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MEASUREMENT OF AURORAL MAGNETIC FIELD WITH THE ANTARCTIC SOUNDING ROCKET S-310JA-12

Fumio TOHYAMA[1], Takao TAKAHASHI[2], Hiroshi FUKUNISHI[3], Susumu KOKUBUN[4], Ryoichi FUJII[5] and Hisao YAMAGISHI[5]

[1]*Faculty of Engineering, Tokai University, Kitakaname, Hiratsuka 259–12*
[2]*Information Science Laboratory, Tokai University, Kitakaname, Hiratsuka 259–12*
[3]*Upper Atmosphere and Space Research Laboratory, Faculty of Science, Tohoku University, Aramaki Aoba, Sendai 980*
[4]*Geophysics Research Laboratory, University of Tokyo, 3–1, Hongo 7-chome, Bunkyo-ku, Tokyo 113*
[5]*National Institute of Polar Research, 9–10, Kaga 1-chome, Itabashi-ku, Tokyo 173*

Abstract: A rocket containing a triaxial fluxgate magnetometer was launched from Syowa Station, Antarctica, at 1935 UT on July 12, 1985. Magnetic anomalous field was measured with high sampling time of every 10 ms. The vector magnetometer indicated an existence of field-aligned currents in the vicinity of an auroral arc and electrojet currents at the ionospheric level.

1. Introduction

Under the project of the MAP (Middle Atmosphere Program), the 26th Japanese Antarctic Research Expedition (JARE-26) carried out two sounding rocket experiments using the S-310JA-11 and -12 rockets at Syowa Station, Antarctica. The sounding rocket S-310JA-12 was traversed active auroral arcs during the ascending and descending flights. The H, D and Z components of the ground geomagnetic field changed more than 300, 400 and 800 nT, respectively, from the quiet level during the flight.

One aim of the rocket experiments was to measure magnetic fields inside the aurora by means of triaxial fluxgate magnetometers. We discussed ionospheric and field-aligned currents taking account of other simultaneous experiments for auroral particles, plasma wave, electron density and electric field.

2. Instruments and Data Processing

Triaxial fluxgate magnetometer with ring core sensors on board the S-310JA-12 rocket has a field range of $+60000$ to -60000 nT and a high sensitivity of 1.8 nT/LSB. The sensor was mounted on a rigid boom of 39.4 cm in length, and was extended after launch by a timer at the height of about 77 km.

The X and Y sensors were placed on a plane perpendicular to the rocket spin axis and the Z sensor was aligned to the axis. Three components of the geomagnetic field in the vehicle coordinate system were obtained every 10 ms. The magnetic

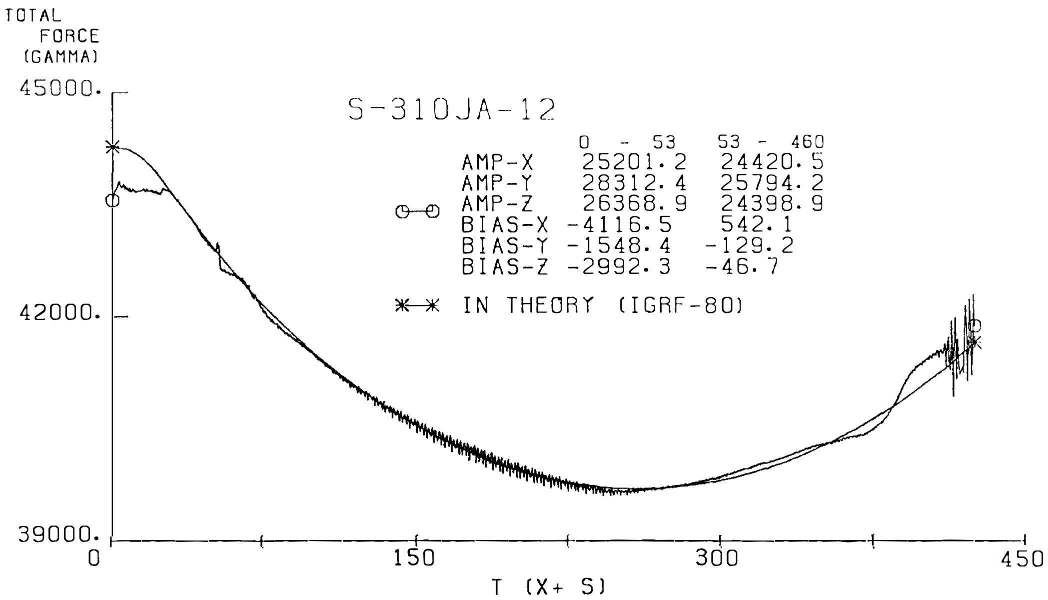

Fig. 1. Adjusted total intensity of the geomagnetic field and a theoretical reference field of IGRF-80 model.

offset or bias fields from the vehicle body or on board instruments had been measured before the launch.

Signal for each component of magnetic field was given in digital form and output intensities were adjusted with a theoretical field by use of the method of least square. Adjusted total force of the geomagnetic field and a theoretical model are shown in Fig. 1. The theoretical field was computed from an IGRF (International Geomagnetic Reference Field) model.

The vehicle was spinning at the rate of 0.56 rps and it showed a precessional motion with its half angle of 25.0° and the period of about 292 s. The influence of the vehicle motion to the magnetic field measurement was reduced from the output field, and the anomalous geomagnetic field (in three components in the geodetic coordinate system) was calculated from vehicle attitudes. The vehicle attitudes were determined by a horizon aspect sensor and geomagnetic aspect information from the magnetometer itself.

3. Preliminary Results

Time dependence of magnetic field anomaly perpendicular to the vehicle axis is shown in Fig. 2. It is obvious that large magnetic field deviations existed in the flight time interval from 275 to 375 s. Three components of the anomalous field, to the geomagnetic north, west and to the direction of geomagnetic field, were transformed from the vehicle sensor coordinate system, and these profiles are shown in Fig. 3. The anomalous field vector perpendicular to the ambient geomagnetic field is illustrated in Fig. 4. An intense northeastward field appeared about 280 s after the launch at the height of 212 km, and its intensity increased thereafter. In the ascending and descending flights at the altitude from 100 to 130 km, anomalous fields of about 500 nT

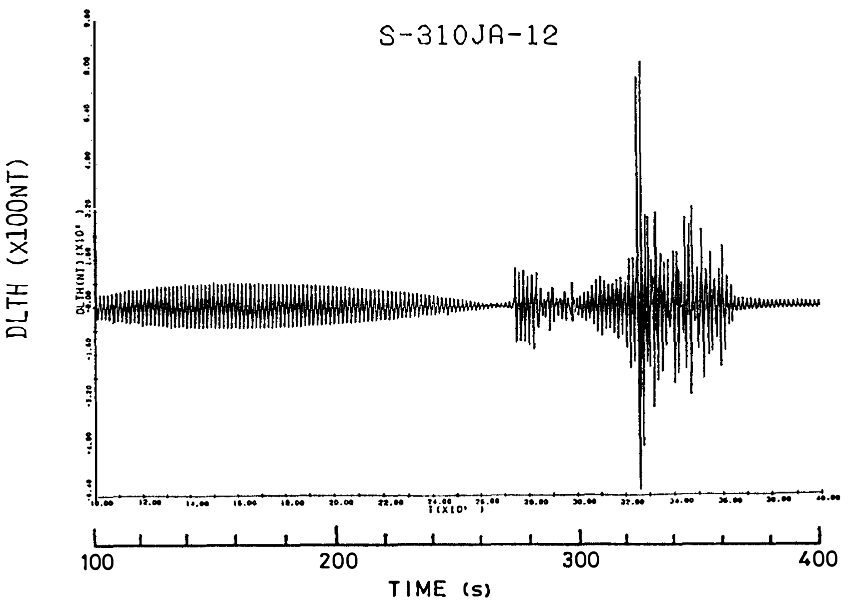

Fig. 2. Time dependence of anomalous magnetic field in arbitrary scale. It is perpendicular component to the rocket axis in the vehicle coordinate system.

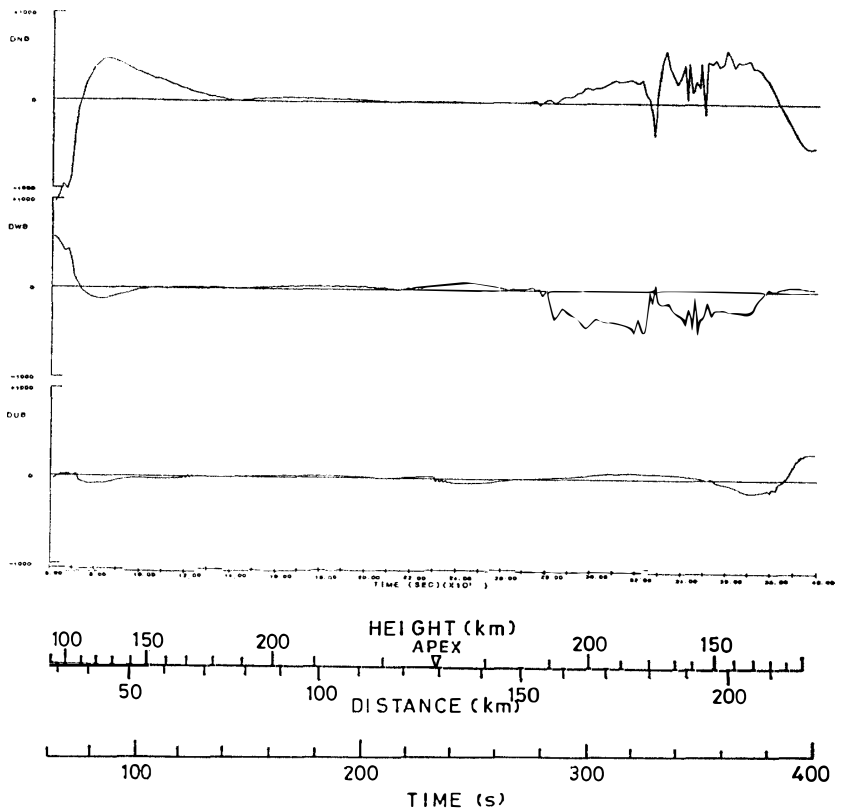

Fig. 3. Magnetic anomaly due to auroral currents during the flight. Three components in the local geomagnetic coordinate system. The directions of geomagnetic north-south (top), west-east and the geomagnetic field vector (bottom). Range of full scale is 1000 nT.

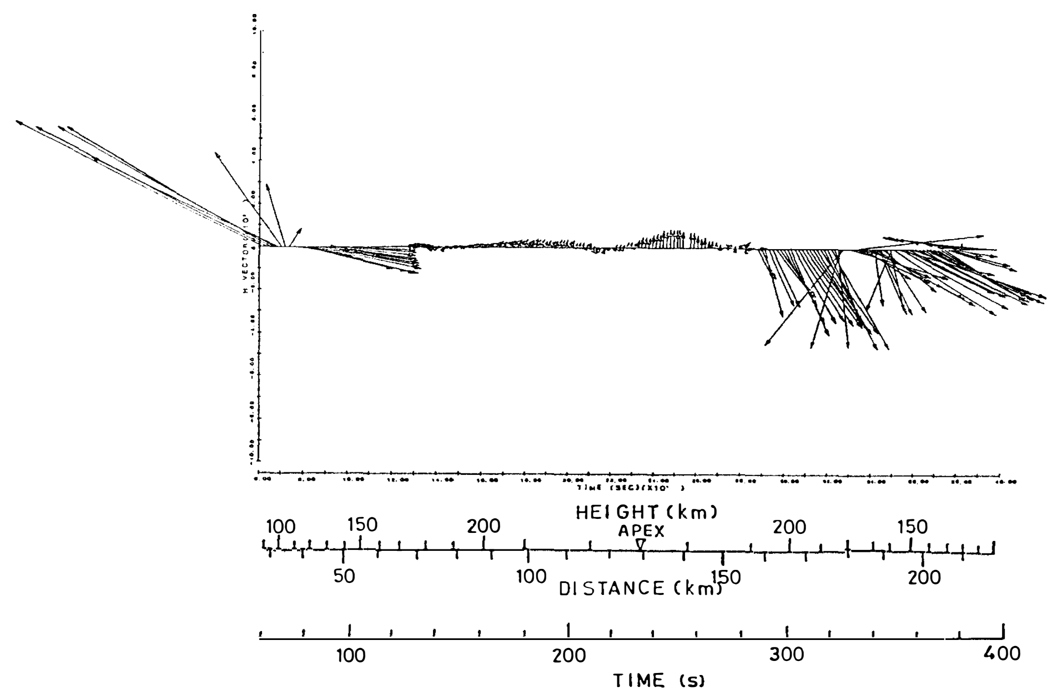

Fig. 4. Vectors of anomalous field perpendicular to the geomagnetic field deduced from Fig. 3. The direction to the right side shows the north and that to the upward shows the west. Range of full scale is 1000 nT.

by ionospheric currents were detected.

We have following problems in the data preprocessing.

(1) Triaxial field intensities were adjusted as shown in Fig. 1 even for including a persistent DC field, so that the zero level of anomalous field in Fig. 3 may slide upward or downward.

(2) An ambiguity of the vehicle attitude determination will result in an ambiguity of the zero level and magnitude of the anomalous magnetic field.

But it is clear that a field aligned current was detected at the altitude of 212 km and ionospheric jet currents existed at 100–130 km in the ascending and descending flights. Auroral pictures were recorded by all sky camera at Syowa Station, and an active auroral arc appeared to north-west direction at the time of the field-aligned current detection. The relationship to auroral electric fields or high energy particles and fine structure of the field-aligned current, amplitude, dimension and direction are to be investigated in more detail.

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