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R/V Mirai Cruise Report
MR21-03

May 26 – July 7, 2021

Tropical Ocean Climate Study (TOCS):

Comprehensive Ocean-Atmosphere observation

in northern edge of the warm pool

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

Contents

1. General information

1.1. Cruise ID

MR21-03

1.2. Name of vessel

R/V Mirai

1.3. Title of cruise

Tropical Ocean Climate Study (TOCS) in the Pacific Ocean:
Comprehensive Ocean-Atmosphere observation in northern edge of the warm pool

1.4. Research area

The western tropical Pacific Ocean

2. Overview and observation summary

2.1. Overview

This cruise is a part of a comprehensive study for short-term climate variability such as ENSO (El Niño/Southern Oscillation), MJO (Madden-Julian Oscillation), and BSISO (Boreal Summer Intraseasonal Oscillation) in the Pacific Ocean. For those phenomena, oceanic and atmospheric processes and interaction of those in the warm pool are crucial. Thus, we conducted detailed observation for the upper ocean and lower atmosphere by multiplatform; research vessel, moorings, floats, and Wave Gliders. In the first half of the cruise, we recoverd 2 TRITON (TRIangle Trans Ocean buoy Network) and a subsurface ADCP moorings, which are part of TAO (Tropical Atmosphere and Ocean)/TRITON array for monitoring ENSO. After that we replaced Phillippine sea mooring at 13˚N 137˚E, and deploy 2 subsurface ADCP moorings at the region; these moorings with several floats, Wave Gliders, and research vessel observations form a comprehensive observing system for upper ocean variability. Using the multiplatform, we conducted stationary observation at 13˚07'N, 136˚30'E from 16 to 29 June. CTD and LADCP measurements for the upper ocean with RINKO profiler measurements from the ocean surface to 15 m depth and GPS radiosonde observations were conducted 3 hourly intervals.

Oceanic and atmospheric conditions in the tropical Pacific Ocean showed ENSO-neutral condition after La Niña condition in the last DJF season. For shorter time scale, a few Equatorial Rossby waves might passed and a typoon was developed at the northeast of our site during the stationary observation. Results of GPS radiosonde and CTD measurements captured gradually increased relative humidity, CAPE (Convective Available Potential Energy), and upper ocean temperature. As expected from variations in those variables, amplitude of diurnal cycle of heat and fresh water flux became large and convective activity in the lower atmosphere increased at the end of the stationary observation. Associated processes will be studied based on those observed data.

2.2. Observation summary

Philippine sea mooring deployment:	1 site
TRITON mooring recovery (including a Philippine sea mooring):	3 sites
ADCP buoy deployment:	2 sites
ADCP buoy recovery:	1 site
Surface drifter installation	2 installed
Argo float installation	5 installed
MOF (Multi-purpose observation float) installation	2 installed
CTD including water sampling:	214 casts
XCTD:	2 launched
Radio sonde:	184 launched
Special sonde (high altitude, ozone, cloud	54 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. Period

May 26 – July 07, 2021

3.2. Ports of call

Shimizu, Japan	(Departure: May 26 2021)
Shimizu, Japan	(Arrival: July 7 2021)

3.3. Cruise log

SMT	UTC	Event
May 26th (Wed.) 2021		
10:00	01:00	Departure from Shimizu port
		[Ship Mean Time (SMT)=UTC+9h]
13:15	04:15	Emergency drill
15:00	06:00	Observation Meeting
		Start of surface sea water sampling
		Start of continuous observations
		Doppler radar observation start
May 27th (Thu.) 2021		
08:30	23:30 (-1day)	Radio Sonde (RS)-001
14:30	05:30	RS-002
15:00	06:00	Observation Meeting
18:44	09:44	Special Sonde (SPS)-01 (Ozone & Water Vapor Sonde)
19:23	10:23	SPS-01 (High Altitude Sonde)
20:30	11:30	RS-003
May 28th (Fri.) 2021		
02:30	17:30 (-1day)	RS-004
08:30	23:30 (-1day)	RS-005
14:30	05:30	RS-006
18:33	09:33	SPS-02 (Ozone & Water Vapor Sonde)
19:23	10:23	SPS-02 (High Altitude Sonde)
20:30	11:30	RS-007
May 29th (Sat.) 2021		
02:30	17:30 (-1day)	RS-008
08:30	23:30 (-1day)	RS-009
18:39	09:39	SPS-03 (Ozone & Water Vapor Sonde)
19:39	10:39	SPS-03 (High Altitude Sonde)
20:30	11:30	RS-010

SMT	UTC	Event
May 30th (Sun.) 2021		
02:30	17:30 (-1day)	RS-011
08:30	23:30 (-1day)	RS-012
18:39	09:39	SPS-04 (Ozone & Water Vapor Sonde)
19:06	10:06	SPS-04 (High Altitude Sonde)
20:30	11:30	RS-013
May 31st (Mon.) 2021		
02:30	17:30 (-1day)	RS-014
08:30	23:30 (-1day)	RS-015
14:39	05:39	SPS-05 (High Altitude Sonde-1)
18:48	09:48	SPS-05 (Ozone & Water Vapor Sonde)
19:23	10:23	SPS-05 (High Altitude Sonde-2)
20:30	11:30	RS-016
June 01st (Tue.) 2021		
02:30	17:30 (-1day)	RS-017
08:30	23:30 (-1day)	RS-018
18:33	09:33	SPS-06 (Ozone & Water Vapor Sonde)
18:58	09:58	SPS-06 (High Altitude Sonde)
20:30	11:30	RS-019
June 02nd (Wed.) 2021		
02:30	17:30 (-1day)	RS-020
08:30	23:30 (-1day)	RS-021
16:00	07:00	SPS-07 (High Altitude Sonde)
16:31	07:31	SPS-07 (Ozone & Water Vapor Sonde)
22:00	12:00	Time adjustment +1h (SMT=UTC+10h)
June 03rd (Thu.) 2021		
16:50	06:50	SPS-08 (High Altitude Sonde)
17:20	07:20	SPS-08 (Ozone & Water Vapor Sonde)
June 04th (Fri.) 2021		
05:30	19:30	CTD B01 (0˚ 01.6’N, 155˚ 57.8’E, 1000m)
08:00 – 11:21	22:00 (-1day) – 01:21	Recovery of TRITON mooring (TR#04) (0˚ 01.0’N, 155˚ 57.5’E, 1940 m)
14:30	04:30	JES10mini experiment

SMT	UTC	Event
June 05th (Sat.) 2021		
08:00 – 11:10	22:00 (-1 day) – 01:10	
		Recovery of ADCP mooring
		(0˚ 02.1’S, 156˚ 08.0’E, 1950 m)
22:00	13:00	Time adjustment -1h (SMT=UTC+9h)
June 06th (Sun.) 2021		
		Cruise to 8˚N 137˚E
June 07th (Mon.) 2021		
16:15	07:15	SPS-09 (High Altitude Sonde)
16:40	07:40	SPS-09 (Ozone Sonde)
June 08th (Tue.) 2021		
16:29	07:29	SPS-10 (High Altitude Sonde)
16:55	07:55	SPS-10 (Ozone Sonde)
June 09th (Wed.) 2021		
16:50	07:50	SPS-11 (High Altitude Sonde)
17:15	08:15	SPS-11 (Ozone Sonde)
June 10th (Thu.) 2021		
05:30	20:30 (-1 day)	CTD B02 (7˚ 52.3’N, 136˚ 28.4’E, 1000m)
08:00 – 11:58	23:00 (-1 day) – 02:58	
		Recovery of TRITON mooring (TR#10)
		(7˚ 52.0’N, 136˚ 29.5’E, 3350 m)
13:00	04:00	CTD A01 (7˚ 52.0’N, 136˚ 29.1’E, 2000m)
16:51	07:51	Installation of an Argo float
June 11th (Fri.) 2021		
17:59	08:59	XCTD-01 (13˚ 05.2’N, 137˚ 02.7’E)
June 12th (Sat.) 2021		
08:00 – 14:18	23:00 (-1day) – 05:18	
		Deployment of Philippine Sea mooring
		(13˚ 06.90’N, 136˚ 56.39’E, 5330 m)
08:30	23:30 (-1day)	RS-022
14:30	05:30	RS-023
15:00	06:00	CTD B03 (13˚ 06.7’N, 136˚ 54.1’E, 1000 m)
15:50	06:50	JES10mini experiment
16:50	07:50	Installation of the Air-sea momentum flux drifting buoy

SMT	UTC	Event
June 12th (Sat.) 2021 (continued)		
17:19	08:19	SPS-12 (High Altitude Sonde)
20:23	11:23	SPS-12 (Ozone Sonde)
20:30	11:30	RS-024
June 13th (Sun.) 2021		
02:30	17:30 (-1day)	RS-025
08:00 – 10:30	23:00 (-1day) – 01:30	Deployment of ADCP mooring (12˚ 59.14’N, 137˚ 08.32’E, 5032 m)
08:30	23:30 (-1day)	RS-026
13:00	04:00	Recovery of the Air-sea momentum flux drifting buoy
13:26	04:26	XCTD-02 (13˚ 01.8’N, 136˚ 46.3’E)
13:47	04:47	JES10mini experiment
14:30	05:30	RS-027
20:30	11:30	RS-028
June 14th (Mon.) 2021		
02:30	17:30 (-1day)	RS-029
08:00 – 10:42	23:00 (-1day) – 01:42	Deployment of ADCP mooring (13˚ 30.85’N, 137˚ 03.57’E, 5120 m)
08:30	23:30 (-1day)	RS-030
14:30	05:30	RS-031
15:00	06:00	Installation of Wave Glider (SV3-252)
15:18	06:18	Installation of Wave Glider (SV3-248)
17:17	08:17	SPS-13 (High Altitude Sonde)
20:15	11:15	SPS-13 (Ozone Sonde)
20:30	11:30	RS-032
June 15th (Tue.) 2021		
02:30	17:30 (-1day)	RS-033
08:30	23:30 (-1day)	RS-034
09:00	00:00	CTD A02 (13˚ 10.1’N, 136˚ 26.2’E, 2000m)
10:17	01:17	Installation of an Argo float
10:20	01:20	Installation of an Argo float
10:25	01:25	Installation of a MOF
10:43	01:43	Installation of Yo-yo drifting buoy
11:30	02:30	RS-035
13:00	04:00	JES10mini experiment
14:30	05:30	RS-036

SMT	UTC	Event
June 15th (Tue.) 2021 (continued)		
15:00	06:00	Installation of Sea snake
17:30	08:30	RS-037
20:30	11:30	RS-038
23:30	14:30	RS-039
June 16th (Wed.) 2021		
02:30	17:30 (-1day)	RS-040
05:30	20:30 (-1day)	RS-041
08:30	23:30 (-1day)	RS-042
09:00	00:00	Start of the stationary observation
		CTD STN001 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-043
12:00	03:00	CTD STN002 (500m with RINKO profiler)
14:30	05:30	RS-044
15:00	06:00	CTD STN003 (500m with RINKO profiler)
17:20	08:20	SPS-14 (High Altitude Sonde)
17:30	08:30	RS-045
18:00	09:00	CTD STN004 (500m with RINKO profiler)
20:18	11:18	SPS-14 (Ozone Sonde)
20:30	11:30	RS-046
21:00	12:00	CTD STN005 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-047
June 17th (Thu.) 2021		
00:00	15:00 (-1day)	CTD STN006 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-048
03:00	18:00 (-1day)	CTD STN007 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-049
06:00	21:00 (-1day)	CTD STN008 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-050
09:00	00:00	CTD STN009 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-051
12:00	03:00	CTD STN010 (500m with RINKO profiler)
14:30	05:30	RS-052
15:00	06:00	CTD STN011 (500m with RINKO profiler)
17:20	08:20	SPS-15 (High Altitude Sonde)
17:30	08:30	RS-053
18:00	09:00	CTD STN012 (500m with RINKO profiler)
20:40	11:40	SPS-15 (Ozone, Water vapor, and Cloud particle Sonde) with RS-054
21:00	12:00	CTD STN013 (500m with RINKO profiler and water sampling)

SMT	UTC	Event
June 17th (Thu.) 2021 (continued)		
23:30	14:30	RS-055
June 18th (Fri.) 2021		
00:00	15:00 (-1day)	CTD STN014 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-056
03:00	18:00 (-1day)	CTD STN015 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-057
06:00	21:00 (-1day)	CTD STN016 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-058
09:00	00:00	CTD STN017 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-059
12:00	03:00	CTD STN018 (500m with RINKO profiler)
14:30	05:30	RS-060
15:00	06:00	CTD STN019 (500m with RINKO profiler)
17:30	08:30	RS-061
18:00	09:00	CTD STN020 (500m with RINKO profiler)
20:30	11:30	RS-062
21:00	12:00	CTD STN021 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-063
June 19th (Sat.) 2021		
00:00	15:00 (-1day)	CTD STN022 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-064
03:00	18:00 (-1day)	CTD STN023 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-065
06:00	21:00 (-1day)	CTD STN024 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-066
09:00	00:00	CTD STN025 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-067
12:00	03:00	CTD STN026 (500m with RINKO profiler)
14:30	05:30	RS-068
15:00	06:00	CTD STN027 (500m with RINKO profiler)
17:19	08:19	SPS-16 (High Altitude Sonde)
17:30	08:30	RS-069
18:00	09:00	CTD STN028 (500m with RINKO profiler)
20:19	11:19	SPS-16 (Ozone Sonde)
20:30	11:30	RS-070
21:00	12:00	CTD STN029 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-071

SMT	UTC	Event
June 20th (Sun.) 2021		
00:00	15:00 (-1day)	CTD STN030 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-072
03:00	18:00 (-1day)	CTD STN031 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-073
06:00	21:00 (-1day)	CTD STN032 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-074
09:00	00:00	CTD STN033 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-075
12:00	03:00	CTD STN034 (500m with RINKO profiler)
14:30	05:30	RS-076
15:00	06:00	CTD STN035 (500m with RINKO profiler)
17:30	08:30	RS-077
18:00	09:00	CTD STN036 (500m with RINKO profiler)
20:30	11:30	RS-078
21:00	12:00	CTD STN037 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-079
June 21st (Mon.) 2021		
00:00	15:00 (-1day)	CTD STN038 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-080
03:00	18:00 (-1day)	CTD STN039 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-081
06:00	21:00 (-1day)	CTD STN040 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-082
09:00	00:00	CTD STN041 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-083
12:00	03:00	CTD STN042 (500m with RINKO profiler)
14:30	05:30	RS-084
15:00	06:00	CTD STN043 (500m with RINKO profiler)
17:20	08:20	SPS-17 (High Altitude Sonde)
17:30	08:30	RS-085
18:00	09:00	CTD STN044 (500m with RINKO profiler)
20:30	11:30	RS-086
21:00	12:00	CTD STN045 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-087
June 22nd (Tue.) 2021		
00:00	15:00 (-1day)	CTD STN046 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-088
03:00	18:00 (-1day)	CTD STN047 (500m with RINKO profiler)

SMT	UTC	Event
June 22nd (Tue.) 2021 (continued)		
05:30	20:30 (-1day)	RS-089
06:00	21:00 (-1day)	CTD STN048 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-090
09:00	00:00	CTD STN049 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-091
12:00	03:00	CTD STN050 (500m with RINKO profiler)
14:30	05:30	RS-092
15:00	06:00	CTD STN051 (500m with RINKO profiler)
17:30	08:30	RS-093
18:00	09:00	CTD STN052 (500m with RINKO profiler)
20:19	11:19	SPS-17 (Ozone and Cloud particle Sonde)
20:30	11:30	RS-094
21:00	12:00	CTD STN053 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-095
June 23rd (Wed.) 2021		
00:00	15:00 (-1day)	CTD STN054 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-096
03:00	18:00 (-1day)	CTD STN055 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-097
06:00	21:00 (-1day)	CTD STN056 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-098
09:00	00:00	CTD STN057 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-099
12:00	03:00	CTD STN058 (500m with RINKO profiler)
14:30	05:30	RS-100
15:00	06:00	CTD STN059 (500m with RINKO profiler)
17:20	08:20	SPS-18 (High Altitude Sonde)
17:30	08:30	RS-101
18:00	09:00	CTD STN060 (500m with RINKO profiler)
20:45	11:45	SPS-18 (Ozone, Water vapor, and Cloud particle Sonde) with RS-102
21:00	12:00	CTD STN061 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-103
June 24th (Thu.) 2021		
00:00	15:00 (-1day)	CTD STN062 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-104
03:00	18:00 (-1day)	CTD STN063 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-105
06:00	21:00 (-1day)	CTD STN064 (500m with RINKO profiler)

SMT	UTC	Event
June 24th (Thu.) 2021 (continued)		
08:30	23:30 (-1day)	RS-106
09:00	00:00	CTD STN065 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-107
12:00	03:00	CTD STN066 (500m with RINKO profiler)
14:30	05:30	RS-108
15:00	06:00	CTD STN067 (500m with RINKO profiler)
17:30	08:30	RS-109
18:00	09:00	CTD STN068 (500m with RINKO profiler)
20:18	11:18	SPS-19 (Ozone Sonde)
20:30	11:30	RS-110
21:00	12:00	CTD STN069 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-111
June 25th (Fri.) 2021		
00:00	15:00 (-1day)	CTD STN070 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-112
03:00	18:00 (-1day)	CTD STN071 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-113
06:00	21:00 (-1day)	CTD STN072 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-114
09:00	00:00	CTD STN073 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-115
12:00	03:00	CTD STN074 (500m with RINKO profiler)
14:30	05:30	RS-116
15:00	06:00	CTD STN075 (500m with RINKO profiler)
17:20	08:20	SPS-20 (High Altitude Sonde)
17:30	08:30	RS-117
18:00	09:00	CTD STN076 (500m with RINKO profiler)
20:39	11:39	SPS-20 (Ozone, Water vapor, and Cloud particle Sonde) with RS-118
21:00	12:00	CTD STN077 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-119
June 26th (Sat.) 2021		
00:00	15:00 (-1day)	CTD STN078 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-120
03:00	18:00 (-1day)	CTD STN079 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-121
06:00	21:00 (-1day)	CTD STN080 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-122
09:00	00:00	CTD STN081 (1000m with RINKO profiler and water sampling)

SMT	UTC	Event
June 26th (Sat.) 2021 (continued)		
11:30	02:30	RS-123
12:00	03:00	CTD STN082 (500m with RINKO profiler)
14:30	05:30	RS-124
15:00	06:00	CTD STN083 (500m with RINKO profiler)
17:30	08:30	RS-125
18:00	09:00	CTD STN084 (500m with RINKO profiler)
20:30	11:30	RS-126
21:00	12:00	CTD STN085 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-127
June 27th (Sun.) 2021		
00:00	15:00 (-1day)	CTD STN086 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-128
03:00	18:00 (-1day)	CTD STN087 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-129
06:00	21:00 (-1day)	CTD STN088 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-130
09:00	00:00	CTD STN089 (1000m with RINKO profiler and water sampling)
11:30	02:30	RS-131
12:00	03:00	CTD STN090 (500m with RINKO profiler)
14:30	05:30	RS-132
15:00	06:00	CTD STN091 (500m with RINKO profiler)
17:15	08:15	SPS-21 (High Altitude Sonde)
17:30	08:30	RS-133
18:00	09:00	CTD STN092 (500m with RINKO profiler)
20:19	11:19	SPS-21 (Ozone Sonde)
20:30	11:30	RS-134
21:00	12:00	CTD STN093 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-135
June 28th (Mon.) 2021		
00:00	15:00 (-1day)	CTD STN094 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-136
03:00	18:00 (-1day)	CTD STN095 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-137
06:00	21:00 (-1day)	CTD STN096 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-138
09:00	00:00	CTD STN097 (1000m with RINKO profiler and water sampling)
10:25	01:25	Installation of a MOF
11:30	02:30	RS-139

SMT	UTC	Event
June 28th (Mon.) 2021 (continued)		
12:00	03:00	CTD STN098 (500m with RINKO profiler)
14:30	05:30	RS-140
15:00	06:00	CTD STN099 (500m with RINKO profiler)
17:30	08:30	RS-141
18:00	09:00	CTD STN100 (500m with RINKO profiler)
20:30	11:30	RS-142
21:00	12:00	CTD STN101 (500m with RINKO profiler and water sampling)
23:30	14:30	RS-143
June 29th (Tue.) 2021		
00:00	15:00 (-1day)	CTD STN102 (500m with RINKO profiler)
02:30	17:30 (-1day)	RS-144
03:00	18:00 (-1day)	CTD STN103 (500m with RINKO profiler)
05:30	20:30 (-1day)	RS-145
06:00	21:00 (-1day)	CTD STN104 (500m with RINKO profiler)
08:30	23:30 (-1day)	RS-146
09:00	00:00	CTD STN105 (1000m with RINKO profiler and water sampling)
		Recovery of Sea snake
		End of the stationary observation
11:30	02:30	RS-147
13:00	04:00	Recovery of Wave Glider (SV3-248)
14:30	05:30	RS-148
15:25	06:25	Recovery of Wave Glider (SV3-252)
17:30	08:30	RS-149
19:30	10:30	CTD B04 (12˚ 53.6’N, 136˚ 50.9’E, 1000m)
20:30	11:30	RS-150
23:30	14:30	RS-151
June 30th (Wed.) 2021		
02:30	17:30 (-1day)	RS-152
05:30	20:30 (-1day)	RS-153
08:30	23:30 (-1day)	RS-154
09:28	00:28	Recovery of of Yo-yo drifting buoy
10:30	01:30	JES10mini experiment
11:30	02:30	RS-155
14:30	05:30	RS-156
17:32	08:32	SPS-22 (High Altitude Sonde)
17:32	08:32	RS-157
20:18	11:18	SPS-22 (Ozone Sonde)
20:30	11:30	RS-158

SMT	UTC	Event
June 30th (Wed.) 2021 (continued)		
23:30	14:30	RS-159
July 01st (Thu.) 2021		
02:30	17:30 (-1day)	RS-160
05:30	20:30 (-1day)	RS-161
08:00 – 14:18	23:00 (-1day) – 05:18	
		Recovery of Philippine Sea mooring
		(12˚ 53.60’N, 136˚ 54.30’E, 5250 m)
08:30	23:30 (-1day)	RS-162
11:30	02:30	RS-163
14:30	05:30	RS-164
17:18	08:18	SPS-23 (High Altitude Sonde)
17:30	08:30	RS-165
20:11	11:11	SPS-23 (Ozone Sonde)
20:30	11:30	RS-166
23:30	14:30	RS-167
July 02nd (Fri.) 2021		
02:30	17:30 (-1day)	RS-168
05:30	20:30 (-1day)	RS-169
08:30	23:30 (-1day)	RS-170
14:00	05:00	CTD A03 (17˚ 00.5’N, 139˚ 35.9’E, 2000m)
14:30	05:30	RS-171
15:20	06:20	Installation of an Argo float
17:19	08:19	SPS-24 (High Altitude Sonde with RS-41)
20:20	11:20	SPS-24 (Ozone Sonde)
20:30	11:30	RS-172
July 03rd (Sat.) 2021		
02:30	17:30 (-1day)	RS-173
08:30	23:30 (-1day)	RS-174
14:30	05:30	RS-175
17:30	08:19	SPS-25 (High Altitude Sonde with RS-41)
20:18	11:18	SPS-25 (Ozone Sonde)
20:30	11:30	RS-176
July 04th (Sun.) 2021		
00:30	15:30 (-1day)	CTD A04 (24˚ 00.0’N, 139˚ 30.0’E, 2000m)
01:40	16:40 (-1day)	Installation of an Argo float
02:30	17:30 (-1day)	RS-177

SMT	UTC	Event
July 04th (Sun.) 2021 (continued)		
08:30	23:30 (-1day)	RS-178
14:30	05:30	RS-179
17:51	08:51	SPS-26 (High Altitude Sonde with RS-41)
20:52	11:52	SPS-26 (Ozone Sonde)
20:52	11:52	RS-180
July 05th (Mon.) 2021		
02:30	17:30 (-1day)	RS-181
08:30	23:30 (-1day)	RS-182
13:00	04:00	Stop of TSG
14:30	05:30	RS-183
17:49	08:49	SPS-27 (High Altitude)
20:57	11:57	SPS-27 (Ozone Sonde)
20:58	11:58	RS-184
July 06th (Tue.) 2021		
13:00	04:00	Stop of Sea beam
		Cruise to Shimizu
July 07th (Wed.) 2021		
08:00	23:00 (-1day)	Stop of continuous observations
09:00	00:00	Arrival at Shimizu

3.4. Cruise track

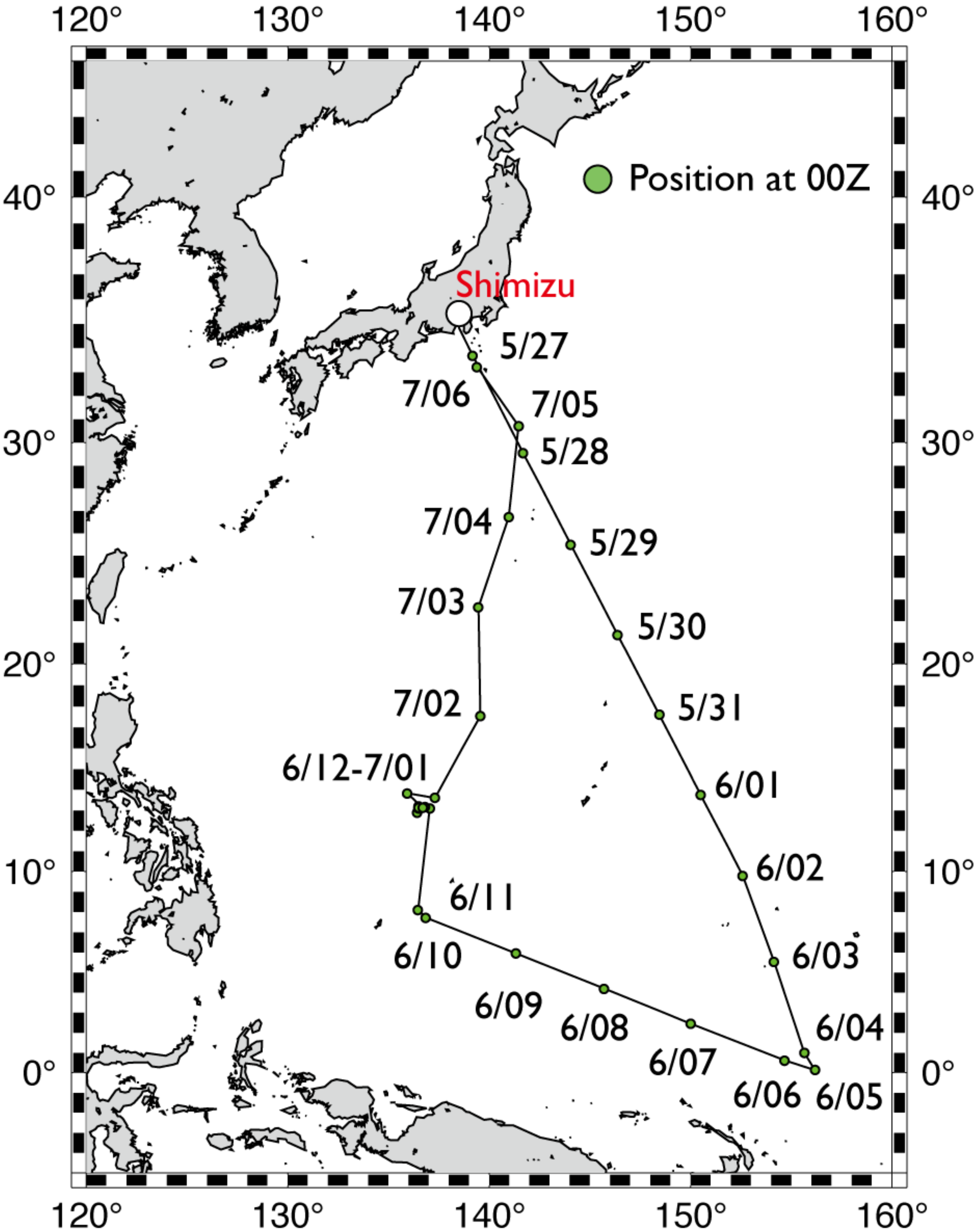


Fig. 3-1: MR21-03 cruise track

4. Research themes and science party

4.1. Chief scientist

Iwao Ueki

Group Leader,

Ocean-Atmosphere Climate Research Group,

Global Ocean Observation Research Center

Research Institute for Global Change,

JAMSTEC

4.2. Main mission

Comprehensive Ocean-Atmosphere observation in northern edge of the warm pool

Principal Investigator (PI): Iwao Ueki

4.3. Applied missions

Aerosol optical characteristics measured by Ship-borne Sky radiometer

PI: Kazuma Aoki

Professor,

Department of Earth Science,

University of Toyama

Material cycles associated with Asian summer monsoon and intraseasonal convective activities

PI: Shinya Ogino

Senior Researcher,

Dynamic Coupling of Ocean-Atmosphere-Land Reseach Program,

Research Institute for Global Change,

JAMSTEC

5. Participants list

5.1. R/V Mirai scientists and technical staffs

Name	Affiliation	Occupation
Iwao Ueki	JAMSTEC	Chief Scientist
Masaki Katsumata	JAMSTEC	Scientist
Biao Geng	JAMSTEC	Scientist
Akira Nagano	JAMSTEC	Scientist
Shinya Ogino	JAMSTEC	Scientist
Kyoko Taniguchi	JAMSTEC	Technical Staff
Kensuke Watari	JAMSTEC	Engineer
Satomi Ogawa	Nippon Marine Enterprises, Ltd. (NME)	Technical Staff
Kazuho Yoshida	NME	Technical Staff
Ryo Oyama	NME	Technical Staff
Yutaro Murakami	NME	Technical Staff
Hiroki Ushiromura	Marine Works Japan Ltd. (MWJ)	Technical Staff
Akira So	MWJ	Technical Staff
Makito Yokota	MWJ	Technical Staff
Masaki Yamada	MWJ	Technical Staff
Masaki Furuhata	MWJ	Technical Staff
Shungo Oshitani	MWJ	Technical Staff
Erii Irie	MWJ	Technical Staff
Airi Hara	MWJ	Technical Staff
Masahiro Orui	MWJ	Technical Staff
Tomomi Sone	MWJ	Technical Staff

5.2. R/V Mirai crew member

Name		Rank or rating
Haruhiko	Inoue	Master
Hiroyuki	Kato	Chief Officer
Shozo	Fujii	Jr.1st Officer
Tomoyuki	Takahashi	2nd Officer
Shoma	Abe	3rd Officer
Keita	Ushimaru	Jr. 3rd Officer
Tadashi	Abe	Chief Engineer
Hiroki	Tanaka	1st Engineer
Kota	Fujii	2nd Engineer
Kazuki	Ono	3rd Engineer
Takatomo	Shirozume	Chief Radio Operator
Kazuyoshi	Kudo	Boatswain
Tsuyoshi	Sato	Quarter Master
Yukito	Ishii	Quarter Master
Shuji	Komata	Quarter Master
Kenji	Nakae	Quarter Master
Hideaki	Tamotsu	Quarter Master
Satoshi	Shimpo	Quarter Master
Masaya	Tanikawa	Quarter Master
Takuya	Yajima	Sailor
Takuma	Tokunaga	Sailor
Keisuke	Isobe	Sailor
Masanori	Ueda	Oiler
Kazuya	Ando	Oiler
Tamaki	Fujishima	Assistant Oiler
Tsuyoshi	Uchiyama	Assistant Oiler
Shodai	Kayaba	Assistant Oiler
Kyotaro	Maruyama	Assistant Oiler
Toru	Wada	Steward
Toshiyuki	Asano	Steward
Hiroyuki	Ohba	Steward
Kanjuro	Murakami	Steward
Koki	Shinohara	Steward

6. Misson observations

6.1. TRITON and Philippine Sea moorings

6.1.1. TRITON mooring operation

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Kensuke Watari	(JAMSTEC)
Tatsuya Fukuda	(JAMSTEC) not on board
Yasuhisa Ishihara	(JAMSTEC) not on board
Masaki Furuhata	(MWJ) Operation Leader
Hiroki Ushiromura	(MWJ) Technical Leader
Akira So	(MWJ)
Makito Yokota	(MWJ)
Masaki Yamada	(MWJ)

(2) Measured parameters

TRITON moorings observed oceanic parameters and meteorological parameters as follow:

Meteorological parameters:

Wind Speed, Direction,

Atmospheric Pressure,

Air Temperature, Relative Humidity,

Shortwave Radiation,

Precipitation.

(3) Instrument

Details of the instruments used on TRITON mooring 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 deg-C
Measurement range, Conductivity :	0 ～ 7 S/m
Measurement range, Pressure :	0 ～ full scale range

2) CRN(Current meter)

SonTek Argonaut ADCM

Sensor frequency :	1500 kHz
Sampling interval :	1200 sec.
Average interval :	120 sec.

Meteorological sensors

1) Precipitation

R.M.YOUNG COMPANY MODEL50202/50203

Sampling interval :	600 sec.

2) Atmospheric pressure

PAROSCIENTIFIC.Inc. DIGIQUARTZ FLOATING BAROMETER_6000SERIES

Sampling interval : 600sec.

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

Woods Hole Institution ASIMET

Sampling interval : 600sec.

(4) Locations of TRITON moorings recovered

Nominal location :	EQ, 156E
ID number at JAMSTEC :	04020
Number on surface float :	T11
ARGOS PTT number :	29641
ARGOS backup PTT number :	29694
Deployed date :	06 Mar. 2020
Recovered date :	04 Jun. 2021
Exact location :	00°01.03' N, 155°57.64' E
Depth :	1,950 m

Nominal location :	8N, 137E
ID number at JAMSTEC :	10015
Number on surface float :	T24
ARGOS PTT number :	28320
ARGOS backup PTT number :	24715
Deployed date :	29 Feb. 2020
Recovered date :	10 Jun. 2021
Exact location :	07°52.07' N, 136°29.48' E
Depth :	3,351m

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

(5) Data archive

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

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

6.1.2. Philippine Sea mooring operation

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Akira Nagano	(JAMSTEC)
Kensuke Watari	(JAMSTEC)
Tatsuya Fukuda	(JAMSTEC) not on board
Yasuhisa Ishihara	(JAMSTEC) not on board
Masaki Furuhata	(MWJ) Operation Leader
Hiroki Ushiromura	(MWJ) Technical Leader
Akira So	(MWJ)
Makito Yokota	(MWJ)
Masaki Yamada	(MWJ)

(2) Measured parameters

Philippine sea mooring observed oceanic parameters and meteorological parameters as follow:

Meteorological parameters:

Wind Speed, Direction,
Atmospheric Pressure,
Air Temperature, Relative Humidity,
Shortwave Radiation,
Precipitation.
Longwave Radiation

Oceanic parameters (Philippine Sea):

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

(3) Instrument

Details of the instruments used on the Philippine sea mooring are summarized as follows:

<u>Oceanic sensors</u>

1) CTD and CT

SBE-37 IM MicroCAT

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

2) CRN(Current meter)

Work Horse ADCP

Sensor frequency : 300kHz

Sampling interval : 20min.

<u>Meteorological sensors</u>

1) Precipitation

R.M.YOUNG COMPANY MODEL50202/50203

Sampling interval : 600sec.

2) Atmospheric pressure

PAROSCIENTIFIC.Inc. DIGIQUARTZ FLOATING BAROMETER 6000SERIES

Sampling interval : 600sec.

3) Relative humidity/air temperature, Shortwave radiation, Longwave radiation, Wind speed/direction

JAMSTEC JAMET

Sampling interval : 600sec.

(4) Locations of deployed Philippine sea mooring

Nominal location :	13N, 137E
ID number at JAMSTEC :	40504
Number on surface float :	J06
Iridium ID number :	300434063013670
ARGOS backup PTT number :	30832
Deployed date :	12 Jun. 2021
Exact location :	13°06.85' N, 136°56.38' E
Depth :	5,327 m

(5) Locations of recovered Philippine sea mooring

Nominal location :	13N, 137E
ID number at JAMSTEC :	40503
Number on surface float :	K03
Iridium ID number :	300434063216270
ARGOS backup PTT number :	29738
Deployed date :	26 Aug. 2020
Recovered date :	1 Jul. 2021
Exact location :	12°53.68' N, 136°54.29' E
Depth :	5,249 m

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

6.2 ADCP subsurface moorings

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Hiroki Ushiromura	(MWJ) Operation Leader
Akira So	(MWJ)
Masaki Furuhata	(MWJ)
Makito Yokota	(MWJ)
Masaki Yamada	(MWJ)
Masahiro Orui	(MWJ)

(2) Objectives

The purpose of the ADCP subsurface mooring is to get knowledge of physical process underlying the dynamics of the equatorial current structure and associated processes in the Western Pacific Ocean. We have been observing subsurface currents using ADCP moorings along the equator. In this cruise (MR21-03), we recovered the mooring at Eq-156E and deployed another mooring at the 13N-137E and 13.5N137E.

(3) Parameters

Current profiles

Echo intensity

Pressure, Temperature and Conductivity

(4) Method and instrumentation

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

1) ADCP

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

Distance to first bin :	7.04 m
Pings per ensemble :	27
Time per ping :	6.66 sec.
Number of depth cells :	60
Bin length :	8.00 m
Sampling interval :	3600 sec.

Recovered ADCP

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

Deployed ADCP

・ Serial Number : 24609 (Mooring No. 210613-13N137E)

・ Serial Number : 2541 (Mooring No. 210614-13.5N137E)

2) CTD

SBE-16 (Sea Bird Electronics Inc.)

Sampling interval : 3600 sec.

Recovered CTD

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

Deployed ADCP

・ Serial Number : 1282 (Mooring No. 210613-13N137E)

・ Serial Number : 1280 (Mooring No. 210614-13.5N137E)

3) Other instruments

(a) Acoustic Release (Teledyne BENTHOS Inc.)

Recovered Acoustic Release

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

Deployed Acoustic Release

・ Serial Number : 636, 956 (Mooring No. 210613-13N137E)

・ Serial Number : 663, 694 (Mooring No. 210614-13.5N137E)

(b) Transponder (Teledyne BENTHOS Inc.)

Recovered Transponder

・ Serial Number : 57069 (Mooring No. 200308-EQ156E)

Deployed Transponder

・ Serial Number : 57114 (Mooring No. 210613-13N137E)

・ Serial Number : 61940 (Mooring No. 210614-13.5N137E)

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

Recovered Flasher

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

Deployed Flasher

・ Serial Number : A02-056 (Mooring No. 210613-13N137E)

・ Serial Number : A02-057 (Mooring No. 210614-13.5N137E)

(5) Deployment

Depths of the top buoy, which includes upward looking ADCP, of the mooring at 13N 137E and 13.5N 137E were planned at about 2000 m for 13˚N 137˚E and 950 m for 13.5˚N 137˚E. The actual depths of each top buoy are 1997 m and 930 m.

Detailes of the mooring No. 210613-13N137E

Deployed date :	13 Jun. 2021
Exact location :	12°59.14' N, 137°08.32' E
Depth :	5,032 m
Top buoy depth:	1,997 m

Detailes of the mooring No. 210614-13.5N137E

Deployed date :	14 Jun. 2021
Exact location :	13°30.85' N, 137°03.57' E
Depth :	5,120 m
Top buoy depth:	930 m

(6) Recovery

We recovered an ADCP mooring at 0˚N 156˚E, which was deployed on 08 Mar 2020 by R/V MIRAI. Although we tried to retrieve ADCP and CTD data, we could not acquire CTD data due to a mechanical trouble on control board. The quick look of ADCP data is shown in Fig. 6.2-1.

Detailes of the mooring No. 200308-EQ156E

Deployed date :	08 Mar. 2020
Recovered date :	05 Jun. 2021
Exact location :	0°02.09' N, 156°07.92' E
Depth :	1,650 m
Top buoy depth:	400 m

(7) Data archive

All data will be available at the following web page:

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

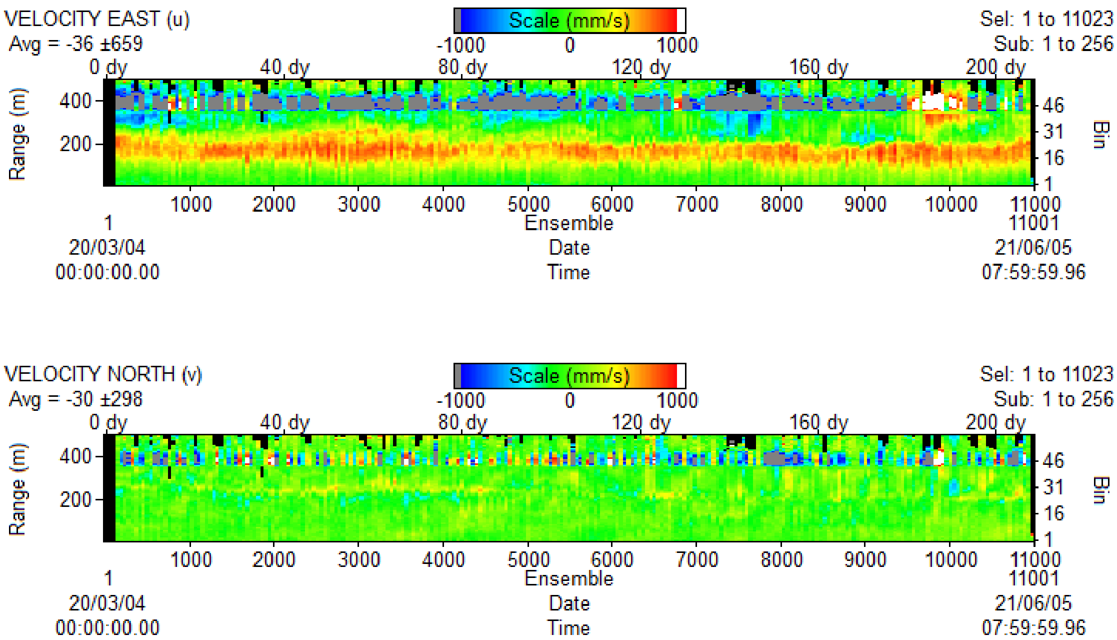


Fig.6.2-1 Time-depth sections of observed zonal (*upper panel*) and meridional (*lower panel*) currents obtained from ADCP mooring at 0˚N 156˚E (2020/03/08 ‐ 2021/06/05).

6.3. Surface drifter observation

6.3.1. **Yo-Yo observation**

(1) Personnel

Kensuke Watari	(JAMSTEC) PI
Makito Yokota	(MWJ)
Masaki Furuhata	(MWJ)

(2) Objectives

The ocean is strongly related to the global climate. In particular, the occurrence of phenomena called El Niño and Indian Ocean dipole mode, where the water temperature distribution differs greatly from normal, is closely related to abnormal weather around the world. JAMSTEC has built an observation network by TRITON moorings as a function of accurate observations to capture such anomalous conditions associated with climate variations. However, while observation by TRITON moorings can acquire precise ocean and weather conditions at a fixed point, the cost of deployment and recovery is relatively high, which is not an economically flexible method. Therefore, we developed an inexpensive and compact automatic raising and lowering float, and by combining it with the TRITON moorings, we aim to construct an observation network with a high degree of freedom that can be scaled. In the MR21-03 cruise, the purpose is to test a small profiling float with Drifting buoy "Yo-Yo" conducted around stationary observation site and to extract future tasks.

(3) Method and instrumentation

Yo-Yo buoy consists of two elements. One is the drifting buoy, which drifts on the sea surface, the other one is profiling float, which can observe vertical profiles of the temperature and salinity. The size of drifting buoy is 800 mm (W) x 800 mm (D) x 600 mm (H)(Fig. 6.3.1-1). That of the profiling float is 120 mm (W) x 120 mm (D) x 900 mm (H)(Fig. 6.3.1-2). The drift buoy can charge internal battery by solar panels and is equipped with a CTD sensor, PH sensor, and wave sensor. The profiling float is equipped with CTD sensor, Iridium communication units. The profiling float rise to the surface along the rope that hang from the drifting buoy. In the MR21-03 cruise, one Yo-Yo buoy deployed at the stationary observation site, observation for 16 days.

Fig. 6.3.1-1 Drifting buoy

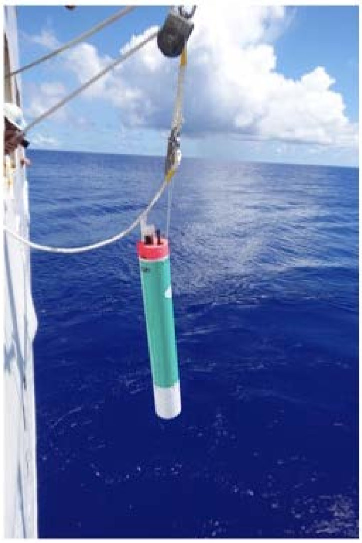


Fig. 6.3.1-2 Profiling float

(4) Preliminary Results

Time series of the sea surface salinity measure by drifting buoy is shown in Fig. 6.3.1-3. Salnity profile and temperature profiles obtained by the profiling float are shown in Fig. 6.3.1-4 and 5. Although the drifting buoy acquired time series of sea surface variables during 16-day observations, the profiling float could gain only one profile because of some mechanical trouble on the float.

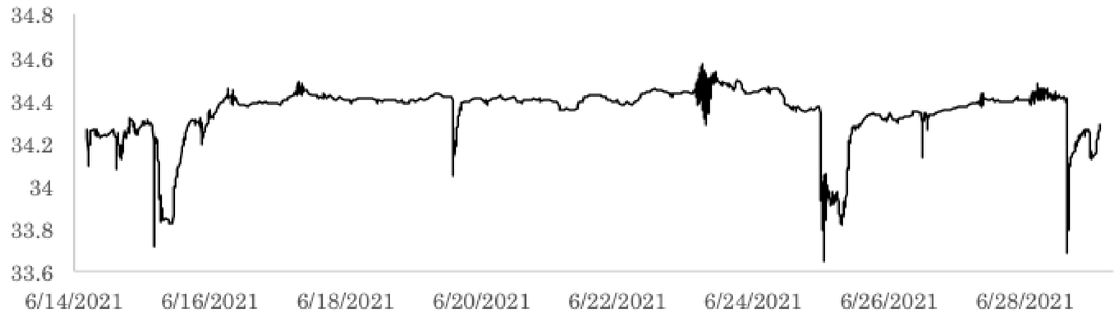
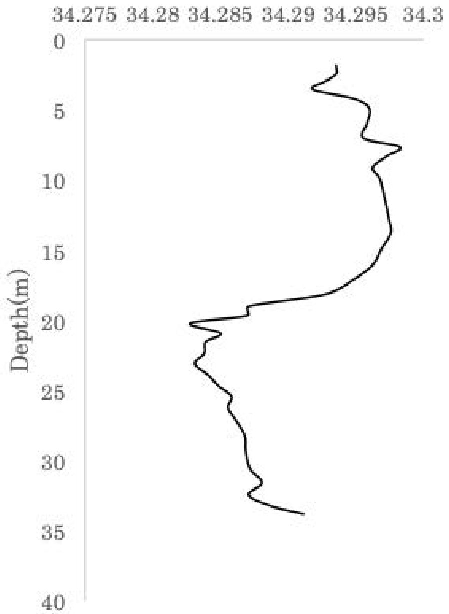


Fig. 6.3.1-3 Time series of sea surface salinity obtained by the drifting buoy



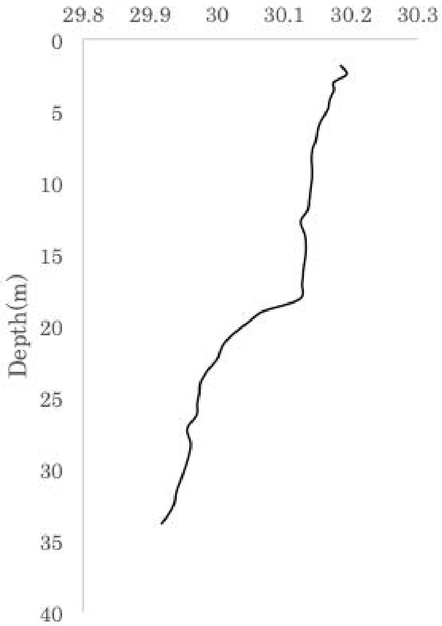


Fig. 6.3.1-4 Salinity profile obtained by the drifting float

Fig. 6.3.1-5 Temperature profile obtained by the drifting float

(5) 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).

6.3.2. Multi-purpose observation float (MOF) experiment

(1) Personnel

Kensuke Watari	(JAMSTEC) PI
Makito Yokota	(MWJ)
Masaki Furuhata	(MWJ)

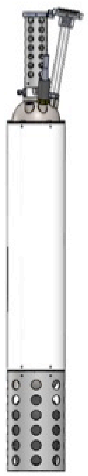
(2) Objectives

To capture upper ocean variability, Multi-purpose observation float (MOF) has been developed as same as Yo-Yo buoy system. The purpose of this experiment is to evaluate performance of several MOFs under the open ocean condition.

(3) Instrumentation and method

MOF is a profiling float, which has a CTD sensor (JES10 Profiler) and can acquire profiles of temperature, salinity down to 500 m depth as default. In this experiment, the parking depth and cycle interval of MOFs were 200 m and 24 hours. Specifications of the MOF are listed in Table 6.3.2-1.

Table 6.3.2-1 Specifications of the MOF



MOF Design

FEATURES	MOF
Size	910×Φ115
Weight	8.1kg
Sensor	JES10_Profiler
Operating System	Tron
Batt Capacity	Controller:7.8V 14Ah Power:14.4V 30Ah
Communication	Iridium
Depth	500m

(4) Preliminary Results

Although two MOFs were installed at 13˚ 12.41’N 136˚ 29.93’E on June 15 and 13˚ 08.73’N 136˚ 29.18’E on June 28, the floats did not send observed data and we acquired only some technical information from the floats. Finally, the float stopped sending those technical information because of unexpected power loss within 2 weeks from deployment.

6.3.3. Air-sea momentum flux observation

(1) Personnel

Naoya Suzuki	(Kinki Univ.) PI not on board
Iwao Ueki	(JAMSTEC)
Hiroki Ushiromura	(MWJ)
Atsutoshi Ikeda	(Kinki Univ.) not on board
Santa Sasak	(Kinki Univ.) not on board

(2) Objectives

The air-sea momentum flux has generally been estimated using the drag coefficient with the wind speed. However, there still exists considerable disagreement among investigators for the parameterization of the drag coefficient. Recently, air-sea momentum flux has been measured by many buoys designed specifically for air-sea interaction. The sizes of these buoys are very large and they cannot easily be deployed in open ocean. In this cruise, our objective is to measure the air-sea momentum flux using the small size buoy with an installed sonic anemometer in open ocean.

(3) Preliminary Results

The air-sea momentum flux was observed at around 13°N137°E for a period of one day from 12th June to 13th June (see Fig. 6.3.3-1). The iridium tracker was installed on the buoy, in order to obtain the location of the buoy. The buoy has a height of 1800 mm, the diameter of 800 mm, and the weight is 50 kg. Two horizontal and one vertical components of the wind velocity are recorded with a sampling frequency of 10 Hz. The motion of the buoy is measured using two IMU sensors to correct the wind component by the motion correction. By using the eddy correlation method with the wind component measurements, the friction velocity is obtained every 10 min.

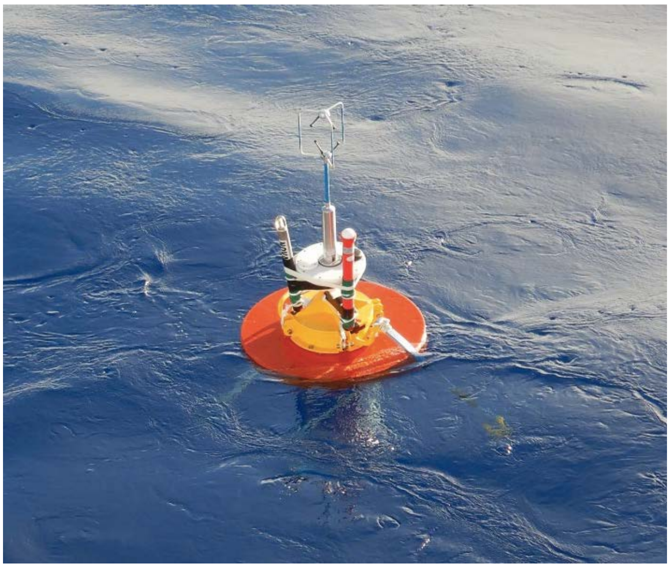


Fig. 6.3.3-1 The air-sea momentum flux buoy

6.4. Argo floats

(1) Personnel

Shigeki Hosoda	(JAMSTEC) PI not on board
Mizue Hirano	(JAMSTEC) not on board
Iwao Ueki	(JAMSTEC)
Hiroki Ushiromura	(MWJ) Operation Leader
Masaki Furuhata	(MWJ)
Masaki Yamada	(MWJ)
Airi Hara	(MWJ)

(2) Objectives

The research objective is to clarify the mechanisms of climate and oceanic environment variability, and to understand changes of earth system through estimations of heat and material transports, improving the Argo observing system in the global ocean. To achieve the objective, five Argo floats are deployed to carry out automatic measurements of long-term temperature and salinity variations in the western equatorial Pacific Ocean where the spatial density of the Argo floats is constantly sparse due to a lack of float deployment opportunities. As the internal wave related to oceanic mixing is enhanced due to oceanic tide in this region, profile frequency of two floats is set every one day to detect short term variability in the upper ocean. Also, the oceanic front of the warm pool locates around 13˚N 137˚E, which migrates in the meridional direction associated with ENSO. A conbination of the mooring and float obsevation enables to clarify changes in temperature, salinity and related values such as heat and freshwater contents in detail. The data accumulated from Argo floats also contribute to improve long-term forecasts of climate changes through data assimilation systems.

(3) Parameters

Water temperature, salinity and pressure

(4) Method and instrumentation

We launched APEX float manufactured by Teledyne Webb Research. This float equips SBE41 CTD sensor manufactured by Sea-Bird Electronics Inc. The float drifts at a depth of 1000 dbar (called the parking depth) during waiting measurement, then goes upward from a depth of 2000 dbar to the sea surface every 1-10 days. The profile frequency will be finally set to 10 days, which is the frequency of normal core Argo scheme, after the target observation is ended. During the ascent, physical values are measured every 2 dbar in advance following depth table. During surfacing for approximately half an hour, the float sends all measured data to the land via the Iridium RUDICS telecommunication system. The lifetime of floats is expected to be about four-eight years. The status of float and its launching information is shown in Table 6.4-1.

Specifications of the floats are as follows:

Float Type	APEX float manufactured by Teledyne Webb Research.
CTD sensor	SBE41 manufactured by Sea-Bird Electronics Inc.
Cycle	every 1-10 day (approximately 30minutes at the sea surface)
Iridium transmit type	Router-Based Unrestricted Digital Internetworking Connectivity Solutions (RUDICS)
Target Parking Pressure	1000 dbar

Sampling layers	2dbar interval from 2000 dbar to surface (approximately 1000 levels)

The launching positions of the floats are listed in Table 6.4-1.

Table 6.4-1. The Launching positions of the floats

Float S/N	WMO ID	Date (UTC)	Location of Launch		Station
8794	TBD	2021/06/10 07:51	7°52.48N	136° 28.27E	A01
8800	TBD	2021/06/15 01:18	13° 09.97N	136° 26.17E	T3
9303	TBD	2021/06/15 01:20	13° 09.96N	136° 26.16E	T3
9192	TBD	2021/07/02 06:20	17° 00.57N	139° 35.94E	T5
9191	TBD	2021/07/03 16:50	24° 00.25N	139° 29.89E	T6

(5) Data archive

The Argo float data will be provided conducting 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 freely available via internet and utilized for not only research but also weather forecasts and any other variable use through internet. Global Data Assembly Center (GDAC: https://nrlgodae1.nrlmry.navy.mil/argo/argo.html, http://www.coriolis.eu.org/), Global Telecommunication System (GTS).

(a) S/N 8800 (b) S/N 9303

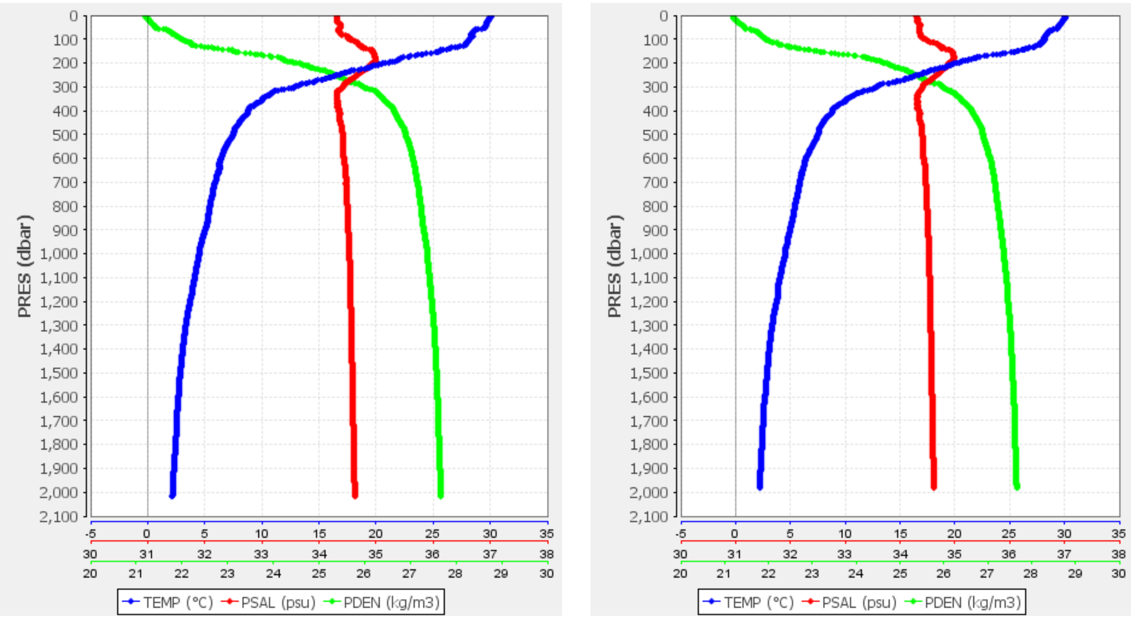


Fig. 6.4-1 (a and b). Prelimilary results of vertical temperature and salinity profiles from their first measurements by the deployed Argo floats. Blue, red and green lines show temperature, salinity and potential density profiles.

6.5. Wave Glider observation

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Tatsuya Fukuda	(JAMSTEC) not on board
Yasuhisa Ishihara	(JAMSTEC) not on board
Makito Yokota	(MWJ) Operation Leader
Hiroki Ushiromura	(MWJ)
Masaki Furuhata	(MWJ)
Masaki Yamada	(MWJ)
Nobuhiro Fujii	(MWJ) not on board
Takayuki Hashimukai	(MWJ) not on board
Shino Sakabe	(MWJ) not on board
Tetsuya Nagahama	(MWJ) not on board

(2) Background and Objectives

Although there are many global air-sea flux products mainly based on Satellite observation, in situ observations by research vessels and mooring buoys are still essential. As a part of the TAO/TRITON array, we are conducting the air-sea flux observation in the western Pacific and eastern Indian Ocean. The mooring observation has the advantage to acquire detailed direct measurement record at a fixed point, however it takes relatively high cost to keep many sites. Because of progress of the development of unmanned ocean surface vehicles, such as the Wave Glider and the Saildrone, we can use these vehicles as a platform for air-sea flux observation. Using the Wave Glider, we developed air-sea flux observing system. Air-sea flux observation by 2 Wave Gliders (serial number is SV3-248 and SV3-252) were conducted as a part of the comprehensive observation by the multiplatform, which consist of moorings, Argo floats, Wavegliders, drifters, and R/V MIRAI.

(3) Instrumentation

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 the data in real time. The Wave Glider consists of two-part architecture; surface float and underwater glider with umbilical cable (Fig. 6.5-1).

As payloads, we install three types of meteorological sensor units on the surface float; the Weather Station, Weather Transmitter, and JAMMET. The observed parameters are air temperature, relative humidity, barometric pressure longwave radiation, shortwave radiation, wind and rain fall amount. Also underwater sensors were installed to the surface float and underwater glider. The observed parameters are ocean current within 120 m depth, temperature, conductivity and pressure. The acquired data are recorded on logger system and transmitted to land station via iridium satellite communication system.

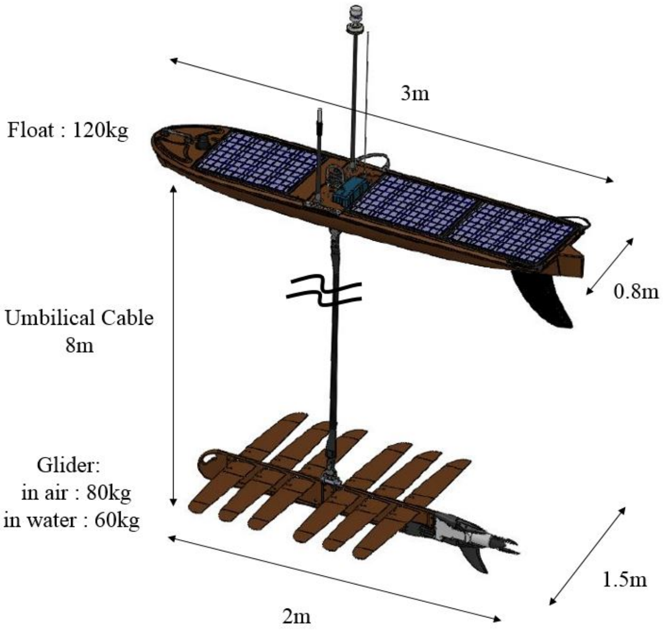


Fig. 6.5-1 Wave Glider SV3 configuration

(4) Optional sensors

1) Series of temperature and pressure sensors

To capture detailed vertical structure near the ocean surface, eight TD sensors and one CTD sensor were installed on the 20 m rope, which has been attached at the end of the surface float of SV3-252. The schematic figure is shown in Fig. 6.5-2.

2) Three axis ultra sonic anemometer system

Three axis ultra sonic anemometer system was installed on the rear pole of the surface float of SV3-248 (Fig. 6.5-3). The system include motion sensor and logger inaddition to three axis ultra sonic anemometer to conduct wind correction for motion of Wave Glider. The system acquired 3 dimensional wind speed, speed of sound, and sonic temperature in every 0.05 sec.

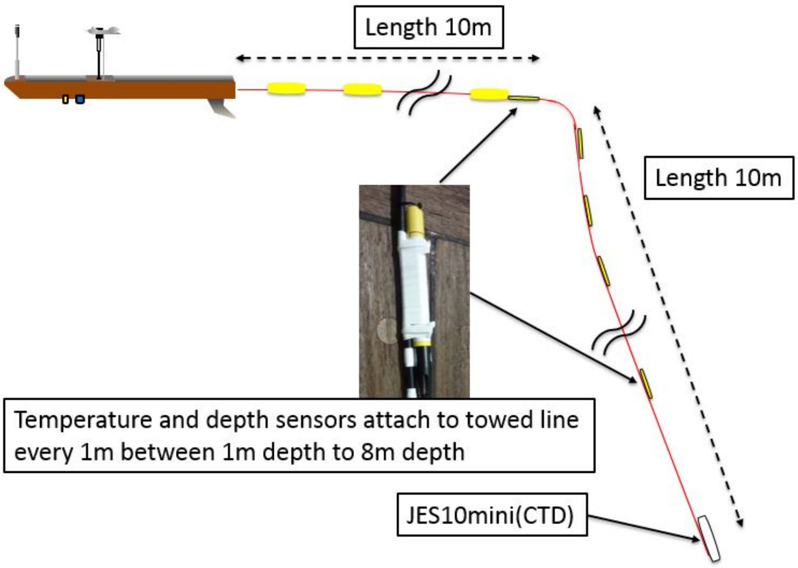


Fig. 6.5-2 Schematic of series of temperature and pressure sensors

Fig. 6.5-3 Three dimensions wind sensor system

(5) Installation and recovery

Two Wave Gliders were deployed from R/V Mirai on 14 Jun 2021, and these were recovered on 29 Jun 2021.

(6) Observation

Two Wave Gliders conducted observation between 14 to 29 June 2021. As shown in Fig. 6.5-4, SV3-252 stayed between 13˚ 32’N 136˚ 30’E to 13˚ 42’N 136˚ 30’E, and the other (SV3-248) stayed between 12˚ 32’N 136˚ 30’E to 12˚ 42’N 136˚ 30’E. These locations are corresponding to about 30 miles north andsouth of stationary observation site of R/V Mirai.

(7) Preliminary Results

Except long wave measurement on SV3-248, most measurements by Wave Gliders were smoothly conducted. As shown in time series of observed variables associated with air-sea interaction by both Wave Gliders (Fig. 6.5-5 and Fig. 6.5-6), condition of the upper ocean and the lower atmosphere is relatively calm during observation period. We can confirm gradually increasing SST, air temperature, and relative humidity. According to the situation, incleasing amplitude of diurnal cycle was also confirmed.

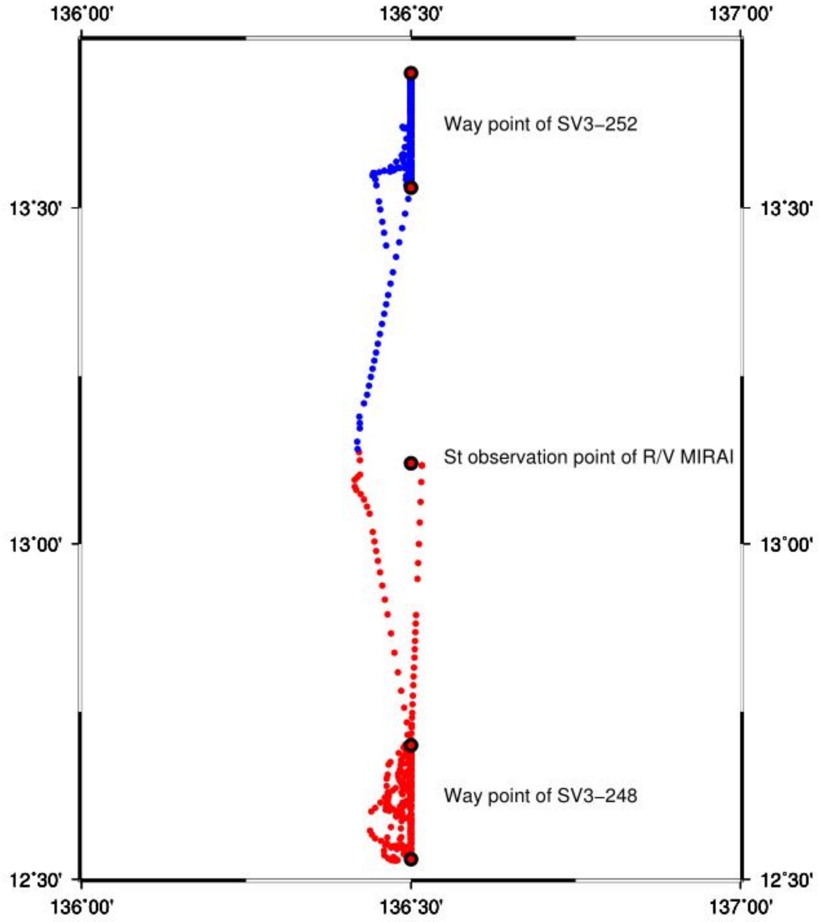


Fig. 6.5-4 Cruise track of two Wave Gliders during the period from 14 Jun. to 29 Jun. 2021
(SV3-248 : red dot, SV3-252 blue dot)

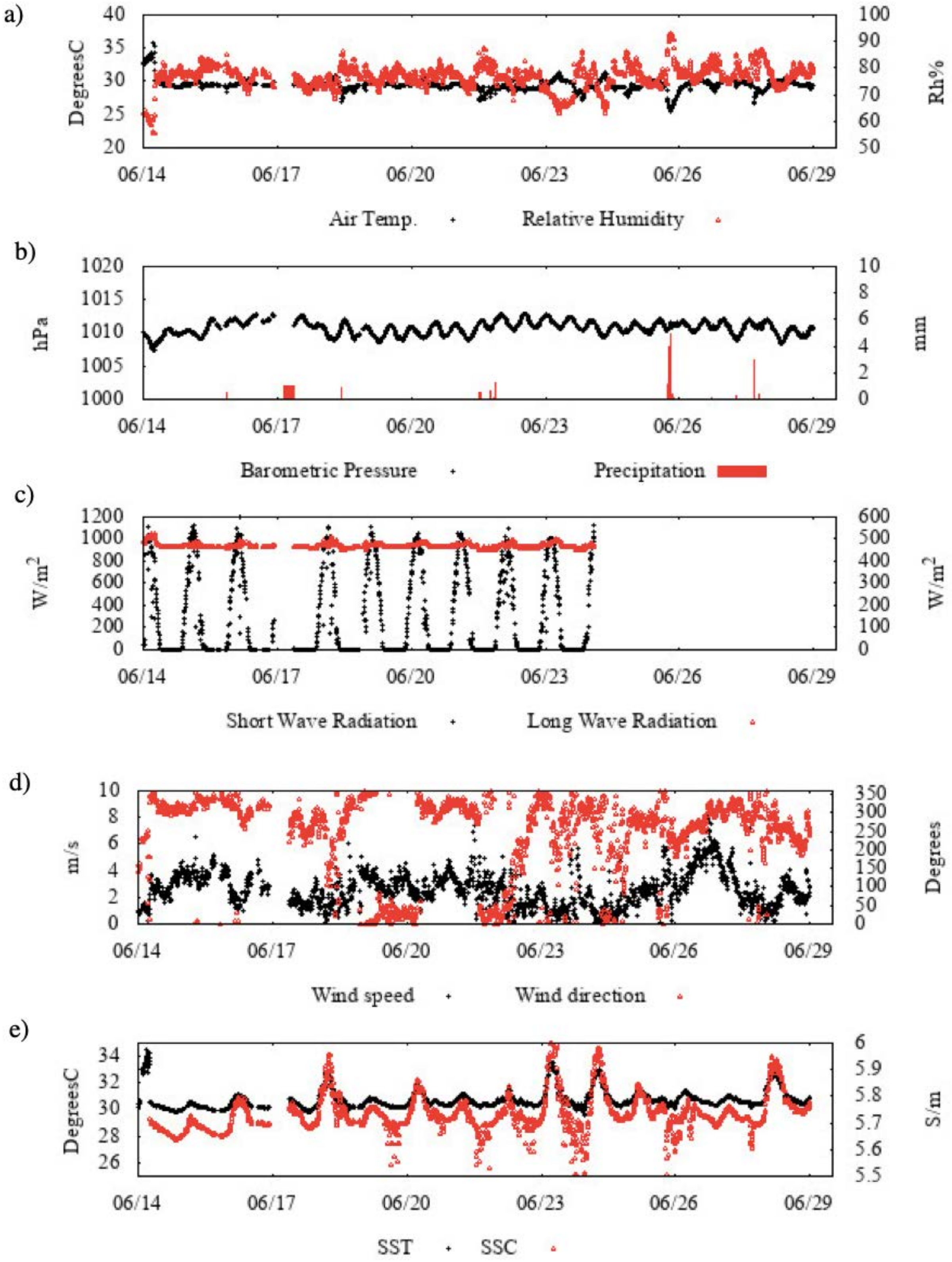


Fig. 6.5-5 Time series of a) air temparature, relative humidity, b) barometric pressure, precipitation, c) Shortwave radiation, Longwave radiation, d) wind speed, wind direction , and e) SST, SSC observed by Wave Glider SV3-248.

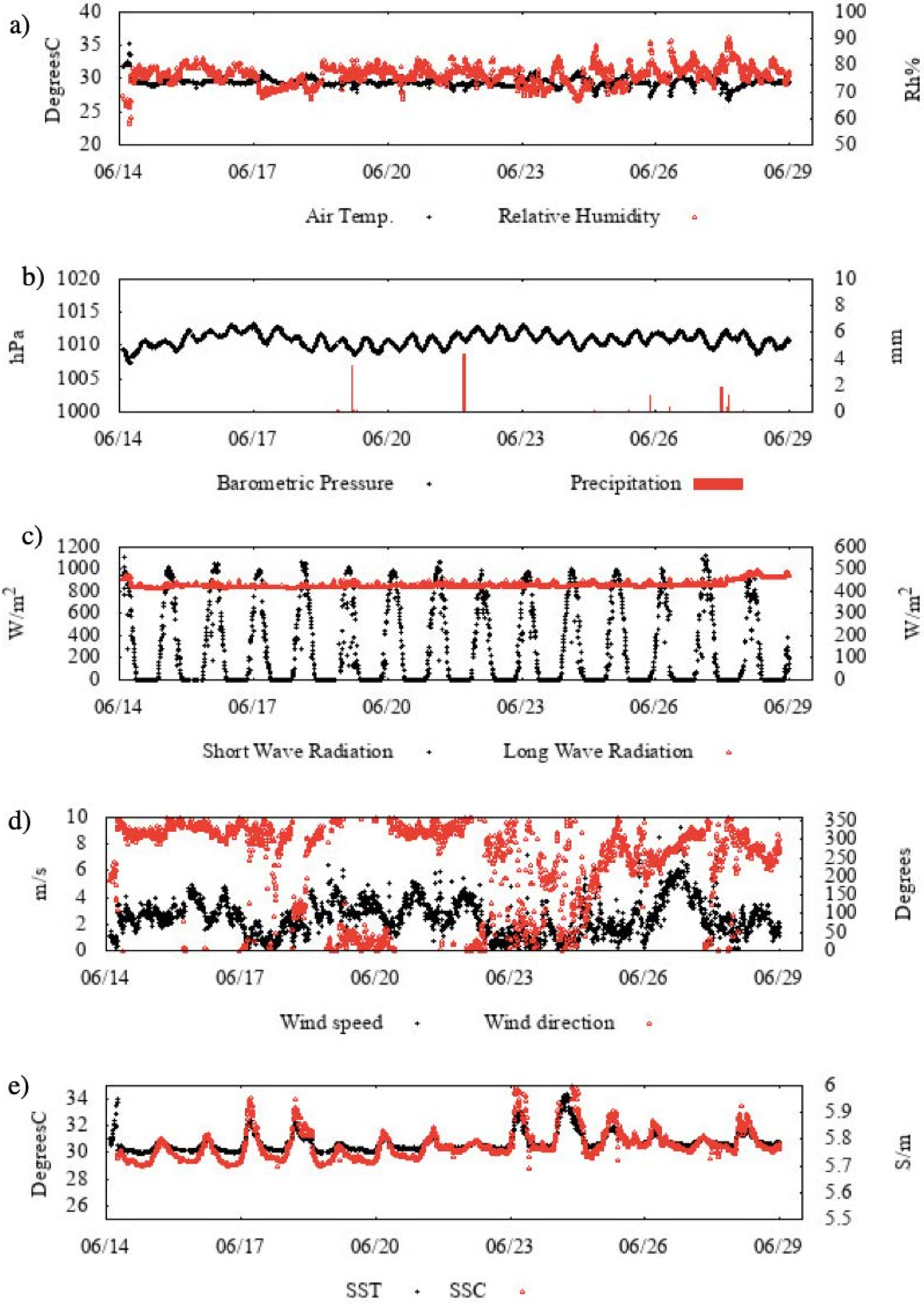


Fig. 6.5-6 As same as Fig. 6.5-5, but by Wave Glider SV3-252.

(8) Remarks

1) The following period, data acuisition by SV3-248 stopped due to logger system trouble.

07:28UTC 16 Jun.2021 - 08:08UTC 17 Jun. 2021

2) After following date, shortwave and longwave radiation data by SV3-248 stopped due to trouble of sensors.

11:18UTC 24 Jun.2021

(9) Data archive

All 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).

6.6. CTD

(1) Personnel

Akira Nagano	(JAMSTEC) PI
Iwao Ueki	(JAMSTEC)
Shungo Oshitani	(MWJ) Operation Leader
Masahiro Orui	(MWJ)
Akira So	(MWJ)
Hiroki Ushiromura	(MWJ)
Airi Hara	(MWJ)
Masaki Furuhata	(MWJ)
Masaki Yamada	(MWJ)
Makito Yokota	(MWJ)

(2) Objectives

Investigation of oceanic structure and water sampling.

(3) Instrumentation

CTD/Carousel Water Sampling System, which is a 36-position Carousel Water Sampler (CWS) with Sea-Bird Electronics, Inc. CTD (SBE9plus), was used during this cruise. 12-liter sample Bottles were used for sampling seawater. The sensors attached on the CTD were temperature (primary and secondary), conductivity (primary and secondary), pressure, dissolved oxygen (primary and secondary), fluorescence. 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: 07-Jul-2020

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: SBE03plus (S/N: 03P2730, Sea-Bird Electronics, Inc.)

Calibrated Date: 28-Dec-2019

Conductivity sensors:

Primary: SBE04C (S/N: 041206, Sea-Bird Electronics, Inc.)

Calibrated Date: 25-Jun-2019

Secondary: SBE04-04/0 (S/N: 041172, Sea-Bird Electronics, Inc.)

Calibrated Date: 10-Jan-2020

Dissolved oxygen sensor:

Primary: SBE43 (S/N:430330, Sea-Bird Electronics, Inc.)

Calibrated Date: 07-Nov-2020

Secondary: SBE43 (S/N: 430949, Sea-Bird Electronics, Inc.)

Calibrated Date: 20 Oct. 2018

Fluorescence:

Chlorophyll Fluorometer (S/N: 3618, Seapoint Sensors, Inc.)

Gain setting: 30X, 0-15 ug/l

Calibrated Date: None

Offset: 0.000

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

Configuration file: MR2103A.xmlcon

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.26.7.121) 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.

The bottle was fired after waiting from the stop for more than 30 seconds below thermocline to stabilize. For depths where vertical gradient of water properties was expected to be large, the bottle was exceptionally fired after waiting 60 seconds from the stop to enhance the exchange of water between inside and outside of the bottle.

113 casts of CTD measurements were conducted (Table 6.6-1).

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 seconds, and the offset was set to 0.0 seconds.

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 are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensor and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 5 seconds advancing to dissolved oxygen sensor (primary and secondary SBE43) output.

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 (SBE43) output.

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

WFILTER: Perform a median filter to remove spikes in the fluorescence data. A median value was determined by 49 scans of the window.

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 was set to be the end time when the package came up from the surface.

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

DERIVE: Compute dissolved oxygen (SBE43).

BINAVG: Average the data into 1-dbar pressure bins, 1-m depth 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 density (sigma-theta).

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

(4) Station list

During this cruise, 113 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 6.6-1.

(5) Preliminary Results

During this cruise, 113 casts of CTD observation were carried out at the stations of the moorings, ARGO float deployments, and stationary observation. Date, time and locations of the CTD casts are listed in Table 6.6.1. Time-depth diagrams of primary temperature, salinity, and fluorescence are shown in Fig. 6.6-1. Vertical profiles of primary temperature, salinity and dissolved oxygen (down cast) are shown as additional figures in Appendix-A.

Table 6.6-1 Date, time and locations of the CTD casts

Stnnbr	CastNo	Date(UTC)	Time(UTC)		Bottom Position		Depth	Wire	Max	Max	CTD
		(mmddyy)	Start	End	Latitude	Longitude	(m)	Out (m)	Depth (m)	Pressure (dbar)	Filename
B01	1	060321	19:34	20:14	00-01.65N	155-57.94E	1958.0	994.1	994.1	1002.0	B01M001
B02	1	060921	20:36	21:17	07-52.31N	136-28.28E	3352.0	993.8	993.0	1001.0	B02M001
A01	2	061021	06:37	07:40	07-52.21N	136-28.40E	3351.0	1981.4	1980.3	2001.0	A01M002
B03	1	061221	06:06	06:44	13-06.74N	136-54.05E	5030.0	993.8	992.8	1001.0	B03M001
A02	1	061521	00:00	01:10	13-10.05N	136-26.20E	4769.0	1979.4	1980.0	2001.0	A02M001
STN	1	061621	00:17	01:14	13-08.11N	136-30.99E	5458.0	991.7	992.8	1001.0	STNM001
STN	2	061621	03:17	03:40	13-07.92N	136-29.39E	5514.0	495.4	496.5	500.0	STNM002
STN	3	061621	06:13	06:35	13-07.47N	136-30.24E	5510.0	497.6	500.5	504.0	STNM003
STN	4	061621	09:15	09:37	13-07.40N	136-30.29E	5508.0	496.0	497.5	501.0	STNM004
STN	5	061621	12:14	12:52	13-08.29N	136-30.54E	5531.0	497.8	497.5	501.0	STNM005
STN	6	061621	15:14	15:36	13-07.19N	136-30.14E	5505.0	496.0	496.5	500.0	STNM006
STN	7	061621	18:17	18:39	13-07.03N	136-29.96E	5493.0	498.7	500.5	504.0	STNM007
STN	8	061621	21:14	21:35	13-07.09N	136-30.42E	5507.0	498.0	500.5	504.0	STNM008
STN	9	061721	00:14	01:11	13-06.89N	136-30.32E	5499.0	994.3	993.8	1002.0	STNM009
STN	10	061721	03:21	03:43	13-06.92N	136-29.99E	5500.0	498.2	499.5	503.0	STNM010
STN	11	061721	06:15	06:36	13-07.08N	136-29.95E	5497.0	498.0	500.5	504.0	STNM011
STN	12	061721	09:13	09:34	13-06.81N	136-30.01E	5498.0	497.2	500.5	504.0	STNM012
STN	13	061721	12:14	12:53	13-07.49N	136-30.17E	5510.0	498.7	500.5	504.0	STNM013
STN	14	061721	15:15	15:37	13-06.98N	136-30.26E	5500.0	498.5	499.5	503.0	STNM014
STN	15	061721	18:15	18:36	13-06.95N	136-29.77E	5489.0	499.3	500.5	504.0	STNM015
STN	16	061721	21:15	21:36	13-06.97N	136-29.85E	5491.0	497.1	499.5	503.0	STNM016
STN	17	061821	00:15	01:10	13-07.08N	136-29.66E	5482.0	991.7	992.8	1001.0	STNM017
STN	18	061821	03:14	03:35	13-07.00N	136-29.89E	5493.0	498.0	500.5	504.0	STNM018
STN	19	061821	06:13	06:35	13-07.33N	136-29.36E	5495.0	495.4	497.5	501.0	STNM019
STN	20	061821	09:12	09:34	13-08.23N	136-29.92E	5526.0	499.1	500.5	504.0	STNM020
STN	21	061821	12:13	12:57	13-07.56N	136-29.58E	5489.0	496.7	496.5	500.0	STNM021
STN	22	061821	15:14	15:36	13-07.06N	136-29.90E	5495.0	497.1	497.5	501.0	STNM022
STN	23	061821	18:14	18:36	13-06.98N	136-30.10E	5499.0	498.3	500.5	504.0	STNM023
STN	24	061821	21:14	21:35	13-07.11N	136-29.89E	5497.0	497.4	497.5	501.0	STNM024
STN	25	061921	00:14	01:12	13-07.18N	136-30.08E	5501.0	996.0	994.8	1003.0	STNM025
STN	26	061921	03:14	03:36	13-06.94N	136-29.89E	5494.0	497.1	499.5	503.0	STNM026

STN	27	061921	06:14	06:35	13-06.67N	136-29.82E	5490.0	498.2	499.5	503.0	STNM027
STN	28	061921	09:12	09:34	13-06.68N	136-29.18E	5485.0	496.7	497.5	501.0	STNM028
STN	29	061921	12:12	12:55	13-07.02N	136-29.36E	5476.0	494.9	496.5	500.0	STNM029
STN	30	061921	15:14	15:36	13-06.35N	136-29.90E	5498.0	495.6	497.5	501.0	STNM030
STN	31	061921	18:14	18:35	13-06.93N	136-29.78E	5490.0	496.7	497.5	501.0	STNM031
STN	32	061921	21:14	21:36	13-07.50N	136-29.72E	5497.0	497.2	498.5	502.0	STNM032
STN	33	062021	00:14	01:08	13-06.71N	136-30.00E	5496.0	992.1	991.8	1000.0	STNM033
STN	34	062021	03:13	03:35	13-06.74N	136-29.88E	5493.0	494.7	496.5	500.0	STNM034
STN	35	062021	06:14	06:35	13-07.27N	136-30.19E	5506.0	497.4	499.5	503.0	STNM035
STN	36	062021	09:12	09:34	13-06.14N	136-29.33E	5481.0	496.0	498.5	502.0	STNM036
STN	37	062021	12:16	13:01	13-07.52N	136-29.55E	5488.0	496.0	496.5	500.0	STNM037
STN	38	062021	15:14	15:37	13-07.50N	136-30.05E	5509.0	497.2	498.5	502.0	STNM038
STN	39	062021	18:16	18:38	13-07.07N	136-29.89E	5496.0	496.7	497.5	501.0	STNM039
STN	40	062021	21:14	21:36	13-07.51N	136-29.94E	5507.0	498.2	499.5	503.0	STNM040
STN	41	062121	00:22	01:18	13-07.56N	136-29.68E	5489.0	992.3	992.8	1001.0	STNM041
STN	42	062121	03:14	03:36	13-07.35N	136-30.05E	5502.0	497.8	499.5	503.0	STNM042
STN	43	062121	06:14	06:35	13-06.81N	136-30.22E	5502.0	496.9	498.5	502.0	STNM043
STN	44	062121	09:12	09:33	13-07.47N	136-29.67E	5487.0	496.9	498.5	502.0	STNM044
STN	45	062121	12:13	12:57	13-07.02N	136-30.46E	5501.0	494.5	496.5	500.0	STNM045
STN	46	062121	15:14	15:36	13-07.15N	136-30.19E	5504.0	495.6	497.5	501.0	STNM046
STN	47	062121	18:14	18:36	13-07.08N	136-30.17E	5508.0	498.5	497.5	501.0	STNM047
STN	48	062121	21:14	21:35	13-07.28N	136-30.94E	5449.0	498.7	498.5	502.0	STNM048
STN	49	062221	00:13	01:08	13-06.89N	136-30.24E	5499.0	993.6	992.8	1001.0	STNM049
STN	50	062221	03:14	03:35	13-07.02N	136-30.14E	5498.0	496.3	498.5	502.0	STNM050
STN	51	062221	06:14	06:35	13-06.68N	136-29.83E	5491.0	497.4	497.5	501.0	STNM051
STN	52	062221	09:11	09:32	13-07.01N	136-29.97E	5497.0	496.0	497.5	501.0	STNM052
STN	53	062221	12:13	12:57	13-05.54N	136-29.25E	5496.0	496.1	497.5	501.0	STNM053
STN	54	062221	15:14	15:36	13-07.18N	136-30.02E	5503.0	498.2	498.5	502.0	STNM054
STN	55	062221	18:16	18:38	13-07.07N	136-30.16E	5503.0	498.3	500.5	504.0	STNM055
STN	56	062221	21:14	21:35	13-06.99N	136-29.98E	5499.0	499.1	499.5	503.0	STNM056
STN	57	062321	00:14	01:09	13-07.16N	136-30.04E	5500.0	993.2	992.8	1001.0	STNM057
STN	58	062321	03:14	03:35	13-06.89N	136-29.71E	5486.0	497.6	497.5	501.0	STNM058
STN	59	062321	06:14	06:35	13-07.78N	136-29.69E	5500.0	498.5	497.5	501.0	STNM059
STN	60	062321	09:12	09:33	13-07.72N	136-30.16E	5516.0	498.0	500.5	504.0	STNM060
STN	61	062321	12:13	12:56	13-07.60N	136-29.45E	5499.0	496.0	497.5	501.0	STNM061
STN	62	062321	15:14	15:36	13-07.47N	136-30.20E	5510.0	497.2	499.5	503.0	STNM062
STN	63	062321	18:14	18:36	13-07.14N	136-30.22E	5502.0	498.3	500.5	504.0	STNM063
STN	64	062321	21:13	21:35	13-06.98N	136-30.20E	5498.0	497.4	498.5	502.0	STNM064
STN	65	062421	00:14	01:09	13-06.97N	136-30.30E	5500.0	993.0	992.8	1001.0	STNM065
STN	66	062421	03:14	03:35	13-06.85N	136-30.43E	5502.0	495.8	497.5	501.0	STNM066

STN	67	062421	06:14	06:35	13-07.06N	136-29.96E	5496.0	496.5	497.5	501.0	STNM067
STN	68	062421	09:11	09:32	13-07.27N	136-30.56E	5510.0	495.6	498.5	502.0	STNM068
STN	69	062421	12:12	12:54	13-08.11N	136-30.09E	5526.0	494.3	496.5	500.0	STNM069
STN	70	062421	15:14	15:36	13-06.69N	136-30.14E	5499.0	497.6	498.5	502.0	STNM070
STN	71	062421	18:14	18:36	13-06.80N	136-29.93E	5495.0	498.3	499.5	503.0	STNM071
STN	72	062421	21:14	21:36	13-07.00N	136-30.35E	5505.0	498.2	498.5	502.0	STNM072
STN	73	062521	00:14	01:09	13-06.73N	136-29.96E	5498.0	993.6	991.8	1000.0	STNM073
STN	74	062521	03:14	03:36	13-07.04N	136-30.15E	5497.0	499.1	500.5	504.0	STNM074
STN	75	062521	06:14	06:35	13-06.74N	136-30.06E	5497.0	498.3	498.5	502.0	STNM075
STN	76	062521	09:12	09:34	13-06.74N	136-29.96E	5496.0	495.8	498.5	502.0	STNM076
STN	77	062521	12:12	12:53	13-06.10N	136-29.01E	5490.0	496.0	496.5	500.0	STNM077
STN	78	062521	15:13	15:35	13-07.21N	136-29.98E	5501.0	497.4	499.5	503.0	STNM078
STN	79	062521	18:14	18:36	13-07.29N	136-30.45E	5507.0	497.8	498.5	502.0	STNM079
STN	80	062521	21:14	21:36	13-06.95N	136-30.13E	5502.0	498.0	498.5	502.0	STNM080
STN	81	062621	00:14	01:08	13-06.95N	136-30.40E	5502.0	993.8	992.8	1001.0	STNM081
STN	82	062621	03:13	03:35	13-07.49N	136-30.11E	5506.0	496.7	498.5	502.0	STNM082
STN	83	062621	06:13	06:34	13-07.19N	136-30.02E	5498.0	498.7	499.5	503.0	STNM083
STN	84	062621	09:11	09:33	13-07.23N	136-30.06E	5505.0	497.6	496.5	500.0	STNM084
STN	85	062621	12:12	12:52	13-07.13N	136-29.74E	5489.0	496.0	496.5	500.0	STNM085
STN	86	062621	15:14	15:36	13-07.10N	136-29.46E	5474.0	496.3	497.5	501.0	STNM086
STN	87	062621	18:14	18:34	13-07.19N	136-29.96E	5501.0	498.5	499.5	503.0	STNM087
STN	88	062621	21:14	21:35	13-07.02N	136-30.25E	5500.0	498.3	500.5	504.0	STNM088
STN	89	062721	00:14	01:08	13-06.89N	136-30.11E	5498.0	993.8	992.8	1001.0	STNM089
STN	90	062721	03:13	03:36	13-06.81N	136-30.41E	5503.0	496.1	498.5	502.0	STNM090
STN	91	062721	06:13	06:35	13-06.82N	136-30.08E	5502.0	496.1	497.5	501.0	STNM091
STN	92	062721	09:11	09:33	13-07.04N	136-30.28E	5503.0	497.2	498.5	502.0	STNM092
STN	93	062721	12:12	12:51	13-07.09N	136-30.89E	5498.0	496.1	497.5	501.0	STNM093
STN	94	062721	15:13	15:35	13-07.04N	136-29.07E	5477.0	496.5	496.5	500.0	STNM094
STN	95	062721	18:16	18:38	13-07.04N	136-29.87E	5495.0	496.9	497.5	501.0	STNM095
STN	96	062721	21:14	21:36	13-06.81N	136-29.79E	5487.0	499.6	498.5	502.0	STNM096
STN	97	062821	00:13	01:08	13-08.52N	136-29.96E	5545.0	1007.4	991.8	1000.0	STNM097
STN	98	062821	03:13	03:36	13-07.04N	136-29.94E	5497.0	496.5	499.5	503.0	STNM098
STN	99	062821	06:14	06:36	13-06.97N	136-29.71E	5484.0	497.6	499.5	503.0	STNM099
STN	100	062821	09:12	09:33	13-06.84N	136-29.81E	5491.0	496.7	498.5	502.0	STNM100
STN	101	062821	12:12	12:53	13-07.25N	136-29.98E	5485.0	496.3	496.5	500.0	STNM101
STN	102	062821	15:14	15:37	13-06.98N	136-29.50E	5474.0	495.2	496.5	500.0	STNM102
STN	103	062821	18:14	18:36	13-07.14N	136-30.01E	5496.0	496.7	497.5	501.0	STNM103
STN	104	062821	21:14	21:36	13-07.03N	136-30.02E	5498.0	499.1	500.5	504.0	STNM104
STN	105	062921	00:13	01:06	13-06.99N	136-30.02E	5501.0	993.0	992.8	1001.0	STNM105
B04	1	062921	10:38	11:17	12-53.66N	136-50.92E	5054.0	993.8	991.9	1000.0	B04M001

A03	1	070221	05:05	06:13	17-00.33N	139-35.87E	4290.0	1992.8	1981.6	2003.0	A03M001
A04	1	070321	15:36	16:43	24-00.12N	139-29.88E	4766.0	1981.1	1978.8	2001.0	A04M001

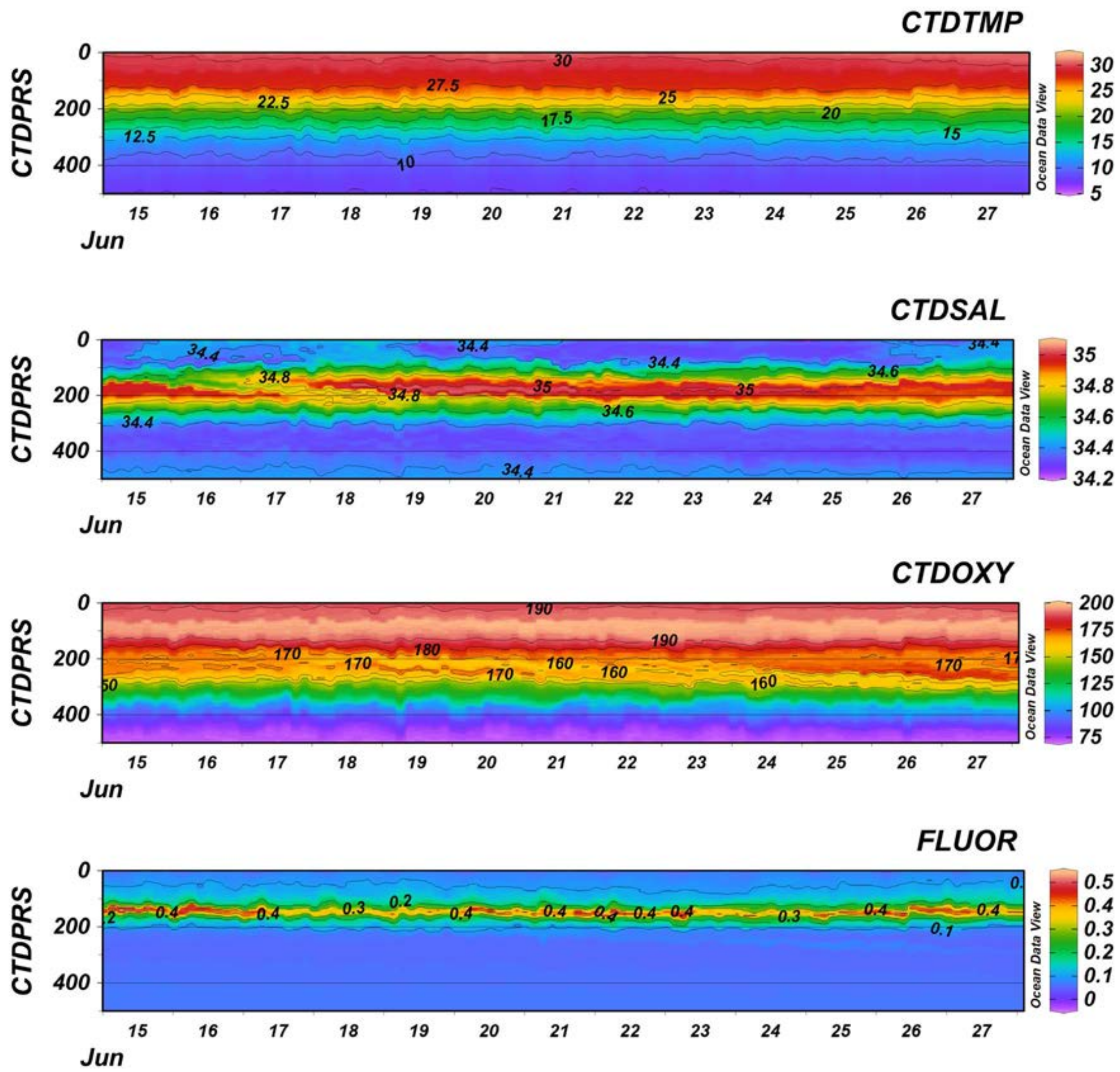


Fig. 6.6-1 Time-depth diagrams of temperature, salinity, oxygen and fluorescence during the stationary observation (STNM001 ~ STNM105).

(6) 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).

6.7. XCTD

(1) Personnel

Iwao Ueki (JAMSTEC) PI
Satomi Ogawa (NME) Operation Leader
Kazuho Yoshida (NME)
Ryo Oyama (NME)
Yutaro Murakami (NME)
Takatomo Shirozume (MIRAI Crew)

(2) Objectives

To obtain vertical profiles of sea water temperature and salinity (calculated by the function of temperature, pressure (depth), and conductivity.

(3) Method and instrumentation

We observed the vertical profiles of the water temperature and conductivity by XCTD system. We launched XCTD-1 (eXpendable Conductivity, Temperature & Depth profiler; Tsurumi-Seiki Co.) probes by using the automatic launcher, MK-150N digital converter (Tsurumi-Seiki Co.) and AL-12B software (Ver.1.6.3; Tsurumi-Seiki Co.). Specifications of XCTD-1 probe are as follows;

Conductivity
range: 0 ~ 60 [mS/cm]
accuracy: +/- 0.03 [mS/cm]

Temperature
range: -2 ~ 35 [deg-C]
accuracy: +/- 0.02 [deg-C]

Depth
range: 0 ~ 1000 [m]
accuracy: 5 [m] or 2 [%] (whichever is greater)

The summary of XCTD observations are shown in Table 6.7-1.

Table 6.7-1 Summary of XCTD observation and launching log

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [deg]	Longitude [deg]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
1	1	2021/06/11	08:59	13-05.1577	137-02.7433	4617	30.012	34.277	20025888
2	2	2021/06/13	04:26	13-01.8420	136-46.2611	4676	30.341	34.272	20025889

Depth: The depth of water [m]
SST: Sea Surface Temperature [deg-C] measured by TSG (ThermoSalinoGraph).
SSS: Sea Surface Salinity [PSU] measured by TSG.

(4) Preliminary Resurts

Figure 6.7-1 and Fig 6.7-2 shows the vertical profile of temperature, salinity, sound velocity and density.

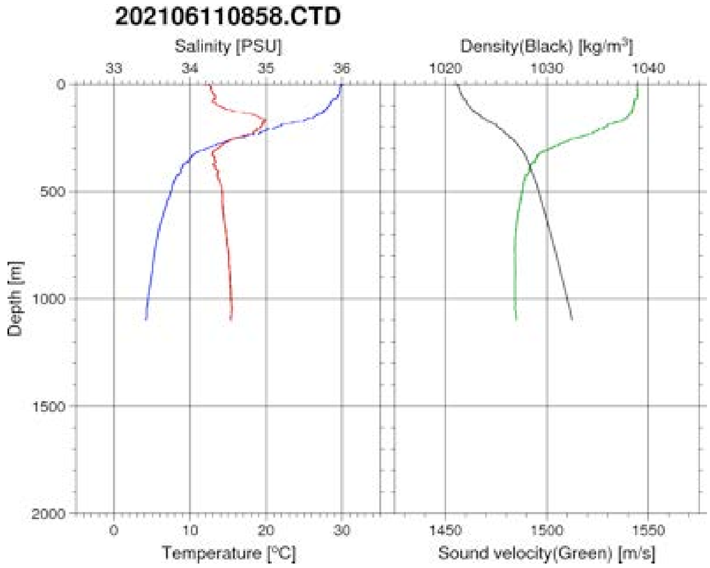


Fig.6.7-1 Vertical profile of (left) Temperature and salinity, and (right) density and sound speed at XCTD station #1.

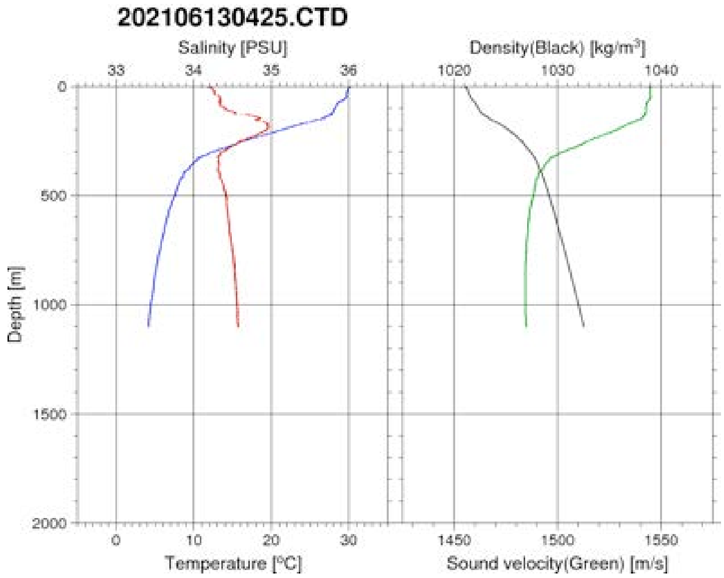


Fig.6.7-2 Vertical profile of (left) Temperature and salinity, and (right) density and sound speed at XCTD station #2.

(5) Data archive

All 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).

6.8. Water sampling

6.8.1. Salinity

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Masahiro Orui	(MWJ) Operation Leader
Hiroki Ushiromura	(MWJ)
Shungo Oshitani	(MWJ)

(2) Objectives

To provide calibrations for the measurements of salinity collected from CTD casts and Continuous Sea Surface Water Monitoring System.

(3) Method

a. Salinity

Seawater sampling were conducted with 12-liter sample bottles and Continuous Sea Surface Water Monitoring System. For the salinity sampling, brown 250ml glass bottles with screw cap were used. Each bottle was rinsed 3 times with the sampled water, and was filled with sampled water to the bottle shoulder. To avoid deterioration of the sampled water, all of bottles were sealed with a plastic cone and a screw cap. The cones were also rinsed 3 times with the sampled seawater before use. Each bottle was stored for more than 12 hours in the laboratory before the salinity measurement.

The total number of bottles for sampled water is 108; 70 is for CTD samplings, 38 for Continuous Sea Surface Water Monitoring System samplings.

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise 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 B81550) were used. One thermometer monitored the ambient temperature and the other monitored the bath temperature. The specifications of the AUTOSAL salinometer and thermometer are listed as below.

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
Resolution	: 0.001
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 22 deg C to 24 deg C, while the bath temperature was very stable and varied within +/- 0.002 deg C on rare occasion. The measurement for each sample was done with a double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 5 seconds after filling the cell with the sample and it took about 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) Preliminary Resurts

a. Standard Seawater

Standardization control of the salinometer was set to 490 and all measurements were done at this setting. The value of STANDBY was 24+5957 ~ 5959 and that of ZERO was 0.0 - 0003 ~ 0004. The conductivity ratio of IAPSO Standard Seawater batch P164 was 0.99985 (double conductivity ratio was 1.99970) and was used as the standard for salinity. 13 bottles of P164 were measured.

Figure 6.8.1-1 shows the time series of the double conductivity ratio of the Standard Seawater batch P164. The average of the double conductivity ratio was 1.99972 and the standard deviation was 0.00001 which is equivalent to 0.0003 in salinity.

Figure 6.8.1-2 shows the time series of the double conductivity ratio of the Standard Seawater batch P164 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 0.0003 in salinity.

The specifications of Standard Sea Water (SSW) used in this cruise are listed as below.

batch	: P164
conductivity ratio	: 0.99985
salinity	: 34.994
use by	: 23rd March 2023

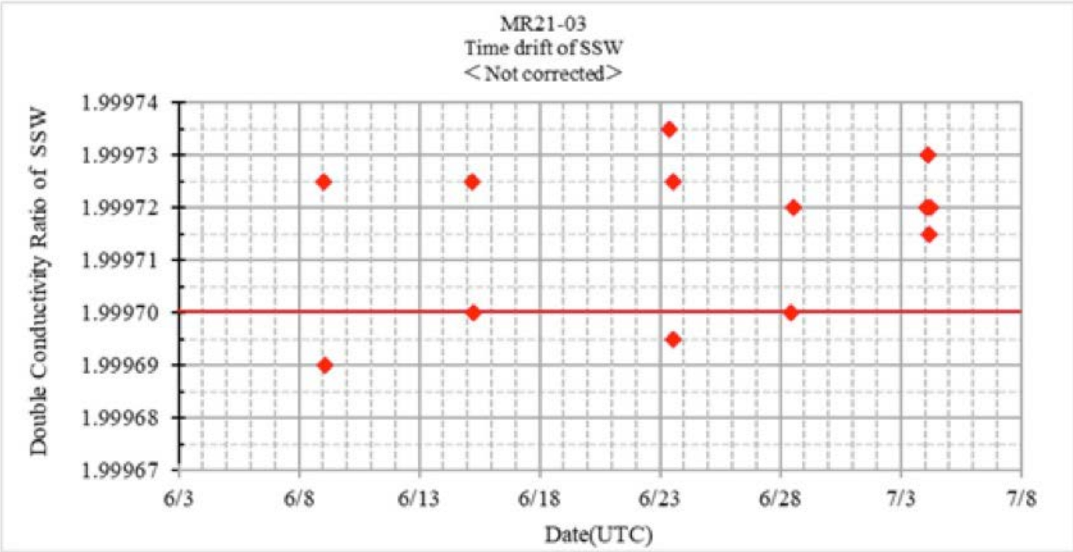


Fig. 6.8.1-1: Time series of double conductivity ratio for the Standard Seawater batch P164 (before correction)

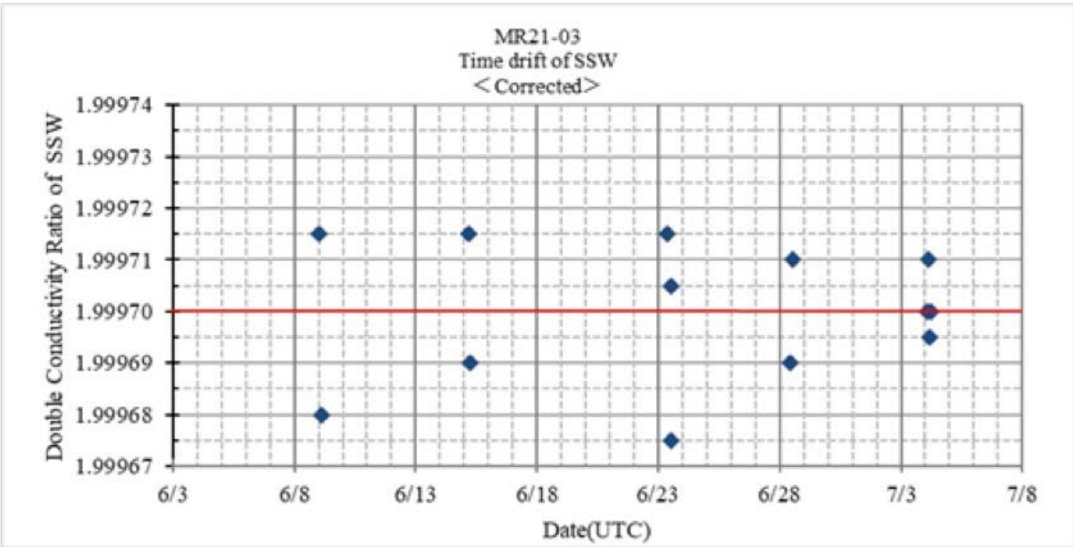


Fig. 6.8.1-2: Time series of double conductivity ratio for the Standard Seawater batch P164 (after correction)

b. Sub-Standard Seawater

Sub-standard seawater was made from Surface-sea water filtered by a pore size of 0.22 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 35 pairs of replicate samples taken from the same sample bottle. The average and the standard deviation of absolute difference among 35 pairs of replicate samples were 0.00064 and 0.00060 in salinity, respectively.

(5) 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).

(6) References

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

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

6.8.2. Dissolved Oxygen

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Erii Irie	(MWJ) Operation Leader
Tomomi Sone	(MWJ)

(2) Objectives

Determination of dissolved oxygen in seawater by Winkler titration.

(3) Method

Based on Winkler method (Dickson, 1996; Culberson, 1991), following procedure has been conducted.

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 transfering 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.

(4) Observation log

a. Standardization and determination of the blank

Table 6.8.2-1 shows results of the standardization and the blank determination during this cruise.

Table 6.8.2-1 Results of the standardization and the blank determinations during cruise

Date	Potassium iodate	Sodium thiosulfate	DOT-01X (No.9)		Stations
(yyyy/mm/dd)	ID	ID	E.P. (cm^3)	Blank (cm^3)	
2021/05/27	K20E03	T-21A	3.957	-0.006	
2021/06/01	K20E04	T-21A	3.958	-0.006	
2021/06/07	K20E05	T-21A	3.959	-0.005	
2021/06/13	K20E06	T-21A	3.960	-0.004	M001, M005, M009, M013, M017, M021, M025
2021/06/13	K20E06	T-21B	3.950	-0.004	M029, M033, M037, M041, M045, M049, M053, M057, M061, M065, M069, M073
2021/06/19	K20E07	T-21B	3.949	-0.006	M077, M081, M085, M089, M093, M097, M101, M105
2021/06/25	K20E08	T-21B	3.957	-0.005	
2021/06/30	K20E09	T-21B	3.951	-0.003	
2021/07/03	K20F01	T-21B	3.950	-0.005	

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 0.08 μmol kg^{-1} (n=54).

(5) 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).

(6) References

Culberson, C. H., Dissolved Oxygen. *WHPO Publication* **91-1**, 1991.

Dickson, A. G., 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**, 1996.

Dickson, A. G., Sabine, C. L., & Christian, J. R.(Eds.), Guide to best practices for ocean CO_2 measurements, PICES Special Publication 3: *North Pacific Marine Science Organization*, 2007.

Murray, C. N., Riley, J. P., & Wilson, T. R. S., The solubility of oxygen in Winklerreagents used for the determination of dissolved oxygen. *Deep Sea Res.*, **15**, 237-238, 1968.

6.8.3. Chrolophyll *a*

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Tomomi Sone	(MWJ) Operation Leader
Erii Irie	(MWJ)

(2) Objectives

We measured total chlorophyll *a* in seawater by using the fluorometric method.

(3) Method

We collected samples for total chlorophyll *a* from 9 depths between the surface and 200 m including the chlorophyll *a* maximum layer within 200 m depth. The chlorophyll *a* maximum layer was determined by a Chlorophyll Fluorometer (Seapoint Sensors, Inc) attached to the CTD system.

Seawater samples for total chlorophyll *a* were vacuum-filtrated (< 0.02 MPa) through glass microfiber filter (Whatman GF/F filter, 25mm-in diameter). Phytoplankton pigments were immediately extracted in a polypropylene tube with 7 ml of *N*,*N*-dimethylformamide (FUJIFILM Wako Pure Chemical Corporation Ltd.) from phytoplankton retained on the filters (Suzuki and Ishimaru, 1990). The tubes were stored at -20 °C under the dark condition to extract chlorophyll *a* at least for 24 hours.

Chlorophyll *a* concentrations were measured by the fluorometer (10-AU, TURNER DESIGNS), which was previously calibrated against a pure chlorophyll *a* (Sigma-Aldrich Co., LLC). To estimate the chlorophyll *a* concentrations, we applied to the fluorometric "Non-acidification method" (Welschmeyer, 1994).

(4) Preliminary results

During stationary observation, 270 samples were collected at the 27 casts. Time-depth diagram of chlorophyll *a* at the stationary observation site is shown in Fig. 6.8.3-1. At each cast, replicate samples were collected from sampled water of chlorophyll *a* maximum layer. The number of replicate sample pairs are 27, and both mean and standard deviation of difference between the sample pairs are 0.0 μg L^{-1}.

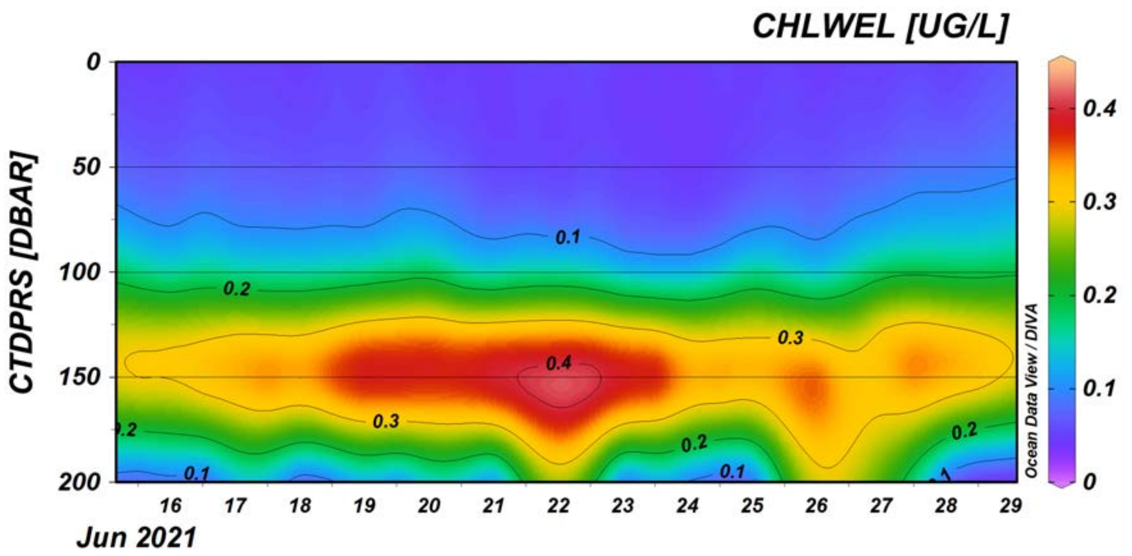


Fig. 6.8.3-1. Time-depth diagram of total chlorophyll *a* at stationary observation site.

(5) 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).

(6) References

Suzuki, R., & Ishimaru T., An improved method for the determination of phytoplankton chlorophyll using N, N-dimethylformamide. *J. Oceanogr. Soc. Japan*, 46, 190-194, 1990.

Welschmeyer, N. A., Fluorometric analysis of chlorophyll *a* in the presence of chlorophyll *b* and pheopigments. *Limnol. Oceanogr.* 39(8), 1985-1992, 1994.

6.9. LADCP

(1) Personnel

Akira Nagano	(JAMSTEC) PI
Iwao Ueki	(JAMSTEC)
Shungo Oshitani	(MWJ)
Masahiro Orui	(MWJ)
Akira So	(MWJ)
Hiroki Ushiromura	(MWJ)
Airi Hara	(MWJ)
Masaki Furuhata	(MWJ)
Masaki Yamada	(MWJ)
Makito Yokota	(MWJ)

(2) Objectives

To obtain horizontal current velocity in high vertical resolution.

(3) Instrumentation

A lowered acoustic doppler current profiler (LADCP) was integrated with the CTD system. The instrument used in this cruise was a Teledyne RD Instruments Workhorse Sentinel 600 kHz ADCP (WHS600-I-UG177, S/N 14557).

The instrument was powered during the CTD casts by a battery pack and has 4 downward-looking transducers with 20-degree beam angles, make direct current measurements at a 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).

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

Depth cell size (in cm): 200 (For sites BUOY02 and 03: 400)
Number of Depth cells: 25
Pings per ensemble: 1
Time between pings in mm:ss: 00:00.25 (For sites BUOY03: 00:01)
Bandwidth: broad (For sites BUOY04: narrow)

(4) Preliminary results

By the inverse method developed by Visbeck (2002), we obtained the absolute current velocity vector profiles (Fig. 6.9-1). The North Equatorial Current (NEC) is illustrated as a westward current in a layer from the sea surface to a depth of approximately 500 dbar. In addition to the diurnal variations possibly due to the tides, the upward phase propagation of internal gravity waves was observed in the main thermocline between depths of approximately 150 and 300 dbar.

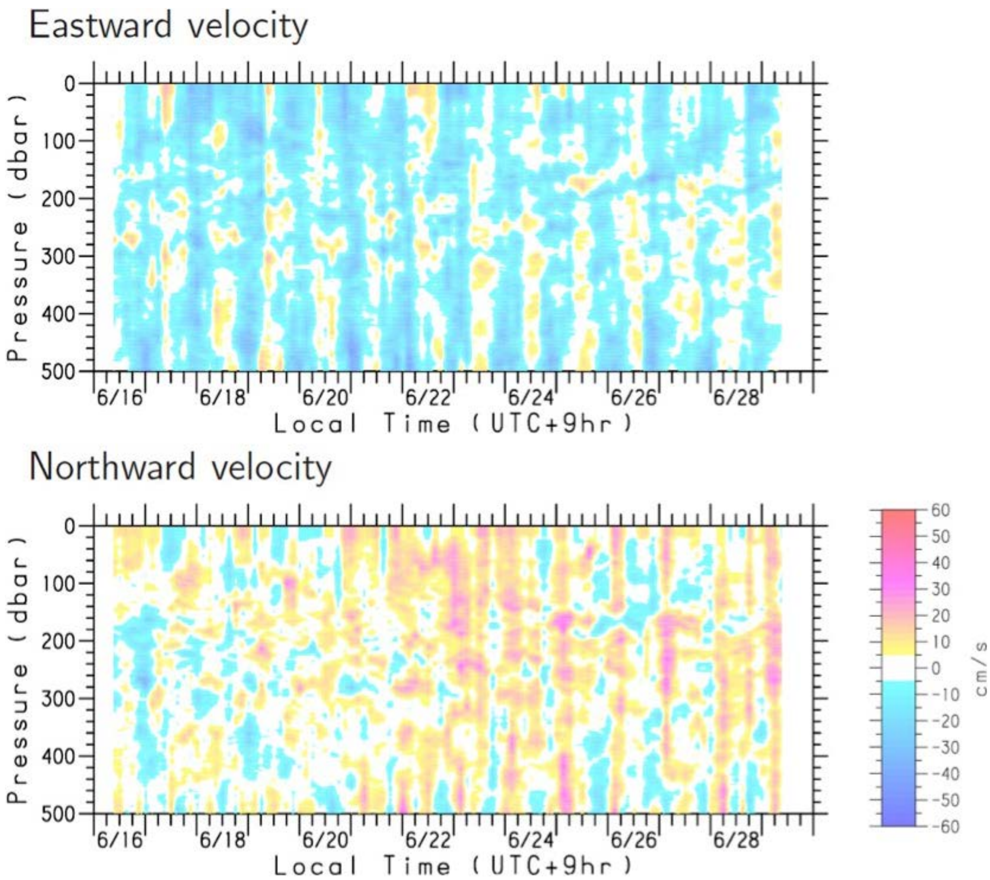


Fig. 6.9-1: Time-pressure diagrams of (a) eastward and (b) northward current velocity components. The abscissa is local time at the observation site (UTC+9hr).

(5) 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).

(6) References

Visbeck, M., Deep velocity profiling using Lowered Acoustic Doppler Current Profilers: Bottom track and inverse solutions. *J. Atmos. Oceanic Technol.*, **19**, 794-807, 2020.

6.10. JES10 experiments

(1) Personnel

Kensuke Watari	(JAMSTEC) PI
Makito Yokota	(MWJ)
Masaki Furuhata	(MWJ)

(2) Objectives

"JES10mini" is a small CTD sensor designed by JAMSTEC(Fig.6.10-1). This sensor can be used for mooring, casting and so on. To evaluate and test the new observation way for the JES10mini several experiments were conducted. The former is CTD casting with SBE-9plus sensor, the latter is towing observation with many JES10mini sensors for cross section observation.

Fig. 6.10-1 JES10mini CTD sensor

(3) Method and instrumentation

As shown in Fig. 6.10-2, the comparative observation of the CTD sensor was carried out by attaching the sensor with the frame of the CTD system. The maximum observation depth was 1000 m, and the parameters of 6 sensors were changed to evaluate the variation in performance and quality. Details of the comparative observation are summarized in Table 6.10-1. For towing observation of CTD sensors, up to 8 CTD sensors were attached with a rope of about 200 m and towed at 1.5 knot. Observations were conducted 5 times around the 13˚N and 13.5˚N 137˚E and length of each section is about 1 km.

Fig. 6.10-2 comparative observation

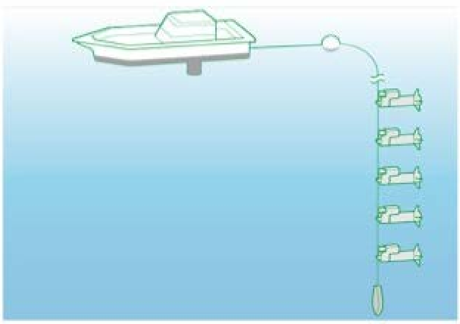


Fig. 6.10-3 Schematic of towing observation

Table 6.10-1 Summary of the comparative observation

Direction	Serial Number					
(depth)	005	006	015	016	017	018
Up (500 m)	6/21 STN043	6/21 STN043	6/23 STN058	6/23 STN058	6/23 STN058	6/23 STN058
Down (500 m)	6/18 STN019	6/23 STN060	6/23 STN060	6/23 STN060	6/23 STN060	6/17 STN012
						6/19 STN027
Up (500 m)	6/21 STN045	6/21 STN045	6/22 STN053	6/21 STN045	6/20 STN037	6/20 STN037
					6/21 STN045	6/21 STN045
Down (500 m)	-	-	-		-	6/25 STN073
						6/26 STN081

(4) Preliminary results

Figure 6.10-4 and 6.10-5 were examples for results of comparison between JES10mini and SBE-9Plus. As shown in those figures, difference of the observed profiles were relatively small. Figure 6.10-6 shows an example for time series of towing observation pressue, temperature, conductivity and salinity during towing observation. In the stable state, the pressure change is suppressed to ±0.7dbar, which is the same tendency as the profile.

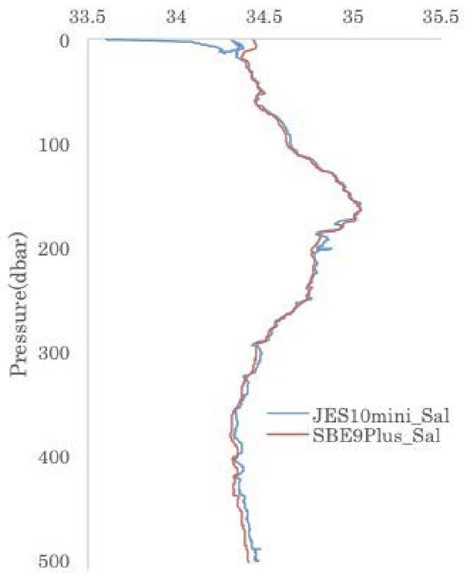


Fig.6.10-4 An example for result of salinity comparison

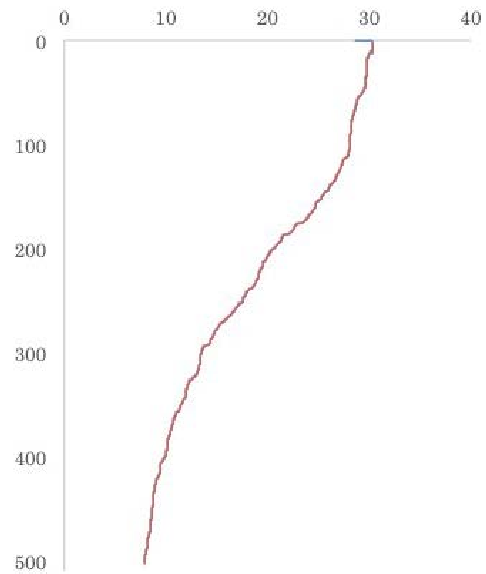


Fig.6.10-5 As same as Fig. 6.10-4, but for temperature

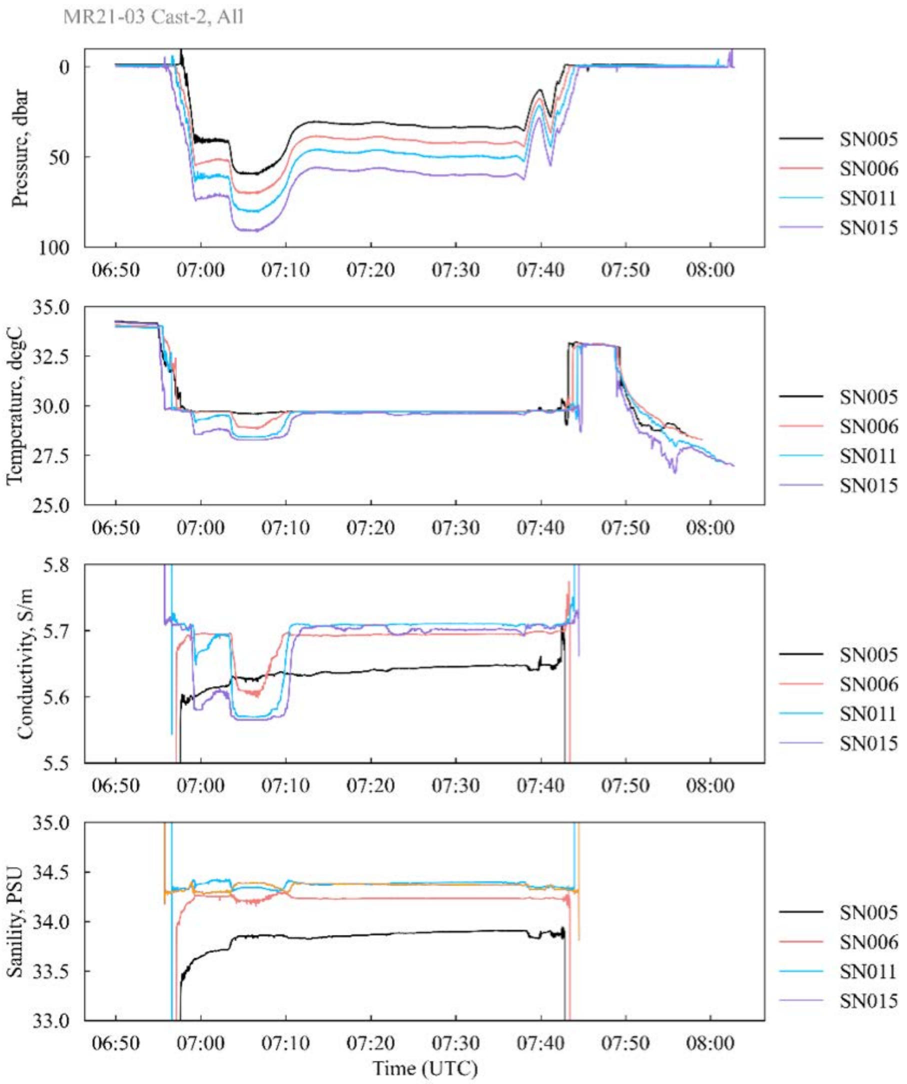


Fig 6.10-6 Time series of pressure, temperature, conductivity and salinity during towing observation.

(5) 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).

6.11. GPS radio sonde observation

(1) Personnel

Masaki Katsumata	(JAMSTEC) PI
Biao Geng	(JAMSTEC)
Kyoko Taniguchi	(JAMSTEC)
Satomi Ogawa	(NME) Operation Leader
Kazuho Yoshida	(NME)
Ryo Oyama	(NME)
Yutaro Murakami	(NME)
Takatomo Shirozume	(MIRAI Crew)

(2) Objectives

To obtain atmospheric profile of temperature, humidity, and wind speed/direction, and their temporal variation.

(3) Method

Atmospheric sounding by radiosonde by using system by Vaisala Oyj was carried out. The GPS radiosonde sensor RS-41SGP was utilized. The on-board system to calibrate, to launch, to log the data and to process the data is MW41, which consists of processor (Vaisala, SPS-311), processing and recording software (MW41, ver.2.11.0), GPS antenna (GA20), UHF antenna (RB21), ground check kit for RS41 (RI41), pressure sensor for ground check (Vaisala PTB-330), and balloon launcher (ASAP). The sensor was launched with balloon (Totex TA-200). When the relative wind to the ship (launcher) was not appropriate to use the ASAP, the handy launch was selected. In addition, three launches were made to replace the regular launches as above by attaching RS41 to other special sensors and larger balloon (Totex TA-1000) as in Section 6.12.

The radiosondes were launched every 3 hours from 00UTC on Jun. 15, to 00UTC on Jul. 2, when the vessel was at or around the station (13˚N, 137˚E). Before and after the period, launches at every 6 hours were made from 00UTC on Jun. 12 to 00UTC on Jun. 15 (near the station), and 00UTC on Jul. 2 to 12UTC on Jul. 5 (when steaming northbound). In addition, observations were carried out when the vessel was steaming southward, from 00UTC on May 27 to 00UTC on Jun. 2. In total, 184 soundings were carried out, as listed in Table 6.11-1.
In addition to the launches to obtain time series as described above, three experimental launches as in Table 6.11-2 were made with the larger balloons (TA-3000) (as in Section 6.12) to compare performances of RS41 and iMS-100 (Meisei Electronics Co., Ltd.) in the stratosphere.

Table 6.11-1: Radiosonde launch log, with surface values, cloud condition when launch, and reached maximum height. The gray-shaded rows indicate the launches with special sensors as in Section 6.12 (see additional ID number for observation number in Section 6.12).

ID	Nominal Time YYYYMMDDhh	Launched Locatio		Surface Values					Max Height	Clouds	
		Lat.	Lon.	P	T	RH	WD	WS			
		deg.N	deg.E	hPa	deg.C	%	deg.	m/s	m	Amount	Types
RS001	2021052700	31.253	140.665	1009.8	23.4	85	183	11.3	23627	10	Cu,St
RS002	2021052706	30.184	141.308	1008.2	24.8	94	204	15.0	25538	3	St,Ci
RS003	2021052712	29.296	141.890	1011.2	24.5	97	199	12.1	24224	1	St
RS004	2021052718	29.249	142.463	1012.0	25.3	95	198	9.6	24266	1	N/A
RS005	2021052800	27.205	143.067	1014.1	26.6	92	203	6.5	25749	2	Cu,As

RS006	2021052806	26.169	143.656	1012.7	26.9	89	174	7.7	25741	2	Sc,St
RS007	2021052812	25.225	144.181	1013.4	26.8	89	128	4.1	24577	1	Cu,St,Cs
RS008	2021052818	24.119	144.827	1012.2	27.7	80	155	5.1	25998	1	Sc
RS009	2021052900	23.049	145.432	1012.4	27.9	81	148	9.1	24815	3	Cu,Sc
RS010	2021052912	21.065	146.434	1011.4	27.6	83	98	13.8	24823	2	–
RS011	2021052918	20.046	147.075	1010.0	28.2	79	125	9.5	24507	2	Cu,As
RS012	2021053000	19.100	141.617	1010.0	28.7	75	114	10.7	26008	3	Sc,Cu
RS013	2021053012	17.324	148.566	1009.9	28.5	81	107	9.6	26130	1	–
RS014	2021053018	16.378	149.098	1008.9	28.4	79	104	10.1	26467	1	Cu, Sc
RS015	2021053100	15.344	149.645	1009.4	28.8	78	98	10.3	26083	3	Cu,Sc
RS016	2021053112	13.459	150.611	1008.7	28.8	77	78	6.3	26999	2	–
RS017	2021053118	12.464	151.182	1007.9	28.3	77	63	7.6	24182	1	Cu, Sc
RS018	2021060100	11.455	151.713	1010.0	28.4	78	86	9.2	25449	5	Cu,Sc,Cs,Ci
RS019	2021060112	9.512	152.723	1009.7	28.4	79	111	6.3	23608	3	–
RS020	2021060118	8.473	153.179	1008.7	28.2	79	60	7.3	23142	6	Cu,Sc, As, Ci
RS021	2021060200	7.314	153.558	1010.5	26.3	88	61	6.0	24460	10	Cu,Sc
RS022	2021061200	13.159	136.817	1011.0	28.6	83	94	5.1	25308	7	Cu,Sc,As,Ac
RS023	2021061206	13.109	136.946	1009.2	29.0	76	99	3.2	25463	5	Cu,Sc,As,Ac,Cc
RS024	2021061212	13.431	136.817	1010.7	28.9	78	81	4.5	22654	2	–
RS025	2021061218	13.077	136.699	1009.7	28.4	82	187	0.9	27871	1	–
RS026	2021061300	12.994	137.104	1011.1	28.6	79	341	1.1	26704	4	Cu,Sc,As,Ns
RS027	2021061306	13.040	136.773	1007.9	29.1	78	57	2.9	27485	3	Cu,Sc,As
RS028	2021061312	12.799	136.616	1009.5	29.6	72	64	4.5	25996	8	–
RS029	2021061318	13.247	137.133	1007.7	29.0	76	108	5.8	24250	1	–
RS030	2021061400	13.571	137.009	1009.2	29.3	77	113	4.1	26717	3	Cu,Sc,As,Cs
RS031	2021061406	13.159	136.460	1006.3	29.5	78	135	4.3	25893	4	Sc,Cu,Nb,As,Ns
RS032	2021061412	13.108	136.580	1008.0	28.9	78	138	2.8	26226	2	–
RS033	2021061418	13.117	136.573	1008.0	28.9	76	126	1.4	25326	1	–
RS034	2021061500	13.161	136.486	1008.4	29.1	78	143	5.1	26551	5	Cu,Sc,As,Cs
RS035	2021061503	13.157	136.426	1008.1	29.3	71	104	4.7	26141	6	Cu,Sc,Ns,As,Cs,Cc
RS036	2021061506	13.209	136.523	1007.6	27.8	84	150	2.2	24710	6	Sc,Su,Nb,Cs,Ns,As
RS037	2021061509	13.175	136.493	1007.2	29.2	82	182	3.6	25437	5	Cu,Nb,Ci,As
RS038	2021061512	13.210	136.508	1009.5	29.3	77	149	4.7	25073	4	Cu,As,Nb
RS039	2021061515	13.200	136.484	1009.7	29.2	78	150	4.2	24037	4	–
RS040	2021061518	13.186	136.482	1008.7	29.2	77	153	5.3	23767	1	Cu
RS041	2021061521	13.188	136.506	1009.0	28.9	78	165	5.4	24939	1	Cu
RS042	2021061600	13,139	136.513	1010.0	29.1	79	145	5.2	26133	5	Cu,Sc,Ns,As,Cs
RS043	2021061603	13.135	136.501	1009.9	29.2	78	163	4.7	26499	5	Cu,Sc,Cs
RS044	2021061606	13.129	136.510	1009.1	29.4	75	162	3.2	26103	3	Cu,Sc,Ns
RS045	2021061609	13.128	136.522	1009.6	29.3	76	104	1.0	26760	3	Cu,St,As,Ns
RS046	2021061612	13.140	136.514	1010.6	29.3	77	111	4.4	16387	2	Cu,As,St
RS047	2021061615	13.126	136.501	1010.4	29.2	75	113	5.0	22868	2	–
RS048	2021061618	13.125	136.509	1009.8	29.1	77	129	3.1	25614	1	–
RS049	2021061621	13.130	136.521	1010.3	28.9	77	135	1.6	25639	1	Cu, Ci
RS050	2021061700	13.128	136.519	1010.9	29.1	78	174	3.6	26336	5	Cu,Sc,Cs
RS051	2021061703	13.123	136.527	1009.9	29.2	76	150	3.1	26021	6	Cu,Sc,As,Cs
RS052	2021061706	13.127	136.524	1008.5	29.5	73	110	1.1	27573	7	Cu,Sc,As,Ns,Nb
RS053	2021061709	13.121	136.523	1008.9	29.4	74	147	0.7	26170	8	Cu,Ns,St,As,Ci
RS054 (SPS-01	2021061712	13.129	136.511	1011.9	29.5	71	50	0.5	29618	4	–
RS055	2021061715	13.125	136.512	1010.4	29.3	72	107	0.9	26492	5	–
RS056	2021061718	13.130	136.518	1008.9	29.1	71	104	1.3	24344	2	–
RS057	2021061721	13.128	136.514	1008.8	28.7	75	93	2.0	25711	2	Cu, Cb, Ci
RS058	2021061800	13.128	136.506	1009.2	29.0	75	125	2.5	25322	5	Cu,Sc,Ns,As,Cs,Ci
RS059	2021061803	13.106	136.483	1007.9	29.1	73	132	3.2	27591	4	Cu,Sc,As,Cs,Ci
RS060	2021061806	13.129	136.519	1007.1	29.4	73	290	2.9	27571	4	Cu,Sc,As,Ci,Cc,Cs
RS061	2021061809	13.131	136.494	1007.8	29.8	72	317	3.2	27164	3	Cu,Nb,St,Ci
RS062	2021061812	13.130	136.478	1009.5	28.6	78	94	4.2	25653	3	Cu,Nb,Ci
RS063	2021061815	13.136	136.504	1008.8	29.1	77	112	2.6	23567	1	As
RS064	2021061818	13.133	136.511	1007.1	28.9	77	142	3.8	26231	1	–
RS065	2021061821	13.119	136.527	1008.1	28.5	81	199	5.7	23372	3	Cu, Ci

RS066	2021061900	13.119	136.516	1009.0	29.2	76	167	4.8	26658	4	Nb,Cu,Sc,As,Cc,Cs
RS067	2021061903	13.119	136.485	1007.7	29.3	77	168	4.8	24481	6	Cu,Sc,Ns,As,Cs
RS068	2021061906	13.115	136.502	1006.8	29.5	75	183	6.0	24816	4	Cu,Sc,As,Ns,Cs
RS069	2021061909	13.120	136.499	1007.2	29.6	74	186	5.0	26392	3	Cu,Nb,As,Ci
RS070	2021061912	13.114	136.505	1008.9	29.4	75	199	3.8	27042	3	Cu,Nb
RS071	2021061915	13.107	136.525	1008.7	29.3	76	190	3.9	26666	3	Cu,Nb
RS072	2021061918	13.104	136.512	1007.0	29.0	77	201	4.8	27412	2	–
RS073	2021061921	13.117	136.499	1007.2	29.0	78	220	4.5	26731	2	Cu,Ci
RS074	2021062000	13.111	136.494	1008.7	29.2	76	193	3.5	24509	4	Cu,Sc,Ns.As,Cs
RS075	2021062003	13.091	136.512	1008.2	29.3	76	221	2.6	24565	3	Cu,Sc,Ns,As,Cs
RS076	2021062006	13.111	136.526	1007.4	28.5	78	328	2.5	27587	6	Cu,Sc,As,Ns
RS077	2021062009	13.115	136.492	1007.7	29.7	72	170	2.4	26059	7	Cu,Nb,As,Ci
RS078	2021062012	13.132	136.498	1009.2	29.4	76	129	2.1	26446	3	Cu,Nb,Ci,Cc,As
RS079	2021062015	13.132	136.497	1009.3	29.3	77	115	3.9	26931	3	Cu,Nb,Ci
RS080	2021062018	13.122	136.504	1007.4	28.6	77	125	3.7	24814	1	–
RS081	2021062021	13.135	136.520	1007.9	28.8	78	133	5.1	25946	1	Cu,As
RS082	2021062100	13.142	136.509	1009.3	28.4	79	164	5.0	26699	5	Ns,Cu,Sc,As
RS083	2021062103	13.142	136.511	1008.4	29.1	76	149	4.6	24347	3	Cu,Sc,Ns,As
RS084	2021062106	13.123	136.509	1007.1	29.5	73	153	3.0	25565	4	Cu,Sc,Ns
RS085	2021062109	13.126	136.500	1007.5	29.4	71	131	3.3	25496	6	Cu,Nb,As,Ci
RS086	2021062112	13.116	136.495	1009.2	28.2	83	81	7.3	25945	7	Nb,As,Ci
RS087	2021062115	13.132	136.507	1009.9	29.1	76	146	5.1	25076	4	Cu,Nb,Sc,As
RS088	2021062118	13.125	136.515	1008.6	28.5	77	147	2.0	26840	2	Cu,As?
RS089	2021062121	13.118	136.514	1009.6	28.7	75	161	3.8	19605	4	Cu,Nb,As,Ci
RS090	2021062200	13.118	136.518	1010.6	28.6	77	187	4.2	9806	7	Cu,Sc,Ac,As,Cs
RS091	2021062203	13.108	136.520	1010.0	29.0	76	183	3.3	25845	8	Cu,Sc,As,Cs
RS092	2021062206	13.113	136.517	1008.7	29.3	75	215	3.0	26497	9	Cu,Sc,Ns,As,Cs
RS093	2021062209	13.102	136.522	1009.1	28.6	78	245	3.9	25342	6	Cu,Nb,As,Ci,Cs
RS094	2021062212	13.088	136.493	1010.7	28.8	77	28	0.5	25166	4	Nb,As,Cs,Cu
RS095	2021062215	13.124	136.497	1010.3	28.8	77	0	0.2	25600	8	Cs,As,Cu
RS096	2021062218	13.125	136.503	1008.7	28.7	77	47	1.3	26273	6	Ci
RS097	2021062221	13.133	136.513	1009.1	28.5	77	123	0.8	23792	1	Cu,Ci
RS098	2021062300	13.120	136.523	1010.5	28.8	75	188	2.0	25338	5	Cu,Sc,As,Cs
RS099	2021062303	13.118	136.521	1010.4	29.2	73	143	0.9	26035	8	Cu,Sc,As,Cs
RS100	2021062306	13.115	136.502	1009.3	29.6	70	352	1.7	26133	4	Cu,Sc,As,Ns,Cs
RS101	2021062309	13.127	136.497	1008.6	29.6	71	284	0.7	26752	3	Cu,Nb,As,Ci
RS102 (SPS-01	2021062312	13.120	136.498	1011.7	29.5	73	267	1.4	32174	2	Cu,Nb,As,St,Cs
RS103	2021062315	13.119	136.508	1010.2	29.4	73	264	0.3	25345	7	Cu,Nb,St,Ci,As,Cs
RS104	2021062318	13.127	136.506	1008.9	29.0	73	75	0.1	24065	3	Cu, Nb, Ci
RS105	2021062321	13.127	136.503	1008.5	28.9	72	356	0.4	25196	3	Cu,Nb, Ci
RS106	2021062400	13.131	136.505	1009.6	29.2	71	178	0.5	24844	3	Cu,Sc,As,Cs,Ci,Nb
RS107	2021062403	13.105	136.524	1009.5	29.3	71	120	0.3	25503	2	Cu,Sc,Ns,As,Cs
RS108	2021062406	13.120	136.507	1007.6	30.1	65	316	0.9	25764	5	Cu,Sc,As,Ns,Ci,Cs
RS109	2021062409	13.123	136.519	1007.5	30.1	65	120	0.4	25272	2	Cu,Nb,As,Ci,Cs
RS110	2021062412	13.135	136.497	1008.9	29.3	76	178	2.7	26270	2	Cu,As,Nb,Ci,Cs
RS111	2021062415	13.110	136.498	1009.1	29.5	72	326	0.5	23895	3	Nb,Cu,As
RS112	2021062418	13.106	136.513	1008.2	27.5	84	282	4.5	25215	6	Cu, Nb, As
RS113	2021062421	13.107	136.520	1008.1	28.3	82	280	2.1	25904	3	Cu, Nb, Ci, Ac, As
RS114	2021062500	13.117	136.497	1009.5	28.4	73	310	0.7	26858	5	Cu,Sc,Nb,As,Ac,Cc,
RS115	2021062503	13.130	136.519	1008.9	28.9	77	133	1.5	26070	4	Cu,Sc,Nb,As,Cs
RS116	2021062506	13.090	136.498	1008.2	28.7	81	28	3.8	25052	6	Cu,Sc,Cs,As,Ns,Ci,C
RS117	2021062509	13.131	136.500	1008.2	29.2	78	31	0.7	26129	4	Nb,As,Cu,Ci,Sc
RS118 (SPS-02	2021062512	13.130	136.492	1011.1	29.3	77	57	1.2	32414	4	Cu,Nb,As,Cs
RS119	2021062515	13.113	136.488	1010.0	29.4	75	82	1.5	26530	4	Cu,Nb,Ci,Cs
RS120	2021062518	13.130	136.500	1008.3	29.3	74	53	1.8	25414	2	Cu,Sc, Nb, Ci
RS121	2021062521	13.124	136.502	1009.8	26.4	92	88	3.6	24526	9	Nb, Cu, ?
RS122	2021062600	13.130	136.500	1009.3	27.6	81	49	2.1	24735	8	Cu,As,Ac,Cs
RS123	2021062603	13.113	136.512	1009.7	29.0	78	74	3.5	25876	6	Cu,Sc,Nb,As.Cs
RS124	2021062606	13.117	136.498	1008.6	29.6	76	47	4.2	23632	8	Cu,Sc,Ns
RS125	2021062609	13.129	136.490	1008.4	29.7	79	64	11.6	24135	6	Cu,Nb,Cs,Sc,Ci

RS126	2021062612	13.131	136.495	1009.4	29.9	75	77	5.6	25493	7	Cu,Sc,Nb
RS127	2021062615	13.131	136.487	1009.5	29.6	75	86	6.6	24701	4	Cu,Nb,Sc
RS128	2021062618	13.135	136.496	1008.7	29.5	79	111	6.6	24501	4	Cu,Nb,As
RS129	2021062621	13.129	136.502	1009.0	29.5	81	125	7.2	26168	4	Cu,Sc,Nb,Cs,Ci
RS130	2021062700	13.127	136.507	1010.2	29.6	77	130	6.1	25399	4	Cu,Sc,Nb,Ns,As,Cs
RS131	2021062703	13.131	136.513	1008.8	29.8	75	125	5.4	26328	4	Cu,Sc,As,Cs,Ci
RS132	2021062706	13.124	136.510	1007.4	29.8	76	142	4.9	25413	8	Cu,Sc,AsAc
RS133	2021062709	13.128	136.512	1007.7	29.6	75	144	2.0	25571	5	Cu,Nb,As,Ac,Cc,Ci
RS134	2021062712	13.111	136.510	1009.7	27.1	90	291	3.9	24544	10	Ns?
RS135	2021062715	13.117	136.496	1009.7	28.2	75	110	0.1	22300	9	Nb,As
RS136	2021062718	13.134	136.497	1008.8	28.2	83	151	2.9	24583	6	Nb, Cu
RS137	2021062721	13.134	136.505	1009.3	27.7	78	167	4.4	25159	8	Nb,Cu,As,Ci,Sc
RS138	2021062800	13.124	136.499	1009.9	28.4	81	99	1.7	26405	8	Cu,Sc,As,Ac,Cc
RS139	2021062803	13.129	136.492	1008.4	28.7	80	130	1.2	26306	6	Cu,Sc,As,Cs,Cc,Ci
RS140	2021062806	13.128	136.503	1007.0	29.3	76	129	2.1	26455	5	Cu,Sc,As,Ns
RS141	2021062809	13.132	136.497	1007.0	29.6	74	83	2.8	26298	3	Cu,Sc,Nb,Ci
RS142	2021062812	13.110	136.506	1008.9	29.0	77	63	3.3	26208	3	–
RS143	2021062815	13.126	136.500	1008.7	27.6	86	193	1.7	26374	9	Nb,As,Cs
RS144	2021062818	13.130	136.487	1007.5	29.1	79	41	1.9	25567	2	Cu, As, Ci, ?
RS145	2021062821	13.131	136.494	1007.6	29.1	78	27	2.1	25767	2	Cu, Nb, Ci
RS146	2021062900	13.129	136.498	1008.7	28.8	83	112	3.7	26382	5	Nb,Cu,Sc,As
RS147	2021062903	13.119	136.491	1007.6	29.2	78	86	3.0	24475	2	Nb,Cu,Sc,As,Cc
RS148	2021062906	13.214	136.491	1006.8	27.7	84	122	8.5	23989	10	Cu,Sc,St,Ns
RS149	2021062909	13.246	136.598	1007.6	28.3	78	263	2.1	16286	10	St,As
RS150	2021062912	12.894	136.848	1009.3	26.1	84	94	8.1	23379	10	St
RS151	2021062915	13.258	136.437	1008.8	27.7	81	143	2.8	24309	10	St,As
RS152	2021062918	13.711	135.931	1006.8	27.7	85	125	0.2	24476	9	As, St, ?
RS153	2021062921	14.105	135.461	1007.8	28.3	79	327	2.7	23552	9	As, Sc, Cu
RS154	2021063000	14.538	135.010	1008.0	28.8	76	156	4.8	25524	9	Cu,Sc,As
RS155	2021063003	14.660	134.935	1008.2	29.1	78	68	3.0	27082	8	Cu,Sc,Nb,Ns,As,Ac,
RS156	2021063006	14.274	135.360	1006.8	29.7	73	84	4.4	23974	9	Cu,Sc,Ns,As,Ac,Cs
RS157	2021063009	13.881	135.813	1007.2	29.6	79	71	5.3	23626	10	Cu,Nb,Sc,St,As
RS158	2021063012	13.516	136.225	1008.1	29.1	73	61	5.9	25190	1	St
RS159	2021063015	13.160	136.608	1007.6	29.5	77	81	6.2	17194	2	Cu,Nb
RS160	2021063018	12.873	136.814	1006.6	29.0	80	97	5.2	25615	4	Cu,Nb,Ci,As,Ac
RS161	2021063021	12.902	136.825	1006.8	29.1	79	94	8.3	25261	8	Cu,Nb,Ci,As
RS162	2021070100	12.890	136.851	1007.5	28.2	80	99	8.9	27266	9	Cu,Sc,As,Ac.Nb
RS163	2021070103	12.904	136.808	1007.2	28.9	80	98	6.5	26358	7	Cu,As,Cs,Cc
RS164	2021070106	13.065	136.966	1006.6	27.6	81	125	5.1	24895	10	As,Sc,Cu,Cc
RS165	2021070109	13.521	137.305	1005.5	29.1	77	101	8.7	24535	10	As,Sc,Cu,Nb
RS166	2021070112	13.938	137.581	1007.8	29.6	77	125	6.5	24159	5	Cu,Nb,As,Ns
RS167	2021070115	14.430	137.896	1007.7	28.8	83	130	5.5	24503	6	Cu,Ns
RS168	2021070118	14.973	138.278	1007.5	27.3	90	128	7.9	20139	10	Nb, Cu, Sc, As, ?
RS169	2021070121	15.565	138.651	1008.4	29.0	79	92	7.0	25528	3	Nb, Cu,As, Ci
RS170	2021070100	15.997	138.944	1009.0	29.5	75	94	6.7	26184	4	Cu,Nb,As,Cs
RS171	2021070106	17.000	139.598	1007.3	29.1	76	87	10.0	25664	6	Cu,Sc,As,Ns,Cs,Cc
RS172	2021070212	17.976	139.586	1009.7	29.2	79	107	10.0	25623	3	Cu
RS173	2021070218	19.199	139.589	1009.1	28.7	79	98	11.1	23520	1	Cu, Nb, As
RS174	2021070300	20.492	139.547	1011.3	29.1	76	96	10.3	25919	7	Cu,Sc,As,Cs
RS175	2021070306	21.905	139.540	1010.8	28.6	76	95	6.2	24687	4	Cu,As,Ns,Cc,Ci,Cs
RS176	2021070312	23.070	139.501	1013.4	28.4	86	123	5.3	25281	1	–
RS177	2021070318	24.022	139.509	1012.3	28.1	83	103	5.8	24629	0+	Cu
RS178	2021070400	25.064	140.067	1013.9	28.0	86	115	6.2	26065	2	Cu,Sc,As
RS179	2021070406	26.058	140.618	1013.5	28.4	84	103	5.6	25737	5	Cu,Sc,As,Cs
RS180	2012070412	27.265	141.238	1015.8	27.8	86	82	3.3	25186	2	–
RS181	2012070418	28.245	141.615	1014.7	26.9	89	161	2.4	25070	0+	Cu
RS182	2021070500	29.442	142.074	1015.3	26.2	89	241	3.1	26491	8	Cu,Sc,As,Ac,Cs
RS183	2021070506	29.977	141.979	1013.3	26.6	85	263	5.2	25953	6	Cu,Sc,As,Cs,Ci
RS184	2021070412	31.183	141.036	1012.8	25.5	93	235	9.1	25687	1	–

Table 6.11-2: Same as Table 6.11-1, but for the experimental launches as in Section 6.12. Observation number in Section 6.12 is also added to "ID" column.

ID	Nominal Time	Launched Location		Surface Values					Max	Clouds	
	YYYYMMDDhh	Lat.	Lon.	P	T	RH	WD	WS	Height		
		deg.N	deg.E	hPa	deg.C	%	deg.	m/s	m	Amount	Types
RS901	2021070209	17.333	139.597	1008.8	27.5	84	134	7.2	16279	3	As,St,Ac,Sc,Cs,Ci
RS902	2021070309	22.481	139.518	1013.2	28.2	81	98	5.5	40660	1	St,As,Nb
RS903	2021070409	26.680	140.947	1015.7	28.3	82	99	5.9	40549	4	Cu,Ci,Cs,As

(4) Preliminary results

The results from Vaisala system are shown in the figures. Figure 6.11-1 is the time-height cross sections during the stationary observation period at around (13N, 137E) for the potential temperature, relative humidity, zonal and meridional wind components. Several vertically-integrated parameters are derived from sounding data as in Fig. 6.11-2, including convective available potential energy (CAPE), convective inhibition (CIN) and total precipitable water vapor (TPW). Each vertical profiles of temperature and dew point temperature on the thermodynamic chart with wind profiles are attached in Appendix-B.

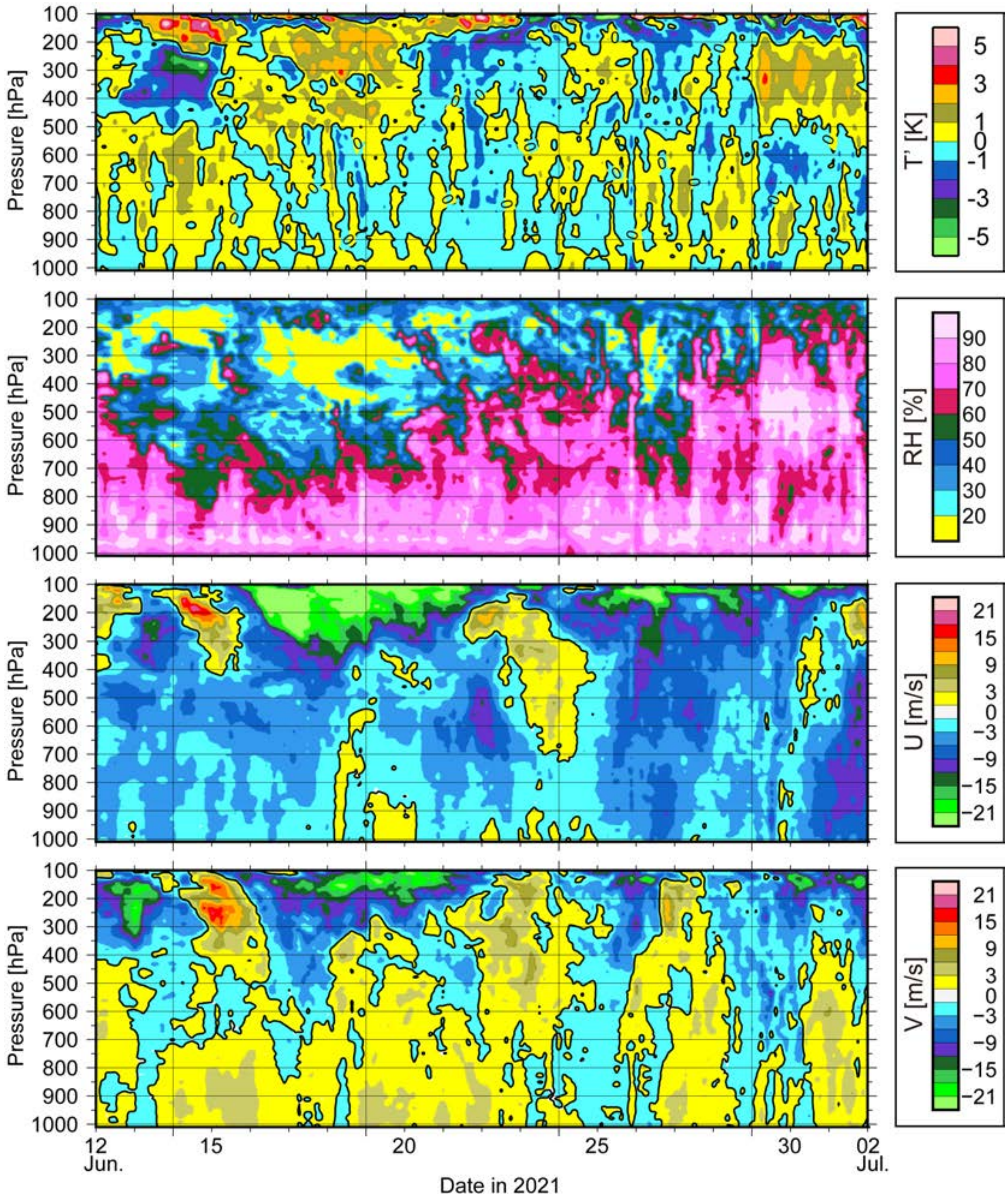


Fig. 6.11-1: Time-height cross sections of observed parameters at and near the station (13N, 137E), from 00Z on Jun.12 to 00Z on Jul.02; (top) temperature, in anomaly to the period-averaged value at each pressure level, (second top) relative humidity, (third top) zonal wind (absolute value), and (bottom) meridional wind (absolute value).

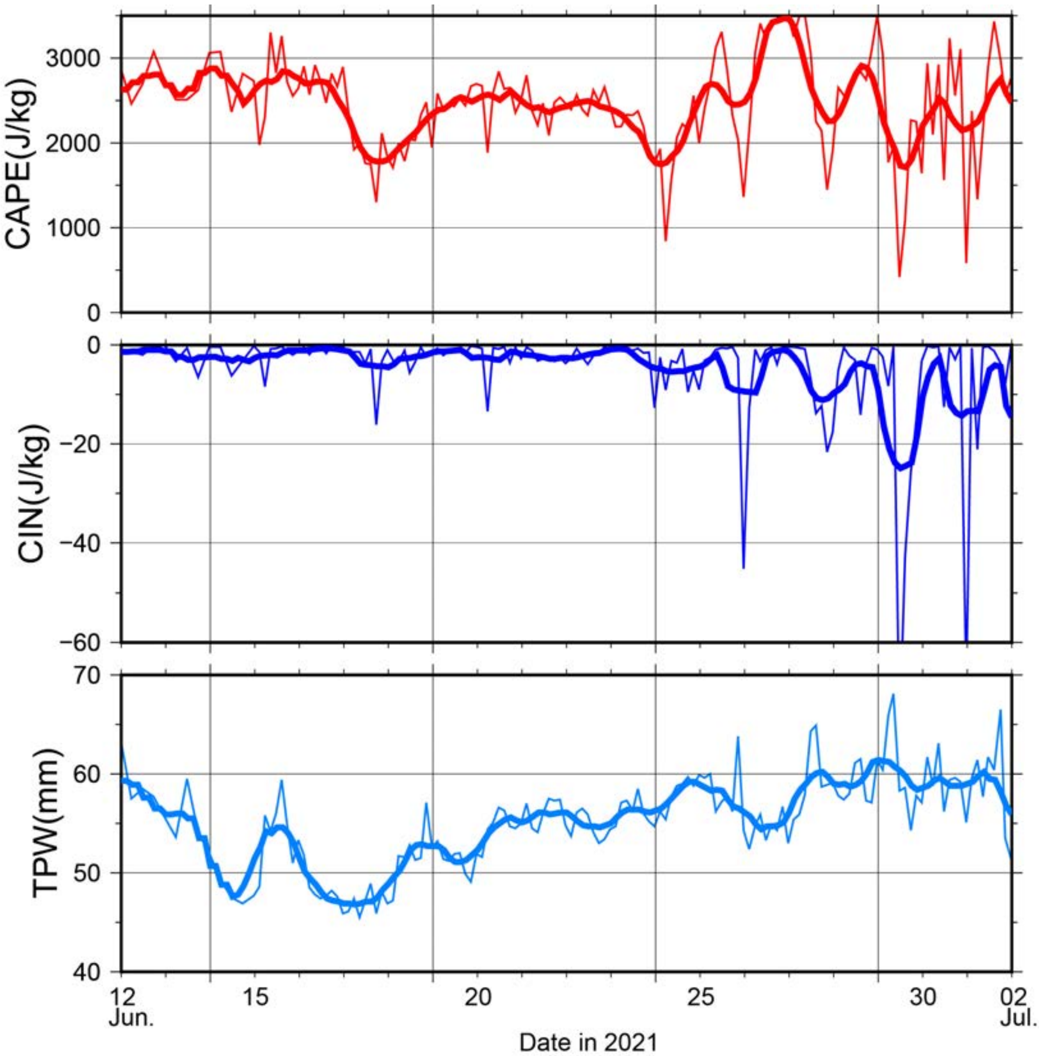


Fig. 6.11-2: Time series of the parameters derived from the radiosonde observations; (top) convective available potential energy (CAPE), (middle) convective inhibition (CIN), and (bottom) total precipitable water vapor (TPW). The thin lines are the values from each sounding, while the thick lines are the running mean for 25 hours.

(5) Data archive

Data were sent to the world meteorological community via Global Telecommunication System (GTS) through the Japan Meteorological Agency, immediately after each observation. The ASCII data, corrected by MW41 software is available for every launch during ascent. Raw data, in the Vaisala original binary format, is also available for each launch during ascent (and descent when available). These datasets will be submitted to JAMSTEC Data Management Group (DMG), 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) Acknowledgments

The chances of flights with special soundings (see Section 6.11) were provided by Dr. Shin-ya Ogino of DCOP / JAMSTEC.

6.12. Ozone, water vapor, and super high-altitude sonde observations

(1) Personnel

Shin-Ya Ogino	(JAMSTEC) PI
Junko Suzuki	(JAMSTEC) not on board
Takenari Kinoshita	(JAMSTEC) not on board
Ryuichi Shirooka	(JAMSTEC) not on board
Masaki Katsumata	(JAMSTEC)
Iwao Ueki	(JAMSTEC)
Biao Geng	(JAMSTEC)
Akira Nagano	(JAMSTEC)
Kyoko Taniguchi	(JAMSTEC)
Satomi Ogawa	(NME)
Kazuho Yoshida	(NME)
Ryo Oyama	(NME)
Yutaro Murakami	(NME)

(2) Objectives

The objectives of this observation are to capture the nature of material transport driven by the active convections associated with the Asian summer monsoon and the boreal summer Intraseasonal oscillation (BSISO), and to measure the vertical profiles of temperature and winds up to 40 km where the normal meteorological balloons cannot reach.

(3) Instrumentation and Method

Following special sensors were used for the material observations:

- En-sci 1Z ECC ozonesonde
- Meisei Skydew chilled-mirror dew/frost point hygrometer
- Meisei CPS cloud particle counter

They were attached to Meisei RS-11G radiosondes and launched by TOTEX TX1200 or TX1000 balloons. The super high-altitude sonde observations were carried out by launching Meisei iMS-100 radiosondes with TOTEX TX3000 or TA4000 balloons. We launched the balloons basically with the balloon launcher made by NME and sometimes a TOTEX balloon cover. The data transmitted from radiosondes were received by three sets of Meisei RD08AC system, each of which consists of a receiver, an antenna, a pre-amplifier, a laptop computer, and cables.

We carried out 27 material observations and 27 super high-altitude observations along the route of the Mirai cruise. The observation point, date, launch time, and maximum altitude of each launch are shown in Table 6.12-1. Among the launches, we made special comparison (1) by attaching Vaisala RS41 and Meisei iMS-100 radiosondes to the ozone, water vapor, cloud particle count sensors launched by TX1200 balloons and (2) by attaching Vaisala RS41 to Meisei iMS-100 radiosonde launched by TX3000 balloons (see Sec. 6.10).

Table 6.12-1: The observation point, date, launch time, and maximum altitude of each launch of the material observations and super high-altitude observations

Date	Obs point number	Time (SMT)	Lat.	Lon.	Launch time (SMT), Sensors, Maximum height	Remarks
May 27	SPS-001	18:44	29.45N	141.76E	18:44 Ozone and water vapor (30.7 km) 19:23 Super high altitude (18 km)	
May 28	SPS-002	18:33	25.37N	144.09E	18:33 Ozone and water vapor (32 km) 19:23 Super high-altitude sonde (19.8 km)	
May 29	SPS-003	18:39	21.13N	146.40E	18:39 Ozone and water vapor (33 km) 19:39 Super high-altitude sonde (21.6 km)	
May 30	SPS-004	18:39	17.40N	148.50E	18:39 Ozone and water vapor (32 km) 19:06 Super high-altitude sonde (19.8 km)	
May 31	SPS-005	18:48	13.65N	150.54E	14:39 Super high-altitude sonde (39.8 km) 18:48 Ozone and water vapor (32 km) 19:23 Super high-altitude sonde (23.0 km)	
Jun 01	SPS-006	18:33	9.72N	152.62E	18:33 Ozone and water vapor (32 km) 18:58 Super high-altitude sonde (16.8 km)	
Jun 02	SPS-007	16:00	05.89N	154.03E	16:00 Super high-altitude sonde (16.2 km) 16:31 Ozone and water vapor (22 km)	
Jun 03	SPS-008	16:50	01.30N	155.55E	16:50 Super high-altitude sonde (39.7 km) 17:20 Ozone and water vapor (33 km)	
Jun 04						
Jun 05						
Jun 06						
Jun 07	SPS-009	16:15	04.09N	146.00E	16:15 Super high-altitude sonde (40.5 km) 16:40 Ozone (29 km)	
Jun 08	SPS-010	16:29	05.87N	141.54E	16:29 Super high-altitude sonde (40.5 km) 16:55 Ozone (33 km)	
Jun 09	SPS-011	16:50	07.67N	137.00E	16:50 Super high-altitude sonde (40.0 km) 17:15 Ozone (32 km)	
Jun 10						
Jun 11						
Jun 12	SPS-012	17:19	13.28N	136.92E	17:19 Super high-altitude sonde (39.6 km) 20:23 Ozone (32 km)	
Jun 13						
Jun 14	SPS-013	17:17	13.10N	136.57E	17:17 Super high-altitude sonde (39.9 km) 20:15 Ozone (32 km)	
Jun 15						

Jun 16	SPS-014	17:20	13.12N	136.52E	17:20 Super high-altitude sonde (39.5 km) 20:18 Ozone (31.1 km)	
Jun 17	SPS-015	17:19	13.12N	136.52E	17:19 Super high-altitude sonde (39.4 km) 20:40 Ozone, water vapor, and cloud particle count attached with RS41 and iMS-100 (29.5 km)	
Jun 18						
Jun 19	SPS-016	17:19	13.12N	136.50E	17:19 Super high-altitude sonde (40.4 km) 20:19 Ozone (31.9 km)	
Jun 20						
Jun 21	SPS-017	17:20	13.13N	136.51E	17:20 Super high-altitude sonde (37.8 km)	
Jun 22	SPS-017	20:19	13.10N	136.49E	20:19 Ozone and cloud particle count (32.0 km)	
Jun 23	SPS-018	17:20	13.12N	136.50E	17:20 Super high-altitude sonde (37.5 km) 20:45 Ozone, water vapor, and cloud particle count attached with RS41 and iMS-100 (32.0 km)	Ozone and water vapor data were obtained up to 400 m.
Jun 24	SPS-019	20:18	13.14N	136.51E	20:18 Ozone (30.6 km)	
Jun 25	SPS-020	17:20	13.12N	136.50E	17:20 Super high-altitude sonde (39.3 km) 20:39 Ozone, water vapor, and cloud particle count attached with RS41 and iMS-100 (32.5 km)	
Jun 26						
Jun 27	SPS-021	17:15	13.12N	136.50E	17:15 Super high-altitude sonde (39.0 km) 20:19 Ozone (31.5 km)	
Jun 28						
Jun 29						
Jun 30	SPS-022	17:32	13.88N	135.89E	17:32 Super high-altitude sonde (12.3 km) 20:18 Ozone (32.0 km)	
Jul 01	SPS-023	17:18	13.55N	137.31E	17:18 Super high-altitude sonde (23.3 km) 20:11 Ozone (31.0 km)	
Jul 02	SPS-024	17:19	18.00N	139.55E	17:19 Super high-altitude sonde (19.8 km) 20:20 Ozone (31.1 km)	Super high-altitude sonde was launched together with Vaisala RS41 radiosonde.

Jul 03	SPS-025	17:30	22.55N	139.49E	17:30 Super high-altitude sonde (40.8 km) 20:18 Ozone (32.3 km)	Super high-altitude sonde was launched together with Vaisala RS41 radiosonde.
Jul 04	SPS-026	17:51	26.72N	140.97E	17:51 Super high-altitude sonde (40.6 km) 20:52 Ozone (32.3 km)	Super high-altitude sonde was launched together with Vaisala RS41 radiosonde.
Jul 05	SPS-027	17:49	30.69N	141.46E	17:49 Super high-altitude sonde (37.2 km) 20:57 Ozone (32.5 km)	TA1000 balloon was used for super high-altitude sonde.

(4) Preliminary results

Figure 6.12-1 shows an example of vertical profile of ozone partial pressure obtained by the sounding on June 12, 2021. We find a remarkable ozone enhancement at about 18 km, which implies the transport of mid-latitude stratospheric air mass into the tropical region. Figure 6.12-2 shows a vertical profile of temperature obtained by the super high-altitude observation on June 13, 2021. The large amplitude wavy structure is found above 35 km which cannot be measured by normal meteorological balloon soundings, and will be useful for understanding the atmospheric dynamics in this altitude range.

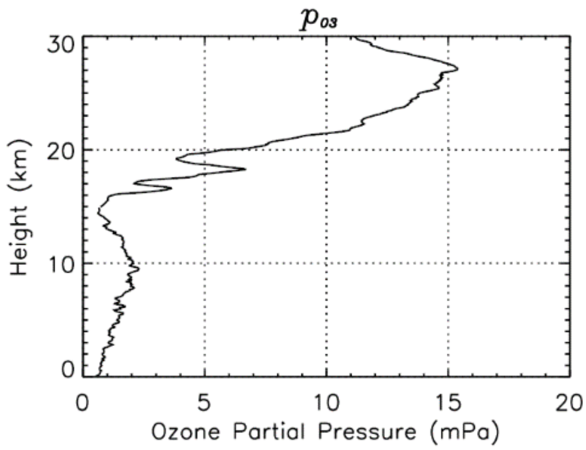


Fig. 6.12-1: Vertical profile of ozone partial pressure obtained by the ozonesonde observation on June 12, 2021.

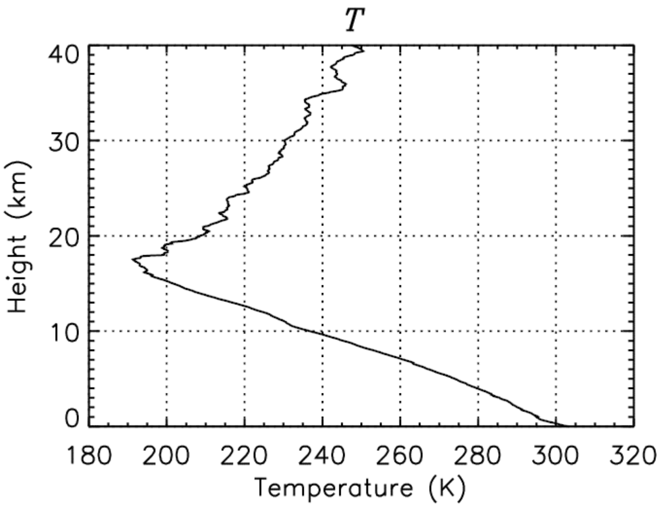


Fig. 6.12-2: Vertical profile of temperature obtained by the super high-altitude sonde observation on June 13, 2021.

(5) Data archive

The data obtained in this cruise were sent to the world meteorological community via Global Telecommunication System (GTS) through the Japan Meteorological Agency, immediately after each observation. The data will be submitted to the Data Management Group (DMG) 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). This observation is a part of Years of the Maritime Continent (YMC). The data will be available at YMC web site (http://www.jamstec.go.jp/ymc/).

6.13. Doppler radar observation

(1) Personnel

Biao Geng	(JAMSTEC) PI
Masaki Katsumata	(JAMSTEC)
Satomi Ogawa	(NME) Operation Leader
Kazuho Yoshida	(NME)
Ryo Oyama	(NME)
Yutaro Murakami	(NME)
Takatomo Shirozume	(MIRAI Crew)

(2) Objectives

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

(3) Radar specifications

The C-band weather 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 peak output power and the pulse width of the radar are checked every day.

During the cruise, the radar is operated in modes shown in Table 6.13-1. A dual PRF mode is used for volume scans. For RHI and surveillance PPI scans, a single PRF mode is used.

Table 6.13-1 Scan modes of the C-band weather radar

<table>
<tr><th></th><th>Surveillance PPI Scan</th><th colspan="6">Volume Scan</th><th>RHI Scan</th></tr>
<tr><td>Repeated Cycle (min.)</td><td>30</td><td colspan="6">6</td><td>6</td></tr>
<tr><td>Times in One Cycle</td><td>1</td><td colspan="6">1</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></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></tr>
<tr><td>Bin Spacing (m)</td><td colspan="8">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></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></tr>
</table>

(6) Data

The radar observation was conducted from 26 May to 6 July 2021. Figure 6.13-1 shows the time series of the areal coverage of radar echoes during the period of the stationary observation of the Mirai (15–29 June). During this period, various precipitating systems have been observed. The observed precipitation exhibited a pronounced diurnal cycle, as well as variations on a timescale of 3-6 days. It should be noted that radar observations were suspended due to the inspection of the antenna and the maintenance of processors. In addition, for the purpose of detecting weak power signal near the detection limit, quality management parameters were adjusted from 10:36 UTC 09 June, before the stationary observation. Some remarks on the status of the radar data are shown in section (8). Detailed analyses of the data observed by the radar will be performed after the cruise.

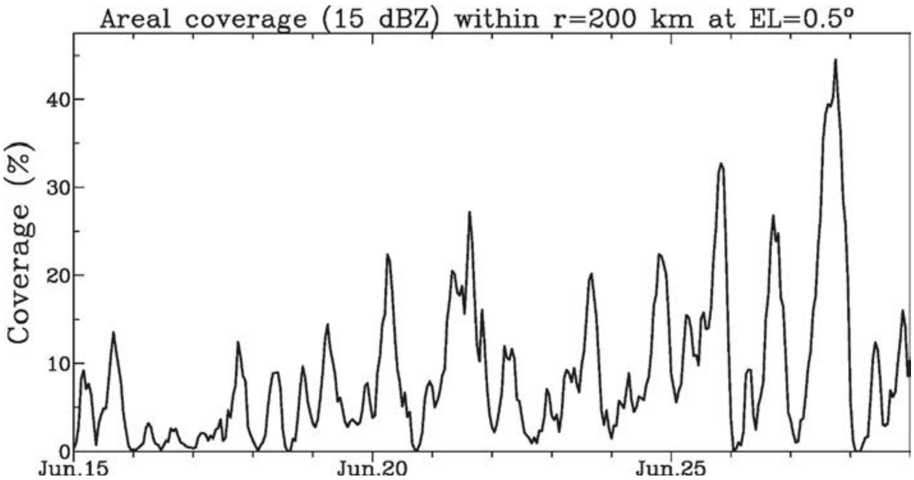


Fig. 6.13-1. Time series of the areal coverage of radar echoes (≥15 dBZ) within a radius of 200 km from the radar during the period of the stationary observation of the R/V Mirai

(7) Data archive

The C-band weather radar 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)” on the JAMSTEC website (http://www.godac.jamstec.go.jp/darwin/e).

(8) Remarks

1). During the following periods, data acquisition was suspended due to the inspection of the antenna and the maintenance of processors.

04:42 UTC 02 Jun. 2021 to 04:48 UTC 02 Jun. 2021
06:36 UTC 06 Jun. 2021 to 06:42 UTC 06 Jun. 2021
04:30 UTC 09 Jun. 2021 to 05:06 UTC 09 Jun. 2021
10:30 UTC 09 Jun. 2021 to 10:36 UTC 09 Jun. 2021
11:00 UTC 09 Jun. 2021 to 11:04 UTC 09 Jun. 2021
11:18 UTC 09 Jun. 2021 to 11:24 UTC 09 Jun. 2021
13:00 UTC 02 Jul. 2021 to 13:12U TC 02 Jul. 2021

2). During the following period, Doppler velocity in the RAW products of RHI and surveillance PPI scans were invalid due to Doppler velocity process defect of single PRF mode.

the beginning of the radar observation to 13:00 UTC 02 Jul. 2021

3). During the following period, Ingest SQI data were invalid due to quality control scheme defect.

the beginning of the radar observation to 04:42 UTC 02 Jun. 2021

6.14. Disdrometer observation

6.14.1. Optical Disdrometer

(1) Personnel

Masaki Katsumata	(JAMSTEC) PI
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 6.13) 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).

The particles are categorized by the detected size and fall speed and counted the number in each category every minutes. The categories are shown in Table 6.14.1-1.

The LPMs are installed on the top (roof) of the anti-rolling system, as shown in Fig. 6.14.1-1. 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.

Table 6.14.1-1: 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

Fig. 6.14.1-1: 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.

(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 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)" on the JAMSTEC website (http://www.godac.jamstec.go.jp/darwin/e).

(6) Acknowledgment

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

6.14.2. Micro Rain Radar

(1) Personnel

Masaki Katsumata	(JAMSTEC) PI
Biao Geng	(JAMSTEC)
Kyoko Taniguchi	(JAMSTEC)

(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) Instrumentations and Methods

The MRR-2 (METEK GmbH) was utilized. The specifications are as follows:

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

The antenna unit was installed at the starboard side of the anti-rolling systems (see Fig. 6.14.2-1), and wired to the junction box and laptop PC inside the vessel.

The data was averaged and stored every 1 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. 6.14.2-1: Onboard MRR sensor. (Left) The location of the sensors, as designated by the red broken circle. (Right) The antenna unit.

(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 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)" on the JAMSTEC website (http://www.godac.jamstec.go.jp/darwin/e).

(6) Acknowledgment

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

6.15. Microwave radiometer and whole sky camera observations

(1) Personnel

Akira Kuwano-Yoshida	(Kyoto Univ.) PI not on board
Masaki Katsumata	(JAMSTEC)
Masahiro Minowa	(Furuno Electric Co., Ltd.) not on bord

(2) Objectives

To retrieve total column integrated water vapor content of the atmosphere.

(3) Method

The microwave radiometer (hereafter MWR; manufactured by Furuno Electric Co., Ltd.) is used. The MWR received natural microwave within the angle of 20 deg. from zenith, at the frequencies around 22 GHz. The received signal can be converted to the column integrated water vapor (or precipitable water). The observation was made every 60 seconds. The rain sensor is equipped to identify the period of rainfall.

In addition to the MWR, the whole sky camera was installed beside the MWR. This is to monitor cloud cover, which also affects the microwave signals. The camera obtained the whole-sky image every 60 seconds.

Both instruments were installed at the top of the roof of aft wheelhouse, as in Fig. 6.15-1. The data were continuously obtained all through the cruise period.

Fig. 6.15-1: Outlook of the microwave radiometer (right) and the whole-sky camera (left) installed at the roof of the aft wheelhouse.

(4) Preliminary results

The time series of the obtained column integrated water vapor is shown in Fig. 6.15-2. Precipitable water is estimated for wide variety ranges from ~10 mm to ~70 mm, with well-defined diurnal cycle from Jun. 13 to 25 when Mirai was at the station (13N, 137E). A sample of the variation within one-day is shown in Fig. 6.15-3, in which the drying around the noon under the clear sky and the following increase of precipitable water accompanying precipitating events are well captured.

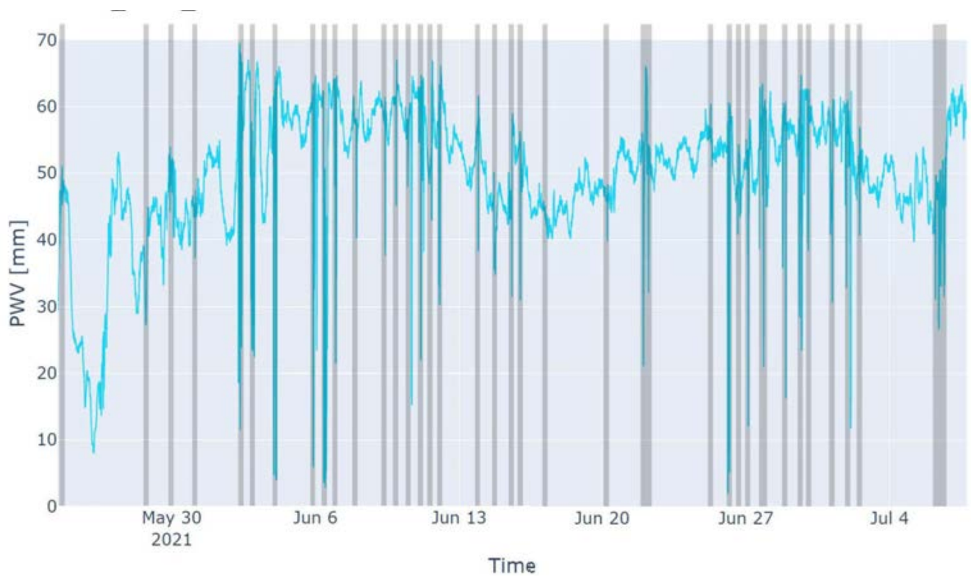


Fig. 6.15-2 Time series of the estimated precipitable water during the cruise.
Note that gray-shaded periods are when rainfall was detected by the rain sensor.

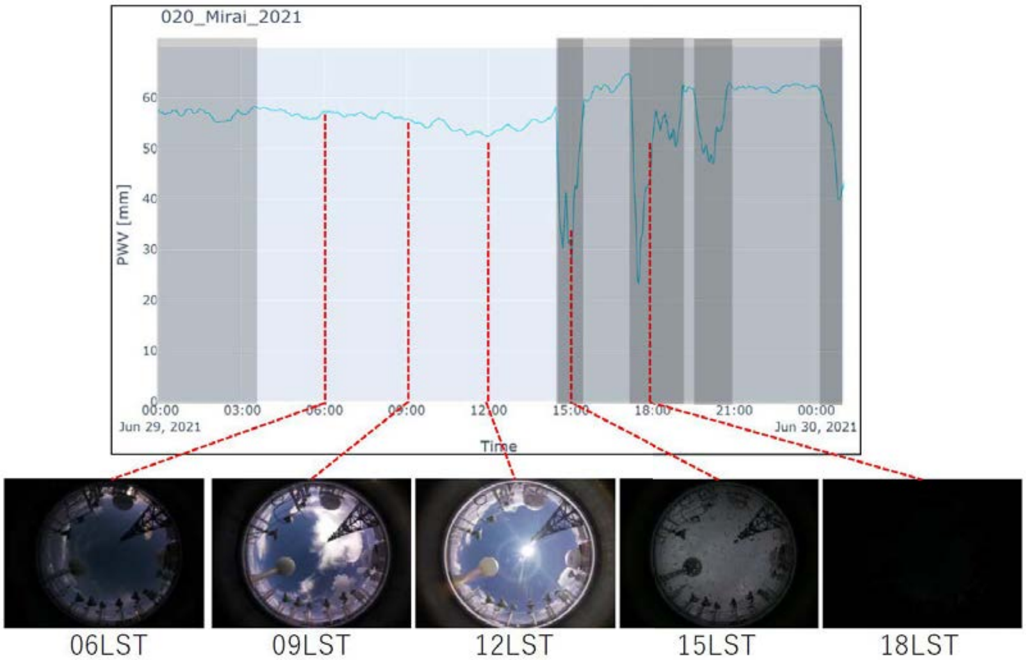


Fig. 6.15-3 An example of obtained data for a day on Jun. 29 (LST). Top panel is same as Fig. 6.15-2, except the period with dark-gray shade when heavy rain is speculated. Bottom panels are the images by whole-sky camera every 3 hours.

(5) Data archive

All 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)" on the JAMSTEC website (http://www.godac.jamstec.go.jp/darwin/e).

(6) Acknowledgment

The observation was supported by the JSPS KAKENHI Grant 20H04306.

6.16. GNSS precipitable water

(1) Personnel

Mikiko Fujita	(JAMSTEC) PI not on board
Masaki Katsumata	(JAMSTEC)

(2) Objectives

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

(3) Instrumentations and Methods

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

(4) Preliminary results

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

(5) Data archive

Raw data is recorded as T02 format and stream data every 5 seconds. These raw datasets are available from Mikiko Fujita of JAMSTEC. Corrected data 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)” on the JAMSTEC website (http://www.godac.jamstec.go.jp/darwin/e).

6.17. Lidar observations of clouds, aerosols and water vapor

(1) Personnel

Masaki Katsumata	(JAMSTEC) PI
Kyoko Taniguchi	(JAMSTEC)
Satomi Ogawa	(NME)
Kazuho Yoshida	(NME)
Ryo Oyama	(NME)
Yutaro Murakami	(NME)

(2) Objectives

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

(3) Method

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 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)” on the JAMSTEC website (http://www.godac.jamstec.go.jp/darwin/e).

6.18. Aerosol optical characteristics measured by Shipborne Sky radiometer

(1) Personnel

Kazuma Aoki (University of Toyama) not onboard

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

(2) Objectives

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) Instrumentations and Methods

i) Sky radiometer measurement

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 and 2020.

ii) 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) Data archive

Aerosol optical data are to be archived at University of Toyama (K.Aoki, SKYNET/SKY: http://skyrad.sci.u-toyama.ac.jp/sobs/) after the quality check and 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)” on the JAMSTEC website (http://www.godac.jamstec.go.jp/darwin/e).

(5) References

Nakajima,T., G.Tonna, R.Rao, P.Boi, Y.Kaufman and B.Holben, Use of sky brightness measurements from ground for remote sensing of particulate polydispersions, Appl. Opt., 35, 2672–2686, https://doi.org/10.1364/AO.35.002672, 1996.

Aoki. K., T.Takemura, K.Kawamoto, and T.Hayasaka, Aerosol climatology over Japan site measured by ground-based sky radiometer, *AIP Conf. Proc*. **1531**, 284-287; doi: 10.1063/1.4804762, 2013.

Nakajima, T., Campanelli, M., Che, H., Estellés, V., Irie, H., Kim, S.-W., Kim, J., Liu, D., Nishizawa, T., Pandithurai ,G., Soni, V.K., Thana, B., Tugjsurn, N.-U., Aoki, K., Hashimoto, M., Higurashi, A., Kazadzis, S., Khatri, P., Kouremeti, N., Kudo, R., Marenco, F., Momoi, M., Ningombam, S. S., Ryder,C.L., and Uchiyama,A., An overview and issues of the sky radiometer technology and SKYNET, *Atmos. Meas. Tech.*, **13**, 4195-4218, 2020, https://doi.org/10.5194/amt-13-4195-2020, 2020.

6.19. Trace gas observation in the marine boundary layer

(1) Personnel

Yugo Kanaya	(JAMSTEC)	not on board
Hisahiro Takashima	(JAMSTEC/Fukuoka Univ.)	not onboard
Fumikazu Taketani	(JAMSTEC)	not on board
Atsushi Ooki	(Hokkaido Univ.)	not on board
Yoko Iwamoto	(Hokkaido Univ.)	not on board
Kazuhiko Takeda	(Hokkaido Univ.)	not on board

Observation was supported by Nippon Marine Enterprises, Ltd., and Marine Works Japan Ltd.

(2) Objectives

- To investigate short-lived climate forcers extending from the Asian continent to the Pacific Ocean.
- To investigate halogen chemistry in the marine atmosphere over the Western Pacific warm pool.

(3) Parameters

- Vertical distributions of nitrogen dioxide (NO_2) and other gases (including IO) in the troposphere
- Aerosol Optical depth (AOD) and Aerosol extinction coefficient (AEC) vertical distribution in the troposphere
- Surface carbon monoxide (CO) and ozone(O_3) mixing ratios
- Concentrations of organohalogen compounds in the air
- Iodide and iodate ion concentrations in the surface seawater

(4) Instrumentations and Methods

i) CO and O_3:

Ambient air was continuously sampled on the compass deck and drawn through ~20-m-long Teflon tubes connected to a nondispersive infrared (NDIR) CO analyzer (Model 48i-TLE, Thermo Fisher Scientific) and a UV photometric ozone analyzer (model 205, 2B Technologies), located in the environmental research room. The data will be used for characterizing air mass origins.

ii) MAX-DOAS:

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 2, 3, 4, 6, 10, 20, 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. The tropospheric vertical column/profile of NO_2 and other gases (including IO) were retrieved using derived aerosol profiles.

iii) Air sampling for the halogen compounds analysis

Canister grab samplings were performed in order to investigate the concentrations of organohalogen compounds in the marine air. These sampling logs are listed in Table 6.19-1. Analysis will be performed in the laboratory after the cruise.

iv) Surface seawater sampling for the halogen compounds analysis

Seawater samplings from the faucet on board (~6 m beneath the sea surface level) were performed in order to investigate the concentrations of iodide and iodate ions in the surface seawater. These sampling logs are listed in Table 6.19-2. Analysis will be performed in the laboratory after the cruise.

(5) Station lists or Observation logs

Air and seawater samplings during MR21-03 were summarized as follows:

Table 6.19-1: Air samplings logs

On board ID	Date Collected					Latitude			Longitude		
	YYY	MM	DD	hh:mm	UTC	Deg.	Min.	N/S	Deg.	Min.	E/W
H1041	2021	05	26	19:10	UTC	31	55.50	N	140	15.30	E
H1247	2021	05	27	19:12	UTC	27	55.00	N	142	38.90	E
1115	2021	05	28	19:06	UTC	03	46.50	N	145	01.70	E
1279	2021	05	29	19:04	UTC	19	44.30	N	147	15.60	E
1314	2021	05	30	19:05	UTC	16	03.30	N	149	15.80	E
H1038	2021	05	31	18:59	UTC	12	08.60	N	151	21.00	E
Y1802	2021	06	01	19:00	UTC	08	06.50	N	153	18.00	E
H1042	2021	06	02	19:00	UTC	03	32.60	N	154	46.90	E
H1024	2021	06	03	19:03	UTC	00	01.90	N	155	57.10	E
4869	2021	06	06	19:27	UTC	03	15.50	N	148	04.40	E
H1221	2021	06	09	19:56	UTC	07	52.10	N	136	27.70	E
4845	2021	06	12	19:52	UTC	12	59.50	N	137	07.10	E
1148	2021	06	15	19:53	UTC	13	11.20	N	136	30.20	E
1281	2021	06	18	19:51	UTC	13	07.20	N	136	31.40	E
1146	2021	06	19	4:35	UTC	13	06.70	N	136	31.30	E
5304	2021	06	21	19:55	UTC	13	07.30	N	136	31.00	E
1284	2021	06	22	4:21	UTC	13	06.80	N	136	31.50	E
1118	2021	06	25	19:55	UTC	13	06.30	N	136	31.50	E
1155	2021	06	25	4:35	UTC	13	06.20	N	136	30.20	E
Y1815	2021	06	27	19:53	UTC	13	08.40	N	136	30.40	E
1269	2021	07	01	19:43	UTC	15	30.40	N	138	36.80	E
1141	2021	07	02	19:35	UTC	19	43.10	N	139	33.40	E
1140	2021	07	03	19:27	UTC	24	24.40	N	139	43.20	E
H1260	2021	07	04	19:09	UTC	28	37.40	N	141	45.70	E

Table 6.19-2: Seawater samplings logs

On board ID	Date Collected					Latitude			Longitude		
	YYYY	MM	DD	hh:mm	UTC	Deg.	Min.	N/S	Deg.	Min.	E/W
MR2103-001	2021	05	27	10:19	UTC	29	22.95	N	141	49.46	E
MR2103-002	2021	05	28	09:46	UTC	25	23.22	N	144	05.54	E
MR2103-003	2021	05	29	09:58	UTC	21	12.18	N	146	26.47	E
MR2103-004	2021	05	30	09:18	UTC	17	33.49	N	148	28.12	E
MR2103-005	2021	05	31	08:59	UTC	13	45.92	N	150	29.44	E
MR2103-006	2021	06	01	08:50	UTC	09	49.74	N	152	34.56	E
MR2103-007	2021	06	02	08:48	UTC	05	33.74	N	154	08.28	E
MR2103-008	2021	06	03	08:12	UTC	01	09.61	N	155	35.59	E
MR2103-009	2021	06	04	08:11	UTC	00	07.65	N	156	09.88	E
MR2103-010	2021	06	05	08:19	UTC	00	33.93	N	154	48.35	E
MR2103-011	2021	06	06	09:00	UTC	02	26.69	N	150	00.40	E
MR2103-012	2021	06	07	09:07	UTC	04	12.47	N	145	41.25	E
MR2103-013	2021	06	08	09:21	UTC	05	58.56	N	141	15.02	E
MR2103-014	2021	06	09	09:45	UTC	07	44.88	N	136	46.64	E
MR2103-015	2021	06	10	09:43	UTC	08	15.18	N	136	30.27	E
MR2103-016	2021	06	11	09:50	UTC	13	13.17	N	137	03.00	E
MR2103-017	2021	06	12	10:20	UTC	13	20.24	N	136	49.00	E
MR2103-018	2021	06	13	10:04	UTC	12	48.00	N	136	28.79	E
MR2103-019	2021	06	14	10:23	UTC	13	06.21	N	136	33.91	E
MR2103-020	2021	06	15	09:55	UTC	13	12.28	N	136	29.59	E
MR2103-021	2021	06	16	10:39	UTC	13	08.66	N	136	30.95	E
MR2103-022	2021	06	17	10:54	UTC	13	07.66	N	136	30.68	E
MR2103-023	2021	06	18	11:12	UTC	13	07.69	N	136	29.05	E
MR2103-024	2021	06	19	10:56	UTC	13	06.91	N	136	30.42	E
MR2103-025	2021	06	20	10:29	UTC	13	08.17	N	136	30.38	E
MR2103-026	2021	06	21	10:50	UTC	13	07.10	N	136	29.77	E
MR2103-027	2021	06	22	11:37	UTC	13	05.62	N	136	29.32	E
MR2103-028	2021	06	23	11:35	UTC	13	07.07	N	136	29.57	E
MR2103-029	2021	06	24	11:39	UTC	13	08.10	N	136	29.78	E
MR2103-030	2021	06	25	10:56	UTC	13	08.01	N	136	29.59	E
MR2103-031	2021	06	26	15:28	UTC	13	07.11	N	136	29.45	E
MR2103-032	2021	06	27	12:33	UTC	13	07.12	N	136	30.85	E
MR2103-033	2021	06	28	11:26	UTC	13	07.16	N	136	29.77	E
MR2103-034	2021	06	29	10:46	UTC	13	53.64	N	136	50.95	E
MR2103-035	2021	06	30	10:03	UTC	13	39.89	N	136	05.64	E
MR2103-036	2021	07	01	10:08	UTC	13	47.22	N	137	27.61	E
MR2103-037	2021	07	02	09:57	UTC	17	44.81	N	139	34.35	E
MR2103-038	2021	07	03	10:08	UTC	22	53.98	N	139	29.38	E

(6) Data archive

All 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)” on the JAMSTEC website (http://www.godac.jamstec.go.jp/darwin/e).

(7) Acknowledgment

The onboard operation and sampling were supported by Satomi Ogawa, Yutaro Murakami, Kazuho Yoshida, and Ryo Oyama of Nippon Marine Enterprises, Ltd. and Erii Irie, Tomomi Sone, and Hiroki Ushiromura, of Marine Works Japan Ltd.

7. General observations

7.1. Meteorological observations

7.1.1. Surface meteorological observation

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Masaki Katsumata	(JAMSTEC)
Satomi Ogawa	(NME) Operation Leader
Kazuho Yoshida	(NME)
Ryo Oyama	(NME)
Yutaro Murakami	(NME)
Takatomo Shirozume	(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) Method

Surface meteorological parameters were observed throughout the MR21-03 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 7.1.1-1 and measured parameters are listed in Table 7.1.1-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-second averaged data.

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

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

a) Analog meteorological data sampling with CR1000 logger manufactured by Campbell Inc., Canada – wind, pressure, and rainfall (by a capacitive rain gauge(CRG)) measurement.

b) Digital meteorological data sampling from individual sensors －air temperature, relative humidity and rainfall (by optical rain gauge (ORG)) measurement.

c) Radiation data sampling with CR1000X logger manufactured by Campbell Inc., Radiometers designed by Hukseflux Thermal Sensors B.V. Netherlands. – short and long wave downward radiation measurement.

d) “SeaSnake” the floating thermistor designed by BNL – skin sea surface temperature (SSST) measurement.

e) Photosynthetically Available Radiation (PAR) and Ultraviolet Irradiance (UV) sensor manufactured by Biospherical Instruments Inc., USA. – PAR and UV measurement

f) Scientific Computer System (SCS) developed by NOAA (National Oceanic and Atmospheric Administration, USA) – centralized data acquisition and logging of all data sets.

SCS recorded Radiation, air temperature, relative humidity, CR1000, ORG and PAR data. SCS composed Event data (JamMet) from these data and ship’s navigation data every 6 seconds. Instruments and their locations are listed in Table 7.1.1-3 and measured parameters are listed in Table 7.1.1-4.

SeaSnake has two thermistor probes (5cm and 100cm from the cable end respectively) 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.

SSST-005

coefficient a: 7.49781E-4

coefficient b: -2.18670E-4

coefficient c: -5.71371E-8

SSST-100

coefficient a: 7.66430E-4

coefficient b: -2.16704E-4

coefficient c: -6.13549E-8

$$y = a + b * x + c * x^3$$

$$x = \log (1 / ((V_{ref} / V - 1) * R_2 - R_1))$$

$$T = 1 / y - 273.15$$

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, we checked the following sensors, before and after the cruise.

i. Young Rain gauge (SMet and SOAR)

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

ii. Barometer (SMet and SOAR)

Comparison with the portable barometer value, PTB330, VAISALA

iii. Thermometer (air temperature and relative humidity) (SMet and SOAR)

Comparison with the portable thermometer value, HM70, VAISALA

iv. SeaSnake SSST (SOAR)

SeaSnake thermistor probes were calibrated by 7008 Calibration bath, FLUKE Inc. USA, equipped with NSR-160 / NS-07115 Standard Platinum Resistance Thermometer (SPRT), Netsusin Co., Ltd., Japan.

Table 7.1.1-1: Instruments and installation locations of R/V MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location
Anemometer	KS-5900	Koshin Denki, Japan	Foremast (25 m)
Tair/RH	HMP155	Vaisala, Finland	Compass deck (21 m)
Thermometer: SST	RFN2-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	Model-370	Setra System, U.S.A.	Captain deck (13 m)
Capacitive rain gauge	50202	R. M. Young, U.S.A.	Compass deck (19 m)
Optical rain gauge	ORG-815DS	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)

Table 7.1.1-2: Parameters of R/V 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
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 7.1.1-3: Instruments and installation locations of SOAR system

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

Sensors (Radiation)	Type	Manufacturer	Location *
Radiometer (short wave)	SR20	Hukseflux Thermal Sensors B.V., Netherlands	Foremast (25 m)
Radiometer (long wave)	IR20	Hukseflux Thermal Sensors B.V., Netherlands	Foremast (25 m)

Sensor (PAR&UV)	Type	Manufacturer	Location *
PAR&UV sensor	PUV-510	Biospherical Instruments Inc., USA	Navigation deck (18m)

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

*Location : Altitude from surface

Table 7.1.1-4: Parameters of SOAR system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 SOG	knot	
4 COG	degree	
5 Relative wind speed	m/s	
6 Relative wind direction	degree	
7 Barometric pressure	hPa	
8 Air temperature	degC	
9 Relative humidity	%	
10 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 infrared radiation	W/m^2	
14 “SeaSnake” raw data	mV	
15 SSST (SeaSnake)	degC	
16 PAR	$microE/cm^2/sec$	
17 UV 305 nm	$microW/cm^2/nm$	
18 UV 320 nm	$microW/cm^2/nm$	
19 UV 340 nm	$microW/cm^2/nm$	
20 UV 380 nm	$microW/cm^2/nm$	

(4) Preliminary results

Figure 7.1.1-1 shows the time series of the following parameters;

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

Figure 7.1.1-2 shows the time series of SSST compared to intake sea surface temperature (TSG).

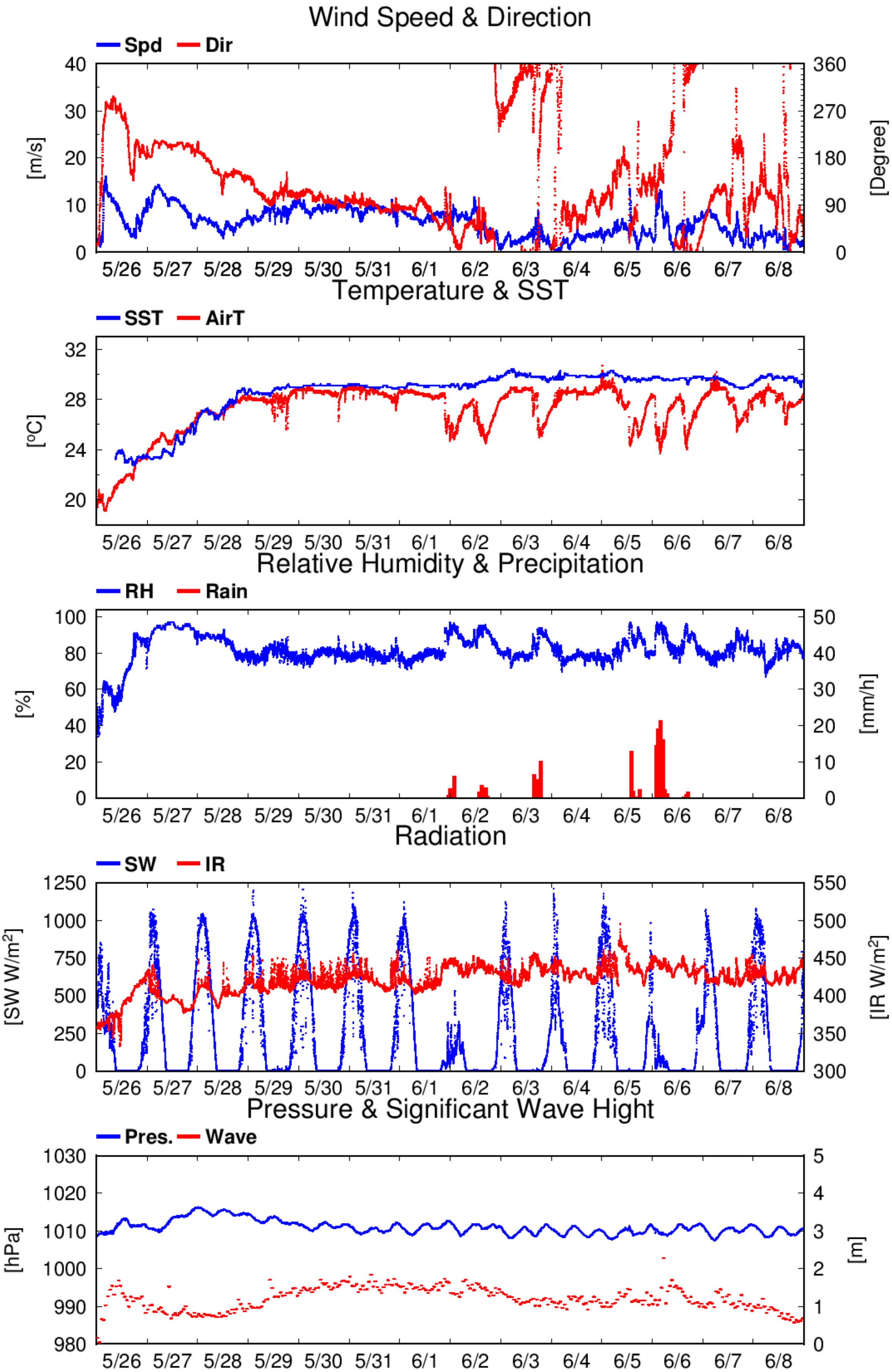


Fig. 7.1.1-1 Time-series of meteorological variables.

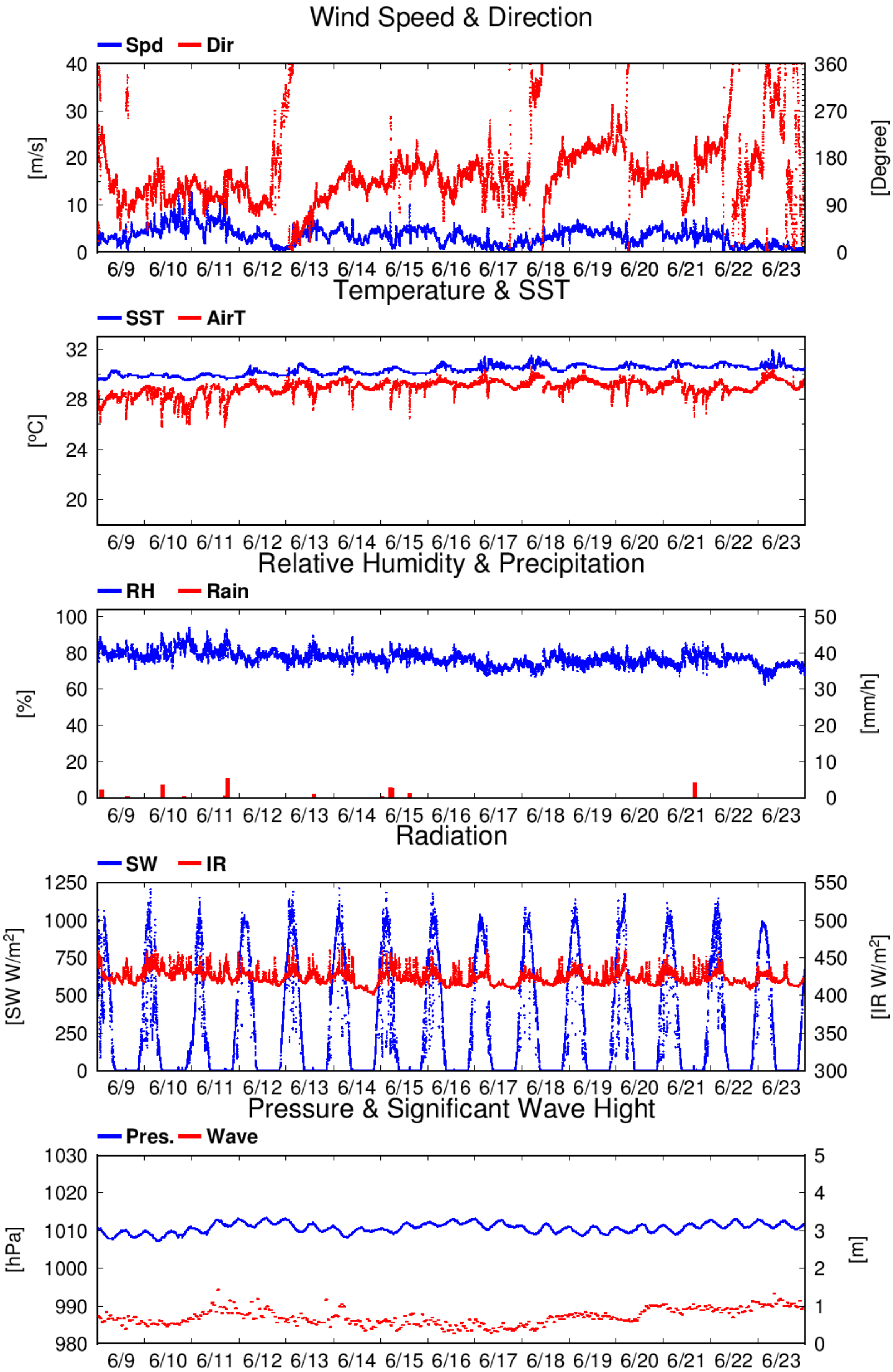


Fig. 7.1.1-1 (continued)

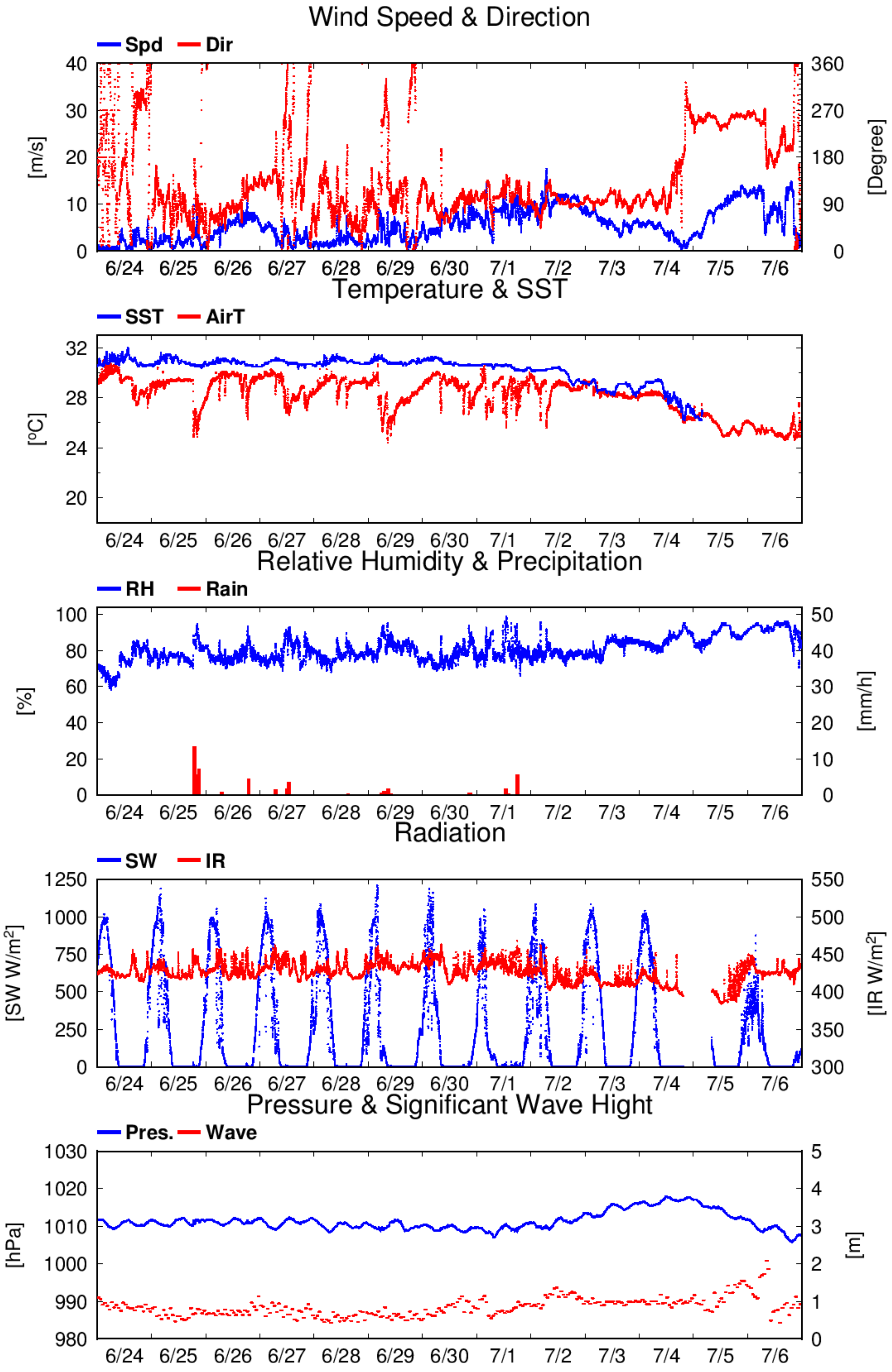


Fig. 7.1.1-1 (continued)

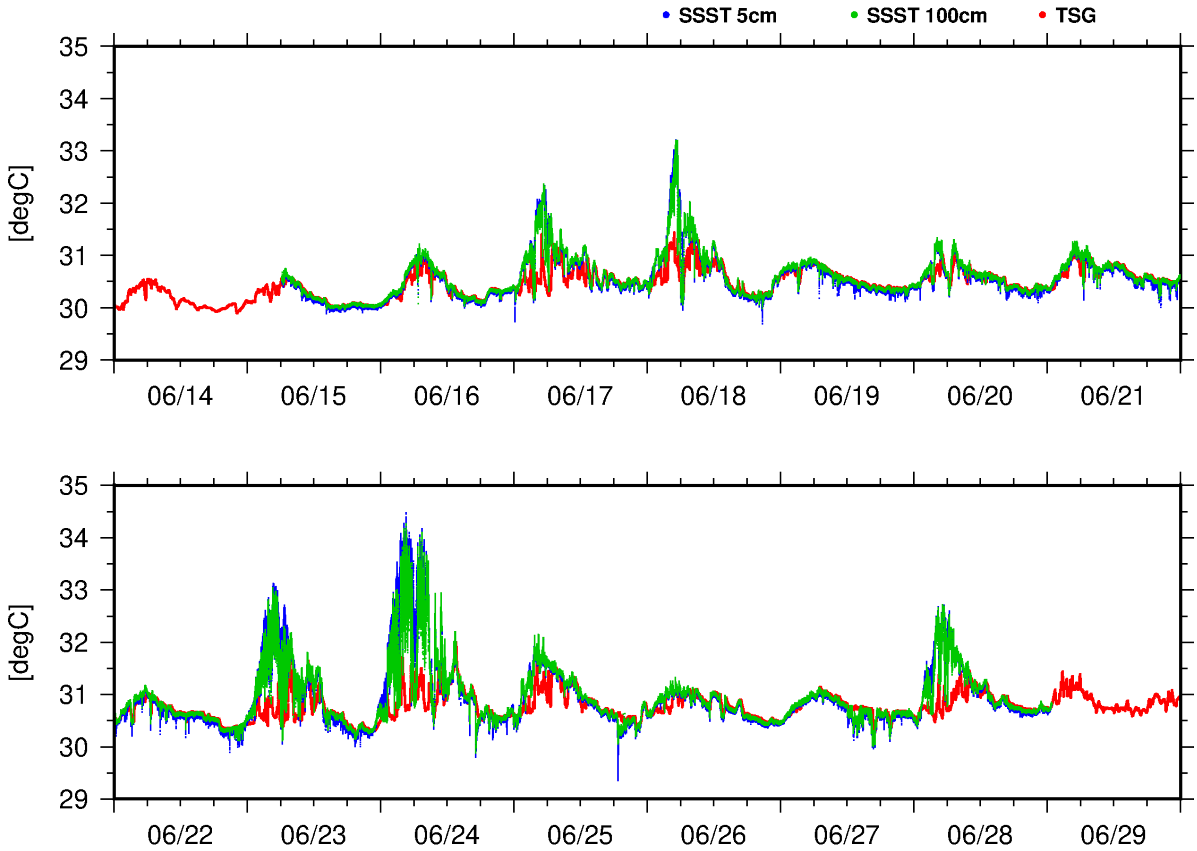


Fig. 7.1.1-2 Time series of Skin Sea Surface Temperature (SSST;5cm:Blue 100cm:Green) and Intake Sea Surface Temperature (TSG:Red).

(5) Data archive

All 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) Remrks

1. The following periods, SST data of SMET was available.
   08:56UTC 26 May 2021 - 04:00UTC 05 Jul. 2021

2. The following time, increasing of SMet capacitive rain gauge data were invalid due to transmitting for MF/HF radio.
   01:00UTC 26 May 2021
   02:09UTC 28 May 2021
   01:46UTC 19 Jun. 2021

3. The following periods, SOAR temperature and relative humidity data were invalid due to the sensor failure.
   12:30UTC, 21 Jun. 2021 - 16:09UTC21 Jun. 2021
   16:37UTC, 21 Jun. 2021 - the end of this cruise.

4. The following periods, some of SOAR data were not acquired due to system maintenance about the T/RH sensor failure.
   (i) Pressure, Rainfall amount(Capacitive), Wind speed and direction
      16:54UTC, 21 Jun. 2021 - 16:56UTC, 21 Jun. 2021
      17:04UTC, 21 Jun. 2021 - 17:06UTC, 21 Jun. 2021
      07:07UTC, 23 Jun. 2021 - 07:09UTC, 23 Jun. 2021
   (ii) Shortwave and Longwave radiation amount
      16:54UTC, 21 Jun. 2021 - 16:56UTC, 21 Jun. 2021
      17:04UTC, 21 Jun. 2021 - 17:06UTC, 21 Jun. 2021
      07:07UTC, 23 Jun. 2021 - 07:09UTC, 23 Jun. 2021
   (iii) Rainfall amount (Optical)
      16:54UTC, 21 Jun. 2021 - 16:58UTC, 21 Jun. 2021
      17:04UTC, 21 Jun. 2021 - 17:09UTC, 21 Jun. 2021
      07:07UTC, 23 Jun. 2021 - 07:11UTC, 23 Jun. 2021
   (iv) JamMet_PARUV(All)
      07:04UTC, 23 Jun. 2021 - 07:05UTC, 23 Jun. 2021
      10:17UTC, 23 Jun. 2021 - 10:19UTC, 23 Jun. 2021

5. The following periods, SOAR wind, rainfall(Optical), shortwave radiation and longwave radiation data were doubtful due to birds perching on the foremast.
   about 11:00UTC, 27 May 2021 - 15:00UTC, 27 May 2021
   about 10:00UTC, 31 May 2021 - 03:00UTC, 01 Jun. 2021
   about 21:00UTC, 04 Jul. 2021 - 08:00UTC, 05 Jul. 2021

6. The following periods, data acquisition of pressure, rainfall amount(Capacitive and Optical), wind speed/direction, and shortwave/longwave radiation amount was stopped due to system trouble.
   05:43UTC, 06 Jul. 2021 - 06:07UTC, 06 Jul. 2021

7. During this cruise, VU-01 Ventilation units (for SR20 and IR20) were not attached.

8. SeaSnake (SSST) observation
   (i) The following period, SSST observation was carried out.
      06:10UTC 15 Jun. 2021 - 00:50UTC 29 Jun. 2021
   (ii) The following periods, SSST data were invalid due to maintenance.
      09:18UTC 15 Jun. 2021 - 09:22UTC 15 Jun. 2021
      06:44UTC 16 Jun. 2021 - 06:50UTC 16 Jun. 2021
      06:49UTC 19 Jun. 2021 - 06:57UTC 19 Jun. 2021
      06:44UTC 24 Jun. 2021 - 06:51UTC 24 Jun. 2021
   (iii) The following time, SSST data were invalid due to unexpected noise.
      05:29UTC, 19 Jun. 2021
      05:30UTC, 19 Jun. 2021

7.1.2. Ceilometer

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Satomi Ogawa	(NME) Operation Leader
Kazuho Yoshida	(NME)
Ryo Oyama	(NME)
Yutaro Murakami	(NME)
Takatomo Shirozume	(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

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

(4) Method

We measured cloud base height and backscatter profile using ceilometer (CL51, VAISALA, Finland) throughout the MR21-03 cruise. Major parameters for the measurement configuration are as follows;

Laser source:	Indium Gallium Arsenide (InGaAs) Diode Laser
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)
Measurement range:	0 ~ 15 km
	0 ~ 13 km (Cloud detection)
Resolution:	10 meter in full range
Sampling rate:	36 sec
Sky Condition	0, 1, 3, 5, 7, 8 oktas (9: Vertical Visibility)
	(0: Sky Clear, 1: Few, 3: Scattered, 5-7: Broken, 8: Overcast)

On the archive dataset, cloud base height and backscatter profile are recorded with the resolution of 10 m (33 ft).

(5) Preliminary results

Figure 7.1.2-1 shows the time series of the lowest, second and third cloud base height during the cruise.

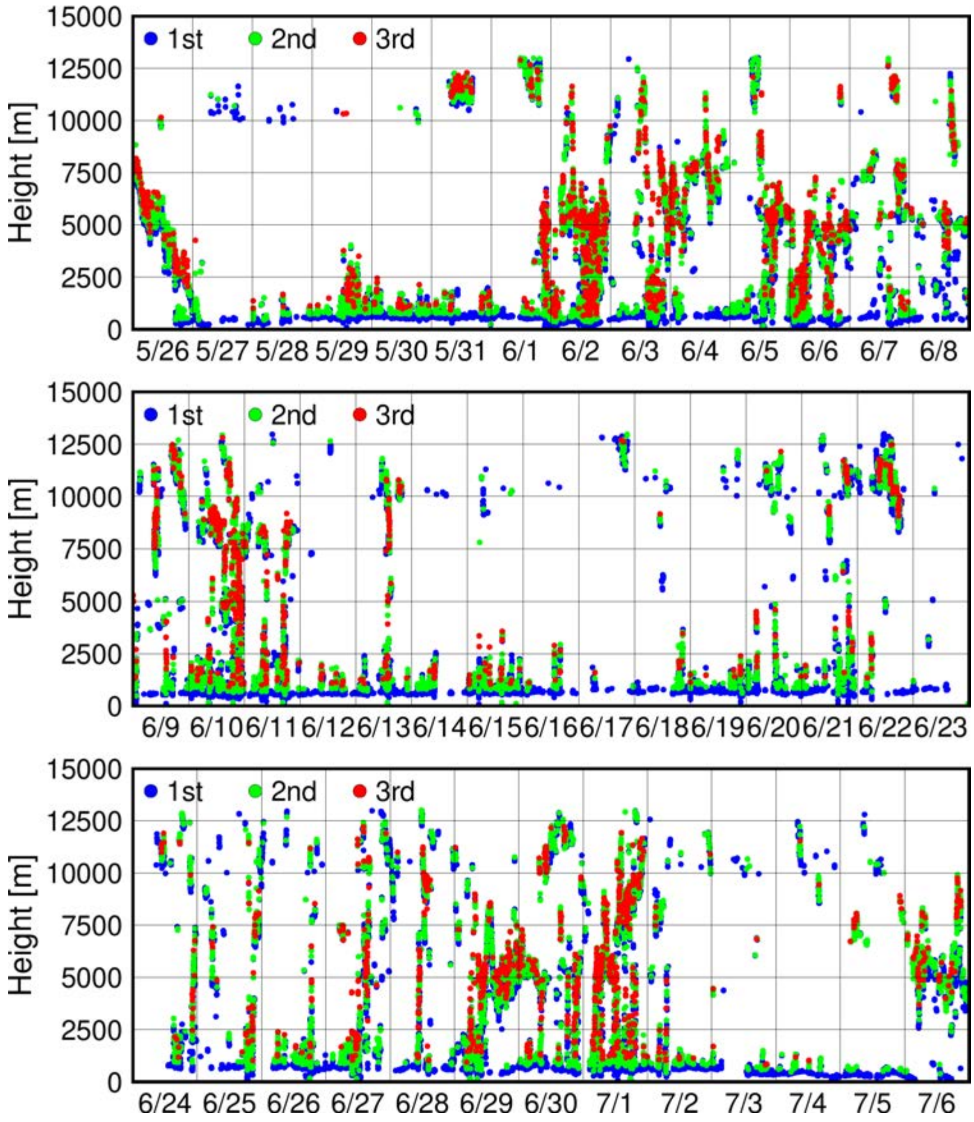


Fig. 7.1.2-1 First (Blue), 2nd (Green) and 3rd (Red) lowest cloud base height during the cruise.

(6) Data archive

All 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

Window Cleaning

23:48UTC 31 May 2021

23:32UTC 06 Jun. 2021

20:57UTC 15 Jun. 2021

23:35UTC 23 Jun. 2021

20:33UTC 03 Jul. 2021

7.2. Ocean observations

7.2.1. Shipboard ADCP

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Satomi Ogawa	(NME) Operation Leader
Kazuho Yoshida	(NME)
Ryo Oyama	(NME)
Yutaro Murakami	(NME)
Takatomo Shirozume	(MIRAI Crew)

(2) Objectives

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

(3) Instrumentations 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. 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, 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 1.50.19 (TRDI) for data acquisition.
5. To synchronize time stamp of ping with Computer time, the clock of the logging computer is adjusted to GNSS 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, 30 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, Direct Command, are shown in Table 7.2.1-1.

Table 7.2.1-1: 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; Vsum; 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 7.2.1-1 shows horizontal velocity along the ship's track. In vertical direction, the data are averaged from 27m to 51m.

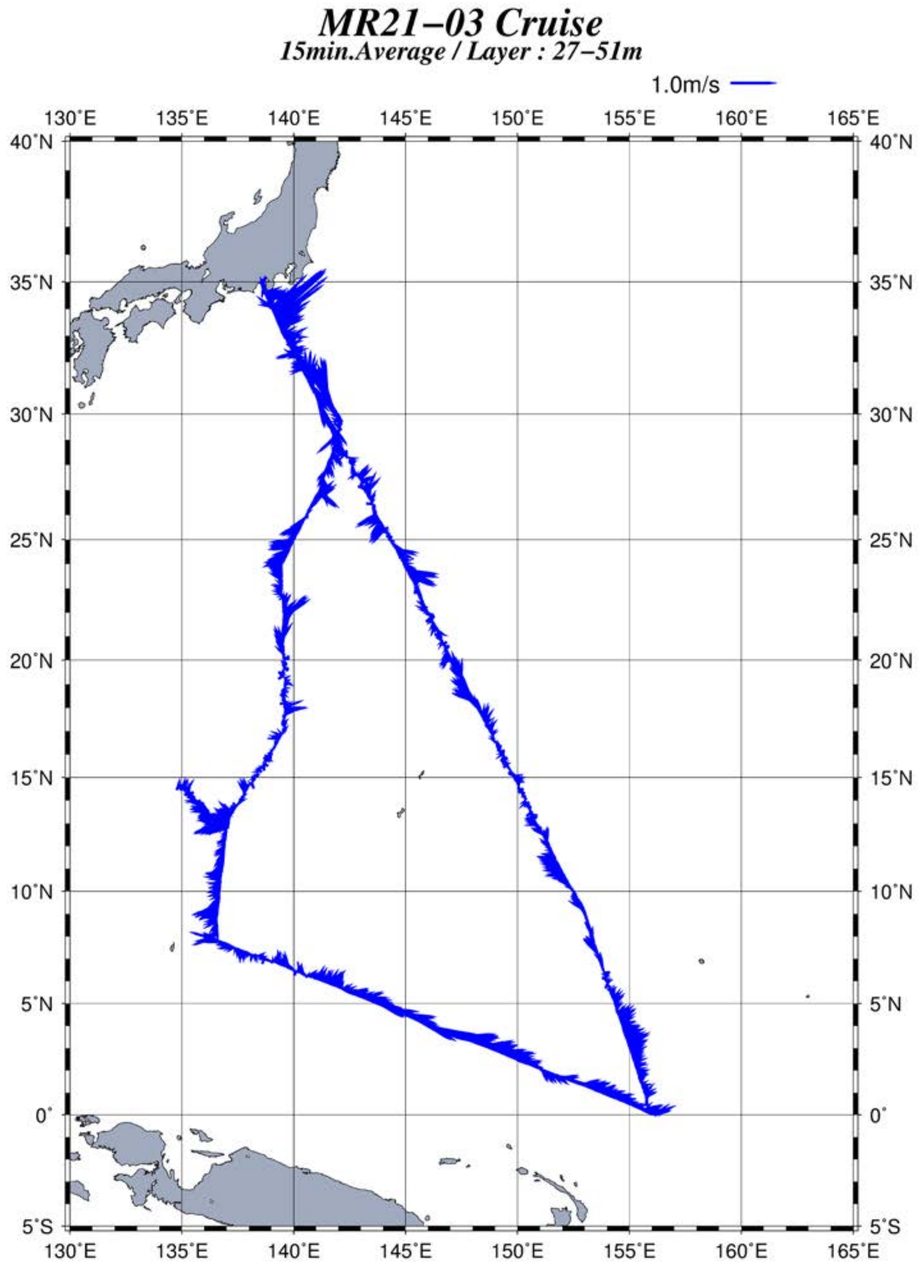


Fig. 7.2.1-1 Horizontal velocity along the ship's track.

(6) Data archive

All 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).

7.2.2. Underway surface water monitoring

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Erii Irie	(MWJ) Operation Leader
Tomomi Sone	(MWJ)

(2) Objectives

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

(3) Instrumentations and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan 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 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}.

Details of software and sensors are listed below.

1) Software

SeaMoni Ver.1.2.0.0

2) Sensors

a. Temperature and Conductivity sensor

Model:	SBE-45, SEA-BIRD ELECTRONICS, INC.	
Serial number:	4552788-0264	
Measurement range:	Temperature	-5 ºC - +35 ºC
	Conductivity	0 S m^{-1} - 7 S m^{-1}
Initial accuracy:	Temperature	0.002 ºC
	Conductivity	0.0003 S m^{-1}
Typical stability (per month):	Temperature	0.0002 ºC
	Conductivity	0.0003 S m^{-1}
Resolution:	Temperature	0.0001 ºC
	Conductivity	0.00001 S m^{-1}

b. Bottom of ship thermometer

Model:	SBE 38, SEA-BIRD ELECTRONICS, INC.
Serial number:	3852788-0457
Measurement range:	-5 ºC - +35 ºC
Initial accuracy:	±0.001 ºC
Typical stability (per 6months):	0.001 ºC
Resolution:	0.00025 ºC

c. Dissolved oxygen sensor

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

d. Fluorescence & Turbidity sensor

Model:	C3, TURNER DESIGNS
Serial number:	2300707
Measurement range:	Chlorophyll in vivo 0 μg L^{-1} – 500 μg L^{-1}
Minimum Detection Limit:	Chlorophyll in vivo 0.03 μg L^{-1}
Measurement range:	Turbidity 0 NTU - 1500 NTU
Minimum Detection Limit:	Turbidity 0.05 NTU

e. Total dissolved gas pressure sensor

Model:	HGTD-Pro, PRO OCEANUS
Serial number:	36-296-10
Temperature range:	-2 °C - 50 °C
Resolution:	0.0001 %
Accuracy:	0.01 % (Temperature Compensated)
Sensor Drift:	0.02 % per year max (0.001 % typical)

(4) Preliminary results

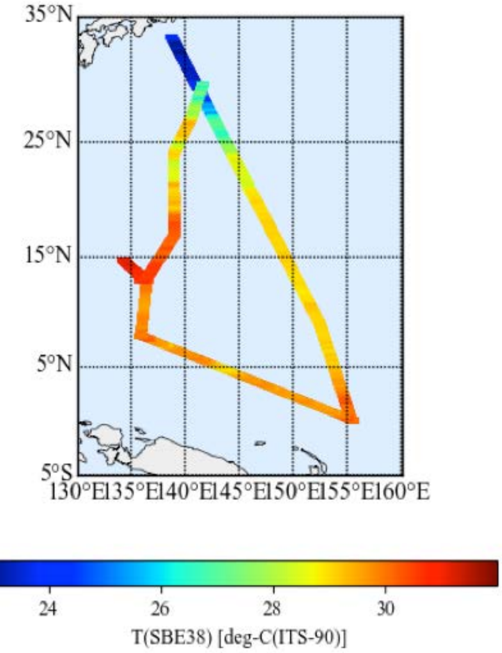
We conducted sea surface water monitoring during the cruise. Periods of measurement, maintenance, and problems during this cruise are listed in Table 7.2.2-1. Observed values of each variables along cruise track are shown in Fig. 7.2.2-1.

Table 7.2.2-1 Events list of the Sea surface water monitoring during MR21-03

System Date	System Time	Events	Remarks
2021/05/26	10:09	All the measurements started and data was available.	Start
2021/06/13	23:04-23:49	Filter Cleaning	-
2021/06/26	16:03-16:24	Filter Cleaning	-
2021/07/05	03:57	All the measurements stopped.	End

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. The results are shown in Fig. 7.2.2-2. All the salinity samples were analyzed by the Model 8400B “AUTOSAL” manufactured by Guildline Instruments Ltd. (see 6.8.1), and dissolve oxygen samples were analyzed by Winkler method (see 6.8.2), chlorophyll a were analyzed by 10-AU manufactured by Turner Designs. (see 6.8.3).

(a)



(b)

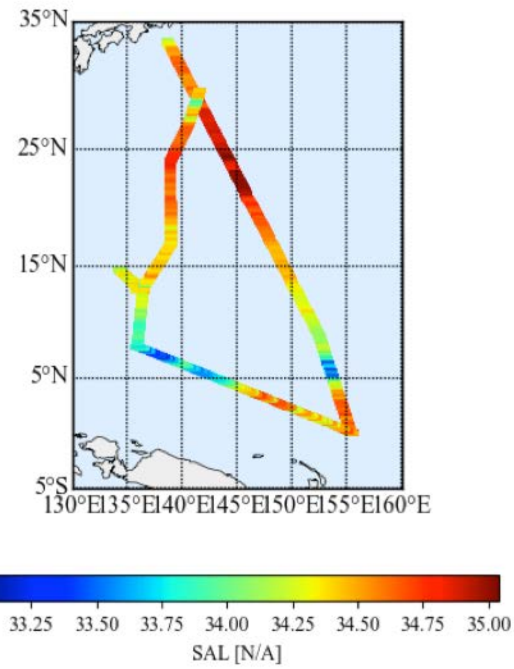


Figure 7.2.2-1 Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen, and (d) fluorescence in MR21-03 cruise.

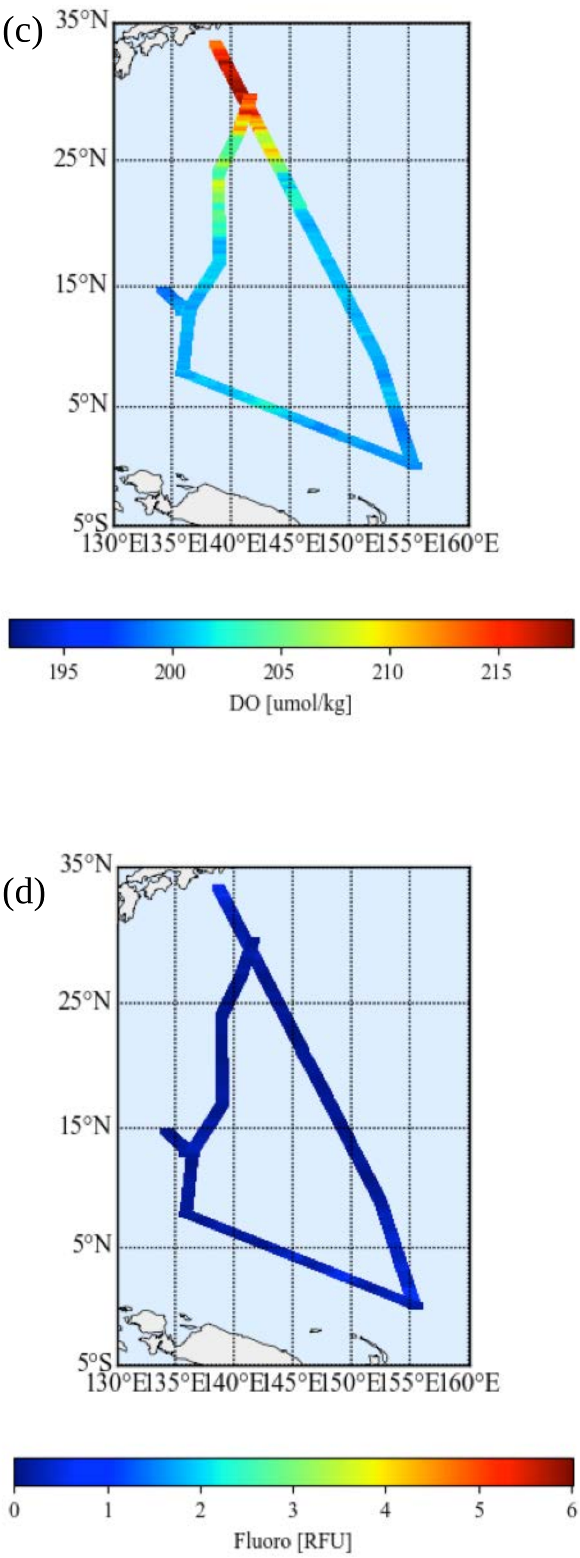
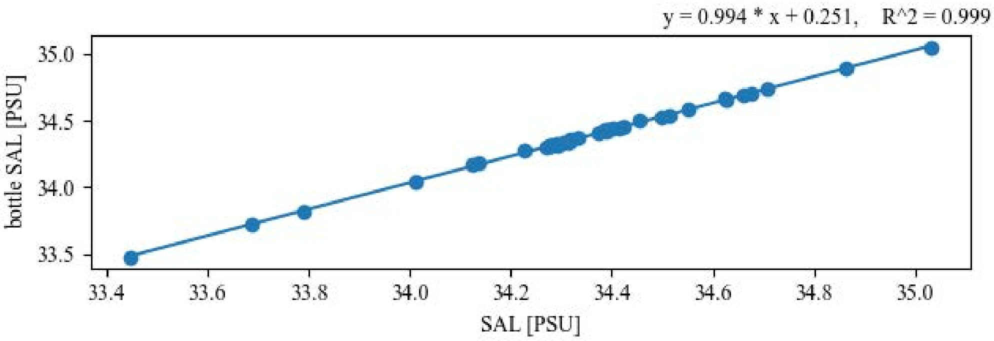
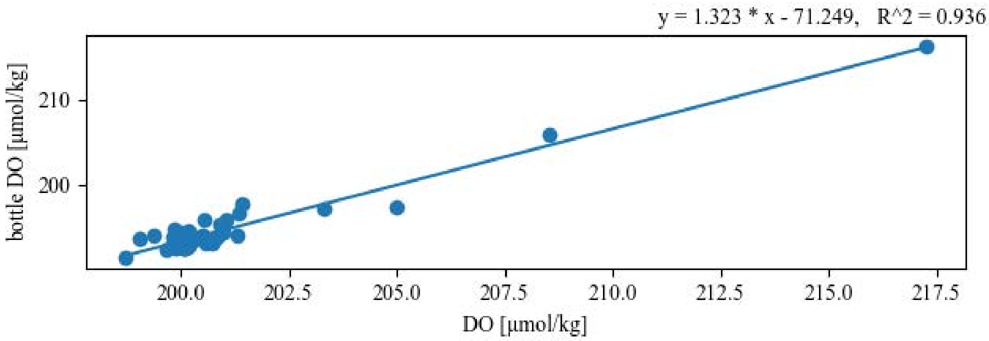


Figure 7.2.2-1 (continued)

(a)



(b)



(c)

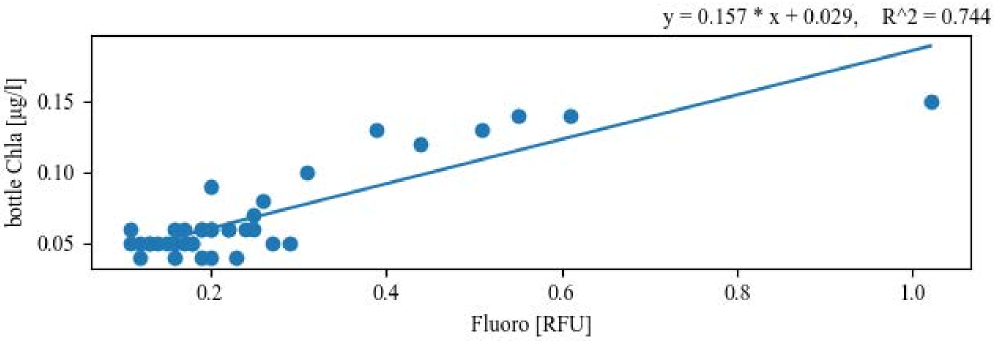


Figure 7.2.2-2 Correlation between sensor and bottle data for (a) Salinity, (b) dissolved oxygen, and (c) fluorescence

(5) Data archive

All 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).

7.3. Geophysical surveys

7.3.1. Sea surface gravity

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Satomi Ogawa	(NME) Operation Leader
Kazuho Yoshida	(NME)
Ryo Oyama	(NME)
Yutaro Murakami	(NME)
Takatomo Shirozume	(MIRAI Crew)

(2) Objectives

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

(3) Instrumentations and Methods

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-G LaCoste, LLC) during this cruise. Parameters of gravity meter are as follows:

Relative Gravity [CU: Counter Unit]

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

(4) Preliminary results

Absolute gravity at Shimizu port before and after cruise was shown in Table 7.3.1-1.

Table 7.3.1-1 Absolute gravity at Shimizu port

No.	Date m/d	UTC hh:mm	Port	Absolute Gravity [mGal]	Sea Level [cm]	Ship Draft [cm]	Gravity by Sensor *1 [mGal]	S-116 Gravity [mGal]
#1	5/26	00:08	Shimizu	979728.87	233	650	979729.86	12005.55
#2	7/07	23:18	Shimizu	979728.87	212	615	979729.71	12006.06

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

(5) Data archive

All 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).

7.3.2. Sea surface three component magnetic field

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Satomi Ogawa	(NME) Operation Leader
Kazuho Yoshida	(NME)
Ryo Oyama	(NME)
Yutaro Murakami	(NME)
Takatomo Shirozume	(MIRAI Crew)

(2) Objectives

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) Instrumentations and Methods

A shipboard three-component magnetometer system (Tierra Tecnica SFG2018) is equipped on-board R/V MIRAI. Three-axes flux-gate sensors with ring-cored coils are fixed on the fore mast. Outputs from the sensors are digitized by a 20-bit A/D converter (1 nT/LSB), and sampled at 8 times per second. Ship's heading, pitch, and roll are measured by the Inertial Navigation System (INS) for controlling attitude of a Doppler radar. Ship's position and speed data are taken from LAN every second.

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, $\mathbf{F}$, (in the Earth's fixed coordinate system) is expressed as:

$$\mathbf{H}_{\mathrm{ob}} = \widetilde{\mathbf{A}}\ \widetilde{\mathbf{R}}\ \widetilde{\mathbf{P}}\ \widetilde{\mathbf{Y}}\ \mathbf{F} + \mathbf{H}_{\mathrm{p}} \quad (7.3.2\text{-a})$$

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. (7.3.2-a) makes

$$\widetilde{\mathbf{B}}\,\mathbf{H}_{\mathrm{ob}} + \mathbf{H}_{bp} = \widetilde{\mathbf{R}}\ \widetilde{\mathbf{P}}\ \widetilde{\mathbf{Y}}\ \mathbf{F} \quad (7.3.2\text{-b})$$

where $\widetilde{\mathbf{B}} = \widetilde{\mathbf{A}}$ and $\mathbf{H}_{\mathbf{ob}}$, if $\widetilde{\mathbf{B}}$ and $\mathbf{H}_{bp}$ is 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 $\mathbf{F}$ is known.

(4) Data archive

All 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

For calibration of the ship's magnetic effect, we made a "figure-eight" turn (a pair of clockwise and counter-clockwise rotation). These calibrations were carried out as below.

05:21UTC - 05:43UTC, 04 Jun. 2021 around 00-02N, 155-57E.

09:07UTC - 09:28UTC, 09 Jun. 2021 around 07-44N, 136-50E.

00:02UTC - 00:25UTC, 04 Jul. 2021 around 25-12N, 134-07E.

7.3.3. Swath bathymetry

(1) Personnel

Iwao Ueki	(JAMSTEC) PI
Satomi Ogawa	(NME) Operation Leader
Kazuho Yoshida	(NME)
Ryo Oyama	(NME)
Yutaro Murakami	(NME)
Takatomo Shirozume	(MIRAI Crew)

(2) Objectives

R/V MIRAI is equipped with a Multi narrow Beam Echo Sounding system (MBES), SEABEAM 3012 Model (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.

In addition, we surveyed around 13˚N, 137˚E in order to draw a bathymetric map of Philippine sea mooring and ADCP moorings deployment area.

(3) Instrumentations and Methods

"SEABEAM 3012 Model" on 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 (6.62m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from CTD, XCTD and Argo float data by the equation in Del Grosso (1974) during the cruise. Specification of SEABEAM 3012 system are listed below.

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
Beam spacing:	Equi-Angle
Number of beams:	301 beams
Swath width:	60 to 150 degree (max)
Depth accuracy:	< 1 % of water depth (average across the swath)

(4) Data archive

All 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

1. Data acquisition was suspended during the stationary observation period.
   15:40UTC 15 Jun. 2021 - 13:12UTC 28 Jun. 2021

2. Data acquisitions were suspended due to ANS system operation.
   20:44UTC 03 Jun. 2021 - 21:04UTC 03 Jun. 2021
   22:07UTC 03 Jun. 2021 - 23:00UTC 03 Jun. 2021
   20:26UTC 04 Jun. 2021 - 21:16UTC 04 Jun. 2021
   21:59UTC 04 Jun. 2021 - 23:09UTC 04 Jun. 2021
   22:27UTC 30 Jun. 2021 - 23:08UTC 30 Jun. 2021

8. Acknowledgement

First of all, I would like to express great thank to Captain Inoue and all of the crew of R/V MIRAI. The all of observation activities were conducted under the cooperation with marine technicians of MWJ and NME. Their efforts were crucially important for our scientific activities. I hope all of scientists joining this cruise will acquire fruitful results. We would like to express our sincere appreciation to the Governments of the United States and the Federated States of Micronesia for allowing us to conduct observations in the areas under their jurisdictions. Finally I appreciate all of people, who have been involved this cruise.

9. Notice on Using

- This cruise report is a preliminary documentation as of the end of cruise.
- This report is not necessarily corrected even if there is any inaccurate description (i.e. taxonomic classifications).
- This report is subject to be revised without notice. Some data on this report may be raw or unprocessed.

If you are going to use or refer the data on this report, it is recommended to ask the Chief Scientist for latest status.

Users of information on this report are requested to submit Publication Report to JAMSTEC.

http://www.godac.jamstec.go.jp/darwin/explain/1/e#report

E-mail: submit-rv-cruise@jamstec.go.jp

Appendix-A Oceanic profiles by the CTDO observations

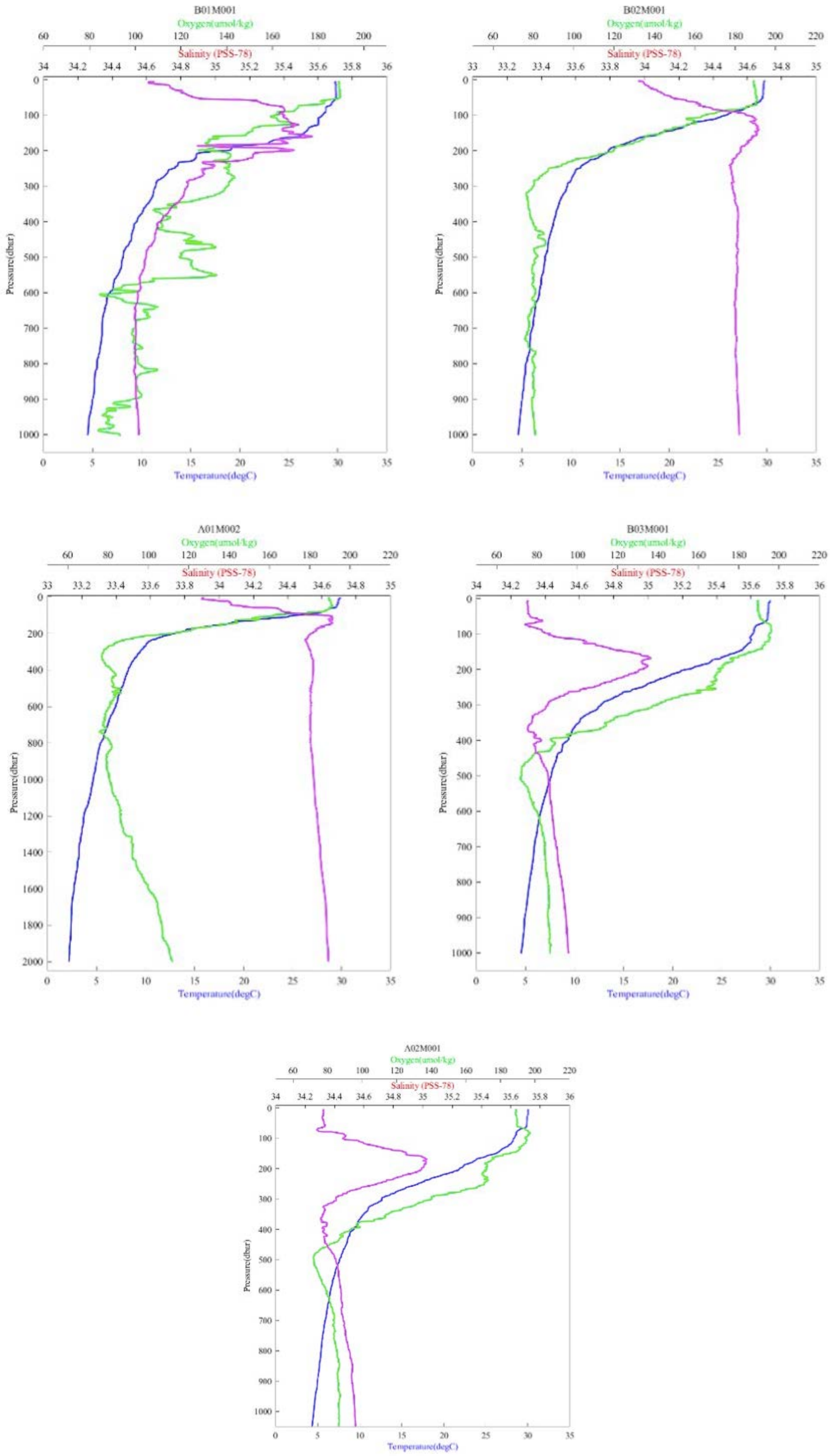


Fig. A-01 CTD profiles at the stations of Triton mooring recovery (B01M001, B02M001), ARGO float deployment (A01M002, A02M001), and Philippine sea mooring deployment (B03M001).

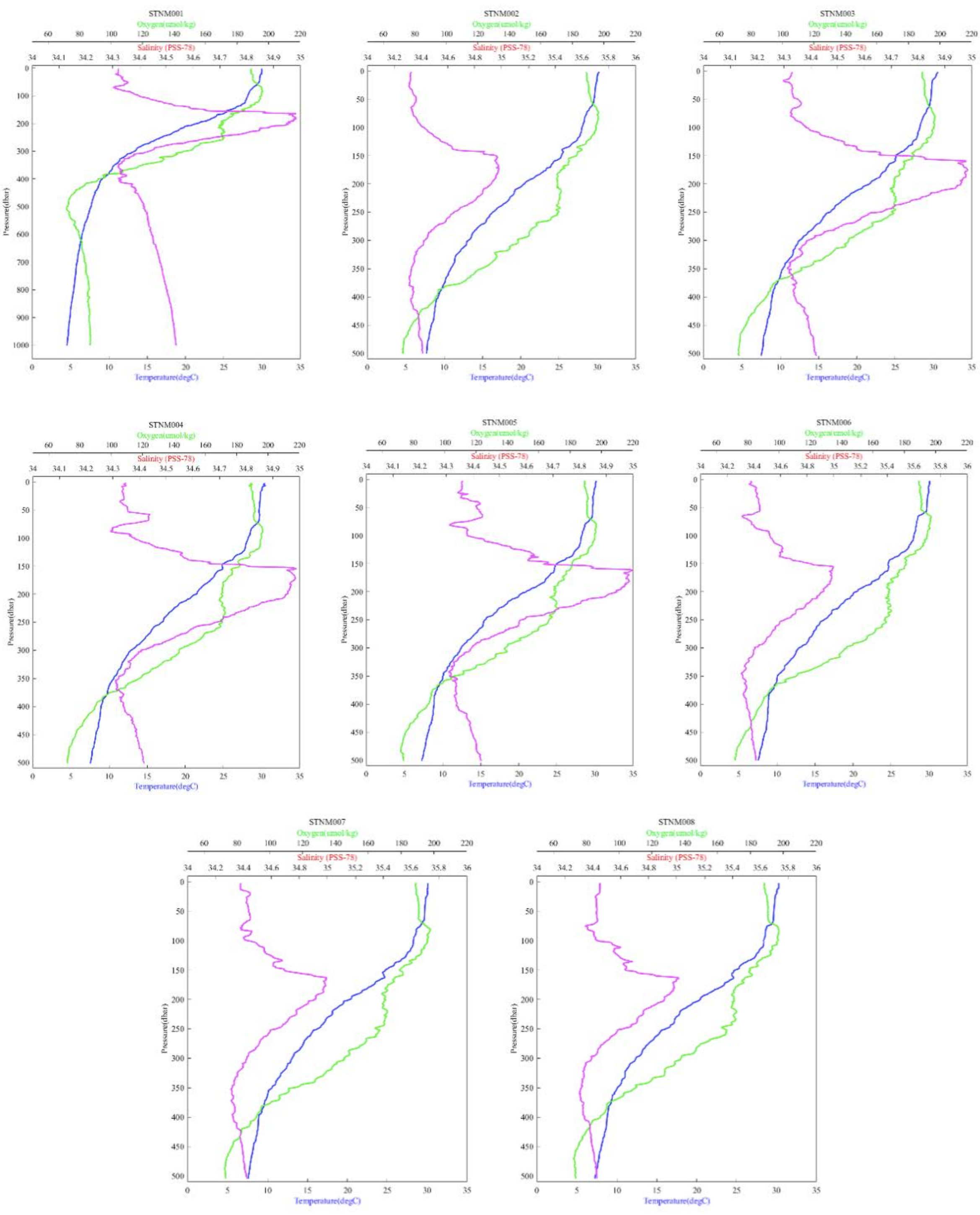


Fig. A-02 CTD profiles at the stationary observation site on 16 June 2021
(STNM001, STNM002, STNM003, STNM004, STNM005, STNM006, STNM007, STNM008).

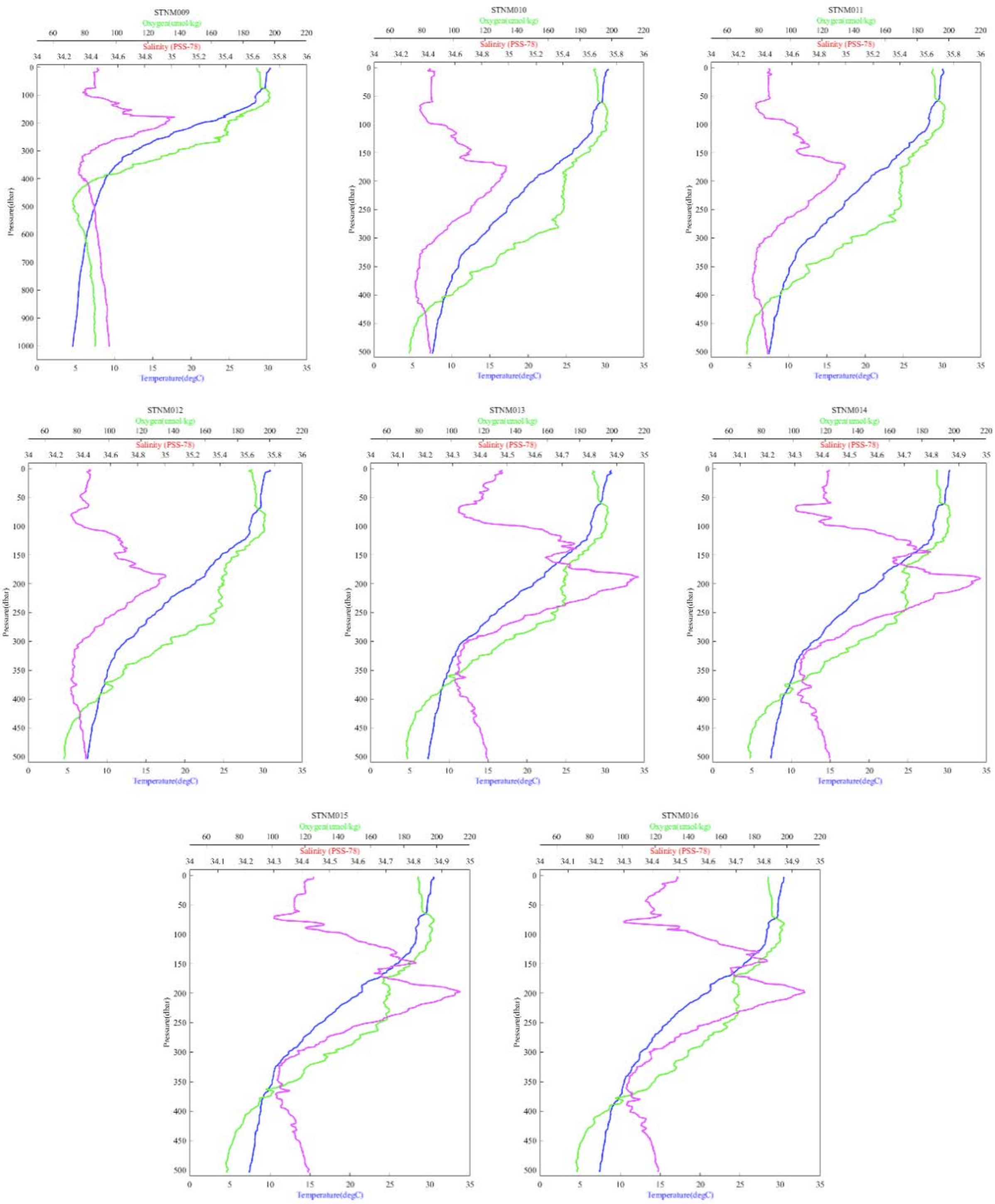


Fig. A-03 CTD profiles at the stationary observation site on 17 June 2021
(STNM009, STNM010, STNM011, STNM012, STNM013, STNM014, STNM015, STNM016).

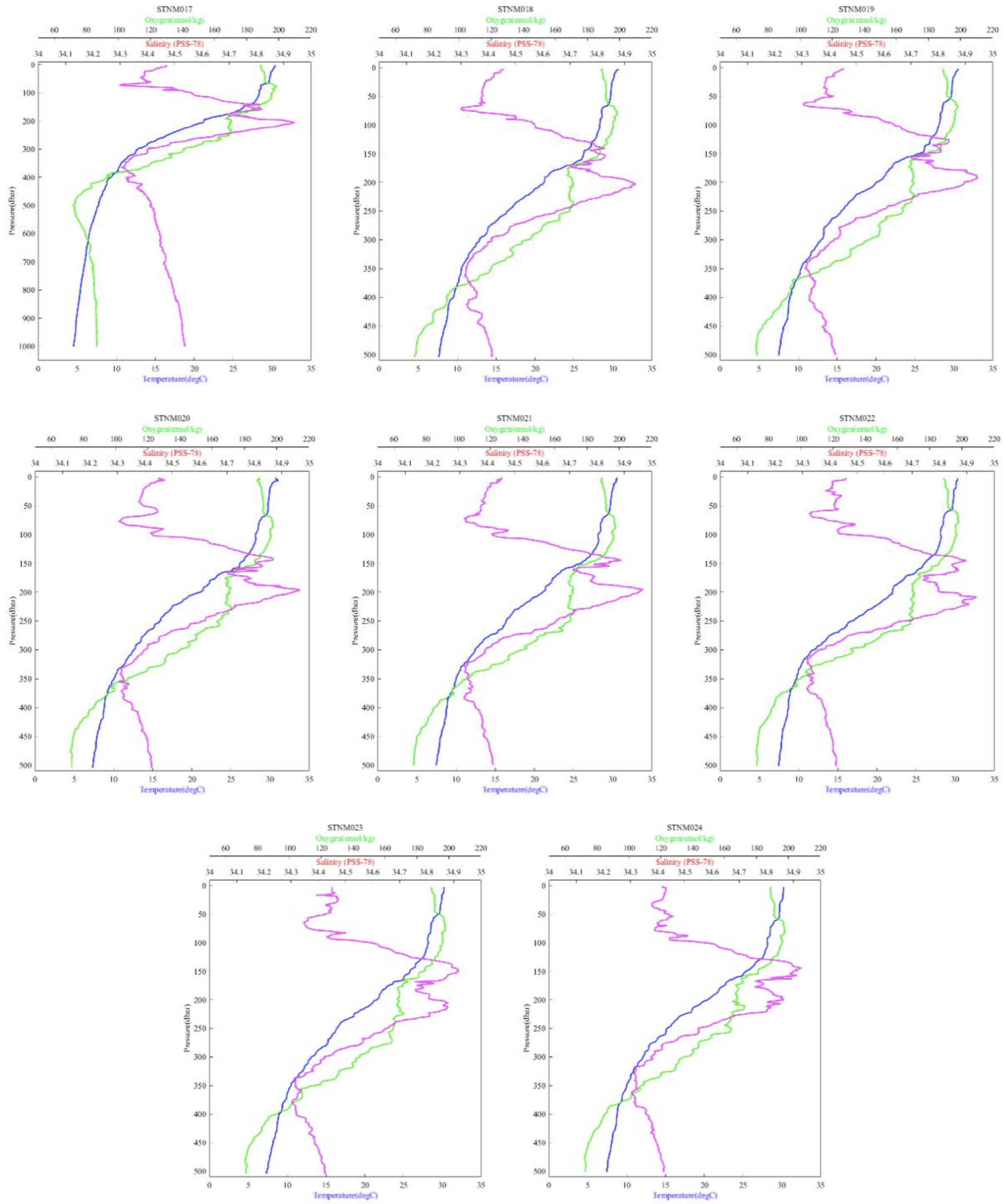


Fig. A-04 CTD profiles at the stationary observation site on 18 June 2021
(STNM017, STNM018, STNM019, STNM020, STNM021, STNM022, STNM023, STNM024).

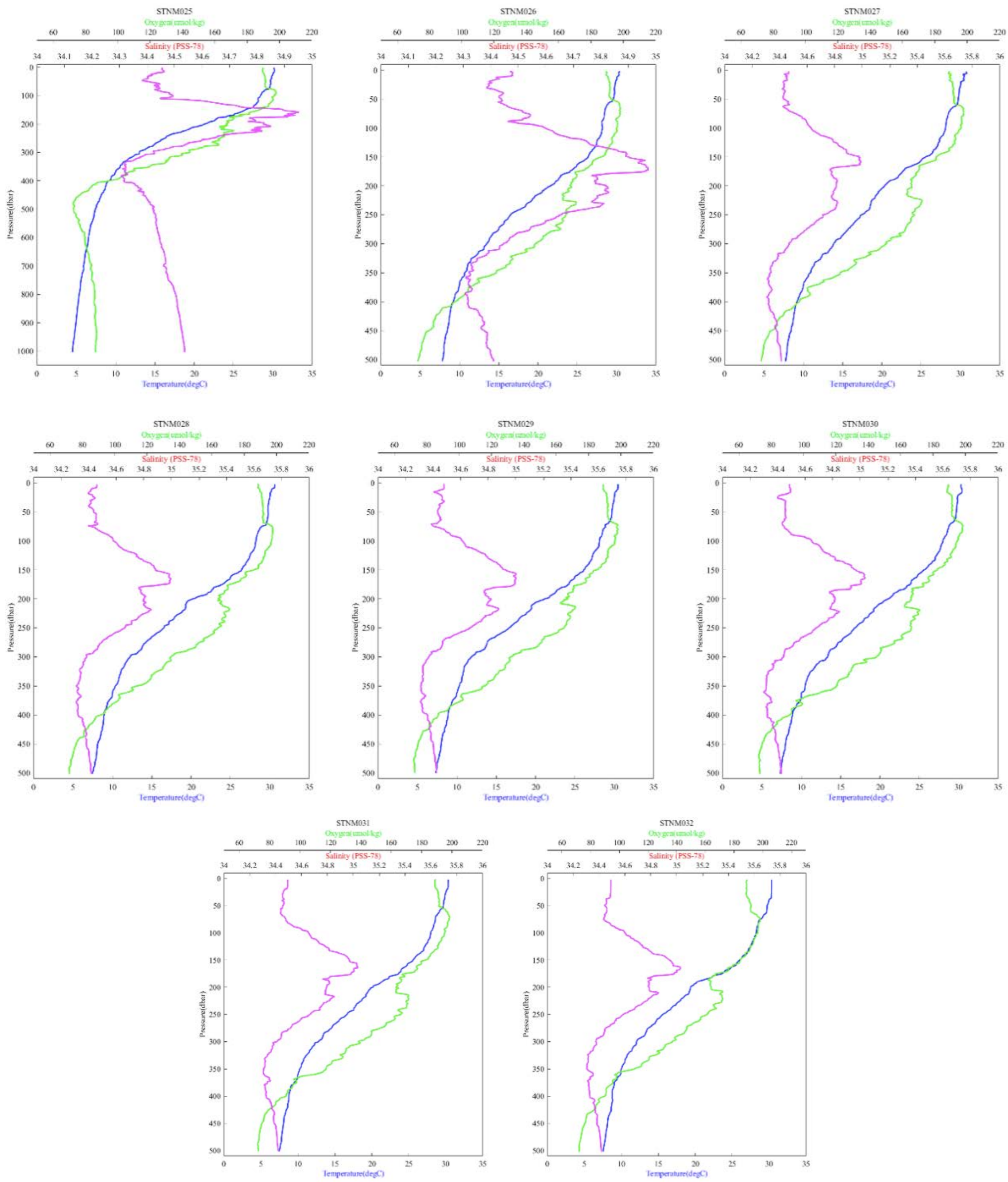


Fig. A-05 CTD profiles at the stationary observation site on 19 June 2021
(STNM025, STNM026, STNM027, STNM028, STNM029, STNM030, STNM031, STNM032).

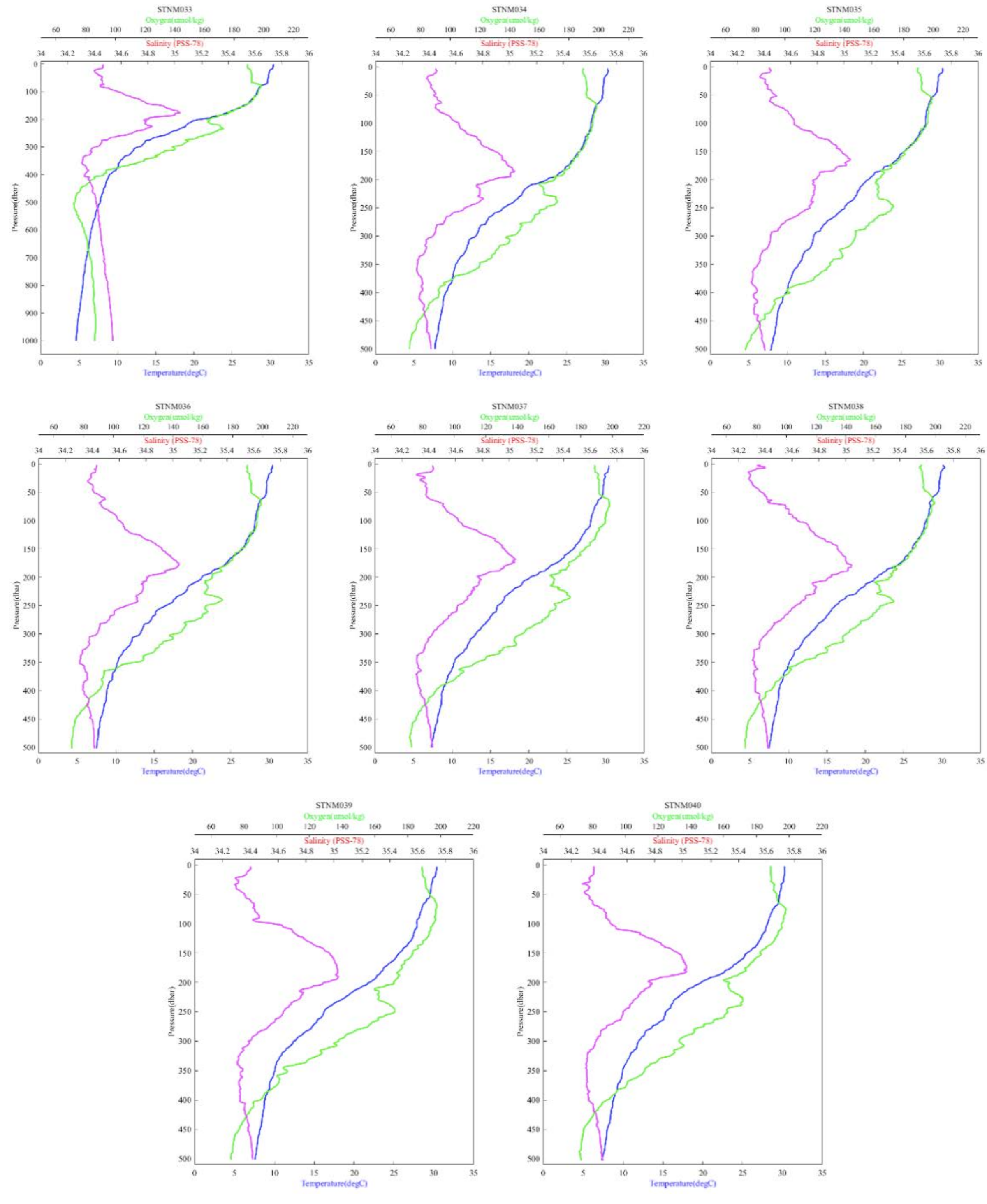


Fig. A-06 CTD profiles at the stationary observation site on 20 June 2021 (STNM033, STNM034, STNM035, STNM036, STNM037, STNM038, STNM039, STNM040).

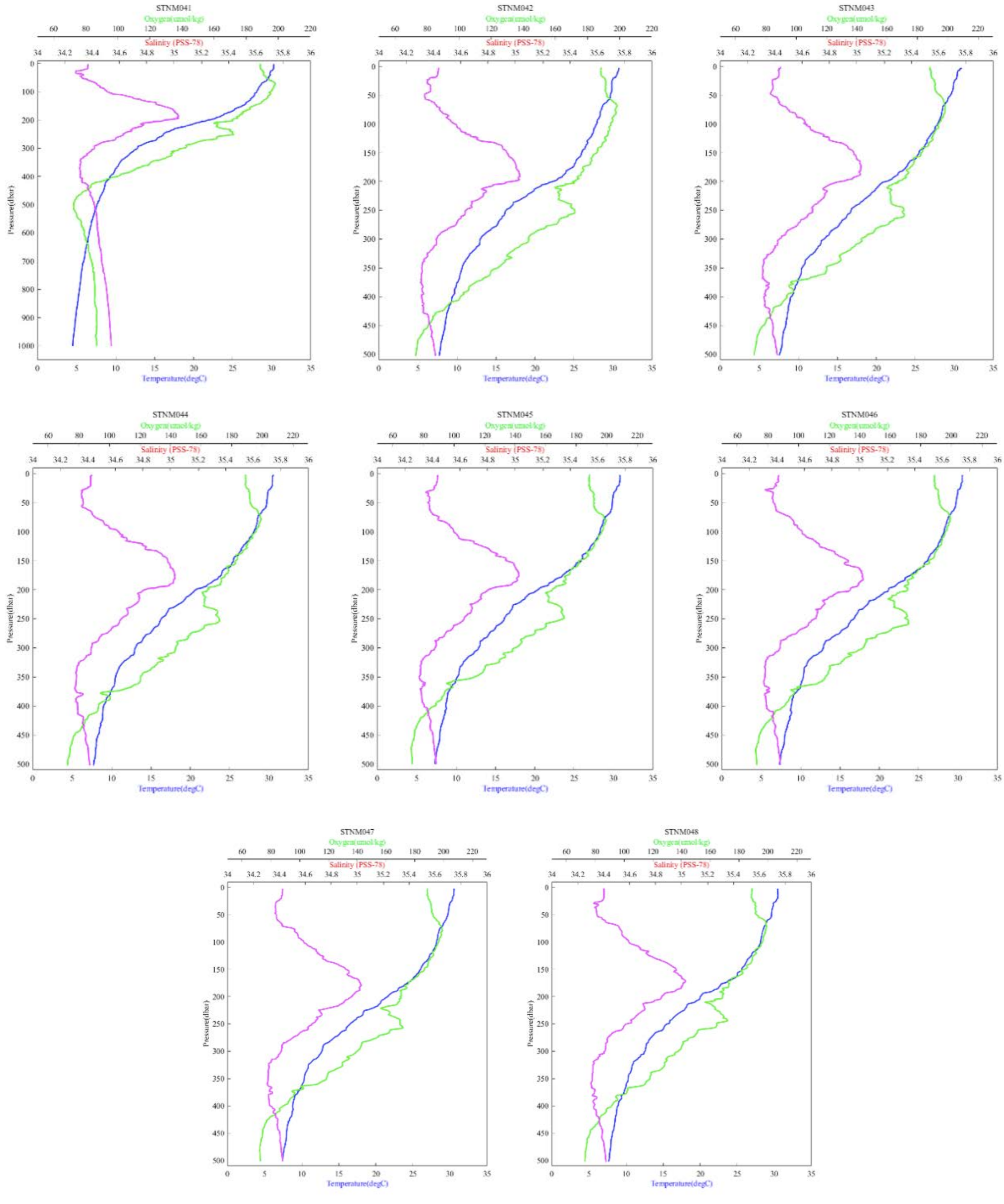


Fig. A-07 CTD profiles at the stationary observation site on 21 June 2021
(STNM041, STNM042, STNM043, STNM044, STNM045, STNM046, STNM047, STNM048).

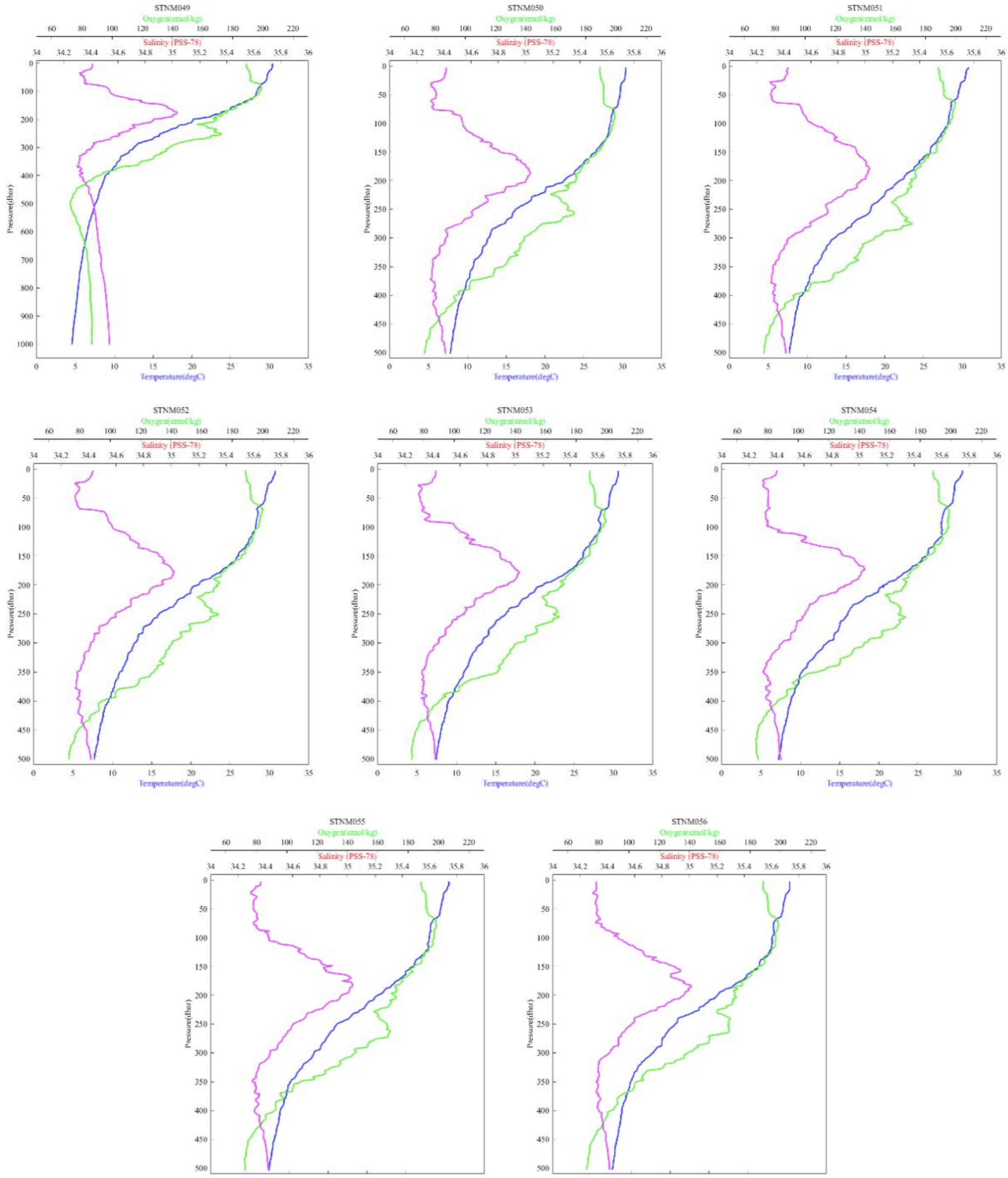


Fig. A-08 CTD profiles at the stationary observation site on 22 June 2021
(STNM049, STNM050, STNM051, STNM052, STNM053, STNM054, STNM055, STNM056).

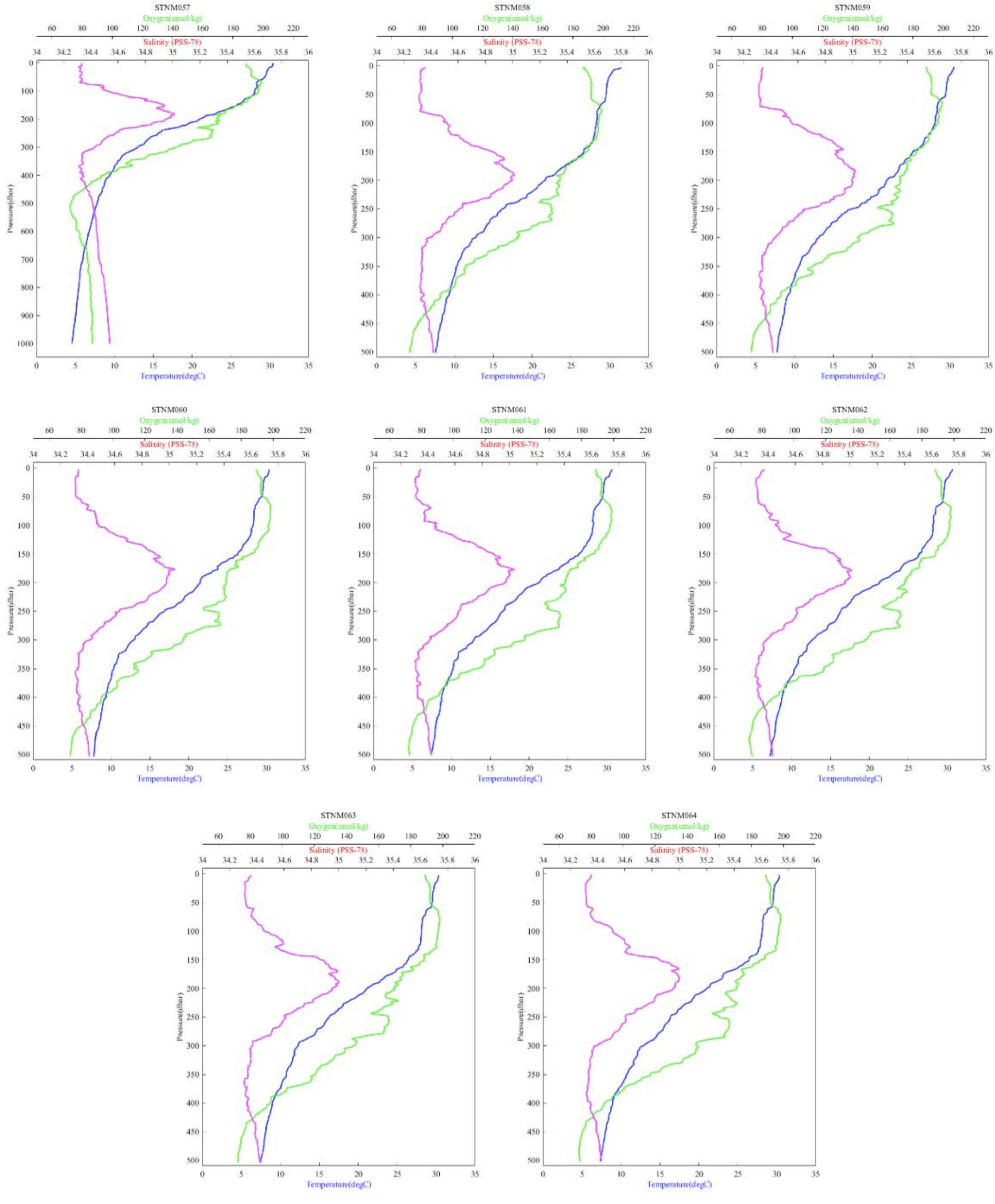


Fig. A-09 CTD profiles at the stationary observation site on 23 June 2021
(STNM057, STNM058, STNM059, STNM060, STNM061, STNM062, STNM063, STNM064).

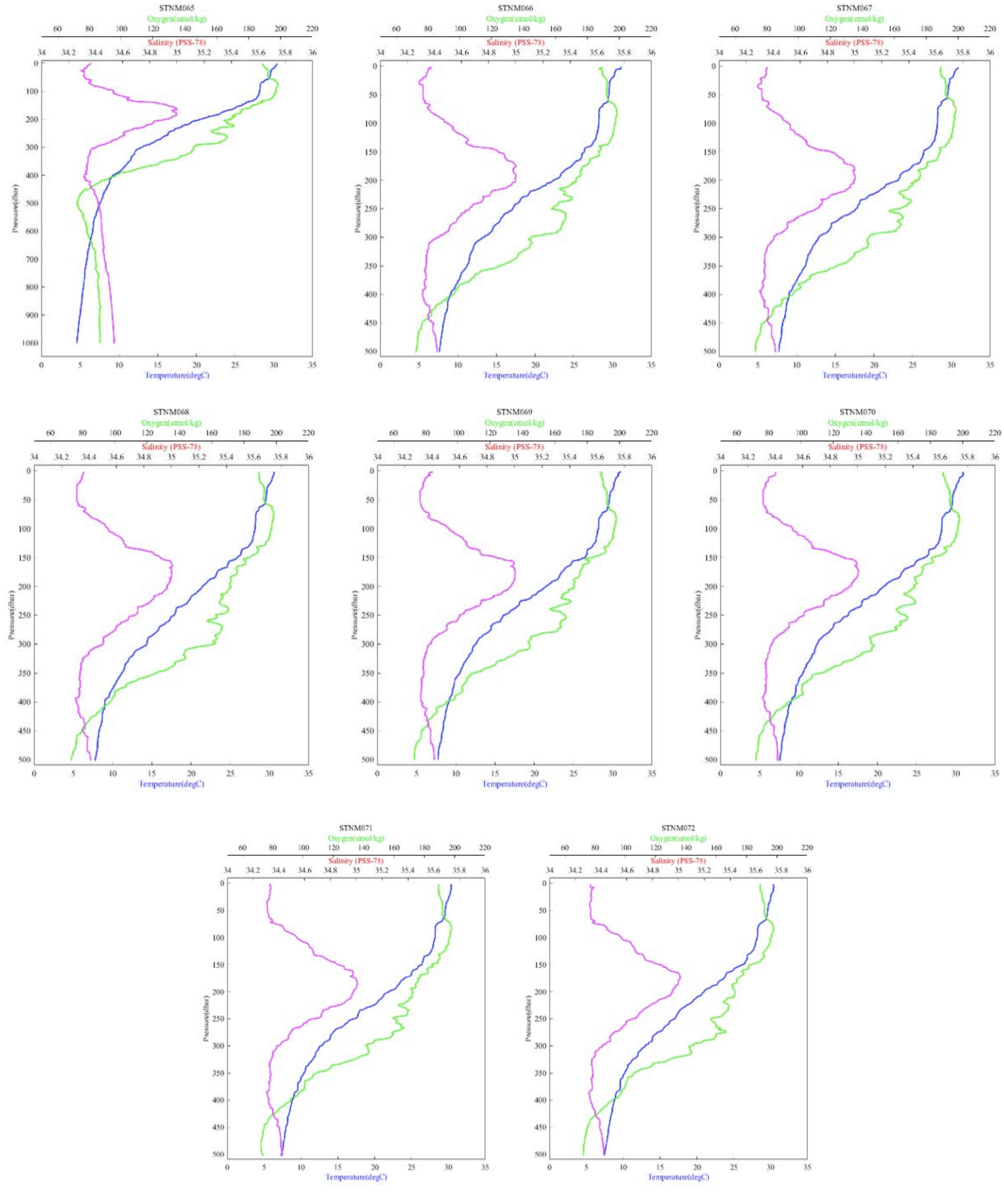


Fig. A-10 CTD profiles at the stationary observation site on 24 June 2021
(STNM065, STNM066, STNM067, STNM068, STNM069, STNM070, STNM071, STNM072).

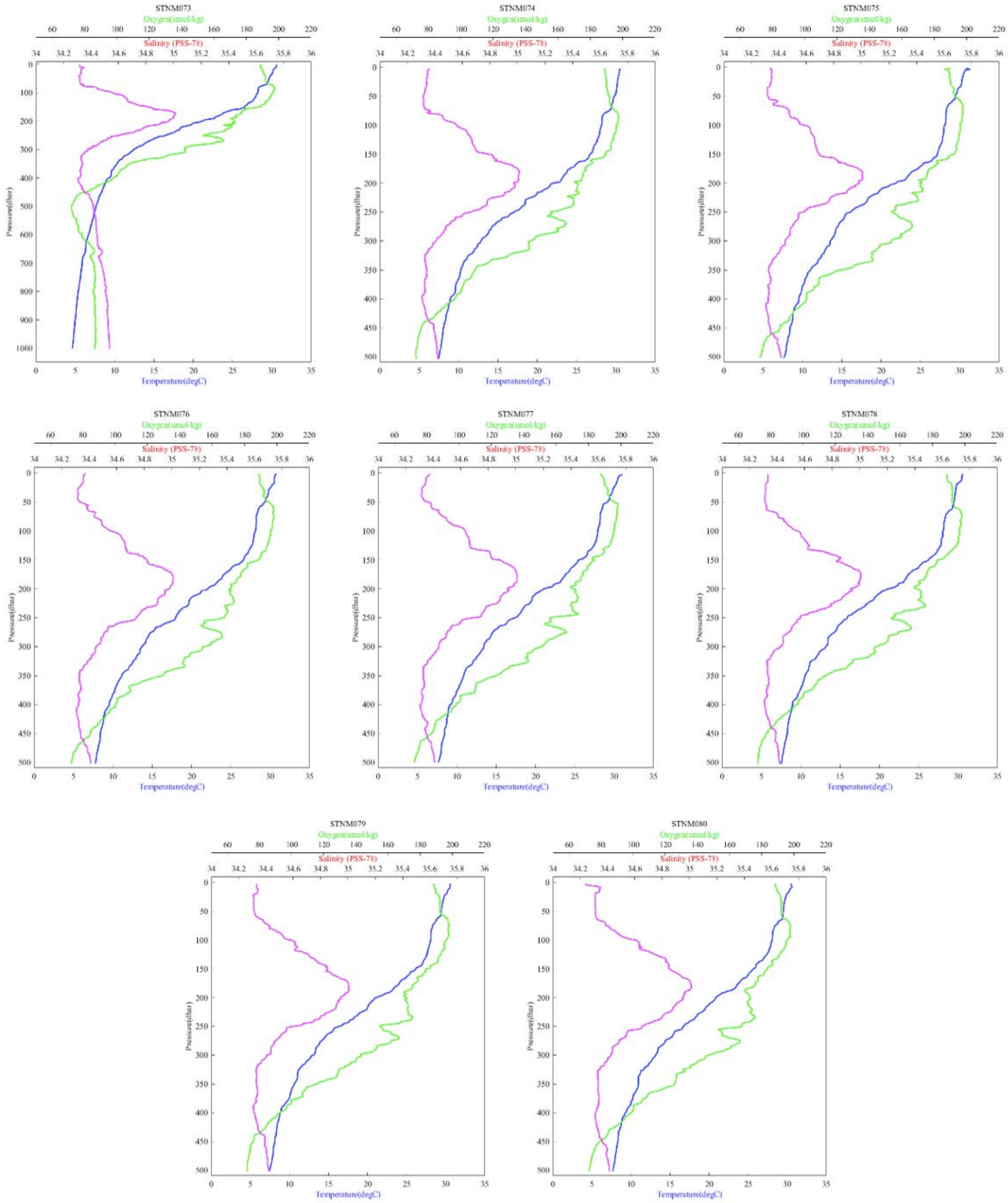


Fig. A-11 CTD profiles at the stationary observation site on 25 June 2021
(STNM073, STNM074, STNM075, STNM076, STNM077, STNM078, STNM079, STNM080).

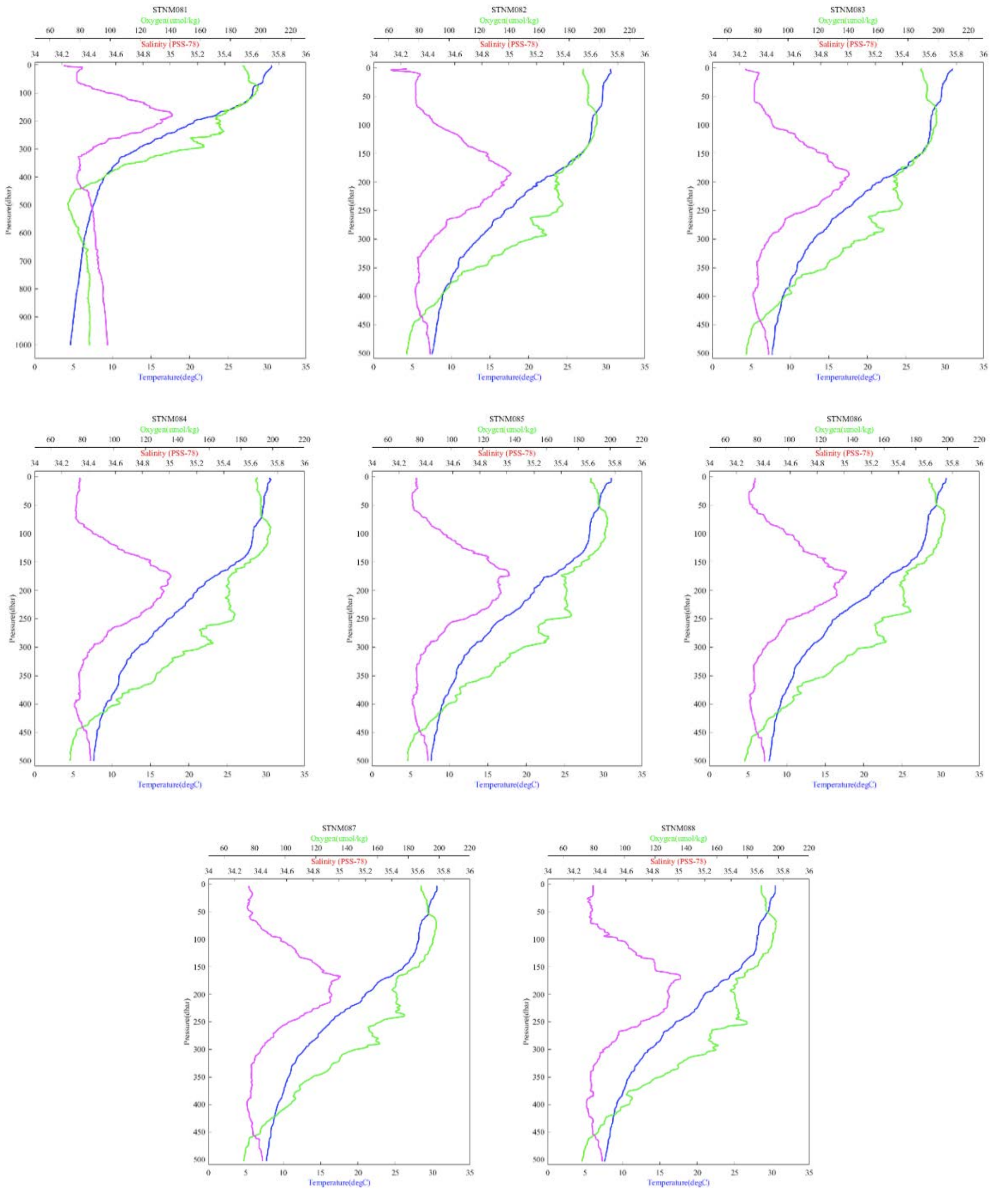


Fig. A-12 CTD profiles at the stationary observation site on 26 June 2021
(STNM081, STNM082, STNM083, STNM084, STNM085, STNM086, STNM087, STNM088).

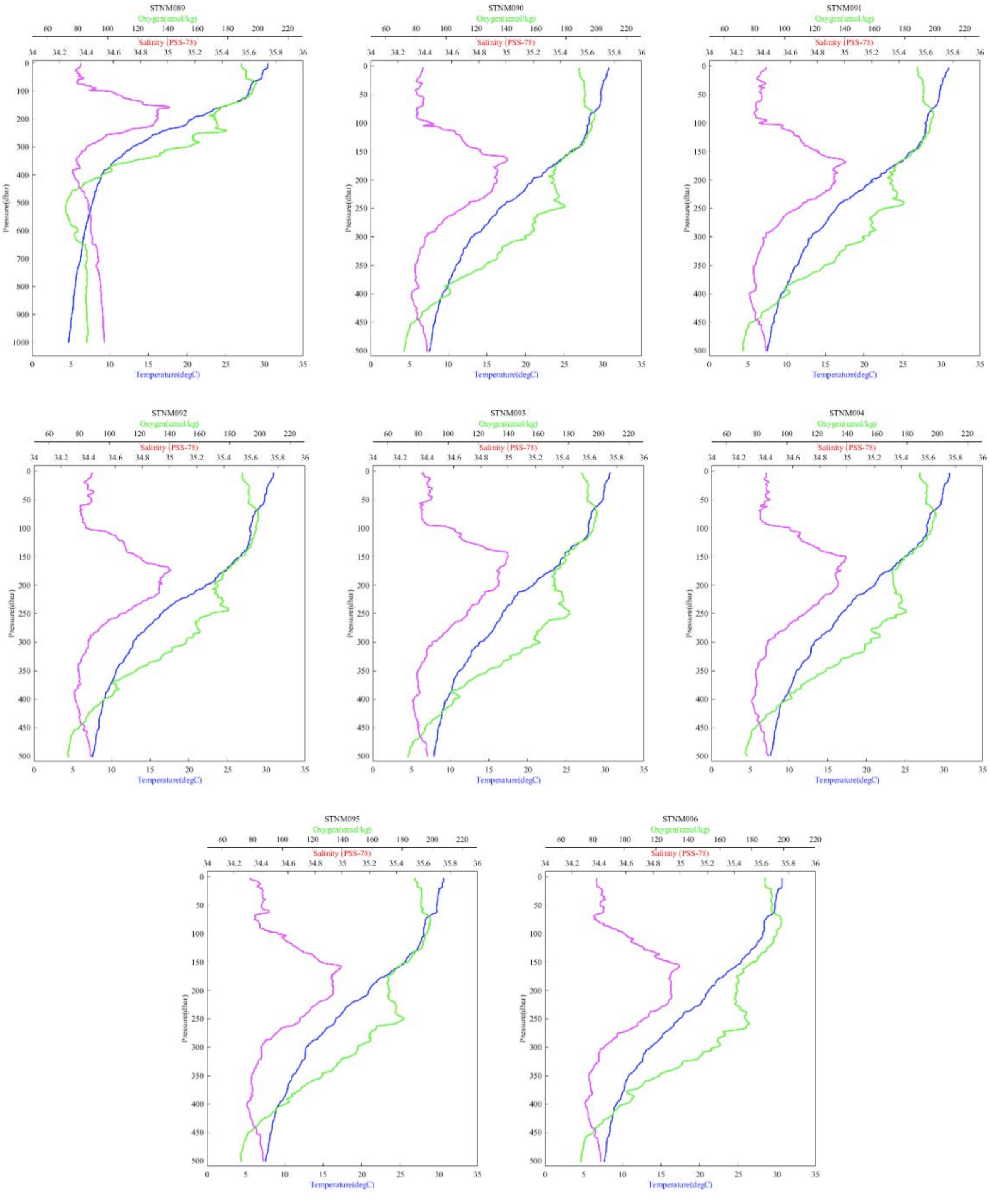


Fig. A-13 CTD profiles at the stationary observation site on 27 June 2021
(STNM089, STNM090, STNM091, STNM092, STNM093, STNM094, STNM095, STNM096).

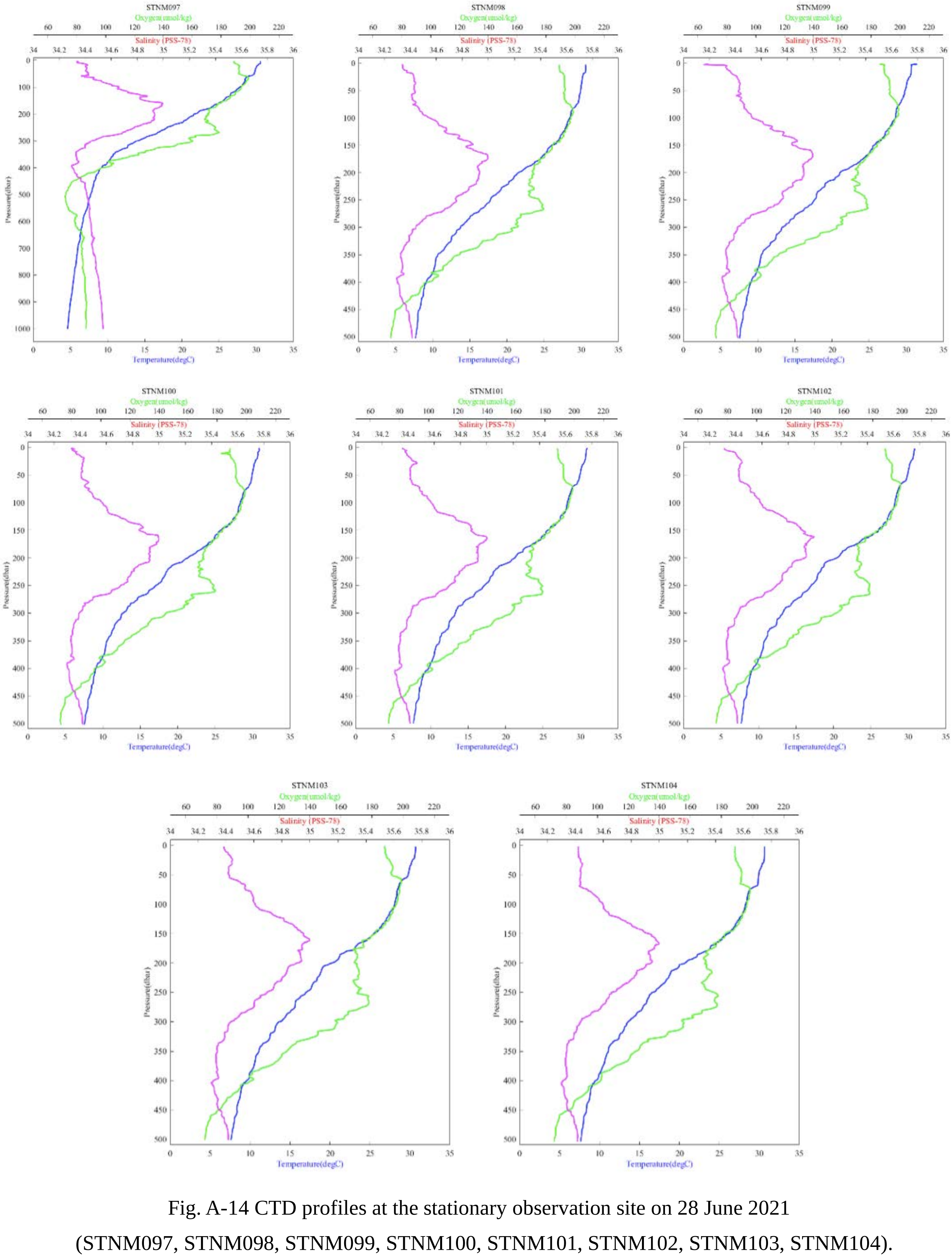


Fig. A-14 CTD profiles at the stationary observation site on 28 June 2021
(STNM097, STNM098, STNM099, STNM100, STNM101, STNM102, STNM103, STNM104).

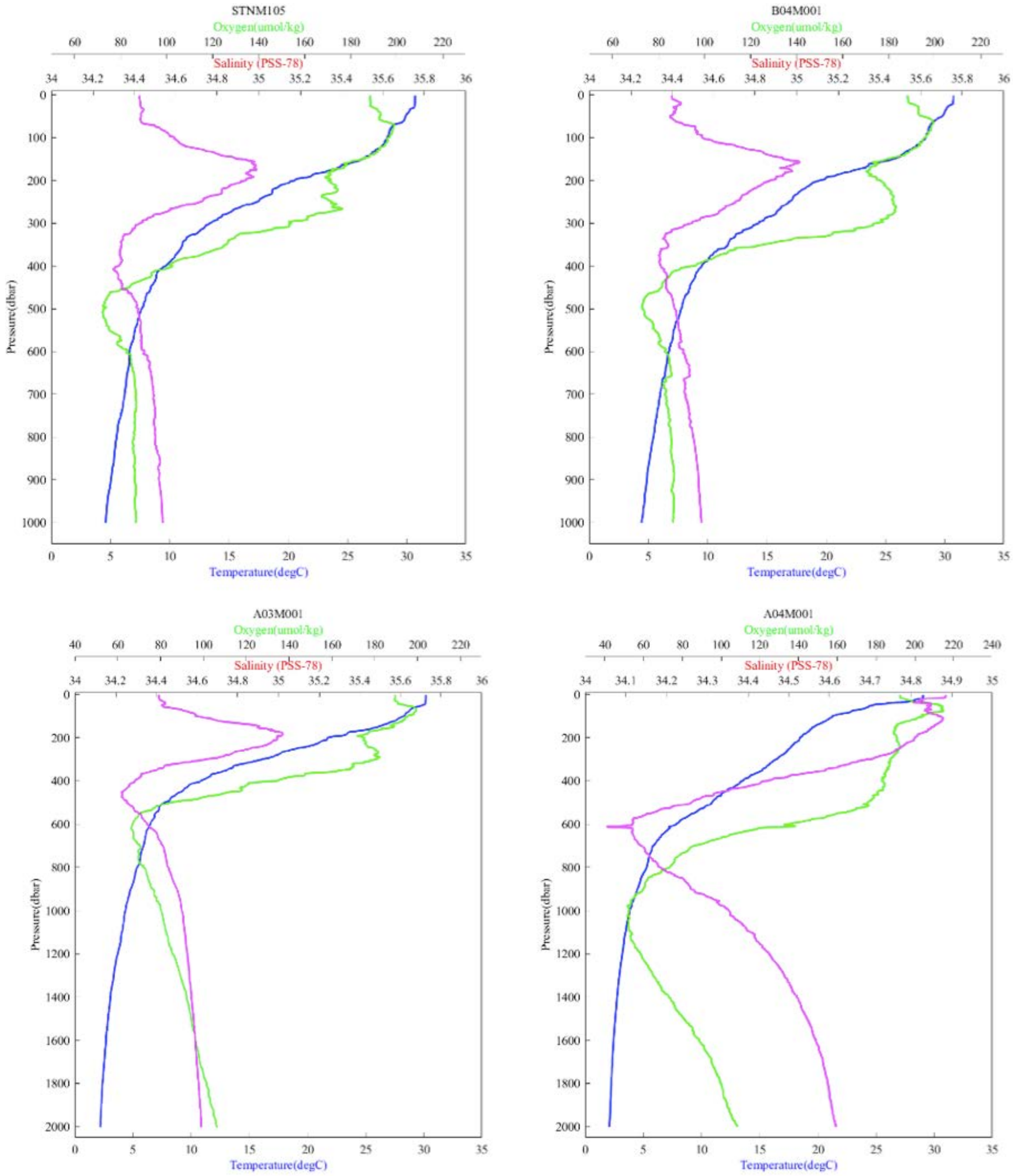


Fig. A-15 CTD profiles at the stationary observation site on 29 June 2021(STNM105), Philippine sea mooring deployment (B04M001), and ARGO float deployment (A03M001, A04M001).

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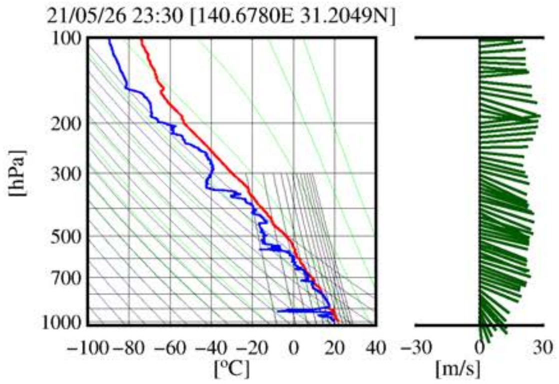
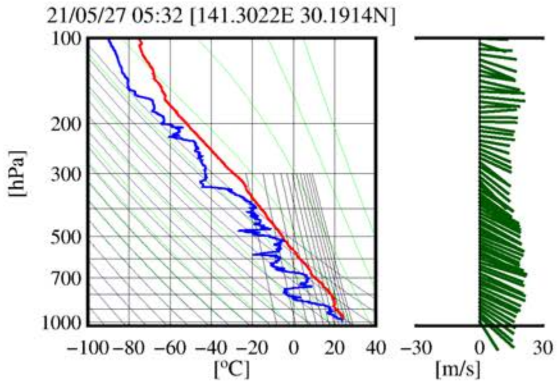
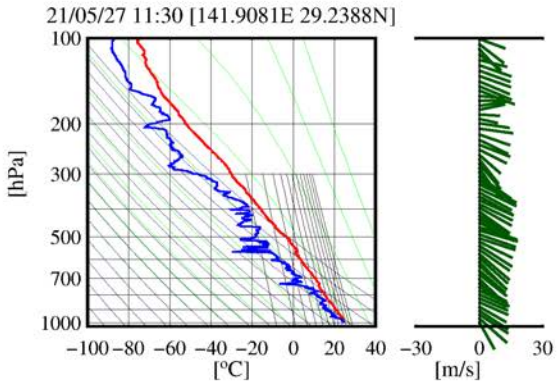
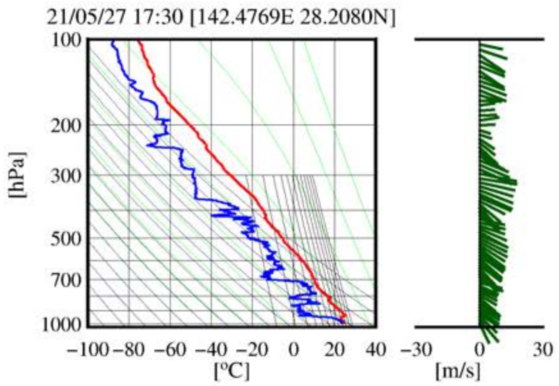
Appendix-B Atmospheric profiles by the radiosonde observations

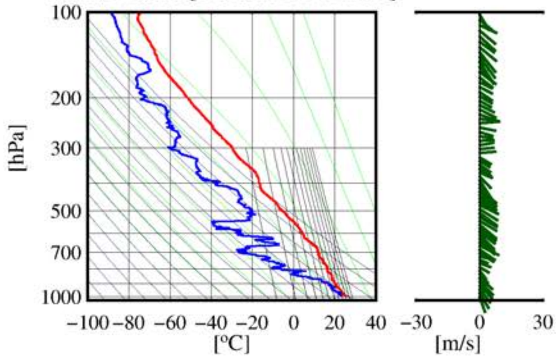




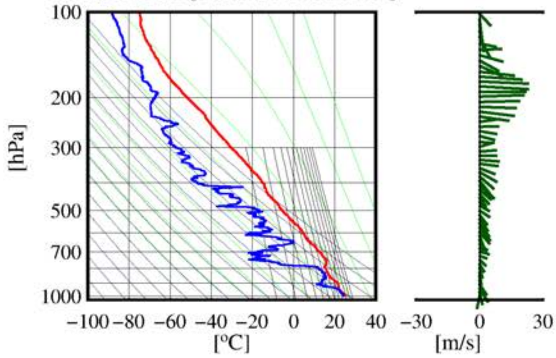




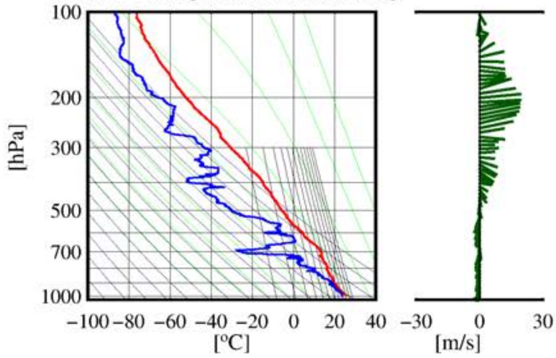
21/05/27 23:30 [143.0939E 27.1428N]



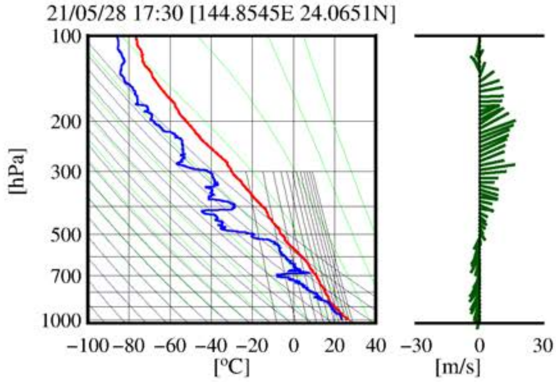
21/05/28 05:30 [143.6756E 26.1072N]

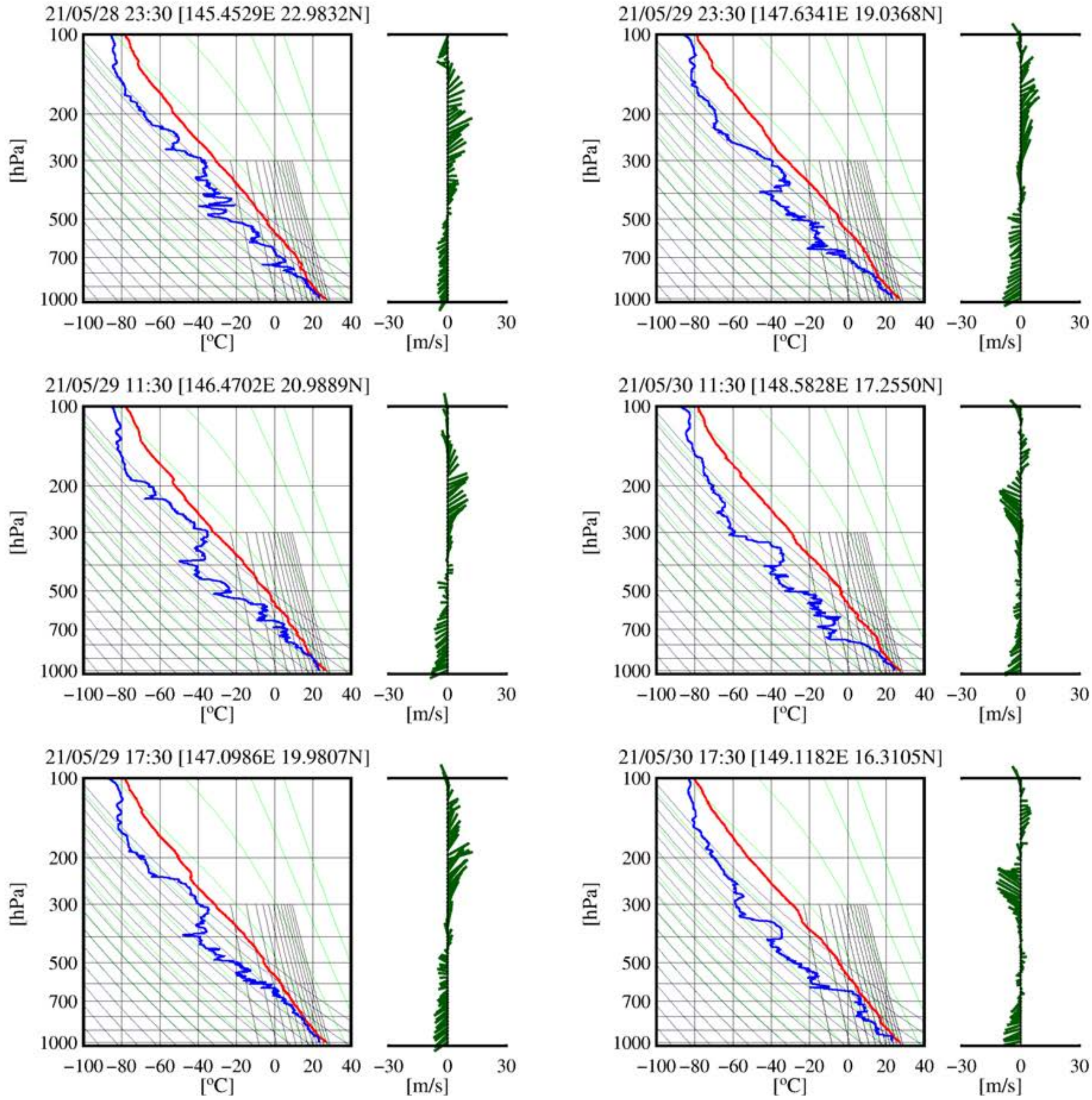


21/05/28 11:30 [144.2159E 25.1575N]

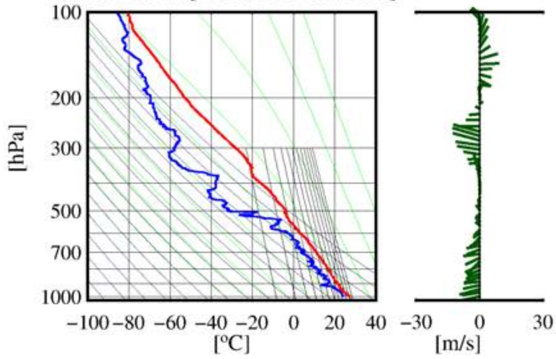


21/05/28 17:30 [144.8545E 24.0651N]

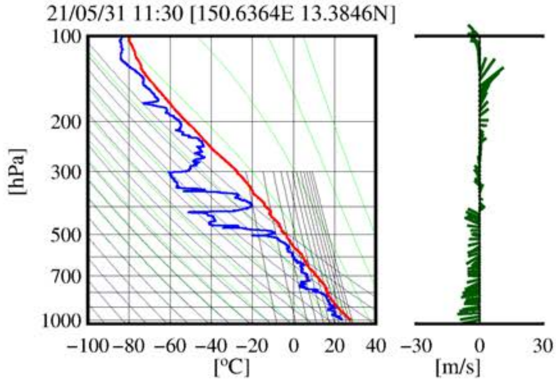



21/05/28 23:30 [145.4529E 22.9832N]
21/05/29 23:30 [147.6341E 19.0368N]
21/05/29 11:30 [146.4702E 20.9889N]
21/05/30 11:30 [148.5828E 17.2550N]
21/05/29 17:30 [147.0986E 19.9807N]
21/05/30 17:30 [149.1182E 16.3105N]
[hPa]
[°C]
[m/s]

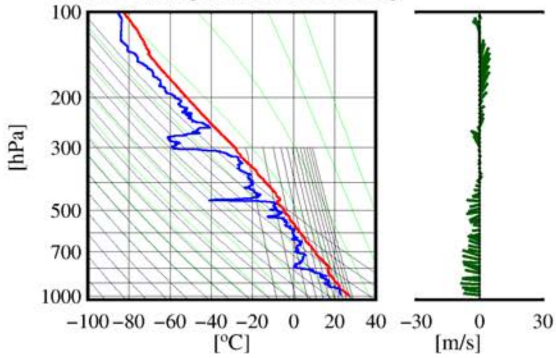
21/05/30 23:40 [149.6322E 15.2926N]



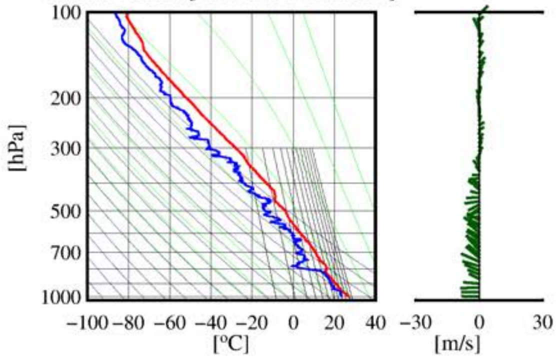
21/05/31 11:30 [150.6364E 13.3846N]



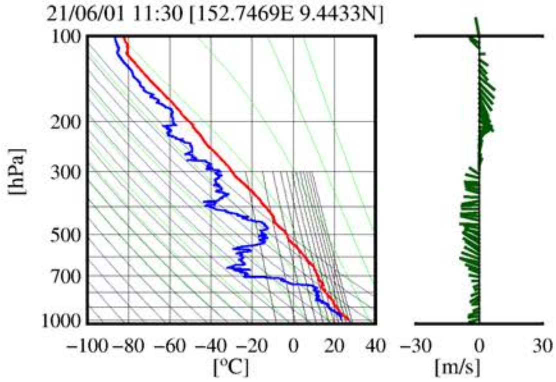
21/05/31 17:30 [151.2139E 12.3906N]



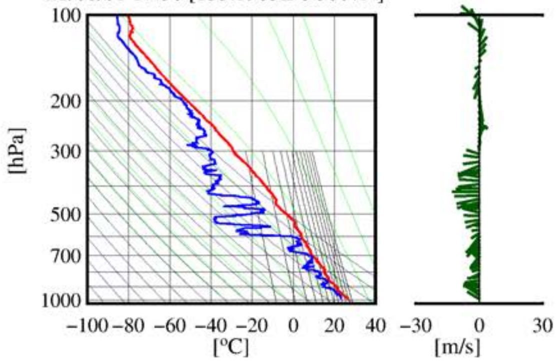
21/05/31 23:30 [151.7328E 11.3809N]



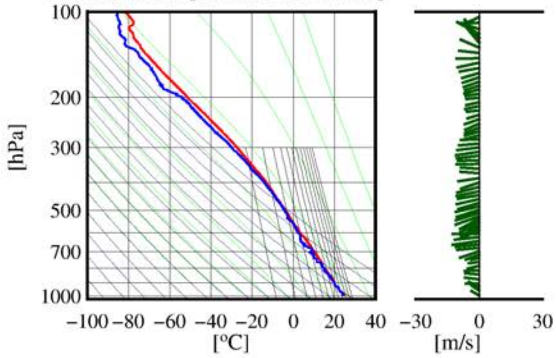
21/06/01 11:30 [152.7469E 9.4433N]



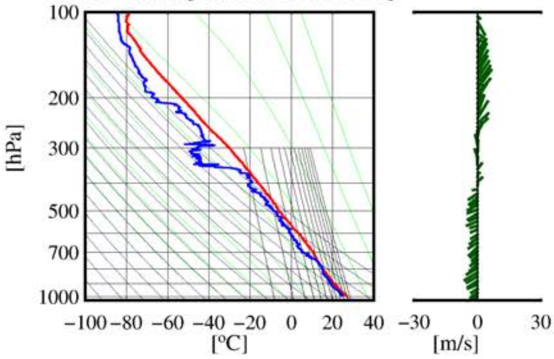
21/06/01 17:30 [153.1983E 8.3867N]



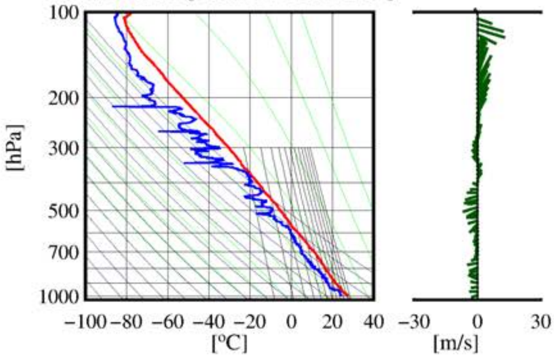
21/06/01 23:30 [153.5680E 7.2746N]



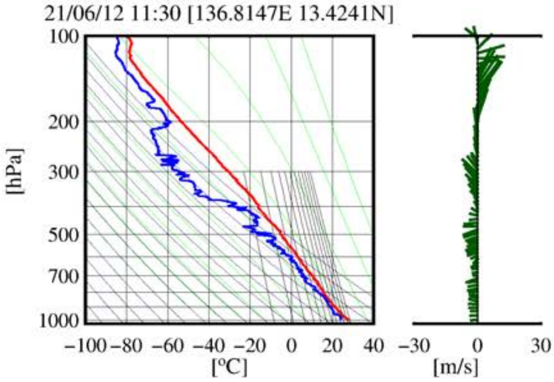
21/06/11 23:30 [136.8206E 13.1588N]



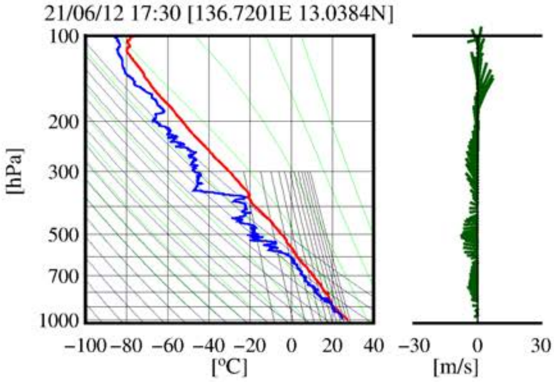
21/06/12 05:30 [136.9397E 13.1055N]

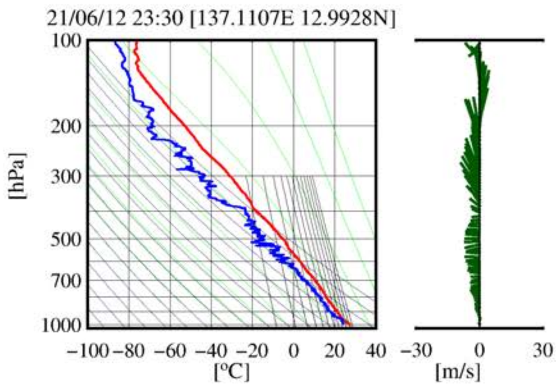


21/06/12 11:30 [136.8147E 13.4241N]



21/06/12 17:30 [136.7201E 13.0384N]

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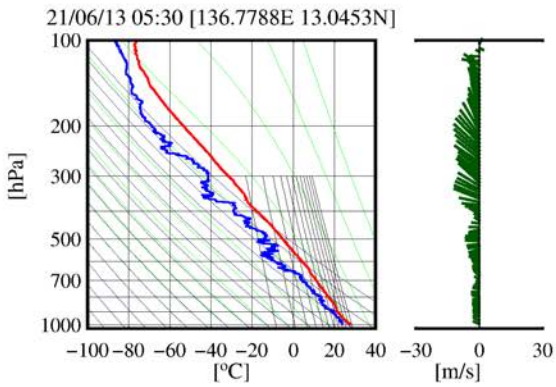
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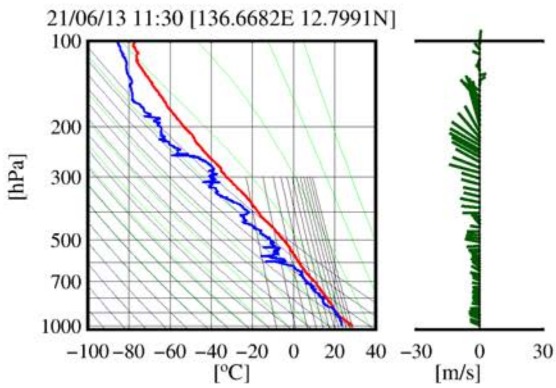
21/06/13 11:30 [136.6682E 12.7991N]
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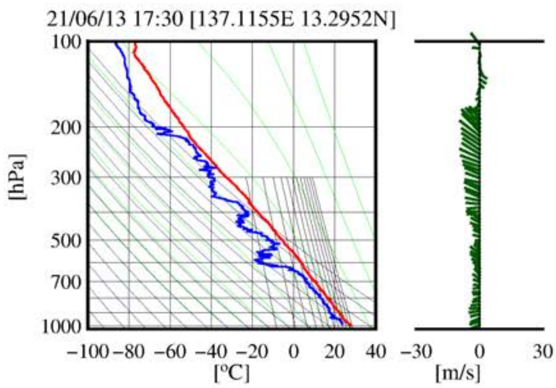
21/06/13 17:30 [137.1155E 13.2952N]
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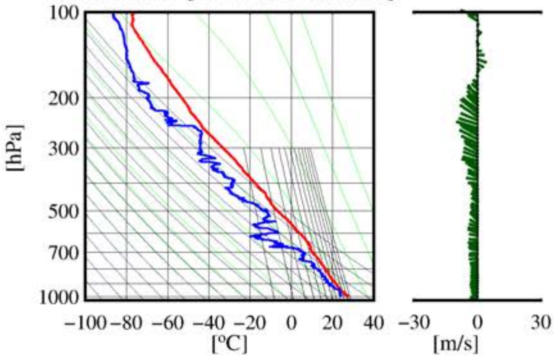
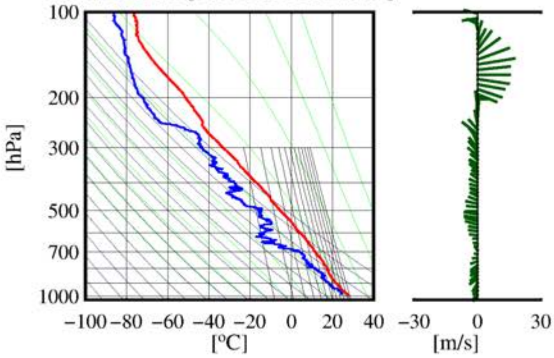
[m/s]

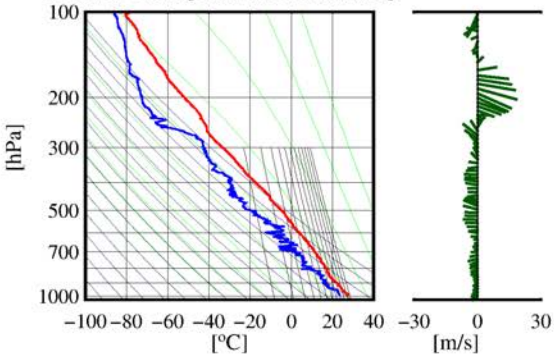
21/06/13 23:29 [137.0163E 13.5638N]



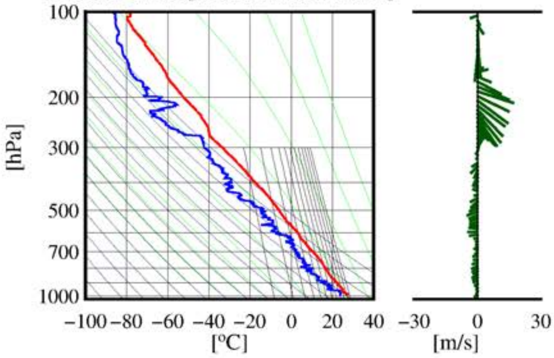
21/06/14 05:30 [136.4188E 13.1464N]



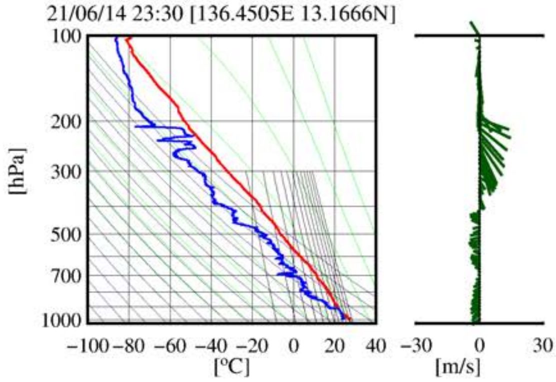
21/06/14 11:30 [136.5735E 13.1074N]



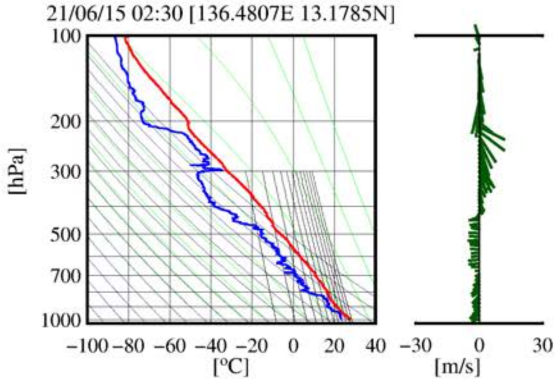
21/06/14 17:30 [136.5694E 13.1114N]



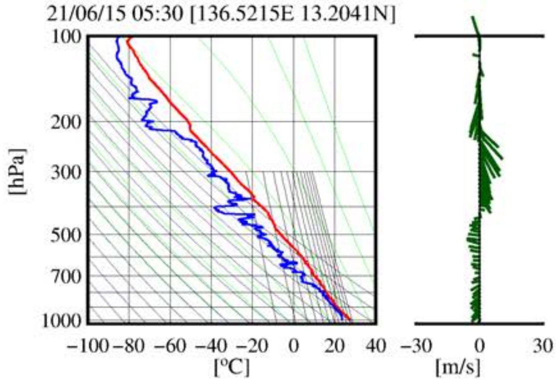
21/06/14 23:30 [136.4505E 13.1666N]



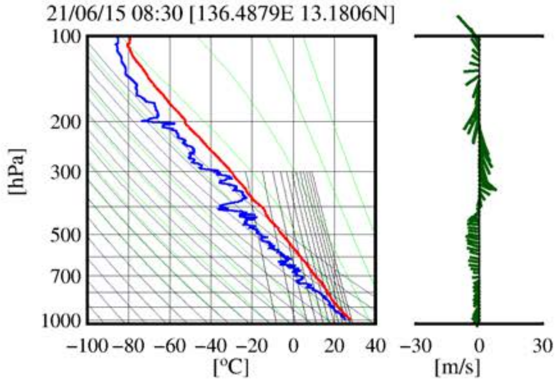
21/06/15 02:30 [136.4807E 13.1785N]



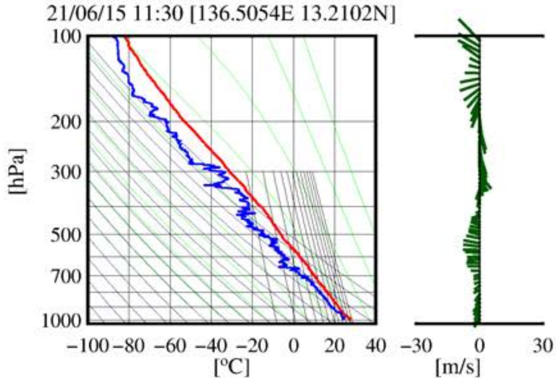
21/06/15 05:30 [136.5215E 13.2041N]



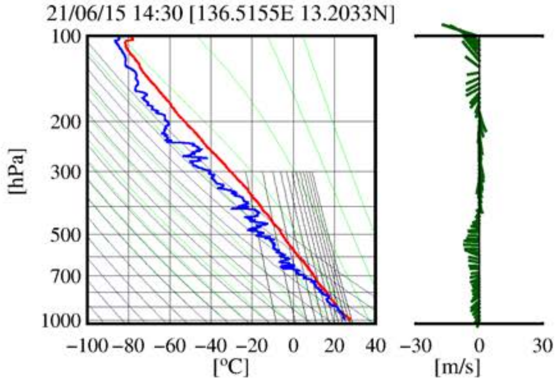
21/06/15 08:30 [136.4879E 13.1806N]



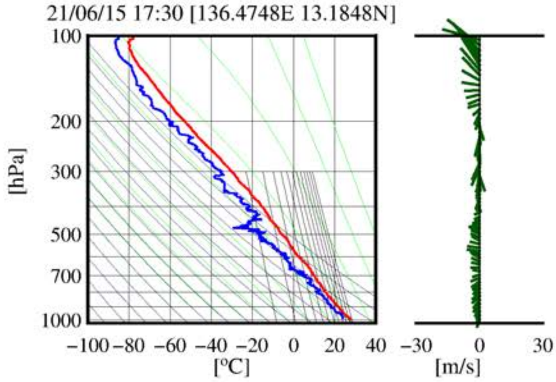
21/06/15 11:30 [136.5054E 13.2102N]



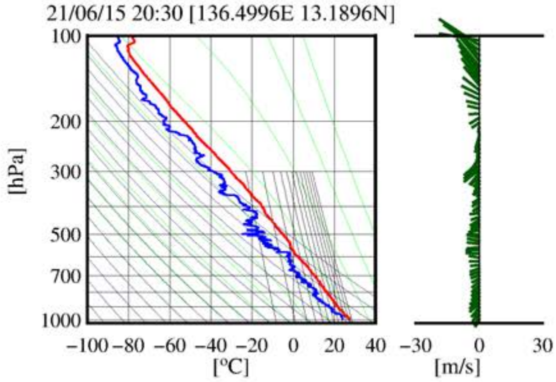
21/06/15 14:30 [136.5155E 13.2033N]



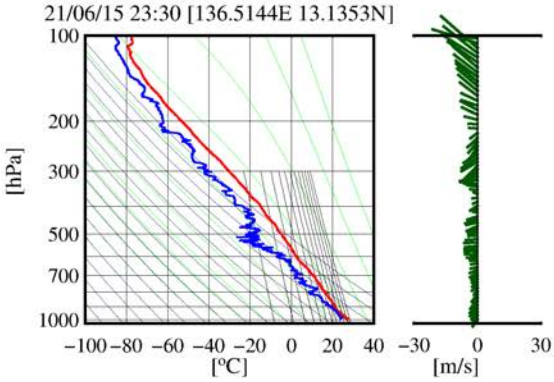
21/06/15 17:30 [136.4748E 13.1848N]



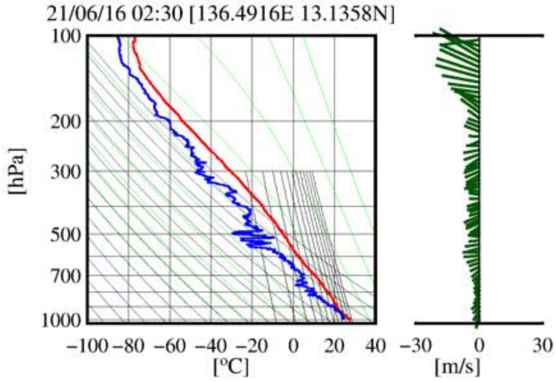
21/06/15 20:30 [136.4996E 13.1896N]



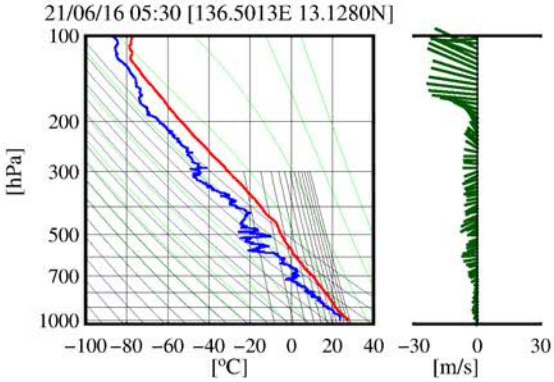
21/06/15 23:30 [136.5144E 13.1353N]



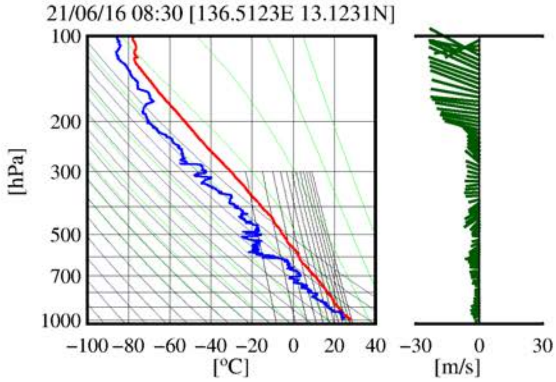
21/06/16 02:30 [136.4916E 13.1358N]



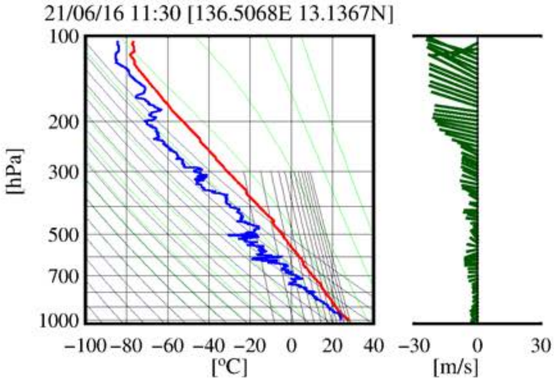
21/06/16 05:30 [136.5013E 13.1280N]



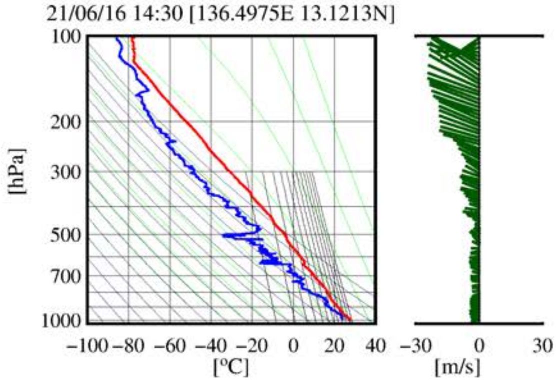
21/06/16 08:30 [136.5123E 13.1231N]



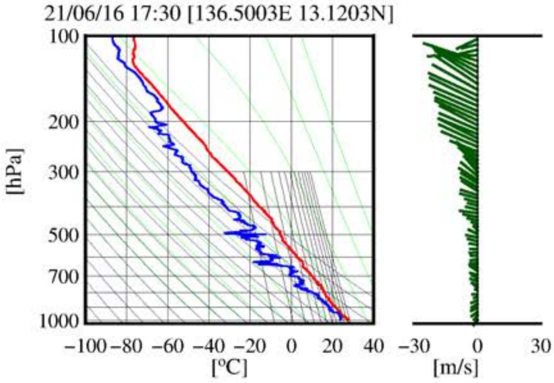
21/06/16 11:30 [136.5068E 13.1367N]



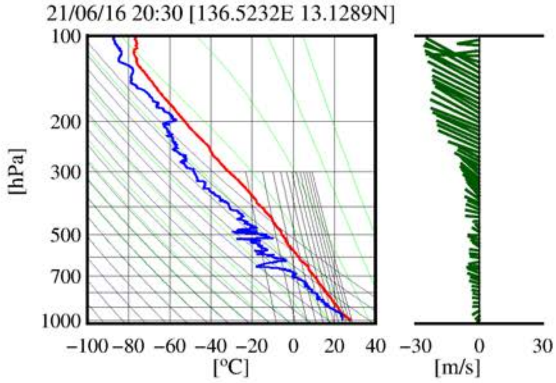
21/06/16 14:30 [136.4975E 13.1213N]



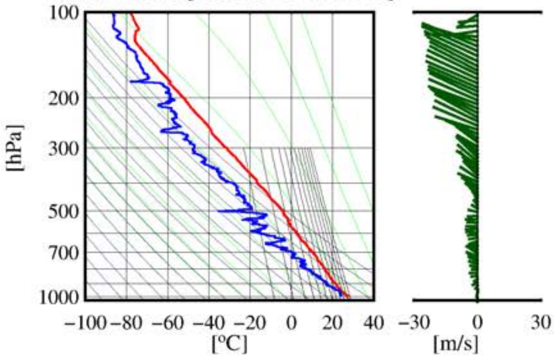
21/06/16 17:30 [136.5003E 13.1203N]



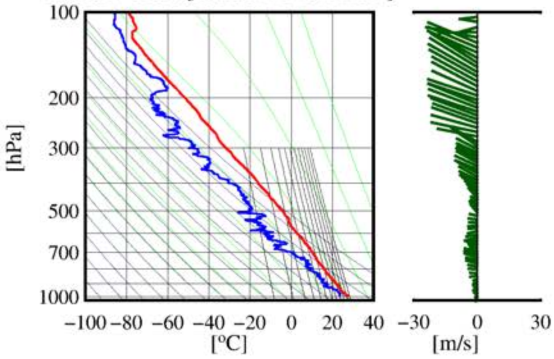
21/06/16 20:30 [136.5232E 13.1289N]



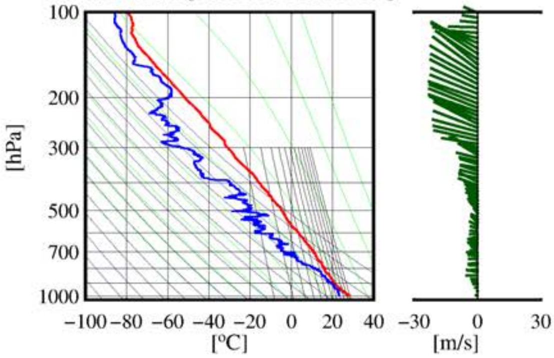
21/06/16 23:30 [136.5061E 13.1227N]



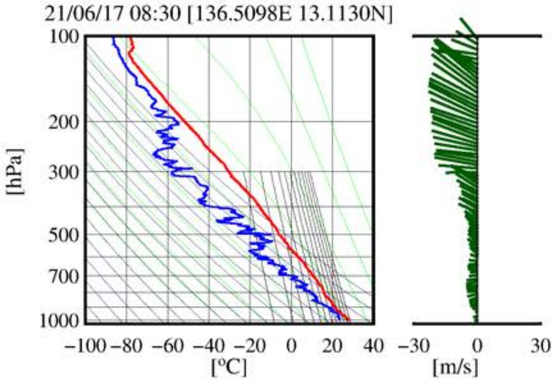
21/06/17 02:30 [136.5044E 13.1225N]



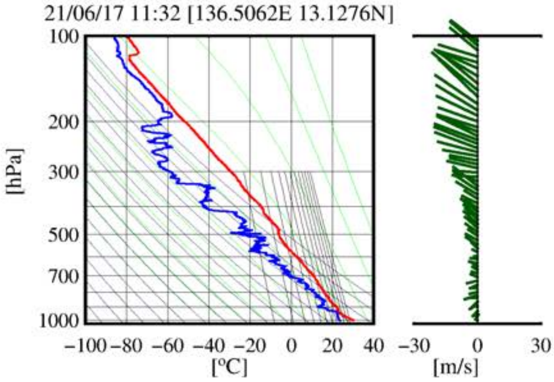
21/06/17 05:30 [136.5013E 13.1191N]



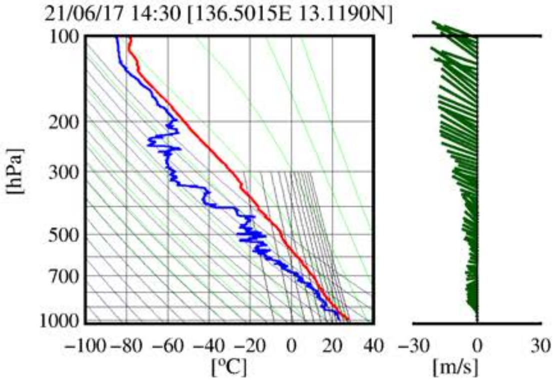
21/06/17 08:30 [136.5098E 13.1130N]



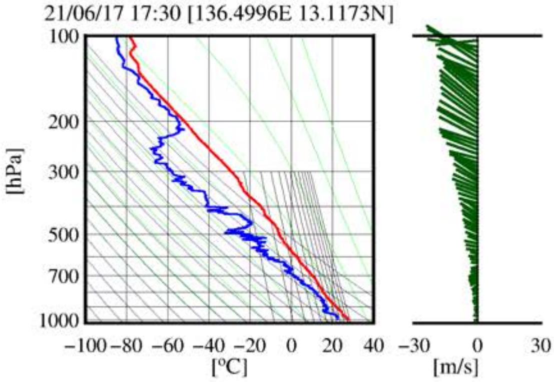
21/06/17 11:32 [136.5062E 13.1276N]



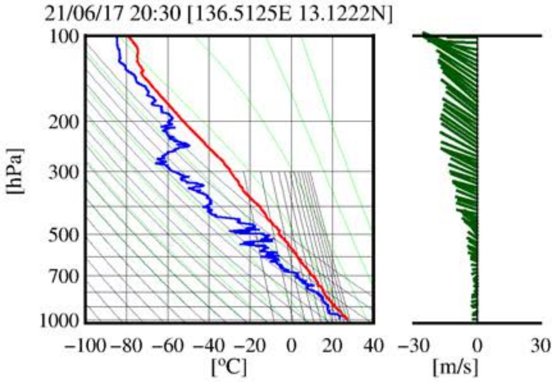
21/06/17 14:30 [136.5015E 13.1190N]

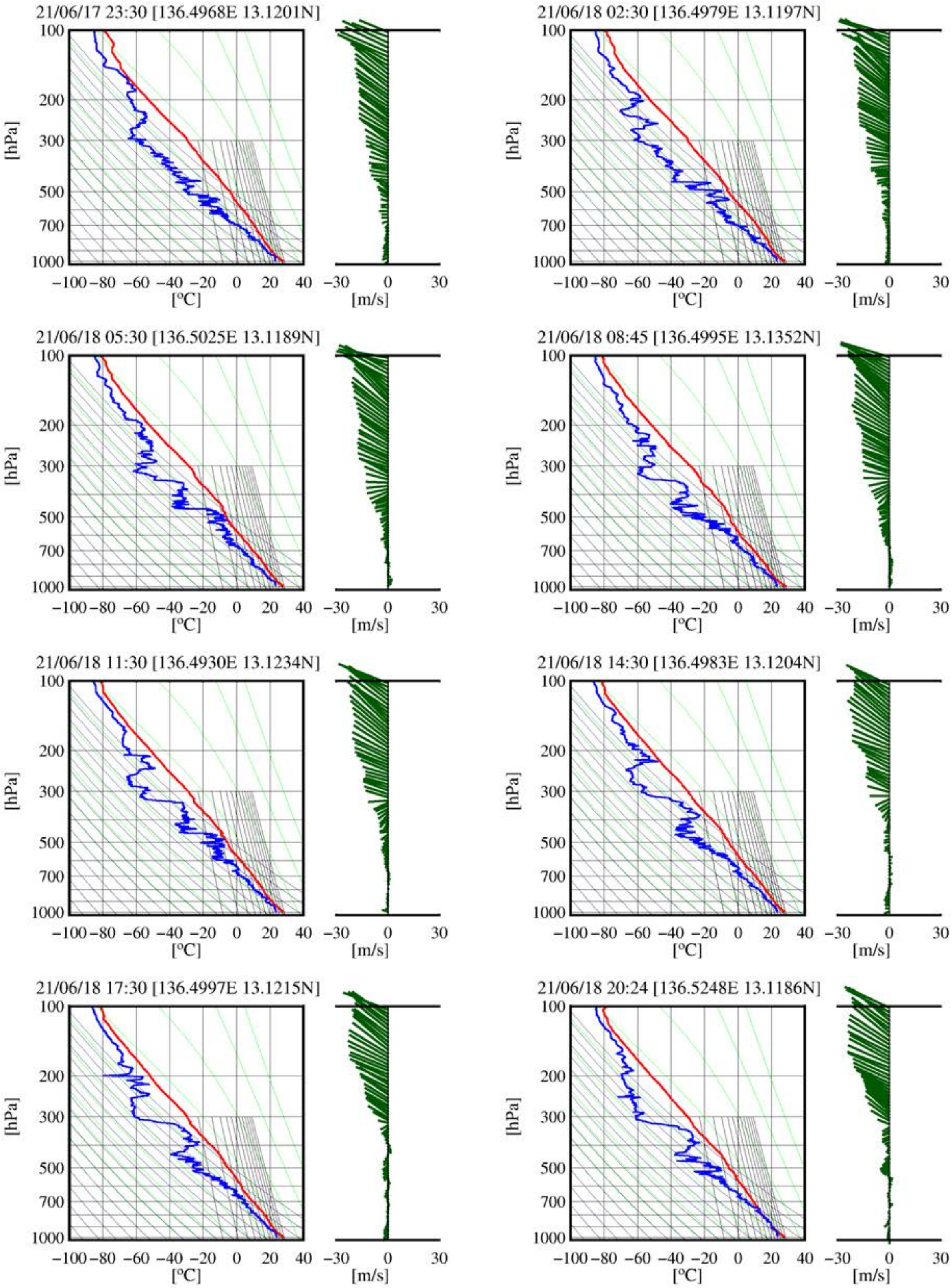


21/06/17 17:30 [136.4996E 13.1173N]



21/06/17 20:30 [136.5125E 13.1222N]




21/06/17 23:30 [136.4968E 13.1201N]
21/06/18 02:30 [136.4979E 13.1197N]
21/06/18 05:30 [136.5025E 13.1189N]
21/06/18 08:45 [136.4995E 13.1352N]
21/06/18 11:30 [136.4930E 13.1234N]
21/06/18 14:30 [136.4983E 13.1204N]
21/06/18 17:30 [136.4997E 13.1215N]
21/06/18 20:24 [136.5248E 13.1186N]
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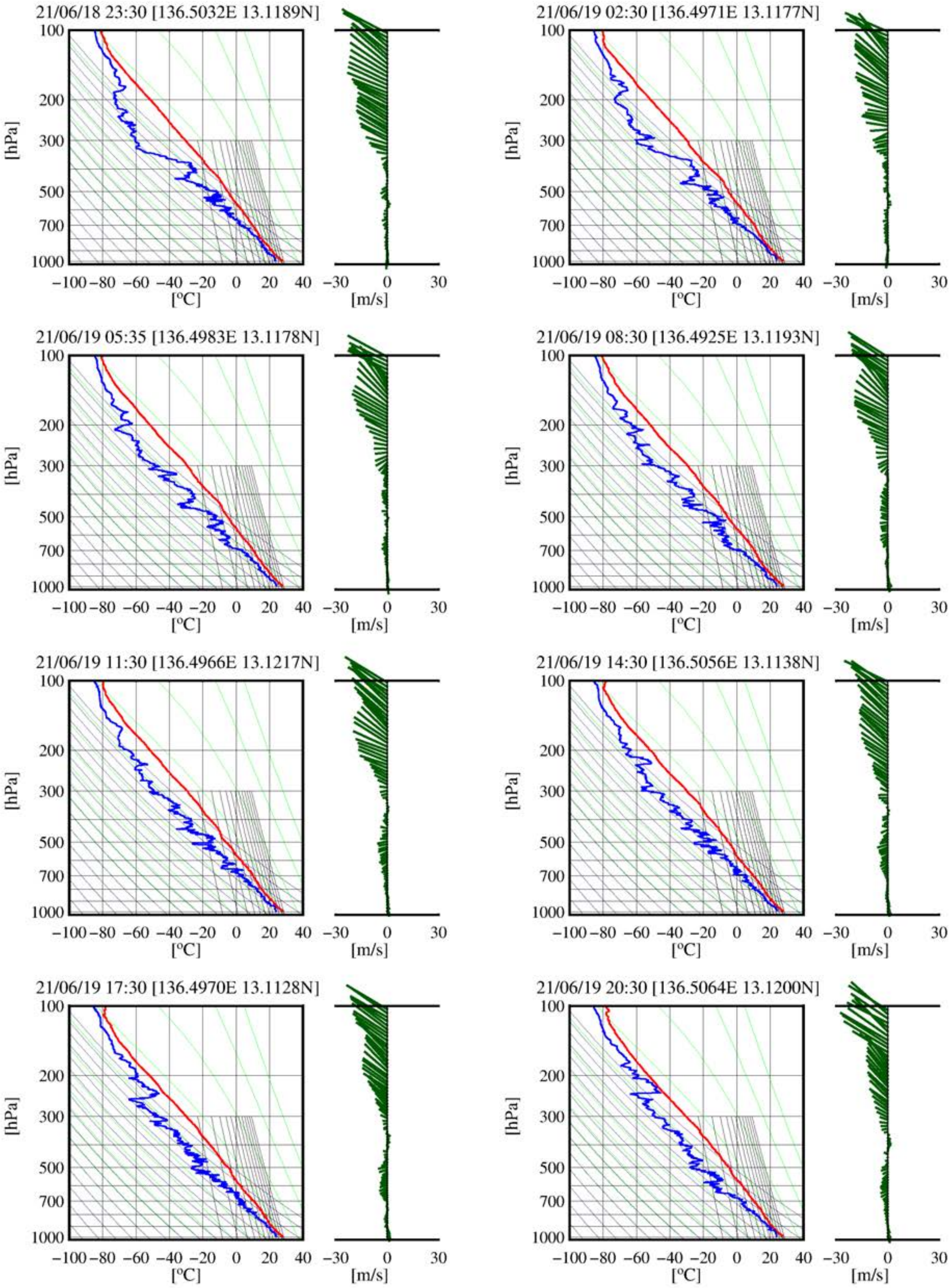
21/06/18 23:30 [136.5032E 13.1189N]
21/06/19 02:30 [136.4971E 13.1177N]
21/06/19 05:35 [136.4983E 13.1178N]
21/06/19 08:30 [136.4925E 13.1193N]
21/06/19 11:30 [136.4966E 13.1217N]
21/06/19 14:30 [136.5056E 13.1138N]
21/06/19 17:30 [136.4970E 13.1128N]
21/06/19 20:30 [136.5064E 13.1200N]
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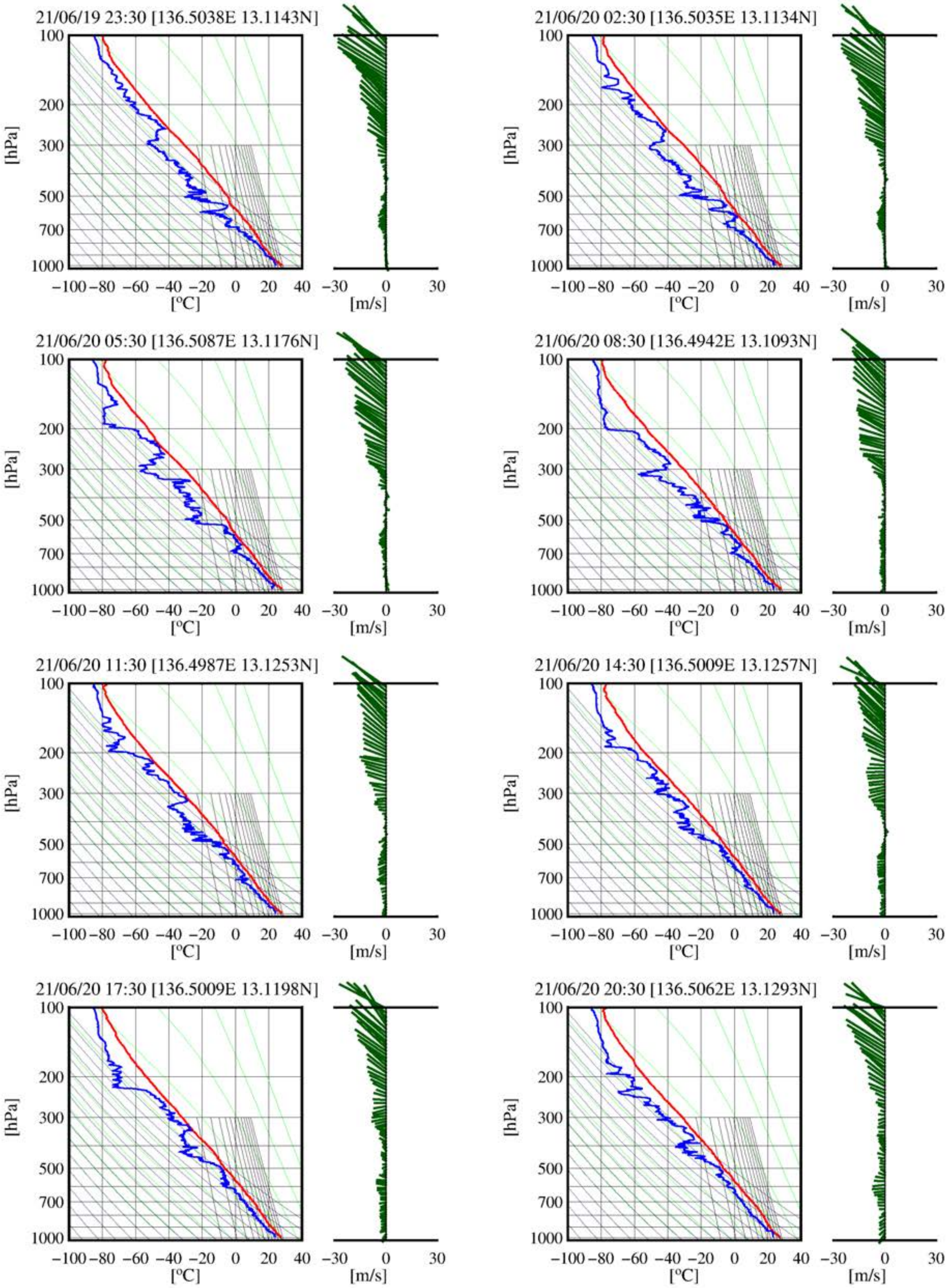
[°C]
[m/s]


21/06/19 23:30 [136.5038E 13.1143N]
21/06/20 02:30 [136.5035E 13.1134N]
21/06/20 05:30 [136.5087E 13.1176N]
21/06/20 08:30 [136.4942E 13.1093N]
21/06/20 11:30 [136.4987E 13.1253N]
21/06/20 14:30 [136.5009E 13.1257N]
21/06/20 17:30 [136.5009E 13.1198N]
21/06/20 20:30 [136.5062E 13.1293N]
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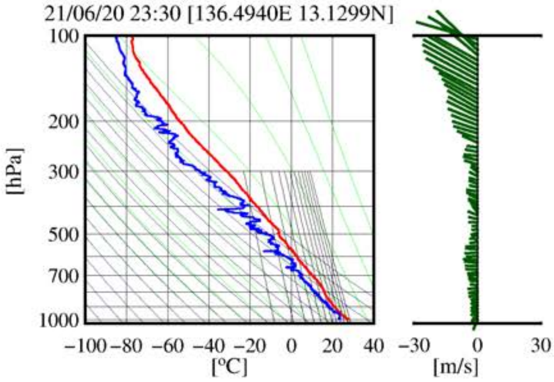
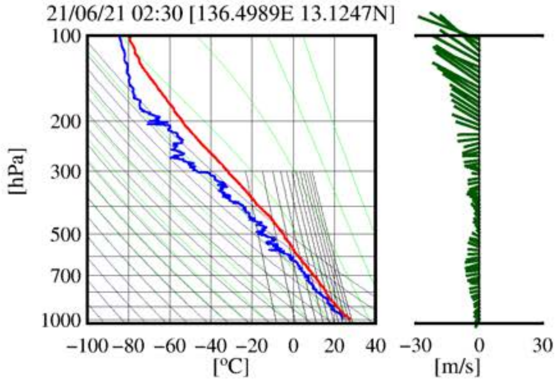
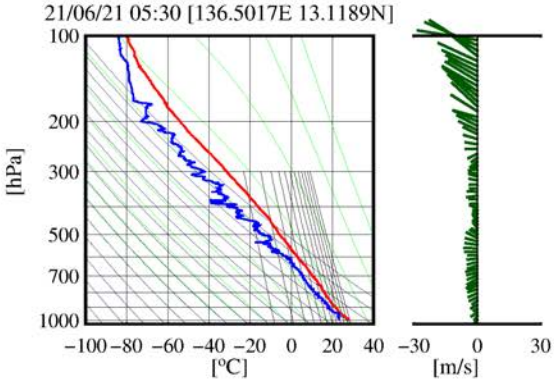
21/06/20 23:30 [136.4940E 13.1299N]



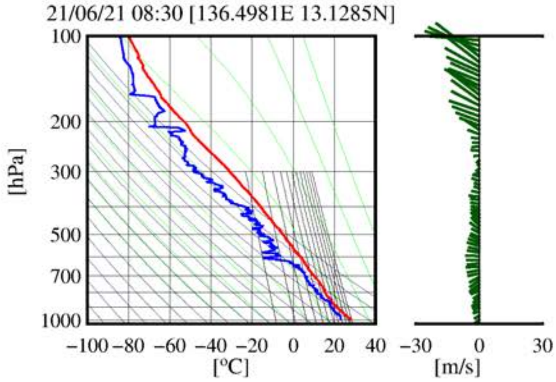
21/06/21 02:30 [136.4989E 13.1247N]



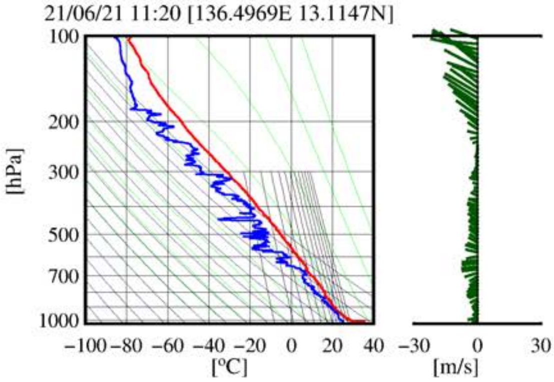
21/06/21 05:30 [136.5017E 13.1189N]



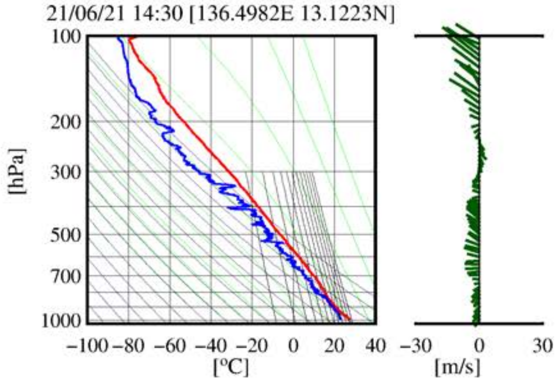
21/06/21 08:30 [136.4981E 13.1285N]



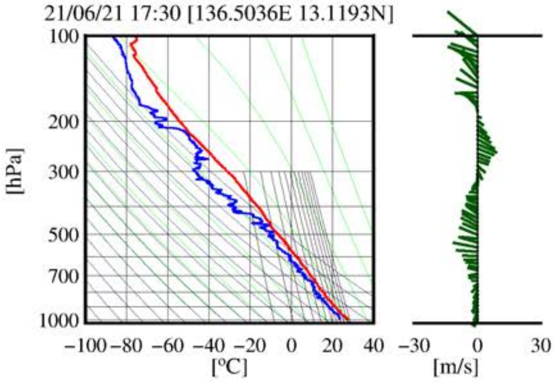
21/06/21 11:20 [136.4969E 13.1147N]



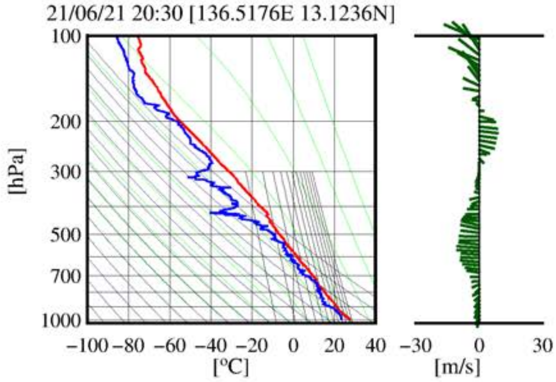
21/06/21 14:30 [136.4982E 13.1223N]

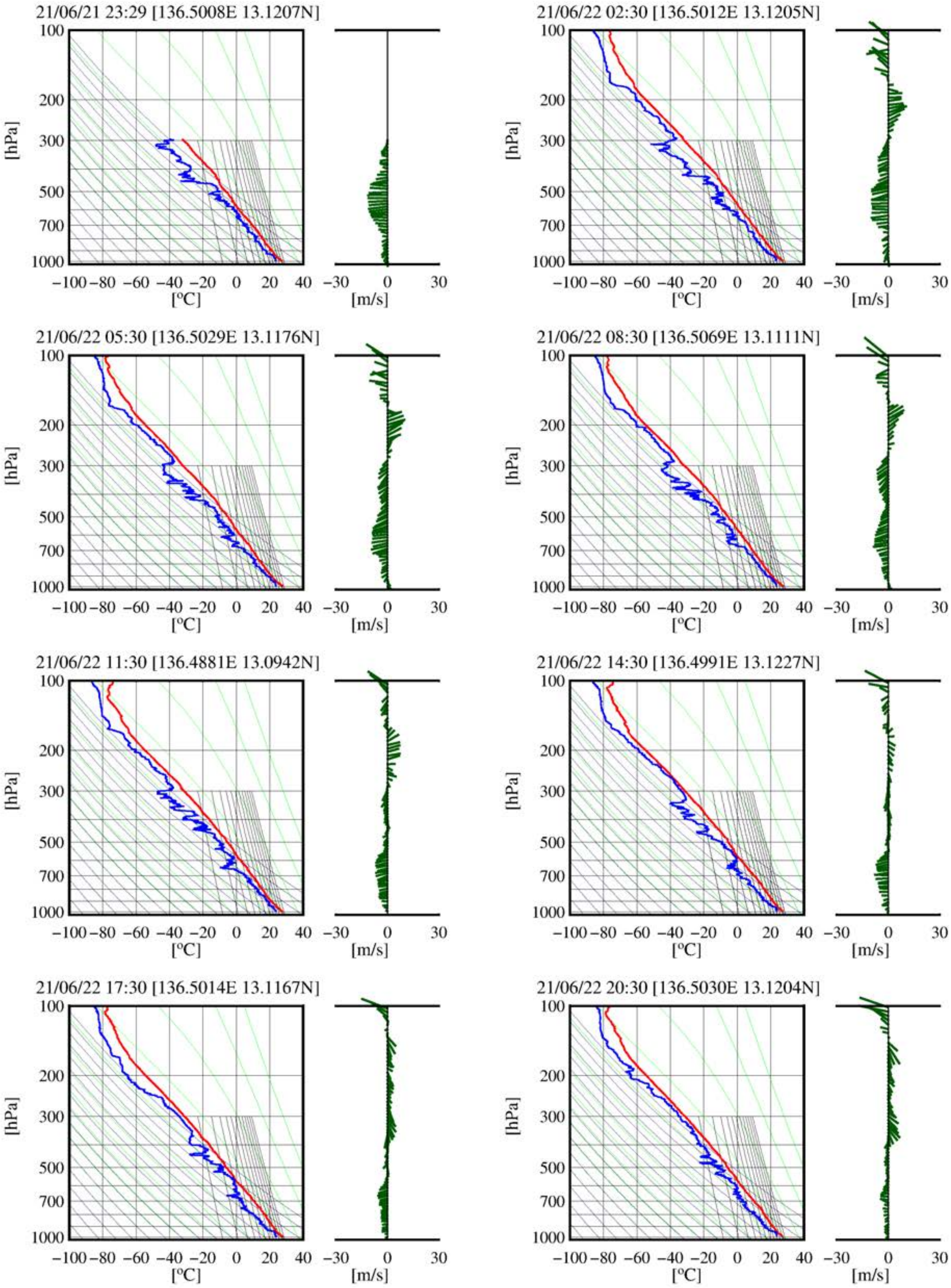


21/06/21 17:30 [136.5036E 13.1193N]

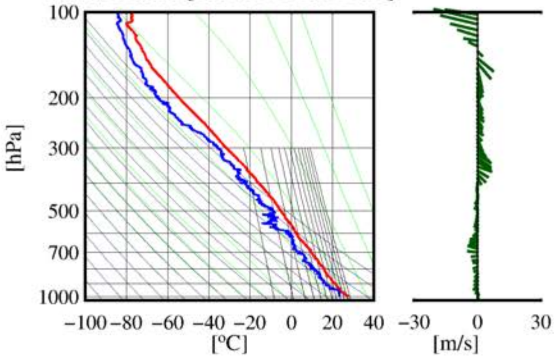


21/06/21 20:30 [136.5176E 13.1236N]

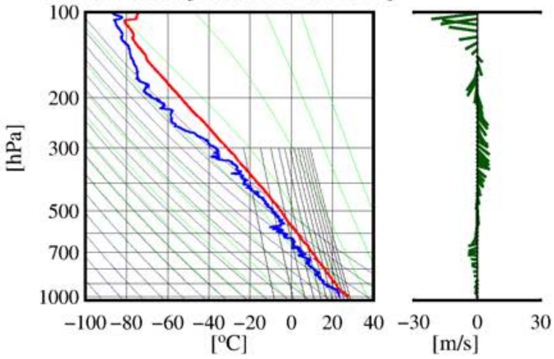



21/06/21 23:29 [136.5008E 13.1207N]
21/06/22 02:30 [136.5012E 13.1205N]
21/06/22 05:30 [136.5029E 13.1176N]
21/06/22 08:30 [136.5069E 13.1111N]
21/06/22 11:30 [136.4881E 13.0942N]
21/06/22 14:30 [136.4991E 13.1227N]
21/06/22 17:30 [136.5014E 13.1167N]
21/06/22 20:30 [136.5030E 13.1204N]
[hPa]
[°C]
[m/s]

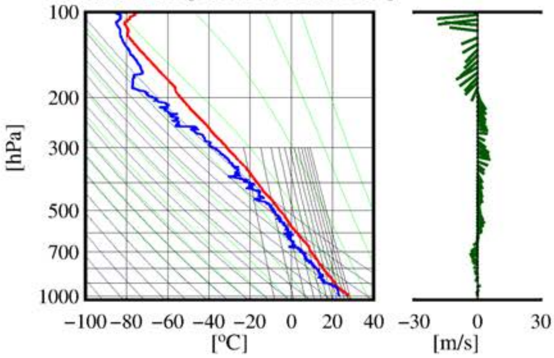
21/06/22 23:30 [136.4994E 13.1193N]



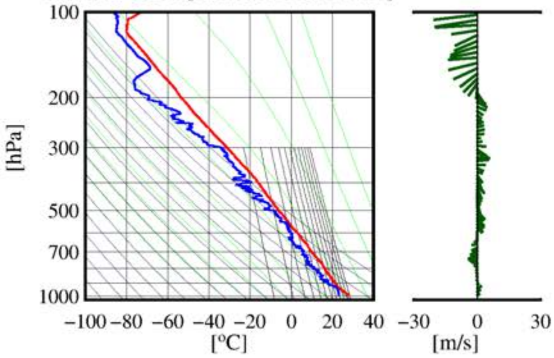
21/06/23 02:30 [136.5017E 13.1197N]



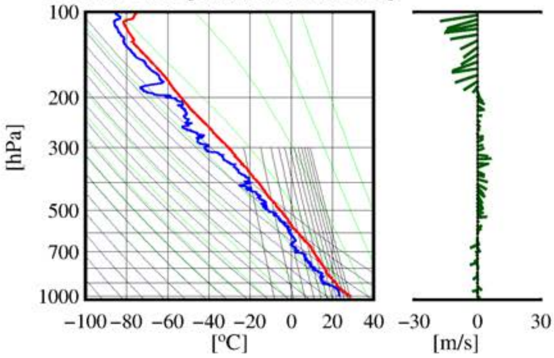
21/06/23 05:30 [136.4964E 13.1213N]



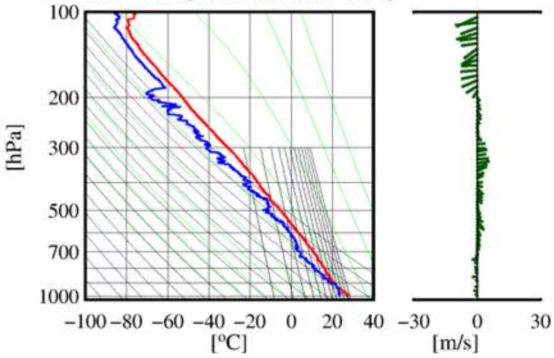
21/06/23 08:30 [136.4967E 13.1226N]



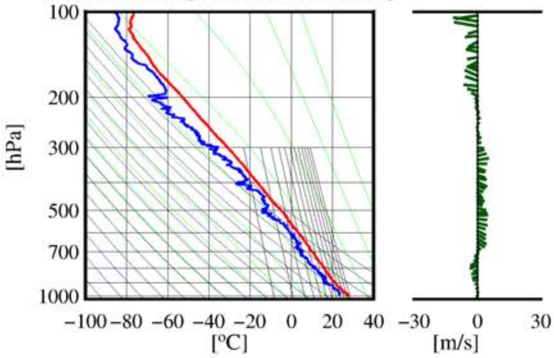
21/06/23 11:43 [136.4913E 13.1203N]



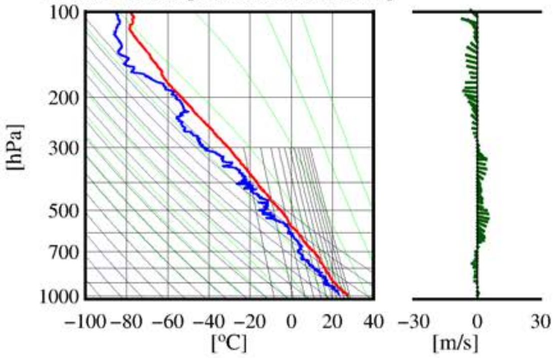
21/06/23 14:30 [136.5003E 13.1198N]



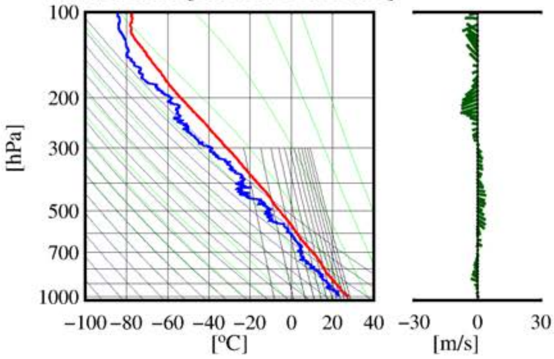
21/06/23 17:30 [136.5034E 13.1213N]



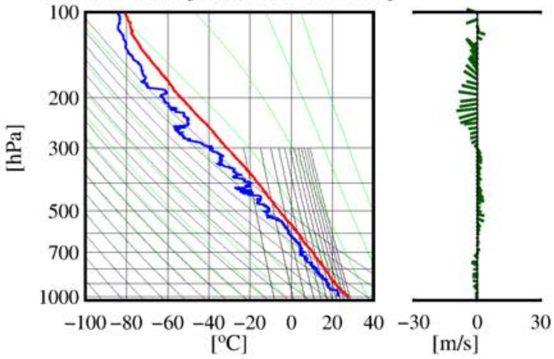
21/06/23 20:30 [136.5019E 13.1211N]



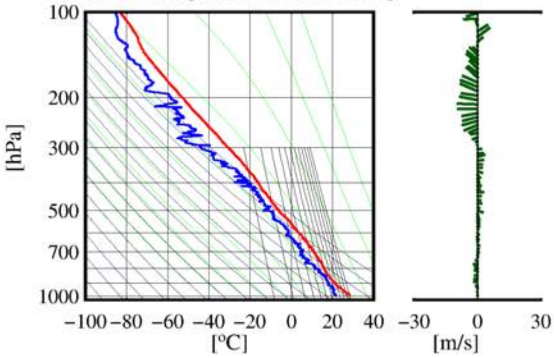
21/06/23 23:30 [136.4989E 13.1203N]



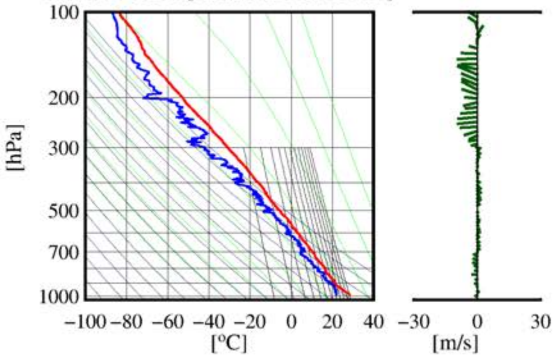
21/06/24 02:30 [136.5028E 13.1169N]



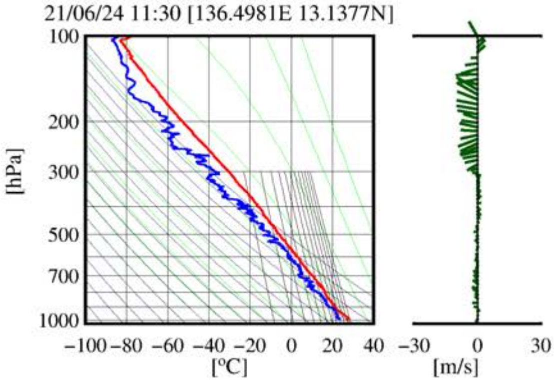
21/06/24 05:30 [136.4993E 13.1172N]



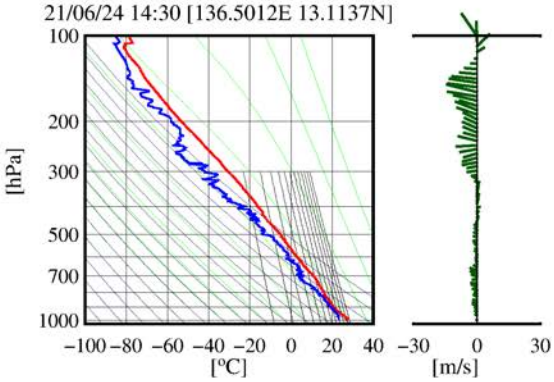
21/06/24 08:30 [136.5043E 13.1176N]



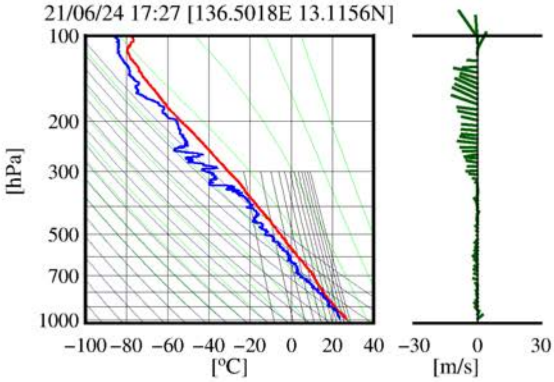
21/06/24 11:30 [136.4981E 13.1377N]



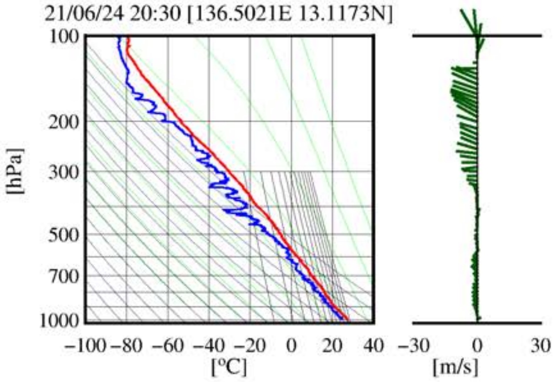
21/06/24 14:30 [136.5012E 13.1137N]



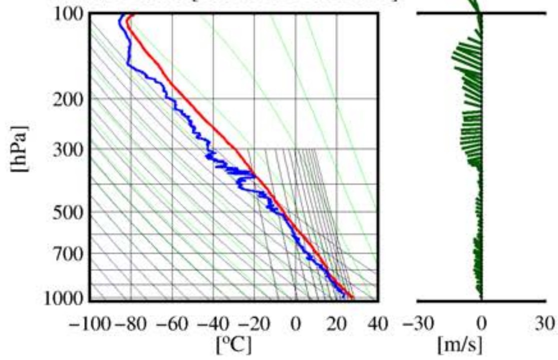
21/06/24 17:27 [136.5018E 13.1156N]



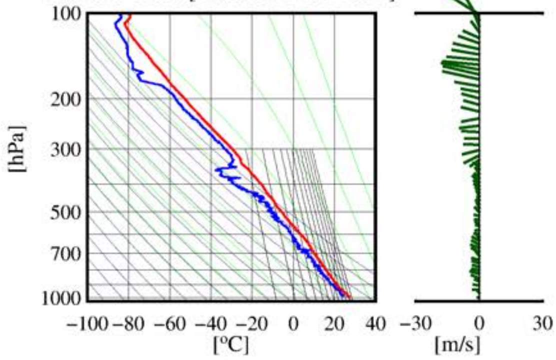
21/06/24 20:30 [136.5021E 13.1173N]



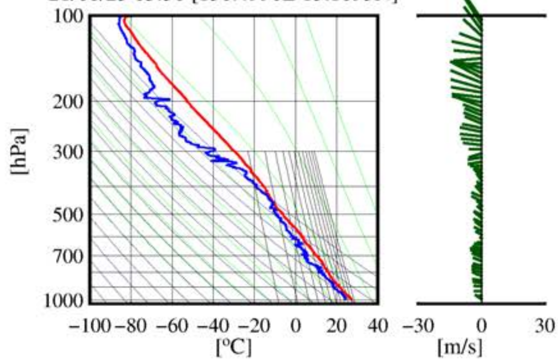
21/06/24 23:30 [136.4949E 13.1208N]



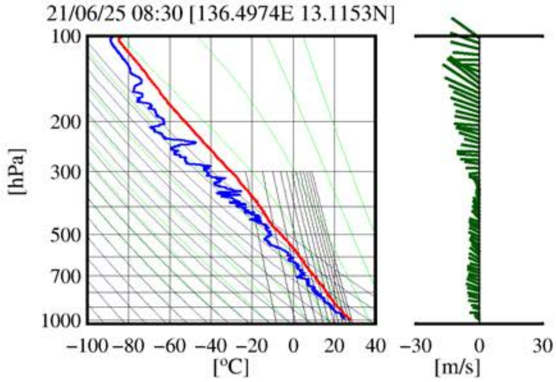
21/06/25 02:30 [136.5053E 13.1196N]



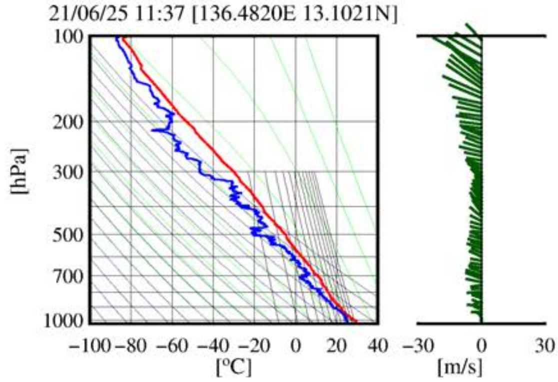
21/06/25 05:30 [136.4990E 13.1093N]



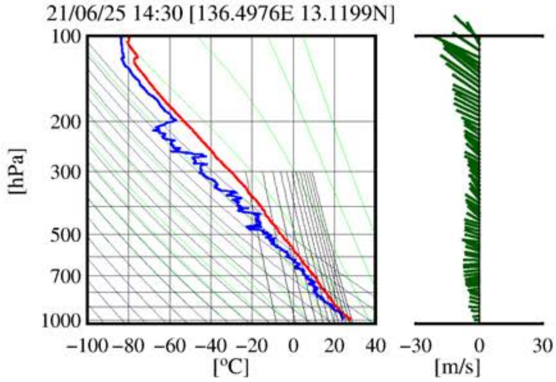
21/06/25 08:30 [136.4974E 13.1153N]



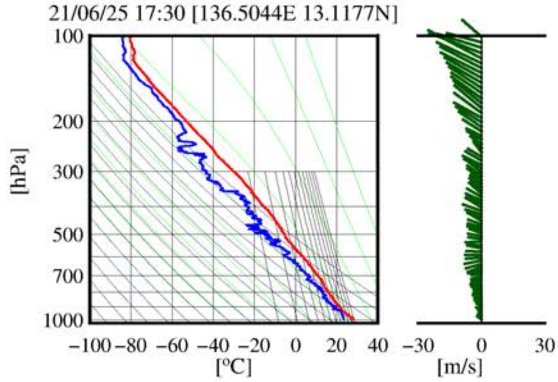
21/06/25 11:37 [136.4820E 13.1021N]



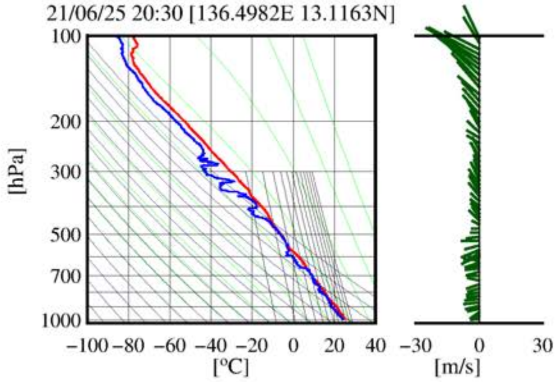
21/06/25 14:30 [136.4976E 13.1199N]



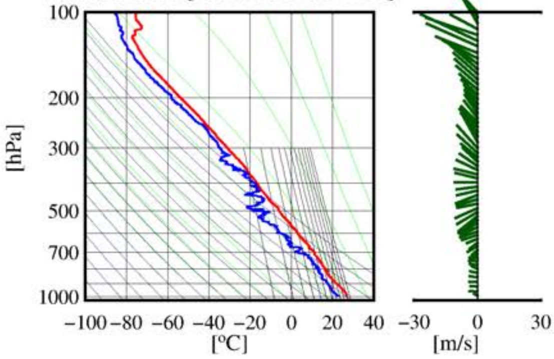
21/06/25 17:30 [136.5044E 13.1177N]



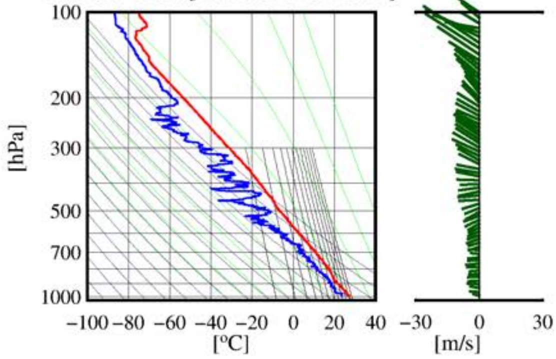
21/06/25 20:30 [136.4982E 13.1163N]



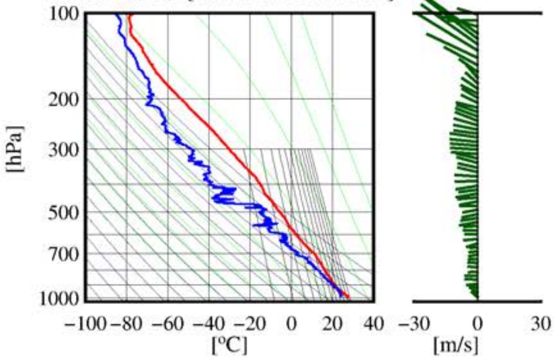
21/06/25 23:30 [136.4993E 13.1172N]



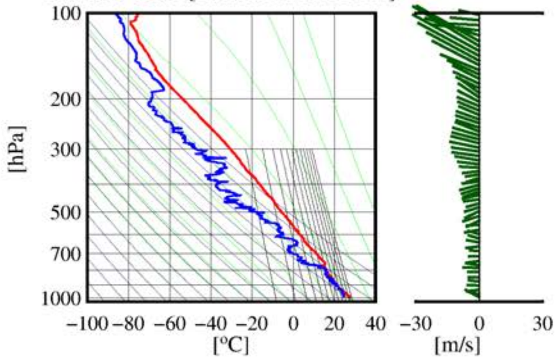
21/06/26 02:30 [136.4983E 13.1250N]



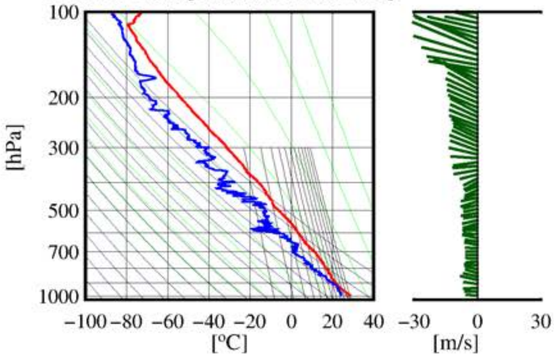
21/06/26 05:45 [136.4980E 13.1154N]



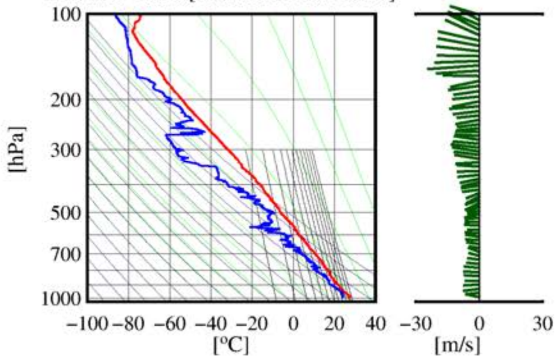
21/06/26 08:29 [136.4952E 13.1181N]



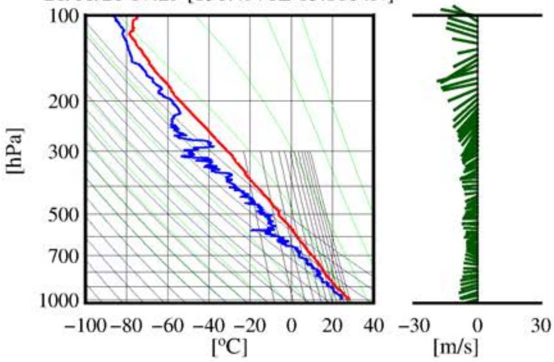
21/06/26 11:30 [136.4932E 13.1176N]



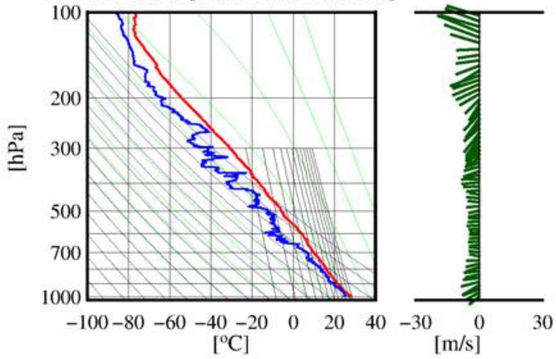
21/06/26 14:30 [136.4891E 13.1182N]

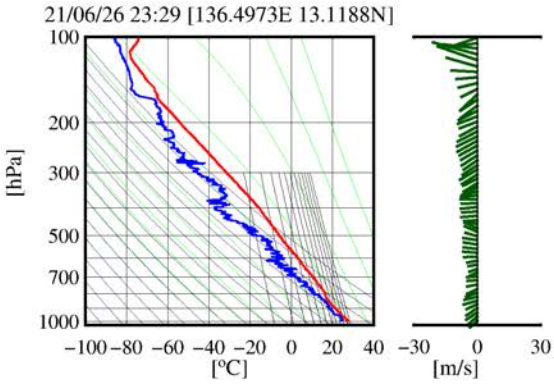


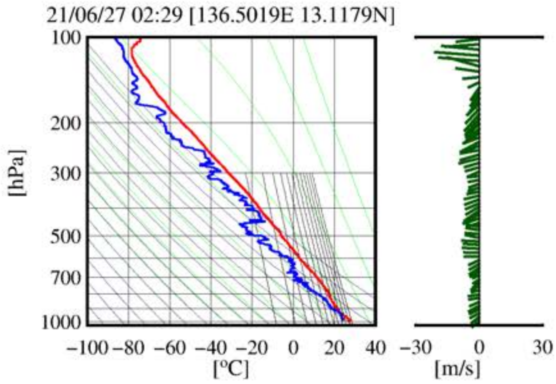
21/06/26 17:29 [136.4970E 13.1184N]

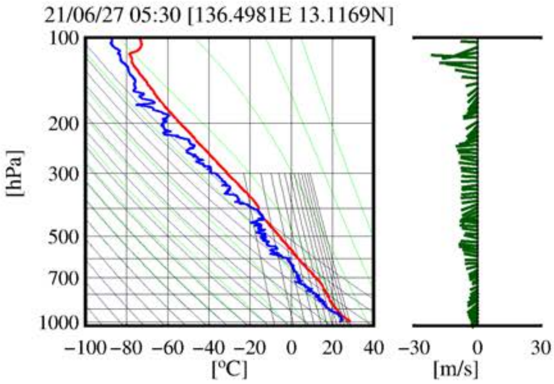


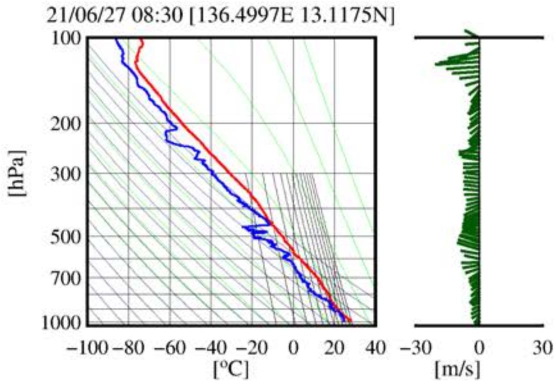
21/06/26 20:30 [136.4987E 13.1188N]

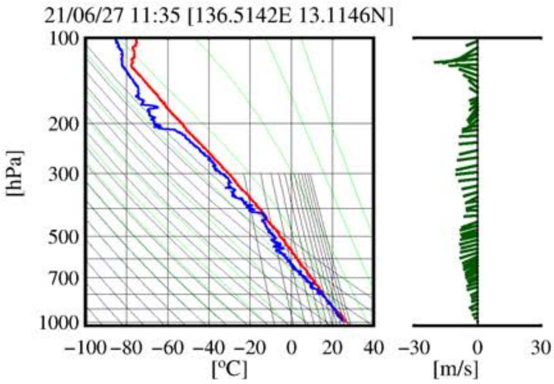



21/06/26 23:29 [136.4973E 13.1188N]
[hPa]
[°C]
[m/s]


21/06/27 02:29 [136.5019E 13.1179N]
[hPa]
[°C]
[m/s]


21/06/27 05:30 [136.4981E 13.1169N]
[hPa]
[°C]
[m/s]


21/06/27 08:30 [136.4997E 13.1175N]
[hPa]
[°C]
[m/s]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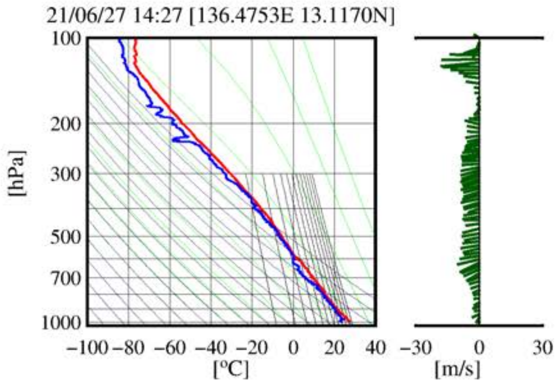
[m/s]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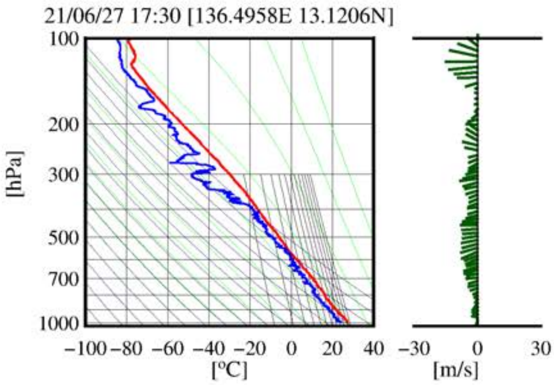
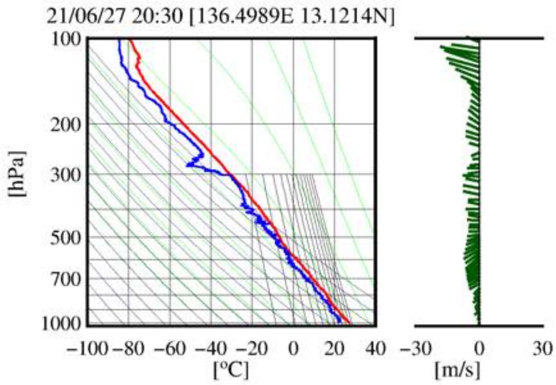
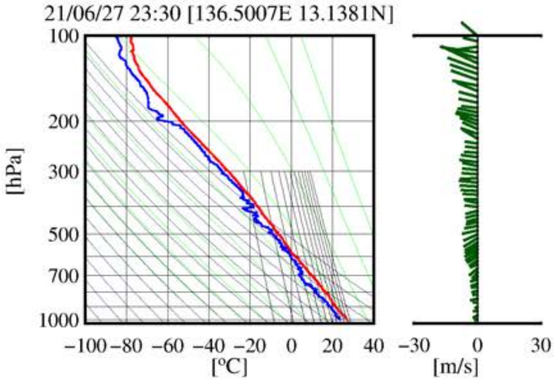
[m/s]

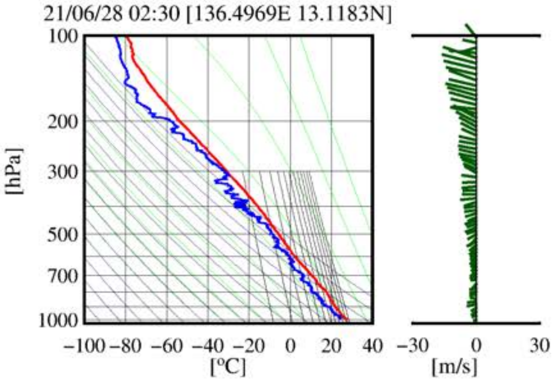

21/06/27 17:30 [136.4958E 13.1206N]
[hPa]
[°C]
[m/s]


21/06/27 20:30 [136.4989E 13.1214N]
[hPa]
[°C]
[m/s]

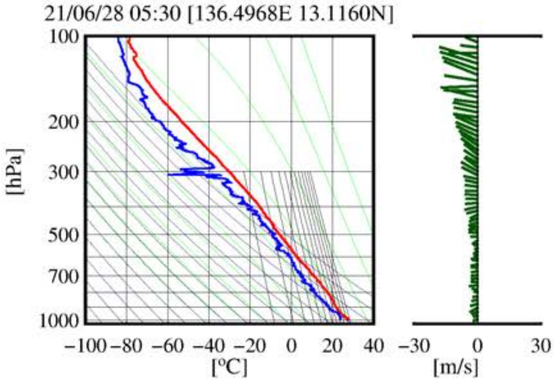
21/06/27 23:30 [136.5007E 13.1381N]



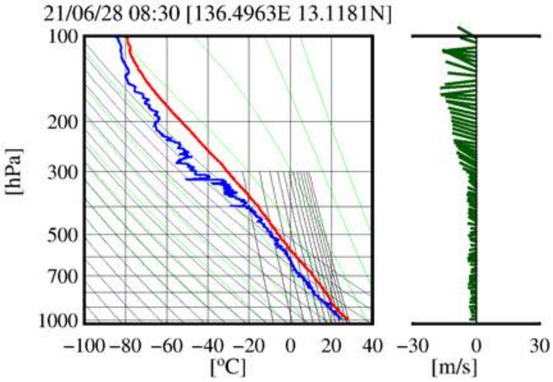
21/06/28 02:30 [136.4969E 13.1183N]



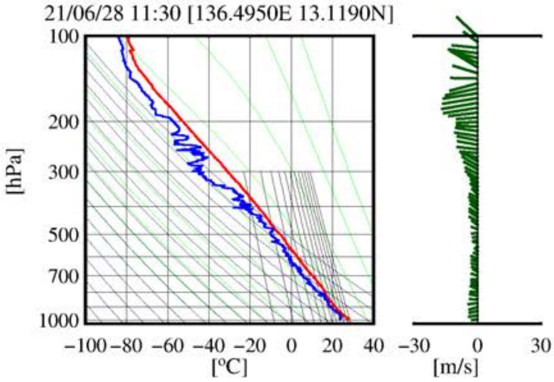
21/06/28 05:30 [136.4968E 13.1160N]



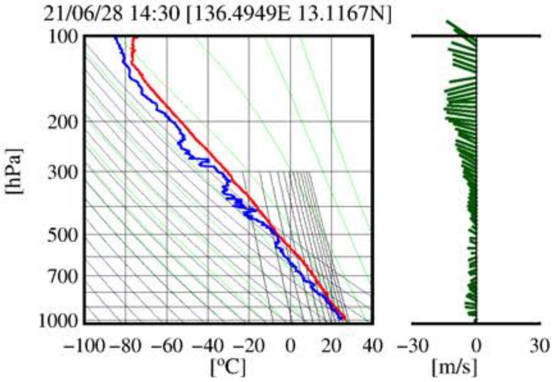
21/06/28 08:30 [136.4963E 13.1181N]



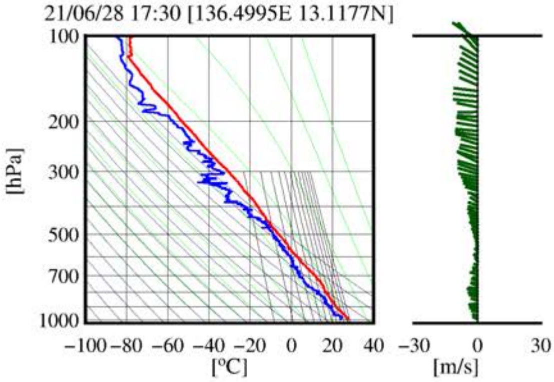
21/06/28 11:30 [136.4950E 13.1190N]



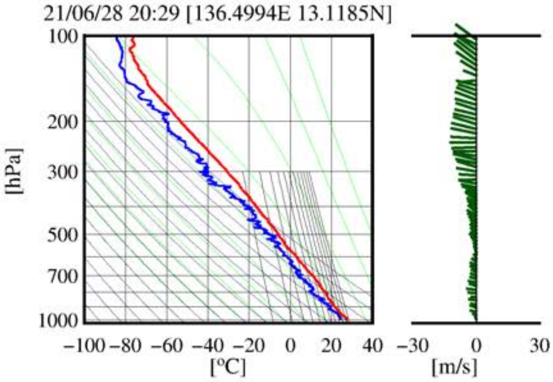
21/06/28 14:30 [136.4949E 13.1167N]



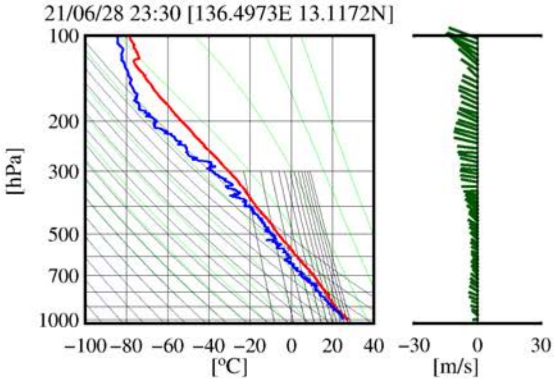
21/06/28 17:30 [136.4995E 13.1177N]



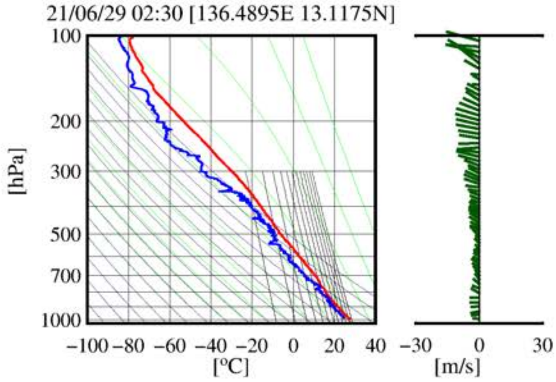
21/06/28 20:29 [136.4994E 13.1185N]



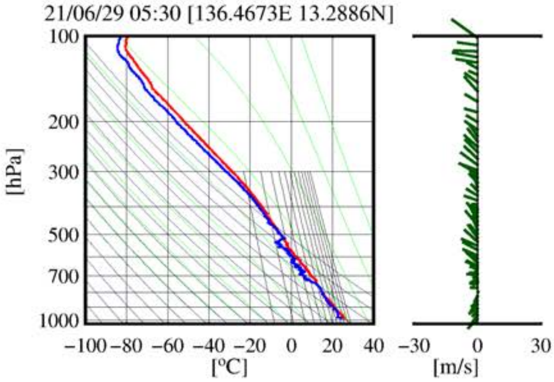
21/06/28 23:30 [136.4973E 13.1172N]



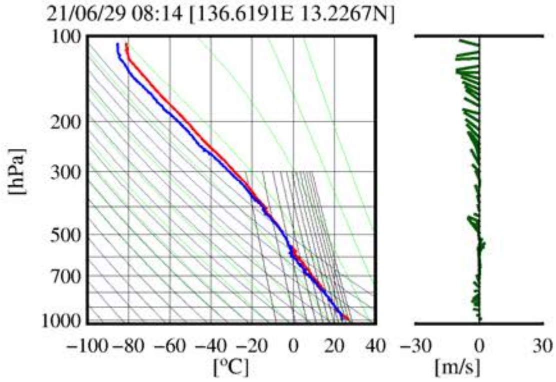
21/06/29 02:30 [136.4895E 13.1175N]



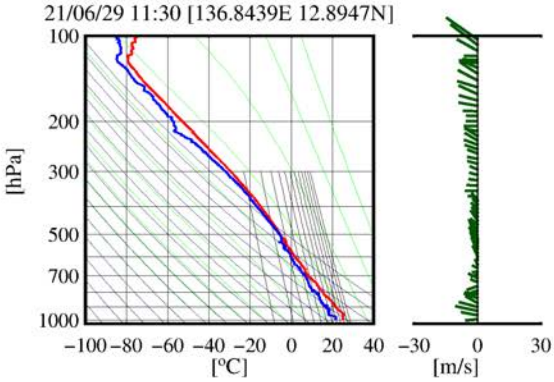
21/06/29 05:30 [136.4673E 13.2886N]



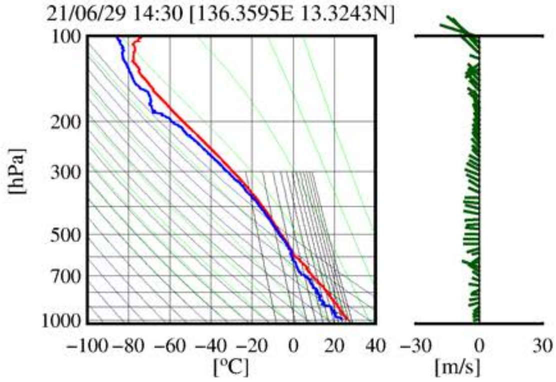
21/06/29 08:14 [136.6191E 13.2267N]



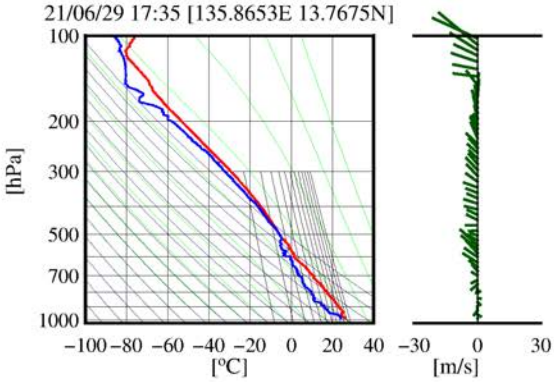
21/06/29 11:30 [136.8439E 12.8947N]



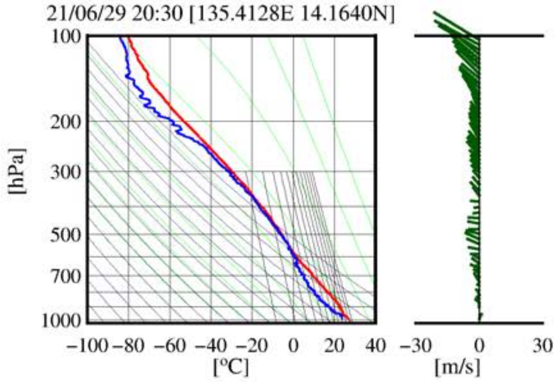
21/06/29 14:30 [136.3595E 13.3243N]

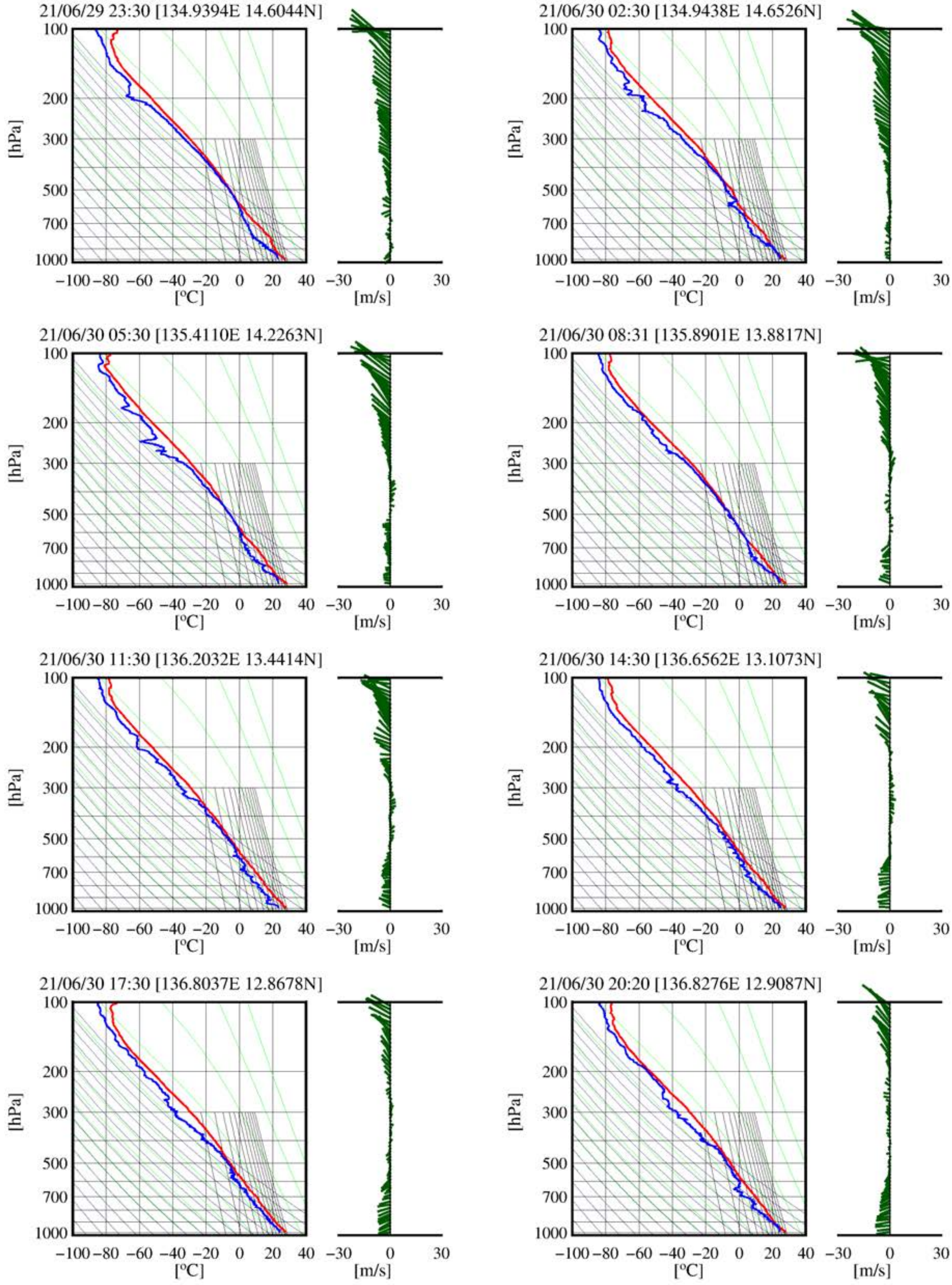


21/06/29 17:35 [135.8653E 13.7675N]



21/06/29 20:30 [135.4128E 14.1640N]




21/06/29 23:30 [134.9394E 14.6044N]
21/06/30 02:30 [134.9438E 14.6526N]
21/06/30 05:30 [135.4110E 14.2263N]
21/06/30 08:31 [135.8901E 13.8817N]
21/06/30 11:30 [136.2032E 13.4414N]
21/06/30 14:30 [136.6562E 13.1073N]
21/06/30 17:30 [136.8037E 12.8678N]
21/06/30 20:20 [136.8276E 12.9087N]
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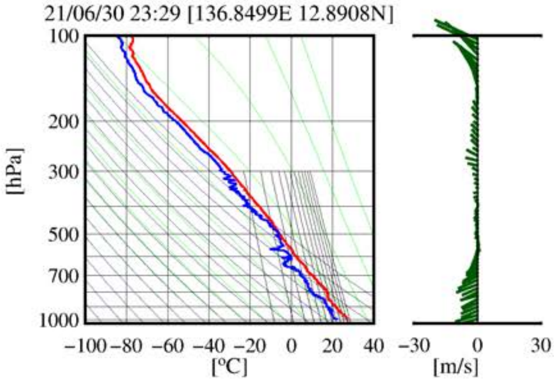
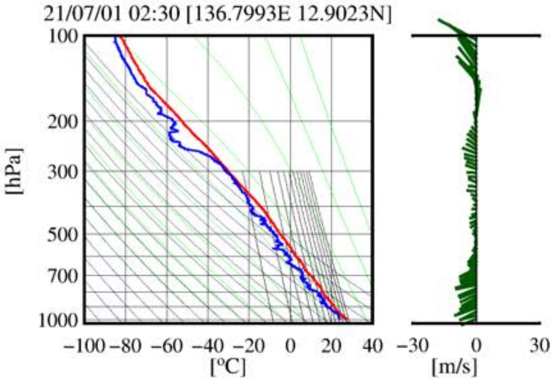
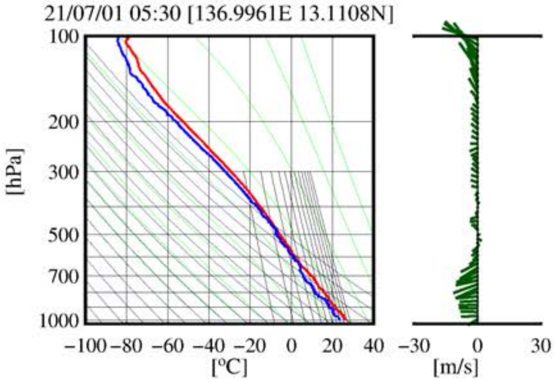
21/06/30 23:29 [136.8499E 12.8908N]



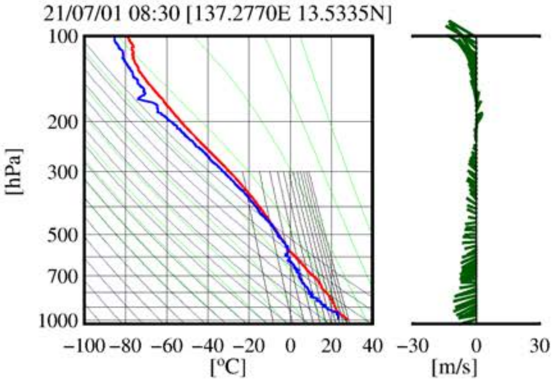
21/07/01 02:30 [136.7993E 12.9023N]



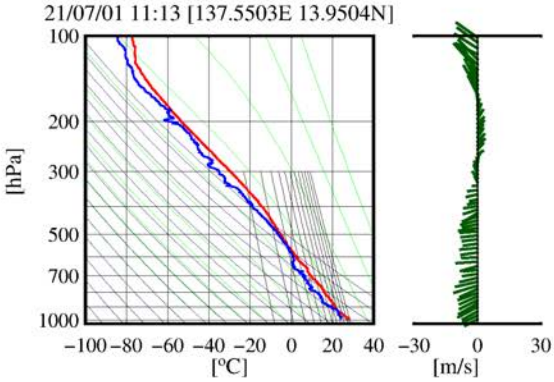
21/07/01 05:30 [136.9961E 13.1108N]



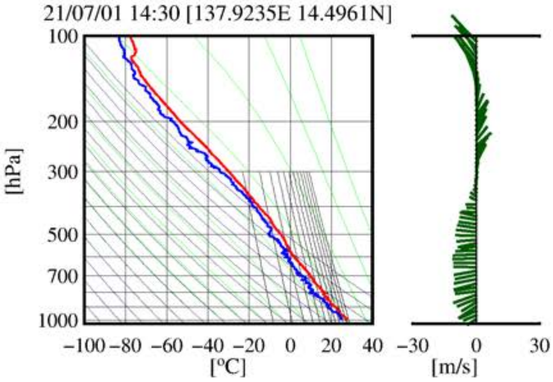
21/07/01 08:30 [137.2770E 13.5335N]



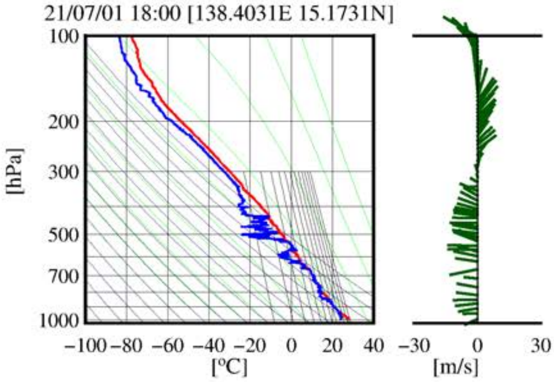
21/07/01 11:13 [137.5503E 13.9504N]



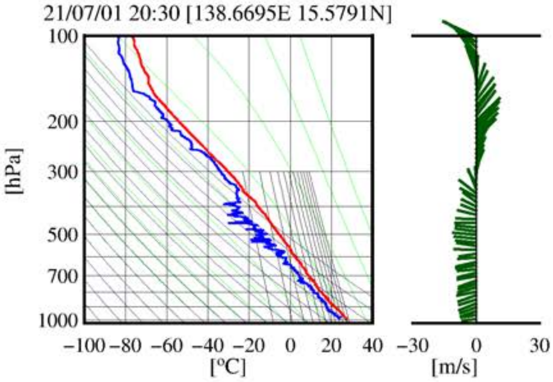
21/07/01 14:30 [137.9235E 14.4961N]

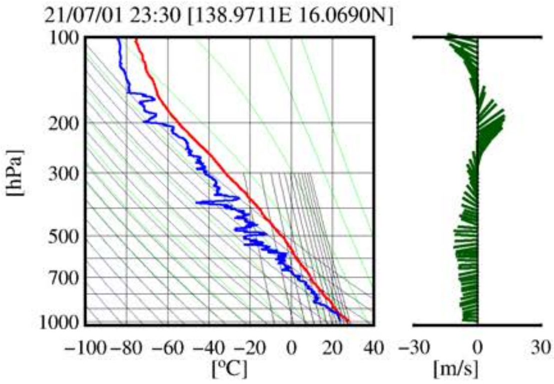


21/07/01 18:00 [138.4031E 15.1731N]



21/07/01 20:30 [138.6695E 15.5791N]

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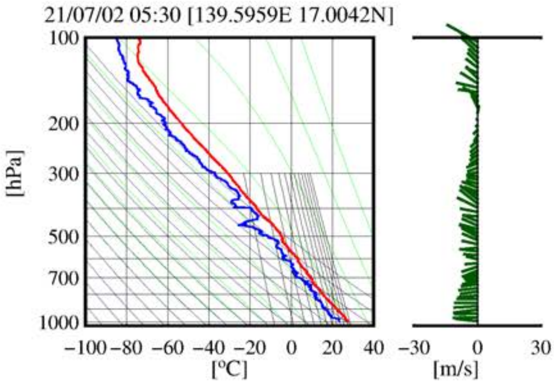
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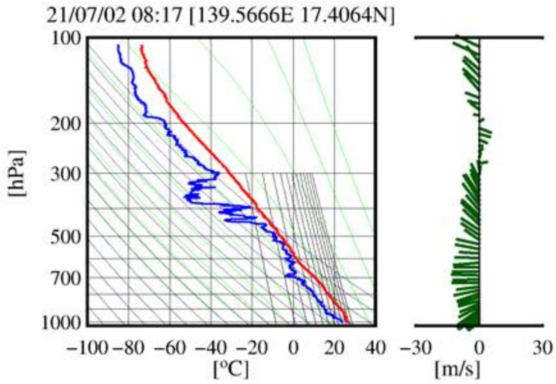
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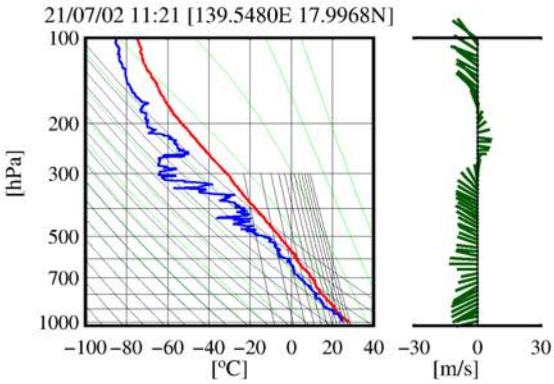
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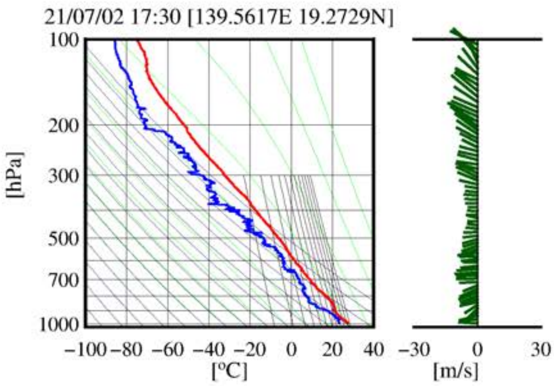
21/07/02 17:30 [139.5617E 19.2729N]
[hPa]
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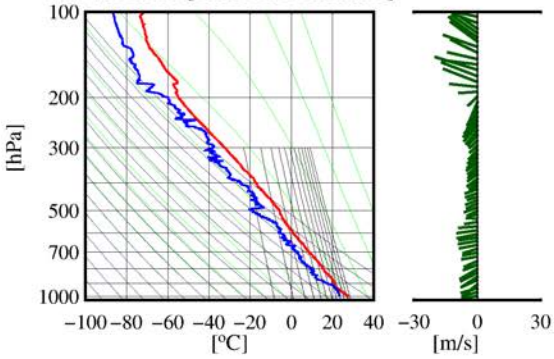
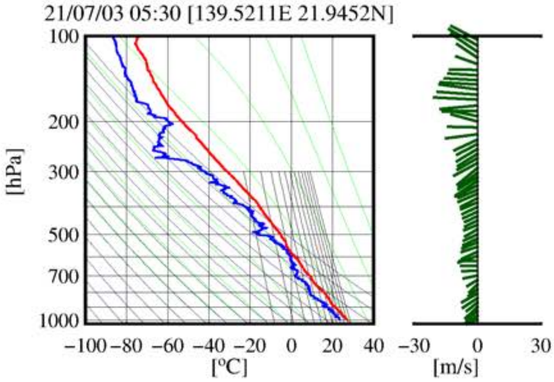
[°C]
−30 0 30
[m/s]

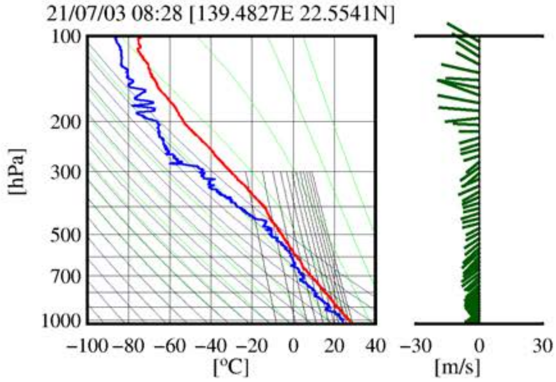
21/07/02 23:30 [139.5215E 20.5665N]



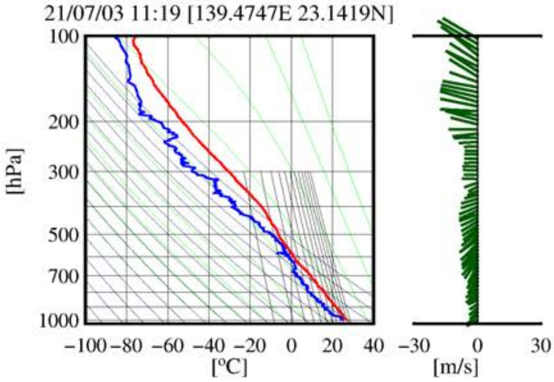
21/07/03 05:30 [139.5211E 21.9452N]



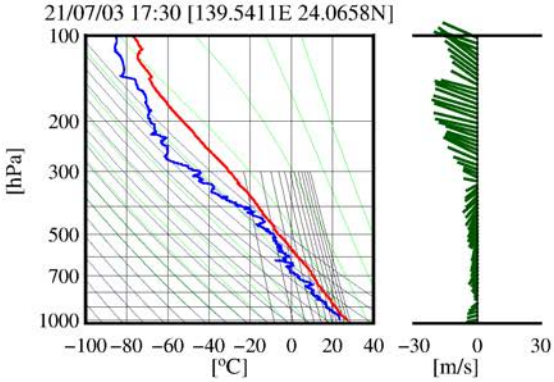
21/07/03 08:28 [139.4827E 22.5541N]



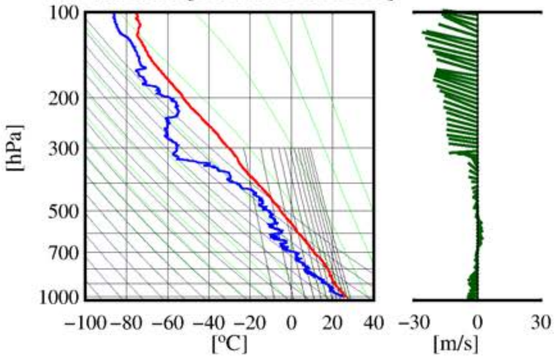
21/07/03 11:19 [139.4747E 23.1419N]



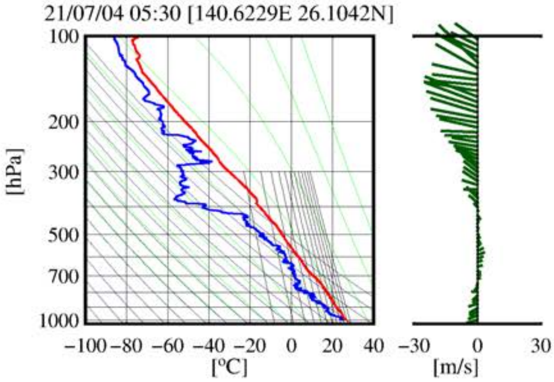
21/07/03 17:30 [139.5411E 24.0658N]



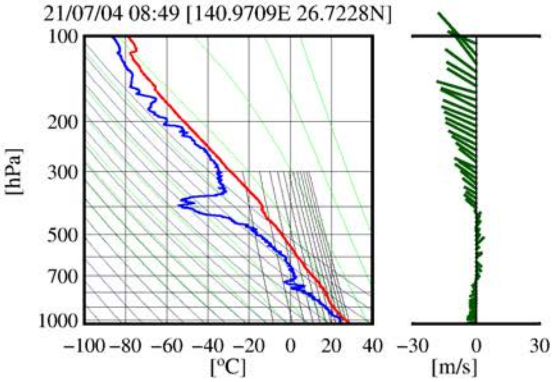
21/07/03 23:30 [140.0886E 25.1292N]



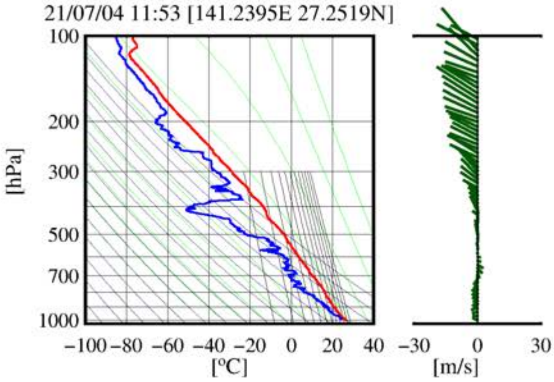
21/07/04 05:30 [140.6229E 26.1042N]



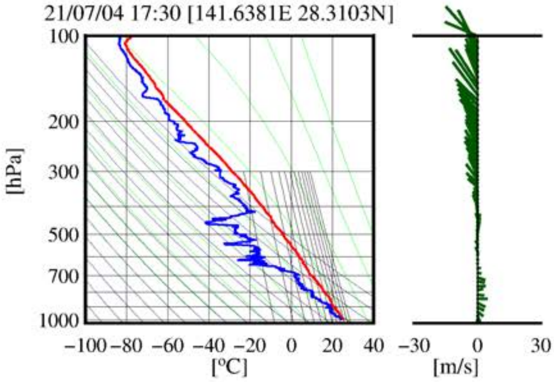
21/07/04 08:49 [140.9709E 26.7228N]

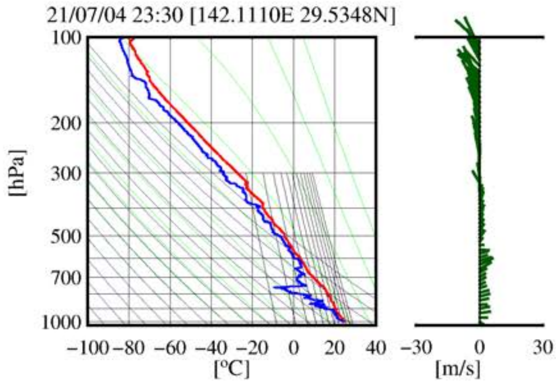


21/07/04 11:53 [141.2395E 27.2519N]



21/07/04 17:30 [141.6381E 28.3103N]

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[ºC]
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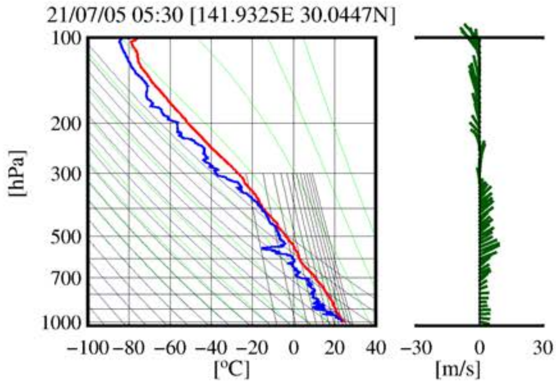
[m/s]


21/07/05 05:30 [141.9325E 30.0447N]
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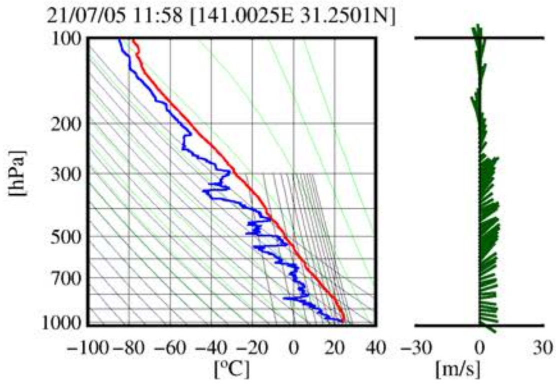
[ºC]
−30 0 30
[m/s]


21/07/05 11:58 [141.0025E 31.2501N]
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[ºC]
−30 0 30
[m/s]