Preliminary Report
of
The Hakuhō Maru
Cruise KH-69-3
(GARP Cruise)

June-July, 1969

East China Sea

Ocean Research Institute
University of Tokyo

1969

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By

The Members of Expedition

Edited by

Y. Ogura and A. Takeda

INTRODUCTION

Y. Ogura
Chief Scientist

The main objective of this cruise was to collect data of meteorological and oceanographic conditions relevant to problems of air-sea interaction, and thereby to increase our understanding of the complex physical processes associated with the vertical transport of heat, energy and momentum in the atmospheric boundary layer over the sea.

Advancing our knowledge of air-sea boundary processes is recognized as an integral part of an international research programme which we call the Global Atmospheric Research Programme (GARP). The cruise of the R. V. Hakuho-Maru (KH-69-3) was intended to be a part of the preparatory research for GARP. The cruise also constituted a part of the Severe Rainstorm Research Project (SRRP), organized and implemented mainly by the Japan Meteorological Agency. These two projects were combined to operate a special observational network over Kyushu and over the sea west off Kyushu. The network included three vessels in addition to the Hakuho-Maru, temporary or supplemented surface weather stations and ground-based aerological stations, weather radar stations and a chartered aircraft (see Appendix I).

Several groups from universities and governmental organizations participated in this cruise. The Hakuho-Maru was anchored for six days from July 3 to July 8 west off Kyushu in the central part of the East China Sea at 31°31.5'N and 127°00.0'E where sea depth was approximately 106 meters. During the period of observation, the weather was mostly windy, and either cloudy, rainy or foggy. The sea was rough with swells and wind waves.

In spite of these unfavorable conditions, efforts were made to measure the following elements: fluctuations of temperature and three-components of wind velocity by sonic anemometer-thermometers mounted on the buoy, on the boom projected from the bow and on the foremast of the vessel; sea surface temperature by an infrared radiation thermometer; vertical profiles of mean temperature and wind velocity in the first 10 meters above the sea surface; temperature, humidity and wind velocity by captive balloons up to a height of 200 meters and the vertical profile of temperature up to a height of 1200 meters by low-level radiosondes, as well as routine surface observations. Radiosonde ascents were also made at 6-hour intervals.

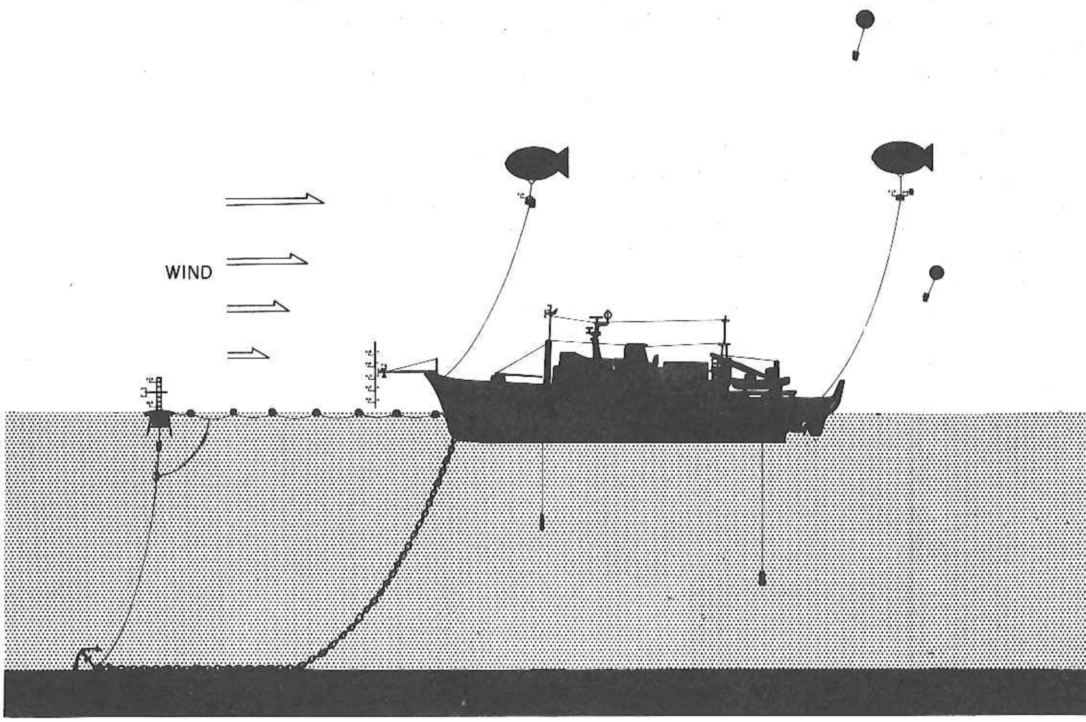
In addition, data of the distribution of sea water droplets ejected from the sea surface were collected. The current velocity and direction at 30 meters below the sea surface were continuously recorded by a Richardson-type current meter. Frequent oceanographic observations by STD cast and measurement of wave height by a sonic wave gauge were also carried out. In order to process a vast amount of data, a computer program for the electronic computer (FACOM 270-20) aboard the vessel was developed.

It may be noted however that the amount of data gathered in the cruise was much less than could be acquired in favorable weather.

Although not directly related to GARP, several groups from universities took this opportunity to advance their atmospheric research programme. Data were gathered of the boron concentration in the atmosphere and atmospheric electric elements such as electric field, electric conductivity, air-sea current, ion density, condensation nuclei etc. in the atmosphere over the sea.

All data are being processed and the results will be published in scientific journals.

Finally, on behalf of all scientists aboard, I would like to extend our thanks to Captain T. Shirasawa and all the crew of the R.V. Hakuho-Maru. They have been most cooperative and helpful. On one occasion, they continued working on deck even in heavy rain which was falling at the rate of 30 mm/hour.



Silhouette of the R. V. Hakuho-Maru with scientific equipments in the GARP observation

List of the members of the expedition

Chief scientist, Ogura, Yoshimitsu: Ocean Research Institute, University of Tokyo

Takeda, Atsushi:	Ocean Research Institute, University of Tokyo
Taira, Keisuke:	"
Sugimori, Yasuhiro:	"
Nakai, Toshisuke:	"
Ishikawa, Koji:	"
Otobe, Hirotaka:	"
Mitsuta, Yasushi:	Disaster Prevention Research Institute, Kyoto University
Hanafusa, Tatsuo:	Geophysical Institute, Kyoto University
Maitani, Toshihiko:	"
Inada, Wataru:	National Research Center for Disaster Prevention, Science and Technology Agency
Watabe, Isao:	"
Shimo, Michikuni:	Department of Nuclear Engineering, Nagoya University
Morita, Yasuhiro:	Research Institute of Atmospherics, Nagoya University
Toba, Yoshiaki:	Geophysical Institute, Kyoto University
Takeuchi, Kiyohide:	Japan Meteorological Agency
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Tosha, Masuo:	"
Takahashi, Tadao:	Faculty of Fishery, Kagoshima University
Chaen, Masaaki:	"
Takeuchi, Kanehito:	"
Nishimura, Hiroshi:	"
Onishi, Gaishi:	Geophysical Institute, Tohoku University
Yokoyama, Osayuki:	Resources Research Institute, Agency of Industrial Science and Technology
Hayashi, Masayasu:	"
Ono, Yuzo:	Ginsei Ad Co. Ltd.
Abe, Akira:	Meisei Electric Co. Ltd.
Suzuki, Ko:	Japan Meteorological Agency
Onoda, Hitoshi:	"
Nakayama, Mitsuo:	"
Shimabukuro, Kazumi:	"
Nakaya, Syu:	Faculty of Fishery, Hokkaido University

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* not aboard

Contributions

(manuscripts received July 11, 1969)

1. Shipboard observations of surface meteorological properties

Y. Ogura, A. Takeda, T. Nakai and K. Ishikawa
Ocean Research Institute, University of Tokyo, Tokyo

Routine surface meteorological data were obtained on the shipboard of the Hakuho-Maru throughout the period of this cruise. Some of them were continuously recorded on the charts and others were observed every an hour or every three hours through the instruments or by the seamen's eyes. The measuring apparatus, their location on the board,

Table 1-1

	Quantities	Apparatus	Location in the ship
1.	Position of ship	Loran	
2.	Atmospheric pressure	Aneroid barometer	Chart room
3.	Air temperature	Tungsten wire thermometer (aspirated)	Compus bridge deck
4.	Dew point temperature	Dew cell (aspirated)	"
5.	Sea surface temperature	Platinum wire thermometer	Sea water intake
6.	Bow azimuth	Gyroscope	Gyro room
7.	Ship speed	Pressure log	Bottom of the ship
8.	Wind direction and speed	Aero vane	Foremast
9.	Cloudiness	Observation by seamen's eyes	
10.	Weather	"	
11.	Wind seas	"	
12.	Swells	"	
13.	Precipitation	Rain gauge	Top of the antirolling tank
14.	Visibility	Observation by naked eyes	
15.	Radiations	Marine radiometer	Bow boom

their height above the mean sea level, the scheme of recording and the period of observations for each property are tabulated below (Table 1-1).

The hourly data are collected in Appendix II. These data will provide the basic information for each study done in this cruise.

Some of these data were provided by the R.V. Hakuho-Maru. The authors wish to thank Captain T. Shirasawa and his subordinates for their valuable advice and help.

Height above M.S.L.	Scheme of original record	Period of observation	Remarks
	Ship's log book	June 30 - July 11	
10.5 m	Drum chart	"	corrected into sea level values
13.5 m	Strip chart	July 3 - July 11	
"	"	July 3 - July 11	
-1.0 m	"	June 30 - July 11	
8.0 m	"	June 30 - July 11	
-5.5 m	"	"	
21.8 m	"	"	
	Ship's log book	July 1 - July 10	
		"	
	Ship's log book or Quartermaster's log book	"	
		"	
11.5 m	Drum chart	July 3 - July 10	
	Quartermaster's log book	July 1 - July 10	
1.5 m	Strip chart	July 5 - July 8	

2. Bow-boom measurements of wind fluctuations and waves

A. Takeda, K. Taira, K. Ishikawa and Y. Ogura
Ocean Research Institute, University of Tokyo, Tokyo

Measurements of turbulent fluctuations of wind velocities with a three dimensional sonic anemometer and surface waves by a sonic wave gauge were carried out on a bow boom (shown in Fig. 2-1)

The observation was intended to obtain the data free from the errors due to obstacle disturbances by the hull and due to motions of the ship, and thereby to make explanation of momentum transfer mechanism at sea surface possible under open sea conditions.

The bow boom, projected ahead horizontally from the top of bow, 10 m in length, and 7.5 m in height above the mean sea level was specially designed for meteorological purpose and is available to minimize the hull disturbances. Quantities of ship motions at bow were also measured with ship motion meters. Instantaneous corrections of errors in wind and wave data are possible through a computer, transforming coordinates by the use of these quantities.

The simultaneously observed quantities in all are as follows:

1. horizontal component (A) of wind velocity
2. horizontal component (B) of wind velocity
3. vertical component of wind velocity
4. relative sea surface level (relative wave) measured from the bow boom
5. rolling angle
6. pitching angle
7. vertical acceleration at the bow
8. azimuth of the bow (by gyroscope).

Data-loggings were done directly through the computer aboard, operating on the real time processing. Descriptions of the computer system may be referred to Chapter 3..

Sampling rate of the data was set at 5 Hz for each quantity. The period of the observational run was 400 seconds.

A list of the observational runs are tabulated below.

Run	Date	Time started
1.	July 7, 1969	16^h30^m
2.	July 7	16^h55^m
3.	July 7	17^h19^m
4.	July 7	17^h47^m
5.	July 7	18^h22^m
6.	July 7	18^h45^m
7.	July 7	19^h12^m
8.	July 8	00^h20^m
9.	July 8	01^h20^m
10.	July 8	09^h25^m
11.	July 8	10^h13^m
12.	July 8	10^h36^m
13.	July 8	11^h00^m
14.	July 8	11^h25^m
15.	July 8	11^h50^m

Spectral analyses were applied to some of uncorrected data by through the computer on the ship, but the detailed analyses are to be continued.

Fig. 2-1 The bow boom with a sonic wave gauge

3. Data-logging and data processing by the computer aboard the Hakuho-Maru

W. Inada and I. Watabe
National Research Center for Disaster Prevention, Hiratsuka

K. Taira and K. Ishikawa
Ocean Research Institute, University of Tokyo, Tokyo

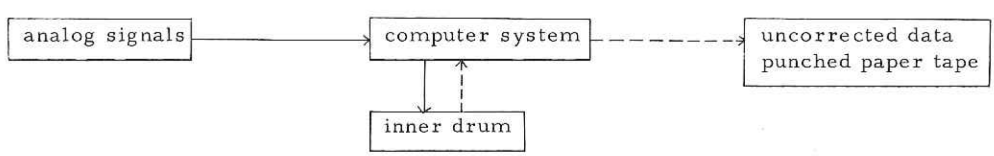
3-1. An application of the Real Time Control on the computer to data-logging and processing

Many properties of the phenomena which we investigate can be expressed with electric analog signals by means of transducers and some devices. To deal with these analog signals, the computer system (FACOM 270-20) on board the ship is provided with the "analog to digital converter with multiplexer" (A-D conv. + MPX) and with the "real time controller" (RTC) (see Fig. 3-1). We can get digital data with the computer system giving external pulses to the RTC. A circuit diagram of a pulse generator for sampling is shown in Fig. 3-2.

On the cruise, we developed computer programs which collected digital data through nine analog signals and calculated power spectra for them.

3-2. Flow-charts of the process

Program 1.

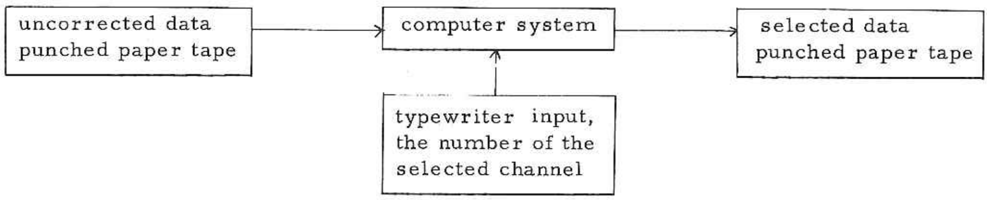


—— real time; ---- on-line;

Remarks:

program language;	FASP
input analog signals;	9 channels. (maximum 16 channels.) maximum voltage ±10 v.
sampling interval;	0.2 sec/9 channels. (maximum 0.02 sec/ 9 channels.)
data file capacity;	2,000 data x 9 channels in the inner drum.
output digital data;	punched out on the paper tape by the BCD code.

Program 2.



Program 3.

Harmonic analyses by the Tukey's method.

The above three programs written by FASP are tabulated in Table 3-1, Table 3-2 and Table 3-3 respectively. On the real time process described in Program 1, all data are stored in the inner memory drum and the following processes can be done on the on-line process.

Acknowledgements:

We would like to thank Mr. T. Igarashi, the operator of the computer, for his help throughout the work.

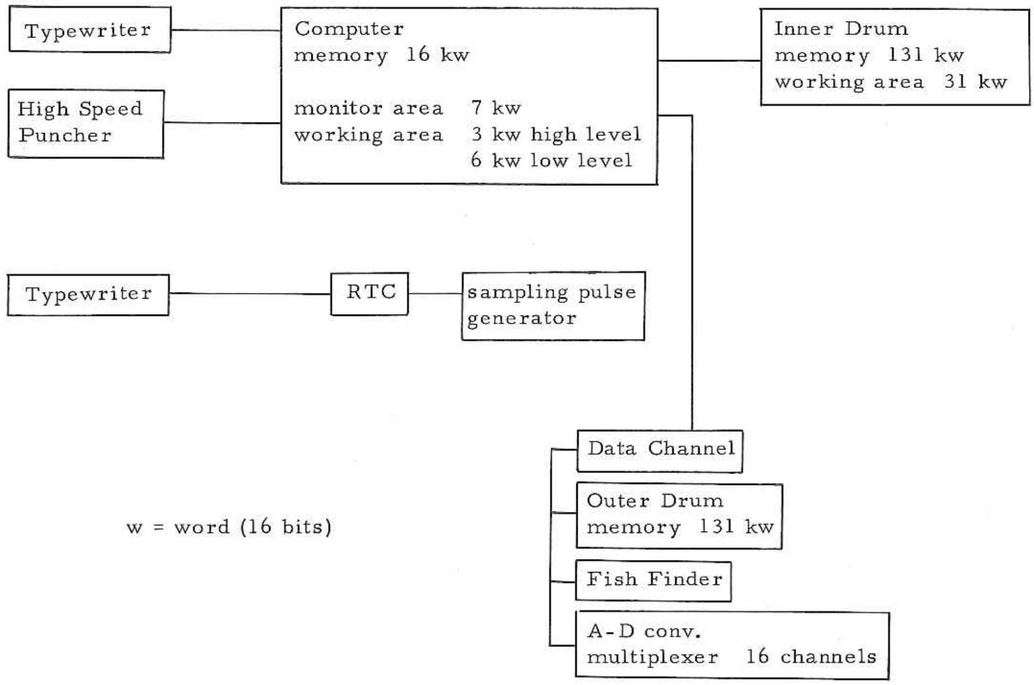


Fig. 3-1 Block diagram of the computer system

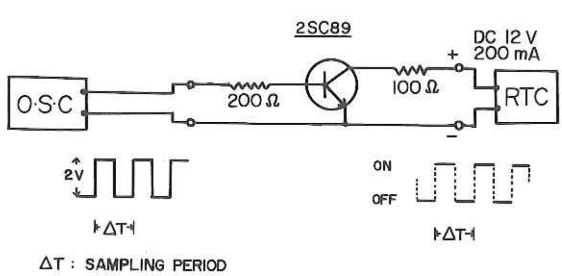


Fig. 3-2 An external pulse generator for sampling signals

Table 3-1

high level

```
    XIO.L,      READ,1
    L.L,      CO
    ST.L,      ※1C6
JMP;   L.L,      C2
    B.L,      JMP,PM
    SL.S,     16
    ST.L,     C2
  LX.I,     *3,INDX3
   LX.L,     *1,-8
JMPA;    L.L,     *1,※F7A+8
    SRA.S,     5
    ST.L,     *3,CA+129
    AX.L,     *3,1
    AX.S,     *1,1
    B.R,     JMPA
    STX.L,     *3,INDX3
    AM.L,     COUNT,1
    L.L,     COUNT
    S.L,     D16
    B.L,     PM,PM
    BABS.S,     =END
PM;   LX.L,     *3,-129
    STX.L,     *3,INDX3
    L.L,     ZERO
    ST.L,     COUNT
    LX.L,     *1,*
    B.L,     =STDR
    VFD,     3/2,13/1
    DN,     CA
DRA;  DN,     ※400
    DN,     -1
    BABS.S,     =END
    AM.L,     DRA,1
    BABS.S,     =END
SENC;     L.R,     CO
    ST.R,     C2
    XIO.L,     SENCE,1
    B.I,     ※187
    QUAD
READ;     DN,     ※2C00,※F7A,8
CO;     DN,     SENC
SENCE;     DN,     ※AC00,0
C2;     BSS,     1
COUNT;     DN,     0
D16;     DN,     16
INDX3;     DN,     -129
ZERO;     DN,     0
CA;     BSS,     128
    END
```

low level

```
    EXTN,     CTPOKI
    LX.L,     *1,*
    B.L,     =STDR
    VFD,     3/1,13/10
    DN,     CAT
DRAK;  DN,     ※400
    DN,     -1
    BABS.S,     =END
    CALL,     OPNP
    DN,     CTPOKI
    BABS.S,     =END
    LX.L,     *1,-1280
KB;    LX.S,     *3,-4
K1;    L.L,     *1,CAT+1280
    CALL,     IBDC
    DN,     OUT
    LX.S,     *2,-6
K2;    L.L,     *2,OUT+6
    CALL,     PUTP
    BABS.S,     =END
    AX.S,     *2,1
    B.R,     K2
    AX.L,     *1,1
    B.R,     JA
    B.R,     JEND
JA;    AX.S,     *3,1
    B.R,     K1
    L.R,     CR
    CALL,     PUTP
    BABS.S,     =END
    B.R,     KB
JEND;     L.R,     CR
    CALL,     PUTP
    BABS.S,     =END
    CALL,     CLSP
    BABS.S,     =END
OUT;     BSS,     6
CR;     DN,     ※000A
CAT;     BSS,     1280
    END
```

Table 3-2

```
           EXTN,CTROKI,CTPOKI,CTRFW,CTPFW 10
           B'.R,START 10
TITLE;     INTC,DECIMAL 5 KETA NO 9 CHANNEL SENTAKU PROGRAM
           NO.OF DATA AND,CANNEL  NO. TYPIN               10
START;     CALL,OPNT 10
           DN,CTPFW 10
           DN,O 10
           LX.S,*1,-50 10
TLS;      L.L,*1,TITLE+50 10
           SR.S,8 10
           CALL,PUTT 10
           B.R,* 10
           L.L,*1,TITLE+50 10
           CALL,PUTT 10
           B.R,* 10
           AX.S,*1,1 10
           B.R,TLS 10
           CALL,CLST 10
           CALL,OPNK 10
           B.R,* 10
           LX.S,*1,-5 10
RB1;       CALL,GETK 10
           B.R,* 10
           ST.L,*1,RK1+5 10
           AX.S,*1,1 10
              B.R,RB1 10
           LX.S,*1,-3 10 .
RB2;       CALL,GETK 10
           B.R,* 10
           ST.L,*1,RK2+3 10
           AX.S,*1,1 10
           B.R,RB2 10
           CALL,CLSK 10
           CALL,IDBC 10
           DN,RK1 10
           DN,O 10
           ST.L,DATA 10
           CALL,IDBC 10
           DN,RK2 10
           DN,O 10
           ST.L,CHNL 10
           L.L,ZERO 10
          S.L,DATA 10
           ST.L,DATA 10
           LX.I,*1,DATA 10
LOOP;     CALL,OPNR 10
           DN,CTROKI 10
           DN,O 10
           LX.S,*2,-9 10
JJJ;       LX.S,*3,-5 10
J1;        CALL,GETR 10
           BABS.S,=END 10
           SKP.S,PM 10
           B.R,J1 10
           ST.L,*3,DEC+5 10
           AX.S,*3,1 10
           B.R,J1 10CALL,IDBC 10
           DN,DEC 10
           B.R,* 10
           ST.L,*2,OUT+9 10
           AX.S,*2,1 10
           B.R,JJJ 10

           LX.I,*2,CHNL 10
           L.L,*2,OUT-1 10
           CALL,CLSR 10
           CALL,OPNP 10
           DN,CTPOKI 10
           DN,O 10
           LX.I,*2,CHNL 10
           L.L,*2,OUT-1 10
           CALL,IBDC 10
           DN,PUNCH 10
           DN,O 10
           LX.S,*2,-5 10
PP;        L.L,*2,PUNCH+7 10
           CALL,PUTP 10
           B.R,* 10
           AX.S,*2,1 10
           B.R,PP 10
           CALL,CLSP 10
           AX.L,*1,1 10
           B.R,LOOP 10
           BABS.S,=END 10
PUNCH;     BSS,6 10
           DN,#002C 10
CHNL;      DN,O 10
DATA;      DN,O 10
RK1;       BSS,6 10
RK2;       BSS,6 10
OUT;       BSS,9 10
DEC;       BSS,6 10
           DN,#002C 10
 ZERO;       DN,O 10
           END 10
```

```
      EXTN,  CTROKI,CTPOKI, CTPFW,CTRFW10
      B.R,  START10
TITLE; INTC, AUTO CORRELOGRAM AND POWER SPECTRUM
PROGRAM NUMBER OF DATA, LAG NUMBER TYP IN10
KOSU; DN, 95010
FILT; DN, 5010
RK1; BSS, 510
RK2; BSS, 410
START; CALL, OPNT10
      DN, CTPFW10
      DN, O10
      LX.S, *1,-3910
TLS;  L.L, *1,TITLE+3910
      SR.S, 810
      CALL, PUTT10
      B.R, *10
      L.L, *1,TITLE+3910
      CALL, PUTT10
      B.R, *10
      AX.S, *1,110
      B.R, TLS10
      CALL, CLST10
      CALL, OPNK10
      B.R, *10
      LX.S, *1,-510
RB1;  CALL, GETK10
      B.R, *10
      ST.L, *1,RK1+510
      AX.S, *1,110
      B.R, RB110
      LX.S, *1,-410
RB2;  CALL, GETK10
      B.R, *10
      ST.L, *1,RK2+410
      AX.S, *1,110
      B.R, RB210
      CALL, CLSK10
      CALL, IDBC10
      DN, RK110
      DN, O10
      ST.L, KOSU10
      CALL, IDBC10
      DN, RK210
      DN, O10
      ST.L, FILT10
      L.L, KOSU10
      SRAD.S, 1610
      CALL, FXFL10
      DN, 3110
      STD.L, TT10
      L.L, KOSU10
      M.L, SIGN10
      SLD.S,1610
      ST.L, DATA10
      S.L, ONE10
      ST.L, KLOOP10
      L.L, STRT10
      S.L, KOSU10
      ST.L, INDX310
      L.L,FILT10
      A.L, FILT10
      ST.L, KARI10
      L.L, ZERO10
      S.L, KARI10
      ST.L, FLK10
      S.L, P210
      ST.L, FL10
      L.L, FLK10
      A.L, P210
      ST.L, LFTR10
      LX.I, *1,DATA10
      CALL, OPNR10
      DN, CTROKI10
      B.R, *10
RD1;  LX.S, *2,-510
READ; CALL, GETR10
      B.R, *10
      SKP.S, PM10
      B.R, READ10
      ST.L, *2,DEC+510
      AX.S, *2,110
      B.R, READ10
      CALL, IDBC10
      DN, DEC10
      DN, O10
      ST.L, *1,X+200010
      AX.L, *1,110
      B.R, RD110
      CALL, CLSR10
      LD.L, FZERO10
      STD.L, DEC10
      LX.I, *1,DATA10
JX1;  L.L, *1,X+200010
      SRAD.S, 1610
      CALL, FXFL10
      DN, 3110
      FA, DEC10
      STD.L, DEC10
      AX.L, *1,110
      B.R, JX110
      L.L, KOSU10
      SRAD.S, 1610
      CALL, FXFL10
      DN, 3110
      STD.L, KARI10
      LD.L, DEC10
      FD, KARI10
      STD.L, MEAN10
      L.L, KLOOP10
      ST.L, T10
      LX.I, *1, FL10
JXB;  LD.L, FZERO10
      STD.L, KARI10
      L.L, T10
      A.L, ONE10
      ST.L, T10
      LX.I, *2,T10
      LX.I, *3,INDX310
JXA;  L.L, *2,X+200010
      SRAD.S, 1610
      CALL, FXFL10
      DN, 3110
      FS, MEAN10
      STD.L, FCON10
      L.L, *3,X10
      SRAD.S, 1610
      CALL, FXFL10
      DN, 3110
      FS, MEAN10
      FM, FCON10
      FA, KARI10
      STD.L, KARI10
      AX.L, *3,110
      AX.L, *2,110
      B.R, JXA10
      LD.L, KARI10
      FD, TT10
      STD.L, *1,CXX+20210
```

```
          AX.L, *1,2
          B.R, JXB
          LX.I, *1,FL
JXS;      LD.L, *1,CXX+202
          CALL, FBDCS
          DN, OUTAREA
          DN, 0
          CALL, OPNP
          DN, CTPOKI
          B.R, *
          LX.S, *2,-13
K2;        L.L, *2,OUTAREA+13
          CALL, PUTP
          B.R, *
          AX.S, *2,1
          B.R, K2
          CALL, CLSP
          AX.L, *1,2
          B.R, JXS
          CALL, OPNP
          DN, CTPOKI
          B.R, *
          LX.S, *2,-100
PFD;      L.L, FEED
          CALL, PUTP
          B.R, *
          AX.S, *2,1
          B.R, PFD
          CALL, CLSP
          LX.I, *1,FL
          LD.L, *1,CXX+202
          STD.L, AO
          L.L, FILT
          SRAD.S, 16
          CALL, FXFL
          DN, 31
          STD.L, FILTER
          LD.L, FZERO
          STD.L, KARI
          STD.L, L
          LX.I, *1,LFTR
JWA;      LD.L, L
          FA, FONE
          STD.L, L
          FM, PAI
          FD, FILTER
          CALL, COS
          FA, FONE
          STD.L, FCON
          LD.L, *1,CXX+200
          FM, FCON
          FA, KARI
          STD.L, KARI
          AX.L, *1,2
          B.R, JWA
          FA, AO
          STD.L, PO
          LD.L, FZERO
          STD.L, K
          LX.I, *2,LFTR
JWE;      LD.L, FONE
          FA, K
          STD.L, K
          LD.L, FZERO
          STD.L, SIGMA
          STD.L, L
          LX.I, *3,LFTR
JWD;      LD.L, FONE
          FA, L
          STD.L, L
          FM, PAI
          FD, FILTER
          STD.L, DV
          CALL, COS
          FA, FONE
          STD.L, FCON
          LD.L, DV
          FM, K
          CALL, COS
          STD.L, KARI
          LD.L, *3,CXX+200
          FM, FCON
          FM, KARI
          FA,      SIGMA
          STD.L, SIGMA
          AX.L, *3,2
          B.R, JWD
          LD.L, SIGMA
          FA, AO
          STD.L, *2,PW+200
          AX.L, *2,2
          B.R,  JWE
          LD.L, PO
          CALL, FBDCS
          DN, OUTAREA
          DN, 0
          CALL, OPNP
          DN, CTPOKI
          B.R, *
          LX.S, *2,-13
K5;       L.L, *2,OUTAREA+13
          CALL, PUTP
          B.R, *
          AX.S, *2,1
          B.R, K5
          LX.I, *1,LFTR
K7;       LD.L, *1,PW+200
          CALL, FBDCS
          DN, OUTAREA
          DN, 0
          LX.S, *2,-13
K8;       L.L, *2,OUTAREA+13
          CALL, PUTP
          B.R, *
          AX.S, *2,1
          B.R, K8
          AX.L, *1,2
          B.R, K7
          CALL, CLSP
          BABS.S, =END
ZERO; DN, 0
KLOOP; DN, 0
DATA; DN, 0
ONE; DN, 1
FLK; DN, 0
P2; DN, 2
FL; DN, 0
STRT; DN, 2000
INDX3;DN,0
T; DN. 0
SIGN; DN, -1
LFTR; DN, 0
FEED; DN, #0000
          EVEN
PAI; FLD, 3.14159
FONE; FLD, 1
FZERO; FLD, 0
FILTER; BSS, 2
AO; BSS, 2
TT; BSS, 2
KEISU; BSS, 2 DV; BSS, 2
L; BSS, 2 K; BSS, 2
SIGMA; BSS, 2 PO; BSS, 2
FCON; BSS, 2 MEAN; BSS, 2
KARI; BSS, 2
OUTAREA; BSS, 11
          DN, #002C
          DN, #000A
          EVEN
DEC;  BSS, 5
          EVEN
CXX;  DA, 202 PW;  DA, 202
X;    DA, 2000
          END
```

4. Surface temperature observations with an infrared radiation thermometer

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Measurements of sea surface temperature with an infrared radiation thermometer were performed continuously throughout the cruise. The thermometer we used was the Model PRT 14-313 made by Barnes Engineering Company of U. S. A. and output signal was recorded by a strip-chart recorder in the analog form. The optical unit was set obliquely on the starboard side of the bridge deck. Analyses of the data are left for the future laboratory works.

5. STD observation at the station point

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The vertical distributions of salinity and temperature were measured down to the bottom layer of 100 meter deep with a STD system (Hytech 9006 STD Data Acquisition System). The observations were made every six hours during the period from July 3, 15:00 (J. S. T) to July 8, 09:00, 1969, at the station point (31. 5°N, 127°E) in the East China Sea where the depth of water was 106 ~ 107 meters.

In this period, from 09:00 to 15:00 on July 7, the observation intervals were reduced to 2 hours to examine a possible variation of salinity distribution subsequent to showers from 08:35 to 09:40 on the same day: the amount of rainfall in that period went on 31. 7 mm, while the 24 hour-amount from 15:00 July 6 to 15:00 July 7 was 33. 8 mm.

In the operation, two vertical profiles for each property were directly drawn on the chart of an X-Y recorder with the lowering or hauling up of the STD.

Between two successive observations, the STD was set at a constant depth of 18 meters, the top of the seasonal thermocline, and continuous recordings were made in digital form so that the time variations of salinity and temperature could be observed.

All the profiles of salinity and temperature obtained in downward casts are shown in Fig. 5-1.

Fig. 5-1 Results of STD observation

6. Measurements of turbulent fluxes over the sea

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6-1. Objective

The purpose of the present study is to measure turbulent fluxes of momentum, sensible heat and water vapor over the sea by the direct method and the indirect methods.

6-2. Instruments and observations

The method of direct observation of the turbulent fluxes from the moving ship is the one used by the present authors in the last ocean expedition of GARP '68 (Mitsuta, Hanafusa and Maitani (1969)) with minor changes in the recording method. The fluctuating components of wind were measured by a sonic anemometer-thermometer and corrected for ship movements. The fluctuation of air temperature was measured by the sonic anemometer-thermometer and a fine thermocouple, and water vapor content by a fine thermocouple psychrometer.

In order to compare the results of direct measurements with other methods of flux estimation, the method of momentum flux estimate by the use of the energy equation (Weiler and Burling (1967)) and the bulk method of momentum, sensible heat and water vapor flux estimate were followed in the present study. For the estimation by the former method, which needed the energy dissipation rate estimate, high frequency parts of wind fluctuations were observed by a fine hot wire anemometer. The second method was a simple traditional one and needed only ordinary weather information available from the ship.

All the sensors of meteorological entities were installed on the top of the foremast which was the position where the effects of the ship body on winds were small. They were a sonic anemometer-thermometer (Kaijo Electric Co., PAT-311-1), a hot wire anemometer (Nihon Kagaku Kogyo Co., Kanomax Model 28-3111) and a fine thermocouple psychrometer (Sano and Mitsuta (1968)). The cold points were dipped into water in a thermos on the mast, the temperature of which was remotely read by a thermistor thermometer.

Pitching and rolling of the ship were measured by an electric clinometer (Sokkisha Co.) in the No. 1 Laboratory of the vessel. The signals of ship heading direction and speed were supplied from the routine observation pannel in the laboratory.

All the signals of the fluctuating components were multiplexed into an FM signal by a multiplexer (TEAC Co., AU-151) and recorded on a magnetic tape recorder (TEAC Co., R-200).

About twenty observations were made during the present expedition. Each run was about an hour in time length. The time of observations and conditions are shown in Tables 6-1 and 6-2.

6-3. Results

The data will be analyzed by the use of a high speed A-D converter and a machine computer of Kyoto University. The results of the turbulent flux estimate together with turbulent spectra of each component will be published in 1970.

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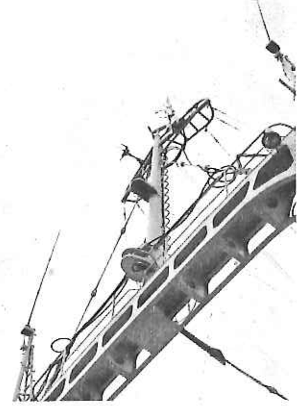

Fig. 6-1 Anemometer installation on the foremast

Table 6-1 Turbulent flux measurements

Run	Date	Time	Wind Direction	Relative Wind Speed		Wind Air Temp. °C	Sea Surface Temp. °C	Ship Speed
GARP '69	July	h m h m		m/sec	from			
1	2	20:30-21:24	SW	3	left 10°	22.8	22.7	13kt
2	4	08:35-09:15	SSW	11	left 20°	22.8	21.0	stop
3	4	20:48-21:30	SW	11	left 10°	22.7	21.0	stop
4	4	23:10-23:50	SSW	11	right 40°	22.7	21.0	stop
5	5	00:20-01:14	WSW	9	right 45°	22.3	21.0	stop
6	6	13:50-14:50	SW	9	right 30°	22.9	21.3	stop
7	7	11:28-12:15	SSE	2	left 30°	23.1	21.4	stop
8	7	14:12-15:06	SSW	5	right 15°	23.9	21.6	stop
9	7	16:43-17:35	SSW	9	left 40°	23.7	21.6	stop
10	7	17:47-18:40	SSW	11	left 30°	23.6	21.6	stop
11	7	20:08-21:10	SSW	11	left 45°	23.2		stop
12	7	22:33-23:27	SSW	11	left 35°	23.1	21.4	stop
13	8	00:52-01:40	SSW	13	right 40°	23.5	21.4	stop
14	8	10:15-11:08	W	14	left 10°	22.0	21.4	stop

Table 6-2 High frequency fluctuation measurements

Run	Date	Time	Wind Direction	Relative Wind Speed		Wind Air Temp. °C	Sea Surface Temp. °C	Remarks
GARP '69	July	h m h m		m/sec	from			
H-1	6	19:25-20:03	SSW	7	left 40°	22.0	21.4	5103 gantry
H-2	7	16:04-16:30	SSW	6	left 25°	24.1	21.7	5105 gantry
H-3	7	19:00-	SSW	11	left 30°	23.4	21.6	5105 mast
H-4	7	21:20-22:18	SW	10	left 30°	23.2	21.4	5105 mast
H-5	7	23:35-	SSW	13	left 25°	23.1	22.4	5105 mast
H-6	8	02:08-02:32	SSW	15	left 15°	23.0	21.4	5105 mast

7. Measurements of wind velocity over the sea

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7-1. Objective

Turbulence in the surface wind is originated in several causes. The irregularity of the surface and the difference of temperature between air and surface are the main causes of the turbulence. The time variation of airflow over the sea is markedly different from that over the land. The objective of this investigation is to make clear the turbulence over the sea by comparing the time variation of flow with that over the land.

7-2. Instruments

1. An anemometer installed on the foremast of the Hakuho-Maru.

2. A three-cup anemometer on the foremast. Number of the rotations was counted by electronic techniques, which was recorded by 8 mm movie camera.

7-3. Measurements

Wind velocities are recorded continuously for 102 hours, from 22:00 on July 3 to 04:00 on July 8. The analysis of data is left for the future laboratory works.

8. Observations of wind, temperature and humidity near the sea surface

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S. Nemoto and M. Tosha
Meteorological Research Institute/JMA, Tokyo

8-1. Objective

Many studies have been done on the turbulent structure in the surface boundary layer near the ground, but rather few data can be found of the meteorological elements observed near the sea surface. It would be attributed to difficulties of observation techniques and to much expense for the observation. The aim of the present observation near the sea surface is to clarify the turbulent structure in the surface boundary layer near the sea and also to study the transfer mechanism of heat and momentum. The observations were made not only of the fluctuations of wind and temperature but also of the profiles of wind, temperature and humidity.

8-2. Observation of the fluctuations by the use of a sonic anemometer-thermometer

The sonic anemometer-thermometer employed here was of "phase-difference" type, by which fluctuations of ship-head and vertical components of the wind and also of temperature were measured. The sonic devices were installed on the top of the foremast. (Incidentally the present instrument was placed by the side of the sonic anemometer-thermometer of Kyoto University and the small three-cup anemometer of Tohoku University).

Seven runs were obtained during 5th through 8th of July. Each run lasted for 30 min to 60 min. The last run conducted on 8th of July can be used for comparison of the three anemometers installed side by side on the top of the mast.

From the data are being calculated the auto- and cross-correlations of wind and temperature, as well as their spectra and cospectra. Here emphasis is put especially on the cross-correlation and the cospectrum for studying the transfer mechanism.

8-3. Observation of the profiles of wind speed, temperature and humidity

The instruments for measuring the profiles were as follows:

1) Wind speed: small three-cup anemometer. The signal of rotation was made through "lamp-photocell" devices for the purpose of minimizing the mechanical friction. The number of the rotations was printed out every 10 min.

2) Temperature and humidity: aspirated psychrometers the sensors of which were thermistors. The observations were made every 30 sec.

Five sets of the instruments mentioned above were installed along the pole (see Figs. 8-1 and 8-2). The pole was supported vertically by the horizontal boom which was 7.5 m high above the mean sea level. The measurement was made for about ten hours on 7th of July. Over fifty runs were obtained, each of which lasted for 10 min. The wind speed changed from almost calm to around 10 m/s, but the thermal stratification was under neutral condition. During the observation, the sea condition was rather rough, with high swells and wind waves.

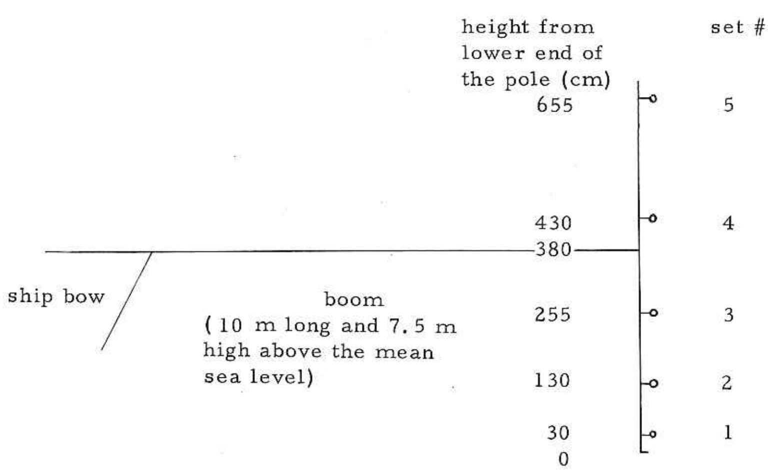

Fig. 8-1 Set-up of the boom, pole and five sets of sensors. A set consists of a three-cup anemometer and an aspirated psychrometer.

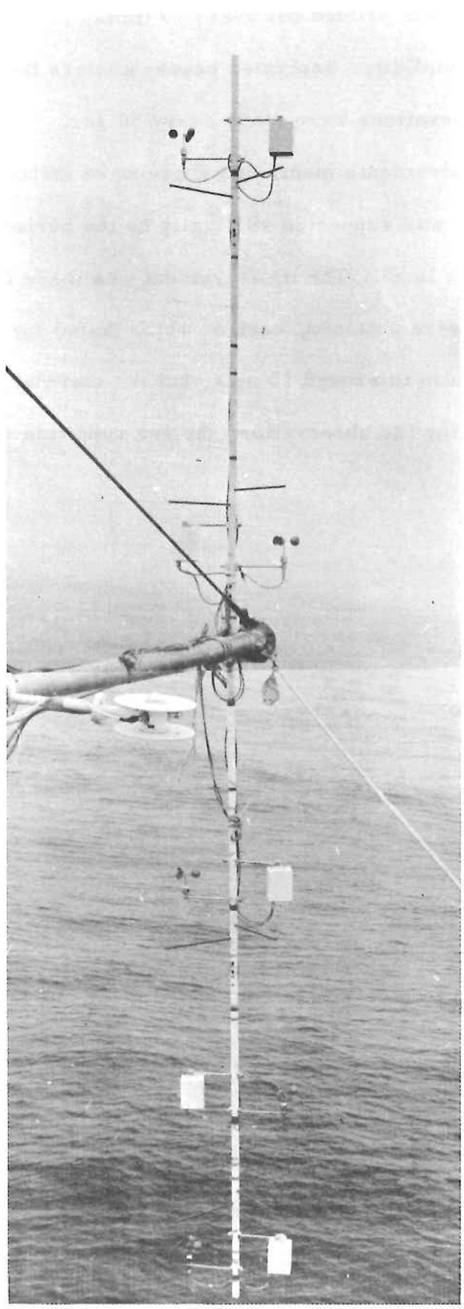

Fig. 8-2 Profile measurements on the bow boom

9. Observations of atmospheric structure in a thin layer next to the sea surface

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As a part of the study of air-sea interaction, associated especially with the GARP and the Severe Rainstorm Research Project, buoy observations of atmospheric structure in a thin layer next to the sea surface were attempted on the sea west off Kyushu, avoiding any influence of ship body. Wind speed, temperature, and humidity were measured at heights of 4 m, 2 m, 1 m and 0.5 m above the sea surface. Cup anemometers of Robinson type were used for wind speed measurement and sets of dry and wet bulbs of resistance thermometers were used for temperature and humidity measurement. Furthermore, an ultrasonic anemometer-thermometer was used at a height of 3 m above the sea surface for turbulence. Instruments were fixed on arms stretching outward from a pole set on a floating buoy (Fig. 9-1), designed specially for this purpose, connected to the anchor of the Hakuho-Maru. Mooring system of the buoy with instruments is shown in Fig. 9-2. Recorders were set in the No. 7 laboratory of the ship. Observations were carried out during two periods, one between 15:30 on July 3 and 10:00 on July 5 and the other between 10:50 on July 7 and 02:00 on July 8. During the latter period, the floating buoy with instruments was not connected to the anchor but to the stern of the ship because of some technical trouble. Data obtained seem to throw some light to a problem of processes concerning air-sea interaction, though complete data could not always be obtained due to some difficulties.

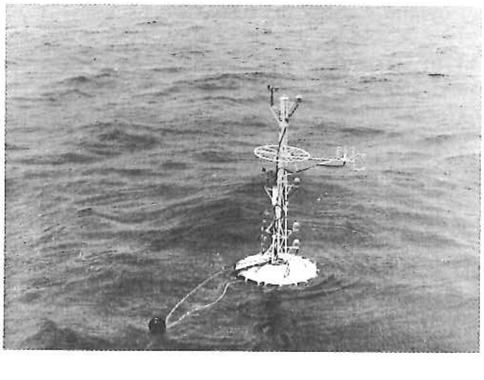

Fig. 9-1 Micrometeorological buoy

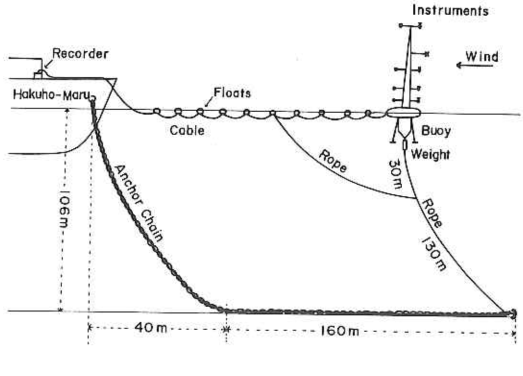

Fig. 9-2 Mooring system of the floating buoy

10. Measurements of vertical profiles in the atmospheric layer, up to 1000 meters high above the sea surface

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Resources Research Institute, Tokyo

and

Y. Ogura
Ocean Research Institute, University of Tokyo, Tokyo

10-1. Purpose

The purpose of the experiment is to clarify the vertical profiles of physical quantities which are related to the diffusion and transfer processes of material and energy in the atmospheric layer up to about 1000 meters high above the sea surface. The physical quantities measured are mean wind speed, temperature and humidity, and also fluctuations of longitudinal, lateral and vertical speeds and temperature.

10-2. Method

Mean profiles of the wind speed, temperature and humidity were measured by a wireless sonde (CBS-1) which was mounted on the cable of a captive blimp. Sensors for these quantities were small three-cup anemometer, platinum wire resistance thermometer and hair hygrometer. Measurement was carried out at a height for 3 to 5 min continuously. Temperature profile was measured by a radiosonde (LST sonde) for low level observations, when the captive balloon could not be well managed against the strong wind.

Fluctuations of the longitudinal, lateral and vertical speeds and temperature were measured by another wireless sonde (CWS-1 sonde) mounted also on the cables of a captive blimp. Sensors for these fluctuating quantities were a small bi-directional vane, a three-cup anemometer, a magnetic compass and a platinum wire resistance thermometer. The measurement of these fluctuations was carried out at a height for 10 to 30 min continuously.

10-3. Description of present observations

Observations were carried out on 4, 5, 6 and 7th July. Time of the observation is presented in the following tables.

Table 10-1 LST sonde observations

Date	Time of release	Maximum height (m)
July 4	12:18	1200
	15:30	1200
	18:30	1200
5	12:30	1200
	18:00	1200
6	16:20	1200
7	12:50	1200
	13:45	1200

Table 10-2 CBS-1 sonde observations

Date	Time of observation	Maximum height (m)	Interval of height (m)
July 5	06:00-07:15	200	20-50
6	19:00-20:00	200	20-30
7	10:35-11:25	200	20-50
	13:12-13:42	200	20-50

Table 10-3 CWS-1 sonde observations

Date	Time of observation	Height of observation (m)
July 5	11:00-11:20	50
	11:23-11:35	100
7	11:30-11:45	50
	11:48-12:10	100

The CWS-1 sonde observations were also carried out on the foremast of the ship, during strong wind conditions.

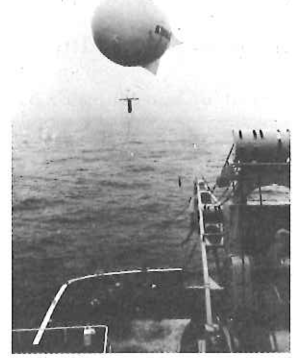

Fig. 10-1 A captive blimp with a CWS-1 sonde

11. Aerological observation with radiosonde

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Japan Meteorological Agency

During the cruise, the following series of aerological observations with radiosonde was made. The data will be analyzed after the cruise.

No.	Date	Time (JST)	Maximum altitude attained (mb)	Remarks
1	July 3	14:25-15:02	197	
2	"	20:33-21:10	197	
3	July 4	02:25-03:08	192	
4	"	08:30-09:05	544	loss of buoyancy by icing
5	"	14:25-15:05	543	loss of buoyancy by icing
6	"	20:30-21:06	200	
7	July 5	02:30-03:14	192	
8	"	08:30-09:14	197	
9	"	14:30-15:05	197	
10	"	20:30-21:11	193	
11	July 6	02:30-03:11	195	
12	"	08:30-09:34	194	
13	"	14:30-15:13	189	
14	"	20:30-21:15	195	
15	July 7	02:30-03:10	189	
16	"	08:30-09:08	196	
17	"	14:30-15:10	196	
18	"	20:30-21:25	190	
19	July 8	02:30-03:40	285	too small ascending rate of balloon
20	"	08:30-09:18	193	

Comments

1. The vessel has no special facility for releasing radiosonde balloons. However the left side of the flat top of the antirolling tank on the deck was so designed that to have fences of 2 meters high and canvas was fixed to the fences to make side-walls. Since this temporary releasing facility whose area was 3.1 m x 4.9 m had no ceiling, the accurate measurement of buoyancy of balloon filled with helium gas was not possible when we had strong wind. In addition, the balloon tended to make vibratory motion while it expanded, and apparently the fear of breaking the balloon by hitting the side-canvas made the operations to release the balloon before the balloon acquired sufficient buoyancy. In fact, one balloon was broken in that way. In general, the ascending rate of balloons in this series of

observation was 250 m/s, relatively small compared with the normal rate of 350 m/s. This was suspected to be the consequence of the above situation.

2. These were our impressions that (i) the release of balloons with the temporary facility we used would be difficult to operate with the wind speed exceeding 15 m/s or so, and (ii) if the entrance to the temporary facility was also covered by the canvas and if the side-canvas had an additional height of 0.5 to 1 meter, the releasing work could be done without much care.

12. Observations of sea-water droplets above the sea surface

—A study of the air-sea boundary processes with special reference to the breaking of wind waves and sea-water droplets—

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and

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12-1. Introduction

When the wind speed on the sea surface exceeds 4 or 5 m/sec, breaking of wind waves occurs and air bubbles are entrained into the water, and when the bubbles burst at the sea surface, many sea-water droplets are ejected into the air. It is considered that a series of these phenomena has the following significance in the air-sea boundary processes.

Firstly, the breaking of wind waves itself means the breaking of the laminar boundary layer at the sea surface, and the momentum of the air is transported to the water directly through turbulence. Consequently, there should be a certain relation between the intensity of the breaking of wind waves and the wind stress at the sea surface (Toba, 1968).

Secondly, there is also a relation between the intensity of the breaking of wind waves and the rate of production of water droplets (Toba, 1961). Consequently, the amount of sea-water droplets in the air near the sea surface should have a definite relation with the intensity of the breaking of wind waves, and consequently with the wind stress at the sea surface.

Thirdly, the sea-water droplets produced are suspended in the air by the balance between the size of suspended sea-water droplets and the $\sqrt{\overline{w'^2}}$ or u_*, the friction velocity of the air.

Fourthly, besides the water vapor evaporating from the sea surface as molecules, the sea-water droplets produced become a source of water vapor in the air above the sea surface, some of them being transported upward as droplets themselves. Therefore, sea-water droplets must have a significant influence on the evaporation from the sea in the case of strong winds (Toba, 1969).

In order to clearly understand these items, we have made observations of the vertical distributions of size and number of the sea-water droplets in the air above the sea surface. At the same time, we have visually observed various aspects of the breaking of wind waves and have taken their photographs.

12-2. Observation of sea-water droplets

Method for the sampling of droplets

The following three different methods have been used simultaneously. The first is the 5-mm film ribbon method. A sampling film 5 mm wide and 4 cm long is mounted in the small window at the end of a special metal rod of about 3 m in length. It is projected as far as possible from the body of the ship, and the window of the rod is opened to expose the film to the air at the right angle to the air flow for a measured time interval ranging from 30 sec to 200 sec. The collection efficiency is calculated for the air speed and the size of droplets. By this method, droplets larger than about 20 μ in diameter, which have comparatively low number concentrations, may be selectively collected. This method has been used for the first time during this cruise.

The second method is the use of a hand-operated impactor with a round hole of 1 mm in diameter. It was already described in detail by Toba and Tanaka (1967).

The other method is to use a sedimentation gauge reported by Toba and Tanaka (1965).

The sampling film

A halide-ion sensitive gelatin film has been used as the sampling surface. It was also already reported by Toba and Tanaka (1967).

Height and location of the sampling

Three locations have been selected for the sampling:

(i) the right or the left end of the Comp. Bri. Deck (about 13 m above the sea surface),

(ii) the P. C. C. or the foremost fair leaders of the Bridge Deck (about 6 m in height), and

(iii) the foremost right side of the Main Deck (about 3 m in height).

Sampling

In total, 28 samples (12 runs) by the 5-mm film ribbon method, and 30 samples (14 runs) by the jet-impactor, have been obtained, for various wind speeds ranging approximately from 5 to 14 m/sec. Each of these runs is a set of 2- or 3-height samples.

The sedimentation gauge was used only for the first a few days. It seemed that the gauge was not so useful for the present observation, since the wind and rain were too strong.

Reading out

Microscopic photographs of the collected samples have been taken on board the ship, but the reading out and their analysis are left for the future.

12-3. Findings by preliminary inspections of the sampled sea-water droplets

Although a quantitative analysis is left for the future laboratory works, the following items have been noted by preliminary inspections of the samples by the use of a microscope.

(i) The size distribution of the droplets suspended in the air above the sea surface shows a well-defined upper limit for each case.

(ii) The size, consequently the velocity of fall (Vc), of the largest droplets suspended in the air, varies considerably with wind speed, and seems nearly constant with height above the sea surface. The largest droplets suspended were of the order of 100 μ in diameter (Vc $\simeq$ 25 cm/sec) for a case of the wind speed of about 14 m/sec.

(iii) The number concentration of the droplets, of course, very much depends on the wind speed.

12-4. Concluding remarks

We have visually observed various aspects of the breaking of wind waves, and have been able to get ideas concerning the mechanism of the breaking.

After completion of the reading out of the samples, we expect to be able to examine the data together with other data on turbulence, waves, and so forth, obtained by other researchers during this cruise.

We would like to take this opportunity to extend our many thanks to Professor Ogura, and to all other people who have been concerned in and have helped our present research work.

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13. Measurements of atmospheric electric variables in the air over the sea

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13-1. Objective

The objective of this study is to collect data of atmospheric electric variables to make clear the macroscopic and microscopic electric structures of the atmosphere. The former is related to the problem of the global electric circuit system and the latter to the problem of atmospheric electricity near the sea surface. Measurements of atmospheric electric variables over the sea surface may be important for two reasons. Firstly, the various charge separation is believed to take place at the sea surface and therefore the phenomena of the electrical interaction between air and sea surface are becoming one of the most important problems of atmospheric electricity. Secondly, the ground-based observation of atmospheric electric variables suffers in general from disturbances by local meteorological conditions. For these reasons, we have attempted to measure atmospheric variables such as electric field, electric conductivity, and air-earth current to investigate the problem of global electric circuit, and attempted to measure atmospheric ion density and ion mobility spectrum to understand the interaction between air and sea surface.

13-2. Measurements and results

An electric field meter and an air-earth current detector were set on the upper and fore decks respectively. The field meter was the ordinary induction type and the current detector was the type of plate sensor. We have made continuous measurements from July 2. The order of magnitude of electric field and that of air-earth current were found to be approximately 100 V/m and 1.0×10^{-12} A/m^2 respectively for calm days. A conductivity meter and a spectrometer were set in the No. 2 laboratory. They were the ordinary aspiration cyclindrical condenser and were composed of two electrodes, inner electrode and outer one. The voltages applied to the outer electrode were stepped from 0 up to 100 V for the conductivity meter and from 0 up to 273 V for the spectrometer. The conductivity meter was used as an ion density meter for high voltages. Furthermore, we could get the weighted means mobility of atmospheric ions from conductivity and ion density. The order of magnitude of ion current obtained was approximately 10^{-13} A for calm days. The instruments functioned normally from July 1. The results obtained, however, were not always satisfactory because they were suffering from local meteorological disturbances. Especially, the electric field and air-earth current measurements were much disturbed. However, the detailed analysis of data would make clear the influence of the meteorological conditions. Furthermore, information of atmospheric ions obtained here would be useful to clarify the electrical interaction between air and sea surface, and the transitional behavior of the atmospheric electricity from the land to the sea.

Acknowledgements:

We wish to express our thanks to Prof. Y. Ogura and his staffs for this work and for their kindly discussions.

14. A study of ionization equilibrium in the air over the sea surface

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14 1. Objective

It is known that ion in the air is in the state of ionization equilibrium under normal conditions. In other words, it holds $q = \beta nN$ where, q = rate of ionization, n = number of small ions, N = number of condensation nuclei and β = attachment coefficient. We have measured previously those components to clarify the ionization equilibrium in the air near the ground surface. The object of this study is to investigate the characteristics of the ionization equilibrium in the air over the sea surface. In collecting data for this purpose, the following factors should be taken into consideration: (1) the contribution of the sea salt nuclei to the condensation nuclei and their effect on the ionization equilibrium, (2) the rate of small ion production by bursting of bubbles at the sea surface, (3) vertical transport of small ion.

14-2. Observation and results

To attain this purpose, the numbers of small ions and condensation nuclei and radius of the condensation nuclei were measured with an ion counter (Gardien type), Pollak counter and diffusion battery respectively. The measurement has been continued in the No. 2 laboratory during the period of the cruise from July 1 to July 10, 1969. The result of a preliminary analysis of the data indicates that the number of small ions was $3 \times 10 \sim 3 \times 10^{2}$ cc^{-1}, and the number of condensation nuclei was $10^{3} \sim 10^{4}$ cc^{-1}. The result of the detailed analysis and discussions will be reported in near future.

Acknowledgements:

We wish to express our thanks to Prof. Y. Ogura and his staffs for this work and for their kindly discussions.

15. Measurements of the boron concentration over the sea

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15-1. Objective

The final goal of this study is to understand the exchange cycle of boron between sea and atmosphere, or in other words, to identify the sources and sinks of boron in the atmosphere.

Several workers reported that the B/Cl ratio in precipitation was higher than that in sea water. This was confirmed also by our observation made previously at Hokkaido. Since atmospheric matters are removed by precipitation, the above results may indicate that not only sea water droplets ejected from the sea surface, but also air pollution particles and others are the sources of atmospheric boron, and boron may also evaporate from the sea surface, as reported by Gast and Thompson. However, little is known about the concentration of boron in the atmosphere.

It is intended to measure the concentrations of boron and chloride and thereby to find the B/Cl ratio in the air over the sea surface. We intend also to measure the concentrations of boron, chloride, calcium, magnesium, sodium and potassium in rainwater to find the ratios of B/Cl, Ca/Cl, Mg/Cl, Na/Cl and K/Cl.

15-2. Observations and results

Air was pumped at the rate of 2 l/min for 9 hours and boron was condensed in test tubes which were cooled approximately -70°C by methylalcohol saturated with dry ice. Chloride was collected in distilled water by bubbling into glass bottles. Air was collectea at the rate of 1.5 l/min for 9 hours. Rain water samples were collected by a 50 cm x 50 cm collector installed on the upper deck. In total, several rainwater samples and 9 air samples for boron and chloride were collected.

After the cruise, boron and chloride will be analyzed by the spectrophotometric method, and calcium, magnesium, sodium and potassium by the atomic absorption method at our laboratory in Hokkaido University. The result of analysis will be published in near future.

Acknowledgements:

The writers wish to thank Professor Y. Ogura and his staffs for this works.

16. Current meter operations

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Measurements of near-bottom currents were carried out from July 3 to July 8 at a location on a continental shelf (31°31.2'N, 126°58.8'E), where the depth of water was 105 meters. Three Savonius meters (Geodyne 102) were installed vertically, two hung in a tripod of stainless steel put on the bottom and another with underwater buoys. The mooring system is sketched in Fig. 16-1.

The mooring ropes were broken down because of rubbing against the ship bottom while the recovery operation was going on under a rough sea condition of 5 in the afternoon on July 8. A search of the current meters by dredging began immediately after and continued in vain until sunset. The recovery failed of success. It is hoped that an operation will be undertaken to recover them another day.

A current meter (Geodyne 102) was lowered with a lead of 50 kg from the ship anchored at a distance of 1.2 mile from the moored current meters to measure flow at a depth of 30 m together with other meteorological observations. The data will be analyzed soon.

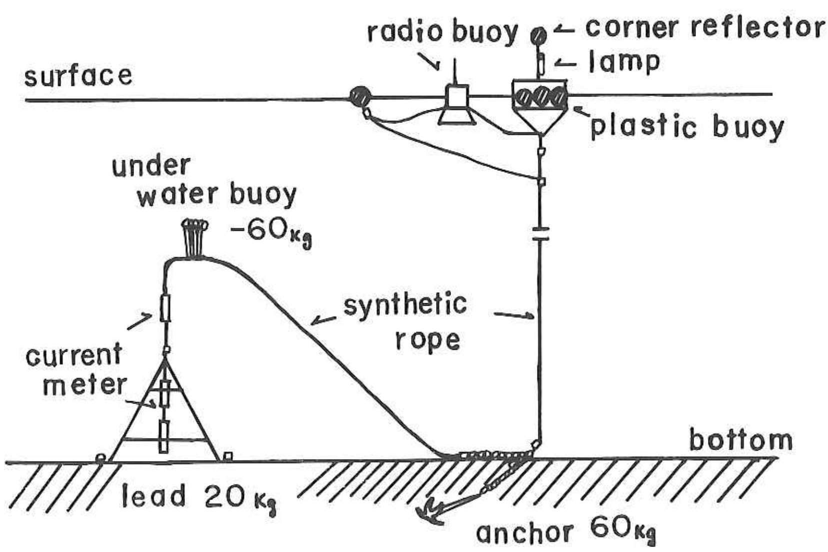

Fig. 16-1 Mooring system of current meters

17. Tests of an underwater spectroradiometer

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Ocean Research Institute, University of Tokyo, Tokyo

17-1. Purpose

An underwater spectroradiometer is designed to measure a spectrum of natural light under water.

Natural lights through the sea surface are absorbed by water molecules and scattered by suspended matters and water molecules so that the light intensity decreases exponentially with depth. Since the sensitivity of the detector N·E·P (noise equivalent power) is $10^{-8} \sim 10^{-10}$ watt·cm^{-2}· $^{-1}$, it is required to collect the optical energy as much as possible.

The first purpose of the present tests is to investigate the order of magnitude of optical energy collected by a new instrument at various depths. The second is a waterproof test of a tank in which the spectroradiometer is held.

17-2. Instruments

As shown in Fig. 17-1, the system of the spectroradiometer consists of a collecting optical system, a spectroscopic system, a drive mechanism, a detector, an amplifier system, a syncronous rectifier system and a recording system.

The weight of the instrument with the tank is about 600 kg in total. The tank is about 60 cm in diameter and 140 cm in length. This instrument is equipped with a gimbal system as shown in Fig. 17-2.

17-3. Tests

A waterproof test of the tank was made on July 4. The tank was submerged at about 80 m depth for 2 hours. The result was satisfactory.

A test installation of the spectroradiometer was tried on July 6, but it failed of success because of troubles in cable connectors adjacent to the tank due to unexpected wave forces, and just data obtained at sea surface level were available.

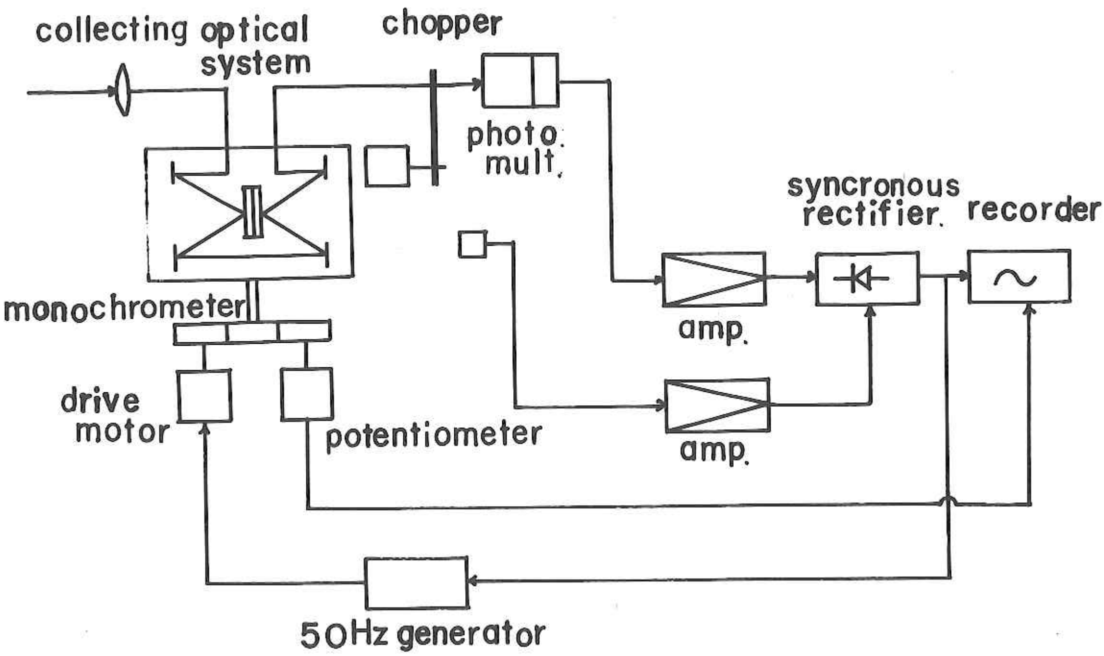

Fig.17-1 Block diagram of spectroradiometer

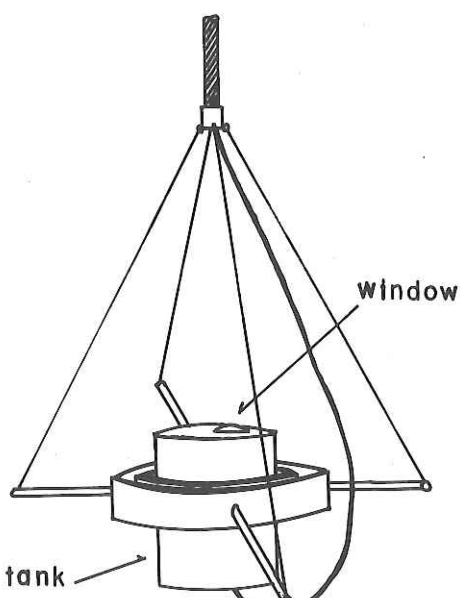

Fig.17-2 Spectroradiometer

18. Hydrographic casts by Nansen bottles

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Ocean Research Institute, University of Tokyo, Tokyo

Hydrographic casts wtih Nansen bottles were done for a study of optical characteristics of sea water through temperature, suspended or dissolved matters on the one hand, and for an investigation of diffusion and advection in bottom layer through information from temperature, salinity and other quantities such as natural radio nuclides on the other.

Two casts were carried out at a station in the East China Sea where the depth of water was 106 m. Eleven sampling levels are shown in Table 18-1. The lowest one was exactly sounded by using a sonar pinger (EG & G, model 220).

The data of temperature are given in the following table.

Table 18-1

Depth (M)	Temperature (°C) Cast 1	Cast 2
0	21.4	21.6
15.3	20.74	20.38
24.8	18.22	16.32
34.3	15.00	14.66
43.8	14.86	13.58
53.3	14.31	13.89
62.9	14.53	13.99
72.4	14.81	14.26
81.9	14.88	14.86
91.4	14.92	14.96
101.0	14.89	14.94

Position of the station;
31°32.3'N 126°59.9'E

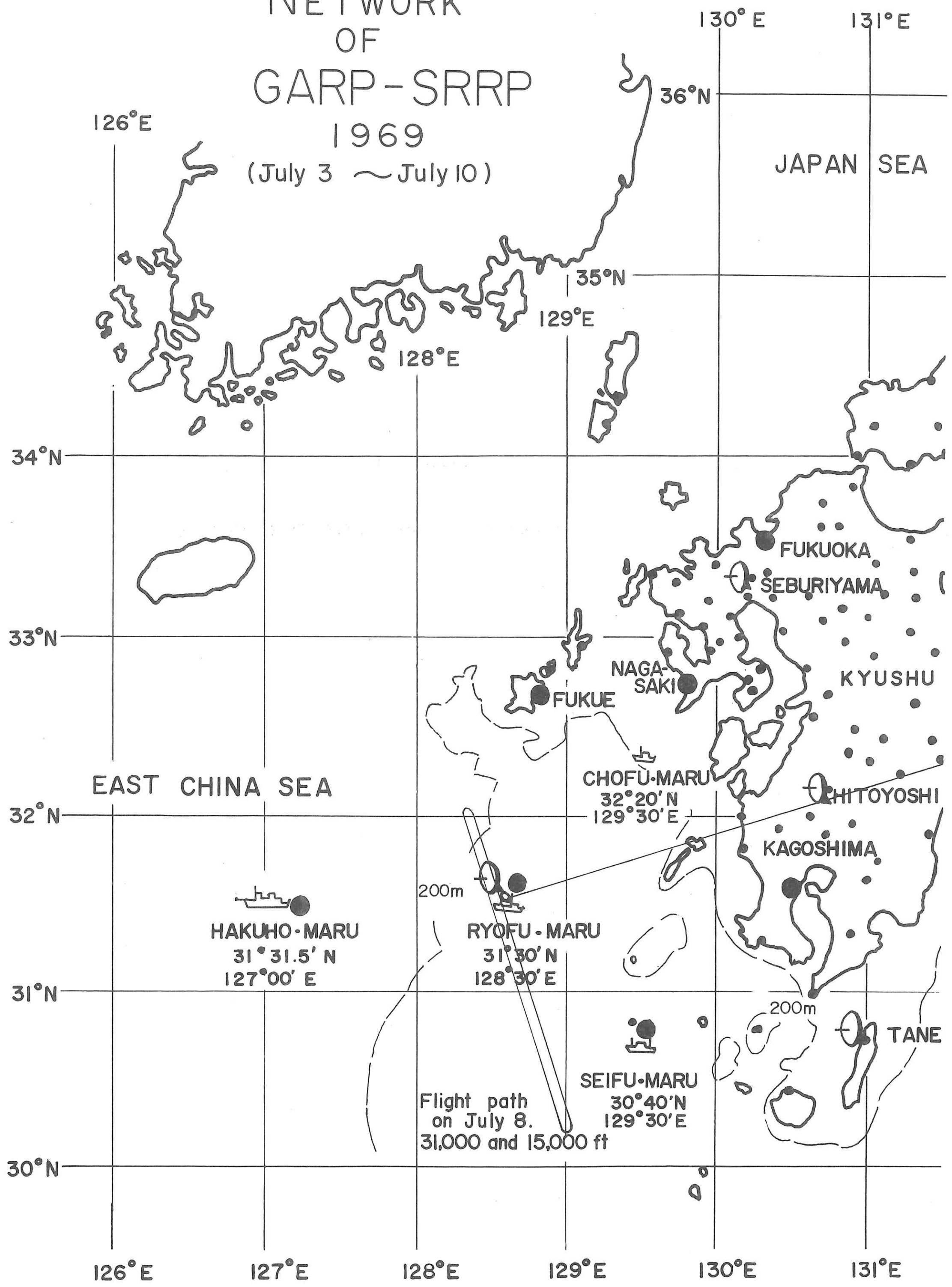
Messenger casting time;
Cast 1. July 6, 13:45
Cast 2. July 7, 13:39

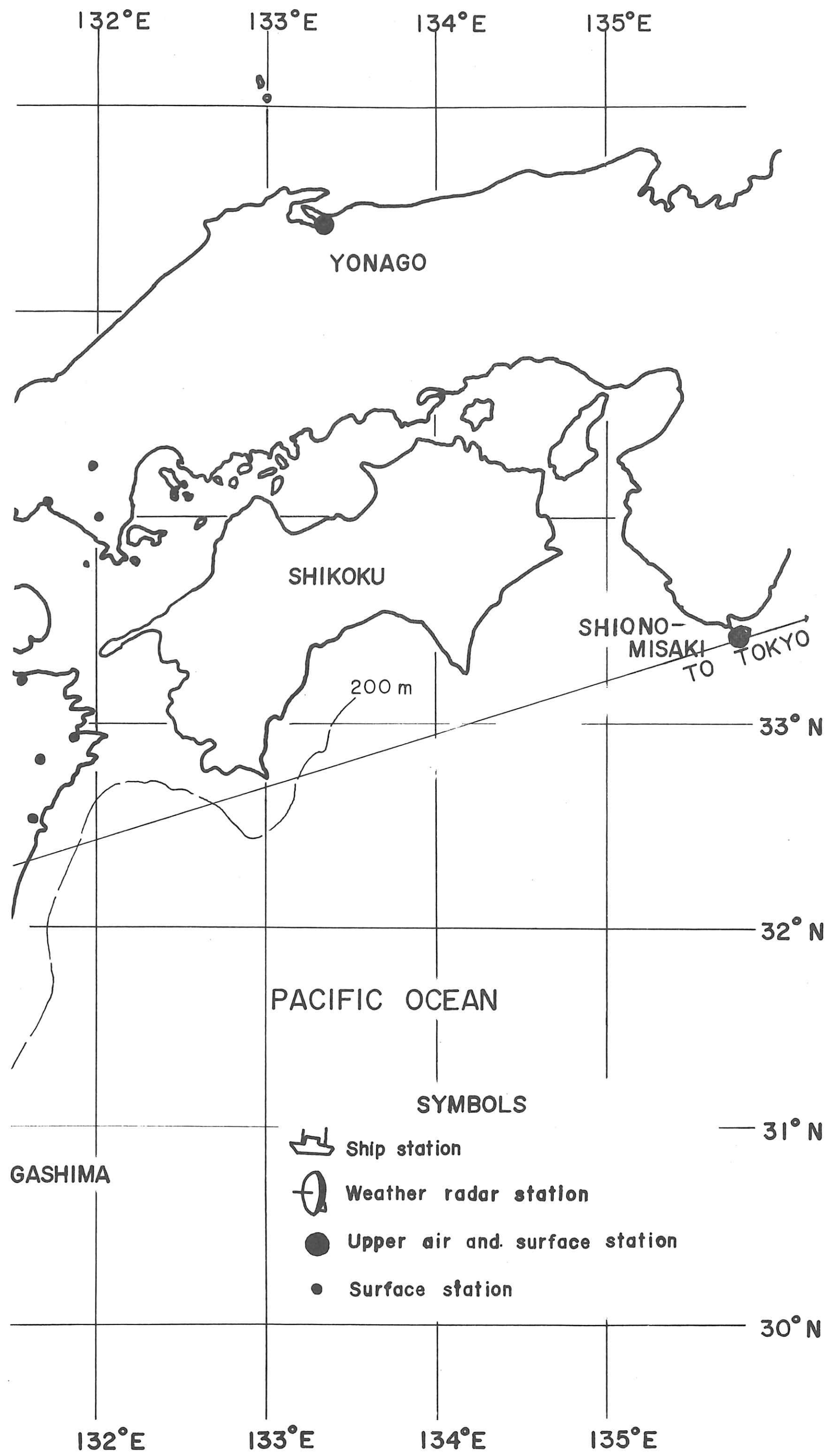
Appendix I

Special observational network of GARP-SRRP 1969

NETWORK OF GARP-SRRP 1969

(July 3 ～ July 10)





Appendix II

Routine surface meteorological data

ROUTINE SURFACE METEOROLOGICAL DATA[1)]

HAKUHO-MARU. June 30~July 11, 1969

Date	Time (J. S. T)	Position Lat. N	Long. E	Atmospheric pressure[2)] (mb)	Temperature Air (°C)	Dew point (°C)	Sea surface (°C)	Wind Direction	Speed (m/s)
June 30	11	—	—	—	—	—	21.3	SSW	—
	12	—	—	—	—	—	21.0	SSW	11
	13	35°-00.5'	139°-42.8'	1001.5	—	—	21.2	S	8
	14	34°-57.6'	139°-31.8'	—	—	—	21.3	S	8.5
	15	34°-51.2'	139°-21.6'	—	—	—	21.3	S	13.5
	16	34°-43.5'	139°-12.2'	—	22.3	—	21.3	S	15
	17	34°-35.4'	139°-03.6'	—	22.4	—	21.2	SW	13
	18	34°-29.3'	138°-53.8'	—	22.2	—	21.3	S	12
	19	34°-25.1'	138°-42.4'	—	21.9	—	21.3	SSW	11.5
	20	34°-19.5'	138°-31.3'	—	21.9	—	21.5	SSW	11.5
	21	34°-14.7'	138°-17.8'	—	22.0	—	21.6	SW	8
	22	34°-09.5'	138°-03.0'	—	22.0	—	21.7	SW	8
	23	34°-04.5'	137°-03.0'	—	22.0	—	22.0	SSW	8
	24	34°-00.0'	137°-34.7'	—	22.0	—	22.0	SSW	9
July 1	01	33°-54.6'	137°-20.0'	1008.9	22.1	—	22.0	SSW	8
	02	33°-49.2'	137°-05.2'	1008.6	22.2	—	22.0	SSW	8
	03	33°-43.8'	136°-50.4'	1008.2	22.1	—	22.0	SW	8.5
	04	33°-38.6'	136°-34.6'	1008.6	22.0	—	21.7	SW	8
	05	33°-33.1'	136°-20.3'	1008.7	21.9	—	21.6	SW	12
	06	33°-26.9'	136°-04.3'	1008.5	22.0	—	21.8	SW	7
	07	33°-20.6'	135°-50.6'	1010.0	22.8	—	22.9	WSW	4
	08	33°-15.8'	135°-37.5'	1009.7	23.8	—	24.6	S	9
	09	33°-10.9'	135°-23.7'	1009.5	23.9	—	23.5	SSW	9
	10	33°-05.5'	135°-09.3'	1009.0	24.0	—	23.4	S	11
	11	33°-02.1'	134°-54.5'	1008.6	24.0	—	23.2	S	10.5
	12	32°-59.7'	134°-40.2'	1007.9	24.2	—	23.6	S	10.5
	13	32°-54.2'	134°-26.2'	1007.8	24.2	—	23.5	SSW	10
	14	32°-54.2'	134°-26.2'	1007.3	24.0	—	23.6	SSW	10.5
	15	32°-44.5'	134°-00.3'	1007.1	24.2	—	23.5	SSW	10
	16	32°-38.4'	133°-47.7'	1006.7	24.8	—	23.6	SSW	10
	17	32°-33.8'	133°-35.5'	1006.3	24.8	—	23.6	SSW	10
	18	32°-29.5'	133°-24.0'	1006.0	25.3	—	23.5	SSW	10
	19	32°-24.7'	133°-13.2'	1006.3	25.6	—	23.1	SSW	12
	20	32°-18.0'	133°-03.9'	1007.2	25.6	—	24.2	SSW	12
	21	32°-11.8'	132°-55.3'	1007.6	25.4	—	24.9	S	10
	22	32°-05.4'	132°-44.9'	1008.1	25.1	—	25.8	S	12
	23	31°-59.5'	132°-33.0'	1008.4	25.2	—	25.1	SSW	11
	24	31°-53.1'	132°-21.5'	1007.7	25.2	—	25.7	SSW	11
July 2	01	31°-48.0'	132°-11.0'	1007.7	25.0	—	25.1	SW	10
	02	31°-42.7'	132°-00.0'	1008.0	25.8	—	25.1	SW	6.5
	03	31°-37.5'	131°-49.0'	1008.3	25.8	—	24.0	WSW	6
	04	31°-29.9'	131°-38.4'	1008.2	25.5	—	23.8	W	2.5
	05	31°-21.9'	131°-27.3'	1009.0	24.3	—	22.7	SW	2.5
	06	31°-13.3'	131°-15.5'	1009.4	23.4	—	22.3	W	3
	07	31°-05.1'	131°-01.1'	1009.6	22.7	—	21.8	WSW	3
	08	30°-58.5'	130°-47.8'	1010.7	22.2	—	22.3	WSW	4
	09	30°-58.6'	130°-37.7'	1011.6	21.2	—	22.4	S	4
	10	31°-12.0'	130°-42.2'	1012.0	21.0	—	23.1	W	3

Cloudiness[3]	Weather[4]	Wind waves[5]	Swells[6]	Amount of precipitation[7] (mm)	Visibility[8]	Ship: Bow azimuth (°)	Ship: Speed (kt)	Remarks	Time
—	o	—	—	—	—	—	—	10:01 left	30/11
—	o	—	—	—	—	—	—	Tokyo	12
—	r	3	2	—	5	—	—		13
—	r	3	2	—	3	—	—		14
—	r	4	3	—	3	—	—		15
—	r	5	4	—	3	220	12		16
—	r	5	4	—	4	220	12		17
—	r	5	4	—	4	245	12		18
—	r	5	4	—	4	245	12		19
—	r	5	4	—	4	245	12		20
—	c	4	4	—	7	245	12.5		21
—	bc	4	4	—	7	245	12.5		22
—	o	4	4	—	7	245	12.2		23
—	o	4	4	—	6	245	12.5		24
—	o	4	4	—	7	245	12.8		1/01
—	c	4	4	—	7	245	12.8		02
—	o	4	4	—	7	245	13.0		03
—	o	4	4	—	6	245	13.0		04
—	c	4	4	—	6	250	13.0		05
—	c	4	4	—	7	250	13.2		06
—	r	3	4	—	7	250	13.2		07
—	c	3	4	—	7	250	13.3		08
—	o	4	3	—	7	250	13.5		09
—	o	5	3	—	7	250	13.5		10
—	o	5	3	—	7	250	13.5		11
—	o	5	3	—	7	245	13.5		12
—	o	4	3	—	7	245	13.5		13
—	c	4	4	—	7	245	13.0		14
—	c	4	4	—	7	245	13.0		15
—	c	4	4	—	7	245	13.0		16
—	c	4	4	—	7	245	12.5		17
—	c	4	4	—	7	245	12.5		18
—	c	4	4	—	7	245	12.5		19
—	c	4	4	—	7	235	12.1		20
—	c	5	4	—	6	235	12.0		21
—	o	5	4	—	6	240	12.5		22
—	o	5	4	—	6	240	12.5		23
—	bc	5	4	—	7	240	12.5		24
—	r	5	4	—	5	245	13.0		2/01
—	r	4	3	—	6	245	13.0		02
—	r	4	3	—	5	245	13.0		03
—	r	2	2	—	6	225	13.2		04
—	r	2	2	—	6	220	13.2		05
—	r	2	2	—	6	230	13.5		06
—	r	2	2	—	6	235	13.5		07
—	r	2	2	—	7	240	13.2		08
—	r	2	2	—	6	330	13.5		09
—	r	1	1	—	7	35	13.5		10

Date	Time (J. S. T)	Position Lat. N	Position Long. E	Atmospheric pressure[2] (mb)	Temperature Air (°C)	Temperature Dew point (°C)	Temperature Sea surface (°C)	Wind Direction	Wind Speed (m/s)
July 2	11	31°-25.1'	130°-36.7'	1011.9	21.0	—	23.4	N	4
	12	31°-29.0'	130°-35.3'	1012.2	23.0	—	23.8	NW	2
	13	—	—	1012.3	24.7	—	23.5	NW	3
	14	—	—	—	25.8	—	—	—	—
	15	—	—	—	26.2	22.4	—	—	—
	16	—	—	1012.0	26.1	22.0	24.6	W	5
	17	—	—	—	26.1	20.0	—	—	—
	18	31°-24.7'	130°-40.1'	1012.0	26.1	20.5	24.0	S	2.5
	19	31°-11.3'	130°-42.0'	1012.3	23.6	20.4	23.7	S	3
	20	31°-03.1'	130°-31.7'	1012.7	22.2	19.6	22.3	W	3
	21	31°-01.5'	130°-15.2'	1013.2	22.4	19.2	23.0	W	1.5
	22	30°-59.6'	129°-59.0'	1013.7	22.5	19.4	22.9	S	3
	23	30°-59.7'	129°-42.7'	1013.7	22.3	19.5	23.8	NE	2
	24	30°-59.0'	129°-25.8'	1013.5	22.8	20.0	23.0	SE	1.5
July 3	01	31°-01.5'	129°-09.7'	1013.0	22.5	20.5	24.4	SSE	3.5
	02	31°-03.8'	128°-53.0'	1012.5	23.0	21.0	24.7	S	5.5
	03	31°-07.9'	128°-35.5'	1012.1	22.6	21.0	25.2	S	6
	04	31°-13.0'	128°-19.7'	1012.0	23.0	21.0	25.1	SSW	4.5
	05	31°-17.3'	128°-03.2'	1011.7	23.0	20.8	22.7	WSW	2
	06	31°-20.2'	127°-47.1'	1011.5	22.0	20.5	22.4	ESE	4
	07	31°-24.2'	127°-31.3'	1011.9	21.7	20.3	21.7	S	3
	08	31°-26.2'	127°-15.1'	1011.0	21.4	20.4	21.7	S	4
	09	31°-29.1'	127°-01.2'	1011.8	21.0	20.3	21.2	SE	5
	10			1011.4	21.0	20.7	21.3	SE	6
	11	31°-32.0'	126°-58.0'	1010.0	21.0	20.5	21.2	E	6
	12	31°-32.4'	126°-56.8'	1010.0	22.0	20.8	21.2	ESE	4
	13	31°-32.4'	126°-56.8'	1010.3	21.8	20.8	21.2	ESE	8
	14	31°-32.4'	126°-56.8'	1009.4	21.6	20.8	21.3	ESE	8
	15	31°-32.4'	126°-56.8'	1008.8	22.0	20.7	21.1	ESE	8
	16	31°-31.5'	127°-00.0'	1008.3	21.9	20.9	21.2	ESE	9
	17	31°-31.5'	127°-00.0'	1008.0	21.5	21.0	21.5	SE	8
	18	31°-31.5'	127°-00.0'	1007.9	21.2	21.0	21.3	SE	8
	19	31°-31.5'	127°-00.0'	1007.0	21.2	21.2	21.2	SE	8
	20	31°-31.5'	127°-00.0'	1007.5	21.5	21.2	21.3	SSE	7
	21	31°-31.5'	127°-00.0'	1007.2	21.1	21.0	21.3	S	6
	22	31°-31.5'	127°-00.0'	1007.6	21.2	21.2	21.3	S	6
	23	31°-31.5'	127°-00.0'	1007.6	21.3	21.5	21.2	SSW	6
	24	31°-31.5'	127°-00.0'	1007.0	21.2	21.2	21.0	SSW	7
July 4	01	31°-31.5'	127°-00.0'	1006.4	21.0	21.1	20.9	SW	6
	02	31°-31.5'	127°-00.0'	1006.0	21.0	21.2	21.0	SSW	6
	03	31°-31.5'	127°-00.0'	1005.7	21.0	21.1	21.0	S	7.5
	04	31°-31.5'	127°-00.0'	1005.6	21.0	21.2	21.0	S	7
	05	31°-31.5'	127°-00.0'	1005.7	21.1	21.4	21.0	S	7.5
	06	31°-31.5'	127°-00.0'	1005.0	21.2	21.6	21.0	S	9
	07	31°-31.5'	127°-00.0'	1004.8	21.1	21.5	21.0	S	10
	08	31°-31.5'	127°-00.0'	1005.0	21.7	21.9	20.9	S	11
	09	31°-31.5'	127°-00.0'	1005.0	21.6	21.9	21.0	S	11
	10	31°-31.5'	127°-00.0'	1004.8	21.8	22.0	21.0	SSW	10
	11	31°-31.5'	127°-00.0'	1004.6	21.8	22.0	21.0	SSW	11
	12	31°-31.5'	127°-00.0'	1003.5	22.0	22.0	21.0	SSW	10
	13	31°-31.5'	127°-00.0'	1003.5	22.2	21.8	21.0	SSW	11
	14	31°-31.5'	127°-00.0'	1003.6	22.0	21.3	21.0	SSW	12.5
	15	31°-31.5'	127°-00.0'	1003.6	21.8	21.5	21.0	SSW	10

Cloudiness[3]	Weather[4]	Wind waves[5]	Swells[6]	Amount of precipitation[7] (mm)	Visibility[8]	Ship		Remarks	Time
						Bow azimuth (°)	Speed (kt)		
–	r	2	1	–	7	340	13.2		2/11
–	o	1	1	–	7	345	0	12:56 arrived	12
–	o	1	1	–	7	355	0	at Kagoshima	13
–	–	–	–	–	–	230	0		14
–	–	–	–	–	–	230	0		15
–	c	–	–	–	–	230	0		16
–	–	–	–	–	–	230	0	17:07 left	17
–	c	–	–	–	–	165	13.2	Kagoshima	18
–	c	–	–	0.0	–	185	13.2		19
–	c	2	1	0.0	7	260	13.2		20
–	bc	1	2	0.0	8	260	13.2		21
–	bc	2	2	0.0	8	260	13.2		22
–	r	1	2	0.0	6	265	13.5		23
–	o	1	2	0.0	7	265	13.5		24
–	o	2	2	0.0	7	280	13.5		3/01
–	o	3	2	0.0	7	280	13.5		02
8	r	3	2	1.7	6	285	13.5		03
–	o	3	2	0.0	6	285	13.5		04
–	o	2	2	0.0	6	285	13.5		05
8	o	2	2	0.0	7	280	13.5		06
–	o	2	2	0.0	7	280	13.5		07
–	o	2	2	0.0	7	280	13.5		08
8	d	2	2	1.1	6	285	13.0		09
–	r	2	2	0.1	5	40	0	10:20 set up	10
–	r	2	2	0.1	6	215	0	current meters	11
7	d	2	2	0.1	7	230	0		12
–	r	3	2	0.1	7	245	0		13
–	r	3	3	0.0	7	220	0	14:00 anchored	14
7	o	3	3	0.3	7	95	0	at the station	15
–	r	3	3	0.1	6	170	0		16
–	r	3	3	1.4	5	180	0		17
8	r	3	3	0.3	5	180	0		18
–	r	3	3	2.3	5	165	0		19
–	r	3	3	12.0	5	165	0		20
8	r	3	3		5	170	0		21
–	r	3	3		5	170	0		22
–	d	3	3		1	180	0		23
8	d	3	3		1	190	0		24
–	d	3	3		1	195	0		4/01
–	d	3	3		1	210	0		02
9	d	3	3		2	220	0		03
–	d	3	3	4.1	1	245	0		04
–	r	3	3		4	255	0		05
8	r	3	3		5	255	0		06
–	d	3	3		5	270	0		07
–	r	3	3		5	255	0		08
8	r	4	3		5	170	0		09
–	r	4	3	0.2	5	180	0		10
–	r	4	3	2.9	5	180	0		11
8	r	4	3	0.3	6	200	0		12
–	r	4	3	0.0	6	180	0		13
–	r	4	4	0.7	5	220	0		14
8	r	4	4	5.5	2	195	0		15

Date	Time (J. S. T)	Position Lat. N	Long. E	Atmospheric pressure[2)] (mb)	Temperature Air (°C)	Dew point (°C)	Sea surface (°C)	Wind Direction	Speed (m/s)
July 4	16	31°-31.5'	127°-00.0'	1003.1	22.1	21.6	21.0	SW	10
	17	"	"	1002.7	22.0	21.1	21.0	SSW	11
	18	"	"	1003.0	22.0	21.7	21.0	SW	8
	19	"	"	1003.0	21.8	21.4	20.9	SW	10
	20	"	"	1002.0	21.8	21.8	20.9	SSW	11
	21	"	"	1003.4	21.8	21.5	21.0	SSW	10
	22	"	"	1003.6	21.7	21.2	21.0	SW	10
	23	"	"	1003.8	21.6	21.1	21.0	SW	11
	24	"	"	1003.5	21.8	21.0	21.0	SW	10
July 5	01	31°-31.5'	127°-00.0'	1003.6	21.5	21.0	21.0	SW	9
	02	"	"	1003.8	21.0	20.9	21.0	SW	9
	03	"	"	1003.8	21.1	20.8	21.0	SW	9
	04	"	"	1003.7	21.3	20.7	21.0	WSW	7
	05	"	"	1003.9	21.0	20.8	21.0	SW	7
	06	"	"	1004.5	20.8	20.6	21.0	SW	5.5
	07	"	"	1004.5	20.8	20.7	21.3	SW	5
	08	"	"	1004.5	21.1	21.0	21.0	SW	4
	09	"	"	1005.2	20.8	20.8	20.9	SW	5
	10	"	"	1005.5	21.0	20.0	21.0	SW	5
	11	"	"	1005.5	21.3	21.2	21.0	SW	7
	12	31°-31.5'	127°-00.0'	1005.6	21.9	21.6	21.1	SSW	8
	13	"	"	1005.4	21.4	21.4	21.1	SSW	6.5
	14	"	"	1005.4	21.6	21.6	21.0	SW	6.5
	15	"	"	1005.0	21.6	20.8	21.1	SW	10
	16	"	"	1004.4	22.0	21.5	21.1	SW	9.5
	17	"	"	1004.9	22.0	21.3	21.1	SSW	9
	18	"	"	1005.0	21.8	21.5	21.3	SW	8
	19	"	"	1005.5	21.6	21.6	21.3	SW	8
	20	"	"	1006.2	21.4	21.4	21.3	SW	6
	21	"	"	1006.8	21.6	21.8	21.2	WSW	6
	22	"	"	1007.2	21.0	21.0	21.3	SW	6
	23	"	"	1007.6	20.8	20.9	21.3	WSW	3.5
	24	"	"	1007.7	21.2	21.5	21.2	Calm	0
July 6	01	31°-31.5'	127°-00.0'	1007.5	21.2	21.3	21.2	Calm	0
	02	"	"	1006.6	21.2	21.6	21.2	Calm	0
	03	"	"	1006.4	21.3	21.6	21.3	Calm	0
	04	"	"	1006.6	21.2	21.6	21.3	Calm	0
	05	"	"	1006.5	21.6	21.8	21.2	SSW	5.5
	06	"	"	1006.5	21.3	21.6	21.3	SSW	7
	07	"	"	1006.9	21.5	21.8	21.2	SSW	6
	08	"	"	1006.5	21.8	22.0	21.3	SSW	8
	09	"	"	1006.5	22.0	22.1	21.3	SSW	8
	10	"	"	1006.4	22.0	21.8	21.2	SSW	7
	11	"	"	1006.2	21.9	21.8	21.2	SSW	10
	12	"	"	1005.7	22.0	21.8	21.2	SSW	10.5
	13	"	"	1006.4	22.2	22.1	21.3	SSW	10
	14	"	"	1005.1	21.8	21.1	21.3	SW	10
	15	"	"	1004.8	21.8	21.5	21.3	SW	10
	16	"	"	1004.1	21.4	21.3	21.3	WSW	5.5
	17	"	"	1004.0	21.6	21.8	21.3	SW	5.5
	18	"	"	1003.0	21.2	21.1	21.4	WSW	7
	19	"	"	1004.6	21.0	21.0	21.4	SW	6.5
	20	"	"	1004.7	21.2	21.1	21.5	SW	6.5

Cloudiness[3]	Weather[4]	Wind waves[5]	Swells[6]	Amount of precipitation[7] (mm)	Visibility[8]	Ship		Remarks	Time
						Bow azimuth (°)	Speed (kt)		
—	r	4	4	3.1	6	215	0		4/16
—	r	4	4	3.5	5	230	0		17
8	r	4	4	5.7	5	255	0		18
—	r	4	4	1.0	5	255	0		19
—	r	4	4	4.1	5	240	0		20
8	r	4	4	0.3	5	240	0		21
—	r	4	4	0.2	5	190	0		22
—	o	4	4	0.0	5	210	0		23
8	o	4	4	0.0	6	195	0		24
—	o	4	4	0.0	6	220	0		5/01
—	d	4	4	0.0	3	225	0		02
8	o	4	4	0.0	6	190	0		03
—	o	3	4	0.0	6	220	0		04
—	f	3	4	0.0	4	250	0		05
9	f	3	4	0.0	2	280	0		06
—	f	3	4	0.1	2	290	0		07
—	o	3	4	0.1	6	290	0		08
9	f	2	3	0.0	3	0	0		09
—	d	2	3	0.5	4	180	0		10
—	r	3	3	1.6	4	210	0		11
8	f	3	3	0.6	4	255	0		12
—	d	3	3	0.0	2	255	0		13
—	d	3	3	0.0	2	270	0		14
8	r	3	3	0.1	5	—	0	$15^h \sim 16^h$	15
—	r	3	3	0.2	5	—	0	anchor reset	16
—	o	3	3	0.0	5	—	0		17
8	f	3	3	0.0	2	—	0		18
—	f	3	3	0.0	2	—	0		19
—	f	3	3	0.0	1	—	0		20
8	f	3	3	0.0	1	—	0		21
—	f	3	3	0.0	1	—	0		22
—	f	2	3	0.0	1	190	0		23
9	f	1	2	0.0	1	180	0		24
—	d	1	2	1.4	1	130	0		6/01
—	d	1	2	0.0	1	145	0		02
9	d	1	2	0.5	2	170	0		03
—	d	1	2	0.0	1	165	0		04
—	d	2	2	0.0	4	180	0		05
8	o	2	3	0.0	5	210	0		06
—	d	2	3	0.0	3	170	0		07
—	d	2	3	0.0	2	180	0		08
8	r	2	4	0.3	3	195	0		09
—	r	2	4	11.1	3	320	0		10
—	r	3	4	13.1	3	195	0		11
8	r	3	4	1.0	6	180	0		12
—	d	3	4	0.0	5	195	0		13
—	o	3	4	0.0	5	215	0		14
8	r	3	4	0.3	5	210	0		15
—	d	2	3	0.3	1	225	0		16
—	r	2	3	0.3	4	240	0		17
8	d	2	3	0.6	3	270	0		18
—	d	2	3	0.0	3	280	0		19
—	d	2	3	0.0	2	195	0		20

Date	Time (J. S. T)	Position Lat. N	Long. E	Atmospheric pressure 2) (mb)	Temperature Air (°C)	Dew point (°C)	Sea surface (°C)	Wind Direction	Speed (m/s)
July 6	21	31°-31.5'	127°-00.0'	1005.5	21.0	21.0	21.4	SW	6
	22	"	"	1006.1	21.0	21.1	21.4	SW	6
	23	"	"	1005.3	21.0	21.1	21.4	SW	6.7
	24	"	"	1005.8	21.0	21.1	21.4	SW	7
July 7	01	31°-31.5'	127°-00.0'	1005.1	21.2	21.3	21.3	SW	6.5
	02	"	"	1004.8	21.1	21.1	21.3	SW	5.5
	03	"	"	1004.8	21.1	21.2	21.3	SW	5
	04	"	"	1004.5	21.0	21.0	21.3	WSW	4
	05	"	"	1004.2	20.9	21.1	21.3	WSW	4
	06	"	"	1004.5	21.0	20.9	21.3	WSW	4
	07	"	"	1004.8	21.1	21.1	21.4	WSW	5
	08	"	"	1004.7	21.0	20.9	21.4	W	4
	09	"	"	1004.5	21.0	21.0	21.4	W	2
	10	"	"	1004.8	21.1	21.2	21.4	Calm	0
	11	"	"	1004.5	21.5	21.6	21.4	Calm	0
	12	31°-31.5'	127°-00.0'	1004.5	22.4	22.4	21.4	SW	1
	13	"	"	1003.8	22.0	21.8	21.5	SW	2
	14	"	"	1003.1	23.0	22.1	21.8	S	3
	15	"	"	1002.7	22.5	22.4	21.7	S	5.5
	16	"	"	1001.6	23.0	21.9	21.6	S	7
	17	"	"	1000.0	23.0	21.8	21.5	S	7.5
	18	"	"	1000.5	23.0	21.9	21.6	S	9
	19	"	"	1000.5	23.0	21.9	21.7	SSW	10
	20	"	"	1001.0	22.8	22.0	21.7	SSW	11
	21	"	"	1001.2	22.6	22.0	21.4	SSW	10
	22	"	"	1001.2	22.3	21.9	21.4	SSW	10
	23	"	"	1001.3	22.2	21.9	21.4	SSW	11
	24	"	"	1001.0	22.8	22.1	21.4	SSW	12
July 8	01	31°-31.5'	127°-00.0'	1000.8	22.9	22.2	21.4	SSW	13
	02	"	"	1000.9	23.0	22.2	21.4	SSW	13
	03	"	"	1000.8	22.8	22.2	21.4	SSW	12
	04	"	"	1000.7	22.5	22.0	21.4	SW	12
	05	"	"	1000.2	22.4	21.3	21.4	SW	12
	06	"	"	1000.2	22.6	20.6	21.4	SW	11
	07	"	"	1000.7	22.3	21.6	21.4	SW	11
	08	"	"	1000.9	22.5	21.7	21.4	SW	10
	09	"	"	1001.3	22.4	21.0	21.4	SW	12
	10	"	"	1001.3	22.0	18.8	21.4	W	13
	11	"	"	1001.7	21.4	18.2	21.4	WSW	13
	12	31°-31.5'	127°-00.0'	1002.2	21.2	17.6	21.4	W	14
	13	"	"	1002.4	21.1	17.8	21.4	W	14
	14	"	"	1002.6	21.0	17.8	21.4	W	14
	15	"	"	1002.8	20.9	17.4	21.4	W	13
	16	"	"	1003.4	20.6	17.2	21.4	W	12
	17	"	"	1002.5	20.5	16.8	21.5	W	11
	18	"	"	1004.3	20.7	16.8	21.5	W	11
	19	"	"	1005.0	20.3	16.8	21.3	W	10
	20	31°-28.0'	127°-11.3'	1005.5	20.2	16.5	21.3	W	10
	21	31°-24.7'	127°-26.5'	1006.6	20.3	16.8	21.4	W	7
	22	31°-21.5'	127°-42.7'	1007.0	20.8	16.8	21.4	W	7
	23	31°-18.2'	127°-59.0'	1006.0	21.1	16.7	22.2	W	6
	24	31°-15.1'	128°-14.5'	1006.7	21.5	16.8	23.7	W	6

Cloudiness[3]	Weather[4]	Wind waves[5]	Swells[6]	Amount of precipitation[7] (mm)	Visibility[8]	Ship: Bow azimuth (°)	Ship: Speed (kt)	Remarks	Time
9	f	3	3	0.0	1	300	0		6/21
—	f	3	3	0.0	1	310	0		22
—	f	3	3	0.0	2	330	0		23
9	f	3	3	0.0	2	330	0		24
—	d	3	3	0.0	1	10	0		7/01
—	d	3	3	0.0	1	105	0		02
9	d	3	3	0.0	1	135	0		03
—	d	3	3	0.0	1	135	0		04
—	d	3	3	0.1	1	150	0		05
9	d	2	3	0.2	1	170	0		06
—	d	2	3	0.1	1	195	0		07
—	d	2	3	0.0	1	200	0		08
9	p	1	2	14.1	1	215	0		09
—	o	0	2	18.3	5	185	0		10
—	o	0	2	0.1	6	180	0		11
9	f	1	3	0.0	1	180	0		12
—	f	1	3	0.0	1	180	0		13
—	f	1	3	0.0	1	180	0		14
8	o	2	3	0.0	5	185	0		15
—	o	3	3	0.0	6	250	0		16
—	c	3	3	0.0	7	215	0		17
7	c	3	4	0.0	7	250	0		18
—	c	3	4	0.0	7	250	0		19
—	c	4	4	0.1	7	250	0		20
6	c	4	4	0.0	7	270	0		21
—	c	4	4	0.0	7	265	0		22
—	c	4	4	0.0	7	250	0		23
6	c	4	4	0.0	6	190	0		24
—	c	5	—	0.0	—	180	0		8/01
—	o	5	—	0.0	—	220	0		02
8	r	5	—	0.0	—	190	0		03
—	r	5	—	0.0	—	185	0		04
—	r	5	5	0.0	5	180	0		05
7	o	5	5	0.0	5	260	0		06
—	r	5	5	0.0	6	190	0		07
—	r	5	5	0.0	6	240	0		08
7	r	5	5	0.0	7	240	0		09
—	bc	5	5	0.0	7	270	0		10
—	c	5	5	0.0	7	270	0		11
7	bc	5	5	0.0	7	270	0	12:37 left the	12
—	c	5	5	0.0	8	270	0	station	13
—	c	5	5	0.0	8	60	0	13:18～19:20	14
6	bc	5	5	0.0	8	250	0	Recovery	15
—	bc	4	5	0.0	8	280	3	operations of	16
—	c	4	5	0.0	8	300	3	current meters	17
—	c	4	5	0.0	7	150	3		18
—	c	4	5	0.0	8	95	3		19
—	o	4	5	0.0	8	105	13		20
8	o	4	4	0.0	7	105	13		21
—	o	4	4	0.0	7	105	13		22
—	bc	4	4	0.0	7	110	13		23
7	o	4	4	0.0	7	—	13		24

Date	Time	Position		Atmospheric	Temperature			Wind	
	(J. S. T)	Lat. N	Long. E	pressure[2] (mb)	Air (°C)	Dew point (°C)	Sea surface (°C)	Direction	Speed (m/s)
July 9	01	31°-12.5'	128°-29.0'	1007.0	22.0	16.3	24.0	W	10
	02	31°-09.2'	128°-43.5'	1007.1	22.0	16.8	24.0	WNW	10
	03	31°-06.3'	128°-58.6'	1007.2	21.9	16.8	24.5	WNW	10
	04	31°--1.4'	129°-13.8'	1007.2	22.2	16.8	24.0	SSW	6
	05	30°-57.3'	129°-29.3'	1007.2	22.1	16.8	23.8	SSW	6
	06	30°-58.9'	129°-45.8'	1007.4	22.2	17.6	23.9	SSW	6
	07	30°-59.7'	130°-03.2'	1008.2	22.6	16.8	23.2	WNW	9
	08	31°-01.9'	130°-19.5'	1008.5	22.8	16.7	22.6	WNW	8
	09	31°-04.2'	130°-36.5'	1008.9	22.8	17.5	22.1	W	6
	10	31°-16.2'	130°-43.1'	1008.9	23.0	18.2	23.7	W	8
	11	31°-30.2'	130°-36.6'	1008.7	22.7	19.1	23.8	S	3
	12	—	—	1008.3	25.1	18.1	24.1	W	3
	13	—	—	—	25.6	18.0	—	—	—
	14	—	—	—	26.1	17.8	—	—	—
	15	—	—	—	25.8	18.0	—	—	—
	16	—	—	1007.3	25.6	18.2	25.5	W	5
	17	—	—	—	25.0	17.2	—	—	—
	18	31°-23.6'	130°-40.3'	1008.2	24.5	18.5	24.5	NW	8
	19	31°-10.1'	130°-41.2'	1008.5	23.5	19.2	24.0	SE	4
	20	30°-58.3'	130°-35.1'	1009.7	22.5	19.2	22.8	WSW	7
	21	30°-55.6'	130°-50.6'	1010.0	22.4	19.3	22.5	WNW	7.5
	22	31°-04.0'	131°-08.1'	1010.3	22.2	19.3	22.8	W	6
	23	31°-12.4'	131°-25.4'	1010.0	22.3	19.0	22.3	NNW	4
	24	31°-20.8'	131°-41.6'	1009.6	23.0	20.8	24.4	NW	5
July 10	01	31°-30.3'	131°-57.1'	1009.0	24.0	19.5	25.1	NE	4
	02	31°-38.2'	132°-15.0'	1009.1	23.4	18.5	26.1	NNE	5
	03	31°-43.9'	132°-31.5'	1009.1	23.0	18.1	26.0	NNE	6.5
	04	31°-53.0'	132°-48.3'	1009.6	22.8	17.7	25.0	N	6.5
	05	31°-55.2'	133°-05.0'	1009.7	22.9	16.6	26.0	NNW	7
	06	32°-06.3'	133°-21.9'	1010.2	23.4	15.4	25.8	NNW	6
	07	32°-14.4'	133°-40.3'	1010.5	24.0	16.8	25.9	NE	2
	08	32°-21.7'	133°-56.8'	1010.2	23.8	17.0	26.0	C	—
	09	32°-29.0'	134°-15.8'	1011.2	23.7	15.0	25.3	C	—
	10	32°-35.9'	134°-34.0'	1011.1	23.0	16.8	25.4	ESE	4
	11	32°-42.1'	134°-51.1'	1011.0	23.2	16.6	23.4	ENE	3
	12	32°-48.5'	135°-09.0'	1010.8	23.1	16.7	23.4	ENE	2
	13	32°-57.3'	135°-22.2'	1010.6	23.1	16.5	23.2	N	2
	14	33°-03.5'	135°-40.0'	1010.8	23.7	18.8	25.1	WSW	1.5
	15	33°-09.8'	135°-54.3'	1010.8	24.0	19.0	24.2	SW	2
	16	33°-16.7'	136°-07.9'	1010.8	23.8	18.6	24.3	SW	3
	17	33°-23.7'	136°-24.2'	1010.9	23.3	19.5	22.6	SSW	5
	18	33°-30.0'	136°-40.4'	1011.0	23.2	20.2	23.3	SSW	5
	19	33°-36.7'	136°-56.7'	1011.7	23.0	20.8	22.9	SE	4
	20	33°-42.8'	137°-13.3'	1012.0	22.4	20.7	22.7	SSE	6.5
	21	33°-44.5'	137°-27.3'	1012.8	22.5	20.6	22.5	S	6
	22	33°-56.4'	137°-42.5'	1013.2	22.6	20.5	22.6	S	6
	23	34°-03.2'	137°-56.3'	1013.4	22.8	19.6	23.0	S	6
	24	34°-10.5'	138°-11.7'	1012.8	23.0	18.8	23.2	SE	5.5
July 11	01	33°-17.2'	138°-29.2'	1013.6	22.8	18.5	23.2	SE	4
	02	33°-24.6'	138°-45.7'	1013.7	22.2	18.0	23.2	ESE	4.5
	03	33°-30.1'	139°-02.2'	1013.6	21.7	18.0	23.1	NE	2.5
	04	33°-42.7'	139°-13.7'	1014.0	21.2	17.5	22.4	NNE	5
	05	33°-54.6'	139°-27.6'	1014.0	21.1	16.4	22.4	NNE	5
	06	34°-03.7'	139°-42.0'	1014.8	20.2	16.8	19.9	NNE	5
	07	34°-16.2'	139°-46.6'	1015.2	20.0	16.3	20.5	NNE	4
	08	34°-28.4'	139°-48.1'	1016.0	20.4	16.1	20.5	NNE	5

Cloudiness[3]	Weather[4]	Wind waves[5]	Swells[6]	Amount of precipitation[7] (mm)	Visibility[8]	Ship Bow azimuth (°)	Ship Speed (kt)	Remarks	Time
—	c	4	4	—	—	105	13.0		9/01
—	bc	4	4	—	—	105	13.1		02
—	c	4	4	—	—	105	13.2		03
—	bc	3	4	—	—	105	13.0		04
—	bc	3	4	—	—	105	13.0		05
—	bc	3	4	—	—	85	13.2		06
—	c	3	4	—	—	85	13.2		07
—	c	3	4	—	—	85	13.2		08
—	bc	3	3	—	—	65	13.5		09
—	c	4	3	—	—	20	13.5		10
—	bc	2	1	—	—	325	13.0	11:42 arrived	11
—	bc	—	—	—	—	230	0	at Kagoshima	12
—	—	—	—	—	—	230	0		13
—	—	—	—	—	—	230	0		14
—	—	—	—	—	—	230	0		15
—	bc	—	—	—	—	230	0		16
—	—	—	—	—	—	230	0	17:04 left	17
—	bc	2	1	—	—	150	13.0	Kagoshima	18
—	c	2	2	—	—	175	13.2		19
—	bc	3	3	—	—	210	13.0		20
—	bc	3	3	—	—	60	13.5		21
—	bc	3	3	—	—	65	13.6		22
—	bc	2	2	—	—	65	13.4		23
—	o	2	2	—	—	65	13.4		24
—	bc	2	3	—	—	65	13.2		10/01
—	bc	2	3	—	—	70	13.1		02
—	bc	3	3	—	—	65	13.0		03
—	b	3	3	—	—	65	13.1		04
—	b	3	3	—	—	65	13.0		05
—	bc	3	3	—	—	65	13.2		06
—	bc	2	3	—	—	65	13.1		07
—	c	2	3	—	—	65	13.1		08
—	c	0	3	—	—	65	13.0		09
—	o	2	3	—	—	65	13.0		10
—	c	2	3	—	—	65	12.8		11
—	c	2	3	—	—	60	13.1		12
—	c	2	3	—	—	65	13.2		13
—	c	1	3	—	—	65	13.2		14
—	c	1	3	—	—	65	13.2		15
—	o	2	3	—	—	65	13.2		16
—	r	2	3	—	—	65	13.2		17
—	o	2	3	—	—	65	13.2		18
—	r	2	3	—	—	65	13.0		19
—	r	2	3	—	—	70	13.2		20
—	o	3	3	—	—	75	13.2		21
—	o	3	3	—	—	70	13.2		22
—	o	3	3	—	—	70	13.2		23
—	r	3	3	—	—	70	13.1		24
—	r	3	3	—	—	70	13.2		11/01
—	r	3	3	—	—	75	13.0		02
—	r	3	3	—	—	90	13.0		03
—	o	3	3	—	—	50	13.0		04
—	o	2	2	—	—	60	13.2		05
—	c	1	1	—	—	65	13.3		06
—	o	1	0	—	—	50	13.2	09:14 arrived	07
—	c	1	0	—	—	70	13.2	at Tokyo	08

Note:

1) Please refer Chapter 2 and Table 2-1.

2) Corrected into the sea level values.

3) 10 grades cloud amount.

4) Weather;

b:	blue sky	d:	drizzling rain
bc:	partly cloudy	p:	passing shower
c:	cloudy	r:	rain
o:	overcast	f:	fog

5) Wind waves;

	height of waves (m)		height of waves (m)
0:	0	5:	2.5 - 4
1:	0 - 0.1	6:	4 - 6
2:	0.1 - 0.5	7:	6 - 9
3:	0.5 - 1.3	8:	9 - 14
4:	1.3 - 2.5	9:	more than 14

6) Swells;

	length	height
0:	no swell	less than 2 m
1:	short or average	"
2:	long	"
3:	short	2 m - 4 m
4:	average	"
5:	long	"
6:	short	more than 4 m
7:	average	"
8:	long	"

short	less than 100 m
average	100 m - 200 m
long	more than 200 m

7) Amount of precipitation;

Amount during a preceding hour.

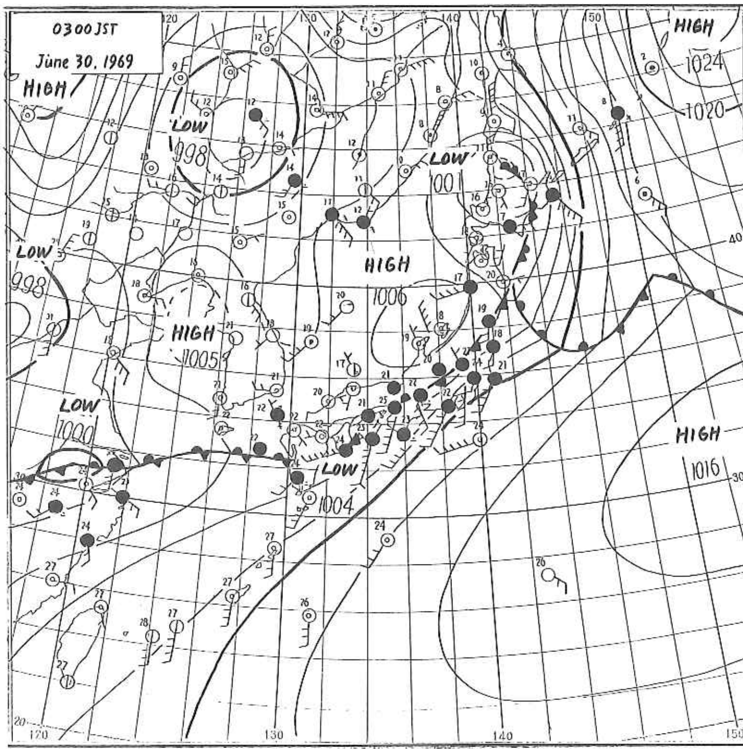
8) Visibility;

0:	0 m - 50 m	5:	2 km - 4 km
1:	50 m - 200 m	6:	4 km - 10 km
2:	200 m - 500 m	7:	10 km - 20 km
3:	500 m - 1 km	8:	20 km - 50 km
4:	1 km - 2 km	9:	more than 50 km

Appendix III

Surface weather charts during the period of the cruise (June 30-July 11, 1969)

—reprinted from 'Daily weather chart' published by the Japan Weather Association—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June 30, 1969
HIGH
LOW
998
LOW
1001
LOW
998
HIGH
1006
HIGH
1005
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1000
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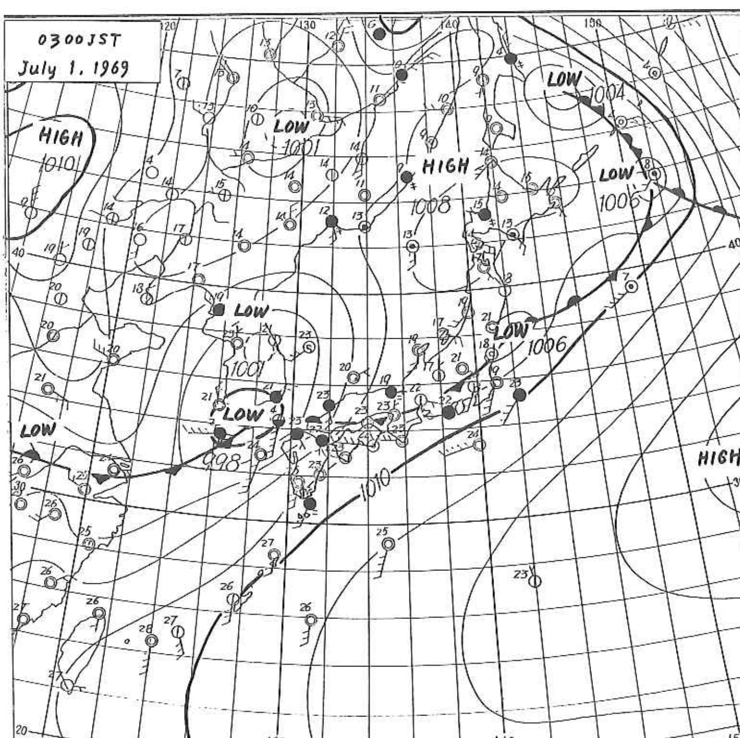
1004
HIGH
1024
1020
HIGH
1016
120
130
140
150
40
30
20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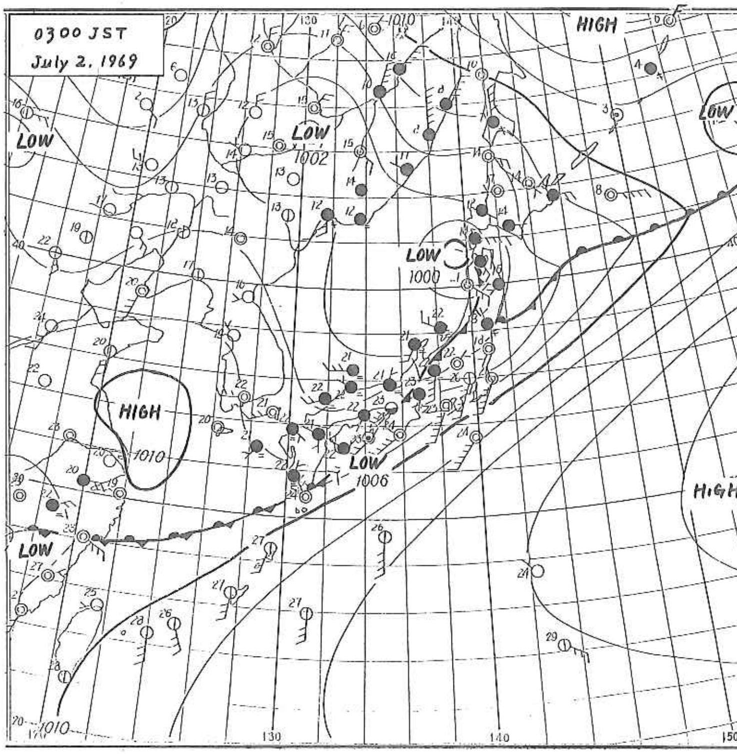
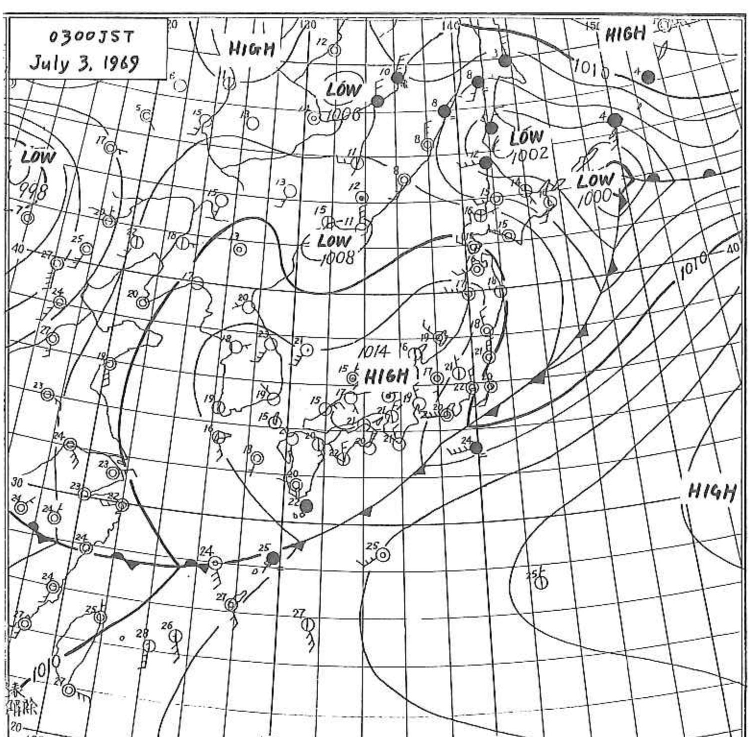
July 1, 1969
HIGH
1010
LOW
1001
HIGH
1008
LOW
1004
LOW
1006
LOW
1006
LOW
1001
LOW
998
LOW
1010
HIGH
120
130
140
150
40
30
20


0300 JST
July 2. 1969
HIGH
LOW
LOW
1002
LOW
1000
HIGH
1010
LOW
1006
HIGH
LOW
130
140
150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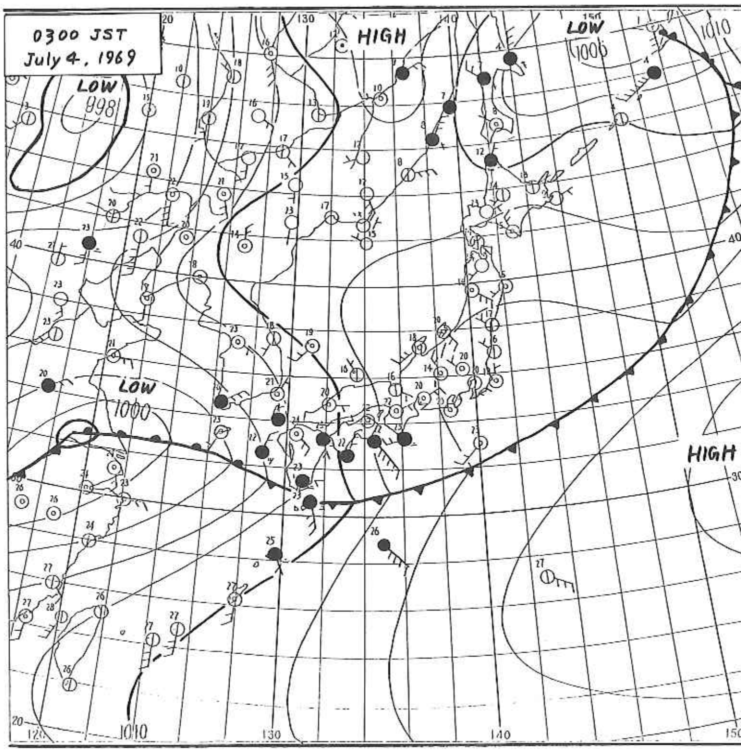
July 3. 1969
HIGH
LOW
1006
HIGH
LOW
998
LOW
1002
LOW
1000
LOW
1008
1014
HIGH
HIGH
120
130
140
150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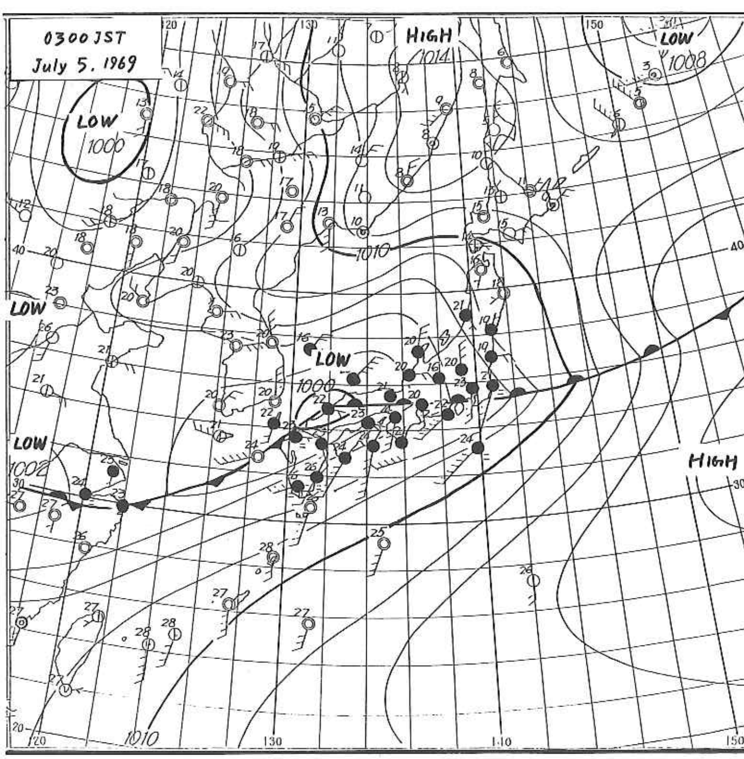
LOW
998
HIGH
LOW
1006
1010
LOW
1000
HIGH
1010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July 5, 1969
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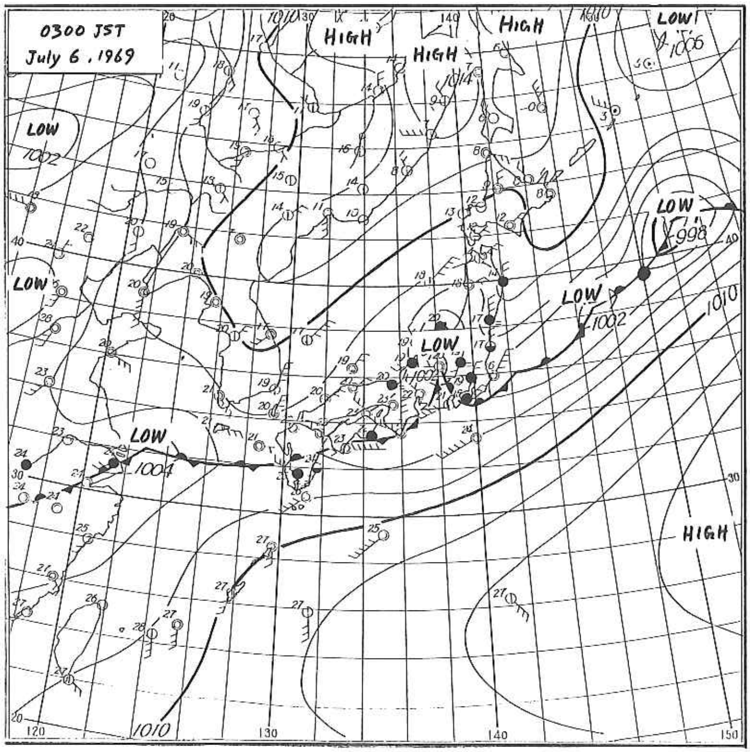
1014
LOW
1008
LOW
1000
1010
LOW
LOW
1000
LOW
1002
HIGH
1010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July 6, 1969
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HIGH
HIGH
LOW
1006
LOW
1002
LOW
LOW
998
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1002
1010
LOW
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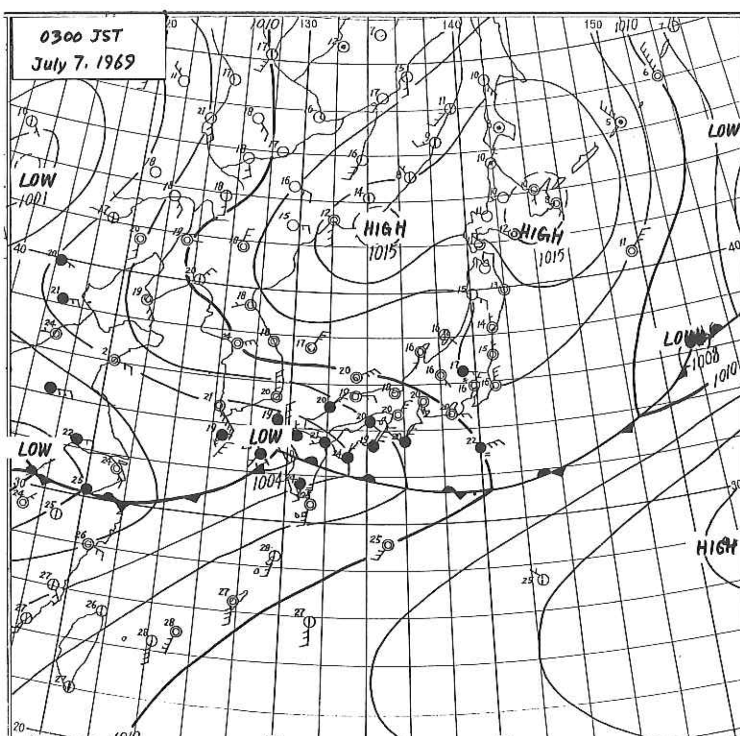
140
150
40
30
20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July 7, 1969
LOW
1001
HIGH
1015
HIGH
1015
LOW
LOW
1008
1010
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LOW
1004
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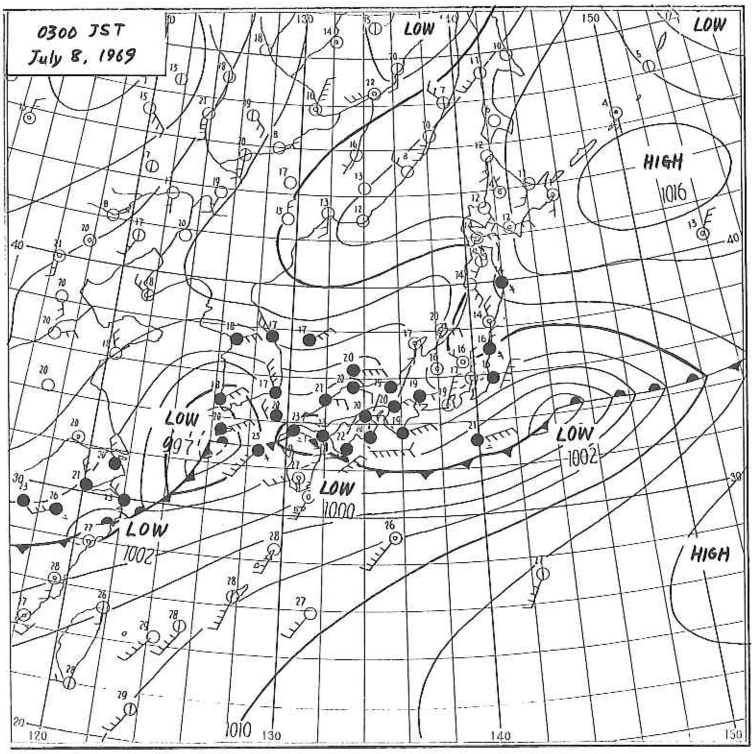
140
150
40
30
20


0300 JST
July 8, 1969
LOW
LOW
HIGH
1016
LOW
997
LOW
1002
LOW
1000
LOW
1002
HIGH
1010
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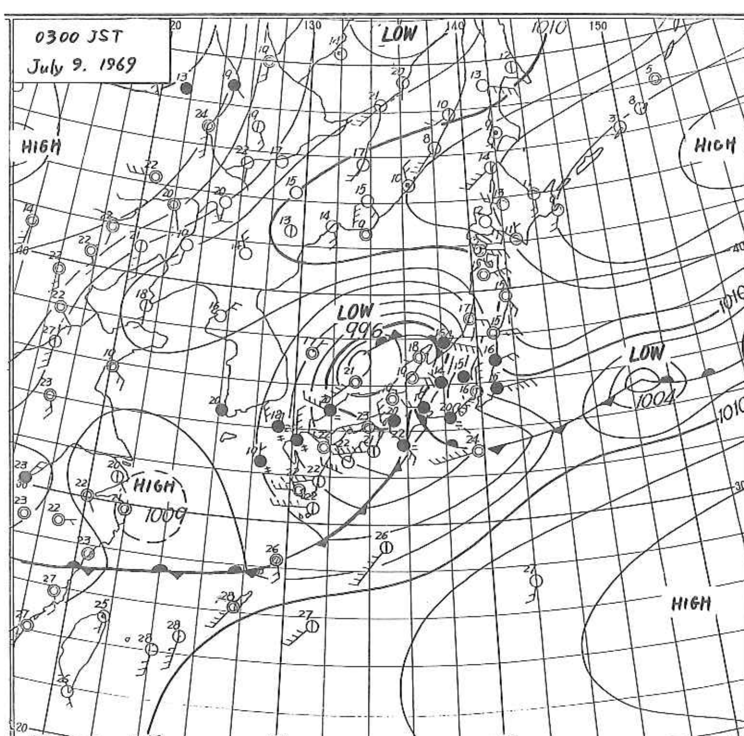
20
120
130
140
150


0300 JST
July 9. 1969
LOW
1010
HIGH
HIGH
LOW
996
LOW
1004
1010
1010
HIGH
1009
HIGH
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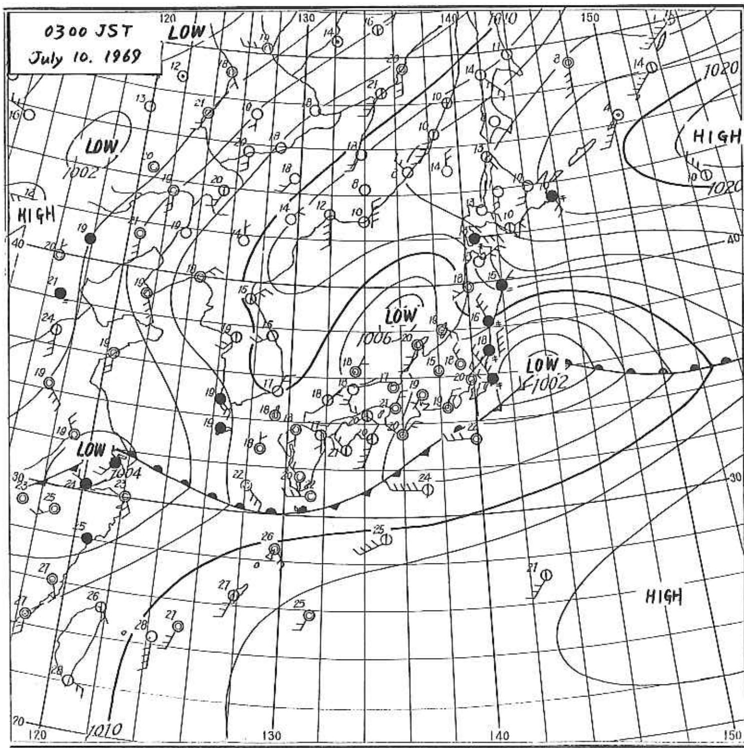
20
120
130
140
150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July 10. 1969
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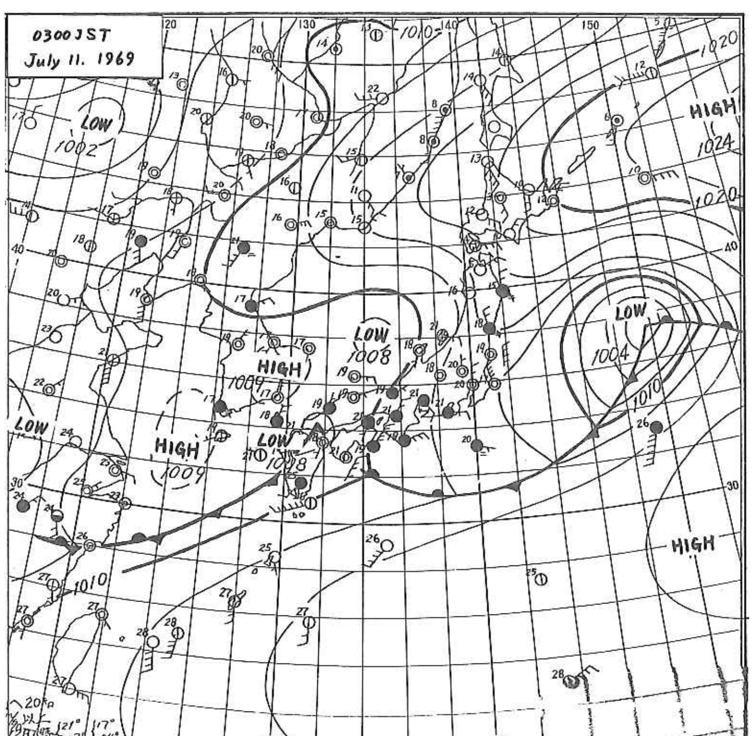
LOW
1002
HIGH
LOW
1006
LOW
1002
LOW
1004
HIGH
1020
HIGH
1010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July 11. 1969
LOW
1002
1010
1020
HIGH
1024
LOW
1008
HIGH
1009
LOW
HIGH
1009
LOW
1008
LOW
1004
1010
HIGH