doi : 10.17596/0002843

R/V Mirai Cruise Report MR15-04

The observational study of the heavy rainfall zone in the eastern Indian Ocean

Eastern Indian Ocean "Maritime Continent"

November 5, 2015 - December 20, 2015

Japan Agency for Marine-Earth Science and Technology

JAMSTEC, Japan

Agency for the Assessment and Application of Technology

BPPT, Indonesia

Cruise Report ERRATA of the Nutrients part

page	Error	Correction
5.19-2	potassium nitrate CAS No. 7757-91-1	potassium nitrate CAS No. 7757-79-1

Cruise Report ERRATA of the Photosynthetic Pigments part

page	Error	Correction
5.21-1	Ethyl-apo-8'-carotenoate	trans-β-Apo-8'-carotenal

MR15-04 Cruise Report

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1. Introduction

The maritime continent (MC) is a key region in the global weather and climate. For example, vital convective activity over MC is a driving force for the global atmospheric circulation. The convective activity over MC is well known to be regulated largely by diurnal cycle, intra-seasonal variations (e.g. Madden-Julian Oscillation (MJO)), seasonal variations (e.g. Asia-Australia monsoon), and inter-annual variations (e.g. El Nino / Southern Oscillation (ENSO)). Among them, for example, the different diurnal characteristics between over landmass and over adjacent seas are still not well reproduced even by the state-of-the-art atmospheric numerical models. The eastward penetration of the MJO over MC from Indian Ocean to the western Pacific is also the big issue to be improved in the numerical models.

The deficiencies to understand and to reproduce these variations are considered to be caused by the lack of our knowledge on, for example, the localized mesoscale circulations associated with coastlines and topography, and /or the moist convection processes over the region. To improve our understandings on these processes in the MC region, the fine-scale, multi-disciplinary observational data is desired.

In the past, many projects have been tried to obtain the observational evidence to reveal the nature of these processes over the MC. While these projects (e.g. CPEA[1], JEPP-HARIMAU[2]) revealed the nature of the convections over the land and coast in the various situations, the ocean-atmosphere processes in the adjacent sea is still remained to be investigated.

To reveal the oceanic and atmospheric processes in the MC, the collaborative team lead by Japan-Agency of Marine-Earth Science and Technology (JAMSTEC), Indonesian Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknology, BPPT), and Indonesian Agency for Meteorlogy, Climatology and Geophysica (Badan Meteorologi, Klimatologi dan Geofisika, BMKG) planned to deploy the observation network off the western Sumatra, which consists of the research vessel (R/V) Mirai, (which equips bunch of observational instruments like C-band polarimetric radar, CTD system, radiosonde launcher, etc.) and the land-based sites near Bengkulu (with weather radars, radiosonde observations, special "videosonde" observations, and so on) to contrast the processes over land and ocean. We set the target area as the ocean near Bengkulu, western Sumatra, with considering the following factors:

(1) The satellite measurements (e.g. TRMM products) tell the heavy oceanic rainfall occurs near the coast in the area.

(2) The coastline is rather straight, where the two-dimensional processes orthogonal to the coastline can be assumed to simplify the background to understand the coastal process, with our limited observational resources.

(3) The small islands off the coast (like in, for example, the near-equator of the western Sumatra), which may disturb the assumption in (2) and hinder the principles we are trying to reveal, are sparse.

(4) The coastline elongated with certain angle (not near-parallel) to the zonal wind which dominate the wind component in the equatorial region (to encourage understanding quasi two-dimensional processes)

This cruise report summarizes the observed items and preliminary results during the R/V Mirai MR15-04 cruise. The cruise consists of three parts. The primary part is the stationary observation off Bengkulu, west of

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[1] Coupled Process of the Equatorial Atmosphere
[2] Japan EOS (Earth Observation System) Promotion Plan (JEPP) Hydro-meteorological Array for ISV-Monsoon Auto-monitoring.

Sumatra Island to obtain continuous, fine temporal-resolution data for both atmospheric and oceanic states. The principle component of the observations are the surface meteorological measurement, atmospheric sounding by radiosonde, CTD and LADCP casting to profile the ocean thermodynamic and dynamic status, as well as the C-band polarimetric radar observation to capture the details of precipitating systems. Before and after the stationary observation period, the oceanic cross sections along the line between (6S, 101E) and (4S, 102E), namely quasi-orthogonal to the coastline, were obtained by CTD or UCTD observations. Oceanic cross sections were obtained also at the Makassar and Lombok straights by utilizing UCTD and XCTD. In addition, the continuous observations by the autonomous / underway instruments were carried out along the track to / from the stationary observation point.

In this report, the first several sections describes the basic information such as cruise track, on board personnel list are described. Details of each observation are described in Section 5. Additional information and figures are also attached as Appendices.

***** Remarks *****

This cruise report is a preliminary documentation as of the end of the cruise. The contents may be not updated after the end of the cruise, while the contents may be subject to change without notice. Data on the cruise report may be raw or not processed. Please ask the Chief Scientist and the Principle Investigators for the latest information.

2. Cruise Summary

2.1 Ship

Name	Research Vessel MIRAI
L x B x D	128.6m x 19.0m x 13.2m
Gross Tonnage	8,706 tons
Call Sign	JNSR
Home Port	Mutsu, Aomori Prefecture, Japan

2.2 Cruise Code

MR15-04

2.3 Project Name (Main mission)

"The observational study of the heavy rainfall zone in the eastern Indian Ocean",
(as a part of the Japan-Indonesia collaborative research project "Observational studies of heavy precipitation caused by air-sea interaction in and around coast of western Sumatra water and intra to inter-decadal climate variability of oceanographic environment in the eastern Indian Ocean off Java")

2.4 Undertaking Institute

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
2-15, Natsushima, Yokosuka, Kanagawa 237-0061, JAPAN
Agency for Assessment and Application of Technology (BPPT)
Jalan Mohammad Hunsni Thamrin 8, Jakarta 10340, INDONESIA

2.5 Chief Scientist

Masaki KATSUMATA
Tropical Climate Variability Research Program,
Research Institute for Global Change, JAMSTEC
Dedy Swandry Banurea
Agency for Meteorology, Climatorlogy and Geophysics (BMKG)

2.6 Representative of the science party [Affiliation]

Kunio Yoneyama [JAMSTEC]

2.7 Periods and Ports of Call

Nov. 5:	departed Sekinehama, Japan
Nov. 6:	called Hachinohe, Japan
Dec. 20:	arrived Jakarta, Indonesia

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

(1) Observational study on clouds and mixed layer depths over the tropical ocean (PI: Kazuaki YASUNAGA / Toyama University)
(2) Researches on the organized precipitation systems and the roles of their accompanying cold pool over the eastern Indian Ocean (PI: Hiroaki MIURA / University of Tokyo)
(3) Physiological and ecological studies on the relationship between the distribution and salinity and temperature tolerance, and environmental factors in oceanic sea skaters, *Halobates*, inhabiting eastern tropical Indian Ocean (PI: Tetsuo HARADA / Kochi University)

(4) Advanced measurements of aerosols in the marine atmosphere: Toward elucidation of interactions with climate and ecosystem (PI: Yugo KANAYA / JAMSTEC)
(5) Videosonde observations of ice particles in the precipitating clouds developed over the tropical ocean (PI: Kenji SUZUKI / Yamaguchi University)
(6) Aerosol optical characteristics measured by ship-borne sky radiometer (PI: Kazuma AOKI / Toyama University)
(7) Shipboard CO_2 observations over the tropical Indo-Pacific Ocean for a simple estimation fo the carbon flux between the ocean and the atmosphere from GOSAT data (PI: Kei SHIOMI / Japan Aerospace Exploration Agency (JAXA))

2.9 Observation Summary

GPS Radiosonde	224 times	Nov. 11 to Dec. 18
GNSS water vapor observation	continuously	Nov. 5 to Nov. 13 / Nov. 15 to Dec. 20
C-band Doppler radar	continuously	Nov. 8 to Nov. 13 / Nov. 15 to Dec. 19
Micro rain radar	continuously	Nov. 5 to Nov. 13 / Nov. 15 to Dec. 20
Disdrometers	continuously	Nov. 5 to Nov. 13 / Nov. 15 to Dec. 20
Videosonde	5 times	Nov. 29 to Dec. 15
Lidar	continuously	Nov. 12 to Nov. 13/ Nov.15 to Dec. 19
Ceilometer	continuously	Nov. 5 to Nov. 13 / Nov. 15 to Dec. 20
Sky Radiometer	continuously	Nov. 5 to Nov. 13 / Nov. 15 to Dec. 20
Aerosol and gas observations	continuously	Nov. 5 to Nov. 13 / Nov. 15 to Dec. 20
Greenhouse gas observations	continuously	Nov. 5 to Nov. 13 / Nov. 15 to Dec. 20
Surface Meteorology	continuously	Nov. 5 to Nov. 13 / Nov. 15 to Dec. 20
Sea surface water monitoring	continuously	Nov. 5 to Nov. 13 / Nov. 15 to Dec. 19
pCO2 observations	continuously	Nov. 8 to Nov. 13
CTDO profiling	221 profiles	Nov. 21 to Dec. 17
Sea water sampling	108 casts	Nov. 21 to Dec. 17
LADCP	221 profiles	Nov. 21 to Dec. 17
Micro structure profiler	46 times	Nov. 23 to Dec. 17
Underway CTD	29 times	Nov. 16 to Dec. 18
eXpendable CTD	11 times	Nov. 16 to Dec. 17
Deployment of Wave Glider	1 time	Dec. 10
Sea skater sampling	27 times	Nov. 20 to Dec. 14
Gravity/Magnetic force	continuously	Nov. 5 to Nov. 13 / Nov. 15 to Dec. 20
Bathymetry	continuously	Nov. 5 to 13 / Nov. 15 to 23 / Dec. 18 to 20

2.10 Overview

In order to investigate the atmospheric and oceanic variations in the Maritime Continent, the intensive observations by using R/V Mirai were carried out. This cruise was a component of the joint field campaign under the collaboration of JAMSTEC and BPPT.

The main part of the cruise was dedicated to perform stationary observation at (4-04N, 101-54E) to obtain high-resolution time series of the oceanic and atmospheric variations. R/V Mirai was at the station for 25 days from Nov. 23 to Dec.17. Before and after the stationary observation period, CTD or UCTD were operated to obtain oceanic cross section between (4S, 102E) and (6S, 101E) as well as along the cruise track at Makassar and Lombok straits. The autonomous instruments were in operation continuously all the way from Japan to Jakarta.

During the cruise, we witnessed the significant diurnal cycle both in the atmospheric and oceanic variations, though the detail of the appearance differ day by day. The atmospheric observations also captured the synoptic-scale variations. The oceanic profiles revealed the gradual deepening of the mixed layer thru the stationary observation period. Finally in the last several days, we experienced strong westerly wind as typically seen in the end of the MJO convectively active phase, namely “westerly burst”.

These observed results will be analyzed further, with combining the data from land sites in Bengkulu. The further analyses will be performed to engrave the detail of the processes to promote the active convections in the coastal area of MC.

2.11 Acknowledgments

We would like to express our sincere thanks to Captain K. Matsuura and his crew for their skillful ship operation. Special thanks are extended to the technical staff of Global Ocean Development Inc. and Marine Works Japan, Ltd. for their continuous and skillful support to conduct the observations. Supports from collaborators in the project, especially by the member of BPPT, are greatly acknowledged.

3. Cruise Track and Log

3.1 Cruise Track

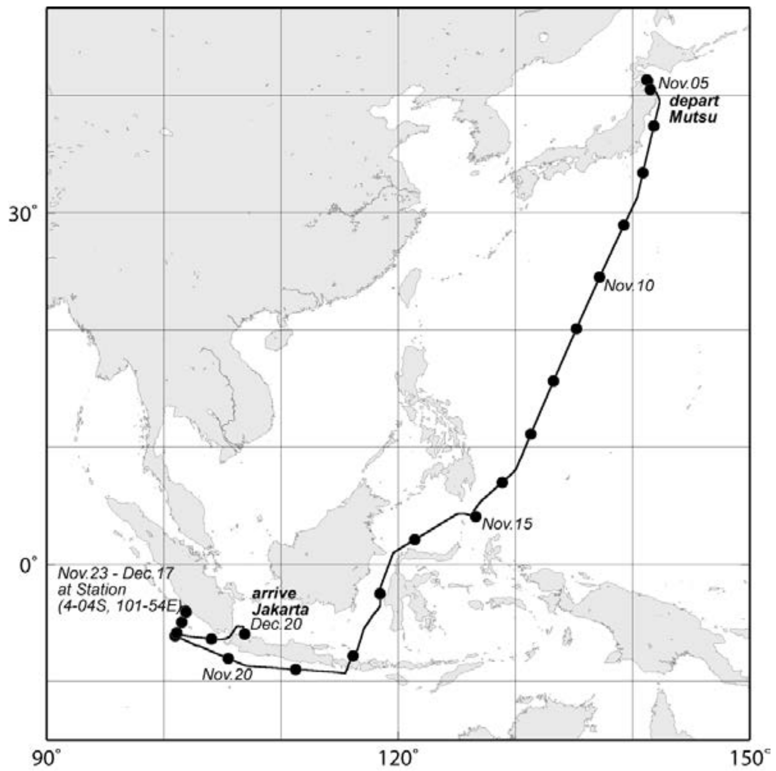

Fig. 3.1-1: Cruise track for all period. Black dots are for the positions at 00UTC at every day.

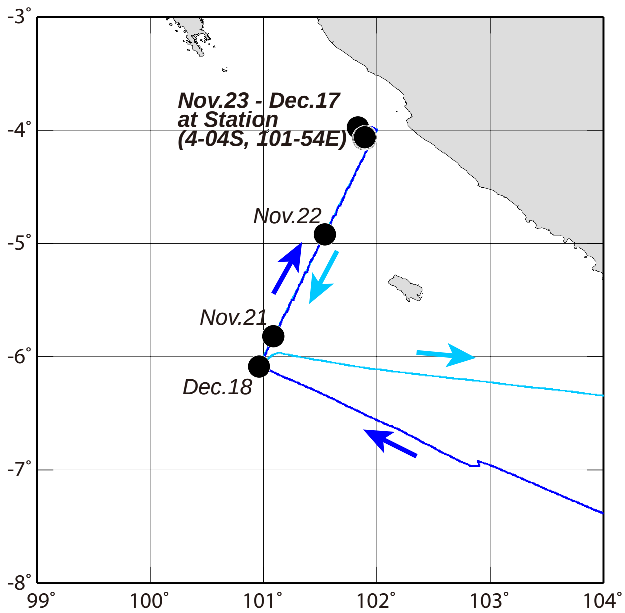

Fig. 3.1-2: Cruise track around the west coast of Sumatra Island, including cross section (6S,101E) - (4S,102E). Blue and cyan line are the cruise track to and from the station (4-04S, 101-54E), respectively.

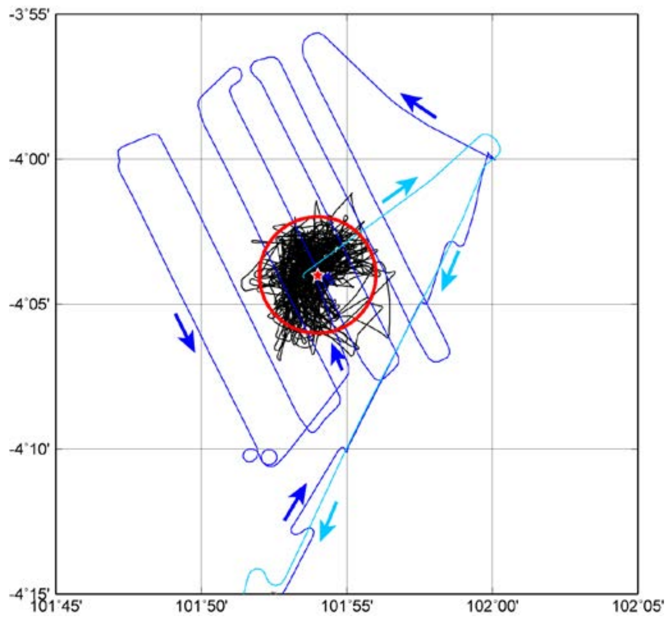

Fig. 3.1-3: Cruise tracks around the station (4-04S, 101-54E). Nominal station is shown by red star. Red circle indicate the area within 2 miles from the station. Black line is the track during stationary observation, while blue and cyan lines are same as Fig. 3.1-2.

3.2 Cruise Log

Date and Time (in UTC)		SMT	Location	Event
Nov. 5	0600	1500		Depart Sekinehama, Japan
	0947	1847	(41-19.46N, 101-43.10E)	Calibration for magnetometer
6	2250	0750		Arrive Hachinohe, Japan
	0620	1520		Depart Hachinohe, Japan
	0745	1645		Start sea surface water monitoring
8	0218	1118		Start C-band radar observation
10	0540	1440	(23-27.86N, 136-42.98E)	Radio Sonde #1
11	0100	1000	(19-57.59N, 135-08.27E)	Radio Sonde #2
	0540	1440	(19-06.16N, 134-45.19E)	Radio Sonde #3
12	0100	1000	(15-28.08N, 133-10.64E)	Radio Sonde #4
13	1300	----		Revision of ship mean time (to UTC+8h)
	1632	0032		Enter Philippine EEZ
				Pause all observations
14	2354	0754		Arrive off Talaud Islands
15	0030	0830		Embarkation of Indonesian Security Officer and scientist from Indonesia
	0042	0842		Depart off Talaud Islands
	0300	1100		Resume all observations
16	0456	1256	(01-33.53N, 120-29.99E)	UCTD #1;200m
	0615	1415	(01-24.50N, 120-15.01E)	UCTD #2;200m
	0731	1531	(01-15.30N, 120-00.01E)	UCTD #3;200m
	0849	1649	(01-06.14N, 119-44.98E)	UCTD #4;200m
	0942	1742	(00-59.98N, 119-35.00E)	XCTD #1
	1042	1842	(00-44.95N, 119-29.41E)	XCTD #2
	1141	1941	(00-29.98N, 119-23.68E)	UCTD #3
	1239	2039	(00-15.03N, 119-18.23E)	XCTD #4
	1341	2141	(00-00.01S, 119-12.75E)	XCTD #5
	1540	2340	(00-30.00S, 119-01.46E)	XCTD #6
	1741	0141	(01-00.00S, 118-50.22E)	XCTD #7
	1945	0345	(01-29.97S, 118-39.01E)	XCTD #8
	2150	0550	(02-00.03S, 118-27.99E)	UCTD #5;200m
	2254	0654	(02-15.05S, 118-28.00E)	UCTD #6;200m
	2357	0757	(02-30.01S, 118-28.19E)	UCTD #7;200m
17	0059	0859	(02-45.01S, 118-28.01E)	UCTD #8;200m
	0200	1000	(03-00.03S, 118-27.99E)	UCTD #9;200m
	0258	1058	(03-15.02S, 118-28.02E)	UCTD #10;200m
	0401	1201	(03-29.99S, 118-28.00E)	UCTD #11;200m
	0519	1319	(03-45.00S, 118-19.19E)	UCTD #12;200m
	0643	1443	(04-00.01S, 118-07.05E)	UCTD #13;200m
18	0109	0909	(08-00.00S, 115-59.99E)	UCTD #14;200m
	0220	1020	(08-15.01S, 115-54.02E)	UCTD #15;200m
	0326	1126	(08-30.01S, 115-48.02E)	UCTD #16;200m
	0439	1239	(08-46.98S, 115-41.71E)	XCTD #9
	0535	1335	(09-00.00S, 115-35.94E)	UCTD #17;200m
	0642	1442	(09-15.00S, 115-29.90E)	UCTD #18;200m
19	1400	----		Revision of ship mean time (to UTC+7h)
20	1219	1919	(06-56.10S, 102-53.82E)	Sample "sea skater" #1-1
	1241	1941	(06-57.09S, 102-54.23E)	Sample "sea skater" #1-2
	1301	2001	(06-58.09S, 102-54.37E)	Sample "sea skater" #1-3
	2330	0630	(06-05.15S, 100-57.44E)	Radio Sonde #5
	2334	0634	(06-05.17S, 100-57.47E)	CTD #1;1000m (with sampling seawater)
	0205	0905	(06-00.13S, 101-00.18E)	CTD #2;500m (with sampling seawater)
	0230	0930	(06-00.18S, 101-00.21E)	Radio Sonde #6

	0400	1100	(05-55.06S, 101-02.76E)	CTD #3;500m
	0530	1230	(05-50.19S, 101-04.89E)	Radio Sonde #7
	0533	1233	(05-50.29S, 101-05.08E)	CTD #4;500m
	0701	1401	(05-45.17S, 101-07.83E)	CTD #5;500m (with sampling seawater)
	0830	1530	(05-42.65S, 101-09.32E)	Radio Sonde #8
	0901	1601	(05-40.21S, 101-10.10E)	CTD #6;500m
	1030	1730	(05-35.22S, 101-12.64E)	CTD #7;500m
	1131	1831	(05-32.93S, 101-12.93E)	Radio Sonde #9
	1201	1901	(05-30.19S, 101-15.04E)	CTD #8;500m (with sampling seawater)
	1354	2054	(05-25.13S, 101-17.61E)	CTD #9;500m
	1430	2130	(05-25.32S, 101-17.97E)	Radio Sonde #10
	1532	2232	(05-20.20S, 101-20.11E)	CTD #10;500m
	1716	0016	(05-14.91S, 101-22.24E)	Radio Sonde #11
	1719	0019	(05-15.05S, 101-22.59E)	CTD #11;500m (with sampling seawater)
	1910	0210	(05-10.09S, 101-25.13E)	CTD #12;500m
	2037	0337	(05-05.03S, 101-27.37E)	CTD #13;500m
	2030	0330	(05-07.59S, 101-26.09E)	Radio Sonde #12
	2100	0400	(05-05.04S, 101-27.38E)	Radio Sonde #13
	2207	0507	(05-00.15S, 101-30.17E)	CTD #14;500m (with sampling seawater)
	2333	0633	(04-56.67S, 101-32.03E)	Radio Sonde #14
	2358	0658	(04-55.12S, 101-32.55E)	CTD #15;500m
	0125	0825	(04-50.04S, 101-35.25E)	CTD #16;500m
	0230	0930	(04-47.93S, 101-35.57E)	Radio Sonde #15
	0315	1015	(04-45.20S, 101-37.72E)	CTD #17;500m (with sampling seawater)
	0515	1215	(04-39.97S, 101-40.09E)	Radio Sonde #16
	0519	1219	(04-40.02S, 101-40.26E)	CTD #18;500m
	0648	1348	(04-35.03S, 101-42.69E)	CTD #19;500m
	0815	1515	(04-30.02S, 101-44.94E)	Radio Sonde #17
	0819	1519	(04-30.04S, 101-45.15E)	CTD #20;500m (with sampling seawater)
	1009	1709	(04-25.09S, 101-47.60E)	CTD #21;500m
	1131	1831	(04-19.90S, 101-49.87E)	Radio Sonde #18
	1145	1845	(04-19.96S, 101-49.98E)	CTD #22;500m
	1318	2018	(04-14.98S, 101-52.57E)	CTD #23;500m (with sampling seawater)
	1431	2131	(04-12.86S, 101-53.45E)	Radio Sonde #19
	1505	2205	(04-10.05S, 101-54.96E)	CTD #24;500m
	1638	2338	(04-04.97S, 101-57.63E)	CTD #25;374m
	1706	0030	(04-02.96S, 101-58.79E)	Radio Sonde #20
	1803	0103	(03-59.86S, 101-59.92E)	CTD #26;200m (with sampling seawater)
	1928	0228		Start bathymetry survey, to determine “Station”
	2024	0324	(04-06.28S, 101-58.40E)	Radio Sonde #21
	2342	0642	(03-57.43S, 101-51.11E)	Radio Sonde #22
23	0231	0931	(04-01.95S, 101-47.96E)	Radio Sonde #23
	0314	1014		End bathymetry survey
	0315	1015	(04-09.92S, 101-52.09E)	Calibration for magnetometer
	0430	1130	(04-04S, 101-54E)	Arrive “Station” (4-04S, 101-54E)
	0532	1232	(04-04.06S, 101-53.93E)	Radio Sonde #24
	0533	1233	(04-04.14S, 101-53.92E)	CTD #27;300m (with sampling seawater)
	0720	1420	(04-05.12S, 101-52.64E)	Deploy Sea Snake
	0830	1530	(04-04.84S, 101-54.13E)	Radio Sonde #25
	0832	1532	(04-04.83S, 101-54.25E)	CTD #28;300m
	0857	1557	(04-04.88S, 101-54.50E)	MSP #1;370m
	1131	1831	(04-04.92S, 101.55.78E)	Radio Sonde #26
	1135	1835	(04-05.01S, 101-55.93E)	CTD #29;300m (with sampling seawater)
	1215	1915	(04-05.20S, 101.56.17E)	Sample "sea skater" #2-1
	1235	1935	(04-05.65S, 101-55.74E)	Sample "sea skater" #2-2
	1255	1955	(04-06.11S, 101-55.36E)	Sample "sea skater" #2-3
	1430	2130	(04-04.95S, 101-53.12E)	Radio Sonde #27
	1434	2134	(04-04.91S, 101-53.23E)	CTD #30;300m

	1730	0030	(04-02.90S, 101-53.24E)	Radio Sonde #28
	1733	0033	(04-02.82S, 101-53.34E)	CTD #31;300m (with sampling seawater)
	2030	0330	(04-04.01S, 101-52.89E)	Radio Sonde #29
	2035	0335	(04-03.97S, 101-53.02E)	CTD #32;300m
	2331	0631	(04-04.37S, 101-52.78E)	Radio Sonde #30
	2335	0635	(04-04.38S, 101-52.80E)	CTD #33;500m (with sampling seawater)
24	0230	0930	(04-02.60S, 101-52.05E)	Radio Sonde #31
	0234	0934	(04-02.57S, 101-53.07E)	CTD #34;300m
	0531	1231	(04-03.58S, 101-53.02E)	Radio Sonde#32
	0537	1237	(04-03.50S, 101-53.07E)	CTD #35;300m (with sampling seawater)
	1830	1530	(04-03.28S, 101-53.45E)	Radio Sonde #33
	1832	1532	(04-03.26S, 101-53.48E)	CTD #36;300m
	1856	1556	(04-03.20S, 101-53.55E)	MSP #2;416m
	1131	1831	(04-04.03S, 101-53.11E)	Radio Sonde #34
	1134	1834	(04-04.00S, 101-53.16E)	CTD #37;300m (with sampling seawater)
	1430	2130	(04-03.10S, 101-53.00E)	Radio Sonde#35
	1433	2133	(04-03.06E, 101-53.04E)	CTD#38;300m
	1730	0030	(04-02.61S, 101-53.84E)	Radio Sonde #36
	1733	0033	(04-02.63S, 101-53.87E)	CTD #39;300m (with sampling seawater)
	2030	0330	(04-03.59S, 101-52.75E)	Radio Sonde #37
	2035	0335	(04-03.68S, 101-52.72E)	CTD #40;300m
	2330	6030	(04-04.22S, 101-53.05E)	Radio Sonde #38
	2334	6034	(04-04.31S, 101-53.05E)	CTD #41;500m (with sampling seawater)
25	0230	0930	(04-03.43S, 101-53.71E)	Radio Sonde #39
	234	0934	(04-03.47S, 101-53.72E)	CTD #42;300m
	0530	1230	(04-03.05S, 101-54.55E)	Radio Sonde #40
	0534	1235	(04-03.10S, 101-54.55E)	CTD #43;300m (with sampling seawater)
	1230	1530	(04-03.41S, 101-54.02E)	Radio Sonde #41
	1233	1533	(04-03.45S, 101-54.10E)	CTD #44;300m
	1256	1556	(04-03.57S, 101-54.29E)	MSP #3;339m
	1130	1830	(04-04.09S, 101-52.82E)	Radio Sonde #42
	1133	1833	(04-04.16S, 101-52.80E)	CTD #45;300m (with sampling seawater)
	1422	2122	(04-04.17S, 101-53.34E)	Radio Sonde #43
	1430	2130	(04-04.24S, 101-53.37E)	CTD #46;300m
	1735	0035	(04-03.22S, 101-52.21E)	CTD #47;300m (with sampling seawater)
	1807	0107	(04-03.19S, 101-52.21E)	Radio Sonde #44
	2030	0330	(04-03.87S, 101-54.72E)	Radio Sonde #45
	2036	0336	(04-03.93S, 101-54.61E)	CTD #48;300m
	2330	0630	(04-03.96S, 101-52.95E)	Radio Sonde #46
	2334	0634	(04-04.18S, 101-53.00E)	CTD #49;500m (with sampling seawater)
26	0230	0930	(04-03.61S, 101-53.91E)	Radio Sonde #47
	0234	0934	(04-03.81S, 101-54.03E)	CTD #50;300m
	0531	1231	(04-03.17S, 101-54.31E)	Radio Sonde #48
	0534	1234	(04-03.29S, 101-54.37E)	CTD #51;300m (with sampling seawater)
	0830	1530	(04-03.96S, 101-54.12E)	Radio Sonde #49
	0833	1533	(04-04.06S, 101-54.12E)	CTD #52;300m
	0856	1556	(04-04.30S, 101-54.12E)	MSP #4;339m
	1130	1839	(04-04.06S, 101-53.37E)	Radio Sonde #50
	1133	1833	(04-04.14S, 101-53.39E)	CTD #53;300m (with sampling seawater)
	1210	1910	(04-04.18S, 101.53.32E)	Sample "sea skater" #3-1
	1232	1932	(04-03.55S, 101-53.23E)	Sample "sea skater" #3-2
	1252	1952	(04-02.94S, 101-53.17E)	Sample "sea skater" #3-3
	1430	2130	(04-03.22S, 101-54.28E)	Radio Sonde #51
	1433	2133	(04-03.21S, 101-54.37E)	CTD #54;300m
	1725	0025	(04-03.15S, 101-54.29E)	Radio Sonde #52
	1730	0030	(04-03.21S, 101-54.44E)	CTD #55;300m (with sampling seawater)
	2030	0330	(04-03.96S, 101-54.15E)	Radio Sonde #53
	2035	0335	(04-04.06S, 101-54.25E)	CTD #53;300m

	2331	0631	(04-04.29S, 101-53.34E)	Radio Sonde#54
	2340	0640	(04-04.44S, 101-53.47E)	CTD #57;500m (with sampling seawater)
27	0230	0930	(04-05.11S, 101-54.16E)	Radio Sonde #55
	0234	0934	(04-05.23S, 101-54.33E)	CTD #58;300m
	0730	1230	(04-04.92S, 101-54.30E)	Radio Sonde #56
	0534	1234	(04-05.01S, 101-54.42E)	CTD #59;300m (with sampling seawater)
	0830	1530	(04-04.00S, 101-54.03E)	Radio Sonde #57
	0832	1532	(04-04.03S, 101-54.14E)	CTD #60;300m
	0855	1555	(04-04.16S, 101-54.30E)	MSP #5;346m
	1131	1831	(04-03.95S, 101-53.24E)	Radio Sonde #58
	1135	1835	(04-03.97S, 101-53.30E)	CTD #61 (with sampling seawater)
	1430	2130	(04-02.86S, 101-54.98E)	Radio Sonde #59
	1434	2134	(04-02.98S, 101-55.19E)	CTD #62;300m
	1730	0030	(04-02.70S, 101-54.35E)	Radio Sonde #60
	1733	0033	(04-02.76S, 101-54.47E)	CTD #63;300m (with sampling seawater)
	2030	0330	(04-03.58S, 101-53.91E)	Radio Sonde #61
	2036	0336	(04-03.65S, 101-54.06E)	CTD #64;300m
	2331	0631	(04-04.14S, 101-53.26E)	Radio Sonde #62
	2335	0635	(04-04.24S, 101-53.34E)	CTD #65;500m (with sampling seawater)
	0230	0930	(04-03.47S, 101-54.11E)	Radio Sonde #63
	0234	0934	(04-03.52S, 101-54.19E)	CTD #66;300m
	0531	1231	(04-04.33S, 101-53.67E)	Radio Sonde #64
	0536	1236	(04-04.32S, 101-53.74E)	CTD #67;300m (with sampling seawater)
	0831	1531	(04-03.26S, 101-53.42E)	Radio Sonde #65
	0832	1532	(04-03.30S, 101-53.40E)	CTD #68;300m
	0856	1556	(04-03.40S, 101-53.45E)	MSP #6;334m
	1131	1831	(04-03.57S, 101-52.94E)	Radio Sonde #66
	1136	1836	(04-03.52S, 101-52.99E)	CTD #69;300m (with sampling seawater)
	1430	2130	(04-02.48S, 101-53.78E)	Radio Sonde #67
	1435	2135	(04-02.50S, 101-53.75E)	CTD #70;300m
	1730	0030	(04-05.38S, 101-54.08E)	Radio Sonde #68
	1748	0048	(04-05.15S, 101-54.35E)	Video Sonde #1
	1757	0057	(04-05.25S, 101-54.40E)	CTD #71;300m (with sampling seawater)
	2031	0331	(04-03.15S, 101-55.57E)	Radio Sonde #69
	2037	0337	(04-03.09S, 101-55.67E)	CTD #72;300m
	2330	0630	(04-04.08S, 101-53.29E)	Radio Sonde #70
	2334	0634	(04-04.18S, 101-53.28E)	CTD #73;500m (with sampling seawater)
29	0230	0930	(04-02.98S, 101-53.84E)	Radio Sonde #71
	0236	0936	(04-03.02S, 101-53.77E)	CTD #74;300m
	0531	1231	(04-04.43S, 101-53.64E)	Radio Sonde #72
	0535	1235	(04-04.49S, 101-53.58E)	CTD #75;300m (with sampling seawater)
	0830	1530	(04-03.49S, 101-53.51E)	Radio Sonde #73
	0832	1532	(04-03.57S, 101-53.53E)	CTD #76;300m
	0857	1557	(04-03.74S, 101-53.66E)	MSP #7;339m
	1130	1830	(04-04.06S, 101-53.31E)	Radio Sonde #74
	1133	1833	(04-04.17S, 101-53.32E)	CTD #77;300m (with sampling seawater)
	1206	1906	(04-04.41S, 101-53.33E)	Sample "sea skater" #4-1
	1227	1927	(04-05.16S, 101-53.06E)	Sample "sea skater" #4-2
	1247	1947	(04-05.84S, 101-52.80E)	Sample "sea skater" #4-3
	1431	2131	(04-04.49S, 101-53.45E)	Radio Sonde #75
	1437	2137	(04-04.59S, 101-53.43E)	CTD #78;300m
	1720	0020	(04-03.13S, 101-53.93E)	Radio Sonde #76
	1732	0032	(04-03.02S, 101-53.99E)	CTD #79;300m (with sampling seawater)
	2030	0330	(04-03.67S, 101-54.71E)	Radio Sonde #77
	2036	0336	(04-03.64S, 101-54.69E)	CTD #80;300m
	2331	0631	(04-03.97S, 101-53.07E)	Radio Sonde #78
	2336	0636	(04-04.10S, 101-52.99E)	CTD #81;500m (with sampling seawater)
30	0230	0930	(04-03.49S, 101-53.55E)	Radio Sonde #79

	0237	0937	(04-03.50S, 101-53.46E)	CTD #82;300m
	0530	1230	(04-04.16S, 101-53.57E)	Radio Sonde #80
	0534	1234	(04-04.23S, 101-53.53E)	CTD #83;300m (with sampling seawater)
	0830	1530	(04-04.62S, 101-53.36E)	Radio Sonde #81
	0832	1532	(04-04.71S, 101-53.49E)	CTD #84;300m
	1130	1830	(04-03.99S, 101-53.73E)	Radio Sonde #82
	1133	1833	(04-04.04S, 101-53.77E)	CTD #85;300m (with sampling seawater)
	1209	1909	(04-04.20S, 101-53.89E)	MSP #8;391m
	1430	2130	(04-05.39S, 101-54.14E)	Radio Sonde #83
	1436	2136	(04-05.40S, 101-54.03E)	CTD #86;300m
	1459	2159	(04-05.43S, 101-53.91E)	MSP #9;375m
	1730	0030	(04-04.15S, 101-53.53E)	Radio Sonde #84
	1733	0033	(04-04.26S, 101-53.48E)	CTD #87;300m (with sampling seawater)
	1812	0112	(04-04.52S, 101-53.40E)	MSP #10;340m
	2030	0330	(04-04.82S, 101-53.17E)	Radio Sonde #85
	2036	0336	(04-04.95S, 101-53.16E)	CTD #88;300m
	2102	0402	(04-05.20S, 101-53.13E)	MSP #11;334m
	2330	0630	(04-04.17S, 101-53.05E)	Radio Sonde #86
	2335	0635	(04-04.20S, 101-52.93E)	CTD #89;500m(with sampling seawater)
Dec. 1	0230	0930	(04-03.27S, 101-53.95E)	Radio Sonde #87
	0235	0935	(04-03.26S, 101-53.84E)	CTD #90;300m
	0531	1231	(04-03.09S, 101-53.61E)	Radio Sonde #88
	0534	1234	(04-03.33S, 101-53.59E)	CTD #91;300m (with sampling seawater)
	0830	1530	(04-03.88S, 101-53.49E)	Radio Sonde #89
	0832	1532	(04-03.98S, 101-53.42E)	CTD #92;300m
	1131	1831	(04-04.00S, 101-52.94E)	Radio Sonde #90
	1133	1833	(04-04.05S, 101-52.90E)	CTD #93;300m (with sampling seawater)
	1210	1910	(04-04.23S, 101-52.88E)	MSP #12;362m
	1425	2125	(04-04.31S, 101-53.78E)	Radio Sonde #91
	1429	2129	(04-04.36S, 101-53.89E)	CTD #94;300m
	1452	2152	(04-04.34S, 101-53.90E)	MSP #13;375m
	1730	0030	(04-02.87S, 101-53.49E)	Radio Sonde #92
	1735	0035	(04-02.88S, 101-53.55E)	CTD #95;299m (with sampling seawater)
	1815	0115	(04-02.74S, 101-53.61E)	MSP #14;357m
	2030	0330	(04-03.66S, 101-53.77E)	Radio Sonde #93
	2036	0336	(04-03.78S, 101-53.83E)	CTD #96;300m
	2103	0403	(04-04.20S, 101-53.92E)	MSP #15;340m
	2330	0630	(04-04.04S, 101-54.05E)	Radio Sonde #94
	2334	0634	(04-04.19S, 101-54.13E)	CTD #97;500m (with sampling seawater)
2	0230	0930	(04-03.31S, 101-54.15E)	Radio Sonde #95
	0236	0936	(04-03.34S, 101-54.19E)	CTD #98;300m
	0530	1230	(04-03.02S, 101-54.85E)	Radio Sonde #96
	0534	1234	(04-03.19S, 101-54.83E)	CTD #99;300m (with sampling seawater)
	0830	1530	(04-03.13S, 101-53.06E)	Radio Sonde #97
	0832	1532	(04-03.19S, 101-53.02E)	CTD #100;300m
	1130	1830	(04-03.68S, 101-53.12E)	Radio Sonde #98
	1135	1835	(04-03.76S, 101-53.16E)	CTD #101;300m (with sampling seawater)
	1211	1911	(04-03.97S, 101-53.14E)	MSP #16;384m
	1240	1940	(04-03.93S, 101-53.18E)	Sample "sea skater" #5-1
	1304	2004	(04-03.21S, 101-53.62E)	Sample "sea skater" #5-2
	1324	2024	(04-02.55S, 101-53.88E)	Sample "sea skater" #5-3
	1431	2131	(04-03.92S, 101-54.21E)	Radio Sonde #99
	1434	2134	(04-04.01S, 101-54.19E)	CTD #102;300m
	1456	2156	(04-04.14S, 101-54.21E)	MSP #17;337m
	1730	0030	(04-02.85S, 101-54.00E)	Radio Sonde #100
	1737	0037	(04-02.86S, 101-53.99E)	CTD #103;300m (with sampling seawater)
	1815	0115	(04-03.04S, 101-53.92E)	MSP #18;360m
	2030	0330	(04-03.76S, 101-54.08E)	Radio Sonde #101

	2035	0335	(04-03.74S, 101-54.22E)	CTD #104;300m
	2101	0401	(04-03.67S, 101-54.30E)	MSP #19;384m
	2330	0630	(04-04.08S, 101-52.80E)	Radio Sonde #102
	2334	0634	(04-04.26S, 101-52.79E)	CTD #105;500m (with sampling seawater)
3	0236	0936	(04-03.09S, 101-54.17E)	Radio Sonde #103
	0243	0943	(04-02.99S, 101-54.29E)	CTD #106;300m
	0530	1230	(04-04.47S, 101-53.71E)	Radio Sonde #104
	0534	1233	(04-04.58S, 101-53.74E)	CTD #107;300m (with sampling seawater)
	0830	1530	(04-03.03S, 101-54.41E)	Radio Sonde #105
	0835	1535	(04-03.15S, 101-54.50E)	CTD #108;300m
	0900	1600	(04-03.35S, 101-54.72E)	MSP #20;348m
	1131	1831	(04-03.86S, 101-53.47E)	Radio Sonde #106
	1134	1834	(04-03.89S, 101-53.48E)	CTD #109;300m (with sampling seawater)
	1406	2106	(04-02.52S, 101-53.27E)	Video Sonde #2
	1430	2130	(04-03.01S, 101-53.37E)	Radio Sonde #107
	1434	2134	(04-03.08S, 101-53.37E)	CTD #110;300m
	1730	0030	(04-02.17S, 101-54.03E)	Radio Sonde #108
	1736	0036	(04-02.15S, 101-54.10E)	CTD #111;300m (with sampling seawater)
	2030	0330	(04-03.72S, 101-55.48E)	Radio Sonde #109
	2036	0336	(04-03.82S, 101-55.55E)	CTD #112;300m
	2330	0630	(04-03.82S, 101-53.56E)	Radio Sonde #110
	2334	0634	(04-03.81S, 101-53.57E)	CTD #113;500m (with sampling seawater)
4	0231	0931	(04-02.54S, 101-53.64E)	Radio Sonde #111
	0237	0937	(04-02.53S, 101-53.65E)	CTD #114;300m
	0531	1231	(04-02.66S, 101-54.77E)	Radio Sonde #112
	0534	1234	(04-02.65S, 101-54.70E)	CTD #115;300m (with sampling seawater)
	0830	1530	(04-04.16S, 101-53.66E)	Radio Sonde #113
	0834	1534	(04-04.23S, 101-53.64E)	CTD #116;300m
	0859	1559	(04-04.42S, 101-53.77E)	MSP #21;344m
	1130	1830	(04-03.87S, 101-53.40E)	Radio Sonde #114
	1136	1836	(04-03.92S, 101-53.42E)	CTD #117;300m (with sampling seawater)
	1430	2130	(04-04.95S, 101-54.05E)	Radio Sonde #115
	1433	2133	(04-04.98S, 101-54.06E)	CTD #118;300m
	1730	0020	(04-03.17S, 101-53.49E)	Radio Sonde #116
	1733	0033	(04-03.23S, 101-53.59E)	CTD #119;300m (with sampling seawater)
	2030	0330	(04-04.28S, 101-53.51E)	Radio Sonde #117
	2035	0335	(04-04.31S, 101-53.71E)	CTD #120;300m
	2331	0631	(04-03.46S, 101-53.40E)	Radio Sonde #118
	2334	0634	(04-03.46S, 101-53.38E)	CTD #121;501m (with sampling seawater)
5	0232	0932	(04-04.43S, 101-52.83E)	Radio Sonde #119
	0234	0934	(04-04.56S, 101-52.90E)	CTD #122;300m
	0530	1230	(04-04.15S, 101-52.71E)	Radio Sonde #120
	0533	1233	(04-04.09S, 101-52.69E)	CTD #123;300m (with sampling seawater)
	0612	1312	(04-04.25S, 101-52.73E)	MSP #22;350m
	0640	1340	(04-04.42S, 101-52.80E)	MSP #23;350m
	0830	1530	(04-03.59S, 101-53.80E)	Radio Sonde #121
	0832	1532	(04-03.69S, 101-53.78E)	CTD #124;300m
	0858	1558	(04-03.93S, 101-53.90E)	MSP #24;361m
	1131	1831	(04-03.79S, 101-53.62E)	Radio Sonde #122
	1133	1833	(04-03.83S, 101-53.62E)	CTD #125;300m (with sampling seawater)
	1210	1910	(04-04.01S, 101-53.72E)	MSP #25;370m
	1233	1933	(04-04.07S, 101.53.67E)	Sample "sea skater" #6-1
	1254	1954	(04-03.95S, 101.53.10E)	Sample "sea skater" #6-2
	1314	2014	(04-03.73S, 101.52.53E)	Sample "sea skater" #6-3
	1425	2125	(04-04.13S, 101-53.71E)	Radio Sonde #123
	1429	2129	(04-04.22S, 101-53.67E)	CTD #126;300m
	1456	2153	(04-04.36S, 101-53.74E)	MSP #26;366m
	1732	0032	(04-05.22S, 101-53.91E)	CTD #127;300m (with sampling seawater)

	1747	0047	(04-05.24S, 101-53.91E)	Radio Sonde #124
	2030	0330	(04-03.99S, 101-54.65E)	Radio Sonde #125
	2034	0334	(04-04.19S, 101-54.72E)	CTD #128;300m
	2330	0630	(04-03.90S, 101-53.22E)	Radio Sonde #126
	2334	0634	(04-04.10S, 101-53.32E)	CTD #129;500m (with sampling seawater)
6	0230	0930	(04-04.39S, 101-54.00E)	Radio Sonde # 127
	0234	0934	(04-04.55S, 101-54.04E)	CTD #130;300m
	0530	1230	(04-04.56S, 101-53.53E)	Radio Sonde #128
	0533	1233	(04-04.66S, 101-53.54E)	CTD #131;300m (with sampling seawater)
	0609	1309	(04-04.76S, 101-53.56E)	MSP #27;395m
	1830	1530	(04-03.47S, 101-54.02E)	Radio Sonde #129
	1832	1532	(04-03.57S, 101-53.99E)	CTD #132;300m
	1857	1557	(04-03.72S, 101-54.12E)	MSP #28;365m
	1130	1830	(04-04.04S, 101-53.15E)	Radio Sonde #130
	1134	1834	(04-04.13S, 101-53.19E)	CTD #133;300m (with sampling seawater)
	1210	1910	(04-04.41S, 101-53.29E)	MSP #29
	1430	2130	(04-03.89S, 101-53.67E)	Radio Sonde 131
	1432	2132	(04-03.91S, 101-53.68E)	CTD #134;300m
	1458	2158	(04-03.97S, 101-53.75E)	MSP #30;317m
	1730	0030	(04-04.76S, 191-53.45E)	Radio Sonde #132
	1734	0034	(04-04.71S, 101-53.47E)	CTD #135;300m (with sampling seawater)
	2030	0330	(04-03.96S, 101-53.83E)	Radio Sonde #133
	2034	0334	(04-03.90S, 101-53.88E)	CTD #136;300m (with sampling seawater)
	2330	0630	(04-04.08S, 101-53.10E)	Radio Sonde #134
	2334	0635	(04-04.26S, 101-53.26E)	CTD #137;500m (with sampling seawater)
7	0118	0818	(04-04.98S, 101-53.20E)	Video Sonde #3
	0230	0930	(04-03.97S, 101-54.07E)	Radio Sonde #135
	0235	0935	(04-04.12S, 101-54.22E)	CTD #138;300m
	0531	1231	(04-03.82S, 101-53.28E)	Radio Sonde #136
	0534	1234	(04-03.89S, 101-53.23E)	CTD#139;300m (with sampling seawater)
	1617	1317	(04-03.93S, 101-53.29E)	MSP #31;400m
	0830	1530	(04-04.92S, 101-52.95E)	Radio Sonde#137
	0832	1532	(04-05.08S, 101-52.93E)	CTD #140;300m
	0856	1556	(04-05.15S, 101-53.11E)	MSP #32;370m
	1131	1831	(04-04.32S, 101-53.16E)	Radio Sonde #138
	1133	1833	(04-04.43S, 101-53.16E)	CTD #141;300m(with sampling seawater)
	1209	1909	(04-04.75S, 101-53.37E)	MSP #33;338m
	1530	2130	(04-03.83S, 101-53.35E)	Radio Sonde #139
	1532	2132	(04-03.90S, 101-53.27E)	CTD #142;300m
	1556	2156	(04-04.01S, 101-53.17E)	MSP #34
	1725	0025	(04-04.67S, 101-53.00E)	Radio Sonde #140
	1732	0032	(04-04.85S, 101-53.11E)	CTD #143;300m (with sampling seawater)
	1802	0102	(04-04.99S, 101-53.16E)	Radio Sonde #141
	2029	0329	(04-03.60S, 101-54.75E)	Radio Sonde #142
	2033	0333	(04-03.78S, 101-54.87E)	CTD #144;300m
	2330	0630	(04-04.14S, 101-52.96E)	Radio Sonde #143
	2334	0634	(04-04.41S, 101-52.99E)	CTD #145;500m (with sampling seawater)
8	0230	0930	(04-04.98S, 101-53.44E)	Radio Sonde #144
	0235	0935	(04-05.17S, 101-53.50E)	CTD #146;300m
	0530	1230	(04-03.91S, 101-53.57E)	Radio Sonde #145
	0534	1234	(04-04.08S, 101-53.61E)	CTD #147;300m (with sampling seawater)
	0830	1530	(04-04.93S, 101-53.58E)	Radio Sonde #146
	0832	1532	(04-05.09S, 101-53.69E)	CTD #148;300m
	0856	1556	(04-05.30S, 101-53.96E)	MSP #35;333m
	1130	1830	(04-04.12S, 101-52.90E)	Radio Sonde #147
	1132	1832	(04-04.18S, 101-53.00E)	CTD #149;300m
	1213	1913	(04-04.67S, 101-53.42E)	Sample "sea skater" #7-1
	1233	1933	(04-05.34S, 101-54.09E)	Sample "sea skater" #7-2

	1251	1951	(04-05.90S, 101-54.72E)	Sample "sea skater" #7-3
	1430	2130	(04-04.02S, 101-53.44E)	Radio Sonde #148
	1434	2134	(04-04.14S, 101-53.60E)	CTD #150;300m
	1730	0030	(04-04.18S, 101-53.02E)	Radio Sonde #149
	1732	0032	(04-04.31S, 101-53.12E)	CTD #151;300m (with sampling seawater)
	2030	0330	(04-03.24S, 101-53.69E)	Radio Sonde #150
	2035	0335	(04-03.45S, 101-53.72E)	CTD #152;300m
	2331	0631	(04-04.04S, 101-53.16E)	Radio Sonde #151
	2334	0634	(04-04.20S, 101-53.22E)	CTD #153;500m (with sampling seawater)
9	0230	0930	(04-03.03S, 101-53.24E)	Radio Sonde #152
	0235	0935	(04-03.17S, 101-53.26E)	CTD #154;300m
	0530	1230	(04-05.30S, 101-53.36E)	Radio Sonde #153
	0534	1234	(04-05.39S, 101-53.39E)	CTD #155;300m (with sampling seawater)
	0830	1530	(04-04.91S, 101-53.11E)	Radio Sonde #154
	0832	1532	(04-05.04S, 101-53.14E)	CTD #156;300m
	0856	1556	(04-05.26S, 101-53.20E)	MSP #36;334m
	1130	1830	(04-04.01S, 101-53.30E)	Radio Sonde #155
	1133	1833	(04-04.10S, 101-53.27E)	CTD #157;300m (with sampling seawater)
	1430	2130	(04-04.71S, 101-53.58E)	Radio Sonde #156
	1432	2132	(04-04.76S, 101-53.55E)	CTD #158;300m
	1730	0030	(04-03.60S, 101-54.07E)	Radio Sonde #157
	1732	0032	(04-03.66S, 101-54.15E)	CTD #159;300m (with sampling seawater)
	2031	0331	(04-03.05S, 101-54.26E)	Radio Sonde #158
	2034	0334	(04-03.18S, 101-54.21E)	CTD #160;300m
	2331	0631	(04-04.11S, 101-52.99E)	Radio Sonde #159
	2334	0634	(04-04.34S, 101-52.97E)	CTD #161;500m (with sampling seawater)
10	0110	0810	(04-04.70S, 101-53.06E)	Deploy waveglider
	0230	0930	(04-04.78S, 101-53.84E)	Radio Sonde #160
	0234	0934	(04-04.87S, 101-52.80E)	CTD #162;300m
	0325	1025	(04-04.05S, 101-53.48E)	Recover waveglider
	0530	1230	(04-04.20S, 101-52.91E)	Radio Sonde #161
	0534	1234	(04-04.17S, 101-52.87E)	CTD #163;300m (with sampling seawater)
	0830	1530	(04-03.64S, 101-52.75E)	Radio Sonde #162
	0832	1532	(04-03.64S, 101-52.73E)	CTD #164;300m
	0855	1555	(04-03.76S, 101-52.78E)	MSP #37
	1125	1825	(04-04.13S, 101-52.94E)	Radio Sonde #163
	1135	1835	(04-04.14S, 101-52.89E)	CTD #165;300m (with sampling seawater)
	1427	2127	(04-03.01S, 101-54.02E)	Radio Sonde #164
	1432	2132	(04-03.05S, 101-53.98E)	CTD #166;300m
	1730	0030	(04-02.77S, 101-53.85E)	Radio Sonde #165
	1733	0033	(04-02.79S, 101-53.79E)	CTD #167; 300m (with sampling seawater)
	2030	0330	(04-03.07S, 101-53.46E)	Radio Sonde #166
	2035	0335	(04-03.12S, 101-53.42E)	CTD #168;300m
	2330	0630	(04-01.15S, 101-52.95E)	Radio Sonde #167
	2333	0633	(04-04.16S, 101-52.82E)	CTD #169;500m with samping seawater
11	0230	0930	(04-02.86S, 101-53.30E)	Radio Sonde #168
	0235	0935	(04-02.92S, 101-53.30E)	CTD #170;300m
	0530	1230	(04-03.99S, 101-52.72E)	Radio Sonde #169
	0533	1233	(04-04.02S, 101-52.72E)	CTD #171;300m (with sampling seawater)
	0830	1530	(04-04.68S, 101-52.76E)	Radio Sonde #170
	0832	1532	(04-04.78S, 101-52.77E)	CTD #172;300m
	0855	1555	(04-04.98S, 101-52.83E)	MSP #38;345m
	1130	1830	(04-03.96S, 101-53.25E)	Radio Sonde #171
	1133	1833	(04-04.03S, 101-53.30E)	CTD #173;300m (with sampling seawater)
	1206	1906	(04-04.14S, 101-53.20E)	Sample "sea skater" #8-1
	1226	1926	(04-04.30S, 101-52.64E)	Sample "sea skater" #8-2
	1245	1945	(04-04.43S, 101-52.05E)	Sample "sea skater" #8-3
	1421	2121	(04-02.75S, 101-53.20E)	Radio Sonde #172

	1427	2127	(04-02.66S, 101-53.23E)	CTD #174;300m
	1730	0030	(04-03.72E, 101-53.88E)	Radio Sonde #173
	1732	0032	(04-03.78S, 101-53.88E)	CTD #175 (with sampling seawater)
	2030	0330	(04-02.68S, 101-54.49E)	Radio Sonde #174
	2034	0334	(04-02.77S, 101-54.51E)	CTD #176;300m
	2331	0631	(04-03.90S, 101-53.32E)	Radio Sonde #175
	2335	0635	(04-04.06S, 101-53.35E)	CTD #177;500m (with sampling seawater)
12	0230	0930	(04-03.23S, 101-54.47E)	Radio Sonde #176
	0235	0935	(04-03.31S, 101-54.59E)	CTD #178;300m
	0530	1230	(04-03.18S, 101-53.77E)	Radio Sonde #177
	0533	1233	(04-03.22S, 101-53.86E)	CTD #179;300m (with sampling seawater)
	0830	1530	(04-03.84S, 101-53.68E)	Radio Sonde #178
	0833	1533	(04-03.88S, 101-53.73E)	CTD #180;300m
	0856	1556	(04-04.09S, 101-53.86E)	MSP #39;351m
	1130	1830	(04-03.99S, 101-53.36E)	Radio Sonde #179
	1133	1833	(04-04.06S, 101-53.41E)	CTD #181;300m (with sampling seawater)
	1430	2130	(04-04.18S, 101-53.48E)	Radio Sonde #180
	1433	2133	(04-04.24S, 101-54.55E)	CTD #182;300m
	1722	0022	(04-03.22S, 101-53.32E)	Radio Sonde #181
	1733	0033	(04-03.25S, 101-53.29E)	CTD #183;300m (with sampling seawater)
	2030	0330	(04-03.21S, 101-53.81E)	Radio Sonde #182
	2034	0334	(04-03.29S, 101-53.82E)	CTD #184;300m
	2330	0630	(04-03.26S, 101-53.86E)	Radio Sonde #183
	2334	0634	(04-03.34S, 101-53.94E)	CTD #185;500m (with sampling seawater)
13	0230	0930	(04-03.40S, 101-53.67E)	Radio Sonde #184
	0234	0934	(04-03.44S, 101-53.78E)	CTD #186;500m
	0529	1229	(04-03.55S, 101-54.08E)	Radio Sonde #185
	0535	1235	(04-03.60S, 101-54.22E)	CTD #187;300m (with sampling seawater)
	0830	1530	(04-03.05S, 101-53.91E)	Radio Sonde #186
	0837	1537	(04-03.16S, 101-54.20E)	CTD #188;300m
	0858	1558	(04-03.36S, 101-54.38E)	MSP #40;341m
	1130	1830	(04-03.05S, 101-53.65E)	Radio Sonde #187
	1135	1835	(04-03.65S, 101-53.82E)	CTD #189;300m (with sampling seawater)
	1430	2130	(04-03.91S, 101-53.58E)	Radio Sonde #188
	1432	2132	(04-04.02S, 101-53.68E)	CTD #190;300m
	1731	0031	(04-03.31S, 101-53.68E)	Radio Sonde #189
	1733	0033	(04-03.44S, 101-53.72E)	CTD #191;300m (with sampling seawater)
	2030	0330	(04-03.62S, 101-53.64E)	Radio Sonde #190
	2034	0334	(04-03.71S, 101-58.70E)	CTD #192;300m
	2330	0630	(04-03.78S, 101-53.88E)	Radio Sonde #191
	2333	0633	(04-03.82S, 101-53.99E)	CTD #193;500m (with sampling seawater)
14	0230	0930	(04-03.12S, 101-53.82E)	Radio Sonde #192
	0234	0934	(04-03.25S, 101-53.91E)	CTD #194;300m
	0530	1230	(04-02.78S, 101-54.07E)	Radio Sonde #193
	0533	1233	(04-02.77S, 101-54.25E)	CTD #195;300m (with sampling seawater)
	0831	1531	(04-03.27S, 101-53.61E)	Radio Sonde #194
	0834	1534	(04-03.23S, 101-53.73E)	CTD #196;300m
	0854	1554	(04-03.43S, 101-53.85E)	MSP #41;330m
	1123	1823	(04-03.34S, 101-53.53E)	Radio Sonde #195
	1128	1828	(04-03.39S, 101-53.61E)	CTD #197;300m (with sampling seawater)
	1204	1904	(04-03.39S, 101-53.62E)	Sample "sea skater" #9-1
	1224	1924	(04-02.76S, 101-53.85E)	Sample "sea skater" #9-2
	1246	1946	(04-02.11S, 101-53.89E)	Sample "sea skater" #9-3
	1413	2113	(04-02.58S, 101-53.06E)	Video Sonde #4
	1430	2130	(04-02.32S, 101-53.34E)	Radio Sonde #196
	1432	2132	(04-02.37S, 101-53.45E)	CTD #198;300m
	1731	0031	(04-03.17S, 101-53.12E)	Radio Sonde #197
	1734	0034	(04-03.22S, 101-53.21E)	CTD #199;300m (with sampling seawater)

	2030	0330	(04-03.82S, 101-53.08E)	Radio Sonde #198
	2034	0334	(04-04.01S, 101-53.07E)	CTD #200;300m
	2331	0631	(04-03.19S, 101-53.19E)	Radio Sonde #199
	2334	0634	(04-93.37S, 101-53.20E)	CTD #201;500m (with sampling seawater)
15	0230	0930	(04-02.86E, 101-54.39E)	Radio Sonde #200
	0234	0934	(04-02.85S, 101-54.47E)	CTD #202;300m
	0530	1230	(04-02.88S, 101-53.66E)	Radio Sonde #201
	0534	1234	(04-02.86S, 101-53.71E)	CTD #203;300m (with sampling seawater)
	0831	1531	(04-04.27S, 101-53.59E)	Radio Sonde #202
	0834	1534	(04-04.37S, 101-53.68E)	CTD #204;300m
	0855	1555	(04-04.61S, 101-53.75E)	MSP #42;334m
	1115	1815	(04-03.27S, 101-53.84E)	Radio Sonde #203
	1121	1821	(04-03.30S, 101-53.90E)	CTD #205;300m (with sampling seawater)
	1218	1918	(04-03.20S, 101-54.01E)	Video Sonde #5
	1428	2128	(04-03.52S, 101-55.55E)	Radio Sonde #204
	1433	2133	(04-03.64S, 101-55.87E)	CTD #206;300m
	1715	0015	(04-05.17S, 101-54.65E)	Radio Sonde #205
	1731	0031	(04-05.23S, 101-54.45E)	CTD #207;300m (with sampling seawater)
	2026	0326	(04-04.13S, 101-53.49E)	Radio Sonde #206
	2032	0332	(04-04.25S, 101-53.62E)	CTD #208;300m
	2326	0626	(04-03.23S, 101-53.66E)	Radio Sonde #207
	2331	0631	(04-03.43S, 101-53.84E)	CTD #209;500m (with sampling seawater)
16	0230	0930	(04-03.38S, 101-53.60E)	CTD #210;300m
	0253	0953	(04-03.55S, 101-53.64E)	Radio Sonde #208
	0529	1229	(04-04.16S, 101-54.44E)	Radio Sonde #209
	0533	1233	(04-04.26S, 101-54.57E)	CTD #211;300m (with sampling seawater)
	0830	1530	(04-03.71S, 101-54.03E)	Radio Sonde #210
	0833	1533	(04-04.82S, 101-54.17E)	CTD #212;300m
	0853	1553	(04-04.12S, 101-54.38E)	MSP #43;324m
	1131	1831	(04-03.92S, 101-53.74E)	Radio Sonde #211
	1134	1834	(04-04.30S, 101-53.88E)	CTD #213;300m (with sampling seawater)
	1423	2123	(04-03.50S, 101-53.26E)	Radio Sonde #212
	1427	2127	(04-03.59S, 101-53.27E)	CTD #214;300m
	1730	0030	(04-03.31S, 101-54.46E)	Radio Sonde #213
	1734	0034	(04-03.44S, 101-54.57E)	CTD #215;300m (with sampling seawater)
	2031	0331	(04-03.76S, 101-53.84E)	Radio Sonde #214
	2035	0335	(04-03.87S, 101-53.90E)	CTD #216;300m
	2330	0630	(04-03.57S, 101-53.56E)	Radio Sonde #215
	2334	0634	(04-03.69S, 101-53.61E)	CTD #217;500m (with sampling seawater)
17	0230	0930	(04-03.64S, 101-53.61E)	Radio Sonde #216
	0234	0934	(04-03.69E, 101-53.67E)	CTD #218;300m
	0529	1229	(04-03.27S, 101-53.76E)	Radio Sonde #217
	0532	1232	(04-03.37S, 101-53.77E)	CTD #219;300m
	0613	1313	(04-03.47S, 101-53.92E)	Recover sea snake
	0830	1530	(04-03.56S, 101-53.06E)	Radio Sonde #218
	0854	1554	(04-03.65S, 101-53.08E)	CTD #220;300m
	0855	1555	(04-03.86S, 101-53.14E)	MSP #44;336m
	1130	1830	(04-03.91S, 101-53.38E)	Radio Sonde #219
	1132	1832	(04-03.98S, 101-53.43E)	CTD #221;300m (with sampling seawater)
	1212	1912		Depart "Station" (4-04S, 101-54E)
	1303	2003	(03-59.92S, 102-00.14E)	XCTD #10
	1359	2059	(04-10.02S, 101-54.97E)	UCTD #19;300m
	1430	2130	(04-14.35S, 101-52.20E)	Radio Sonde #220
	1503	2203	(04-02.02S, 101-50.02E)	UCTD #20;300m
	1601	2301	(04-30.03S, 101-44.96E)	UCTD #21;300m
	1700	0000	(04-04.00S, 101-39.98E)	UCTD #22;300m
	1731	0031	(04-43.55S, 101-38.14E)	Radio Sonde #221
	1809	0109	(04-50.00S, 101-35.00E)	UCTD #23;300m

	1905	0205	(05-00.00S, 101-30.01E)	UCTD #24;300m
	2001	0301	(05-10.00S, 101-25.00E)	UCTD #25;300m
	2029	0329	(05-14.74S, 101-22.58E)	Radio Sonde #222
	2057	0357	(05-19.98S, 101-20.00E)	UCTD #26;300m
	2156	0456	(05-30.02S, 101-14.99E)	UCTD #27;300m
	2255	0555	(05-40.00S, 101-10.00E)	UCTD #28;300m
	2337	0637	(05-46.32S, 101-06.43E)	Radio Sonde #223
18	0004	0704	(05-50.01S, 101-05.00E)	UCTD #29;300m
	0100	0800	(06-00.01S, 101-00.00E)	UCTD #30;300m
	0115	0815	(06-02.28S, 100-58.95E)	Calibration for magnetometer
19	0200	0900		Stop sea surface water monitoring
	0900	1700		Stop C-band radar observation
20	0300	1000		Arrive Jakarta

4. List of Participants

4.1 Participants (on board)

Name	Affiliation	*Theme No.
Masaki KATSUMATA	JAMSTEC	M
Biao GENG	JAMSTEC	M
Kyoko TANIGUCHI	JAMSTEC	M
Qoosaku MOTEKI	JAMSTEC	M
Tamaki SUEMATSU	JAMSTEC	M
Makito YOKOTA	JAMSTEC	M
Ichiro MATSUI	National Institute for Environmental Science (NIES)	M
Yuki KANEKO	Japan Aerospace Exploration Agency (JAXA)	M
Atsushi YAMASE	Nagoya Univ.	1
Shuhei MATSUGISHI	Univ. Tokyo	2
Tetsuo HARADA	Kochi Univ.	3
Noritomo UMAMOTO	Kochi Univ.	3
Takahiro FURUKI	Kochi Univ.	3
Wataru OHOKA	Kyoto Univ.	3
Kazuho YOSHIDA	Global Ocean Development Inc. (GODI)	T
Souichiro SUEYOSHI	GODI	T
Shinya OKUMURA	GODI	T
Miki MORIOKA	GODI	T
Kenichi KATAYAMA	Marine Works Japan Ltd. (MWJ)	T
Tomohide NOGUCHI	MWJ	T
Rei ITO	MWJ	T
Keisuke TAKEDA	MWJ	T
Masanori ENOKI	MWJ	T
Atsushi ONO	MWJ	T
Tomomi SONE	MWJ	T
Misato KUWAHARA	MWJ	T
Hiroshi HOSHINO	MWJ	T
Haruka TAMADA	MWJ	T
Masaki FURUHATA	MWJ	T
Katsumi KOTERA	MWJ	T

* Theme number corresponds to that shown in Section 2.7.
M and T means main mission and technical staff, respectively.

4.2 Participants (not on board)

Name	Affiliation	*Theme No.
Kunio YONEYAMA	JAMSTEC	M
Kazuaki YASUNAGA	Toyama Univ.	1
Hiroaki MIURA	Univ. Tokyo	2
Yugo KANAYA	JAMSTEC	4
Kenji SUZUKI	Yamaguchi Univ.	5
Kazuma AOKI	Toyama Univ.	6
Kei SHIOMI	JAXA	7

4.3 Ship Crew

Kan MATSUURA	Master
Haruhiko INOUE	Chief Officer
Takeshi ISOHI	First Officer
Toshihisa AKUTAGAWA	Jr. First Officer
Hiroki KOBAYASHI	Second Officer
Akihiro NUNOME	Third Officer
Yoichi FURUKAWA	Chief Engineer
Yu WATANABE	First Engineer
Wataru OKUMA	Second Engineer
Ryota HASHIDA	Third Engineer
Ryo KIMURA	Technical Officer
Kazuyoshi KUDO	Boatswain
Takeharu AISAKA	Able Seaman
Tsuyoshi MONZAWA	Able Seaman
Masashige OKADA	Able Seaman
Shuji KOMATA	Able Seaman
Kaito MURATA	Able Seaman
Hideyuki OKUBO	Ordinary Seaman
Akiya CHISHIMA	Ordinary Seaman
Kosuke ECHIZEN	Ordinary Seaman
Tetsuya SAKAMOTO	Ordinary Seaman
Tenki YAMASHIRO	Ordinary Seaman
Yoshihiro SUGIMOTO	No.1 Oiler
Daisuke TANIGUCHI	Oiler
Fumihito KAIZUKA	Oiler
Toshiyuki FURUKI	Oiler
Keisuke YOSHIDA	Oiler
Kazuya ANDO	Wiper
Kazuhiko HAYASHIDA	Chief Steward
Yukio SHIGE	Cook
Tamotsu UEMURA	Cook
Sakae HOSHIKUMA	Cook
Tsuneaki YOSHINAGA	Cook
Yukio CHIBA	Cook

5. Summary of Observations

5.1 GPS Radiosonde

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	- Principal Investigator
Biao GENG	(JAMSTEC)	
Tamaki SUEMATSU	(JAMSTEC)	
Shuhei MATSUGISHI	(Univ. Tokyo)	
Atsushi YANASE	(Nagoya Univ.)	
Kunio YONEYAMA	(JAMSTEC)	(not on board)
Kazuaki YASUNAGA	(Toyama Univ.)	(not on board)
Hiroaki MIURA	(Univ. Tokyo)	(not on board)
Kazuho YOSHIDA	(GODI)	- Operation Leader
Miki MORIOKA	(GODI)	
Souichiro SUEYOSHI	(GODI)	
Shinya OKUMURA	(GODI)	
Ryo KIMURA	(MIRAI Crew)	

(2) Objectives

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

(3) Methods

(3-1) Time series observation using Vaisala system

Atmospheric sounding by radiosonde by using system by Vaisala Oyj was carried out. The GPS radiosonde sensor RS92-SGPD and RS-41SGP was launched with the balloons (Totex TA-200 or TA-350). 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.2.2.1), GPS antenna (GA20), UHF antenna (RB21), ground check kit for RS92 (GC25), ground check kit for RS41 (RI41), and balloon launcher (ASAP). In the ”ground-check” process, the pressure sensor (Vaisala PTB-330) was also utilized as the standard. In case the relative wind to the ship (launcher) is not appropriate for the launch, the handy launch was selected.

The radiosondes were launched every 3 hours from 00UTC on Nov.21, 2015, to 00UTC on Dec.18, 2015, when the vessel was at or around the station (4-04S, 101-54E). In addition, 4 additional launches were done at the western Pacific. In total, 224 soundings were carried out, as listed in Table 5.1-1.

(3-2) Multi-sensor launches for sensor intercomparison

Among the launches in (3-1), 18 launches were dedicated to “multi-sensor” launches for the sensor intercomparison. In the launches, we attached two (RS92-SGPD and RS41-SGP) or three (adding Meisei iMS-100, see below) sensors to one balloon (TA-350) and launched. In the case, the MW41 receiver system in (3-1) were utilized to receive data from RS41-SGP, while data from RS92-SGPD were received by the other MW31 receiver system which installed at aft wheel house. The data from Meisei iMS-100 were received by the receiver system for the Videosonde observation (see Section 5.7).

The multi-sensor launches can be found in gray-shaded rows in Table 5.1-1. The three-sensor (RS92-SGPD, RS41-SGP and iMS-100) launches (8 launches) are written by bold letters, while two-sensor (RS92-SGPD and RS41-SGP) launches (10 launches) are in normal letters.

(4) Preliminary Results

The results from Vaisala system are shown in the figures. Figure 5.1-1 is the time-height cross sections during the stationary observation period at (4-04S, 101-54E) for equivalent potential temperature, relative humidity, zonal and meridional wind components. Several basic parameters are derived from sounding data as in Fig. 5.1-2, 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-A.

(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. Raw data is recorded in Vaisala original binary format during both ascent and descent. The ASCII data is also available. These raw datasets will be submitted to JAMSTEC Data Management Group (DMG). The corrected datasets will be available from Mirai website at http://www.jamstec.go.jp/cruisedata/mirai/e/ .

(6) Acknowledgments

The MW31 receiver system was kindly provided by the Institute of Arctic Climate and Environmental Research (IACE) of JAMSTEC.

Table 5.1-1: Radiosonde launch log, with surface values and maximum height. The gray-shaded rows indiacates the multi-sensor launch, with the bold letters for three-sensors (RS41-SGP, RS92-SGPD and iMS-100) launch while normal letters for two-sensor (RS41-SGP and RS92-SGPD) launch.

ID	Nominal Time YYYYMMDDhh	Launched Location		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	**2015111006**	**23.565**	**136.761**	**1011.6**	**26.7**	**83**	**357**	**3.3**	**25395**	**2**	**Cu, Ci**
RS002	2015111100	20.057	135.180	1014.0	27.9	80	79	7.3	24345	3	Cu
RS003	**2015111106**	**19.210**	**134.811**	**1011.6**	**28.0**	**81**	**72**	**8.1**	**26589**	**1**	**Cu**
RS004	2015111200	15.557	133.216	1012.4	28.6	77	62	10.7	25221	2	Cu
RS005	2015112100	−6.098	101.002	1006.6	27.2	81	83	7.0	24231	9	Cu,St
RS006	2015112103	−6.000	101.001	1007.3	28.6	85	123	8.6	25213	10	Cu,St
RS007	2015112106	−5.869	101.068	1005.8	28.5	86	125	8.6	24288	8	Cu,St
RS008	2015112109	−5.755	101.136	1003.8	28.5	86	130	7.6	24766	6	Cu,Ci,As
RS009	2015112112	−5.589	101.213	1005.5	28.4	83	126	9.1	23136	4	Cu,Ci,As
RS010	2015112115	−5.418	101.296	1007.1	28.6	83	124	8.8	23749	7	Cu,Ac,Cb,,Str
RS011	2915112118	−5.276	101.359	1006.3	28.5	84	127	7.5	23314	8	Cu,St
RS012	2015112121	−5.127	101.435	1005.1	25.1	90	108	4.4	−	10	−
RS013	2015112121	−5.084	101.456	1004.8	25.7	94	26	7.3	21044	10	−
RS014	2015112200	−4.965	101.528	1000.6	26.1	90	121	0.7	24976	10	St
RS015	2015112203	−4.835	101.593	1007.7	27.1	88	121	5.4	24453	10	Cu,St,As
RS016	2015112206	−4.691	101.658	1006.6	28.0	85	109	3.9	25478	7	Ci,As,Cu
RS017	2015112209	−4.538	101.730	1003.8	28.6	83	154	5.6	24412	4	Cu,Cb,Ci
RS018	2015112212	−4.388	101.807	1005.4	28.7	86	178	5.5	23501	7	Cu,Cb,St
RS019	2015112215	−4.251	101.878	1007.6	27.0	86	96	6.2	21477	10	Cb,Ns
RS020	2015112218	−4.083	101.961	1005.9	27.2	84	68	5.3	24630	7	As,Ns
RS021	2015112221	−4.046	101.944	1004.7	27.7	82	13	1.1	24155	10	−
RS022	2015112300	−4.035	101.885	1006.3	27.9	85	349	4.9	25226	8	Cu,St,As
RS023	2015112303	−4.001	101.817	1007.7	28.3	82	350	4.1	21851	7	Cu,Cs,Sc

RS024	2015112306	−4.066	101.905	1006.0	28.3	82	227	2.1	24345	9	Ns,Ac,As,Cu
RS025	2015112309	−4.082	101.903	1004.1	28.2	82	194	5.0	24927	6	Cu
RS026	2015112312	−4.095	101.903	1005.6	28.3	86	167	7.6	21758	10	St,Ns?
RS027	2015112315	−4.090	101.893	1007.5	28.7	81	114	3.4	21013	10	Cu,St,As
RS028	2015112318	−4.060	101.891	1006.8	28.4	83	141	4.7	21241	8	Cu,St
RS029	2015112321	−4.072	101.874	1004.7	26.7	87	136	3.7	22615	5	−
RS030	2015112400	−4.088	101.887	1006.2	27.5	87	90	0.4	22054	7	Cu,As,St
RS031	2015112403	−4.041	101.885	1008.4	28.1	86	227	4.0	22619	9	Cu,St
RS032	2015112406	−4.064	101.868	1006.9	25.8	95	196	9.3	508	−	−
RS033	2015112409	−4.053	101.889	1004.9	27.3	87	218	8.2	20811	10	Cb,Ns,St
RS034	2015112412	−4.061	101.889	1006.3	27.9	85	166	3.2	20885	10	St,Ns,Cu
RS035	2015112415	−4.057	101.881	1007.9	27.0	87	64	5.1	20843	10	St,Ns
RS036	2015112418	−4.042	101.904	1006.8	27.1	87	318	5.1	21666	8	Cu,St,Ns
RS037	2015112421	−4.055	101.881	1005.3	27.6	84	318	6.2	8654	8	St
RS038	2015112500	−4.058	101.891	1005.8	27.9	80	312	3.8	22668	4	Cu,As
RS039	2015112503	−4.055	101.897	1007.6	27.7	84	6	4.8	23983	4	Cu,Ci,As
RS040	2015112506	−4.054	101.901	1006.1	28.5	77	275	3.6	23485	5	Ci,Cu,Cs
RS041	2015112509	−4.059	101.902	1003.3	28.7	79	248	6.7	23107	5	Ci,Cu,As
RS042	2015112512	−4.075	101.885	1005.3	28.7	79	270	5.5	20404	5	Cu,Cb,St
RS043	2015112515	−4.073	101.885	1007.1	28.3	82	10	2.6	19641	10	Cu,Ac,Cb,,Str
RS044	2015112518	−4.048	101.889	1007.2	26.6	90	343	6.5	4848	8	St,Ns
RS045	2015112518	−4.054	101.887	1007.0	26.7	86	343	6.1	18277	9	St,Ns
RS046	2015112521	−4.061	101.913	1005.7	26.8	88	323	10.3	20026	8	St
RS047	2015112600	−4.072	101.883	1006.6	25.2	94	308	8.0	24859	10	−
RS048	2015112603	−4.061	101.896	1008.3	26.3	90	343	6.0	5307	10	St
RS049	2015112606	−4.054	101.901	1007.1	27.5	80	312	5.5	22824	9	St,Cu
RS050	2015112609	−4.068	101.900	1004.2	27.7	78	288	3.9	22948	8	Cu,Cb,St,Ac,As
RS051	2015112612	−4.067	101.900	1005.7	28.1	78	313	4.9	20615	9	Cu,Cb,As,St
RS052	2015112615	−4.041	101.908	1007.1	28.3	79	327	4.3	20583	10	Cu,As,St
RS053	2015112618	−4.053	101.905	1006.5	27.9	81	344	3.7	21470	5	As,St,Cu,Nb
RS054	2015112621	−4.063	101.899	1005.0	26.5	89	0	8.8	17237	10	−
RS055	2015112700	−4.072	101.889	1006.1	26.6	84	299	9.3	21028	8	Cu,St
RS056	2015112703	−4.091	101.902	1008.7	25.6	89	282	7.4	23211	10	As,St,Cu,Ns
RS057	2015112706	−4.085	101.903	1007.3	26.3	89	288	4.7	21341	10	St,Cu
RS058	2015112709	−4.069	101.899	1004.5	26.7	88	295	3.2	21636	9	Cu,Cb,St,As
RS059	2015112712	−4.076	101.892	1005.8	27.1	86	358	0.9	20062	8	Cu,St,As
RS060	2015112715	−4.038	101.925	1008.2	27.8	84	354	1.0	19386	8	St,As,Ac
RS061	2015112718	−4.045	101.903	1007.7	28.2	81	331	4.4	21832	10	St,Cu
RS062	2015112721	−4.057	101.894	1006.5	28.1	85	358	4.7	22569	6	St,Cu
RS063	2015112800	−4.039	101.894	1007.0	28.1	81	323	1.3	22042	6	Cu,St
RS064	2015112803	−4.056	101.909	1009.0	28.5	81	347	1.7	24084	4	Cu,Ci
RS065	2015112806	−4.067	101.897	1007.7	28.8	79	316	0.9	21096	6	Cu,Cs
RS066	2015112809	−4.057	101.891	1006.2	29.3	76	174	2.9	23026	6	Cu,Ci,Cc,Cb
RS067	2015112812	−4.068	101.873	1007.9	27.0	89	342	5.9	20191	9	Cu,Cb,As,St
RS068	2015112815	−4.040	101.899	1010.3	28.0	84	329	5.7	18852	10	Cu,As,St
RS069	2015112818	−4.081	101.900	1010.0	25.3	95	284	5.5	18202	10	−
RS070	2015112821	−4.053	101.913	1008.8	25.0	96	275	0.4	20623	8	St
RS071	2015112900	−4.067	101.890	1009.6	26.2	90	319	3.0	21724	9	Ns,St,Cu
RS072	2015112903	−4.051	101.900	1011.4	26.2	88	243	3.9	23755	7	Sc,St
RS073	2015112906	−4.074	101.896	1009.8	27.1	86	259	2.5	24240	5	Cs,Cc,Ci,Cu,St
RS074	2015112909	−4.062	101.893	1007.3	27.7	83	219	6.5	19788	7	Cu,Ci,Cc,Sc,As,Ns
RS075	2015112912	−4.059	101.883	1008.5	28.0	81	199	4.9	20913	9	Cu,St,As
RS076	2015112915	−4.080	101.892	1009.7	28.3	83	193	4.6	19054	10	−
RS077	2015112918	−4.060	101.897	1010.4	25.6	94	133	5.7	18333	10	−
RS078	2015112921	−4.062	101.917	1008.2	25.8	91	325	2.0	20329	9	St
RS079	2015113000	−4.070	101.883	1009.5	26.6	84	335	3.6	23601	10	St,Cu
RS080	2015113003	−4.057	101.900	1009.7	27.4	79	334	2.3	22578	6	Cu,Ci
RS081	2015113006	−4.076	101.889	1007.9	27.8	81	250	0.9	23188	4	Cu,St
RS082	**2015113009**	**−4.076**	**101.885**	**1006.2**	**28.5**	**75**	**202**	**4.2**	**22184**	**7**	**Cu,Ci,Cb,St,As**
RS083	2015113012	−4.070	101.889	1007.7	28.8	78	187	3.8	18009	9	Cu,St
RS084	2015113015	−4.097	101.901	1009.4	26.3	90	31	9.5	18420	10	Cb,Ns

RS085	2015113018	−4.079	101.897	1009.3	26.1	88	101	0.4	20286	9	St
RS086	2015113021	−4.081	101.880	1006.6	26.7	87	335	7.6	22394	5	St
RS087	2015120100	−4.073	101.887	1007.7	27.3	83	323	5.7	24545	6	Cu,Cs
RS088	2015120103	−4.059	101.897	1009.2	28.1	83	344	4.2	23536	6	Cu,Cs
RS089	**2015120106**	**−4.051**	**101.887**	**1008.1**	**28.4**	**79**	**298**	**2.7**	**26507**	**3**	**Cu,Ci,Cs,St**
RS090	2015120109	−4.053	101.891	1006.6	28.3	81	257	3.0	22607	7	Cu,Ns
RS091	2015120112	−4.078	101.884	1008.3	28.0	80	272	3.3	19117	9	Cu,Cb,As,St
RS092	2015120115	−4.069	101.881	1009.9	26.0	92	130	3.8	22986	10	Ns
RS093	2015120118	−4.055	101.891	1009.1	26.2	87	329	6.6	20581	8	St
RS094	2015120121	−4.060	101.883	1007.5	26.6	81	338	5.1	20429	10	St
RS095	2015120200	−4.068	101.907	1008.4	27.4	83	353	2.6	20625	9	St,Cu,Cc
RS096	2015120203	−4.058	101.908	1009.5	27.6	83	6	4.8	23417	7	As,Cb
RS097	2015120206	−4.052	101.904	1008.1	27.9	82	327	3.5	22053	8	St, Cu
RS098	2015120209	−4.056	101.888	1006.2	28.3	80	268	5.1	21195	9	Cu,As,St
RS099	2015120212	−4.063	101.883	1008.1	27.3	83	294	7.2	21351	6	Cu,Cb,Cc,St,As
RS100	2015120215	−4.053	101.911	1010.2	25.8	92	283	5.1	19277	10	−
RS101	2015120218	−4.053	101.897	1009.1	26.6	89	335	1.3	19445	10	−
RS102	2015120221	−4.053	101.911	1007.8	27.2	85	55	0.9	21828	8	−
RS103	2015120300	−4.064	101.893	1008.8	27.5	83	91	0.5	21995	7	Cu,Cs,Ac,Sc
RS104	2015120303	−4.055	101.895	1009.9	28.1	81	57	1.8	21836	8	Cs,Sc
RS105	2015120306	−4.067	101.893	1008.5	28.0	82	275	4.2	28801	8	Cu,Cs,Cb
RS106	2015120309	−4.054	101.903	1006.0	28.1	85	224	5.7	21665	5	Cu,Cb,Ci,St,As
RS107	2015120312	−4.056	101.896	1007.7	28.1	82	237	5.1	17910	7	Cu,Cb,As
RS108	2015120315	−4.042	101.888	1010.2	26.5	89	232	4.4	7559	10	−
RS109	2015120318	−4.040	101.900	1009.4	25.0	93	114	2.3	20121	10	−
RS110	2015120321	−4.061	101.927	1007.3	26.0	89	304	2.8	20177	8	−
RS111	2015120400	−4.065	101.893	1008.6	26.8	84	337	1.6	25631	4	Cc,Cs,Ci,Ac.Cu,St
RS112	2015120403	−4.045	101.895	1010.5	27.4	84	4	1.5	22689	9	Cu,Ci
RS113	2015120406	−4.046	101.903	1008.7	27.8	84	329	2.1	24883	1	Cu,As,Ci
RS114	2015120409	−4.070	101.898	1005.7	28.4	81	200	3.8	25758	1	Cu,Ci,Nb
RS115	2015120412	−4.074	101.889	1007.2	28.1	81	198	4.2	21640	3	Cu,Cb,Ci
RS116	2015120415	−4.092	101.891	1009.0	27.7	85	230	3.7	23487	3	−
RS117	2015120418	−4.058	101.892	1007.9	28.1	82	230	3.3	21596	10	−
RS118	2015120421	−4.077	101.897	1006.6	26.0	95	240	1.7	6705	10	−
RS119	2015120500	−4.059	101.892	1008.1	25.3	91	60	3.1	24956	10	Ns,As,St
RS120	**2015120503**	**−4.069**	**101.883**	**1009.5**	**26.0**	**92**	**254**	**1.9**	**28016**	**10**	**Ns,Sc,St**
RS121	2015120506	−4.069	101.880	1007.2	27.2	84	289	3.1	25287	7	Cu,Cb,Ci,Ac,St
RS122	2015120509	−4.064	101.894	1005.9	27.9	83	277	3.6	25080	9	Cu,As,Ci,St
RS123	2015120512	−4.060	101.899	1007.3	28.1	78	279	2.9	21864	6	Cu,St,Cb,As
RS124	2015120515	−4.064	101.897	1009.7	28.3	79	248	1.8	20824	10	St,Cu,Cb,Ns
RS125	2015120518	−4.085	101.893	1008.6	27.4	86	80	1.3	26822	10	−
RS126	2015120521	−4.060	101.914	1007.0	27.0	87	130	3.2	24033	−	−
RS127	2015120600	−4.061	101.892	1008.0	27.6	83	106	4.6	24395	9	Cu,Ci,As,Sc
RS128	2015120603	−4.066	101.921	1009.4	28.5	78	139	4.7	24601	6	Ci,Sc,St
RS129	2015120606	−4.068	101.900	1007.4	28.5	84	174	5.4	25368	3	Cu,Cb,Ci,St
RS130	2015120609	−4.051	101.902	1004.2	28.8	81	161	4.9	25061	7	Cu,St
RS131	2015120612	−4.073	101.893	1005.9	28.7	80	159	4.0	24451	5	Cu,As,Ci
RS132	2015120615	−4.084	101.896	1008.2	29.2	79	116	5.9	22953	7	Cb,Cu
RS133	2015120618	−4.067	101.901	1008.2	27.4	87	137	6.5	22096	10	−
RS134	2015120621	−4.067	101.910	1005.8	27.9	85	139	6.2	27514	3	−
RS135	2015120700	−4.064	101.893	1007.3	28.5	85	144	6.6	25243	7	Cu,Ci,As
RS136	2015120703	−4.074	101.892	1008.8	28.6	84	120	6.0	24044	8	Cb,St,Sc
RS137	2015120706	−4.056	101.899	1006.9	29.2	82	188	2.6	23675	7	Cb,St,Ac
RS138	2015120709	−4.077	101.872	1005.1	29.2	82	158	6.3	24875	9	Cb,Ac,Cu
RS139	2015120712	−4.087	101.884	1006.8	27.4	84	101	3.0	19814	9	Ns,St,Cb,As
RS140	2015120715	−4.066	101.888	1009.0	28.1	83	342	4.0	13369	10	−
RS141	2015120718	−4.070	101.873	1008.8	25.6	93	210	5.2	4157	10	−
RS142	2015120718	−4.081	101.885	1008.4	25.8	96	185	5.0	332	10	−
RS143	2015120721	−4.061	101.927	1007.1	26.1	96	209	3.7	5398	10	−
RS144	2015120800	−4.075	101.885	1008.4	26.2	91	200	3.5	22859	10	Cb,Ns,St
RS145	2015120803	−4.091	101.894	1010.6	27.6	86	155	2.0	23381	9	St,Sc,Cs,Cc,Ns

RS146	2015120806	−4.063	101.896	1009.6	27.5	88	228	3.3	24686	10	St,Sc,As
RS147	2015120809	−4.089	101.887	1006.9	27.7	85	138	4.4	25423	9	Sc,Cb,As,Ns
RS148	2015120812	−4.080	101.887	1008.4	27.5	85	112	3.0	24282	10	St,Cb
RS149	**2015120815**	**−4.079**	**101.890**	**1010.5**	**27.9**	**82**	**126**	**3.0**	**26965**	**5**	**−**
RS150	2015120818	−4.062	101.887	1009.5	28.1	86	90	4.3	23767	10	−
RS151	2015120821	−4.044	101.897	1007.2	28.0	79	136	5.7	24338	3	−
RS152	2015120900	−4.080	101.883	1008.2	26.7	84	146	2.9	24804	7	Cu,Cb,St
RS153	2015120903	−4.053	101.887	1010.0	27.4	81	298	1.9	27123	8	St,Sc,Cu
RS154	2015120906	−4.084	101.878	1008.9	27.9	85	144	1.7	23050	3	Cu,Cb,Ci,St,Ac
RS155	2015120909	−4.089	101.889	1006.3	28.9	77	180	5.7	25435	6	St,Ci,As,Cb,Cu
RS156	2015120912	−4.061	101.893	1008.0	28.8	75	153	4.9	23118	5	Cc,Cb,Cu,As,St
RS157	2015120915	−4.084	101.899	1009.5	28.7	78	151	6.6	19438	10	−
RS158	2015120918	−4.056	101.906	1009.4	26.3	92	216	2.7	26204	10	−
RS159	2015120921	−4.047	101.921	1006.9	27.9	82	94	4.3	24830	3	−
RS160	2015121000	−4.060	101.890	1008.0	28.1	85	106	2.8	24979	4	Cu,Cb,Cc,As,St
RS161	2015121003	−4.083	101.881	1009.4	28.0	85	175	0.9	24510	7	St,Cb,As
RS162	2015121006	−4.074	101.885	1008.1	28.5	84	276	1.9	22855	5	Cu,Cb,Cc,Ci,St
RS163	2015121009	−4.055	101.880	1005.8	29.2	79	241	4.7	21199	6	St,Cb,Ac,Cc,Ci
RS164	2015121012	−4.068	101.876	1006.7	25.4	85	98	2.1	6571	10	Ns,Cb
RS165	2015121015	−4.047	101.898	1009.1	26.4	92	48	3.3	16993	10	Ns
RS166	**2015121018**	**−4.042**	**101.890**	**1009.1**	**27.0**	**87**	**6**	**1.4**	**24650**	**10**	**−**
RS167	2015121021	−4.049	101.880	1006.6	27.5	87	20	3.2	23711	7	−
RS168	2015121100	−4.065	101.887	1007.3	27.7	81	354	4.1	23580	3	Cu,Cb,Ci,Cs,Cc,St
RS169	2015121103	−4.052	101.884	1008.9	28.1	80	349	1.0	23898	2	Cu,Ci,Cs,As
RS170	2015121106	−4.065	101.880	1006.9	28.7	78	292	2.7	25404	2	Cu,Cb,Cs,Ci,As
RS171	2015121109	−4.073	101.865	1004.1	29.1	76	201	0.9	24461	2	Cu,St,Cb,As,Ci
RS172	2015121112	−4.076	101.883	1006.0	29.2	77	302	1.5	21808	10	Ns
RS173	2015121115	−4.053	101.873	1008.0	25.5	98	5	10.3	15050	10	Cb
RS174	205121118	−4.055	101.902	1008.9	24.9	93	301	5.8	16366	10	−
RS175	2015121121	−4.041	101.914	1007.0	26.7	87	272	6.1	22403	10	−
RS176	2015121200	−4.064	101.888	1007.2	27.3	82	309	5.2	17503	9	Cu,Ns,As
RS177	2015121203	−4.057	101.909	1008.9	27.8	82	337	5.3	24822	8	Cu,Sc,Ns
RS178	2015121206	−4.054	101.894	1007.3	28.4	80	326	5.3	24569	7	Cu,Cb,Ci,Cs,Ac,As
RS179	2015121209	−4.073	101.897	1004.5	28.6	78	285	7.5	20582	5	St,Cu,Cb,As
RS180	2015121212	−4.060	101.902	1006.4	28.0	83	261	5.7	17993	7	St,Cb,Ns,Ci
RS181	2015121215	−4.077	101.888	1008.9	28.3	85	274	1.6	18733	10	Ns
RS182	2015121218	−4.051	101.891	1008.8	25.6	96	5	6.7	4759	10	−
RS183	2015121221	−4.050	101.895	1006.7	26.3	90	356	8.6	22762	10	−
RS184	2015121300	−4.054	101.893	1008.2	26.8	87	344	7.8	19178	9	As,St
RS185	2015121303	−4.057	101.887	1009.9	26.7	90	354	8.8	23047	9	St,Cu
RS186	2015121306	−4.057	101.895	1008.9	27.5	82	332	9.8	25358	10	St,As
RS187	2015121309	−4.061	101.897	1005.9	27.1	84	311	12.6	24886	10	St,As
RS188	2015121312	−4.056	101.891	1006.9	28.2	81	322	10.6	22146	10	St,As
RS189	2015121315	−4.063	101.888	1009.0	28.0	79	329	9.0	19845	10	−
RS190	2015121318	−4.055	101.892	1007.7	28.2	73	336	10.3	20525	10	−
RS191	**2015121321**	**−4.059**	**101.894**	**1006.1**	**28.1**	**77**	**324**	**6.2**	**20798**	**10**	**−**
RS192	2015121400	−4.063	101.895	1007.1	28.5	76	312	7.1	23595	9	Cu,Ac,As,St
RS193	2015121403	−4.056	101.895	1009.5	28.7	82	332	4.6	21653	10	Cu,St
RS194	2015121406	−4.046	101.896	1008.6	26.6	83	341	6.3	5829	10	Cu,Ns,As
RS195	2015121409	−4.053	101.892	1006.2	27.5	84	338	2.6	22201	10	St,Cu,As
RS196	2015121412	−4.058	101.894	1007.0	27.2	89	297	1.4	20377	10	St,Ns
RS197	2015121415	−4.043	101.896	1009.0	25.4	92	309	4.2	17791	10	Ns
RS198	2015121418	−4.053	101.883	1009.0	26.3	90	349	8.0	18128	10	−
RS199	2015121421	−4.057	101.880	1007.0	25.5	92	341	10.3	16023	10	−
RS200	2015121500	−4.052	101.885	1007.0	26.7	88	323	12.5	24091	10	Cu,St,As
RS201	2015121503	−4.049	101.900	1008.5	27.1	86	343	10.8	24865	6	Sc,St
RS202	2015121506	−4.045	101.896	1007.9	27.6	82	339	8.6	23698	8	Cu,As,Ac,St
RS203	2015121509	−4.073	101.889	1005.9	28.2	76	295	9.6	22950	10	St,Sc,Cu,As
RS204	2015121512	−4.058	101.895	1007.0	25.8	84	326	6.7	15348	10	St,Ns,As
RS205	2015121515	−4.038	101.924	1009.0	25.6	93	301	7.2	17974	10	Ns
RS206	2015121518	−4.092	101.921	1009.6	24.5	94	256	10.4	5178	10	−

RS207	2015121521	−4.070	101.892	1006.9	27.0	83	297	7.6	20122	10	−
RS208	2015121600	−4.056	101.892	1007.9	26.8	78	274	9.5	21229	10	Cu,As,St
RS209	2015121603	−4.057	101.886	1010.3	25.0	94	310	5.2	4803	10	Ns,St
RS210	2015121606	−4.061	101.903	1009.8	24.1	91	286	6.0	21785	10	Ns
RS211	2015121609	−4.060	101.899	1007.4	25.8	85	311	7.9	22402	10	St,As,Ns
RS212	2015121612	−4.065	101.892	1008.7	25.6	85	322	5.2	18459	10	St,Ns
RS213	2015121615	−4.062	101.889	1010.1	26.2	90	11	7.9	21629	10	−
RS214	2015121618	−4.055	101.902	1009.4	25.9	85	343	8.7	21149	10	−
RS215	2015121621	−4.066	101.894	1007.3	26.3	81	329	5.4	21907	7	−
RS216	2015121700	−4.058	101.891	1007.8	27.4	80	341	3.8	22364	4	Ci,Cs,As,St
RS217	2015121703	−4.061	101.890	1009.3	28.1	73	343	4.2	23883	6	Ac,St,Ci
RS218	2015121706	−4.053	101.896	1008.2	28.2	72	278	1.4	21607	3	Cu,Ci,Ac
RS219	2015121709	−4.060	101.888	1006.3	28.7	72	294	3.5	23317	4	St,Cu,Cb,As,Cs,Ci,Cc
RS220	2015121712	−4.058	101.889	1006.9	28.7	79	257	5.0	23101	1	Cu,Ci,Cs
RS221	2015121715	−4.182	101.909	1009.2	28.4	78	265	4.1	21480	1	Ci
RS222	2015121718	−4.672	101.664	1008.5	28.1	81	287	5.3	23200	3	−
RS223	2015121721	−5.173	101.413	1007.2	28.2	79	303	6.0	24944	2	−
RS224	2015121800	−5.690	101.155	1008.4	26.4	85	278	4.8	23356	9	Cu,Cb,Ns,As,St

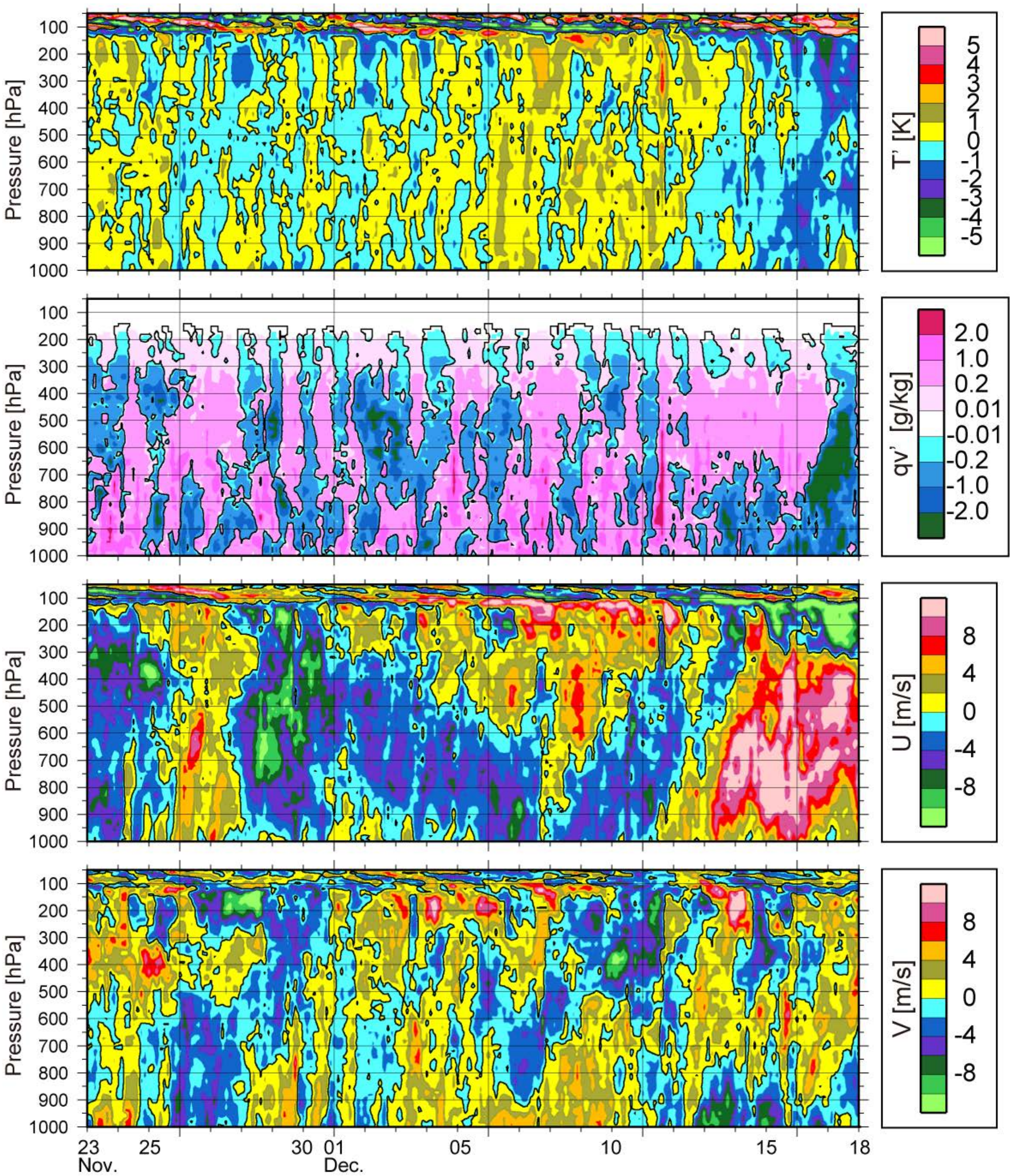

Fig. 5.1-1: Time-height cross sections of observed parameters at the station (4-04S, 101-54E); (a) temperature, in anomaly to the period-averaged value at each pressure level, (b) water vapor mixing ratio, in anomaly to the period-averaged value at each pressure level, (c) zonal wind (absolute value), and (d) meridional wind (absolute value).

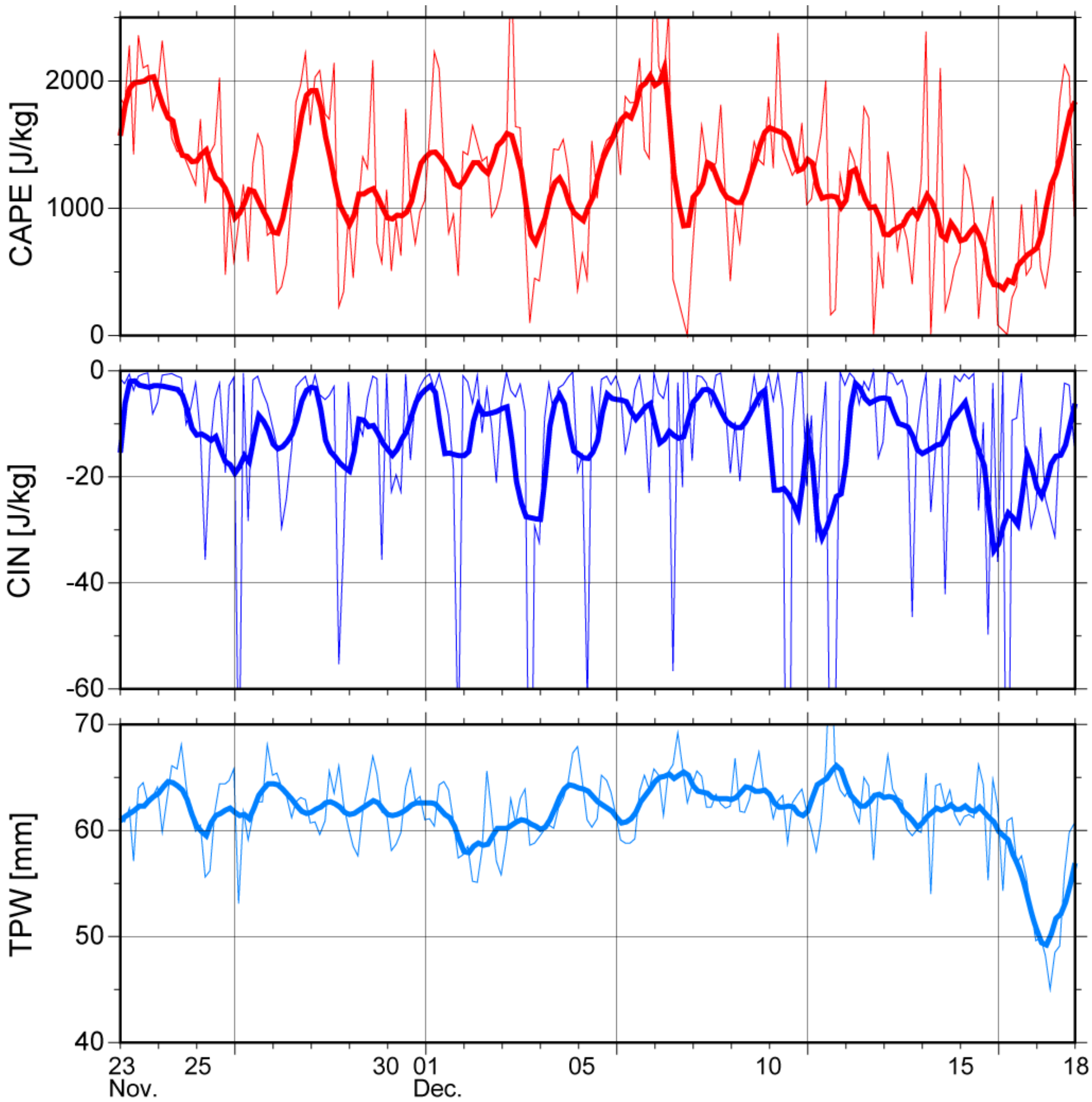

Fig. 5.1-2: Time series of the parameters derived from the radiosonde observations; (a) CAPE, (b) CIN, and (c) precipitable water. The thin lines are from the 3-hourly snapshots, while the thick lines are the running mean for 25 hours.

5.2 GNSS precipitable water

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	- Principal Investigator	
Kazuho YOSHIDA	(GODI)	- Operation Leader	
Souichiro SUEYOSHI	(GODI)		
Shinya OKUMURA	(GODI)		
Miki MORIOKA	(GODI)		
Mikiko FUJITA	(JAMSTEC)		(not on board)
Saji HAMEED	(University of Aizu)		(not on board)

(2) Objective

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

(3) Method

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 radar operation room?. Also we set the simplified GNSS receiver (NV08C-CSM) and antenna (NV2410) at the short distance. The observations were carried out all thru the cruise.

(4) 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 JAMSTEC Marine-Earth Data and Information Department and will be archived there. A List of raw data files is as follows.

Filename	File size
1511040000C.T02	9.0MB
1511050000C.T02	9.6MB
1511060000C.T02	9.9MB
1511070000C.T02	10MB
1511080000C.T02	9.9MB
1511090000C.T02	10MB
1511100000C.T02	10MB
1511110000C.T02	10MB
1511120000C.T02	11MB
1511130000C.T02	11MB
1511140000C.T02	11MB

1511150000C.T02 11MB
1511160000C.T02 11MB
1511170000C.T02 11MB
1511180000C.T02 11MB
1511190000C.T02 11MB
1511200000C.T02 11MB
1511210000C.T02 11MB
1511220000C.T02 11MB
1511230000C.T02 11MB
1511240000C.T02 11MB
1511250000C.T02 11MB
1511260000C.T02 11MB
1511270000C.T02 11MB
1511280000C.T02 11MB
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1512020000C.T02 11MB
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1512040000C.T02 11MB
1512050000C.T02 11MB
1512060000C.T02 11MB
1512070000C.T02 11MB
1512080000C.T02 10MB
1512090000C.T02 11MB
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1512120000C.T02 11MB
1512130000C.T02 11MB
1512140000C.T02 11MB
1512150000C.T02 11MB
1512160000C.T02 11MB
1512170000C.T02 11MB
1512180000C.T02 11MB
nvc08_2015_11_04.bin 1.2GB
nvc08_2015_11_29.bin 966MB

5.3 C-band Weather Radar

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	- Principal Investigator
Biao GENG	(JAMSTEC)	
Tamaki SUEMATSU	(JAMSTEC)	
Shuhei MATSUGISHI	(Univ. Tokyo)	
Atsushi YANASE	(Nagoya Univ.)	
Kunio YONEYAMA	(JAMSTEC)	(not on board)
Kazuaki YASUNAGA	(Toyama Univ.)	(not on board)
Hiroaki MIURA	(Univ. Tokyo)	(not on board)
Kazuho YOSHIDA	(GODI)	- Operation Leader
Souichiro SUEYOSHI	(GODI)	
Shinya OKUMURA	(GODI)	
Miki MORIOKA	(GODI)	
Ryo KIMURA	(MIRAI Crew)	

(2) Objective

The objective of weather radar observations in this cruise is to evaluate the performance of the radar, develop the better strategy of the radar observation, and investigate the structure and evolution of precipitating systems around the Maritime Continent.

(3) Radar specifications

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

Frequency:	5370 MHz (C-band)
Polarimetry:	Horizontal and vertical (simultaneously transmitted and received)
Transmitter:	Solid-state transmitter
Pulse Configuration:	Using pulse-compression
Output Power:	6 kW (H) + 6 kW (V)
Antenna Diameter:	4 meter
Beam Width:	1.0 degrees
Laser Gyro:	PHINS (Ixsea S.A.S.)

(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) Operation 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 laser gyro. The Doppler velocity is also corrected by subtracting the ship movement in beam direction.

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

During the cruise, the radar is operated in four modes, which are shown in Tables 5.3-1, 5.3-2, 5.3-3, and 5.3-4, respectively. Mode 1 is operated usually. Mode 2 and Mode 3 are operated when videosonde observations are conducted in Bengkulu, Indonesia and on board the Mirai, respectively. On the time when the GPM (Global Precipitation Measurement) satellite passes over the Mirai, Mode 4 is operated. A dual PRF mode is used for a volume scan. For a RHI, vertical point, and surveillance PPI scans, a single PRF mode is used.

(6) Obtained Data

The C-band weather radar observations were conducted from Nov. 8 to Dec. 19, 2015. Figure 5.3-1 shows a time series of the areal coverage of radar echoes. The figure illustrate the evolution of precipitation systems in the period when the Mirai remains stationary at (-4.67S, 101.90E). During this period, many precipitating systems have been observed. These precipitation systems developed and evolved in time scales ranging from diurnal to seasonal variations. Detailed analyses of the data observed by the weather radar will be performed after the cruise.

(7) Data archive

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

Table 5.3-1 Parameters for scans in mode 1

	Surveillance PPI Scan	Volume Scan						RHI Scan	Vertical Point Scan
Repeated Cycle (min.)	30	6						12	
Times in One Cycle	1	1						3	3
Pulse Width (long / short, in microsec)	200 / 2	64 / 1		32 / 1		32 / 1		32 / 1	32 / 1
Scan Speed (deg/sec)	36	18		24		36		9	36
PRF(s) (Hz)	400	dual PRF (ray alternative)						1250	2000
		667	833	938	1250	1333	2000		
Pulses / Ray	8	26	33	27	34	37	55	32	64
Ray Spacing (deg.)	0.7	0.7		0.7		1.0		0.2	1.0
Azimuth (deg)	Full Circle							Option	Full Circle
Bin Spacing (m)	150								
Max. Range (km)	300	150		100		60		100	60
Elevation Angle(s) (deg.)	0.5	0.5		1.0, 1.8, 2.6, 3.4, 4.2, 5.1, 6.2, 7.6, 9.7, 12.2, 15.2		18.7, 23.0, 27.9, 33.5, 40.0		0.0~ 60.0	90

Table 5.3-2 Parameters for scans in mode 2

<table>
<tr><th></th><th colspan="6">Volume Scan</th><th>RHI Scan</th></tr>
<tr><td>Repeated Cycle (min.)</td><td colspan="7">6</td></tr>
<tr><td>Times in One Cycle</td><td colspan="6">1</td><td>15</td></tr>
<tr><td>Pulse Width
(long / short, in microsec)</td><td colspan="2">64 / 1</td><td colspan="2">32 / 1</td><td colspan="2">32 / 1</td><td>32 / 1</td></tr>
<tr><td>Scan Speed (deg/sec)</td><td colspan="2">18</td><td colspan="2">24</td><td colspan="2">36</td><td>9</td></tr>
<tr><td rowspan="2">PRF(s)
(Hz)</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>Pulses / Ray</td><td>26</td><td>33</td><td>27</td><td>34</td><td>37</td><td>55</td><td>32</td></tr>
<tr><td>Ray Spacing (deg.)</td><td colspan="2">0.7</td><td colspan="2">0.7</td><td colspan="2">1.0</td><td>0.2</td></tr>
<tr><td>Azimuth (deg)</td><td colspan="6">Full Circle</td><td>Option</td></tr>
<tr><td>Bin Spacing (m)</td><td colspan="7">150</td></tr>
<tr><td>Max. Range (km)</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 colspan="2">0.5</td><td colspan="2">1.8, 3.4,
5.1, 7.6,
12.2,
or
1.0, 2.6,
4.2, 6.2,
9.7, 15.2</td><td colspan="2">18.7, 27.9,
40.0
or
23.0, 33.5</td><td>0.0~
60.0</td></tr>
</table>

Table 5.3-3 Parameters for scans in mode 3

	Surveillance PPI Scan	Volume Scan						Vertical Point Scan
Repeated Cycle (min.)	30	6						
Times in One Cycle	1	1						15
Pulse Width (long / short, in microsec)	200 / 2	64 / 1		32 / 1		32 / 1		32 / 1
Scan Speed (deg/sec)	36	18		24		36		36
PRF(s) (Hz)	400	dual PRF (ray alternative)						2000
		667	833	938	1250	1333	2000	
Pulses / Ray	8	26	33	27	34	37	55	64
Ray Spacing (deg.)	0.7	0.7		0.7		1.0		1.0
Azimuth (deg)	Full Circle							
Bin Spacing (m)	150							
Max. Range (km)	300	150		100		60		60
Elevation Angle(s) (deg.)	0.5	0.5		1.8, 3.4, 5.1, 7.6, 12.2, or 1.0, 2.6, 4.2, 6.2, 9.7, 15.2		18.7, 27.9, 40.0 or 23.0, 33.5		90.0

Table 5.3-2 Parameters for scans in mode 4

	Volume Scan				Vertical Point Scan
Repeated Cycle (min.)	6				
Times in One Cycle	1				24
Pulse Width (long / short, in microsec)	64 / 1		32 / 1		32 / 1
Scan Speed (deg/sec)	18		24		36
PRF(s) (Hz)	dual PRF (ray alternative)				2000
	667	833	938	1250	
Pulses / Ray	26	33	27	34	64
Ray Spacing (deg.)	0.7		0.7		1.0
Azimuth (deg)	Full Circle				
Bin Spacing (m)	150				
Max. Range (km)	150		100		60
Elevation Angle(s) (deg.)	0.5		1.8, 3.4, 5.1		90.0

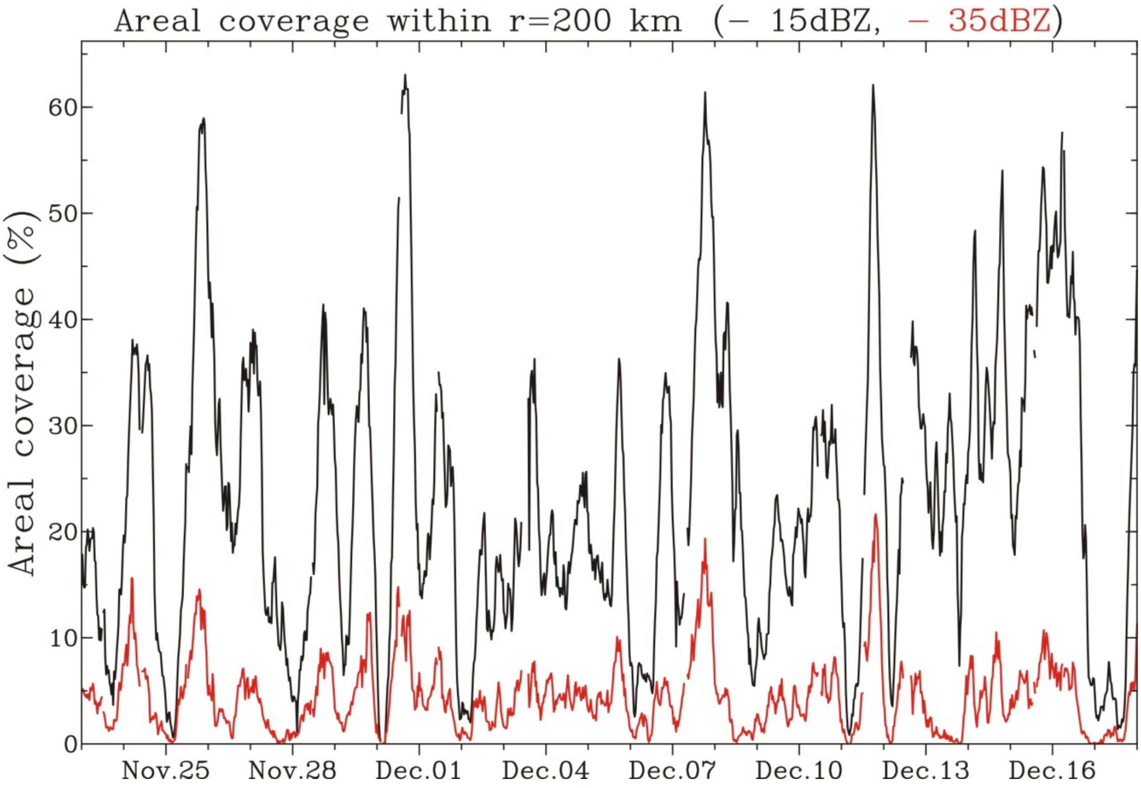

Figure 5.3-1. Time series of the areal coverage of echoes within a radius of 200 km from the radar.

5.4 Ka-band Radar

(1) Personnel

Masaki Katsumata (JAMSTEC)
Yuki Kaneko (JAXA)
Kazuhide Yamamoto (JAXA) (not on board)

(2) Objective

The objective of Ka-band radar observation is to investigate the vertical structure and evolution of precipitating systems in high spatial resolution.

(3) Instrumentation and Methods

Basic specifications of the used radar are as follows:

Frequency	35.25 GHz (Ka-band)
Modulation Principle	FMCW
Minimum Detect Zm	-20 dBZ at 10 km
Minimum Range Resolution	12.5 m
Minimum Time Resolution	10 sec
Niquist Velocity	±10.6 m/s
Observable range	From 500 m to 30 km (Depends on the observation mode)
Antenna beam width	0.6 deg
Antenna sidelobe	< 25 dBZ
Radar Variables	Radar reflectivity and Doppler spectrum

Elevation angle was fixed at vertical through whole cruise. Beam angle should be corrected by rolling/pitching information of R/V Mirai.

(4) Preliminary Results

The Ka-band radar observations were conducted from November 5 to December 20 2015, except for November 25 and 26, because of the malfunction. While the continuous observation, it was stopped a few hours per week when the echo is clear due to the maintenances. Figure 5.4-1 and Fig.5.4-3 shows a time series of the radar reflectivity. Figure 5.4-2 shows a time series of the Doppler velocity. Those figures show the typical evolution of precipitation systems with high spatial resolution and high time resolution. Addition to the precipitation observation, Ka-radar can detect ice cloud. Detailed analyses of the data observed by the Ka radar will be performed after the cruise.

(5) Data Archive

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

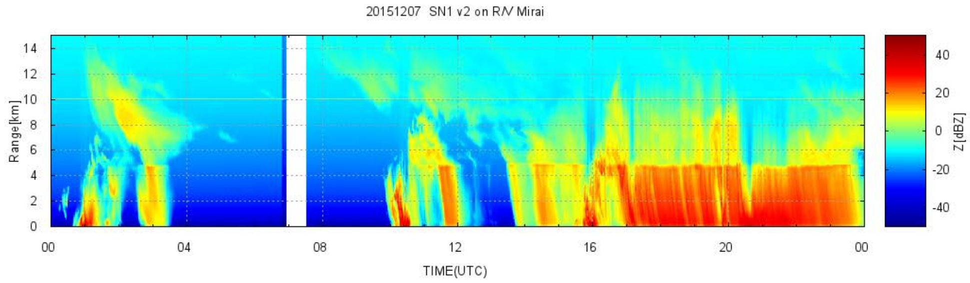

Figure 5.4-1. Time series of the radar reflectivity (dBZ) on December 7.

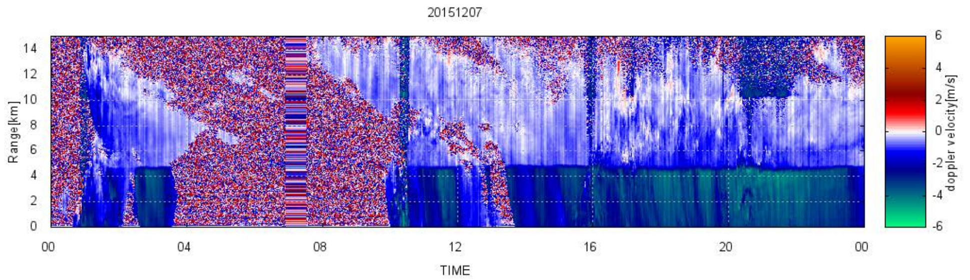

Figure 5.4-2: Time series of the Doppler velocity (m/s, positive means upward)on December 7.

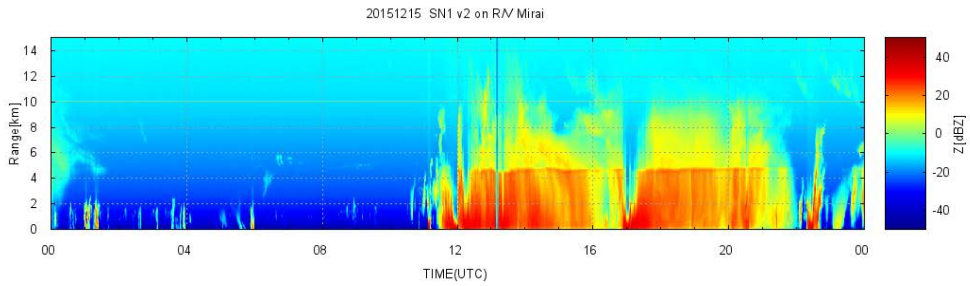

Figure 5.4-3: Time series of the radar reflectivity (dBZ) on December 15.

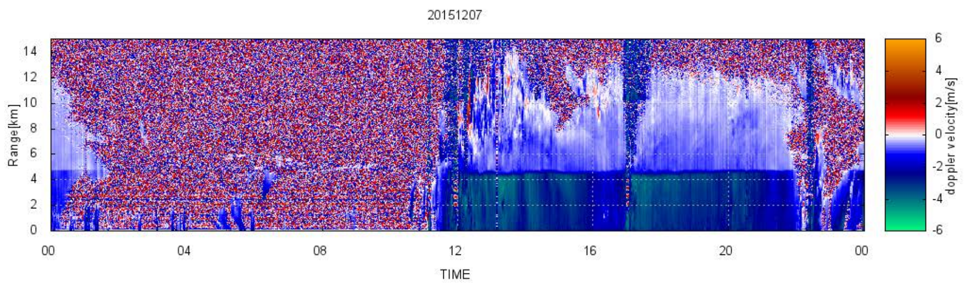

Figure 5.4-4: Time series of the Doppler velocity (m/s, positive means upward) on December 15.

5.5 Micro Rain Radar

(1) Personnel

Masaki KATSUMATA (JAMSTEC) - Principal Investigator
Yuki KANEKO (JAXA)

(2) Objectives

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

(3) Instruments and Methods

The MRR-2 (METEK GmbH) was utilized. The specifications are in Table 5.5-1. The antenna unit was installed at the starboard side of the anti-rolling systems (see Fig. 5.5-1), and wired to the junction box and laptop PC inside the vessel.

The data was averaged and stored every one minute. The vertical profile of each parameter was obtained every 200 meters in range distance (i.e. height) up to 6200 meters, i.e. well beyond the melting layer. The recorded parameters were; Drop size distribution, radar reflectivity, path-integrated attenuation, rain rate, liquid water content and fall velocity.

Fig. 5.5-1: Photo of the antenna unit of MRR

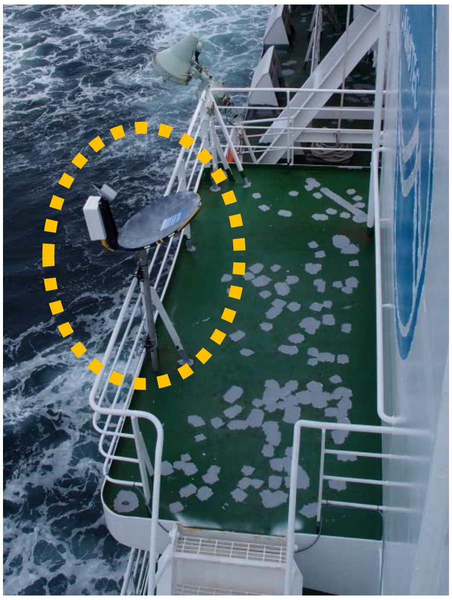

Table 5.5-1: Specifications of the MRR-2.

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

(4) Preliminary Results

Figure 5.5-2 displays an example of the time-height cross section for one day. The temporal variation reasonably corresponds to the rainrall measured by the Mirai Surface Met sensors (see Section 5.8), disdrometers (see Section 5.4), etc. The further analyses will be after the cruise.

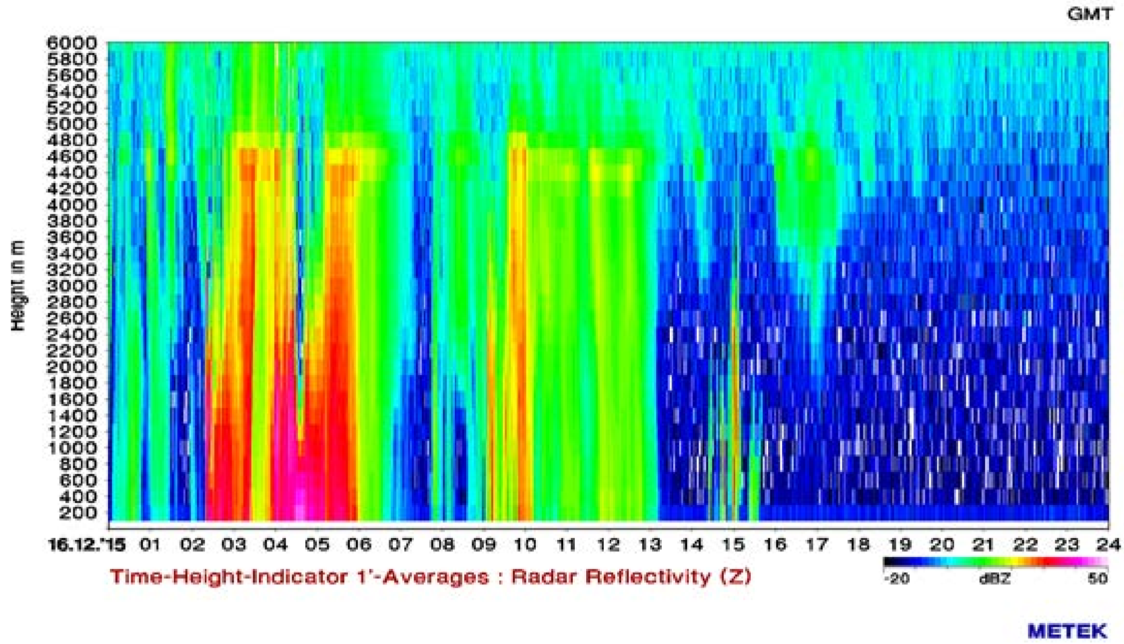

Fig. 5.5-2: An example of the time-height cross section of the radar reflectivity, from 00UTC on Dec. 16 to 00UTC on Dec.17 (24 hours).

(5) Data Archive

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

(6) Acknowledgment

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

5.6 Disdrometers

(1) Personnel

Masaki KATSUMATA (JAMSTEC) - Principal Investigator
Yuki KANEKO (JAXA)

(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 Doppler radar in Section 5.3) to the rainfall amount, and (c) to validate the algorithms and the product of the satellite-borne precipitation radars; TRMM/PR and GPM/DPR.

(3) Methods

Three different types of disdrometers are utilized to obtain better reasonable and accurate value on the moving vessel. All three, and one optical rain gauge, are installed in one place, the starboard side on the roof of the anti-rolling system of R/V Mirai, as in Fig. 5.6-1. The details of the sensors are described below. All the sensors archive data every one minute, except Parsivel for every 10 seconds.

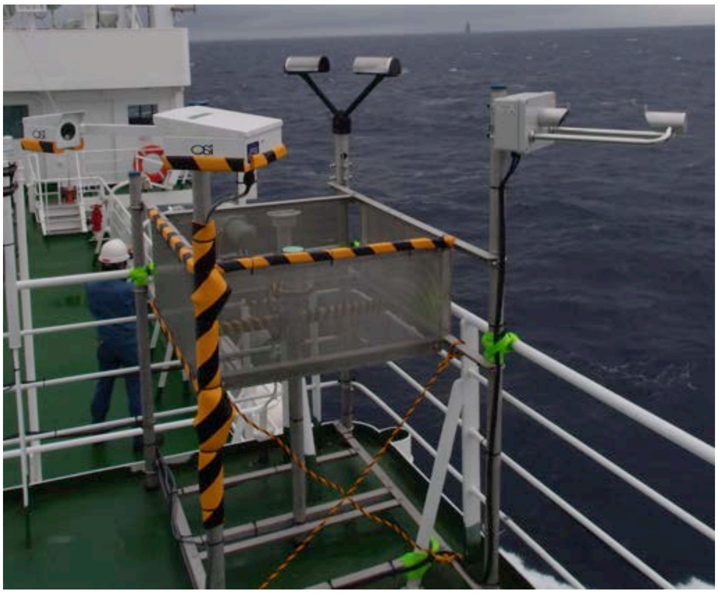

Fig. 5.6-1: The disdrometers, installed on the roof of the anti-rolling tank.

(3-1) Joss-Waldvogel type disdrometer

The "Joss-Waldvogel-type" disdrometer system (RD-80, Disdromet Inc.) (hereafter JW) equipped a microphone on the top of the sensor unit. When a raindrop hit the microphone, the magnitude of induced sound is converted to the size of raindrops. The logging program "DISDRODATA" determines the size as one of the 20 categories as in Table 5.6-1, and accumulates the number of raindrops at each category. The rainfall amount could be also retrieved from the obtained drop size distribution. The number of raindrops in each category, and converted rainfall amount, are recorded every one minute.

(3-2) Laser Precipitation Monitor (LPM) optical disdrometer

The “Laser Precipitation Monitor (LPM)” (Adolf Thies GmbH & Co) 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 number of particles are categorized by the detected size and fall speed and counted every minutes. The categories are shown in Table 5.6-2.

(3-3) “Parsivel” optical disdrometer

The “Parsivel” (Adolf Thies GmbH & Co) is another optical disdrometer. The principle is same as the LPM. The sampling volume, i.e. the size of the laser beam “sheet”, is 30 mm (W) x 180 mm (D). The categories are shown in Table 5.6-3.

(3-4) Optical rain gauge

The optical rain gauge, which detect scintillation of the laser by falling raindrops, is installed beside the above three disdrometers to measure the exact rainfall. The ORG-815DR (Optical Scientific Inc.) is utilized with the controlling and recording software (manufactured by Sankosha Co.).

(4) Preliminary Results

An example of the obtained data is shown in Fig. 5.6-1. The further analyses for the rainfall amount, drop-size-distribution parameters, etc., will be carried out after the cruise.

(5) Data Archive

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

(6) Acknowledgment

The optical rain gauge is kindly provided by National Institute for Information and Communication Technology (NICT). The operations are supported by Japan Aerospace Exploration Agency (JAXA) Precipitation Measurement Mission (PMM).

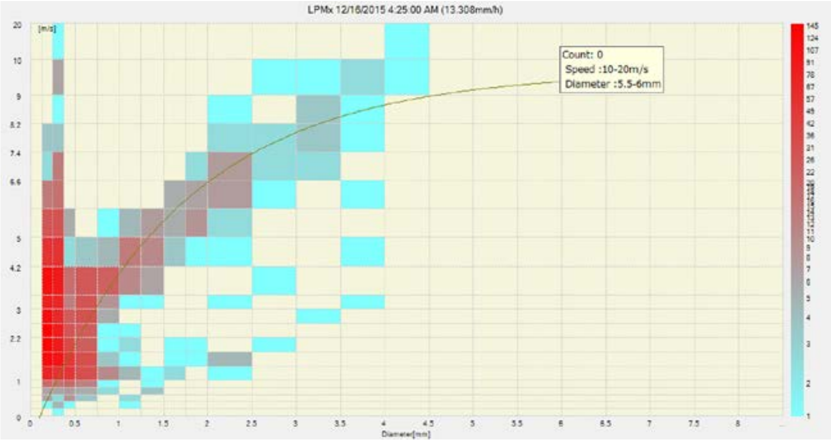

Fig. 5.6-1: An example of 1-minute data, obtained by LPM at 0425UTC on Dec.16, 2015. Data is shown by two-dimensional histogram to display numbers of observed raindrops categorized by diameter and fall speed.

Table 5.6-1: Category number and corresponding size of the raindrop for JW disdrometer.

Category	Corresponding size range [mm]		
1	0.313	-	0.405
2	0.405	-	0.505
3	0.505	-	0.696
4	0.696	-	0.715
5	0.715	-	0.827
6	0.827	-	0.999
7	0.999	-	1.232
8	1.232	-	1.429
9	1.429	-	1.582
10	1.582	-	1.748
11	1.748	-	2.077
12	2.077	-	2.441
13	2.441	-	2.727
14	2.727	-	3.011
15	3.011	-	3.385
16	3.385	-	3.704
17	3.704	-	4.127
18	4.127	-	4.573
19	4.573	-	5.145
20	5.145	or larger	

Table 5.6-2: Categories of the size and the fall speed for LPM.

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

Table 5.6-3: Categories of the size and the fall speed for Parsivel.

Particle Size		
Class	Average Diameter [mm]	Class spread [mm]
1	0.062	0.125
2	0.187	0.125
3	0.312	0.125
4	0.437	0.125
5	0.562	0.125
6	0.687	0.125
7	0.812	0.125
8	0.937	0.125
9	1.062	0.125
10	1.187	0.125
11	1.375	0.250
12	1.625	0.250
13	1.875	0.250
14	2.125	0.250
15	2.375	0.250
16	2.750	0.500
17	3.250	0.500
18	3.750	0.500
19	4.250	0.500
20	4.750	0.500
21	5.500	1.000
22	6.500	1.000
23	7.500	1.000
24	8.500	1.000
25	9.500	1.000
26	11.000	2.000
27	13.000	2.000
28	15.000	2.000
29	17.000	2.000
30	19.000	2.000
31	21.500	3.000
32	24.500	3.000

Fall Speed		
Class	Average Speed [m/s]	Class Spread [m/s]
1	0.050	0.100
2	0.150	0.100
3	0.250	0.100
4	0.350	0.100
5	0.450	0.100
6	0.550	0.100
7	0.650	0.100
8	0.750	0.100
9	0.850	0.100
10	0.950	0.100
11	1.100	0.200
12	1.300	0.200
13	1.500	0.200
14	1.700	0.200
15	1.900	0.200
16	2.200	0.400
17	2.600	0.400
18	3.000	0.400
19	3.400	0.400
20	3.800	0.400
21	4.400	0.800
22	5.200	0.800
23	6.000	0.800
24	6.800	0.800
25	7.600	0.800
26	8.800	1.600
27	10.400	1.600
28	12.000	1.600
29	13.600	1.600
30	15.200	1.600
31	17.600	3.200
32	20.800	3.200

5.7 Videosonde

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	- Principal Investigator
Biao GENG	(JAMSTEC)	
Kyoko TANIGUCHI	(JAMSTEC)	
Qoosaku MOTEKI	(JAMSTEC)	
Tamaki SUEMATSU	(JAMSTEC)	
Shuhei MATSUGISHI	(Univ. Tokyo)	
Atsushi YANASE	(Nagoya Univ.)	
Kunio YONEYAMA	(JAMSTEC)	(not on board)
Kenji SUZUKI	(Yamaguchi Univ.)	(not on board)
Kazuho YOSHIDA	(GODI)	
Souichiro SUEYOSHI	(GODI)	
Shinya OKUMURA	(GODI)	
Miki MORIOKA	(GODI)	
Ryo KIMURA	(MIRAI Crew)	

(2) Objective

The objective of videosonde observations is to investigate microphysical processes of cloud and precipitation systems developed around the Maritime Continent.

(3) Method

Videosonde is a balloon-borne sounding system which takes images of precipitation particles. The videosonde system consists of a CCD camera, a video amplifier, an infrared sensor, a transmitter, and a control circuit. It also has a stroboscopic illumination, which illustrates the size and shape of precipitation particles. Images of precipitation particles are transmitted by the 1680 MHz carrier wave to a receiving system on board the R/V Mirai. The receiving system displays and records the images of precipitation particles. Each videosonde is launched together with a Meisei RS-06G radiosonde.

(4) Obtained Data

Five videosondes were launched on board the R/V Mirai during the cruise (Table 5.7-1). Examples of the obtained images of precipitation particles are shown in Figure 5.7-1. Different distributions of precipitation particles were found. The temporal and spatial distribution of precipitation particles will be analyzed in the future.

(5) Data Archive

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

Table 5.7-1. List of videosondes launched during the cruise

Videosonde #	Date	Time (UTC)	Remarks of precipitation system
1	Nov. 28, 2015	1748	Linear convective system Nearby lighting and thunder Echo top around 12 km
2	Dec. 03, 2015	1406	Linear convective system Nearby lighting and thunder Echo top around 12 km
3	Dec. 07, 2015	0118	Cumulonimbus (w/ waterspout) Echo top around 13 km
4	Dec. 14, 2015	1413	Stratiform precipitation Echo top around 10 km
5	Dec. 15, 2015	1217	Large stratiform precipitating system Echo top around 12 km

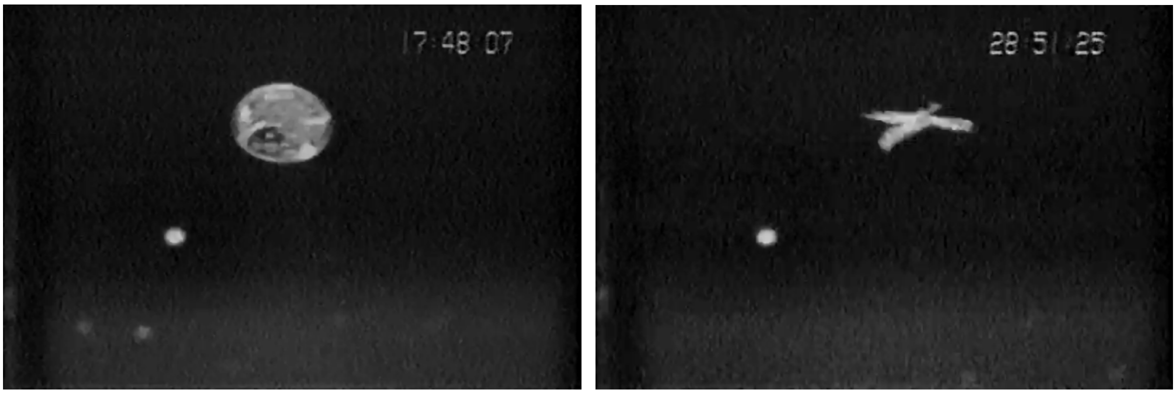

Figure 5.7-1: Example of the images of precipitation particles obtained by the Videosonde, obtained by 5th launch: (left) liquid precipitation, and (right) solid precipitation, respectively. The width of each image corresponds 22 mm.

5.8 Lidar

(1) Personal

Masaki KATSUMATA	(JAMSTEC)	- Principal Investigator
Kyoko TANIGUCHI	(JAMSTEC)	
Ichiro MATSUI	(NIES)	
Tomoaki NISHIZAWA	(NIES)	(not on board)
Atsushi SHIMIZU	(NIES)	(not on board)

(2) Objective

To capture distributions of cloud, aerosol and water vapor in high temporal and special resolutions.

(3) Instrumentation and Methods

During the cruise, additional observation channels were equipped on the lidar observation system on R/V Mirai. The upgraded lidar system now transmits laser in three wavelengths, 1064 nm, 532 nm and 355 nm at 10 Hz. Available observations are Mie channels at 1064 nm, 532 nm, 355 nm, depolarization at 532 nm and 355 nm, Raman water vapor (Raman shift: 3652 cm^{-1}) at 660 nm for 532 nm light source, and Raman nitrogen (Raman shift: 3652 cm^{-1}) at 607 nm and 387 nm for 532 nm and 355 nm light source, respectively. Additionally, near distance 532 nm signals are also observed separately to expand a cover range of the system.

Raman channels have 7.5 m vertical resolution and 1min temporal resolution. The observation in these channels is available only in the nighttime. The rest of the channels have 6 m vertical resolution and 10 s temporal resolution. At 23:56-00:00 UTC each day, the system was paused for calibration.

(4) Preliminary Results

The observation was carried out from Nov.12, 2015 to Dec.19, 2015 (in UTC).

Fig 5.8-1 shows preliminary results of 355 nm, 532 nm and 1064 nm data obtained between 12:00 and 16:00 UTC on 22 November 2015. On each wavelength, a layer of high aerosol known as boundary layer is captured below altitude of 1km layer around noon, then clouds appears on top of the layer. Also, dark bands at 5km altitude around before 13:00 to 14:00 suggest a layer height of the 0 degree C.

Fig 5.8-2 is a preliminary result of Raman channels of 607 nm and 660 nm on the same day. The ratio of 660 nm and 607 nm is a proportional to the water vapor mixing ratio. The nitrogen channel expands the ability of water vapor observation by normalizing the effects of signal reduction due to the observation window conditions, especially after rains.

The all data will be reviewed and quality-controlled after the cruise.

(5) Data Archive

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

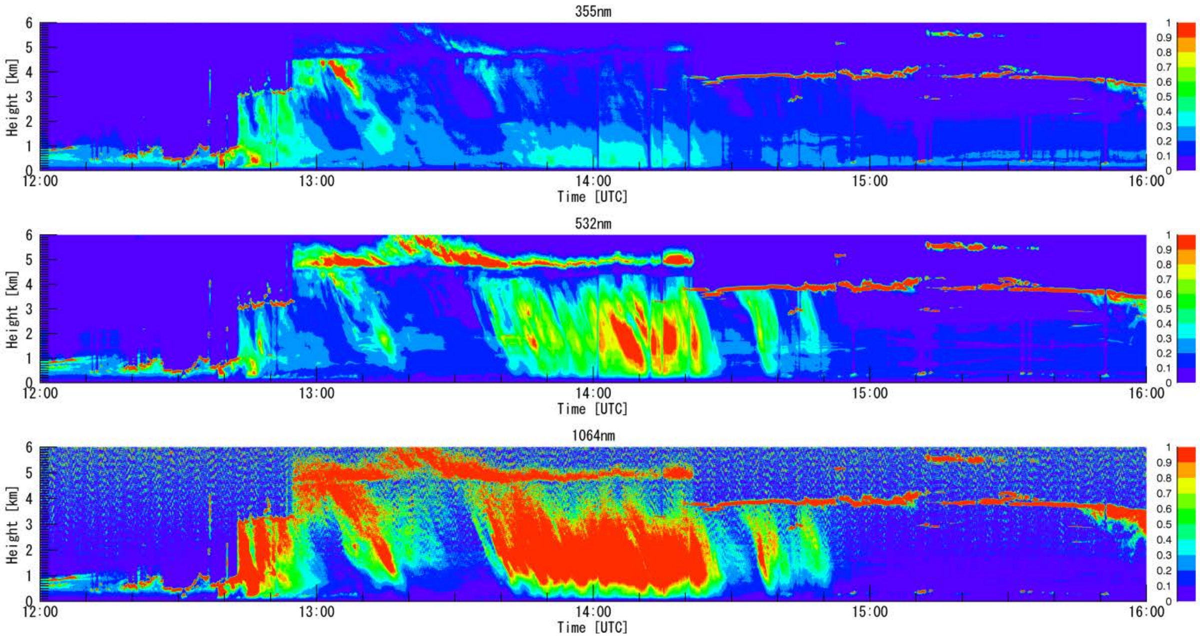

Fig 5.8-1: Preliminary results of 355nm, 532nm and 1064nm data obtained between 12:00 and 16:00 UTC on 22 November 2015.

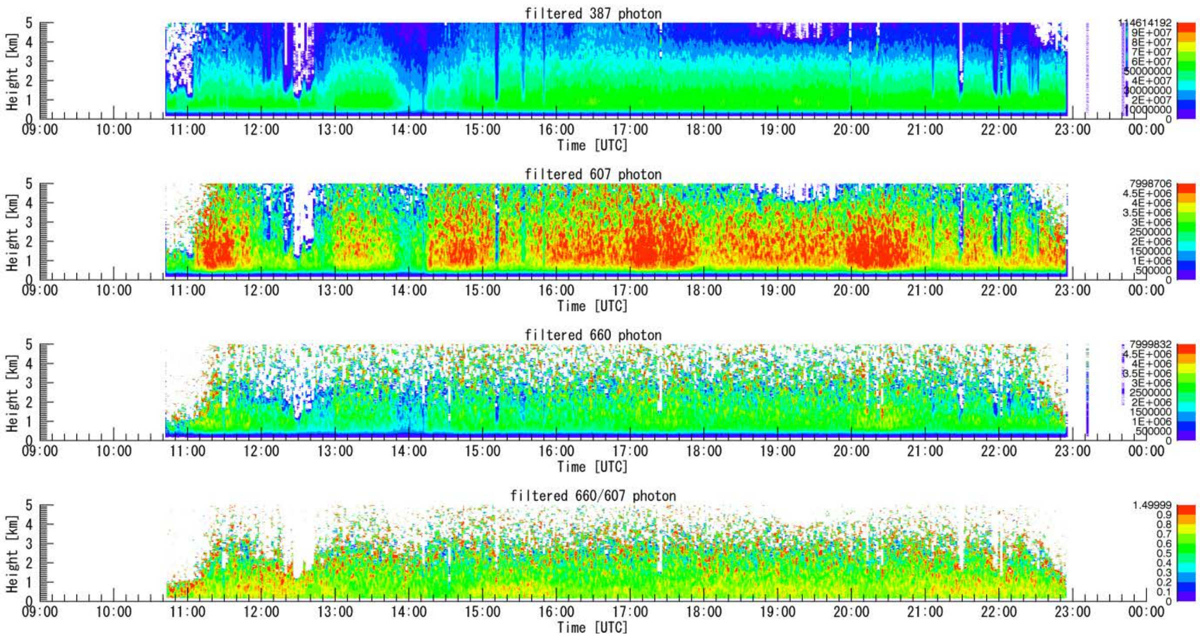

Fig 5.8-2: Preliminary results of 387nm, 607nm, 660nm, and ratio of 660nm and 607nm data obtained nighttime on 22 November 2015.

5.9 Ceilometer

(1) Personnel

Masaki KATSUMATA	(JAMSTEC) - Principal Investigator
Kazuho YOSHIDA	(Global Ocean Development Inc., GODI)
Souichiro SUEYOSHI	(GODI)
Shinya OKUMURA	(GODI)
Miki MORIOKA	(GODI)
Ryo KIMURA	(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) Instruments and Methods

We measured cloud base height and backscatter profile using ceilometer (CL51, VAISALA, Finland) throughout the MR15-04 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).

Obtained Parameters are as follows:

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

(4) Preliminary results

Fig.5.9-1 shows the time series plot of the lowest, second and third cloud base height during the cruise.

(5) Data archive

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

(6) Remarks

1) The following period, data acquisition was suspended in Philippine EEZ.
   16:32UTC 13 Nov. 2015 - 02:48UTC 15 Nov. 2015

2) Window Cleaning
   00:05UTC 05 Nov. 2015
   04:18UTC 11 Nov. 2015
   05:04UTC 19 Nov. 2015
   03:47UTC 03 Dec. 2015
   06:37UTC 10 Dec. 2015
   00:21UTC 19 Dec. 2015

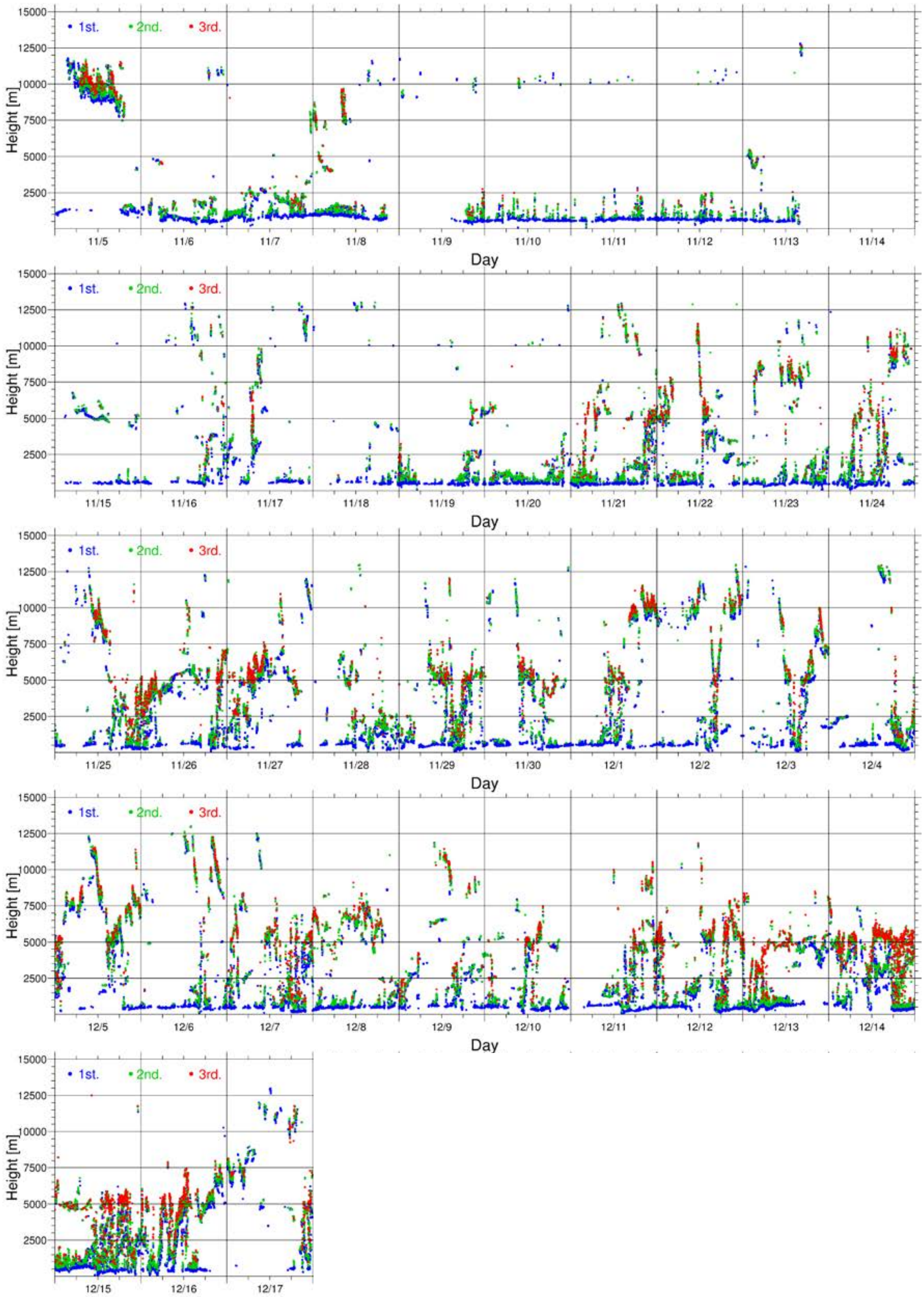

Fig. 5.9-1: First (Blue), 2nd (Green) and 3rd (Red) lowest cloud base height during the cruise.

5.10. Aerosol optical characteristics measured by Ship-borne Sky radiometer

(1) Personnel

Kazuma Aoki (University of Toyama) - Principal Investigator (not on board)
Tadahiro Hayasaka (Tohoku University) - Co-Investigator (not onboard)
(Sky radiometer operation was supported by Global Ocean Development Inc.)

(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 MKII: PREDE Co. Ltd., Japan). Furthermore, collections of the data for calibration and validation to the remote sensing data were performed simultaneously.

(3) Methods and Instruments

The sky radiometer measures the direct solar irradiance and the solar aureole radiance distribution with seven interference filters (0.34, 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.

@ Measured parameters

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

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

(4) Preliminary results

Only data collection were performed onboard. At the time of writing, the data obtained in this cruise are under post-cruise processing at University of Toyama.

(5) Data archives

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

5.11 Aerosol and gas observations

(1) Personnel

Yugo KANAYA (JAMSTEC DEGCR, not on board)
Fumikazu TAKETANI (JAMSTEC DEGCR, not on board)
Takuma MIYAKAWA (JAMSTEC DEGCR, not on board)
Hisahiro TAKASHIMA (JAMSTEC DEGCR, not on board)
Yuichi KOMAZAKI (JAMSTEC DEGCR, not on board)
Hitoshi MATSUI (JAMSTEC DEGCR, not on board)
Kazuhiko MATSUMOTO (JAMSTEC DEGCR, not on board)
Operation was supported by Global Ocean Development Inc.

(2) Objectives

Objectives of the observations are to investigate roles of atmospheric aerosols and gases, including black carbon and ozone, in the marine atmosphere in relation to climate change, and to investigate processes of biogeochemical cycles between the atmosphere and the ocean.

(3) Methods and Instruments

The observed parameters are

- Black carbon (BC) and fluorescent particles
- Aerosol optical depth (AOD) and aerosol extinction coefficient (AEC)
- Surface ozone (O_3), and carbon monoxide (CO) mixing ratios

Aerosol particles were also collected on filters for offline chemical analysis (e.g., water-soluble ions, metal elements etc.).

Online observations black carbon (BC) and fluorescent particles were made by the instruments based on laser-induced incandescence (SP2, Droplet Measurement Technologies) and on flash-lamp-induced fluorescence (WIBS-4A, Droplet Measurement Technologies). Ambient air was continuously sampled from the flying bridge and drawn through a ~3-m-long conductive tube and introduced to the instruments after dried. In WIBS-4A, two pulsed xenon lamps emitting UV light (280 nm and 370 nm) were used for excitation and fluorescence emitted from a single particle within 310–400 nm and 420–650 nm wavelength windows was recorded.

Ambient aerosol particles were collected along cruise track using a high-volume air sampler (HV-525PM, SIBATA) located on the flying bridge operated at a flow rate of 500 L min^{-1}. To avoid collecting particles emitted from the funnel of the own vessel, the sampling period was controlled automatically by using a “wind-direction selection system”. Coarse and fine particles separated at the diameter of 2.5 μm were collected. The filter samples obtained during the cruise are subject to chemical analysis of aerosol composition, including water-soluble ions and trace metals.

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 multiple elevation angles, 1.5, 3, 5, 10, 20, 30, 90 degrees, were scanned repeatedly (every ~15-min) using a movable prism. For the selected spectra recorded with elevation angles with good accuracy, DOAS spectral fitting was performed to quantify the slant column density (SCD) of NO_2 (and other gases) and O_4 (O_2-O_2, collision complex of oxygen) for each elevation angle. Then, the O_4 SCDs were converted to the aerosol optical depth (AOD) and the vertical profile of aerosol extinction coefficient (AEC) using an optimal estimation inversion method with a radiative transfer model. Using derived aerosol information, retrievals of the tropospheric vertical column/profile of NO_2 and other gases were made.

For ozone and CO measurements, ambient air was continuously sampled on the compass deck and drawn through ~20-m-long Teflon tubes connected to a gas filter correlation CO analyzer (Model 48C, Thermo Fisher Scientific) and a UV photometric ozone analyzer (Model 49C, Thermo Fisher Scientific), located in the Research Information Center. The data will be used for characterizing air mass origins.

(4) Preliminary results

N/A (Data analysis is to be conducted.)

(5) Data archives

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

5.12 Greenhouse gas observations

(1) Personnel

Kei SHIOMI (JAXA)
Shuji KAWAKAMI (JAXA)

(2) Objective

Greenhouse gases Observing SATellite (GOSAT) was launched on 23 January 2009 in order to observe the global distributions of atmospheric greenhouse gas concentrations: column-averaged dry-air mole fractions of carbon dioxide (CO_2) and methane (CH_4). A network of ground-based high-resolution Fourier transform spectrometers provides essential validation data for GOSAT. Vertical CO_2 profiles obtained during ascents and descents of commercial airliners equipped with the in-situ CO_2 measuring instrument are also used for the GOSAT validation. Because such validation data are obtained mainly over land, there are very few data available for the validation of the over-sea GOSAT products. The objectives of our research are to acquire the validation data over the Indian Ocean and the tropical Pacific Ocean using an automated compact instrument, to compare the acquired data with the over-sea GOSAT products, and to develop a simple estimation of the carbon flux between the ocean and the atmosphere from GOSAT data.

(3) Instrumentation

The column-averaged dry-air mole fractions of CO_2 and CH_4 can be estimated from absorption by atmospheric CO_2 and CH_4 that is observed in a solar spectrum. An optical spectrum analyzer (OSA, Yokogawa M&I co., AQ6370) was used for measuring the solar absorption spectra in the near-infrared spectral region. A solar tracker (PREDE co., ltd.) and a small telescope (Figure 1) collected the sunlight into the optical fiber that was connected to the OSA. The solar tracker searches the sun every one minute until the sunlight with a defined intensity. The measurements of the solar spectra were performed during solar zenith angles less than 80°.

Figure 1. Solar tracker and telescope. The sunlight collected into optical fiber was introduced into the OSA that was installed in an observation room in the MIRAI.

(4) Analysis method

The CO_2 absorption spectrum at the 1.6 μm band measured with the OSA is shown in Figure 2. The absorption spectrum can be simulated based on radiative transfer theory using assumed atmospheric profiles of pressure, temperature, and trace gas concentrations. The column abundance of CO_2 (CH_4) was retrieved by adjusting the assumed CO_2 (CH_4) profile to minimize the differences between the measured and simulated spectra. Figure 3 shows an example of spectral fit performed for the spectral region with the CO_2 absorption lines. The column-averaged dry-air mole fraction of CO_2 (CH_4) was obtained by taking the ratio of the CO_2 (CH_4) column to the dry-air column.

(5) Preliminary results

The observations were made from November 5 to December 17, 2015 continuously in daytime (Table 1 and Figure 2), except in Philippine EEZ and Indonesian EEZ before permitted

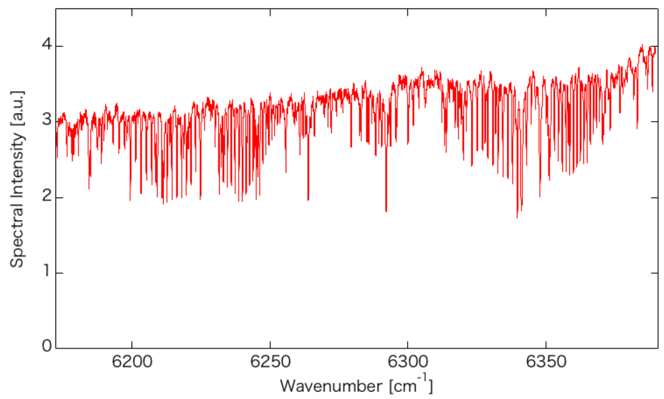

Figure 2. 1.6 µm CO_2 absorption spectrum measured with the OSA.

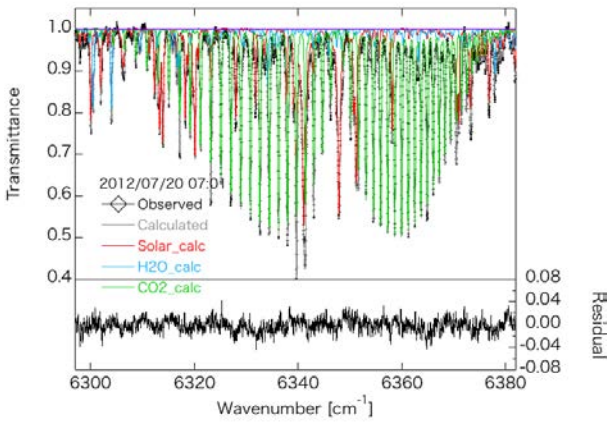

Figure 3. Spectral fit performed for the 6297–6382 cm^{-1} region using an OSA spectrum. Open diamonds denote the measured spectrum, and the solid line denotes the spectrum calculated from the retrieval result. The residual between the measured and calculated spectra is also shown.

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CO_2 observations		
Date	Start Time(JST)	End Time(JST)
2015/11/05	07:15	15:10
2015/11/06	07:33	14:49
2015/11/07	07:06	14:54
2015/11/08	08:00	15:17
2015/11/09	06:55	16:41
2015/11/10	06:55	14:57
2015/11/11	06:57	16:45
2015/11/12	07:01	16:50
2015/11/13	06:59	17:28
2015/11/15	11:59	16:45
2015/11/16	07:24	18:08
2015/11/21	11:17	15:24
2015/11/22	12:11	18:38
2015/11/23	09:38	18:15
2015/11/24	09:30	12:54
2015/11/25	08:42	19:24
2015/11/25	08:42	19:24
2015/11/27	12:35	13:16
2015/11/28	08:38	17:29
2015/11/29	11:31	17:38
2015/11/30	09:38	17:41
2015/12/01	08:45	18:43
2015/12/02	12:49	15:58
2015/12/03	08:41	17:49
2015/12/04	08:59	19:11
2015/12/05	15:50	18:11
2015/12/06	09:54	19:26
2015/12/07	08:41	16:54
2015/12/08	12:06	18:20
2015/12/09	09:15	19:12
2015/12/10	08:55	18:17
2015/12/11	08:43	19:14
2015/12/12	11:20	18:04
2015/12/13	09:19	16:48
2015/12/14	18:13	18:56
2015/12/15	10:30	18:59
2015/12/17	08:46	19:28

Table 1. Period of CO_2 observations

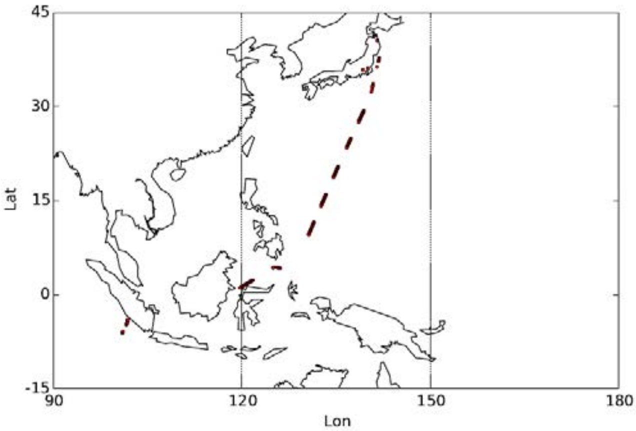

Figure 2. Locations of CO_2 observations

(6) Data archive

The column-averaged dry-air mole fractions of CO_2 and CH_4 retrieved from the OSA spectra will be submitted to the JAMSTEC Data Management Group (DMG).

5.13 Surface Meteorological Observations

(1) Personnel

Masaki KATSUMATA (JAMSTEC) - Principal Investigator
Kazuho YOSHIDA (Global Ocean Development Inc., GODI) - Operation Leader
Souichro SUEYOSHI (GODI)
Shinya OKUMURA (GODI)
Miki MORIOKA (GODI)
Ryo KIMURA (Mirai Crew)

(2) Objectives

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

(3) Methods

Surface meteorological parameters were observed throughout the MR15-04 cruise. During this cruise, we used two systems for the observation.

i. MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table 5.13-1 and measured parameters are listed in Table 5.13-2. 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) Portable Radiation Package (PRP) designed by BNL – short and long wave downward radiation.
b) Analog meteorological data sampling with CR1000 logger manufactured by Campbell Inc. Canada – wind pressure, and rainfall (by a capacitive rain gauge) measurement.
c) Digital meteorological data sampling from individual sensors - air temperature, relative humidity and rainfall (by optical rain gauge (ORG)) measurement.
d) “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 PRP, air temperature and relative humidity, CR1000 and ORG 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 5.13-3 and measured parameters are listed in Table 5.13-4.

SeaSnake has two thermistor probes and output voltage was converted to SSST by Steinhart-Hart equation with the following coefficients led from the calibration data.

Sensor	a	b	c
T04-005 Sensor:	7.48919E-04	-2.19375E-04	-5.33227E-08
T04-100 Sensor:	8.83640E-04	-2.02001E-04	-9.58779E-08

$$y = a + b * x + c * x^3$$
$$x = \log (1 / ((Vref / V - 1) * R2 - R1))$$
$$T = 1 / y - 273.15$$

Vref = 2500[mV], R1=249000[Ω], R2=1000[Ω]
T: Temperature [degC], V: Sensor output voltage [mV]

For the quality control as post processing, we 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, PTB220, 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 probe was calibrated by the bath equipped with SBE-3 plus, Sea-Bird Electronics, Inc.

(4) Preliminary results

Figure 5.13-1 shows the time series of the following parameters;

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

Figure 5.13-2 shows the time series of SSST compared to sea surface temperature (TSG).

(5) Data archives

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

(6) Remarks

1. The following period, data acquisition was suspended in the Philippine EEZ.
16:32UTC 13 Nov. 2015 - 02:48UTC 15 Nov. 2015

2. The following periods, SST data was available.
07:45UTC 06 Nov. 2015 - 12:01UTC 13 Nov. 2015
02:49UTC 15 Nov. 2015 - 01:59UTC 19 Dec. 2015

3. The following period, SeaSnake SSST data was available.
   07:28UTC 23 Nov. 2015 - 06:01UTC 17 Dec. 2015

4. The following periods, SSST data were invalid due to maintenance.
   03:03UTC 24 Nov. 2015 - 03:07UTC 24 Nov. 2015
   03:03UTC 25 Nov. 2015 - 03:05UTC 25 Nov. 2015
   02:59UTC 30 Nov. 2015 - 03:01UTC 30 Nov. 2015
   02:58UTC 04 Dec. 2015 - 03:01UTC 24 Dec. 2015
   02:58UTC 05 Dec. 2015 - 03:00UTC 05 Dec. 2015
   02:54UTC 06 Dec. 2015 - 03:00UTC 06 Dec. 2015
   03:04UTC 14 Dec. 2015 - 03:06UTC 14 Dec. 2015

5. The following period, PRP data of SOAR were invalid due to PRP logging error.
   0:34UTC 28 Nov. 2015 - 0:39UTC 28 Nov. 2015
   1:18UTC 13 Dec. 2015 - 3:28UTC 13 Dec. 2015

6. The following time, increasing of SMet capacitive rain gauge data were invalid due to transmitting for MF/HF radio.
   17:46UTC 15 Nov. 2015
   15:25UTC 16 Nov. 2015
   01:03UTC 17 Nov. 2015

7. The following period, significant wave height and period data were not updated due to software error.
   19:35UTC 29 Nov. 2015 - 03:25UTC 30 Nov. 2015

Table 5.13-1: Instruments and installation locations of MIRAI Surface Meteorological observation system

Sensors	Type	Manufacturer	Location (altitude from surface)
Anemometer	KE-500	Koshin Denki, Japan	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland with	
43408 Gill aspirated radiation shield		R.M. Young, USA	compass deck (21 m) starboard side and port side
Thermometer: SST	RFN2-0	Koshin Denki, Japan	4th deck (-1m, inlet -5m)
Barometer	Model-370	Setra System, USA	captain deck (13 m) weather observation room
Rain gauge	50202	R. M. Young, USA	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 5.13-2: Parameters of MIRAI Surface Meteorological observation system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	

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

Table 5.13-3: Instruments and installation locations of SOAR system

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

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

Sensor (PAR&UV)	Type	Manufacturer	Location (altitude from surface)
PAR&UV sensor	PUV-510	Biospherical Instrum-ents Inc., USA	Navigation deck (18m)

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

Table 5.13-4: Parameters of SOAR system

Parameter	Units	Remarks
1 Latitude	degree	
2 Longitude	degree	
3 SOG	knot	
4 COG	degree	
5 Relative wind speed	m/s	
6 Relative wind direction	degree	
7 Barometric pressure	hPa	
8 Air temperature	degC	
9 Relative humidity	%	
10 Rain rate (optical rain gauge)	mm/hr	
11 Precipitation (capacitive rain gauge)	mm	reset at 50 mm
12 Down welling shortwave radiation	W/m2	
13 Down welling infra-red radiation	W/m2	
14 Defuse irradiance	W/m2	
15 “SeaSnake” raw data	mV	
16 SSST (SeaSnake)	degC	
17 PAR	microE/cm2/sec.	
18 UV	microW/cm2/nm	

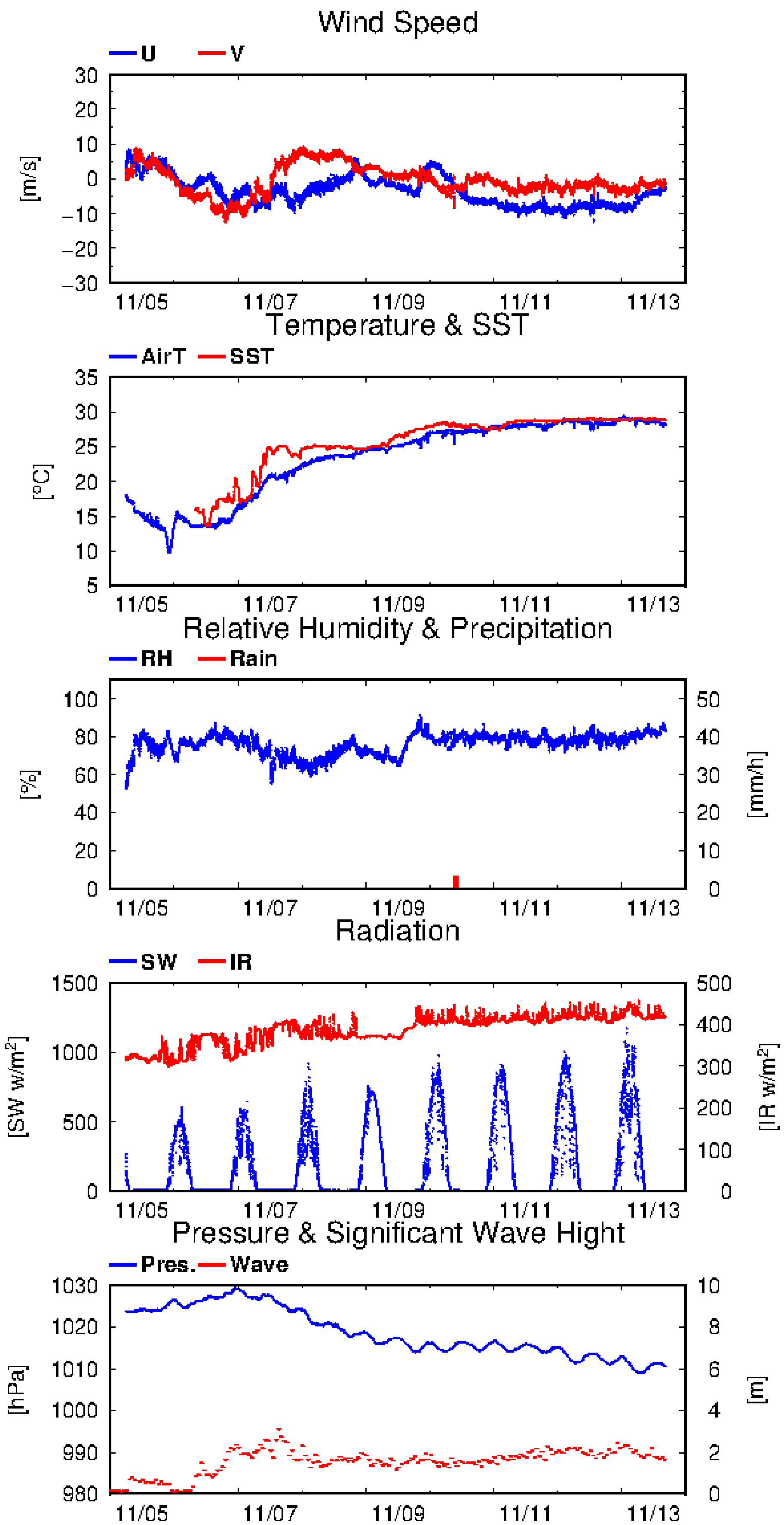

Fig. 5.13-1 Time series of surface meteorological parameters during the cruise

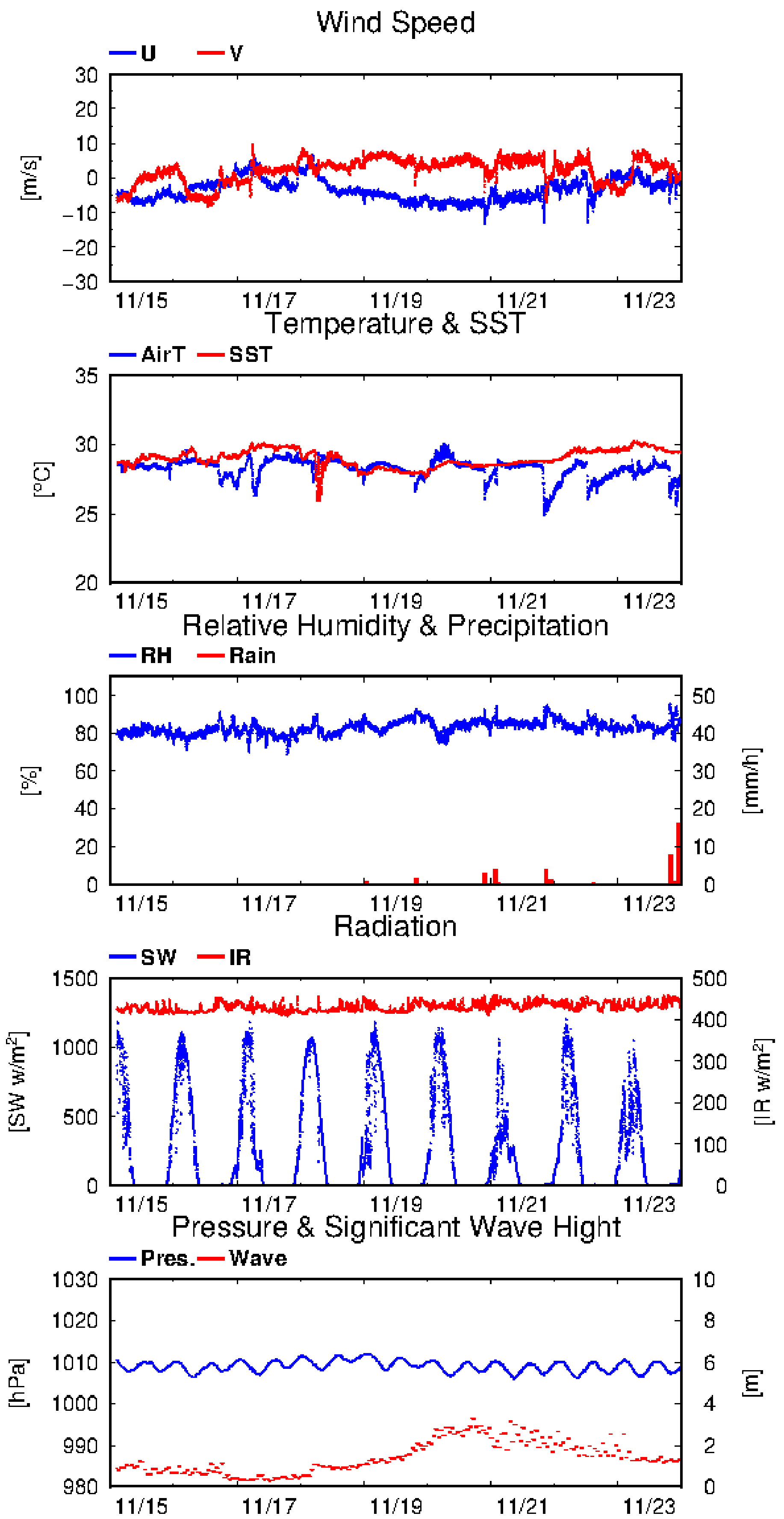

Fig. 5.13-1 (Continued)

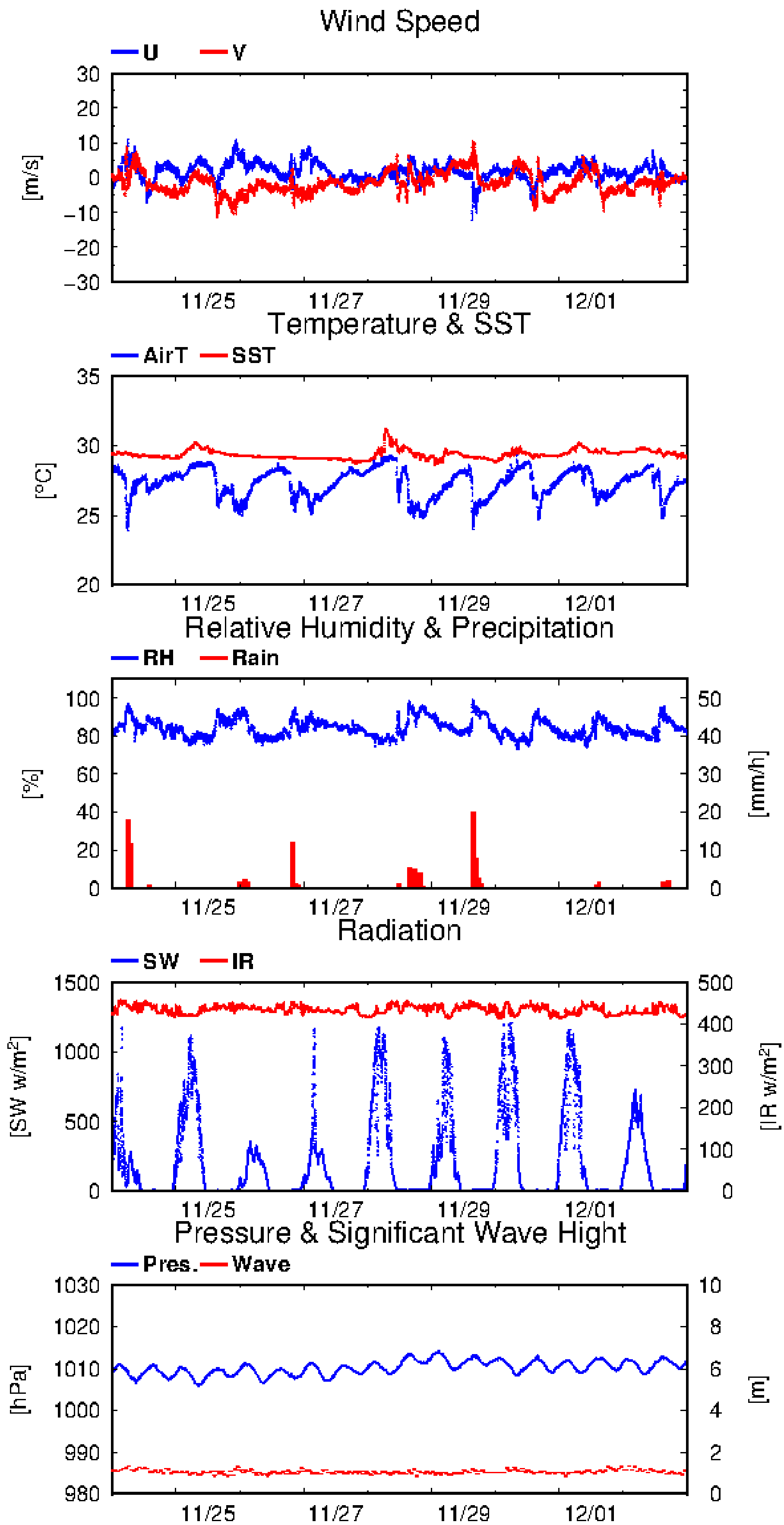

Fig. 5.13-1 (Continued)

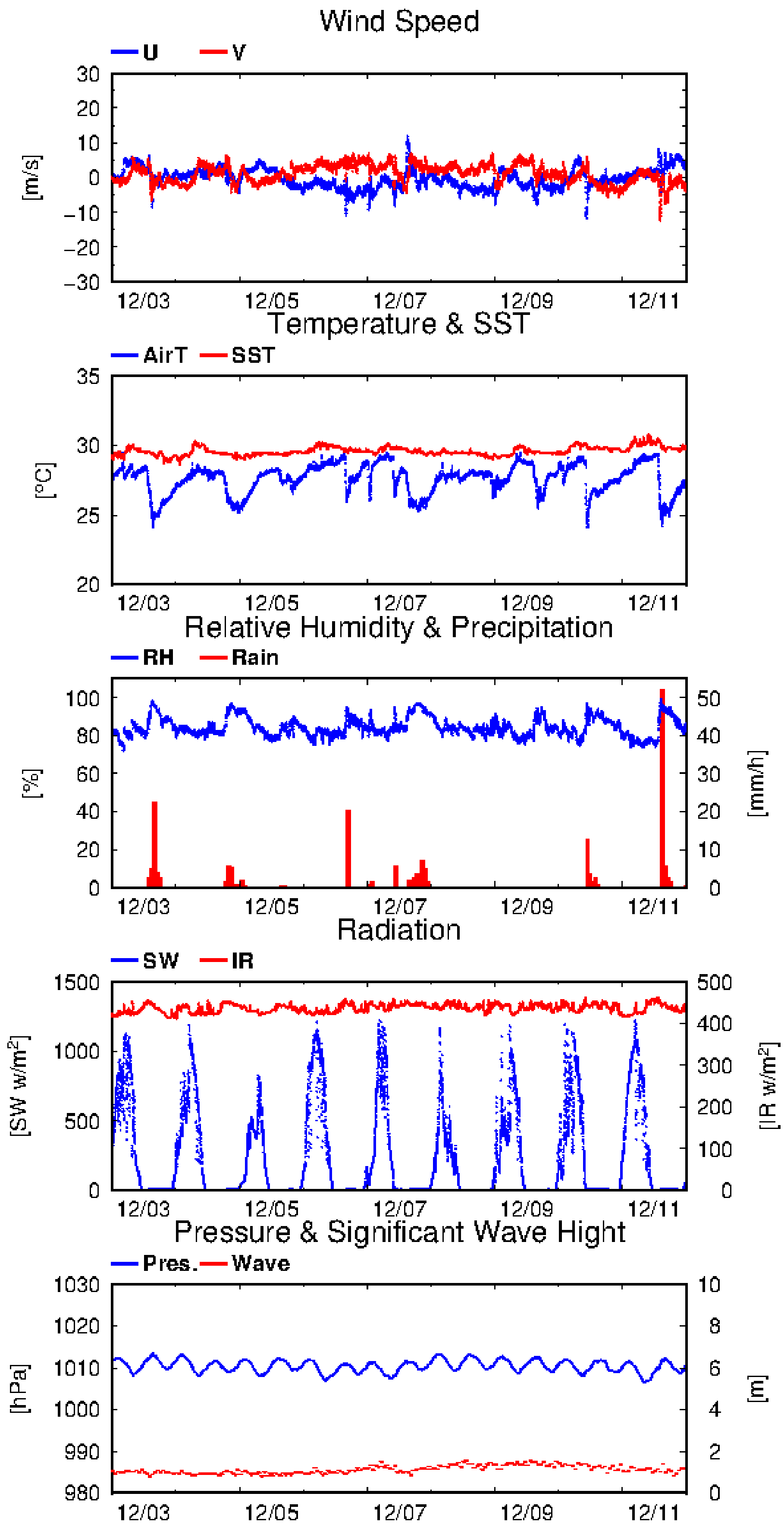

Fig. 5.13-1 (Continued)

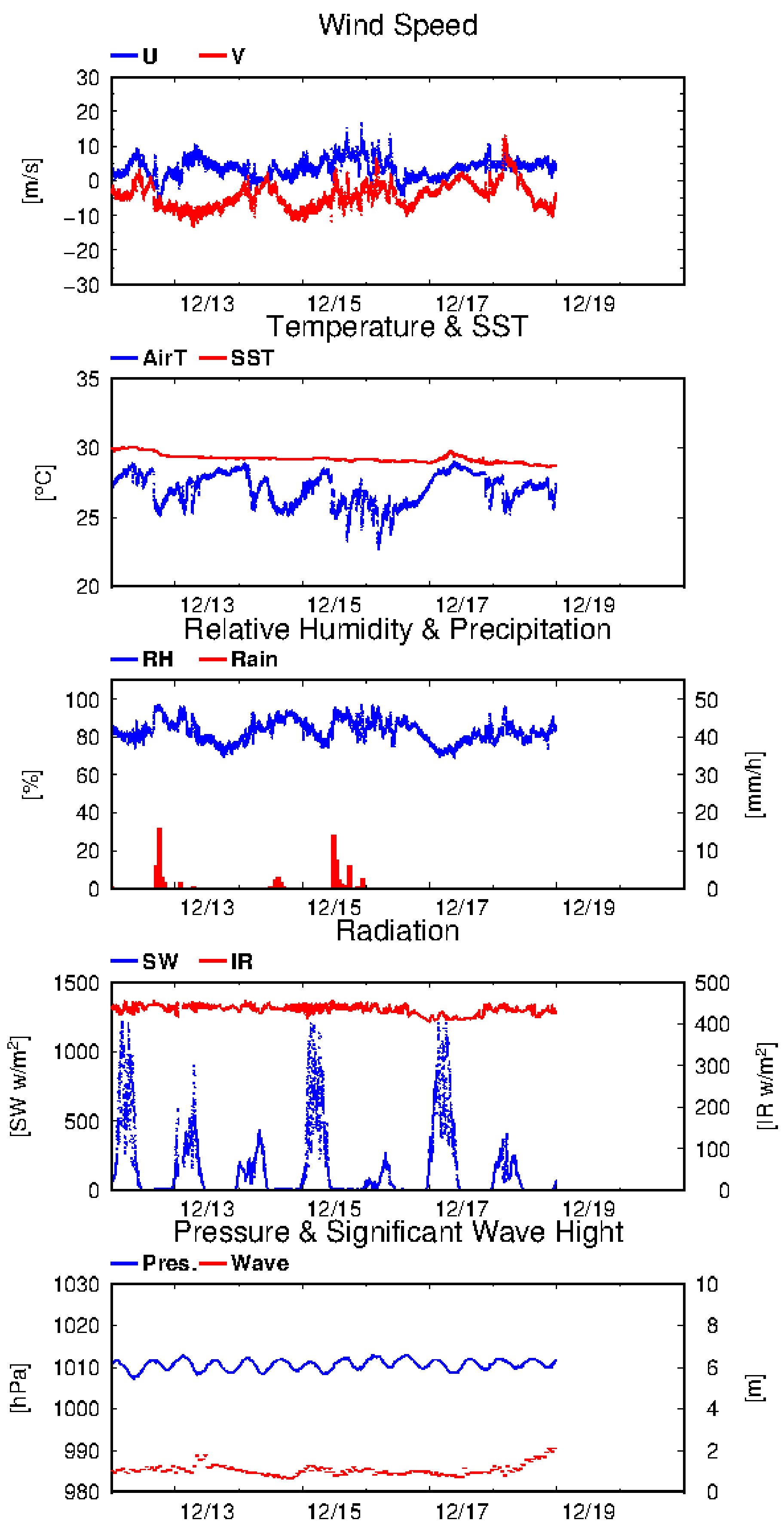

Fig. 5.13-1 (Continued)

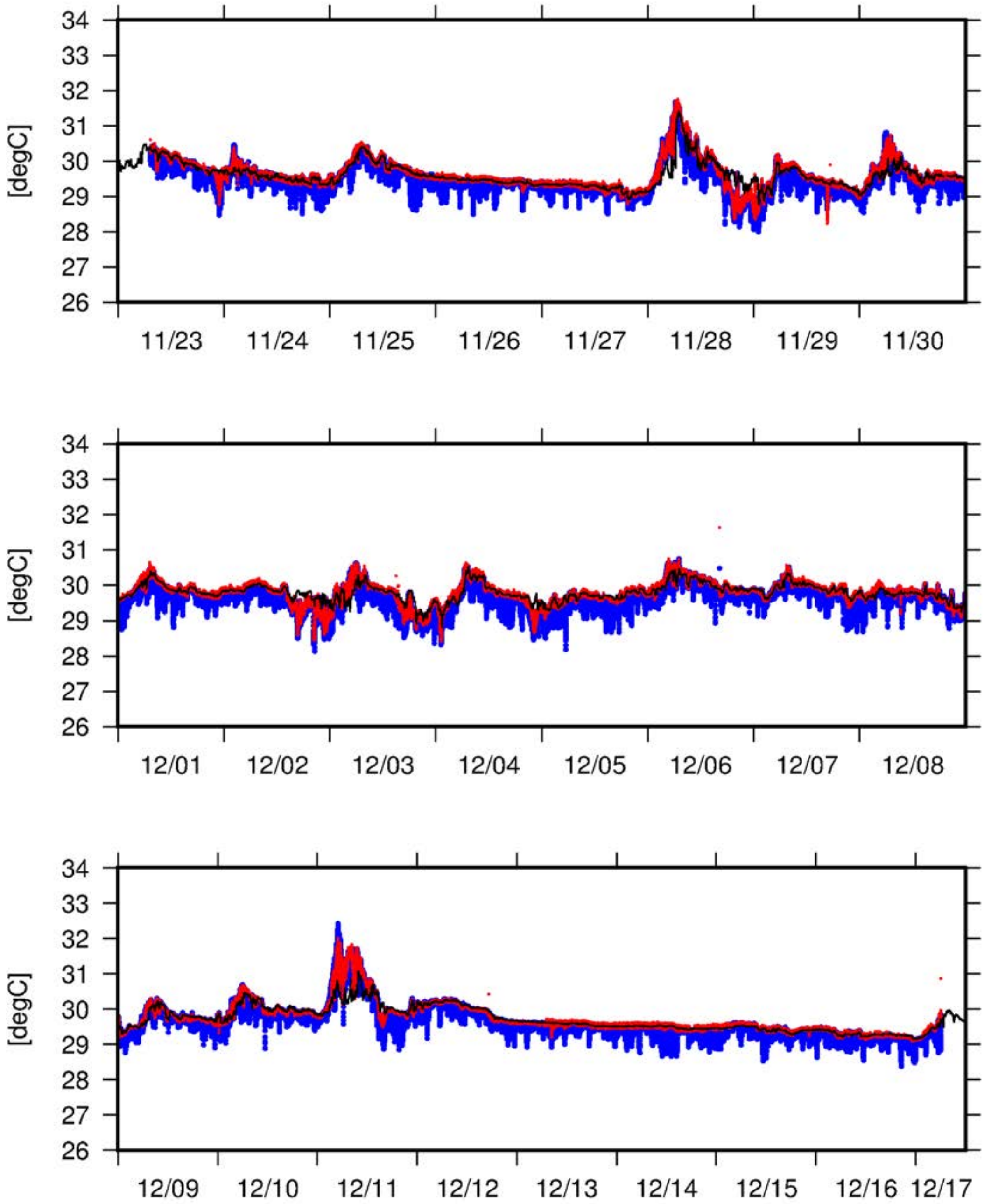

Fig. 5.13-2: Time series of and Skin Sea Surface Temperature (SSST; short(005):Blue, long(100):Red) measured by "SeaSnake", along with the Sea Surface Temperature (measured by TSG, black line) during Stationary observation.

5.14 Continuous monitoring of surface seawater

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	- Principal Investigator
Haruka TAMADA	(Marine Works Japan Co. Ltd)	- Operation Leader
Misato KUWAHARA	(Marine Works Japan Co. Ltd)	

(2) Objective

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

(3) Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co. Ltd.) has five sensors and automatically measures temperature, salinity, dissolved oxygen and fluorescence in near-sea surface water every one minute. This system is located in the "*sea surface monitoring laboratory*" and connected to shipboard LAN-system. Measured data, time, and location of the ship were stored in a data management PC. The near-surface water was continuously pumped up to the laboratory from about 4.5 m water depth and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was adjusted to be 10 dm^3 min^{-1}.

- Software

Seamoni-kun Ver.1.50

- Sensors

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

a) Temperature and Conductivity sensor

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

b) Bottom of ship thermometer

Model: SBE 38, SEA-BIRD ELECTRONICS, INC.

Serial number: 3852788-0457

Measurement range: -5 to +35 ^{o}C

Initial accuracy: ±0.001 ^{o}C

Typical stability (per 6 month): 0.001 ^{o}C

Resolution: 0.00025 ^{o}C

c) Dissolved oxygen sensor

Model: OPTODE 3835, AANDERAA Instruments.

Serial number: 1915

Measuring range: 0 - 500 µmol dm^{-3}

Resolution: < 1 µmol dm^{-3}

Accuracy: < 8 µmol dm^{-3} or 5 % whichever is greater

Settling time: < 25 s

d) Dissolved oxygen sensor

Model: RINKO II, JFE ADVANTECH CO. LTD.

Serial number: 13

Measuring range: 0 - 540 µmol dm^{-3}

Resolution: < 0.1 µmol dm^{-3}
or 0.1 % of reading whichever is greater

Accuracy: < 1 µmol dm^{-3}
or 5 % of reading whichever is greater

e) Fluorescence & Turbidity sensor

Model: C3, TURNER DESIGNS

Serial number: 2300384

Measuring range: Turbidity 0 - 3000 NTU

Minimum Detection Limit: Turbidity 0.05 NTU

(4) Observation log

Periods of measurement, maintenance, and problems during MR15-04 are listed in Table 5.14.

Table 5.14: Events list of the Sea surface water monitoring during MR15-04

System Date [UTC]	System Time [UTC]	Events	Remarks
2015/11/06	08:41	All the measurements started and data was available.	Start observation
2015/11/13	16:33	All the measurements stopped.	Enter to Philippine EEZ
2015/11/15	03:00	All the measurements started.	Observation permitted from Indonesian Security Officer
2015/11/23	19:02	All the measurements stopped.	Maintenance
2015/11/23	19:52	All the measurements started.	Logging restart
2015/11/26	21:34	All the measurements stopped.	Maintenance
2015/11/26	21:40	All the measurements started.	Logging restart
2015/11/30	19:01	All the measurements stopped.	Maintenance
2015/11/30	19:55	All the measurements started.	Logging restart
2015/12/07	19:01	All the measurements stopped.	Maintenance
2015/12/07	19:48	All the measurements started.	Logging restart
2015/12/14	19:02	All the measurements stopped.	Maintenance
2015/12/14	19:49	All the measurements started.	Logging restart
2015/12/19	00:05	All the measurements stopped.	End observation

We took the surface water samples once a day to compare sensor data with bottle data of salinity, dissolved oxygen and chlorophyll *a*. The results are shown in Fig. 5.14-2-1 ~ 5.14-2-3. All the salinity samples were analyzed by the Guideline 8400B “AUTOSAL” (see 5.17), and dissolved oxygen samples were analyzed by Winkler method (see 5.18), chlorophyll *a* were analyzed by 10-AU (see 5.20).

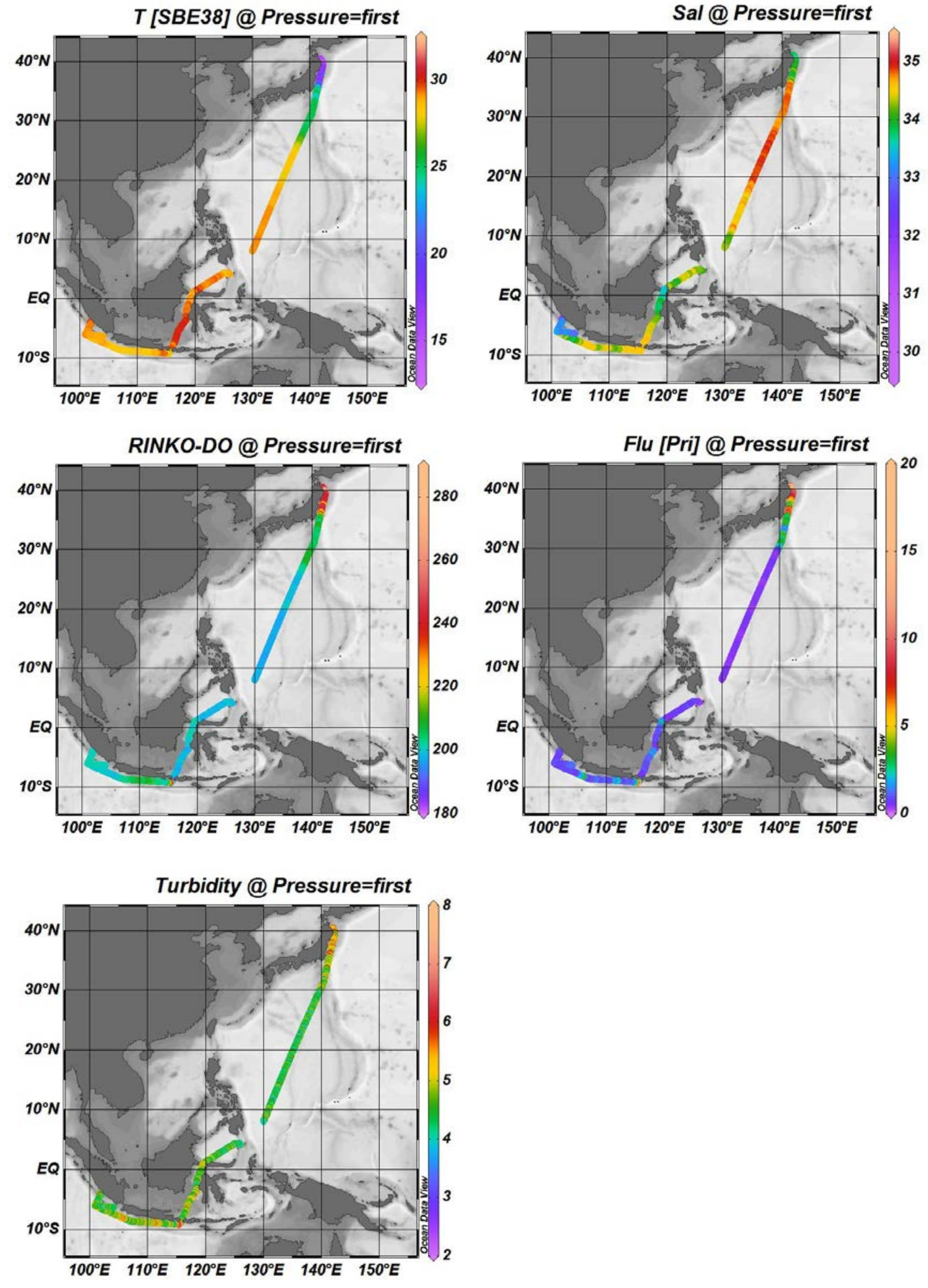

Figure 5.14-1: Spatial and temporal distribution of (a) temperature [℃], (b) salinity [PSU], (c) dissolved oxygen [μmol kg^{-1}], (d) fluorescence, and (e) turbidity [NTU] in MR15-04 cruise.

5.15 Underway pCO_2

(1) Personnel

Yoshiyuki NAKANO (JAMSTEC) - Principal Investigator
Kei SHIOMI (JAXA) - Co- Investigator
Atsushi ONO (MWJ) - Operation Leader

(2) Objectives

Concentrations of CO_2 in the atmosphere are increasing at a rate of 1.5 ppmv yr^{-1} owing to human activities such as burning of fossil fuels, deforestation, and cement production. Oceanic CO_2 concentration is also considered to be increased with the atmospheric CO_2 increase, however, its variation is widely different by time and locations. Underway pCO_2 observation is indispensable to know the pCO_2 distribution, and it leads to elucidate the mechanism of oceanic pCO_2 variation. We here report the underway pCO_2 measurements performed during MR15-04 cruise.

(3) Methods, Apparatus and Performance

Oceanic and atmospheric CO_2 concentrations were measured during the cruise using an automated system equipped with a non-dispersive infrared gas analyzer (NDIR; LI-7000, Li-Cor). Measurements were done every about one and a half hour, and 4 standard gasses, atmospheric air, and the CO_2 equilibrated air with sea surface water were analyzed subsequently in this hour. The concentrations of the CO_2 standard gases were 269.08, 330.17, 359.32 and 419.30 ppmv. Atmospheric air taken from the bow of the ship (approx.30 m above the sea level) was introduced into the NDIR by passing through a electrical cooling unit, a mass flow controller which controls the air flow rate of 0.5 L min^{-1}, a membrane dryer (MD-110-72P, perma pure llc.) and chemical desiccant ($Mg(ClO_4)_2$). The CO_2 equilibrated air was the air with its CO_2 concentration was equivalent to the sea surface water. Seawater was taken from an intake placed at the approximately 4.5 m below the sea surface and introduced into the equilibrator at the flow rate of 4 - 5 L min^{-1} by a pump. The equilibrated air was circulated in a closed loop by a pump at flow rate of 0.6 - 0.8 L min^{-1} through two cooling units, a membrane dryer, the chemical desiccant, and the NDIR.

(3) Preliminary results

Cruise track during pCO_2 observation is shown in Figure 5.15-1.Temporal variations of both oceanic and atmospheric CO_2 concentration (xCO_2) are shown in Fig. 5.15-2.

(4) Data Archive

Data obtained in this cruise will be submitted to the Data Management Office (DMO) of JAMSTEC, and will be opened to public via JAMSTEC web page.

(5) Reference

Dickson, A. G., Sabine, C. L. & Christian, J. R. (2007), Guide to best practices for ocean CO_2 measurements; PICES Special Publication 3, 199pp.

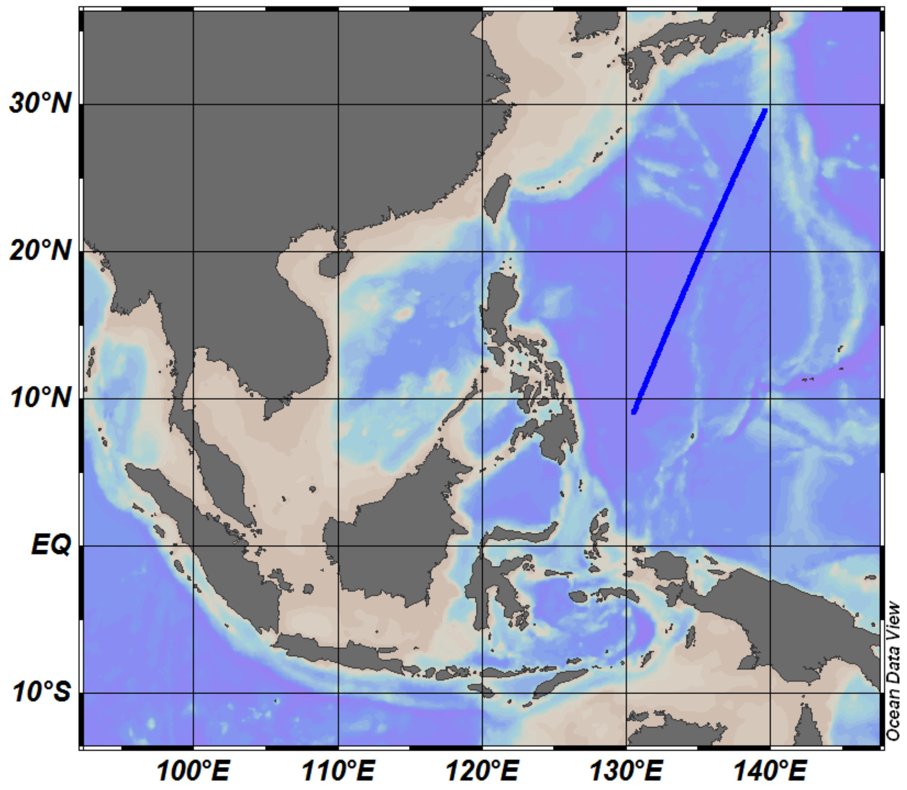

Figure 5.15-1 Observation map

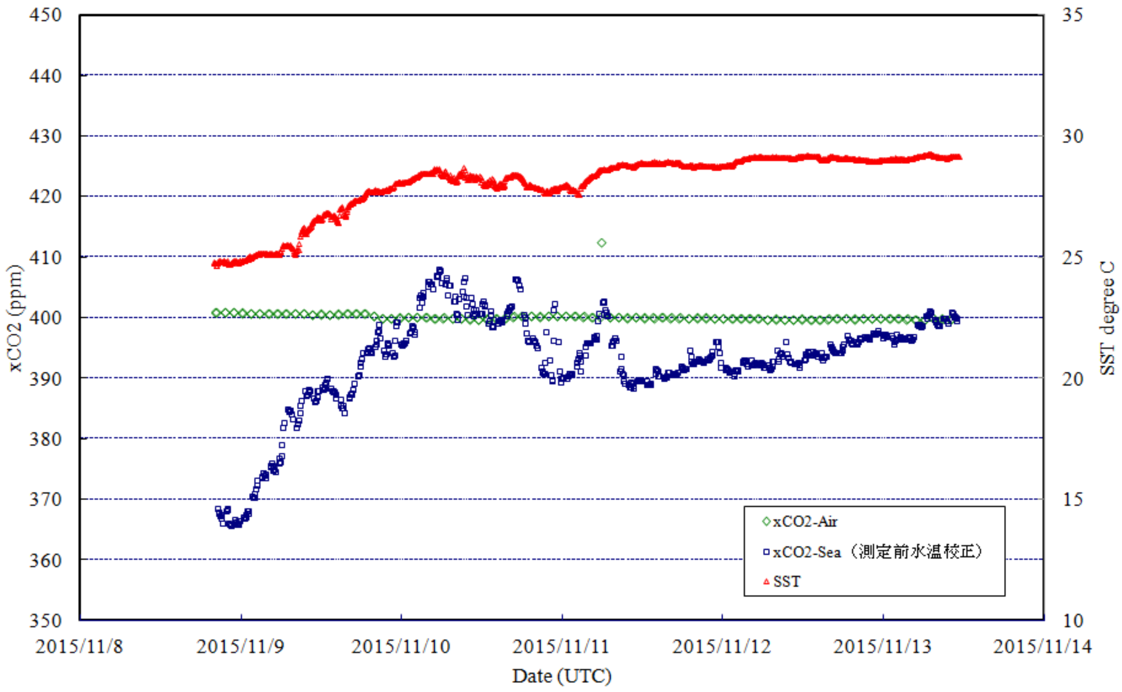

Figure 5.15-2 Temporal variations of oceanic and atmospheric CO_2 concentration (xCO_2). Blue dots represent oceanic xCO_2 variation and green atmospheric xCO_2. SST variation (red) is also shown.

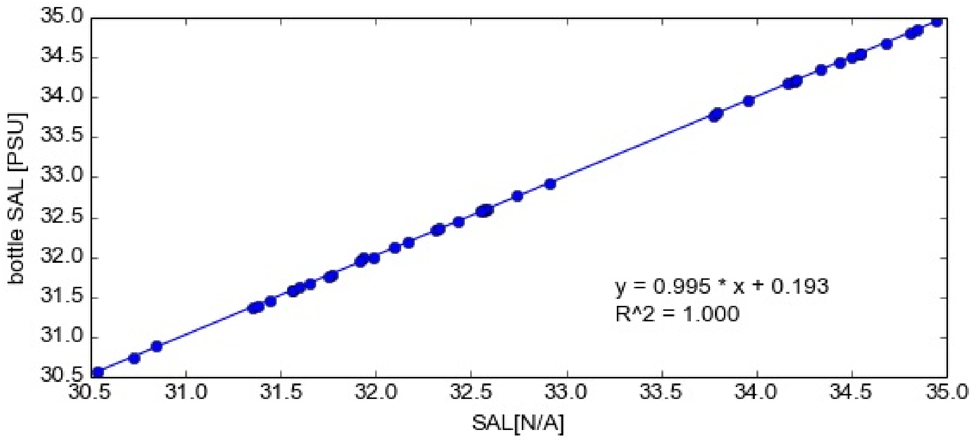

Figure 5.14-2-1: Correlation of salinity between sensor data and bottle data.

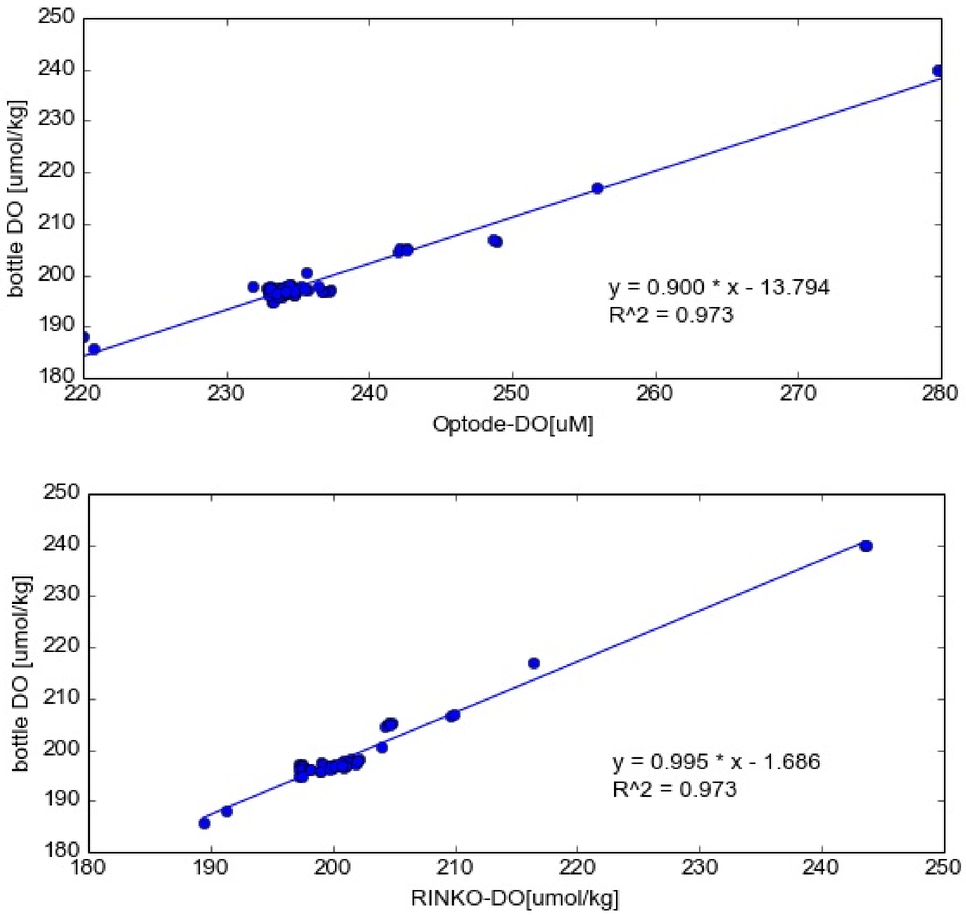

Figure 5.14-2-2: Correlation of dissolved oxygen between sensor data and bottle data.
(upper panel: OPTODE, lower panel: RINKO)

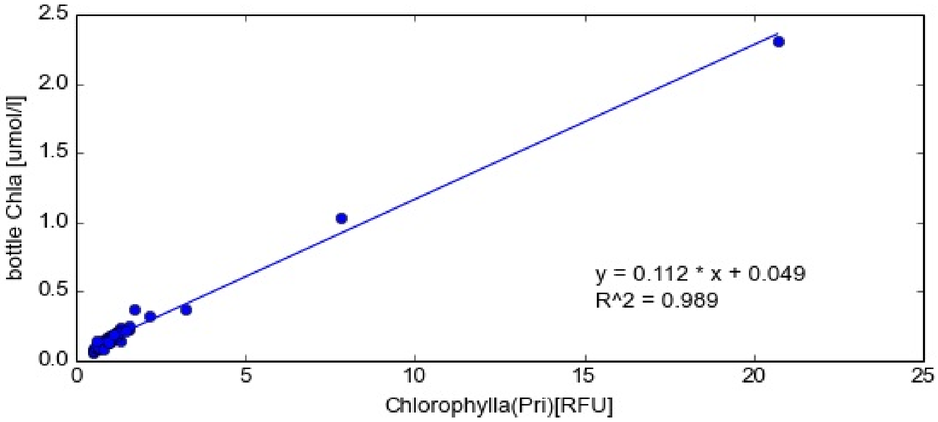

Figure 5.14-2-3: Correlation of fluorescence between sensor data and bottle data.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Office (DMO) of JAMSTEC, and will be opened to public via JAMSTEC web site.

5.16 CTDO profiling

(1) Personnel

Masaki Katsumata	(JAMSTEC)	*Principal Investigator
Rei Ito	(MWJ)	*Operation Leader
Kenichi Katayama	(MWJ)	
Masaki Furuhata	(MWJ)	
Tomohide Noguthi	(MWJ)	
Katsumi Kotera	(MWJ)	
Keisuke Takeda	(MWJ)	

(2) Objective

Investigation of oceanic structure and water sampling.

(3) Instruments and Methods

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

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.23.2) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled during the up cast by sending fire commands from the personal computer. We usually stop for 30 seconds to stabilize then fire. 221 casts of CTD measurements were conducted (Table 5.16.1).

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.23.2) and SEASOFT were as follows:

(The process in order)

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

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

ALIGNCTD: Convert the time-sequence of sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Dissolved oxygen data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensor and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 2 seconds advancing dissolved oxygen sensor output (dissolved oxygen voltage) relative to the temperature data.

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

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

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

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

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

DERIVE: Compute dissolved oxygen (SBE43).

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

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

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

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

Configuration file: MR1504A.xmlcon

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:

SBE9plus (S/N 09P21746-0575, Sea-Bird Electronics, Inc.)

Pressure sensor: Digiquartz pressure sensor (S/N 0575_79492)

Calibrated Date: 07 Apr. 2015

Temperature sensors:

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

Calibrated Date: 01 May 2015

Secondary: SBE03Plus (S/N 03P4421, Sea-Bird Electronics, Inc.)

Calibrated Date: 29 Oct. 2014

Conductivity sensors:

Primary: SBE04C (S/N 043036, Sea-Bird Electronics, Inc.)

Calibrated Date: 06 May 2015

Secondary: SBE04-04/0 (S/N 041206, Sea-Bird Electronics, Inc.)

Calibrated Date: 17 Sep. 2015

Dissolved Oxygen sensor:

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

Calibrated Date: 21 Jul. 2015

Secondary: SBE43 (S/N 432211, Sea-Bird Electronics, Inc.)

Calibrated Date: 26 Feb. 2015

Fluorescence:

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

Gain setting: 10X, 0-15 μg/l

Calibrated Date: None

Offset: 0.000

Photosynthetically Active Radiation:

PAR sensor (S/N 049, Satlantic Inc.)

Calibrated Date: 22 Jan. 2009

Altimeter:

Benthos PSA-916T (S/N 1157, Teledyne Benthos, Inc.)

Carousel water sampler:

SBE32 (S/N 3271515-0924, Sea-Bird Electronics, Inc.)

Submersible Pump:

Primary: SBE5T (S/N 054595, Sea-Bird Electronics, Inc.)

Secondary: SBE5T (S/N 053118, Sea-Bird Electronics, Inc.)

Bottom contact switch: (Sea-Bird Electronics, Inc.)
Used cast: L01M001 ~ L26M001

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

(4) Preliminary Results

During this cruise, 221casts of CTD observation were carried out on line observation and fixed point observation. Date, time and locations of the CTD casts are listed in Table 5.16.1.

The time series contours of primary temperature, salinity, dissolved oxygen, fluorescence, with pressure are shown in Figure. 5.16.1, and Figure. 5.16.2. Vertical profile (down cast) of primary temperature, salinity and dissolved oxygen with pressure are shown in the appendix.

In some cast, we judged noise, spike or shift in the data. These were as follows.

L18M001: Secondary Conductivity and Salinity
down 503 dbar - down 507 dbar (shift)
up 506 dbar – up322 dbar (shift)

STNM035: Secondary Temperature, Conductivity, Salinity and Dissolved Oxygen
down 151 dbar - down 302 dbar (shift)
up 301 dbar - 228 dbar (shift)

STNM069: Primary Dissolved Oxygen
up 9 dbar – up 1 dbar (shift)

(5) Remarks

JES-10 profiler mounted with CTD frame for the purpose of compare data of JES-10 profiler with data of CTD between station L01M001 and station L26M001. Moreover, CTD stopped winch up at 1000m, 500m and 300m for 5 minutes in Station L01M001.

The data communications from CTD under water unit was abruptly cut off on Station L21M001. It was happened when winch up at 223 dbar and so we stopped observation and winched up CTD. As a result, we did not collected data of all sensors between 223 dbar to surface in up cast.

We lost the water sample that took at 40m in STNM045. Because of Niskin bottle for sample of 40m was leak and a spare sample was not collected.

(6) Data archive

All raw and processed data will be submitted to the Data Management Office (DMO), JAMSTEC, and will be opened to public via JAMSTEC web page.

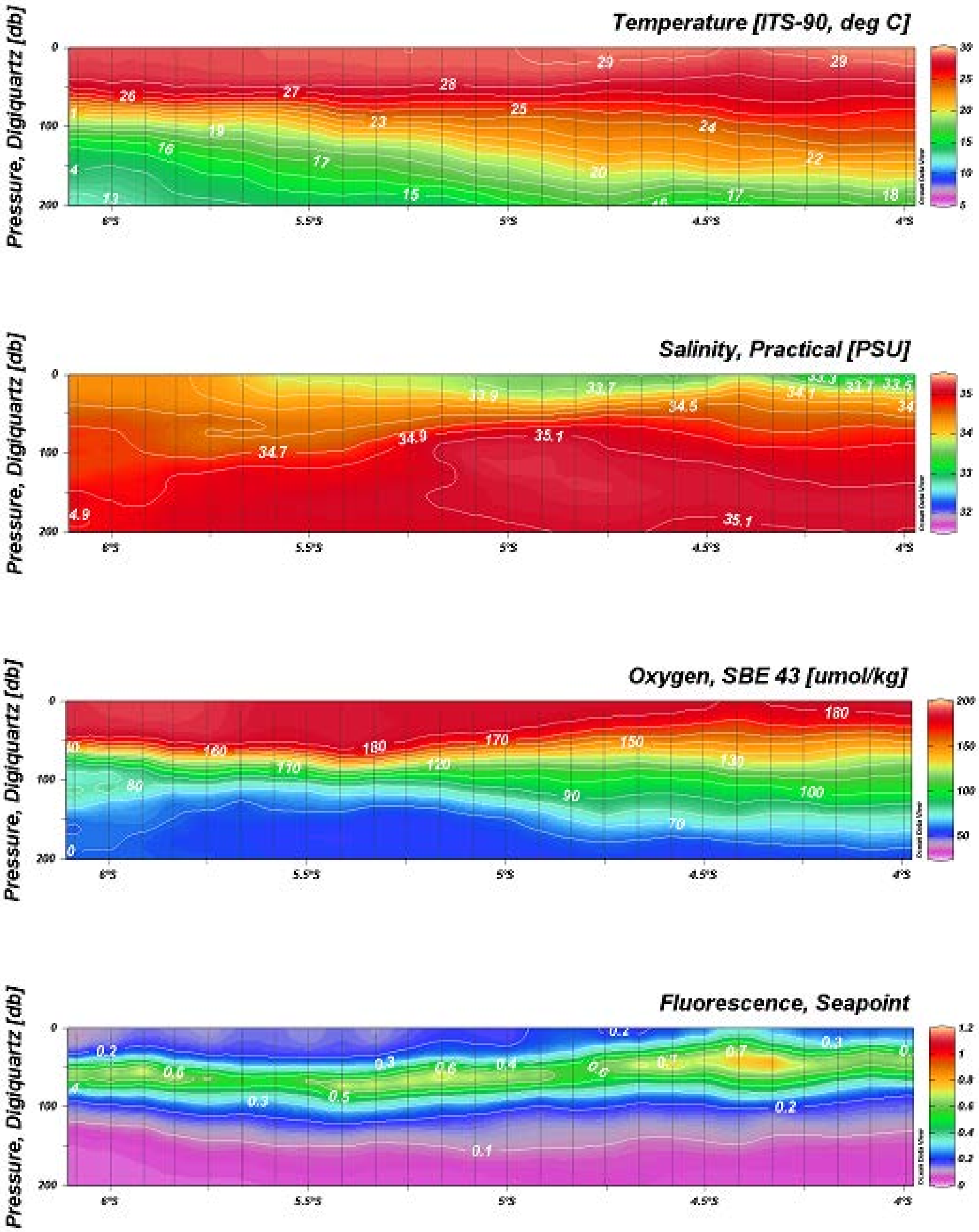

Figure 5.16.1 the time series contours (temperature, salinity oxygen and fluorescence) in line measurement (L01M001 ~ L26M001).

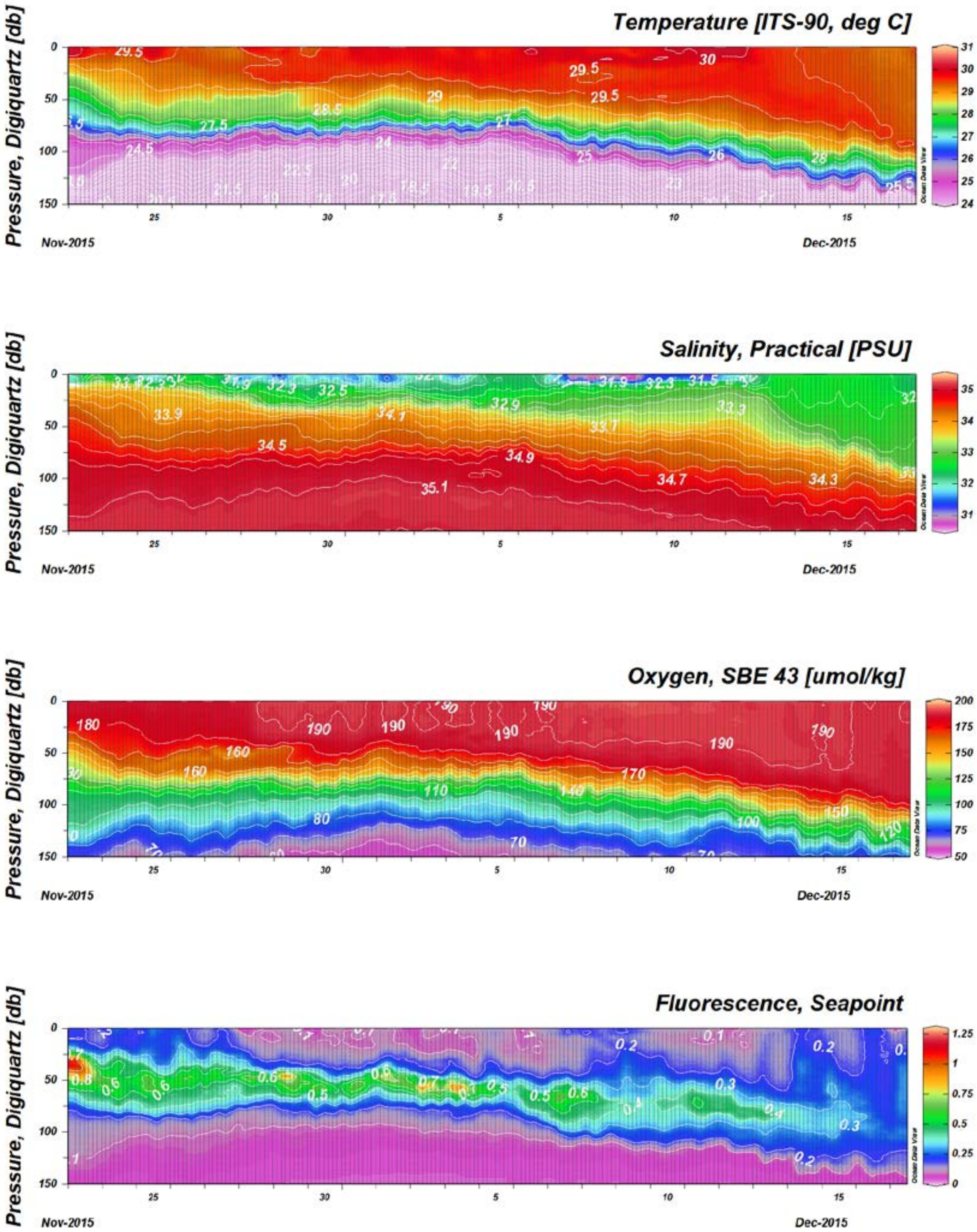

Figure 5.16.2 the time series contours (temperature, salinity oxygen and fluorescence) in fixed point measurement (STNM001 ~ STNM195).

Table 5.16.1 MR15-04 cast table

Stnnbr	Castno	Date(UTC) (mmddyy)	Time(UTC) Start	End	BottomPosition Latitude	Longitude	Depth	Wire Out	Height Above Bottom	Max Depth	Max Pressure	CTD Filename	Remarks
L01	1	112015	23:41	00:39	06-05.29S	100-57.50E	5364.0	993.8	-	1001.0	1009.0	L01M001	
L02	1	112115	02:10	02:49	06-00.11S	101-00.18E	5590.0	500.3	-	502.6	506.0	L02M001	
L03	1	112115	04:05	04:26	05-55.06S	101-02.75E	5922.0	499.0	-	501.6	505.0	L03M001	
L04	1	112115	05:39	06:00	05-50.28S	101-05.07E	6130.0	498.4	-	500.6	504.0	L04M001	
L05	1	112115	07:07	07:51	05-45.17S	101-07.82E	6042.0	498.3	-	503.6	507.0	L05M001	
L06	1	112115	09:06	09:29	05-40.21S	101-10.09E	5373.0	496.2	-	501.6	505.0	L06M001	
L07	1	112115	10:35	10:58	05-35.22S	101-12.63E	4219.0	495.7	-	502.6	506.0	L07M001	
L08	1	112115	12:05	12:42	05-30.19S	101-15.04E	3104.0	497.0	-	500.6	504.0	L08M001	
L09	1	112115	13:59	14:25	05-25.13S	101-17.80E	3628.0	500.1	-	503.6	507.0	L09M001	
L10	1	112115	15:38	16:03	05-20.20S	101-20.11E	3299.0	499.7	-	503.6	507.0	L10M001	
L11	1	112115	17:24	18:00	05-15.04S	101-22.58E	2719.0	497.3	-	500.6	504.0	L11M001	
L12	1	112115	19:15	19:36	05-10.10S	101-25.13E	2858.0	499.0	-	499.6	503.0	L12M001	
L13	1	112115	20:43	21:05	05-05.03S	101-27.37E	2271.0	497.7	-	501.6	505.0	L13M001	
L14	1	112115	22:12	22:53	05-00.15S	101-30.17E	1311.0	498.1	-	502.6	506.0	L14M001	
L15	1	112215	00:03	00:24	04-55.12S	101-32.55E	1012.0	498.4	-	501.6	505.0	L15M001	
L16	1	112215	01:30	01:52	04-50.03S	101-35.25E	929.0	501.0	-	504.6	508.0	L16M001	
L17	1	112215	03:20	04:02	04-45.19S	101-37.72E	814.0	497.5	-	502.6	506.0	L17M001	
L18	1	112215	05:24	05:45	04-40.02S	101-40.26E	1000.0	499.7	-	503.6	507.0	L18M001	
L19	1	112215	06:54	07:15	04-35.03S	101-42.69E	1219.0	497.7	-	500.6	504.0	L19M001	

L20	1	112215	08:24	09:01	04-30.03S	101-45.15E	1284.0	500.6	-	502.6	506.0	L20M001	
L21	1	112215	10:14	10:39	04-25.08S	101-47.60E	1448.0	499.0	-	502.6	506.0	L21M001	
L22	1	112215	11:50	12:11	04-19.96S	101-49.98E	1367.0	498.6	-	502.6	506.0	L22M001	
L23	1	112215	13:23	14:00	04-14.98S	101-52.56E	1139.0	499.7	-	503.6	507.0	L23M001	
L24	1	112215	15:11	15:32	04-10.05S	101-54.96E	875.0	499.4	-	500.6	504.0	L24M001	
L25	1	112215	16:43	17:01	04-04.97S	101-57.64E	394.0	371.4	18.9	374.6	377.0	L25M001	
L26	1	112215	18:08	18:32	03-59.86S	101-59.91E	217.0	197.5	15.4	200.8	202.0	L26M001	
STN	1	112315	05:37	06:09	04-04.14S	101-53.92E	677.0	297.8	-	300.1	302.0	STNM001	
STN	2	112315	08:37	08:49	04-04.83S	101-54.25E	758.0	298.7	-	300.1	302.0	STNM002	
STN	3	112315	11:39	12:07	04-05.00S	101-55.92E	553.0	296.5	-	300.1	302.0	STNM003	
STN	4	112315	14:39	14:54	04-04.90S	101-53.23E	766.0	297.3	-	301.1	303.0	STNM004	
STN	5	112315	17:38	18:04	04-02.82S	101-53.34E	705.0	297.1	-	300.1	302.0	STNM005	
STN	6	112315	20:41	20:54	04-03.97S	101-53.02E	745.0	296.4	-	300.1	302.0	STNM006	
STN	7	112315	23:40	00:25	04-04.38S	101-52.80E	772.0	498.4	-	501.6	505.0	STNM007	
STN	8	112415	02:40	02:54	04-02.56S	101-53.07E	732.0	298.4	-	301.1	303.0	STNM008	
STN	9	112415	05:42	06:08	04-03.50S	101-53.07E	742.0	298.4	-	301.1	303.0	STNM009	
STN	10	112415	08:37	08:49	04-03.26S	101-53.48E	690.0	297.5	-	300.1	302.0	STNM010	
STN	11	112415	11:40	12:06	04-04.00S	101-53.16E	738.0	298.2	-	301.1	303.0	STNM011	
STN	12	112415	14:39	14:51	04-03.05S	101-53.04E	713.0	297.8	-	301.1	303.0	STNM012	
STN	13	112415	17:38	18:03	04-02.63S	101-53.87E	676.0	297.3	-	300.1	302.0	STNM013	
STN	14	112415	20:41	20:54	04-03.68S	101-52.72E	780.0	296.4	-	300.1	302.0	STNM014	
STN	15	112415	23:39	00:22	04-04.30S	101-53.04E	753.0	496.6	-	500.6	504.0	STNM015	
STN	16	112515	02:40	02:55	04-03.46S	101-53.71E	674.0	298.0	-	301.1	303.0	STNM016	

STN	17	112515	05:40	06:13	04-03.10S	101-54.55E	600.0	297.6	-	301.1	303.0	STNM017	
STN	18	112515	08:37	08:50	04-03.45S	101-54.10E	646.0	298.6	-	300.1	302.0	STNM018	
STN	19	112515	11:38	12:05	04-04.15S	101-52.80E	771.0	297.8	-	301.1	303.0	STNM019	
STN	20	112515	14:35	14:48	04-04.23S	101-53.36E	731.0	297.5	-	300.1	302.0	STNM020	
STN	21	112515	17:37	18:03	04-03.22S	101-53.21E	708.0	297.1	-	300.1	302.0	STNM021	
STN	22	112515	20:41	20:54	04-03.93S	101-54.61E	632.0	296.9	-	301.1	303.0	STNM022	
STN	23	112515	23:39	00:34	04-04.17S	101-52.99E	754.0	498.3	-	501.6	505.0	STNM023	
STN	24	112615	02:41	02:53	04-03.80S	101-54.02E	669.0	297.8	-	300.1	302.0	STNM024	
STN	25	112615	05:40	06:13	04-03.29S	101-54.37E	617.0	298.0	-	301.1	303.0	STNM025	
STN	26	112615	08:37	08:49	04-04.06S	101-54.11E	659.0	298.2	-	300.1	302.0	STNM026	
STN	27	112615	11:38	12:04	04-04.14S	101-53.38E	725.0	297.3	-	301.1	303.0	STNM027	
STN	28	112615	14:38	14:51	04-03.20S	101-54.37E	618.0	298.2	-	301.1	303.0	STNM028	
STN	29	112615	17:35	18:00	04-03.21S	101-54.44E	613.0	298.0	-	300.1	302.0	STNM029	
STN	30	112615	20:41	20:53	04-04.06S	101-54.24E	654.0	296.4	-	301.1	303.0	STNM030	
STN	31	112615	23:45	00:24	04-04.44S	101-53.47E	739.0	496.4	-	500.6	504.0	STNM031	
STN	32	112715	02:41	02:54	04-05.22S	101-54.33E	691.0	297.1	-	300.1	302.0	STNM032	
STN	33	112715	05:39	06:04	04-05.01S	101-54.42E	690.0	298.4	-	301.1	303.0	STNM033	
STN	34	112715	08:37	08:49	04-04.03S	101-54.13E	659.0	297.8	-	301.1	303.0	STNM034	
STN	35	112715	11:40	12:07	04-03.97S	101-53.30E	722.0	298.0	-	300.1	302.0	STNM035	
STN	36	112715	14:41	14:53	04-02.97S	101-55.19E	543.0	297.8	-	300.1	302.0	STNM036	
STN	37	112715	17:38	18:02	04-02.76S	101-54.46E	628.0	296.9	-	300.1	302.0	STNM037	
STN	38	112715	20:42	20:55	04-03.65S	101-54.06E	655.0	296.5	-	300.1	302.0	STNM038	
STN	39	112715	23:40	00:22	04-04.24S	101-53.33E	734.0	498.4	-	503.6	507.0	STNM039	

STN	40	112815	02:39	02:51	04-03.51S	101-54.18E	643.0	297.6	-	301.1	303.0	STNM040	
STN	41	112815	05:40	06:12	04-04.32S	101-53.73E	704.0	297.5	-	300.1	302.0	STNM041	
STN	42	112815	08:37	08:49	04-03.30S	101-53.40E	696.0	296.9	-	300.1	302.0	STNM042	
STN	43	112815	11:41	12:07	04-03.51S	101-52.99E	750.0	297.6	-	301.1	303.0	STNM043	
STN	44	112815	14:40	14:52	04-02.49S	101-53.75E	648.0	297.8	-	301.1	303.0	STNM044	
STN	45	112815	18:02	18:26	04-05.25S	101-54.40E	682.0	298.2	-	300.1	302.0	STNM045	
STN	46	112815	20:42	20:55	04-03.09S	101-55.67E	509.0	297.1	-	300.1	302.0	STNM046	
STN	47	112815	23:39	00:16	04-04.17S	101-53.27E	735.0	497.2	-	500.6	504.0	STNM047	
STN	48	112915	02:42	02:54	04-03.02S	101-53.77E	656.0	297.5	-	300.1	302.0	STNM048	
STN	49	112915	05:40	06:11	04-04.49S	101-53.57E	749.0	298.6	-	301.1	303.0	STNM049	
STN	50	112915	08:38	08:50	04-03.57S	101-53.52E	692.0	298.0	-	301.1	303.0	STNM050	
STN	51	112915	11:38	12:02	04-04.16S	101-53.32E	732.0	296.4	-	301.1	303.0	STNM051	
STN	52	112915	14:42	14:52	04-04.56S	101-53.43E	780.0	296.5	-	301.1	303.0	STNM052	
STN	53	112915	17:37	18:03	04-03.02S	101-53.99E	639.0	297.3	-	301.1	303.0	STNM053	
STN	54	112915	20:40	20:53	04-03.64S	101-54.69E	615.0	296.9	-	300.1	302.0	STNM054	
STN	55	112915	23:41	00:24	04-04.09S	101-52.98E	754.0	500.6	-	500.6	504.0	STNM055	
STN	56	113015	02:42	02:52	04-03.50S	101-53.46E	696.0	298.4	-	301.1	303.0	STNM056	
STN	57	113015	05:39	06:06	04-04.23S	101-53.53E	717.0	297.8	-	300.1	302.0	STNM057	
STN	58	113015	08:38	08:50	04-04.71S	101-53.49E	760.0	300.8	-	301.1	303.0	STNM058	
STN	59	113015	11:37	12:02	04-04.04S	101-53.77E	687.0	296.7	-	300.1	302.0	STNM059	
STN	60	113015	14:41	14:52	04-05.39S	101-54.03E	730.0	300.2	-	301.1	303.0	STNM060	
STN	61	113015	17:38	18:05	04-04.26S	101-53.47E	723.0	298.0	-	300.1	302.0	STNM061	
STN	62	113015	20:41	20:54	04-04.95S	101-53.16E	772.0	296.7	-	301.1	303.0	STNM062	

STN	63	113015	23:40	00:19	04-04.19S	101-52.92E	759.0	498.3	-	500.6	504.0	STNM063	
STN	64	120115	02:40	02:51	04-03.26S	101-53.84E	660.0	298.4	-	301.1	303.0	STNM064	
STN	65	120115	05:40	06:12	04-03.32S	101-53.60E	681.0	302.6	-	302.1	304.0	STNM065	
STN	66	120115	08:38	08:51	04-03.98S	101-53.42E	714.0	298.2	-	301.1	303.0	STNM066	
STN	67	120115	11:37	12:02	04-04.05S	101-52.90E	760.0	296.9	-	300.1	302.0	STNM067	
STN	68	120115	14:34	14:46	04-04.36S	101-53.89E	712.0	296.9	-	300.1	302.0	STNM068	
STN	69	120115	17:40	18:08	04-02.87S	101-53.55E	687.0	296.7	-	301.1	303.0	STNM069	
STN	70	120115	20:42	20:55	04-03.78S	101-53.83E	691.0	296.2	-	301.1	303.0	STNM070	
STN	71	120115	23:39	00:16	04-04.19S	101-54.12E	671.0	497.0	-	500.6	504.0	STNM071	
STN	72	120215	02:41	02:52	04-03.34S	101-54.19E	635.0	297.8	-	300.1	302.0	STNM072	
STN	73	120215	05:39	06:09	04-03.04S	101-54.83E	579.0	296.9	-	300.1	302.0	STNM073	
STN	74	120215	08:37	08:50	04-03.19S	101-53.02E	721.0	298.2	-	300.1	302.0	STNM074	
STN	75	120215	11:40	12:04	04-03.76S	101-53.15E	737.0	297.1	-	300.1	302.0	STNM075	
STN	76	120215	14:39	14:50	04-04.00S	101-54.19E	653.0	298.0	-	300.1	302.0	STNM076	
STN	77	120215	17:42	18:09	04-02.85S	101-53.99E	673.0	297.6	-	301.1	303.0	STNM077	
STN	78	120215	20:40	20:53	04-03.74S	101-54.22E	657.0	296.0	-	300.1	302.0	STNM078	
STN	79	120215	23:39	00:26	04-04.26S	101-52.78E	770.0	501.9	-	501.6	505.0	STNM079	
STN	80	120315	02:47	02:58	04-02.98S	101-54.28E	628.0	292.9	-	301.1	303.0	STNM080	
STN	81	120315	05:39	06:04	04-04.58S	101-53.74E	743.0	299.3	-	301.1	303.0	STNM081	
STN	82	120315	08:40	08:53	04-03.15S	101-54.50E	607.0	298.0	-	300.1	302.0	STNM082	
STN	83	120315	11:38	12:05	04-03.89S	101-53.47E	705.0	297.8	-	301.1	303.0	STNM083	
STN	84	120315	14:39	14:50	04-03.07S	101-53.37E	685.0	297.6	-	300.1	302.0	STNM084	
STN	85	120315	17:41	18:07	04-02.14S	101-54.10E	618.0	297.6	-	301.1	303.0	STNM085	

STN	86	120315	20:41	20:54	04-03.82S	101-55.55E	546.0	297.8	-	301.1	303.0	STNM086	
STN	87	120315	23:39	00:19	04-03.80S	101-53.57E	698.0	496.8	-	500.6	504.0	STNM087	
STN	88	120415	02:42	02:52	04-02.52S	101-53.64E	683.0	298.2	-	300.1	302.0	STNM088	
STN	89	120415	05:40	06:13	04-02.65S	101-54.70E	600.0	298.7	-	301.1	303.0	STNM089	
STN	90	120415	08:39	08:52	04-04.23S	101-53.64E	703.0	297.5	-	300.1	302.0	STNM090	
STN	91	120415	11:40	12:07	04-03.91S	101-53.41E	715.0	297.8	-	300.1	302.0	STNM091	
STN	92	120415	14:37	14:48	04-04.98S	101-54.06E	785.0	297.6	-	300.1	302.0	STNM092	
STN	93	120415	17:39	18:06	04-03.23S	101-53.59E	680.0	300.4	-	301.1	303.0	STNM093	
STN	94	120415	20:40	20:52	04-04.31S	101-53.71E	711.0	296.7	-	300.1	302.0	STNM094	
STN	95	120415	23:39	00:16	04-03.45S	101-53.37E	707.0	498.4	-	502.6	506.0	STNM095	
STN	96	120515	02:39	02:50	04-04.55S	101-52.90E	789.0	299.3	-	300.1	302.0	STNM096	
STN	97	120515	05:39	06:05	04-04.09S	101-52.69E	770.0	298.0	-	300.1	302.0	STNM097	
STN	98	120515	08:38	08:51	04-03.69S	101-53.78E	675.0	299.3	-	301.1	303.0	STNM098	
STN	99	120515	11:38	12:03	04-03.82S	101-53.62E	697.0	296.0	-	300.1	302.0	STNM099	
STN	100	120515	14:34	14:46	04-04.22S	101-53.66E	703.0	297.8	-	300.1	302.0	STNM100	
STN	101	120515	17:38	18:04	04-05.22S	101-53.91E	762.0	298.6	-	301.1	303.0	STNM101	
STN	102	120515	20:40	20:52	04-04.19S	101-54.72E	621.0	298.9	-	301.1	303.0	STNM102	
STN	103	120515	23:39	00:20	04-04.09S	101-53.32E	727.0	496.8	-	500.6	504.0	STNM103	
STN	104	120615	02:39	02:50	04-04.55S	101-54.03E	686.0	298.9	-	300.1	302.0	STNM104	
STN	105	120615	05:38	06:03	04-04.65S	101-53.54E	769.0	297.8	-	301.1	303.0	STNM105	
STN	106	120615	08:38	08:50	04-03.57S	101-53.99E	658.0	297.6	-	301.1	303.0	STNM106	
STN	107	120615	11:38	12:03	04-04.12S	101-53.19E	738.0	297.3	-	301.1	303.0	STNM107	
STN	108	120615	14:38	14:50	04-03.91S	101-53.68E	698.0	297.3	-	300.1	302.0	STNM108	

STN	109	120615	17:39	18:05	04-04.71S	101-53.47E	766.0	298.0	-	301.1	303.0	STNM109	
STN	110	120615	20:39	20:52	04-03.89S	101-53.88E	678.0	296.0	-	300.1	302.0	STNM110	
STN	111	120615	23:40	00:18	04-04.26S	101-53.26E	744.0	498.6	-	500.6	504.0	STNM111	
STN	112	120715	02:40	02:52	04-04.12S	101-54.21E	662.0	299.1	-	301.1	303.0	STNM112	
STN	113	120715	05:40	06:11	04-03.89S	101-53.23E	729.0	297.6	-	300.1	302.0	STNM113	
STN	114	120715	08:38	08:50	04-05.08S	101-52.93E	797.0	298.7	-	301.1	303.0	STNM114	
STN	115	120715	11:38	12:02	04-04.42S	101-53.15E	769.0	297.1	-	301.1	303.0	STNM115	
STN	116	120715	14:38	14:49	04-03.89S	101-53.27E	727.0	297.6	-	300.1	302.0	STNM116	
STN	117	120715	17:37	18:03	04-04.85S	101-53.11E	807.0	298.9	-	301.1	303.0	STNM117	
STN	118	120715	20:38	20:50	04-03.78S	101-54.86E	603.0	296.9	-	300.1	302.0	STNM118	
STN	119	120715	23:39	00:12	04-04.41S	101-52.98E	764.0	502.8	-	502.6	506.0	STNM119	
STN	120	120815	02:40	02:51	04-05.17S	101-53.49E	815.0	299.1	-	300.1	302.0	STNM120	
STN	121	120815	05:39	06:10	04-04.08S	101-53.61E	703.0	300.9	-	302.1	304.0	STNM121	
STN	122	120815	08:37	08:50	04-05.09S	101-53.69E	812.0	300.8	-	301.1	303.0	STNM122	
STN	123	120815	11:37	12:01	04-04.17S	101-53.00E	757.0	297.5	-	300.1	302.0	STNM123	
STN	124	120815	14:39	14:51	04-04.13S	101-53.59E	711.0	300.2	-	301.1	303.0	STNM124	
STN	125	120815	17:37	18:03	04-04.31S	101-53.12E	749.0	298.7	-	301.1	303.0	STNM125	
STN	126	120815	20:40	20:52	04-03.45S	101-53.72E	674.0	298.4	-	301.1	303.0	STNM126	
STN	127	120815	23:39	00:12	04-04.19S	101-53.22E	739.0	495.1	-	500.6	504.0	STNM127	
STN	128	120915	02:40	02:51	04-03.17S	101-53.26E	701.0	300.0	-	300.1	302.0	STNM128	
STN	129	120915	05:39	06:11	04-05.39S	101-53.39E	833.0	298.0	-	300.1	302.0	STNM129	
STN	130	120915	08:37	08:50	04-05.04S	101-53.13E	771.0	299.3	-	301.1	303.0	STNM130	
STN	131	120915	11:38	12:06	04-04.09S	101-53.27E	732.0	297.1	-	300.1	302.0	STNM131	

STN	132	120915	14:37	14:48	04-04.77S	101-53.54E	739.0	298.6	-	302.1	304.0	STNM132	
STN	133	120915	17:37	18:02	04-03.66S	101-54.15E	653.0	298.0	-	301.1	303.0	STNM133	
STN	134	120915	20:40	20:52	04-03.18S	101-54.21E	628.0	297.3	-	300.1	302.0	STNM134	
STN	135	120915	23:39	00:19	04-04.34S	101-52.96E	757.0	501.7	-	505.6	509.0	STNM135	
STN	136	121015	02:39	02:50	04-04.86S	101-52.80E	846.0	298.6	-	301.1	303.0	STNM136	
STN	137	121015	05:39	06:09	04-04.16S	101-52.87E	767.0	298.0	-	300.1	302.0	STNM137	
STN	138	121015	08:37	08:50	04-03.64S	101-52.73E	781.0	297.8	-	301.1	303.0	STNM138	
STN	139	121015	11:40	12:02	04-04.13S	101-52.89E	761.0	297.6	-	301.1	303.0	STNM139	
STN	140	121015	14:36	14:47	04-03.04S	101-53.98E	641.0	297.3	-	301.1	303.0	STNM140	
STN	141	121015	17:37	18:03	04-02.79S	101-53.79E	704.0	297.8	-	301.1	303.0	STNM141	
STN	142	121015	20:40	20:53	04-03.12S	101-53.43E	682.0	296.2	-	300.1	302.0	STNM142	
STN	143	121015	23:38	00:12	04-04.16S	101-52.82E	766.0	498.1	-	500.6	504.0	STNM143	
STN	144	121115	02:41	02:52	04-02.92S	101-53.30E	695.0	298.9	-	300.1	302.0	STNM144	
STN	145	121115	05:38	06:08	04-04.02S	101-52.72E	769.0	297.6	-	300.1	302.0	STNM145	
STN	146	121115	08:37	08:49	04-04.78S	101-52.77E	834.0	298.6	-	300.1	302.0	STNM146	
STN	147	121115	11:38	12:02	04-04.03S	101-53.30E	729.0	297.5	-	300.1	302.0	STNM147	
STN	148	121115	14:32	14:44	04-02.86S	101-53.23E	711.0	299.5	-	301.1	303.0	STNM148	
STN	149	121115	17:37	18:06	04-03.78S	101-53.87E	684.0	297.6	-	301.1	303.0	STNM149	
STN	150	121115	20:39	20:52	04-02.77S	101-54.51E	628.0	292.1	-	301.1	303.0	STNM150	
STN	151	121115	23:40	00:19	04-04.06S	101-53.34E	725.0	501.4	-	503.6	507.0	STNM151	
STN	152	121215	02:40	02:51	04-03.30S	101-54.58E	610.0	298.7	-	300.1	302.0	STNM152	
STN	153	121215	05:38	06:02	04-03.22S	101-53.86E	658.0	298.7	-	300.1	302.0	STNM153	
STN	154	121215	08:38	08:50	04-03.88S	101-53.72E	693.0	297.8	-	300.1	302.0	STNM154	

STN	155	121215	11:37	12:03	04-04.06S	101-53.40E	719.0	297.5	-	300.1	302.0	STNM155	
STN	156	121215	14:39	14:50	04-04.23S	101-53.55E	718.0	297.6	-	300.1	302.0	STNM156	
STN	157	121215	17:37	18:02	04-03.25S	101-53.28E	706.0	296.7	-	300.1	302.0	STNM157	
STN	158	121215	20:39	20:52	04-03.29S	101-53.81E	662.0	296.4	-	300.1	302.0	STNM158	
STN	159	121215	23:39	00:16	04-03.34S	101-53.94E	657.0	496.6	-	501.6	505.0	STNM159	
STN	160	121315	02:39	03:21	04-03.44S	101-53.78E	669.0	497.9	-	500.6	504.0	STNM160	
STN	161	121315	05:39	06:08	04-03.60S	101-54.22E	642.0	297.5	-	300.1	302.0	STNM161	
STN	162	121315	08:42	08:53	04-03.16S	101-54.22E	624.0	295.8	-	300.1	302.0	STNM162	
STN	163	121315	11:40	12:04	04-03.64S	101-53.81E	672.0	297.6	-	301.1	303.0	STNM163	
STN	164	121315	14:37	14:49	04-04.01S	101-53.67E	696.0	297.5	-	300.1	302.0	STNM164	
STN	165	121315	17:38	18:04	04-03.44S	101-53.72E	674.0	297.5	-	301.1	303.0	STNM165	
STN	166	121315	20:40	20:52	04-03.71S	101-53.70E	683.0	296.5	-	300.1	302.0	STNM166	
STN	167	121315	23:39	00:12	04-03.82S	101-53.99E	670.0	497.7	-	502.6	506.0	STNM167	
STN	168	121415	02:40	02:51	04-03.24S	101-53.90E	654.0	298.4	-	300.1	302.0	STNM168	
STN	169	121415	05:38	06:06	04-02.77S	101-54.25E	654.0	298.7	-	301.1	303.0	STNM169	
STN	170	121415	08:37	08:48	04-03.23S	101-53.72E	668.0	298.2	-	300.1	302.0	STNM170	
STN	171	121415	11:33	11:57	04-03.38S	101-53.61E	684.0	298.0	-	301.1	303.0	STNM171	
STN	172	121415	14:37	14:49	04-02.37S	101-53.45E	653.0	298.2	-	300.1	302.0	STNM172	
STN	173	121415	17:38	18:03	04-03.22S	101-53.21E	709.0	297.5	-	300.1	302.0	STNM173	
STN	174	121415	20:39	20:52	04-04.01S	101-53.07E	746.0	298.0	-	301.1	303.0	STNM174	
STN	175	121415	23:40	00:19	04-03.36S	101-53.19E	733.0	499.4	-	500.6	504.0	STNM175	
STN	176	121515	02:39	02:50	04-02.85S	101-54.47E	640.0	297.8	-	300.1	302.0	STNM176	
STN	177	121515	05:39	06:06	04-02.85S	101-53.71E	691.0	295.8	-	300.1	302.0	STNM177	

STN	178	121515	08:39	08:49	04-04.37S	101-53.67E	716.0	298.2	-	300.1	302.0	STNM178	
STN	179	121515	11:26	11:50	04-03.30S	101-53.89E	657.0	298.0	-	300.1	302.0	STNM179	
STN	180	121515	14:38	14:50	04-03.63S	101-55.87E	513.0	297.8	-	301.1	303.0	STNM180	
STN	181	121515	17:35	18:01	04-05.23S	101-54.45E	679.0	297.1	-	300.1	302.0	STNM181	
STN	182	121515	20:37	20:49	04-04.25S	101-53.62E	708.0	296.9	-	300.1	302.0	STNM182	
STN	183	121515	23:36	00:11	04-03.42S	101-53.84E	664.0	498.8	-	500.6	504.0	STNM183	
STN	184	121615	02:35	02:47	04-03.37S	101-53.59E	685.0	300.0	-	301.1	303.0	STNM184	
STN	185	121615	05:37	06:05	04-04.26S	101-54.57E	637.0	296.7	-	301.1	303.0	STNM185	
STN	186	121615	08:37	08:48	04-03.82S	101-54.17E	655.0	301.7	-	301.1	303.0	STNM186	
STN	187	121615	11:38	12:04	04-04.03S	101-53.87E	677.0	298.7	-	301.1	303.0	STNM187	
STN	188	121615	14:32	14:43	04-03.59S	101-53.26E	718.0	298.0	-	300.1	302.0	STNM188	
STN	189	121615	17:38	18:04	04-03.44S	101-54.57E	610.0	297.6	-	301.1	303.0	STNM189	
STN	190	121615	20:41	20:53	04-03.87S	101-53.90E	675.0	296.5	-	300.1	302.0	STNM190	
STN	191	121615	23:39	00:15	04-03.68S	101-53.61E	690.0	499.4	-	501.6	505.0	STNM191	
STN	192	121715	02:39	02:51	04-03.69S	101-53.67E	686.0	298.7	-	301.1	303.0	STNM192	
STN	193	121715	05:36	06:04	04-03.36S	101-53.76E	671.0	297.6	-	301.1	303.0	STNM193	
STN	194	121715	08:39	08:50	04-03.65S	101-53.08E	739.0	299.1	-	300.1	302.0	STNM194	
STN	195	121715	11:37	12:04	04-03.98S	101-53.43E	715.0	297.5	-	300.1	302.0	STNM195	

5.17 Salinity of sampled water

(1) Personnel

Masaki Katsumata	(JAMSTEC)	- Principal Investigator
Kenichi Katayama	(MWJ)	- Operation Leader

(2) Objective

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

(3) Method

a. Salinity Sample Collection

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

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

Table 5.17-1 Kind and number of samples

Kind of Samples	Number of Samples
Samples for CTD	66
Samples for TSG	41
Total	107

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR15-04 using the salinometer (Model 8400B “AUTOSAL” ; Guildline Instruments Ltd.: S/N 62556) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). A pair of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.) were used. The thermometer monitored the ambient temperature and the other monitored a bath temperature.

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

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

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

Thermometer (Model 9540 ; Guildline Instruments Ltd.)

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

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 22 deg C to 24 deg C, while the bath temperature was very stable and varied within +/- 0.004 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 4 hours per day and the cell was cleaned with soap after the measurement of the day.

(4) Results

a. Standard Seawater

Standardization control of the salinometer was set to 713 and all measurements were done at this setting. The value of STANDBY was 24+5215~5216 and that of ZERO was 0.0-0001~0000. The conductivity ratio of IAPSO Standard Seawater batch P157 was 0.99985 (double conductivity ratio was 1.99970) and was used as the standard for salinity. 15 bottles of P157 were measured.

Fig.5.17-1 shows the time series of the double conductivity ratio of the Standard Seawater batch P157. The average of the double conductivity ratio was 1.99969 and the standard deviation was 0.00001 which is equivalent to 0.0002 in salinity.

Fig.5.17-2 shows the time series of the double conductivity ratio of the Standard Seawater batch P157 after correction. The average of the double conductivity ratio after correction was 1.99970 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

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

batch	:	P157
conductivity ratio	:	0.99985
salinity	:	34.994
use by	:	15th May 2017

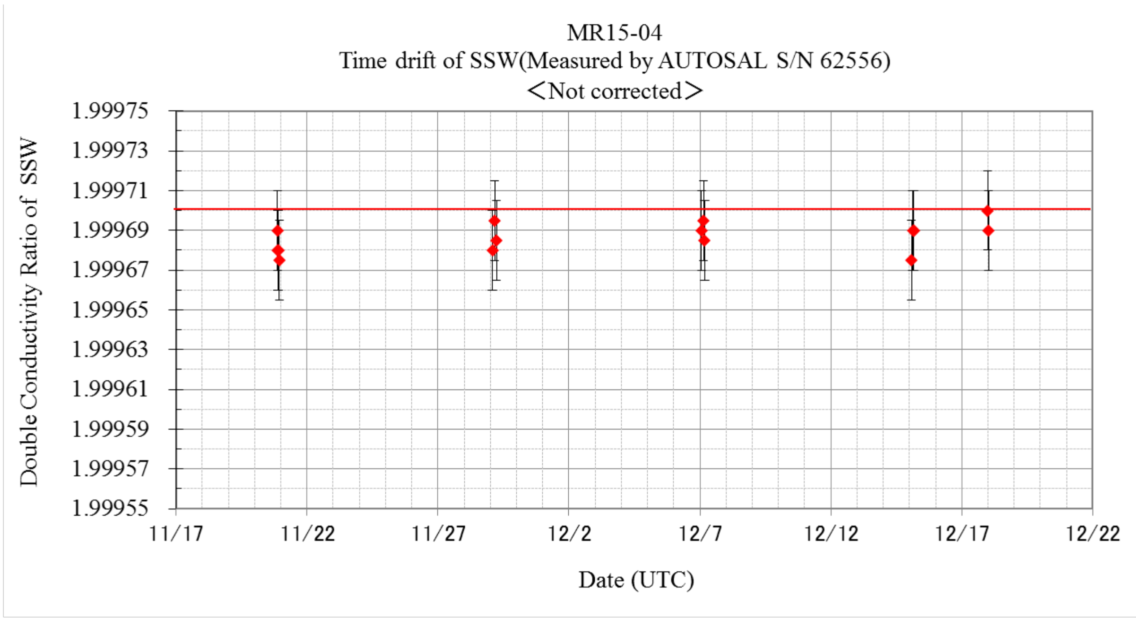

Fig. 5.17-1: Time series of double conductivity ratio for the Standard Seawater batch P157 (before correction)

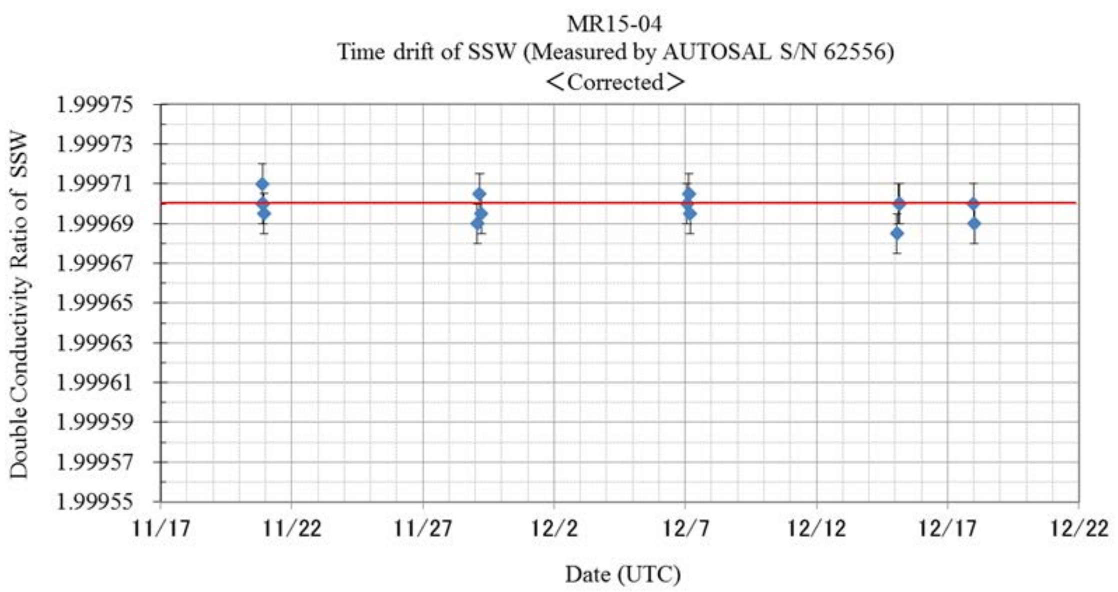

Fig. 5.17-2: Time series of double conductivity ratio for the Standard Seawater batch P157 (after correction)

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 33 pairs of replicate samples taken from the same Niskin bottle. The average and the standard deviation of absolute difference among 33 pairs of replicate samples were 0.0003 and 0.0002 in salinity, respectively.

(5) Data archive

These raw datasets will be submitted to JAMSTEC Data Management Office (DMO).

(6) Reference

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

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

5.18 Dissolved oxygen of sampled water

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	- Principal Investigator
Haruka TAMADA	(Marine Works Japan Co. Ltd)	- Operation Leader
Misato KUWAHARA	(Marine Works Japan Co. Ltd)	

(2) Objective

Determination of dissolved oxygen in seawater by Winkler titration.

(3) Instruments and Methods

Following procedure is based on an analytical method, entitled by "Determination of dissolved oxygen in sea water by Winkler titration", in the WHP Operations and Methods (Dickson, 1996).

a. Instruments

Burette for sodium thiosulfate and potassium iodate;

APB-510 / APB-620 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel

Detector;

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

Software;

DOT_Terminal Ver. 1.2.0

b. Reagents

Pickling Reagent I: Manganese 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 iodide (0.001667 mol dm^{-3})

CSK standard of potassium iodide:

Lot KPG6393, Wako Pure Chemical Industries Ltd., 0.0100N

c. Sampling

Seawater samples were collected with Niskin bottle attached to the CTD-system and surface bucket sampler. Seawater for oxygen measurement was transferred from sampler to a volume calibrated flask (ca. 100 cm^3). Three times volume of the flask of seawater was overflowed. Temperature was measured by digital thermometer during the overflowing. Then two reagent solutions (Reagent I and II) of 0.5 cm^3 each were added immediately into the sample flask and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

d. Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. 1 cm^3 sulfuric acid solution and a magnetic stirrer bar were added into the sample flask and stirring began. Samples were titrated by sodium thiosulfate solution whose morality was determined by potassium iodate solution. Temperature of sodium thiosulfate during titration was recorded by a digital thermometer. During this cruise, we measured dissolved oxygen concentration using 2 sets of the titration apparatus. Dissolved oxygen concentration (μmol kg^{-1}) was calculated by sample temperature during seawater sampling, salinity of the bottle sampling, 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 130ºC. 1.7835g potassium iodate weighed out accurately was dissolved in deionized water and diluted to final volume of 5 dm^3 in a calibrated volumetric flask (0.001667 mol dm^{-3}). 10 cm^3 of the standard potassium iodate solution was added to a flask using a volume-calibrated dispenser. Then 90 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the flask in order. Amount of titrated volume of sodium thiosulfate (usually 5 times measurements average) gave the morality of sodium thiosulfate titrant.

The oxygen in the pickling reagents I (0.5 cm^3) and II (0.5 cm^3) was assumed to be 3.8 x 10^{-8} mol (Murray *et al.*, 1968). The blank due to other than oxygen was determined as follows.1 and 2 cm^3 of the standard potassium iodate solution were added to two flasks respectively using a calibrated dispenser. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I each were added into the flask in order. The blank was determined by difference between the first (1 cm^3 of KIO_3) titrated volume of the sodium thiosulfate and the second (2 cm^3 of KIO_3) one. The results of 3 times blank determinations were averaged.

(4) Observation log

a. Standardization and determination of the blank

Table 5.18-1 shows results of the standardization and the blank determination during this cruise.

Table 5.18-1 Results of the standardization and the blank determinations during cruise.

Date	KIO_3 ID	$Na_2S_2O_3$	DOT-01X(No.6)		DOT-01X(No.8)		Stations
			E.P.	Blank	E.P.	Blank	
2015/11/12	K1504C09	T1505F	4.022	0.006	4.023	0.005	
2015/11/20	CSK_KPG6393	T1505F	4.026	0.007	4.028	0.005	
2015/11/20	K1504D02	T1505F	4.021	0.007	4.025	0.005	L01, L02, L05, L08, L11, L14, L17, L20, L23, L26, STN(cast001, 003, 005, 007, 009, 011, 015, 017, 019, 023, 025, 027, 029, 031, 033)
2015/11/27	K1504D03	T1505F	4.023	0.004	4.026	0.006	STN(cast035, 037, 039, 041, 043, 045, 047, 049, 051, 053, 055, 057, 059, 061, 063, 065)
2015/12/2	K1504D04	T1505F	4.024	0.010	4.027	0.005	
2015/12/2	K1504D04	T1505G	3.963	0.005	3.962	0.001	STN(cast067, 069, 071, 073, 075, 077, 079, 081, 083, 085, 087, 089, 091, 093, 095, 097, 099, 101, 103, 105, 107, 109, 111, 113, 115, 117, 119, 121)
2015/12/8	K1504D05	T1505G	3.962	0.008	3.961	0.002	STN(cast123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165)
2015/12/15	K1504D06	T1505G	3.963	0.006	3.963	0.002	STN(cast167, 169, 171, 173, 175, 177, 179, 181, 183, 185, 187, 189, 191, 193, 195)

b. Results

Time-series profile for dissolved oxygen fixed point is shown in figure 5.18-1.

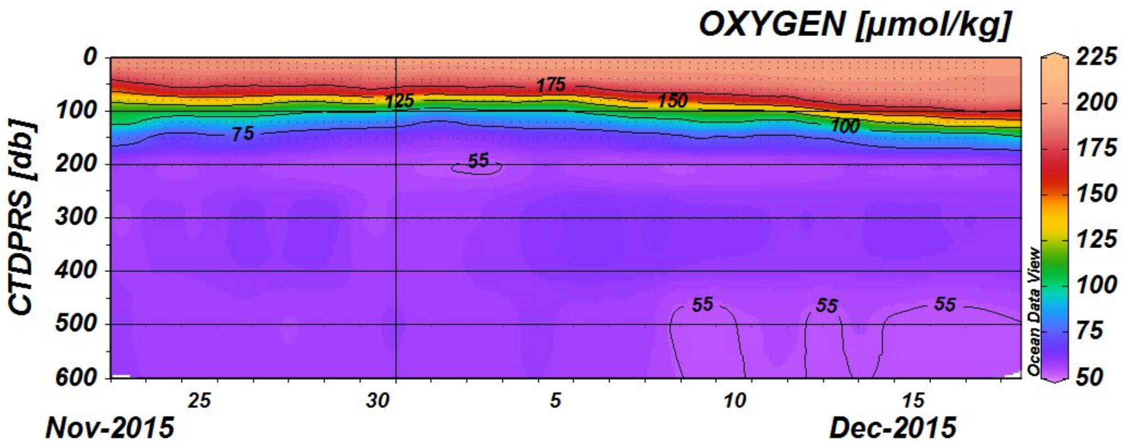

Figure 5.18-1 Time-series profile of dissolved oxygen.

c. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. Total amount of the replicate sample pairs of good measurement was 108. The standard deviation of the replicate measurement was 0.10 μmol kg^{-1} that was calculated by a procedure in Guide to best practices for ocean CO_2 measurements Chapter4 SOP23 Ver.3.0 (2007). Results of replicate samples diagram were shown in Fig. 5.18-2.

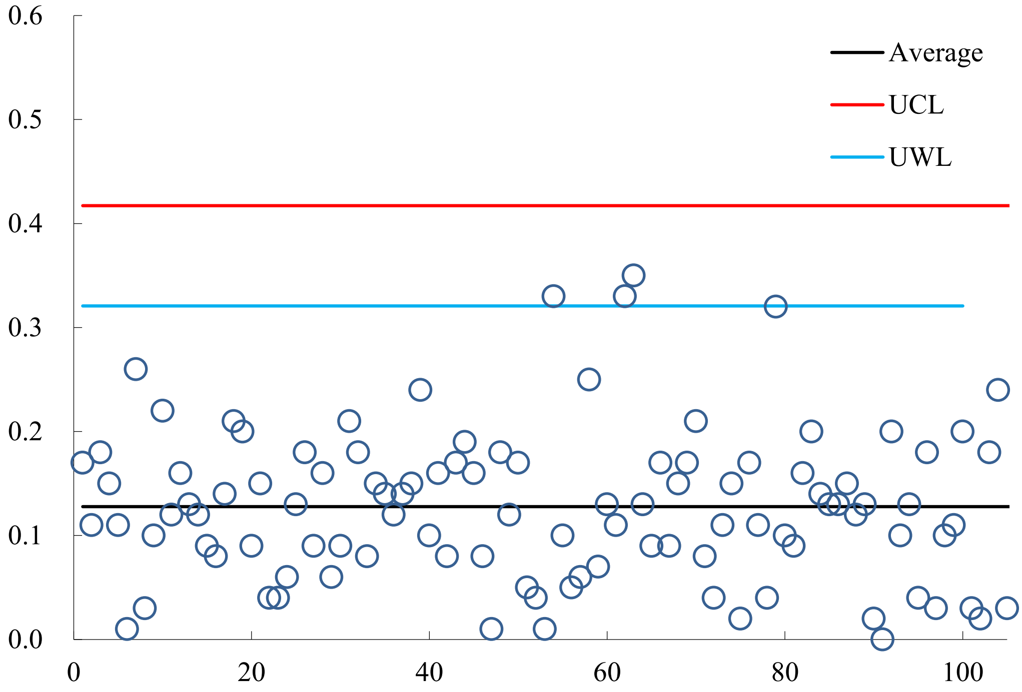

Fig. 5.18-2 Differences of replicate samples against sequence number.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Office (DMO) of JAMSTEC, and will be opened to public via JAMSTEC web site.

(6) References

Dickson, A.G., Determination of dissolved oxygen in sea water by Winkler titration. (1996)

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.), Guide to best practices for ocean CO2 measurements. (2007)

Culberson, C.H., WHP Operations and Methods July-1991 “Dissolved Oxygen”, (1991)

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

KIMOTO electric CO. LTD., Automatic photometric titrator DOT-01 Instruction manual

5.19 Nutrients of Sampled Water

(1) Personnel

Masaki Katsumata	(JAMSTEC)	: Principal Investigator
Tomomi Sone	(MWJ)	: Operating Leader
Masanori Enoki	(MWJ)	: Operator

(2) Objectives

The vertical and horizontal distributions of the nutrients are one of the most important factors on the primary production. During this cruise nutrient measurements will give us the important information on the mechanism of the primary production or seawater circulation.

(3) Methods

Nutrient analysis was performed on the BL-Tech QUAATRO system. The laboratory temperature was maintained between 20.0-22.5 deg C.

The analytical methods of the nutrients, nitrate, nitrite, silicate and phosphate, during this cruise were same as the methods used in Kawano et al. (2009).

a. Measured Parameters

Nitrate + nitrite and nitrite were analyzed according to the modification method of Grasshoff (1970). The sample nitrate was reduced to nitrite in a cadmium tube inside of which was coated with metallic copper. The sample streamed with its equivalent nitrite was treated with an acidic, sulfanilamide reagent and the nitrite forms nitrous acid which reacted with the sulfanilamide to produce a diazonium ion. N-1-Naphthylethylene-diamine added to the sample stream then coupled with the diazonium ion to produce a red, azo dye. With reduction of the nitrate to nitrite, both nitrate and nitrite reacted and were measured; without reduction, only nitrite reacted. Thus, for the nitrite analysis, no reduction was performed and the alkaline buffer was not necessary. Nitrate was computed by difference.

Absorbance of 550 nm by azo dye in analysis is measured using a 1 cm length cell for nitrate and 3 cm length cell for nitrite. At L02M001-L26M001 and STNM001-STNM009, however, 2cm length cell was used for measuring nitrite.

The silicate method was analogous to that described for phosphate. The method used was essentially that of Grasshoff et al. (1983), wherein silicomolybdic acid was first formed from the silicate in the sample and added molybdic acid; then the silicomolybdic acid was reduced to silicomolybdous acid, or "molybdenum blue" using ascorbic acid as the reductant.

Absorbance of 630 nm by silicomolybdous acid in analysis is measured using a 1 cm length cell.

The phosphate analysis was a modification of the procedure of Murphy and Riley (1962). Molybdic acid was added to the seawater sample to form phosphomolybdic acid which was in turn reduced to phosphomolybdous acid using L-ascorbic acid as the reductant.

Absorbance of 880 nm by phosphomolybdous acid in analysis is measured using a 1 cm length cell.

b. Nutrients Standard

Specifications

For nitrate standard, "potassium nitrate 99.995 suprapur®" provided by Merck, Lot. B0771365211, CAS No.: 7757-91-1, was used.

For nitrite standard solution, we used "nitrous acid iron standard solution (NO_2^- 1000) provided by Wako, Lot ECP4122, Code. No. 140-06451." This standard solution was certified by Wako using Ion chromatograph method. Calibration result is 999 mg/L at 20 deg. C. Expanded uncertainty of calibration (k=2) is 0.7 % for the calibration result.

For phosphate standard, "potassium dihydrogen phosphate anhydrous 99.995 suprapur®" provided by Merck, Lot. B0691108204, CAS No.: 7778-77-0, was used.

For the silicate standard, we use "Silicon standard solution SiO_2 in NaOH 0.5 mol/l CertiPUR®" provided by Merck, CAS No.: 1310-73-2, of which lot number is HC54715536 are used. The silicate concentration is certified by NIST-SRM3150 with the uncertainty of 0.5 %. HC54715536 is certified as 1001 mg L^{-1}.

Ultra pure water (Milli-Q) freshly drawn was used for preparation of reagent, standard solutions and for measurement of reagent and system blanks.

Concentrations of nutrients for A, B and C standards

Concentrations of nutrients for A, B and C standards (working standards) were set as shown in Table 5.19.1 Then the actual concentration of nutrients in each fresh standard was calculated based on the ambient temperature, solution temperature and determined factors of volumetric laboratory wares.

The calibration curves for each run were obtained using 4 levels working standards, C-1, C-2, C-3, and C-4.

Table 5.19.1 Nominal concentrations of nutrients for A, B and C standards.

	A	B	C-1	C-2	C-3	C-4
Nitrate (µmol/l)	22500	770	0.02	13.96	27.96	42.85
Nitrite (µmol/l)	22000	26	0.02	0.53	1.05	1.57
Silicate (µmol/l)	36000	1430	0.68	29.15	57.65	86.05
Phosphate (µmol/l)	3000	60	0.027	1.223	2.420	3.612

c. Sampling Procedures

Sampling of nutrients followed that of oxygen. Samples were drawn into two of virgin 10 ml polyacrylates vials without sample drawing tubes. These were rinsed three times before filling and vials were capped immediately after the drawing. The vials were put into water bath adjusted to ambient temperature, 22 ± 1 deg. C, in about 30 minutes before use to stabilize the temperature of samples. The samples of bottle 16 (or 15 at deep cast), and 22 (or 21, 20) were measured in replicate and the rest were measured in single on each sample run.

No transfer was made and the vials were set an auto sampler tray directly. All the samples put into aluminum bag were stored in iced water to avoid concentration change of nutrients and analyzed after collection basically within 48 hours. The samples collected at STNM171-195 were analyzed after collection within 24 hours, as nitrite concentration of some samples stored for 2days decreased from initial concentration by more than 10% maybe due to biological activity.

Sets of 4 different concentrations for nitrate, nitrite, silicate, phosphate of the shipboard standards were analyzed at beginning and end of each group of analysis. The standard solutions of highest concentration were measured every 14 - 15 samples and were used to evaluate precision of nutrients analysis during the cruise. We also used reference material for nutrients in seawater, RMNS (KANSO Co., Ltd., Lot CA), for every 2 runs to secure comparability on nutrient analysis throughout the cruise. We used same serial RMNS for 4 days.

d. Low Nutrients Sea Water (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.20 µm pore size membrane filter at MR14-06 cruise on November, 2014. This water is stored in 20 liter cubitainer with paper box.

We put 800 liter LNSW into gather the 1000 liter plastic bag (SHOWA PAXXS), which was pasteurized at 70 deg. C, in the Tank (S-CUBE). Filtering with 0.20 µm/0.45 µm pore size membrane filter, we've sterilized UV ray to LNSW for 36 hours used by "Onboard UV sterilization system." After that, LNSW was stored in 20 liter cubitainer with paper box again. LNSW' concentrations were assigned to August, 2015 on MR15-03 cruise.

(4) Results

We made 16 QuAAtro runs for the water columns sample at 107 casts during MR15-04 (9cast in line observation, 98cast in fixed point observation). The total amount of layers of the seawater sample reached up to 1430. We made basically single measurement. The station locations for nutrients measurement is shown in Figure 5.19.1.

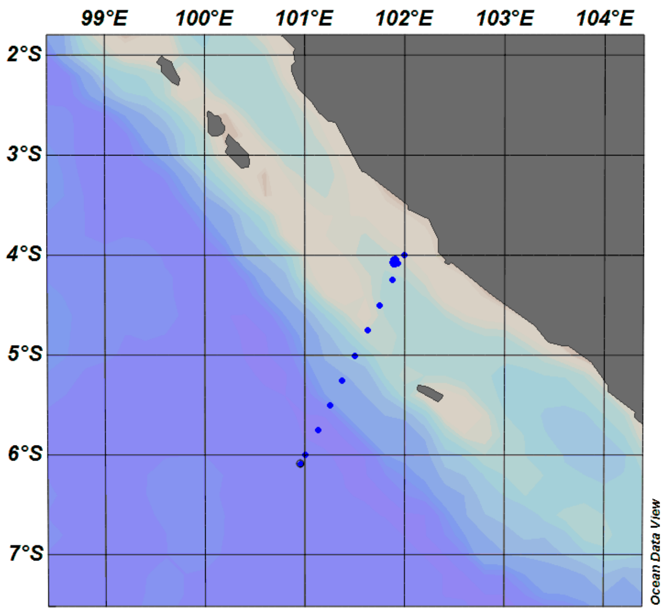

Figure 5.19.1 Sampling positions of nutrients sample.

Time-series profile for each nutrient at fixed point is shown in figure 5.19.2-5.19.5.

Analytical precisions in this cruise were 0.08% for nitrate, 0.18% for nitrite, 0.11% for silicate, 0.14% for phosphate in terms of median of precision, respectively. Results of analytical precisions for nitrate, nitrite, silicate and phosphate are shown in Table 5.19.2 for the cast's comparability.

Results of RMNS analysis are shown in Table 5.19.3 for the cast's comparability.

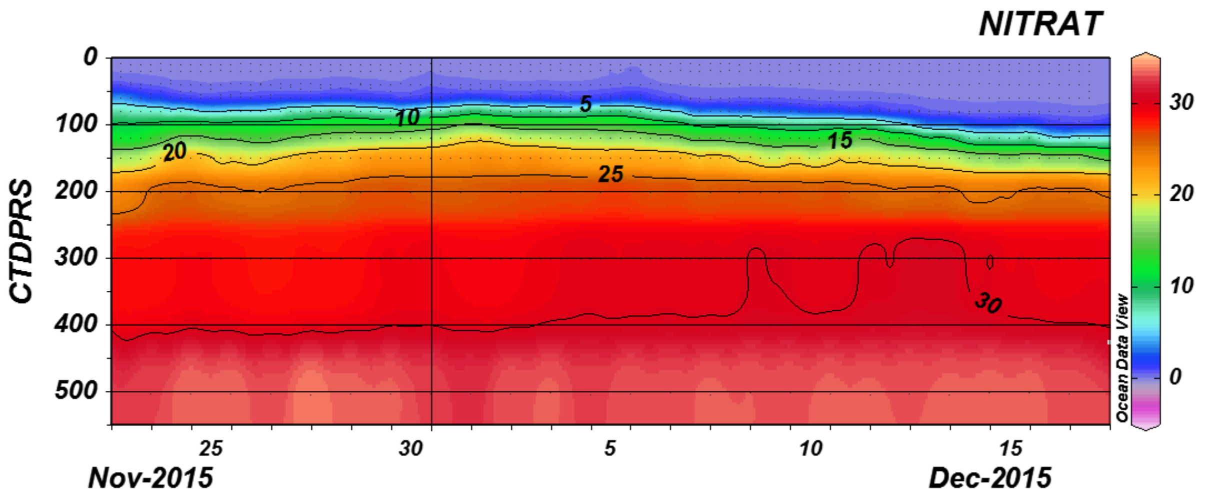

Figure 5.19.2 Time-series profile of nitrate

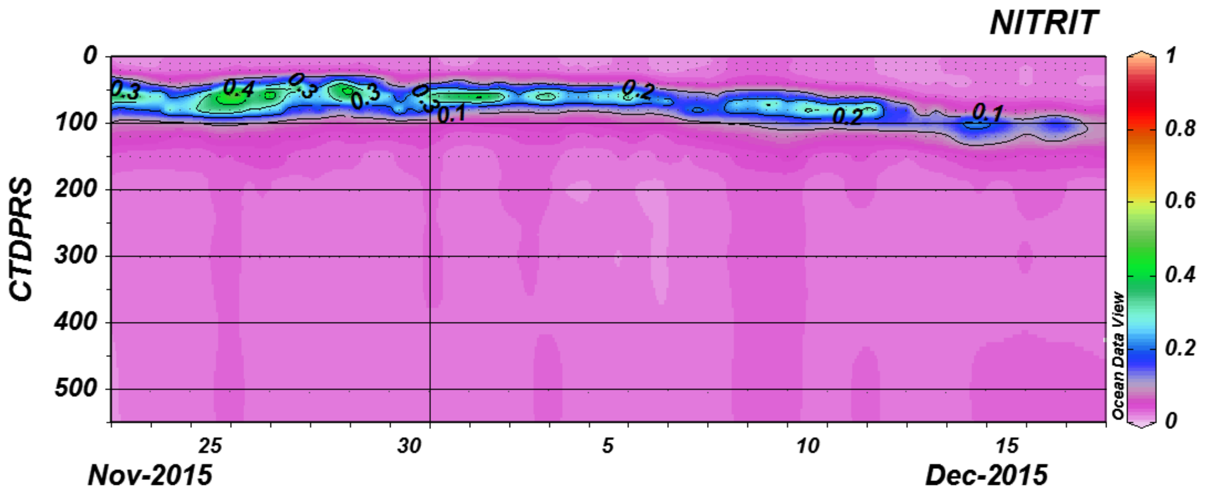

Figure 5.19.3 Time-series profile of nitrite

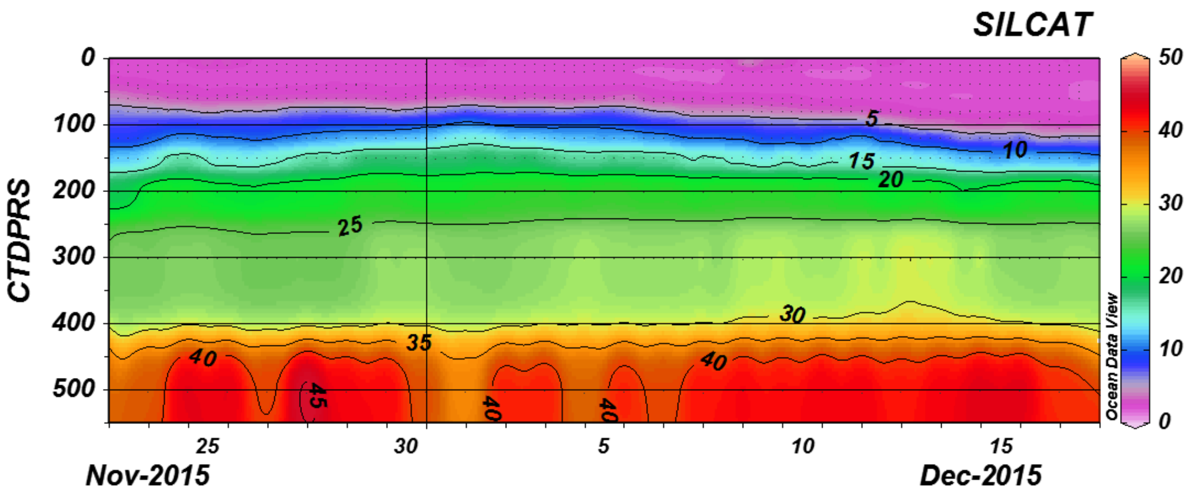

Figure 5.19.4 Time-series profile of silicate

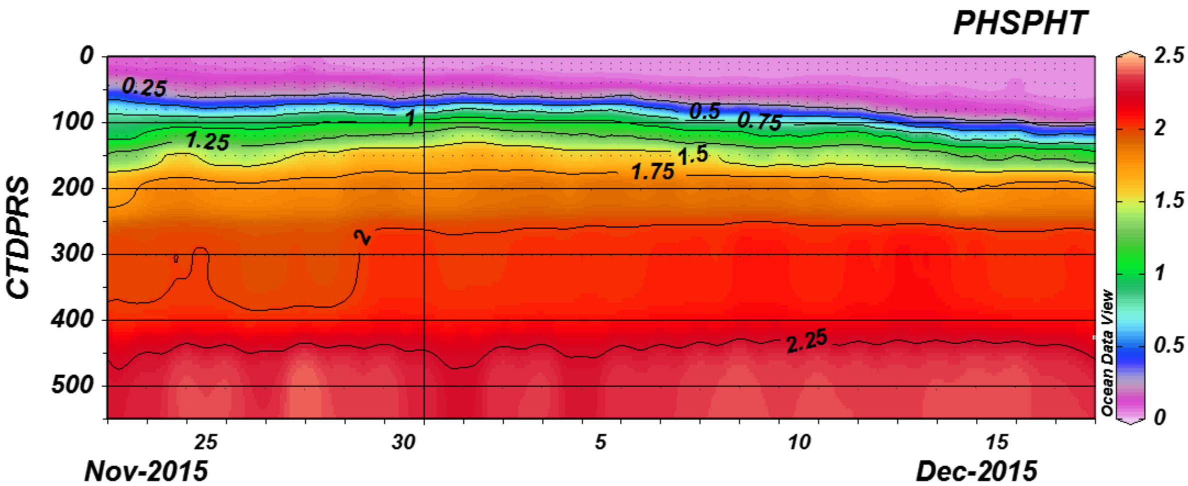

Figure 5.19.5 Time-series profile of phosphate

Table 5.19.2 Summary of precision based on the analyses

	Nitrate CV %	Nitrite CV %	Silicate CV %	Phosphate CV %
Median	0.08	0.18	0.11	0.14
Mean	0.08	0.18	0.11	0.14
Maximum	0.17	0.35	0.17	0.24
Minimum	0.03	0.10	0.05	0.05
N	16	16	16	16

Table 5.19.3 Results of RMNS Lot CA analysis in this cruise

Date(UTC)	Serial	Station	Nitrate µmol/kg)	Nitrite µmol/kg)	Silicate µmol/kg)	Phosphate µmol/kg)
22 Nov	0438	L02,L05,L08,L11,L14,L17	19.65	0.07	36.59	1.414
24 Nov	0438	L20,L23,L26,001,003,005,007,009	19.64	0.07	36.60	1.407
26 Nov	1245	011,013,015,017,019,021,023,025	19.62	0.07	36.61	1.413
28 Nov	1245	027,029,031,033,035,037,039,041	19.66	0.07	36.62	1.405
30 Nov	0616	043,045,047,049,051,053,055,057	19.62	0.07	36.59	1.41
3 Dec	1612	059,061,063,065,067,069,071,073	19.67	0.07	36.62	1.414
4 Dec	0290	075,077,079,081,083,085,087,089	19.63	0.07	36.59	1.41
6 Dec	0290	091,093,095,097,099,101,103,105	19.62	0.07	36.56	1.404
8 Dec	0204	107,109,111,113,115,117,119,121	19.65	0.07	36.65	1.418
10 Dec	0204	123,125,127,129,131,133,135,137	19.64	0.07	36.58	1.415
12 Dec	0818	139,141,143,145,147,149,151,153	19.62	0.08	36.60	1.413
14 Dec	0818	155,157,159,161,163,165,167,169	19.63	0.07	36.56	1.417
15 Dec	0818	171,173,175,177	19.64	0.07	36.55	1.412
16 Dec	2297	179,181,183,185	19.61	0.07	36.57	1.406
17 Dec	2297	187,189,191	19.58	0.07	36.57	1.405
17 Dec	2297	193,195	19.57	0.07	36.58	1.414
		Average	19.63	0.07	36.59	1.411
		S.D.	±0.03	±0.00	±0.03	±0.004

(5) Data Archive

These data obtained in this cruise will be submitted to the Data Management Office (DMO) of JAMSTEC, and will be opened to public via JAMSTEC web site.

(6) Reference

Grasshoff, K. (1970), Technicon paper, 691-57.

Grasshoff, K., Ehrhardt, M., Kremling K. et al. (1983), Methods of seawater analysis. 2nd rev. Weinheim: Verlag Chemie, Germany, West.

Kawano, T., Uchida, H. and Doi, T. WHP P01, P14 REVISIT DATA BOOK, (Ryoin Co., Ltd., Yokohama, 2009).

Murphy, J., and Riley, J.P. (1962), Analytica chim. Acta 27, 31-36.

5.20 Chlorophyll *a* of sampled water

(1) Personnel

Masaki Katsumata (JAMSTEC) - Principal Investigator
Misato Kuwahara (MWJ) - Operation Leader
Haruka Tamada (MWJ)

(2) Objective

We measured total chlorophyll *a and* size-fractionated chlorophyll *a* in seawater by using the fluorometric method.

(3) Instruments and methods

We collected samples for total chlorophyll *a* (chl-*a*) from 11 depths and size-fractionated chl-*a* from 11 depths between the surface and 200 m depth including a chl-*a* maxmum layer. The chl-*a* maximum layer was determined by a fluorometer (Seapoint Sensors, Inc.) attached to the CTD system.

Water samples for total chl-*a* were vacuum-filtrated (<0.02MPa) through 25mm-diameter Whatman GF/F filter. 10µm, 3µm and 1µm pore-size nuclepore filters (47 mm in diameter), and Whatman GF/F filter (25 mm in diameter) under gentle vacuum (<0.02MPa). Phytoplankton ipigments retained on the filters were immediately extracted in a polypropylene tube with 7 ml of N,N-dimethylformamide. The tubes were stored at –20°C under the dark condition to extract chl-*a* at least for 24 hours.

Fluorescences of each sample were measured by Turner Design fluorometer (10-AU-005), which was calibrated against a pure chl-*a* (Sigma chemical Co.). We applied fluorometric determination for the samples of chl-*a* "Non-acidification method" (Welschmeyer, 1994). Analytical conditions of this method were listed in Table 5.20-1.

(4) Station list

Samples for total and size-fractionated chl-*a* were collected at 10 Station and 107 casts. Samples for size-fractionated chl-*a* were collected at 1 Station and 8 casts. The numbers of samples for total and size-fractionated chl-*a* were 1284 and 352, respectively.

(5) Preliminary results

Time-series profile for chl-*a* fixed point is shown in figure 5.20-1.

At each station, water samples were taken in replicate for water of chl-*a* maximum layer. The relative error was 2 % (n = 107).

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Office (DMO) of JAMSTEC, and will be opened to public via JAMSTEC web site.

(7) Reference

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

Table 5.20-1. Analytical conditions of non-acidification method for chlorophyll *a* with Turner Design fluorometer (10-AU-005).

	Non-acidification method
Excitation filter (nm)	436
Emission filter (nm)	680
Lamp	Blue F4T5,B2/BP

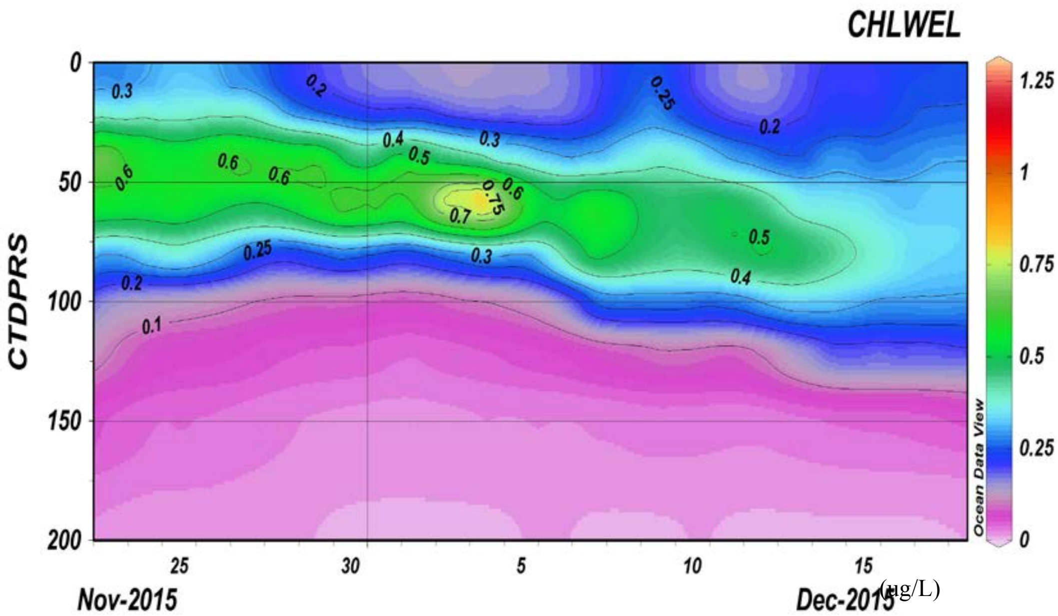

Figure 5.20-1 Time-series profile of chlorophyll *a*

5.21 HPLC

(1) Personnel

Masaki KATSUMATA	(JAMSTEC)	Principal Investigator
Hiroshi HOSHINO	(MWJ)	Operation Leader
Atsushi ONO	(MWJ)	

(2) Objective

The chemotaxonomic assessment of phytoplankton populations present in natural seawater requires taxon-specific algal pigments as good biochemical markers. A high-performance liquid chromatography (HPLC) measurement is an optimum method for separating and quantifying phytoplankton pigments in natural seawater. In this cruise, we measured the marine phytoplankton pigments by HPLC to investigate the marine phytoplankton community structure.

(3) Methods, Apparatus and Performance

Seawater samples were collected from 11 depths between the surface and 200 m. Seawater samples were collected using Niskin bottles, except for the surface water, which was taken by a bucket. For the total phytoplankton pigment measurements, 2L of seawater samples were filtered (<0.02 MPa) through the 47-mm diameter Whatman GF/F filter. For the size fractionated phytoplankton pigment measurements, 3 L of seawater samples were filtered by the 1, 3 or 10 μm pore size of nuclepore filters prior to the GF/F filter. To remove retaining seawater in the sample filters, GF/F filters were vacuum-dried in a freezer (0 °C) within 13.5 hours. Subsequently, phytoplankton pigments retained on a filter were extracted in a glass tube with 4 ml of N,N-dimethylformamide (HPLC-grade) for at least 24 hours in a freezer (-20 °C), and analyzed by HPLC within a few days.

Residua cells and filter debris were removed through PTFE syringe filter (pore size: 0.2 μm) before the analysis. The samples injection of 500 μl was conducted by auto-sampler with the mixture of extracted pigments (350 μl), pure water (150 μl) and internal standard (10 μl). Phytoplankton pigments were quantified based on C_8 column method containing pyridine in the mobile phase (Zapata *et al*., 2000).

(i) HPLC System

HPLC System was composed by Agilent 1200 modular system, G1311A Quaternary pump (low-pressure mixing system), G1329A auto-sampler and G1315D photodiode array detector.

(ii) Stationary phase

Analytical separation was performed using a YMC C_8 column (150×4.6 mm). The column was thermostatted at 35 °C in the column heater box.

(iii) Mobile phases

The eluant A was a mixture of methanol: acetonitrile: aqueous pyridine solution (0.25M pyridine), (50:25:25, v:v:v). The eluant B was a mixture of methanol: acetonitrile: acetone (20:60:20, v:v:v). Organic solvents for mobile phases were used reagents of HPLC-grade.

(iv) Calibrations

HPLC was calibrated using the standard pigments (Table 5.21-1).

(v) Internal standard

Ethyl-apo-8’-carotenoate was added into the samples prior to the injection as the internal standard. The mean chromatogram area and coefficient of variation (CV) of internal standard were estimated as the following two samples:

Standard samples: 186.4 ± 3.4 (n = 50), CV=1.8%
Seawater samples: 186.6 ± 2.5 (n = 84), CV=1.4%

(vi) Pigment detection and identification

Chlorophylls and carotenoids were detected by photodiode array spectroscopy (350~800 nm). Pigment concentrations were calculated from the chromatogram area at different five channels (Table 5.21-1). First channel was allocated at 409 nm of wavelength for the absorption maximum of Pheophorbide a and Pheophytin a. Second channel was allocated at 431 nm for the absorption maximum of chlorophyll *a*. Third channel was allocated at 440 nm for the absorption maximum of [3,8-divinyl]-protochlorophyllide. Fourth channel was allocated at 450 nm for other pigments. Fifth channel was allocated at 462 nm for chlorophyll *b*.

(4) Preliminary results

Almost data are under the processing. Vertical profiles of major pigments (Chlorophyll *a*, Chlorophyll *b*, Divinyl Chlorophyll *a,* and Zeaxanthin) at stations from L02 to L26 were shown in Figure 5.21-1 and 5.21-2.

(5) Data archives

The processed data file of pigments will be submitted to the JAMSTEC Data Management Office (DMO) within a restricted period. Please ask PI for the latest information.

(6) Reference

Zapata M, Rodriguez F, Garrido JL (2000), Separation of chlorophylls and carotenoids from marine phytoplankton: a new HPLC method using a reversed phase C_8 column and pyridine-containing mobile phases, *Mar. Ecol. Prog. Ser.,* 195, 29-45.

Table 5.21-1 Wavelength of identification for pigment standards.

No.	Pigment	Productions	Wavelength of identification (nm)
1	Chlorophyll *c3*	DHI Co.	462
2	Chlorophyllide *a*	DHI Co.	431
3	[3,8-Divinyl]-Protochlorophyllide	DHI Co.	440
4	Chlorophyll *c2*	DHI Co.	450
5	Peridinin	DHI Co.	462
6	Pheophorbide *a*	DHI Co.	409
7	19'-butanoyloxyfucoxanthin	DHI Co.	450
8	Fucoxanthin	DHI Co.	450
9	Neoxanthin	DHI Co.	440
10	Prasinoxanthin	DHI Co.	450
11	19'-hexanoyloxyfucoxanthin	DHI Co.	450
12	Violaxanthin	DHI Co.	440
13	Diadinoxanthin	DHI Co.	450
14	Dinoxanthin	DHI Co.	440
15	Alloxanthin	DHI Co.	450
17	Diatoxanthin	DHI Co.	450
18	Zeaxanthin	DHI Co.	450
19	Lutein	DHI Co.	450
20	Ethyl-apo-8’-carotenoate	Sigma-Aldrich Co.	462
21	Chlorophyll *b*	DHI Co.	462
22	Divinyl Chlorophyll *a*	DHI Co.	440
23	Chlorophyll *a*	Sigma-Aldrich Co.	431
24	Pheophytin a	DHI Co.	409
25	Alpha-carotene	DHI Co.	450
26	Beta-carotene	DHI Co.	450

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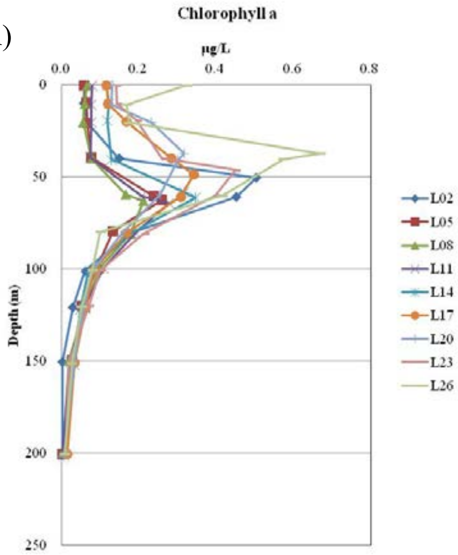
(A)



(B)

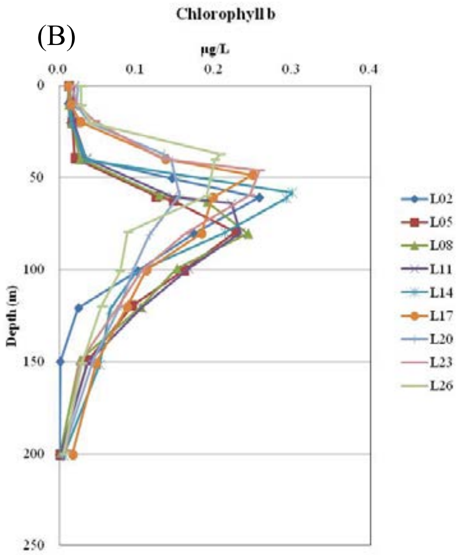
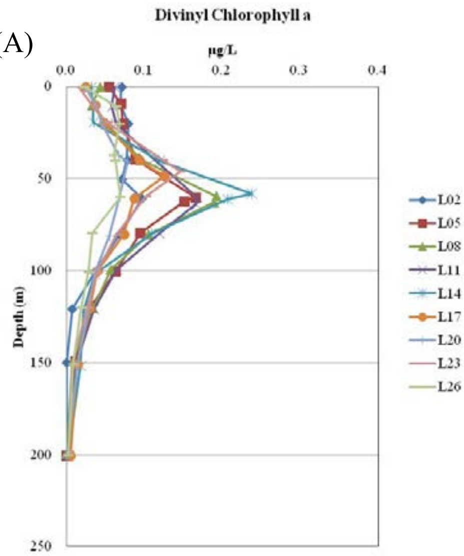


Figure 5.21-1-(A). Vertical distributions of Chlorophyll *a* at stations from L02 to L26.

Figure 5.21-1-(B). Vertical distributions of Chlorophyll *b* at stations from L02 to L26.

(A)



(B)

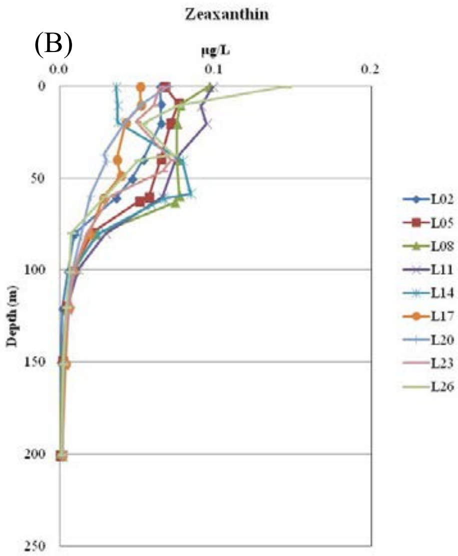


Figure 5.21-2-(A). Vertical distributions of Divinyl Chlorophyll *a* at stations from L02 to L26.

Figure 5.21-2-(B). Vertical distributions of Zeaxanthin at stations from L02 to L26.

5.22 LADCP

(1) Personnel

Masaki Katsumata	(JAMSTEC)	Principal investigator
Tomohide Noguchi	(MWJ)	Operation leader
Kenichi Katayama	(MWJ)	
Masaki Furuhata	(MWJ)	
Katsumi Kotera	(MWJ)	
Rei Ito	(MWJ)	
Keisuke Takeda	(MWJ)	

(2) Objectives

To obtain horizontal current velocity in high vertical resolution.

(3) Methods

In order to measure the velocity structure at fine vertical scales a high frequency ADCP was used in lowered mode (LADCP). The instrument was a Teledyne RDI Workhorse Sentinel 600kHz ADCP rated for 1000m depth.

The instrument was attached to the frame of the CTD system using a steel collar sealed around the instrument by three bolts on each side, with the collar attached to the rosette frame by two u-bolts on two mounting points (see Figure 5.22-1).

The instrument was deployed on all CTD stations in the tropics, performing well throughout its use. The instrument is self-contained with an internal battery pack. The health of the battery is monitored by the recorded voltage count.

Figure 5.22-1:Mounting of LADCP on CTD System

The instrument was controlled at deploy and recover stages by the RDI software (BBTalk) installed on the Windows PC. The commands sent to the instrument at setup were contained in ladcp600.cmd. The instrument was set up to have a relatively small bin depth (2m) and a fast ping rate (every 0.25 sec). The full list of commands sent to the instrument were:

CR1 # Retrieve parameter (default)
TC2 # Ensemble per burst
WP1 # Pings per ensemble
TE 00:00:00.00 # Time per ensemble (time between data collection cycles)
TP 00:00.25 # Time between pings in mm:ss
WN25 # Number of Depth cells
WS0200 # Depth cell size (in cm)
WF0088 # Blank after transit (recommended setting for 600kHz)
WB0 # Mode 1 bandwidth control (default - wide)
WV250 # Ambiguity velocity (in cm/s)
EZ0111101 # Sensor source (speed of sound excluded)
EX00000 # Beam coordinates
CF11101 # Data flow control parameters

(see the RDI Workhorse "Commands and Data Output Format" document for details.)

(4) Preliminary results

During the cruise, 221 profiles were obtained in total, including fixed point measurement and line measurement. All the data has to be converted and quality-controlled before the analyses. The further analyses will be in near future.

(5) Data archive

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

5.23 Microstructure profiler (MSP) for the ocean

(1) Personnel

MOTEKI Qoosaku	(JAMSTEC)	- Principle Investigator
YOSHIDA Kazuho	(GODI)	- Operation Leader
SUEYOSHI Soichiro	(GODI)	
OKUMURA Satoshi	(GODI)	
MORIOKA Miki	(GODI)	

(2) Objectives

To obtain oceanic vertical profiles of the dissipation rate of turbulent kinematic energy, as well as dissipation rate of temperature variance, turbulent mixing rate of substances, etc.

(3) Methods

The instrument in this observation consists of sensor unit "TurboMAP-L" (manufactured by JFE Advantech Inc., serial no. 34) and the software "TMtools" (ver. 3.04D) on PC to monitor, record and process the data. The probes on the TurboMAP sensor unit are as follows:

- Vertical shear of the horizontal current speed (two sensors, 512 Hz)
- Fast thermistor temperature "FPO-7" (512Hz)
- Slow response temperature (64Hz)
- Conductivity (64Hz)
- Pressure (64Hz)
- Acceleration in X, Y and Z dimensions (256Hz for horizontal, 64Hz for vertical)
- Fluorescence (256Hz) (*see (6)Remarks)
- Turbidity (256Hz)

These parameters were obtained during the sensor descends without artificial accelerations (i.e. "free fall"). The obtained data was monitored and stored in the PC on the vessel in real-time. The instruments were operated to obtain profiles down to 300m depth (see (6) Remarks for exceptions). To do it by minimized time consumption, the cable between PC and the sensor unit were deployed until the sensor unit reached 260-m depth, and then started winding up when sensor reached 300-m depth. The data was recorded until the sensor stopped its free-fall (i.e. falling speed start decreasing).

All profiles were obtained at (4-04S, 101-54E). The observations were conducted once per day during the stationary observation period (23 November, 2015 – 17 December, 2015) at 09UTC. For the days of 30 November, 1, 2, 5, 6, 7, December, the observations of 4 times per day were conducted for measuring the variation by the oceanic tide. Each profile was obtained sequentially, while one or several profiles were obtained occasionally. As in Table 5.20-1, 874 profiles were obtained in total during the present cruise.

(4) Preliminary Results

Figure 5.23-1 is the time-depth cross section of the dissipation rate of kinematic energy (epsilon). The high epsilon values are generally found in the layer above 300 m depth before the neap tide and the epsilon values are clearly decreased after the neap tide on 9 December. After 14 December, the epsilon values are rapidly increased in the layer above 100 m with significant westerly burst after the passage of the MJO. The further detailed analyses will be in near future.

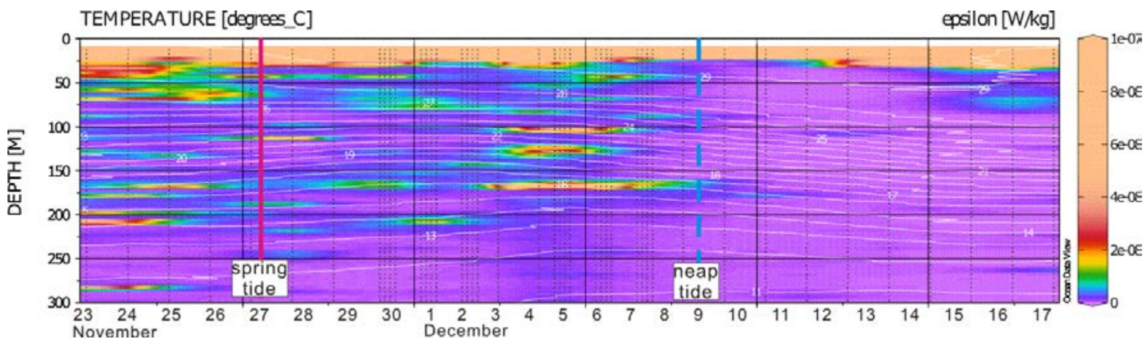


Fig.5.23-1: Time-depth cross section of the dissipation ratio of the kinematic energy from 23 November to 17 December, 2015. The spring and neap tide dates on 27 November and 9 December are indicated by red solid and blue dashed lines, respectively.

(5) Data archive

All corrected data during this cruise will be available at pre-YMC website.

(6) Remarks

a) Data from fluorescence sensor is not valid for all profiles because the sensor was covered by black tape to prevent the light going out. This was to reduce the risk of accidents due to oceanic creatures which may attracted by the light from the fluorescence sensor.
b) Data from secondary sensor were continuously noisy.

Table 5.23-1 List of the MSP

No.	Date [YYYY/MM/DD]	Latitude [deg-min]	Longitude [deg-min]	Logging Time		Depth [m]	Observation Depth[m]	Wire Length [m]	File name	Sensor S/N		
				Start	Stop					FPO7	Shear 1	Shear 2
01	2015/11/23	04-04.8407S	101-54.3894E	8:57	9:09	741	370	470	MR1504-1.BIN	229	922	877
02	2015/11/24	04-03.2090S	101-53.5227E	8:56	9:08	680	416	450	MR1504-2.BIN	229	922	877
03	2015/11/25	04-03.5078S	101-54.2019E	8:57	9:07	640	339	520	MR1504-3.BIN	229	922	1341
04	2015/11/26	04-04.1743S	101-54.0933E	8:55	9:06	668	339	560	MR1504-4.BIN	229	1341	922
05	2015/11/27	04-04.0707S	101-54.2110E	8:55	9:06	656	346	530	MR1504-5.BIN	229	922	877
06	2015/11/28	04-03.3505S	101-53.4121E	8:56	9:06	699	334	470	MR1504-6.BIN	229	922	877
07	2015/11/29	04-03.6668S	101-53.6051E	8:57	9:08	690	339	490	MR1504-7.BIN	229	922	877
08	2015/11/29	04-04.1339S	101-53.8427E	12:09	12:21	683	391	520	MR1504-8.BIN	229	922	877
09	2015/11/30	04-05.4295S	101-53.9504E	14:59	15:10	735	375	460	MR1504-9.BIN	229	922	877
10	2015/11/30	04-04.4577S	101-53.4807E	18:12	18:22	738	340	540	MR1504-10.BIN	229	922	877
11	2015/11/30	04-05.0786S	101-53.1469E	21:02	21:14	771	334	530	MR1504_11.BIN	229	922	877
12	2015/12/01	04-04.1809S	101-52.8788E	12:10	12:20	762	356	480	MR1504_12.BIN	229	922	877
13	2015/12/01	04-04.3547S	101-52.8995E	14:53	15:04	708	375	480	MR1504_13.BIN	229	922	877
14	2015/12/01	04-02.7709S	101-53.5543E	18:14	18:25	721	357	510	MR1504_14.BIN	229	922	877
15	2015/12/01	04-03.9052S	101-53.8567E	21:04	21:13	685	310	400	MR1504_15.BIN	229	922	877
16	2015/12/01	04-04.0860S	101-53.8996E	21:21	21:30	685	340	520	MR1504_16.BIN	229	922	877
17	2015/12/02	04-03.9202S	101-53.1412E	12:12	12:23	738	384	500	MR1504_17.BIN	229	922	877
18	2015/12/02	04-04.0663S	101-54.1704E	14:57	15:07	657	337	490	MR1504_18.BIN	229	922	877
19	2015/12/02	04-02.9847S	101-53.9650E	18:15	18:26	646	360	500	MR1504_19.BIN	229	922	877
20	2015/12/02	04-03.7156S	101-54.2347E	21:01	21:12	664	389	530	MR1504_20.BIN	229	922	877
21	2015/12/03	04-03.2711S	101-54.6225E	9:01	9:11	603	348	500	MR1504_21.BIN	229	922	877

22	2015/12/04	04-04.3187S	101-53.7072E	9:00	9:09	707	344	490	MR1504_22.BIN	229	922	877
23	2015/12/05	04-04.1550S	101-52.6769E	6:12	6:23	776	350	510	MR1504_23.BIN	229	922	877
24	2015/12/05	04-04.3267S	101-52.7369E	6:31	6:40	770	350	505	MR1504_24.BIN	229	922	877
25	2015/12/05	04-03.8313S	101-53.8367E	8:57	9:08	693	361	500	MR1504_25.BIN	229	1341	877
26	2015/12/05	04-03.9520S	101-53.6944E	12:09	12:21	697	370	480	MR1504_26.BIN	229	1341	877
27	2015/12/05	04-04.2912S	101-53.7279E	14:53	15:04	704	366	460	MR1504_27.BIN	229	1341	877
28	2015/12/06	04-04.6886S	101-53.5464E	6:10	6:21	762	395	510	MR1504_28.BIN	229	922	877
29	2015/12/06	04-03.6474S	101-54.0389E	8:56	9:07	657	365	450	MR1504_29.BIN	229	922	877
30	2015/12/06	04-03.3086S	101-53.2475E	12:10	12:22	746	404	500	MR1504_30.BIN	229	922	877
31	2015/12/06	04-03.9188S	101-53.7395E	14:58	15:08	693	317	430	MR1504_31.BIN	229	922	877
32	2015/12/07	04-03.8853S	101-53.2346E	6:17	6:29	729	400	480	MR1504_32.BIN	229	922	877
33	2015/12/07	04-05.1553S	101-53.0078E	8:56	9:07	789	370	510	MR1504_33.BIN	229	922	877
34	2015/12/07	04-04.6517S	101-53.3601E	12:09	12:19	795	338	470	MR1504_34.BIN	229	922	877
35	2015/12/07	04-03.9566S	101-53.1911E	14:56	15:07	731	358	500	MR1504_35.BIN	229	922	877
36	2015/12/08	04-05.1944S	101-538544E	8:56	9:06		333	510	MR1504_36.BIN	229	922	1341
37	2015/12/09	04-05.1599S	101-53.1758E	8:56	9:06	776	334	480	MR1504_37.BIN	229	922	1341
38	2015/12/10	04-05.1599S	101-53.1758E	8:55	9:06	781	366	480	MR1504_38.BIN	229	922	1341
39	2015/12/11	04-04.8953S	101-52.7958E	8:55	9:06	845	345	480	MR1504_39.BIN	229	922	1341
40	2015/12/11	04-05.0372S	101-52.8502E	9:13	9:22	-	341	480	MR1504_40.BIN	229	922	1341
41	2015/12/12	04-03.9730S	101-53.7939E	8:56	9:07	690	351	570	MR1504_41.BIN	229	922	1341
42	2015/12/13	04-03.2610S	101-54.3169E	8:58	9:09	625	341	530	MR1504_42.BIN	229	922	1341
43	2015/12/14	04-03.3003S	101-53.8005E	8:54	9:06	663	330	530	MR1504_43.BIN	229	922	1341
44	2015/12/15	04-04.4987S	101-53.7484E	8:55	9:05	663	334	540	MR1504_44.BIN	229	922	1341
45	2015/12/16	04-03.9777S	101-54.2591E	8:53	9:05	647	324	550	MR1504_45.BIN	229	922	1341
46	2015/12/17	04-03.7374S	101-53.1189E	8:55	9:05	739	336	570	MR1504_46.BIN	229	922	1341

5.24 Underway CTD

(1) Personnel

Masaki Katsumata	(JAMSTEC)	- Principal investigator
Kyoko Taniguchi	(JAMSTEC)	
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Kenichi Katayama	(MWJ)	
Masaki Furuhata	(MWJ)	
Katsumi Kotera	(MWJ)	
Rei Ito	(MWJ)	
Keisuke Takeda	(MWJ)	

(2) Objective

The “Underway CTD” (UCTD) system measures vertical profiles of temperature, conductivity and pressure like traditional CTD system. The advantage of the UCTD system is to obtain good-quality CTD profiles from moving vessels with repeatable operation. In addition, the UCTD data are more accurate than those from XCTD because the sensor of the UCTD is basically same as that used in the traditional CTD system.

The purpose of UCTD observation in this cruise is to explore oceanic structure of temperature and salinity at the Makassar Strait, Lombok Strait and offshore Sumatran. The station locations is shown in Figure 5.24-1.

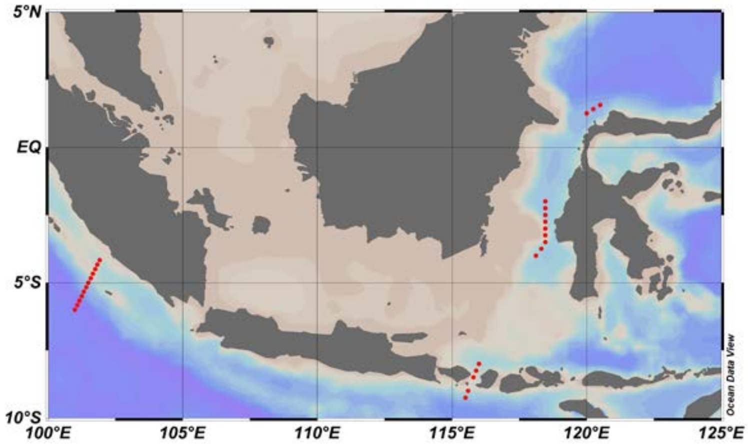

Figure 5.24-1:Research area of MR15-04

(3) Methods

The UCTD system, manufactured by Oceanscience Group, was utilized in this cruise. The system consists of the probe unit and on-deck unit with the winch and the rewinder, as in Figure 5.24-2. After spooling the line for certain length onto the probe unit (in “tail spool” part), the probe unit is released from the vessels in to the ocean, and then measure temperature, conductivity, and pressure during its free-fall with speed of roughly 4 m/s in the ocean. The probe unit is physically connected to the winch on the vessel by line. Releasing the line from the tail spool ensure the probe unit to be fall without physical forcing by the movement of vessel. After the probe unit reaches the deepest layer for observation, it is recovered by using the winch on the vessel. The observed data are stored in the memory within the probe unit. The dataset can be downloaded into PCs via Bluetooth communication on the deck.

The specifications of the sensors are listed in Table 5.24-1. The UCTD system used in this cruise can observe temperature, conductivity and pressure from surface to 1000 m depth with 16 Hz sampling rate.

During the profiling, the vessel can be cruised (straight line recommended). The manufacturer recommends the maximum speed of the vessel during the profiling as in Table 5.24-2.

Table 5.24-1:Specification of the sensors of the UCTD system in this cruise.

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

Table 5.24-2:Maximum depth and speed of the vessel during profile.

Maximum depth to profile	Maximum ship speed (knot)
0 to 350 m	13
350 to 400 m	12
400 to 450 m	11
450 to 500 m	10
500 to 550 m	8
550 to 600 m	6
600 to 650 m	4
650 to 1000 m	2

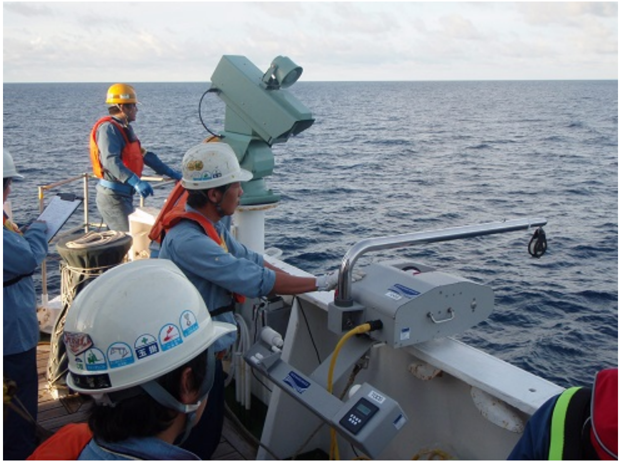

Figure 5.24-2:UCTD system installed and operated on R/V Mirai.

(4) Preliminary Results

During this cruise, 30 casts of UCTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 5.24-3.

Vertical profiles (down cast) of temperature, conductivity, salinity with descent rate are shown in Figure 5.24-3－5.24-7. Unfortunately, the data of station MKS04 was not stored in the memory within the probe unit.

(5) Data archive

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

Table 5.24-3: List of UCTD stations during MR15-04 cruise.

Station Number	Cast Number	Time Towed (UTC)	Position Towed		Depth to go (m)	Ship speed (knot)		S/N of sensor	Notes
			Lat. (deg-min)	Lon. (deg-min)		Tow	Recovery		
MKS01	1	Nov.16 04:56	01-33.54N	120-29.99E	250	11.0	11.0	0236	
MKS02	1	Nov.16 06:16	01-24.49N	120-15.01E	250	11.2	11.2	0236	
MKS03	1	Nov.16 07:31	01-15.30N	120-00.01E	250	11.2	11.1	0236	
MKS04	1	Nov.16 08:49	01-06.14N	119-44.99E	385	11.3	11.3	0236	Not logging data
MKS13	1	Nov.16 21:50	02-00.02S	118-27.99E	385	11.7	11.6	0236	
MKS14	1	Nov.16 22:54	02-15.03S	118-27.99E	335	11.5	11.3	0236	
MKS15	1	Nov.16 23:57	02-30.02S	118-28.09E	335	12.0	11.8	0257	
MKS16	1	Nov.17 00:59	02-45.00S	118-28.00E	335	11.5	11.4	0236	
MKS17	1	Nov.17 02:00	03-00.03S	118-27.98E	335	11.4	11.3	0257	
MKS18	1	Nov.17 02:58	03-15.02S	118-28.00E	335	10.9	10.8	0236	
MKS19	1	Nov.17 04:00	03-29.98S	118-28.00E	335	10.9	10.8	0257	
MKS20	1	Nov.17 05:19	03-45.00S	118-19.19E	335	10.9	10.9	0236	
MKS21	1	Nov.17 06:43	04-00.00S	118-07.05E	335	10.4	10.4	0257	
LBK01	1	Nov.18 01:09	08-00.01S	115-59.99E	335	10.8	10.8	0236	
LBK02	1	Nov.18 02:33	08-15.01S	115-54.01E	335	11.5	11.3	0257	
LBK03	1	Nov.18 03:26	08-30.01S	115-48.02E	335	10.0	10.0	0236	
LBK05	1	Nov.18 05:36	09-00.00S	115-35.93E	335	11.2	11.3	0257	
LBK06	1	Nov.18 06:44	09-15.01S	115-29.89E	335	10.9	10.9	0236	
L24	1	Dec.17 14:01	04-10.02S	101-54.96E	335	10.9	10.4	0236	
L22	1	Dec.17 15:03	04-20.01S	101-50.02E	335	10.3	10.3	0257	
L20	1	Dec.17 16:01	04-30.02S	101-44.96E	335	10.3	10.1	0236	
L18	1	Dec.17 17:00	04-40.00S	101-39.98E	335	10.4	10.6	0257	
L16	1	Dec.17 18:09	04-49.99S	101-35.00E	335	11.0	11.0	0236	
L14	1	Dec.17 19:05	04-59.99S	101-30.00E	335	10.8	10.5	0257	

L12	1	Dec.17 20:01	05-09.81S	101-25.00E	335	11.0	10.4	0236	
L10	1	Dec.17 20:57	05-19.98S	101-20.00E	335	11.2	10.4	0257	
L08	1	Dec.17 21:56	05-30.00S	101-14.99E	335	10.8	10.2	0236	
L06	1	Dec.17 22:55	05-40.00S	101-09.99E	335	11.0	10.4	0257	
L04	1	Dec.18 00:03	05-50.00S	101-04.99E	335	11.1	10.5	0236	
L02	1	Dec.18 01:00	06-00.00S	100-59.99E	335	10.3	10.3	0257	

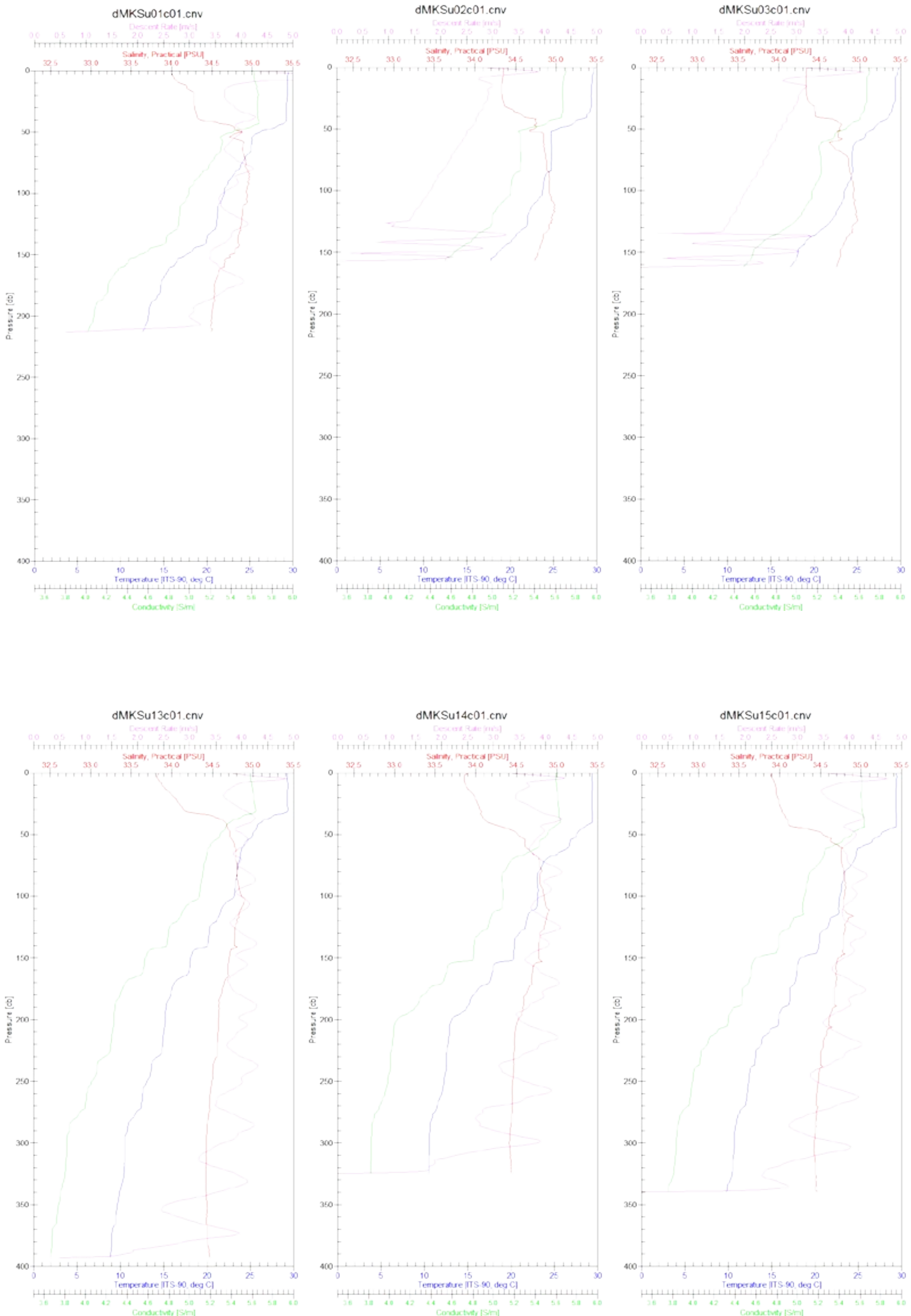

Figure 5.24-3: UCTD profiles of temperature (blue line), salinity (red line), conductivity (green line), and descent rate (pink line) at the station of MKS01, MKS02, MKS03, MKS13, MKS14 and MKS15.

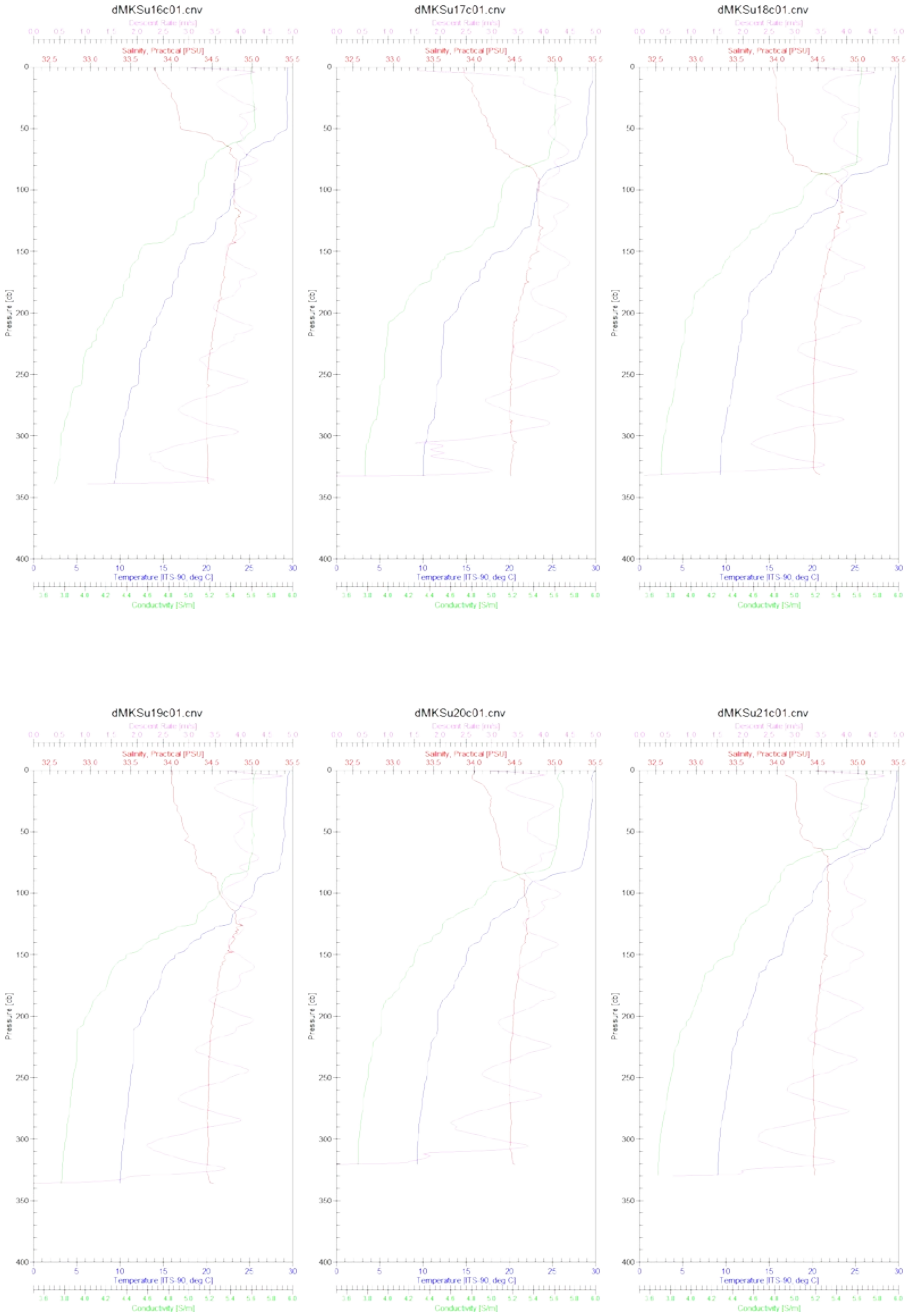

Figure 5.24-4: UCTD profiles of temperature (blue line), salinity (red line), conductivity (green line), and descent rate (pink line) at the station of MKS16, MKS17, MKS18, MKS19, MKS20 and MKS21.

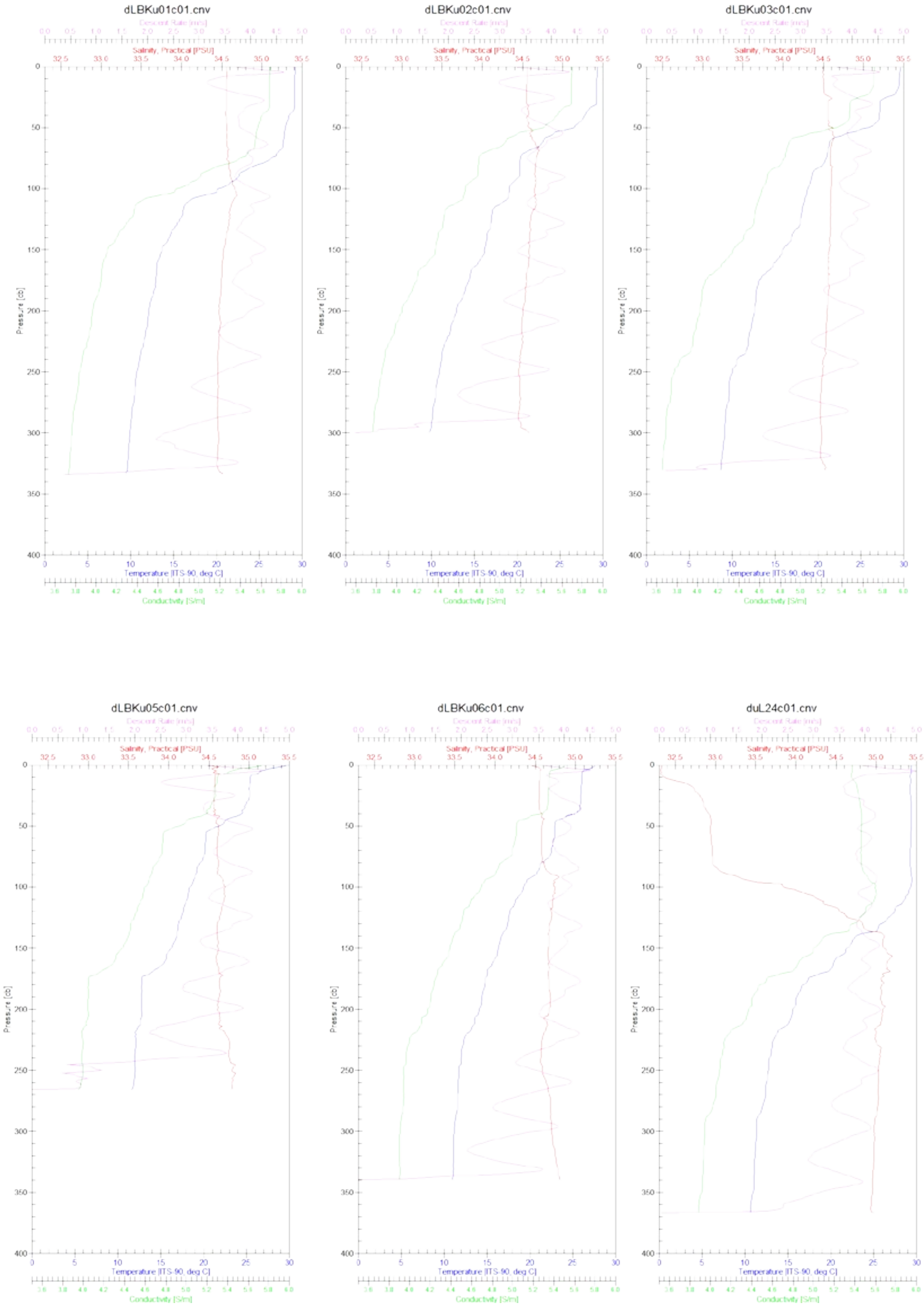

Figure 5.24-5: UCTD profiles of temperature (blue line), salinity (red line), conductivity (green line), and descent rate (pink line) at the station of LBK01, LBK02, LBK03, LBK05, LBK06 and L24.

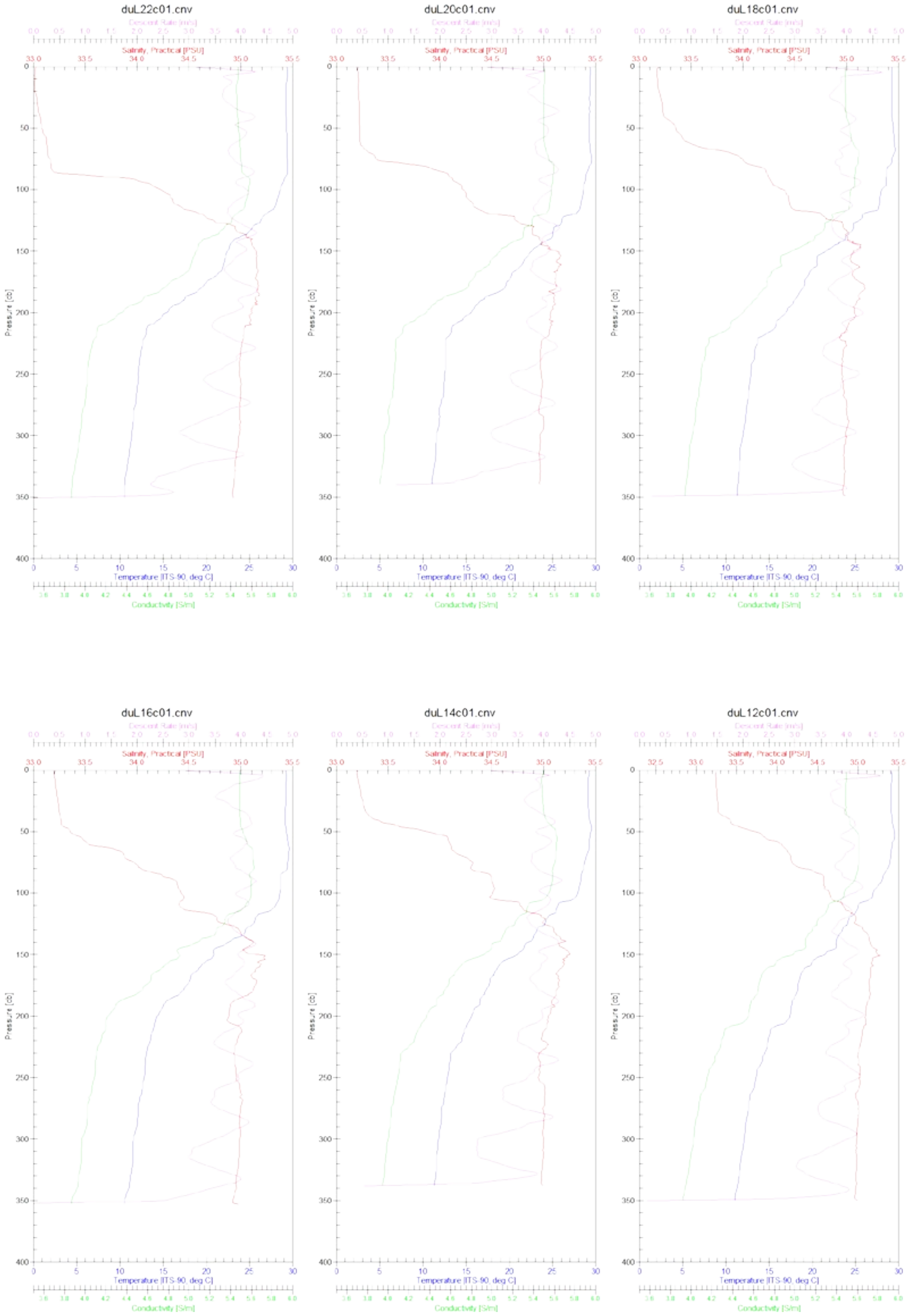

Figure 5.24-6: UCTD profiles of temperature (blue line), salinity (red line), conductivity (green line), and descent rate (pink line) at the station of L22, L20, L18, L16, L14 and L12.

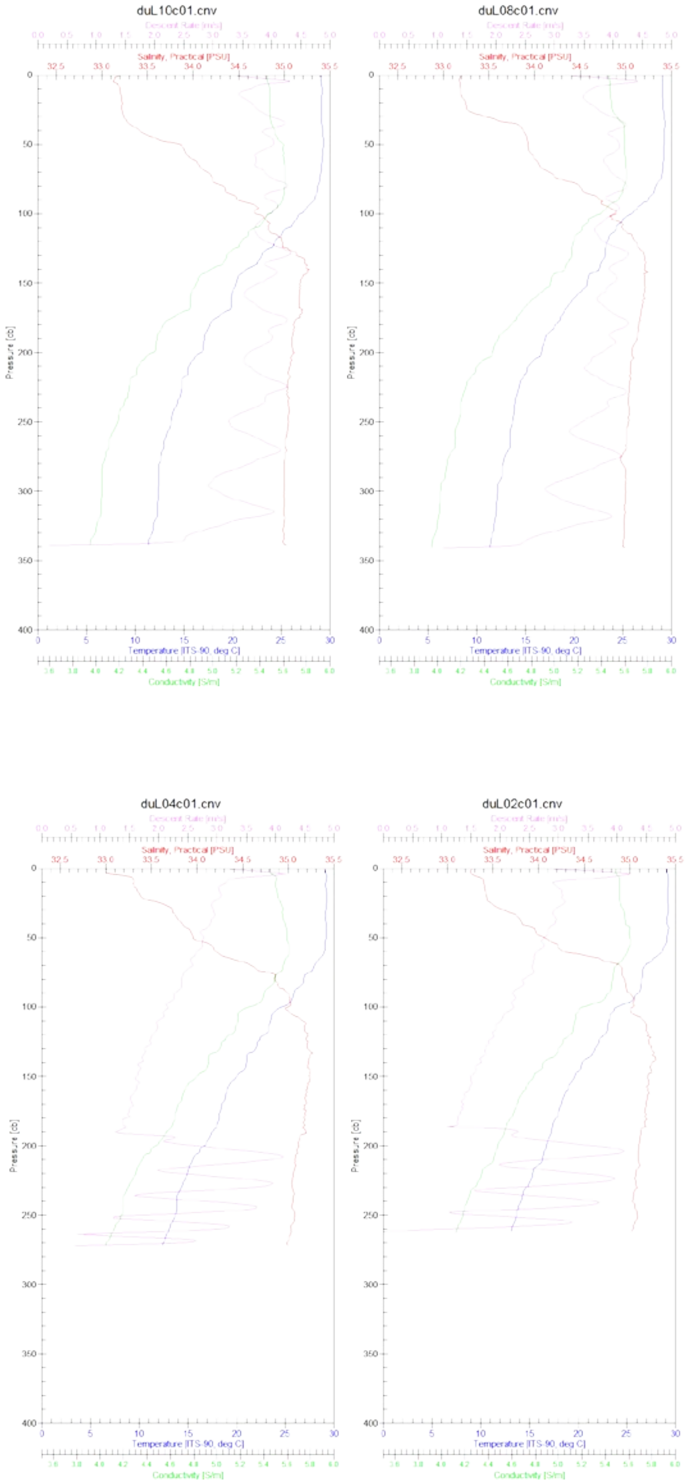

Figure 5.24-7: UCTD profiles of temperature (blue line), salinity (red line), conductivity (green line), and descent rate (pink line) at the station of L10, L08, L06, L04 and L02.

5.25 XCTD

(1) Personnel

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Kazuho YOSHIDA	(Global Ocean Development Inc., GODI)	
Souichiro SUEYOSHI	(GODI)	
Shinya OKUMURA	(GODI)	
Miki MORIOKA	(GODI)	
Ryo KIMURA	(MIRAI Crew)	

(2) Objective

Investigation of oceanic structure.

(3) Methods

We observed the vertical profiles of the sea water temperature and salinity measured by XCTD-1 (manufactured by Tsurumi-Seiki Co.). The signal was converted by MK-150N (Tsurumi-Seiki Co.) and was recorded by AL-12B software (Ver.1.1.4; Tsurumi-Seiki Co). The specifications of the measured parameters are as in Table 5.25-1. We launched probes by using automatic launcher during MR15-04 cruise as listed in Table 5.25-2.

Table 5.25-1: The range and accuracy of parameters measured by XCTD-1.

Parameter	Range	Accuracy
Conductivity	0 ~ 60 [mS/cm]	+/- 0.03 [mS/cm]
Temperature	-2 ~ 35 [deg-C]	+/- 0.02 [deg-C]
Depth	0 ~ 1000 [m]	5 [m] or 2 [%] (either of them is major)

(4) Data archive

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

Table 5.25-2: List of XCTD observations. SST (sea surface temperature) and SSS (sea surface salinity).

No.	Date	Time	Latitude [dd-mm.mmmm]	Longitude [ddd-mm.mmmm]	SST [deg-C]	SSS [PSU]	Probe S/N
01	2015/11/16	09:42	00-59.9825 N	119-34.9974 E	29.147	33.470	13010569
02	2015/11/16	10:41	00-44.9522 N	119-29.4113 E	28.891	33.534	13010571
03	2015/11/16	11:40	00-29.9817 N	119-28.6782 E	28.994	33.447	13010571
04	2015/11/16	12:39	00-15.0283 N	119-18.2253 E	28.829	33.509	13010566
05	2015/11/16	13:41	00-00.0078 S	119-12.7450 E	29.057	33.530	13010573
06	2015/11/16	15:39	00-29.9999 S	119-01.4568 E	28.966	33.501	13010563
07	2015/11/16	17:40	00-59.9991 S	118-50.2164 E	29.385	33.879	13010575
08	2015/11/16	19:45	01-29.9740 S	118-39.0089 E	29.267	33.849	13010572
09	2015/11/18	04:39	08-46.9806 S	115-41.7081 E	29.702	34.564	13010570
10	2015/12/17	13:02	03-59.9172 S	102-00.1409 E	29.524	32.290	13010560

5.26 Wave Gilder

(1) Personnel

Makito Yokota	(JAMSTEC) - Principal Investigator
Iwao Ueki	(JAMSTEC) - Not Onboard
Yasuhisa Ishihara	(JAMSTEC) - Not Onboard
Tatsuya Fukuda	(JAMSTEC) - Not Onboard
Masaki Furuhata	(MWJ)
Nobuhiro Fujii	(MWJ) - Not Onboard

(2) Background and Objectives

Sea surface heat flux variability is crucial for understanding of the ocean-atmosphere interaction. However our knowledge, especially based on in situ measurements, is limited because of lack of observation opportunity. Although we usually use surface moorings, such as TRITON buoy, for the meteorological measurements, it is difficult to capture horizontal structure of sea surface heat flux variability by limited number of the moorings. Thus, we try to capture the structure by meteorological and underwater sensors installed with the Wave Glider. In this cruise, we tried to evaluate the performance of the Wave Glider observation.

(3) Instrumentation

The Wave Glider is an autonomous surface vehicle, which utilize wave motion for forward propolution. The Wave Glider consists of two-part architecture; float and glider connected umbilical cable (Figure 5.26-1). The Wave Glider can install several payloads for measurement.

Meteorological sensors (air temperature, relative humidity, barometric pressure, longwave and shortwave radiation, and wind speed and direction) were installed with a JAMSTEC developed logger on the surface float. The acquired data are transmitted to land station via iridium satellite communication system. Temperature sensors also installed on the wire cable attached with the end of the surface float for temperature profile measurements within the ocean uppermost layer.

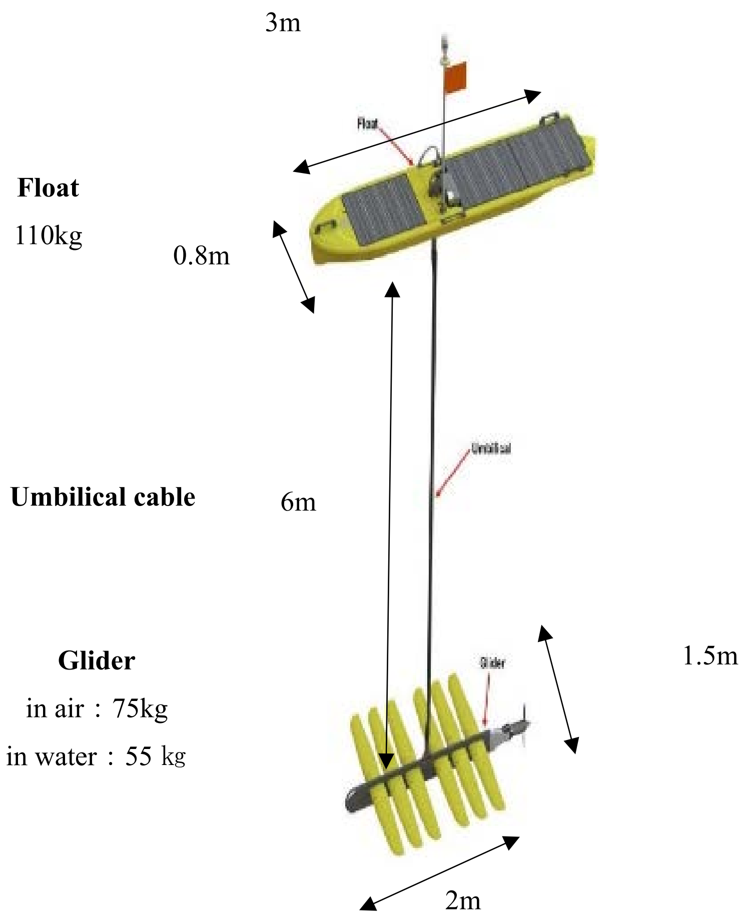


Fig 5.26-1: Wave Glider overview

(4) Method

① Operation

Deploy and recovery of Wave Glider from R/V MIRAI.

The wire rope with the temperature and pressure sensors was attached with the end of the surface float after deploy. (See specifications and configuration for Table 5.26-1, 5.26-2 and Figure 5.26-1)

Table 5.26-1: Specification of temperature and pressure sensors

Sensor	Parameter	Range	Accuracy	Observation interval
SBE56	Temperature	-5 - 45degC	±0.002degC	2Hz
RBRsoloD	Depth	0 - 50m	±0.05% full scale	2Hz

Table 5.26-2: Configuration of the temperature profile measurements

	Sensor type	Manufacture	Parameter	Distance from Wave Glider bottom(mm)
K	SBE56	SBE	Temperature	970
L	SBE56	SBE	Temperature	1970
M	SBE56	SBE	Temperature	2970
N	SBE56	SBE	Temperature	3970
O	SBE56 RBRsoloD	SBE RBR	Temperature Depth	4970

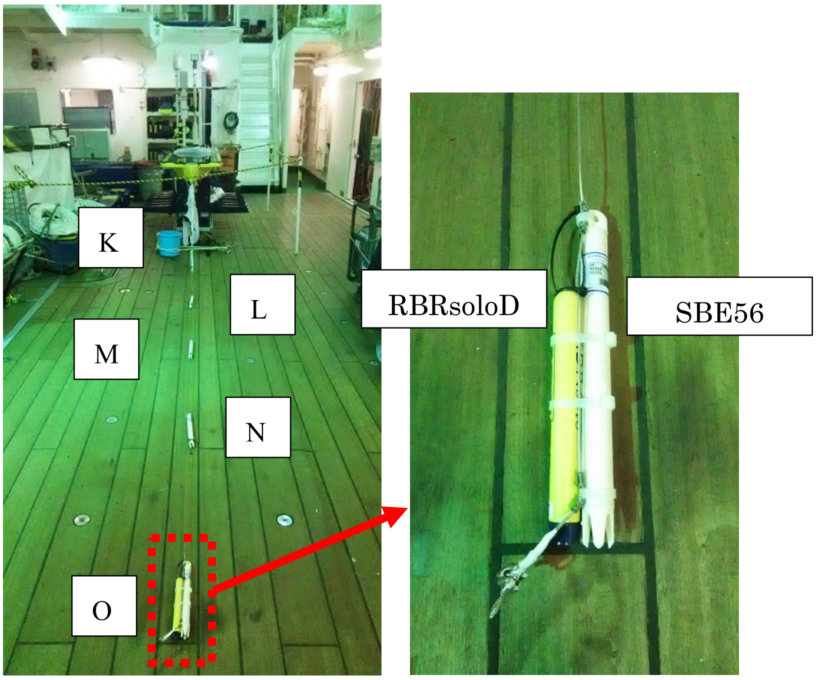


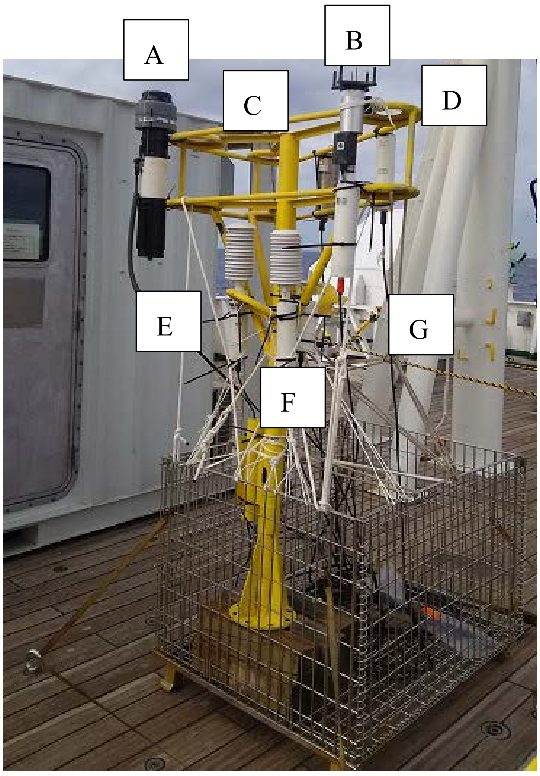
Fig 5.26-1: Thermistor chain overview

② Evaluation of the meteorological sensors

Through the side-by-side experiment on the R/V MIRAI deck, we compared performance of each meteorological sensor attached with the Wave Glider and with a tower (Table 5.26-3 and Figure 5.26-2). For the meteorological sensors attached with the tower, the measurement interval is 1 minute, whereas that for the Wave Glider is 10 minutes. The comparison was conducted for divided periods described in Table 5.26-4.

Table5.26-3: Configuration of meteorological sensors

	Sensor type	Manufacture	Parameter	Location(height from deck)
A	JAMMET_RAN	JAMSTEC	Precipitation(RAN)	Tower(2320mm)
B	JAMMET_WNDu	JAMSTEC	Wind speed(WS) Wind direction(WD) Magnetic direction(MD)	Tower(2300mm) Wave Glider(2190mm)
C	ASIMET_PIR	WHOI,USA	Long wave radiation(LWR)	Tower(2200mm)
D	JAMMET_SWR	JAMSTEC	Short wave radiation(SWR)	Tower(2200mm)
E	JAMMET_HRH	JAMSTEC	Air temperature(AT) Relative humidity(RH)	Tower(1810mm)
F	EasyJAMMET_HRH,BAR	JAMSTEC	Air temperature(AT) Relative humidity(RH) Barometric(BAR)	Tower(AT,RH:1780mm, BAR:1550mm) Wave Glider(AT,RH:950mm, BAR:720mm)
G	Paroscientific_BAR	Paroscientific Inc,USA	Barometric(BAR)	Tower(1610mm)
H	Weather Station (Airmar PB200)	AIRMAR,USA	Wind Speed(WS_WS) Wind Direction(WS_WD) Air Temperature(WS_AT) Barometric(WS_BAR)	Wave Glider(1120mm)
I	EasyJAMMET_SWR,LWR	JAMSTEC	Short wave radiation(SWR) Long wave radiation(LWR)	Wave Glider(1200mm)
J	Weather transmitter	Vaisala,Finland	Wind Speed(WXT_WS) Wind Direction(WXT_WD) Air Temperature(WXT_AT) Relative Humidity(WXT_RH) Barometric(WXT_BAR) Precipitation(WXT_RAN)	Wave Glider(1170mm)



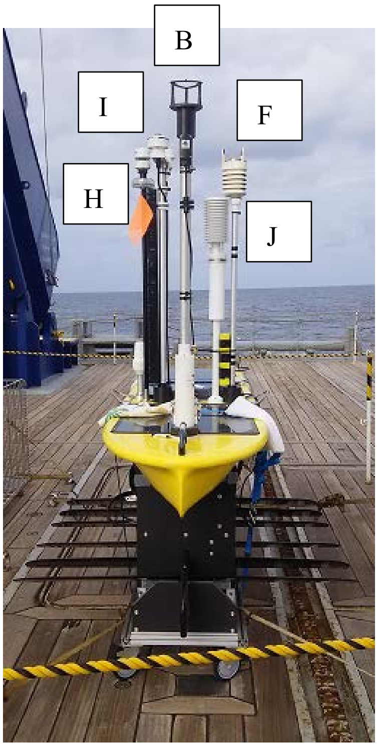


Fig5.26-2:Photo of the tower was attached meteorological sensors on R/V MIRAI deck.(left) The Wave Glider was attached meteorological sensors on MIRAI deck.(right)

Table 5.26-4: Periods of comparison meteorological sensors

	Started	Ended
Period 1	0000UTC 09 Nov. 2015	0533UTC 13 Nov. 2015
Period 2	0133UTC 17 Nov. 2015	0000UTC 21 Nov. 2015
Period 3	0704UTC 06 Dec. 2015	0000UTC 14 Dec. 2015

(5) Field experiment

① Time record

The field experiment for the Wave Glider was conducted at 10th December 2015.

<Deploy>

01:15z Operation started

01:15z Deployment tool was set to the Wave Glider and the Aframe crane.

01:23z MIRAI stopped thruster.

01:30z Operation vehicle (MIRAI6) was deployed.

01:33z MIRAI turned to face wave direction.

01:40z Wave Glider was hanged. (Figure 5.26-3)

01:42z Wave Glider was deployed. (Figure 5.26-3)

01:43z Launching saddle was recovered by operation vehicle.

01:45z Thermistor chain was attached to Wave Glider by operation vehicle.
01:53z Operation vehicle was recovered.
02:01z Wave Glider was confirmed by MIRAI's radar.

<Observation>
02:01z to 03:30z Wave Glider observed ocean. (Figure 5.26-4)

<Recovery>
03:25z MIRAI stopped thruster. Operation vehicle was deployed.
03:30z Operation vehicle attached mooring line to Wave Glider and recovered thermistor chain. MIRAI turned to face wave direction.
03:36z Recovery tool was set to crane. Operation vehicle towed Wave Glider near MIRAI. (Figure 5.26-4)
03:43z Wave Glider was set recovery tool and was hanged. (Figure 5.26-5)
03:45z Messenger was set to umbilical. (Figure 5.26-5)
03:51z Glider on deck. (Figure 5.26-6)
03:53z Float on deck.
04:00z Operation vehicle on deck.
04:00z Operation finished

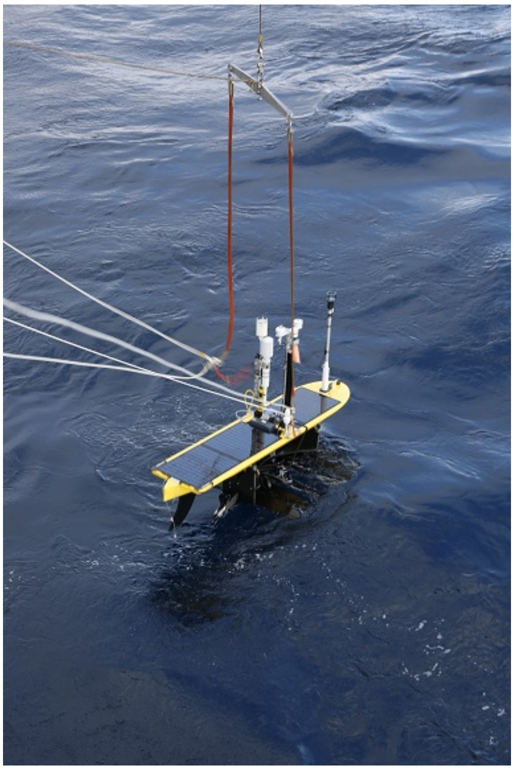



Fig5.26-3: Wave Glider was hanged (left) and was deployed. (right)

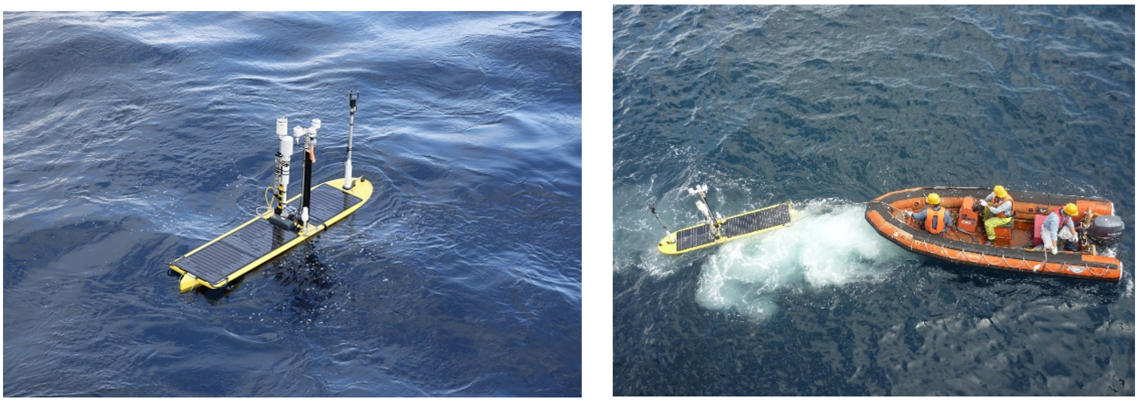


Fig5.26-4: During observation (left) and was towed near MIRAI to recovery. (right)

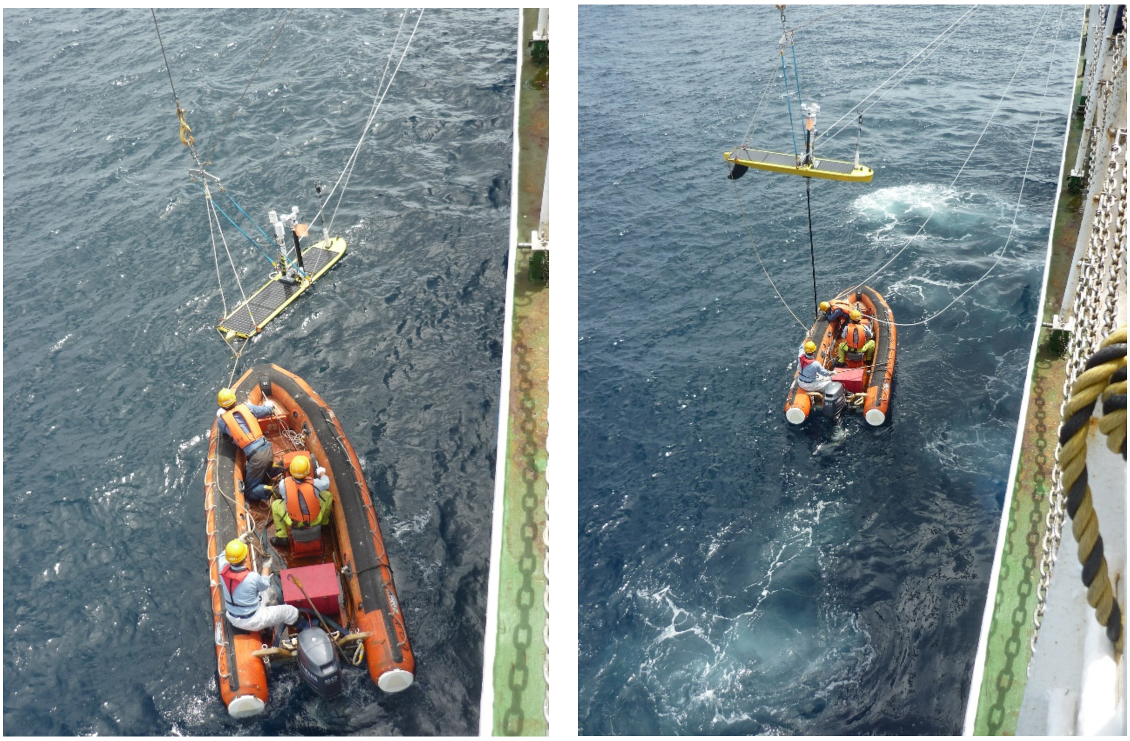


Fig5.26-5: Recovery tool was set. (left) Messenger was set. (right)

Fig5.26-6: Wave Glider was hanged to recovery. (left) On deck. (right)

② Wave Glider location during operation

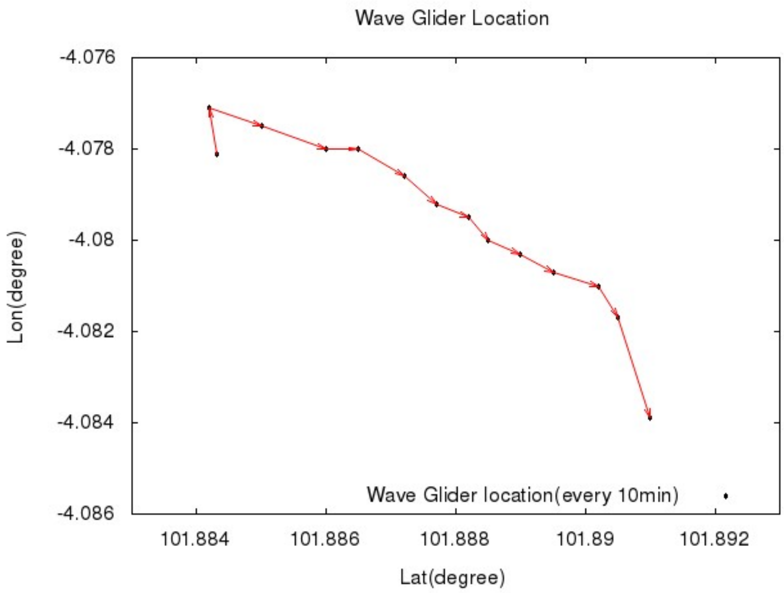


Fig 5.26-7: Wave Glider location during operation

(6) Preliminary Result

① Temperature profile within ocean uppermost layer

Figure 5.26-4 show the time series of the temperature profile measurements during the Wave Glider operation.

② Observation of meteorological elements

Figure 5.26-5 show the time series of the meteorological elements.

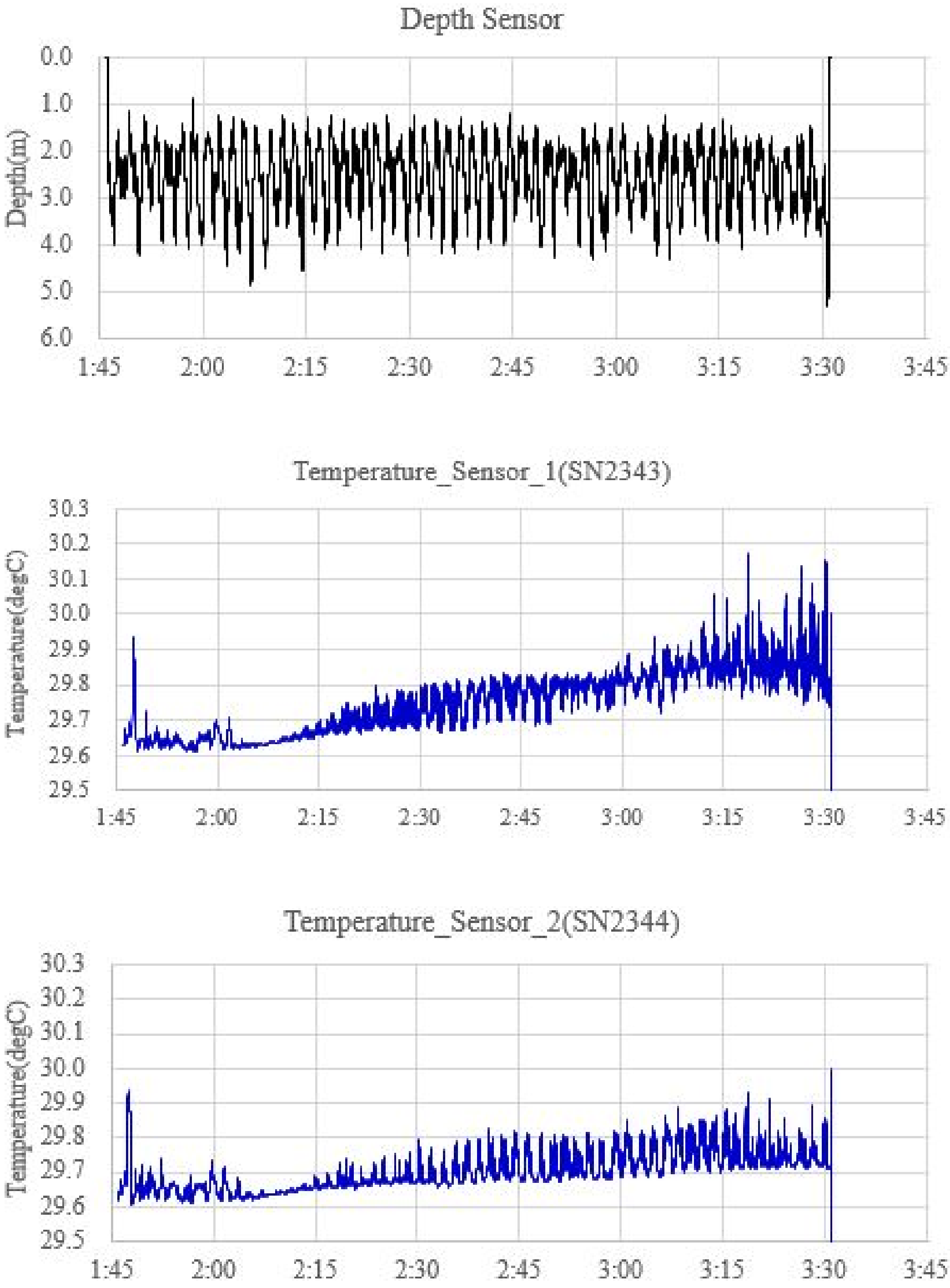
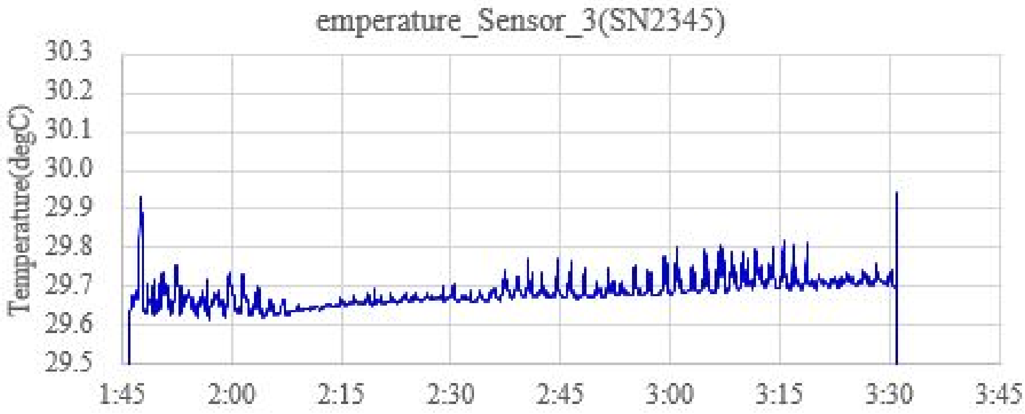
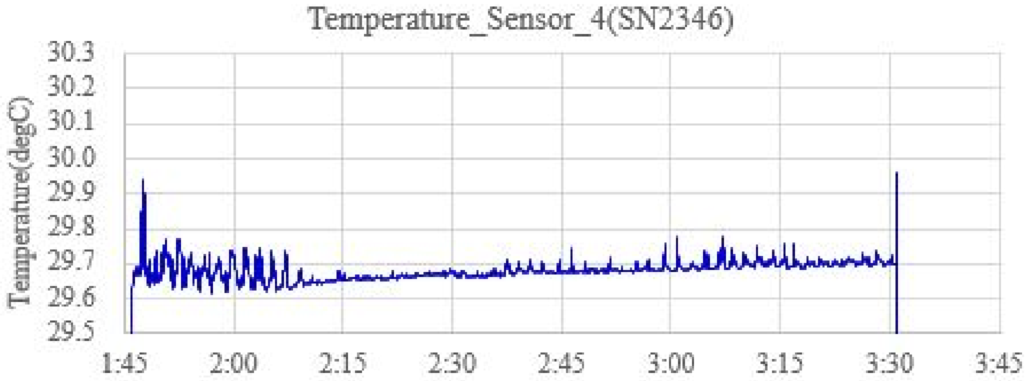


Fig.5.26-8 Time series of the temperature profile.





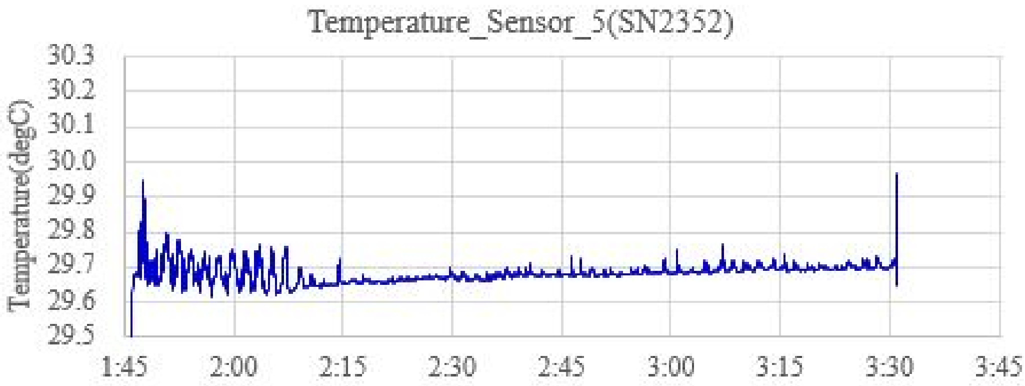


Fig.5.26-8 (Continued)

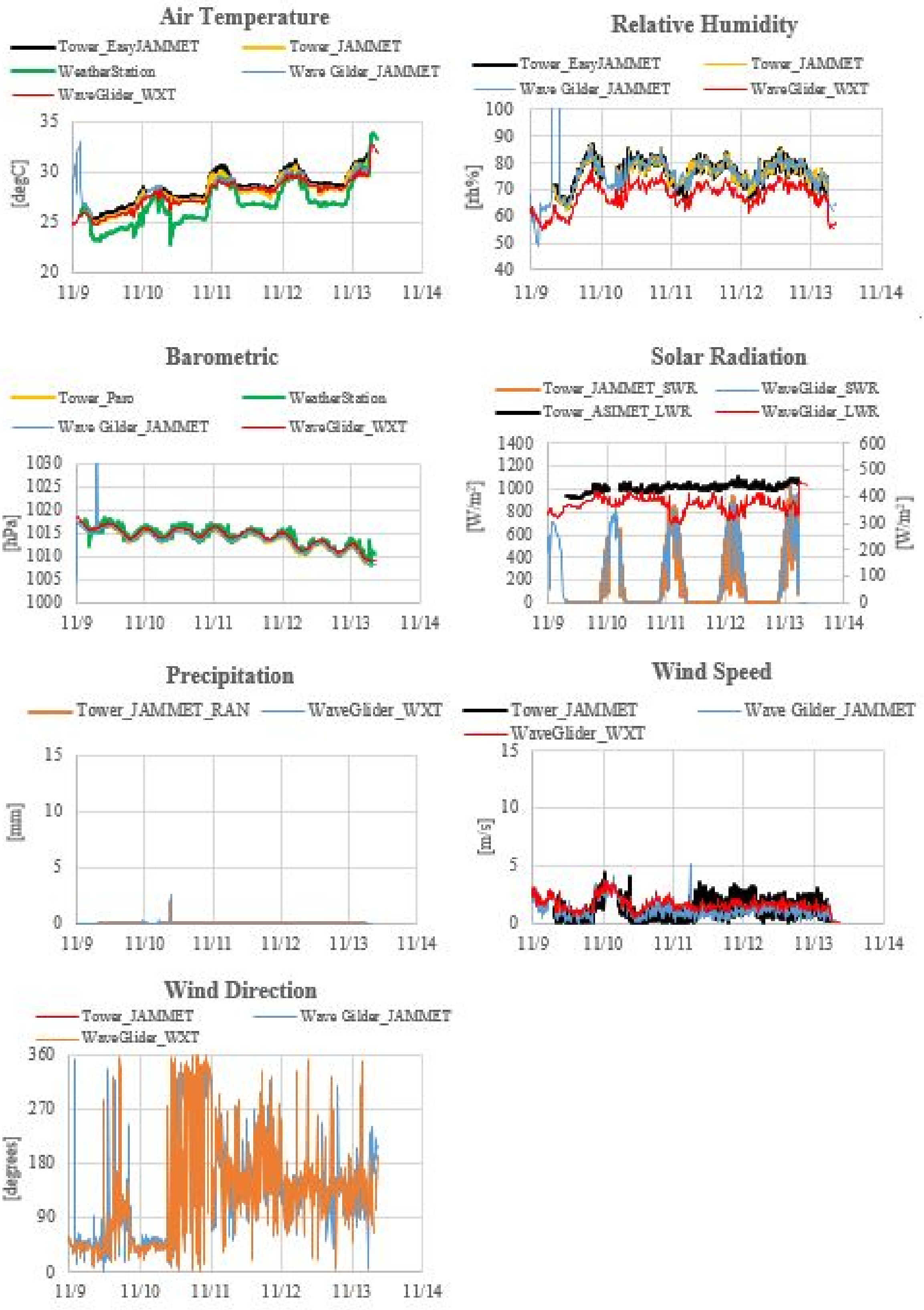


Fig.5.26-9 Time series of meteorological elements.

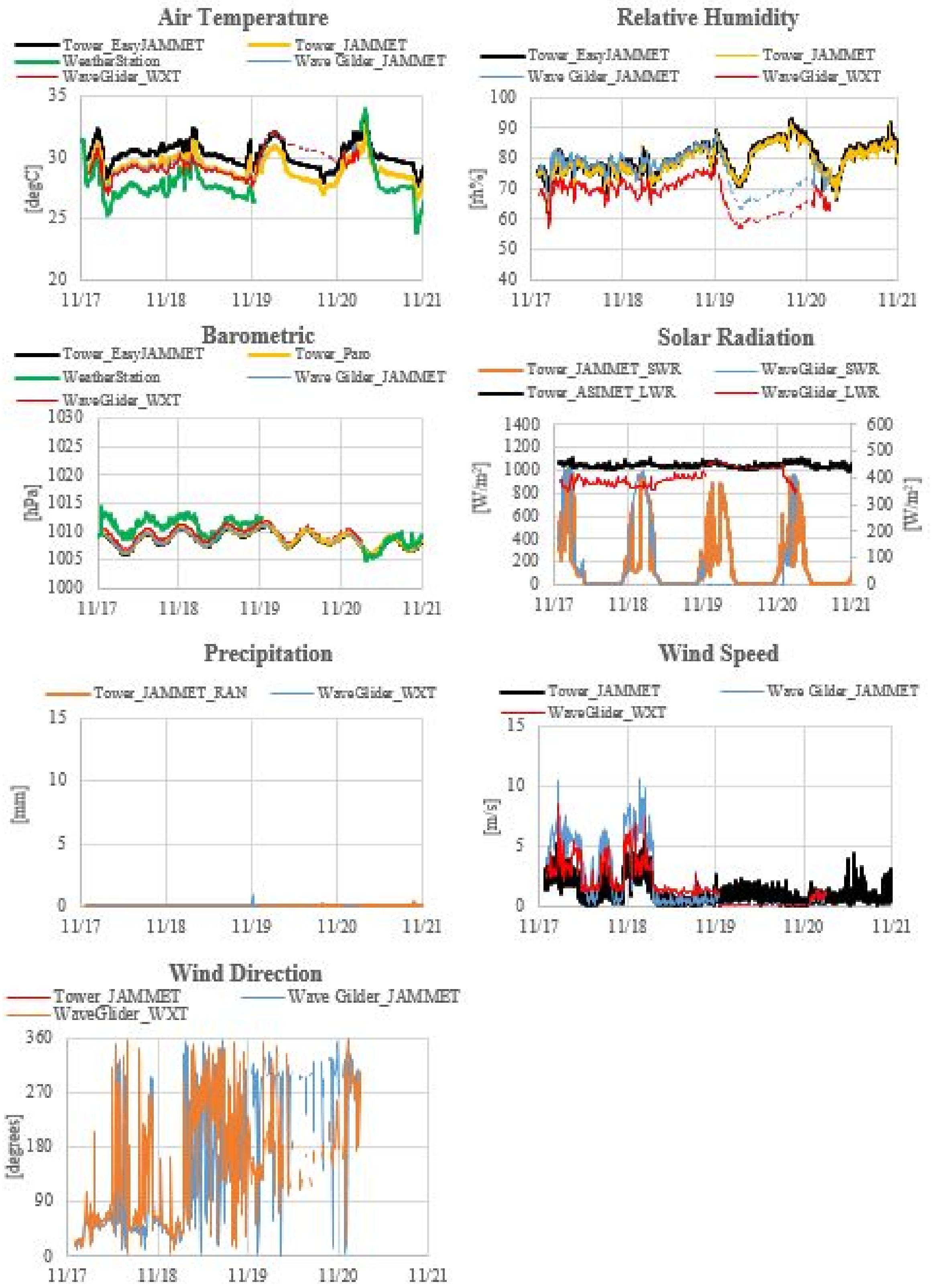


Fig.5.26-9 (Continued)

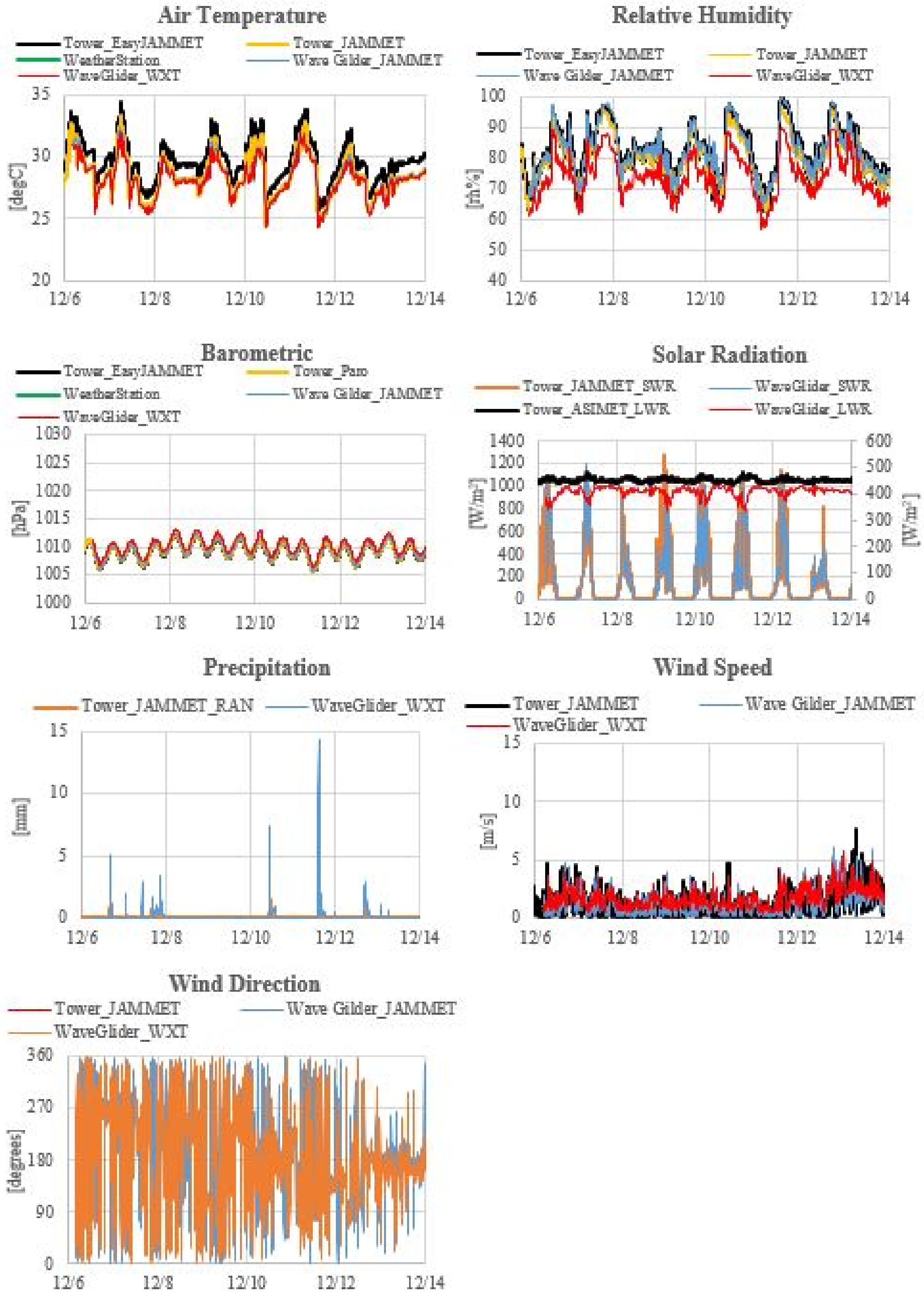


Fig.5.26-9 (Continued)

5.27 Testing CTD sensor for the new floats

(1) Personnel

Yukio TAKAHASHI	(JAMSTEC, not on board)	- Principal Investigator
Makito YOKOTA	(JAMSTEC)	
Kensuke WATARI	(JAMSTEC, not on board)	

(2) Objective

JES10 Profiler (JES10) is JAMSTEC original CTD sensor for the profiling float. (Figure 5.29-1)This operation was conducted to evaluate two things.

① Pressure dependence of the water temperature sensor

② Profiling data comparison with 9plus

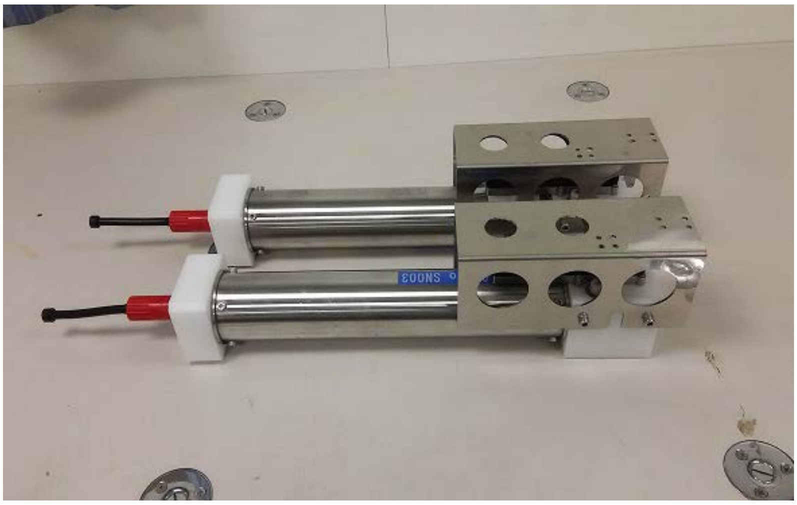


Fig5.29-1 JES10 Profiler

(3) Method

Two JES10 was cast with CTD system and compared with SBE 9plus. These sensors attached near SBE 9Plus and one of it installed pump. (Figure 5.29-2) Table 5.29-1 is casts specification.

① Pressure dependence of the water temperature sensor

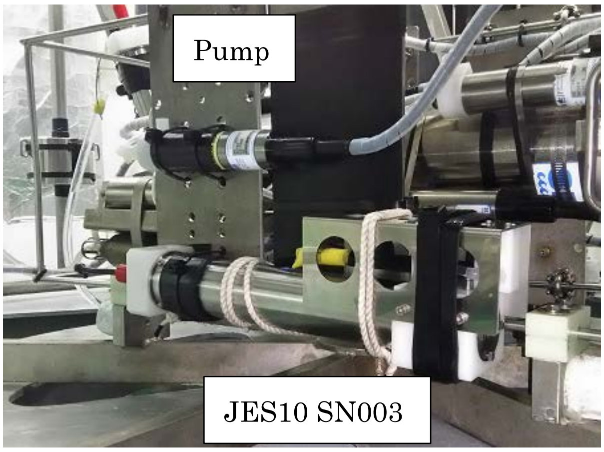
The CTD system was stopped for 5 minutes at each depth 1000m, 500m, and 300m. JES10 and SBE 9plus water temperature data was averaged and compared.

② Profiling data comparison with 9plus

Profiling data was measured decent(L03) to 500m and ascent(STN) from 500m .Station STN cast ascent rate was controlled like a profiling float.

Table 5.29-1 List of CTD casts for JES10.

Station	Date	Rate(m/sec)	Max Depth	Stop Depth(m)(5min)
L01	Nov.20 2015	Decent:1.0,Ascent:1.2	1000m	1000,500,300 at ascent
L03	Nov.21 2015	Decent:1.0,Ascent:1.2	500m	-
STN	Dec.13 2015	Decent:1.0,Ascent:0.2-0.3	500m	-



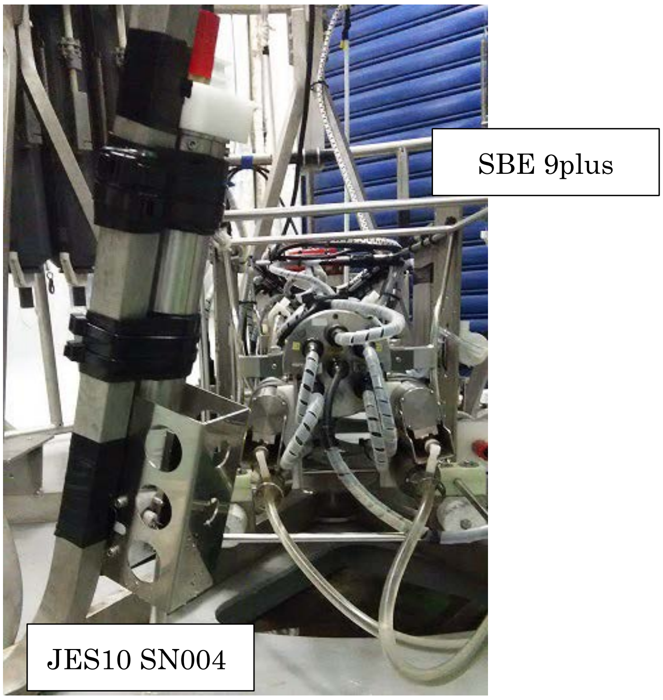


Fig 5.29-2 CTD frame with JES10

(4) Preliminary Result

① Pressure dependence of the water temperature sensor

JES10 is the goal of temperature accuracy 0.005K. Temperature difference was less than goal at each depth. (Table 5.29-2)

Table 5.29-2 List of temperature difference each depth

	Temperature(degC)			Temperature difference	
Depth	9plus	JES10_SN003	JES10_SN004	JES10_SN003 - 9plus	JES10_SN004 - 9plus
1000m	5.9260	5.9281	5.9234	0.0021	-0.0027
500m	9.7179	9.7203	9.7140	0.0024	-0.0039
300m	11.4315	11.4322	11.4271	0.0006	-0.0044

② Profiling data comparison with 9plus

All the sensors successfully provide the data during observation. The data will be processed after the end of the cruise.

5.28 Distribution, Cool- and Heat-Tolerances of the Oceanic Sea Skaters of *Halobates* (Heteroptera: Gerridae) Inhabiting tropical area of 4ºS-06ºS 101ºE-102ºE in the Indian Ocean

(1) PERSONNEL

Tetsuo Harada	(Kochi Univ.)
Takahiro Furuki	(Kochi Univ.)
Wataru Ohoka	(Kyoto Univ.)
Noritomo Umamoto	(Kochi Univ.)

(2) PURPOSE

This study during this scientific cruise, MR15-04 aims, first, to examine the relationship between the population density of the oceanic sea skaters of *Halobates* (Heteroptera: Gerridae) inhabiting the tropical Indian Ocean of 4ºS-7ºS, 101ºE-103ºE and meteorological change (for example precipitation and atmospheric temperarure) in November and December 2015. This study aims, second, to examine whether sea skaters, living in the tropical Indian Ocean, show a positive or negative correlation between hardiness to lower temperature and that to higher temperature. The third aim of this study is to examine the relationship between such hardiness to lower and higher temperatures and meteorological changes during the three weeks at the fixed station, 4ºS, 101ºE.

(3) MATERIALS AND METHODS

Samplings

Samplings were performed every three days in 20th November 2015 to 14th December 2015 in the area of 4ºS-7ºS, 101ºE-103ºE with a Neuston NET (6 m long and with diameter of 1.3 m.) (Photo 1). The Neuston NET was trailed for 15 mm x 3 times as one set-trial on the sea surface. Nine set-trials have been performed in total from the starboard side of R/V MIRAI (8687t) which is owned by JAMSTEC (Japan Agency for Marine-earth Science and TECHnology). The trailing was performed for 15min at night for the all 9 set-trials with the ship speed of 2.0 knot to the sea water (Photo 1). It was repeated 2 times in each station. Surface area which was swept by Neuston NET was evaluated as an expression of [flow-meter value x 1.3m of width of the Neuston NET.

Treatments of specimens after the samplings and before the experiments

Sea skaters trapped in the pants (grey plastic bottle) located and fixed at the end of Neuston NET (Photo 2) were paralyzed with the physical shock due to the trailing of the NET. Such paralyzed sea skaters were transferred on the surface of paper towel to respire. Then, the paralysis of most of the paralyzed individuals was discontinued within 20 min. When sea skaters were trapped in the jelly of jelly fishes, the jelly was removed from the body of sea skaters very carefully and quickly by hand for recovery out of the paralysis.

Adults which recovered out of the paralysis were moved on the sea water in the aquaria set in the laboratory for the Cool Coma and Heat Coma Experiments. Many white cube aquaria (30cm × 30cm × 40cm) were used in the laboratory of the ship for rearing the adults which had been recovered out of the paralysis due to the trailing. Each aquarium contained ten to forty adults of *Halobates*. Both the room temperature and sea water temperature in the aquaria were kept at 29 ± 2℃. For 11-12 hours after the collection, sea skaters were kept in the aquaria without foods. The adults kept for 11-12 hours after the collection were used for Cool and Heat Coma experiments. When those kept more than 12 hours after the collection were used for the experiments, the adults were fed on adult flies, *Lucillia illustris* before the Cool and Heat Coma Experiments. Foods were given and replaced to new ones every 6-12 hours and sea water in the aquaria was replaced by the new one three times at 8:00, 13:00 and 18:00 because of avoidance from water pollution due to the foods.

Cool Coma Experiments and Heat Coma Experiments

Twelve or thirteen adults and/or 5th and 4th instars larvae specimens were moved from the cube aquaria in which those specimen had been kept, to the two machines as Low Temperature Thermostatic Water Bathes (Thomas: T22LA) (55cm × 40cm × 35cm). Temperature was gradually decreased (1 ºC per 3-5 min) by 1℃ or increased every 15 min by the automatic cooling/heating system of the water bathes till the cool or heat temperature comas which occur in all the experimental specimens.

Temperature was very precisely controlled by automatic thermo-stat system of the water bath. Temperature at which Semi Cool Coma or Semi Heat Coma (Semi Cool Coma Temperature [SCCT] or Semi Heat Coma Temperature [SHCT]: The temperature at which skating behavior stopped completely for more than 5 seconds) occurs and Temperature at which Cool Coma or Heat Coma (Cool Coma Temperature [CCT] or Heat Coma Temperature [HCT]: The temperature when ventral surface of the body was caught by sea water film and the ability to skate was lost, or when abnormal postures on the sea-water were observed - for example, one leg sank into the water, the body was upside down, or the mid-leg moved behind and attached to hind leg) occurs was recorded (Table 4 and 5).

Recovery Experiments

When they suffered Cool Coma (CC) or Heat Coma (HC), the experimental specimens were transferred from the Experimental Water Bathes to the sea water in the round shaped transparent small containers (17cm diameter and 6cm height) at 29±2ºC as air and water temperatures and observed for two hours to detect and the recovery from these comas and measure the time for the recovery. Any individuals have never recovered from the comas after two hours in coma. The recovery was judged when the specimen began to skate normally on the surface. All individuals who recovered from the comas did the continuous “cleaning behavior” using all 6 legs before the recovery.

Measurement of body sizes

Body length, body width and head width of all individuals as sea skaters which have been collected in this cruise were measured and photos of adults and larvae (H. germanus, H. micans, H. princeps and H. sp [a proposed name: *H. sumatraensis*] were taken during this cruise.

(4) RESULTS AND DISCUSSION

Distribution

The samplings of *Halobates* (Table 1) (Photo 2) inhabiting tropical stations in the eastern Indian Ocean showed that 12-327 individuals per one-set trial of three species of *Halobates sericeus* (Photo 1)*, H. princeps* and un-described and relatively large (about 5 cm of body length of adults with "gourd" like shape)(probably new species and proposed name is *Halobates sumatraensis*) due to an morphological study and precise comparison with all the 71 species described in the Appendix as the Key of the identification of *Halobates* Eschsholtz: Andersen and Chang, 2004) were collected at the stations within 04˚00'S-06˚00'S, 101˚00'E-103˚00'E. The population density of the station A (Table 2-7A) was moderate as about 6000 individuals / km^2 and exclusively *H. germanus* seems to occupy this area. On the other hand at the fixed station (04˚02'S 101˚53'E) located about 50 km in the southern-western direction from the shore of Sumatra Island, Indonesia, three species of *Halobates* (*H. germanus, H. princeps and H. sp.*) were collected. However, H. germanus was dominant species in this fixed station. The number of individuals collected were greatly varied from 12 to 327 individuals. This results imply that sea skaters inhabit sea surface not averagely but gregariously in some specific place like as Station 7 (Tables 1, 3) in this area. On average, the population density of dominant species, *H. gerumanus* and *H.* sp. (*H. sumatoraensis*) were about 20,000 and 2,500, respectively at the fixed station (Stations 2-9 in Tables 1, 3). At the Stations 6 and 7, 50 and 152 larvae were collected, respectively, and 51 exuviae (wasted skin at molting) were caught in total. Reproductive and growth activity might be very active at the two stations.

Cool Coma Experiments (CCEs), Heat Coma Experiments (HCEs) and Recovery Time from CC and HC (RTCC and RTHC)

All the individuals of *H. germanus and H.* sp (proposed *H. sumatraensis*) collected at Stations 1-9 which had been completely recovered from the paralysis by the physical shock due to the neuston net sweeping were used for Cool Coma Experiments and Heat Coma Experiments. Semi-Cool-Coma Temperature (SCCT), Cool-Coma Temperature (CCT), Gap Temperature for Cool Coma (GTCC), Recovery Time from Cool-Coma (RTCC) were ranged 13.1ºC to 25.0ºC, 13.0ºC to 25.0ºC, 3.1ºC to 16.1ºC, 1 second to 4370 seconds, respectively (Table 4). On the other hand, Semi-Heat-Coma Temperature (SHCT), Heat-Coma Temperature (HCT), Gap Temperature for Heat Coma (GTHC), Recovery Time from Heat-Coma (RTHC) were ranged 29.4ºC to 43.1ºC, 29.4ºC to 43.1ºC, 1.9 ºC to 15.5ºC, 2 second to 6420 seconds, respectively (Table 4). In many and most of the experimental individuals, Semi-Cool Coma and Cool Coma, and Semi-Heat Coma and Heat Coma, respectively, have occurred at the same time.

The mean and standard deviation of CCT, GCCT , RTCT, HCT, GHCT and RTHT were shown in Table 6 and Table 7. At the Station 1, experimental individuals of *H. germanus* showed significantly lower SCCT and CCT, higher GTCC and longer RTCC than those collected at Stations 2-9. The CCT and GTCC showed the change in a fluctuated manner with 14 days period (Fig. 1) (One-Way ANOVA: F-value=2.314, df=7, p=0.028). Average HCT was extremely high as around 40 ºC at the Stations 4, 6, 7 and 9, whereas it was quite low as 35.5ºC of the individuals collected at the Station 5 (Fig. 2). Both cool tolerance and heat tolerance of H. germanus collected at the Site 1 (Station 1) were significantly harder than those at the Site 2 (Stations 2-9) (Table 6). However, the recovery time shown by the specimens at the Site 1 was longer than that by those at the Site 2, probably because of exposure to higher temperature (Table 6).

Most of individuals which suffered from CC have recovered within 20 seconds (Fig. 3), whereas the recovery time was significantly longer when they recovered from HC which occurred at the temperature higher than 38 ºC (Fig. 4). Some of the individuals which suffered from HC at 40º-42º C did not recover. When they suffered from HC at 43ºC, all individuals did not recover any more (Fig.4). Males recovered from HC with shorter seconds than females (Table 7). There were no significant differences in both cool hardiness and heat hardiness between sexes and nor between species (Table 7).

The exposure to around 40ºC might make some injury in neurophysiological function for sea skaters, whereas that to around 15ºC seems to make a moderate and temporary damage in this function and such damage would be possible to be recovered.

(5) ADDITIONAL ANALYSYS

It will be analyzed how the data on field samplings and hardiness to lower and higher temperature in this study are related to environmental data as the oceanography data at the sampling stations of this cruise, MR15-04. This relationship can be compared to other similar analyses on the data collected in the area of 4ºS to 13ºS and 8ºN to 6ºS in the Indian Ocean at two cruises, KH-10-05-Leg 1 (Harada et al., 2010a) and KH-07-04-Leg1 (Harada et al., 2010b, 2011a), respectively and also in the area of 30º-35ºN along the Kuroshio Current at the cruises, KT-07-19, KT-08-23, KT-09-20 and the other R/V TANSEIMARU cruises held in the past. The relationship between the sampling data and oceanographic data (for example, surface sea temperature and air temperature, chlorophyll contents and dissolved oxygen level) will be analyzed. The body size data will be compared among the three species of *H. germanus, H. micans* and *H.* sp (*H. sumatraensis*) and morphological analysis on larvae and adults will be done in the near future.

(6) ACKNOWLEDGEMENT

We would like to thank Dr. Masaki KATSUMATA (Chief Scientist of the cruise: MR15-04, Senior Scientist, Japan Agency for Marine-Earth Science and Technology: JAMSTEC) for his permission of doing this study during the cruise boarding on the R/V MIRAI, for his warm suggestion on this study, and encouragement and help throughout this cruise. The samplings and the experimental study were also possible due to supports from all of the crew (Captain: Mr. Hiroshi MATSUURA) and all the scientists and the engineers from MWJ and GODI in this cruise. We would like to give special thanks to them. Thanks are also due to Dr Dedy Swandry Banurea (BMKG) and Mr. Bangbang Soetarutono (Security Officer) for nice friendship and discussion during this group with us.

(7) REFERENCE AND RELATED LITERATURE

Harada T 2005: Geographical distribution of three oceanic *Halobates* spp. and an account of the behaviour of *H. sericeus* (Heteroptera: Gerridae). *European Journal of Entomology* 102: 299-302.

Harada T, Sekimoto T 2013 Distribution and ecology of oceanic *Halobates* inhabiting tropical area of Pacific Ocean and their responding system to several environmental factors. *The Cruise Report of MR-13-03, JAMSTEC*

Harada T, Iyota K, Sekimoto T 2010a: Distribution and tolerance to brackish water bodies as habitat in oceanic sea skater of *Halobates* (Heteroptera: Gerridae) inhabiting Tropical Indian Ocean. *The Cruise Report of KH-10-05-Leg 1, JAMSTEC*

Harada T, Sekimoto T, Iyota K, Shiraki T, Takenaka S, Nakajyo M, Osumi O and Katagiri C 2010b: Comparison of the population density of oceanic sea skater of *Halobates* (Heteroptera: Gerridae) among several areas in the tropical pacific ocean and the tropical Indian Ocean. *Formosan Entomologist* 30: 307-316.

Harada T, Takenaka S, Sekimoto T, Ohsumi Y, Nakajyo M, Katagiri C 2011a: Heat coma and its relationship to ocean dynamics in the oceanic sea skaters of *Halobates* (Heteroptera: Gerridae) inhabiting Indian and Pacific Oceans. *Journal of Thermal Bi*ology 36: 299–305.

Harada T, Sekimoto T, Osumi Y, Kobayashi A, Shiraki T 2011b: Distribution and ecology of oceanic *Halobates* inhabiting tropical area of Indian Ocean and their responding system to several environmental factors.*The Cruise Report of MR-11-07 JAMSTEC*

Harada T, Takenaka S, Sekimoto, T, Nakajyo M, Inoue T, Ishibashi T and Katagiri C (2011c) Heat coma as an indicator of resistance to environmental stress and its relationship to ocean dynamics in the sea skaters, Ha-lobates (Heteroptera: Gerridae). *Insect Science* 18: 703-711. http://dx.doi.org/10.1111/j.1744-7917.2011.01409.x

Harada T, Takenaka S, Sekimoto T, Osumi Y, Iyota K, Furutani T, Shiraki T, Nakajo M, Katagiri C, Moku M, Koštál V 2012: Correlation analysis of heat hardiness and super-cooling point in the oceanic sea skaters, *Halobate*s. *Trends in Entomology* 10:115-124.

Harada T, Takenaka S, Iyota K, Shiraki T, Moku M, Katagiri C, Koštál V 2013: Supercooling points and heat coma temperatures in four species of oceanic sea skaters of the genus *Halobates* (Heteroptera: Gerridae: Halobatinae). *Journal of Asia-Pacific Entomology* 16: 219–222.

Harada T, Osumi Y, Shiraki T, Kobayashi A, Sekimoto T, Nakajo M, Takeuchi H, Iyota K 2014: Abundance of oceanic sea skaters, Halobates in the tropical Indian Ocean with respect to surface chlorophyll and oxygen concentrations. *Journal of Experimental Marine Biology and Ecology* 460: 32–36.

Nakajo M, Sekimoto T, Emi K, Ide R, Wada K, Inoue T, Moku M, Koštál V, Katagiri C, Harada T 2013: Comparison of temperature preference for habitat among three species of oceanic sea skaters, *Halobates micans*, *H. germanus* and *H. sericeus. Natural Science* 5-12A: 9-15 http://dx.doi.org/10.4236/ns.2013.512A002

Sekimoto T, Iyota K, Osumi Y, Shiraki T, Harada T 2013: Supercooling points and heat coma temperatures in four species of oceanic sea skaters of the genus *Halobates* (Heteroptera: Gerridae: Halobatinae). *Environmental Entomology* 42: 572–577.

Sekimoto T, Osumi Y, Shiraki T, Kobayashi A, Emi K., Nakajo M., Moku M, Koštál V, Katagiri C, Harada T 2014: Comparative study of salinity tolerance an oceanic sea skater, *Halobates micans* and its closely related fresh water species, *Metrocoris histrio. Natural Science* 6: 1141-1148.

Takenaka S, Katagiri C, Koštál V, Harada T 2014: Heat coma temperature, relative contents of saturated/unsaturated fatty acids and reproductive maturation in the oceanic sea skaters, *Halobates micans. Journal of Asia-Pacific Entomology* 17: 633–637.

Zhao YX, Kang L. 2000: Cold tolerance of the leafminer *Liriomyza sativae* (Dipt., Agromyzidae). *J. Appl. Entomol.* 124: 185-189.

Table 1: Number of oceanic sea skaters, *Halobates* collected at locations in the tropical Indian Ocean in November 20th, 2015 - December 14th 2015 during the science cruise, MR15-04 (N: Total number of individuals collected; H.g.: *Halobates germanus*, H.sp.: un-described species (a proposed name: *H. sumatraensis*), H.p.: *Halobates princeps*; Stat: Station number; WT: Water temperature (℃); AT: Air temp.; L: N of larvae; A: N of adults, E: N of exuviae; EG: number of eggs (on some substrates like as polystyrene form); Date: sampling date; Sampling was performed for 15min. S: Surface area which was swept by Neuston NET was expressed as value of flow-meter x 1.3m of width of Neuston NET; WS: wind speed (m/s); W: weather; TD: Time of day; WS: Wind speed, CS: Current speed(m/s)CD: Current direction; F: female; M: male, S: salinity of sea surface (‰), Chla: Chlorophyll A (ug/L) No other species of oceanic sea skaters were collected in this area.

Latitude	Longitude	N	L	A		H.g	H.sp	H.p.	EG	E	Stat	WT	AT	WS	W	CS	S	CD	TD	Date	S (x1.3 m^2)	Ch	OD
				F	M																		
06°56'S	102°53'E	7	4	1	2	7	0	0	0	0	St.1-1	28.7	28.9	10.3	Cloudy	1.0	31	151	19:22~37	Nov 20	1991.0	-	-
06°57'S	102°54'E	17	11	5	1	17	0	0	0	1	St.1-2	28.7	28.9	8.9	Cloudy	1.0	31	145	19:45~57	Nov 20	1929.5	-	-
06°58'S	102°54'E	22	14	4	4	22	0	0	0	1	St.1-3	28.7	28.9	11.2	Cloudy	1.1	31	141	20:02~15	Nov 20	1803.0	-	-
04°05'S	101°56'E	14	9	3	2	5	9	0	0	0	St.2-1	29.9	28.2	5.9	R/C	0.7	28.9	122	19:16~31	Nov 23	1955.0	-	-
04°05'S	101°55'E	9	6	1	2	1	8	0	0	0	St.2-2	29.9	28.2	5.3	Cloudy	0.6	28.9	115	19:36~51	Nov 23	1754.0	-	-
04°06'S	101°55'E	8	5	3	0	1	7	0	0	0	St.2-3	29.9	28.2	6.3	Cloudy	0.6	28.9	119	19:56-20:11	Nov 23	1712.0	-	-
04°04'S	101°53'E	10	6	2	2	10	0	0	0	0	St.3-1	29.3	28.2	6.3	Cloudy	0.4	30.0	219	19:12~27	Nov 26	964.5	-	-
04°03'S	101°53'E	6	3	2	1	6	0	0	0	0	St.3-2	29.3	28.2	5.5	Cloudy	0.4	30.0	196	19:32~47	Nov 26	956.0	-	-
04°02'S	101°53'E	8	3	5	0	8	0	0	0	0	St.3-3	29.3	28.2	5.4	Cloudy	0.4	30.0	190	19:53-20:08	Nov 26	891.5	-	-
04°04'S	101°53'E	39	19	9	11	39	0	0	0	0	St.4-1	29.3	29.5	5.7	Cloudy	0.2	28.5	242	19:08~23	Nov 29	1831.0	-	-
04°05'S	101°53'E	27	16	9	2	27	0	0	0	0	St.4-2	29.3	29.5	4.4	Cloudy	0.1	28.5	227	19:28~43	Nov 29	1822.0	-	-
04°05'S	101°52'E	13	6	3	4	13	0	0	0	0	St.4-3	29.3	29.5	3.9	Cloudy	0.1	28.5	265	19:48-20:03	Nov 29	1693.0	-	-
04°03'S	101°53'E	16	3	9	4	16	0	0	0	0	St.5-1	29.6	28.8	3.3	Cloudy	0.1	28.9	66	19:41-56	Dec 02	799.0	-	-
04°03'S	101°53'E	30	18	3	9	30	0	0	0	0	St.5-2	29.6	28.8	1.2	Cloudy	0.0	28.9	105	20:05~20	Dec 02	733.0	-	-
04°03'S	101°53'E	14	1	6	7	13	0	1	0	0	St.5-3	29.6	28.8	3.4	Cloudy	0.1	28.9	136	20:25-40	Dec 02	784.0	-	-
04°04'S	101°53'E	37	24	7	6	37	0	0	0	6	St.6-1	29.0	28.2	3.5	Cloudy	0.4	30.1	132	19:34~49	Dec 05	634.0	-	-
04°03'S	101°53'E	30	18	8	4	28	2	0	0	27	St.6-2	29.0	28.2	3.9	Cloudy	0.4	30.1	125	19:55~20:10	Dec 05	596.5	-	-
04°03'S	101°52'E	46	33	10	3	46	0	0	0	17	St.6-3	29.0	28.2	2.6	Cloudy	0.3	30.1	129	20:15~20:30	Dec 05	612.8	-	-
04°04'S	101°53'E	90	34	25	31	74	16	0	0	1	St.7-1	29.7.	28.7	3.7	Cloudy	0.7	27.6	140	19:14-29	Dec 08	467.5	-	-
04°04'S	101°53'E	131	55	44	32	116	15	0	0	0	St.7-2	29.7.	28.7	3.4	Cloudy	0.7	27.6	136	19:33~48	Dec 08	485.1	-	-
04°05'S	101°54'E	109	63	24	22	71	38	0	0	0	St.7-3	29.7	28.7	3.1	Cloudy	0.7	27.6	136	19: 52-20:07	Dec 08	466.0	-	-
04°04'S	101°53'E	2	0	2	0	2	0	0	0	0	St.8-1	30.3	30.0	2.9	Cloudy	0.3	27.7	126	19:07-22	Dec 11	725.0		-
(At St.8-1, one adult male individual of *Gerris* sp was collected)																							
04°04'S	101°52'E	4	4	0	0	3	1	0	1	0	St.8-2	30.3	30.0	2.2	Cloudy	0.3	27.7	117	19:26~19:41	Dec 11	816.0		-
04°04'S	101°52'E	6	3	2	1	5	1	0	3 (*H*.sp)	0	St.8-3	30.3	30.0	3.9	Cloudy	0.3	27.7	107	19:46~20;01	Dec 11	762.5		-
04°03'S	101°53'E	31	14	11	6	20	11(H.m.)	0	0	0	St.9-1	29.2	27.7	4.0	Rainy	0.6	31.0	119	19:05~20	Dec 14	794.0		-
04°02'S	101°53'E	23	12	6	5	17	6(H.m.)	0	0	0	St.9-2	29.2	27.7	4.6	Rainy	0.5	31.0	122	19:26~41	Dec 14	710.5		-
04°02'S	101°53'E	10	3	4	3	4	6(H.m.)	0	1	0	St.9-3	29.2	27.7	5.1	Rainy	0.4	31.0	120	19:46-20:01	Dec 14	671.0		-

Table 2: A comparison of population density of oceanic sea skaters, *Halobates* among four areas of open Indian and Pacific Oceans. Samplings were performed during the seven cruises including this cruise. *H.m: Halobates micans: H.g.: H. germanus; H.s.: H. sericeus; H.p.: H. princeps; H. sumatoraensis=H.*sp (un-described species collected during this cruise). Density: individual number/km^2

1.KH-07-04-Leg 1: Eastern Tropical Indian Ocean, 8ºN-6º35'S, 86ºE- 76º36'E) (Harada et al., 2010b, 2011a)

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS#
	Nymphs	Adults						
Number	1291	706	1886	111	0	0	0	0.044292
Density	29147.5	15939.7	42581.1	2506.1	0	0	0	-

2. MR-11-07-Leg 1: Eastern Tropical Indian Ocean, 01º55'S, 083º24E; 8ºS, 80º30'E) (Harada et al., 2011b)

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS#
	Nymphs	Adults						
Number	551	255	697	109	0	0	0	0.0438607
Density	12562.5	5813.9	15891.2	2485.1	0	0	0	-

3. MR-12-05-Leg 1 (Stations A, B and C)): Western Subtropical and Tropical Pacific Ocean (Nakajo et al., 2013)

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS#
	Nymphs	Adults						
A. 13º59'N 149º16'E								
Number	44	73	43	0	74	0	0	0.0061659
Density	7136.0	11839.3	6973.8	0	12001.5	0	0	-

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS#
	Nymphs	Adults						
B. 01º55'N 150º31'E								
Number	66	379	8	437	0	0	0	0.0043914
Density	15029.4	86305.1	1821.7	99512.7	0	0	0	-
C. 26º55'S 165º34'E								
Number	71	183	0	0	254	0	0	0.0066742
Density	10638.0	27419.0	0	0	38057.0	0	0	-

4. MR-13-03 (Stations 1-10): Western Subtropical and Tropical Pacific Ocean (Harada and Sekimoto, 2013)

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS[#]
	Nymphs	Adults						
A. 24º00'N 138º10'E (Station 1)								
Number	179	126	6	0	299	0	0	0.0031594
Density	56656.5	39881.1	1899,1	0	94638.5	0	0	-

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS[#]
	Nymphs	Adults						
B. 12º00'N 135º00'E (Stations 2-10)								
Number	484	119	276	327	0	0	0	0.02802519
Density	17270.2	4246.2	9848.3	11688.1	0	0	0	-

5. KH-14-02 (Stations A and B): Western Subtropical and Tropical Pacific Ocean

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS[#]
	Nymphs	Adults						
A: Northern Station at 47º00'N 160º00'N								
Number	0	0	0	0	0	0	0	0.0126451
Density	0	0	0	0	0	0	0	-

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS[#]
	Nymphs	Adults						
B: Southern Station at 25º00'N 160º00'E								
Number	593	254	0	0	847	0	0	0.0162708
Density	36445.7	15610.8	0	0	52056.4	0	0	-

6. MR14-06 leg 2: Western Tropical Pacific Ocean (Harada and Umamoto, 2015)

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS[#]
	Nymphs	Adults						
Number	266	367	112	521	0	0	0	0.03036016
Density	8761.5	12088.2	3689.0	17160.6	0	0	0	-

AS[#] : Area of surface where the Neuston net has swept (km^2)

7. MR15-04: Eastern Tropical Indian Ocean (this cruise)

A. 06˚56-58'S 102˚53-54'E (Station 1)

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS#
	Nymphs	Adults						
Number	29	17	0	46	0	0	0	0.00744055
Density	3897.6	2284.8	0	6182.3	0	0	0	-

B. 04˚02-06'S 101˚52-55'E (Stations 2-8)

	Total		*H.m*	*H.g*	*H. s .*	*H. p*	*H. sumatoraensis*	AS#
	Nymphs	Adults						
Number	358	355	23	621	0	1	68	0.03072667
Density	11651.1	11553.5	748.5	20210.5	0	32.5	2213.1	-

Table 3-A. Components of instars of larvae and adults of oceanic sea skaters, *Halobates germanus* sampled at Stations located in 4 º S-7 º S, 101º E~103º E in the tropical Indean Ocean during the science cruise, MR15-04.

	Halobates germanus						
	Larvae					**Adults**	
	1st	**2nd**	**3rd**	**4th**	**5th**	**F**	**M**
St.1-1	**0**	**3**	**0**	**1**	**0**	**1**	**2**
St.1-2	**0**	**6**	**2**	**0**	**3**	**5**	**1**
St.1-3	**1**	**7**	**1**	**2**	**3**	**4**	**4**
St.2-1	**0**	**0**	**0**	**0**	**2**	**2**	**1**
St.2-2	**0**	**0**	**0**	**0**	**0**	**0**	**1**
St.2-3	**0**	**0**	**0**	**0**	**0**	**1**	**0**
St.3-1	**2**	**0**	**2**	**1**	**1**	**2**	**2**
St.3-2	**1**	**0**	**2**	**0**	**0**	**2**	**1**
St.3-3	**0**	**2**	**0**	**1**	**0**	**5**	**0**
St.4-1	**2(1)***	**2**	**2**	**2**	**11**	**9**	**11**
St.4-2	**2**	**2**	**0**	**1**	**11**	**9**	**2**
St.4-3	**1**	**0**	**3**	**0**	**2**	**3**	**4**
St.5-1	**0**	**0**	**0**	**0**	**3**	**9**	**4**
St.5-2	**7(3)***	**1**	**2**	**5**	**3**	**3**	**9**
St.5-3	**1**	**0**	**0**	**0**	**0**	**6**	**6**
St.6-1	**2**	**4**	**3**	**6**	**9**	**7**	**6**
St.6-2	**2(2)***	**3**	**7**	**1**	**5**	**8**	**4**
St.6-3	**16(7)***	**2**	**4**	**5**	**4**	**10**	**3**
St.7-1	**8(1)***	**4**	**1**	**1**	**4**	**25**	**31**
St.7-2	**15(4)***	**9**	**7**	**5**	**4**	**44**	**32**
St.7-3	**13(2)***	**1**	**4**	**1**	**6**	**24**	**22**
St.8-1	**0**	**0**	**0**	**0**	**0**	**2**	**0**
St.8-2	**1**	**1**	**0**	**0**	**1**	**0**	**0**
St.8-3	**0**	**0**	**0**	**1**	**1**	**2**	**1**
St.9-1	**1**	**3**	**0**	**0**	**4**	**6**	**6**
St.9-2	**4**	**2**	**0**	**4**	**2**	**3**	**2**
St.9-3	**0**	**0**	**1**	**0**	**0**	**2**	**1**
Total	**79**	**52**	**41**	**37**	**79**	**194**	**156**

***: number of smaller individuals which can be supposed to be just after hatching (0^{th} instar)**

Table 3-B. Components of instars of larvae and adults of oceanic sea skaters, *Halobates* sp sampled at Stations located in 10 º N-5 º S, 130 º E~160 º E in the tropical Pacific Ocean during the science cruise, MR15-04.

	***Halobates* sp. (a proposed name: *H. sumatraensis*)**						
	Larvae					**Adults**	
	1st	**2nd**	**3rd**	**4th**	**5th**	**F**	**M**
St.1-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.1-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.1-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.2-1	**2**	**1**	**0**	**2**	**2**	**1**	**1**
St.2-2	**0**	**2**	**0**	**1**	**3**	**1**	**1**
St.2-3	**0**	**1**	**1**	**0**	**3**	**1**	**1**
St.3-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.3-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.3-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.4-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.4-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.4-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.5-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.5-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.5-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.6-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.6-2	**1**	**1**	**0**	**0**	**0**	**0**	**0**
St.6-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.7-1	**9(7) ***	**2**	**1**	**2**	**2**	**0**	**0**
St.7-2	**13(10) ***	**0**	**0**	**1**	**1**	**0**	**0**
St.7-3	**15(8) ***	**8**	**7**	**3**	**5**	**0**	**0**
St.8-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.8-2	**0**	**1**	**0**	**0**	**0**	**0**	**0**
St.8-3	**0**	**1**	**0**	**0**	**0**	**0**	**0**
(At St.3, three exuviae of *H.* sp were collected)							
St.9-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.9-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.9-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total	**31**	**17**	**9**	**9**	**16**	**3**	**3**

***: number of smaller individuals which can be supposed to be just after hatching (0th instar)**

Table 3-C. Components of instars of larvae and adults of oceanic sea skaters, *Halobates princeps* sampled at Stations located in 10 º N-5 º S, 130 º E~160 º E in the tropical Pacific Ocean during the science cruise, MR15-04.

	Halobates princeps						
	Larvae					**Adults**	
	1st	**2nd**	**3rd**	**4th**	**5th**	**F**	**M**
St.1-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.1-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.1-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.2-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.2-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.2-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.3-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.3-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.3-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.4-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.4-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.4-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.5-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.5-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.5-3	**0**	**0**	**0**	**0**	**0**	**0**	**1**
St.6-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.6-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.6-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.7-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.7-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.7-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.8-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.8-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.8-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.9-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.9-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.9-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**1**

Table 3-D. Components of instars of larvae and adults of oceanic sea skaters, *Halobates micans* sampled at Stations located in 10 º N-5 º S, 130 º E~160 º E in the tropical Pacific Ocean during the science cruise, MR15-04.

	Halobates micans						
	Larvae					**Adults**	
	1st	**2nd**	**3rd**	**4th**	**5th**	**F**	**M**
St.1-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.1-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.1-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.2-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.2-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.2-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.3-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.3-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.3-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.4-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.4-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.4-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.5-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.5-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.5-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.6-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.6-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.6-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.7-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.7-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.7-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.8-1	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.8-2	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.8-3	**0**	**0**	**0**	**0**	**0**	**0**	**0**
St.9-1	**0**	**0**	**3**	**0**	**3**	**5**	**0**
St.9-2	**0**	**0**	**0**	**0**	**0**	**3**	**3**
St.9-3	**1**	**0**	**0**	**1**	**0**	**2**	**2**
Total	**1**	**0**	**3**	**1**	**3**	**10**	**5**

Table 4-Sheet 1. Results of "Cool-coma" experiments and measurement of recovery time from the cool coma (RTCC as seconds) performed on adults of *H. germanus* (H.g) ; TA: temp. at which specimen adapted, SCCT: temp. at which semi-cool coma occurred; CCT: temp. at which cool coma occurred ; GTCC: gap temp. for cool coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when cool coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SCCT	CCT	GTCC	RTCC	Species	Sex	Date	TD
St.1-2,3	06°56'S	102°53'E	1	28.0	16.1	16.1	11.9	10	H.g.	Male	Nov 21	8:00~
St.1-2,3	06°56'S	102°53'E	1	28.0	15.0	14.1	13.9	30	H.g.	Female	Nov 21	8:00~
St.1-2,3	06°56'S	102°53'E	1	28.0	14.1	14.0	14.0	3060	H.g.	Female	Nov 21	8:00~
St.1-2,3	06°56'S	102°53'E	1	28.0	14.0	14.0	14.0	26	H.g.	Female	Nov 21	8:00~
St.1-2,3	06°56'S	102°53'E	1	28.0	14.0	14.0	14.0	6	H.g.	Female	Nov 21	8:00~
St.1-2,3	06°56'S	102°53'E	1	28.0	15.0	14.0	14.0	22	H.g.	Male	Nov 21	8:00~
St.1-2,3	06°56'S	102°53'E	1	28.0	15.0	14.0	14.0	43	H.g.	Male	Nov 21	8:00~
St.1-2,3	06°56'S	102°53'E	1	28.0	14.0	14.0	14.0	>2(hours)	H.g.	5th instar	Nov 21	8:00~
St.1-2,3	06°56'S	102°53'E	1	28.0	13.3	13.3	14.7	60	H.g.	Female	Nov 21	8:00~
St.1-2,3	06°56'S	102°53'E	1	28.0	13.1	13.1	14.9	2	H.g.	Male	Nov 21	8:00~
St.1-1,2,3	06°56'S	102°53'E	2	28.0	22.0	22.0	6.0	180	H.g.	4th instar	Nov 21	8:00~
St.1-1,2,3	06 °56'S	102°53'E	2	28.0	18.0	18.0	10.0	>2(hours)	H.g.	Female	Nov 21	8:00~
St.1-1,2,3	06 °56'S	102°53'E	2	28.0	18.0	18.0	10.0	1320	H.g.	Female	Nov 21	8:00~
St.1-1,2,3	06°56'S	102°53'E	2	28.0	16.0	16.0	12.0	15	H.g.	Male	Nov 21	8:00~
St.1-1,2,3	06°56'S	102°53'E	2	28.0	14.1	14.1	13.9	>2(hours)	H.g.	4th instar	Nov 21	8:00~
St.1-1,2,3	06°56'S	102°53'E	2	28.0	13.5	13.5	14.5	4	H.g.	5th instar	Nov 21	8:00~
St.1-1,2,3	06°56'S	102°53'E	2	28.0	17.0	17.0	11.0	10	H.g.	Female	Nov 21	8:00~
St.2-1,2,3	04°05'S	101°55'E	3	28.1	19.0	19.0	9.1	45	H.g.	Female	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55'E	3	28.1	18.0	18.0	10.1	12	H.g.	Female	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55'E	3	28.1	16.0	16.0	12.1	2	H.g.	Male	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55'E	3	28.1	16.0	16.0	12.1	49	H.sp.	5th instar	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55'E	3	28.1	15.0	15.0	13.1	270	H.sp.	5th instar	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55'E	3	28.1	15.0	14.0	14.1	5	H.sp.	4th instar	Nov 24	07:45~
St.2-1.2.3	04°05'S	101°55'E	3	28.1	15.0	14.0	14.1	16	H.g.	5th instar	Nov 24	07:45~
St.2-1.2.3	04°05'S	101°55'E	3	28.1	15.0	14.0	14.1	31	H.sp.	Male	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55'E	3	28.1	15.0	14.0	14.1	42	H.sp.	5th instar	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55'E	3	28.1	15.0	13.7	14.4	360	H.sp.	Female	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55'E	3	28.1	15.0	12.0	16.1	4	H.sp.	5th instar	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55' E	4	28.1	25.0	25.0	3.1	105	H.g.	Female	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55' E	4	28.1	24.0	24.0	4.1	(<900)	H.g.	5th instar	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55' E	4	28.1	20.0	20.0	8.1	18	H.g.	Female	Nov 24	07:45~
St.2-1,2,3	04°05'S	101°55'E	4	28.1	17.0	14.0	14.1	467	H.g.	Male	Nov 24	07:45~

Table 4-Sheet 2. Results of “Cool-coma” experiments and measurement of recovery time from the cool coma (RTCC as seconds) performed on adults of *H. germanus* (H.g) ; TA: temp. at which specimen adapted, SCCT: temp. at which semi-cool coma occurred; CCT: temp. at which cool coma occurred ; GTCC: gap temp. for cool coma (from base temp.); “Date and Time of Day” when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when cool coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SCCT	CCT	GTCC	RTCC	Species	Sex	Date	TD
St.3-1,2,3	04°03’S	101°53’E	5	28.3	21.0	21.0	7.3	45	H.g.	Male	Nov 27	07:45~
St.3-1,2,3	04°03’N	101°53’ E	5	28.3	18.4	18.4	10.0	5	H.g.	Male	Nov 27	07:45~
St.3-1,2,3	04°03’S	101°53’E	5	28.3	17.5	17.5	10.8	31	H.g.	Female	Nov 27	07:45~
St.3-1,2,3	04°03’S	101°53’E	5	28.3	16.2	16.2	12.1	7	H.g.	Female	Nov 37	07:45~
St.3-1,2,3	04°03’S	101°53’E	5	28.3	15.8	15.8	12.5	23	H.g.	Male	Nov 27	07:45~
St.3-1,2,3	04°03’S	101°53’E	5	28.3	15.7	15.7	12.6	25	H.g.	Female	Nov 27	07:45~
St.3-1,2,3	04°03’S	101°53’E	5	28.3	14.2	14.2	14.1	19	H.g.	Female	Nov 27	07:45~
St.3-1,2,3	04°03’S	101°53’E	5	28.3	14.0	13.3	15.0	11	H.g.	Female	Nov 27	07:45~
St.3-1,2,3	04°03’S	101°53’E	5	28.3	14.0	13.1	15.2	9	H.g.	Female	Nov 27	07:45~
St.3-1,2,3	04°03’S	101°53’E	5	28.3	14.0	12.5	15.8	18	H.g.	Female	Nov 27	07:45~
St.3-1,2,3	04°03’S	101°53’E	6	28.3	22.2	22.2	6.1	22	H.g.	Female	Nov 27	07:45~
St.3-1,2,3	04º03’S	101º53’E	6	28.3	22.0	22.0	6.3	12	H.g.	Female	Nov 27	07:45~
St.3-1,2,3	04º03’S	101º53’E	6	28.3	14.0	13.0	10.3	9	H.g.	2nd instar	Nov 27	07:45~
St.4-1,2,3	04°05’S	101°53’E	7	28.2	22.7	22.7	5.5	31	H.g.	Male	Nov 30	07:45~
St.-4-1,2,3	04º05’S	101º53’E	7	28.2	22.3	22.3	5.9	1096	H.g.	Female	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	7	28.2	21.2	21.2	7.0	1	H.g.	Male	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	7	28.2	20.0	20.0	8.2	6	H.g.	Female	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	7	28.2	18.7	18.7	9.5	96	H.g.	Female	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	7	28.2	18.0	18.0	10.2	22	H.g.	Female	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	7	28.2	18.0	18.0	10.2	23	H.g.	Female	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	7	28.2	17.8	17.8	10.4	18	H.g.	Female	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	7	28.2	17.0	17.0	11.2	8	H.g.	Male	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	7	28.2	17.0	17.0	11.2	13	H.g.	Male	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	7	28.2	16.2	16.2	12.0	18	H.g.	Male	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	7	28.2	16.0	16.0	12.2	10	H.g.	Male	Nov 30	07:45~
St.4-1,2,3	04º05’S	101º53’E	8	28.3	18.0	17.0	10.3	17	H.g.	5th instar	Dec 1	07:45~
St.4-1,2,3	04º05’S	101º53’E	8	28.3	16.3	16.3	12.0	5	H.g.	5th instar	Dec 1	07:45~
St.4-1,2,3	04º05’S	101º53’E	8	28.3	16.0	16.0	12.3	11	H.g.	5th instar	Dec 1	07:45~
St.4-1,2,3	04º05’S	101º53’E	8	28.3	15.2	15.2	13.1	2	H.g.	Female	Dec 1	07:45~
St.4-1,2,3	04º05’S	101º53’E	8	28.3	15.1	15.1	13.2	24	H.g.	5th instar	Dec 1	07:45~
St.4-1,2,3	04º05’S	101º53’E	8	28.3	15.0	15.0	13.3	35	H.g.	5th instar	Dec 1	07:45~

Table 4-Sheet 3. Results of "Cool-coma" experiments and measurement of recovery time from the cool coma (RTCC as seconds) performed on adults of *H. germanus* (H.g) ; TA: temp. at which specimen adapted, SCCT: temp. at which semi-cool coma occurred; CCT: temp. at which cool coma occurred ; GTCC: gap temp. for cool coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when cool coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SCCT	CCT	GTCC	RTCC	Species	Sex	Date	TD
St.4-1,2,3	**04º05'S**	**101º53'E**	**8**	**28.3**	**15.0**	**15.0**	**13.3**	**14**	**H.g.**	**5th instar**	**Dec 1**	**07:45~**
St.4-1,2,3	**04˚05'S**	**101˚53' E**	**8**	**28.3**	**14.9**	**14.9**	**13.4**	**26**	**H.g.**	**5th instar**	**Dec 1**	**07:45~**
St.4-1,2,3	**04˚05'S**	**101˚53' E**	**8**	**28.3**	**14.7**	**14.7**	**13.6**	**9**	**H.g.**	**Female**	**Dec 1**	**07:45~**
St.4-1,2,3	**04˚05'S**	**101˚53' E**	**8**	**28.3**	**14.5**	**14.5**	**13.8**	**4**	**H.g.**	**5th instar**	**Dec 1**	**07:45~**
St.4-1,2,3	**04˚05'S**	**101˚53' E**	**8**	**28.3**	**14.4**	**14.4**	**13.9**	**16**	**H.g.**	**5th instar**	**Dec 1**	**07:45~**
St.4-1,2,3	**04˚05'S**	**101˚53' E**	**8**	**28.3**	**14.0**	**13.2**	**15.1**	**14**	**H.g.**	**Female**	**Dec 1**	**07:45~**
St.4-1,2,3	**04˚05'S**	**101˚53' E**	**8**	**28.3**	**14.0**	**13.1**	**15.2**	**7**	**H.g.**	**Female**	**Dec 1**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**21.8**	**21.8**	**6.1**	**9**	**H.g.**	**Female**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**21.1**	**21.1**	**6.8**	**11**	**H.g.**	**Female**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**19.8**	**19.8**	**8.1**	**26**	**H.g.**	**Male**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**19.5**	**19.5**	**8.4**	**102**	**H.g.**	**Female**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**19.0**	**19.0**	**8.9**	**14**	**H.g.**	**Male**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**18.8**	**18.8**	**9.1**	**15**	**H.g.**	**Male**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**18.0**	**18.0**	**9.9**	**13**	**H.g.**	**Female**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**17.4**	**17.4**	**10.5**	**6**	**H.g.**	**Female**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**17.1**	**17.1**	**10.8**	**9**	**H.g.**	**Male**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**17.0**	**17.0**	**10.9**	**9**	**H.g.**	**Female**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**16.6**	**16.6**	**11.3**	**26**	**H.g.**	**Male**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**9**	**27.9**	**15.3**	**15.3**	**12.6**	**17**	**H.g.**	**Male**	**Dec 3**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**10**	**27.9**	**24.6**	**24.6**	**3.3**	**5**	**H.g.**	**Male**	**Dec 4**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**10**	**27.9**	**17.9**	**17.9**	**10.0**	**23**	**H.g.**	**Female**	**Dec 4**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**10**	**27.9**	**17.6**	**17.6**	**10.3**	**7**	**H.g.**	**5th instar**	**Dec 4**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53'E**	**10**	**27.9**	**17.3**	**17.3**	**10.6**	**1**	**H.g.**	**Female**	**Dec 4**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53'E**	**10**	**27.9**	**17.0**	**17.0**	**10.9**	**22**	**H.g.**	**4th instar**	**Dec 4**	**07:45~**
St.5-1,2,3	**04˚03'S**	**101˚53' E**	**10**	**27.9**	**16.1**	**16.1**	**11.8**	**7**	**H.g.**	**Male**	**Dec 4**	**07:45~**
St.6-1,2,3	**04˚03'S**	**101˚53' E**	**11**	**27.8**	**24.0**	**24.0**	**3.8**	**20**	**H.g.**	**Female**	**Dec 6**	**07:45~**
St.6-1,2,3	**04˚03'S**	**101˚53' E**	**11**	**27.8**	**22.0**	**22.0**	**5.8**	**4**	**H.g.**	**Male**	**Dec 6**	**07:45~**
St.6-1,2,3	**04˚03'S**	**101˚53' E**	**11**	**27.8**	**19.6**	**19.6**	**8.2**	**10**	**H.g.**	**Male**	**Dec 6**	**07:45~**
St.6-1,2,3	**04˚03'S**	**101˚53' E**	**11**	**27.8**	**19.2**	**19.2**	**8.6**	**18**	**H.g.**	**Female**	**Dec 6**	**07:45~**
St.6-1,2,3	**04˚03'S**	**101˚53' E**	**11**	**27.8**	**19.1**	**19.1**	**8.7**	**3**	**H.g.**	**Female**	**Dec 6**	**07:45~**
St.6-1,2,3	**04˚03'S**	**101˚53' E**	**11**	**27.8**	**18.0**	**18.0**	**9.8**	**8**	**H.g.**	**Female**	**Dec 6**	**07:45~**

Table 4-Sheet 4. Results of "Cool-coma" experiments and measurement of recovery time from the cool coma (RTCC as seconds) performed on adults of *H. germanus* (H.g) ; TA: temp. at which specimen adapted, SCCT: temp. at which semi-cool coma occurred; CCT: temp. at which cool coma occurred ; GTCC: gap temp. for cool coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when cool coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SCCT	CCT	GTCC	RTCC	Species	Sex	Date	TD
St.6-1,2,3	04°03'S	101°53' E	11	27.8	17.3	17.3	10.5	7	H.g.	Female	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53' E	11	27.8	17.0	17.0	10.8	7	H.g.	Male	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53' E	11	27.8	17.0	17.0	10.8	18	H.g.	Female	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53' E	11	27.8	17.0	17.0	10.8	10	H.g.	Female	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53' E	11	27.8	17.0	17.0	10.8	12	H.g.	Male	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53' E	11	27.8	14.3	14.3	13.5	13	H.g.	Female	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53' E	12	28.8	23.1	23.1	5.7	8	H.g.	4th instar	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53' E	12	28.8	19.0	19.0	9.8	208	H.g.	5th instar	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53' E	12	28.8	18.0	18.0	10.8	2	H.g.	5th instar	Dec 7	07:45~
St.6-1,2,3	04°03S	101°53' E	12	28.8	17.7	17.7	11.1	20	H.g.	4th instar	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53' E	12	28.8	17.3	17.3	11.5	15	H.g.	Female	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53' E	12	28.8	17.0	17.0	11.8	6	H.g.	Female	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53' E	12	28.8	17.0	16.7	12.1	5	H.g.	5th instar	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53' E	12	28.8	15.5	15.5	13.3	13	H.g.	5th instar	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53' E	12	28.8	15.0	14.4	14.4	10	H.g.	Female	Dec 7	07:45~
St.7-1	04°04'S	101°53' E	13	28.1	22.0	22.0	6.1	3	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	20.0	20.0	8.1	168	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	20.0	20.0	8.1	21	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	18.7	18.7	9.4	16	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	18.1	18.1	10.0	11	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	17.2	17.2	10.9	9	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	17.1	17.1	11.0	7	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	17.0	17.0	11.1	18	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	16.9	16.9	11.2	7	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	16.2	16.2	11.9	2	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	15.7	15.7	12.4	4	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	15.1	15.1	13.0	7	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	13	28.1	15.1	15.1	13.0	18	H.g.	Female	Dec 9	06:45~
St.7-2	04°04'S	101°53' E	14	28.4	18.0	18.0	10.4	12	H.g.	Male	Dec 9	06:45~
St.7-2	04°04'S	101°53' E	14	28.4	18.0	18.0	10.4	14	H.g.	Male	Dec 9	06:45~
St.7-2	04°04'S	101°53' E	14	28.4	17.0	16.5	11.9	8	H.g.	Female	Dec 9	06:45~

Table 4-Sheet 5. Results of "Cool-coma" experiments and measurement of recovery time from the cool coma (RTCC as seconds) performed on adults of *H. germanus* (H.g) ; TA: temp. at which specimen adapted, SCCT: temp. at which semi-cool coma occurred; CCT: temp. at which cool coma occurred ; GTCC: gap temp. for cool coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when cool coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SCCT	CCT	GTCC	RTCC	Species	Sex	Date	TD
St.7-2	04°04'S	101°53'E	14	28.4	16.0	16.0	12.4	24	H.g.	Female	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	14	28.4	17.0	15.8	12.6	6	H.g.	Male	Dec 9	10:30~
St.7-2	04°04'S	101°53' E	14	28.4	17.0	15.5	12.9	8	H.g.	Male	Dec 9	10:30~
St.7-2	04°04'S	101°53' E	14	28.4	15.3	15.3	13.1	12	H.g.	Male	Dec 9	10:30~
St.7-2	04°04'S	101°53' E	14	28.4	15.1	15.1	13.3	12	H.g.	Male	Dec 9	10:30~
St.7-2	04°04'S	101°53' E	14	28.4	15.0	15.0	13.4	12	H.g.	Male	Dec 9	10:30~
St.7-2	04°04'S	101°53' E	14	28.4	16.0	15.0	13.4	23	H.g.	Female	Dec 9	10:30~
St.7-2	04°04'S	101°53' E	14	28.4	16.0	14.3	14.1	7	H.g.	Female	Dec 9	10:30~
St.7-2	04°04'S	101°53' E	14	28.4	13.4	13.4	15.0	13	H.g.	Female	Dec 9	10:30~
St.7-3	04°05'S	101°54'E	15	28.0	23.0	23.0	5.0	120	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54' E	15	28.0	22.0	22.0	6.0	36	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54' E	15	28.0	18.0	18.0	10.0	13	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	15	28.0	18.0	18.0	10.0	3	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	15	28.0	17.1	17.1	10.9	5	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	15	28.0	19.0	17.0	11.0	16	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	15	28.0	17.0	17.0	11.0	10	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	15	28.0	17.0	17.0	11.0	11	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	15	28.0	19.0	17.0	11.0	8	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	15	28.0	16.0	15.8	12.2	5	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	15	28.0	16.0	15.0	13.0	25	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	15	28.0	15.0	15.0	13.0	7	H.g.	Female	Dec 10	06:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	18.4	18.4	10.0	14	H.g.	Female	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	18.3	18.3	10.1	9	H.g.	Female	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	18.2	18.2	10.2	9	H.g.	Female	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	18.0	17.0	11.4	17	H.g.	Male	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	16.0	16.0	12.4	5	H.g.	Male	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	16.0	16.0	12.4	9	H.g.	Male	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	16.0	16.0	12.4	6	H.g.	Female	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	16.0	16.0	12.4	6	H.g.	Female	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	15.8	15.8	12.6	4	H.g.	Male	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	15.1	15.1	13.3	3	H.g.	Male	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	15.0	15.0	13.4	10	H.g.	Male	Dec 10	10:30~

Table 4-Sheet 6. Results of "Cool-coma" experiments and measurement of recovery time from the cool coma (RTCC as seconds) performed on adults of *H. germanus* (H.g) ; TA: temp. at which specimen adapted, SCCT: temp. at which semi-cool coma occurred; CCT: temp. at which cool coma occurred ; GTCC: gap temp. for cool coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when cool coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SCCT	CCT	GTCC	RTCC	Species	Sex	Date	TD
St.7-1,2,3	04°04'S	101°53'E	16	28.4	14.1	14.1	14.3	10	H.g.	Male	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	16	28.4	14.0	14.0	14.4	57	H.g.	Male	Dec 10	10:30~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	17.0	16.0	11.5	15	H.g.	Male	Dec 11	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	16.0	16.0	11.5	31	H.g.	Female	Dec 11	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	17.0	16.0	11.5	9	H.g.	Female	Dec 11	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	17.0	15.9	11.6	5	H.sp	5^{th} instar	Dec 11	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	15.6	15.6	11.9	15	H.g.	Female	Dec 11	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	15.2	15.2	12.3	9	H.g.	Female	Dec 11	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	15.0	15.0	12.5	12	H.g.	Female	Dec 11	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	17.0	15.0	12.5	10	H.g.	Male	Dec 11	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	15.0	15.0	12.5	14	H.g.	Female	Dec 11	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	14.9	14.9	12.6	11	H.g.	Male	Dec 10	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	14.0	14.0	13.5	4370	H.g.	5^{th} instar	Dec 11	06:45~
St.7-1,2,3	04°04'S	101°53'E	17	27.5	13.9	13.9	13.6	4	H.g.	Male	Dec 11	06:45~
St.8-1,2,3	04°04'S	101°52'E	17	28.0	19.0	18.0	10.0	14	H.g.	5^{th} instar	Dec 12	07:45~
St.8-1,2,3	04°04'S	101°52'E	18	28.0	18.0	18.0	10.0	10	H.g.	Male	Dec 12	07:45~
St.8-1,2,3	04°04'S	101°52'E	18	28.0	17.0	17.0	11.0	19	H.g.	Female	Dec 12	07:45~
St.8-1,2,3	04°04'S	101°52'E	18	28.0	17.0	17.0	11.0	9	H.g.	Female	Dec 12	07:45~
St.8-1,2,3	04°04'S	101°52'E	18	28.0	16.1	16.1	11.9	5	H.g.	5^{th} instar	Dec 12	07:45~
St.8-1,2,3	04°04'S	101°52'E	18	28.0	16.0	16.0	12.0	4	H.g.	5^{th} instar	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°52'E	19	28.3	25.0	25.0	3.3	18	H.sp.	5^{th} instar	Dec 13	07:45~
St.7-1,2,3	04°04'S	101°52'E	19	28.3	22.8	22.8	5.5	6	H.g.	5^{th} instar	Dec 13	07:45~
St.7-1,2,3	04°04'S	101°52'E	19	28.3	20.0	20.0	8.3	27	H.g.	Male$^{\#}$	Dec 13	07:45~
St.7-1,2,3	04°04'S	101°52'E	19	28.3	18.0	18.0	10.3	28	H.g.	4^{th} instar	Dec 13	07:45~
St.7-1,2,3	04°04'S	101°52'E	19	28.3	16.0	16.0	12.3	8	H.g.	5^{th} instar	Dec 13	07:45~
St.9-1,2	04°03'S	101°53'E	20	27.8	22.1	22.1	5.7	6	H.g.	5^{th} instar	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	20	27.8	21.6	21.6	6.2	17	H.g.	Female	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	20	27.8	18.4	18.4	9.4	3	H.g.	Male	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	20	27.8	18.0	18.0	9.8	2	H.g.	5^{th} instar	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	20	27.8	17.0	17.0	10.8	3	H.g.	5^{th} instar	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	20	27.8	16.0	16.0	11.8	3	H.g.	Male	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	20	27.8	16.0	16.0	11.8	4	H.g.	Male	Dec 15	06:30~

Table 4-Sheet 7. Results of "Cool-coma" experiments and measurement of recovery time from the cool coma (RTCC as seconds) performed on adults of *H. germanus* (H.g) ; TA: temp. at which specimen adapted, SCCT: temp. at which semi-cool coma occurred; CCT: temp. at which cool coma occurred ; GTCC: gap temp. for cool coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when cool coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SCCT	CCT	GTCC	RTCC	Species	Sex	Date	TD
St.9-1,2	**04°03'S**	**101°53'E**	**20**	**27.8**	**16.0**	**16.0**	**11.8**	**10**	**H.g.**	**Male**	**Dec 15**	**06:30~**
St.9-1,2	**04°03'S**	**101°53'E**	**20**	**27.8**	**16.0**	**16.0**	**11.8**	**10**	**H.g.**	**Female**	**Dec 15**	**06:30~**
St.9-1,2	**04°03'S**	**101°53'E**	**20**	**27.8**	**16.0**	**16.0**	**11.8**	**17**	**H.g.**	**Male**	**Dec 15**	**06:30~**
St.9-1,2	**04°03'S**	**101°53'E**	**20**	**27.8**	**15.1**	**15.1**	**12.7**	**10**	**H.g.**	**Female**	**Dec 15**	**06:30~**
St.9-1,2	**04°03'S**	**101°53'E**	**20**	**27.8**	**14.5**	**14.5**	**13.3**	**5**	**H.g.**	**Male**	**Dec 15**	**06:30~**
St.9-1,2,3	**04°03'S**	**101°53'E**	**21**	**28.2**	**17.0**	**16.6**	**11.6**	**22**	**H.g.**	**5^{th} instar**	**Dec 15**	**10:15~**
St.9-1,2,3	**04°03'S**	**101°53'E**	**21**	**28.2**	**17.0**	**16.3**	**11.9**	**3**	**H.g.**	**Female**	**Dec 15**	**10:15~**
St.9-1,2,3	**04°03'S**	**101°53'E**	**21**	**28.2**	**17.0**	**15.3**	**12.9**	**22**	**H.g.**	**Female**	**Dec 15**	**10:15~**
St.9-1,2,3	**04°03'S**	**101°53'E**	**21**	**28.2**	**15.0**	**15.0**	**13.2**	**11**	**H.g.**	**Female**	**Dec 15**	**10:15~**
St.9-1,2,3	**04°03'S**	**101°53'E**	**21**	**28.2**	**14.2**	**14.2**	**14.0**	**6**	**H.g.**	**5^{th} instar**	**Dec 15**	**10:15~**

#with no left-mid-leg but very active

Table 5-Sheet 1. Results of "Heat-coma" experiments and measurement of recovery time from the heat coma (RTHC as seconds) performed on adults of *H. germanus* (H.g); TA: temp. at which specimen adapted, SHCT: temp. at which semi-heat coma occurred; HCT: temp. at which heat coma occurred ; GTHC: gap temp. for heat coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when heat coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SHCT	HCT	GTHC	RTHC	Species	Sex	Date	TD
St.4-1,2	04º05'S	101º53'E	1	28.2	35.7	35.8	7.6	>2 (hours)	H.g.	Female	Nov 30	07:45~
St.4-1,2	04˚05'S	101˚53'E	1	28.2	39.3	39.3	11.1	4	H.g.	Female	Nov 30	07:45~
St.4-1,2	04˚05'S	101˚53'E	1	28.2	39.4	39.5	11.3	3	H.g.	Female	Nov 30	07:45~
St.4-1,2	04˚05'S	101˚53'E	1	28.2	39.6	39.6	11.4	116	H.g.	Female	Nov 30	07:45~
St.4-1,2	04˚05'S	101˚53'E	1	28.2	41.2	41.2	13.0	150	H.g.	Male	Nov 30	07:45~
St.4-1,2	04˚05'S	101˚53'E	1	28.2	41.8	41.8	13.6	1117	H.g.	Male	Nov 30	07:45~
St.4-1,2	04˚05'S	101˚53'E	1	28.2	42.1	42.1	13.9	>6 (hours)	H.g.	Female	Nov 30	07:45~
St.4-1,2	04˚05'S	101˚53'E	1	28.2	42.9	42.9	14.7	>6 (hours)	H.g.	Female	Nov 30	07:45~
St.4-1,2	04˚05'S	101˚53'E	1	28.2	43.1	43.1	14.9	>6 (hours)	H.g.	Female	Nov 30	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	33.7	33.7	5.4	3	H.g.	5th instar	Dec 1	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	37.0	37.0	8.7	14	H.g.	5th instar	Dec 1	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	37.2	37.2	8.9	53	H.g.	Male	Dec 1	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	39.0	39.0	10.7	13	H.g.	5th instar	Dec 1	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	40.2	40.2	11.9	118	H.g.	5th instar	Dec 1	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	40.9	40.9	12.6	2	H.g.	Male	Dec 1	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	40.9	40.9	12.6	522	H.g.	Male	Dec 1	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	41.7	41.7	13.4	>2(hours)	H.g.	Female	Dec 1	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	41.9	41.9	13.6	>2(hours)	H.g.	Female	Dec 1	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	42.0	42.0	13.7	>2(hours)	H.g.	5th instar	Dec 1	07:45~
St.4-1,2,3	04˚05'S	101˚53'E	2	28.3	42.0	42.0	13.7	>2(hours)	H.g.	Female	Dec 1	07:45~
St.4-1,2	04˚03'S	101˚53'E	3	27.9	32.6	32.6	4.7	19	H.g.	Female	Dec 3	07:45~
St.4-1,2	04˚03'S	101˚53'E	3	27.9	32.6	32.6	4.7	57	H.g.	Male	Dec 3	07:45~
St.4-1,2	04˚03'S	101˚53'E	3	27.9	32.9	32.9	5.0	5	H.g.	Female	Dec 3	07:45~
St.4-1,2	04˚03'S	101˚53'E	3	27.9	34.5	34.5	6.6	26	H.g.	Female	Dec 3	07:45~
St.4-1,2	04˚03'S	101˚53'E	3	27.9	35.0	35.0	7.1	3	H.g.	Male	Dec 3	07:45~
St.4-1,2	04˚03'S	101˚53'E	3	27.9	35.0	35.0	7.1	>2(hours)	H.g.	Female	Dec 3	07:45~
St.4-1,2	04˚03'S	101˚53'E	3	27.9	38.1	38.1	10.2	1305	H.g.	Female	Dec 3	07:45~
St.4-1,2	04˚03'S	101˚53'E	3	27.9	38.0	38.0	10.1	12	H.g.	Male	Dec 3	07:45~
St.4-1,2	04˚03'S	101˚53'E	3	27.9	39.0	39.0	11.1	59	H.g.	Male	Dec 3	07:45~
St.4-1,2	04˚03'S	101˚53' E	3	27.9	40.0	40.0	12.1	166	H.g.	Male	Dec 3	07:45~
St.4-1,2	04˚03'S	101˚53'E	3	27.9	41.0	41.0	13.1	627	H.g.	Male	Dec 3	07:45~

Table 5-Sheet 2. Results of "Heat-coma" experiments and measurement of recovery time from the heat coma (RTHC as seconds) performed on adults of *H. germanus* (H.g); TA: temp. at which specimen adapted, SHCT: temp. at which semi-heat coma occurred; HCT: temp. at which heat coma occurred ; GTHC: gap temp. for heat coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when heat coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SHCT	HCT	GTHC	RTHC	Species	Sex	Date	TD
St.5-1,2	04°03'S	101°53'E	3	27.9	41.0	41.0	13.1	1371	H.g.	Female	Dec 3	07:45~
St.-5-2,3	04°03'S	101°53'E	4	27.9	29.4	29.4	1.5	19	H.g.	Male	Dec 4	07:45~
St.5-2,3	04°03'S	101°53'E	4	27.9	30.1	30.1	2.2	717	H.g.	5th instar	Dec 4	07:45~
St.5-2,3	04°03'S	101°53'E	4	27.9	32.0	32.0	4.1	51	H.g.	Female	Dec 4	07:45~
St.5-2,3	04°03'S	101°53'E	4	27.9	37.3	37.3	9.4	14	H.g.	Female	Dec 4	07:45~
St.5-2,3	04°03'S	101°53'E	4	27.9	40.0	40.0	12.1	30	H.g.	5th instar	Dec 4	07:45~
St.6-1,2,3	04°03'S	101°53'E	5	27.9	36.0	36.0	8.1	12	H.g.	Male	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53'E	5	27.9	37.0	37.0	9.1	13	H.g.	Female	Dec 6	07:45~
St.6-1,23	04°03'S	101°53'E	5	27.9	38.1	38.1	10.2	11	H.g.	Female	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53'E	5	27.9	38.7	38.7	10.8	18	H.g.	Male	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53'E	5	27.9	39.0	39.0	11.1	165	H.g.	Female	Dec 6	07:45~
St.6-1,23	04°03'S	101°53'E	5	27.9	41.9	41.9	14.0	3843	H.g.	Female	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53'E	5	27.9	42.0	42.0	14.1	3515	H.g.	Male	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53'E	5	27.9	42.0	42.0	14.1	>2hours	H.g.	Female	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53'E	5	27.9	42.0	42.0	14.1	>2hours	H.g.	Female	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53'E	5	27.9	42.0	42.0	14.1	>2hours	H.g.	Female	Dec 6	07:45~
St.6-1,2,3	04°03'S	101°53'E	6	28.9	35.0	35.0	6.1	5	H.g.	Female	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53'E	6	28.9	40.0	40.0	11.1	72	H.g.	Female	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53'E	6	28.9	40.0	40.0	11.1	429	H.g.	5th instar	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53'E	6	28.9	40.9	40.9	12.0	537	H.g.	5th instar	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53'E	6	28.9	41.0	41.0	12.1	426	H.g.	Female	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53'E	6	28.9	41.0	41.0	12.1	1885	H.g.	Female	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53'E	6	28.9	41.0	41.0	12.1	>2hours	H.g.	5th instar	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53'E	6	28.9	41.0	41.0	12.1	>2hours	H.g.	4th instar	Dec 7	07:45~
St.6-1,2,3	04°03'S	101°53'E	6	28.9	41.2	41.2	12.3	>2hours	H.g.	4th instar	Dec 7	07:45~
St.7-1	04°04'S	101°53'E	7	28.1	36.0	36.0	7.9	32	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53'E	7	28.1	38.0	38.0	9.9	39	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53'E	7	28.1	40.0	40.0	11.9	-	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53'E	7	28.1	40.0	40.0	11.9	>2hours	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	7	28.1	40.0	40.0	11.9	153	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53' E	7	28.1	40.1	40.1	11.9	>2hours	H.g.	Female	Dec 9	06:45~

Table 5-Sheet 3. Results of "Heat-coma" experiments and measurement of recovery time from the heat coma (RTHC as seconds) performed on adults of *H. germanus* (H.g); TA: temp. at which specimen adapted, SHCT: temp. at which semi-heat coma occurred; HCT: temp. at which heat coma occurred ; GTHC: gap temp. for heat coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when heat coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SHCT	HCT	GTHC	RTHC	Species	Sex	Date	TD
St.7-1	04°04'S	101°53'E	7	28.1	40.9	40.9	12.8	2616	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53'E	7	28.1	41.0	41.0	12.9	>2hours	H.g.	Male	Dec 9	06:45~
St.7-1	04°04'S	101°53'E	7	28.1	41.0	41.0	12.9	>2hours	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53'E	7	28.1	41.0	41.0	12.9	>2hours	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53'E	7	28.1	41.0	41.0	12.9	877	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53'E	7	28.1	41.0	41.0	12.9	>2hours	H.g.	Female	Dec 9	06:45~
St.7-1	04°04'S	101°53'E	7	28.1	41.0	41.0	12.9	>2hours	H.g.	Female	Dec 9	06:45~
St.7-2	04°04'S	101°53'E	8	28.4	39.0	39.0	10.6	65	H.g.	Female	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	40.1	40.1	11.7	21	H.g.	Male	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	40.0	40.0	11.6	20	H.g.	Male	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	40.0	40.0	11.6	25	H.g.	Male	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	40.5	40.5	12.1	>2hours	H.g.	Female	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	41.0	41.0	12.6	600	H.g.	Female	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	41.1	41.1	12.7	2980	H.g.	Female	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	41.0	41.0	12.6	>2hours	H.g.	Female	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	41.0	41.0	12.6	39	H.g.	Female	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	41.0	41.0	12.6	>2hours	H.g.	Female	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	41.6	41.6	13.2	>2hours	H.g.	Male	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	42.0	42.0	13.6	>2hours	H.g.	Male	Dec 9	10:30~
St.7-2	04°04'S	101°53'E	8	28.4	42.0	42.0	13.6	>2hours	H.g.	Female	Dec 9	10:30~
St.7-3	04°05'S	101°54'E	9	28.0	38.0	38.0	10.0	188	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	39.0	39.0	11.0	716	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	39.8	39.8	11.8	1389	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	40.0	40.0	12.0	458	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	40.0	40.0	12.0	553	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	40.9	40.9	12.9	570	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	41.0	41.0	13.0	572	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	41.0	41.0	13.0	2641	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	41.0	41.0	13.0	>7200	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	41.0	41.0	13.0	2533	H.g.	Female	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	41.0	41.0	13.0	501	H.g.	Male	Dec 10	06:30~
St.7-3	04°05'S	101°54'E	9	28.0	41.0	41.0	13.0	870	H.g.	Male	Dec 10	06:30~

Table 5-Sheet 4. Results of "Heat-coma" experiments and measurement of recovery time from the heat coma (RTHC as seconds) performed on adults of *H. germanus* (H.g); TA: temp. at which specimen adapted, SHCT: temp. at which semi-heat coma occurred; HCT: temp. at which heat coma occurred ; GTHC: gap temp. for heat coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when heat coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SHCT	HCT	GTHC	RTHC	Species	Sex	Date	TD
St.7-3	04°05'S	101°54'E	9	28.0	42.0	42.0	14.0	>7200	H.g.	Female	Dec 10	06:30~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	36.9	36.9	8.5	-	H.g.	Female	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	36.9	36.9	8.5	15	H.g.	Male	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	37.0	37.0	8.6	27	H.g.	Female	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	39.0	39.0	10.6	947	H.g.	Female	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	40.1	40.1	11.7	1111	H.g.	Male	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	40.0	40.0	11.6	57	H.g.	Female	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	40.0	40.0	11.6	33	H.g.	Male	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	41.0	41.0	12.6	6420	H.g.	Female	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	41.0	41.0	12.6	6180	H.g.	Male	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	41.0	41.0	12.6	>7200	H.g.	Female	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	41.0	41.0	12.6	1258	H.g.	Female	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	42.0	42.0	13.6	>7200	H.g.	Male	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	42.0	42.0	13.6	>7200	H.g.	Female	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	10	28.4	43.0	43.0	14.6	>7200	H.g.	Female	Dec 10	10:45~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	32.0	32.0	4.5	765	H.g.	Female	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	32.0	32.0	4.5	170	H.g.	Female	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	38.0	38.0	10.5	81	H.g.	Male	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	39.9	39.9	12.4	771	H.g.	Female	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	40.3	40.3	12.8	4174	H.g.	Male	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	40.9	40.9	13.4	858	H.g.	Male	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	41.0	41.0	13.5	>7200	H.g.	Female	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	41.0	41.0	13.5	>7200	H.g.	Female	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	41.0	41.0	13.5	>7200	H.g.	Female	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	41.2	41.2	13.7	>7200	H.g.	Female	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	42.0	42.0	14.5	>7200	H.g.	Male	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	43.0	43.0	15.5	>7200	H.g.	Male	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	11	27.5	43.0	43.0	15.5	>7200	H.g.	Male	Dec 11	06:30~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	38.0	38.0	10.0	509	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	38.0	38.0	10.0	254	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	40.0	40.0	12.0	205	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	40.0	40.0	12.0	2791	H.g.	Female	Dec 12	07:45~

Table 5-Sheet 5. Results of "Heat-coma" experiments and measurement of recovery time from the heat coma (RTHC as seconds) performed on adults of *H. germanus* (H.g); TA: temp. at which specimen adapted, SHCT: temp. at which semi-heat coma occurred; HCT: temp. at which heat coma occurred ; GTHC: gap temp. for heat coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when heat coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SHCT	HCT	GTHC	RTHC	Species	Sex	Date	TD
St.7-1,2,3	04°04'S	101°53'E	12	28.0	40.0	40.0	12.0	6035	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	40.5	40.5	12.5	794	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	41.0	41.0	13.0	604	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	41.0	41.0	13.0	>7200	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	41.0	41.0	13.0	5630	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	42.0	42.0	14.0	>7200	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	42.0	42.0	14.0	>7200	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	42.0	42.0	14.0	>7200	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	43.0	43.0	15.0	>7200	H.g.	Male	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	12	28.0	43.0	43.0	15.0	>7200	H.g.	Female	Dec 12	07:45~
St.7-1,2,3	04°04'S	101°53'E	13	28.3	38.1	38.1	9.8	304	H.g.	5th instar	Dec 13	07:45~
St.7-1,2,3	04°04'S	101°53'E	13	28.3	39.9	39.9	11.6	861	H.g.	5th instar	Dec 13	07:45~
St.7-1,2,3	04°04'S	101°53'E	13	28.3	40.0	40.0	11.7	55	H.g.	Male	Dec 13	07:45~
St.7-1,2,3	04°04'S	101°53'E	13	28.3	40.8	40.8	12.5	67	H.g.	5th instar	Dec 13	07:45~
St.7-1,2,3	04°04'S	101°53'E	13	28.3	41.8	41.8	13.5	1020	H.sp.	5th instar	Dec 13	07:45~
St.7-1,2,3	04°04'S	101°53'E	13	28.3	42.0	42.0	13.7	>7200	H.g.	Female	Dec 13	07:45~
St.9-1,2	04°03'S	101°53'E	14	27.8	31.0	31.0	3.2	68	H.m.	5th instar	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	31.7	31.7	3.9	46	H.m.	5th instar	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	32.0	32.0	4.2	15	H.m.	Female	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	37.0	37.0	9.2	788	H.m.	5th instar	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	37.5	37.5	9.7	25	H.m.	Female	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	39.0	39.0	11.2	32	H.m.	Female	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	40.0	40.0	12.2	>7200	H.m.	Male	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	40.0	40.0	12.2	>7200	H.m.	5th instar	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	40.8	40.8	13.0	>7200	H.m.	Female	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	41.0	41.0	13.2	>7200	H.m.	Female	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	41.0	41.0	13.2	>7200	H.m.	Female	Dec 15	06:30~
St.9-1,2	04°03'S	101°53'E	14	27.8	41.0	41.0	13.2	>7200	H.m.	Female	Dec 15	06:30~
St.9-1	04°03'S	101°53'E	15	28.2	40.0	40.0	11.8	1352	H.m.	Female	Dec 15	10:15~
St.9-1	04°03'S	101°53'E	15	28.2	36.0	40.0	11.8	>7200	H.m.	5th instar	Dec 15	10:15~
St.9-1	04°03'S	101°53'E	15	28.2	40.0	40.0	11.8	>7200	H.m.	3rd instar	Dec 15	10:15~
St.9-1	04°03'S	101°53'E	15	28.2	40.0	40.0	11.8	>7200	H.m.	3rd instar	Dec 15	10:15~

Table 5-Sheet 6. Results of "Heat-coma" experiments and measurement of recovery time from the heat coma (RTHC as seconds) performed on adults of *H. germanus* (H.g); TA: temp. at which specimen adapted, SHCT: temp. at which semi-heat coma occurred; HCT: temp. at which heat coma occurred ; GTHC: gap temp. for heat coma (from base temp.); "Date and Time of Day" when experiments were performed. (MR15-04: November 5, 2015 ~ December 20, 2015), TD: Time of day when heat coma experiment was performed

St.No.	Latitude	Longitude	Exp.No.	TA	SHCT	HCT	GTHC	RTHC	Species	Sex	Date	TD
St.9-1	04°03'S	101°53'E	15	28.2	40.0	40.0	11.8	>7200	H.m.	3rd instar	Dec 15	10:15~

Table 6. Comparison of Semi-Cool Coma Temperature (SCCT), Cool Coma Temperature (CCT), Gap Temperature for Cool Coma (GTHC), Recovery Time from Cool Coma (RTCC), Semi-Cool Coma Temperature (SHCT), Heat Coma Temperature (HCT), Gap Temperature for Heat Coma (GTHC), Recovery Time from Heat Coma (RTHC) in *Halobates germanus.* between the individuals collected at two stations: one (A: 06˚56'-58'S 102˚53'-54'E) and another fixed one (B: 04˚02'-06'S, 101˚52'-55'E) in this cruise. Experiments were performed in the period from 21st November to 15th December 2015 during this cruise, MR15-04, in in the wet-lab. 2 of R/V MIRAI.

	SCCT	CCT	GTCC	RTCC
A site (Station 1)				
Adults	15.28 ± 1.65 (13)	15.05 ± 1.74 (13)	12.95 ± 1.74 (13)	908.00 ± 2086.38 (13)
5th instars	13.75 ± 0.35 (2)	13.75 ± 0.35 (2)	14.25 ± 0.35 (2)	3602.00 ± 5088.34 (2)
4th instars	18.05 ± 5.59 (2)	18.05 ± 5.59 (2)	9.95 ± 5.59 (2)	3690.00 ± 4963.89 (2)
Total	15.42 ± 2.28 (17)	15.25 ± 2.35 (17)	12.75 ± 2.35 (17)	1552.24 ± 2802.97(17)

	SCCT	CCT	GTCC	RTCC
B site (Stations 2-9)				
Adults	17.36 ± 2.39(142)	17.20 ± 2.48 (142)	10.93 ± 2.59 (142)	24.12 ± 93.21 (142)
5th instars	16.92 ± 2.60 (27)	16.67 ± 2.66 (27)	11.51 ± 2.69 (27)	229.96 ± 849.10 (27)
4th instars	18.95 ± 2.80 (4)	18.95 ± 2.80 (4)	9.50 ± 2.56 (4)	19.5 ± 8.39 (4)
Total (including one 2nd instar)	17.31 ± 2.44 (173)	17.13 ± 2.54 (173)	10.99 ± 2.61 (173)	56.17 ± 348.89 (173)

	SCCT			CCT			GTCC			RTCC		
ANCOVA	*F-value*	*P-value*	*df*	*F-value*	*P-value*	*df*	*F-value*	*P-value*	*df*	*F-value*	*P-value*	*df*
Sites	*9.159*	*0.003*	*1*	*8.364*	*0.004*	*1*	*7.276*	*0.008*	*1*	*43.160*	*<0.001*	*1*
Stages	*0.48*	*0.827*	*1*	*0.124*	*0.725*	*1*	*0.143*	*0.706*	*1*	*6.564*	*0.011*	*1*

	SHCT	HCT	GTHC	RTHC
B site (Stations 2-9)				
Adults	39.80 ± 2.58 (125)	39.83 ± 2.58 (125)	11.74 ±2.55 (125)	3175.78 ± 3253.78(125)
5th instars	38.19 ± 3.68 (14)	38.19 ± 3.68 (14)	9.85 ± 3.50 (14)	1253.14 ± 2534.95 (14)
4th instars	41.10 ± 0.14 (2)	41.10 ± 0.14 (14)	12.20 ± 0.14 (2)	7200 ± 0.00 (2)
Total	39.68 ± 2.73 (141)	39.69 ± 2.72 (141)	11.56 ± 2.69 (141)	3040.00 ± 3249.01 (139)

	SHCT			HCT			GTHC			RTHC		
ANOVA	*F-value*	*P-value*	*df*	*F-value*	*P-value*	*df*	*F-value*	*P-value*	*df*	*F-value*	*P-value*	*df*
Stages	*2.599*	*0.078*	*2*	*2.605*	*0.078*	*2*	*3.275*	*0.041*	*2*	*4.034*	*0.020*	*2*

Table 7. Comparison of Semi-Cool Coma Temperature (SCCT), Cool Coma Temperature (CCT), Gap Temperature for Cool Coma (GTHC) and Recovery Time from Cool Coma (RTCC) Semi-Cool Coma Temperature (SHCT), Heat Coma Temperature (HCT), Gap Temperature for Heat Coma (GTHC), Recovery Time from Heat Coma (RTHC) between *Halobates germanus* and *H. micans* or *H.*sp. (un-described species and a proposed name: *H. sumatoraensis*) and comparison of these values between adults males and females in all 9 stations (Station 1: 06˚56'-58'S 102˚53'-54'E; Stations 2-9: 04˚02'-06'S, 101˚52'-55'E) in this cruise. Experiments were performed in the period from 21st November to 15th December 2015 during this cruise, MR15-04, in in the wet-lab. 2 of R/V MIRAI.

A. *Cool Coma*	**SCCT**	**CCT**	**GTCC**	**RTCC**
Halobates germanus	17.14 ± 2.47 (191)	16.96 ± 2.57 (191)	11.14 ± 2.63 (191)	189.05 ± 976.90 (191)
Halobates sp (proposed name: *H. sumatraensis*)	16.44 ± 3.28 (9)	15.51 ± 3.76 (9)	12.54 ± 3.71 (9)	87.11 ± 132.16 (9)
Total	17.05 ± 2.65 (200)	16.90 ± 2.64 (200)	11.24 ± 2.73 (200)	184.46 ± 955.15 (200)
Females (adults)	17.26 ± 2.51 (91)	17.04 ± 2.64 (91)	11.02 ± 2.70 (91)	160.78 ± 829.95 (91)
Males (adults)	16.85 ± 2.66 (67)	16.89 ± 2.29 (67)	11.39 ± 2.58 (67)	14.78 ± 21.76 (67)
Total	17.08±2.57 (158)	16.98±2.49 (158)	11.18±2.65 (158)	98.87±632.70 (158)

	SCCT			**CCT**			**GTCC**			**RTCC**		
ANCOVA	***F-value***	***P-value***	***df***	***F-value***	***P-value***	***df***	***F-value***	***P-value***	***df***	***F-value***	***P-value***	***df***
Species	***1.627***	***0.204***	***1***	***3.163***	***0.077***	***1***	***2.897***	***0.091***	***1***	***0.058***	***0.810***	***1***
Sex	***0.334***	***0.564***	***1***	***0.143***	***0.706***	***1***	***0.387***	***0.535***	***1***	***2.032***	***0.156***	***1***

One-Way ANOVA	**SCCT**			**CCT**			**GTCC**			**RTCC**		
	F-value	***P-value***	***df***	***F-value***	***P-value***	***df***	***F-value***	***P-value***	***df***	***F-value***	***P-value***	***df***
Stations 1-9	***3.264***	***0.002***	***8***	***3.179***	***0.002***	***8***	***3.088***	***0.003***	***8***	***5.443***	***<0.001***	***8***

Heat Coma	**SHCT**	**HCT**	**GTHC**	**RTHC**
Halobates germanus	39.68 ± 2.73 (141)	38.35 ± 2.73 (141)	11.56 ± 2.69 (141)	3249.01±3249.01(139)
Halobates micans	38.12 ± 3.44 (17)	38.35 ± 3.42(17)	10.44± 3.37(17)	4372.1±3499.07 (17)
Females	39.76 ± 2.64 (90)	39.76 ± 2.64 (90)	11.68 ± 2.60 (90)	3733.65 ± 3300.93(89)
Males	39.83 ± 2.53 (44)	39.83 ± 2.53 (44)	11.78 ± 2.53 (44)	2226.65 ± 3009.61 (43)
Total				

	SHCT			**HCT**			**GTHC**			**RTHC**		
ANCOVA	***F-value***	***P-value***	***df***	***F-value***	***P-value***	***df***	***F-value***	***P-value***	***df***	***F-value***	***P-value***	***df***
Species	***0.556***	***0.457***	***1***	***0.560***	***0.456***	***1***	***0.222***	***0.638***	***1***	***0.332***	***0.565***	***1***
Sex	***0.003***	***0.958***	***1***	***0.002***	***0.961***	***1***	***0.024***	***0.878***	***1***	***5.909***	***0.016***	***1***

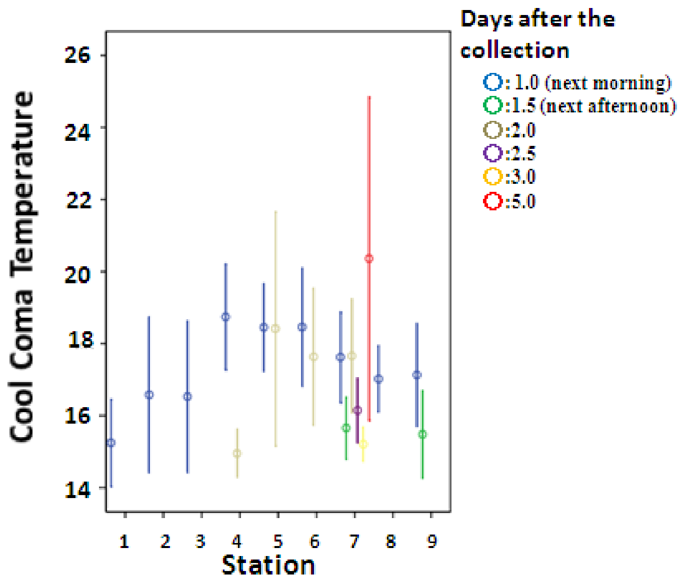


Fig. 1: Comparison of Cool Coma Temperature (C°) (CCT: Mean ± 95% confidence value) and the Site 1 (06˚54'-56'S 102˚53'-54'E) and Site 2 (04˚02'-06'S 101˚52'-56'E) and change in CCT according to time course (every 3 days samplings showing Stations 2-9 at the Site 2. Experiments were performed using specimens which had been kept in the aquarium of the laboratory in the ship till the next morning of the sampling day (1.0 day), the next afternoon (1.5 day), the morning of 2 days after sampling (2.0 days), the afternoon of 2 days (2.5 days), the morning of 3 days (3.0 days) and the morning of 5 days (5 days).

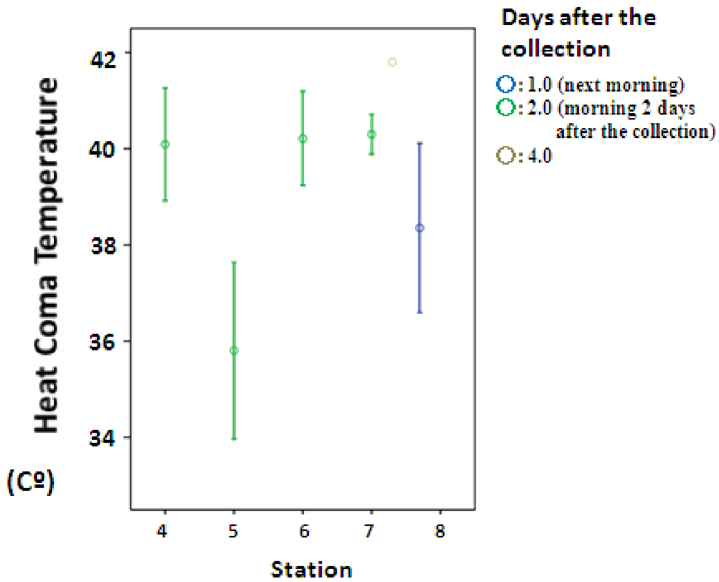


Fig. 2: The time course change in Heat Coma Temperature (C°) (HCT: Mean ± 95% confidence value) (every 3 days samplings showing Stations 4-8) at the Site 2 (04˚02'-06'S 101˚52'-56'E). Experiments were performed using specimens which had been kept in the aquarium of the laboratory in the ship till the next morning of the sampling day (1.0 day), the morning of 2 days after sampling (2.0 days) and the morning of 4 days (4.0 days).

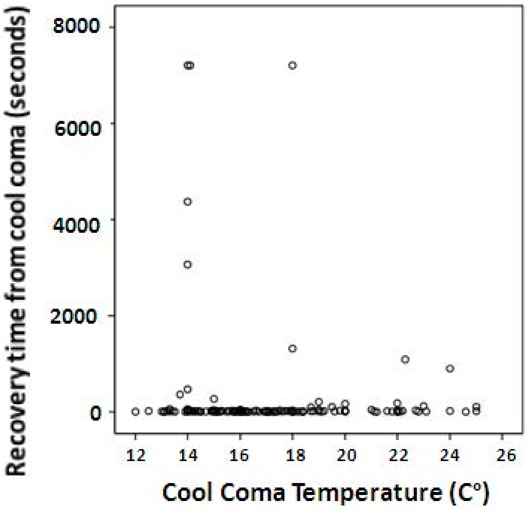


Fig. 3: Relationship between the temperature at which cool coma occurred and recovery time
There was no correlative relationship (Pearson's correlation test: r=-0.080, p=0.250n n=200).

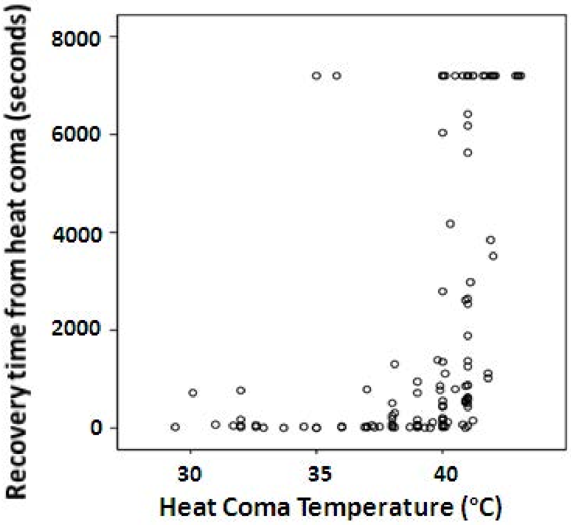


Fig. 4: Relationship between the temperature at which heat coma occurred and recovery time
There was clear positive correlative relationship (Pearson's correlation test: r=0.522, p<0.001, n=157). Observation was continued within 2 hours after the onset of heat coma. 7200 seconds (2 hours) mean that no recovery from the coma for 2 hours.

Photo 1: A trailing scene of Neuston-NET

Photo 2: Female adult of *Halobates germanus* making “cleaning behavior”.

5.29 Underway Geophysics

Personnel

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5.29.1 Sea surface gravity

(1) Introduction

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

(2) Data Acquisition

We measured relative gravity [CU: Counter Unit] ([mGal] = (coef1: 0.9946) * [CU]), using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during thins cruise. To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter CG-5 (Scintrex), at Sekinehama as the reference point.

(3) Preliminary Results

Absolute gravity table was shown in Table.5.29-1.

(4) Data Archives

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

(6) Remarks

1) The follwing period, data acquisition was suspended in the EEZs of Philippine and Indonesia.
16:32UTC 13 Nov. 2015 - 02:48UTC 15 Nov. 2015

Table 5.29-1 Absolute gravity table

No	Date	UTC	Port	Absolute Gravity [mGal]	Sea Level [cm]	Draft [cm]	Gravity at Sensor *1 [mGal]	L&R*2 Gravity [mGal]
#1	NOV/05	01:07	Sekinehama	980,371.86	251	607	980,372.81	12662.42

*1: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.2222
*2: LaCoste and Romberg air-sea gravity meter S-116

5.29.2 Sea surface three-component magnetometer

(1) Introduction

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

(2) Principle of ship-board geomagnetic vector measurement

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

$$\mathrm{Hob} = \tilde{\mathbf{A}}\ \tilde{\mathbf{R}}\ \tilde{\mathbf{P}}\ \tilde{\mathbf{Y}}\ \mathrm{F} + \mathrm{Hp} \qquad \text{(a)}$$

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

$$\tilde{\mathbf{R}}\ \mathrm{Hob} + \mathrm{Hbp} = \tilde{\mathbf{R}}\ \tilde{\mathbf{P}}\ \tilde{\mathbf{Y}}\ \mathrm{F} \qquad \text{(b)}$$

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

(3) Instruments on R/V MIRAI

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

(4) Data Archives

Surface gravity 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) The following period, data acquisition was suspended in the EEZs of Philippine and Indonesia.
16:32UTC 13 Nov. 2015 - 02:48UTC 15 Nov. 2015
2) For calibration of the ship's magnetic effect, we made a "figure-eight" turn (a pair of clockwise and anti-clockwise rotation). This calibration was carried out as below.
09:47UTC - 10:14UTC 05 Nov. 2015 around 41-19N, 141-43E
03:15UTC - 03:42UTC 23 Nov. 2015 around 04-10S, 101-52E
01:14UTC - 01:42UTC 18 Dec. 2015 around 06-01S, 101-00E

5.29.3 Swath Bathymetry

(1) Introduction

R/V MIRAI equips 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.

(2) Data Acquisition

The "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. Table 5.29.3-1 shows system configuration and performance of SEABEAM 3012 system.

Table 5.29.3-1 SEABEAM 3012 System configuration and performance

Frequency:	12 kHz
Transmit beam width:	1.6 degree
Transmit power:	20 kW
Transmit pulse length:	2 to 20 msec.
Receive beam width:	1.8 degree
Depth range:	100 to 11,000 m
Beam spacing:	0.5 degree athwart ship
Swath width:	150 degree (max)
	120 degree to 4,500 m
	100 degree to 6,000 m
	90 degree to 11,000 m
Depth accuracy:	Within < 0.5% of depth or ±1m,
	Whichever is greater, over the entire swath.
	(Nadir beam has greater accuracy;
	typically within < 0.2% of depth or ±1m, whichever is greater)

(3) Preliminary Results

The results will be published after primary processing.

(4) Data Archives

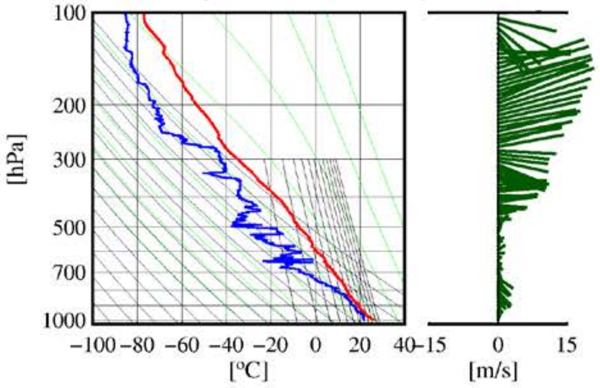
Bathymetric data obtained in this cruise will be submitted to the Data Management Group of JAMSTEC, and will be opened to the public via "Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)" in JAMSTEC web site.
<http://www.godac.jamstec.go.jp/darwin/e>

(5) Remarks

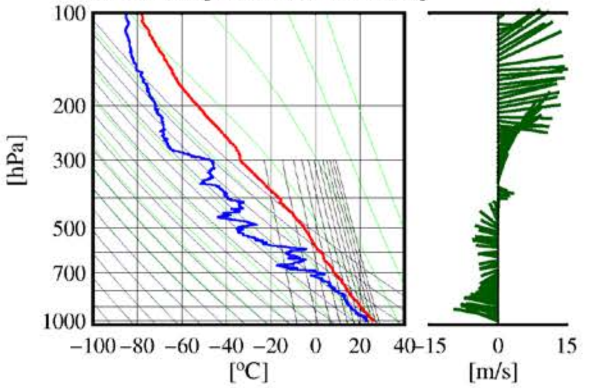
1) The following period, data acquisition was suspended in the EEZs of Philippine and Indonesia.
   12:00UTC 13 Nov. 2015 - 03:04UTC 15 Nov. 2015

Appendix A: Atmospheric profiles by the radiosonde observations

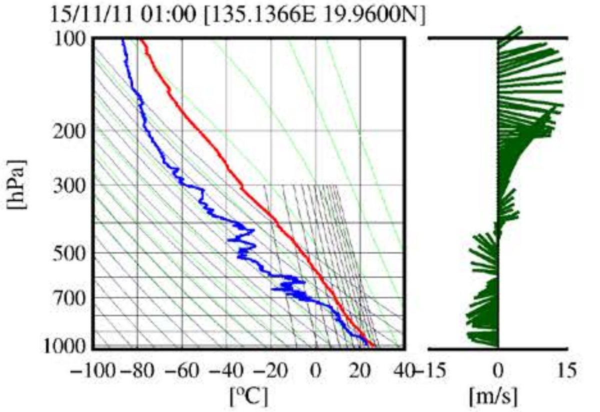
15/11/10 05:38 [136.7170E 23.4641N]



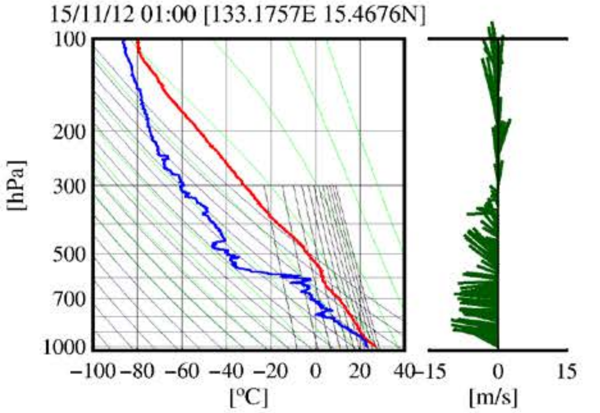
15/11/11 05:39 [134.7520E 19.1017N]



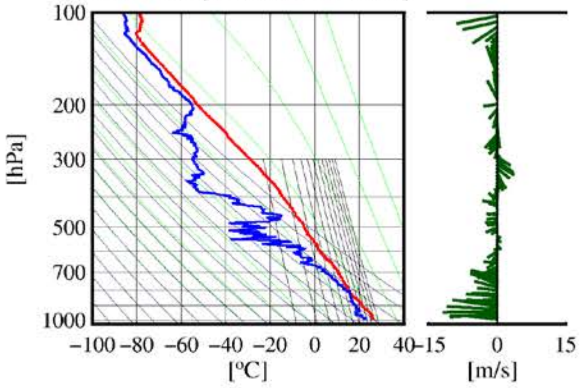
15/11/11 01:00 [135.1366E 19.9600N]



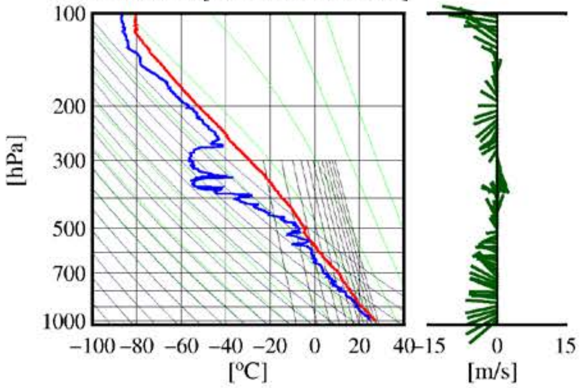
15/11/12 01:00 [133.1757E 15.4676N]



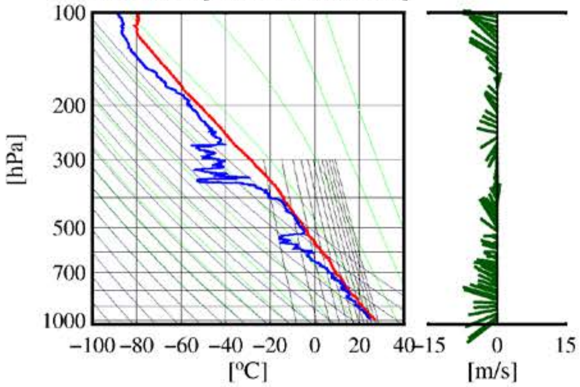
15/11/20 23:30 [100.9555E 6.0859S]



15/11/21 02:30 [101.0020E 6.0017S]



15/11/21 05:30 [101.0800E 5.8352S]



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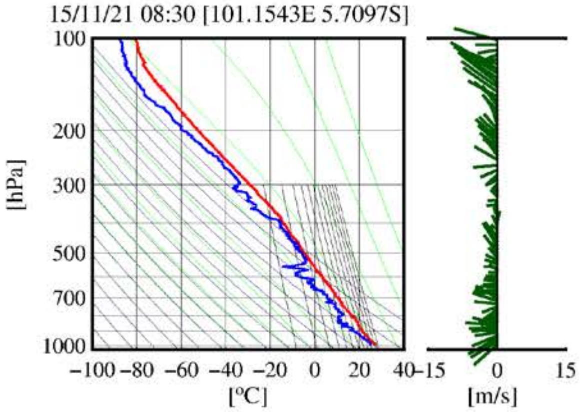

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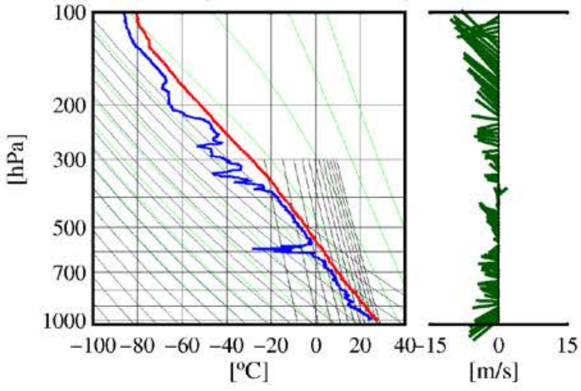

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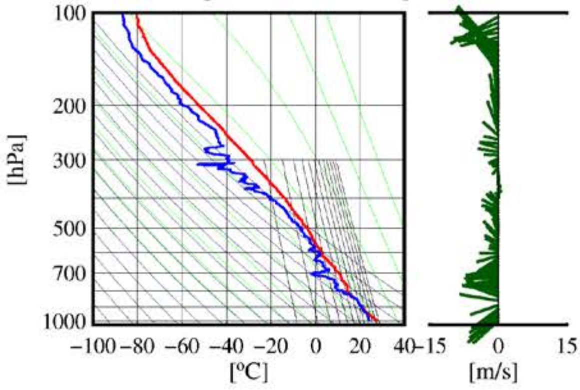

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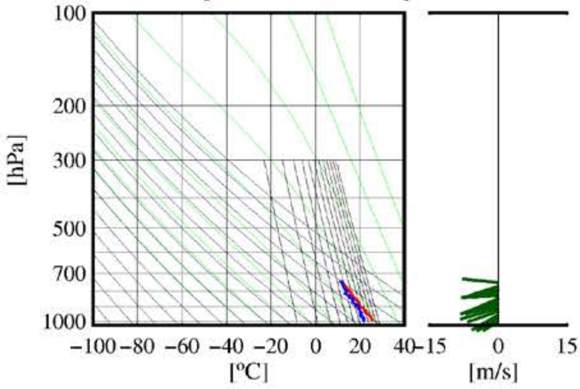

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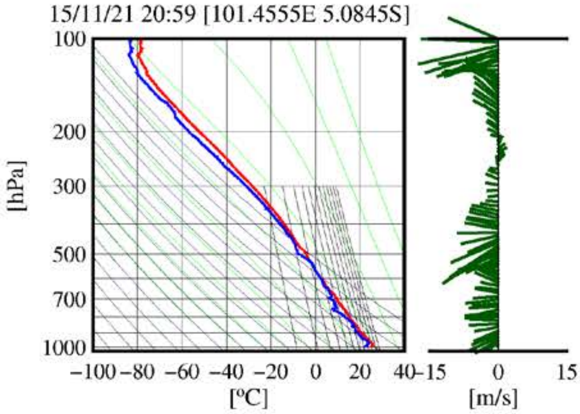

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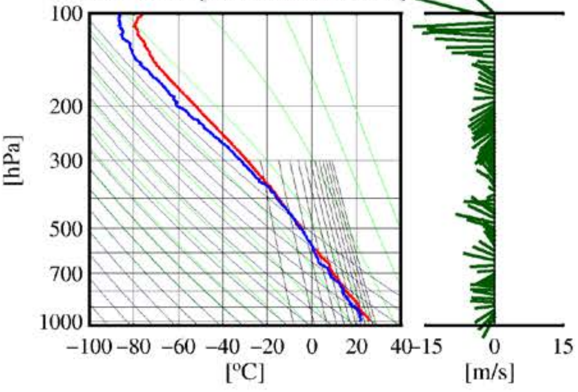

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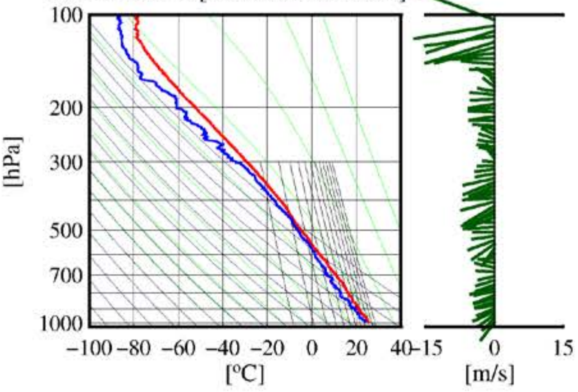

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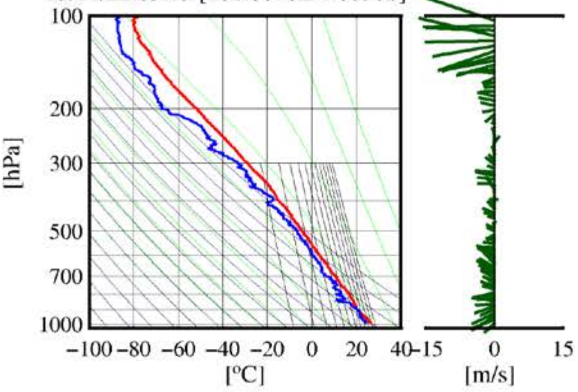

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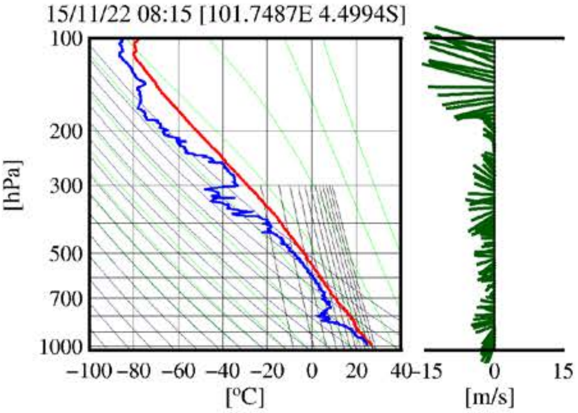

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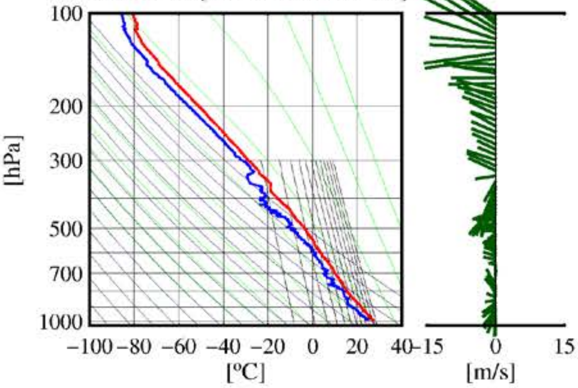

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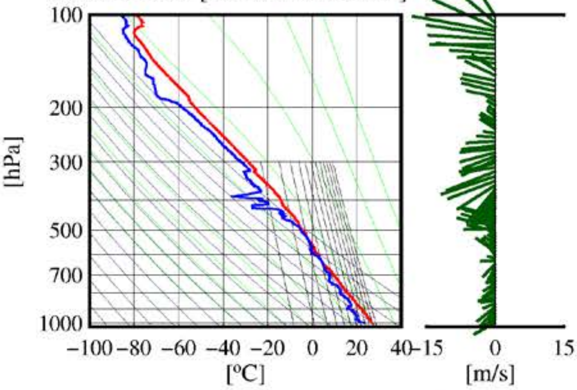

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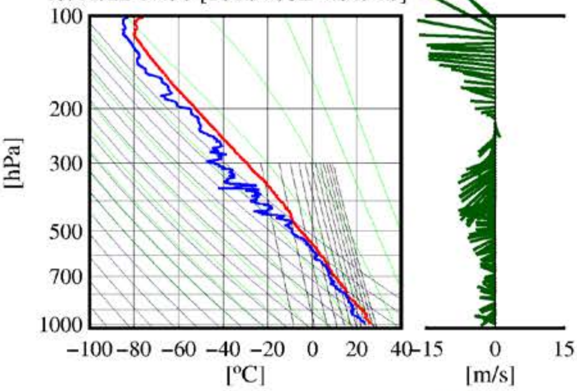

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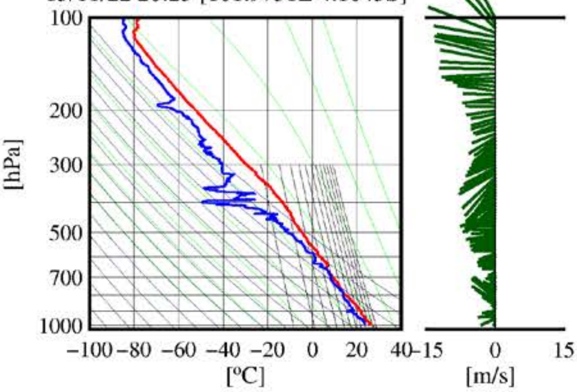

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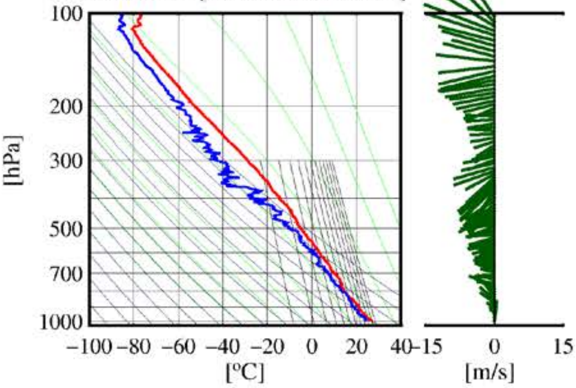

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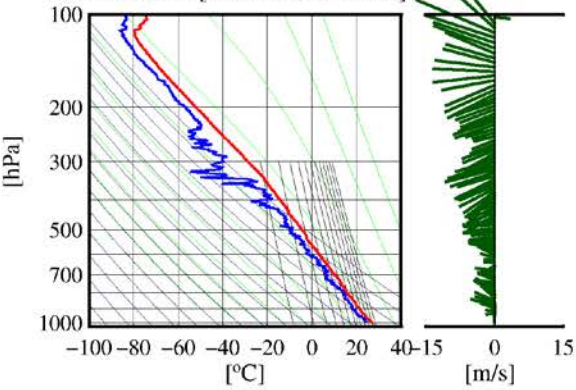

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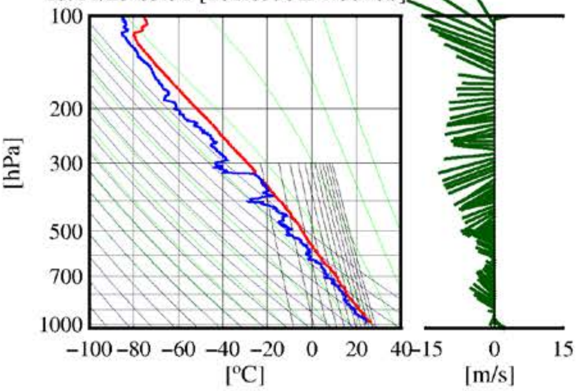

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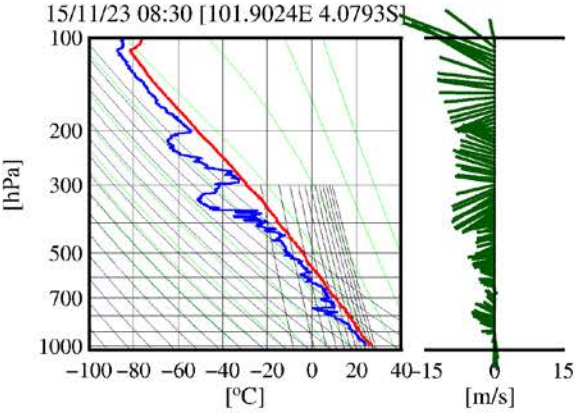

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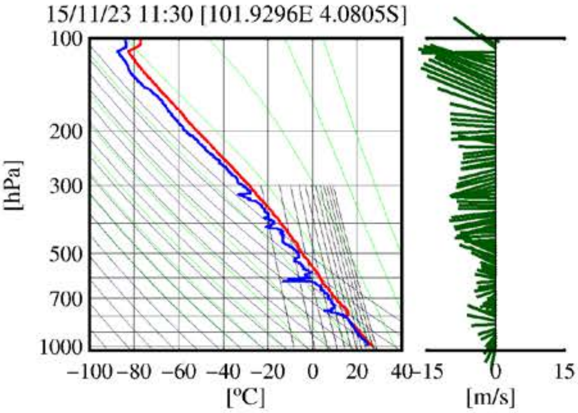

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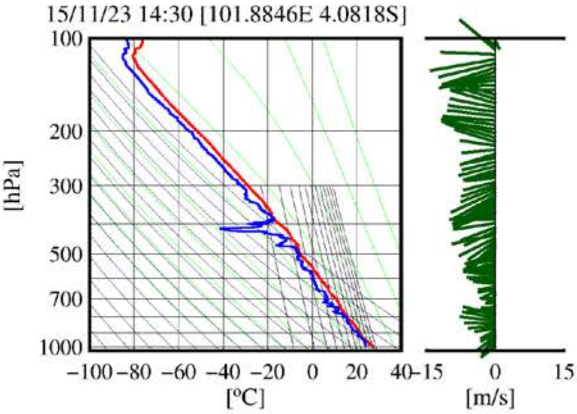

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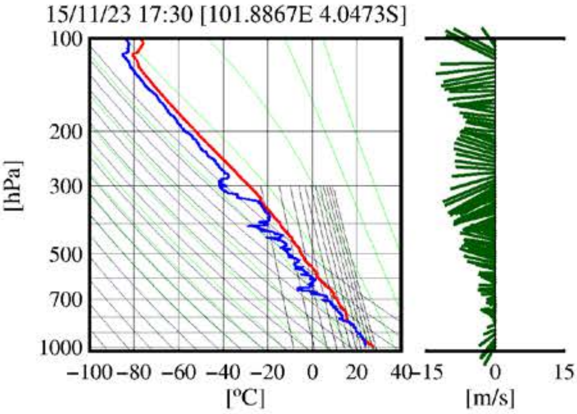

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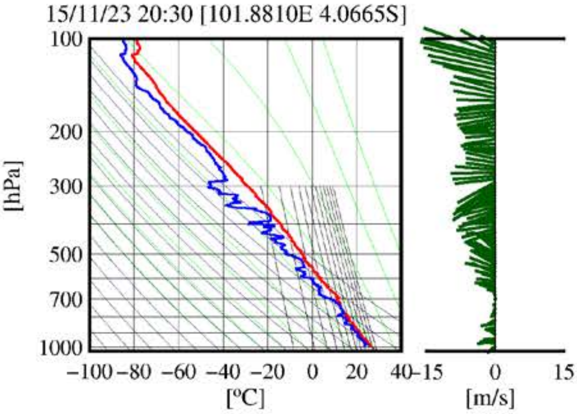

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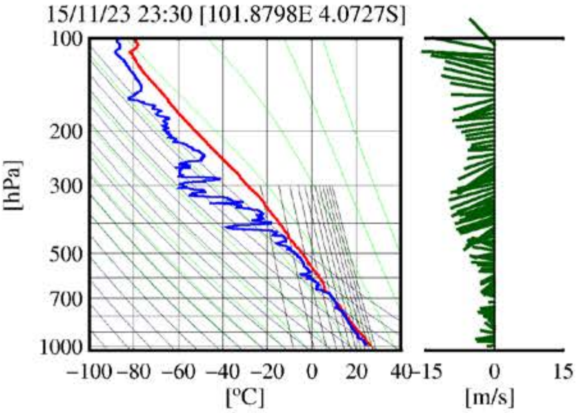

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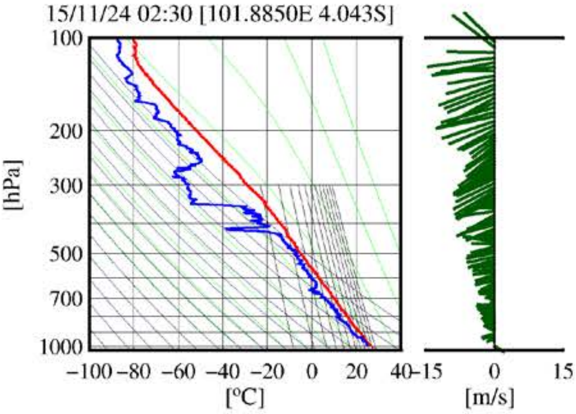

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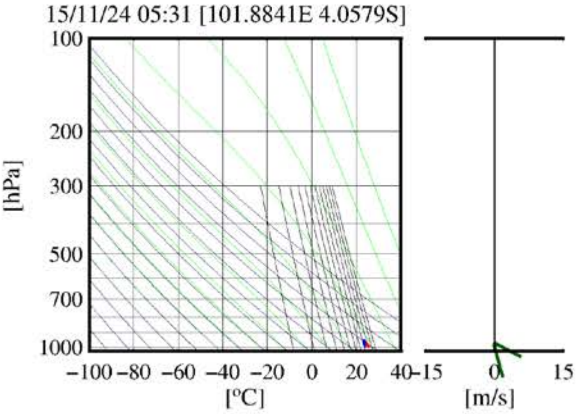

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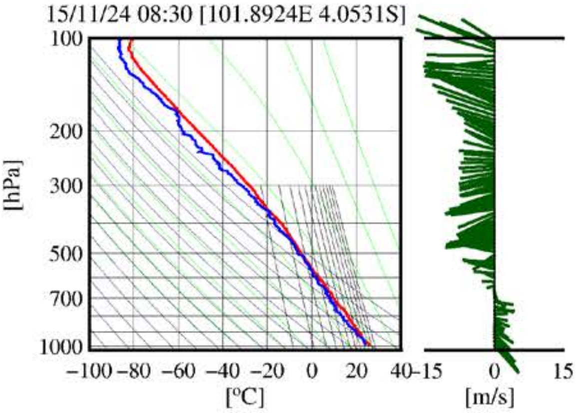

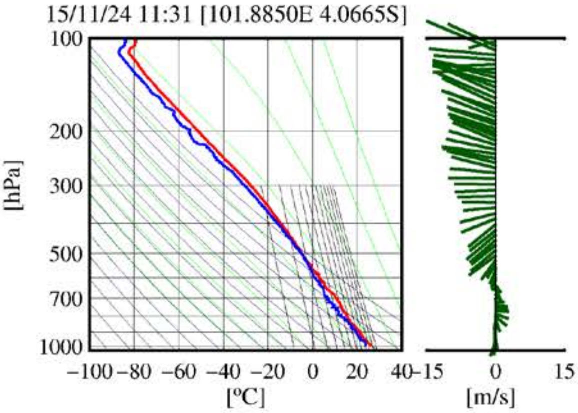
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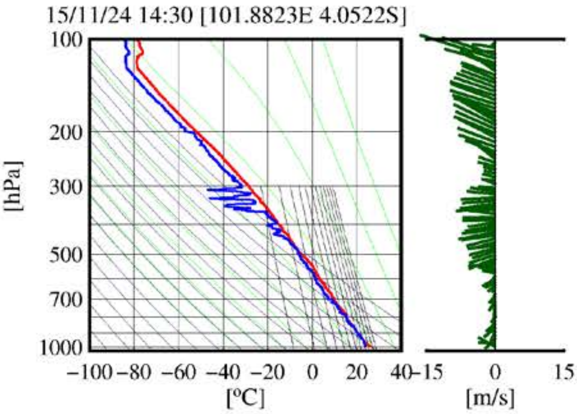
[hPa]
[ºC]
[m/s]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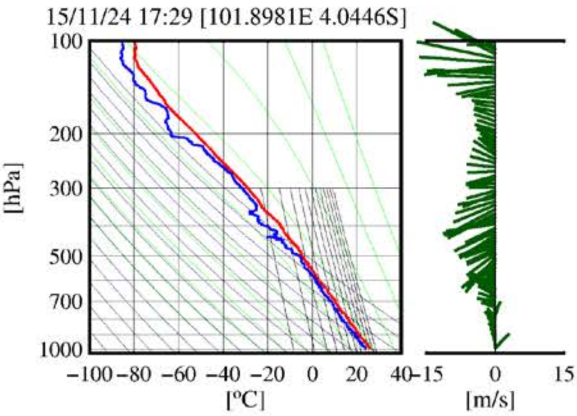
[hPa]
[ºC]
[m/s]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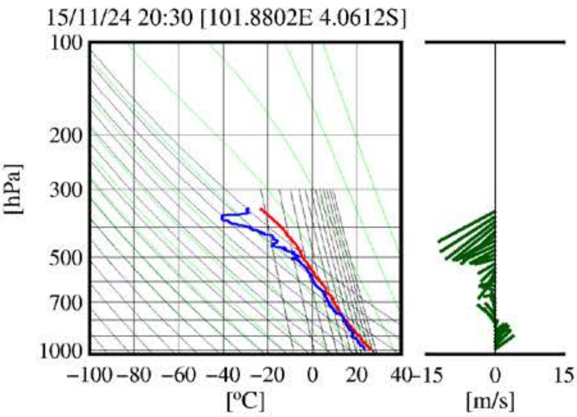
[m/s]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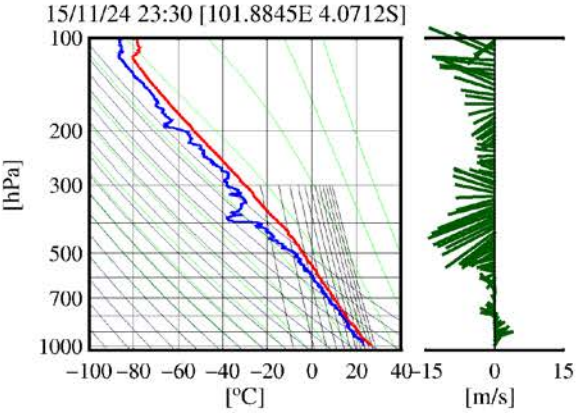
[ºC]
[m/s]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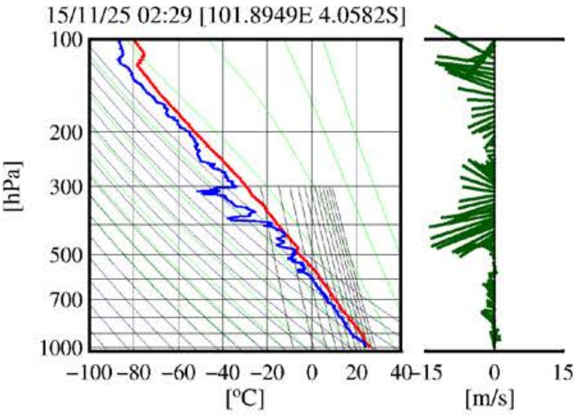
[m/s]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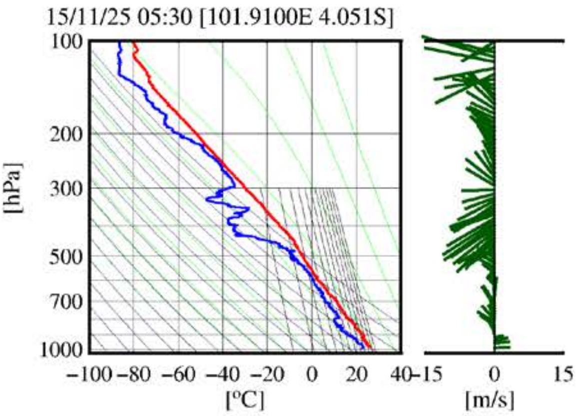
[hPa]
[ºC]
[m/s]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[hPa]
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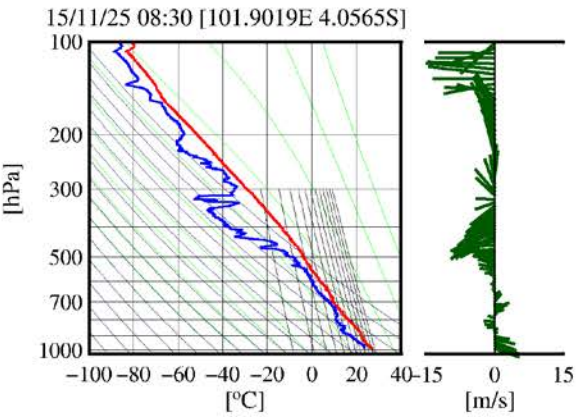
[m/s]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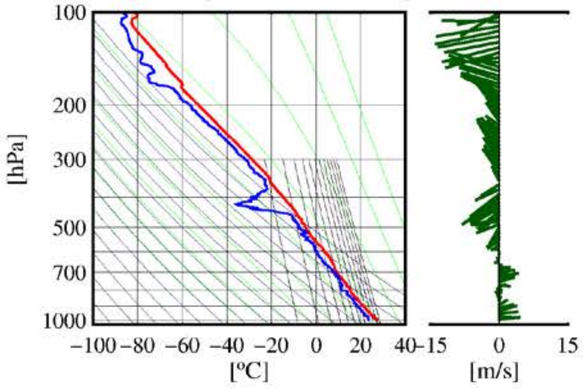
[hPa]
[ºC]
[m/s]

15/11/25 11:30 [101.8815E 4.0683S]



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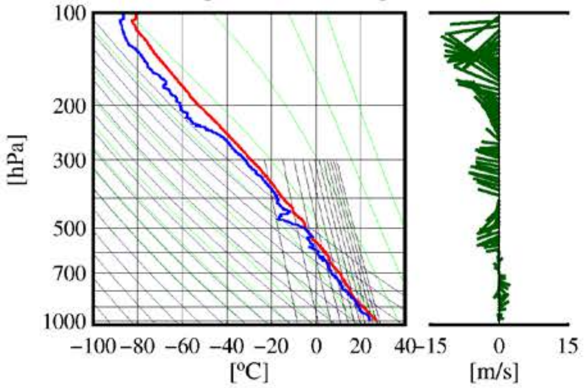

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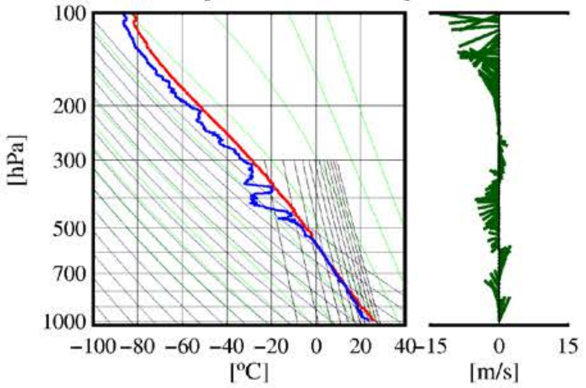

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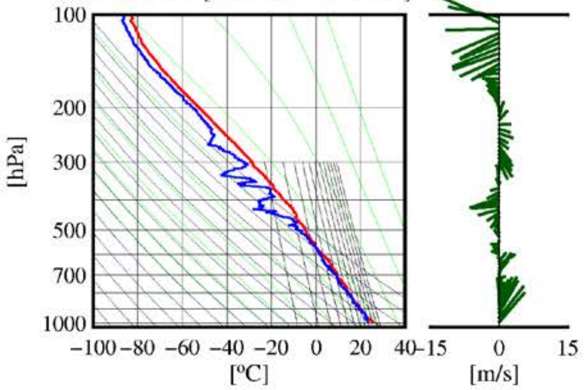

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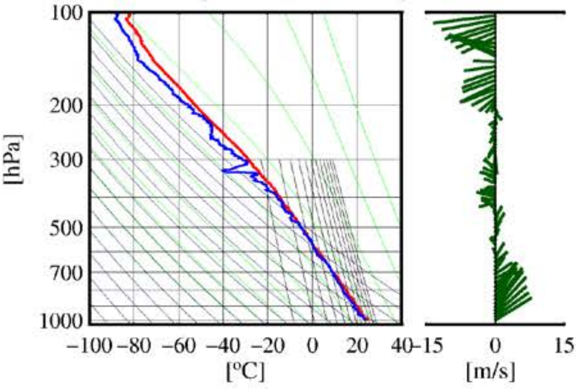

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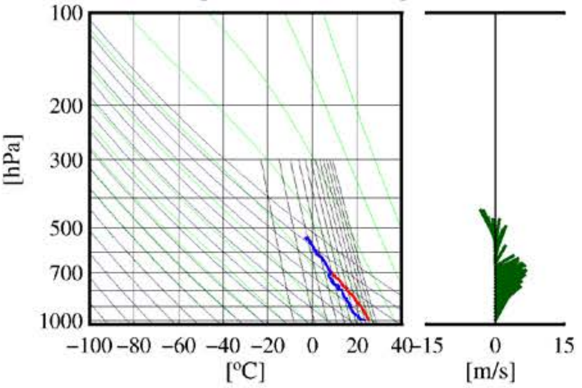

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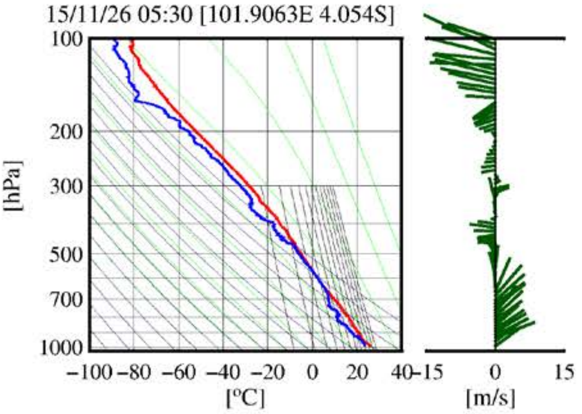

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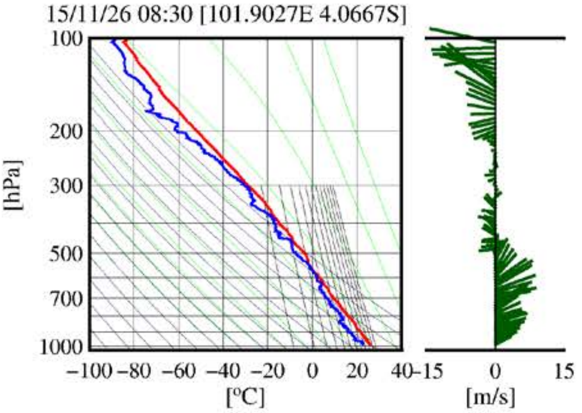

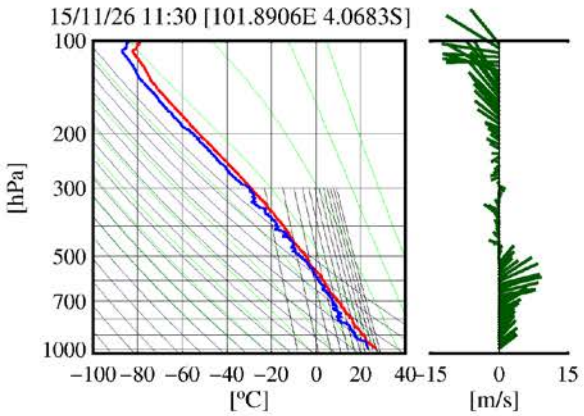
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200
300
500
700
1000
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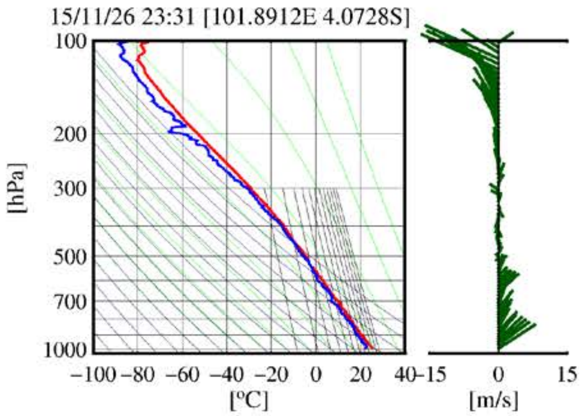
[ºC]
−15 0 15
[m/s]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700
1000
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[ºC]
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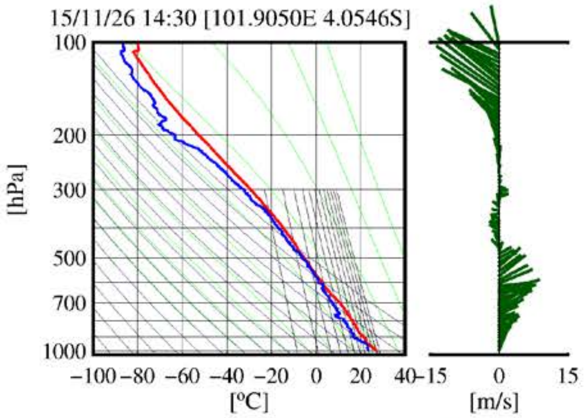
[m/s]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300
500
700
1000
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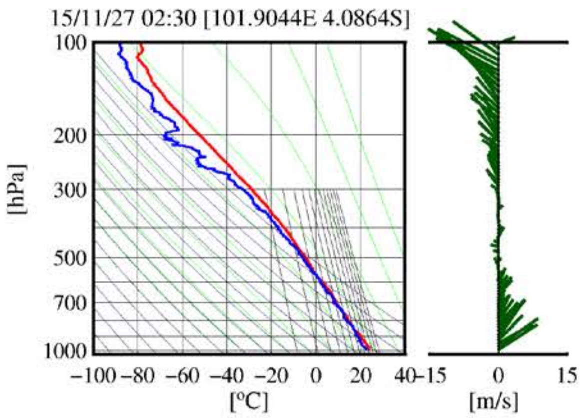
[ºC]
−15 0 15
[m/s]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200
300
500
700
1000
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[ºC]
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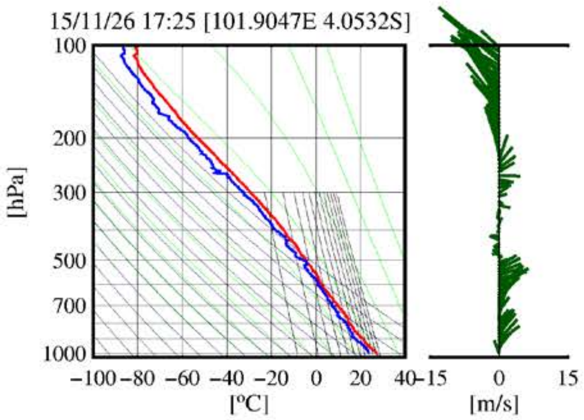
[m/s]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200
300
500
700
1000
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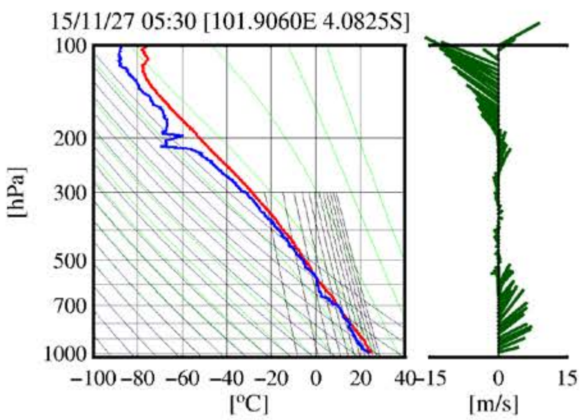
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200
300
500
700
1000
−100 −80 −60 −40 −20 0 20 40
[ºC]
−15 0 15
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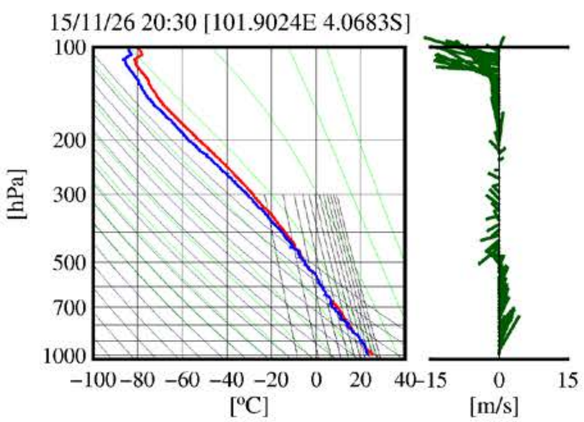
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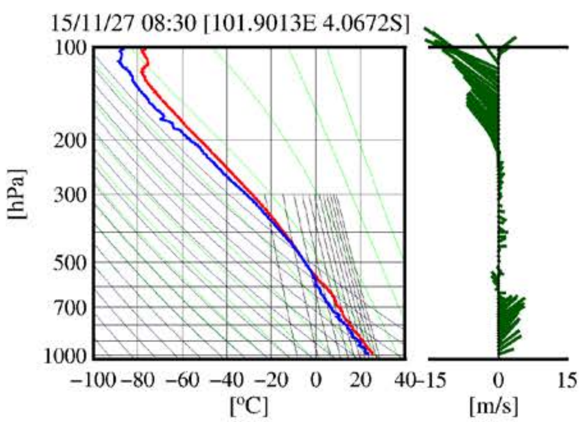
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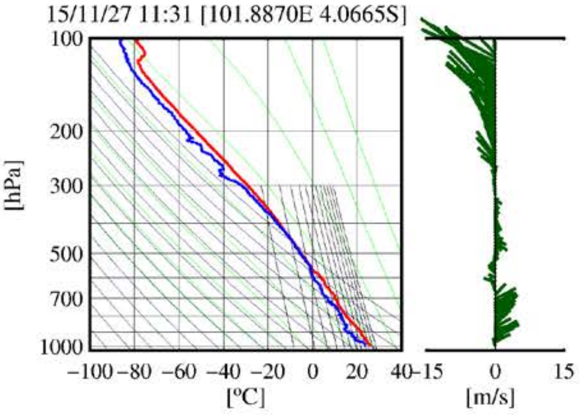
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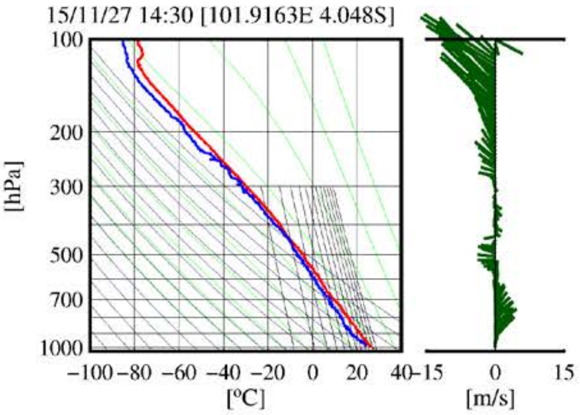
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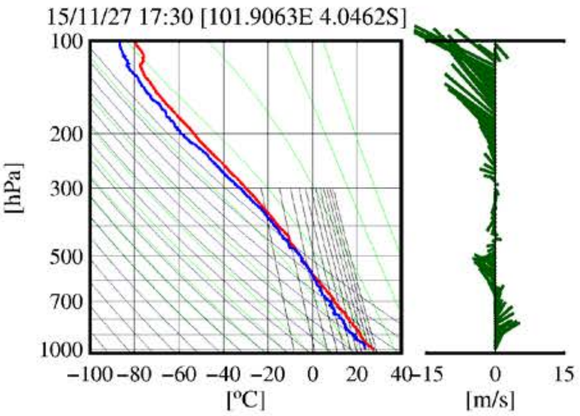
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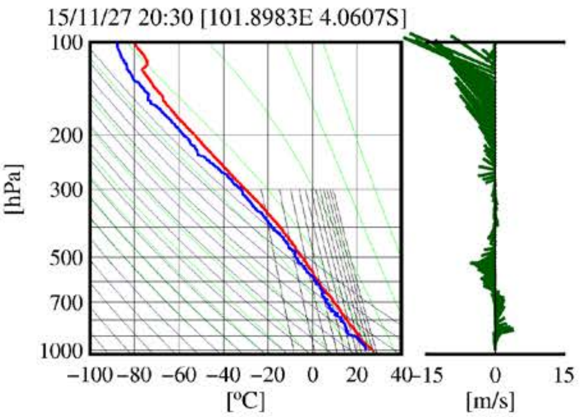
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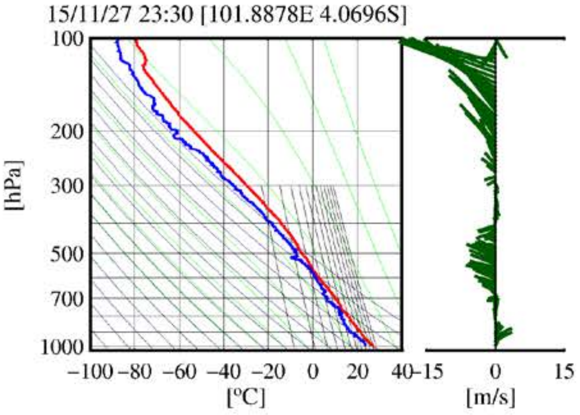
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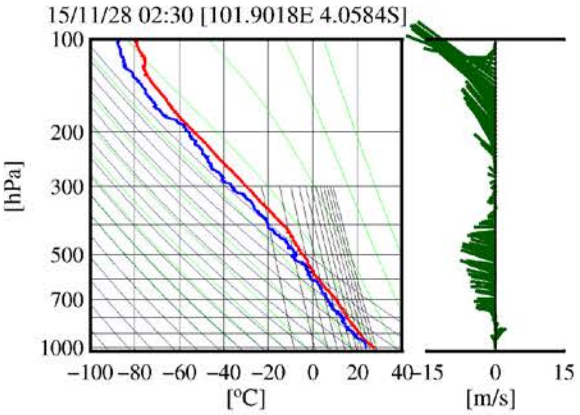
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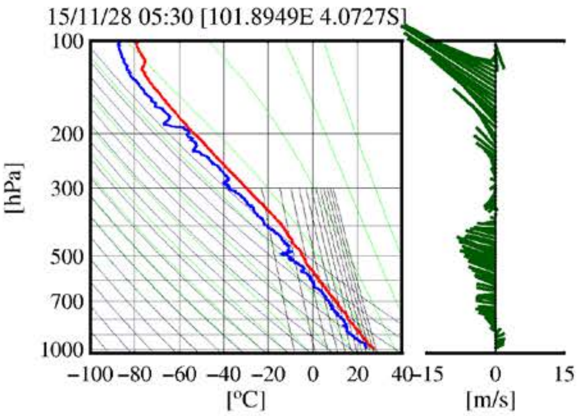
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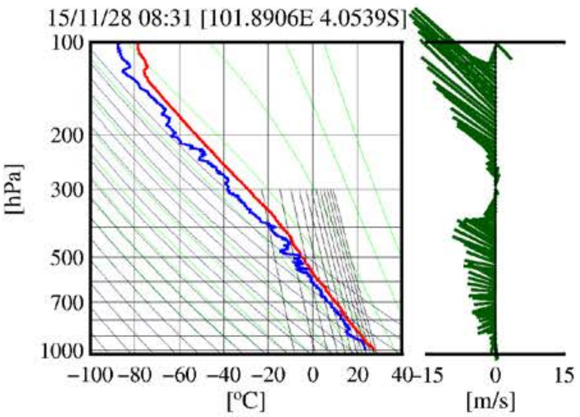
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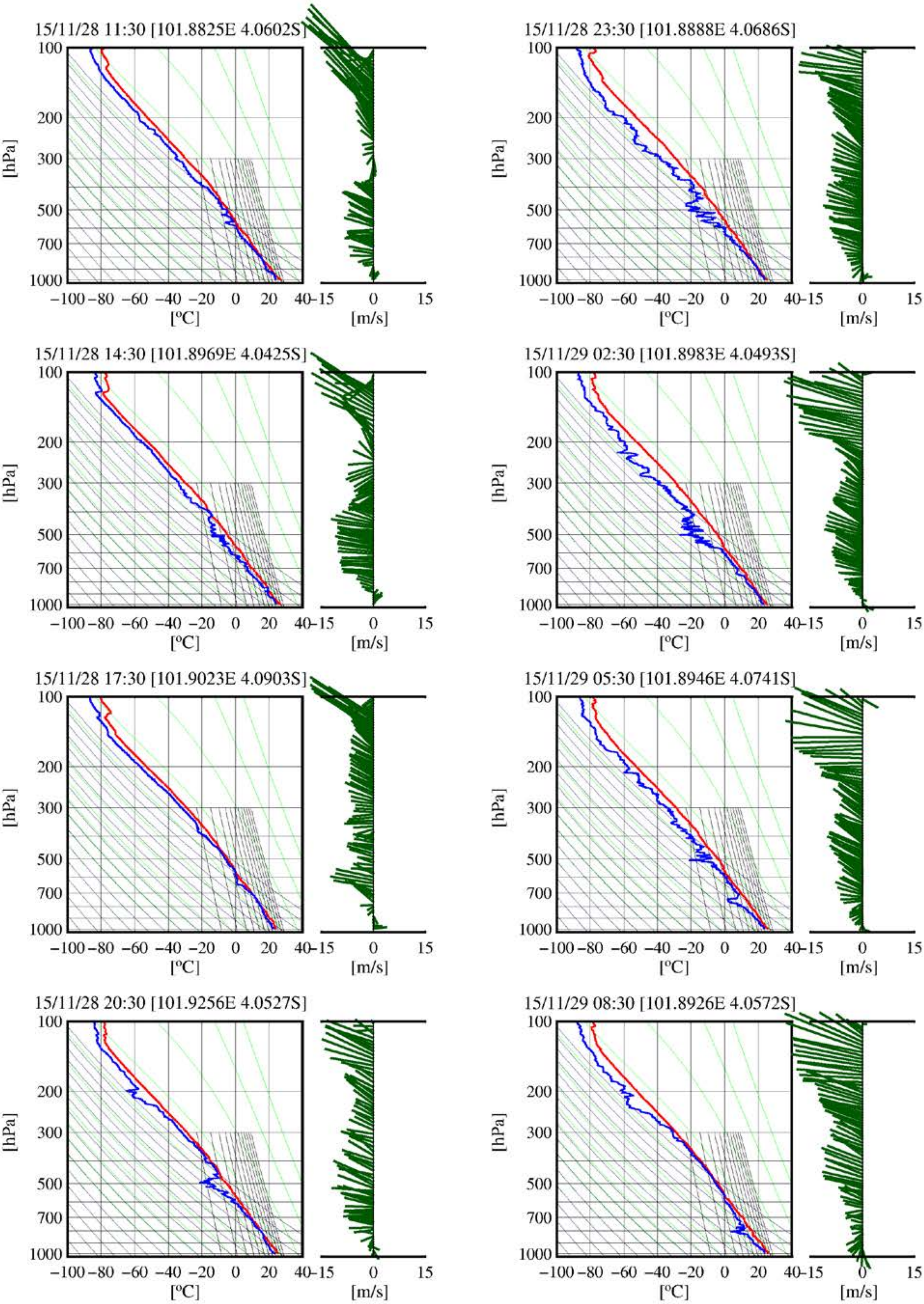

15/11/28 11:30 [101.8825E 4.0602S]
15/11/28 23:30 [101.8888E 4.0686S]
15/11/28 14:30 [101.8969E 4.0425S]
15/11/29 02:30 [101.8983E 4.0493S]
15/11/28 17:30 [101.9023E 4.0903S]
15/11/29 05:30 [101.8946E 4.0741S]
15/11/28 20:30 [101.9256E 4.0527S]
15/11/29 08:30 [101.8926E 4.0572S]
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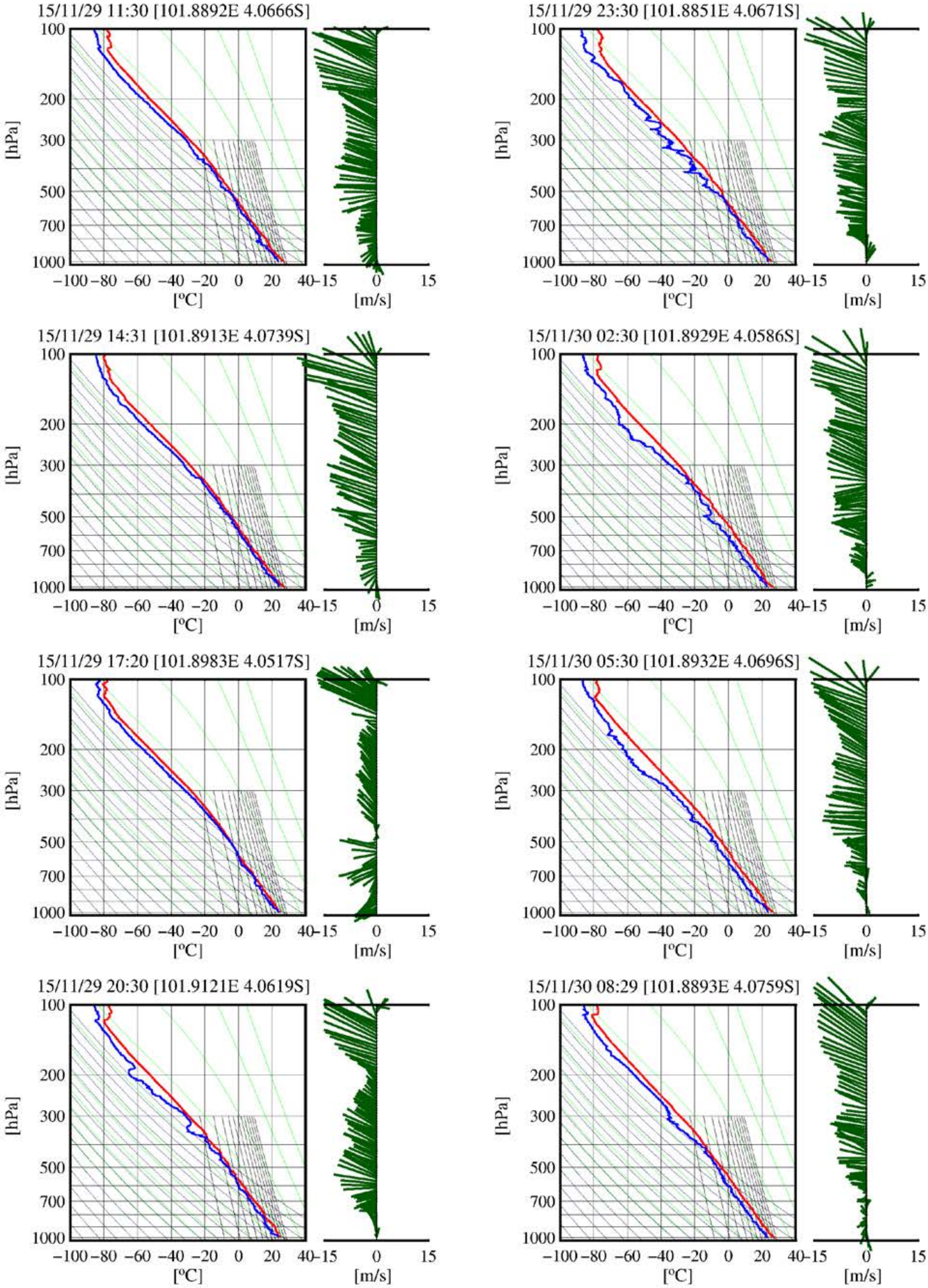
15/11/29 11:30 [101.8892E 4.0666S]
15/11/29 23:30 [101.8851E 4.0671S]
15/11/29 14:31 [101.8913E 4.0739S]
15/11/30 02:30 [101.8929E 4.0586S]
15/11/29 17:20 [101.8983E 4.0517S]
15/11/30 05:30 [101.8932E 4.0696S]
15/11/29 20:30 [101.9121E 4.0619S]
15/11/30 08:29 [101.8893E 4.0759S]
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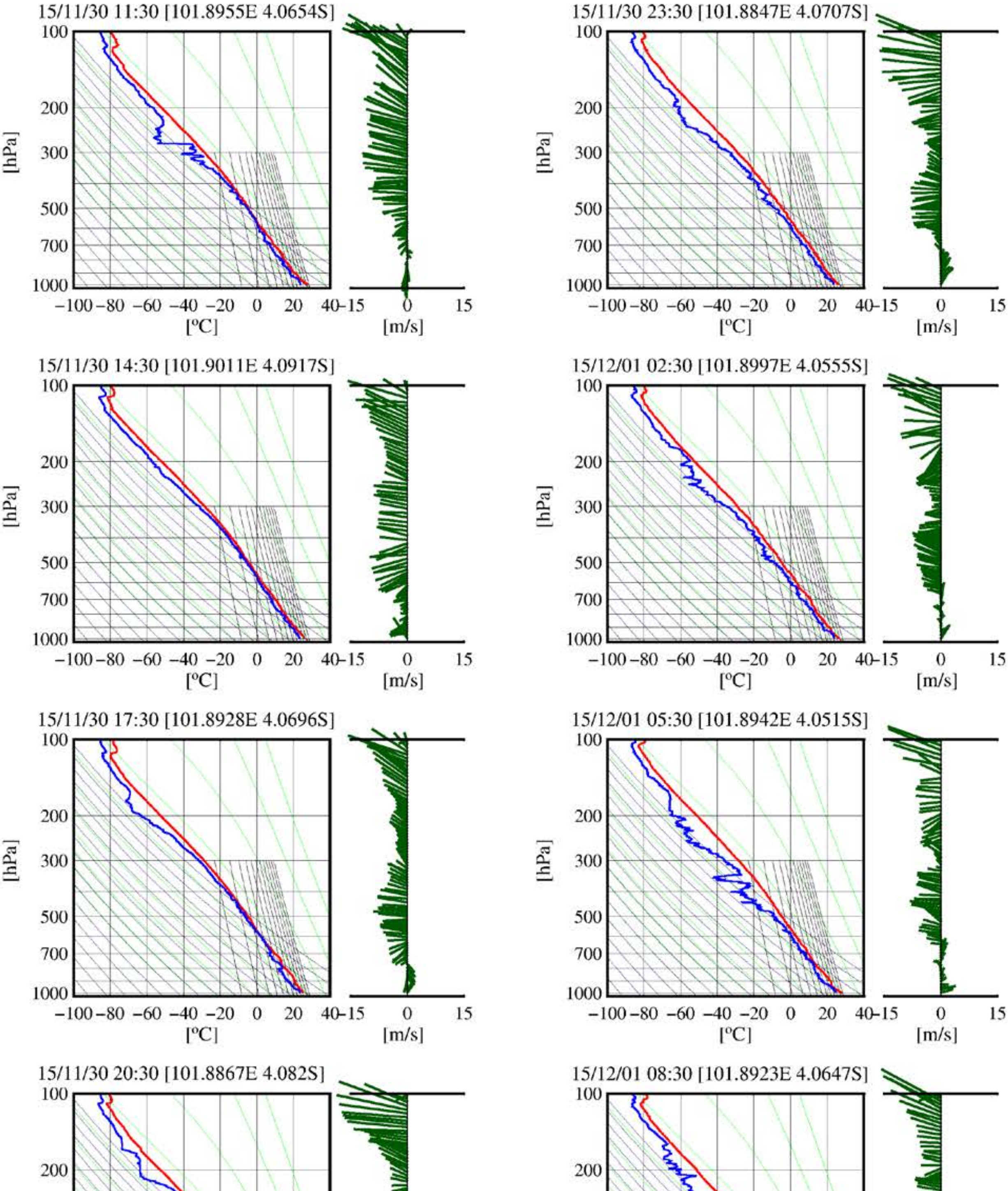

15/11/30 11:30 [101.8955E 4.0654S]
15/11/30 23:30 [101.8847E 4.0707S]
15/11/30 14:30 [101.9011E 4.0917S]
15/12/01 02:30 [101.8997E 4.0555S]
15/11/30 17:30 [101.8928E 4.0696S]
15/12/01 05:30 [101.8942E 4.0515S]
15/11/30 20:30 [101.8867E 4.082S]
15/12/01 08:30 [101.8923E 4.0647S]
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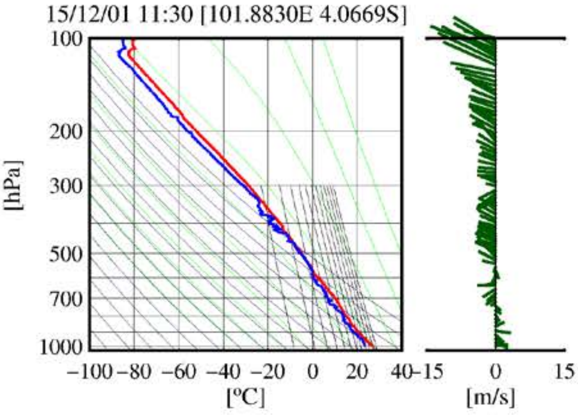
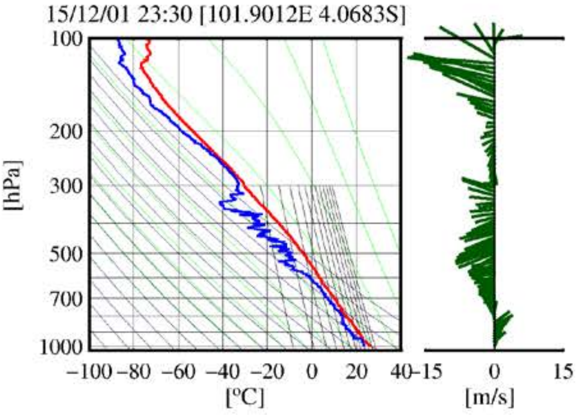
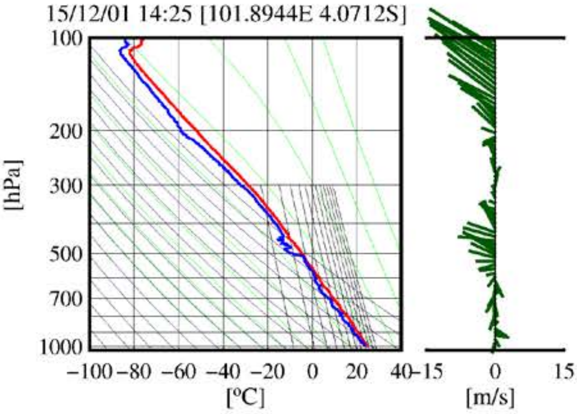
15/12/01 11:30 [101.8830E 4.0669S]



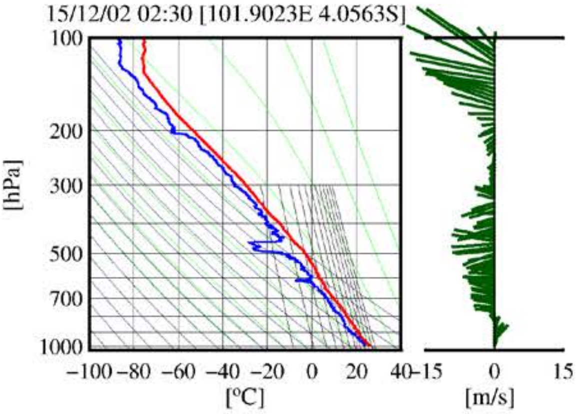
15/12/01 23:30 [101.9012E 4.0683S]



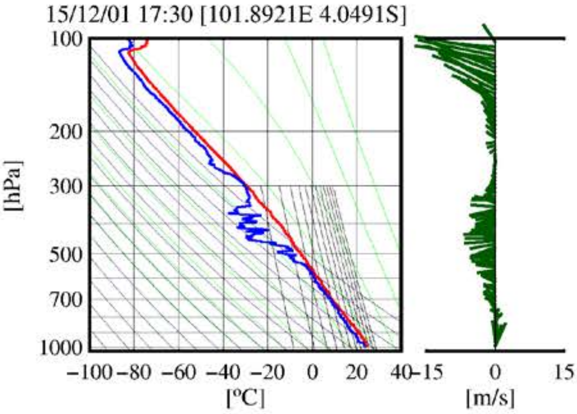
15/12/01 14:25 [101.8944E 4.0712S]



15/12/02 02:30 [101.9023E 4.0563S]



15/12/01 17:30 [101.8921E 4.0491S]



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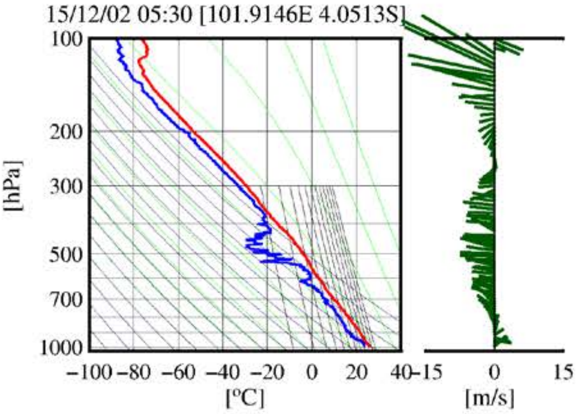
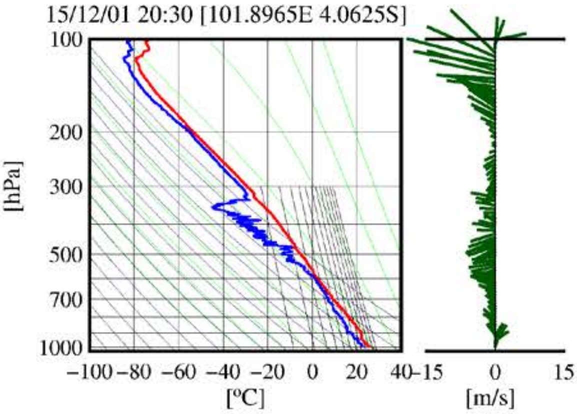


15/12/01 20:30 [101.8965E 4.0625S]



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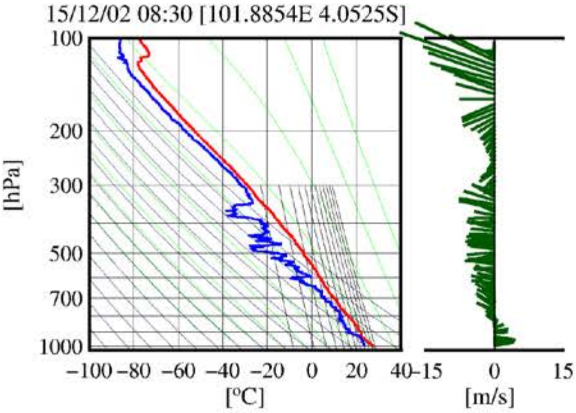

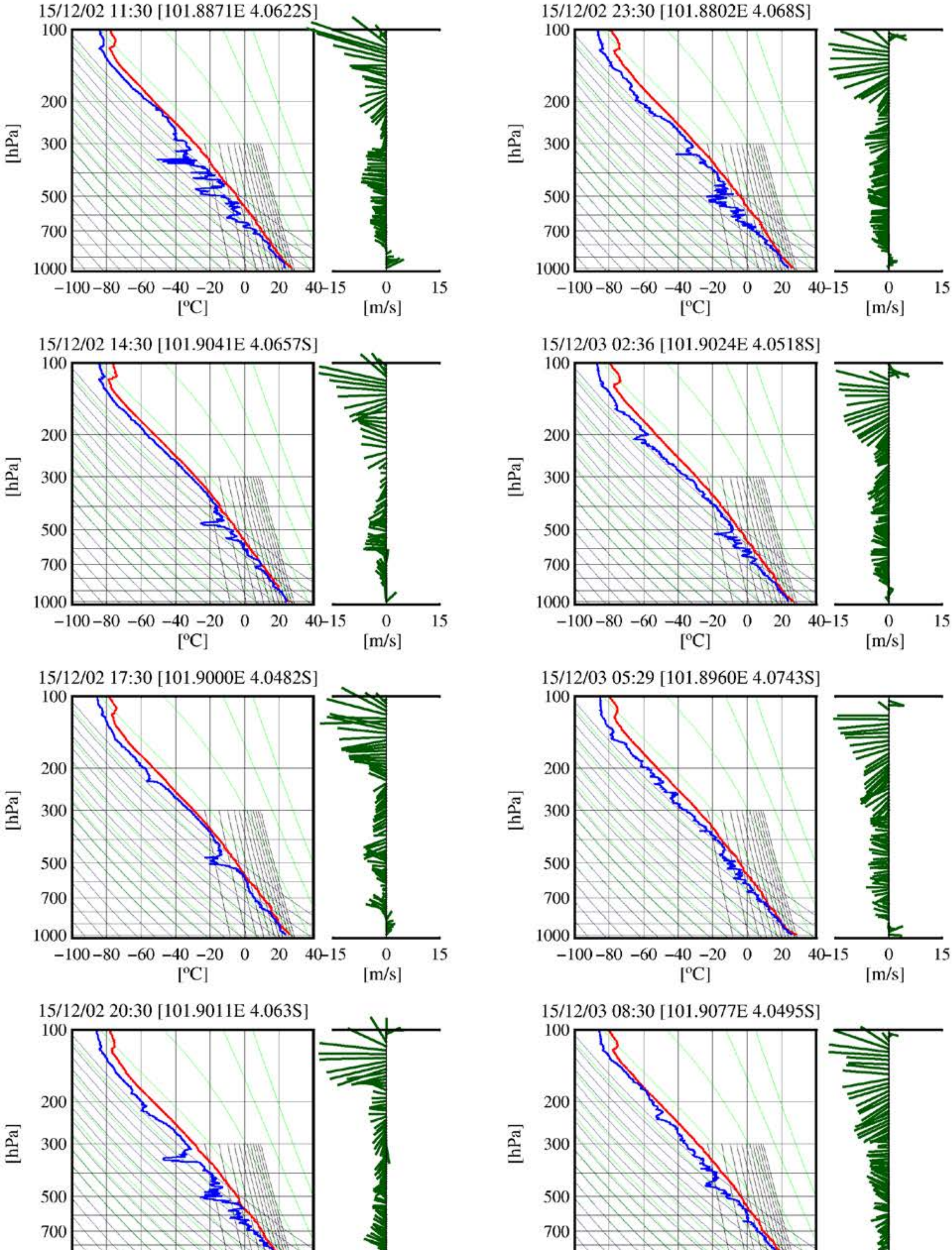
15/12/02 11:30 [101.8871E 4.0622S]
15/12/02 23:30 [101.8802E 4.068S]
15/12/02 14:30 [101.9041E 4.0657S]
15/12/03 02:36 [101.9024E 4.0518S]
15/12/02 17:30 [101.9000E 4.0482S]
15/12/03 05:29 [101.8960E 4.0743S]
15/12/02 20:30 [101.9011E 4.063S]
15/12/03 08:30 [101.9077E 4.0495S]
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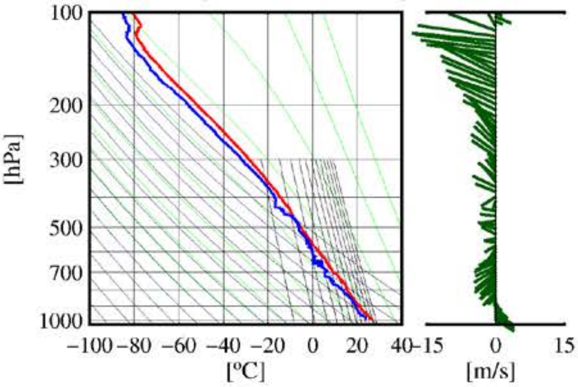
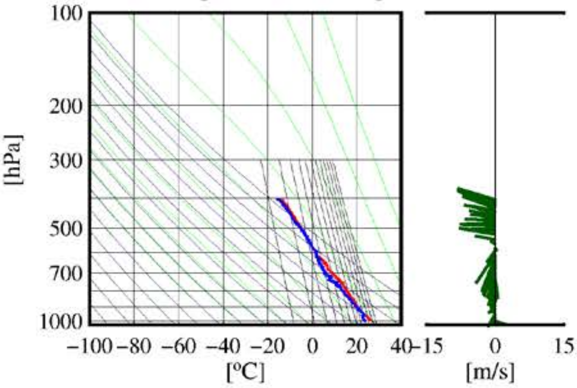
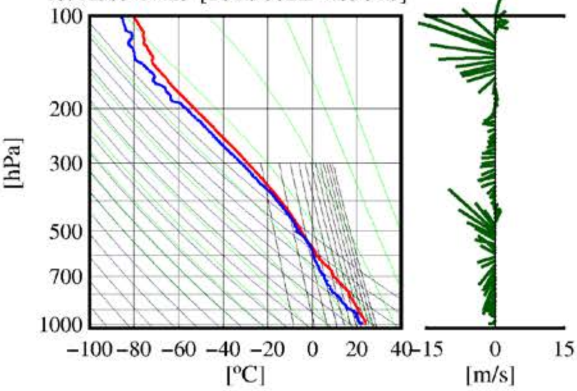
15/12/03 11:30 [101.8921E 4.0637S]



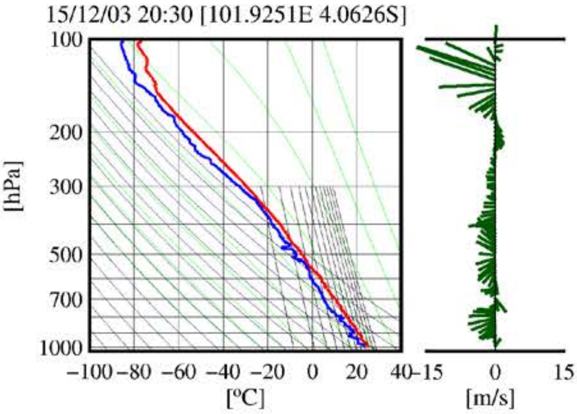
15/12/03 14:30 [101.8905E 4.05S]



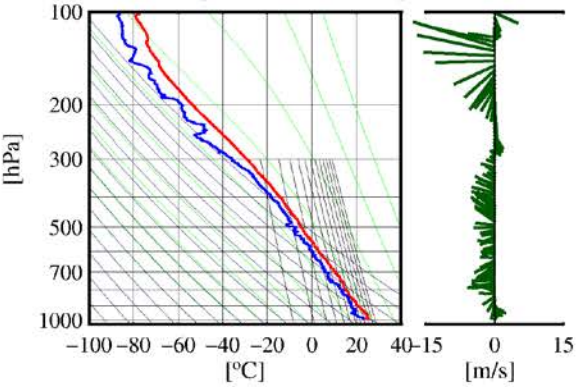
15/12/03 17:29 [101.9002E 4.0364S]



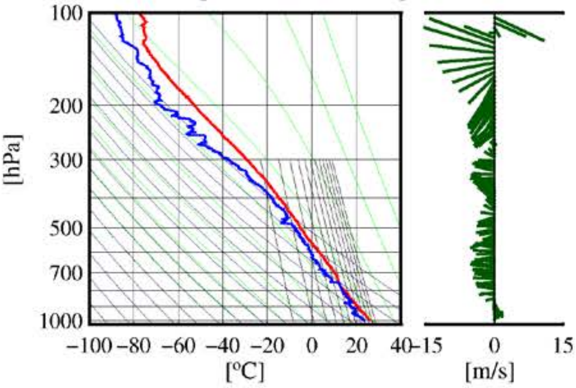
15/12/03 20:30 [101.9251E 4.0626S]



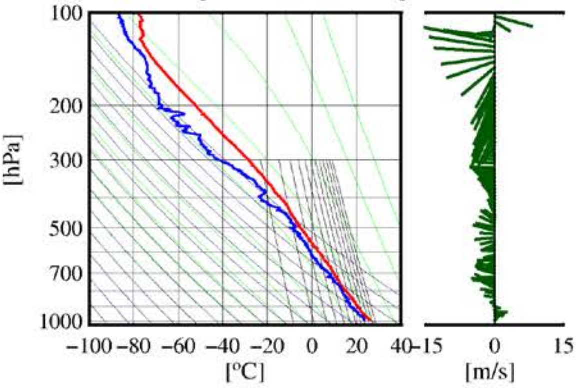
15/12/03 23:30 [101.8931E 4.0642S]



15/12/04 02:31 [101.8939E 4.0429S]



15/12/04 05:30 [101.9130E 4.0448S]



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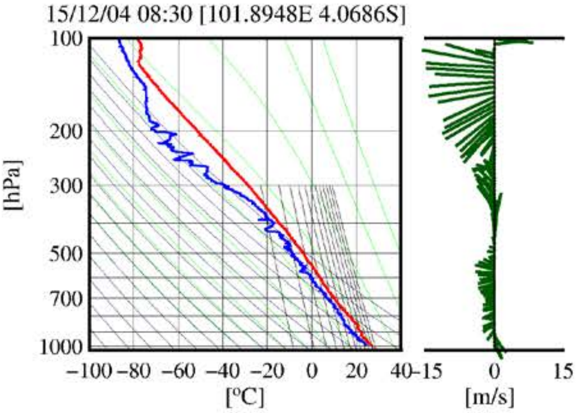

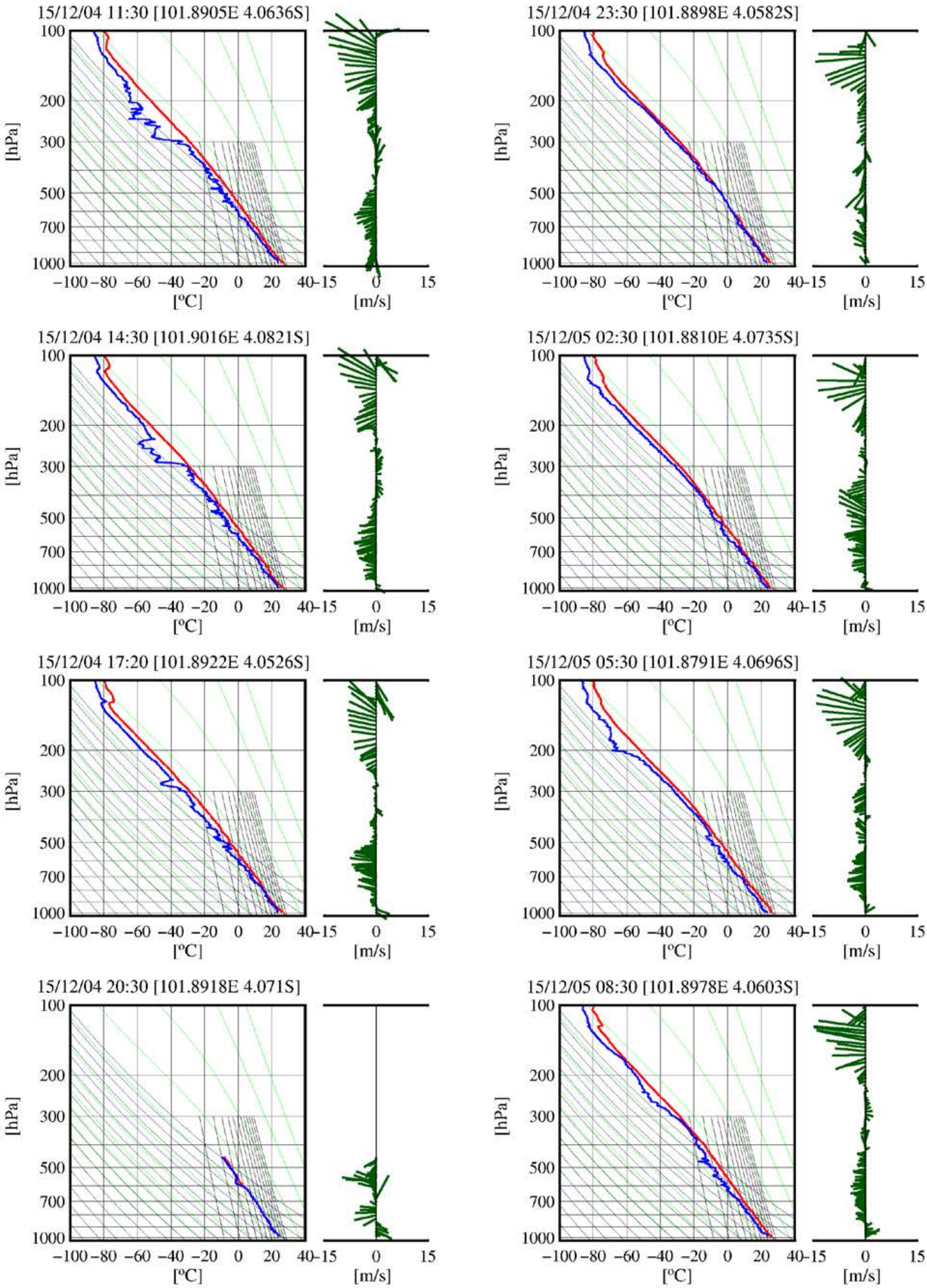
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15/12/04 23:30 [101.8898E 4.0582S]
15/12/04 14:30 [101.9016E 4.0821S]
15/12/05 02:30 [101.8810E 4.0735S]
15/12/04 17:20 [101.8922E 4.0526S]
15/12/05 05:30 [101.8791E 4.0696S]
15/12/04 20:30 [101.8918E 4.071S]
15/12/05 08:30 [101.8978E 4.0603S]
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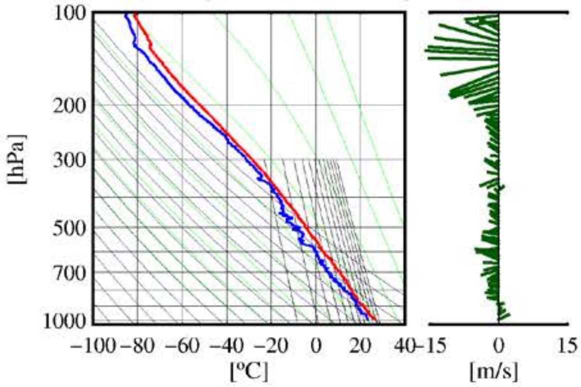
15/12/05 11:31 [101.8945E 4.0636S]



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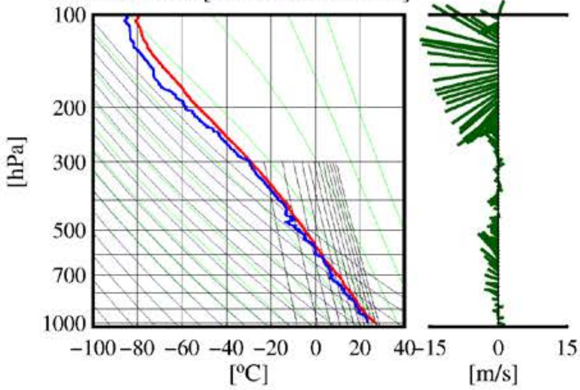
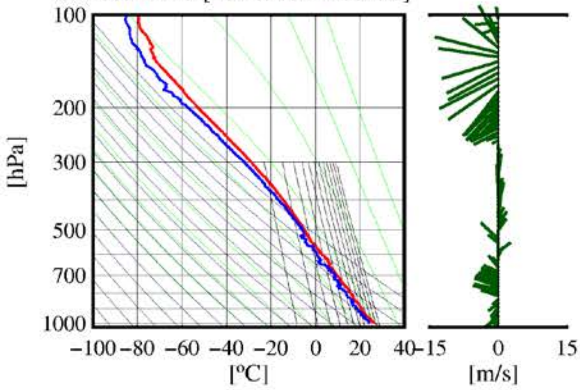
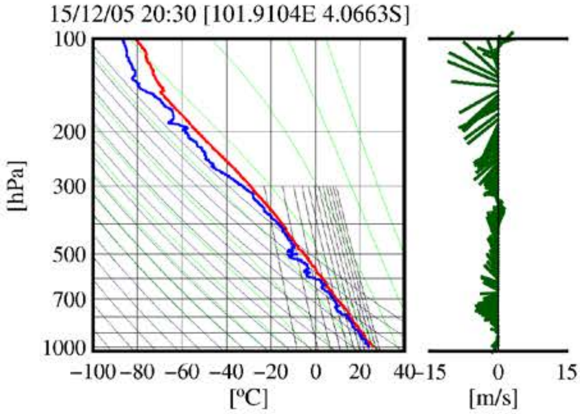


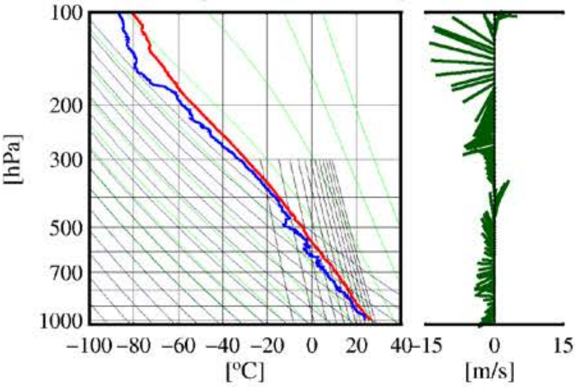
15/12/05 17:45 [101.8983E 4.0873S]



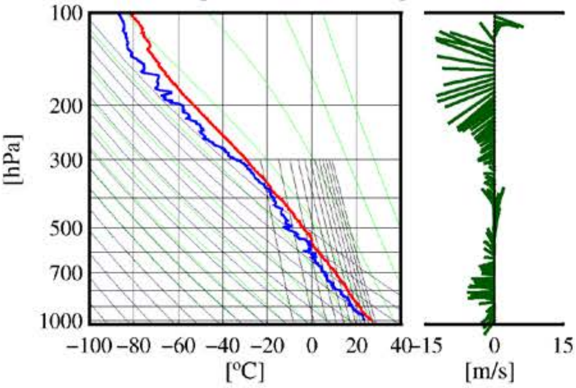
15/12/05 20:30 [101.9104E 4.0663S]



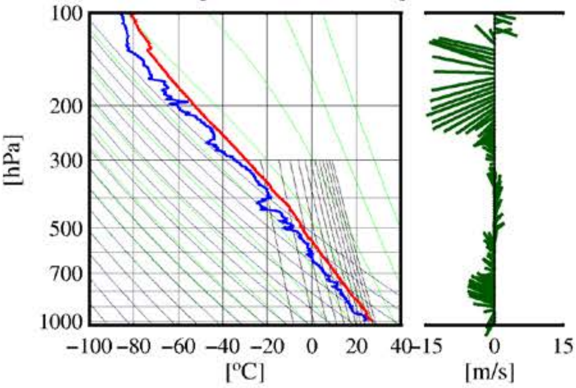
15/12/05 23:30 [101.8864E 4.0645S]



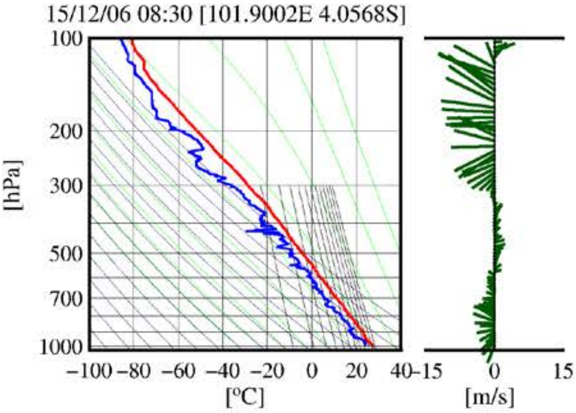
15/12/06 02:30 [101.8995E 4.0723S]



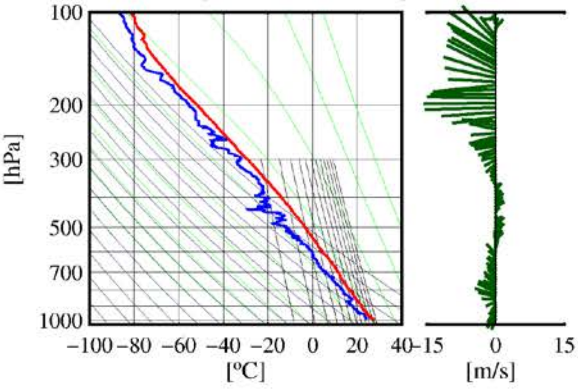
15/12/06 05:30 [101.8921E 4.0751S]



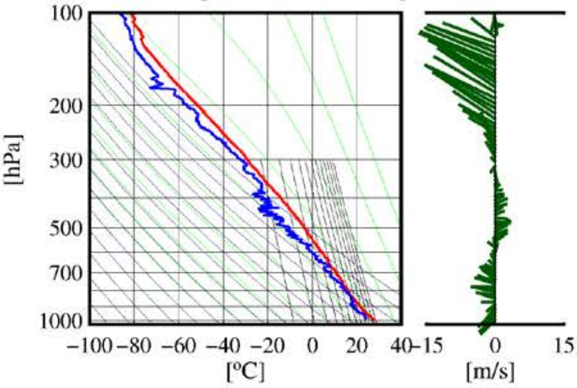
15/12/06 08:30 [101.9002E 4.0568S]



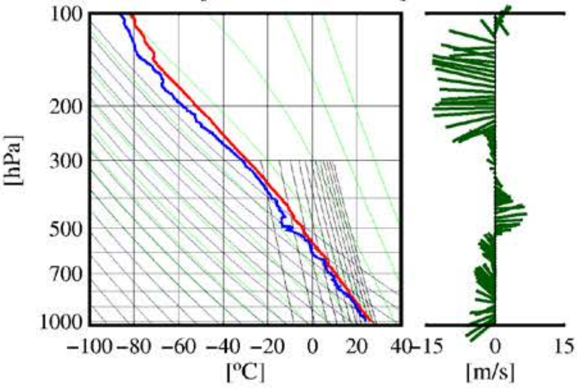
15/12/06 11:30 [101.8856E 4.0668S]



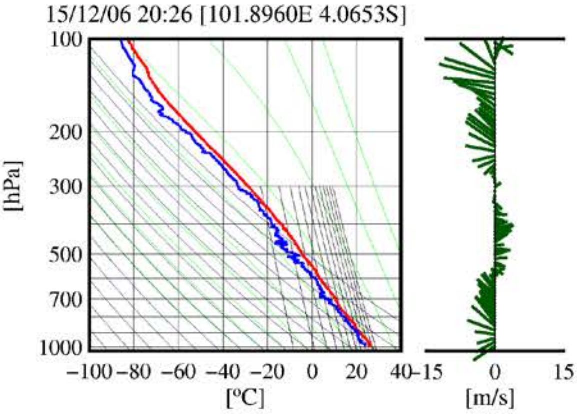
15/12/06 14:30 [101.8940E 4.0639S]



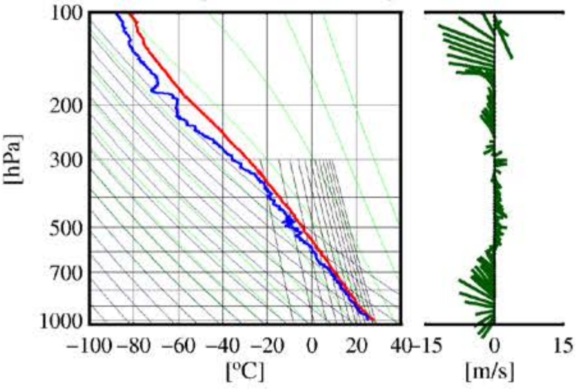
15/12/06 17:30 [101.8897E 4.0781S]



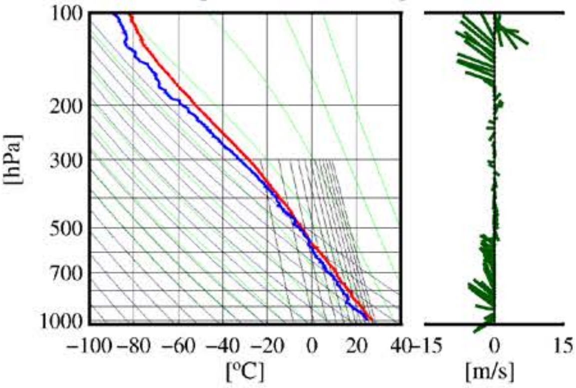
15/12/06 20:26 [101.8960E 4.0653S]



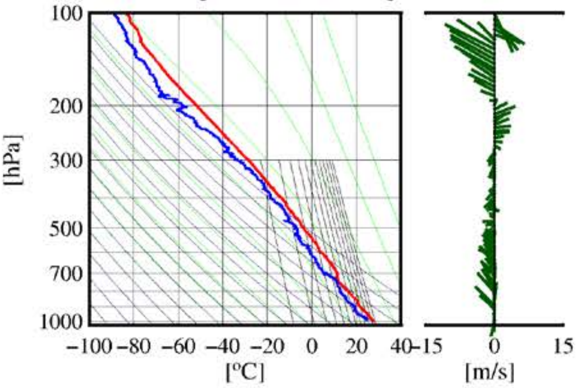
15/12/06 23:30 [101.8844E 4.067S]



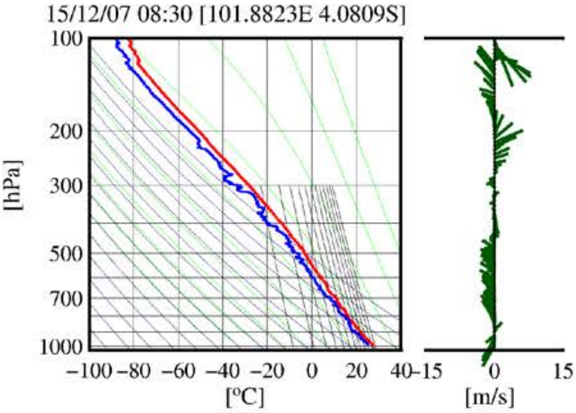
15/12/07 02:30 [101.9000E 4.0654S]

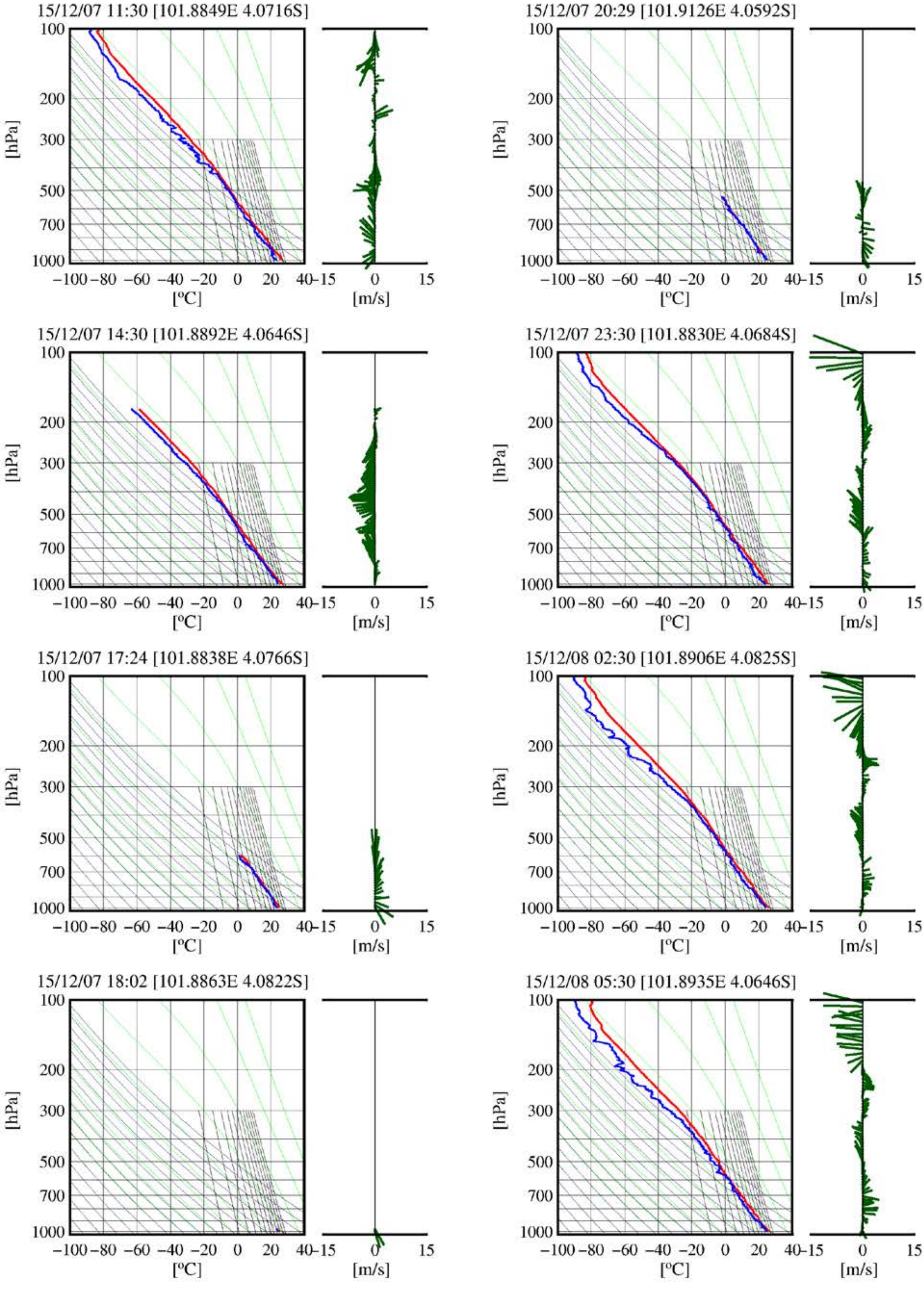


15/12/07 05:30 [101.8880E 4.063S]



15/12/07 08:30 [101.8823E 4.0809S]




15/12/07 11:30 [101.8849E 4.0716S]
15/12/07 20:29 [101.9126E 4.0592S]
15/12/07 14:30 [101.8892E 4.0646S]
15/12/07 23:30 [101.8830E 4.0684S]
15/12/07 17:24 [101.8838E 4.0766S]
15/12/08 02:30 [101.8906E 4.0825S]
15/12/07 18:02 [101.8863E 4.0822S]
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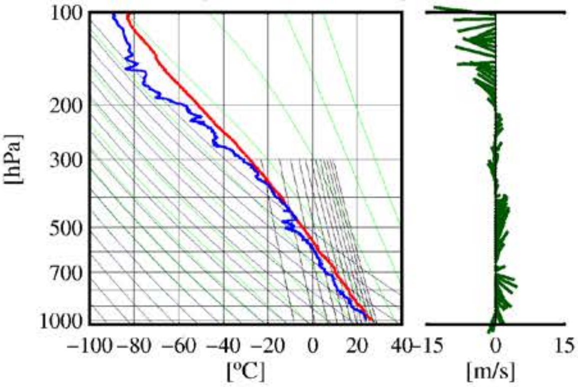
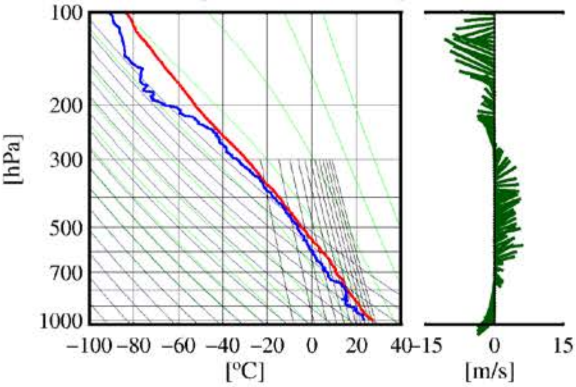
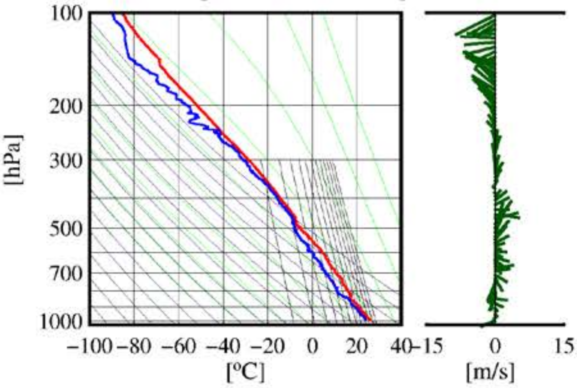
15/12/08 08:30 [101.8925E 4.0812S]



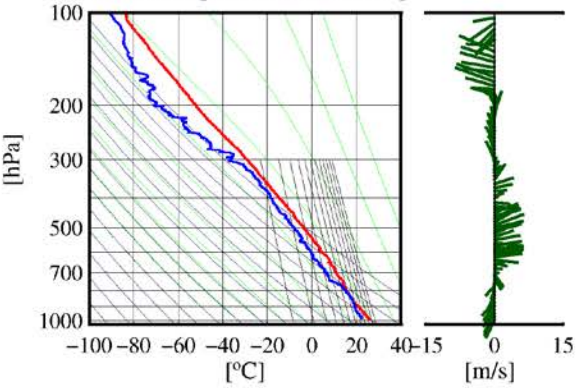
15/12/08 20:30 [101.8941E 4.0532S]



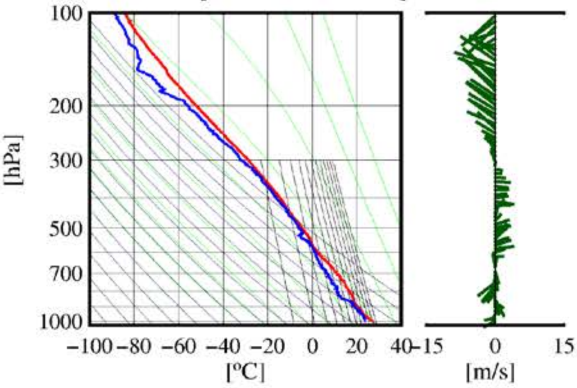
15/12/08 11:30 [101.8811E 4.0682S]



15/12/08 23:30 [101.8854E 4.0664S]



15/12/08 14:29 [101.8900E 4.0667S]



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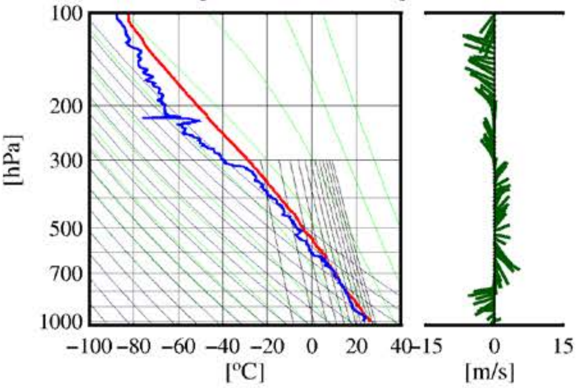

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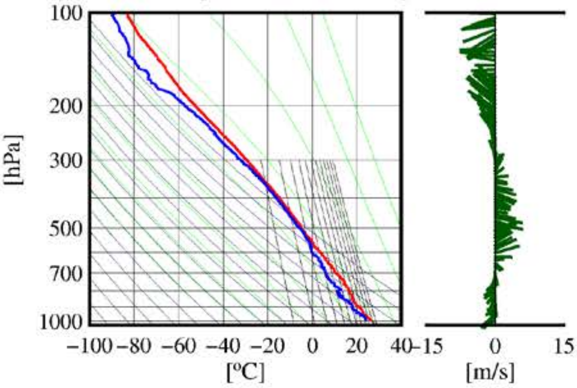

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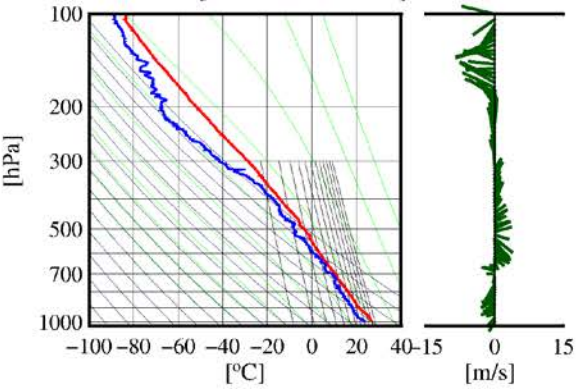

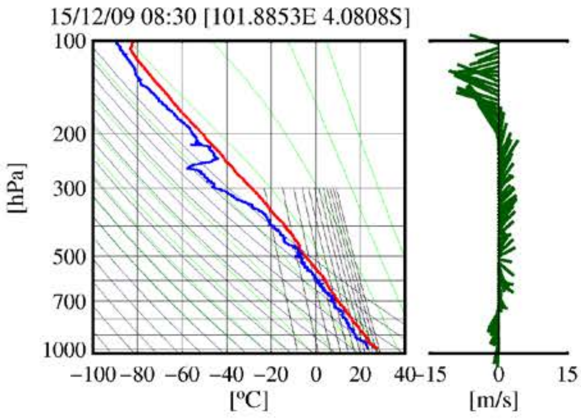
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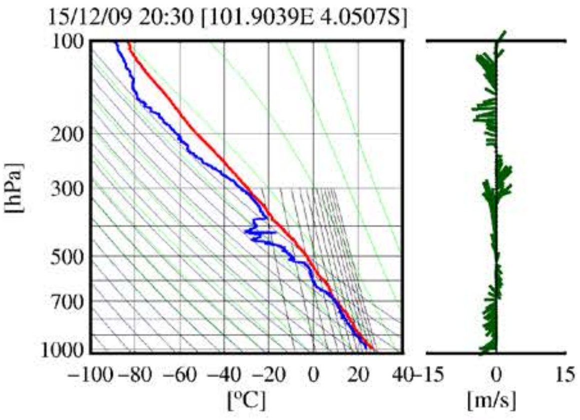
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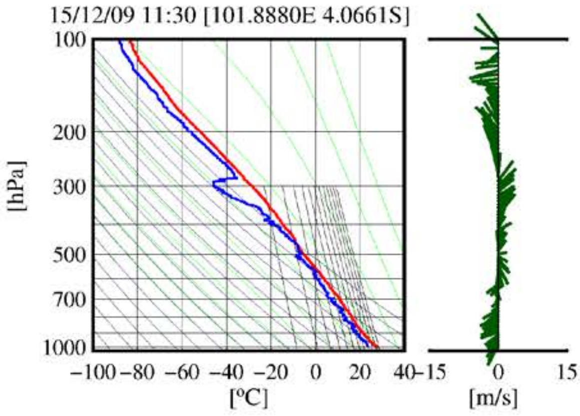
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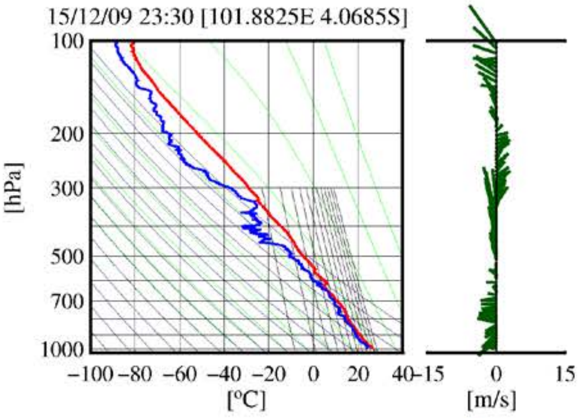
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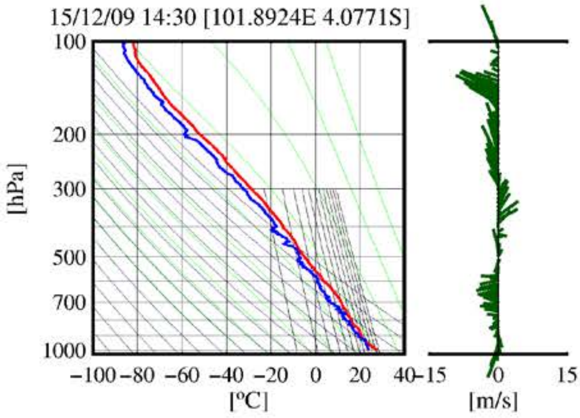
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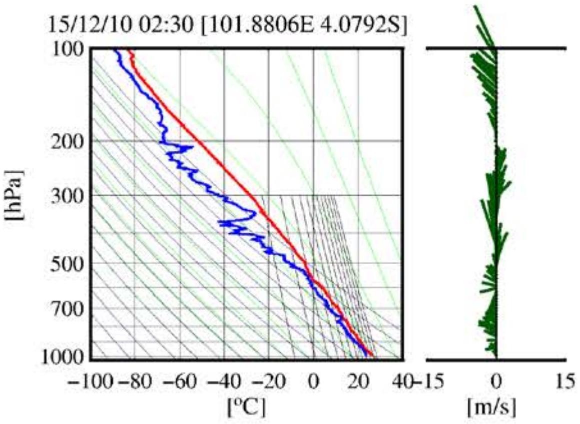
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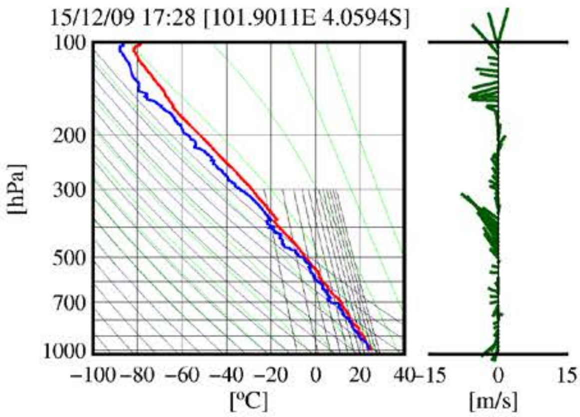
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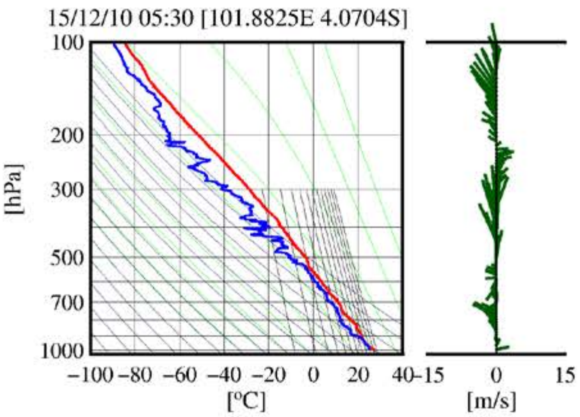
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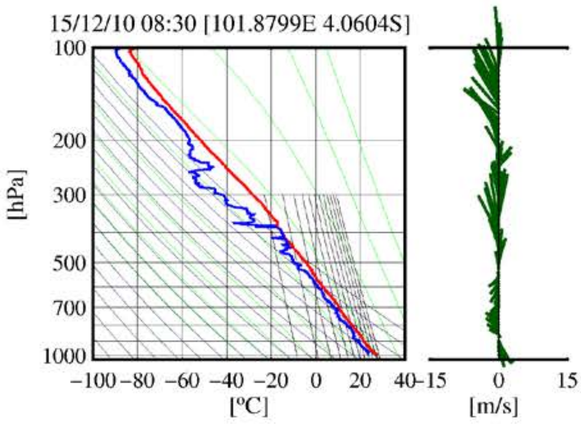
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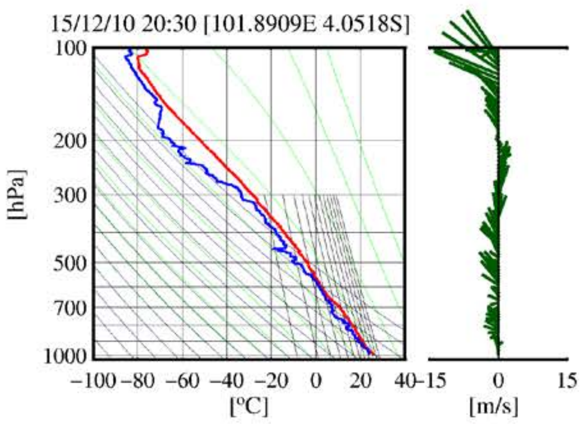
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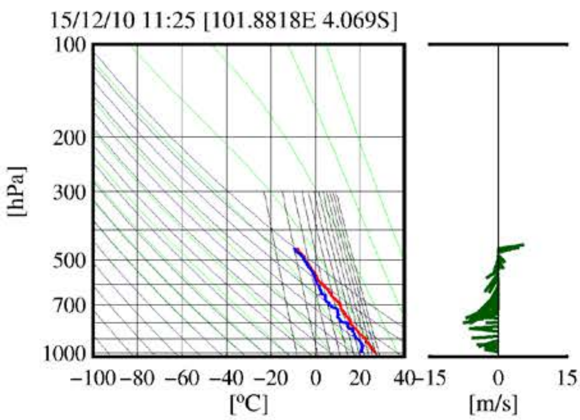
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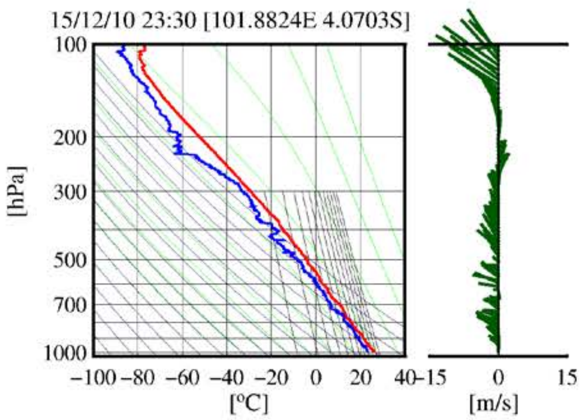
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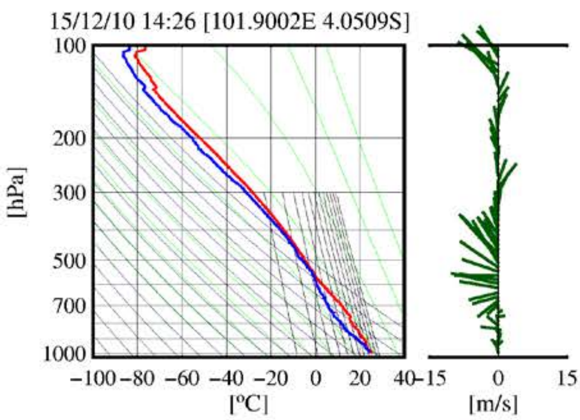
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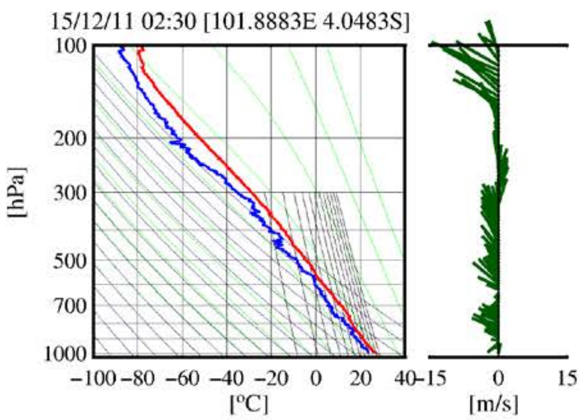
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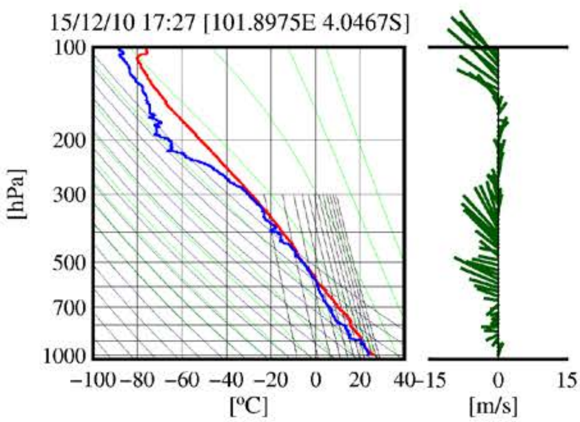
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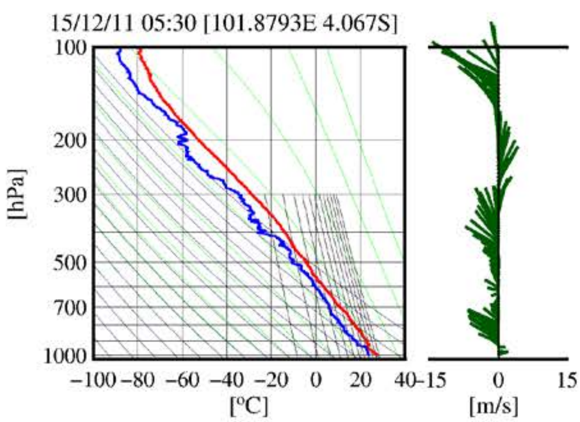
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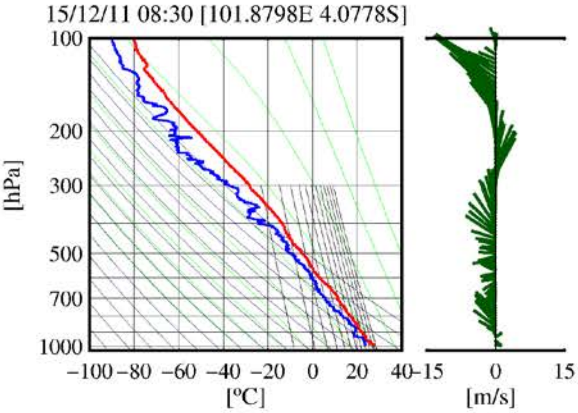
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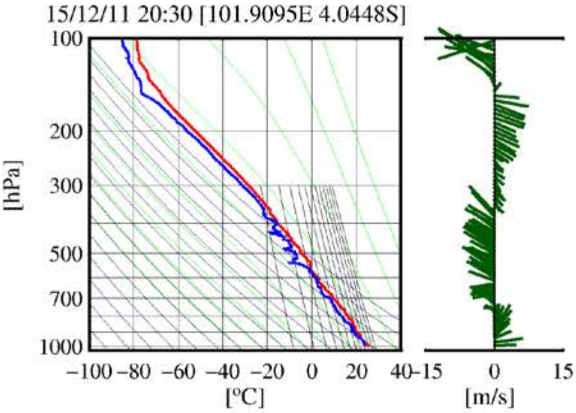
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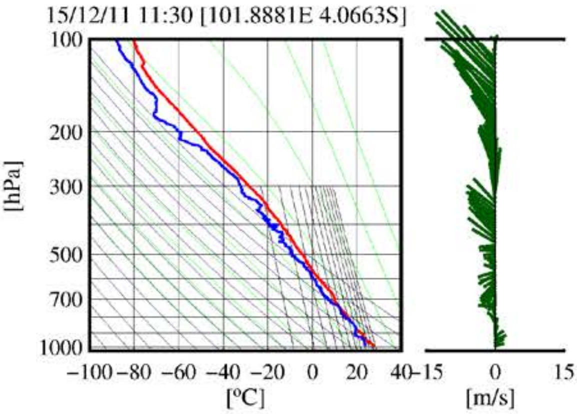
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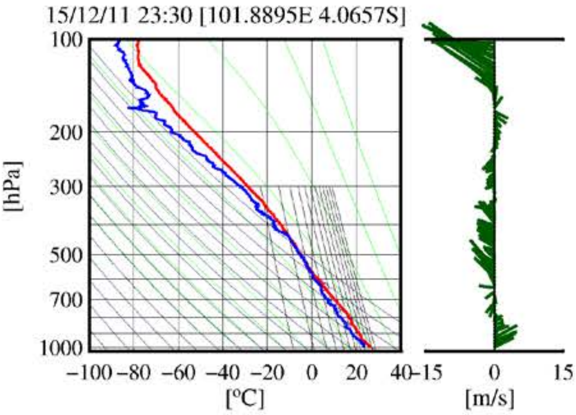
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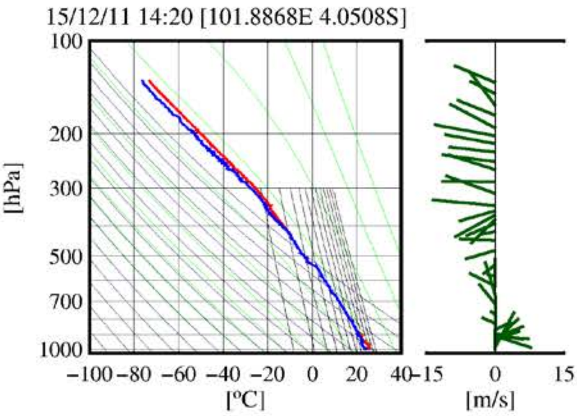
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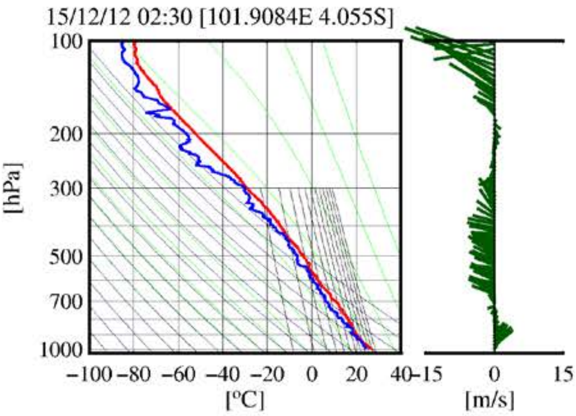
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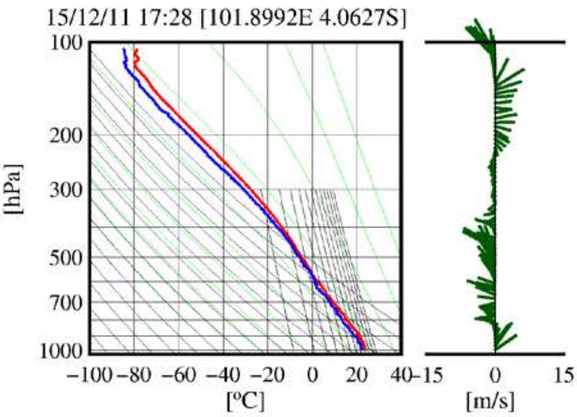
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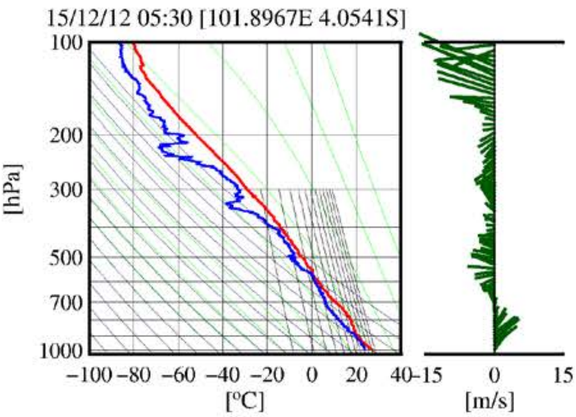
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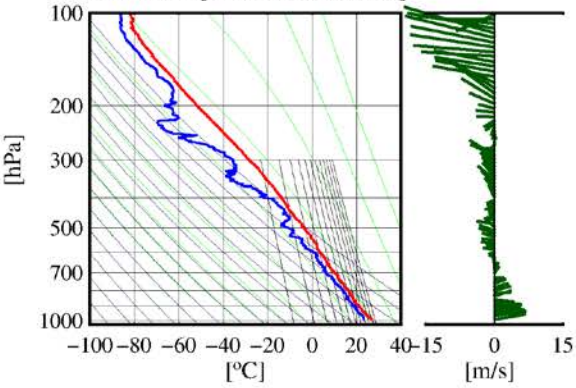
15/12/12 08:30 [101.8963E 4.0645S]



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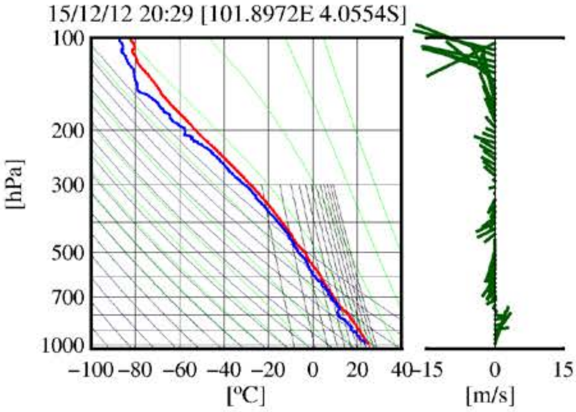
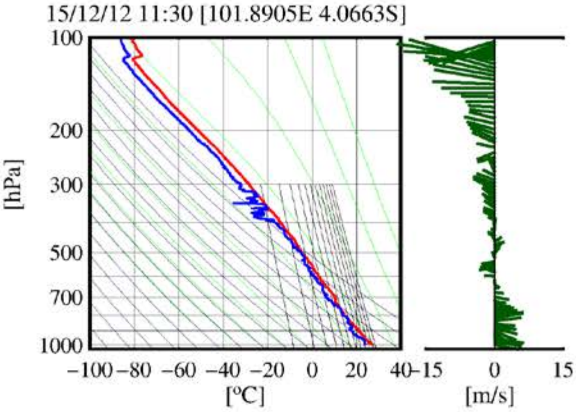


15/12/12 11:30 [101.8905E 4.0663S]



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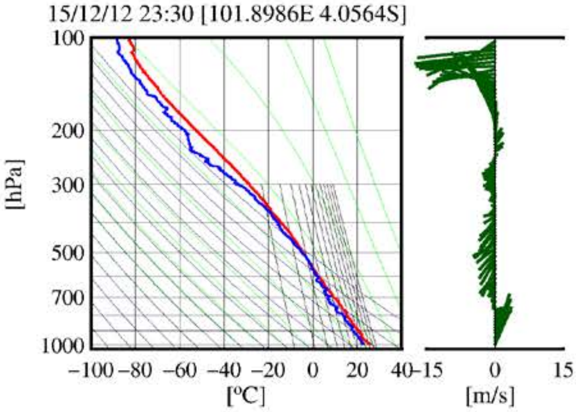

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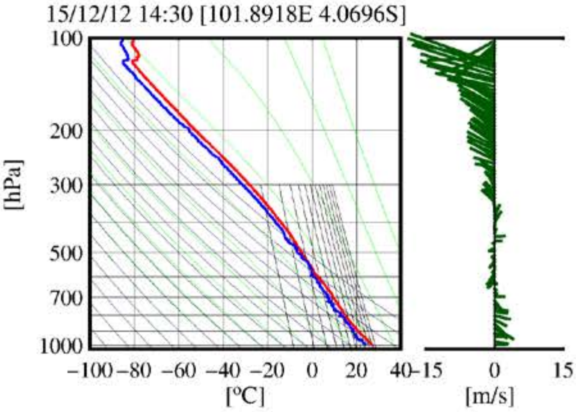

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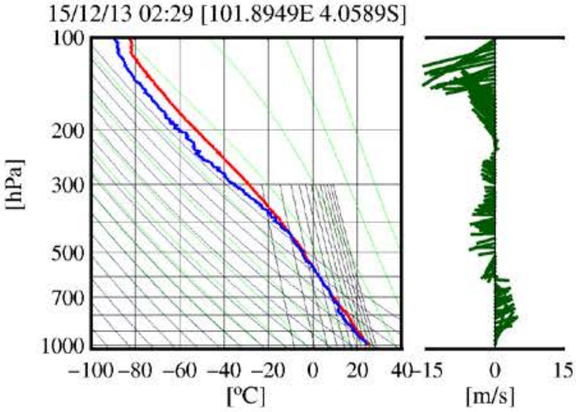
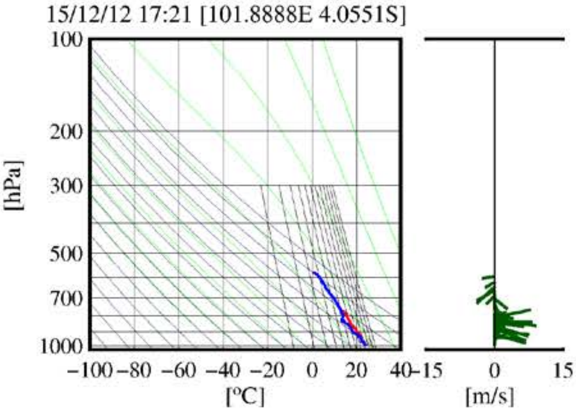


15/12/12 17:21 [101.8888E 4.0551S]



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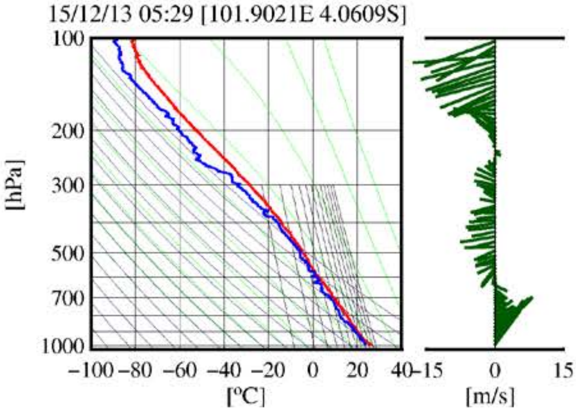

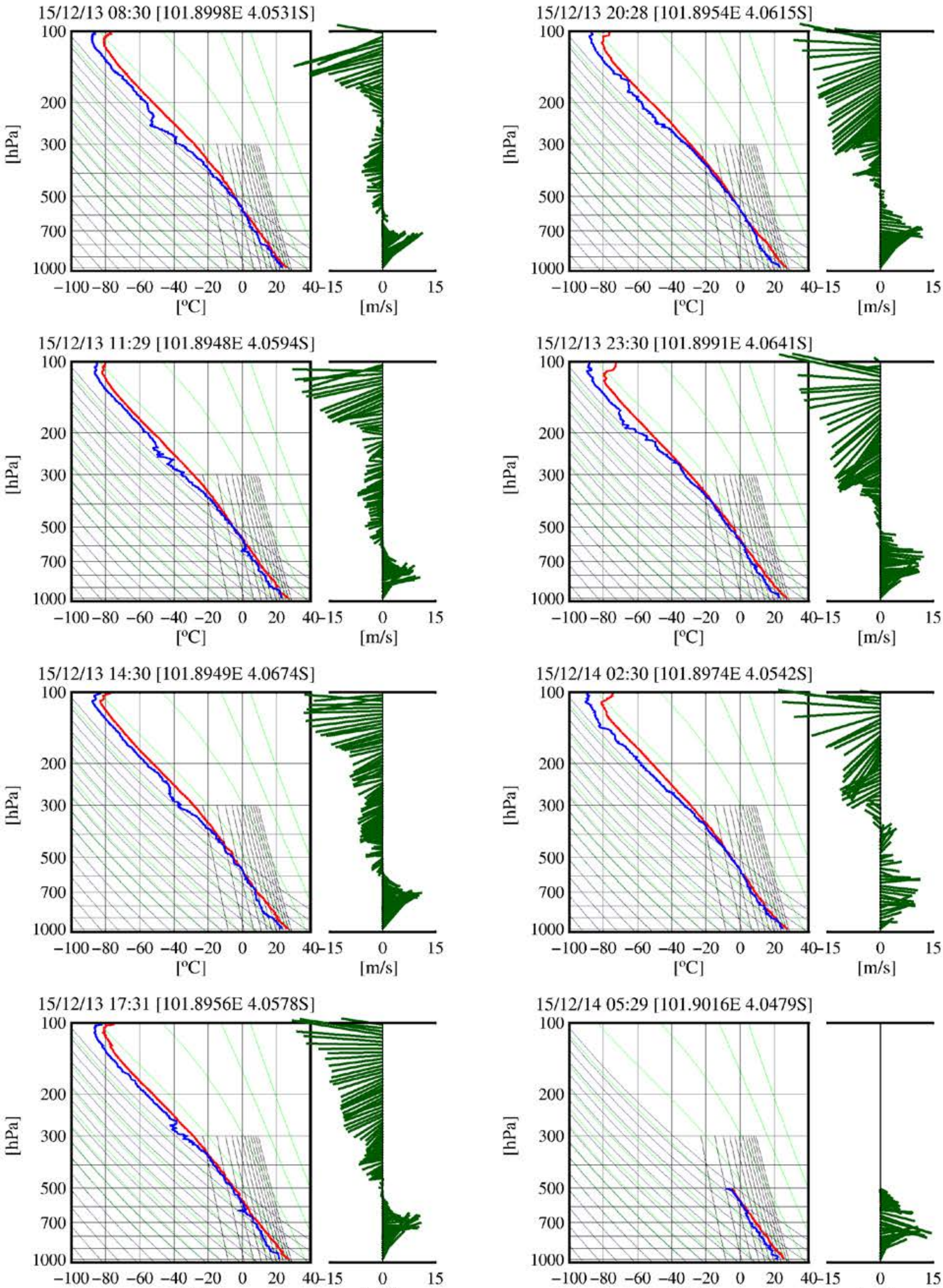
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15/12/13 20:28 [101.8954E 4.0615S]
15/12/13 11:29 [101.8948E 4.0594S]
15/12/13 23:30 [101.8991E 4.0641S]
15/12/13 14:30 [101.8949E 4.0674S]
15/12/14 02:30 [101.8974E 4.0542S]
15/12/13 17:31 [101.8956E 4.0578S]
15/12/14 05:29 [101.9016E 4.0479S]
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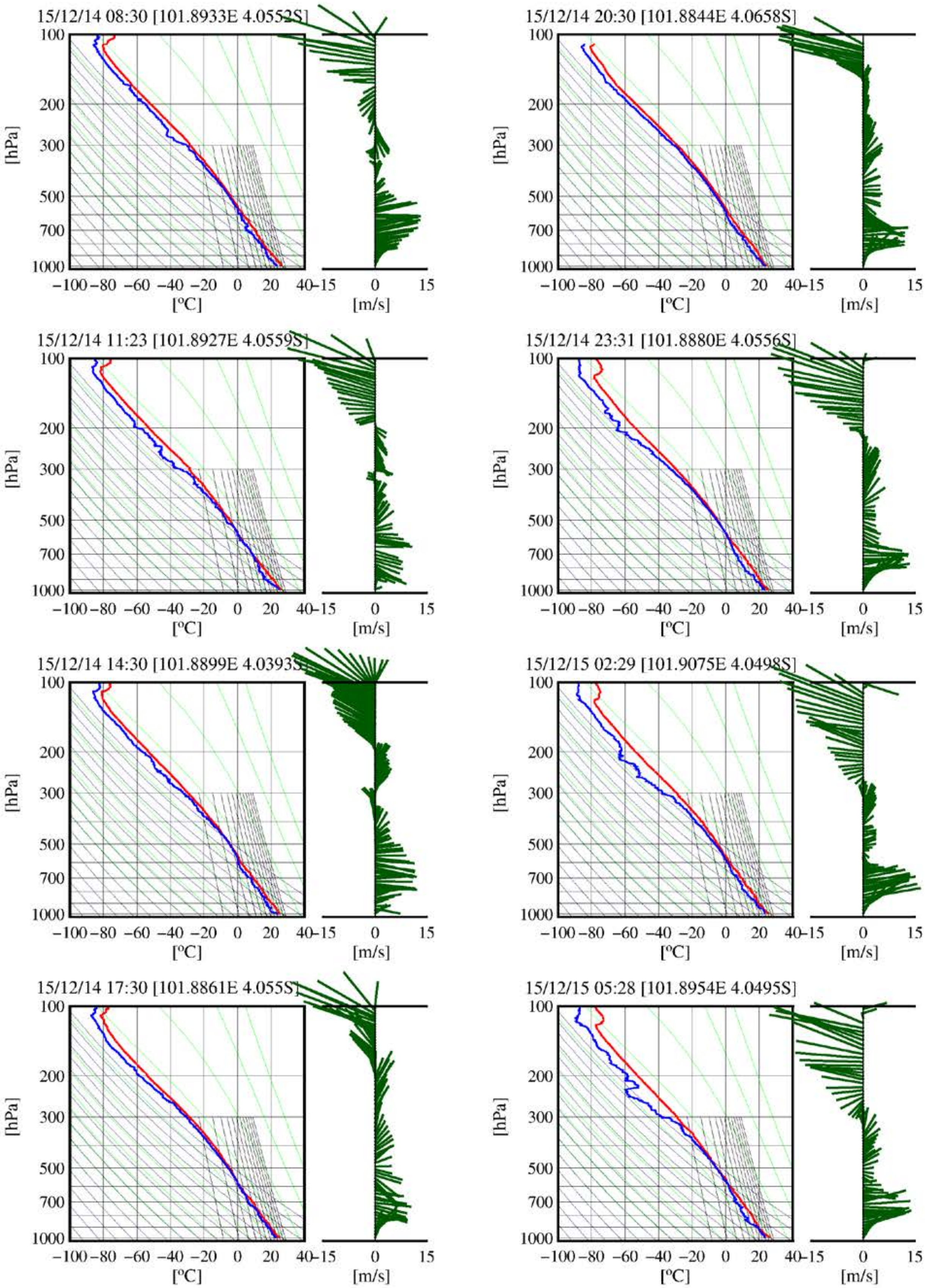

15/12/14 08:30 [101.8933E 4.0552S]
15/12/14 20:30 [101.8844E 4.0658S]
15/12/14 11:23 [101.8927E 4.0559S]
15/12/14 23:31 [101.8880E 4.0556S]
15/12/14 14:30 [101.8899E 4.0393S]
15/12/15 02:29 [101.9075E 4.0498S]
15/12/14 17:30 [101.8861E 4.055S]
15/12/15 05:28 [101.8954E 4.0495S]
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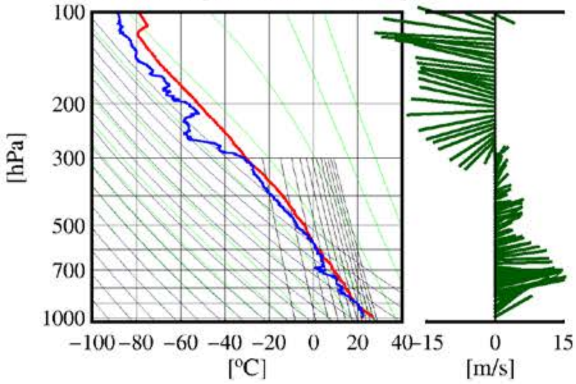
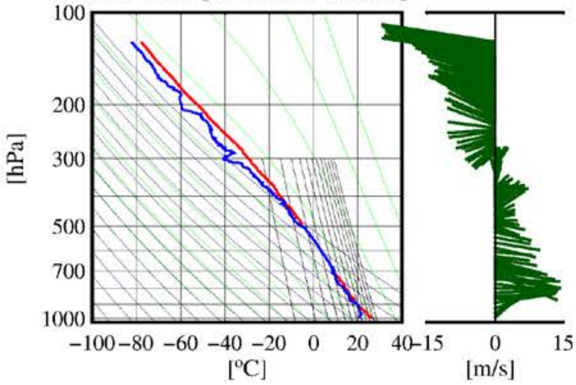
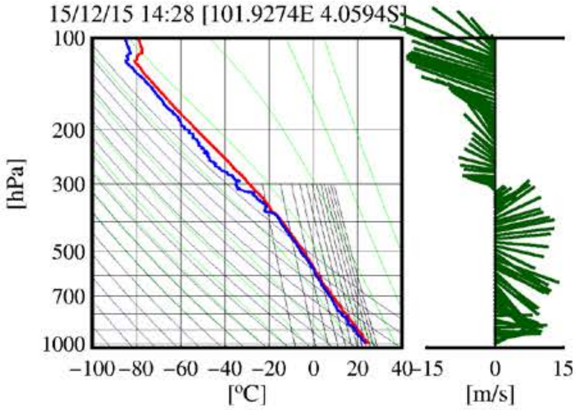
15/12/15 08:30 [101.8949E 4.0721S]



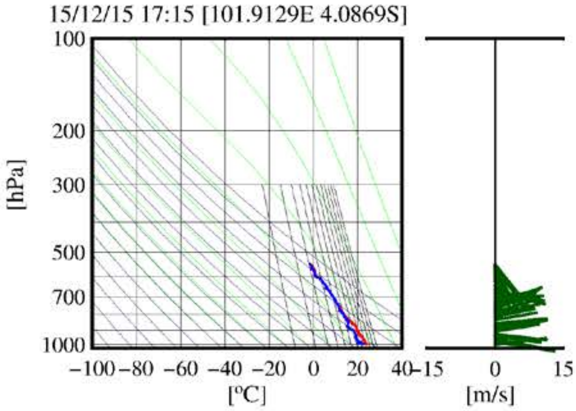
15/12/15 11:15 [101.8986E 4.0564S]



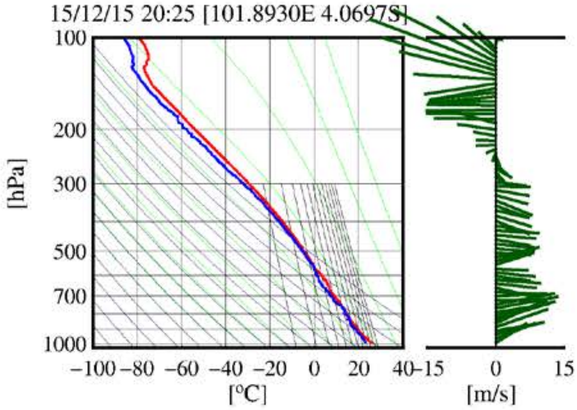
15/12/15 14:28 [101.9274E 4.0594S]



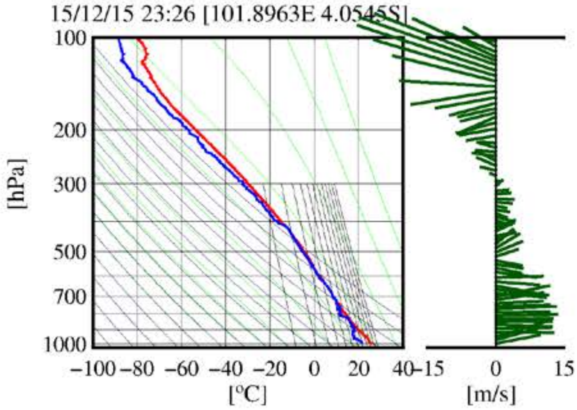
15/12/15 17:15 [101.9129E 4.0869S]



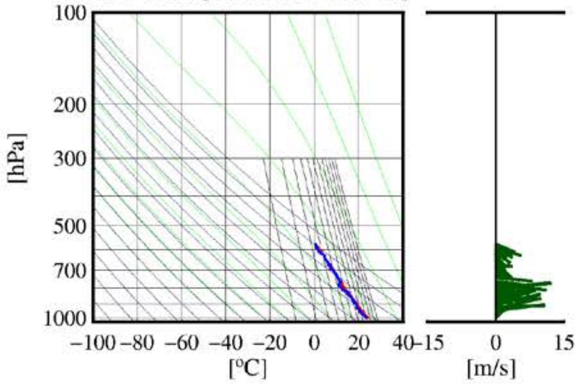
15/12/15 20:25 [101.8930E 4.0697S]



15/12/15 23:26 [101.8963E 4.0545S]



15/12/16 02:50 [101.8950E 4.0597S]



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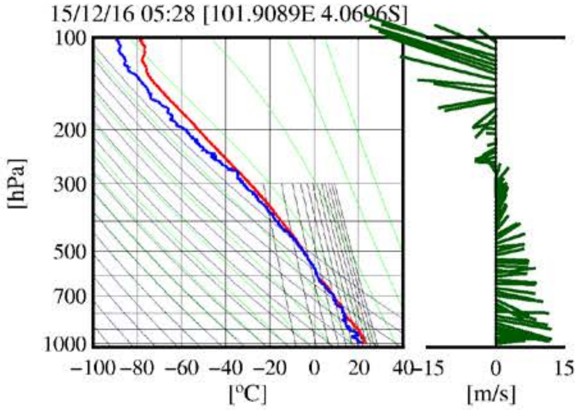

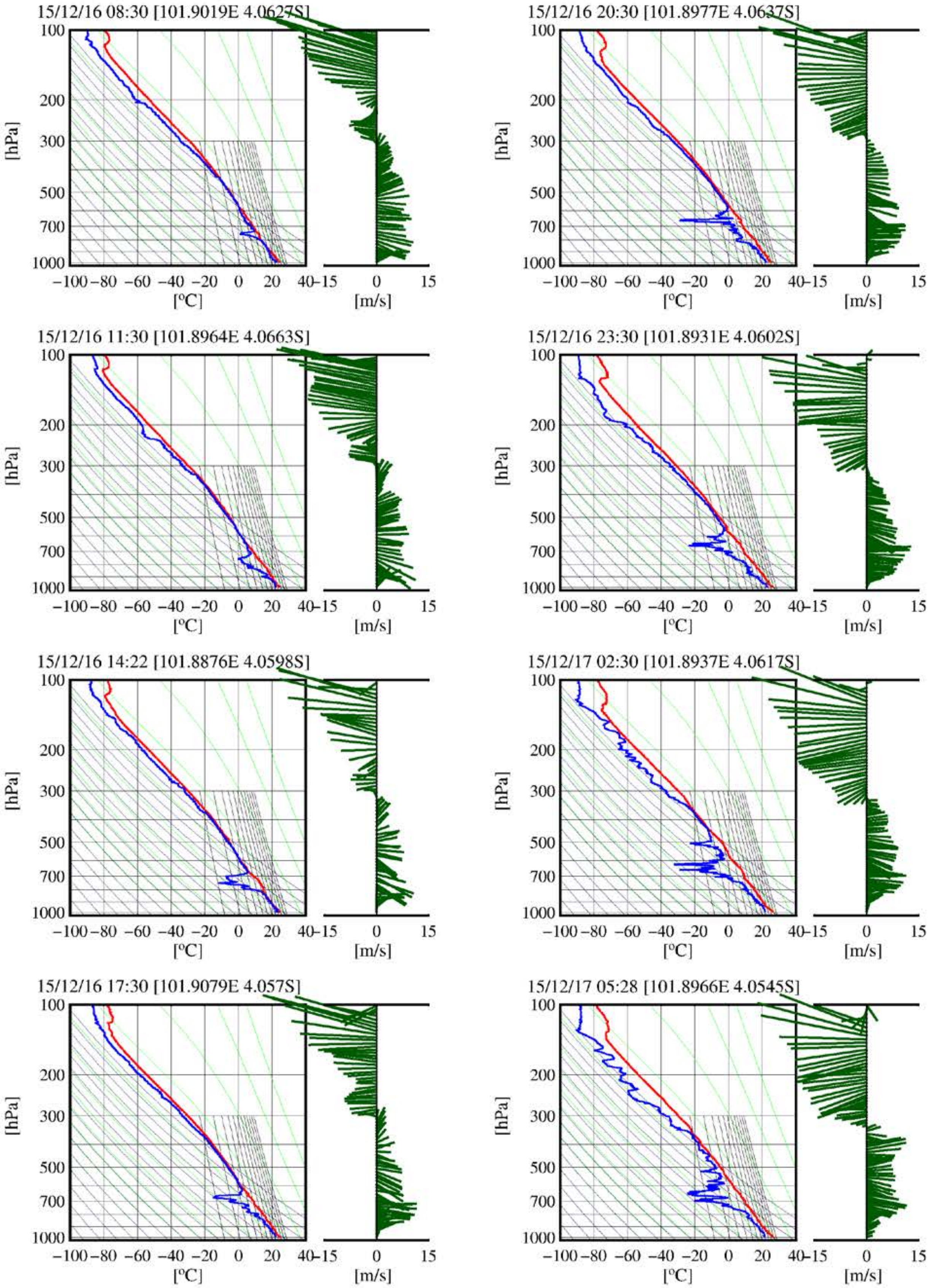
15/12/16 08:30 [101.9019E 4.0627S]
15/12/16 20:30 [101.8977E 4.0637S]
15/12/16 11:30 [101.8964E 4.0663S]
15/12/16 23:30 [101.8931E 4.0602S]
15/12/16 14:22 [101.8876E 4.0598S]
15/12/17 02:30 [101.8937E 4.0617S]
15/12/16 17:30 [101.9079E 4.057S]
15/12/17 05:28 [101.8966E 4.0545S]
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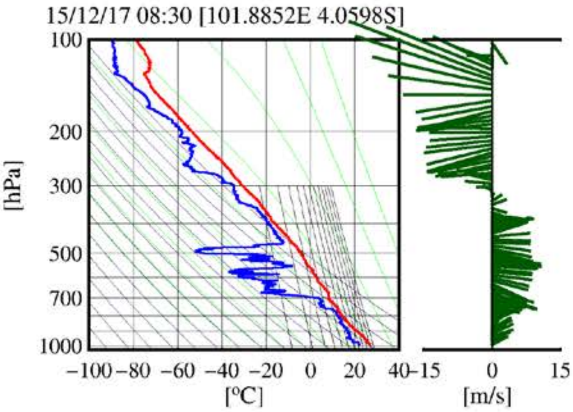
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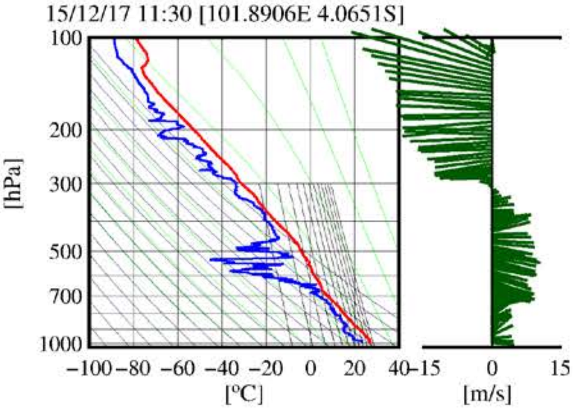
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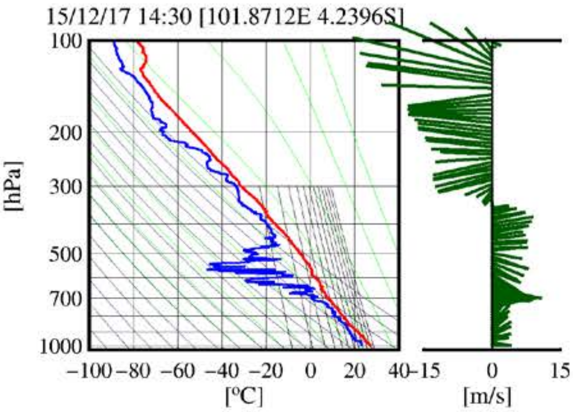
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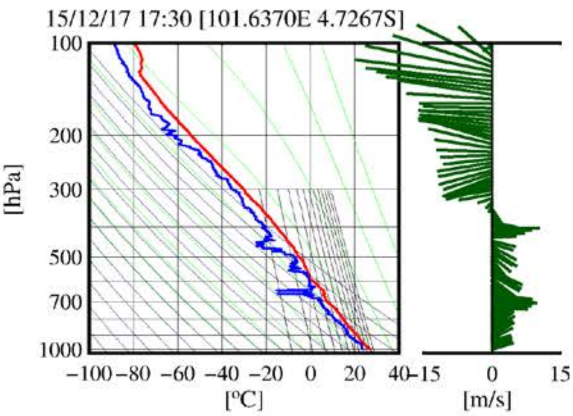
[m/s]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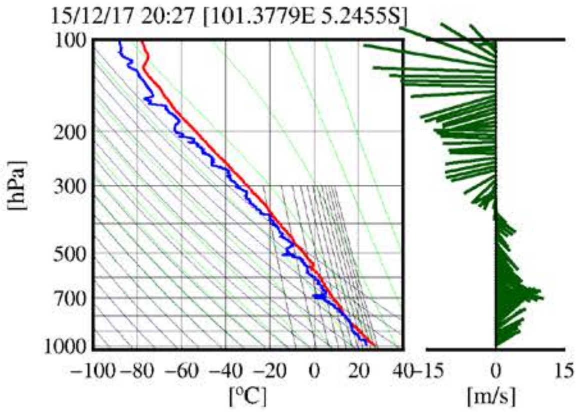
[hPa]
100
200
300
500
700
1000
−100 −80 −60 −40 −20 0 20 40
[ºC]
−15 0 15
[m/s]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1000
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[ºC]
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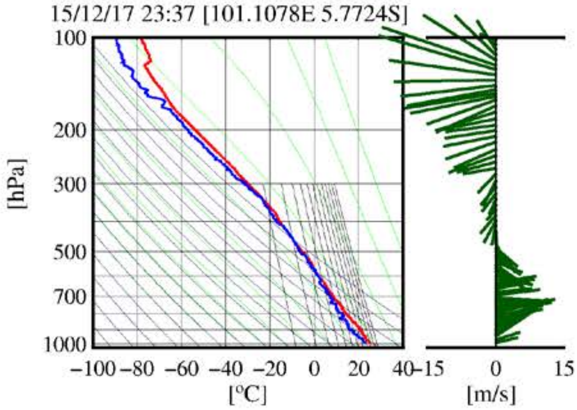
[m/s]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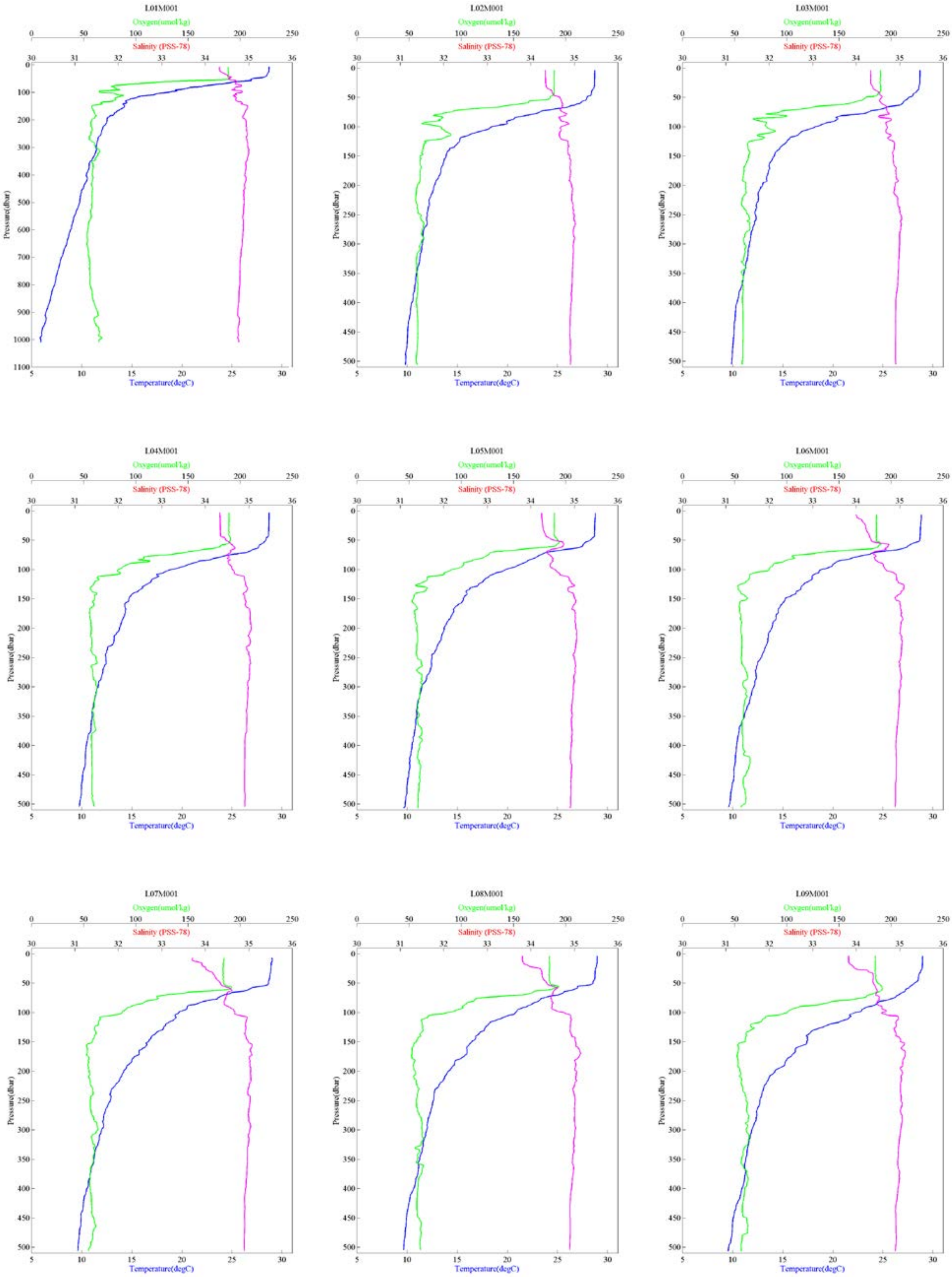
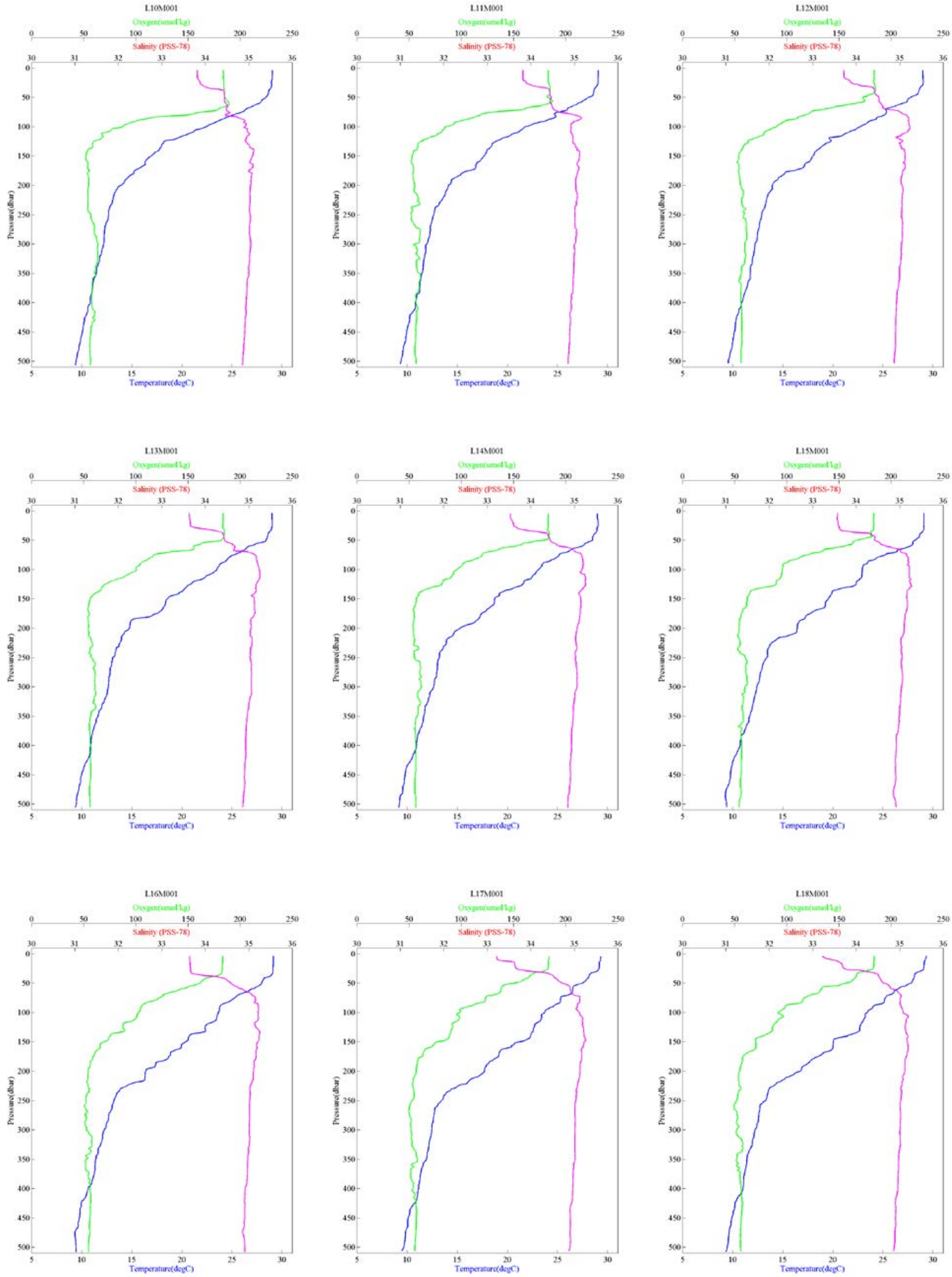
[hPa]
100
200
300
500
700
1000
−100 −80 −60 −40 −20 0 20 40
[ºC]
−15 0 15
[m/s]

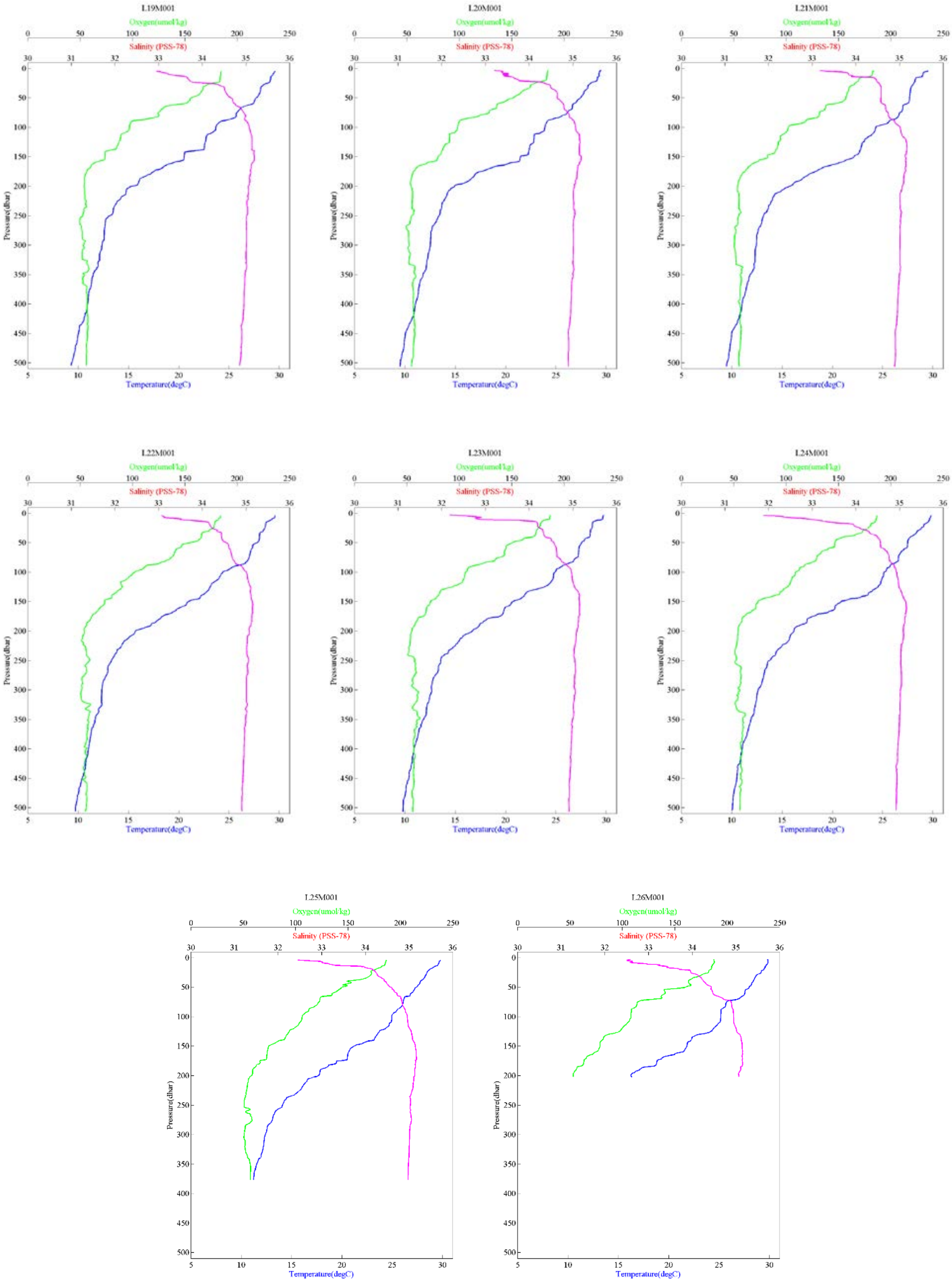
Appendix B: Oceanic profiles by the CTDO observations



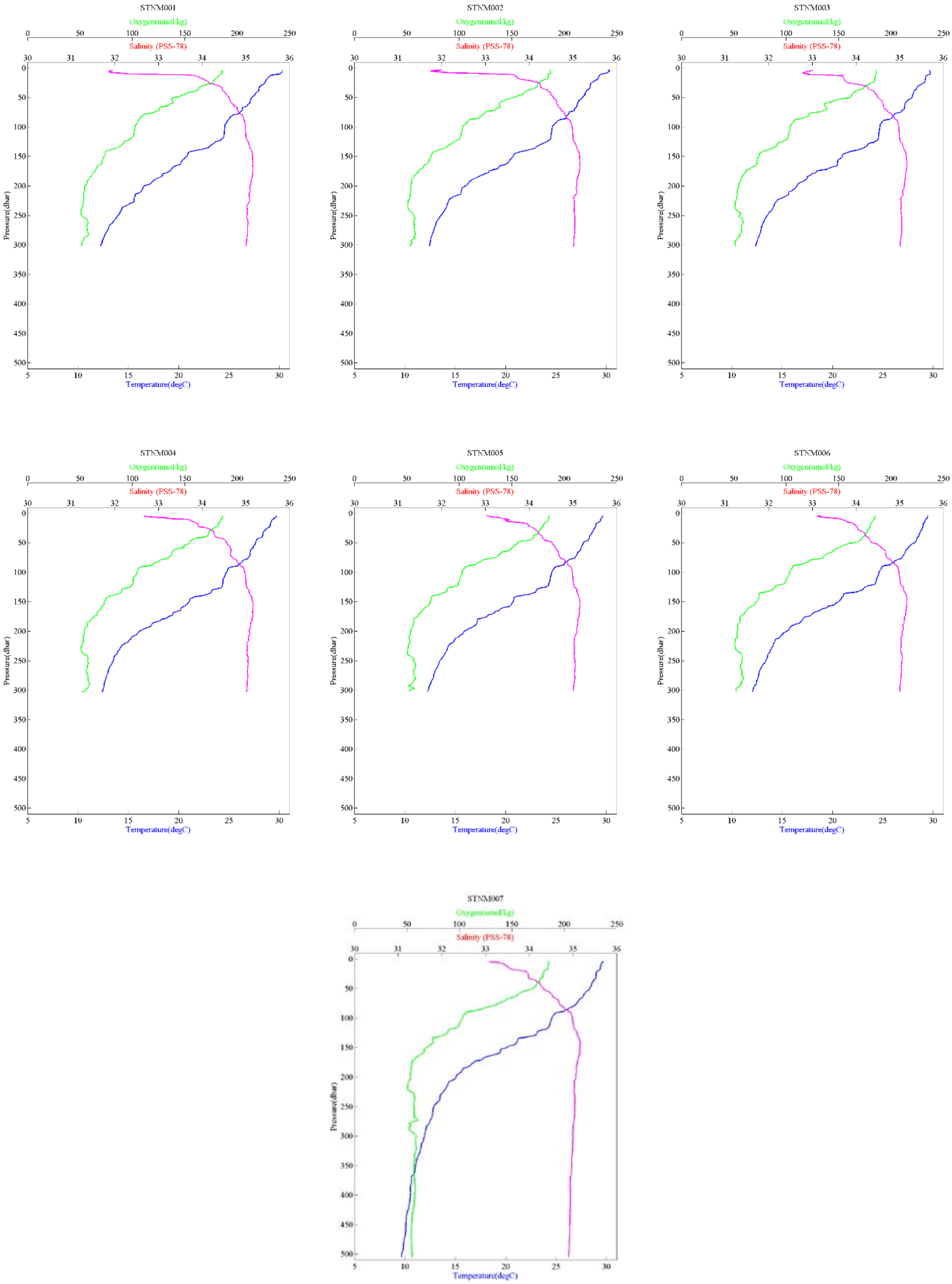
CTD profile (L01M001, L02M001, L03M001, L04M001, L05M001, L06M001, L07M001, L08M001 and L09M001)



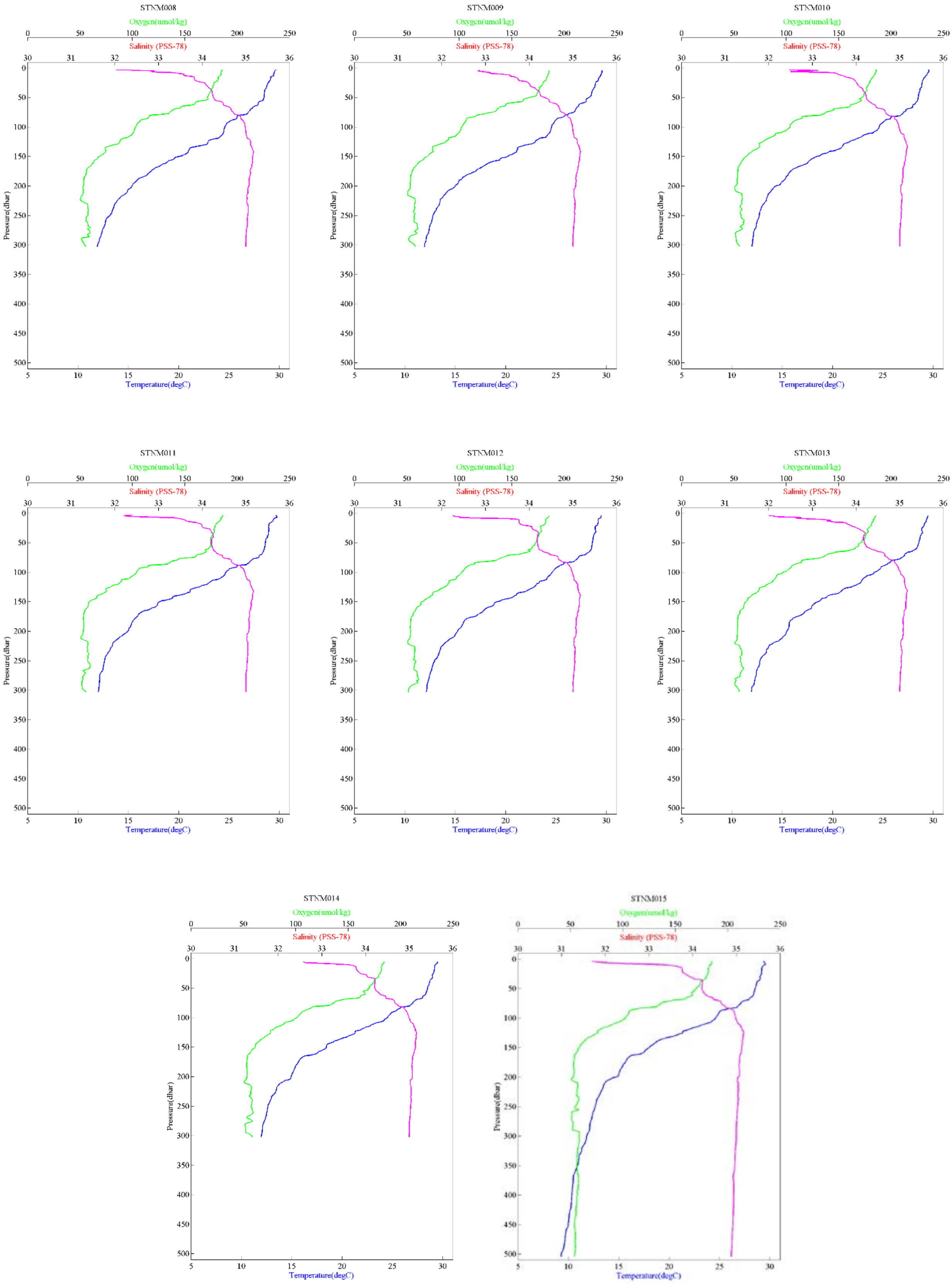
CTD profile (L10M001, L11M001, L12M001, L13M001, L14M001, L15M001, L16M001, L17M001 and L18M001)



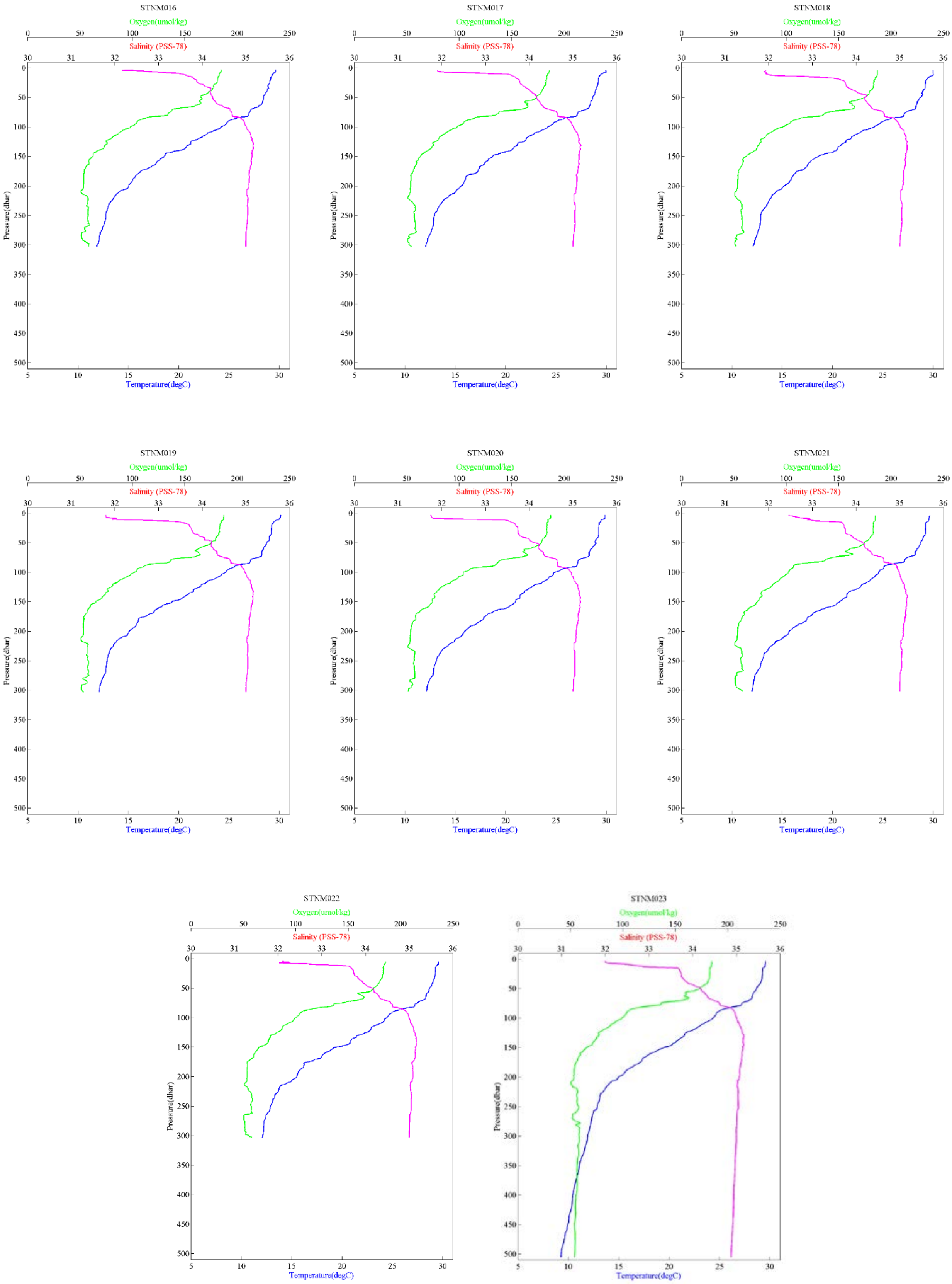
CTD profile (L19M001, L20M001, L21M001, L22M001, L23M001, L24M001, L25M001 and L26M001)



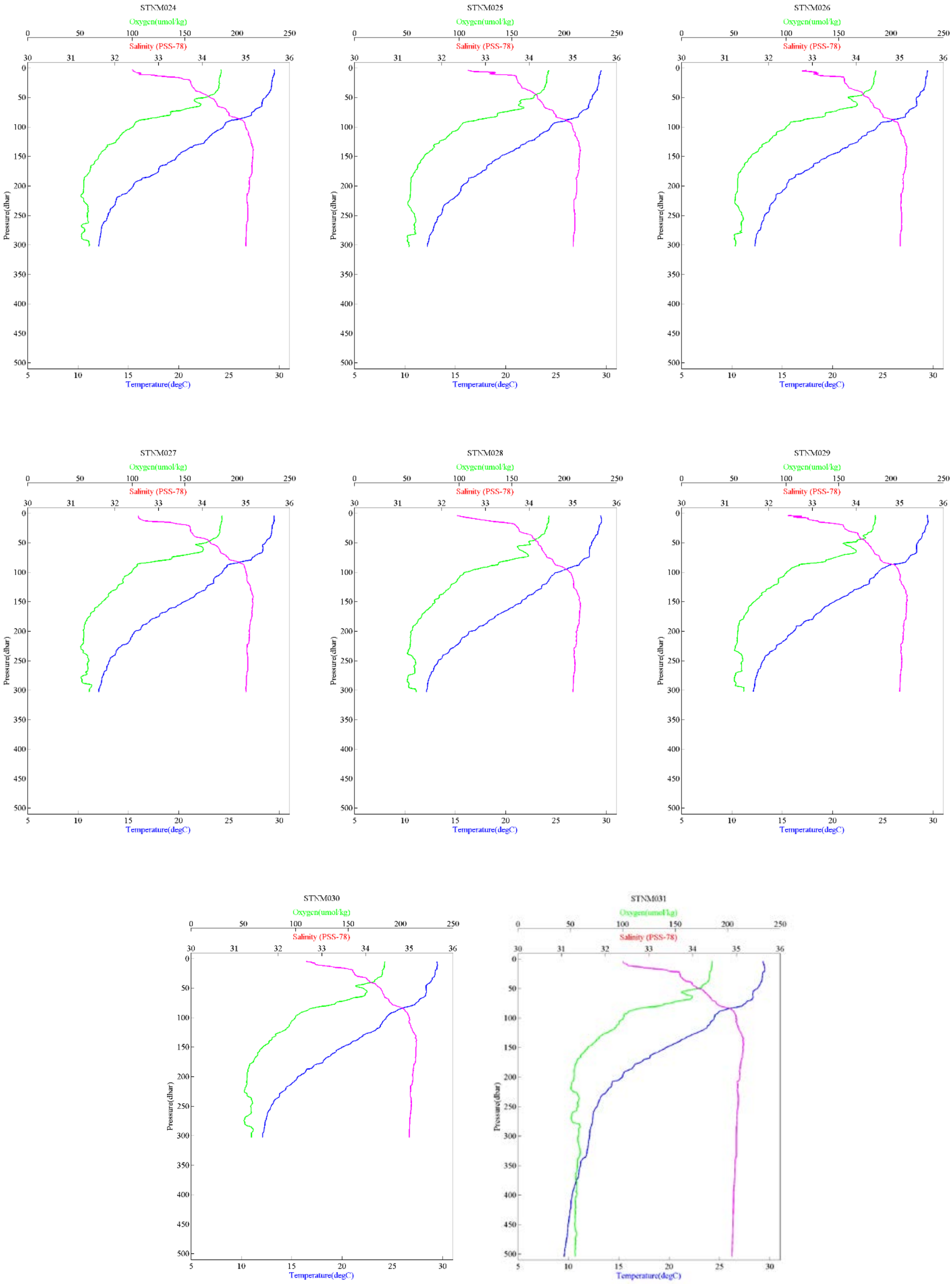
CTD profile (Fixed Point 23 Nov. 2015)



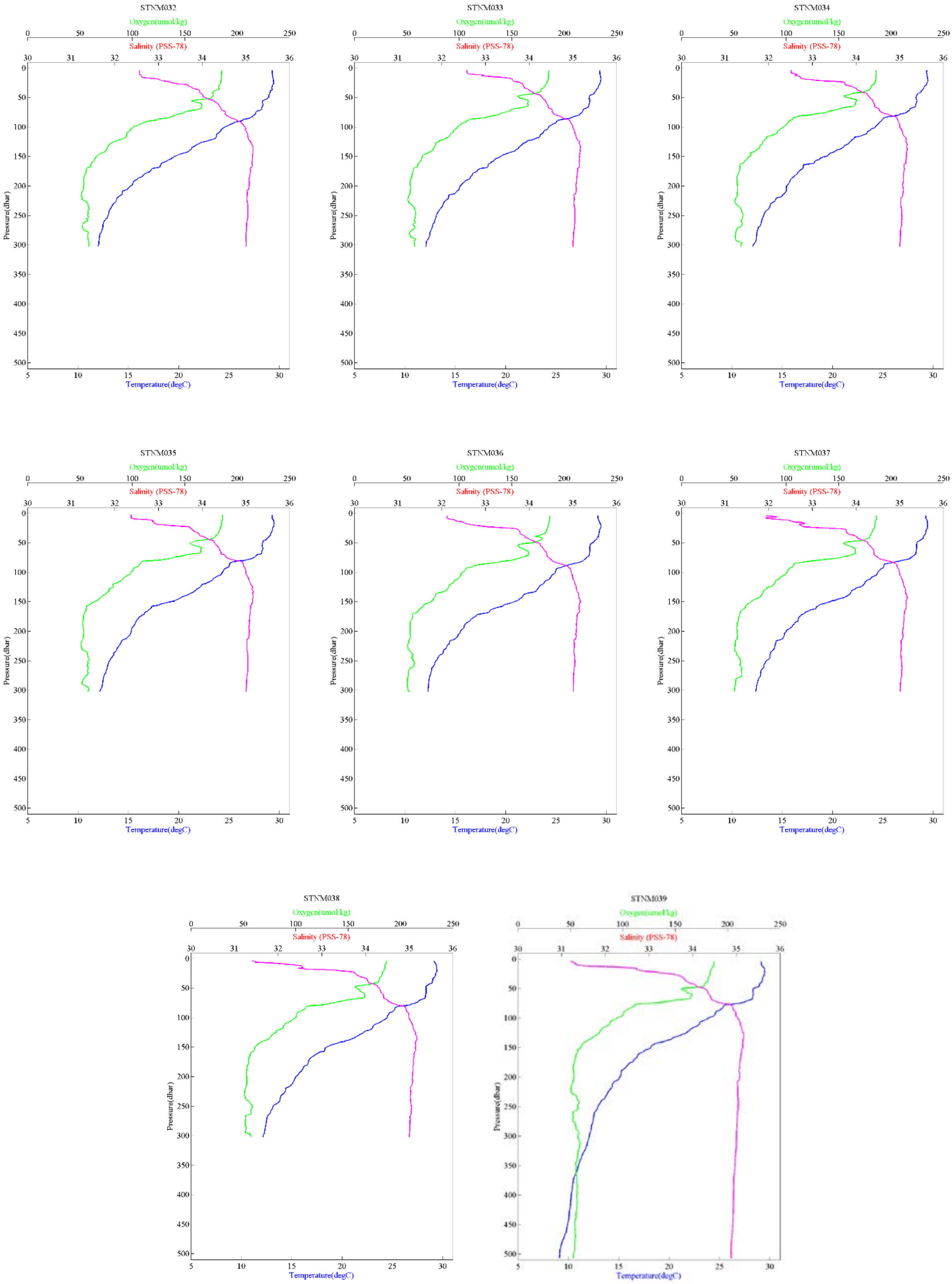
CTD profile (Fixed Point 24 Nov. 2015)



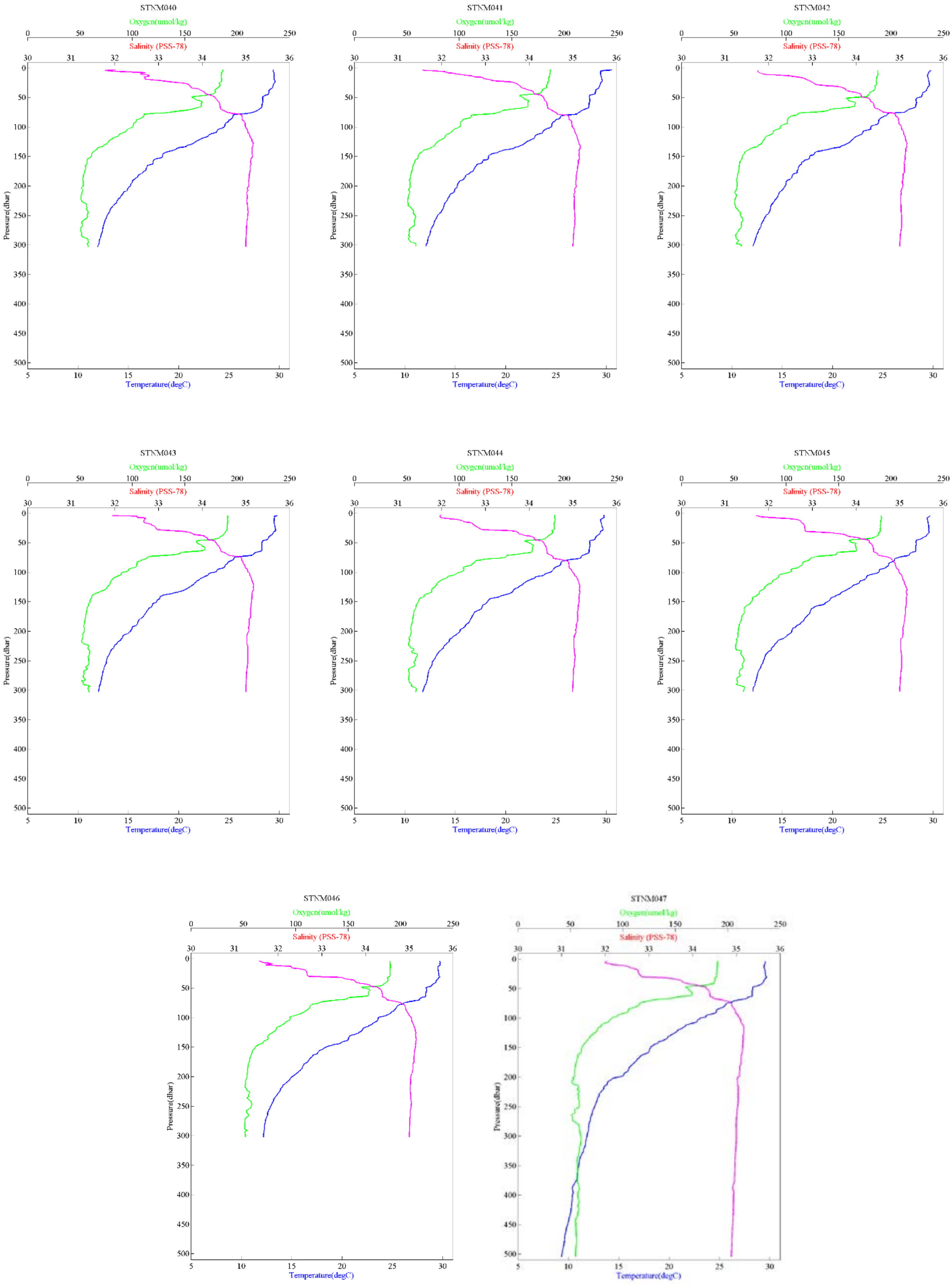
CTD profile (Fixed Point 25 Nov. 2015)



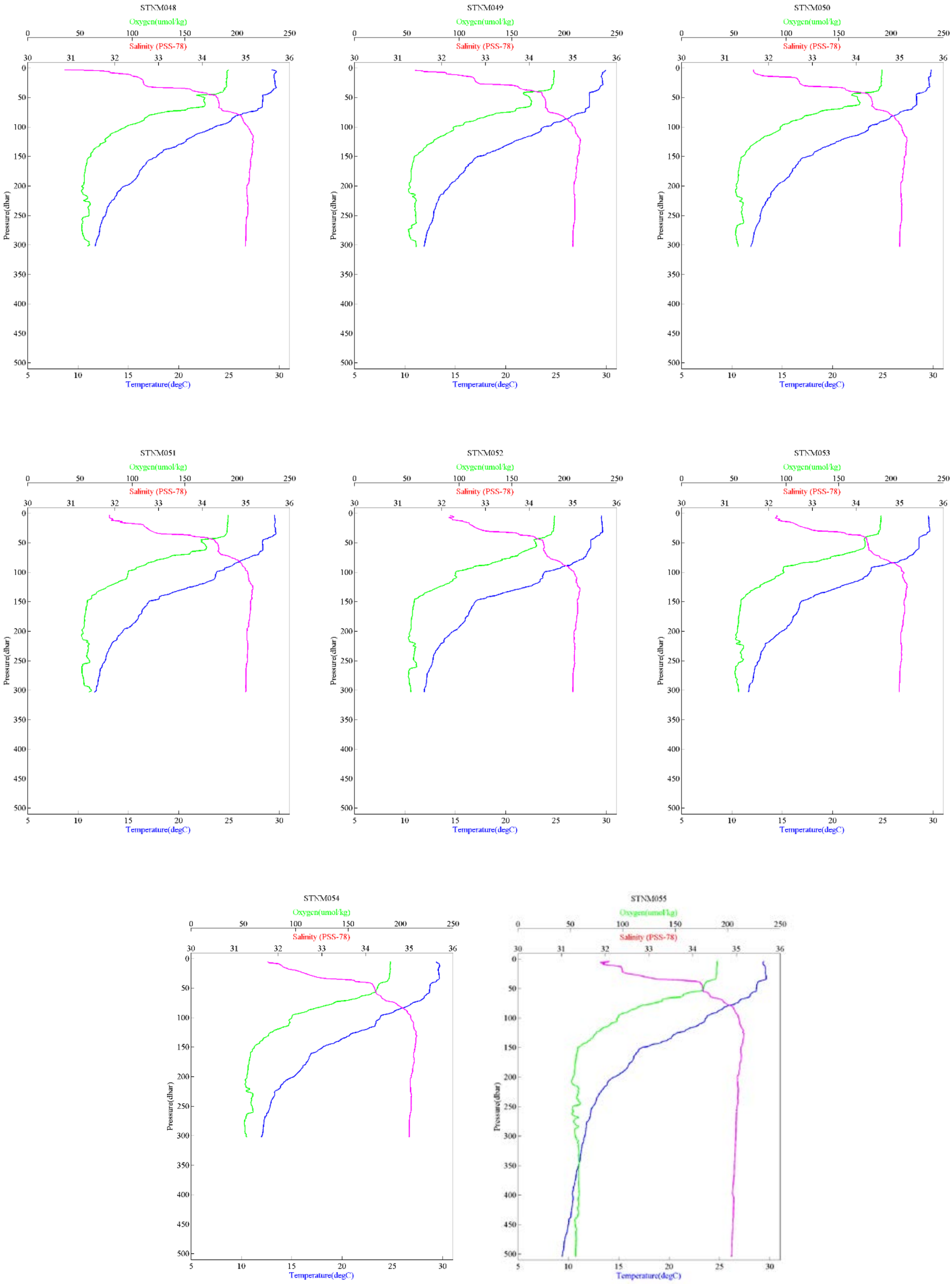
CTD profile (Fixed Point 26 Nov. 2015)



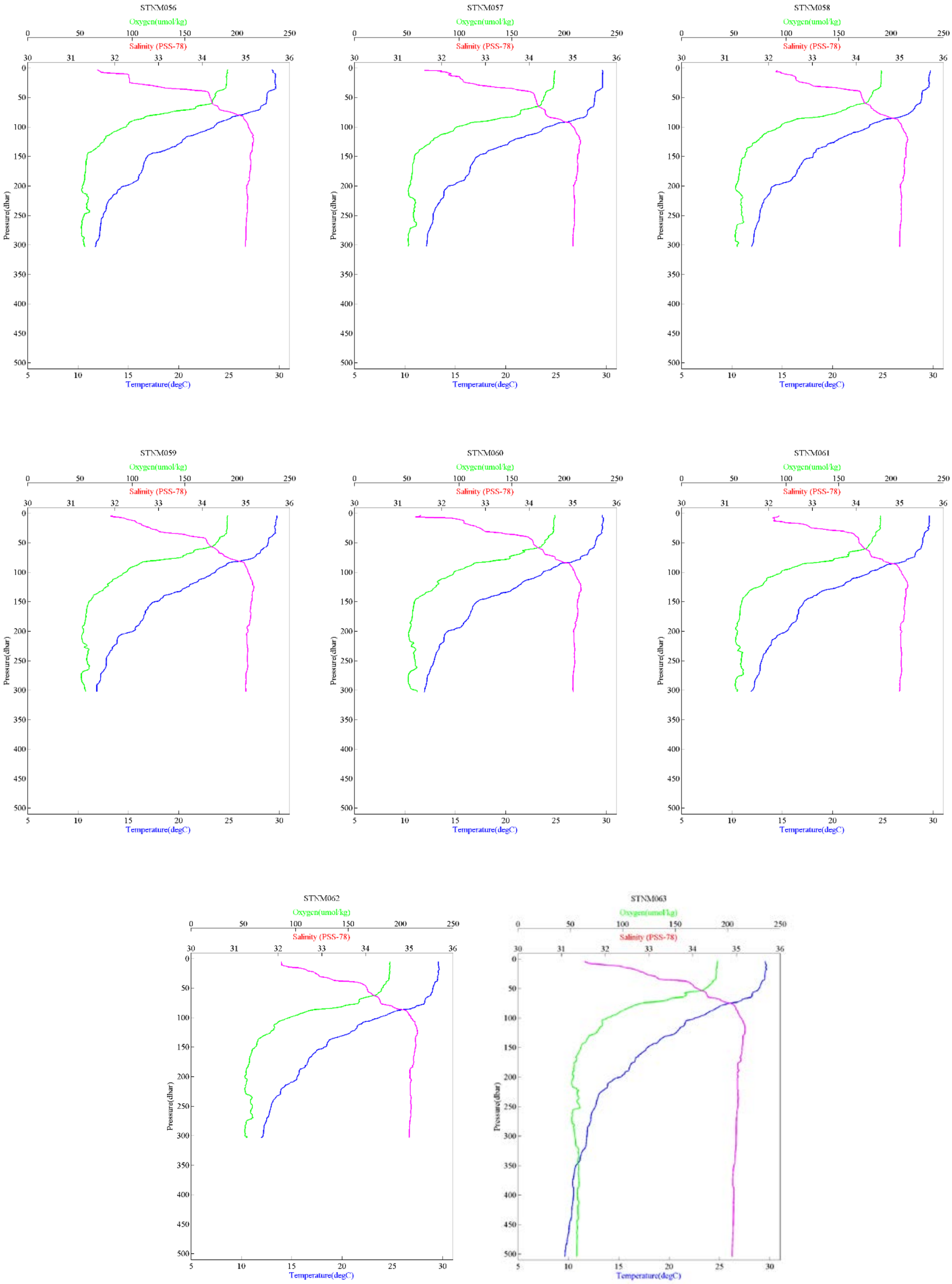
CTD profile (Fixed Point 27 Nov. 2015)



CTD profile (Fixed Point 28 Nov. 2015)



CTD profile (Fixed Point 29 Nov. 2015)



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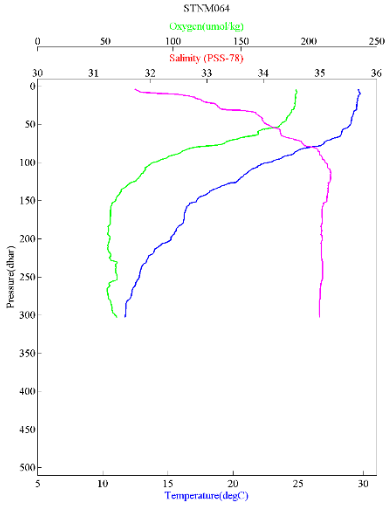
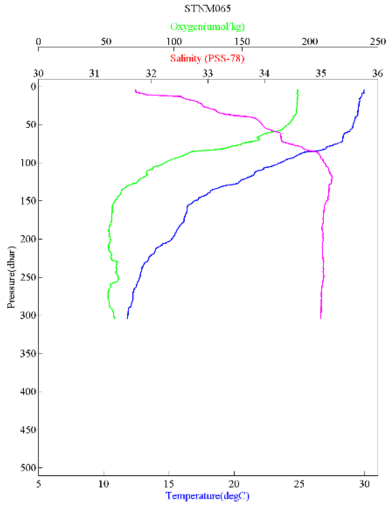
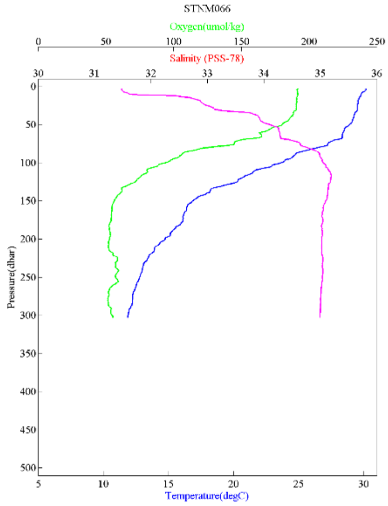
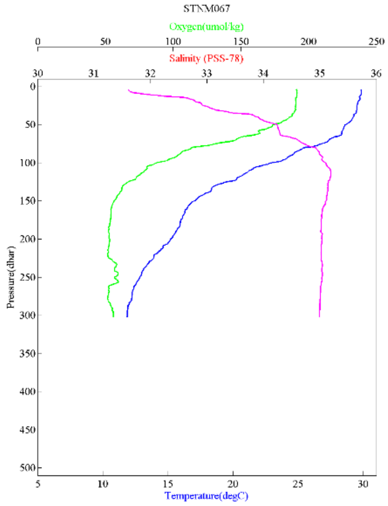
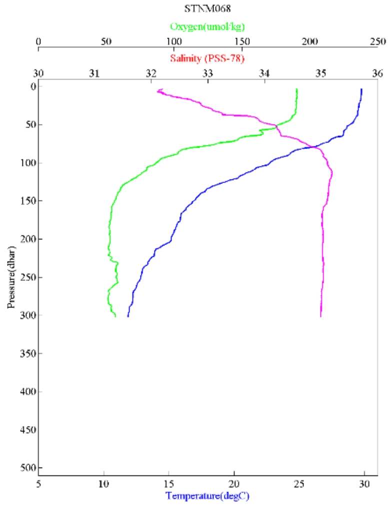
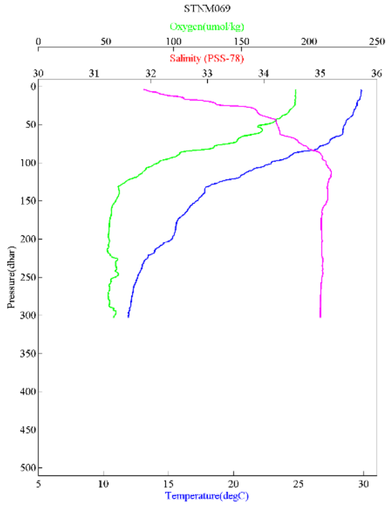


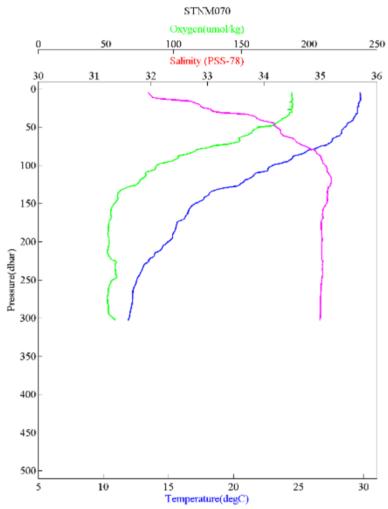


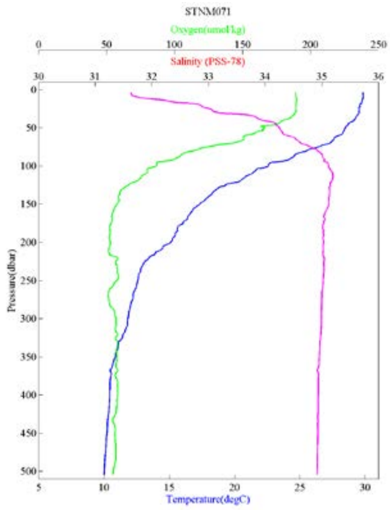




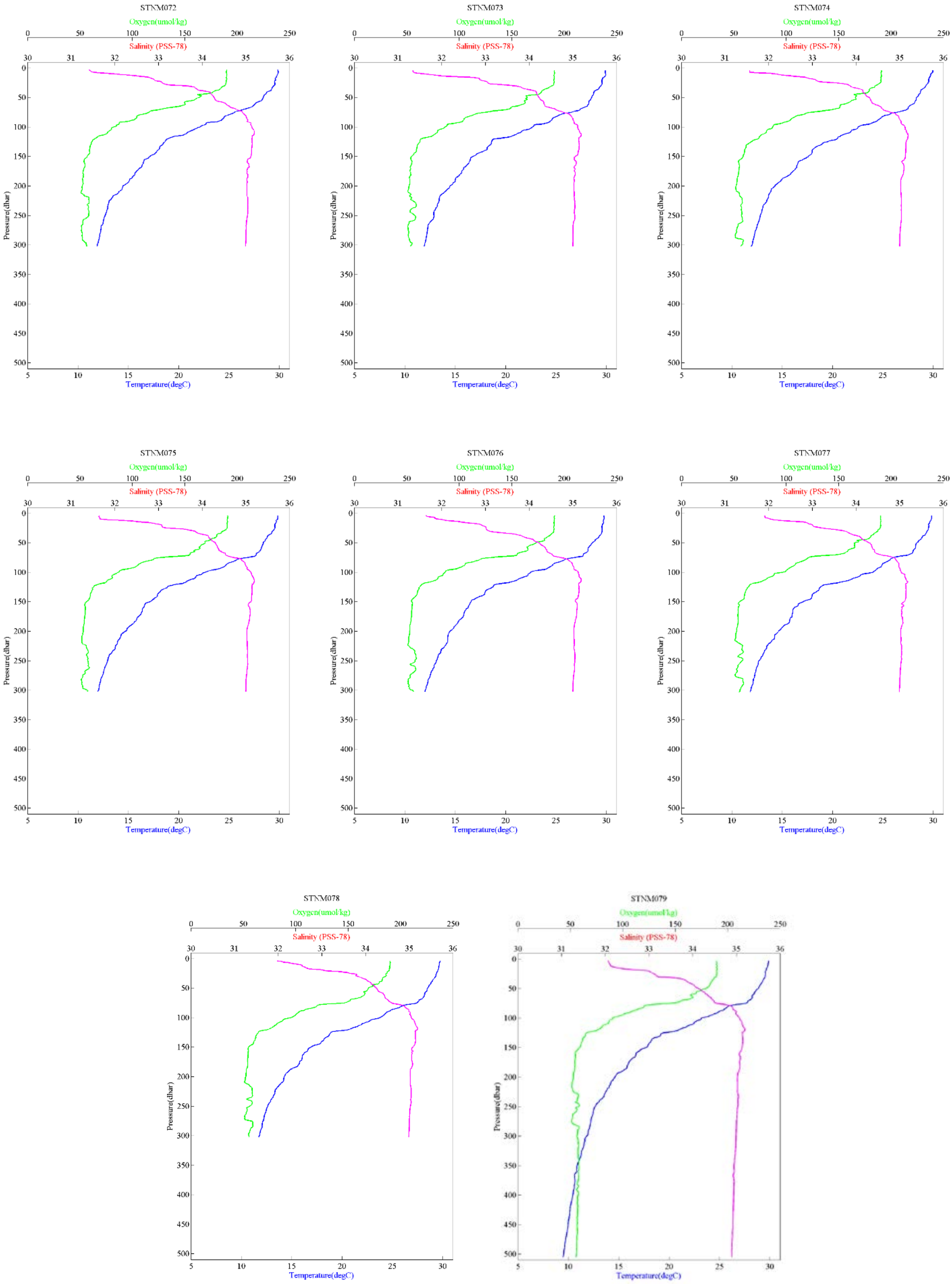




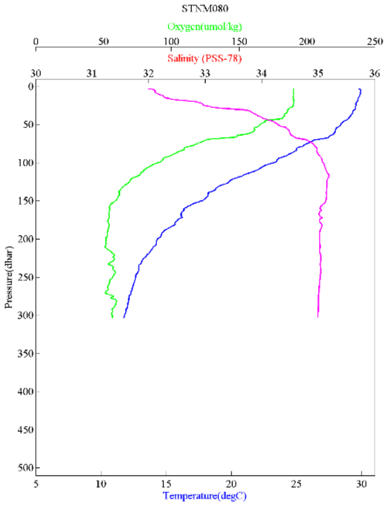


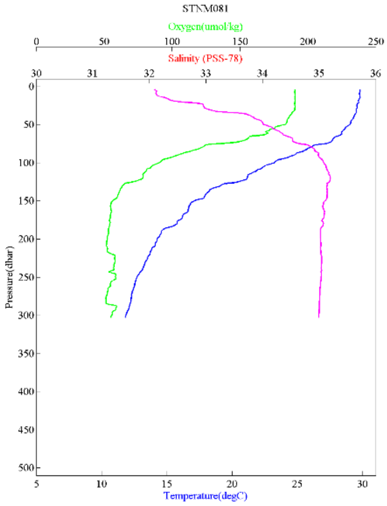


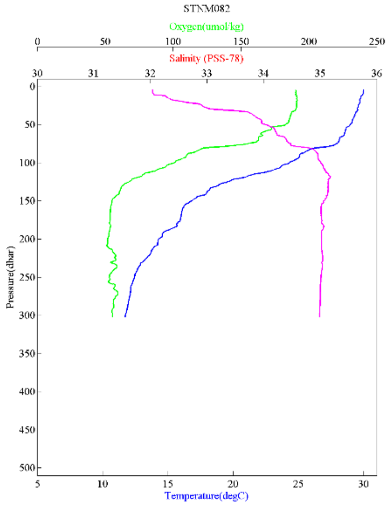
CTD profile (Fixed Point 1 Dec. 2015)

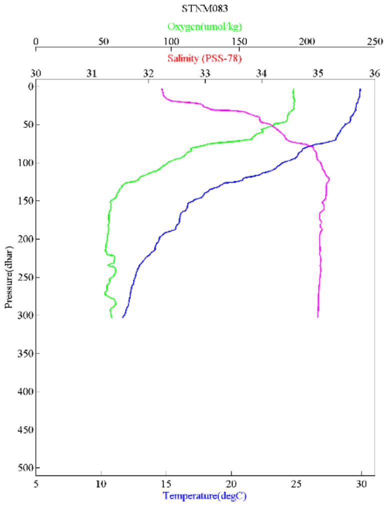


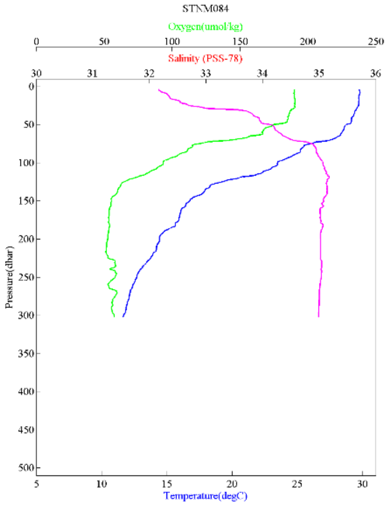
CTD profile (Fixed Point 2 Dec. 2015)

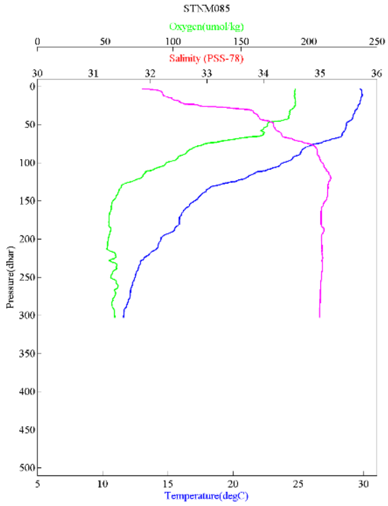


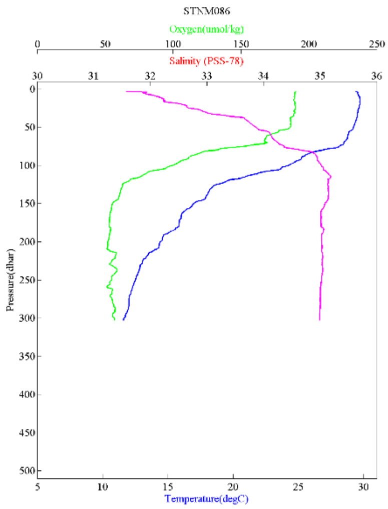


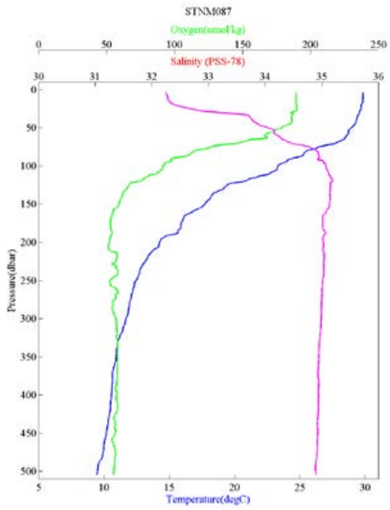




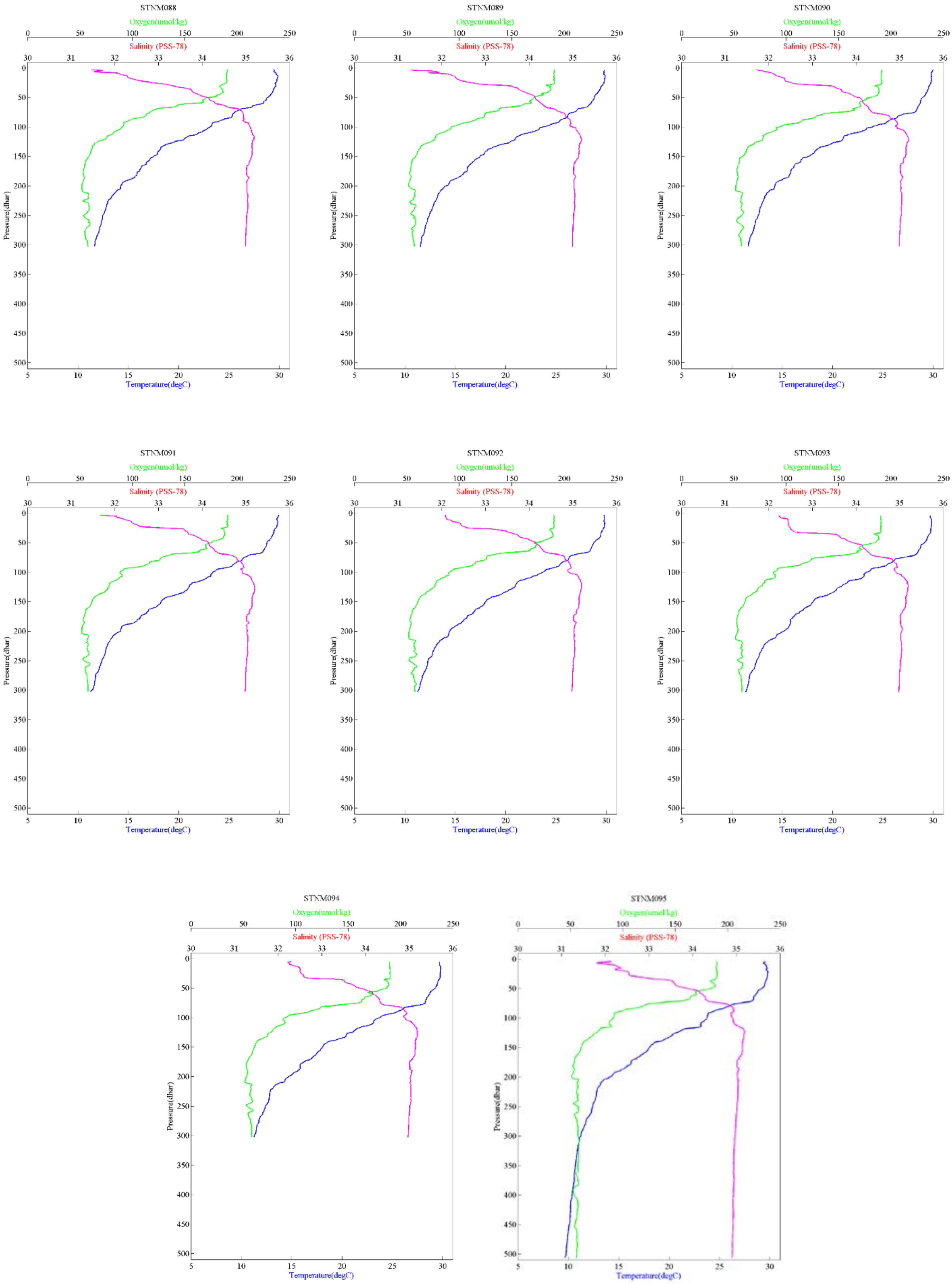




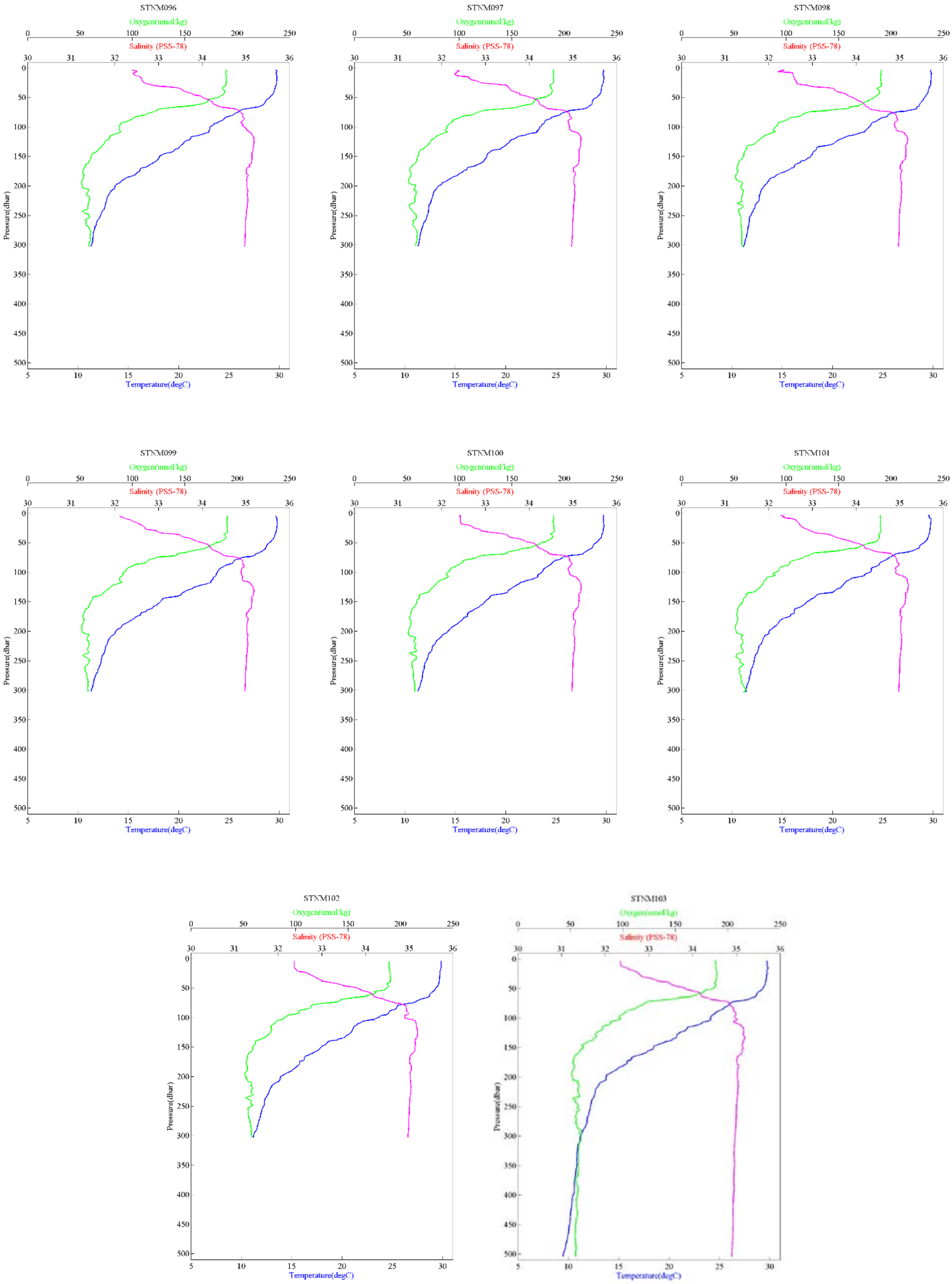




CTD profile (Fixed Point 3 Dec. 2015)



CTD profile (Fixed Point 4 Dec. 2015)



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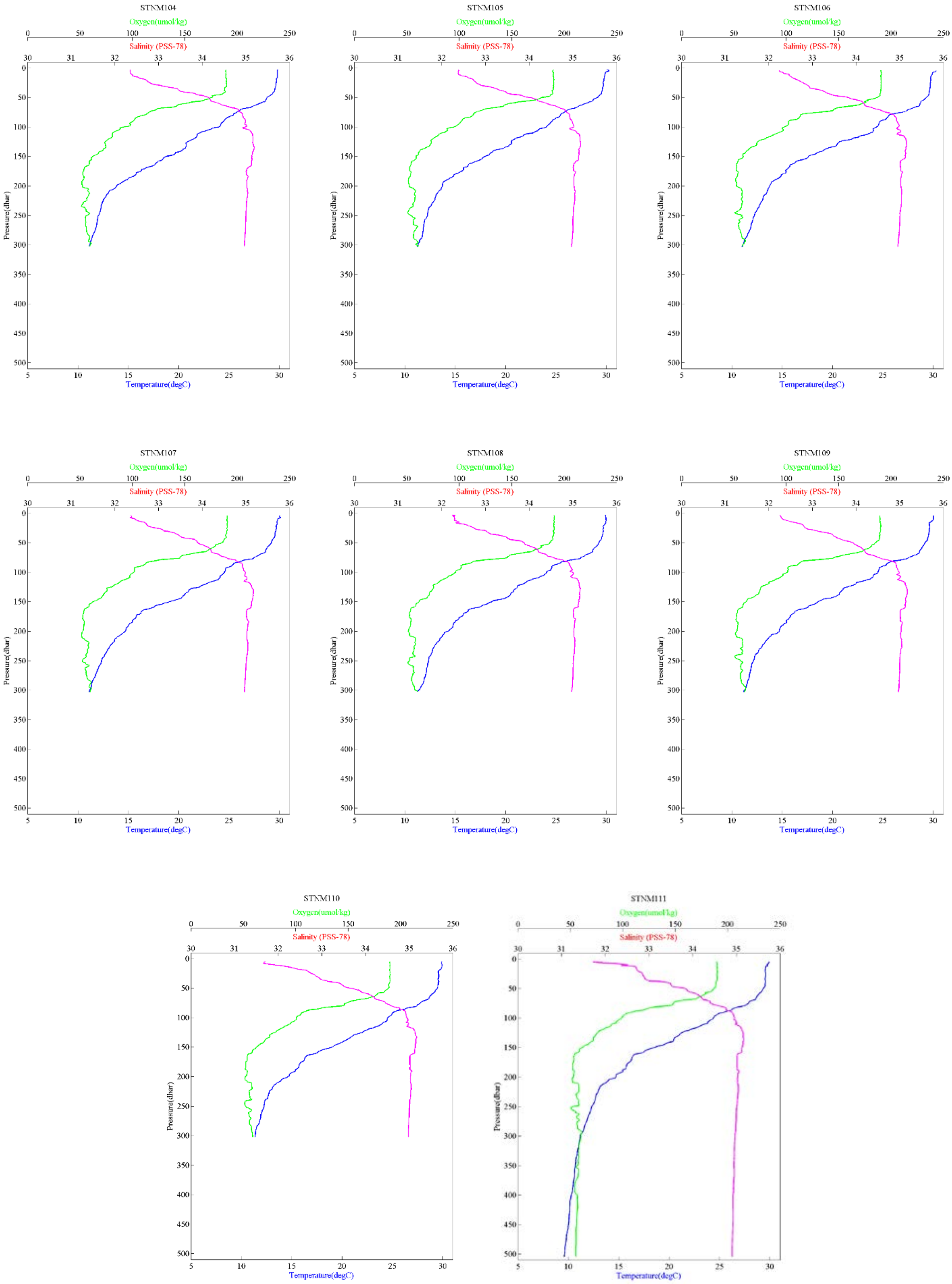

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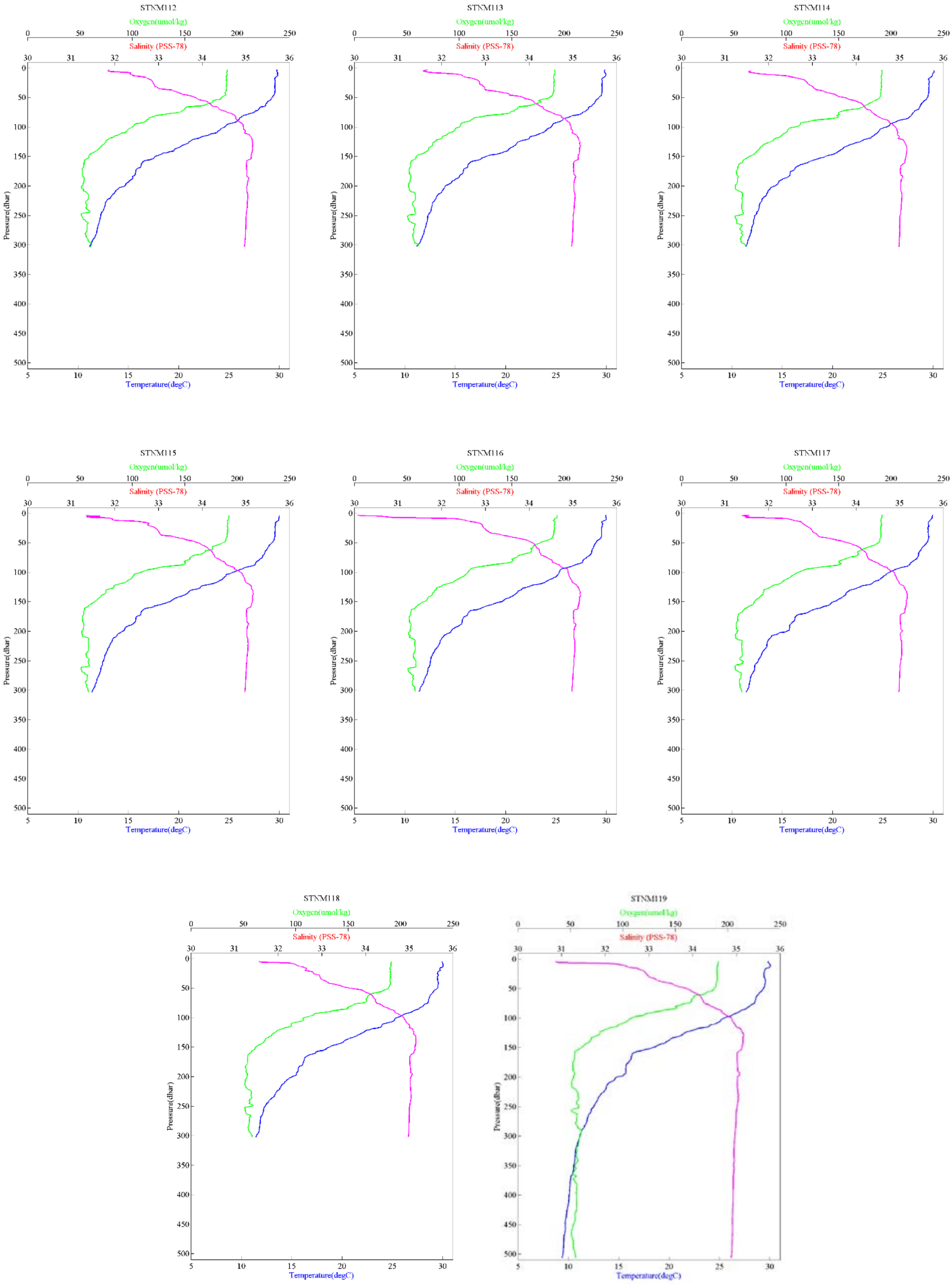

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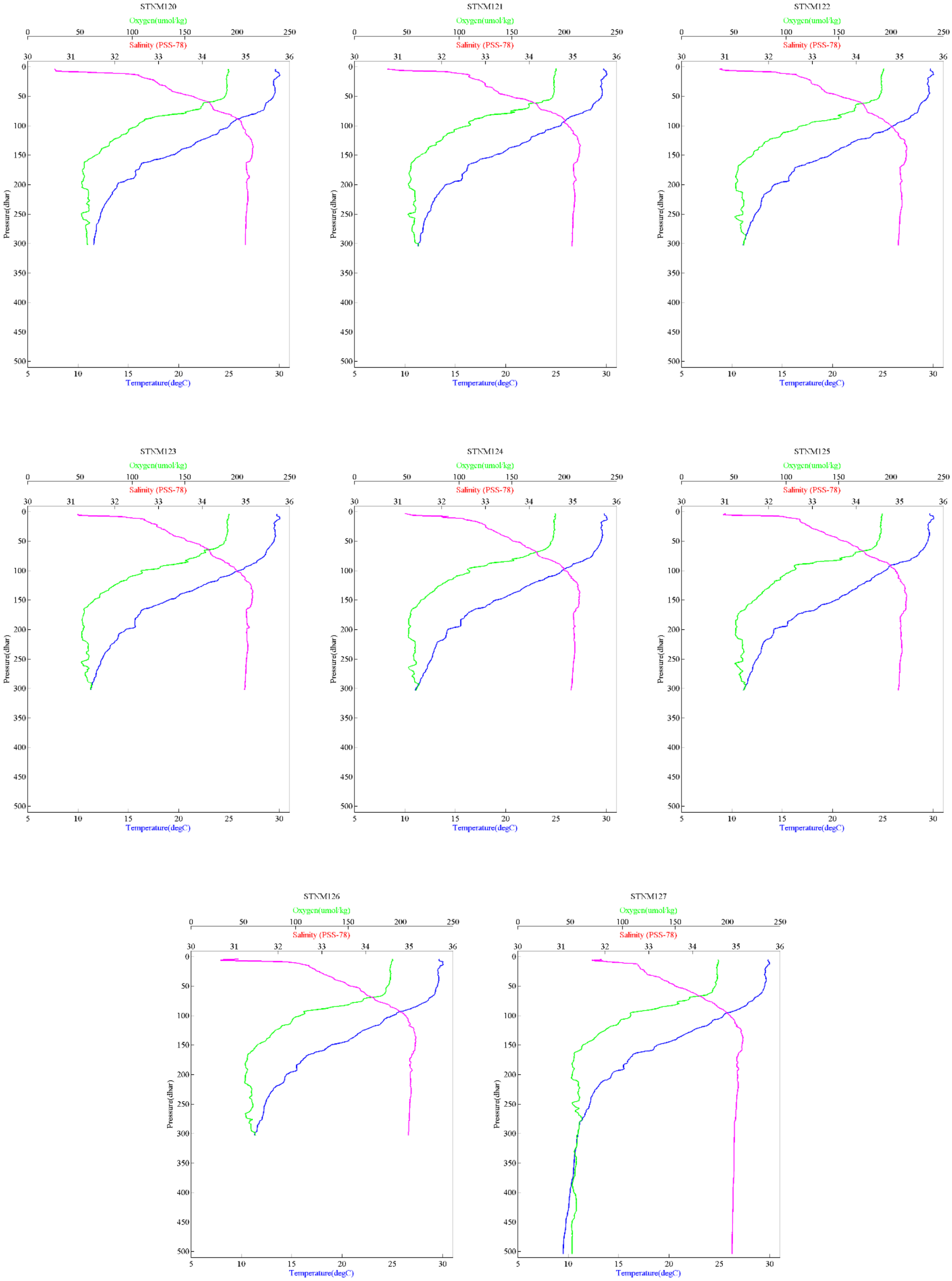

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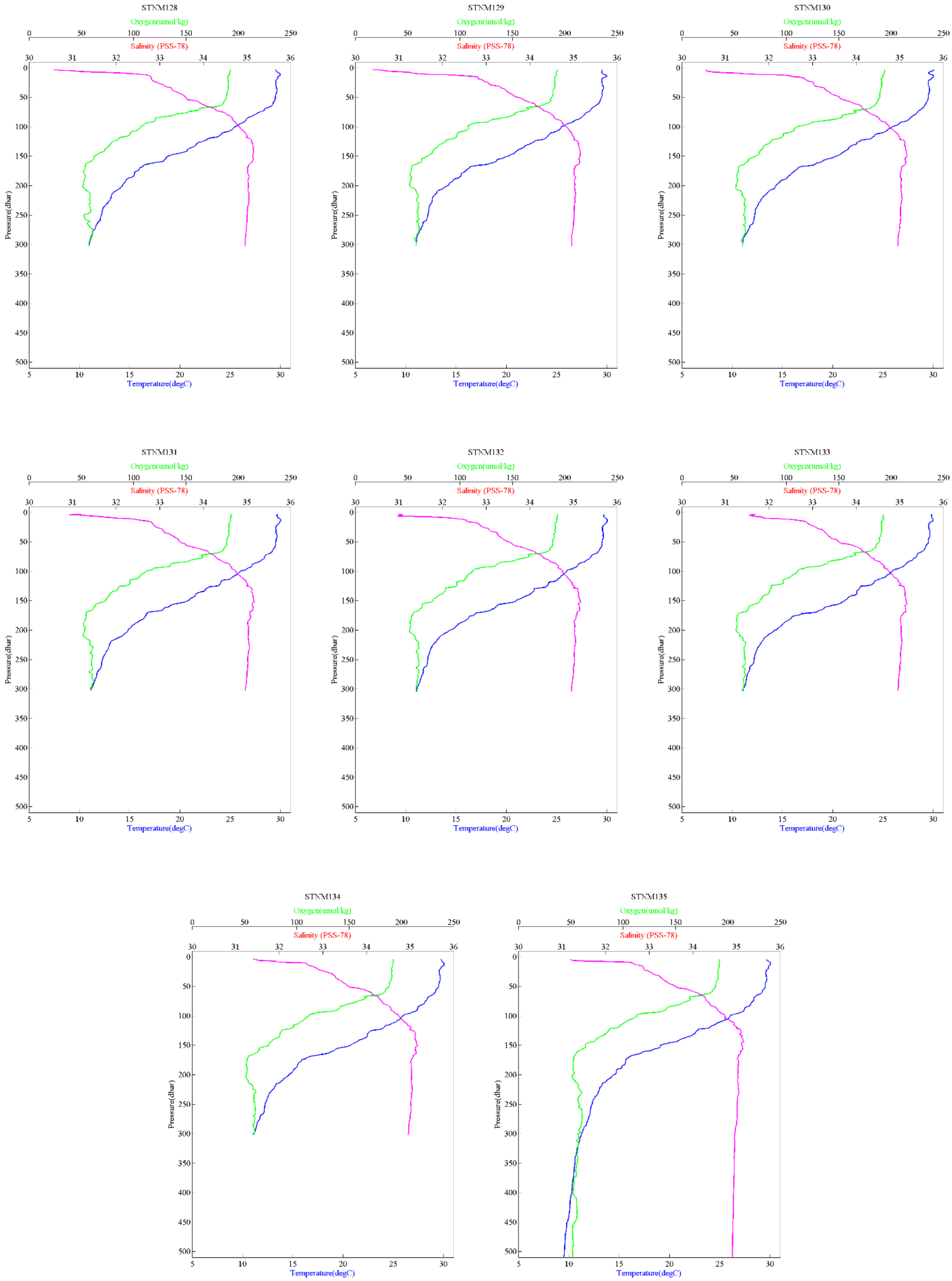

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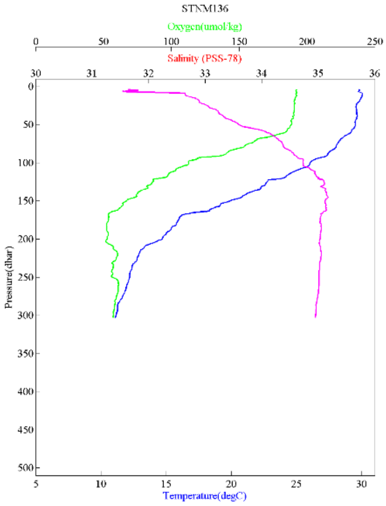
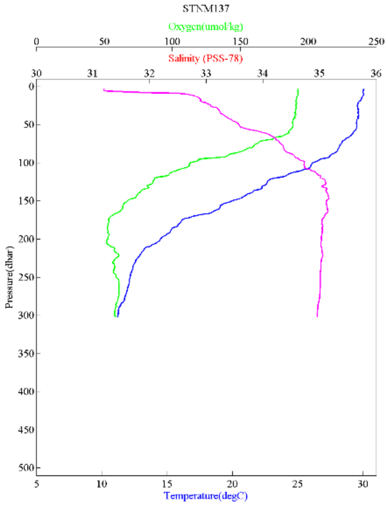
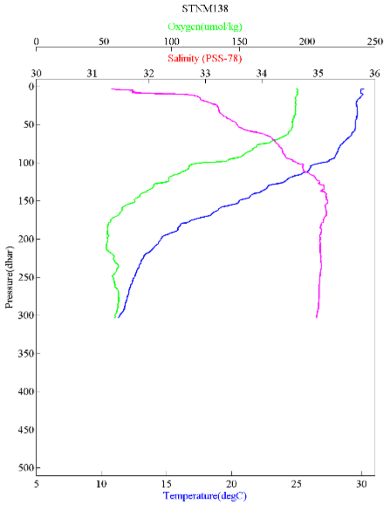
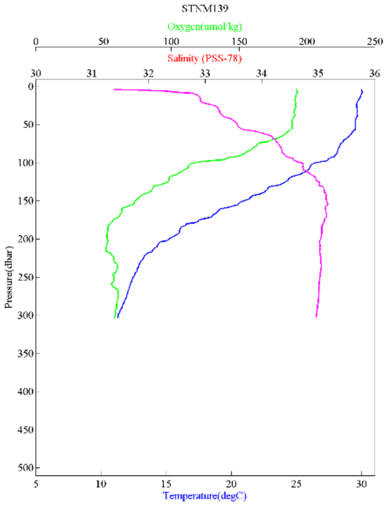
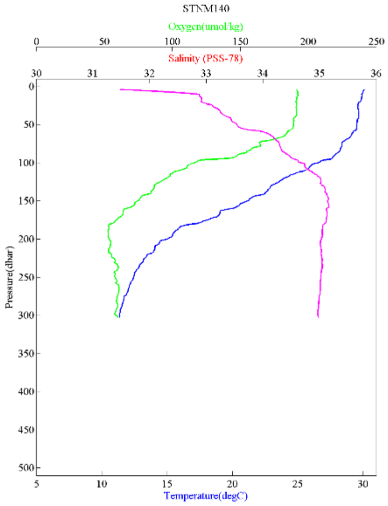
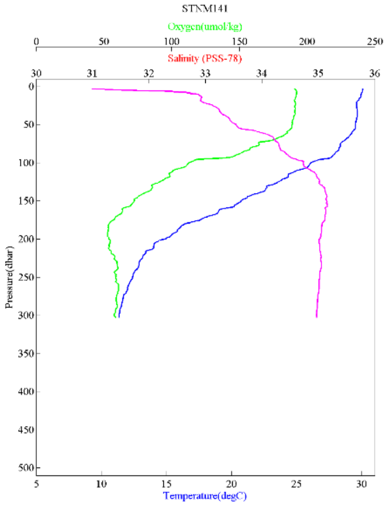


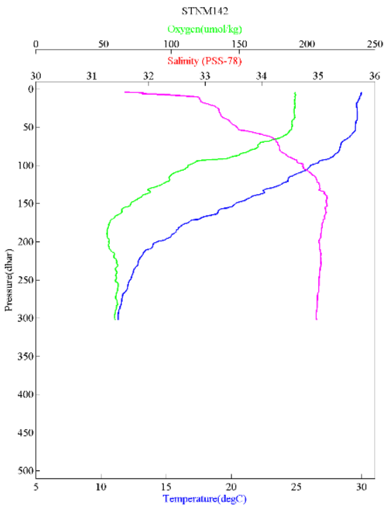


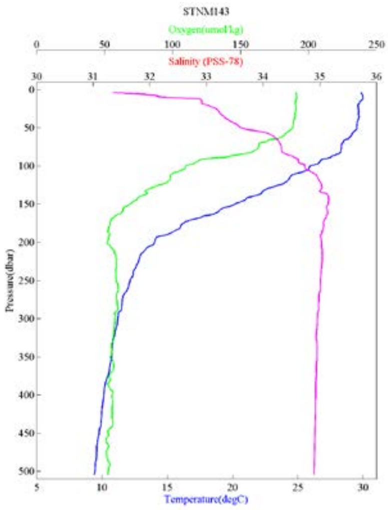




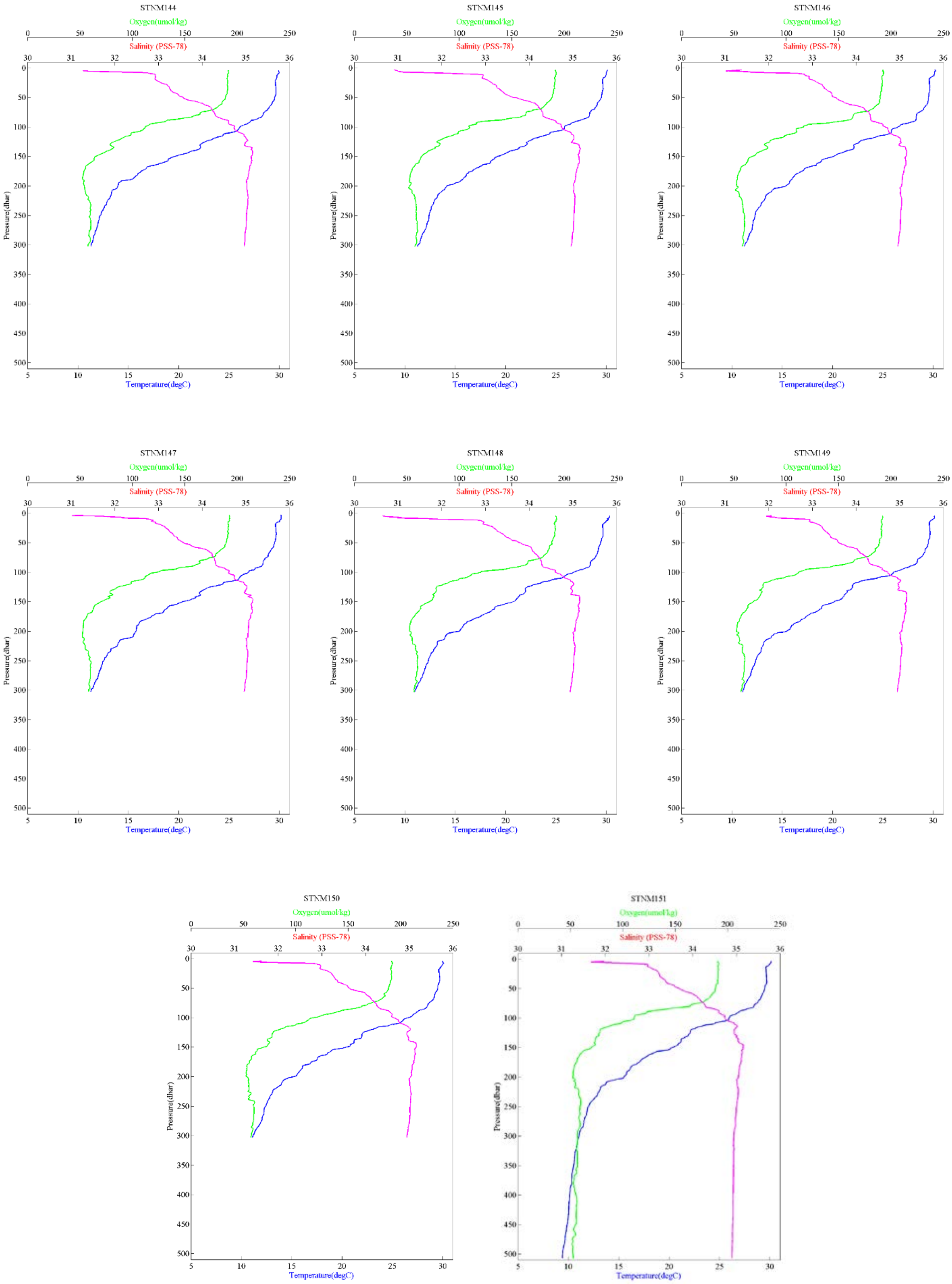








CTD profile (Fixed Point 10 Dec. 2015)



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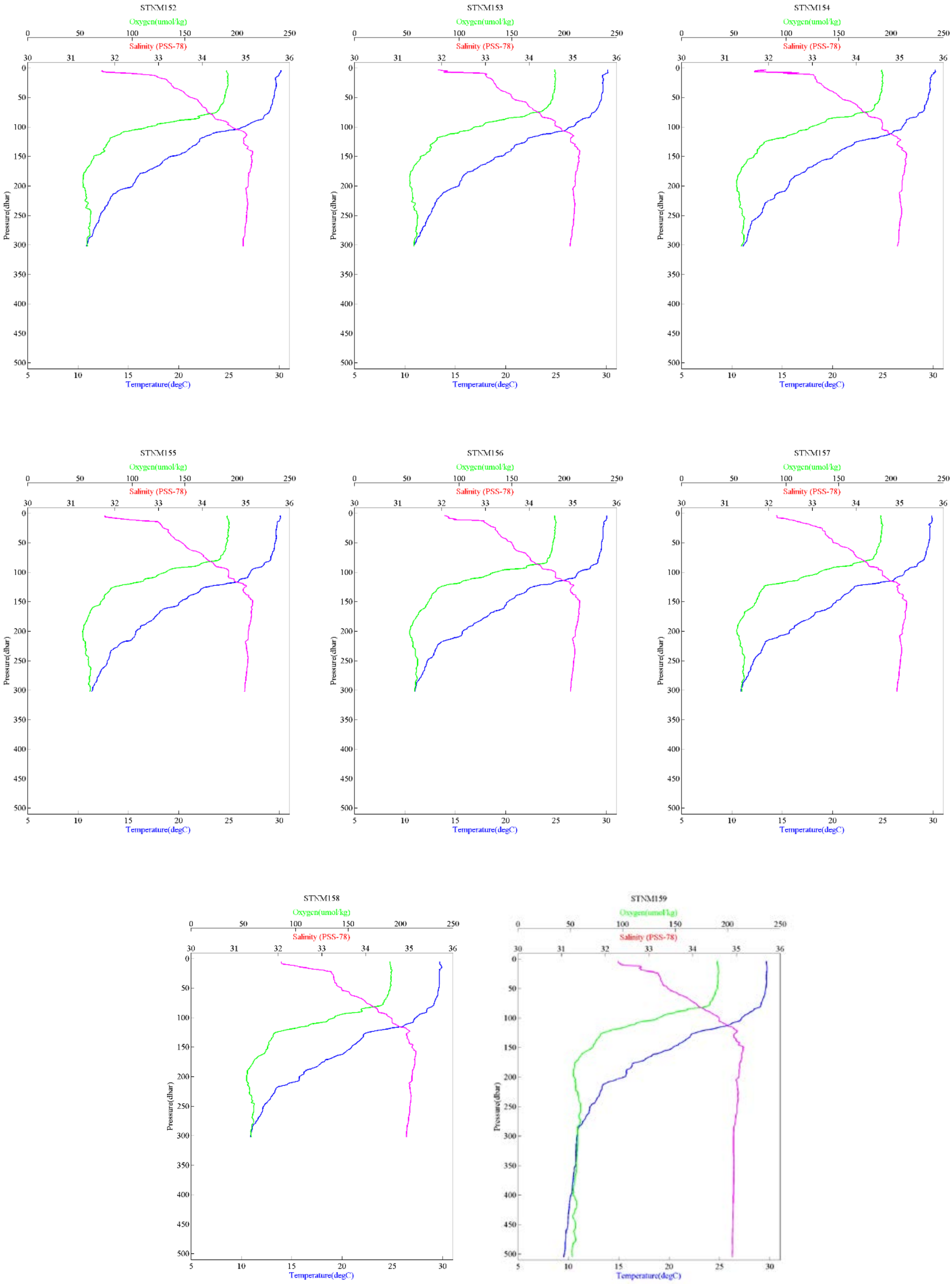
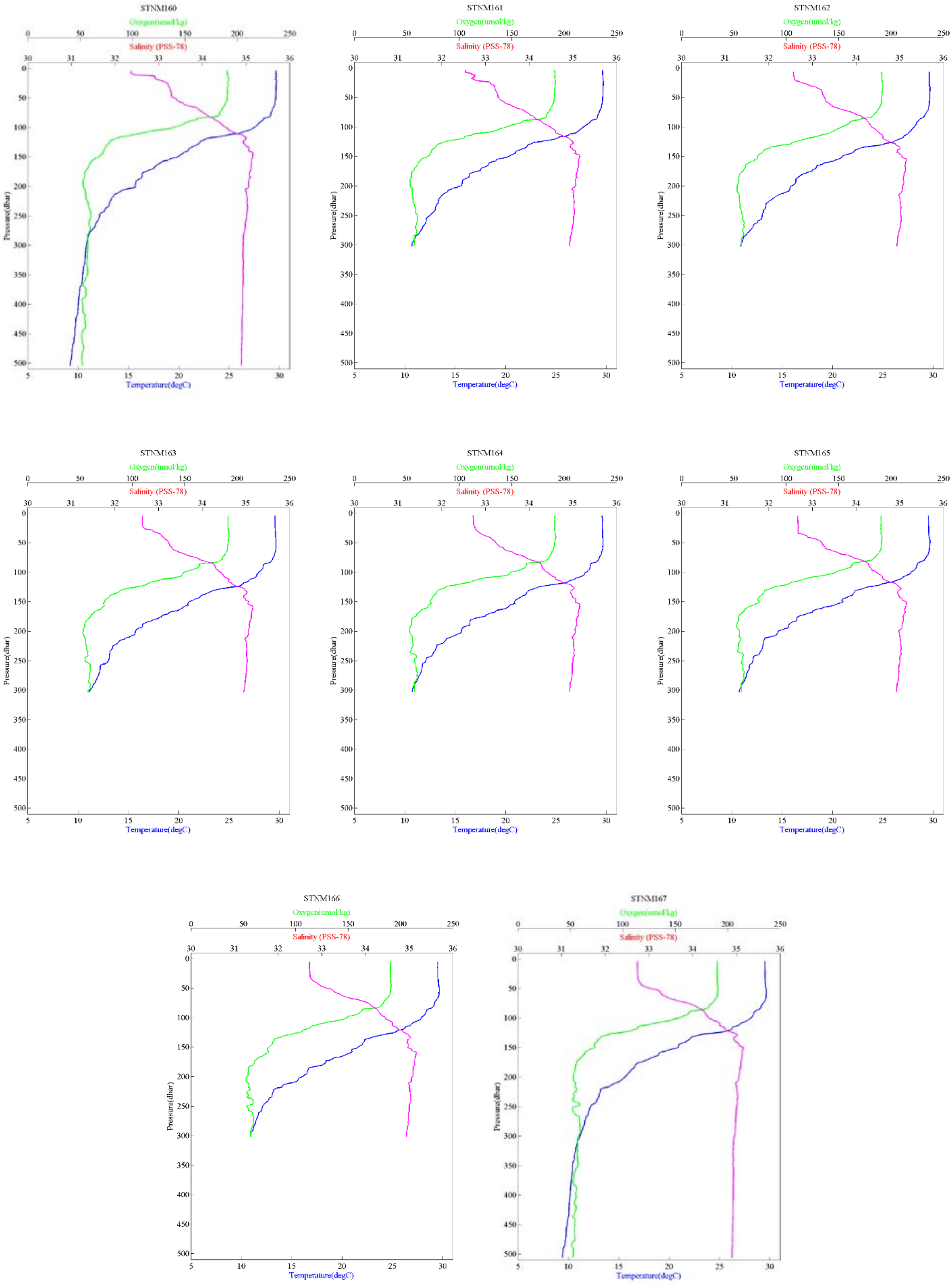
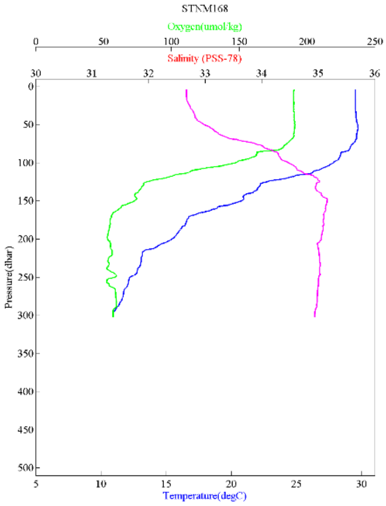
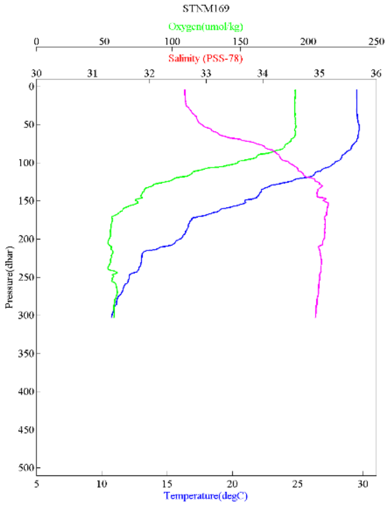


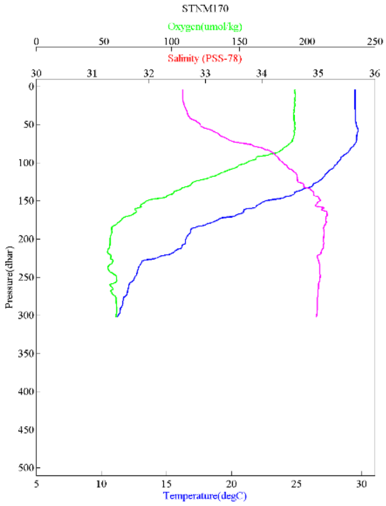
CTD profile (Fixed Point 12 Dec. 2015)

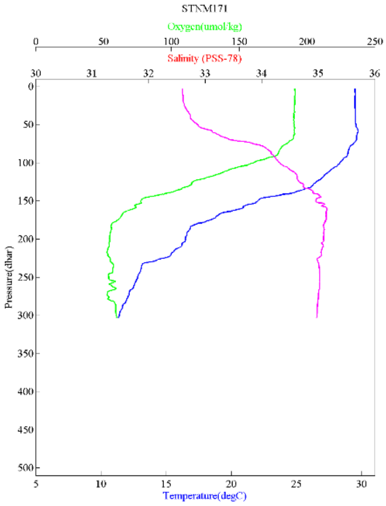


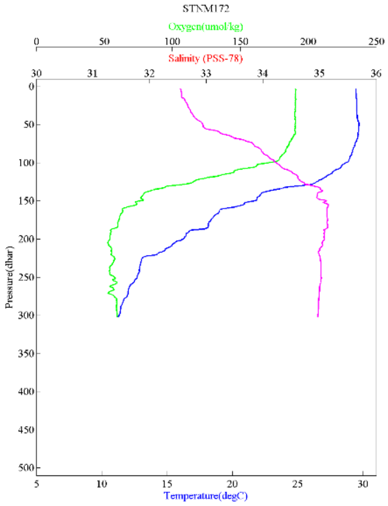
CTD profile (Fixed Point 13 Dec. 2015)

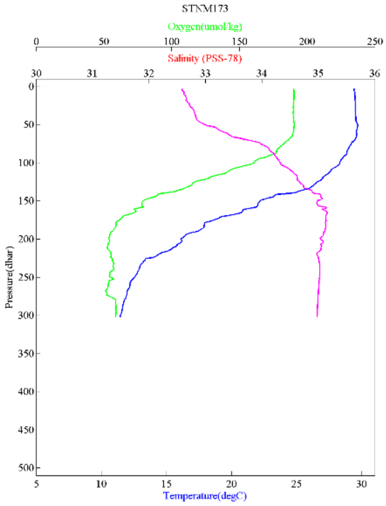


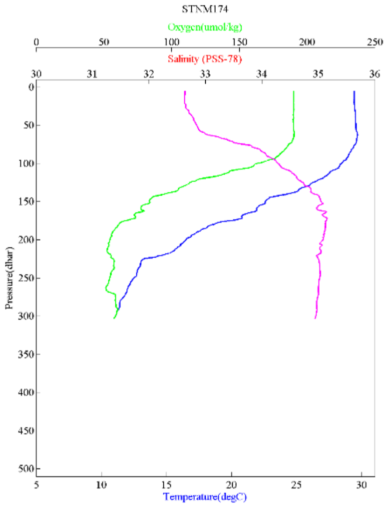


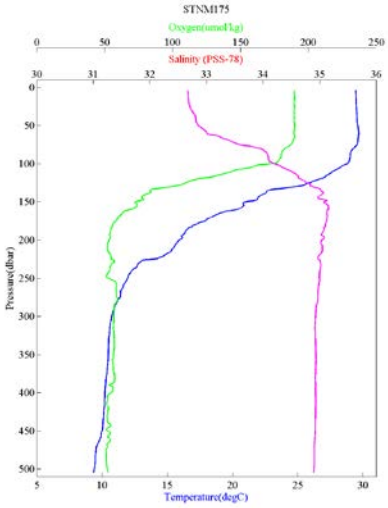












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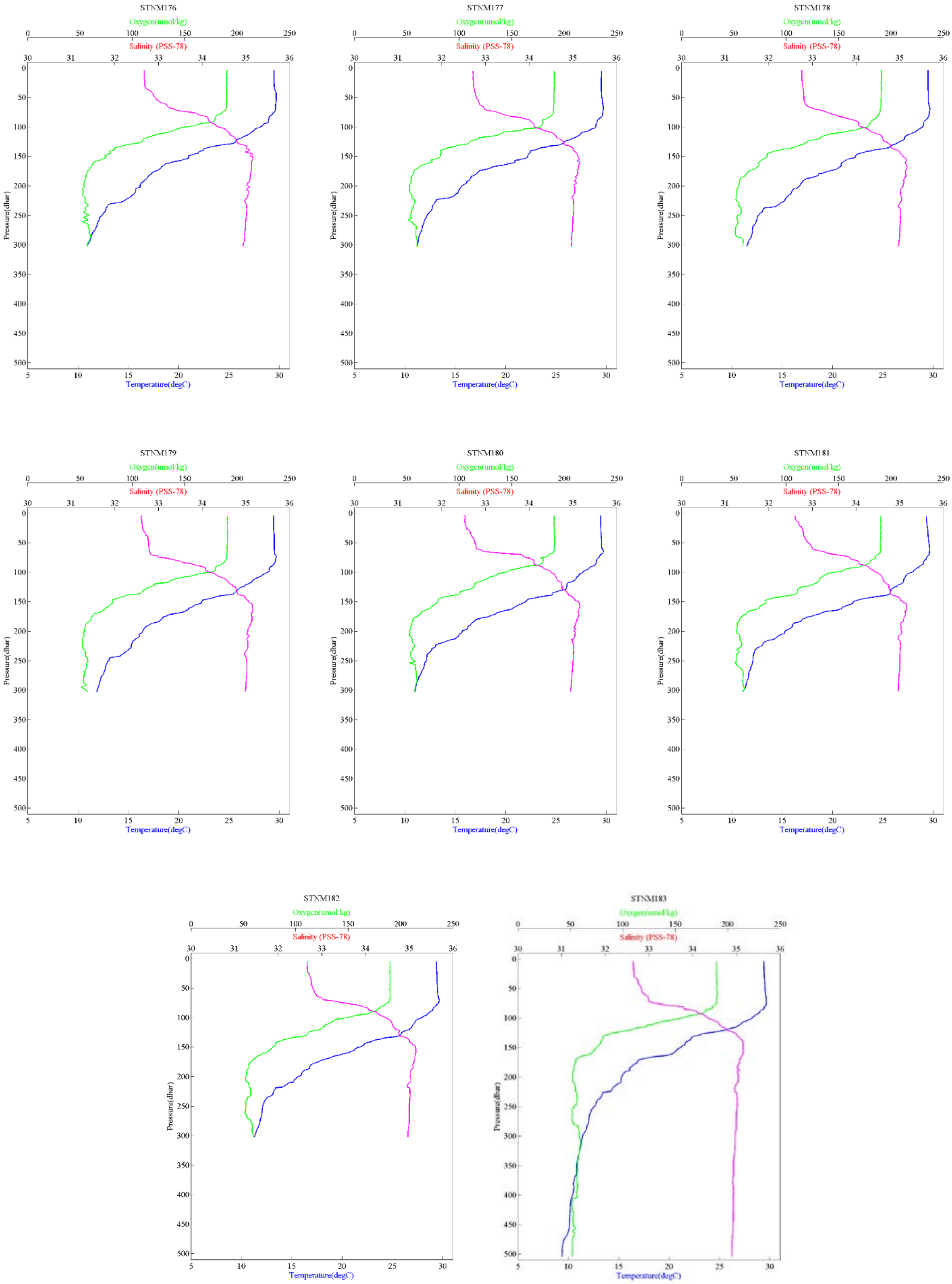

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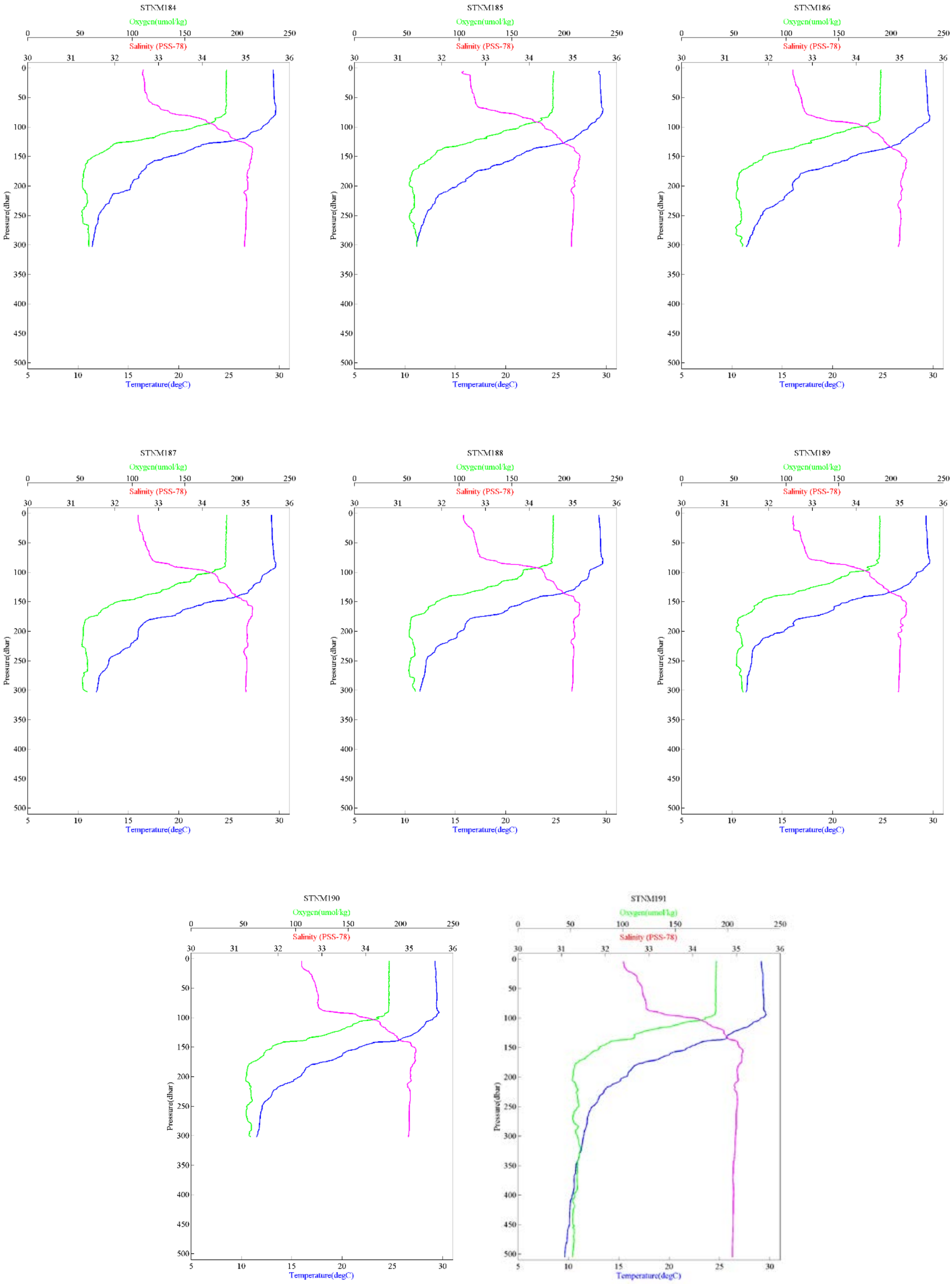

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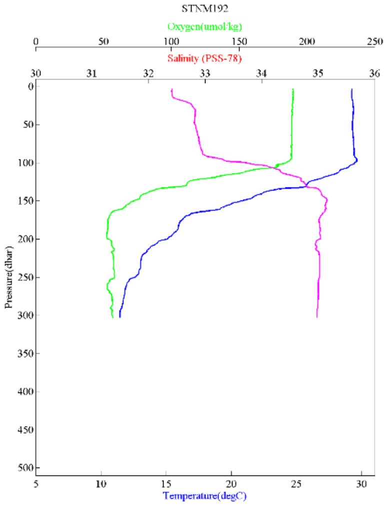

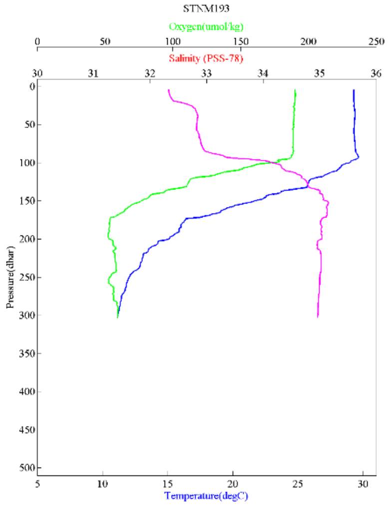

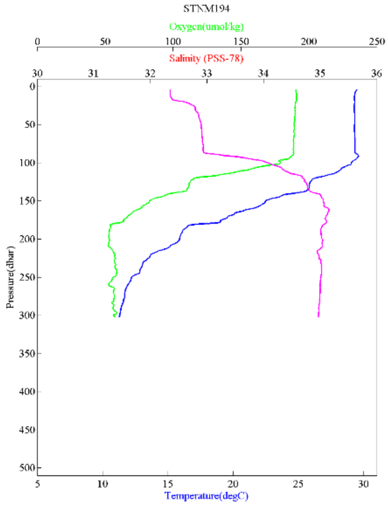

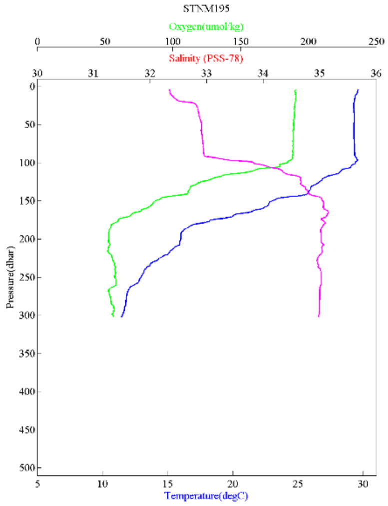

CTD profile (Fixed Point 17 Dec. 2015)