

Antarctic Climate Research Data, Part 2
Radar and Microwave Radiometer Data at Syowa Station, Antarctica
from March to December 1988

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1. Introduction

A five-year program of Antarctic Climate Research (ACR) was planned to be carried out at Syowa, Asuka and Mizuho Stations, surrounding the ice sheet and sea ice area from 1987 to 1991 by the Japanese Antarctic Research Expedition (JARE) as part of the international cooperating World Climate Research Program (WCRP) (Yamanouchi, 1989). The main research subjects are; 1) interannual variation of Antarctic atmosphere, 2) sea ice-atmosphere interaction, 3) variation of ice sheet and ice shelf, 4) ice core analysis. In JARE-29 (the 2nd year of this program) we have mainly observed the items related to the interannual variation of Antarctic atmosphere. The observational data of clouds and precipitation are shown in this report. These data are useful for studying short- and long-term variations of clouds and precipitation.

2. Instruments and Observations

A vertical pointing radar and two microwave radiometers were used for measuring integrated ice water contents (IWC mg/cm^2) and brightness temperature (TB K) of atmosphere, which is related to liquid water content (LWC mg/cm^2). Specifications of instruments are shown in Tables 1 and 2. System diagrams including data collecting hardwares are also shown in Figs. 1 and 2. The data obtained for a period only from March to December 1988 are listed in this report.

A vertical pointing radar was set near the Earth

Science Laboratory and the data collecting hardwares were set in the Laboratory. Radar data are collected every 10 s and the all data are written into 8" floppy disk every 5 min. Radar echo intensity at 128 points along altitude (50 m interval) is sampled every time. The echo intensity is expressed in 255 levels.

Two microwave radiometers were set on the roof of the Upper and Lower Atmosphere Laboratory and the data collecting hardwares were set in the Laboratory in 1987. Data of microwave radiometers are sampled every 10 s but only 1-min averaged data only are written into 8" floppy disk every 4 min.

3. Data Reduction

Rainfall rate (R mm/hr) and ice water content (M mg/m³) at each altitude are calculated by the following equations using the radar reflectivity factor (Z mm⁶/m³),

$$Z = 500 \times R^{2.0},$$

$$M = 49 \times Z^{0.9} \quad (\text{Sato et al., 1981}).$$

Integrated ice water contents (IWC mg/cm²) are calculated from ice water contents of 128 levels from 0.5 km to 6.4 km altitude. Namely,

$$IWC = \sum_{i=1}^{128} M_i \times (z_i - z_{i-1}),$$

where M_i means ice water content at i -th altitude and z_i means i -th altitude, e.g. $z_0=0$, $z_1=0.5$, ..., $z_{128}=6.4$.

Ground echo data and the other noise data (we say minimum value) are contained in our radar data. The fluctuation of minimum value is caused mainly by the change of output of logarithmic amplifier or magnetron. We estimate the minimum

values from echo intensities on the clear sky days. The minimum values are decided in each month (Table 3) and the values of them are subtracted from calculating values R, M and IWC. We express corrected R, M and IWC as R_t , M_t and IWC_t . Averaged values of R_t , M_t , IWC_t are shown in this report.

Five-min mean brightness temperatures (TB K) of atmosphere are obtained from the following procedure. Temperatures (T_i K) expressed by the output of microwave radiometer are shown as

$$T_i = aV + b,$$

where V is 5-min mean output voltage (V volts), a and b are constants (Table 4). On the other hand, T_i is related to the brightness temperature (TB K) and antenna physical temperature (T_A K), namely

$$T_i = L_a \times TB + (1-L_a) \times T_A,$$

where L_a is antenna loss. The antenna loss of 37.0 GHz radiometer is estimated at 0.758. The surface air temperature (T_a K) observed by the meteorological staff every hour (Japan Meteorological Agency, 1990) replaced T_A . It is thought that large error for TB would not be made since T_A does not much change during an hour. Five-min averaged values of TB are shown in this report. Observations of brightness temperature are done by two microwave radiometers. However, as large uncertainty was found in the data of 19.35 GHz radiometer, data of 37.0 GHz radiometer are only shown in this report.

4. Description of Figures

Figure 3 shows the daily variation of total rainfall from March to December 1988. Total rainfall is calculated from radar echo intensity at the altitude of 300 m. In the figures the horizontal axis is total rainfall and the vertical one is month and day. Figure 4 shows a time-height cross section of daily

mean echo intensity. Daily mean echo intensity is expressed by 8 symbols which indicate the grades of echo intensity. Order of the grades is symbol 5, 4, 3, 2, 1, asterisk, period, and space, symbol 5 being the strongest and space the weakest. Figure 5 shows the variation of 5-min mean brightness temperature by 37.0 GHz radiometer and 5-min mean integrated ice water content by the vertical pointing radar for 2 days. Figures from March to December 1988 are listed here. In the figure the horizontal axis indicates time and the vertical one indicates brightness temperature (TB K) and integrated ice water content (IW_C mg/cm²). Solid circle shows brightness temperature and open circle shows integrated ice water content.

5. Data List of Microwave Radiometer and Vertical Pointing Radar

1) Microwave radiometer (19.35 GHz and 37.0 GHz)

Observational periods were from 1 February 1988 to 31 January 1989.

- * 1-min mean (10 s sampling) voltage output data
- * 5-min mean voltage output data
- * 5-min mean brightness temperature data
- * 5-min mean liquid water content data

All are stored in 5" floppy disk.

2) Vertical pointing radar

Observational periods were from 24 February 1988 to 31 January 1989.

- * Echo intensity data from surface to 6.4 km altitude (50 m interval) every 10 s are stored in 8" and 5" floppy disks.
- * 5-min mean ice water content (M mg/cm³) data are stored in 5" floppy disks.
- * About 1-day total rainfall (R mm) data are stored in 5" floppy disks.

References

- Japan Meteorological Agency (1990): Meteorological data at the Syowa Station in 1988. *Antarct. Meteorol. Data*, 29 (in press).
- Sato, N., Kikuchi, K., Barnard, S.C. and Hogan, A.W.(1981): Some characteristic properties of ice crystal precipitation in the summer season at South Pole Station, Antarctica. *J. Meteorol. Soc. Jpn.*, 59, 772-781.
- Yamanouchi, T. (1989): Antarctic climate research data, Part 1. Radiation data at Syowa Station, Antarctica from February 1987 to January 1988. *JARE Data Rep.*, 144(Meteorology 22), 193p.

Table 1. Specifications of vertical pointing radar.

Antenna

Parabolic antenna with radome in 2.0 m diameter

Antenna gain : 44 db

Beam width : 1.0

Transmitter and receiver

Carrier frequency : 9410 MHz

Peak power : 40 kW

Pulse width : 0.5 ms

Repetition frequency: 750 Hz

Receiver sensitivity: -106 dbm

Log amp linearity : 70 db

Table 2. Specifications of microwave radiometers.

	(1)	(2)
Receiver		
Frequency	: 37.0 GHz	19.35 GHz
Type	: Dicke	Dicke
Polarization	: Lineary polarization	
Bandwidth	: 100 MHz	100 MHz
Sensitivity	: 0.2 K	0.5 K
(integrated time):	(1 s)	(1 s)
Temperature range:	50-500 K	50-500 K
AGC	: Yes	Yes
Antenna		
Diameter	: 0.2 m	0.5 m with radome
Gain	: 25 db	33 db

Table 3. The minimum integrated ice water content (mg/cm^2) data which are recognized as ground echo and the other noise data from March to December 1988.

March	12.0	August	42.0
April	12.5	September	44.0
May	14.5	1- 3 October	35.0
1-15 June	13.0	3-31 October	22.0
15-17 June	10.0	November	22.0
17-30 June	50.0	December	24.0
July	45.0		

Table 4. The value of constants a and b of 37.0 GHz radiometer.

	a	b
March-April	0.372	330.6
May-September	0.381	330.6
September-December	0.383	330.6

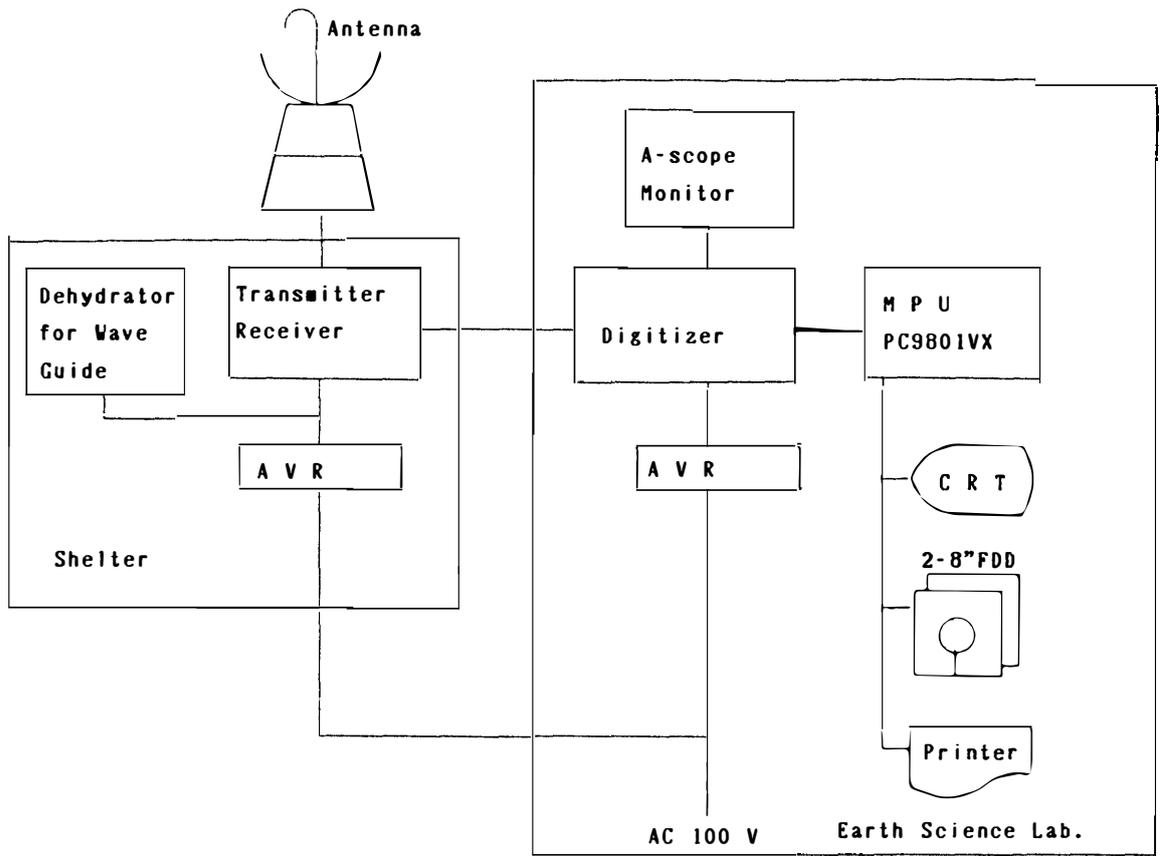


Fig. 1. System diagram of vertical pointing radar.

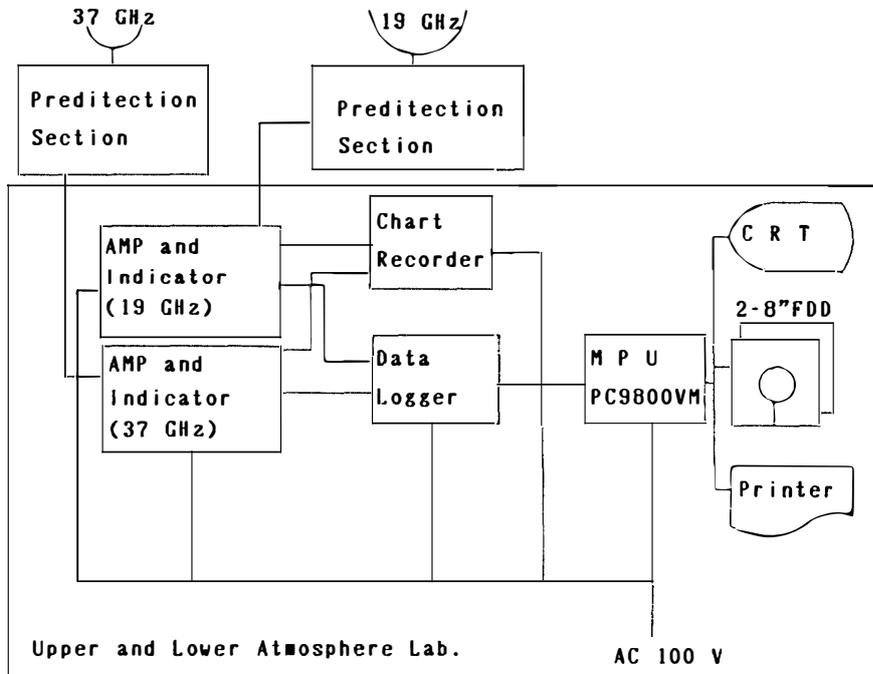


Fig. 2. System diagram of microwave radiometers.

MMDDOMM	1MM	2MM	3MM
3 1!***	!	!	!
3 2!***	!	!	!
3 3!***	!	!	!
3 4!**	!	!	!
3 5!**	!	!	!
3 6!*****	!	!	!
3 7!*****	!	!	!
3 8!*****	!	!	!
3 9!*****	!	!	!
310!*****	!	!	!
311!**	!	!	!
312!**	!	!	!
313!	!	!	!
314!*	!	!	!
315!*****	!	!	!
316!**	!	!	!
317!*****	!	!	!
318!***	!	!	!
319!*****	!	!	!
320!**	!	!	!
321!***	!	!	!
322!*	!	!	!
323!*	!	!	!
324!*	!	!	!
325!*	!	!	!
326!**	!	!	!
327!	!	!	!
328!*	!	!	!
329!*	!	!	!
330!*	!	!	!
331!**	!	!	!

MMDDOMM	1MM	2MM	3MM
4 1!*	!	!	!
4 2!***	!	!	!
4 3!***	!	!	!
4 4!*	!	!	!
4 5!***	!	!	!
4 6!*****	!	!	!
4 7!*****	!	!	!
4 8!**	!	!	!
4 9!*****	!	!	!
410!****	!	!	!
411!*****	!	!	!
412!***	!	!	!
413!***	!	!	!
414!**	!	!	!
415!****	!	!	!
416!****	!	!	!
417!****	!	!	!
418!*****	!	!	!
419!*****	!	!	!
420!*****	!	!	!
421!****	!	!	!
422!****	!	!	!
423!*****	!	!	!
424!**	!	!	!
425!*	!	!	!
426!***	!	!	!
427!***	!	!	!
428!*****	!	!	!
429!*****	!	!	!
430!*****	!	!	!

Fig. 3. Variation of total rainfall at the altitude of 300 m.

MMDDOMM	1MM	2MM	3MM
5 1!*****	!	!	!
5 2!*****	!	!	!
5 3!*****	!	!	!
5 4!****	!	!	!
5 5!****	!	!	!
5 6!*****	!	!	!
5 7!*****	!	!	!
5 8!****	!	!	!
5 9!****	!	!	!
510!****	!	!	!
511!****	!	!	!
512!****	!	!	!
513!****	!	!	!
514!*****	!	!	!
515!**	!	!	!
516!**	!	!	!
517!	!	!	!
518!*	!	!	!
519!*	!	!	!
520!*	!	!	!
521!***	!	!	!
522!**	!	!	!
523!**	!	!	!
524!**	!	!	!
525!***	!	!	!
526!**	!	!	!
527!**	!	!	!
528!****	!	!	!
529!*****	!	!	!
530!*****	!	!	!
531!*****	!	!	!

MMDDOMM	1MM	2MM	3MM
6 1!*****	!	!	!
6 2!*	!	!	!
6 3!*****	!	!	!
6 4!*****	!	!	!
6 5!**	!	!	!
6 6!*	!	!	!
6 7!*	!	!	!
6 8!	!	!	!
6 9!*	!	!	!
610!	!	!	!
611!	!	!	!
612!	!	!	!
613!	!	!	!
614!*	!	!	!
615!*	!	!	!
616!****	!	!	!
617!*****	!	!	!
618!*****	!	!	!
619!**	!	!	!
620!*****	!	!	!
621!*****	!	!	!
622!	!	!	!
623!	!	!	!
624!	!	!	!
625!***	!	!	!
626!**	!	!	!
627!**	!	!	!
628!	!	!	!
629!*	!	!	!
630!*	!	!	!

MMDDOMM	1MM	2MM	3MM
7 1!**	!	!	!
7 2!	!	!	!
7 3!**	!	!	!
7 4!**	!	!	!
7 5!***	!	!	!
7 6!*****	!	!	!
7 7!**	!	!	!
7 8!*	!	!	!
7 9!***	!	!	!
710!**	!	!	!
711!	!	!	!
712!	!	!	!
713!	!	!	!
714!*	!	!	!
715!**	!	!	!
716!****	!	!	!
717!***	!	!	!
718!**	!	!	!
719!*****	!	!	!
720!*****	!	!	!
721!*****	!	!	!
722!*****	!	!	!
723!***	!	!	!
724!*	!	!	!
725!***	!	!	!
726!**	!	!	!
727!****	!	!	!
728!****	!	!	!
729!**	!	!	!
730!	!	!	!
731!*	!	!	!

MMDDOMM	1MM	2MM	3MM
8 1!**	!	!	!
8 2!***	!	!	!
8 3!**	!	!	!
8 4!**	!	!	!
8 5!*****	!	!	!
8 6!****	!	!	!
8 7!	!	!	!
8 8!**	!	!	!
8 9!*****	!	!	!
810!	!	!	!
811!	!	!	!
812!	!	!	!
813!**	!	!	!
814!*	!	!	!
815!****	!	!	!
816!*****	!	!	!
817!****	!	!	!
818!*	!	!	!
819!*	!	!	!
820!*	!	!	!
821!*	!	!	!
822!*	!	!	!
823!*	!	!	!
824!***	!	!	!
825!	!	!	!
826!*	!	!	!
827!	!	!	!
828!	!	!	!
829!	!	!	!
830!	!	!	!
831!*	!	!	!

MMDDOMM	1MM	2MM	3MM
9 1!	!	!	!
9 2!*****	!	!	!
9 3!**	!	!	!
9 4!	!	!	!
9 5!**	!	!	!
9 6!****	!	!	!
9 7!	!	!	!
9 8!****	!	!	!
9 9!	!	!	!
910!	!	!	!
911!	!	!	!
912!*	!	!	!
913!*	!	!	!
914!	!	!	!
915!*	!	!	!
916!	!	!	!
917!	!	!	!
918!	!	!	!
919!	!	!	!
920!***	!	!	!
921!	!	!	!
922!	!	!	!
923!	!	!	!
924!	!	!	!
925!**	!	!	!
926!**	!	!	!
927!*	!	!	!
928!	!	!	!
929!*	!	!	!
930!**	!	!	!

MMDDOMM	1MM	2MM	3MM
10 1!*****	!	!	!
10 2!*	!	!	!
10 3!*	!	!	!
10 4!*	!	!	!
10 5!*	!	!	!
10 6!	!	!	!
10 7!*	!	!	!
10 8!*	!	!	!
10 9!*	!	!	!
1010!	!	!	!
1011!	!	!	!
1012!	!	!	!
1013!	!	!	!
1014!	!	!	!
1015!*	!	!	!
1016!*****	!	!	!
1017!**	!	!	!
1018!	!	!	!
1019!*	!	!	!
1020!*	!	!	!
1021!*	!	!	!
1022!**	!	!	!
1023!***	!	!	!
1024!***	!	!	!
1025!***	!	!	!
1026!***	!	!	!
1027!***	!	!	!
1028!***	!	!	!
1029!**	!	!	!
1030!**	!	!	!
1031!**	!	!	!

MMDDOMM	1MM	2MM	3MM
11 1!**	!	!	!
11 2!***	!	!	!
11 3!*****	!	!	!
11 4!**	!	!	!
11 5!*	!	!	!
11 6!*	!	!	!
11 7!***	!	!	!
11 8!***	!	!	!
11 9!**	!	!	!
1110!*	!	!	!
1111!	!	!	!
1112!****	!	!	!
1113!*****	!	!	!
1114!*****	!	!	!
1115!*	!	!	!
1116!*	!	!	!
1117!*	!	!	!
1118!**	!	!	!
1119!**	!	!	!
1120!**	!	!	!
1121!***	!	!	!
1122!***	!	!	!
1123!***	!	!	!
1124!**	!	!	!
1125!**	!	!	!
1126!*	!	!	!
1127!*****	!	!	!
1128!*****	!	!	!
1129!*	!	!	!
1130!*	!	!	!

MMDDOMM	1MM	2MM	3MM
12 1!*	!	!	!
12 2!**	!	!	!
12 3!**	!	!	!
12 4!**	!	!	!
12 5!*	!	!	!
12 6!*	!	!	!
12 7!*	!	!	!
12 8!*	!	!	!
12 9!*	!	!	!
1210!	!	!	!
1211!	!	!	!
1212!	!	!	!
1213!*****	!	!	!
1214!*****	!	!	!
1215!***	!	!	!
1216!***	!	!	!
1217!*****	!	!	!
1218!*****	!	!	!
1219!*****	!	!	!
1220!**	!	!	!
1221!*****	!	!	!
1222!****	!	!	!
1223!**	!	!	!
1224!***	!	!	!
1225!***	!	!	!
1226!*****	!	!	!
1227!****	!	!	!
1228!***	!	!	!
1229!***	!	!	!
1230!*****	!	!	!
1231!****	!	!	!

MMDDOKM	2KM	4KM	6KM
5 1!32	!	!	!
5 2!33	*****	!	!
5 3!32	*****	!	!
5 4!3	.....*****11111111*****	!	!
5 5!3	.....*****11111111*****	!	!
5 6!3	.....*****11111111*****	!	!
5 7!3	.....**112222222111**	!	!
5 8!31	!	!	!
5 9!31	!	!	!
510!31	!	!	!
511!31	!	!	!
512!31	!	!	!
513!31	!	!	!
514!31	*112111111*****	!	!
515!3	!	!	!
516!31	.....	.....	.....
517!3*	.....	.....	.....
518!3*	!	!	!
519!3	!	!	!
520!3*	!	!	!
521!33	!	!	!
522!32	!	!	!
523!33	!	!	!
524!33	!	!	!
525!33	.....	!	!
526!32	!	!	!
527!3*	.....	!	!
528!3*	.....*****11111122222211111111*****	!	!
529!32	.....	!	!
530!32	35555555555554443333322222222111111111111*****	!	!
531!32	*12221111*****	!	!

MMDDOKM	2KM	4KM	6KM
6 1!31	.....	!	!
6 2!3	!	!	!
6 3!3	*****	!	!
6 4!3	.....	!	!
6 5!3*****.*	!	!
6 6!2	!	!	!
6 7!2*	!	!	!
6 8!31	!	!	!
6 9!21	!	!	!
610!2*	!	!	!
611!2*	.....	.....	.....
612!2	.....*11222222111**	!	!
613!21	!	!	!
614!2*	!	!	!
615!**	.....	!	!
616!	.....*122222222223334445555555555555555555444443333222211111	!	!
617!	.....13455544433222211111111*****	!	!
618!1	*355554443333222221111111*****	!	!
619!1	.....	!	!
620!11	.....*11112222222222222222222222221111111111111*****	!	!
621!1	12233221111111*1*****	!	!
622!1*	!	!	!
623!11	!	!	!
624!1*	!	!	!
625!11*****11111222222222221111*****	!	!
626!11	!	!
627!11	!	!
628!	!	!	!
629!*****	!	!
630!	!	!	!

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MMDDOKM                2KM                4KM                6KM
7 1! 2                !                !                !
7 2! *                !                !                !
7 3! .                !                !                !
7 4! 1                !                !                !
7 5! 1 ..*****.....!                !                !
7 6! 2 ..*****.....!                !                !
7 7! 4                !                !                !
7 8! 1                !                !                !
7 9! 2                !                !                !
710! 1                !                !                !
711! 1                !                !                !
712! .                !                !                !
713! 1                !                !                !
714! 1                !                !                !
715! 1                !                !                !
716! 3                !                !                !
717! 2                !                !                !
718! 2                !                !                !
719! 1. ....!                !                !
720! *. ....*****.....*.....!                !
721! ***123333332222111111*****.....!                !
722! ****11*****1111*****.....!                !
723! *                !                !                !
724! 1                !                !                !
725! * ..*****11111111111111111111*****.....!                !
726! * .....*111112222232222111***.....!                !
727! * .....*****.....!                !
728! * ..*****.....!                !
729! 1 ..*****1111*****.....!                !
730! 1                !                !                !
731! 1                !                !                !

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MMDDOKM                2KM                4KM                6KM
8 1! 1                !                !                !
8 2! *                !                !                !
8 3! 1                !                !                !
8 4! 1                !                !                !
8 5! .....!                !                !
8 6! . ..*****1*111111*****.....!                !
8 7!                !                !                !
8 8! 1                !                !                !
8 9! ..*****.....!                !                !
810! .                !                !                !
811! 2                !                !                !
812! 2                !                !                !
813! *                !                !                !
814! *                !                !                !
815! .1 ..*****.....!                !                !
816! .*111221111*****.....!                !
817! *                !                !                !
818! .1                !                !                !
819! .1                !                !                !
820! .1                !                !                !
821! .1                !                !                !
822! .1                !                !                !
823! .1                !                !                !
824! -                !                !                !
825! -                !                !                !
826! *                !                !                !
827! *                !                !                !
828! ..                !                !                !
829! .*                !                !                !
830! .*                !                !                !
831! ..                !                !                !

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```

MMDDOKM          2KM          4KM          6KM
9 1!.*          !
9 2!.*.**1111111*****.....
9 3!..          !
9 4!.*          !
9 5!.*          !
9 6!.*          !
9 7!.*          !
9 8!.*          !
9 9!..          !
910!.*          !
911!.*          !
912!.*          !
913!.1         !
914!.*          !
915!**         !
916!**         !
917!*..        !
918!*..        !
919!*..        !
920!*..        !
921!*..        !
922!*..        !
923!*..        !
924!*..        !
925!*..        !
926!..         !
927!..         !
928!..         !
929!..         !
930!..         !
.....*****111111111*****.....
.....*****111*1111111*****.....
.....*****111111111*****.....

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MMDDOKM          2KM          4KM          6KM
10 1!..        !
10 2!..        !
10 3!..        !
10 4!..        !
10 5!..        !
10 6!..        !
10 7!..        !
10 8!..        !
10 9!..        !
1010!..        !
1011!..        !
1012!..        !
1013!..        !
1014!..        !
1015!..        !
1016!..        !
1017!..        !
1018!..        !
1019!..        !
1020!..        !
1021!..        !
1022!..        !
1023!..        !
1024!..        !
1025!..        !
1026!..        !
1027!..        !
1028!..        !
1029!..        !
1030!..        !
1031!..        !
.....*****1111*****.....
.....*****1111*****.....
.....*****1111*****.....

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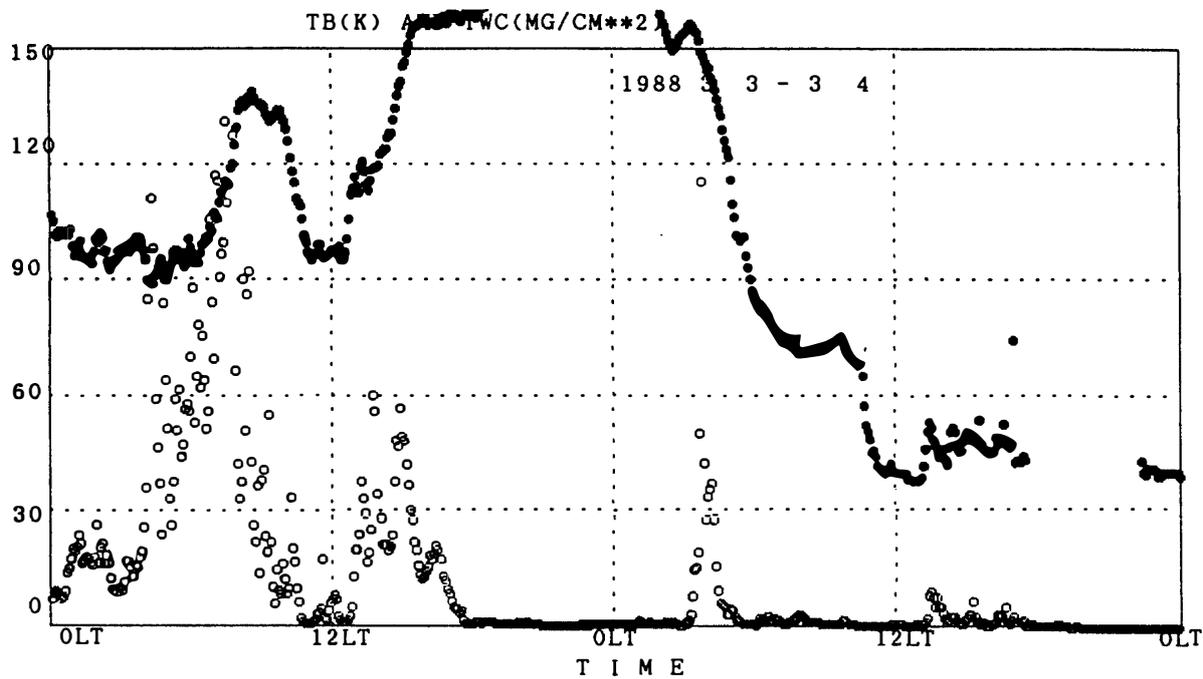
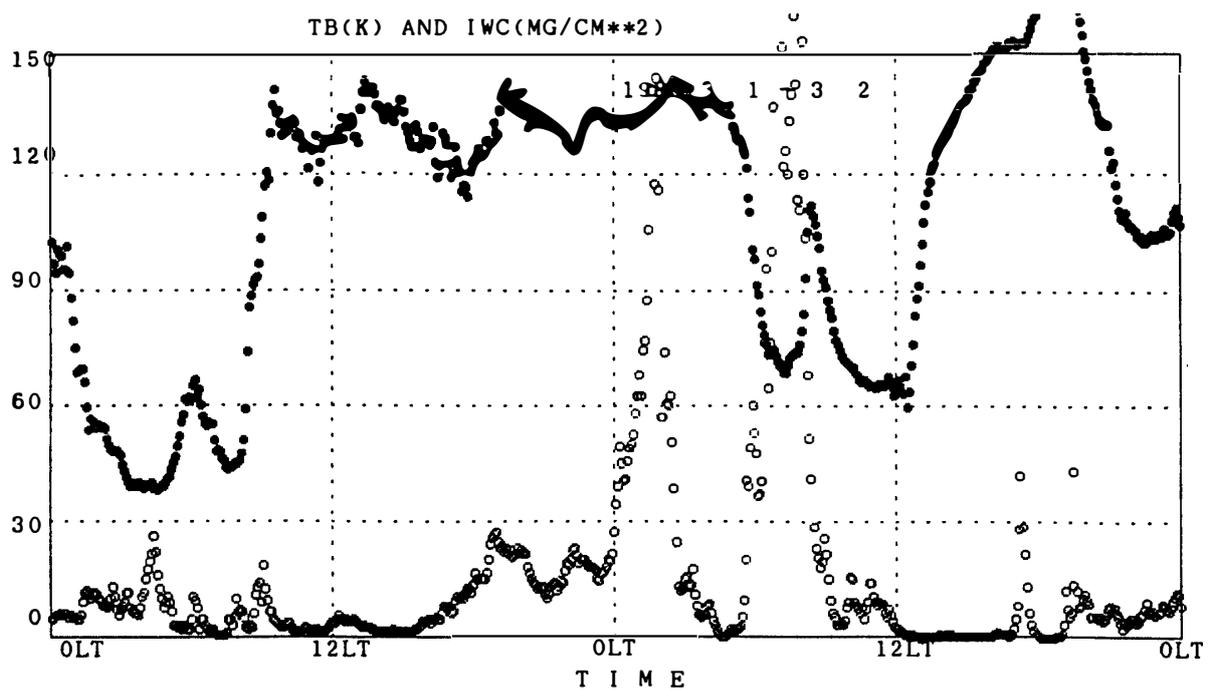
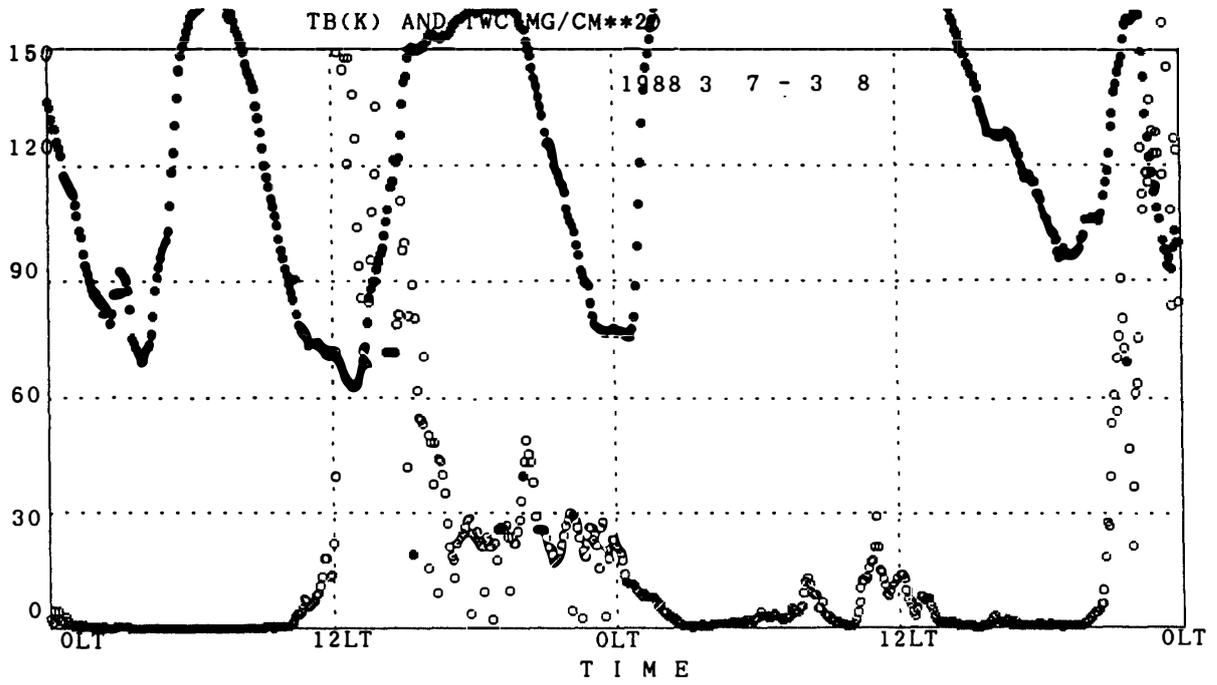
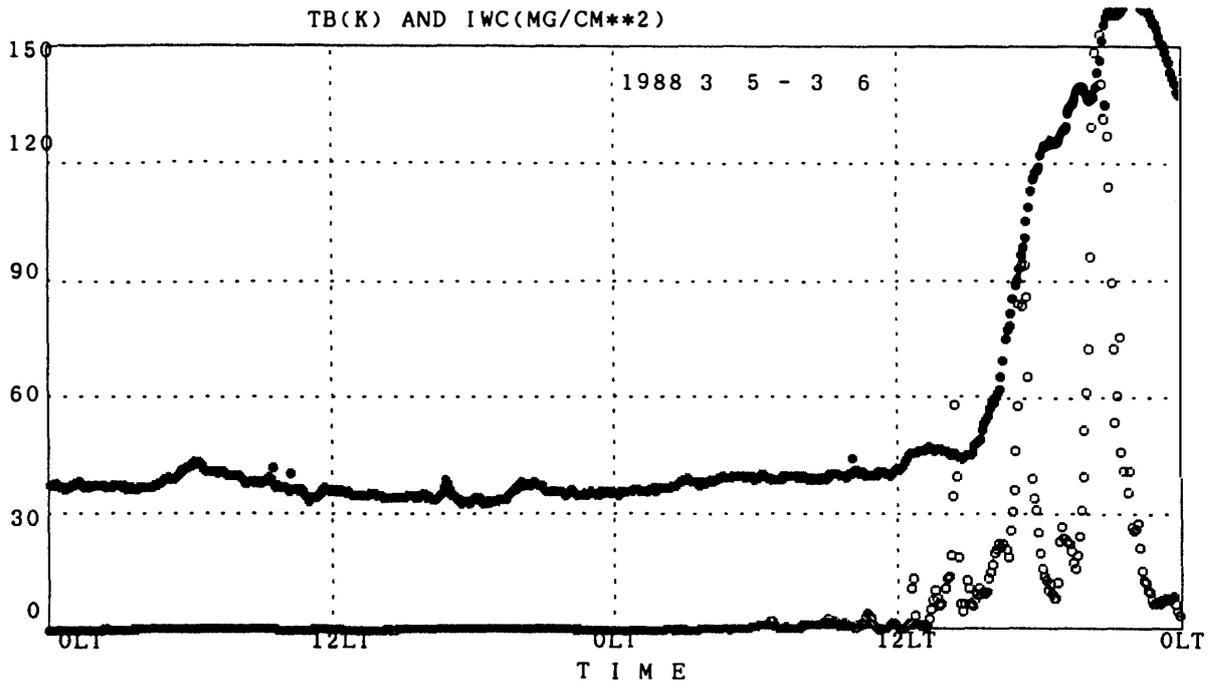
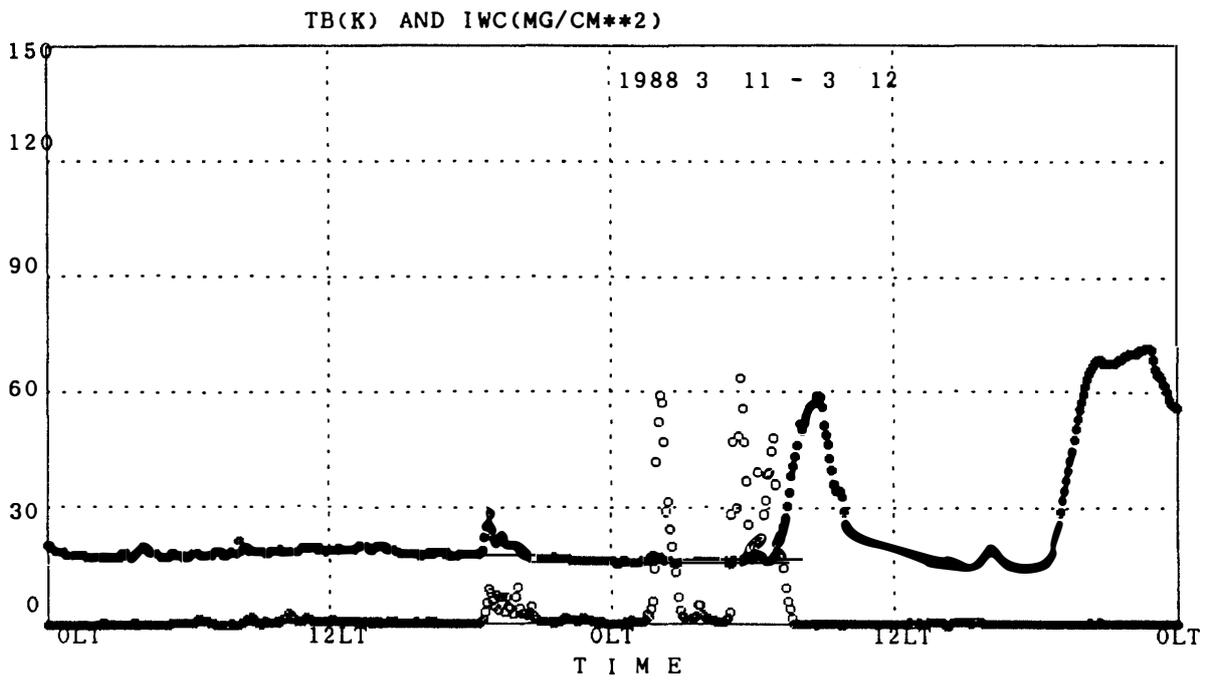
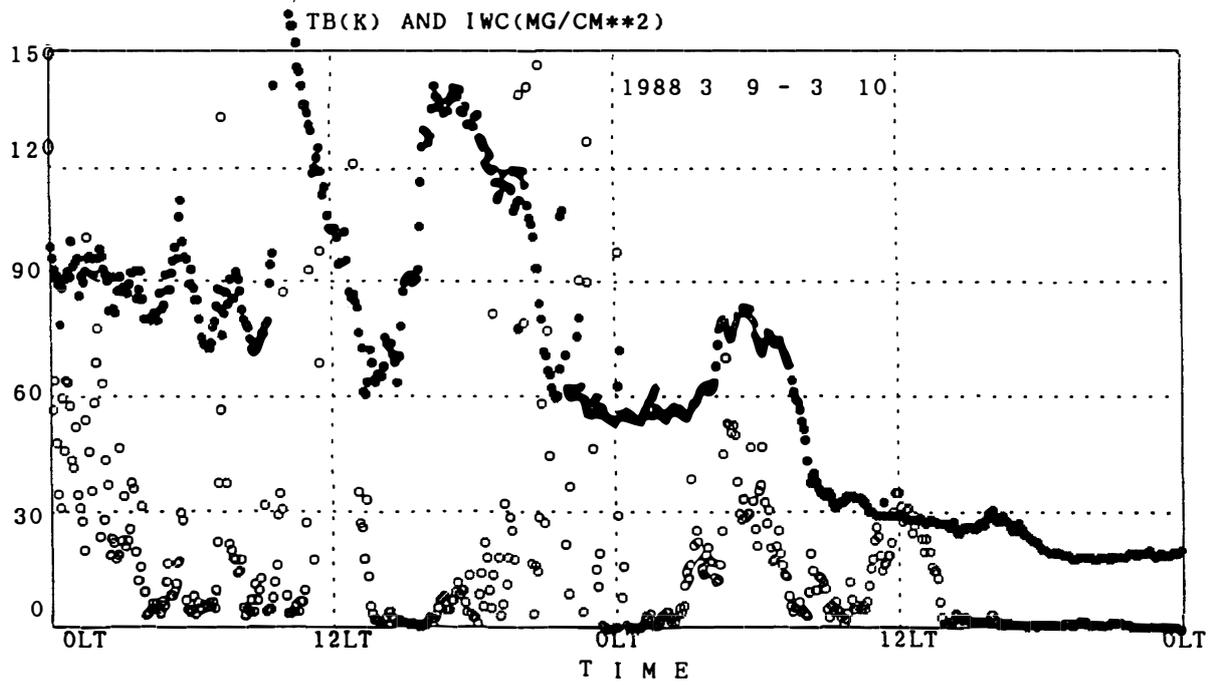
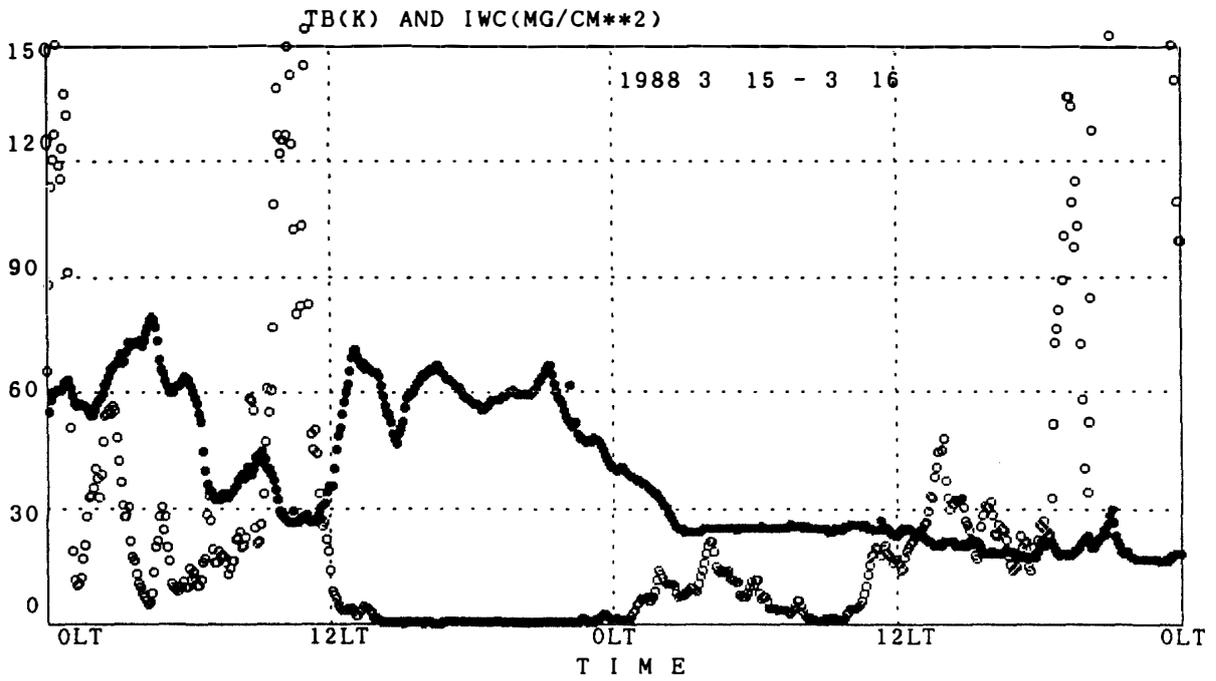
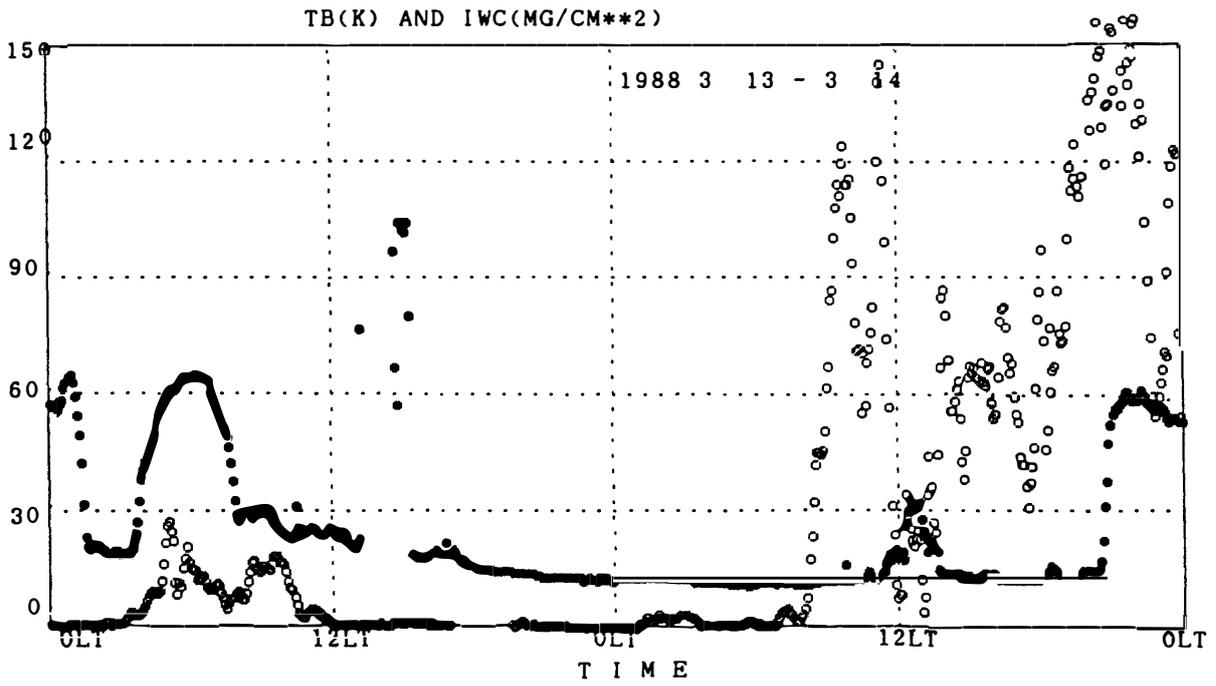
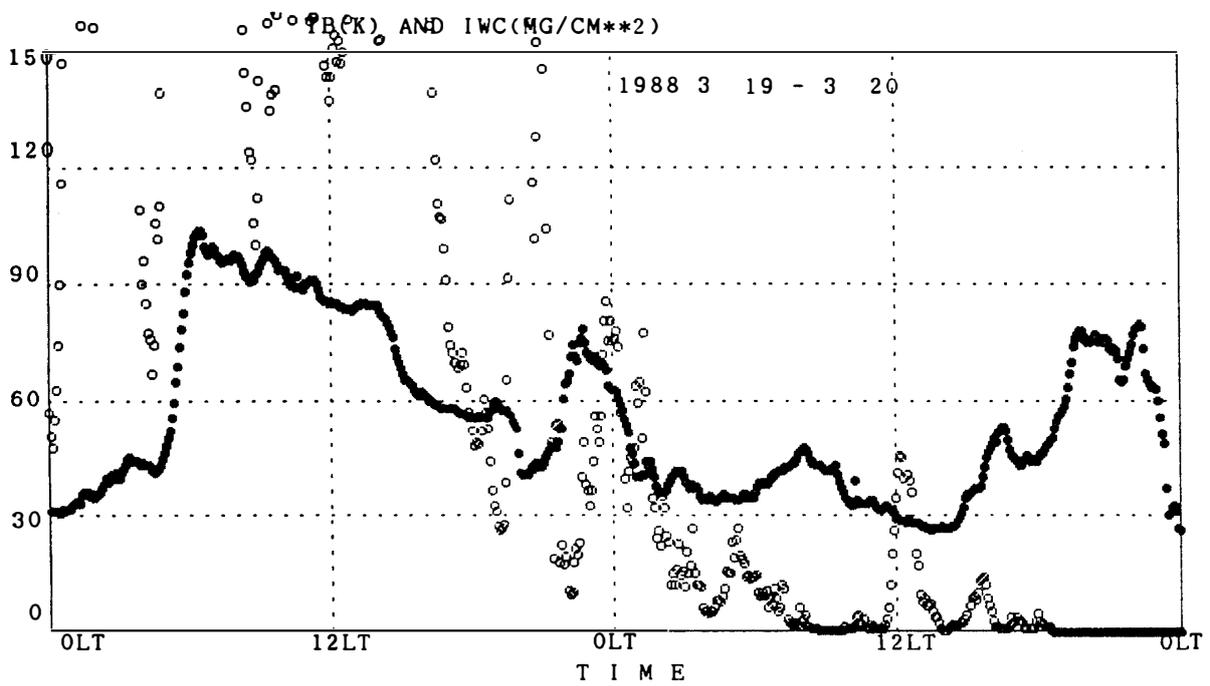
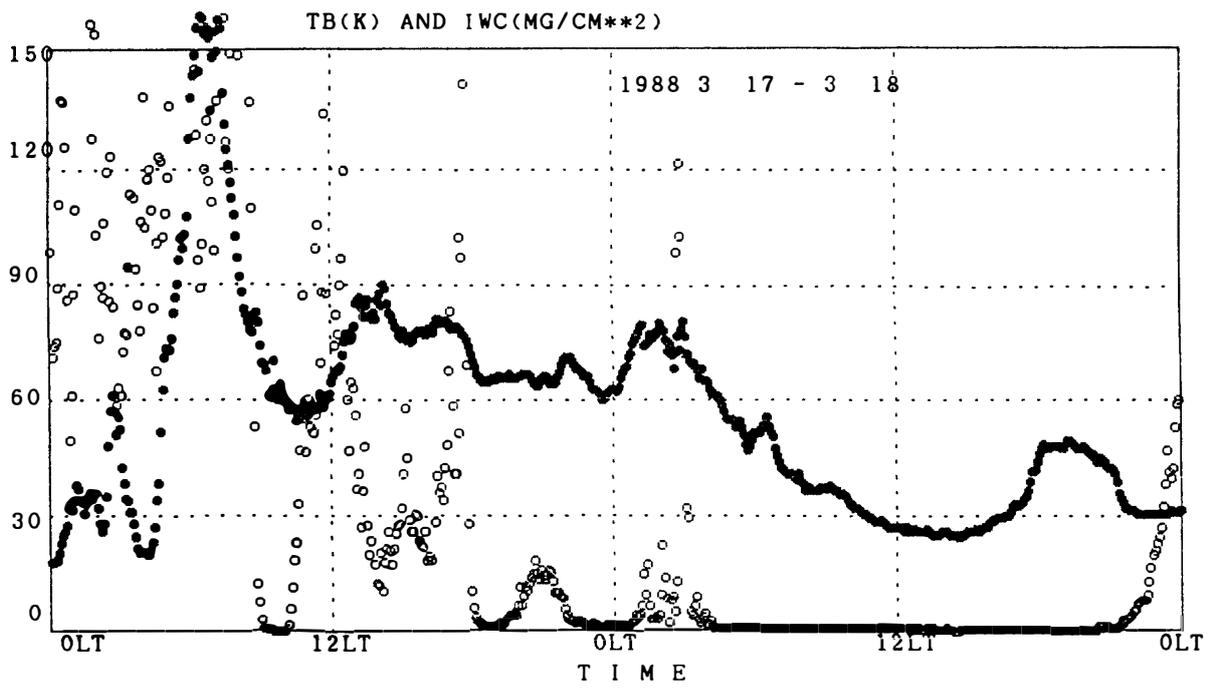



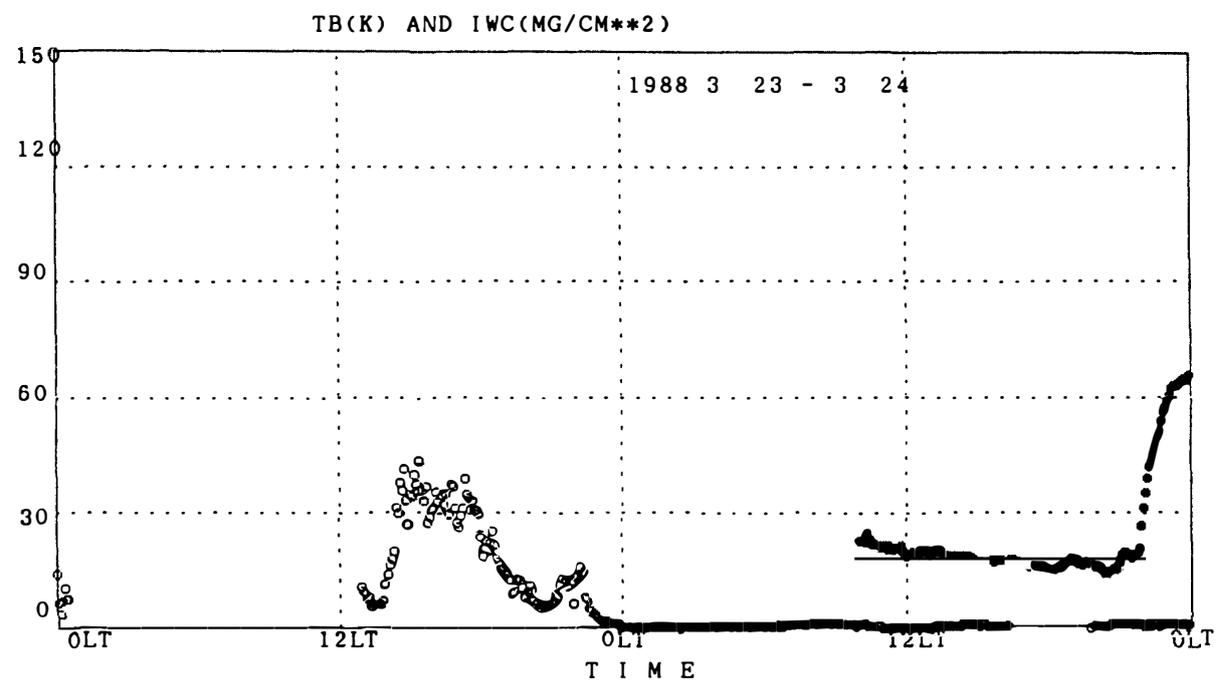
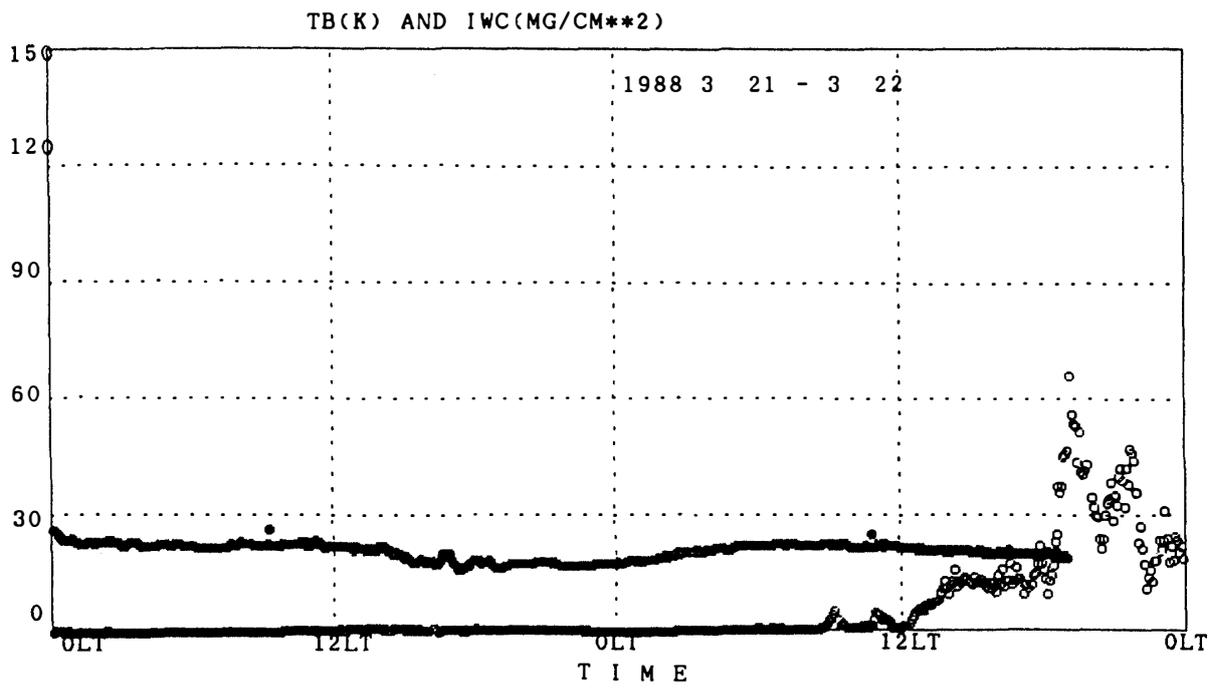
Fig. 5. Variation of 5-min mean 37.0 GHz brightness temperature and integrated ice water content.

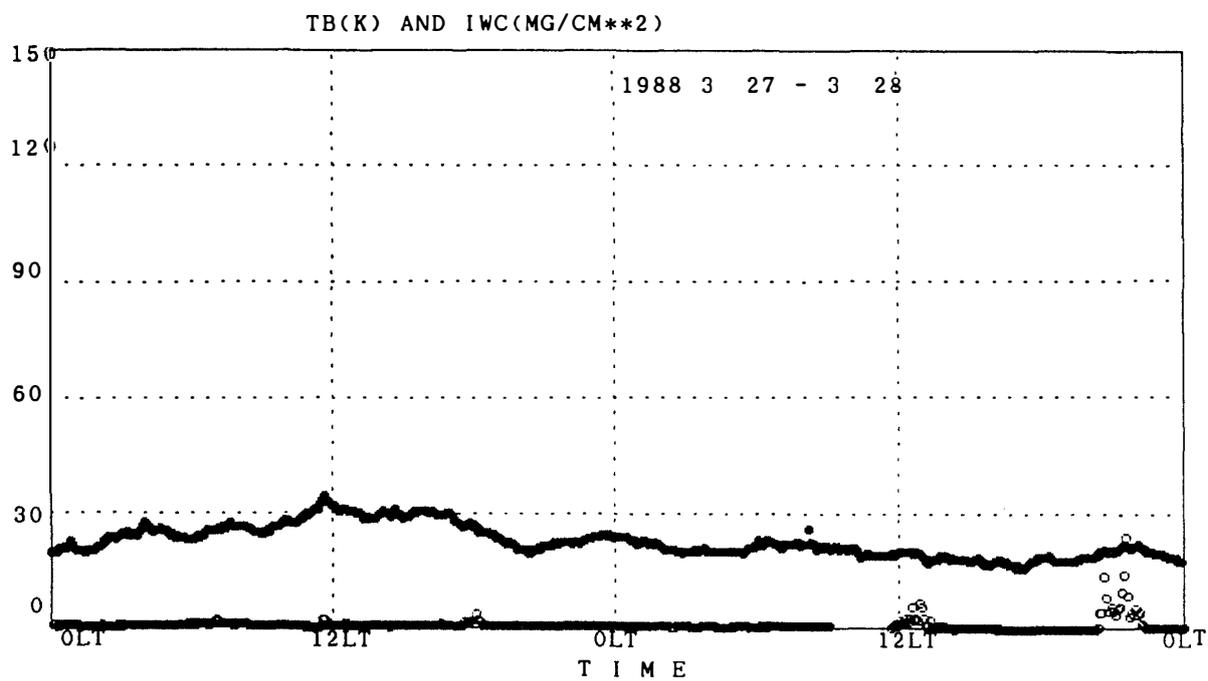
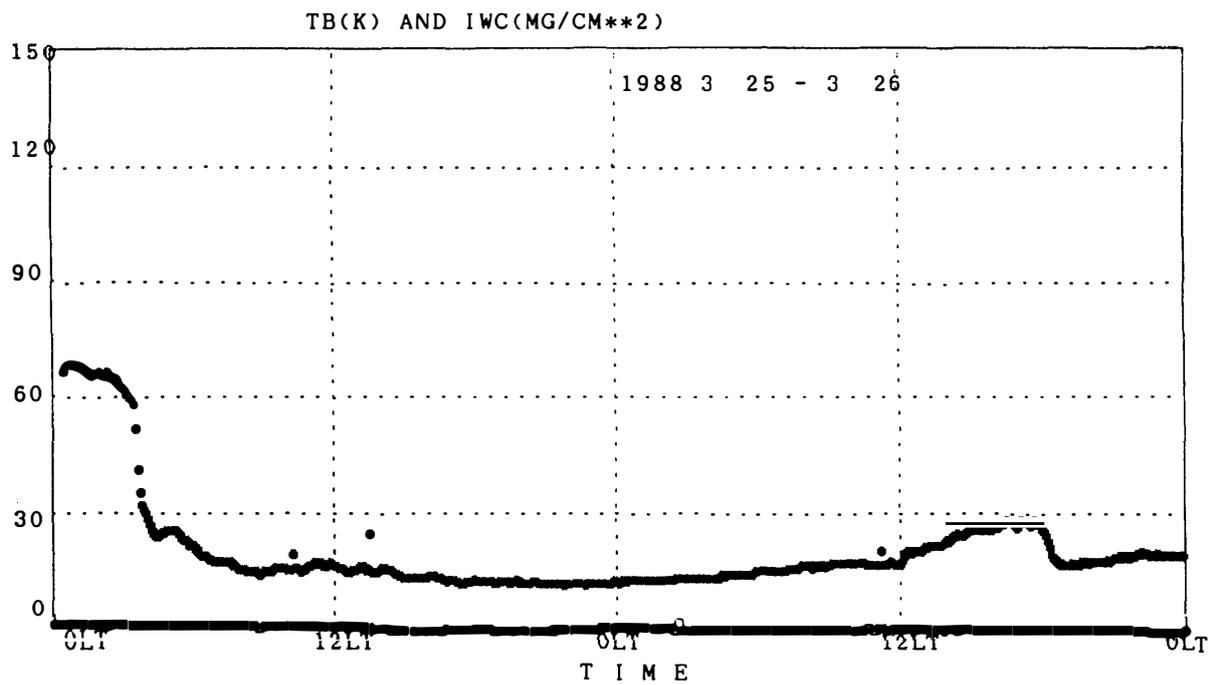


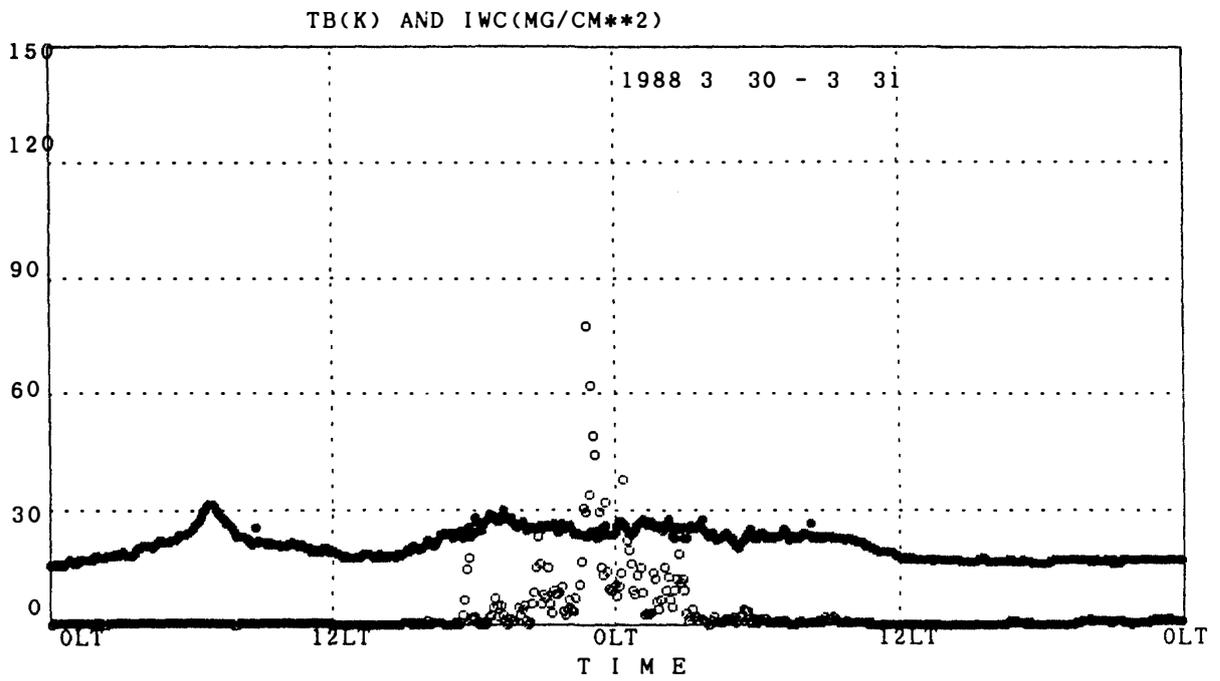
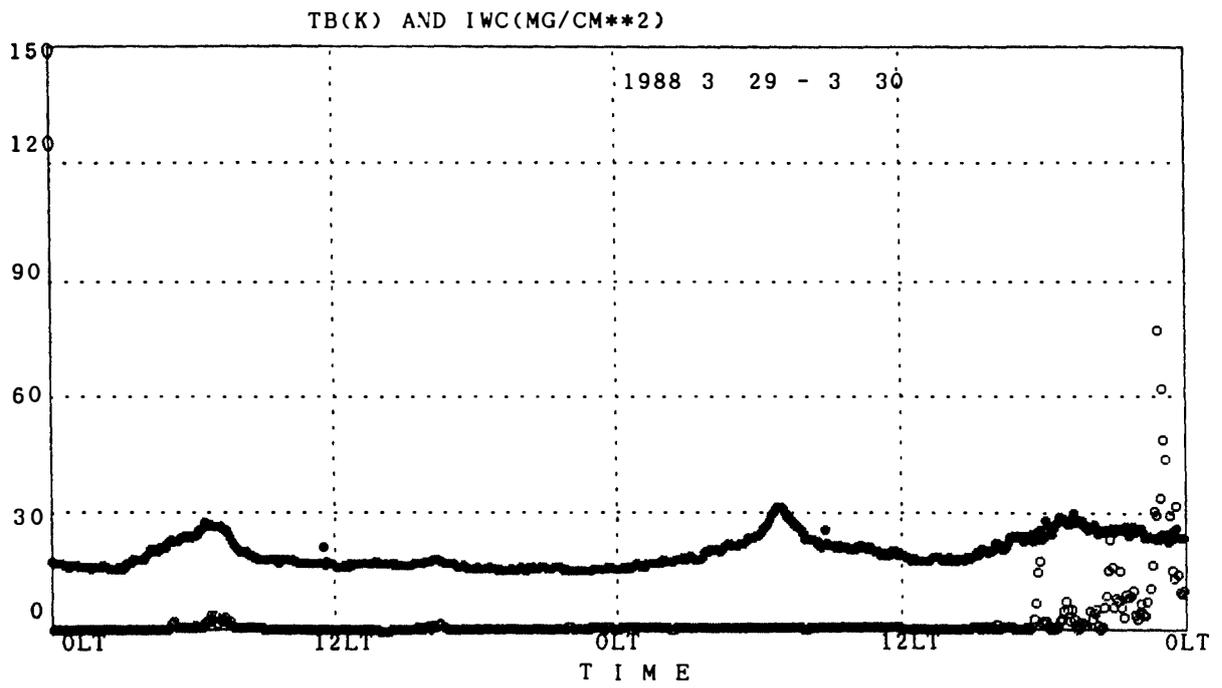


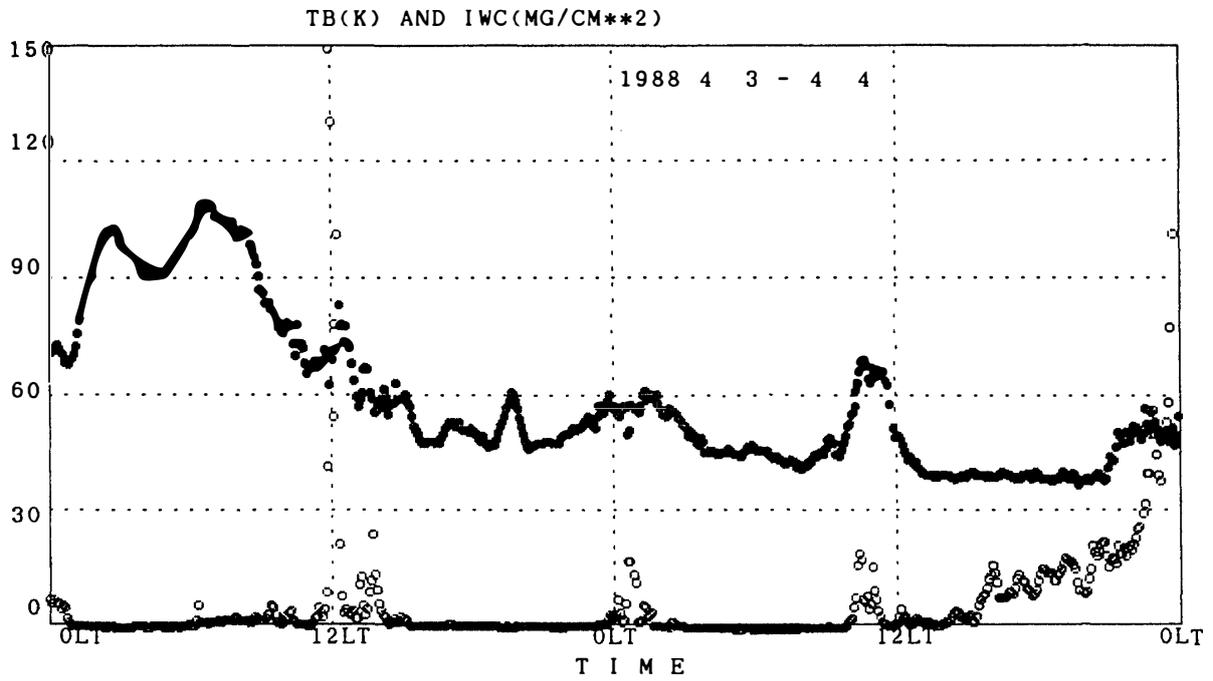
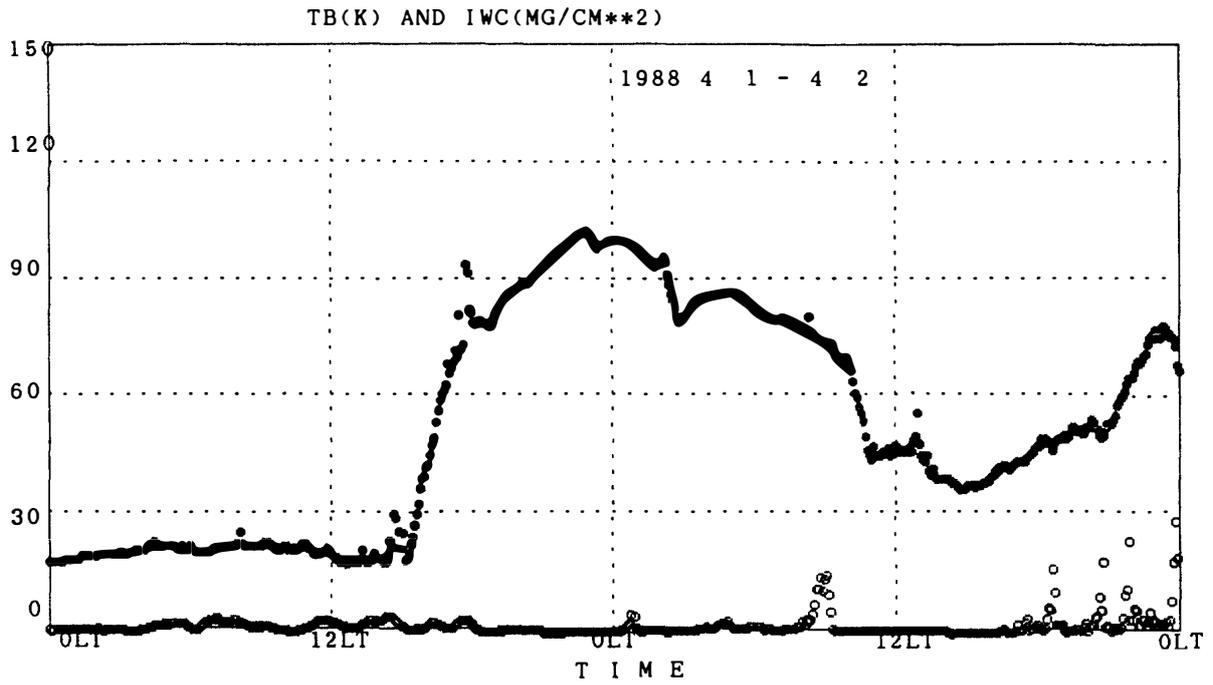


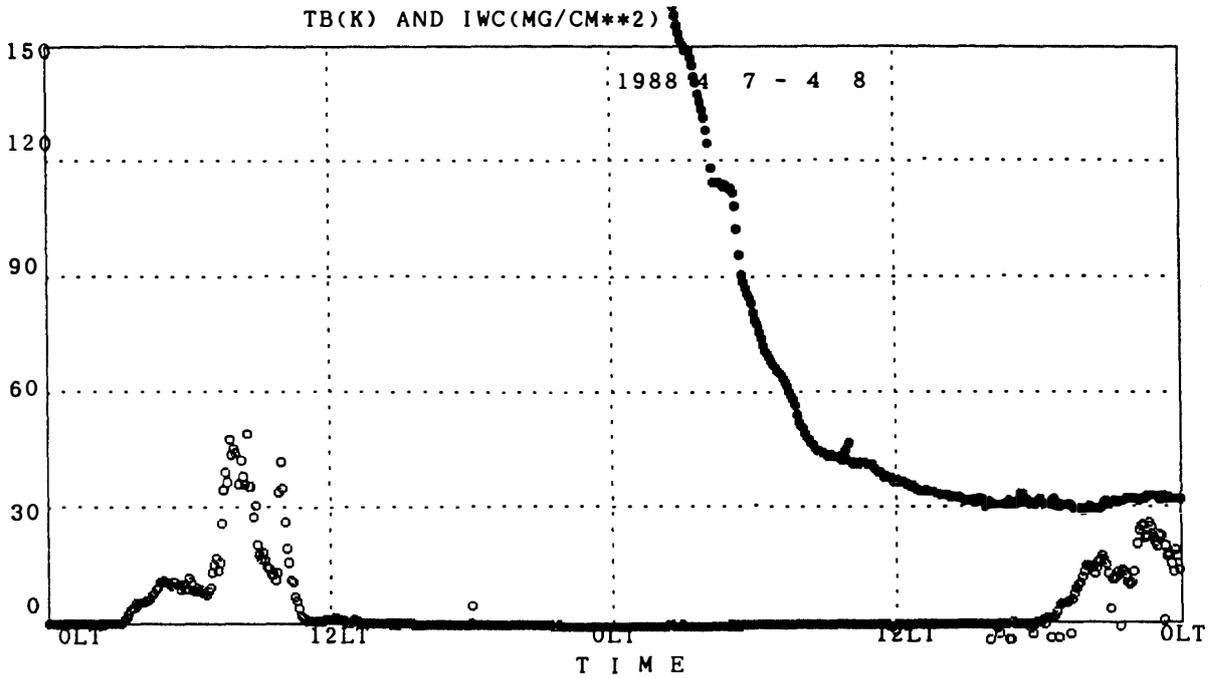
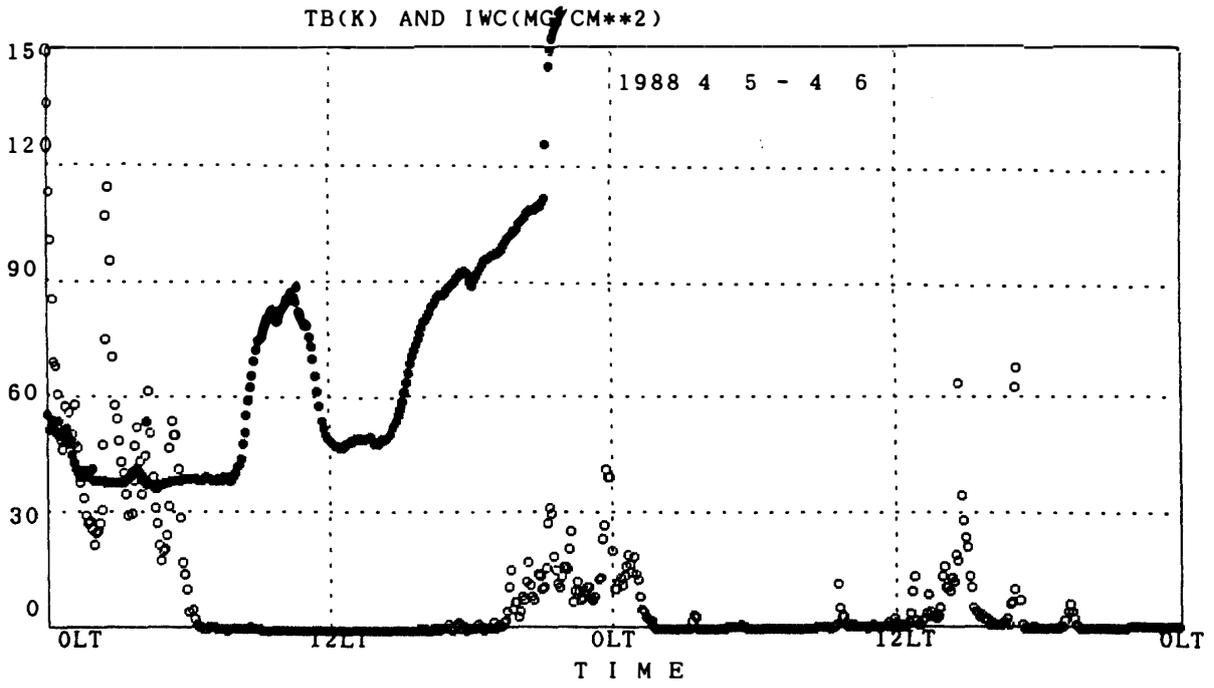


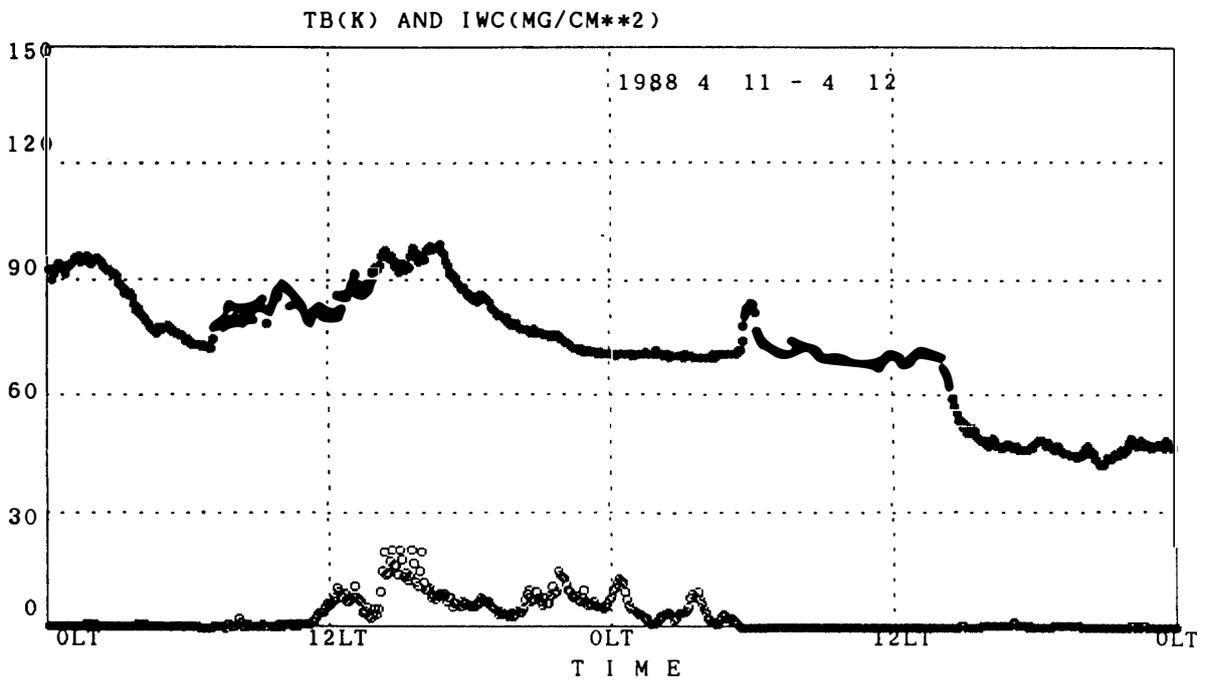
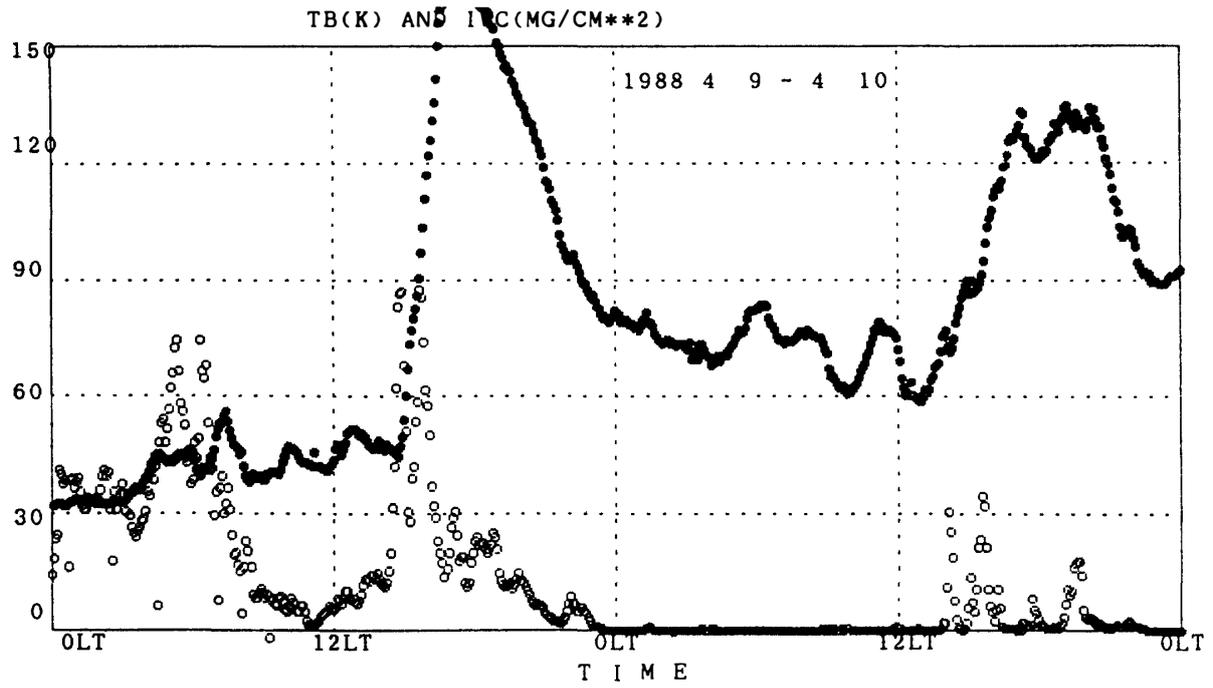


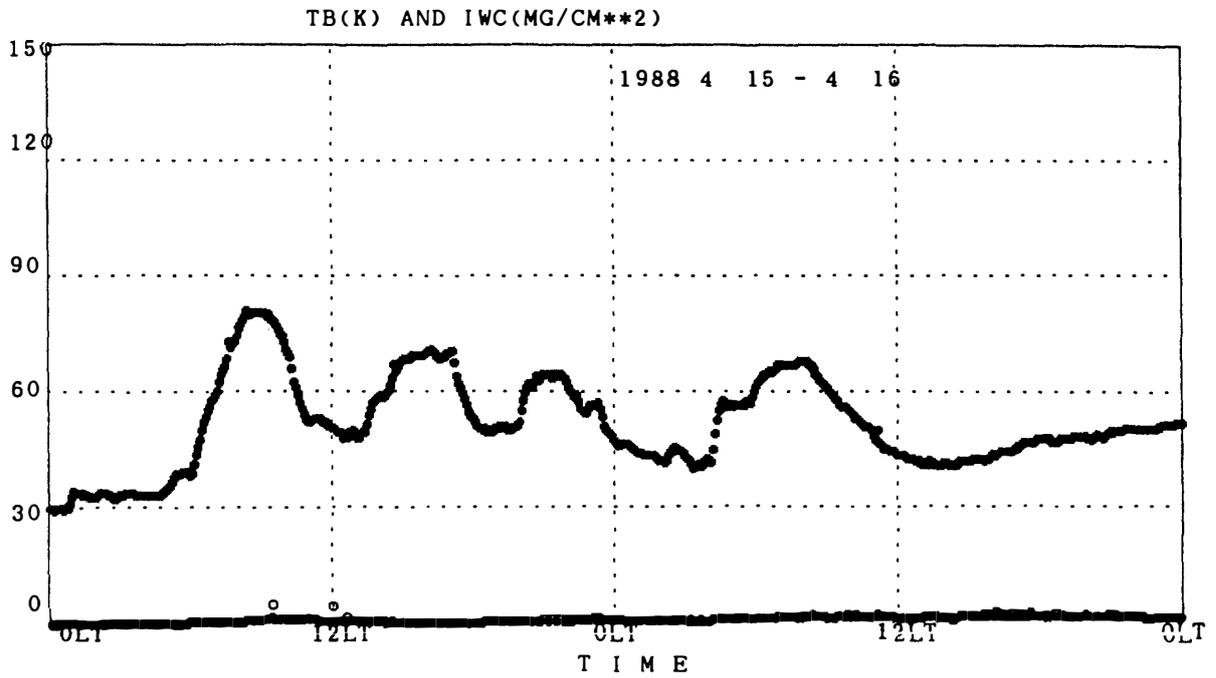
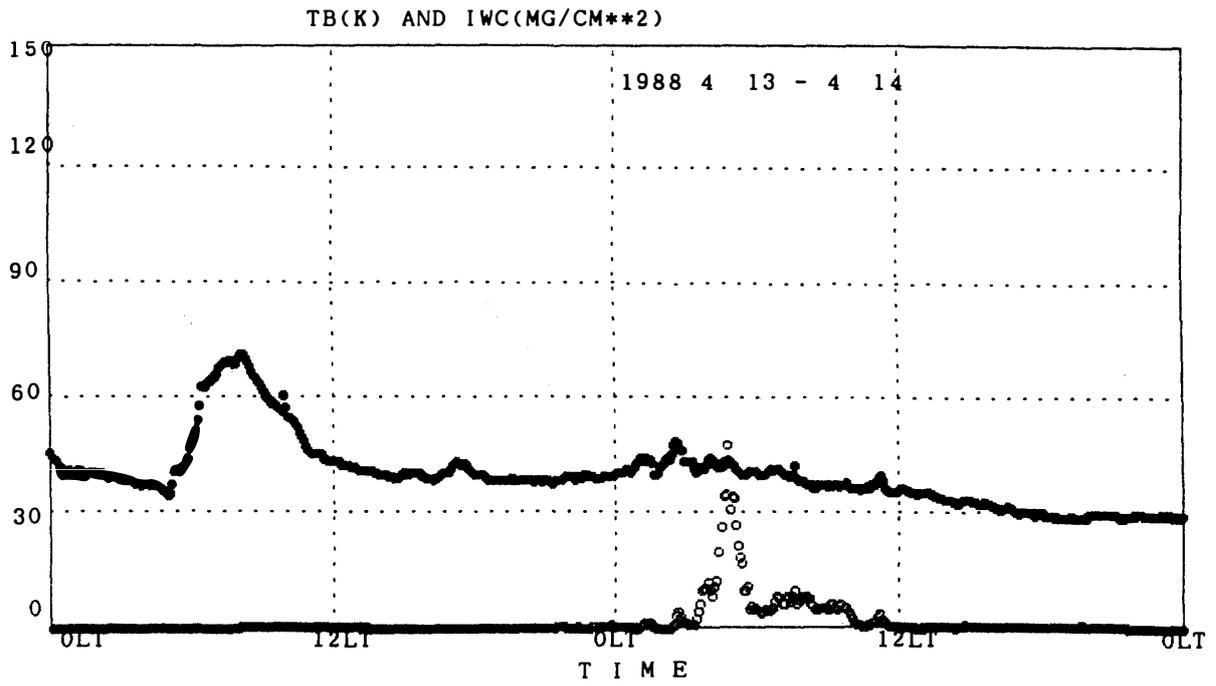


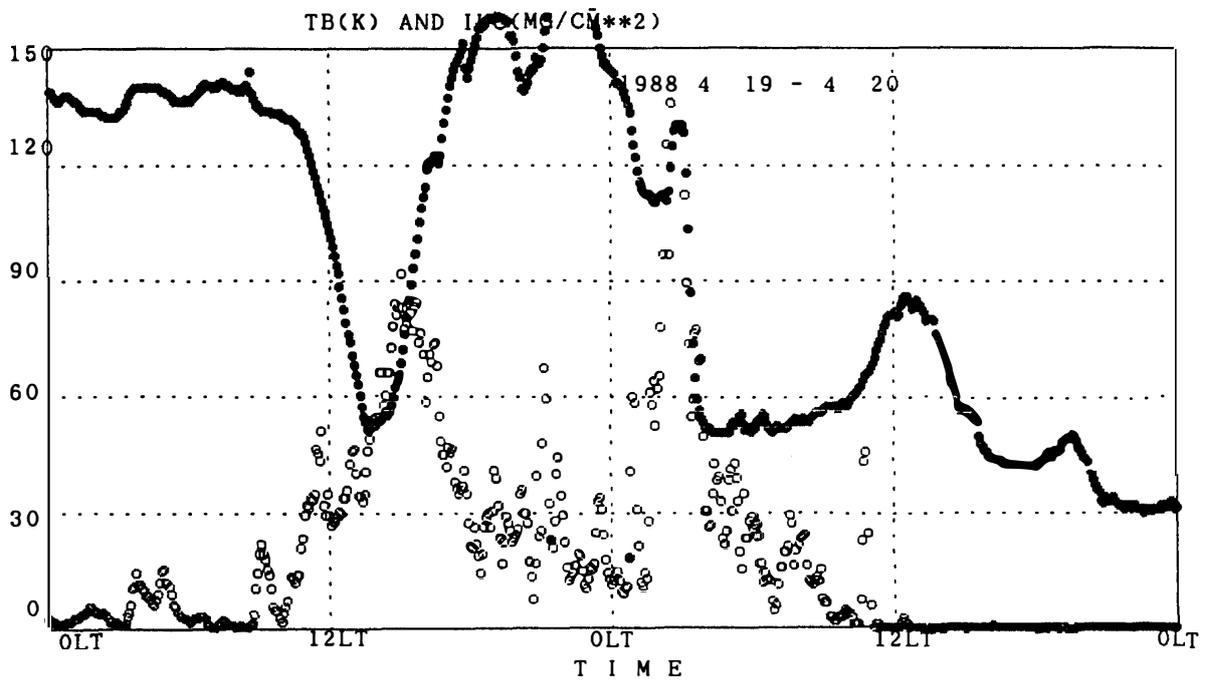
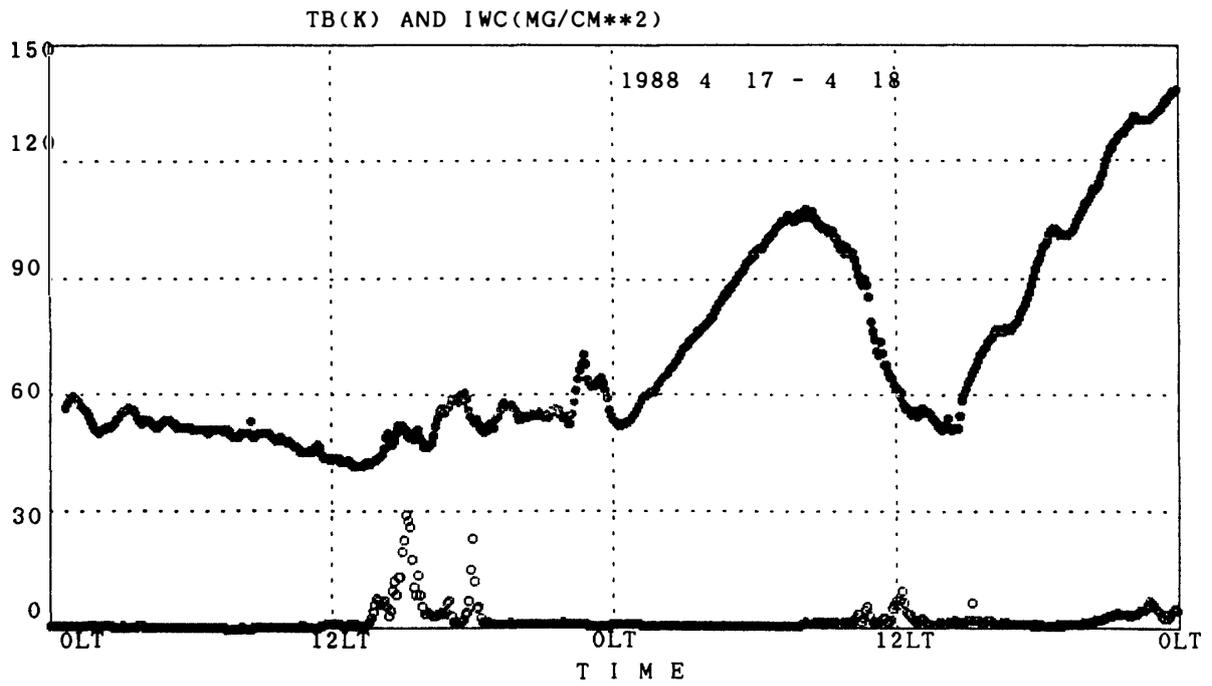


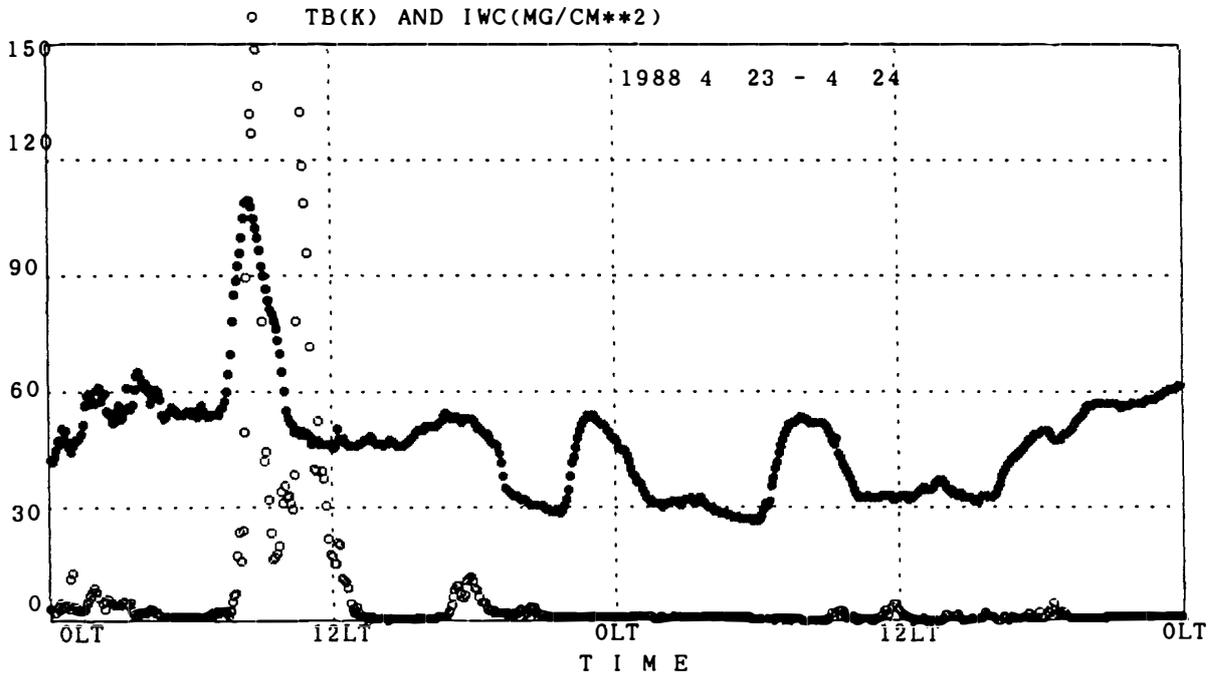
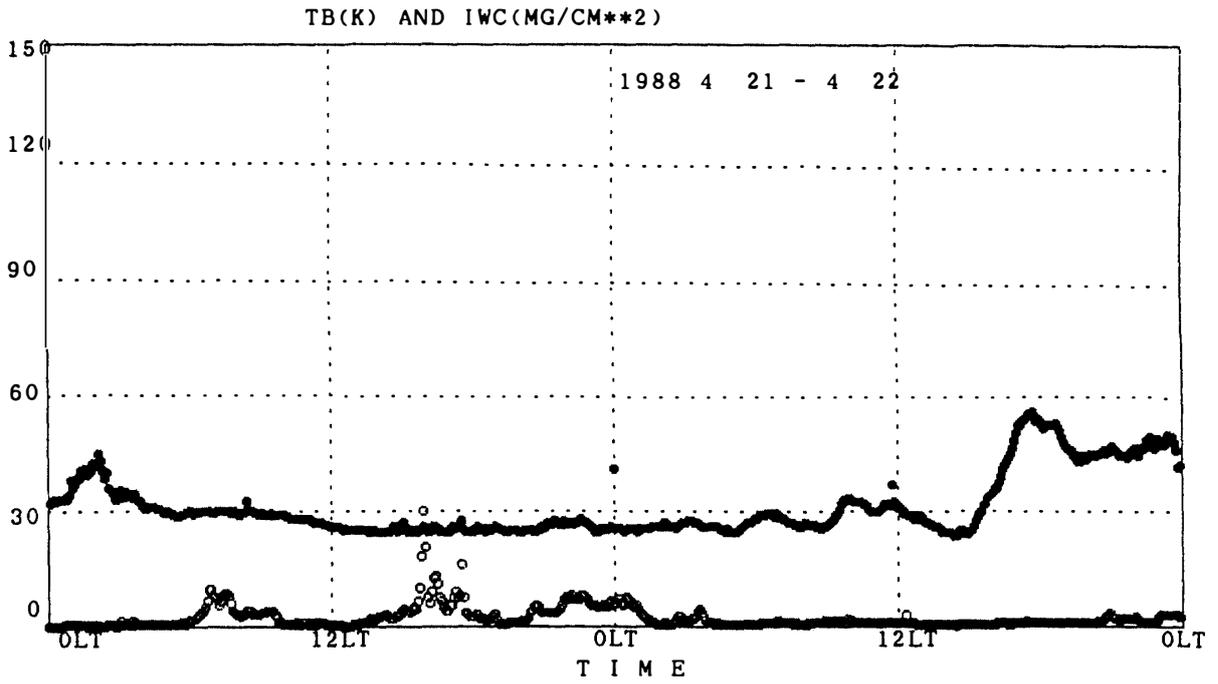


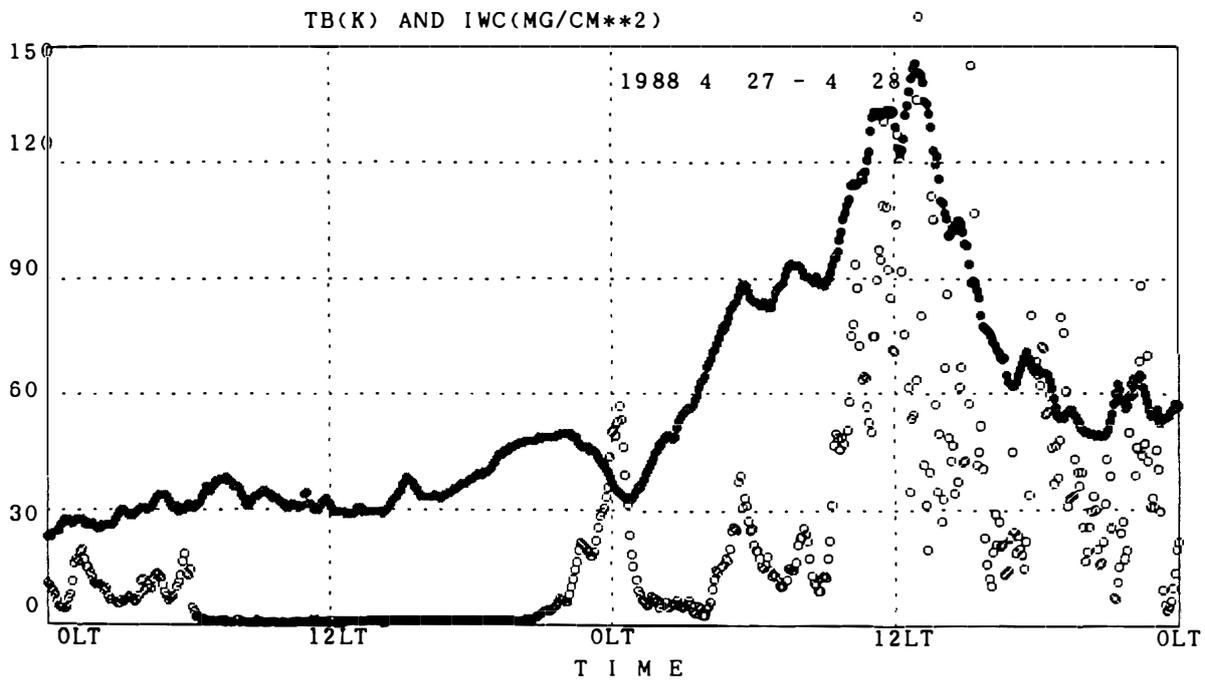
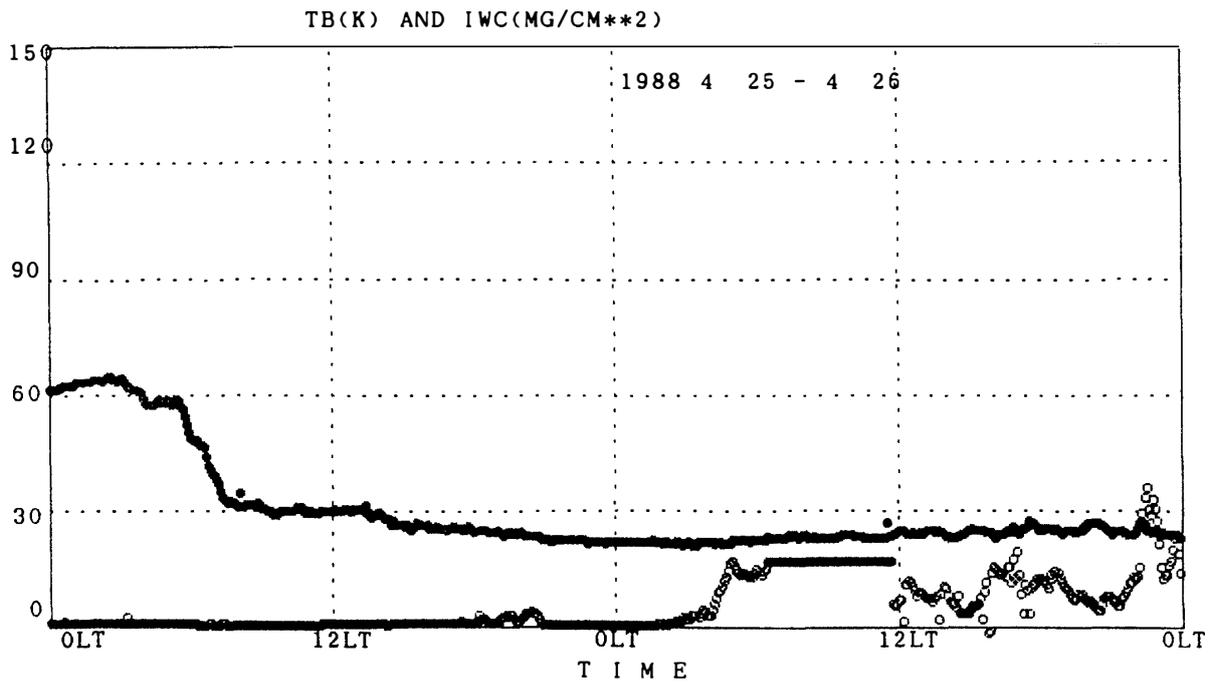












TB(K) AND IWC(MG/CM**2)

