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A geomagnetic reference field for Canada 1985

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The recently developed technique of spherical cap harmonic analysis (SCHA) is ideally suited for the analysis of potential fields over a portion of a sphere. SCHA is a regional analog of ordinary spherical harmonics involving associated Legéndre functions of integral order but non-integral degree, and ensures that the curl and divergence of the magnetic field vector are zero (Haines 1985a). The method has been used to produce a Canadian Geomagnetic Reference Field for 1985 (CGRF 1985) and the associated series of magnetic charts.

The primary data set consisted of Canadian vector aeromagnetic survey data collected between 1965 and 1976 and contained approximately 120 000 0.5 min averages gathered along 600 000 km of flight tracks. Line spacings varied from 37 km to 74 km, and altitudes from 3 km to 5 km. The data from each survey were averaged in cells approximately 127 km on a side to reduce the number of data to a manageable number for analysis and to reduce the possibility of aliasing. A total of 4350 averaged component-observations were obtained in this manner.

The aeromagnetic data provided adequate coverage over Canada and some adjacent areas, but did not cover the entire area of the spherical cap. They were, however, supplemented by the recent and important MAGSAT satellite data. The MAGSAT data used consisted of a subset of the quiet-time data used by Haines (1985b) to produce a Z anomaly map of the region north of 40°N. They were decimated to give a uniform areal coverage, eliminating the extremely dense coverage near the pole which was a result of the satellite's polar orbit. A total of 5622 component observations were retained, with a nominal spacing of 150 km.

All data were updated to 1985 using a model of the secular variation in Canada between 1960 and 1985, produced using SCHA (Haines 1985c). It is estimated that updating errors were less than 50 nT.

The IGRF 1980, updated to 1985, was subtracted from the updated aeromagnetic and satellite data. Next, positional co-ordinates were transformed from geodetic to geocentric, and rotated to a co-ordinate system with a pole at (65°N, 85°W); the centre of a spherical cap of radius 30° which covered all Canada and some adjacent areas.

A spherical cap harmonic analysis was performed on the combined data set, with the MAGSAT and aeromagnetic data being given equal weight. A spatial index of K = 16 was chosen, corresponding to ordinary spherical harmonic degrees up to 49. This procedure should allow the depiction of features with a scale size of approximately 800 km. An expansion to K = 16 comprises 259 coefficients, although only 95 were found to be statistically significant at $F = 4$. The scatter, or standard error of estimate, of all data to the model was 63 nT.

The main field components are obtained by adding the IGRF at 1985 to the residual field derived from the SCHA. This composite is called the Canadian Geomagnetic Reference Field 1985. Magnetic charts of five components of the magnetic field were produced by computer contouring an equally spaced array of values computed from the CGRF.

Incorporation of the secular variation model into the CGRF makes the model valid for the period 1960 to 1985 with extrapolation to 1990 possible. The annual change shown on the chart is the average secular variation over the 5 year lifetime of the chart.

The Canadian Geomagnetic Reference Field has been produced because many users find that the information given by a national model is more timely and more accurate than the information available from world models. Information on declination is most frequently requested, and is used in the production of topographical, aeronautical, hydrographical and many other charts published by Canadian federal and provincial charting agencies. Accurate declination information is also needed by a multitude of other organizations, especially the petroleum industry, which uses borehole compasses for directional drilling.

References

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