MAGSAT PROGRAM

PROGRESS REPORT

INVESTIGATION NUMBER M-41

# THE REDUCTION, VERIFICATION AND INTERPRETATION OF MAGSAT MAGNETIC DATA OVER CANADA

R.L. Coles, P.I.

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Geomagnetic Service
Earth Physics Branch
Energy, Mines and Resources Canada
1 Observatory Crescent
Ottawa, Ontario, Canada
K1A 0Y3



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## I. INTRODUCTION

The primary concern of this investigation is to detect and study variations in the magnetic field originating in the solid earth, as measured by Magsat. Most of this field originates in the core, but an important part of the field is of lithospheric origin. Magnetic anomalies of lithospheric origin are weak at Magsat altitudes (20 to 30 nT at most), and they can easily be masked by much larger effects caused by field-aligned and other currents at high latitudes. Most of Canada lies under the influence of ionospheric currents in the auroral zone and polar cap.

Therefore, before Magsat data had become available, but after the October 30th 1979 launch, we set out to develop some criteria for selecting times when subsets of potentially usable Magsat data could be expected.

Subsequently, as Magsat data became available, these criteria have been applied.

Co-Investigators:

G. Jansen van Beek

G.V. Haines

E. Dawson

J.K. Walker

Computing Advisor: A. Nandi

## II. TECHNIQUES

The primary data base used for establishing criteria was the preliminary (without full baseline control) digital records from Canadian magnetic observatories. Fig. 1 shows the Canadian magnetic observatory network. The full observatories can be grouped into three magnetic regions, the mid-latitude zone, the auroral zone, and the polar cap. Although there are differences in detailed field behaviour between observatories within a group, they do display the same general character of activity. As an initial step, we chose one observatory from each region as being representative. For the polar cap, Resolute Bay was chosen; for the auroral zone, Fort Churchill; for mid-latitudes, Ottawa or St. John's, depending on data availability.

With 15 or so Magsat passes each day for several months, some simple screening procedure had to be developed to sort out which passes were likely to be sufficiently quiet for detection of lithospheric anomalies, and thus be sufficiently free from fields external to the solid earth.

Magsat takes about 15 minutes to cross the Canadian region. The basic observatory data consist of values at 1 minute intervals. We estimate the short period activity using 4-minute ranges, and longer period activity using 1 hour ranges, in the three components of the magnetic field at the selected observatories. For each pass over Canada, preliminary predictions of pass times were available from J. Popelar (satellite tracking, Gravity and Geodynamics Division, Earth Physics Branch). For each pass, we compute ten sequential 4-minute ranges, and also the hourly ranges immediately preceding and following the time of the pass.

Criteria were set up for classifying the activity in each zone as quiet, unsettled, or disturbed -- A, B, or C. The screening is done first on the hourly ranges and then on the 4-minute ranges. This is because if there is major activity within an hour of the pass, the general field level is probably quite far from the quiet level.

The criteria originally chosen are now considered to be not stringent enough and revisions are in progress. The modified criteria will be used for the bulk of the Magsat data, when received.

We realize of course that what is seen on the ground may not fully reflect the field at the satellite altitudes, but it does provide some constraints.

We can look at the general activity of the geomagnetic field in a much coarser way by means of the Kp indices. These are not intended for auroral and polar cap regions, but do include Meanook, Victoria, and Ottawa as input observatories.

Fig. 2 shows Kp musical diagrams for the early part of the Magsat lifetime. The solid bars under each cycle show intervals of 9 hours or more for which Kp was 1+ or less, indicating fairly quiet conditions. However, at high latitudes, significant external fields may still be present.

The basic Magsat product which has been used so far has been the CHRONINT data tapes containing scalar and coarse-attitude vector data. For computing efficiency, only those sections of the data occurring north of latitude 37°N and during times of "quiet external field" were extracted from the CHRONINT tapes.

These "quiet times" were derived from the Kp plots in Fig. 2, on the basis that if Kp was high, then fields at high latitudes would almost certainly be disturbed. The criterion for acceptance was Kp less than or equal to 1+.

The CHRONINT tapes and derived data were processed using software developed by Earth Physics Branch investigators, but which incorporated several orbit decoding subroutines provided by NASA. Primary processing used an IBM 370/3033; subsequent processing used a CDC Cyber 74 computer. The high resolution Magsat data were "decimated" by factor 80 to give data points every 5 seconds (about 36 km distance) to conform with the planned Investigator tapes. This decimation, without filtering, appears to be adequate at this stage, although certain types of interpretation (e.g., downward continuation) might suffer from the noise content.

A reference field was removed. For the time being during these early stages, MGST 3/80 was used. It will later be replaced by improved models, incorporating secular variation terms. (The secular change over Canada is significant during the lifetime of Magsat.)

The positional information and magnetic field components were converted from a geocentric to a geodetic frame of reference. This procedure is essential for any studies relating to ground-based data and maps.

The scalar data were not always available in the data records on the CHRONINT tapes, and the vector components contained serious biasses (these facts were subsequently noted in Bulletins from NASA). Consequently, since our primary aim was to reduce and analyze the scalar field, and to await the arrival of fine-attitude data before considering the vector field, we computed the scalar field from the root sum of squares of the three coarse vector components. Checks showed that this computed scalar field was generally well within 1nT of the measured scalar field.

Using these techniques, we have now processed selected data sections from November 2, 1979 through to January 18, 1980. During this period, several very quiet intervals occurred. We are now in the process of selecting, on the basis of very low Kp (often only 0 and 0+) and of the local magnetic observatory criteria and by visually examining the Magsat data, those Magsat passes for which the external field was the quietest.

## III. ACCOMPLISHMENTS

The first objective of this investigation is to select a subset of Magsat data during quiet times of little or no disturbance fields. This cannot be met until all data has been received. However, as noted in section II, considerable progress has been made with the data already at hand. The selected passes have been plotted on a Canadian map outline base, and examples are shown in Figs. 3, 4, 5, and 6. Superimposed on Fig. 3 is a contoured version of the long-wavelength magnetic anomaly field derived from Canadian airborne vector magnetometer data, upward continued to an altitude of 500 km (Langel, Coles and Mayhew, 1980; Coles and Haines, 1979). There is good agreement between the Magsat anomalies and the airborne anomalies. The anomalies seen in these very quiet Magsat data are also in good agreement with the anomaly field derived from the POGO satellites over the Canadian region (Langel et al. 1980, and unpublished maps).

The Magsat data are beginning to provide a more detailed view of these long-wavelength anomalies not attainable either from the earlier POGO data or from the airborne data. Much reduction work lies ahead. Even in the quiet times, there remain contributions from external fields. This is evidenced by the level shifts between adjacent or intersecting profiles. Also, no adjustment for satellite altitude variations has been made in these preliminary displays.

## IV. SIGNIFICANT RESULTS

It is not appropriate at this time to enter into a detailed discussion of significant results, except to say that the work so far has demonstrated that lithospheric anomalies can successfully be measured from a space vehicle such as Magsat.

## V. PUBLICATIONS

A short talk was presented at the Spring 1980 AUG/CGU meeting in Toronto, based on EPB observatory data and 2 days of preliminary Magsat data. The abstract follows:

**Geomagnetic Activity over Canada during early part of MAGSAT Mission, and some preliminary quiet-time MAGSAT RESULTS**

R.L. Coles, G. Jansen van Beek, A. Nandi, G.V. Haines

(all at: Earth Physics Branch, Division of Geomagnetism,

Energy Mines and Resources Canada, Ottawa, Canada, K1A 0Y3)

Analyses of data from Canadian magnetic observatories are used to indicate the levels of geomagnetic field activity at the times of passes of the MAGSAT satellite over Canada during the first 4 months of the mission. Three zones of different characteristic activity are transversed by the satellite - the mid-latitude zone, the auroral zone, and the polar cap. During about 40% of this time period, the magnetic activity could be classified as "quiet" in the mid-latitude and auroral zones, with a higher percentage in the polar cap. Criteria for classifying activity levels are based primarily on the short period variations in the field. A critical factor in the auroral zone is the frequent occurrence of pulsational activity at periods of a few minutes. MAGSAT traverses through each zone in a few minutes. In this context, comparisons between the local analyses and Kp indices serve to emphasize the non-applicability of the latter as general activity indicators for the higher latitudes. AE indices are not yet available.

Preliminary analyses of some early MAGSAT data obtained during quiet times show good agreements between intersecting passes over Canada, and give indications of anomaly features seen in earlier studies of POGO satellite and airborne magnetic data.

## VI PROBLEMS

As with many investigations, early delays in data shipments from NASA have prevented the original schedule of work being followed. The work to date on CHRONINT tapes has provided a basis for work on reduction of scalar data and elimination of disturbance fields to begin. However, the full scalar data set cannot be analyzed and corrected until a complete Investigator tape is received. No work on fine-attitude data can start until a substantial amount of such data is received, since we are only concerned with quiet conditions (as discussed in section II).

## VII DATA QUALITY AND DELIVERY

The quality of data in production tapes received is excellent. Some comments regarding data delivery were made in section VI. The pattern of data shipments has not followed the outline originally given to investigators. This has caused internal problems in readjusting assignments and schedules at Earth Physics Branch.

## VIII RECOMMENDATIONS

Regarding data shipments to foreign countries, the Data Centre should ensure that full and correct Customs documentation be attached to all shipments whether by mail or other carrier. Delays in Customs have resulted from insufficient documentation.

## IX CONCLUSIONS

The Magsat data are basically good and their usefulness for lithospheric studies over Canada is apparent from the preliminary plots shown in this report. It is premature to conclude further at this stage.

## X REFERENCES

Coles, R.L. and Haines, G.V. 1979. Long-wavelength magnetic anomalies over Canada, using polynomial and upward continuation techniques. J. Geomag. Geoelectr., 31, 545-566.

Langel, R.A., Coles, R.L., and Mayhew, M.A. 1980. Comparisons of magnetic anomalies of lithospheric origin measured by satellite and airborne magnetometers over western Canada. Can. J. Earth Sci., 17, 876-887.

## FIGURE CAPTIONS

Fig. 1. The Canadian magnetic observatory network.

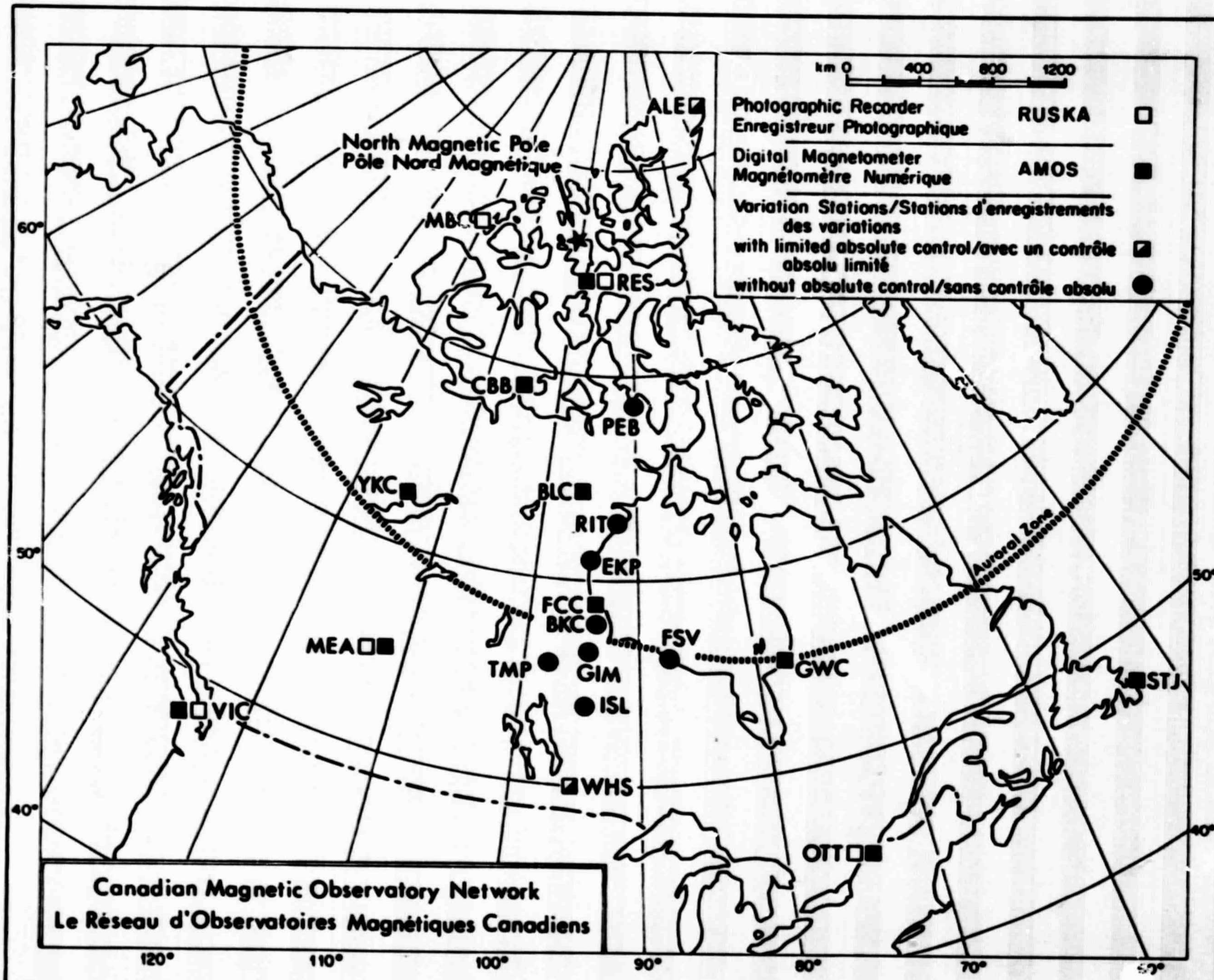
Fig. 2. Musical diagram of Kp indices for late 1979 and early 1980. The solid bars below each row of indices represent intervals of time greater than 9 hours for which Kp was less than or equal to 1+.

Fig. 3. Profiles of Magsat scalar field residuals, relative to MGST 3/80, over Canada. These profiles were the quietest on Days 306 and 307, 1979. The heavy line contours represent the upward-continued Earth Physics Branch airborne magnetometer data.

Fig. 4. Selected profiles of Magsat scalar field residuals for Days 322 through 327, 1979.

Fig. 5. Selected profiles of Magsat scalar field residuals for Days 355, 357, 359, 1979.

Fig. 6. Selected profiles of Magsat scalar field residuals for Days 007, 009, 010, 016, 1980.




Canadian Magnetic Observatory Network
Le Réseau d'Observatoires Magnétiques Canadiens

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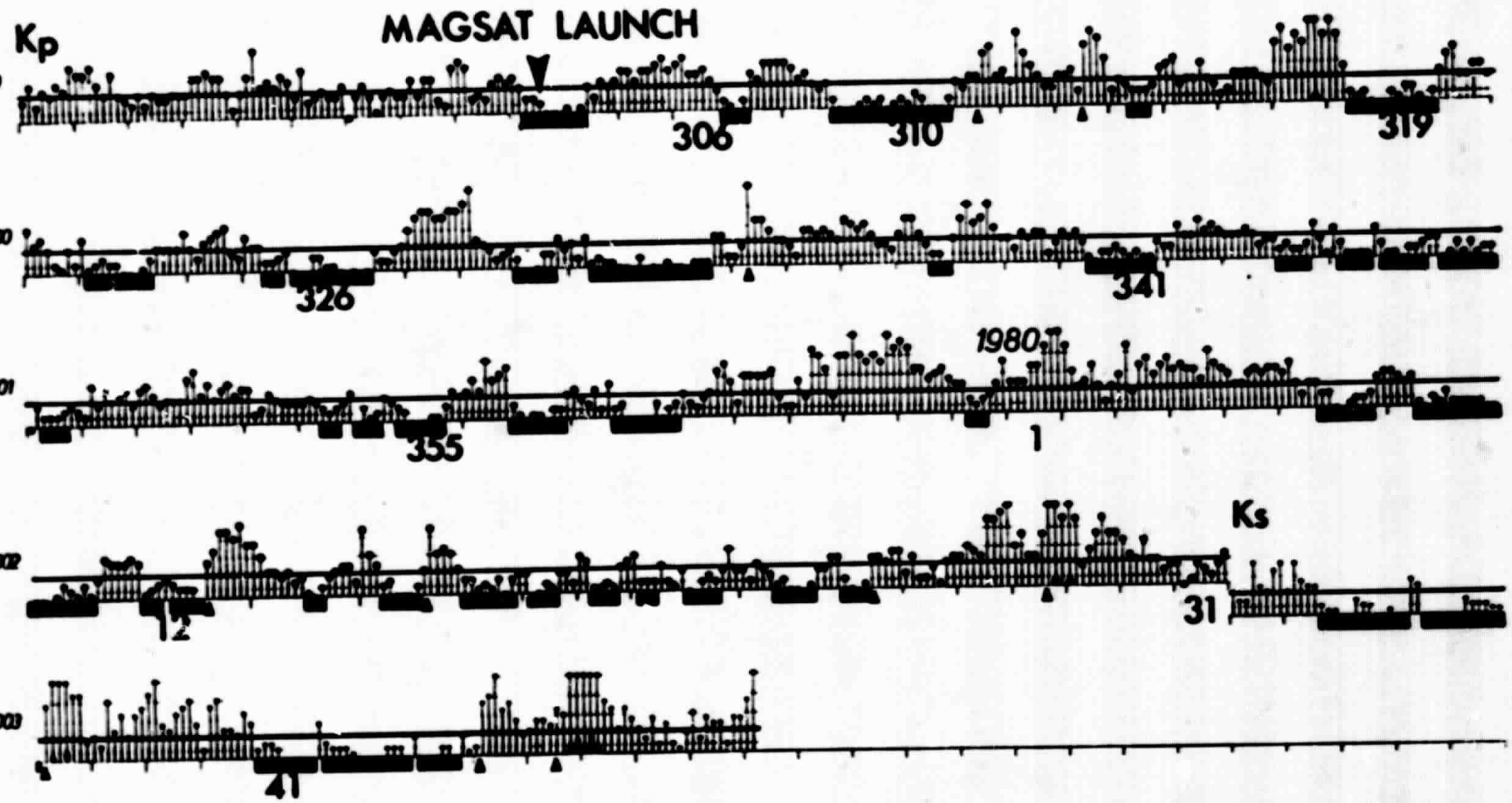
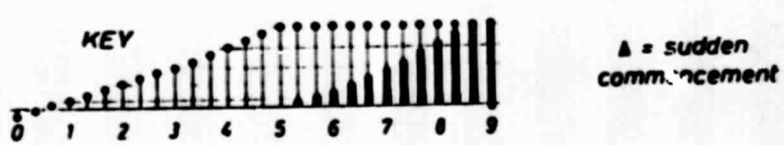
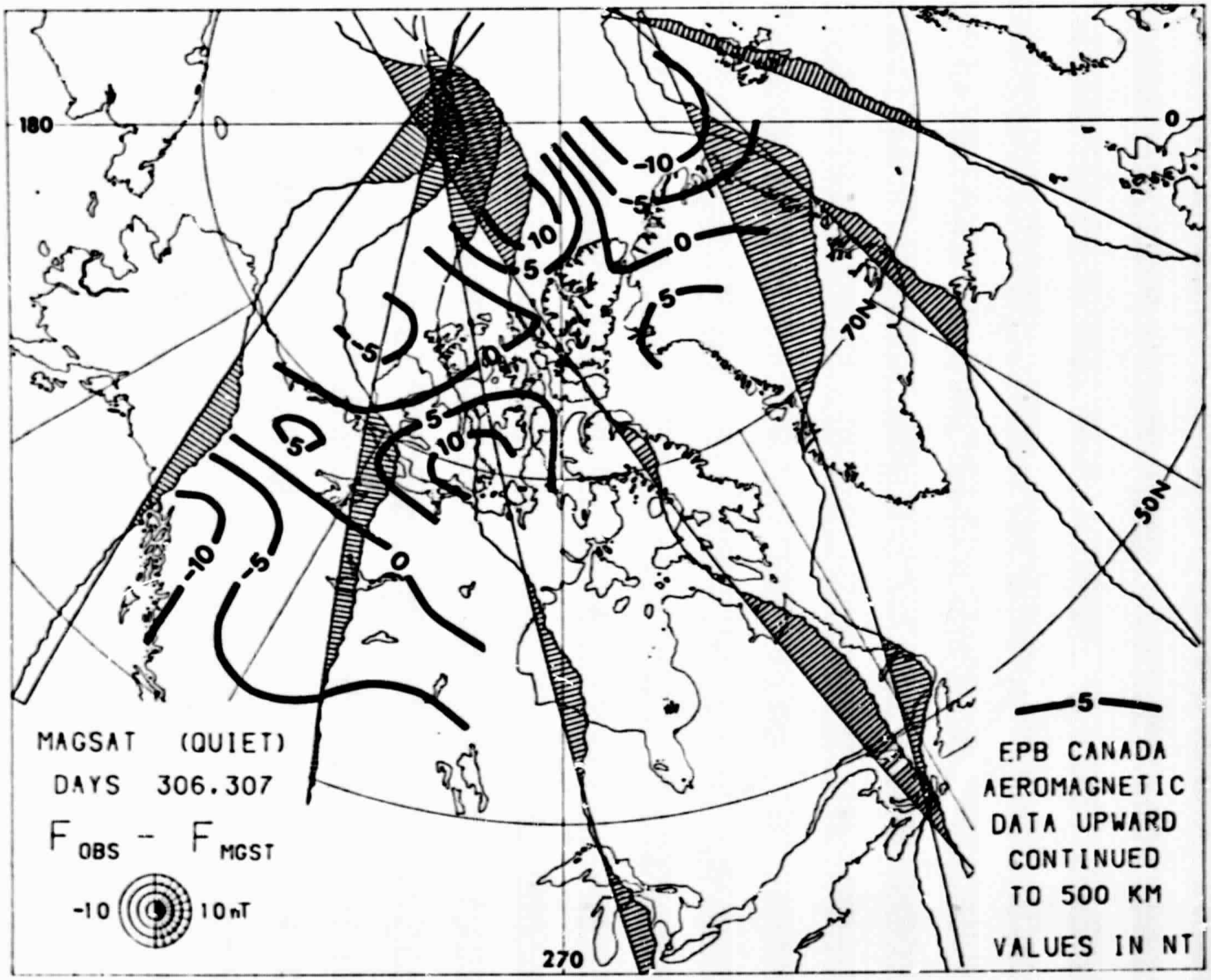



**PLANETARY MAGNETIC THREE-HOUR-RANGE INDICES Kp (after Bartels)**

Kp till 1980 January 31

Ks (from Wingst and Göttingen) till Feb 19


MAGSAT (QUIET)
DAYS 306.307
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-10 10nT
EPB CANADA
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DATA UPWARD
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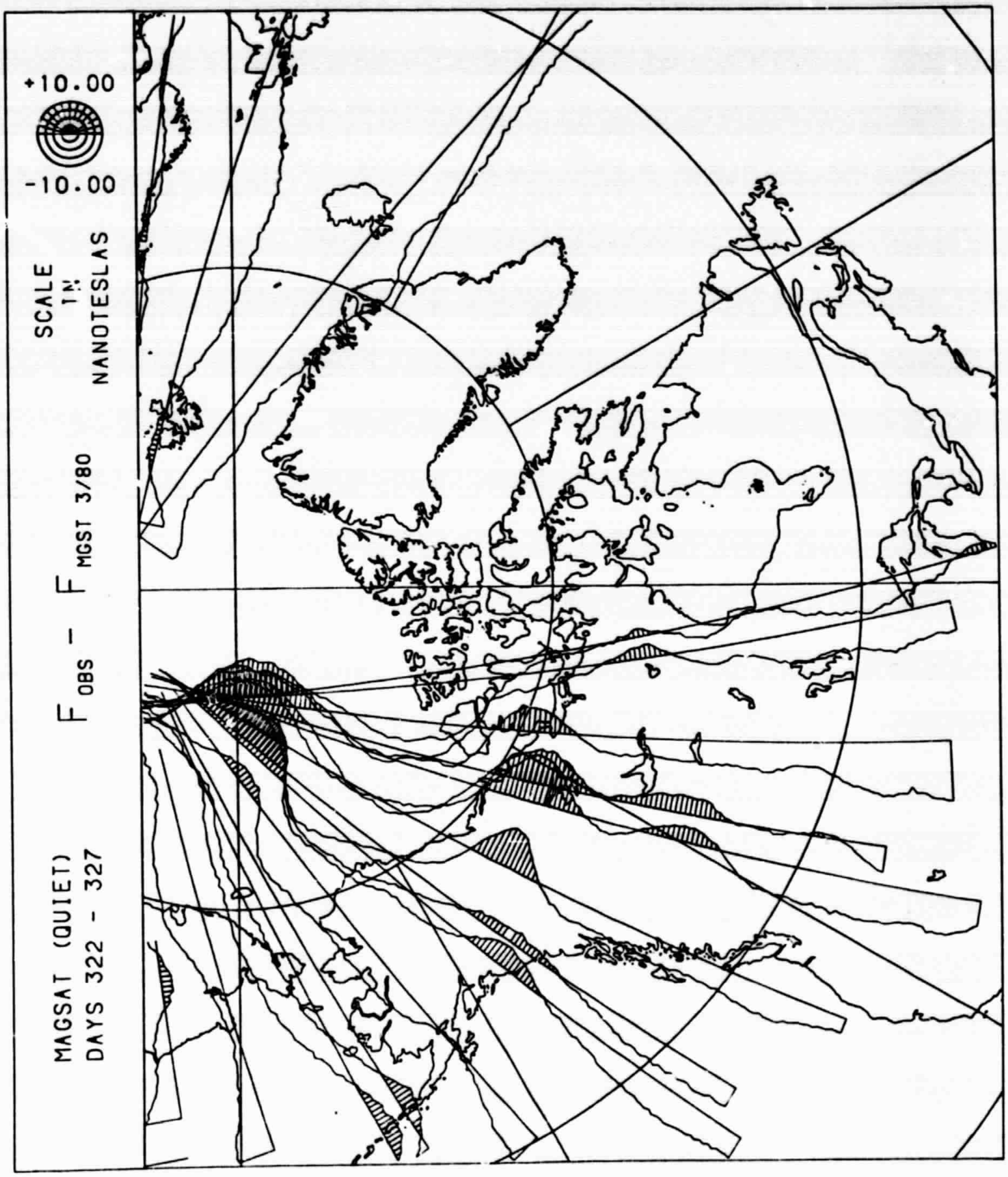
MAGSAT (QUIET)
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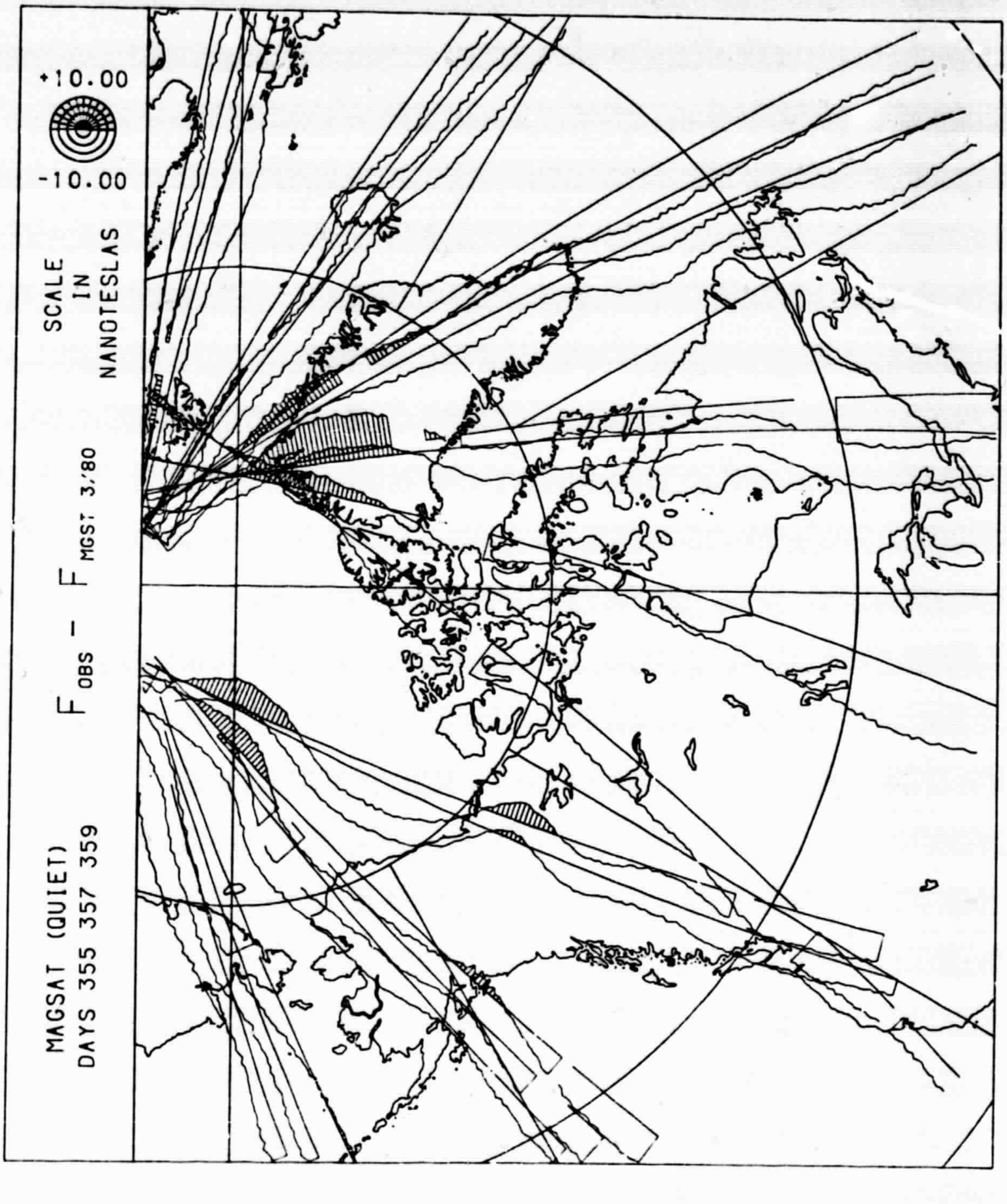
MAGSAT (QUIET)
DAYS 355 357 359
F OBS - F MGST 3/80
SCALE
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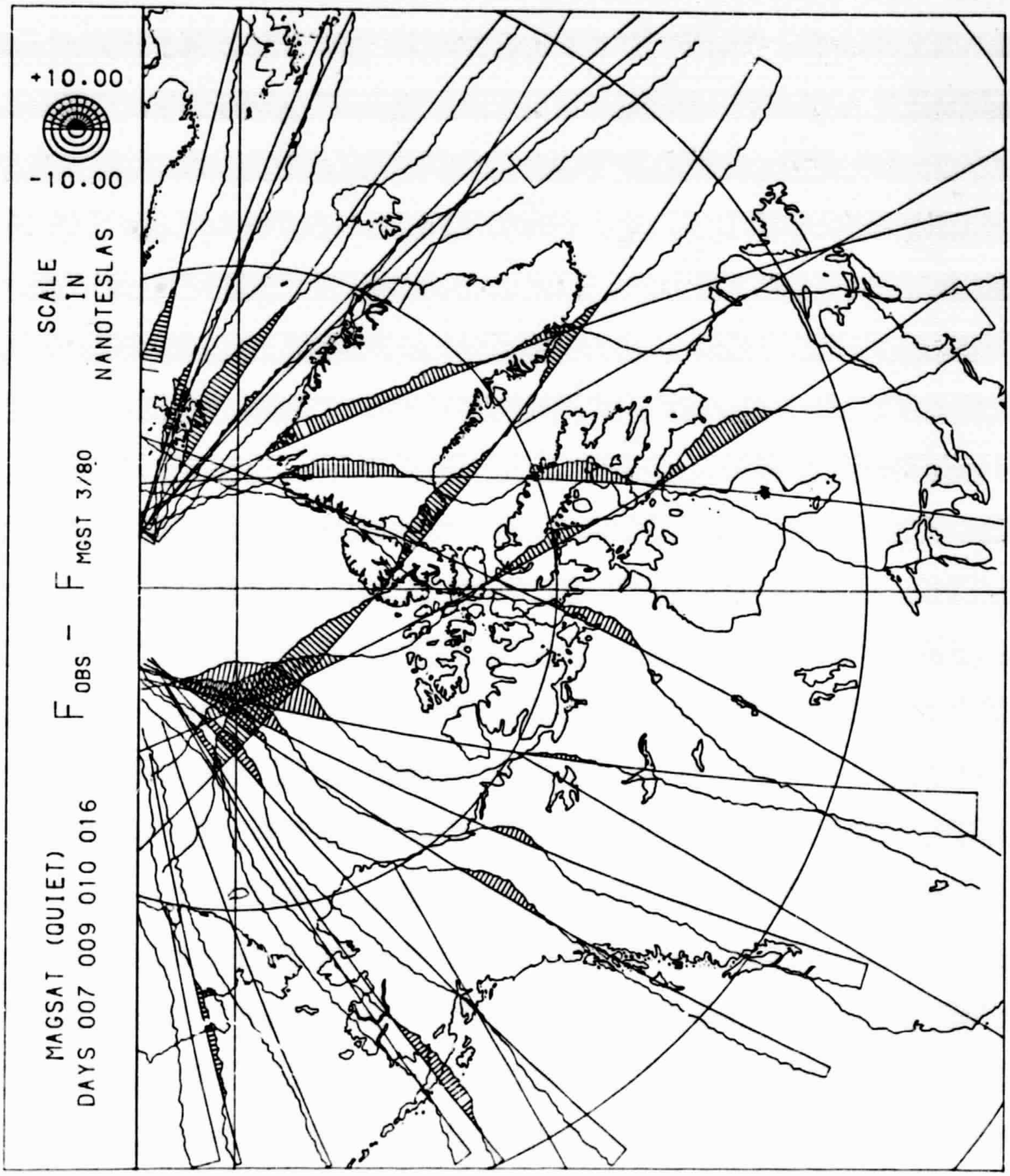


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