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UNIQUENESS AND NONUNIQUENESS OF THE FEBRUARY 1986 MAGNETIC STORM

Y. Kamide

Kyoto Sangyo University, Kamigamo Kita-ku, Kyoto 603, Japan

Abstract

This writeup outlines the characteristics of the February 7–9, 1986, magnetic storm, with special emphasis on its unique nature in terms of global magnetic activity. It lists several problems that we might be able to solve on the basis of a systematic gathering of data sets for this intense magnetic storm.

1. Introduction

The current solar cycle, cycle 22, began in 1986 when a minimum in solar activity was recognized. It is expected that the next solar maximum will occur sometime in the second half of 1990 or the first half of 1991 (Wilson, 1988). One interesting fact is that the 11–year solar cycle is asymmetric: it increases to a maximum more quickly than it declines to a minimum. Moreover, the shorter the rise time, the more intense the solar activity is. Available records indicate that the rate of increase for cycle 22 is much faster than for previous cycles, implying that a number of intense magnetic storms may occur during the present cycle.

The magnetic storm of February 7–9, 1986 was the last burst of activity caused by a sequence of solar flares that occurred daily from February 3 to 7. Some of the largest flares occurred at the following times: 2049 UT on February 3; 0740 UT on February 4; 1255 UT on February 5; 0625 UT on February 6; and 1034 UT on February 7. This magnetic storm was one of the largest in 40 years. It should be noted that this flare series and the corresponding magnetic storm occurred near the minimum, not the maximum, of the sunspot cycle.

The purpose of this report is twofold: to describe the characteristics of the February 1986 storm, primarily using ground magnetometer data, and to identify some of the key problems for which the data sets might provide valuable insight.

2. Special Note on the February 1986 Magnetic Storm

Table 1 lists several storm-induced damages that occurred at various places on the rth during the February storm. Outages in radio communication systems were reported. Canada, there is legal as well as scientific interest in the possible role that the February large magnetic field changes may have played in a head-on collision between a freight ain and a passenger train. The question is whether induced potentials could have affected e operation system of a microwave device that was supposed to control the red light at should have stopped the freight train. Geosynchronous telecommunications satellites ere found to have several types of anomalies, including power outages, on February 8. me of the low-altitude spacecraft encountered orbit shifts due to high drag. Other types anomalies in satellite recordings were reported, probably caused by differential surface arging.

In more scientific terms, satellites in synchronous orbit at 6.6 R_E observed several agnetopause crossings; the magnetopause is normally found near 10–15 R_E on the dayside. was also reported that the SCATHA satellite at 7.5 R_E was outside the bowshock and tered interplanetary space near 1700 UT on February 7 (at 1100 LT) and 2030 UT on ebruary 8 (at 1330 LT).

The auroral zone descended as far south as northern Florida, indicating that the noral auroral zone might have become the polar cap during the main phase of the magnetic orm. Disturbances also existed in the mid-latitude ionosphere where an order of magnide increase in electron density over the U. S. occurred from 2000 to 2400 on February 8.

Table 1. Severe Damages Reported for the February 1986 Storms

STORM-INDUCED DAMAGE

Geostationary telecommunications satellites	power outage
Navigation satellites	orbit shift
Radio communication	outage
Long lines	power surges
Telephone microwave relay circuit	impaired
Train head-on collision (Canada)	due to microwave device failure

3. Global Magnetic Activity

Preliminary inspections of selected ground magnetograms indicated impressively large magnetic variations during the magnetic storm. The College observatory, one of the standard auroral latitude observatories, recorded a maximum change exceeding −6000 nT in the *H* component and 17° in the *D* component at 1530 UT on February 8. Observatories at mid and low latitudes also recorded 400–500 nT *H* changes during the main phase.

Figure 1 shows the standard *Dst* and K_p indices for the first half of February, representing global magnetic activity. It is surprising to see three 9's in the K_p index, corresponding to about 230 in the A_p index. Also, the magnetospheric ring current measured by the *Dst* index showed that the storm effects remained for some 50 days in the plasma density of the ring currents.

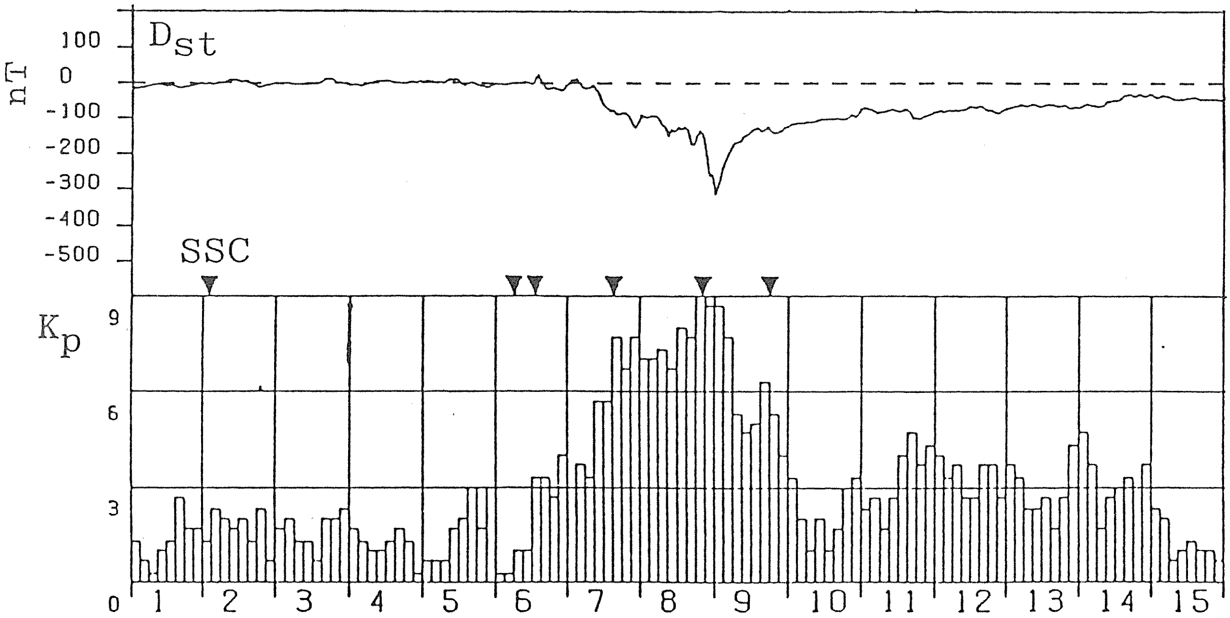

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Fig. 1. *Dst* and K_p variations for the first half of February 1986. Six SSC's (storm sudden commencements) are marked by triangles.

4. Auroral Electrojet Activity

Figure 2 shows the superposed H (or X) component magnetograms from the 26 observatories listed in Table 2. At some stations, where no digital equipment is being used, the records were saturated for an extended period of time on February 8 and 9. One such case near 2100 UT on February 8 is marked by "?" in Figure 2.

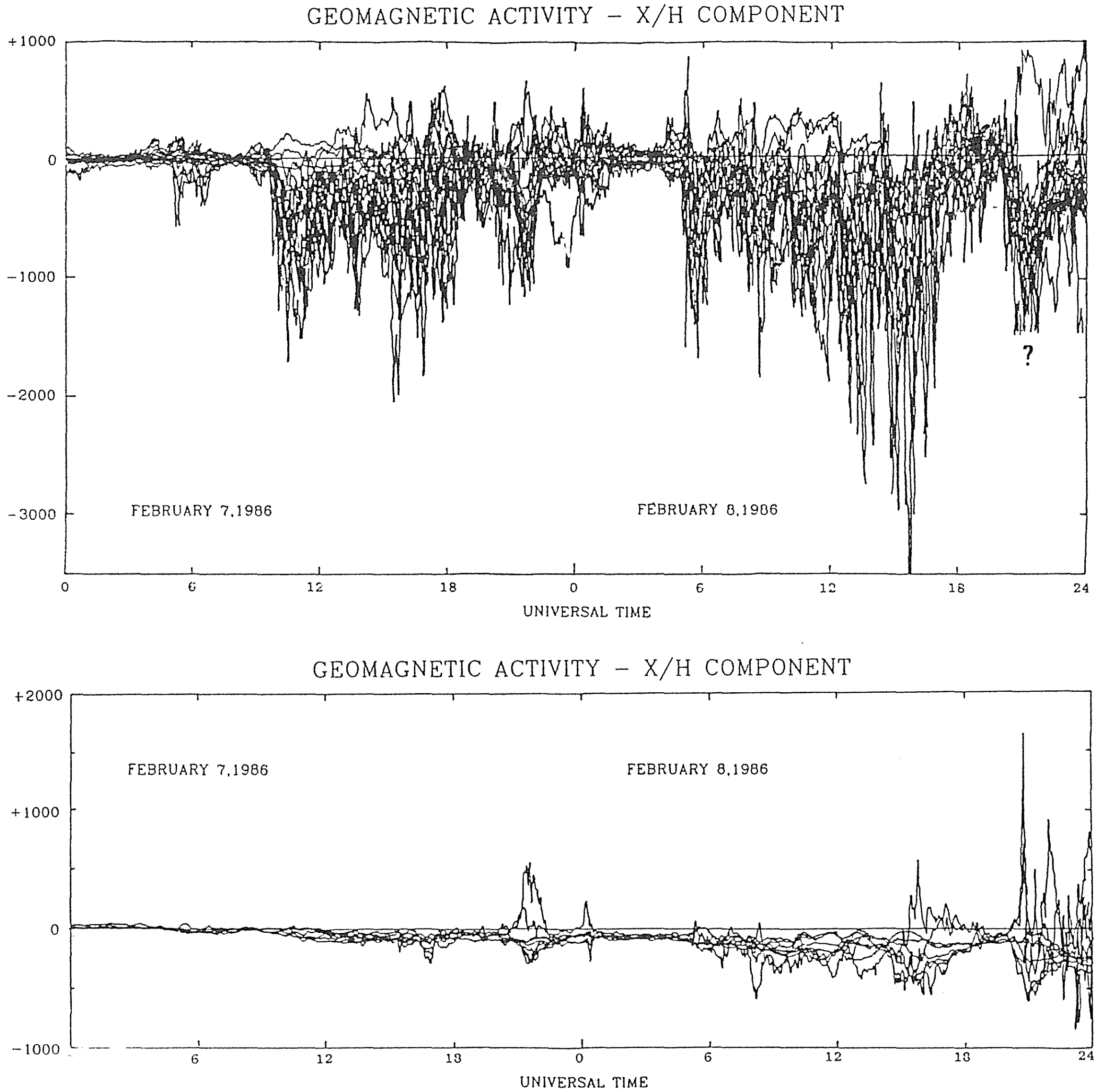

Fig. 2. Superposed H (or X) component magnetic records from 16 high-latitude observatories (top panel) and 10 low-latitude observatories (bottom panel). Corrected geomagnetic coordinates are listed in Table 2.

Table 2. Geomagnetic Observatories Whose Data are Included in Constructing Traces in Figure 2

	Corrected Geomagnetic	
	Latitude	Longitude
(a) High Latitudes		
Alert	86.70	115.03
Baker Lake	74.64	323.91
Barrow	69.67	248.14
Cambridge Bay	77.79	303.93
College	64.80	261.22
Fort Churchill	69.67	329.46
Glenlea	60.34	326.84
Kiruna	64.40	104.08
Meanook	62.39	303.33
Mould Bay	80.75	267.03
Narssarssuaq	67.29	44.66
Newport	55.19	301.39
Resolute Bay	83.92	312.48
Sitka	59.82	277.77
Sodankyla	63.56	108.54
Yellowknife	69.73	297.26
(b) Low Latitude		
Boulder	49.28	317.98
Fredericksburg	50.24	355.59
Guam	5.82	214.98
Honolulu	21.83	268.68
Kakioka	28.73	210.76
Ottawa	57.20	359.08
St. Johns	55.48	30.86
San Juan	29.86	8.22
Tucson	39.89	313.24
Victoria	54.05	294.23

As is evident from Figure 2, the two-day interval is characterized by the frequent occurrence of extremely intense substorms. In fact, even the "normally intense" substorms that occurred between 0430 and 0700 UT on February 7 seem weak compared to subsequent substorm activity starting at 0930 UT on February 7 and 0430 UT on February 8. In particular, negative *H* magnetic disturbances near 1530 UT on February 8 are the largest. It is interesting to see that there is no positive *H* disturbance in the available data during this interval. The corresponding magnetic perturbations at mid-latitude grow progressively larger, reaching a maximum at the end on February 8: see the *Dst* curve in Figure 1. It should be noted that although the upper and lower envelopes of the superposed *H* component plots from the standard auroral zone observatories well distributed in longitude, such as the one shown in Figure 2, are defined as the *AU* and *AL* indices, respectively, Figure 2 traces cannot be used to derive the indices values. This is because there are regions where no high-quality magnetic data are available for this interval; data from Siberia are not included in Figure 2.

5. Problems to be Solved

There is no doubt that the STP events of February 1986 offer a unique opportunity to study the transfer of energy from the sun to the near-earth space environment. In particular, there are several important topics that can be studied only by using the data from abnormally large magnetic storms.

Some of the characteristics of the February 1986 magnetic storm can be summarized in the following way:

1. The total energy involved in the whole process in the magnetosphere and the ionosphere, and in the upper atmosphere, is enormous. This is evident in every aspect of the measurable parameters, such as the intensity of magnetic disturbances at both high and low latitudes, the lifetime of the ring current, the luminosity of optical auroras, the intensity of precipitating particles, Joule heating and the latitudinal width of as well as the longitudinal extension of the auroral oval.

2. It is clearly not an easy task to examine the spatial/temporal changes in electromagnetic parameters describing this extremely intense magnetic storm. The reasons why this is a difficult undertaking are: the quality of many data sets obtained during the storm is not necessarily high, and the magnetospheric configurations, such as the location of the magnetopause and plasma pause, are abnormal, making it impossible to locate the key regions in the magnetosphere.

3. Release of energy from the magnetosphere onto the polar ionosphere took place intermittently over the course of nearly two days. This is noticed in the *H* component plots in Figure 2, where there are many up-down's or fluctuations, each of which signals either a large intensification or rapid movements of the auroral electrojets. It has been known that the main phase of magnetic storms is associated with successive occurrence of intense substorms, but this relationship is only qualitatively understood. Thus, basic questions remain unanswered concerning the hypothesis that a storm is a non-linear (or linear) superposition of intense substorms. There are two major problems of interest that the intense substorms of February 1986 might offer some hint about:

(a) Kamide and Fukushima (1971) pointed out that time changes in the *Dst* index can be reproduced by changes in the *AE* index, assuming that the energy injection rate into the ring current is proportional to the polar substorm activity. The February 1986 storm is unusual, however, in that while the *AE* maximum is as large as 6000 nT, the corresponding minimum *Dst* index is only –312 nT. We need to discover why this is so.

(b) It is quite common that during the early part of major magnetic storms, the *AU* index is very large, comparable to the *AL* magnitude. Figure 2 indicates, however, that the eastward electrojet did not reach very high values.

References

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