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SCANDINAVIAN IMS MAGNETOMETER ARRAY DATA AND THEIR USE FOR STUDIES OF GEOMAGNETIC RAPID VARIATIONS

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Abstract: A data set which was newly open to the public from the World Data Center C2 for Geomagnetism is introduced. It was obtained from geomagnetic observations at 36 stations in Scandinavia during the International Magnetospheric Study (1977–1979). A few examples of analysis using the data are shown.

1. Introduction

For the operation during the IMS (International Magnetospheric Study) period (1977–1979) a two-dimensional magnetometer array consisting of 36 magnetometers was installed in Scandinavia. Some of them began operation in 1974 earlier than the IMS period. The original data have been used by a research group of the Institute of Geophysics, University of Münster and a set of back-up film data had been stored in the Geophysical Institute, University of Göttingen.

The World Data Center C2 for Geomagnetism, Kyoto University, negotiated for release of the data to the public, and the back-up film was kindly transferred to the Center in 1989. The original back-up data which were accommodated in 42 large film reels were copied and classified by the stations and observation period into 567 small reels so as to be read by ordinary film reader-printers. A Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture was used to make copies of the data. The data have been open to the public since January 1991.

The data seem to be useful for studying fine structures of geomagnetic rapid variations. Dependence of the rapid variations upon longitude or local time will also be effectively studied by combining the data with the North American IMS Magnetometer Network data which have been open to the public since 1979.

The purpose of this note is to introduce the details of the data and show a few examples of analysis of the data.

2. Description of the Data

Table 1 is a brief summary of the Scandinavian Magnetometer Array (SMA) observation described in KÜPPERS *et al.* (1979). SMA consisted of 36 Gough-Reitzel type magnetometers, each of which was housed in an airtight tube and buried in the ground. Deflections of three wire-suspended magnets were optically recorded on 35 mm film every 10 sec (20 sec at some of the stations). The system operated unattended for approximately 73 days.

The observation was conducted by a research group of Geophysical Institute, University of Münster, led by Prof. J. UNTIEDT. Persons who are most acquainted with the data may be Drs. W. BAUMJOHANN, Max-Planck Institute for Extra-Terrestrial Physics in Garching/München, and K.-H. GLASSMEIER, Institute for Geophysics and Meteorology, University of Köln.

Table 2 gives names and locations of the 36 stations of which distribution is shown in Fig. 1. Data period of each station is shown in Fig. 2.

3. Examples of Data Analysis

3.1. Geomagnetic sudden commencement

VOLPERS (1984) analyzed two sudden commencements (SC's) observed by SMA on January 9, 1979 and April 5, 1979. Here we will compare his results with observations at the North American IMS Magnetometer Network (abbreviated as NAMN). Difference in the onset time of the two SC's (0335UT and 0156UT) is small and we do not need to worry about the difference in local time at each station.

Table 1. Summary of the Scandinavian Magnetometer Array observation (from KÜPPERS et al., 1979).

Stations	36 stations in Denmark, Norway, Sweden and Finland
Data period	August 1, 1974 (earliest station)–October 26, 1979 (last station), supplemented by a few stations data up to June 19, 1980
Number of film reels	567 (one reel contains data for approximately 73 days)
Magnetometer	Gough-Reitzel type; 3 wire-suspended magnets, optical recording on 35 mm film with every 10 or 20 sec exposure, the whole system in an airtight 1.6 m-long aluminum tube buried in the ground
Components	H(northward; negative on the film frame), D(eastward; positive), Z(downward; negative)
Range	H: −1500 nT–1000 nT, D: −500 nT–1000 nT, Z: −800 nT–1200 nT
Clock	Quartz clock (nominal error is less than 5 sec in 73 days)
Drift	Usually less than 0.1 nT/day
Resolution	2 nT (40 nT/mm on film, optical resolution=0.05 mm)
Film speed	Approximately 27.3 mm/h
Time mark	Every 6 (or 12) hours (shown by a thick vertical line), 1 hour (thin vertical line), 6 (or 12) min (thick dot) 10 sec (thin dot)
Calibration	Every 6 (or 12) hours (00–06 min, by small Helmholtz coils)
Traces on film	H, D, Z, T (temperature), B_1, B_2 (base line); there is a list which shows distance between the two base lines.

Table 2. Station list of the Scandinavian Magnetometer Array (from KÜPPERS et al., 1979).

Symbol	Name	Country	Geographic Lat.	Geographic Long.	Rev. Corr. Geomag. Lat.	Rev. Corr. Geomag. Long.	x_{KI} (km)	y_{KI} (km)	γ_{KI} (deg)	D (deg)	Installation
MAL	Malöy	N	62.18	5.10	60.67	88.99	−350	−887	26.2	−6.5	76/9
HEL	Hellvik	N	58.52	5.77	56.75	87.44	−735	−1033	25.5	−3.9	76/9
KLI	Klim	DK	57.12	9.17	54.96	89.37	−961	−911	22.4	−6.0	76/10
NAM	Namsos	N	64.45	11.13	62.24	94.95	−239	−509	20.8	−2.9	76/9
FLO	Flötningen	S	61.88	12.23	59.55	94.13	−527	−557	19.8	−1.0	78/7
ARV	Arvika	S	59.60	12.60	57.19	93.18	−774	−623	19.4	−1.9	76/9
ESM	Esmared	S	56.74	13.22	54.16	92.35	−1089	−694	18.7	−1.5	78/7
FRE	Fredvang	N	68.08	13.17	65.67	99.20	108	−285	19.0	−0.5	76/9
GLO	Glomfjord	N	66.90	13.58	64.44	98.55	− 20	−311	18.6	−1.2	75/10
OKS	Okstindan	N	65.90	14.27	63.37	98.29	−136	−317	18.0	−0.4	76/9
RIS	Risede	S	64.50	15.13	61.89	97.95	−296	−326	17.2	−0.5	76/9
HAS	Hassela	S	62.07	16.50	59.35	97.45	−575	−338	15.9	0.5	76/9
AND	Andenes	N	69.30	16.02	66.62	102.38	202	−134	16.4	−0.1	76/9
EVE	Evenes	N	68.53	16.77	65.79	102.22	112	−129	15.7	0.4	76/9
RIJ	Ritsemjokk	S	67.70	17.50	64.90	102.06	15	−124	15.0	−1.1	76/9
KVI	Kvikkjokk	S	66.90	17.92	64.07	101.72	− 75	−130	14.6	4.0	76/9
SRV	Storavan	S	65.78	18.18	62.93	101.04	−198	−150	14.4	1.7	76/9
LYC	Lycksele	S	64.57	18.68	61.67	100.55	−335	−160	13.9	1.3	76/9
MIK	Mikkelvik	N	70.07	19.03	67.14	105.12	255	0	13.6	0.7	74/8
ROS	Rostadalen	N	68.97	19.67	65.99	104.64	130	− 4	13.0	2.7	74/8
KIR	Kiruna	S	67.83	20.42	64.80	104.27	0	− 2	12.3	0.0	74/12
NAT	Nattavaara	S	66.75	21.00	63.67	103.82	−122	− 3	11.8	3.0	74/8
PIT	Pitea	S	65.25	21.58	62.16	103.22	−291	− 10	11.3	5.1	74/8
HOP	Hööpaka	SF	63.01	22.56	59.86	102.60	−545	− 11	10.4	3.0	78/7
SOY	Söröya	N	70.60	22.22	67.39	107.94	287	129	10.6	4.4	75/10
MAT	Mattisdalen	N	69.85	22.92	66.62	107.77	200	139	10.0	4.5	75/10
MIE	Mieron	N	69.12	23.27	65.86	107.40	118	139	9.7	4.7	75/10
MUO	Muonio	SF	68.03	23.57	64.75	106.70	− 2	131	9.4	4.7	75/10
PEL	Pello	SF	66.85	24.73	63.47	106.59	−140	159	8.3	5.5	75/10
OUL	Oulu	SF	65.10	25.48	61.77	106.07	−337	166	7.7	5.1	75/10
JOK	Jokikylä	SF	63.77	26.13	60.39	105.73	−488	177	7.1	7.5	75/10
SAU	Sauvamäki	SF	62.30	26.65	58.82	105.32	−654	184	6.7	5.1	75/10
BER	Berlevag	N	70.85	29.13	67.16	113.10	282	384	4.2	8.2	76/9
VAD	Vadsö	N	70.10	29.65	66.42	112.75	197	397	3.7	7.1	76/9
SKO	Skogfoss	N	69.37	29.42	65.70	111.95	117	383	3.9	8.8	76/9
RKS	Roksä	SF	62.57	30.26	58.95	108.29	−640	372	3.4	6.9	78/7

Country: DK, Denmark; N, Norway; S, Sweden: SF, Finland. Rev. Corr. Geomag.: revised corrected geomagnetic coordinates according to GUSTAFFSON (1970). x_{KI}, y_{KI}: coordinates in Kiruna System. γ_{KI}: westerly deviation of the positive x_{KI} axis from geographic north. D: magnetic easterly declination. Last column: year/month of installation.

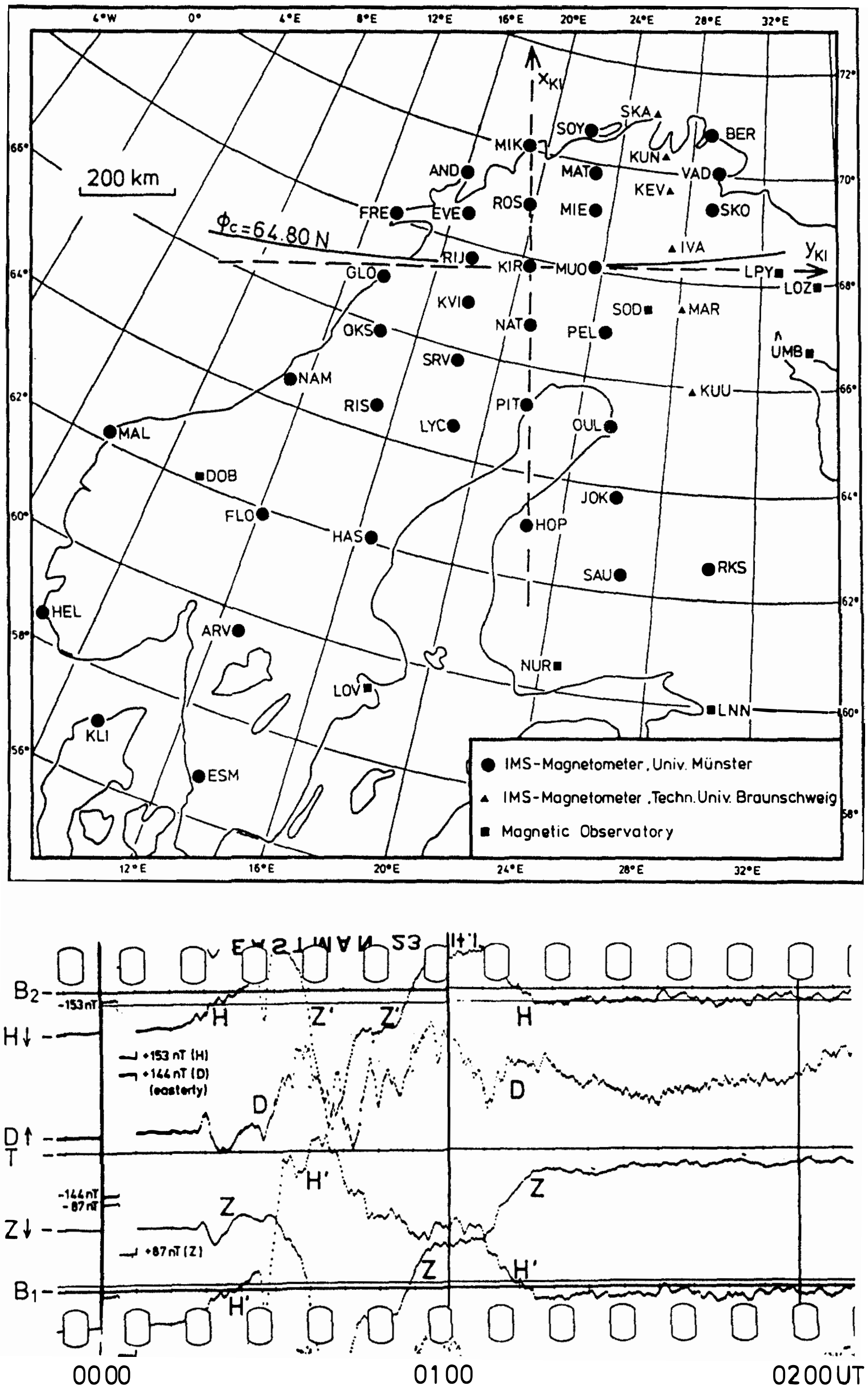

Fig. 1. *Upper panel: Station map of the Scandinavian Magnetometer Array in geographic coordinates given by KÜPPERS et al. (1979). Solid curve through KIR shows 64.80N corrected geomagnetic latitude (GUSTAFFSON, 1970). Broken lines are the axes of the Kiruna system defined by KÜPPERS et al. (1979). Lower panel: Example of a film record from station EVE of the Scandinavian Magnetometer Array (KÜPPERS et al., 1979). Curves for the H-, D- and Z-components consist of dots optically recorded by every 10 sec (20 sec at some of the stations) exposure.*

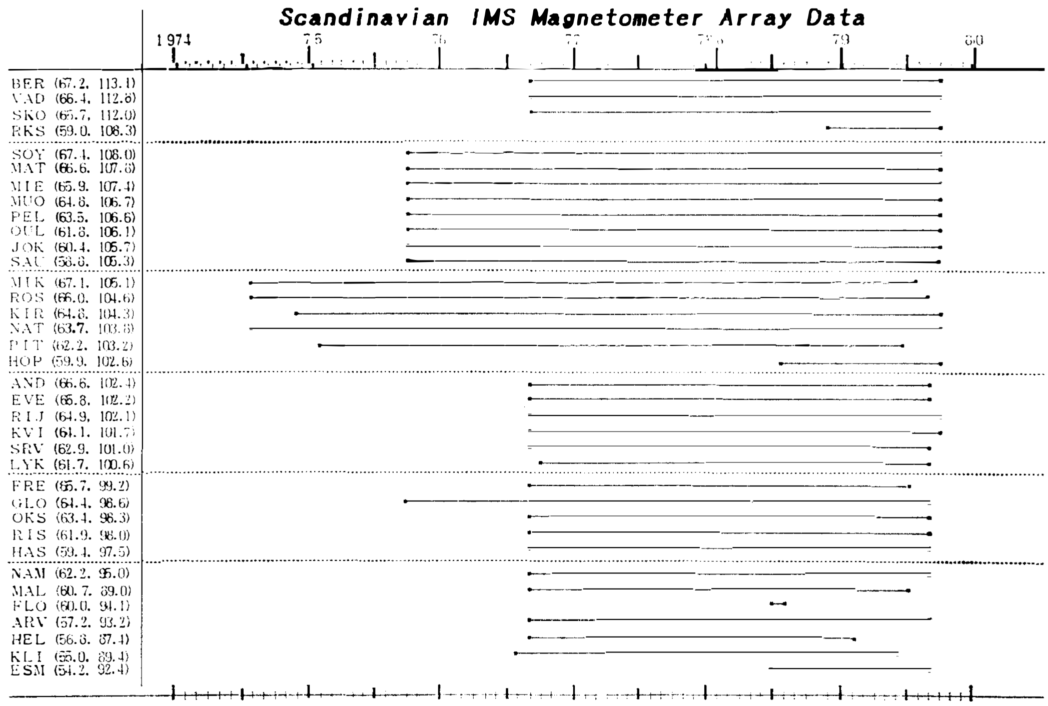

Fig. 2. Interval of available data for each station of the Scandinavian Magnetometer Array.

In Figs. 3 and 4 time sequential plots of 30 min data for the 2 events (abbreviated as 1.9 SC and 4.5 SC, respectively) observed along the Alaska chain of NAMN are shown together with VOLPERS's plots of the SMA data. A- and B-components of the SMA data correspond to the H- and D-components of the Alaska chain data.

According to a model of SC proposed by ARAKI (1979, 1987 and 1988), waveform of SC in high latitudes consists of two pulses (DP_{pi} and DP_{mi}) with opposite sense. On the lower latitude side of the auroral zone a positive pulse of the H-component precedes a negative pulse in the morning and a positive pulse follows a negative pulse in the afternoon. The sense reverses on the higher latitude side. The A-component of the SMA data of the both events seems to follow this rule if we assume that most of stations in SMA are at the lower latitude side, because it consists of a positive pulse followed by a negative pulse. The H-component of 4.5 SC observed along the Alaska chain in the afternoon also seems to follow this rule. The first pulse of it is negative at lower latitude stations (TLK, COL, FYU and AVI) and positive at higher latitude station (JOP) as shown by a broken vertical line in Fig. 4. The dotted curves show following pulses (DP_{mi}).

While waveform of the H-component of 1.9 SC is similar to that of 4.5 SC at TLK, it becomes much different from 4.5 SC at higher latitude stations (especially at AVI and INK) because of superposition of a large amplitude oscillation on 1.9 SC. Since the A- and B-components of both events are similar at SMA, the oscillation seems to appear in a limited longitudinal extent in the afternoon. The Y-component of the interplanetary magnetic field (IMF) is negative for both events and the Z-component is strongly positive for 1.9 SC and nearly zero for 4.5 SC. It should

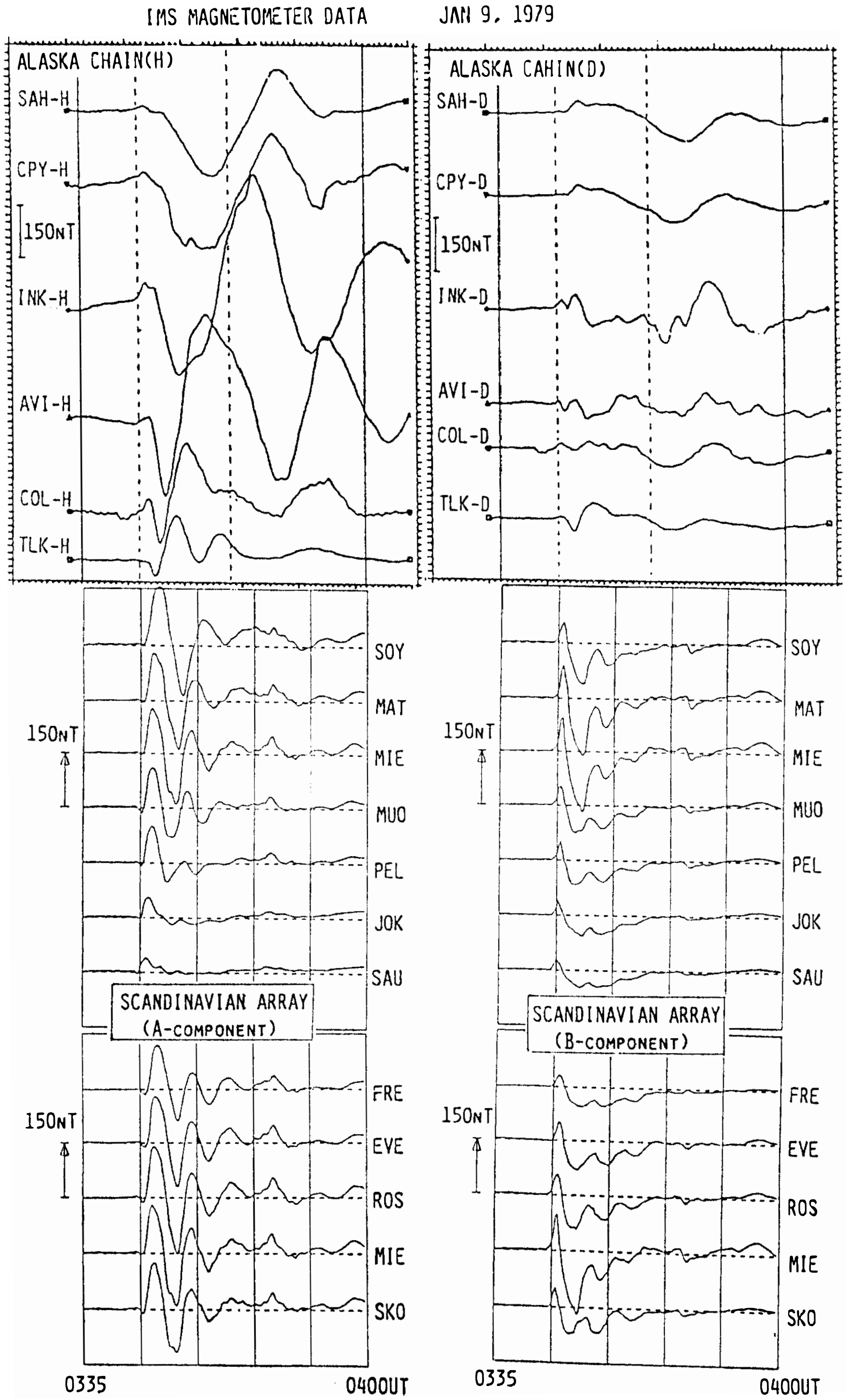

Fig. 3. Geomagnetic sudden commencement occurred on January 9, 1979. Upper panel: records from 6 stations of the Alaska chain (in north-south direction) of the North American IMS Magnetometer Network. Middle panel: from 7 stations of a north-south chain of the Scandinavian Magnetometer Array. Lower panel: from an east-west chain of SMA.

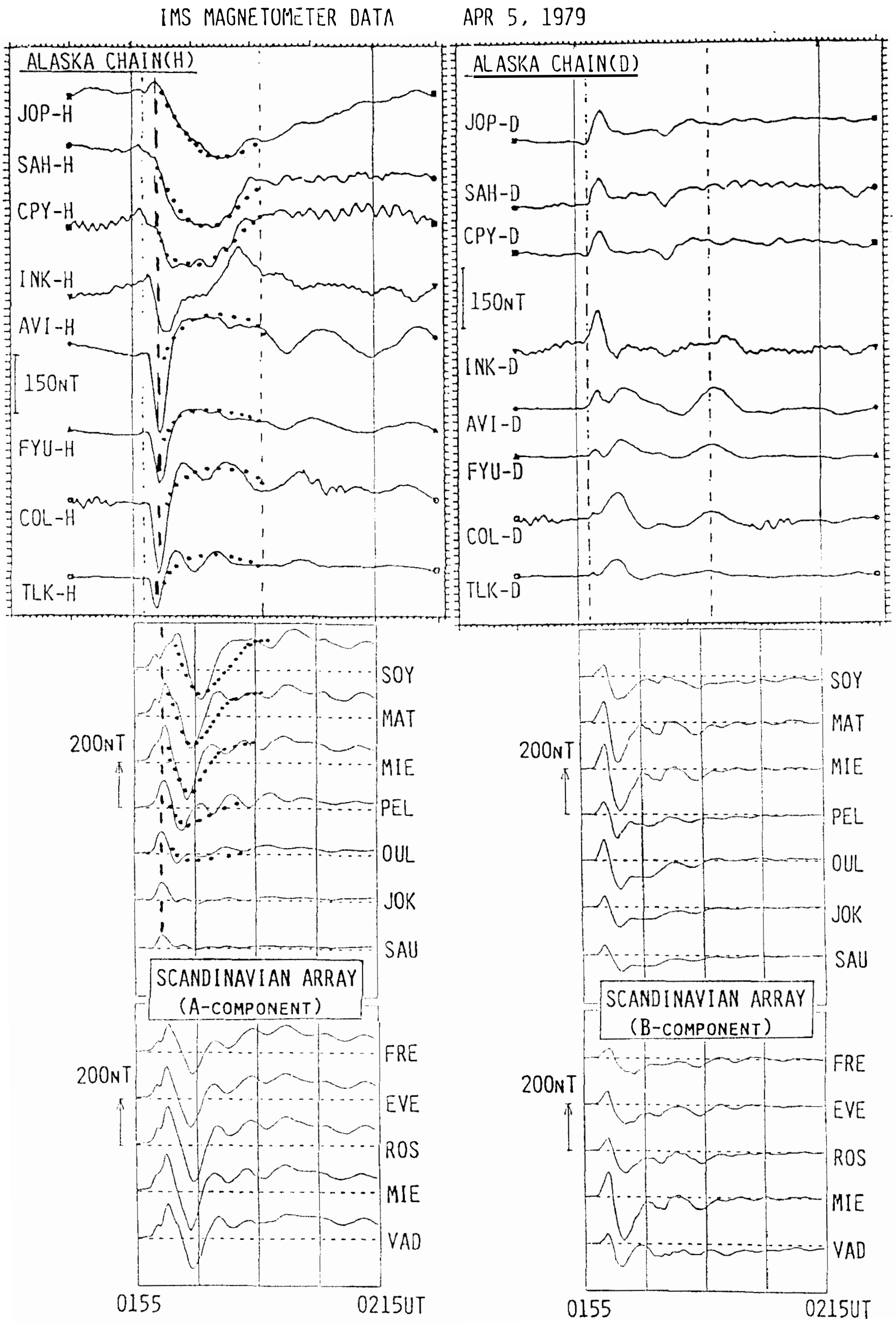

Fig. 4. Geomagnetic sudden commencement of April 5, 1979. Upper panel: records from 8 stations along the Alaska chain of the North American IMS Magnetometer Network. Middle panel: from 7 stations of a north-south chain of the Scandinavian Magnetometer Array. Lower panel: from 5 stations of an east-west chain of SMA.

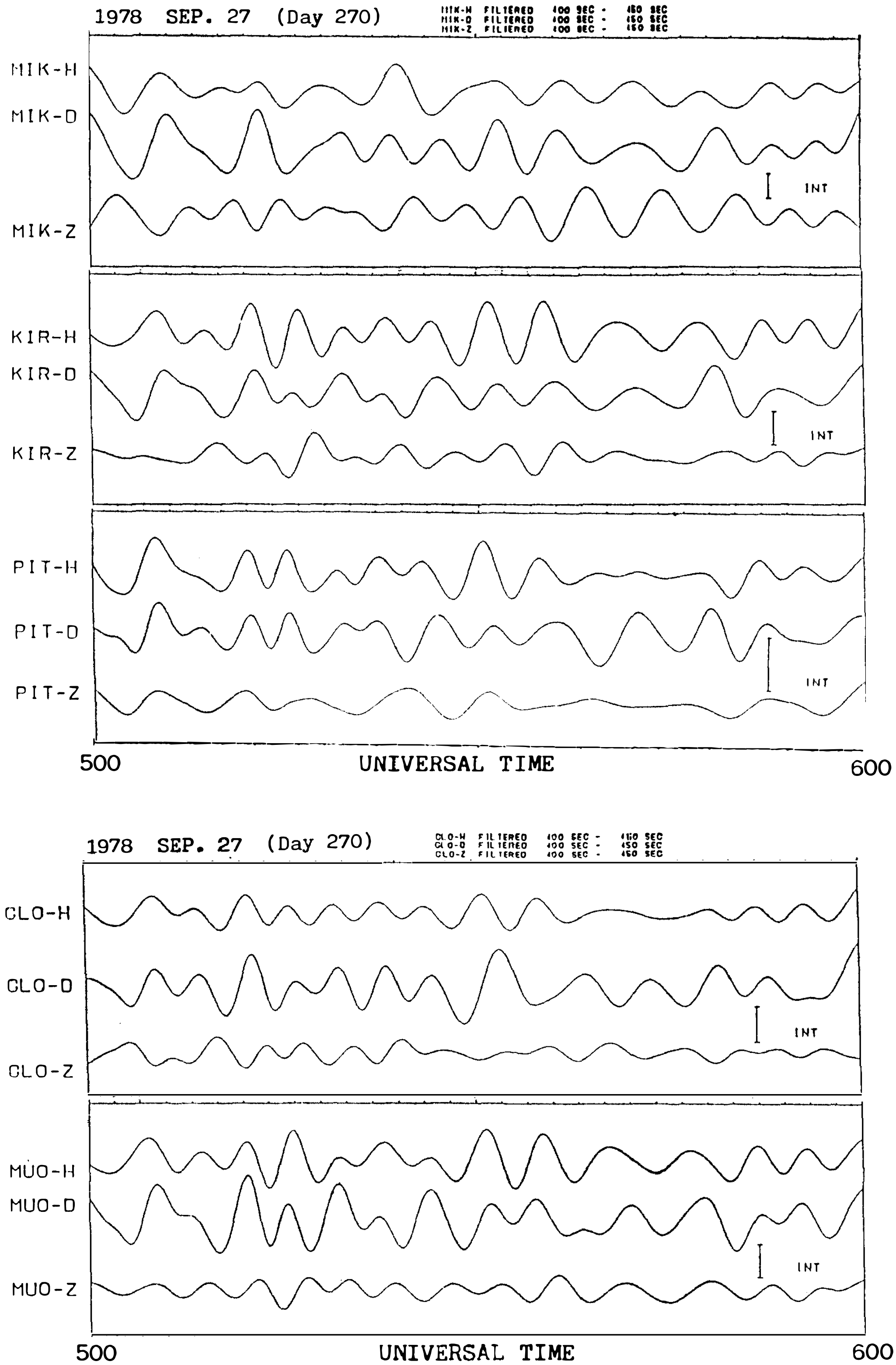

Fig. 5. One hour records of a geomagnetic pulsation observed by the Scandinavian Magnetometer Array on September 27, 1978. Upper 3 panels: from a north-south chain. Lower 2 panels: from an east-west chain. The positive direction for the H-, and Z-components is downward.

be further studied whether or not the difference in waveform of the both events depends upon the IMF polarity.

3.2. Geomagnetic pulsation

Geomagnetic pulsations have been analyzed by the following procedure;

(1) Twenty-four pulsation events were picked up by examining the SMA data from April to December in 1978 at KIR (Kiruna).

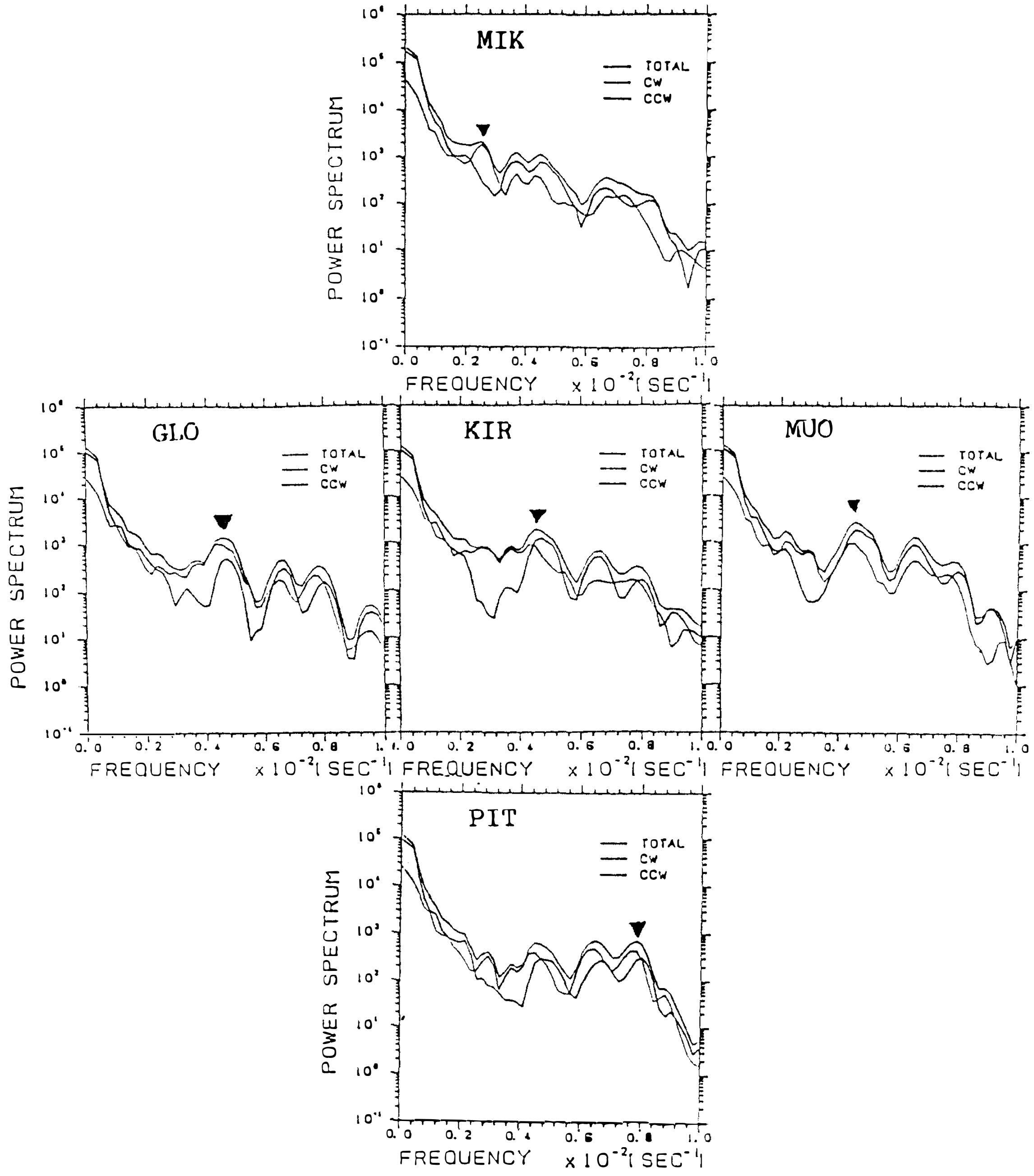

Fig. 6. Power spectrum of the geomagnetic pulsation shown in Fig. 5. The spectrum was calculated separately for clockwise-, counter clockwise-components of horizontal polarization and total horizontal vector.

(2) Corresponding NAMN data at COL (College) in nearly the same geomagnetic latitude as KIR were checked and pulsation activity was found in 9 events.

(3) The SMA data at KIR for the events were digitized and plotted. The waveforms at KIR and COL were compared.

(4) Detailed properties of the spectrum and polarization were studied for 2 events among the 9 events above.

Figure 5 shows one hour plots of a geomagnetic pulsation observed along the north-south (MIK, KIR, PIT) and the east-west (GLO, MUO) chain of SMA. The phase of the oscillation proceeds from south to north and from east to west. This is consistent with an assumption that the pulsation is caused by the Kelvin-Helmholtz instability on the magnetopause. The result of the spectrum analysis at the 5 stations is given in Fig. 6. The dominant frequency decreases with increasing latitude along the north-south chain, whereas it is nearly constant along the east-west chain.

It was found that simultaneous occurrence of pulsations with similar period at SMA and NAMN was very rare. Figure 7 is a plot of an event in which a geomagnetic pulsation appeared in both SMA and the Alaska chain. This event is very peculiar in the fact that not only the frequency but also waveform is similar at College in the morning and Kiruna in the afternoon. Detailed properties of this event are now investigated.

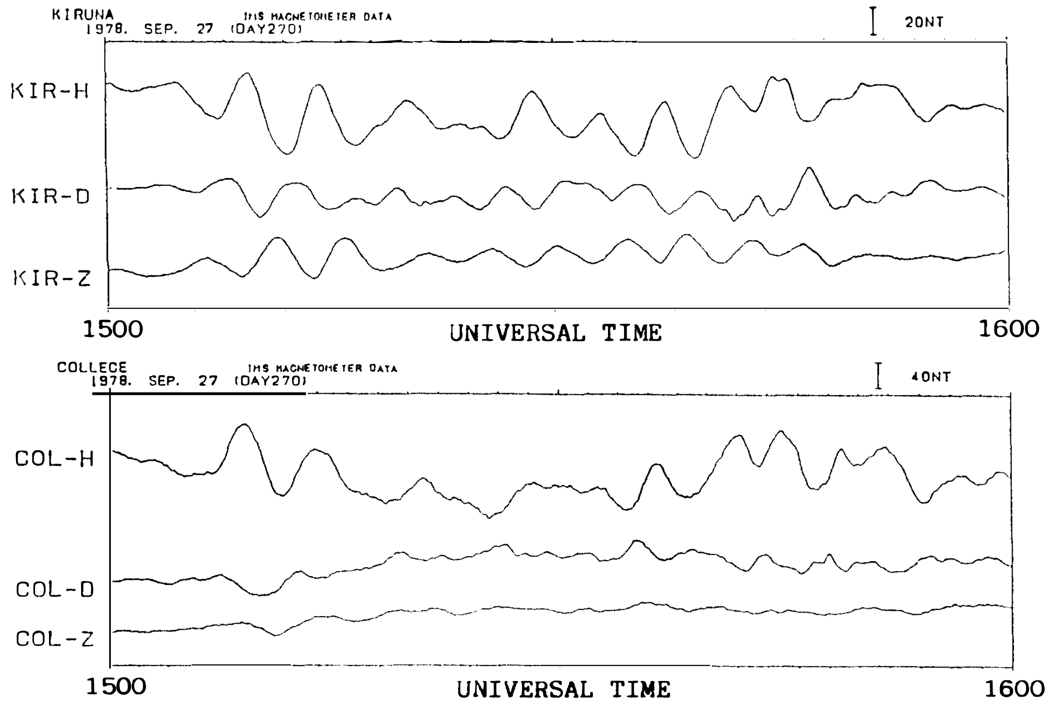

Fig. 7. One hour records of a geomagnetic pulsation observed simultaneously in the afternoon (KIR: Kiruna in Scandinavia) and morning (COL: College in Alaska) with similar waveform. Positive direction for the H- and Z-components at KIR is downward.

4. Conclusions

Although the analysis of the SMA data has just begun in Japan and it is still in the beginning stage, we have confirmed from our provisional experience that the data are very useful for studying fine structure and local time dependence of geomagnetic rapid variations. We hope, therefore, that many research workers will be interested in the data and use the data for their research. One problem is a considerable amount of time required for digitizing the data, so that it is desirable to develop a way of automatic digitization of the data.

Acknowledgments

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