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The Magnetic Charts of the United States for Epoch 1975

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THE MAGNETIC CHARTS OF THE UNITED STATES FOR EPOCH 1975

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Abstract

Approximately 34,000 measurements taken from 1900 to 1974 were analyzed by least-squares methods to produce a series of five magnetic charts of the United States for 1975. A feature of the analysis, differing from techniques used for previous editions of the national chart, is that analytic models define the regional magnetic field and are used to contour the magnetic charts.

An overall rms (root mean square) fit of less than 235 nT was obtained for the horizontal and vertical intensities; for the chart of magnetic declination, the rms deviation was on the order of 0.5°. The models of annual change, derived from data at repeat stations and observatories operated by the U.S. Geological Survey, yielded an rms deviation of approximately 6 nT/yr in the force components and 0.7 min/yr in magnetic declination.

Introduction

This report describes the method used to produce the magnetic charts of the United States for 1975, which were published by the U.S. Geological Survey in cooperation with the National Oceanic and Atmospheric Administration (Fabiano and Jones, 1976; Fabiano and others, 1976; Peddie and others, 1976; Jones and others, 1976; Fabiano, 1975). The charts are a continuation of a series that began with the isogonic chart for 1850 and, with a few exceptions, have been published at 5- and 10-year intervals since then. Deel and Howe (1948) and Svendsen (1962) provided historical summaries related to the magnetic surveys and charts of the United States. In 1975, five charts were published: declination (D), inclination (I), horizontal intensity (H), vertical intensity (Z), and total intensity (F). The general objective for these charts was to provide the users of geomagnetic data, such as surveyors and navigators, with references depicting the smoothed distribution of the five components of the Earth's magnetic field in the region of the United States. A secondary objective, related to techniques, was to determine if the regional field could be adequately modeled using simple analytic expressions which subsequently could be used as a convenient means for contouring the isolines and also for synthesizing chart values for varied user needs.

Procedures

The charts for magnetic declination, D, are discussed in a later part of this report. The following brief outline describes the procedures used to obtain the I, H, Z, and F charts:

1. Determine models of current secular change for data reduction.
2. Reduce magnetic survey measurements of H and Z (taken from 1900 through 1974) to epoch 1975.
3. Delete from the reduced file those measurements which appear to be either in error or highly anomalous.
4. Obtain one-degree tessera means of H and Z.
5. Perform separate polynomial analysis of H and Z for the conterminous 48 States region (COT48) and for Alaska. For Hawaii, copy the results from AWC75, the model obtained to create the American World Charts for 1975 (Peddie and Fabiano, 1976).
6. Evaluate and adopt final models; prepare magnetic charts.

Main Field Data

The initial file of magnetic survey data consisted of measurements at 26,097 locations within the COT48 region and 8,036 locations in Alaska. A record for each location was considered acceptable only if both H and Z were measured at the station. Some 70 percent of the data were measured prior to 1963, and more than one-half of the entire file were obtained from the airborne surveys conducted by the U.S. Naval Oceanographic Office and the Department of Energy, Mines and Resources of Canada. Airborne survey data now constitute more than 85 percent of the survey file measured since 1953.

The file of measurements obtained from 1900 to 1962 had been previously reduced for the 1965 series of magnetic charts. Consequently, the reduction procedure for this subset of data involved corrections for the last few years of the previous update (1962.5-1965.0) and the application of the more recent secular variation until the epoch date of 1975.0. Aeromagnetic data were corrected to sea level using an approximation suggested by Chapman (1951). For small heights (h) measured in kilometers, any component will be decreased by a fraction h/2123 of itself at height h.

To identify and remove what appear to be erroneous or anomalous values, residuals were computed for each measurement using the world magnetic charts model for epoch 1970 (Hurwitz and others, 1974) as the reference field and 1967.5 as the reference date. Data with residuals exceeding 800 nT (1,000 nT for Alaska) were rejected and, as a result of this screening process, 12 percent of the original file was omitted from the analysis.

Appendix A shows the distribution of H and Z observations used in obtaining the tessera means for the COT48 region. The gaps represent the areas where no H and Z measurements were available. For Alaska, since one-third of the area lacked vector data, values were synthesized from AWC75 and used to supplement this file for each 2^{o} by 2^{o} gap.

Because relatively few D measurements had been acquired since the last series of D charts, published in 1970, the decision was made to synthesize one value for each one-degree quad from these charts, apply SV (secular variation) corrections from 1967.5-1975.0 and then perform the least-squares analysis.

Secular Variation Data

The file used for the SV analysis consisted of three categories of data:

1. The annual mean values of D, H, and Z from Canadian and U.S. magnetic observatories.
2. Vector field measurements at some 100 repeat stations in COT48, which are occupied every 5-7 years.
3. Supplemental values of annual change, synthesized from AWC75. These consisted of values on a $3^{o} \times 3^{o}$ grid in the ocean areas and were included to minimize edge effects at the chart borders.

At the time this chart was being compiled, no repeat station data since 1965 were available on time to perform a regional SV analysis for Alaska. Therefore, for Alaska, grid values of annual change from AWC75 were used to derive the SV polynomial coefficients. (Appendix B lists the Alaskan repeat stations which, nevertheless, were useful in the subsequent evaluation.)

SV Analysis for COT48

For the intervals 1962.5-1967.5 and 1967.5-1975.0, the linear rates of change for D, H, and Z were determined by straight lines fitted to the OAM (observatory annual means) and the repeat-station measurements. Data were reviewed for errors, and on the basis of a preliminary analysis, the observatory rates were given seven times greater weight than the repeat-station rates.

The function adopted for the least-squares procedure is of the form

$$K = \sum_{i=o}^{n} \sum_{j=o}^{i} a_{ij} (\theta_c^{i-j})(\lambda_c^{j}),$$

where K is the linear rate of change; n, the degree of the polynomial; a_{ij}, the coefficients to be determined; and θ_c, λ_c, the normalized geographic coordinates. For COT48, coordinates were normalized so that $\theta_c = \theta - 52^{o}$ and $\lambda_c = \lambda - 268^{o}$. Here, θ = colatitude and λ = east longitude.

Analyses were performed for degrees 4 and 6 (15 and 28 coefficients respectively). On the basis of the rms deviations, shown in table 1, the latter models were adopted for final use.

Table 1.–*Statistics of fit of SV models to initial linear rates of change at U.S. repeat stations and observatories*

[SV1, model for 1962.5-1967.5; SV2, model for 1967.5-1975.0. Column entries show the rms deviations. Leaders (- - -) indicate no data]

Degree	Model	D (min/yr)	H (nT/yr)	Z (nT/yr)
4	SV 1	---	5.2	6.4
	SV 2	0.8	5.5	7.1
6	SV 1	---	4.3	5.8
	SV 2	.7	4.7	6.4

Main Field Analysis

Values of H and Z were averaged to obtain means for each one-degree tessera, and the data were subsequently analyzed using polynomial functions of the form described in the section entitled "SV Analysis for COT48." Tests were run for n=4, 7, and 9, with the objective of determining the optimum fit with the fewest number of coefficients. Finally, the models for n=7 were adopted.

For Alaska, the analysis presented two difficulties:

1. The data-selection region for Alaska, consisting of 2,556 one-degree

tesserae, contained acceptable H and Z data for 1,675 tesserae, only 66 percent of the region.

2. Because of the chart projections used, the COT48 area in the northwest overlaps the region on the Alaska side of the same chart. Since the COT48 and Alaskan models were to be derived separately, it was necessary to insure that the models were consistent in the region of overlap.

Consequently, fill-in grid values were synthesized from the AWC75 model for the sparsely surveyed region and from the COT48 models of H and Z in the overlap area. This amalgamated data set for Alaska, consisting of both sets of synthesized values and the one-degree tessera means, was then analyzed to produce degree-7 polynomial models for H and Z, using colatitude 32° and east longitude 205° to normalize the coordinates.

D Models for COT48 and Alaska

The COT48 region was partitioned into five areas, each consisting of 12-degree longitudinal bands. Separate analyses, degrees 4 and 7, were performed for each band, allowing for 2-degree longitudinal overlaps at the partition boundaries to minimize edge-effect distortions.

For Alaska, a single model n=7 for the entire region was obtained from values synthesized and updated from the 1970 Alaska magnetic chart (U.S. Department of Commerce, 1970) and additional fill-in values from the COT48 and AWC75 models.

Inclination and Total Intensity

The charts of I and F were derived from the H and Z models using the formulas

$$I = \arctan Z/H \text{ and } F = (H^2 + Z^2)^{1/2}$$

The annual change rates, $\dot{I}$ and $\dot{F}$, were computed from the first derivatives, where

$$\dot{I} = (H\dot{Z} - Z\dot{H})/(H^2 + Z^2) \text{ and}$$

$$\dot{F} = (H\dot{H} + Z\dot{Z})/(H^2 + Z^2)^{1/2}.$$

Model Coefficients and Final Charts

The coefficients for the components D, H, and Z, shown in Appendix C, was subsequently used to contour the five magnetic components. Where required, near the chart borders, isolines were manually adjusted to merge with the corresponding isolines of the American World Magnetic Charts for 1975. Consequently, we recommend that for synthesizing values from the analytic models, one should use the American World Charts for ocean areas 200 km beyond the U.S. coastlines.

Evaluation and Discussion

Tables 2, 3, and 4 summarize the major statistics pertinent to the evaluation of the models. In table 2, the lower rms deviations shown for degree 7 are what one may anticipate from an analysis of averaged values.

In table 3, the adopted models for degree 7 are compared to the survey data file. The slightly larger rms deviations for COT48 column A (compared to column B) probably result from the fact that A contains the older data. However, the differences are not large and are within the probable error limits for measured data. Both tables suggest that the COT48 and Alaska charts have comparable accuracies.

The most recent data available for determining the quality of the fit to the models are the vector measurements at the magnetic observatories and repeat stations for the interval 1971-74. The residuals for these stations, shown in Appendix B, are applicable for the epoch date of the measurement indicated in the last column; the summarized statistics are shown in table 4.

Measurements from repeat stations and observatories represent the most reliable survey data available. By comparison with other measurements, they are only marginally affected by temporal and transient variations and generally the stations are located in nonanomalous regions. As a result, these corresponding rms fits are quite good and serve to substantiate the rms fits shown in tables 2 and 3.

Table 2.–*Main field rms deviations, in nanoteslas, for the one-degree tessera means (units of nT)*

	COT48			Alaska
Degree -------	4	7	9	7
Component:				
H	156	118	116	115
Z	152	130	128	148

Table 3.–*Summary of rms deviations of main field models with subsets of survey data using models of n=7 (units of nT)*

	A	B	C
	COT48		Alaska
Component	(Every 5th value, 1900-74)	(All values, 1939-74)	(All values, 1900-74)
H	188	188	184
Z	226	197	234
Number of values	4,409	15,420	7,881

Table 4.–*Summary of rms deviations of the fit of models with data from repeat stations and observatories in COT48 and Alaska*

[COT48, 113 stations; Alaska, 26 stations]

Component	COT48	Alaska
D	0.37°	0.52°
H	145 nT	106 nT
I	0.18°	0.13°
Z	225 nT	184 nT
F	205 nT	174 nT

Table 5 refers to the partitioning scheme and related statistics for the D models of COT48. Because the values analyzed are scaled from a smooth chart, the overall fit, as one might anticipate, is remarkably close, to within 6 minutes of arc for most partitions, providing some evidence for the adequacy of the modeling process for regions as large as 2 million square kilometers--the approximate size of each partitioned area. The larger rms values in bands 2 and 3 probably indicate the numerous declination anomalies in the Great Lakes region.

Table 5.—*Summary of rms deviations of D models to tessera means of declination*

[γ column shows the east longitude normalizing factor]

Band	Partition °W. long	rms (in degrees) Degree 4	7	γ (in degrees)
1	66-77	0.11	0.01	289
2	78-89	.18	.14	277
3	90-101	.14	.10	265
4	102-113	.08	.06	253
5	114-125	.06	.05	241

The D models were also evaluated by comparing them to two subsets of survey data. The first set consisted of 1,450 station values, updated to 1975.0 and randomly distributed within COT48. From these measurements, an overall rms of 0.50° was determined. The second subset, comprising survey data excluded from the file of analysis data, consisted of 287 airborne measurements from the Project Magnet surveys made from 1967 to 1970. With this set, the computed rms was 0.52°.

Among the reasons for the lack of fit that one may observe from the differences which exist between the data and models, the following should be noted:

1. Errors in the data. This problem was discussed earlier. Wherever possible, it is important to determine whether the errors are random or systematic. Hannaford and Haines (1969), for example, reported probable errors in aeromagnetic data of 0.4° in D, 40 nT in H, and 70 nT in Z. In the older land survey data, Deel and Howe (1948) reported possible errors as large as 150 nT in the computed value of Z due to instrumental uncertainties.
2. Secular variation. The secular-variation estimates for the earlier years, especially prior to the 1930's, are less reliable, due primarily to insufficient data as well as to the quality of the instrumentation. In addition, the use of linear SV estimates, though convenient and in some instances practical, introduces errors in data reduction because the SV is not necessarily linear. This is not a serious problem for data-reduction intervals of a few years. However, for a 5- or 10- year interval, significant errors could accumulate.
3. Local and regional anomalies. It is difficult at this time to assess the impact resulting from the local and regional magnetic anomalies on the statistics relating to the fit of the data to the model. If, for example, one had available up-to-date vector measurements spaced a few kilometers apart nationwide, relatively accurate assessments of the "normal" and anomalous fields could be made. To date, however, the available vector data are too poorly distributed, both in space and in time.

A small-scale chart of total intensity and its annual change for 1975 in the United States is shown in figure 1. This chart was adapted from the 1975 U.S. total intensity chart (Fabiano and others, 1976). Figure 2 illustrates how SV estimates of total intensity (FDOT) can change over a 10-year period. Note that at latitude 45° and longitude 90° the estimated rates of SV differ by more than 60 nT/yr.

Conclusion

The various statistics of fit presented indicate that the polynomial technique is generally adequate for producing models of the smoothed field suitable for national reference charts. The major deterrent for obtaining more reliable models appears to lie not so much in technique as it does in the accuracy of the available data base.

Dependence on these data may soon be minimized and perhaps eliminated as a result of two magnetic surveys, one completed and the other planned. During 1977-78, the U.S. Naval Oceanographic Office completed a vector survey of the United States with north-south tracklines flown at approximately 100-km spacing; several east-west lines were also flown. In 1979 the National Aeronautics and Space Administration in cooperation with the U.S. Geological Survey will launch MAGSAT, a low-level satellite which will obtain worldwide vector data. The acquisition of measurements from both sources will substantially improve the data base used for future national charts.

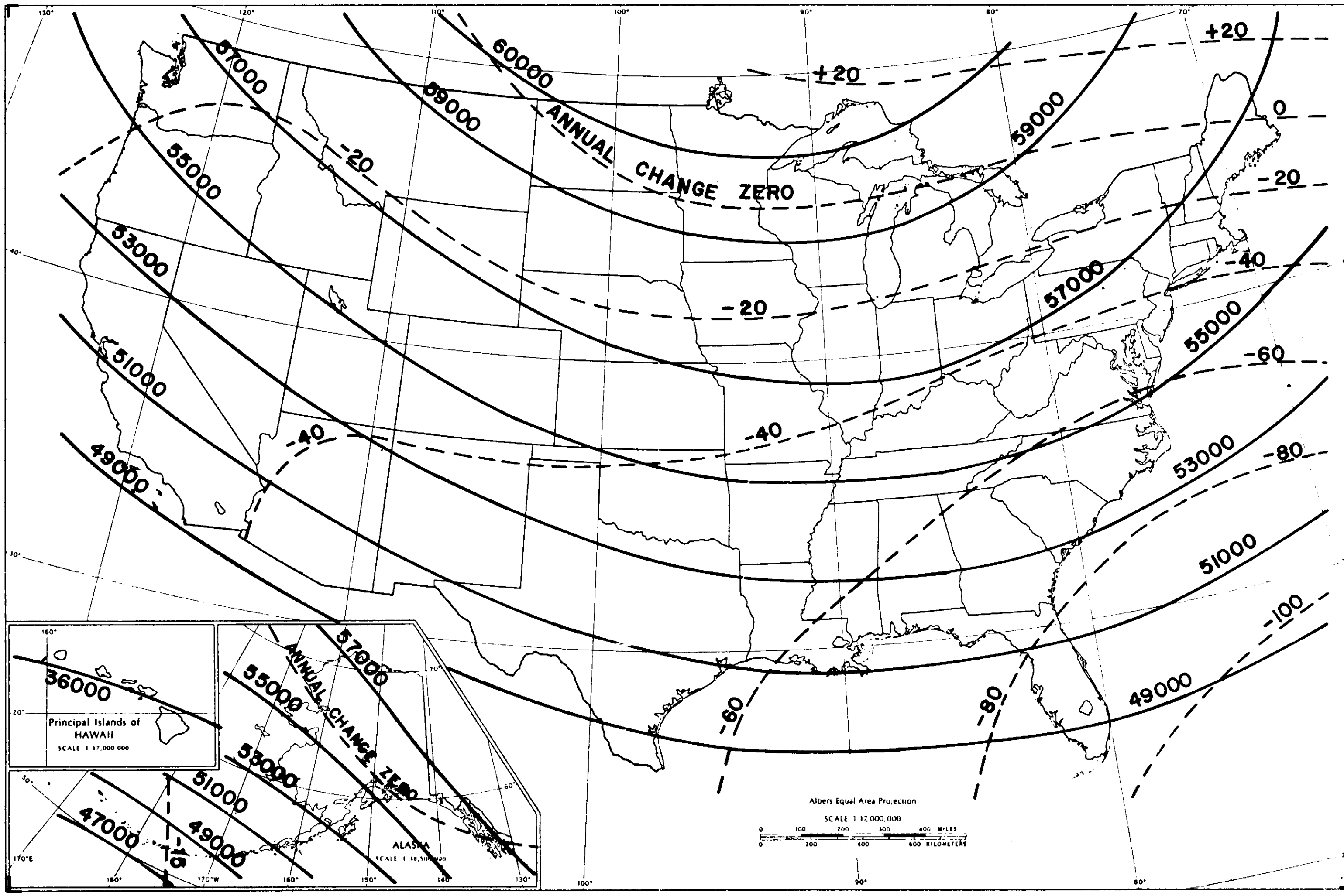

Figure 1. Total Intensity in the United States for 1975. (Solid lines are field contours in units of nanotesla (nT); dashed lines are annual change contours in units of nT/yr.)

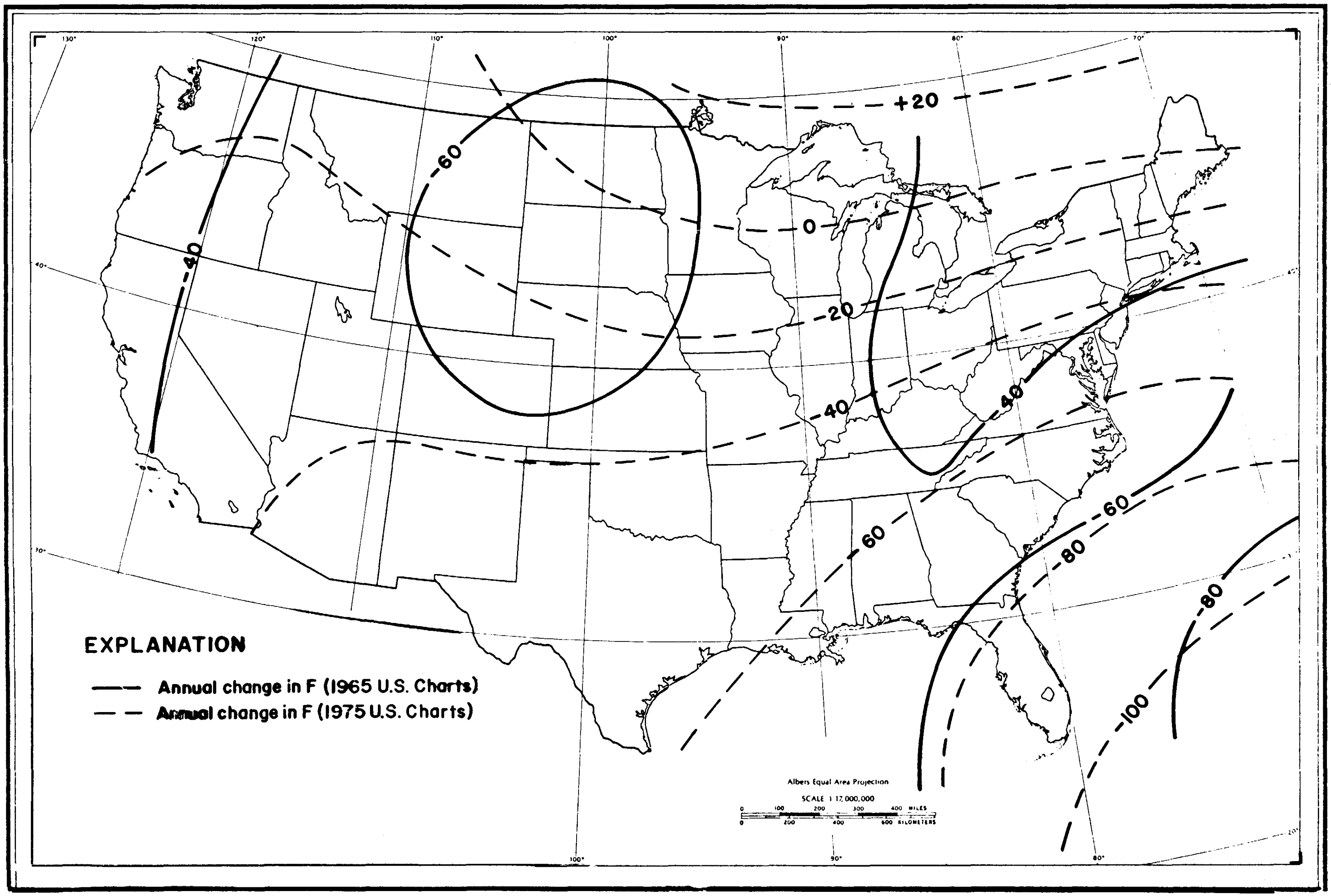

Figure 2. Comparison of FDOT 1965 and 1975 United States magnetic charts (in units of nT/yr.)

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Appendix A.--*The number of H and Z survey measurements by one-degree tessera within the conterminous 48 States*

[Latitude and longitude, in degrees, are shown in the extreme left-hand column and top row, respectively]

	-130	-129	-128	-127	-126	-125	-124	-123	-122	-121	-120	-119	-118	-117	-116	-115	-114	-113	-112	-111	-110	-109	-108	-107	-106
56																									
	9	7	6	6	6	9	2	4	10	15	17	21	12	11	8	9	9	15	7	5	4	7	8	3	
55																									
	9	12	14	12	14	13	6	7	11	8	10	19	17	17	17	16	87	19	10	5	6	3	6	4	
54																									
	5	10	3	11	4	8	16	10	13	12	7	18	20	18	11	25	26	16	10	20	37	10	7	11	
53																									
	6	14	14	6	8	7	15	9	7	8	8	21	6	7	9	22	35	12	14	12	21	35	26	32	
52																									
	13	11	12	7	9	5	10	13	12	10	9	15	11	8	42	36	21	12	9	6	10	11	18	11	
51																									
	11	15	17	20	9	6	8	17	20	23	19	12	13	13	9	16	34	15	21	22	12	19	20	28	
50																									
	12	12	7	8	13	39	27	14	22	9	21	12	17	13	22	11	28	17	11	14	7	4	5	8	
49																									
	10	13	13	12	10	16	32	17	5	3	8	12	7	12	11	6	18	7	13	9	15	9	11	10	
48																									
	4	4	4	6	4	5	0	63	4	8	4	11	11	6	4	3	1	1	0	2	2	1	0	2	
47																									
	2	0	0	0	5	8	6	3	0	8	4	4	5	0	1	2	11	18	2	2	2	1	1	0	
46																									
	1	3	3	6	9	8	12	18	13	6	2	15	3	3	0	0	2	4	1	4	6	9	3	1	
45																									
	0	2	5	6	7	9	20	3	3	3	1	5	6	18	0	0	0	2	0	0	2	3	1	11	
44																									
	6	4	0	4	3	10	8	2	2	0	4	2	1	8	4	2	1	5	8	3	3	4	1	3	
43																									
	3	0	0	2	3	11	4	2	3	2	1	0	0	0	0	15	6	11	4	1	0	3	0	5	
42																									
	0	4	2	2	0	14	3	16	2	2	0	1	2	0	0	1	0	1	18	2	12	4	12	11	
41																									
	5	2	1	6	2	14	2	7	2	4	4	3	15	2	10	10	12	16	27	16	22	17	13	20	
40																									
	4	5	3	1	2	11	16	3	6	5	19	11	14	12	19	14	11	4	12	14	2	12	9	10	
39																									
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36																									
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35																									
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33																									
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32																									
	14	9	3	2	5	11	13	12	13	11	6	1	11	18	4	7	9	6	5	13	6	7	3	19	
31																									
	2	7	7	7	7	8	7	7	8	1	4	2	13	6	7	4	5	10	7	4	0	0	5	1	
30																									
	8	3	3	2	0	0	2	5	1	5	1	7	10	3	17	7	4	4	8	10	1	0	0	0	
29																									
	4	3	3	2	3	3	0	5	4	0	4	11	17	6	14	2	7	3	10	9	6	3	2	10	
28																									
	0	0	0	0	0	1	4	3	9	8	8	7	9	4	14	8	6	9	5	21	2	5	3	1	
27																									
	0	0	0	1	0	0	0	0	0	0	6	6	4	5	7	8	11	5	3	1	12	1	3	3	
26																									
	3	3	5	3	3	3	3	3	4	6	1	1	9	3	6	8	3	2	8	6	6	6	3	3	
25																									
	0	0	0	0	0	0	0	0	0	0	0	0	1	7	7	4	10	8	3	7	3	4	10	1	
24																									
	0	0	0	0	0	0	0	3	2	3	5	4	2	6	5	5	3	9	7	4	6	3	1	12	
23																									
	2	3	3	1	3	3	2	0	0	0	0	0	0	0	3	5	6	5	5	8	7	4	5	6	
22																									
	3	3	0	0	0	0	1	0	0	0	0	0	0	0	0	4	0	2	6	0	2	4	6	9	
21																									
	0	1	3	2	3	4	3	3	2	0	1	3	5	4	2	0	3	2	6	10	7	5	1	0	
20																									

Appendix A.--*The number of H and Z survey measurements by one-degree tessera within the conterminous 48 States*--Continued

	-106	-105	-104	-103	-102	-101	-100	-99	-98	-97	-96	-95	-94	-93	-92	-91	-90	-89	-88	-87	-86	-85	-84	-83	-82
56	8	5	10	13	8	6	5	6	12	9	6	9	10	5	15	2	0	6	5	3	10	1	3	10	
55	3	0	1	17	12	6	6	4	9	4	6	7	8	5	9	10	5	8	4	4	12	6	4	12	
54	24	7	4	14	21	9	9	6	22	5	5	11	2	2	8	8	8	6	1	2	6	6	5	6	
53	21	29	7	17	20	5	3	4	9	5	7	11	1	3	8	2	10	11	6	3	8	3	8	11	
52	24	21	24	28	15	17	7	16	7	3	2	9	0	1	10	4	0	14	0	5	10	6	6	14	
51	13	16	14	18	30	26	20	39	32	30	9	10	3	12	29	8	13	18	5	8	11	1	0	6	
50	13	10	14	21	14	21	31	17	44	21	31	36	28	29	31	10	4	20	8	14	12	10	20	8	
49	8	5	4	11	7	5	9	5	17	10	5	16	8	9	20	16	48	33	15	4	18	16	9	11	
48	1	18	2	3	6	7	6	4	7	4	3	9	3	0	2	0	4	26	25	27	11	6	13	16	
47	1	2	3	7	3	10	3	12	4	21	6	2	2	12	3	13	3	21	21	3	29	36	15	35	
46	0	1	3	3	5	4	5	7	3	5	10	9	9	15	14	4	18	9	10	5	2	31	13	6	
45	5	1	13	0	0	6	2	22	7	8	5	7	18	19	11	7	6	11	5	3	12	14	11	4	
44	2	4	4	5	8	6	7	9	8	8	15	12	28	14	23	7	16	14	11	8	6	10	19	16	
43	1	5	14	4	3	2	11	4	14	11	7	10	7	10	19	15	8	24	6	5	34	14	17	36	
42	10	40	20	13	6	11	9	10	12	24	32	19	25	12	26	17	12	30	14	24	18	12	13	8	
41	14	14	15	23	19	19	22	23	23	27	22	25	21	21	28	19	16	29	19	37	26	22	20	26	
40	16	8	5	10	11	13	10	18	16	9	22	23	21	14	13	11	18	16	17	24	27	40	25	29	
39	16	19	3	13	9	8	6	8	39	11	69	9	15	19	15	24	20	19	31	41	41	37	49	40	
38	23	30	22	30	28	37	22	37	21	41	23	23	29	26	44	28	30	34	44	27	31	43	25	18	
37	2	11	2	6	4	5	9	12	8	14	20	10	23	17	14	15	25	8	16	24	14	18	19	34	
36	5	3	15	8	17	12	12	11	19	22	14	15	10	9	9	23	19	20	15	19	19	30	42	35	
35	7	9	4	8	6	8	13	23	11	17	11	16	6	18	13	8	9	15	13	35	23	15	28	15	
34	6	8	4	6	8	7	10	8	8	17	11	18	8	18	9	8	25	14	18	18	24	37	34	22	
33	10	5	5	5	15	12	13	9	13	11	9	7	15	15	13	20	11	18	18	20	12	15	20	16	
32	9	10	10	8	3	6	8	8	4	9	6	7	5	19	9	20	20	11	17	9	11	18	14	22	
31	4	6	6	5	8	7	8	5	15	12	9	9	19	15	19	17	14	24	15	8	12	28	13	14	
30	0	1	1	0	3	8	3	10	16	13	14	14	2	1	11	14	13	1	0	1	6	6	3	21	
29	0	0	0	2	0	6	7	5	22	10	5	7	1	0	4	6	1	0	4	2	5	7	5	16	
28	0	2	3	0	6	3	19	7	12	0	2	2	2	7	8	0	0	2	4	1	7	6	8	10	
27	3	1	0	1	4	1	1	4	11	2	2	2	2	10	0	0	3	1	0	9	9	6	1	9	
26	4	3	5	2	3	7	7	0	29	5	2	2	9	1	0	1	2	2	4	8	8	2	0	2	
25	0	5	4	0	5	3	1	0	10	5	4	9	4	0	0	4	4	1	4	12	13	13	9	10	
24	0	0	1	4	4	4	4	6	8	3	12	6	0	0	6	3	0	0	8	9	3	0	5	29	
23	5	0	0	5	6	5	1	4	17	7	4	2	7	4	3	0	1	5	15	1	4	1	11	5	
22	7	12	4	4	11	6	6	5	13	9	1	2	4	4	0	0	4	4	12	5	5	1	0	0	
21	1	3	12	13	15	14	17	11	16	16	14	7	7	12	5	3	15	11	9	17	4	4	1	0	
20																									

Appendix A.--*The number of H and Z survey measurements by one-degree tessera within the conterminous 48 States*--Continued

	-82	-81	-80	-79	-78	-77	-76	-75	-74	-73	-72	-71	-70	-69	-68	-67	-66	-65	-64	-63	-62	-61	-60
56																							
		2	2	11	2	3	3	11	7	18	12	12	5	10	3	10	13	6	6	4	0	7	11
55																							
		5	7	8	4	3	6	1	8	13	0	4	2	8	7	9	20	3	12	0	3	4	7
54																							
		2	2	8	3	2	7	6	12	20	3	7	13	9	4	9	5	0	11	2	4	6	16
53																							
		9	2	7	5	2	8	9	0	13	2	3	9	4	2	13	5	3	10	6	11	12	16
52																							
		6	8	9	6	7	18	5	5	17	7	3	9	12	10	10	15	0	13	7	4	8	9
51																							
		9	4	7	4	8	7	3	3	18	1	4	12	7	6	2	20	11	10	7	4	16	7
50																							
		22	10	12	9	5	10	5	12	12	8	9	4	5	13	16	20	7	6	0	12	4	3
49																							
		8	24	17	12	4	19	11	17	15	25	14	14	16	39	20	8	6	11	2	11	0	5
48																							
		13	6	38	2	2	8	3	15	13	12	0	27	26	32	16	19	7	9	11	10	15	8
47																							
		24	26	36	33	11	11	18	14	13	28	44	15	10	6	24	12	4	33	29	17	11	34
46																							
		10	11	14	17	25	18	67	37	33	41	17	21	20	22	31	32	12	15	18	22	27	17
45																							
		2	14	23	16	16	32	20	24	45	15	14	11	14	33	6	23	33	37	46	5	9	22
44																							
		10	15	80	7	8	20	11	6	7	29	15	23	2	12	18	30	12	8	6	13	11	11
43																							
		20	6	9	14	5	22	6	6	23	28	41	29	15	16	12	13	6	10	8	0	6	11
42																							
		18	25	10	5	10	12	12	14	19	58	53	18	14	8	2	12	8	10	1	7	13	10
41																							
		16	17	13	6	11	31	28	55	34	18	9	5	4	6	5	7	2	9	4	0	9	5
40																							
		39	35	34	24	34	24	71	27	5	2	5	2	7	3	7	8	0	2	3	10	3	6
39																							
		35	24	27	34	47	84	9	20	18	10	11	6	5	7	1	4	1	5	9	14	4	9
38																							
		17	34	65	38	41	19	7	10	22	20	9	4	3	6	1	7	3	0	14	7	0	5
37																							
		27	12	18	23	25	46	16	17	6	13	17	18	3	3	8	3	0	0	21	1	3	8
36																							
		24	32	19	22	23	13	29	8	9	11	10	13	24	9	4	6	3	8	11	4	3	8
35																							
		42	18	32	6	23	11	15	14	17	5	0	6	12	18	21	5	2	14	8	2	11	8
34																							
		28	16	10	10	15	6	11	7	15	10	6	7	4	5	16	29	0	16	15	21	17	7
33																							
		24	13	14	4	12	7	11	3	3	23	7	4	8	10	11	14	19	226	36	19	18	12
32																							
		15	2	8	8	11	11	6	9	0	8	12	3	0	3	7	0	11	12	10	10	11	8
31																							
		17	0	6	1	13	7	9	14	5	5	10	6	0	0	8	9	7	9	4	8	4	3
30																							
		29	9	3	0	0	14	4	9	6	10	6	6	7	0	11	5	7	4	4	1	7	4
29																							
		10	33	3	1	0	5	8	10	7	4	13	13	7	8	11	0	11	11	2	3	4	4
28																							
		8	12	3	4	5	4	0	14	4	0	7	10	11	8	9	7	8	6	0	7	3	7
27																							
		14	18	0	0	7	2	3	6	7	3	0	7	18	8	8	0	14	9	0	4	0	4
26																							
		10	11	2	0	7	6	5	7	2	11	0	6	3	19	6	14	13	5	7	4	0	1
25																							
		40	6	4	0	4	2	9	0	8	6	11	0	3	9	8	8	14	14	8	9	1	0
24																							
		8	0	2	4	2	3	5	8	9	3	10	6	0	7	5	8	14	0	0	4	10	0
23																							
		1	10	6	2	3	2	4	5	13	4	3	28	26	4	11	9	16	6	10	5	10	5
22																							
		5	0	0	0	13	0	0	8	14	5	0	31	43	15	4	6	13	12	6	0	8	9
21																							
		0	5	0	0	4	4	16	6	10	4	4	5	17	12	5	7	7	16	9	0	9	10
20																							

Appendix B.--Residuals--U.S. repeat stations and observatories, including Alaskan repeat stations

[Station value minus model value for the date of measurement; for example, 1971.4 = 71.4; Lat, latitude; Long, longitude; Decl, declination; Horiz, horizontal; Vert, vertical; °, degrees; nT, nanotesla]

State (Abbr)	Station (name)	Lat °	Long °	Decl °	Dip °	Horiz nT	Vert nT	Total nT	Date
AL----	Marion (FISH)---------	32.73	-87.28	-0.20	0.08	121.	421.	431.	71.4
AL----	Marion (FISH)---------	32.73	-87.28	-0.21	0.09	98.	392.	395.	72.9
AL----	Gadsden---------------	34.00	-86.00	0.04	-0.14	226.	179.	258.	74.4
AZ----	Nogales---------------	31.35	-110.94	0.12	-0.09	-9.	-164.	-144.	72.9
AZ----	Phoenix---------------	33.46	-111.96	0.33	-0.05	-44.	-161.	-161.	72.8
CA----	Bishop----------------	37.36	-118.36	-0.45	0.03	-17.	20.	10.	72.8
CA----	Lompoc----------------	34.64	-120.53	0.29	0.22	-203.	36.	-73.	72.7
CA----	San Diego (CAMP ELL2)-	32.89	-117.07	0.42	0.17	172.	556.	564.	72.8
CA----	San Diego (MIRAMAR)---	32.84	-117.16	-0.54	0.60	-178.	709.	512.	72.8
CA----	San Francisco (1952)--	37.72	-122.49	0.15	-0.05	29.	-43.	-24.	72.7
CA----	San Francisco (GOLF)--	37.72	-122.49	0.25	-0.20	125.	-144.	-67.	72.7
CO----	Cortez (ARPT)---------	37.30	-108.63	-0.48	0.17	-201.	-61.	-142.	73.8
FL----	Fort Meyers-----------	26.61	-81.88	-0.36	0.01	27.	61.	66.	71.4
FL----	Fort Meyers-----------	26.61	-81.88	-0.30	0.07	-40.	47.	19.	74.3
FL----	Key West (RK PT)------	24.56	-81.68	-0.20	0.16	-109.	87.	12.	71.3
FL----	Key West (GOLF)-------	24.57	-81.74	-0.19	0.19	-128.	101.	13.	71.3
FL----	Key West (GOLF) Aux-2-	24.57	-81.74	-0.18	0.30	-236.	92.	-55.	74.3
FL----	Spruce Creek (TEL)----	29.07	-81.05	0.15	0.54	-289.	477.	279.	71.4
FL----	Spruce Creek (A)------	29.08	-81.03	0.09	0.49	-263.	438.	258.	71.4
FL----	Spruce Creek----------	29.07	-81.05	0.08	0.51	-305.	391.	195.	74.3
GA----	Bainbridge (1958)-----	30.91	-84.60	-0.12	-0.13	84.	-105.	-54.	71.4
GA----	Bainbridge (1958)-----	30.91	-84.60	-0.15	-0.14	56.	-166.	-121.	74.3
GA----	Milledgeville---------	33.09	-83.28	1.11	-0.04	-77.	-246.	-255.	71.4
GA----	Waycross--------------	31.24	-82.35	0.03	-0.14	104.	-82.	-25.	74.3
ID----	Weiser----------------	44.26	-116.97	0.41	0.03	98.	318.	332.	73.8
IL----	Joliet (CC 2)---------	41.50	-88.05	0.26	-0.10	65.	-114.	-87.	72.4
IL----	Joliet (WDRF)---------	41.54	-88.01	0.09	0.01	11.	51.	52.	72.4
IA----	Indianapolis----------	39.73	-86.28	-0.47	0.00	-43.	-118.	-126.	72.4
KY----	Lexington (CC)--------	38.08	-84.45	0.57	0.46	-542.	-141.	-326.	73.6
ME----	Bangor (BROADWAY)-----	44.83	-68.79	-0.14	0.09	-87.	36.	8.	73.5
ME----	Bangor (GRIFFIN)------	44.83	-68.81	-0.12	0.08	-74.	41.	17.	73.5
ME----	Fort Kent (B HOSP)----	47.27	-68.60	-0.19	0.03	-5.	91.	86.	73.6
ME----	Fort Kent (PASTURE)---	47.25	-68.59	-0.20	0.06	-38.	102.	88.	73.6
MI----	Detroit (PARK)--------	42.36	-83.26	-0.09	-0.22	155.	-236.	-178.	72.5
MI----	Detroit (RR)----------	42.34	-83.25	-0.01	-0.22	143.	-272.	-215.	72.5
MI----	Marquette (GF2 1972)--	46.54	-87.42	0.82	0.01	-56.	-170.	-178.	72.5
MO----	Rolla (EAST)----------	37.95	-91.78	-0.45	0.00	31.	88.	93.	73.7
MS----	Brooklyn--------------	31.03	-89.17	-0.04	-0.07	26.	-93.	-70.	72.9
MS----	Grenada (A)-----------	33.75	-89.80	-0.24	0.00	72.	160.	175.	72.9
MS----	Granada (71)----------	33.75	-89.80	-0.24	0.02	63.	166.	177.	72.9
MS----	Lamar (B GUM)---------	30.92	-89.39	0.06	-0.06	21.	-79.	-60.	72.9
MT----	Billings (PP)---------	45.79	-108.53	-0.72	-0.04	81.	113.	132.	72.5
MT----	Glendive (ARPT 71)----	47.13	-104.81	-0.17	0.00	-14.	-36.	-38.	71.6
MT----	Havre-----------------	48.56	-109.72	0.02	0.10	-77.	122.	96.	71.5
MT-----	Helena (ARPT 71)------	46.60	-111.98	-0.36	-0.07	-11.	-246.	-236.	71.6

Appendix B.--Residuals--U.S. repeat stations and observatories, including Alaskan repeat stations --Continued.

State (Abbr)	Station (name)	Lat °	Long °	Decl °	Dip °	Horiz nT	Vert nT	Total nT	Date
MT----	Helena (GR MDW)-------	46.62	-112.07	-0.74	-0.32	264.	-216.	-121.	71.6
MT----	Helena (ARPT 2)-------	46.60	-111.98	-0.50	-0.14	48.	-307.	-275.	71.6
MO----	Carrollton------------	39.37	-93.49	-0.20	-0.06	33.	-85.	-67.	73.7
MO----	Rolla (WEST)----------	37.95	-91.78	-0.64	0.02	31.	124.	127.	73.7
NE----	Fremont (ARPT-64)-----	41.45	-96.52	0.55	-0.03	-71.	-286.	-293.	73.7
NE----	Fremont (ARPT-73)-----	41.45	-96.52	0.62	-0.03	-69.	-283.	-290.	73.7
NE----	Halsey (B 73)---------	41.90	-100.28	0.33	-0.17	163.	-49.	10.	73.7
NE----	Fremont (ARPT)--------	41.45	-96.52	0.62	-0.03	-69.	-283.	-290.	73.7
NV----	Ely (BLM)-------------	39.32	-114.88	0.09	0.08	22.	213.	202.	72.6
NV----	Las Vegas (M GLF)-----	36.19	-115.18	-0.10	0.39	-296.	191.	30.	72.6
NV----	Winnemuca (ARPT)------	40.90	-117.80	-0.22	0.03	-41.	-15.	-31.	72.6
NH----	Keene (ARPT)----------	42.90	-72.26	-0.39	-0.13	170.	100.	148.	73.5
NH----	Surry-----------------	43.00	-72.32	0.12	0.10	-34.	229.	208.	73.5
NM----	Deming----------------	32.25	-107.77	-0.12	-0.04	-2.	-77.	-68.	72.9
NM----	Deming (ARPT 72)------	32.26	-107.72	-0.12	-0.05	1.	-85.	-73.	72.9
NM----	Hobbs-----------------	32.68	-103.21	0.74	0.18	-150.	70.	-11.	72.7
NM----	Soccoro (ARPT 72)-----	34.02	-106.90	-0.12	0.05	-128.	-144.	-187.	72.9
NY----	Syracuse (DRUM)-------	43.02	-76.10	-0.27	0.04	-16.	75.	67.	73.6
NY----	Syracuse (DRUM B)-----	43.02	-76.11	-0.33	0.03	-9.	80.	73.	73.6
NC----	Wadesboro-------------	34.94	-80.04	1.40	0.67	-598.	231.	-26.	74.4
NC----	Wilmington (GOLF 1)---	34.21	-77.87	0.32	0.09	105.	432.	437.	71.3
NC----	Wilmington (GOLF 2)---	34.21	-77.87	0.31	0.11	85.	444.	440.	71.3
NC----	Wilmington (GOLF 2)---	34.21	-77.87	0.27	0.12	47.	374.	360.	74.4
ND----	Bowbells--------------	48.81	-102.25	0.48	-0.08	81.	-24.	-3.	72.6
ND----	Jamestown-------------	46.91	-98.70	0.72	0.10	-62.	160.	138.	72.6
ND----	Jamestown (ARPT)------	46.93	-98.68	0.51	0.11	-55.	230.	207.	72 6
ND----	Pembina (PARK)--------	48.97	-97.25	0.11	0.01	-32.	-77.	-83.	72.6
OK----	Carmen (PARK)---------	36.58	-98.45	0.65	-0.05	-38.	-202.	-200.	73.8
OK----	Tulsa (LEONARD)-------	35.91	-95.79	0.24	0.01	-50.	-87.	-100.	73.8
OR----	Burns (FGNDS)---------	43.58	-119.02	0.49	0.14	27.	428.	406.	72.6
OR----	Eugene (RESV)---------	44.06	-123.29	0.09	-0.09	103.	19.	58.	72.6
PA----	Indiantown Gap (AF)---	40.45	-76.55	-0.23	0.01	19.	87.	88.	74.5
PA----	Indiantown Gap (LAKE)-	40.42	-76.60	-0.26	0.03	-9.	69.	62.	74.5
RI----	Kingston (CAMPUS)-----	41.48	-71.52	-0.01	0.12	-80.	113.	81.	73.5
RI----	Kingston (TURF)-------	41.49	-71.55	-0.18	0.29	-162.	397.	323.	73.5
SC----	Fort Jackson----------	34.02	-80.92	0.24	0.22	-318.	-208.	-321.	74.4
SD----	Belle Fourche 2-------	44.70	-103.87	0.32	-0.11	47.	-218.	-193.	72.6
SD----	Huron (CC)------------	44.40	-98.22	0.23	-0.21	350.	383.	470.	72.6
TN----	Clarksville 73--------	36.64	-87.48	0.18	-0.19	-41.	-570.	-541.	73.6
TX----	Brownsville (GOLF 2)--	25.88	-97.50	0.01	0.12	-74.	63.	9.	72.8
TX----	Austin (DS)-----------	30.21	-98.07	0.05	0.21	-83.	237.	163.	72.8
TX----	Austin (GOLF)---------	30.37	-97.69	-0.09	-0.01	-59.	-129.	-141.	72.8
TX----	Hereford--------------	34.86	-102.32	0.57	-0.25	128.	-259.	-175.	72.7
TX----	Laredo (NORTH)--------	27.56	-99.47	0.02	0.01	-53.	-60.	-80.	72.8
TX----	Laredo (WEST)---------	27.56	-99.48	0.02	0.01	-53.	-67.	-85.	72.8
TX----	Orange (C)------------	30.06	-93.80	0.08	0.14	-64.	136.	87.	72.9
TX----	Van Horn (1972)-------	31.05	-104.84	0.00	-0.11	-32.	-249.	-230.	72.8
TX----	Pandale---------------	30.21	-101.37	-0.32	-0.26	164.	-169.	-60.	72.8
UT----	Cedar City (ARPT)-----	37.70	-113.09	-0.19	0.16	-117.	100.	38.	73.8

Appendix B.--Residuals.--U.S. repeat stations and observatories, including Alaskan repeat stations --Continued.

State (Abbr)	Station (name)	Lat °	Long °	Decl °	Dip °	Horiz nT	Vert nT	Total nT	Date
UT----	Salt Lake City--------	40.78	-111.86	-0.36	-0.10	75.	-73.	-37.	73.8
VT----	Burlington (LP)-------	44.46	-73.16	0.15	-0.28	311.	52.	141.	73.6
VT----	Burlington (RS)-------	44.47	-73.20	0.13	-0.32	353.	42.	144.	73.6
WA----	Coulee Dam------------	48.06	-118.95	-0.01	0.00	57.	176.	184.	71.5
WA----	Quillayute------------	47.94	-124.55	-0.04	-0.04	40.	-10.	4.	71.5
WV----	Parkersburg (GOLF)----	39.28	-81.51	0.16	0.15	-28.	361.	330.	72.4
WA----	Seattle (ST EDWD)-----	47.73	-122.26	0.05	0.01	-2.	35.	33.	72.6
WA----	Seattle (ST THOS)-----	47.73	-122.26	-0.02	0.03	-52.	-47.	-62.	72.6
WI----	Tomahawk--------------	45.47	-89.74	0.49	-0.18	110.	-316.	-274.	72.6
WI----	Tomahawk (ARPT)-------	45.47	-89.74	0.01	-0.33	265.	-305.	-221.	72.6
WI----	Eau Claire------------	44.83	-91.53	0.74	-0.20	94.	-404.	-362.	72.6
WY----	Sheridan--------------	44.85	-106.96	-0.24	-0.08	18.	-187.	-171.	71.6
WA----	Newport[1]--------------	48.26	-117.12	0.12	0.01	1.	33.	32.	74.5
CO----	Boulder[1]--------------	40.14	-105.24	0.17	-0.11	20.	-224.	-200.	74.5
VA----	Fredericksburg[1]-------	38.20	-77.37	-0.19	0.04	47.	222.	224.	74.5
CA----	Castle Rock[1]----------	37.24	-122.13	0.04	0.17	-123.	83.	15.	74.5
TX----	Dallas[1]---------------	32.99	-96.75	0.41	-0.13	17.	-220.	-188.	74.5
AZ----	Tucson[1]---------------	32.25	-110.83	-0.12	0.20	-109.	166.	87.	74.5
AK----	Anchorage (NBS)-------	61.24	-149.87	0.63	0.18	-21.	565.	537.	75.4
AK----	Barter Is (IGY)-------	70.13	-143.65	0.40	0.07	-85.	-77.	-89.	75.6
AK----	Bethel (AIRPORT)------	60.78	-161.83	0.40	0.07	9.	241.	231.	75.7
AK----	Chitina---------------	61.52	-144.44	0.66	-0.13	102.	-116.	-85.	75.5
AK----	Cordova 3 (1975)------	60.55	-145.76	-0.07	-0.08	103.	82.	108.	75.5
AK----	Fort Yukon (IGY)------	66.56	-145.26	-0.03	0.10	-112.	-56.	-78.	75.6
AK----	Homer 1 (AIRPORT)-----	59.64	-151.49	-0.81	-0.07	73.	2.	24.	75.4
AK----	Hughes (1975)---------	66.05	-154.26	0.91	0.15	-198.	-209.	-249.	75.7
AK----	Kenai (APT) 1975------	60.56	-151.26	0.32	0.19	-48.	480.	445.	75.4
AK----	Kodiak (1975)---------	57.80	-152.37	0.26	-0.02	47.	80.	91.	75.5
AK----	Kotzebue (IGY)--------	66.88	-162.64	0.40	-0.09	62.	-119.	-101.	75.6
AK----	Kotzebue (1975)-------	66.88	-162.64	0.33	-0.03	8.	-88.	-84.	75.6
AK----	Nome (APT) Aux A (58)-	64.53	-165.37	0.19	-0.02	-20.	-129.	-130.	75.6
AK----	Northway (IGY) 2------	63.02	-141.80	0.21	0.17	-131.	163.	128.	75.5
AK----	Platinum--------------	59.02	-161.82	-0.67	0.32	-301.	47.	-56.	75.7
AK----	Pt Hope (CEMETERY)----	68.35	-166.78	0.71	-0.12	114.	-40.	-14.	75.6
Ak----	Prudhoe Bay (1975)----	70.29	-148.70	0.46	0.05	-73.	-123.	-134.	75.6
AK----	Ruby 3 (1975)---------	64.73	-155.46	0.19	-0.06	46.	-69.	-55.	75.6
AK----	Seward----------------	60.13	-149.42	0.60	-0.03	68.	115.	130.	75.5
AK----	Shungnak--------------	66.89	-157.03	0.31	-0.05	63.	38.	51.	75.6
AK----	Unalakleet (1975)-----	63.89	-160.80	0.57	0.04	-25.	45.	36.	75.7
AK----	Unalaska--------------	53.86	-166.55	1.22	-0.28	152.	-266.	-179.	75.7
AK----	Yakutat 5 (1975)------	59.51	-139.66	-0.21	0.16	-162.	-1.	-43.	75.5
AK----	Barrow[1]---------------	71.30	-156.75	0.46	-0.07	49.	-116.	-106.	74.5
AK----	College[1]--------------	64.86	-147.84	0.26	0.06	-67.	-25.	-40.	74.5
AK----	Sitka[1]----------------	57.06	-135.33	0.13	-0.08	63.	-67.	-47.	74.5

[1]Observatory.

Appendix C.--Coefficients of chart models

[The coefficients can be related to the function as follows: The coefficients numbered 1, 2, 3, 4, 5, 6,...35, 36 are equivalent to the coefficients a_{oo}, a_{10}, a_{20}, a_{21}, a_{22},...a_{77}, of the function]

No.	Declination for band 1 in conterminous 48 States	Declination for band 2 in conterminous 48 States	Declination for band 3 in conterminous 48 States	Declination for band 4 in conterminous 48 States	Declination for band 5 in conterminous 48 States	Secular change in conterminous 48 States
1	-1.28334e+001	-2.67351e+000	6.75344e+000	1.30355e+001	1.62869e+001	-5.91190e+000
2	5.01082e-001	2.93044e-001	-2.61824e-002	-2.64830e-001	-4.17347e-001	-1.68142e-001
3	-7.83442e-001	-8.34178e-001	-6.07717e-001	-4.03658e-001	-1.79067e-001	-6.48094e-002
4	-1.27714e-002	-1.93867e-002	-1.48153e-002	-9.50477e-004	6.25598e-003	5.93866e-003
5	4.01399e-004	2.36374e-002	3.12457e-002	1.73702e-002	1.14608e-002	-2.44053e-002
6	2.24954e-002	1.12795e-002	-1.00242e-002	-1.41128e-002	-7.77271e-003	5.85988e-003
7	3.13086e-004	1.57874e-003	1.84189e-003	4.06045e-004	1.43361e-004	-3.50743e-004
8	4.48060e-004	-2.94205e-004	-1.49579e-003	-6.43100e-004	2.79125e-004	3.53160e-004
9	-1.10156e-003	-1.02440e-003	1.43483e-003	4.28903e-004	1.57742e-004	-6.38998e-005
10	9.44875e-004	-2.44400e-003	-9.51459e-004	2.70990e-004	1.65545e-004	2.92968e-004
11	9.11331e-006	1.65647e-004	1.61507e-004	5.78007e-005	4.11723e-006	3.15289e-005
12	5.93444e-005	1.50505e-005	-1.15636e-004	1.63057e-005	-7.78303e-005	5.54197e-005
13	-3.52190e-006	1.24418e-005	7.82886e-005	3.03403e-005	7.57472e-005	-9.22212e-006
14	7.38989e-005	-1.10751e-004	2.73149e-005	5.68502e-006	-7.25254e-005	1.83674e-005
15	-3.28303e-004	-3.42778e-004	-4.35186e-005	1.40600e-005	-5.68903e-005	3.60506e-006
16	6.01171e-007	-1.31804e-005	-1.72357e-005	-4.28104e-006	-2.37039e-006	9.04572e-007
17	-5.53779e-006	-7.94759e-006	1.51265e-005	3.08059e-006	1.50295e-006	3.37064e-007
18	-1.60637e-006	-1.91323e-005	-1.97283e-005	-2.19284e-006	8.47179e-006	1.88045e-007
19	-2.94657e-006	1.87905e-005	-3.45291e-006	3.48935e-006	-2.91265e-005	-3.41158e-007
20	4.97808e-006	4.95508e-005	-1.24430e-005	2.15235e-006	1.40922e-005	3.90881e-008
21	-7.12612e-006	5.29946e-005	1.21007e-005	-1.37227e-005	1.76083e-006	-1.23375e-007
22	-5.90044e-008	-7.03108e-007	-4.98975e-007	-1.43236e-007	-2.33909e-008	-9.49271e-008
23	-3.61589e-007	2.07349e-007	5.00559e-007	-3.37714e-008	2.62577e-007	-1.11951e-007
24	1.30831e-007	6.24651e-008	-4.41287e-007	-1.65453e-007	-4.61616e-007	1.23254e-008
25	-5.39791e-008	-3.95413e-007	5.95931e-007	-1.64965e-008	7.10883e-007	-2.28627e-008
26	-3.82329e-008	-8.15560e-008	-1.80810e-007	-2.04933e-007	1.69253e-007	-4.11474e-009
27	-4.19099e-007	1.19152e-006	-1.25743e-006	9.80213e-008	-1.26358e-006	-4.37217e-009
28	2.71842e-006	2.62015e-006	4.17432e-007	2.92552e-007	1.47596e-006	-2.49154e-009
29	-1.59998e-010	4.77462e-008	4.68736e-008	9.88492e-009	6.27482e-009	
30	2.66724e-008	1.87578e-008	-5.95585e-008	-9.18516e-009	-8.55351e-009	
31	-1.07483e-008	4.05456e-008	7.54625e-008	5.95536e-009	-4.70189e-008	
32	-1.20473e-008	-1.07154e-008	-2.59804e-008	1.05229e-008	1.34212e-007	
33	3.34444e-008	5.66433e-008	7.19575e-008	1.37968e-008	-2.76226e-008	
34	3.90318e-008	-1.53129e-007	9.23312e-008	-6.92023e-008	-4.80626e-008	
35	-3.19948e-008	-4.16239e-007	-4.68828e-009	-1.36467e-008	2.37465e-008	
36	3.55637e-008	-2.64805e-007	-7.84304e-008	1.52980e-007	-8.59178e-009	

No.	Horizontal intensity for conterminous 48 States	Vertical intensity for conterminous 48 States	Secular change in horizontal intensity for 48 States	Secular change in vertical intensity for 48 States
1	1.11283e+004	2.22299e+004	3.45744e+001	-5.37212e+001
2	5.93553e+002	-8.05063e+002	-3.70315e+000	-4.10167e+000
3	-9.76034e+001	8.25874e+001	2.63540e+000	-1.70578e+000
4	-7.37877e+000	-1.65495e+001	-1.61374e-001	2.71050e-001
5	-1.39807e-001	5.82352e+000	-2.14846e-002	-1.65244e-001
6	1.76988e+000	-7.58918e+000	4.01055e-002	-7.91053e-002
7	-1.23084e-001	1.65418e-001	7.56505e-003	5.79294e-003
8	1.06707e-001	-1.30201e-001	-5.45952e-003	2.38760e-003
9	-2.53787e-001	3.81803e-002	2.64150e-003	-3.30138e-004
10	6.94785e-002	-4.28637e-002	-1.10277e-003	8.04257e-004
11	1.01022e-002	3.09667e-003	9.34116e-004	-1.13355e-003
12	-4.45213e-003	4.57084e-004	9.15822e-005	5.58794e-005
13	2.05698e-003	1.13402e-002	-4.94533e-005	-1.78677e-005
14	8.49875e-004	-4.59439e-003	5.47427e-005	-1.95663e-005
15	4.39136e-004	1.79758e-003	-2.62497e-005	1.10482e-004
16	3.38103e-004	-1.74924e-004	-6.85746e-006	-6.10629e-006
17	-7.43830e-005	5.25474e-004	-1.38716e-007	-4.91566e-006
18	9.43317e-005	3.66931e-005	-4.11077e-006	-2.97886e-006
19	-9.52152e-005	2.66568e-005	1.84179e-006	-6.65628e-007
20	1.18625e-004	-5.80020e-005	-6.31355e-007	1.59898e-007
21	-4.92413e-006	-9.27872e-006	1.70413e-007	-8.00258e-008
22	-2.07456e-005	4.24327e-006	-2.05289e-006	2.05089e-006
23	5.69064e-006	-2.58297e-006	-1.61247e-008	2.94269e-007
24	-5.69877e-007	-8.01126e-006	-1.91784e-007	3.37098e-007
25	1.41786e-006	1.65673e-006	-8.08162e-008	4.86363e-008
26	-1.77985e-006	-3.03678e-006	4.97069e-008	-1.26056e-007
27	-3.64791e-007	1.24441e-006	-2.27589e-008	5.20045e-008
28	-4.97382e-007	-3.95024e-007	3.80636e-009	-3.83451e-008
29	-7.86331e-007	3.37905e-007		
30	-6.84156e-008	-6.94873e-007		
31	-3.28319e-008	-1.32518e-007		
32	1.00894e-007	-2.68581e-007		
33	7.58462e-009	3.81435e-008		
34	-2.27681e-009	4.44719e-008		
35	-3.43554e-008	1.62086e-008		
36	-9.48324e-009	5.55452e-009		

Appendix C.--Coefficients of chart models--Continued

Declination for Alaska		Horizontal intensity for Alaska		Vertical intensity for Alaska		Secular change in declination for Alaska		Secular change in horizontal intensity for Alaska		Secular change in vertical intensity for Alaska	
2.15098e+001	1	1.28701e+004	1	2.06571e+004	1	1.95174e-001	1	1.21089e+001	1	-8.40721e+000	1
-3.12571e-001	2	5.18878e+002	2	-6.05428e+002	2	-5.30394e-002	2	-1.03493e+000	2	-8.68283e-001	2
4.91087e-001	3	-1.00820e+002	3	1.97897e+002	3	-6.93826e-002	3	2.69529e-001	3	3.36583e-001	3
3.23674e-003	4	-9.02027e+000	4	-9.99413e+000	4	-9.20386e-004	4	1.09158e-003	4	1.22695e-002	4
-1.86390e-002	5	2.58613e+000	5	8.84446e+000	5	-1.45384e-003	5	7.47848e-003	5	-3.19064e-002	5
-5.69661e-003	6	-1.40507e+000	6	2.89759e+000	6	-1.03906e-003	6	9.37768e-003	6	-4.80588e-003	6
2.77264e-005	7	-6.59361e-002	7	-2.26663e-002	7	-1.32668e-006	7	1.12332e-004	7	1.02101e-003	7
4.11507e-004	8	2.72348e-001	8	-2.16847e-001	8	1.00093e-004	8	-1.53755e-003	8	-9.26915e-004	8
-3.34078e-004	9	6.11470e-002	9	3.10657e-002	9	-4.85534e-005	9	2.18876e-004	9	-8.09038e-004	9
-1.72609e-005	10	-9.01411e-003	10	-3.77748e-002	10	-7.96214e-007	10	3.61790e-005	10	8.37542e-006	10
1.38057e-005	11	2.41091e-003	11	-2.56118e-003	11	2.88554e-005	11	-1.25999e-005	11	1.56455e-004	11
-4.08427e-006	12	-6.30494e-003	12	-9.13153e-003	12	4.68273e-006	12	-6.11094e-005	12	1.11795e-004	12
1.43227e-005	13	4.71303e-003	13	-6.19806e-003	13	9.25196e-007	13	-2.82389e-005	13	-4.74751e-006	13
-3.78117e-008	14	-4.12616e-004	14	-6.47016e-004	14	2.22493e-007	14	9.39469e-006	14	-9.60527e-006	14
3.43098e-007	15	-1.14520e-004	15	-6.21374e-004	15	1.56201e-007	15	-3.91379e-006	15	3.87091e-006	15
-1.45688e-006	16	-1.57527e-005	16	1.27664e-003	16	1.06060e-007	16	1.63643e-006	16	-1.91582e-006	16
-1.41208e-006	17	-3.36178e-004	17	1.22739e-004	17	-1.23968e-007	17	1.49433e-006	17	1.67819e-006	17
8.36353e-007	18	-9.66833e-005	18	1.94955e-004	18	1.27469e-007	18	-3.68627e-007	18	4.45756e-007	18
-2.13940e-007	19	-7.09362e-005	19	5.85795e-005	19	-1.50581e-008	19	1.38704e-007	19	-4.37977e-007	19
1.92664e-007	20	3.59370e-006	20	3.88750e-006	20	-1.11625e-008	20	-7.57077e-009	20	1.84588e-007	20
-4.30511e-008	21	3.09613e-006	21	-3.02166e-006	21	6.11890e-009	21	-7.56994e-009	21	2.30814e-008	21
-4.39980e-008	22	7.94337e-006	22	8.37796e-006	22	-6.18670e-008	22	-8.26998e-009	22	-3.34610e-007	22
1.99973e-008	23	9.40849e-006	23	3.91646e-006	23	1.76829e-009	23	9.34528e-008	23	-9.34949e-008	23
-4.57007e-009	24	-4.09482e-006	24	5.44917e-006	24	-4.22369e-009	24	3.68985e-008	24	4.87487e-009	24
2.50965e-009	25	-1.35836e-007	25	1.43020e-006	25	-9.96162e-011	25	-8.15906e-009	25	-1.72291e-008	25
-2.70142e-009	26	-5.05727e-007	26	1.30237e-006	26	1.58122e-013	26	3.22362e-009	26	-4.20822e-009	26
1.40864e-009	27	-2.22449e-007	27	-2.34036e-007	27	-3.36216e-010	27	-1.07443e-009	27	4.67631e-009	27
-2.22711e-010	28	1.02968e-007	28	1.68652e-007	28	7.60982e-011	28	7.79046e-010	28	-4.13954e-010	28
9.37746e-010	29	-2.69126e-007	29	-2.24851e-006	29						
1.20184e-009	30	2.12069e-007	30	1.73023e-008	30						
-1.83249e-010	31	1.68482e-007	31	-2.78735e-007	31						
1.03445e-009	32	5.70517e-008	32	-2.49108e-008	32						
-7.40522e-010	33	-3.31915e-009	33	-8.86630e-008	33						
9.24793e-011	34	3.00740e-008	34	-3.19313e-009	34						
-2.09843e-011	35	-5.55377e-009	35	6.01991e-009	35						
6.52480e-012	36	-7.13698e-010	36	-3.49593e-010	36						

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