

# MULTIPOINT GROUND OBSERVATIONS AROUND SYOWA STATION, ANTARCTICA BY MEANS OF UNMANNED AND AUTOMATIC OBSERVATORIES

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**Abstract:** Four unmanned ground-based observatories will be established in the neighboring area of Syowa (69°00'S, 39°35'E) and Mizuho (70°42'S, 44°17'E) Stations, in coordination with the sounding rocket and balloon experiments at Syowa Station, and the GEOS-satellite and the Syowa-Iceland conjugate point program. A proto-type observatory has been accomplished and tested. The preliminary design is as follows:

Scientific instruments: fluxgate and induction magnetometers, riometer (30 MHz), VLF-detector.

Power supply: wind generator and alkaline batteries.

Timing: chronometer (stability  $10^8$ ).

Data acquisition: heat pen and magnetic tape recorder.

Instrument shelter: sheeted with wood plate and insulated with styrene plate.

Operating life: more than 4 months.

## 1. Introduction

It is well known that the geophysical phenomena such as auroras, geomagnetic disturbances, ULF and VLF emissions and ionospheric absorptions appear accompanying the drastic space-time developments during a magnetospheric substorm (AKASOFU, 1968). Observations of these space-time variations using the ground-based station network are a useful technique for studying the physical mechanism of the magnetospheric substorm. Therefore, during the IMS period, we are planning to establish a station network, which consists of 2 manned stations and 4 unmanned stations in the area around Syowa Station, Antarctica. The area where the station network is arrayed corresponds to the magnetic conjugate area of Iceland in the northern hemisphere and it is the southern hemisphere foot of the magnetic field line through ESRO geostational satellite "GEOS" when GEOS is stationary at 0° longitude.

## 2. Station Network

Syowa Station (69°00'S, 39°35'E) is located at latitude 69.6°S and longitude 77.1°E in the geomagnetic coordinates and one of the most suitable stations for

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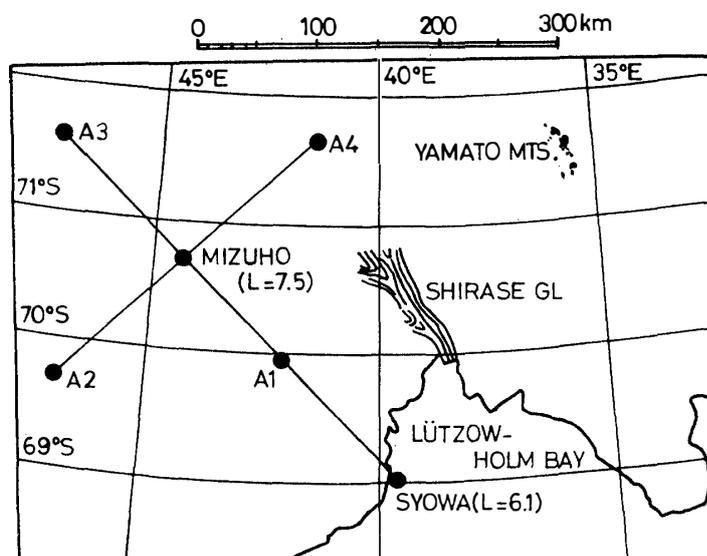


Fig. 1. Location of 2 manned stations (Syowa and Mizuho) and 4 unmanned stations (A1-A4) to be established during the IMS period.

Table 1. Equipments to be used at Syowa and Mizuho Stations.

Item	Equipment	Recorder	Remarks
Aurora	All-sky camera	35 mm camera	6 frames/min
	Meridian scanning photometer ( $H_{\beta}$ , 5577 Å)	3 ch. pen oscillograph Digital data recorder	Chart speed, 30 cm/min Sampling freq., 1 Hz
	High sensitive TV camera	Video tape recorder	60 frames/sec
Magnetism	Fluxgate magnetometer	3 ch. pen oscillograph Digital data recorder	Chart speed, 15 cm/hour Sampling freq., 0.1 Hz
	Induction magnetometer	5 ch. scratch film recorder Analog data recorder	Chart speed, 15 cm/hour Magnetic tape speed, 3 mm/sec Frequency range, 0.001-3 Hz
VLF emissions	Wide-band receiver	Analog data recorder	Magnetic tape speed, 4.75 cm/sec Frequency range, 0.2-10kHz
	Narrow-band intensity recorder (0.75, 1, 2, 4, 8, 28 kHz)	6 ch. pen oscillograph	Chart speed, 30 cm/hour
	Direction finder	6 ch. pen oscillograph Video tape recorder	Chart speed, 15 cm/hour 60 frames/sec
Ionospheric absorption	Riometer (30 MHz)	Pen oscillograph	Chart speed, 6 cm/hour

Table 2. Additional equipments to be used at Syowa Station.

Item	Equipment	Recorder	Remarks
Aurora	Aurora rader (50, 60, 80, 112 MHz)	Oscilloscope with 35 mm camera	Film speed, 1 cm/min
Ionosphere	Ionosonde	Oscilloscope with 35 mm camera	Every 15 minutes
Ionospheric absorption	Riometer (20, 50 MHz)	Pen oscillograph	Chart speed, 6 cm/hour
	JJY (10, 15 MHz) receiver	Pen oscillograph	Chart speed, 6 cm/hour
	NWC (22.3 kHz) and Usami (17.4 kHz, Japan) receiver	Pen oscillograph	Chart speed, 6 cm/hour

the auroral observation. The observation program for the upper atmosphere physics research at Syowa during the IMS period is listed in Tables 1 and 2. Mizuho Station ( $70^{\circ}42'S$ ,  $44^{\circ}17'E$ ) which is located at about 270 km from Syowa towards the Geomagnetic South Pole is an inland station which was established in 1970 as an observatory of glaciology and meteorology. During the IMS period, new facilities for studying the upper atmosphere physics (Table 1) will be installed at Mizuho and four or five members will engage in the semi-routine observations there.

A preliminary observation of geomagnetic variations with a fluxgate magnetometer and an induction magnetometer was carried out at Mizuho from September to October 1973 (KUWASHIMA, 1976). Fig. 2 is an example of the magnetograms of the  $H$  and  $Z$  components simultaneously observed at Syowa and Mizuho. It is found that, during the negative bay in the  $H$  components, the  $Z$  component

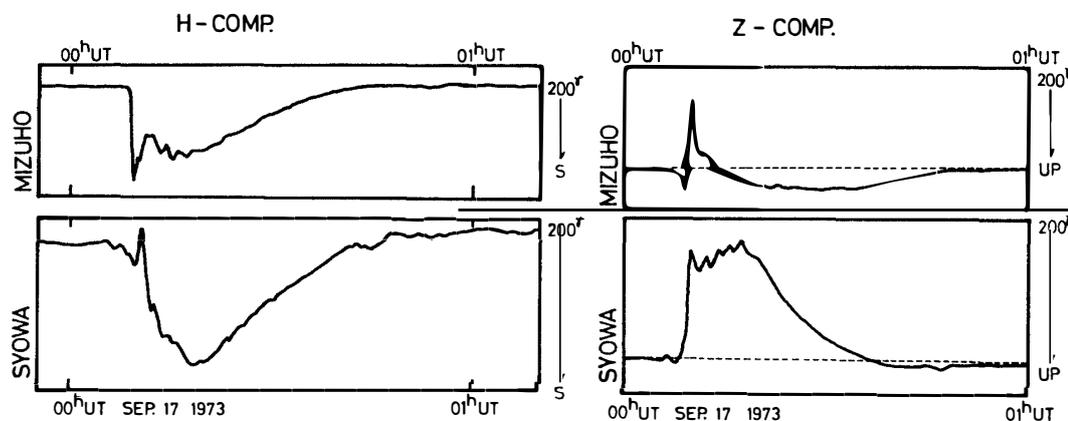


Fig. 2. Magnetograms of the  $H$  and  $Z$  components recorded at Syowa and Mizuho Stations.

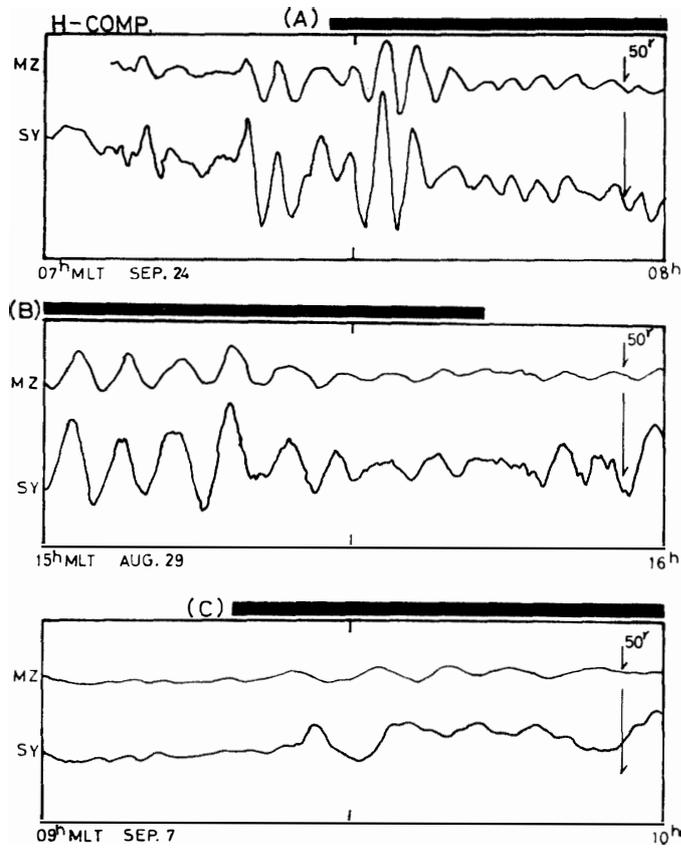


Fig. 3. *H* component wave trains simultaneously recorded at Syowa and Mizuho Stations.

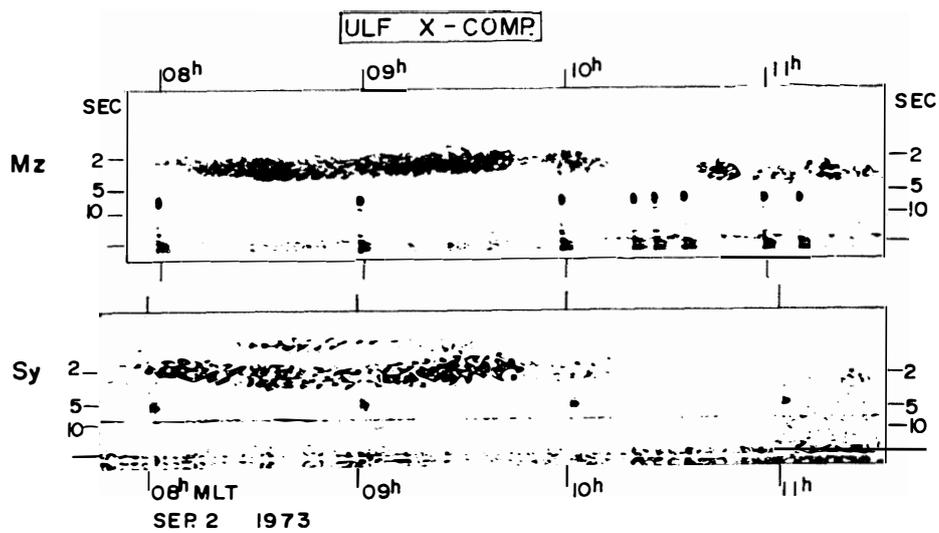


Fig. 4. Sonograms of Pc 1 events simultaneously recorded at Syowa and Mizuho Stations.

variations are negative at Syowa and positive at Mizuho, the fact suggesting that the center of the electrojet current was located between Syowa and Mizuho Stations during this event. Fig. 3 is an example of Pc 5 pulsations. It is apparent that during the events A and B, the  $H$  components oscillate in phase at the both stations, while, during the event C, the  $H$  components oscillate out of phase. Fig. 4 is an example of the sonagrams of Pc 1 emissions simultaneously observed at Syowa and Mizuho. The sonagram at Syowa shows additional emissions with the center frequency of  $\sim 0.6$  Hz in the time interval 0830 to 0930 MLT, while the sonagram at Mizuho shows the occurrence of Pc 1 emissions in the time interval 1030 to 1130 MLT.

From these examples, it is predicted that the station network given in Fig. 1 is quite useful for observing geophysical phenomena associated with the magnetospheric substorm.

In addition to the two manned station (Syowa and Mizuho), four unmanned and automatic observatories will be arrayed in the shape of a cross at a distance of 150 km from Mizuho, as illustrated in Fig. 1. Syowa, A1, Mizuho and A3 stations are located on the geomagnetic meridian, while A2, Mizuho and A4 are arrayed in the longitudinal direction. The position of A1 unmanned observatory denoted in Fig. 1 is also very close to the calculated southern foot of the field line through GEOS satellite when GEOS is kept stationary at  $0^\circ$  longitude.

### 3. Unmanned Observatory for Antarctic Operation

The inland of Antarctic Continent is covered with the thick ice sheet and the climate is very severe. As to the climate at and around Mizuho Station, the mean and maximum wind speed are  $\sim 10$  m/s and  $\sim 22$  m/s, respectively, while the mean and minimum temperature are  $-40^\circ\text{C}$  and  $-60^\circ\text{C}$ , respectively. The annual net accumulation of snow is about 10 cm/year. The designed observatory must be subjected to such severe natural environment.

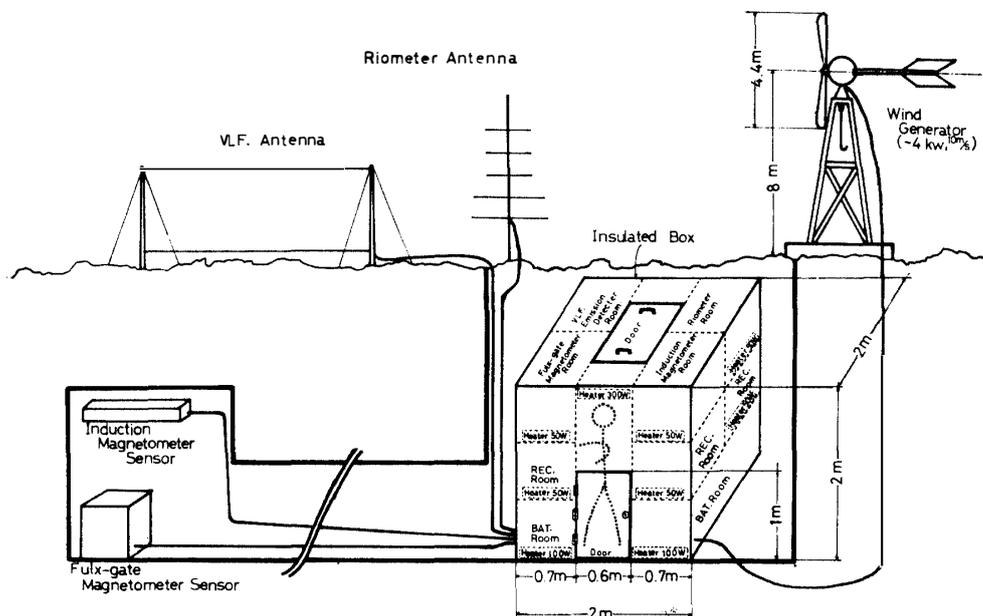
The overall constitution of the unmanned observatory for the inland Antarctic operation is schematically illustrated in Fig. 5. The main parts of the observatory and the practical layout are as follows.

#### 3.1. Wind-driven generator

A wind-driven generator is used to keep warm the batteries and instruments and to charge alkaline batteries from which the power of electric instruments is supplied. The generator can supply about 4 kVA on average when the wind blows continuously at the speed of 10 m/s.

#### 3.2. Instrument cabin

All instruments and batteries are kept in the insulated rooms in a cabin which is buried in the snow in order to avoid the strong snow wind (cf. Fig. 5). The insulated rooms are designed to protect the batteries and instruments from low



**UNMANNED OBSERVATORY**

Fig. 5. The overall constitution of the unmanned observatory for the inland Antarctic operation.

temperature. They are made of the wooden and styrene plates 10 cm thick. With the aid of heating systems (~100 W for each battery room and ~50 W for each instrument room), it is expected that the room temperature is kept above 0°C throughout the year.

The antennas of a VLF emission detector and a riometer are set up on the snow field, while the sensors of a fluxgate magnetometer and an induction magnetometer are set up in a tunnel which is connected to the cabin.

**3.3. Physical instrumentation**

i) Magnetometer

Type: fluxgate magnetometer.

Component: *H, D, Z* components.

Sensitivity: 10  $\gamma$ /mm on the chart record.

Range:  $\pm 1250 \gamma$ .

Power consumption: +18 V/100 mA, -18 V/50 mA.

Block diagram is shown in Fig. 6.

ii) Induction magnetometer

Component: *H, D, Z* components.

Pick-up coil: Thin enamel-coated copper wire is wound about 10,000 turns. A high- $\mu$  metal bar (apparent permeability, about 2400) is used. The induced voltage of the coil is 1.5  $\mu$ V for the flux change

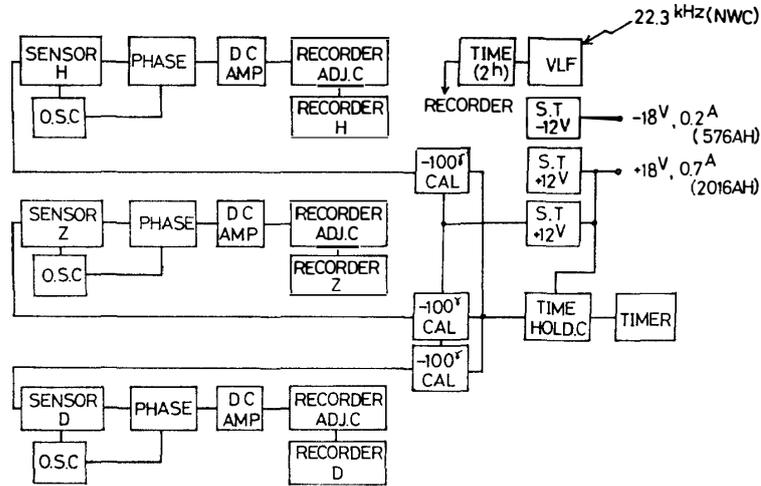


Fig. 6. Block diagram of fluxgate type magnetometer.

of  $0.1 \gamma/\text{sec}$ .

Power consumption: about  $+18 \text{ V}/50 \text{ mA}$ .

iii) Riometer

Receiver: standard riometer at  $30 \text{ MHz}$  with  $3.5 \text{ kHz}$  bandwidth.

Antenna: a vertically directed five-element Yagi antenna.

Sensitivity:  $0.1 \text{ dB/mm}$  on the chart record.

Power consumption:  $+18 \text{ V}/100 \text{ mA}$ .

iv) VLF emission detector

Amplifire gain:  $120 \text{ dB}$ .

Frequency response:  $0.2\text{--}50 \text{ kHz}$ .

Power consumption: about  $+18 \text{ V}/100 \text{ mA}$ .

### 3.4. Data recording

The data observed at the unmanned observatories are recorded on both a chart and a slow-running magnetic tape, which are replaced every three or four months. The telemetry of the data to Mizuho or Syowa Station by UHF radio wave is also planned.

### 3.5. Time keeping

An accurate time keeping is the fundamental requirement in geophysical researches for the inter-relation of data. The observatories are equipped with a stable chronometer with long-term stability of  $10^8$ . In addition to the chronometer, it is planned that the time correction can be made by the signal on-off of NWC VLF radio waves ( $22.3 \text{ kHz}$ ) received through the VLF-emission detector every hour.

#### 4. Test Results

The running test of an accomplished prototype observatory was carried out in the large refrigerator room of Misawa Home Co., Tokyo. The room temperature was kept  $-30^{\circ}\text{C}$  and the artificial wind of 20 m/sec in speed was given. Test measurements over a week have indicated that the thermal control system works well with temperature fluctuations of less than  $5^{\circ}\text{C}$ .

#### 5. Conclusion

The practical schedule of the construction of a station array around Syowa Station is as follows.

- 1976: New observational facilities listed in Table 1 are installed at Mizuho Station. Unmanned observatory A1 (cf. Fig. 1) is built up.
- 1977: Unmanned observatories A2 and A3 are built up.
- 1978: Unmanned observatory A4 is built up. A station array around Syowa and Mizuho Stations is completed.

Our IMS program of the multipoint ground observations in Antarctica will play an important role in the GEOS and Syowa-Iceland conjugate point experiments, together with the rocket, balloon and ground-based observations at Syowa Station.

#### References

- AKASOFU, S.-I. (1968): Polar and magnetospheric substorms. D. Reidel, Dordrecht, 280 pp.
- KUWASHIMA, M. (1976): Some characteristics of substorm-associated geomagnetic phenomena in the south polar region (1). Mem. Kakioka Mag. Obs., **16**, 95-110.