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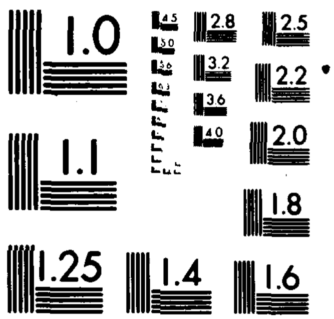

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Behavior of High-Latitude [illegible] During Geomagnetic Disturbances

ZWI HOUMINER
JULES AARONS

24 June

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SPACE PHYSICS DIVISION PROJECT [illegible]
AIR FORCE GEOPHYSICS LABORATORY
HANSCOM AFB, MASSACHUSETTS [illegible]

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Scintillation observations of VHF and UHF transmissions from geostationary satellites at Goose Bay have been used to study the average characteristics of the high latitude irregularity region. The paper describes the average time development and mean diurnal pattern of irregularities during 58 magnetic storms in 1971-1976. The diurnal variation at Goose Bay shows two peaks of scintillation activity. One peak occurs during the afternoon hours, while the second occurs during the night. The average diurnal pattern is independent

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20. Abstract (Continued)

of type of storm. Diurnal and seasonal effects appear only in the first day of storm commencement and not in the following days which show a very similar diurnal picture.

Contents

Illustrations

Illustrations

Table

Behavior of High - Latitude Irregularities During Geomagnetic Disturbances

1. INTRODUCTION

Scintillation observations of VHF and UHF transmissions from geostationary satellites at high-latitude stations can be used to study the average characteristics of the irregularity region during magnetic storms. Houminer et al[1] described the average time development and mean diurnal pattern of irregularities during 12 magnetic storms in 1971–1972, based on observations taken at Goose Bay and Sagamore Hill. This paper will present results of the average behavior of irregularities in the auroral region, using scintillation observations of geostationary satellites at Goose Bay during 58 magnetic storms in 1971–1976.

2. DATA ANALYSIS

The data base used in the present analysis is a continuous series of scintillation measurements taken at Goose Bay (GB) during periods of geomagnetic activity. The GB invariant latitude of the 350 km ionospheric intersection to the satellite is 60°. Table 1 lists the storm commencement periods. The storms were of the

(Received for publication 20 June 1980)

1. Houminer, Z., Aarons, J., and MacKenzie, E. (1980) Plasmapause and auroral oval irregularities during magnetic storms, URSI-IEEE Symposium, June 2–6, 1980, Quebec.

Table 1. Storm Periods

Number	Date	S.C. Time (U.T.)	Station Name	Max. Value of K_p	Max. Value of A_p
1	17 December 1971	SSC = 14:18	FRED	6	67
2	21 January 1972	SSC = 11:51	FRED	5	32
3	24 February 1972	SSC = 06:42	SJUA	5	33
4	6 March 1972	SSC = 21:08	SJUA	7	45
5	29 April 1972	GSC = 03:--	FRED	6	42
6	15 May 1972	SSC = 18:49	FRED	6	38
7	17 June 1972	SSC = 13:12	FRED	8	126
8	24 July 1972	GSC = 19:--	FRED	6	33
9	4 August 1972	SSC = 01:19	FRED	9	182
10	8 August 1972	SSC = 23:54	FRED	6	74
11	13 September 1972	SSC = 12:40	FRED	8	54
12	18 October 1972	SSC = 17:46	FRED	5	34
13	31 October 1972	SSC = 16:58	FRED	7	98
14	15 November 1972	GSC = 09:--	NEWP	5	31
15	12 December 1972	SSC = 21:45	BOUL	5	30
16	27 January 1973	GSC = 04:--	FRED	5	33
17	21 February 1973	GSC = 16:--	BOUL	6	54
18	1 March 1973	GSC = 15:--	TUCS	5	40
19	18 March 1973	GSC = 12:--	FRED	6	82
20	31 March 1973	GSC = 13:--	BOUL	6	91
21	13 April 1973	SSC = 04:34	FRED	6	57
22	26 April 1973	GSC = 12:--	FRED	5	59
23	13 May 1973	GSC = 17:--	FRED	7	80
24	21 May 1973	SSC = 02:54	FRED	6	46
25	10 June 1973	GSC = 15:--	FRED	5	34
26	17 June 1973	GSC = 19:--	FRED	5	38
27	28 June 1973	GSC = 21:--	FRED	5	41
28	14 July 1973	GSC = 15:--	FRED	5	32
29	26 July 1973	GSC = 03:--	FRED	5	36
30	23 August 1973	GSC = 12:--	FRED	6	46
31	9 September 1973	GSC = 08:--	TUCS	5	44
32	22 September 1973	GSC = 21:--	FRED	6	63
33	2 October 1973	GSC = 05:--	FRED	6	48
34	16 October 1973	SSC = 05:20	TUCS	5	30
35	21 October 1973	GSC = 01:--	FRED	5	37
36	28 October 1973	GSC = 07:--	FRED	6	86
37	24 November 1973	GSC = 13:--	FRED	6	42

SSC (Sudden Storm Commencements) and GSC (Gradual Storm Commencements) types, and were chosen according to the criteria of Mendillo.[2]

For each storm, five days of scintillation data (a day before storm commencement, the day of the storm, and three days after) were used to determine the average storm pattern. The data consisted of 15-minute scintillation indices reduced by the method of Whitney et al.[3] Examples of the five-day scintillation data are shown in Figures 1 and 2.

For each storm, the Storm Enhancement Factor (S) was calculated to eliminate the quiet day diurnal pattern. This factor S:

$$S = F(t) - \overline{F}$$

where F(t) is the observed scintillation index (SI) in dB for the 5-day period, and $\overline{F}$ is the average scintillation index in dB determined for magnetically quiet days. $\overline{F}$ is determined as shown in Aarons et al[4] and varies with local time, season and solar flux for each station.

This average storm enhancement factor was then analyzed using two different time approaches. The first involves construction of average storm time (Dst). This represents the storm induced variations calculated at hourly intervals from the time of commencement of each storm. The second method is the average local time behavior SD(t). In this method, the first day of a storm is defined to be the remaining portion of the day after the Sudden Commencement. Following this definition of the first day, each hourly value is set into its correct local time for the averaging process. (Mendillo and Klobuchar,[5] Mendillo[2])

It should be noted that scintillations are rather low for Goose Bay during quiet magnetic conditions. The mean scintillation index ($\overline{F}$) is zero for 75 percent of the time, and is greater than 4 dB for 3 percent of the time. It does not exceed 5 dB.

3. SCINTILLATION STORM PATTERNS

The average local time storm pattern SD(t) for 58 storms during 1971–1976 is shown in Figure 3. It can be seen that the diurnal pattern of scintillation at Goose Bay shows two peaks of scintillation activity. One peak occurs during the afternoon at about 17-18 hours local time, especially on the days following the storm

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2. Mendillo, M. (1978) Behavior of the Ionospheric F-Region During Geomagnetic Storms, AFGL-TR-78-0092 (II), AD A056 978.

3. Whitney, H. E., Aarons, J., and Malik, C. (1969) A proposed index for measuring ionospheric scintillations, Planet. Space Sci. 17:1069.

4. Aarons, J., MacKenzie, E., and Bhavnani, K. (1980) High-latitude analytical formulas for scintillation levels, Radio Sci. 15:115.

5. Mendillo, M. and Klobuchar, J.A. (1974) An Atlas of the Mid-Latitude F-Region Response to Geomagnetic Storms, AFCRL-TR-74-0065, AD 778 069.

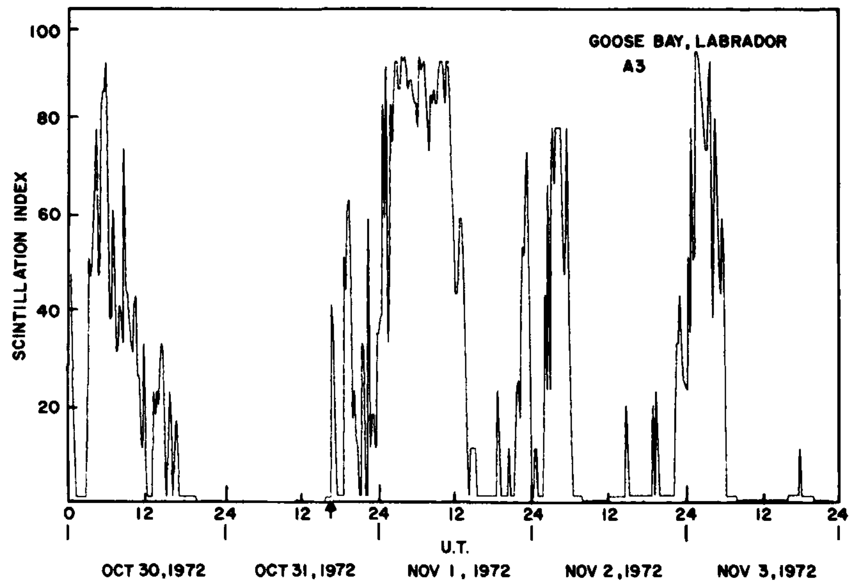

Figure 1. 15-Minute Scintillation Indices for ATS-3 Signal Recorded at Goose Bay During October 30–November 3, 1972. The geomagnetic storm commencement is indicated with an arrow.

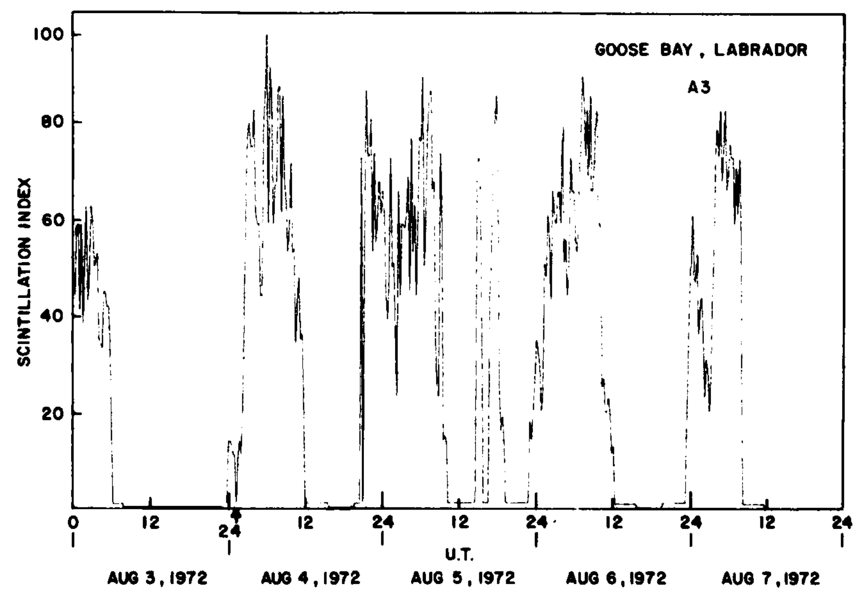

Figure 2. 15-Minute Scintillation Indices for ATS-3 Signal Recorded at Goose Bay During August 3–7, 1972. The storm commencement is indicated with an arrow.

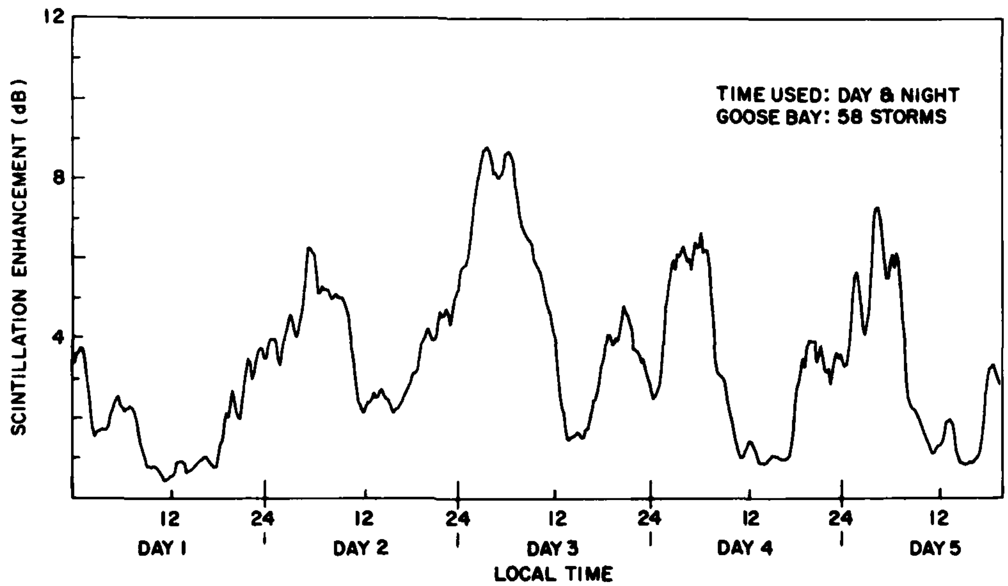

Figure 3. Average Diurnal Variation Pattern SD(t) for 58 Magnetic Storms During 1971–1976

commencement. The second peak occurs during the night and is centered at about local midnight.

Figure 4 shows SD(t) for 26 sudden commencement storms (type 1) while Figure 5 gives SD(t) for 32 gradual commencement storms (type 2). Figures 4 and 5 show large similarity in the diurnal pattern with two peaks in scintillation activity. Thus, the diurnal pattern does not depend on the type of storm.

Next, the storms were grouped according to the time of storm commencement. Figure 6 gives SD(t) for storms which commenced during the day, while Figure 7 gives SD(t) for nighttime storm commencement. Comparison of Figure 6 to Figure 7 shows a large difference in the diurnal pattern at the day of the storm commencement. However, the diurnal pattern during the following days is very similar for day or nighttime storms.

The seasonal effect on SD(t) is shown in Figures 8 to 11, where storms were grouped according to season. Again, there are some differences in the diurnal pattern at the day of storm commencement. However, for the following days, the diurnal pattern is very similar, showing the double hump characteristics.

The average storm commencement time pattern Dst(t) for 58 storms in 1971–1976 is shown in Figure 12. The Dst(t) pattern shows an immediate response to the storm commencement. However, this increase is small in comparison to the scintillation increase during the main phase of the storm. The Dst(t) patterns for

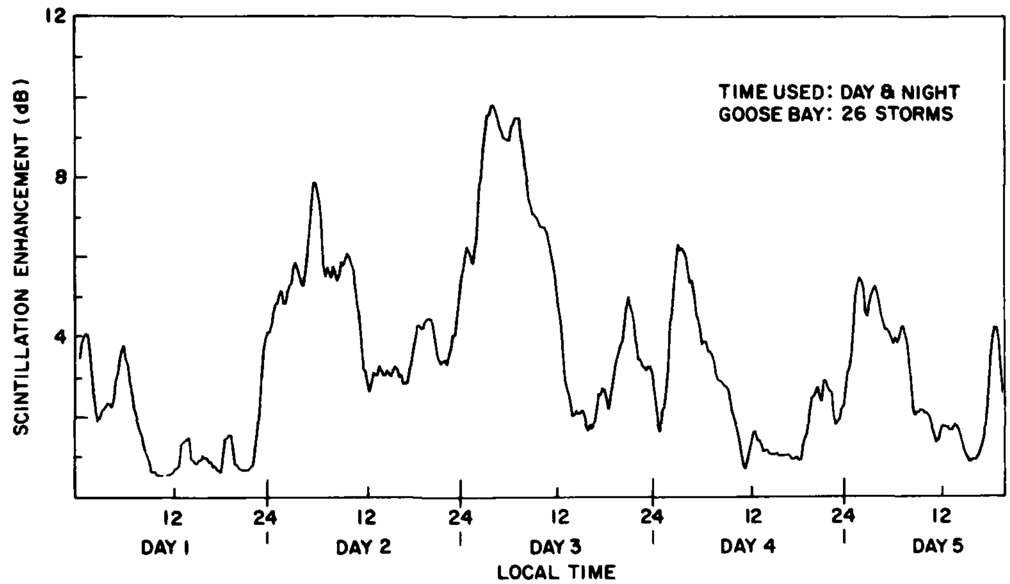

Figure 4. Average Diurnal Variation Pattern SD(t) for 26 Sudden Commencement Storms During 1971–1976

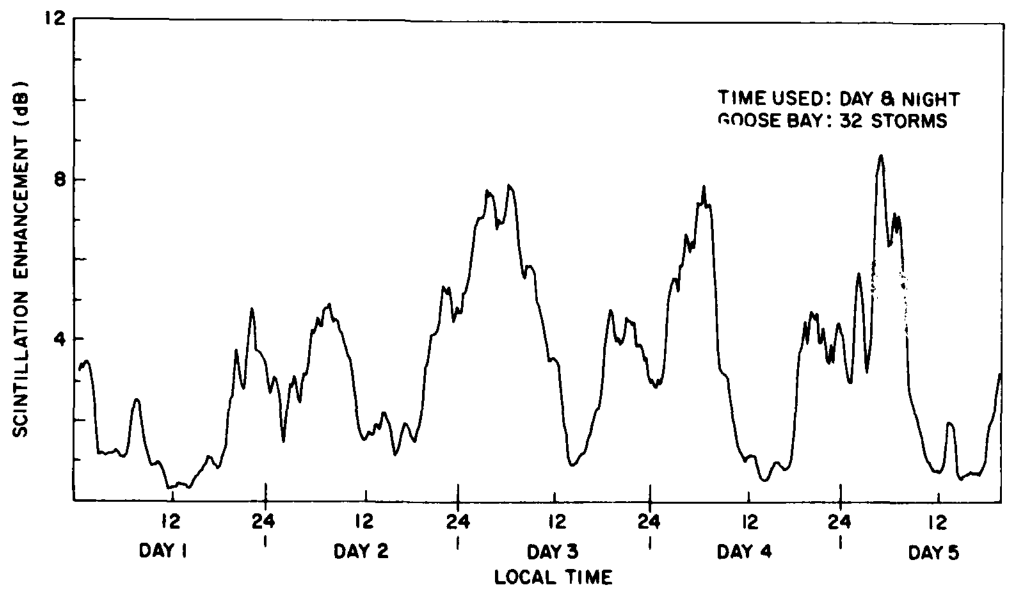

Figure 5. Average Diurnal Variation Pattern SD(t) for 32 Gradual Commencement Storms During 1971–1976

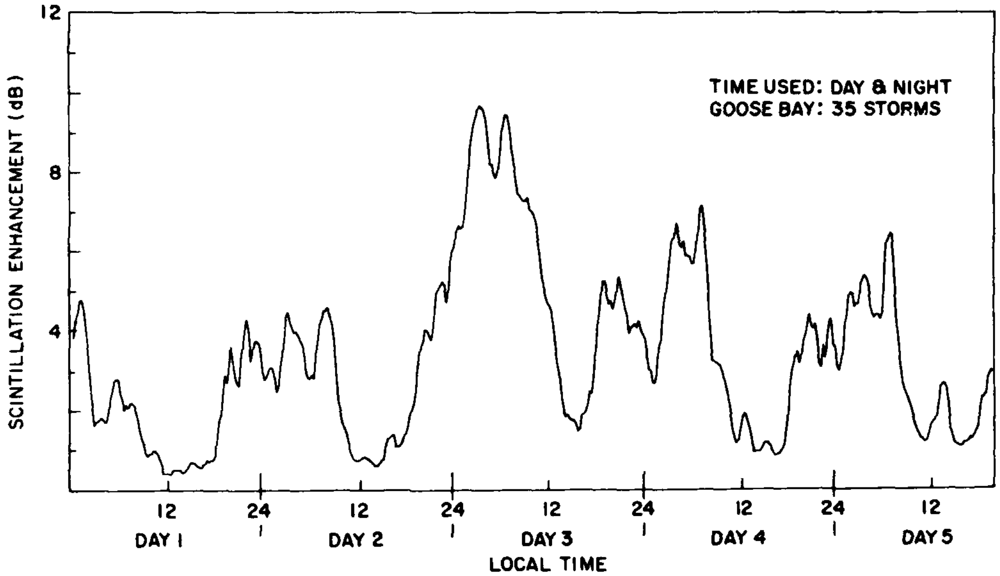

Figure 6. Average Diurnal Variation Pattern SD(t) for 35 Storms Which Started During Daytime

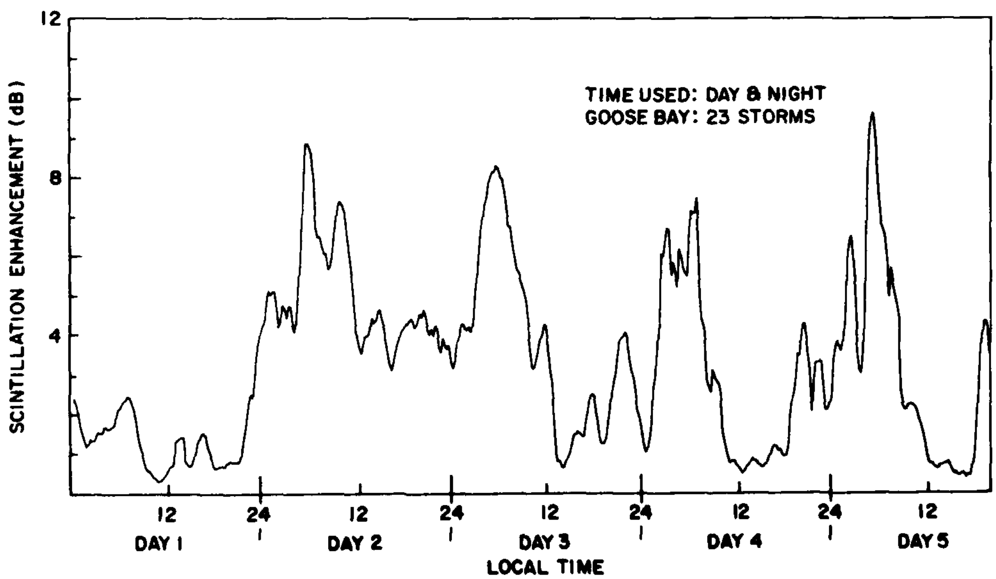

Figure 7. Average Diurnal Variation Pattern SD(t) for 23 Storms Which Started During Nighttime

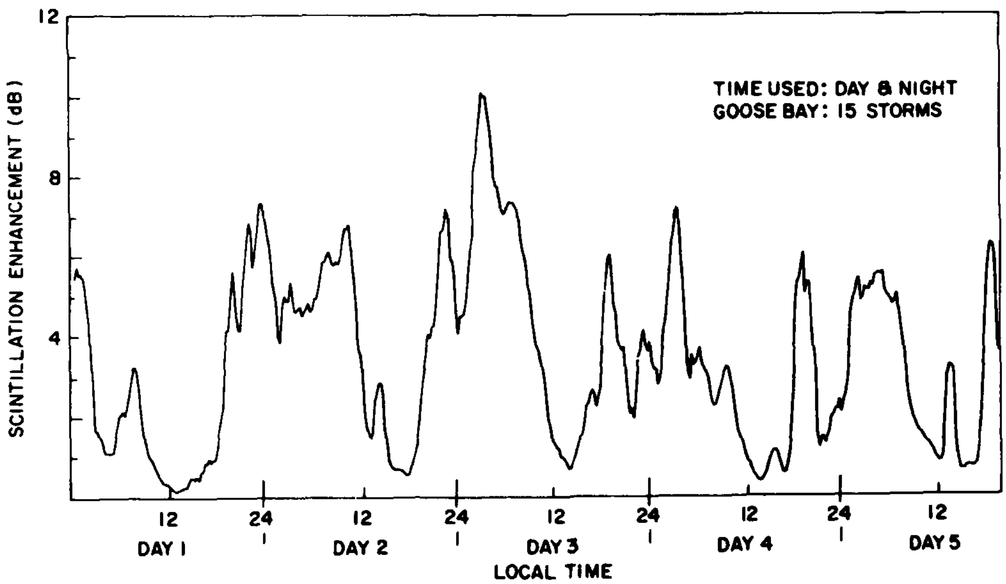

Figure 8. Average Diurnal Variation Pattern SD(t) for 15 Storms Occurring in Spring

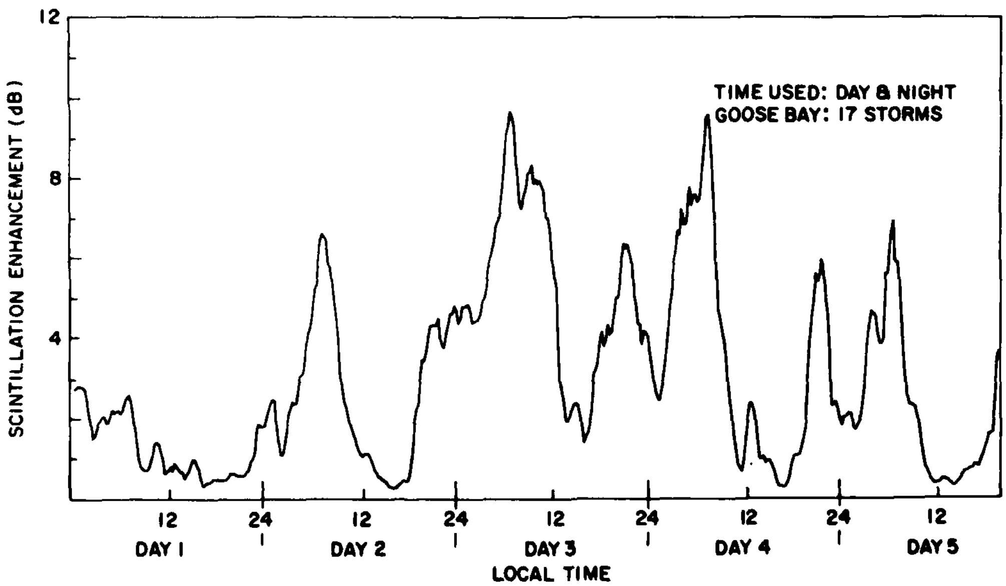

Figure 9. Average Diurnal Variation Pattern SD(t) for 17 Storms Occurring in Summer

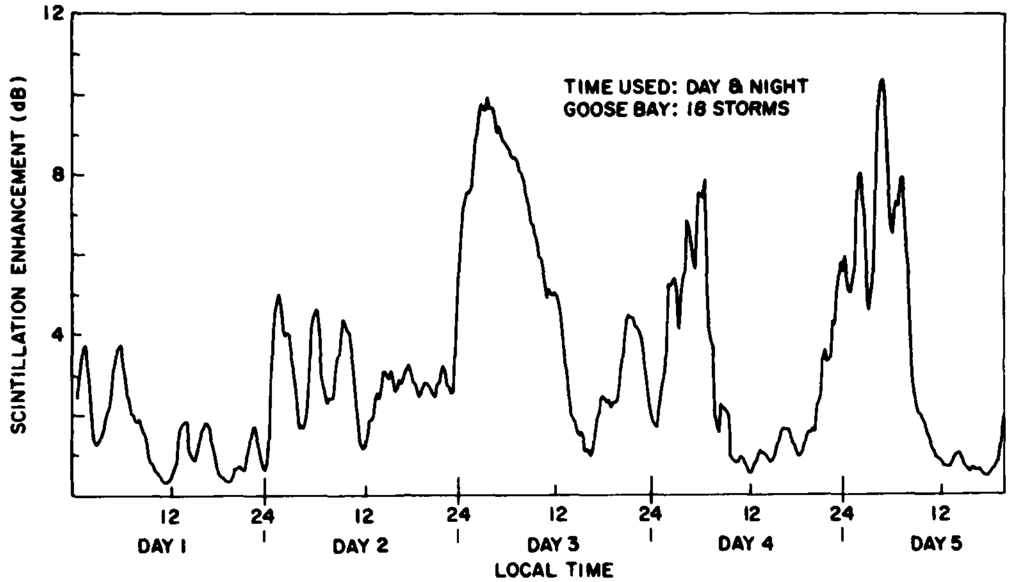

Figure 10. Average Diurnal Variation Pattern SD(t) for 18 Storms Occurring in Autumn

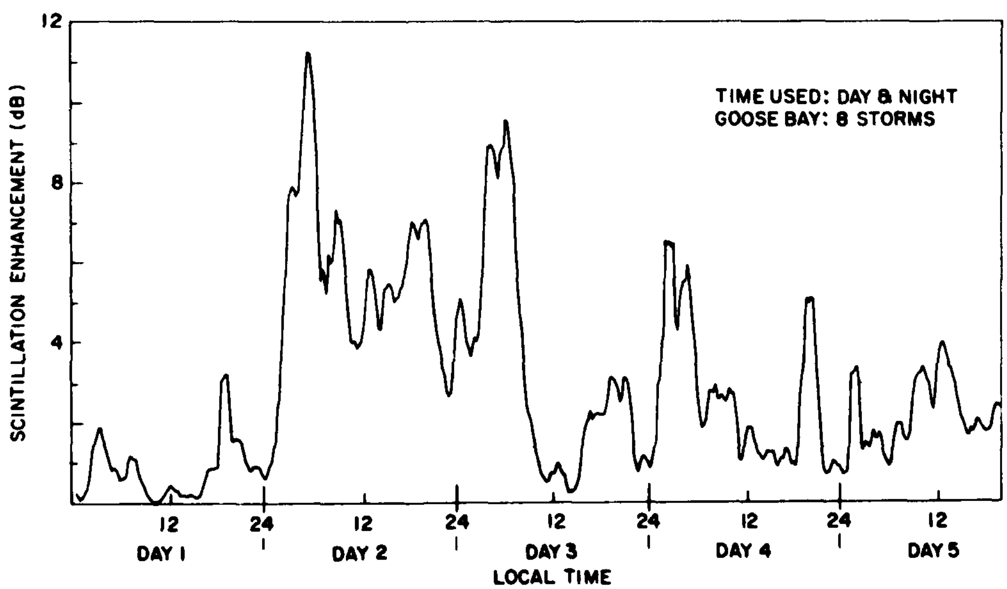

Figure 11. Average Diurnal Variation Pattern SD(t) for Eight Storms Occurring in Winter

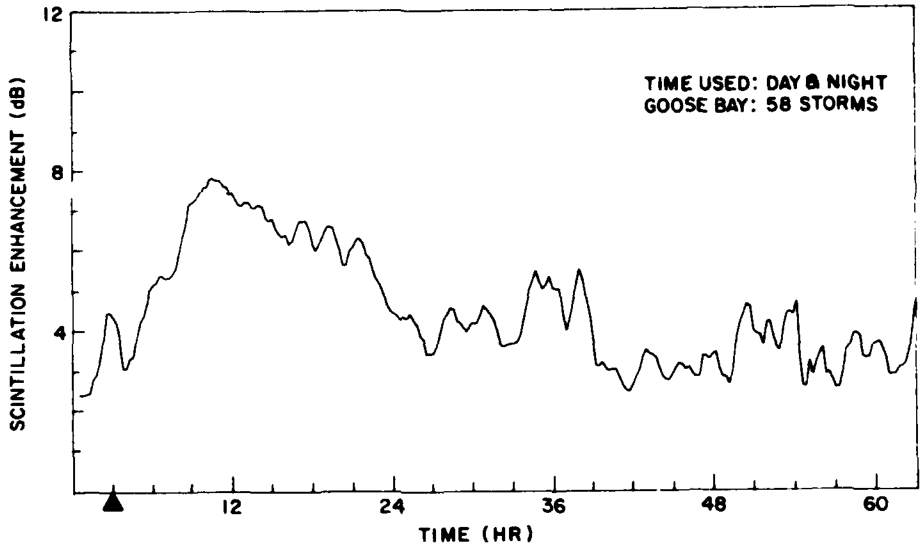

Figure 12. Average Storm Commencement Time Pattern Dst(t) for 58 Magnetic Storms in 1971–1976

types 1 and 2 storms are shown in Figures 13 and 14. The patterns indicate that the immediate increase in scintillation occurs only for type 1 storms, that is, sudden storm commencement. Figures 15 and 16, which give Dst(t) for day and nighttime storms, indicate that the sudden scintillation response is a nighttime phenomena.

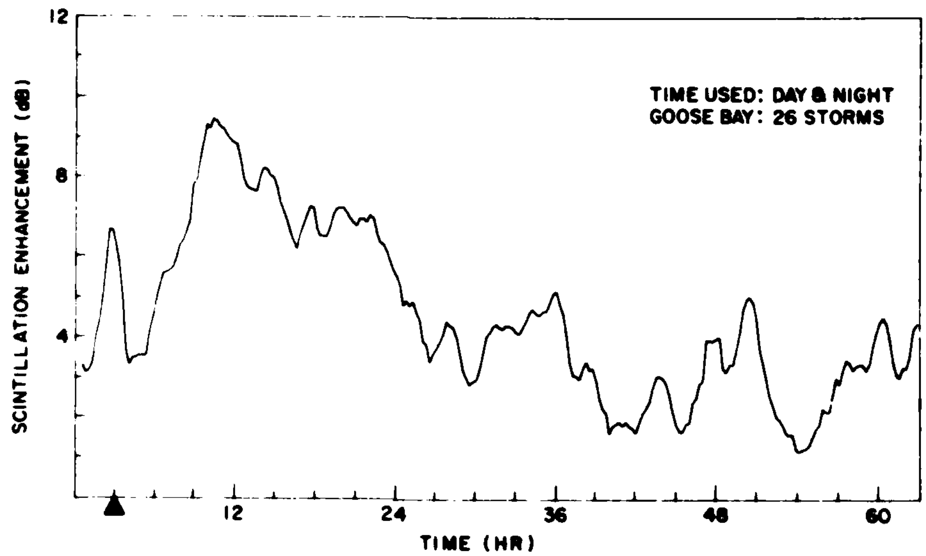

Figure 13. Average Storm Commencement Time Pattern Dst(t) for 26 SSC storms in 1971–1976

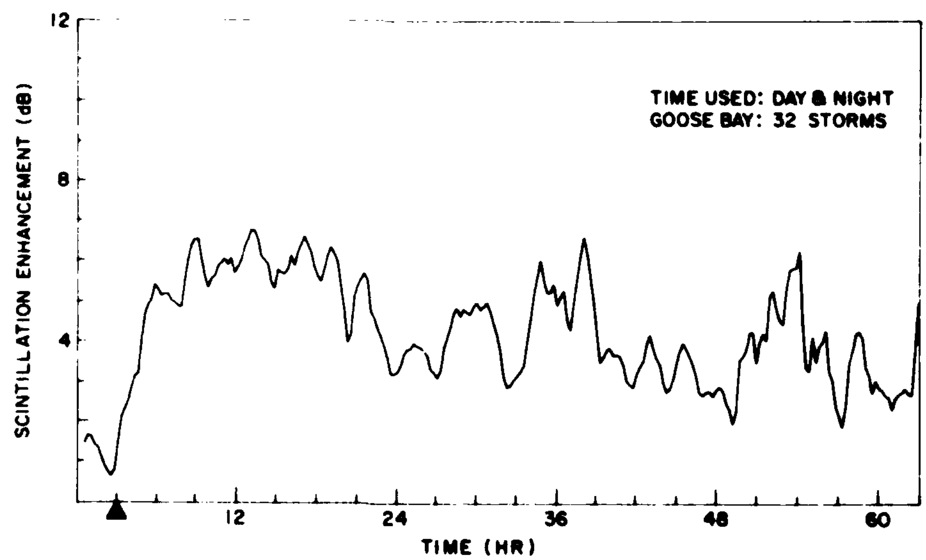

Figure 14. Average Storm Commencement Time Pattern Dst(t) for 32 GSC Storms in 1971–1976

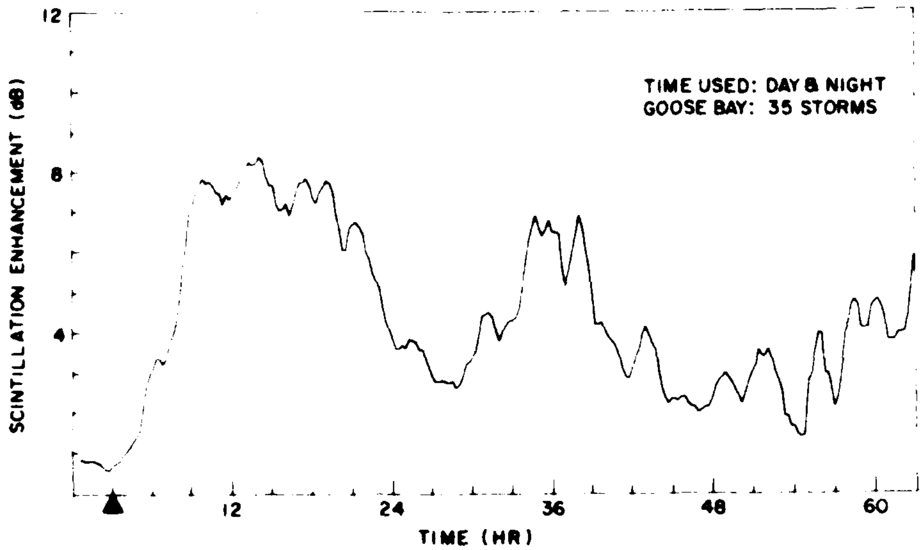

Figure 15. Average Storm Commencement Time Pattern Dst(t) for 35 Daytime Storms

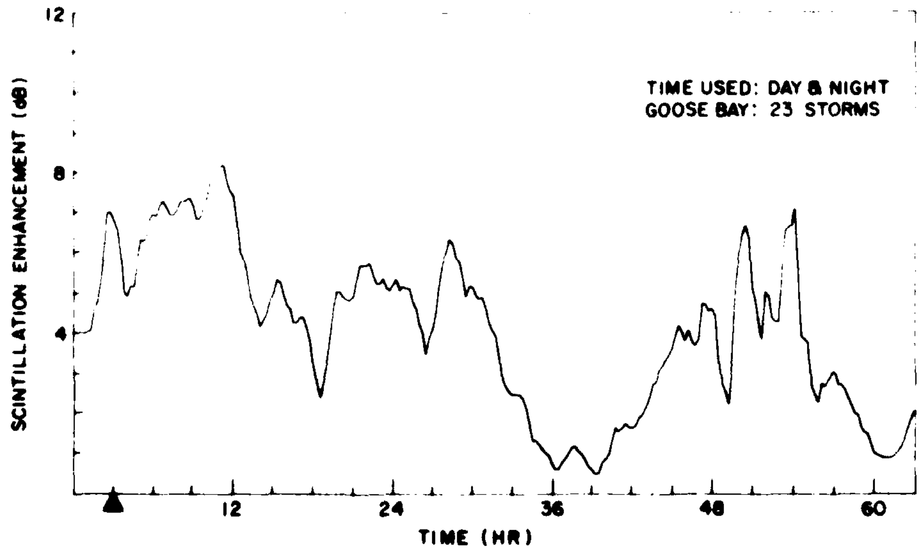

Figure 16. Average Storm Commencement Time Pattern Dst(t) for 23 Nighttime Storms

4. CONCLUSION

Scintillation observations of VHF and UHF transmissions from geostationary satellites at Goose Bay show a two-peak diurnal behavior of scintillation during magnetic storms. One peak occurs during the afternoon hours, while the second occurs during the night. Houminer et al[1] have shown that the afternoon scintillations at Goose Bay occur when the southern wall of the electron density trough, or the plasmapause, passes through the line of sight to the satellite. The nighttime scintillation is associated with auroral oval electron density irregularities.

Figure 17 shows the average behavior of the H component of the magnetic field during eight magnetic storms in 1972. The magnetic data were recorded in St. John's, which is roughly at the same longitude and latitude as the subionospheric point to the satellite from Goose Bay.

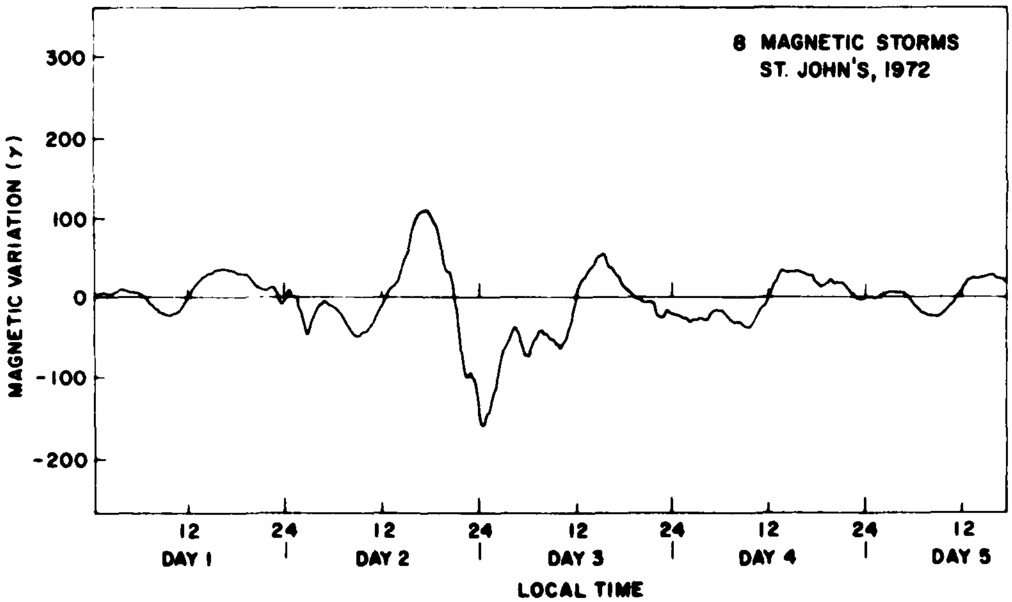

Figure 17. The Average Diurnal Pattern of the H Component of the Magnetic Field, Recorded at St. John's, for Eight Magnetic Storms in 1972

The average H behavior shows a positive increase in H during the afternoon hours, and a negative excursion at local midnight. The similarity in time indicates that the afternoon increase is correlated with the plasmapause scintillation, while the midnight peak is correlated with the auroral irregularities.

The results presented here show that the average diurnal pattern of scintillation is not dependent on type of storm. The commencement time of the storm affects the diurnal behavior during the first day; however, the following days show a very similar diurnal picture. Seasonal effects also appear in the first day of storm commencement and not in the following days.

The immediate response of scintillation enhancement to storm commencement seems to occur only for sudden commencement storms, and only for storms with SSC at night.

References

1. Houminer, Z., Aarons, J., and MacKenzie, E. (1980) Plasmapause and auroral oval irregularities during magnetic storms, URSI-IEEE Symposium, June 2–6, 1980, Quebec.
2. Mendillo, M. (1978) Behavior of the Ionospheric F-Region During Geomagnetic Storms, AFGL-TR-78-0092 (II), AD A056 978.
3. Whitney, H.E., Aarons, J., and Malik, C. (1969) A proposed index for measuring ionospheric scintillations, Planet. Space Sci. 17:1069.
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5. Mendillo, M. and Klobuchar, J.A. (1974) An Atlas of the Mid-Latitude F-Region Response to Geomagnetic Storms, AFCRL-TR-74-0065, AD 778 069.

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