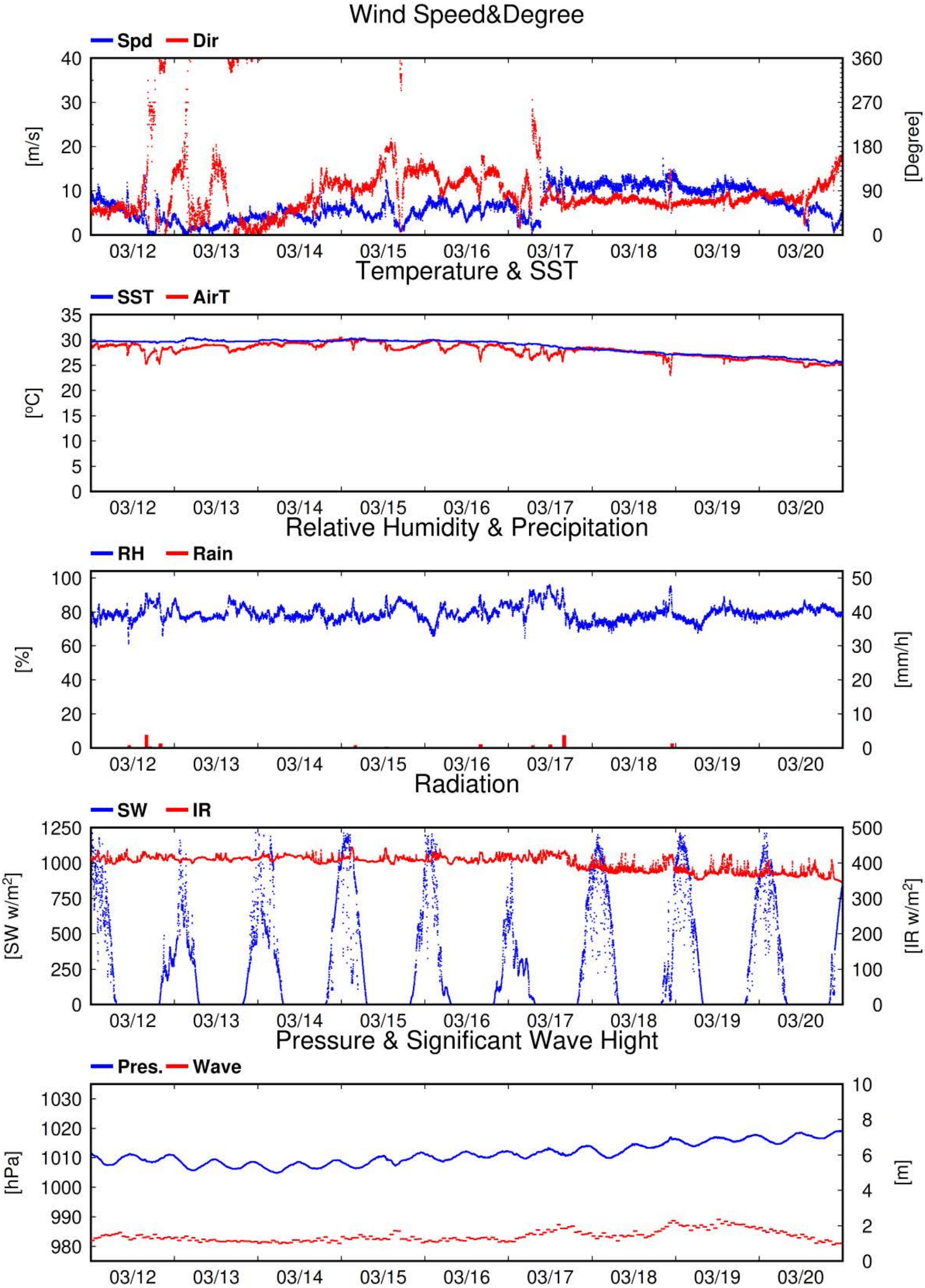

Fig. 5.12.1-1 (Continued)

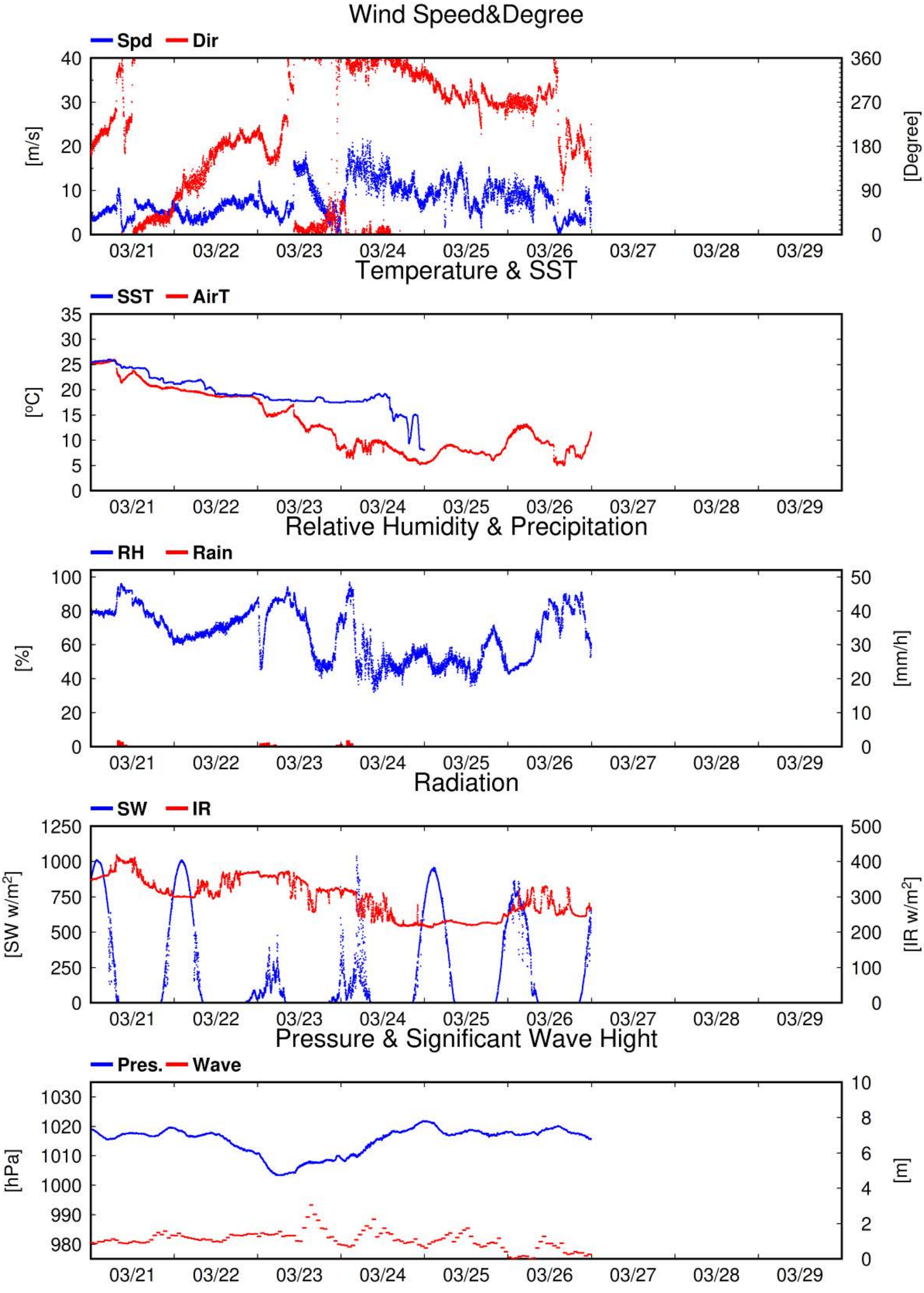

Fig. 5.12.1-1 (Continued)

5.12.2 Ceilometer

(1) Personnel

Akira NAGANO	(JAMSTEC) * Principal Investigator
Masanori MURAKAMI	(Nippon Marine Enterprises Ltd., NME)
Ryo OYAMA	(NME)
Yutaro MURAKAMI	(NME)
Yoichi INOUE	(Mirai Crew)

(2) Objectives

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

(3) Parameters

1. Cloud base height [m].
2. Backscatter profile, sensitivity and range normalized at 10 m resolution.
3. Estimated cloud amount [oktas] and height [m]; Sky Condition Algorithm.

(4) Methods

Cloud base height and backscatter profile were observed by ceilometer (CL51, VAISALA, Finland). The measurement configurations are shown in Table 5.12.2-1. On the archive dataset, cloud base height and backscatter profile are recorded with the resolution of 10 m.

Table 5.12.2-1 The measurement configurations

Property	Description
Laser source	Indium Gallium Arsenide (InGaAs) Diode
Transmitting center wavelength	910±10 nm at 25 degC
Transmitting average power	19.5 mW
Repetition rate	6.5 kHz
Detector	Silicon avalanche photodiode (APD)
Responsibility at 905 nm	65 A/W
Cloud detection range	0 ~ 13 km
Measurement range	0 ~ 15 km
Resolution	10 m in full range
Sampling rate	36 sec.
Sky Condition	Cloudiness in octas (0 ~ 9) 0 Sky Clear 1 Few 3 Scattered 5-7 Broken 8 Overcast 9 Vertical Visibility

(5) Preliminary results

Figure 5.12.2-1 shows the time-series of the lowest, second and third cloud base height during the cruise.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.

http://www.godac.jamstec.go.jp/darwin/e

(7) Remarks

i) Window Cleaning
   00:28UTC 26 Feb. 2020
   00:22UTC 05 Mar. 2020
   00:15UTC 13 Mar. 2020
   00:29UTC 20 Mar. 2020

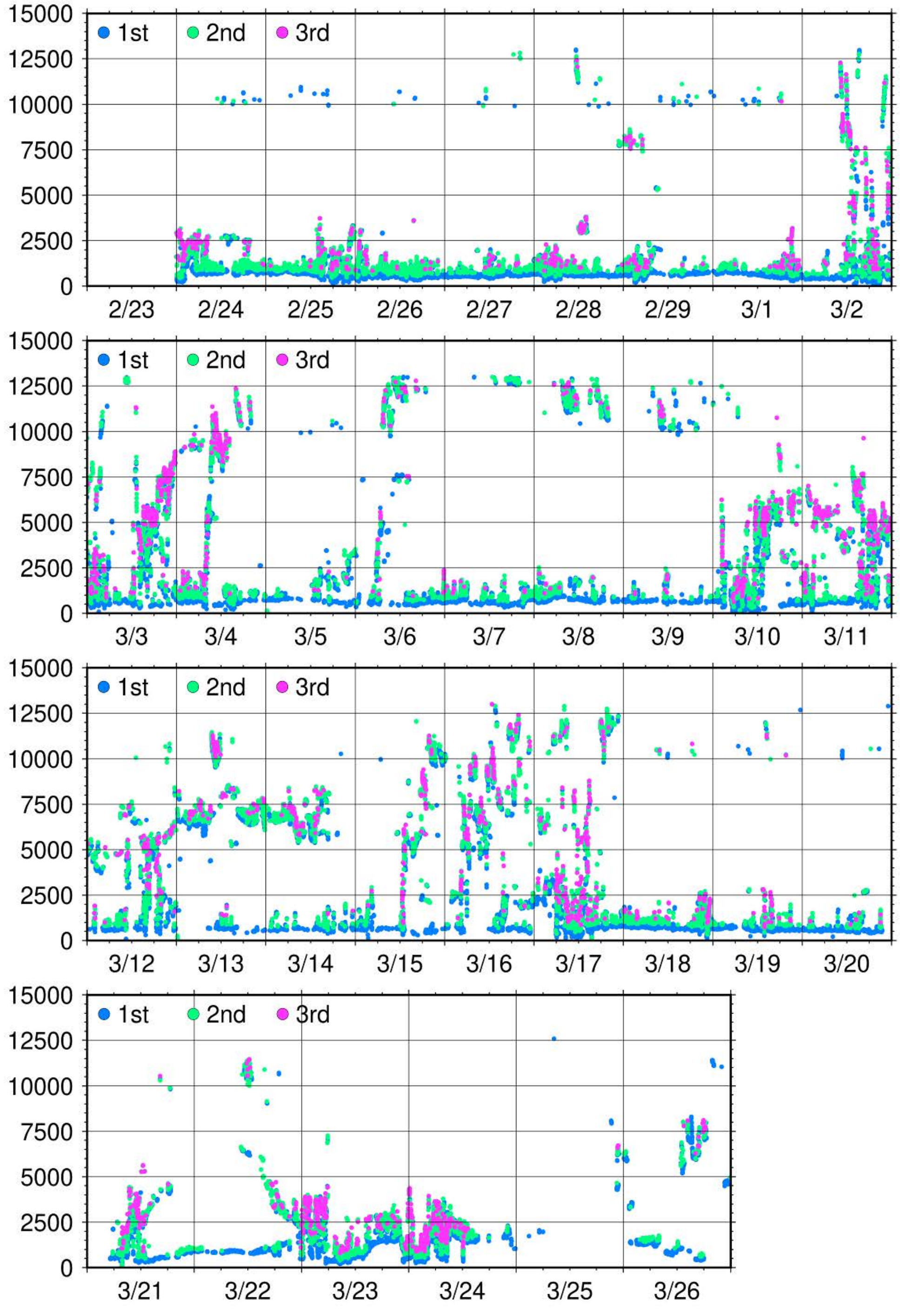

Fig. 5.12.2-1 First, second, and third cloud base height during this cruise.

5.13 Ocean observations

5.13.1 CTD

(1) Personnel

Akira NAGANO	(JAMSTEC)	- Principal Investigator
Hiroki USHIROMURA	(MWJ)	- Operation Leader
Hiroshi MATSUNAGA	(MWJ)	
Keisuke MATSUMOTO	(MWJ)	
Hironori SATO	(MWJ)	
Masaki YAMADA	(MWJ)	
Keisuke TAKEDA	(MWJ)	
Tun Htet Aung	(MWJ)	

(2) Objective

Investigation of oceanic structure and water sampling.

(3) Parameters

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

(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. Twelve-liter sample bottles were used for sampling seawater. Salinity was calculated by measured values of pressure, conductivity, and temperature. The CTD/CWS was deployed from starboard on working deck.

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: 01 Aug. 2019

Carousel water sampler:
SBE32 (S/N: 3254451-0826, Sea-Bird Electronics, Inc.)

Temperature sensors:
Primary: SBE03-04/F (S/N: 031359, Sea-Bird Electronics, Inc.)
Calibrated Date: 27 Jun. 2019
Secondary: SBE03-04/F (S/N: 031464, Sea-Bird Electronics, Inc.)
Calibrated Date: 01 Jun. 2019

Conductivity sensors:

Primary: SBE04C (S/N: 041206 Sea-Bird Electronics, Inc.)
Calibrated Date: 25 Jun 2019

Secondary: SBE04C (S/N: 041088, Sea-Bird Electronics, Inc.)
Calibrated Date: 21 Feb. 2019

Dissolved Oxygen sensor:

Primary: SBE43 (S/N: 430330, Sea-Bird Electronics, Inc.)
Calibrated Date: 02 Jul. 2019

Secondary: RINKOIII (S/N: 0287_163011BA, JFE Advantech Co., Ltd.)
Calibrated Date: 04 Jun 2019

Deck unit: SBE11plus (S/N 11P54451-0872, Sea-Bird Electronics, Inc.)

Configuration file: MR2001A.xmlcon
C01M001 – STNM030

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.23.2) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled during the up cast by sending fire commands from the personal computer.

For depths where vertical gradient of water properties were exchanged to be large, the bottle was exceptionally fired after waiting from the stop for 60 seconds to enhance exchanging the water between inside and outside of the bottle. Otherwise below thermocline we waited for 30 seconds to stabilize then fire. 39 casts of CTD measurements were conducted (Table 6.13.1-1).

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.26.7.129.) and SEASOFT were as follows:

(The process in order)

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

TCORP (original module): Corrected the pressure sensitivity of the temperature (SBE3) sensor.
S/N 1359: -2.29885054e-007 (degC/dbar)
S/N 1464: -7.75293156e-009 (degC/dbar)

BOTTLESUM: Create a summary of the bottle data. The data were averaged over 3 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 and transmission 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 ware compensated by 3.0 sec advancing primary oxygen sensor (SBE43), 1.0 seconds advancing secondary dissolved oxygen sensor (RINKOIII) output relative to temperature data.

WILDEDIT: Mark extreme outliers in the data files. The first pass of WILDEDIT obtained the 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 (SBE43).

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 and depth data 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).

DESPIKE (original module): Remove spikes of the data. A median and mean absolute deviation was calculated in 1-dbar pressure bins for both down and up cast, excluding the flagged values. Values greater than 4 mean absolute deviations from the median were marked bad for each bin. This process was performed twice for temperature, conductivity and dissolved oxygen (RINKOIII and SBE43) voltage.

DERIVE: Compute dissolved oxygen (SBE43).

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

BOTTOMCUT (original module): Deletes discontinuous scan bottom data, when it's created by BINAVG.

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

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

(5) Station list

During this cruise, 39 casts of CTD observation were carried out on buoy observation, ARGO Float and stationary observation. Date, time and locations of the CTD casts are listed in Table 5.13.1-1.

(6) Preliminary Results

The time series contours of primary temperature, salinity, dissolved oxygen with pressure are shown in Fig. 5.13.1-1. Vertical profile (down cast) of primary temperature, salinity and dissolved oxygen with pressure are shown in the appendix.

During this cruise, we judged noise, spike or shift in the data of some casts. These were as follows.

C09M001: Secondary temperature, salinity
up 1000 dbar - up 0 dbar: shift

Table 5.13.1-1 MR20-01 CTD cast table

MR20-01 CTD cast table

Stnnbr	Castno	Date(UTC) (mmddyy)	Time(UTC) Start	End	BottomPosition Latitude	Longitude	Depth (m)	Wire Out (m)	HT Above Bottom (m)	Max Depth	Max Pressure	CTD Filename	Remark
C01	1	022620	06:45	07:08	12-53.81N	136-53.80E	5251.0	97.0	-	100.4	101.0	C01M001	JES10-mini , Rinko Profiler cast Ph Buoy 13N137E Dep No sampling
C02	1	022620	07:53	08:52	12-54.11N	136-52.61E	5075.0	994.7	-	994.8	1003.0	C02M001	Ph Buoy 13N137E Dep
C03	1	022620	21:03	22:35	13-06.63N	136-53.16E	4949.0	1982.0	-	1981.0	2002.0	C03M001	Ph Buoy 13N137E Rec ARGO Float Dep
C04	1	022920	05:08	05:21	07-52.46N	136-29.03E	3346.0	106.2	-	109.4	110.0	C04M001	JES10-mini , Rinko Profiler cast TRITON Buoy 8N137E Dep No sampling
C05	1	022920	05:45	06:22	07-52.49N	136-28.82E	3345.0	993.2	-	994.0	1002.0	C05M001	TRITON Buoy 8N137E Dep
C06	1	022920	21:04	22:38	07-38.65N	136-40.96E	3171.0	1982.4	-	1981.3	2002.0	C06M001	TRITON Buoy 8N137E Rec ARGO Float Dep
C07	1	030620	03:14	03:24	00-00.81N	155-57.11E	1949.0	107.3	-	110.4	111.0	C07M001	Rinko Profiler cast TRITON Buoy EQ156E Dep No sampling
C08	1	030620	03:47	04:47	00-01.19N	155-56.63E	1953.0	991.7	-	992.1	1000.0	C08M001	TRITON Buoy EQ156E Dep
C09	1	030620	20:07	21:05	00-00.88N	156-01.67E	1951.0	994.3	-	995.1	1003.0	C09M001	TRITON Buoy EQ156E Rec
STN	1	031020	20:41	21:03	00-00.15N	160-59.72E	3376.0	494.9	-	497.6	501.0	STNM001	
STN	2	031020	23:53	00:17	00-00.14N	160-59.74E	3375.0	562.7	-	564.1	568.0	STNM002	
STN	3	031120	02:51	03:14	00-00.04N	160-59.89E	3379.0	537.1	-	540.3	544.0	STNM003	
STN	4	031120	05:51	06:15	00-00.04N	161-00.00E	3378.0	494.5	-	498.6	502.0	STNM004	
STN	5	031120	08:54	09:17	00-00.08N	160-59.80E	3377.0	494.1	-	497.6	501.0	STNM005	
STN	6	031120	11:52	12:14	00-00.03N	160-59.90E	3376.0	496.0	-	499.6	503.0	STNM006	
STN	7	031120	14:51	15:11	00-00.08N	160-59.94E	3378.0	494.9	-	497.6	501.0	STNM007	
STN	8	031120	17:53	18:16	00-00.09N	161-00.04E	3378.0	496.3	-	499.6	503.0	STNM008	
STN	9	031120	20:51	21:13	00-00.23S	161-00.19E	3388.0	497.1	-	498.6	502.0	STNM009	
STN	10	031120	23:53	00:15	00-00.09S	160-59.68E	3374.0	497.4	-	498.6	502.0	STNM010	

STN	11	031220	02:51	03:13	00-00.06S	160-59.88E	3383.0	497.8	-	498.6	502.0	STNM011	
STN	12	031220	05:54	06:16	00-00.04N	160-59.82E	3381.0	494.5	-	498.6	502.0	STNM012	
STN	13	031220	08:50	09:12	00-00.06S	160-59.81E	3381.0	495.0	-	497.6	501.0	STNM013	
STN	14	031220	11:53	12:15	00-00.07N	160-59.69E	3376.0	498.3	-	499.6	503.0	STNM014	
STN	15	031220	14:52	15:14	00-00.07S	160-59.89E	3382.0	498.3	-	499.6	503.0	STNM015	
STN	16	031220	17:53	18:16	00-00.16N	160-59.80E	3378.0	496.0	-	498.6	502.0	STNM016	
STN	17	031220	20:51	21:13	00-00.28N	160-59.80E	3377.0	496.9	-	498.6	502.0	STNM017	
STN	18	031220	23:53	00:15	00-00.07S	160-59.76E	3381.0	497.8	-	498.6	502.0	STNM018	
STN	19	031320	02:53	03:14	00-00.06S	160-59.88E	3382.0	497.6	-	497.6	501.0	STNM019	
STN	20	031320	05:53	06:15	00-00.09S	161-00.08E	3386.0	497.4	-	499.6	503.0	STNM020	
STN	21	031320	08:54	09:17	00-00.17N	160-59.99E	3376.0	495.4	-	497.6	501.0	STNM021	
STN	22	031320	11:54	12:16	00-00.25S	160-59.48E	3365.0	498.3	-	500.6	504.0	STNM022	
STN	23	031320	14:51	15:13	00-00.01N	160-59.86E	3380.0	496.0	-	497.6	501.0	STNM023	
STN	24	031320	17:52	18:14	00-00.39N	161-00.08E	3377.0	496.3	-	497.6	501.0	STNM024	
STN	25	031320	20:52	21:13	00-00.14N	160-59.94E	3378.0	496.0	-	498.6	502.0	STNM025	
STN	26	031320	23:52	00:13	00-00.02N	160-59.83E	3379.0	495.8	-	497.6	501.0	STNM026	
STN	27	031420	02:51	03:12	00-00.00S	160-59.98E	3380.0	496.1	-	496.7	500.0	STNM027	
STN	28	031420	05:54	06:16	00-00.03S	160-59.90E	3383.0	497.1	-	499.6	503.0	STNM028	
STN	29	031420	08:51	09:27	00-00.28N	160-59.98E	3378.0	495.6	-	496.7	500.0	STNM029	
STN	30	031420	11:55	12:18	00-00.06N	160-59.72E	3377.0	499.6	-	500.6	504.0	STNM030	

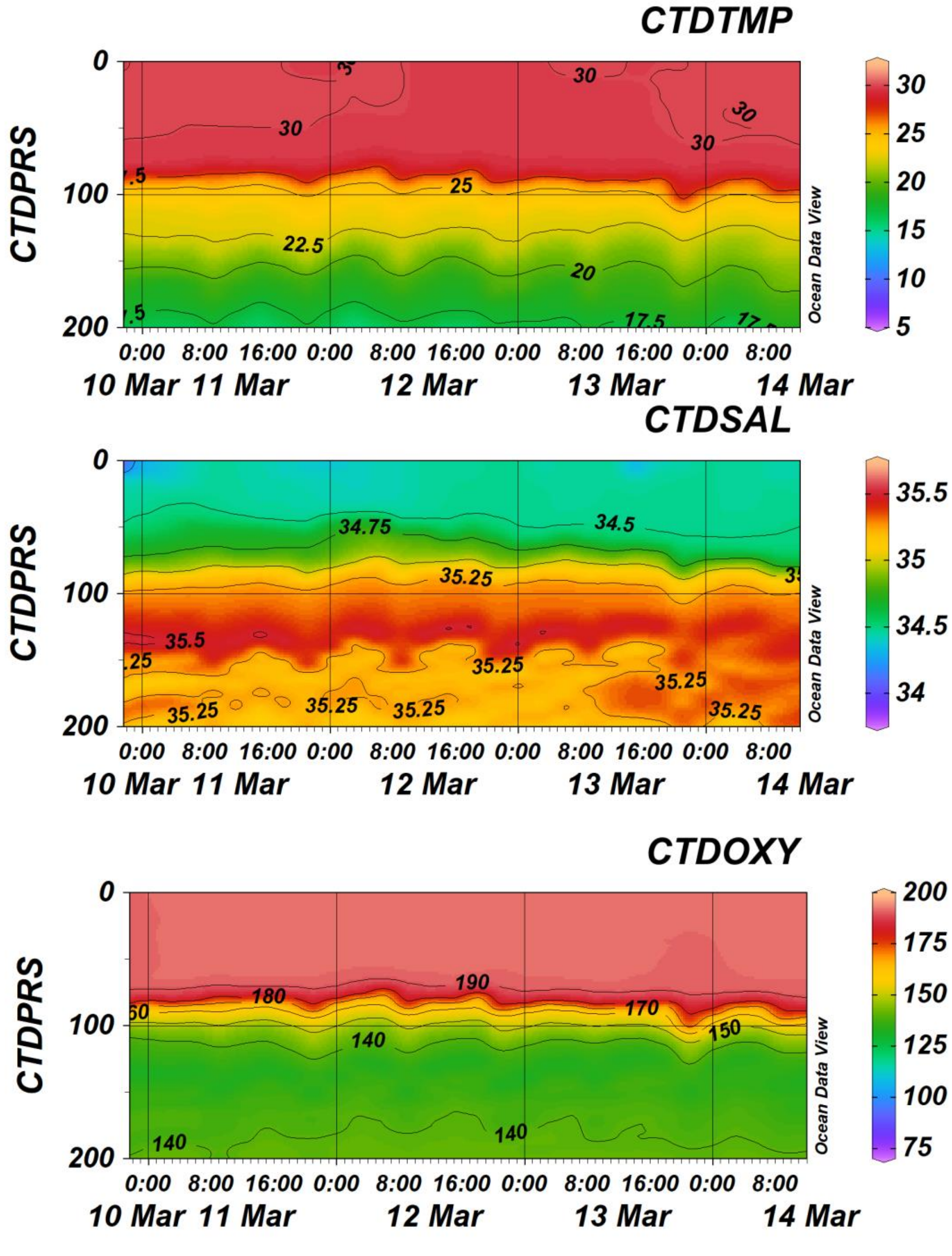

Fig. 5.13.1-1 the time series contours (temperature, salinity, dissolved oxygen) in stationary observation data. (STNM001 ~ STNM030)

(7) Data archive

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

5.13.2 LADCP

(1) Personnel

Akira NAGANO	(JAMSTEC)	- Principal Investigator
Hiroki USHIROMURA	(MWJ)	- Operation Leader
Hiroshi MATSUNAGA	(MWJ)	
Keisuke MATSUMOTO	(MWJ)	
Hironori SATO	(MWJ)	
Masaki YAMADA	(MWJ)	
Keisuke TAKEDA	(MWJ)	
Tun Htet Aung	(MWJ)	

(2) Overview of the equipment

A lowered acoustic doppler current profiler (LADCP), Workhorse Monitor WHM300 (Teledyne RD Instruments, San Diego, California, USA), was integrated with the CTD system. The instruments used in this cruise was Teledyne RD Instruments, WHM300 S/N 24545.

The instrument was powered during the CTD casts by a 48 volts battery pack and has 4 downward-looking transducers with 20-degree beam angles, rated to 6000 m, make direct current measurements at the depth of the CTD, providing a full profile of current velocity. The LADCP unit was set for recording internally prior to each cast. After each cast, the internally stored observed data were uploaded to the computer. By combining the measured velocity of the seawater with respect to the instrument and shipboard navigation data during the CTD cast, the absolute velocity profile can be obtained (e.g. Visbeck, 2002 as implemented by A. Thunherr and available online at ftp://ftp.ldeo.columbia.edu/pub/LADCP).

(3) Data collection

In this cruise, data were collected with the following configuration.

Depth cell size (in cm): 400
Number of Depth cells: 25
Pings per ensemble: 1
Time between pings in mm:ss: 00:01

(4) Results

By a method developed by Visbeck (2002), we obtained the absolute current velocity vector profiles (Fig. 5.13.2-1). The south equatorial current (SEC) and equatorial undercurrent (EUC) are illustrated as a westward current in the top 100 dbar and an eastward countercurrent in the subsurface layer between depths of approximately 100 and 300 dbar, respectively. In addition to the semidiurnal variations possibly due to the tides, the simultaneous intensification of the SEC and EUC (Fig. 5.13.2-1a) and the associated significant northward currents between them (Fig. 5.13.2-1b) on longer (2-3 days) timescales were observed to be intensified.

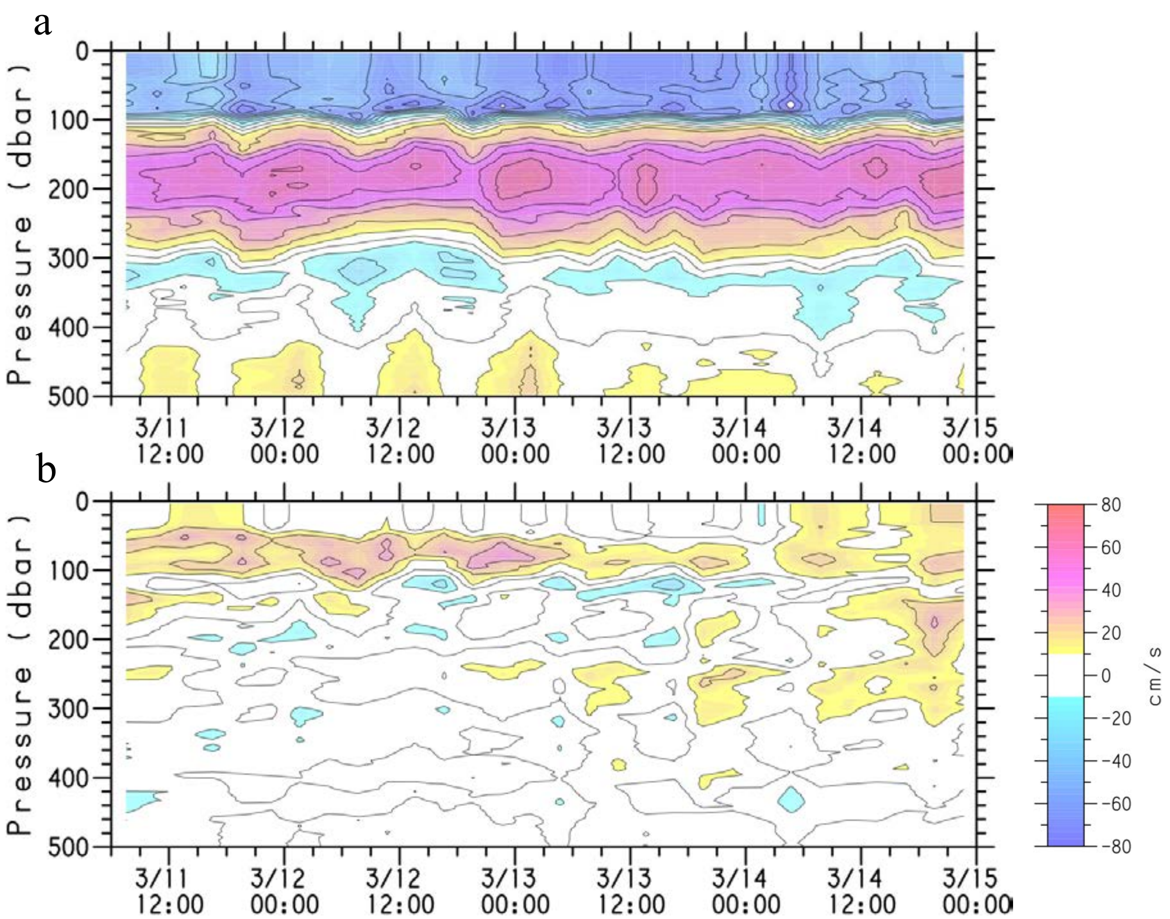

Fig. 5.13.2-1: Time-pressure diagrams of (a) northward and (b) eastward current velocity components. The abscissa is local time at the observation site (UTC+11hr).

Reference

Visbeck, M. (2002): Deep velocity profiling using Lowered Acoustic Doppler Current Profilers: Bottom track and inverse solutions. *J. Atmos. Oceanic Technol.*, **19**, 794-807.

5.13.3 Water sampling

5.13.3.1 Salinity

(1) Personnel

Akira NAGANO	(JAMSTEC)	- Principal Investigator
Hiroki USHIROMURA	(MWJ)	- Operation Leader

(2) Objective

To provide calibrations for the measurements of salinity collected from CTD casts and the continuous sea surface water monitoring system (TSG).

(3) Method

a. Salinity Sample Collection

Seawater samples were collected with 12-liter water sampling bottles and TSG. The salinity sample bottle of the 250ml brown glass bottle with screw cap was used for collecting the sample water. Each bottle was rinsed 3 times with the sample water, and was filled with sample water to the bottle shoulder. All of sample bottle were sealed with a plastic cone and a screw cap because we took into consideration the possibility of storage for about a month. The cone was rinsed 3 times with the sample seawater before its use. Each bottle was stored for more than 12 hours in the laboratory before the salinity measurement.

The kind and number of samples taken are shown in Table 5.13.3.1-1.

Table 5.13.3.1-1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD	93
Samples for TSG	29
Total	122

b. Instruments and Method

The salinity analysis was carried out on the R/V Mirai during the cruise of MR20-01 using the salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.: S/N 72874) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). A pair of precision digital thermometers (1502A; FLUKE: S/N B78466 and B81549) were used for monitoring the ambient temperature and 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 (1502A: FLUKE)

Measurement Range: 16 to 30 deg C (Full accuracy)

Resolution: 0.001 deg C
Accuracy: 0.006 deg C (@ 0 deg C)

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 20 deg C to 23 deg C, while the bath temperature was very stable and varied within +/- 0.003 deg C on rare occasion. The measurement for each sample was done with a double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 5 seconds after filling the cell with the sample and it took about 10 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for the practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. The measurement was conducted in about 5 hours per day and the cell was cleaned with soap after the measurement of the day.

(4) Results

a. Standard Seawater

Standardization control of the salinometer was set to 545 and all measurements were done at this setting. The value of STANDBY was 24+5999-6001 and that of ZERO was 0.0-0001-0002. The conductivity ratio of IAPSO Standard Seawater batch P163 was 0.99985 (double conductivity ratio was 1.99970) and was used as the standard for salinity. 9 bottles of P163 were measured.

Figure 5.13.3.1-1 shows the time series of the double conductivity ratio of the Standard Seawater batch P163. The average of the double conductivity ratio was 1.99968 and the standard deviation was 0.00001 which is equivalent to 0.0002 in salinity.

Figure 5.13.3.1-2 shows the time series of the double conductivity ratio of the Standard Seawater batch P163 after correction. The average of the double conductivity ratio after correction was 1.99970 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: P163
Conductivity ratio: 0.99985
Salinity : 34.994
Use by: 10th April. 2022

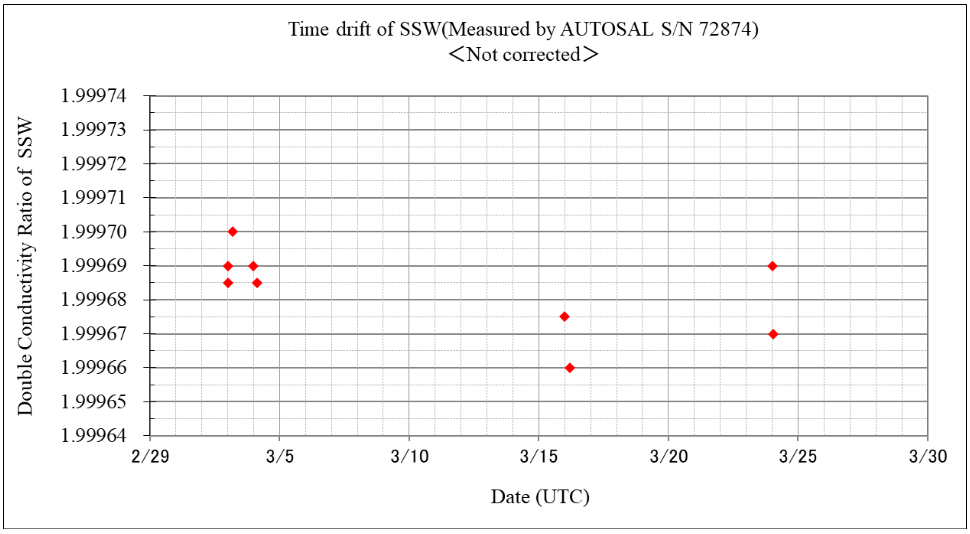

Fig. 5.13.3.1-1: Time series of double conductivity ratio for the Standard Seawater batch P163 (before correction)

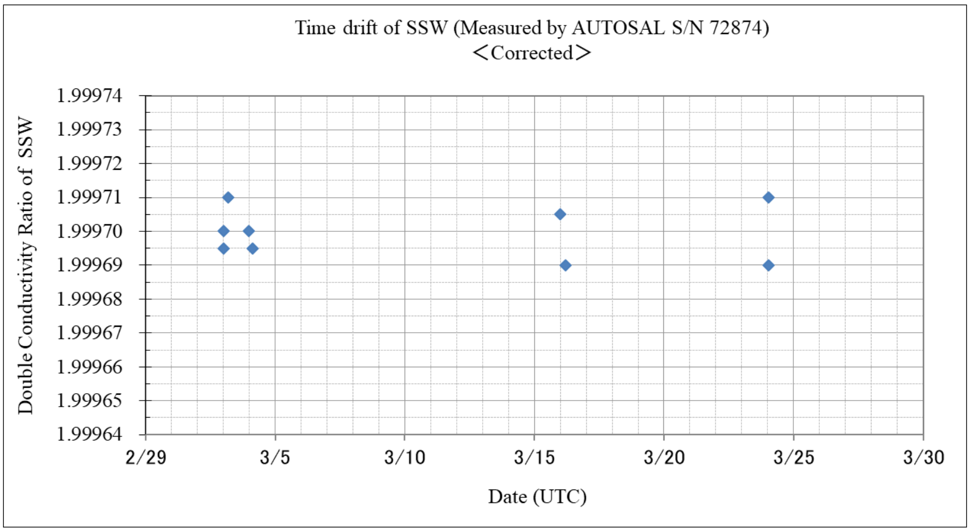

Fig. 5.13.3.1-2: Time series of double conductivity ratio for the Standard Seawater batch P163 (after correction)

b. Sub-Standard Seawater

Sub-standard seawater was made from surface sea water filtered by a pore size of 0.2 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 18 pairs of replicate samples taken from the same water sampling bottle. The average and the standard deviation of absolute difference among 18 pairs of replicate samples were 0.0007 and 0.0006 in salinity, respectively.

(5) Data archive

These raw datasets will be submitted to JAMSTEC Data Management Group (DMG).

(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

5.13.3.2 Dissolved Oxygen

(1) Personnel

Akira Nagano (JAMSTEC): Principal Investigator
Hironori Sato (MWJ): Operation Leader

(2) Objective

Determination of dissolved oxygen in seawater by the Winkler titration.

(3) Parameters

Dissolved Oxygen

(4) Instruments and Methods

Following procedure is based on the Winkler method (Dickson, 1996; Culberson, 1991).

a. Instruments

Burette for sodium thiosulfate and potassium iodate: Automatic piston burette (APB-510 / APB-620) manufactured by Kyoto Electronics Manufacturing Co., Ltd. / 10 cm^3 of titration vessel

Detector: Automatic photometric titrator (DOT-15X) manufactured by Kimoto Electric Co., Ltd.

Software: DOT_Terminal Ver. 1.3.1

b. Reagents

Pickling Reagent I: Manganese (II) chloride solution (3 mol dm^{-3})

Pickling Reagent II:

Sodium hydroxide (8 mol dm^{-3}) / Sodium iodide solution (4 mol dm^{-3})
Sulfuric acid solution (5 mol dm^{-3})
Sodium thiosulfate (0.025 mol dm^{-3})
Potassium iodate (0.001667 mol dm^{-3})

c. Sampling

Seawater samples were collected with Niskin bottle attached to the CTD/Carousel Water Sampling System (CTD system). Seawater for oxygen measurement was transferred from the bottle to a volume calibrated flask (ca. 100 cm^3), and three times volume of the flask was overflowed. Temperature was simultaneously measured by digital thermometer during the overflowing. After transferring the sample, two reagent solutions (Reagent I and II) of 1 cm^3 each were added immediately and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

d. Sample measurement

For over two hours after the re-shaking, the pickled samples were measured on board. Sulfuric acid solution with its volume of 1 cm^3 and a magnetic stirrer bar were put into the sample flask and the sample was stirred. The samples were titrated by sodium thiosulfate solution whose morality was determined by potassium iodate solution. Temperature of sodium thiosulfate during titration was recorded by a digital thermometer. Dissolved oxygen concentration (μmol kg^{-1}) was calculated by sample temperature during seawater sampling, salinity of the sensor on CTD system, flask volume, and titrated volume of sodium thiosulfate solution without the blank.

e. Standardization and determination of the blank

Concentration of sodium thiosulfate titrant was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130 ºC, and 1.7835 g of it was dissolved in deionized water and diluted to final weight of 5 kg in a flask. After 10 cm^3 of the standard potassium iodate solution was added to another flask using a volume-calibrated dispenser, 90 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 1 cm^3 of pickling reagent solution II and I were added in order. Amount of titrated volume of sodium thiosulfate for this diluted standard potassium iodate solution (usually 5 times measurements average) gave the morality of sodium thiosulfate titrant.

The oxygen in the pickling reagents I (1 cm^3) and II (1 cm^3) was assumed to be 7.6 × 10^{-8} mol (Murray et al., 1968). The blank due to other than oxygen was determined as follows. First, 1 and 2 cm^3 of the standard potassium iodate solution were added to each flask using a calibrated dispenser. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, 1 cm^3 of pickling II reagent solution, and same volume of pickling I reagent solution were added into the flask in order. The blank was determined by difference between the first (1 cm^3 of potassium iodate) titrated volume of the sodium thiosulfate and the second (2 cm^3 of potassium iodate) one. The titrations were conducted for 3 times and their average was used as the blank value.

(5) Observation log

a. Standardization and determination of the blank

Table 5.13.3.2-1 shows results of the standardization and the blank determination during this cruise.

Table 5.13.3.2-1 Results of the standardization and the blank determinations during cruise

Date (yyyy/mm/dd)	Potassium iodate ID	Sodium thiosulfate ID	DOT-15X (No.10)		Stations
			E.P. (cm^3)	Blank (cm^3)	
2020/02/25	K1805E08	T-19O	3.976	0.003	C02, C03
2020/02/29	K1805E09	T-19O	3.973	0.004	
2020/03/05	K1805I06	T-19O	3.975	0.003	C09
2020/03/09	K1805I07	T-19O	3.981	0.006	
2020/03/14	K19A01	T-19O	3.979	0.003	STN029
2020/03/19	K19A07	T-19O	3.980	0.006	

b. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. The standard deviation of the replicate measurement (Dickson et al., 2007) was 0.12 μmol kg^{-1} (n = 12).

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

(7) References

Culberson, C. H. (1991). *Dissolved Oxygen.* WHPO Publication 91-1.
Dickson, A. G. (1996). Determination of dissolved oxygen in sea water by Winkler titration. In *WOCE Operations Manual*, Part 3.1.3 Operations & Methods, WHP Office Report WHPO 91-1.
Dickson, A. G., Sabine, C. L., & Christian, J. R. (Eds.), (2007). *Guide to best practices for ocean CO_2 measurements, PICES Special Publication 3*: North Pacific Marine Science Organization.
Murray, C. N., Riley, J. P., & Wilson, T. R. S. (1968). The solubility of oxygen in Winkler reagents used for the determination of dissolved oxygen. *Deep Sea Res.*, 15, 237-238.

5.13.3.3 Polycyclic Aromatic Hydrocarbons (PAHs)

(1) Personnel

Yuichiro Kumamoto (JAMSTEC): Principal investigator

(2) Objective

Determination of polycyclic aromatic hydrocarbons (PAHs) concentration in the North Pacific Ocean.

(3) Parameter

Polycyclic Aromatic Hydrocarbons (PAHs)

(4) Instruments and Methods

a. Sampling

Surface seawater samples were collected from continuous pumped-up water from about 4-m depth. The sample volumes for PAHs are 10 L (a 10-L stainless container). Just after the water sampling, 300 ml of methanol was added.

b. Preparation and analysis

Particulate and dissolved phases of 10 L seawater sample are separated by filtration through 0.5 μm glass-fiber filters. Dissolved organic compounds, including PAHs, are concentrated using C18 solid-phase extraction disks. Particulate and dissolved PAHs are respectively extracted from the glass-fiber filters using an ultrasonic method and eluted from the C18 disks with dichloromethane. Dimethyl sulfoxide is added to both extracted solutions, the dichloromethane is evaporated to dryness, and the residue of dimethyl sulfoxide is dissolved in acetonitrile. PAHs in the samples were quantified using the HPLC system with a fluorescence detector.

(5) Sample list

We collected 6 seawaters for PAHs measurement (Table 5.13.3.3-1).

Table 5.13.3.3-1: Seawater samples collected for PAHs measurements.

No.	Station	Depth (m)	Method	Latitude (N)	Longitude (E)	Date (UTC)
1	surface-1	4	pump	14.324	153.495	2020/03/18
2	surface-2	4	pump	16.324	152.594	2020/03/19
3	surface-3	4	pump	19.323	151.244	2020/03/20
4	surface-4	4	pump	23.459	149.693	2020/03/21
5	surface-5	4	pump	27.508	147.977	2020/03/22
6	surface-6	4	pump	31.914	146.038	2020/03/23

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.

5.13.4 JES10 mini experiment

(1) Personnel

Masahiro Kaku (JAMSTEC)
Kensuke Watari (JAMSTEC)
Yukio Takahashi (JAMSTEC)

(2) Objective

Performance verification of newly developed CTD sensor (JES10 mini)

(3) Description

JES10 mini is a CTD sensor developed by JAMSTEC. (See Figure 5.13.4-1) Since it became smaller than JES10 (JAMSTEC Electronics Sensor Type 10) moored with TRITON buoy, the ease of use is improved. In this observation, performance verification is performed by comparing with SBE 9plus data.

Fig. 5.13.4-1 JES10 mini

(4) Instruments and Methods

The instrument is a stand-alone system with a lithium primary battery in the main body. Command transmission and data extraction are performed via Bluetooth communication.

The observation was attached to the frame of the CTD system and observed. (See Fig. 5.13.4-2) Since the sensor is mounted upward, observation is performed at the time of up cast. The observation depth of specification was up to 110m, and a total 2 times were observed. Various parameters for each cast are as Table 5.13.4-1.

Fig. 5.13.4-2 Mounting of JES10 mini on CTD System

Table 5.13.4-1 JES10 mini cast table

Cast No.	#1	#2
Date (UTC)	Feb 26 2020	Feb 29 2020
Time (UTC)	06:21 (Start Command) 07:24 (Stop Command)	04:49 (Start Command) 05:33 (Stop Command)
Position	12-53.70 N, 136-54.11 E	07-52.38 N, 136-29.24 E
Target Depth [m]	100m	110m
Descent rate	0.1m/s	0.4m/s

(5) Preliminary result

Among the observation data obtained by this measurement, the data obtained by Cast #2 is shown below. (See Fig. 5.13.4-2)

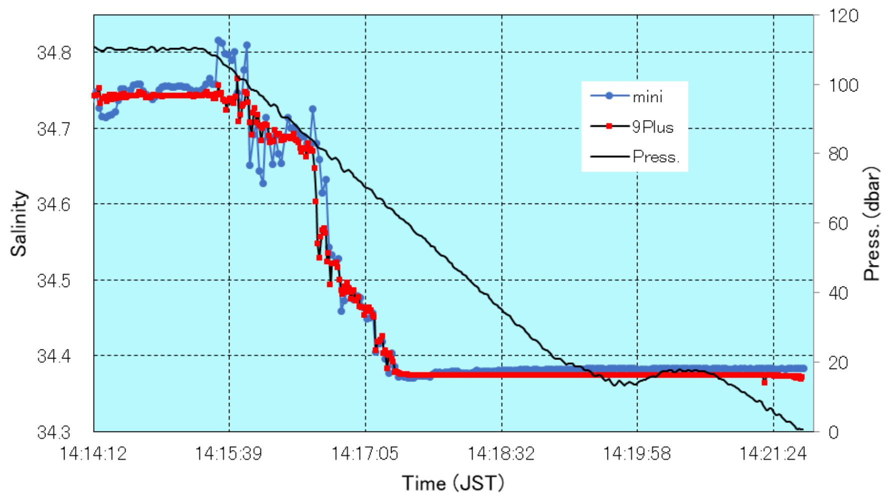

Fig. 5.13.4-2 Observation data (Cast #2)

Although the same results as 9 Plus data are shown, the salinity spike stands out where there are many changes. Based on the data obtained this time, we will continue to improve quality and ease of use.

(6) Data archive

These obtained data will be submitted to JAMSTEC Data Management Group (DMG).

5.13.5 Underway CTD

(1) Personnel

Akira Nagano	(JAMSTEC): Chief Scientist
Masahiro Kaku	(JAMSTEC)
Keisuke Takeda	(MWJ): Operation Leader
Hiroshi Matsunaga	(MWJ)
Keisuke Matsumoto	(MWJ)
Masaki Yamada	(MWJ)
Hiroki Ushiromura	(MWJ)
Hironori Sato	(MWJ)
Tun Htet Aung	(MWJ)

(2) Objective

Using an Underway CTD (UCTD) system, we observed vertical profiles of temperature, conductivity, and pressure to explore the oceanic structure of temperature and salinity in the eastern ledge of warm pool on the equator. The station locations are shown in Figure 5.13.5-1.

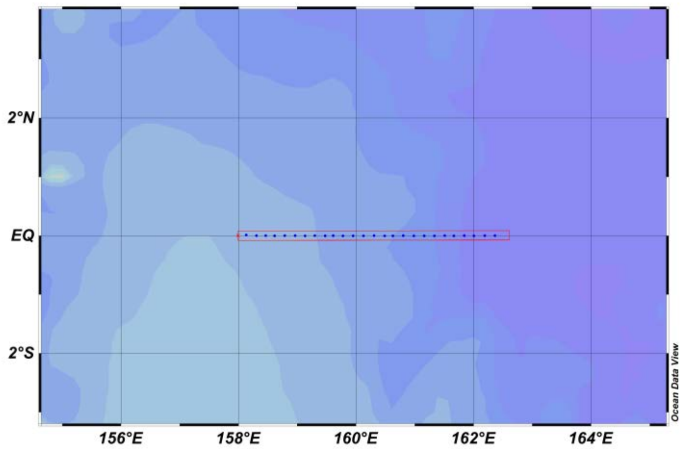

Fig. 5.13.5-1 UCTD Station locations

(3) Methods

In this cruise, we used a UCTD system manufactured by TELEDYNE OCEANSCIENCE. The system consists of the probe unit and on-deck unit with a winch and rewinder. After spooled line for a certain length onto the probe unit (in “tail spool” part), the probe unit is released into ocean from the vessel. The probe unit is connected to winch on the vessel by line, and then measures temperature, conductivity, and pressure during a free-fall with a speed of about 4 m/s in the ocean, while the vessel traveling (in this cruise, with a speed of about 10 knot/h). After the probe unit reaches the targeted depth, it is recovered by the winch.

The UCTD system used in this cruise observed temperature, conductivity (salinity), and pressure from the sea surface to a depth level exceeding 250 dbar with a 16 Hz sampling rate.

The observed data were stored in the memory within the probe unit, and after recovery, downloaded into a PC via Bluetooth communication. The accuracy, resolution, and range of the UCTD observation are listed in Table 5.13.5-1.

Table 5.13.5-1: The accuracy, resolution, and range of the UCTD observation.

Parameter	Accuracy	Resolution	Range
Temperature (˚C)	0.004	0.002	−5 to 43
Conductivity (S/m)	0.0003	0.0005	0 to 9
Pressure (dbar)	1.0	0.5	0 to 2000

(4) Preliminary Results

During this cruise, 26 UCTD casts were carried out. Date, time, and locations of the UCTD casts are listed in Table 5.13.5-2. Section of potential temperature and salinity along the equator based on down casts are shown in Fig. 5.13.5-2.

Table 5.13.5-2 UCTD observation list

Station Number	Cast Number	Time Towed (UTC)	Position Towed		Depth to go (m)	Log speed (knot)		S/N of sensor	Notes
			Latitude (deg-min)	Longtude (deg-min)		Tow	Recovery		
1	1	Mar.09 2020 03:00	00-00.78N	158-07.74E	250.0	10	10	0236	
2	1	Mar.09 2020 04:00	00-00.03N	158-18.09E	250.0	10	10	0236	
3	1	Mar.09 2020 05:00	00-00.15N	158-27.77E	250.0	10	10	0236	
4	1	Mar.09 2020 06:00	00-00.13S	158-36.61E	250.0	10	10	0236	
5	1	Mar.09 2020 07:00	00-00.01N	158-47.16E	250.0	10	10	0236	
6	1	Mar.09 2020 08:00	00-00.04N	158-57.64E	150.0	10	10	0236	
7	1	Mar.09 2020 09:00	00-00.01S	158-07.87E	250.0	10	10	0236	
8	1	Mar.09 2020 10:00	00-00.02N	159-17.84E	250.0	10	10	0236	
9	1	Mar.09 2020 11:00	00-00.10S	159-28.38E	250.0	10	10	0236	
10	1	Mar.09 2020 12:00	00-00.02N	159-36.49E	250.0	10	10	0236	
11	1	Mar.09 2020 13:00	00-00.00S	159-46.48E	250.0	10	10	0236	
12	1	Mar.09 2020 14:00	00-00.02S	159-56.90E	250.0	10	10	0236	
13	1	Mar.09 2020 15:00	00-00.05N	160-07.55E	250.0	10	10	0236	
14	1	Mar.09 2020 16:00	00-00.01N	160-18.19E	250.0	10	10	0236	
15	1	Mar.09 2020 17:00	00-00.01S	160-29.04E	160.5	10	8	0236	
16	1	Mar.09 2020 18:00	00-00.06S	160-37.48E	250.0	10	10	0236	
17	1	Mar.09 2020 19:00	00-00.09N	160-48.10E	250.0	10	10	0236	
18	1	Mar.09 2020 20:00	00-00.02S	160-58.82E	250.0	10	10	0236	
19	1	Mar.09 2020 21:00	00-00.06S	161-09.48E	162.0	10	10	0236	
20	1	Mar.09 2020 22:00	00-00.12S	161-19.85E	250.0	10	10	0236	
21	1	Mar.09 2020 23:00	00-00.02N	161-30.43E	250.0	10	10	0236	
22	1	Mar.10 2020 00:00	00-00.00N	161-39.86E	250.0	10	10	0236	
23	1	Mar.10 2020 01:00	00-00.04N	161-50.38E	250.0	10	10	0236	
24	1	Mar.10 2020 02:00	00-00.03S	162-00.83E	250.0	10	10	0236	
25	1	Mar.10 2020 03:00	00-00.01N	162-11.31E	250.0	10	10	0236	
26	1	Mar.10 2020 04:00	00-00.02N	162-21.73E	250.0	10	10	0236	

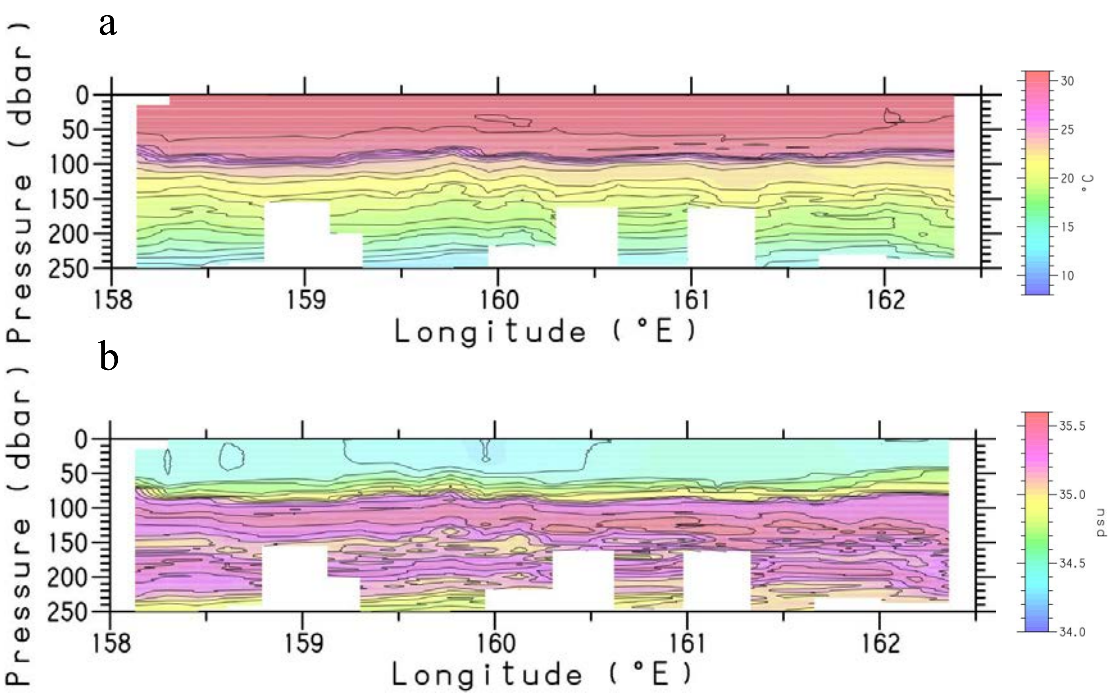

Fig. 5.13.5-2 UCTD Sections of (a) potential temperature and (b) salinity along the equator. Contour intervals in (a) and (b) are 1˚C and 0.1, respectively.

(5) Data archive

All data obtained during this cruise will be submitted to the JAMSTEC Data Management Office (DMO).

5.13.6 Shipboard ADCP

(1) Personnel

Akira NAGANO	(JAMSTEC) * Principal Investigator
Kenichi SASAKI	(JAMSTEC)
Masanori MURAKAMI	(Nippon Marine Enterprises Ltd., NME)
Ryo OYAMA	(NME)
Yutaro MURAKAMI	(NME)
Yoichi INOUE	(Mirai Crew)

(2) Objectives

The aims of this shipboard ADCP observation are to obtain continuous measurement data of the current profile along the ship's track and to perform a combined analysis with the HF radar observation in the eastern region of the Tsugaru Strait.

(3) Instruments and methods

Upper ocean current measurements were made in this 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. The R/V Mirai has installed the Ocean Surveyor for vessel-mount ADCP (frequency 76.8 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 (Tokyo Keiki, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System (Phins, IXBLUE SAS, France) which provide high-precision heading, attitude information, pitch and roll. They are stored in ".N2R" data files with a time stamp.
3. Differential GNSS system (StarPack-D, Fugro, Netherlands) providing precise ship's position.
4. We used VmDas software version 1.49 (TRDI) for data acquisition.
5. To synchronize time stamp of ping with Computer time, the clock of the logging computer is adjusted to GPS time server continuously by the application software.
6. Fresh water is charged in the sea chest to prevent bio fouling at transducer face.
7. The sound speed at the transducer does affect the vertical bin mapping and vertical velocity measurement, and that 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 "8 m" layer intervals starting about 23m below sea surface and recorded every ping as raw ensemble data (.ENR). Additionally, 15 seconds averaged data were recorded as short-term average (.STA). 300 seconds averaged data were long-term average (.LTA), respectively.

(4) Parameters

Major parameters for the measurement and Direct Command are shown in Table 5.13.6-1.

Table 5.13.6-1 Major parameters

Bottom-Track Commands

BP = 001 Pings per Ensemble (almost less than 1,300m depth)

Environmental Sensor Commands

EA = 04500	Heading Alignment (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	Coordinate 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
EV = 0	Heading Bias (1/100 deg)

Water-Track Commands

WA = 255	False Target Threshold (Max) (0-255 count)
WC = 120	Low Correlation Threshold (0-255)
WD = 111 100 000	Data Out (V; C; A; PG; St; V sum; Vsum^2; #G; P0)
WE = 1000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WN = 100	Number of depth cells (1-128)
WP = 00001	Pings per Ensemble (0-16384)
WS = 800	Depth Cell Size (cm)
WV = 0390	Mode 1 Ambiguity Velocity (cm/s radial)

(5) Preliminary results

Figure 5.13.6-1 shows horizontal velocity along the ship’s track. Fig. 5.13.6-2 shows the velocity time series at the station point (near EQ161E).

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.
http://www.godac.jamstec.go.jp/darwin/e

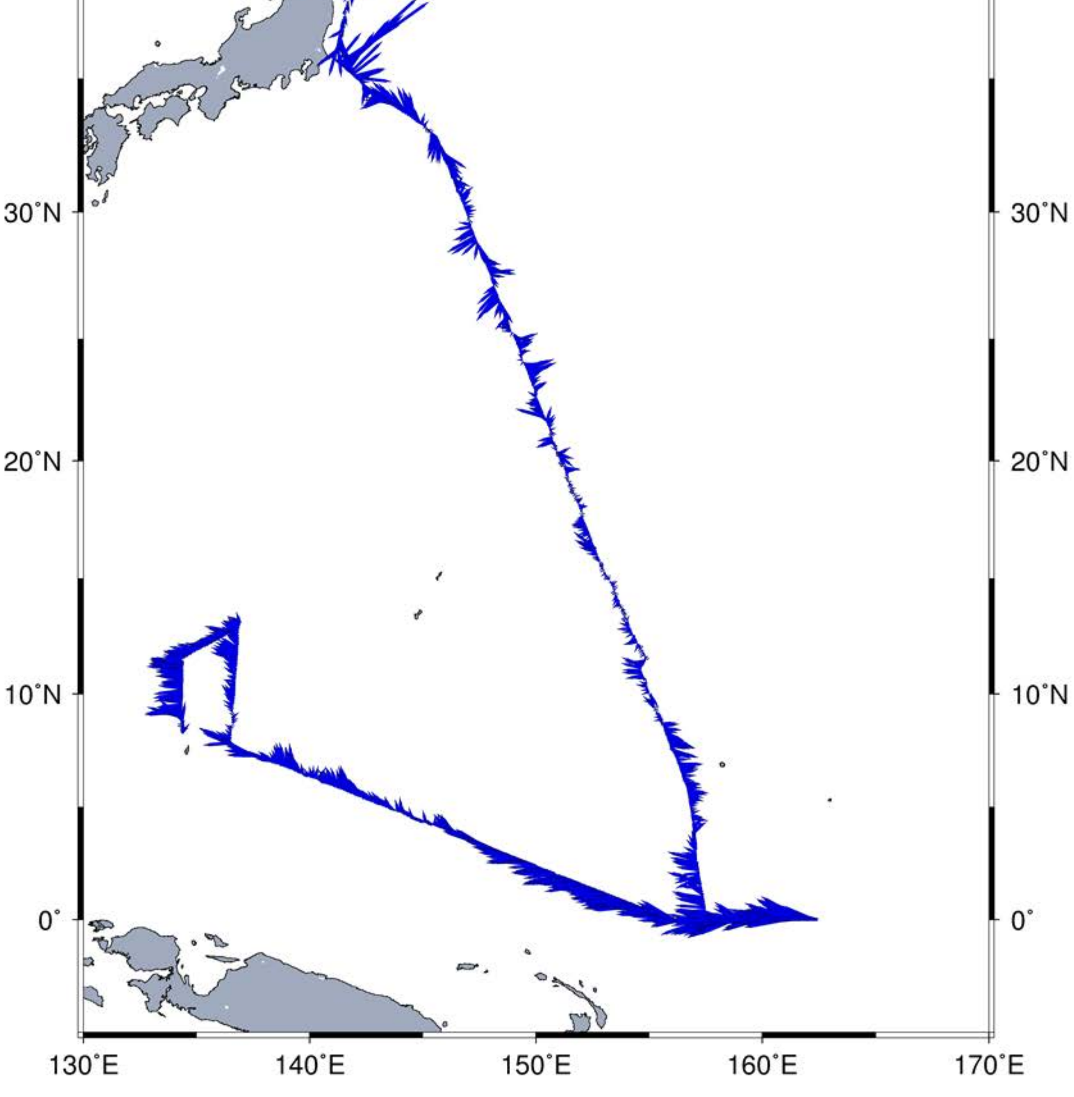

Fig. 5.13.6-1 Horizontal Velocity along the ship’s track

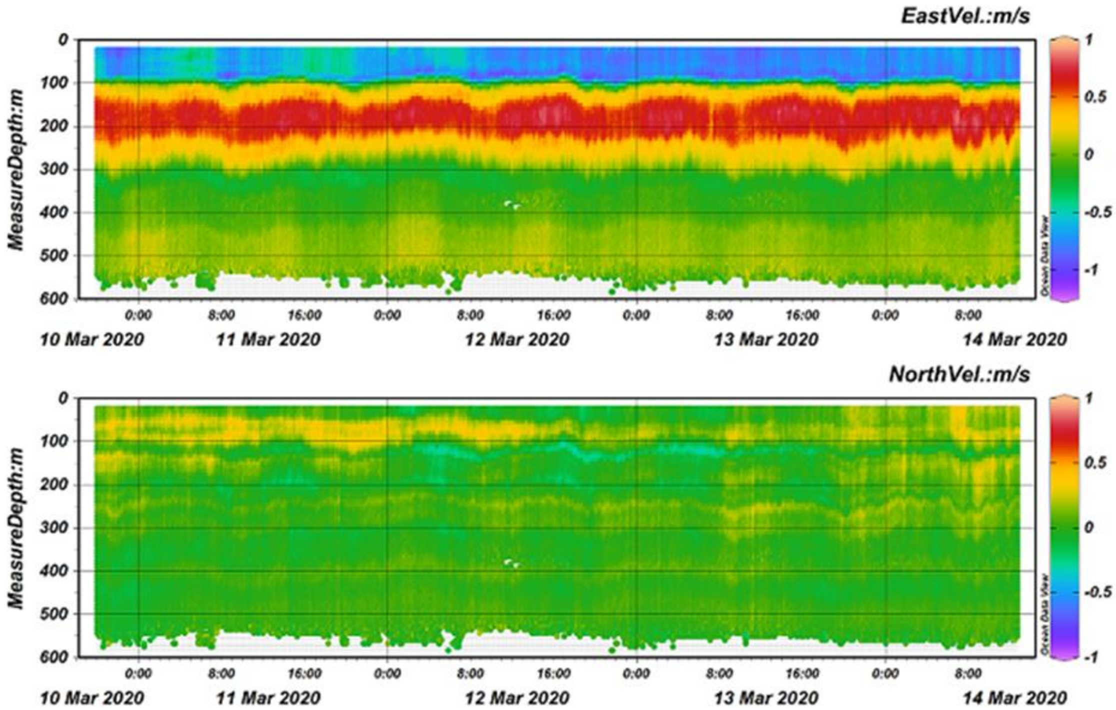

Fig. 5.13.6-2 current velocity time series at the station point (near EQ161E)

5.13.7 Underway surface water monitoring

(1) Personnel

Akira Nagano (JAMSTEC): Principal Investigator

Hironori Sato (MWJ): Operation leader

(2) Objective

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

(3) Parameters

Temperature

Salinity

Dissolved oxygen

Fluorescence

Total dissolved gas pressure

(4) Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co. Ltd.) has four sensors and automatically measures temperature, salinity, dissolved oxygen, fluorescence, and turbidity 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. Sea water was continuously pumped up to the laboratory from an intake placed at the approximately 4.5 m below the sea surface and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was adjusted to 10 dm^3 min^{-1}.

a. Instruments

Software

SeaMoni Ver.1.2.0.0

Sensors

Specifications of each sensor in this system are listed below.

Temperature and Conductivity sensor

Model:	SBE-45, SEA-BIRD ELECTRONICS, INC.
Serial number:	4563325-0362
Measurement range:	Temperature -5 ^{o}C - +35 ^{o}C
	Conductivity 0 S m^{-1} - 7 S m^{-1}
Initial accuracy:	Temperature 0.002 ^{o}C
	Conductivity 0.0003 S m^{-1}
Typical stability (per month):	Temperature 0.0002 ^{o}C
	Conductivity 0.0003 S m^{-1}
Resolution:	Temperature 0.0001 ^{o}C
	Conductivity 0.00001 S m^{-1}

Bottom of ship thermometer

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

Dissolved oxygen sensor

Model:	RINKO II, JFE ADVANTECH CO. LTD.
Serial number:	13
Measuring range:	0 mg L^{-1} - 20 mg L^{-1}
Resolution:	0.001 mg L^{-1} - 0.004 mg L^{-1} (25 ^{o}C)
Accuracy:	Saturation ± 2 % F.S. (non-linear) (1 atm, 25 ^{o}C)

Fluorescence sensor

Model:	C3, TURNER DESIGNS
Serial number:	2300123
Measuring range:	Chlorophyll in vivo 0 µg L^{-1} – 500 µg L^{-1}
Minimum Detection Limit:	Chlorophyll in vivo 0.03 µg L^{-1}

Total dissolved gas pressure sensor

Model:	HGTD-Pro, PRO OCEANUS
Serial number:	37-394-10
Temperature range:	-2 °C - 50 °C
Resolution:	0.0001 %
Accuracy:	0.01 % (Temperature Compensated)
Sensor Drift:	0.02 % per year max (0.001 % typical)

(5) Observation log

Periods of measurement, maintenance, and problems during this cruise are listed in Table 5.13.7.1-1.

Table 5.13.7.1-1 Events list of the Sea surface water monitoring during MR20-01

System Date [UTC]	System Time [UTC]	Events
2020/02/23	08:09	Start logging.
2020/03/06	00:08 – 00:15	Filter Cleaning.
2020/03/24	23:57	End logging.

We took the surface water samples from this system once a day to compare sensor data with bottle data of salinity, dissolved oxygen, and chlorophyll a. All the salinity samples were analyzed by the Model 8400B “AUTOSAL” manufactured by Guildline Instruments Ltd., and dissolve oxygen samples were analyzed by Winkler method, chlorophyll a samples were analyzed by 10-AU manufactured by Turner Designs..

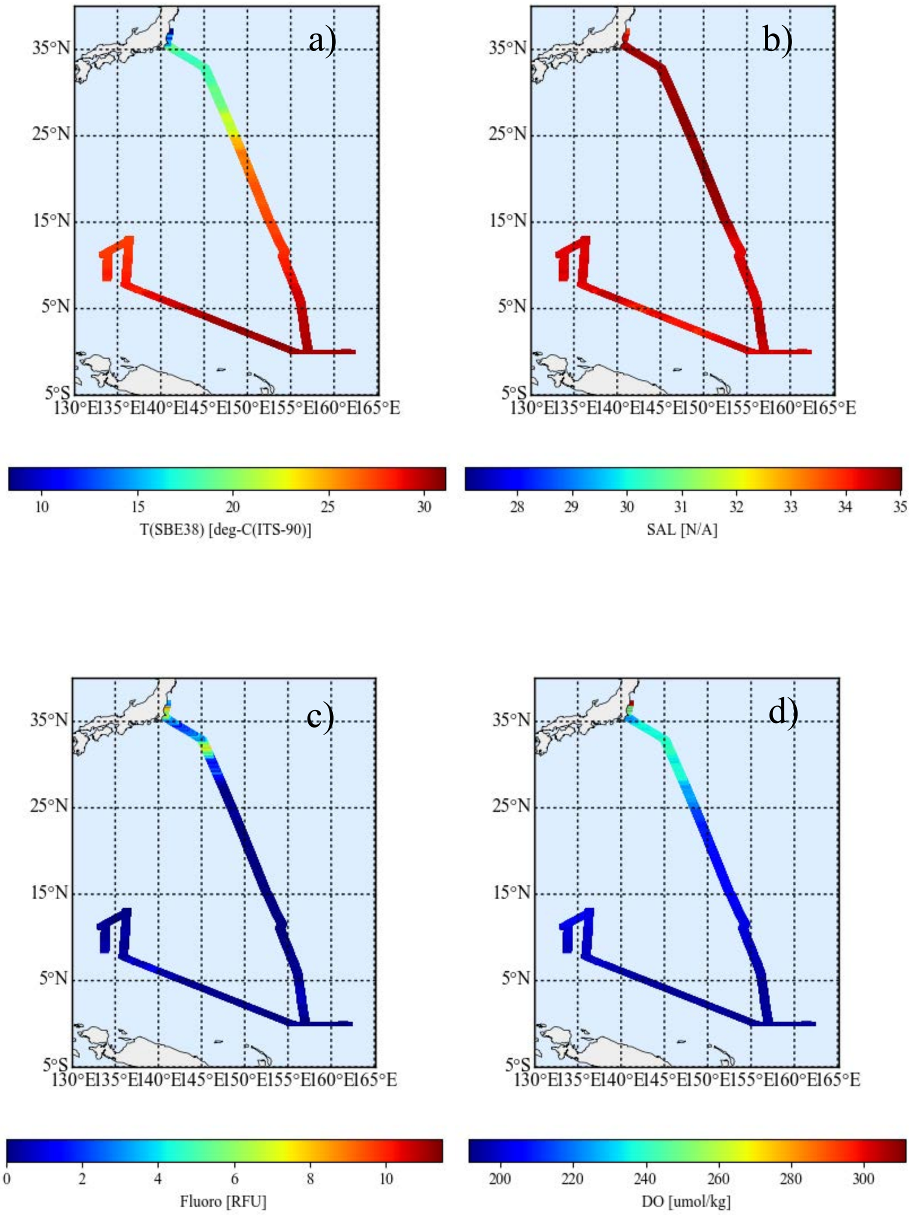

Fig. 5.13.7.1-1 Spatial and temporal distribution of a) temperature, b) salinity, c) dissolved oxygen and d) fluorescence in MR20-01 cruise.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.

<http://www.godac.jamstec.go.jp/darwin/e>

5.14 Geophysical surveys

5.14.1 Sea Surface Gravity

(1) Personnel

Akira NAGANO	(JAMSTEC) * Principal Investigator
Masanori MURAKAMI	(Nippon Marine Enterprises Ltd., NME)
Ryo OYAMA	(NME)
Yutaro MURAKAMI	(NME)
Yoichi INOUE	(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) during this cruise.

To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (CG-5, Scintrex), at Singapore and Sekinehama as the reference points.

(5) Preliminary Results

Absolute gravity table is shown in Table 5.14.1-1.

Table 5.14.1-1 Absolute gravity table of the MR20-01cruise

No.	Date mm/dd	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Ship Draft [cm]	Gravity at Sensor * [mGal]	S-116 Gravity [mGal]
#1	02/10	08:13	Singapore	978,066.06	339	640	978,067.35	N/A
#2	03/28	06:19	Sekinehama	978,371.82	266	620	980,372.84	12650.98

*:Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + aft-530)/100*0.2222

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC and will be opened to the public via “Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” in JAMSTEC web site.

http://www.godac.jamstec.go.jp/darwin/e

(7) Remarks (Times in UTC)

i) The following period, data were invalid due to system trouble.

04:00UTC 04 Mar. 2020 - 10:00UTC 04 Mar. 2020

5.14.2 Sea surface three component magnetic field

(1) Personnel

Akira NAGANO	(JAMSTEC) * Principal Investigator
Masanori MURAKAMI	(Nippon Marine Enterprises Ltd., NME)
Ryo OYAMA	(NME)
Yutaro MURAKAMI	(NME)
Yoichi INOUE	(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 during this cruise.

(3) Principle of ship-board geomagnetic vector measurement

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

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

where $\widetilde{\mathbf{R}}$, $\widetilde{\mathbf{P}}$ and $\widetilde{\mathbf{Y}}$ are the matrices of rotation due to roll, pitch and heading of a ship, respectively. $\widetilde{\mathbf{A}}$ is a 3 x 3 matrix which represents magnetic susceptibility of the ship, and $\mathbf{H}_{\mathrm{p}}$ is a magnetic field vector produced by a permanent magnetic moment of the ship's body.

Rearrangement of Eq. (a) makes

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

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

(4) Instruments on the R/V Mirai

A shipboard three-component magnetometer system (Tierra Tecnica SFG2018) is equipped on-board the 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 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 of JAMSTEC and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.

http://www.godac.jamstec.go.jp/darwin/e

(7) Remarks

i) The following periods, we made a "figure-eight" turn (a pair of clockwise and anti-clockwise rotation) for calibration of the ship's magnetic effect.

07:30 - 07:57UTC, 28 Feb. 2020 around 07-55N, 136-29E
23:35 - 00:00UTC, 14 Mar. 2020 around 00-02N, 161-56E
06:00 - 06:25UTC, 25 Mar. 2020 around 38-16N, 141-55E

5.14.3 Swath bathymetry

(1) Personnel

Akira NAGANO	(JAMSTEC) * Principal Investigator
Masanori MURAKAMI	(Nippon Marine Enterprises Ltd., NME)
Ryo OYAMA	(NME)
Yutaro MURAKAMI	(NME)
Yoichi INOUE	(Mirai Crew)

(2) Introduction

The R/V Mirai is equipped with a Multi narrow Beam Echo Sounding system (MBES), SEABEAM 3012 (L3 Communications, ELAC Nautik). 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 3012" on the R/V Mirai was used for bathymetry mapping during this cruise.

To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data to get the sea surface sound velocity (at 6.62m), and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from CTD and XCTD data by the equation in Del Grosso (1974) during this cruise.

Table 5.14.3-1 shows system configuration and performance of SEABEAM 3012.

Table 5.14.3-1 SEABEAM 3012 system configuration and performance

Frequency	: 12 kHz
Transmit beam width	: 2.0 degree
Transmit power	: 4 kW
Transmit pulse length	: 2 to 20 msec.
Receive beam width	: 1.6 degree
Depth range	: 50 to 11,000 m
Number of beams	: 301 beams
Beam spacing	: Equi-angle

Swath width	: 60 to 150 degrees
Depth accuracy	: 1 % of water depth (average across the swath)

(4) Data archives

These data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.

http://www.godac.jamstec.go.jp/darwin/e

(5) Remarks

i) The following periods, the observations were carried out.

07:00UTC, 23 Feb. 2020 - 23:55 UTC, 24 Mar. 2020

6 Acknowledgement

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