
ARGO
: ARGO

**Global Ocean Observation with ARGO Floats
: Introduction to ARGO Program**

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Abstract

To monitor the world 's oceans and understand the role of the oceans for climate change, an Array for Real-time Geostrophic Oceanography (ARGO) program has been carried out since year 2000. Autonomous profiling floats of about 820 are reporting the vertical temperature, salinity, and pressure profiles of the upper 2000 m underwater at regular time intervals. Meteorological Research Institute (METRI) of Korea Meteorological Administration (KMA) launched 45 floats at the East Sea and the western Pacific to understand characteristics of water properties and develop the global ocean observation system as a part of international cooperation project. In this study, we introduce ARGO program, METRI-ARGO and the features of APEX float itself and their data formats. We also describe the significant points to be considered for using ARGO data.

Key words: ARGO program, Autonomous profiling float, Global ocean observation, APEX floats, METRI-ARGO

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(Lorenz, (Global Telecommunications System)

1984),

- 1.
2. : ARGO
3. : Argos
4. ARGO
- 5.
- 6.

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Table 1. International commitments for ARGO floats (AST, 2003).

Number of Floats by Country	Argo Funded	Float Equiv 's	Argo Funded	Float Equiv 's	Argo Funded	Float Equiv 's	Argo Funded	Float Equiv 's	Argo Funded	Float Equiv 's	Prop Float Equiv 's	Prop Float Equiv 's
	FY99	FY99	FY00	FY00	FY01	FY01	FY02	FY02	FY03	FY03	over 3 yrs	over 3 yrs
Australia	10				19		7		50		163	
Canada	10		42		20		25		30		90	
China					10		8		12		80	
Denmark						5						
E.U Comm.			10		70						40	
France		8	3		50		80		90		240	
Germany				18		22		42		40	105	20
India							10		25		115	
Japan			24	4	7	8	110	3	80	3	150	9
New Zealand			2		2				2		6	
Norway							3				30	
Rep.of Korea					19		25		30		90	
Russia		1		2		2	2	1	2		6	
Spain									10		20	
U.K.			13		50	6	40	10	38	5	95	14
U.S.A.	55		131	51	174	43	315	39	413	20	1239	75
TOTALS	75	9	225	75	490	86	625	95	782	68	2469	118
TOTALS BY YEAR	FY99 = 84		FY00 = 300		FY01 = 576		FY02 = 720		FY03 = 850		Ave/Yr = 862.33	

The 'Float Equivalent' float is a profiling float not strictly funded under the Argo label.

(Bluestein, 1992).

3

가

(Peterson et al., 1997), Array for Real-time Geostrophic Oceanography (ARGO)

3

ARGO
: ARGO

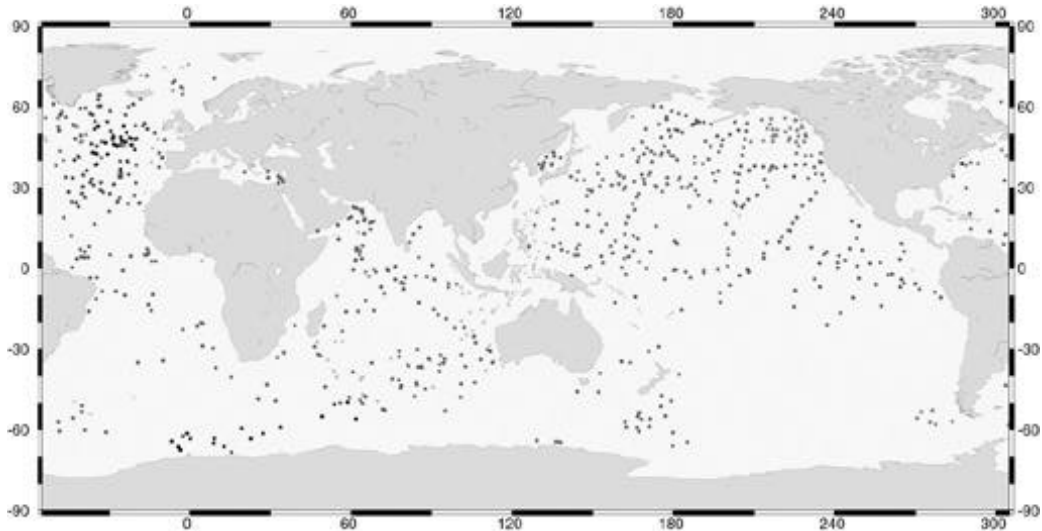


Fig. 1. Distribution of ARGO floats active on August 2003.

- | | | | | |
|-----------|----------------|---------|----------------|--------------------|
| Australia | Denmark | Germany | Korea(Rep. of) | Russian Federation |
| Canada | European Union | India | New Zealand | United Kingdom |
| China | France | Japan | Norway | United States |

(AST, 1998, 1999a, 1999b). ARGO

(Global Climate Observing System/
Global Ocean Observing System; Nowlin et. al.,
1996), (Climate
Variability and Predictability Experiment;
WCRP, 1998),

(Global Ocean Data Assimilation Experiment;
GODAE, 2001)

(WMO) UNESCO 가
(IOC)

“ ARGO ”

300km 3,000
(0 ~ 2,000m)

ARGO

3

Lagrangian

(monsoon)

, ENSO (Bjerknes,
1969; Philander, 1990)

al., 1997)

(Zang et

1.	4. ARGO
2. : ARGO	5.
3. : Argos	6.
	/

(Broecker, 1991; Broecker et al., 1997)

Table 1 ARGO 가 Sound Fixing and Ranging(SOFAR; Rossby and Webb, 1970)

(2003 3) (Richardson and Schmits, 1993). 1980

. 2003 6 15 ()

ARGO 820

가 (Fig. 1) 3,000 27 , 가

%가 (AST, 2003).

가 2001 , 가

30 (Table 1) 가 SOFAR

, RAFOS ,

가 (Rossby et al. 1986; Swift and Riser, 1994).

(, 2002; , 2001, 1980

2002).

ARGO

(profile) Autonomous Lagrangian Circulation Explorer (ALACE; Davis et al., 1992; Davis et al., 1996, Siedler et al., 2001)가 ,

2. : ARGO Profiling Autonomous Lagrangian Circulation Explorer(P-ALACE)가 ARGO

2.1 (Subsurface floats)

Lagrangian ARGO

Swallow , , , .

(free drifting float)가 1950 Webb Research Corporation

Massachusetts Institute of Technology (MIT) (WRC) Autonomous Profiling Explorer

Henry Stommel John Swallow (APEX; WRC, 2002), Scripps Institute of Oceanography(SOI) Woods Hole Oceanographic Institution(WHOI) Sounding Oceanographic Lagrangian Observer(SOLO; Davis et al., 2001), Metocean

(Swallow, 1955). Swallow

1971 2

MODE(Mid-Ocean Dynamics Experiment; McWilliams, 1976)

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Table 2. The comparison of three kinds of ARGO floats.

Type (Manufacture, Country)	APEX (WEBB, USA)	PROVOR (Metocean, Canada)	NINJA (TSK, Japan)
Dimensions (Diameter x Length weight) Not include antenna	16.5x127cm 26kg	17x190cm 37kg	16.5x215cm 32kg
Battery type	Alkaline	Lithium	Lithium
No. of cycles	More than 150 ascents	Approx. 150	unknown
Buoyancy engine capacity (cc)	260	300	350
“ Start ” procedure	Simple	Complex	Simple
Telemetry	Argos	Argos	Argos
Engine type	Hydraulic and Pneumatic system	Hydraulic-single system	Hydraulic Plunger type
User interface	20mA current loop	RS232-direct connection	20mA current loop
Drifting	Isopycnal	User programmable	Isopycnal
Sensors (CTD manufacturing)	Sea Bird Electronics (SBE), Falmouth Scientific Inc.(FSI)	SBE, FSI	Two types -T: TSK CTD -S: SBE CTD

Provior(Loaec et al., 1999; Metocean, 2002),
Tsurumi Seiki Corporation
(TSK) New profiling float of Japan(NINJA;
AST, 2003) China Ocean Profiling
Explorer(COPEX; AST, 2003)가
, APEX Provior
(Table 2).

2.2 ARGO

ARGO

- 1.
- 2. : ARGO
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- 4. ARGO
- 5.
- 6.

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Table 3. The accuracy of Argos locations(CLS, 1996)

Service	Class	Estimated accuracy in latitude and longitude
Standard Location: calculated from at least four messages received during the satellite pass	3	• accuracy < 150 m
	2	• 150 m accuracy 350 m
	1	• 350 m accuracy 1,000 m
	0*	• accuracy > 1,000 m
		(Class 0 is for special cases. On request only.)

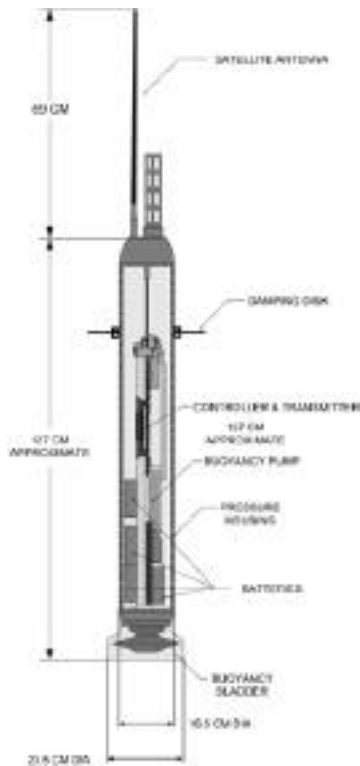


Fig. 2. Schematic of APEX type profiling float. A CTD sensor and an Argos antenna are on top of the float.

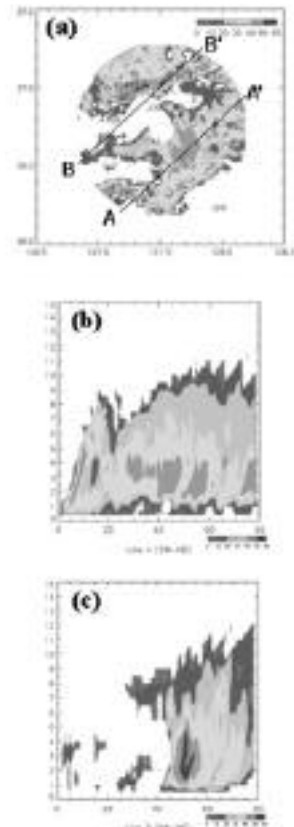


Fig. 3. An observation cycle of the profiling float.

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Argos

(WMO, 2002a).

(hydraulic bladder) 800 m 1 0.016 volt , 2000 m 1 0.027 volt (, 2002).

(Fig. 2).

(CTD; Conductivity Temperature Depth) SeaBird SBE CTD, Falmouth Scientific Inc.(FSI) EXCELL CTD, CTPS202D CTD SeaScan TD sensor가 가 , (2000m) , APEX SeaBird SBE model 41 CTD . 1

Fig.3

1.5 volt

2000±15 dbar

10 0.5 m

(parking depth) (a)

(isopycnal) (b)

(c).

3. : Argos

(d), Argos

Argos (space segment),

(ground receiving station),

APEX Alkaline D-cells, 15 Volt

(processing center) . 1978

(NOAA) (NASA),

(CNES; Centre National

d Etudes Spatiales) Argos

Service가 (CLS/Service, 1989).

Argos 850 km

(POES; Polar Orbiting Environmental Satellites) , ±

55.4°

3,000 km, 5,000 km

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2.	: ARGO	5.
3.	: Argos	6.

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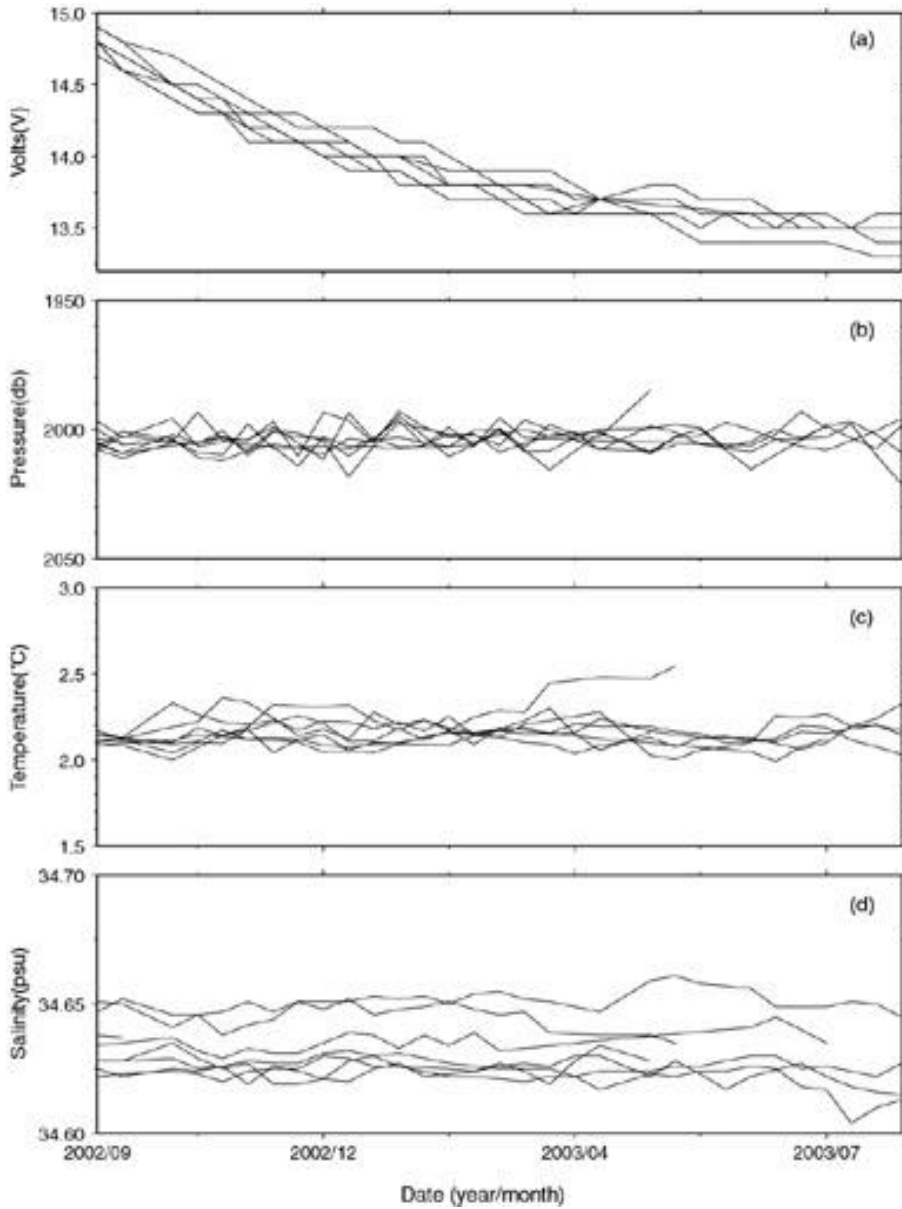


Fig. 4. Time series of battery consumption(a), pressure(b), water temperature(c), and salinity(d) of APEX floats launched by METRI in the Pacific Ocean. A float observing relatively lower pressure and higher temperature on April 2003 is drifted at the shallow area.

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Table 4. Example of hex data with 32 bit; DS type.

02397 25968 105 32 M 2 2003-01-03 03:01:58 24.013 132.666 0.000 401652335				
2003-01-03 02:57:22 1	C4	0C	48	6A
	87	E5	07	C5
	49	86	87	F0
	07	65	4A	93
	87	F8	07	02
	4A	D9	87	FB
	06	9E	4C	B7
	87	FF	06	38

102 , (surface drifter)
25 ° SVP SVP-B
(Sherman, 1992; CLS/Service, 1996). 367
Argos NOAA 15(K), 16(L), m, 656 m 가
17(M) 14(J), 11(H), 17(M), 12(D) (WMO, 2002).
ADEOS
II, Eumetsat, 4 ARGO
Argos 가 .(WMO, ARGO
2002b).
Argos Platform Transmitter Terminal 가 (ADM,
(PTT) 2000),
Doppler GPS(Global Service Argos
Positioning System) 가 가 가 GTS ARGO
, ARGO (GDAC) (Pouliquen, 2002;
Doppler . ADM, 2002), TESAC(or KKYY;
4 가 WMO, 2001) NetCDF (Network Common
, 가 2 Data Form) . ARGO
32bit 'TX(
PTT 4)' 'DS(
, 150 m 가 e-mail(SMTP), fax, printout,
가 (Table 3 Class 3). NOAA Argos , CD , 가 telnet

- 1. 4. ARGO
- 2. : ARGO 5.
- 3. : Argos 6.

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Table 5. Description of the header on the example in Table 4.

Example	02397 25968 105 32 M 2 2003-01-03 03:01:58 24.013 132.666 0.000 401652335 2003-01-03 02:57:22 1
Field	Contents
02397	Argo Program Number
25968	Argos PTT identifier (ID)
105	The Number of lines in this Satellite transmission
32	The Number of bytes in a single message block
M	The Satellite that received the Transmission (NOAA-L)
2	The location class (Can be 0, 1, 2, 3)
2003-01-03	Date (as YYYY-MM-DD)
03:01:58	Time of the Satellite location fix as HH:MM:SS
24.013	Latitude (Decimal degrees, North of the equator)
132.666	Longitude (Decimal degrees, east of Greenwich)
0.000	Altitude of measurements (i.e. meter above the mean sea level)
4001652335	Frequency of the satellite transmission(0.1Hz)
2003-01-03	Date that the message was sent
02:57:22	Time That the message was sent
1	Number of repeats of this message in the transmission

Table 6. Example of GTS format data.

KKYY 03013 0359/ 124007 132663 88872 00120 20007 32274 43481 20009 32274 43481 20019 32274 43481 20029 32273 43481 20039 32273 43481 20049 32273 43481 20059 32273 43481 20069 32273 43481 20079 32274 43481 20089 32274 43481 20099 32274 43482 20110 32274 43481 20119 32262 43480 20129 32219 43481 20140 32064 43482 20149 32009 43482 20159 31965 43482 20169 31916 43481 20179 31909 43481 20189 31882 43480 20199 31854 43479 20209 31831 43478 20219 31816 43477 20229 31795 43476 20239 31775 43475 20249 31763 43475 20259 31735 43474 20269 31717 43473 20279 31691 43471 20289 31658 43470 20299 31648 43469 20309 31627 43468 20319 31598 43466 20330 31564 43464 20339 31544 43463 20349 31495 43460 20359 31461 43458 20379 31384 43452 20399 31326 43448 20449 31233 43442 20499 31099 43433 20550 30962 43425 20599 30835 43419 20649 30697 43415 20699 30634 43416 20749 30567 43418 20799 30505 43422 20849 30459 43427 20899 30422 43431 20949 30397 43435 20999 30374 43437 21049 30353 43440 21099 30337 43443 21149 30325 43444 21199 30311 43446 21249 30301 43447 21299 30289 43449 21349 30283 43450 21399 30272 43451 21449 30256 43453 21499 30248 43454 21549 30239 43455 21599 30233 43456 21650 30226 43457 21699 30220 43458 21750 30216 43458 21799 30213 43459 21849 30212 43459 21899 30208 43460 21949 30202 43461 21999 30198 43461 5900139=

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Table 7. Description on the example in Table 6.

Field	Example	Contents
YYMMJ	03013	Day in the month, Month, Year
GGgg	0359	Hour, Minutes (UTC)
QcLaLaLaLaLa	124007	Quadrant of the globe (1:NE, 3:SE, 5:SW, 7:NW, Latitude (1/1000 Degrees)
LoLoLoLoLoLo	132663	Longitude (1/1000 Degrees)
888k ₁ k ₂	88872	k ₁ :Indicator for digitization; k ₂ : Indicator for salinity
I _x I _x	001	Instrument type for CTD with fall rate equation coefficients (table 1770 from WMO Manual on codes (No. 306))
X _R X _R	20	Recorder types (table 4770 from WMO Manual on codes (No. 306))
2Z _n Z _n Z _n Z _n	20007	Depth (meter)
3T _n T _n T _n T _n	32274	Water temperature at depth (1/100 Celsius)
4S _n S _n S _n S _n	43481	Water salinity at depth (1/100 PSU)
A1b _w n _b n _b n _b	5900139	WMO Identification number

가 . GTS ARGO
Table 6 , WMO ID,
Table 7
GTS WMO ID 5900139 가 2003 01 03
APEX DS (Table 4) 03 59 UTC, 24.007°N, 132.663°E
(header part) 8 CTD 7 m 22.74
, 16 , 34.81 pus .
32 Field 가 . Header ARGO GTS Table 4
, PTT ID, Argos , 가 가
, , 가 , Data
(Message Number; 2 가 ,
MN) , PTT
, Cyclic 3 DS
Redundancy Check(CRC) 가 .
(Table 5). Table 8 Table 4 ASCII

1. 4. ARGO
 2. : ARGO 5.
 3. : Argos 6.

Table 8. Data converted from hex Argos message(Table 4) to decimal numbers.

# METRI APEX ARGOS ID: 25968				: ARGOS ID Number			
# Profile Number : 059				: Profile Number			
# Battery Voltage : 11.3				: Battery voltage(volt)			
# Header:	Long	Lat	Date	Time			
# Fix:	132.666	24.013	2003-01-03	03:01:58	: First location(pop up)		
# Fix:	132.667	24.011	2003-01-03	03:21:08	: Location during surface drifting		
# Fix:	132.663	24.007	2003-01-03	04:04:04	: "		
# Fix:	132.661	23.984	2003-01-03	05:44:07	: "		
# Fix:	132.659	23.975	2003-01-03	06:58:29	: "		
# Fix:	132.649	23.969	2003-01-03	07:43:20	: "		
# Fix:	132.653	23.958	2003-01-03	08:35:28	: "		
# Fix:	132.652	23.951	2003-01-03	09:02:41	: Last location(sinking)		
Sampling	Obs.	Temp.-90	Salinity	Sampling	Obs.	Temp.-90	Salinity
Pressure	Pres.(10Pa)	(°C)	(PSU)	Pressure	Pres.(10Pa)	(°C)	(PSU)
4 or surf	7.1	22.740	34.807	360	359.4	14.610	34.577
10	9.1	22.741	34.811	380	379.1	13.843	34.520
20	19.4	22.736	34.811	400	399.1	13.257	34.479
30	29.0	22.730	34.812	450	449.2	12.330	34.418
40	38.8	22.729	34.812	500	499.3	10.988	34.329
50	48.9	22.730	34.813	550	549.5	9.622	34.249
60	58.8	22.731	34.813	600	599.1	8.346	34.187
70	69.2	22.731	34.813	650	649.3	6.966	34.149
80	79.2	22.737	34.814	700	699.1	6.343	34.156
90	89.2	22.739	34.814	750	749.3	5.672	34.175
100	99.4	22.741	34.815	800	799.2	5.053	34.217
110	109.5	22.736	34.813	850	848.9	4.589	34.265
120	119.4	22.619	34.802	900	899.2	4.223	34.312
130	129.3	22.189	34.807	950	949.3	3.970	34.345
140	139.5	20.639	34.818	1000	999.1	3.740	34.372
150	149.3	20.087	34.818	1050	1049.4	3.532	34.400
160	159.2	19.647	34.815	1100	1099.2	3.366	34.425
170	169.4	19.161	34.811	1150	1149.1	3.247	34.439
180	179.4	19.091	34.808	1200	1199.3	3.113	34.457
190	189.3	18.822	34.800	1250	1249.3	3.010	34.472
200	198.9	18.538	34.789	1300	1299.2	2.893	34.486
210	209.0	18.308	34.778	1350	1349.2	2.827	34.496
220	219.3	18.161	34.770	1400	1399.2	2.717	34.507
230	229.1	17.948	34.762	1450	1448.9	2.560	34.526
240	238.9	17.752	34.754	1500	1499.2	2.475	34.538
250	248.7	17.629	34.747	1550	1549.0	2.388	34.551
260	259.4	17.345	34.737	1600	1599.1	2.331	34.560
270	269.3	17.166	34.728	1650	1649.6	2.264	34.572
280	279.4	16.911	34.714	1700	1699.4	2.200	34.580
290	289.3	16.581	34.700	1750	1749.5	2.162	34.584
300	299.1	16.479	34.693	1800	1799.0	2.131	34.589
310	309.3	16.265	34.681	1850	1849.4	2.115	34.592
320	318.9	15.980	34.664	1900	1899.2	2.082	34.597
330	329.5	15.637	34.644	1950	1949.2	2.019	34.605
340	339.1	15.443	34.632	2000	1999.2	1.975	34.610
350	349.0	14.951	34.600				

ARGO
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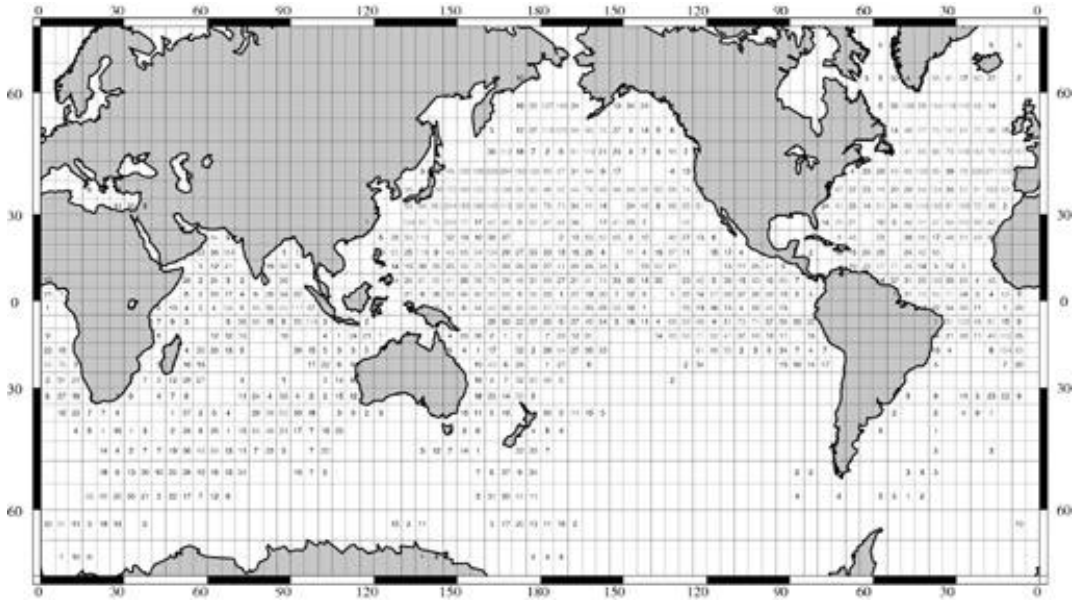


Fig. 5. Distribution of ARGO data per 5 by 5 grid.
(black<20, 20 blue<40, 40 red<60, 60 deep red)

가 . ' Arogs ID ' PTT ID, 0 °-360°E 70°S-70°N
' Profile Number ' CTD , 2016 5 °
PTT (Fig. 5). 70%
(GTS 1411 , 2003
) (; ITS90 temperature 7 847 60%(847/1411)
scale) (: PSU)가 3 28672 가

ARGO

5.

가 , /

5.1

2003 7

ARGO

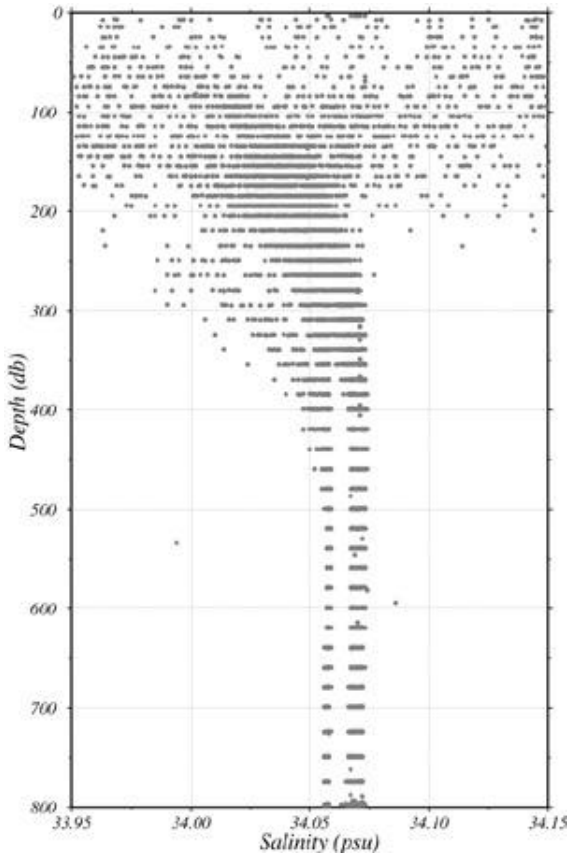
ARGO

(Fig. 5)

(Fig. 1)

- 1.
2. : ARGO
3. : Argos
4. ARGO
- 5.
- 6.

/



(Godfrey et al., 1993)

(EEZ)

가
가
30° S
ARGO 가

5.2 가 CTD

ARGO

Fig. 6. Example of salinity offset problem

가 ARGO

가

ARGO

가
(TBTO;

biocide TributylTin Oxide)

가

ARGO
: ARGO

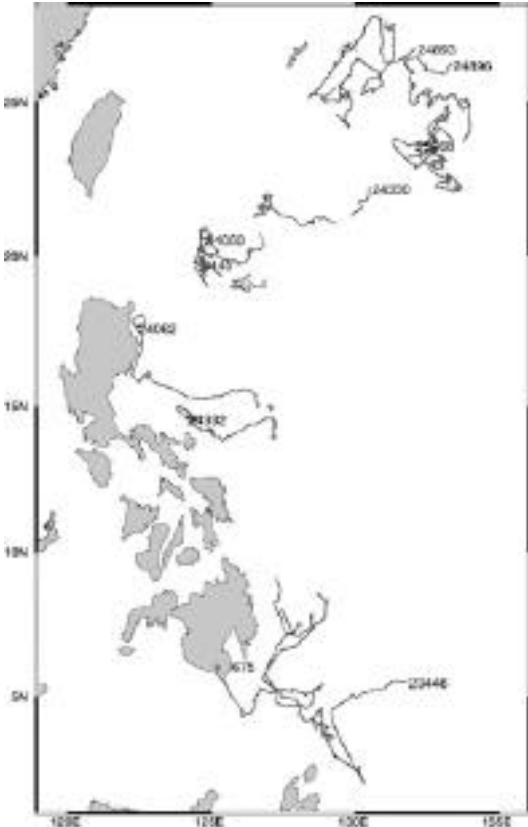


Fig. 7. Trajectory of METRI-ARGO float deployed in western Pacific. Blue(Red) line indicate the trajectory at the surface(subsurface).

가
(Quality Control)

(salinity offset) ARGO
(AST, 1999, 2000) , Wong (2003)
historical hydrographic data
(objective mapping technique)

가
Fig. 6 WMO ID 5900193 CTD

5. 3

Fig. 6 2001, 2002
APEX
20

(Kuroshio
Current)
(Mindanao
(Halmahera)
Guinea Under Current)

Argos ID 23446

, Argos ID 24332, 24062
2000m

가
Argos ID 23445 APEX 1

가

- 1.
2. : ARGO
3. : Argos
4. ARGO
- 5.
- 6.

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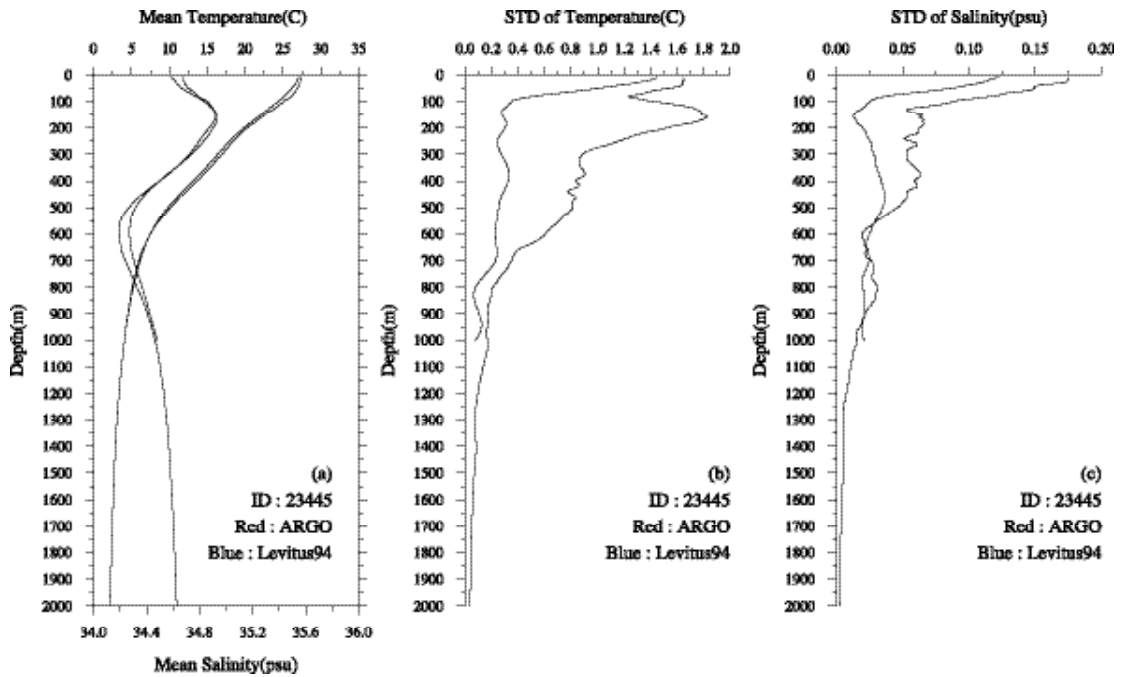


Fig. 8. Vertical profiles of time-mean temperature and salinity(a) and their standard deviations(b and c) for ARGO(red line) and Levitus94(blue line) data.

(Levitus-94)

Fig. 7

(Fig. 7(b)) ARGO

spike

200m

1.8

(, 2002), cubic spline

0.175psu

interpolation method(De Boor, 1978)

1m

200m

(Fig. 7(a))

27

200m

(34.95 psu)

ARGO
: ARGO

6.

ARGO
300 km

10

Salinity offset, SeaBird CTD
homepage) 가

(WRC
가

ARGO
2000 , ()

(ARGO)”

• -

(: Met
Office operational ocean prediction
system (FOAM), AST, 2003)

• 10 km,

(: Global High
Quality SST; GST, 2002)

• 가
(Joos et al., 2003)

•
(Davis, 1998)

ARGO

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(ARGO) I. MR020M11, 289 pp.
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1.		4. ARGO
2.	: ARGO	5.
3.	: Argos	6.

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