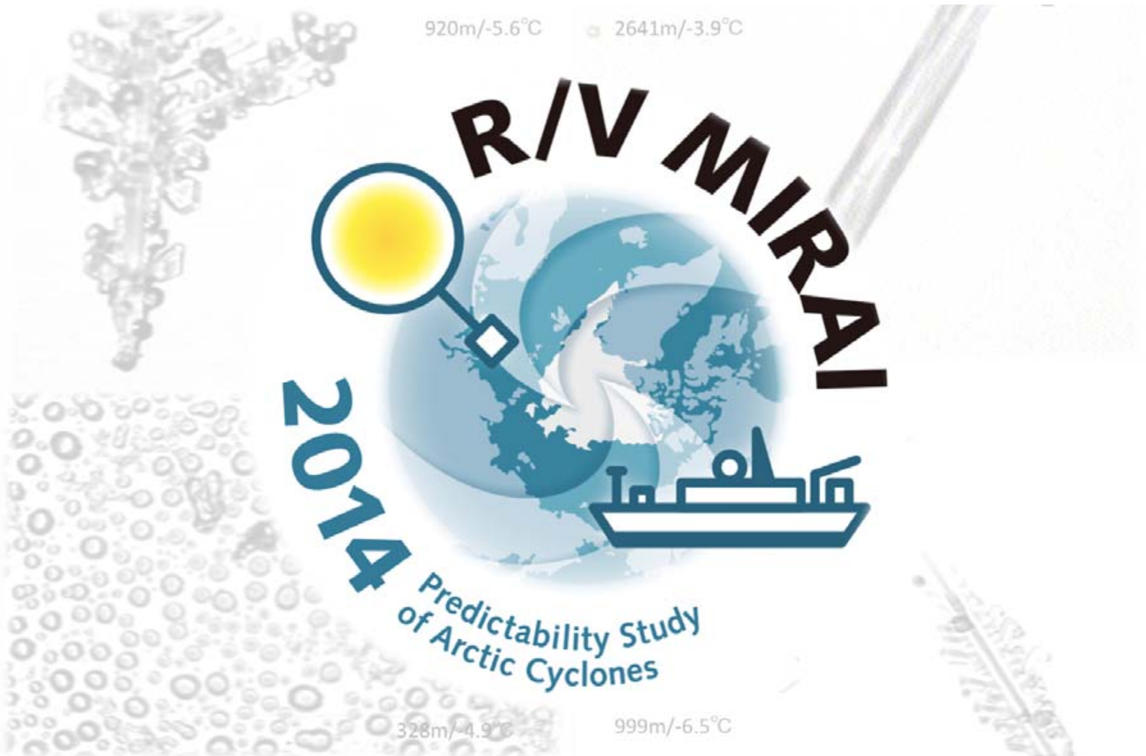
R/V Mirai Cruise Report

MR14-05



The Predictability study of the Arctic cyclones

Arctic Ocean, Bering Sea, and North Pacific
August 31- October 10, 2014

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

Contents

1. Cruise Summary

1.1. Brief Summary of MR14-05

Arctic cyclones are very influential phenomenon for weather forecasts, sea-ice decrease, and vertical and horizontal oceanic/biochemistry structure. To understand the role of Arctic cyclones and severe winds for the Arctic climate system, this cruise focused on:

I. Obtaining the upper sounding data over ice-free ocean and their application for predictability studies
II. Detection of a part of seasonal cycle of air-sea coupled system under diminished sea-ice condition
III. Understanding of the impact of atmospheric disturbances on the ocean structure and biochemical cycles

Here, we conducted stationary point observation (74.75N 162W) with radiosonde, Doppler radar, general meteorological equipment, Ozonesondes, HYVIS, gas samplings, atmospheric turbulence measurements, CTD (Conductivity, temperature, and depth sensors), XCTD (expendable CTD), seawater samplers, current profilers, turbulence ocean microstructure acquisition profile, sea surface monitoring system, drifting buoys, multiple core samplings, and so on. Continuous observations were also made along the cruise track (sea bottom topography, gravity, and magnetic fields in addition to the meteorological and oceanographic observations by using general meteorological equipment and sea surface monitoring system).

This cruise included the following publicly-offered studies:

- Studies on board
  - (a) Nitrogen cycle in the Pacific Arctic (Tokyo University of Marine Science and Technology)
  - (b) Advanced continuous measurements of aerosols in the marine atmosphere: Elucidation of the roles in the Earth system (JAMSTEC)
  - (c) Applied research of MIRAI brand-new shipboard weather radar: Validation and utilization of dual-polarization information for global deployment (JAMSTEC)
  - (d) Studies on greenhouse gas cycles in the Arctic and their responses to climate change (Meteorological Research institute)
  - (e) Estimation of hazardous chemicals discharge form the melting ice in the Arctic Ocean (National Institute of Advanced Industrial Science and Technology)
- Studies not on board

(a) Tectonic history of the Pacific Plate during mid-Cretaceous (Chiba University)
(b) Global distribution of drop size distribution of precipitating particles over pure-oceanic background (JAMSTEC)
(c) Daily simulation using a cloud-resolving model over the Arctic Ocean (Nagoya University)
(d) Aerosol optical characteristics measured by ship-borne sky radiometer (Toyama University)
(e) Standardization of marine geophysical data and its application to geodynamics studies (Ryuku University)

1.2. Basic information

Name of vessel	R/V Mirai	
	L x B x D 128.58m x 19.0m x 13.2m	
	Gross Tonnage: 8,706 tons	
	Call Sign JNSR	
Cruise code	MR14-05	
Undertaking institute	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	
Chief scientist	Jun Inoue	
	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	
Cruise periods	31 August 2014 – 10 October 2014	
Ports call	31 August 2014, Dutch Harbor (leave port)	
	10 October 2014, Yokohama (arrival in port)	
Research areas	Arctic Ocean, Bering Sea, and North Pacific Ocean	
Research activities	Radiosonde	239 launches
	Ozonesonde	10 launches
	HYVIS	10 launches
	TurboMap	2 stns / 177cast
	SVP	7 deployments
	XCTDs	60 stns
	CTD	17stns / 97casts
	Water sampling	17stns / 60casts
	Multiple core sampling	6 stns

(Underway observations)

Doppler Radar

Ceilometer

Dual polarization lidar

Optical Absorption Spectroscope/MAX-DOAS

Sky radiometer

Meteorological observation system

Sea surface water monitoring system

Total carbonate monitoring system

Greenhouse gases monitoring system (CRDS)

Satellite data observations system

Air samplings

Sea surface water samplings

ADCP

Seabeam/Sub bottom profiler

Magnetometer

Gravity meter

1.3. Cruise track

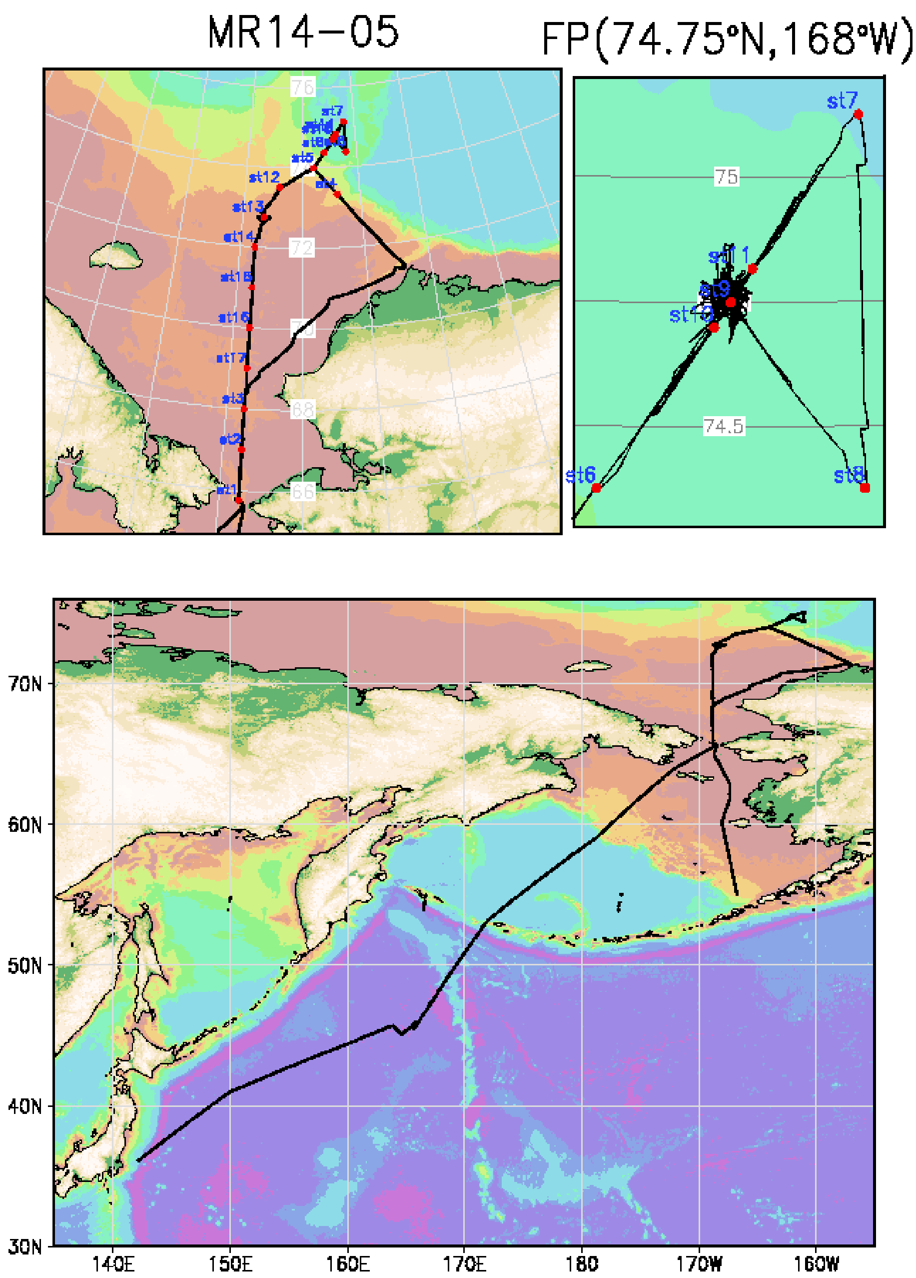


Figure 1.3-1: Research area and cruise track of MR14-05.

1.4. List of participants

Table 1.4.1: List of participants of MR14-05.

No.	Name	Organization	Position
1	Jun Inoue	JAMSTEC / National Institute of Polar Research	Research Scientist / Associate Professor
2	Shigeto Nishino	JAMSTEC	Research Scientist
3	Yusuke Kawaguchi	JAMSTEC	Research Scientist
4	Kazuhiro Oshima	JAMSTEC	Research Scientist
5	Kazutoshi Sato	JAMSTEC / The Graduate University for Advanced Study	Graduate Student
6	Taku Mitsui	JAMSTEC / The Graduate University for Advanced Study	Graduate Student
7	Hiroki Takeda	JAMSTEC / Tokyo Gakugei University	Undergraduate Student
8	Hiroaki Asai	JAMSTEC / Tokyo Gakugei University	Undergraduate Student
9	Byron W. Blomquist	University of Colorado	Research Scientist
10	Xiangdong Zhang	University of Alaska Fairbanks	Professor
11	Fumikazu Taketani	JAMSTEC	Research Scientist
12	Masaki Katsumata	JAMSTEC	Research Scientist
13	Shuichi Mori	JAMSTEC	Research Scientist
14	Naohiro Kosugi	Japan Meteorological Agency	Research Scientist
15	Taniyasu Sachi	National Institute of Advanced Industrial Science and Technology	Research Scientist
16	Michiyo Kawai	Tokyo University of Marine Science and Technology	Associate Professor
17	Shinji Takada	Tokyo University of Marine Science and Technology	Graduate Student
18	Katsuhisa Maeno	Global Ocean Development Inc.	Technical Stuff
19	Soichiro Sueyoshi	Global Ocean Development Inc.	Technical Stuff
20	Shinya Okumura	Global Ocean Development Inc.	Technical Stuff
21	Koichi Inagaki	Global Ocean Development Inc.	Technical Stuff
22	Miki Morioka	Global Ocean Development Inc.	Technical Stuff
23	Shinichiro Yokogawa	Marine Works Japan Ltd.	Technical Stuff
24	Kenichi Katayama	Marine Works Japan Ltd.	Technical Stuff
25	Tomohide Noguchi	Marine Works Japan Ltd.	Technical Stuff
26	Keisuke Matsumoto	Marine Works Japan Ltd.	Technical Stuff
27	Hiroki Ushiromura	Marine Works Japan Ltd.	Technical Stuff
28	Shungo Oshitani	Marine Works Japan Ltd.	Technical Stuff
29	Kenichiro Sato	Marine Works Japan Ltd.	Technical Stuff
30	Masanori Enoki	Marine Works Japan Ltd.	Technical Stuff
31	Yoshiko Ishikawa	Marine Works Japan Ltd.	Technical Stuff

32	Makoto Takada	Marine Works Japan Ltd.	Technical Stuff
33	Elena Hayashi	Marine Works Japan Ltd.	Technical Stuff
34	Emi Deguchi	Marine Works Japan Ltd.	Technical Stuff
35	Atsushi Ono	Marine Works Japan Ltd.	Technical Stuff
36	Tomomi Sone	Marine Works Japan Ltd.	Technical Stuff
37	Hideki Yamamoto	Marine Works Japan Ltd.	Technical Stuff
38	Katsunori Sagishima	Marine Works Japan Ltd.	Technical Stuff
39	Misato Kuwahara	Marine Works Japan Ltd.	Technical Stuff
40	Kanako Yoshida	Marine Works Japan Ltd.	Technical Stuff
41	Keitaro Matsumoto	Marine Works Japan Ltd.	Technical Stuff
42	Haruka Tamada	Marine Works Japan Ltd.	Technical Stuff
43	Yasumi Yamada	Marine Works Japan Ltd.	Technical Stuff
44	Mika Yamaguchi	Marine Works Japan Ltd.	Technical Stuff
45	Shuichi Yohen	Marine Works Japan Ltd.	Technical Stuff
46	David Duke Snider	Martech Polar	Ice Pilot

2. Meteorology

2.1. GPS Radiosonde

(1) Personnel

Jun Inoue	JAMSTEC / NIPR	- PI
Xiangdong Zhang	IARC	
Kazuhiro Oshima	JAMSTEC	
Kazutoshi Sato	JAMSTEC / SOKENDAI	
Taku Mitsui	JAMSTEC / SOKENDAI	
Hiroaki Asai	JAMSTEC / Tokyo Gakugei Univ.	
Hiroki Takeda	JAMSTEC/ Tokyo Gakugei Univ.	
Katsuhisa Maeno	GODI	
Souichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Koichi Inagaki	GODI	
Miki Morioka	GODI	
Kimura Ryo	MIRAI Crew	

(2) Objectives

To understand the thermodynamic structure of the boundary layer, and migratory cyclones and anticyclones, a 3-hourly radiosonde observation was conducted over the Arctic Ocean during 3-27 September 2014 which includes a stationary observation period during 6-25 September 2014 at the location of 74.75°N, 162.00°W. The dataset includes 6-hourly initial-observations and post-observations conducted near the Bering Strait on 1-3 September 2014 and over the Bering Sea and North Pacific Ocean from 29 September through 8 October 2014. Obtained data will be used mainly for studies of clouds, validation of reanalysis data as well as satellite analysis, and data assimilation. This observation is also a part of a joint international observation period conducted on 6-25 September 2014.

(3) Parameters

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

(4) Instruments and Methods

Radiosonde observations were carried out from 1 September to 8 October 2014, by using GPS radiosonde (RS92-SGPD). We used software (DigiCORA III, ver.3.64), processor (SPS311), GPS antenna (GA20), UHF antenna (RB21) and balloon launcher (ASAP) made by Vaisala Oyj. Prior to launch, humidity, air temperature, and pressure sensors were calibrated by using the calibrator system (GC25 and PTB330, Vaisala). In case the relative wind to the ship is not appropriate for the launch, the handy launch was selected.

(5) Station List

Table 2.1-1 summarizes the log of upper air soundings. All data were sent to the world meteorological community by the global telecommunication system (GTS) through the Japan Meteorological Agency immediately after each observation. Raw data was recorded as binary format during ascent. ASCII data was converted from raw data.

(6) Preliminary results

Location of all radiosonde observations during the cruise is shown in Figure 2.1.1. Time-height section of observed air temperature and wind during the cruise are shown in Figure 2.1.2.

The former period at the stationary observation is characterized by warm advection over Chukchi Sea where the strong pressure gradient between the synoptic low pressure systems over the Beaufort Sea and high pressure system over the East Siberian Sea.

On 15-22 September, the anticyclone over the Beaufort Sea was strong, and GPS radiosonde observation was primarily conducted under a strong pressure gradient along the outer rim of the anticyclone. During this period, we observed strong and cold easterly wind. In addition, inversion layers were frequently observed in this period.

After this event, air temperatures at the surface and 500hPa were recorded below freezing and around –30 ^{O}C, suggesting the coming of winter season.

(7) Data Archive

All datasets obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “R/V MIRAI Data Webpage” in JAMSTEC web site.

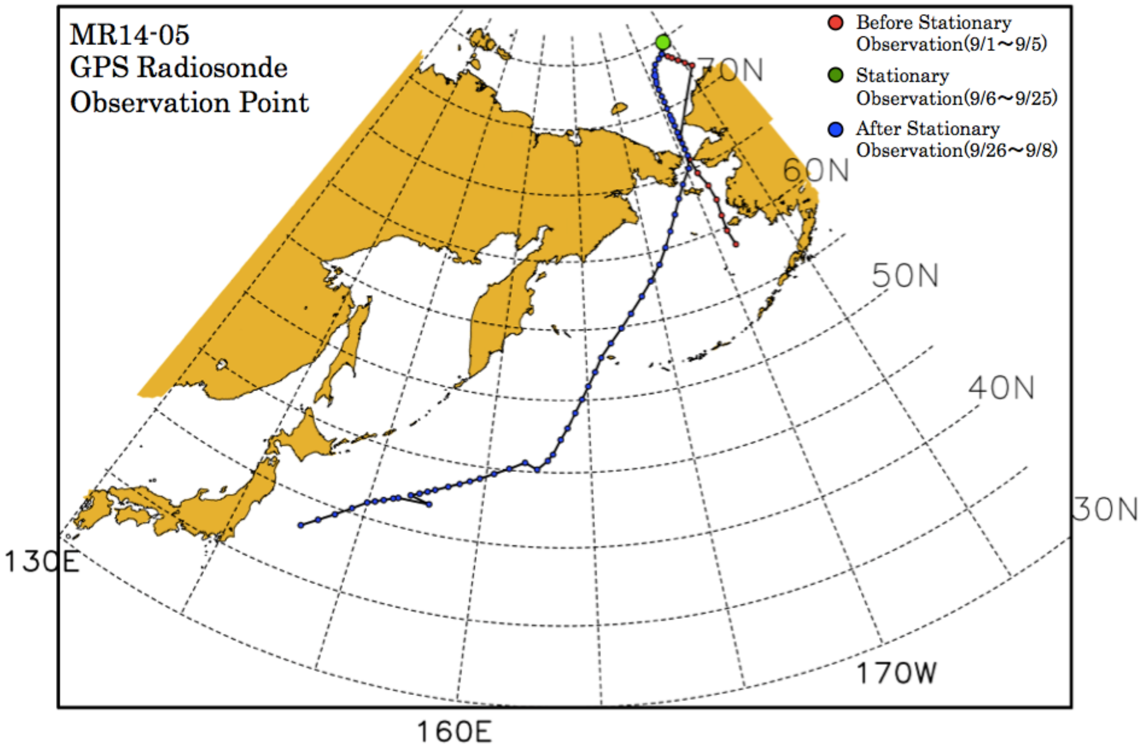


Figure 2.1-1: Sounding stations during the cruise.

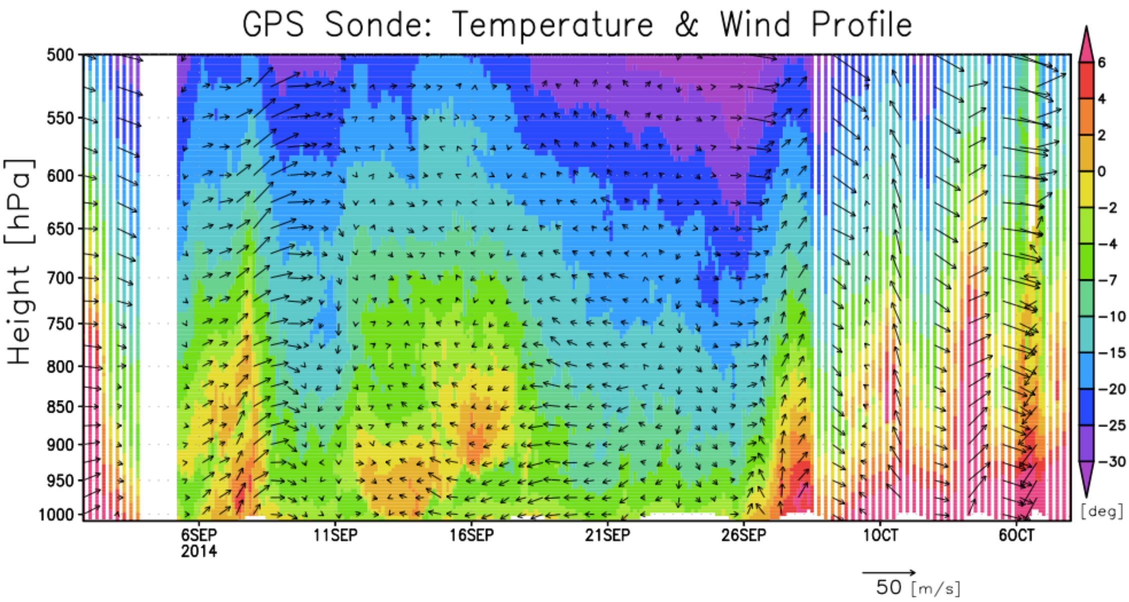


Figure 2.1-2: Time-height section of air temperature (shade) and wind (vectors).

Table 2.1-1: Launch log

ID	Date	Latitude	Longitude	Psfc	Tsfc	RHsfc	WD	Wsp	SST	Max height			Cloud	
	YYYYMMDDHH	degN	degE	hPa	degC	%	deg	m/s	degC	hPa	m	Duration	Amount	Type
RS001	2014090118	58.527	−167.603	1013.6	11.7	85	241	15.2	11.478	35.7	22945	5310	10	St,Sc
RS002	2014090200	59.730	−167.917	1010.0	10.0	99	232	11.0	9.366	31.3	23785	6258	10	St
RS003	2014090206	60.914	−167.720	1007.7	10.8	100	264	7.6	11.489	83.4	17432	4806	10	St
RS004	2014090212	62.139	−167.371	1010.6	9.0	82	357	4.8	10.968	40.2	22126	5980	−	−
RS005	2014090218	63.353	−167.636	1012.0	7.6	71	230	4.8	8.350	40.6	22052	5988	7	st, sc
RS006	2014090300	64.563	−168.420	1012.5	7.3	73	263	3.4	9.896	34.6	23079	6752	0	−
RS007	2014090306	65.752	−168.757	1014.3	4.7	77	337	2.2	4.033	46.2	21174	5650	1	Cu,Ac,Sc
RS008	2014090312	66.630	−168.820	1015.6	4.6	68	318	7.7	9.350	48.5	20848	5602	−	−
RS009	2014090318	67.497	−168.834	1016.4	3.3	62	312	2.6	4.026	45.8	21200	5870	9	ST
RS010	2014090506	72.006	−158.583	1019.9	−0.7	84	304	6.8	1.046	38.3	22363	5766	10	St
RS011	2014090509	72.482	−159.768	1020.8	−1.7	85	300	4.4	1.578	41.9	21786	5296	−	St
RS012	2014090512	72.941	−160.953	1021.7	−2.8	86	270	4.6	1.102	45.4	21264	4894	−	−
RS013	2014090515	73.338	−162.000	1021.1	−2.7	89	219	3.6	1.952	77.0	17810	4390	10	St
RS014	2014090518	73.611	−162.823	1020.6	−2.4	88	235	5.1	1.383	161.9	12969	3206	9	St
RS015	2014090521	73.999	−164.006	1019.8	−1.4	89	200	5.6	1.055	38.6	22303	5422	8	Cu, St
RS016	2014090600	74.377	−163.033	1019.0	−0.5	86	230	8.0	1.525	37.0	22594	5634	6	Cu,St
RS017	2014090603	74.532	−162.590	1018.7	0.2	84	207	8.0	1.026	39.5	22174	5440	9	Sc
RS018	2014090606	75.029	−161.262	1016.9	0.2	92	214	10.8	−0.070	36.0	22755	5616	10	St
RS019	2014090609	75.087	−160.968	1017.1	0.3	96	222	9.9	0.015	30.8	23880	6116	10	St
RS020	2014090612	74.555	−160.998	1018.1	0.7	92	219	10.8	0.114	31.5	23641	5620	−	−
RS021	2014090615	74.375	−161.001	1017.9	1.0	93	210	9.6	0.450	42.9	21626	4852	10	Sc, St
RS022	2014090618	74.750	−162.000	1017.0	1.4	95	226	8.3	0.522	31.6	23604	5906	10	St,Sc
RS023	2014090621	74.754	−161.983	1017.2	1.2	98	218	9.0	0.572	34.8	23001	5672	10	St
RS024	2014090700	74.743	−162.028	1017.1	1.3	97	209	9.3	0.577	36.8	22659	5126	10	St
RS025	2014090703	74.589	−161.975	1016.2	1.0	93	203	13.5	0.564	41.0	21930	5448	10	St
RS026	2014090706	74.752	−161.957	1014.8	1.2	89	186	10.7	1.183	35.6	22852	5272	9	Ac
RS027	2014090709	74.752	−161.989	1013.0	1.5	93	182	10.4	1.174	40.3	22045	5594	10	Sc
RS028	2014090712	74.754	−162.040	1011.8	1.9	90	189	11.3	1.335	31.3	23668	5658	−	−
RS029	2014090715	74.763	−161.981	1009.4	1.7	93	171	11.8	1.085	35.8	22804	4652	8	Sc
RS030	2014090718	74.517	−161.997	1006.7	1.9	96	185	15.3	0.882	38.6	22317	4998	10	St,Sc
RS031	2014090721	74.725	−161.949	1004.1	2.3	94	184	13.4	1.033	44.1	21456	5328	10	Sc, As
RS032	2014090800	74.804	−162.037	1003.5	2.3	99	214	15.0	0.905	416.8	6809	1390	10	St

RS033	2014090803	74.794	−161.989	1004.6	1.0	97	252	9.8	1.147	34.3	23074	5712	10	St
RS034	2014090806	74.755	−161.968	1006.0	−0.2	98	247	10.4	1.019	97.9	16262	3794	10	St
RS035	2014090809	74.742	−161.993	1007.4	−0.6	97	247	11.2	0.705	26.4	**24780**	6954	10	St
RS036	2014090812	74.739	−162.002	1008.4	−0.1	95	268	12.5	1.137	32.5	23425	5520	−	−
RS037	2014090815	74.746	−161.972	1009.4	0.1	82	258	12.9	1.033	47.0	21022	4770	7	St
RS038	2014090818	74.735	−162.012	1010.4	0.2	88	272	12.4	1.141	34.1	23103	5384	10	St,Sc
RS039	2014090821	74.782	−161.951	1012.0	0.0	84	281	10.2	0.640	40.2	22040	5428	9	Sc
RS040	2014090900	74.764	−161.990	1014.2	−1.1	82	292	10.4	1.112	34.3	23078	5648	10	St,Sc
RS041	2014090903	74.747	−161.986	1015.4	−1.0	82	290	9.3	1.104	31.3	23647	6306	10	St, Ns
RS042	2014090906	74.740	−161.975	1016.8	−0.7	86	284	9.6	1.112	55.1	20008	4562	9	Ns
RS043	2014090909	74.748	−161.990	1018.5	−1.0	78	294	6.2	0.557	33.7	23187	5862	10	−
RS044	2014090912	74.744	−161.993	1019.8	−1.2	88	304	6.6	0.561	57.3	19747	4906	−	−
RS045	2014090915	74.751	−161.997	1021.1	−1.6	88	310	4.0	0.559	39.0	22226	5212	5	St,Sc
RS046	2014090918	74.754	−162.006	1021.2	−0.8	91	262	3.4	0.553	29.9	23934	6440	8	St.Sc,Ns,Ci
RS047	2014090921	74.762	−162.041	1022.5	−1.1	87	290	3.3	0.669	36.8	22623	5898	7	Sc, Cc
RS048	2014091000	74.756	−162.018	1022.9	−0.6	81	298	1.1	0.556	35.9	22792	5196	10	St,Sc
RS049	2014091003	74.771	−162.008	1022.9	−1.2	94	13	4.4	0.229	40.6	22007	5476	9	St,Sc,Ns
RS050	2014091006	74.760	−162.042	1023.1	−1.4	79	343	3.3	0.211	33.5	23240	5618	8	Sc, St
RS051	2014091009	74.761	−162.087	1023.3	−1.7	80	107	1.3	0.192	39.2	22220	5252	8	−
RS052	2014091012	74.753	−161.993	1023.3	−1.7	86	308	1.2	0.394	32.5	23431	5616	−	−
RS053	2014091015	74.768	−162.019	1023.1	−1.5	90	298	0.6	0.225	38.1	22390	4956	10	Sc,St
RS054	2014091018	74.766	−161.972	1023.3	−1.5	93	165	0.4	0.443	46.0	21168	5112	10	St
RS055	2014091021	74.805	−162.002	1023.6	−1.1	89	358	3.4	0.279	32.1	23492	5650	10	St, As
RS056	2014091100	74.748	−161.979	1023.8	−1.6	89	345	4.8	0.769	34.8	22979	5638	6	Ac,Cc,Sc,Ci
RS057	2014091103	74.758	−161.997	1023.9	−1.9	90	358	5.2	0.784	31.6	23617	5624	6	St.Sc
RS058	2014091106	74.755	−161.984	1024.8	−2.2	86	326	5.2	0.798	53.9	20142	5548	10	St
RS059	2014091109	74.777	−161.968	1024.9	−3.2	89	316	3.0	0.625	36.3	22696	5536	−	−
RS060	2014091112	74.731	−162.044	1025.0	−2.7	88	293	3.6	0.375	36.2	22724	5674	−	−
RS061	2014091115	74.768	−161.974	1024.9	−2.5	86	289	5.4	0.252	37.5	22493	5304	10	Sc
RS062	2014091118	74.817	−161.827	1024.7	−2.5	92	262	5.3	0.166	40.1	22045	5010	8	St,Sc,Ns
RS063	2014091121	74.744	−161.954	1024.6	−2.4	88	263	7.9	0.106	30.3	23863	6044	7	St
RS064	2014091200	74.734	−161.974	1024.2	−2.0	89	256	8.9	0.174	51.5	20449	5274	9	St
RS065	2014091203	74.747	−161.977	1023.4	−2.1	90	271	7.9	0.039	37.3	22523	5668	10	St,Sc
RS066	2014091206	74.758	−161.976	1022.9	−2.3	96	264	6.2	−0.020	36.3	22705	5236	10	St
RS067	2014091209	74.795	−162.053	1022.7	−2.7	97	268	6.9	0.642	40.4	22019	5502	−	−

RS068	2014091212	74.752	−162.016	1022.2	−3.0	97	249	6.5	−0.010	41.8	21795	5138	−	−
RS069	2014091215	74.775	−162.027	1021.6	−3.3	97	275	3.9	−0.010	35.0	22930	5314	10	Sc,St
RS070	2014091218	74.752	−161.991	1021.0	−3.5	97	277	1.9	−0.070	32.5	23405	5530	9	St
RS071	2014091221	74.793	−162.055	1020.6	−3.1	97	283	1.4	−0.100	35.9	22757	5726	6	St, Ci
RS072	2014091300	74.533	−162.012	1020.1	−2.9	97	315	2.6	0.000	31.9	23547	6276	6	St
RS073	2014091303	74.754	−162.074	1019.0	−2.3	98	34	2.9	0.040	39.1	22214	5370	4	St
RS074	2014091306	74.748	−162.035	1018.5	−1.9	98	68	3.9	0.087	38.8	22278	5614	4	Ci, St
RS075	2014091309	74.790	−162.089	1018.3	−1.2	97	84	3.9	0.012	54.2	20129	5052	2	Ci
RS076	2014091312	74.767	−162.030	1017.9	−0.9	95	77	4.2	0.106	33.6	23185	5842		Ci, Sc
RS077	2014091315	74.750	−162.028	1018.1	−0.2	95	75	6.7	−0.060	58.1	19668	4332	3	Sc
RS078	2014091318	74.759	−162.016	1017.3	−0.3	91	83	7.2	−0.150	34.3	23022	5872	1	Sc
RS079	2014091321	74.788	−162.126	1017.6	−0.6	92	96	6.5	−0.100	36.4	22664	5982	0+	Ci
RS080	2014091400	74.749	−162.027	1017.3	−0.4	86	81	8.0	−0.220	28.4	24254	6458	0+	Ci
RS081	2014091403	74.751	−162.011	1017.5	−1.6	93	92	7.5	−0.140	38.2	22360	5502	2	Ci
RS082	2014091406	74.754	−162.019	1017.3	−3.2	98	82	8.8	−0.190	59.7	19487	5420	10	St
RS083	2014091409	74.748	−162.054	1017.5	−3.0	96	95	6.3	−0.310	53.8	20157	4934	−	−
RS084	2014091412	74.634	−162.297	1017.3	−2.3	98	96	9.9	−0.260	42.3	21702	5232	−	−
RS085	2014091415	74.772	−162.026	1016.6	−1.9	91	96	10.7	0.169	37.6	22455	5782	10	St
RS086	2014091418	74.831	−161.786	1016.8	−2.2	95	97	9.8	0.111	45.4	21235	4868	10	st
RS087	2014091421	74.813	−162.015	1016.9	−1.4	94	101	9.9	0.155	34.0	23098	5952	9	St, As
RS088	2014091500	74.503	−162.048	1016.1	−1.0	87	85	11.8	0.071	33.5	23191	5430	6	Cc,Ci,As
RS089	2014091503	74.759	−162.040	1015.7	−0.9	87	86	12.9	0.080	40.4	21998	5168	5	St,Ci
RS090	2014091506	74.753	−162.208	1015.4	−1.1	89	79	11.5	0.132	58.8	19575	4614	4	As, Ci
RS091	2014091509	74.806	−162.006	1015.8	−2.3	92	91	12.4	0.226	56.5	19837	4912	−	−
RS092	2014091512	74.762	−162.026	1015.2	−2.0	91	79	11.3	−0.180	37.3	22488	5132	−	−
RS093	2014091515	74.757	−162.022	1014.5	−2.0	90	87	10.4	0.000	35.2	22867	5716	10	St
RS094	2014091518	74.756	−162.029	1014.1	−1.7	91	90	10.1	0.022	120.9	14921	3642	10	st
RS095	2014091521	74.776	−162.080	1013.7	−1.7	92	79	11.5	−0.040	35.0	22899	5182	10	St
RS096	2014091600	74.754	−162.010	1013.2	−1.5	90	83	12.2	0.145	32.1	23450	5498	10	St
RS097	2014091603	74.766	−161.997	1012.9	−1.4	86	79	8.1	0.124	37.5	22463	5204	10	St
RS098	2014091606	74.758	−161.998	1012.2	−1.3	89	66	10.2	0.247	43.9	21444	5072	10	St
RS099	2014091609	74.798	−162.079	1012.0	−1.1	93	78	9.7	−0.010	39.2	22172	5244	−	−
RS100	2014091612	74.759	−162.015	1011.5	−1.3	93	60	9.5	0.277	35.0	22870	5506	−	−
RS101	2014091615	74.758	−162.013	1010.5	−1.1	89	61	9.8	0.243	48.4	20791	5004	10	St,Sc
RS102	2014091618	74.763	−162.028	1010.1	−1.4	88	66	10.6	0.063	33.4	23168	5458	10	St

RS103	2014091621	74.771	−162.041	1009.9	−1.5	84	73	10.0	−0.100	94.6	16457	3716	10	St
RS104	2014091700	74.750	−162.008	1009.4	−1.6	85	68	11.8	0.016	30.3	23780	5958	10	St
RS105	2014091703	74.760	−162.026	1008.8	−2.0	81	61	10.3	0.008	41.6	21754	5218	10	St
RS106	2014091706	74.754	−162.007	1008.4	−2.1	85	54	10.3	0.420	38.8	22194	5216	10	St
RS107	2014091709	74.790	−162.088	1008.1	−2.0	84	50	8.4	0.222	37.0	22486	5516	−	−
RS108	2014091712	74.746	−162.003	1007.4	−2.4	85	60	10.9	0.449	37.4	22404	5482	−	−
RS109	2014091715	74.763	−162.065	1006.8	−2.1	88	59	11.2	0.358	61.1	19223	5024	10	Sc
RS110	2014091718	74.760	−162.044	1006.5	−1.6	94	56	11.8	0.106	31.2	23530	5888	10	st
RS111	2014091721	74.789	−162.099	1006.2	−1.2	94	63	10.1	0.261	46.5	20975	5136	10	st
RS112	2014091800	74.748	−161.994	1006.2	−1.0	92	72	10.3	0.274	37.9	22288	4716	10	st
RS113	2014091803	74.753	−162.014	1006.0	−1.2	87	68	10.3	0.249	38.5	22169	4976	10	St
RS114	2014091806	74.813	−161.845	1006.4	−1.3	88	70	10.9	0.272	71.6	18159	4262	10	St
RS115	2014091809	74.771	−162.141	1006.6	−0.9	83	76	15.2	0.339	46.0	21025	4836	−	−
RS116	2014091812	74.720	−162.092	1006.7	−1.1	80	72	12.5	0.442	53.6	20023	4550	−	−
RS117	2014091815	74.762	−162.077	1007.0	−1.7	91	70	12.5	0.096	45.3	21108	4958	10	St, As
RS118	2014091818	74.800	−162.036	1007.5	−1.7	93	68	13.6	0.321	52.9	20092	4488	10	St,Sc、Ns
RS119	2014091821	74.778	−162.087	1008.2	−1.5	92	80	13.6	0.183	35.7	22633	5154	10	St、Sc, Ns
RS120	2014091900	74.786	−161.952	1008.6	−1.3	82	73	14.4	−0.140	35.8	22704	5260	10	Sc,St
RS121	2014091903	74.762	−162.032	1009.1	−1.4	82	82	14.8	0.254	37.2	22363	4974	10	St
RS122	2014091906	74.745	−161.922	1010.0	−2.1	84	83	12.8	−0.110	37.7	22268	4988	10	St
RS123	2014091909	74.786	−162.200	1010.5	−2.0	84	79	11.3	0.157	54.0	19951	4526	−	−
RS124	2014091912	74.755	−161.978	1010.5	−2.2	89	84	13.1	−0.310	44.4	21220	4696	−	−
RS125	2014091915	74.782	−161.917	1011.2	−2.3	85	82	10.3	−0.300	94.0	16358	3998	10	St,Sc
RS126	2014091918	74.757	−161.864	1011.8	−2.7	85	91	13.5	−0.260	41.0	21729	5164	10	St,Sc
RS127	2014091921	74.796	−162.031	1012.2	−2.8	86	83	12.2	−0.280	31.0	23508	5754	10	St,Sc
RS128	2014092000	74.752	−161.942	1012.4	−3.0	87	80	12.1	−0.230	41.3	21675	5238	10	St,Sc
RS129	2014092003	74.767	−161.973	1012.8	−3.1	85	84	10.8	−0.280	34.5	22840	5540	10	St
RS130	2014092006	74.734	−161.984	1013.1	−3.3	84	73	9.4	−0.280	52.3	20174	4758	10	St
RS131	2014092009	74.779	−162.110	1013.3	−3.4	83	86	8.2	−0.330	38.0	22222	4950	−	−
RS132	2014092012	74.762	−162.023	1013.1	−3.5	81	96	9.4	−0.290	40.8	21756	5060	−	−
RS133	2014092015	74.764	−162.015	1013.7	−3.5	82	86	9.4	−0.240	42.6	21476	5186	−	−
RS134	2014092018	74.763	−161.997	1013.2	−3.5	81	70	9.1	−0.200	33.6	22995	5620	10	St,Sc
RS135	2014092021	74.703	−161.986	1013.1	−3.7	85	74	8.6	−0.300	31.5	23404	5840	10	St,Sc
RS136	2014092100	74.741	−162.075	1013.2	−3.2	87	84	9.6	−0.260	45.0	21129	5120	10	St,Sc
RS137	2014092103	74.755	−162.015	1012.7	−3.1	83	82	11.5	−0.100	42.3	21537	5014	10	St,Sc

RS138	2014092106	74.738	−162.002	1012.6	−2.9	81	83	8.7	−0.040	37.1	22378	5194	10	Sc
RS139	2014092109	74.772	−162.135	1012.6	−2.6	83	59	7.4	−0.220	41.1	21718	5368	−	−
RS140	2014092112	74.748	−162.042	1012.3	−1.8	82	75	6.6	−0.030	34.8	22782	5456	−	−
RS141	2014092115	74.753	−162.014	1011.9	−1.4	76	67	8.3	−0.250	37.9	22232	5302	−	−
RS142	2014092118	74.741	−162.012	1011.1	−2.1	82	44	9.3	−0.290	35.7	22615	5668	10−	Sc,As,Ac
RS143	2014092121	74.748	−162.029	1010.1	−3.0	85	83	7.8	−0.330	36.4	22494	5212	10	St,Sc
RS144	2014092200	74.749	−162.021	1008.6	−2.6	87	93	7.1	−0.290	36.7	22431	5104	10	As,St,Sc
RS145	2014092203	74.758	−161.988	1007.8	−3.3	89	111	6.3	−0.120	40.3	21849	5150	10	St
RS146	2014092206	74.747	−161.994	1006.1	−3.2	78	82	3.8	−0.210	39.7	21921	5116	10	Ns, St
RS147	2014092209	74.711	−162.006	1004.9	−2.5	82	90	5.0	0.754	38.9	22042	5458	−	−
RS148	2014092212	74.752	−162.002	1003.8	−2.6	87	86	4.9	0.002	43.5	21320	5282	−	−
RS149	2014092215	74.753	−162.027	1002.9	−2.5	87	85	6.2	−0.390	39.9	21876	5344	−	−
RS150	2014092218	74.742	−161.983	1001.4	−2.6	84	42	2.4	−0.270	30.8	23532	5796	10	St,Sc,Ns
RS151	2014092221	74.165	−162.001	1000.6	−2.5	91	60	5.0	0.396	36.3	22484	5346	10	St
RS152	2014092300	74.750	−161.997	1000.2	−2.2	87	67	7.8	−0.410	37.7	22248	5832	10	St
RS153	2014092303	74.758	−162.011	999.5	−2.3	90	49	8.1	−0.400	36.8	22408	5336	10	St
RS154	2014092306	74.761	−162.002	999.2	−2.4	87	41	7.6	−0.300	47.0	20832	4788	10	St
RS155	2014092309	74.729	−161.933	999.1	−2.7	91	38	7.9	−0.070	36.5	22437	5452	−	−
RS156	2014092312	74.751	−162.011	999.6	−2.6	90	20	9.0	−0.200	39.6	21923	5208	−	−
RS157	2014092315	74.752	−161.970	999.8	−2.8	86	4	10.3	−0.450	40.4	21792	4948	−	−
RS158	2014092318	74.757	−161.955	1000.2	−2.8	83	357	10.5	−0.500	38.7	22078	5320	10	St,Sc
RS159	2014092321	74.730	−162.140	1001.0	−3.5	83	333	7.4	0.048	51.7	20186	5060	10	St,Sc
RS160	2014092400	74.745	−162.004	1001.7	−3.9	82	339	6.3	−0.350	35.7	22652	5786	10	St,Sc
RS161	2014092403	74.746	−162.050	1001.6	−3.3	80	300	5.1	−0.370	40.8	21710	5242	10	St
RS162	2014092406	74.756	−162.993	1002.2	−3.6	77	333	6.6	−0.290	42.8	21394	4882	10	St, Sc
RS163	2014092409	74.747	−162.109	1001.4	−3.2	88	329	5.0	−0.360	43.5	21288	4992	−	−
RS164	2014092412	74.740	−162.013	1001.1	−2.8	83	326	7.0	−0.400	43.6	21263	5162	−	−
RS165	2014092415	74.760	−162.008	1001.0	−3.1	82	332	6.7	−0.450	60.2	19174	4796	−	−
RS166	2014092418	74.751	−162.087	1001.2	−2.6	81	3	6.1	−0.460	38.1	22131	5794	10	Ns,St.Sc
RS167	2014092421	74.720	−162.217	1002.1	−2.1	79	339	3.9	−0.100	38.5	22062	5332	10	Ns, St
RS168	2014092500	74.748	−161.995	1003.0	−2.2	77	342	3.1	−0.420	38.2	22114	5726	10	As,Ns
RS169	2014092503	74.660	−162.252	1004.1	−2.3	87	120	1.9	0.429	43.7	21255	5130	10	St,Ns
RS170	2014092506	74.375	−163.009	1005.2	−1.3	62	302	1.7	0.830	32.7	23131	6062	10	St, Ns
RS171	2014092509	73.995	−164.002	1006.7	−1.6	73	326	2.7	0.504	41.0	21676	5512	−	−
RS172	2014092512	73.778	−165.385	1008.0	−1.7	70	284	9.9	0.239	39.0	21999	5376	−	−

RS173	2014092515	73.501	−166.984	1010.4	−2.0	61	298	9.8	0.013	53.5	19948	4918	−	−
RS174	2014092518	73.111	−167.768	1012.9	−2.2	61	303	10.7	2.459	37.8	22209	5450	3	Sc
RS175	2014092521	72.750	−168.248	1015.2	−1.1	56	275	5.4	2.605	36.3	22476	5062	6	St,Ns,Ac,Sc
RS176	2014092600	72.599	−168.253	1016.3	−0.6	63	225	5.4	2.934	29.6	23808	6118	10−	Sc,As
RS177	2014092603	72.749	−168.238	1016.4	0.6	72	188	8.6	2.479	39.3	21984	5054	10	St,Sc
RS178	2014092606	72.793	−168.135	1016.4	1.0	88	204	7.7	2.430	38.2	22160	5140	10	Sc, As
RS179	2014092609	72.750	−168.502	1016.9	0.6	95	217	9.8	2.580	53.6	19964	4950	−	−
RS180	2014092612	72.760	−168.243	1017.1	2.4	68	192	10.6	2.714	35.4	22652	5040	−	−
RS181	2014092615	72.735	−168.231	1016.5	2.1	77	145	10.4	2.720	42.1	21529	5278	−	−
RS182	2014092618	72.274	−168.616	1015.0	2.3	75	145	10.4	3.469	28.1	24184	6264	8	Sc,Ac,St,Ci
RS183	2014092621	72.084	−168.834	1013.3	2.5	85	142	12.6	3.605	48.4	20656	5408	10−	St,Sc
RS184	2014092700	71.614	−168.831	1011.9	4.0	85	133	8.8	4.077	33.6	23059	5472	9	As,Sc
RS185	2014092703	71.041	−168.832	1009.5	3.8	94	133	10.3	3.377	109.2	15356	3234	10	St
RS186	2014092706	70.550	−168.807	1007.7	4.0	100	193	8.5	3.680	31.6	23457	5888	10	St
RS187	2014092709	70.001	−168.825	1006.3	4.9	99	178	12.0	3.675	49.2	20584	5072	−	−
RS188	2014092712	69.449	−168.823	1004.3	5.8	92	163	14.6	5.593	38.4	22208	5234	−	−
RS189	2014092715	69.139	−168.822	1001.7	5.7	96	155	14.0	5.885	34.9	22826	5908	−	−
RS190	2014092718	68.983	−168.757	999.1	5.5	98	169	14.2	5.144	37.4	22371	6262	10	St
RS191	2014092721	68.543	−168.794	999.2	4.9	99	194	11.1	3.475	35.4	22753	5356	10	Ns
RS192	2014092800	68.011	−168.834	998.8	5.8	100	196	9.5	4.738	168.9	12563	3254	10	Ns
RS193	2014092803	67.632	−168.823	998.0	6.1	98	192	9.0	6.793	32.7	23284	6536	10	St
RS194	2014092806	67.088	−168.781	997.9	6.1	98	199	9.5	6.688	36.0	22657	5414	10	St
RS195	2014092809	66.595	−168.800	997.3	5.4	89	234	7.7	6.197	35.8	22690	5388	−	−
RS196	2014092812	66.060	−168.780	998.4	4.9	90	262	8.2	4.396	33.9	23044	6044	−	−
RS197	2014092818	65.137	−169.514	1003.6	2.9	86	283	7.7	1.067	36.6	22538	5476	7	St, Sc
RS198	2014092900	64.182	−171.570	1009.7	3.3	82	281	7.4	2.405	33.2	23229	5448	6	Ac,Sc
RS199	2014092906	63.283	−173.066	1016.0	5.2	66	298	9.6	8.376	39.8	22004	5012	5	Sc
RS200	2014092912	62.244	−174.508	1021.6	5.7	55	300	7.9	9.236	34.1	23028	5660	−	−
RS201	2014092918	61.157	−175.984	1023.9	7.3	61	238	5.1	10.071	112.1	15319	4226	5	St,Sc,Ac
RS202	2014093000	60.094	−177.369	1024.3	8.8	56	194	6.8	10.715	35.2	22856	6188	2	Sc,Ci
RS203	2014093006	58.970	−178.857	1023.8	9.6	50	161	3.4	11.272	39.5	22109	5078	8	Sc
RS204	2014093012	57.940	179.409	1023.7	9.9	59	136	7.1	11.005	81.2	17479	4142	−	−
RS205	2014093018	56.959	177.818	1020.4	8.8	83	139	10.1	11.025	33.5	23186	5564	−	−
RS206	2014100100	55.850	176.054	1018.0	10.4	69	106	9.8	11.180	33.0	23328	5814	10	Ns,Sc
RS207	2014100106	54.895	174.581	1012.4	10.0	74	124	15.3	10.824	32.5	23425	5854	10	Sc

RS208	2014100112	53.901	173.085	1007.8	9.9	85	131	14.0	10.836	30.2	23898	6020	–	–
RS209	2014100118	52.926	171.771	1001.6	10.0	95	130	15.5	10.181	34.9	22921	6986	–	–
RS210	2014100200	51.936	170.939	998.7	10.1	86	248	9.6	10.498	30.9	23734	5958	9	Ns,Sc
RS211	2014100206	50.949	170.095	1002.3	10.1	65	258	12.2	10.855	39.3	22183	5458	6	Cu
RS212	2014100212	50.052	169.354	1005.6	9.7	74	252	11.5	11.182	38.3	22340	5632	–	–
RS213	2014100218	49.106	168.578	1009.6	10.0	69	270	12.7	10.927	36.0	22730	5598	–	–
RS214	2014100300	48.047	167.739	1014.3	10.1	66	290	13.9	11.195	35.7	22778	5784	2	Ns
RS215	2014100306	47.255	167.048	1018.4	10.0	68	291	10.7	11.662	42.4	21706	5278	5	Sc, Ac
RS216	2014100312	46.234	166.303	1021.1	9.6	70	300	5.5	11.686	30.8	23775	5650	–	–
RS217	2014100318	45.791	165.806	1019.8	10.0	70	164	1.9	11.341	37.5	22517	5178	–	–
RS218	2014100400	45.169	164.787	1014.6	13.1	97	167	10.7	13.293	35.2	22940	6086	10	Ns
RS219	2014100406	45.589	163.600	1005.4	13.3	98	194	13.4	11.089	52.9	20373	4812	10	Ns
RS220	2014100412	45.094	162.111	1000.1	14.0	99	175	11.2	11.663	27.4	24576	6222	–	–
RS221	2014100418	44.644	160.735	999.9	11.1	82	305	17.0	10.855	36.2	22767	5590	–	–
RS222	2014100500	44.204	159.436	1006.4	11.1	61	299	15.4	13.670	36.9	22658	5086	2	Sc,Cu,Ci
RS223	2014100506	43.921	158.552	1007.6	11.3	53	276	15.8	14.944	36.5	22685	5806	5	Cu
RS224	2014100512	43.629	157.649	1009.7	11.6	54	286	15.2	13.555	40.4	22063	5324	–	–
RS225	2014100518	43.305	156.660	1010.8	11.1	55	291	14.3	13.639	33.1	23308	5906	–	–
RS226	2014100600	42.926	155.540	1012.9	12.1	61	312	12.6	17.773	37.4	22525	4954	7	Ac,Sc,Cu
RS227	2014100603	42.704	154.895	1011.9	12.3	74	317	11.9	17.897	29.8	23985	5768	10–	Sc,Cu,Ci
RS228	2014100606	42.464	154.225	1011.7	12.1	65	297	10.1	16.860	37.2	22574	4910	10	Ns
RS229	2014100609	42.220	153.504	1010.0	12.3	70	30	3.0	17.211	32.6	23434	6016	–	–
RS230	2014100612	41.913	155.261	1003.2	12.0	88	96	10.5	18.853	661.9	3387	1136	–	–
RS231	2014100613	41.846	152.474	999.3	12.4	87	83	17.3	18.743	641.7	3607	998	–	–
RS232	2014100615	41.718	152.053	996.9	11.0	89	42	20.5	19.610	647.4	3499	980	–	–
RS233	2014100618	41.447	151.291	994.0	9.7	93	26	19.4	17.523	38.4	22380	6662	–	–
RS234	2014100621	41.199	150.577	1001.8	10.4	78	15	15.7	17.378	39.9	22149	5002	10	Sc,St
RS235	2014100700	40.978	149.957	1007.1	11.8	67	349	15.5	17.173	27.8	24429	5840	10	As,Sc
RS236	2014100706	40.317	148.866	1012.8	13.5	51	335	12.5	19.105	32.4	23449	5786	3	Sc
RS237	2014100712	39.563	147.671	1017.2	14.0	53	327	5.3	17.330	28.7	24226	6400	7	Sc,Ns
RS238	2014100718	38.851	146.496	1018.3	14.0	67	232	2.6	15.318	82.2	17611	4038	4	Cb
RS239	2014100800	38.122	145.351	1019.8	17.6	52	327	4.8	19.939	156.0	13689	3428	6	St,Sc,Ns

2.2. C-band Weather Radar

(1) Personnel

Masaki Katsumata	JAMSTEC	- PI
Shuichi Mori	JAMSTEC	
Biao Geng	JAMSTEC	- not on board
Jun Inoue	JAMSTEC / NIPR	
Kazuhiro Oshima	JAMSTEC	
Kazutoshi Sato	JAMSTEC / SOKENDAI	
Taku Mitsui	JAMSTEC / SOKENDAI	
Hiroaki Asai	JAMSTEC / Tokyo Gakugei Univ.	
Hiroki Takeda	JAMSTEC / Tokyo Gakugei Univ.	
Katsuhisa Maeno	GODI	
Souichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Kouichi Inagaki	GODI	
Miki Morioka	GODI	
Ryo Kimra	MIRAI Crew	

(2) Objective

The objective of the C-band weather radar observation in this cruise is to capture the structure of precipitating systems and their temporal and spatial evolution over the Arctic Ocean. At the same time, scans are performed to evaluate the performance of the radar, and to develop the better strategy of the radar observation.

(3) Method

The C-band weather radar on board R/V Mirai is used. The basic specification of the radar is 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.)

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 motion in beam direction.

As the maintenance, internal parameters 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 was operated typically by repeating a volume scan with 17 PPIs (Plan Position Indicators) every 6-minute. A dual PRF mode with the maximum range of, typically 100 km, is used for the volume scan. Meanwhile, a surveillance PPI scan is performed every 30 minutes in a single PRF mode with the maximum range of 300 km. Furthermore, RHI (Range Height Indicator) scans are also operated whenever detailed vertical structures are necessary in certain azimuth directions. Over the Arctic Ocean, the scan strategy is kept same, as in Table 2.2-1, to provide the same data quality to highlight the temporal variation of the precipitating systems. On the other hand, some other scan strategies were adopted out of Arctic Ocean to examine the performance of the radar.

Table 2.2-1: Parameters for scan strategy in the Arctic Ocean.

<table>
<tr><th></th><th>Surveillance PPI</th><th colspan="6">Volume Scan</th><th>RHI</th></tr>
<tr><td>Repeated Cycle (min.)</td><td>30</td><td colspan="6">6</td><td>6</td></tr>
<tr><td>Pulse Width (long / short, in microsec)</td><td>200 / 2</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>36</td><td colspan="2">18</td><td colspan="2">24</td><td colspan="2">36</td><td>9 (in el.)</td></tr>
<tr><td rowspan="2">PRF(s) (Hz)</td><td rowspan="2">400</td><td colspan="6">dual PRF (ray alternative)</td><td rowspan="2">1250</td></tr>
<tr><td>667</td><td>833</td><td>938</td><td>1250</td><td>1333</td><td>2000</td></tr>
<tr><td>Pulses / Ray</td><td>8</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>0.7</td><td colspan="2">0.7</td><td colspan="2">0.7</td><td colspan="2">1.0</td><td>0.23</td></tr>
<tr><td>Azimuth</td><td colspan="7">Full Circle</td><td>Optional</td></tr>
<tr><td>Bin Spacing (m)</td><td colspan="8">150</td></tr>
<tr><td>Max. Range (km)</td><td>300</td><td colspan="2">150</td><td colspan="2">100</td><td colspan="2">60</td><td>100</td></tr>
<tr><td>Elevation Angle(s) (deg.)</td><td>0.5</td><td colspan="2">0.5</td><td colspan="2">1.0, 1.7, 2.4, 3.1, 3.8, 4.6, 5.5, 6.5, 7.6, 8.9</td><td colspan="2">10.4, 12.0, 13.8, 16.0, 18.3, 21.0</td><td>0.0 to 45.0 (to 70.0 when necessary)</td></tr>
</table>

(4) Preliminary results

The radar was operated continuously from Aug. 31 to Oct. 09 during the cruise. Figure 2.2-1 shows the temporal variation of the areal coverage of the radar echo within 200-km range on the surveillance PPIs, and representing PPI images for precipitating events. The event in Sep.7-8 was captured when the cold front passed over with liquid rain at the surface, while the events in Sep.18-19 was observed when the low pressure system approached with snow at the surface.

The further detailed analyses will be performed after the cruise.

(5) Data archive

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

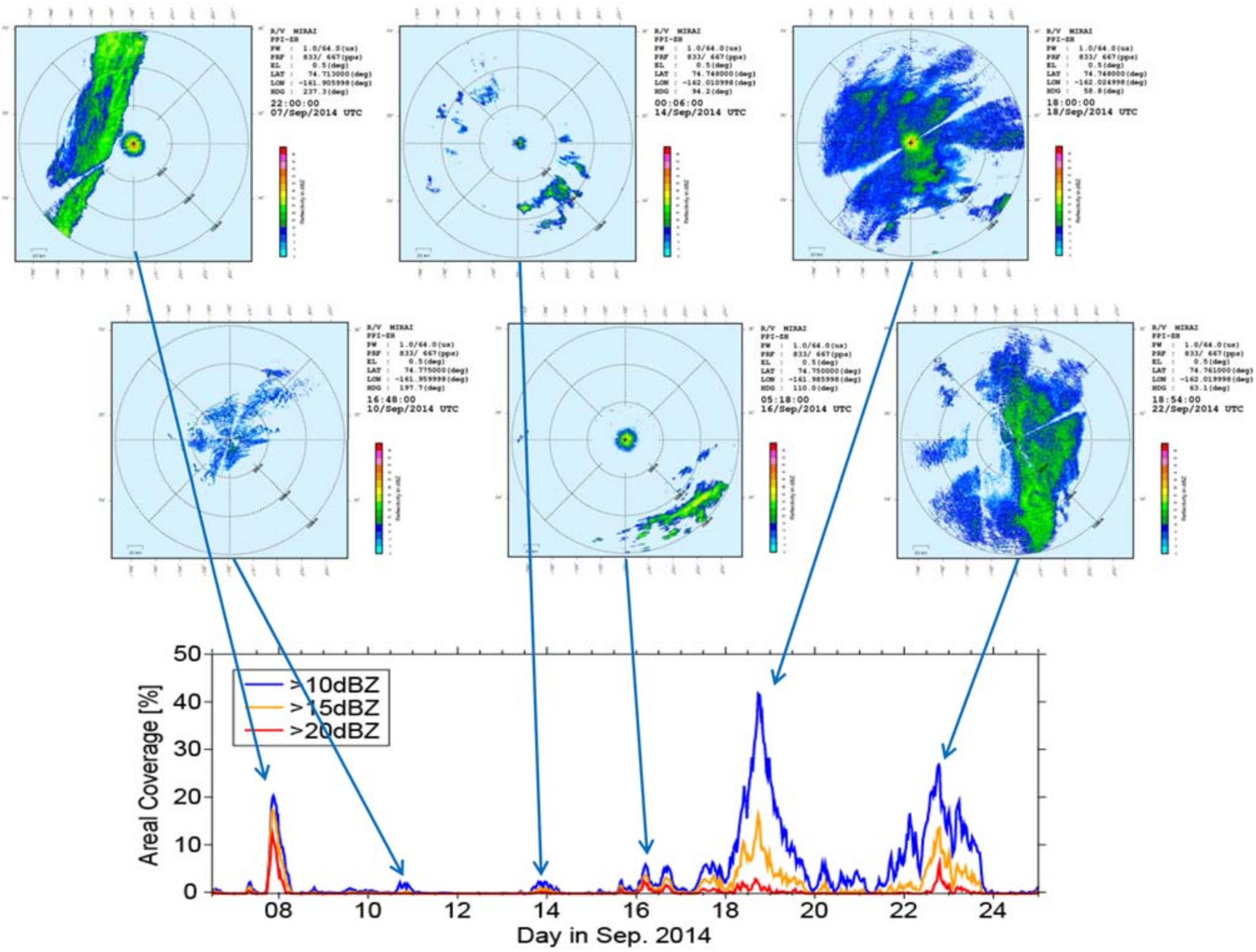


Figure 2.2-1: (Bottom) The temporal variations of the areal coverage of the echo exceeding threshold as 10 dBZ (blue), 15 dBZ (yellow) and 20 dBZ (red), within 200-km range distance on the surveillance PPI scans. (top) the six representing PPI images for characteristic precipitating event, obtained by the first PPI in the volume scan (at elevation angle of 0.5 degrees).

2.3. Surface Meteorological Observations

(1) Personnel

Jun Inoue	JAMSTEC / NIPR	- PI
Kazuhiro Oshima	JAMSTEC	
Kazuhiro Sato	JAMSTEC / SOKENDAI	
Katsuhisa Maeno	GODI	
Souichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Koichi Inagaki	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 during the MR14-05 cruise from 31th August 2014 to 10th October 2014. In this cruise, we used two systems for the observation.

i. *MIRAI Surface Meteorological observation (SMet) system*

Instruments of SMet system are listed in Table 2.3-1 and measured parameters are listed in Table 2.3-2. 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 five 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 ORG (optical rain gauge)) measurement.
d) Photosynthetically Available Radiation (PAR) sensor manufactured by

Biospherical Instruments Inc. (USA) - PAR measurement.

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

SCS recorded PRP data every 6 seconds, CR1000 data every 10 seconds, air temperature and relative humidity data every 2 seconds and ORG data every 5 seconds. SCS composed Event data (JamMet) from these data and ship's navigation data. Instruments and their locations are listed in Table 2.3-3 and measured parameters are listed in Table 2.3-4.

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, HMP41/45, VAISALA

(4) Preliminary results

Fig. 2.3-1 shows the time series of the following parameters;

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

(5) Data archives

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

(6) Remarks (Times in UTC)

i) The following periods, Sea surface temperature of SMet data was available.
   03:30 31 Aug. 2014 - 05:00 04 Aug. 2014
   02:30 05 Aug. 2014 - 06:00 09 Oct. 2014

ii) The following time, increasing of SMet capacitive rain gauge data were invalid due to test transmitting for VHF radio.
   18:58 15 Sep. 2014

iii) The following period, PAR data was invalid due to Deck BOX trouble.
05:17 19 Sep. 2014 - 14:29 19 Sep. 2014

iv) The following period, ORG data of JamMet was invalid.
19:03 24 Sep. 2014 - 19:06 24 Sep. 2014,
03:33 29 Sep. 2014 - 03:35 29 Oct. 2014

Table 2.3-1: 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	compass deck (21 m)
with 43408 Gill aspirated radiation shield		R.M. Young, USA	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 2.3-2: 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,TOKYO-KEIKI
5 Relative wind speed	m/s	6sec./10min. averaged
6 Relative wind direction	degree	6sec./10min. averaged
7 True wind speed	m/s	6sec./10min. averaged
8 True wind direction	degree	6sec./10min. averaged
9 Barometric pressure	hPa	adjusted to sea surface level 6sec. averaged
10 Air temperature (starboard side)	degC	6sec. averaged
11 Air temperature (port side)	degC	6sec. averaged
12 Dewpoint temperature (starboard side)		degC 6sec. averaged
13 Dewpoint temperature (port side)	degC	6sec. averaged
14 Relative humidity (starboard side)	%	6sec. averaged
15 Relative humidity (port side)	%	6sec. averaged
16 Sea surface temperature	degC	6sec. averaged
17 Rain rate (optical rain gauge)	mm/hr	hourly accumulation
18 Rain rate (capacitive rain gauge)	mm/hr	hourly accumulation
19 Down welling shortwave radiation	W/m^2	6sec. averaged
20 Down welling infra-red radiation	W/m^2	6sec. averaged
21 Significant wave height (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 2.3-3 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	61302V	R.M. Young, USA	
with 61002 Gill pressure port		R.M. Young, USA	foremast (23 m)
Rain gauge	50202	R.M. Young, USA	foremast (24 m)
Tair/RH	HMP155	Vaisala, Finland	
with 43408 Gill aspirated radiation shield		R.M. Young, USA	foremast (23 m)
Optical rain gauge	ORG-815DR	Osi, USA	foremast (24 m)

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

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

Table 2.3-4: Parameters of SOAR system (JamMet)

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/m^2	
13 Down welling infra-red radiation	W/m^2	
14 Defuse irradiance	W/m^2	
15 PAR	microE/cm2/sec	

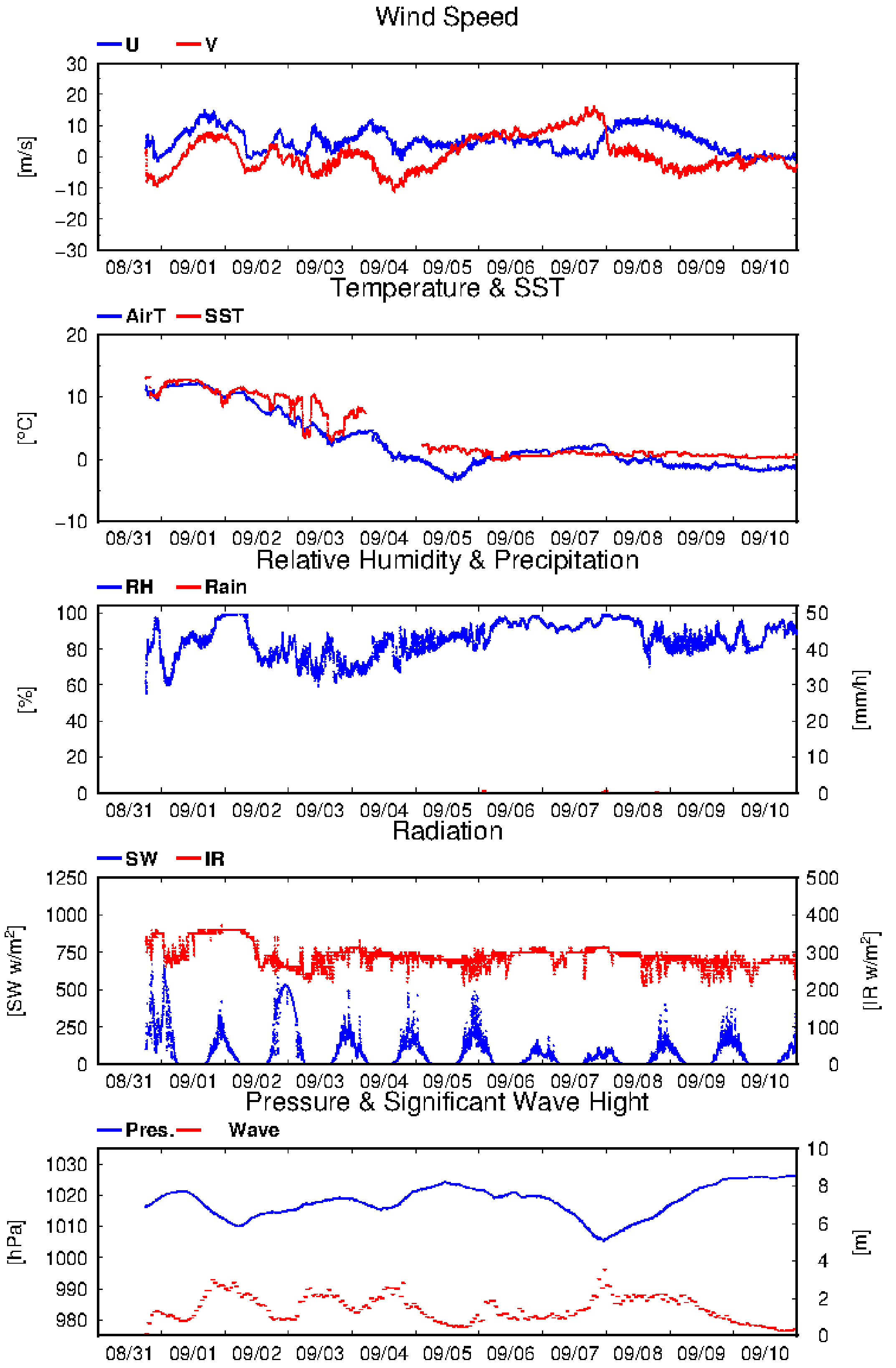


Figure 2.3-1: Time series of surface meteorological parameters during the MR14-05 cruise

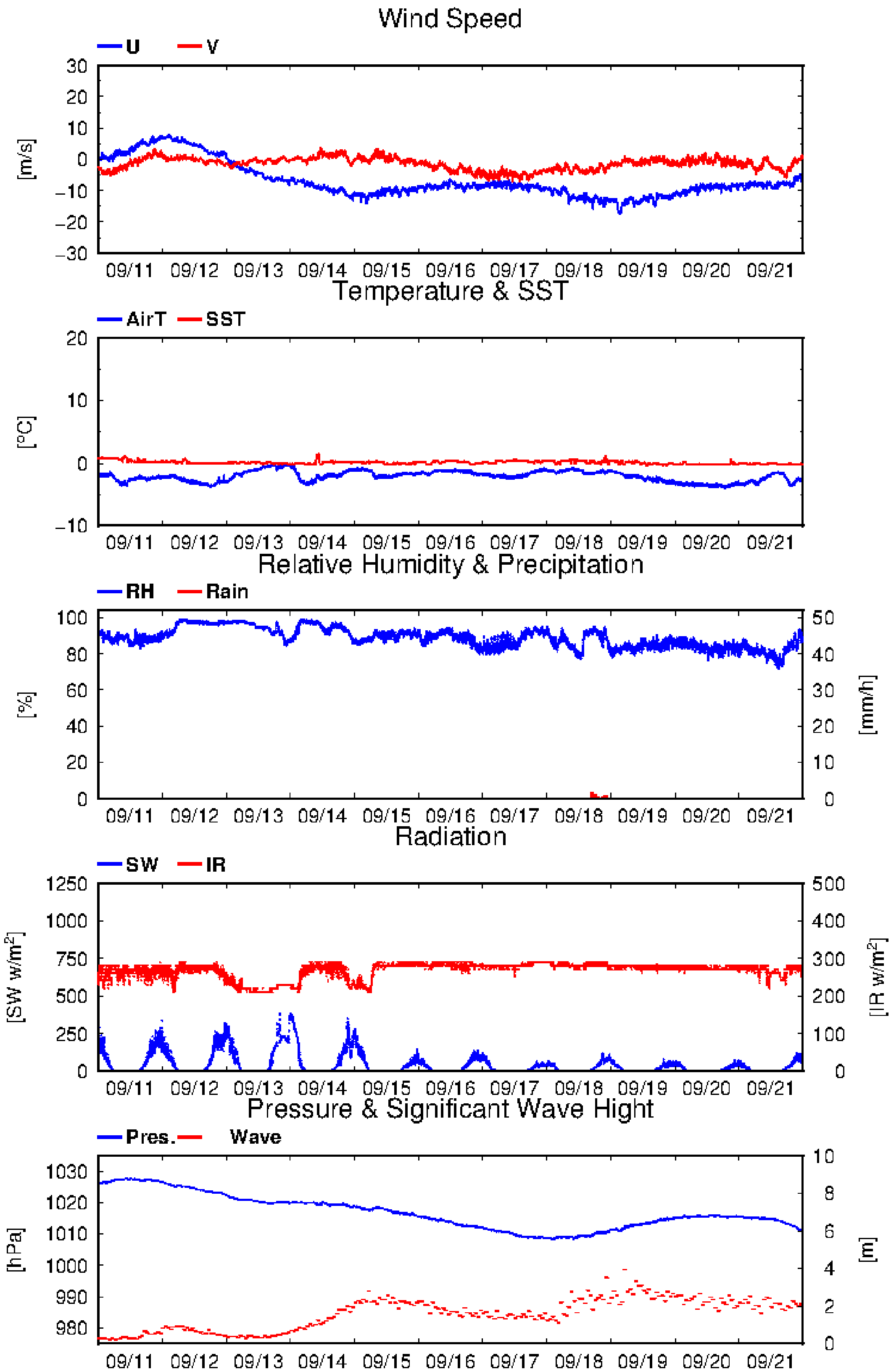


Figure 2.3-1: (Continued)

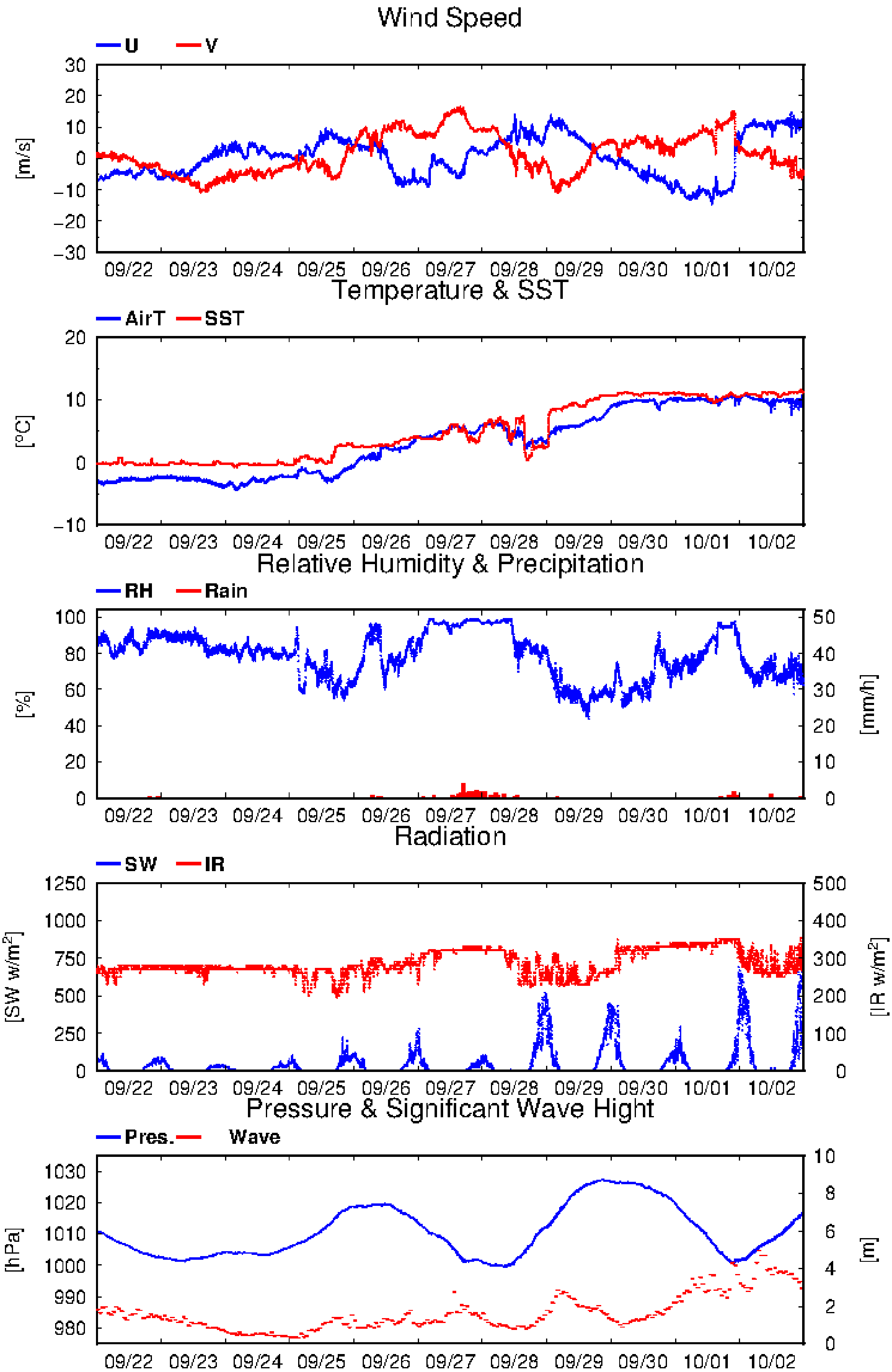


Figure 2.3-1: (Continued)

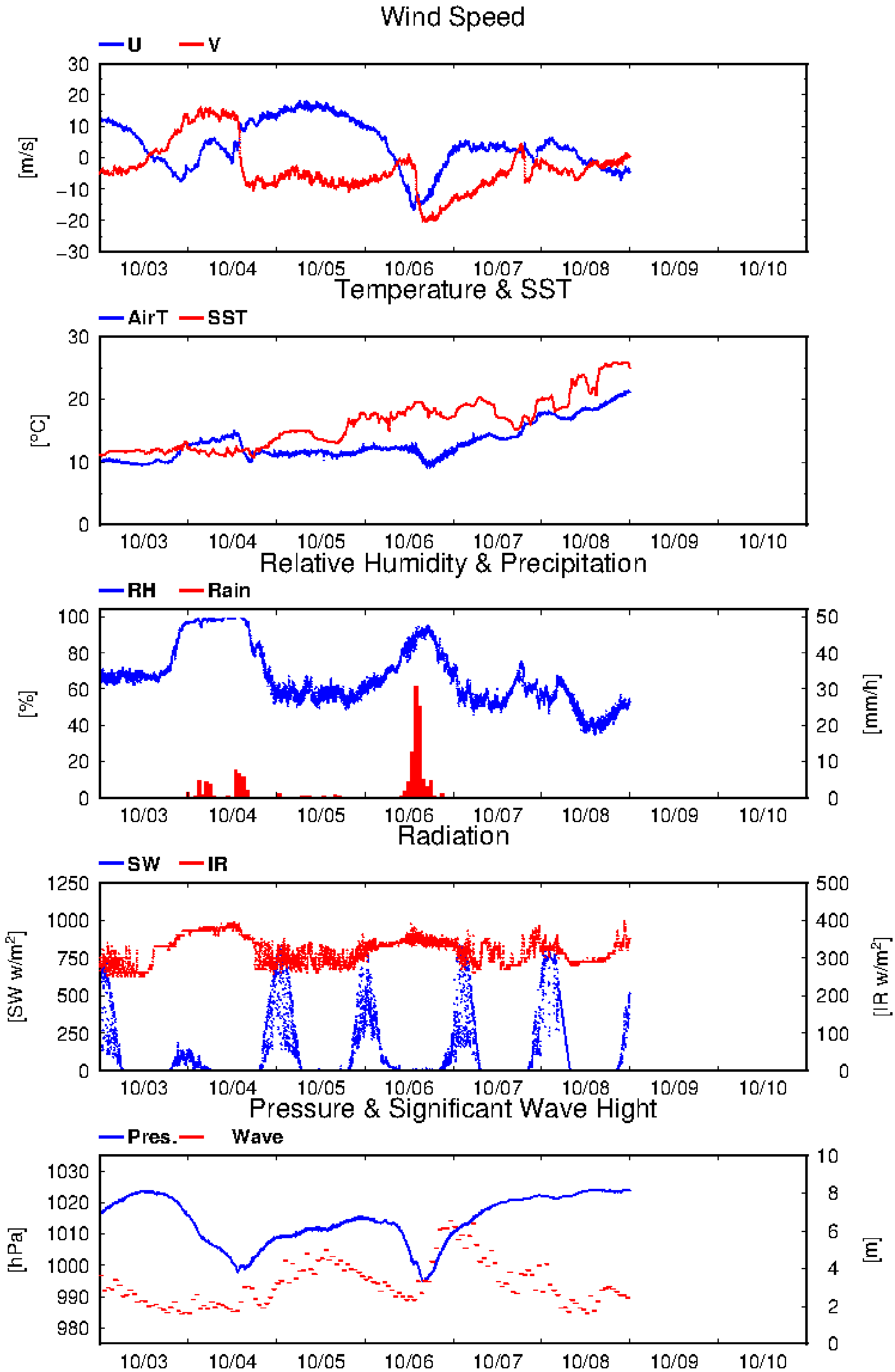


Figure 2.3-1: (Continued)

2.4. Disdrometers

(1) Personnel

Masaki Katsumata JAMSTEC - PI

(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 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

Four different types of disdrometers are utilized to obtain better reasonable and accurate value on the moving vessel. Three of the disdrometers 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. 2.4-1. One of the disdrometers named "micro rain radar" is installed at the starboard side of the anti-rolling systems (see Fig. 2.4-2).

The details of the sensors are described below. All the sensors archive data every one minute.

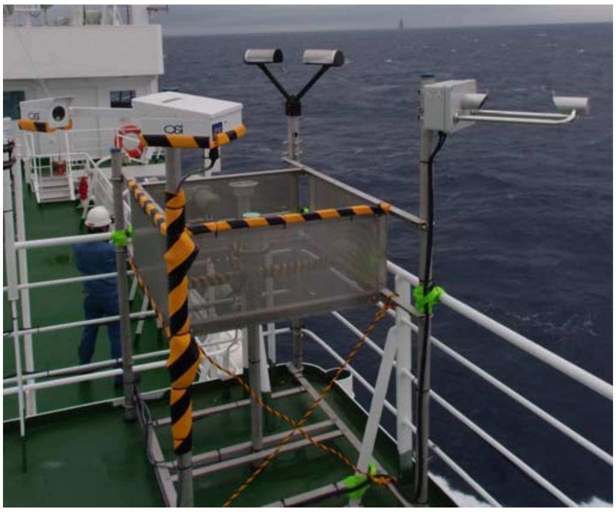


Figure 2.4-1: The three disdrometers (Parsivel, LPM and Joss-Waldvogel disdrometer) and an optical rain gauge, installed on the roof of the anti-rolling tank.

Figure 2.4-2: The micro rain radar, installed on the starboard side 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 2.4-1, 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 2.4-2.

(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 2.4-3.

(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.).

(3-5) Micro rain radar

The MRR-2 (METEK GmbH) was utilized. The specifications are in Table 2.4-4. The antenna unit was installed at the starboard side of the anti-rolling systems (see Fig. 2.4-2), 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 drop size distribution is recorded, as well as radar reflectivity, path-integrated attenuation, rain rate, liquid water content and fall velocity.

(4) Preliminary Results

The data were obtained continuously thru the cruise from Aug. 31 to Oct. 10. The further analyses will be done 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).

Table 2.4-1: 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 2.4-2: 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 2.4-3: 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

Table 2.4-4: 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

2.5. Ceilometer

(1) Personnel

Jun Inoue	JAMSTEC / NIPR	- PI
Kazuhiro Oshima	JAMSTEC	
Kazutoshi Sato	JAMSTEC / SOKENDAI	
Katsuhisa Maeno	GODI	
Souichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Koichi Inagaki	GODI	
Miki Morioka	GODI	
Kimura Ryo	MIRAI Crew	

(2) Objective

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

(3) Parameters

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

(4) Instruments and Methods

We measured cloud base height and backscatter profile using ceilometer (CL51,VAISALA, Finland) throughout the MR14-05 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 recordedwith the resolution of 10 m.

(5) Preliminary results

Figure 2.5-1 shows the time series of cloud-base heights derived from the ceilometer (black line) during arctic clue (north of 70 ^{o}N). In most of periods, although the cloud base height was below 500m, it sometimes exceeded 500m. As shown in Figure 2.5-1, the stationary observation period (18z 6 September – 00z 25sep) was characterized by low cloud-base height (below 500 m). Fogs were predominant under a high-pressure situation (12 September). On the other hand, high-bese height clouds were dominated during first and last periods when cyclones closed to the ship.

Figure 2.5-2 shows frequency distribution of the cloud-base heights detected by the ceilometer. The frequency of cloud-base heights below the 500 m level was about 75% over the Arctic Ocean (black bar). However, the frequency of the cloud-base heights (below 500 m) was 85% during the stationary observation period (gray bar).

(6) Data archives

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

(7) Remarks

Window cleaning;
00:40UTC 06 Sep. 2014
17:45UTC 12 Sep. 2014
18:08UTC 22 Sep. 2014
18:04UTC 28 Sep. 2014
23:53UTC 07 Oct. 2014

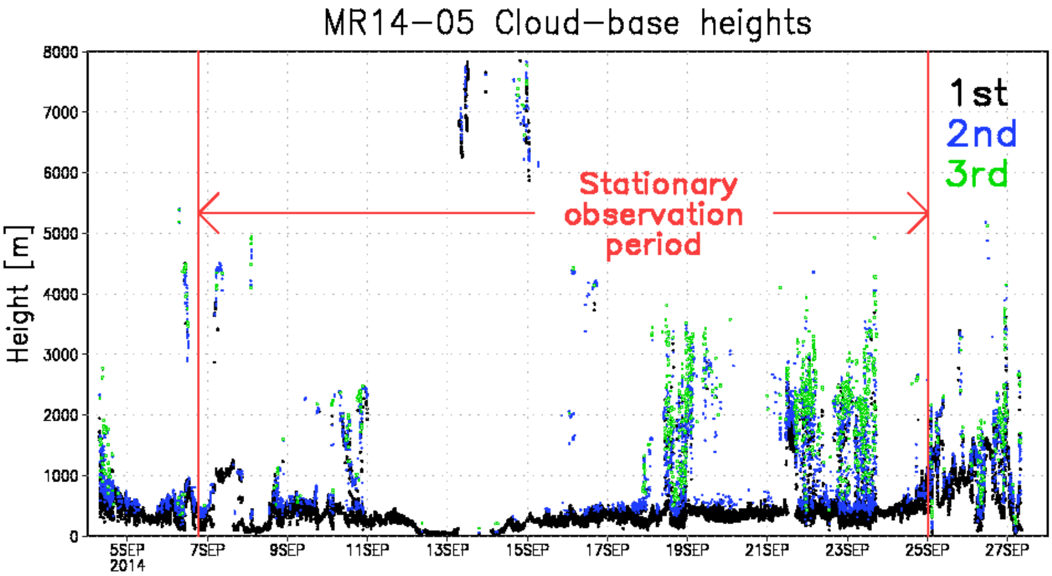


Figure 2.5-1: The time series of 1st layer (black), 2nd layer and 3rd layer (green) cloud-base heights during the Arctic cruise (north of 70 °N). Vertical lines in color denote the Stationary observation period.

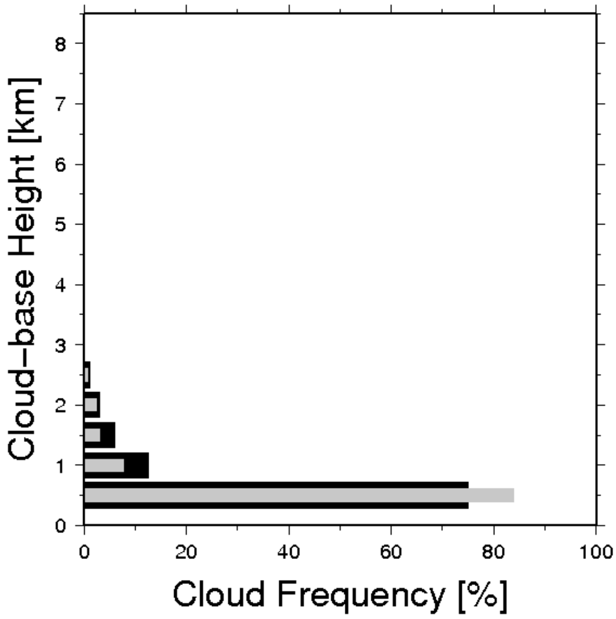


Figure 2.5-2: Frequency distributions of the cloud-base height (km) detected by a ceilometer during the Arctic cruise (north of 70 °N; black bar) and the stationary observation period (gray bar).

2.6. Lidar Observations of Clouds and Aerosols

(1) Personnel

Masaki Katsumata	JAMSTEC	- PI
Kyoko Taniguchi	JAMSTEC	- not on board

(2) Objectives

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

(3) Parameters

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

(4) Instruments and Methods

Vertical profiles of aerosols and clouds were measured with a two-wavelength lidar. The lidar employs a Nd:YAG laser as a light source which generates the fundamental output at 1064 nm and the second harmonic at 532 nm. Transmitted laser energy is typically 100 mJ per pulse at 1064 nm and 50 mJ per pulse at 532 nm. The pulse repetition rate is 10 Hz. The receiver telescope has a diameter of 20 cm. The receiver has three detection channels to receive the lidar signals at 1064 nm and the parallel and perpendicular polarization components at 532 nm. An analog-mode avalanche photo diode (APD) is used as a detector for 1064 nm, and photomultiplier tubes (PMTs) are used for 532 nm. The detected signals are recorded with a digital oscilloscope and stored on a hard disk with a computer. The lidar system was installed in the radiosonde container on the compass deck. The container has a glass window on the roof, and the lidar was operated continuously regardless of weather.

The data is obtained continuously (without intermittence) with the vertical resolution is 6 meter.

(5) Results

The data is obtained continuously through the cruise from Aug. 31 to Oct. 10. The data obtained in this cruise will be analyzed after the cruise.

(6) Data archive

The data will be archived in NIES. The data will be also submitted to JAMSTEC Data Management Group (DMG) and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC website.

2.7. Ozonesonde

(1) Personnel

Jun Inoue	JAMSTEC / NIPR	- PI
Kazuhiro Oshima	JAMSTEC	
Kazutoshi Sato	JAMSTEC / SOKENDAI	

(2) Objective

To understand time changes in ozone profile over the Arctic region, ozonesonde observation was conducted during the stationary observation period at the location of 74°45'N, 162°00'W. This is a first trial of ozonesonde observation over the Arctic Ocean on R/V Mirai.

(3) Parameters

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

(4) Instruments and Methods

Ozonesonde observations were carried out from 6th to 24th September 2014. The ozonesonde consists of Electrochemical Concentration Cell (ECC) ozonesonde (6A, Science Pump Corp.), Ozone Interface Kit (RSA921, Vaisala), and GPS radiosonde (RS92-SGPD, Vaisala). The ozonesonde was connected with 1200g balloon and parachute (TOTEX). We used software (DigiCORA III, ver.3.61), processor (SPS311), GPS antenna (GA31) and UHF antenna (RM32). Prior to launch, ozone sensor was calibrated by using ECC Ozonesonde Ozonizer/Test Unit TSC-1 (Science Pump Corp.), and pressure, air temperature, and humidity sensors were calibrated by using the calibrator system (GC25 and PTB330, Vaisala).

(5) Station list

Table 2.7-1 summarizes the log of the soundings. Raw data was recorded as binary format during ascent. ASCII data was converted from raw data.

Table 2.7-1: Launch log

ID	Date	Latitude	Longitude	Psfc	Tsfc	RHsfc	WD	Wsp	SST	Max height		
	YYYYMMDDHH	degN	degE	hPa	degC	%	deg	m/s	degC	hPa	m	Duration
OS001	2014090622	74.76	-161.99	1016.7	1.3	99	212	10.3	0.50	13.7	29104	3928
OS002	2014090822	74.78	-161.95	1011.7	-0.1	96	281	9.3	0.83	89.8	16813	2346

OS003	2014091022	74.80	-162.02	1025.2	-1.0	93	354	3.3	0.25	99.8	16148	2234
OS004	2014091222	74.79	-162.06	1020.7	-2.4	99	305	1.9	-0.07	10.9	30516	4332
OS005	2014091422	74.81	-162.02	1019.4	-1.1	94	101	10.7	0.08	42.9	21641	3372
OS006	2014091622	74.79	-162.07	1012.5	-1.5	89	50	10.7	-0.14	11.9	29805	4672
OS007	2014091822	74.78	-162.10	1010.5	-0.9	86	79	12.6	0.26	7.8	32435	5102
OS008	2014092022	74.70	-161.99	1015.6	-3.3	86	91	11.0	0.10	8.3	31949	5284
OS009	2014092221	74.73	-162.00	1002.6	-2.2	92	53	5.0	-0.07	8.2	32075	4924
OS010	2014092422	74.72	-162.22	1004.5	-1.8	80	337	3.8	-0.16	12.6	29254	4578

(6) Preliminary results

We launched ten ozonesondes every other day from 6th to 24th September 2014 at the stationary observation point (74°45'N, 162°00'W). Vertical profiles of ozone up to about 30 km were obtained and those maximum peaks were about 19-20km. Total ozone ranges from 250 – 290 DU, which are quantitatively consistent with satellite observation. Time change in ozone was large in mid-stratosphere (21-26km). The large changes associated with transition of the tropopose and some changes in the troposphere were also observed during this observation period. We will examine relationship between those ozone changes and atmospheric circulation in the stratosphere and troposphere, and effect of ozone changes on the solar radiation.

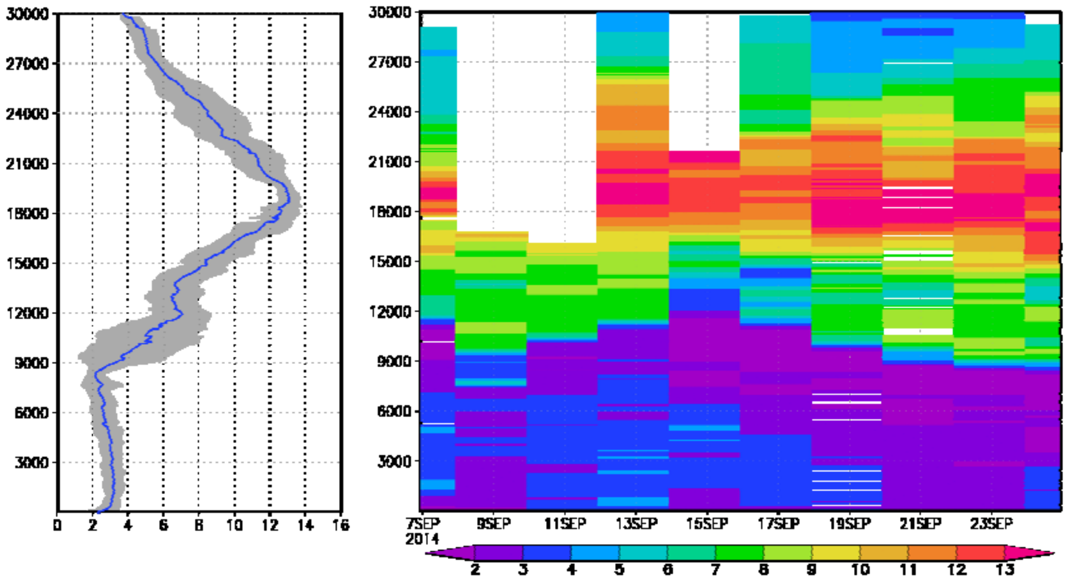


Figure 2.7-1: Vertical profile of ozone. (Left panel) average of ten ozone profiles (blue solid line) and those standard deviation (gray shade). (Right panel) time-height cross section of ozone during the stationary observation period. Those units are mPa.

(7) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC web site.

2.8. HYVIS

(1) Personnel

Masaki Katsumata	JAMSTEC	- PI
Shuichi Mori	JAMSTEC	
Ryuichi Shirooka	JAMSTEC	- not on board
Biao Geng	JAMSTEC	- not onboard
Katsuhisa Maeno	GODI	
Soichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Koichi Inagaki	GODI	
Miki Morioka	GODI	
Ryo Kimura	MIRAI Crew	

(2) Objective

We conducted HYdrometer VIdeo Sonde (HYVIS) observations for validation of the newly installed C-band dual polarimetric Doppler radar system (see 2.2). The HYVIS obtains sequential images of raindrops, snow crystals, and other ice particles in and out of clouds up to approximately 20 km high from the sea surface as well as profiles of pressure, temperature, relative humidity, wind direction, and wind speed. The profiles of hydrometer images and atmospheric conditions are utilized as in situ data to validate dual polarimetric parameters and hydrometer identification (or classification) function observed with the C-band dual polarimetric Doppler radar.

(3) Parameters

Hydrometer images (microscopic and close up)
Pressure
Temperature
Relative humidity
Wind speed and direction

(4) Instruments and Methods

Ten (10) HYVISs were launched during 07 and 27 September 2014 only when we identified rainclouds covered over the R/V Mirai by the C-band dual polarimetric Doppler radar. HYVIS observation system consists of a Meisei HYVIS receiver/antenna controller, a 1680 MHz Yagi antenna for video image signals, HYVIS transmitters

(Meisei WUA-11: standard and suction types), and 1,200 g balloons (Totex TA-1200). Each The HYVIS transmitter was launched with a GPS rawinsondes transmitter (Meisei RS-06G) by the same balloon. The GPS rawinsondes signals were received by a receiver/signal processor (Meisei RD-08AC) with MGPS_R software through a 400 MHz omnidirectional whip antenna. Azimuth elevation angles of 1680 MHz Yagi antenna was automatically controlled to direct the HYVIS transmitter based on geolocation and height of the RS-06G transmitter detected by the RD-08AC receiver.

The HYVIS transmitter has two charge-coupled device (CCD) video cameras: one is a close-up camera and the other is a microscopic one. The former (latter) has a size of 7.00 mm x 5.25 mm (1.200 mm x 0.90 mm). The video images are sent every 10 sec by a sequence of 7 sec microscopic image, 1 sec blank, and 3 sec close-up one. The minimum detectable particle size is approximately 10 micro m by the microscopic camera. Received images are recorded by digital time-laps video software (5 fps).

In addition, we launched experimentally launched a Video Sonde, which was handcrafted by Prof. Kenji SUZUKI (Yamaguchi University), instead of HYVIS with the RS-06G transmitter and RD-08AC receiver system.

(5) Observation log

See Table 2.8-1 "HYVIS launch log with surface observation and maximum sounding height".

(6) Preliminary results

We successfully received image data from eight (8) HYVISs and one (1) Video Sonde, and failed to receive any data from two (2) HYVISs (suction type) because of trouble with RS-06G GPS rawinsondes transmitters with them. The cause of trouble has been under investigation by theRS-06G manufacture company (Meisei Electric Co., Ltd.).

Figures 2.8-1 to 2.8-37 show NOAA Ch.4 and radar reflectivity (ZH) images at the time close to HYVISs (No.01-08) were launched, temperature, relative humidity, supersaturated water vapor density on the ice surface, wind direction and speed obtained by RS-06G GPS rawinsondes, and typical hydrometer images obtained by HYVIS microscopic camera.

Further analyses of HYVIS images, e.g., hydrometer classification, drop size distribution, and number density, will be performed after the cruise for the validation of polarimetric parameters obtained by the C-band dual polarimetric Doppler radar.

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group

(DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC web site.

Table 2.8-1: HYVIS launch log with surface observation and maximum sounding height

No.	Date(YYYY/MMDD) Time (HH:MM:SS)UTC	Lat(degN) Lon(degW)	HYVIS S/N (Type) RS-06G S/N	Psfc (hPa)	Tsfc (degC)	RHsfc (%)	WD (deg) WS (m/s)	SFC WX	Max Alt (m)	Remarks
01	2014/0907 22:48:12	74.800 162.0456	35032 (Standard) 404113	1004.8	2.3	100	201 13.1	-RA	32,057	
02	2014/0910 19:40:19	74.864 162.045	35033 (Standard) 404114	1025.2	-1.2	92	016 2.3	-SN	13,153	
03	2014/0917 21:51:40	74.856 162.005	35034 (Standard) 40116	1008.2	-1.0	95	066 11.1	SHSN	30,511	
04	2014/0918 17:33:52	74.751 162.019	35012 (Suction) 404124	1009.3	-1.5	96	074 12.0	SHSN	31,672	
05	2014/0918 21:48:04	74.688 162.231	35014 (Suction) 404126	1009.9	-1.4	94	069 13.3	SHSN	32,851	
06	2014/09/22 19:26:28	74.749 161.987	35035 (Standard) 404118	1002.5	-2.5	92	046 4.6	SN	20,336	
Ext.	2014/09/22 21:52:17	74.709 161.961	(Video Sonde) 404117	1001.9	-2.2	92	061 5.8	-SN	16,327	
07	2014/09/26 09:56:10	72.865 168.449	35036 (Standard) 404119	1018.5	1.0	95	184 3.8	SHSN GS	17,732	
08	2014/09/27 12:42:30	69.330 168.847	35037 (Suction) 404125	1005.1	5.5	98	161 17.1	RA	21,147	
09	2014/09/27 16:03:06	69.013 168.844	35015 (Suction) 404127	1001.2	5.3	99	157 15.1	RA	---	Data not received
10	2014/09/27 17:34:00	68.974 168.974	35016 (Suction) 290127	1000.4	5.4	100	171 13.2	RA	---	Data not received

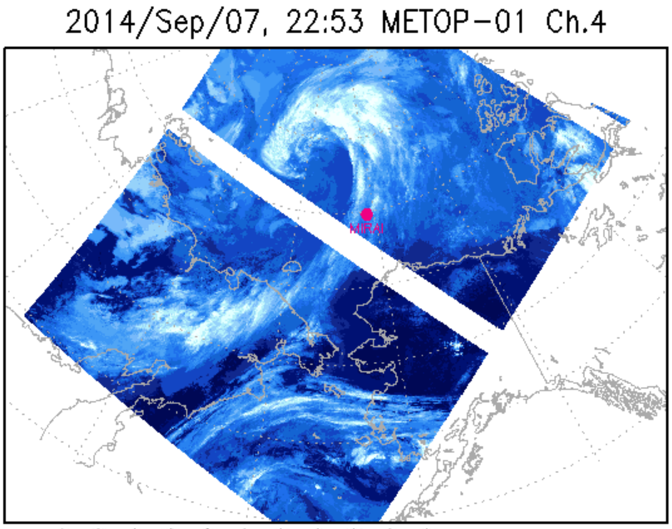


Figure 2.8-1: NOAA Ch.4 image at the time close to HYVIS No.01 was launched.

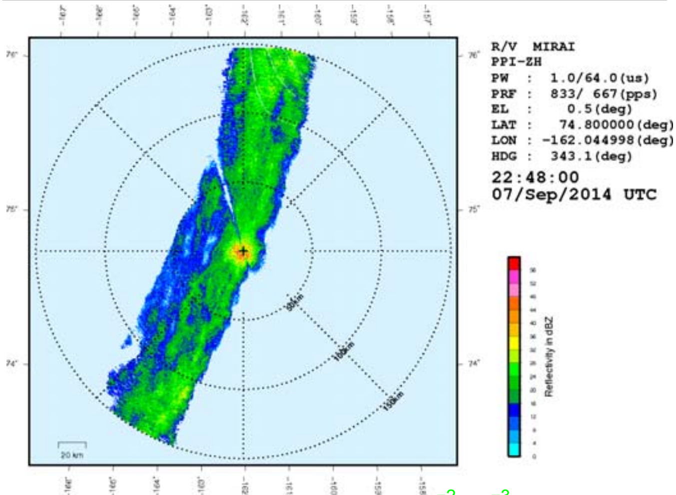


Figure 2.8-2: Radar reflectivity (ZH) at the time close to HYVIS No.01 was launched.

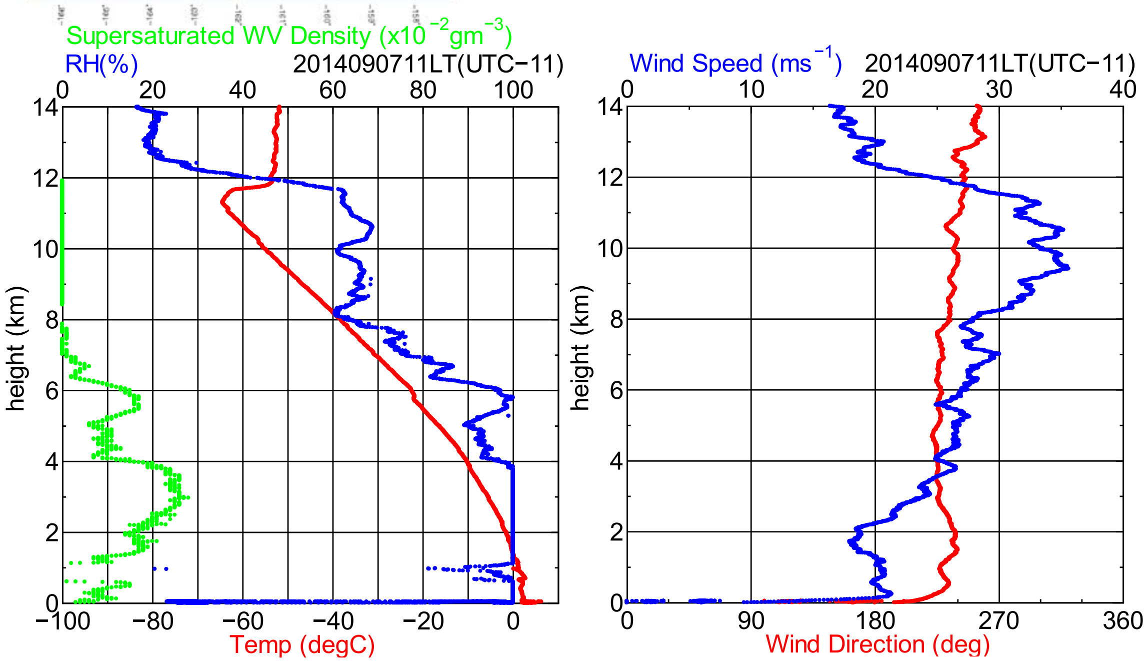


Figure 2.8-3: Temperature, relative humidity, supersaturated water vapor density on the ice surface (left panel), and wind direction and speed (right panel) obtained by RS-06G GPS rawinsondes launched with HYVIS No.01.

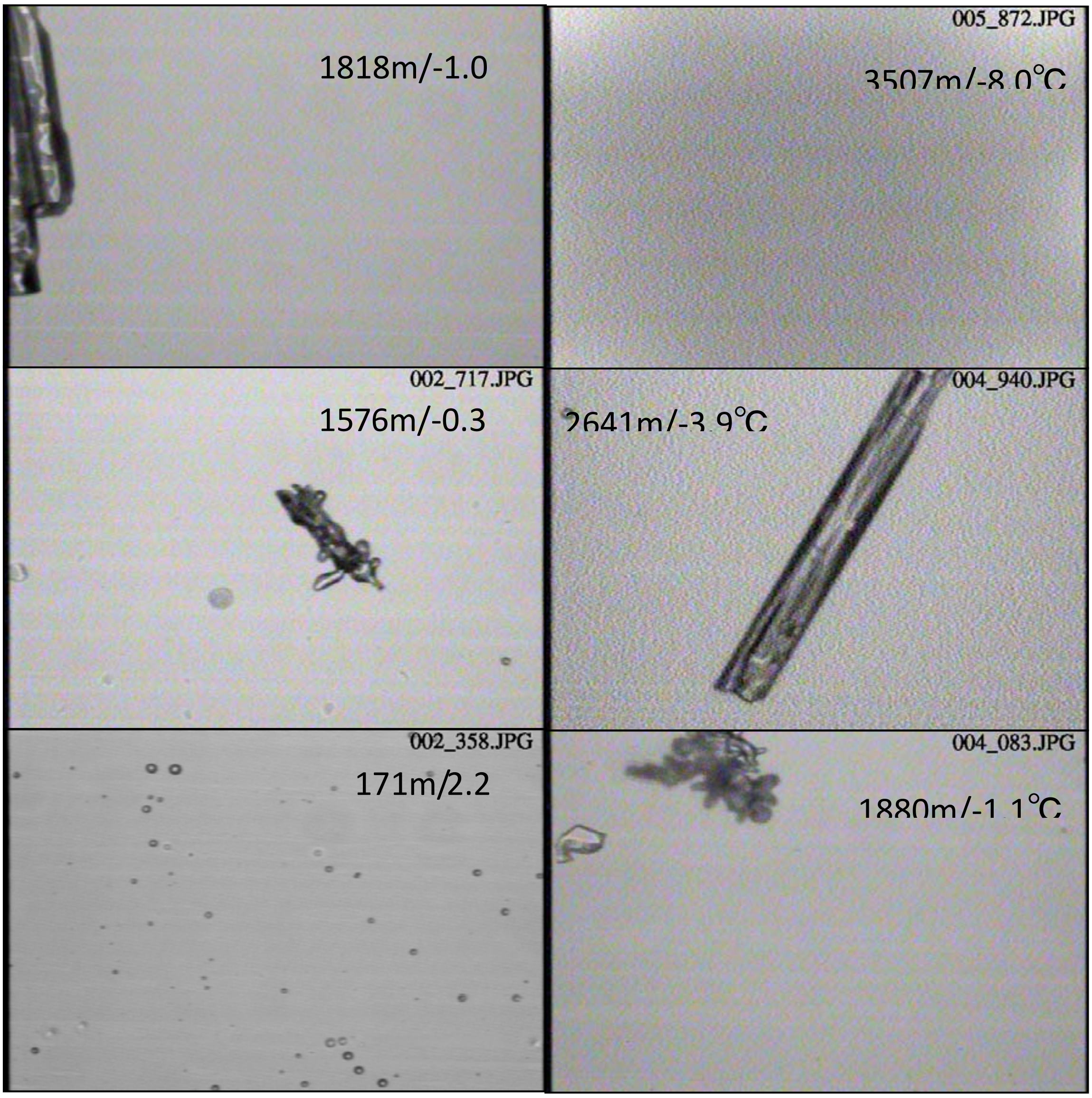


Figure 2.8-4: Typical hydrometer images obtained by HYVS No.01 microscopic camera (1.20 mm x 0.90 mm). The. Heights and temperatures superimposed in the each panel show those at the time when the HYVIS images were recorded.

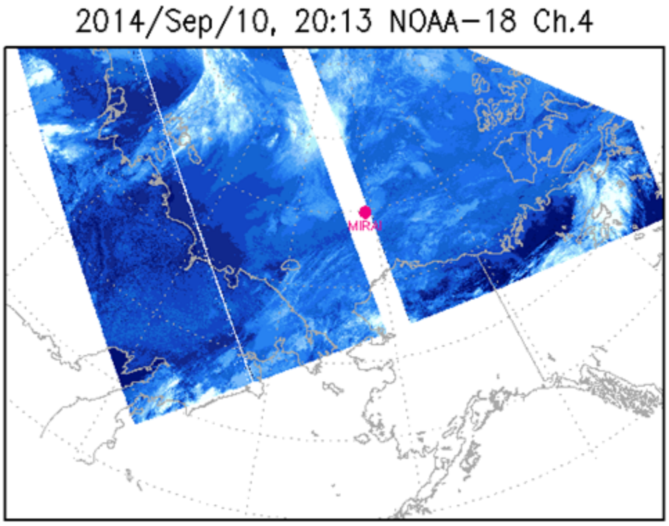


Figure 2.8-5: Same as Fig. 2.8-1 except for HYVIS No.02.

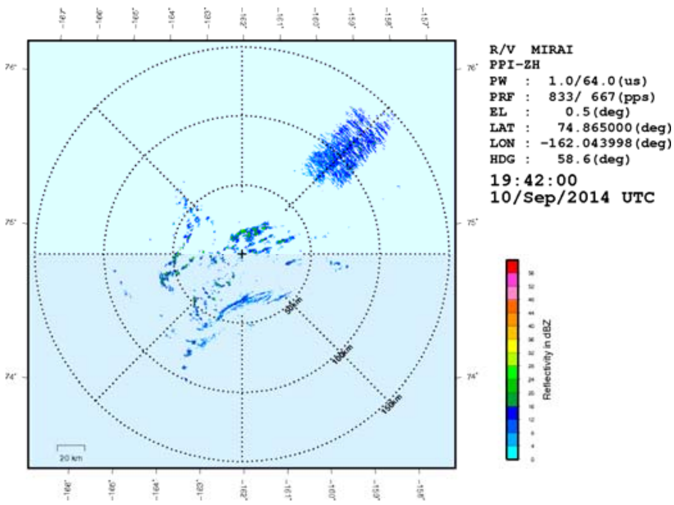


Figure 2.8-6: Same as Fig. 2.8-2 except for HYVIS No.02.

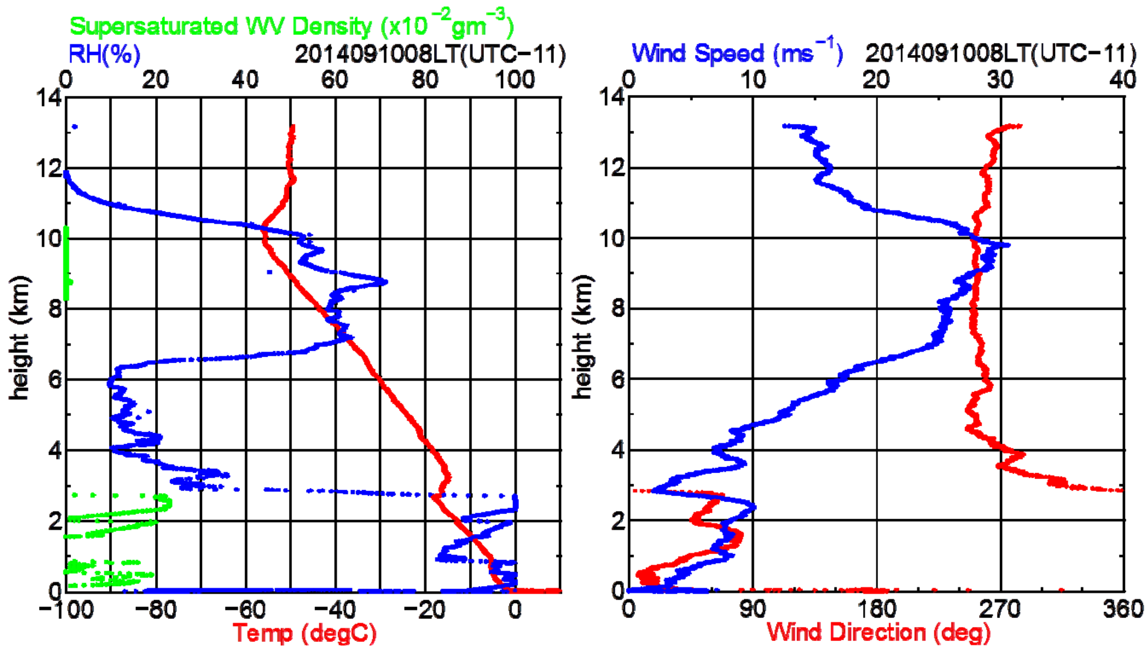


Figure 2.8-7: Same as Fig. 2.8-3 except for HYVIS No.02.

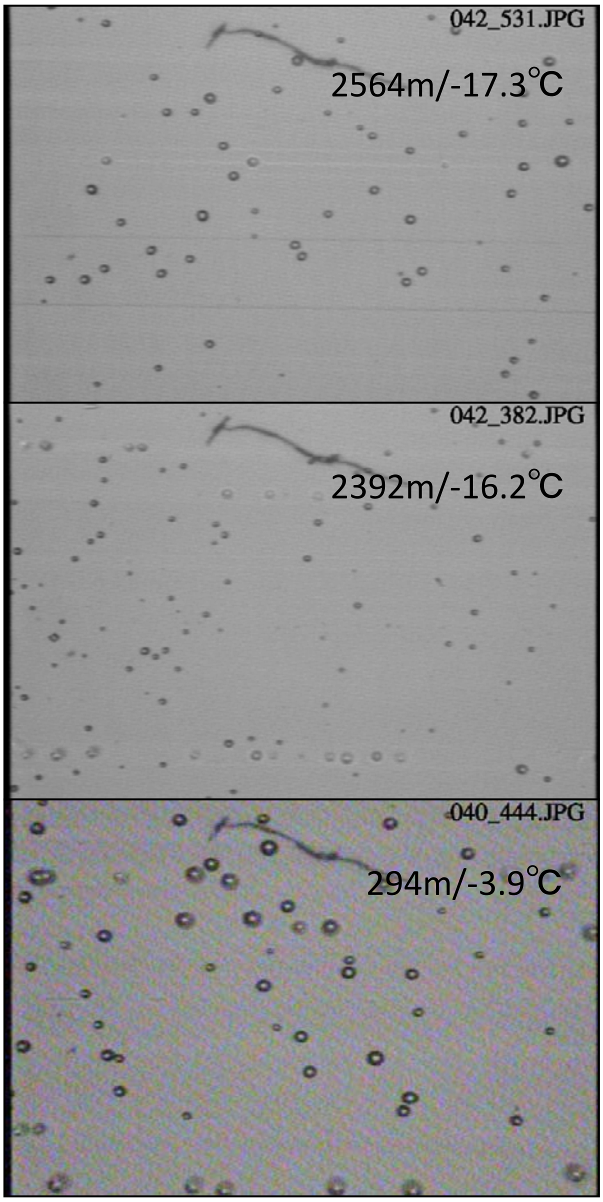


Figure 2.8-8: Same as Fig. 2.8-4 except for HYVIS No.02.

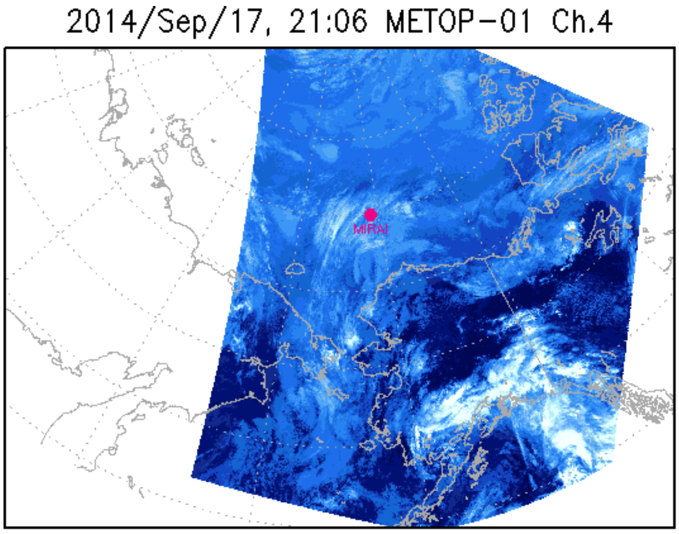


Figure 2.8-9: Same as Fig. 2.8-1 except for HYVIS No.03.

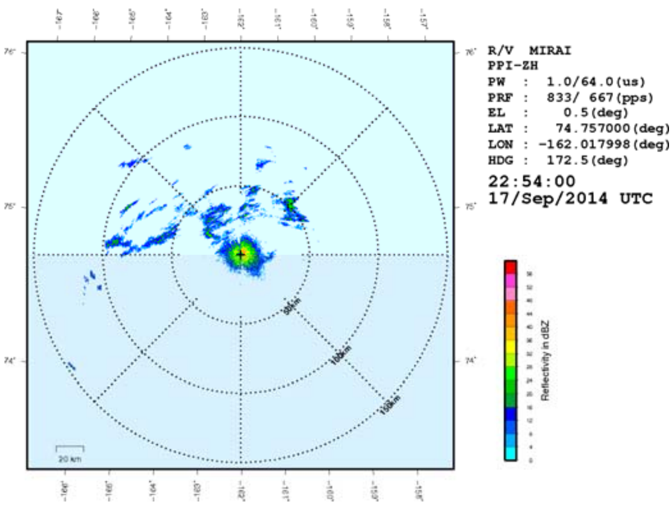


Figure 2.8-10: Same as Fig. 2.8-2 except for HYVIS No.03.

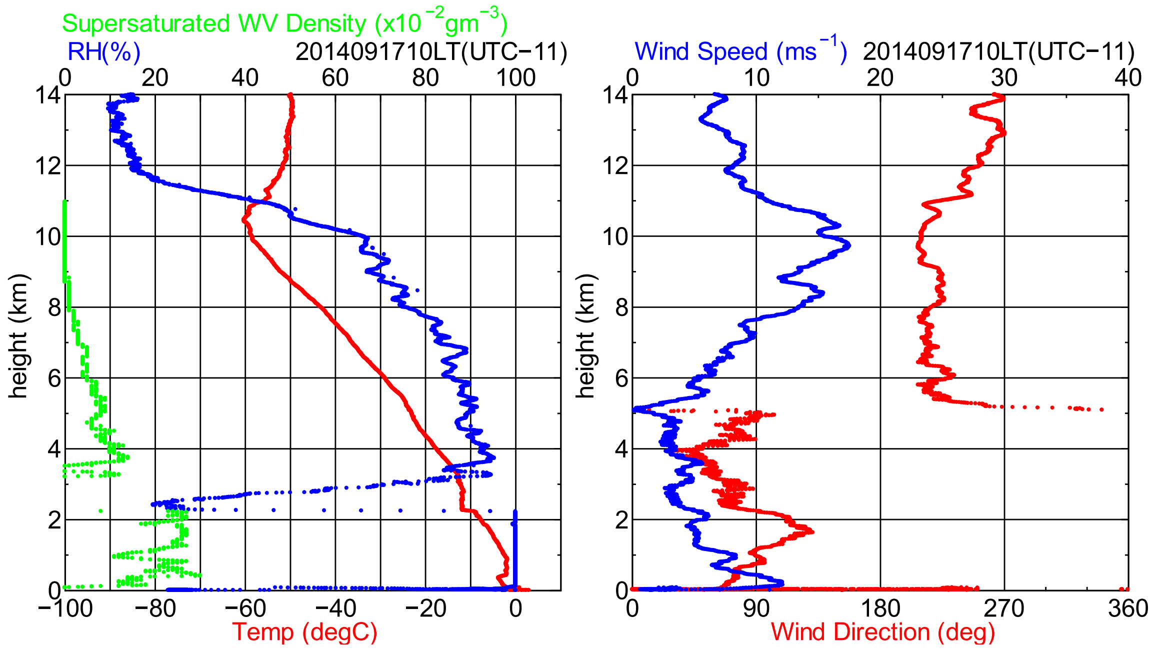


Figure 2.8-11: Same as Fig. 2.8-3 except for HYVIS No.03.

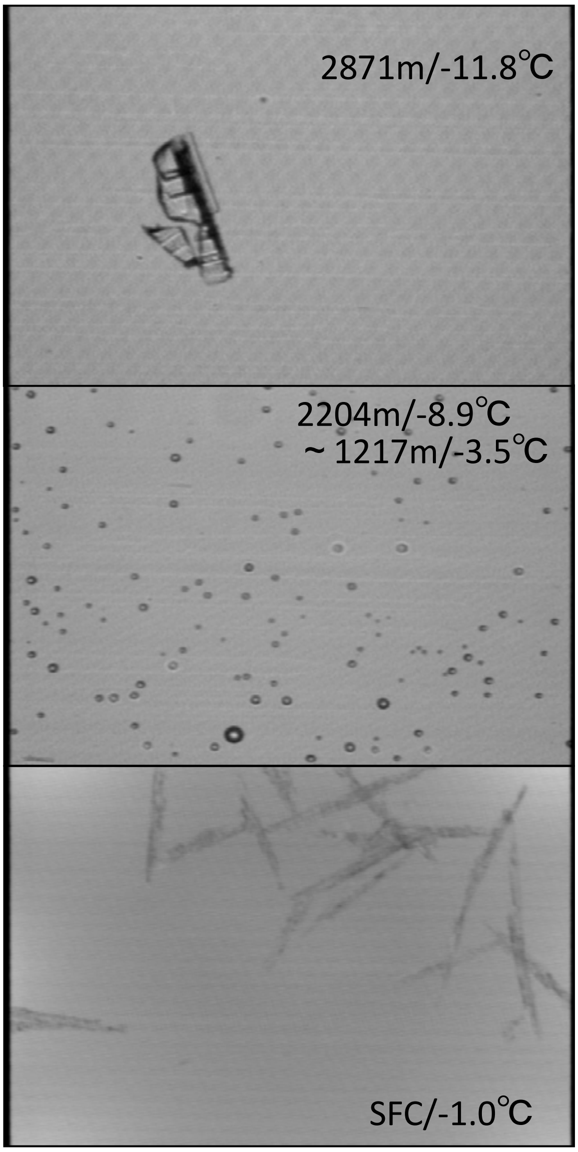


Figure 2.8-12: Same as Fig. 2.8-4 except for HYVIS No.03.

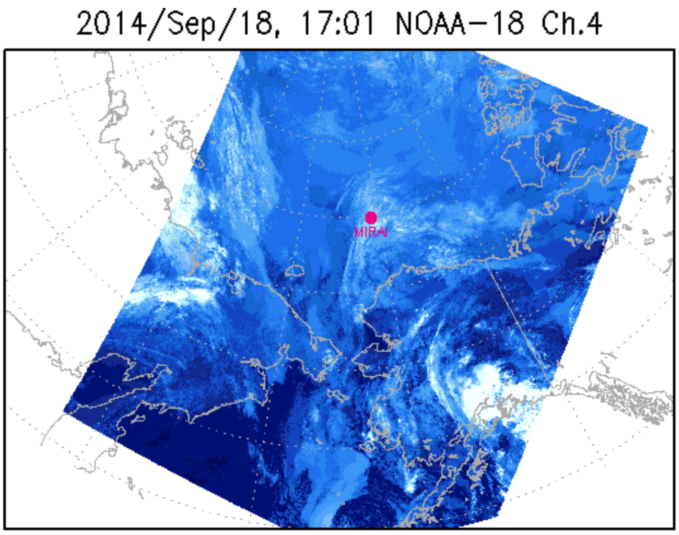


Figure 2.8-13: Same as Fig. 2.8-1 except for HYVIS No.04.

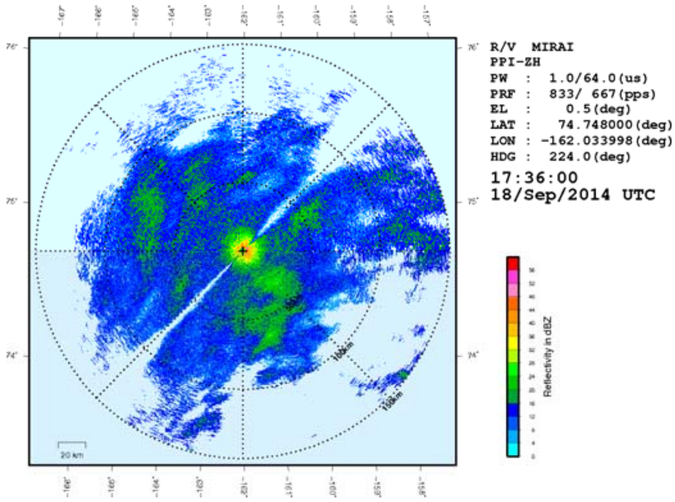


Figure 2.8-14: Same as Fig. 2.8-2 except for HYVIS No.04.

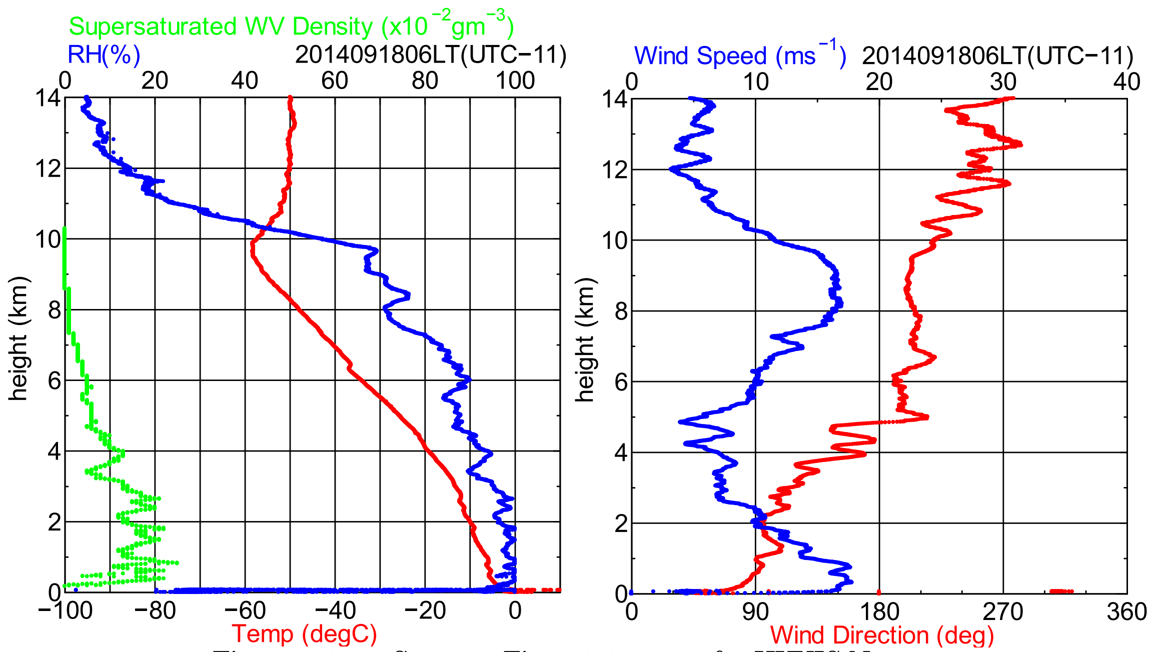


Figure 2.8-15: Same as Fig. 2.8-3 except for HYVIS No.04.

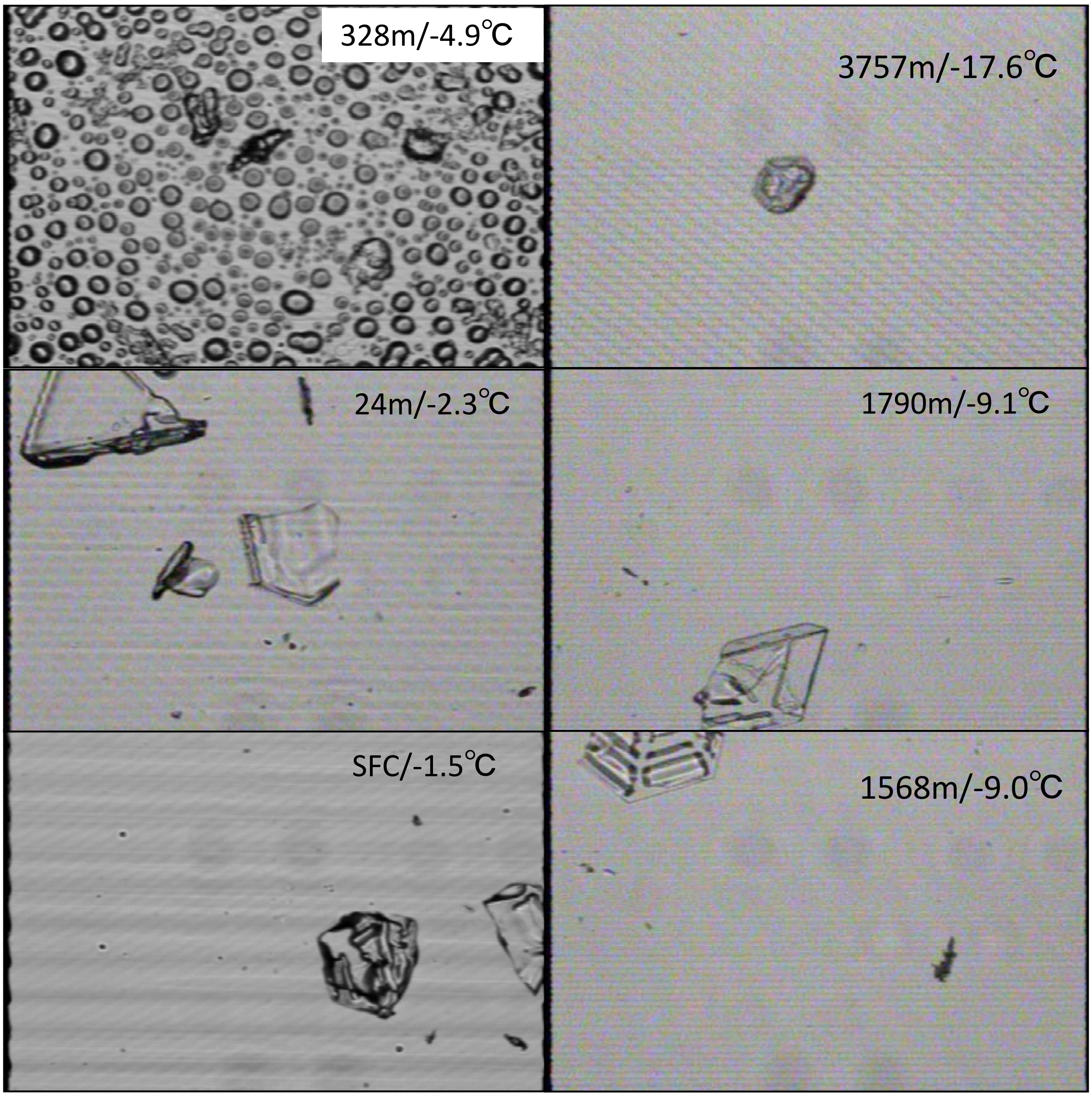


Figure 2.8-16: Same as Fig. 2.8-4 except for HYVIS No.04.

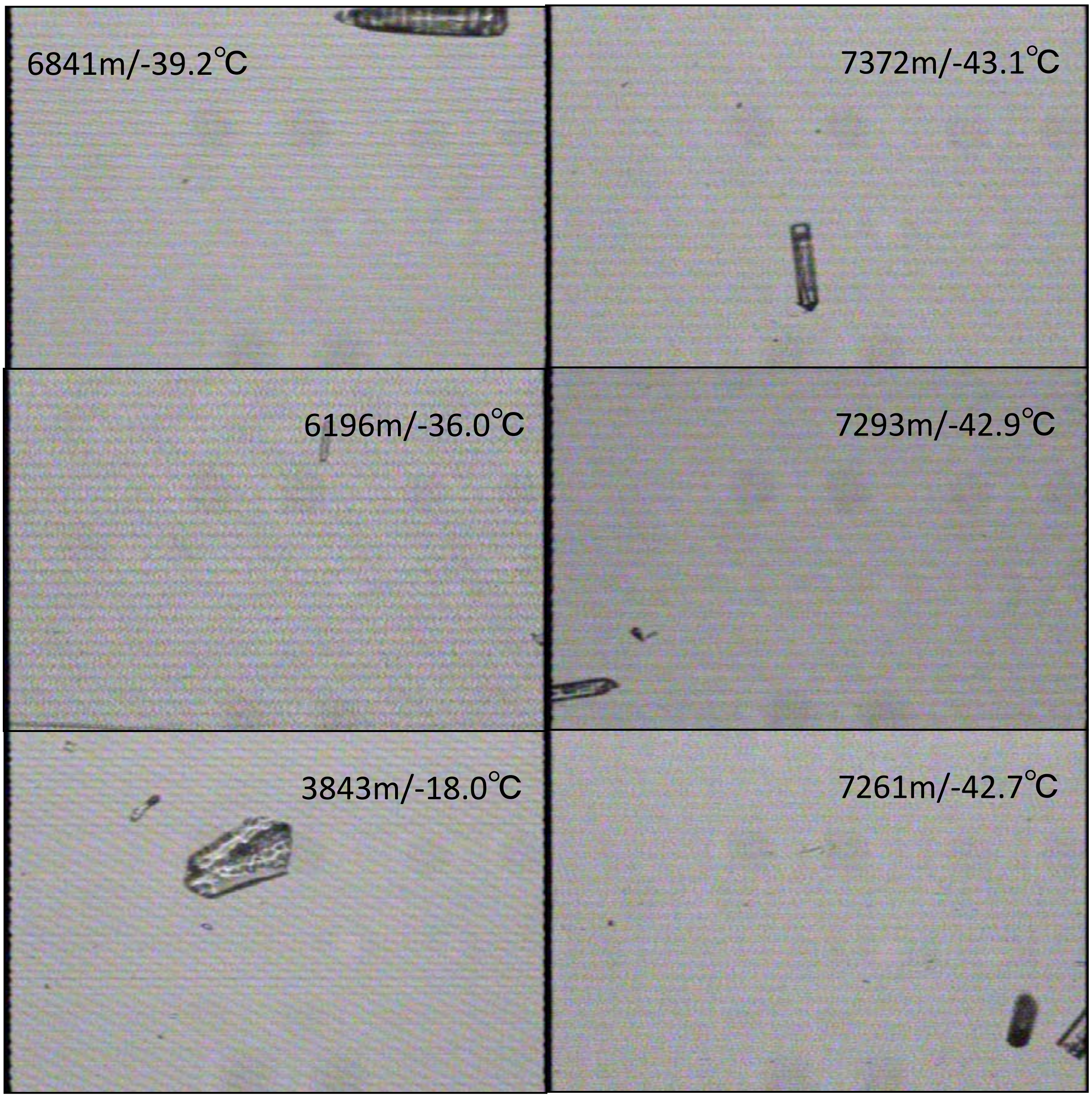


Figure 2.8-17: Same as Fig. 2.8-4 except for HYVIS No.04.

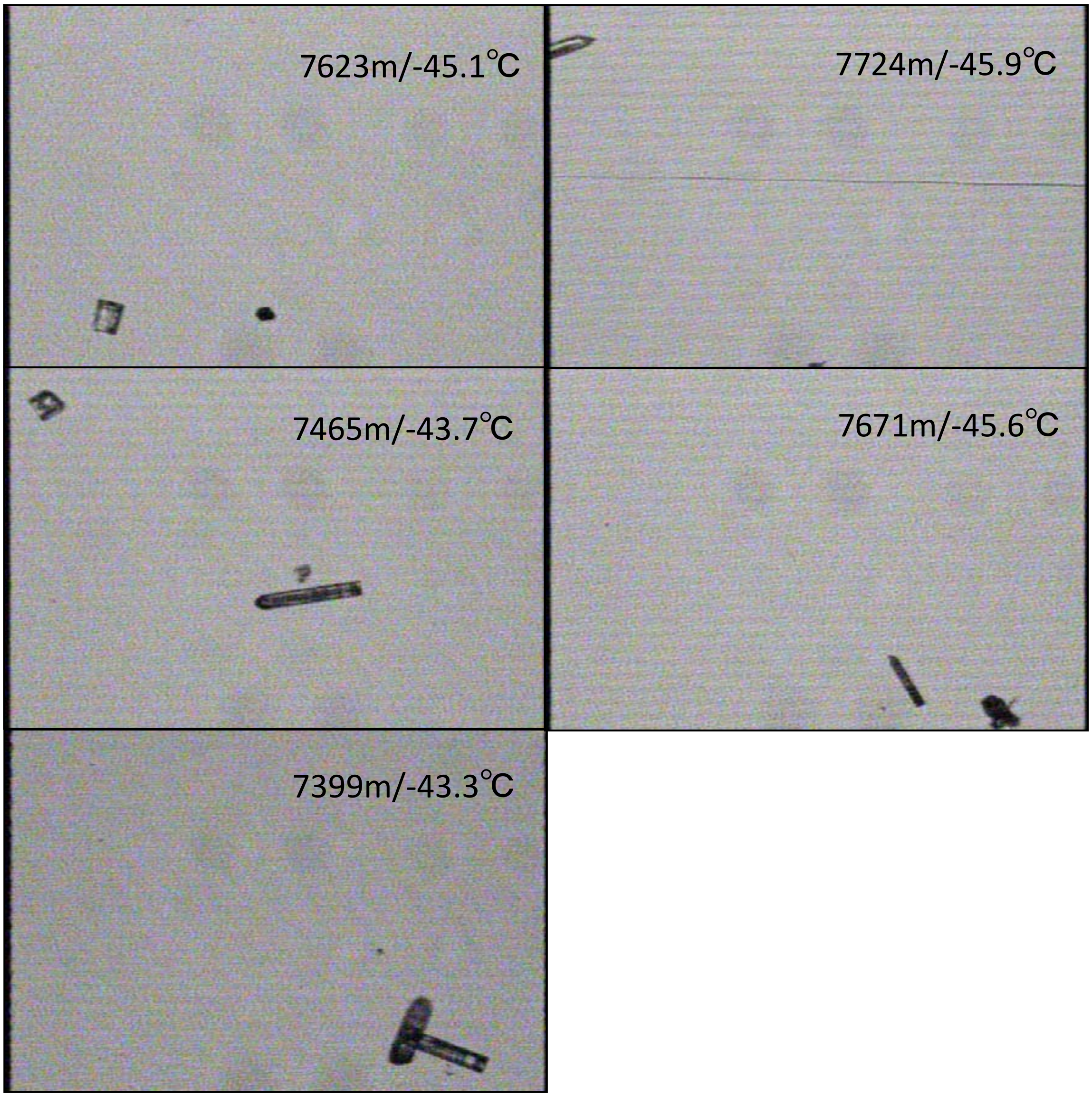


Figure 2.8-18: Same as Fig. 2.8-4 except for HYVIS No.04.

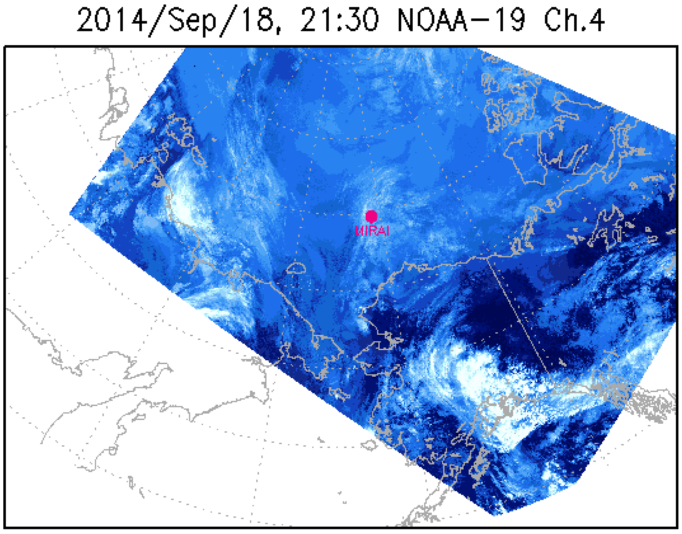


Figure 2.8-19: Same as Fig. 2.8-1 except for HYVIS No.05.

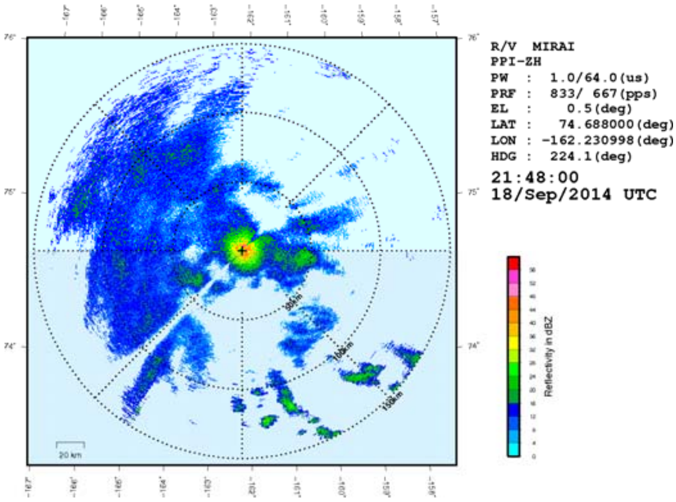


Figure 2.8-20: Same as Fig. 2.8-2 except for HYVIS No.05.

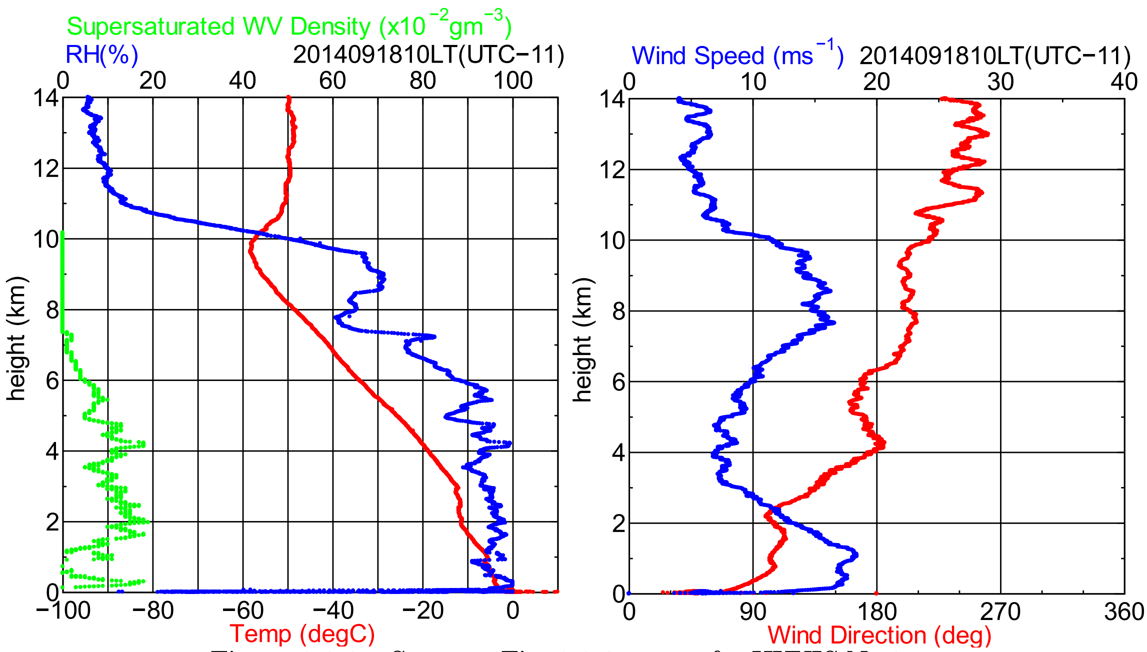


Figure 2.8-21: Same as Fig. 2.8-3 except for HYVIS No.05.

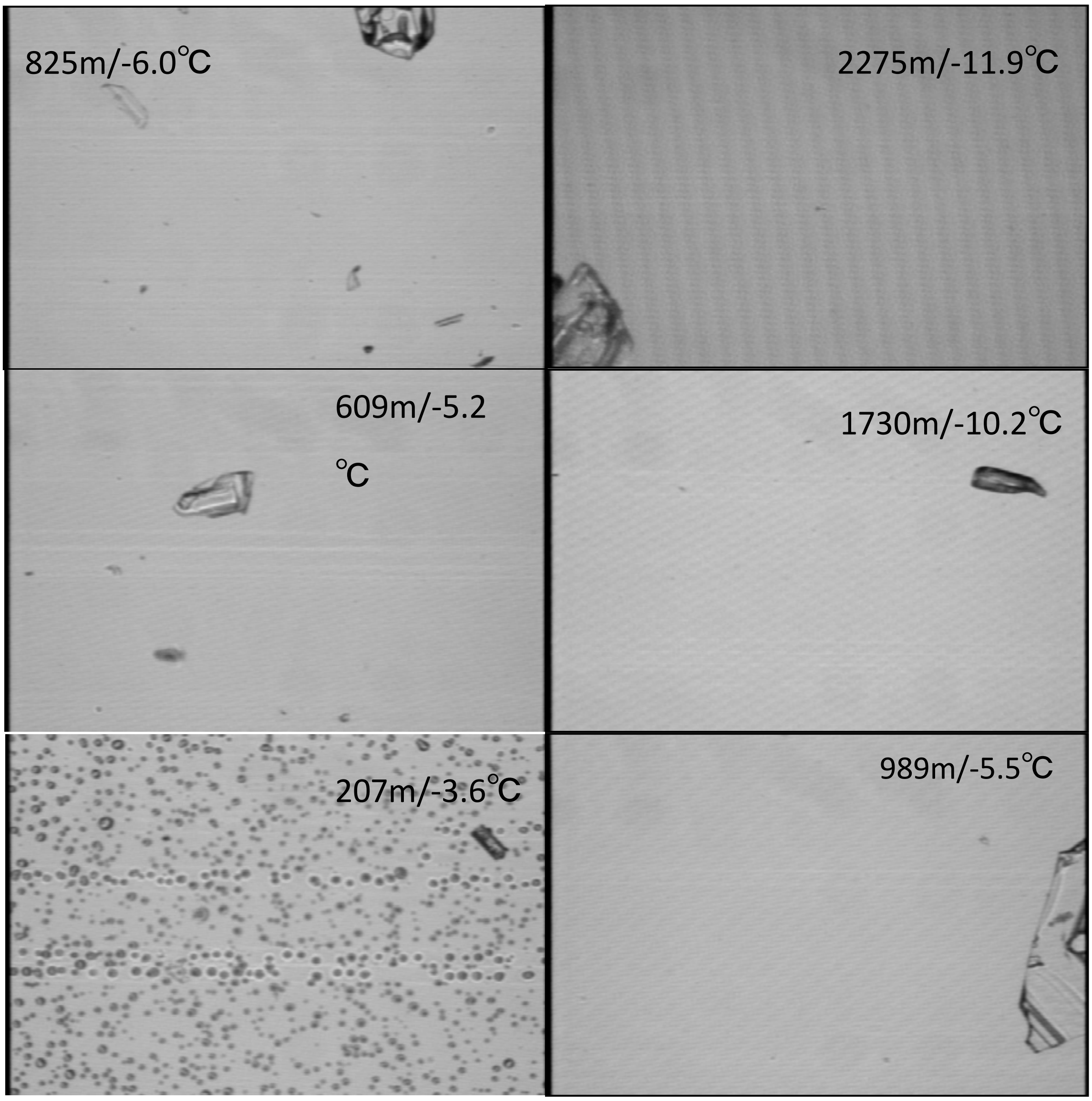


Figure 2.8-22: Same as Fig. 2.8-4 except for HYVIS No.05.

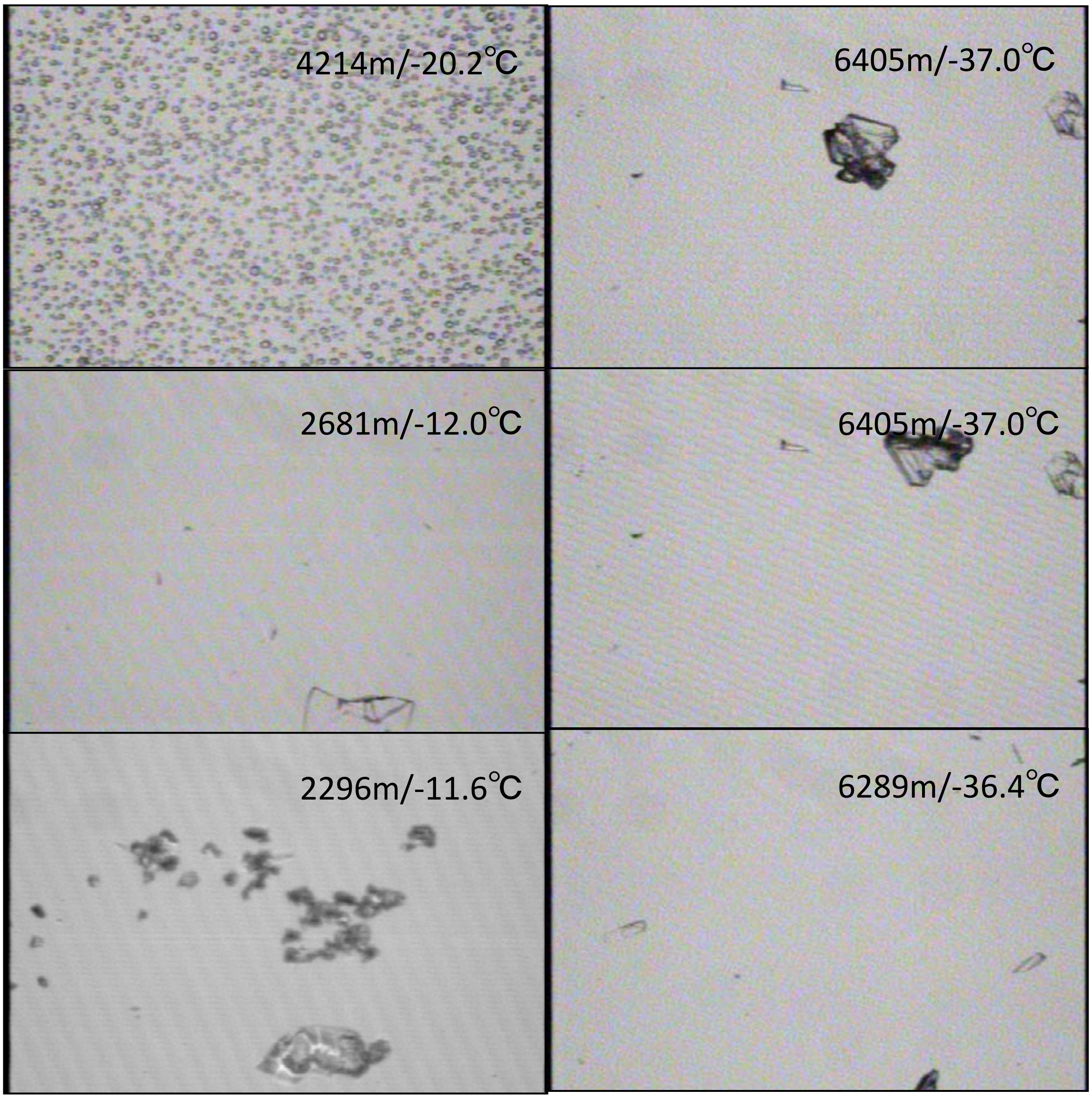


Figure 2.8-23: Same as Fig. 2.8-4 except for HYVIS No.05.

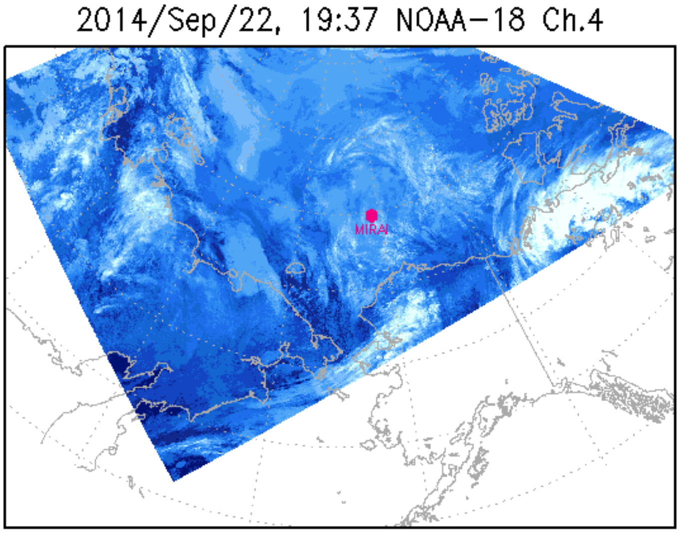


Figure 2.8-24: Same as Fig. 2.8-1 except for HYVIS No.06.

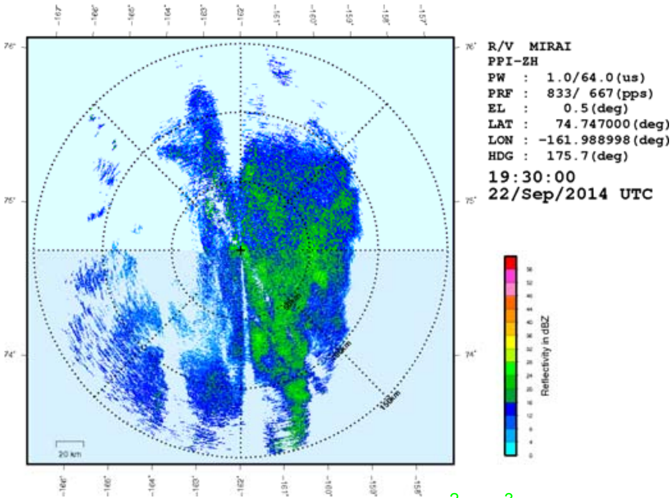


Figure 2.8-25: Same as Fig. 2.8-2 except for HYVIS No.06.

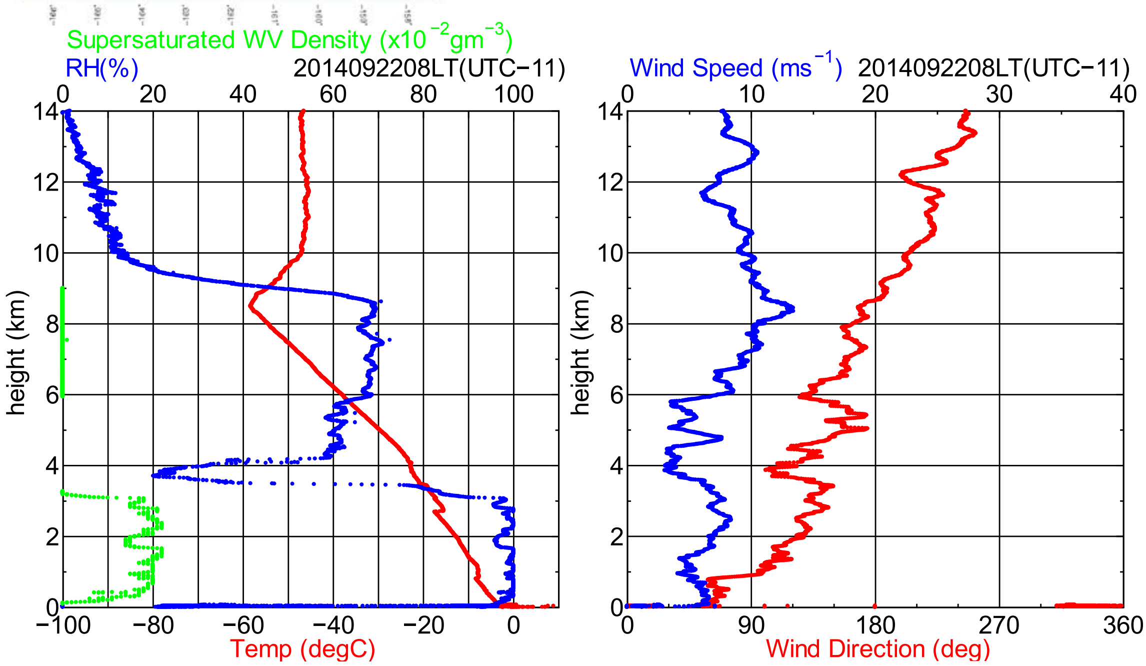


Figure 2.8-26: Same as Fig. 2.8-3 except for HYVIS No.06.

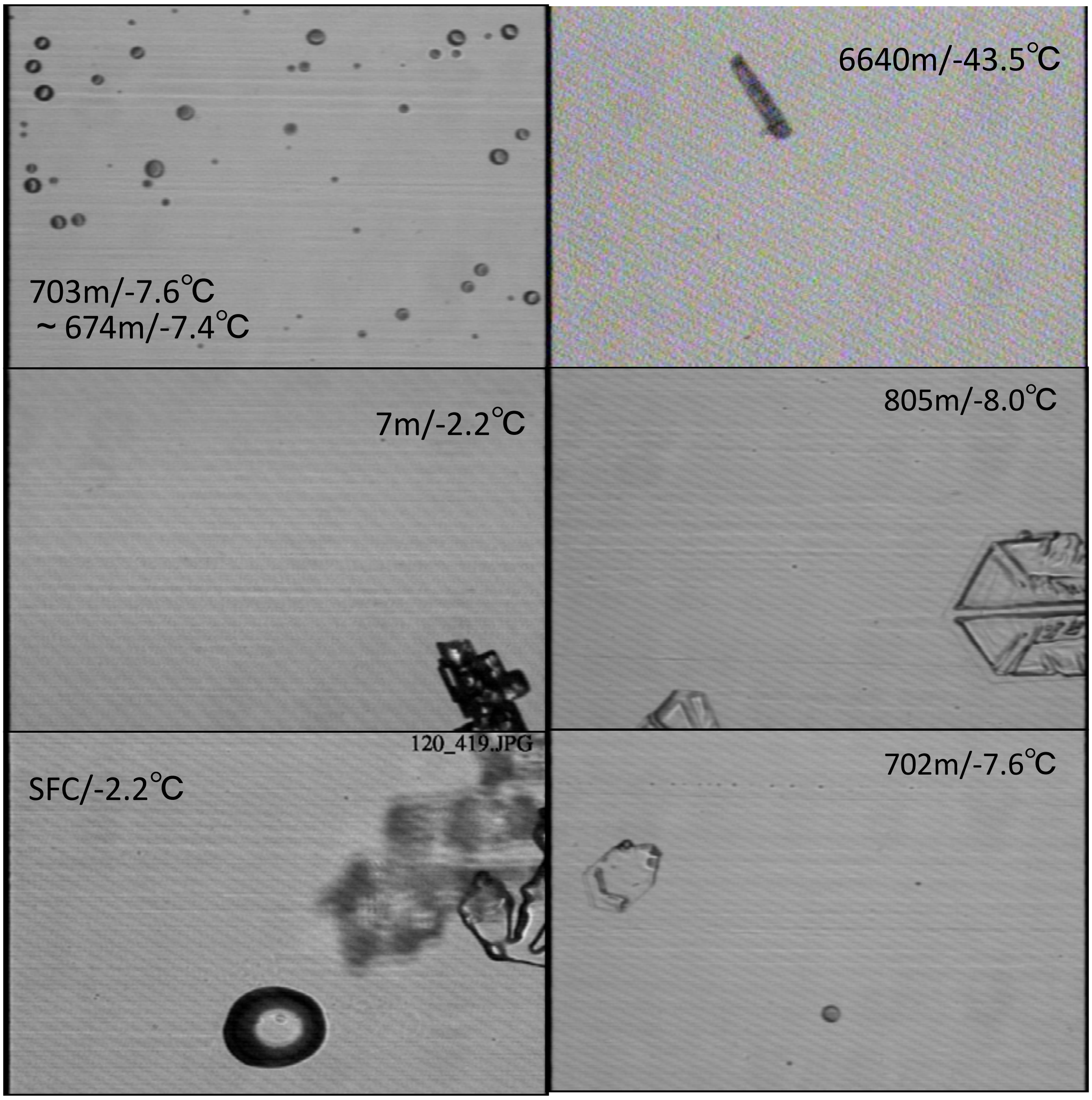


Figure 2.8-27: Same as Fig. 2.8-4 except for HYVIS No.06.

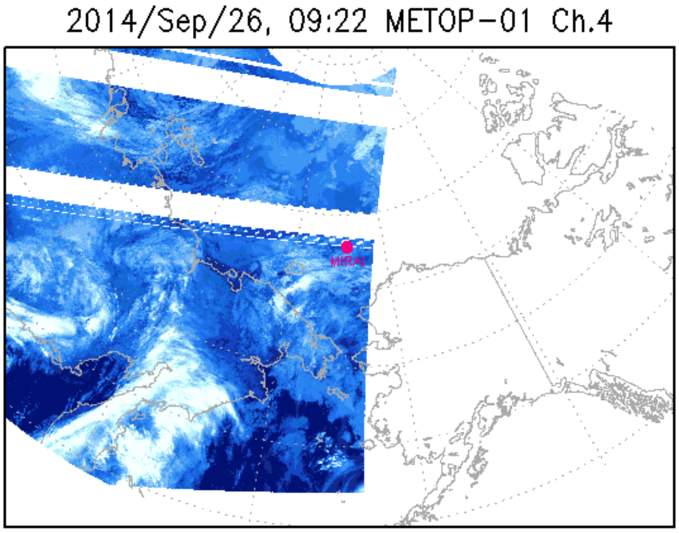


Figure 2.8-28: Same as Fig. 2.8-1 except for HYVIS No.07.

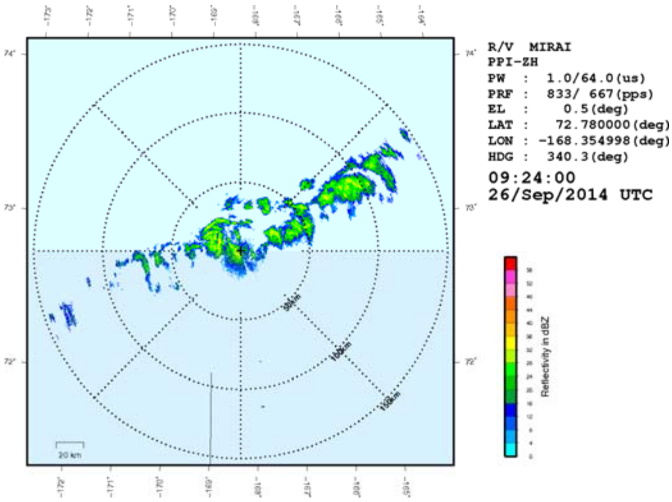


Figure 2.8-29: Same as Fig. 2.8-2 except for HYVIS No.07

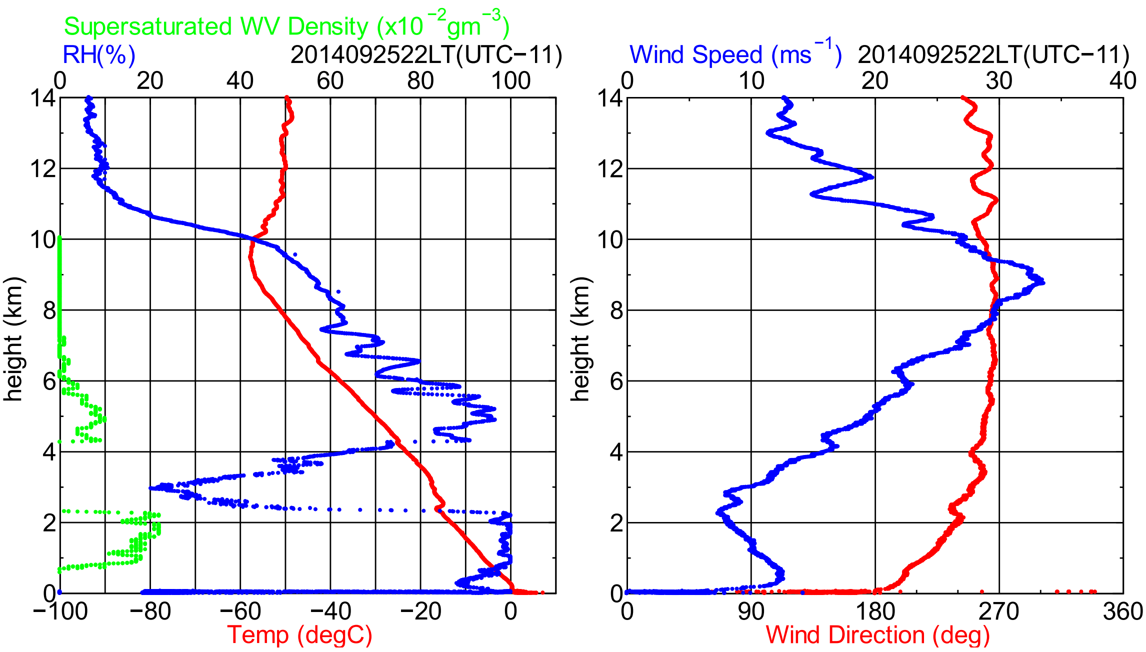


Figure 2.8-30: Same as Fig. 2.8-3 except for HYVIS No.07.

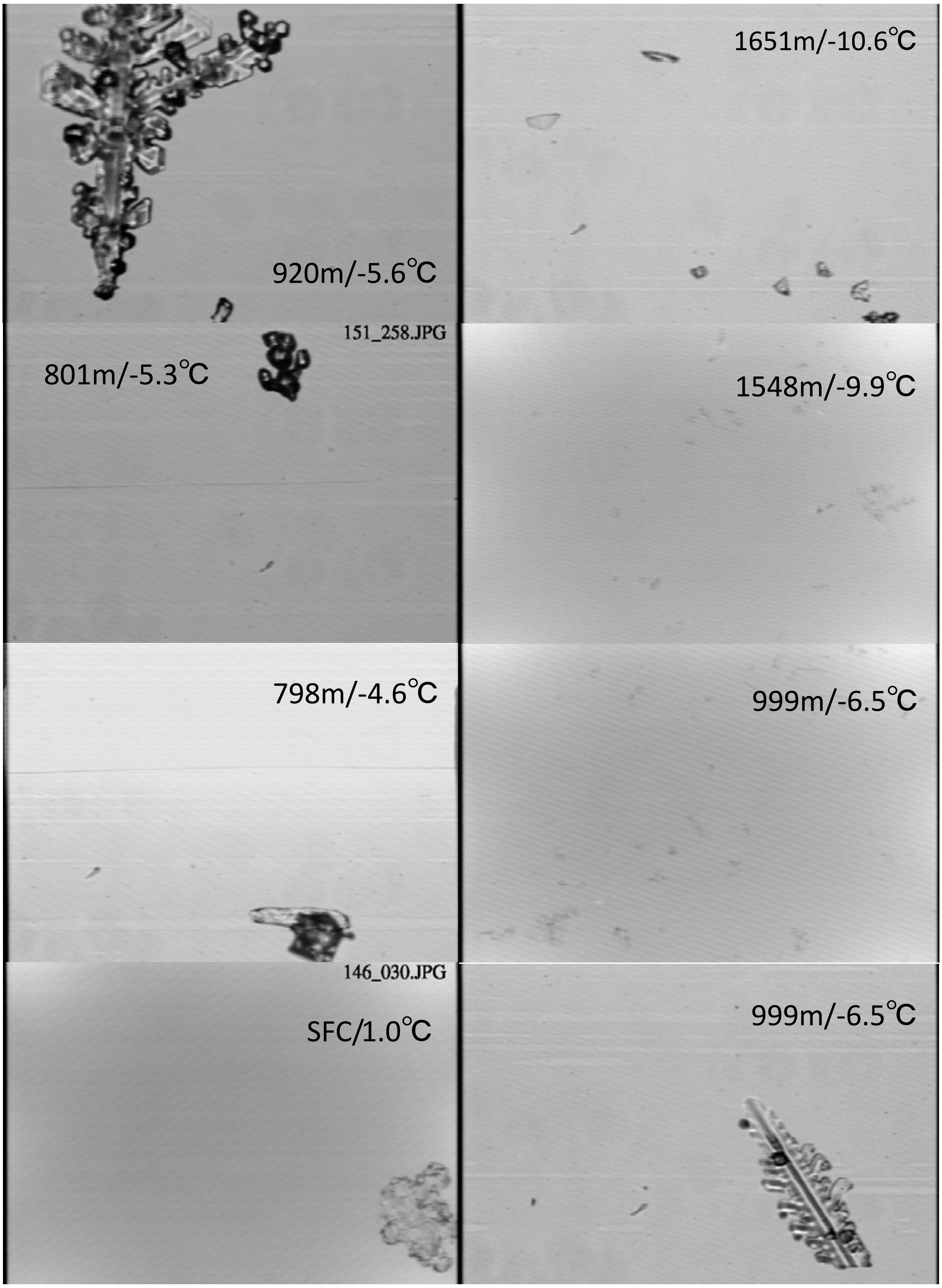


Figure 2.8-31: Same as Fig. 2.8-4 except for HYVIS No.07.

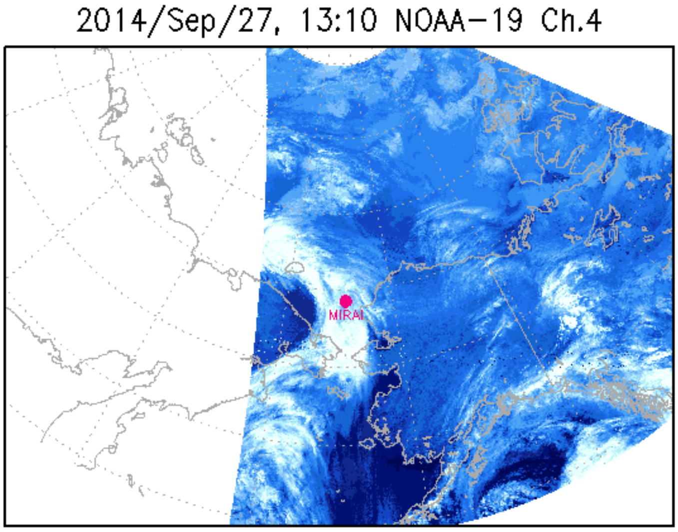


Figure 2.8-32: Same as Fig. 2.8-1 except for HYVIS No.08.

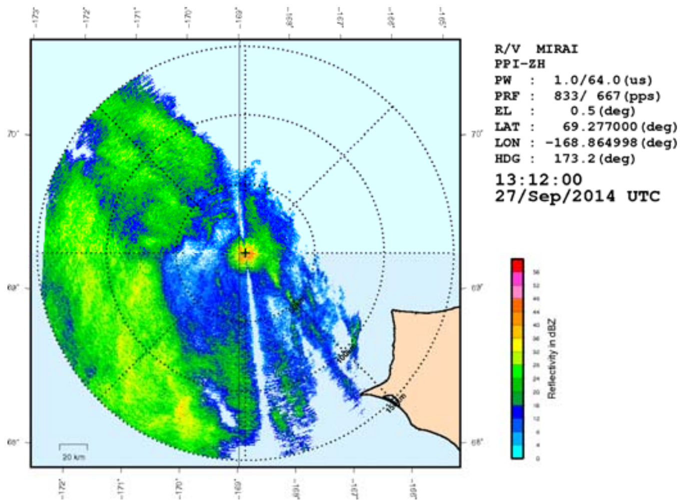


Figure 2.8-33: Same as Fig. 2.8-2 except for HYVIS No.08.

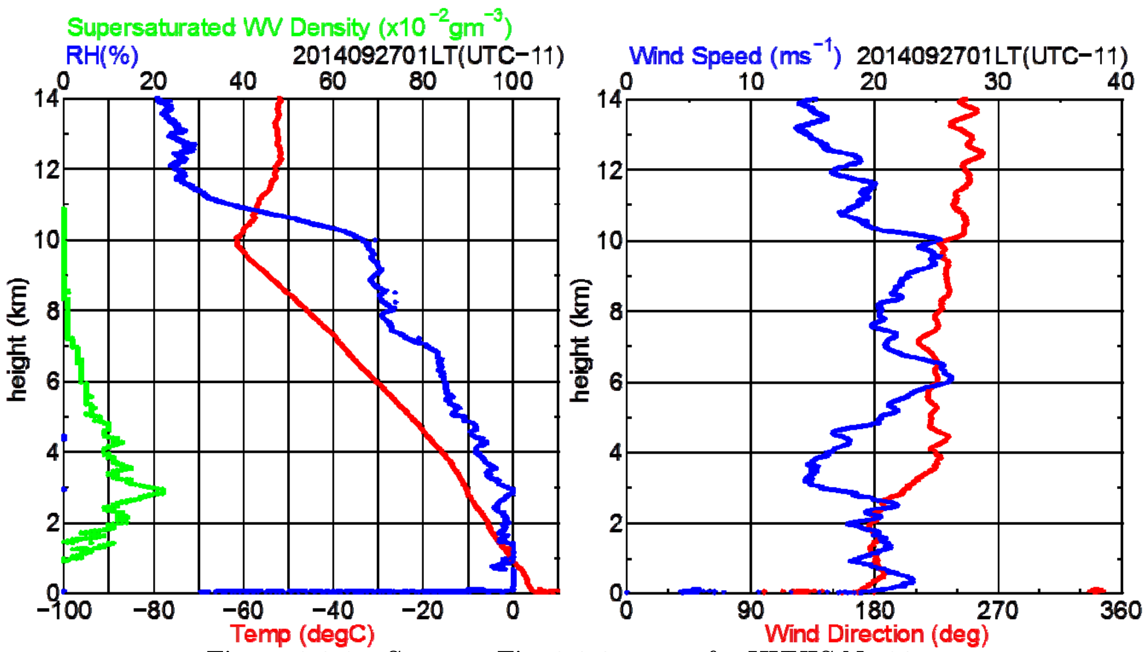


Figure 2.8-34: Same as Fig. 2.8-3 except for HYVIS No.08.

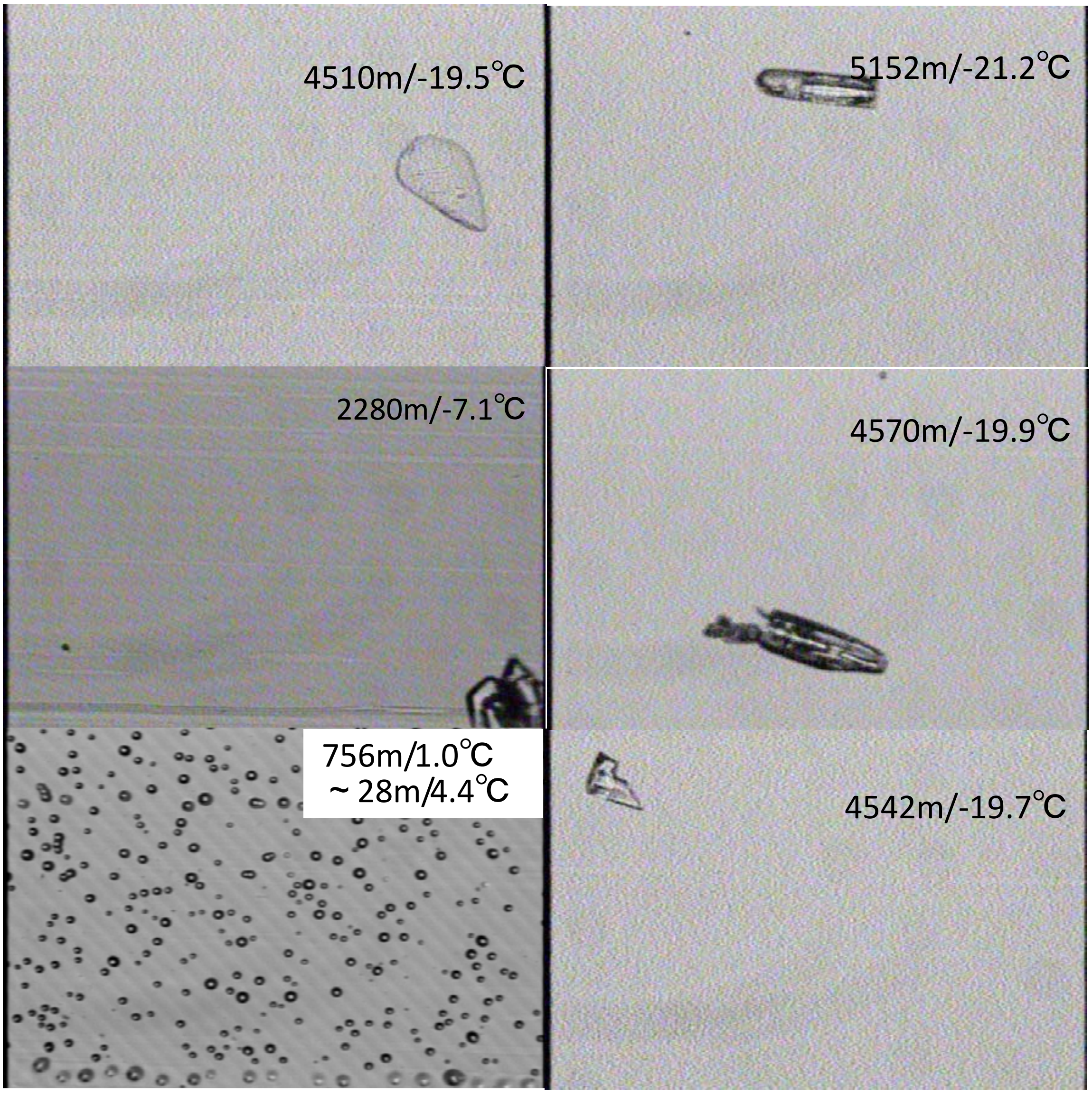


Figure 2.8-35: Same as Fig. 2.8-4 except for HYVIS No.08.

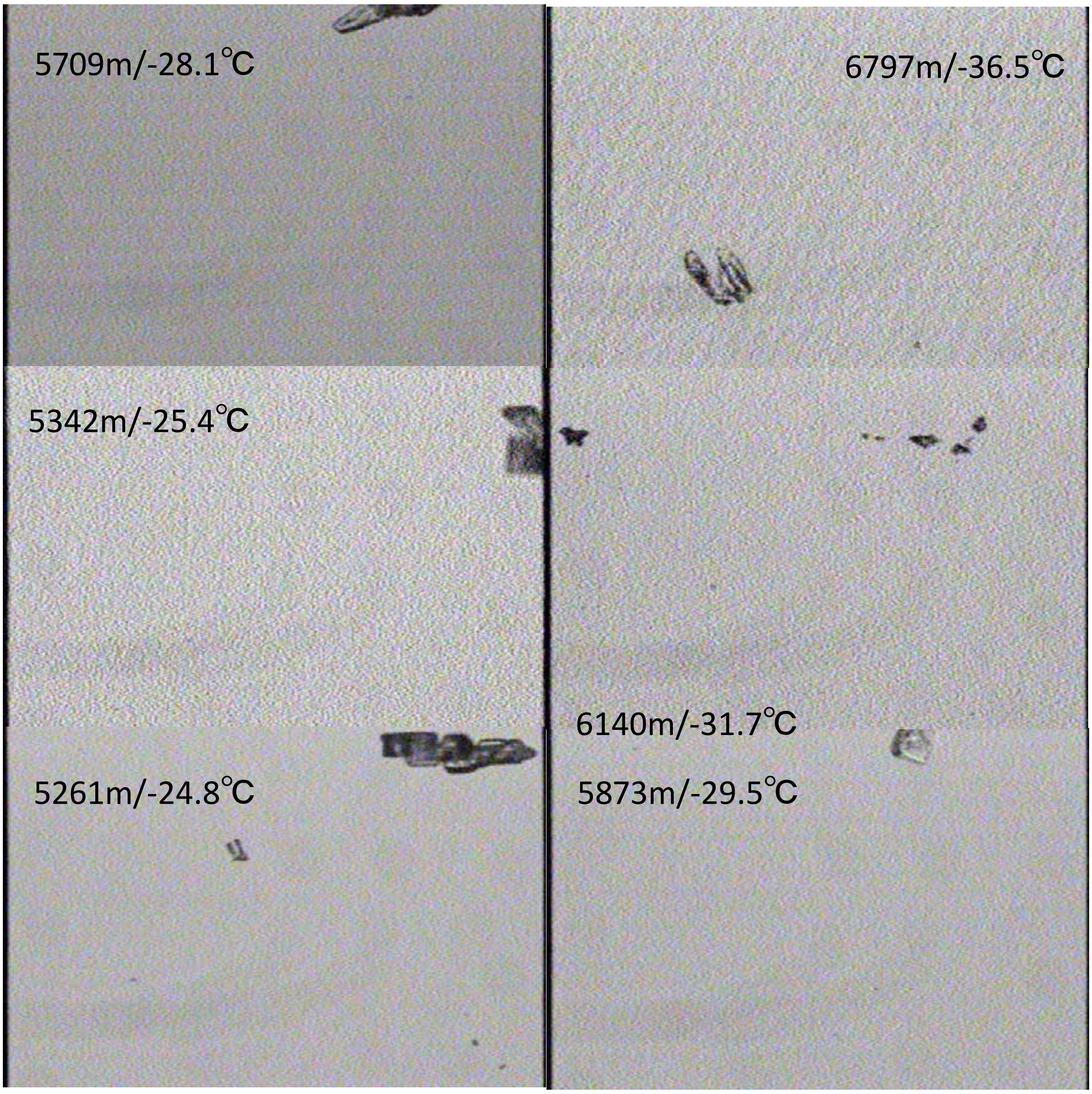


Figure 2.8-36: Same as Fig. 2.8-4 except for HYVIS No.08.

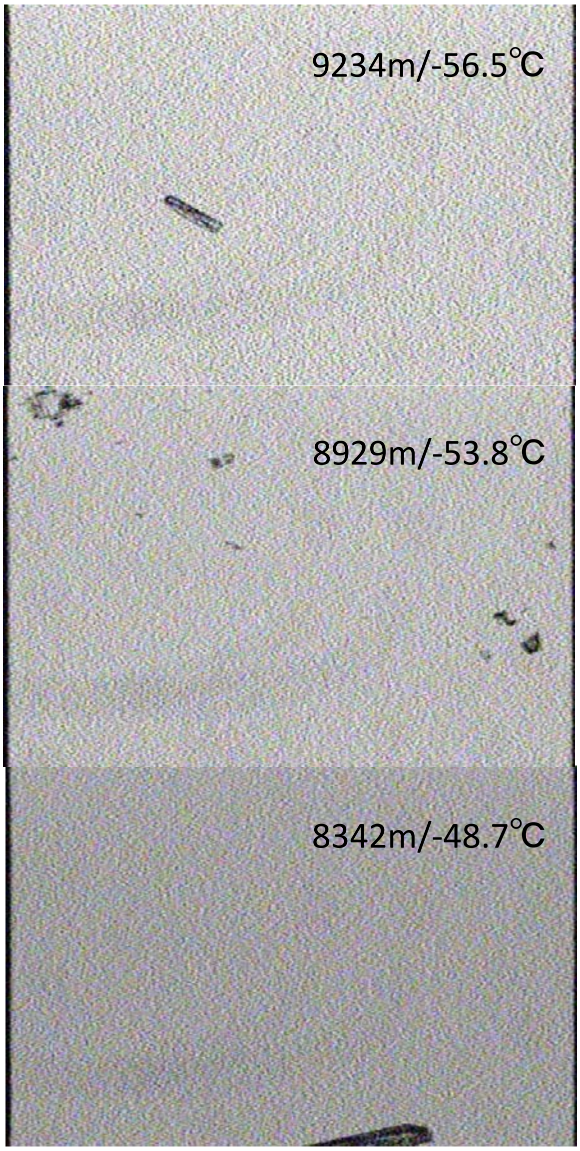


Figure 2.8-37: Same as Fig. 2.8-4 except for HYVIS No.08.

2.9. Sea surface flux measurements

(1) Personnel

Byron Blomquist Univ. Colorado/CIRES and NOAA/ESRL/PSD3 - PI

(2) Objective

Determination of air–sea heat and momentum fluxes from turbulence measurements and computation of the same quantities from bulk meteorological data using the NOAA COARE model.

(3) Parameters

Bulk meteorological quantities: air temperature, relative humidity, pressure, down–welling solar radiation (PSP), and down–welling infrared radiation (PIR).

Turbulence quantities: 3–axis wind speed (U,V,W) corrected for ship motion, sonic air temperature, and water vapor – all at 10 Hz.

Other: ship heading, lat, lon, speed and roll angle from GPS, also at 10 Hz.

(4) Instruments and Methods

Temperature / RH: Vaisala HMP 337 s/n C1110008, mounted on the foremast met tower.

Pressure: Vaisala PTB 220 s/n A2710003, mounted on the bridge deck roof.

Wind and Sonic Air Temperature: Gill Wind Master Pro model 1561 s/n Y063002, mounted on the foremast met tower.

Solar Radiation: Two Eppley Precision Spectral Pyronometers (PSP) s/n 34290 and 28110, mounted on the navigation deck roof.

Infrared Radiation: Two Eppley Precision Infrared Radiometers (PIR) s/n 30558 and 30433, mounted on the navigation deck roof.

Water Vapor: LI-COR model 7500 s/n 75B-0072, mounted on the foremast met tower.

GPS: Hemisphere Crescent VS-100 heading and position system, with GPS antennas mounted on the navigation deck roof.

Ship Motion: Custom–built 6–channel motion measurement system with 3–axis Systron-Donner accelerometers and 3–axis Sundstrand rotational rate sensors, mounted with the sonic anemometer on the foremast met tower. Data are 10 Hz.

Methods: Raw turbulent wind measurements are corrected for ship motion with NOAA algorithms using information from the 10 Hz ship motion and heading sensors. Fluxes of momentum, sensible heat and latent heat are then computed in 10–minute intervals using NOAA algorithms by two methods: eddy correlation and inertial dissipation. Turbulent flux results are screened for unsuitable conditions on the basis of relative wind direction, ship speed and heading variance, ship motion variance, and turbulent wind variances. Additional data may be discarded on the basis of adverse experimental conditions such as icing or excessive data loss in the sonic wind measurements.

Bulk meteorological data from NOAA and ship sensors are averaged to the 10-minute time base. Heat and momentum fluxes are then computed at both 10-minute and 1-hour intervals using the NOAA COARE bulk flux model. For this cruise, ship meteorological data was utilized in the model calculations, with some corrections based on a comparison with NOAA measurements outlined below.

The final dataset includes the raw 10–minute flux and bulk measurements in addition to refined 10–minute and 1–hour results. MATLAB computer code necessary to re–run the refined data analysis and bulk model computations is also supplied.

(5) Station list or Observation log

Measurements were continuous for the duration of the cruise and therefore no specific station information is relevant.

For one period during the transit North (9/3 0600 UTC to 9/4 0600 UTC), bulk model results were not computed because the ship sea surface temperature measurement was shut down. Model results for this period could be computed if an alternate SST measurement were available (satellite perhaps?).

At the fixed–point station (74N), air temperatures were consistently below 0°C and RH was often over 90%. Under these conditions, the sonic anemometer and LI-COR water vapor sensor have interferences and excessive data loss, affecting the quality of turbulent flux measurements and mean wind speed. Figure 2.9.1 illustrates the data loss experienced under these conditions. During 9/12–9/15 severe icing shut down the sonic anemometer and LI-COR sensors. Ship radiometers were also affected. NOAA radiometers were accessible for cleaning, so COARE calculations for this period use data from the NOAA PSP and PIR. The ship's technicians cleared some ice on 9/13 and sunny conditions removed most of the remaining ice. In other periods, notably 9/6–9/9 and 9/14–9/20, conditions were sub–freezing with high RH and the sonic anemometer frequently experienced 5-10% data loss in many 10-min intervals. These periods are excluded from the refined dataset. Mean wind speed results from the NOAA/PSD anemometer in Fig. 2.9.1 for these periods show a definite bias relative to the ship wind speed. For this reason, ship wind speeds are used for COARE model calculations.

Figure 2.9.2 and 2.9.3 summarize heat flux measurements and COARE model results. For periods when the sonic anemometer and LI-COR data are good and conditions optimal, both methods are in reasonable agreement with the bulk model prediction. During periods of excessive data loss, the covariance latent heat measurement is clearly degraded. The best value for sensible heat is taken as the mean of covariance and inertial dissipation results, while for latent heat we take only the inertial dissipation result, although we could average the covariance and inertial dissipation results for periods other than 9/14–9/25.

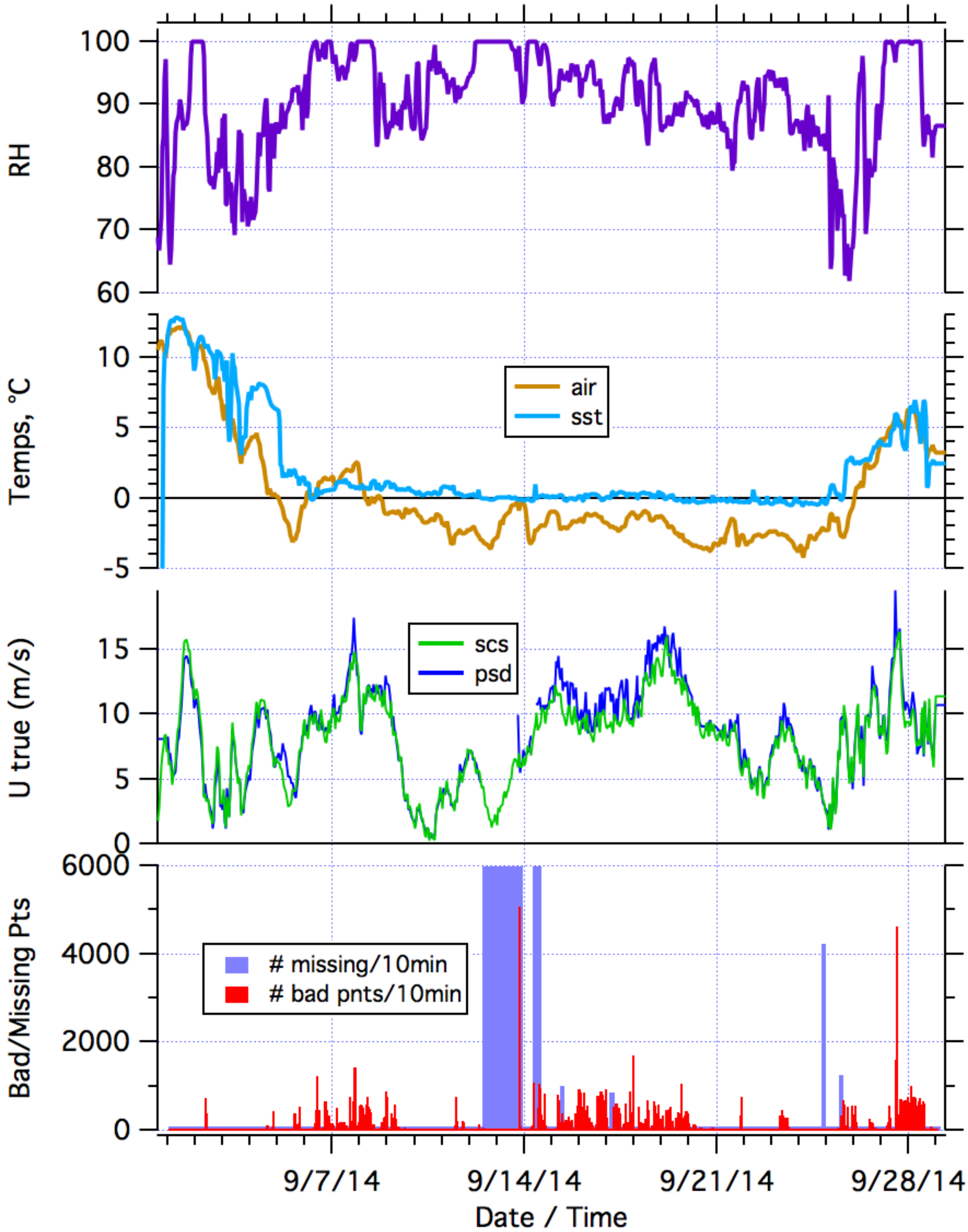


Figure 2.9.1: A time series of RH, temperatures, wind and missing data values from the NOAA/PSD sonic anemometer. Over the period 9/12-9/15 a significant amount of data is completely missing due to icing on the anemometer. At other times, excessive data loss degrades performance of the NOAA sonic anemometer.

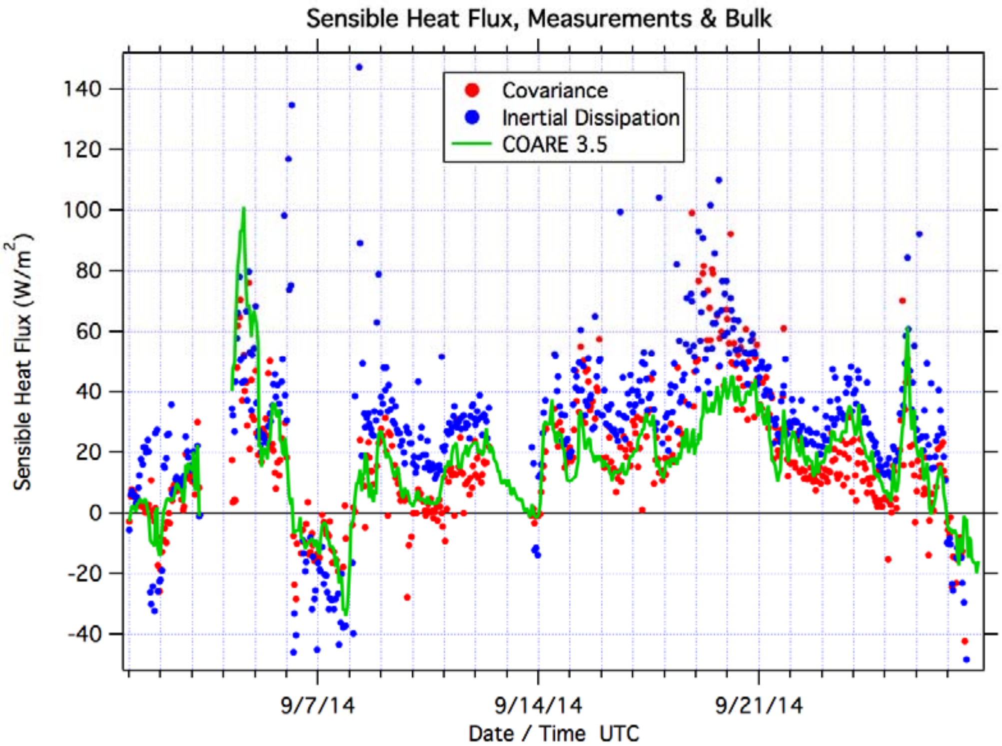


Figure 2.9.2: Sensible heat flux times series, turbulence and model results.

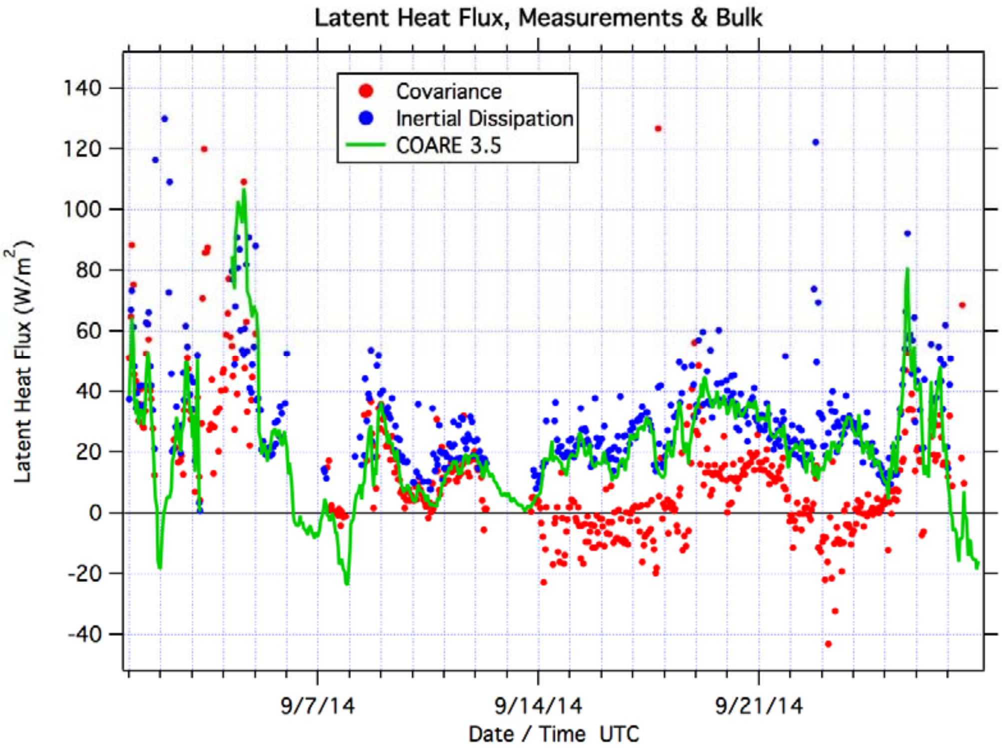


Figure 2.9.3: Latent heat flux times series, turbulence and model results.

Net heat flux with respect to the sea surface is computed from measured and/or modeled quantities as

$H_{net} \quad 0.955R_s \quad R_{L,net} \quad H_s \quad H_l \quad H_{rain}$

where

$R_{L,net} \quad 0.97(S_b T_{s,K}^4 \quad R_l)$

R_s measured PSP flux

R_l measured PIR flux

H_s sensible heat flux (measured or COARE)

H_l latent heat flux (measured or COARE)

H_r rain heat flux (COARE)

S_b $5.67e^{-8}$ (Stefan Boltzmann const.)

$T_{s,K}$ SST in deg K

Note, turbulent latent heat fluxes from the LI-COR must be corrected for “Webb” density effects, so the true latent heat flux is $H_l = H_{l,licor} + H_{l,webb}$. The components of net heat flux are illustrated in Figure 2.9.4 for the period 9/11–9/23. Net solar radiation is clearly the largest term, as expected, but is attenuated considerably in cloudy conditions and decreased steadily over the period at the fixed site due to decreasing day length and solar zenith angle. The sum of latent and sensible losses is often larger than net infrared heat loss. Cloudy conditions during the experiment contributed greatly to reduced IR heat loss. Rain heat flux is insignificant and the few occasions where it is large may be an error, as precipitation was snow and thus not properly measured by the ship's ORG rain sensor. For this reason, it may be wise to ignore the rain heat flux term.

A time series of net heat flux from both COARE and measured latent and sensible heat fluxes is shown in Figure 2.9.5. The two estimates are in close agreement except for periods when the turbulence measurements were affected by frost. Gaps in the turbulent net heat time series reflect missing data or results discarded for quality control reasons.

The trend in net heat flux is best illustrated with the daily average, shown in Figure 2.9.6. The COARE model results are used for the daily average since turbulent flux data are not continuous and thus yield a biased daily average. The period of observations for MR14-05 covers the transition from net heating to net cooling, as seen in Fig. 2.9.6. A period of deep cloud cover toward the end of fixed–point observations probably reduced IR heat loss, moderating the overall decreasing trend in the daily average.

Finally, a few adjustments were made to ship radiometer data used in these calculations. The temperature correction to PIR measurements was recomputed from the raw PIRu and case/dome temperatures from the JamMet data file using the following equation:

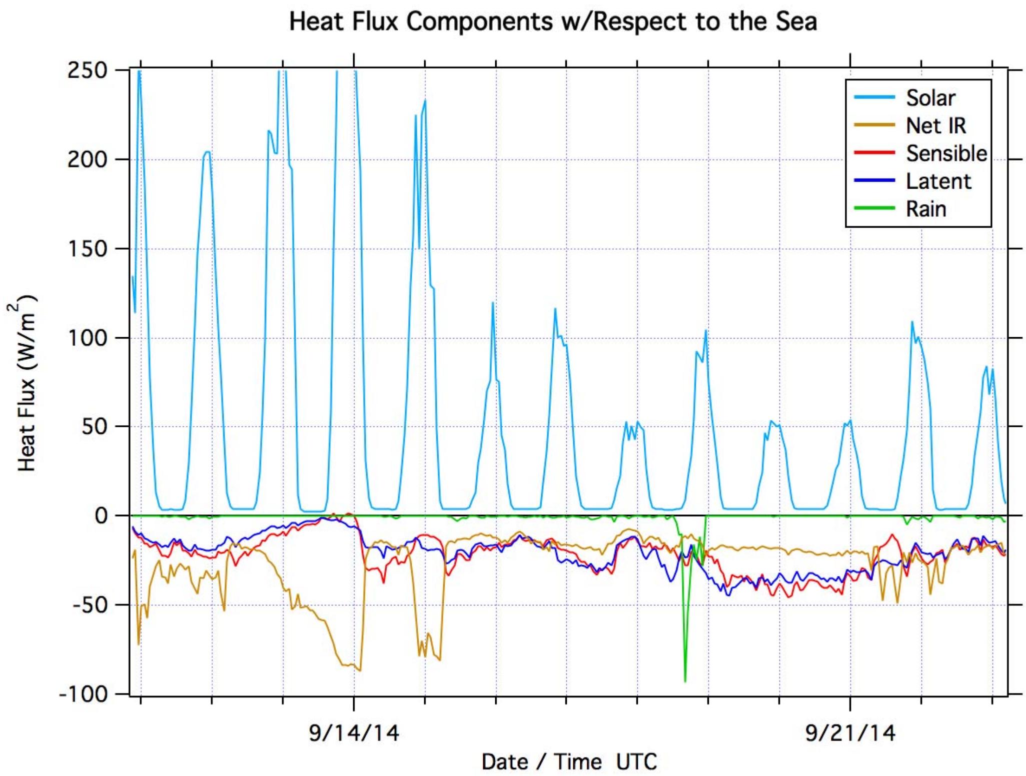


Figure 2.9.4: Time series of heat flux components (with respect to the sea) from COARE.

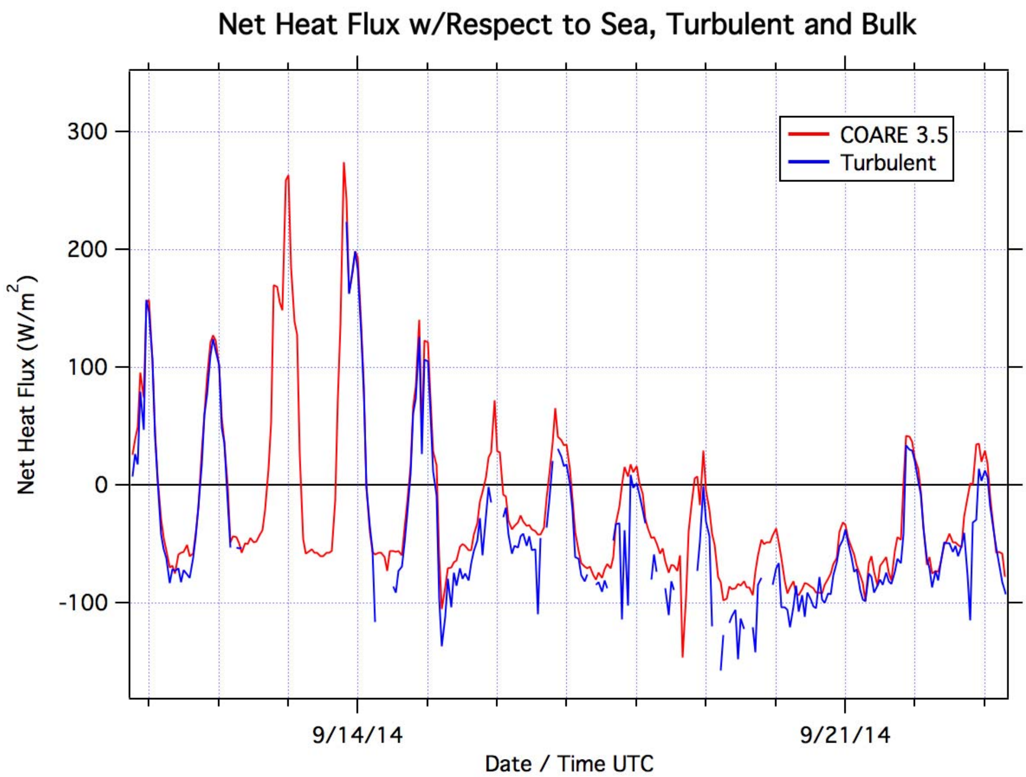


Figure 2.9.5: Net heat flux, COARE 3.5 (red) and turbulent H_s and H_l (blue).

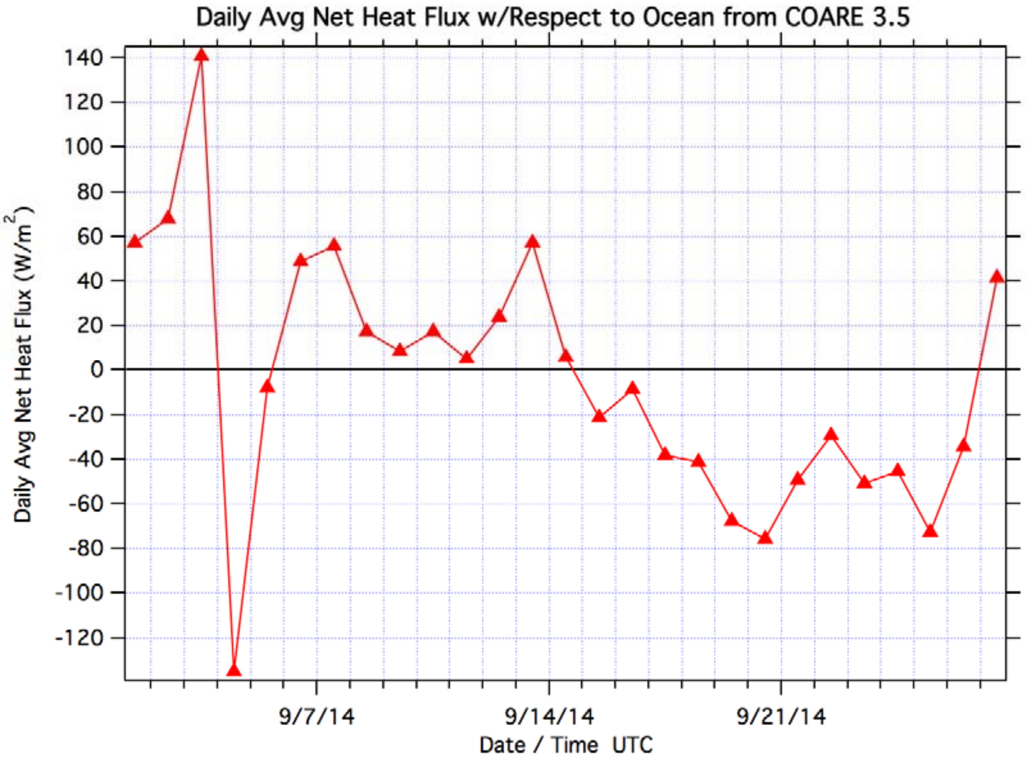


Figure 2.9.6: Daily average net heat flux for the sea surface.

$$PIR \quad PIRu + E S_b T^4_{case,K} \quad 4 S_b (T^4_{dome,K} \quad T^4_{case,K})$$

where $E \quad 1.00$

following the result in Fairall et al., 1998 (Fairall, C. W., O.P.G. Persson, R. E. Payne, and E. F. Bradley, 1998: A new look at calibration and use of Eppley precision infrared radiometers. *J. Atmos. Oceanic Tech.*, **15**, 1230-1243) which shows the E factor to be unnecessary in PIR corrections.

With respect to the ship's solar radiation measurement, a small nighttime offset is apparent in Fig. 2.9.4. Also, a comparison with the mean of the two NOAA PSP measurements shows a positive gain bias of about 10% (Fig. 2.9.7). NOAA radiometers were recently calibrated and are in close agreement with each other. The position of the ship PSP is superior, however, since the NOAA instruments are occasionally shaded by the C-band radome.

Because the solar radiation term is the largest component of the net heat budget, a correction is desirable. Thus, the ship PSP result is adjusted for gain and offset in the refined output files and then used in COARE model and net heat calculations. At a later date, any of these adjustments may be modified in the MATLAB code and the refined results recomputed if desired.

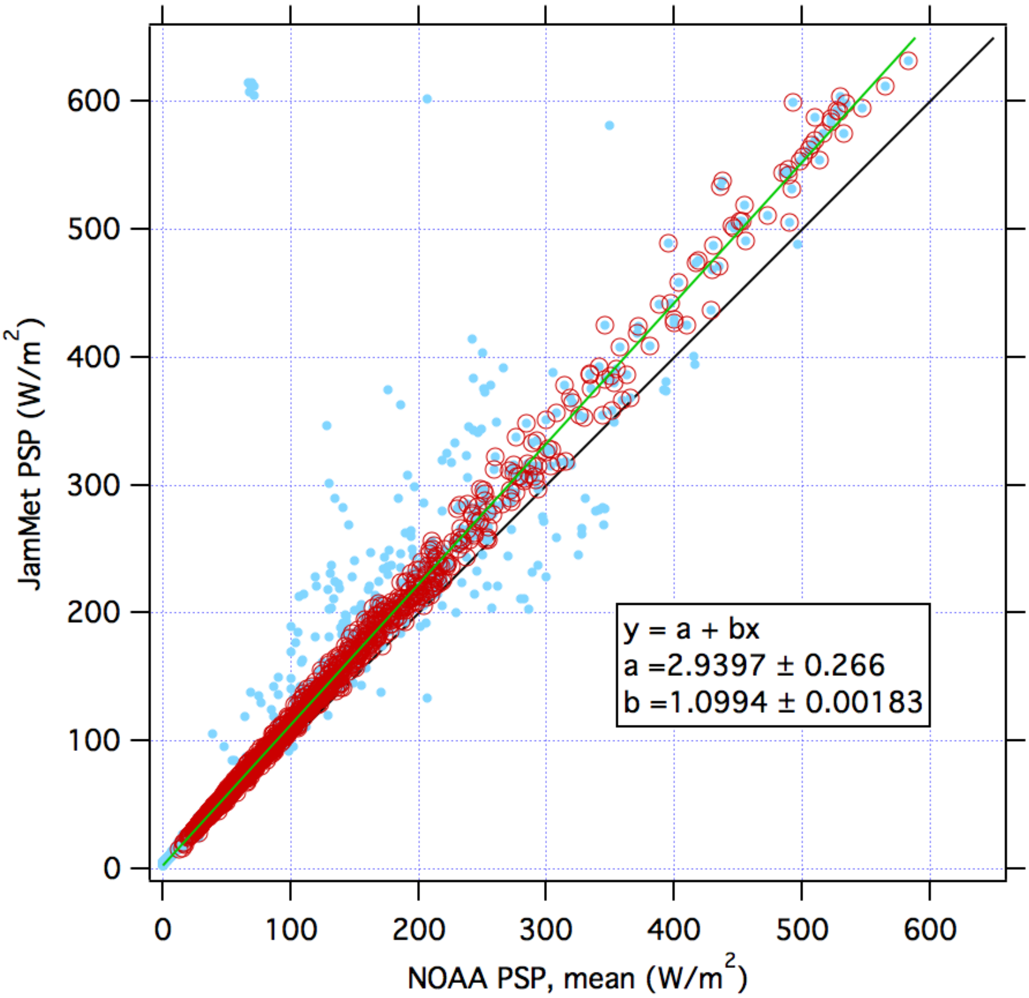


Figure 2.9.7: A comparison of ship (JamMet) and NOAA PSP data. A linear regression applied to periods when the NOAA radiometers are mostly free from shadowing or reflections (red points) reveals a mean gain bias of about 10% between the two systems.

(6) Data archives

All 10-minute raw and 10–minute / 1–hour refined data products obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site. In addition, MATLAB codes necessary for recalculating the refined result will be provided. A readme file within each data directory describes file format and identifies variables. All data files are ASCII text.

In addition, all data, including raw uncorrected 10Hz turbulence and motion measurements, will be archived on the NOAA/PSD ftp site for full public access at the conclusion of the cruise (ftp://ftp1.esrl.noaa.gov/psd3/cruises/Mirai_MR14_05/).

Cruise data submitted to JAMSTEC are organized in a directory structure as follows:

root/daily/ : daily raw 10-min flux and bulk met data files

root/total/ : whole project raw 10-min flux and bulk met data and refined 10-min and 1–hr flux and met files.

root/MATLAB/ : MATLAB script directory and subdirectories containing code for the refined data analysis and COARE bulk model run. A readme file gives instructions for running the scripts. Routines for clear-sky solar and infrared radiances are also provided.

root/plots/analysis : plots of fluxes and derived quantities from the MATLAB code

root/plots/measurements: plots of bulk met data comparisons from MATLAB code

2.10. Greenhouse gases

2.10.1. Continuous measurements

(1) Personal

Shuji Aoki	Tohoku University	- PI
Naohiro Kosugi	Meteorological Research Institute / JMA	
Yasunori Tohjima	National Institute for Environmental Studies	
Keiichi Katsumata	National Institute for Environmental Studies	

(2) Objective

In arctic region, there are a lot of vulnerable carbon pools, which have the potential to become strong sources of CO_2 and CH_4 release into the atmosphere when the destabilization occurs through climate change. Therefore, it is important to understand the current situation of the greenhouse gas emissions around the arctic region. The purpose of present study is to observe the atmospheric CO_2 and CH_4 mixing ratios during the cruse, detect the enhanced mixing ratios associated with the regional emissions, and estimate the distribution of the regional emission sources. The atmospheric CO mixing ratios, which are also observed at the same time, can be used as an indicator of the anthropogenic emissions associated with the combustion processes.

(3) Parameters

Mixing ratio of atmospheric CO_2, CH_4, and CO.

(4) Instruments and Methods

Atmospheric CO_2, CH_4, and CO mixing ratios were measured by a wavelength-scanned cavity ring-down spectroscopy (WS-CRDS) instrument (Picarro, G2401). An air intake, capped with an inverted stainless steel beaker covered with stainless steel mesh, was placed on the right-side of the upper deck. A diaphragm pump (GAST, MOA-P108) was used to draw in the outside air at a flow rate of ~10 L min^{-1}. Water vapor in the sample air was removed to a dew pint of about 2°C and about -35°C by passing it through a thermoelectric dehumidifier (KELK, DH-109) and a Nafion drier (PERMA PURE, PD-50T-24), respectively. Then, the dried sample air was introduced into the WS-CRDS instrument at a flow rate of 100 ml min^{-1}. The WS-CRDS instrument was automatically calibrated every 24 hour by introducing 3 standard gases with known CO_2, CH_4 and CO mixing ratios. These 3 standard gases are compressed into 2-L aluminum high pressure cylinders. The analytical precisions for CO_2, CH_4, and CO mixing ratios are about 0.02 ppm, 0.3 ppb and 3 ppb, respectively.

(5) Observation log

The shipboard measurements were conducted during the entire cruse.

(6) Data archives

The data obtained during this cruise will be analyzed by the member of NIES. All the data will be opened within a few years.

2.10.2. Greenhouse gasses (Discrete flask sampling)

(1) Personnel

Shuji Aoki	Tohoku University	- PI
Shigeyuki Ishidoya	National Institute of Advanced Industrial Science and Technology (AIST)	
Naohiro Kosugi	Japan Meteorological Agency	
Masao Ishii	Japan Meteorological Agency	
Yasunori Tohjima	National Institute for Environmental Studies	
Hiroshi Uchida	JAMSTEC	
Daisuke Sasano	Japan Meteorological Agency	
Shinji Morimoto	Tohoku University	
Hisayuki Yoshikawa	Hokkaido University	
Chika Minejima	Tokyo University of Agriculture and Technology	
Daisuke Goto	Tohoku University	
Shoichi Taguchi	National Institute of Advanced Industrial Science and Technology (AIST)	
Kentaro Ishijima	JAMSTEC	
Prabir Patra	JAMSTEC	
Shohei Murayama	National Institute of Advanced Industrial Science and Technology (AIST)	

(2) Objective

In order to clarify space variations and air-sea exchanges of the green house gases at northern high latitude, air samples were corrected into 40 stainless-steel flasks on the Western North Pacific. The collected air samples will be analyzed for the concentrations of CO_2, O_2, Ar, CH_4, CO, N_2O and SF_6 and the isotopic ratios of CO_2 and CH_4.

(3) Parameters

Atmospheric CO_2 concentration, O_2/N_2 ratio (O_2 concentration), Ar/N_2 ratio (Ar concentration), CH_4 concentration, CO concentration, N_2O concentration, SF_6 concentration, $\delta^{13}C$ of CO_2, $\delta^{18}O$ of CO_2, $\delta^{13}C$ of CH_4 and δD of CH_4.

(4) Instruments and Methods

The air sampling equipment consisted of an air intake, a piston pump (GAST LOA), a water trap, solenoid valves (CKD), an ethanol bath as refrigerant, a flow meter and an immersion cooler (EYELA ECS-80). Ambient air was pumped using a piston pump from an air intake and dried cryogenically, and filled into a 1 L stainless-steel flask at a pressure of 0.44 MPa.

(5) Station list or Observation log

The air samplings were conducted once a day. Table 2.10.2.1 shows time and position of each sampling.

Table 2.10.2-1: Date and position of the air flask sampling.

Sample No.	Sampling date and time (yyyy/mm/dd hh:mm UTC)	Sampling Position
1	2014/09/01 04:17	55-53N, 166-56W
2	2014/09/02 05:17	60-56N, 167-43W
3	2014/09/03 10:38	66-32N, 168-49W
4	2014/09/04 07:40	70-04N, 164-53W
5	2014/09/05 08:10	72-28N, 159-42W
6	2014/09/06 06:46	75-07N, 160-59W
7	2014/09/07 09:45	74-45N, 161-59W
8	2014/09/08 05:22	74-45N, 161-59W
9	2014/09/09 08:00	74-45N, 161-59W
10	2014/09/10 14:23	74-46N, 162-01W
11	2014/09/11 10:22	74-35N, 162-27W
12	2014/09/12 10:30	74-45N, 162-01W
13	2014/09/13 10:08	74-48N, 162-04W
14	2014/09/14 09:50	74-34N, 162-27W
15	2014/09/15 10:03	74-47N, 162-03W
16	2014/09/16 10:03	74-46N, 162-04W
17	2014/09/17 09:56	74-46N, 162-02W
18	2014/09/18 11:46	74-45N, 162-00W
19	2014/09/19 10:23	74-45N, 162-05W
20	2014/09/20 10:01	74-45N, 162-02W
21	2014/09/21 10:04	74-45N, 162-08W
22	2014/09/22 10:33	74-44N, 161-59W
23	2014/09/23 14:16	74-45N, 161-59W
24	2014/09/24 10:22	74-45N, 162-06W
25	2014/09/24 14:26	74-45N, 162-01W
26	2014/09/25 10:34	73-52N, 164-55W
27	2014/09/26 12:21	72-47N, 168-15W
28	2014/09/27 09:42	69-50N, 168-48W
29	2014/09/28 09:07	66-28N, 168-48W
30	2014/09/29 10:56	62-19N, 174-25W
31	2014/09/30 11:47	57-54N, 179-15E

32	2014/10/01 20:18	52-23N, 171-19E
33	2014/10/02 10:27	50-11N, 169-28E
34	2014/10/03 06:52	47-06N, 167-00E
35	2014/10/04 06:54	45-31N, 163-18E
36	2014/10/05 07:22	43-49N, 158-19E
37	2014/10/06 08:57	42-10N, 153-24E
38	2014/10/07 08:49	39-54N, 148-13E
39	2014/10/08 09:33	37-20N, 144-06E
40	2014/10/09 02:22	35-54N, 141-53E

2.11. Tropospheric gas and particles observation in the Arctic Marine Atmosphere

(1) Personnel

Yugo Kanaya	JAMSTEC	- PI, not on board
Fumikazu Taketani	JAMSTEC	- on board
Takuma Miyakawa	JAMSTEC	- not on board
Hisahiro Takashima	JAMSTEC	- not on board
Yuichi Komazaki	JAMSTEC	- not on board
Maki Noguchi	JAMSTEC	- not on board

(2) Objective

- To investigate roles of aerosols in the marine atmosphere in relation to climate change
- To investigate processes of biogeochemical cycles between the atmosphere and the ocean.
- To investigate contribution of suspended particles to the rain, snow, and ocean

(3) Parameter

- Black carbon(BC) and fluorescent particles
- Particle size distribution
- Composition of ambient particles
- Composition and BC in snow and rain
- Composition and BC in seawater
- Aerosol optical depth (AOD) and aerosol extinction coefficient (AEC)
- Surface ozone(O3), and carbon monoxide(CO) mixing ratios

(4) Description of instruments deployed

(4-1) Online aerosol observations: black carbon (BC), fluorescent properties, and size distribution

BC and fluorescent properties of aerosol particles were measured by an instrument based on laser-induced incandescence (SP2, Droplet Measurement Technologies) and by a single particle fluorescence sensor, WIBS4 (Waveband Integrated bioaerosol sensor). The size distribution of particles was measured by the two instruments and also by a handheld optical particle counter (KR-12A, Rion).

The measurements of fluorescent properties by WIBS4 were made on the flying bridge. 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.

For KR-12A and SP2, ambient air was commonly sampled from the flying bridge by a 3-m-long conductive tube through the Diffusion Dryer(model TSI) to dry up the particles, and then introduced to each instrument. Using scattering light intensity, KR-12A estimate the particle size and concentration. The laser-induced incandescence technique based on intracavity Nd:YVO4 laser operating at 1064 nm were used for detection of single particles of BC.

(4-2) Ambient air sampling

Ambient air samplings were carried out by air sampler. Ambient air was sampled from the flying bridge by a 3-m-long conductive tube. Ambient particles were collected on the cellulose membrane or Teflon filter (ϕ =47mm) to analyze their composition. These samples are going to be analyzed in laboratory. Sampling logs are listed in Table 2.11-1.

(4-3) Snow and rain sampling

Snow and rain samples were corrected using metal tray on the flying bridge to investigate the interaction between aerosols and rain/snow or contribution to the ocean. These samples are going to be analyzed in laboratory. Sampling logs are listed in Table 2.11-2.

(4-4) Seawater sampling

To investigate the contribution of BC to the ocean, the seawater samples were collected with Niskin bottle attached to the CTD-system, surface bucket sampler, and tap. BC in seawater will be analyzed by SP2 instrument. These samples are going to be analyzed in laboratory. Sampling logs are listed in Table 2.11-3.

(4-5) MAX-DOAS

Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS), a passive remote sensing technique measuring spectra of scattered visible and ultraviolet (UV) solar radiation, was used for atmospheric aerosol and gas profile measurements. Our MAX-DOAS instrument consists of two main parts: an outdoor telescope unit and an indoor spectrometer (Acton SP-2358 with Princeton Instruments PIXIS-400B), connected to each other by a 14-m bundle optical fiber cable. The telescope unit was updated before the cruise; only one-axis scan for elevation angle was attained, while capability of azimuth scan was not employed. The line of sight was in the directions of the portside of the vessel and the scanned elevation angles were 1.5, 3, 5, 10, 20, 30, 90 degrees in the 30-min cycle. The roll motion of the ship was measured to autonomously compensate additional motion of the prism, employed for scanning the elevation angle.

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

AOD data were also measured by MICROTOPS II in the clear day. Measurement logs are listed in Table 2.11-4.

(4-6) CO and O_3

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.

(5) Observation log

List of samples of ambient air, rain/snow, and seawater were presented in Table 2.11- 1, Table 2.11- 2, and Table 2.11- 3, respectively. Table 2.11- 4 was list of measurement logs of AOD.

Table 2.11-1: Sampling logs of ambient air

	sampling		Flow	date			latitude			longitude		
ID	start	stop	L/mi	yyyy	m	dd	deg	min	NS	Deg	min	EW
MR1405-A-IN001	20:2		16.8	2014	8	3	54	14.	N	166	33.	W
		3:20	16.8	2014	8	3	55	44.	N	166	44.	W
MR1405-A-IN002	8:28		15.8	2014	9	2	61	37	N	167	26	W
		17:00	16.0	2014	9	2	63	20	N	167	37	W
MR1405-A-IN003	17:5		15.8	2014	9	2	63	33	N	167	45.	W
		23:40	15.8	2014	9	2	64	41.	N	168	32	W
MR1405-A-IN004	4:40		15.1	2014	9	3	65	40	N	168	32	W
		19:20	15.4	2014	9	4	71	22.	N	157	16.	W
MR1405-A-IN005	1:32		15.8	2014	9	5	71	28.	N	157	5.7	W
		19:22	16	2014	9	6	74	45	N	162	0	W
MR1405-A-IN006	0:50		16	2014	9	7	74	45	N	162	0	W
		0:08	16.2	2014	9	1	74	45	N	162	0	W
MR1405-A-IN007	6:17		16.8	2014	9	1	74	45	N	162	0	W
		22:38	16.4	2014	9	1	74	45	N	162	0	W
MR1405-A-IN008	23:3		11.4	2014	9	1	74	45	N	162	0	W
		4:29	11.4	2014	9	1	74	45	N	162	0	W
MR1405-A-IN009	5:36		16.6	2014	9	1	74	45	N	162	0	W
		19:37	16.7	2014	9	2	74	45	N	162	0	W
MR1405-A-IN010	21:1		16.7	2014	9	2	74	45	N	162	0	W
		19:45	16.7	2014	9	2	74	45	N	162	0	W
MR1405-A-IN011	22:5		10.7	2014	9	2	74	45	N	162	0	W
		1:49	10.7	2014	9	2	74	45	N	162	0	W
MR1405-A-IN012	0:20	2:38	10.7	2014	9	2	72	45	N	167	47	W

	3:40	9:08	10.5	2014	9	2	72	45	N	167	47	W
MR1405-A-IN013	17:4	20:40	11.6	2014	9	2	72	13	N	168	42	W
	20:4	23:25	11	2014	9	2						
	23:4	5:09	10.9	2014	9	2	70	33	N	168	48	W
MR1405-A-IN014	3:15	5:18	11	2014	9	2	67	27	N	168	50	W
	5:39	8:28	11	2014	9	2						
	8:31	10:33	11	2014	9	2	66	8	N	168	47.	W
MR1405-A-IN015	19:4		11.5	2014	9	2	64	45	N	170	22	W
		3:55	11.5	2014	9	2	63	30	N	172	44	W
MR1405-A-IN016	21:3		11	2014	1	3	45	22	N	165	7	W
		8:25	11	2014	1	5	42	10	N	153	26	W
MR1405-A-BP001	18:44		2.17	2014	9	2	63	40.	N	167	51.	W
		22:44	2.07	2014	9	2	64	31.	N	168	23.	W
MR1405-A-BP002	23:40		2.2	2014	9	1	74	45	N	162	0	W
		1:41	2.32	2014	9	1	74	45	N	162	0	W
MR1405-A-BP003	2:30		2.33	2014	9	1	74	45	N	162	0	W
		4:29	2.3	2014	9	1	74	45	N	162	0	W
MR1405-A-BP004	23:55		2.36	2014	9	1	74	45	N	162	0	W
		1:55	2.3	2014	9	1	74	45	N	162	0	W
MR1405-A-BP005	0:35		2.27	2014	9	1	74	45	N	162	0	W
		1:41	2.27	2014	9	1	74	45	N	162	0	W
MR1405-A-BP006	0:10		2.34	2014	9	1	74	45	N	162	0	W
		2:10	2.34	2014	9	1	74	45	N	162	0	W
MR1405-A-BP007	23:40		2.4	2014	9	2	74	45	N	162	0	W
		1:35	2.3	2014	9	2	74	45	N	162	0	W
MR1405-A-BP008	23:50		2.23	2014	9	2	74	45	N	162	0	W
		1:23	2.3	2014	9	2	74	45	N	162	0	W
MR1405-A-BP009	23:50		2.3	2014	9	2	72	3	N	168	50	W
		21:55	2.3	2014	9	2	71	48	N	168	50	W
MR1405-A-BP010	23:30		2.3	2014	9	2	68	0	N	168	50	W
		0:30	2.3	2014	9	2	67	56	N	168	50	W
MR1405-A-BP011	2:05		2.3	2014	9	2	67	33	N	168	49	W
		3:35	2.3	2014	9	2	67	22	N	168	49.	W
MR1405-A-BP012	23:45		2.35	2014	9	2	59	58	N	177	33	W
		3:35	2.3	2014	9	3	59	10	N	178	34	W
MR1405-A-BP013	3:50		2.3	2014	1	7	40	28	N	149	6	E
		4:50	2.28	2014	1	7	40	21	N	148	55	E

MR1405-A-ME001	0:30		41	2014	9	1	55	47	N	166	55	W
		16:54		2014	9	1	57	30	N	167	36	W
MR1405-A-ME002	23:45		42	2014	9	2	64	44	N	168	33	W
		4:32	41	2014	9	3	65	39	N	168	31	W
MR1405-A-ME003	23:52		41.5	2014	9	14	74	46	N	162	9	W
		8:00	41.5	2014	9	15	74	46	N	162	0	W
MR1405-A-ME004	0:00		41	2014	9	16	74	46	N	162	0	W
		3:50		2014	9	16	74	46	N	162	0	W
MR1405-A-ME005	20:00		41.1	2014	9	16	74	46	N	162	0	W
		22:00	41	2014	9	16	74	46	N	162	0	W
MR1405-A-ME006	1:50	3:58	42	2014	9	25	74	45	N	162	0	W
	5:30	8:42	41	2014	9	25	74	22	N	163	0	W
	8:50	10:08	41	2014	9	25	74	0		164	0	W
MR1405-A-ME007	5:34		41	2014	9	27	70	29	N	168	48	W
		11:05	41.1	2014	9	27	69	32	N	168	48	W
MR1405-A-ME008	18:15			2014	9	27	68	53	N	168	48	W
		2:30		2014	9	28	67	30	N	168	52	W
MR1405-A-ME009	20:25		41	2014	9	29	60	35	N	176	45	W
		20:35	42	2014	9	30	56	21	N	176	50	E
MR1405-A-ME010	20:34		41	2014	10	1	52	19	N	171	16	E
		5:25	41	2014	10	2	50	55	N	170	2	E
MR1405-A-ME011	20:39		41	2014	10	2	48	33	N	168	8	E
		11:09	41	2014	10	3	46	14	N	167	2	E
MR1405-A-ME012	2:52		41	2014	10	7	40	35	N	149	17	E
		2:10	41	2014	10	9	35	54	N	141	54	E

Table 2.11-2: Sampling logs of rain and snow

	sampling		date start	sampling(UTC)		latitude			longitude		
ID	start	stop	yyyy	mm	dd	deg	min	N-S	Deg	min	E-W
MR1405-RS001	3:55	6:46	2014	9	5 5	71 72	49 17.8	N	158 159	7 15.7	W
MR1405-RS002	6:50	20:19	2014	9	5 5	72 74	18.9 00	N	159 164	15.8 00	W
MR1405-RS003	20:30	19:30	2014	9	5 6	74 74	0 45	N	164 162	0 00	W

MR1405-RS004	4:30	1:10	2014	9	6	74	45	N	162	0	W
MR1405-RS005	1:20	19:40	2014	9	8	74	45	N	162	0	W
MR1405-RS006	19:50	20:00	2014	9	8	74	45	N	162	0	W
MR1405-RS007	21:50	4:45	2014	9	14	74	45	N	162	0	W
MR1405-RS008	5:45	0:00	2014	9	17	74	45	N	162	0	W
MR1405-RS009	23:50	0:00	2014	9	20 22	74	45	N	162	0	W
MR1405-RS010P	0:10	2:45	2014	9	22 22	74	45	N	162	0	W
MR1405-RS010	3:00	22:20	2014	9	22 22	74	45	N	162	0	W
MR1405-RS011	22:35	0:57	2014	9	22 23	74	45	N	162	0	W
MR1405-RS012	1:00	20:03	2014	9	23 23	74	45	N	162	0	W
MR1405-RS013	1:30	4:50	2014	9	25 25	74	45	N	162	0	W
MR1405-RS014	0:50	19:50	2014	9	25 26	74 72	22 05	N	163 168	0 50	W
MR1405-RS015	20:00	18:10	2014	9	26 27	72 68	05 53	N	168 168	50 50	W
MR1405-RS016	1:00	19:50	2014	9	27 28	68 67	53 53	N	168 168	50 50	W
MR1405-RS017	1:00	19:50	2014	9	26 27	67 64	53 44.3	N	168 170	50 24.7	W
MR1405-RS018	19:55	1:31	2014	9 10	27 2	64 51	39 34	N	170 170	36 37	W E
MR1405-RS019	1:35	6:35	2014	10	2 3	51 47	34 06	N	170 167	37 01	E
MR1405-RS020	6:40	0:05	2014	10	3 4	47 45	06 04	N	167 164	01 36	E
MR1405-RS021	0:10	21:44	2014	10	4	45 44	04 17	N	164 159	36 42	E
MR1405-RS022	21:50	22:43	2014	10	4 6	44 41	17 0	N	159 150	42 02	E

Table 2.11-3a: Sampling logs of seawater sampled by Niskin bottle

			date (UTC)				latitude(N)		longitude			Depth
ID	Sta	Cast	yyyy	M	DD	h:mm	deg	min	deg	min	EW	m
MR1405-blue-BC-3	9	18	2014	9	11	1:20	74	45	162	0	W	1500
MR1405-blue-BC-4	9	18	2014	9	11	1:20	74	45	162	0	W	1000
MR1405-blue-BC5	9	18	2014	9	11	1:20	74	45	162	0	W	800
MR1405-blue-BC7	9	18	2014	9	11	1:20	74	45	162	0	W	500
MR1405-blue-BC8	9	18	2014	9	11	1:20	74	45	162	0	W	400
MR1405-blue-BC9	9	18	2014	9	11	1:20	74	45	162	0	W	300
MR1405-blue-BC10	9	18	2014	9	11	1:20	74	45	162	0	W	250
MR1405-blue-BC12	9	18	2014	9	11	1:20	74	45	162	0	W	200
MR1405-blue-BC14	9	18	2014	9	11	1:20	74	45	162	0	W	150
MR1405-blue-BC16	9	18	2014	9	11	1:20	74	45	162	0	W	100
MR1405-blue-BC18	9	18	2014	9	11	1:20	74	45	162	0	W	50
MR1405-blue-BC20	9	18	2014	9	11	1:20	74	45	162	0	W	30
MR1405-blue-BC21	9	18	2014	9	11	1:20	74	45	162	0	W	20
MR1405-blue-BC23	9	18	2014	9	11	1:20	74	45	162	0	W	10
MR1405-blue-BC24	9	18	2014	9	11	1:20	74	45	162	0	W	5
MR1405-blue-BCbucket	9	18	2014	9	11	1:20	74	45	162	0	W	0
MR1405-black-BC3	9	66	2014	9	23	1:20	74	45	162	0	W	1500
MR1405-black-BC4	9	66	2014	9	23	1:20	74	45	162	0	W	1000
MR1405-black-BC5	9	66	2014	9	23	1:20	74	45	162	0	W	800
MR1405-black-BC7	9	66	2014	9	23	1:20	74	45	162	0	W	500
MR1405-black-BC8	9	66	2014	9	23	1:20	74	45	162	0	W	400
MR1405-black-BC9	9	66	2014	9	23	1:20	74	45	162	0	W	300
MR1405-black-BC10	9	66	2014	9	23	1:20	74	45	162	0	W	250
MR1405-black-BC12	9	66	2014	9	23	1:20	74	45	162	0	W	200
MR1405-black-BC14	9	66	2014	9	23	1:20	74	45	162	0	W	150
MR1405-black-BC16	9	66	2014	9	23	1:20	74	45	162	0	W	100
MR1405-black-BC18	9	66	2014	9	23	1:20	74	45	162	0	W	50
MR1405-black-BC20	9	66	2014	9	23	1:20	74	45	162	0	W	30
MR1405-black-BC21	9	66	2014	9	23	1:20	74	45	162	0	W	20
MR1405-black-BC23	9	66	2014	9	23	1:20	74	45	162	0	W	10
MR1405-black-BC24	9	66	2014	9	23	1:20	74	45	162	0	W	5
MR1405-black-BCbucket	9	66	2014	9	23	1:20	74	45	162	0	W	0
MR1405-black-BCbucket	9	66	2014	9	23	1:20	74	45	162	0	W	0

Table 2.11-3b: Sampling logs of seawater sampled by Tap

	sampling	date sampling(UTC)			latitude			longitude			Depth
ID	hh:mm	yyyy	mm	dd	deg	min	N-S	deg	min	E-W	m
MR1405-WJ001	4:00	2014	9	2	60	43	n	167	48	W	4
MR1405-WJ002	0:18	2014	9	3	64	49	N	168	36	W	4
MR1405-WJ003	5:19	2014	9	6	75	0	N	161	12	W	4
MR1405-WJ004	23:50	2014	9	13	74	45	N	162	0	W	4
MR1405-WJ005	19:36	2014	9	27	68	38	N	168	48	W	4
MR1405-WJ006	4:20	2014	9	28	68	22	N	168	48	W	4
MR1405-WJ007	19:20	2014	9	28	64	49.5	N	170	13.7	W	4
MR1405-WJ008	5:56	2014	9	28	63	10.3	N	173	9	W	4
MR1405-WJ009	19:57	2014	9	28	60	40	N	176	38	W	4
MR1405-WJ010	11:15	2014	9	30	57	55	N	179	22	E	4
MR1405-WJ011	19:44	2014	10	30	56	30	N	177	5	E	4
MR1405-WJ012	11:48	2014	10	1	53	49.5	N	172	16	E	4
MR1405-WJ013	20:38	2014	10	1	52	19	N	171	16	E	4
MR1405-WJ014	19:51	2014	10	2	48	41.6	N	168	14.5	E	4
MR1405-WJ015	20:58	2014	10	3	45	28	N	165	16	E	4
MR1405-WJ016	21:10	2014	10	4	44	19	N	159	50	E	4
MR1405-WJ017	22:15	2014	10	5	42	58	N	155	42	E	4
MR1405-WJ018	22:10	2014	10	6	41	3	N	150	7	E	4
MR1405-WJ019	22:56	2014	10	7	38	8	N	145	22	E	4
MR1405-WJ020	23:15	2014	10	8	36	9	N	142	15.5	E	4

Table 2.11-4: Measurement logs of AOD

	date (UTC)				latitude(N)		longitude		
ID	yyyy	mm	dd	h:mm	deg	min	deg	min	E-W
MR1405-AOD002	2014	9	1	1:01	55	14	166	46	W
MR1405-AOD003	2014	9	1	3:59	55	51	166	56	W
MR1405-AOD004	2014	9	2	18:50	63	41	167	52	W
MR1405-AOD005	2014	9	2	21:38	64	16	168	13	W
MR1405-AOD006	2014	9	3	1:26	65	0	168	40	W
MR1405-AOD007	2014	9	13	4:13	74	45	162	2	W
MR1405-AOD008	2014	9	13	19:11	74	45	162	2	W
MR1405-AOD009	2014	9	13	22:35	74	45	162	2	W
MR1405-AOD010	2014	9	14	1:06	74	45	162	2	W
MR1405-AOD011	2014	9	14	1:41	74	45	162	2	W
MR1405-AOD012	2014	9	14	2:01	74	45	162	1	W
MR1405-AOD013	2014	9	14	213	74	45	162	1	W

MR1405-AOD014	2014	9	2	213	72	47	168	15	W
MR1405-AOD015	2014	9	28	19:34	64	47	170	18	W
MR1405-AOD016	2014	9	30	5:20	58	56	178	54	W
MR1405-AOD017	2014	10	2	2:51	51	26	170	31	E
MR1405-AOD018	2014	-	-	-	-	-	-	-	-
MR1405-AOD019	2014	10	2	23:40	48	1	167	46	E
MR1405-AOD020	2014	10	4	22:34	44	14	159	33	E
MR1405-AOD021	2014	10	4	23:27	44	11	159	22	E
MR1405-AOD022	2014	10	5	3:49	43	59	158	46	E
MR1405-AOD023	2014	10	7	2:56	40	34	149	17	E
MR1405-AOD024	2014	10	7	23:49	38	6	145	16	E
MR1405-AOD025	2014	10	8	4:49	37	35	144	29	E
MR1405-AOD026	2014	10	8	7:45	37	30	144	23	E

(6) Preliminary results

The time profile of number concentration of BC measured by SP2 instrument at stationary point(74-45N, 162-00W) was shown in Figure 2.11-1. To avoid the ship plume contribution, the data in the rage of 90-310 degree for relative wind direction were eliminated. Because the ship funnel was installed at south west from the inlet of particles. From this result, the concentration of BC was roughly estimated to be 0-2ng/m3 at the stationary point. Analysis of mixing state of BC using delay time difference between scattering signal and incandescence signal was also carried out, suggesting that BC particles in arctic were almost coated by other materials. To check the mixing state of BC, we also are going to analyze the sampled particles using the electronic telescope.

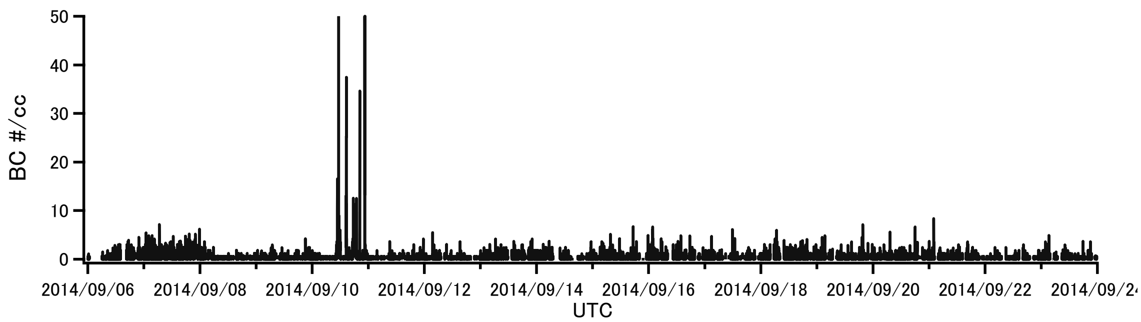


Figure 2.11-1: Variation of BC number concentration at stationary point(Sep.6-24)

Other data analysis is to be conducted.

(7) Data archive

The data files will be submitted to JAMSTEC Data Integration and Analyses Group (DIAG), after the full analysis is completed, which will be <2 years after the end of the cruise.

2.12. Aerosol optical characteristics measured by ship-borne sky radiometer

(1) Personnel

Kazuma Aoki	University of Toyama	- PI, not onboard
Tadahiro Hayasaka	Tohoku University	- not onboard

Sky radiometer operation was supported by Global Ocean Development Inc.

(2) Objective

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

(3) Parameters

- Aerosol optical thickness at five wavelengths (400, 500, 675, 870 and 1020 nm)
- Ångström exponent
- Single scattering albedo at five wavelengths
- Size distribution of volume (0.01 μm – 20 μm)
- # GPS provides the position with longitude and latitude and heading direction of the vessel, and azimuth and elevation angle of the sun. Horizon sensor provides rolling and pitching angles.

(4) Instruments and Methods

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

(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.

2.13. Perfluoroalkyl substances (PFASs)

(1) Personnel

Nobuyoshi Yamashita	National Institute of Advanced Industrial Science and Technology (AIST)	- PI
Sachi Taniyasu	AIST	

(2) Objective

Environmentally persistent perfluoroalkyl substances (PFASs, shown in Figure 2.13-1) have appeared as a new class of global pollutants.

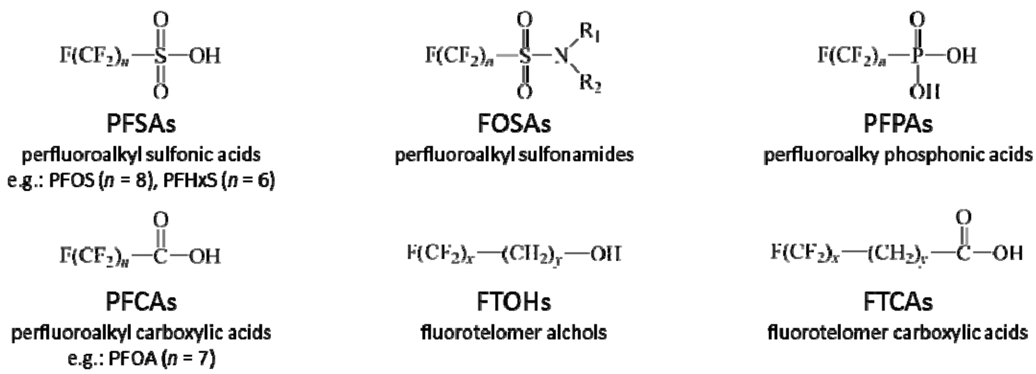


Figure 2.13-1: Perfluoroalkyl substances (PFASs)

These compounds have recently emerged as a priority environmental pollutant due to its widespread finding in biota including both Arctic and Antarctic species and its persistent and bioaccumulative nature, especially for PFOS (perfluorooctane sulfonate) and PFOA (perfluorooctane carboxylic acid). The physicochemical properties of PFASs, especially of PFSAs (perfluoroalkyl sufonic acids) and PFCAs (perfluoroalkyl carboxylic acids) are unique in that they have high water solubility despite the low reactivity of carbon-fluorine bond, which also imparts high stability in the environment.

PFOS was found in polar bears in the Arctic. It is the evidence that PFOS was transported to the Polar region by long-range transportation. However it is not well known about environmental fate of PFASs, especially for global transportation. It is important to determine environmental fate of PFASs such as the mechanism of global transport and distribution of PFASs, especially in the Polar region.

In MR14-05, we will survey PFASs in the air and precipitation on the Arctic Ocean to understand global distribution of PFASs.

(3) Parameters

Perfluoroalkyl substances (PFASs)

(4) Instruments and Methods

Air samples were taken with a comprehensive cryogenic moisture sampler (CMS; prototype type 5) which was developed by AIST and SIBATA Co (Figure 2.13-2). The air sampler was operated with a flow rate of 20 L/min. Gas and particle phase of PFASs in atmosphere were collected into bubbler solvent consisted of methanol in Milli-Q water by bubbling and then trapped into cold trap by cooling with -4 ˚C. Samples were collected during underway and CTD operation to avoid contamination from exhaust gas from ship.

Precipitation samples were also collected using polypropylene funnel (16.5 cm φ).

Air and precipitation samples were stored in clean polypropylene bottles and were kept frozen at below -20°C until analysis.

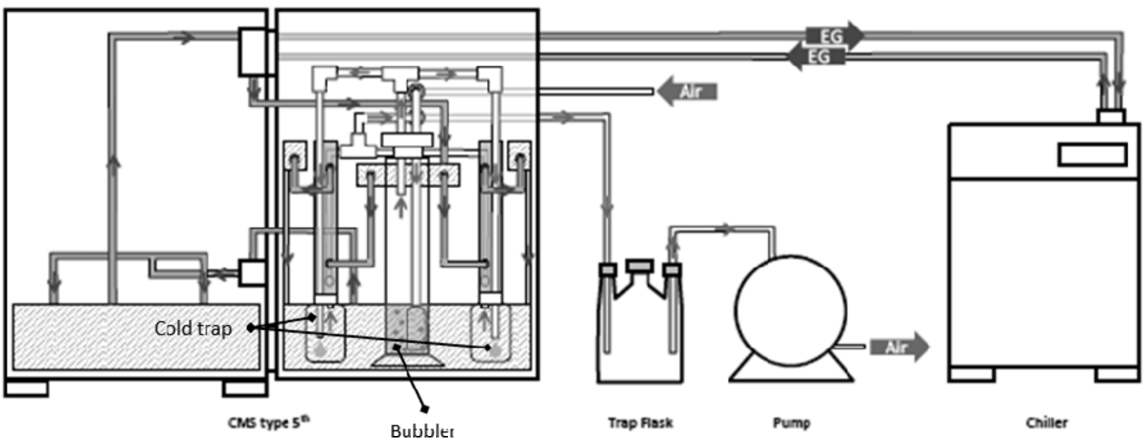


Figure 2.13-2: Schematic diagram of CMS type 5th system

Samples were thawed at room temperature, and a solid phase extraction method using Oasis®WAX cartridge (150 mg, 30 µm) (Waters Co.) (1-3). The HPLC tandem mass spectrometry (HPLC-MS/MS) was used for sample analysis (1-3). Briefly, after preconditioning with ammonium hydroxide in methanol, methanol, and then Millipore water, the cartridges were loaded water samples at approximately 1 drop sec^{-1}. Seawater samples were adjusted pH3 by acetic acid and then spiked surrogate standard (1 ng of each compound) before sample loading. The cartridges were then washed with Milli-Q water and then 25 mM ammonium acetate buffer (pH 4) in Milli-Q water and dried. The elution was then divided into two fractions. The first fraction was carried out with methanol and the second with 0.1% ammoniumhydroxide in methanol. Both fractions were reduced to 1 mL under a nitrogen stream and analyzed separately. HPLC-MS/MS, composed of a HP1100 liquid chromatograph (Agilent Technologies, Palo Alto, CA) interfaced with a Micromass® (Beverly, MA) Quattro Ultima Pt mass spectrometer was operated in the electrospray negative ionization mode. A 10-µL aliquot of the sample extract was injected into a Betasil C18 column (2.1 mm i.d. × 50 mm length, 5 µm; Termo Hypersil-Keystone, Bellefonte, PA). The capillary is held at 1.2 kV. Cone-gas and desolvation-gas flows are kept at 60 and 650 L/h, respectively. Source and desolvation temperatures were kept at 120 and 420°C respectively. MS/MS parameters are optimized so as to transmit the $[M-K]^-$ or $[M-H]^-$ ions.

(5) Observation log

List of air and precipitation samples were presented in Table 2.13-1 and in Table 2. 13-2, respectively.

Table 2.13-1: Summary of air sampling by CMS for PFASs analysis

On board ID		Date collected					Latitude			Longitude			Total Run Time	Total Vol.
		YYYY	MM	DD	hh:mm		deg	min	N/S	deg	min	E/W	(hrs)	(m^3)
MR1405-AR01	start	2014	08	31	20:04	UTC	54	13.66	N	166	32.90	W	28.15	33.832
	stop	2014	09	02	01:11	UTC	60	56.35	N	168	06.06	W		
MR1405-AR02	start	2014	09	02	06:34	UTC	61	13.07	N	167	35.75	W	32.28	37.262
	stop	2014	09	03	19:41	UTC	67	59.95	N	168	49.79	W		
MR1405-AR03	start	2014	09	03	20:58	UTC	68	07.62	N	168	49.97	W	23.50	28.238
	stop	2014	09	05	00:50	UTC	71	23.89	N	157	01.91	W		
MR1405-AR04	start	2014	09	05	01:37	UTC	71	28.17	N	157	05.80	W	18.42	23.762
	stop	2014	09	06	14:09	UTC	74	22.65	N	161	01.14	W		
MR1405-AR05	start	2014	09	06	16:41	UTC	74	45.00	N	161	59.97	W	68.90	82.419
	stop	2014	09	10	08:42	UTC	74	45.43	N	162	03.28	W		
MR1405-AR06	start	2014	09	10	19:26	UTC	74	49.34	N	162	01.61	W	64.30	77.370
	stop	2014	09	14	08:51	UTC	74	42.37	N	162	06.63	W		
MR1405-AR07	start	2014	09	14	17:42	UTC	74	45.16	N	161	59.88	W	71.67	86.192
	stop	2014	09	18	08:25	UTC	74	44.43	N	162	01.78	W		
MR1405-AR08	start	2014	09	18	17:58	UTC	74	44.79	N	162	01.81	W	115.70	139.225
	stop	2014	09	25	00:00	UTC	74	45.12	N	161	59.03	W		
MR1405-AR09	start	2014	09	25	01:34	UTC	74	44.38	N	162	02.17	W	43.37	52.195
	stop	2014	09	27	05:08	UTC	70	33.24	N	168	48.42	W		
MR1405-AR10	start	2014	09	27	05:34	UTC	70	29.45	N	168	48.53	W	29.33	35.279
	stop	2014	09	28	16:52	UTC	65	10.11	N	169	26.96	W		
MR1405-AR11	start	2014	09	28	22:18	UTC	64	21.20	N	171	13.95	W	57.00	68.479
	stop	2014	10	01	11:06	UTC	53	55.04	N	173	06.48	E		
MR1405-AR12	start	2014	10	01	11:34	UTC	53	51.91	N	172	58.56	E	71.33	85.714
	stop	2014	10	05	04:50	UTC	43	56.26	N	158	35.85	E		
MR1405-AR13	start	2014	10	05	05:36	UTC	43	53.29	N	158	34.54	E	26.20	31.483
	stop	2014	10	06	10:13	UTC	42	02.81	N	153	00.64	E		
MR1405-AR14	start	2014	10	07	01:11	UTC	40	45.20	N	149	36.95	E	30.78	36.991
	stop	1900	01	00	00:00	UTC	0	00.00	N	0	00.00	E		

Table 2.13-2: Summary of precipitation sampling for PFASs analysis

On board ID		Date collected					Latitude			Longitude		
		YYYY	MM	DD	hh : mm		deg	min	N/S	deg	min	E/W
MR1405-R01	start	2014	08	31	20:04	UTC	54	13.66	N	166	32.90	W
	stop	2014	09	07	06:23	UTC	74	45.27	N	161	58.56	W
MR1405-R02	start	2014	09	07	06:23	UTC	74	45.27	N	161	58.56	W
	stop	2014	09	14	20:43	UTC	74	48.23	N	161	01.36	W
MR1405-R03	start	2014	09	14	20:43	UTC	74	48.23	N	161	01.36	W
	stop	2014	09	18	17:58	UTC	74	44.79	N	162	01.81	W
MR1405-R04	start	2014	09	18	17:58	UTC	74	44.79	N	162	01.81	W
	stop	2014	09	24	02:21	UTC	74	43.05	N	162	01.71	W
MR1405-R05	start	2014	09	19	05:33	UTC	74	44.53	N	162	01.62	W
	stop	2014	09	23	19:22	UTC	74	44.81	N	162	02.98	W
MR1405-R06	start	2014	09	24	21:22	UTC	74	43.05	N	162	01.71	W
	stop	2014	09	27	05:48	UTC	70	26.78	N	168	48.56	W
MR1405-R07	start	2014	09	27	05:48	UTC	70	26.78	N	168	48.56	W
	stop	2014	09	28	22:18	UTC	64	21.20	N	171	13.95	W
MR1405-R08	start	2014	09	30	21:34	UTC	64	21.20	N	171	13.95	E
	stop	2014	10	02	02:25	UTC	51	25.02	N	170	29.39	E
MR1405-R09	start	2014	10	02	02:25	UTC	51	25.02	N	170	29.39	E
	stop	2014	10	04	23:22	UTC	44	11.24	N	159	22.98	E
MR1405-R10	start	2014	10	06	05:43	UTC	42	25.74	N	154	06.18	E
	stop	2014	10	06	22:21	UTC	41	02.12	N	150	06.62	E

(6) Data archives

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

(7) References

1) Yamashita N, Kannan K, Taniyasu S, Horii Y, Okazawa T, Petrick G, Gamo T, Analysis of Perfluorinated Acids at Parts-Per-Quadrillion Levels in Seawater Using Liquid Chromatography-Tandem Mass Spectrometry, Environ. Sci. Technol. (2004) 38, 5522-5528

2) Taniyasu S, Kannan K, So MK, Gulkowskad A, Sinclair E, Okazawa T, Yamashita N, Analysis of fluorotelomer alcohols, fluorotelomer acids, and short- and long-chain perfluorinated acids in water and biota, Journal of Chromatography A, 1093 (2005) 89–97

3) ISO 25101 (2009 March 1st) Water quality — Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) — Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry

3. Physical Oceanography

3.1. CTD cast and water samplings

(1) Personnel

Shigeto Nishino	JAMSTEC	- PI
Shungo Oshitani	MWJ	
Kenichi Katayama	MWJ	
Tomohide Noguchi	MWJ	
Keisuke Matsumoto	MWJ	

(2) Objective

Investigation of oceanic structure and water sampling.

(3) Parameters

Temperature
Conductivity
Pressure
Dissolved Oxygen voltage
Dissolved Oxygen
Transmission %, beam attenuation coefficient and voltage
Fluorescence
Photosynthetically Active Radiation
Altimeter

(4) Instruments and Methods

CTD/Carousel Water Sampling System, which is 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, RINKO III (dissolved oxygen sensor), dissolved oxygen (SBE43), transmission, fluorescence, PAR, deep ocean standards thermometer, and altimeter. The Practical 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 stop at each layer for 1 minute above thermo cline or 30 seconds below thermo cline to stabilize then fire.

97 casts of CTD measurements were conducted (Table 3.1-1).

In the 009M058 cast, the CTD winch trouble occurred and the cast was cancelled.

In 001M001 and 003M001 cast the value of fluorescence performed out of range, therefore the cable of fluorescence gain 10x was changed to gain 3x after 009M073.

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

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 4.4 seconds, and the offset was set to 0.0 seconds.

TCORP (original module): Corrected the pressure sensitivity of the secondary temperature (SBE3) sensor.

S/N 031524: -2.5868e-007 (degC/dbar)

RINKOCOR (original module): Corrected the time dependent, pressure induced effect (hysteresis) of the RINKO for both profile data.

RINKOCORROS (original module): Corrected the time dependent, pressure induced effect (hysteresis) of the RINKO for bottle information data by using the hysteresis corrected profile data.

BOTTLESUM: Create a summary of the bottle data. The data were averaged over 4.4 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 (SBE43) data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensors and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 5 seconds advancing dissolved oxygen sensors output (dissolved oxygen voltage) relative to the temperature data. RINKO-III voltage, transmission data and voltage are also delayed by slightly slow response time to the sensor. The delay was compensated by 1 second advancing.

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 (SBE43) 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 transmission data, voltage and 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).

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

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

Stn.001-001 - Stn.009-073 : MR1405A.xmlcon

Stn.009-074 - Stn.001-002 : MR1405B.xmlcon

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:

SBE9plus (S/N 09P54451-1027, Sea-Bird Electronics, Inc.)

Pressure sensor: Digiquartz pressure sensor (S/N 117457)

Calibrated Date: 09 Apr 2014

Temperature sensors:

Primary: SBE03-04/F (S/N 031525, Sea-Bird Electronics, Inc.)

Calibrated Date: 01 May 2014

Secondary: SBE03-04/F (S/N 031524, Sea-Bird Electronics, Inc.)

Calibrated Date: 12 Nov 2013

Conductivity sensors:

Primary: SBE04-04/0 (S/N 041203 Sea-Bird Electronics, Inc.)

Calibrated Date: 01 May 2014

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

Calibrated Date: 01 May 2014

Dissolved Oxygen sensors:

RINKO III (S/N 0024 (14402A), Alec Electronics Co. Ltd.)

Calibrated Date: 14 May 2014

RINKO- III (S/N 037 (1204), Alec Electronics Co. Ltd.)

Calibrated Date: 09 Aug. 2013

SBE43 (S/N 430575, Sea-Bird Electronics, Inc.)

Calibrated Date: 19 Apr 2014

Transmissonmeter:

C-Star (S/N CST-1363DR, WET Labs, Inc.)

Calibrated Date: 05 Aug. 2013

Fluorescence:

Chlorophyll Fluorometer (S/N 2936, Seapoint Sensors, Inc.)

Chlorophyll Fluorometer (S/N 3497, Seapoint Sensors, Inc.)

Photosynthetically Active Radiation:

PAR sensor (S/N 0049, Satlantic Inc.)

Calibrated Date: 22 Jan. 2009

Altimeter:

Benthos PSA-916T (S/N 1100, Teledyne Benthos, Inc.)

Used period: 001M001 - 009M073

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

Used period: 009M074 -

Deep Ocean Standards Thermometer:

SBE35 (S/N 0053, Sea-Bird Electronics, Inc.)

Calibrated Date: 02 May 2014

Carousel water sampler:

SBE32 (S/N 321746-0278, Sea-Bird Electronics, Inc.)

Submersible Pump:

Primary: SBE5T (S/N 054598, Sea-Bird Electronics, Inc.)

Secondary: SBE5T (S/N 053293, Sea-Bird Electronics, Inc.)

Bottom contact switch: (Sea-Bird Electronics, Inc.)

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

(5) Preliminary Results

During this cruise, 97 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 3.1-1. In some casts, we used a bottom contact sensor also.

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

001M001: Primary Fluorescence; up 15 db - surface,

Bottle data #22 - #26 (outside measurement range)

003M001: Primary Fluorescence; down surface -19 db and up 23 db -surface,
Secondary Fluorescence; down surface -17 db and up 22 db -surface,
bottle data #7, #21, #23 - #26 (outside measurement range)

008M001: Primary salinity down 435 db (spike)

009M066: Secondary salinity; down 676 db (spike)

006M002: Primary temperature and salinity; down 1091, up 1090 db (spike)

(6) Data archive

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

Table 3.1-1: MR14-05 CTD cast table

Stnnbr	Castno	Date(UTC) (mmddyy)	Time(UTC) Start	End	BottomPosition Latitude	Longitude	Depth	Wire Out	HT Above Bottom	Max Depth	Max Pressure	CTD Filename	Remark
001	1	090314	06:02	06:18	65-46.23N	168-47.54W	52.0	44.0	-	47.5	48.0	001M001	fluorescence out of range
002	1	090314	13:17	13:34	66-59.96N	168-50.02W	46.0	35.6	-	41.6	42.0	002M001	
003	1	090314	19:51	20:09	67-59.98N	168-50.05W	57.0	48.2	-	53.5	54.0	003M001	fluorescence out of range
004	1	090514	13:51	14:19	73-19.78N	161-59.95W	172.0	164.9	-	167.2	169.0	004M001	
005	1	090514	19:51	20:28	74-00.00N	164-00.47W	254.0	249.4	2.5	251.2	254.0	005M001	
006	1	090514	23:30	00:53	74-22.62N	162-59.75W	1098.0	1085.5	9.3	1085.7	1100.0	006M001	
007	1	090614	05:59	07:48	75-07.43N	160-59.41W	2075.0	2055.4	10.1	2057.0	2089.0	007M001	
008	1	090614	12:28	14:01	74-22.46N	160-59.87W	1587.0	1562.3	8.4	1564.6	1587.0	008M001	
009	1	090614	18:23	18:43	74-45.04N	161-59.88W	1882.0	393.4	-	396.5	401.0	009M001	no water sampling
009	2	090614	23:42	01:26	74-45.23N	161-59.98W	1882.0	1870.7	8.3	1870.8	1899.0	009M002	
009	3	090714	05:41	05:59	74-45.09N	161-59.29W	1883.0	394.5	-	396.5	401.0	009M003	no water sampling
009	4	090714	11:43	12:31	74-45.11N	162-01.04W	1881.0	393.5	-	396.5	401.0	009M004	
009	5	090714	17:43	18:00	74-45.33N	161-59.18W	1884.0	394.3	-	397.4	402.0	009M005	no water sampling
009	6	090714	23:47	00:41	74-45.46N	161-59.57W	1883.0	394.5	-	396.5	401.0	009M006	
009	7	090814	05:42	05:59	74-45.10N	161-59.80W	1881.0	392.4	-	396.5	401.0	009M007	no water sampling
009	8	090814	11:43	12:34	74-44.95N	161-59.98W	1882.0	394.3	-	396.5	401.0	009M008	
009	9	090814	17:42	17:59	74-44.96N	161-58.19W	1883.0	391.3	-	396.5	401.0	009M009	no water sampling
009	10	090814	23:40	01:25	74-45.12N	161-59.14W	1883.0	1874.2	8.6	1872.8	1901.0	009M010	

009	11	090914	05:42	05:59	74-45.13N	161-59.78W	1882.0	393.9	-	396.5	401.0	009M011	no water sampling
009	12	090914	11:43	12:34	74-45.06N	161-59.63W	1882.0	395.0	-	396.5	401.0	009M012	
009	13	090914	17:41	17:58	74-45.37N	162-00.60W	1881.0	392.3	-	396.5	401.0	009M013	no water sampling
009	14	090914	23:40	00:41	74-45.62N	162-01.24W	1880.0	395.6	-	396.5	401.0	009M014	
009	15	091014	05:43	06:00	74-45.39N	162-00.74W	1881.0	393.9	-	396.5	401.0	009M015	no water sampling
009	16	091014	11:40	12:31	74-45.32N	161-59.49W	1884.0	395.4	-	396.5	401.0	009M016	
009	17	091014	17:41	17:58	74-45.20N	161-59.71W	1882.0	393.5	-	396.5	401.0	009M017	no water sampling
009	18	091014	23:40	01:14	74-45.20N	161-59.75W	1883.0	1482.1	-	1479.1	1500.0	009M018	
009	19	091114	05:42	05:59	74-45.37N	161-58.98W	1885.0	394.1	-	396.5	401.0	009M019	no water sampling
009	20	091114	11:39	12:31	74-45.24N	162-00.06W	1882.0	396.3	-	397.4	402.0	009M020	
009	21	091114	18:05	18:22	74-45.10N	161-59.23W	1883.0	396.3	-	396.4	401.0	009M021	no water sampling
009	0	091114	20:46	21:31	74-44.93N	161-59.54W	1882.0	792.6	-	792.2	802.0	009M000	Cs sampling
009	22	091114	23:42	00:36	74-44.79N	162-00.20W	1881.0	391.9	-	396.4	401.0	009M022	
009	23	091214	05:42	05:59	74-45.04N	161-59.61W	1883.0	394.8	-	396.5	401.0	009M023	no water sampling
009	24	091214	11:45	12:34	74-45.24N	162-00.85W	1880.0	393.9	-	395.5	400.0	009M024	
009	25	091214	17:42	18:00	74-45.21N	161-59.83W	1883.0	394.8	-	396.5	401.0	009M025	no water sampling
009	26	091214	23:40	01:28	74-45.00N	162-01.12W	1880.0	1878.2	9.5	1867.9	1896.0	009M026	
009	27	091314	05:40	05:57	74-45.02N	162-01.56W	1880.0	395.4	-	395.5	400.0	009M027	no water sampling
009	28	091314	11:44	12:35	74-45.20N	162-01.89W	1879.0	396.5	-	396.5	401.0	009M028	
009	29	091314	17:41	17:58	74-44.62N	162-00.73W	1878.0	396.7	-	396.5	401.0	009M029	no water sampling
009	30	091314	23:40	00:32	74-44.77N	162-00.46W	1881.0	395.4	-	396.5	401.0	009M030	
009	31	091414	05:39	05:57	74-44.71N	162-00.43W	1880.0	395.4	-	396.5	401.0	009M031	no water sampling

009	32	091414	12:05	12:51	74-45.14N	162-00.68W	1881.0	394.6	-	397.4	402.0	009M032	
009	33	091414	17:50	18:07	74-45.26N	161-59.89W	1883.0	391.5	-	396.5	401.0	009M033	no water sampling
009	34	091414	23:41	01:11	74-45.11N	162-00.91W	1881.0	1498.8	-	1482.1	1503.0	009M034	
009	35	091514	05:45	06:03	74-45.08N	161-59.80W	1882.0	394.1	-	396.5	401.0	009M035	no water sampling
009	36	091514	11:40	12:31	74-45.15N	162-01.18W	1879.0	394.8	-	397.4	402.0	009M036	
009	37	091514	17:40	17:58	74-44.85N	162-00.77W	1879.0	393.5	-	396.5	401.0	009M037	no water sampling
009	38	091514	23:43	00:35	74-44.98N	161-59.43W	1883.0	392.0	-	396.5	401.0	009M038	
009	39	091614	05:40	05:57	74-45.11N	162-00.12W	1881.0	393.9	-	396.5	401.0	009M039	no water sampling
009	40	091614	11:39	12:24	74-45.02N	161-59.42W	1883.0	393.7	-	397.4	402.0	009M040	
009	41	091614	17:40	17:57	74-45.00N	161-59.95W	1883.0	394.5	-	396.5	401.0	009M041	no water sampling
009	42	091614	23:37	01:21	74-44.93N	161-59.68W	1881.0	1869.8	9.5	1869.8	1898.0	009M042	
009	43	091714	05:40	05:57	74-45.05N	161-59.74W	1883.0	394.5	-	396.5	401.0	009M043	no water sampling
009	44	091714	11:40	12:31	74-44.80N	162-00.27W	1881.0	393.7	-	396.5	401.0	009M044	
009	45	091714	17:40	17:58	74-45.14N	162-00.08W	1882.0	393.9	-	396.5	401.0	009M045	no water sampling
009	46	091714	23:40	00:35	74-44.86N	161-59.73W	1883.0	394.5	-	396.5	401.0	009M046	
009	47	091814	05:44	06:01	74-44.96N	162-00.71W	1881.0	394.1	-	396.5	401.0	009M047	no water sampling
009	48	091814	11:47	12:34	74-44.94N	162-01.66W	1878.0	392.3	-	396.5	401.0	009M048	
010	1	091814	15:07	15:58	74-42.06N	162-07.96W	1844.0	394.5	-	397.4	402.0	010M001	
009	49	091814	18:11	18:29	74-45.12N	162-01.09W	1880.0	394.1	-	396.5	401.0	009M049	no water sampling
009	50	091814	23:44	01:12	74-44.92N	162-00.77W	1880.0	1493.9	-	1481.1	1502.0	009M050	
009	51	091914	05:49	06:06	74-44.67N	162-01.17W	1878.0	391.9	-	396.5	401.0	009M051	no water sampling
009	52	091914	11:45	12:36	74-44.89N	162-01.62W	1879.0	393.4	-	396.5	401.0	009M052	

009	53	091914	17:43	18:01	74-45.00N	162-00.29W	1883.0	395.4	-	396.5	401.0	009M053	no water sampling
009	54	091914	23:42	00:33	74-45.08N	162-00.24W	1883.0	395.0	-	397.4	402.0	009M054	
011	1	092014	03:14	03:58	74-49.16N	161-50.27W	1925.0	393.7	-	396.5	401.0	011M001	
009	55	092014	05:40	05:57	74-45.09N	162-00.08W	1884.0	391.5	-	396.5	401.0	009M055	no water sampling
009	56	092014	11:42	12:31	74-45.08N	162-00.39W	1882.0	392.3	-	396.5	401.0	009M056	
009	57	092014	17:40	17:58	74-45.03N	161-59.65W	1884.0	392.6	-	396.5	401.0	009M057	no water sampling
009	59	092114	06:35	06:52	74-45.40N	162-01.98W	1881.0	393.9	-	397.5	402.0	009M059	no water sampling
009	60	092114	11:41	12:26	74-45.02N	162-00.76W	1881.0	395.7	-	397.5	402.0	009M060	
009	61	092114	17:40	17:57	74-44.91N	161-59.86W	1883.0	395.6	-	397.5	402.0	009M061	no water sampling
009	62	092114	23:40	01:23	74-44.90N	161-59.04W	1884.0	1877.1	9.0	1870.8	1899.0	009M062	
009	63	092214	05:41	05:58	74-44.99N	161-59.52W	1885.0	393.5	-	396.5	401.0	009M063	no water sampling
009	64	092214	11:40	12:29	74-45.20N	162-00.55W	1882.0	396.3	-	397.4	402.0	009M064	
009	65	092214	17:41	17:58	74-45.28N	161-59.88W	1884.0	393.7	-	396.5	401.0	009M065	no water sampling
009	66	092214	23:40	01:06	74-45.06N	161-59.41W	1886.0	1478.6	-	1480.1	1501.0	009M066	
009	67	092314	05:40	05:56	74-44.78N	161-59.08W	1884.0	392.4	-	395.5	400.0	009M067	no water sampling
009	68	092314	11:41	12:25	74-44.97N	161-59.58W	1884.0	394.3	-	396.5	401.0	009M068	
009	69	092314	17:40	17:56	74-45.05N	162-00.38W	1882.0	394.3	-	396.5	401.0	009M069	no water sampling
009	70	092314	23:40	00:29	74-44.87N	161-59.92W	1882.0	395.4	-	396.5	401.0	009M070	
009	71	092414	05:40	05:57	74-44.78N	162-01.74W	1878.0	395.0	-	396.5	401.0	009M071	no water sampling
009	72	092414	11:41	12:30	74-45.02N	161-59.91W	1884.0	393.5	-	395.5	400.0	009M072	
009	73	092414	17:40	17:56	74-45.32N	162-01.41W	1881.0	392.4	-	395.5	400.0	009M073	no water sampling
009	74	092414	23:40	01:22	74-45.13N	161-58.98W	1885.0	1872.5	9.4	1871.8	1900.0	009M074	changed fluorescence

													cable (gain 30x → gain 3x)
006	2	092514	04:08	05:21	74-22.49N	163-00.59W	1090.0	1074.5	8.8	1077.9	1092.0	006M002	
005	2	092514	08:01	08:39	73-59.98N	164-00.12W	251.0	240.6	9.5	242.3	245.0	005M002	
012	1	092514	14:14	14:39	73-30.00N	166-59.93W	105.0	96.6	5.2	100.9	102.0	012M001	
013	1	092514	19:37	19:56	72-45.00N	168-14.86W	56.0	48.8	4.6	51.5	52.0	013M001	
013	2	092614	01:15	01:37	72-44.96N	168-14.81W	56.0	48.2	4.6	51.5	52.0	013M002	
013	3	092614	07:07	07:27	72-44.88N	168-14.80W	56.0	48.2	5.6	50.5	51.0	013M003	
013	4	092614	13:03	13:24	72-45.11N	168-14.60W	56.0	44.2	5.7	50.5	51.0	013M004	
014	1	092614	19:05	19:25	72-05.00N	168-50.01W	52.0	40.7	5.2	46.5	47.0	014M001	
015	1	092714	02:29	02:45	71-00.03N	168-49.98W	44.0	35.4	5.2	38.6	39.0	015M001	
016	1	092714	08:13	08:29	70-00.06N	168-49.33W	39.0	29.2	5.3	33.7	34.0	016M001	
017	1	092714	15:12	15:30	69-00.12N	168-49.92W	51.0	39.8	6.8	44.5	45.0	017M001	
003	2	092714	23:21	23:44	67-59.97N	168-50.09W	58.0	46.4	6.7	50.5	51.0	003M002	
001	2	092814	12:54	13:14	65-46.48N	168-47.10W	52.0	44.6	4.3	47.5	48.0	001M002	

3.2. XCTD

(1) Personnel

Shigeto Nishino	JAMSTEC	- PI
Katsuhisa Maeno	GODI	
Souichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Koichi Inagaki	GODI	
Miki Morioka	GODI	
Ryo Kimura	MIRAI Crew	

(2) Objective

To obtain vertical profiles of sea water temperature and salinity.

(3) Parameters

According to the manufacturer's nominal specifications, the range and accuracy of parameters measured by the XCTD (eXpendable Conductivity, Temperature & Depth profiler) are as follows;

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) 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 digital converter MK-150N, and was recorded by AL-12B software (Ver.1.1.4). We launched 60 probes (XCTD-1 – XCTD-60) by using automatic launcher. The summary of XCTD observation log is shown in Table 3.2-1.

(5) Observation log

Table 3.2-1: XCTD observation log

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [degN]	Longitude [degW]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
1	XCTD01	2014/09/05	21:08	74-04.5344	163-47.9282	294	1.359	27.559	14046683
2	XCTD02	2014/09/05	21:37	74-09.1360	163-35.9839	342	1.401	27.825	14046686
3	XCTD03	2014/09/05	22:05	74-13.7288	163-23.9898	416	1.385	27.780	14046688
4	XCTD04	2014/09/05	22:34	74-18.2673	163-12.0206	850	1.492	26.994	14046684
5	XCTD05	2014/09/06	01:12	74-23.2165	162-55.8323	1143	1.378	26.997	12057588
6	XCTD06	2014/09/06	01:40	74-27.7252	162-44.9813	1291	0.497	27.204	14046692
7	XCTD07	2014/09/06	02:17	74-33.9876	162-30.0020	1572	0.600	27.281	14046693

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [degN]	Longitude [degW]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
8	XCTD08	2014/09/06	02:51	74-39.3839	162-15.0746	1779	1.438	27.328	14046685
9	XCTD09	2014/09/06	03:26	74-44.9237	162-00.0202	1881	0.876	27.394	14046694
10	XCTD10	2014/09/06	04:12	74-52.6447	161-39.7072	1959	1.116	27.358	14046690
11	XCTD11	2014/09/06	04:58	75-00.2183	161-19.8416	1661	1.029	27.269	13114414
12	XCTD12	2014/09/06	09:25	74-52.4841	161-00.0048	1729	-0.059	26.966	14046691
13	XCTD13	2014/09/06	10:43	74-37.5011	161-59.7259	1746	0.559	27.099	13114413
14	XCTD14	2014/09/06	14:54	74-30.2419	161-20.0694	1715	0.078	26.997	14046689
15	XCTD15	2014/09/06	15:38	74-37.3894	161-39.9664	1809	0.587	27.215	14046687
16	XCTD16	2014/09/11	10:06	74-34.0653	162-29.9777	1570	1.136	25.862	12057590
17	XCTD17	2014/09/11	10:39	74-39.3767	162-15.0419	1778	0.921	25.990	12057594
18	XCTD18	2014/09/11	15:10	74-51.9717	161-40.0422	1955	0.472	26.632	12057589
19	XCTD19	2014/09/11	16:00	75-00.0178	161-20.0568	1670	0.110	27.094	12057593
20	XCTD20	2014/09/14	08:59	74-41.0220	162-09.9647	1825	-0.260	26.849	12057592
21	XCTD21	2014/09/14	09:24	74-37.0293	162-19.9488	1697	-0.182	26.872	12057597
22	XCTD22	2014/09/14	09:49	74-32.9997	162-29.9951	1553	1.103	26.239	12057596
23	XCTD23	2014/09/14	14:55	74-49.0307	161-50.0358	1922	0.105	27.133	12057600
24	XCTD24	2014/09/14	15:20	74-52.9311	161-40.0357	1960	0.279	26.795	12057599
25	XCTD25	2014/09/14	15:46	74-57.0239	161-30.0493	1831	0.104	27.014	12057595
26	XCTD26	2014/09/18	03:51	74-57.0689	161-29.9775	1828	-0.015	27.095	14046598
27	XCTD27	2014/09/18	04:28	74-55.1185	161-34.9867	1980	-0.075	27.116	12057598
28	XCTD28	2014/09/18	04:41	74-53.0145	161-40.0789	1962	-0.140	27.222	14046599
29	XCTD29	2014/09/18	04:53	74-51.0894	161-44.9386	1943	-0.187	27.246	14045697
30	XCTD30	2014/09/18	05:06	74-48.9857	161-50.0629	1923	-0.033	26.695	14046675
31	XCTD31	2014/09/18	05:18	74-47.0232	161-55.0085	1902	0.203	26.312	14046676
32	XCTD32	2014/09/18	08:35	74-42.9855	162-04.8752	1860	0.410	26.150	14046682
33	XCTD33	2014/09/18	08:48	74-40.9828	162-09.9515	1823	0.580	26.049	14046679
34	XCTD34	2014/09/18	09:00	74-39.0323	162-15.0244	1770	0.130	26.243	14046678
35	XCTD35	2014/09/18	09:12	74-36.9854	162-19.9850	1688	-0.129	26.227	14046600
36	XCTD36	2014/09/18	09:25	74-34.9093	162-25.0164	1612	0.484	26.204	14046677
37	XCTD37	2014/09/18	09:37	74-32.9203	162-29.9587	1551	0.524	26.312	14046681
38	XCTD38	2014/09/19	02:54	74-43.2007	161-55.0320	1884	0.095	26.313	14046680
39	XCTD39	2014/09/19	03:07	74-41.2868	161-50.0341	1868	-0.254	26.350	12036666
40	XCTD40	2014/09/19	03:21	74-39.3357	161-44.9320	1841	-0.212	26.436	11011574
41	XCTD41	2014/09/19	03:34	74-37.5447	161-39.8724	1815	-0.099	26.431	12036664
42	XCTD42	2014/09/19	03:55	74-35.5782	161-35.1668	1750	0.290	26.307	11011575
43	XCTD43	2014/09/21	01:19	74-45.4760	162-01.8666	1880	-0.066	26.452	11011573
44	XCTD44	2014/09/24	03:53	74-56.9950	161-30.3515	1829	-0.629	26.683	11011578
45	XCTD45	2014/09/24	04:06	74-54.8844	161-34.9783	1977	-0.575	26.631	11011576
46	XCTD46	2014/09/24	04:18	74-52.7932	161-39.9821	1962	-0.682	26.715	11011579
47	XCTD47	2014/09/24	04:29	74-51.0402	161-44.9295	1941	-0.529	26.604	11011577
48	XCTD48	2014/09/24	04:42	74-49.0118	161-49.9914	1924	-0.436	26.411	11011581

No.	Station No.	Date [YYYY/MM/DD]	Time [hh:mm]	Latitude [degN]	Longitude [degW]	Depth [m]	SST [deg-C]	SSS [PSU]	Probe S/N
49	XCTD49	2014/09/24	04:53	74-47.1551	161-54.9734	1904	-0.348	26.367	11011580
50	XCTD50	2014/09/25	02:05	74-39.3090	162-15.0468	1780	-0.254	26.421	14015282
51	XCTD51	2014/09/25	02:45	74-33.6241	162-30.2171	1565	0.419	26.803	14015279
52	XCTD52	2014/09/25	03:19	74-28.0117	162-45.2389	1300	0.177	26.655	14015277
53	XCTD53	2014/09/25	05:56	74-18.0066	163-11.9716	839	1.018	27.937	14015276
54	XCTD54	2014/09/25	06:24	74-13.5939	163-23.9514	418	1.172	27.783	14015280
55	XCTD55	2014/09/25	06:51	74-09.1335	163-35.9589	348	0.506	27.435	14015285
56	XCTD56	2014/09/25	07:19	74-04.5199	163-47.9564	293	1.000	27.918	14015278
57	XCTD57	2014/09/25	18:40	72-53.9544	168-15.0403	56	2.673	31.063	14015286
58	XCTD58	2014/09/25	21:59	72-44.9890	168-45.0376	57	3.022	31.154	14015284
59	XCTD59	2014/09/25	23:04	72-35.9848	168-15.3677	54	2.843	31.107	14015281
60	XCTD60	2014/09/26	00:12	72-45.0217	167-45.0052	55	2.411	30.944	14015283

Acronyms in Table XCTD observation log are as follows;

Depth: Water Depth [m]

SST: Sea Surface Temperature [deg-C] measured by TSG (ThermoSalinoGraph).

SSS: Sea Surface Salinity [PSU] measured by TSG.

(6) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC web site.

3.3. Shipboard ADCP

(1) Personnel

Shigeto Nishino	JAMSTEC	- PI
Katsuhisa Maeno	GODI	
Souichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Koichi Inagaki	GODI	
Miki Morioka	GODI	
Ryo Kimura	MIRAI Crew	

(2) Objectives

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

(3) Instruments and methods

Upper ocean current measurements were made in MR14-05 cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation the instrument was configured for water-tracking mode. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made to get the calibration data for evaluating transducer misalignment angle in the shallow water. The system consists of following components;

1. R/V MIRAI has installed the Ocean Surveyor for vessel-mount ADCP (frequency 76.8 kHz; Teledyne RD Instruments, USA). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel
2. For heading source, we use ship's gyro compass (Tokimec, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System which provide high-precision heading, attitude information, pitch and roll, are stored in ".N2R" data files with a time stamp.
3. DGPS system (Trimble SPS751 & Fugro Multifix ver.6) providing precise ship's position.
4. We used VmDas software version 1.46.5 (TRDI) for data acquisition.
5. To synchronize time stamp of ping with GPS time, the clock of the logging computer is adjusted to GPS time every 1 minute.
6. Fresh water is charged in the sea chest to prevent bio fouling at transducer face.
7. The sound speed at the transducer does affect the vertical bin mapping and vertical velocity measurement, is calculated from temperature, salinity (constant value; 35.0 PSU) and depth (6.5 m; transducer depth) by equation

in Medwin (1975).

Data was configured for “8 m” intervals starting about 23 m below sea surface. Data was recorded every ping as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds averaged data were recorded as short-term average (.STA) and long-term average (.LTA) data, respectively. Major parameters for the measurement, Direct Command, are shown in Table 3.3-1.

Table 3.3-1: Major parameters

Bottom-Track Commands	
BP = 001	Pings per Ensemble (almost less than 1,200m depth)
Environmental Sensor Commands	
EA = 04500	Heading Alignment (1/100 deg)
EB = +00000	Heading Bias (1/100 deg)
ED = 00065	Transducer Depth (0 - 65535 dm)
EF = +001	Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99]
EH = 00000	Heading (1/100 deg)
ES = 35	Salinity (0-40 pp thousand)
EX = 00000	Coordinate Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 10200010	Sensor Source (C; D; H; P; R; S; T; U)
C (1): Sound velocity calculates using ED, ES, ET (temp.)	
D (0): Manual ED	
H (2): External synchro	
P (0), R (0): Manual EP, ER (0 degree)	
S (0): Manual ES	
T (1): Internal transducer sensor	
U (0): Manual EU	
Timing Commands	
TE = 00:00:02.00	Time per Ensemble (hrs:min:sec.sec/100)
TP = 00:02.00	Time per Ping (min:sec.sec/100)
Water-Track Commands	
WA = 255	False Target Threshold (Max) (0-255 count)
WB = 1	Mode 1 Bandwidth Control (0=Wid, 1=Med, 2=Nar)
WC = 120	Low Correlation Threshold (0-255)
WD = 111 100 000	Data Out (V; C; A; PG; St; Vsum; Vsum^2; #G; P0)
WE = 1000	Error Velocity Threshold (0-5000 mm/s)
WF = 0800	Blank After Transmit (cm)
WG = 001	Percent Good Minimum (0-100%)
WI = 0	Clip Data Past Bottom (0 = OFF, 1 = ON)
WJ = 1	Rcvr Gain Select (0 = Low, 1 = High)
WM = 1	Profiling Mode (1-8)
WN = 100	Number of depth cells (1-128)

WP = 00001	Pings per Ensemble (0-16384)
WS = 800	Depth Cell Size (cm)
WT = 000	Transmit Length (cm) [0 = Bin Length]
WV = 0390	Mode 1 Ambiguity Velocity (cm/s radial)

(4) Data archives

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

3.4. Microstructure observations

(1) Personnel

Yusuke Kawaguchi	JAMSTEC / Univ. Washington	- PI
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(2) Objectives and methodology

To understand turbulent mixing and diapycnal heat transfer in the ice-free region of the Western Arctic Ocean, microscale temperature and vertical shear data were acquired during MR14-05. During the fixed-point observation on September 6–26 in 2014 in the North-Wind Abyssal Plain, the microstructure measurements were operated at a regular frequency of every 6 hours. The measurements were generally performed within an hour of the shipboard CTD observation by virtue of the quality control of temperature and salinity.

(3) Parameters

According to the manufacture's nominal specifications, the range, accuracy and sample rate of parameters are shown in Table 3.4-1.

Table 3.4-1: Detail lists of sencors.

Parameter	Type	Range	Accuracy	Sampling rate
$\partial u/\partial z$ (primary)	Shear probe	0~10 /s	5%	512Hz
$T+\partial T/\partial z$	FPO-7 thermistor	−5~45°C	±0.01°C	512Hz
T	Platinum wire thermometer	−5~45°C	±0.01°C	64 Hz
Conductivity	Inductive Cell	0~70 mS	±0.01 mS	64 Hz

Depth	Semiconductor strain gauge	0~1000 m	±0.2%	64 Hz
x- acceleration	Solid-state fixed mass	±2 G	±1%	256 Hz
y- acceleration	Solid-state fixed mass	±2 G	±1%	256 Hz
z- acceleration	Solid-state fixed mass	±2 G	±1%	64Hz
Chlorophyll	Fluorescence	0~100 µg/Lm	0.5 µg/L or ±1%	256 Hz
Turbidity	Backscatter	0~100 ppm	1ppm or ±2%	256 Hz
∂u/∂z (Secondary)	∂u/∂z Shear	0~10 s^{-1}	5%	512 Hz

(4) Instruments and Methodology

Turbulence Ocean Microstructure Acquisition Profiles (TurboMAP-L, build by Alec Electronics Co Ltd.) was used to measure turbulence-scale temperature and current shear. TurboMap is a quasi-free-falling instrument that measures turbulent mixing parameters (∂u/∂z and ∂T/∂z), bio-optical parameters (in vivo fluorescence and back scatter) and hydrographic parameters (conductivity, temperature, and pressure). The TurboMAP is a loosely tethered free-fall profiler that is equipped with two airfoil shear probes, a fast-response thermistor (FP07), a light-emitting diode fluorescence/turbidity probe, and a CTD package (Wolk et al. 2002). The TurboMAP collects vertical profiles of microscale velocity shear, high- and low-resolution temperature, conductivity, and pressure, as the underwater device descends from the surface to maximum depth (400–500 m). The free-falling speed of the instrument is roughly at 0.5–0.6 m s^{-1}. Operation of the ship's side thrusters is halted during micro-data acquisition so that they may not create any artificial noise corruption in the micro-scale data. The microscale data within 7 m depth are not recommended for the analysis as they may include potential noise corruption due to the instrument's initial adjustment to free-falling or/and due to pitching/rolling of ship body.

(5) Station list

The operational information of all TurboMAP observations is listed in Table 3.4-2.

(6) Technical report: quality and diversity of micro-scale shear probes

During the FPO program, we attempted multiple combinations of shear probes (as primary and secondary) for the TurboMAP observation in order to explore quality and diversity of micro-shear data. Figure 3.4-1 compares the estimates of kinetic energy dissipation rate (ε) between primary and secondary shear probes, where ε was calculated using a software TMTool (Alec Electronics Co Ltd.). Comparing the estimate from probes 504 versus 503 during casts 01–41, they show certainly a positive correlation with each other, but they also have substantial discrepancy particularly when probe 503 gives $\log_{10}(\varepsilon) > -8.8$. From the comparison between probes 504 versus 503, it seems that probe 504 tends to overestimate the ε estimate relative to that from probe 503. In the mean time, probes 505 and 506 (cast 62–106) shows the best correlation of the overall combination of the probe pairs. Probe 505 also shows a good relationship with probe 507 (for cast 107–121), with an offset of ~$10^{0.2}$ W kg^{-1} though. From these results, we may conclude that probe 505 presumably retrieves the most reliable micro-scale shear data, and hence, probes 506 and 507 can be favorably used as the secondary spare sensor since they show relatively good correlation with the results from probe 505.

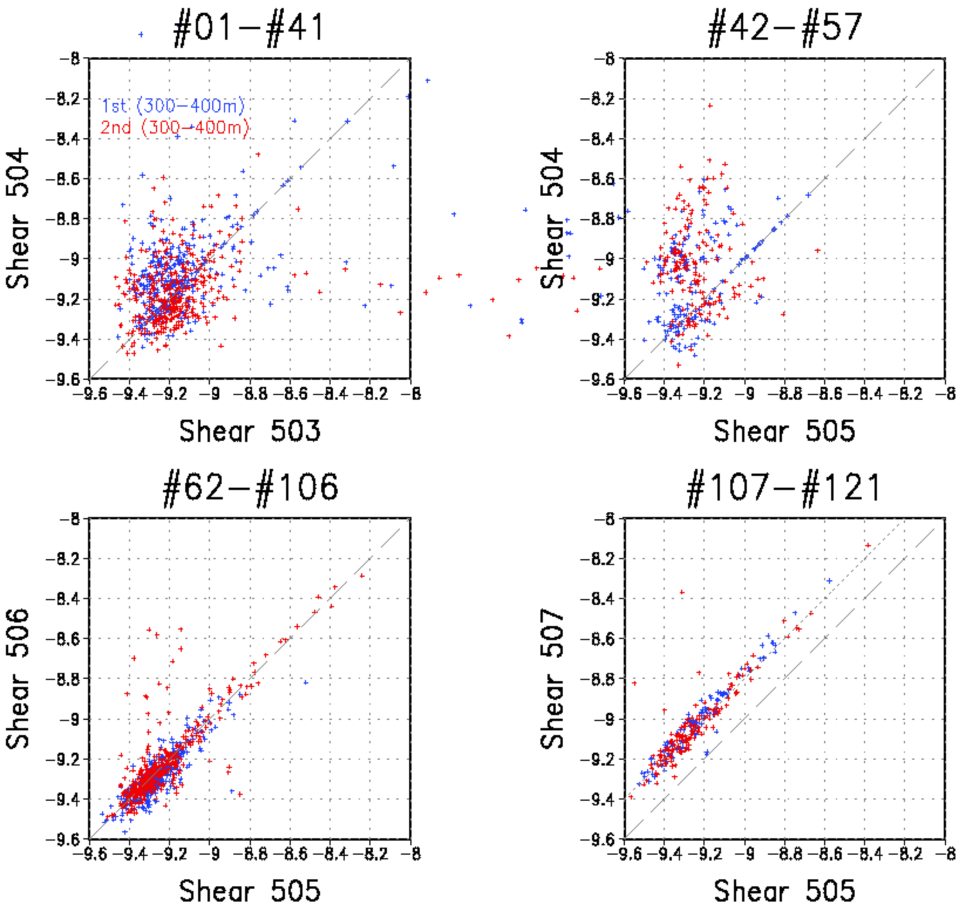


Figure 3.4-1: A scatter diagram of kinetic energy dissipation rate (ε) estimates, comparing between primary and secondary shear probes. For TurboMAP casts (a) 1–41, (b) 42–57, (c) 62–106, and (d) 107–121, the pair of primary and secondary shear probes is respectively as follows: (503, 504), (505, 504), (505, 506), and (505, 507). Note that ε is shown in a logarithmic scale. (Figure courtesy: J. Inoue).

Table 3.4-2: Observation log.

No.	Date [YYYY/ MM/DD]	Latitude [deg-min]	Longitude [deg-min]	Logging Time (UTC)		Depth [m]	Obs. Dep. [m]	Sensor S/N		
				Start	Stop			FPO7	Shear-1	Shear-2
01	2014/09/06	74-45.0686N	161-59.8979W	19:05	19:09	1882	530	144	503	504
02	2014/09/06	74-45.0943N	161-59.8025W	19:32	19:36	-	517	144	503	504
03	2014/09/07	74-45.3794N	161-59.0848W	1:35	1:53	1885		144	503	504
04	2014/09/07	74-45.4963N	161-58.5706W	2:04	2:19	-	500	144	503	504
05	2014/09/07	74-45.1330N	161-58.9854W	6:07	6:22	1884	469	144	503	504
06	2014/09/07	74-45.2896N	161-58.4733W	6:31	6:45	-	455	144	503	504
07	2014/09/07	74-45.4141N	162-00.4123W	12:39	12:55	1881	455	144	503	504
08	2014/09/07	74-45.6461N	161-59.9342W	13:04	13:17	-	462	144	503	504
09	2014/09/07	74-45.8106N	161-59.5124W	13:26	13:40	-	455	144	503	504
10	2014/09/07	74-45.4149N	161-58.5917W	18:07	18:20	1887	470	144	503	504
11	2014/09/07	74-45.5916N	161-57.5263W	18:36	18:50	-	467	144	503	504
12	2014/09/08	74-45.4176N	161-58.7736W	0:49	1:04	1885	477	144	503	504
13	2014/09/08	74-45.3155N	161-58.2542W	1:14	1:29	-	485	144	503	504
14	2014/09/08	74-45.1004N	161-59.4001W	6:07	6:21	1883	433	144	503	504
15	2014/09/08	74-45.1208N	161-57.9818W	6:33	6:46	-	459	144	503	504
16	2014/09/08	74-44.7107N	161-59.5090W	12:42	12:58	1880	495	144	503	504
17	2014/09/08	74-44.6352N	161-59.2005W	13:07	13:21	-		144	503	504
18	2014/09/08	74-44.9607N	161-57.9984W	18:08	18:22	1885	456	144	503	504
19	2014/09/08	74-44.8595N	161-57.5329W	18:32	18:47	-	471	144	503	504
20	2014/09/09	74-44.8530N	161-59.1398W	1:34	1:48	1883	428	144	503	504
21	2014/09/09	74-44.8346N	161-59.1782W	1:54	2:07	-	442	144	503	504
22	2014/09/09	74-45.0516N	161-59.5764W	6:06	6:21	1882	471	144	503	504
23	2014/09/09	74-44.8746N	161-59.3352W	6:53	7:09	-	480	144	503	504
24	2014/09/09	74-44.8305N	161-59.1903W	7:17	7:29	-	420	144	503	504
25	2014/09/09	74-44.8765N	161-59.5668W	12:41	12:56	1880	472	144	503	504
26	2014/09/09	74-44.7698N	161-59.3282W	13:05	13:21	-	492	144	503	504
27	2014/09/09	74-45.3320N	162-00.7264W	18:06	18:20	1881	455	144	503	504
28	2014/09/09	74-45.2950N	162-00.6633W	18:30	18:45	-	489	144	503	504
29	2014/09/09	74-45.2704N	162-00.6021W	18:52	19:00	-	276	144	503	504
30	2014/09/10	74-45.7221N	162-01.3972W	0:49	1:03	1880	460	144	503	504

31	2014/09/10	74-45.6907N	162-01.1771W	1:13	1:29	-	572	144	503	504
32	2014/09/10	74-45.3888N	162-01.1523W	6:08	6:23	1883	490	144	503	504
33	2014/09/10	74-45.3761N	162-01.4829W	6:32	6:46	-	488	144	503	504
34	2014/09/10	74-45.3665N	162-01.7496W	6:55	7:09	-	484	144	503	504
35	2014/09/10	74-45.5534N	161-59.8531W	12:38	12:54	1884	488	144	503	504
36	2014/09/10	74-45.6525N	162-00.2363W	13:05	13:15	-	499	144	503	504
37	2014/09/10	74-45.7794N	162-00.6592W	13:27	13:41	-	505	144	503	504
38	2014/09/10	74-45.1913N	161-59.5724W	18:05	18:20	1882	475	144	503	504
39	2014/09/10	74-45.2391N	161-59.3381W	18:28	18:41	-	432	144	503	504
40	2014/09/11	74-45.3453N	161-59.5700W	1:21	1:36	1883	485	144	503	504
41	2014/09/11	74-45.4289N	161-59.7361W	1:45	1:58	-	440	144	503	504
42	2014/09/11	74-45.4955N	161-59.0388W	6:07	6:23	1885	542	144	505	504
43	2014/09/11	74-45.6727N	161-59.4256W	6:32	6:44	-	427	144	505	504
44	2014/09/11	74-45.4103N	161-59.4444W	12:38	12:52	1884	434	144	505	504
45	2014/09/11	74-45.4797N	161-59.0032W	13:00	13:14	-	449	144	505	504
46	2014/09/11	74-45.0478N	161-58.9424W	18:29	18:43	1884	408	144	505	504
47	2014/09/11	74-45.0553N	161-58.5149W	18:53	19:06	-	404	144	505	504
48	2014/09/12	74-44.7341N	161-59.9799W	0:44	0:57	1880	407	144	505	504
49	2014/09/12	74-44.7579N	161-59.5620W	1:04	1:17	-	418	144	505	504
50	2014/09/12	74-44.9739N	161-59.3080W	6:09	6:21	1882	400	144	505	504
51	2014/09/12	74-44.9256N	161-59.2915W	6:30	6:42	-	417	144	505	504
52	2014/09/12	74-45.4768N	162-00.3314W	12:41	12:55	1883	428	144	505	504
53	2014/09/12	74-45.6367N	162-00.0077W	13:03	13:16	-	447	144	505	504
54	2014/09/12	74-45.1987N	161-59.9173W	18:08	18:21	1883	415	144	505	504
55	2014/09/12	74-45.1807N	161-59.8452W	18:30	18:43	-	418	144	505	504
56	2014/09/13	74-45.0556N	162-03.3673W	1:37	1:50	1874	448	144	505	504
57	2014/09/13	74-45.1717N	162-04.0319W	1:58	2:11	-	441	144	505	504
58	2014/09/13	74-45.5607N	162-04.3935W	2:38	2:51	1875	426	144	506	504
59	2014/09/13	74-45.6461N	162-04.9582W	2:58	3:10	-	431	144	506	504
60	2014/09/13	74-45.7993N	162-05.9418W	3:38	3:52	1873	449	144	505	506
61	2014/09/13	74-45.9038N	162-06.4911W	3:59	4:12	-	435	144	505	506
62	2014/09/13	74-45.1632N	162-01.8323W	6:04	6:18	1878	454	144	505	506
63	2014/09/13	74-45.2778N	162-02.4877W	6:25	6:39	-	448	144	505	506
64	2014/09/13	74-45.3620N	162-03.9591W	12:42	12:56	1874	436	144	505	506
65	2014/09/13	74-45.4581N	162-04.8452W	13:04	13:17	-	432	144	505	506

66	2014/09/13	74-44.6738N	162-00.8152W	18:06	18:19	1879	450	144	505	506
67	2014/09/13	74-44.8751N	162-01.2332W	18:29	18:43	-	474	144	505	506
68	2014/09/14	74-45.0732N	162-00.8963W	0:40	0:54	1880	444	144	505	506
69	2014/09/14	74-45.2924N	162-01.2275W	1:04	1:17	-	437	144	505	506
70	2014/09/14	74-44.8521N	162-00.6165W	6:04	6:18	1880	453	144	505	506
71	2014/09/14	74-45.0824N	162-01.1882W	6:26	6:39	-	429	144	505	506
72	2014/09/14	74-45.5508N	162-01.3559W	12:59	13:13	1881	450	144	505	506
73	2014/09/14	74-45.8327N	162-01.7548W	13:23	13:36	-	449	144	505	506
74	2014/09/14	74-45.4059N	162-00.0107W	18:15	18:28	1883	433	144	505	506
75	2014/09/14	74-45.6547N	162-00.1910W	18:38	18:51	1883	437	144	505	506
76	2014/09/15	74-45.6161N	162-01.2008W	1:20	1:33	1881	422	144	505	506
77	2014/09/15	74-45.8528N	162-01.6540W	1:41	1:54	-	428	144	505	506
78	2014/09/15	74-45.3188N	162-00.2097W	6:10	6:24	1884	433	144	505	506
79	2014/09/15	74-45.6948N	162-00.7469W	6:35	6:46	-	372	144	505	506
80	2014/09/15	74-46.1339N	162-01.6973W	6:59	7:12	-	443	144	505	506
81	2014/09/15	74-45.4886N	162-02.0330W	12:40	12:53	1881	432	144	505	506
82	2014/09/15	74-45.7433N	162-02.5896W	13:03	13:17	-	441	144	505	506
83	2014/09/15	74-44.9642N	162-00.9785W	18:06	18:19	1880	439	144	505	506
84	2014/09/15	74-45.1992N	162-01.5055W	18:29	18:41	-	423	144	505	506
85	2014/09/16	74-45.3803N	161-59.5619W	0:43	0:57	1883	426	144	505	506
86	2014/09/16	74-45.5899N	162-00.0549W	1:05	1:15	-	431	144	505	506
87	2014/09/16	74-45.8316N	162-00.5971W	1:29	1:41	-	429	144	505	506
88	2014/09/16	74-45.2686N	162-00.3519W	6:06	6:19	1881	447	144	505	506
89	2014/09/16	74-45.4583N	162-00.7119W	6:30	6:43	-	455	144	505	506
90	2014/09/16	74-45.3255N	162-00.5193W	12:32	12:47	1882	444	144	505	506
91	2014/09/16	74-45.5517N	162-01.1539W	12:56	13:10	-	461	144	505	506
92	2014/09/16	74-45.0684N	162-00.0024W	18:06	18:19	1885	445	144	505	506
93	2014/09/16	74-45.3013N	162-00.6564W	18:32	18:45	-	442	144	505	506
94	2014/09/17	74-45.3097N	162-00.4260W	1:29	1:42	1882	442	144	505	506
95	2014/09/17	74-45.5003N	162-01.0381W	1:51	2:04	-	437	144	505	506
96	2014/09/17	74-45.8070N	162-01.8584W	2:35	2:49	1882	447	144	505	507
97	2014/09/17	74-45.9948N	162-02.5172W	2:58	3:11	-	455	144	505	507
98	2014/09/17	74-46.3105N	162-03.4373W	3:37	3:50	1883	432	144	507	506
99	2014/09/17	74-46.4975N	162-04.0626W	3:58	4:10	-	427	144	507	506
100	2014/09/17	74-45.1603N	162-00.1388W	6:04	6:19	1883	455	144	505	506

101	2014/09/17	74-45.3394N	162-00.6961W	6:27	6:40	-	441	144	505	506
102	2014/09/17	74-45.0217N	162-01.5164W	12:39	12:50	1879	458	144	505	506
103	2014/09/17	74-45.3044N	162-02.3246W	13:06	13:20	-	449	144	505	506
104	2014/09/17	74-45.6337N	162-03.1660W	13:42	14:01	-	587	144	505	506
105	2014/09/17	74-45.2767N	162-00.4090W	18:08	18:21	1882	441	144	505	506
106	2014/09/17	74-45.4839N	162-01.2326W	18:32	18:45	-	421	144	505	506
107	2014/09/18	74-45.1231N	162-00.2403W	0:43	0:57	1882	431	144	505	507
108	2014/09/18	74-45.3314N	162-00.8392W	1:05	1:17	-	435	144	505	507
109	2014/09/18	74-45.0751N	162-01.1965W	6:08	6:21	1880	435	144	505	507
110	2014/09/18	74-45.3121N	162-01.7505W	6:32	6:46	-	454	144	505	507
111	2014/09/18	74-45.2587N	162-02.6553W	12:42	12:56	1877	463	144	505	507
112	2014/09/18	74-45.5286N	162-03.2223W	13:09	13:22	-	441	144	505	507
113	2014/09/18	74-45.2540N	162-01.5341W	18:35	18:49	1879	418	144	505	507
114	2014/09/18	74-45.4874N	162-02.1510W	19:01	19:14	-	443	144	505	507
115	2014/09/19	74-45.3715N	162-01.3425W	1:20	1:24	1880	-	144	505	507
116	2014/09/19	74-45.4587N	162-01.2501W	1:35	1:48	1880	454	144	505	507
117	2014/09/19	74-45.6624N	162-01.5722W	1:58	2:11	-	455	144	505	507
118	2014/09/19	74-45.1673N	162-00.7701W	18:11	18:24	1881	417	144	505	507
119	2014/09/19	74-45.4527N	162-01.0780W	18:37	18:50	-	418	144	505	507
120	2014/09/20	74-45.5663N	162-00.8307W	0:42	0:55	1884	411	144	505	507
121	2014/09/20	74-45.8567N	162-01.1682W	1:05	1:18	-	417	144	505	507
122	2014/09/20	74-45.1559N	162-00.4989W	6:03	6:16	1881	417	144	505	507
123	2014/09/20	74-45.3655N	162-00.9367W	6:28	6:41	-	420	144	505	507
124	2014/09/20	74-45.3615N	162-00.6456W	12:38	12:52	1883	419	144	505	507
125	2014/09/20	74-45.5357N	162-00.6344W	13:20	13:40	1883	426	144	505	507
126	2014/09/20	74-45.7145N	162-00.7765W	13:43	13:56	-	442	144	505	507
127	2014/09/20	74-45.1664N	161-59.7938W	18:07	18:20	1884	417	144	505	507
128	2014/09/20	74-45.4051N	162-00.1912W	18:32	18:44	-	406	144	505	507
129	2014/09/21	74-44.8452N	162-00.8101W	0:12	0:25	1881	397	144	505	507
130	2014/09/21	74-45.1405N	162-01.3403W	0:38	0:50	-	407	144	505	507
131	2014/09/21	74-44.7702N	162-00.4590W	5:34	5:57	1881	415	144	505	507
132	2014/09/21	74-44.9415N	162-00.9705W	5:56	6:08	-	422	144	505	507
133	2014/09/21	74-45.3706N	162-01.3774W	12:34	12:48	1881	451	144	505	507
134	2014/09/21	74-45.5457N	162-01.6957W	12:59	13:12	-	415	144	505	507
135	2014/09/21	74-45.0657N	162-00.3347W	18:08	18:21	1882	420	144	505	507

136	2014/09/21	74-45.2708N	162-00.8749W	18:32	18:45	-	419	144	505	507
137	2014/09/21	74-44.6423N	162-0.02576W	20:35	20:48	1878	421	144	505	503
138	2014/09/21	74-44.8442N	162-02.5605W	20:59	21:12	-	432	144	505	503
139	2014/09/21	74-45.0773N	162-02.8780W	21:25	21:37	-	412	144	505	503
140	2014/09/22	74-45.1873N	161-58.9691W	1:31	1:44	1886	412	144	505	507
141	2014/09/22	74-45.3498N	161-59.0431W	1:52	2:05	-	433	144	505	507
142	2014/09/22	74-45.0607N	161-59.7048W	6:03	6:17	1883	448	144	505	503
143	2014/09/22	74-45.2629N	162-00.0414W	6:28	6:41	-	429	144	505	503
144	2014/09/22	74-45.4315N	162-01.0741W	12:36	12:51	1882	438	144	505	503
145	2014/09/22	74-45.5624N	162-01.3438W	13:00	13:12	-	423	144	505	503
146	2014/09/22	74-45.3831N	162-00.0854W	18:06	18:20	1884	478	144	505	503
147	2014/09/22	74-45.5175N	162-00.5702W	18:30	18:43	-	428	144	505	503
148	2014/09/23	74-45.2009N	161-59.8979W	1:14	1:27	1884	413	144	505	503
149	2014/09/23	74-45.3547N	162-00.5223W	1:36	1:49	-	414	144	505	503
150	2014/09/23	74-44.8125N	161-59.3990W	6:01	6:15	1883	443	144	505	503
151	2014/09/23	74-44.9123N	161-59.8520W	6:26	6:39	-	449	144	505	503
152	2014/09/23	74-45.0356N	162-00.1268W	12:33	12:47	1882	436	144	505	503
153	2014/09/23	74-45.1056N	162-00.6319W	12:57	13:10	-	448	144	505	503
154	2014/09/23	74-45.0092N	162-00.7825W	18:04	18:17	1882	424	144	505	503
155	2014/09/23	74-44.9890N	162-01.5023W	18:27	18:40	-	464	144	505	503
156	2014/09/24	74-44.9164N	162-00.6802W	0:37	0:50	1881	434	144	505	503
157	2014/09/24	74-44.8844N	162-01.5382W	1:13	1:27	1881	447	144	502	503
158	2014/09/24	74-44.8592N	162-02.1194W	1:36	1:49	-	444	144	502	503
159	2014/09/24	74-44.7952N	162-01.9982W	6:13	6:16	1878	436	144	505	503
160	2014/09/24	74-44.7240N	162-02.6290W	6:25	6:38	-	447	144	505	503
161	2014/09/24	74-44.7240N	162-02.6290W	12:37	12:52	1881	468	144	505	503
162	2014/09/24	74-44.9423N	162-0.2325W	13:02	13:14	-	432	144	505	503
163	2014/09/24	74-45.2999N	162-01.6699W	18:04	18:17	1879	451	144	505	503
164	2014/09/24	74-45.2641N	162-02.2927W	18:27	18:40	-	444	144	505	503
165	2014/09/25	72-44.9594N	168-15.1340W	20:43	20:46	56	49	144	505	503
166	2014/09/25	72-44.9405N	168-15.1212W	20:47	20:49	-	47	144	505	503
167	2014/09/25	72-44.8981N	168-15.1358W	20:53	20:55	-	42	144	505	503
168	2014/09/25	72-44.8745N	168-15.1008W	20:56	20:58	-	46	144	505	503
169	2014/09/26	72-44.9263N	168-14.3906W	1:46	1:49	56	48	144	505	503
170	2014/09/26	72-44.9265N	168-14.3230W	1:50	1:52	-	47	144	505	503

171	2014/09/26	72-44.9295N	168-14.2660W	1:53	1:55	-	48	144	505	503
172	2014/09/26	72-44.8896N	168-14.4463W	7:37	7:39	56	49	144	505	503
173	2014/09/26	72-44.8793N	168-14.3352W	7:40	7:42	-	47	144	505	503
174	2014/09/26	72-44.8679N	168-14.2214W	7:43	7:45	-	47	144	505	503
175	2014/09/26	72-45.1894N	168-13.8737W	13:35	13:39	56	43	144	505	503
176	2014/09/26	72-45.2241N	168-13.7088W	13:40	13:43	-	47	144	505	503
177	2014/09/26	72-45.2578N	168-13.5463W	13:44	13:47	-	43	144	505	503

3.5. Subsurface ocean current observation with drifting buoys

(1) Personnel

Yusuke Kawaguchi	JAMSTEC/Univ. Washington	- PI
Shigeto Nishino	JAMSTEC	
Kazuhiro Oshima	JAMSTEC	
Jun Inoue	JAMSTEC/NIPR	
Mike Steele	Univ. Washington	- not on board
Kristina Colburn	Univ. Washington	- not on board

(2) Objectives

To examine subsurface ocean current in ice-free and ice-cover areas of the Western Arctic Ocean.

(3) Parameters

GPS positions of drifting buoys

(4) Instruments and methodology

We utilized Surface Velocity Profiler (SVP) (manufactured by Zeni Lite Buoy Co., Ltd.), which comprises a surface-floating unit (a GPS sensor and Iridium communication system) and a holey-sock drogue at mid-depth; they are connected with a fabric nylon rope to each other. The rope length is adjusted on the ship's deck if necessary so that it could acquire accurate current velocity at a level of interest. SVP sends hourly geographical information with nearly 15 m accuracy. The holey-sock drogue is considered to give current velocity with an accuracy of within 10% of current speed at the drogued depth.

We deployed four SVPs around the south branch of Beaufort Gyre that flows northwestward along the continental slope in the North-Wind Abyssal Plain (see Table 3.5-1 and Fig. 3.5-1). Two buoys, SVP3340 and SVP1340, were deployed on 8th September in 2014, while then SVP5110 and SVP6350 were on 14th and 19th September, respectively. A drogue was set at 50 m depth for SVP1340 and SVP5110, 20 m for SVP6350, and 10 m for SVP3340. SVP3340 has terminated its data sending from 13th September, 2014 onward. The remainder of SVPs is scheduled to continue the data acquisition until 1st December, 2014.

We also deployed UpTempO (a brand name, Marlin Iridium SVP-BTC60/RTC/GPS manufactured by Marlin-Yug). UpTempO is designed to drift with subsurface ocean current approximately averaged within 60 m depth. The buoy sends real-time geographical information via the Iridium satellite. Three UpTempOs (UpT7170, 6150 and 5320) were deployed on a nearly straight line across the shelf slope in the North-Wind Abyssal Plain (see Table 3.5-1 and Fig. 3.5-1). As of October 2014, they show a relatively fast migration along the shelf slope, which we suppose is principally driven by the Beaufort Gyre stream as aimed. The near-real time data from UpTempO is published on a webpage of Polar Science Center, University of Washington (http://psc.apl.washington.edu/UpTempO/).

(5) Observation logs

Deployment information such as unit identification number, deployment time and location is overviewed in Table 3.5-1. Note that UpT is an abbreviated form of UpTempO.

(6) Data archives

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

Table 3.5-1: Buoys deployment information

Unit NO.	Deployment information			Drogue depth [m]
	Date [YYYY/MM/DD]	Longitude [deg.-min]	Latitude [deg.-min]	
SVP1340	2014/09/08	74-45.04	–161-57.22	10
SVP 3340	2014/09/08	74-45.03	–161-57.28	50
SVP 5110	2014/09/14	74-54.97	–161-34.45	50
SVP 6350	2014/09/19	74-36.21	–161-36.54	20
UpT6150	2014/09/06	74-22.50	–163-00.00	N/A
UpT5320	2014/09/14	74-33.02	–162-30.14	N/A
UpT7170	2014/09/14	74-54.74	–161-34.98	N/A

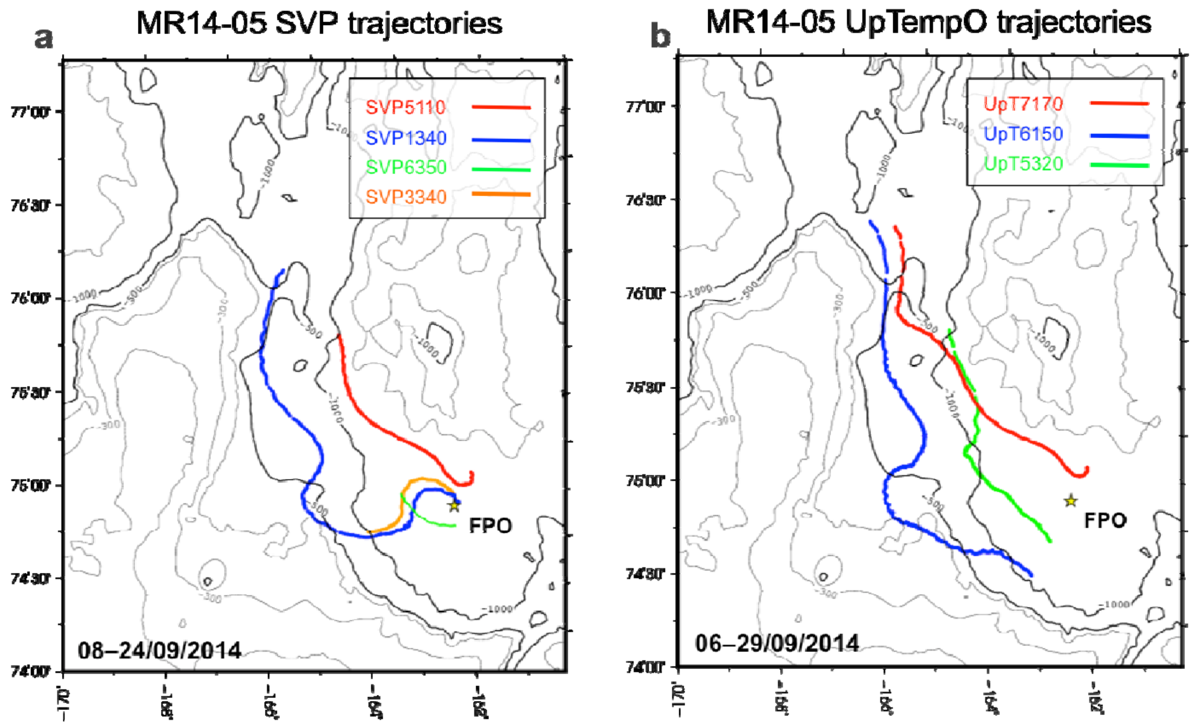


Figure 3.5-1: Trajectories of drifting buoys: (a) SVP5110 (red), SVP3340 (orange), SVP1340 (blue) and SVP6350 (green), between 8–24 September, (b) UpT7170 (red), UpT6150 (blue), and UpT5320 (green), between 6–29 September, 2014. Bold contours show local bathymetry of 300, 500 and 1000 m. On the plots, ☆ illustrates an approximate position of the fixed-point observation (FPO) program.

3.6. Salinity measurements

(1)Personnel

Shigeto Nishino	JAMSTEC	- PI
Hiroki Ushiromura	MWJ	

(2)Objective

To understand the spatial and temporal variation of salinity and to provide calibrations for the measurements of salinity collected from CTD and TSG (Underway surface water monitoring).

(3)Parameters

The specifications of the AUTOSAL salinometer 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)

(4) Instruments and Methods

a. Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles, bucket, and TSG. The salinity sample bottle of 250ml brown glass 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 bottles for TSG were sealed with a plastic insert thimble and a screw cap because we took into consideration the possibility of storage for about a month. The thimble was rinsed 3 times with the sample water before use. The bottle was stored for more than 24 hours in the laboratory before the salinity measurement.

Types and numbers (n) of the samples are shown in Table 3.6-1.

Table 3.6-1: Types and numbers (n) of samples

Types	N
Samples for CTD and bucket	1176
Samples for TSG in Leg1	34
Total	1210

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR14-05 using the salinometer (Model 8400B "AUTOSAL" ; Guildline Instruments Ltd.: S/N 62556) with an additional peristaltic-type intake pump (Ocean Scientific

International, Ltd.).

One pair of precision digital thermometers (Model 9540 ; Guildline Instruments Ltd.) were used. The thermometer monitored the ambient temperature and the other monitored the bath temperature.

The specifications of the thermometer are shown as follows ;

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 22.4 deg C to 24.6 deg C, while the bath temperature was very stable and varied within +/- 0.006 deg C on rare occasion.

The measurement for each sample was done with a double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 10 seconds after filling the cell with the sample and it took about 15 seconds to collect 31 readings by the personal computer. Data were taken for the sixth and seventh filling of the cell after rinsing 5 times. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for the practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. In the case of the double conductivity ratio of eighth filling did not satisfy the criteria above, the operator measured a ninth or tenth filling of the cell and calculated the bottle salinity above. The cell was cleaned with detergent after the measurement of the day.

(5) Results

a. Standard Seawater (SSW)

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

Batch	:	P156
conductivity ratio	:	0.99984
salinity	:	34.994
expiration date	:	23^{rd} July 2016

Standardization control of the salinometer S/N 62556 was set to 693 (3rd Sep.) and all measurements were carried out at this setting. The value of STANDBY was 5199 +/- 0001 and that of ZERO was 0.0-0000 +/- 0001. 73 bottles of SSW were measured.

Figure 3.6-1 shows the history of the double conductivity ratio of the Standard Seawater batch P156 before correction. The average of the double conductivity ratio was 1.99963 and the standard deviation was 0.00002, which is equivalent to 0.0005 in salinity.

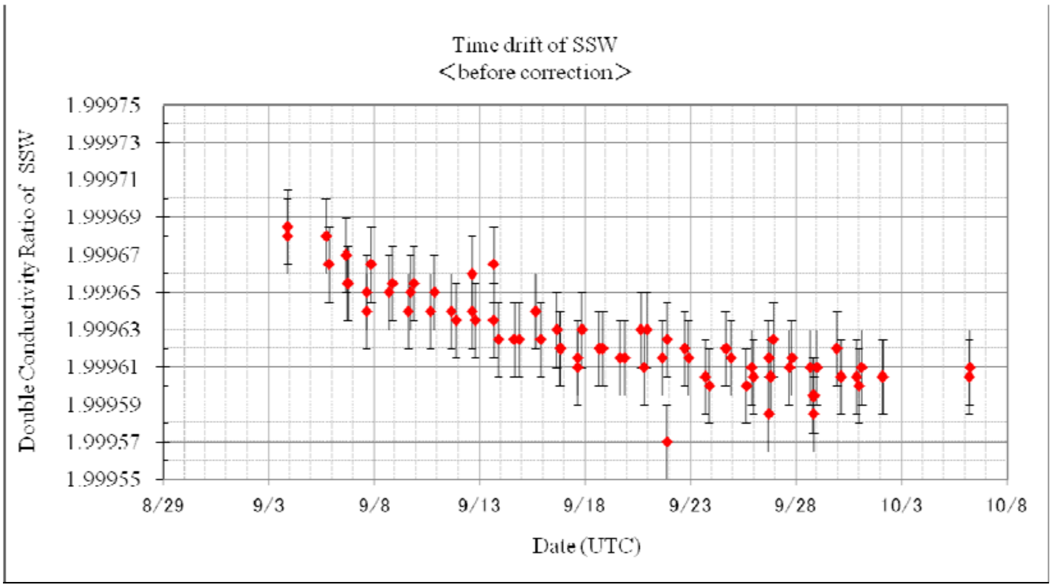


Figure 3.6-1: History of double conductivity ratio for the Standard Seawater batch P156 (before correction)

Figure 3.6-2 shows the history of the double conductivity ratio of the Standard Seawater batch P156 after correction. The average of the double conductivity ratio after correction was 1.99968 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

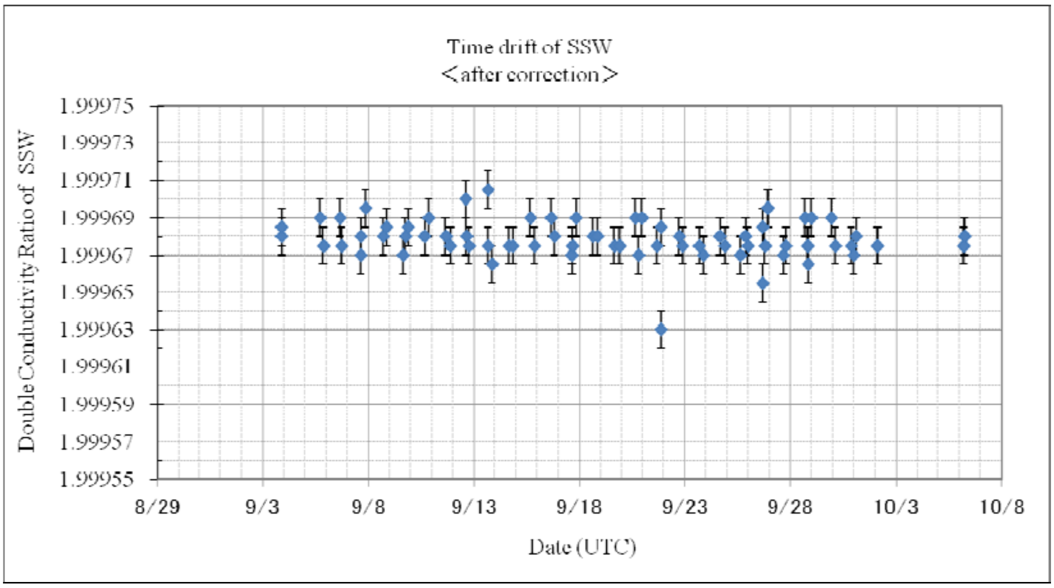


Figure 3.6-2: History of double conductivity ratio for the Standard Seawater batch P156 (after correction)

b. Sub-Standard Seawater

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

c. Replicate Samples

We estimated the precision of this method using 127 pairs of replicate samples taken from the same Niskin bottle.

Figure 3.6-3 shows the histogram of the absolute difference between each pair of all replicate samples. The average and the standard deviation of absolute difference among 127 pairs were 0.0027 and 0.0101 in salinity, respectively.

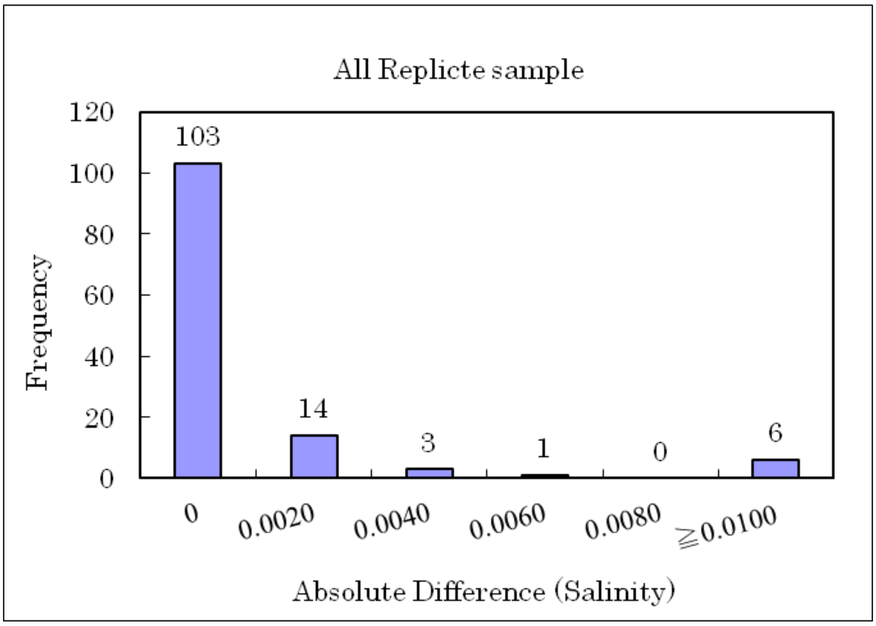


Figure 3.6-3: Histogram of the Absolute Difference of all Replicate Samples

74 pairs of replicate samples were to estimate the precision of shallow (<200dbar) samples. Figure 3.6-4 shows the histogram of the absolute difference between each pair of shallow (<200dbar) replicate samples. The average and the standard deviation of absolute difference among 74 pairs were 0.0043 and 0.0131 in salinity, respectively.

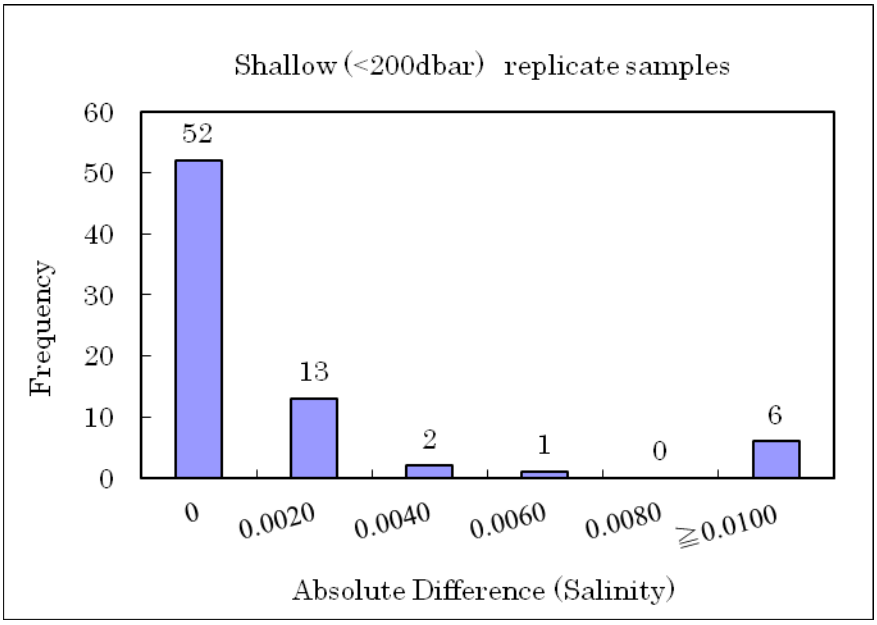


Figure 3.6-4: Histogram of the Absolute Difference between Shallow (<200dbar) Replicate Samples

53 pairs of replicate samples were to estimate the precision of deep (>200dbar)

samples. Figure 3.6-5 shows the histogram of the absolute difference between each pair of deep (>200dbar) replicate samples. The average and the standard deviation of absolute difference among 53 pairs were 0.0006 and 0.0007 in salinity, respectively.

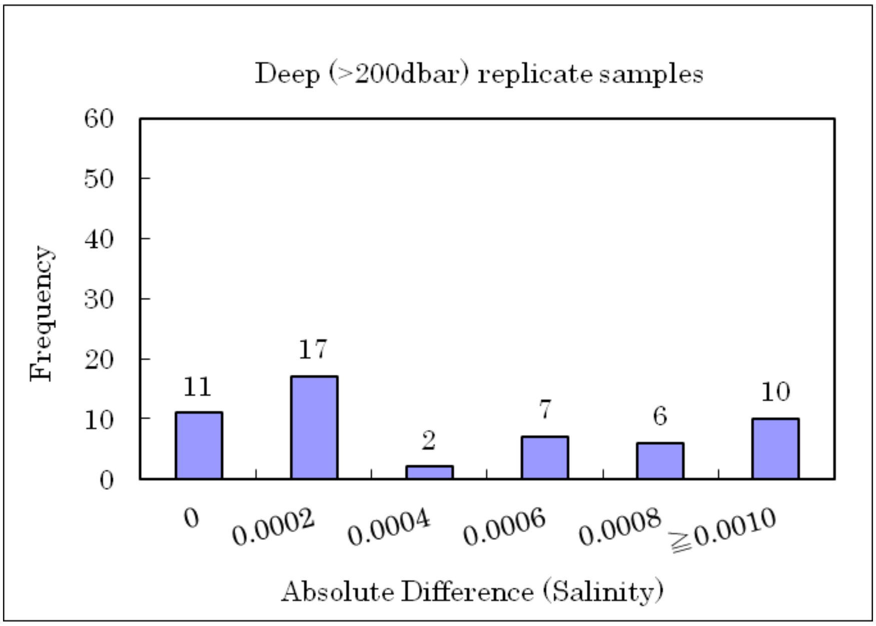


Figure 3.6-5: Histogram of the Absolute Difference between Deep (>200dbar) Replicate Samples

d. Data Correction for Samples

All data were corrected according to the result of the offset correction for SSW.

(6) Data archives

a. Data Policy

These raw datasets will be submitted to JAMSTEC Data Management Office (DMO) and corrected datasets are available from Mirai Web site.

b. Citation

・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

3.7. Density

(1) Personnel

Hiroshi Uchida JAMSTEC - PI

Shigeto Nishino JAMSTEC

(2) Objectives

The objective of this study is to collect absolute salinity (also called "density salinity") data, and to evaluate an algorithm to estimate absolute salinity provided along with TEOS-10 (the International Thermodynamic Equation of Seawater 2010) (IOC et al., 2010).

(3) Parameter

Density (density salinity)

(4) Instruments and methods

Seawater densities were measured after the cruise with an oscillation-type density meter (DMA 5000M, serial no. 80570578, Anton-Paar GmbH, Graz, Austria) with a sample changer (Xsample 122, serial no. 80548492, Anton-Paar GmbH) in a laboratory of JAMSTEC, Yokosuka. The sample changer was used to load samples automatically from up to ninety-six 12-mL glass vials.

The water samples were collected in 100-mL aluminum bottles (Mini Bottle Can, Daiwa Can Company, Japan). The bottles were stored at room temperature (~23 °C) upside down. Densities of the samples were measured at 20 °C by the density meter two times for each bottle and averaged to estimate the density. When the difference between the two measurements was greater than 0.002 kg m^{-3}, additional measurements were conducted until two samples satisfying the above criteria were obtained.

Time drift of the density meter was monitored by periodically measuring the density of ultra-pure water (Milli-Q water, Millipore, Billerica, Massachusetts, USA) prepared from Yokosuka (Japan) tap water in October 2012. The true density at 20 °C of the Milli-Q water was estimated to be 998.2042 kg m^{-3} from the isotopic composition ($\delta D = -8.76$ ‰, $\delta^{18}O = -56.86$ ‰) and International Association for the Properties of Water and Steam (IAPWS)-95 standard. An offset correction was applied to the measured density by using the Milli-Q water measurements ($\rho_{Milli\text{-}Q}$) with a slight modification of the density dependency (Uchida et al., 2011). The offset (ρ_{offset}) of the measured density (ρ) was estimated from the following equation:

$$\rho_{offset} = (\rho_{Milli\text{-}Q} - 998.2042) - (\rho - 998.2042) \times 0.000241 \text{ [kg m}^{-3}\text{]}.$$

The offset correction was verified by measuring Reference Material for Density of Seawater (prototype Dn-RM1) developing with Marine Works Japan, Ltd., Kanagawa, Japan, and produced by Kanso Technos Co., Ltd., Osaka, Japan, along with the Milli-Q water.

Density salinity can be back calculated from measured density and temperature

(20 °C) with TEOS-10.

(5) Results

Results of density measurements of Dn-RM1 are shown in Table 3.7-1. Mean densities of the Dn-RM1 were smaller than the results of measurement before May 2014. Difference between the density of Dn-RM1 measured for this cruise and the results before May 2014 were estimated and the additional offset correction was applied to the seawater density measurements for this cruise.

A total of 20 pairs of replicate samples were measured. The root-mean square of the absolute difference of replicate samples was 0.0009 g/kg.

The measured density salinity anomalies (δS_A) are shown in Fig. 3.7-1. The measured δS_A well agree with calculated δS_A from Pawlowicz et al. (2011) which exploits the correlation between δS_A and nutrient concentrations and carbonate system parameters based on mathematical investigation using a model relating composition, conductivity and density of arbitrary seawaters.

(6) Observation log

The sampling list is summarized in Table 3.7-2.

(7) References

IOC, SCOR and IAPSO (2010): The international thermodynamic equation of seawater – 2010: Calculation and use of thermodynamic properties. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56, United Nations Educational, Scientific and Cultural Organization (English), 196 pp.

Pawlowicz, R., D. G. Wright and F. J. Millero (2011): The effects of biogeochemical processes on ocean conductivity/salinity/density relationships and the characterization of real seawater. *Ocean Science*, 7, 363–387.

Uchida, H., T. Kawano, M. Aoyama and A. Murata (2011): Absolute salinity measurements of standard seawaters for conductivity and nutrients. *La mer*, 49, 237–244.

(8) Data archives

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

Table 3.7-1: Result of density measurements of the Reference Material for Density in Seawater (prototype Dn-RM1).

Date	Sample bottle no.	Mean density of Dn-RM1 (kg/m^3)	Note
2014/10/24	361-390	1024.2594	
2014/10/25	391-428	1024.2588	
2014/10/27	429-468	1024.2585	
2014/10/27	469-509	1024.2585	
2014/10/28	510-549	1024.2588	
2014/10/28	550-591	1024.2596	
2014/10/29	592-631	1024.2589	
2014/10/29	632-674	1024.2584	
2014/10/30	675-718	1024.2583	
2014/10/30	390,391,448,551,573, 601,666	1024.2573	after adjustment
		Average: 1024.2587± 0.0006	
Recent measurements before May 2014			
2014/04/03-06		1024.2623 ± 0.0007	8 bottles
		Estimated offset: –0.0036 kg/m^3	

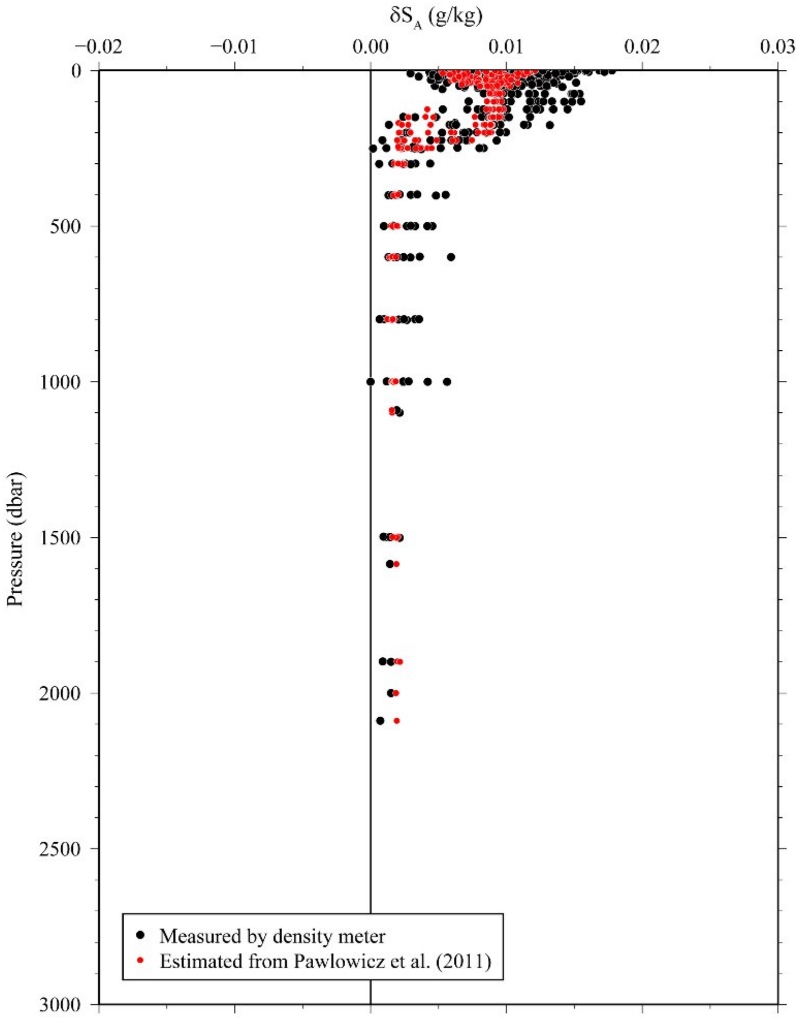


Figure 3.7-1: Vertical distribution of density salinity anomaly measured by the density meter. Absolute Salinity anomaly estimated from nutrients and carbonate parameters (Pawlowicz et al., 2011) are also shown for comparison.

Table 3.7-1: Sampling list for density (density salinity)

On board ID	Sampling Method	Date Collected				Latitude			Longitude			Depth
		YYYY	MM	DD	hh:mm	Deg.	Min.	N/S	Deg.	Min.	E/W	[m]
MR14-05_St001_Den_#0361-W001	Bucket	2014	09	03	5:56	65	46.33	N	168	47.64	W	0
MR14-05_St001_Den_#0362-W002	Bucket	2014	09	03	5:56	65	46.33	N	168	47.64	W	0
MR14-05_St001_Den_#0363-W003	Niskin#25	2014	09	03	5:56	65	46.33	N	168	47.64	W	Chl-aMax
MR14-05_St001_Den_#0364-W004	Niskin#23	2014	09	03	5:56	65	46.33	N	168	47.64	W	5
MR14-05_St001_Den_#0365-W005	Niskin#22	2014	09	03	5:56	65	46.33	N	168	47.64	W	10
MR14-05_St001_Den_#0366-W006	Niskin#21	2014	09	03	5:56	65	46.33	N	168	47.64	W	20
MR14-05_St001_Den_#0367-W007	Niskin#20	2014	09	03	5:56	65	46.33	N	168	47.64	W	30
MR14-05_St001_Den_#0368-W008	Niskin#19	2014	09	03	5:56	65	46.33	N	168	47.64	W	40
MR14-05_St001_Den_#0369-W009	Niskin#18	2014	09	03	5:56	65	46.33	N	168	47.64	W	Not sampled
MR14-05_St001_Den_#0370-W010	Niskin#01	2014	09	03	5:56	65	46.33	N	168	47.64	W	B-10
MR14-05_St002_Den_#0371-W011	Bucket	2014	09	03	13:12	67	0	N	168	50	W	0
MR14-05_St002_Den_#0372-W012	Bucket	2014	09	03	13:12	67	0	N	168	50	W	0
MR14-05_St002_Den_#0373-W013	Niskin#25	2014	09	03	13:12	67	0	N	168	50	W	Chl-aMax
MR14-05_St002_Den_#0374-W014	Niskin#23	2014	09	03	13:12	67	0	N	168	50	W	5
MR14-05_St002_Den_#0375-W015	Niskin#22	2014	09	03	13:12	67	0	N	168	50	W	10
MR14-05_St002_Den_#0376-W016	Niskin#21	2014	09	03	13:12	67	0	N	168	50	W	20
MR14-05_St002_Den_#0377-W017	Niskin#20	2014	09	03	13:12	67	0	N	168	50	W	30
MR14-05_St002_Den_#0378-W018	Niskin#19	2014	09	03	13:12	67	0	N	168	50	W	40
MR14-05_St002_Den_#0379-W019	Niskin#18	2014	09	03	13:12	67	0	N	168	50	W	Not sampled
MR14-05_St002_Den_#0380-W020	Niskin#01	2014	09	03	13:12	67	0	N	168	50	W	B-10
MR14-05_St003_Den_#0381-W021	Bucket	2014	09	03	19:45	68	0	N	168	50	W	0
MR14-05_St003_Den_#0382-W022	Bucket	2014	09	03	19:45	68	0	N	168	50	W	0
MR14-05_St003_Den_#0383-W023	Niskin#25	2014	09	03	19:45	68	0	N	168	50	W	Chl-aMax
MR14-05_St003_Den_#0384-W024	Niskin#23	2014	09	03	19:45	68	0	N	168	50	W	5
MR14-05_St003_Den_#0385-W025	Niskin#22	2014	09	03	19:45	68	0	N	168	50	W	10
MR14-05_St003_Den_#0386-W026	Niskin#21	2014	09	03	19:45	68	0	N	168	50	W	20
MR14-05_St003_Den_#0387-W027	Niskin#20	2014	09	03	19:45	68	0	N	168	50	W	30
MR14-05_St003_Den_#0388-W028	Niskin#19	2014	09	03	19:45	68	0	N	168	50	W	40
MR14-05_St003_Den_#0389-W029	Niskin#18	2014	09	03	19:45	68	0	N	168	50	W	Not sampled
MR14-05_St003_Den_#0390-W030	Niskin#01	2014	09	03	19:45	68	0	N	168	50	W	B-10
MR14-05_St004_Den_#0391-W031	Bucket	2014	09	04	13:46	73	20	N	162	0	W	0
MR14-05_St004_Den_#0392-W032	Bucket	2014	09	04	13:46	73	20	N	162	0	W	0

MR14-05_St004_Den_#0393-W033	Niskin#25	2014	09	04	13:46	73	20	N	162	0	W	Chl-aMax
MR14-05_St004_Den_#0394-W034	Niskin#23	2014	09	04	13:46	73	20	N	162	0	W	5
MR14-05_St004_Den_#0395-W035	Niskin#22	2014	09	04	13:46	73	20	N	162	0	W	10
MR14-05_St004_Den_#0396-W036	Niskin#21	2014	09	04	13:46	73	20	N	162	0	W	20
MR14-05_St004_Den_#0397-W037	Niskin#20	2014	09	04	13:46	73	20	N	162	0	W	30
MR14-05_St004_Den_#0398-W038	Niskin#19	2014	09	04	13:46	73	20	N	162	0	W	40
MR14-05_St004_Den_#0399-W039	Niskin#18	2014	09	04	13:46	73	20	N	162	0	W	50
MR14-05_St004_Den_#0400-W040	Niskin#17	2014	09	04	13:46	73	20	N	162	0	W	75
MR14-05_St004_Den_#0401-W041	Niskin#16	2014	09	04	13:46	73	20	N	162	0	W	100
MR14-05_St004_Den_#0402-W042	Niskin#15	2014	09	04	13:46	73	20	N	162	0	W	125
MR14-05_St004_Den_#0403-W043	Niskin#14	2014	09	04	13:46	73	20	N	162	0	W	150
MR14-05_St004_Den_#0404-W044	Niskin#13	2014	09	04	13:46	73	20	N	162	0	W	Not sampled
MR14-05_St004_Den_#0405-W045	Niskin#12	2014	09	04	13:46	73	20	N	162	0	W	Not sampled
MR14-05_St004_Den_#0406-W046	Niskin#02	2014	09	04	13:46	73	20	N	162	0	W	B-10
MR14-05_St005_Den_#0407-W047	Bucket	2014	09	04	19:46	74	0	N	164	0	W	0
MR14-05_St005_Den_#0408-W048	Bucket	2014	09	04	19:46	74	0	N	164	0	W	0
MR14-05_St005_Den_#0409-W049	Niskin#25	2014	09	04	19:46	74	0	N	164	0	W	Chl-aMax
MR14-05_St005_Den_#0410-W050	Niskin#23	2014	09	04	19:46	74	0	N	164	0	W	5
MR14-05_St005_Den_#0425-W051	Niskin#22	2014	09	04	19:46	74	0	N	164	0	W	10
MR14-05_St005_Den_#0412-W052	Niskin#21	2014	09	04	19:46	74	0	N	164	0	W	20
MR14-05_St005_Den_#0413-W053	Niskin#20	2014	09	04	19:46	74	0	N	164	0	W	30
MR14-05_St005_Den_#0414-W054	Niskin#19	2014	09	04	19:46	74	0	N	164	0	W	40
MR14-05_St005_Den_#0415-W055	Niskin#18	2014	09	04	19:46	74	0	N	164	0	W	50
MR14-05_St005_Den_#0416-W056	Niskin#17	2014	09	04	19:46	74	0	N	164	0	W	75
MR14-05_St005_Den_#0417-W057	Niskin#16	2014	09	04	19:46	74	0	N	164	0	W	100
MR14-05_St005_Den_#0418-W058	Niskin#15	2014	09	04	19:46	74	0	N	164	0	W	125
MR14-05_St005_Den_#0419-W059	Niskin#14	2014	09	04	19:46	74	0	N	164	0	W	150
MR14-05_St005_Den_#0420-W060	Niskin#13	2014	09	04	19:46	74	0	N	164	0	W	175
MR14-05_St005_Den_#0421-W061	Niskin#12	2014	09	04	19:46	74	0	N	164	0	W	200
MR14-05_St005_Den_#0422-W062	Niskin#11	2014	09	04	19:46	74	0	N	164	0	W	225
MR14-05_St005_Den_#0423-W063	Niskin#10	2014	09	04	19:46	74	0	N	164	0	W	250
MR14-05_St005_Den_#0424-W064	Niskin#01	2014	09	04	19:46	74	0	N	164	0	W	B-10
MR14-05_St006_Den_#0426-W065	Bucket	2014	09	05	23:24	74	22.5	N	163	0	W	0
MR14-05_St006_Den_#0427-W066	Bucket	2014	09	05	23:24	74	22.5	N	163	0	W	0
MR14-05_St006_Den_#0428-W067	Niskin#25	2014	09	05	23:24	74	22.5	N	163	0	W	Chl-aMax

MR14-05_St006_Den_#0429-W068	Niskin#23	2014	09	05	23:24	74	22.5	N	163	0	W	5
MR14-05_St006_Den_#0430-W069	Niskin#22	2014	09	05	23:24	74	22.5	N	163	0	W	10
MR14-05_St006_Den_#0431-W070	Niskin#21	2014	09	05	23:24	74	22.5	N	163	0	W	20
MR14-05_St006_Den_#0432-W071	Niskin#20	2014	09	05	23:24	74	22.5	N	163	0	W	30
MR14-05_St006_Den_#0433-W072	Niskin#19	2014	09	05	23:24	74	22.5	N	163	0	W	40
MR14-05_St006_Den_#0434-W073	Niskin#18	2014	09	05	23:24	74	22.5	N	163	0	W	50
MR14-05_St006_Den_#0435-W074	Niskin#17	2014	09	05	23:24	74	22.5	N	163	0	W	75
MR14-05_St006_Den_#0436-W075	Niskin#16	2014	09	05	23:24	74	22.5	N	163	0	W	100
MR14-05_St006_Den_#0437-W076	Niskin#15	2014	09	05	23:24	74	22.5	N	163	0	W	125
MR14-05_St006_Den_#0438-W077	Niskin#14	2014	09	05	23:24	74	22.5	N	163	0	W	150
MR14-05_St006_Den_#0439-W078	Niskin#13	2014	09	05	23:24	74	22.5	N	163	0	W	175
MR14-05_St006_Den_#0440-W079	Niskin#12	2014	09	05	23:24	74	22.5	N	163	0	W	200
MR14-05_St006_Den_#0441-W080	Niskin#11	2014	09	05	23:24	74	22.5	N	163	0	W	225
MR14-05_St006_Den_#0442-W081	Niskin#10	2014	09	05	23:24	74	22.5	N	163	0	W	250
MR14-05_St006_Den_#0443-W082	Niskin#09	2014	09	05	23:24	74	22.5	N	163	0	W	300
MR14-05_St006_Den_#0444-W083	Niskin#08	2014	09	05	23:24	74	22.5	N	163	0	W	400
MR14-05_St006_Den_#0445-W084	Niskin#07	2014	09	05	23:24	74	22.5	N	163	0	W	500
MR14-05_St006_Den_#0446-W085	Niskin#06	2014	09	05	23:24	74	22.5	N	163	0	W	600
MR14-05_St006_Den_#0447-W086	Niskin#05	2014	09	05	23:24	74	22.5	N	163	0	W	800
MR14-05_St006_Den_#0448-W087	Niskin#04	2014	09	05	23:24	74	22.5	N	163	0	W	1000
MR14-05_St006_Den_#0449-W088	Niskin#01	2014	09	05	23:24	74	22.5	N	163	0	W	B-10
MR14-05_St007_Den_#0450-W089	Bucket	2014	09	06	5:54	75	7.5	N	161	0	W	0
MR14-05_St007_Den_#0451-W090	Bucket	2014	09	06	5:54	75	7.5	N	161	0	W	0
MR14-05_St007_Den_#0452-W091	Niskin#25	2014	09	06	5:54	75	7.5	N	161	0	W	Chl-aMax
MR14-05_St007_Den_#0453-W092	Niskin#23	2014	09	06	5:54	75	7.5	N	161	0	W	5
MR14-05_St007_Den_#0454-W093	Niskin#22	2014	09	06	5:54	75	7.5	N	161	0	W	10
MR14-05_St007_Den_#0455-W094	Niskin#21	2014	09	06	5:54	75	7.5	N	161	0	W	20
MR14-05_St007_Den_#0456-W095	Niskin#20	2014	09	06	5:54	75	7.5	N	161	0	W	30
MR14-05_St007_Den_#0457-W096	Niskin#19	2014	09	06	5:54	75	7.5	N	161	0	W	40
MR14-05_St007_Den_#0458-W097	Niskin#18	2014	09	06	5:54	75	7.5	N	161	0	W	50
MR14-05_St007_Den_#0459-W098	Niskin#17	2014	09	06	5:54	75	7.5	N	161	0	W	75
MR14-05_St007_Den_#0460-W099	Niskin#16	2014	09	06	5:54	75	7.5	N	161	0	W	100
MR14-05_St007_Den_#0461-W100	Niskin#15	2014	09	06	5:54	75	7.5	N	161	0	W	125
MR14-05_St007_Den_#0462-W101	Niskin#14	2014	09	06	5:54	75	7.5	N	161	0	W	150
MR14-05_St007_Den_#0463-W102	Niskin#13	2014	09	06	5:54	75	7.5	N	161	0	W	175

MR14-05_St007_Den_#0464-W103	Niskin#12	2014	09	06	5:54	75	7.5	N	161	0	W	200
MR14-05_St007_Den_#0465-W104	Niskin#11	2014	09	06	5:54	75	7.5	N	161	0	W	225
MR14-05_St007_Den_#0466-W105	Niskin#10	2014	09	06	5:54	75	7.5	N	161	0	W	250
MR14-05_St007_Den_#0467-W106	Niskin#09	2014	09	06	5:54	75	7.5	N	161	0	W	300
MR14-05_St007_Den_#0468-W107	Niskin#08	2014	09	06	5:54	75	7.5	N	161	0	W	400
MR14-05_St007_Den_#0469-W108	Niskin#07	2014	09	06	5:54	75	7.5	N	161	0	W	500
MR14-05_St007_Den_#0470-W109	Niskin#06	2014	09	06	5:54	75	7.5	N	161	0	W	600
MR14-05_St007_Den_#0471-W110	Niskin#05	2014	09	06	5:54	75	7.5	N	161	0	W	800
MR14-05_St007_Den_#0472-W111	Niskin#04	2014	09	06	5:54	75	7.5	N	161	0	W	1000
MR14-05_St007_Den_#0473-W112	Niskin#03	2014	09	06	5:54	75	7.5	N	161	0	W	1500
MR14-05_St007_Den_#0474-W113	Niskin#02	2014	09	06	5:54	75	7.5	N	161	0	W	2000
MR14-05_St007_Den_#0475-W114	Niskin#01	2014	09	06	5:54	75	7.5	N	161	0	W	B-10
MR14-05_St008_Den_#0476-W115	Bucket	2014	09	06	14:04	74	22.5	N	161	0	W	0
MR14-05_St008_Den_#0477-W116	Bucket	2014	09	06	14:04	74	22.5	N	161	0	W	0
MR14-05_St008_Den_#0478-W117	Niskin#25	2014	09	06	14:04	74	22.5	N	161	0	W	Chl-aMax
MR14-05_St008_Den_#0479-W118	Niskin#23	2014	09	06	14:04	74	22.5	N	161	0	W	5
MR14-05_St008_Den_#0480-W119	Niskin#22	2014	09	06	14:04	74	22.5	N	161	0	W	10
MR14-05_St008_Den_#0481-W120	Niskin#21	2014	09	06	14:04	74	22.5	N	161	0	W	20
MR14-05_St008_Den_#0482-W121	Niskin#20	2014	09	06	14:04	74	22.5	N	161	0	W	30
MR14-05_St008_Den_#0483-W122	Niskin#19	2014	09	06	14:04	74	22.5	N	161	0	W	40
MR14-05_St008_Den_#0484-W123	Niskin#18	2014	09	06	14:04	74	22.5	N	161	0	W	50
MR14-05_St008_Den_#0485-W124	Niskin#17	2014	09	06	14:04	74	22.5	N	161	0	W	75
MR14-05_St008_Den_#0486-W125	Niskin#16	2014	09	06	14:04	74	22.5	N	161	0	W	100
MR14-05_St008_Den_#0487-W126	Niskin#15	2014	09	06	14:04	74	22.5	N	161	0	W	125
MR14-05_St008_Den_#0488-W127	Niskin#14	2014	09	06	14:04	74	22.5	N	161	0	W	150
MR14-05_St008_Den_#0489-W128	Niskin#13	2014	09	06	14:04	74	22.5	N	161	0	W	175
MR14-05_St008_Den_#0490-W129	Niskin#12	2014	09	06	14:04	74	22.5	N	161	0	W	200
MR14-05_St008_Den_#0491-W130	Niskin#11	2014	09	06	14:04	74	22.5	N	161	0	W	225
MR14-05_St008_Den_#0492-W131	Niskin#10	2014	09	06	14:04	74	22.5	N	161	0	W	250
MR14-05_St008_Den_#0493-W132	Niskin#09	2014	09	06	14:04	74	22.5	N	161	0	W	300
MR14-05_St008_Den_#0494-W133	Niskin#08	2014	09	06	14:04	74	22.5	N	161	0	W	400
MR14-05_St008_Den_#0495-W134	Niskin#07	2014	09	06	14:04	74	22.5	N	161	0	W	500
MR14-05_St008_Den_#0496-W135	Niskin#06	2014	09	06	14:04	74	22.5	N	161	0	W	600
MR14-05_St008_Den_#0497-W136	Niskin#05	2014	09	06	14:04	74	22.5	N	161	0	W	800
MR14-05_St008_Den_#0498-W137	Niskin#04	2014	09	06	14:04	74	22.5	N	161	0	W	1000

MR14-05_St008_Den_#0499-W138	Niskin#03	2014	09	06	14:04	74	22.5	N	161	0	W	1500
MR14-05_St008_Den_#0500-W139	Niskin#01	2014	09	06	14:04	74	22.5	N	161	0	W	B-10
MR14-05_St009_Cast002_Den_#0501-W140	Bucket	2014	09	06	23:42	74	45	N	162	0	W	0
MR14-05_St009_Cast002_Den_#0502-W141	Bucket	2014	09	06	23:42	74	45	N	162	0	W	0
MR14-05_St009_Cast002_Den_#0503-W142	Niskin#26	2014	09	06	23:42	74	45	N	162	0	W	Chl-aMax
MR14-05_St009_Cast002_Den_#0504-W143	Niskin#24	2014	09	06	23:42	74	45	N	162	0	W	5
MR14-05_St009_Cast002_Den_#0505-W144	Niskin#23	2014	09	06	23:42	74	45	N	162	0	W	10
MR14-05_St009_Cast002_Den_#0506-W145	Niskin#22	2014	09	06	23:42	74	45	N	162	0	W	15
MR14-05_St009_Cast002_Den_#0507-W146	Niskin#21	2014	09	06	23:42	74	45	N	162	0	W	20
MR14-05_St009_Cast002_Den_#0508-W147	Niskin#20	2014	09	06	23:42	74	45	N	162	0	W	30
MR14-05_St009_Cast002_Den_#0509-W148	Niskin#19	2014	09	06	23:42	74	45	N	162	0	W	40
MR14-05_St009_Cast002_Den_#0510-W149	Niskin#18	2014	09	06	23:42	74	45	N	162	0	W	50
MR14-05_St009_Cast002_Den_#0511-W150	Niskin#17	2014	09	06	23:42	74	45	N	162	0	W	75
MR14-05_St009_Cast002_Den_#0512-W151	Niskin#16	2014	09	06	23:42	74	45	N	162	0	W	100
MR14-05_St009_Cast002_Den_#0513-W152	Niskin#15	2014	09	06	23:42	74	45	N	162	0	W	125
MR14-05_St009_Cast002_Den_#0514-W153	Niskin#14	2014	09	06	23:42	74	45	N	162	0	W	150
MR14-05_St009_Cast002_Den_#0515-W154	Niskin#13	2014	09	06	23:42	74	45	N	162	0	W	175
MR14-05_St009_Cast002_Den_#0516-W155	Niskin#12	2014	09	06	23:42	74	45	N	162	0	W	200
MR14-05_St009_Cast002_Den_#0517-W156	Niskin#11	2014	09	06	23:42	74	45	N	162	0	W	225
MR14-05_St009_Cast002_Den_#0518-W157	Niskin#10	2014	09	06	23:42	74	45	N	162	0	W	250
MR14-05_St009_Cast002_Den_#0519-W158	Niskin#09	2014	09	06	23:42	74	45	N	162	0	W	300
MR14-05_St009_Cast002_Den_#0520-W159	Niskin#08	2014	09	06	23:42	74	45	N	162	0	W	400
MR14-05_St009_Cast002_Den_#0521-W160	Niskin#07	2014	09	06	23:42	74	45	N	162	0	W	500
MR14-05_St009_Cast002_Den_#0522-W161	Niskin#06	2014	09	06	23:42	74	45	N	162	0	W	600
MR14-05_St009_Cast002_Den_#0523-W162	Niskin#05	2014	09	06	23:42	74	45	N	162	0	W	800
MR14-05_St009_Cast002_Den_#0524-W163	Niskin#04	2014	09	06	23:42	74	45	N	162	0	W	1000
MR14-05_St009_Cast002_Den_#0525-W164	Niskin#03	2014	09	06	23:42	74	45	N	162	0	W	1500
MR14-05_St009_Cast002_Den_#0526-W165	Niskin#01	2014	09	06	23:42	74	45	N	162	0	W	B-10
MR14-05_St009_Cast034_Den_#0527-W166	Bucket	2014	09	14	23:36	74	45	N	162	0	W	0
MR14-05_St009_Cast034_Den_#0528-W167	Bucket	2014	09	14	23:36	74	45	N	162	0	W	0
MR14-05_St009_Cast034_Den_#0529-W168	Niskin#26	2014	09	14	23:36	74	45	N	162	0	W	Chl-aMax
MR14-05_St009_Cast034_Den_#0530-W169	Niskin#24	2014	09	14	23:36	74	45	N	162	0	W	5
MR14-05_St009_Cast034_Den_#0531-W170	Niskin#23	2014	09	14	23:36	74	45	N	162	0	W	10
MR14-05_St009_Cast034_Den_#0532-W171	Niskin#22	2014	09	14	23:36	74	45	N	162	0	W	15
MR14-05_St009_Cast034_Den_#0533-W172	Niskin#21	2014	09	14	23:36	74	45	N	162	0	W	20

MR14-05_St009_Cast034_Den_#0534-W173	Niskin#20	2014	09	14	23:36	74	45	N	162	0	W	30
MR14-05_St009_Cast034_Den_#0535-W174	Niskin#19	2014	09	14	23:36	74	45	N	162	0	W	40
MR14-05_St009_Cast034_Den_#0536-W175	Niskin#18	2014	09	14	23:36	74	45	N	162	0	W	50
MR14-05_St009_Cast034_Den_#0537-W176	Niskin#17	2014	09	14	23:36	74	45	N	162	0	W	75
MR14-05_St009_Cast034_Den_#0538-W177	Niskin#16	2014	09	14	23:36	74	45	N	162	0	W	100
MR14-05_St009_Cast034_Den_#0539-W178	Niskin#15	2014	09	14	23:36	74	45	N	162	0	W	125
MR14-05_St009_Cast034_Den_#0540-W179	Niskin#14	2014	09	14	23:36	74	45	N	162	0	W	150
MR14-05_St009_Cast034_Den_#0541-W180	Niskin#13	2014	09	14	23:36	74	45	N	162	0	W	175
MR14-05_St009_Cast034_Den_#0542-W181	Niskin#12	2014	09	14	23:36	74	45	N	162	0	W	200
MR14-05_St009_Cast034_Den_#0543-W182	Niskin#11	2014	09	14	23:36	74	45	N	162	0	W	225
MR14-05_St009_Cast034_Den_#0544-W183	Niskin#10	2014	09	14	23:36	74	45	N	162	0	W	250
MR14-05_St009_Cast034_Den_#0545-W184	Niskin#09	2014	09	14	23:36	74	45	N	162	0	W	300
MR14-05_St009_Cast034_Den_#0546-W185	Niskin#08	2014	09	14	23:36	74	45	N	162	0	W	400
MR14-05_St009_Cast034_Den_#0547-W186	Niskin#07	2014	09	14	23:36	74	45	N	162	0	W	500
MR14-05_St009_Cast034_Den_#0548-W187	Niskin#06	2014	09	14	23:36	74	45	N	162	0	W	600
MR14-05_St009_Cast034_Den_#0549-W188	Niskin#05	2014	09	14	23:36	74	45	N	162	0	W	800
MR14-05_St009_Cast034_Den_#0550-W189	Niskin#04	2014	09	14	23:36	74	45	N	162	0	W	1000
MR14-05_St009_Cast034_Den_#0551-W190	Niskin#03	2014	09	14	23:36	74	45	N	162	0	W	1500
MR14-05_St010_Cast001_Den_#0552-W191	Bucket	2014	09	18	15:01	74	41.99	N	162	07.90	W	0
MR14-05_St010_Cast001_Den_#0553-W192	Bucket	2014	09	18	15:01	74	41.99	N	162	07.90	W	0
MR14-05_St010_Cast001_Den_#0554-W193	Niskin#35	2014	09	18	15:01	74	41.99	N	162	07.90	W	Chl-aMax
MR14-05_St010_Cast001_Den_#0555-W194	Niskin#33	2014	09	18	15:01	74	41.99	N	162	07.90	W	5
MR14-05_St010_Cast001_Den_#0556-W195	Niskin#31	2014	09	18	15:01	74	41.99	N	162	07.90	W	10
MR14-05_St010_Cast001_Den_#0557-W196	Niskin#29	2014	09	18	15:01	74	41.99	N	162	07.90	W	15
MR14-05_St010_Cast001_Den_#0558-W197	Niskin#27	2014	09	18	15:01	74	41.99	N	162	07.90	W	20
MR14-05_St010_Cast001_Den_#0559-W198	Niskin#25	2014	09	18	15:01	74	41.99	N	162	07.90	W	30
MR14-05_St010_Cast001_Den_#0560-W199	Niskin#23	2014	09	18	15:01	74	41.99	N	162	07.90	W	40
MR14-05_St010_Cast001_Den_#0561-W200	Niskin#21	2014	09	18	15:01	74	41.99	N	162	07.90	W	50
MR14-05_St010_Cast001_Den_#0562-W201	Niskin#19	2014	09	18	15:01	74	41.99	N	162	07.90	W	75
MR14-05_St010_Cast001_Den_#0563-W202	Niskin#17	2014	09	18	15:01	74	41.99	N	162	07.90	W	100
MR14-05_St010_Cast001_Den_#0564-W203	Niskin#15	2014	09	18	15:01	74	41.99	N	162	07.90	W	125
MR14-05_St010_Cast001_Den_#0565-W204	Niskin#13	2014	09	18	15:01	74	41.99	N	162	07.90	W	150
MR14-05_St010_Cast001_Den_#0566-W205	Niskin#11	2014	09	18	15:01	74	41.99	N	162	07.90	W	175
MR14-05_St010_Cast001_Den_#0567-W206	Niskin#09	2014	09	18	15:01	74	41.99	N	162	07.90	W	200
MR14-05_St010_Cast001_Den_#0568-W207	Niskin#07	2014	09	18	15:01	74	41.99	N	162	07.90	W	225

MR14-05_St010_Cast001_Den_#0569-W208	Niskin#05	2014	09	18	15:01	74	41.99	N	162	07.90	W	250
MR14-05_St010_Cast001_Den_#0570-W209	Niskin#03	2014	09	18	15:01	74	41.99	N	162	07.90	W	300
MR14-05_St010_Cast001_Den_#0571-W210	Niskin#01	2014	09	18	15:01	74	41.99	N	162	07.90	W	400
MR14-05_St011_Cast001_Den_#0572-W211	Bucket	2014	09	20	3:14	74	49.10	N	161	50.23	W	0
MR14-05_St011_Cast001_Den_#0573-W212	Bucket	2014	09	20	3:14	74	49.10	N	161	50.23	W	0
MR14-05_St011_Cast001_Den_#0574-W213	Niskin#35	2014	09	20	3:14	74	49.10	N	161	50.23	W	Chl-aMax
MR14-05_St011_Cast001_Den_#0575-W214	Niskin#33	2014	09	20	3:14	74	49.10	N	161	50.23	W	5
MR14-05_St011_Cast001_Den_#0576-W215	Niskin#31	2014	09	20	3:14	74	49.10	N	161	50.23	W	10
MR14-05_St011_Cast001_Den_#0577-W216	Niskin#29	2014	09	20	3:14	74	49.10	N	161	50.23	W	15
MR14-05_St011_Cast001_Den_#0578-W217	Niskin#27	2014	09	20	3:14	74	49.10	N	161	50.23	W	20
MR14-05_St011_Cast001_Den_#0579-W218	Niskin#25	2014	09	20	3:14	74	49.10	N	161	50.23	W	30
MR14-05_St011_Cast001_Den_#0580-W219	Niskin#23	2014	09	20	3:14	74	49.10	N	161	50.23	W	40
MR14-05_St011_Cast001_Den_#0581-W220	Niskin#21	2014	09	20	3:14	74	49.10	N	161	50.23	W	50
MR14-05_St011_Cast001_Den_#0582-W221	Niskin#19	2014	09	20	3:14	74	49.10	N	161	50.23	W	75
MR14-05_St011_Cast001_Den_#0583-W222	Niskin#17	2014	09	20	3:14	74	49.10	N	161	50.23	W	100
MR14-05_St011_Cast001_Den_#0584-W223	Niskin#15	2014	09	20	3:14	74	49.10	N	161	50.23	W	125
MR14-05_St011_Cast001_Den_#0585-W224	Niskin#13	2014	09	20	3:14	74	49.10	N	161	50.23	W	150
MR14-05_St011_Cast001_Den_#0586-W225	Niskin#11	2014	09	20	3:14	74	49.10	N	161	50.23	W	175
MR14-05_St011_Cast001_Den_#0587-W226	Niskin#09	2014	09	20	3:14	74	49.10	N	161	50.23	W	200
MR14-05_St011_Cast001_Den_#0588-W227	Niskin#07	2014	09	20	3:14	74	49.10	N	161	50.23	W	225
MR14-05_St011_Cast001_Den_#0589-W228	Niskin#05	2014	09	20	3:14	74	49.10	N	161	50.23	W	250
MR14-05_St011_Cast001_Den_#0590-W229	Niskin#03	2014	09	20	3:14	74	49.10	N	161	50.23	W	300
MR14-05_St011_Cast001_Den_#0591-W230	Niskin#01	2014	09	20	3:14	74	49.10	N	161	50.23	W	400
MR14-05_St009_Cast074_Den_#0592-W231	Bucket	2014	09	24	23:40	74	45.09	N	161	58.88	W	0
MR14-05_St009_Cast074_Den_#0593-W232	Bucket	2014	09	24	23:40	74	45.09	N	161	58.88	W	0
MR14-05_St009_Cast074_Den_#0594-W233	Niskin#26	2014	09	24	23:40	74	45.09	N	161	58.88	W	Chl-aMax
MR14-05_St009_Cast074_Den_#0595-W234	Niskin#24	2014	09	24	23:40	74	45.09	N	161	58.88	W	5
MR14-05_St009_Cast074_Den_#0596-W235	Niskin#23	2014	09	24	23:40	74	45.09	N	161	58.88	W	10
MR14-05_St009_Cast074_Den_#0597-W236	Niskin#22	2014	09	24	23:40	74	45.09	N	161	58.88	W	15
MR14-05_St009_Cast074_Den_#0598-W237	Niskin#21	2014	09	24	23:40	74	45.09	N	161	58.88	W	20
MR14-05_St009_Cast074_Den_#0599-W238	Niskin#20	2014	09	24	23:40	74	45.09	N	161	58.88	W	30
MR14-05_St009_Cast074_Den_#0600-W239	Niskin#19	2014	09	24	23:40	74	45.09	N	161	58.88	W	40
MR14-05_St009_Cast074_Den_#0601-W240	Niskin#18	2014	09	24	23:40	74	45.09	N	161	58.88	W	50
MR14-05_St009_Cast074_Den_#0602-W241	Niskin#17	2014	09	24	23:40	74	45.09	N	161	58.88	W	75
MR14-05_St009_Cast074_Den_#0603-W242	Niskin#16	2014	09	24	23:40	74	45.09	N	161	58.88	W	100

MR14-05_St009_Cast074_Den_#0604-W243	Niskin#15	2014	09	24	23:40	74	45.09	N	161	58.88	W	125
MR14-05_St009_Cast074_Den_#0605-W244	Niskin#14	2014	09	24	23:40	74	45.09	N	161	58.88	W	150
MR14-05_St009_Cast074_Den_#0606-W245	Niskin#13	2014	09	24	23:40	74	45.09	N	161	58.88	W	175
MR14-05_St009_Cast074_Den_#0607-W246	Niskin#12	2014	09	24	23:40	74	45.09	N	161	58.88	W	200
MR14-05_St009_Cast074_Den_#0608-W247	Niskin#11	2014	09	24	23:40	74	45.09	N	161	58.88	W	225
MR14-05_St009_Cast074_Den_#0609-W248	Niskin#10	2014	09	24	23:40	74	45.09	N	161	58.88	W	250
MR14-05_St009_Cast074_Den_#0610-W249	Niskin#09	2014	09	24	23:40	74	45.09	N	161	58.88	W	300
MR14-05_St009_Cast074_Den_#0611-W250	Niskin#08	2014	09	24	23:40	74	45.09	N	161	58.88	W	400
MR14-05_St009_Cast074_Den_#0612-W251	Niskin#07	2014	09	24	23:40	74	45.09	N	161	58.88	W	500
MR14-05_St009_Cast074_Den_#0613-W252	Niskin#06	2014	09	24	23:40	74	45.09	N	161	58.88	W	600
MR14-05_St009_Cast074_Den_#0614-W253	Niskin#05	2014	09	24	23:40	74	45.09	N	161	58.88	W	800
MR14-05_St009_Cast074_Den_#0615-W254	Niskin#04	2014	09	24	23:40	74	45.09	N	161	58.88	W	1000
MR14-05_St009_Cast074_Den_#0616-W255	Niskin#03	2014	09	24	23:40	74	45.09	N	161	58.88	W	1500
MR14-05_St009_Cast074_Den_#0617-W256	Niskin#01	2014	09	24	23:40	74	45.09	N	161	58.88	W	B-10
MR14-05_St006_Cast002_Den_#0618-W257	Bucket	2014	09	25	4:08	74	22.49	N	163	00.55	W	0
MR14-05_St006_Cast002_Den_#0619-W258	Bucket	2014	09	25	4:08	74	22.49	N	163	00.55	W	0
MR14-05_St006_Cast002_Den_#0620-W259	Niskin#26	2014	09	25	4:08	74	22.49	N	163	00.55	W	Chl-aMax
MR14-05_St006_Cast002_Den_#0621-W260	Niskin#24	2014	09	25	4:08	74	22.49	N	163	00.55	W	5
MR14-05_St006_Cast002_Den_#0622-W261	Niskin#23	2014	09	25	4:08	74	22.49	N	163	00.55	W	10
MR14-05_St006_Cast002_Den_#0623-W262	Niskin#22	2014	09	25	4:08	74	22.49	N	163	00.55	W	15
MR14-05_St006_Cast002_Den_#0624-W263	Niskin#21	2014	09	25	4:08	74	22.49	N	163	00.55	W	20
MR14-05_St006_Cast002_Den_#0625-W264	Niskin#20	2014	09	25	4:08	74	22.49	N	163	00.55	W	30
MR14-05_St006_Cast002_Den_#0626-W265	Niskin#19	2014	09	25	4:08	74	22.49	N	163	00.55	W	40
MR14-05_St006_Cast002_Den_#0627-W266	Niskin#18	2014	09	25	4:08	74	22.49	N	163	00.55	W	50
MR14-05_St006_Cast002_Den_#0628-W267	Niskin#17	2014	09	25	4:08	74	22.49	N	163	00.55	W	75
MR14-05_St006_Cast002_Den_#0629-W268	Niskin#16	2014	09	25	4:08	74	22.49	N	163	00.55	W	100
MR14-05_St006_Cast002_Den_#0630-W269	Niskin#15	2014	09	25	4:08	74	22.49	N	163	00.55	W	125
MR14-05_St006_Cast002_Den_#0631-W270	Niskin#14	2014	09	25	4:08	74	22.49	N	163	00.55	W	150
MR14-05_St006_Cast002_Den_#0632-W271	Niskin#13	2014	09	25	4:08	74	22.49	N	163	00.55	W	175
MR14-05_St006_Cast002_Den_#0633-W272	Niskin#12	2014	09	25	4:08	74	22.49	N	163	00.55	W	200
MR14-05_St006_Cast002_Den_#0634-W273	Niskin#11	2014	09	25	4:08	74	22.49	N	163	00.55	W	225
MR14-05_St006_Cast002_Den_#0635-W274	Niskin#10	2014	09	25	4:08	74	22.49	N	163	00.55	W	250
MR14-05_St006_Cast002_Den_#0636-W275	Niskin#09	2014	09	25	4:08	74	22.49	N	163	00.55	W	300
MR14-05_St006_Cast002_Den_#0637-W276	Niskin#08	2014	09	25	4:08	74	22.49	N	163	00.55	W	400
MR14-05_St006_Cast002_Den_#0638-W277	Niskin#07	2014	09	25	4:08	74	22.49	N	163	00.55	W	500

MR14-05_St006_Cast002_Den_#0639-W278	Niskin#06	2014	09	25	4:08	74	22.49	N	163	00.55	W	600
MR14-05_St006_Cast002_Den_#0640-W279	Niskin#05	2014	09	25	4:08	74	22.49	N	163	00.55	W	800
MR14-05_St006_Cast002_Den_#0641-W280	Niskin#04	2014	09	25	4:08	74	22.49	N	163	00.55	W	1000
MR14-05_St006_Cast002_Den_#0642-W281	Niskin#01	2014	09	25	4:08	74	22.49	N	163	00.55	W	B-10
MR14-05_St005_Cast002_Den_#0643-W282	Bucket	2014	09	25	8:01	73	59.98	N	164	00.06	W	0
MR14-05_St005_Cast002_Den_#0644-W283	Bucket	2014	09	25	8:01	73	59.98	N	164	00.06	W	0
MR14-05_St005_Cast002_Den_#0645-W284	Niskin#35	2014	09	25	8:01	73	59.98	N	164	00.06	W	Chl-aMax
MR14-05_St005_Cast002_Den_#0646-W285	Niskin#33	2014	09	25	8:01	73	59.98	N	164	00.06	W	5
MR14-05_St005_Cast002_Den_#0647-W286	Niskin#31	2014	09	25	8:01	73	59.98	N	164	00.06	W	10
MR14-05_St005_Cast002_Den_#0648-W287	Niskin#29	2014	09	25	8:01	73	59.98	N	164	00.06	W	15
MR14-05_St005_Cast002_Den_#0649-W288	Niskin#27	2014	09	25	8:01	73	59.98	N	164	00.06	W	20
MR14-05_St005_Cast002_Den_#0650-W289	Niskin#25	2014	09	25	8:01	73	59.98	N	164	00.06	W	30
MR14-05_St005_Cast002_Den_#0651-W290	Niskin#23	2014	09	25	8:01	73	59.98	N	164	00.06	W	40
MR14-05_St005_Cast002_Den_#0652-W291	Niskin#21	2014	09	25	8:01	73	59.98	N	164	00.06	W	50
MR14-05_St005_Cast002_Den_#0653-W292	Niskin#19	2014	09	25	8:01	73	59.98	N	164	00.06	W	75
MR14-05_St005_Cast002_Den_#0654-W293	Niskin#17	2014	09	25	8:01	73	59.98	N	164	00.06	W	100
MR14-05_St005_Cast002_Den_#0655-W294	Niskin#15	2014	09	25	8:01	73	59.98	N	164	00.06	W	125
MR14-05_St005_Cast002_Den_#0656-W295	Niskin#13	2014	09	25	8:01	73	59.98	N	164	00.06	W	150
MR14-05_St005_Cast002_Den_#0657-W296	Niskin#11	2014	09	25	8:01	73	59.98	N	164	00.06	W	175
MR14-05_St005_Cast002_Den_#0658-W297	Niskin#09	2014	09	25	8:01	73	59.98	N	164	00.06	W	200
MR14-05_St005_Cast002_Den_#0659-W298	Niskin#07	2014	09	25	8:01	73	59.98	N	164	00.06	W	225
MR14-05_St005_Cast002_Den_#0660-W299	Niskin#05	2014	09	25	8:01	73	59.98	N	164	00.06	W	Not sampled
MR14-05_St005_Cast002_Den_#0661-W300	Niskin#01	2014	09	25	8:01	73	59.98	N	164	00.06	W	B-10
MR14-05_St012_Cast001_Den_#0662-W301	Bucket	2014	09	25	14:09	73	30.03	N	166	59.96	W	0
MR14-05_St012_Cast001_Den_#0663-W302	Bucket	2014	09	25	14:09	73	30.03	N	166	59.96	W	0
MR14-05_St012_Cast001_Den_#0664-W303	Niskin#35	2014	09	25	14:09	73	30.03	N	166	59.96	W	Chl-aMax
MR14-05_St012_Cast001_Den_#0665-W304	Niskin#33	2014	09	25	14:09	73	30.03	N	166	59.96	W	5
MR14-05_St012_Cast001_Den_#0666-W305	Niskin#31	2014	09	25	14:09	73	30.03	N	166	59.96	W	10
MR14-05_St012_Cast001_Den_#0667-W306	Niskin#29	2014	09	25	14:09	73	30.03	N	166	59.96	W	15
MR14-05_St012_Cast001_Den_#0668-W307	Niskin#27	2014	09	25	14:09	73	30.03	N	166	59.96	W	20
MR14-05_St012_Cast001_Den_#0669-W308	Niskin#25	2014	09	25	14:09	73	30.03	N	166	59.96	W	30
MR14-05_St012_Cast001_Den_#0670-W309	Niskin#23	2014	09	25	14:09	73	30.03	N	166	59.96	W	40
MR14-05_St012_Cast001_Den_#0671-W310	Niskin#21	2014	09	25	14:09	73	30.03	N	166	59.96	W	50
MR14-05_St012_Cast001_Den_#0672-W311	Niskin#19	2014	09	25	14:09	73	30.03	N	166	59.96	W	75
MR14-05_St012_Cast001_Den_#0673-W312	Niskin#17	2014	09	25	14:09	73	30.03	N	166	59.96	W	100

MR14-05_St012_Cast001_Den_#0674-W313	Niskin#01	2014	09	25	14:09	73	30.03	N	166	59.96	W	B-10
MR14-05_St013_Cast001_Den_#0675-W314	Bucket	2014	09	25	19:32	72	45.01	N	168	14.87	W	0
MR14-05_St013_Cast001_Den_#0676-W315	Bucket	2014	09	25	19:32	72	45.01	N	168	14.87	W	0
MR14-05_St013_Cast001_Den_#0677-W316	Niskin#35	2014	09	25	19:32	72	45.01	N	168	14.87	W	Chl-aMax
MR14-05_St013_Cast001_Den_#0678-W317	Niskin#33	2014	09	25	19:32	72	45.01	N	168	14.87	W	5
MR14-05_St013_Cast001_Den_#0679-W318	Niskin#31	2014	09	25	19:32	72	45.01	N	168	14.87	W	10
MR14-05_St013_Cast001_Den_#0680-W319	Niskin#29	2014	09	25	19:32	72	45.01	N	168	14.87	W	15
MR14-05_St013_Cast001_Den_#0681-W320	Niskin#27	2014	09	25	19:32	72	45.01	N	168	14.87	W	20
MR14-05_St013_Cast001_Den_#0682-W321	Niskin#25	2014	09	25	19:32	72	45.01	N	168	14.87	W	30
MR14-05_St013_Cast001_Den_#0683-W322	Niskin#23	2014	09	25	19:32	72	45.01	N	168	14.87	W	40
MR14-05_St013_Cast001_Den_#0684-W323	Niskin#21	2014	09	25	19:32	72	45.01	N	168	14.87	W	50
MR14-05_St013_Cast001_Den_#0685-W324	Niskin#01	2014	09	25	19:32	72	45.01	N	168	14.87	W	B-10
MR14-05_St014_Cast001_Den_#0686-W325	Bucket	2014	09	26	19:00	72	04.99	N	168	50.04	W	0
MR14-05_St014_Cast001_Den_#0687-W326	Bucket	2014	09	26	19:00	72	04.99	N	168	50.04	W	0
MR14-05_St014_Cast001_Den_#0688-W327	Niskin#35	2014	09	26	19:00	72	04.99	N	168	50.04	W	Chl-aMax
MR14-05_St014_Cast001_Den_#0689-W328	Niskin#33	2014	09	26	19:00	72	04.99	N	168	50.04	W	5
MR14-05_St014_Cast001_Den_#0690-W329	Niskin#31	2014	09	26	19:00	72	04.99	N	168	50.04	W	10
MR14-05_St014_Cast001_Den_#0691-W330	Niskin#29	2014	09	26	19:00	72	04.99	N	168	50.04	W	15
MR14-05_St014_Cast001_Den_#0692-W331	Niskin#27	2014	09	26	19:00	72	04.99	N	168	50.04	W	20
MR14-05_St014_Cast001_Den_#0693-W332	Niskin#25	2014	09	26	19:00	72	04.99	N	168	50.04	W	30
MR14-05_St014_Cast001_Den_#0694-W333	Niskin#23	2014	09	26	19:00	72	04.99	N	168	50.04	W	40
MR14-05_St014_Cast001_Den_#0695-W334	Niskin#21	2014	09	26	19:00	72	04.99	N	168	50.04	W	Not sampled
MR14-05_St014_Cast001_Den_#0696-W335	Niskin#01	2014	09	26	19:00	72	04.99	N	168	50.04	W	B-10
MR14-05_St015_Cast001_Den_#0697-W336	Bucket	2014	09	27	2:29	71	00.03	N	168	50.01	W	0
MR14-05_St015_Cast001_Den_#0698-W337	Bucket	2014	09	27	2:29	71	00.03	N	168	50.01	W	0
MR14-05_St015_Cast001_Den_#0699-W338	Niskin#35	2014	09	27	2:29	71	00.03	N	168	50.01	W	Chl-aMax
MR14-05_St015_Cast001_Den_#0700-W339	Niskin#33	2014	09	27	2:29	71	00.03	N	168	50.01	W	5
MR14-05_St015_Cast001_Den_#0701-W340	Niskin#31	2014	09	27	2:29	71	00.03	N	168	50.01	W	10
MR14-05_St015_Cast001_Den_#0702-W341	Niskin#29	2014	09	27	2:29	71	00.03	N	168	50.01	W	15
MR14-05_St015_Cast001_Den_#0703-W342	Niskin#27	2014	09	27	2:29	71	00.03	N	168	50.01	W	20
MR14-05_St015_Cast001_Den_#0704-W343	Niskin#25	2014	09	27	2:29	71	00.03	N	168	50.01	W	30
MR14-05_St015_Cast001_Den_#0705-W344	Niskin#23	2014	09	27	2:29	71	00.03	N	168	50.01	W	Not sampled
MR14-05_St015_Cast001_Den_#0706-W345	Niskin#21	2014	09	27	2:29	71	00.03	N	168	50.01	W	Not sampled
MR14-05_St015_Cast001_Den_#0707-W346	Niskin#01	2014	09	27	2:29	71	00.03	N	168	50.01	W	B-10
MR14-05_St017_Cast001_Den_#0708-W347	Bucket	2014	09	27	15:06	69	00.10	N	168	49.94	W	0

MR14-05_St017_Cast001_Den_#0709-W348	Bucket	2014	09	27	15:06	69	00.10	N	168	49.94	W	0
MR14-05_St017_Cast001_Den_#0710-W349	Niskin#35	2014	09	27	15:06	69	00.10	N	168	49.94	W	Chl-aMax
MR14-05_St017_Cast001_Den_#0711-W350	Niskin#33	2014	09	27	15:06	69	00.10	N	168	49.94	W	5
MR14-05_St017_Cast001_Den_#0712-W351	Niskin#31	2014	09	27	15:06	69	00.10	N	168	49.94	W	10
MR14-05_St017_Cast001_Den_#0713-W352	Niskin#29	2014	09	27	15:06	69	00.10	N	168	49.94	W	15
MR14-05_St017_Cast001_Den_#0714-W353	Niskin#27	2014	09	27	15:06	69	00.10	N	168	49.94	W	20
MR14-05_St017_Cast001_Den_#0715-W354	Niskin#25	2014	09	27	15:06	69	00.10	N	168	49.94	W	30
MR14-05_St017_Cast001_Den_#0716-W355	Niskin#23	2014	09	27	15:06	69	00.10	N	168	49.94	W	40
MR14-05_St017_Cast001_Den_#0717-W356	Niskin#21	2014	09	27	15:06	69	00.10	N	168	49.94	W	Not sampled
MR14-05_St017_Cast001_Den_#0718-W357	Niskin#01	2014	09	27	15:06	69	00.10	N	168	49.94	W	B-10

4. Chemical and biological Oceanography

4.1. Dissolved Oxygen

(1) Personnel

Shigeto Nishino	JAMSTEC	- PI
Keitaro Matsumoto	MWJ	
Kanako Yoshida	MWJ	
Haruka Tamada	MWJ	

(2) Objective

Determination of dissolved oxygen in seawater by Winkler titration.

(3) Parameters

Dissolved Oxygen

(4) 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 TLM1372, 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 130^o C. 1.7835 g 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.

(5) Observation log

a. Standardization and determination of the blank

Table 4.1-1 shows results of the standardization and the blank determination during this cruise.

Table 4.1-1: Results of the standardization and the blank determinations during cruise.

Date	KIO_3 ID	$Na_2S_2O_3$	DOT-01X(No.7)		DOT-01X(No.8)		Stations
			E.P.	Blank	E.P.	Blank	
2014/9/1	K1404C05	T1406H	3.962	0.002	3.964	0.002	001, 002, 003, 004, 005, 006, 007, 008, 009(cast002, 004, 006)
2014/9/8	K1404C06	T1406H	3.962	0.001	3.965	0.002	009(cast008, 010, 012, 014, 016, 018, 020, 022, 024, 026, 028, 030)
2014/9/14	K1404C10	T1406H	3.965	0.002	3.966	0.002	
2014/9/15	K1404C08	T1406I	3.962	0.003	3.966	0.002	009(cast032, 034, 036, 038, 040, 042, 044, 046, 048, 050, 052, 054, 056), 010, 011
2014/9/21	CSK_TLM1372	T1406I	3.962	0.001	3.965	0.001	
2014/9/21	K1404D01	T1406I	3.961	0.001	3.964	0.001	009(cast060, 062, 064)
2014/9/23	K1404D02	T1406I	3.961	0.000	3.963	0.000	
2014/9/23	K1404D02	T1406J	3.962	0.003	3.965	0.001	009(cast068, 070, 072, 074), 006(cast002), 005(cast002), 012, 013(cast001, 002, 003, 004), 014, 015, 016, 017, 003(cast002), 001(cast002)
2014/9/29	K1404D03	T1406J	3.959	0.003	3.9653	0.002	

b. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. Total amount of the replicate sample pairs of good measurement was 142. The standard deviation of the replicate measurement was 0.23 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 Figs. 4.1-1 and -2

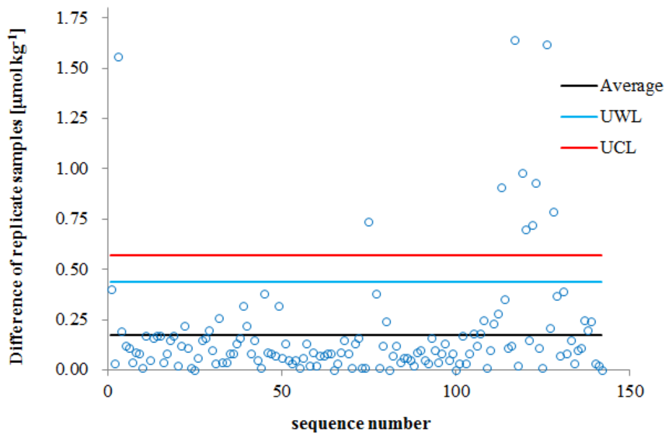


Figure 4.1-1: Differences of replicate samples against sequence number

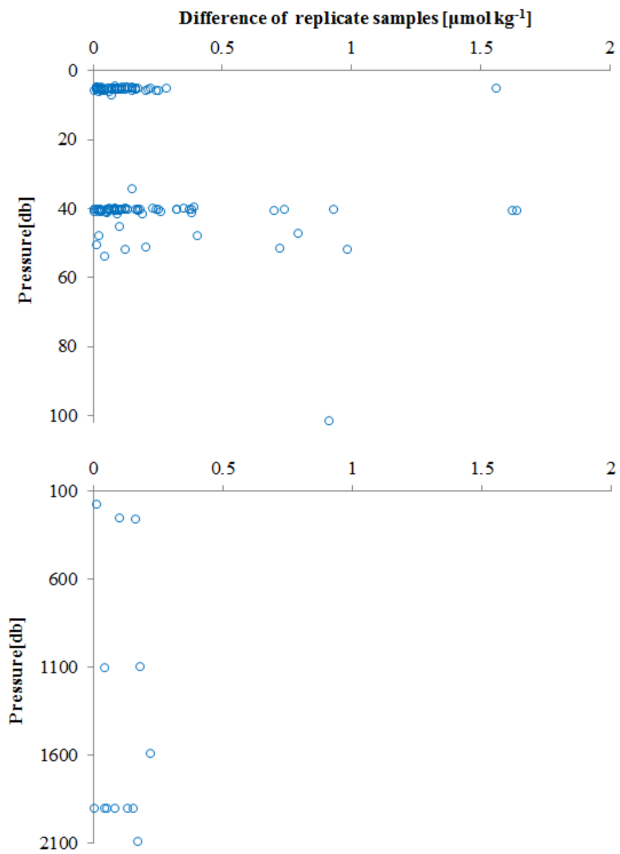


Figure 4.1-2: Differences of replicate samples against pressure

(6) Data archives

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

(7) 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

4.2. Nutrients

(1) Personnel

Shigeto Nishino	JAMSTEC	- PI
Masanori Enoki	MWJ	
Elena Hayashi	MWJ	
Yoshiko Ishikawa	MWJ	
Tomomi Sone	MWJ	

(2) Objectives

The objectives of nutrients analyses during the R/V Mirai MR14-05 cruise in the Arctic Ocean is as follows:

- Describe the present status of nutrients concentration with excellent comparability.

(3) Parameters

The determinants are nitrate, nitrite, phosphate, silicate and ammonia in the Arctic Ocean.

(4) Summary of nutrients analysis

We made 50 QuAAtro runs for the water columns sample at 59 casts during MR14-05. The total amount of layers of the seawater sample reached up to 1059. We made basically duplicate measurement. The station locations for nutrients measurement is shown in Figure 4.2.1

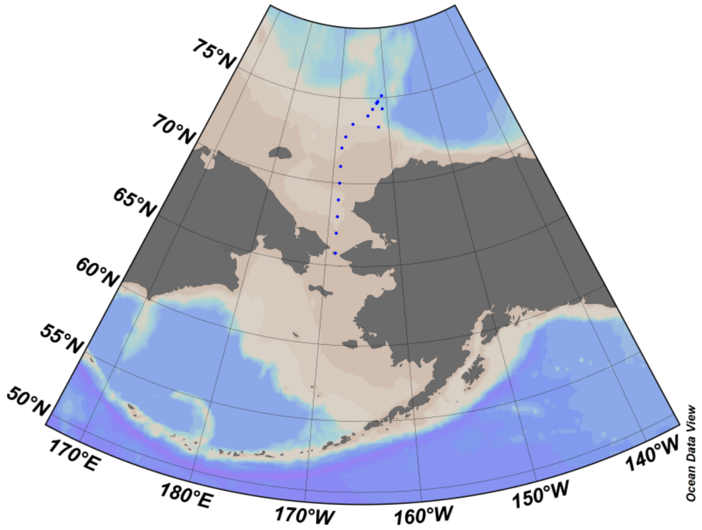


Figure 4.2-1: Sampling positions of nutrients sample.

(5) Instrument and Method

Analytical detail using QuAAtro system

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

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

The silicate method is analogous to that described for phosphate. The method used is essentially that of Grasshoff et al. (1983), wherein silicomolybdic acid is first formed from the silicate in the sample and added molybdic acid; then the silicomolybdic acid is reduced to silicomolybdous acid, or "molybdenum blue," using ascorbic acid as the reductant. The analytical methods of the nutrients, nitrate, nitrite, silicate and phosphate, during this cruise are same as the methods used in (Kawano et al. 2009).

The ammonia in seawater is mixed with an alkaline containing EDTA, ammonia as gas state is formed from seawater. The ammonia (gas) is absorbed in sulfuric acid by way of 0.5 μm pore size membrane filter (ADVANTEC PTFE) at the dialyzer attached to analytical system. The ammonia absorbed in sulfuric acid is determined by coupling with phenol and hypochlorite to form indophenols blue. Wavelength using ammonia analysis is 630 nm, which is absorbance of indophenols blue.

The flow diagrams and reagents for each parameter are shown in Figures 4.2.2 to 4.2.6.

c. Nitrate + Nitrite Reagents

Imidazole (buffer), 0.06 M (0.4 % w/v)

Dissolve 4 g imidazole, $C_3H_4N_2$, in ca. 1000 ml DIW; add 2 ml concentrated HCl. After mixing, 0.2ml metallic copper solution (dissolved 5g metallic copper in 500ml of DIW and add 25ml concentrated H_2SO_4), 1 ml Triton®X-100 (50 % solution in ethanol) is added.

Sulfanilamide, 0.06 M (1 % w/v) in 1.2M HCl

Dissolve 10 g sulfanilamide, $4\text{-}NH_2C_6H_4SO_3H$, in 900 ml of DIW, add 100 ml concentrated HCl. After mixing, 2 ml Triton®X-100 (50 % solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride, 0.004 M (0.1 %f w/v)

Dissolve 1 g NED, $C_{10}H_7NHCH_2CH_2NH_2 \cdot 2HCl$, in 1000 ml of DIW and add 10 ml concentrated HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added. This reagent is stored in a dark bottle.

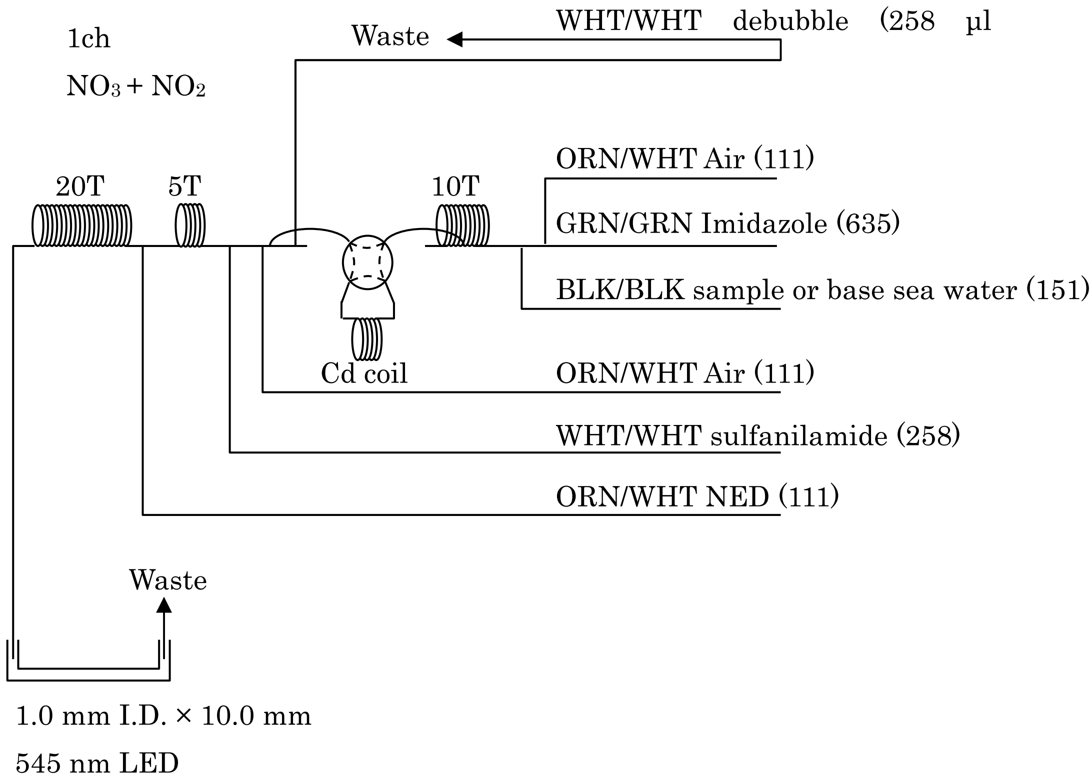


Figure 4.2-2: NO_3+NO_2 (1ch.) Flow diagram.

d. Nitrite Reagents

Sulfanilamide, 0.06 M (1 % w/v) in 1.2 M HCl

Dissolve 10g sulfanilamide, 4-$NH_2C_6H_4SO_3H$, in 900 ml of DIW, add 100 ml concentrated HCl. After mixing, 2 ml Triton®X-100 (50 % solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride, 0.004 M (0.1 % w/v)

Dissolve 1 g NED, $C_{10}H_7NHCH_2CH_2NH_2 \cdot 2HCl$, in 1000 ml of DIW and add 10 ml concentrated HCl. After mixing, 1 ml Triton®X-100 (50 % solution in ethanol) is added. This reagent is stored in a dark bottle.

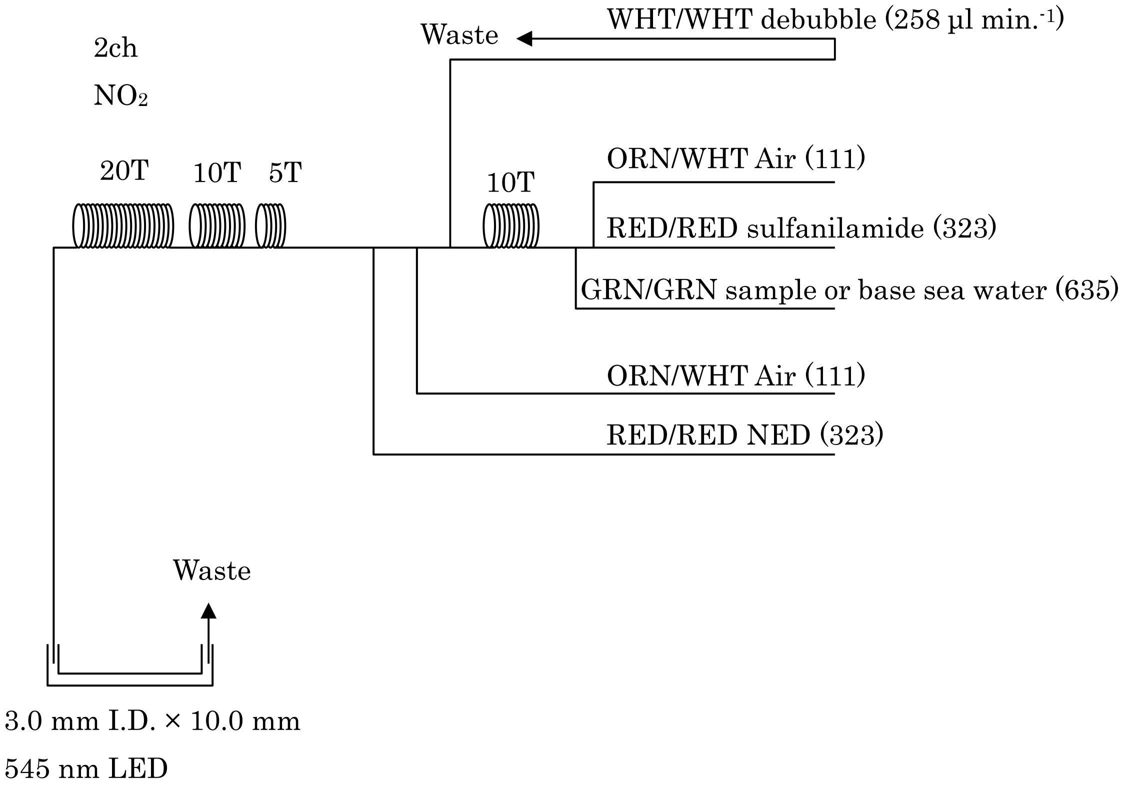


Figure 4.2-3: NO_2 (2ch.) Flow diagram.

e. Silicate Reagents

Molybdic acid, 0.06 M (2 % w/v)

Dissolve 15 g disodium molybdate(VI) dihydrate, $Na_2M_oO_4 \cdot 2H_2O$, in 980 ml DIW, add 8 ml concentrated H_2SO_4. After mixing, 20 ml sodium dodecyl sulphate (15 % solution in water) is added.

Oxalic acid, 0.6 M (5 % w/v)

Dissolve 50 g oxalic acid anhydrous, HOOC: COOH, in 950 ml of DIW.

Ascorbic acid, 0.01M (3 % w/v)

Dissolve 2.5g L (+)-ascorbic acid, $C_6H_8O_6$, in 100 ml of DIW. Stored in a dark bottle and freshly prepared before every measurement.

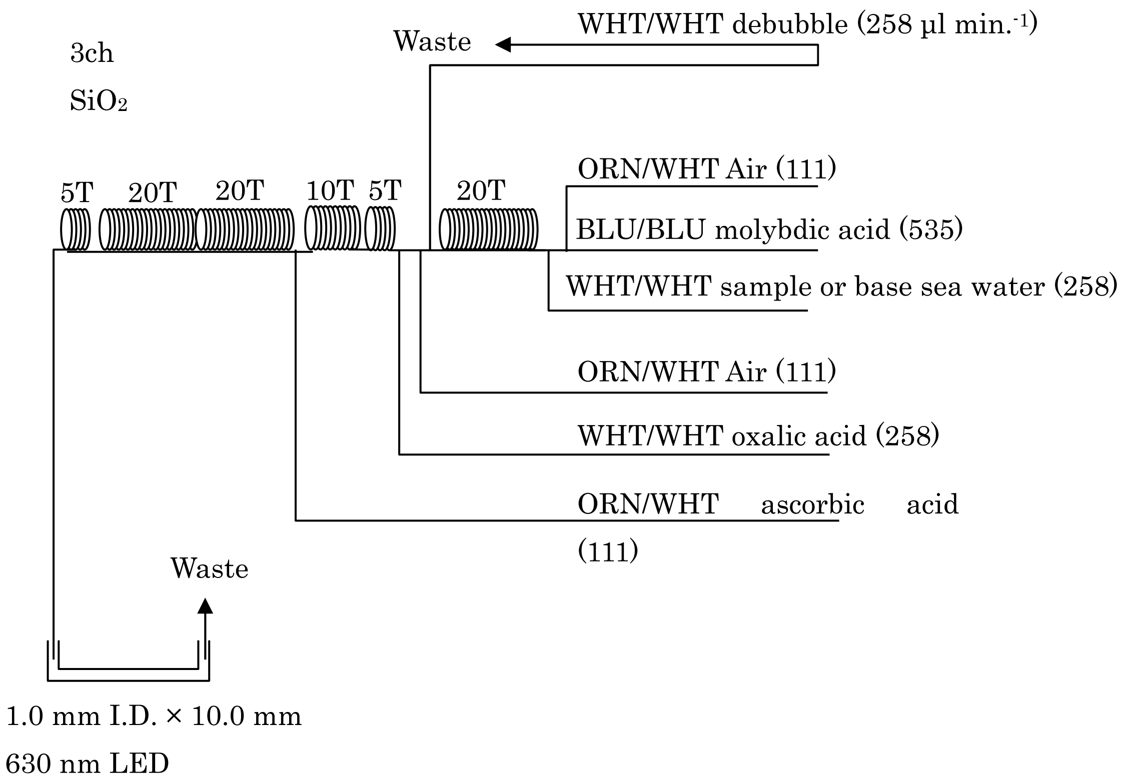


Figure4.2.4 SiO_2 (3ch.) Flow diagram.

f. Phosphate Reagents

Stock molybdate solution, 0.03M (0.8 % w/v)

Dissolve 8 g disodium molybdate(VI) dihydrate, $Na_2M_oO_4 \cdot 2H_2O$, and 0.17 g antimony potassium tartrate, $C_8H_4K_2O_{12}Sb_2 \cdot 3H_2O$, in 950 ml of DIW and add 50 ml concentrated H_2SO_4.

Mixed Reagent

Dissolve 1.2 g L (+)-ascorbic acid, $C_6H_8O_6$, in 150 ml of stock molybdate solution. After mixing, 3 ml sodium dodecyl sulphate (15 % solution in water) is added. Stored in a dark bottle and freshly prepared before every measurement.

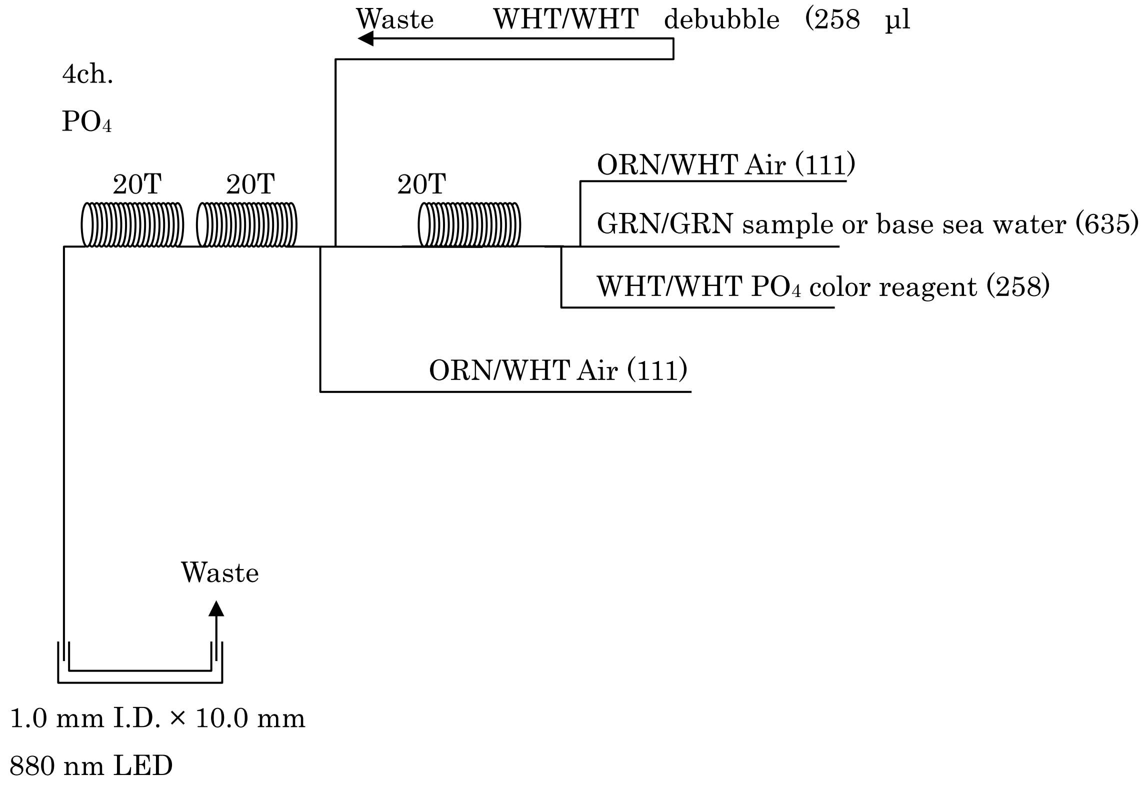


Figure 4.2-5: PO_4 (4ch.) Flow diagram.

g. Ammonia Reagents

EDTA

Dissolve 41 g EDTA (ethylenediaminetetraacetatic acid tetrasodium salt), $C_{10}H_{12}N_2O_8Na_4 \cdot 4H_2O$, and 2 g boric acid, H_3BO_3, in 200 ml of DIW. After mixing, 1 ml Triton®X-100 (30 % solution in DIW) is added. This reagent is prepared at a week about.

NaOH

Dissolve 5 g sodium hydroxide, NaOH, and 16 g EDTA in 100 ml of DIW. This reagent is prepared at a week about.

Stock Nitroprusside

Dissolved 0.25 g sodium pentacyanonitrosylferrate(II), $Na_2[Fe(CN)_5NO]$, in 100 ml of DIW and add 0.2 ml 1N H_2SO_4. Stored in a dark bottle and prepared at a month about.

Nitroprusside solution

Mixed 4 ml stock nitroprusside and 5 ml 1N H_2SO_4 in 500 ml of DIW. After mixing, 2ml Triton®X-100 (30 % solution in DIW) is added. This reagent is stored in a dark bottle and prepared at every 2 or 3 days.

Alkaline phenol

Dissolved 10 g phenol, C_6H_5OH, 5 g sodium hydroxide and citric acid, $C_6H_8O_7$, in 200 ml DIW. Stored in a dark bottle and prepared at a week about.

NaClO solution

Mixed 3 ml sodium hypochlorite solution, NaClO, in 47 ml DIW. Stored in a dark bottle and fleshly prepared before every measurement. This reagent is prepared 0.3% available chlorine.

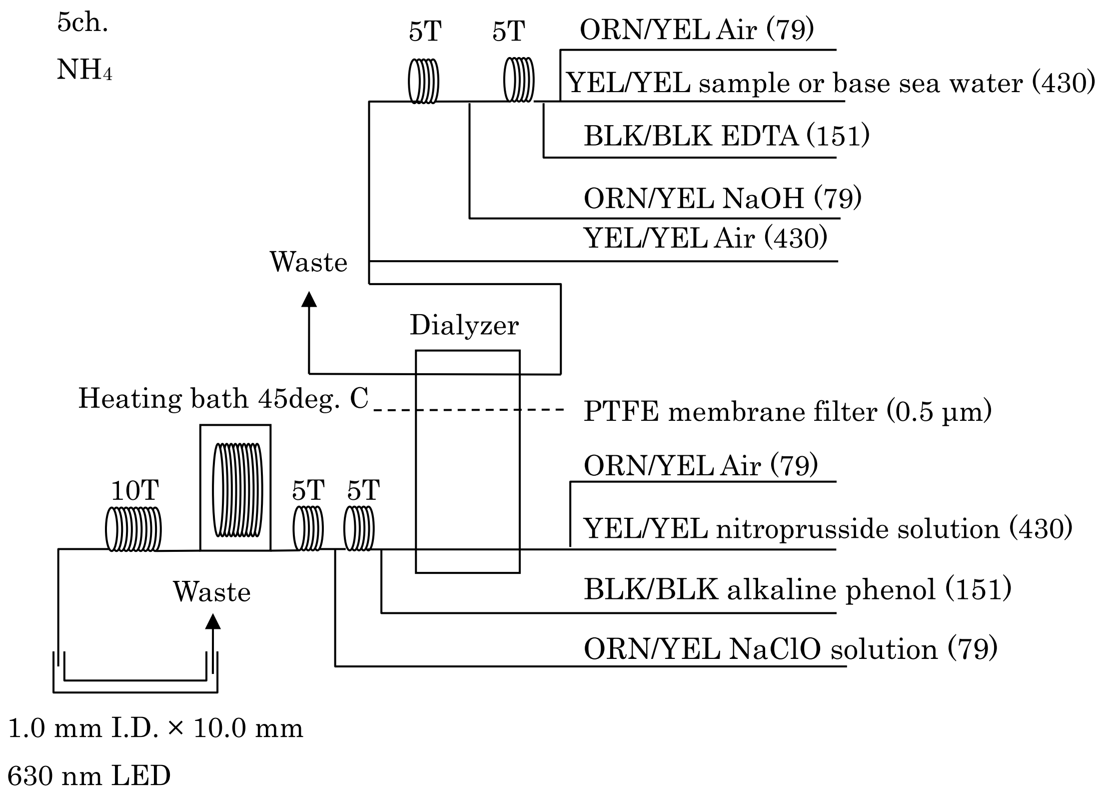


Figure 4.2-6: NH_4 (5ch.) Flow diagram.

i. Sampling procedures

Sampling of nutrients followed that oxygen, salinity and trace gases. Samples were drawn into a 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 are put into water bath adjusted to ambient temperature, 22 ± 1.1 deg. C, in about 30 minutes before use to stabilize the temperature of samples.

No transfer was made and the vials were set an auto sampler tray directly. Samples were analyzed after collection basically within 24 hours.

j. Data processing

Raw data from QuAAtro were treated as follows:

- Check baseline shift.
- Check the shape of each peak and positions of peak values taken, and then change the positions of peak values taken if necessary.
- Carry-over correction and baseline drift correction were applied to peak heights of each samples followed by sensitivity correction.
- Baseline correction and sensitivity correction were done basically using liner regression.
- Load pressure and salinity from CTD data due to calculate density of seawater.
- Calibration curves to get nutrients concentration were assumed second order equations.

(5) Nutrients standards

a. Volumetric laboratory ware of in-house standards

All volumetric glass ware and polymethylpentene (PMP) ware used were gravimetrically calibrated. Plastic volumetric flasks were gravimetrically calibrated at the temperature of use within 0 to 4 K.

Volumetric flasks

Volumetric flasks of Class quality (Class A) are used because their nominal tolerances are 0.05 % or less over the size ranges likely to be used in this work. Class A flasks are made of borosilicate glass, and the standard solutions were transferred to plastic bottles as quickly as possible after they are made up to volume and well mixed in order to prevent excessive dissolution of silicate from the glass. PMP volumetric flasks were gravimetrically calibrated and used only within 0 to 4 K of the calibration temperature.

The computation of volume contained by glass flasks at various temperatures other than the calibration temperatures were done by using the coefficient of linear expansion of borosilicate crown glass.

Because of their larger temperature coefficients of cubical expansion and lack of tables constructed for these materials, the plastic volumetric flasks were gravimetrically calibrated over the temperature range of intended use and used at the temperature of calibration within 0 to 4 K. The weights obtained in the calibration weightings were corrected for the density of water and air buoyancy.

Pipettes and pipettors

All pipettes have nominal calibration tolerances of 0.1 % or better. These were gravimetrically calibrated in order to verify and improve upon this nominal tolerance.

b. Reagents, general considerations

Specifications

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

For nitrite standard, "sodium nitrite" provided by Wako, CAS No.:7632-00-0, was used. And assay of nitrite was determined according JIS K8019 and assays of nitrite salts were 98.73%. We use that value to adjust the weights taken.

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 HC382250 are used. The silicate concentration is certified by NIST-SRM3150 with the uncertainty of 0.5 %. HC382250 is certified as 1000±5 mg L^{-1}, however, our direct comparison between two Merck standards and estimation based on 7 lots of RMNS gave us a factor of 973 mg L^{-1} for HC097572 which was 5mg of certification by Merck. We use this factor throughout MR14-05 to keep comparability for silicate concentration.

For ammonia standard, "ammonia sulfate" provided by Wako, CAS No.: 7783-20-2, was used. The purity of this standard was greater than 99.5%.

Ultra pure water

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

Low-nutrients seawater (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.45 μm pore size membrane filter. This water is stored in 20 liter cubitainer with paper box.

The concentrations of nutrient of this water were measured carefully in June 2014.

c. Concentrations of nutrients for A, B and C standards

Concentrations of nutrients for A, B and C standards are set as shown in Table 4.2.1. The C standard is prepared according recipes as shown in Table 4.2.2. All volumetric laboratory tools were calibrated prior the cruise as stated in chapter (5)a. Then the actual concentration of nutrients in each fresh standard was calculated based on the ambient, solution temperature and determined factors of volumetric laboratory wares.

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

For high concentration of ammonia in Chukchi Sea at MR13-06 cruise, we used 5 levels calibration curve adding to C-5 standard in Chukchi Sea observation.

Table 4.2-1: Nominal concentrations of nutrients for A, B and C standards.

	A	B	C-1	C-2	C-3	C-4	C-5
NO_3 (μM)	22550	680	0.05	13	27	40	-
NO_2 (μM)	4000	40	0.00	0.4	0.8	1.2	-
SiO_2 (μM)	35000	1400	0.8	28	56	83	-
PO_4 (μM)	3000	60	0.1	01.3	2.5	3.7	-
NH_4 (μM)	4000	320	0.00	3.2	6.4	9.6	12.8

Table 4.2-2: Working calibration standard recipes.

C Std.	B-1 Std.	B-2 Std.	B-3 Std.	DIW
C-1	0 ml	0 ml	0 ml	60 ml
C-2	10 ml	5 ml	5 ml	40 ml
C-3	20 ml	10 ml	10 ml	20 ml

C-4	30 ml	15 ml	15 ml	0 ml
C-5	0 ml	0 ml	20 ml	40 ml

B-1 Std.: Mixture of nitrate, silicate and phosphate
B-2 Std.: Nitrite
B-3 Std.: Ammonia

d. Renewal of in-house standard solutions

In-house standard solutions as stated in paragraph c were renewed as shown in Table 4.2.3(a) to (c).

Table 4.2-3(a): Timing of renewal of in-house standards.

NO_3, NO_2, SiO_2, PO_4, NH_4	Renewal
A-1 Std. (NO_3)	maximum a month
A-2 Std. (NO_2)	maximum a month
A-3 Std. (SiO_2)	commercial prepared solution
A-4 Std. (PO_4)	maximum a month
A-5 Std. (NH_4)	maximum a month
B-1 Std. (mixture of NO_3, SiO_2, PO_4)	maximum a week
B-2 Std. (NO_2)	maximum a week
B-3 Std. (NH_4)	maximum a week

Table 4.2-3(b): Timing of renewal of working calibration standards.

C Std.	Renewal
C Std. (mixture of B-1 , B-2 and B-3 Std.)	every 24 hours

Table 4.2-3(c): Timing of renewal of in-house standards for reduction estimation.

Reduction estimation	Renewal
D-1 Std. (3600 µM NO_3)	maximum a week
22 µM NO_3	when C Std. renewed
24 µM NO_2	when C Std. renewed

(6) Reference material of nutrients in seawater

To get the more accurate and high quality nutrients data to achieve the objectives stated above, huge numbers of the bottles of the reference material of nutrients in seawater (hereafter RMNS) are prepared (Aoyama et al., 2006, 2007, 2008, 2009). In the previous worldwide expeditions, such as WOCE cruises, the higher reproducibility and precision of nutrients measurements were required (Joyce and Corry, 1994). Since no standards were available for the measurement of nutrients in seawater at that time, the requirements were described in term of reproducibility. The required reproducibility was 1 %, 1 to 2 %, 1 to 3 % for nitrate, phosphate and silicate, respectively. Although nutrient data from the WOCE one-time survey was of unprecedented quality and coverage due to much care in sampling and measurements, the differences of nutrients concentration at crossover points are still found among the expeditions (Aoyama and Joyce, 1996, Mordy et al., 2000, Gouretski and Jancke, 2001). For instance, the mean offset of nitrate concentration at deep waters was 0.5 μmol kg^{-1} for 345 crossovers at world oceans, though the maximum was 1.7 μmol kg^{-1} (Gouretski and Jancke, 2001). At the 31 crossover points in the Pacific WHP one-time lines, the WOCE standard of reproducibility for nitrate of 1 % was fulfilled at about half of the crossover points and the maximum difference was 7 % at deeper layers below 1.6 deg. C in potential temperature (Aoyama and Joyce, 1996).

a. RMNS for this cruise

RMNS lots BS, BU, CA and BD, which cover full range of nutrients concentrations in the Arctic ocean are prepared. 50 sets of BS, BU, CA and BD are prepared.

These RMNS assignment were completely done based on random number. The RMNS bottles were stored at a room in the ship, REAGENT STORE, where the temperature was maintained around 18.7 deg. C.

b. Assigned concentration for RMNSs

We assigned nutrients concentrations for RMNS lots BS, BU, CA and BD as shown in Table 4.2.4.

Table 4.2-4: Assigned concentration of RMNSs.

unit: μmol kg^{-1}

	Nitrate	Nitrite	Phosphate	Silicate	Ammonia	Assigned year
BS	0.07	0.02	0.063	1.61	―	2011
BU	3.96	0.07	0.358	20.27	0.990	2014
CA	19.65	0.07	1.433	35.66	0.670	2014
BD	29.82	0.05	2.191	64.30	―	2011

(7) Quality control

a. Precision of nutrients analyses during the cruise

Precision of nutrients analyses during this cruise was evaluated based on the 6 to 8 measurements, which are measured every 9 to 14 samples, during a run at the concentration of C-4 std. Summary of precisions are shown as shown in Table 4.2.5 and Figures 4.2.8 to 4.2.12, Analytical precisions previously evaluated were 0.08 % for nitrate, 0.10 % for phosphate and 0.07 % for silicate in CLIVAR P21 revisited cruise of MR09-01 cruise in 2009, respectively. During in this cruise, analytical precisions were 0.07% for nitrate, 0.14% for nitrite, 0.13% for phosphate, 0.11% for silicate and 0.17% for ammonia in terms of median of precision, respectively. Then we can conclude that the analytical precisions for nitrate, nitrite, phosphate and silicate were maintained throughout this cruise. The time series of precision are shown in Figures 4.2.8 to 4.2.12.

Table 4.2-5: Summary of precision based on the replicate analyses.

	Nitrate	Nitrite	Phosphate	Silicate	Ammonia
	CV %	CV %	CV %	CV %	CV%
Median	0.07	0.14	0.13	0.11	0.17
Mean	0.08	0.14	0.14	0.11	0.19
Maximum	0.17	0.26	0.27	0.22	0.39
Minimum	0.03	0.05	0.02	0.03	0.06
N	50	50	50	50	50

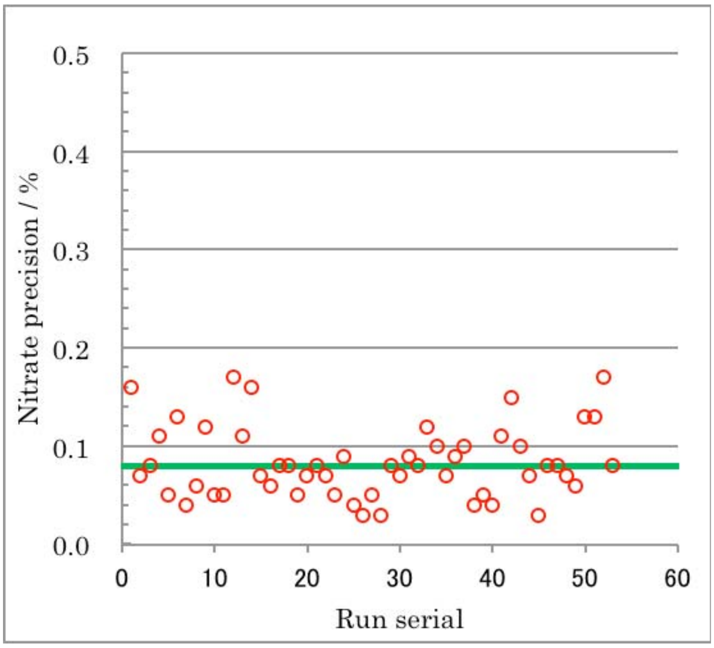


Figure 4.2-8: Time series of precision of nitrate for MR14-05.

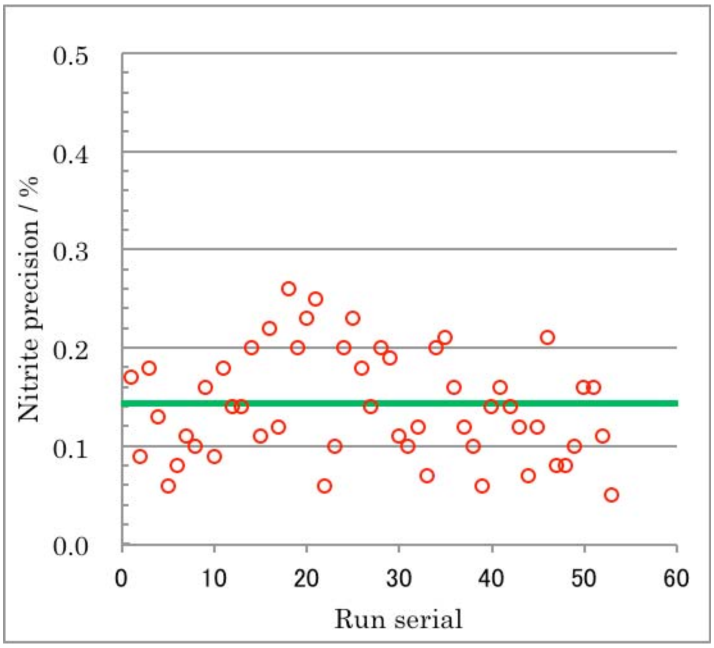


Figure 4.2-9: Time series of precision of nitrite for MR14-05.

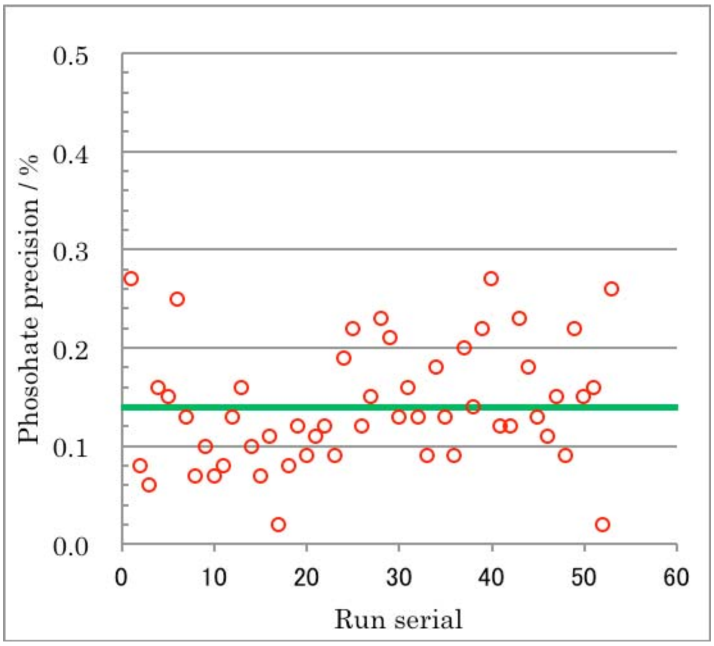


Figure 4.2-10: Time series of precision of phosphate for MR14-05.

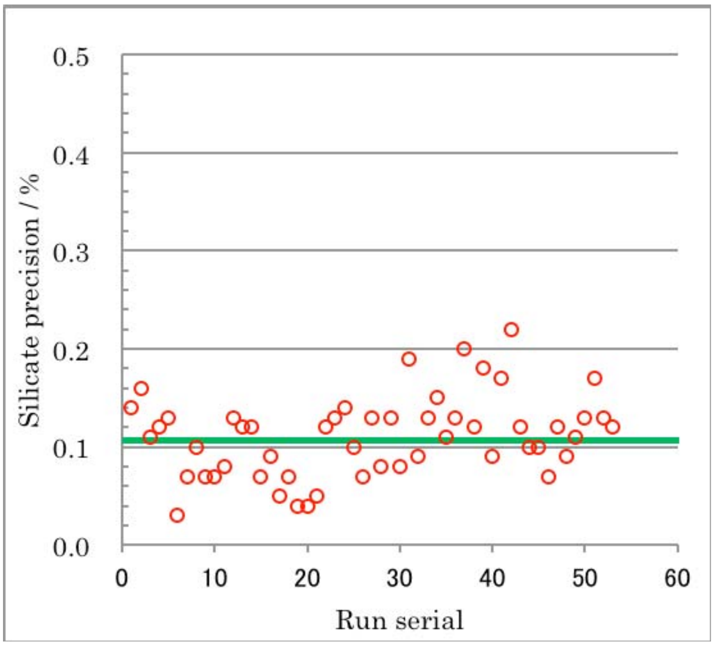


Figure 4.2-11: Time series of precision of silicate for MR14-05.

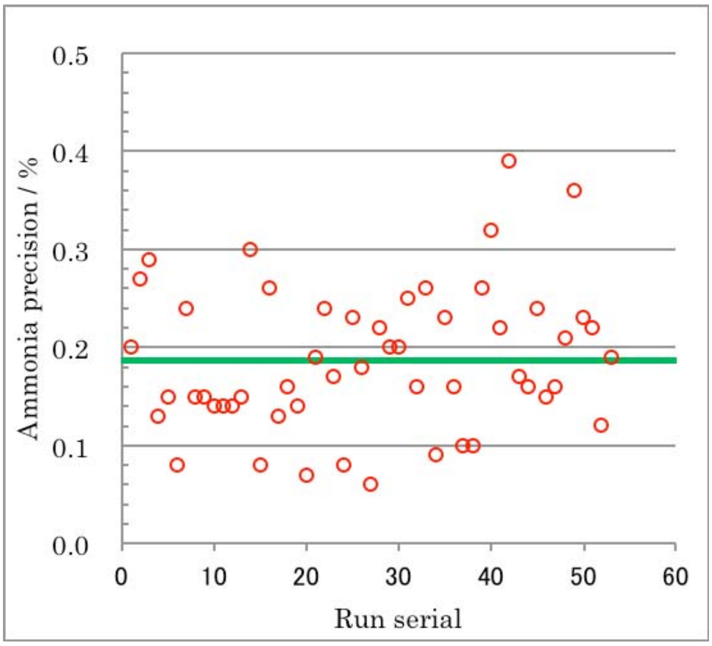


Figure 4.2-12: Time series of precision of ammonia for MR14-05.

b. Results of RMNS mesurements

We measured RMNSs in every run during this cruise. The control chart of RM-BD are shown in Figures 4.2.13 to 4.2.17.

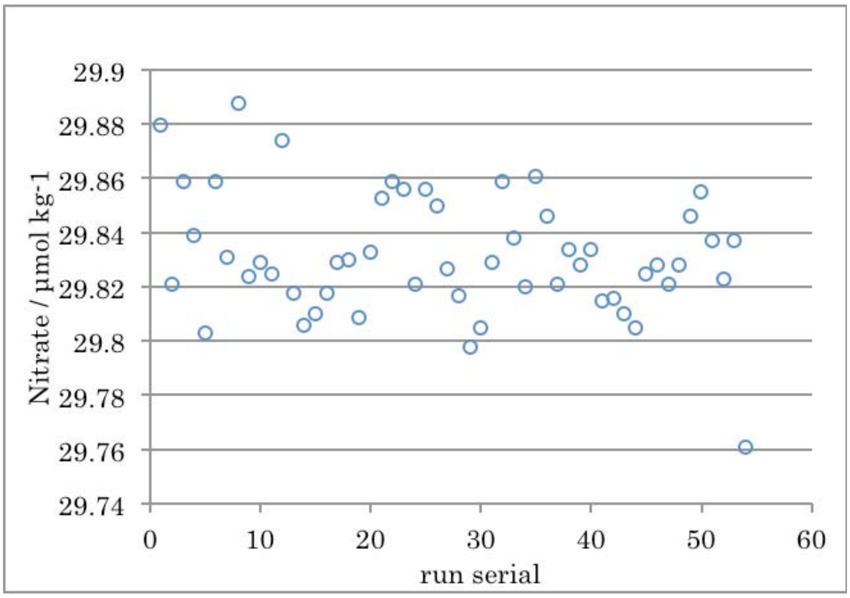


Figure 4.2-13: Summary of nitrate concentration of RM-BD.

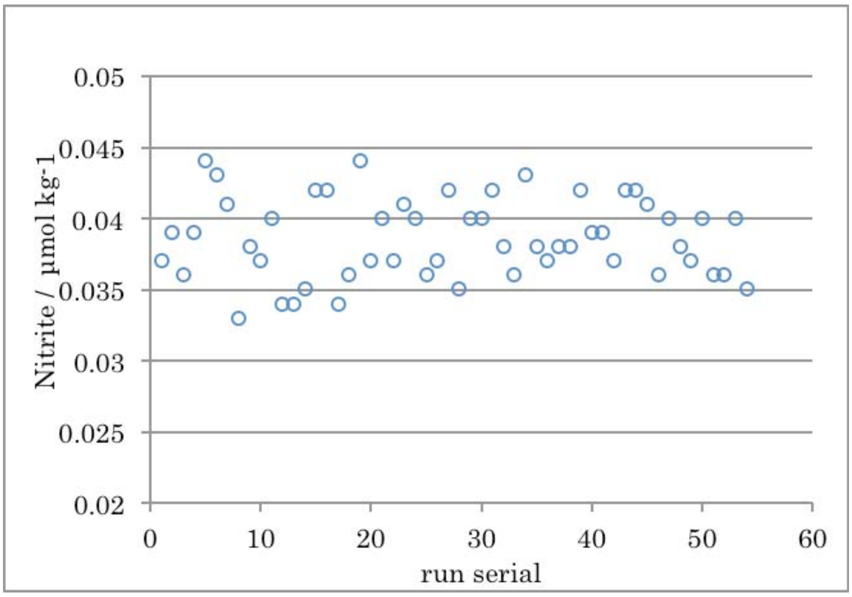


Figure 4.2-14: Summary of nitrite concentration of RM-BD.

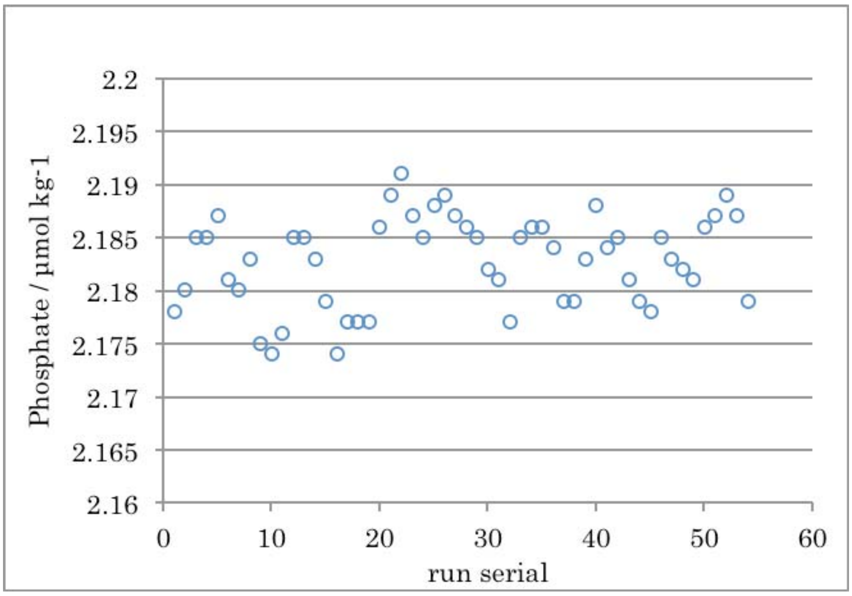


Figure 4.2-15: Summary of phosphate concentration of RM-BD.

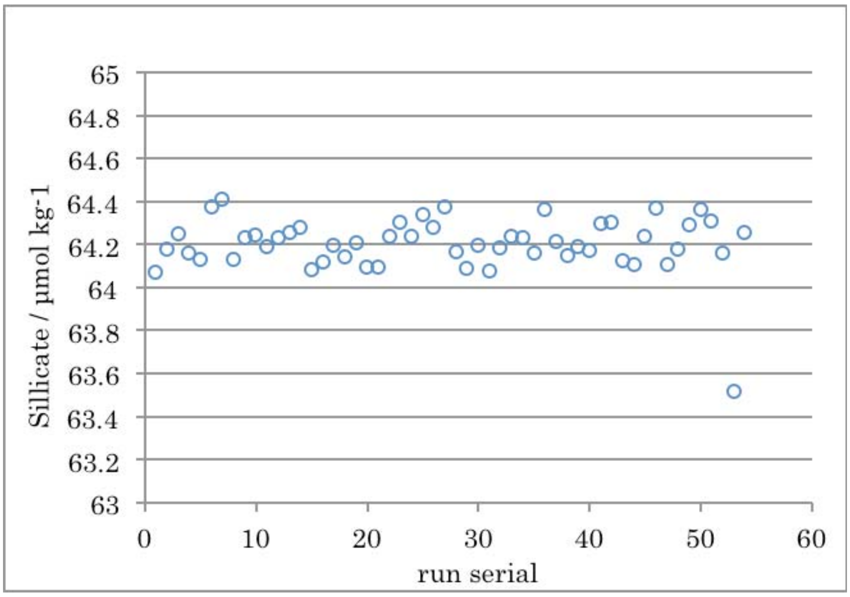


Figure 4.2-16: Summary of silicate concentration of RM-BD.

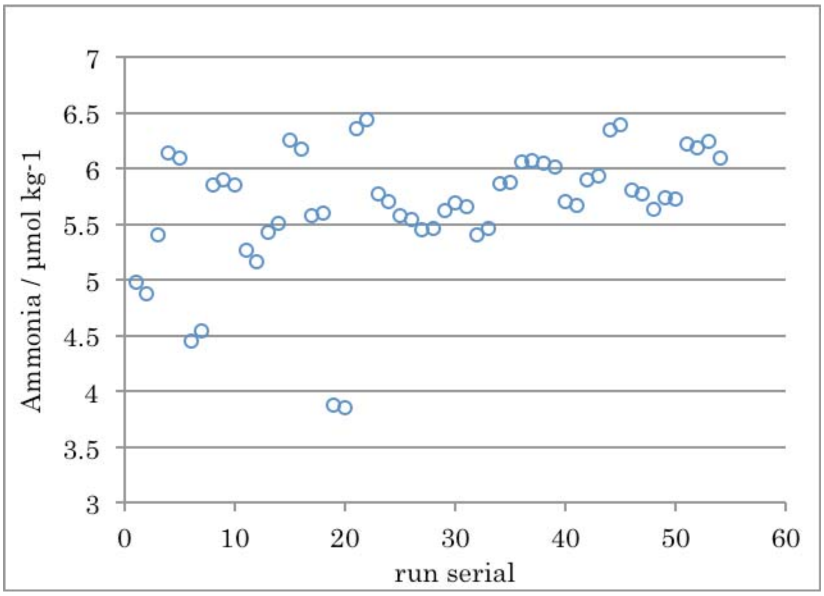


Figure 4.2-17: Summary of ammonia concentration of RM-BD.

c. Carry over

We can also summarize the magnitudes of carry over throughout the cruise. These are small enough within acceptable levels as shown in Table 4.2.6.

Table 4.2.6: Summary of carry over throughout MR14-05.

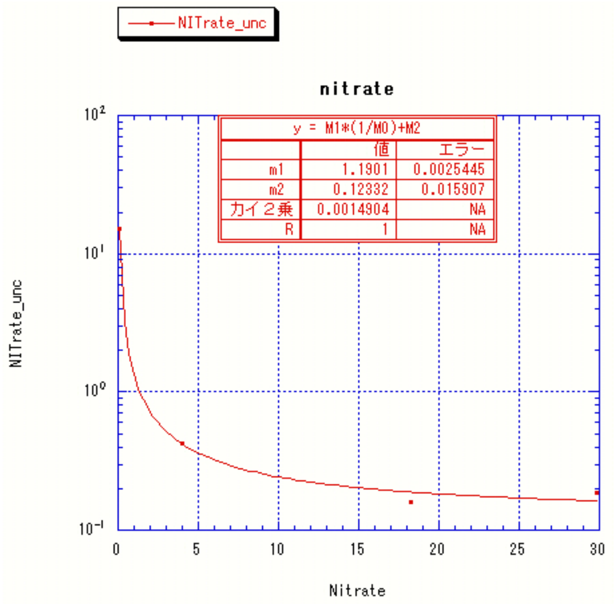
	Nitrate %	Nitrite %	Phosphate %	Silicate %	Ammonia %
Median	0.24	0.13	0.19	0.34	0.69
Mean	0.24	0.15	0.19	0.33	0.67
Maximum	0.30	0.62	0.28	0.51	1.02
Minimum	0.19	0.00	0.12	0.13	0.42
N	50	50	50	50	50

d　Concentration dependent uncertainty

We can evaluate concentration dependent uncertainty based on repeat RMNS measurements.

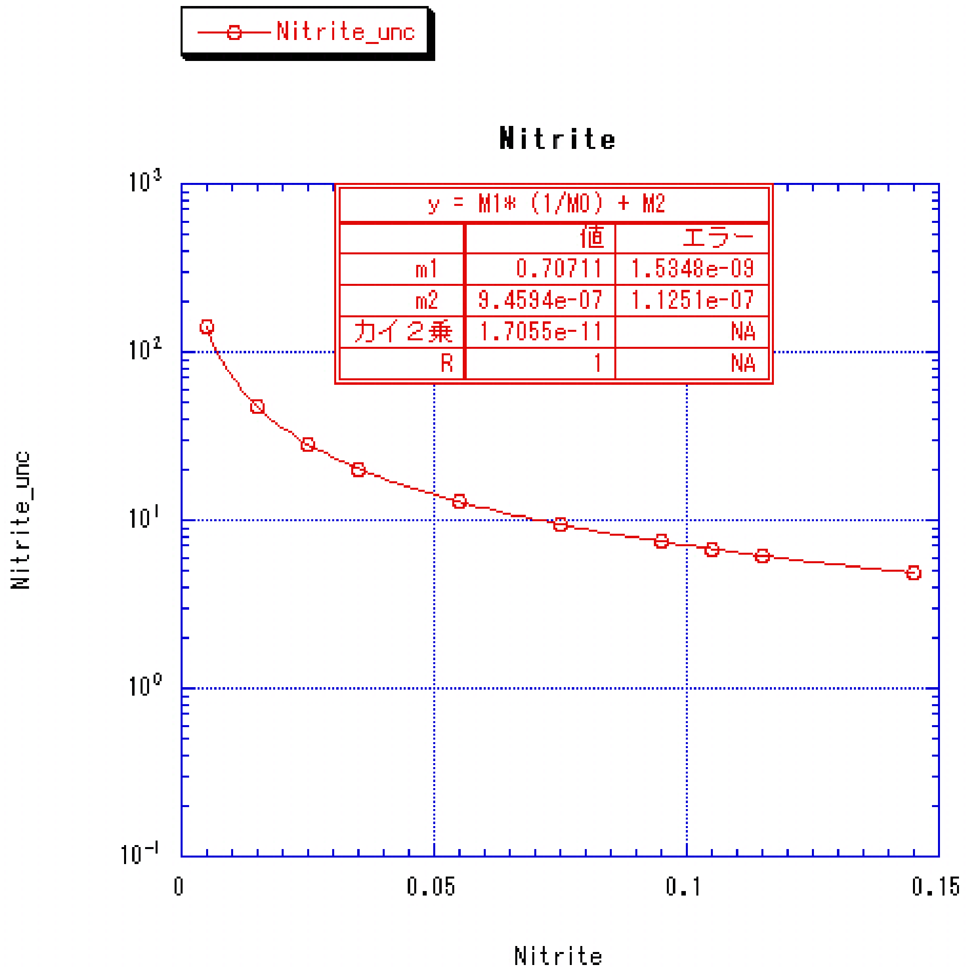
For Nitrate, uncertainty in terms of % is expressed by eq. （1）

$$Unc\ (\%) = 0.113 + 1.055 / C_{no3} \qquad (1)$$



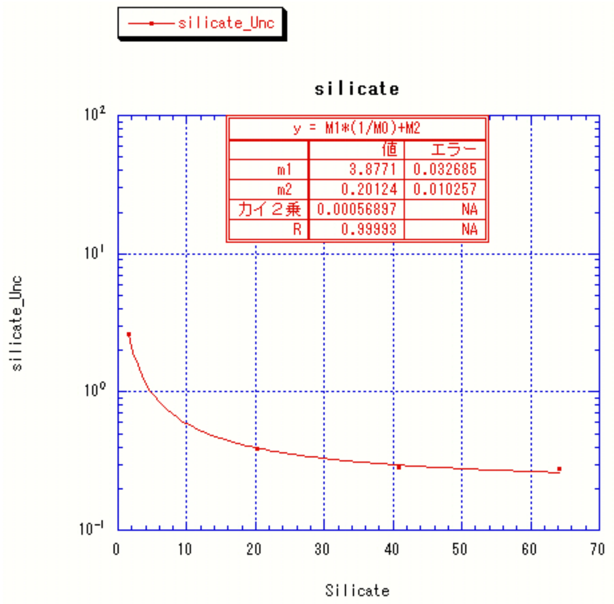
For nitrite, uncertainty in terms of % is expressed by eq. (2)

Unc (%) = 4.426 + 0.20265 / C_{no2} (2)



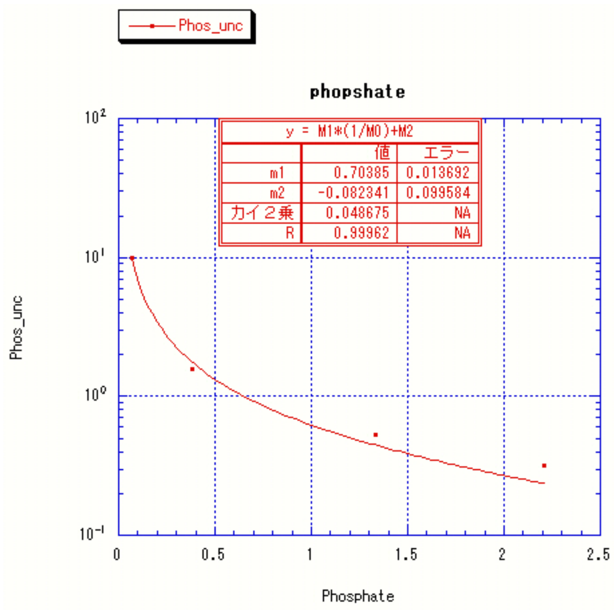
For silicate, uncertainty in terms of % is expressed by eq. (3)

Unc (%) = 0.15 + 5.162 / C_{sil} (3)



For phosphate, uncertainty in terms of % is expressed by eq. (4)

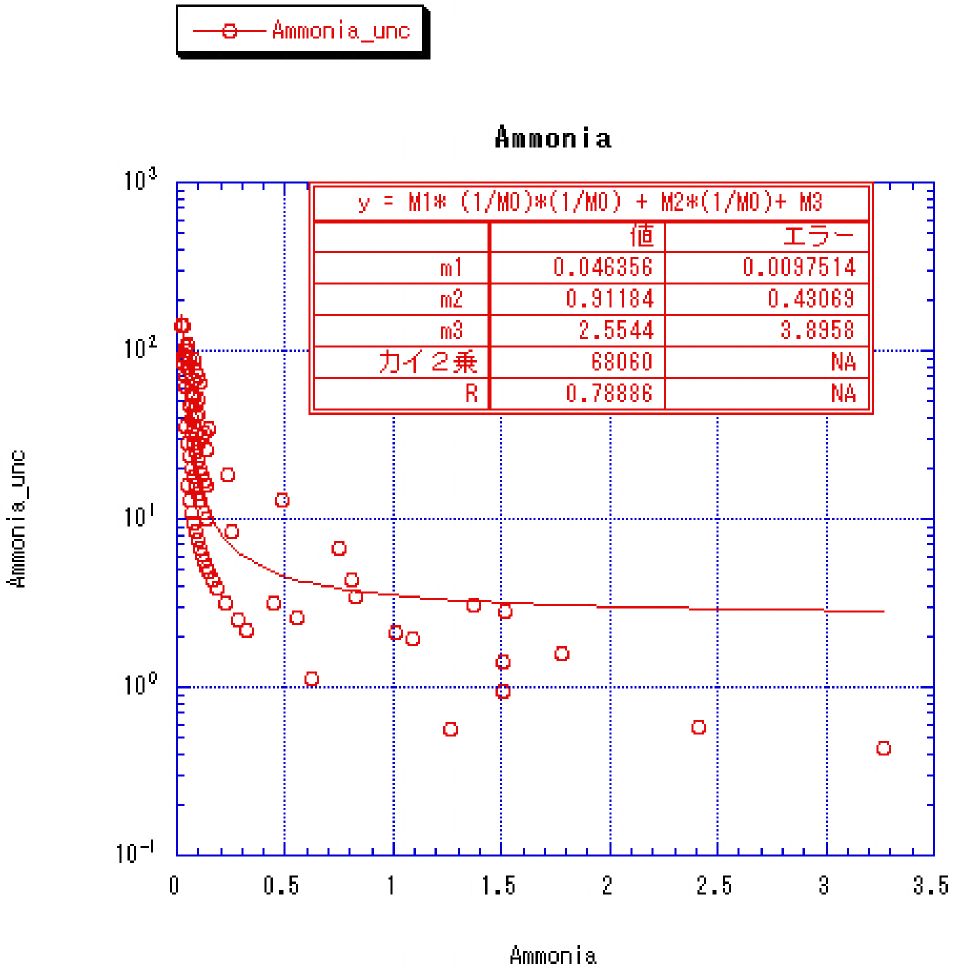
Unc (%) = 0.0145 + 0.518 / C_{po4} (4)



We can also evaluate concentration dependent uncertainty for ammonia based on duplicate measurements of the samples.

For ammonia, uncertainty in terms of % is expressed by eq. (5)

Unc (%) = 1.8485+ 1.7755 / C_{NH4} - 0.01445/C_{NH4}/C_{NH4} (5)



For ammonia, uncertainty in terms of % is expressed by eq. (4)

$$\text{Unc (\%)} = a + b / C_{sil} \quad (4)$$

(8) Problems/improvements occurred and solutions.

During this cruse, we observed noisy signals in 2ch output of QuAAtro 2-HR systems. Then, It corresponded by exchanging the pump tube of 2ch. But, it was nearly a half of the enduring time of a tube.

(9) Station list

The sampling station list for nutrients is shown in Table 4.2.7.

Table 4.2.7: List of stations

Station	Cast	Latitude	Longitude
1	1	65.7706	191.2076
2	1	66.9994	191.1662
3	1	67.9997	191.1657
4	1	73.3297	198.0007
5	1	74	195.9922
6	1	74.377	197.004
7	1	75.124	199.0098
8	1	74.3744	199.0021
9	2	74.7539	198.0003
9	4	74.752	197.9826
9	6	74.7577	198.0071
9	8	74.7492	198.0002
9	10	74.7521	198.0142
9	12	74.7511	198.0061
9	14	74.7604	197.9792
9	16	74.7554	198.0084
9	18	74.7535	198.0041
9	20	74.754	197.999
9	22	74.7466	197.9966
9	24	74.7541	197.9858
9	26	74.7501	197.9813
9	28	74.7535	197.9684
9	30	74.7462	197.9923
9	32	74.7524	197.9885
9	34	74.7519	197.9847
9	36	74.7526	197.9802
9	38	74.7498	198.0095
9	40	74.7505	198.0096
9	42	74.7489	98.0052

9	44	74.7468	197.9955
9	46	74.7478	198.0044
9	48	74.7491	197.9722
10	1	74.701	197.8673
9	50	74.7488	197.9872
9	52	74.7482	197.9729
9	54	74.7515	197.996
11	1	74.8194	198.1621
9	56	74.7515	197.9934
9	58	74.7505	197.9873
9	60	74.7505	197.9873
9	62	74.7485	198.0159
9	64	74.7535	197.9907
9	66	74.7511	198.0098
9	68	74.7495	198.0069
9	70	74.7479	198.0013
9	72	74.7505	198.0014
9	74	74.7523	198.0169
6	2	74.3749	196.9901
5	2	73.9997	195.9979
12	1	73.5001	193.0011
13	1	72.7501	191.7523
13	2	72.7495	191.7531
13	3	72.7481	191.7533
13	4	72.7519	191.7567
14	1	72.0834	191.1664
15	1	71.0005	191.167
16	1	70.0011	191.1777
17	1	69.002	191.168
3	2	67.9996	191.165
1	2	65.7748	191.2149

(10) Data archive

These data obtained in this cruise will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC home page.

(11) Acknowledgment

We would like to express our sincere thanks to Dr. Michio Aoyama in University of Fukushima, who largely contributed to the quality control of the data with valuable suggestions from his laboratory.

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4.3. Dissolved Inorganic Carbon

4.3.1. Bottled-water analysis

(1) Personnel

Shigeto Nishino	JAMSTEC	- PI
Atsushi Ono	MWJ	
Makoto Takada	MWJ	

(2) Objective

The Arctic Ocean has a characteristic that Dissolved Inorganic Carbon (DIC) concentrations are low because of the influence of inflow of the large amount of river water, dilution by sea-ice melt water and high biological productivity. Recently, the undersaturation of the calcium carbonate and a change of pCO_2 have been observed in the Arctic Ocean. It is considered that the change of seawater pH and a decrease in the saturation state of calcium carbonate affect a growth of the species that form shells of calcium carbonate. Therefore, quantitative understanding of the cause of these changes is necessary for better assessments and future predictions. The percentage saturation of seawater with respect to calcium carbonate can be computed from DIC and Total Alkalinity (TA; ref. Section 4.4). Accordingly, we measured DIC on-board during the MR14-05 cruise.

(3) Parameters

Dissolved Inorganic Carbon (DIC)

(4) Instruments and Methods

I. Seawater sampling

Seawater samples were collected by 12 L Niskin bottles and a bucket at 17 stations (total 1,180 samples). Seawater was transported into a 300 mL glass bottle (SCHOTT DURAN) which was previously soaked in 5% non-phosphoric acid detergent (pH13) solution at least 3 hours, and rinsed with fresh water for 5 times and Milli-Q deionized water for 3 times. A sampling tube was connected to the Niskin bottle when the sampling was conducted. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 20 seconds. They were sealed using the 29 mm polyethylene inner lids with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the sampling bottles were moved to the laboratory. Prior to the analysis, 3 mL of the samples (1% of the bottle volume) was removed from the glass bottles to make a headspace. The samples were then poisoned with 100 μL of over saturated solution of mercury chloride within one hour after samplings. The samples were sealed with 31.9 mm polyethylene inner lids and stored in a refrigerator at approximately 5 ˚C until the analysis.

II. Seawater analysis

Measurements of DIC were made with total CO_2 measuring system (System D; Nippon ANS, Inc.). The system comprises of seawater dispensing system, a CO_2 extraction system and a coulometer (Model 3000, Nippon ANS, Inc.).

The seawater dispensing system has an auto-sampler (6 ports), which takes seawater from a glass bottle to a pipette of nominal 15 mL volume by PC control. The pipette was kept at 20 ± 0.05 ˚C by a water jacket, in which water is circulated from a thermostatic water bath (RTE10, Thermo) set at 20 ˚C.

The CO_2 dissolved in a seawater sample is extracted in a stripping chamber of the CO_2 extraction system by phosphoric acid (10% v/v). The stripping chamber is made approximately 25 cm long and has a fine frit at the bottom. A constant volume of acid is added to the stripping chamber from its bottom by pressurizing an acid bottle with nitrogen gas (99.9999%). A seawater sample kept in a constant volume pipette is introduced to the stripping chamber by the same method. Nitrogen gas is bubbled through a fine frit at the bottom of the stripping chamber to make the reaction well. The stripped CO_2 is carried by the nitrogen gas (flow rate of 140 mL min^{-1}) to the coulometer through a dehydrating module consists of two electronic dehumidifiers (kept at 2 ˚C) and a chemical desiccant ($Mg(ClO_4)_2$).

Measurements of 1.5% CO_2 standard gas in a nitrogen base, system blank (phosphoric acid blank) and seawater samples (6 samples) were programmed to repeat. The variation of our own-made JAMSTEC DIC reference material or 1.5% CO_2 standard gas signal was used to correct the signal drift results from chemical alternation of coulometer solution.

(5) Observation log

The sampling stations for DIC were shown in Fig. 4.3-1-1.

(5) Preliminary results

During the cruise, 1180 samples were analyzed for DIC. A few replicate samples were taken at most of the stations and difference between each pair of analyses was plotted on a range control chart (Fig. 4.3-1-2). The average of the differences was 0.95 μmol kg^{-1} (n = 131), and the standard deviation was 1.00 μmol kg^{-1} (n = 131), which indicate the analysis was accurate enough according to the Guide to the best practices for ocean CO_2 measurements (Dickson et al., 2007).

(6) Data archives

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

(7) References

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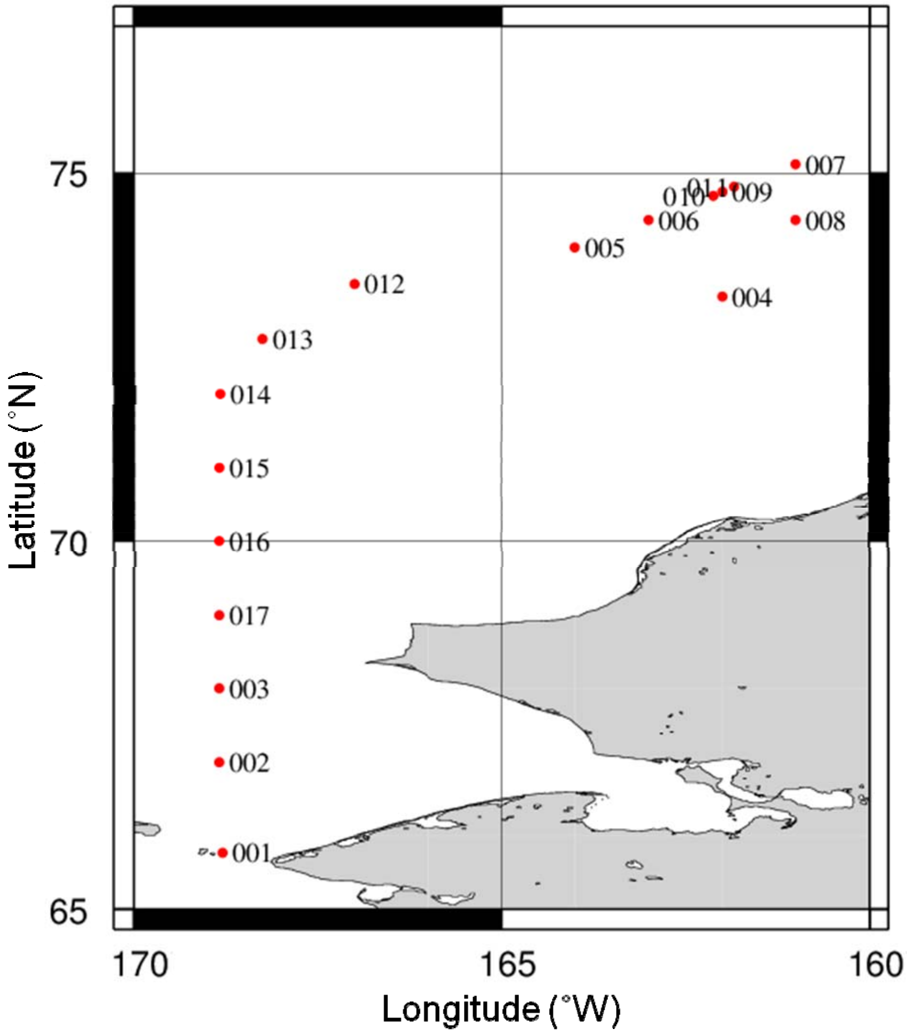

Figure 4.3-1-: DIC sampling stations in the Arctic Ocean in 2014.

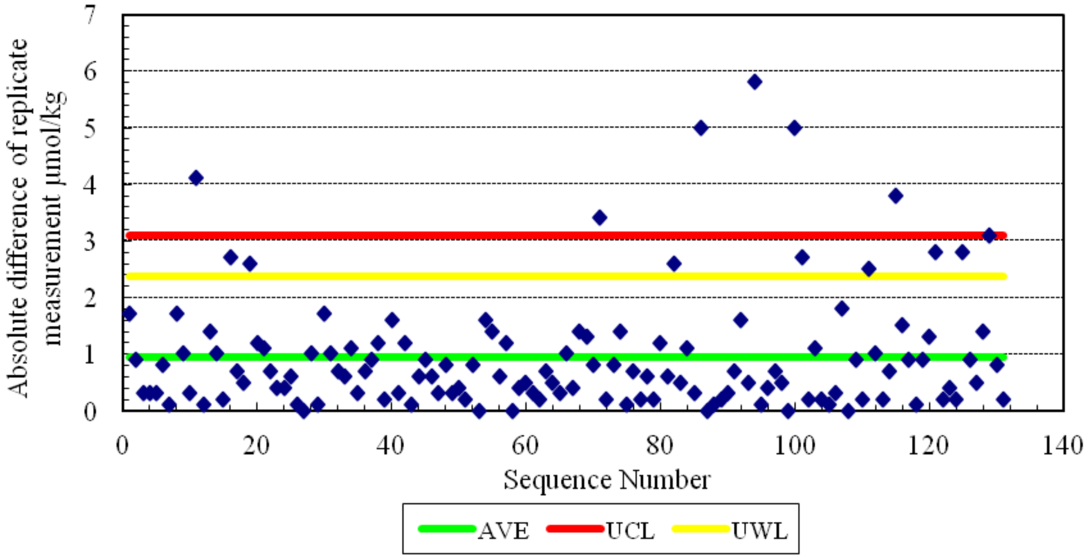

Figure 4.3-1-2: Range control chart of the absolute differences of replicate measurements carried out in the analysis of DIC during the MR14-05. UCL and UWL represent the upper control limit (Average × 3.267) and upper warning limit (Average × 2.512), respectively.

4.3.2. Underway TDIC

(1) Personnel

Shuji Aoki	Tohoku University	- PI
Masao Ishii	Meteorological Research Institute / JMA	
Daisuke Sasano	Meteorological Research Institute / JMA	
Naohiro Kosugi	Meteorological Research Institute / JMA	
Hiroshi Uchida	JAMSTEC	

(2) Objective

CO_2 in the atmosphere is increasing at nearly 2 ppm/year owing to human activities such as burning of fossil fuels, deforestation, and cement production. The ocean plays an important role in buffering the increase of atmospheric CO_2. On the other hand, accumulation of surplus CO_2 alters budgets of ions and decreases saturation state of calcium carbonate ($CaCO_3$) in seawater. This phenomenon called "Ocean acidification" may be harmful to some creatures which have Skelton or shell made of $CaCO_3$. Furthermore, not only accumulation of CO_2 but also the dilutions of seawater by the increase of sea ice meltwater will reduce the saturation state of $CaCO_3$ in the Arctic Ocean. Comprehensive carbonate measurement is needed for better understanding of ocean acidification.

As for oceanic carbonate system, in case that two of 4 primary parameters (pCO_2, DIC, TA, and pH) were determined, we can calculate the others and additional parameters such as the saturation state of $CaCO_3$ and buffer factor (Revelle factor). Hence, underway DIC measurements were conducted to calculate other carbonate parameters in combination with continuous measurements of pCO_2 (see section 4.11.1)

(3) Parameter

Total Dissolved Inorganic Carbon (DIC)

(4) Instruments and Methods

Surface seawater was taken from an intake placed at the approximately 4.5 m below the sea surface by a pump, and was filled in a 300 ml glass bottle (SCHOTT DURAN). The glass bottles were filled from the bottom, without rinsing, and were overflowed for more than 2 times the amount. Before the analysis, the samples were put in an isothermal bath (BH201, Yamato) to keep them about 20 deg C for more than one hour.

Measurements of DIC were made with total CO_2 measuring system (Nippon ANS, Inc.). The system was comprised of seawater dispensing unit, a CO_2 extraction unit, and a coulometer (Model 3000, Nippon ANS, Inc.) The seawater dispensing unit had an auto-sampler (6 ports), which dispenses the seawater from a glass bottle to a pipette of nominal 15 ml volume. The pipette was kept at 20 ± 0.05 deg C by a water jacket by water circulation from the isothermal bath.

Dissolved CO_2 in seawater was extracted in a stripping chamber of the CO_2 extraction unit by adding phosphoric acid (10 % v/v). The stripping chamber was made approx. 25 cm long and has a fine frit at the bottom. First, the certain amount (~2 ml) of acid was taken to the constant volume tube from an acid bottle and transferred to the stripping chamber from its bottom by nitrogen gas (99.9999 %). Second, a seawater sample kept in a pipette was introduced to the stripping chamber by the same method as that for an acid. The seawater and phosphoric acid were stirred by the nitrogen bubbles through a fine frit at the bottom of the stripping chamber. The stripped CO_2 was carried to the coulometer through two electric dehumidifiers (kept at 2-10 deg C) and a chemical desiccant ($Mg(ClO_4)_2$) by the nitrogen gas at 140 ml/min flow rate.

(5) Observation log

The underway measurements were conducted from September 2nd (UTC) to October 6th (UTC).

(6) Results

During the cruise, 32 bottles of CRM (Scripps Institute of Oceanography; Batch 121 and 133) were measured in order to check a stability of the system and to determine the calibration factor. Average and standard deviations of the difference between certified and measured of 32 bottles were -0.25 μmol/kg and 1.93 μmol/kg respectively. Figure 4.3.2.1 shows the variation of surface DIC at the fixed point (CTD Station 09) from September 6th to September 25th. Figure 4.3.2.2 shows the spatial distribution of surface DIC in the Arctic Ocean, the Bering Sea and North Pacific after September 25th.

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC home page.

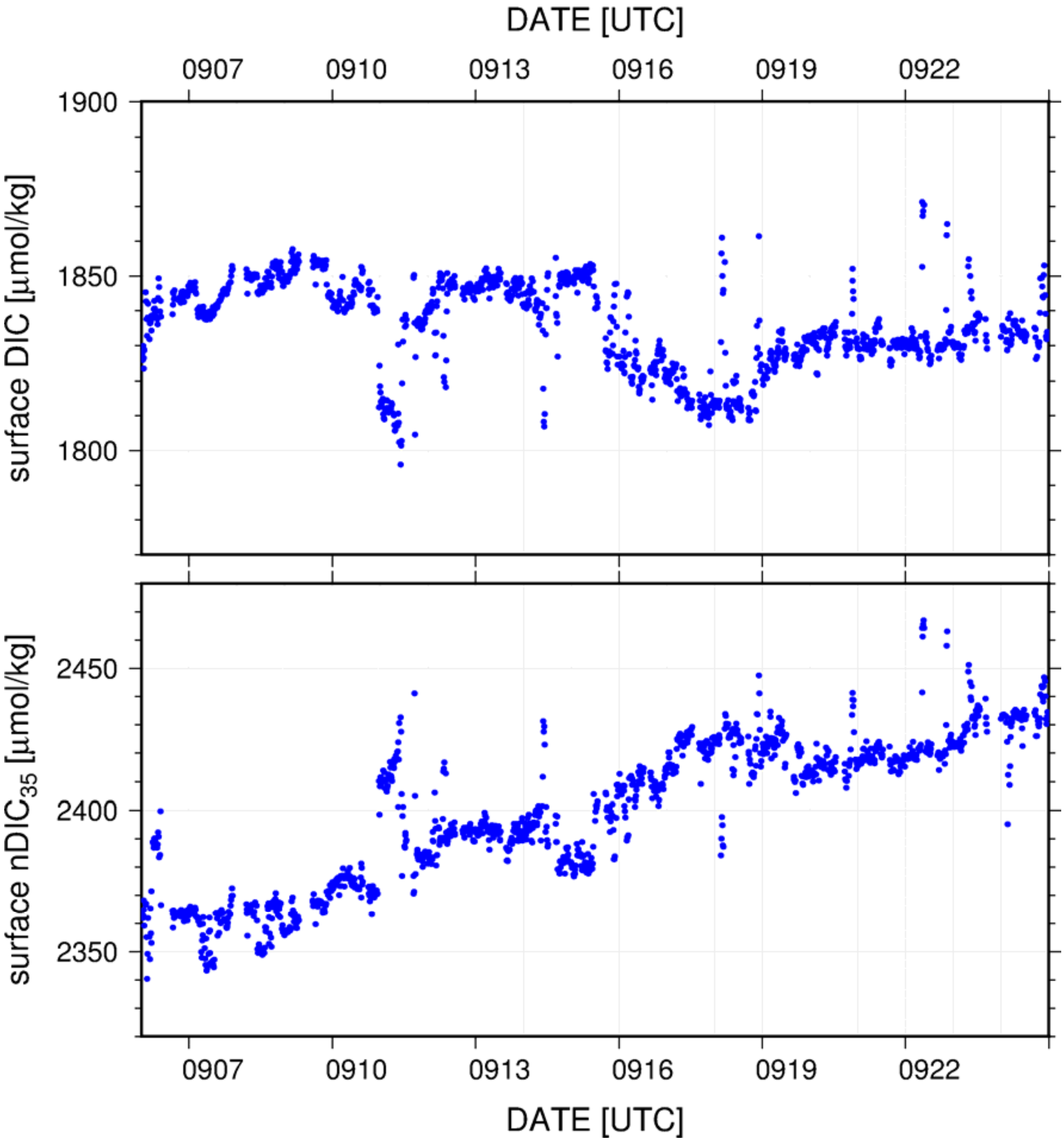

Figure 4.3.2-1: Variation of surface DIC and surface $nDIC_{35}$ (e.g. DIC normalized to salinity 35; $nDIC_{35}$ = DIC / salinity *35) at the fixed point.

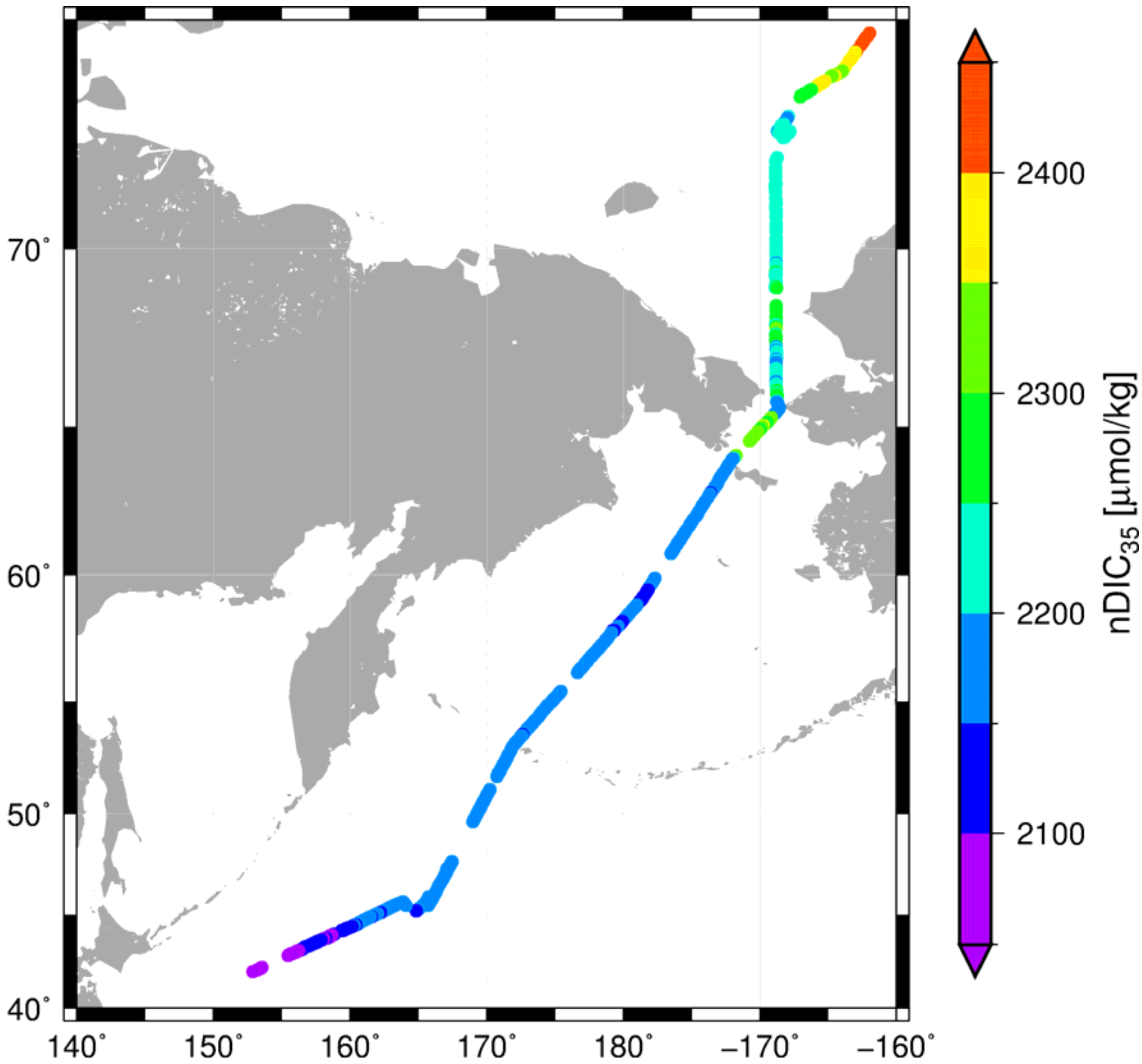

Figure 4.3.2-2: Surface $nDIC_{35}$ along cruise track after September 25th.

4.4. Total Alkalinity

(1) Personnel

Shigeto Nishino	JAMSTEC	- PI
Emi Deguchi	MWJ	
Kenichiro Sato	MWJ	

(2) Objective

As described in the Section 4.3. (DIC), total Alkalinity (TA) is an essential parameter in carbonate system in the ocean. We have measured TA during the MR14-05 cruise to estimate pH, calcium carbonate saturation state and pCO_2. Furthermore, TA is a useful tracer for river water in the Arctic Ocean: TA is high in river runoff (especially in North American rivers) and low in sea ice meltwater. Because river water carries freshwater, carbon, nutrients, contaminants etc., changes in distribution of river water in the Arctic Ocean may affect regional and global climate, productivity and human health. Distribution of river water in the Chukchi Sea/Canada Basin region during the MR14-05 cruise will be estimated from TA and results will be compared with those observed in previous years.

(3) Parameters

Total Alkalinity, TA

(4) Instruments and Methods

(4)-1 Seawater sampling

Seawater samples were collected at 17 stations / 59 casts in 12 L Niskin bottles mounted on the CTD-carousel system. A sampling silicone rubber with PFA tip was connected to the Niskin bottle when the sampling was carried out. The 125 ml borosilicate glass bottles (SHOTT DURAN) were filled from the bottom smoothly, without rinsing, and were overflowed for 2 times bottle volume (10 seconds) with care not to leave any bubbles in the bottle. These bottles were pre-washed by soaking in 5 % non-phosphoric acid detergent (pH = 13) for more than 3 hours and then rinsed 5 times with tap water and 3 times with Milli-Q deionized water. After collecting the samples on the deck, the bottles were carried into the lab and stored in the refrigerator until the measurement. The samples were put in the water bath kept about 25° C for one hour before the measurement.

(4)-2 Seawater analysis

Measurement of alkalinity was made using a spectrophotometric system (Nippon ANS, Inc.) using a scheme of Yao and Byrne (1998). The sampled seawater in the glass bottle is transferred to a sample cell via dispensing unit, and its temperature is kept at 25° C in a thermostatic compartment. The TA is calculated by measuring two sets of absorbance at three wavelengths (730, 616 and 444 nm) applied by the spectrometer (TM-UV/VIS C10082CAH, HAMAMATSU). One is the absorbance of seawater sample before injecting an acid with indicator solution (bromocresol green) and another is the one after the injection. For mixing the acid with indicator solution and the seawater sufficiently, they are circulated through the line by a peristaltic pump 9 minutes before the measurement.

The TA is calculated based on the following equation:

$$pH_T = 4.2699 + 0.002578 \times (35 - S) + \log ((R(25) - 0.00131) / (2.3148 - 0.1299 \times R(25))) - \log (1 - 0.001005 \times S), \quad (1)$$

$$A_T = (N_A \times V_A - 10^{pH_T} \times DensSW (T, S) \times (V_S + V_A)) \times (DensSW (T, S) \times V_S)^{-1}, \quad (2)$$

where R(25) represents the difference of absorbance at 616 and 444 nm between before and after the injection. The absorbance of wavelength at 730 nm is used to subtract the variation of absorbance caused by the system. DensSW (T, S) is the density of seawater at temperature (T) and salinity (S), N_A the concentration of the added acid, V_A and V_S the volume of added acid and seawater, respectively.

To keep the high analysis precision, some treatments were carried out during the cruise. The acid with indicator solution stored in 1 L DURAN bottle is kept in room temperature, and about 10 mL of it is discarded at first before the batch of measurement. Furthermore, we injected the acid so that pH_T of a sample might become the range of 3.6 to 4.6 values. For mixing the seawater and the acid with indicator solution sufficiently, TYGON tube used on the peristaltic pump was periodically renewed. Absorbance measurements were done 5 times during each analysis, and each five values are averaged and used for above listed calculation for before and after the injection, respectively.

(5) Station list or Observation log

Seawater samples were collected at 17 stations / 59 casts (Figure 4.4-1).

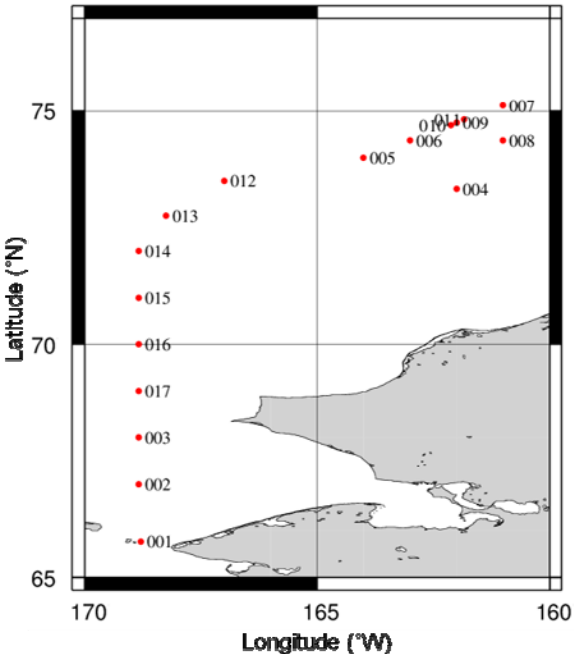

Figure 4.4-1: Map of sampling station.

(6) Preliminary results

The repeatability of this system was 2.92μmol kg^{-1} (n = 53) which was estimated from standard deviation of measured CRM value during this cruise. At each station, samples were taken in duplicate for waters of the following table 4.4-1. The difference between each pair of analyses was plotted on a range control chart (Figure 4.4-2). The average of the difference was 2.54 μmol kg^{-1} (n = 129 pair) with its standard deviation of 2.37 μmol kg^{-1}, which indicates that the analysis was accurate enough according to Guide to best practices for ocean CO_2 measurements (Dickson et al., 2007).

Table 4.4-1: The layer taken in duplicate for waters.

Bottom depth	Duplicate layer
< 100 m	10 m, Bottom
100 - 400 m	50 m, 100 m, Bottom
> 400 m	100 m, 400 m, Bottom

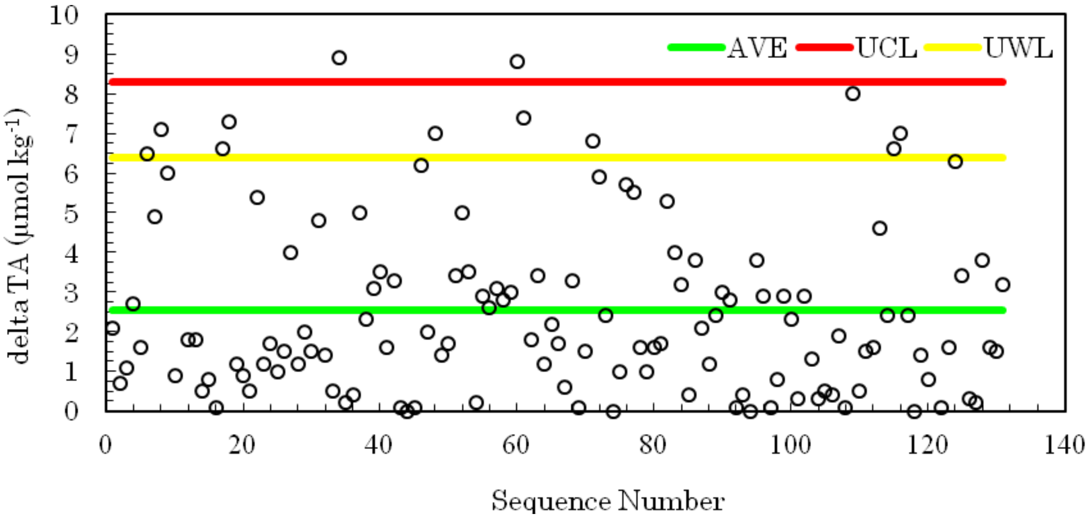

Figure 4.4-2: Range control chart of the absolute differences of duplicate measurements of TA carried out during this cruise.

(7) Data Archives

All data will be submitted to Data Management Group (DMG) in JAMSTEC and is currently under its control.

(8) References

Yao, W. and Byrne, R. H. (1998), Simplified seawater alkalinity analysis: Use of linear array spectrometers. *Deep-Sea Research Part I, Vol. 45,* 1383-1392.

Dickson, A. G., Sabine, C. L. & Christian, J. R. (2007), Guide to best practices for ocean CO2 measurements; PICES Special Publication 3, 199

4.5. Stable isotopes of water (δ18O and □D)

(1) Personnel

Hiroshi Uchida	JAMSTEC	- PI
Shigeto Nishino	JAMSTEC	

(2) Objectives

Oxygen isotope ratio ($\delta^{18}O$) and hydrogen isotope ratio (δD) of seawater is a tracer to distinguish the source of freshwater between sea ice meltwater and meteoric water (river runoff and precipitation). We have collected seawater samples for $\delta^{18}O$ and δD analysis during the cruise. Results will be compared with previous observations ($\delta^{18}O$) observed during cruises of R/V Mirai in 2002, 2008, 2009, and 2010 in order to detect on-going changes in freshwater distributions in the Arctic Ocean under the recent conditions of warming and attendant increase in sea ice melt. Furthermore, a combination of $\delta^{18}O$ with total alkalinity (Section 4.4) may provide additional information about the distribution of North American river runoff because, although American and Eurasian rivers have identical oxygen isotope ratios, the total alkalinity of American river water is higher than that of Eurasian river water.

(3) Parameter

Oxygen isotope ratio ($\delta^{18}O$) and hydrogen isotope ratio (δD)

(4) Instruments and methods

Seawater samples were collected in 12L Niskin bottles mounted on the CTD-rosette system and then transferred into 10 ml glass vials for $\delta^{18}O$ and δD analysis. Samples are stored in room temperature and will be analyzed at JAMSTEC after the cruise. Results will be reported as a permil deviation of stable isotope ratio of water from that of Vienna Standard Mean Ocean Water (VSMOW):

$$\delta^{18}O\ [‰] = 1000\ \{(^{18}O/^{16}O)_{sample}/(^{18}O/^{16}O)_{VSMOW} - 1\}.$$

$$\delta D\ [‰] = 1000\ \{(D/H)_{sample}/(D/H)_{VSMOW} - 1\}$$

(5) Observation log

The sampling list is summarized in Table 4.5-1.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole

Cruise Information in JAMSTEC" in JAMSTEC web site.

Table 4.5-1: Sampling list for $\delta^{18}O$ and δD

On board ID	Sampling Method	Date Collected YYYY	MM	DD	hh:mm	Latitude Deg.	Min.	N/S	Longitude Deg.	Min.	E/W	Depth [m]
MR14-05_St001_O18_#0248-W001	Bucket	2014	09	03	5:56	65	46.33	N	168	47.64	W	0
MR14-05_St001_O18_#0249-W002	Bucket	2014	09	03	5:56	65	46.33	N	168	47.64	W	0
MR14-05_St001_O18_#0250-W003	Niskin#25	2014	09	03	5:56	65	46.33	N	168	47.64	W	Chl-aMax
MR14-05_St001_O18_#0251-W004	Niskin#23	2014	09	03	5:56	65	46.33	N	168	47.64	W	5
MR14-05_St001_O18_#0252-W005	Niskin#22	2014	09	03	5:56	65	46.33	N	168	47.64	W	10
MR14-05_St001_O18_#0253-W006	Niskin#21	2014	09	03	5:56	65	46.33	N	168	47.64	W	20
MR14-05_St001_O18_#0254-W007	Niskin#20	2014	09	03	5:56	65	46.33	N	168	47.64	W	30
MR14-05_St001_O18_#0255-W008	Niskin#19	2014	09	03	5:56	65	46.33	N	168	47.64	W	40
MR14-05_St001_O18_#0256-W009	Niskin#18	2014	09	03	5:56	65	46.33	N	168	47.64	W	Not sampled
MR14-05_St001_O18_#0257-W010	Niskin#02	2014	09	03	5:56	65	46.33	N	168	47.64	W	B-10
MR14-05_St002_O18_#0258-W011	Bucket	2014	09	03	13:12	67	0	N	168	50	W	0
MR14-05_St002_O18_#0259-W012	Bucket	2014	09	03	13:12	67	0	N	168	50	W	0
MR14-05_St002_O18_#0260-W013	Niskin#25	2014	09	03	13:12	67	0	N	168	50	W	Chl-aMax
MR14-05_St002_O18_#0261-W014	Niskin#23	2014	09	03	13:12	67	0	N	168	50	W	5
MR14-05_St002_O18_#0262-W015	Niskin#22	2014	09	03	13:12	67	0	N	168	50	W	10
MR14-05_St002_O18_#0263-W016	Niskin#21	2014	09	03	13:12	67	0	N	168	50	W	20
MR14-05_St002_O18_#0264-W017	Niskin#20	2014	09	03	13:12	67	0	N	168	50	W	30
MR14-05_St002_O18_#0265-W018	Niskin#19	2014	09	03	13:12	67	0	N	168	50	W	40
MR14-05_St002_O18_#0266-W019	Niskin#18	2014	09	03	13:12	67	0	N	168	50	W	Not sampled
MR14-05_St002_O18_#0267-W020	Niskin#02	2014	09	03	13:12	67	0	N	168	50	W	B-10
MR14-05_St003_O18_#0268-W021	Bucket	2014	09	03	19:45	68	0	N	168	50	W	0
MR14-05_St003_O18_#0269-W022	Bucket	2014	09	03	19:45	68	0	N	168	50	W	0
MR14-05_St003_O18_#0270-W023	Niskin#25	2014	09	03	19:45	68	0	N	168	50	W	Chl-aMax
MR14-05_St003_O18_#0271-W024	Niskin#23	2014	09	03	19:45	68	0	N	168	50	W	5
MR14-05_St003_O18_#0272-W025	Niskin#07	2014	09	03	19:45	68	0	N	168	50	W	10
MR14-05_St003_O18_#0273-W026	Niskin#21	2014	09	03	19:45	68	0	N	168	50	W	20
MR14-05_St003_O18_#0274-W027	Niskin#20	2014	09	03	19:45	68	0	N	168	50	W	30
MR14-05_St003_O18_#0275-W028	Niskin#19	2014	09	03	19:45	68	0	N	168	50	W	40
MR14-05_St003_O18_#0276-W029	Niskin#18	2014	09	03	19:45	68	0	N	168	50	W	Not sampled
MR14-05_St003_O18_#0277-W030	Niskin#02	2014	09	03	19:45	68	0	N	168	50	W	B-10
MR14-05_St004_O18_#0278-W031	Bucket	2014	09	04	13:46	73	20	N	162	0	W	0
MR14-05_St004_O18_#0279-W032	Bucket	2014	09	04	13:46	73	20	N	162	0	W	0

MR14-05_St004_O18_#0280-W033	Niskin#25	2014	09	04	13:46	73	20	N	162	0	W	Chl-aMax
MR14-05_St004_O18_#0281-W034	Niskin#23	2014	09	04	13:46	73	20	N	162	0	W	5
MR14-05_St004_O18_#0282-W035	Niskin#22	2014	09	04	13:46	73	20	N	162	0	W	10
MR14-05_St004_O18_#0283-W036	Niskin#21	2014	09	04	13:46	73	20	N	162	0	W	20
MR14-05_St004_O18_#0284-W037	Niskin#20	2014	09	04	13:46	73	20	N	162	0	W	30
MR14-05_St004_O18_#0285-W038	Niskin#19	2014	09	04	13:46	73	20	N	162	0	W	40
MR14-05_St004_O18_#0286-W039	Niskin#18	2014	09	04	13:46	73	20	N	162	0	W	50
MR14-05_St004_O18_#0287-W040	Niskin#17	2014	09	04	13:46	73	20	N	162	0	W	75
MR14-05_St004_O18_#0288-W041	Niskin#16	2014	09	04	13:46	73	20	N	162	0	W	100
MR14-05_St004_O18_#0289-W042	Niskin#15	2014	09	04	13:46	73	20	N	162	0	W	125
MR14-05_St004_O18_#0290-W043	Niskin#14	2014	09	04	13:46	73	20	N	162	0	W	150
MR14-05_St004_O18_#0291-W044	Niskin#13	2014	09	04	13:46	73	20	N	162	0	W	Not sampled
MR14-05_St004_O18_#0292-W045	Niskin#12	2014	09	04	13:46	73	20	N	162	0	W	Not sampled
MR14-05_St004_O18_#0293-W046	Niskin#02	2014	09	04	13:46	73	20	N	162	0	W	B-10
MR14-05_St005_O18_#0294-W047	Bucket	2014	09	04	19:46	74	0	N	164	0	W	0
MR14-05_St005_O18_#0295-W048	Bucket	2014	09	04	19:46	74	0	N	164	0	W	0
MR14-05_St005_O18_#0296-W049	Niskin#25	2014	09	04	19:46	74	0	N	164	0	W	Chl-aMax
MR14-05_St005_O18_#0297-W050	Niskin#23	2014	09	04	19:46	74	0	N	164	0	W	5
MR14-05_St005_O18_#0298-W051	Niskin#22	2014	09	04	19:46	74	0	N	164	0	W	10
MR14-05_St005_O18_#0299-W052	Niskin#21	2014	09	04	19:46	74	0	N	164	0	W	20
MR14-05_St005_O18_#0300-W053	Niskin#20	2014	09	04	19:46	74	0	N	164	0	W	30
MR14-05_St005_O18_#0301-W054	Niskin#19	2014	09	04	19:46	74	0	N	164	0	W	40
MR14-05_St005_O18_#0302-W055	Niskin#18	2014	09	04	19:46	74	0	N	164	0	W	50
MR14-05_St005_O18_#0303-W056	Niskin#17	2014	09	04	19:46	74	0	N	164	0	W	75
MR14-05_St005_O18_#0304-W057	Niskin#16	2014	09	04	19:46	74	0	N	164	0	W	100
MR14-05_St005_O18_#0305-W058	Niskin#15	2014	09	04	19:46	74	0	N	164	0	W	125
MR14-05_St005_O18_#0306-W059	Niskin#14	2014	09	04	19:46	74	0	N	164	0	W	150
MR14-05_St005_O18_#0307-W060	Niskin#13	2014	09	04	19:46	74	0	N	164	0	W	175
MR14-05_St005_O18_#0308-W061	Niskin#12	2014	09	04	19:46	74	0	N	164	0	W	200
MR14-05_St005_O18_#0309-W062	Niskin#11	2014	09	04	19:46	74	0	N	164	0	W	225
MR14-05_St005_O18_#0310-W063	Niskin#10	2014	09	04	19:46	74	0	N	164	0	W	250
MR14-05_St005_O18_#0311-W064	Niskin#01	2014	09	04	19:46	74	0	N	164	0	W	B-10
MR14-05_St006_O18_#0312-W065	Bucket	2014	09	05	23:24	74	22.5	N	163	0	W	0
MR14-05_St006_O18_#0313-W066	Bucket	2014	09	05	23:24	74	22.5	N	163	0	W	0
MR14-05_St006_O18_#0314-W067	Niskin#25	2014	09	05	23:24	74	22.5	N	163	0	W	Chl-aMax

MR14-05_St006_O18_#0315-W068	Niskin#23	2014	09	05	23:24	74	22.5	N	163	0	W	5
MR14-05_St006_O18_#0316-W069	Niskin#22	2014	09	05	23:24	74	22.5	N	163	0	W	10
MR14-05_St006_O18_#0317-W070	Niskin#21	2014	09	05	23:24	74	22.5	N	163	0	W	20
MR14-05_St006_O18_#0318-W071	Niskin#20	2014	09	05	23:24	74	22.5	N	163	0	W	30
MR14-05_St006_O18_#0319-W072	Niskin#19	2014	09	05	23:24	74	22.5	N	163	0	W	40
MR14-05_St006_O18_#0320-W073	Niskin#18	2014	09	05	23:24	74	22.5	N	163	0	W	50
MR14-05_St006_O18_#0321-W074	Niskin#17	2014	09	05	23:24	74	22.5	N	163	0	W	75
MR14-05_St006_O18_#0322-W075	Niskin#16	2014	09	05	23:24	74	22.5	N	163	0	W	100
MR14-05_St006_O18_#0323-W076	Niskin#15	2014	09	05	23:24	74	22.5	N	163	0	W	125
MR14-05_St006_O18_#0324-W077	Niskin#14	2014	09	05	23:24	74	22.5	N	163	0	W	150
MR14-05_St006_O18_#0325-W078	Niskin#13	2014	09	05	23:24	74	22.5	N	163	0	W	175
MR14-05_St006_O18_#0326-W079	Niskin#12	2014	09	05	23:24	74	22.5	N	163	0	W	200
MR14-05_St006_O18_#0327-W080	Niskin#11	2014	09	05	23:24	74	22.5	N	163	0	W	225
MR14-05_St006_O18_#0328-W081	Niskin#10	2014	09	05	23:24	74	22.5	N	163	0	W	250
MR14-05_St006_O18_#0329-W082	Niskin#09	2014	09	05	23:24	74	22.5	N	163	0	W	300
MR14-05_St006_O18_#0330-W083	Niskin#08	2014	09	05	23:24	74	22.5	N	163	0	W	400
MR14-05_St006_O18_#0331-W084	Niskin#07	2014	09	05	23:24	74	22.5	N	163	0	W	500
MR14-05_St006_O18_#0332-W085	Niskin#06	2014	09	05	23:24	74	22.5	N	163	0	W	600
MR14-05_St006_O18_#0333-W086	Niskin#05	2014	09	05	23:24	74	22.5	N	163	0	W	800
MR14-05_St006_O18_#0334-W087	Niskin#04	2014	09	05	23:24	74	22.5	N	163	0	W	1000
MR14-05_St006_O18_#0335-W088	Niskin#01	2014	09	05	23:24	74	22.5	N	163	0	W	B-10
MR14-05_St007_O18_#0336-W089	Bucket	2014	09	06	5:54	75	7.5	N	161	0	W	0
MR14-05_St007_O18_#0337-W090	Bucket	2014	09	06	5:54	75	7.5	N	161	0	W	0
MR14-05_St007_O18_#0338-W091	Niskin#25	2014	09	06	5:54	75	7.5	N	161	0	W	Chl-aMax
MR14-05_St007_O18_#0339-W092	Niskin#23	2014	09	06	5:54	75	7.5	N	161	0	W	5
MR14-05_St007_O18_#0340-W093	Niskin#22	2014	09	06	5:54	75	7.5	N	161	0	W	10
MR14-05_St007_O18_#0341-W094	Niskin#21	2014	09	06	5:54	75	7.5	N	161	0	W	20
MR14-05_St007_O18_#0342-W095	Niskin#20	2014	09	06	5:54	75	7.5	N	161	0	W	30
MR14-05_St007_O18_#0343-W096	Niskin#19	2014	09	06	5:54	75	7.5	N	161	0	W	40
MR14-05_St007_O18_#0344-W097	Niskin#18	2014	09	06	5:54	75	7.5	N	161	0	W	50
MR14-05_St007_O18_#0345-W098	Niskin#17	2014	09	06	5:54	75	7.5	N	161	0	W	75
MR14-05_St007_O18_#0346-W099	Niskin#16	2014	09	06	5:54	75	7.5	N	161	0	W	100
MR14-05_St007_O18_#0347-W100	Niskin#15	2014	09	06	5:54	75	7.5	N	161	0	W	125
MR14-05_St007_O18_#0348-W101	Niskin#14	2014	09	06	5:54	75	7.5	N	161	0	W	150
MR14-05_St007_O18_#0349-W102	Niskin#13	2014	09	06	5:54	75	7.5	N	161	0	W	175

MR14-05_St007_O18_#0350-W103	Niskin#12	2014	09	06	5:54	75	7.5	N	161	0	W	200
MR14-05_St007_O18_#0351-W104	Niskin#11	2014	09	06	5:54	75	7.5	N	161	0	W	225
MR14-05_St007_O18_#0352-W105	Niskin#10	2014	09	06	5:54	75	7.5	N	161	0	W	250
MR14-05_St007_O18_#0353-W106	Niskin#09	2014	09	06	5:54	75	7.5	N	161	0	W	300
MR14-05_St007_O18_#0354-W107	Niskin#08	2014	09	06	5:54	75	7.5	N	161	0	W	400
MR14-05_St007_O18_#0355-W108	Niskin#07	2014	09	06	5:54	75	7.5	N	161	0	W	500
MR14-05_St007_O18_#0356-W109	Niskin#06	2014	09	06	5:54	75	7.5	N	161	0	W	600
MR14-05_St007_O18_#0357-W110	Niskin#05	2014	09	06	5:54	75	7.5	N	161	0	W	800
MR14-05_St007_O18_#0358-W111	Niskin#04	2014	09	06	5:54	75	7.5	N	161	0	W	1000
MR14-05_St007_O18_#0359-W112	Niskin#03	2014	09	06	5:54	75	7.5	N	161	0	W	1500
MR14-05_St007_O18_#0360-W113	Niskin#02	2014	09	06	5:54	75	7.5	N	161	0	W	2000
MR14-05_St007_O18_#0361-W114	Niskin#01	2014	09	06	5:54	75	7.5	N	161	0	W	B-10
MR14-05_St008_O18_#0362-W115	Bucket	2014	09	06	14:04	74	22.5	N	161	0	W	0
MR14-05_St008_O18_#0363-W116	Bucket	2014	09	06	14:04	74	22.5	N	161	0	W	0
MR14-05_St008_O18_#0364-W117	Niskin#25	2014	09	06	14:04	74	22.5	N	161	0	W	Chl-aMax
MR14-05_St008_O18_#0365-W118	Niskin#23	2014	09	06	14:04	74	22.5	N	161	0	W	5
MR14-05_St008_O18_#0366-W119	Niskin#22	2014	09	06	14:04	74	22.5	N	161	0	W	10
MR14-05_St008_O18_#0367-W120	Niskin#21	2014	09	06	14:04	74	22.5	N	161	0	W	20
MR14-05_St008_O18_#0368-W121	Niskin#20	2014	09	06	14:04	74	22.5	N	161	0	W	30
MR14-05_St008_O18_#0369-W122	Niskin#19	2014	09	06	14:04	74	22.5	N	161	0	W	40
MR14-05_St008_O18_#0370-W123	Niskin#18	2014	09	06	14:04	74	22.5	N	161	0	W	50
MR14-05_St008_O18_#0371-W124	Niskin#17	2014	09	06	14:04	74	22.5	N	161	0	W	75
MR14-05_St008_O18_#0372-W125	Niskin#16	2014	09	06	14:04	74	22.5	N	161	0	W	100
MR14-05_St008_O18_#0373-W126	Niskin#15	2014	09	06	14:04	74	22.5	N	161	0	W	125
MR14-05_St008_O18_#0374-W127	Niskin#14	2014	09	06	14:04	74	22.5	N	161	0	W	150
MR14-05_St008_O18_#0375-W128	Niskin#13	2014	09	06	14:04	74	22.5	N	161	0	W	175
MR14-05_St008_O18_#0376-W129	Niskin#12	2014	09	06	14:04	74	22.5	N	161	0	W	200
MR14-05_St008_O18_#0377-W130	Niskin#11	2014	09	06	14:04	74	22.5	N	161	0	W	225
MR14-05_St008_O18_#0378-W131	Niskin#10	2014	09	06	14:04	74	22.5	N	161	0	W	250
MR14-05_St008_O18_#0379-W132	Niskin#09	2014	09	06	14:04	74	22.5	N	161	0	W	300
MR14-05_St008_O18_#0380-W133	Niskin#08	2014	09	06	14:04	74	22.5	N	161	0	W	400
MR14-05_St008_O18_#0381-W134	Niskin#07	2014	09	06	14:04	74	22.5	N	161	0	W	500
MR14-05_St008_O18_#0382-W135	Niskin#06	2014	09	06	14:04	74	22.5	N	161	0	W	600
MR14-05_St008_O18_#0383-W136	Niskin#05	2014	09	06	14:04	74	22.5	N	161	0	W	800
MR14-05_St008_O18_#0384-W137	Niskin#04	2014	09	06	14:04	74	22.5	N	161	0	W	1000

MR14-05_St008_O18_#0385-W138	Niskin#03	2014	09	06	14:04	74	22.5	N	161	0	W	1500
MR14-05_St008_O18_#0386-W139	Niskin#01	2014	09	06	14:04	74	22.5	N	161	0	W	B-10
MR14-05_St009_Cast002_O18_#0387-W140	Bucket	2014	09	06	23:42	74	45	N	162	0	W	0
MR14-05_St009_Cast002_O18_#0388-W141	Bucket	2014	09	06	23:42	74	45	N	162	0	W	0
MR14-05_St009_Cast002_O18_#0389-W142	Niskin#26	2014	09	06	23:42	74	45	N	162	0	W	Chl-aMax
MR14-05_St009_Cast002_O18_#0390-W143	Niskin#24	2014	09	06	23:42	74	45	N	162	0	W	5
MR14-05_St009_Cast002_O18_#0391-W144	Niskin#23	2014	09	06	23:42	74	45	N	162	0	W	10
MR14-05_St009_Cast002_O18_#0392-W145	Niskin#22	2014	09	06	23:42	74	45	N	162	0	W	15
MR14-05_St009_Cast002_O18_#0393-W146	Niskin#21	2014	09	06	23:42	74	45	N	162	0	W	20
MR14-05_St009_Cast002_O18_#0394-W147	Niskin#20	2014	09	06	23:42	74	45	N	162	0	W	30
MR14-05_St009_Cast002_O18_#0395-W148	Niskin#19	2014	09	06	23:42	74	45	N	162	0	W	40
MR14-05_St009_Cast002_O18_#0396-W149	Niskin#18	2014	09	06	23:42	74	45	N	162	0	W	50
MR14-05_St009_Cast002_O18_#0397-W150	Niskin#17	2014	09	06	23:42	74	45	N	162	0	W	75
MR14-05_St009_Cast002_O18_#0398-W151	Niskin#16	2014	09	06	23:42	74	45	N	162	0	W	100
MR14-05_St009_Cast002_O18_#0399-W152	Niskin#15	2014	09	06	23:42	74	45	N	162	0	W	125
MR14-05_St009_Cast002_O18_#0400-W153	Niskin#14	2014	09	06	23:42	74	45	N	162	0	W	150
MR14-05_St009_Cast002_O18_#0401-W154	Niskin#13	2014	09	06	23:42	74	45	N	162	0	W	175
MR14-05_St009_Cast002_O18_#0402-W155	Niskin#12	2014	09	06	23:42	74	45	N	162	0	W	200
MR14-05_St009_Cast002_O18_#0403-W156	Niskin#11	2014	09	06	23:42	74	45	N	162	0	W	225
MR14-05_St009_Cast002_O18_#0404-W157	Niskin#10	2014	09	06	23:42	74	45	N	162	0	W	250
MR14-05_St009_Cast002_O18_#0405-W158	Niskin#09	2014	09	06	23:42	74	45	N	162	0	W	300
MR14-05_St009_Cast002_O18_#0406-W159	Niskin#08	2014	09	06	23:42	74	45	N	162	0	W	400
MR14-05_St009_Cast002_O18_#0407-W160	Niskin#07	2014	09	06	23:42	74	45	N	162	0	W	500
MR14-05_St009_Cast002_O18_#0408-W161	Niskin#06	2014	09	06	23:42	74	45	N	162	0	W	600
MR14-05_St009_Cast002_O18_#0409-W162	Niskin#05	2014	09	06	23:42	74	45	N	162	0	W	800
MR14-05_St009_Cast002_O18_#0410-W163	Niskin#04	2014	09	06	23:42	74	45	N	162	0	W	1000
MR14-05_St009_Cast002_O18_#0411-W164	Niskin#03	2014	09	06	23:42	74	45	N	162	0	W	1500
MR14-05_St009_Cast002_O18_#0412-W165	Niskin#01	2014	09	06	23:42	74	45	N	162	0	W	B-10
MR14-05_St009_Cast034_O18_#0413-W166	Bucket	2014	09	14	23:36	74	45	N	162	0	W	0
MR14-05_St009_Cast034_O18_#0414-W167	Bucket	2014	09	14	23:36	74	45	N	162	0	W	0
MR14-05_St009_Cast034_O18_#0415-W168	Niskin#26	2014	09	14	23:36	74	45	N	162	0	W	Chl-aMax
MR14-05_St009_Cast034_O18_#0416-W169	Niskin#24	2014	09	14	23:36	74	45	N	162	0	W	5
MR14-05_St009_Cast034_O18_#0417-W170	Niskin#23	2014	09	14	23:36	74	45	N	162	0	W	10
MR14-05_St009_Cast034_O18_#0418-W171	Niskin#22	2014	09	14	23:36	74	45	N	162	0	W	15
MR14-05_St009_Cast034_O18_#0419-W172	Niskin#21	2014	09	14	23:36	74	45	N	162	0	W	20

MR14-05_St009_Cast034_O18_#0420-W173	Niskin#20	2014	09	14	23:36	74	45	N	162	0	W	30
MR14-05_St009_Cast034_O18_#0421-W174	Niskin#19	2014	09	14	23:36	74	45	N	162	0	W	40
MR14-05_St009_Cast034_O18_#0422-W175	Niskin#18	2014	09	14	23:36	74	45	N	162	0	W	50
MR14-05_St009_Cast034_O18_#0423-W176	Niskin#17	2014	09	14	23:36	74	45	N	162	0	W	75
MR14-05_St009_Cast034_O18_#0424-W177	Niskin#16	2014	09	14	23:36	74	45	N	162	0	W	100
MR14-05_St009_Cast034_O18_#0425-W178	Niskin#15	2014	09	14	23:36	74	45	N	162	0	W	125
MR14-05_St009_Cast034_O18_#0426-W179	Niskin#14	2014	09	14	23:36	74	45	N	162	0	W	150
MR14-05_St009_Cast034_O18_#0427-W180	Niskin#13	2014	09	14	23:36	74	45	N	162	0	W	175
MR14-05_St009_Cast034_O18_#0428-W181	Niskin#12	2014	09	14	23:36	74	45	N	162	0	W	200
MR14-05_St009_Cast034_O18_#0429-W182	Niskin#11	2014	09	14	23:36	74	45	N	162	0	W	225
MR14-05_St009_Cast034_O18_#0430-W183	Niskin#10	2014	09	14	23:36	74	45	N	162	0	W	250
MR14-05_St009_Cast034_O18_#0431-W184	Niskin#09	2014	09	14	23:36	74	45	N	162	0	W	300
MR14-05_St009_Cast034_O18_#0432-W185	Niskin#08	2014	09	14	23:36	74	45	N	162	0	W	400
MR14-05_St009_Cast034_O18_#0433-W186	Niskin#07	2014	09	14	23:36	74	45	N	162	0	W	500
MR14-05_St009_Cast034_O18_#0434-W187	Niskin#06	2014	09	14	23:36	74	45	N	162	0	W	600
MR14-05_St009_Cast034_O18_#0435-W188	Niskin#05	2014	09	14	23:36	74	45	N	162	0	W	800
MR14-05_St009_Cast034_O18_#0436-W189	Niskin#04	2014	09	14	23:36	74	45	N	162	0	W	1000
MR14-05_St009_Cast034_O18_#0437-W190	Niskin#03	2014	09	14	23:36	74	45	N	162	0	W	1500
MR14-05_St010_Cast001_O18_#0438-W191	Bucket	2014	09	18	15:01	74	41.99	N	162	07.90	W	0
MR14-05_St010_Cast001_O18_#0439-W192	Bucket	2014	09	18	15:01	74	41.99	N	162	07.90	W	0
MR14-05_St010_Cast001_O18_#0440-W193	Niskin#35	2014	09	18	15:01	74	41.99	N	162	07.90	W	Chl-aMax
MR14-05_St010_Cast001_O18_#0441-W194	Niskin#33	2014	09	18	15:01	74	41.99	N	162	07.90	W	5
MR14-05_St010_Cast001_O18_#0442-W195	Niskin#31	2014	09	18	15:01	74	41.99	N	162	07.90	W	10
MR14-05_St010_Cast001_O18_#0443-W196	Niskin#29	2014	09	18	15:01	74	41.99	N	162	07.90	W	15
MR14-05_St010_Cast001_O18_#0444-W197	Niskin#27	2014	09	18	15:01	74	41.99	N	162	07.90	W	20
MR14-05_St010_Cast001_O18_#0445-W198	Niskin#25	2014	09	18	15:01	74	41.99	N	162	07.90	W	30
MR14-05_St010_Cast001_O18_#0446-W199	Niskin#23	2014	09	18	15:01	74	41.99	N	162	07.90	W	40
MR14-05_St010_Cast001_O18_#0447-W200	Niskin#21	2014	09	18	15:01	74	41.99	N	162	07.90	W	50
MR14-05_St010_Cast001_O18_#0448-W201	Niskin#19	2014	09	18	15:01	74	41.99	N	162	07.90	W	75
MR14-05_St010_Cast001_O18_#0449-W202	Niskin#17	2014	09	18	15:01	74	41.99	N	162	07.90	W	100
MR14-05_St010_Cast001_O18_#0450-W203	Niskin#15	2014	09	18	15:01	74	41.99	N	162	07.90	W	125
MR14-05_St010_Cast001_O18_#0451-W204	Niskin#13	2014	09	18	15:01	74	41.99	N	162	07.90	W	150
MR14-05_St010_Cast001_O18_#0452-W205	Niskin#11	2014	09	18	15:01	74	41.99	N	162	07.90	W	175
MR14-05_St010_Cast001_O18_#0453-W206	Niskin#09	2014	09	18	15:01	74	41.99	N	162	07.90	W	200
MR14-05_St010_Cast001_O18_#0454-W207	Niskin#07	2014	09	18	15:01	74	41.99	N	162	07.90	W	225

MR14-05_St010_Cast001_O18_#0455-W208	Niskin#05	2014	09	18	15:01	74	41.99	N	162	07.90	W	250
MR14-05_St010_Cast001_O18_#0456-W209	Niskin#03	2014	09	18	15:01	74	41.99	N	162	07.90	W	300
MR14-05_St010_Cast001_O18_#0457-W210	Niskin#01	2014	09	18	15:01	74	41.99	N	162	07.90	W	400
MR14-05_St011_Cast001_O18_#0458-W211	Bucket	2014	09	20	3:14	74	49.10	N	161	50.23	W	0
MR14-05_St011_Cast001_O18_#0459-W212	Bucket	2014	09	20	3:14	74	49.10	N	161	50.23	W	0
MR14-05_St011_Cast001_O18_#0460-W213	Niskin#35	2014	09	20	3:14	74	49.10	N	161	50.23	W	Chl-aMax
MR14-05_St011_Cast001_O18_#0461-W214	Niskin#33	2014	09	20	3:14	74	49.10	N	161	50.23	W	5
MR14-05_St011_Cast001_O18_#0462-W215	Niskin#31	2014	09	20	3:14	74	49.10	N	161	50.23	W	10
MR14-05_St011_Cast001_O18_#0463-W216	Niskin#29	2014	09	20	3:14	74	49.10	N	161	50.23	W	15
MR14-05_St011_Cast001_O18_#0464-W217	Niskin#27	2014	09	20	3:14	74	49.10	N	161	50.23	W	20
MR14-05_St011_Cast001_O18_#0465-W218	Niskin#25	2014	09	20	3:14	74	49.10	N	161	50.23	W	30
MR14-05_St011_Cast001_O18_#0466-W219	Niskin#23	2014	09	20	3:14	74	49.10	N	161	50.23	W	40
MR14-05_St011_Cast001_O18_#0467-W220	Niskin#21	2014	09	20	3:14	74	49.10	N	161	50.23	W	50
MR14-05_St011_Cast001_O18_#0468-W221	Niskin#19	2014	09	20	3:14	74	49.10	N	161	50.23	W	75
MR14-05_St011_Cast001_O18_#0469-W222	Niskin#17	2014	09	20	3:14	74	49.10	N	161	50.23	W	100
MR14-05_St011_Cast001_O18_#0470-W223	Niskin#15	2014	09	20	3:14	74	49.10	N	161	50.23	W	125
MR14-05_St011_Cast001_O18_#0471-W224	Niskin#13	2014	09	20	3:14	74	49.10	N	161	50.23	W	150
MR14-05_St011_Cast001_O18_#0472-W225	Niskin#11	2014	09	20	3:14	74	49.10	N	161	50.23	W	175
MR14-05_St011_Cast001_O18_#0473-W226	Niskin#09	2014	09	20	3:14	74	49.10	N	161	50.23	W	200
MR14-05_St011_Cast001_O18_#0474-W227	Niskin#07	2014	09	20	3:14	74	49.10	N	161	50.23	W	225
MR14-05_St011_Cast001_O18_#0475-W228	Niskin#05	2014	09	20	3:14	74	49.10	N	161	50.23	W	250
MR14-05_St011_Cast001_O18_#0476-W229	Niskin#03	2014	09	20	3:14	74	49.10	N	161	50.23	W	300
MR14-05_St011_Cast001_O18_#0477-W230	Niskin#01	2014	09	20	3:14	74	49.10	N	161	50.23	W	400
MR14-05_St009_Cast074_O18_#0478-W231	Bucket	2014	09	24	23:40	74	45.09	N	161	58.88	W	0
MR14-05_St009_Cast074_O18_#0479-W232	Bucket	2014	09	24	23:40	74	45.09	N	161	58.88	W	0
MR14-05_St009_Cast074_O18_#0480-W233	Niskin#26	2014	09	24	23:40	74	45.09	N	161	58.88	W	Chl-aMax
MR14-05_St009_Cast074_O18_#0481-W234	Niskin#24	2014	09	24	23:40	74	45.09	N	161	58.88	W	5
MR14-05_St009_Cast074_O18_#0482-W235	Niskin#23	2014	09	24	23:40	74	45.09	N	161	58.88	W	10
MR14-05_St009_Cast074_O18_#0483-W236	Niskin#22	2014	09	24	23:40	74	45.09	N	161	58.88	W	15
MR14-05_St009_Cast074_O18_#0484-W237	Niskin#21	2014	09	24	23:40	74	45.09	N	161	58.88	W	20
MR14-05_St009_Cast074_O18_#0485-W238	Niskin#20	2014	09	24	23:40	74	45.09	N	161	58.88	W	30
MR14-05_St009_Cast074_O18_#0486-W239	Niskin#19	2014	09	24	23:40	74	45.09	N	161	58.88	W	40
MR14-05_St009_Cast074_O18_#0487-W240	Niskin#18	2014	09	24	23:40	74	45.09	N	161	58.88	W	50
MR14-05_St009_Cast074_O18_#0488-W241	Niskin#17	2014	09	24	23:40	74	45.09	N	161	58.88	W	75
MR14-05_St009_Cast074_O18_#0489-W242	Niskin#16	2014	09	24	23:40	74	45.09	N	161	58.88	W	100

MR14-05_St009_Cast074_O18_#0490-W243	Niskin#15	2014	09	24	23:40	74	45.09	N	161	58.88	W	125
MR14-05_St009_Cast074_O18_#0491-W244	Niskin#14	2014	09	24	23:40	74	45.09	N	161	58.88	W	150
MR14-05_St009_Cast074_O18_#0492-W245	Niskin#13	2014	09	24	23:40	74	45.09	N	161	58.88	W	175
MR14-05_St009_Cast074_O18_#0493-W246	Niskin#12	2014	09	24	23:40	74	45.09	N	161	58.88	W	200
MR14-05_St009_Cast074_O18_#0494-W247	Niskin#11	2014	09	24	23:40	74	45.09	N	161	58.88	W	225
MR14-05_St009_Cast074_O18_#0495-W248	Niskin#10	2014	09	24	23:40	74	45.09	N	161	58.88	W	250
MR14-05_St009_Cast074_O18_#0496-W249	Niskin#09	2014	09	24	23:40	74	45.09	N	161	58.88	W	300
MR14-05_St009_Cast074_O18_#0497-W250	Niskin#08	2014	09	24	23:40	74	45.09	N	161	58.88	W	400
MR14-05_St009_Cast074_O18_#0498-W251	Niskin#07	2014	09	24	23:40	74	45.09	N	161	58.88	W	500
MR14-05_St009_Cast074_O18_#0499-W252	Niskin#06	2014	09	24	23:40	74	45.09	N	161	58.88	W	600
MR14-05_St009_Cast074_O18_#0500-W253	Niskin#05	2014	09	24	23:40	74	45.09	N	161	58.88	W	800
MR14-05_St009_Cast074_O18_#0501-W254	Niskin#04	2014	09	24	23:40	74	45.09	N	161	58.88	W	1000
MR14-05_St009_Cast074_O18_#0502-W255	Niskin#03	2014	09	24	23:40	74	45.09	N	161	58.88	W	1500
MR14-05_St009_Cast074_O18_#0503-W256	Niskin#01	2014	09	24	23:40	74	45.09	N	161	58.88	W	B-10
MR14-05_St006_Cast002_O18_#0504-W257	Bucket	2014	09	25	4:08	74	22.49	N	163	00.55	W	0
MR14-05_St006_Cast002_O18_#0505-W258	Bucket	2014	09	25	4:08	74	22.49	N	163	00.55	W	0
MR14-05_St006_Cast002_O18_#0506-W259	Niskin#26	2014	09	25	4:08	74	22.49	N	163	00.55	W	Chl-aMax
MR14-05_St006_Cast002_O18_#0507-W260	Niskin#24	2014	09	25	4:08	74	22.49	N	163	00.55	W	5
MR14-05_St006_Cast002_O18_#0508-W261	Niskin#23	2014	09	25	4:08	74	22.49	N	163	00.55	W	10
MR14-05_St006_Cast002_O18_#0509-W262	Niskin#22	2014	09	25	4:08	74	22.49	N	163	00.55	W	15
MR14-05_St006_Cast002_O18_#0510-W263	Niskin#21	2014	09	25	4:08	74	22.49	N	163	00.55	W	20
MR14-05_St006_Cast002_O18_#0511-W264	Niskin#20	2014	09	25	4:08	74	22.49	N	163	00.55	W	30
MR14-05_St006_Cast002_O18_#0512-W265	Niskin#19	2014	09	25	4:08	74	22.49	N	163	00.55	W	40
MR14-05_St006_Cast002_O18_#0513-W266	Niskin#18	2014	09	25	4:08	74	22.49	N	163	00.55	W	50
MR14-05_St006_Cast002_O18_#0514-W267	Niskin#17	2014	09	25	4:08	74	22.49	N	163	00.55	W	75
MR14-05_St006_Cast002_O18_#0515-W268	Niskin#16	2014	09	25	4:08	74	22.49	N	163	00.55	W	100
MR14-05_St006_Cast002_O18_#0516-W269	Niskin#15	2014	09	25	4:08	74	22.49	N	163	00.55	W	125
MR14-05_St006_Cast002_O18_#0517-W270	Niskin#14	2014	09	25	4:08	74	22.49	N	163	00.55	W	150
MR14-05_St006_Cast002_O18_#0518-W271	Niskin#13	2014	09	25	4:08	74	22.49	N	163	00.55	W	175
MR14-05_St006_Cast002_O18_#0519-W272	Niskin#12	2014	09	25	4:08	74	22.49	N	163	00.55	W	200
MR14-05_St006_Cast002_O18_#0520-W273	Niskin#11	2014	09	25	4:08	74	22.49	N	163	00.55	W	225
MR14-05_St006_Cast002_O18_#0521-W274	Niskin#10	2014	09	25	4:08	74	22.49	N	163	00.55	W	250
MR14-05_St006_Cast002_O18_#0522-W275	Niskin#09	2014	09	25	4:08	74	22.49	N	163	00.55	W	300
MR14-05_St006_Cast002_O18_#0523-W276	Niskin#08	2014	09	25	4:08	74	22.49	N	163	00.55	W	400
MR14-05_St006_Cast002_O18_#0524-W277	Niskin#07	2014	09	25	4:08	74	22.49	N	163	00.55	W	500

MR14-05_St006_Cast002_O18_#0525-W278	Niskin#06	2014	09	25	4:08	74	22.49	N	163	00.55	W	600
MR14-05_St006_Cast002_O18_#0526-W279	Niskin#05	2014	09	25	4:08	74	22.49	N	163	00.55	W	800
MR14-05_St006_Cast002_O18_#0527-W280	Niskin#04	2014	09	25	4:08	74	22.49	N	163	00.55	W	1000
MR14-05_St006_Cast002_O18_#0528-W281	Niskin#01	2014	09	25	4:08	74	22.49	N	163	00.55	W	B-10
MR14-05_St005_Cast002_O18_#0529-W282	Bucket	2014	09	25	8:01	73	59.98	N	164	00.06	W	0
MR14-05_St005_Cast002_O18_#0530-W283	Bucket	2014	09	25	8:01	73	59.98	N	164	00.06	W	0
MR14-05_St005_Cast002_O18_#0531-W284	Niskin#35	2014	09	25	8:01	73	59.98	N	164	00.06	W	Chl-aMax
MR14-05_St005_Cast002_O18_#0532-W285	Niskin#33	2014	09	25	8:01	73	59.98	N	164	00.06	W	5
MR14-05_St005_Cast002_O18_#0533-W286	Niskin#31	2014	09	25	8:01	73	59.98	N	164	00.06	W	10
MR14-05_St005_Cast002_O18_#0534-W287	Niskin#29	2014	09	25	8:01	73	59.98	N	164	00.06	W	15
MR14-05_St005_Cast002_O18_#0535-W288	Niskin#27	2014	09	25	8:01	73	59.98	N	164	00.06	W	20
MR14-05_St005_Cast002_O18_#0536-W289	Niskin#25	2014	09	25	8:01	73	59.98	N	164	00.06	W	30
MR14-05_St005_Cast002_O18_#0537-W290	Niskin#23	2014	09	25	8:01	73	59.98	N	164	00.06	W	40
MR14-05_St005_Cast002_O18_#0538-W291	Niskin#21	2014	09	25	8:01	73	59.98	N	164	00.06	W	50
MR14-05_St005_Cast002_O18_#0539-W292	Niskin#19	2014	09	25	8:01	73	59.98	N	164	00.06	W	75
MR14-05_St005_Cast002_O18_#0540-W293	Niskin#17	2014	09	25	8:01	73	59.98	N	164	00.06	W	100
MR14-05_St005_Cast002_O18_#0541-W294	Niskin#15	2014	09	25	8:01	73	59.98	N	164	00.06	W	125
MR14-05_St005_Cast002_O18_#0542-W295	Niskin#13	2014	09	25	8:01	73	59.98	N	164	00.06	W	150
MR14-05_St005_Cast002_O18_#0543-W296	Niskin#11	2014	09	25	8:01	73	59.98	N	164	00.06	W	175
MR14-05_St005_Cast002_O18_#0544-W297	Niskin#09	2014	09	25	8:01	73	59.98	N	164	00.06	W	200
MR14-05_St005_Cast002_O18_#0545-W298	Niskin#07	2014	09	25	8:01	73	59.98	N	164	00.06	W	225
MR14-05_St005_Cast002_O18_#0546-W299	Niskin#05	2014	09	25	8:01	73	59.98	N	164	00.06	W	Not sampled
MR14-05_St005_Cast002_O18_#0547-W300	Niskin#01	2014	09	25	8:01	73	59.98	N	164	00.06	W	B-10
MR14-05_St012_Cast001_O18_#0548-W301	Bucket	2014	09	25	14:09	73	30.03	N	166	59.96	W	0
MR14-05_St012_Cast001_O18_#0549-W302	Bucket	2014	09	25	14:09	73	30.03	N	166	59.96	W	0
MR14-05_St012_Cast001_O18_#0550-W303	Niskin#35	2014	09	25	14:09	73	30.03	N	166	59.96	W	Chl-aMax
MR14-05_St012_Cast001_O18_#0551-W304	Niskin#33	2014	09	25	14:09	73	30.03	N	166	59.96	W	5
MR14-05_St012_Cast001_O18_#0552-W305	Niskin#31	2014	09	25	14:09	73	30.03	N	166	59.96	W	10
MR14-05_St012_Cast001_O18_#0553-W306	Niskin#29	2014	09	25	14:09	73	30.03	N	166	59.96	W	15
MR14-05_St012_Cast001_O18_#0554-W307	Niskin#27	2014	09	25	14:09	73	30.03	N	166	59.96	W	20
MR14-05_St012_Cast001_O18_#0555-W308	Niskin#25	2014	09	25	14:09	73	30.03	N	166	59.96	W	30
MR14-05_St012_Cast001_O18_#0556-W309	Niskin#23	2014	09	25	14:09	73	30.03	N	166	59.96	W	40
MR14-05_St012_Cast001_O18_#0557-W310	Niskin#21	2014	09	25	14:09	73	30.03	N	166	59.96	W	50
MR14-05_St012_Cast001_O18_#0558-W311	Niskin#19	2014	09	25	14:09	73	30.03	N	166	59.96	W	75
MR14-05_St012_Cast001_O18_#0559-W312	Niskin#17	2014	09	25	14:09	73	30.03	N	166	59.96	W	100

MR14-05_St012_Cast001_O18_#0560-W313	Niskin#01	2014	09	25	14:09	73	30.03	N	166	59.96	W	B-10
MR14-05_St013_Cast001_O18_#0561-W314	Bucket	2014	09	25	19:32	72	45.01	N	168	14.87	W	0
MR14-05_St013_Cast001_O18_#0562-W315	Bucket	2014	09	25	19:32	72	45.01	N	168	14.87	W	0
MR14-05_St013_Cast001_O18_#0563-W316	Niskin#35	2014	09	25	19:32	72	45.01	N	168	14.87	W	Chl-aMax
MR14-05_St013_Cast001_O18_#0564-W317	Niskin#33	2014	09	25	19:32	72	45.01	N	168	14.87	W	5
MR14-05_St013_Cast001_O18_#0565-W318	Niskin#31	2014	09	25	19:32	72	45.01	N	168	14.87	W	10
MR14-05_St013_Cast001_O18_#0566-W319	Niskin#29	2014	09	25	19:32	72	45.01	N	168	14.87	W	15
MR14-05_St013_Cast001_O18_#0567-W320	Niskin#27	2014	09	25	19:32	72	45.01	N	168	14.87	W	20
MR14-05_St013_Cast001_O18_#0568-W321	Niskin#25	2014	09	25	19:32	72	45.01	N	168	14.87	W	30
MR14-05_St013_Cast001_O18_#0569-W322	Niskin#23	2014	09	25	19:32	72	45.01	N	168	14.87	W	40
MR14-05_St013_Cast001_O18_#0570-W323	Niskin#21	2014	09	25	19:32	72	45.01	N	168	14.87	W	50
MR14-05_St013_Cast001_O18_#0571-W324	Niskin#01	2014	09	25	19:32	72	45.01	N	168	14.87	W	B-10
MR14-05_St014_Cast001_O18_#0572-W325	Bucket	2014	09	26	19:00	72	04.99	N	168	50.04	W	0
MR14-05_St014_Cast001_O18_#0573-W326	Bucket	2014	09	26	19:00	72	04.99	N	168	50.04	W	0
MR14-05_St014_Cast001_O18_#0574-W327	Niskin#35	2014	09	26	19:00	72	04.99	N	168	50.04	W	Chl-aMax
MR14-05_St014_Cast001_O18_#0575-W328	Niskin#33	2014	09	26	19:00	72	04.99	N	168	50.04	W	5
MR14-05_St014_Cast001_O18_#0576-W329	Niskin#31	2014	09	26	19:00	72	04.99	N	168	50.04	W	10
MR14-05_St014_Cast001_O18_#0577-W330	Niskin#29	2014	09	26	19:00	72	04.99	N	168	50.04	W	15
MR14-05_St014_Cast001_O18_#0578-W331	Niskin#27	2014	09	26	19:00	72	04.99	N	168	50.04	W	20
MR14-05_St014_Cast001_O18_#0579-W332	Niskin#25	2014	09	26	19:00	72	04.99	N	168	50.04	W	30
MR14-05_St014_Cast001_O18_#0580-W333	Niskin#23	2014	09	26	19:00	72	04.99	N	168	50.04	W	40
MR14-05_St014_Cast001_O18_#0581-W334	Niskin#21	2014	09	26	19:00	72	04.99	N	168	50.04	W	Not sampled
MR14-05_St014_Cast001_O18_#0582-W335	Niskin#01	2014	09	26	19:00	72	04.99	N	168	50.04	W	B-10
MR14-05_St015_Cast001_O18_#0583-W336	Bucket	2014	09	27	2:29	71	00.03	N	168	50.01	W	0
MR14-05_St015_Cast001_O18_#0584-W337	Bucket	2014	09	27	2:29	71	00.03	N	168	50.01	W	0
MR14-05_St015_Cast001_O18_#0585-W338	Niskin#35	2014	09	27	2:29	71	00.03	N	168	50.01	W	Chl-aMax
MR14-05_St015_Cast001_O18_#0586-W339	Niskin#33	2014	09	27	2:29	71	00.03	N	168	50.01	W	5
MR14-05_St015_Cast001_O18_#0587-W340	Niskin#31	2014	09	27	2:29	71	00.03	N	168	50.01	W	10
MR14-05_St015_Cast001_O18_#0588-W341	Niskin#29	2014	09	27	2:29	71	00.03	N	168	50.01	W	15
MR14-05_St015_Cast001_O18_#0589-W342	Niskin#27	2014	09	27	2:29	71	00.03	N	168	50.01	W	20
MR14-05_St015_Cast001_O18_#0590-W343	Niskin#25	2014	09	27	2:29	71	00.03	N	168	50.01	W	30
MR14-05_St015_Cast001_O18_#0591-W344	Niskin#23	2014	09	27	2:29	71	00.03	N	168	50.01	W	Not sampled
MR14-05_St015_Cast001_O18_#0592-W345	Niskin#21	2014	09	27	2:29	71	00.03	N	168	50.01	W	Not sampled
MR14-05_St015_Cast001_O18_#0593-W346	Niskin#01	2014	09	27	2:29	71	00.03	N	168	50.01	W	B-10
MR14-05_St016_Cast001_O18_#0594-W347	Bucket	2014	09	27	8:13	70	00.06	N	168	49.37	W	0

MR14-05_St016_Cast001_O18_#0595-W348	Bucket	2014	09	27	8:13	70	00.06	N	168	49.37	W	0
MR14-05_St016_Cast001_O18_#0596-W349	Niskin#35	2014	09	27	8:13	70	00.06	N	168	49.37	W	Chl-aMax
MR14-05_St016_Cast001_O18_#0597-W350	Niskin#33	2014	09	27	8:13	70	00.06	N	168	49.37	W	5
MR14-05_St016_Cast001_O18_#0598-W351	Niskin#31	2014	09	27	8:13	70	00.06	N	168	49.37	W	10
MR14-05_St016_Cast001_O18_#0599-W352	Niskin#29	2014	09	27	8:13	70	00.06	N	168	49.37	W	15
MR14-05_St016_Cast001_O18_#0600-W353	Niskin#27	2014	09	27	8:13	70	00.06	N	168	49.37	W	20
MR14-05_St016_Cast001_O18_#0601-W354	Niskin#25	2014	09	27	8:13	70	00.06	N	168	49.37	W	30
MR14-05_St016_Cast001_O18_#0602-W355	Niskin#23	2014	09	27	8:13	70	00.06	N	168	49.37	W	Not sampled
MR14-05_St016_Cast001_O18_#0603-W356	Niskin#21	2014	09	27	8:13	70	00.06	N	168	49.37	W	Not sampled
MR14-05_St016_Cast001_O18_#0604-W357	Niskin#01	2014	09	27	8:13	70	00.06	N	168	49.37	W	B-10
MR14-05_St017_Cast001_O18_#0605-W358	Bucket	2014	09	27	15:06	69	00.10	N	168	49.94	W	0
MR14-05_St017_Cast001_O18_#0606-W359	Bucket	2014	09	27	15:06	69	00.10	N	168	49.94	W	0
MR14-05_St017_Cast001_O18_#0607-W360	Niskin#35	2014	09	27	15:06	69	00.10	N	168	49.94	W	Chl-aMax
MR14-05_St017_Cast001_O18_#0608-W361	Niskin#33	2014	09	27	15:06	69	00.10	N	168	49.94	W	5
MR14-05_St017_Cast001_O18_#0609-W362	Niskin#31	2014	09	27	15:06	69	00.10	N	168	49.94	W	10
MR14-05_St017_Cast001_O18_#0610-W363	Niskin#29	2014	09	27	15:06	69	00.10	N	168	49.94	W	15
MR14-05_St017_Cast001_O18_#0611-W364	Niskin#27	2014	09	27	15:06	69	00.10	N	168	49.94	W	20
MR14-05_St017_Cast001_O18_#0612-W365	Niskin#25	2014	09	27	15:06	69	00.10	N	168	49.94	W	30
MR14-05_St017_Cast001_O18_#0613-W366	Niskin#23	2014	09	27	15:06	69	00.10	N	168	49.94	W	40
MR14-05_St017_Cast001_O18_#0614-W367	Niskin#21	2014	09	27	15:06	69	00.10	N	168	49.94	W	Not sampled
MR14-05_St017_Cast001_O18_#0615-W368	Niskin#01	2014	09	27	15:06	69	00.10	N	168	49.94	W	B-10
MR14-05_St003_Cast002_O18_#0616-W369	Bucket	2014	09	27	23:16	67	59.96	N	168	50.12	W	0
MR14-05_St003_Cast002_O18_#0617-W370	Bucket	2014	09	27	23:16	67	59.96	N	168	50.12	W	0
MR14-05_St003_Cast002_O18_#0618-W371	Niskin#35	2014	09	27	23:16	67	59.96	N	168	50.12	W	Chl-aMax
MR14-05_St003_Cast002_O18_#0619-W372	Niskin#33	2014	09	27	23:16	67	59.96	N	168	50.12	W	5
MR14-05_St003_Cast002_O18_#0620-W373	Niskin#31	2014	09	27	23:16	67	59.96	N	168	50.12	W	10
MR14-05_St003_Cast002_O18_#0621-W374	Niskin#29	2014	09	27	23:16	67	59.96	N	168	50.12	W	15
MR14-05_St003_Cast002_O18_#0622-W375	Niskin#27	2014	09	27	23:16	67	59.96	N	168	50.12	W	20
MR14-05_St003_Cast002_O18_#0623-W376	Niskin#25	2014	09	27	23:16	67	59.96	N	168	50.12	W	30
MR14-05_St003_Cast002_O18_#0624-W377	Niskin#23	2014	09	27	23:16	67	59.96	N	168	50.12	W	40
MR14-05_St003_Cast002_O18_#0625-W378	Niskin#21	2014	09	27	23:16	67	59.96	N	168	50.12	W	Not sampled
MR14-05_St003_Cast002_O18_#0626-W379	Niskin#01	2014	09	27	23:16	67	59.96	N	168	50.12	W	B-10
MR14-05_St001_Cast002_O18_#0627-W380	Bucket	2014	09	28	12:54	65	46.46	N	168	47.19	W	0
MR14-05_St001_Cast002_O18_#0628-W381	Bucket	2014	09	28	12:54	65	46.46	N	168	47.19	W	0
MR14-05_St001_Cast002_O18_#0629-W382	Niskin#35	2014	09	28	12:54	65	46.46	N	168	47.19	W	Chl-aMax

MR14-05_St001_Cast002_O18_#0630-W383	Niskin#33	2014	09	28	12:54	65	46.46	N	168	47.19	W	5
MR14-05_St001_Cast002_O18_#0631-W384	Niskin#31	2014	09	28	12:54	65	46.46	N	168	47.19	W	10
MR14-05_St001_Cast002_O18_#0632-W385	Niskin#29	2014	09	28	12:54	65	46.46	N	168	47.19	W	15
MR14-05_St001_Cast002_O18_#0633-W386	Niskin#27	2014	09	28	12:54	65	46.46	N	168	47.19	W	20
MR14-05_St001_Cast002_O18_#0634-W387	Niskin#25	2014	09	28	12:54	65	46.46	N	168	47.19	W	30
MR14-05_St001_Cast002_O18_#0635-W388	Niskin#23	2014	09	28	12:54	65	46.46	N	168	47.19	W	40
MR14-05_St001_Cast002_O18_#0636-W389	Niskin#21	2014	09	28	12:54	65	46.46	N	168	47.19	W	Not sampled
MR14-05_St001_Cast002_O18_#0637-W390	Niskin#01	2014	09	28	12:54	65	46.46	N	168	47.19	W	B-10

4.6. Radionuclides

(1) Personnel

Yuichiro Kumamoto	JAMSTEC	- PI
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(2) Objective

Determination of activity concentrations of radionuclides, including radiocesium and radioiodine.

(3) Parameters

^{134}Cs, ^{137}Cs, and ^{129}I

(4) Instruments and Methods

a. Sampling

Seawater samples for the radionuclides were collected using 12-liter Niskin-X bottles and a bucket. In addition, surface seawater was also collected from continuous pumped-up water from about 4-m depth. The seawater sample was collected into a 20-L plastic container after two time washing. In our laboratory on shore, a seawater sample was divided into two for radiocesium (about 20-L) and radioiodine (about 1-L). The seawater for radiocesium was then acidified by 40-cm^3 of concentrated nitric acid. The seawater for radioiodine was siphoned into 1-L plastic bottle.

b. Preparation and analysis

In our laboratory on shore, radiocesium in the seawater samples will be concentrated using ammonium phosphomolybdate (AMP) that forms insoluble compound with cesium. The radiocesium (^{134}Cs and ^{137}Cs) in AMP will be measured using Ge γ-ray spectrometer. Measurements of radioiodine will be also conducted at our laboratory on shore. Iodine in the seawater samples is extracted by the solvent extraction technique. Extracted iodine is then precipitated as silver iodide by the addition of the silver nitrate. Iodine isotopic ratios (^{129}I/^{127}I) of the silver iodide are measured by the Accelerator Mass Spectrometry (AMS). To evaluate the ^{129}I concentration in the seawater samples, iodine concentration (^{127}I) will be measured by the inductively coupled plasma mass spectrometry (ICP-MS) and/or the voltammetry.

(5) Sample list

We collected 28 seawaters for the radionuclide measurement in Arctic Sea, Bering Sea, and northern North Pacific Ocean during this cruise (Table 4.6-1).

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC web site.

Table 4.6-1: Seawater samples collected for the radionuclide measurement.

No.	Station	Sampling depth (m)	Method	Latitude (N)	Longitude (E)	Date (UTC)
1	surface	4	pump	63.88	192.03	2 Sep. 2014
2	surface	4	pump	74.81	198.10	8 Sep. 2014
3	009	0	bucket	74.75	198.01	11 Sep. 2014
4	009	0	bucket	74.75	198.01	11 Sep. 2014
5	009	800	niskin	74.75	198.01	11 Sep. 2014
6	009	800	niskin	74.75	198.01	11 Sep. 2014
7	009	600	niskin	74.75	198.01	11 Sep. 2014
8	009	600	niskin	74.75	198.01	11 Sep. 2014
9	009	400	niskin	74.75	198.01	11 Sep. 2014
10	009	400	niskin	74.75	198.01	11 Sep. 2014
11	009	300	niskin	74.75	198.01	11 Sep. 2014
12	009	300	niskin	74.75	198.01	11 Sep. 2014
13	009	200	niskin	74.75	198.01	11 Sep. 2014
14	009	200	niskin	74.75	198.01	11 Sep. 2014
15	009	150	niskin	74.75	198.01	11 Sep. 2014
16	009	150	niskin	74.75	198.01	11 Sep. 2014
17	009	100	niskin	74.75	198.01	11 Sep. 2014
18	009	100	niskin	74.75	198.01	11 Sep. 2014
19	009	50	niskin	74.75	198.01	11 Sep. 2014
20	009	50	niskin	74.75	198.01	11 Sep. 2014
21	009	25	niskin	74.75	198.01	11 Sep. 2014
22	009	25	niskin	74.75	198.01	11 Sep. 2014
23	surface	4	pump	72.30	191.40	26 Sep. 2014

24	surface	4	pump	64.57	189.23	28 Sep. 2014
25	surface	4	pump	55.52	175.54	1 Oct. 2014
26	surface	4	pump	47.77	167.55	3 Oct. 2014
27	surface	4	pump	44.03	158.91	5 Oct. 2014
28	surface	4	pump	40.70	149.52	7 Oct. 2014

4.7. Pigment and images of planktons

4.7.1. Chlorophyll *a*

(1) Personnel

Shigeto Nishino	JAMSTEC	- PI
Hideki Yamamoto	MWJ	
Misato Kuwahara	MWJ	
Katsunori Sagishima	MWJ	
Shuichi Yohen	MWJ	

(2) Objective

Phytoplankton distributes in various species and sizes in the ocean were examined. Phytoplankton species are roughly characterized by the cell size. The objective of this study is to investigate the vertical and horizontal distributions of phytoplankton in the Arctic Ocean, in terms of phytoplankton pigment, chlorophyll *a*, by using the size-fractionated filtration method.

(3) Parameters

Total chlorophyll *a*

Size-fractionated chlorophyll *a*

(4) Instruments and methods

We collected samples for chlorophyll *a* (chl-*a*) from 8 – 13 depths and size-fractionated chl-*a* from 7 – 12 depths between the surface and 200 m depth including a chl-*a* maxmum layer at routine casts. 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. Water samples for size-fractionated chl-*a* were sequentially vacuum-filtrated (<0.02MPa) through the four types of 47mm-diameter Nylone filters (pore size of 20.0μm), 47mm-diameter nuclepore filters (pore size of 10μm and 2.0μm) and the 25mm-diameter Whatman GF/F filter. Phytoplankton pigments 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* for 24 hours or more.

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 4.7a-1.

(5) Results

Samples for total and size-fractionated chl-*a* were collected at 59 casts (See Fig. 4.7.1-1). The numbers of samples for total and size-fractionated chl-*a* were 826 and 1528, respectively.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in 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 4.7.1-1: 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

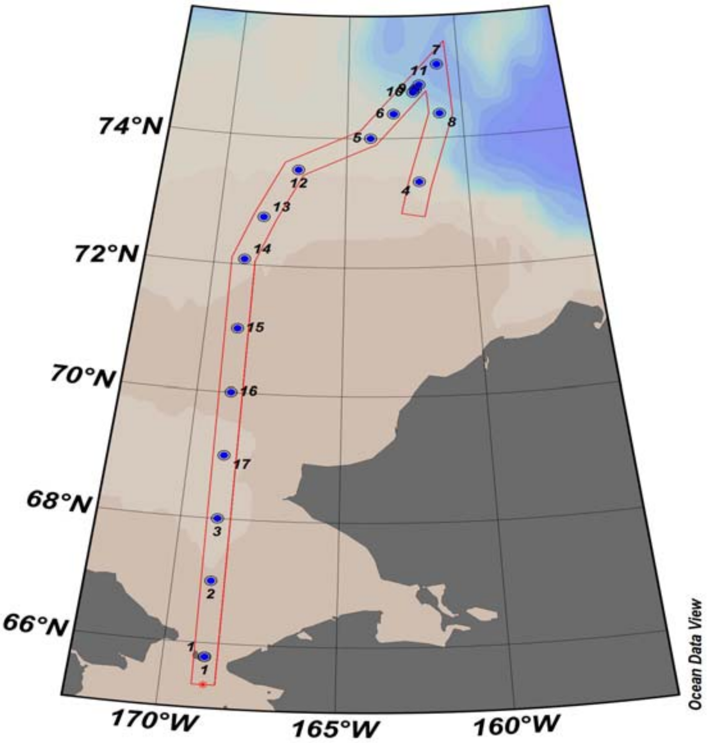


Figure 4.7.1-1:　Maps of stations for total and size-fractionated chlorophyll *a* measurements.

4.7.2. Plankton photographs

(1) Personnel

Hiroshi Uchida	JAMSTEC	- PI
Shigeto Nishino	JAMSTEC	

(2) Objective

To obtain images and components of planktons, photographs were taken by a camera with a microscope.

(3) Parameter

Plankton photographs

(4) Instruments and methods

Intake water or water from Niskin bottles or bucket, which was filtered through a funnel with 200 μm mesh, was collected in a 1L plastic bottle. The water in the bottle was condensed to be 10 mL through a filter with a pore size of 20 μm. The condensed water was pumped to a cell and planktons with sizes of 20 – 200 μm in the condensed water flowing in a cell was taken by a camera with a microscope (× 400).

(5) Observation log

The sampling list is summarized in Table 4.7.2-1.

(6) Data archives

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

Table 4.7.2-1: Sampling list for plankton photographs

On board ID	Sampling Method	Condensation rate	Date Collected				Latitude			Longitude			Depth [m]
			YYYY	MM	DD	hh:mm	Deg.	Min.	N/S	Deg.	Min.	E/W	
MR14-05_TSG_FlowCAM_#244-200034-P01	Intake	100	2014	09	01	15:36	58	12.71	N	167	31.37	W	0
MR14-05_TSG_FlowCAM_#245-092316-P02	Intake	100	2014	09	02	7:39	61	26.28	N	167	30.57	W	0
MR14-05_TSG_FlowCAM_#247-091513-P03	Intake	100	2014	09	03	9:53	66	25.06	N	168	48.50	W	0
MR14-05_St003_FlowCAM_#247-101854-P04	Bucket	100	2014	09	03	19:45	68	0.00	N	168	50.00	W	0
MR14-05_St003_FlowCAM_#247-110650-P05 (*Note1)	Niskin#25	100	2014	09	03	19:45	68	0.00	N	168	50.00	W	Chl-aMax(15m)
MR14-05_St003_FlowCAM_#248-110606-P06 (*Note2)	Niskin#02	100	2014	09	03	19:45	68	0.00	N	168	50.00	W	B-10
MR14-05_TSG_FlowCAM_#248-115633-P07	Intake	100	2014	09	05	8:21	72	30.57	N	159	50.28	W	0
MR14-05_TSG_FlowCAM_#250-085435-P08	Intake	100	2014	09	06	9:16	74	54.20	N	161	0.01	W	0
MR14-05_TSG_FlowCAM_#250-141004-P09	Intake	200	2014	09	07	11:11	74	45.18	N	162	2.40	W	0
MR14-05_St009_Cast004_FlowCAM_#250-150920-P10	Niskin#27	200	2014	09	07	11:38	74	45.00	N	162	0.00	W	Chl-aMax(32m)
MR14-05_TSG_FlowCAM_#251-145924-P11	Intake	200	2014	09	08	11:05	74	44.22	N	162	0.13	W	0
MR14-05_St009_Cast008_FlowCAM_#251-153159-P12	Niskin#27	200	2014	09	08	11:38	74	45.00	N	162	0.00	W	Chl-aMax(42m)
MR14-05_TSG_FlowCAM_#252-150145-P13	Intake	200	2014	09	09	11:07	74	44.62	N	161	59.60	W	0
MR14-05_St009_Cast012_FlowCAM_#252-153528-P14	Niskin#27	200	2014	09	09	11:39	74	45.00	N	162	0.00	W	Chl-aMax(27m)
MR14-05_TSG_FlowCAM_#253-145913-P15	Intake	200	2014	09	10	11:05	74	45.27	N	161	59.26	W	0
MR14-05_St009_Cast016_FlowCAM_#253-154315-P16	Niskin#36	200	2014	09	10	11:36	74	45.00	N	162	0.00	W	Chl-aMax(21m)
MR14-05_TSG_FlowCAM_#254-175435-P17	Intake	200	2014	09	11	11:18	74	45.04	N	161	59.78	W	0
MR14-05_St009_Cast020_FlowCAM_#254-192925-P18	Niskin#36	200	2014	09	11	11:35	74	45.00	N	162	0.00	W	Chl-aMax(60m)
MR14-05_TSG_FlowCAM_#256-100150-P19	Intake	200	2014	09	12	11:06	74	45.11	N	162	0.98	W	0

MR14-05_St009_Cast024_FlowCAM_#256-103340-P20	Niskin#36	200	2014	09	12	11:41	74	45.00	N	162	0.00	W	Chl-aMAX(57m)
MR14-05_TSG_FlowCAM_#256-112522-P21	Intake	200	2014	09	13	11:04	74	46.41	N	162	2.10	W	0
MR14-05_St009_Cast028_FlowCAM_#256-135011-P22	Niskin#36	200	2014	09	13	11:39	74	45.00	N	162	0.00	W	Chl-aMAX(60m)
MR14-05_TSG_FlowCAM_#xxx-xxxxxx-P23 (*Note3)	Intake	200	2014	09	14	12:11	74	45.11	N	162	0.67	W	0
MR14-05_St009_Cast032_FlowCAM_#xxx-xxxxxx-P24 (*Note3)	Niskin#36	200	2014	09	14	12:01	74	45.00	N	162	0.00	W	Chl-aMAX(61m)
MR14-05_TSG_FlowCAM_#258-115533-P25	Intake	200	2014	09	15	11:36	74	45.03	N	162	0.80	W	0
MR14-05_St009_Cast036_FlowCAM_#258-135848-P26	Niskin#36	200	2014	09	15	11:36	74	45.00	N	162	0.00	W	Chl-aMAX(60m)
MR14-05_TSG_FlowCAM_#259-112727-P27	Intake	200	2014	09	16	11:15	74	45.19	N	161	59.48	W	0
MR14-05_St009_Cast040_FlowCAM_#259-134911-P28	Niskin#36	200	2014	09	16	11:35	74	45.00	N	162	0.00	W	Chl-aMAX(52m)
MR14-05_TSG_FlowCAM_#260-115723-P29	Intake	200	2014	09	17	11:17	74	44.85	N	161	59.44	W	0
MR14-05_St009_Cast044_FlowCAM_#260-134816-P30	Niskin#36	200	2014	09	17	11:35	74	45.00	N	162	0.00	W	Chl-aMAX(45m)
MR14-05_TSG_FlowCAM_#261-112911-P31	Intake	200	2014	09	18	11:11	74	43.41	N	162	4.85	W	0
MR14-05_St009_Cast048_FlowCAM_#261-142057-P32	Niskin#36	200	2014	09	18	11:40	74	45.00	N	162	0.00	W	Chl-aMAX(28m)
MR14-05_St010_Cast001_FlowCAM_#261-175700-P33	Niskin#36	200	2014	09	18	15:01	74	41.92	N	162	7.66	W	Chl-aMAX(24m)
MR14-05_TSG_FlowCAM_#262-112734-P34	Intake	200	2014	09	19	11:08	74	45.31	N	161	58.60	W	0
MR14-05_St009_Cast052_FlowCAM_#262-135057-P35	Niskin#36	200	2014	09	19	11:41	74	45.00	N	162	0.00	W	Chl-aMAX(48m)
MR14-05_TSG_FlowCAM_#263-113526-P36	Intake	200	2014	09	20	11:11	74	45.55	N	162	1.15	W	0
MR14-05_TSG_FlowCAM_#264-115742-P37	Intake	200	2014	09	21	11:17	74	45.01	N	162	0.29	W	0
MR14-05_St009_Cast060_FlowCAM_#264-134552-P38	Niskin#36	200	2014	09	21	11:37	74	45.00	N	162	0.00	W	Chl-aMAX(56m)
MR14-05_TSG_FlowCAM_#265-122737-P39	Intake	200	2014	09	22	11:05	74	45.08	N	162	0.04	W	0

MR14-05_TSG_FlowCAM_#266-113025-P40	Intake	200	2014	09	23	11:14	74	45.01	N	161	59.93	W	0
MR14-05_St009_Cast068_FlowCAM_#266-134941-P41	Niskin#36	200	2014	09	23	11:37	74	45.00	N	162	0.00	W	Chl-aMAX(61m)
MR14-05_TSG_FlowCAM_#267-115707-P42	Intake	200	2014	09	24	11:09	74	44.47	N	162	0.74	W	0
MR14-05_St009_Cast072_FlowCAM_#267-140401-P43	Niskin#36	200	2014	09	24	11:38	74	45.00	N	162	0.00	W	Chl-aMAX(23m)
MR14-05_TSG_FlowCAM_#268-124833-P44	Intake	100	2014	09	25	11:14	73	46.01	N	165	26.46	W	0
MR14-05_TSG_FlowCAM_#269-141732-P45	Intake	100	2014	09	26	11:16	72	45.67	N	168	15.16	W	0
MR14-05_TSG_FlowCAM_#270-134613-P46	Intake	100	2014	09	27	11:13	69	30.66	N	168	47.64	W	0
MR14-05_St003_Cast002_FlowCAM_#271-022157-P47	Bucket	10	2014	09	27	23:16	68	0.00	N	168	50.00	W	0
MR14-05_St003_Cast002_FlowCAM_#271-033024-P48	Niskin#36	10	2014	09	27	23:16	68	0.00	N	168	50.00	W	Chl-aMax(25m)
MR14-05_St003_Cast002_FlowCAM_#271-044018-P49	Niskin#02	10	2014	09	27	23:16	68	0.00	N	168	50.00	W	B-10
MR14-05_TSG_FlowCAM_#271-114313-P50	Intake	10	2014	09	28	11:07	66	2.30	N	168	46.70	W	0
MR14-05_TSG_FlowCAM_#272-201633-P51	Intake	10	2014	09	29	6:40	63	3.01	N	173	20.66	W	0
MR14-05_TSG_FlowCAM_#273-111508-P52	Intake	10	2014	09	30	6:58	58	40.25	N	179	22.25	W	0
MR14-05_TSG_FlowCAM_#275-014534-P53	Intake	10	2014	10	01	17:39	52	49.58	N	171	39.67	E	0
MR14-05_TSG_FlowCAM_#275-104838-P54	Intake	10	2014	10	02	7:38	50	36.60	N	169	48.56	E	0
MR14-05_TSG_FlowCAM_#276-114958-P55	Intake	10	2014	10	03	7:40	46	54.62	N	166	51.59	E	0
MR14-05_TSG_FlowCAM_#277-091958-P56	Intake	100	2014	10	04	8:16	45	22.19	N	162	52.95	E	0
MR14-05_TSG_FlowCAM_#278-115532-P57	Intake	100	2014	10	05	8:51	43	45.35	N	158	03.03	E	0

*Note1: Cell was broken and replaced.

*Note2: Analysis was abnormally finished.

*Note3: Water was sampled but not analyzed.

4.8. Nitrogenous nutrients at nanomolar levels

(1) Personnel

Michiyo Yamamoto-Kawai	Tokyo Univ. Marine Science and Technology	- PI
Fuminori Hashihama	Tokyo Univ. Marine Science and Technology	
Shinji Takada	Tokyo Univ. Marine Science and Technology	

(2) Objective

In the Pacific sector of the Arctic Ocean, nitrogen is the limiting nutrients for primary production. During summer, concentrations of nitrogenous nutrients in surface waters are very low, usually near or below the detection limit of the common analytical system. However, significant concentration of chlorophyll *a* is often observed in these nitrogen depleted surface waters. In order to understand the supply of nitrogen to primary producers during summer, we analyze concentrations of nitrogenous nutrients in surface waters at very low concentration level (nmol/kg).

(3) Parameters

Nitrate, nitrite and ammonium at nanomolar levels

(4) Instruments and Methods

Seawater samples were collected by 12 L Niskin bottles mounted on the CTD-rosette system or by a bucket. Samples for nanomolar nutrients were drawn into 30 ml polypropylene tubes with polyethylene caps. Before each sampling, sample tubes were soaked in 2% Extran solution for at least two hours, rinsed with Milli-Q deionized water for 10 times, and kept with 3-5ml of 10% HCl until 1 or 2 hours before sampling. Samples are kept frozen (-20C) and will be analyzed on land with a highly sensitive colorimetric system [Hashihama, 2013 Oceanogr. Japan].

(5) Station list or Observation log

Total 471 samples from the upper ~50 m of the water column were taken for nanomolar nutrients from every CTD/rosette cast (except Cs cast and repeated casts at station 13) as listed in Table 4.8-1. Of these, 7 samples were taken in duplicate for precision analysis. For 8 casts at station 9, surface samples were taken from a regular bucket and also from a clean bucket prepared for PFASs sampling to check the influence of cleaning method.

Table 4.8-1: List of station/cast for nanomolar nutrient sampling.

Station-Cast	Date (UTC)	time	Lat [N]	Long [E]
1-1	09/03/2014	6:04	65.771	191.208
1-2	09/28/2014	12:57	65.775	191.215
2-1	09/03/2014	13:20	66.999	191.166
3-1	09/03/2014	19:54	68.000	191.166
3-2	09/27/2014	23:25	68.000	191.165
4-1	09/05/2014	13:55	73.330	198.001
5-1	09/05/2014	19:57	74.000	195.992
5-2	09/25/2014	8:07	74.000	195.998
6-1	09/05/2014	23:51	74.377	197.004
6-2	09/25/2014	4:27	74.375	196.990
7-1	09/06/2014	6:33	75.124	199.010
8-1	09/06/2014	12:56	74.374	199.002
9-2	09/07/2014	0:12	74.754	198.000
9-4	09/07/2014	11:50	74.752	197.983
9-6	09/07/2014	23:56	74.758	198.007
9-8	09/08/2014	11:52	74.749	198.000
9-10	09/09/2014	0:11	74.752	198.014
9-12	09/09/2014	11:53	74.751	198.006
9-14	09/09/2014	23:50	74.760	197.979
9-16	09/10/2014	11:49	74.755	198.008
9-18	09/11/2014	0:04	74.754	198.004
9-20	09/11/2014	11:49	74.754	197.999
9-22	09/11/2014	23:52	74.747	197.997
9-24	09/12/2014	11:54	74.754	197.986
9-26	09/13/2014	0:10	74.750	197.981
9-28	09/13/2014	11:53	74.754	197.968
9-30	09/13/2014	23:49	74.746	197.992
9-32	09/14/2014	12:15	74.752	197.989
9-34	09/15/2014	0:07	74.752	197.985
9-36	09/15/2014	11:49	74.753	197.980
9-38	09/15/2014	23:53	74.750	198.010
9-40	09/16/2014	11:48	74.751	198.010
9-42	09/17/2014	0:08	74.749	198.005
9-44	09/17/2014	11:49	74.747	197.996
9-46	09/17/2014	23:49	74.748	198.004
9-48	09/18/2014	11:57	74.749	197.972
9-50	09/19/2014	0:08	74.749	197.987
9-52	09/19/2014	11:55	74.748	197.973
9-54	09/19/2014	23:53	74.752	197.996
9-56	09/20/2014	11:52	74.752	197.993
9-60	09/21/2014	11:50	74.751	197.987
9-62	09/22/2014	0:11	74.749	198.016
9-64	09/22/2014	11:49	74.754	197.991
9-66	09/23/2014	0:05	74.751	198.010
9-68	09/23/2014	11:50	74.750	198.007
9-70	09/23/2014	23:50	74.748	198.001
9-72	09/24/2014	11:51	74.751	198.001
9-74	09/25/2014	0:11	74.752	198.017
10-1	09/18/2014	15:16	74.701	197.867
11-1	09/20/2014	3:23	74.819	198.162
12-1	09/25/2014	14:19	73.500	193.001
13-1	09/25/2014	19:40	72.750	191.752
14-1	09/26/2014	19:09	72.083	191.166
15-1	09/27/2014	2:32	71.001	191.167
16-1	09/27/2014	8:15	70.001	191.178
17-1	09/27/2014	15:14	69.002	191.168

(6) Data Archives

All data will be submitted to the Data Management Group (DMG) of JAMSTEC when ready.

4.9. Phytoplankton community

(1) Personnel

Michiyo Yamamoto-Kawai	Tokyo Univ. Marine Science and Technology	- PI
Fuminori Hashihama	Tokyo Univ. Marine Science and Technology	
Shinji Takada	Tokyo Univ. Marine Science and Technology	

(2) Objective

To investigate the response of phytoplankton community to nutrient supply during summer, seawater samples for microscopy, DNA and HPLC analysis were collected. Results will be analyzed with distributions of nitrogenous nutrients at nanomolar levels (section 4.8).

(3) Parameters

Phytoplankton community (microscopy and DNA)

Phytoplankton pigments (HPLC)

(4) Instruments and Methods

Seawater samples were collected from 5 m and the depth of subsurface chlorophyll *a* maximum using 12L-niskin bottles mounted on a CTD system. The Chl *a* maximum layer was determined at each station based on a fluorometer (Seapoint Sensors, Inc.) attached to the CTD system. For microscopic analysis, 1 L of seawater was refrigerated after adding 5 mL of acidified Lugol's solution. For DNA and HPLC analysis, samples were gently filtered (<0.02 MPa) through a 25mm-diameter Whatman GF/F filter and a 47-mm diameter Whatman Nuclepore filter (0.2 µm pore size), respectively. Filters with concentrated phytoplankton were then stored in liquid N_2 for at least 1 day and then stored in a deep freezer at -80°C. All samples will be analyzed on land after the cruise.

(5) Station list or Observation log

Total 122, 122, and 106 samples were processed for DNA, HPLC and microscopic analysis, respectively. Stations/casts for these sampling are listed in Table 4.9-1.

(6) Data Archives

All data will be submitted to the Data Management Group (DMG) of JAMSTEC when ready.

Table 4.9-1:List of stations/casts for sampling for HPLC, DNA and microscopic analysis.

Station−Cast	Date (UTC)	time	Lat [N]	Long [E]	HPLC/DNA	Microscopy
1−1	09/03/2014	6:04	65.7706	191.2076	x	x
1−2	09/28/2014	12:57	65.7748	191.2149	x	
2−1	09/03/2014	13:20	66.9994	191.1662	x	x
3−1	09/03/2014	19:54	67.9997	191.1657	x	x
3−2	09/27/2014	23:25	67.9996	191.165	x	
4−1	09/05/2014	13:55	73.3297	198.0007	x	x
5−1	09/05/2014	19:57	74	195.9922	x	x
5−2	09/25/2014	8:07	73.9997	195.9979	x	x
6−1	09/05/2014	23:51	74.377	197.004	x	x
6−2	09/25/2014	4:27	74.3749	196.9901	x	x
7−1	09/06/2014	6:33	75.124	199.0098	x	x
8−1	09/06/2014	12:56	74.3744	199.0021	x	x
9−2	09/07/2014	0:12	74.7539	198.0003	x	x
9−2	09/07/2014	0:12	74.7539	198.0003	x	x
9−4	09/07/2014	11:50	74.752	197.9826	x	x
9−6	09/07/2014	23:56	74.7577	198.0071	x	x
9−8	09/08/2014	11:52	74.7492	198.0002	x	x
9−10	09/09/2014	0:11	74.7521	198.0142	x	x
9−12	09/09/2014	11:53	74.7511	198.0061	x	x
9−14	09/09/2014	23:50	74.7604	197.9792	x	x
9−16	09/10/2014	11:49	74.7554	198.0084	x	x
9−18	09/11/2014	0:04	74.7535	198.0041	x	x
9−20	09/11/2014	11:49	74.754	197.999	x	x
9−22	09/11/2014	23:52	74.7466	197.9966	x	x
9−24	09/12/2014	11:54	74.7541	197.9858	x	x
9−26	09/13/2014	0:10	74.7501	197.9813	x	x
9−28	09/13/2014	11:53	74.7535	197.9684	x	x
9−30	09/13/2014	23:49	74.7462	197.9923	x	x
9−32	09/14/2014	12:15	74.7524	197.9885	x	x
9−34	09/15/2014	0:07	74.7519	197.9847	x	x
9−36	09/15/2014	11:49	74.7526	197.9802	x	x
9−38	09/15/2014	23:53	74.7498	198.0095	x	x
9−40	09/16/2014	11:48	74.7505	198.0096	x	x
9−42	09/17/2014	0:08	74.7489	198.0052	x	x
9−44	09/17/2014	11:49	74.7468	197.9955	x	x
9−46	09/17/2014	23:49	74.7478	198.0044	x	x
9−48	09/18/2014	11:57	74.7491	197.9722	x	x
9−50	09/19/2014	0:08	74.7488	197.9872	x	x
9−52	09/19/2014	11:55	74.7482	197.9729	x	x
9−54	09/19/2014	23:53	74.7515	197.996	x	x
9−56	09/20/2014	11:52	74.7515	197.9934	x	x
9−60	09/21/2014	11:50	74.7505	197.9873	x	x
9−62	09/22/2014	0:11	74.7485	198.0159	x	x
9−64	09/22/2014	11:49	74.7535	197.9907	x	x
9−66	09/23/2014	0:05	74.7511	198.0098	x	x
9−68	09/23/2014	11:50	74.7495	198.0069	x	x
9−70	09/23/2014	23:50	74.7479	198.0013	x	x
9−72	09/24/2014	11:51	74.7505	198.0014	x	x
9−74	09/25/2014	0:11	74.7523	198.0169	x	x
10−1	09/18/2014	15:16	74.701	197.8673	x	x
11−1	09/20/2014	3:23	74.8194	198.1621	x	x
12−1	09/25/2014	14:19	73.5001	193.0011	x	
13−1	09/25/2014	19:40	72.7501	191.7523	x	
14−1	09/26/2014	19:09	72.0834	191.1664	x	
15−1	09/27/2014	2:32	71.0005	191.167	x	
16−1	09/27/2014	8:15	70.0011	191.1777	x	
17−1	09/27/2014	15:14	69.002	191.168	x	

4.10. Underway surface water monitoring

(1) Personnel

Shigeto Nishino	JAMSTEC	-PI
Hiroshi Uchida	JAMSTEC	
Kanako Yoshida	WMJ	
Keitaro Masumoto	MWJ	
Haruka Tamada	MWJ	

(2) Objective

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

(3) Parameters

Temperature (surface water)
Salinity (surface water)
Dissolved oxygen (surface water)
Fluorescence (surface water)
Nitrate (surface water)

(4) 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 $dm^3\ min^{-1}$.

A chemical-free nitrate sensor was also used with the Continuous Sea Surface Monitoring System. The nitrate sensor was attached using a flow cell next to the thermo-salinograph.

a. Instruments

Software

Seamoni-kun Ver.1.50

Sensors

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

Temperature and Conductivity sensor

Model:	SBE-45, SEA-BIRD ELECTRONICS, INC.
Serial number:	4557820-0319
Measurement range:	Temperature -5 to +35 ^{o}C
	Conductivity 0 to 7 S m^{-1}
Initial accuracy:	Temperature 0.002 ^{o}C
	Conductivity 0.0003 S m^{-1}
Typical stability (per month):	Temperature 0.0002 ^{o}C
	Conductivity 0.0003 S m^{-1}
Resolution:	Temperatures 0.0001 ^{o}C
	Conductivity 0.00001 S m^{-1}

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

Dissolved oxygen sensor

Model:	OPTODE 3835, AANDERAA Instruments.
Serial number:	1519
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

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

Fluorometer

Model: C3, TURNER DESIGNS

Serial number: 2300123

Nitrate sensor

Model: Deep SUNA, SATLANTIC, LP.

Serial number: 0385

(5) Observation log

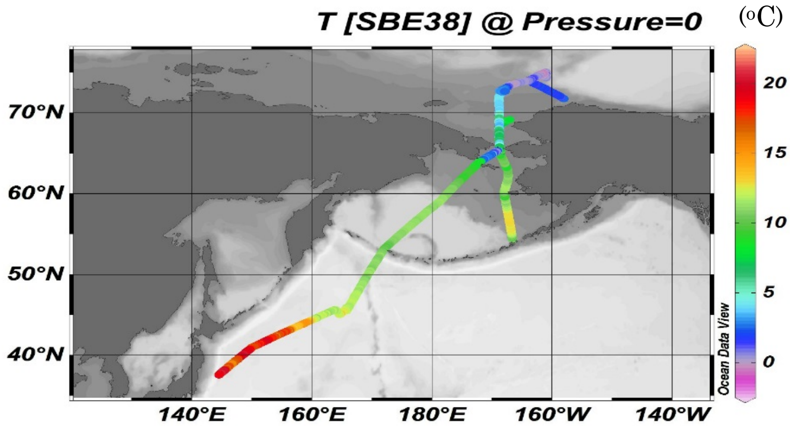
Periods of measurement, maintenance, and problems during MR14-05 are listed in Table 4.10-1.

Table 4.10-1: Events list of the Sea surface water monitoring during MR14-05

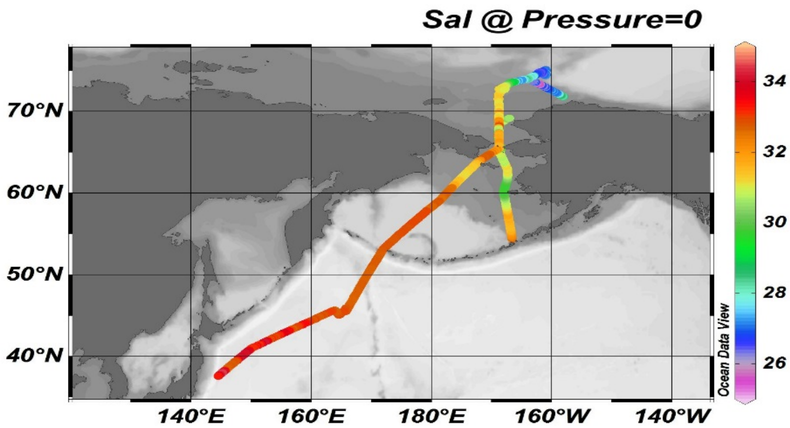
System Date [UTC]	System Time [UTC]	Events	Remarks
2014/08/31	20:47	All the measurements started and data was available.	Cruise start
2014/09/04	02:44	All the measurements stopped.	Filter Cleaning Change OPTODE sensor to S/N985.
2014/09/05	03:40	All the measurements started.	Logging restart
2014/09/05	16:13	Optode correspondence stopped.	
2014/09/05	17:53	All the measurements stopped.	Change OPTODE sensor to S/N1519.
2014/09/05	19:19	All the measurements started.	Logging restart
2014/09/24	02:31	All the measurements stopped.	Filter Cleaning
2014/09/25	00:40	All the measurements started.	Logging restart
2014/10/08	06:00	All the measurements stopped.	Cruise end

We took the surface water samples once a day to compare sensor data with bottle data of salinity, dissolved oxygen, chlorophyll *a* and nitrate. The results are shown in Fig. 4.10 -2. All the salinity samples were analyzed by the Guideline 8400B "AUTOSAL" (see 3.6), and dissolve oxygen samples were analyzed by Winkler method (see 4.1), chlorophyll *a* were analyzed by 10-AU (see 4.7), and nitrate were analyzed by QuAAtro (see 4.8).

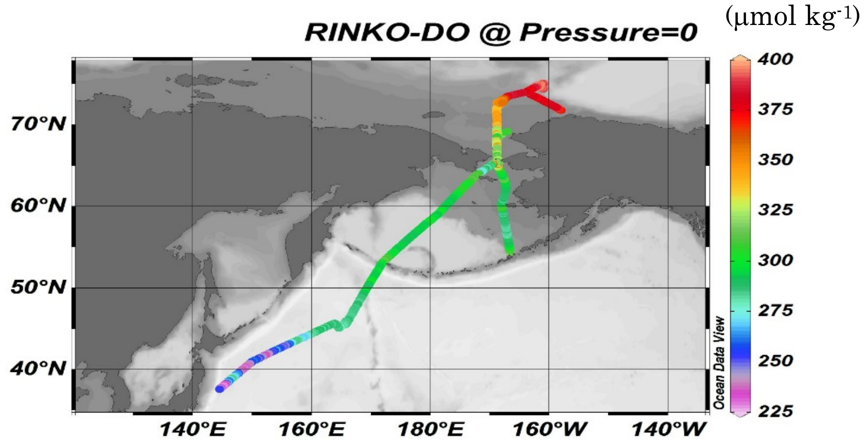
(a)



(b)



(c)



(d)

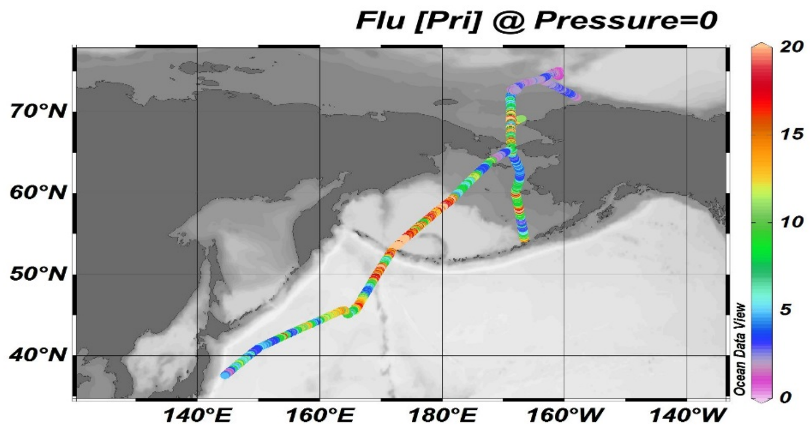


Figure 4.10-1: Spatial and temporal distribution of (a) temperature, (b) salinity, (c) dissolved oxygen, and (d) fluorescence in MR14-05 cruise.

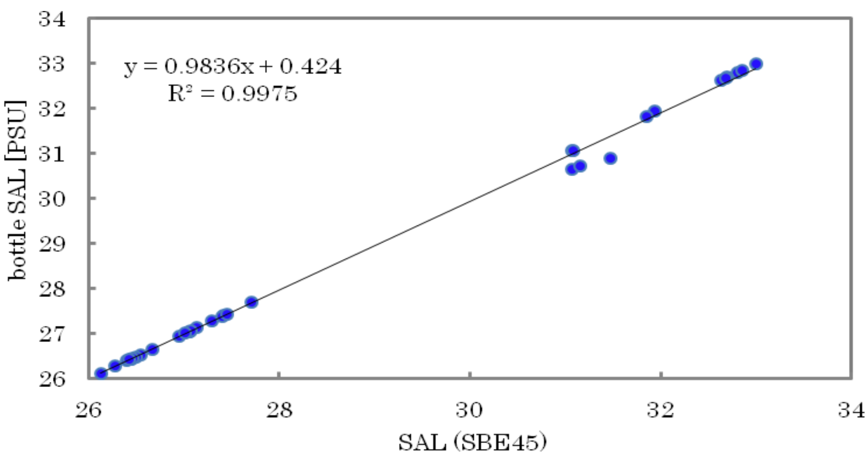
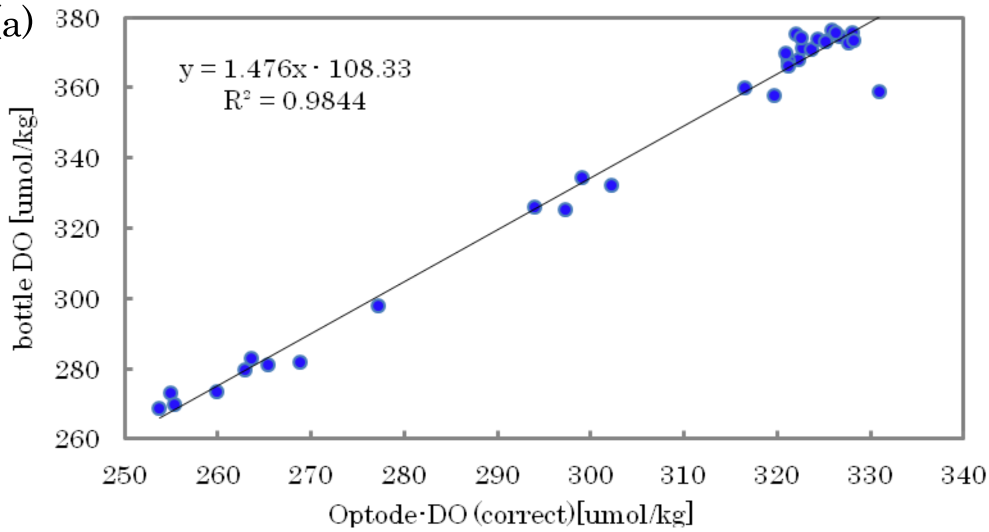


Figure 4.10-2-1: Correlation of salinity between sensor data and bottle data.

(a)



(b)

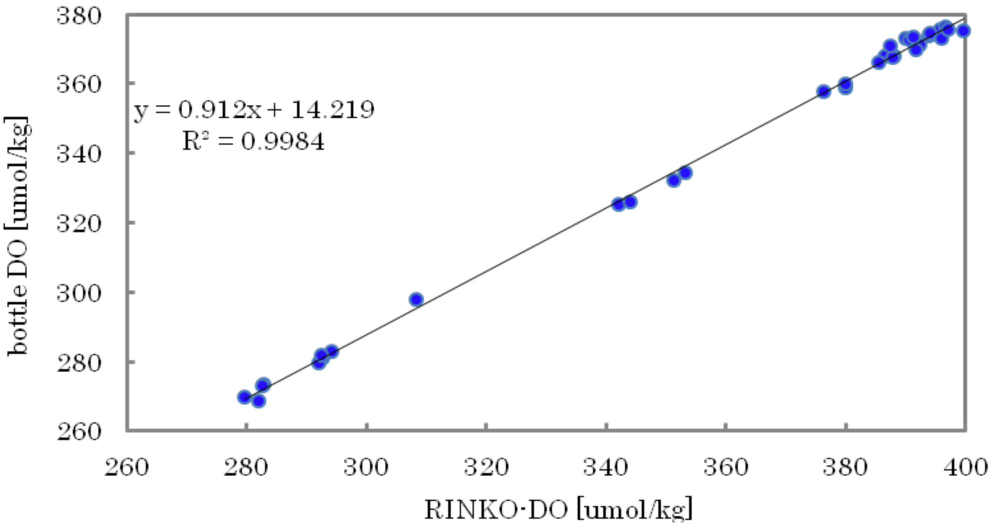
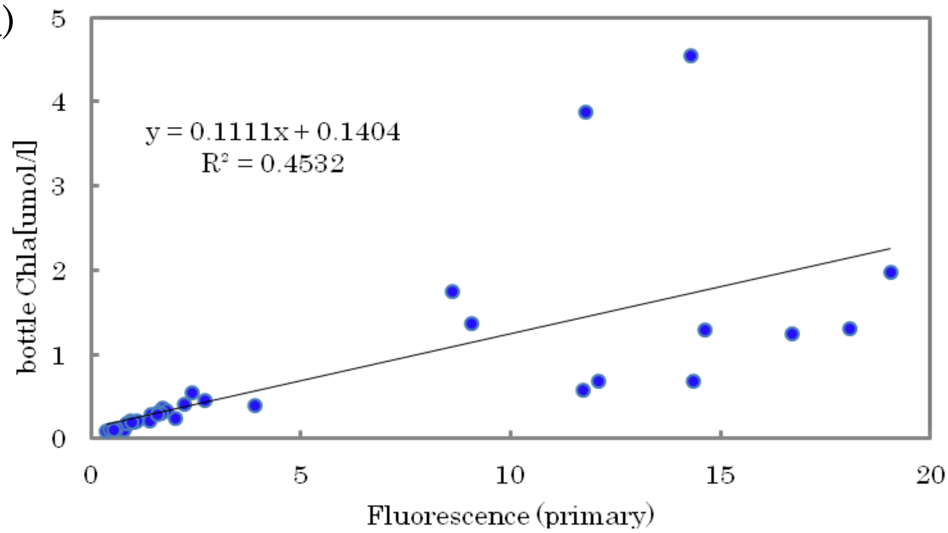


Figure 4.10-2-2: Correlation of dissolved oxygen between sensor data and bottle data.
(a: OPTODE, b: RINKO)

(a)



(b)

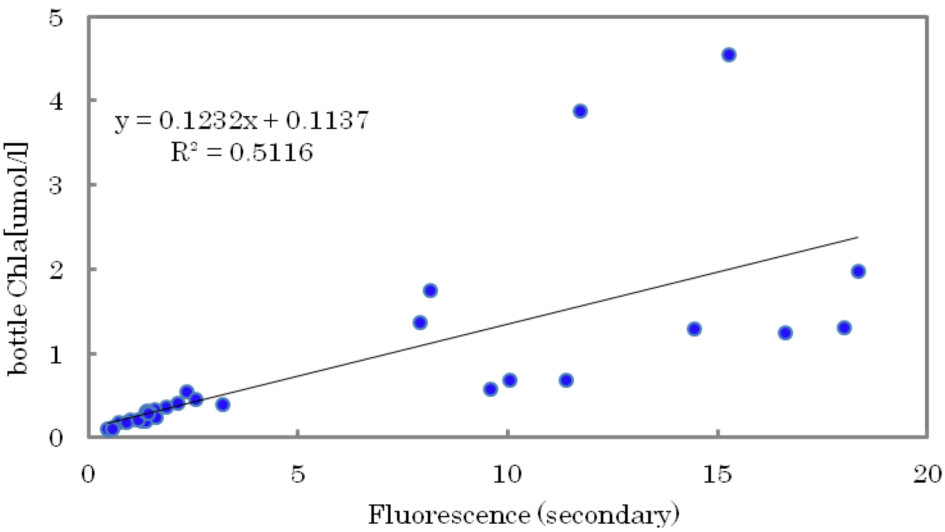


Figure 4.10-2-3: Correlation of fluorescence between sensor data and bottle data. (a: Primary Sensor, b: Secondary Sensor)

(6) Post-cruise calibration

Data from the Continuous Sea Surface Water Monitoring System were processed as follows. Spikes in the temperature and salinity data were removed using a median filter with a window of 3 scans (3 minutes) when difference between the original data and the median filtered data was larger than 0.1 °C for temperature and 0.5 for salinity. Data gaps were linearly interpolated when the gap was ≤ 13 minutes. Fluorometer data were low-pass filtered using a median filter with a window of 3 scans (3 minutes) to remove spikes. Raw data from the RINKO oxygen sensor, fluorometer and nitrate data were low-pass filtered using a Hanning filter with a window of 15 scans (15 minutes).

Salinity (S [PSU]), dissolved oxygen (O [μmol/kg]), fluorescence (Fl [RFU]), and nitrate (NRA [μmol/kg]) data were corrected using the water sampled data. Corrected salinity (S_{cor}), dissolved oxygen (O_{cor}), estimated chlorophyll *a* (Chl-a), and nitrate (NRA_{cor}) were calculated from following calibration equations

$$S_{cor}\ [PSU] = c_0 + c_1\ S + c_2\ t$$

$$O_{cor}\ [\mu mol/kg] = c_0 + c_1\ O + c_2\ T + c_3\ t$$

$$\text{Chl-a}\ [\mu g/L] = c_0 + c_1\ Fl$$

$$NRA_{cor}\ [\mu mol/kg] = NRA + c_0 + c_1\ t$$

where S is practical salinity, t is days from a reference time (2014/08/31 20:47 [UTC]), T is temperature in °C. The best fit sets of calibration coefficients (c_0~c_3) were determined by a least square technique to minimize the deviation from the water sampled data. The calibration coefficients were listed in Table 4.10-2. Comparisons between the Continuous Sea Surface Water Monitoring System data and water sampled data are shown in from Figs. 4.10-3-1 to 4.10-3-4.

For fluorometer data, sensitivity of the fluorometer to chlorophyll *a* may be different for the Arctic Ocean (latitude ≥ 61°N) and for the other area (latitude ≤ 60°N). Therefore, the calibration coefficients were changed for latitude range (Table 4.10-2). For latitude between 60 °N and 61 °N, chlorophyll *a* was estimated from weighted mean of the two equations as

$$\text{Chl-a} = \text{Chl-a}_1\ f_1 + \text{Chl-a}_2\ f_2$$

$$f_1 = 1 - (\text{Latitude} - 60°N)$$

$$f_2 = 1 - f_1$$

where Chl-a1 is chlorophyll *a* calculated by using the set of coefficients A, and Chl-a_2 is chlorophyll *a* calculated by using the set of coefficients B (Table 4.10-2). The fluorometer data was abnormally oscillated for the period: $2.88541 \leq t < 4.13403$ and the data quality flag was set to 3 (questionable) for the period.

Nitrate data for the period $t \geq 35$ were drifted in time (Fig. 4.10-3-4) and couldn't be corrected since water sampled data wasn't available for the period. Therefore, the data quality flag was set to 3 (questionable) for the period.

Table 4.10-2: Calibration coefficients for the salinity, oxygen, chlorophyll *a*, and nitrate.

c0	c1	c2	c3	Note
Salinity				
0.383848	1.00148	2.36859e-5		for t ≤ 2.92014
0.528048	1.00148	2.36859e-5		for 2.92014 < t ≤ 4.13403
-3.39525e-2	1.00148	2.36859e-5		for t ≥ 4.13403
Oxygen				
2.75626	0.939702	0.241297	3.48784e-2	
Chlorophyll a (set A for latitude ≤ 60°N)				
1.17569e-2	5.34644e-2			for Fl ≤ 13 [RFU]
-1.42304	0.164080			for Fl > 13 [RFU]
Chlorophyll a (set B for latitude ≥ 61°N)				
1.17569e-2	0.175650			for Fl ≤ 9 [RFU]
-2.84817	0.493130			for Fl > 9 [RFU]
Nitrate				
4.56926	-0.152014			for t < 4
1.10871	0.0810544			for 4 ≤ t < 13.3
-2.03342	0.317305			for 13.3 ≤ t < 24.15
-8.67279	0.398732			for t ≥ 24.15

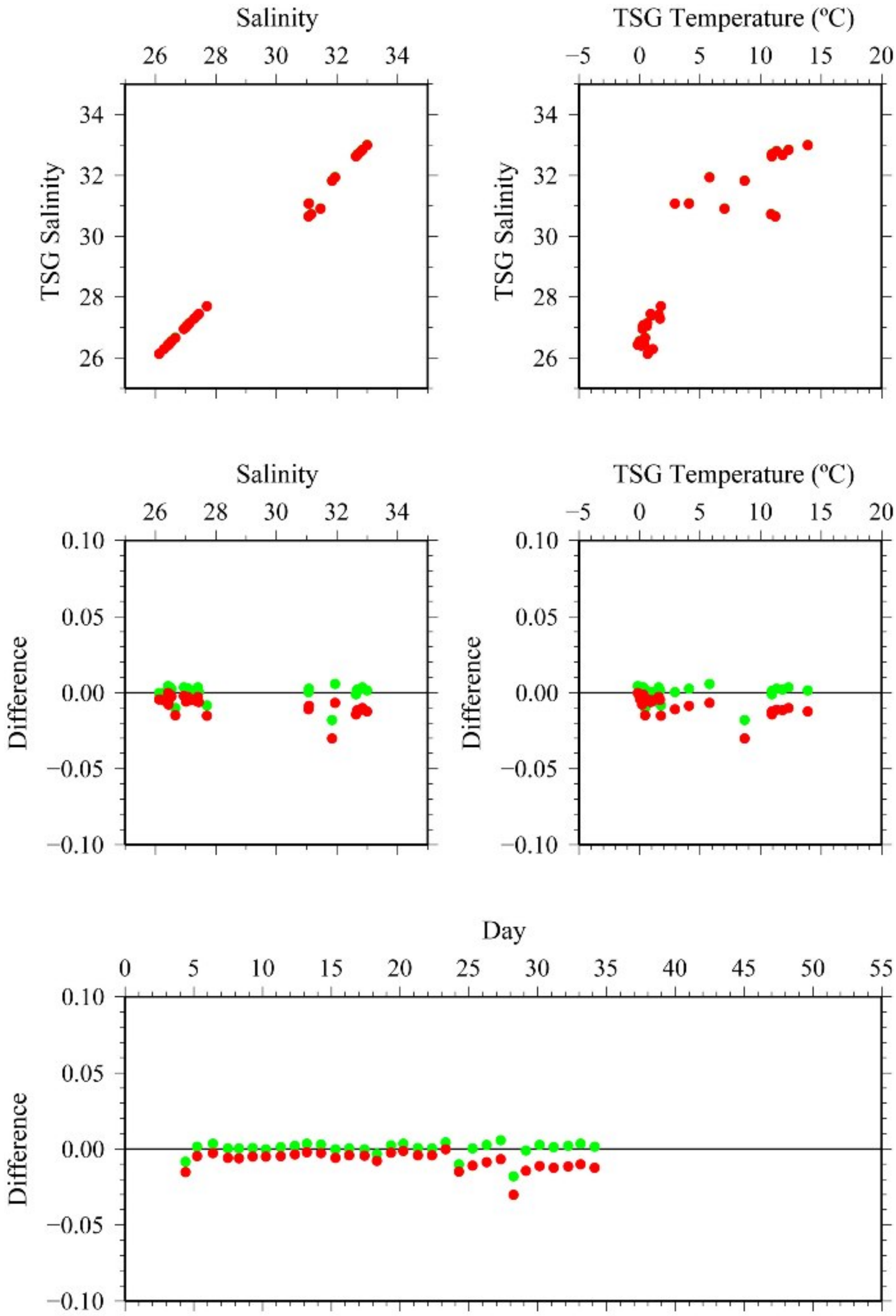


Figure 4.10-3-1: Comparison between TSG salinity (red: before correction, green: after correction) and sampled salinity.

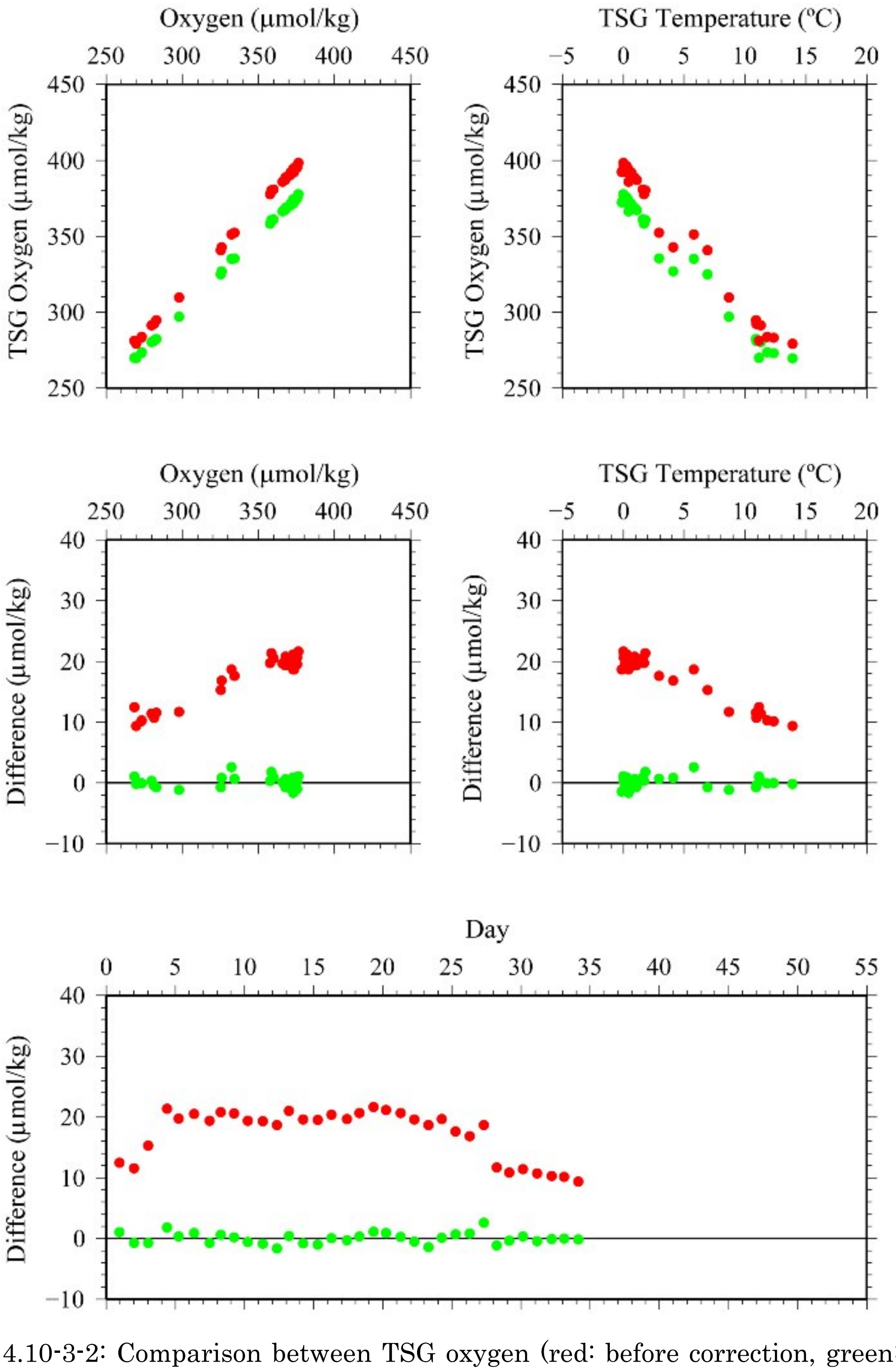


Figure 4.10-3-2: Comparison between TSG oxygen (red: before correction, green: after correction) and sampled oxygen.

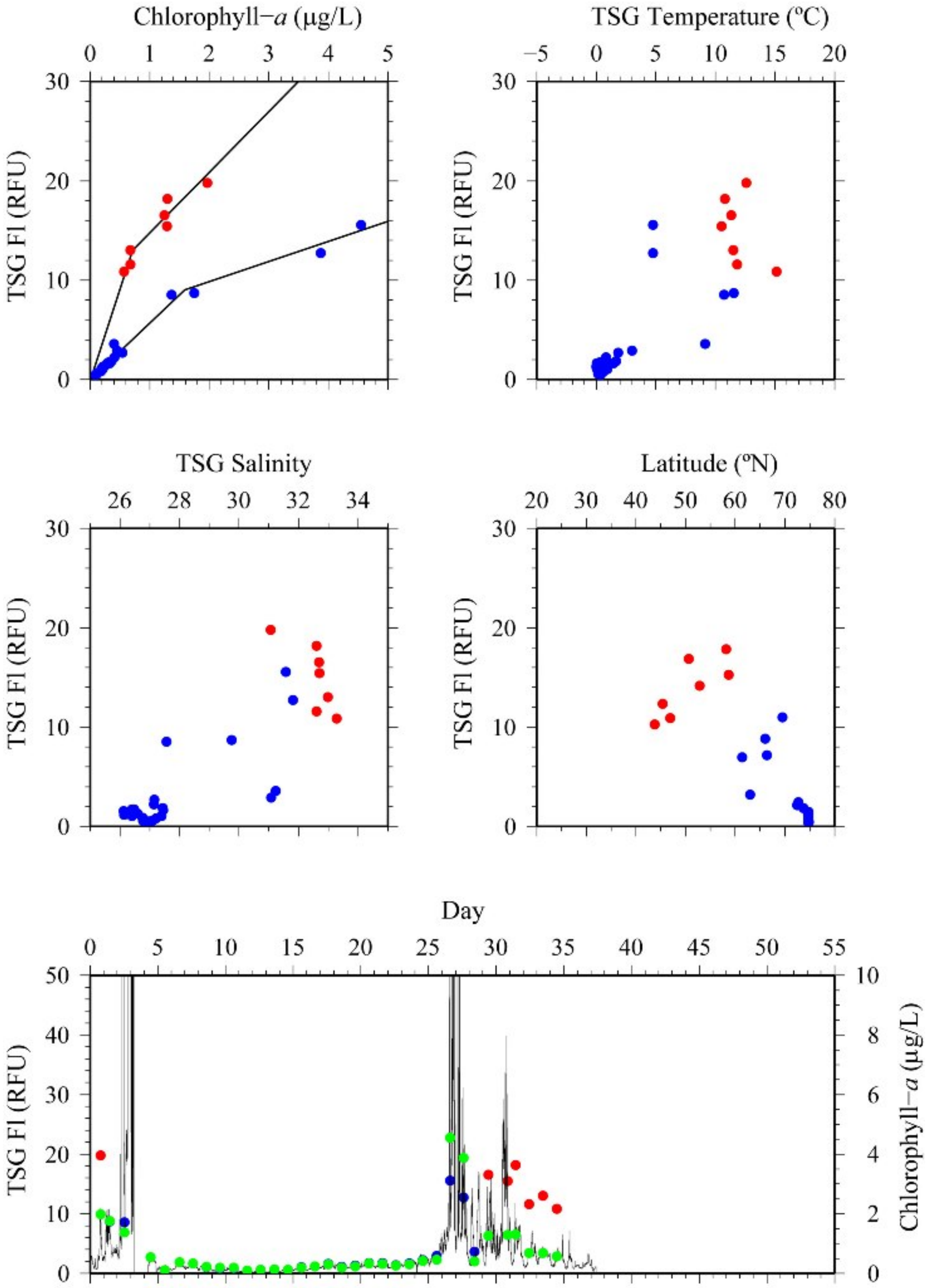


Figure 4.10-3-3: Comparison between TSG fluorescence and sampled chlorophyll a. Blue dots indicate data obtained at latitude higher than 61ºN and red dots indicate data obtained at latitude lower than 60ºN. For bottom panel, blue or red dots indicate fluorescence and green dots indicate water sampled chlorophyll *a*. Line indicates chlorophyll *a* estimated from fluorometer.

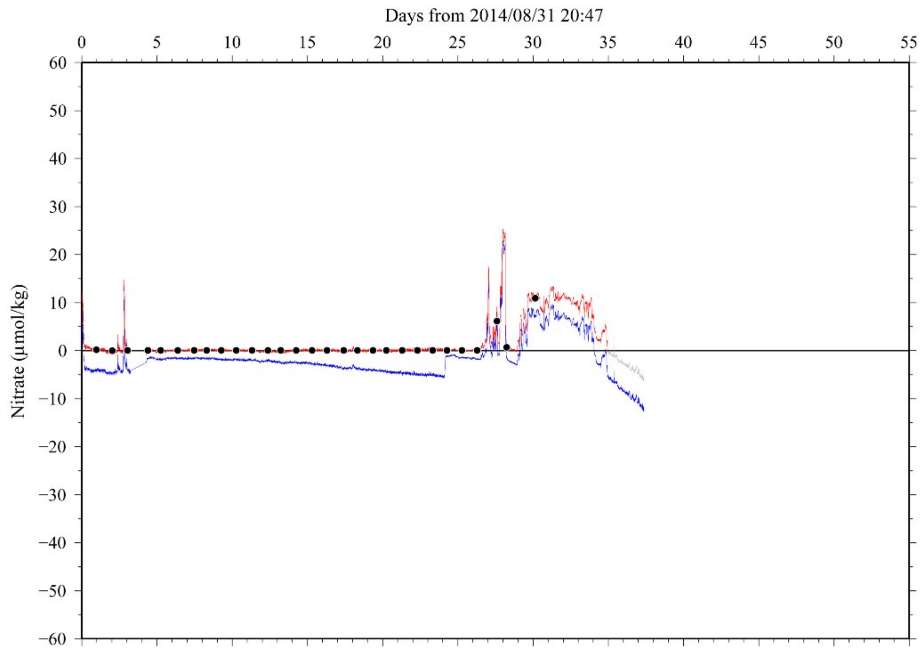


Figure 4.10-3-4: Comparison between TSG nitrate (blue line: before correction, red and gray lines: after correction) and sampled nitrate (dots). Gray line indicates questionable data obtained during following period: $t \geq 35$.

(7) Data archive

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

4.11. Dissolved greenhouse Gases

4.11.1. Underway measurement of surface water for pCO_2/pCH_4

(1) Personnel

Shuji Aoki	Tohoku University	- PI
Masao Ishii	Meteorological Research Institute / JMA	
Daisuke Sasano	Meteorological Research Institute / JMA	
Naohiro Kosugi	Meteorological Research Institute / JMA	
Hisayuki Yoshikawa-Inoue	Hokkaido University	
Hiroshi Uchida	JAMSTEC	

(2) Objective

The ocean has strong interactions with the atmosphere and absorbs a significant fractions of increasing anthropogenic CO_2. Although it is believed that the Arctic Ocean is playing an important role for the variations of greenhouse gases in the atmosphere, their spatial and temporal variations there is not well known. Furthermore, recent decline of sea ice in the Arctic Ocean is likely to alter the air-sea interaction because of an expansion of the sea ice-free area and period. These changes will affect global carbon cycle.

Recently, a new analyzer for WS-CRDS was developed on the basis of Cavity Ring-Down Spectroscopy. The advantage of this analyzer is a high precision and stability. In addition, the analyzer can simultaneously measure other trace gases such as CH_4. In this study, we challenge to apply WS-CRDS to the underway measurements of pCO_2 and pCH_4 in the atmosphere and in surface seawater to clarify the distributions of pCO_2 and pCH_4 and their controlling mechanisms in the Arctic Ocean.

(3) Parameters

Partial pressure of CO_2 (pCO_2) and CH_4 (pCH_4) in the atmosphere and in near-surface seawater.

(4) Instruments and Methods

We made simultaneous measurements of the CO_2 and CH_4 concentrations in the dry air equilibrated with the great excess of surface seawater during the whole cruise using an automated measuring system (Nippon ANS Co.). Seawater was taken continuously from the seachest located ca.4.5 m below the sea level and introduced into the MRI-shower-type equilibrator. Wavelength-scanned cavity ring-down spectrometer (Los Gatos Research, Greenhouse Gas Analyzer) was used as a detector. We used three standard gases with known CO_2 and CH_4 mixing ratios once a day. Corrections for the temperature-rise from the seachest to the equilibrator are also to be made. Partial pressure of CO_2 and CH_4 will be calculated from the concentration of CO_2 and CH_4 by taking the water vapor pressure and the atmospheric pressure into account.

(5) Station list or Observation log

Continuous observation has started on September 1st (UTC). But leakage in system was detected on September 10th (UTC). Oceanic pCO_2 was raised by atmosphere in the room by 20-30 μatm before that. The observation has finished on October 8th.

Figure 4.11.1-1 shows pCO_2 and pCH_4 around fixed station in the period from September 11th to September 25th (UTC). Figure 4.11.1.2 shows spatial distributions of pCO_2 and pCH_4 in the Arctic Ocean, Bering Sea and North Pacific from September 25th (UTC) to October 7th (UTC).

(6) Data archives

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

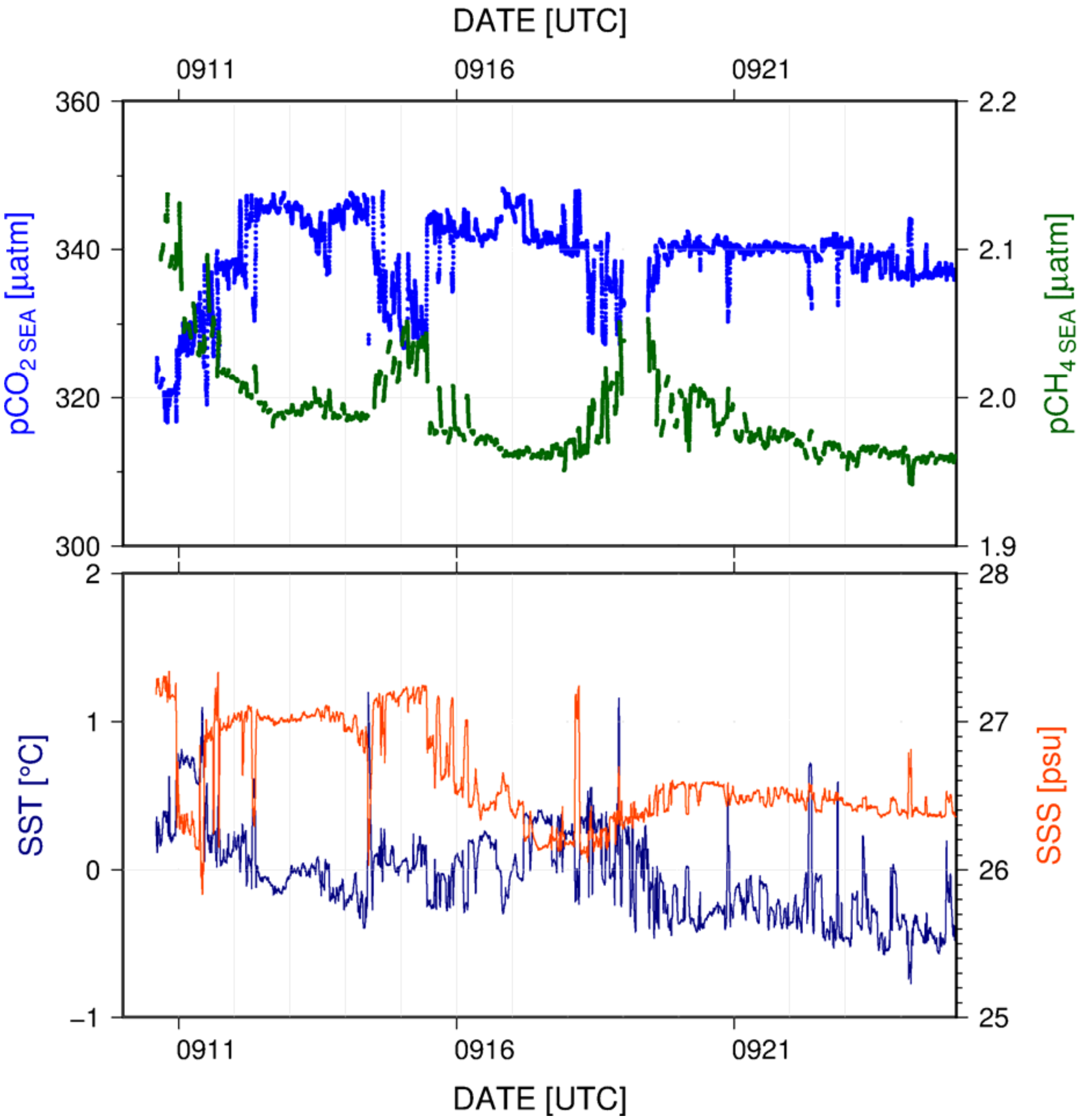


Figure 4.11.1-1: (Top) Variation of pCO_2 (blue dots; left axis) and pCH_4 (green dots; right axis). (Bottom) Sea surface temperature (blue line; left axis) and sea surface salinity (orange line; right axis) at the fixed point.

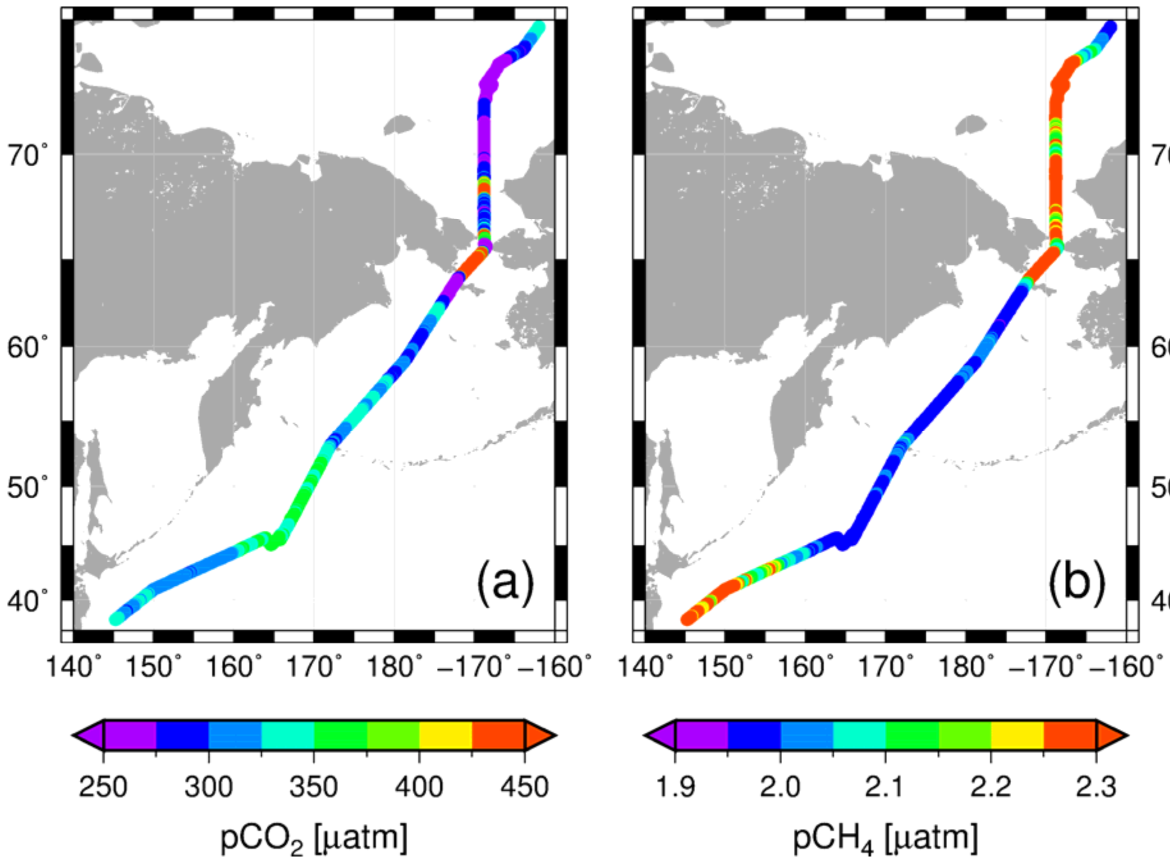


Figure 4.11.1-2: Spatial distributions of (a) pCO_2 and (b) pCH_4 in the Arctic Ocean, the Bering Sea and North Pacific after September 25th (UTC).

4.11.2. Discrete bottle sampling for CH_4, N_2O and their isotopomers

(1) Personnel

Sakae Toyoda	Interdisciplinary Graduate School of Science and Engineering Tokyo Institute of Technology - PI
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Keita Yamada	Interdisciplinary Graduate School of Science and Engineering Tokyo Institute of Technology
Florian Breider	Interdisciplinary Graduate School of Science and Engineering Tokyo Institute of Technology
Naohiro Yoshida	Interdisciplinary Graduate School of Science and Engineering Tokyo Institute of Technology

(2) Objective

Methane (CH_4) and nitrous oxide (N_2O) are increasing greenhouse gases, and N_2O is also the most important ozone-depleting gas in the stratosphere (IPCC, 2013; Ravishankara et al., 2009). Atmospheric concentrations of CH_4 and N_2O were respectively 1803 and 324 ppb in 2011, and have increased by about 150% and 20%, respectively, since 1750 (IPCC, 2013). Although the increase of CH_4 and N_2O is mainly caused by anthropogenic emissions such as agriculture and fossil fuel combustion, they are biogenically produced or consumed, and emitted from various sources including oceans. Several studies have reported over-saturation of CH_4 and N_2O with respect to atmospheric equilibrium in the surface water of several regions in the Arctic Ocean (Kitidis et al., 2010 and references therein). Sources of CH_4 in the Arctic Ocean include degradation of subsea permafrost on the eastern Siberian shelf (ESAS) (Shakhova et al., 2010), aerobic CH_4 production by methylotrophic methanogenesis in the central Arctic Ocean (Damm et al., 2010). There is also a report on absorption of atmospheric CH_4 by sea ice and CH_4 is potentially oxidized by photochemical and biochemical reactions (He et al., 2013). On the other hand, a study conducted in the Bering and Chukchi Seas suggested that N_2O is primarily produced through denitrification in sediments. (Hirota et al., 2009). In this study, we aimed (1) to reveal the horizontal and vertical distributions of CH_4 and N_2O in the Bering Strait and the Chukchi Sea, (2) to analyze their production or consumption processes based on relative abundance of isotopomers, isotope-substituted molecules such as $^{13}CH_4$, CH_3D, ^{15}NNO, $N^{15}NO$, and $NN^{18}O$, and (3) to examine year-to-year variation by comparing the results obtained with samples collected in previous cruises (MR12-E03 and MR13-06) in the Arctic Ocean.

(3) Parameters

Concentration, stable carbon and hydrogen isotope ratios of dissolved CH_4

Concentration, stable nitrogen and oxygen isotope ratios including ^{15}N-site preference (SP) in dissolved N_2O

(4) Instruments and Methods

Seawater samples were collected using CTD-CAROUSEL system equipped with 12-L Niskin bottles. Surface water were also sampled with a bucket. Sampling locations and depth profile are listed in Table 4.11.2-1 Each sample was subsampled into 30, 125, 600, and 225 (duplicate) ml glass vials to avoid air contamination for analysis of CH_4 concentration, stable carbon and hydrogen isotope ratio of CH_4 and N_2O isotope ratios, respectively. These seawater samples were sterilized by adding saturated mercuric chloride ($HgCl_2$) solution to avoid excess CH_4 emission from microbe, and were sealed with rubber stoppers and aluminum caps. They will be stored in a dark and cool place until measurements.

Concentration of dissolved CH_4 will be measured with a gas chromatograph equipped with a flame ionization detector (GC-FID). Stable carbon isotope ratio will be measured with gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) (Tsunogai et al., 2000). Stable hydrogen isotope ratio will be measured with gas chromatography-high-temperature conversion-isotope ratio mass spectrometry (GC-TC-IRMS) (Yamada et al., 2003). Each analytical system is equipped with a purge and trap unit, and CH_4 is further concentrated in a cryogenic trap in the case of isotopic measurement. Precisions of repeated analyses of CH_4 concentration, and carbon and hydrogen isotope ratio are estimated to be better than 5%, 0.3‰ and 3‰, respectively.

Dissolved N_2O concentrations and its isotopic compositions will be measured similarly by mass spectrometry, although the extracted and purified N_2O is directly introduced into the mass spectrometry (GC-IRMS) which was modified for site-specific ^{15}N analysis (Yamagishi et al., 2007)

(5) Station list or Observation log

Station, cast and depth of each sampling were shown in Table 4.11.2.1

(6) Expected results

In our previous observations, concentrations of dissolved CH_4 and N_2O ranged from 0.5 to 48.5 nmol/kg and from 9.3 to 49.0 nmol/kg, respectively, and most of the samples showed oversaturation of these gases with respect to the atmosphere. The highest values were observed near the seafloor at a shallow station in continental shelf in 2013. Results obtained from the present cruise will clarify the variability of distribution and production/consumption processes of CH_4 and N_2O.

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC web site.

After the measurements and quality check, concentration and isotopic data will be submitted to JAMSTEC.

(8) References

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Table 4.11.2-1: Stations, casts and depths (dbar) of sampling

No.	CH_4 concentration			CH_4-^{13}C			CH_4-D			N_2O		
	Stn	Cast	Depth [dbar]	Stn	Cast	Depth [dbar]	Stn	Cast	Depth [dbar]	Stn	Cast	Depth [dbar]
1	1	1	B-10	1	1	B-10	1	1	B-10	1	1	B-10
2	1	1	40	1	1	40	1	1	20	1	1	B-10
3	1	1	30	1	1	30	1	1	5	1	1	30
4	1	1	20	1	1	20	3	1	B-10	1	1	30
5	1	1	10	1	1	10	3	1	20	1	1	20
6	1	1	5	1	1	5	3	1	5	1	1	20
7	1	1	0	1	1	0	9	10	B-10	1	1	10
8	3	1	B-10	3	1	B-10	9	10	200	1	1	10
9	3	1	40	3	1	40	9	10	150	1	1	5
10	3	1	30	3	1	30	9	10	100	1	1	5
11	3	1	20	3	1	20	9	10	50	3	1	B-10
12	3	1	10	3	1	10	9	10	20	3	1	B-10
13	3	1	5	3	1	5	9	10	5	3	1	30
14	3	1	0	3	1	0	9	12	200	3	1	30
15	5	1	B-10	5	1	B-10	9	12	150	3	1	20
16	5	1	250	5	1	250	9	12	100	3	1	20
17	5	1	200	5	1	200	9	12	50	3	1	10
18	5	1	150	5	1	150				3	1	10
19	5	1	100	5	1	100				3	1	5
20	5	1	50	5	1	50	9	12	20	3	1	5

21	5	1	40	5	1	40				5	1	B-10
22	5	1	30	5	1	30	9	12	5	5	1	B-10
23	5	1	20	5	1	20	9	62	B-10			
24	5	1	10	5	1	10						
25	5	1	5	5	1	5	9	62	200	5	1	200
26	7	1	B-10	7	1	B-10	9	62	150	5	1	200
27	7	1	500	7	1	500	9	62	100	5	1	150
28	7	1	250	7	1	250	9	62	50	5	1	150
29	7	1	200	7	1	200	9	62	20	5	1	100
30	7	1	150	7	1	150	9	62	5	5	1	100
31	7	1	100	7	1	100	3	2	B-10	5	1	50
32	7	1	50	7	1	50	3	2	20	5	1	50
33	7	1	40	7	1	40	3	2	5			
34	7	1	30	7	1	30	3	2	0			
35	7	1	20	7	1	20	1	2	B-10	5	1	30
36	7	1	10	7	1	10	1	2	20	5	1	30
37	7	1	5	7	1	5	1	2	5	5	1	20
38	9	10	B-10	9	10	B-10				5	1	20
39	9	10	1500	9	10	1500				5	1	10
40	9	10	1000	9	10	1000				5	1	10
41	9	10	400	9	10	400				5	1	5
42	9	10	250	9	10	250				5	1	5
43	9	10	200	9	10	200				9	10	B-10
44	9	10	150	9	10	150				9	10	B-10
45	9	10	100	9	10	100				9	10	1500
46	9	10	50	9	10	50				9	10	1500
47	9	10	40	9	10	40				9	10	1000
48	9	10	30	9	10	30				9	10	1000
49	9	10	20	9	10	20				9	10	400
50	9	10	10	9	10	10				9	10	400
51	9	10	5	9	10	5				9	10	200
52	9	12	400	9	12	400				9	10	200
53	9	12	250	9	12	250				9	10	150
54	9	12	200	9	12	200				9	10	150
55	9	12	150	9	12	150				9	10	100

56	9	12	100	9	12	100				9	10	100
57	9	12	50	9	12	50				9	10	50
58	9	12	40	9	12	40				9	10	50
59	9	12	30	9	12	30				9	10	30
60	9	12	20	9	12	20				9	10	30
61	9	12	10	9	12	10				9	10	10
62	9	12	5	9	12	5				9	10	10
63	9	62	B-10	9	62	B-10				9	10	5
64	9	62	1500	9	62	1500				9	10	5
65	9	62	1000	9	62	1000				9	12	200
66	9	62	400	9	62	400				9	12	200
67	9	62	250	9	62	250				9	12	150
68	9	62	200	9	62	200				9	12	150
69	9	62	150	9	62	150				9	12	100
70	9	62	100	9	62	100				9	12	100
71	9	62	50	9	62	50				9	12	50
72	9	62	40	9	62	40				9	12	50
73	9	62	30	9	62	30				9	12	30
74	9	62	20	9	62	20				9	12	30
75	9	62	10	9	62	10				9	12	10
76	9	62	5	9	62	5				9	12	10
77	3	2	B-10	3	2	B-10				9	12	5
78	3	2	40	3	2	40				9	12	5
79	3	2	30	3	2	30				13	2	B-10
80	3	2	20	3	2	20				13	2	B-10
81	3	2	10	3	2	10				13	2	30
82	3	2	5	3	2	5				13	2	30
83	3	2	0	3	2	0				13	2	20
84	1	2	B-10	1	2	B-10				13	2	20
85	1	2	40	1	2	40				13	2	10
86	1	2	30	1	2	30				13	2	10
87	1	2	20	1	2	20				13	2	5
88	1	2	10	1	2	10				13	2	5
89	1	2	5	1	2	5				1	2	B-10
90										1	2	B-10

91										1	2	20
92										1	2	20
93										1	2	5
94										1	2	5

4.12. VOC

(1) Personnel

Sohiko Kameyama	Hokkaido University	- PI
Hisayuki Yoshikawa-Inoue	Hokkaido University	
Naohiro Kosugi	Meteorological Research Institute / JMA	

(2) Objective

Air–sea exchange of volatile organic compounds (VOCs) plays an important role in the earth's biogeochemical cycles and in the chemistry of the atmosphere. It is known that the Arctic Ocean is sensitive to climate change such as global warming and ocean acidification. To estimate behavior of especially biogenic VOCs in future, it is important to know the distribution of VOCs in the "changing" Arctic Ocean. The variability of phytoplankton activity is large there; therefore, distribution of biogenic VOCs including dimethyl sulfide (DMS) and isoprene should be variable. DMS and isoprene is known as a precursor of cloud condensation nuclei (CCN) over the ocean (Andreae and Raemdonck, 1983; Grenfell et al., 1999), but the degree of its contribution to formation of cloud is still uncertain. In order to investigate the factor controlling the distribution of VOCs especially sulfur compounds and hydrocarbons in surface water column we took seawater samples during the cruise.

(3) Parameters

Sulfur compounds including DMS and methanethiol

Hydrocarbons including isoprene and monoterpene

(4) Instruments and Methods

We tested to preserve VOCs extracted from seawater by concentrating on the cold trap (dry ice/ethanol temperature) with TENAX TA. Dissolved VOCs in seawater were extracted by an equilibrator usually used for pCO_2 measurement. When extracted VOCs were concentrated, the extracted gas including VOCs was introduced to pre-cooled cold trap by switching the electric valves (see Figure 4.12.1). We continued concentrating sulfur compounds and hydrocarbons for 2 and 10 minutes, respectively. After finish the concentration, U-shaped trap was removed from the system and sealed by swagelok cap. U-shaped trap including VOCs was stored in deep freezer.

All samples will be measured by gas chromatography (GC) coupling with Curie Point Pyrolyzer by introducing to GC (GC-2014, Shimadzu) with Flame Photometric Detector (FPD) for sulfur compounds and Flame Ionization Detector (FID) for hydrocarbons.

(5) Station list

Time and position of sampling are shown in Table 4.12.1.

(6) Data archives

Obtained samples will be analyzed in the laboratory in Hokkaido University. All data will be opened within a year.

(7) References

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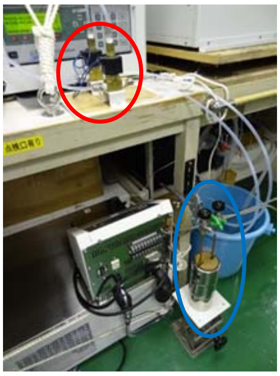

Figure 4.12-1: Cold trap system. Red, switching valves; blue, cold trap.

Table 4.12-1: Time and position of sampling

Sample No.	Date and time of sampling (yyyy/mm/dd hh:mm)	Position of sampling
1	2014/09/03 12:43	66-56N, 166-50W
2	2014/09/03 13:09	67-00N, 166-50W
3	2014/09/05 11:30	73-00N, 161-04W
4	2014/09/05 11:35	73-01N, 161-05W
5	2014/09/06 00:48	74-23N, 162-59W
6	2014/09/06 00:54	74-23N, 162-59W
7	2014/09/06 14:18	74-24N, 161-05W
8	2014/09/06 14:24	74-25N, 161-08W
9	2014/09/14 01:57	74-45N, 162-01W
10	2014/09/14 02:07	74-45N, 162-01W
11	2014/09/25 10:51	73-49N, 165-13W
12	2014/09/25 11:07	73-47N, 165-22W
13	2014/09/26 15:08	72-36N, 168-23W
14	2014/09/26 15:19	72-35N, 168-25W
15	2014/09/27 10:10	69-42N, 168-49W
16	2014/09/27 10:16	69-41N, 168-49W
17	2014/09/28 02:53	67-32N, 168-50W
18	2014/09/28 02:58	67-31N, 168-50W
19	2014/09/28 14:42	65-32N, 168-42W
20	2014/09/28 14:56	65-30N, 168-47W

4.13. Perfluoroalkyl substances (PFASs)

(1) Personnel

Nobuyoshi Yamashita	National Institute of Advanced Industrial Science and Technology (AIST)	- PI
Sachi Taniyasu	AIST	

(2) Objective

Environmentally persistent perfluoroalkyl substances (PFASs, shown in Figure 4.13- 1) have appeared as a new class of global pollutants for the last thirteen years.

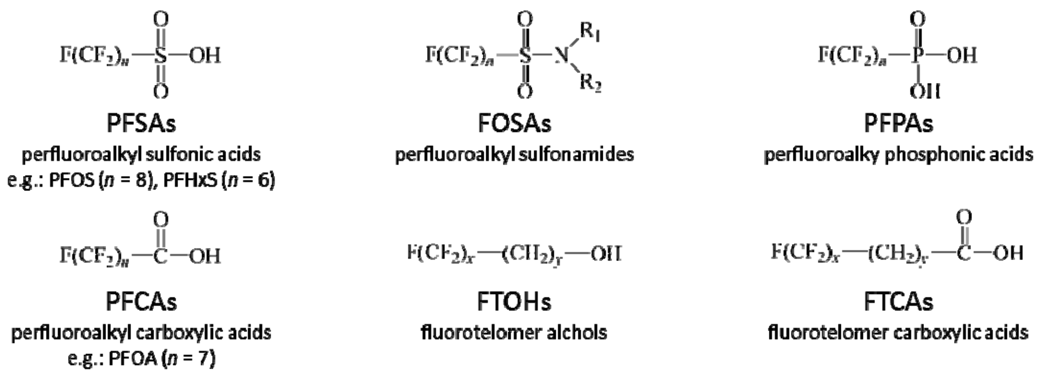

Figure 4.13- 1 Perfluoroalkyl substances (PFASs)

These compounds have recently emerged as a priority environmental pollutant due to its widespread finding in biota including both Arctic and Antarctic species and its persistent and bioaccumulative nature, especially for PFOS (perfluorooctane sulfonate) and PFOA (perfluorooctane carboxylic acid). The physicochemical properties of PFASs, especially of PFSAs (perfluoroalkyl sufonic acids) and PFCAs (perfluoroalkyl carboxylic acids) are unique in that they have high water solubility despite the low reactivity of carbon-fluorine bond, which also imparts high stability in the environment. However, little is known on the distribution of PFASs in the oceans around the world, so far. We have conducted several international joint cruises, including South China Sea and Sulu Seas (KH-02-4), the central to Western Pacific Ocean (KH03-1 and MR11-08), North Pacific Ocean (KH-12-04, MR14-04), Arctic Ocean (MR13-06), North and middle Atlantic Ocean, Southern Pacific and Antarctic Ocean (KH04-5, MR12-05), Labrador Sea and coastal seawater from Asian countries (Japan, China, Hong Kong, Korea) [1, 2, 3]. Vertical profiles of PFASs in the marine water column were associated with the global ocean circulation theory. We found that vertical profiles of PFASs in water columns from the Labrador Sea reflected the influx of the North Atlantic Current in surface waters, the Labrador Current in subsurface waters, and the Denmark Strait Overflow Water in deep layers below 2000 m. Striking differences in the vertical and spatial distribution of PFASs, depending on the oceans, suggest that these persistent organic acids can serve as useful chemical tracers to allow us to study oceanic transportation by major water currents. The results provide evidence that PFAS concentrations and profiles in the oceans adhere to a pattern consistent with the global "Broecker's Conveyor Belt" theory of open ocean water circulation.

In MR14-05 cruise, we will survey PFASs in surface and vertical seawater to understand the Arctic and global distribution of PFASs in Open Ocean environment.

(3) Parameters

Perfluoroalkyl substances (PFASs)

(4) Instruments and Methods

Water samples were stored in clean polypropylene bottles and were kept frozen until analysis. Samples were thawed at room temperature, and a solid phase extraction method using Oasis®WAX-Sea cartridge (500 mg, 30 μm) (Waters Co.) for seawater samples which cartridge was developed specially for open seawater samples by AIST. The HPLC tandem mass spectrometry (HPLC-MS/MS) was used for sample analysis [4,5]. Briefly, after preconditioning with ammonium hydroxide in methanol, methanol, and then Millipore water, the cartridges were loaded water samples at approximately 1 drop sec^{-1}. Seawater samples were adjusted pH3 by acetic acid and then spiked surrogate standard (1 ng of each compound) before sample loading. The cartridges were then washed with Milli-Q water and then 25 mM ammonium acetate buffer (pH 4) in Milli-Q water and dried. The elution was then divided into two fractions. The first fraction was carried out with methanol and the second with 0.1% ammoniumhydroxide in methanol. Both fractions were reduced to 1 mL under a nitrogen stream and analyzed separately. HPLC-MS/MS, composed of a HP1100 liquid chromatograph (Agilent Technologies, Palo Alto, CA) interfaced with a Micromass® (Beverly, MA) Quattro Ultima Pt mass spectrometer was operated in the electrospray negative ionization mode. A 10-μL aliquot of the sample extract was injected into a Betasil C18 column (2.1 mm i.d. × 50 mm length, 5 μm; Termo Hypersil-Keystone, Bellefonte, PA). The capillary is held at 1.2 kV. Cone-gas and desolvation-gas flows are kept at 60 and 650 L/h, respectively. Source and desolvation temperatures were kept at 120 and 420°C respectively. MS/MS parameters are optimized so as to transmit the $[M-K]^-$ or $[M-H]^-$ ions.

(5) Observation log

List of seawater samples (surface, subsurface and deep water) collected were presented in Figure 4.13- 1 and Table 4.13-2. Deep seawater samples were taken by Conductivity temperature depth profiler-Carousel multiple sampling system (CTD-CMS) attached X-Niskin samplers of 12 L, together with surface seawater samples taken by stainless bucket at all the water sampling stations. Subsurface waters were also collected from the out let tube of surface water analysis facility in MIRAI.

(6) Data archives

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

(7) References

1) Yamashita N, Kannan K, Taniyasu S, Horii Y, Petrick G, Gamo T, A global survey of perfluorinated acids in oceans, Marine Pollution Bulletin 51 (2005) 658–668
2) Wei S, Chen LQ, Taniyasu S, So MK, Murphy MB, Yamashita N, Yeung LWY, Lam PKS, Distribution of perfluorinated compounds in surface seawaters between Asia and Antarctica, Marine Pollution Bulletin 54 (2007) 1813–1838
3) Yamashita N, Taniyasu S, Petrick G, Wei S, Gamo T, Lam PKL, Kannan K, Perfluorinated acids as novel chemical tracers of global circulation of ocean waters, Chemosphere 70 (2008) 1247–1255
4) Yamashita N, Kannan K, Taniyasu S, Horii Y, Okazawa T, Petrick G, Gamo T, Analysis of Perfluorinated Acids at Parts-Per-Quadrillion Levels in Seawater Using Liquid Chromatography-Tandem Mass Spectrometry, Environ. Sci. Technol. (2004) 38, 5522-5528
5) Taniyasu S, Kannan K, So MK, Gulkowskad A, Sinclair E, Okazawa T, Yamashita N, Analysis of fluorotelomer alcohols, fluorotelomer acids, and short- and long-chain perfluorinated acids in water and biota, Journal of

Chromatography A, 1093 (2005) 89–97
6) ISO 25101 (2009 March 1st) Water quality — Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) — Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry

Table 4.13-1: Summary of surface and deep seawater sampling for PFASs analysis

Stn	Cast	Date collected					Latitude			Longitude			Depth	Sampling Depth													
		YYYY	MM	DD	hh : mm		deg	min	N/S	deg	min	E/W	m	m													
1	1	2014	09	03	06:04	UTC	65	46.24	N	168	47.54	W	52	0	5	10	20	30	40	47							
2	1	2014	09	03	13:20	UTC	66	59.96	N	168	50.03	W	47	0	5	10	20	30	39	41							
3	1	2014	09	03	19:54	UTC	67	59.98	N	168	50.06	W	58	0	5	10	21	30	41	53							
4	1	2014	09	05	13:55	UTC	73	19.78	N	161	59.96	W	172	0	5	10	20	30	40	50	75	99	149	167			
9	10	2014	09	09	00:11	UTC	74	45.13	N	161	59.15	W	1883	0	5	10	20	50	99	148	198	296	395	593	986	1478	1872
9	26	2014	09	13	00:10	UTC	74	45.01	N	162	01.12	W	1880	0	5	10	20	49	99	149	198	296	396	593	988	1481	1868
9	42	2014	09	17	00:08	UTC	74	44.93	N	161	59.69	W	1881	0	5	9	19	50	99	149	198	296	395	592	987	1479	1870
9	62	2014	09	22	00:11	UTC	74	44.91	N	161	59.05	W	1884	0	5	10	20	50	99	149	197	297	394	593	988	1479	1871
9	74	2014	09	25	08:07	UTC	74	45.14	N	161	58.99	W	1885	0	5	10	20	50	99	150	197	298	397	592	987	1479	1872
5	2	2014	09	25	19:40	UTC	73	59.98	N	164	00.13	W	252	0	5	10	20	29	39	49	99	148	198	242			
13	1	2014	09	25	19:40	UTC	72	45.01	N	168	14.86	W	56	0	5	10	20	30	40	51							
16	1	2014	09	27	08:15	UTC	70	00.07	N	168	49.34	W	40	0	5	10	20	30	15	34							
3	2	2014	09	27	23:25	UTC	67	59.98	N	168	50.10	W	58	0	6	10	20	30	40	50							
1	2	2014	09	28	12:57	UTC	65	46.49	N	168	47.11	W	52	0	5	10	20	30	40	47							

Table 4.13-2: Summary of sub-surface seawater sampling for PFASs analysis

On board ID	Stn	Cast	Date collected					Latitude			Longitude		
			YYYY	MM	DD	hh : mm		deg	min	N/S	deg	min	E/W
MR1405-WS01	-	-	2014	09	01	03:08	UTC	55	41.14	N	166	53.74	W
MR1405-WS02	-	-	2014	09	02	00:31	UTC	60	00.72	N	168	00.38	W
MR1405-WS03	-	-	2014	09	02	20:49	UTC	64	06.69	N	168	07.58	W
MR1405-WS04	1	1	2014	09	03	06:04	UTC	65	46.24	N	168	47.54	W
MR1405-WS05	2	1	2014	09	03	13:20	UTC	66	59.96	N	168	50.03	W
MR1405-WS06	3	1	2014	09	03	19:54	UTC	67	59.98	N	168	50.06	W
MR1405-WS07	-	-	2014	09	04	03:31	UTC	69	19.36	N	166	38.79	W
MR1405-WS08	-	-	2014	09	05	03:44	UTC	71	47.27	N	158	02.39	W
MR1405-WS09	4	1	2014	09	05	13:55	UTC	73	19.78	N	161	59.96	W
MR1405-WS10	7	1	2014	09	06	07:08	UTC	75	07.44	N	160	59.20	W
MR1405-WS11	9	10	2014	09	09	00:11	UTC	74	45.13	N	161	59.15	W
MR1405-WS12	9	26	2014	09	13	00:10	UTC	74	45.01	N	162	01.12	W
MR1405-WS13	9	42	2014	09	17	00:08	UTC	74	44.93	N	161	59.69	W
MR1405-WS14	9	62	2014	09	22	00:11	UTC	74	44.91	N	161	59.05	W
MR1405-WS15	9	74	2014	09	25	08:07	UTC	74	45.14	N	161	58.99	W
MR1405-WS16	5	2	2014	09	25	19:40	UTC	73	59.98	N	164	00.13	W
MR1405-WS17	13	1	2014	09	25	19:40	UTC	72	45.01	N	168	14.86	W
MR1405-WS18	16	1	2014	09	27	08:15	UTC	70	00.07	N	168	49.34	W
MR1405-WS19	3	2	2014	09	27	23:25	UTC	67	59.98	N	168	50.10	W
MR1405-WS20	-	-	2014	09	28	06:15	UTC	66	57.72	N	168	47.74	W
MR1405-WS21	1	2	2014	09	28	12:57	UTC	65	46.49	N	168	47.11	W
MR1405-WS22	-	-	2014	09	28	22:40	UTC	64	18.05	N	171	20.90	W
MR1405-WS23	-	-	2014	09	29	10:48	UTC	62	18.54	N	174	25.13	W
MR1405-WS24	-	-	2014	09	29	21:24	UTC	60	24.33	N	176	58.31	W
MR1405-WS25	-	-	2014	09	30	07:28	UTC	58	35.02	N	179	31.30	W
MR1405-WS26	-	-	2014	09	30	19:09	UTC	56	36.23	N	177	14.78	E
MR1405-WS27	-	-	2014	10	01	11:45	UTC	53	50.05	N	172	56.32	E
MR1405-WS28	-	-	2014	10	01	20:47	UTC	52	17.13	N	171	13.92	E
MR1405-WS29	-	-	2014	10	02	03:58	UTC	51	08.95	N	170	15.73	E
MR1405-WS30	-	-	2014	10	02	20:30	UTC	48	34.85	N	168	09.20	E
MR1405-WS31	-	-	2014	10	03	07:41	UTC	46	54.38	N	166	51.40	E
MR1405-WS32	-	-	2014	10	04	05:03	UTC	45	37.22	N	163	41.81	E
MR1405-WS33	-	-	2014	10	04	22:48	UTC	44	13.18	N	159	29.22	E
MR1405-WS34	-	-	2014	10	05	11:43	UTC	43	35.50	N	157	35.36	E
MR1405-WS35	-	-	2014	10	05	23:49	UTC	42	51.88	N	155	26.20	E
MR1405-WS36	-	-	2014	10	06	10:22	UTC	42	02.02	N	152	58.36	E
MR1405-WS37	-	-	2014	10	06	22:11	UTC	41	02.90	N	150	08.83	E
MR1405-WS38	-	-	2014	10	07	09:54	UTC	39	45.72	N	147	58.74	E
MR1405-WS39	-	-	2014	10	07	23:47	UTC	38	05.48	N	145	15.76	E
MR1405-WS40	-	-	2014	10	08	11:02	UTC	37	11.80	N	143	53.14	E
MR1405-WS41	-	-	2014	10	08	16:50	UTC	36	41.51	N	143	06.34	E
MR1405-WS42	-	-	2014	10	08	23:01	UTC	36	10.24	N	142	17.35	E
MR1405-WS43	-	-	2014	10	09	05:10	UTC	35	38.86	N	141	30.23	E

4.14. Multiple Core sampling

(1) Personnel

Michiyo Yamamoto-Kawai Tokyo Univ. Marine Science and Technology - PI
Shinji Takada Tokyo Univ. Marine Science and Technology
Yasumi Yamada MWJ
Mika Yamaguchi MWJ

(2) Objective

Denitrification and anammox are processes removing nitrogen from the ocean. Because of these processes in the sediment on the Chukchi sea shelf, primary production in the Arctic Ocean is often limited by nitrogen. It is known that responses of denitrification and anammox responses to increasing temperature can be different, and that temperature of the Chukchi sea is increasing due to the global warming. Therefore quantitative understanding of these processes and their temperature dependence are needed to better predict future nitrogen cycle and productivity in the Arctic Ocean. During the MR14-05 cruise, we have collected sediment core samples to qualify denitrification and anammox processes and their responses to temperature increase.

(3) Parameters

- Slurry incubation
- Core incubation (Isotope Pairing Technique)
- Nutrient concentration of pore-water
- Organic carbon, Total nitrogen, Chlorophyll *a* content and Porosity of sediment

(4) Instruments and Methods

i) Core sampling

Multiple Corer (MC) consists of body (620 kg weight) and eight sub-corer attachments. Eight acryl pipes are used for sediment coring. The pipe is 60 cm in length with a diameter of 74 mm. Also attached to the body were four Niskin bottles (8-liter), a SBE 39 temperature recorder with an optional pressure sensor and a magnet switch data logger.

The MC was dropped at 0.3~1.0 m/s down to 50 m above the seafloor, suspended for 3 minutes, and then dropped at 0.3 m/s to the seafloor. Wire tension was monitored to judge the arrival or departure of MC at the seafloor. When MC came back on the deck, sub-corer attachments and Niskin bottles were detached from the body for sub sampling of sediment and bottom water.

ii) Slurry incubation

Surface sediments from top 4 cm of a core were used in this experiment. Overlying seawater in the core pipe was collected and deoxygenated by bubbling Ar for 1 hour. In a portable glove box purged with Ar gas, 2 ml of well-mixed sediment and 10 ml of deoxygenated seawater were homogenized in 12 ml gas-tight glass vials. The slurries were kept in incubator at *in situ* temperature for 24 hours to remove remaining oxygen or NOx^- (pre-incubation). Then, $Na^{15}NO_3$, $K^{14}NO_3^-$ or $(^{15}NH_4)_2SO_4$ were added to slurries to have final concentrations 50 μM of $^{15}NO_3^-$, $^{15}NH_4^+$, or $^{15}NH_4^+$+$^{14}NO_3^-$. 9 vials of for each of these tracers and without tracer addition (control) were prepared and incubated in an incubator set to the *in situ* temperature. At 0, 6 and 12 hours of incubation, a headspace of 5 ml with He gas was introduced and 200 μl of 50%w/v $ZnCl_2$ was added to 3 vials for each tracer and control to stop biological activities. The samples were then stored upside-down until the analysis in the lab on land with a mass spectrometer connected to an elemental analyzer (ANCA-GSL, SerCon Ltd., UK). The 5 ml of water samples replaced by He gas were filtered with Dismic-25CS (Advantec) into sample tubes and frozen. These will be analyzed for NO_3^-, NO_2^-, NH_4^+ after the cruise.

At 2 stations (Stations 003 and 009), 21 more slurry vials were prepared for each of $^{15}NO_3^-$, $^{15}NH_4^+$+$^{14}NO_3^-$ and control experiments. Of these, 9 and 12 vials were kept at *in situ* temperature and at 16°C, respectively, for 30 minutes after the tracer addition. After the 30 minutes, 3 vials for each temperature were taken as 0-hour samples. Vials at in situ temperature were then incubated at 4 or 8°C, and those at 16°C were incubated at 12, 16 or 20°C for 12 hours.

iii) Core incubation (Isotope Pairing Technique)

At each station, total 6-10 sub-cores were taken from 4-5 sediment cores into acrylic tubes (22 cm length, 31 mm diameter) with silicon bottom stoppers. These sub-cores were soaked in a bucket filled with bottom water that was collected at the core sampling site by 8 L Niskin bottles attached to the MC. The water column in each sub-core was stirred by a small magnet driven by a large external rotating magnet. The bucket was kept at *in situ* temperature, and dissolved oxygen of the water in the bucket was controlled to be the *in situ* concentration by bubbling Ar mixed with O_2. After 6 hours, a sub-core was taken from the bucket, and sediment and water were mixed well with a glass stick. After most of sediments settled, supernatant was siphoned into 2 or 3 vials. A headspace of 5 ml with He gas was introduced and 200 μl of 50%w/v $ZnCl_2$ was added to stop biological activities (control). Then, $^{15}NO_3^-$ was added to the bottom water to have concentration of 50 μM and mixed with a glass stick. Before and after water the addition of $^{15}NO_3^-$ bottom water was sampled, filtered with Dismic-25CS (Advantec) and kept frozen at -20 ˚C. After 6 hours of the tracer addition, the top of core tubes were closed with silicon stopper. The water column in a core tube was stirred by a stir bar hanging from the top stopper. Then, incubation was terminated at 3 hours intervals (0, 3 and 6 hours). At the termination, 2-3 sub-cores were taken from the bucket. 5 ml of overlying water was sampled from each sub-core, filtered and frozen for NO_3^- measurement. Then, sediment and water in sub-core were mixed and sampled into vials. A headspace of 5 ml with He gas were introduced and 50%w/v $ZnCl_2$ were added to stop biological activities. The samples were then stored upside-down until the analysis in the lab on land with a mass spectrometer connected to an elemental analyzer (ANCA-GSL, SerCon Ltd., UK).

iv) Nutrient concentration of pore-water

For each station, a sediment core was sliced with 1 cm intervals. Sediments were then put into a 50 ml plastic syringe with quartz wool at the spout. Pore-water was squeezed by a clamp and sampled into a plastic tube through a Dismic-25CS filter. A portion of each sample was diluted by seawater with undetectable content of nutrients to be 1/10 and 1/100 of original concentration. All diluted and undiluted samples were frozen at -80 ˚C. Once frozen, they were transferred to a -20 ˚C freezer. At the end of the cruise, samples diluted at 1/10 and 1/100 were defrosted for pore-water from 0-5 cm and 5-10 cm of cores, respectively, at room temperature (about 20 ˚C) for about 4 hours and were analyzed for nutrients (refer to "4.2. Nutrients" for analytical method).

v) Organic carbon, total nitrogen, chlorophyll *a* content and porosity

At each station, a sediment core was sliced with 1 cm intervals and 10 ml of each slice was sampled with a 5 ml plastic tube with a plunger (made from a syringe) and frozen in plastic bags at -80 ˚C. These samples will be analyzed for organic carbon content, total nitrogen and chlorophyll *a* content and porosity.

(5) Station list

Table 4.14-1: List of core samples collected by multiple corer.

Station No.	Latitude	Longtitude	Date (UTC)	Time (UTC)	Depth (m)
002	67-00.00 N	168-50.09 W	3-Sep	14:04	47
004	73-20.01 N	161-59.80 W	5-Sep	14:56	172
009	74-44.97 N	162-00.07 W	6-Sep	17:16	1881
013	72-45.02 N	168-15.03 W	25-Sep	20:17	57
014	72-05.01 N	168-50.03 W	26-Sep	20:20	52
003	67-59.98 N	168-49.99 W	28-Sep	00:03	58

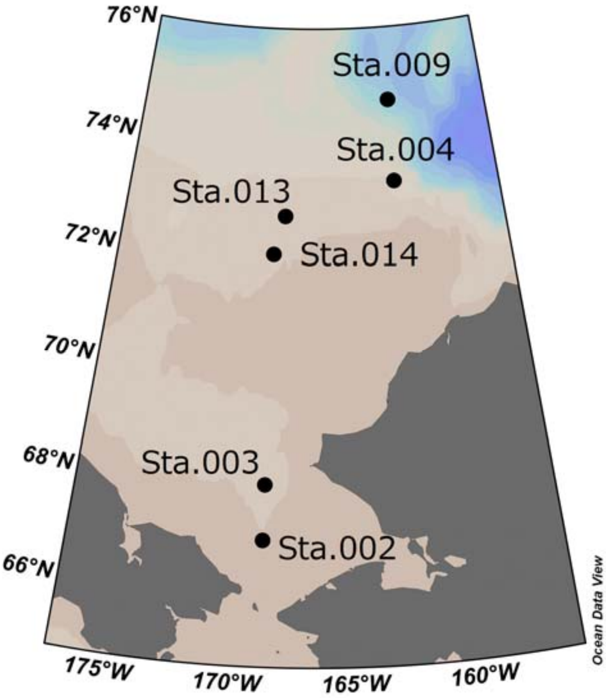

Figure 4.14-1: Map core sampling stations

(6) Data archives

All data will be submitted to the Data Management Group (DMG) of JAMSTEC when ready.

5. Geology

5.1. Sea bottom topography measurements

(1) Personnel

Masao Nakanishi	Chiba University	-PI, not on-board
Katsuhisa Maeno	GODI	
Souichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Koichi Inagaki	GODI	
Miki Morioka	GODI	
Ryo Kimura	MIRAI Crew	

(2) Objective

R/V MIRAI is equipped with the Multi narrow Beam Echo Sounding system (MBES; SEABEAM 3012 (L3 Communications ELAC Nautik) and the Sub-bottom Profiler (SBP; Bathy2010 (SyQwest). The objective of MBES and SBP is collecting continuous bathymetric data along ship's track, to make a contribution to geological and geophysical studies.

(3) Instruments and Methods

The "SEABEAM 3012" on R/V MIRAI was used for bathymetry mapping during the MR14-05 cruise.

To get accurate sound velocity of water column for ray-path correction of acoustic beams, we determined sound velocities at the depth of 6.62m, the bottom of the ship, by a surface sound velocimeter. We made sound velocity profiles based on the observations of CTD, XCTD and Argo float conducted in this cruise by the equation in Del Grosso (1974).

The system configuration and performance are shown in Table 5.1-1 and Table 5.1-2.

Table 5.1-1: SEABEAM 3012 System configuration and performance

Frequency:	12 kHz
Transmit beam width:	2.0 degree
Transmit power:	4 kW
Transmit pulse length:	2 to 20 msec.
Receive beam width:	1.6 degree
Depth range:	50 to 11,000 m
Number of beams:	301 beams (Spacing mode: Equi-angle)
Beam spacing:	1.5 % of water depth (Spacing mode: Equi-distance)
Swath width:	60 to 150 degrees
Depth accuracy:	< 1 % of water depth (average across the swath)

Table 5.1-2: Bathy2010 System configuration and performance

Frequency:	3.5 kHz
Transmit beam width:	23 degree
Transmit pulse length:	0.5 to 50 msec.
Strata resolution:	Up to 8 cm with 300 m of bottom penetration according to bottom type
Depth resolution:	0.1 feet, 0.1m
Depth accuracy:	±10 cm to 100 m, ±0.3% to 6,000 m

(4) Preliminary Results

The results will be published after the primary processing.

(5) Data archives

The data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC web site.

5.2. Sea surface gravity measurement

(1) Personnel

Masao Nakanishi	Chiba University	-PI, not on-board
Katsuhisa Maeno	GODI	
Souichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Koichi Inagaki	GODI	
Miki Morioka	GODI	
Ryo Kimura	MIRAI Crew	

(2) Objective

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data during this cruise.

(3) Parameters

Relative Gravity [CU: Counter Unit]

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

(4) Instruments and Methods

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during the cruise. To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (Scintrex gravity meter CG-5), at Yokohama, Yokosuka, and Kushiro ports as the reference points.

(5) Preliminary Results

Absolute gravity table is shown in Table 5.2-1

Table 5.2-1: Absolute gravity table of the MR14-05 cruise

No.	Date M/D	UTC hh:mm	Port	Absolute Gravity [mGal]	Sea level [cm]	Draft [cm]	Gravity at Senor*1 [mGal]	L&R*2 [mGal]
#01	04/Jul	04:30	Yokohama 249 Bit	979741.75	281	655	979742.89	12034.09
#02	07/Jul	07:41	Yokosuka	979757.91	276	650	979759.03	12051.11
#03	16/Jul	22:02	Kushiro	980600.69	132	655	980601.31	12892.39

#04	10/Oct	06:28	Yokohama 224 Bit	979741.76	184	635	979742.56	12031.46*3

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

*2: Micro-g LaCoste air-sea gravity meter S-116

*3: Refer to Remarks ii)

(6) Data archives

The data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC web site.

(7) Remarks (Times in UTC)

i) The data acquisition was suspended due to a sensor trouble The following periods in the following period.

23:10 - 23:25 02 Oct., 2014

ii) The gravity value of Oct. 10 in Table5.2-1 was corrected because spring tension value decreased 1.6 CU by the above trouble.

iii) The pring tension value shifted about 1.6 CU by the above trouble in the following period.

23:25 02 Oct. 2014 - 08:03 10 Oct. 2014

5.3. Surface magnetic field measurements

5.3.1. Three-components magnetometer

(1) Personnel

Masao Nakanishi	Chiba University	-PI, not on-board
Katsuhisa Maeno	GODI	
Souichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Koichi Inagaki	GODI	
Miki Morioka	GODI	
Ryo Kimura	MIRAI Crew	

(2) Objective

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during the MR14-05 cruise.

(3) Instruments and Methods

A shipboard three-component magnetometer system (SFG1214, Tierra Tecnica) 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.

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

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

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

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

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

(4) Data archives

The data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC web site.

(5) Remarks

For calibration of the ship's magnetic effect, we made "figure-eight" turns (a pair of clockwise and anti-clockwise rotation) at the following positions.

08:48 - 09:20 20 Sep. 2014 around 74-45N, 162-04E

05:58 - 06:29 03 Oct. 2014 around 47-08N, 167-02E

03:34 - 03:56 04 Oct. 2014 around 45-42N, 163-53E

5.3.2. Cesium magnetometer

(1) Personnel

Masao Nakanishi	Chiba University	-PI, not on-board
Katsuhisa Maeno	GODI	
Souichiro Sueyoshi	GODI	
Shinya Okumura	GODI	
Koichi Inagaki	GODI	
Miki Morioka	GODI	
Ryo Kimura	MIRAI Crew	

(2) Objective

Measurement of the total force of the geomagnetic field on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure.

(3) Data Period

04:01 03 Oct. 2014 - 04:16 04 Oct. 2014

(4) Instruments and Methods

We measured the total force using a cesium marine magnetometer (G-882, Geometrics Inc.) and recorded by G-882 data logger (Ver.1.0.0, Clovertech Co.). The G-882 magnetometer uses an optically pumped Cesium-vapor atomic resonance system. The sensor fish towed 500 m behind the vessel to minimize the effects of the ship's magnetic field. Table 5.3-1 shows system configuration of MIRAI cesium magnetometer system.

Table 5.3.1-1: System configuration of MIRAI cesium magnetometer system

Dynamic operating range:	20,000 to 100,000 nT	
Absolute accuracy:	< ±2 nT throughout range	
Setting:	Cycle rate;	0.1 sec
	Sensitivity;	0.001265 nT at a 0.1 second cycle rate
	Sampling rate;	1 sec

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V Mirai Data Web Page" in JAMSTEC web site.

6. Notice on Using

This cruise report is a preliminary documentation as of the end of the cruise.
This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.
Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.