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THE JOINT US/UK 1990 EPOCH WORLD MAGNETIC MODEL

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FOREWORD

As it has in centuries past, the Earth's magnetic field still plays a vital role in global navigation. All navigational aids or attitude/heading reference systems (AHRS), regardless of their operating principles, must speak a common language. That common language is in terms of the Earth's magnetic declination. Consequently, magnetic-related navigational aids are integrated, in the form of computer hardware and software, into virtually every major weapons system of the Army, Air Force, Navy, and Marines. In order to maintain optimum performance, these systems must be periodically updated with regard to the Earth's magnetic field, which is a dynamic entity that changes slowly but erratically with time.

For well over a century, it has been the responsibility of the U.S. Naval Oceanographic Office to monitor the Earth's changing magnetic field and periodically report on these changes in the form of magnetic charts and mathematical models. For the past forty years, this task has involved an intensive data collection effort through the Project MAGNET program, which in April 1990 made the transition from primarily aeromagnetic surveying to satellite surveying with the launch of the Polar Orbiting Geomagnetic Survey (POGS) satellite. Follow-on satellite missions to secure data for future needs, well into the twenty-first century, are now being vigorously pursued.

This report is a comprehensive summary of the cooperative effort between the U.S. Naval Oceanographic Office and the British Geological Survey in producing the 1990 Epoch World Magnetic Model, WMM-90.


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Captain, U.S. Navy
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SECTION 1. THE GEOMAG ALGORITHM AND THE 1990 MODEL

1.0 Introduction

The Earth's magnetic field, as measured by a magnetic sensor on or above the Earth's surface, is actually a composite of several magnetic fields generated by a variety of sources, which are superimposed on each other and which interact with each other. The most important of these geomagnetic sources are:

- a. the Earth's fluid outer core;
- b. the Earth's crust/upper mantle;
- c. the ionosphere; and
- d. the magnetosphere.

The magnetic variation algorithm (GEOMAG) is a Fortran subroutine which is based on a spherical harmonic expansion of the Earth's magnetic field, the coefficients of which comprise the World Magnetic Model (WMM). These coefficients are produced jointly by the U.S. Naval Oceanographic Office (NAVOCEANO)'s Geopotential Division and the British Geological Survey (BGS). The WMM is distributed by NAVOCEANO for the Defense Mapping Agency (DMA) in accordance with DMA Instructions 8000.1 and 8000.2. The WMMs are usually produced at 5-year intervals and are composed of two parts: a main field model, which describes the Earth's magnetic field at some base epoch, and a secular variation model, which accounts for the slow temporal variations in the main geomagnetic field from the base epoch to a maximum of 5 years beyond the base epoch. For example, the base epoch of the WMM-90 magnetic field model is 1990.0. This model is therefore considered valid between 1990.0 and 1995.0 and will subsequently be replaced at 1995.0 by the WMM-95 magnetic field model.

It is extremely important to recognize that the WMM series of geomagnetic models and the charts produced from these models characterize only that portion of the Earth's magnetic field which is generated by the Earth's fluid outer core. The portions of the geomagnetic field generated by the Earth's crust, mantle, ionosphere, and magnetosphere are not represented in these models. Consequently, a magnetic sensor such as a compass or magnetometer may observe spatial and temporal magnetic anomalies when referenced to the appropriate WMM. In particular, certain local, regional, and temporal magnetic declination anomalies can exceed 10 degrees. Anomalies of this magnitude are not common, but they do exist. Declination anomalies on the order of 3 or 4 degrees are not uncommon, but are of small spatial extent and relatively isolated. On land, spatial anomalies are produced by mountain ranges; ore deposits; ground which has been struck by lightning; geological faults; and cultural features such as trains, planes, tanks, railroad tracks, power lines, etc. In ocean areas, spatial anomalies are produced by continental margins, seamounts, oceanic ridges, trenches and fault zones, and ships and submarines. Temporal anomalies in either ocean or land areas can last from a few minutes to several days and are produced by ionospheric and magnetospheric processes which are driven by the solar wind.

Magnetic storms in particular can cause severe and persistent magnetic anomalies. Even in periods of quiet solar activity, significant spatial and temporal magnetic anomalies are found in the polar and equatorial regions of the Earth, where magnetic fields produced by ionospheric current systems, such as the auroral electrojets and the equatorial electrojet, are always present. Most of the possible sources of magnetic anomalies are comparatively isolated in either space or time. Therefore, from a global perspective, the root-mean-square (RMS), declination (DEC), and inclination (DIP) errors at sea level of the WMM are estimated to be less than 0.5 degrees in ocean areas and less than 1.0 degrees in land areas at the Earth's surface over the entire 5-year life of a particular model. Also, the RMS errors at sea level of the horizontal (H) and total intensity (F) components of the WMM over ocean and land areas are estimated to be less than 200 nanoteslas (nT) over the entire 5-year life of the models.

1.1 The Mathematical Model

The Earth's magnetic field has associated with it a geomagnetic potential $V(r, \theta, \phi, \tau)$, which can be expressed in spherical coordinates in terms of a spherical harmonic expansion of the following form:

$$V(r, \theta, \phi, \tau) = R_E \sum_{n=1}^N \left(\frac{R_E}{r} \right)^{n+1} \sum_{m=0}^n \{g_{nm}(\tau) \cos m\phi + h_{nm}(\tau) \sin m\phi\} P_n^m(\theta) \quad (1)$$

where the spherical coordinates (r, θ, ϕ) correspond to the radius from the center of the Earth, the colatitude (i.e., 90° - latitude), and the longitude. R_E is the mean radius of the Earth; $g_{nm}(\tau)$ and $h_{nm}(\tau)$ are referred to as the Gauss coefficients at time τ , where τ is the time in years (e.g., 1987.312). $P_n^m(\theta)$ represents a particular associated Legendre polynomial of degree n and order m . These polynomials are functions of the colatitude θ . The Gauss coefficients are slowly varying functions of time and are expressed in the form:

$$g_{nm}(\tau) = g_{nm}(T_{EPOCH}) + \dot{g}_{nm}(\tau - T_{EPOCH}) \quad (2a)$$

$$h_{nm}(\tau) = h_{nm}(T_{EPOCH}) + \dot{h}_{nm}(\tau - T_{EPOCH}) \quad (2b)$$

where T_{EPOCH} is the base epoch of the model, which for WMM-90 is 1990.0. Thus, $g_{nm}(T_{EPOCH})$ and $h_{nm}(T_{EPOCH})$ are the Gauss coefficients of the WMM at the model's base epoch, while $\dot{g}_{nm}$ and $\dot{h}_{nm}$ (pronounced g_{nm} dot and h_{nm} dot) are the annual rates of change of the Gauss coefficients. The Gauss coefficients $g_{nm}(T_{EPOCH})$ and $h_{nm}(T_{EPOCH})$ and their annual rates of change are spherical harmonic coefficients. The Gauss coefficients $g_{nm}(T_{EPOCH})$ and $h_{nm}(T_{EPOCH})$ characterize the Earth's main magnetic field at the base epoch of the model, T_{EPOCH} , while $\dot{g}_{nm}$ and $\dot{h}_{nm}$ characterize the

secular change of the Earth's main magnetic field during the 5-year life of the model. These coefficients, up to degree and order 12 for the main field and up to degree and order 8 for the secular variation of the main field, comprise the WMM. Currently, the secular variation model from degree 8 through degree 12 is padded with zeros.

The Earth's magnetic field $\vec{B}(r, \theta, \phi, \tau)$ is a vector quantity having three components which correspond to the projection of the magnetic field vector onto the three coordinate axes. Thus, $B_r(r, \theta, \phi, \tau)$ is that portion of the field pointing in the radial direction (i.e., perpendicular to the surface of the Earth), $B_\theta(r, \theta, \phi, \tau)$ is that portion of the field pointing locally due south, and $B_\phi(r, \theta, \phi, \tau)$ is that portion of the field pointing locally due east. The magnetic field vector can be computed from the geomagnetic potential by taking its gradient, thus:

$$\vec{B}(r, \theta, \phi, \tau) = -\vec{\nabla}V(r, \theta, \phi, \tau) \quad (3)$$

Consequently, the magnetic field components are related to the geomagnetic potential as follows:

$$B_r(r, \theta, \phi, \tau) = - \frac{\partial V(r, \theta, \phi, \tau)}{\partial r} \quad (4a)$$

$$B_\theta(r, \theta, \phi, \tau) = - \frac{1}{r} \frac{\partial V(r, \theta, \phi, \tau)}{\partial \theta} \quad (4b)$$

$$B_\phi(r, \theta, \phi, \tau) = - \frac{1}{r \sin \theta} \frac{\partial V(r, \theta, \phi, \tau)}{\partial \phi} \quad (4c)$$

which yield the following spherical harmonic expansions:

$$B_r(r, \theta, \phi, \tau) = \sum_{n=1}^N (n+1) \left(\frac{R_E}{r} \right)^{n+2} \sum_{m=0}^n \{g_{nm}(\tau) \cos m\phi + h_{nm}(\tau) \sin m\phi\} P_n^m(\theta) \quad (5a)$$

$$B_\theta(r, \theta, \phi, \tau) = - \sum_{n=1}^N \left(\frac{R_E}{r} \right)^{n+2} \sum_{m=0}^n \{g_{nm}(\tau) \cos m\phi + h_{nm}(\tau) \sin m\phi\} \frac{dP_n^m(\theta)}{d\theta} \quad (5b)$$

$$B_\phi(r, \theta, \phi, \tau) = \frac{1}{\sin \theta} \sum_{n=1}^N \left(\frac{R_E}{r} \right)^{n+2} \sum_{m=0}^n m \{g_{nm}(\tau) \sin m\phi - h_{nm}(\tau) \cos m\phi\} P_n^m(\theta) \quad (5c)$$

It must be noted that the Gauss coefficients $g_{nm}(\tau)$ and $h_{nm}(\tau)$, as well as the associated Legendre polynomials and their derivatives, are Schmidt normalized by an international agreement (circa 1930) of the International Union of Geodesy and Geophysics. This particular

normalization allows one to determine which terms of the spherical harmonic model are the most significant simply by a cursory inspection of the model coefficients. The Schmidt-normalized associated Legendre Polynomials $P_n^m(\theta)$ are related to the unnormalized associated Legendre Polynomials $P^{nm}(\theta)$ (note position of indices) by the following relation:

$$P_n^m(\theta) = S^{nm} P^{nm}(\theta) \quad (6)$$

The Schmidt normalization factors S^{nm} and the unnormalized associated Legendre Polynomials $P^{nm}(\theta)$ are computed via recurrence relationships as follows:

$$P^{\infty}(\theta) = 1 \quad (7a)$$

$$P^{nm}(\theta) = \sin \theta P^{n-1,m-1}(\theta) \quad m = n \neq 0 \quad (7b)$$

$$P^{nm}(\theta) = \cos \theta P^{n-1,m}(\theta) - \kappa^{nm} P^{n-2,m}(\theta) \quad m \neq n, n \geq 1 \quad (7c)$$

$$\frac{dP^{\infty}(\theta)}{d\theta} = 0 \quad (7d)$$

$$\frac{dP^{nm}(\theta)}{d\theta} = \sin \theta \frac{dP^{n-1,m-1}(\theta)}{d\theta} + \cos \theta P^{n-1,m-1}(\theta) \quad , m = n \neq 0 \quad (7e)$$

$$\frac{dP^{nm}(\theta)}{d\theta} = \cos \theta \frac{dP^{n-1,m}(\theta)}{d\theta} - \sin \theta P^{n-1,m}(\theta) - \kappa^{nm} \frac{dP^{n-2,m}(\theta)}{d\theta} \quad , m \neq n, n \geq 1 \quad (7f)$$

where:

$$\kappa^{nm} = \frac{(n-1)^2 - m^2}{(2n-1)(2n-3)} \quad (8)$$

and where it is understood that the undefined polynomials $P^{-1,0}(\theta)$ and $\frac{dP^{-1,0}}{d\theta}(\theta)$ are to be set equal to zero. Similarly,

$$S^{\infty} = 1 \quad (9a)$$

$$S^{n0} = \left(\frac{2n-1}{n} \right) S^{n-1,0} \quad , n > 0 \quad (9b)$$

$$S^{nm} = \sqrt{\frac{(n-m+1)J}{n+m}} S^{n,m-1}, \quad \begin{cases} J=2 & \text{for } m=1 \\ J=1 & \text{for } m>1 \end{cases} \quad (9c)$$

Also, computed via recursion relations are the longitudinally dependent functions $\cos(m\phi)$ and $\sin(m\phi)$, which are computed as follows:

$$\sin(m\phi) = 0, \quad m=0 \quad (10a)$$

$$\cos(m\phi) = 1, \quad m=0 \quad (10b)$$

$$\sin(m\phi) = \sin(\phi)\cos(m-1)\phi + \cos(\phi)\sin(m-1)\phi, \quad m>0 \quad (10c)$$

$$\cos(m\phi) = \cos(\phi)\cos(m-1)\phi - \sin(\phi)\sin(m-1)\phi, \quad m>0 \quad (10d)$$

1.2 Coordinate Transformations

GEOMAG is intended to compute various components of the geomagnetic field in a geodetic coordinate system that uses the WGS-84 ellipsoid as the reference ellipsoid. However, the mathematical analysis in the previous section is based on spherical coordinates. Consequently, some coordinate transformations are necessary. A three-step procedure is required.

a. Convert the geodetic latitude, longitude, and altitude (λ, ϕ, h) to spherical coordinates (r, θ, ϕ) .

b. Compute the magnetic field components $B_r(r, \theta, \phi, \tau)$, $B_\theta(r, \theta, \phi, \tau)$, and $B_\phi(r, \theta, \phi, \tau)$.

c. Rotate the magnetic field components from spherical coordinates to geodetic coordinates yielding the magnetic field components $B_x(\lambda, \phi, h, \tau)$, $B_y(\lambda, \phi, h, \tau)$, and $B_z(\lambda, \phi, h, \tau)$, which are the projections of the magnetic field vector $\vec{B}(\lambda, \phi, h, \tau)$ onto the X-north, Y-east, and Z-vertically down coordinates of a local rectangular coordinate system defined by the tangent plane to the ellipsoid which is concentric about the WGS-84 reference ellipsoid but which encompasses the point (λ, ϕ, h) .

The transformations in step a are as follows:

$$\cos \theta = \frac{\sin \lambda}{\sqrt{Q^2 \cos^2 \lambda + \sin^2 \lambda}} \quad (11a)$$

$$\sin \theta = \sqrt{1 - \cos^2 \theta} \quad (11b)$$

where, if a and b are respectively the semi-major and semi-minor axes of the WGS-84 ellipsoid:

$$Q = \frac{h\sqrt{a^2 - (a^2 - b^2)\sin^2\lambda} + a^2}{h\sqrt{a^2 - (a^2 - b^2)\sin^2\lambda} + b^2} \quad (12)$$

Furthermore:

$$r^2 = h^2 + 2h\sqrt{a^2(a^2 - b^2)\sin^2\lambda} + \frac{a^4 - (a^4 - b^4)\sin^2\lambda}{a^2 - (a^2 - b^2)\sin^2\lambda} \quad (13)$$

The transformation in step c depends on the rotation angle α through which the magnetic field vector must be rotated in going from spherical to geodetic coordinates. This rotation angle is defined by the following rotations:

$$\cos \alpha = \{h + \sqrt{a^2 \cos^2 \lambda + b^2 \sin^2 \lambda}\} / r \quad (14a)$$

$$\sin \alpha = (a^2 - b^2) \cos \lambda \sin \lambda / \{r \sqrt{a^2 \cos^2 \lambda + b^2 \sin^2 \lambda}\} \quad (14b)$$

$$\alpha = \lambda - \frac{\pi}{2} + \theta \quad (14c)$$

Consequently, the components of the magnetic field vector in geodetic coordinates may be computed as follows:

$$B_x(\lambda, \phi, h, \tau) = -\cos \alpha B_\theta(r, \theta, \phi, \tau) - \sin \alpha B_r(r, \theta, \phi, \tau) \quad (15a)$$

$$B_y(\lambda, \phi, h, \tau) = B_\phi(r, \theta, \phi, \tau) \quad (15b)$$

$$B_z(\lambda, \phi, h, \tau) = \sin \alpha B_\theta(r, \theta, \phi, \tau) - \cos \alpha B_r(r, \theta, \phi, \tau) \quad (15c)$$

From these rectangular components of the geomagnetic field, it is possible to construct all others. In particular, the following parameters may be computed:

$$B_H(\lambda, \phi, h, \tau) = \sqrt{B_x^2(\lambda, \phi, h, \tau) + B_y^2(\lambda, \phi, h, \tau)} \quad (\text{Horizontal Intensity}) \quad (16a)$$

$$B_F(\lambda, \phi, h, \tau) = \sqrt{B_H^2(\lambda, \phi, h, \tau) + B_z^2(\lambda, \phi, h, \tau)} \quad (\text{Total Intensity}) \quad (16b)$$

$$B_D(\lambda, \phi, h, \tau) = \tan^{-1} \left\{ \frac{B_y(\lambda, \phi, h, \tau)}{B_x(\lambda, \phi, h, \tau)} \right\} \quad (\text{Declination}) \quad (16c)$$

$$B_I(\lambda, \phi, h, \tau) = \tan^{-1} \left\{ \frac{B_Z(\lambda, \phi, h, \tau)}{B_H(\lambda, \phi, h, \tau)} \right\} \quad (\text{Inclination}) \quad (16d)$$

$$B_G(\lambda, \phi, h, \tau) = \begin{cases} B_D - \phi & \lambda \geq 0 \\ B_D + \phi & \lambda < 0 \end{cases} \quad (\text{Grid Variation}) \quad (16e)$$

1.3 The Computer Algorithm

The Gauss coefficients at the base epoch, T_{EPOCH} , are stored in array C so that the lower half of array C is occupied by the even harmonic Gauss coefficients $g_{nm}(T_{EPOCH})$, while the upper half of array C is occupied by the odd harmonic Gauss coefficients $h_{nm}(T_{EPOCH})$. Table 1 illustrates the details of the storage scheme, which is equivalent to the following mathematical assignments:

$$C_{nm} = \begin{cases} g_{nm} & , m \leq n \\ h_{m,n+1} & , m > n \end{cases} \quad (17)$$

which implies that:

$$g_{nm} = C_{nm} \quad , m \leq n \quad (18a)$$

$$h_{nm} = C_{m-1,n} \quad , m \leq n, m \neq 0 \quad (18b)$$

The annual rates of change of the Gauss coefficients are stored in array CD (which stands for $\dot{C}$) so that the lower half of array CD is occupied by the even harmonic coefficients $\dot{g}_{nm}$, while the upper half of the array is occupied by the odd harmonic coefficients $\dot{h}_{nm}$. Table 2 illustrates the details of the storage scheme for array CD . It is essentially the same as table 1 for array C and corresponds to the following mathematical assignments:

$$\dot{C}_{nm} = \begin{cases} \dot{g}_{nm} & , m \leq n \\ \dot{h}_{m,n+1} & , m > n \end{cases} \quad (19)$$

which implies that:

$$\dot{g}_{nm} = \dot{C}_{nm} \quad , m \leq n \quad (20a)$$

$$\dot{h}_{nm} = \dot{C}_{m-1,n} \quad , m \leq n, m \neq 0 \quad (20b)$$

TABLE 1. ARRANGEMENT OF MAIN FIELD COEFFICIENTS IN ARRAY C_{nm}

$n \backslash m$	0	1	2	3	4	5	6	7	8	9	10	11	12
0	g_{00}	h_{11}	h_{21}	h_{31}	h_{41}	h_{51}	h_{61}	h_{71}	h_{81}	h_{91}	$h_{10,1}$	$h_{11,1}$	$h_{12,1}$
1	g_{10}	g_{11}	h_{22}	h_{32}	h_{42}	h_{52}	h_{62}	h_{72}	h_{82}	h_{92}	$h_{10,2}$	$h_{11,2}$	$h_{12,2}$
2	g_{20}	g_{21}	g_{22}	h_{33}	h_{43}	h_{53}	h_{63}	h_{73}	h_{83}	h_{93}	$h_{10,3}$	$h_{11,3}$	$h_{12,3}$
3	g_{30}	g_{31}	g_{32}	g_{33}	h_{44}	h_{54}	h_{64}	h_{74}	h_{84}	h_{94}	$h_{10,4}$	$h_{11,4}$	$h_{12,4}$
4	g_{40}	g_{41}	g_{42}	g_{43}	g_{44}	h_{55}	h_{65}	h_{75}	h_{85}	h_{95}	$h_{10,5}$	$h_{11,5}$	$h_{12,5}$
5	g_{50}	g_{51}	g_{52}	g_{53}	g_{54}	g_{55}	h_{66}	h_{76}	h_{86}	h_{96}	$h_{10,6}$	$h_{11,6}$	$h_{12,6}$
6	g_{60}	g_{61}	g_{62}	g_{63}	g_{64}	g_{65}	g_{66}	h_{77}	h_{87}	h_{97}	$h_{10,7}$	$h_{11,7}$	$h_{12,7}$
7	g_{70}	g_{71}	g_{72}	g_{73}	g_{74}	g_{75}	g_{76}	g_{77}	h_{88}	h_{98}	$h_{10,8}$	$h_{11,8}$	$h_{12,8}$
8	g_{80}	g_{81}	g_{82}	g_{83}	g_{84}	g_{85}	g_{86}	g_{87}	g_{88}	h_{99}	$h_{10,9}$	$h_{11,9}$	$h_{12,9}$
9	g_{90}	g_{91}	g_{92}	g_{93}	g_{94}	g_{95}	g_{96}	g_{97}	g_{98}	g_{99}	$h_{10,10}$	$h_{11,10}$	$h_{12,10}$
10	$g_{10,0}$	$g_{10,1}$	$g_{10,2}$	$g_{10,3}$	$g_{10,4}$	$g_{10,5}$	$g_{10,6}$	$g_{10,7}$	$g_{10,8}$	$g_{10,9}$	$g_{10,10}$	$h_{11,11}$	$h_{12,11}$
11	$g_{11,0}$	$g_{11,1}$	$g_{11,2}$	$g_{11,3}$	$g_{11,4}$	$g_{11,5}$	$g_{11,6}$	$g_{11,7}$	$g_{11,8}$	$g_{11,9}$	$g_{11,10}$	$g_{11,11}$	$h_{12,12}$
12	$g_{12,0}$	$g_{12,1}$	$g_{12,2}$	$g_{12,3}$	$g_{12,4}$	$g_{12,5}$	$g_{12,6}$	$g_{12,7}$	$g_{12,8}$	$g_{12,9}$	$g_{12,10}$	$g_{12,11}$	$g_{12,12}$

TABLE 2. ARRANGEMENT OF SECULAR VARIATION COEFFICIENTS IN ARRAY $\dot{C}_{nm}$

$n \backslash m$	0	1	2	3	4	5	6	7	8	9	10	11	12
0	$\dot{g}_{00}$	$\dot{h}_{11}$	$\dot{h}_{21}$	$\dot{h}_{31}$	$\dot{h}_{41}$	$\dot{h}_{51}$	$\dot{h}_{61}$	$\dot{h}_{71}$	$\dot{h}_{81}$	$\dot{h}_{91}$	$\dot{h}_{10,1}$	$\dot{h}_{11,1}$	$\dot{h}_{12,1}$
1	$\dot{g}_{10}$	$\dot{g}_{11}$	$\dot{h}_{22}$	$\dot{h}_{32}$	$\dot{h}_{42}$	$\dot{h}_{52}$	$\dot{h}_{62}$	$\dot{h}_{72}$	$\dot{h}_{82}$	$\dot{h}_{92}$	$\dot{h}_{10,2}$	$\dot{h}_{11,2}$	$\dot{h}_{12,2}$
2	$\dot{g}_{20}$	$\dot{g}_{21}$	$\dot{g}_{22}$	$\dot{h}_{33}$	$\dot{h}_{43}$	$\dot{h}_{53}$	$\dot{h}_{63}$	$\dot{h}_{73}$	$\dot{h}_{83}$	$\dot{h}_{93}$	$\dot{h}_{10,3}$	$\dot{h}_{11,3}$	$\dot{h}_{12,3}$
3	$\dot{g}_{30}$	$\dot{g}_{31}$	$\dot{g}_{32}$	$\dot{g}_{33}$	$\dot{h}_{44}$	$\dot{h}_{54}$	$\dot{h}_{64}$	$\dot{h}_{74}$	$\dot{h}_{84}$	$\dot{h}_{94}$	$\dot{h}_{10,4}$	$\dot{h}_{11,4}$	$\dot{h}_{12,4}$
4	$\dot{g}_{40}$	$\dot{g}_{41}$	$\dot{g}_{42}$	$\dot{g}_{43}$	$\dot{g}_{44}$	$\dot{h}_{55}$	$\dot{h}_{65}$	$\dot{h}_{75}$	$\dot{h}_{85}$	$\dot{h}_{95}$	$\dot{h}_{10,5}$	$\dot{h}_{11,5}$	$\dot{h}_{12,5}$
5	$\dot{g}_{50}$	$\dot{g}_{51}$	$\dot{g}_{52}$	$\dot{g}_{53}$	$\dot{g}_{54}$	$\dot{g}_{55}$	$\dot{h}_{66}$	$\dot{h}_{76}$	$\dot{h}_{86}$	$\dot{h}_{96}$	$\dot{h}_{10,6}$	$\dot{h}_{11,6}$	$\dot{h}_{12,6}$
6	$\dot{g}_{60}$	$\dot{g}_{61}$	$\dot{g}_{62}$	$\dot{g}_{63}$	$\dot{g}_{64}$	$\dot{g}_{65}$	$\dot{g}_{66}$	$\dot{h}_{77}$	$\dot{h}_{87}$	$\dot{h}_{97}$	$\dot{h}_{10,7}$	$\dot{h}_{11,7}$	$\dot{h}_{12,7}$
7	$\dot{g}_{70}$	$\dot{g}_{71}$	$\dot{g}_{72}$	$\dot{g}_{73}$	$\dot{g}_{74}$	$\dot{g}_{75}$	$\dot{g}_{76}$	$\dot{g}_{77}$	$\dot{h}_{88}$	$\dot{h}_{98}$	$\dot{h}_{10,8}$	$\dot{h}_{11,8}$	$\dot{h}_{12,8}$
8	$\dot{g}_{80}$	$\dot{g}_{81}$	$\dot{g}_{82}$	$\dot{g}_{83}$	$\dot{g}_{84}$	$\dot{g}_{85}$	$\dot{g}_{86}$	$\dot{g}_{87}$	$\dot{g}_{88}$	$\dot{h}_{99}$	$\dot{h}_{10,9}$	$\dot{h}_{11,9}$	$\dot{h}_{12,9}$
9	$\dot{g}_{90}$	$\dot{g}_{91}$	$\dot{g}_{92}$	$\dot{g}_{93}$	$\dot{g}_{94}$	$\dot{g}_{95}$	$\dot{g}_{96}$	$\dot{g}_{97}$	$\dot{g}_{98}$	$\dot{g}_{99}$	$\dot{h}_{10,10}$	$\dot{h}_{11,10}$	$\dot{h}_{12,10}$
10	$\dot{g}_{10,0}$	$\dot{g}_{10,1}$	$\dot{g}_{10,2}$	$\dot{g}_{10,3}$	$\dot{g}_{10,4}$	$\dot{g}_{10,5}$	$\dot{g}_{10,6}$	$\dot{g}_{10,7}$	$\dot{g}_{10,8}$	$\dot{g}_{10,9}$	$\dot{g}_{10,10}$	$\dot{h}_{11,11}$	$\dot{h}_{12,11}$
11	$\dot{g}_{11,0}$	$\dot{g}_{11,1}$	$\dot{g}_{11,2}$	$\dot{g}_{11,3}$	$\dot{g}_{11,4}$	$\dot{g}_{11,5}$	$\dot{g}_{11,6}$	$\dot{g}_{11,7}$	$\dot{g}_{11,8}$	$\dot{g}_{11,9}$	$\dot{g}_{11,10}$	$\dot{g}_{11,11}$	$\dot{h}_{12,12}$
12	$\dot{g}_{12,0}$	$\dot{g}_{12,1}$	$\dot{g}_{12,2}$	$\dot{g}_{12,3}$	$\dot{g}_{12,4}$	$\dot{g}_{12,5}$	$\dot{g}_{12,6}$	$\dot{g}_{12,7}$	$\dot{g}_{12,8}$	$\dot{g}_{12,9}$	$\dot{g}_{12,10}$	$\dot{g}_{12,11}$	$\dot{g}_{12,12}$

The numerical values of the Gauss coefficients at the base epoch and their corresponding annual rates of change for the WMM-90 geomagnetic model are listed in table 3. These numerical values are inserted into arrays *C* and *CD* through data statements. The base epoch of the model is also assigned through a data statement. In order to update the GEOMAG algorithm to a new epoch geomagnetic model such as WMM-95, it is necessary to replace only the data statements with the new model coefficients and the new base epoch.

Important parameters in the GEOMAG routine and their mathematical correspondences are:

$A \sim a = 6378.137 \text{ km}$
 $B \sim b = 6356.7523142 \text{ km}$
 $RE \sim R_E = 6371.2 \text{ km}$
 $TIME \sim \tau$
 $EPOCH \sim T_{EPOCH}$
 $DT \sim \tau - T_{EPOCH}$
 $ALT \sim h$
 $SNORM(N,M) \sim S^{nm}$
 $K(N,M) \sim \kappa^{nm}$
 $GLAT \sim \lambda$
 $GLON \sim \phi$
 $SP(M) \sim \sin(m\phi)$
 $CP(M) \sim \cos(m\phi)$
 $ST \sim \sin(\theta)$
 $CT \sim \cos(\theta)$
 $CA \sim \cos(\alpha)$
 $SA \sim \sin(\alpha)$
 $BR \sim B_r$
 $BT \sim B_\theta$
 $BP \sim B_\phi$
 $BX \sim B_x$
 $BY \sim B_y$
 $BZ \sim B_z$
 $BH \sim B_H$
 $DEC \sim B_D$
 $DIP \sim B_I$
 $TI \sim B_{TI}$
 $MAXDEG \sim N$
 $MAXORD \sim M = N$
 $P(N,M) \sim P^{nm}$
 $DP(N,M) \sim \frac{dP^{nm}}{d\theta}$

$$\begin{aligned} TC &\sim C + (\tau - T_{EPOCH}) \dot{C} \\ CD &\sim \dot{C} \\ Q2 &\sim Q^2 \end{aligned}$$

Note that R_E is not intended to be the mean radius of the WGS-84 ellipsoid. It is the mean radius of a modified IAU-66 ellipsoid.

The GEOMAG algorithm is organized into two modules, each with its own entry point. The first is an Initialization Module. Its purpose is to compute all constants such as the recursion relation factors for the associated Legendre polynomials κ^m , the Schmidt normalization factors S^m , and any other parameters that do not depend on position or time. The entry point for this module is GEOMAG (MAXDEG). The parameter MAXDEG determines the maximum degree and order of the magnetic model to be used in the computations. Normally, MAXDEG = 12, which is the maximum degree and order of the WMM series geomagnetic models. In order to reduce computation time, MAXDEG may be set to a number less than 12 (e.g., 8 or 10). However, the accuracy of the computed magnetic parameters is correspondingly reduced. MAXDEG must be set in the calling program. The second module is the Processing Module, which has the entry point

GEOMG1 (ALT, GLAT, GLON, TIME, DEC, DIP, TI, GV).

The purpose of this module is to compute the magnetic declination, inclination, total intensity, and grid variation of each geodetic position and time supplied to it. The units of the parameters in the argument list of the GEOMG1 entry point are as follows:

ALT ~ kilometers (e.g., 5.314)	(In)
GLAT ~ degrees (e.g., 33.716)	(In)
GLON ~ degrees (e.g., -163.315)	(In)
TIME ~ years (e.g., 1992.427)	(In)
DEC ~ degrees (e.g., -121.734)	(Out)
DIP ~ degrees (e.g., 48.387)	(Out)
TI ~ nanoteslas (e.g., 35781.7)	(Out)
GV ~ degrees (e.g., 51.768)	(Out)

The computed magnetic field parameters are referenced to the WGS-84 ellipsoid. The last parameter, GV, is the grid variation which is computed only in the polar regions (i.e., above + 55° latitude or below - 55° latitude). Outside of this region, a value of -999.0 is dummied in. It is referenced to grid north of a polar stereographic projection. The model is considered valid at altitudes ranging from sea level to 1000 km.

TABLE 3. WMM-90 SCHMIDT NORMALIZED GAUSS COEFFICIENTS (nT)

n	m	g_{nm}	h_{nm}	$\dot{g}_{nm}$	$\dot{h}_{nm}$
1	0	-29780.5	.0	16.0	.0
1	1	-1851.7	5407.2	9.3	-13.8
2	0	-2134.3	.0	-11.7	.0
2	1	3062.2	-2278.3	3.7	-12.8
2	2	1691.9	-384.3	1.8	-14.9
3	0	1312.9	.0	2.1	.0
3	1	-2244.7	-284.9	-7.6	3.1
3	2	1246.8	291.7	.0	.8
3	3	808.6	-352.4	-5.8	-11.3
4	0	933.5	.0	-.8	.0
4	1	784.9	249.4	1.0	3.3
4	2	323.5	-232.7	-7.4	3.7
4	3	-421.7	91.3	.8	2.8
4	4	139.2	-296.5	-6.4	.0
5	0	-208.3	.0	1.7	.0
5	1	352.2	40.8	.0	.0
5	2	246.5	148.7	.0	-2.1
5	3	-110.8	-154.6	-2.7	1.2
5	4	-162.3	-67.6	.0	1.2
5	5	-37.2	97.4	3.0	.6
6	0	59.0	.0	.8	.0
6	1	63.7	-14.7	.0	-.6
6	2	60.0	82.2	1.5	-.6
6	3	-181.3	70.0	.0	.0
6	4	.4	-56.2	.0	-2.3
6	5	15.4	-1.4	.0	.0
6	6	-96.0	24.6	.0	.0
7	0	76.1	.0	.5	.0
7	1	-62.1	-78.6	.0	.6
7	2	1.3	-26.7	-.9	.8
7	3	30.2	.1	1.5	.0
7	4	4.7	19.9	2.7	.0
7	5	7.9	17.9	-1.0	.0
7	6	10.1	-21.5	.0	.4
7	7	1.9	-6.8	.0	.0
8	0	22.9	.0	.0	.0
8	1	2.3	9.7	-1.1	.4
8	2	-1.2	-19.3	.0	-.8
8	3	-11.7	6.6	.0	.5
8	4	-17.5	-20.1	-2.1	.3
8	5	2.2	13.4	.0	.5
8	6	5.7	9.8	1.0	.0
8	7	3.0	-19.0	.0	-.7
8	8	-7.0	-9.1	.0	.0

TABLE 3. WMM-90 SCHMIDT NORMALIZED GAUSS COEFFICIENTS (con.)

n	m	g_{nm}	h_{nm}	$\dot{g}_{nm}$	$\dot{h}_{nm}$
9	0	3.6	.0	.0	.0
9	1	9.5	-21.9	.0	.0
9	2	-.9	14.3	.0	.0
9	3	-10.7	9.5	.0	.0
9	4	10.7	-6.7	.0	.0
9	5	-3.2	-6.4	.0	.0
9	6	-1.4	9.1	.0	.0
9	7	6.3	8.9	.0	.0
9	8	.8	-8.0	.0	.0
9	9	-5.5	2.1	.0	.0
10	0	-3.3	.0	.0	.0
10	1	-2.6	2.6	.0	.0
10	2	4.5	1.2	.0	.0
10	3	-5.6	2.6	.0	.0
10	4	-3.6	5.7	.0	.0
10	5	3.9	-4.0	.0	.0
10	6	3.2	-.4	.0	.0
10	7	1.7	-1.7	.0	.0
10	8	3.0	3.8	.0	.0
10	9	3.7	-.8	.0	.0
10	10	.7	-6.5	.0	.0
11	0	1.3	.0	.0	.0
11	1	-1.4	.0	.0	.0
11	2	-2.5	1.0	.0	.0
11	3	3.2	-1.6	.0	.0
11	4	.2	-2.2	.0	.0
11	5	-1.1	1.1	.0	.0
11	6	.3	-.7	.0	.0
11	7	-.3	-1.7	.0	.0
11	8	.9	-1.5	.0	.0
11	9	-1.1	-1.3	.0	.0
11	10	2.4	-1.1	.0	.0
11	11	3.0	.6	.0	.0
12	0	-1.3	.0	.0	.0
12	1	.1	.7	.0	.0
12	2	.5	.7	.0	.0
12	3	.7	1.3	.0	.0
12	4	.4	-1.5	.0	.0
12	5	-.2	.3	.0	.0
12	6	-1.1	.2	.0	.0
12	7	.9	-1.1	.0	.0
12	8	-.6	1.2	.0	.0
12	9	.8	-.2	.0	.0
12	10	.2	-1.3	.0	.0
12	11	.4	.6	.0	.0
12	12	.2	.6	.0	.0

SECTION 2. THE 1990 EPOCH WORLD MAGNETIC MODEL (DERIVATION)

2.0 Overview

There were four major data sets available for the 1990 model. These were: the MAGSAT satellite data collected during 1979 and 1980; the DE-2 satellite data collected from 1981 through 1983; Project MAGNET aeromagnetic data collected between 1980 and 1990; and geomagnetic observatory annual magnetic means data collected between 1980 and 1990. The global distribution of these data is illustrated in charts 1 through 4.

Four factors which affect the quality of the model produced and which influence the overall approach taken to produce the model are:

- a. The age of the data relative to the model epoch;
- b. The temporal coherence of the data;
- c. The spatial uniformity of the data; and
- d. The data density.

With respect to these factors, none of the four data sets are ideal. All four data sets, especially the satellite data sets, are dominated by older data. The Project MAGNET data, in addition, are neither temporally coherent nor spatially uniform. Furthermore, the observatory annual means data are sparse and suffer from severe spatial nonuniformity.

The modeling objective is to create two spherical harmonic models. One model characterizes the Earth's main (core-generated) magnetic field at the 1990.0 epoch. The other model characterizes the Earth's secular (slow temporal) magnetic variations of Earth core origin for five years beyond the 1990 epoch.

Given the objective and the available data, the following procedure was adopted:

- a. Use the observatory annual magnetic means to create two definitive secular variation models, the first covering the 5-year interval 1980 to 1985, and the second covering the 5-year interval 1985 to 1990. These are referred to as the 1982.5 and 1987.5 definitive secular variation models, respectively.

- b. Use the observatory annual magnetic means to create, by extrapolation, one predictive secular variation model covering the 5-year interval 1990 to 1995. It is referred to as the 1992.5 predictive secular variation model.

- c. Use the two definitive secular variation models to push the satellite and aircraft magnetic field observations forward or backward, as appropriate, to 1985.0.



CHART 1. PROJECT MAGNET DATA DISTRIBUTION (FROM SURVEYS
PERFORMED DURING THE PERIOD 1980-1989)

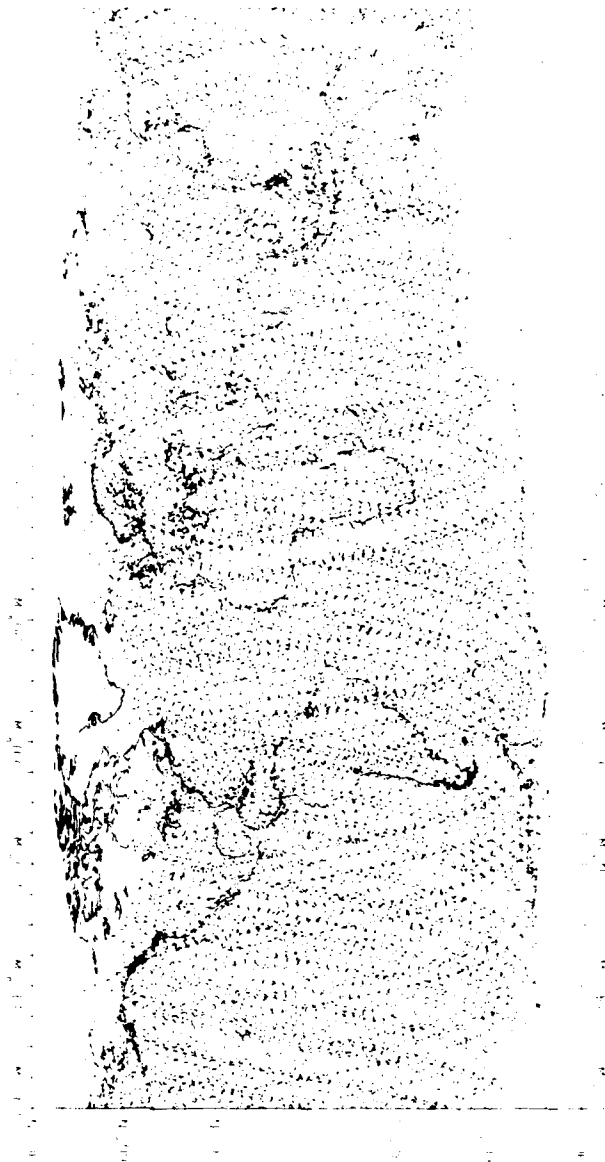


CHART 2. MAGSAT DATA DISTRIBUTION

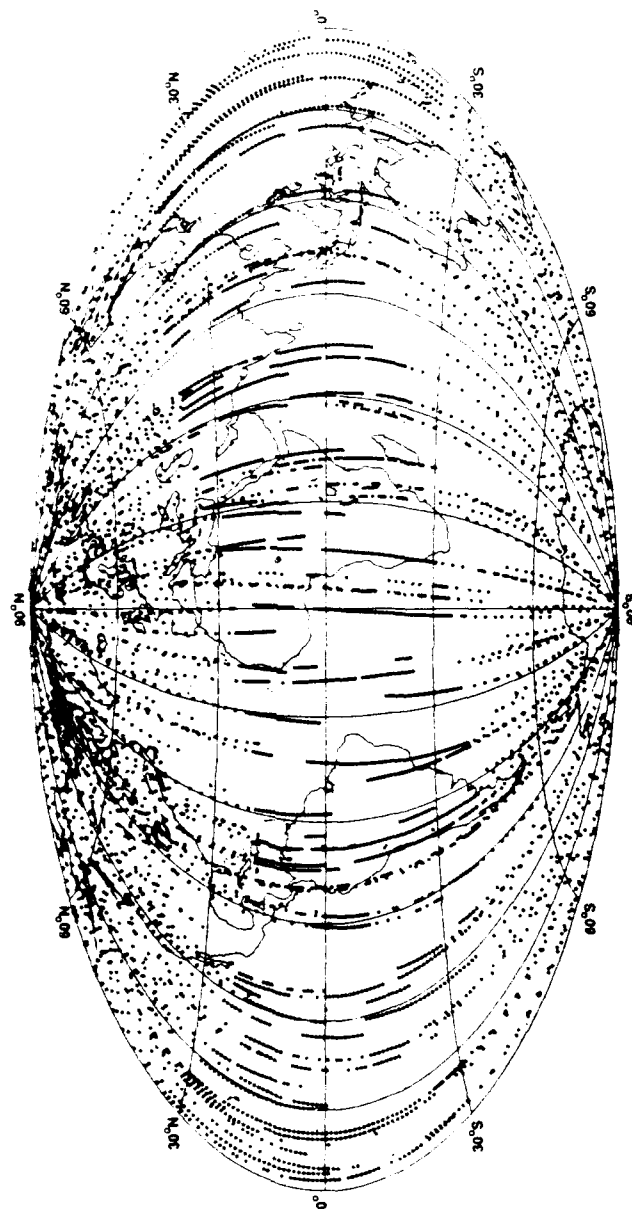


CHART 3. DE-2 DATA DISTRIBUTION

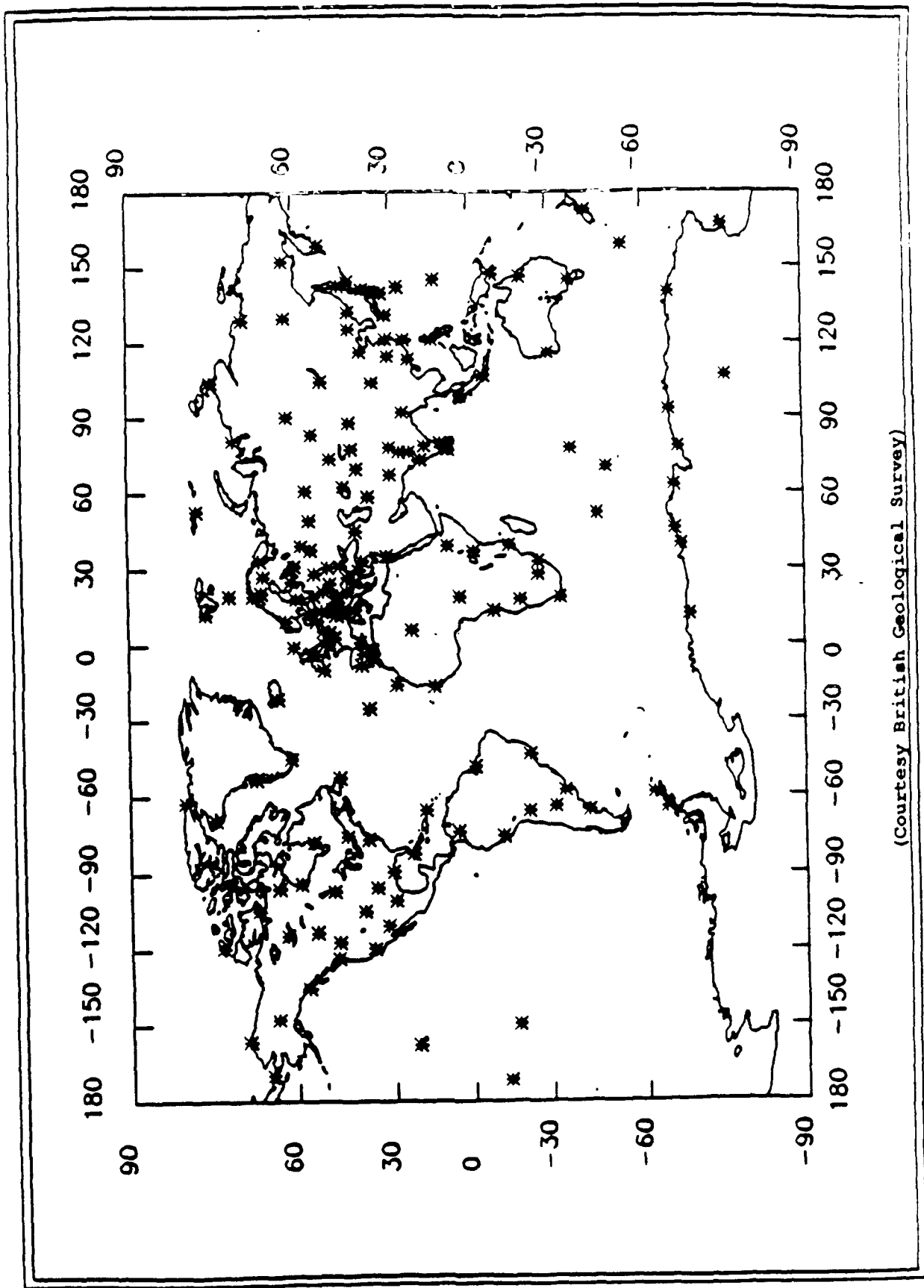


CHART 4. GEOMAGNETIC OBSERVATORY DISTRIBUTION

d. Create a 1985.0 epoch main field model using the time-adjusted satellite and aircraft magnetic field observations via a weighted least-square inversion.

e. Use the 1987.5 definitive secular variation model to push the spherical harmonic coefficients of the 1985.0 epoch main field model forward to the 1990.0 epoch, thereby yielding the 1990.0 epoch main field model.

f. Combine the 1990 epoch main field model coefficients with the 1992.5 predictive secular variation model coefficients to form the 1990 World Magnetic Model, WMM-90.

A by-product of this procedure is a revised 1985.0 epoch World Chart Model which is obtained by combining the 1985.0 main field coefficients generated in step d with the 1987.5 definitive secular variation model coefficients generated in step a.

2.1 Secular Variation Data Analysis (British Responsibility)

The only data available for secular variation modeling are the observatory magnetic annual means, the first time derivative which provides information concerning the slow (greater than one year) rates of change of various components of the Earth's main magnetic field at various geographic locations (roughly 200) around the world. Because of the sparsity and spatial nonuniformity of this data, it is possible to generate only a degree and order 8 spherical harmonic model of the secular variation. Furthermore, the predictive model is necessarily based on extrapolations of each magnetic component at each observatory site. Examples of observatory annual means from a few selected sites such as Honolulu, Huancayo, Pilar, and Rude Skov, for the X-north, Y-east, and Z-vertically down components of the Earth's magnetic field, are given in figures (1a), (1b), (1c), (1d), (1e) and (1f) through (4a), (4b), (4c), (4d), (4e) and (4f). The discontinuities in the field components at Honolulu are due to repositioning of the observatory at two separate instances. In several instances, the rate of change of one or more field components at an observatory has reversed direction over time intervals as short as two or three years. The sudden, unpredictable nature of the Earth's field is well illustrated by these observatories. The first-order time derivative of these data contains magnetic field contributions from the Earth's core as well as from the ionosphere and magnetosphere. It is difficult to remove the external field effects from these data because much of it is related to the solar cycle and many observatories do not have a sufficiently long history for a detailed analysis. Consequently, some external field effects are not removed from these data at the expense of a somewhat larger uncertainty in the secular variation model coefficients.

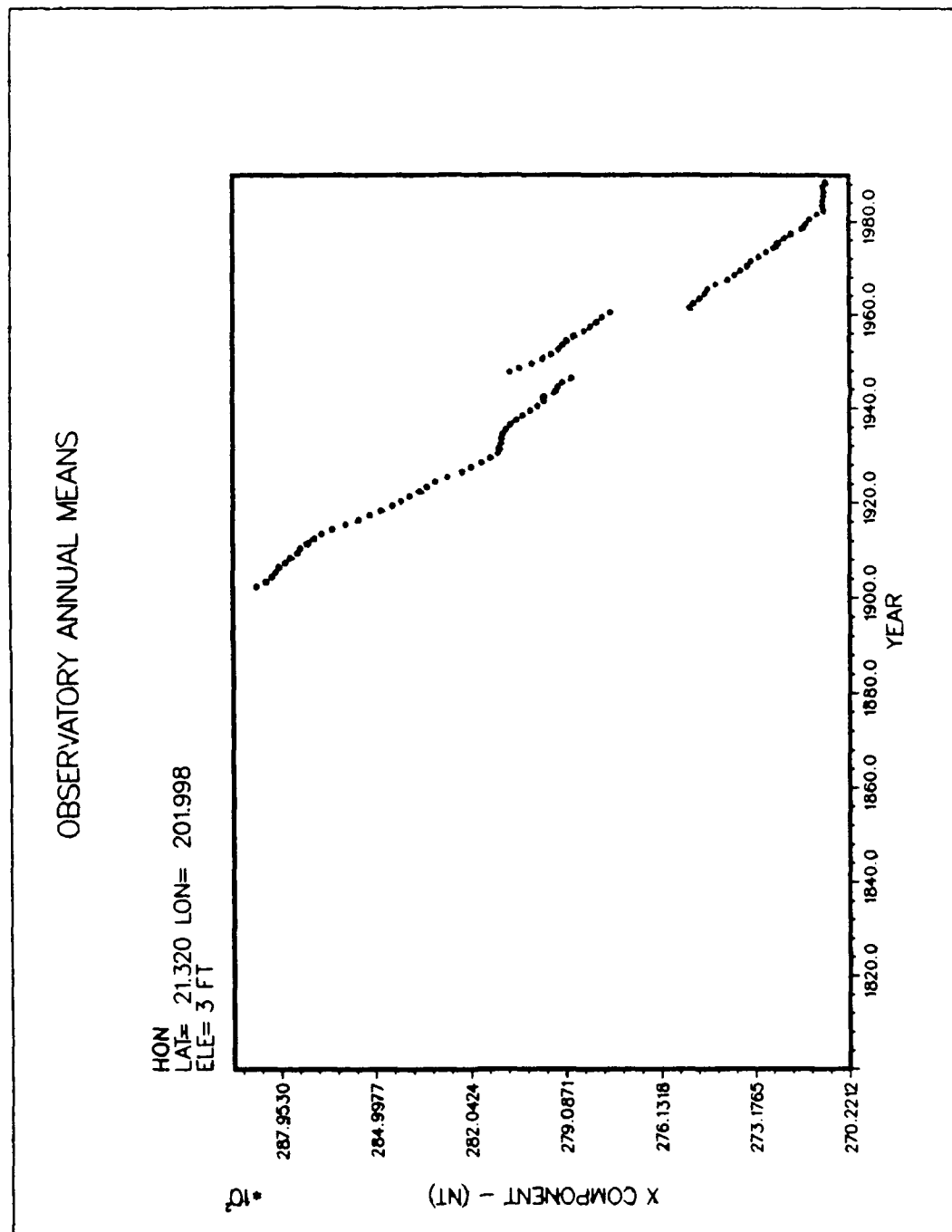


FIGURE 1a. NORTH X COMPONENT AT HONOLULU (HON).

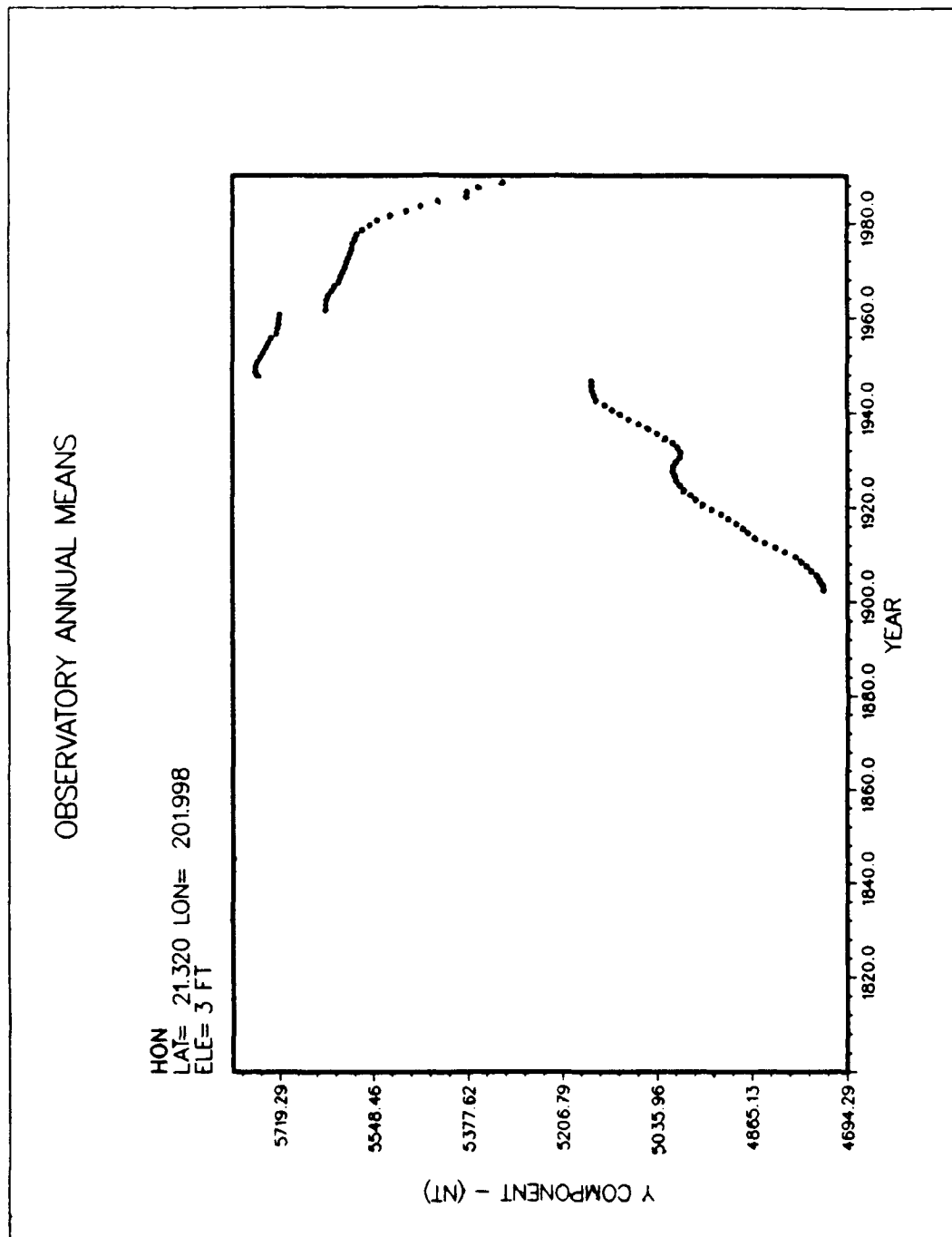


FIGURE 1b. EAST Y COMPONENT AT HONOLULU (HON).

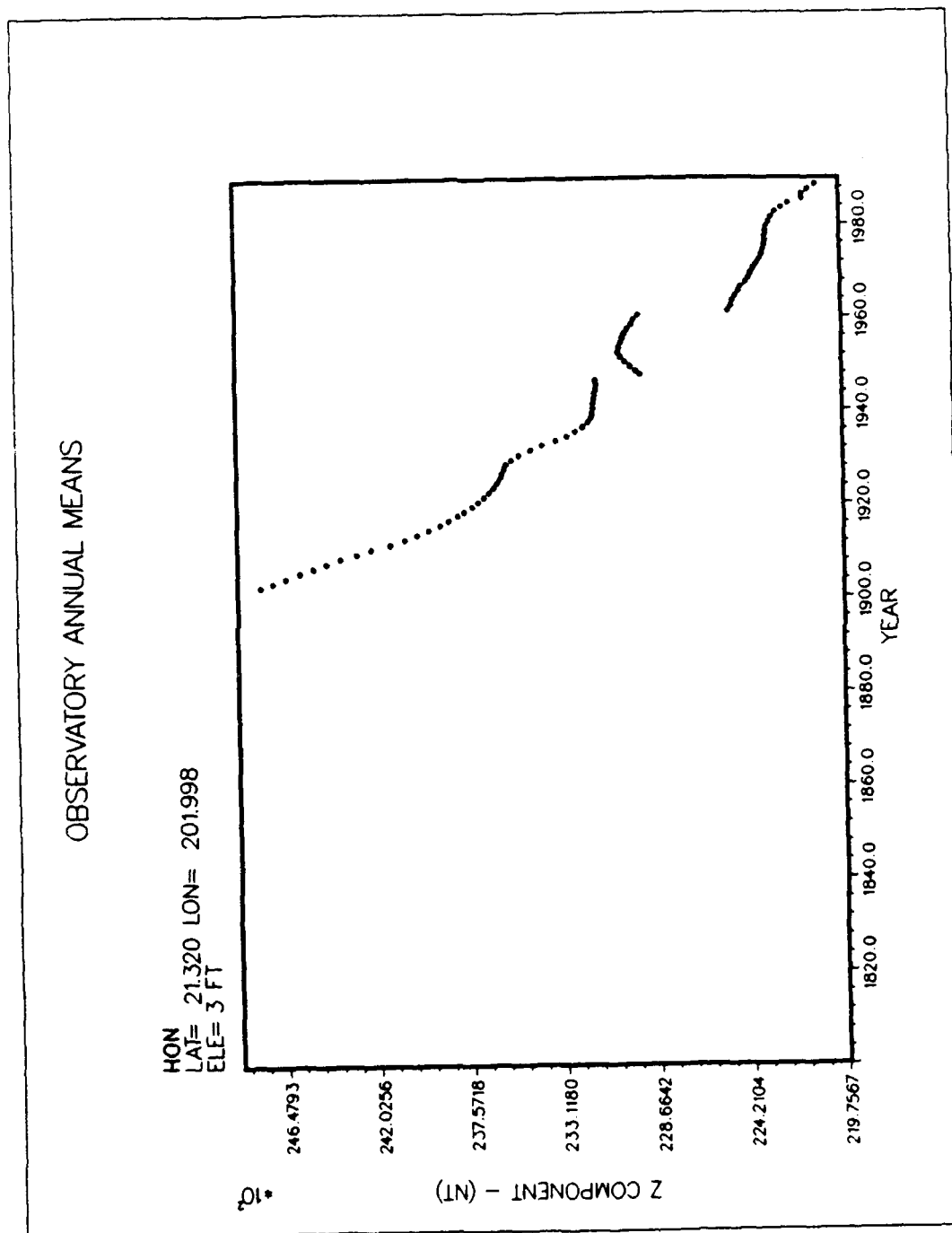


FIGURE 1c. VERTICAL Z COMPONENT AT HONOLULU (HON).

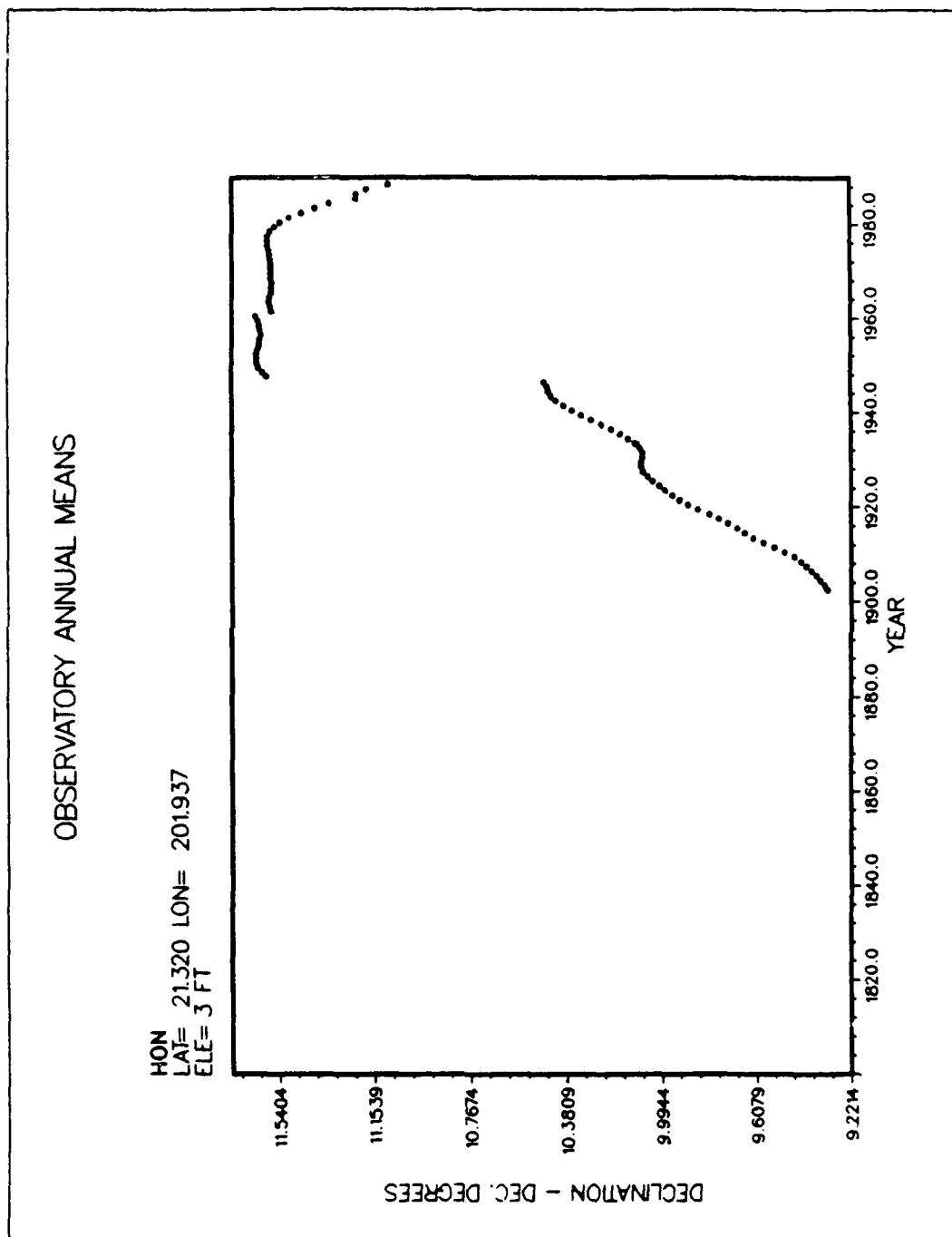


FIGURE 1d. DECLINATION D COMPONENT AT HONOLULU (HON).

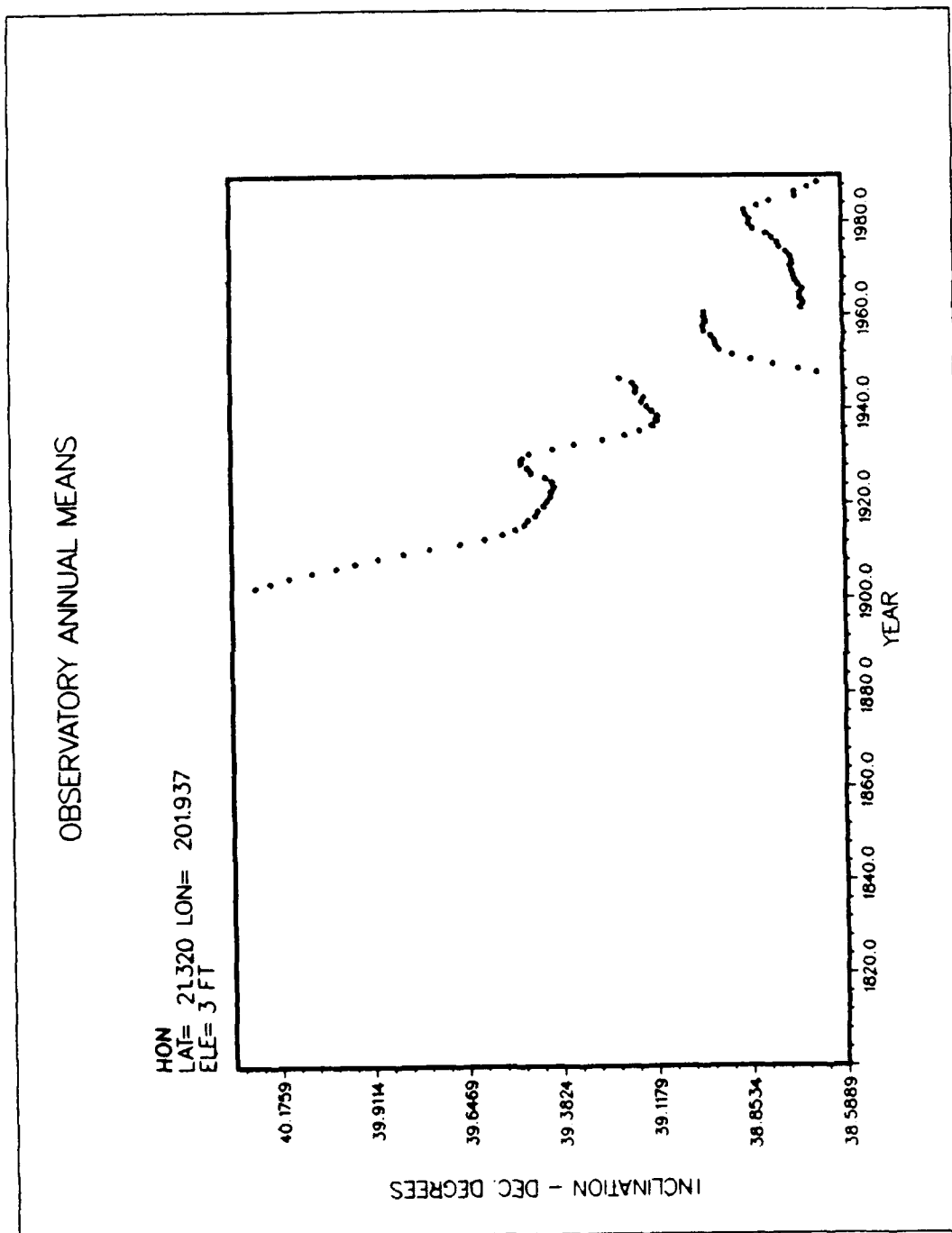


FIGURE 1c. INCLINATION I COMPONENT AT HONOLULU (HON).

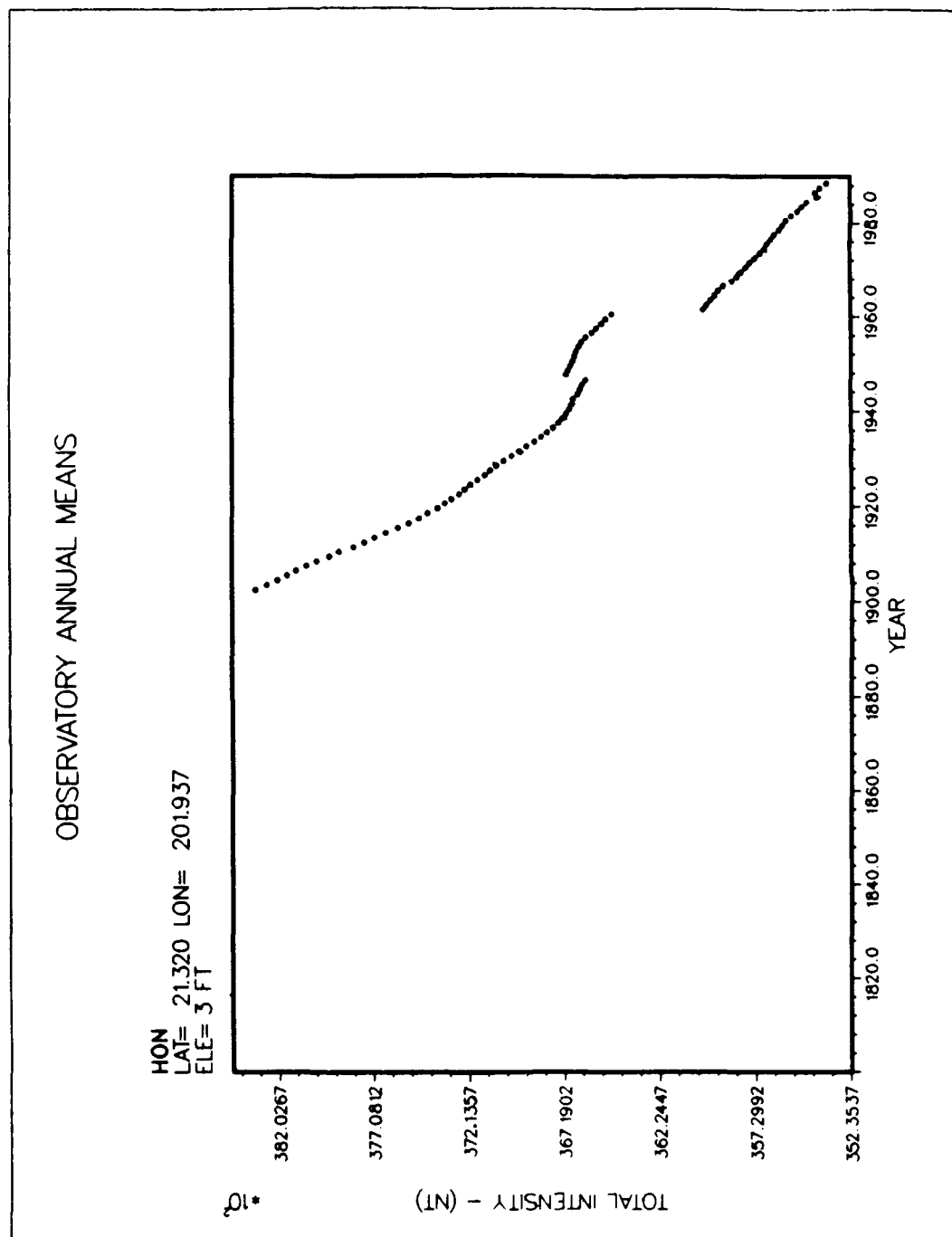


FIGURE 1f. TOTAL INTENSITY F COMPONENT AT HONOLULU (HON).

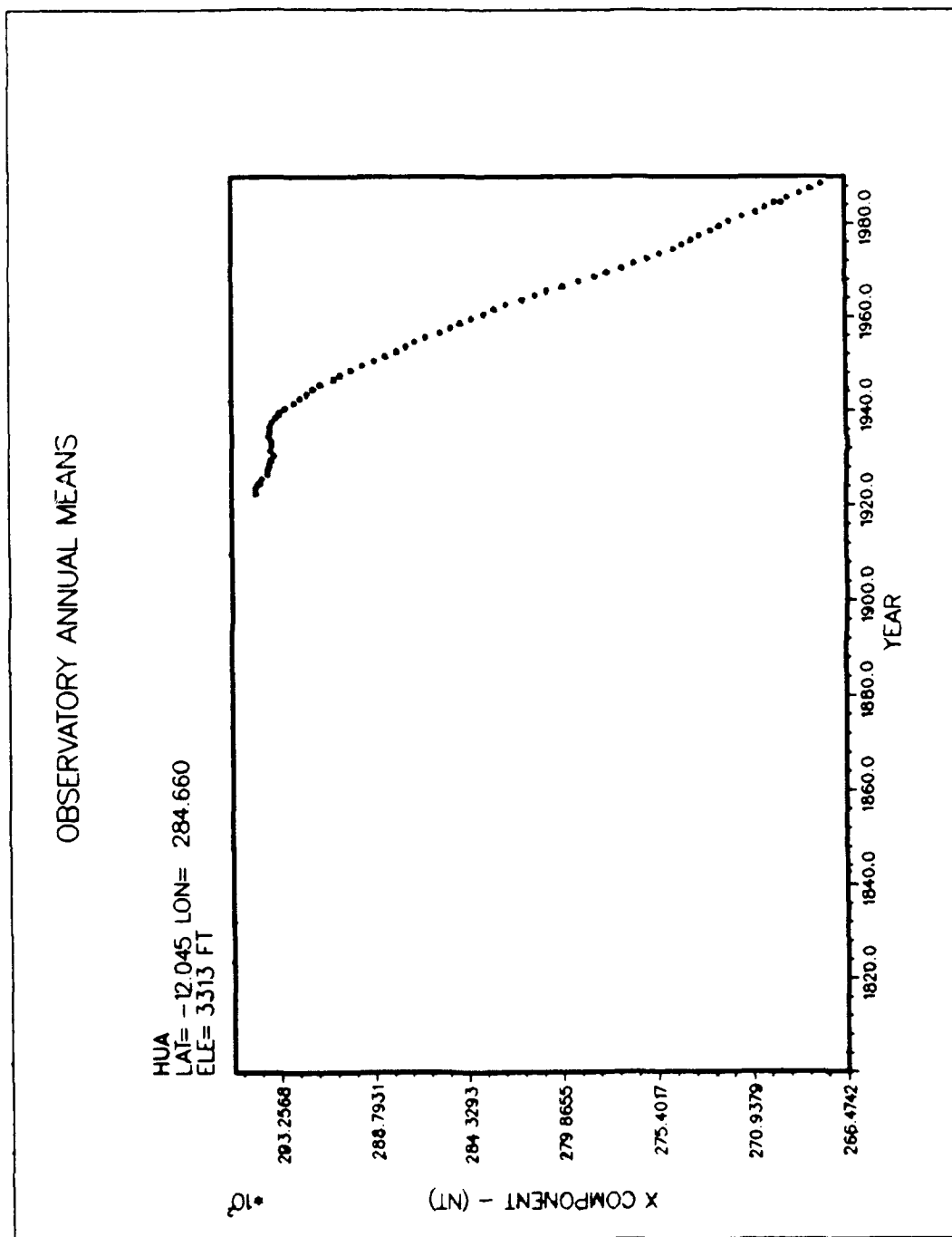


FIGURE 2a. NORTH X COMPONENT AT HUANCAYO (HUA).

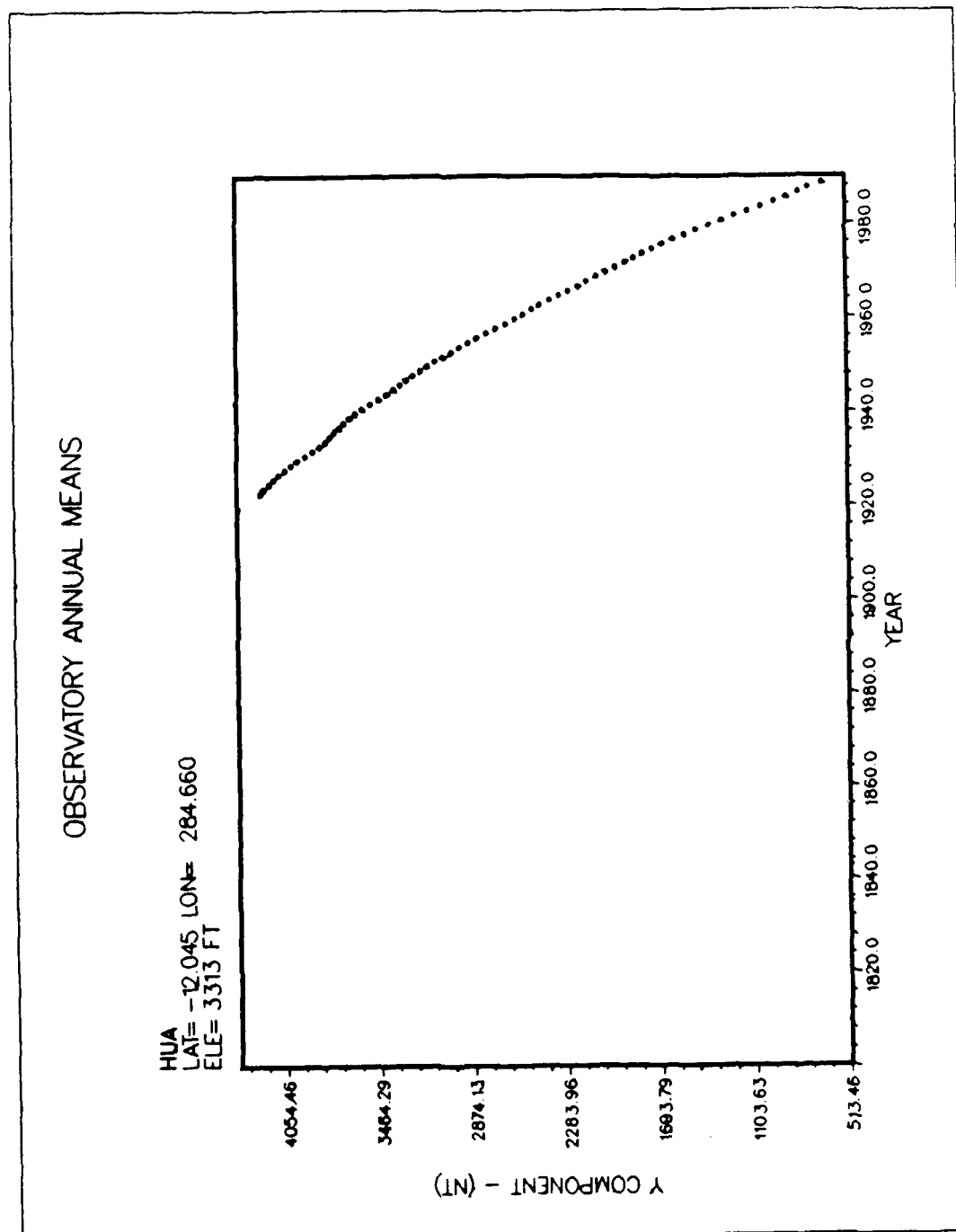


FIGURE 2b. EAST Y COMPONENT AT HUANCAYO (HUA).

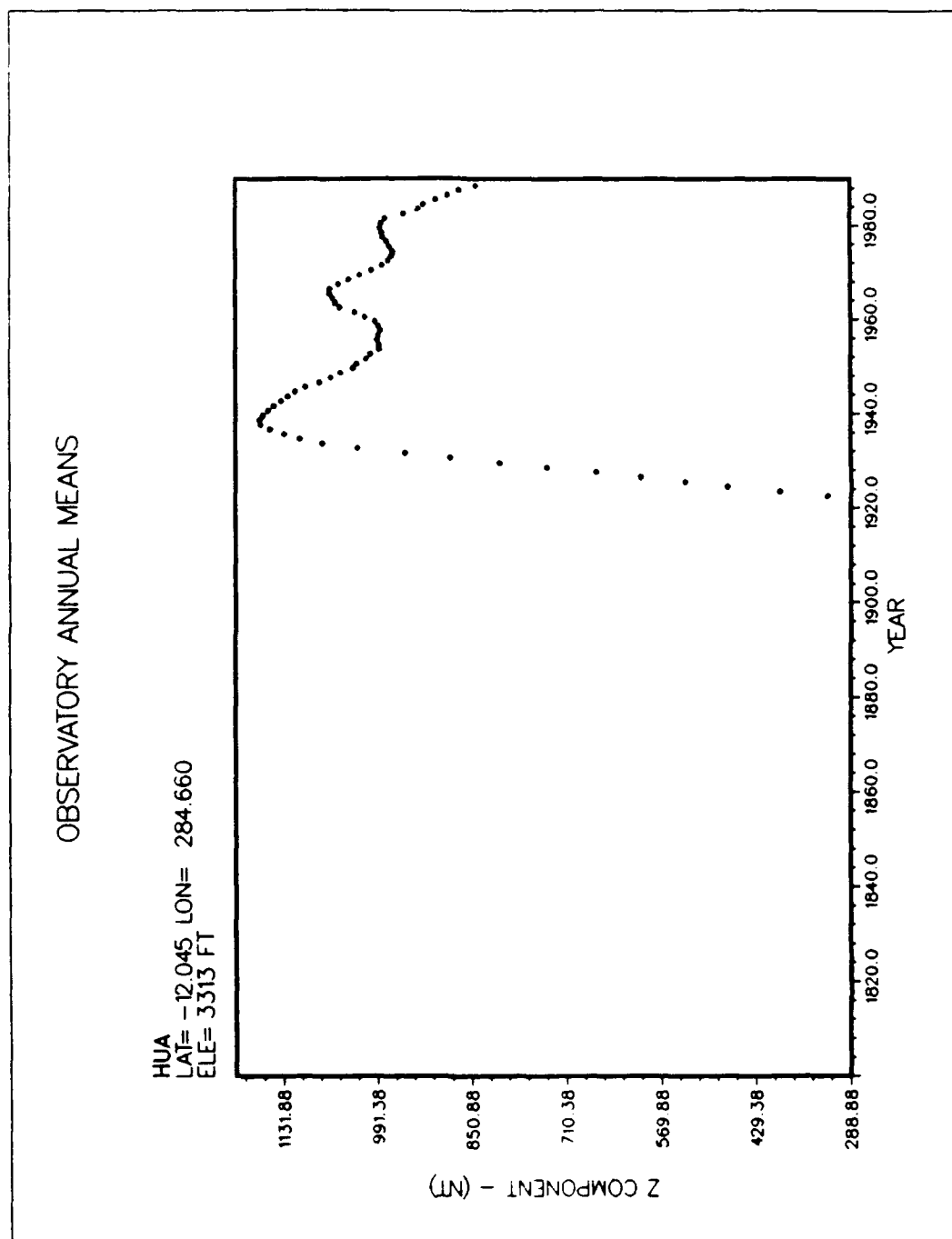


FIGURE 2c. VERTICAL Z COMPONENT AT HUANCAYO (HUA).

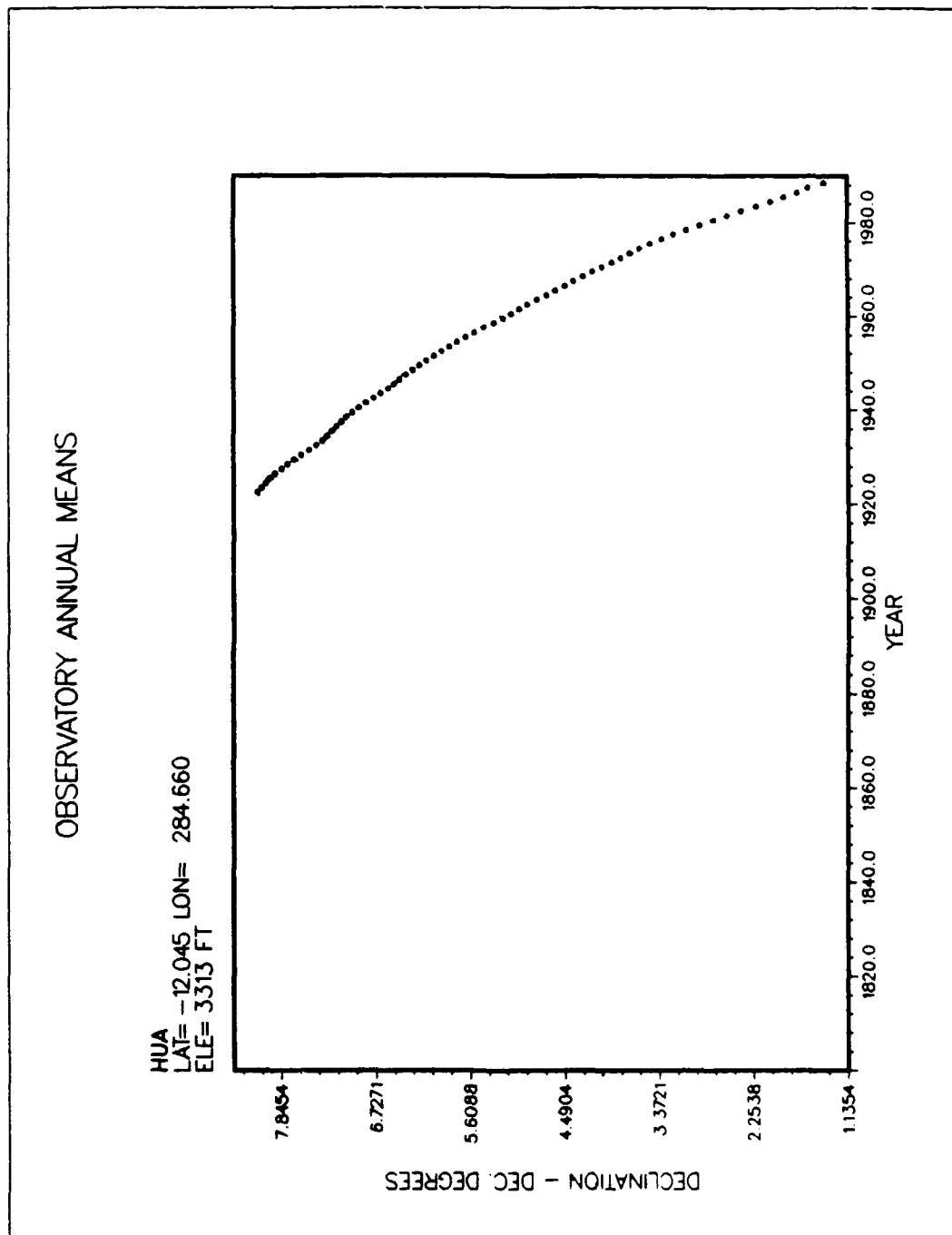


FIGURE 2d. DECLINATION D COMPONENT AT HUANCANO (HUA).

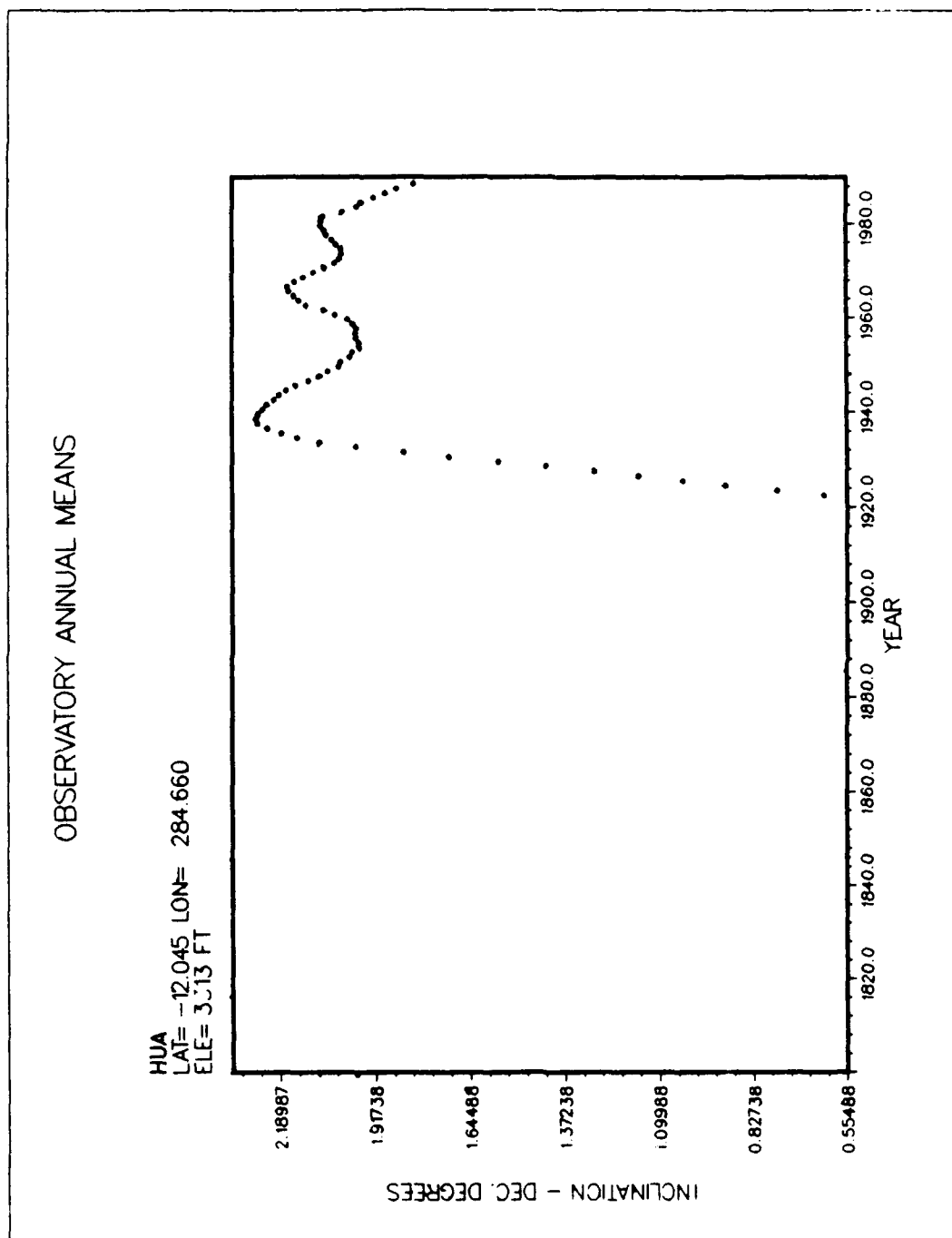


FIGURE 2c: INCLINATION I COMPONENT AT HUANCAYO (HUA).

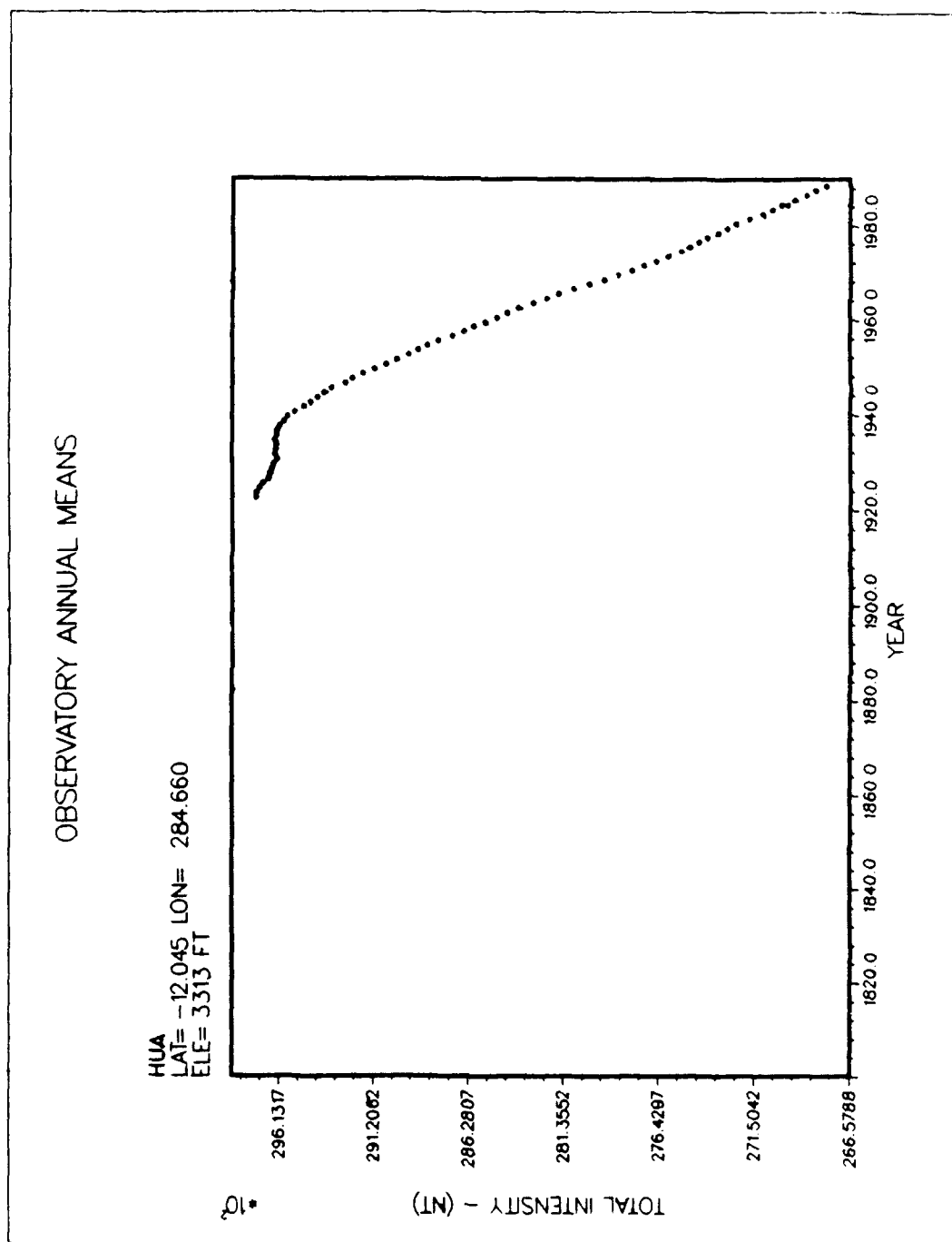


FIGURE 2f. TOTAL INTENSITY F COMPONENT AT HUANCAYO (HUA).

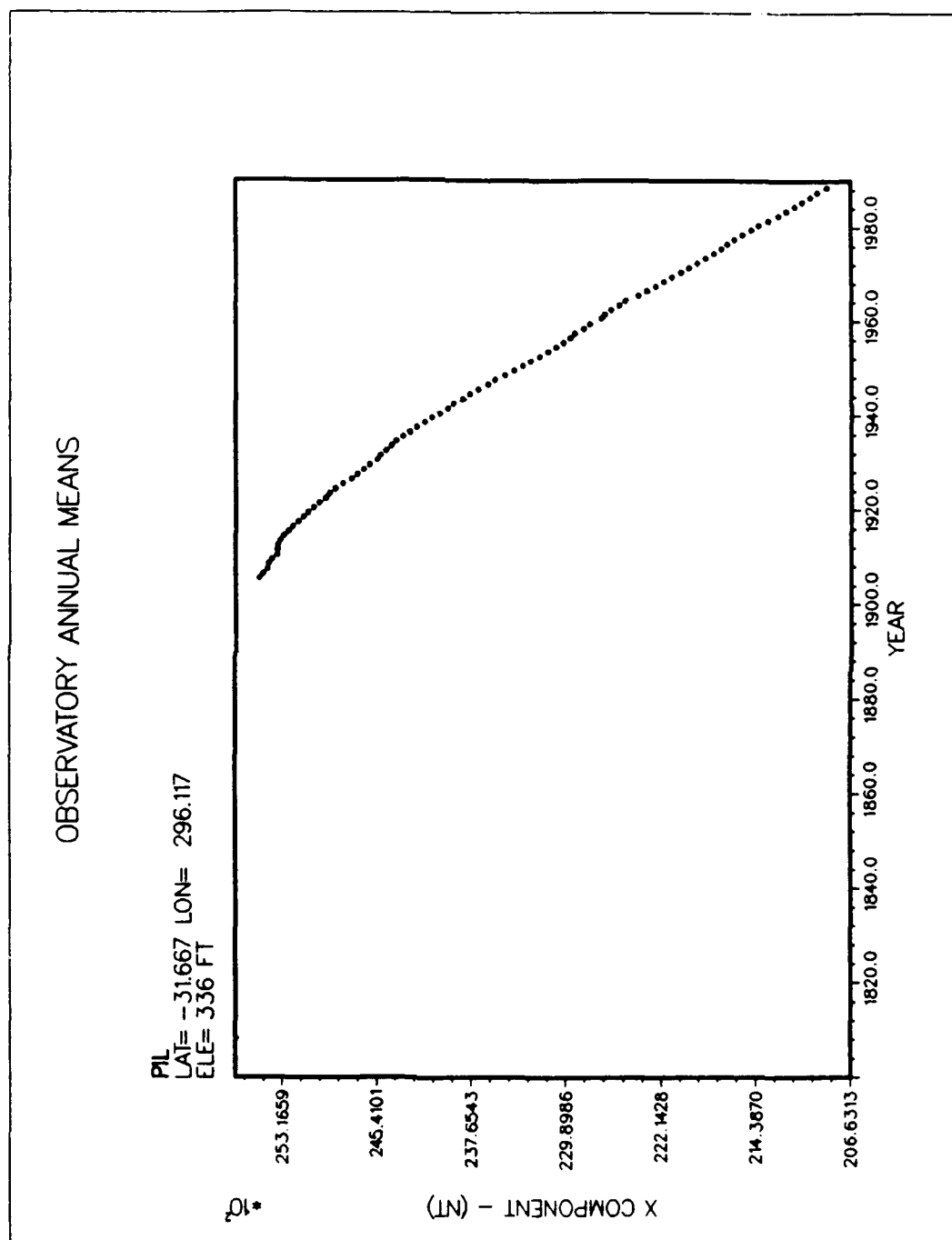


FIGURE 3a. NORTH X COMPONENT AT PILAR (PIL).

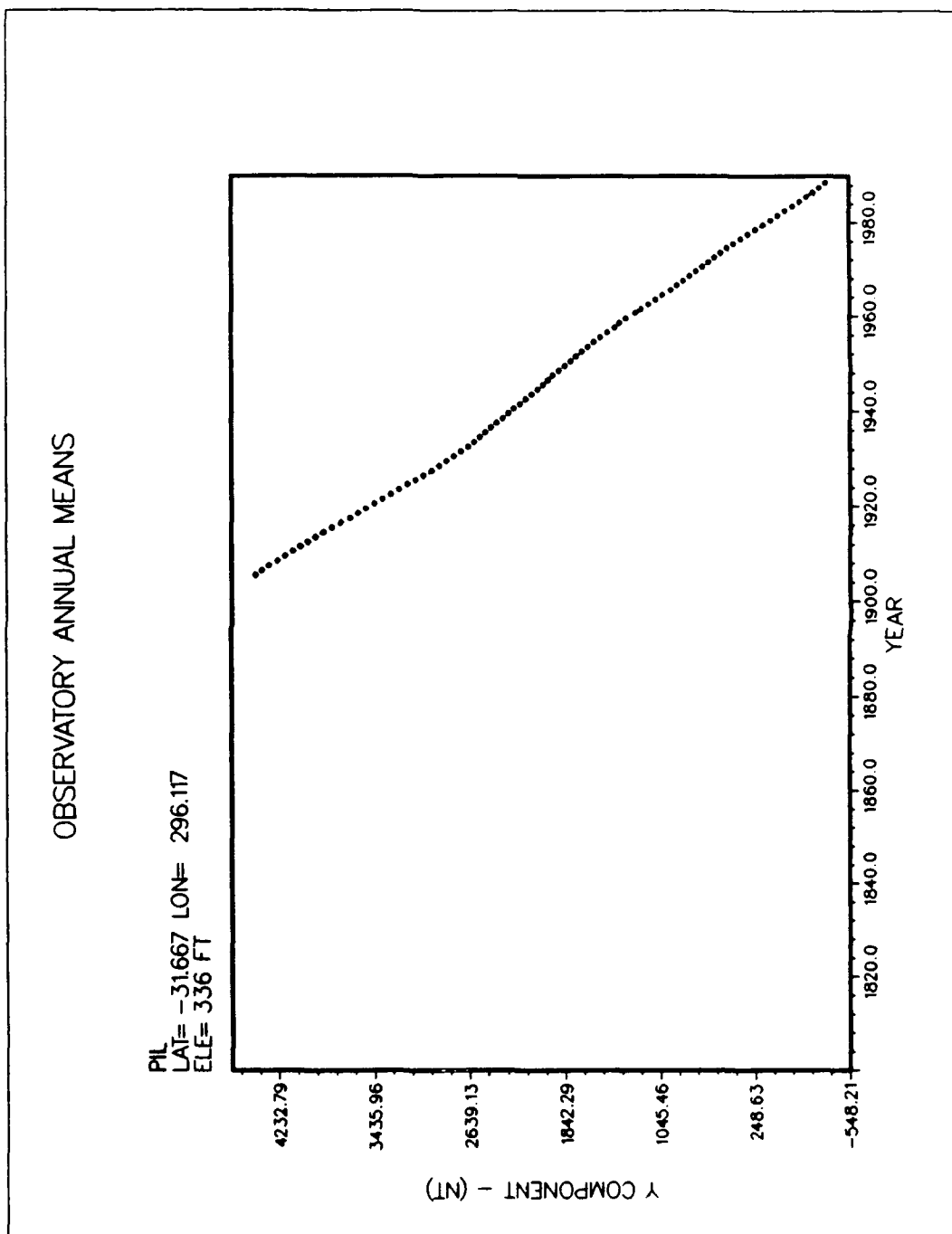


FIGURE 3b. EAST Y COMPONENT AT PILAR (PIL).

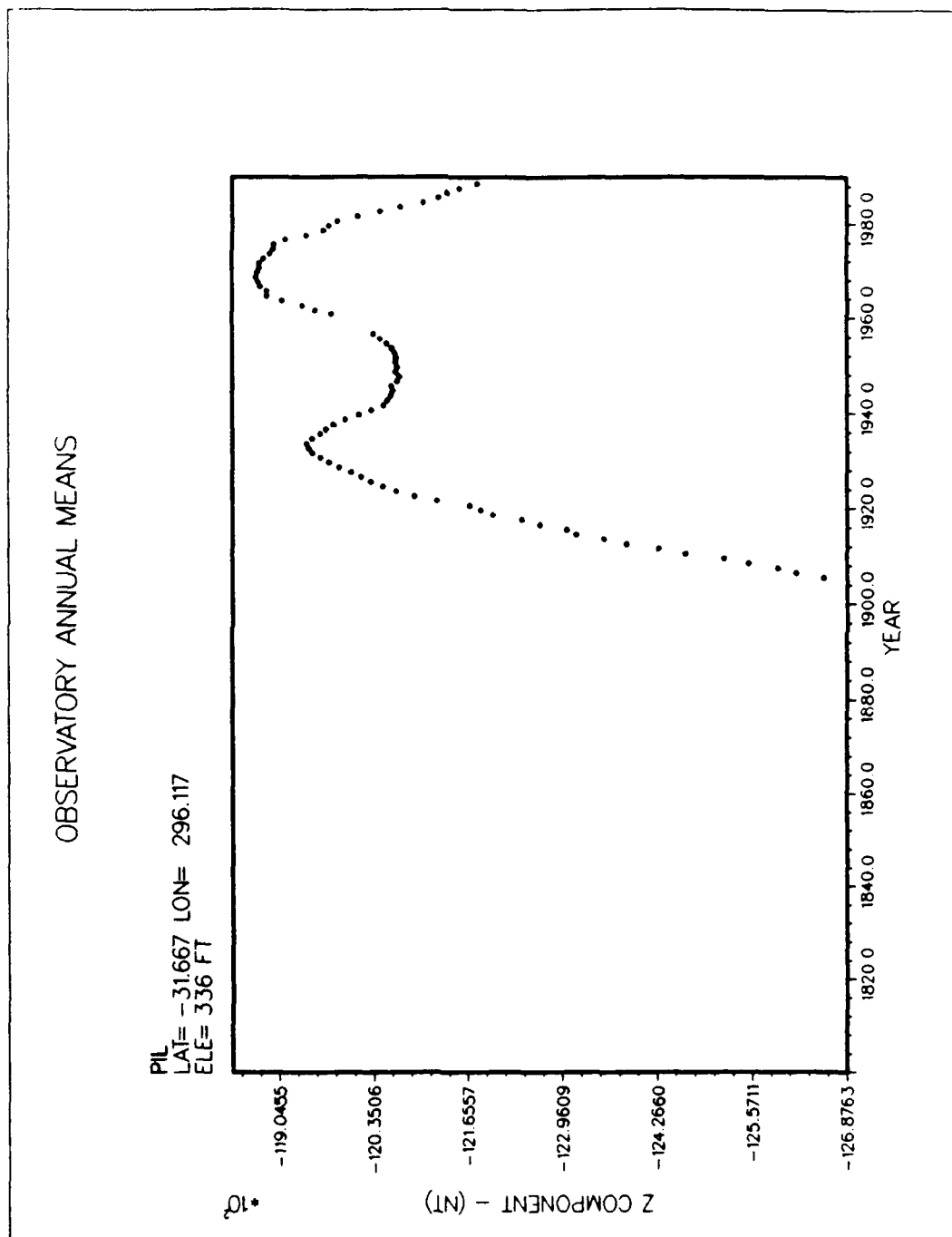


FIGURE 3c. VERTICAL Z COMPONENT AT PILAR (PIL).

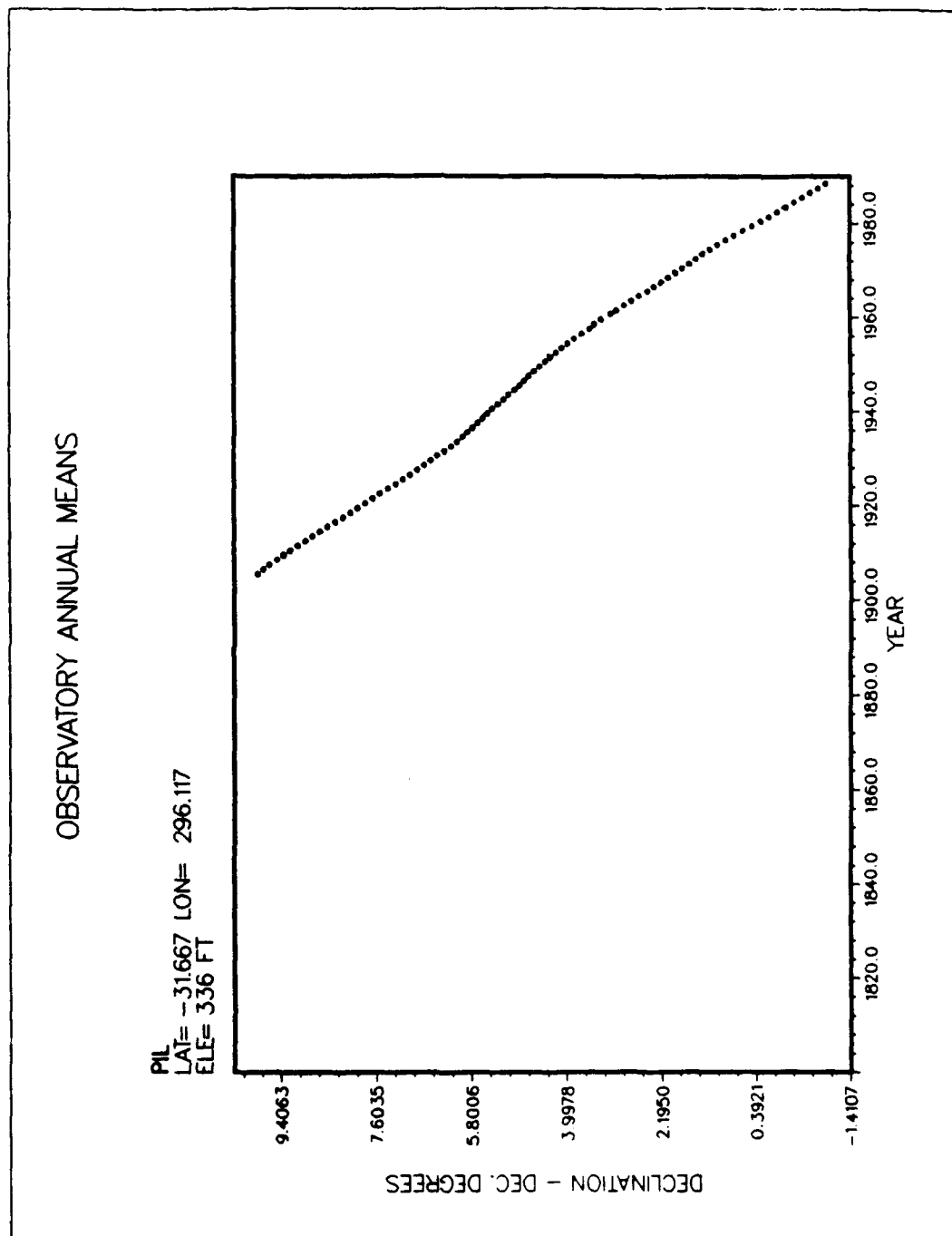


FIGURE 3d. DECLINATION D COMPONENT AT PILAR (PIL).

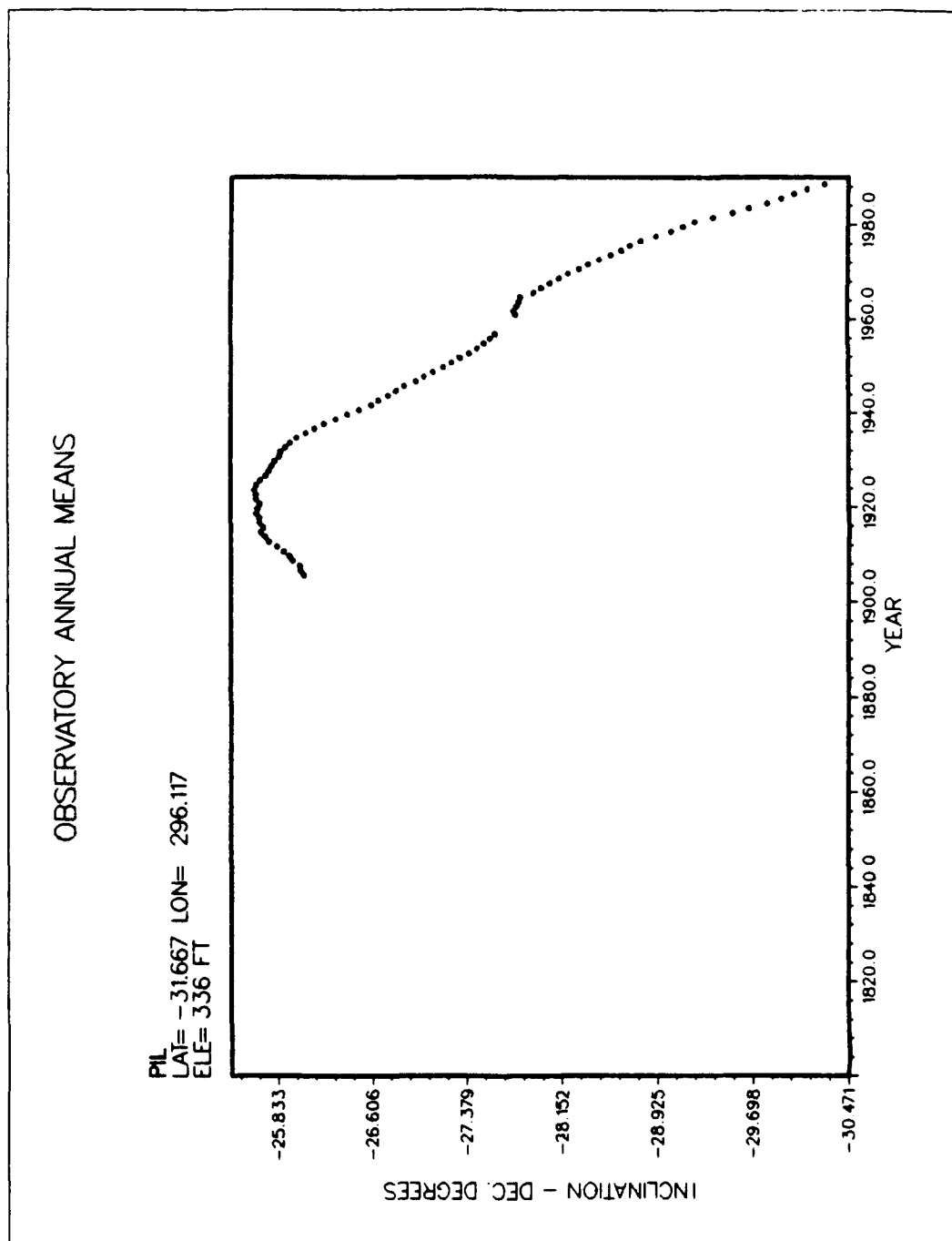


FIGURE 3c. INCLINATION 1 COMPONENT AT PILAR (PIL).

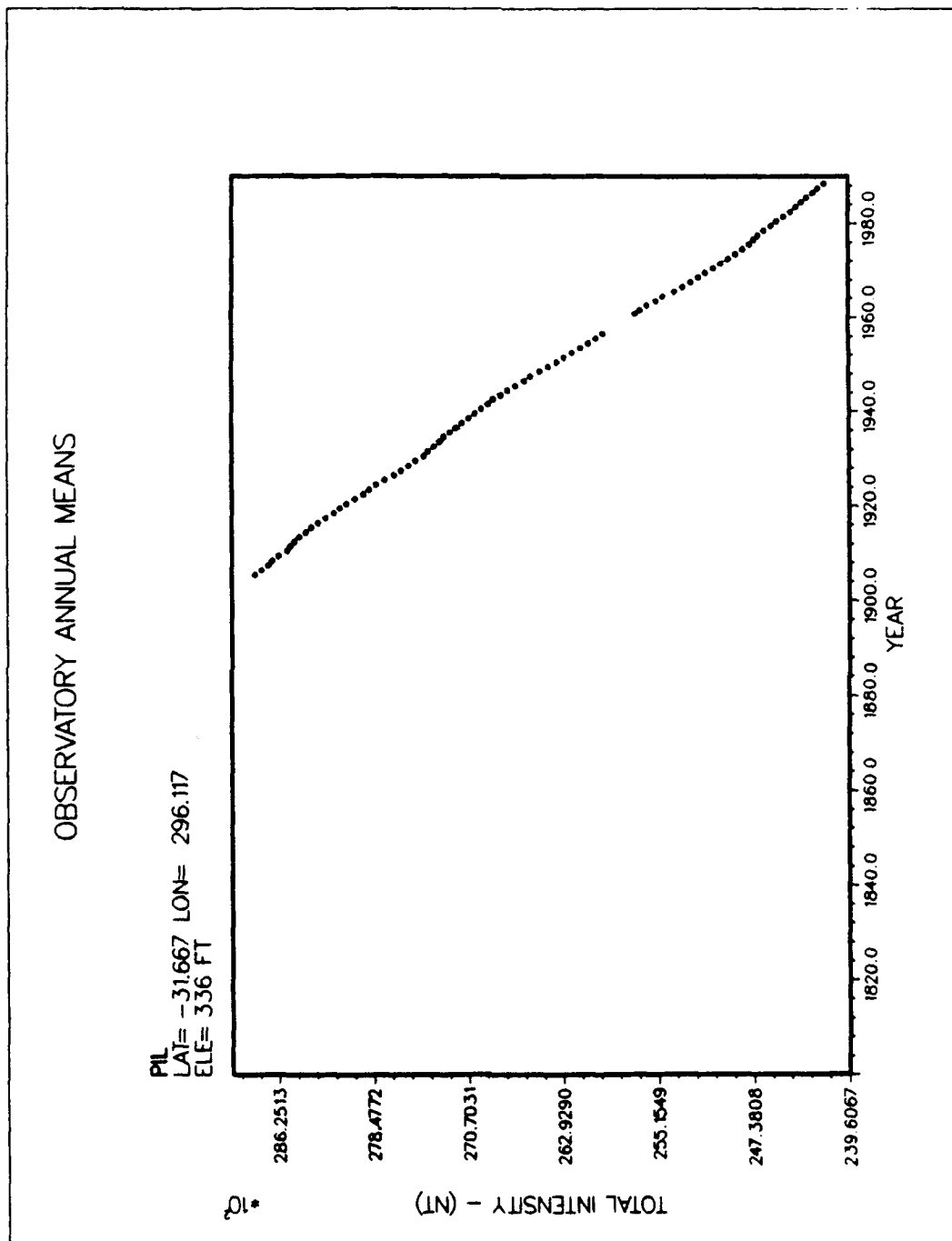


FIGURE 3f. TOTAL INTENSITY F COMPONENT AT PILAR (PIL).

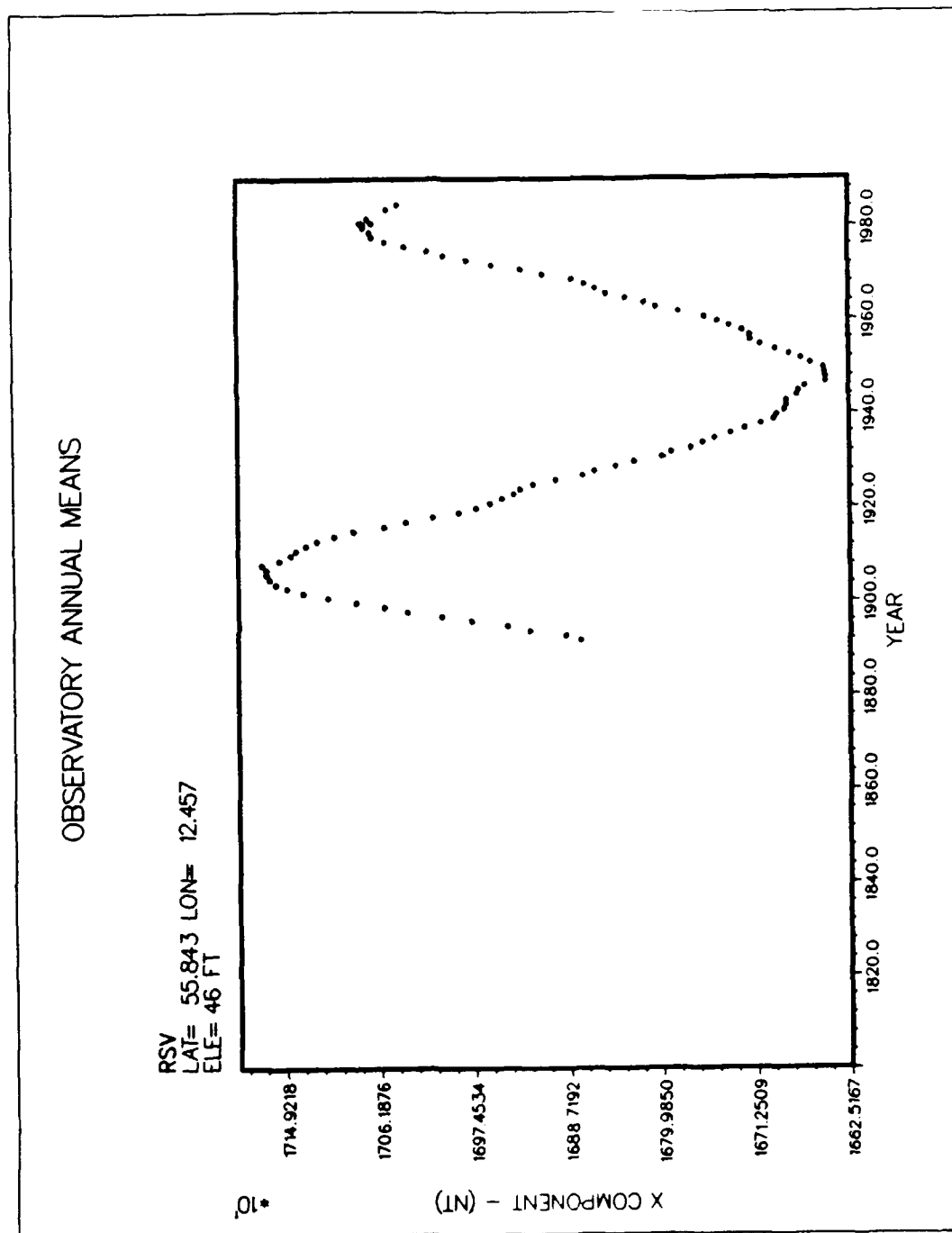


FIGURE 4a. NORTH X COMPONENT AT RUDE SKOV (RSV).

OBSERVATORY ANNUAL MEANS

RSV
LAT= 55.843 LON= 12.457
ELE= 46 FT

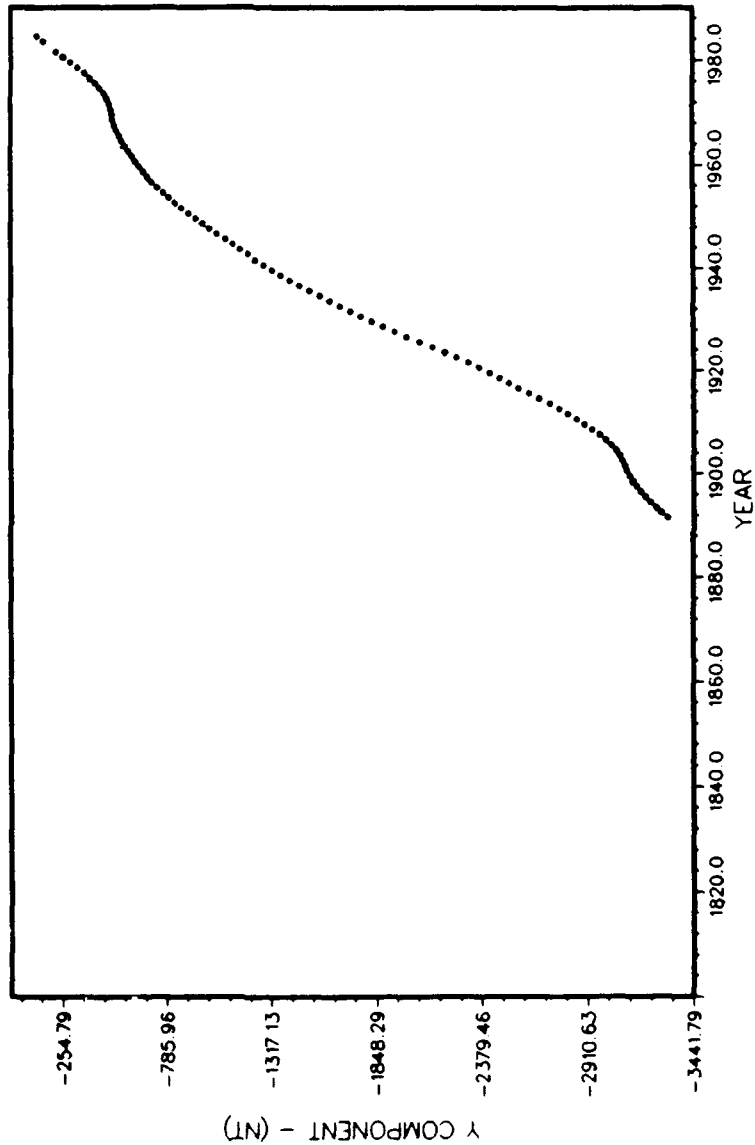


FIGURE 4b. EAST Y COMPONENT AT RUDE SKOV (RSV).

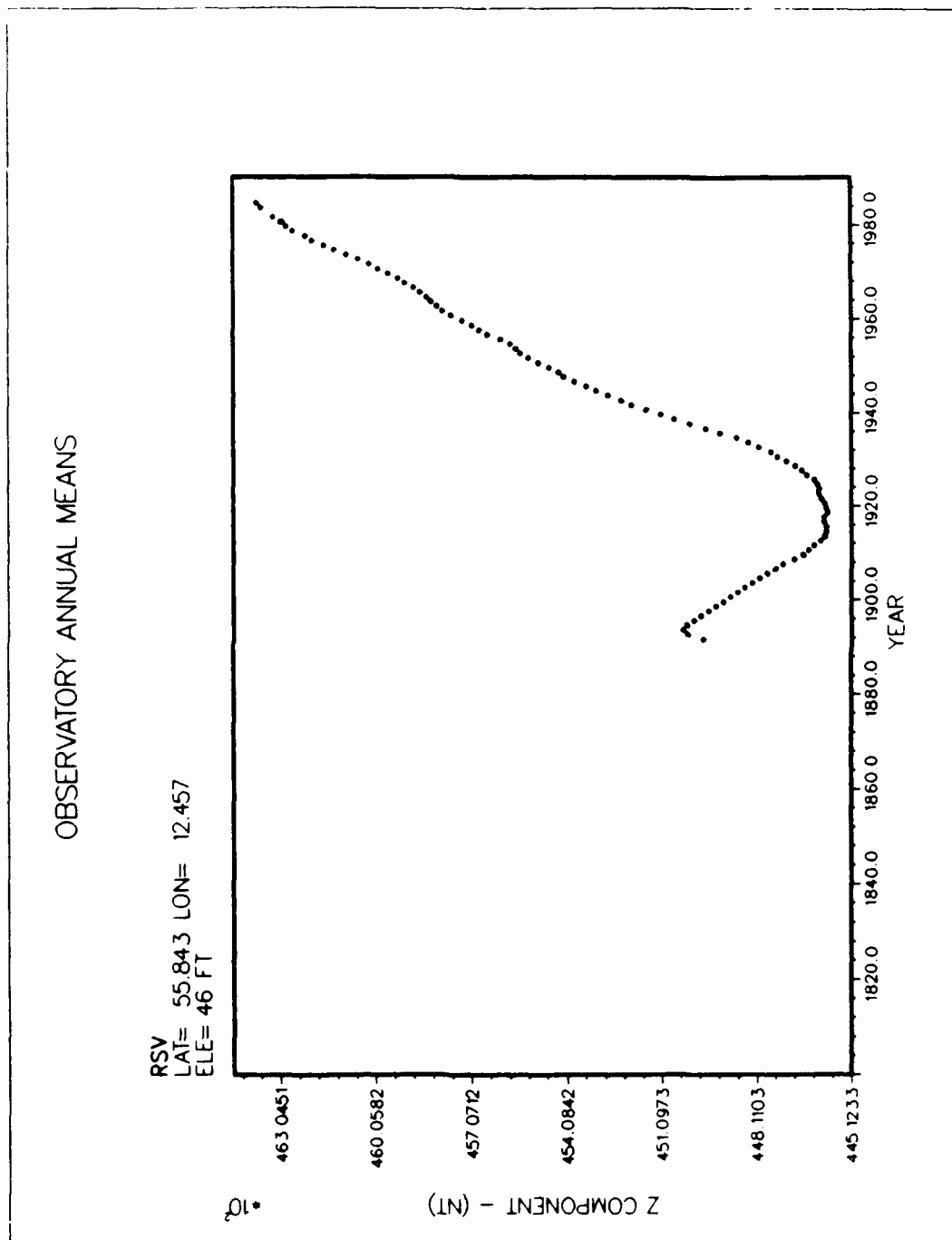


FIGURE 4c. VERTICAL Z COMPONENT AT RUDE SKOV (RSV).

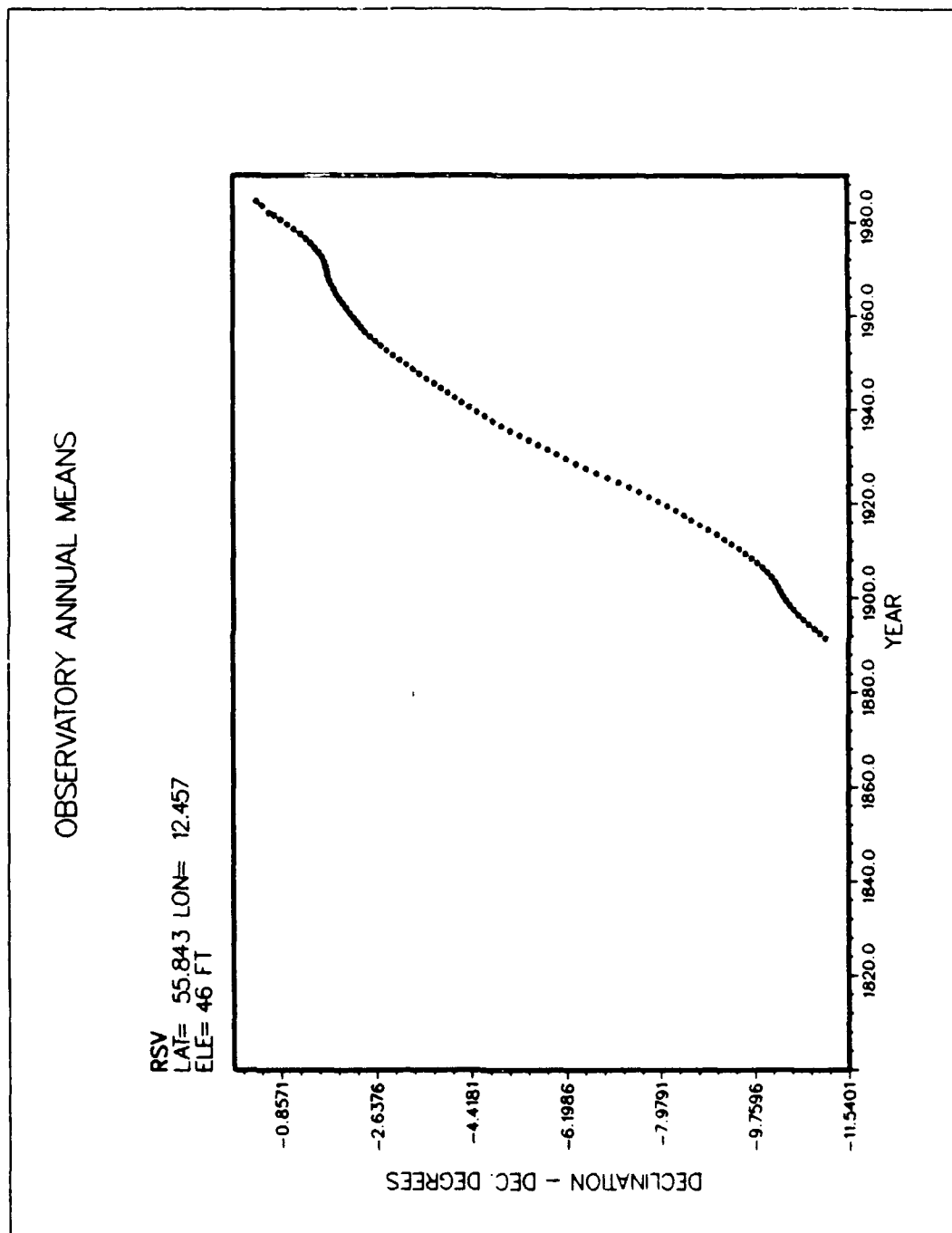


FIGURE 4d. DECLINATION D COMPONENT AT RUDE SKOV (RSV).

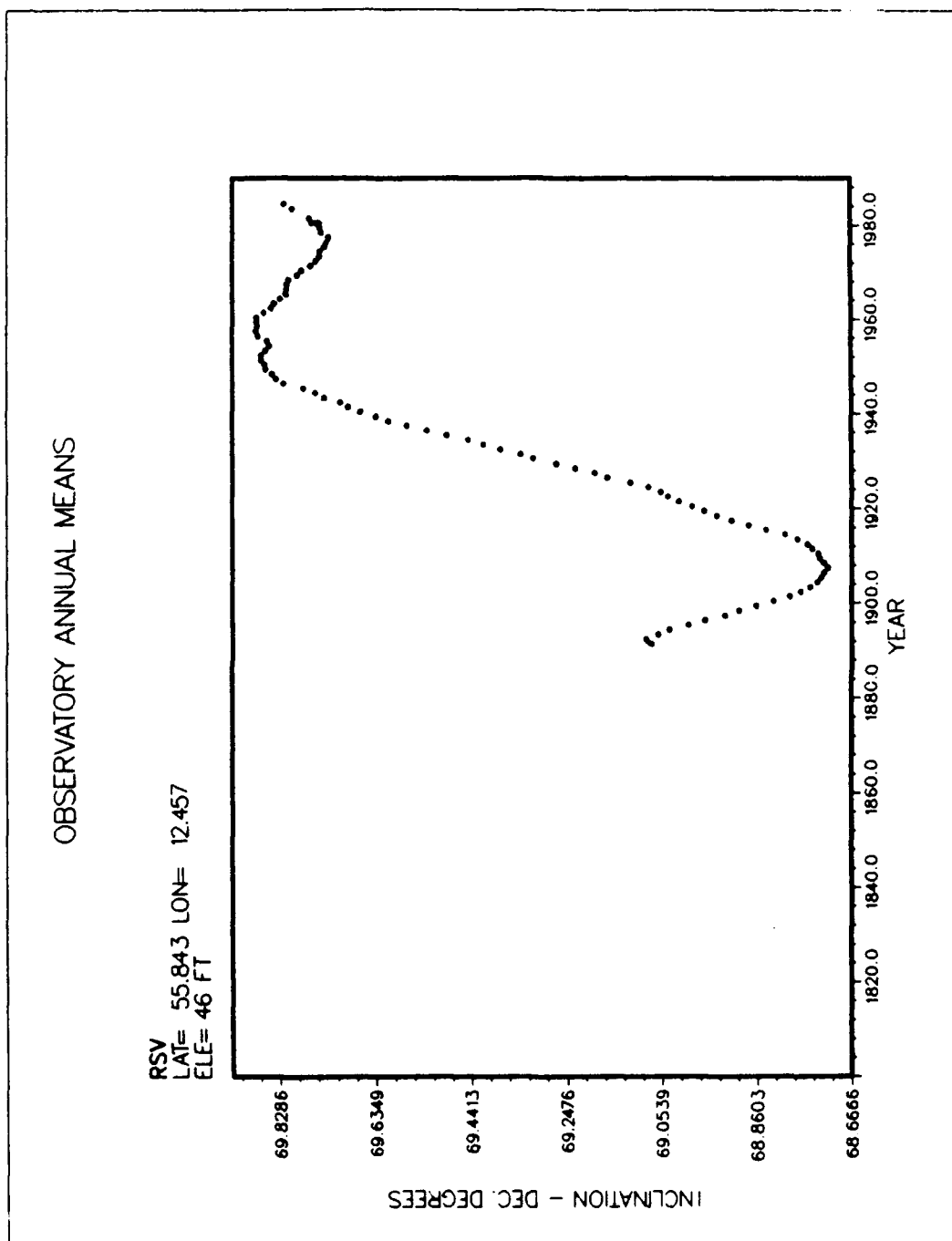


FIGURE 4c. INCLINATION 1 COMPONENT AT RUDE SKOV (RSV).

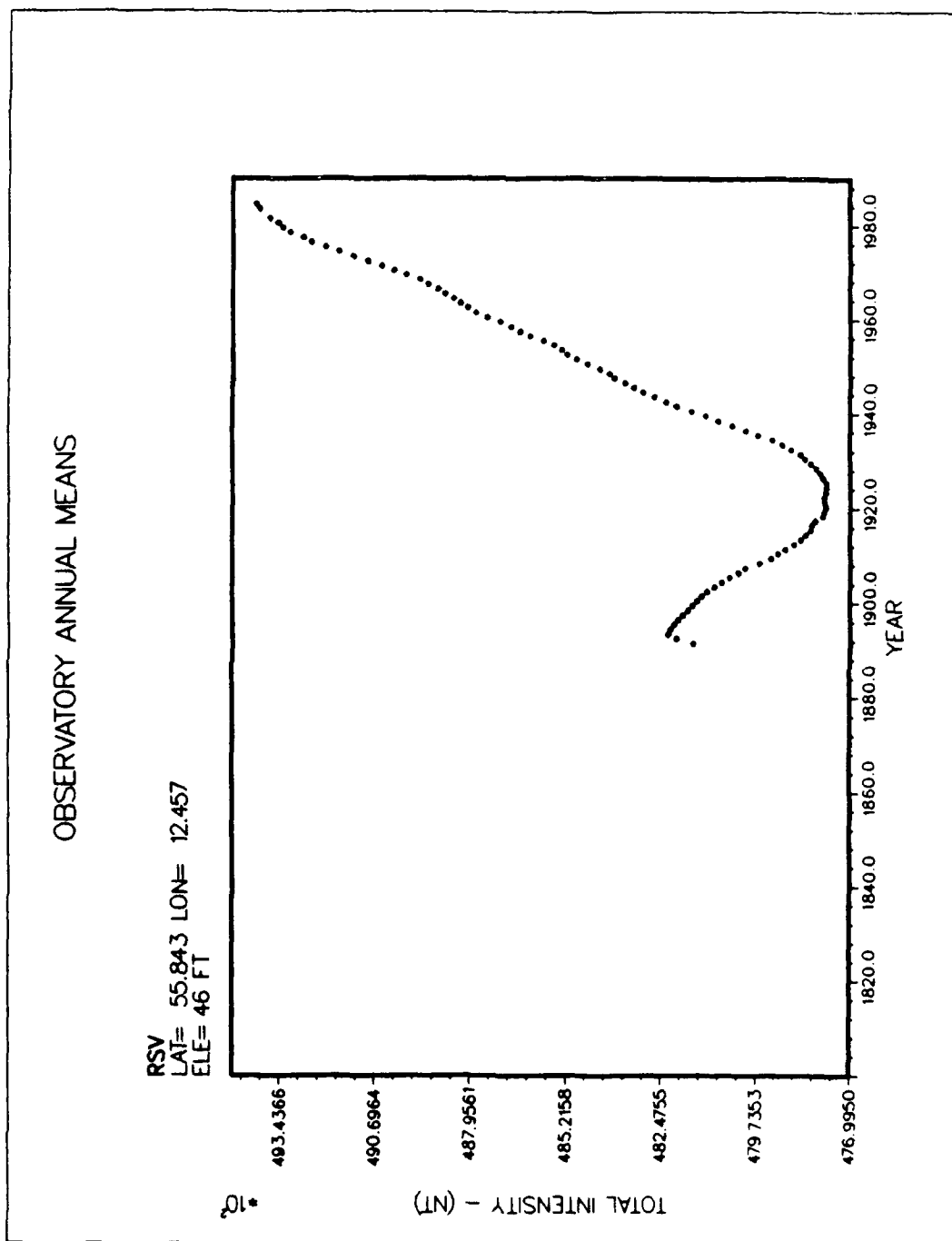


FIGURE 4f. TOTAL INTENSITY F COMPONENT AT RUDE SKOV (RSV).

Three secular variation models are generated by performing a weighted, least-square fit of the degree and order 8 spherical harmonic model to the first-order time derivative of the observatory annual means. These models were supplied by the British Geological Survey and are given in table 4.

2.2 Main Field Data Analysis (United States Responsibility)

The observatory annual magnetic means were not used in the main field modeling because those data contain, in addition to small external field contributions, some rather large local and regional magnetic biases of crustal origin. A detailed survey at each observatory site would be necessary to remove these biases. Such surveys have rarely been performed due to the prohibitive cost, logistics, and international politics involved.

The MAGSAT data consisted of 30,473 vector magnetic field values selected from 401 of the first 804 orbits. To minimize solar influences, the K_p magnetic index was required to be equal to, or less than, 2 ($K_p \leq 2$). These orbits were individually edited by an interactive graphics process to delete field aligned current effects and spurious data. Also, the following corrections for magnetospheric effects due to the ring current, magnetopause currents, and magnetotail currents were applied:

$$B_x(r, \theta, \phi, \tau) = -q_1^0(\tau) \sin \theta + \{q_1^1(\tau) \cos \phi + s_1^1(\tau) \sin \phi\} \cos \theta \quad (21a)$$

$$B_y(r, \theta, \phi, \tau) = q_1^1(\tau) \sin \phi - s_1^1(\tau) \cos \phi \quad (21b)$$

$$B_z(r, \theta, \phi, \tau) = q_1^0(\tau) \cos \theta + \{q_1^1(\tau) \cos \phi + s_1^1(\tau) \sin \phi\} \sin \theta \quad (21c)$$

where the time-dependent coefficients are functions of the Disturbance Storm Time (Dst) index:

$$q_1^0(\tau) = 19.69 - 0.63Dst(\tau) \quad (22a)$$

$$q_1^1(\tau) = -0.38 - 0.06Dst(\tau) \quad (22b)$$

$$s_1^1(\tau) = -2.90 + 0.17Dst(\tau) \quad (22c)$$

These corrections are derived from the external magnetic field potential:

TABLE 4. SECULAR VARIATION MODELS (units: nanotesles/year)

		1982.5 Epoch		1987.5 Epoch		1992.5 Epoch	
n	m	$\dot{g}_n^m$	$\dot{h}_n^m$	$\dot{g}_n^m$	$\dot{h}_n^m$	$\dot{g}_n^m$	$\dot{h}_n^m$
1	0	22.601	0.000	18.745	0.000	16.013	0.000
1	1	10.491	-20.091	10.554	-17.836	9.259	-13.759
2	0	-14.454	0.000	-12.552	0.000	-11.703	0.000
2	1	3.389	-14.476	3.290	-15.523	3.715	-12.790
2	2	5.043	-20.686	0.656	-15.631	1.767	-14.865
3	0	2.839	0.000	3.644	0.000	2.115	0.000
3	1	-5.747	4.810	-6.918	4.285	-7.596	3.082
3	2	-1.857	3.013	0.000	1.498	0.000	0.844
3	3	-1.130	-10.049	-4.759	-10.351	-5.815	-11.342
4	0	0.000	0.000	0.000	0.000	-0.770	0.000
4	1	0.000	5.277	0.483	3.375	0.968	3.281
4	2	-6.929	1.770	-7.391	2.994	-7.414	3.680
4	3	0.000	4.323	0.510	3.812	0.715	2.799
4	4	-6.192	0.771	-5.343	0.000	-6.361	0.000
5	0	0.952	0.000	0.808	0.000	1.662	0.000
5	1	-0.577	0.000	-0.357	-0.593	0.000	0.000
5	2	-1.578	-0.402	-1.730	0.000	0.000	-2.096
5	3	-3.916	-0.501	-3.250	0.000	-2.699	1.226
5	4	0.000	0.000	0.000	1.712	0.000	1.193
5	5	1.018	0.532	2.001	0.464	3.001	0.650
6	0	0.962	0.000	1.296	0.000	0.751	0.000
6	1	0.000	-1.107	0.000	0.000	0.000	-0.583
6	2	1.678	-0.821	1.799	-1.277	1.451	-0.644
6	3	0.755	-0.428	0.834	0.000	0.000	0.000
6	4	0.000	-0.954	-0.667	-1.664	0.000	-2.266
6	5	0.000	0.349	0.000	0.000	0.000	0.000
6	6	1.437	0.456	0.663	1.381	0.000	0.000
7	0	0.376	0.000	0.670	0.000	0.505	0.000
7	1	-0.645	0.223	-0.483	0.978	0.000	0.599
7	2	0.457	0.321	0.000	0.000	-0.869	0.793
7	3	1.020	0.375	1.010	0.390	1.457	0.000
7	4	1.583	0.880	1.903	0.000	2.650	0.000
7	5	0.893	0.000	0.597	0.000	-1.020	0.000
7	6	0.387	0.467	0.000	0.000	0.000	0.417
7	7	0.000	0.825	0.543	0.000	0.000	0.000
8	0	0.651	0.000	0.237	0.000	0.000	0.000
8	1	0.000	0.459	-0.692	0.399	-1.089	0.427
8	2	-0.176	-0.332	-0.367	-0.195	0.000	-0.809
8	3	0.000	0.330	0.000	0.586	0.000	0.507
8	4	-0.842	-0.268	-1.292	0.519	-2.114	0.349
8	5	-0.222	0.428	0.000	0.520	0.000	0.499
8	6	0.000	-0.967	0.423	-0.742	0.978	0.000
8	7	-0.394	-0.994	0.000	-0.713	0.000	-0.684
8	8	-0.516	0.693	-0.562	0.0000	0.000	0.000

$$V_{ext}(r, \theta, \phi, \tau) = a \sum_{n=1}^{N_{ext}} \sum_{m=0}^n \left(\frac{r}{a} \right)^n \{q_n^m(\tau) \cos m\phi + s_n^m(\tau) \sin m\phi\} P_n^m(\cos \theta) \quad (23)$$

when $N_{ext}=1$, via the relations:

$$B_x = -B_\theta = \frac{1}{r} \frac{\partial V}{\partial \theta} \quad (24a)$$

$$B_y = +B_\phi = - \frac{1}{r \sin \theta} \frac{\partial V}{\partial \phi} \quad (24b)$$

$$B_z = -B_r = \frac{\partial V}{\partial r} \quad (24c)$$

A further correction takes into account the magnetic fields induced in the Earth by the external fields which, because of their time dependence and the generally low but finite conductivity of the crust and mantle, induce electric currents in the crust and mantle, which in turn generate secondary magnetic fields. These secondary fields are of internal origin and primarily affect the g_1^0 coefficients of the internal magnetic potential:

$$V_{int}(r, \theta, \phi, \tau) = a \sum_{n=1}^{N_{int}} \sum_{m=0}^n \left(\frac{a}{r} \right)^{n+1} \{g_n^m(\tau) \cos m\phi + h_n^m(\tau) \sin m\phi\} P_n^m(\cos \theta) \quad (25)$$

Taking derivatives as before with $n=1$ and $m=0$, the magnetic field corrections due to induction effects are:

$$B_x(r, \theta, \phi, \tau) = - \left(\frac{a}{r} \right)^3 g_{11}^0(\tau) \sin \theta \quad (26a)$$

$$B_y(r, \theta, \phi, \tau) = 0 \quad (26b)$$

$$B_z(r, \theta, \phi, \tau) = - 2 \left(\frac{a}{r} \right)^3 g_{11}^0(\tau) \cos \theta \quad (26c)$$

where the induced part of the g_1^0 coefficient is given as:

$$g_{11}^0(\tau) = 0.27 q_1^0(\tau) \quad (27)$$

The external and induced magnetic field corrections given above were subtracted from the MAGSAT observations. These corrections are based on previous analyses of MAGSAT data by Langel and Estes (1985) and by Quinn, Kerridge, and Barraclough (1986).

No attempts were made to remove magnetic influences due to ionospheric currents such as those generated by solar quiet (*SQ*) currents, auroral electrojet currents, and equatorial electrojet currents, which are located below the MAGSAT orbit altitudes. These influences, though generated external to the Earth's surface, are nevertheless part of $V_m(r, \theta, \phi, \tau)$ because their sources are internal to the point of observation. Consequently, separating core-generated fields from crustal and ionospherically generated fields measured by satellite magnetometers is difficult and is still a research matter. Fortunately, fields generated in the Earth's crust and ionosphere are significantly attenuated at satellite altitudes. Therefore, errors in the main field model coefficients due to contamination of the satellite data by these two sources are comparatively small.

MAGSAT was a joint National Aeronautics and Space Administration (NASA)/U.S. Geological Survey mission. These data were supplied by NASA in the form of investigator B tapes.

The DE-2 satellite data set consisted of 5,100 data points gleaned from the low-altitude end of a comparatively eccentric orbit. This data set contained only scalar total intensity measurements of the Earth's magnetic field. However, this data set exhibited a substantially higher rms error relative to the DGRF-80 model than the MAGSAT data. Consequently, for this and other reasons, the DE-2 data were not used in the final main field model determination. This data set originated with M. Sugiura of Japan (formerly of NASA). It was edited by J.R. Ridgeway of Science Applications Research Corporation and it was subsequently supplied to NAVOCEANO by Dr. Robert Langel of NASA.

The Project MAGNET aeromagnetic data consisted of 338 high-level flights ($\geq 15,000$ feet) of vector component measurements. These data are routinely processed by NAVOCEANO at a 2-second sample rate and sent to the National Geophysical Data Center (NGDC) in Boulder, Colorado. A weak low-pass filter with a cut-off wavelength of approximately 7 km is routinely applied to this high-level data. The cut-off wavelength will vary slightly, depending on the average speed of the aircraft, which depends on prevailing wind conditions at the time of flight. Typical flights last 10 to 12 hours and are flown at an average speed of 440 km/hr. They are generally flown at night in order to minimize solar-driven external field effects which contribute to the Daily Variation (*DV*) of the Earth's field. Project MAGNET flights are of long range in remote ocean areas, which precludes the monitoring of *DV*. Therefore, no explicit *DV* corrections are

made to the data. Also, the aircraft's vector magnetometer is calibrated at the NASA Coil Room Facility at the Goddard Space Flight Center in Maryland at least once a year.

The magnetic field observations returned from each Project MAGNET flight are routinely reduced in accordance with the following procedures:

a. Rotate vector measurements from magnetometer coordinates to instantaneous aircraft coordinates. This rotation involves only small misalignments relative to an imaginary coordinate system rigidly attached to the aircraft.

b. Compensate in aircraft coordinates for the perturbing magnetic effects associated with the presence of the aircraft by removing a field phenomenologically modeled as:

$$\vec{B}_C(\tau) = \vec{B}_{Perm} + \vec{\alpha} \vec{B}_M(\tau) + \vec{\beta} \frac{d\vec{B}_M(\tau)}{d\tau} \quad (28)$$

where the first term represents the permanent magnetic field generated by the remnant magnetization of the aircraft's metal parts, the second term represents the field induced in the aircraft's metal structure by the presence of the ambient field $\vec{B}_M(\tau)$, and the third term represents magnetic fields generated by eddy currents created on the aircraft's metal surfaces by the aircraft's motion through the Earth's spatially varying field. Here, $\vec{B}_M(\tau)$ is the magnetic field measured by the magnetometer after it has been rotated into aircraft coordinates as indicated in step a. The compensation model contains 21 coefficients, 3 in the vector $\vec{B}_{Perm}$, 9 in the 3x3 matrix $\vec{\alpha}$, and 9 in the 3x3 matrix $\vec{\beta}$.

c. Rotate the compensated field from instantaneous aircraft coordinates to geodetic coordinates, taking into account the misalignment of the inertial attitude device relative to the instantaneous aircraft coordinates.

d. Visually edit the data in each flight via interactive graphics techniques.

The compensation coefficients are determined by performing calibration flights at an altitude of 1,500 feet above a designated magnetic observatory. These flights consist of a set of yaw, pitch, and roll maneuvers performed along the four cardinal headings (north, south, east, and west). The coefficients are then determined by a least-squares procedure that minimizes the squared difference between

the observatory field (upward continued and rotated into instantaneous aircraft coordinates using the inertial attitude devices on the aircraft) and the field measured by the aircraft's magnetometer.

Using this minimization technique, the 21 compensation coefficients are determined simultaneously with 6 Euler angles (3 for the magnetometer misalignment mentioned in step a and 3 for the inertial attitude device misalignment mentioned in step c. The overall process is, therefore, nonlinear, requiring several iterations to converge. Note, however, that it is possible to determine only the relative misalignment between the magnetometer axes and the inertial system axes. Therefore, the three magnetometer bias angles are arbitrarily set to zero so that, in practice, only the three inertial system bias angles (Euler angles) are computed.

After compensation and editing, the aeromagnetic data were decimated to a 200-second sample interval (i.e., every hundredth point was selected), yielding 54,656 vector magnetic observations. The resulting Project MAGNET data set was finally converted from geodetic coordinates to spherical coordinates, using the coordinate transformations of the previous section.

For modeling, it is desirable to have all data sets pushed forward or backward to a common epoch. Consequently, the MAGSAT data set, which was originally in spherical coordinates, was pushed forward to 1985.0 via the 1982.5 secular variation model. The portion of the Project MAGNET data set collected prior to 1985.0 was pushed forward to 1985.0 via the 1982.5 secular variation model, while the portion of the Project MAGNET data set collected after 1985.0 was pushed backward to 1985.0 by the 1987.5 secular variation model. Subsequently, a revised 1985.0 epoch main field model was generated by performing a weighted least-squares fit of the degree and order 12 spherical harmonic model to the combined MAGSAT and Project MAGNET data sets. The resulting main field model, when combined with the 1987.5 secular variation model, is referred to as WC-85 (revised). These coefficients are listed in table 5. The 1990.0 main field model was produced by pushing the WC-85 (revised) main field spherical harmonic coefficients forward in time using the 1987.5 secular variation coefficients. The resulting 1990.0 epoch main field model was then combined with the 1992.5 secular variation model to form WMM-90, the coefficients of which are listed in table 3 of section 1.3.

2.3 Mathematical Details of Main Field Inverse Modeling

The modeling procedure used was a modification of that formulated by Cain et al. (1967). The objective was to minimize the chi-square (χ^2) function

$$\chi^2 = \chi_r^2 + \chi_\theta^2 + \chi_\phi^2 + \chi_F^2 \quad (29)$$

TABLE 5. WC-85 (REVISED) SCHMIDT NORMALIZED GAUSS COEFFICIENTS

n	m	g_n^m (nT)	h_n^m (nT)	$\dot{g}_n^m$ (nT/yr)	$\dot{h}_n^m$ (nT/yr)
1	0	-29874.2	.0	18.7	.0
1	1	-1904.5	5496.4	10.6	-17.8
2	0	-2071.6	.0	-12.6	.0
2	1	3045.7	-2200.6	3.3	-15.5
2	2	1688.7	-306.1	.7	-15.6
3	0	1294.7	.0	3.6	.0
3	1	-2210.1	-306.4	-6.9	4.3
3	2	1246.8	284.2	.0	1.5
3	3	832.4	-300.7	-4.8	-10.4
4	0	933.5	.0	.0	.0
4	1	782.5	232.5	.5	3.4
4	2	360.5	-247.6	-7.4	3.0
4	3	-424.2	72.2	.5	3.8
4	4	166.0	-296.5	-5.3	.0
5	0	-212.3	.0	.8	.0
5	1	354.0	43.7	-.4	-.6
5	2	255.2	148.7	-1.7	.0
5	3	-94.6	-154.6	-3.3	.0
5	4	-162.3	-76.2	.0	1.7
5	5	-47.2	95.0	2.0	.5
6	0	52.5	.0	1.3	.0
6	1	63.7	-14.7	.0	.0
6	2	51.0	88.6	1.8	-1.3
6	3	-185.4	70.0	.8	.0
6	4	3.8	-47.8	-.7	-1.7
6	5	15.4	-1.4	.0	.0
6	6	-99.3	17.7	.7	1.4
7	0	72.8	.0	.7	.0
7	1	-59.7	-83.5	-.5	1.0
7	2	1.3	-26.7	.0	.0
7	3	25.1	-1.9	1.0	.4
7	4	-4.8	19.9	1.9	.0
7	5	4.9	17.9	.6	.0
7	6	10.1	-21.5	.0	.0
7	7	-.8	-6.8	.5	.0

TABLE 5. WC-85 (REVISED) SCHMIDT NORMALIZED GAUSS COEFFICIENTS (con.)

n	m	g_n^m (nT)	h_n^m (nT)	$\dot{g}_n^m$ (nT/yr)	$\dot{h}_n^m$ (nT/yr)
8	0	21.7	.0	.2	.0
8	1	5.8	7.7	-.7	.4
8	2	.6	-18.3	-.4	-.2
8	3	-11.7	3.7	.0	.6
8	4	-11.0	-22.7	-1.3	.5
8	5	2.2	10.8	.0	.5
8	6	3.6	13.5	.4	-.7
8	7	3.0	-15.4	.0	-.7
8	8	-4.2	-9.1	-.6	.0
9	0	3.6	.0	.0	.0
9	1	9.5	-21.9	.0	.0
9	2	-.9	14.3	.0	.0
9	3	-10.7	9.5	.0	.0
9	4	10.7	-6.7	.0	.0
9	5	-3.2	-6.4	.0	.0
9	6	-1.4	9.1	.0	.0
9	7	6.3	8.9	.0	.0
9	8	.8	-8.0	.0	.0
9	9	-5.5	2.1	.0	.0
10	0	-3.3	.0	.0	.0
10	1	-2.6	2.6	.0	.0
10	2	4.5	1.2	.0	.0
10	3	-5.6	2.6	.0	.0
10	4	-3.6	5.7	.0	.0
10	5	3.9	-4.0	.0	.0
10	6	3.2	-.4	.0	.0
10	7	1.7	-1.7	.0	.0
10	8	3.0	3.8	.0	.0
10	9	3.7	-.8	.0	.0
10	10	.7	-6.5	.0	.0

TABLE 5. WC-85 (REVISED) SCHMIDT NORMALIZED GAUSS COEFFICIENTS (con.)

n	m	g_n^m (nT)	h_n^m (nT)	$\dot{g}_n^m$ (nT/yr)	$\dot{h}_n^m$ (nT/yr)
11	0	1.3	.0	.0	.0
11	1	-1.4	.0	.0	.0
11	2	-2.5	1.0	.0	.0
11	3	3.2	-1.6	.0	.0
11	4	.2	-2.2	.0	.0
11	5	-1.1	1.1	.0	.0
11	6	.3	-.7	.0	.0
11	7	-.3	-1.7	.0	.0
11	8	.9	-1.5	.0	.0
11	9	-1.1	-1.3	.0	.0
11	10	2.4	-1.1	.0	.0
11	11	3.0	.6	.0	.0
12	0	-1.3	.0	.0	.0
12	1	.1	.7	.0	.0
12	2	.5	.7	.0	.0
12	3	.7	1.3	.0	.0
12	4	.4	-1.5	.0	.0
12	5	-.2	.3	.0	.0
12	6	-1.1	.2	.0	.0
12	7	.9	-1.1	.0	.0
12	8	-.6	1.2	.0	.0
12	9	.8	-.2	.0	.0
12	10	.2	-1.3	.0	.0
12	11	.4	.6	.0	.0
12	12	.2	.6	.0	.0

with respect to the 168 internal Gauss coefficients of a degree and order 12 spherical harmonic model, where:

$$\chi_r^2 = \sum_{i=1}^{I_r} w_{r,i} (B_{r,i} - b_{r,i})^2 \quad (30a)$$

$$\chi_\theta^2 = \sum_{i=1}^{I_\theta} w_{\theta,i} (B_{\theta,i} - b_{\theta,i})^2 \quad (30b)$$

$$\chi_\phi^2 = \sum_{i=1}^{I_\phi} w_{\phi,i} (B_{\phi,i} - b_{\phi,i})^2 \quad (30c)$$

$$\chi_F^2 = \sum_{i=1}^{I_F} w_{F,i} (B_{F,i} - b_{F,i})^2 \quad (30d)$$

where the upper case B's refer to the model values of their respective magnetic components, while the lower case b's refer to the observed (measured) values of their respective magnetic components. The subscript i refers to a particular data point, the total number I of which may differ for each magnetic component. Each data point is weighted by a weight factor, w, which depends on several factors:

a. Data type W_m

MAGSAT = 1

Project MAGNET = 1/4

Project MAGNET observatory airswing calibrations yield rms errors on the order of 35 nT, while MAGSAT rms differences from degree 12 spherical harmonic models yield rms values on the order of 9 nT. Consequently, the relative weight of the two data sets is taken to be $\approx \frac{9}{35} \approx \frac{1}{4}$. This factor characterizes the relative quality of the two data sets.

b. The relative number of data points per equal area (5°x5° at the equator) cell; each cell was given equal weight. Therefore, data points corresponding to cells with more than the average number of points per cell, $\bar{N}$, received less weight and vice versa.

c. The relative rms error of data in a particular flight or orbit relative to the rms error, $\bar{\sigma}$, for all data of the corresponding data type (MAGSAT or Project MAGNET).

d. The relative rms error of data of a specified type in an equal area cell relative to all data of that type, $\bar{\sigma}$.

e. The age of the data relative to the model epoch 1985.0. Thus, data collected five years away from this epoch get a weight of approximately 1/3, while data collected at the model epoch get a weight of 1.

f. Distance of geomagnetic latitude, Θ , from the geomagnetic equator.

$$|\Theta_M| \leq 20^\circ \quad \left\{ \begin{array}{l} w_{\Theta mn} = 1 \text{ for } k=1,2,3(r,\theta,\phi) \\ w_{\Theta mn} = 0 \text{ for } k=4(F) \end{array} \right\} ; \quad n \equiv 1 \quad (31a)$$

$$|\Theta_M| > 20^\circ \quad \left\{ \begin{array}{l} w_{\Theta mn} = 0 \text{ for } k=1,2,3(r,\theta,\phi) \\ w_{\Theta mn} = 1 \text{ for } k=4(F) \end{array} \right\} ; \quad n \equiv 2 \quad (31b)$$

This weighting scheme then takes the following mathematical form:

$$W_{ijklmn} = W_m w_{\Theta mn} \left(\frac{\bar{N}_{km}}{N_{kmj}} \right) \left(\frac{\bar{\sigma}_{km}}{\sigma_{kml}} \right) \left(\frac{\bar{\sigma}_{km}}{\sigma_{kmj}} \right) e^{-\left(\frac{\tau_i}{\tau}\right)^2} \quad (32)$$

where the indices correspond to the following:

- i*th - data point
- j*th - equal area cell (1654 total)
- k*th - magnetic component (r, θ, ϕ, F)
- l*th - aircraft flight or satellite orbit
- m*th - data type (MAGSAT, Project MAGNET)
- n*th - geomagnetic latitude band ($n=1$ or $n=2$)

The decay constant τ was arbitrarily chosen to be 5 years, while:

$$\Delta\tau_i = \tau_i - T_{EPOCH} \quad (33)$$

where τ_i is the time of observation in years and T_{EPOCH} is 1985.0.

Table 6 gives the overall rms errors of a particular magnetic component for each of the three separate data sets relative to the DGRF/IGRF series of WMMs. Table 7 lists the number of data points associated with each magnetic component for each of the three data sets. Table 8 lists the average number of data points per 5°x5° equal area cell for each magnetic component for each data set. Rms statistics relative to the DGRF/IGRF series of models for the Project MAGNET data set are further broken down by Project ID and flight number in table 9. Due

TABLE 6. RMS ERRORS RELATIVE TO IGRF/DGRF MODELS

	$\bar{\sigma}_x$ rms (nT)	$\bar{\sigma}_y$ rms (nT)	$\bar{\sigma}_z$ rms (nT)	$\bar{\sigma}_F$ rms (nT)
MAGSAT	14.7	12.0	13.2	12.7
Project MAGNET	101.7	107.9	105.5	96.4
DE-2	---	---	---	122.4

TABLE 7. NUMBER OF RECORDS

	N_x	N_y	N_z	N_F
MAGSAT	30473	30473	30473	30473
Project MAGNET	54656	54656	54656	54656
DE-2	---	---	---	5100

TABLE 8. AVERAGE NUMBER OF RECORDS PER CELL

	$\bar{N}_x$	$\bar{N}_y$	$\bar{N}_z$	$\bar{N}_F$
MAGSAT	18.4	18.4	18.4	18.4
Project MAGNET	33.0	33.0	33.0	33.0
DE-2	---	---	---	3.1

TABLES 9. PROJECT MAGNET FLIGHT STATISTICS RELATIVE TO IGRF/DGRF
MODELS (RMS units: nT)

<u>PROJECT</u>	<u>FLIGHT</u>	<u>YEAR</u>	<u>JULIAN</u> <u>DAY</u>	RMS <u>X</u>	RMS <u>Y</u>	RMS <u>Z</u>	RMS <u>E</u>
A32-153	6005	1981	129	116.4	92.3	159.0	156.6
A32-153	6006	1981	133	141.4	98.4	106.1	104.6
A32-153	6007	1981	139	223.7	242.1	191.5	200.9
A32-153	6008	1981	143	88.5	121.4	138.6	137.5
A32-153	6009	1981	146	138.3	86.6	105.3	113.9
A32-153	6010	1981	149	132.5	135.3	151.6	151.5
A32-153	6011	1981	153	200.1	115.8	177.9	176.0
A32-153	6012	1981	155	107.8	233.3	107.0	106.8
A32-153	6013	1981	157	283.0	128.6	181.6	175.2
A32-153	6014	1981	159	146.4	166.2	110.6	111.3
A32-153	6015	1981	162	111.3	101.2	135.2	135.8
C32-252	1074	1982	62	60.1	51.9	49.2	73.2
C32-252	2007	1982	64	68.9	96.6	87.4	82.1
C32-252	2009	1982	67	79.4	76.6	85.1	74.0
C32-252	2011	1982	74	84.0	108.4	103.9	103.4
C32-252	2012	1982	77	95.1	74.4	65.7	94.5
C32-252	2013	1982	89	63.4	60.0	64.8	61.8
C32-252	2014	1982	96	80.5	70.8	79.8	76.8
C32-253	1077	1982	135	85.4	68.7	93.7	93.8
C32-253	1080	1982	149	86.0	121.8	58.9	66.3
C32-253	1081	1982	161	133.6	48.8	48.8	126.9
C32-253	1084	1982	171	63.0	54.8	99.1	91.1
C32-253	1085	1982	175	58.4	61.6	78.1	73.5
C32-253	1086	1982	177	164.8	103.3	162.0	185.9
C32-253	1087	1982	180	98.2	87.1	119.7	122.7
C32-253	1088	1982	182	122.5	134.2	160.7	154.8
C32-253	1091	1982	186	112.4	66.2	98.3	100.1
C32-254	4027	1982	231	86.4	91.4	64.1	70.2
C32-254	4028	1982	233	155.3	81.4	81.1	76.4
C32-254	4049	1982	236	120.9	87.9	89.2	78.1
C32-254	5022	1982	243	100.2	71.1	50.6	60.9
C32-254	5023	1982	246	87.9	74.2	67.2	60.8
C32-254	5026	1982	251	88.4	63.5	71.6	84.4
C32-254	5037	1982	260	81.1	79.5	60.3	83.0
C32-254	5030	1982	274	81.1	80.3	83.0	84.0
C32-254	5031	1982	277	131.6	46.9	90.3	81.1
C32-351	1097	1982	304	150.6	91.3	128.3	147.6
C32-351	3074	1982	305	109.4	126.3	63.6	101.4
C32-351	3075	1982	307	105.5	137.6	89.6	99.9
C32-351	4031	1982	309	103.6	57.3	79.9	96.1
C32-351	4032	1982	312	86.5	128.3	88.9	91.8
C32-351	4033	1982	314	94.9	101.6	97.9	100.0
C32-351	4034	1982	320	73.0	92.1	115.1	93.1
C32-351	4035	1982	322	59.1	144.1	64.6	66.8
C32-351	4036	1982	324	71.6	85.6	105.2	100.3
C32-351	5033	1982	327	208.2	191.1	118.5	124.3

TABLES 9. PROJECT MAGNET FLIGHT STATISTICS RELATIVE TO IGRF/DGRF
MODELS (RMS units: nT)(con.)

<u>PROJECT</u>	<u>FLIGHT</u>	<u>YEAR</u>	<u>JULIAN DAY</u>	<u>RMS X</u>	<u>RMS Y</u>	<u>RMS Z</u>	<u>RMS E</u>
C32-351	4037	1982	332	64.3	75.7	69.8	69.5
C32-351	4038	1982	334	83.3	87.6	89.7	76.5
C32-351	4039	1982	337	72.9	91.8	90.8	84.5
C32-351	4040	1982	339	52.6	67.9	90.9	90.2
C32-351	4041	1982	341	146.6	104.0	81.2	135.6
C32-351	4042	1982	345	83.8	78.9	52.6	82.9
C32-351	4044	1982	350	63.0	83.2	86.0	73.5
C32-351	1098	1982	351	129.4	67.8	145.8	160.9
C32-352	1089	1983	27	64.4	65.0	81.3	78.5
C32-352	1090	1983	31	50.1	80.2	37.3	44.1
C32-352	1099	1983	34	75.6	75.2	101.3	87.3
C32-352	5045	1983	75	98.9	101.5	79.9	98.0
C32-352	5046	1983	78	89.6	80.5	81.6	80.3
C32-352	5047	1983	81	109.5	72.7	83.2	75.0
C32-352	5048	1983	84	212.6	106.5	145.5	130.5
C32-352	4045	1983	87	255.4	236.2	116.9	138.8
C32-352	4046	1983	91	39.4	76.6	56.8	45.1
C32-352	4048	1983	96	59.2	93.9	58.7	69.6
C32-352	1100	1983	99	31.8	35.3	71.1	64.3
C32-353	3076	1983	228	86.3	76.8	111.5	114.6
C32-353	3077	1983	130	64.1	191.7	94.8	76.7
C32-353	3080	1983	161	91.0	71.4	67.8	94.8
C32-353	3081	1983	166	124.0	61.9	115.2	136.6
C32-353	3082	1983	169	96.1	51.1	98.2	93.4
C32-353	3083	1983	171	59.7	121.5	76.2	67.0
C32-353	3084	1983	175	73.2	110.1	96.5	93.4
C32-353	3085	1983	179	91.6	100.1	103.9	114.5
C32-353	3086	1983	183	82.7	64.7	87.7	105.9
C32-353	3087	1983	186	44.8	100.9	64.8	58.9
C32-451	3088	1983	325	73.4	73.7	78.4	83.8
C32-451	3089	1983	327	92.5	66.1	60.9	96.1
C32-451	3090	1983	330	107.6	169.3	112.0	125.5
C32-451	5050	1983	144	93.4	81.6	138.8	134.3
C32-451	5051	1983	336	48.9	49.9	56.8	57.6
C32-451	4051	1983	340	174.0	133.1	103.2	114.6
C32-451	4052	1983	343	114.6	67.4	95.5	105.8
C32-451	4053	1983	346	109.1	130.4	109.4	107.4
C32-451	4054	1983	349	77.8	74.0	94.5	101.6
C32-352	4046	1983	91	39.4	76.6	56.8	45.1
C32-451	1103	1983	354	29.7	35.8	52.8	47.5
C32-452	1108	1984	35	103.7	86.2	110.9	54.4
C32-452	1106	1984	41	115.3	113.8	124.9	122.6
C32-452	5049	1984	45	105.9	58.8	156.2	63.5
C32-452	3091	1984	51	53.2	265.5	242.9	56.3
C32-452	5052	1984	64	120.5	194.8	111.9	97.0
C32-452	4050	1984	67	168.6	175.2	80.7	64.3
C32-452	4055	1984	73	146.1	91.9	174.5	101.3
C32-452	4057	1984	76	61.8	58.1	123.0	44.3
C32-452	4058	1984	78	86.2	68.6	127.7	55.3
C32-452	4059	1984	84	51.3	139.6	158.6	45.2
C32-452	4060	1984	88	28.8	138.5	98.0	38.3

TABLE 9. PROJECT MAGNET FLIGHT STATISTICS RELATIVE TO IGRF/DCRF
MODELS (RMS units: nT) (con.)

PROJECT	FLIGHT	YEAR	JULIAN DAY	RMS X	RMS Y	RMS Z	RMS E
C32-452	4061	1984	91	76.2	62.7	93.1	90.9
C32-452	1107	1984	93	105.8	79.1	139.6	112.5
C32-453	1109	1984	137	97.5	86.3	116.8	115.4
C32-453	3092	1984	140	163.7	83.1	96.5	83.5
C32-453	3094	1984	157	80.1	99.9	119.2	86.9
C32-453	3095	1984	161	70.8	64.8	63.8	79.6
C32-453	3096	1984	164	71.5	153.6	121.6	68.7
C32-453	3097	1984	171	100.8	71.3	88.8	69.9
C32-453	3098	1984	168	138.9	149.5	115.5	81.9
C32-453	3099	1984	171	114.3	79.5	98.6	107.2
C32-453	3101	1984	176	61.4	72.5	75.3	76.2
C32-453	3100	1984	180	98.4	83.6	113.5	118.0
C32-453	3102	1984	183	78.8	69.8	101.2	101.8
C32-453	3103	1984	186	96.7	78.4	125.3	113.1
C32-453	3104	1984	190	68.7	84.4	79.0	88.2
C32-453	1110	1984	192	83.5	88.6	127.5	122.6
C32-454	1048	1984	215	135.4	111.5	165.6	165.2
C32-454	1075	1984	219	62.7	61.5	96.2	96.6
C32-454	1070	1984	221	59.2	74.2	96.3	95.8
C32-454	1121	1984	224	75.6	86.2	100.3	84.0
C32-454	1122	1984	227	69.4	71.7	88.2	70.5
C32-454	1123	1984	230	54.4	52.2	77.8	70.1
C32-454	1124	1984	237	59.7	62.5	100.3	106.8
C32-454	1117	1984	242	101.4	79.2	126.6	129.0
C32-454	1118	1984	246	44.2	78.5	66.4	57.9
C32-454	1119	1984	249	52.6	55.5	71.1	61.1
C32-454	1120	1984	252	57.9	41.8	83.9	66.1
C32-454	1111	1984	255	74.4	63.4	101.4	100.0
C32-454	1112	1984	258	93.6	91.6	113.1	111.5
C32-454	1114	1984	262	66.3	60.8	42.3	55.4
C32-454	1115	1984	272	34.8	37.4	57.2	52.3
C32-551	1126	1984	290	64.6	69.8	81.9	70.9
C32-551	2015	1984	292	117.5	134.4	44.2	141.8
C32-551	2016	1984	295	54.2	101.1	97.9	94.2
C32-551	7005	1984	298	174.7	91.3	114.3	112.2
C32-551	7006	1984	304	80.4	97.5	75.4	76.0
C32-551	7007	1984	307	218.4	186.7	96.3	96.8
C32-551	4065	1984	310	206.9	218.9	121.1	85.7
C32-551	4066	1984	313	101.5	103.3	81.6	79.7
C32-551	4067	1984	319	70.7	137.9	87.8	59.1
C32-551	4068	1984	321	198.6	160.0	107.2	86.6
C32-551	4069	1984	325	119.4	170.7	97.7	62.9
C32-551	4070	1984	329	76.6	232.9	79.9	63.3
C32-551	4071	1984	333	121.9	124.8	74.6	69.4
C32-551	4072	1984	337	91.2	109.8	104.4	93.2
C32-551	3105	1984	342	84.6	52.4	150.7	97.3
C32-551	1127	1984	345	45.9	48.7	95.5	87.6
C32-552	1125	1985	16	81.6	61.5	77.1	54.4
C32-552	1131	1985	19	87.2	105.9	85.2	54.0
C32-552	1132	1985	27	115.7	106.3	72.2	62.7
C32-552	1133	1985	30	88.6	260.8	138.9	124.5

TABLE 9. PROJECT MAGNET FLIGHT STATISTICS RELATIVE TO IGRF/DGRF
MODELS (RMS units: nT) (con.)

<u>PROJECT</u>	<u>FLIGHT</u>	<u>YEAR</u>	<u>JULIAN</u> <u>DAY</u>	RMS <u>X</u>	RMS <u>Y</u>	RMS <u>Z</u>	RMS <u>E</u>
C32-552	2017	1985	33	58.0	136.3	49.0	65.1
C32-552	2029	1985	35	46.1	182.4	41.7	39.0
C32-552	2030	1985	37	68.9	198.5	59.2	78.5
C32-552	2031	1985	40	85.4	127.8	46.0	105.1
C32-552	2032	1985	43	62.6	137.2	104.0	111.7
C32-552	2033	1985	46	54.4	113.0	73.8	71.2
C32-552	2034	1985	49	35.3	110.4	48.6	40.4
C32-552	2022	1985	53	33.6	116.8	59.5	46.1
C32-552	2023A	1985	57	40.0	125.1	64.1	51.9
C32-552	2023	1985	61	75.3	127.6	89.7	85.4
C32-552	7009	1984	62	114.5	99.4	107.0	132.0
C32-552	7008	1985	66	73.0	103.3	75.8	73.0
C32-552	7010	1984	69	101.7	104.1	93.0	102.1
C32-552	7011	1985	71	51.4	123.0	65.5	68.5
C32-552	2036	1985	75	78.6	158.4	83.4	63.6
C32-552	1129	1985	80	209.1	201.6	127.2	51.3
C32-552	1130	1985	84	63.3	59.0	71.4	70.1
C32-553	1134	1985	114	135.9	130.2	96.9	75.0
C32-553	3106	1985	116	54.1	112.2	88.0	92.6
C32-553	3108	1985	120	57.3	112.8	74.9	72.2
C32-553	3109	1985	123	62.7	112.7	55.0	56.2
C32-553	3110	1985	126	59.2	99.9	59.2	56.4
C32-553	3107	1985	129	50.1	131.1	52.2	55.8
C32-553	3111	1985	136	101.9	63.2	157.6	72.9
C32-553	3112	1985	140	60.6	79.0	145.9	61.2
C32-553	3113	1985	144	93.0	67.1	82.7	89.7
C32-553	3114	1985	148	61.0	158.4	80.6	61.3
C32-553	3116	1985	154	81.2	75.5	120.8	61.2
C32-553	3117	1985	157	132.3	82.7	120.9	75.1
C32-553	3118	1985	160	129.8	89.1	145.6	106.9
C32-553	3119	1985	169	223.0	145.9	114.4	111.3
C32-553	3121	1985	171	232.4	111.7	127.1	132.9
C32-553	3122	1985	174	134.8	193.1	130.4	122.9
C32-554	1135	1985	196	105.3	123.5	137.1	131.2
C32-554	1137	1985	210	62.2	58.0	69.9	71.6
C32-554	1136	1985	202	60.8	89.1	85.9	85.3
C32-554	1138	1985	213	109.1	115.5	111.9	109.7
C32-554	1139	1985	217	68.0	78.5	85.3	86.3
C32-554	1140	1985	220	155.7	109.2	126.9	134.0
C32-554	6016	1985	230	151.3	158.4	165.6	174.5
C32-554	1144	1985	244	147.6	116.2	186.4	181.8
C32-554	1141	1985	249	96.4	83.0	91.0	92.6
C32-554	1142	1985	250	155.0	128.9	151.0	151.9
C32-554	6017	1985	252	182.3	94.8	136.2	117.9
C32-651	1143	1985	281	65.6	101.2	88.1	72.2
C32-651	4074	1985	285	32.3	148.1	83.1	36.0
C32-651	4075	1985	290	38.0	225.2	85.0	52.8
C32-651	3125	1985	301	72.0	236.2	95.8	70.4
C32-651	3126	1985	305	61.4	110.8	80.4	62.6
C32-651	5053	1985	314	77.3	178.2	105.1	98.0
C32-651	4077	1985	317	97.0	202.1	114.7	112.4

TABLE 9. PROJECT MAGNET FLIGHT STATISTICS RELATIVE TO IGRF/DGRF
MODELS (RMS units: nT) (con.)

<u>PROJECT</u>	<u>FLIGHT</u>	<u>YEAR</u>	<u>JULIAN</u> <u>DAY</u>	RMS <u>X</u>	RMS <u>Y</u>	RMS <u>Z</u>	RMS <u>E</u>
C32-651	5054	1985	321	83.8	129.6	166.1	145.2
C32-651	5055	1985	324	50.6	68.9	74.4	74.2
C32-651	4078	1985	327	78.6	133.7	68.8	68.6
C32-651	4079	1985	331	78.6	152.5	82.6	74.5
C32-651	4080	1985	334	151.6	247.3	182.1	166.7
C32-651	4081	1985	340	89.5	216.9	119.7	89.5
C32-651	4083	1985	343	78.5	96.0	136.6	143.6
C32-651	4084	1985	345	64.8	77.3	75.3	60.7
C32-652	1128	1986	27	52.7	53.2	47.8	53.1
C32-652	2019	1986	32	62.2	54.5	95.4	78.1
C32-652	5059A	1986	36	49.6	39.4	88.6	63.5
C32-652	5058	1986	40	104.6	42.9	137.4	67.5
C32-652	5057	1986	42	84.3	58.1	154.9	92.3
C32-652	5067	1986	47	55.3	61.7	122.5	102.3
C32-652	5068	1986	51	65.3	61.6	127.9	102.5
C32-652	5056	1986	53	99.4	52.0	128.4	86.7
C32-652	5059B	1986	65	63.7	58.7	116.9	61.4
C32-652	5059C	1986	71	54.5	56.6	70.1	64.3
C32-652	5059D	1986	77	44.2	42.8	58.7	41.9
C32-652	5060	1986	79	45.0	71.0	69.4	49.8
C32-652	5061	1986	81	37.0	72.0	94.0	35.8
C32-652	5062	1986	85	54.2	70.0	78.4	54.2
C32-652	5063	1986	88	100.8	74.4	150.5	139.5
C32-652	5065	1986	95	102.7	75.0	122.6	122.2
C32-652	4085	1986	98	57.0	70.3	103.1	95.9
C32-652	3123	1986	101	56.3	54.8	65.6	65.2
C32-652	3124	1986	104	51.9	99.5	82.4	82.6
C32-754	3147	1987	261	135.5	116.5	90.1	98.6
C32-751	3142	1986	297	75.0	72.6	71.5	74.4
C32-751	3130	1986	327	85.1	52.9	83.4	77.5
C32-751	3131	1986	329	107.6	51.1	81.1	103.2
C32-751	3132	1986	334	89.2	50.9	95.7	85.8
C32-751	3133	1986	337	77.2	55.6	71.5	71.6
C32-751	3140	1986	343	69.1	72.8	63.6	60.8
C32-751	3134	1986	345	55.3	58.7	66.1	53.7
C32-751	3141	1986	347	40.7	48.9	64.4	51.4
C32-751	3135	1986	350	66.6	123.2	143.7	52.2
C32-751	3136	1986	353	44.1	70.3	61.1	39.8
C32-751	3138	1986	354	53.4	51.6	55.9	63.5
C32-753	1154	1987	108	107.4	101.8	140.2	138.1
C32-753	6019	1987	147	100.2	125.5	130.4	128.4
C32-753	1164	1987	181	128.8	120.9	135.7	136.7
C32-753	1160	1987	154	90.1	74.1	117.5	98.5
C32-753	1161	1987	156	31.1	76.9	15.7	21.4
C32-754	1159	1987	203	69.9	52.8	71.6	63.2
C32-754	3143	1987	206	92.5	59.7	80.2	94.0
C32-754	3144	1987	212	74.6	52.2	78.7	79.4
C32-754	4098	1987	216	67.6	135.7	97.0	65.1
C32-754	3145A	1987	231	32.8	200.2	100.4	36.8
C32-552	1133	1985	30	88.6	260.8	138.9	124.5
C32-754	5069	1987	233	83.8	181.5	85.2	88.6

TABLE 9. PROJECT MAGNET FLIGHT STATISTICS RELATIVE TO IGRF/DGRF
MODELS (RMS units: nT) (con.)

PROJECT	FLIGHT	YEAR	JULIAN DAY	RMS X	RMS Y	RMS Z	RMS E
C32-754	5071	1987	251	43.4	54.7	128.0	62.5
C32-754	3145	1987	245	63.3	109.9	78.5	59.7
C32-754	4100	1987	251	64.6	70.3	134.2	61.8
C32-754	3146	1987	246	116.9	81.8	114.4	90.3
C32-851	3148	1987	291	98.6	100.0	103.0	105.9
C32-851	3149	1987	295	61.9	104.6	96.1	80.3
C32-851	3150	1987	299	103.3	88.3	104.1	111.4
C32-851	3152	1987	306	130.9	97.7	116.4	108.3
C32-851	3154	1987	312	69.6	131.4	77.5	69.0
C32-851	3155	1987	316	76.5	60.7	68.1	74.5
C32-851	3156	1987	320	66.1	76.6	81.6	66.7
C32-851	3157	1987	325	81.5	159.6	112.9	88.9
C32-851	3158	1987	29	146.3	87.1	94.3	100.8
C32-851	3159	1987	32	93.8	78.8	110.4	55.5
C32-851	3160	1987	335	63.7	68.6	75.5	73.9
C32-851	3161	1987	348	78.8	45.3	78.0	60.5
C32-852	1167	1988	20	85.2	58.2	101.3	71.7
C32-852	4101	1988	24	42.1	32.6	84.9	33.3
C32-852	4102	1988	27	45.5	67.9	61.1	47.8
C32-852	4103	1988	30	51.7	59.1	68.3	44.3
C32-852	4104	1988	34	103.8	40.7	97.6	57.6
C32-852	4106	1988	39	78.9	70.3	80.6	77.7
C32-852	4107	1988	41	53.9	63.7	80.4	40.2
C32-852	4111	1988	43	84.9	66.2	65.7	70.2
C32-852	4108	1988	49	83.4	56.2	93.5	81.4
C32-852	3162	1988	50	71.9	54.9	82.7	74.2
C32-852	3163	1988	56	58.3	74.1	116.4	67.6
C32-852	3167	1988	59	78.4	131.6	105.8	71.4
C32-852	4110	1988	63	49.2	59.8	94.5	56.6
C32-852	4105	1988	62	71.8	72.3	67.4	63.2
C32-852	3164	1988	77	87.9	49.7	113.9	59.9
C32-952	1177	1989	77	118.1	98.2	139.4	147.2
C32-952	1178	1989	79	115.5	88.6	136.5	147.5
C32-952	1179	1989	81	111.8	79.2	119.8	133.8
C32-952	1180	1989	83	138.4	95.6	122.8	149.6
C32-553	3115	1985	151	122.6	142.2	113.2	88.0
C32-651	3123A	1985	292	53.2	162.1	88.3	63.0
C32-651	3124A	1985	294	56.3	188.8	86.5	64.0
C32-352	5044	1983	69	97.6	88.2	92.9	67.7
C32-853	4113	1988	153	80.3	89.1	114.8	87.9
C32-453	4063	1984	150	71.3	60.2	108.6	78.8
C32-453	4064	1984	152	55.7	53.8	87.6	58.4
C32-951	4122	1988	283	100.9	135.6	151.5	160.6
C32-951	4123	1988	291	96.6	67.8	106.5	92.8
C32-951	4124	1988	295	77.4	66.2	91.0	80.2
C32-951	4125	1988	295	130.2	82.5	75.5	122.6
C32-951	4126	1988	303	103.0	129.4	114.6	92.5
C32-951	4127	1988	310	57.1	77.4	82.7	73.5
C32-951	4120	1988	297	107.7	69.3	80.0	91.0
C32-951	4135	1988	345	71.1	39.9	79.4	48.7
C32-951	5084	1988	324	78.8	44.6	108.0	81.1

TABLE 9. PROJECT MAGNET FLIGHT STATISTICS RELATIVE TO IGRF/DGRF
MODELS.(RMS units: nT) (con.)

<u>PROJECT</u>	<u>FLIGHT</u>	<u>YEAR</u>	<u>JULIAN</u> <u>DAY</u>	<u>RMS</u> <u>X</u>	<u>RMS</u> <u>Y</u>	<u>RMS</u> <u>Z</u>	<u>RMS</u> <u>E</u>
C32-253	1079	1982	145	59.4	53.4	80.5	75.1
C32-853	5073	1988	117	117.5	93.1	261.8	263.4
C32-853	5081	1988	119	73.9	154.1	190.2	182.8
C32-853	5082	1988	122	114.2	110.7	209.3	182.8
C32-853	1168	1988	105	45.9	99.5	66.4	58.6
C32-853	1169	1988	174	82.2	57.7	106.3	58.0
C32-853	5076B	1988	131	72.2	98.1	86.3	84.0
C32-853	5083	1988	124	133.5	60.2	257.0	189.4
C32-853	4114	1988	164	61.5	76.7	85.1	74.5
C32-853	4115	1988	168	108.9	96.5	99.6	87.3
C32-853	4116	1988	171	104.9	66.0	91.4	88.8
C32-951	1171	1988	277	74.8	55.5	79.4	78.2
C32-951	3177	1988	307	62.5	79.5	96.4	87.1
C32-951	4119	1988	281	70.3	71.7	75.5	63.4
C32-951	4121	1988	299	113.5	117.9	195.2	215.4
C32-951	4128	1988	314	73.2	103.4	85.3	84.8
C32-951	4129	1988	318	82.6	81.7	140.2	135.7
C32-951	4130	1988	321	121.6	97.9	107.2	112.2
C32-951	4131	1988	328	73.1	90.9	141.5	126.7
C32-951	4132	1988	331	52.1	89.6	140.1	109.6
C32-951	4133	1988	333	70.6	70.4	66.9	68.8
C32-954	1184	1989	207	104.5	194.1	101.5	109.3
C32-954	1186	1989	212	106.9	171.0	99.2	94.0
C32-954	1188	1989	218	149.6	111.6	94.7	83.0
C32-954	1189	1989	223	99.8	136.8	114.4	111.8
C32-954	1190	1989	228	218.5	160.4	166.2	118.5
C32-954	1196	1989	270	99.7	72.6	79.6	72.7
C32-954	1197	1989	229	173.3	112.3	129.4	86.6
C32-954	1198	1989	234	266.8	79.3	102.3	83.3
C32-954	1199	1989	244	108.4	72.5	66.0	68.9
C32-954	4139	1989	255	102.5	116.5	93.2	78.1
C32-954	1195	1989	267	52.4	119.1	104.3	89.4
C32-954	2057	1989	263	81.3	40.7	107.8	95.3
C32-954	2052	1989	247	103.0	83.9	161.4	173.7
C32-954	2055	1989	258	77.9	68.3	88.2	93.2
C32-954	2056	1989	261	55.2	83.2	173.0	131.6
C32-954	7012	1989	252	99.8	64.4	93.9	45.3

to the uniformity of satellite data, the orbit-by-orbit statistics for MAGSAT and DE-2 data were taken to be the same as for each entire data set for each magnetic component. Note that data occupying cells for which there were fewer than 10 points were discarded due to the presumed unreliability of their cell statistics.

Now, the double summation expression over degree n and order m for $B_r(r, \theta, \phi)$, $B_\theta(r, \theta, \phi)$ and $B_\phi(r, \theta, \phi)$ can be converted to single summation expressions over the coefficient number l which ranges from 1 to 168. Then, we may write:

$$B_r(r, \theta, \phi) = \sum_{l=1}^{168} C_l Q_{rl}(r, \theta, \phi) \quad (34a)$$

$$B_\theta(r, \theta, \phi) = \sum_{l=1}^{168} C_l Q_{\theta l}(r, \theta, \phi) \quad (34b)$$

$$B_\phi(r, \theta, \phi) = \sum_{l=1}^{168} C_l Q_{\phi l}(r, \theta, \phi) \quad (34c)$$

$$B_F(r, \theta, \phi) = \sum_{l=1}^{168} C_l Q_{Fl}(r, \theta, \phi) \quad (34d)$$

where the set of coefficients $\{C_l\}_{l=1}^{168}$ are the Gauss coefficients g_{nm} and h_{nm} arbitrarily arranged so that:

$$C_l = \begin{cases} g_{nm}; & l(n, m) = n(n+1)/2 + m \\ h_{nm}; & l(n, m) = n(n-1)/2 + m + 90 \end{cases} \quad (35)$$

This ordering then requires:

$$Q_{rl}(r, \theta, \phi) = \begin{cases} (n+1) \left(\frac{R_E}{r} \right)^{n+2} \cos m \phi P_n^m(\theta) & ; \quad l(n, m) = n(n+1)/2 + m \\ (n+1) \left(\frac{R_E}{r} \right)^{n+2} \sin m \phi P_n^m(\theta) & ; \quad l(n, m) = n(n-1)/2 + m + 90 \end{cases} \quad (36a)$$

$$Q_{\theta l}(r, \theta, \phi) = \begin{cases} - \left(\frac{R_E}{r} \right)^{n+2} \cos m \phi \frac{dP_n^m(\theta)}{d\theta} & ; \quad l(n, m) = n(n+1)/2 + m \\ - \left(\frac{R_E}{r} \right)^{n+2} \sin m \phi \frac{dP_n^m(\theta)}{d\theta} & ; \quad l(n, m) = n(n-1)/2 + m + 90 \end{cases} \quad (36b)$$

$$Q_{\theta l}(r, \theta, \phi) = \left\{ \begin{array}{ll} m \left(\frac{R_E}{r} \right)^{n+2} \sin m \phi P_n^m(\theta) / \sin \theta & ; \quad l(n, m) = n(n+1)/2 + m \\ -m \left(\frac{R_E}{r} \right)^{n+2} \cos m \phi P_n^m(\theta) / \sin \theta & ; \quad l(n, m) = n(n-1)/2 + m + 90 \end{array} \right\} \quad (36c)$$

$$Q_{Fl} = \frac{1}{B_F(r, \theta, \phi)} \{ B_r(r, \theta, \phi) Q_{r,l}(r, \theta, \phi) + B_\theta(r, \theta, \phi) Q_{\theta,l}(r, \theta, \phi) + B_\phi(r, \theta, \phi) Q_{\phi,l}(r, \theta, \phi) \} \quad (36d)$$

These expressions are the most useful forms in which the spherical harmonic equations for the magnetic field components can be cast for a least-squares problem.

Minimization of the chi-square function then requires that

$$\delta \chi^2 = \sum_{j=1}^{168} \frac{\partial \chi^2}{\partial C_j} \delta C_j \quad (37)$$

be a minimum, where the symbol δ means variation. This in turn requires:

$$\frac{\partial \chi^2}{\partial C_j} = 0 \quad j = 1, \dots, 168 \quad (38)$$

Therefore, we must have:

$$\frac{\partial \chi_r^2}{\partial C_j} + \frac{\partial \chi_\theta^2}{\partial C_j} + \frac{\partial \chi_\phi^2}{\partial C_j} + \frac{\partial \chi_F^2}{\partial C_j} = 0 \quad j = 1, \dots, 168 \quad (39)$$

which is a nonlinear system of 168 equations for the 168 unknown coefficient set $\{C_i\}_{i=1}^{168}$. This system of equations is nonlinear since χ^2 depends on B_F which depends nonlinearly on the coefficients through the expression:

$$B_F(r, \theta, \phi) = \sqrt{B_r^2(r, \theta, \phi) + B_\theta^2(r, \theta, \phi) + B_\phi^2(r, \theta, \phi)} \quad (40)$$

where, B_r , B_θ , and B_ϕ all depend linearly on the coefficients.

Consequently, after noting that:

$$\frac{\partial \chi_r^2}{\partial C_j} = \sum_{l=1}^{168} C_l \sum_{i=1}^{l_r} w_{ri} Q_{r,i}(r_i, \theta_i, \phi_i) Q_{r,j}(r_i, \theta_i, \phi_i) - \sum_{i=1}^{l_r} w_{ri} b_{ri} Q_{r,i}(r_i, \theta_i, \phi_i) \quad (41a)$$

$$\frac{\partial \chi_{\theta}^2}{\partial C_j} = \sum_{i=1}^{168} C_i \sum_{\alpha=1}^{I_{\theta}} w_{\alpha} Q_{\alpha}(r_i, \theta_i, \phi_i) Q_{\theta_j}(r_i, \theta_i, \phi_i) - \sum_{\alpha=1}^{I_{\theta}} w_{\alpha} b_{\alpha} Q_{\theta_j}(r_i, \theta_i, \phi_i) \quad (42b)$$

$$\frac{\partial \chi_{\phi}^2}{\partial C_j} = \sum_{i=1}^{168} C_i \sum_{\phi=1}^{I_{\phi}} w_{\phi} Q_{\phi}(r_i, \theta_i, \phi_i) Q_{\phi_j}(r_i, \theta_i, \phi_i) - \sum_{\phi=1}^{I_{\phi}} w_{\phi} b_{\phi} Q_{\phi_j}(r_i, \theta_i, \phi_i) \quad (42c)$$

$$\begin{aligned} \frac{\partial \chi_F^2}{\partial C_j} = & \sum_{i=1}^{168} C_i \sum_{F=1}^{I_F} w_{F_i} \{ Q_{r_i}(r_i, \theta_i, \phi_i) Q_{r_j}(r_i, \theta_i, \phi_i) + Q_{\alpha}(r_i, \theta_i, \phi_i) Q_{\theta_j}(r_i, \theta_i, \phi_i) + \\ & Q_{\phi}(r_i, \theta_i, \phi_i) Q_{\phi_j}(r_i, \theta_i, \phi_i) \} - \sum_{F=1}^{I_F} w_{F_i} b_{F_i} Q_{F_j} \end{aligned} \quad (42d)$$

we have:

$$\sum_{i=1}^{168} C_i Q_{ij} = \mathfrak{R}_j, \quad j = 1, \dots, 168 \quad (42)$$

where:

$$\begin{aligned} Q_{ij} = & \sum_{\alpha=1}^{I_r} w_{r_i} Q_{r_i}(r_i, \theta_i, \phi_i) Q_{r_j}(r_i, \theta_i, \phi_i) + \sum_{\alpha=1}^{I_{\theta}} w_{\alpha} Q_{\alpha}(r_i, \theta_i, \phi_i) Q_{\theta_j}(r_i, \theta_i, \phi_i) + \\ & \sum_{\phi=1}^{I_{\phi}} w_{\phi} Q_{\phi}(r_i, \theta_i, \phi_i) Q_{\phi_j}(r_i, \theta_i, \phi_i) + \sum_{F=1}^{I_F} w_{F_i} \{ Q_{r_i}(r_i, \theta_i, \phi_i) Q_{r_j}(r_i, \theta_i, \phi_i) + \\ & Q_{\alpha}(r_i, \theta_i, \phi_i) Q_{\theta_j}(r_i, \theta_i, \phi_i) + Q_{\phi}(r_i, \theta_i, \phi_i) Q_{\phi_j}(r_i, \theta_i, \phi_i) \} \end{aligned} \quad (43)$$

and

$$\begin{aligned} \mathfrak{R}_j = & \sum_{\alpha=1}^{I_r} w_{r_i} b_{r_i} Q_{r_j}(r_i, \theta_i, \phi_i) + \sum_{\alpha=1}^{I_{\theta}} w_{\alpha} b_{\alpha} Q_{\theta_j}(r_i, \theta_i, \phi_i) + \\ & \sum_{\phi=1}^{I_{\phi}} w_{\phi} b_{\phi} Q_{\phi_j}(r_i, \theta_i, \phi_i) + \sum_{F=1}^{I_F} w_{F_i} b_{F_i} Q_{F_j}(r_i, \theta_i, \phi_i) \end{aligned} \quad (44)$$

This system of 168 equations can be written in matrix form as:

$$CQ = \mathfrak{R} \quad (45)$$

which has the inverse:

$$C = Q^{-1} \mathfrak{R} \quad (46)$$

This is not the solution to the problem, however, since the right-hand side of this equation also depends on the unknown coefficients C_i . That is, each element, $\mathfrak{R}_j$, of the vector $\mathfrak{R}$ depends on $Q_F(r, \theta, \phi)$, which depends on the unknown coefficients C_i in a very nonlinear way.

In order to solve this system of equations, we must iterate. If p is the iteration index, then we can let:

$$C_i^{(p)} = C_i^{(p-1)} + \delta C_i \quad (47)$$

Then, in matrix form, we choose the following iteration scheme:

$$C^{(p)} \equiv Q^{-1} \mathfrak{R}^{(p-1)} \quad p = 1, 2, \dots, p_{\max} \quad (48)$$

The maximum number of iterations $p_{\max}$ is determined by requiring that:

$$\sum_{i=1}^{168} \delta C_i \leq 1 \text{ nanotesla at } p = p_{\max} \quad (49)$$

This condition must be tested after each iteration until it is satisfied.

The rate of convergence of the algorithm depends strongly on the amount of noise (i.e., crustal influences, etc.) in the data. Aeromagnetic data have a great deal of crustal noise in them. Filtering the data to remove short wavelength (≤ 700 km) features from the data can improve the convergence rate by an order of magnitude. However, it has been shown that one-dimensional filters along the survey track leave short wavelength biases in the cross-track direction which adversely affect the final model. Consequently, no filtering (except for a very short wavelength (≤ 7 km) low-pass filter) was done on the aeromagnetic data. The number of iterations required for the model was $p_{\max} = 14$.

In order to implement the algorithm it is necessary to have an initial guess solution $C^{(0)}$ that is as close as possible to the actual solution. The a priori model coefficients used were the existing WC-85 model coefficients (Quinn, Kerridge, and Barraclough, 1986).

Notice that in this iteration scheme, the Q matrix, which has (168 x 168) elements (as does its inverse Q^{-1}), needs to be computed only once since it does not depend on the coefficients C_i . Note, too, that Q is a symmetric matrix so that only half of the elements in Q actually need to be computed.

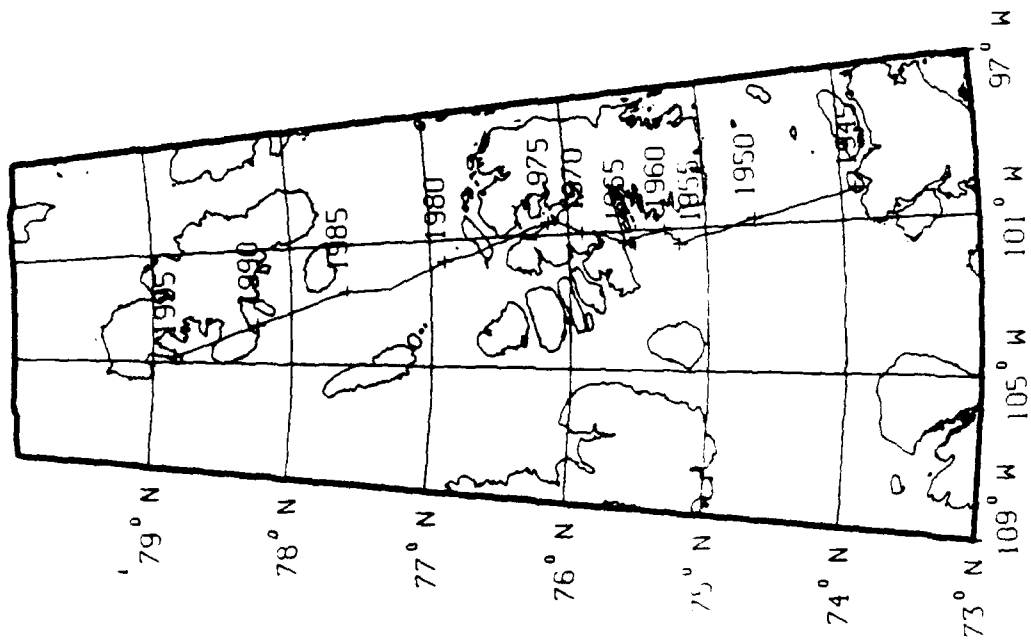
SECTION 3. DISCUSSION

3.0 Modeling Results

An indication of the erratic nature of the geomagnetic field is provided by the wandering of the North and South Geomagnetic Poles. The pole movements since 1945 are illustrated in charts 5 and 6 which are based on the International Geomagnetic Reference Field (IGRF) models, WC-85 (revised) and WMM-90. The pole movements illustrate a poorly understood phenomena known as the geomagnetic jerk which occurred around 1970. The South Magnetic Pole movement in particular illustrates a sudden change in direction at about that time. These jerks occur only a few times per century and are thought to be due to a sudden release of magnetic energy built up from the electromagnetic coupling between the top of the fluid core and the lower mantle, both of which have substantial electrical conductivities. The numerical pole positions at one-year intervals for both poles are listed in table 10.

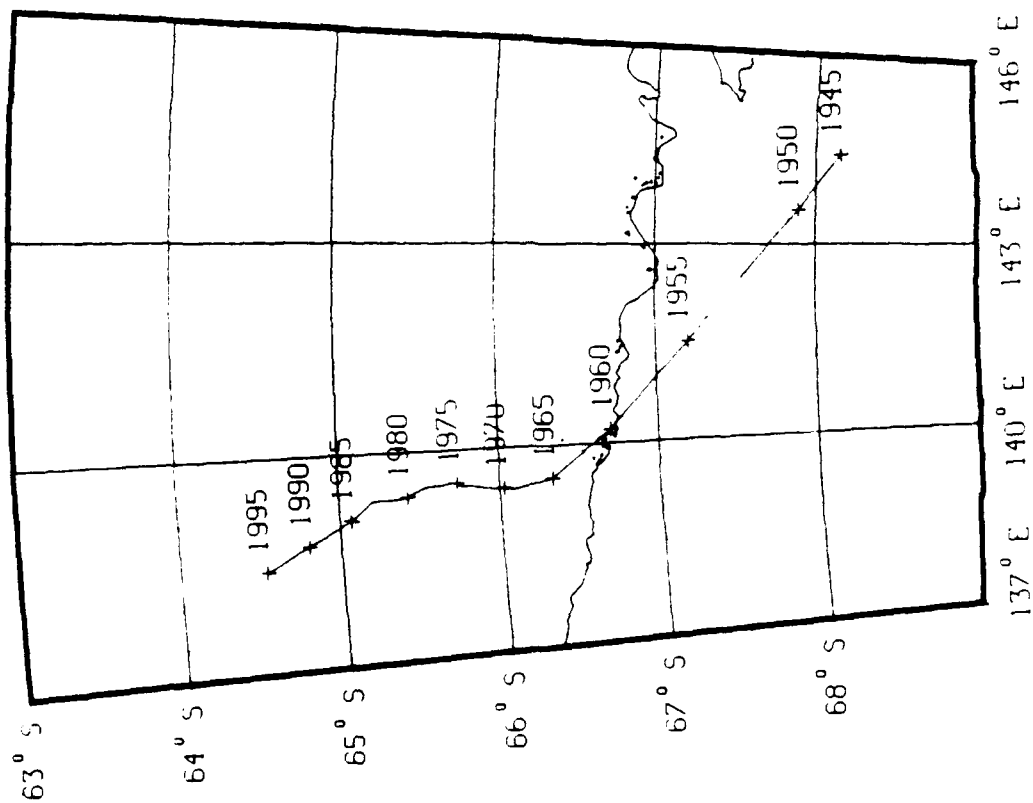
It should be noted that roughly 90 percent of the Earth's magnetic field is contained in the degree 1 spherical harmonic coefficients: g_1^0 , g_1^1 , and h_1^1 . These three coefficients characterize the Earth's magnetic dipole field and form the basis of the geomagnetic coordinate system, which for the 1990 epoch is illustrated in chart 7. The axis of the geomagnetic coordinate system pierces the Earth's surface at the Earth's magnetic dipoles, which are different from the dip poles. The location of the dipole poles is determined when the horizontal (H) component of the dipole field, computed from just the degree $n=1$ coefficients, is equal to zero. The dip poles on the other hand are determined when the horizontal (H) component of the field is computed using all 168 coefficients of the full-degree $n=12$ model is equal to zero. For the WMM-90 model at 1990.0, the North magnetic dipole pole position is located at +79.35 degrees latitude and -71.10 degrees longitude, while the South magnetic dipole pole position is located at -79.35 degrees latitude and +108.86 degrees longitude. The displacement vector for the eccentric dipole for 1990.0 in the usual Earth-fixed spherical coordinate system (i.e., Z-axis is the rotation axis, X-axis points to the prime meridian and the Y-axis is orthogonal to the other two, thereby creating a right-handed system) is 512 km radially outward from the Earth's center, with a colatitude 21.12 degrees and a longitude of 145.70 degrees.

A grid of main field and annual change values of the Earth's magnetic field derived from WMM-90 are tabulated in table 11 for seven basic magnetic field components (X,Y,Z,H,F,D,I). Contours of five of these components (Z,H,F,D,I) for the main field are illustrated in charts 8 through 12. Contours of the annual change of these five components are illustrated in charts 13 through 17. These charts were plotted on a corrected Mercator projection.



1945-1984 DGRF MODELS
 1985-1989 WC-85 (REVISED)
 1990-1995 WMM-90

CHART 5. NORTH MAGNETIC POLE MOVEMENT



1945-1984 DGRF MODELS
 1985-1989 WC-85 (REVISED)
 1990-1995 WMM-90

CHART 6. SOUTH MAGNETIC POLE MOVEMENT

TABLE 10. DIP POLE POSITIONS

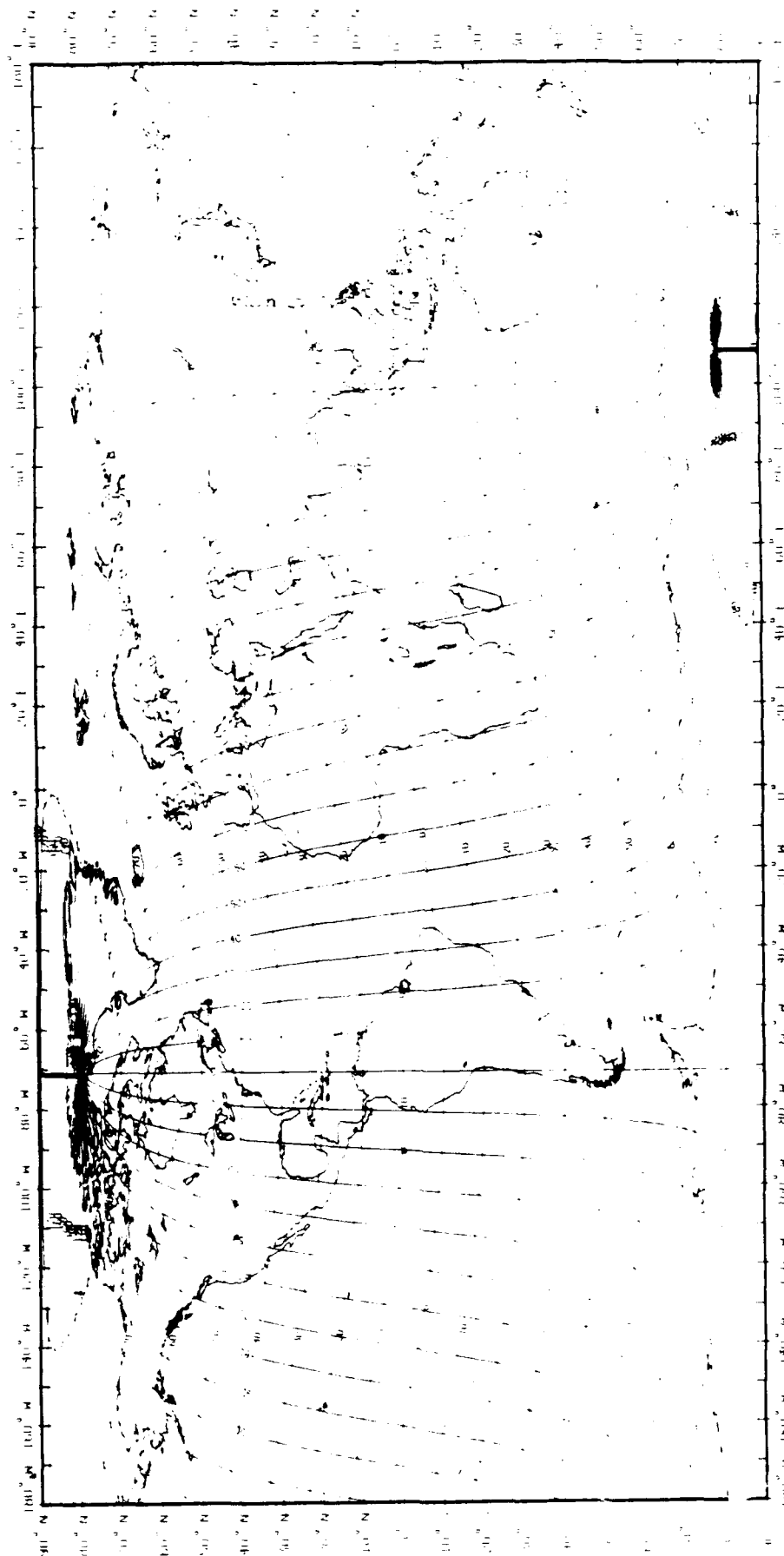
	<u>Year</u>	<u>North Pole</u>		<u>South Pole</u>	
		<u>Latitude</u> (degrees)	<u>Longitude</u> (degrees)	<u>Latitude</u> (degrees)	<u>Longitude</u> (degrees)
1	1945.000	73.90	-100.20	-68.15	144.42
2	1946.000	74.05	-100.35	-68.10	144.25
3	1947.000	74.20	-100.45	-68.05	144.08
4	1948.000	74.35	-100.60	-68.00	143.91
5	1949.000	74.50	-100.75	-67.94	143.71
6	1950.000	74.65	-100.85	-67.89	143.53
7	1951.000	74.75	-100.95	-67.75	143.12
8	1952.000	74.85	-101.10	-67.62	142.72
9	1953.000	74.95	-101.20	-67.48	142.31
10	1954.000	75.05	-101.25	-67.34	141.90
11	1955.000	75.20	-101.45	-67.20	141.50
12	1956.000	75.20	-101.35	-67.10	141.24
13	1957.000	75.25	-101.30	-67.00	140.99
14	1958.000	75.25	-101.20	-66.91	140.75
15	1959.000	75.30	-101.15	-66.81	140.50
16	1960.000	75.30	-101.05	-66.70	140.21
17	1961.000	75.35	-101.10	-66.63	140.03
18	1962.000	75.45	-101.15	-66.55	139.93
19	1963.000	75.50	-101.25	-66.48	139.79
20	1964.000	75.55	-101.25	-66.41	139.67
21	1965.000	75.60	-101.35	-66.33	139.51
22	1966.000	75.65	-101.25	-66.27	139.43
23	1967.000	75.70	-101.20	-66.21	139.44
24	1968.000	75.75	-101.10	-66.15	139.41
25	1969.000	75.80	-101.05	-66.09	139.38
26	1970.000	75.90	-101.00	-66.03	139.40
27	1971.000	75.95	-100.90	-65.96	139.40
28	1972.000	76.00	-100.80	-65.90	139.43
29	1973.000	76.05	-100.70	-65.84	139.46
30	1974.000	76.10	-100.60	-65.77	139.46
31	1975.000	76.15	-100.65	-65.74	139.51
32	1976.000	76.30	-100.85	-65.69	139.51
33	1977.000	76.40	-101.05	-65.63	139.49
34	1978.000	76.55	-101.25	-65.58	139.49
35	1979.000	75.65	-101.45	-65.52	139.46
36	1980.000	76.90	-101.70	-65.43	139.35
37	1981.000	77.00	-101.90	-65.37	139.33
38	1982.000	77.10	-102.10	-65.31	139.32
39	1983.000	77.20	-102.30	-65.26	139.33
40	1984.000	77.30	-102.55	-65.20	139.31
41	1985.000	77.60	-102.60	-65.07	139.06
42	1986.000	77.75	-102.80	-65.02	139.00
43	1987.000	77.85	-103.00	-64.96	138.93
44	1988.000	78.00	-103.25	-64.91	138.87
45	1989.000	78.10	-103.40	-64.86	138.81
46	1990.000	78.25	-103.70	-64.80	138.74
47	1991.000	78.35	-103.85	-64.75	138.69
48	1992.000	78.50	-104.15	-64.69	139.61
49	1993.000	78.60	-104.35	-64.64	138.56
50	1994.000	78.70	-104.55	-64.58	138.48
51	1995.000	78.85	-104.80	-64.53	138.43

Contours of these same five main field magnetic components plus grid variation in the north polar region are given in charts 18 through 23, while contours of their secular variations are given in charts 24 through 29. Similarly, for the south polar region, the main field contours are given in charts 30 through 35, while the corresponding secular variations are given in charts 36 through 41. These polar charts were plotted on a polar stereographic projection. Both the Mercator and polar stereographic charts were generated with respect to the 1984 World Geodetic System (WGS-84) ellipsoid.

3.1 Final Comments

The Polar Orbiting Geomagnetic Survey (POGS) satellite was launched in April of 1990, too late to be used in the 1990 epoch model. WMM-90, having been derived from data sets independent of POGS, will be a useful tool for evaluating POGS data and vice versa. Initial quantitative comparisons between WMM-90 and the POGS data indicate excellent agreement between the two. The POGS data will be used to fabricate the 1995 epoch model. Furthermore, if the satellite remains operational for its maximum expected lifetime of three years, it will for the first time be possible to generate a secular variation model to the same degree and order as the main field (i.e., $N=M=12$).

Looking toward the end of this century and beyond, efforts have been made to secure data for modeling purposes via the Defense Meteorological Satellite Program (DMSP) platform. Efforts are underway to secure scalar data from a boom-mounted POGS-type magnetometer on the S-15 DMSP satellite. This data will support the Epoch 2000 WMM. Further out, efforts are being made to secure full vector magnetic capability from DMSP Block 6 satellites that will operate during the first quarter of the next century.



U. S. NAVAL OCEANOGRAPHIC OFFICE

CHART 7. GEOMAGNETIC COORDINATES

TABLE 11. WMM-90 MAIN FIELD AND ANNUAL CHANGE GRID VALUES

NORTH COMPONENT (X) WMM-90

L. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG
LAT													LAT
90	1819 -0.5	1914 -2.8	2012 -9.2	2029 -10.2	2124 -11.3	2156 -12.3	2172 -13.2	2171 -14.0	2153 -14.3	2120 -14.5	2070 -15.8	2004 -16.1	90
85	4511 -12.1	4553 -13.6	4615 -15.2	4627 -16.2	4693 -18.0	4721 -19.2	4803 -20.6	4855 -22.5	4876 -23.8	4863 -24.3	4813 -25.3	4746 -26.6	85
80	6113 -14.6	6157 -15.8	6219 -17.2	6212 -18.2	6266 -19.6	6278 -20.2	6332 -21.2	6384 -23.1	6406 -23.8	6373 -24.3	6323 -25.3	6256 -26.6	80
75	8199 -18.6	8245 -18.2	8299 -18.2	8299 -19.2	8326 -19.2	8293 -21.2	8200 -22.2	8151 -23.1	8051 -23.8	7708 -24.3	7329 -25.3	6925 -26.6	75
70	10241 -22.1	10218 -20.8	10228 -19.2	10280 -18.2	10221 -16.2	10806 -18.2	10630 -19.2	10421 -20.8	10157 -20.5	9850 -21.2	9509 -22.3	9133 -23.0	70
65	12840 -25.1	12840 -25.1	12884 -25.0	12978 -21.2	12928 -13.2	12838 -14.3	12710 -15.2	12548 -16.9	12351 -16.3	12122 -16.7	11862 -17.0	11576 -17.5	65
60	15419 -29.2	15098 -27.2	15312 -25.2	15089 -23.2	15038 -21.2	14965 -19.2	14874 -18.2	14768 -17.2	14642 -16.3	14510 -15.7	14353 -15.2	14190 -14.5	60
55	17413 -32.6	17439 -31.1	17422 -28.8	17378 -26.2	17319 -24.2	17253 -22.0	17188 -20.7	17126 -19.7	17070 -18.2	17018 -17.4	16972 -16.2	16929 -15.2	55
50	19953 -36.3	19953 -36.3	19923 -34.2	19965 -32.1	19801 -29.1	19743 -27.3	19693 -26.0	19663 -24.6	19652 -23.0	19666 -21.8	19708 -20.0	19777 -18.2	50
45	22609 -40.0	22609 -40.0	22584 -37.2	22532 -35.2	22580 -33.2	22536 -31.8	22483 -30.3	22396 -28.6	22313 -26.1	22269 -24.8	22320 -23.0	22378 -21.2	45
40	25217 -43.7	25217 -43.7	25222 -41.2	25317 -39.2	25306 -37.6	25299 -36.0	25283 -34.3	25296 -32.6	25326 -30.9	25406 -29.0	25549 -27.2	25757 -25.2	40
35	27872 -47.2	27928 -45.2	28049 -42.0	28103 -39.9	28149 -37.8	28189 -35.3	28222 -32.5	28253 -29.9	28299 -27.8	28385 -25.4	28519 -23.8	28780 -21.9	35
30	30532 -50.7	30412 -48.2	30563 -45.2	30704 -42.2	30829 -39.2	30933 -36.3	31014 -33.4	31074 -30.4	31136 -27.8	31228 -25.4	31389 -23.0	31644 -21.1	30
25	32102 -54.2	32391 -51.0	32665 -48.6	32875 -45.2	33081 -42.1	33251 -39.2	33385 -36.5	33481 -33.1	33570 -29.4	33682 -26.0	33859 -23.6	34110 -21.0	25
20	33245 -57.2	33639 -53.5	33906 -50.0	34221 -46.2	34608 -42.3	34946 -38.8	35032 -36.0	35172 -32.6	35307 -29.3	35461 -26.6	35678 -24.2	35986 -21.6	20
15	34607 -60.7	35001 -56.6	35368 -52.8	35776 -48.4	36137 -44.3	36437 -40.3	36679 -36.7	36861 -33.1	36976 -29.6	37026 -26.1	37099 -23.6	37187 -21.1	15
10	35447 -64.2	35821 -59.6	36166 -55.2	36509 -50.8	36844 -46.4	37060 -42.3	37159 -38.3	37120 -34.2	37051 -30.1	36966 -26.1	36828 -22.7	36614 -19.4	10
5	36926 -67.7	37306 -62.1	37599 -57.3	37838 -52.9	38008 -48.6	38099 -44.3	38168 -40.3	38128 -36.2	38069 -32.1	37998 -28.0	37873 -24.0	37688 -20.0	5
0	37448 -71.2	37829 -65.7	38027 -60.2	38164 -55.8	38221 -51.3	38271 -46.8	38347 -42.4	38344 -38.4	38271 -34.3	38145 -30.3	37971 -26.3	37753 -22.3	0
L. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG
LAT													LAT

nT
(units: nT)

NORTH COMPONENT (X) WMM-90

L. LONG	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG	LAT
90	192.3 -16.2	182.7 -16.5	171.6 -16.4	159.3 -16.3	146.0 -16.0	132.6 -15.6	119.3 -15.3	99.4 -14.1	82.1 -13.2	64.3 -12.9	45.3 -12.0	27.3 -10.9	90	90
85	192.8 -20.2	180.2 -20.2	169.0 -19.9	156.0 -19.3	142.8 -18.7	129.1 -18.1	115.4 -17.4	95.6 -15.8	77.1 -14.8	58.0 -13.8	38.1 -12.8	18.1 -11.4	85	85
80	192.8 -25.8	175.2 -25.2	162.2 -24.2	148.2 -23.2	134.2 -22.2	120.2 -21.2	106.2 -20.2	86.2 -18.2	67.2 -17.2	48.2 -16.2	29.2 -15.2	9.2 -13.2	80	80
75	192.8 -30.2	170.2 -29.2	156.2 -28.2	142.2 -27.2	128.2 -26.2	114.2 -25.2	100.2 -24.2	79.2 -22.2	59.2 -21.2	39.2 -20.2	19.2 -19.2	-1.2 -17.2	75	75
70	192.8 -35.2	165.2 -34.2	151.2 -33.2	137.2 -32.2	123.2 -31.2	109.2 -30.2	95.2 -29.2	73.2 -27.2	53.2 -26.2	33.2 -25.2	13.2 -24.2	-7.2 -23.2	70	70
65	192.8 -40.2	160.2 -39.2	146.2 -38.2	132.2 -37.2	118.2 -36.2	104.2 -35.2	90.2 -34.2	68.2 -32.2	48.2 -31.2	28.2 -30.2	8.2 -29.2	-12.2 -28.2	65	65
60	192.8 -45.2	155.2 -44.2	141.2 -43.2	127.2 -42.2	113.2 -41.2	99.2 -40.2	85.2 -39.2	63.2 -37.2	43.2 -36.2	23.2 -35.2	3.2 -34.2	-17.2 -33.2	60	60
55	192.8 -50.2	150.2 -49.2	136.2 -48.2	122.2 -47.2	108.2 -46.2	94.2 -45.2	80.2 -44.2	58.2 -42.2	38.2 -41.2	18.2 -40.2	-2.2 -39.2	-22.2 -38.2	55	55
50	192.8 -55.2	145.2 -54.2	131.2 -53.2	117.2 -52.2	103.2 -51.2	89.2 -50.2	75.2 -49.2	53.2 -47.2	33.2 -46.2	13.2 -45.2	-7.2 -44.2	-32.2 -43.2	50	50
45	192.8 -60.2	140.2 -59.2	126.2 -58.2	112.2 -57.2	98.2 -56.2	84.2 -55.2	70.2 -54.2	48.2 -52.2	28.2 -51.2	8.2 -50.2	-12.2 -49.2	-42.2 -48.2	45	45
40	192.8 -65.2	135.2 -64.2	121.2 -63.2	107.2 -62.2	93.2 -61.2	79.2 -60.2	65.2 -59.2	43.2 -57.2	23.2 -56.2	3.2 -55.2	-17.2 -54.2	-62.2 -53.2	40	40
35	192.8 -70.2	130.2 -69.2	116.2 -68.2	102.2 -67.2	88.2 -66.2	74.2 -65.2	60.2 -64.2	38.2 -62.2	18.2 -61.2	-2.2 -60.2	-22.2 -59.2	-82.2 -58.2	35	35
30	192.8 -75.2	125.2 -74.2	111.2 -73.2	97.2 -72.2	83.2 -71.2	69.2 -70.2	55.2 -69.2	33.2 -67.2	13.2 -66.2	-7.2 -65.2	-27.2 -64.2	-102.2 -63.2	30	30
25	192.8 -80.2	120.2 -79.2	106.2 -78.2	92.2 -77.2	78.2 -76.2	64.2 -75.2	50.2 -74.2	28.2 -72.2	8.2 -71.2	-12.2 -70.2	-32.2 -69.2	-132.2 -68.2	25	25
20	192.8 -85.2	115.2 -84.2	101.2 -83.2	87.2 -82.2	73.2 -81.2	59.2 -80.2	45.2 -79.2	23.2 -77.2	3.2 -76.2	-17.2 -75.2	-37.2 -74.2	-182.2 -73.2	20	20
15	192.8 -90.2	110.2 -89.2	96.2 -88.2	82.2 -87.2	68.2 -86.2	54.2 -85.2	40.2 -84.2	18.2 -82.2	-2.2 -81.2	-22.2 -80.2	-42.2 -79.2	-202.2 -78.2	15	15
10	192.8 -95.2	105.2 -94.2	91.2 -93.2	77.2 -92.2	63.2 -91.2	49.2 -90.2	35.2 -89.2	13.2 -87.2	-7.2 -86.2	-27.2 -85.2	-47.2 -84.2	-252.2 -83.2	10	10
5	192.8 -100.2	100.2 -99.2	86.2 -98.2	72.2 -97.2	58.2 -96.2	44.2 -95.2	30.2 -94.2	8.2 -92.2	-12.2 -91.2	-32.2 -90.2	-52.2 -89.2	-292.2 -88.2	5	5
0	192.8 -105.2	95.2 -104.2	81.2 -103.2	67.2 -102.2	53.2 -101.2	39.2 -100.2	25.2 -99.2	3.2 -97.2	-17.2 -96.2	-37.2 -95.2	-57.2 -94.2	-312.2 -93.2	0	0
LAT														
L. LONG	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG	LAT

NORTH COMPONENT (X) WMM-90

L. LONG.	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG.
LAT													LAT
90	-9.8	-10.6	-7.4	-4.1	-6.4	-3.3	-10.4	-1.7	-1.32	-1.477	-1.610	-1.731	90
85	-10.5	-11.5	-9.5	-8.5	-5.8	-2.5	-12.8	-1.2	-1.31	-1.21	-1.290	-1.355	85
80	-10.8	-12.5	-10.8	-11.6	-13.5	-10.6	-13.5	-1.5	-1.425	-1.35	-1.437	-1.524	80
75	-10.0	-11.3	-9.7	-10.2	-10.5	-8.9	-12.3	-2.6	-2.60	-2.1	-2.168	-2.225	75
70	-7.68	-7.93	-7.47	-7.66	-9.98	-10.55	-10.67	-11.10	-11.62	-11.705	-11.827	-11.921	70
65	-7.80	-7.99	-7.79	-7.75	-10.39	-10.69	-14.81	-14.60	-14.93	-15.225	-15.324	-15.385	65
60	-7.84	-7.57	-7.28	-7.25	-10.17	-10.23	-17.50	-17.56	-18.243	-18.607	-18.659	-18.550	60
55	-7.968	-7.609	-7.601	-7.409	-10.65	-10.25	-20.52	-20.15	-21.073	-21.17	-21.958	-20.881	55
50	-7.97	-7.906	-7.360	-7.271	-10.77	-10.16	-23.381	-23.457	-24.39	-25.225	-25.121	-22.847	50
45	-7.288	-7.436	-7.581	-7.704	-12.83	-12.75	-25.795	-25.595	-25.369	-25.070	-24.712	-24.315	45
40	-7.958	-7.929	-7.869	-7.857	-12.92	-10.81	-27.61	-27.788	-28.559	-28.963	-29.510	-29.412	40
35	-7.741	-7.513	-7.239	-7.007	-10.08	-9.23	-29.501	-28.912	-29.279	-27.919	-26.953	-26.316	35
30	-7.51	-7.036	-6.548	-6.029	-9.33	-8.25	-31.011	-30.242	-29.451	-28.658	-27.888	-27.171	30
25	-7.661	-7.129	-6.575	-6.018	-9.42	-8.21	-32.316	-31.466	-30.556	-29.687	-28.865	-28.119	25
20	-7.349	-6.732	-6.023	-5.238	-9.158	-8.358	-33.518	-32.578	-31.658	-30.781	-29.868	-29.242	20
15	-7.456	-6.814	-6.090	-5.266	-9.392	-8.582	-34.562	-33.655	-32.783	-31.962	-31.213	-30.555	15
10	-7.923	-7.168	-6.375	-5.511	-10.11	-9.271	-35.444	-34.442	-33.879	-33.169	-32.527	-31.963	10
5	-7.912	-7.198	-6.303	-5.350	-10.66	-9.771	-36.091	-35.40	-34.826	-34.260	-33.745	-33.288	5
0	-7.924	-7.905	-7.450	-7.247	-10.71	-9.896	-36.386	-35.902	-35.450	-35.033	-34.650	-34.297	0
LAT													LAT
L. LONG.	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG.

NORTH COMPONENT (X) WMM-90

L. LONG LAT	180	185	190	195	200	205	210	215	220	225	230	235	L. LONG LAT
90	-18.9 5.5	-17.6 5.5	-16.2 5.8	-14.8 6.1	-13.4 6.4	-11.9 6.7	-10.5 7.0	-9.1 7.3	-7.7 7.6	-6.3 7.9	-4.9 8.2	-3.5 8.5	0
85	-17.1 5.5	-15.7 5.8	-14.3 6.1	-12.9 6.4	-11.5 6.7	-10.1 7.0	-8.7 7.3	-7.3 7.6	-5.9 7.9	-4.5 8.2	-3.1 8.5	-1.7 8.8	5
80	-15.3 5.5	-13.9 5.8	-12.5 6.1	-11.1 6.4	-9.7 6.7	-8.3 7.0	-6.9 7.3	-5.5 7.6	-4.1 7.9	-2.7 8.2	-1.3 8.5	0.1 8.8	10
75	-13.5 5.5	-12.1 5.8	-10.7 6.1	-9.3 6.4	-7.9 6.7	-6.5 7.0	-5.1 7.3	-3.7 7.6	-2.3 7.9	-0.9 8.2	0.5 8.5	1.9 8.8	15
70	-11.7 5.5	-10.3 5.8	-8.9 6.1	-7.5 6.4	-6.1 6.7	-4.7 7.0	-3.3 7.3	-1.9 7.6	-0.5 7.9	0.9 8.2	2.3 8.5	3.7 8.8	20
65	-9.9 5.5	-8.5 5.8	-7.1 6.1	-5.7 6.4	-4.3 6.7	-2.9 7.0	-1.5 7.3	-0.1 7.6	1.3 7.9	2.7 8.2	4.1 8.5	5.5 8.8	25
60	-8.1 5.5	-6.7 5.8	-5.3 6.1	-3.9 6.4	-2.5 6.7	-1.1 7.0	0.3 7.3	1.7 7.6	3.1 7.9	4.5 8.2	5.9 8.5	7.3 8.8	30
55	-6.3 5.5	-4.9 5.8	-3.5 6.1	-2.1 6.4	-0.7 6.7	0.7 7.0	2.1 7.3	3.5 7.6	4.9 7.9	6.3 8.2	7.7 8.5	9.1 8.8	35
50	-4.5 5.5	-3.1 5.8	-1.7 6.1	-0.3 6.4	1.1 6.7	2.5 7.0	3.9 7.3	5.3 7.6	6.7 7.9	8.1 8.2	9.5 8.5	10.9 8.8	40
45	-2.7 5.5	-1.3 5.8	0.1 6.1	1.5 6.4	2.9 6.7	4.3 7.0	5.7 7.3	7.1 7.6	8.5 7.9	9.9 8.2	11.3 8.5	12.7 8.8	45
40	-0.9 5.5	0.5 5.8	1.9 6.1	3.3 6.4	4.7 6.7	6.1 7.0	7.5 7.3	8.9 7.6	10.3 7.9	11.7 8.2	13.1 8.5	14.5 8.8	50
35	0.9 5.5	2.3 5.8	3.7 6.1	5.1 6.4	6.5 6.7	7.9 7.0	9.3 7.3	10.7 7.6	12.1 7.9	13.5 8.2	14.9 8.5	16.3 8.8	55
30	2.7 5.5	4.1 5.8	5.5 6.1	6.9 6.4	8.3 6.7	9.7 7.0	11.1 7.3	12.5 7.6	13.9 7.9	15.3 8.2	16.7 8.5	18.1 8.8	60
25	4.5 5.5	5.9 5.8	7.3 6.1	8.7 6.4	10.1 6.7	11.5 7.0	12.9 7.3	14.3 7.6	15.7 7.9	17.1 8.2	18.5 8.5	19.9 8.8	65
20	6.3 5.5	7.7 5.8	9.1 6.1	10.5 6.4	11.9 6.7	13.3 7.0	14.7 7.3	16.1 7.6	17.5 7.9	18.9 8.2	20.3 8.5	21.7 8.8	70
15	8.1 5.5	9.5 5.8	10.9 6.1	12.3 6.4	13.7 6.7	15.1 7.0	16.5 7.3	17.9 7.6	19.3 7.9	20.7 8.2	22.1 8.5	23.5 8.8	75
10	9.9 5.5	11.3 5.8	12.7 6.1	14.1 6.4	15.5 6.7	16.9 7.0	18.3 7.3	19.7 7.6	21.1 7.9	22.5 8.2	23.9 8.5	25.3 8.8	80
5	11.7 5.5	13.1 5.8	14.5 6.1	15.9 6.4	17.3 6.7	18.7 7.0	20.1 7.3	21.5 7.6	22.9 7.9	24.3 8.2	25.7 8.5	27.1 8.8	85
0	13.5 5.5	14.9 5.8	16.3 6.1	17.7 6.4	19.1 6.7	20.5 7.0	21.9 7.3	23.3 7.6	24.7 7.9	26.1 8.2	27.5 8.5	28.9 8.8	90

NORTH COMPONENT (X) WMM-90

L. LONG LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG LAT
90	-19.23 16.26	-19.27 16.25	-17.18 16.26	-15.95 16.25	-14.68 16.25	-13.14 16.25	-11.58 16.25	-9.94 16.24	-8.23 16.21	-6.43 15.25	-4.58 14.26	-2.73 13.25	90
85	-8.41 12.24	-9.34 13.26	-9.89 14.26	-10.04 15.26	-9.75 15.26	-9.00 16.25	-7.80 16.25	-6.16 16.24	-4.08 16.21	-1.61 15.25	1.23 14.26	4.37 13.25	85
80	3.56 10.22	7.4 12.21	14.5 14.25	29.4 16.24	38.0 16.20	39.3 16.25	28.2 16.25	20.7 16.25	12.5 16.25	4.14 16.26	8.04 16.20	12.28 16.20	80
75	19.11 10.22	14.61 13.21	10.24 16.24	8.21 16.21	2.82 16.25	23.3 16.25	24.2 16.25	29.2 16.25	30.4 16.25	34.8 16.25	38.3 16.25	41.4 16.25	75
70	49.04 49.04	34.15 34.15	39.29 39.29	33.44 33.44	22.88 22.88	21.54 21.54	21.18 21.18	31.49 31.49	32.48 32.48	39.22 39.22	40.99 40.99	49.58 49.58	70
65	62.78 16.26	60.04 18.21	54.24 21.23	49.54 24.22	46.19 26.22	44.04 29.21	43.42 31.21	44.29 32.23	46.58 33.23	49.58 36.23	53.04 38.26	60.83 41.26	65
60	98.18 16.26	91.09 18.21	84.80 21.23	78.48 24.22	73.13 26.22	68.58 29.21	64.18 31.21	60.88 32.23	58.58 33.23	56.13 36.23	53.04 38.26	49.58 41.26	60
55	131.75 14.28	124.94 17.21	118.63 19.21	113.04 22.20	108.48 24.21	104.96 26.21	102.90 27.21	102.36 31.21	103.40 34.20	105.98 36.20	109.92 42.22	115.14 45.22	55
50	164.62 11.20	158.63 12.22	153.21 13.23	147.39 14.25	142.62 16.21	138.77 18.25	136.19 21.21	134.80 24.20	135.03 26.20	137.29 28.24	140.00 31.20	144.42 34.22	50
45	195.40 10.22	189.69 11.20	184.28 12.21	179.08 13.22	173.83 14.25	168.52 16.25	163.28 18.25	160.28 21.20	165.58 23.20	169.88 26.20	174.08 29.20	178.28 32.20	45
40	219.1 10.22	213.67 11.20	208.38 12.21	203.14 13.22	197.88 14.25	192.58 16.25	187.28 18.25	182.88 21.20	188.58 23.20	193.28 26.20	197.98 29.20	202.68 32.20	40
35	241.28 11.21	235.94 12.22	230.63 13.23	225.33 14.25	219.98 16.25	214.68 18.25	209.38 21.20	204.08 23.20	208.78 26.20	213.48 29.20	218.18 32.20	222.88 35.20	35
30	259.34 12.22	254.01 13.23	248.70 14.25	243.39 16.25	238.08 18.25	232.78 21.20	227.48 23.20	222.18 26.20	226.88 29.20	231.58 32.20	236.28 35.20	240.98 38.20	30
25	274.92 13.20	269.59 14.21	264.28 15.23	258.97 16.25	253.66 18.25	248.35 21.20	243.05 23.20	237.75 26.20	242.45 29.20	247.15 32.20	251.85 35.20	256.55 38.20	25
20	288.25 14.25	282.92 15.26	277.60 16.28	272.28 18.25	266.96 21.20	261.64 23.20	256.32 26.20	251.00 29.20	255.68 32.20	260.36 35.20	265.04 38.20	269.72 41.20	20
15	298.90 15.25	293.57 16.26	288.24 17.28	282.91 18.25	277.58 21.20	272.25 23.20	266.92 26.20	261.59 29.20	266.26 32.20	270.93 35.20	275.60 38.20	280.27 41.20	15
10	306.14 16.26	300.81 17.27	295.48 18.29	290.15 20.21	284.82 23.20	279.49 26.20	274.16 29.20	268.83 32.20	273.50 35.20	278.17 38.20	282.84 41.20	287.51 44.20	10
5	309.69 16.26	304.36 17.28	299.03 18.30	293.70 20.22	288.37 23.20	283.04 26.20	277.71 29.20	272.38 32.20	277.05 35.20	281.72 38.20	286.39 41.20	291.06 44.20	5
0	309.05 16.26	303.72 17.29	298.39 18.31	293.06 20.23	287.73 23.20	282.40 26.20	277.07 29.20	271.74 32.20	276.41 35.20	281.08 38.20	285.75 41.20	290.42 44.20	0
LAT													
L. LONG	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG

NORTH COMPONENT (X) WMM-90

L. LONG LAT	100	105	110	115	120	125	130	135	140	145	150	155	L. LONG LAT
90	-84 9.28	106 8.26	9.24	481 6.21	664 4.27	863 3.23	1016 1.9	1177 .5	1333 -1.0	1477 -2.4	1610 -3.28	1731 -4.22	90
85	1773 3.731	1833 3.501	1876 3.261	1908 3.061	2356 0.53	2628 0.28	2973 0.23	3308 0.18	3608 0.08	3878 0.03	4103 -0.03	-4303 -0.08	85
80	1494 3.526	1593 3.529	1713 3.513	1840 3.497	1963 3.481	2079 3.465	2186 3.449	2283 3.433	2370 3.417	2448 3.401	2517 3.385	-2579 -3.369	80
75	2910 24.9	3514 23.22	4140 21.1	4775 19.25	5400 17.25	6004 15.22	6573 13.27	7096 11.3	7566 9.36	7975 7.41	8314 5.46	8594 3.51	75
70	4578 32.0	5249 31.23	5941 29.22	6634 26.26	7314 23.24	7960 19.27	8559 15.27	9102 11.25	9581 7.23	9991 5.22	10329 3.27	10595 1.32	70
65	6235 49.24	7433 38.23	8152 27.20	8966 16.25	9556 11.22	10203 6.20	10792 1.28	11315 -3.73	11767 -8.76	12145 -13.79	12447 -18.82	12678 -23.85	65
60	9303 24.08	9995 22.06	10709 19.03	11408 16.01	12078 13.08	12698 10.05	13253 7.03	13739 4.01	14148 1.00	14478 -2.02	14733 -5.05	14918 -8.08	60
55	12120 48.0	12729 44.0	13400 40.0	14132 36.0	14760 32.0	15351 28.0	15869 24.0	16315 20.0	16684 16.0	16978 12.0	17191 8.0	17335 4.0	55
50	14993 20.0	15603 19.0	16253 18.0	16874 17.0	17481 16.0	18035 15.0	18527 14.0	18958 13.0	19300 12.0	19573 11.0	19771 10.0	19893 9.0	50
45	17740 49.0	18340 48.0	18884 47.0	19409 46.0	19905 45.0	20362 44.0	20775 43.0	21146 42.0	21468 41.0	21746 40.0	21971 39.0	22137 38.0	45
40	20523 20.0	20706 19.0	20877 18.0	20994 17.0	21058 16.0	21069 15.0	21027 14.0	20934 13.0	20791 12.0	20598 11.0	20356 10.0	20063 9.0	40
35	23356 22.0	22765 21.0	22222 20.0	21848 19.0	21563 18.0	21364 17.0	21255 16.0	21127 15.0	20980 14.0	20816 13.0	20637 12.0	20444 11.0	35
30	26180 47.0	24428 41.0	24082 37.0	23654 33.0	23101 29.0	22508 25.0	21878 21.0	21214 17.0	20518 13.0	19791 9.0	19034 5.0	18247 1.0	30
25	28953 23.0	28006 21.0	27003 19.0	26039 17.0	24908 15.0	23706 13.0	22438 11.0	21107 9.0	19716 7.0	18268 5.0	16766 3.0	15214 1.0	25
20	31769 26.0	30343 24.0	28802 22.0	27193 20.0	25463 18.0	23706 16.0	21927 14.0	20129 12.0	18316 10.0	16491 8.0	14658 6.0	12819 4.0	20
15	34584 28.0	32716 26.0	30729 24.0	28651 22.0	26498 20.0	24276 18.0	22000 16.0	19674 14.0	17303 12.0	14891 10.0	12443 8.0	9964 6.0	15
10	37362 25.0	34900 23.0	32368 21.0	29791 19.0	27172 17.0	24517 15.0	21832 13.0	19122 11.0	16391 9.0	13644 7.0	10886 5.0	8124 3.0	10
5	40139 22.0	37113 20.0	33903 18.0	30551 16.0	27072 14.0	23473 12.0	19851 10.0	16212 8.0	12561 6.0	8896 4.0	5224 2.0	1552 0.0	5
0	42929 19.0	38370 17.0	34670 15.0	30829 13.0	26868 11.0	22793 9.0	18611 7.0	14332 5.0	9951 3.0	5474 1.0	924 -1.0	-3624 -3.0	0
LAT													
L. LONG	100	105	110	115	120	125	130	135	140	145	150	155	L. LONG

NORTH COMPONENT (X) WMM-90

LAT	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG
0	89445	49785	72885	29185	29835	49885	49885	49885	49885	49885	49885	49885	0
5	49885	69885	89885	29885	49885	49885	49885	49885	49885	49885	49885	49885	5
10	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	10
15	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	15
20	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	20
25	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	25
30	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	30
35	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	35
40	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	40
45	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	45
50	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	50
55	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	55
60	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	60
65	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	65
70	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	70
75	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	75
80	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	80
85	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	85
90	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	49885	90
LAT	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG

NORTH COMPONENT (X) WMM-90

L - LONG	60	65	70	75	80	85	90	95	100	105	110	115	L - LONG
LAT													LAT
0	144101	15252	16112	16941	17710	18308	18946	19565	19614	19751	19724	19564	0
5	113460	12520	13303	14150	14916	15608	16293	16957	17283	18068	18210	18216	-5
-10	12303	19287	19346	11364	12328	13221	14029	14737	15329	15792	16118	16303	-10
-15	14718	23862	24853	27999	28999	29949	30839	31659	32392	33016	33514	33874	-15
-20	21484	22570	23613	24617	25583	26523	27431	28303	29121	29860	30493	30999	-20
-25	18672	19631	20547	21430	22290	23142	23992	24841	25674	26464	27178	27786	-25
-30	14508	17158	17871	18555	19217	19861	20498	21119	21719	22292	22843	23348	-30
-35	14671	15151	15604	16050	16507	16965	17431	17907	18373	18829	19285	19744	-35
-40	13341	13519	13699	13863	14018	14161	14301	14439	14568	14693	14817	14936	-40
-45	12343	12233	12073	11846	11554	11203	10878	10503	10176	9794	9461	9141	-45
-50	11308	11078	10817	10516	10174	9821	9468	9128	8782	8433	8083	7748	-50
-55	10242	10019	9749	9413	9018	8613	8208	7803	7393	6978	6565	6153	-55
-60	9079	8831	8561	8207	7800	7396	6993	6593	6189	5782	5370	4953	-60
-65	8146	7891	7610	7250	6881	6509	6131	5754	5371	4986	4598	4207	-65
-70	7118	6843	6529	6162	5826	5486	5141	4800	4458	4116	3771	3428	-70
-75	6015	5690	5348	4989	4619	4250	3872	3508	3141	2774	2401	2023	-75
-80	5309	4849	4376	3907	3519	3145	2763	2393	2024	1650	1279	9111	-80
-85	4241	3803	3341	2853	2358	1928	1568	1206	843	479	117	-244	-85
-90	315	263	209	1548	968	418	-142	-672	-1218	-1831	-2411	-2967	-90
L - LONG	60	65	70	75	80	85	90	95	100	105	110	115	L - LONG
LAT													LAT

NORTH COMPONENT (X) WMM-90

LAT	175	170	165	160	155	150	145	140	135	130	125	120	LONG	LAT
0	72941	6721	6231	5751	5261	4781	4291	3801	3311	2821	2331	1841	0	0
5	82941	7721	7231	6751	6261	5781	5291	4801	4311	3821	3331	2841	5	5
10	92941	8721	8231	7751	7261	6781	6291	5801	5311	4821	4331	3841	10	10
15	102941	9721	9231	8751	8261	7781	7291	6801	6311	5821	5331	4841	15	15
20	112941	10721	10231	9751	9261	8781	8291	7801	7311	6821	6331	5841	20	20
25	122941	11721	11231	10751	10261	9781	9291	8801	8311	7821	7331	6841	25	25
30	132941	12721	12231	11751	11261	10781	10291	9801	9311	8821	8331	7841	30	30
35	142941	13721	13231	12751	12261	11781	11291	10801	10311	9821	9331	8841	35	35
40	152941	14721	14231	13751	13261	12781	12291	11801	11311	10821	10331	9841	40	40
45	162941	15721	15231	14751	14261	13781	13291	12801	12311	11821	11331	10841	45	45
50	172941	16721	16231	15751	15261	14781	14291	13801	13311	12821	12331	11841	50	50
55	182941	17721	17231	16751	16261	15781	15291	14801	14311	13821	13331	12841	55	55
60	192941	18721	18231	17751	17261	16781	16291	15801	15311	14821	14331	13841	60	60
65	202941	19721	19231	18751	18261	17781	17291	16801	16311	15821	15331	14841	65	65
70	212941	20721	20231	19751	19261	18781	18291	17801	17311	16821	16331	15841	70	70
75	222941	21721	21231	20751	20261	19781	19291	18801	18311	17821	17331	16841	75	75
80	232941	22721	22231	21751	21261	20781	20291	19801	19311	18821	18331	17841	80	80
85	242941	23721	23231	22751	22261	21781	21291	20801	20311	19821	19331	18841	85	85
90	252941	24721	24231	23751	23261	22781	22291	21801	21311	20821	20331	19841	90	90

NORTH COMPONENT (X) WMM-90

L - LONG	180	185	190	195	200	205	210	215	220	225	230	235	L - LONG
LAT													LAT
0	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	0
-5	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-5
-10	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-10
-15	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-15
-20	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-20
-25	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-25
-30	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-30
-35	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-35
-40	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-40
-45	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-45
-50	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-50
-55	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-55
-60	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-60
-65	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-65
-70	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-70
-75	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-75
-80	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-80
-85	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-85
-90	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	5964	-90
LAT													LAT
L - LONG	180	185	190	195	200	205	210	215	220	225	230	235	L - LONG

NORTH COMPONENT (X) WMM-90

[illegible]

NORTH COMPONENT (X) WMM-90

L. LONG LAT	00	30S	31S	32S	33S	34S	35S	36S	37S	38S	39S	40S	41S	42S	43S	44S	45S	46S	47S	48S	49S	50S	51S	52S	53S	54S	55S	L. LONG LAT
0	24929	24570	24029	23330	22584	21722	20752	19682	18512	17242	15872	14402	12832	11162	9392	7522	5552	3482	1312	-852	-262	-102	102	292	502	712	912	1106
-5	24196	23735	23194	22495	21749	20982	20112	19242	18272	17202	16032	14762	13392	11922	10352	8682	6912	5042	3072	1002	-107	-297	-487	-677	-867	-1057	-1247	-1437
-10	23452	22991	22450	21751	21005	20248	19482	18716	17850	16880	15810	14640	13370	12000	10530	8960	7290	5520	3650	1680	-32	-222	-412	-602	-792	-982	-1172	-1362
-15	22708	22247	21706	21007	20261	19504	18748	17992	17136	16176	15116	13956	12686	11316	9846	8276	6606	4836	2966	996	-104	-294	-484	-674	-864	-1054	-1244	-1434
-20	21964	21503	20962	20263	19517	18760	18004	17248	16392	15432	14372	13212	11942	10572	9102	7532	5862	4092	2222	22	-188	-378	-568	-758	-948	-1138	-1328	-1518
-25	21220	20759	20218	19519	18773	18016	17260	16504	15648	14688	13628	12468	11208	9838	8368	6798	5128	3358	1488	-52	-242	-432	-622	-812	-1002	-1192	-1382	-1572
-30	20476	20015	19474	18775	18029	17272	16516	15660	14704	13644	12484	11324	10064	8694	7224	5654	3984	2114	24	-174	-364	-554	-744	-934	-1124	-1314	-1504	-1694
-35	19732	19271	18730	18031	17285	16528	15772	14916	13960	12800	11640	10480	9320	8050	6680	5110	3440	1570	26	-166	-356	-546	-736	-926	-1116	-1306	-1496	-1686
-40	18988	18527	17986	17287	16541	15784	15028	14172	13216	12056	10896	9736	8576	7306	5936	4366	2696	86	28	-158	-348	-538	-728	-918	-1108	-1298	-1488	-1678
-45	18244	17783	17242	16543	15797	15040	14284	13428	12472	11312	10152	8992	7832	6562	5192	3622	1952	88	30	-150	-340	-530	-720	-910	-1100	-1290	-1480	-1670
-50	17500	17039	16498	15799	15053	14296	13540	12684	11728	10568	9408	8248	7088	5818	4448	2878	1208	90	32	-142	-332	-522	-712	-902	-1092	-1282	-1472	-1662
-55	16756	16295	15754	15055	14309	13552	12796	11940	10984	9928	8768	7608	6448	5178	3808	2238	1128	92	34	-134	-324	-514	-704	-894	-1084	-1274	-1464	-1654
-60	16012	15551	15010	14311	13565	12808	12052	11196	10240	9184	8024	6864	5704	4434	3064	1494	114	94	36	-126	-316	-506	-696	-886	-1076	-1266	-1456	-1646
-65	15268	14807	14266	13567	12821	12064	11308	10452	9496	8440	7280	6120	4960	3690	2320	1050	96	96	38	-118	-308	-498	-688	-878	-1068	-1258	-1448	-1638
-70	14524	14063	13522	12823	12077	11320	10564	9708	8752	7696	6536	5376	4216	2946	1576	107	98	100	40	-110	-299	-489	-679	-869	-1059	-1249	-1439	-1629
-75	13780	13319	12778	12079	11333	10576	9820	8964	7908	6852	5692	4532	3372	2102	102	100	102	102	42	-102	-291	-481	-671	-861	-1051	-1241	-1431	-1621
-80	13036	12575	12034	11335	10589	9832	9076	8220	7164	6108	4948	3788	2628	1358	104	102	104	104	44	-94	-283	-473	-663	-853	-1043	-1233	-1423	-1613
-85	12292	11831	11290	10591	9845	9088	8332	7476	6420	5364	4204	3044	1884	1104	106	104	106	106	46	-86	-275	-465	-655	-845	-1035	-1225	-1415	-1605
-90	11548	11087	10546	9847	9101	8344	7588	6732	5676	4620	3460	2300	1140	112	108	108	110	110	48	-78	-267	-457	-647	-837	-1027	-1217	-1407	-1597

EAST COMPONENT (Y) WMM-90

E. LONG	0	5	10	15	20	25	30	35	40	45	50	55	LAT
90	-115.1	-094	-021	-047	-12.0	-023	-04	10.8	3.5	6.1	6.9	8.3	90
85	-129.8	-044	-34.4	-22.5	12.6	4.4	7.2	10.7	13.4	15.7	17.4	19.9	85
80	-146.8	-063	-56.3	15.3	13.8	10.8	16.0	17.9	21.3	23.9	26.3	28.9	80
75	-162.2	-102.3	-42.2	16.9	7.4	12.6	17.2	22.5	26.5	29.6	32.4	34.2	75
70	-171.7	-106.1	-41.0	22.6	8.1	14.1	19.0	24.6	29.8	32.8	35.7	37.8	70
65	-171.8	-105.7	-39.2	25.1	8.7	14.5	19.9	24.9	29.4	33.7	36.5	38.7	65
60	-168.8	-100.2	-34.3	27.8	8.5	14.6	19.3	24.5	28.3	32.1	35.2	37.5	60
55	-159.0	-90.6	-26.7	32.1	8.3	13.6	18.2	23.5	26.2	29.7	32.4	34.8	55
50	-147.7	-79.8	-17.6	37.9	8.7	13.2	17.0	20.5	23.5	26.1	28.7	30.3	50
45	-138.3	-69.3	-6.8	42.8	8.3	12.8	16.8	19.0	21.9	24.3	26.9	28.8	45
40	-128.7	-58.8	4.1	47.1	8.5	12.5	16.8	17.3	19.6	20.8	21.0	21.0	40
35	-117.2	-48.6	17.9	50.0	7.9	12.0	16.1	15.8	17.2	17.7	17.3	16.4	35
30	-104.5	-37.3	29.1	51.3	6.7	11.2	15.4	14.9	15.5	15.4	14.4	13.1	30
25	-91.7	-25.9	39.4	50.6	4.1	10.8	14.7	13.0	13.9	13.1	11.9	10.7	25
20	-78.6	-13.6	49.8	47.3	1.9	10.3	14.0	11.3	12.3	11.1	9.2	8.3	20
15	-64.2	-0.9	59.3	43.3	-0.7	10.8	14.8	10.1	10.2	8.7	7.0	6.1	15
10	-48.6	11.9	67.9	37.5	-6.9	10.3	14.2	7.0	7.5	5.1	3.6	2.7	10
5	-32.3	23.4	74.0	30.1	-18.4	10.4	14.3	2.3	2.8	1.0	-0.4	-1.0	5
0	-15.3	33.9	79.0	21.2	-29.9	10.4	14.4	-4.5	-10.5	-4.7	-10.6	-17.0	0
LAT													
E. LONG	0	5	10	15	20	25	30	35	40	45	50	55	LAT

EAST COMPONENT (Y) WMM-90

LAT	LONG	60	65	70	75	80	85	90	95	100	105	110	115	LAT	LONG
90	20	1919	1177	1116	1177	1919	1733	1838	1938	2018	-1878	-1124	-1158	90	20
85	25	2014	1102	1145	2146	2100	2046	1850	1832	1710	-1876	-1138	-1100	85	25
80	30	2084	2906	2853	2735	2863	2333	2057	1741	1419	-1081	-750	-419	80	30
75	35	1910	3505	3405	3312	2931	2569	2139	1657	1141	-913	-906	-190	75	35
70	40	1981	3879	3759	3526	3172	2717	2169	1545	-875	-180	-503	-1147	70	40
65	45	3998	4003	3888	3639	3256	2748	2123	1401	-615	-207	-1081	-1793	65	45
60	50	3884	3904	3798	3553	3170	2645	1988	1218	-363	-538	-1443	-2304	60	50
55	55	3583	3606	3512	3286	2920	2411	1763	991	122	-809	-1753	-2655	55	55
50	60	3147	3157	3067	2862	2535	2063	1461	731	-101	-1008	-1941	-2841	50	60
45	65	2628	2605	2509	2326	2036	1631	1103	459	-293	-1130	-2003	-2863	45	65
40	70	2078	2000	1886	1717	1473	1149	721	188	-168	-1173	-1954	-2729	40	70
35	75	1519	1483	1341	1087	891	646	332	-64	-553	-1134	-1784	-2453	35	75
30	80	991	763	605	453	308	150	141	-365	-607	-1023	-1524	-2065	30	80
25	85	495	313	81	-151	-351	-1329	-1383	-468	-614	-853	-1193	-1596	25	85
20	90	17	-714	-383	-728	-780	-760	-692	-615	-381	-643	-820	-1083	20	90
15	95	-473	-882	-1157	-1290	-1290	-929	-977	-739	-531	-420	-440	-564	15	95
10	100	-1018	-1469	-1758	-1868	-1810	-1588	-1263	-869	-493	-211	-172	-227	10	100
5	105	-1056	-2138	-2428	-2507	-2380	-2064	-1597	-1047	-512	-83	-187	-321	5	105
0	110	-2428	-2927	-3207	-3245	-3044	-2623	-2023	-1324	-634	-57	-152	-610	0	110
LAT	LONG	60	65	70	75	80	85	90	95	100	105	110	115	LAT	LONG

EAST COMPONENT (Y) WMM-90

LAT	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG
90	-3173	-3171	-3153	-3120	-3078	-3004	-1923	-1827	-1718	-1593	-1468	-1314	90
85	-3174	-1903	-1868	-1828	-1848	-1813	-1809	-1828	-1858	-1906	-1961	-1932	85
80	-928	-74	-254	-373	-424	-408	-328	-187	-76	-858	-836	-832	80
75	-821	-1176	-1439	-1594	-1645	-1578	-1400	-1118	-747	-301	198	731	75
70	-1716	-2181	-2518	-2709	-2742	-2617	-2337	-1917	-1375	-735	-26	723	70
65	-2428	-3033	-3423	-3632	-3643	-3453	-3074	-2524	-1828	-1029	-132	794	65
60	-3064	-3678	-4104	-4312	-4289	-4034	-3561	-2897	-2076	-1137	-329	933	60
55	-3456	-4097	-4530	-4721	-4654	-4331	-3773	-3018	-2103	-1076	19	1138	55
50	-3642	-4279	-4693	-4951	-4731	-4343	-3613	-2883	-1904	-832	-1293	-1428	50
45	-3628	-4330	-4603	-4614	-4638	-4084	-3398	-2618	-1808	-1028	-703	-1793	45
40	-3427	-3972	-4399	-4638	-4202	-3388	-2849	-2039	-912	-169	-1849	-3262	40
35	-3064	-3531	-3776	-3752	-3448	-2887	-2114	-1588	-122	-822	-1883	-2811	35
30	-2570	-2944	-3106	-3006	-2639	-2033	-1240	-317	672	1664	2594	3407	30
25	-1984	-2256	-2326	-2148	-1721	-1080	-279	624	1570	2494	3328	4016	25
20	-1349	-1515	-1492	-1237	-759	-91	705	1576	2466	3311	4042	4800	20
15	-723	-772	-659	-334	191	870	1650	2479	3306	4069	4698	5173	15
10	-2143	-2229	-1729	-800	1042	1741	3399	4283	4948	4731	5273	5803	10
5	-401	-534	-603	1234	1810	2483	3316	3959	4667	3890	5738	6017	5
0	-798	-1828	-1253	1829	2418	3877	4588	4688	3839	3237	6158	6376	0
LAT	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG

EAST COMPONENT (Y) WMM-90

E. LONG LAT	180	185	190	195	200	205	210	215	220	225	230	235	E. LONG LAT
90	-1358	-1223	-1321	-1222	-1220	-1220	-928	-106	-295	-681	-662	-843	90
85	-1096	-1154	-1199	-1329	-1319	-1306	-1153	-1065	-942	-783	-590	-363	85
80	-1016	-1133	-1206	-1947	-1413	-1328	-1331	-1354	-1282	-1136	-1911	-1623	80
75	-1273	-1804	-2300	-2243	-1712	-1937	-1582	-3600	-3826	-3480	-1223	-2862	75
70	-1483	-2222	-2913	-3531	-4052	-4459	-4737	-4876	-4872	-4723	-4434	-4011	70
65	-1228	-2632	-3476	-4229	-4866	-5368	-5718	-5907	-5929	-5783	-5475	-5012	65
60	-1983	-2996	-3916	-4776	-5489	-6054	-6455	-6822	-6730	-6599	-6293	-5819	60
55	-2243	-3300	-4278	-5148	-5891	-6584	-7013	-7165	-7239	-7134	-6853	-6402	55
50	-2521	-3559	-4533	-5359	-6092	-6664	-7093	-7359	-7456	-7386	-7149	-6747	50
45	-3333	-4301	-5224	-5934	-6598	-7031	-7338	-7593	-7519	-7424	-7201	-6867	45
40	-4508	-5498	-6388	-7033	-7582	-7949	-8198	-8366	-8276	-8178	-7852	-7493	40
35	-5824	-6812	-7698	-8271	-8711	-8948	-9066	-9093	-8903	-8734	-8352	-7962	35
30	-7072	-8053	-8929	-9498	-9920	-1017	-1028	-1023	-9863	-9627	-9171	-8736	30
25	-8524	-9491	-10367	-10927	-11333	-11582	-11647	-11593	-10914	-1066	-9948	-9556	25
20	-9856	-10823	-11671	-12227	-12549	-12708	-1268	-1246	-11503	-110	-9238	-8762	20
15	-11522	-12476	-13219	-13750	-14039	-14039	-13928	-13721	-1277	-1199	-1084	-1045	15
10	-13714	-14629	-15277	-15624	-15733	-15648	-15471	-1520	-1477	-1409	-1281	-1202	10
5	-16921	-17798	-18339	-18627	-18750	-18628	-18376	-1797	-1736	-1693	-1548	-1410	5
0	-19778	-20498	-20928	-21138	-21108	-20958	-2073	-2035	-1969	-1928	-1826	-1702	0
E. LONG LAT	180	185	190	195	200	205	210	215	220	225	230	235	E. LONG LAT

EAST COMPONENT (Y) WMM-90

E. LONG LAT	240	245	250	255	260	265	270	275	280	285	290	295	E. LONG LAT
90	-1014 90	-1177 90	-1332 90	-1477 90	-1610 90	-1731 90	-1819 90	-1933 90	-2012 90	-2076 90	-2124 90	-2156 90	90
85	-1177 85	-1332 85	-1477 85	-1610 85	-1731 85	-1819 85	-1933 85	-2012 85	-2076 85	-2124 85	-2156 85	-2156 85	85
80	-1332 80	-1477 80	-1610 80	-1731 80	-1819 80	-1933 80	-2012 80	-2076 80	-2124 80	-2156 80	-2156 80	-2156 80	80
75	-1477 75	-1610 75	-1731 75	-1819 75	-1933 75	-2012 75	-2076 75	-2124 75	-2156 75	-2156 75	-2156 75	-2156 75	75
70	-1610 70	-1731 70	-1819 70	-1933 70	-2012 70	-2076 70	-2124 70	-2156 70	-2156 70	-2156 70	-2156 70	-2156 70	70
65	-1731 65	-1819 65	-1933 65	-2012 65	-2076 65	-2124 65	-2156 65	-2156 65	-2156 65	-2156 65	-2156 65	-2156 65	65
60	-1819 60	-1933 60	-2012 60	-2076 60	-2124 60	-2156 60	-2156 60	-2156 60	-2156 60	-2156 60	-2156 60	-2156 60	60
55	-1933 55	-2012 55	-2076 55	-2124 55	-2156 55	-2156 55	-2156 55	-2156 55	-2156 55	-2156 55	-2156 55	-2156 55	55
50	-2012 50	-2076 50	-2124 50	-2156 50	-2156 50	-2156 50	-2156 50	-2156 50	-2156 50	-2156 50	-2156 50	-2156 50	50
45	-2076 45	-2124 45	-2156 45	-2156 45	-2156 45	-2156 45	-2156 45	-2156 45	-2156 45	-2156 45	-2156 45	-2156 45	45
40	-2124 40	-2156 40	-2156 40	-2156 40	-2156 40	-2156 40	-2156 40	-2156 40	-2156 40	-2156 40	-2156 40	-2156 40	40
35	-2156 35	-2156 35	-2156 35	-2156 35	-2156 35	-2156 35	-2156 35	-2156 35	-2156 35	-2156 35	-2156 35	-2156 35	35
30	-2156 30	-2156 30	-2156 30	-2156 30	-2156 30	-2156 30	-2156 30	-2156 30	-2156 30	-2156 30	-2156 30	-2156 30	30
25	-2156 25	-2156 25	-2156 25	-2156 25	-2156 25	-2156 25	-2156 25	-2156 25	-2156 25	-2156 25	-2156 25	-2156 25	25
20	-2156 20	-2156 20	-2156 20	-2156 20	-2156 20	-2156 20	-2156 20	-2156 20	-2156 20	-2156 20	-2156 20	-2156 20	20
15	-2156 15	-2156 15	-2156 15	-2156 15	-2156 15	-2156 15	-2156 15	-2156 15	-2156 15	-2156 15	-2156 15	-2156 15	15
10	-2156 10	-2156 10	-2156 10	-2156 10	-2156 10	-2156 10	-2156 10	-2156 10	-2156 10	-2156 10	-2156 10	-2156 10	10
5	-2156 5	-2156 5	-2156 5	-2156 5	-2156 5	-2156 5	-2156 5	-2156 5	-2156 5	-2156 5	-2156 5	-2156 5	5
0	-2156 0	-2156 0	-2156 0	-2156 0	-2156 0	-2156 0	-2156 0	-2156 0	-2156 0	-2156 0	-2156 0	-2156 0	0

EAST COMPONENT (Y) WMM-90

LAT	E. LONG	EAST COMPONENT (Y) WMM-90												E. LONG	LAT
		100	105	110	115	120	125	130	135	140	145	150	155		
00	00	2131-	0721-	4211-	0721-	2070	3004	1921	2821-	7011-	5911-	0601-	0111-	00	00
05	05	2111-	0701-	4191-	0701-	2050	2982-	1853-	2753-	6943-	5843-	0503-	0003-	05	05
10	10	2091-	0681-	4171-	0681-	2030	2962-	1833-	2733-	6923-	5823-	0483-	0003-	10	10
15	15	2071-	0661-	4151-	0661-	2010	2942-	1813-	2713-	6903-	5803-	0463-	0003-	15	15
20	20	2051-	0641-	4131-	0641-	1990	2922-	1793-	2693-	6883-	5783-	0443-	0003-	20	20
25	25	2031-	0621-	4111-	0621-	1970	2902-	1773-	2673-	6863-	5763-	0423-	0003-	25	25
30	30	2011-	0601-	4091-	0601-	1950	2882-	1753-	2653-	6843-	5743-	0403-	0003-	30	30
35	35	1991-	0581-	4071-	0581-	1930	2862-	1733-	2633-	6823-	5723-	0383-	0003-	35	35
40	40	1971-	0561-	4051-	0561-	1910	2842-	1713-	2613-	6803-	5703-	0363-	0003-	40	40
45	45	1951-	0541-	4031-	0541-	1890	2822-	1693-	2593-	6783-	5683-	0343-	0003-	45	45
50	50	1931-	0521-	4011-	0521-	1870	2802-	1673-	2573-	6763-	5663-	0323-	0003-	50	50
55	55	1911-	0501-	3991-	0501-	1850	2782-	1653-	2553-	6743-	5643-	0303-	0003-	55	55
60	60	1891-	0481-	3971-	0481-	1830	2762-	1633-	2533-	6723-	5623-	0283-	0003-	60	60
65	65	1871-	0461-	3951-	0461-	1810	2742-	1613-	2513-	6703-	5603-	0263-	0003-	65	65
70	70	1851-	0441-	3931-	0441-	1790	2722-	1593-	2493-	6683-	5583-	0243-	0003-	70	70
75	75	1831-	0421-	3911-	0421-	1770	2702-	1573-	2473-	6663-	5563-	0223-	0003-	75	75
80	80	1811-	0401-	3891-	0401-	1750	2682-	1553-	2453-	6643-	5543-	0203-	0003-	80	80
85	85	1791-	0381-	3871-	0381-	1730	2662-	1533-	2433-	6623-	5523-	0183-	0003-	85	85
90	90	1771-	0361-	3851-	0361-	1710	2642-	1513-	2413-	6603-	5503-	0163-	0003-	90	90

EAST COMPONENT (Y) WMM-90

LAT	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG
0	0.149	0.339	0.593	0.905	1.279	1.705	2.181	2.702	3.261	3.851	4.464	5.091	0
5	0.369	0.885	1.591	2.385	3.261	4.211	5.225	6.292	7.401	8.541	9.701	10.871	5
10	0.805	2.279	4.211	6.591	9.311	12.361	15.721	19.381	23.331	27.561	32.061	36.811	10
15	1.059	3.591	6.591	10.051	13.961	18.211	22.791	27.691	32.891	38.361	44.091	49.991	15
20	1.259	4.791	9.311	13.961	18.211	22.791	27.691	32.891	38.361	44.091	49.991	55.991	20
25	1.409	5.491	10.871	15.721	20.211	24.791	29.361	34.091	38.961	44.091	49.361	54.791	25
30	1.509	6.191	12.361	17.471	21.791	26.361	30.931	35.561	40.211	44.961	49.711	54.461	30
35	1.559	6.791	13.961	19.051	23.361	27.931	32.501	37.131	41.791	46.461	51.131	55.801	35
40	1.599	7.391	15.551	20.631	24.931	29.511	34.081	38.711	43.361	47.931	52.501	57.071	40
45	1.629	7.991	17.131	22.211	26.511	31.091	35.661	40.291	44.931	49.501	54.071	58.641	45
50	1.649	8.591	18.711	23.791	28.091	32.671	37.241	41.871	46.511	51.081	55.651	60.221	50
55	1.659	9.191	20.291	25.371	29.671	34.251	38.821	43.451	48.091	52.661	57.231	61.791	55
60	1.659	9.791	21.871	26.951	31.251	35.831	40.401	44.931	49.671	54.241	58.811	63.371	60
65	1.649	10.391	23.451	28.531	32.831	37.411	41.981	46.511	51.251	55.821	60.391	64.951	65
70	1.619	10.991	25.031	30.111	34.411	38.991	43.561	48.091	52.831	57.401	61.971	66.531	70
75	1.569	11.591	26.611	31.691	35.991	40.571	45.141	49.671	54.411	58.981	63.551	68.111	75
80	1.489	12.191	28.191	33.271	37.571	42.151	46.721	51.251	56.001	60.561	65.131	69.691	80
85	1.379	12.791	29.771	34.851	39.151	43.731	48.301	52.831	57.581	62.141	66.711	71.271	85
90	1.229	13.391	31.351	36.431	40.731	45.311	49.881	54.411	59.161	63.721	68.291	72.851	90
95	1.049	13.991	32.931	38.011	42.311	46.891	51.461	56.001	60.741	65.301	69.871	74.431	95
100	0.829	14.591	34.511	39.591	43.891	48.471	53.041	57.581	62.321	66.881	71.451	76.011	100

EAST COMPONENT (Y) WMM-90

L. LONG LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG LAT
0	-24.8	-23.2	-22.0	-20.4	-18.4	-16.2	-13.2	-12.4	-6.4	-11.0	-13.4	-14.4	0
-5	-11.0	-10.0	-9.2	-8.2	-7.2	-6.2	-5.2	-4.2	-2.0	-1.2	-1.0	-1.2	-5
-10	-44.8	-44.8	-44.1	-43.2	-42.2	-41.2	-40.2	-39.2	-38.2	-37.2	-36.2	-35.2	-10
-15	-29.0	-28.2	-27.2	-26.2	-25.2	-24.2	-23.2	-22.2	-21.2	-20.2	-19.2	-18.2	-15
-20	-20.4	-20.2	-20.2	-20.2	-20.2	-20.2	-20.2	-20.2	-20.2	-20.2	-20.2	-20.2	-20
-25	-33.0	-33.0	-33.0	-33.0	-33.0	-33.0	-33.0	-33.0	-33.0	-33.0	-33.0	-33.0	-25
-30	-38.0	-38.2	-38.2	-38.2	-38.2	-38.2	-38.2	-38.2	-38.2	-38.2	-38.2	-38.2	-30
-35	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-35
-40	-24.2	-24.2	-24.2	-24.2	-24.2	-24.2	-24.2	-24.2	-24.2	-24.2	-24.2	-24.2	-40
-45	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-45
-50	-14.4	-14.4	-14.4	-14.4	-14.4	-14.4	-14.4	-14.4	-14.4	-14.4	-14.4	-14.4	-50
-55	-15.2	-15.2	-15.2	-15.2	-15.2	-15.2	-15.2	-15.2	-15.2	-15.2	-15.2	-15.2	-55
-60	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-60
-65	-18.0	-18.0	-18.0	-18.0	-18.0	-18.0	-18.0	-18.0	-18.0	-18.0	-18.0	-18.0	-65
-70	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-70
-75	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-75
-80	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-80
-85	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-85
-90	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-90

EAST COMPONENT (Y) WMM-90

E. LONG	120	125	130	135	140	145	150	155	160	165	170	175	E. LONG
LAT													LAT
0	-799 -20.0	-1021 -18.6	-1354 -14.1	-1824 -7.5	-2412 -8	-3077 9.1	-3783 15.8	-4489 19.6	-5159 19.2	-5737 14.5	-6154 5.8	-6376 -5.5	0
-5	-1056 -14.3	-1364 -11.1	-1760 -10.9	-2364 -4.4	-2863 2.6	-3522 8.9	-4244 12.4	-4844 15.7	-5338 16.3	-6092 8.4	-6494 -2.3	-6694 -1.5	-5
-10	-1153 -15.3	-1558 -13.5	-2048 -10.8	-2568 -3.5	-3176 3.7	-3869 6.6	-4532 9.3	-5198 10.9	-5833 14.6	-6377 6.1	-6724 -2.4	-6999 -2.2	-10
-15	-1090 -10.9	-1604 -16.0	-2136 -13.6	-2729 -7.2	-3376 -6	-4058 5	-4752 13.2	-5433 17.7	-6068 18.8	-6617 6.5	-7033 -4.0	-7284 -5.1	-15
-20	-866 -5.6	-1503 -4.3	-2133 -3.0	-2792 1.1	-3487 -1.3	-4204 -1.3	-4923 -2.1	-5620 -4	-6266 0.3	-6827 4.4	-7263 6.3	-7554 7.1	-20
-25	-690 -9.3	-1271 -11.2	-1918 -10.4	-2566 -0.4	-3257 2.3	-4298 8.2	-5051 10.3	-5774 12.1	-6438 1.1	-7015 2.9	-7478 5.9	-7806 8.3	-25
-30	-25 -10.1	-817 -11.8	-1808 -10.8	-2698 -0.8	-3507 1.0	-4364 4.1	-5194 7.7	-5988 10.5	-6718 0.1	-7382 7.1	-7962 6.2	-8434 8.3	-30
-35	-664 -8.6	-1449 -12.1	-2187 -10.1	-2975 -0.1	-3764 2.4	-4534 8.5	-5294 12.4	-6038 16.0	-6769 0.9	-7428 7.4	-8033 5.8	-8583 8.3	-35
-40	-1410 -14.1	-324 -11.8	-1071 -10.1	-1808 -0.8	-2591 2.4	-3408 8.0	-4260 12.6	-5139 16.0	-6029 0.9	-6928 7.4	-7858 6.2	-8733 8.3	-40
-45	-244 -10.1	-118 -11.8	-634 -10.1	-1081 -0.8	-1602 2.4	-2188 8.0	-2834 12.6	-3548 16.0	-4340 0.9	-5228 7.4	-6150 6.2	-7091 8.3	-45
-50	-1156 -11.6	-1592 -12.1	-2113 -10.1	-2801 -0.1	-3524 2.4	-4341 8.0	-5184 12.4	-6061 16.0	-6986 0.9	-7962 7.4	-8987 6.2	-10000 8.3	-50
-55	-4118 -11.8	-2472 -12.1	-4068 -10.1	-6010 -0.8	-8004 2.4	-10048 8.0	-12142 12.6	-14286 16.0	-16480 0.9	-18724 7.4	-21018 6.2	-23362 8.3	-55
-60	-5103 -11.0	-3426 -12.1	-5102 -10.1	-7248 -0.8	-9434 2.4	-11660 8.0	-13936 12.6	-16262 16.0	-18638 0.9	-21064 7.4	-23540 6.2	-26066 8.3	-60
-65	-6082 -10.8	-4423 -12.1	-6283 -10.1	-8519 -0.8	-10805 2.4	-13141 8.0	-15527 12.6	-17963 16.0	-20449 0.9	-22985 7.4	-25571 6.2	-28207 8.3	-65
-70	-6898 -10.8	-5399 -12.1	-7397 -10.1	-9683 -0.8	-12019 2.4	-14405 8.0	-16841 12.6	-19327 16.0	-21863 0.9	-24449 7.4	-27085 6.2	-29771 8.3	-70
-75	-7791 -11.0	-6282 -12.1	-8449 -10.1	-10811 -0.8	-13267 2.4	-15773 8.0	-18339 12.6	-20965 16.0	-23651 0.9	-26387 7.4	-29173 6.2	-32009 8.3	-75
-80	-8392 -11.0	-6987 -12.1	-9319 -10.1	-11800 -0.8	-14386 2.4	-17042 8.0	-19758 12.6	-22534 16.0	-25370 0.9	-28256 7.4	-31192 6.2	-34178 8.3	-80
-85	-8749 -10.9	-7433 -12.1	-9971 -10.1	-12668 -0.8	-15612 2.4	-18398 8.0	-21244 12.6	-24150 16.0	-27116 0.9	-30142 7.4	-33218 6.2	-36344 8.3	-85
-90	-8796 -10.9	-7566 -12.1	-10259 -10.1	-13044 -0.8	-15971 2.4	-18887 8.0	-21863 12.6	-24909 16.0	-28025 0.9	-31201 7.4	-34427 6.2	-37703 8.3	-90
LAT													LAT
E. LONG	170	175	180	185	190	195	200	205	210	215	220	225	E. LONG
LAT													LAT
0	6154 5.8	6376 -5.5	6583 -10.1	6774 -14.6	6949 -19.2	7108 -23.8	7251 -28.4	7378 -33.0	7490 -37.6	7587 -42.2	7669 -46.8	7736 -51.4	0
-5	6494 -2.3	6694 -1.5	6879 -3.0	7049 -4.5	7204 -6.0	7344 -7.5	7469 -9.0	7579 -10.5	7674 -12.0	7754 -13.5	7819 -15.0	7869 -16.5	-5
-10	6724 -2.4	6999 -2.2	7254 -3.9	7499 -5.6	7724 -7.3	7929 -9.0	8114 -10.7	8279 -12.4	8424 -14.1	8549 -15.8	8654 -17.5	8739 -19.2	-10
-15	7033 -4.0	7284 -5.1	7519 -6.8	7739 -8.5	7934 -10.2	8104 -11.9	8259 -13.6	8399 -15.3	8524 -17.0	8634 -18.7	8729 -20.4	8809 -22.1	-15
-20	7263 6.3	7554 7.1	7806 8.3	8033 9.5	8234 10.8	8409 12.1	8559 13.4	8694 14.7	8814 16.0	8919 17.3	9009 18.6	9084 19.9	-20
-25	7478 5.9	7806 8.3	8091 9.5	8344 10.8	8564 12.1	8759 13.4	8929 14.7	9074 16.0	9194 17.3	9299 18.6	9389 19.9	9464 21.2	-25
-30	7662 6.2	8034 9.5	8319 10.8	8514 12.1	8679 13.4	8814 14.7	8929 16.0	9024 17.3	9104 18.6	9169 19.9	9219 21.2	9254 22.5	-30
-35	7833 7.4	8230 10.6	8484 11.9	8659 13.2	8804 14.5	8919 15.8	9004 17.1	9069 18.4	9114 19.7	9149 21.0	9174 22.3	9189 23.6	-35
-40	7958 8.3	8383 11.5	8594 12.8	8769 14.1	8904 15.4	9004 16.7	9079 18.0	9124 19.3	9149 20.6	9154 21.9	9149 23.2	9124 24.5	-40
-45	8039 8.6	8491 11.8	8654 13.1	8799 14.4	8914 15.7	9004 17.0	9069 18.3	9104 19.6	9114 20.9	9104 22.2	9079 23.5	9034 24.8	-45
-50	8027 8.2	8503 11.4	8684 12.7	8804 14.0	8884 15.3	8929 16.6	8944 17.9	8924 19.2	8879 20.5	8804 21.8	8699 23.1	8564 24.4	-50
-55	7929 7.9	8421 11.1	8594 12.4	8704 13.7	8759 15.0	8774 16.3	8744 17.6	8679 18.9	8584 20.2	8459 21.5	8294 22.8	8084 24.1	-55
-60	7704 7.1	8209 10.3	8384 11.6	8484 12.9	8504 14.2	8434 15.5	8374 16.8	8314 18.1	8224 19.4	8094 20.7	7924 22.0	7704 23.3	-60
-65	7349 6.4	7854 9.6	8024 10.9	8104 12.2	8094 13.5	8004 14.8	7914 16.1	7814 17.4	7694 18.7	7544 20.0	7354 21.3	7114 22.6	-65
-70	6881 5.8	7394 8.9	7554 10.2	7624 11.5	7594 12.8	7474 14.1	7344 15.4	7204 16.7	7044 18.0	6854 19.3	6624 20.6	6344 21.9	-70
-75	6353 4.9	6864 8.0	7014 9.3	7074 10.6	7034 11.9	6894 13.2	6734 14.5	6554 15.8	6344 17.1	6094 18.4	5804 19.7	5464 21.0	-75
-80	5800 4.0	6304 7.1	6444 8.4	6404 9.7	6254 11.0	6084 12.3	5894 13.6	5674 14.9	5424 16.2	5134 17.5	4794 18.8	4404 20.1	-80
-85	5256 3.1	5754 6.2	5884 7.5	5734 8.8	5554 10.1	5344 11.4	5104 12.7	4824 14.0	4504 15.3	4134 16.6	3714 17.9	3244 19.2	-85
-90	4681 2.2	5174 5.3	5294 6.6	5044 7.9	4754 9.2	4414 10.5	4014 11.8	3554 13.1	3034 14.4	2454 15.7	1814 17.0	1114 18.3	-90
LAT													LAT
E. LONG	175	180	185	190	195	200	205	210	215	220	225	230	E. LONG
LAT													LAT

EAST COMPONENT (Y) WMM-90

E. LONG	180	185	190	195	200	205	210	215	220	225	230	235	E. LONG
LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT
0	-6376	-6198	-5928	-5636	-5406	-5258	-5172	-5125	-5069	-4998	-4922	-4867	0
-5	-6700	-6535	-6375	-6203	-6029	-5855	-5729	-5645	-5572	-5523	-5469	-5408	-5
-10	-7039	-6895	-6748	-6598	-6445	-6289	-6182	-6084	-5995	-5920	-5861	-5797	-10
-15	-7362	-7235	-7112	-6987	-6857	-6723	-6593	-6458	-6333	-6208	-6082	-5957	-15
-20	-7688	-7587	-7494	-7457	-7317	-7197	-7097	-7006	-6906	-6785	-6645	-6497	-20
-25	-7996	-7909	-7833	-7752	-7645	-7529	-7456	-7374	-7289	-7189	-7072	-6950	-25
-30	-8274	-8198	-8130	-8067	-7989	-7899	-7806	-7725	-7628	-7511	-7378	-7243	-30
-35	-8512	-8447	-8389	-8330	-8266	-8198	-8125	-8063	-8654	-8656	-8663	-8665	-35
-40	-8705	-8655	-8609	-8572	-8535	-8495	-8458	-8420	-8364	-8352	-8329	-8313	-40
-45	-8849	-8815	-8783	-8754	-8721	-8685	-8648	-8609	-8577	-8540	-8501	-8461	-45
-50	-8944	-8928	-8914	-8901	-8889	-8880	-8867	-8851	-8831	-8808	-8784	-8761	-50
-55	-8983	-8985	-8987	-8989	-8991	-8993	-8995	-8996	-8997	-8998	-8999	-9000	-55
-60	-9041	-9042	-9043	-9044	-9045	-9046	-9047	-9048	-9049	-9050	-9051	-9052	-60
-65	-9071	-9072	-9073	-9074	-9075	-9076	-9077	-9078	-9079	-9080	-9081	-9082	-65
-70	-9098	-9099	-9100	-9101	-9102	-9103	-9104	-9105	-9106	-9107	-9108	-9109	-70
-75	-9125	-9126	-9127	-9128	-9129	-9130	-9131	-9132	-9133	-9134	-9135	-9136	-75
-80	-9145	-9146	-9147	-9148	-9149	-9150	-9151	-9152	-9153	-9154	-9155	-9156	-80
-85	-9156	-9157	-9158	-9159	-9160	-9161	-9162	-9163	-9164	-9165	-9166	-9167	-85
-90	-9168	-9169	-9170	-9171	-9172	-9173	-9174	-9175	-9176	-9177	-9178	-9179	-90
LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT
E. LONG	180	185	190	195	200	205	210	215	220	225	230	235	E. LONG

EAST COMPONENT(Y) WMM-90

E. LONG LAT	240	245	250	255	260	265	270	275	280	285	290	295	E. LONG LAT
0	4849	4861	4857	4766	4502	3988	1175	-204	-863	-918	-8624	-7825	0
-5	4823	4829	4823	4955	4741	4336	-290	-281	-1863	-909	-2115	-3847	-5
-10	4822	4811	4825	5208	5019	4626	-674	-287	-1889	149	-1549	-3291	-10
-15	4802	4715	4868	5257	5374	5097	4406	3482	2252	756	-918	-2652	-15
-20	4861	4749	4819	4838	5846	4497	-432	-405	-2868	-1412	-7224	-2938	-20
-25	4828	4819	4808	4874	4662	4065	-582	-488	-3278	-328	-529	-3163	-25
-30	4835	4713	4712	4867	4731	4065	-453	-402	-455	-385	-1322	-539	-30
-35	4853	4816	4818	4816	4828	4722	-308	-426	-303	-320	-3158	-423	-35
-40	4828	4721	4822	4839	4961	4808	-382	-303	609	454	3025	1425	-40
-45	4813	4856	4864	4826	4800	4886	-106	-205	6772	5420	3929	2722	-45
-50	4848	4883	4853	4889	4961	4808	452	-422	7628	6315	4869	4863	-50
-55	4814	4808	4877	4889	4819	4837	1053	9634	8497	7215	5831	4403	-55
-60	4865	4843	4872	4872	4882	4810	1135	10415	9324	8108	6806	5461	-60
-65	4819	4864	4874	4874	4833	4859	12023	11133	10109	8975	7263	6509	-65
-70	4862	4869	4847	4826	4873	4838	12628	11278	10839	9793	8673	7503	-70
-75	4895	4871	4824	4850	4845	4812	11355	12362	11535	10538	9496	8396	-75
-80	4838	4822	4838	4816	4878	4863	13628	12919	12062	11383	10192	9133	-80
-85	4889	4861	4813	4852	4812	4884	14086	13382	12386	11695	10721	9669	-85
-90	4833	4826	4868	4823	4838	4878	14480	13723	12068	12669	11049	9959	-90
E. LONG LAT	240	245	250	255	260	265	270	275	280	285	290	295	E. LONG LAT

EAST COMPONENT (Y) WMM-90

E. LONG	300	305	310	315	320	325	330	335	340	345	350	355	E. LONG
LAT													LAT
0	-5930	-7354	-8513	-9330	-9763	-9785	-9532	-8720	-7899	-6818	-5920	-4975	0
-5	-6551	-6922	-8125	-9021	-9498	-9584	-9313	-8751	-7998	-7148	-6272	-5436	-5
-10	-6624	-6924	-8169	-9021	-9498	-9584	-9313	-8751	-7998	-7148	-6272	-5436	-10
-15	-6858	-8152	-9021	-9839	-1037	-1156	-1009	-8544	-7930	-7227	-6453	-5677	-15
-20	-7019	-8320	-9119	-9902	-10432	-1150	-1021	-8624	-8023	-7313	-6556	-5741	-20
-25	-7178	-8478	-9278	-10021	-10521	-1159	-1028	-8695	-8094	-7384	-6627	-5812	-25
-30	-7337	-8637	-9437	-10180	-10680	-1166	-1035	-8742	-8141	-7431	-6674	-5859	-30
-35	-7496	-8796	-9596	-10339	-10839	-1177	-1046	-8853	-8252	-7542	-6785	-5970	-35
-40	-7655	-8955	-9755	-10502	-10992	-1186	-1055	-8942	-8341	-7631	-6874	-6059	-40
-45	-7814	-9114	-9914	-10665	-11155	-1202	-1071	-9032	-8431	-7721	-6964	-6149	-45
-50	-7973	-9273	-10073	-10828	-11318	-1220	-1087	-9199	-8598	-7888	-7131	-6316	-50
-55	-8132	-9432	-10232	-10985	-11475	-1235	-1103	-9360	-8759	-8049	-7292	-6477	-55
-60	-8291	-9591	-10391	-11138	-11628	-1250	-1119	-9519	-8918	-8208	-7451	-6636	-60
-65	-8450	-9750	-10550	-11297	-11787	-1260	-1135	-9678	-9077	-8367	-7610	-6795	-65
-70	-8609	-9909	-10709	-11456	-11946	-1270	-1151	-9837	-9236	-8526	-7769	-6954	-70
-75	-8768	-10068	-10868	-11615	-12105	-1280	-1167	-9996	-9395	-8685	-7928	-7113	-75
-80	-8927	-10227	-11027	-11774	-12264	-1290	-1183	-10155	-9554	-8844	-8087	-7272	-80
-85	-9086	-10386	-11186	-11934	-12424	-1300	-1199	-10314	-9713	-9003	-8246	-7431	-85
-90	-9245	-10545	-11345	-12093	-12583	-1320	-1217	-10473	-9872	-9162	-8405	-7590	-90
LAT													LAT
E. LONG	300	305	310	315	320	325	330	335	340	345	350	355	E. LONG
0	-5930	-7354	-8513	-9330	-9763	-9785	-9532	-8720	-7899	-6818	-5920	-4975	0
-5	-6551	-6922	-8125	-9021	-9498	-9584	-9313	-8751	-7998	-7148	-6272	-5436	-5
-10	-6624	-6924	-8169	-9021	-9498	-9584	-9313	-8751	-7998	-7148	-6272	-5436	-10
-15	-6858	-8152	-9021	-9839	-1037	-1156	-1009	-8544	-7930	-7227	-6453	-5677	-15
-20	-7019	-8320	-9119	-9902	-10432	-1150	-1021	-8624	-8023	-7313	-6556	-5741	-20
-25	-7178	-8478	-9278	-10021	-10521	-1159	-1028	-8695	-8094	-7384	-6627	-5812	-25
-30	-7337	-8637	-9437	-10180	-10680	-1166	-1035	-8742	-8141	-7431	-6674	-5859	-30
-35	-7496	-8796	-9596	-10339	-10839	-1177	-1046	-8853	-8252	-7542	-6785	-5970	-35
-40	-7655	-8955	-9755	-10502	-10992	-1186	-1055	-8942	-8341	-7631	-6874	-6059	-40
-45	-7814	-9114	-9914	-10665	-11155	-1202	-1071	-9032	-8431	-7721	-6964	-6149	-45
-50	-7973	-9273	-10073	-10828	-11318	-1220	-1087	-9199	-8598	-7888	-7131	-6316	-50
-55	-8132	-9432	-10232	-10985	-11475	-1235	-1103	-9360	-8759	-8049	-7292	-6477	-55
-60	-8291	-9591	-10391	-11138	-11628	-1250	-1119	-9519	-8918	-8208	-7451	-6636	-60
-65	-8450	-9750	-10550	-11297	-11787	-1260	-1135	-9678	-9077	-8367	-7610	-6795	-65
-70	-8609	-9909	-10709	-11456	-11946	-1270	-1151	-9837	-9236	-8526	-7769	-6954	-70
-75	-8768	-10068	-10868	-11615	-12105	-1280	-1167	-9996	-9395	-8685	-7928	-7113	-75
-80	-8927	-10227	-11027	-11774	-12264	-1290	-1183	-10155	-9554	-8844	-8087	-7272	-80
-85	-9086	-10386	-11186	-11934	-12424	-1300	-1199	-10314	-9713	-9003	-8246	-7431	-85
-90	-9245	-10545	-11345	-12093	-12583	-1320	-1217	-10473	-9872	-9162	-8405	-7590	-90
LAT													LAT

VERTICAL COMPONENT (Z) WMM-90

L. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG	LAT
LAT														
90	56401 -21.0	56401 -21.0	56401 -21.0	56401 -21.0	56401 -21.0	56401 -21.0	56401 -21.0	56401 -21.0	56401 -21.0	56401 -21.0	56401 -21.0	56401 -21.0	56401 -21.0	90
85	55294 -12.5	55318 -12.5	55359 -12.7	55407 -12.9	55471 -13.1	55546 -13.5	55632 -13.9	55728 -14.4	55833 -14.9	55944 -15.5	56060 -16.2	56180 -16.9	56304 -17.6	85
80	53989 -2.2	54021 -2.0	54088 -2.1	54190 -2.3	54326 -2.7	54494 -3.3	54692 -4.0	54918 -4.9	55167 -5.9	55437 -7.1	55723 -8.5	56018 -9.7	56314 -11.0	80
75	52607 7.1	52631 7.5	52712 7.7	52852 7.6	53048 7.2	53299 6.5	53603 5.6	53956 4.5	54354 3.3	54790 1.9	55258 .3	55750 -1.4	56254 -3.0	75
70	51182 13.8	51192 14.7	51278 15.1	51442 15.1	51680 14.7	51992 14.0	52375 13.1	52828 12.0	53345 10.7	53921 9.3	54549 7.8	55217 6.2	55933 4.6	70
65	49661 17.8	49668 19.1	49764 19.8	49946 19.9	50212 19.2	50562 18.8	50994 17.9	51507 16.7	52100 15.4	52770 14.1	53508 12.9	54307 11.6	55156 10.3	65
60	47910 19.5	47956 21.4	48078 22.5	48387 23.8	48881 25.1	49566 26.8	50424 28.4	51553 30.3	52881 32.8	54417 36.4	56162 41.1	58116 46.8	60180 52.5	60
55	45845 18.5	45919 22.5	46090 24.2	46346 25.4	46678 26.8	47083 28.3	47557 29.8	48107 31.4	48726 33.1	49449 34.9	50246 36.7	51121 38.5	52083 40.3	55
50	43875 18.7	43919 22.5	44050 26.0	44253 29.8	44507 31.3	44813 33.1	45282 35.2	45926 37.6	46737 40.1	47717 42.7	48876 45.4	50124 48.1	51471 50.8	50
45	40096 16.2	40321 22.0	40650 26.6	41053 30.8	41507 34.6	42099 38.5	42828 42.4	43797 46.3	44917 50.2	46287 54.1	47916 58.0	49804 61.9	51951 65.8	45
40	36222 11.6	36527 19.6	36938 26.3	37417 31.2	37933 34.0	38474 36.5	39039 39.0	39633 41.6	40257 44.2	40907 46.8	41574 49.4	42251 52.0	42938 54.6	40
35	31570 4.6	31936 14.8	32410 23.7	32944 30.5	33503 34.6	34078 38.8	34675 43.0	35301 47.2	35952 51.4	36608 55.6	37246 59.8	37846 64.0	38400 68.2	35
30	26988 2.8	26403 14.2	26898 23.7	27542 30.5	28113 34.6	28699 38.8	29318 43.0	29980 47.2	30674 51.4	31363 55.6	31997 59.8	32547 64.0	33101 68.2	30
25	19789 18.2	20175 21.5	20668 26.0	21203 30.8	21752 34.6	22327 38.5	22932 42.4	23555 46.3	24204 50.2	24887 54.1	25603 58.0	26318 61.9	27021 65.8	25
20	12813 12.1	13138 13.8	13579 15.7	14055 17.6	14553 19.6	15094 21.6	15720 23.6	16453 25.6	17265 27.6	18067 29.6	18957 31.6	19834 33.6	20700 35.6	20
15	5453 -19.3	5661 -23.6	5990 -27.7	6373 -31.2	6793 -34.6	7288 -38.5	7907 -42.4	8672 -46.3	9535 -50.2	10389 -54.1	11106 -58.0	11897 -61.9	12671 -65.8	15
10	-1858 -18.5	-1823 -18.2	-1865 -18.6	-1918 -19.1	-1981 -19.6	-2054 -20.1	-2137 -20.6	-2229 -21.1	-2329 -21.6	-2437 -22.1	-2553 -22.6	-2676 -23.1	-2806 -23.6	10
5	-8608 -54.9	-8816 -58.4	-9070 -61.8	-9307 -65.1	-9613 -68.5	-10000 -71.9	-10469 -75.4	-11021 -78.8	-11655 -82.3	-12374 -85.7	-13188 -89.2	-14097 -92.7	-15101 -96.1	5
0	-15361 -15.3	-15839 -16.8	-16319 -18.3	-16801 -19.8	-17284 -21.3	-17868 -22.8	-18453 -24.3	-19039 -25.8	-19626 -27.3	-20214 -28.8	-20803 -30.3	-21393 -31.8	-21984 -33.3	0
LAT														
L. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG	LAT

nT
(units: nT)

VERTICAL COMPONENT (Z) WMM-90

LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG
90	56402	56402	56402	56402	56402	56402	56402	56402	56402	56402	56402	56402	90
85	56502	56423	56543	56552	56669	56872	56967	57052	57127	57191	57243	57285	85
80	56320	56620	56714	57196	57459	57699	57910	58089	58232	58339	58407	58437	80
75	56255	56763	57262	57741	58186	58586	58930	59209	59415	59544	59593	59644	75
70	55913	56922	57322	58002	58635	59203	59682	60058	60319	60452	60553	60622	70
65	55150	56019	56890	57739	58534	59247	59847	60308	60607	60728	60861	60967	65
60	53879	54845	55825	56784	57694	58510	59194	59711	60028	60121	60175	60208	60
55	52962	53926	54905	55866	56812	57678	58490	59129	59632	59999	60265	60433	55
50	49872	50815	51803	52852	53866	54895	55890	56803	57728	58641	59508	60380	50
45	46652	47493	48349	49302	50250	51161	52084	52962	53869	54776	55676	56506	45
40	42934	43625	44320	45210	46079	46876	47680	48422	49142	49827	50521	51184	40
35	38405	38932	39441	39936	40410	40842	41204	41460	41568	41477	41134	40495	35
30	32991	33359	33678	33971	34244	34493	34704	34855	34916	34835	34553	34010	30
25	26672	26907	27052	27153	27235	27307	27375	27438	27469	27429	27242	26849	25
20	19551	19666	19661	19593	19504	19422	19370	19364	19398	19430	19380	19163	20
15	11826	11833	11895	11907	11944	11933	11889	11847	11831	11849	11829	11729	15
10	3802	3708	3513	3282	3213	3199	3176	3129	3235	3476	3729	3924	10
5	-4086	-4332	-4759	-5271	-5784	-6219	-6502	-6571	-6411	-6073	-5661	-5245	5
0	-11438	-11883	-12512	-13220	-13911	-14491	-14871	-14984	-14812	-14412	-13892	-13342	0
LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG

VERTICAL COMPONENT (Z) WMM-90

L. LONG	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG
LAT													LAT
90	-5940.7	-5940.7	-5940.7	-5940.7	-5940.7	-5940.7	-5940.7	-5940.7	-5940.7	-5940.7	-5940.7	-5940.7	90
85	-5733.5	-5733.4	-5733.4	-5733.4	-5733.8	-5732.9	-5730.9	-5727.9	-5724.8	-5721.9	-5718.8	-5715.7	85
80	-5443.2	-5439.5	-5432.8	-5423.8	-5412.9	-5400.7	-5387.9	-5375.1	-5362.2	-5349.6	-5337.2	-5324.8	80
75	-5046.2	-5029.3	-5006.7	-4979.8	-4949.8	-4918.3	-4886.6	-4855.5	-4824.1	-4792.9	-4761.9	-4730.6	75
70	-4607.3	-4571.6	-4526.3	-4474.5	-4418.2	-4359.3	-4294.5	-4224.8	-4155.1	-4086.3	-4017.3	-3948.3	70
65	-4097.7	-4039.7	-3967.7	-3887.2	-3797.4	-3701.4	-3597.0	-3484.3	-3367.5	-3241.0	-3115.3	-2990.8	65
60	-3597.9	-3515.5	-3417.6	-3308.0	-3187.9	-3058.4	-2922.8	-2784.7	-2648.6	-2508.6	-2368.6	-2232.3	60
55	-3096.8	-2994.3	-2872.8	-2738.4	-2597.3	-2452.4	-2307.8	-2164.1	-2024.4	-1882.6	-1742.9	-1607.3	55
50	-2596.5	-2472.9	-2338.0	-2194.9	-2045.1	-1890.3	-1732.1	-1571.9	-1412.6	-1258.0	-1105.2	-955.5	50
45	-2090.3	-1943.3	-1782.9	-1610.7	-1430.4	-1247.3	-1064.3	-884.1	-709.0	-542.2	-385.3	-232.2	45
40	-1588.3	-1418.9	-1236.7	-1053.3	-870.6	-690.3	-514.7	-347.2	-189.9	-32.6	125.8	279.5	40
35	-1084.4	-907.8	-724.5	-536.3	-344.0	-150.3	48.2	257.3	492.7	685.6	826.4	915.7	35
30	-581.7	-397.8	-207.4	-11.3	181.3	367.9	548.8	715.3	868.7	1009.3	1137.2	1253.3	30
25	-73.3	129.3	241.8	347.0	445.8	538.9	627.4	711.2	790.6	865.6	937.2	1005.3	25
20	482.3	606.9	722.9	831.6	934.8	1032.9	1125.9	1213.7	1296.2	1373.4	1445.2	1501.5	20
15	982.8	1033.4	1079.9	1122.3	1161.5	1197.6	1230.7	1260.8	1287.9	1312.1	1333.4	1351.7	15
10	1482.8	1483.4	1479.9	1472.3	1461.5	1447.6	1430.7	1410.8	1387.9	1362.1	1333.4	1301.5	10
5	-503.3	-493.3	-482.9	-472.3	-461.5	-450.3	-438.7	-426.8	-414.6	-402.1	-389.2	-375.8	5
0	-1298.0	-1266.9	-1240.0	-1208.8	-1165.9	-1107.2	-1031.1	-947.1	-854.6	-755.0	-650.2	-540.3	0
LAT													LAT
L. LONG	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG

VERTICAL COMPONENT (Z) WMM-90

L. LONG LAT	180	185	190	195	200	205	210	215	220	225	230	235	L. LONG LAT
90	56401 -21.6	56401 -21.6	56401 -21.6	56401 -21.6	56401 -21.6	56401 -21.6	56401 -21.6	56401 -21.6	56401 -21.6	56401 -21.6	56401 -21.6	56401 -21.6	90
85	57127 -25.0	57097 -25.0	57068 -25.0	57039 -25.0	57010 -25.0	56981 -25.0	56952 -25.0	56923 -25.0	56894 -25.0	56865 -25.0	56836 -25.0	56807 -25.0	85
80	57263 -25.8	57234 -25.8	57205 -25.8	57176 -25.8	57147 -25.8	57118 -25.8	57089 -25.8	57060 -25.8	57031 -25.8	57002 -25.8	56973 -25.8	56944 -25.8	80
75	56618 -15.6	56589 -15.6	56560 -15.6	56531 -15.6	56502 -15.6	56473 -15.6	56444 -15.6	56415 -15.6	56386 -15.6	56357 -15.6	56328 -15.6	56299 -15.6	75
70	55027 -10.2	54998 -10.2	54969 -10.2	54940 -10.2	54911 -10.2	54882 -10.2	54853 -10.2	54824 -10.2	54795 -10.2	54766 -10.2	54737 -10.2	54708 -10.2	70
65	52930 -9.6	52901 -9.6	52872 -9.6	52843 -9.6	52814 -9.6	52785 -9.6	52756 -9.6	52727 -9.6	52698 -9.6	52669 -9.6	52640 -9.6	52611 -9.6	65
60	49393 -18.2	49364 -18.2	49335 -18.2	49306 -18.2	49277 -18.2	49248 -18.2	49219 -18.2	49190 -18.2	49161 -18.2	49132 -18.2	49103 -18.2	49074 -18.2	60
55	45579 -17.5	45550 -17.5	45521 -17.5	45492 -17.5	45463 -17.5	45434 -17.5	45405 -17.5	45376 -17.5	45347 -17.5	45318 -17.5	45289 -17.5	45260 -17.5	55
50	41468 -14.2	41439 -14.2	41410 -14.2	41381 -14.2	41352 -14.2	41323 -14.2	41294 -14.2	41265 -14.2	41236 -14.2	41207 -14.2	41178 -14.2	41149 -14.2	50
45	37242 -11.2	37213 -11.2	37184 -11.2	37155 -11.2	37126 -11.2	37097 -11.2	37068 -11.2	37039 -11.2	37010 -11.2	36981 -11.2	36952 -11.2	36923 -11.2	45
40	33136 -8.2	33107 -8.2	33078 -8.2	33049 -8.2	33020 -8.2	32991 -8.2	32962 -8.2	32933 -8.2	32904 -8.2	32875 -8.2	32846 -8.2	32817 -8.2	40
35	29029 -5.2	28999 -5.2	28970 -5.2	28941 -5.2	28912 -5.2	28883 -5.2	28854 -5.2	28825 -5.2	28796 -5.2	28767 -5.2	28738 -5.2	28709 -5.2	35
30	25423 -2.2	25394 -2.2	25365 -2.2	25336 -2.2	25307 -2.2	25278 -2.2	25249 -2.2	25220 -2.2	25191 -2.2	25162 -2.2	25133 -2.2	25104 -2.2	30
25	21696 -0.2	21667 -0.2	21638 -0.2	21609 -0.2	21580 -0.2	21551 -0.2	21522 -0.2	21493 -0.2	21464 -0.2	21435 -0.2	21406 -0.2	21377 -0.2	25
20	17829 11.2	17799 11.2	17770 11.2	17741 11.2	17712 11.2	17683 11.2	17654 11.2	17625 11.2	17596 11.2	17567 11.2	17538 11.2	17509 11.2	20
15	13619 28.2	13589 28.2	13560 28.2	13531 28.2	13502 28.2	13473 28.2	13444 28.2	13415 28.2	13386 28.2	13357 28.2	13328 28.2	13299 28.2	15
10	9858 40.2	9828 40.2	9799 40.2	9770 40.2	9741 40.2	9712 40.2	9683 40.2	9654 40.2	9625 40.2	9596 40.2	9567 40.2	9538 40.2	10
5	3436 44.2	3406 44.2	3377 44.2	3348 44.2	3319 44.2	3290 44.2	3261 44.2	3232 44.2	3203 44.2	3174 44.2	3145 44.2	3116 44.2	5
0	-2649 -16.2	-2619 -16.2	-2590 -16.2	-2561 -16.2	-2532 -16.2	-2503 -16.2	-2474 -16.2	-2445 -16.2	-2416 -16.2	-2387 -16.2	-2358 -16.2	-2329 -16.2	0
LAT	180	185	190	195	200	205	210	215	220	225	230	235	LAT
E. LONG	180	185	190	195	200	205	210	215	220	225	230	235	E. LONG

VERTICAL COMPONENT (Z) WMM-90

L. LONG LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG LAT
90	56401 -21.4	56401 -21.4	56401 -21.4	56401 -21.4	56401 -21.4	56401 -21.4	56401 -21.4	56401 -21.4	56401 -21.4	56401 -21.4	56401 -21.4	56401 -21.4	90
85	56252 -22.2	56252 -22.2	56400 -21.0	56602 -21.2	56818 -20.8	56668 -20.8	56395 -19.9	56315 -19.4	56236 -18.9	56163 -18.3	56088 -17.8	55966 -17.2	85
80	56202 -21.4	56189 -21.3	56353 -21.2	56294 -20.9	56210 -20.5	56101 -20.1	56069 -19.5	56213 -18.9	56636 -18.0	56449 -17.4	56229 -16.8	56006 -16.0	80
75	56216 -20.3	56104 -21.0	56346 -21.0	56335 -22.0	56270 -22.1	56149 -22.0	56271 -21.6	56243 -21.4	56263 -21.0	56217 -20.5	56276 -19.8	56187 -19.2	75
70	56226 -20.6	56178 -22.6	56350 -24.2	56434 -24.2	56424 -24.2	56218 -24.2	56111 -24.2	56112 -24.2	56427 -24.5	56263 -24.5	56235 -24.1	56156 -23.5	70
65	56182 -21.2	56644 -22.2	56904 -22.2	60209 -21.3	60291 -21.2	60229 -21.2	60258 -21.2	59671 -21.8	59188 -21.4	58586 -21.7	57884 -21.3	57106 -20.8	65
60	56653 -28.8	56343 -28.2	56896 -28.0	60288 -28.0	60497 -28.2	60118 -28.2	60343 -28.2	59275 -28.2	59413 -28.2	58888 -28.6	57823 -28.1	56856 -28.0	60
55	56121 -35.7	56043 -48.9	56811 -48.1	56394 -47.4	56269 -48.2	56011 -49.1	56806 -50.5	56451 -51.4	56854 -52.4	58016 -53.4	57034 -53.9	55891 -54.3	55
50	56557 -42.2	56661 -48.3	56653 -48.2	56434 -48.5	56288 -48.8	56280 -48.8	56258 -48.8	56285 -48.5	56119 -48.1	56136 -47.6	56268 -47.2	56124 -46.4	50
45	56107 -47.7	56382 -51.3	56316 -57.3	56475 -59.3	56203 -60.4	56553 -61.5	56852 -62.5	56875 -62.5	56875 -62.5	56875 -62.5	56875 -62.5	56875 -62.5	45
40	47013 -48.9	48364 -55.4	49679 -58.2	50897 -58.2	52167 -58.2	52168 -58.2	52422 -65.6	52318 -65.6	51831 -65.6	50775 -64.2	49788 -60.9	48336 -59.8	40
35	47508 -48.7	48863 -53.1	49145 -55.6	49301 -56.4	47266 -57.9	47971 -60.3	48351 -65.0	48357 -72.3	47661 -71.8	46264 -69.4	45997 -102.2	44523 -109.8	35
30	37718 -44.2	39027 -48.4	40279 -47.3	41445 -47.2	42458 -49.0	43242 -52.8	43623 -53.6	43838 -53.6	43449 -53.0	42841 -52.5	41734 -51.1	40276 -52.0	30
25	33248 -36.8	33812 -38.2	35498 -39.8	36226 -39.2	36352 -39.2	36893 -39.2	36869 -38.8	36890 -38.2	36231 -38.2	34834 -38.2	33718 -37.2	33210 -36.0	25
20	28518 -28.18	28543 -28.9	29013 -29.8	29695 -30.0	31729 -31.2	32628 -32.8	33303 -33.0	33690 -33.0	33628 -33.0	33168 -32.8	32263 -32.8	31859 -32.8	20
15	22053 -14.5	22939 -15.8	23895 -15.8	24930 -10.6	24976 -9.8	26946 -2.9	27233 -2.3	28228 -2.8	28358 -2.8	28042 -8.4	27272 -110.8	26068 -135.5	15
10	16607 -20.7	17158 -21.8	18018 -21.8	19038 -21.8	20102 -21.8	21152 -21.8	22080 -21.8	22708 -21.8	22991 -21.8	22446 -21.8	22213 -21.8	21829 -21.8	10
5	10703 -17.6	11368 -17.6	12161 -17.6	13161 -17.6	14252 -17.6	15369 -17.6	16396 -17.6	17182 -17.6	17625 -17.6	17638 -17.6	17158 -17.6	16124 -17.6	5
0	5073 -15.6	5702 -15.6	6485 -15.6	7440 -15.6	8219 -15.6	8703 -15.6	10813 -15.6	11710 -21.6	12323 -15.6	12484 -15.6	12147 -15.6	11285 -15.6	0
L. LONG LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG LAT

[illegible]

VERTICAL COMPONENT (Z) WMM-90

LAT	0	5	10	15	20	25	30	35	40	45	50	55	L - LONG
0	1430	3182	8745	1245	623	934	724	941	323	307	947	323	0
-5	1435	1551	6002	5102	404	202	651	920	318	227	644	245	-5
-10	1472	2242	9111	6061	914	808	1932	222	845	032	207	363	-10
-15	8215	2245	9052	1003	9062	9002	509	203	219	235	117	158	-15
-20	4094	3232	8132	2262	8262	818	1038	9838	0338	8638	9432	628	-20
-25	2012	6032	9002	6632	3632	8582	8482	9582	0292	3022	3082	130	-25
-30	2012	3205	4032	1162	6232	4342	1532	9502	1032	8112	8062	316	-30
-35	4202	2242	5192	7162	4232	4342	1532	9502	1032	8112	8062	316	-35
-40	2202	2242	3205	6232	3632	8582	8482	9582	0292	3022	3082	130	-40
-45	4202	3205	4032	1162	6232	4342	1532	9502	1032	8112	8062	316	-45
-50	3205	2242	5192	7162	4232	4342	1532	9502	1032	8112	8062	316	-50
-55	3205	3205	4032	1162	6232	4342	1532	9502	1032	8112	8062	316	-55
-60	3205	3205	4032	1162	6232	4342	1532	9502	1032	8112	8062	316	-60
-65	3205	3205	4032	1162	6232	4342	1532	9502	1032	8112	8062	316	-65
-70	3205	3205	4032	1162	6232	4342	1532	9502	1032	8112	8062	316	-70
-75	3205	3205	4032	1162	6232	4342	1532	9502	1032	8112	8062	316	-75
-80	3205	3205	4032	1162	6232	4342	1532	9502	1032	8112	8062	316	-80
-85	3205	3205	4032	1162	6232	4342	1532	9502	1032	8112	8062	316	-85
-90	3205	3205	4032	1162	6232	4342	1532	9502	1032	8112	8062	316	-90
LAT	L - LONG	5	10	15	20	25	30	35	40	45	50	55	L - LONG

VERTICAL COMPONENT (Z) WMM-90

L. LONG LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG LAT
0	-174.8 41.3	-174.8 41.3	-175.1 18.0	-175.4 41.1	-175.7 18.0	-176.0 41.1	-176.3 18.0	-176.6 41.1	-176.9 18.0	-177.2 41.1	-177.5 18.0	-177.8 41.1	0
-5	-178.7 2.2	-178.8 2.2	-179.0 2.2	-179.2 2.2	-179.4 2.2	-179.6 2.2	-179.8 2.2	-180.0 2.2	-180.2 2.2	-180.4 2.2	-180.6 2.2	-180.8 2.2	-5
-10	-182.6 35.1	-182.7 35.1	-182.9 35.1	-183.1 35.1	-183.3 35.1	-183.5 35.1	-183.7 35.1	-183.9 35.1	-184.1 35.1	-184.3 35.1	-184.5 35.1	-184.7 35.1	-10
-15	-186.5 4.2	-186.6 4.2	-186.8 4.2	-187.0 4.2	-187.2 4.2	-187.4 4.2	-187.6 4.2	-187.8 4.2	-188.0 4.2	-188.2 4.2	-188.4 4.2	-188.6 4.2	-15
-20	-190.4 1.8	-190.5 1.8	-190.7 1.8	-190.9 1.8	-191.1 1.8	-191.3 1.8	-191.5 1.8	-191.7 1.8	-191.9 1.8	-192.1 1.8	-192.3 1.8	-192.5 1.8	-20
-25	-194.3 2.2	-194.4 2.2	-194.6 2.2	-194.8 2.2	-195.0 2.2	-195.2 2.2	-195.4 2.2	-195.6 2.2	-195.8 2.2	-196.0 2.2	-196.2 2.2	-196.4 2.2	-25
-30	-198.2 2.2	-198.3 2.2	-198.5 2.2	-198.7 2.2	-198.9 2.2	-199.1 2.2	-199.3 2.2	-199.5 2.2	-199.7 2.2	-199.9 2.2	-200.1 2.2	-200.3 2.2	-30
-35	-202.1 2.2	-202.2 2.2	-202.4 2.2	-202.6 2.2	-202.8 2.2	-203.0 2.2	-203.2 2.2	-203.4 2.2	-203.6 2.2	-203.8 2.2	-204.0 2.2	-204.2 2.2	-35
-40	-206.0 2.2	-206.1 2.2	-206.3 2.2	-206.5 2.2	-206.7 2.2	-206.9 2.2	-207.1 2.2	-207.3 2.2	-207.5 2.2	-207.7 2.2	-207.9 2.2	-208.1 2.2	-40
-45	-209.9 2.2	-210.0 2.2	-210.2 2.2	-210.4 2.2	-210.6 2.2	-210.8 2.2	-211.0 2.2	-211.2 2.2	-211.4 2.2	-211.6 2.2	-211.8 2.2	-212.0 2.2	-45
-50	-213.8 2.2	-213.9 2.2	-214.1 2.2	-214.3 2.2	-214.5 2.2	-214.7 2.2	-214.9 2.2	-215.1 2.2	-215.3 2.2	-215.5 2.2	-215.7 2.2	-215.9 2.2	-50
-55	-217.7 2.2	-217.8 2.2	-218.0 2.2	-218.2 2.2	-218.4 2.2	-218.6 2.2	-218.8 2.2	-219.0 2.2	-219.2 2.2	-219.4 2.2	-219.6 2.2	-219.8 2.2	-55
-60	-221.6 2.2	-221.7 2.2	-221.9 2.2	-222.1 2.2	-222.3 2.2	-222.5 2.2	-222.7 2.2	-222.9 2.2	-223.1 2.2	-223.3 2.2	-223.5 2.2	-223.7 2.2	-60
-65	-225.5 2.2	-225.6 2.2	-225.8 2.2	-226.0 2.2	-226.2 2.2	-226.4 2.2	-226.6 2.2	-226.8 2.2	-227.0 2.2	-227.2 2.2	-227.4 2.2	-227.6 2.2	-65
-70	-229.4 2.2	-229.5 2.2	-229.7 2.2	-229.9 2.2	-230.1 2.2	-230.3 2.2	-230.5 2.2	-230.7 2.2	-230.9 2.2	-231.1 2.2	-231.3 2.2	-231.5 2.2	-70
-75	-233.3 2.2	-233.4 2.2	-233.6 2.2	-233.8 2.2	-234.0 2.2	-234.2 2.2	-234.4 2.2	-234.6 2.2	-234.8 2.2	-235.0 2.2	-235.2 2.2	-235.4 2.2	-75
-80	-237.2 2.2	-237.3 2.2	-237.5 2.2	-237.7 2.2	-237.9 2.2	-238.1 2.2	-238.3 2.2	-238.5 2.2	-238.7 2.2	-238.9 2.2	-239.1 2.2	-239.3 2.2	-80
-85	-241.1 2.2	-241.2 2.2	-241.4 2.2	-241.6 2.2	-241.8 2.2	-242.0 2.2	-242.2 2.2	-242.4 2.2	-242.6 2.2	-242.8 2.2	-243.0 2.2	-243.2 2.2	-85
-90	-245.0 2.2	-245.1 2.2	-245.3 2.2	-245.5 2.2	-245.7 2.2	-245.9 2.2	-246.1 2.2	-246.3 2.2	-246.5 2.2	-246.7 2.2	-246.9 2.2	-247.1 2.2	-90

VERTICAL ONENT (Z) WMM-90

L. LONG	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG	LAT
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0	0
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	5	5
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	10	10
15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	15	15
20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	20	20
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	25	25
30	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	30	30
35	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	35	35
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	40	40
45	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	45	45
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	50	50
55	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	55	55
60	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	60	60
65	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	65	65
70	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	70	70
75	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	75	75
80	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	80	80
85	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	85	85
90	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	90	90

VERTICAL COMPONENT (Z) WMM-90

L. LONG LAT	180	185	190	195	200	205	210	215	220	225	230	235	L. LONG LAT
0	4.91- 26.44	1.07 14.00	8.21 0.00	6.19 6.25	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	0
-5	4.96- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-5
-10	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-10
-15	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-15
-20	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-20
-25	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-25
-30	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-30
-35	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-35
-40	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-40
-45	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-45
-50	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-50
-55	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-55
-60	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-60
-65	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-65
-70	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-70
-75	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-75
-80	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-80
-85	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-85
-90	4.91- 3.36	3.23 3.26	0.00 0.00	6.12 6.12	8.92 3.60	1.27 1.37	4.27 8.14	5.95 8.22	3.82 2.92	3.23 5.03	4.04 1.41	4.54 10.22	-90

VERTICAL COMPONENT (Z) WMM-90

L. LONG	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG
LAT													LAT
0	3072	3073	3066	3059	3053	3048	3041	3034	3027	3020	3014	3007	0
-5	-3035	-3034	-3041	-3048	-3055	-3062	-3069	-3076	-3083	-3090	-3097	-3104	-5
-10	-3099	-3098	-3105	-3112	-3119	-3126	-3133	-3140	-3147	-3154	-3161	-3168	-10
-15	-3161	-3160	-3167	-3174	-3181	-3188	-3195	-3202	-3209	-3216	-3223	-3230	-15
-20	-3231	-3230	-3237	-3244	-3251	-3258	-3265	-3272	-3279	-3286	-3293	-3300	-20
-25	-3302	-3301	-3308	-3315	-3322	-3329	-3336	-3343	-3350	-3357	-3364	-3371	-25
-30	-3372	-3371	-3378	-3385	-3392	-3399	-3406	-3413	-3420	-3427	-3434	-3441	-30
-35	-3442	-3441	-3448	-3455	-3462	-3469	-3476	-3483	-3490	-3497	-3504	-3511	-35
-40	-3511	-3510	-3517	-3524	-3531	-3538	-3545	-3552	-3559	-3566	-3573	-3580	-40
-45	-3580	-3579	-3586	-3593	-3600	-3607	-3614	-3621	-3628	-3635	-3642	-3649	-45
-50	-3649	-3648	-3655	-3662	-3669	-3676	-3683	-3690	-3697	-3704	-3711	-3718	-50
-55	-3718	-3717	-3724	-3731	-3738	-3745	-3752	-3759	-3766	-3773	-3780	-3787	-55
-60	-3787	-3786	-3793	-3800	-3807	-3814	-3821	-3828	-3835	-3842	-3849	-3856	-60
-65	-3856	-3855	-3862	-3869	-3876	-3883	-3890	-3897	-3904	-3911	-3918	-3925	-65
-70	-3925	-3924	-3931	-3938	-3945	-3952	-3959	-3966	-3973	-3980	-3987	-3994	-70
-75	-3994	-3993	-4000	-4007	-4014	-4021	-4028	-4035	-4042	-4049	-4056	-4063	-75
-80	-4063	-4062	-4069	-4076	-4083	-4090	-4097	-4104	-4111	-4118	-4125	-4132	-80
-85	-4132	-4131	-4138	-4145	-4152	-4159	-4166	-4173	-4180	-4187	-4194	-4201	-85
-90	-4201	-4200	-4207	-4214	-4221	-4228	-4235	-4242	-4249	-4256	-4263	-4270	-90
LAT													LAT

VERTICAL COMPONENT (Z) WMM-90

LAT	100	105	110	115	120	125	130	135	140	145	150	155	156	LAT
0	45521-	75391-	65611-	15491-	05691-	28992-	16131-	93391-	52961-	93991-	80911-	91291-	52961-	0
5-	105	51511-	69511-	42111-	11811-	23451-	33981-	23451-	76511-	25001-	82511-	65191-	80661-	5-
10-	8189-	61291-	35869-	61891-	93391-	92861-	62291-	62291-	93391-	60091-	60091-	45381-	623892-	10-
15-	6792-	7001-	27911-	62691-	10361-	40931-	62511-	40361-	35981-	35981-	35981-	52692-	52692-	15-
20-	3039-	3039-	4539-	26291-	86491-	46391-	29291-	29291-	35961-	30012-	30012-	42392-	42392-	20-
25-	4708-	4568-	8139-	66891-	93391-	86391-	93391-	93391-	81392-	61392-	61392-	61392-	93852-	25-
30-	3971-	3581-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	30-
35-	62811-	1568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	35-
40-	82891-	3581-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	40-
45-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	45-
50-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	50-
55-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	55-
60-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	60-
65-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	65-
70-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	70-
75-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	75-
80-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	80-
85-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	85-
90-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	90-
LAT	100	105	110	115	120	125	130	135	140	145	150	155	156	LAT
0	45521-	75391-	65611-	15491-	05691-	28992-	16131-	93391-	52961-	93991-	80911-	91291-	52961-	0
5-	105	51511-	69511-	42111-	11811-	23451-	33981-	23451-	76511-	25001-	82511-	65191-	80661-	5-
10-	8189-	61291-	35869-	61891-	93391-	92861-	62291-	62291-	93391-	60091-	60091-	45381-	623892-	10-
15-	6792-	7001-	27911-	62691-	10361-	40931-	62511-	40361-	35981-	35981-	35981-	52692-	52692-	15-
20-	3039-	3039-	4539-	26291-	86491-	46391-	29291-	62291-	93391-	60091-	60091-	45381-	623892-	20-
25-	4708-	4568-	8139-	66891-	93391-	86391-	93391-	93391-	81392-	61392-	61392-	61392-	93852-	25-
30-	3971-	3581-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	30-
35-	62811-	1568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	35-
40-	82891-	3581-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	40-
45-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	45-
50-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	50-
55-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	55-
60-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	60-
65-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	65-
70-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	70-
75-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	75-
80-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	80-
85-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	85-
90-	93852-	4568-	66131-	45691-	80891-	62291-	29391-	29391-	61692-	93692-	93692-	32892-	32892-	90-

HORIZONTAL COMPONENT (H) WMM-90

L. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG	LAT
LAT														
90	-117.6	-117.6	-117.6	-117.6	-117.6	-117.6	-117.6	-117.6	-117.6	-117.6	-117.6	-117.6	-117.6	90
85	-16.7	-17.0	-17.3	-17.5	-17.7	-17.9	-18.1	-18.3	-18.5	-18.7	-18.9	-19.1	-19.4	85
80	-48.9	-49.2	-49.5	-49.7	-49.9	-50.1	-50.3	-50.5	-50.7	-50.9	-51.1	-51.3	-51.6	80
75	-89.1	-89.4	-89.7	-89.9	-90.1	-90.3	-90.5	-90.7	-90.9	-91.1	-91.3	-91.5	-91.8	75
70	-129.7	-130.0	-130.3	-130.5	-130.7	-130.9	-131.1	-131.3	-131.5	-131.7	-131.9	-132.1	-132.4	70
65	-170.3	-170.6	-170.9	-171.1	-171.3	-171.5	-171.7	-171.9	-172.1	-172.3	-172.5	-172.7	-173.0	65
60	-210.9	-211.2	-211.5	-211.7	-211.9	-212.1	-212.3	-212.5	-212.7	-212.9	-213.1	-213.3	-213.6	60
55	-251.5	-251.8	-252.1	-252.3	-252.5	-252.7	-252.9	-253.1	-253.3	-253.5	-253.7	-253.9	-254.2	55
50	-292.1	-292.4	-292.7	-292.9	-293.1	-293.3	-293.5	-293.7	-293.9	-294.1	-294.3	-294.5	-294.8	50
45	-332.7	-333.0	-333.3	-333.5	-333.7	-333.9	-334.1	-334.3	-334.5	-334.7	-334.9	-335.1	-335.4	45
40	-373.3	-373.6	-373.9	-374.1	-374.3	-374.5	-374.7	-374.9	-375.1	-375.3	-375.5	-375.7	-376.0	40
35	-413.9	-414.2	-414.5	-414.7	-414.9	-415.1	-415.3	-415.5	-415.7	-415.9	-416.1	-416.3	-416.6	35
30	-454.5	-454.8	-455.1	-455.3	-455.5	-455.7	-455.9	-456.1	-456.3	-456.5	-456.7	-456.9	-457.2	30
25	-495.1	-495.4	-495.7	-495.9	-496.1	-496.3	-496.5	-496.7	-496.9	-497.1	-497.3	-497.5	-497.8	25
20	-535.7	-536.0	-536.3	-536.5	-536.7	-536.9	-537.1	-537.3	-537.5	-537.7	-537.9	-538.1	-538.4	20
15	-576.3	-576.6	-576.9	-577.1	-577.3	-577.5	-577.7	-577.9	-578.1	-578.3	-578.5	-578.7	-579.0	15
10	-616.9	-617.2	-617.5	-617.7	-617.9	-618.1	-618.3	-618.5	-618.7	-618.9	-619.1	-619.3	-619.6	10
5	-657.5	-657.8	-658.1	-658.3	-658.5	-658.7	-658.9	-659.1	-659.3	-659.5	-659.7	-659.9	-660.2	5
0	-698.1	-698.4	-698.7	-698.9	-699.1	-699.3	-699.5	-699.7	-699.9	-700.1	-700.3	-700.5	-700.8	0
LAT														
L. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG	LAT

nT
(units: nT)

HORIZONTAL COMPONENT (H) WMM-90

L. LONG LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG LAT
90	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	90
85	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	85
80	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	80
75	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	75
70	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	70
65	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	65
60	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	60
55	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	55
50	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	50
45	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	45
40	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	40
35	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	35
30	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	30
25	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	25
20	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	20
15	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	15
10	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	10
5	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	5
0	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	0
L. LONG LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG LAT

HORIZONTAL COMPONENT (H) WMM-90

L. LONG	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG
LAT													LAT
90	-317.6	-317.6	-317.6	-317.6	-317.6	-317.6	-317.6	-317.6	-317.6	-317.6	-317.6	-317.6	90
85	-185.8	-136.8	-121.5	-119.0	-118.0	-130.3	-132.8	-155.7	-158.3	-160.8	-161.5	-160.9	85
80	-267.3	-285.3	-308.3	-333.6	-359.2	-384.0	-406.6	-426.7	-442.3	-454.6	-461.8	-462.8	80
75	-483.8	-524.7	-569.6	-615.3	-659.3	-699.9	-735.7	-765.8	-789.3	-806.7	-817.0	-820.5	75
70	-766.3	-832.7	-882.9	-926.3	-968.8	-1008.0	-1043.8	-1076.3	-1105.4	-1132.8	-1158.3	-1181.4	70
65	-1096.6	-1180.7	-1237.9	-1293.3	-1353.8	-1406.9	-1453.7	-1495.6	-1531.6	-1562.8	-1589.2	-1611.6	65
60	-1456.8	-1520.9	-1586.1	-1653.1	-1703.6	-1753.1	-1799.8	-1842.8	-1882.0	-1918.3	-1951.9	-1982.4	60
55	-1839.7	-1886.0	-1942.2	-1998.4	-2046.3	-2085.2	-2119.3	-2149.8	-2177.5	-2194.0	-2209.8	-2225.1	55
50	-2199.6	-2241.8	-2282.8	-2321.4	-2358.3	-2393.7	-2427.4	-2459.8	-2490.9	-2519.8	-2547.3	-2573.8	50
45	-2554.7	-2578.5	-2599.3	-2617.3	-2632.8	-2646.1	-2658.2	-2669.2	-2679.2	-2688.3	-2696.5	-2703.8	45
40	-2886.9	-2890.0	-2888.0	-2882.2	-2873.6	-2862.1	-2849.7	-2835.7	-2820.2	-2803.3	-2785.0	-2765.4	40
35	-3188.8	-3171.1	-3153.1	-3133.6	-3112.8	-3090.7	-3067.2	-3042.5	-3016.6	-2989.5	-2961.2	-2931.7	35
30	-3453.1	-3416.3	-3373.2	-3326.6	-3277.4	-3225.6	-3172.0	-3116.7	-3060.0	-3001.9	-2942.5	-2881.8	30
25	-3671.3	-3619.8	-3568.7	-3517.9	-3466.4	-3414.2	-3361.3	-3307.8	-3253.8	-3199.3	-3144.3	-3088.8	25
20	-3837.8	-3776.6	-3715.4	-3655.3	-3595.2	-3535.1	-3475.0	-3414.9	-3354.8	-3294.7	-3234.6	-3174.5	20
15	-3946.2	-3882.2	-3818.6	-3756.0	-3693.4	-3630.8	-3568.2	-3505.6	-3443.0	-3380.4	-3317.8	-3255.2	15
10	-3997.4	-3916.8	-3835.3	-3754.3	-3673.8	-3593.7	-3514.1	-3435.0	-3356.4	-3278.3	-3199.7	-3120.6	10
5	-3991.4	-3940.3	-3881.2	-3822.5	-3764.2	-3706.3	-3648.8	-3591.7	-3535.0	-3478.7	-3422.8	-3367.2	5
0	-3929.3	-3891.8	-3847.4	-3799.1	-3750.8	-3702.6	-3654.6	-3606.7	-3559.0	-3511.5	-3464.2	-3417.1	0
LAT													LAT
L. LONG	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG

HORIZONTAL COMPONENT (H) WMM-90

L. LONG	180	185	190	195	200	205	210	215	220	225	230	235	240	L. LONG
LAT														LAT
90	-2126	-2126	-2126	-2126	-2126	-2126	-2126	-2126	-2126	-2126	-2126	-2126	-2126	90
85	-1591	-1558	-1501	-1441	-1391	-1341	-1276	-1205	-1126	-1043	-956	-865	-770	85
80	-4641	-4234	-3728	-3224	-2744	-2286	-1851	-1431	-1026	-626	-231	164	568	80
75	-1228	-823	-428	964	2422	4961	7561	10161	12761	15361	17961	20561	23161	75
70	3231	3231	3231	3231	3231	3231	3231	3231	3231	3231	3231	3231	3231	70
65	1532	1532	1532	1532	1532	1532	1532	1532	1532	1532	1532	1532	1532	65
60	1941	1941	1941	1941	1941	1941	1941	1941	1941	1941	1941	1941	1941	60
55	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	55
50	2422	2422	2422	2422	2422	2422	2422	2422	2422	2422	2422	2422	2422	50
45	2642	2642	2642	2642	2642	2642	2642	2642	2642	2642	2642	2642	2642	45
40	2862	2862	2862	2862	2862	2862	2862	2862	2862	2862	2862	2862	2862	40
35	3082	3082	3082	3082	3082	3082	3082	3082	3082	3082	3082	3082	3082	35
30	3302	3302	3302	3302	3302	3302	3302	3302	3302	3302	3302	3302	3302	30
25	3522	3522	3522	3522	3522	3522	3522	3522	3522	3522	3522	3522	3522	25
20	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	20
15	3962	3962	3962	3962	3962	3962	3962	3962	3962	3962	3962	3962	3962	15
10	4182	4182	4182	4182	4182	4182	4182	4182	4182	4182	4182	4182	4182	10
5	4402	4402	4402	4402	4402	4402	4402	4402	4402	4402	4402	4402	4402	5
0	4622	4622	4622	4622	4622	4622	4622	4622	4622	4622	4622	4622	4622	0
LAT														LAT
L. LONG	180	185	190	195	200	205	210	215	220	225	230	235	240	L. LONG

HORIZONTAL COMPONENT (H) WMM-90

L. LONG	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG
LAT													LAT
90	-11.26	-11.26	-11.26	-11.26	-11.26	-11.26	-11.26	-11.26	-11.26	-11.26	-11.26	-11.26	90
85	-13.23	-12.22	-10.94	-10.24	-9.59	-8.84	-8.04	-7.28	-6.50	-5.78	-5.06	-4.31	85
80	-13.20	-11.22	-9.50	-8.04	-7.04	-6.20	-5.26	-4.22	-3.19	-2.06	-0.90	0.00	80
75	-10.75	-8.64	-6.45	-4.11	-2.61	-1.86	-1.06	-0.20	0.69	1.54	2.34	3.08	75
70	-8.25	-4.25	-3.82	-2.83	-2.33	-1.83	-1.24	-0.58	0.10	0.74	1.32	1.83	70
65	-7.99	-7.03	-6.11	-5.21	-4.31	-3.40	-2.49	-1.58	-0.67	0.24	1.09	1.83	65
60	-11.01	-10.12	-9.26	-8.23	-7.53	-6.83	-6.03	-5.33	-4.53	-3.73	-2.93	-2.13	60
55	-14.38	-13.69	-12.99	-11.71	-10.81	-9.91	-8.91	-7.91	-6.91	-5.91	-4.91	-3.91	55
50	-17.84	-16.73	-15.94	-15.15	-14.44	-13.71	-13.01	-12.24	-11.60	-10.97	-10.25	-9.51	50
45	-20.52	-19.80	-19.14	-18.41	-17.73	-17.02	-16.46	-15.72	-15.00	-14.21	-13.64	-12.94	45
40	-29.00	-28.35	-27.90	-27.23	-26.74	-26.24	-25.80	-25.22	-24.63	-24.04	-23.53	-22.94	40
35	-28.23	-27.63	-27.23	-26.52	-25.98	-25.48	-24.90	-24.24	-23.67	-23.07	-22.51	-21.95	35
30	-26.67	-26.05	-25.72	-24.99	-24.56	-24.03	-23.52	-22.97	-22.41	-21.87	-21.33	-20.78	30
25	-28.71	-28.08	-27.60	-26.88	-26.45	-25.92	-25.41	-24.89	-24.32	-23.78	-23.24	-22.69	25
20	-29.20	-28.51	-28.38	-27.71	-27.28	-26.84	-26.39	-25.84	-25.28	-24.73	-24.18	-23.62	20
15	-30.18	-29.50	-29.37	-28.64	-28.21	-27.76	-27.31	-26.85	-26.29	-25.74	-25.19	-24.63	15
10	-31.01	-30.31	-30.05	-29.38	-28.95	-28.50	-28.04	-27.59	-27.03	-26.48	-25.93	-25.37	10
5	-31.71	-31.01	-30.72	-29.99	-29.56	-29.11	-28.66	-28.21	-27.65	-27.10	-26.54	-25.98	5
0	-32.83	-32.11	-31.54	-30.89	-30.43	-29.97	-29.52	-29.06	-28.50	-27.95	-27.39	-26.83	0
LAT													LAT
L. LONG	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG

HORIZONTAL COMPONENT (H) WMM-90

L. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG LAT
90	-2174	-2174	-2174	-2174	-2174	-2174	-2174	-2174	-2174	-2174	-2174	-2174	90
85	-3412	-3406	-3390	-3269	-3182	-3063	-2903	-2708	-2403	-1956	-1620	-1403	85
80	-4328	-4007	-3538	-3053	-2538	-2004	-1461	-919	-349	9538	1623	2441	80
75	-5322	-4095	-2700	-990	7379	7713	8003	8251	8460	8631	8769	8873	75
70	-7090	-7235	8313	8923	9264	9498	9664	10232	10448	10623	10754	10857	70
65	-8894	-9219	10358	10913	11385	11779	12101	12359	12591	12716	12828	12907	65
60	-11290	-12041	12203	13269	13742	14126	14432	14698	14849	14974	15059	15109	60
55	-13859	-14608	15253	15807	16261	16628	16913	17111	17288	17396	17461	17486	55
50	-16328	-17233	17861	18296	18632	18881	19058	19170	19219	19261	19293	19318	50
45	-19107	-19770	20278	20807	21251	21677	21993	22298	22580	22831	23059	23268	45
40	-21659	-22072	22648	23171	23632	24027	24348	24593	24761	24856	24879	24897	40
35	-24372	-24632	25008	25332	25622	25877	26088	26256	26382	26467	26502	26527	35
30	-27349	-27632	28103	28453	28789	29072	29303	29486	29622	29717	29764	29789	30
25	-30417	-30874	31392	31967	32452	32898	33293	33646	33954	34218	34448	34646	25
20	-33438	-33728	34228	34804	35387	35898	36353	36756	37108	37392	37618	37789	20
15	-37899	-38229	38670	39184	39734	30285	30814	31308	31767	32201	32618	32997	15
10	-42154	-42379	42828	43437	44054	44692	45219	45746	46263	46765	47252	47707	10
5	-47031	-47168	47633	48123	48643	49091	49525	49942	50341	50724	51091	51432	5
0	-50000	-47568	47614	47651	47629	47528	47332	47127	46912	46679	46428	46160	0
L. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG LAT

HORIZONTAL COMPONENT (H) WMM-90

L. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG
LAT	0	5	10	15	20	25	30	35	40	45	50	55	LAT
0	2232	2432	2632	2832	3032	3232	3432	3632	3832	4032	4232	4432	0
5	2432	2632	2832	3032	3232	3432	3632	3832	4032	4232	4432	4632	5
10	2632	2832	3032	3232	3432	3632	3832	4032	4232	4432	4632	4832	10
15	2832	3032	3232	3432	3632	3832	4032	4232	4432	4632	4832	5032	15
20	3032	3232	3432	3632	3832	4032	4232	4432	4632	4832	5032	5232	20
25	3232	3432	3632	3832	4032	4232	4432	4632	4832	5032	5232	5432	25
30	3432	3632	3832	4032	4232	4432	4632	4832	5032	5232	5432	5632	30
35	3632	3832	4032	4232	4432	4632	4832	5032	5232	5432	5632	5832	35
40	3832	4032	4232	4432	4632	4832	5032	5232	5432	5632	5832	6032	40
45	4032	4232	4432	4632	4832	5032	5232	5432	5632	5832	6032	6232	45
50	4232	4432	4632	4832	5032	5232	5432	5632	5832	6032	6232	6432	50
55	4432	4632	4832	5032	5232	5432	5632	5832	6032	6232	6432	6632	55
60	4632	4832	5032	5232	5432	5632	5832	6032	6232	6432	6632	6832	60
65	4832	5032	5232	5432	5632	5832	6032	6232	6432	6632	6832	7032	65
70	5032	5232	5432	5632	5832	6032	6232	6432	6632	6832	7032	7232	70
75	5232	5432	5632	5832	6032	6232	6432	6632	6832	7032	7232	7432	75
80	5432	5632	5832	6032	6232	6432	6632	6832	7032	7232	7432	7632	80
85	5632	5832	6032	6232	6432	6632	6832	7032	7232	7432	7632	7832	85
90	5832	6032	6232	6432	6632	6832	7032	7232	7432	7632	7832	8032	90

HORIZONTAL COMPONENT (H) WMM-90

LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG
0	34476 9	35374 8	36254 8	37083 3	37812 6	38477 9	38999 0	39387 3	39812 3	39753 3	39728 3	39568 9	0
-5	31718 11.6	32757 21.7	33755 28.2	34684 32.9	35523 38.0	36268 40.3	36886 41.8	37498 42.5	37794 35.2	38068 31.4	38212 26.2	38223 19.8	-5
-10	28559 46.2	29702 31.1	30756 16.6	31780 0	32678 40.8	33480 40.3	34190 38.0	34816 36.6	35355 35.1	35796 33.7	36214 32.2	36512 31.2	-10
-15	25384 36.1	26598 20.8	27694 6.9	28692 8	29582 37.4	30388 37.8	31128 37.2	31814 36.1	32455 34.5	33031 32.1	33514 29.8	33878 28.2	-15
-20	22802 8	23854 23.9	24823 38.2	25718 38	26533 37.3	27259 36.4	27898 35.2	28459 33.9	28941 32.6	29358 31.2	30503 29.0	31000 27.8	-20
-25	20497 8	21357 23.2	22133 38.2	22827 36.7	23365 35.8	23744 34.4	24037 32.8	24244 31.1	24360 29.6	24387 28.1	24213 26.5	23887 25.0	-25
-30	18150 8	18890 23.2	19468 38.2	19876 36.6	20199 35.9	20434 34.4	20583 32.8	20647 31.1	20623 29.6	20501 28.1	20287 26.5	19989 25.0	-30
-35	16554 8	17094 23.2	17468 38.2	17676 36.6	17799 35.9	17834 34.4	17783 32.8	17647 31.1	17423 29.6	17112 28.1	16719 26.5	16268 25.0	-35
-40	15001 8	15357 23.2	15568 38.2	15639 36.6	15568 35.9	15359 34.4	15008 32.8	14517 31.1	13886 29.6	13123 28.1	12239 26.5	11258 25.0	-40
-45	13466 8	13657 23.2	13708 38.2	13639 36.6	13429 35.9	13078 34.4	12587 32.8	11956 31.1	11193 29.6	10330 28.1	9367 26.5	8312 25.0	-45
-50	11932 8	11983 23.2	11908 38.2	11739 36.6	11478 35.9	11027 34.4	10386 32.8	9645 31.1	8804 29.6	7873 28.1	6842 26.5	5711 25.0	-50
-55	10400 8	10351 23.2	10182 38.2	9913 36.6	9542 35.9	9071 34.4	8500 32.8	7829 31.1	7068 29.6	6227 28.1	5306 26.5	4315 25.0	-55
-60	8868 8	8719 23.2	8450 38.2	8081 36.6	7610 35.9	7039 34.4	6368 32.8	5597 31.1	4736 29.6	3795 28.1	2774 26.5	1693 25.0	-60
-65	7336 8	7087 23.2	6718 38.2	6249 36.6	5678 35.9	5007 34.4	4236 32.8	3365 31.1	2404 29.6	1363 28.1	262 26.5	-167 25.0	-65
-70	5804 8	5455 23.2	4986 38.2	4417 36.6	3746 35.9	3075 34.4	2304 32.8	1433 31.1	572 29.6	-1389 28.1	-2408 26.5	-3427 25.0	-70
-75	4272 8	3823 23.2	3254 38.2	2585 36.6	1814 35.9	943 34.4	-828 32.8	-1699 31.1	-2568 29.6	-3437 28.1	-4306 26.5	-5175 25.0	-75
-80	2740 8	2191 23.2	1522 38.2	753 36.6	-1118 35.9	-2089 34.4	-3060 32.8	-4031 31.1	-5002 29.6	-5973 28.1	-6944 26.5	-7915 25.0	-80
-85	1208 8	559 23.2	-1120 38.2	-1889 36.6	-2658 35.9	-3427 34.4	-4196 32.8	-4965 31.1	-5734 29.6	-6503 28.1	-7272 26.5	-8041 25.0	-85
-90	-34 8	-1895 23.2	-3466 38.2	-5037 36.6	-6608 35.9	-8179 34.4	-9750 32.8	-11321 31.1	-12892 29.6	-14463 28.1	-16034 26.5	-17605 25.0	-90
LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG

HORIZONTAL COMPONENT (H) WMM-90

LAT	120	125	130	135	140	145	150	155	160	165	170	175	L - LONG
0	39293 16.2	18918 11.4	38474 7.6	17091 5.4	37409 5.2	17024 6.9	36582 10.0	16182 13.5	35624 15.9	35509 16.2	35193 11.1	34884 8.5	0
-5	38113 11.0	17903 6.9	37629 11.3	37120 12.1	37006 10.9	36709 9.5	36440 5.5	36203 11.1	35992 16.2	35810 16.1	35622 10.4	35402 15.3	-5
-10	36381 8.0	36347 9.9	36229 4.8	36104 8.2	35952 8.8	35820 8.4	35701 11.4	35605 4.9	35529 11.2	35460 15.7	35378 17.1	35253 14.3	-10
-15	34374 4.4	34353 5.9	34309 9.2	34322 11.8	34319 14.0	34317 12.7	34324 9.1	34344 11.9	34372 11.7	34411 16.2	34384 8.4	34389 7.3	-15
-20	31386 1.2	31665 6.9	31861 0.1	32003 3.7	32123 16.1	32233 19.5	32345 15.1	32466 3.1	32595 10.0	32722 8.6	32829 5.7	32888 1.7	-20
-25	28272 2.8	28670 0.8	28882 1.8	29334 2.2	29484 1.4	29884 6.9	29873 12.8	30085 10.6	30363 16.1	30823 2.8	30763 1.2	30889 8.8	-25
-30	24982 5.0	25422 2.5	25722 2.2	26172 1.9	26442 1.4	26742 3.5	27042 12.8	27332 10.3	27622 16.2	27984 5.4	28282 2.2	28554 2.4	-30
-35	21374 1.2	21864 1.6	22242 2.2	22722 4.5	23152 1.4	23582 12.1	23942 12.8	24342 6.8	24812 16.2	25332 6.3	25642 3.2	26025 2.6	-35
-40	17763 11.1	18213 2.8	18581 8.5	19101 0.7	19461 1.4	20201 12.1	20701 12.8	21211 9.6	21832 16.2	22374 9.1	22894 19.8	23395 19.8	-40
-45	14153 5.1	14474 1.4	14823 1.8	15451 1.1	16062 1.4	16701 12.8	17361 9.6	18071 12.1	18751 10.3	19432 19.1	20081 12.1	20699 2.6	-45
-50	10653 15.1	10711 1.8	11033 1.5	11571 0.1	12031 12.1	13031 12.8	13861 9.6	14731 12.1	15551 16.2	16392 9.8	17174 2.1	17918 1.6	-50
-55	7268 8.8	7172 1.2	7152 0.1	7332 6.3	7446 12.1	8081 12.8	8681 10.1	9231 11.1	9721 12.1	10324 13.1	10841 1.1	11619 1.6	-55
-60	5255 1.9	4643 1.4	3503 1.8	3314 1.1	4232 12.1	5231 12.8	6441 9.6	7672 11.1	8863 16.2	9997 2.2	11069 1.1	12081 1.6	-60
-65	4743 1.4	4504 1.4	2873 2.6	2091 1.6	1341 12.1	8261 12.8	3231 10.1	4384 11.1	5285 16.2	6174 2.1	8279 8.2	9349 9.3	-65
-70	8979 28.6	6862 37.5	5720 33.0	4728 36.1	4009 40.6	3602 38.8	3041 38.1	3351 31.1	5174 25.6	5990 19.6	6913 14.1	7840 10.4	-70
-75	19376 10.3	9592 32.3	8878 8.6	8243 34.6	7732 31.8	7380 38.8	7192 31.2	7181 34.5	7338 23.3	7642 11.1	8042 8.4	8382 8.8	-75
-80	13353 1.8	13120 1.1	11271 0.2	11374 11.1	11081 11.8	10851 12.8	10681 12.1	10607 16.2	10361 16.1	10461 19.6	10861 10.8	11011 1.1	-80
-85	14318 8.1	14249 3.7	14293 2.7	14260 1.1	13446 12.1	13831 12.8	13781 12.1	13743 11.1	13721 11.1	13731 12.1	13731 11.1	13831 1.1	-85
-90	14302 14.3	14302 14.3	14302 14.3	14302 14.3	14302 14.3	14302 14.3	14302 14.3	14302 14.3	14302 14.3	14302 14.3	14302 14.3	14302 14.3	-90
LAT	120	125	130	135	140	145	150	155	160	165	170	175	L - LONG

HORIZONTAL COMPONENT (H) WMM-90

LAT	180	185	190	195	200	205	210	215	220	225	230	235	L. LONG
0	56557 1.4	56204 -6.6	55844 -14.2	55477 -20.7	55123 -25.3	54793 -30.0	54489 -34.6	54218 -39.3	53978 -44.0	53758 -48.7	53578 -53.4	53413 -58.1	0
-5	55845 1.8	55482 -1.1	55119 -6.8	54756 -12.5	54393 -18.2	54030 -23.9	53667 -29.6	53304 -35.3	52941 -41.0	52578 -46.7	52215 -52.4	51852 -58.1	-5
-10	55042 2.8	54679 -1.5	54316 -7.2	53953 -12.9	53590 -18.6	53227 -24.3	52864 -30.0	52501 -35.7	52138 -41.4	51775 -47.1	51412 -52.8	51049 -58.5	-10
-15	54280 6.3	53917 -1.0	53554 -6.7	53191 -12.4	52828 -18.1	52465 -23.8	52102 -29.5	51739 -35.2	51376 -40.9	51013 -46.6	50650 -52.3	50287 -58.0	-15
-20	53527 3.0	53164 -1.4	52801 -7.1	52438 -12.8	52075 -18.5	51712 -24.2	51349 -29.9	50986 -35.6	50623 -41.3	50260 -47.0	49897 -52.7	49534 -58.4	-20
-25	52765 5.0	52402 -1.0	52039 -6.7	51676 -12.4	51313 -18.1	50950 -23.8	50587 -29.5	50224 -35.2	49861 -40.9	49498 -46.6	49135 -52.3	48772 -58.0	-25
-30	52002 8.0	51639 -1.0	51276 -6.7	50913 -12.4	50550 -18.1	50187 -23.8	49824 -29.5	49461 -35.2	49098 -40.9	48735 -46.6	48372 -52.3	48009 -58.0	-30
-35	51239 5.0	50876 -1.0	50513 -6.7	50150 -12.4	49787 -18.1	49424 -23.8	49061 -29.5	48698 -35.2	48335 -40.9	47972 -46.6	47609 -52.3	47246 -58.0	-35
-40	50476 8.0	50113 -1.0	49750 -6.7	49387 -12.4	49024 -18.1	48661 -23.8	48298 -29.5	47935 -35.2	47572 -40.9	47209 -46.6	46846 -52.3	46483 -58.0	-40
-45	49713 1.0	49350 -1.0	48987 -6.7	48624 -12.4	48261 -18.1	47898 -23.8	47535 -29.5	47172 -35.2	46809 -40.9	46446 -46.6	46083 -52.3	45720 -58.0	-45
-50	48950 8.0	48587 -1.0	48224 -6.7	47861 -12.4	47498 -18.1	47135 -23.8	46772 -29.5	46409 -35.2	46046 -40.9	45683 -46.6	45320 -52.3	44957 -58.0	-50
-55	48187 1.0	47824 -1.0	47461 -6.7	47098 -12.4	46735 -18.1	46372 -23.8	46009 -29.5	45646 -35.2	45283 -40.9	44920 -46.6	44557 -52.3	44194 -58.0	-55
-60	47424 8.0	47061 -1.0	46698 -6.7	46335 -12.4	45972 -18.1	45609 -23.8	45246 -29.5	44883 -35.2	44520 -40.9	44157 -46.6	43794 -52.3	43431 -58.0	-60
-65	46661 1.0	46298 -1.0	45935 -6.7	45572 -12.4	45209 -18.1	44846 -23.8	44483 -29.5	44120 -35.2	43757 -40.9	43394 -46.6	43031 -52.3	42668 -58.0	-65
-70	45898 8.0	45535 -1.0	45172 -6.7	44809 -12.4	44446 -18.1	44083 -23.8	43720 -29.5	43357 -35.2	42994 -40.9	42631 -46.6	42268 -52.3	41905 -58.0	-70
-75	45135 1.0	44772 -1.0	44409 -6.7	44046 -12.4	43683 -18.1	43320 -23.8	42957 -29.5	42594 -35.2	42231 -40.9	41868 -46.6	41505 -52.3	41142 -58.0	-75
-80	44372 8.0	44009 -1.0	43646 -6.7	43283 -12.4	42920 -18.1	42557 -23.8	42194 -29.5	41831 -35.2	41468 -40.9	41105 -46.6	40742 -52.3	40379 -58.0	-80
-85	43609 1.0	43246 -1.0	42883 -6.7	42520 -12.4	42157 -18.1	41794 -23.8	41431 -29.5	41068 -35.2	40705 -40.9	40342 -46.6	39979 -52.3	39616 -58.0	-85
-90	42846 8.0	42483 -1.0	42120 -6.7	41757 -12.4	41394 -18.1	41031 -23.8	40668 -29.5	40305 -35.2	39942 -40.9	39579 -46.6	39216 -52.3	38853 -58.0	-90
LAT	180	185	190	195	200	205	210	215	220	225	230	235	L. LONG

HORIZONTAL COMPONENT (H) WMM-90

L. LONG	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG
LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT
0	3137	3141	3145	3149	3153	3157	3161	3165	3169	3173	3177	3181	0
-5	3085	3089	3093	3097	3101	3105	3109	3113	3117	3121	3125	3129	-5
-10	3033	3037	3041	3045	3049	3053	3057	3061	3065	3069	3073	3077	-10
-15	2981	2985	2989	2993	2997	3001	3005	3009	3013	3017	3021	3025	-15
-20	2929	2933	2937	2941	2945	2949	2953	2957	2961	2965	2969	2973	-20
-25	2877	2881	2885	2889	2893	2897	2901	2905	2909	2913	2917	2921	-25
-30	2825	2829	2833	2837	2841	2845	2849	2853	2857	2861	2865	2869	-30
-35	2773	2777	2781	2785	2789	2793	2797	2801	2805	2809	2813	2817	-35
-40	2721	2725	2729	2733	2737	2741	2745	2749	2753	2757	2761	2765	-40
-45	2669	2673	2677	2681	2685	2689	2693	2697	2701	2705	2709	2713	-45
-50	2617	2621	2625	2629	2633	2637	2641	2645	2649	2653	2657	2661	-50
-55	2565	2569	2573	2577	2581	2585	2589	2593	2597	2601	2605	2609	-55
-60	2513	2517	2521	2525	2529	2533	2537	2541	2545	2549	2553	2557	-60
-65	2461	2465	2469	2473	2477	2481	2485	2489	2493	2497	2501	2505	-65
-70	2409	2413	2417	2421	2425	2429	2433	2437	2441	2445	2449	2453	-70
-75	2357	2361	2365	2369	2373	2377	2381	2385	2389	2393	2397	2401	-75
-80	2305	2309	2313	2317	2321	2325	2329	2333	2337	2341	2345	2349	-80
-85	2253	2257	2261	2265	2269	2273	2277	2281	2285	2289	2293	2297	-85
-90	2201	2205	2209	2213	2217	2221	2225	2229	2233	2237	2241	2245	-90
LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT	LAT
L. LONG	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG

HORIZONTAL COMPONENT (H) WMM-90

L. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG LAT
0	22574	22568	22562	22556	22550	22544	22538	22532	22526	22520	22514	22508	0
-5	22572	22566	22560	22554	22548	22542	22536	22530	22524	22518	22512	22506	-5
-10	22570	22564	22558	22552	22546	22540	22534	22528	22522	22516	22510	22504	-10
-15	22568	22562	22556	22550	22544	22538	22532	22526	22520	22514	22508	22502	-15
-20	22566	22560	22554	22548	22542	22536	22530	22524	22518	22512	22506	22500	-20
-25	22564	22558	22552	22546	22540	22534	22528	22522	22516	22510	22504	22498	-25
-30	22562	22556	22550	22544	22538	22532	22526	22520	22514	22508	22502	22496	-30
-35	22560	22554	22548	22542	22536	22530	22524	22518	22512	22506	22500	22494	-35
-40	22558	22552	22546	22540	22534	22528	22522	22516	22510	22504	22498	22492	-40
-45	22556	22550	22544	22538	22532	22526	22520	22514	22508	22502	22496	22490	-45
-50	22554	22548	22542	22536	22530	22524	22518	22512	22506	22500	22494	22488	-50
-55	22552	22546	22540	22534	22528	22522	22516	22510	22504	22498	22492	22486	-55
-60	22550	22544	22538	22532	22526	22520	22514	22508	22502	22496	22490	22484	-60
-65	22548	22542	22536	22530	22524	22518	22512	22506	22500	22494	22488	22482	-65
-70	22546	22540	22534	22528	22522	22516	22510	22504	22498	22492	22486	22480	-70
-75	22544	22538	22532	22526	22520	22514	22508	22502	22496	22490	22484	22478	-75
-80	22542	22536	22530	22524	22518	22512	22506	22500	22494	22488	22482	22476	-80
-85	22540	22534	22528	22522	22516	22510	22504	22498	22492	22486	22480	22474	-85
-90	22538	22532	22526	22520	22514	22508	22502	22496	22490	22484	22478	22472	-90
L. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG LAT

TOTAL INTENSITY (F) WMM-90

L. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG	LAT
LAT														
90	56443 -21.9	56443 -21.9	56443 -21.9	56443 -21.9	56443 -21.9	56443 -21.9	56443 -21.9	56443 -21.9	56443 -21.9	56443 -21.9	56443 -21.9	56443 -21.9	56443 -21.9	90
85	55488 -13.9	55513 -13.9	55513 -14.1	55600 -16.3	55663 -16.3	55726 -16.3	55832 -16.3	55901 -15.8	55997 -16.3	56099 -16.8	56206 -17.4	56315 -18.1	56443 -18.1	85
80	54428 -6.4	54603 -6.6	54731 -6.5	54829 -6.2	54958 -5.2	54915 -5.8	55009 -6.5	55308 -7.9	55537 -8.3	55781 -9.4	56043 -10.6	56311 -11.9	56443 -11.9	80
75	53363 4.3	53393 4.6	53476 4.7	53612 4.4	53799 4.0	54035 3.2	54318 2.3	54645 1.2	55011 0	55410 -1.4	55836 -2.9	56282 -4.4	56443 -4.4	75
70	52135 11.0	52154 11.3	52163 11.6	52193 11.8	52228 12.0	52262 12.2	52296 12.4	52329 12.6	52362 12.8	52395 13.0	52428 13.2	52461 13.4	52494 13.6	70
65	51323 13.2	51337 13.3	51351 13.4	51365 13.5	51379 13.6	51393 13.7	51407 13.8	51421 13.9	51435 14.0	51449 14.1	51463 14.2	51477 14.3	51491 14.4	65
60	50261 17.9	50287 18.1	50308 18.2	50329 18.3	50350 18.4	50371 18.5	50392 18.6	50413 18.7	50434 18.8	50455 18.9	50476 19.0	50497 19.1	50518 19.2	60
55	49067 19.2	49127 19.3	49273 19.4	49498 19.5	49793 19.6	50162 19.7	50609 19.8	51114 19.9	51706 20.0	52380 20.1	53114 20.2	53962 20.3	54949 20.4	55
50	47673 19.8	47789 19.9	47990 20.0	48262 20.1	48595 20.2	48986 20.3	49434 20.4	49945 20.5	50526 20.6	51183 20.7	51915 20.8	52722 20.9	53622 21.0	50
45	46047 19.9	46233 20.0	46501 20.1	46832 20.2	47212 20.3	47632 20.4	48092 20.5	48602 20.6	49162 20.7	49772 20.8	50432 20.9	51142 21.0	51902 21.1	45
40	44190 19.2	44459 19.3	44787 19.4	45179 19.5	45627 19.6	46127 19.7	46682 19.8	47292 19.9	47957 20.0	48677 20.1	49452 20.2	50282 20.3	51167 20.4	40
35	43136 17.8	43461 17.9	43863 18.0	44304 18.1	44766 18.2	45240 18.3	45729 18.4	46243 18.5	46786 18.6	47359 18.7	47962 18.8	48602 18.9	49277 19.0	35
30	39952 15.1	40335 15.2	40778 15.3	41250 15.4	41728 15.5	42207 15.6	42686 15.7	43165 15.8	43644 15.9	44123 16.0	44602 16.1	45081 16.2	45560 16.3	30
25	37251 12.4	37726 12.5	38201 12.6	38676 12.7	39151 12.8	39626 12.9	40101 13.0	40576 13.1	41051 13.2	41526 13.3	42001 13.4	42476 13.5	42951 13.6	25
20	35687 9.9	36136 10.0	36611 10.1	37086 10.2	37561 10.3	38036 10.4	38511 10.5	38986 10.6	39461 10.7	39936 10.8	40411 10.9	40886 11.0	41361 11.1	20
15	33939 8.2	34412 8.3	34895 8.4	35358 8.5	35881 8.6	36404 8.7	36927 8.8	37450 8.9	37973 9.0	38496 9.1	39019 9.2	39542 9.3	40065 9.4	15
10	32935 7.0	33444 7.1	33963 7.2	34482 7.3	35001 7.4	35520 7.5	36039 7.6	36558 7.7	37077 7.8	37596 7.9	38115 8.0	38634 8.1	39153 8.2	10
5	31787 5.0	32352 5.1	32885 5.2	33355 5.3	33825 5.4	34295 5.5	34765 5.6	35235 5.7	35705 5.8	36175 5.9	36645 6.0	37115 6.1	37585 6.2	5
0	31266 3.0	31909 3.1	32491 3.2	32981 3.3	33471 3.4	33961 3.5	34451 3.6	34941 3.7	35431 3.8	35921 3.9	36411 4.0	36901 4.1	37391 4.2	0
LAT														
L. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG	LAT

(units: nT)

LAT	60	65	70	75	80	85	90	95	100	105	110	115	L- LONG
90	56443	56443	56443	56443	56443	56443	56443	56443	56443	56443	56443	56443	LAT
85	56426	56536	56644	56748	56848	56941	57026	57103	57170	57227	57273	57311	85
80	56583	56854	57116	57377	57607	57823	58017	58172	58302	58399	58463	58494	80
75	56718	57196	57643	58070	58467	58824	59132	59383	59572	59696	59748	59785	75
70	56725	57363	57994	58599	59163	59667	60097	60458	60728	60913	60939	60950	70
65	56731	57319	58006	58767	59479	60117	60657	61076	61361	61493	61473	61396	65
60	56806	56896	57590	58363	59287	60023	60669	61128	61438	61561	61583	61519	60
55	56851	55781	56727	57659	58540	59334	60004	60517	60839	60930	60798	60430	55
50	56991	56307	55463	56375	57269	58062	58739	59263	59543	59612	59429	58978	50
45	57054	52909	53708	54665	55593	56263	56902	57377	57648	57680	57498	56940	45
40	57058	51919	51803	52590	53344	54029	54602	55023	55359	55369	54981	54438	40
35	49215	48875	49551	50226	50877	51467	51959	52313	52591	52455	52172	51622	35
30	45971	46538	47112	47686	48232	48728	49136	49427	49554	49493	49209	48676	30
25	43617	44321	44624	45119	45599	46011	46350	46583	46774	46999	47326	47829	25
20	41313	41798	42378	42847	43306	43740	44073	44369	44617	44804	44977	45148	20
15	39264	39787	40308	40814	41281	41683	41992	42186	42298	42362	42371	42316	15
10	37683	38303	38974	39547	40110	40591	40956	41162	41256	41179	40949	40589	10
5	36704	37482	38267	39074	39799	40418	40889	41184	41293	41228	41011	40671	5
0	36324	37316	38352	39369	40309	41118	41738	42143	42316	42283	42086	41773	0
LAT	60	65	70	75	80	85	90	95	100	105	110	115	L- LONG

TOTAL INTENSITY (F) WMM-90

E. LONG LAT	120	125	130	135	140	145	150	155	160	165	170	175	E. LONG LAT
00	5944.6	5944.6	5944.6	5944.6	5944.6	5944.6	5944.6	5944.6	5944.6	5944.6	5944.6	5944.6	90
05	5733.8	5735.3	5736.8	5736.8	5735.3	5736.3	5737.2	5739.8	5737.1	5724.2	5721.8	5718.0	85
10	5849.4	5846.4	5840.9	5833.3	5826.5	5813.4	5802.3	5780.5	5780.9	5789.8	5789.6	5781.8	80
15	5965.8	5952.4	5934.1	5911.9	5888.9	5860.6	5823.8	5805.0	5782.7	5761.2	5743.4	5729.6	75
20	6056.9	6032.8	5991.7	5949.4	5903.5	5855.6	5802.9	5763.2	5722.4	5688.3	5661.2	5642.4	70
25	6082.1	6051.4	5994.8	5929.9	5860.9	5788.3	5712.3	5653.0	5582.3	5542.3	5511.4	5488.2	65
30	6074.5	6011.0	5933.8	5845.2	5751.9	5652.7	5546.9	5429.7	5405.8	5345.4	5301.6	5274.4	60
35	5981.5	5903.9	5807.9	5698.5	5583.4	5462.6	5336.3	5205.8	5167.3	5096.9	5056.0	5016.0	55
40	5827.5	5734.3	5622.8	5497.2	5365.4	5233.5	5107.9	4990.0	4896.9	4819.4	4764.9	4711.9	50
45	5616.0	5513.4	5390.9	5254.6	5112.9	4969.6	4835.3	4712.5	4612.3	4531.6	4474.3	4422.8	45
50	5361.8	5254.6	5126.9	4985.4	4837.3	4691.8	4554.9	4432.8	4330.2	4250.5	4194.6	4144.3	40
55	5080.8	4972.9	4845.2	4705.2	4559.2	4415.2	4281.9	4163.5	4065.1	3989.6	3938.6	3892.2	35
60	4788.8	4686.3	4564.8	4431.0	4282.8	4137.3	4001.7	3879.4	3820.7	3762.5	3718.1	3677.2	30
65	4510.9	4415.9	4304.6	4182.3	4056.3	3933.4	3819.8	3720.6	3639.7	3579.9	3547.5	3526.9	25
70	4289.2	4186.6	4068.8	3940.4	3809.6	3681.8	3562.9	3572.8	3503.8	3451.4	3414.2	3386.6	20
75	4094.2	4022.7	3938.7	3846.8	3732.6	3609.2	3490.2	3490.8	3433.6	3386.7	3355.3	3332.9	15
80	4002.3	3947.0	3876.4	3799.3	3719.3	3631.8	3564.5	3496.0	3437.1	3389.9	3352.9	3329.0	10
85	4023.8	3970.8	3911.9	3846.8	3778.5	3709.6	3641.2	3572.9	3518.5	3467.1	3424.9	3389.8	5
90	4134.1	4082.4	4042.3	3986.7	3927.0	3864.4	3800.7	3737.6	3674.1	3617.3	3562.4	3511.9	0
LAT													LAT
E. LONG	120	125	130	135	140	145	150	155	160	165	170	175	E. LONG

WMM-90

[illegible]

TOTAL INTENSITY (F) WMM-90

LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG
90	58443	58443	58443	58443	58443	58443	58443	58443	58443	58443	58443	58443	90
85	58263	58229	58218	58214	58257	58294	58427	58356	58283	58204	58126	58047	85
80	57420	57396	57355	57294	57216	57114	56993	56857	56696	56524	56318	56144	80
75	56297	56352	56369	56344	56274	56152	57995	57789	57543	57260	56946	56608	75
70	55163	55343	55458	55502	55569	55552	55167	54901	54564	54164	53709	53213	70
65	53728	54057	54307	54462	54673	54990	55190	54878	54459	53943	53350	52693	65
60	52693	53207	53693	54052	54380	54651	54868	54933	54952	54948	54912	54808	60
55	51905	52584	53178	53636	54072	54428	54689	54859	54844	54759	54632	54495	55
50	51329	52153	52858	53499	54161	54812	55353	55876	56224	56471	56623	56639	50
45	50550	51401	52299	53074	53787	54453	55073	55635	56143	56602	57011	57370	45
40	49796	50715	51623	52498	53333	54025	54568	55048	55426	55713	55923	56053	40
35	49176	50117	51056	51974	52719	53346	53817	54205	54518	54735	54871	54929	35
30	48687	49653	50602	51504	52341	53018	53529	53975	54355	54669	54926	55124	30
25	48332	49325	50369	51324	52199	52908	53424	53880	54289	54643	54943	55190	25
20	48053	49063	50129	51145	52093	52883	53533	54060	54476	54786	55093	55317	20
15	47891	48926	50004	51079	52045	52896	53589	54183	54696	55124	55478	55756	15
10	47823	48879	50001	51067	52023	52880	53523	54098	54627	55089	55483	55810	10
5	47897	48972	50113	51177	52129	52999	53628	54188	54699	55163	55593	55908	5
0	47992	49189	50353	51479	52530	53511	54381	55092	55658	56172	56646	57088	0
LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG

TOTAL INTENSITY (F) WMM-90

L. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG LAT
90	56443 -211.9	56443 -211.9	56443 -211.9	56443 -211.9	56443 -211.9	56443 -211.9	56443 -211.9	56443 -211.9	56443 -211.9	56443 -211.9	56443 -211.9	56443 -211.9	90
85	55868 -175.3	55868 -175.3	55868 -175.3	55868 -175.3	55868 -175.3	55868 -175.3	55868 -175.3	55868 -175.3	55868 -175.3	55868 -175.3	55868 -175.3	55868 -175.3	85
80	55243 -140.2	55243 -140.2	55243 -140.2	55243 -140.2	55243 -140.2	55243 -140.2	55243 -140.2	55243 -140.2	55243 -140.2	55243 -140.2	55243 -140.2	55243 -140.2	80
75	54618 -105.1	54618 -105.1	54618 -105.1	54618 -105.1	54618 -105.1	54618 -105.1	54618 -105.1	54618 -105.1	54618 -105.1	54618 -105.1	54618 -105.1	54618 -105.1	75
70	53993 -70.0	53993 -70.0	53993 -70.0	53993 -70.0	53993 -70.0	53993 -70.0	53993 -70.0	53993 -70.0	53993 -70.0	53993 -70.0	53993 -70.0	53993 -70.0	70
65	53368 -34.9	53368 -34.9	53368 -34.9	53368 -34.9	53368 -34.9	53368 -34.9	53368 -34.9	53368 -34.9	53368 -34.9	53368 -34.9	53368 -34.9	53368 -34.9	65
60	52743 0.0	52743 0.0	52743 0.0	52743 0.0	52743 0.0	52743 0.0	52743 0.0	52743 0.0	52743 0.0	52743 0.0	52743 0.0	52743 0.0	60
55	52118 34.8	52118 34.8	52118 34.8	52118 34.8	52118 34.8	52118 34.8	52118 34.8	52118 34.8	52118 34.8	52118 34.8	52118 34.8	52118 34.8	55
50	51493 69.7	51493 69.7	51493 69.7	51493 69.7	51493 69.7	51493 69.7	51493 69.7	51493 69.7	51493 69.7	51493 69.7	51493 69.7	51493 69.7	50
45	50868 104.6	50868 104.6	50868 104.6	50868 104.6	50868 104.6	50868 104.6	50868 104.6	50868 104.6	50868 104.6	50868 104.6	50868 104.6	50868 104.6	45
40	50243 139.5	50243 139.5	50243 139.5	50243 139.5	50243 139.5	50243 139.5	50243 139.5	50243 139.5	50243 139.5	50243 139.5	50243 139.5	50243 139.5	40
35	49618 174.4	49618 174.4	49618 174.4	49618 174.4	49618 174.4	49618 174.4	49618 174.4	49618 174.4	49618 174.4	49618 174.4	49618 174.4	49618 174.4	35
30	48993 209.3	48993 209.3	48993 209.3	48993 209.3	48993 209.3	48993 209.3	48993 209.3	48993 209.3	48993 209.3	48993 209.3	48993 209.3	48993 209.3	30
25	48368 244.2	48368 244.2	48368 244.2	48368 244.2	48368 244.2	48368 244.2	48368 244.2	48368 244.2	48368 244.2	48368 244.2	48368 244.2	48368 244.2	25
20	47743 279.1	47743 279.1	47743 279.1	47743 279.1	47743 279.1	47743 279.1	47743 279.1	47743 279.1	47743 279.1	47743 279.1	47743 279.1	47743 279.1	20
15	47118 314.0	47118 314.0	47118 314.0	47118 314.0	47118 314.0	47118 314.0	47118 314.0	47118 314.0	47118 314.0	47118 314.0	47118 314.0	47118 314.0	15
10	46493 348.9	46493 348.9	46493 348.9	46493 348.9	46493 348.9	46493 348.9	46493 348.9	46493 348.9	46493 348.9	46493 348.9	46493 348.9	46493 348.9	10
5	45868 383.8	45868 383.8	45868 383.8	45868 383.8	45868 383.8	45868 383.8	45868 383.8	45868 383.8	45868 383.8	45868 383.8	45868 383.8	45868 383.8	5
0	45243 418.7	45243 418.7	45243 418.7	45243 418.7	45243 418.7	45243 418.7	45243 418.7	45243 418.7	45243 418.7	45243 418.7	45243 418.7	45243 418.7	0
L. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG LAT

TOTAL INTENSITY (F) WMM-90

L. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG
LAT	0	5	10	15	20	25	30	35	40	45	50	55	LAT
0	31800	31000	29400	28000	26800	25800	25000	24300	23700	23200	22700	22300	0
-5	30800	30000	28400	27000	25800	24800	24000	23300	22700	22200	21700	21300	-5
-10	30000	29200	27600	26200	25000	24000	23200	22500	21900	21400	20900	20500	-10
-15	29000	28200	26600	25200	24000	23000	22200	21500	20900	20400	19900	19500	-15
-20	28000	27200	25600	24200	23000	22000	21200	20500	19900	19400	18900	18500	-20
-25	27000	26200	24600	23200	22000	21000	20200	19500	18900	18400	17900	17500	-25
-30	26000	25200	23600	22200	21000	20000	19200	18500	17900	17400	16900	16500	-30
-35	25000	24200	22600	21200	20000	19000	18200	17500	16900	16400	15900	15500	-35
-40	24000	23200	21600	20200	19000	18000	17200	16500	15900	15400	14900	14500	-40
-45	23000	22200	20600	19200	18000	17000	16200	15500	14900	14400	13900	13500	-45
-50	22000	21200	19600	18200	17000	16000	15200	14500	13900	13400	12900	12500	-50
-55	21000	20200	18600	17200	16000	15000	14200	13500	12900	12400	11900	11500	-55
-60	20000	19200	17600	16200	15000	14000	13200	12500	11900	11400	10900	10500	-60
-65	19000	18200	16600	15200	14000	13000	12200	11500	10900	10400	9900	9500	-65
-70	18000	17200	15600	14200	13000	12000	11200	10500	9900	9400	8900	8500	-70
-75	17000	16200	14600	13200	12000	11000	10200	9500	8900	8400	7900	7500	-75
-80	16000	15200	13600	12200	11000	10000	9200	8500	7900	7400	6900	6500	-80
-85	15000	14200	12600	11200	10000	9000	8200	7500	6900	6400	5900	5500	-85
-90	14000	13200	11600	10200	9000	8000	7200	6500	5900	5400	4900	4500	-90
LAT	L. LONG	0	5	10	15	20	25	30	35	40	45	50	LAT

TOTAL INTENSITY (F) WMM-90

E. LONG LAT	60	65	70	75	80	85	90	95	100	105	110	115	E. LONG LAT
0	3632.4	3731.6	3835.2	3936.9	4030.2	4115.8	4173.8	4214.3	4231.6	4228.3	4208.6	4177.3	0
-5	3640.8	3766.2	3897.7	4025.6	4149.9	4248.3	4329.6	4384.9	4402.9	4405.8	4400.3	4372.9	-5
-10	3675.8	3831.0	3991.6	4169.1	4295.8	4424.3	4526.3	4601.8	4644.2	4658.4	4650.9	4629.4	-10
-15	3730.8	3907.8	4098.1	4306.7	4459.1	4614.0	4741.9	4837.3	4898.4	4927.9	4932.4	4920.9	-15
-20	3768.3	3984.7	4203.9	4417.4	4618.0	4798.1	4950.5	5069.1	5151.6	5200.9	5220.3	5220.3	-20
-25	3828.8	4041.6	4266.1	4474.5	4674.0	4866.4	5031.3	5227.1	5347.3	5457.1	5495.9	5510.8	-25
-30	3870.3	4081.9	4309.4	4511.0	4705.4	4895.8	5072.9	5271.0	5392.8	5508.3	5746.2	5778.9	-30
-35	3935.5	4238.3	4469.3	4673.0	4863.8	5042.3	5212.3	5372.8	5527.8	5688.5	5966.4	6016.6	-35
-40	4031.8	4268.0	4499.4	4706.8	4896.3	5072.9	5239.6	5397.9	5547.1	6055.3	6151.9	6237.3	-40
-45	4167.4	4435.3	4703.3	4966.3	5220.1	5459.4	5679.8	5876.6	6046.3	6186.3	6296.3	6377.1	-45
-50	4301.7	4555.4	4810.8	5063.3	5308.5	5542.1	5759.5	5956.3	6130.3	6277.5	6397.3	6489.2	-50
-55	4450.5	4683.9	4920.2	5155.4	5385.3	5606.3	5814.4	6004.9	6175.7	6323.9	6447.8	6546.6	-55
-60	4612.1	4819.2	5030.8	5241.3	5449.0	5650.6	5841.4	6018.7	6179.6	6322.8	6444.3	6545.7	-60
-65	4785.3	4961.6	5141.6	5322.6	5501.7	5676.1	5842.8	5999.6	6143.8	6273.8	6387.9	6484.4	-65
-70	4967.8	5109.3	5286.3	5460.1	5635.3	5807.3	5974.6	6134.3	6286.3	6419.8	6528.4	6637.8	-70
-75	5155.9	5260.6	5367.7	5476.0	5583.9	5690.2	5793.6	5892.7	5986.3	6073.6	6153.4	6225.3	-75
-80	5341.6	5409.1	5478.8	5549.0	5619.2	5688.7	5756.7	5822.6	5885.4	5945.3	6000.8	6052.0	-80
-85	5511.8	5544.3	5577.9	5611.6	5645.0	5679.1	5712.3	5744.9	5775.9	5805.9	5834.3	5860.9	-85
-90	5669.7	5689.7	5699.7	5699.7	5699.7	5699.7	5699.7	5699.7	5699.7	5699.7	5699.7	5699.7	-90
LAT													LAT
E. LONG	60	65	70	75	80	85	90	95	100	105	110	115	E. LONG

TOTAL INTENSITY (F) WMM-90

E. LONG LAT	120	125	130	135	140	145	150	155	160	165	170	175	E. LONG LAT
0	41381 12.6	40929 12.2	40423 12.1	39867 11.1	39270 11.1	38644 11.5	38007 11.9	37376 12.0	36761 11.4	36173 10.0	35624 7.5	35119 0	0
-5	41381 12.1	42985 9.8	42546 8.1	42058 7.4	41529 7.0	40937 8.9	40319 10.5	39675 12.5	39011 12.8	38334 12.3	37655 10.1	36986 6.2	-5
-10	45909 10.0	45656 6.2	45271 3.4	44834 2.0	44338 2.3	43780 4.1	43163 6.8	42497 9.8	41777 12.0	41012 12.6	40211 11.1	39391 7.4	-10
-15	48978 7.0	48690 1.9	48354 2.0	47958 4.2	47492 4.3	46950 2.4	46329 1.1	45631 5.1	44858 8.5	44016 10.2	43114 9.8	42172 6.2	-15
-20	52071 3.5	51853 2.2	51567 6.9	51207 9.9	50764 10.7	50228 9.2	49596 5.8	48868 4.8	48059 4.0	47246 2.6	46170 2.5	45119 1.6	-20
-25	55092 3.3	54955 5.1	54723 9.9	54397 13.5	53971 16.7	53436 14.3	52791 11.7	52038 8.1	51183 5.9	50337 3.8	49312 3.8	48127 2.4	-25
-30	57908 2.8	57868 4.8	57690 7.8	57298 12.6	56886 16.8	56458 19.8	55993 16.3	55303 12.9	54543 9.3	53728 5.7	52824 2.4	51818 0.8	-30
-35	60420 2.0	60483 4.2	60378 7.8	60126 12.6	59742 16.8	59198 19.8	58536 16.3	57758 12.9	56867 9.3	55891 5.7	54844 2.4	53743 0.8	-35
-40	62178 2.8	62150 4.8	62126 7.8	62123 12.6	62053 16.8	61839 19.8	61481 16.3	60909 12.9	59932 9.3	58873 5.7	57748 2.4	56529 0.8	-40
-45	64308 2.0	64597 4.8	64663 7.8	64528 12.6	64211 16.8	63732 19.8	63110 16.3	62367 12.9	61525 9.3	60607 5.7	59632 2.4	58629 0.8	-45
-50	65344 2.0	65944 4.8	66109 7.8	66061 12.6	65828 16.8	65416 19.8	64861 16.3	64186 12.9	63416 9.3	62572 5.7	61678 2.4	60750 0.8	-50
-55	66205 2.2	66702 4.1	66971 7.1	67030 12.0	66898 16.0	66599 18.6	66156 14.5	65593 11.0	64936 7.6	64206 3.5	63425 3.4	62610 1.7	-55
-60	68126 2.6	68809 4.4	69176 7.2	69359 12.0	69467 16.0	69188 18.8	68888 14.7	68473 11.3	67968 7.8	67389 3.0	66754 3.4	66078 0.8	-60
-65	69819 2.9	69756 4.6	69896 7.6	69975 12.1	70101 16.1	70047 18.5	69951 14.1	69707 11.1	69372 7.2	68964 3.3	68496 3.6	67928 0.8	-65
-70	71378 2.9	71388 4.8	71369 7.9	71316 12.0	71448 16.1	71358 18.8	71268 14.6	71182 11.2	71013 7.3	70771 3.1	70469 3.7	70103 0.0	-70
-75	72884 2.2	72825 4.6	72880 7.6	72843 12.1	72918 16.1	72907 18.8	72818 14.6	72723 11.3	72552 7.3	72309 3.0	72038 3.8	71715 0.3	-75
-80	74392 2.4	74393 4.6	74351 7.6	74321 12.1	74305 16.1	74298 18.8	74245 14.5	74221 11.3	74154 7.3	74036 3.0	73878 3.8	73656 0.6	-80
-85	75884 2.9	75928 4.9	75928 7.8	75956 12.6	75904 16.0	75927 18.7	75824 14.4	75893 11.3	75838 7.8	75742 3.8	75638 3.8	75497 0.7	-85
-90	76497 2.0	76497 4.0	76497 7.0	76497 12.0	76497 16.0	76497 18.0	76497 14.0	76497 11.0	76497 7.0	76497 3.0	76497 3.0	76497 0.0	-90
E. LONG LAT	120	125	130	135	140	145	150	155	160	165	170	175	E. LONG LAT

TOTAL INTENSITY (F) WMM-90

L. LONG LAT	180	185	190	195	200	205	210	215	220	225	230	235	L. LONG LAT
0	5455.8 -12.8	5433.7 -12.3	5384.9 -12.6	5348.9 -12.9	5283.9 -13.2	5225.9 -13.5	5165.9 -13.8	5105.9 -14.1	5045.9 -14.4	4985.9 -14.7	4925.9 -15.0	4865.9 -15.3	0
-5	5633.8 -6.1	5571.9 -6.4	5510.0 -6.7	5448.1 -7.0	5386.2 -7.3	5324.3 -7.6	5262.4 -7.9	5200.5 -8.2	5138.6 -8.5	5076.7 -8.8	5014.8 -9.1	4952.9 -9.4	-5
-10	5852.2 -1.6	5777.1 -2.8	5702.0 -3.9	5626.9 -5.0	5551.8 -6.1	5476.7 -7.2	5401.6 -8.3	5326.5 -9.4	5251.4 -10.5	5176.3 -11.6	5101.2 -12.7	5026.1 -13.8	-10
-15	6121.3 -7.3	6026.0 -8.5	5930.7 -9.6	5835.4 -10.7	5740.1 -11.8	5644.8 -12.9	5549.5 -14.0	5454.2 -15.1	5358.9 -16.2	5263.6 -17.3	5168.3 -18.4	5073.0 -19.5	-15
-20	6407.9 -12.9	6301.4 -14.1	6194.9 -15.2	6088.4 -16.3	5981.9 -17.4	5875.4 -18.5	5768.9 -19.6	5662.4 -20.7	5555.9 -21.8	5449.4 -22.9	5342.9 -24.0	5236.4 -25.1	-20
-25	6700.6 -19.2	6587.3 -20.4	6474.0 -21.5	6360.7 -22.6	6247.4 -23.7	6134.1 -24.8	6020.8 -25.9	5907.5 -27.0	5794.2 -28.1	5680.9 -29.2	5567.6 -30.3	5454.3 -31.4	-25
-30	7087.3 -26.3	6970.9 -27.5	6854.6 -28.6	6738.3 -29.7	6622.0 -30.8	6505.7 -31.9	6389.4 -33.0	6273.1 -34.1	6156.8 -35.2	6040.5 -36.3	5924.2 -37.4	5807.9 -38.5	-30
-35	7560.7 -32.6	7435.4 -33.8	7310.1 -34.9	7184.8 -36.0	7059.5 -37.1	6934.2 -38.2	6808.9 -39.3	6683.6 -40.4	6558.3 -41.5	6433.0 -42.6	6307.7 -43.7	6182.4 -44.8	-35
-40	8136.9 -38.9	7998.6 -40.1	7860.3 -41.2	7722.0 -42.3	7583.7 -43.4	7445.4 -44.5	7307.1 -45.6	7168.8 -46.7	7030.5 -47.8	6892.2 -48.9	6753.9 -50.0	6615.6 -51.1	-40
-45	8812.9 -45.2	8658.6 -46.4	8504.3 -47.5	8350.0 -48.6	8195.7 -49.7	8041.4 -50.8	7887.1 -51.9	7732.8 -53.0	7578.5 -54.1	7424.2 -55.2	7269.9 -56.3	7115.6 -57.4	-45
-50	9680.6 -52.8	9498.3 -54.0	9316.0 -55.1	9133.7 -56.2	8951.4 -57.3	8769.1 -58.4	8586.8 -59.5	8404.5 -60.6	8222.2 -61.7	8039.9 -62.8	7857.6 -63.9	7675.3 -65.0	-50
-55	10772.3 -60.2	10551.0 -61.4	10330.7 -62.5	10110.4 -63.6	9890.1 -64.7	9669.8 -65.8	9449.5 -66.9	9229.2 -68.0	9008.9 -69.1	8788.6 -70.2	8568.3 -71.3	8348.0 -72.4	-55
-60	12074.3 -68.4	11818.0 -69.6	11561.7 -70.7	11305.4 -71.8	11049.1 -72.9	10792.8 -74.0	10536.5 -75.1	10280.2 -76.2	10023.9 -77.3	9767.6 -78.4	9511.3 -79.5	9255.0 -80.6	-60
-65	13641.3 -77.7	13338.0 -78.9	13034.7 -80.0	12731.4 -81.1	12428.1 -82.2	12124.8 -83.3	11821.5 -84.4	11518.2 -85.5	11214.9 -86.6	10911.6 -87.7	10608.3 -88.8	10305.0 -89.9	-65
-70	15468.8 -87.0	15112.5 -88.2	14756.2 -89.3	14400.9 -90.4	14045.6 -91.5	13690.3 -92.6	13335.0 -93.7	12979.7 -94.8	12624.4 -95.9	12269.1 -97.0	11913.8 -98.1	11558.5 -99.2	-70
-75	17619.8 -96.3	17201.5 -97.5	16783.2 -98.6	16364.9 -99.7	15946.6 -100.8	15528.3 -101.9	15110.0 -103.0	14691.7 -104.1	14273.4 -105.2	13855.1 -106.3	13436.8 -107.4	13018.5 -108.5	-75
-80	20040.0 -105.9	19562.7 -107.1	19085.4 -108.2	18608.1 -109.3	18130.8 -110.4	17653.5 -111.5	17176.2 -112.6	16698.9 -113.7	16221.6 -114.8	15744.3 -115.9	15267.0 -117.0	14789.7 -118.1	-80
-85	22831.1 -116.6	22293.8 -117.8	21756.5 -118.9	21219.2 -120.0	20681.9 -121.1	20144.6 -122.2	19607.3 -123.3	19070.0 -124.4	18532.7 -125.5	17995.4 -126.6	17458.1 -127.7	16920.8 -128.8	-85
-90	26807.3 -128.7	26197.0 -129.9	25586.7 -131.0	24976.4 -132.1	24366.1 -133.2	23755.8 -134.3	23145.5 -135.4	22535.2 -136.5	21924.9 -137.6	21314.6 -138.7	20704.3 -139.8	20094.0 -140.9	-90
LAT	L. LONG	185	190	195	200	205	210	215	220	225	230	235	L. LONG LAT

TOTAL INTENSITY (F) WMM-90

E. LONG LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG LAT
0	31892	31988	31728	31729	31839	31841	31713	31828	31649	30852	30368	29898	0
-5	32864	32868	32604	32609	32323	32363	29951	29646	29279	29821	29318	27794	-5
-10	30953	30557	30200	29961	29529	29146	28726	28241	27724	27273	26671	26106	-10
-15	31638	31049	30490	29941	29328	28728	28133	27448	26744	26054	25412	24876	-15
-20	32843	33360	33409	33631	29837	29903	28126	27320	26320	25408	24624	23723	-20
-25	32756	33295	32824	31831	30803	29623	28627	27306	26412	25398	24324	23842	-25
-30	32853	33829	34950	33632	32184	30890	29370	28253	26984	25828	24823	24046	-30
-35	30603	31118	30728	30365	30009	32449	30914	29435	28023	26734	25628	24752	-35
-40	41994	40592	39105	37544	35935	34295	32657	31058	29455	28167	26976	26015	-40
-45	44637	43150	41585	39936	38232	36508	34797	33138	31574	30149	28903	27872	-45
-50	47263	45760	44163	42491	40772	39039	37326	35671	34111	32684	31420	30344	-50
-55	49811	48340	46786	45165	43505	41837	40192	38594	37103	35720	34472	33391	-55
-60	52506	50812	49167	47464	45733	43997	42383	40819	40429	39134	37952	36893	-60
-65	54318	52628	50853	50456	49106	47754	46424	45131	43893	42738	41650	40664	-65
-70	56018	54364	52626	52267	51633	50809	49892	48873	47869	46873	45833	44864	-70
-75	57158	55423	53678	54604	53328	52854	51988	51149	50317	49525	48776	48063	-75
-80	57615	56038	54448	55849	55246	54643	54045	53448	52884	52330	51799	51293	-80
-85	57273	56075	54768	56457	56153	55838	55523	55219	54922	54632	54356	54093	-85
-90	56497	56497	56497	56497	56497	56497	56497	56497	56497	56497	56497	56497	-90
LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG

TOTAL INTENSITY (F) WMM-90

LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG	LAT
0	29209 -70.5	28717 -68.5	28609 -66.5	27830 -64.5	27612 -62.5	27660 -60.5	27850 -58.5	28228 -56.5	28732 -54.5	29115 -52.5	29947 -50.5	30604 -48.5	0	
-5	27809 -65.7	26939 -63.7	26499 -61.7	26308 -59.7	26309 -57.7	26685 -55.7	26848 -53.7	27357 -51.7	27868 -49.7	28653 -47.7	29779 -45.7	30124 -43.7	-5	
-10	25664 -62.8	25333 -60.8	25144 -58.8	25121 -56.8	25273 -54.8	25592 -52.8	26064 -50.8	26659 -48.8	27321 -46.8	28053 -44.8	28827 -42.8	29625 -40.8	-10	
-15	24669 -59.9	24323 -57.9	24151 -55.9	24151 -53.9	24329 -51.9	24941 -49.9	25448 -47.9	26000 -45.9	26557 -43.9	27485 -41.9	28248 -39.9	29035 -37.9	-15	
-20	23717 -57.0	23508 -55.0	23518 -53.0	23703 -51.0	24048 -49.0	24509 -47.0	25059 -45.0	25650 -43.0	26298 -41.0	26952 -39.0	27658 -37.0	28254 -35.0	-20	
-25	23394 -54.1	23193 -52.1	23224 -50.1	23445 -48.1	23818 -46.1	24287 -44.1	24813 -42.1	25396 -40.1	25931 -38.1	26501 -36.1	27025 -34.1	27632 -32.1	-25	
-30	23329 -51.2	23281 -49.2	23383 -47.2	23688 -45.2	24019 -43.2	24378 -41.2	24762 -39.2	25176 -37.2	25589 -35.2	26032 -33.2	26511 -31.2	26842 -29.2	-30	
-35	24150 -48.3	23820 -46.3	23743 -44.3	23871 -42.3	24141 -40.3	24596 -38.3	24976 -36.3	25247 -34.3	25587 -32.3	25891 -30.3	26169 -28.3	26394 -26.3	-35	
-40	25312 -45.4	24872 -43.4	24673 -41.4	24672 -39.4	24811 -37.4	25029 -35.4	25275 -33.4	25512 -31.4	25718 -29.4	25890 -27.4	26039 -25.4	26149 -23.4	-40	
-45	27075 -42.5	26516 -40.5	26169 -38.5	26003 -36.5	25972 -34.5	26019 -32.5	26104 -30.5	26192 -28.5	26267 -26.5	26326 -24.5	26375 -22.5	26418 -20.5	-45	
-50	29471 -39.6	28797 -37.6	28309 -35.6	27977 -33.6	27766 -31.6	27637 -29.6	27558 -27.6	27504 -25.6	27463 -23.6	27436 -21.6	27431 -19.6	27464 -17.6	-50	
-55	32473 -36.7	31714 -34.7	31109 -32.7	30637 -30.7	30275 -28.7	29994 -26.7	29777 -24.7	29607 -22.7	29477 -20.7	29391 -18.7	29357 -16.7	29391 -14.7	-55	
-60	35967 -33.8	35169 -31.8	34494 -29.8	33929 -27.8	33462 -25.8	33077 -23.8	32764 -21.8	32515 -19.8	32327 -17.8	32205 -15.8	32155 -13.8	32190 -11.8	-60	
-65	39726 -30.9	38987 -28.9	38294 -26.9	37694 -24.9	37178 -22.9	36742 -20.9	36381 -18.9	36091 -16.9	35875 -14.9	35733 -12.9	35672 -10.9	35704 -8.9	-65	
-70	43804 -28.0	42957 -26.0	42388 -24.0	41807 -22.0	41301 -20.0	40869 -18.0	40503 -16.0	40111 -14.0	39892 -12.0	39749 -10.0	39663 -8.0	39718 -6.0	-70	
-75	47604 -25.1	46793 -23.1	46238 -21.1	45745 -19.1	45309 -17.1	44918 -15.1	44598 -13.1	44349 -11.1	44148 -9.1	44023 -7.1	43969 -5.1	43987 -3.1	-75	
-80	50821 -22.2	50380 -20.2	49976 -18.2	49611 -16.2	49287 -14.2	49006 -12.2	48771 -10.2	48582 -8.2	48443 -6.2	48353 -4.2	48318 -2.2	48336 -0.2	-80	
-85	53845 -19.3	53616 -17.3	53403 -15.3	53211 -13.3	53042 -11.3	52897 -9.3	52776 -7.3	52690 -5.3	52611 -3.3	52570 -1.3	52557 0.7	52571 2.7	-85	
-90	56497 -16.4	56497 -14.4	56497 -12.4	56497 -10.4	56497 -8.4	56497 -6.4	56497 -4.4	56497 -2.4	56497 -0.4	56497 1.6	56497 3.6	56497 5.6	-90	
LAT													LAT	
L. LONG	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG	

TOTAL INTENSITY (F) WMM-90

E. LONG LAT	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG LAT
90	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	90
85	-16.4	-18.2	-7.9	-2.9	8.9	8.8	18.1	18.1	18.1	22.1	25.9	28.0	85
80	-12.8	-8.0	-3.8	7.7	4.3	8.3	12.8	19.5	19.5	22.8	26.3	28.2	80
75	-10.4	-6.5	-2.7	8.1	6.0	8.3	11.8	18.3	18.3	21.3	23.4	26.3	75
70	-9.8	-5.1	-2.9	3.3	5.4	7.3	10.1	16.4	16.4	18.2	20.0	22.9	70
65	-3.2	-4.8	-1.3	1.1	3.8	5.4	8.3	13.4	13.4	15.4	17.0	18.8	65
60	-6.4	-3.8	-1.3	1.1	3.3	5.4	7.3	11.0	11.0	12.5	13.8	14.8	60
55	-3.8	-8.0	5.8	1.1	3.8	5.3	8.0	8.0	8.0	9.7	10.8	11.3	55
50	-6.8	-2.8	5.3	1.1	3.3	3.8	5.8	6.8	6.8	7.7	8.8	8.8	50
45	-3.3	-1.8	5.3	1.1	3.3	3.3	4.1	5.1	5.1	5.9	6.3	6.3	45
40	-3.0	-1.0	5.1	1.0	1.9	3.2	3.4	4.1	4.1	4.6	4.7	4.7	40
35	-2.8	-1.4	5.2	4.8	1.6	3.2	3.8	3.5	3.5	3.8	3.3	3.2	35
30	-2.8	-1.5	5.2	4.3	1.2	1.8	3.3	2.9	2.9	2.8	2.6	2.3	30
25	-3.0	-1.7	5.2	4.1	3.8	1.4	1.9	2.4	2.4	2.3	1.9	1.4	25
20	-3.8	-2.8	-1.2	4.4	3.4	2.8	1.8	2.8	2.8	1.8	1.2	3	20
15	-4.2	-2.9	-1.8	4.2	3.2	2.8	1.1	1.6	1.6	1.4	.8	.9	15
10	-3.8	-3.8	-3.9	-1.7	4.8	3.9	2.7	1.3	1.3	1.9	.6	.2	10
5	-6.4	-5.1	-3.2	-3.9	5.7	3.9	3.0	1.9	1.9	1.2	.3	.2	5
0	-8.5	-6.8	-5.2	-3.9	-2.6	-1.4	3.4	.2	.2	.8	-1.9	-3.9	0
LAT													LAT
E. LONG	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG

TOTAL INTENSITY (F) WMM-90

L. LONG LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG LAT
90	27:8 14:8	32:8 19:3	37:8 24:4	42:8 29:0	47:8 34:6	52:8 39:2	57:8 44:8	62:8 50:4	67:8 56:0	72:8 61:6	77:8 67:2	82:8 72:8	90
85	33:0 20:0	38:3 25:3	43:6 30:6	48:9 36:0	54:2 41:3	59:5 46:6	64:8 52:0	70:1 57:3	75:4 62:6	80:7 67:9	86:0 73:2	91:3 78:5	85
80	39:9 26:9	45:2 32:2	50:5 37:5	55:8 42:8	61:1 48:1	66:4 53:4	71:7 58:7	77:0 64:0	82:3 69:3	87:6 74:6	92:9 79:9	98:2 85:2	80
75	46:4 33:4	51:7 38:7	57:0 44:0	62:3 49:3	67:6 54:6	72:9 59:9	78:2 65:2	83:5 70:5	88:8 75:8	94:1 81:1	99:4 86:4	104:7 91:7	75
70	53:0 40:0	58:3 45:3	63:6 50:6	68:9 55:9	74:2 61:2	79:5 66:5	84:8 71:8	89:1 76:1	94:4 81:4	99:7 86:7	105:0 91:0	110:3 96:3	70
65	60:3 47:3	65:6 52:6	70:9 57:9	76:2 63:2	81:5 68:5	86:8 73:8	91:1 78:1	96:4 83:4	101:7 88:7	107:0 93:0	112:3 98:3	117:6 104:6	65
60	67:6 54:6	72:9 59:9	77:2 64:2	82:5 69:5	87:8 74:8	92:1 79:1	97:4 84:4	102:7 89:7	108:0 94:0	113:3 99:3	118:6 105:6	123:9 110:9	60
55	74:9 61:9	79:2 66:2	84:5 71:5	89:8 76:8	94:1 81:1	99:4 86:4	104:7 91:7	109:0 96:0	114:3 101:3	119:6 106:6	124:9 111:9	129:2 115:2	55
50	81:2 68:2	86:5 73:5	91:8 78:8	96:1 83:1	101:4 88:4	106:7 93:7	111:0 98:0	116:3 103:3	121:6 108:6	126:9 113:9	131:2 118:2	136:5 123:5	50
45	88:5 75:5	93:8 80:8	98:1 85:1	103:4 90:4	108:7 95:7	113:0 100:0	118:3 105:3	123:6 110:6	128:9 115:9	133:2 120:2	138:5 125:5	143:8 130:8	45
40	95:8 82:8	100:1 87:1	105:4 92:4	110:7 97:7	115:0 102:0	120:3 107:3	125:6 112:6	130:9 117:9	135:2 122:2	140:5 127:5	145:8 132:8	150:1 137:1	40
35	102:1 89:1	107:4 94:4	112:7 99:7	117:0 104:0	122:3 109:3	127:6 114:6	132:9 119:9	137:2 124:2	142:5 129:5	147:8 134:8	152:1 139:1	157:4 144:4	35
30	109:4 96:4	114:7 101:7	119:0 106:0	124:3 111:3	129:6 116:6	134:9 121:9	139:2 126:2	144:5 131:5	149:8 136:8	154:1 141:1	159:4 146:4	164:7 151:7	30
25	116:7 103:7	121:0 108:0	126:3 113:3	131:6 118:6	136:9 123:9	141:2 128:2	146:5 133:5	151:8 138:8	156:1 143:1	161:4 148:4	166:7 153:7	171:0 158:0	25
20	123:0 110:0	128:3 115:3	133:6 120:6	138:9 125:9	143:2 130:2	148:5 135:5	153:8 140:8	158:1 145:1	163:4 150:4	168:7 155:7	173:0 160:0	178:3 165:3	20
15	130:3 117:3	135:6 122:6	140:9 127:9	145:2 132:2	150:5 137:5	155:8 142:8	160:1 147:1	165:4 152:4	170:7 157:7	175:0 162:0	180:3 167:3	185:6 172:6	15
10	137:6 124:6	142:9 129:9	147:2 134:2	152:5 139:5	157:8 144:8	162:1 149:1	167:4 154:4	172:7 159:7	177:0 164:0	182:3 169:3	187:6 174:6	192:9 180:9	10
5	144:9 131:9	149:2 136:2	154:5 141:5	159:8 146:8	164:1 151:1	169:4 156:4	174:7 161:7	179:0 166:0	184:3 171:3	189:6 176:6	194:9 181:9	199:2 186:2	5
0	151:2 138:2	156:5 143:5	161:8 148:8	166:1 153:1	171:4 158:4	176:7 163:7	181:0 168:0	186:3 173:3	191:6 178:6	196:9 183:9	201:2 188:2	206:5 193:5	0
LAT													LAT
L. LONG	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG

DECLINATION (D) WMM-90

E. LONG LAT	120	125	130	135	140	145	150	155	160	165	170	175	E. LONG LAT
90	92:8	92:8	92:8	92:8	92:8	92:8	92:8	92:8	92:8	92:8	92:8	92:8	90
85	45:5	45:5	45:5	45:5	45:5	45:5	45:5	45:5	45:5	45:5	45:5	45:5	85
80	-11:5	-11:5	-11:5	-11:5	-11:5	-11:5	-11:5	-11:5	-11:5	-11:5	-11:5	-11:5	80
75	-8:3	-8:3	-8:3	-8:3	-8:3	-8:3	-8:3	-8:3	-8:3	-8:3	-8:3	-8:3	75
70	-12:8	-12:8	-12:8	-12:8	-12:8	-12:8	-12:8	-12:8	-12:8	-12:8	-12:8	-12:8	70
65	-13:8	-13:8	-13:8	-13:8	-13:8	-13:8	-13:8	-13:8	-13:8	-13:8	-13:8	-13:8	65
60	-12:5	-12:5	-12:5	-12:5	-12:5	-12:5	-12:5	-12:5	-12:5	-12:5	-12:5	-12:5	60
55	-10:8	-10:8	-10:8	-10:8	-10:8	-10:8	-10:8	-10:8	-10:8	-10:8	-10:8	-10:8	55
50	-8:8	-8:8	-8:8	-8:8	-8:8	-8:8	-8:8	-8:8	-8:8	-8:8	-8:8	-8:8	50
45	-6:5	-6:5	-6:5	-6:5	-6:5	-6:5	-6:5	-6:5	-6:5	-6:5	-6:5	-6:5	45
40	-5:5	-5:5	-5:5	-5:5	-5:5	-5:5	-5:5	-5:5	-5:5	-5:5	-5:5	-5:5	40
35	-4:8	-4:8	-4:8	-4:8	-4:8	-4:8	-4:8	-4:8	-4:8	-4:8	-4:8	-4:8	35
30	-3:8	-3:8	-3:8	-3:8	-3:8	-3:8	-3:8	-3:8	-3:8	-3:8	-3:8	-3:8	30
25	-3:1	-3:1	-3:1	-3:1	-3:1	-3:1	-3:1	-3:1	-3:1	-3:1	-3:1	-3:1	25
20	-2:9	-2:9	-2:9	-2:9	-2:9	-2:9	-2:9	-2:9	-2:9	-2:9	-2:9	-2:9	20
15	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	15
10	-2:5	-2:5	-2:5	-2:5	-2:5	-2:5	-2:5	-2:5	-2:5	-2:5	-2:5	-2:5	10
5	-2:8	-2:8	-2:8	-2:8	-2:8	-2:8	-2:8	-2:8	-2:8	-2:8	-2:8	-2:8	5
0	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	-1:8	0

Deg.
(units : min/yr)

DECLINATION (D) WMM-90

LAT	180	185	190	195	200	205	210	215	220	225	230	235	L. LONG
90	167:8	152:8	147:8	162:8	167:8	172:8	177:8	182:8	187:8	192:8	197:8	202:8	LAT
85	5:34-	2:24-	2:29-	2:41-	2:46-	2:51-	2:56-	3:01-	3:06-	3:11-	3:16-	3:21-	90
80	4:31-	3:41-	2:53-	2:07	1:21	3:35	4:05	4:34	5:04	5:34	6:04	6:34	85
75	0:3-	8:31	0:48	0:12	0:32	0:52	1:12	1:32	1:52	2:12	2:32	2:52	80
70	3:1-	0:11	6:31	0:46	1:22	1:58	2:34	3:10	3:46	4:22	4:58	5:34	75
65	2:4-	1:01	1:31	0:21	1:02	1:42	2:22	3:02	3:42	4:22	5:02	5:42	70
60	3:4-	0:8	6:31	0:31	1:06	1:42	2:18	2:54	3:30	4:06	4:42	5:18	65
55	0:6-	8:3	3:31	0:31	1:06	1:42	2:18	2:54	3:30	4:06	4:42	5:18	60
50	4:4-	0:3-	1:11	1:41	2:11	2:41	3:11	3:41	4:11	4:41	5:11	5:41	55
45	6:3-	0:2-	1:11	1:41	2:11	2:41	3:11	3:41	4:11	4:41	5:11	5:41	50
40	7:2-	4:3-	1:11	1:41	2:11	2:41	3:11	3:41	4:11	4:41	5:11	5:41	45
35	8:2-	0:2-	1:11	1:41	2:11	2:41	3:11	3:41	4:11	4:41	5:11	5:41	40
30	9:3-	0:0	1:0	1:3	2:0	2:3	3:0	3:3	4:0	4:3	5:0	5:3	35
25	9:3-	0:3	1:0	1:3	2:0	2:3	3:0	3:3	4:0	4:3	5:0	5:3	30
20	8:3-	0:5	1:6	1:9	2:2	2:5	3:2	3:5	4:2	4:5	5:2	5:5	25
15	10:1	1:0	1:3	1:6	1:9	2:2	2:5	3:2	3:5	4:2	4:5	5:2	20
10	9:3	1:0	1:4	1:7	2:0	2:3	3:0	3:3	4:0	4:3	5:0	5:3	15
5	10:4	1:3	1:6	1:9	2:2	2:5	3:2	3:5	4:2	4:5	5:2	5:5	10
0	10:8	1:4	1:7	2:0	2:3	2:6	2:9	3:2	3:5	3:8	4:1	4:4	5
LAT	180	185	190	195	200	205	210	215	220	225	230	235	L. LONG

DECLINATION (D) WMM-90

LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG
90	-142:2	-147:2	-142:2	-147:2	-142:2	-147:2	-142:2	-147:2	-142:2	-147:2	-142:2	-147:2	90
85	133:2	-138:2	133:2	-138:2	133:2	-138:2	133:2	-138:2	133:2	-138:2	133:2	-138:2	85
80	-74:4	-79:4	109:2	54:4	-79:4	109:2	54:4	33:2	-79:4	109:2	54:4	-79:4	80
75	-33:3	-38:3	46:9	35:4	-38:3	46:9	35:4	0:3	-38:3	46:9	35:4	-38:3	75
70	-49:0	-54:0	33:3	8:0	-54:0	33:3	8:0	6:0	-54:0	33:3	8:0	-54:0	70
65	-72:4	-77:4	22:6	36:3	-77:4	22:6	36:3	4:2	-77:4	22:6	36:3	-77:4	65
60	-27:9	-32:9	22:5	17:1	-32:9	22:5	17:1	0:1	-32:9	22:5	17:1	-32:9	60
55	-23:7	-28:7	18:0	13:4	-28:7	18:0	13:4	0:1	-28:7	18:0	13:4	-28:7	55
50	20:8	-6:0	16:6	12:2	-6:0	16:6	12:2	0:3	-6:0	16:6	12:2	0:3	50
45	16:2	-4:8	14:8	10:4	-4:8	14:8	10:4	0:2	-4:8	14:8	10:4	0:2	45
40	13:2	-1:4	11:4	7:0	-1:4	11:4	7:0	0:0	-1:4	11:4	7:0	0:0	40
35	14:3	13:2	12:2	10:6	13:2	12:2	10:6	0:3	13:2	12:2	10:6	0:3	35
30	13:0	12:1	11:1	9:7	12:1	11:1	9:7	0:2	12:1	11:1	9:7	0:2	30
25	11:2	11:1	10:3	8:1	11:1	10:3	8:1	0:0	11:1	10:3	8:1	0:0	25
20	10:3	10:2	9:5	7:7	10:2	9:5	7:7	0:3	10:2	9:5	7:7	0:3	20
15	9:7	9:4	9:1	8:5	9:4	8:5	8:0	0:0	9:4	8:5	8:0	0:0	15
10	9:1	8:9	8:8	8:4	8:9	8:4	8:0	0:0	8:9	8:4	8:0	0:0	10
5	8:8	8:6	8:6	8:0	8:6	8:0	7:3	0:3	8:6	8:0	7:3	0:3	5
0	6:9	6:0	6:0	6:0	6:0	6:0	6:0	0:0	6:0	6:0	6:0	0:0	0
LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG

DECLINATION (D) WMM-90

E. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	E. LONG LAT
90	-92:2	-87:2	-84:2	-77:2	-72:2	-67:2	-62:2	-57:2	-52:2	-47:2	-42:2	-37:2	90
	14:8	14:8	14:8	14:8	14:8	14:8	14:8	14:8	14:8	14:8	14:8	14:8	
85	-76:0	-70:8	-65:0	-60:0	-54:8	-48:8	-43:8	-38:8	-33:8	-28:8	-23:8	-18:8	85
	16:0	15:8	15:0	14:0	13:8	13:8	13:8	13:8	13:8	13:8	13:8	13:8	
80	-60:0	-54:2	-48:6	-42:8	-37:0	-31:0	-25:3	-19:6	-13:0	-7:0	-1:0	4:8	80
	18:0	17:2	16:6	15:8	15:0	14:0	13:3	12:6	11:0	10:4	9:8	9:2	
75	-44:5	-38:8	-32:2	-26:6	-20:9	-14:9	-8:8	-2:2	4:4	9:2	14:4	19:6	75
	18:5	17:1	16:1	15:1	14:3	13:4	12:6	11:6	10:6	10:2	9:6	9:0	
70	-29:4	-22:2	-15:4	-8:4	-1:2	5:5	12:1	18:8	25:4	32:1	38:6	45:0	70
	19:4	17:2	15:4	13:4	11:2	9:5	8:1	6:8	5:4	4:0	2:6	1:0	
65	-14:3	-7:4	0:1	6:7	13:1	19:0	25:3	31:8	37:4	43:1	48:6	54:0	65
	24:3	22:1	20:1	17:7	15:1	13:1	11:0	9:2	7:4	5:7	4:1	2:5	
60	1:0	8:5	16:3	23:1	30:3	36:8	43:4	49:8	56:4	62:1	68:6	75:0	60
	14:0	13:5	13:1	12:6	12:3	12:4	12:8	13:1	13:4	13:8	14:1	14:5	
55	16:8	23:2	30:0	36:6	43:0	49:4	55:8	62:1	68:5	74:1	80:6	87:0	55
	28:8	28:2	28:0	27:6	27:0	26:8	26:4	25:8	25:1	24:5	23:9	23:3	
50	29:8	35:2	41:0	46:4	51:8	57:2	62:6	68:0	73:4	78:8	84:2	89:6	50
	39:8	39:2	39:0	38:6	38:0	37:4	36:8	36:1	35:5	34:9	34:3	33:7	
45	34:8	39:2	44:0	48:4	52:8	57:2	61:6	66:0	70:4	74:8	79:2	83:6	45
	44:8	44:2	44:0	43:6	43:0	42:4	41:8	41:1	40:5	39:9	39:3	38:7	
40	39:1	43:5	47:3	50:8	54:2	57:6	61:0	64:4	67:8	71:2	74:6	78:0	40
	49:1	48:5	48:3	47:8	47:2	46:6	46:0	45:4	44:8	44:2	43:6	43:0	
35	34:1	38:5	42:3	45:8	49:2	52:6	55:0	58:4	61:8	65:2	68:6	72:0	35
	44:1	43:5	43:3	42:8	42:2	41:6	41:0	40:4	39:8	39:2	38:6	38:0	
30	29:1	33:5	37:3	40:8	44:2	47:6	50:0	53:4	56:8	60:2	63:6	67:0	30
	39:1	38:5	38:3	37:8	37:2	36:6	36:0	35:4	34:8	34:2	33:6	33:0	
25	24:1	28:5	32:3	35:8	39:2	42:6	45:0	48:4	51:8	55:2	58:6	62:0	25
	34:1	33:5	33:3	32:8	32:2	31:6	31:0	30:4	29:8	29:2	28:6	28:0	
20	19:1	23:5	27:3	30:8	34:2	37:6	40:0	43:4	46:8	50:2	53:6	57:0	20
	29:1	28:5	28:3	27:8	27:2	26:6	26:0	25:4	24:8	24:2	23:6	23:0	
15	14:1	18:5	22:3	25:8	29:2	32:6	35:0	38:4	41:8	45:2	48:6	52:0	15
	24:1	23:5	23:3	22:8	22:2	21:6	21:0	20:4	19:8	19:2	18:6	18:0	
10	9:1	13:5	17:3	20:8	24:2	27:6	30:0	33:4	36:8	40:2	43:6	47:0	10
	19:1	18:5	18:3	17:8	17:2	16:6	16:0	15:4	14:8	14:2	13:6	13:0	
5	4:1	8:5	12:3	15:8	19:2	22:6	25:0	28:4	31:8	35:2	38:6	42:0	5
	14:1	13:5	13:3	12:8	12:2	11:6	11:0	10:4	9:8	9:2	8:6	8:0	
0	-1:4	-5:5	-9:3	-12:8	-16:2	-19:6	-23:0	-26:4	-29:8	-33:2	-36:6	-40:0	0
	9:4	9:5	9:3	8:8	8:2	7:6	7:0	6:4	5:8	5:2	4:6	4:0	
LAT	E. LONG	305	310	315	320	325	330	335	340	345	350	355	

DECLINATION (D) WMM-90

E. LONG LAT	0	5	10	15	20	25	30	35	40	45	50	55	E. LONG LAT
0	-8:0	-9:8	-8:6	-8:9	-8:2	-7:4	-5:4	-7:2	-7:2	-8:0	-1:4	-3:0	0
-5	-10:9	-9:0	-8:8	-8:4	-8:0	-7:5	-1:9	-8:3	-1:3	-2:4	-3:7	-5:6	-5
-10	-13:8	-11:1	-8:7	-7:4	-8:0	-6:3	-3:3	-6:1	-3:6	-4:0	-6:8	-7:9	-10
-15	-17:1	-15:0	-12:8	-10:5	-9:4	-6:7	-3:8	-5:9	-7:0	-8:6	-10:3	-11:2	-15
-20	-20:6	-18:8	-16:3	-13:8	-11:7	-10:2	-9:7	-10:3	-11:0	-13:0	-15:2	-17:3	-20
-25	-23:1	-21:5	-19:8	-17:5	-15:8	-14:1	-14:1	-16:3	-18:1	-20:3	-22:3	-24:7	-25
-30	-24:9	-23:3	-21:5	-19:2	-17:0	-15:9	-14:8	-17:6	-19:9	-22:3	-24:1	-26:4	-30
-35	-27:4	-25:9	-24:3	-22:7	-20:7	-18:5	-16:5	-18:4	-20:0	-23:3	-25:8	-28:6	-35
-40	-29:8	-27:7	-25:2	-23:5	-21:8	-19:0	-16:8	-17:9	-19:5	-23:0	-25:7	-28:9	-40
-45	-32:5	-30:2	-27:5	-26:5	-24:2	-21:3	-18:9	-19:2	-21:8	-25:9	-28:9	-32:0	-45
-50	-35:3	-32:3	-29:5	-27:2	-24:3	-21:1	-18:5	-17:0	-19:7	-24:0	-27:7	-31:1	-50
-55	-38:0	-34:3	-31:5	-28:5	-25:7	-22:0	-19:0	-17:5	-20:3	-25:0	-28:8	-32:3	-55
-60	-40:3	-36:0	-33:2	-29:5	-26:7	-22:8	-19:5	-18:0	-20:8	-25:6	-29:5	-33:0	-60
-65	-42:9	-38:0	-35:2	-31:5	-28:7	-24:6	-21:0	-19:5	-22:3	-27:0	-31:0	-34:8	-65
-70	-45:8	-40:9	-38:1	-34:2	-31:5	-27:2	-23:5	-22:0	-24:8	-29:5	-33:5	-37:2	-70
-75	-48:1	-43:1	-40:2	-36:5	-33:8	-29:3	-25:8	-24:2	-27:0	-32:0	-36:0	-39:8	-75
-80	-50:8	-45:8	-42:9	-39:0	-36:3	-32:0	-28:5	-26:9	-29:7	-34:8	-38:8	-42:3	-80
-85	-53:3	-48:3	-45:4	-41:5	-38:8	-34:5	-31:0	-29:4	-32:2	-37:3	-41:3	-44:9	-85
-90	-56:3	-51:3	-48:4	-44:5	-41:8	-37:5	-34:0	-32:4	-35:2	-40:3	-44:3	-47:9	-90
LAT													LAT
E. LONG	0	5	10	15	20	25	30	35	40	45	50	55	E. LONG

DECLINATION (D) WMM-90

LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG LAT
0	-4:0	-4:2	-5:1	-5:0	-4:0	-3:2	-3:0	-1:0	-0:5	-0:0	-1:3	-1:0	0
-5	-6:1	-6:8	-7:0	-6:8	-6:0	-5:2	-6:0	-2:7	-1:4	-1:3	-1:0	-1:1	-5
-10	-9:0	-9:0	-9:9	-9:1	-8:4	-7:1	-5:2	-4:0	-2:2	-0:8	-0:4	-1:2	-10
-15	-13:0	-13:0	-13:3	-12:6	-11:4	-9:8	-7:8	-5:5	-3:6	-1:7	-0:3	-0:0	-15
-20	-18:0	-18:0	-18:0	-17:0	-15:6	-13:0	-10:0	-8:0	-5:4	-3:0	-1:1	-0:3	-20
-25	-24:0	-24:0	-23:0	-22:0	-20:0	-17:1	-14:1	-11:1	-8:0	-5:0	-2:0	-0:0	-25
-30	-31:0	-30:0	-29:1	-28:0	-26:0	-23:2	-20:0	-16:5	-13:6	-9:0	-5:4	-2:0	-30
-35	-37:0	-37:0	-36:0	-35:0	-33:0	-30:4	-26:0	-22:0	-18:0	-13:4	-9:0	-5:0	-35
-40	-42:0	-43:0	-42:0	-40:0	-37:0	-34:0	-30:0	-25:0	-20:0	-15:0	-10:0	-6:0	-40
-45	-47:0	-48:0	-46:0	-43:0	-40:0	-36:0	-32:0	-28:0	-24:0	-20:0	-15:0	-10:0	-45
-50	-53:0	-53:0	-50:0	-47:0	-43:0	-39:0	-35:0	-31:0	-27:0	-23:0	-18:0	-13:0	-50
-55	-59:0	-57:0	-54:0	-50:0	-46:0	-42:0	-38:0	-34:0	-30:0	-26:0	-22:0	-18:0	-55
-60	-66:0	-60:0	-56:0	-52:0	-48:0	-44:0	-40:0	-36:0	-32:0	-28:0	-24:0	-20:0	-60
-65	-68:0	-64:0	-60:0	-56:0	-52:0	-48:0	-44:0	-40:0	-36:0	-32:0	-28:0	-24:0	-65
-70	-67:0	-63:0	-59:0	-55:0	-51:0	-47:0	-43:0	-39:0	-35:0	-31:0	-27:0	-23:0	-70
-75	-67:0	-63:0	-59:0	-55:0	-51:0	-47:0	-43:0	-39:0	-35:0	-31:0	-27:0	-23:0	-75
-80	-72:0	-68:0	-64:0	-60:0	-56:0	-52:0	-48:0	-44:0	-40:0	-36:0	-32:0	-28:0	-80
-85	-78:0	-74:0	-70:0	-66:0	-62:0	-58:0	-54:0	-50:0	-46:0	-42:0	-38:0	-34:0	-85
-90	-87:0	-83:0	-79:0	-75:0	-71:0	-67:0	-63:0	-59:0	-55:0	-51:0	-47:0	-43:0	-90
LAT	L. LONG	65	70	75	80	85	90	95	100	105	110	115	L. LONG LAT

DECLINATION (D) WMM-90

L. LONG LAT	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG LAT
0	-1:28	-1:5	-2:0	2:8	3:0	4:8	5:9	7:1	8:0	9:3	10:1	10:5	0
-5	-1:9	-2:1	-2:0	3:5	4:4	5:5	6:6	7:8	8:8	9:8	10:2	10:9	-5
-10	-1:8	-2:5	-2:6	4:1	5:0	6:2	7:3	8:6	9:6	10:6	11:0	11:5	-10
-15	0:1	2:2	3:6	4:6	5:6	6:8	8:0	9:1	10:2	11:1	11:8	12:2	-15
-20	1:6	2:7	3:8	5:0	6:2	7:5	8:8	10:0	11:1	12:0	12:8	13:3	-20
-25	1:0	2:0	4:8	5:8	6:8	8:3	9:7	11:1	12:2	13:3	14:1	14:6	-25
-30	2:1	2:1	4:0	5:8	7:6	9:3	11:0	12:5	13:8	14:9	15:2	16:0	-30
-35	-1:5	1:5	3:8	6:2	8:3	10:6	12:5	14:2	15:2	16:9	17:8	18:4	-35
-40	-4:8	1:5	3:3	6:6	8:0	12:3	14:5	16:5	18:1	19:5	20:3	21:0	-40
-45	-9:1	-3:8	3:1	6:7	10:7	14:2	17:0	19:6	21:2	22:6	23:8	24:3	-45
-50	-12:8	-8:6	1:8	6:6	12:8	16:9	20:5	23:3	26:9	29:8	27:9	28:4	-50
-55	-22:9	-20:1	-7:2	5:6	14:0	21:0	28:0	29:4	31:7	33:2	34:1	34:5	-55
-60	-36:5	-30:2	-32:9	-3:2	17:4	28:9	32:0	40:8	42:8	43:8	46:9	48:9	-60
-65	-38:0	-30:0	-104:2	-105:2	30:8	76:2	38:0	69:8	68:8	64:6	61:3	60:2	-65
-70	-120:0	-128:1	-138:8	-142:0	-170:2	167:5	145:0	126:4	112:6	102:4	94:7	88:6	-70
-75	-128:3	-138:1	-147:6	-152:1	-162:6	-175:5	170:1	158:8	147:2	137:3	129:0	118:8	-75
-80	-136:0	-144:8	-151:8	-159:1	-169:5	-174:3	174:1	170:2	162:6	155:0	147:5	140:6	-80
-85	-143:0	-148:8	-154:6	-160:6	-169:6	-172:6	-178:8	175:4	169:5	163:4	157:4	151:5	-85
-90	-147:3	-152:3	-157:3	-162:3	-167:3	-172:3	-177:3	177:2	172:2	167:2	162:2	157:2	-90
L. LONG LAT	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG LAT

DECLINATION (D) WMM-90

E. LONG LAT	180	185	190	195	200	205	210	215	220	225	230	235	E. LONG LAT
0	19:08	19:06	19:02	18:57	18:52	18:47	18:42	18:37	18:32	18:27	18:22	18:17	0
-5	11:09	10:59	10:50	10:40	10:30	10:20	10:10	10:00	9:50	9:40	9:30	9:20	-5
-10	11:08	11:04	11:00	10:56	10:52	10:48	10:44	10:40	10:36	10:32	10:28	10:24	-10
-15	12:04	12:02	12:00	11:58	11:56	11:54	11:52	11:50	11:48	11:46	11:44	11:42	-15
-20	13:08	13:06	13:05	13:03	13:02	13:01	13:00	12:59	12:58	12:57	12:56	12:55	-20
-25	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	-25
-30	16:07	16:08	16:09	16:08	16:07	16:06	16:05	16:04	16:03	16:02	16:01	16:00	-30
-35	18:08	18:00	18:01	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	-35
-40	21:04	21:06	21:08	21:07	21:06	21:05	21:04	21:03	21:02	21:01	21:00	21:00	-40
-45	24:08	24:03	24:07	24:06	24:05	24:04	24:03	24:02	24:01	24:00	24:00	24:00	-45
-50	28:08	28:08	28:07	28:06	28:05	28:04	28:03	28:02	28:01	28:00	28:00	28:00	-50
-55	34:06	34:03	34:03	34:01	33:59	33:57	33:56	33:55	33:54	33:53	33:52	33:51	-55
-60	43:07	43:07	43:07	43:05	43:03	43:02	43:01	43:00	43:00	43:00	43:00	43:00	-60
-65	59:09	57:06	56:08	54:07	53:05	52:04	51:04	50:03	49:03	48:03	47:03	46:03	-65
-70	83:07	79:06	78:04	76:02	75:00	74:00	73:00	72:00	71:00	70:00	69:00	68:00	-70
-75	112:05	106:08	100:08	95:08	90:08	86:08	83:08	80:08	77:08	74:08	71:08	68:08	-75
-80	133:03	126:08	120:07	114:07	109:07	104:07	99:07	94:07	89:07	84:07	79:07	74:07	-80
-85	145:07	139:09	134:03	129:07	123:02	117:08	112:05	107:06	102:08	97:03	92:01	87:02	-85
-90	152:07	147:07	142:07	137:07	132:07	127:07	122:07	117:07	112:07	107:07	102:07	97:07	-90
LAT	180	185	190	195	200	205	210	215	220	225	230	235	LAT
E. LONG	180	185	190	195	200	205	210	215	220	225	230	235	E. LONG

DECLINATION (D) WMM-90

LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG
0	8:8	8:8	8:8	8:8	8:8	8:8	8:8	8:8	10:2	11:8	13:3	15:8	0
-5	8:8	8:8	8:8	9:3	9:8	9:8	9:8	9:8	10:2	11:8	13:3	15:8	-5
-10	10:1	10:1	10:3	10:1	10:8	10:8	10:8	10:8	11:2	12:8	14:3	16:8	-10
-15	11:2	11:2	11:3	11:3	11:8	11:8	11:8	11:8	12:2	13:8	15:3	17:8	-15
-20	12:8	12:8	12:5	12:5	13:1	13:1	13:1	13:1	14:5	16:0	17:5	19:0	-20
-25	14:1	14:1	14:3	14:3	14:8	14:8	14:8	14:8	16:2	17:7	19:2	20:7	-25
-30	16:5	16:5	16:8	16:8	17:3	17:3	17:3	17:3	19:7	21:2	22:7	24:2	-30
-35	19:0	19:2	19:3	19:3	19:8	19:8	19:8	19:8	22:2	23:7	25:2	26:7	-35
-40	22:1	22:3	22:4	22:4	22:9	22:9	22:9	22:9	25:3	26:8	28:3	29:8	-40
-45	25:5	25:7	25:8	25:8	26:3	26:3	26:3	26:3	29:7	31:2	32:7	34:2	-45
-50	29:5	29:7	29:8	29:8	30:3	30:3	30:3	30:3	33:7	35:2	36:7	38:2	-50
-55	33:8	33:5	33:8	33:8	34:3	34:3	34:3	34:3	37:7	39:2	40:7	42:2	-55
-60	39:0	38:8	37:9	37:9	38:4	38:4	38:4	38:4	41:8	43:3	44:8	46:3	-60
-65	45:8	45:4	45:7	45:7	46:2	46:2	46:2	46:2	49:6	51:1	52:6	54:1	-65
-70	52:2	49:8	47:9	45:8	43:1	40:3	37:8	35:3	32:7	30:2	27:7	25:2	-70
-75	61:3	57:8	54:8	52:3	49:8	47:3	44:8	42:3	39:7	37:2	34:7	32:2	-75
-80	71:6	67:3	63:3	59:8	56:3	53:8	51:3	48:8	46:3	43:8	41:3	38:8	-80
-85	83:8	79:8	75:8	71:8	67:8	64:3	61:8	59:3	56:8	54:3	51:8	49:3	-85
-90	92:7	87:7	82:7	77:7	72:7	67:7	62:7	57:7	52:7	47:7	42:7	37:7	-90
LAT													
L. LONG	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG

DECLINATION (D) WMM-90

L. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG LAT
0	-12.5	-15.5	-15.0	-13.7	-20.2	-20.8	-20.3	-18.7	-17.0	-14.8	-13.1	-10.5	0
-5	-11.6	-15.8	-16.0	-14.7	-21.1	-21.2	-20.6	-19.0	-18.1	-16.2	-14.1	-11.1	-5
-10	-11.0	-14.7	-17.6	-15.5	-21.9	-22.1	-21.3	-19.4	-18.4	-16.7	-14.1	-11.5	-10
-15	-10.1	-14.1	-17.4	-15.2	-22.3	-22.2	-21.4	-19.3	-18.3	-16.8	-14.2	-11.8	-15
-20	-9.0	-13.1	-16.8	-14.9	-22.5	-22.2	-21.6	-19.2	-18.2	-16.9	-14.3	-11.9	-20
-25	-7.9	-12.1	-16.1	-14.4	-22.5	-22.1	-21.7	-19.0	-18.1	-17.2	-14.5	-12.2	-25
-30	-6.8	-11.1	-15.2	-13.7	-22.0	-21.5	-21.8	-18.7	-17.8	-17.2	-14.6	-12.3	-30
-35	-5.7	-10.1	-14.3	-12.8	-21.1	-20.3	-21.7	-18.3	-17.4	-17.0	-14.4	-12.4	-35
-40	-4.6	-9.0	-13.4	-11.9	-20.1	-19.1	-21.6	-17.9	-17.0	-16.7	-14.1	-12.5	-40
-45	-3.5	-7.9	-12.5	-11.0	-19.1	-17.9	-21.5	-17.0	-16.0	-15.9	-13.9	-12.6	-45
-50	-2.4	-6.8	-11.6	-10.1	-18.0	-16.7	-21.4	-15.9	-14.9	-14.9	-13.4	-12.7	-50
-55	-1.3	-5.7	-10.7	-9.2	-16.9	-15.5	-21.3	-14.8	-13.8	-13.8	-12.9	-13.2	-55
-60	-0.2	-4.6	-9.8	-8.3	-15.8	-14.3	-21.2	-13.7	-12.7	-12.7	-12.4	-13.5	-60
-65	9.1	-3.5	-8.9	-7.4	-14.7	-13.1	-21.1	-12.6	-11.6	-11.6	-11.9	-14.6	-65
-70	17.3	-2.4	-8.0	-6.5	-13.6	-11.9	-21.0	-11.5	-10.5	-10.5	-11.2	-15.8	-70
-75	20.7	-1.3	-7.1	-5.6	-12.5	-10.8	-20.9	-10.4	-9.4	-9.4	-10.3	-16.9	-75
-80	24.4	0.0	-6.2	-4.7	-11.4	-9.7	-20.8	-9.3	-8.3	-8.3	-9.4	-17.9	-80
-85	28.2	0.8	-5.3	-3.8	-10.3	-8.6	-20.7	-8.2	-7.2	-7.2	-8.4	-18.9	-85
-90	32.7	1.5	-4.4	-2.9	-9.2	-7.5	-20.6	-7.1	-6.1	-6.1	-7.4	-22.3	-90

INCLINATION (I) WMM-90

L. LONG LAT	0	5	10	15	20	25	30	35	40	45	50	55	L. LONG LAT
90	87.8 1.0	87.8 1.0	87.8 1.0	87.8 1.0	87.8 1.0	87.8 1.0	87.8 1.0	87.8 1.0	87.8 1.0	87.8 1.0	87.8 1.0	87.8 1.0	90
85	85.2 1.0	85.2 1.0	85.2 1.0	85.2 1.0	85.2 1.0	85.2 1.0	85.2 1.0	85.2 1.0	85.2 1.0	85.2 1.0	85.2 1.0	85.2 1.0	85
80	82.7 1.1	82.7 1.1	82.7 1.2	82.7 1.2	82.7 1.2	82.7 1.2	82.7 1.2	82.7 1.2	82.7 1.2	82.7 1.2	82.7 1.2	82.7 1.2	80
75	80.3 1.1	80.3 1.1	80.3 1.2	80.3 1.2	80.3 1.2	80.3 1.2	80.3 1.2	80.3 1.2	80.3 1.2	80.3 1.2	80.3 1.2	80.3 1.2	75
70	77.9 1.0	77.9 1.0	77.9 1.1	77.9 1.1	77.9 1.1	77.9 1.1	77.9 1.1	77.9 1.1	77.9 1.1	77.9 1.1	77.9 1.1	77.9 1.1	70
65	75.5 1.0	75.5 1.0	75.5 1.0	75.5 1.0	75.5 1.0	75.5 1.0	75.5 1.0	75.5 1.0	75.5 1.0	75.5 1.0	75.5 1.0	75.5 1.0	65
60	72.5 1.0	72.5 1.0	72.5 1.0	72.5 1.0	72.5 1.0	72.5 1.0	72.5 1.0	72.5 1.0	72.5 1.0	72.5 1.0	72.5 1.0	72.5 1.0	60
55	69.1 1.0	69.1 1.0	69.1 1.0	69.1 1.0	69.1 1.0	69.1 1.0	69.1 1.0	69.1 1.0	69.1 1.0	69.1 1.0	69.1 1.0	69.1 1.0	55
50	65.2 1.0	65.2 1.0	65.2 1.0	65.2 1.0	65.2 1.0	65.2 1.0	65.2 1.0	65.2 1.0	65.2 1.0	65.2 1.0	65.2 1.0	65.2 1.0	50
45	60.5 1.0	60.5 1.0	60.5 1.0	60.5 1.0	60.5 1.0	60.5 1.0	60.5 1.0	60.5 1.0	60.5 1.0	60.5 1.0	60.5 1.0	60.5 1.0	45
40	55.1 1.0	55.1 1.0	55.1 1.0	55.1 1.0	55.1 1.0	55.1 1.0	55.1 1.0	55.1 1.0	55.1 1.0	55.1 1.0	55.1 1.0	55.1 1.0	40
35	48.8 1.0	48.8 1.0	48.8 1.0	48.8 1.0	48.8 1.0	48.8 1.0	48.8 1.0	48.8 1.0	48.8 1.0	48.8 1.0	48.8 1.0	48.8 1.0	35
30	41.8 1.0	41.8 1.0	41.8 1.0	41.8 1.0	41.8 1.0	41.8 1.0	41.8 1.0	41.8 1.0	41.8 1.0	41.8 1.0	41.8 1.0	41.8 1.0	30
25	31.8 1.0	31.8 1.0	31.8 1.0	31.8 1.0	31.8 1.0	31.8 1.0	31.8 1.0	31.8 1.0	31.8 1.0	31.8 1.0	31.8 1.0	31.8 1.0	25
20	21.0 1.0	21.0 1.0	21.0 1.0	21.0 1.0	21.0 1.0	21.0 1.0	21.0 1.0	21.0 1.0	21.0 1.0	21.0 1.0	21.0 1.0	21.0 1.0	20
15	9.2 1.0	9.2 1.0	9.2 1.0	9.2 1.0	9.2 1.0	9.2 1.0	9.2 1.0	9.2 1.0	9.2 1.0	9.2 1.0	9.2 1.0	9.2 1.0	15
10	-3.1 1.0	-3.1 1.0	-3.1 1.0	-3.1 1.0	-3.1 1.0	-3.1 1.0	-3.1 1.0	-3.1 1.0	-3.1 1.0	-3.1 1.0	-3.1 1.0	-3.1 1.0	10
5	-15.7 1.0	-15.7 1.0	-15.7 1.0	-15.7 1.0	-15.7 1.0	-15.7 1.0	-15.7 1.0	-15.7 1.0	-15.7 1.0	-15.7 1.0	-15.7 1.0	-15.7 1.0	5
0	-27.3 1.0	-27.3 1.0	-27.3 1.0	-27.3 1.0	-27.3 1.0	-27.3 1.0	-27.3 1.0	-27.3 1.0	-27.3 1.0	-27.3 1.0	-27.3 1.0	-27.3 1.0	0

Deg.
(units: min/yr)

INCLINATION (I) WMM-90

L. LONG LAT	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG LAT
90	87:8	87:8	87:8	87:8	87:8	87:8	87:8	87:8	87:8	87:8	87:8	87:8	90
85	86:2 1:0	86:4 1:0	86:6 1:0	86:8 1:0	87:0 1:0	87:2 1:0	87:4 1:0	87:6 1:0	87:8 1:0	87:9 1:0	88:1 1:0	88:2 1:0	85
80	84:3	84:9	85:5	85:5	85:9	86:3	86:9	86:9	87:3	87:4	87:8	87:9	80
75	82:5 1:4	83:0 1:4	83:4 1:4	83:9 1:4	84:4 1:4	84:8 1:4	85:3 1:4	85:6 1:3	85:8 1:3	85:9 1:2	85:9 1:1	85:7 1:0	75
70	80:3	80:9	81:3	81:8	81:3	82:8	82:3	82:8	83:8	83:3	83:9	83:3	70
65	77:8	78:3	78:2	78:3	78:8	80:3	80:8	80:8	81:8	80:8	80:2	80:2	65
60	74:9	75:3	75:8	76:2	76:7	77:3	77:5	77:6	77:7	77:8	77:3	76:8	60
55	71:7 1:6	72:0 1:6	72:4 1:6	72:8 1:6	73:1 1:6	73:6 1:6	73:7 1:0	73:9 1:2	73:9 1:3	73:7 1:4	73:6 1:5	72:9 1:6	55
50	68:0	68:2	68:3	68:8	69:0	69:3	69:8	69:8	69:3	69:4	69:0	68:8	50
45	63:7	63:8	64:0	64:3	64:3	64:3	64:9	64:8	64:8	64:4	64:1	63:7	45
40	58:7	58:8	58:8	59:2	58:9	58:9	59:0	59:0	58:9	58:8	58:5	58:0	40
35	52:8	52:8	52:7	52:7	52:6	52:5	52:5	52:4	52:4	52:3	52:0	51:7	35
30	45:9 1:6	45:8 1:6	45:6 1:6	45:4 1:6	45:2 1:5	45:1	44:8	44:8	44:8	44:7	44:6	44:3	30
25	37:7 1:1	37:9	37:3	37:0	36:8	36:4	36:3	36:8	36:8	36:1	36:0	35:8	25
20	28:8	28:1	27:0	27:3	26:8	26:6	26:3	26:8	26:1	26:8	26:3	26:8	20
15	17:3	17:3	16:9	16:3	15:8	15:3	15:0	14:8	14:0	14:3	13:6	13:6	15
10	5:8	5:1	3:2	6:8	3:8	2:4	3:0	3:0	3:1	3:4	3:6	4:8	10
5	-6:4	-6:8	-7:1	-7:8	-8:4	-8:9	-9:1	-9:2	-8:9	-8:8	-7:8	-7:4	5
0	-18:4 3:7	-18:6 1:7	-19:0 3:0	-19:6 1:7	-20:2 3:7	-20:6	-20:9	-20:8	-20:9	-19:9	-19:3	-18:7 1:8	0
LAT													LAT
L. LONG	60	65	70	75	80	85	90	95	100	105	110	115	L. LONG

INCLINATION (I) WMM-90

E. LONG LAT	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG LAT
90	87:8	87:8	87:8	87:8	87:8	87:8	87:8	87:8	87:8	87:8	87:8	87:8	90
85	88:4	88:4	88:5	88:5	88:5	88:5	88:5	88:5	88:5	88:5	88:5	88:5	85
80	87:4	87:2	87:4	86:2	86:2	86:2	86:0	85:8	85:6	85:4	85:4	85:4	80
75	85:3	84:9	84:5	84:0	83:6	83:0	82:8	82:6	82:0	82:0	81:8	81:8	75
70	82:2	81:1	81:3	80:9	80:3	79:2	79:2	78:2	78:4	78:2	77:9	77:5	70
65	79:9	78:8	78:3	77:4	76:9	75:8	75:3	74:8	74:3	74:0	73:8	73:5	65
60	76:3	75:3	74:3	73:6	73:2	72:9	71:8	70:8	70:3	69:8	69:6	69:6	60
55	73:2	72:6	71:8	70:3	69:6	68:5	67:8	66:3	65:8	65:3	65:3	65:4	55
50	69:8	68:0	66:0	65:3	64:2	63:3	62:5	61:8	61:3	61:0	61:0	61:1	50
45	62:9	62:3	61:8	60:3	59:2	58:3	57:3	56:8	56:6	56:3	56:0	56:2	45
40	57:4	56:6	55:2	54:2	53:8	52:9	52:2	51:2	51:5	51:3	51:2	52:2	40
35	51:8	50:9	49:3	48:6	47:3	46:8	46:0	46:0	45:8	46:2	46:1	47:9	35
30	42:8	43:2	43:3	43:5	42:8	42:0	41:5	40:8	39:2	40:3	41:1	42:2	30
25	33:5	34:9	34:3	33:3	32:8	32:4	32:6	32:3	32:8	33:2	34:9	36:6	25
20	29:0	28:9	28:4	26:4	25:8	25:2	25:0	24:3	23:0	26:3	28:8	29:3	20
15	13:8	13:3	14:8	15:4	15:2	14:1	14:4	14:1	14:3	17:8	19:8	21:9	15
10	4:2	4:1	3:3	3:0	3:0	3:8	4:2	5:3	6:9	8:2	10:9	13:2	10
5	7:3	7:1	7:8	7:1	6:9	6:8	5:2	4:1	3:9	1:8	1:8	3:3	5
0	10:3	10:0	10:9	10:6	10:6	10:6	10:3	10:3	10:3	10:3	10:3	10:3	0
LAT													LAT
E. LONG	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG

INCLINATION (I) WMM-90

[illegible]

INCLINATION (I) WMM-90

L. LONG LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG LAT
90	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	90
85	89.1	89.1	89.1	89.1	89.1	89.1	89.1	89.1	89.1	89.1	89.1	89.1	85
80	88.7	88.7	88.7	88.7	88.7	88.7	88.7	88.7	88.7	88.7	88.7	88.7	80
75	87.0	87.7	88.4	89.0	89.6	89.9	89.9	89.6	89.9	89.9	89.6	89.9	75
70	84.9	85.7	86.5	87.2	87.8	88.1	88.1	87.8	88.1	88.1	87.8	88.1	70
65	82.3	83.3	84.2	85.0	85.6	85.8	85.7	85.2	85.6	85.6	85.2	85.8	65
60	79.3	80.3	81.2	82.1	82.8	83.2	83.2	82.8	83.2	83.2	82.8	83.2	60
55	75.9	76.8	77.6	78.4	79.1	79.4	79.3	78.8	79.1	79.4	78.8	79.4	55
50	72.1	73.2	74.3	75.2	76.0	76.4	76.3	75.8	76.0	76.4	75.8	76.4	50
45	68.2	69.3	70.3	71.2	72.1	72.6	72.5	71.9	72.1	72.6	71.9	72.6	45
40	64.0	65.1	66.0	66.9	67.8	68.3	68.2	67.6	67.8	68.3	67.6	68.3	40
35	59.6	60.7	61.7	62.6	63.5	64.0	63.9	63.3	63.5	64.0	63.3	64.0	35
30	54.8	55.8	56.8	57.7	58.6	59.1	59.0	58.4	58.6	59.1	58.4	59.1	30
25	49.0	50.0	51.0	51.9	52.8	53.3	53.2	52.6	52.8	53.3	52.6	53.3	25
20	43.3	44.3	45.3	46.2	47.2	47.7	47.6	47.0	47.2	47.7	47.0	47.7	20
15	36.0	37.0	38.0	39.0	40.0	40.5	40.4	39.8	40.0	40.5	39.8	40.5	15
10	27.7	28.7	29.7	30.7	31.7	32.2	32.1	31.5	31.7	32.2	31.5	32.2	10
5	18.9	19.9	20.9	21.9	22.9	23.4	23.3	22.7	22.9	23.4	22.7	23.4	5
0	9.7	10.7	11.7	12.7	13.7	14.2	14.1	13.5	13.7	14.2	13.5	14.2	0
L. LONG LAT	240	245	250	255	260	265	270	275	280	285	290	295	L. LONG LAT

INCLINATION (I) WMM-90

L. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG LAT
90	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	90
85	86.7	86.5	86.3	86.1	86.0	85.8	85.7	85.6	85.4	85.4	85.3	85.2	85
80	85.6	85.2	84.8	84.4	84.1	83.8	83.6	83.4	83.2	83.0	82.8	82.8	80
75	84.3	83.7	83.2	82.7	82.3	81.9	81.5	81.3	80.9	80.7	80.6	80.4	75
70	82.8	82.3	81.4	80.8	80.3	79.7	79.3	78.9	78.6	78.4	78.3	78.0	70
65	80.9	80.1	79.3	78.5	77.9	77.3	76.8	76.4	76.1	75.8	75.6	75.3	65
60	78.6	77.6	76.9	75.9	75.1	74.5	73.8	73.3	73.1	72.8	72.6	72.4	60
55	75.8	74.7	73.7	72.8	71.9	71.3	70.6	70.1	69.7	69.4	69.2	69.1	55
50	73.8	71.5	70.3	69.3	68.3	67.3	66.8	66.3	65.8	65.6	65.3	65.3	50
45	69.8	67.8	66.6	65.3	64.3	63.3	63.4	63.7	63.3	63.0	62.6	62.3	45
40	65.3	63.9	62.4	61.0	59.6	58.5	57.4	56.6	55.9	55.4	55.1	55.0	40
35	61.3	59.6	57.9	56.2	54.5	53.0	51.7	50.6	49.7	49.0	48.8	48.5	35
30	56.9	55.0	53.0	50.9	48.9	48.0	45.2	43.6	43.4	41.5	40.9	40.7	30
25	52.8	50.1	47.1	45.1	43.2	41.9	39.5	38.6	37.9	36.7	36.1	35.8	25
20	47.8	44.9	41.8	38.7	35.4	32.3	29.1	28.4	26.3	26.0	25.9	25.1	20
15	41.2	38.8	35.3	31.9	28.4	25.1	21.9	18.1	13.3	11.4	10.1	9.4	15
10	34.8	31.8	28.3	23.7	19.9	17.3	16.7	15.2	13.2	11.3	10.9	10.0	10
5	27.7	24.4	20.2	15.3	10.9	6.5	1.8	1.0	1.2	1.6	1.4	1.2	5
0	19.8	16.3	11.8	6.3	2.7	2.0	1.0	1.7	1.8	1.9	1.1	1.0	0
L. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG LAT

INCLINATION (I) WMM-90

E. LONG LAT	0	5	10	15	20	25	30	35	40	45	50	55	E. LONG LAT
0	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	0
5	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	5
10	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	10
15	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	15
20	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	20
25	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	25
30	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	30
35	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	35
40	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	40
45	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	45
50	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	50
55	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	55
60	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	60
65	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	65
70	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	70
75	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	75
80	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	80
85	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	85
90	8°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	9°22'	90

INCLINATION (I) WMM-90

E. LONG LAT	60	65	70	75	80	85	90	95	100	105	110	115	E. LONG LAT
0	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	0
-5	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-5
-10	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-10
-15	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-15
-20	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-20
-25	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-25
-30	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-30
-35	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-35
-40	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-40
-45	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-45
-50	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-50
-55	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-55
-60	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-60
-65	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-65
-70	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-70
-75	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-75
-80	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-80
-85	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-85
-90	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-18.4	-90
E. LONG LAT	60	65	70	75	80	85	90	95	100	105	110	115	E. LONG LAT

INCLINATION (I) WMM-90

L. LONG LAT	120	125	130	135	140	145	150	155	160	165	170	175	L. LONG LAT
0	-18.3	-18.0	-12.8	-12.6	-17.3	-16.6	-15.7	-14.5	-13.0	-11.1	-8.9	-6.6	0
-5	-28.3	-27.8	-23.8	-22.5	-27.0	-26.3	-25.3	-24.1	-22.1	-20.8	-18.3	-16.8	-5
-10	-37.2	-36.8	-32.8	-31.5	-35.8	-35.1	-34.2	-33.1	-31.2	-30.2	-28.4	-26.5	-10
-15	-45.8	-45.3	-41.3	-40.0	-44.3	-43.6	-42.2	-41.2	-39.3	-38.6	-37.0	-35.4	-15
-20	-52.9	-52.4	-48.4	-47.1	-51.7	-50.9	-49.3	-48.4	-47.3	-46.0	-44.7	-43.3	-20
-25	-59.1	-58.6	-54.6	-53.3	-57.8	-56.3	-55.5	-54.7	-53.1	-51.5	-51.4	-50.0	-25
-30	-64.5	-64.0	-60.0	-58.8	-62.4	-61.7	-61.0	-60.2	-58.1	-56.3	-57.1	-56.8	-30
-35	-69.3	-68.8	-64.8	-63.5	-67.2	-66.5	-65.8	-65.0	-64.1	-63.2	-62.1	-61.0	-35
-40	-73.5	-73.1	-69.1	-67.8	-71.3	-70.9	-70.3	-69.3	-68.4	-67.5	-66.5	-65.4	-40
-45	-77.3	-77.1	-73.1	-71.8	-75.3	-74.8	-74.0	-73.2	-72.2	-71.3	-70.3	-69.3	-45
-50	-80.7	-80.7	-76.7	-75.4	-78.9	-78.3	-77.7	-76.7	-75.8	-74.8	-73.8	-72.8	-50
-55	-83.4	-83.9	-79.9	-78.5	-82.9	-82.1	-81.3	-80.1	-79.1	-78.1	-77.1	-76.1	-55
-60	-85.0	-86.2	-82.2	-80.9	-84.9	-83.5	-82.5	-81.4	-80.3	-79.3	-78.3	-77.2	-60
-65	-86.4	-88.1	-84.1	-82.8	-86.7	-85.4	-84.2	-83.0	-81.9	-80.8	-79.7	-78.7	-65
-70	-87.8	-90.1	-86.1	-84.8	-88.5	-87.2	-86.0	-84.8	-83.7	-82.6	-81.5	-80.5	-70
-75	-89.0	-92.3	-88.3	-87.0	-90.5	-89.3	-88.1	-86.9	-85.8	-84.7	-83.6	-82.6	-75
-80	-90.1	-94.6	-90.6	-89.3	-92.7	-91.5	-90.3	-89.1	-88.0	-86.9	-85.8	-84.8	-80
-85	-91.3	-96.8	-92.8	-91.5	-94.9	-93.7	-92.5	-91.3	-90.2	-89.1	-88.0	-87.0	-85
-90	-92.5	-98.0	-94.0	-92.7	-96.1	-94.9	-93.7	-92.5	-91.4	-90.3	-89.2	-88.2	-90
LAT	L. LONG	120	125	130	135	140	145	150	155	160	165	170	L. LONG LAT

INCLINATION (I) WMM-90

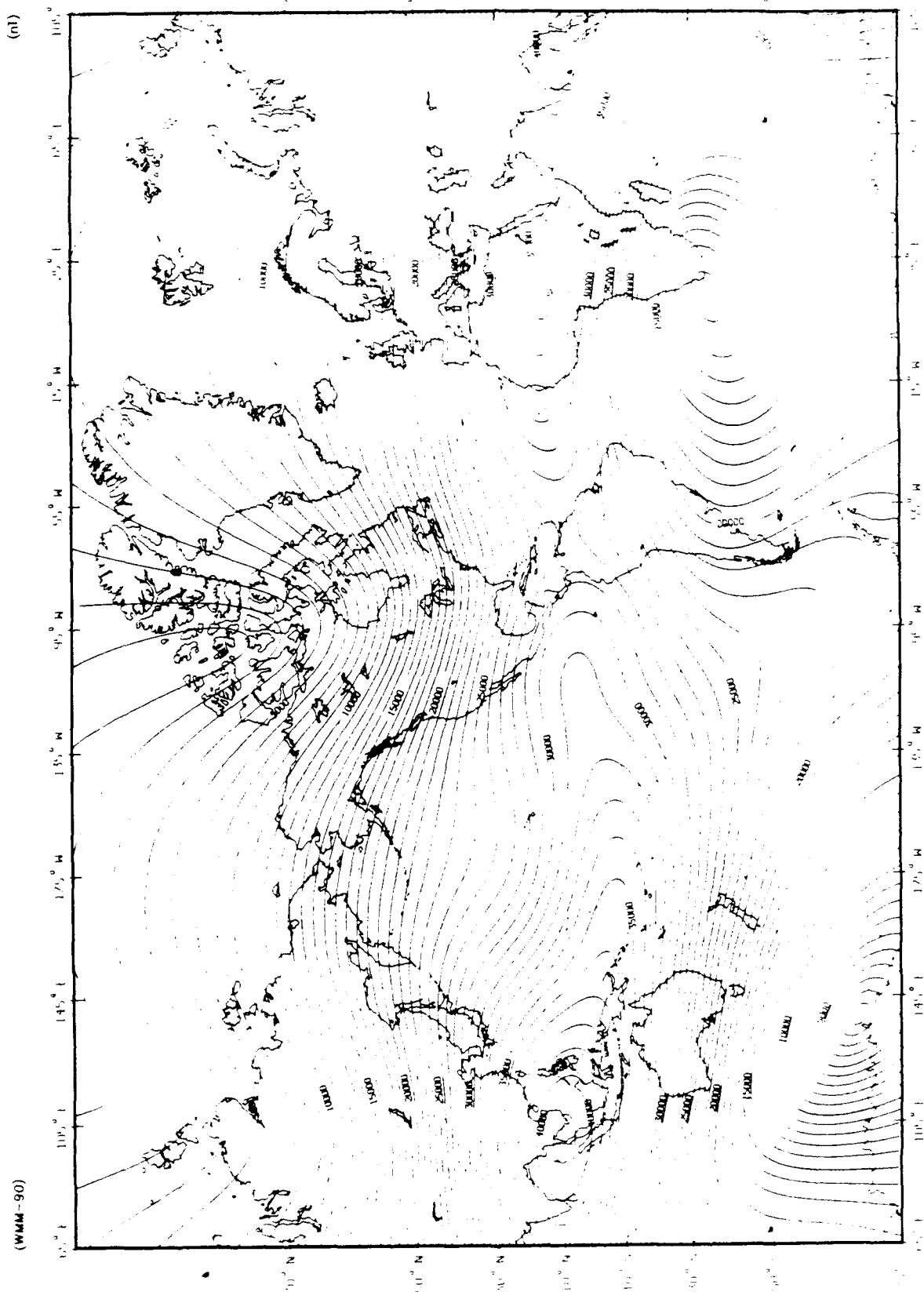
E. LONG LAT	180	185	190	195	200	205	210	215	220	225	230	235	E. LONG LAT
0	-3.9	-2.9	-1.9	-2.7	-1.7	-2.7	-3.6	-4.6	-5.5	-6.4	-7.3	-8.2	0
-5	-14.7	-13.8	-11.3	-9.9	-8.2	-7.7	-6.7	-5.7	-4.7	-3.7	-2.7	-1.7	-5
-10	-24.6	-22.9	-21.4	-20.9	-18.9	-17.8	-16.8	-15.8	-14.7	-13.6	-12.5	-11.4	-10
-15	-33.7	-32.2	-30.7	-29.8	-28.4	-27.3	-26.2	-25.1	-24.0	-22.8	-21.7	-20.6	-15
-20	-41.8	-40.4	-39.1	-37.9	-36.7	-35.7	-34.6	-33.5	-32.3	-31.2	-30.1	-28.9	-20
-25	-49.9	-47.5	-46.3	-45.1	-44.0	-42.9	-41.8	-40.8	-39.7	-38.6	-37.5	-36.4	-25
-30	-54.8	-53.6	-52.4	-51.3	-50.3	-49.2	-48.2	-47.2	-46.1	-45.0	-44.0	-42.9	-30
-35	-59.9	-58.9	-57.7	-56.7	-55.7	-54.7	-53.7	-52.7	-51.8	-50.7	-49.8	-48.8	-35
-40	-64.4	-63.3	-62.3	-61.3	-60.3	-59.3	-58.3	-57.3	-56.2	-55.2	-54.2	-53.2	-40
-45	-68.9	-67.7	-66.6	-65.6	-64.5	-63.5	-62.5	-61.5	-60.5	-59.5	-58.5	-57.5	-45
-50	-71.9	-70.9	-70.0	-69.1	-68.2	-67.2	-66.3	-65.3	-64.2	-63.2	-62.2	-61.2	-50
-55	-75.2	-74.2	-73.3	-72.4	-71.6	-70.7	-69.8	-68.9	-68.0	-67.0	-66.0	-65.0	-55
-60	-78.3	-77.3	-76.3	-75.4	-74.6	-73.7	-72.8	-71.9	-70.9	-69.9	-68.8	-67.8	-60
-65	-80.8	-79.8	-78.9	-78.0	-77.1	-76.2	-75.3	-74.4	-73.3	-72.3	-71.2	-70.2	-65
-70	-82.3	-81.3	-80.3	-79.4	-78.5	-77.6	-76.8	-75.9	-74.9	-73.9	-72.8	-71.7	-70
-75	-84.8	-83.8	-82.8	-81.9	-80.9	-79.9	-79.1	-78.2	-77.2	-76.2	-75.1	-74.1	-75
-80	-89.9	-88.9	-87.9	-87.0	-86.0	-85.0	-84.1	-83.2	-82.2	-81.2	-80.1	-79.1	-80
-85	-94.4	-93.4	-92.4	-91.4	-90.4	-89.4	-88.5	-87.5	-86.5	-85.5	-84.4	-83.4	-85
-90	-99.9	-98.9	-97.9	-96.9	-95.9	-94.9	-93.9	-92.9	-91.8	-90.8	-89.7	-88.7	-90
E. LONG LAT	180	185	190	195	200	205	210	215	220	225	230	235	E. LONG LAT

INCLINATION (I) WMM-90

E. LONG LAT	240	245	250	255	260	265	270	275	280	285	290	295	I. LONG LAT
0	2:3	19:4	18:8	18:3	18:8	18:8	18:8	2:7	2:1	2:3	2:3	2:3	0
-5	5:8	8:3	16:0	10:1	8:8	8:8	14:1	12:1	14:1	15:0	14:8	13:7	-5
-10	10:4	9:2	10:8	6:1	10:1	8:8	7:4	2:8	4:8	5:2	5:8	4:6	-10
-15	19:5	18:4	17:1	15:5	15:8	15:8	9:2	6:8	5:1	3:8	3:9	4:0	-15
-20	27:8	26:8	25:8	24:2	23:8	23:8	18:8	14:1	14:2	13:8	13:8	13:8	-20
-25	33:4	34:8	33:4	31:8	30:8	28:8	26:8	24:2	22:2	21:2	20:2	21:3	-25
-30	42:0	40:8	39:8	38:4	36:8	35:8	33:4	31:5	29:6	28:5	27:5	28:2	-30
-35	47:7	46:8	45:4	44:0	42:5	40:8	39:1	37:4	35:8	34:5	33:4	34:5	-35
-40	52:6	51:4	50:1	48:7	47:2	45:5	43:8	42:2	40:7	39:8	38:8	38:8	-40
-45	56:8	55:8	54:1	53:7	51:8	49:4	47:8	46:8	44:8	43:7	43:0	43:8	-45
-50	60:4	59:0	57:6	56:1	54:5	52:8	51:3	49:8	48:5	47:5	46:8	46:6	-50
-55	63:4	62:1	60:8	59:1	57:5	55:8	54:0	53:5	51:5	51:1	50:5	50:8	-55
-60	66:8	64:8	63:0	61:0	59:8	57:5	56:2	54:7	53:6	52:4	51:2	51:8	-60
-65	68:8	67:8	66:0	64:8	63:8	62:2	60:3	58:7	57:1	55:8	54:2	53:3	-65
-70	70:1	69:6	68:2	67:1	66:1	65:0	63:4	61:8	60:3	58:8	57:0	56:1	-70
-75	72:3	71:4	70:8	69:7	68:8	67:8	66:0	64:7	63:0	61:0	59:7	58:1	-75
-80	73:8	73:8	72:4	71:6	70:8	70:5	69:8	69:4	68:0	66:6	65:8	64:9	-80
-85	73:7	73:4	72:7	72:8	72:5	72:2	71:8	71:6	71:4	71:1	70:9	70:7	-85
-90	73:3	73:2	73:2	73:2	73:2	73:2	73:2	73:2	73:2	73:2	73:2	73:2	-90

INCLINATION (I) WMM-90

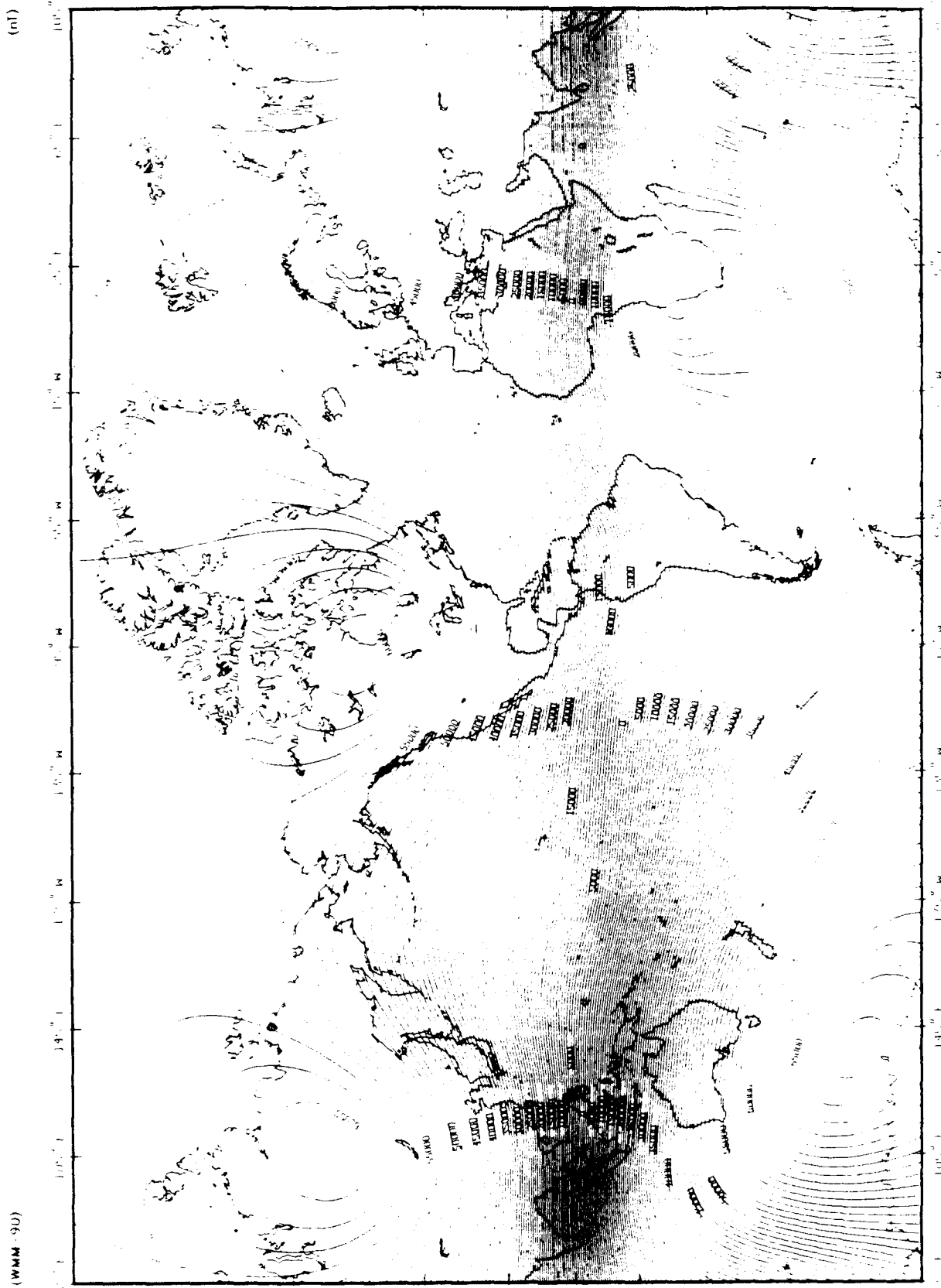
L. LONG LAT	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG LAT
0	-12:7	-15:3	-18:8	-20:3	-21:0	-20:2	-19:2	-15:7	-19:8	-22:8	-25:1	-26:5	0
-5	-12:6	-16:4	-18:0	-20:5	-21:4	-21:3	-20:3	-14:8	-22:3	-24:3	-27:8	-28:3	-5
-10	-12:5	-16:3	-18:5	-20:3	-21:2	-21:0	-20:0	-16:8	-22:8	-24:7	-27:6	-28:5	-10
-15	-12:4	-16:2	-18:4	-20:2	-21:1	-20:8	-19:8	-18:2	-22:7	-24:6	-27:5	-28:4	-15
-20	-12:3	-16:1	-18:3	-20:1	-21:0	-20:8	-19:7	-18:1	-22:6	-24:5	-27:4	-28:3	-20
-25	-12:2	-16:0	-18:2	-20:0	-20:9	-20:7	-19:6	-18:0	-22:5	-24:4	-27:3	-28:2	-25
-30	-12:1	-15:5	-18:1	-19:9	-20:8	-20:6	-19:5	-17:9	-22:4	-24:3	-27:2	-28:1	-30
-35	-12:0	-15:4	-18:0	-19:8	-20:7	-20:5	-19:4	-17:8	-22:3	-24:2	-27:1	-28:0	-35
-40	-11:59	-15:3	-17:59	-19:7	-20:6	-20:4	-19:3	-17:7	-22:2	-24:1	-27:0	-27:59	-40
-45	-11:58	-15:2	-17:58	-19:6	-20:5	-20:3	-19:2	-17:6	-22:1	-24:0	-26:59	-27:58	-45
-50	-11:57	-15:1	-17:57	-19:5	-20:4	-20:2	-19:1	-17:5	-22:0	-23:59	-26:58	-27:57	-50
-55	-11:56	-15:0	-17:56	-19:4	-20:3	-20:1	-19:0	-17:4	-21:59	-23:58	-26:57	-27:56	-55
-60	-11:55	-14:59	-17:55	-19:3	-20:2	-20:0	-18:59	-17:3	-21:58	-23:57	-26:56	-27:55	-60
-65	-11:54	-14:58	-17:54	-19:2	-20:1	-19:59	-18:58	-17:2	-21:57	-23:56	-26:55	-27:54	-65
-70	-11:53	-14:57	-17:53	-19:1	-20:0	-19:58	-18:57	-17:1	-21:56	-23:55	-26:54	-27:53	-70
-75	-11:52	-14:56	-17:52	-19:0	-19:59	-19:57	-18:56	-17:0	-21:55	-23:54	-26:53	-27:52	-75
-80	-11:51	-14:55	-17:51	-18:59	-19:58	-19:56	-18:55	-16:59	-21:54	-23:53	-26:52	-27:51	-80
-85	-11:50	-14:54	-17:50	-18:58	-19:57	-19:55	-18:54	-16:58	-21:53	-23:52	-26:51	-27:50	-85
-90	-11:49	-14:53	-17:49	-18:57	-19:56	-19:54	-18:53	-16:57	-21:52	-23:51	-26:50	-27:49	-90
LAT													LAT
L. LONG	300	305	310	315	320	325	330	335	340	345	350	355	L. LONG



1930 U of surface of WGS 84 reference ellipsoid

U.S. NAVAL OCEANOGRAPHIC OFFICE

CHART 8. HORIZONTAL INTENSITY (11)

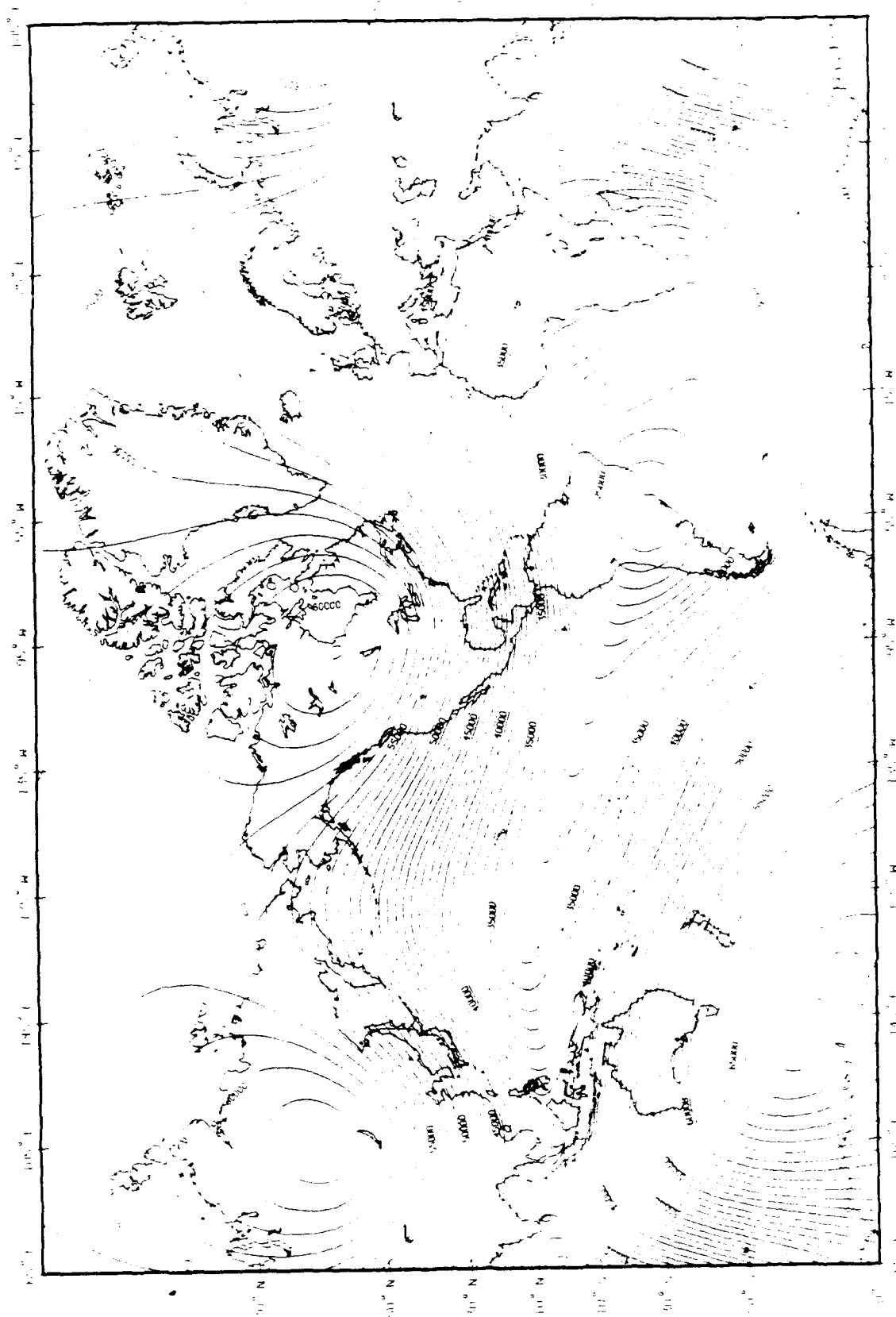


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CHART 9. VERTICAL COMPONENT (Z)

(nl)

(WMM 90)



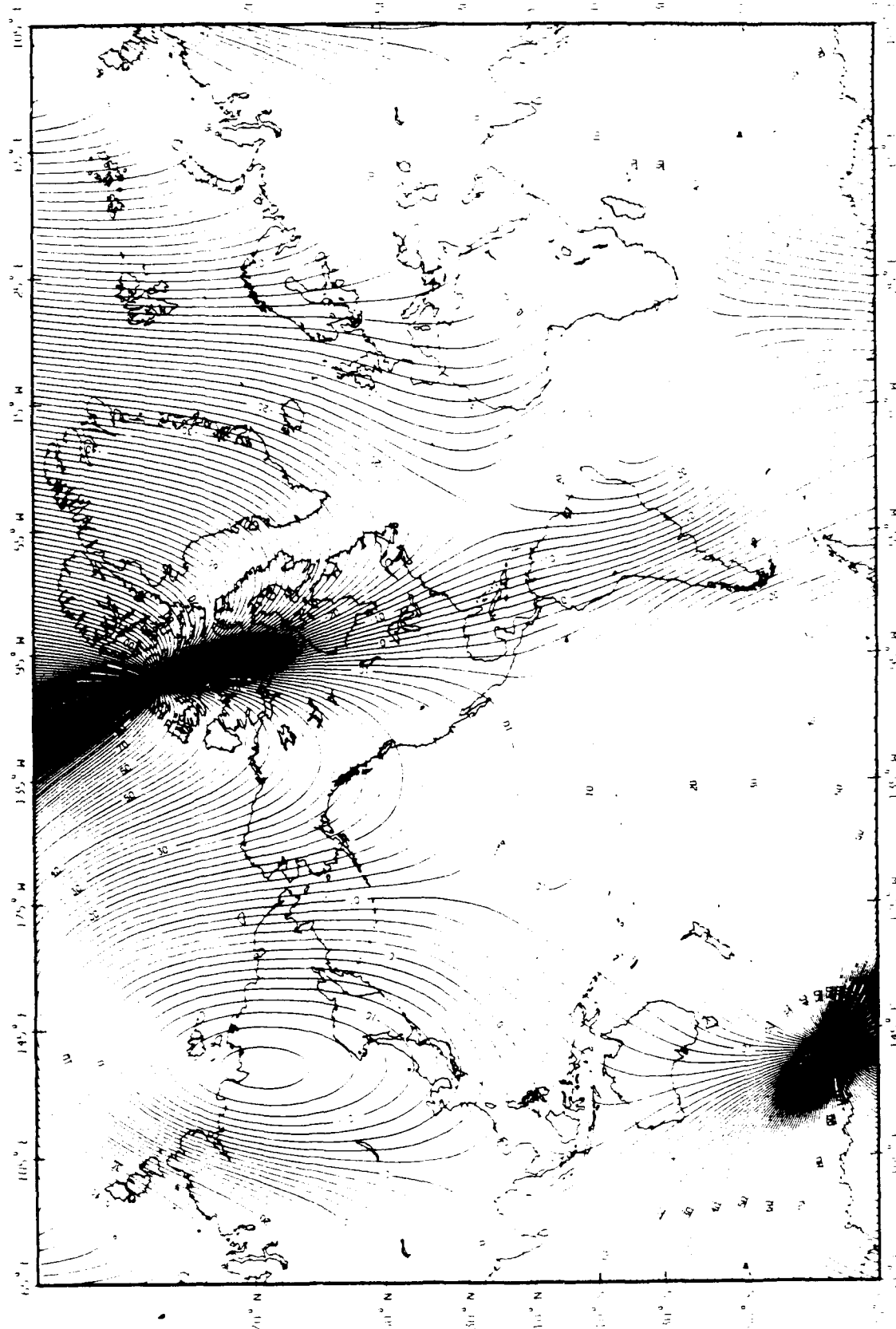
1940.0 at surface of WGS 84 reference ellipsoid

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CHART 10. TOTAL INTENSITY (F)

(WMM-90)

(degrees)



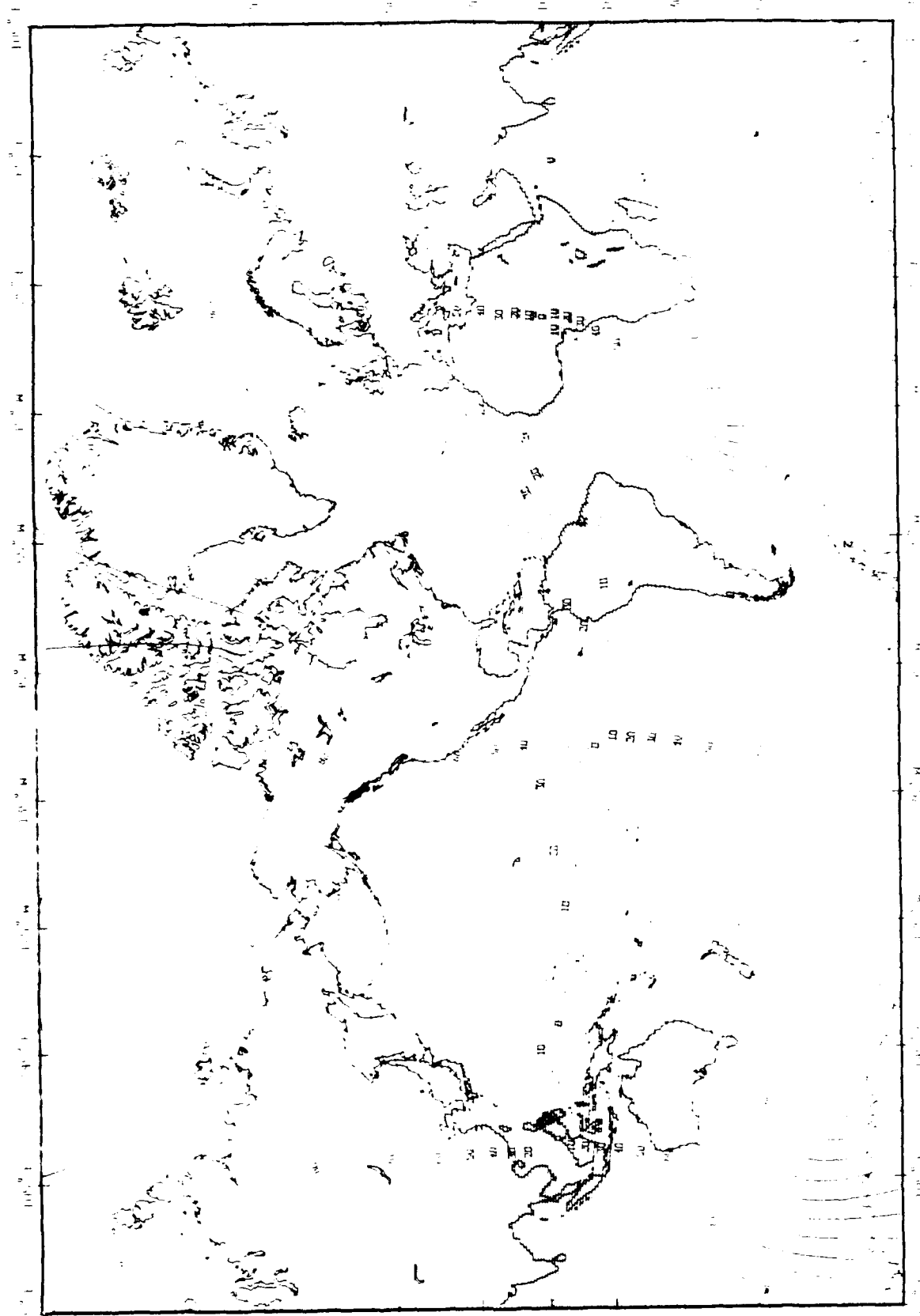
1930.0 at surface of WGS-84 reference ellipsoid

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CHART 11. DECLINATION (D)

(degrees)

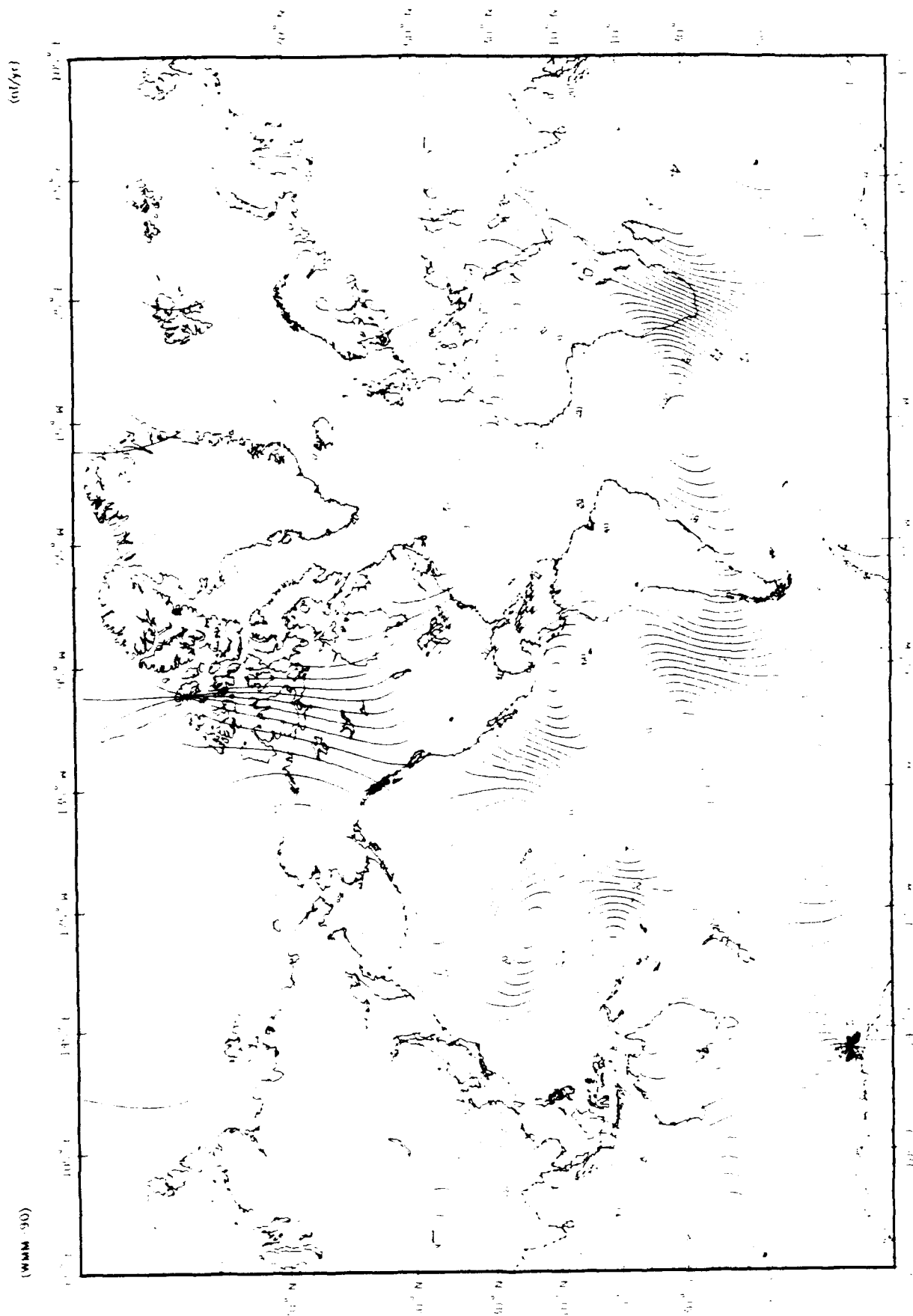
(WMM 90)



1990.0 of surface of WGS-84 reference ellipsoid

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CHART 12. INCLINATION (I)

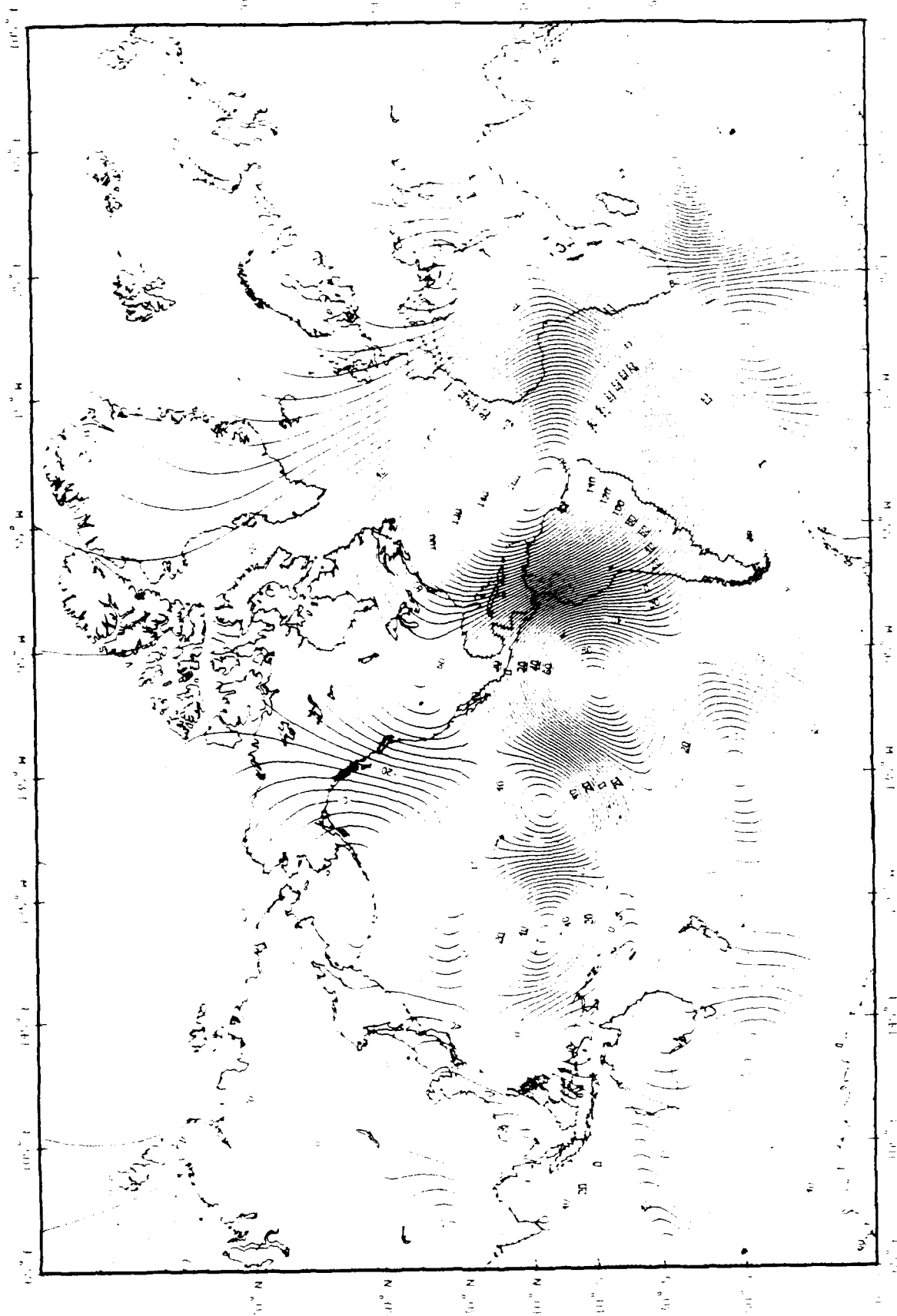


U.S. NAVAL GEOGRAPHIC OFFICE

CHART 13. HORIZONTAL INTENSITY (H)

(ml/yr)

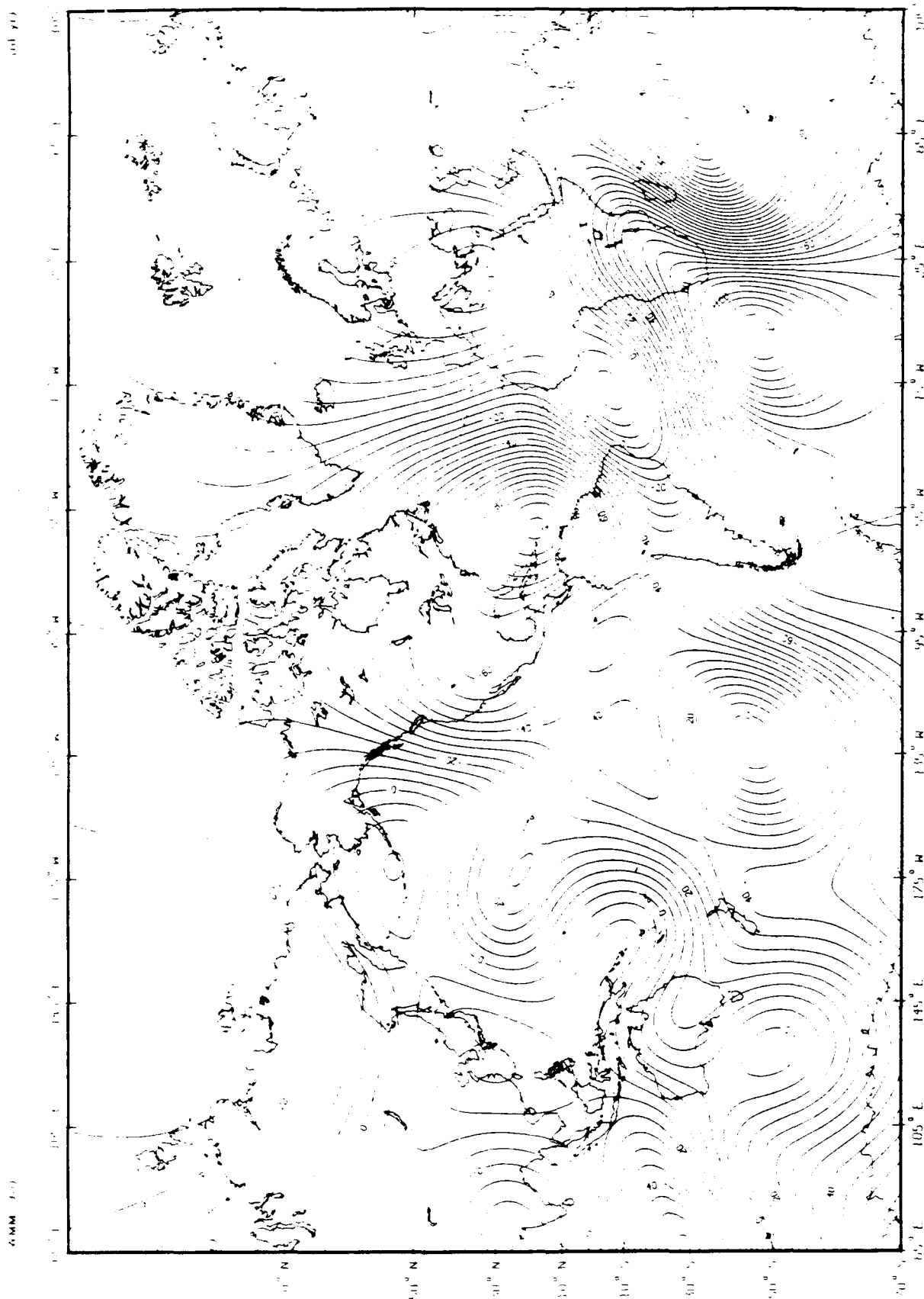
(WMM 90)



1990 0 of surface of WGS 84 reference ellipsoid

U.S. NAVAL HYDROGRAPHIC OFFICE

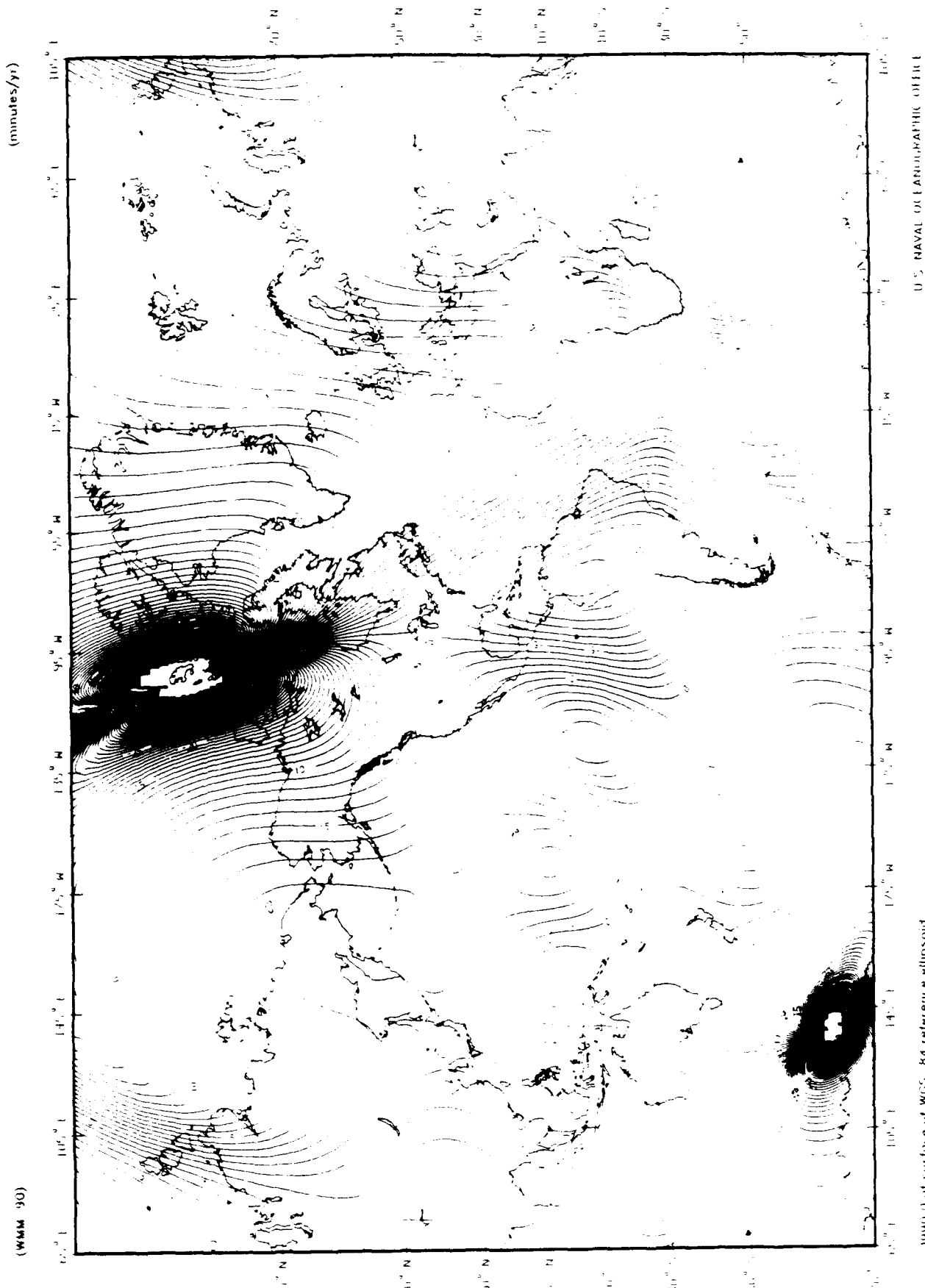
CHART 14 VERTICAL COMPONENT (Z)

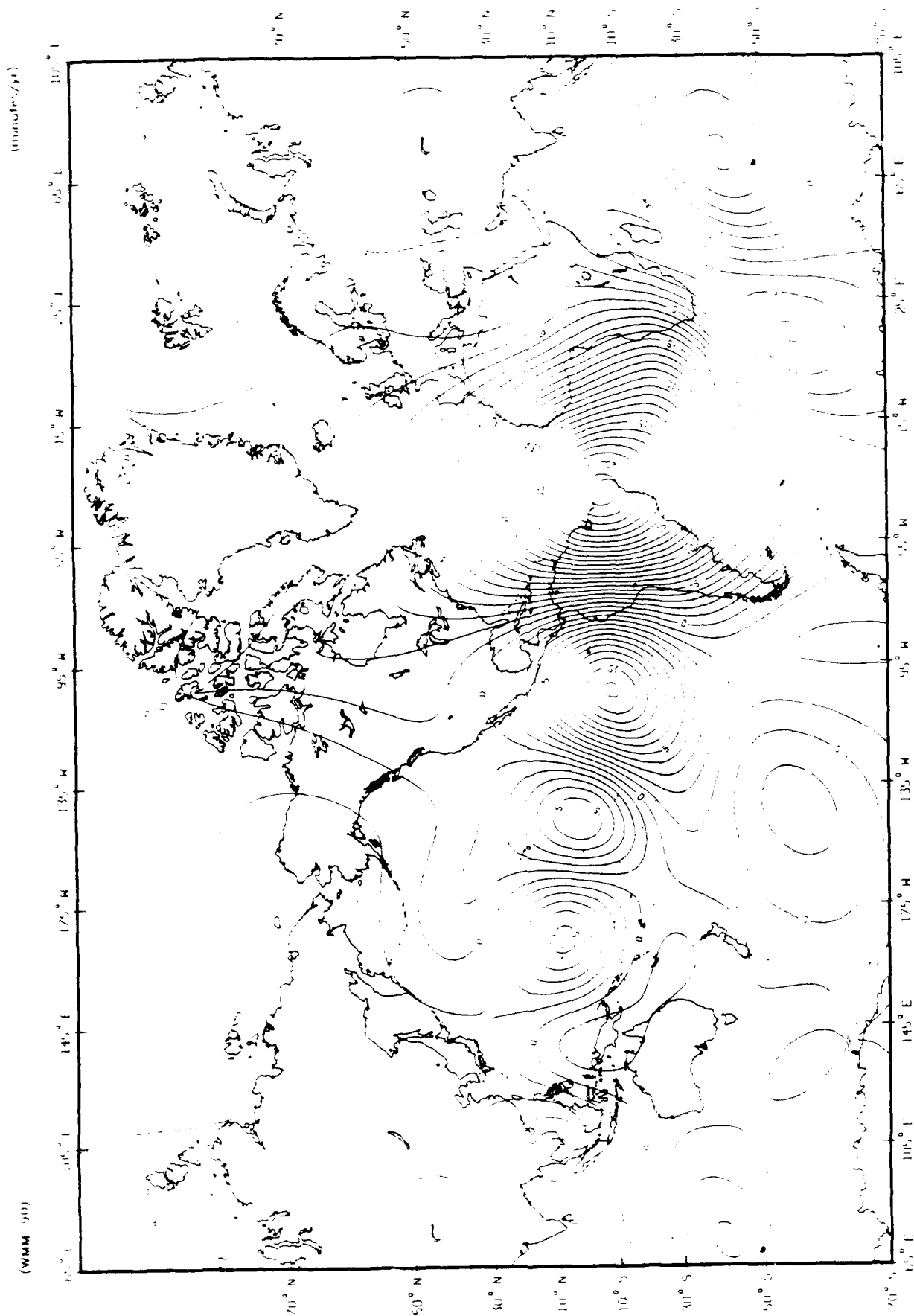


U.S. NAVAL OCEANOGRAPHIC OFFICE

CHART 15. TOTAL INTENSITY (I)

1990.0 of surface of WGS-84 reference ellipsoid.



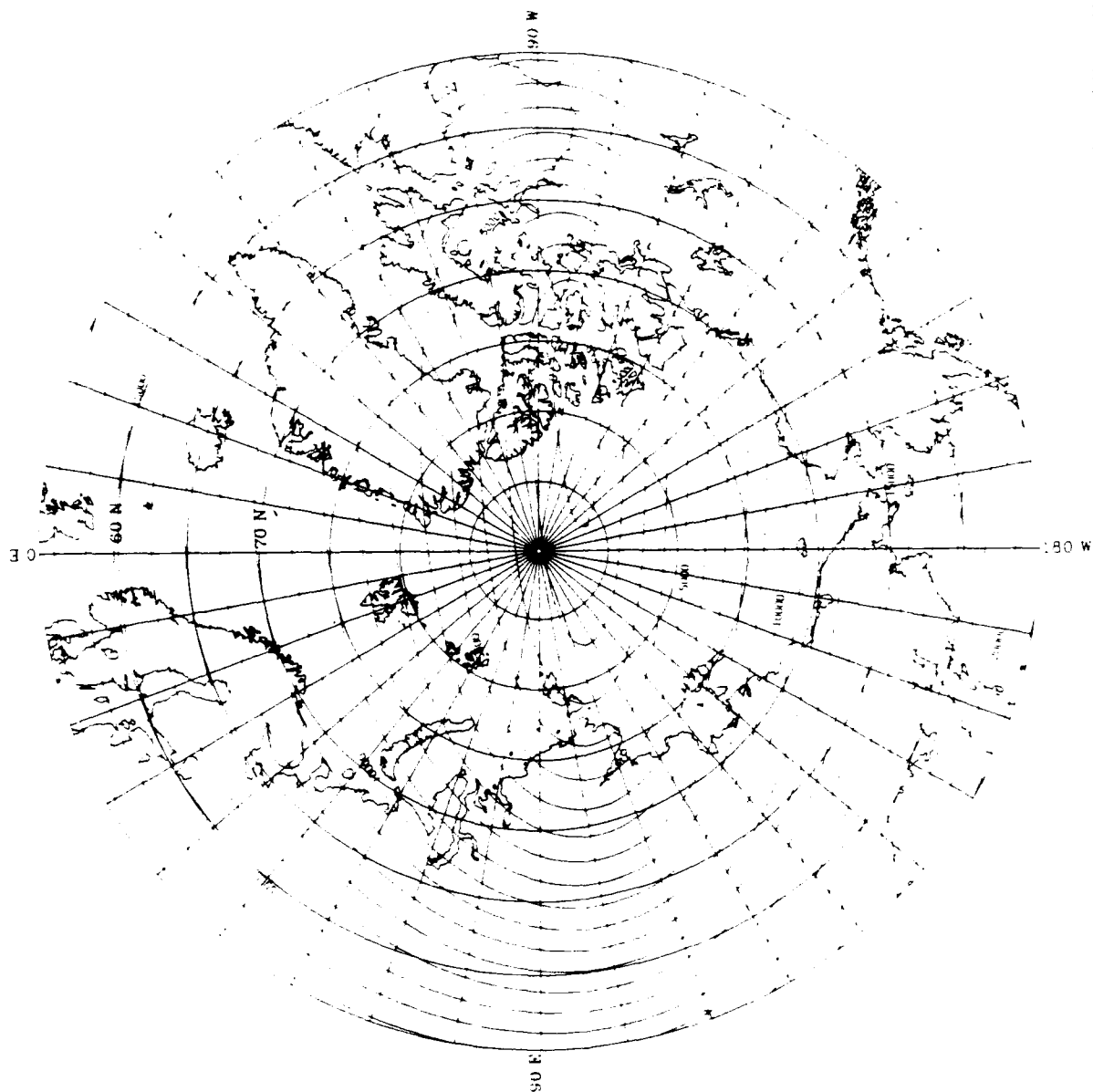


1990.0 at surface of WGS-84 reference ellipsoid.

U.S. NAVAL OCEANOGRAPHIC OFFICE

CHART 17. INCLINATION (I)

(m)



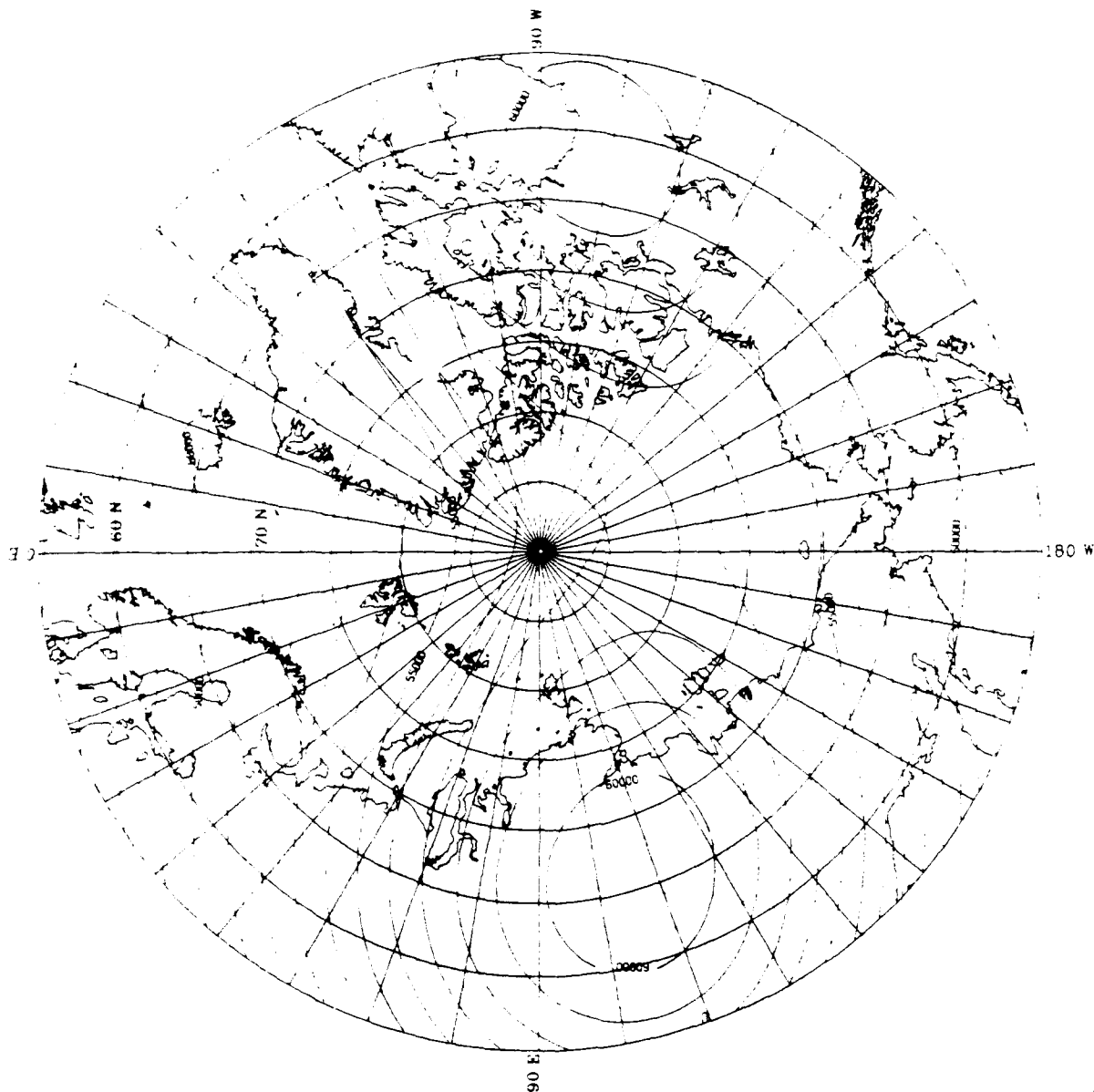
(WMM 90)

U.S. NAVAL HYDROGRAPHIC OFFICE

1990.0 at Surface of WGS 84 reference ellipsoid

CHART 18. HORIZONTAL INTENSITY (I)

(a)



(WMM-90)

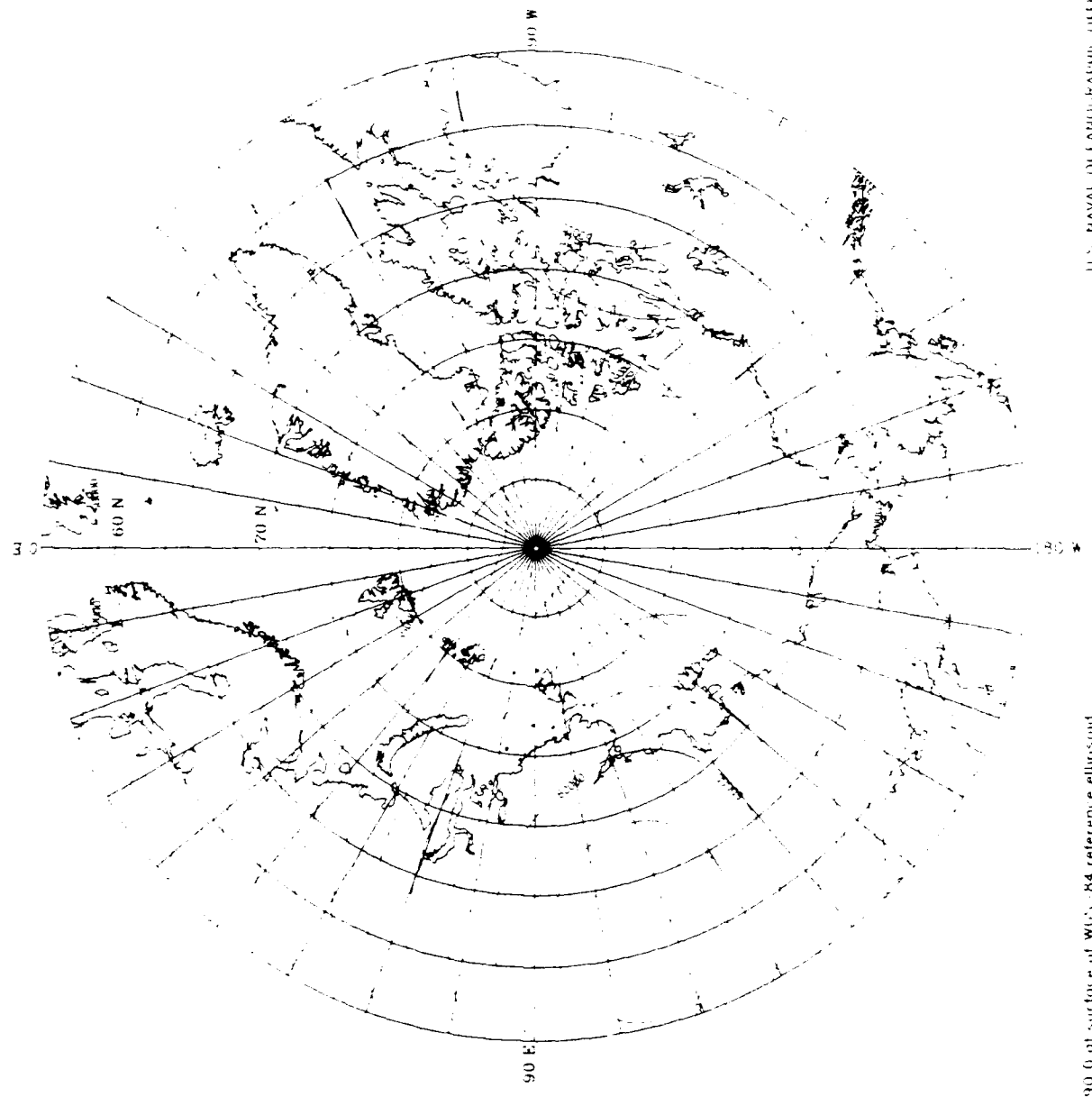
U.S. NAVAL OCEANOGRAPHIC OFFICE

1990.0 at surface of WGS-84 reference ellipsoid

CHART 19. VERTICAL COMPONENT (Z)

(oil)

(WMM-90)

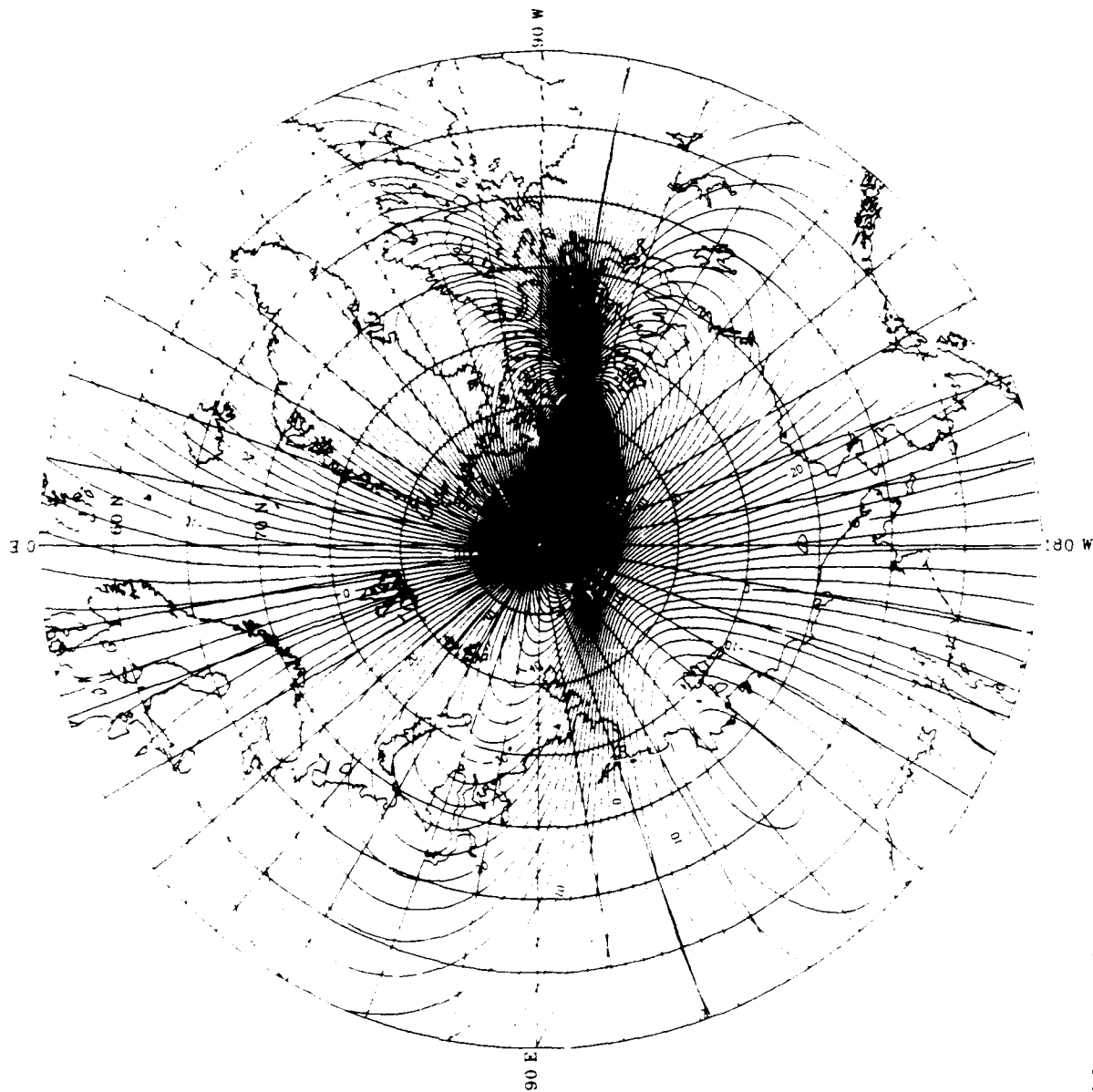


U.S. NAVAL OCEANOGRAPHIC OFFICE

1990 6 of surface of WGS-84 reference ellipsoid

CHART 20. TOTAL INTENSITY (I)

(degrees)

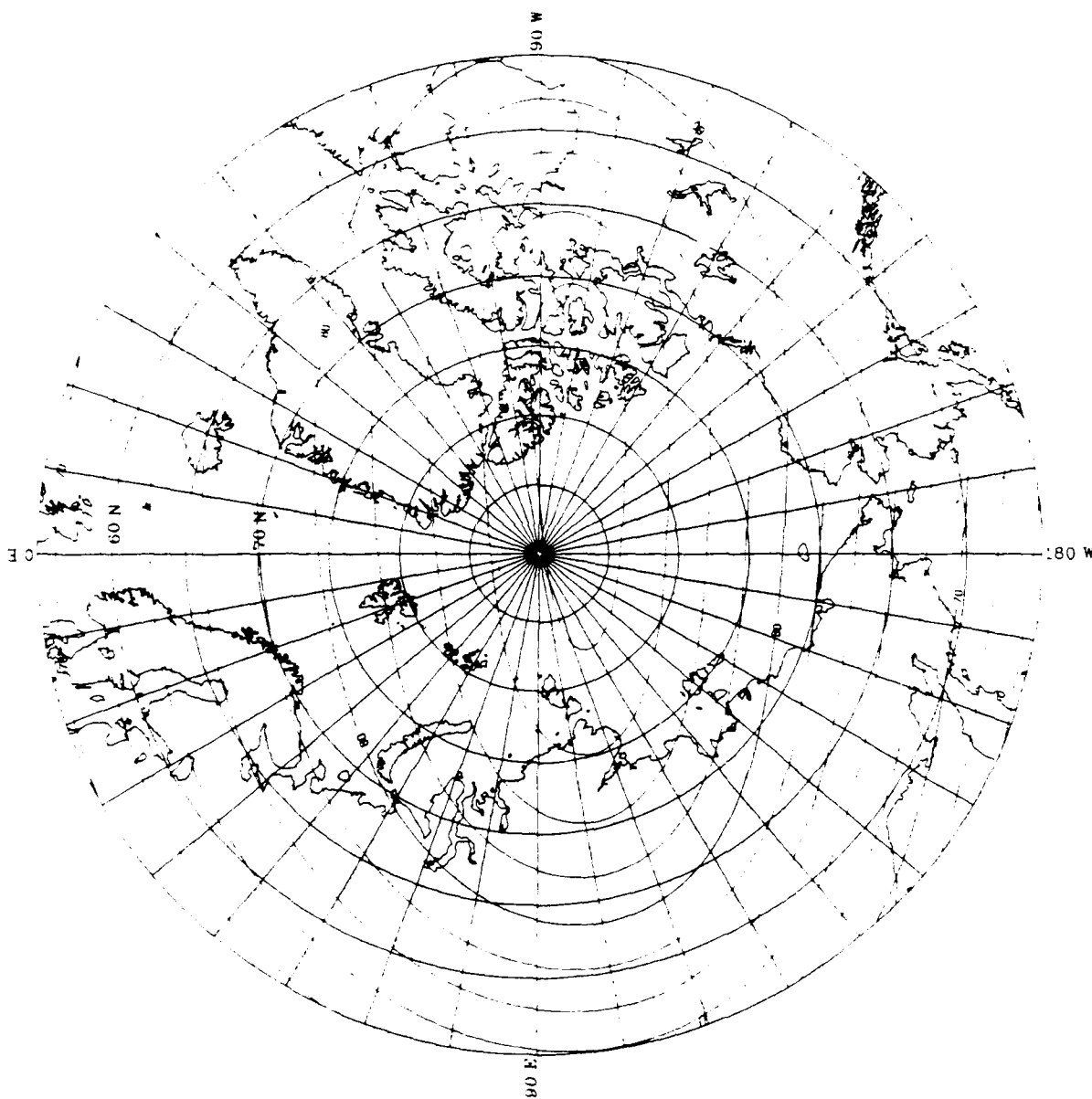


U.S. NAVAL OCEANOGRAPHIC OFFICE

CHART 21. DECLINATION (D)

(degrees)

(WMM 310)

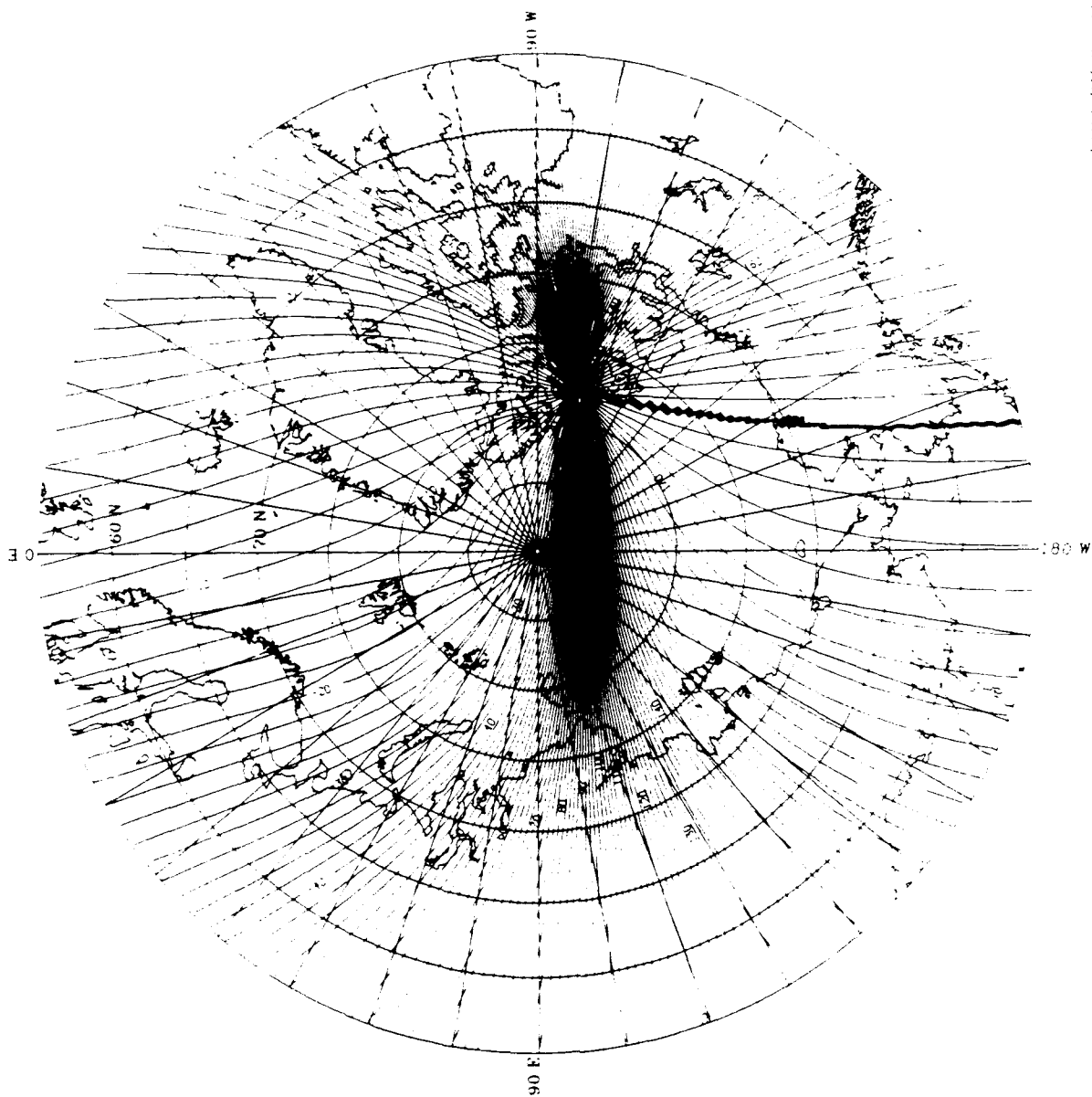


U.S. NAVAL OCEANOGRAPHIC OFFICE

1990.0 at surface of WGS-84 reference ellipsoid.

CHART 22. INCLINATION (I)

(degrees)



(WMM-90)

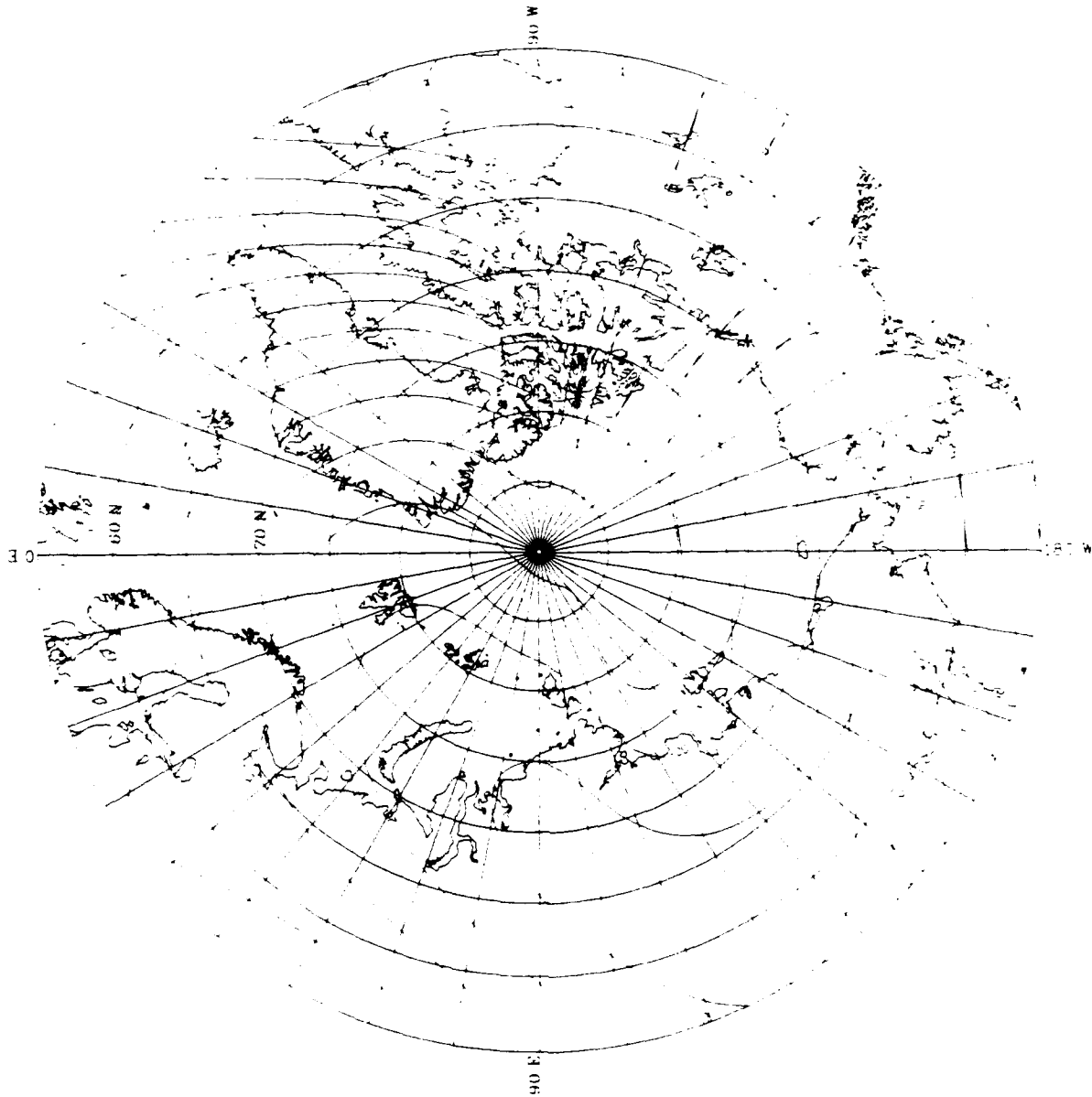
U.S. NAVAL OCEANOGRAPHIC OFFICE

1990.0 at surface of WGS 84 reference ellipsoid

CHART 23. GRID VARIATION (GV)

(m/y)

(WMM-90)



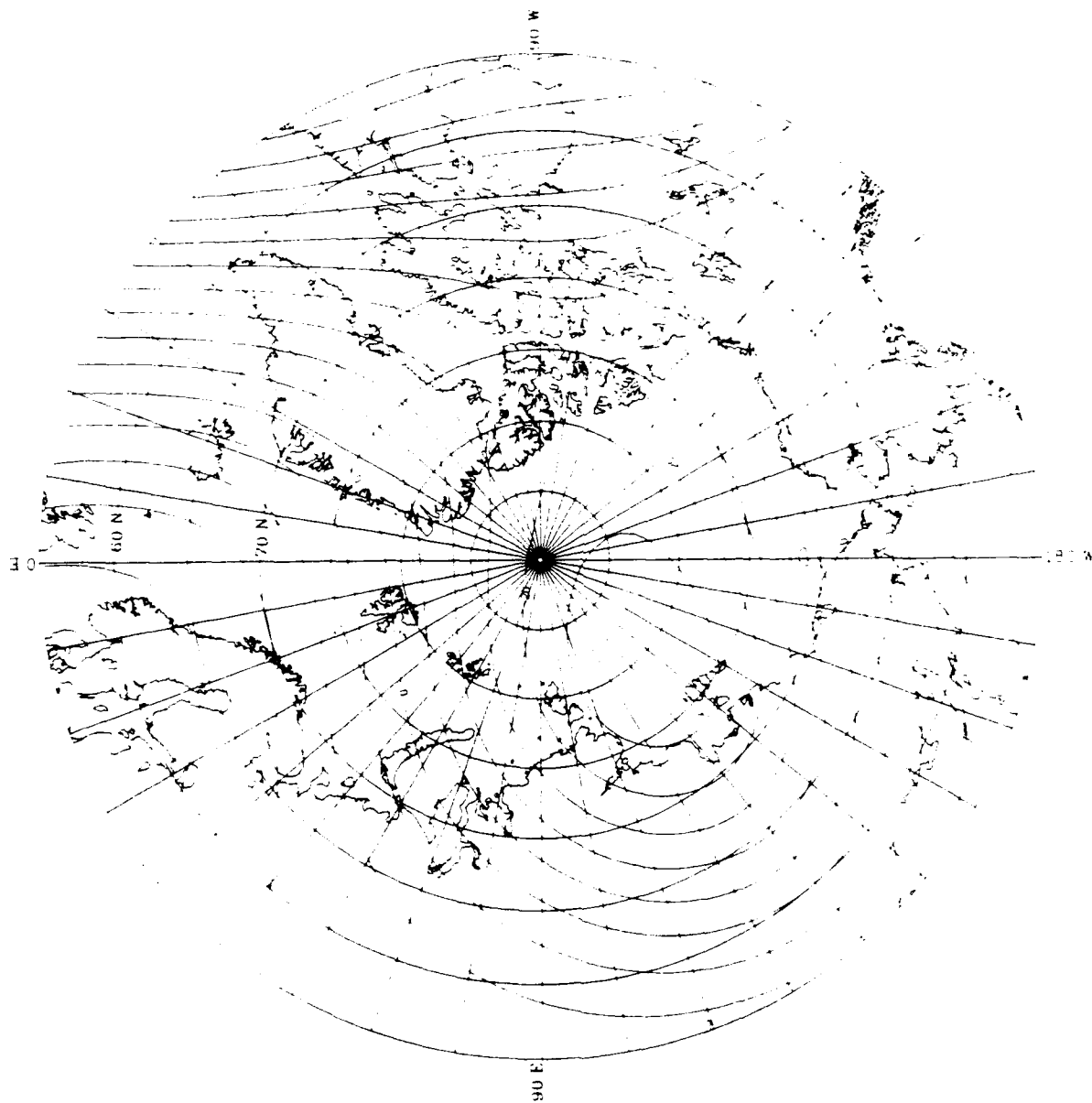
U.S. NAVAL OFFICE OF NAUTICAL INFORMATION

1990 01 surface of WGS 84 reference ellipsoid

CHART 24. HORIZONTAL INTENSITY (II)

(ml/yr)

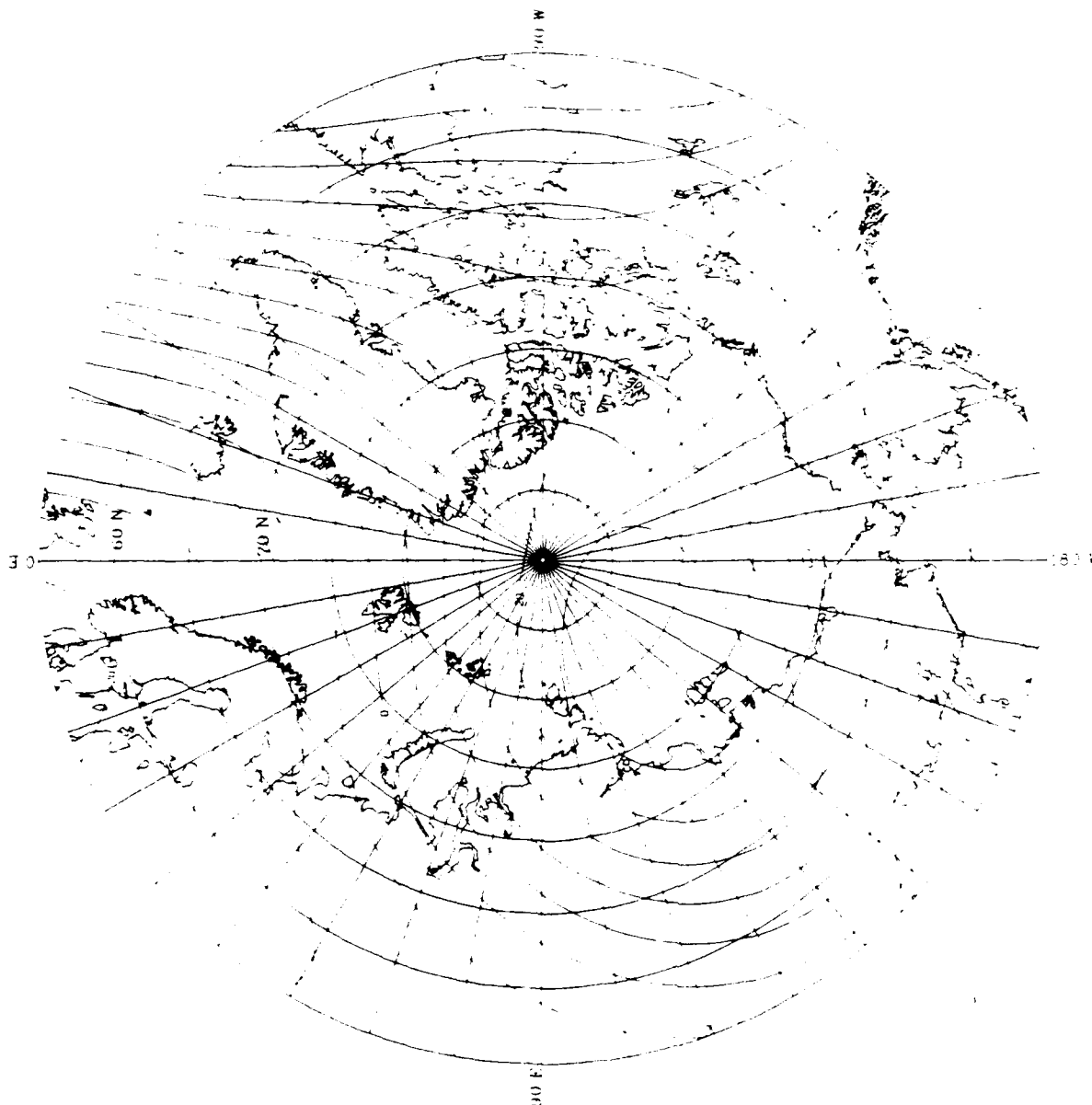
(WMM - 90)



U.S. NAVAL HYDROGRAPHIC OFFICE

(m/y)

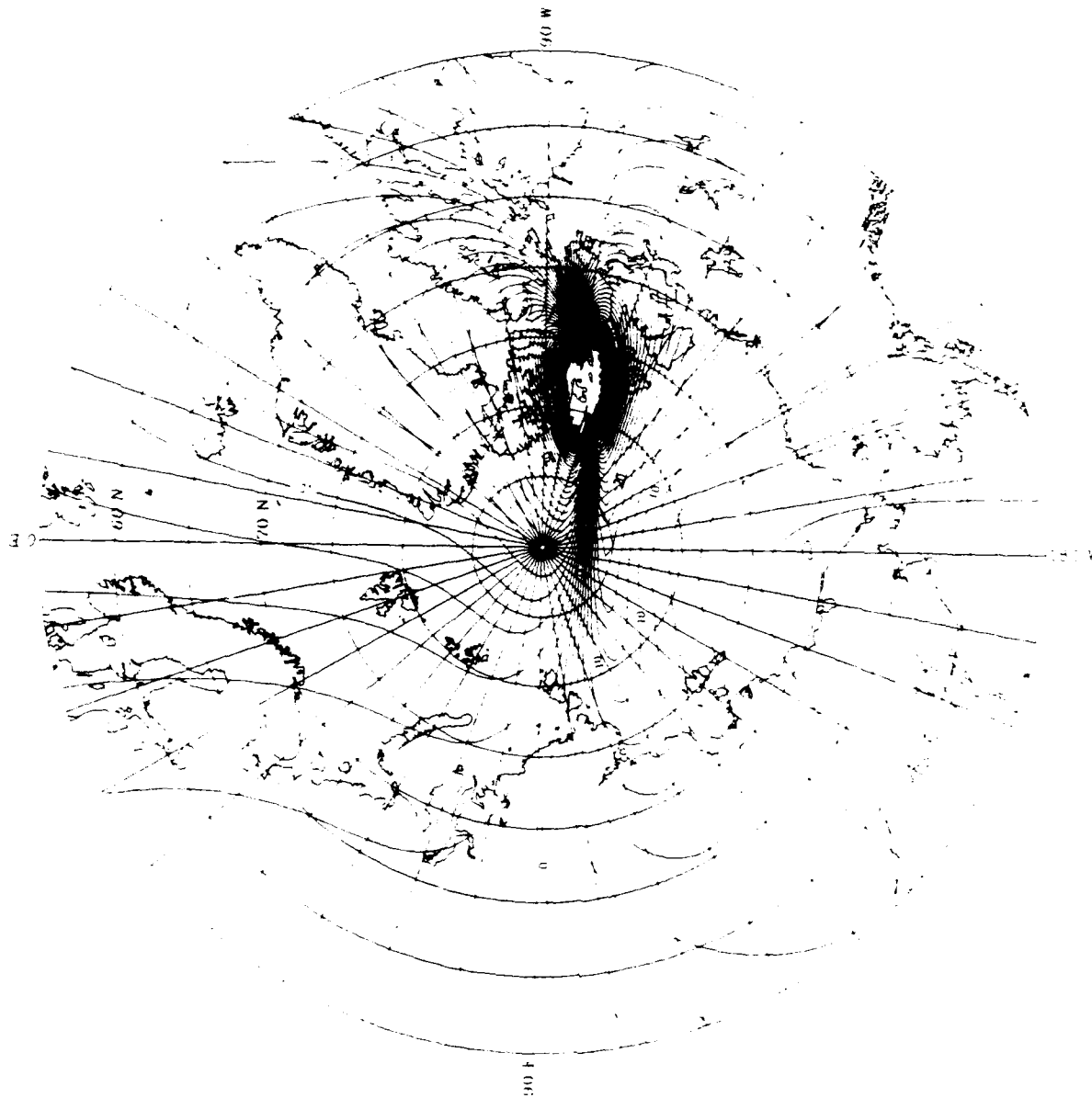
(mm 90)



U.S. NAVAL OCEANOGRAPHIC OFFICE

(WMM 90)

(minutes/yr)



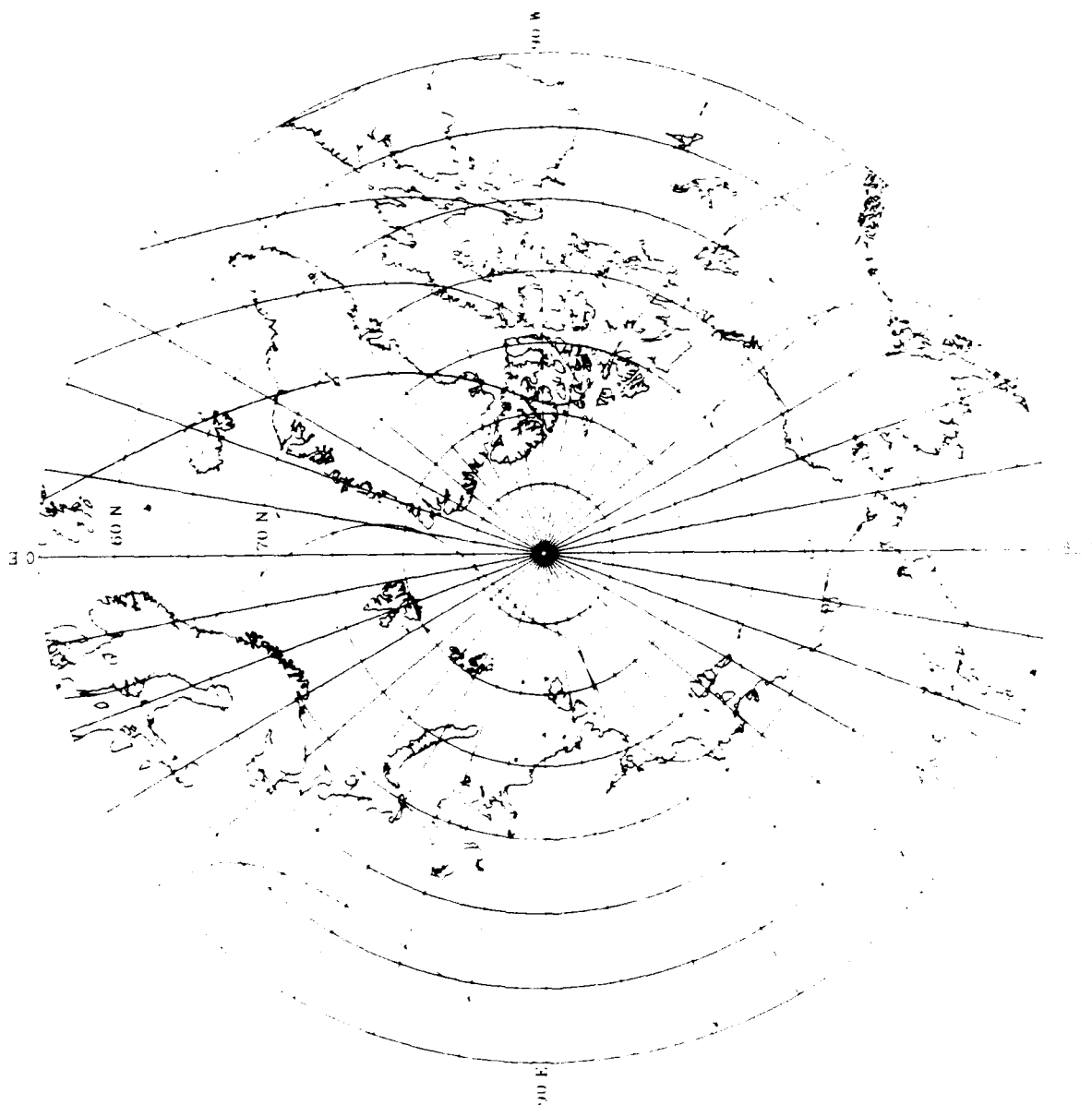
PROJ. U.S. SURFACE OF WGS 84 reference ellipsoid

U.S. NAVAL HYDROGRAPHIC OFFICE

CHART 27. DECLINATION (D)

(minutes/yr)

(WMM '90)



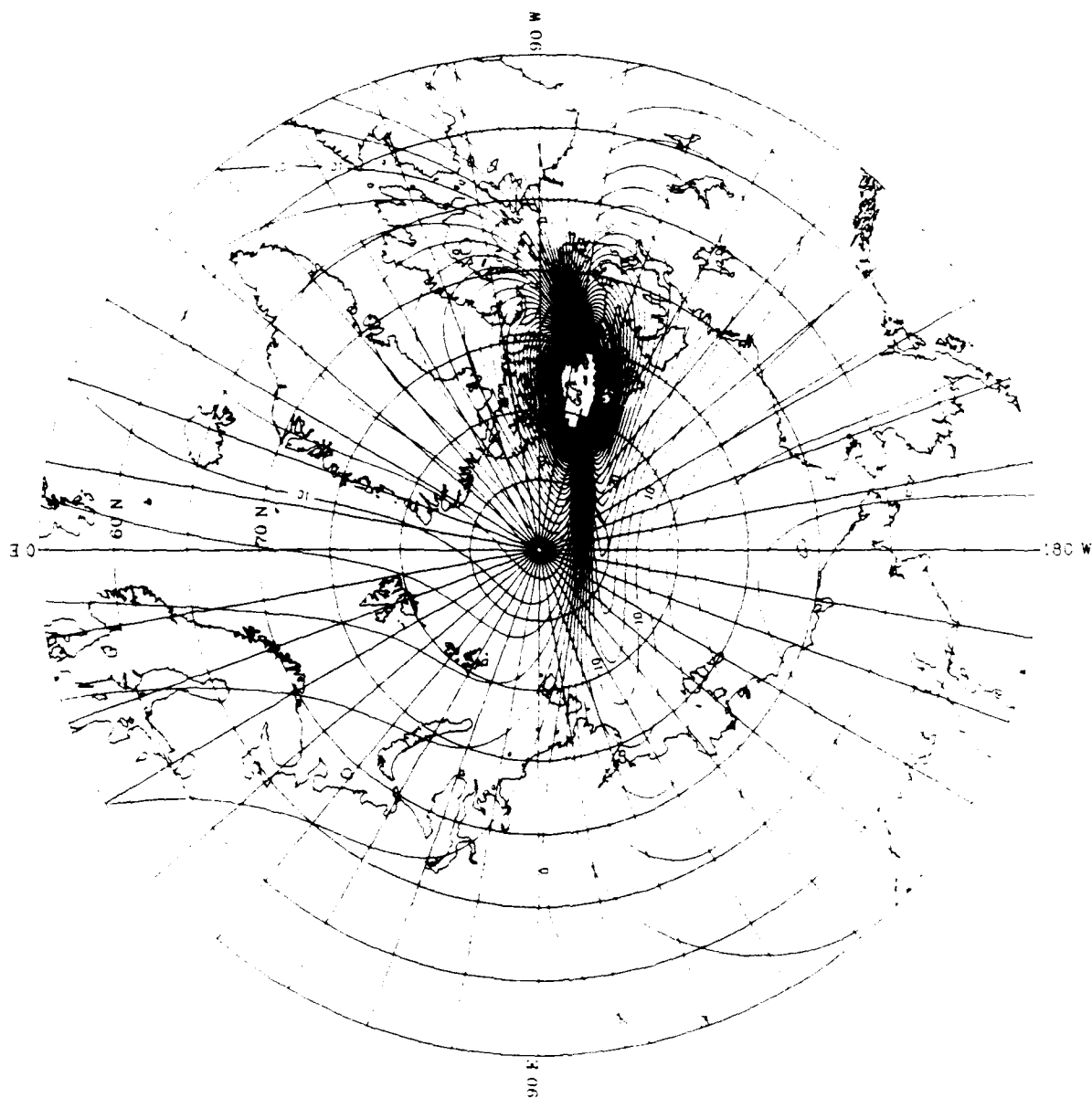
From 0 to 100 of WMM '90, 24 reference ellipsoid

U.S. NAVAL AIR PHOTOGRAPHIC CENTER

CHART 28. INCLINATION (I)

(minutes/yr)

(WMM-90)



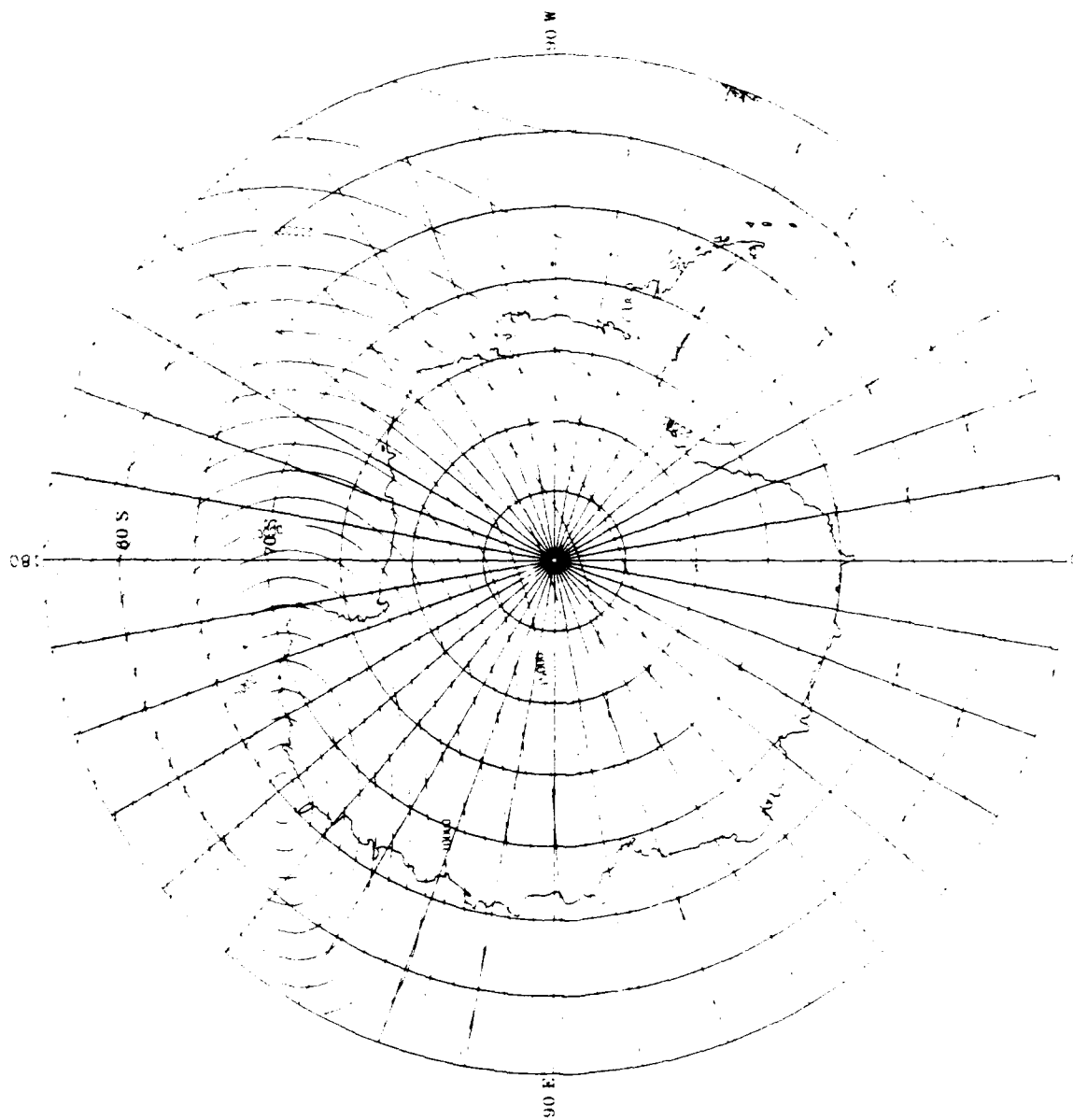
1990.0 at surface of WGS-84 reference ellipsoid

U.S. NAVAL HYDROGRAPHIC OFFICE

CHART 29. GRID VARIATION (GV)

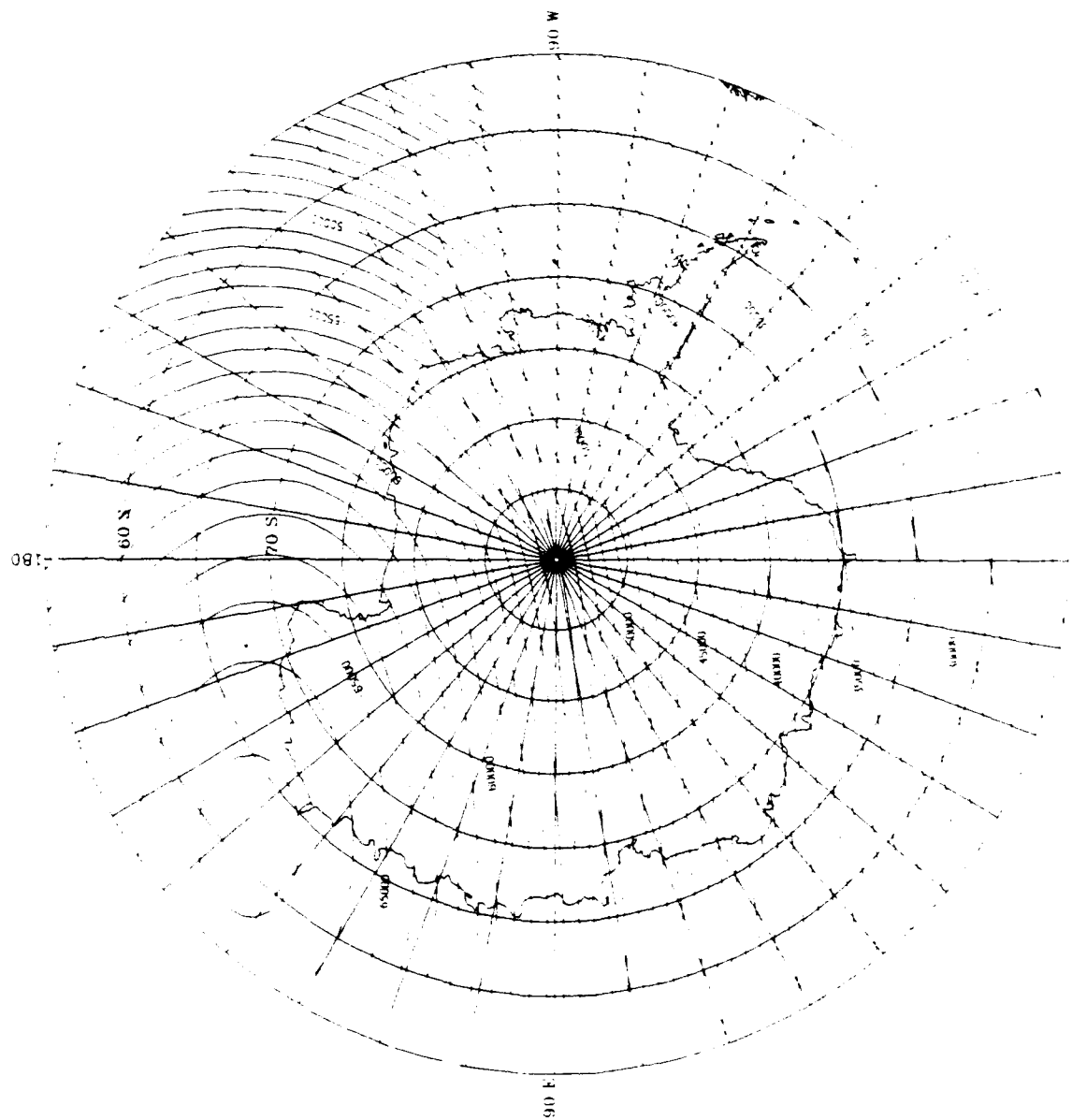
(WMM-90)

(nt)



(WMM '90)

(m)



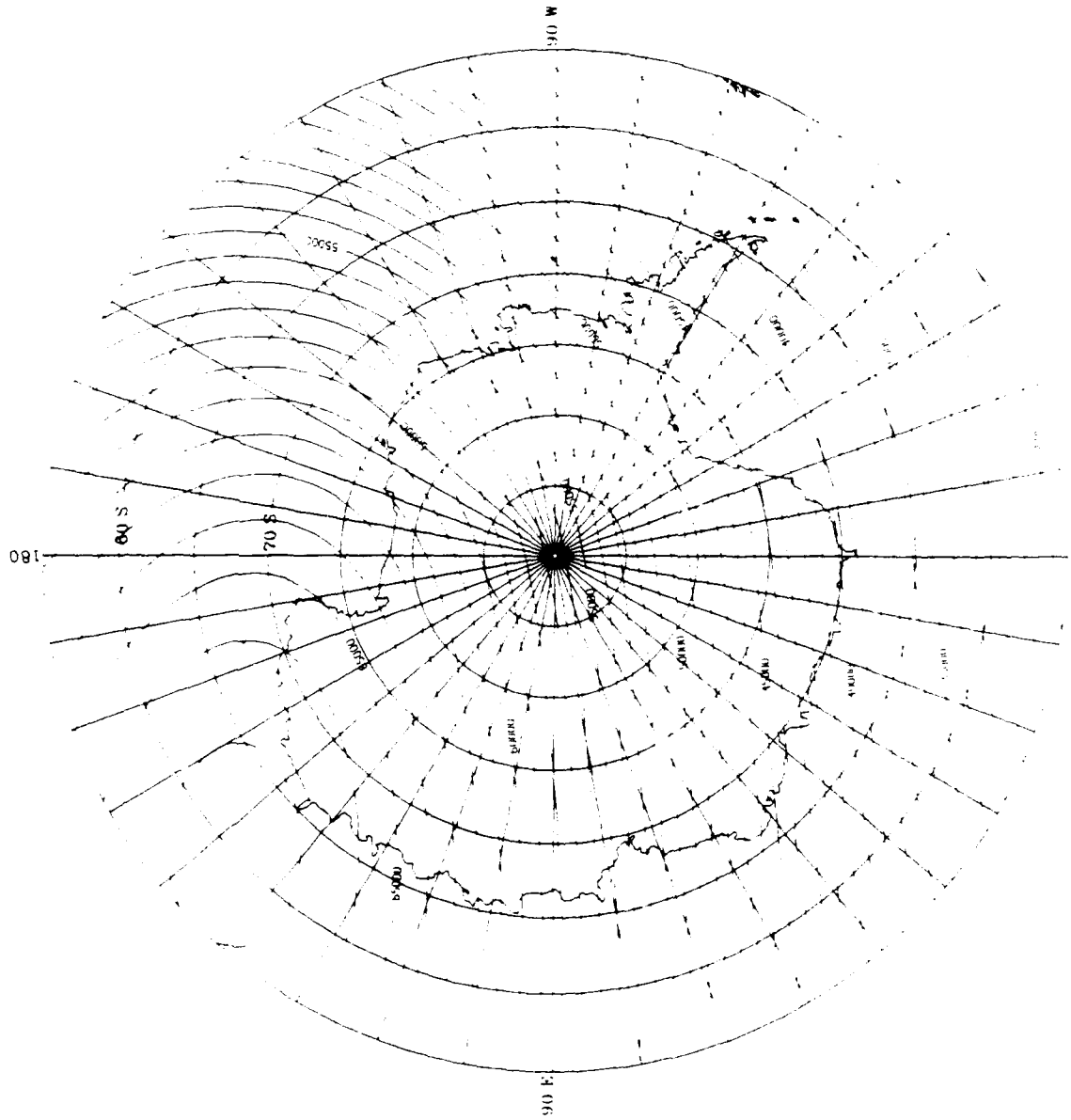
1984 0 at surface of WGS 84 reference ellipsoid

U.S. NAVAL HYDROGRAPHIC OFFICE

CHART 31. VERTICAL COMPONENT (Z)

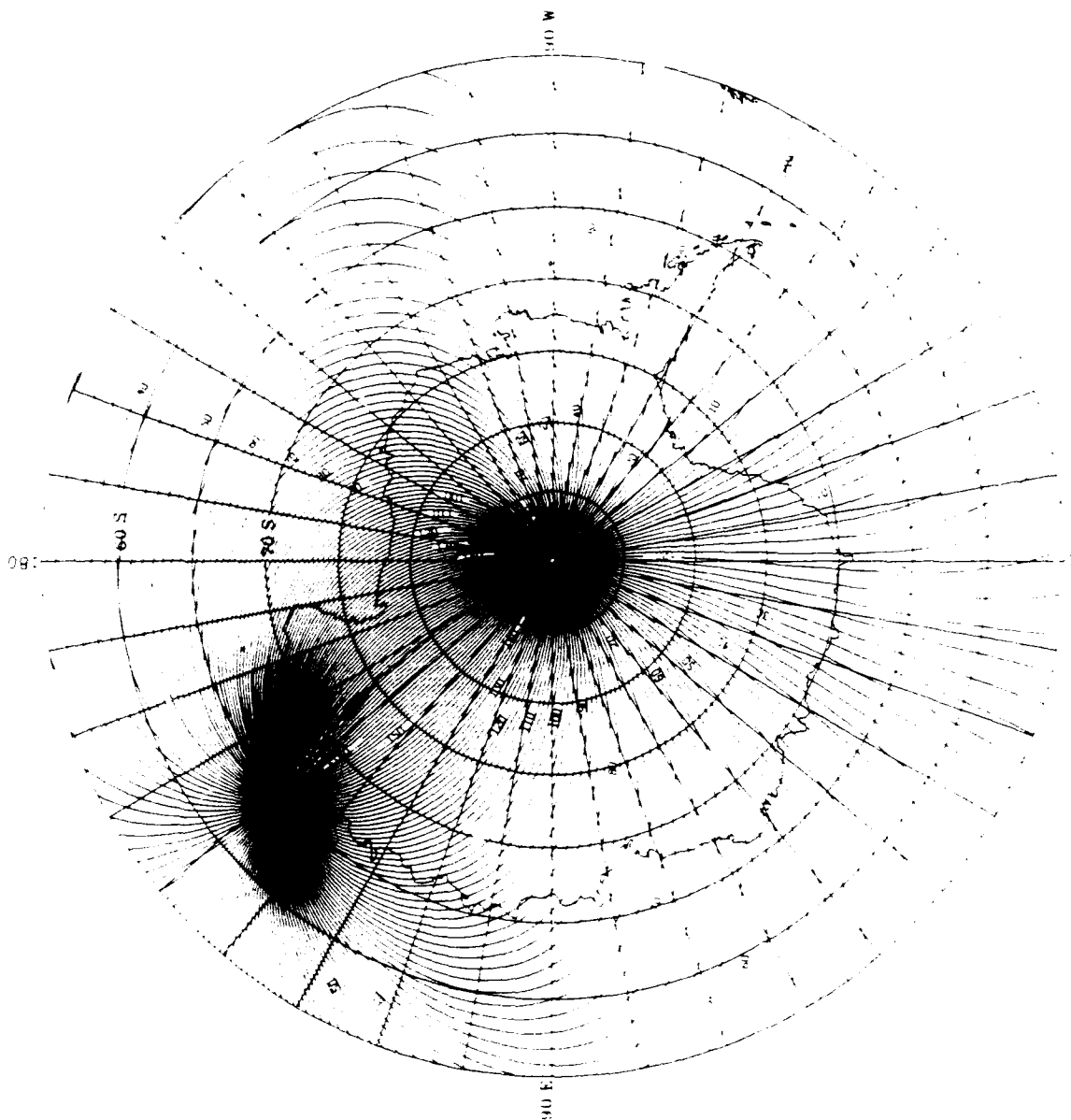
(WMM 90)

(nl)



(degrees)

(WMM-90)



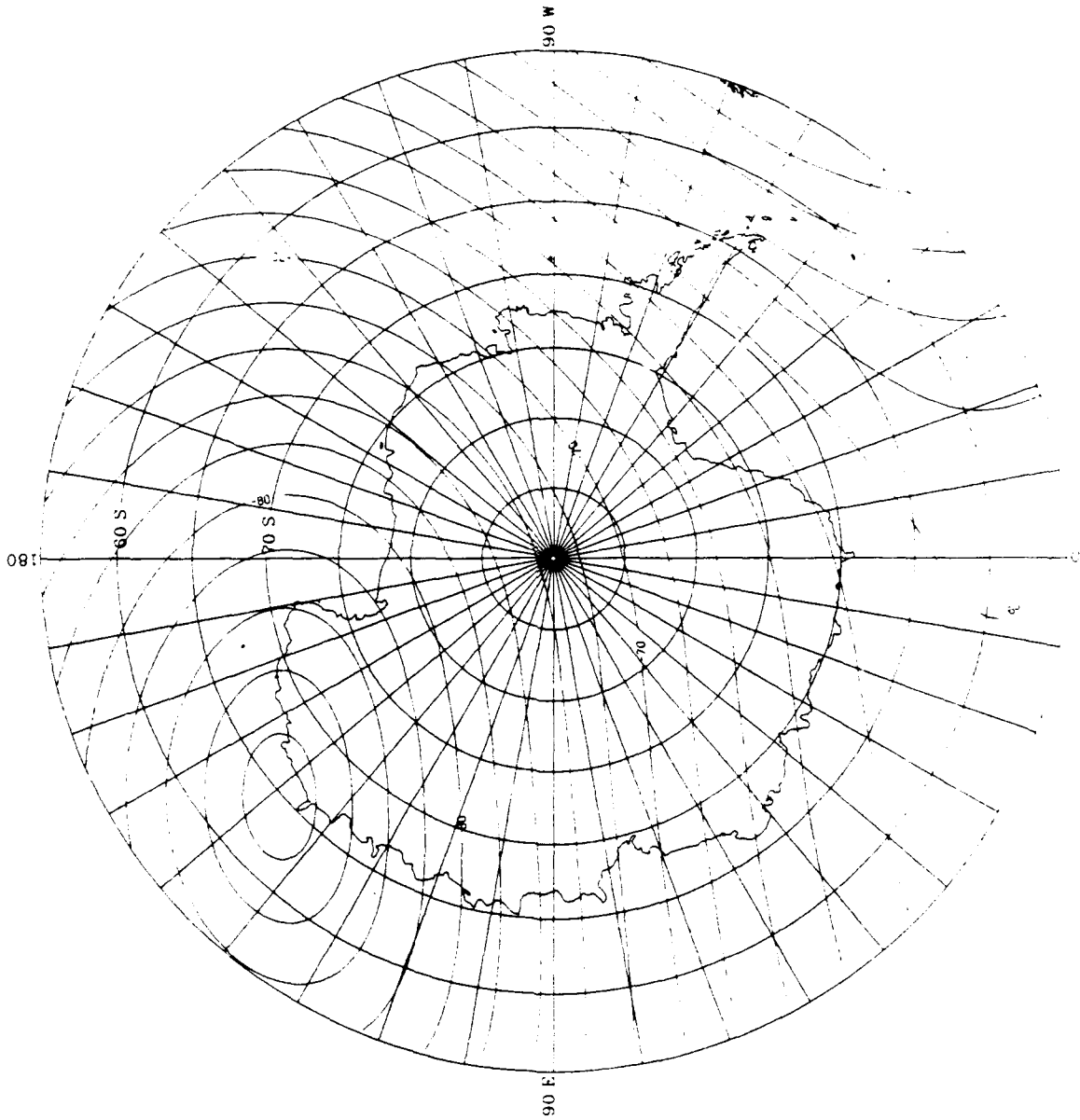
1990.0 of surface of WGS 84 reference ellipsoid

U.S. NAVAL HYDROGRAPHIC OFFICE

CHART 33. DECLINATION (D)

(WMM-90)

(degrees)

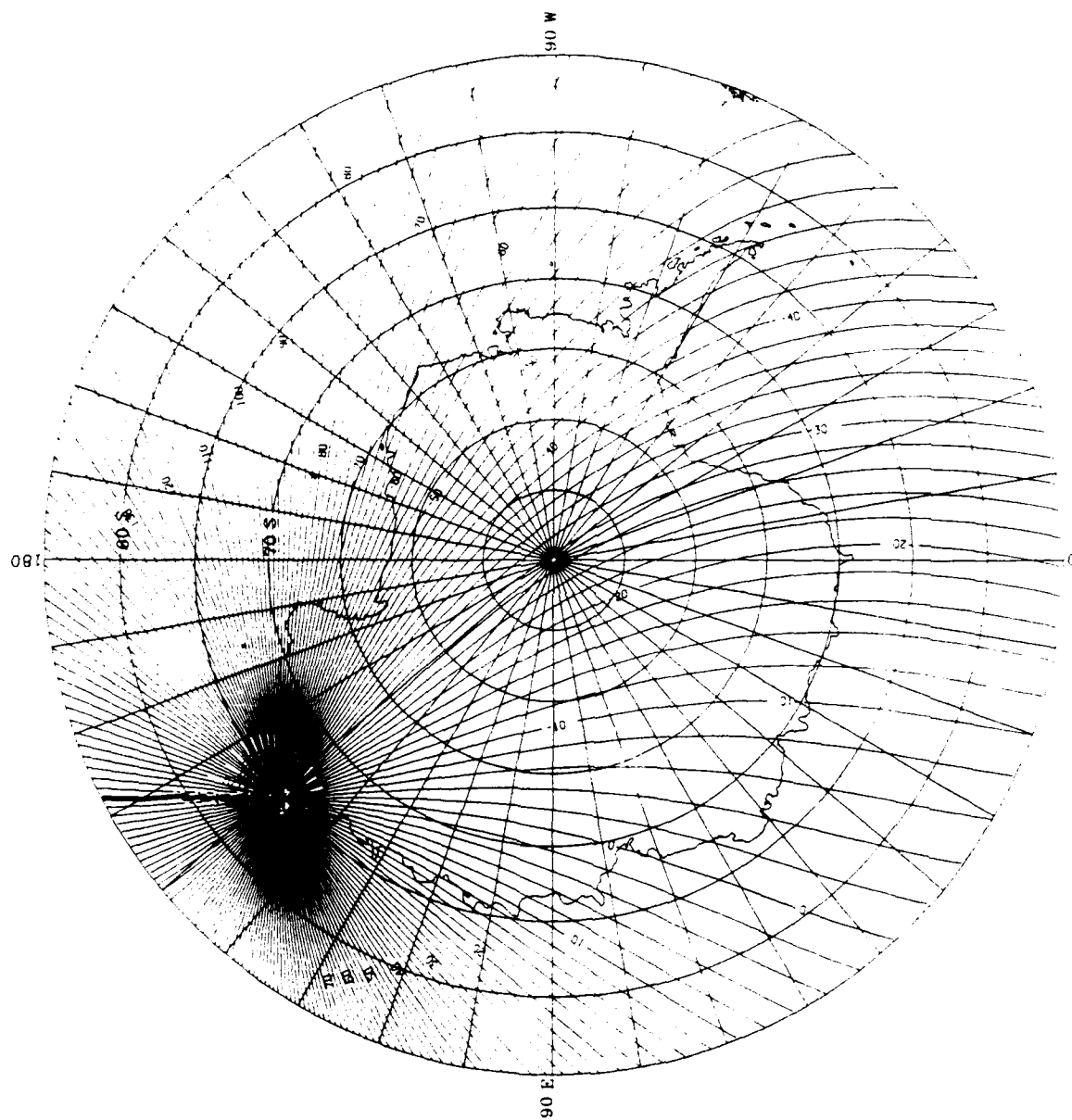


1990 U of surface of WGS-84 reference ellipsoid

U.S. NAVAL OCEANOGRAPHIC OFFICE

CHART 34 INCLINATION (I)

(WMM-90)



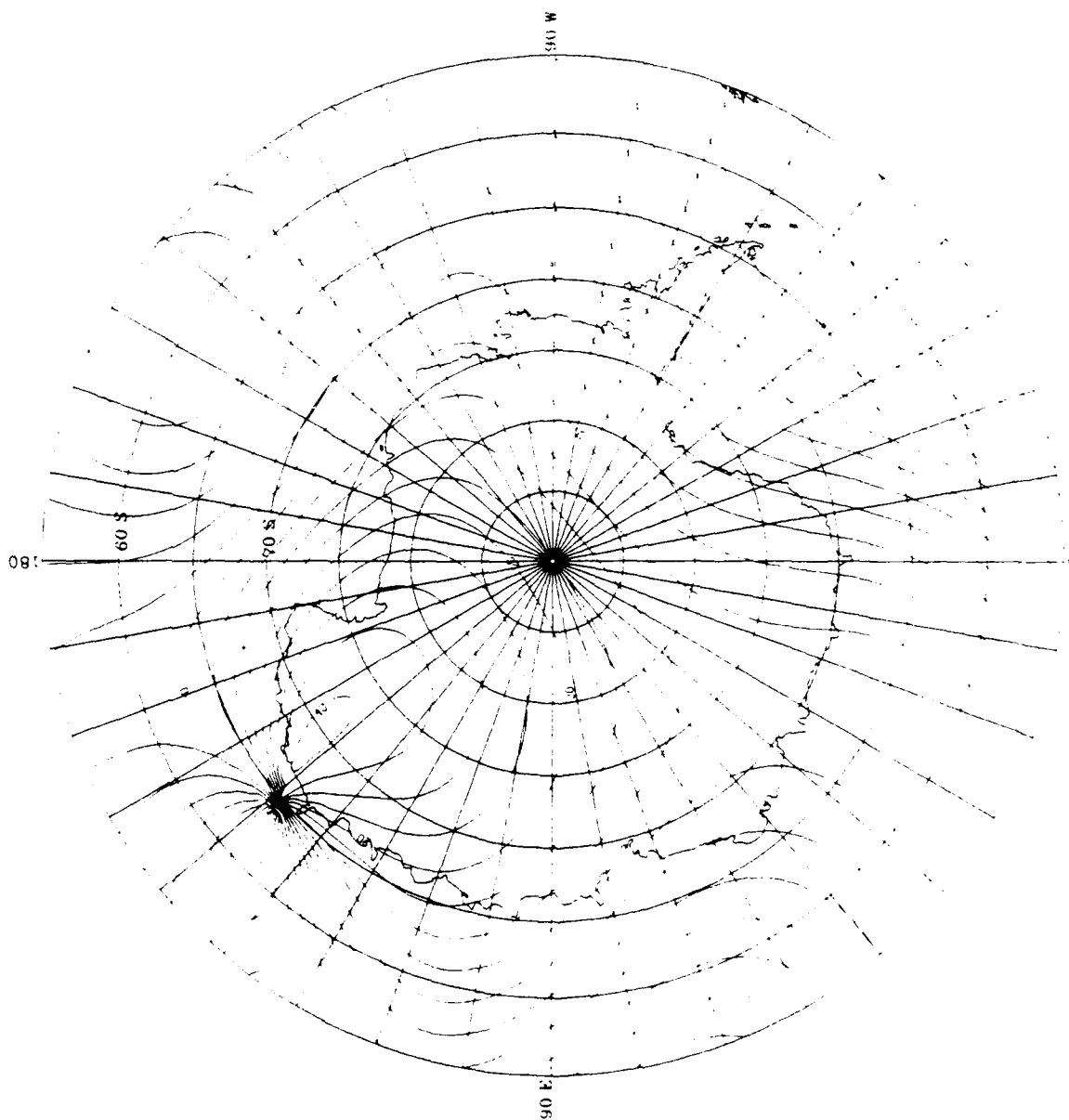
1990.0 of surface of WGS-84 reference ellipsoid.

U.S. NAVAL OR FANOTGRAPHIC OFFICE

CHART 35. GRID VARIATION (GV)

(m/yr)

(WMM-90)



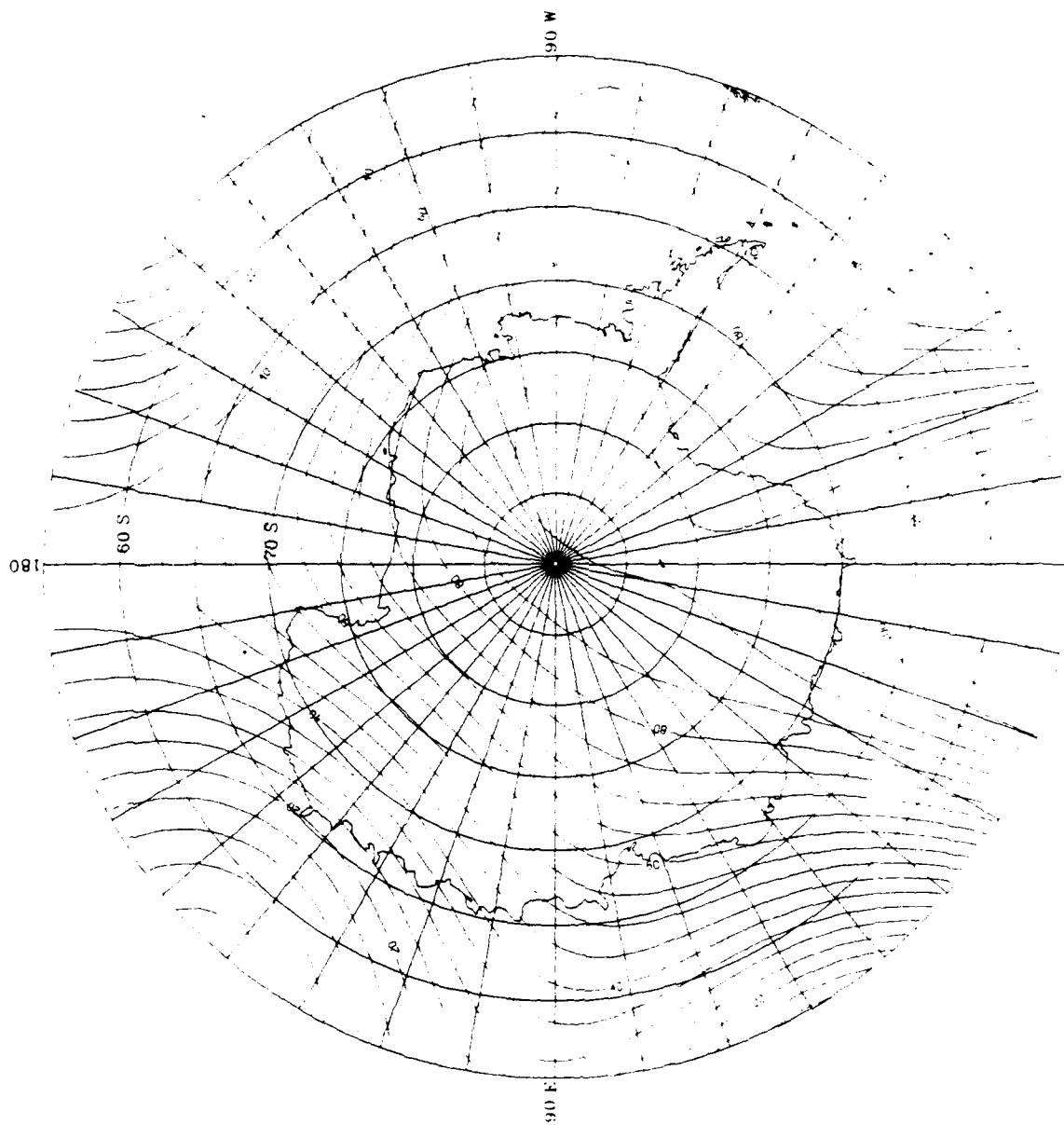
1990.0 at surface of WGS 84 reference ellipsoid

U.S. NAVAL OCEANOGRAPHIC OFFICE

CHART 36 HORIZONTAL INTENSITY (I)

(m/y)

(WMM-90)



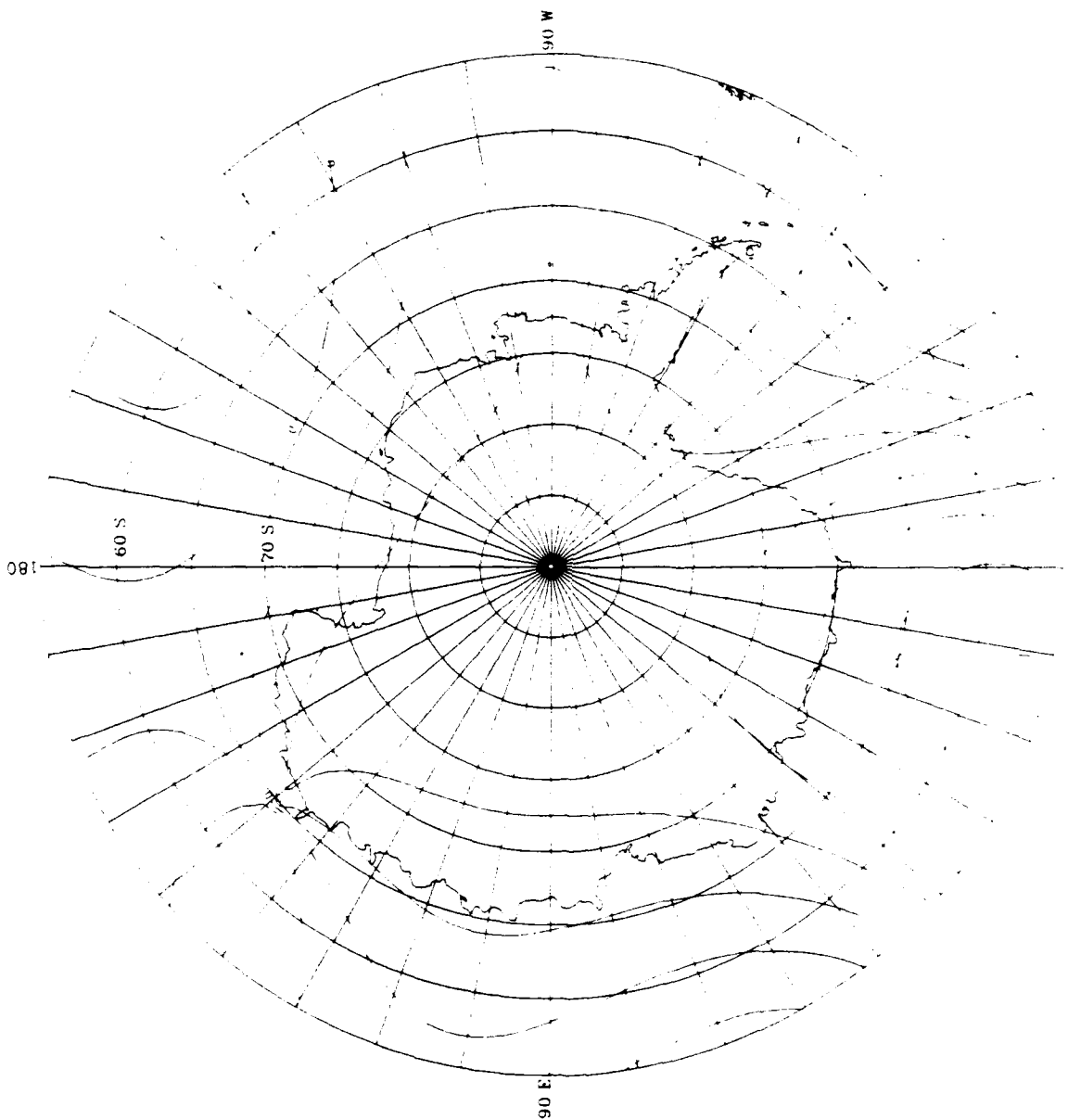
1940 (1) of surface of WGS-84 reference ellipsoid

U.S. NAVAL HYDROGRAPHIC OFFICE

CHART 37. VERTICAL COMPONENT (Z)

(minutes/yr)

(WMM-90)



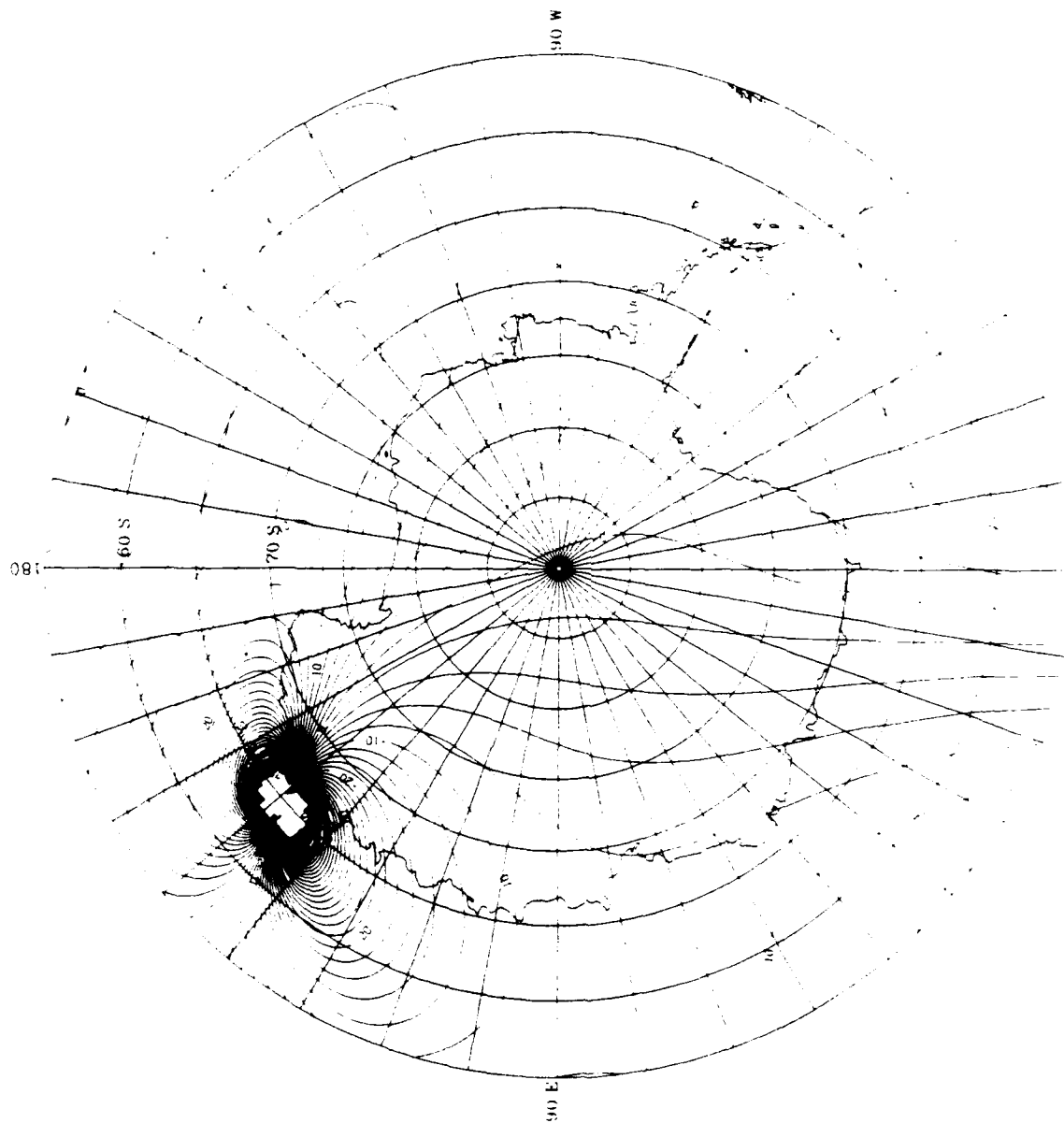
1990.0 at Surface of WGS-84 reference ellipsoid

U.S. NAVAL OFFICIALS

CHART 39. DECLINATION (D)

(minutes/yr)

(WMM-90)



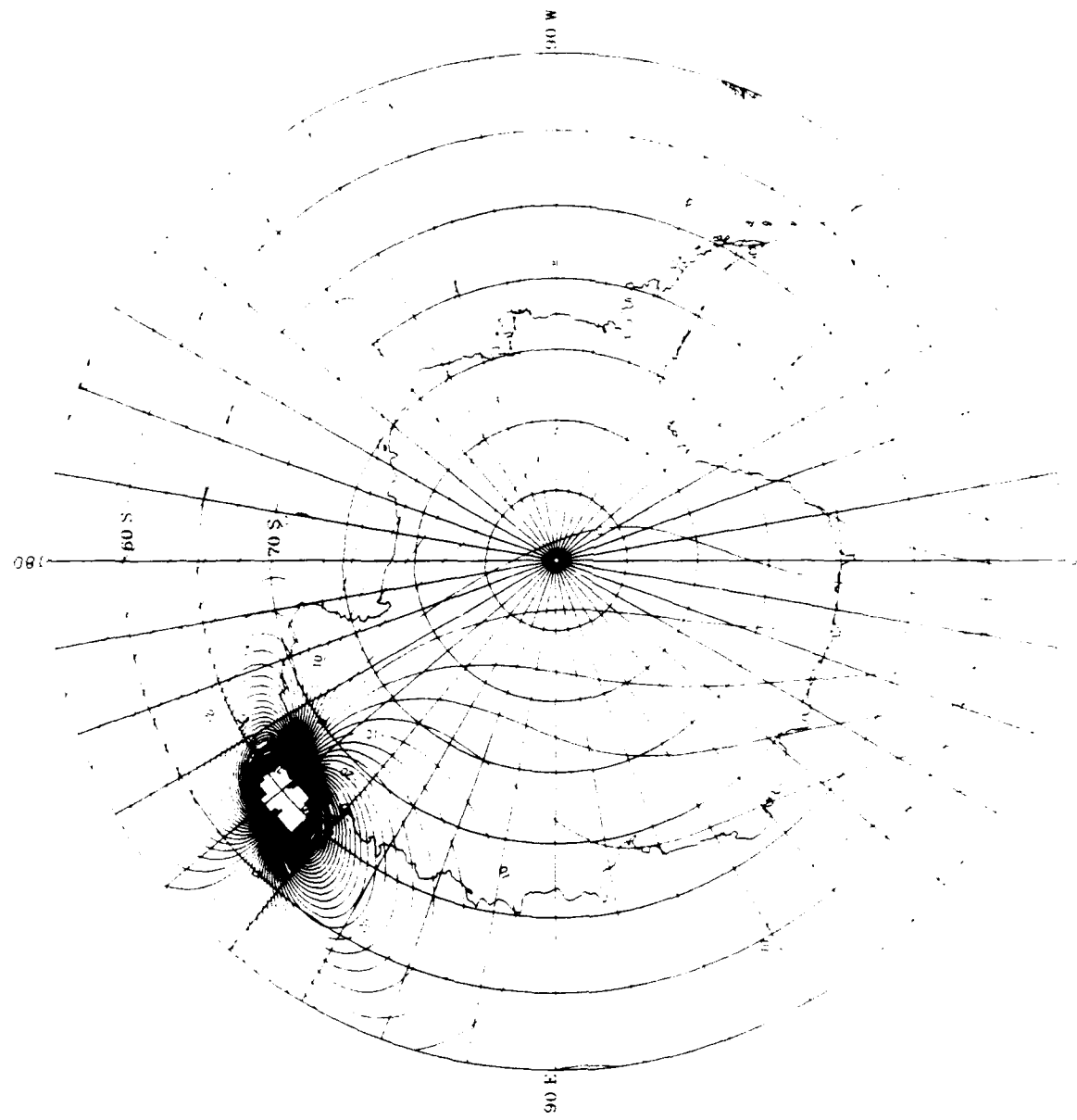
1990 is at surface of WGS 84 reference ellipsoid

U.S. NAVAL OCEANOGRAPHIC OFFICE

CHART 40. INCLINATION (I)

(minutes/yr)

(WMM-90)



U.S. NAVAL OCEANOGRAPHIC OFFICE

1990.0 of surface of WGS 84 reference ellipsoid

CHART 41. GRID VARIATION (GV)

REFERENCES

- Cain, Joseph C., et al.; A Proposed Model for the International Geomagnetic Reference Field 1965, Journal of Geomagnetism and Geoelectricity, Vol. 19, No. 4, pp. 335-355, 1967. (see appendix)
- Department of Defense World Geodetic System 1984, Technical Report TR 8350.2, Defense Mapping Agency, 1987.
- Langel, Robert A.; The Main Field in Geomagnetism, Vol. 1, Chapter 4, edited by J.A. Jacobs, Academic Press, New York, pp. 249-512, 1987.
- Langel, Robert A. and R. H. Estes; The near-Earth magnetic field at 1980 determined from MAGSAT data, J. Geophys. Res. 90, pp. 2495-2509, 1985.
- Quinn, John M., David J. Kerridge, and David R. Baraclough; World Magnetic Charts for 1985 - spherical harmonic models of the geomagnetic field and its secular variation, Geophys. J.R. Astr. Soc. Vol. 87, pp. 1143-1157, 1986.
- Zmuda, Alfred J.; World Magnetic Survey 1957-1969, International Association of Geomagnetism and Aeronomy (IAGA) Bulletin #28, pp. 186-188, 1971.

APPENDIX

FORTRAN LISTING OF SUBROUTINE GEOMAG
WITH
THE WMM-90 MODEL COEFFICIENTS

SUBROUTINE GEOMAG (GEOMAGNETIC FIELD COMPUTATION)

WMM-90 is a proposed Defense Mapping Agency (DMA) standard product.
For information on the use and applicability of this product contact:

DIRECTOR
DEFENSE MAPPING AGENCY/HEADQUARTERS
ATTN: CODE PR
8613 LEE HIGHWAY
FAIRFAX, VA 22031-2137

GEOMAG PROGRAMMED BY:

JOHN M. QUINN 7/19/90
GEOPOTENTIAL DIVISION, CODE GGM
U.S. NAVAL OCEANOGRAPHIC OFFICE (NAVOCEANO)
STENNIS SPACE CENTER (SSC), MS 39522-5001
PHONE: COM: (601) 688-4252
AV: 485-4252
FAX: (601) 688-5701

PURPOSE: THIS ROUTINE COMPUTES THE DECLINATION (DEC),
INCLINATION (DIP), TOTAL INTENSITY (TI), AND
GRID VARIATION (GV - POLAR REGIONS USING A POLAR
STEREOGRAPHIC PROJECTION ONLY) OF THE
EARTH'S MAGNETIC FIELD IN GEODETIC COORDINATES
FROM THE COEFFICIENTS OF THE CURRENT OFFICIAL
DEPARTMENT OF DEFENSE (DOD) SPHERICAL HARMONIC WORLD
MAGNETIC MODEL (WMM-90). THE WMM SERIES OF MODELS IS
UPDATED EVERY 5 YEARS ON 1 JANUARY OF THOSE YEARS
WHICH ARE DIVISIBLE BY 5 (I.E., 1980, 1985, 1990, ETC.)
BY THE U.S. NAVAL OCEANOGRAPHIC OFFICE IN COOPERATION
WITH THE BRITISH GEOLOGICAL SURVEY (BGS) AND
IS BASED ON GEOMAGNETIC SURVEY MEASUREMENTS FROM
AIRCRAFT, SATELLITE, AND GEOMAGNETIC OBSERVATORIES.

IF THE REQUIRED DECLINATION ACCURACY IS MORE STRINGENT THAN THE WMM SERIES OF MODELS PROVIDE, THE USER IS ADVISED TO REQUEST SPECIAL (REGIONAL OR LOCAL) SURVEYS BE PERFORMED AND MODELS PREPARED BY NAVOCEANO, WHICH OPERATES THE PROJECT MAGNET AIRCRAFT AND THE POLAR ORBITING GEOMAGNETIC SURVEY (POGS) SATELLITE. REQUESTS OF THIS NATURE SHOULD BE MADE THROUGH DMA AT THE ADDRESS ABOVE.

USAGE: THIS ROUTINE IS BROKEN UP INTO TWO PARTS:

- A) AN INITIALIZATION MODULE, WHICH IS CALLED ONLY ONCE AT THE BEGINNING OF THE MAIN (CALLING) PROGRAM
- B) A PROCESSING MODULE, WHICH COMPUTES THE MAGNETIC FIELD PARAMETERS FOR EACH SPECIFIED GEODETIC POSITION (ALTITUDE, LATITUDE, LONGITUDE) AND TIME

INITIALIZATION IS MADE VIA A SINGLE CALL TO THE MAIN ENTRY POINT (GEOMAG), WHILE SUBSEQUENT PROCESSING CALLS ARE MADE THROUGH THE SECOND ENTRY POINT (GEOMG1). ONE CALL TO THE PROCESSING MODULE IS REQUIRED FOR EACH POSITION AND TIME.

THE VARIABLE MAXDEG IN THE INITIALIZATION CALL IS THE MAXIMUM DEGREE TO WHICH THE SPHERICAL HARMONIC MODEL IS TO BE COMPUTED. IT MUST BE SPECIFIED BY THE USER IN THE CALLING ROUTINE. NORMALLY IT IS 12 BUT IT MAY BE SET LESS THAN 12 TO INCREASE COMPUTATIONAL SPEED AT THE EXPENSE OF REDUCED ACCURACY.

THE PC VERSION OF THIS SUBROUTINE MUST BE COMPILED WITH A FORTRAN 77 COMPATIBLE COMPILER SUCH AS THE MICROSOFT OPTIMIZING FORTRAN COMPILER VERSION 4.1 OR LATER.

REFERENCES:

JOHN M. QUINN, DAVID J. KERRIDGE, AND DAVID R. BARRACLOUGH, WORLD MAGNETIC CHARTS FOR 1985 - SPHERICAL HARMONIC MODELS OF THE GEOMAGNETIC FIELD AND ITS SECULAR VARIATION, GEOPHYS. J. R. ASTR. SOC. (1986) Vol. 87, PP. 1143-1157

DEFENSE MAPPING AGENCY TECHNICAL REPORT TR 8350.2:
DEPARTMENT OF DEFENSE WORLD GEODETIC SYSTEM 1984,
SEPT. 30 (1987)

JOSEPH C. CAIN, ET AL., A PROPOSED MODEL FOR THE
INTERNATIONAL GEOMAGNETIC REFERENCE FIELD - 1965,
J. GEOMAG. AND GEOELECT. VOL. 19, NO. 4, PP. 335-355
(1967) (SEE APPENDIX)

ALFRED J. ZMUDA, WORLD MAGNETIC SURVEY 1957-1969,
INTERNATIONAL ASSOCIATION OF GEOMAGNETISM AND
AERONOMY (IAGA) BULLETIN #28, PP. 186-188 (1971)

PARAMETER DESCRIPTIONS:

A	- SEMIMAJOR AXIS OF WGS-84 ELLIPSOID (KM)	
B	- SEMIMINOR AXIS OF WGS-84 ELLIPSOID (KM)	
RE	- MEAN RADIUS OF IAU-66 ELLIPSOID (KM)	
SNORM	- SCHMIDT NORMALIZATION FACTORS	
C	- GAUSS COEFFICIENTS OF MAIN GEOMAGNETIC MODEL (NT)	
CD	- GAUSS COEFFICIENTS OF SECULAR GEOMAGNETIC MODEL (NT/YR)	
TC	- TIME ADJUSTED GEOMAGNETIC GAUSS COEFFICIENTS (NT)	
OTIME	- TIME ON PREVIOUS CALL TO GEOMAG (YRS)	
OALT	- GEODETIC ALTITUDE ON PREVIOUS CALL TO GEOMAG (YRS)	
OLAT	- GEODETIC LATITUDE ON PREVIOUS CALL TO GEOMAG (DEG.)	
OLON	- GEODETIC LONGITUDE ON PREVIOUS CALL TO GEOMAG (DEG.)	
TIME	- COMPUTATION TIME (YRS)	(INPUT)
	(E.G., 1 JULY 1985 = 1985.5)	
ALT	- GEODETIC ALTITUDE (KM)	(INPUT)
GLAT	- GEODETIC LATITUDE (DEG.)	(INPUT)
GLON	- GEODETIC LONGITUDE (DEG.)	(INPUT)
EPOCH	- BASE TIME OF GEOMAGNETIC MODEL (YRS)	
DTR	- DEGREE TO RADIAN CONVERSION	
SP(M)	- SINE OF (M*SPHERICAL COORD. LONGITUDE)	
CP(M)	- COSINE OF (M*SPHERICAL COORD. LONGITUDE)	
ST	- SINE OF (SPHERICAL COORD. LATITUDE)	
CT	- COSINE OF (SPHERICAL COORD. LATITUDE)	
R	- SPHERICAL COORDINATE RADIAL POSITION (KM)	
CA	- COSINE OF SPHERICAL TO GEODETIC VECTOR ROTATION ANGLE	
SA	- SINE OF SPHERICAL TO GEODETIC VECTOR ROTATION ANGLE	
BR	- RADIAL COMPONENT OF GEOMAGNETIC FIELD (NT)	
BT	- THETA COMPONENT OF GEOMAGNETIC FIELD (NT)	
BP	- PHI COMPONENT OF GEOMAGNETIC FIELD (NT)	
P(N,M)	- ASSOCIATED LEGENDRE POLYNOMIALS (UNNORMALIZED)	
PP(N)	- ASSOCIATED LEGENDRE POLYNOMIALS FOR M=1 (UNNORMALIZED)	
DP(N,M)	- THETA DERIVATIVE OF P(N,M) (UNNORMALIZED)	
BX	- NORTH GEOMAGNETIC COMPONENT (NT)	
BY	- EAST GEOMAGNETIC COMPONENT (NT)	
BZ	- VERTICALLY DOWN GEOMAGNETIC COMPONENT (NT)	
BH	- HORIZONTAL GEOMAGNETIC COMPONENT (NT)	
DEC	- GEOMAGNETIC DECLINATION (DEG.)	(OUTPUT)
	EAST=POSITIVE ANGLES	
	WEST=NEGATIVE ANGLES	

DIP	- GEOMAGNETIC INCLINATION (DEG.) DOWN=POSITIVE ANGLES UP=NEGATIVE ANGLES	(OUTPUT)
TI	- GEOMAGNETIC TOTAL INTENSITY (NT)	(OUTPUT)
GV	- GEOMAGNETIC GRID VARIATION (DEG.) REFERENCED TO GRID NORTH GRID NORTH REFERENCED TO 0 MERIDIAN OF A POLAR STEREOGRAPHIC PROJECTION (ARCTIC/ANTARCTIC ONLY)	(OUTPUT)
MAXDEG	- MAXIMUM DEGREE OF SPHERICAL HARMONIC MODEL	(INPUT)
MOXORD	- MAXIMUM ORDER OF SPHERICAL HARMONIC MODEL	

NOTE: THIS VERSION OF GEOMAG USES THE WMM-90 GEOMAGNETIC
MODEL REFERENCED TO THE WGS-84 GRAVITY MODEL ELLIPSOID

INITIALIZATION MODULE

SUBROUTINE GEOMAG(MAXDEG)

DIMENSION C(0:12,0:12),CD(0:12,0:12),TC(0:12,0:12)
DIMENSION P(0:12,0:12),DP(0:12,0:12),SNORM(0:12,0:12)
DIMENSION SP(0:12),CP(0:12),FN(0:12),FM(0:12),PP(0:12)
REAL K(0:12,0:12)
EQUIVALENCE (SNORM,P)

DATA EPOCH/1990.0/

DATA C/		0.0,	-29780.5,	-2134.3,	1312.9,	933.5,	-208.3,		
*		59.0,	76.1,	22.9,	3.6,	-3.3,	1.3,		
*		-1.3,	5407.2,	-1851.7,	3062.2,	-2244.7,	784.9,		
*		352.2,	63.7,	-62.1,	2.3,	9.5,	-2.6,		
*		-1.4,	0.1,	-2278.3,	-384.3,	1691.9,	1246.8,		
*		323.5,	246.5,	60.0,	1.3,	-1.2,	-0.9,		
*		4.5,	-2.5,	0.5,	-284.9,	291.7,	-352.4,		
*		808.6,	-421.7,	-110.8,	-181.3,	30.2,	-11.7,		
*		-10.7,	-5.6,	3.2,	0.7,	249.4,	-232.7,		
*		91.3,	-296.5,	139.2,	-162.3,	0.4,	4.7,		
*		-17.5,	10.7,	-3.6,	0.2,	0.4,	40.8,		
*		148.7,	-154.6,	-67.6,	97.4,	-37.2,	15.4,		
*		7.9,	2.2,	-3.2,	3.9,	-1.1,	-0.2,		
*		-14.7,	82.2,	70.0,	-56.2,	-1.4,	24.6,		
*		-96.0,	10.1,	5.7,	-1.4,	3.2,	0.3,		
*		-1.1,	-78.6,	-26.7,	0.1,	19.9,	17.9,		
*		-21.5,	-6.8,	1.9,	3.0,	6.3,	1.7,		
*		-0.3,	0.9,	9.7,	-19.3,	6.6,	-20.1,		
*		13.4,	9.8,	-19.0,	-9.1,	-7.0,	0.8,		
*		3.0,	0.9,	-0.6,	-21.9,	14.3,	9.5,		
*		-6.7,	-6.4,	9.1,	8.9,	-8.0,	2.1,		
*		-5.5,	3.7,	-1.1,	0.8,	2.6,	1.2,		
*		2.6,	5.7,	-4.0,	-0.4,	-1.7,	3.8,		
*		-0.8,	-6.5,	0.7,	2.4,	0.2,	0.0,		
*		1.0,	-1.6,	-2.2,	1.1,	-0.7,	-1.7,		
*		-1.5,	-1.3,	-1.1,	0.6,	3.0,	0.4,		
*		0.7,	0.7,	1.3,	-1.5,	0.3,	0.2,		
*		-1.1,	1.2,	-0.2,	-1.3,	0.6,	0.6,		
*		0.2/							
C									
C									
DATA CD/		0.0,	16.0,	-11.7,	2.1,	-0.8,	1.7,	0.8,	0.5,
*		0.0,	0.0,	0.0,	0.0,	0.0,	-13.8,	9.3,	3.7,
*		-7.6,	1.0,	0.0,	0.0,	0.0,	-1.1,	0.0,	0.0,
*		0.0,	0.0,	-12.8,	-14.9,	1.8,	0.0,	-7.4,	0.0,
*		1.5,	-0.9,	0.0,	0.0,	0.0,	0.0,	0.0,	3.1,
*		0.8,	-11.3,	-5.8,	0.8,	-2.7,	0.0,	1.5,	0.0,
*		0.0,	0.0,	0.0,	0.0,	3.3,	3.7,	2.8,	0.0,
*		-6.4,	0.0,	0.0,	2.7,	-2.1,	0.0,	0.0,	0.0,
*		0.0,	0.0,	-2.1,	1.2,	1.2,	0.6,	3.0,	0.0,
*		-1.0,	0.0,	0.0,	0.0,	0.0,	0.0,	-0.6,	-0.6,
*		0.0,	-2.3,	0.0,	0.0,	0.0,	0.0,	1.0,	0.0,
*		0.0,	0.0,	0.0,	0.6,	0.8,	0.0,	0.0,	0.0,
*		0.4,	0.0,	0.0,	0.0,	0.0,	0.0,	0.0,	0.0,
*		0.4,	-0.8,	0.5,	0.3,	0.5,	0.0,	-0.7,	0.0,
*		57*0.0/							
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INITIALIZE CONSTANTS

```

IF (MAXDEG .GT. 12) MAXDEG=12
MAXORD=MAXDEG
PI=3.14159265359
DTR=PI/180.0
SP(0)=0.
CP(0)=1.
P(0,0)=1.
PP(0)=1.
DP(0,0)=0.
A=6378.137
B=6356.7523142
RE=6371.2
A2=A**2
B2=B**2
C2=A2-B2
A4=A2**2
B4=B2**2
C4=A4-B4

```

C
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C

CONVERT SCHMIDT NORMALIZED GAUSS COEFFICIENTS TO UNNORMALIZED

```

SNORM(0,0)=1.
DO 20 N=1,MAXORD
SNORM(N,0)=SNORM(N-1,0)*FLOAT(2*N-1)/FLOAT(N)
J=2
DO 10 M=0,N
K(N,M)=FLOAT((N-1)**2-M**2)/FLOAT((2*N-1)*(2*N-3))
IF (M .GT. 0) THEN
FLNMJ=FLOAT((N-M+1)*J)/FLOAT(N+M)
SNORM(N,M)=SNORM(N,M-1)*SQRT(FLNMJ)
J=1
C(M-1,N)=SNORM(N,M)*C(M-1,N)
CD(M-1,N)=SNORM(N,M)*CD(M-1,N)
ENDIF
C(N,M)=SNORM(N,M)*C(N,M)
CD(N,M)=SNORM(N,M)*CD(N,M)
10 CONTINUE
FN(N)=FLOAT(N+1)
FM(N)=FLOAT(N)
20 CONTINUE
K(1,1)=0.

```

C
C

```

OTIME=-1000.
OALT=-1000.
OLAT=-1000.
OLON=-1000.

```

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```

Q1=ALT*Q
Q2=((Q1+A2)/(Q1+B2))**2
CT=SRLAT/SQRT(Q2*CRLAT2+SRLAT2)
ST=SQRT(1.0-CT**2)
R2=ALT**2+2.0*Q1+(A4-C4*SRLAT2)/Q**2
R=SQRT(R2)
D=SQRT(A2*CRLAT2+B2*SRLAT2)
CA=(ALT+D)/R
SA=C2*CRLAT*SRLAT/(R*D)
ENDIF

```

C
C

```

IF (GLON .NE. OLON) THEN
DO 40 M=2,MAXORD
SP(M)=SP(1)*CP(M-1)+CP(1)*SP(M-1)
CP(M)=CP(1)*CP(M-1)-SP(1)*SP(M-1)
40 CONTINUE
ENDIF

```

C
C

```

AOR=RE/R
AR=AOR**2

```

C
C

```

BR=0.
BT=0.
BP=0.
BPP=0.

```

C
C

```

DO 70 N=1,MAXORD
AR=AR*AOR
DO 60 M=0,N

```

C

COMPUTE UNNORMALIZED ASSOCIATED LEGENDRE POLYNOMIALS
AND DERIVATIVES VIA RECURSION RELATIONS

C

```

IF (ALT .NE. OALT .OR. GLAT .NE. OLAT) THEN
IF (N .EQ. M) THEN
P(N,M)=ST*P(N-1,M-1)
DP(N,M)=ST*DP(N-1,M-1)+CT*P(N-1,M-1)
GO TO 50
ENDIF
IF (N .EQ. 1 .AND. M .EQ. 0) THEN
P(N,M)=CT*P(N-1,M)
DP(N,M)=CT*DP(N-1,M)-ST*P(N-1,M)
GO TO 50
ENDIF
IF (N .GT. 1 .AND. N .NE. M) THEN
IF (M .GT. N-2) P(N-2,M)=0.0
IF (M .GT. N-2) DP(N-2,M)=0.0

```

```

P(N,M)=CT*P(N-1,M)-K(N,M)*P(N-2,M)
DP(N,M)=CT*DP(N-1,M)-ST*P(N-1,M)-K(N,M)*DP(N-2,M)
ENDIF
ENDIF
50  CONTINUE

C      TIME ADJUST THE GAUSS COEFFICIENTS
C
IF (TIME .NE. OTIME) THEN
TC(N,M)=C(N,M)+DT*CD(N,M)
IF (M .NE. 0) THEN
TC(M-1,N)=C(M-1,N)+DT*CD(M-1,N)
ENDIF
ENDIF

C      ACCUMULATE TERMS OF THE SPHERICAL HARMONIC EXPANSIONS
C
PAR=AR*P(N,M)
IF (M .EQ. 0) THEN
TEMP1=TC(N,M)*CP(M)
TEMP2=TC(N,M)*SP(M)
ELSE
TEMP1=TC(N,M)*CP(M)+TC(M-1,N)*SP(M)
TEMP2=TC(N,M)*SP(M)-TC(M-1,N)*CP(M)
ENDIF
BT=BT-AR*TEMP1*DP(N,M)
BP=BP+FM(M)*TEMP2*PAR
BR=BR+FN(N)*TEMP1*PAR

C      SPECIAL CASE: NORTH/SOUTH GEOGRAPHIC POLES
C
IF (ST .EQ. 0.0 .AND. M .EQ. 1) THEN
IF (N .EQ. 1) THEN
PP(N)=PP(N-1)
ELSE
PP(N)=CT*PP(N-1)-K(N,M)*PP(N-2)
ENDIF
PARP=AR*PP(N)
BPP=BPP+FM(M)*TEMP2*PARP
ENDIF

C
C
60  CONTINUE
70  CONTINUE

C
C
IF (ST .EQ. 0.0) THEN
BP=BPP
ELSE
BP=BP/ST
ENDIF

```

```

C      ROTATE MAGNETIC VECTOR COMPONENTS FROM SPHERICAL TO
      GEODETIC COORDINATES
C
      BX=-BT*CA-BR*SA
      BY=BP
      BZ=BT*SA-BR*CA
C
      COMPUTE DECLINATION (DEC), INCLINATION (DIP), AND
      TOTAL INTENSITY (TI)
C
      BH=SQRT(BX**2+BY**2)
      TI=SQRT(BH**2+BZ**2)
      DEC=ATAN2(BY,BX)/DTR
      DIP=ATAN2(BZ,BH)/DTR
C
      COMPUTE MAGNETIC GRID VARIATION IF THE CURRENT
      GEODETIC POSITION IS IN THE ARCTIC OR ANTARCTIC
      (I.E. GLAT > +55 DEGREES OR GLAT < -55 DEGREES)
C
      OTHERWISE, SET MAGNETIC GRID VARIATION TO -999.0
C
      GV=-999.0
      IF (ABS(GLAT) .GE. 55.) THEN
      IF (GLAT .GT. 0. .AND. GLON .GE. 0.) GV=DEC-GLON
      IF (GLAT .GT. 0. .AND. GLON .LT. 0.) GV=DEC+ABS(GLON)
      IF (GLAT .LT. 0. .AND. GLON .GE. 0.) GV=DEC+GLON
      IF (GLAT .LT. 0. .AND. GLON .LT. 0.) GV=DEC-ABS(GLON)
      IF (GV .GT. +180.) GV=GV-360.
      IF (GV .LT. -180.) GV=GV+360.
      ENDIF
C
C      OTIME=TIME
      OALT=ALT
      OLAT=GLAT
      OLON=GLON
C
C      RETURN
C
C      END

```

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