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National Aeronautics and
Space Administration

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Introduction

This report describes the estimation of mean gravity anomalies from Geos-3 altimeter data. The work itself extended from April 15, 1974 to December 31, 1977. The main effort was concentrated in the last eighteen months when sufficient data became available for large scale computations to be carried out.

This specific report describes results obtained to fulfill the given NASA contract written in response to a proposal made by the author. A number of other reports have been prepared related to the altimeter data analysis. These will be referenced in the text of this report.

The Altimeter Data

All data used for this study was transmitted to us on magnetic tape by the Wallops Flight Center. Originally, we received some data in the BCD mode (Leitao, Purdy and Brooks, 1975), but later this data was discarded in favor of data distributed to us in the binary mode (Ibid.). The data that we received in binary form was read using a slightly modified version of the "Caltor" program (Leitao et. al., 1975, revised 1976), Serelis (1975, revised 1976). For our specific purposes we created from the original tapes a BCD type of tape but with certain additional information that was to be used for editing purposes. We should note here that the BCD format contains information that represents averages in a certain time interval. This average represents a "frame" value where the time extent of a frame depends on the data rate used in the data transmissions. In the low data rate the frame length is 2.048 seconds while in the high data rate the frame length is 3.277 seconds. In the low data rate frame there are 20 observations while in the high data rate there are either 32 observations (mode 2) or 320 observations (mode 3).

The additional information obtained from the binary tapes was as follows:

1. The Calculated Averaged Automatic Gain Control Voltage (AGC) for the frame. This value is given on the Wallops binary tape.

2. The square root of the variance of the AGC voltage within the frame as determined from the individual AGC voltage measurements within the frame.

3. The Radar Altimeter Average Attitude/Specular Gate voltage which was given on the Wallops binary tape.

4. The $H_{1/3}$ value which is a measure of sea state. This value is computed for a frame and is given on the Wallops tape (see revisions dated 3/3/76 of the Leitao et al. report).

We should note here that the altimeter data was taken in a global mode and in an intensive mode, the latter being the more accurate. For our studies we used only the intensive mode data.

For a more detailed explanation of the tapes created by us, see the report by Herbrechtsmeier (1977).

Altimeter Data Editing

The actual data type that we are interested in was the separation between the reference ellipsoid and the sea surface. This quantity, referred to as "Sea Surface Height", is computed as follows:

$$SSH = h - (A - R + b) \tag{1}$$

where

SSH is the sea surface height given with respect to a specified ellipsoid;
h is the height of the altimeter above the reference ellipsoid as determined from the "known" portion of the satellite;
A is the altimeter measurement;
R is the refraction correction;
b is the a priori altimeter bias, if any.

If the sea surface and the geoid would coincide, SSH would be the geoid height which is of specific interest to us.

Errors in the sea surface height as computed from (1) could occur if the altimeter measurement was incorrect, the orbit of the satellite was in error or the altimeter bias was not known. To edit out bad data we initially made plots of the sea surface heights in comparison with the approximately known geoid undulations over the corresponding arc segment. Visual comparisons enabled the identification of potentially bad data. However, it became readily apparent that such a visual process could not be effectively done because of the large amounts of data being received. Consequently, we developed an automatic editing process using criteria found reasonable in the visual editing process, and from comments made about the data by Wallops personnel.

For a frame measurement to be accepted for further processing, it must meet the following criteria:

1. $0.25 < \sigma_{ALT} < 8.00$ meters where σ_{ALT} is the "Altitude Measurement Standard Deviation" given on the binary tape;

2. The absolute value of the sea surface height should be less than 170 meters;

3. The Automatic Gain Control Voltage should lie within the following range: $-78 < AGC < -62$ dbm;

4. The square root of the variance of the AGCV should be less than 2 dbm;

5. The Average Attitude/Specular Gate voltage should be within the following range: $35 < AASG < 999$ dbm;

6. The $H_{1/3}$ value (sea state measure) should be less than 88 meters.

Criterion one was established to delete too noisy or too smooth data. Criterion two was used to delete data that could be off because of very bad orbits. Criterion three checked to see if the AGC voltage fell within normal limits while criterion four examines the variation of the AGCV within the frame. Criterion five was used to detect data taken over land, ice, etc. (Miller, 1977, p. 15). Criterion six was used to see if convergence had been reached in the iterative computation of the sea surface height. If it had not been, we felt the data was poor and should be rejected.

Clearly, the above criteria are somewhat arbitrary. However, they appear to be able to detect most, but not all, of the bad data. A more extensive editing discussion may be found in Herbrechtsmeier (1977).

All the intensive mode data received by us was processed through the data editing program. The original number of frame averages that we started with was 469,800. Of this number 52,111 were deleted by the automatic editing process. We give in Table 1 information related to the number of measurements deleted by one or more of the edit criteria previously described. The ith diagonal elements in this table indicates the number of measurements that have been rejected because the ith criterion and possibly one or more of the other criteria have been met. The off diagonal ij elements in the table indicate the number rejected because the i and j criteria have been met together. The numbers listed in the "independent" column indicate the measurements neglected because only the ith criterion had been met.

Table 1

Data Rejection by Criteria
(see text for explanation)

Criteria No.	1	2	3	4	5	6	Independent
1	7455	1214	1489	2883	3141	2974	1888
2		7079	1890	3980	4828	2083	412
3			14145	3835	8950	3408	3614
4				20102	12539	4578	4483
5					30432	8951	6059
6						18673	6474

In some cases, short one or two data point gaps existed in the data. In this case, a simple linear interpolation was used to fill in the gaps. In this way 9,704 interpolated sea surface heights were generated.

After this analysis it was discovered that certain longitudes were in error (see letter dated November 8, 1977 from H. Ray Stanley). To eliminate this error (it was found some months before the November 8 letter) all data was gone through by hand so that the longitude error and other small errors not detected by the automatic edit process could be found. In this process an additional 5,559 measurements were deleted, leaving a total of 421,834 measurements distributed in 2003 arc segments. The distribution of these arcs is shown in Figure 1.

As a last edit, the new data set was examined to find adjacent values that differed by more than 3 meters. If such unexpected variations were found, they were deleted. A total of 2,540 measurements were so deleted, leaving a final data set of 1976 arcs containing 419,294 "frame" observations.

The Ocean Tide Model

The sea surface height should be corrected for the ocean tide at the time of measurement. The binary tapes supplied by the Wallops Flight Center gave, for each frame average, the ocean tide associated with the Hendershott (1972) tidal model. The specific implementation of this spherical harmonic model (to degree 9) is described by Goodman (1975, p. 4 - 14).

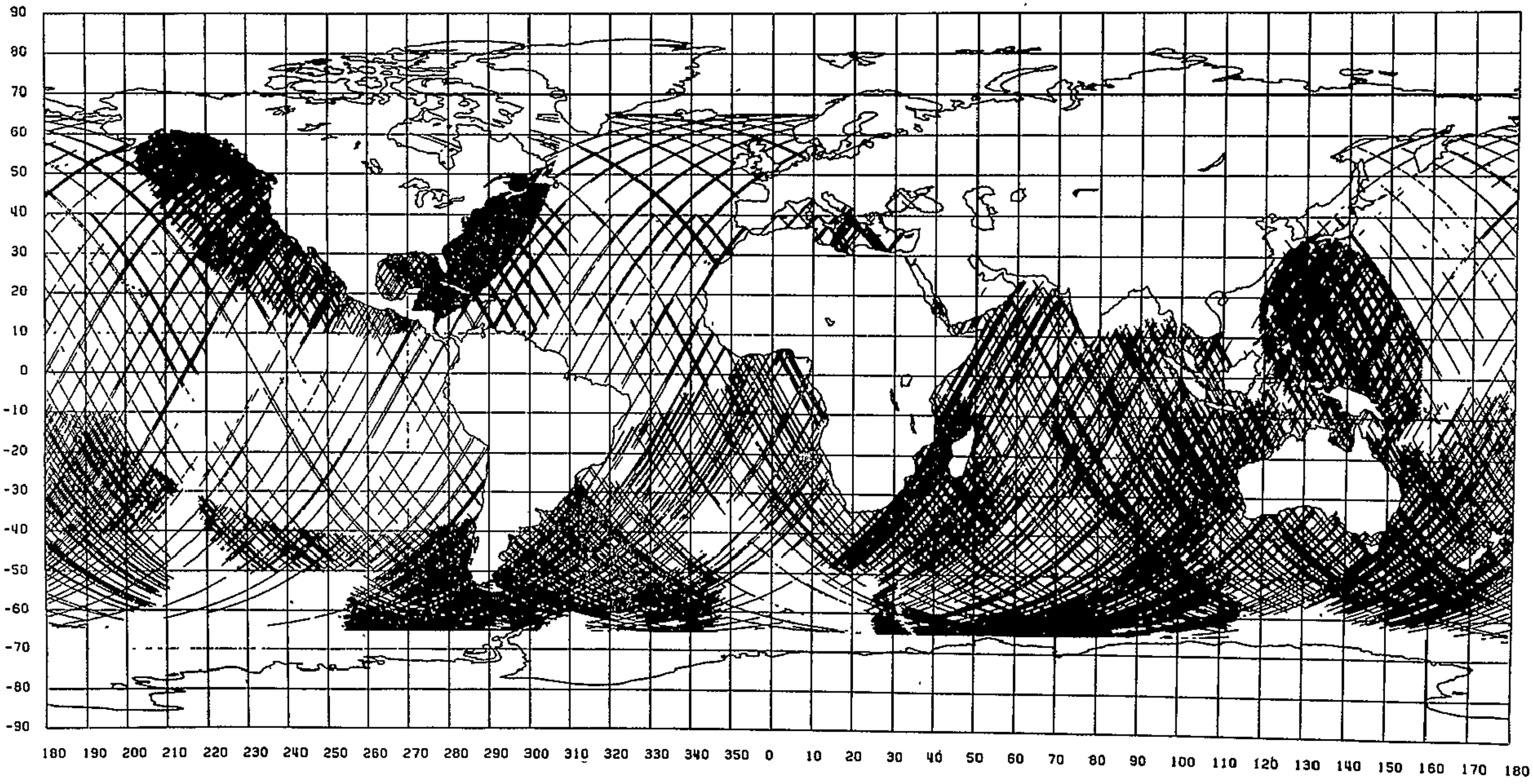

Figure 1

Distribution of Arcs Selected After Editing

Recently, a more detailed M_2 tidal model was developed by Schwiderski (1977). Tests made by Schwiderski indicate that his model gives better fit to real world data than the Hendershott (1972) model. This newer model is defined by a set of amplitudes and phases for each $1^\circ \times 1^\circ$ block on the earth's surface. Given a specific location and time, the M_2 ocean tide can be obtained through fairly simple formulas after appropriate interpolations are carried out.

Tidal values for the Schwiderski model were compared with approximately 4300 Hendershott values already given on the altimeter data records. In some cases the agreement was good between the models, but differences up to 1.2 meters were found. We consequently decided to compute and use the Schwiderski tide value at all altimeter "frame" data points that had survived our edit process.

Bias Removal and Models

The edited values of the sea surface heights now available are still subject to errors caused by an altimeter bias and orbit error.

The altimeter bias has been discussed by Martin and Butler (1977). In their study they estimated that the intensive mode bias (measured minus true) was -5.3 ± 0.21 m. Although we could have adopted this as constant for all our data, we chose to solve for the bias and orbit error because of the success of our initial efforts (Rummel and Rapp, 1977) in this area.

The orbit error arises from a number of sources including gravity field error, etc. The orbits used for the Geos-3 data were classified by the Wallops Flight Center as to their accuracy as shown in Table 2.

Table 2

Accuracy Classification of Geos-3 Orbits Used in the Reduction of the Altimeter Data

Code	Source	Quality	Orbit Type
A	WFC	10 M + RMS	1 DAY ARC
D	WFC	3-10 M + RMS	1-8 REV ARC
G	NSWC	5 M + RMS	3 DAY ARC
J	NSWC	3 M + RMS	3 REV ARC
N	GSFC	1-2 M + RMS	5 DAY ARC

WFC = Wallops Flight Center
NSWC = Naval Surface Weapons Center
GSFC = Goddard Space Flight Center

The majority of the orbits computed in the early period of the satellites were from WFC and were of code A. From September 1975 through May of 1976 the orbits were of code J; from May through early June 1976 the orbits were code N with the remaining orbits code G. It was thus clear that we had a diverse set of orbits to work with and that the selection of an approximate error model for the bias and radial orbit error would be very important.

Another possible source of error in the determination of the sea surface heights were the parameters of the reference ellipsoid. (The values used as a reference by the Wallops Flight Center were 6378145 meters for the equatorial radius and 1/298.255 for the flattening.) For most gravimetric geodesy problems, it is desirable to have quantities (such as geoid undulations) referred to a mean or general terrestrial ellipsoid (Heiskanen and Moritz, 1967, p. 214). With respect to such an ellipsoid, the global average geoid undulation would be zero. Since the adopted ellipsoid parameters may not refer to the general terrestrial ellipsoid it is desirable to use a procedure that will yield the sea surface heights with respect to the general terrestrial ellipsoid even though we may not know specifically the parameters (or at least the equatorial radius) of the ellipsoid.

Thus in developing our error model we wish to consider three error sources: altimeter bias, radial orbit error and equatorial radius error.

In order to adjust our data, we decided to fit (through an approximate error model) the sea surface heights defined along an arc segment to the geoid heights defined by a set of potential coefficients. We would then find the parameters of the error model that would yield the best agreement between the potential coefficient model and the adjusted sea surface heights (which had been corrected for tidal effects).

For simplicity, consider this adjustment for a single arc. We write for a single point on the arc:

$$N_b + B\Delta = N_R + v \tag{2}$$

where

N_b is the sea surface height based on the Geos-3 data from the Wallops Flight Center;
N_R is the geoid undulation implied by a set of potential coefficients;
Δ represents parameters of the error model;

B is the design matrix or coefficients of the error model parameters;
v is the residual after the adjustment

The adjusted (bias removed) sea surface height would be:

$$N_{ADJ} = N_b + B\Delta \tag{3}$$

For our work the geoid undulations were computed from the following (Rapp, 1971):

$$N_R = \frac{GM}{\gamma r} \sum_{\ell=2}^{\ell_{MAX}} \left(\frac{a}{r}\right)^{\ell} \sum_{m=0}^{\ell} (\bar{C}_{\ell m} \cos m\lambda + \bar{S}_{\ell m} \sin m\lambda)\, \bar{P}_{\ell m}(\sin\bar{\varphi}) \tag{4}$$

where:

GM	is the geocentric gravitational constant;
r	is the geocentric distance to the point at which N_R is being computed;
a	is an equatorial radius;
$\bar{C}_{\ell m}$, $\bar{S}_{\ell m}$	are fully normalized potential coefficients with $\bar{C}_{2,0}$ and $\bar{C}_{4,0}$ referred to an ellipsoid of a specified flattening;
$\bar{P}_{\ell m}$	are the fully normalized Legendre functions;
$\bar{\varphi}$, λ	are the geocentric latitude and longitude;
γ	is the normal gravity at $\bar{\varphi}$

A number of different error models and ℓ_{MAX} values were used to determine their effect on the adjusted undulations as given by equation (3), and on the fit itself as represented by the root mean square residual. The error models tested are shown in Table 3.

Table 3

Form of Error Model Tested

Model	Form
1	$X_1 + X_2 \cos\psi + X_3 \sin\psi$
2	X_1
3	$X_1 + X_2 (t - t_0)$
4	$X_1 + X_2 (t - t_0) + X_3 (t - t_0)^3$

Model 1 was suggested by Rummel (1976) for use with arcs of length greater than 22°5. In this model ψ is the spherical distance from the equator crossing. In models 3 and 4 t is the time of observation and t_0 is a reference time.

Six arcs of various lengths were selected for testing. The arcs described in Table 4.

Table 4

Arc Information for Model Tests

Number	No. of obs.	Length (km)
1	533	7570
2	67	970
3	262	3600
4	106	1700
5	603	14100
6	355	5230

The first test was to see the effect of ℓ_{MAX} on the adjusted undulations or sea surface height. To find this, the first three arcs in Table 4 were separately fitted to the GEM 7 coefficients to degree 16 using error model 1 for arcs 1 and 3 and model 2 for arc 2. The fit was repeated with $\ell_{MAX} = 4$, 8, and 12 with the adjusted undulations being compared to those found from the degree 16 solution. The root mean square differences are given in Table 5.

Table 5

Root Mean Square Adjusted Sea Surface Height Differences vs ℓ_{MAX} with GEM 7

Arc	Degree 16 Adjustment Minus Adj. to Specified ℓ_{MAX}		
	$\ell_{MAX}=12$	$\ell_{MAX}=8$	$\ell_{MAX}=4$
1	±0.6 m	±3.3 m	±3.5 m
2	±1.6 m	±1.5 m	±7.7 m
3	±1.2 m	±3.9 m	±7.9 m

We conclude that at the ± 1 meter level the adjusted undulations are sensitive to the chosen ℓ_{MAX}.

A second test was run to determine the effect of errors in the GEM 7 potential coefficients on the adjusted sea surface heights. To do this a modified GEM 7 coefficient set was generated by adding to each of the coefficients a number dependent on the standard deviation of that coefficient as given by Wagner (1976). The previous adjustments were repeated and the adjusted undulations compared. These results are shown in Table 6.

Table 6

Root Mean Square Adj. Sea Surface Height Differences Between Original GEM 7 and Modified GEM 7 Potential Coefficients

Arc	ℓ_{MAX}			
	16	12	8	4
1	±1.4 m	±1.1 m	±0.3 m	±0.2 m
2	±2.3 m	±1.3 m	±1.1 m	±0.1 m
3	±2.0 m	±1.1 m	±1.1 m	±0.2 m

We conclude that at the ±1 m level the errors in the potential coefficients reflect in the adjusted undulation values when only single arcs are being adjusted.

We next tested the fits obtained by the different error models using the GEM 7 coefficients to degree 16. These results are given in Table 7.

Table 7

RMS Residual After Adjustment of Test Arcs Using Different Error Models and GEM 7 to Degree 16

Arc	Error Model			
	1	2	3	4
1	± 2.73 m	± 3.67 m	±3.66 m	± 2.74 m
2	0.75	2.60	1.32	0.75
3	1.45	2.75	2.20	1.45
4	6.97	8.12	8.11	6.97
5	3.40	4.13	3.38	3.36
6	2.81	3.27	3.05	2.81

We see that assuming a constant bias (model 2) gives the poorest fit to the data. Models 1 and 4 give essentially identical results while model 3 gives somewhat poorer results than either 1 or 4. One would prefer to choose, from these tests, either error model 1 or 4. However, later tests conducted using global data sets showed that it was difficult to separate in the adjustment the X_2 and X_3 unknown model parameters. We consequently decided to adopt model 3 for our error model when the arc length was greater than 22°.5. Arguments by Rummel (1977) suggest that for arc lengths below this, with the use of the GEM 7 reference field, only a single bias term should be solved for (i.e. error model 2). Such a procedure was followed in the actual computations to be described in a subsequent section.

Sea Surface Topography Modeling

The tests conducted so far assume that the sea surface heights correspond to the geoid. In fact, they do not because of the existence of sea surface topography caused by prevailing winds, currents, etc. in the oceans. We consequently felt that we should try to see if correcting our sea surface heights for sea surface topography using available information would be of help.

To do this, the sea surface topography map given by Lisitzin (1974, p. 149) was digitized in such a way (Katsambalos, 1977) that an interpolated value could be obtained at a specified point. A mean value of 280 dyn. centimeters was subtracted to give the actual sea surface topography with respect to the geoid.

With this data, error model 1 was used to fit the corrected (for sea surface topography) altimeter derived undulations. The results of these fits are given in Table 8.

Table 8

RMS Residuals After Adjustment With Error Model 3,
With and Without Sea Surface Topography

Arc	With Sea Surface Topography	Without Sea Surface Topography
1	±2.75 m	±2.73 m
2	0.75	0.97
3	1.45	1.52
4	6.97	6.99
5	3.40	3.43
6	2.81	2.84

We can see that no significant improvement in fit is obtained by incorporating sea surface topography estimates in our data. However, slight improvements are noted and further tests should be made. For this report we will not consider any corrections for sea surface topography.

The Adjustment Model

We have discussed a technique for removing bias from the sea surface heights using a simple model such as equation (2) with a specific error model being chosen from Table 3. In addition, we can incorporate into our adjustment an equation to represent the fact that when two arcs cross, the resultant sea surface height should be approximately the same. The two heights will not be identical because of sea state and observational noise. We now develop the mathematical model considering these ideas using a somewhat different notation than Rummel (1976, 1977).

We start by writing a matrix form of equation (2), considering an unspecified number of arcs. Then (2) becomes:

$$\underline{N}_b + \underline{B}\,\underline{\Delta} = \underline{N}_R + \underline{v} \tag{5}$$

where

N_b, N_R, v and Δ are column vectors, and
B is the observation coefficient matrix.

Equation (5) is of the following form (Mikhail, 1976, p. 111):

$$\underline{A}\,\underline{v} + \underline{B}\,\underline{\Delta} = \underline{f} \tag{6}$$

where, by analogy with (2), we have:

$$\begin{aligned} A &= -I \\ f &= \underline{N}_R - \underline{N}_b \end{aligned} \tag{7}$$

The cross-over model for the i and j th arcs can be written as:

$$N_{ADJ(i)} - N_{ADJ(j)} = C_{ij} \tag{8}$$

where N_{ADJ} is the adjusted undulation (or sea surface height) and C_{ij} is the cross-over discrepancy after the adjustment. Using equation (3), (8) can be written as:

(9) $$N_b(i) + B_i \Delta_i - N_b(j) - B_j \Delta_j = C_{ij}$$

Equation (9) can be written as:

(10) $$-C_{ij} + B_i \Delta_i - B_j \Delta_j = N_b(j) - N_b(i)$$

which is of the general form of (6) with:

(11) $$\begin{aligned} C_{ij} &= v \\ A &= -I \\ f &= N_b(j) - N_b(i) \end{aligned}$$

Considering all cross-overs between all arcs considered in the adjustment, we can write a general cross-over observation equation as:

(12) $$-\underline{v}_c + \underline{B}_c \underline{\Delta} = \underline{f}_c$$

where

$$\underline{B}_c = [B_{i,j} - B_j]$$

Equation (5) can also be written in the following form:

(13) $$-\underline{v}_A + \underline{B}_A \underline{\Delta} = \underline{f}_A$$

where

$$f_A = N_R - N_b$$

We can combine (12) and (13) into a single matrix equation:

(14) $$- \begin{bmatrix} v_A \\ v_c \end{bmatrix} + \begin{bmatrix} B_A \\ B_c \end{bmatrix} \underline{\Delta} = \begin{bmatrix} f_A \\ f_c \end{bmatrix}$$

We let W_A be the weight matrix of the altimeter derived undulations, and W_c the weight matrix of the cross-over observation equations. Then a solution for Δ of (14) is sought such that:

(15) $$v_A^t W_A v_A + v_c^t W_c v_c = \text{a minimum}$$

Under this specification the general solution of:

(16) $$Av + B\Delta = f$$

is

(17) $$\Delta = N^{-1} f$$

where

(18) $$N = B^t (A W^{-1} A^t)^{-1} B$$

(19) $$t = B^t (A W^{-1} A^t)^{-1} f$$

In our case $A = -I$ so that (18) and (19) become:

(20) $$N = B^t W B$$

(21) $$t = B^t W f$$

Considering (14) and (16) we also have:

$$B = \begin{bmatrix} B_A \\ B_c \end{bmatrix} ; \qquad f = \begin{bmatrix} f_A \\ f_c \end{bmatrix} ; \qquad W = \begin{bmatrix} W_A & 0 \\ 0 & W_c \end{bmatrix}$$

so that equation (17) becomes:

(22) $$\Delta = [B_A^t W_A B_A + B_c^t W_c B_c]^{-1} \; [B_A^t W_A f_A + B_c^t W_c f_c]$$

Knowing the error model parameters from (22) we can determine the adjusted undulations from:

(23) $$N_{ADJ} = N_b + B\Delta$$

while the undulation residuals would be:

(24) $$v = N_{ADJ} - N_R$$

The cross-over discrepancy, after the adjustment, would be given by equation (8).

If there were no cross-over observations, the normal equations in (22) would be block diagonal where the size of the block would correspond to the number of unknowns for the error model for the specified arc. The block diagonal nature of the normal equations reflects the fact that without the cross-over observations, each arc can be adjusted separately.

The cross-over observation equations destroy the block diagonal nature of the normal equations. The resulting normal equations in (22) will have the block diagonal terms, and also the off diagonal terms reflecting the cross-over information between the different arcs. Since, a priori, there will be no particular pattern to the normal equations, the solution of them may be time consuming as the number of unknowns to be solved for may vary from 1500 to 4000 or more.

Although the number of unknowns in the normal equations may be large, we also expect many zero elements to appear. This suggests that the order of the unknowns in the normal equations be arranged in such a way that the column profile (for example) of a set of normal equations be minimized so that most zero elements are not stored. Then very efficient computations for the unknowns can be made. A procedure for minimizing the column profile in normal equations has been described by Snay (1976a, b) for possible use in the solution of normal equations arising in the adjustment of triangulation networks. The algorithm and Fortran program developed by Snay was used in our altimeter adjustment, enabling a large number of arcs and cross-overs to be handled in relatively small amounts of computer time on our IBM 370/168 operating under MVS.

Adopted Geodetic Constants

For a number of computations to be performed it will be necessary to adopt the best available set of geodetic parameters. For these purposes, we use the values given in Moritz (1975):

$a = 6378140$ m
$GM = 3.986005 \times 10^{-14}$ $m^3 s^{-2}$
$J_2 = 1082.63 \times 10^{-6}$
$\omega = 7.292115 \times 10^{-5}$ rad s^{-1}

The implied flattening is 1/298.257 and the equatorial gravity is 978031.8 mgals. At the 0.1 mgal level there is no difference between the gravity formula of these constants and that of the Geodetic Reference System 1967.

The Actual Altimeter Adjustments

In order to adjust the altimeter arcs shown in Figure 1, we first decided to use the GEM 9 potential coefficients (Lerch et al., 1977) to degree 20. This coefficient set is based only on satellite data with no terrestrial gravity data in the solution. In addition, it is given to a higher degree than GEM 7, and tests reported by Lerch indicate the GEM 9 is an improved solution with respect to GEM 7.

We developed a procedure to develop the cross-over observation equations and discrepancies starting from information given in Brown and Schroeder (1977) and kindly provided to us on tape by Brown. With information in Brown and Schroeder, a procedure was developed to pass through the edited tapes to find all cross-overs in a specified geographic region (which could be world wide). This program would then interpolate to the exact cross-over point the sea surface height and develop the observation equation coefficients. A more detailed explanation of the crossover determination may be found in Herbrechtsmeier (1977).

To implement the discussion in the previous paragraphs, we decided to first perform a primary adjustment using a select set of long arcs that had a good geographic distribution. The number of such arcs were chosen to be sufficiently large such that good coverage with available data would be obtained, and the computer time and storage requirements be within our available means. The location of the 854 primary arcs are shown in Figure 2.

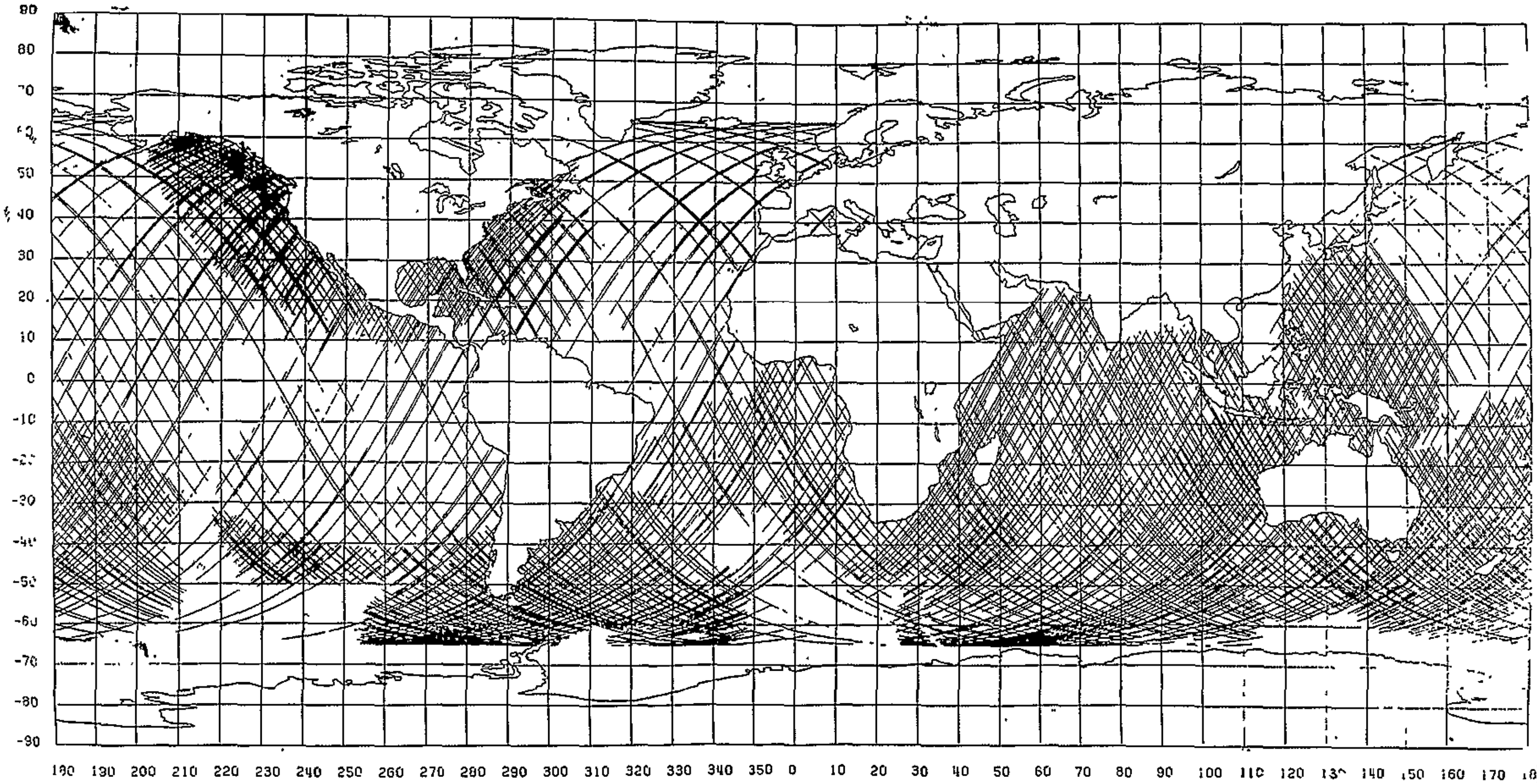

Figure 2. Location of Arcs Used in the Primary Adjustment

After adjusting the primary arcs, adjustments were planned for regional areas in which sufficient altimeter data was available. In these regional adjustments, the primary arcs were held fixed while the non-primary arcs in the region received adjustment using the standard procedure using arc and cross-over observation equations. The location of the six regional adjustment areas is shown in Figure 3. The designations and locations are given in Table 9.

Table 9

Regional Adjustment Locations

Name	Location	
Alaska	φ: 10° to 66°	λ: 200° to 260°
Calibration	φ: 10° to 50°	λ: 260° to 310°
Indian Ocean	φ: -70° to 30°	λ: 20° to 120°
Philippines	φ: -20° to 40°	λ: 120° to 150°
New Zealand	φ: -70° to 0°	λ: 120° to 214°
South America	φ: -70° to 10°	λ: 214° to 20°

In carrying out the adjustments the standard deviations given for the altimeter measured height were used in computing the W_A matrix. These standard deviations ranged from 0.25 to 8.0 meters with an average value being on the order of 0.7 meters. To enforce the crossover constraints (or observation equation) the standard deviation of this observation equation was chosen as ±0.05 m giving a weight of 1/400. In the regional adjustments, a weight of 1/800 was given to those cross-overs involving a primary arc and a secondary arc. All observation equations were regarded as independent.

In carrying out the global and regional adjustments it was first necessary, in some cases, to carry out an initial adjustment. We then examined the cross-over discrepancies after the adjustment. In some cases certain arcs gave excessively large (greater than 3.5 meters) cross-over discrepancies. Such arcs were rejected from the data set and the adjustment repeated. Some statistical information concerning the global adjustment and each of the regional adjustments is given in Table 10.

From Table 10 it is readily apparent that the adjustment process has been successful in the reduction of the a priori cross-over discrepancies. The discrepancies after the adjustment are of the expected accuracy of the instrument.

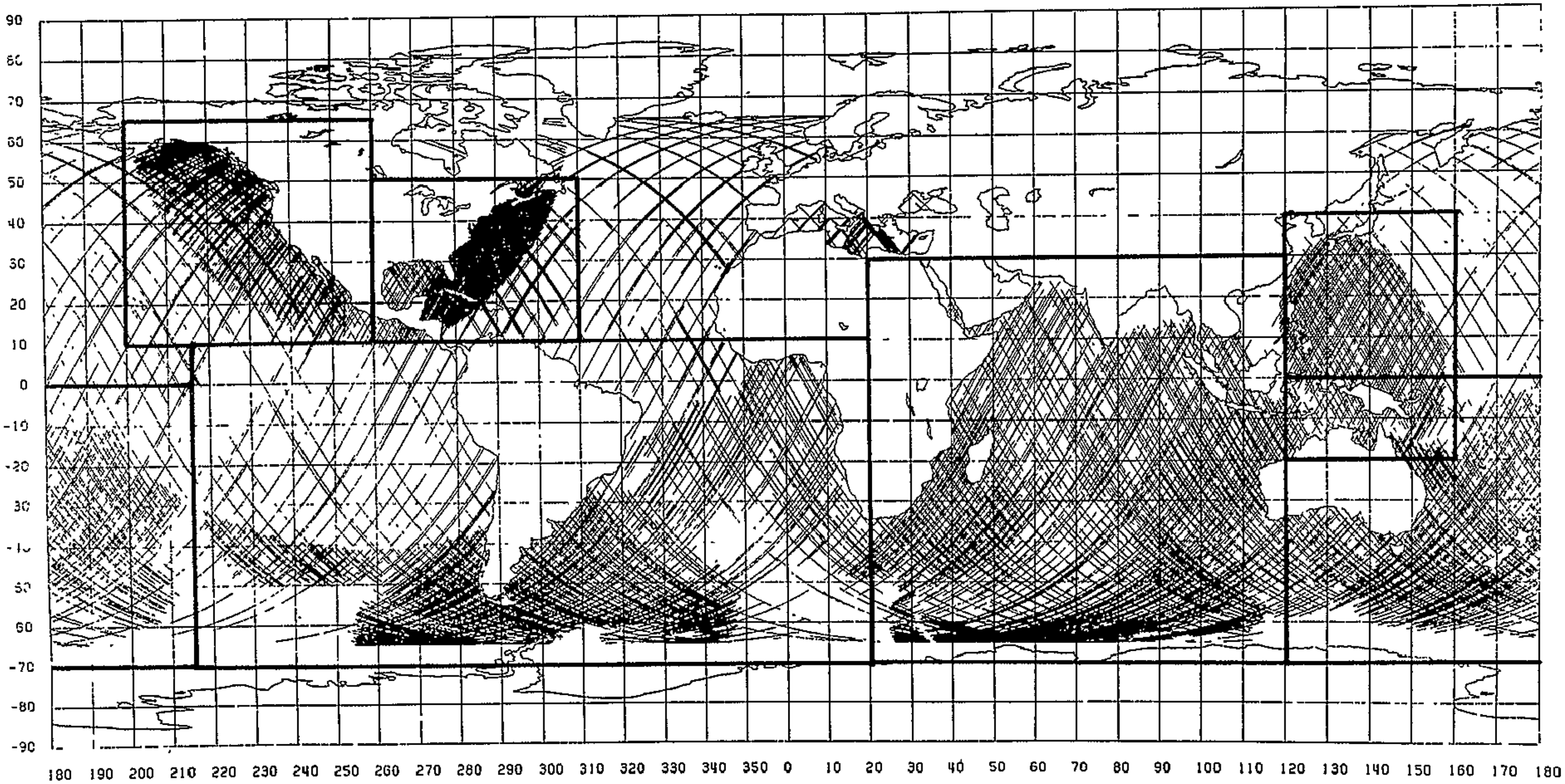

Figure 3

Location of the Six Regional Adjustment Areas

Table 10

Information Related to Primary and Regional Adjustments

Region	Arcs	Number of:			Crossover Discrepancies	
		Unknowns	Obs.	Cross-overs	a priori	a posteriori
Global	854	1568	260789	11406	±8.27 m	±0.56 m
Alaska	75	93	12739	1575	9.63	0.60
Calibration	345	478	46617	28920	7.77	0.65
Indian Ocean	143	251	35587	4912	8.77	0.50
Philippines	42	72	9634	662	13.59	0.69
New Zealand	104	173	25486	3193	8.27	0.60
South America	185	281	34892	4981	9.81	0.57

We show in Figure 4 a histogram plot of the cross-over discrepancies for the global adjustment. Although tests show these discrepancies are not normally distributed, the cross-over discrepancy distribution appears reasonable.

At this point we have a set of sea surface heights (or geoid heights), referred to the general terrestrial ellipsoid, and for which we have removed the effects of altimeter bias, orbit error, etc. These adjusted values can now be used for making geoid maps, the determination of gravity anomalies, or other such dependent quantities.

The Dependence of the Adjusted Sea Surface Heights on the GEM 9 Potential Coefficients

Since we have fitted, by a first degree polynomial, the altimeter derived data, there is some concern about the dependence on GEM 9 in the final result. From the results previously reported in Tables 5 and 6, we have seen the dependence of the adjusted undulations along single arcs on potential coefficient variations. However, what may hold along a single track may not hold when the cross-over observation equations are introduced.

To see the effect of potential coefficient changes on the adjusted values of the sea surface heights, we repeated the primary adjustment using a modified set of GEM 9 potential coefficients to degree 20. This modified set was determined using the following equations:

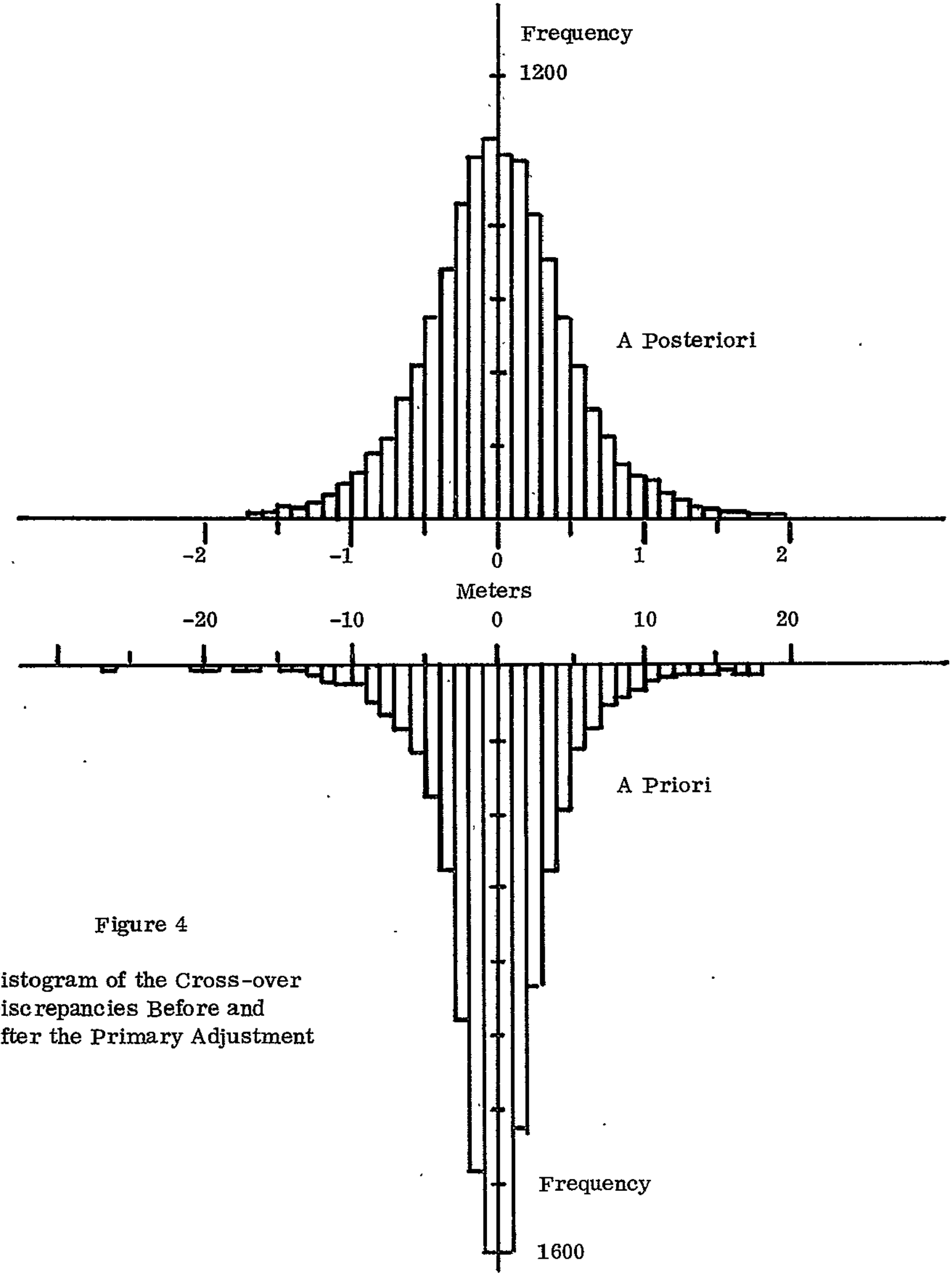

Figure 4

Histogram of the Cross-over
Discrepancies Before and
After the Primary Adjustment

$$\begin{Bmatrix}\bar{C}_{\ell m}\\ \bar{S}_{\ell m}\end{Bmatrix}_{\text{GEM 9M}} = \begin{Bmatrix}\bar{C}_{\ell m}\\ \bar{S}_{\ell m}\end{Bmatrix}_{\text{GEM 9}} + 2\begin{Bmatrix}d\\ e\end{Bmatrix}\begin{Bmatrix}m(\bar{C}_{\ell m})\\ m(\bar{S}_{\ell m})\end{Bmatrix} \tag{25}$$

where m represents the standard deviation for the GEM 9 coefficient as given by Lerch et al. (1977) and d and e are normal deviates drawn from a normal distribution with zero mean and a variance of 1. The factor 2 was used simply to provide a pessimistic error statement.

The modified potential coefficients were then compared to the original coefficient set. The global undulation difference was ±3.5 meters with the largest difference being 11 meters.

The complete primary adjustment was redone with this modified GEM 9 potential coefficient set. The adjusted sea surface heights were then compared to the corresponding values found from the original solution. The mean difference between the two sets of sea surface heights was 0.07 m while the root mean square difference was ± 0.85 m.

We thus see that a global difference of ±3.5 meters in the potential coefficient sets has been reduced by a factor of about four in the adjusted sea surface heights. If we accept the original Lerch et al. accuracy estimates as given, the root mean square undulation difference would be about ±1.7 m and we would expect this error would propagate into about ±0.4 m in the adjusted sea surface heights. This error is slightly below the average noise level of our observations.

We thus conclude that errors in the GEM 9 coefficients will effect our final adjusted values, but that any error is reduced by a factor of about 4 and in our case, this error will be on the order of ±0.4 m.

Sea Surface Heights or Geoid Undulations as Derived from the Adjusted Data

The usual geoid maps can be produced from the adjusted data if we assume the geoid and sea surface heights coincide. If we do not make such an assumption, sea surface height maps can be constructed that should be associated with a certain time period. In our case, we choose to produce such maps noting that they refer to a time period from April 1975 through approximately November 1976.

A procedure for constructing these contour maps is described by Kearsley (1977). He has used the regional adjustments to construct 2 m contour maps in the areas shown in Figure 5 which has been taken from his report. Basically, Kearsley has used a least squares prediction procedure, including data noise, to predict a geoid undulation and its accuracy on a uniform grid.

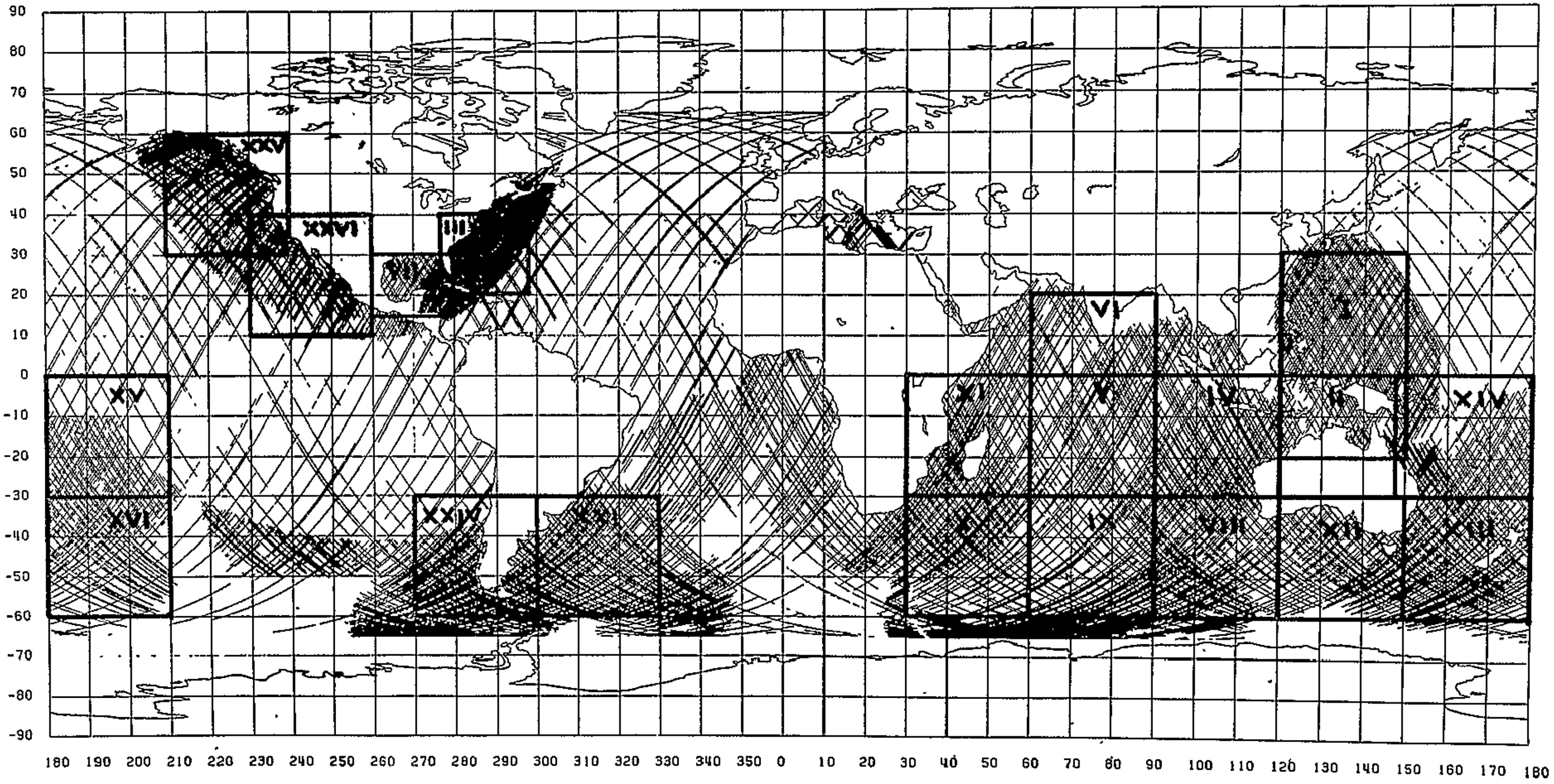

Figure 5

Index of Geoid Maps from Geos-3 Altimetry
(from Kearsley, 1977)

These values were then contoured using a standard contouring algorithm. The data noise was taken as the altimeter measurement standard deviation. No error component due to the errors in the GEM 9 coefficients nor errors in the adjustment process were incorporated. Consequently, the undulation accuracies may be somewhat optimistic.

For purposes of this report, I give two geoid maps taken from the Kearsley report. The first is map III which is off the east coast of the United States. This geoid map and its corresponding accuracy map are given in Figures 6 and 7. No altimeter tracks are plotted on these maps because of the great density of the available data. This geoid (or sea surface height) was compared by Kearsley to a geoid ($N_{R,R}$) derived from the GEM 6 potential coefficients and 1°x 1° terrestrial gravity data by Rapp and Rummel (1975, Table 5), and to the geoid ($N_{M,C}$) by Marsh and Chang (1976) who used the GEM 8 potential coefficients and 1°x 1°, 15'x 15' and 5'x 5' mean gravity anomalies. The results of these comparisons are shown in Table 11.

Table 11

Comparisons of the Altimeter Derived Geoid with Ground Truth Determined from Potential Coefficients and Terrestrial Gravity Data

	$N_{ALT} - N_{R,R}$	$N_{ALT} - N_{M,C}$
Mean Difference	- 0.3 m	- 1.0 m
RMS Difference	± 1.2	± 1.5
$[\text{Variance}]^{\frac{1}{2}}$	± 1.2	± 1.1
Number of Comparisons	337	335
Maximum Difference	5.0	9.2
Minimum Difference	- 3.5	- 4.6

From this table we can see that there is a greater systematic difference with the Marsh, Chang geoid than with the Rapp, Rummel geoid. The RMS differences and square root of the variance is consistent with the accuracy of the ground truth geoid, being on the order of ±1.6 m (Rapp and Rummel, 1975, Table 6). A map of the undulation differences (both $N_{R,R}$ and $N_{M,C}$) with the altimeter geoid reveals slopes that could be indicative of small errors in the potential coefficient sets used in this analysis (Marsh, 1977, private communication).

The second area in which we give the geoid map (and its accuracy) from Kearsley is in the Philippines area (Area I in Figure 5). This information is shown in Figures 8 and 9 where the altimeter tracks are represented by the dashed lines. From Figure 8 we can see the rapid undulation variation across the Philippine Trench, the Mariana Trench and the Izu Trench. The undulation variation between the Philippine Trench and the Mariana and Izu Trench is smooth.

Gravity Anomaly Recovery - Theory

The main proposed goal of our investigation was the determination of mean gravity anomalies from the Geos-3 altimetry data. A number of investigations were carried out under this contract to determine possible techniques for the anomaly recovery. Three such methods are described in a report for this contract by Rummel, Sjöberg and Rapp (1977). These methods involved 1) the use (by Rummel) of the inverse Stokes equation or the Molodensky equation to compute anomalies from geoid undulations; 2) the application of a spectral analysis approach (by Sjöberg) to the anomaly recovery and (3) the use of least squares collocation (by Rapp). These methods are detailed in the Rummel, Sjöberg and Rapp report with each method being tested with altimeter derived undulations that had been determined through the adjustment procedure described in the previous sections of this report.

For the purposes of prediction anomaly recovery, we have chosen the method of least squares collocation (Moritz, 1975). For the specific equations for the anomaly recovery, we have:

$$\Delta g = \underline{C}_{gh} \, (\underline{C}_{hh} + \underline{D})^{-1} \, \underline{h} \tag{26}$$

$$m^2_g = C_{gg} - \underline{C}_{gh} \, (\underline{C}_{hh} + \underline{D})^{-1} \, C_{hg} \tag{27}$$

where

Δg: the predicted gravity anomaly (either a point or mean anomaly depending on the interpretation of the covariances);
$\underline{h}$: a column vector of the given geoid undulations (or sea surface heights);
$\underline{C}_{gh}$: the row vector containing the covariance between the anomaly being predicted and the given geoid undulation;
$\underline{C}_{hh}$: the square, symmetric matrix containing the covariances between the given geoid undulations;
D: the error-covariance matrix of the given geoid undulations which was taken, in our computations, as a diagonal matrix whose elements corresponded to the square of the standard deviation of the altimeter measurement;

Figure 6

Geoid Undulations in Geos-3 Calibration Area
From Adjusted Altimeter Data
Contour Interval: 2 meters

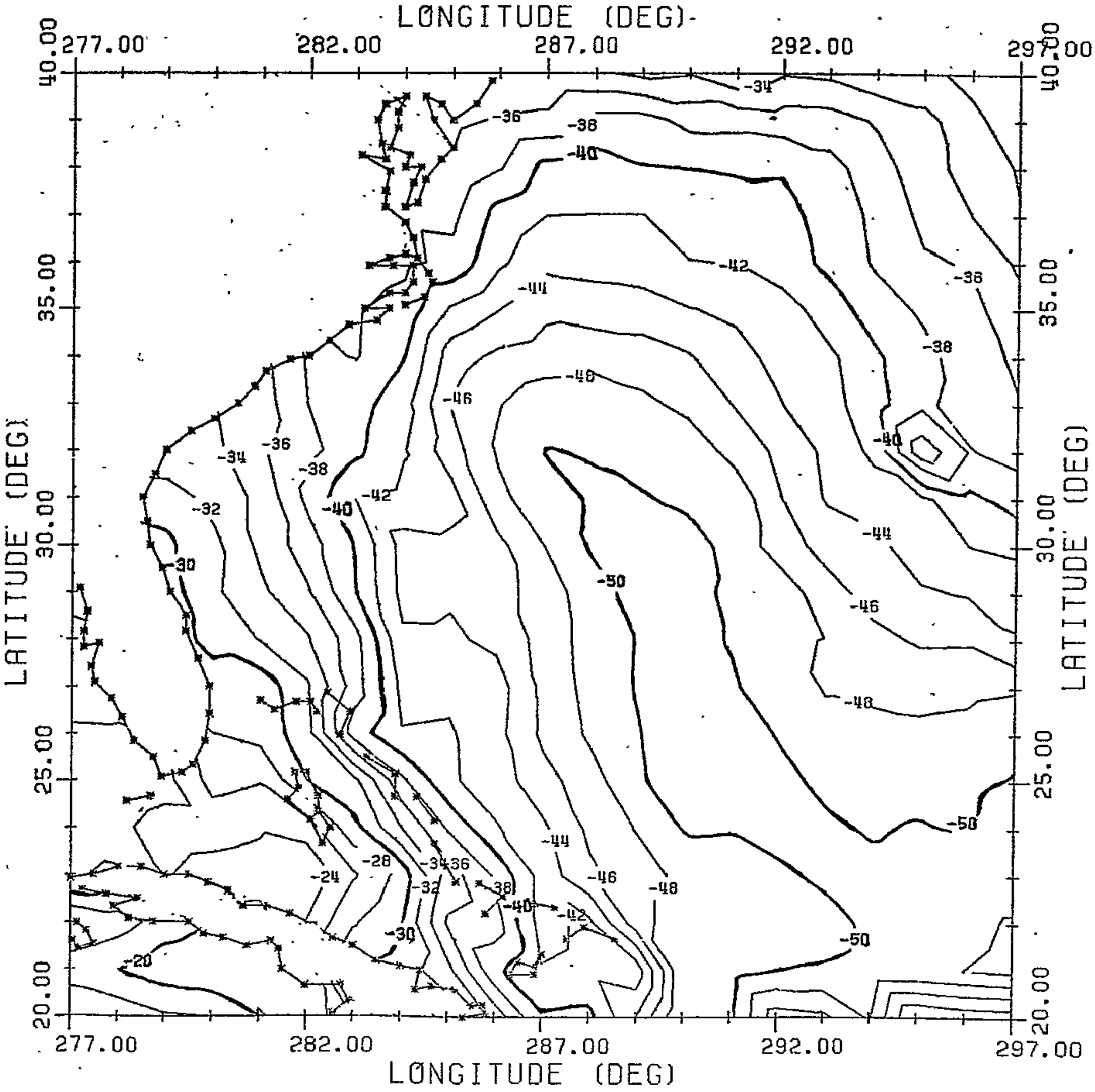

Figure 7

Geoid Undulation Accuracy in Geos-3 Calibration Area
From Adjusted Altimeter Data
Contour Interval: 0.5 meters

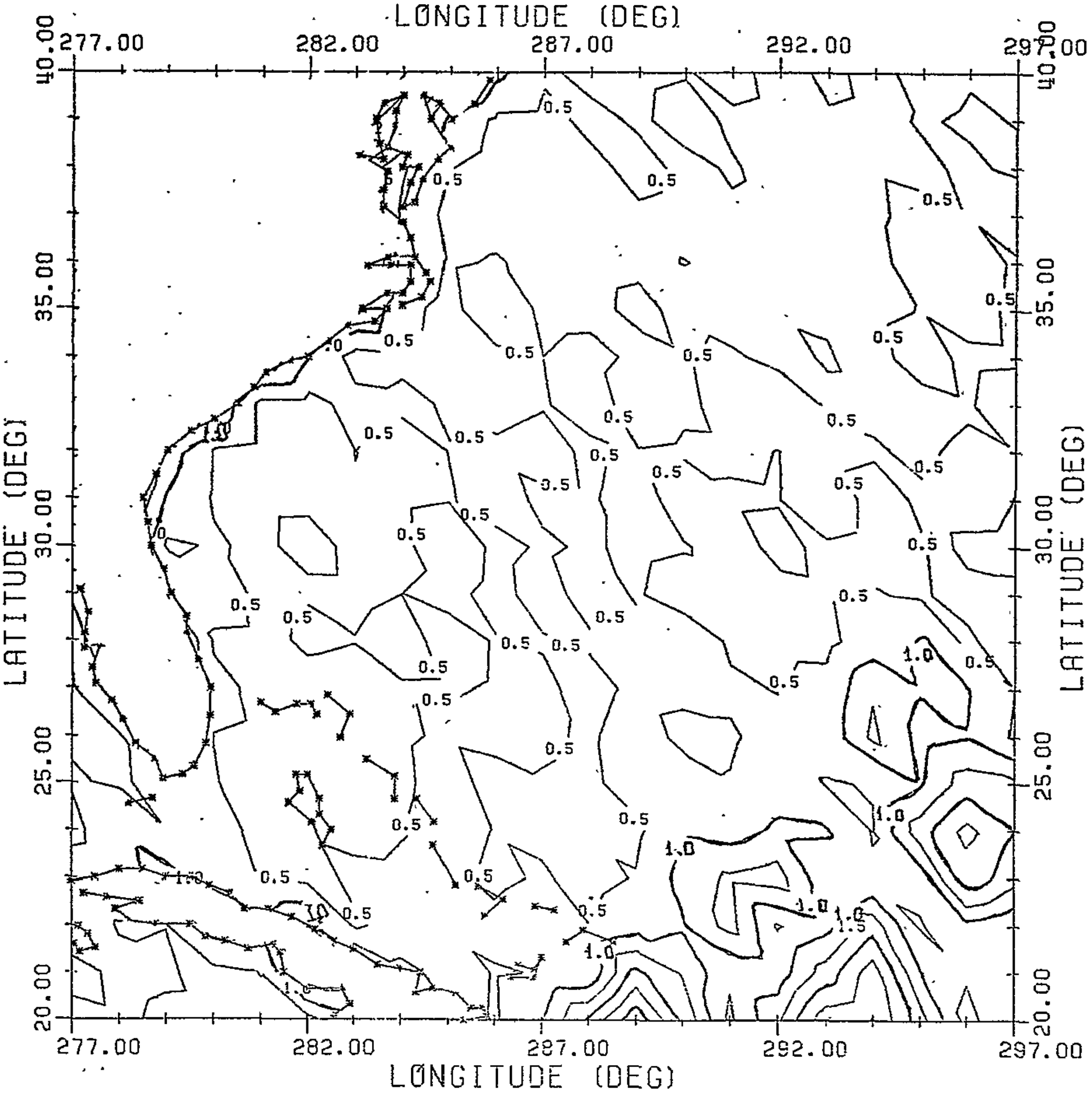

Figure 8

Geoid Undulations in the Philippines
From Adjusted Altimeter Data
Contour Interval : 2 meters

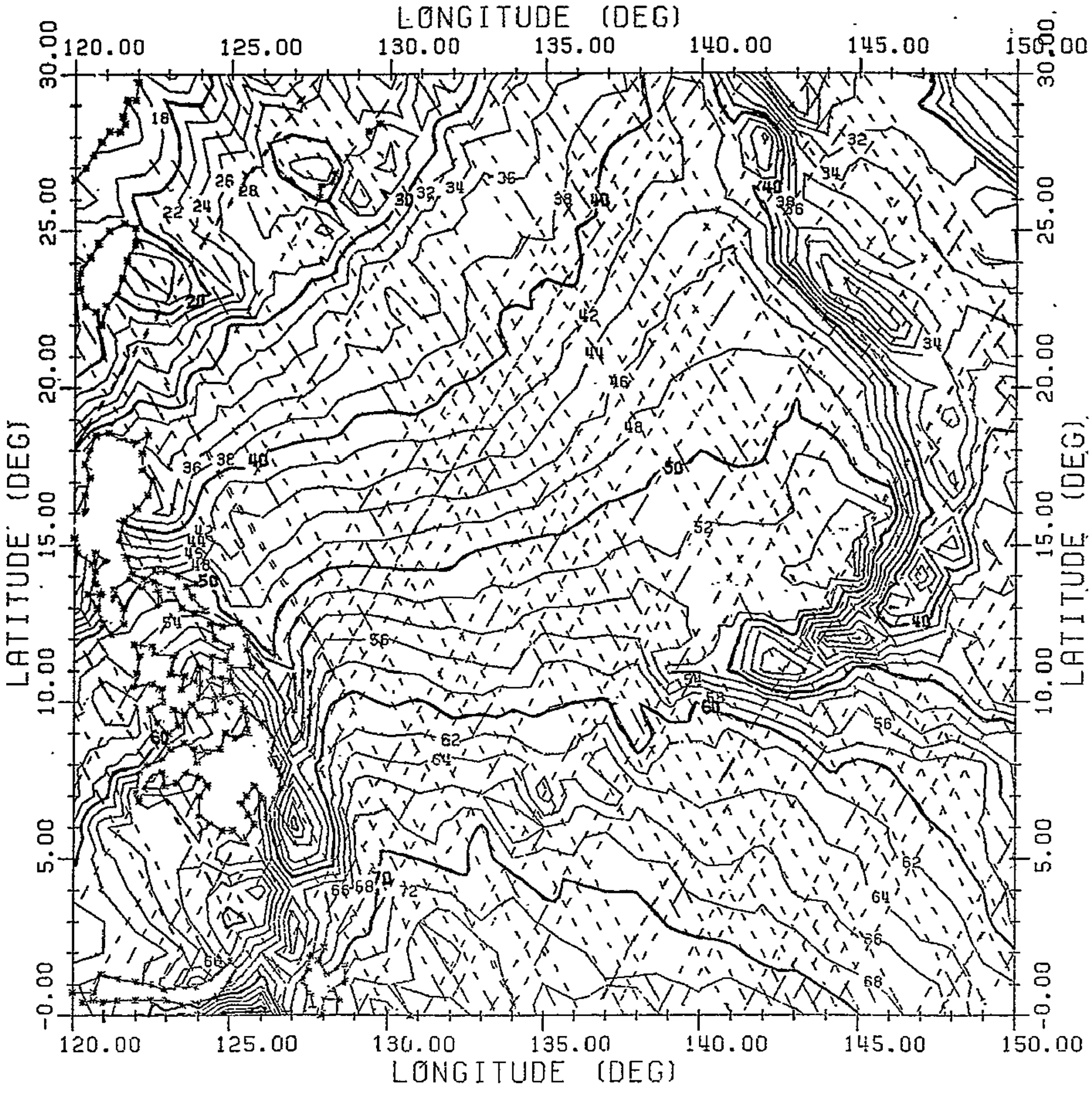

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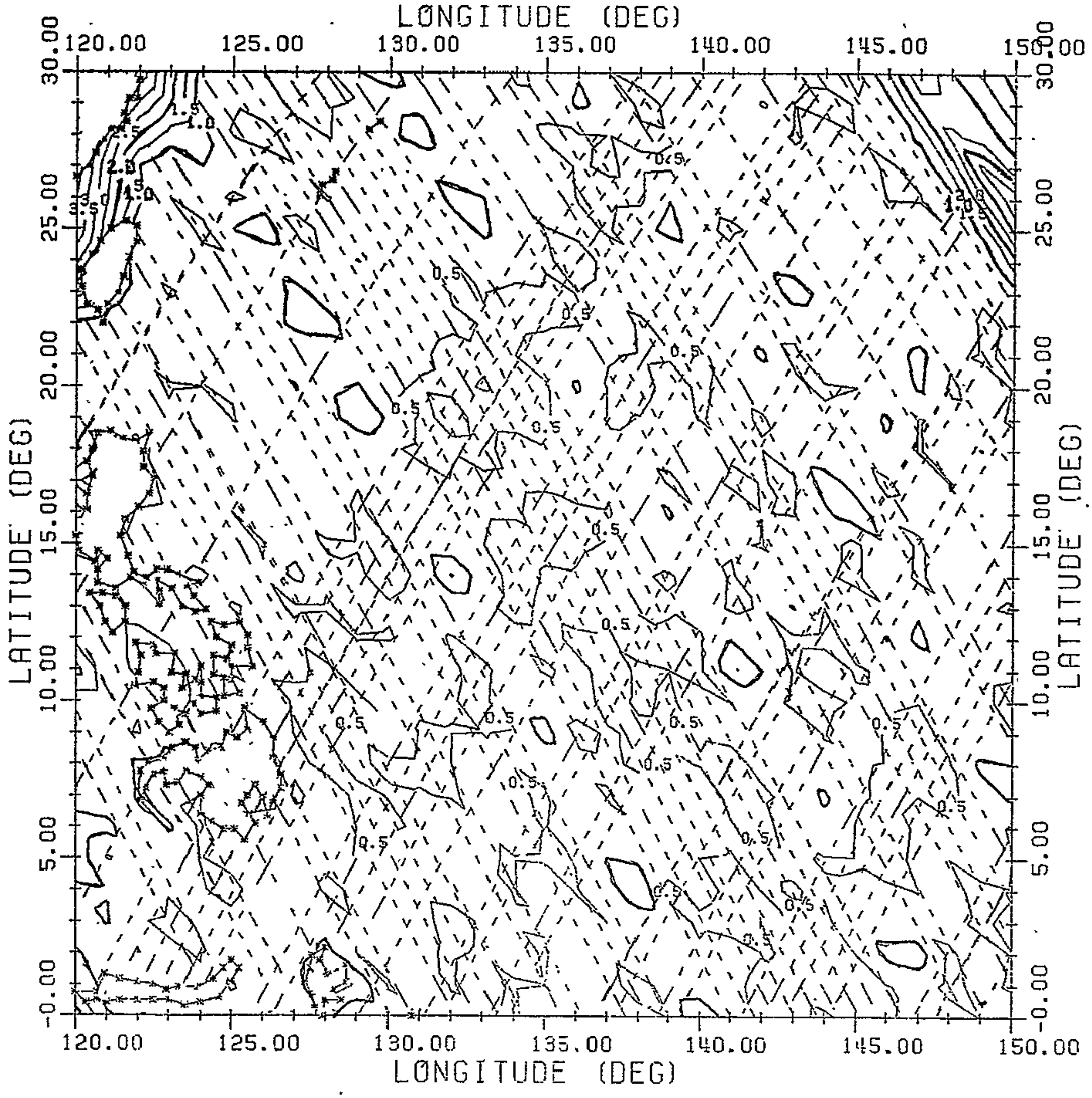
Figure 9

Geoid Undulation Accuracy in the Philippines
From Adjusted Altimeter Data
Contour Interval: 0.5 meters



C_{gg}: the expected mean square value (variance) in a global sample, of the anomaly being predicted;
m_g: the predicted standard deviation of the predicted anomaly

We not only intend to predict the mean anomalies in a block, but the mean geoid undulations. To do this we write a similar set of equations to (26) and (27):

$$N = \underline{C}_{Nh} (\underline{C}_{hh} + D)^{-1} \underline{h} \tag{28}$$

$$m^2_N = \underline{C}_{NN} - \underline{C}_{Nh} (\underline{C}_{hh} + \underline{D})^{-1} C_{hN} \tag{29}$$

In this case:

N: the predicted geoid undulation;
$\underline{C}_{Nh}$: the row vector containing the covariance between the undulation being predicted and the given geoid undulation;
C_{NN}: the expected mean square value (variance), in a global sample, of the undulation being predicted;
m_N: the predicted standard deviation of the predicted anomaly

We note that the matrix to be inverted in (26) and (27) is identical to the one to be inverted in (28) and (29).

The interpretation of the predicted quantity as a point or mean value depends on the interpretation of or determination of the covariances that are used in equations (26) through (28). In our computations we intend to use the point covariance function developed in Tscherning and Rapp (1974) on the basis of a hypothetical anomaly degree variance model. If we are predicting point undulations and point anomalies, the covariances from subroutine COVA (in Tscherning and Rapp) can be used directly. If we are determining mean anomalies or mean undulations, the appropriate mean covariance functions must be derived. There are a number of ways to do this with the technique chosen here to be one of numerical integration. Consider two blocks A_1 and A_2 whose dimensions are a x b (for A_1) and a' x b' for A_2. These blocks are, for now, considered to be located on a plane in non-identical positions. Now let C(P, Q) be a point covariance function between points P (in A_1) and Q (in A_2). Then we can write (following from equation (7-82) in Heiskanen and Moritz, 1967):

$$C_{A_1 A_2} = \frac{1}{(ab)(a'b')} \int_{x=0}^{a} \int_{y=0}^{b} \int_{x'=0}^{a'} \int_{y=0}^{b'} C(x, y, x', y')\, dx\, dy\ \ dx'\, dy' \tag{30}$$

If we now let:

$$a = n\,dy; \quad b = n\,dx; \quad a' = n\,dy'; \quad b' = n\,dx'$$

we can express (30) in the following numerical integration form:

$$C_{A_1A_2} = \frac{1}{n^4} \sum_{i}^{n} \sum_{j}^{n} \sum_{i}^{n} \sum_{j}^{n} C\,(x_i, y_i, x'_i, y'_i) \tag{31}$$

The accuracy of this computation will improve as n increases, but so will the computation time. One wishes to choose n to be as small as possible being consistent with the accuracy objectives of the computations. In the computations to be described in this report, we choose n = 10 when dealing with 5° anomalies and n = 5 when dealing with 1° x 1° anomalies. In addition, we interpreted the altimeter measurement to be a point value, although the measurement has a finite (but small) footprint.

Gravity Anomaly Recovery - Test Results

The implementation of the preceding theory required a number of decisions on data selection, reference fields, computational efficiencies, etc. that had to be made before production computations could be started. We describe in this section some of these computations.

Grid Interval:

A number of prediction tests were made to select the optimum value of n appearing in equation (31). For 5° anomaly predictions, n was chosen as 10 and for 1° predictions, n was chosen as 5. Improvement, caused by increasing n, in the anomaly predictions (and accuracy) could be on the order of 0.3 mgals, while for undulation estimation, it would be on the order of 0.1 meters.

Covariance Tabulation:

The computation of the needed covariances from COVA (Tscherning and Rapp, 1974) can be expensive when many computer subroutine calls are made, such as is done in the numerical integration. To get around this, tables were constructed of the needed covariances as a function of the spherical distance at 0°.05 interval. These tables were stored in the program with linear interpolation being used to determine the needed covariance. Such a procedure considerably reduced the computer time and caused no errors in the final results at the 0.1 mgal and 0.1 meter levels.

Plane Coordinates:

The covariance functions are usually given as a function of the spherical distance ψ separating the points of interest. This spherical distance is usually computed given the latitude and longitude of the two points involved. This requires the solution of the spherical law of cosines and the use of an arc cosine subroutine. Since we planned on extensive computations with this procedure, we examined the idea of getting away from spherical coordinates and use plane coordinates instead. The use of plane coordinates might be justified due to the fact that we would be working, for each prediction, with data in a limited part of the earth.

The type of plane coordinate system should be simple, should have small length distortion, and should have an x coordinate (positive east) that was independent of latitude changes, and the y coordinate (positive north) independent of longitude, so that the numerical integration technique could simply be applied. Two such sets of mapping equations were tested. They were the "Carte Parallelogrammatique" (Pearson, 1977, p. 250) and a modified Mercator projection where the distance is held true at a specified latitude. Not noting any significant differences between the results of the two projections, we elected to use the following form of the Carte Parallelogrammatique projection:

$$x = R \cos \varphi_0 (\lambda - \lambda_0) \tag{32}$$

$$y = R (\varphi - \varphi_0) \tag{33}$$

where R is a mean earth radius (6371 km), φ_0, λ_0 are the coordinates of the midpoint of the 5° block being predicted, and φ, λ are the coordinates of the point whose x, y coordinates are being determined. The spherical distances needed for covariance evaluation were found by multiplying the plane coordinate distance by RAD/R where RAD is the radian conversion to degrees factor.

Limited tests with predictions with plane coordinates gave no changes to predicted N values and standard deviation at the 0.02 meter level and at less than the 0.1 mgal level for the anomaly standard deviation. All further computations used plane coordinates except for a subroutine computing the block variances, which was retained in spherical form.

Data Selection:

Previous experience (Rapp, 1974) and Rummel and Rapp (1977) had shown us two facts: 1) only data with about 3° of the edge of a mean anomaly block was needed when a high degree reference field on the order of 12-20 was used; 2) the computational effort in selecting data for a single block and the subsequent matrix inversion required a significant amount (about 2 min. of IBM 370/168 time). Although this time may seem short by itself, when one contemplates over 10,000 separate mean anomaly computations, the actual time and expense is not reasonable.

In order to reduce the required computer time, we decided to select the data with respect to the 5° equal area block whose mean anomaly was being estimated. Specifically, all data within a 3° border surrounding the 5° block was selected for possible use. This data was then selected so that all data outside a spherical radius of ψ° was detected (ψ was usually 4° from the center of the 5° block). We then said that the maximum matrix that we would invert would be about 420 x 420. The available data was then selected to be every n th point where n was chosen so that the final data set did not exceed 420 (although some tests were made up to 475). We then used this data set to compute the matrix inverse needed in equations (27), (28), (29) and (30). Then the appropriate mean covariance functions were determined to predict, first the 5° block mean (of Δg and N), and then the prediction of all $1^\circ \times 1^\circ$ mean values that fell within the 5° equal area block. Thus, if there are s $1^\circ \times 1^\circ$ values in the 5° block, we will save s data selections and s inversions of a 420 x 420 (roughly) matrix. The time saving is obvious. However, we do potentially increase the error in our prediction because the data will not be selected optimally for each block being predicted. This is a compromise that one must accept for production predictions.

A number of tests were made comparing the $1^\circ \times 1^\circ$ anomalies predicted separately, and predicted as part of the $1^\circ \times 1^\circ$ anomalies within the 5° equal area block.

Some tests were run that showed the error in the $1^\circ \times 1^\circ$ anomaly prediction caused by the 5° data selection was on the order of 0.5 mgals reaching 5 mgals in one case (where the 5 mgals was less than the predicted standard deviation of the anomaly). Considering the tests made, the error attributed to the anomaly prediction caused by the prediction of the $1^\circ \times 1^\circ$ anomaly with the 5° anomaly data set is probably on the order of 1 to 2 mgals, considerably below the expected ± 6 mgal accuracy in the anomalies to be predicted.

A number of tests were also made specifying the data interval along a profile such that every n th point would be used. In average coverage areas with respect to the altimeter data, n was 6. In sparse areas n could be 2 or 3 (no n below 2 was allowed for stability reasons in the matrix inverse). In the densest area, n could reach 19. In these latter cases, special tests were made to see if a significant improvement in accuracy could be made by reducing n (or increasing the data points selected) with the subsequent increase in computer time. Comparing the predicted anomalies with terrestrial anomalies on an area off the east coast of the United States, the improvement in going from an n of 15 to an n of 12 was only 7%, which was considered negligable. These and other tests were used to establish the maximum number of data points to be used as around 420, provided they were chosen in a manner such that all areas had data, if possible.

Influence of the Reference Field on the Anomaly Prediction:

The gravity anomalies and geoid undulations predicted from (26) and (28) refer to the reference gravity field to which the given geoid undulations (h) and the covariances are referred. Usual practice is to give the final values with respect to an equipotential ellipsoid model, but a higher degree model such as GEM 9 could be used as a reference. Then (26) and (28) would become:

$$(32) \qquad \Delta g = \underline{C}_{ghR} \, (\underline{C}_{hhR} + \underline{D})^{-1} \, (\underline{h} - \underline{h}_R) + \Delta g_R$$

$$(33) \qquad N = \underline{C}_{NhR} \, (\underline{C}_{hhR} + D)^{-1} \, (\underline{h} - \underline{h}_R) + N_R$$

where the subscript R indicates a value given with respect to the adopted reference field. The needed covariances can be obtained from subroutine COVA previously discussed. The reference undulation, h_R, can be computed from equation (4). The reference gravity anomaly, Δg_R, can be computed from:

$$(34) \qquad \Delta g_R = \frac{GM}{r^2} \sum_{\ell=2}^{\ell_{MAX}} (\ell-1) \left(\frac{a}{r}\right)^{\ell} \sum_{m=0}^{\ell} (\overline{C}_{\ell m} \cos m\lambda + \overline{S}_{\ell m} \sin m\lambda) \, \overline{P}_{\ell m}(\sin\varphi)$$

For reference fields to degree 20, (34) is sufficiently accurate for 1°x 1° mean values when the coordinates of the center point are taken. For the larger 5° equal area block the following integrated form of (34) should be used:

$$(35) \qquad \overline{\Delta g}_R = \frac{GM}{r^2 \Delta\lambda (\sin\varphi_2 - \sin\varphi_1)} \sum_{\ell=2}^{\ell_{MAX}} (\ell-1) \left[\Delta\lambda \, \overline{C}_{n,o} \int_{\varphi_1}^{\varphi_2} \overline{P}_{n,o}(\sin\overline{\varphi}) \cos\varphi \, d\varphi \right.$$

$$+ \sum_{m=1}^{\ell} \frac{1}{m} \left[\overline{C}_{\ell m} (\sin m\lambda_2 - \sin m\lambda_1) - \overline{S}_{\ell m} (\cos m\lambda_2 - \cos m\lambda_1)\right]$$

$$\cdot \int_{\varphi_1}^{\varphi_2} \overline{P}_{\ell m} (\sin\overline{\varphi}) \cos\varphi \, d\varphi$$

A similar equation to (35) follows from equation (4).

We proposed to test the prediction method using an ellipsoidal model ($\Delta g_R = N_R = 0$) and a reference model defined by the GEM 9 coefficients taken to degree 20. This test used the adjusted data in the Philippines regional adjustment for the prediction of 140 $1^\circ \times 1^\circ$ anomalies using the ellipsoidal model and the GEM 9 model. The predicted anomalies were compared with a set of terrestrial anomalies estimated fromacontour map of Watts (1976). The results are given in Table 12.

Table 12

$1^\circ \times 1^\circ$ Anomaly Comparisons in the Philippines Regional Adjustment

	Ellipsoidal Ref.	GEM 9 Ref.
Mean Diff. (Alt. - Terr.)	2.3 mgals	1.5 mgals
RMS Diff. (Alt. - Terr.)	±13.4	±12.3
RMS Alt. Std. Dev.	±10.4	± 7.8

We see from these values that the influence of the reference field in the final predicted values is small with the use of the GEM 9 model yielding slightly better results than the ellipsoidal mode. The main difference is the 25% reduction of the predicted standard error in going to the GEM 9 field, but the predicted standard deviation does not include an error contribution from the potential coefficients. Because of these tests we decided to use in all further predictions the GEM 9 potential coefficients as the reference field.

Mean Anomaly and Undulation Production Results

Using the geoid undulations (or sea surface heights) obtained from the regional adjustments, and using the procedures outlined in the previous paragraphs, 301 5° equal area mean anomalies and undulations and 9995 $1^\circ \times 1^\circ$ mean anomalies and undulations were computed. The 5° equal area blocks division used is that described in Rapp (1977). This scheme, originally suggested by Kaula, was used because recent estimates of the anomalies in these blocks were available from terrestrial gravity sources, Rapp (Ibid.).

The areas in which the mean values were determined are shown in Figure 10. These areas were chosen so that they maximized the available altimeter data. In addition, emphasis was given to the estimation of anomalies in areas where little or no terrestrial data was available. Such areas are apparent from Figure 11 taken from Rapp (1977), which reflected the status of the available gravity data as of August 1976.

We report these results in the following way:

1. In Appendix A we give a listing of the 5° mean anomalies and undulations, and their predicted accuracy.

2. In Appendix B we give maps, containing shoreline plots, where all 1°x 1° anomalies and their accuracy are shown.

3. In Appendix C we give, for a single geographic area, maps showing the 1°x 1° mean geoid undulations and their accuracy. Only this area was plotted for space reasons in this report.

4. A separate listing of all the 1°x 1° anomalies, undulations and their accuracy which is available from the author.

Five Degree Mean Anomaly Comparisons

The predicted 5° equal area anomalies from altimeter data have been compared to the corresponding terrestrial values as given in Rapp (1977). These comparisons have been carried out with several subsets of the 5° anomalies. These subsets are:

1. The seven anomalies (287, 342, 343, 402, 403, 465, 466) that lie off the east coast of the United States in an area of dense altimeter coverage and good terrestrial gravity data.

2. The 153 anomalies in which the terrestrial standard deviation was better than ±6 mgals.

3. All 301 5° anomalies independent of the accuracy of the terrestrial estimates.

The results of these comparisons are given in Table 13.

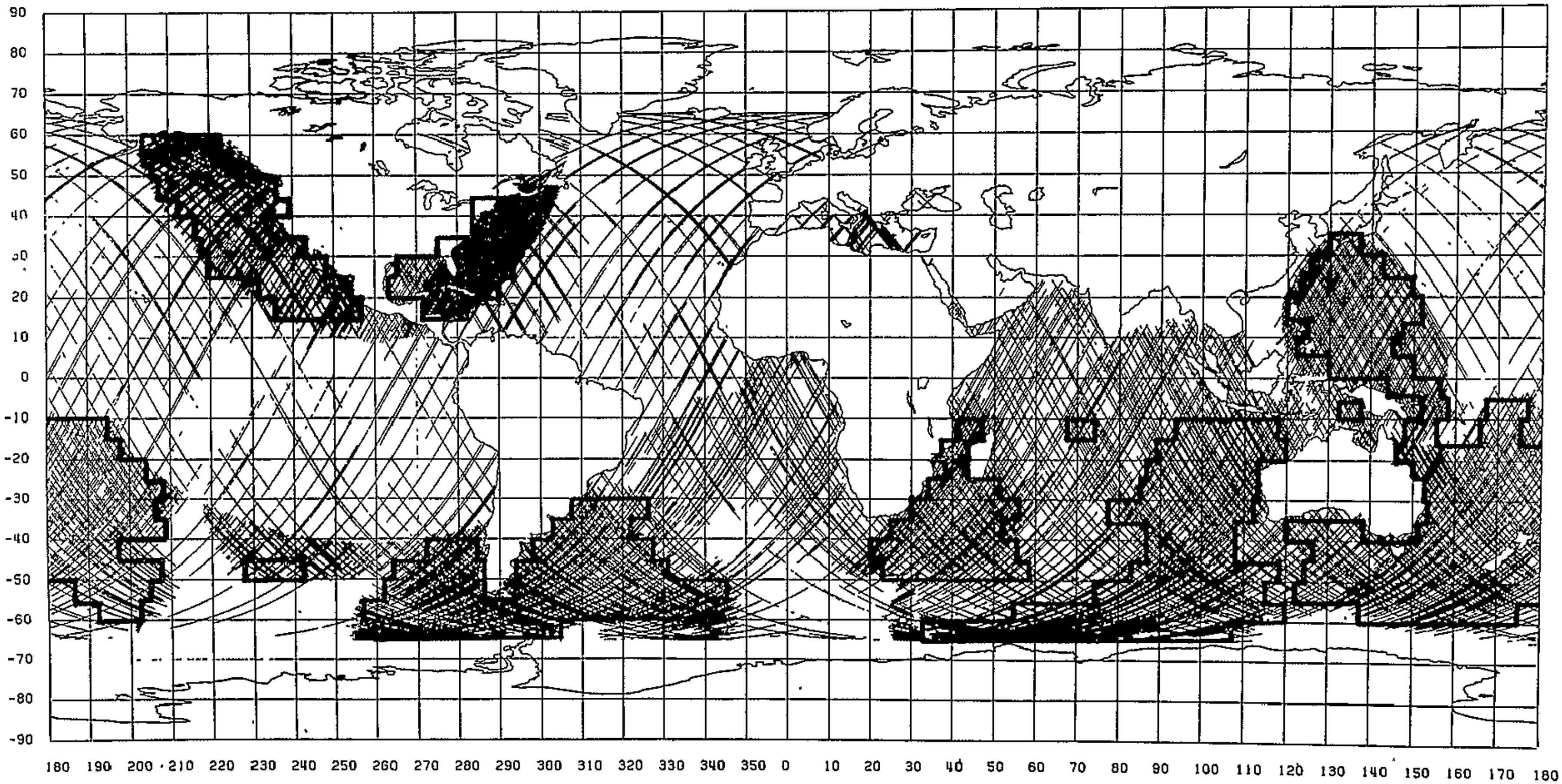


Figure 10

Location of Areas Where 5° Equal Area and 1° x 1° Mean Anomalies and Undulations Have Been Computed

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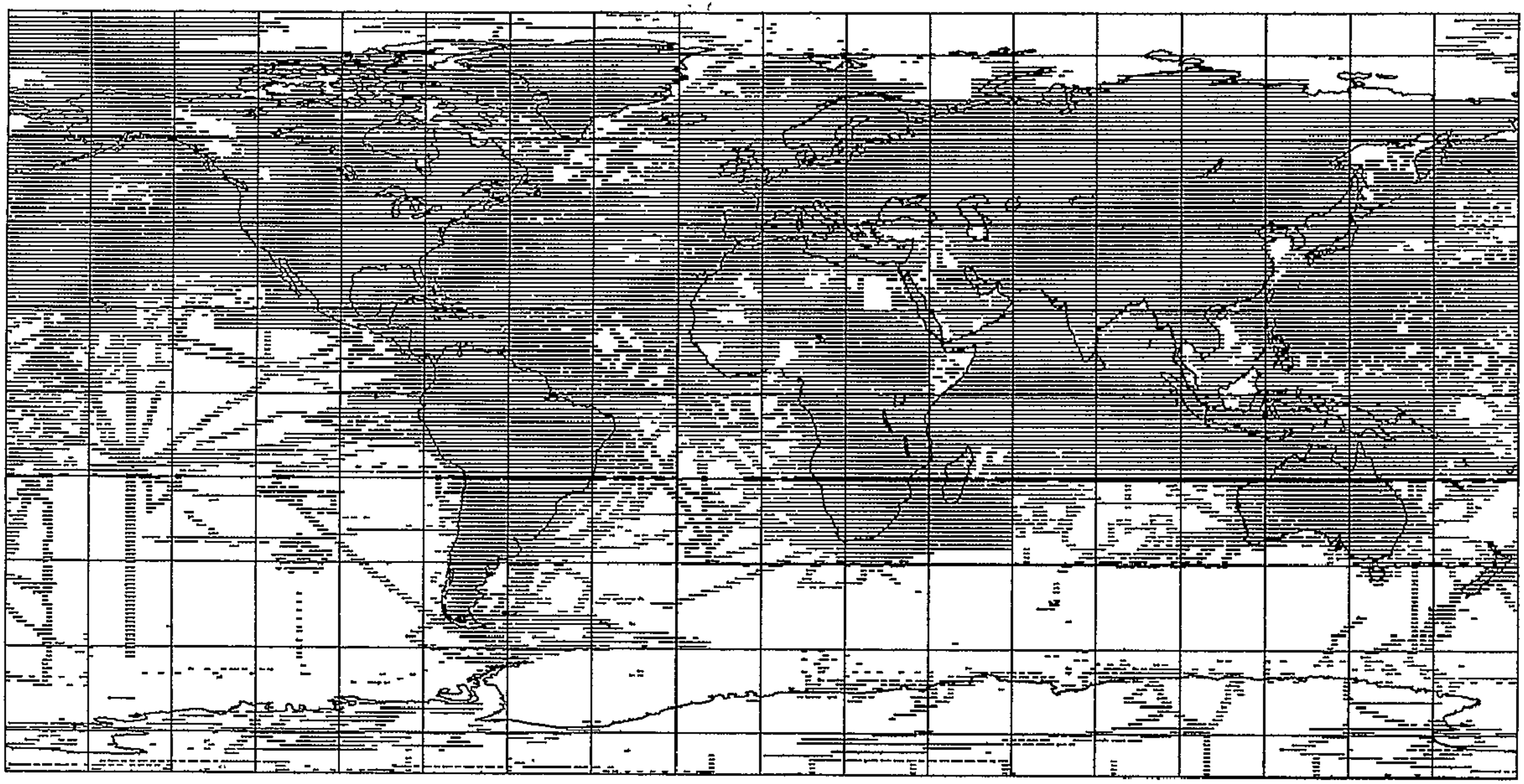

Figure 11

Location of the 1°x 1° Anomalies on the August 1976 Data Tape (Rapp, 1977)

Table 13

Comparison of Altimeter Derived 5° Equal Area Anomalies with Corresponding Terrestrial Values (mgals)

Quantity	Subset*		
	One	Two	Three
Mean Diff. (GEM 9 - Terr.)	1.3	1.5	1.7
Mean Diff. (Alt. - Terr.)	0.2	1.2	1.8
RMS Diff. (GEM 9 - Terr.)	6.9	10.0	12.3
RMS Diff. (Alt. - Terr.)	1.7	6.6	11.1
RMS GEM 9 Anomaly	22.6	14.8	13.8
RMS Alt. Anomaly	23.9	16.3	14.8
RMS Terr. Anomaly	24.3	17.8	15.9
RMS Terr. Std. Error	2.3	3.6	9.7
RMS Alt. Std. Error	2.5	2.6	2.5
Number of Blocks	7	153	301

* see text for description of subsets

Considering the comparisons with subset one, we see excellent agreement of the altimeter derived 5° anomalies with the terrestrial data. The smaller root mean square difference (±1.7) mgals with the altimeter anomalies than with the GEM 9 anomalies (±6.9 mgals) is a strong measure of the possibility of improving the GEM 9 gravity field.

The differences seen for subset two of the 5° equal area anomaly set reflect the somewhat poorer terrestrial gravity data in this area. The root mean square difference between the altimeter derived anomalies and the terrestrial data (of ±6.6 mgals) is consistent with the standard deviations of the altimeter and terrestrial anomalies.

The comparisons with the full 301 value data set are shown for general purposes only as some of the terrestrial estimates are based on predictions using no 1°x 1° terrestrial anomalies within the 5° block. In examining the differences of all the anomalies predicted, a number of large discrepancies are seen with the terrestrial data. Specifically, we found 18 values where the differences were greater than 20 mgals (in absolute value). I give in Table 14 the blocks and pertinent information having anomaly differences greater than 30 mgals.

Table 14

5° Blocks in Which the Difference Between the
Altimeter Derived Anomaly and the Terrestrial Anomaly
is Greater Than 30 mgals (in Absolute Value)

Block	Δg_{ALT}	Δg_{TERR}	Difference
1363	1.3 ± 2.5 mgals	67.1 ± 7.8 mgals	-65.8 mgals
1209	17.1 ± 2.5	-34.4 ± 6.3	51.5
1269	11.0 ± 2.5	-35.6 ± 10.5	46.6
1272	15.2 ± 2.4	-24.1 ± 12.0	39.3
1332	8.4 ± 2.5	-26.3 ± 10.1	34.7
1386	9.5 ± 2.5	-22.4 ± 12.8	31.9

In most cases these discrepancies are much larger than expected considering the given standard deviations. In the case of block 1363, the positive terrestrial anomaly estimate is based on some 1°x 1° anomalies on the order of 100 mgals. Such magnitudes are not in agreement with the altimeter derived values. To explain the large discrepancies shown in Table 14, a more detailed examination of the terrestrial gravity data in these areas is needed.

One Degree by One Degree Anomaly Comparisons

We have compared the predicted 1°x 1° anomalies with existing terrestrial gravity data in two areas: the area (in 8 5° equal area blocks) off the east coast of the United States having dense altimeter coverage and good gravity data; and the area (in 20 5° equal area blocks) in the Philippines regional adjustment area where a new gravity anomaly map by Watts (1976) is available. In addition, the anomaly variations in the Philippines area is much greater than in the U. S. calibration area. The results of these comparisons are given in Table 15. The increased discrepancy in the Philippines Area (over the calibration area) is due to the much larger anomaly variations that exist in the Philippines Area. In both areas the predicted standard deviations of the altimeter derived anomalies (on the order of ±7 mgals) appears to be consistent with the root mean square differences between the altimeter and terrestrial anomalies.

In addition to the above comparisons, we also compared all the 1°x 1° altimeter derived anomalies to the anomalies (when available) on the August 76 tape (Rapp, 1977). We found that there were 5119 altimeter anomalies where there were no terrestrial estimates available. In addition, we found a number of blocks where the discrepancies were quite large between the two anomaly types. Specifically, we found 157 blocks where the absolute anomaly difference was greater than 50 mgals, and 10 blocks where the difference was greater than 100

Table 15

Comparison of Altimeter Derived 1°x 1° Anomalies with Corresponding Terrestrial Values (mgals)

	Calibration Area	Philippines Area
Mean Diff. (GEM 9 - Terr.)	1.8	-0.4
Mean Diff. (Alt. - Terr.)	1.3	0.1
RMS Diff. (GEM 9 - Terr.)	±16.3	±30.8
RMS Diff. (Alt. - Terr.)	± 8.0	±15.8
RMS Alt. Anomaly	26.1	31.0
RMS Terr. Anomaly	28.2	33.4
RMS Terr. Std. Error	12.4	10.7
RMS Alt. Std. Error	8.3	7.3
Number of Blocks	245	520

Table 16

Selected 1°x 1° Mean Anomalies Across the Philippine and Mariana Trench (mgals)

Philippine Trench					Mariana Trench				
φ°	λ°	Δg_{GEM9}	Δg_{ALT}	$\Delta g_{(TERR)}$	φ°	λ°	Δg_{GEM9}	Δg_{ALT}	$\Delta g_{(TERR)}$
11	123	35	59 ±11	45 ±10	14	142	7	39 ±10	27 ±10
11	124	33	85 ± 9	70 ±12	14	143	7	47 ± 7	52 ±10
11	125	31	140 ± 9	153 ±20	14	144	6	102 ± 6	92 ±20
11	126	29	-97 ± 6	-107 ±25	14	145	6	1 ± 8	40 ±15
11	127	27	21 ± 6	31 ±10	14	146	5	-135 ± 7	-148 ±25
11	128	25	37 ± 6	43 ±10	14	147	5	- 47 ± 7	- 38 ±15
11	129	23	31 ± 6	38 ±10	14	148	5	18 ± 7	22 ±12

mgals. The largest difference found was 169 mgals at a block whose northwest corner was -32° (φ), 181° (λ). Here the altimeter anomaly was -16 ±6 mgals while the terrestrial estimate was 153 ±19 mgals. A complete list of the locations of these large discrepancy blocks is available.

The success of the 1° predictions in reliable ground truth areas suggests that bad or questionable terrestrial data may be screened by comparisons with the altimeter derived anomalies.

To demonstrate the ability of the altimeter derived anomalies to reproduce the rapid variations of the anomaly field in certain cases, I give in Table 16, 1° x 1° mean anomalies across a portion of the Philippine Trench and a portion of the Mariana Trench from GEM 9 potential coefficients, from altimeter data and as estimated from the Watts (1976) map.

From this table we can see the rapid variation of the anomaly that is implied by the altimeter data and is not seen in the low degree anomalies derived from a set of potential coefficients given to degree 20. We also see a good agreement between the altimeter and terrestrial data.

Preliminary computations have shown that it is possible to produce essentially a continuous anomaly profile from the altimeter data that agrees quite well with estimated values based on terrestrial data. With such a procedure, we have seen anomaly changes of 450 mgals in 130 km.

Summary and Conclusions

In this report we have described the methods used to determine mean anomalies and mean undulations from the Geos-3 altimeter data available to us by the end of September, 1977, without having a complete set of precise orbits. The editing of the data was extensive to remove questionable data, although no filtering of the data was carried out. An adjustment process was carried out to remove orbit error and an altimeter bias. This adjustment was carried out first in a primary net, and then in regional nets. This adjustment used a very simple first degree polynomial in time for the orbit and bias error (for sufficiently long arcs) and introduced cross-over observation equations. After the adjustment, a set of adjusted geoid undulations were available that were used to produce geoid undulation maps (of about ± 1 m accuracy) and mean gravity anomalies and undulations in 301 5° equal area blocks and 9995 1° x 1° blocks. The predicted accuracy of a 5° block was ± 3 mgals while it was ± 6 mgals for 1° x 1° anomalies. These accuracies indicate a significant improvement (by a factor of roughly 2) over the accuracies that could be obtained from the GEM 9 potential coefficients themselves. Values were predicted only where the altimeter data was of sufficient density to yield best results. Other areas could also be predicted with somewhat poorer accuracies. 5119 1° x 1° anomaly estimates took place in areas where no terrestrial data had previously been available. Where terrestrial data was available, comparisons with the altimeter derived data were made. For the most part, excellent agreement was found between the two sets of anomalies indicating the predicted standard deviations are reasonable.

In the future, more altimeter data is needed to fill in the gaps obvious in Figure 1. When such data is available, additional anomaly estimations can be made. Because of the homogeneity of the altimeter data, and because of its distribution, it would appear that anomalies derived from satellite altimeter may be more reliable, as a whole, than those derived from ship board data.

We finally note that additional work needs to be done to improve the orbit error model, and to investigate the errors caused by sea surface topography.

The gravity anomalies derived from the altimeter data appear to be an excellent source of information for improving our knowledge of the structure of the earth.

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Appendix A

This appendix contains a listing of the 5° equal area free-air anomalies and undulations as derived from Geos-3 altimeter data. These values refer to an ellipsoid whose flattening is 1/298.257 and whose equatorial radius is theoretically unknown, being actually the equatorial radius of the general terrestrial ellipsoid.

SEQ	LAT		LONG		ANOM	S.D.	UND	S.D.
134	60	55	212	203	15.0	2.9	12.4	0.2
176	55	50	213	205	23.6	2.5	7.2	0.1
178	55	50	229	221	-2.7	2.6	-9.4	0.1
224	50	45	220	213	-4.2	2.5	-13.2	0.1
226	50	45	235	228	-6.7	2.7	-21.7	0.1
276	45	40	224	217	-12.2	2.5	-26.5	0.1
278	45	40	238	231	-7.6	3.0	-28.3	0.4
287	45	40	299	292	-6.6	2.5	-24.7	0.1
332	40	35	227	221	-21.9	2.5	-34.8	0.1
342	40	35	291	284	-23.3	2.7	-45.9	0.1
391	35	30	224	218	-9.1	2.5	-29.8	0.1
393	35	30	236	230	-15.0	2.5	-40.4	0.1
401	35	30	283	277	-3.9	3.6	-33.7	0.6
403	35	30	295	289	-23.9	2.5	-44.8	0.1
438	30	25	135	129	-13.8	2.5	-2.7	0.1
454	30	25	225	219	-5.4	2.6	-27.9	0.1
456	30	25	236	231	-16.3	2.4	-35.7	0.1
458	30	25	248	242	-13.7	2.7	-39.4	0.1
463	30	25	276	270	-3.3	2.7	-26.1	0.1
465	30	25	287	281	-17.8	2.5	-39.8	0.1
502	25	20	129	124	3.4	2.5	30.0	0.1
504	25	20	140	134	14.4	2.5	51.5	0.1
506	25	20	150	145	0.9	2.6	34.9	0.1
523	25	20	242	236	-26.6	2.5	-55.5	0.1
525	25	20	253	247	-9.4	2.6	-39.8	0.1
529	25	20	274	269	6.6	2.6	-16.9	0.2
531	25	20	285	279	8.1	2.5	-31.1	0.1
569	20	15	125	120	16.0	2.9	36.4	0.2
571	20	15	136	130	5.8	2.5	53.8	0.1
573	20	15	146	141	31.2	2.5	50.7	0.1
591	20	15	240	235	-20.4	2.6	-44.3	0.1
593	20	15	250	245	-12.4	2.6	-37.0	0.1
598	20	15	277	271	13.2	2.9	-7.2	0.1
639	15	10	129	123	29.3	2.6	64.2	0.1
641	15	10	139	134	11.8	2.4	55.1	0.1
643	15	10	149	144	-10.8	2.5	45.4	0.1
711	10	5	137	132	20.0	2.5	64.4	0.1
713	10	5	147	142	19.3	2.4	60.3	0.1
783	5	0	140	135	24.7	2.5	70.7	0.1
785	5	0	150	145	12.3	2.4	63.4	0.1
858	0	-5	155	150	21.0	2.5	65.9	0.1
930	-5	-10	157	152	20.1	2.5	67.6	0.1
979	-10	-15	46	41	-14.1	2.5	-25.4	0.1
989	-10	-15	98	93	-13.7	2.5	-45.3	0.1
991	-10	-15	108	103	1.2	2.5	-14.5	0.1
993	-10	-15	118	113	-14.9	2.4	9.2	0.1
1003	-10	-15	170	165	11.8	2.5	58.4	0.1
1005	-10	-15	180	175	12.2	2.5	46.8	0.1
1007	-10	-15	190	185	3.6	2.5	28.6	0.1
1048	-15	-20	42	37	-13.7	3.0	-12.6	0.3
1059	-15	-20	99	94	-22.6	2.5	-46.4	0.1
1061	-15	-20	110	104	-25.9	2.5	-31.3	0.1
1063	-15	-20	120	115	-13.4	2.7	1.4	0.1
1070	-15	-20	157	151	19.5	2.6	73.7	0.1

SEQ	LAT		LONG		ANOM	S.D.	UND	S.D.
135	60	55	222	212	14.0	2.7	8.3	0.1
177	55	50	221	213	8.8	2.5	-1.1	0.1
223	50	45	213	206	3.0	2.5	-5.8	0.1
225	50	45	228	220	-14.8	2.5	-23.2	0.1
275	45	40	217	211	-5.9	2.5	-17.1	0.1
277	45	40	231	224	-12.2	2.5	-29.8	0.1
286	45	40	292	285	0.6	3.9	-29.2	0.8
331	40	35	221	215	-21.1	2.5	-29.7	0.1
333	40	35	234	227	-24.1	2.5	-44.0	0.1
343	40	35	297	291	-23.4	2.4	-36.8	0.1
392	35	30	230	224	-14.1	2.5	-36.4	0.1
394	35	30	242	236	-13.9	2.6	-39.5	0.1
402	35	30	289	283	-32.5	2.5	-45.8	0.1
437	30	25	129	124	18.6	2.5	23.1	0.1
439	30	25	141	135	20.5	2.5	40.4	0.1
455	30	25	231	225	-12.0	2.5	-36.4	0.1
457	30	25	242	236	-18.3	2.5	-44.2	0.1
462	30	25	270	264	-12.0	2.9	-26.7	0.1
464	30	25	281	276	5.8	2.6	-21.8	0.2
466	30	25	293	287	-30.2	2.5	-49.2	0.1
503	25	20	134	129	9.1	2.5	37.2	0.1
505	25	20	145	140	14.6	2.5	43.1	0.1
522	25	20	236	231	-16.2	2.5	-42.5	0.1
524	25	20	247	242	-19.3	2.5	-42.9	0.1
528	25	20	269	263	-20.7	2.6	-25.8	0.1
530	25	20	279	274	-5.4	2.4	-19.9	0.1
532	25	20	290	285	-32.5	2.6	-42.4	0.1
570	20	15	130	125	13.1	2.5	42.0	0.1
572	20	15	141	136	13.9	2.4	49.4	0.1
574	20	15	151	146	-4.5	2.4	39.7	0.1
592	20	15	245	240	-20.7	2.5	-44.0	0.1
594	20	15	256	250	-4.3	2.6	-31.0	0.1
599	20	15	282	277	12.2	2.5	-10.2	0.1
640	15	10	134	129	9.9	2.4	54.1	0.1
642	15	10	144	139	-4.4	2.5	51.4	0.1
710	10	5	132	127	10.0	2.5	62.5	0.1
712	10	5	142	137	21.9	2.4	63.4	0.1
782	5	0	135	130	37.9	2.5	72.9	0.1
784	5	0	145	140	19.2	2.4	68.5	0.1
857	0	-5	150	145	44.7	2.5	75.5	0.1
926	-5	-10	137	132	21.5	2.5	63.0	0.1
934	-5	-10	177	172	-5.2	2.4	37.1	0.1
984	-10	-15	72	67	-4.5	2.5	-49.0	0.1
990	-10	-15	103	98	-9.2	2.5	-30.3	0.1
992	-10	-15	113	108	-1.0	2.5	-1.6	0.1
1000	-10	-15	154	149	11.2	2.5	67.3	0.1
1004	-10	-15	175	170	22.3	2.5	55.6	0.1
1006	-10	-15	185	180	10.5	2.5	38.5	0.1
1008	-10	-15	195	190	-2.2	2.5	19.5	0.1
1058	-15	-20	94	89	-22.4	2.5	-51.4	0.1
1060	-15	-20	104	99	-26.0	2.4	-39.0	0.1
1062	-15	-20	115	110	-17.7	2.4	-12.8	0.1
1069	-15	-20	151	146	18.9	2.9	61.4	0.2
1072	-15	-20	167	162	17.9	2.5	60.4	0.1

SEQ	LAT		LONG		ANOM	S.D.	UND	S.D.	SEQ	LAT		LONG		ANOM	S.D.	UND	S.D.
1073	-15	-20	172	167	31.4	2.5	63.7	0.1	1074	-15	-20	177	172	32.4	2.5	61.2	0.1
1075	-15	-20	183	177	25.9	2.5	62.0	0.1	1076	-15	-20	188	183	22.5	2.5	41.6	0.1
1077	-15	-20	193	188	6.7	2.4	25.4	0.1	1078	-15	-20	198	193	-3.6	2.4	15.4	0.1
1117	-20	-25	43	38	-1.3	2.5	-0.6	0.1	1126	-20	-25	91	86	-7.1	2.5	-40.2	0.1
1127	-20	-25	97	91	-20.3	2.5	-53.0	0.1	1128	-20	-25	102	97	-25.8	2.4	-43.3	0.1
1129	-20	-25	107	102	-16.5	2.4	-35.9	0.1	1130	-20	-25	113	107	-22.5	2.5	-33.1	0.1
1138	-20	-25	156	150	18.7	2.7	62.4	0.1	1139	-20	-25	161	156	11.2	2.4	52.1	0.1
1140	-20	-25	167	161	18.4	2.5	65.9	0.1	1141	-20	-25	172	167	17.7	2.4	56.8	0.1
1142	-20	-25	177	172	24.4	2.5	56.5	0.1	1143	-20	-25	183	177	28.7	2.5	62.0	0.1
1144	-20	-25	188	183	11.3	2.4	38.6	0.1	1145	-20	-25	193	188	5.1	2.4	25.1	0.1
1146	-20	-25	199	193	-1.5	2.5	16.9	0.1	1147	-20	-25	204	199	6.2	2.5	9.1	0.1
1183	-25	-30	39	34	0.1	2.5	11.5	0.1	1184	-25	-30	45	39	-7.6	2.5	9.7	0.1
1185	-25	-30	51	45	5.7	2.5	10.6	0.1	1192	-25	-30	90	84	-0.8	2.5	-26.3	0.1
1193	-25	-30	96	90	-13.6	2.5	-35.2	0.1	1194	-25	-30	101	96	-10.0	2.4	-31.2	0.1
1195	-25	-30	107	101	-11.5	2.5	-37.2	0.1	1196	-25	-30	113	107	-24.0	2.5	-34.1	0.1
1204	-25	-30	158	152	7.9	2.8	39.5	0.2	1205	-25	-30	163	158	9.2	2.4	35.1	0.1
1206	-25	-30	169	163	10.1	2.5	45.6	0.1	1207	-25	-30	174	169	18.8	2.4	41.8	0.1
1208	-25	-30	180	174	18.0	2.5	48.7	0.1	1209	-25	-30	186	180	17.1	2.5	40.2	0.1
1210	-25	-30	191	186	17.8	2.4	24.5	0.1	1211	-25	-30	197	191	0.6	2.5	16.6	0.1
1212	-25	-30	203	197	-0.7	2.5	8.0	0.1	1213	-25	-30	208	203	-2.7	2.5	1.7	0.1
1246	-30	-35	35	30	5.5	2.5	22.9	0.1	1247	-30	-35	41	35	0.4	2.5	22.5	0.1
1248	-30	-35	47	41	22.6	2.5	26.3	0.1	1249	-30	-35	53	47	7.1	2.5	23.5	0.1
1254	-30	-35	83	77	11.6	2.5	-1.8	0.1	1255	-30	-35	89	83	6.6	2.5	-12.0	0.1
1256	-30	-35	94	89	-3.0	2.4	-18.3	0.1	1257	-30	-35	100	94	-10.8	2.5	-30.4	0.1
1258	-30	-35	106	100	-23.9	2.5	-37.4	0.1	1259	-30	-35	112	106	-21.3	2.5	-38.1	0.1
1267	-30	-35	159	153	-7.3	2.5	24.7	0.1	1268	-30	-35	165	159	8.4	2.5	30.6	0.1
1269	-30	-35	171	165	11.0	2.5	36.4	0.1	1270	-30	-35	177	171	23.8	2.5	41.9	0.1
1271	-30	-35	183	177	17.9	2.4	37.3	0.1	1272	-30	-35	189	183	15.2	2.4	26.9	0.1
1273	-30	-35	195	189	1.7	2.5	17.3	0.1	1274	-30	-35	201	195	4.1	2.5	9.4	0.1
1275	-30	-35	207	201	2.1	2.5	2.8	0.1	1293	-30	-35	313	307	1.9	2.7	3.8	0.1
1294	-30	-35	319	313	-15.0	2.5	-5.7	0.1	1295	-30	-35	325	319	-8.7	2.5	-4.0	0.1
1306	-35	-40	32	25	7.5	2.5	37.2	0.1	1307	-35	-40	38	32	5.5	2.5	31.7	0.1
1308	-35	-40	44	38	11.4	2.5	34.1	0.1	1309	-35	-40	51	44	34.0	2.5	44.8	0.1
1316	-35	-40	95	88	1.8	2.5	-12.6	0.1	1317	-35	-40	101	95	-8.7	2.5	-22.7	0.1
1318	-35	-40	107	101	-16.2	2.4	-31.3	0.1	1321	-35	-40	126	120	-32.3	2.7	-33.3	0.1
1322	-35	-40	133	126	-34.7	2.6	-32.1	0.1	1323	-35	-40	139	133	-22.2	2.6	-15.7	0.1
1326	-35	-40	158	152	-4.1	2.4	10.1	0.1	1327	-35	-40	164	158	-7.8	2.4	14.5	0.1
1328	-35	-40	171	164	15.1	2.5	27.4	0.1	1329	-35	-40	177	171	24.4	2.7	29.2	0.2
1330	-35	-40	183	177	3.4	2.5	23.9	0.1	1331	-35	-40	189	183	8.9	2.5	18.6	0.1
1332	-35	-40	196	189	8.4	2.5	13.3	0.1	1333	-35	-40	202	196	8.1	2.5	5.6	0.1
1334	-35	-40	208	202	4.8	2.7	0.2	0.1	1350	-35	-40	309	303	4.6	2.6	7.7	0.1
1351	-35	-40	316	309	-16.6	2.5	-3.5	0.1	1352	-35	-40	322	316	-14.7	2.5	-5.4	0.1
1362	-40	-45	27	20	8.3	2.7	33.8	0.1	1363	-40	-45	34	27	1.3	2.5	35.0	0.1
1364	-40	-45	41	34	22.8	2.5	41.6	0.1	1365	-40	-45	48	41	21.7	2.5	43.9	0.1
1366	-40	-45	54	48	14.7	2.4	35.8	0.1	1372	-40	-45	95	88	11.7	2.5	0.9	0.1
1373	-40	-45	102	95	0.3	2.5	-12.0	0.1	1374	-40	-45	109	102	-8.1	2.5	-22.7	0.1
1377	-40	-45	129	122	-13.6	2.5	-27.8	0.1	1378	-40	-45	136	129	-13.5	2.5	-22.7	0.1
1379	-40	-45	143	136	-16.4	2.5	-15.7	0.1	1380	-40	-45	149	143	4.3	2.5	-5.0	0.2
1381	-40	-45	156	149	-14.7	2.5	-4.3	0.1	1382	-40	-45	163	156	-9.3	2.5	0.2	0.1
1383	-40	-45	170	163	-2.9	2.6	7.5	0.1	1384	-40	-45	177	170	12.4	2.6	13.2	0.1
1385	-40	-45	183	177	21.7	2.5	12.6	0.1	1386	-40	-45	190	183	9.5	2.5	7.3	0.1
1387	-40	-45	197	190	0.1	2.5	0.5	0.1	1399	-40	-45	278	272	4.0	2.4	3.1	0.1
1400	-40	-45	285	278	2.7	2.5	9.6	0.1	1403	-40	-45	306	299	-2.9	2.5	7.3	0.1
1404	-40	-45	312	306	-10.5	2.4	-0.7	0.1	1405	-40	-45	319	312	-15.4	2.5	-4.3	0.1

SEQ	LAT		LONG		ANOM	S.D.	UND	S.D.	SEQ	LAT		LONG		ANOM	S.D.	UND	S.D.
1406	-40	-45	326	319	-17.1	2.5	-3.3	0.1	1415	-45	-50	29	22	1.5	2.6	34.5	0.1
1416	-45	-50	37	29	21.6	2.5	47.3	0.1	1417	-45	-50	44	37	13.7	2.5	44.5	0.1
1418	-45	-50	51	44	20.3	2.5	45.5	0.1	1419	-45	-50	59	51	23.6	2.5	49.2	0.1
1423	-45	-50	88	81	18.3	2.5	19.0	0.1	1424	-45	-50	96	88	15.1	2.5	8.8	0.1
1425	-45	-50	103	96	6.9	2.4	-4.4	0.1	1426	-45	-50	110	103	0.0	2.5	-14.6	0.1
1427	-45	-50	118	110	-7.1	2.5	-25.2	0.1	1429	-45	-50	132	125	-4.7	2.4	-23.0	0.1
1430	-45	-50	140	132	-1.3	2.5	-21.4	0.1	1431	-45	-50	147	140	-7.0	2.5	-15.5	0.1
1432	-45	-50	154	147	-7.8	2.5	-13.1	0.1	1433	-45	-50	162	154	-10.9	2.5	-12.0	0.1
1434	-45	-50	169	162	3.9	2.5	-4.5	0.1	1435	-45	-50	176	169	3.1	2.5	-2.0	0.1
1436	-45	-50	184	176	-0.7	2.5	-5.8	0.1	1437	-45	-50	191	184	-10.0	2.5	-10.3	0.1
1438	-45	-50	198	191	-4.5	2.5	-11.6	0.1	1439	-45	-50	206	198	2.1	2.5	-12.8	0.1
1443	-45	-50	235	228	0.8	2.5	-13.6	0.1	1444	-45	-50	242	235	5.0	2.6	-11.0	0.1
1448	-45	-50	272	264	1.3	2.5	-4.1	0.1	1449	-45	-50	279	272	2.1	2.4	2.7	0.1
1450	-45	-50	287	279	9.3	2.9	12.5	0.3	1452	-45	-50	301	294	1.9	2.5	11.6	0.1
1453	-45	-50	309	301	-18.2	2.5	3.9	0.1	1454	-45	-50	316	309	-23.2	2.5	-1.8	0.1
1455	-45	-50	323	316	-17.6	2.4	-0.7	0.1	1456	-45	-50	331	323	-16.0	2.5	5.1	0.1
1470	-50	-55	82	74	26.5	2.5	30.5	0.1	1471	-50	-55	90	82	14.4	2.5	18.6	0.1
1472	-50	-55	98	90	11.3	2.5	7.9	0.1	1473	-50	-55	106	98	7.2	2.5	-3.2	0.1
1474	-50	-55	115	106	0.1	2.5	-15.6	0.1	1476	-50	-55	131	123	-4.9	2.5	-23.1	0.1
1477	-50	-55	139	131	-0.4	2.5	-21.3	0.1	1478	-50	-55	147	139	2.3	2.5	-18.9	0.1
1479	-50	-55	155	147	-3.4	2.5	-18.9	0.1	1480	-50	-55	164	155	-1.1	2.5	-20.3	0.1
1481	-50	-55	172	164	6.5	2.5	-16.9	0.1	1482	-50	-55	180	172	-14.5	2.5	-22.4	0.1
1484	-50	-55	196	188	-10.2	2.5	-24.0	0.1	1485	-50	-55	205	196	-5.1	2.6	-24.2	0.1
1493	-50	-55	270	262	-1.2	2.5	-7.2	0.1	1494	-50	-55	278	270	-1.1	2.5	-1.6	0.1
1495	-50	-55	286	278	-0.2	2.7	6.2	0.1	1497	-50	-55	303	295	8.0	2.4	13.0	0.1
1498	-50	-55	311	303	-6.9	2.5	8.6	0.1	1499	-50	-55	319	311	-1.4	2.5	7.9	0.1
1500	-50	-55	327	319	-0.2	2.5	10.4	0.1	1501	-50	-55	335	327	-1.7	2.5	13.7	0.1
1502	-50	-55	344	335	11.4	2.5	23.3	0.1	1511	-55	-60	65	55	9.8	2.5	38.9	0.1
1512	-55	-60	74	65	15.0	2.5	32.4	0.1	1513	-55	-60	83	74	21.4	2.4	27.1	0.1
1514	-55	-60	92	83	6.7	2.5	14.6	0.1	1515	-55	-60	102	92	8.0	2.5	3.3	0.1
1516	-55	-60	111	102	1.9	2.5	-8.6	0.1	1517	-55	-60	120	111	-4.9	2.9	-18.7	0.1
1520	-55	-60	148	138	-0.2	2.6	-29.2	0.1	1521	-55	-60	157	148	1.7	2.5	-26.3	0.1
1522	-55	-60	166	157	-20.2	2.5	-32.1	0.1	1523	-55	-60	175	166	-29.8	2.5	-38.3	0.1
1526	-55	-60	203	194	-10.0	2.7	-32.8	0.1	1533	-55	-60	268	258	-2.1	2.5	-13.4	0.1
1534	-55	-60	277	268	-2.6	2.4	-6.3	0.1	1535	-55	-60	286	277	-0.3	2.4	1.4	0.1
1536	-55	-60	295	286	11.0	2.5	11.6	0.1	1537	-55	-60	305	295	24.5	2.5	20.1	0.1
1538	-55	-60	314	305	17.6	2.5	18.5	0.1	1539	-55	-60	323	314	9.8	2.4	18.3	0.1
1540	-55	-60	332	323	30.0	2.5	21.0	0.1	1541	-55	-60	342	332	-2.5	2.5	19.2	0.1
1547	-60	-65	44	33	6.4	2.6	29.9	0.1	1548	-60	-65	55	44	2.7	2.6	31.2	0.1
1549	-60	-65	65	55	7.3	2.5	27.6	0.1	1550	-60	-65	76	65	8.7	2.6	26.2	0.1
1551	-60	-65	87	76	12.6	2.6	18.8	0.1	1552	-60	-65	98	87	-1.4	2.7	4.9	0.1
1553	-60	-65	109	98	-6.6	2.7	-8.2	0.1	1568	-60	-65	273	262	-8.8	2.6	-14.7	0.1
1569	-60	-65	284	273	-6.6	2.6	-5.8	0.1	1570	-60	-65	295	284	9.7	2.6	7.9	0.1
1571	-60	-65	305	295	28.3	2.8	17.4	0.1									

Appendix B

This appendix contains geographic area maps containing the $1^\circ \times 1^\circ$ mean free-air anomalies, and (on an adjacent map) the corresponding predicted accuracies, as estimated from the Geos-3 altimeter data. These maps have been prepared for 30 areas, approximately 30° in latitude extent and 20° in longitude extent. An index map for the individual maps is shown in Figure B_0. The individual maps follow, labeled Figures B_1 through B_{30} with the anomaly map given first, followed by the standard deviation map.

The values given refer to an ellipsoid whose flattening is 1/298.257 and whose equatorial radius is theoretically unknown, being actually the equatorial radius of the general terrestrial ellipsoid.

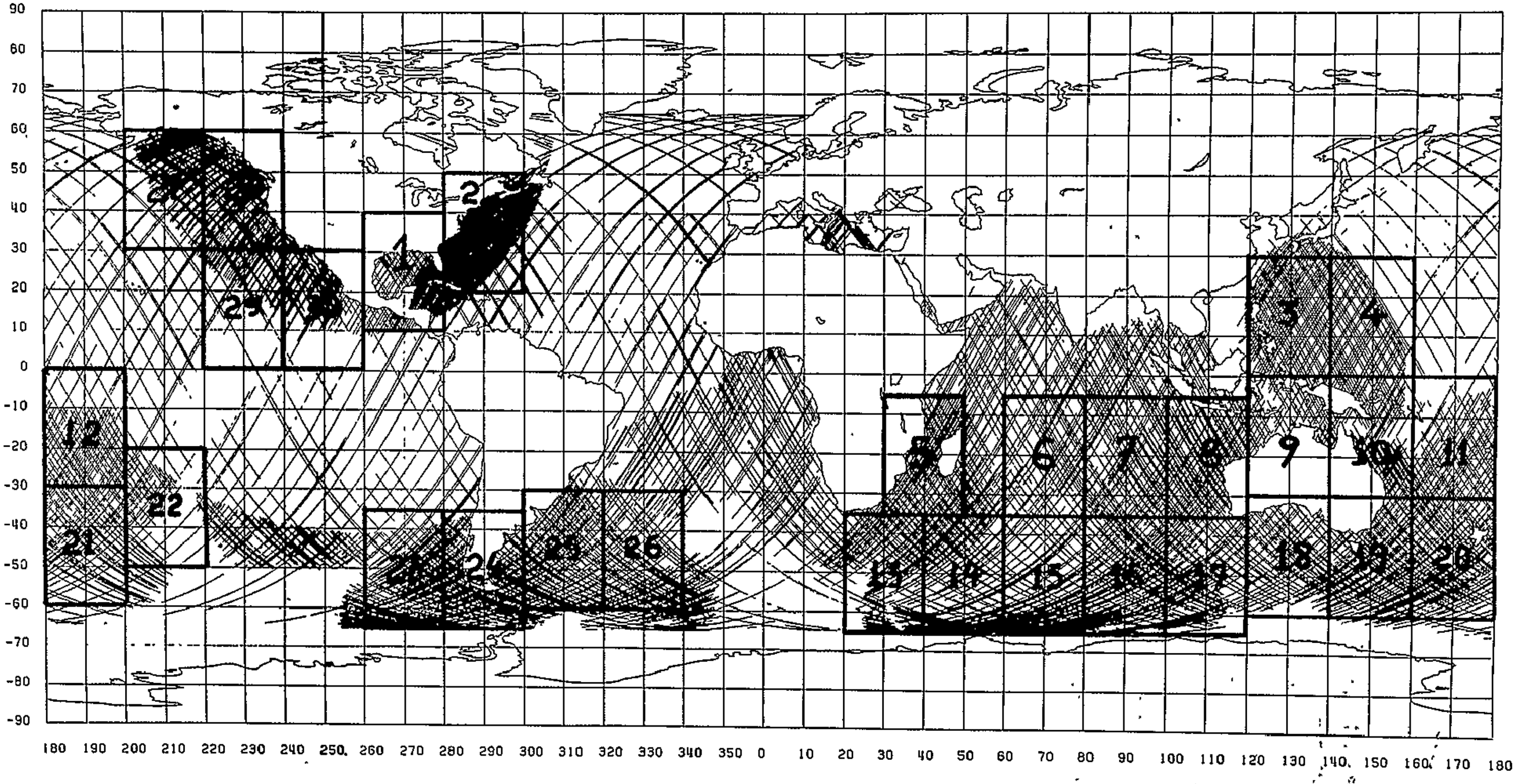
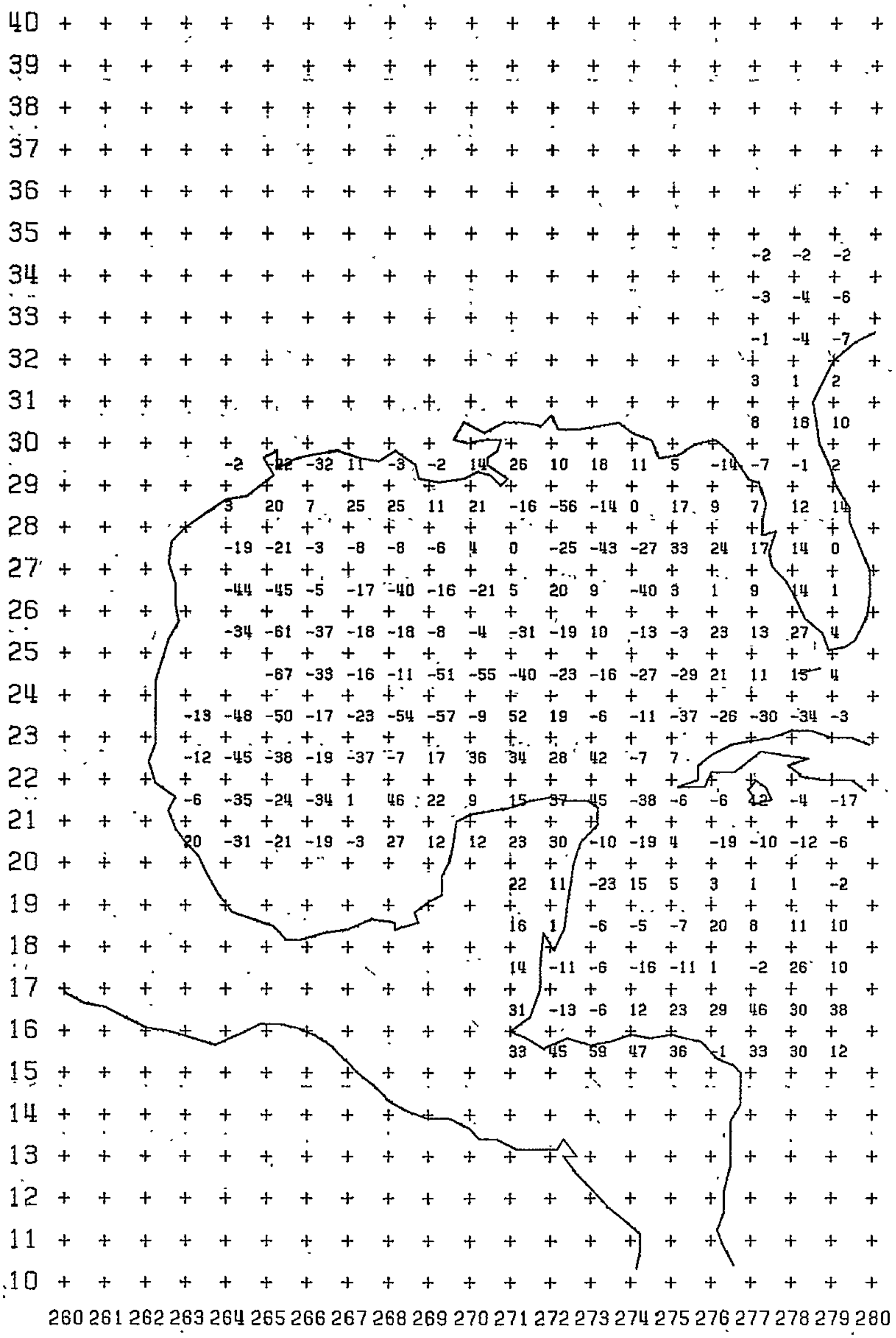


Figure B₀

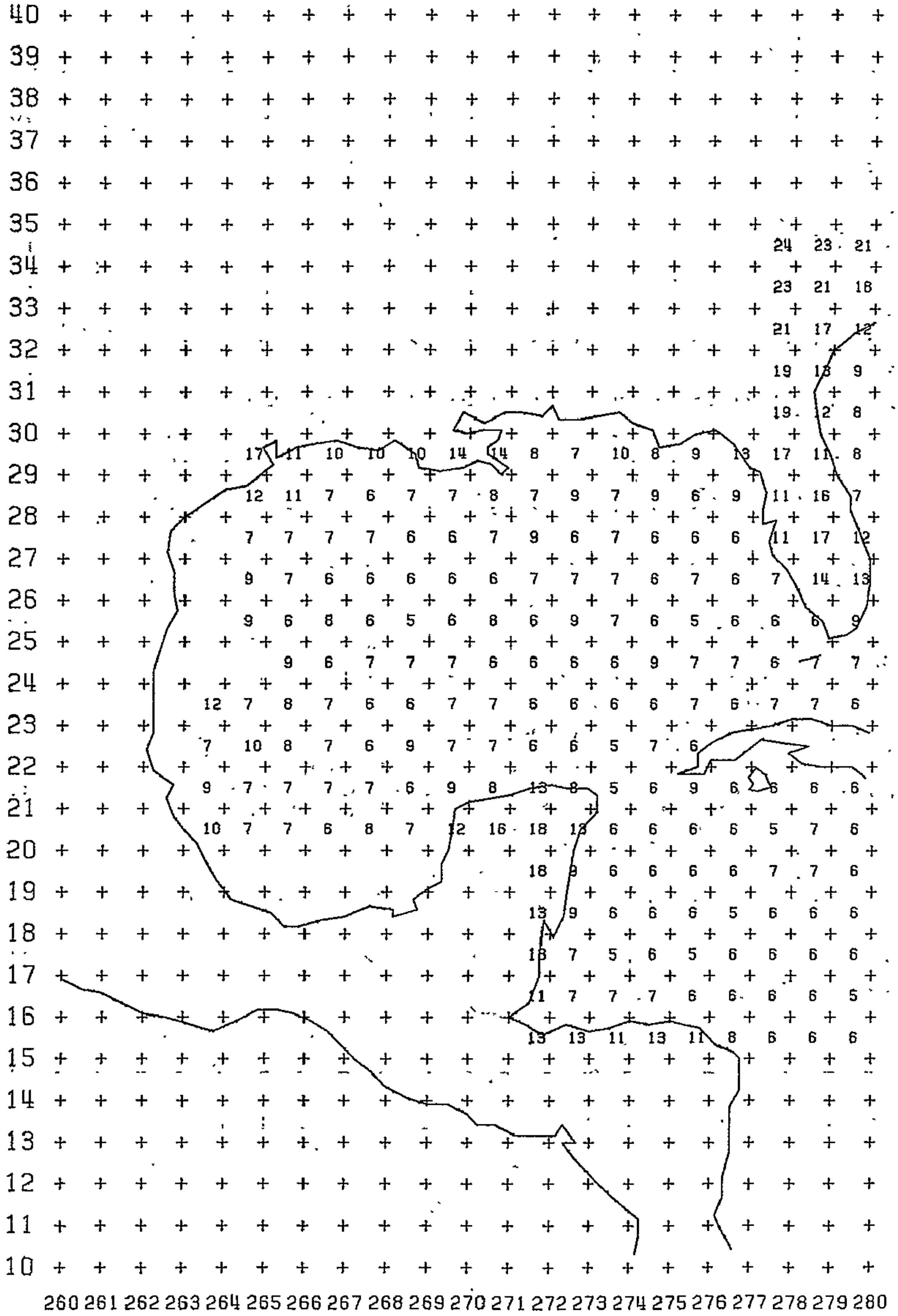
Map Showing Areas Where 1° x 1° Anomalies and Their Accuracy are Given

Figure B1A



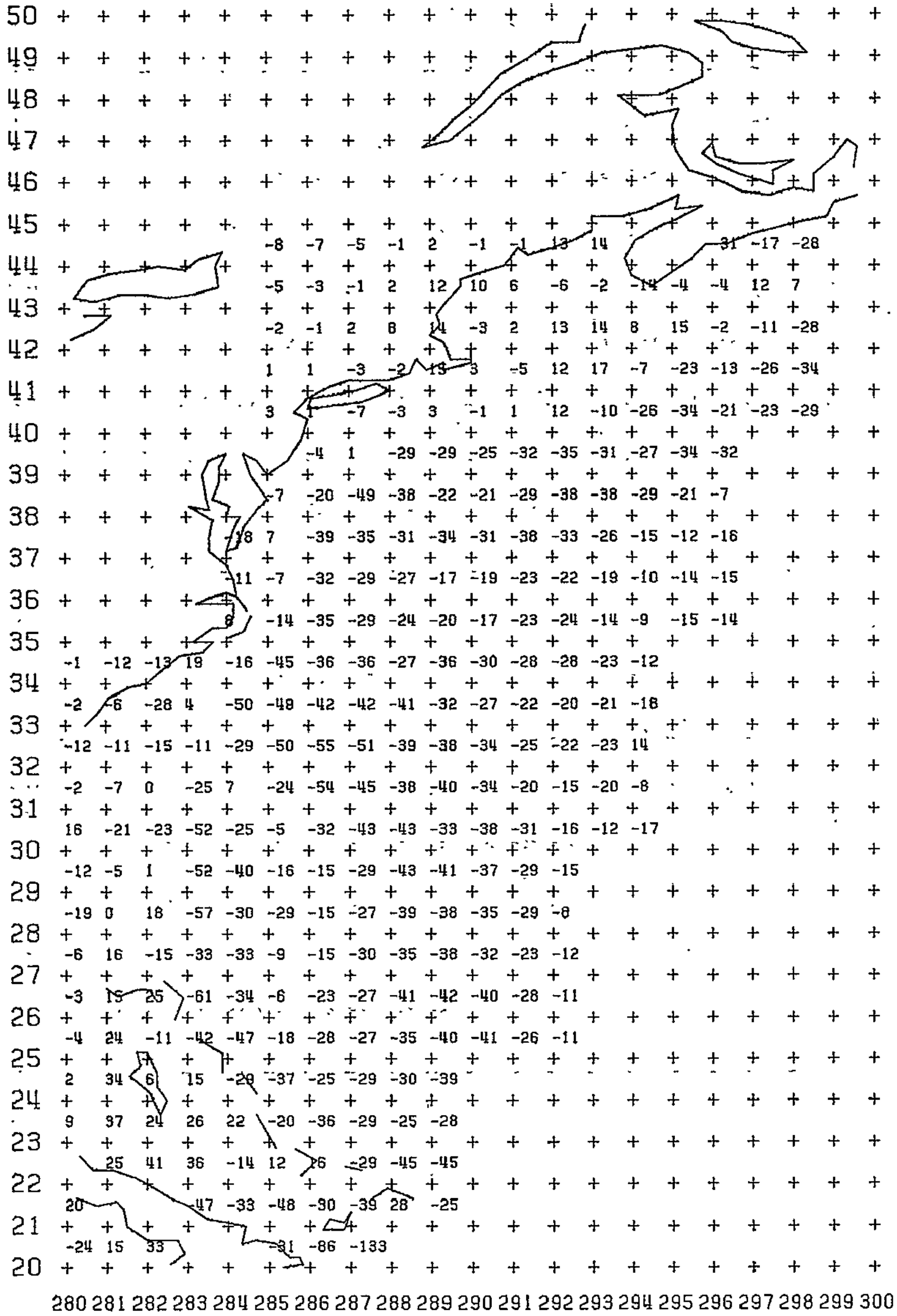
1° x 1° Mean Free-Air Anomalies (mgals)

Figure B1B



Accuracy of Predicted 1°x 1° Mean Anomalies (mgals)

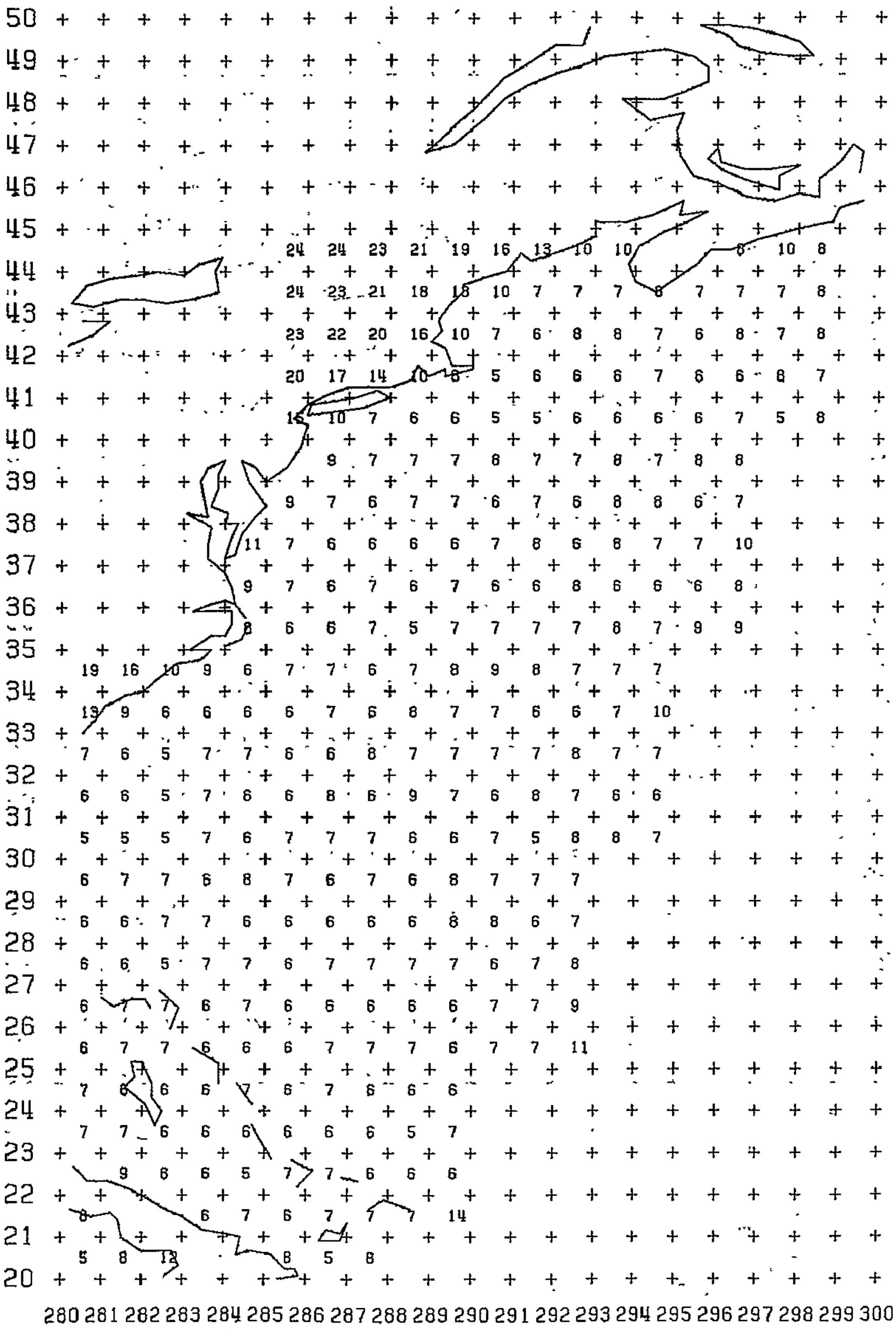
Figure B 2A



	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298
45						-8	-7	-5	-1	2	-1	-1	13	14			-31	-17	-28
44						-5	-3	-1	2	12	10	6	-6	-2	-14	-4	-4	12	7
43						-2	-1	2	8	14	-3	2	13	14	8	15	-2	-11	-28
42						1	1	-3	-2	13	3	-5	12	17	-7	-23	-13	-26	-34
41						3	1	-7	-3	3	-1	1	12	-10	-26	-34	-21	-23	-29
40							-4	1	-29	-29	-25	-32	-35	-31	-27	-34	-32		
39						-7	-20	-49	-38	-22	-21	-29	-38	-38	-29	-21	-7		
38					-18	7	-39	-35	-31	-34	-31	-38	-33	-26	-15	-12	-16		
37					-11	-7	-32	-29	-27	-17	-19	-23	-22	-19	-10	-14	-15		
36					8	-14	-35	-29	-24	-20	-17	-23	-24	-14	-9	-15	-14		
35	-1	-12	-13	19	-16	-45	-36	-36	-27	-36	-30	-28	-28	-23	-12				
34	-2	-6	-28	4	-50	-48	-42	-42	-41	-32	-27	-22	-20	-21	-18				
33	-12	-11	-15	-11	-29	-50	-55	-51	-39	-38	-34	-25	-22	-23	14				
32	-2	-7	0	-25	7	-24	-54	-45	-38	-40	-34	-20	-15	-20	-8				
31	16	-21	-23	-52	-25	-5	-32	-43	-43	-33	-38	-31	-16	-12	-17				
30	-12	-5	1	-52	-40	-16	-15	-29	-43	-41	-37	-29	-15						
29	-19	0	18	-57	-30	-29	-15	-27	-39	-38	-35	-29	-8						
28	-6	16	-15	-33	-33	-9	-15	-30	-35	-38	-32	-23	-12						
27	-3	15	25	-61	-34	-6	-23	-27	-41	-42	-40	-28	-11						
26	-4	24	-11	-42	-47	-18	-28	-27	-35	-40	-41	-26	-11						
25	2	34	6	15	-28	-37	-25	-29	-30	-39									
24	9	37	24	26	22	-20	-36	-29	-25	-28									
23		25	41	36	-14	12	26	-29	-45	-45									
22	20			-47	-33	-48	-30	-39	28	-25									
21	-24	15	33			-31	-86	-133											

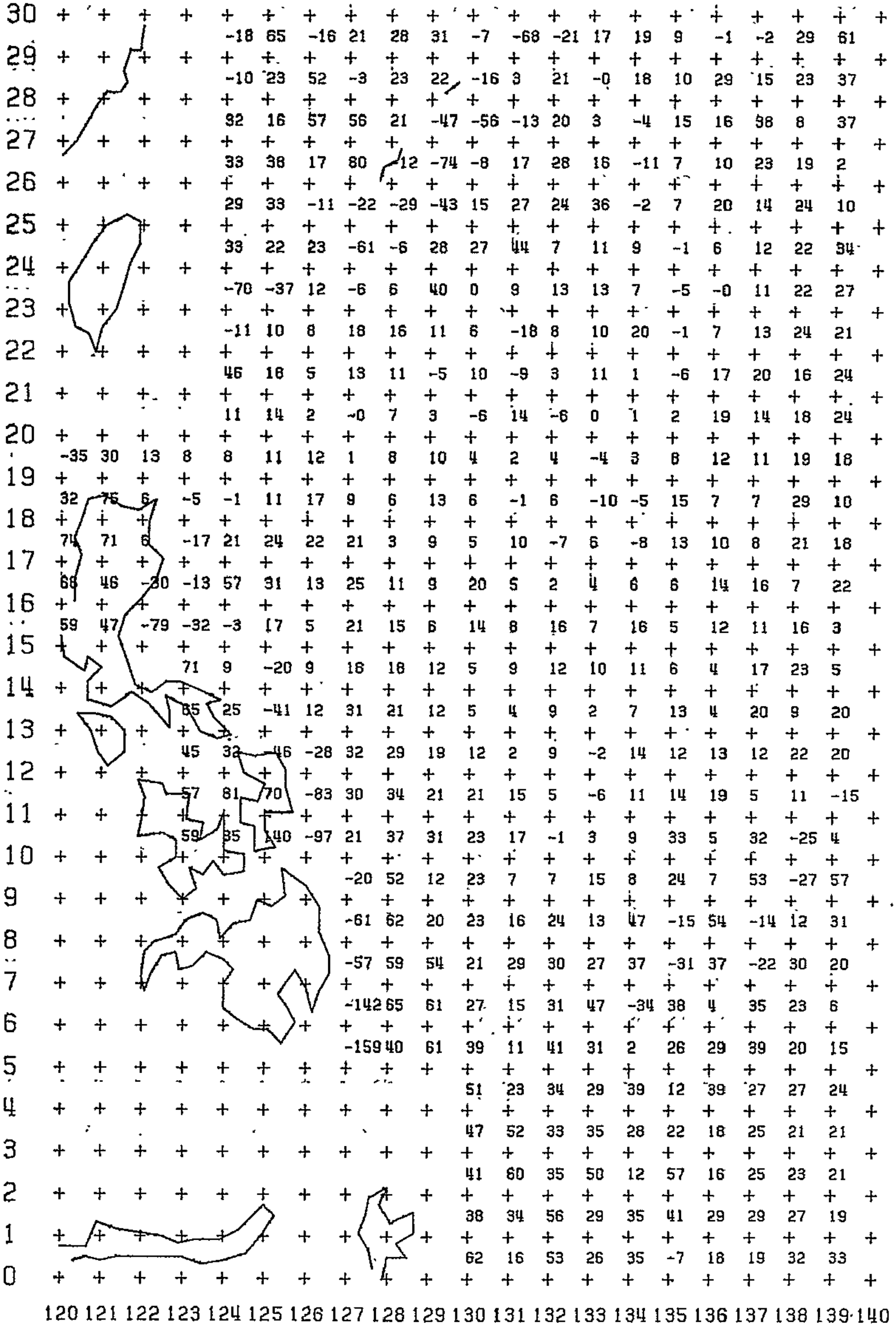
1° x 1° Mean Free-Air Anomalies (mgals)

Figure B 2B



Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

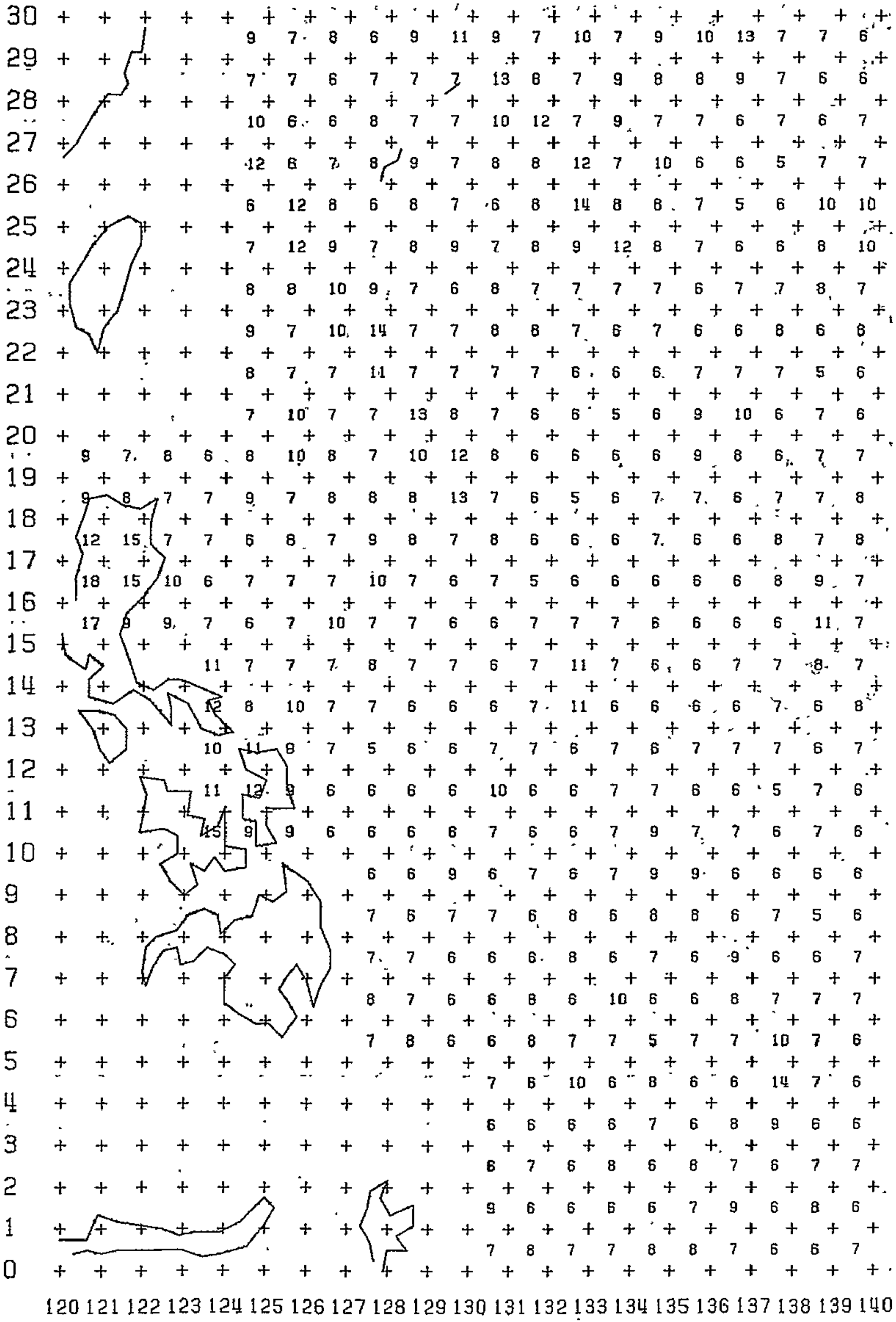
Figure B 3A



	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139
30–29					-18	65	-16	21	28	31	-7	-68	-21	17	19	9	-1	-2	29	61
29–28					-10	23	52	-3	23	22	-16	3	21	-0	18	10	29	15	23	37
28–27					32	16	57	56	21	-47	-56	-13	20	3	-4	15	16	38	8	37
27–26					33	38	17	80	12	-74	-8	17	28	16	-11	7	10	23	19	2
26–25					29	33	-11	-22	-29	-43	15	27	24	36	-2	7	20	14	24	10
25–24					33	22	23	-61	-6	28	27	44	7	11	9	-1	6	12	22	34
24–23					-70	-37	12	-6	6	40	0	9	13	13	7	-5	-0	11	22	27
23–22					-11	10	8	18	16	11	6	-18	8	10	20	-1	7	13	24	21
22–21					46	18	5	13	11	-5	10	-9	3	11	1	-6	17	20	16	24
21–20					11	14	2	-0	7	3	-6	14	-6	0	1	2	19	14	18	24
20–19	-35	30	13	8	8	11	12	1	8	10	4	2	4	-4	3	8	12	11	19	18
19–18	32	75	6	-5	-1	11	17	9	6	13	6	-1	6	-10	-5	15	7	7	29	10
18–17	74	71	6	-17	21	24	22	21	3	9	5	10	-7	6	-8	13	10	8	21	18
17–16	68	46	-30	-13	57	31	13	25	11	9	20	5	2	4	6	6	14	16	7	22
16–15	59	47	-79	-32	-3	17	5	21	15	6	14	8	16	7	16	5	12	11	16	3
15–14				71	9	-20	9	16	18	12	5	9	12	10	11	6	4	17	23	5
14–13				65	25	-41	12	31	21	12	5	4	9	2	7	13	4	20	9	20
13–12				45	32	-46	-28	32	29	19	12	2	9	-2	14	12	13	12	22	20
12–11				57	81	70	-83	30	34	21	21	15	5	-6	11	14	19	5	11	-15
11–10				59	85	140	-97	21	37	31	23	17	-1	3	9	33	5	32	-25	4
10–9								-20	52	12	23	7	7	15	8	24	7	53	-27	57
9–8								-61	62	20	23	16	24	13	47	-15	54	-14	12	31
8–7								-57	59	54	21	29	30	27	37	-31	37	-22	30	20
7–6								-142	65	61	27	15	31	47	-34	38	4	35	23	6
6–5								-159	40	61	39	11	41	31	2	26	29	39	20	15
5–4											51	23	34	29	39	12	39	27	27	24
4–3											47	52	33	35	28	22	18	25	21	21
3–2											41	60	35	50	12	57	16	25	23	21
2–1											38	34	56	29	35	41	29	29	27	19
1–0											62	16	53	26	35	-7	18	19	32	33

1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 3B



Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B 4A

	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
30	11																				
29	39																				
28	14																				
27	36																				
26	43																				
25	37	65	-3	-112	-7	59	21	3	-5	-4											
24	31	53	16	-85	-92	-12	34	18	12	-3											
23	40	49	46	30	-53	-119	-48	15	34	21											
22	28	23	22	62	47	-41	-95	-7	23	13											
21	19	26	40	36	53	56	-17	-7	33	31											
20	17	13	29	18	46	36	-27	-80	1	26	43										
19	18	8	20	42	34	30	-3	-80	-9	25	13										
18	9	10	8	51	29	34	13	-106	-17	30	68										
17	8	13	10	41	40	73	33	-81	-9	41	11										
16	24	7	9	20	51	106	-9	-56	19	37	4										
15	17	18	26	26	68	100	-44	-109	-7												
14	6	28	39	47	102	1	-135	-47	18												
13	13	14	57	59	-74	-156	-80	21	25												
12	-10	-101	-161	-123	-97	2	19	7	-5												
11	-10	-52	-30	-3	63	41	9	11	-2												
10	58	43	25	-9	14	11	-1														
9	16	34	45	19	9	30	19														
8	24	29	27	34	14	23	30														
7	14	15	29	22	21	18	14														
6	8	21	24	14	16	16	15														
5	1	24	20	13	22	11	10	22	19	-6											
4	17	14	21	15	14	10	6	20	14	7											
3	22	8	17	21	9	10	9	19	7	14											
2	29	19	22	17	14	13	14	26	-5	38											
1	32	27	32	25	22	18	7	13	-11	14											
0																					

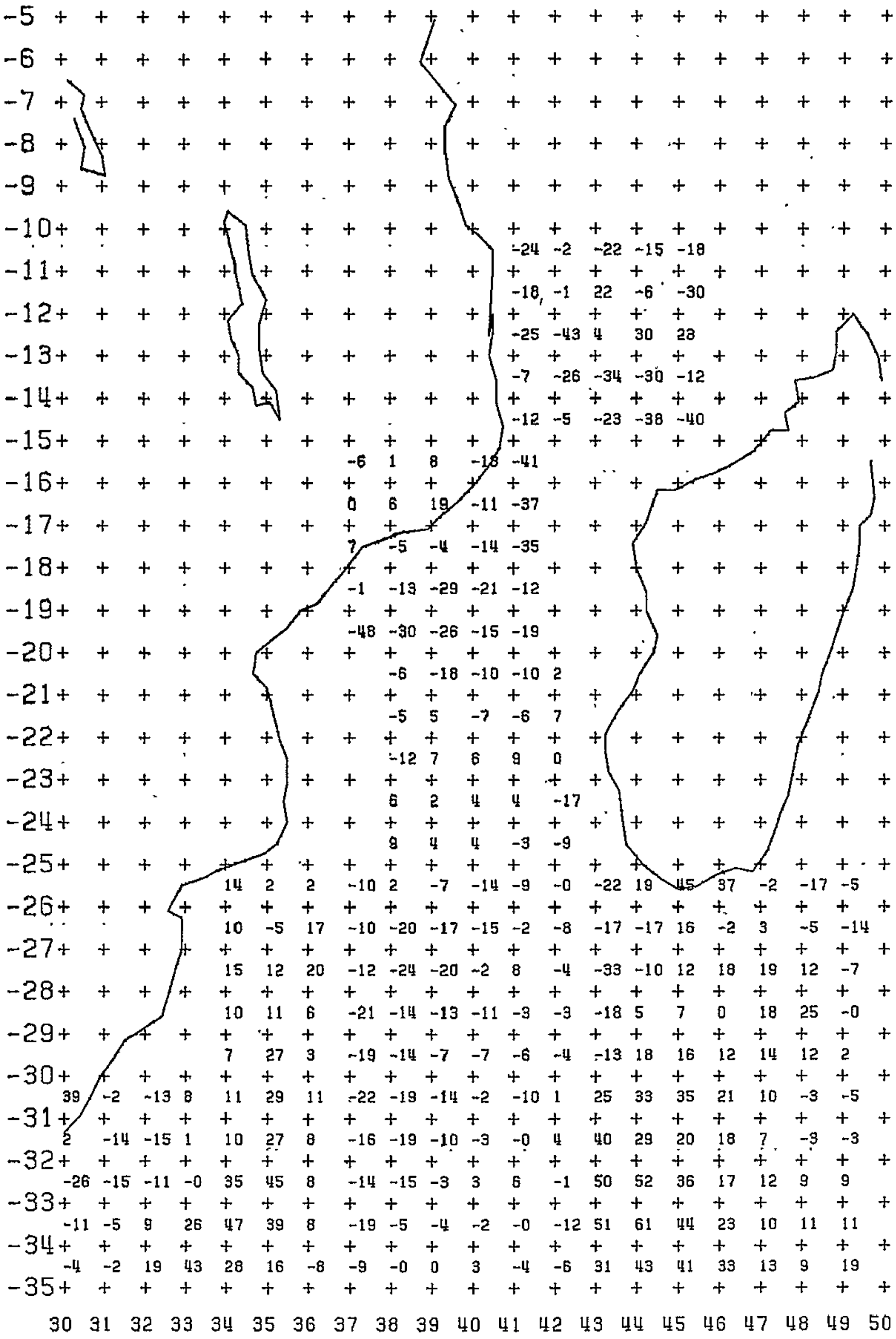
1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 4B

	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
30	8																				
29	7																				
28	12																				
27	9																				
26	6																				
25	6	7	11	7	13	7	8	6	8	13											
24	7	6	7	10	7	8	6	6	7	9											
23	7	8	6	9	6	10	6	10	6	7											
22	7	8	7	6	10	6	10	8	7	6											
21	6	9	7	6	8	6	12	10	6	6											
20	8	7	6	8	6	12	8	6	7	7	6										
19	7	5	7	7	6	10	9	6	9	6	7										
18	8	6	6	6	10	7	6	6	6	7	9										
17	7	6	5	6	13	6	7	8	6	13	6										
16	6	8	6	7	9	7	6	6	8	8	7										
15	7	6	7	8	6	8	7	8	13												
14	7	6	10	7	6	8	7	7	7												
13	7	7	8	6	7	6	9	9	7												
12	7	13	7	7	7	7	7	7	6												
11	7	12	7	7	6	6	7	9	6												
10	7	7	8	7	7	7	6														
9	5	6	10	7	7	8	6														
8	7	6	6	7	7	6	6														
7	6	7	6	10	9	6	7														
6	6	6	6	7	7	6	7														
5	7	6	7	6	7	7	6	10	7	6											
4	6	6	7	6	6	7	7	7	7	6											
3	6	6	6	6	6	7	12	7	7	7											
2	6	7	5	6	6	7	13	6	6	7											
1	9	6	5	5	6	7	7	7	6	6											
0																					

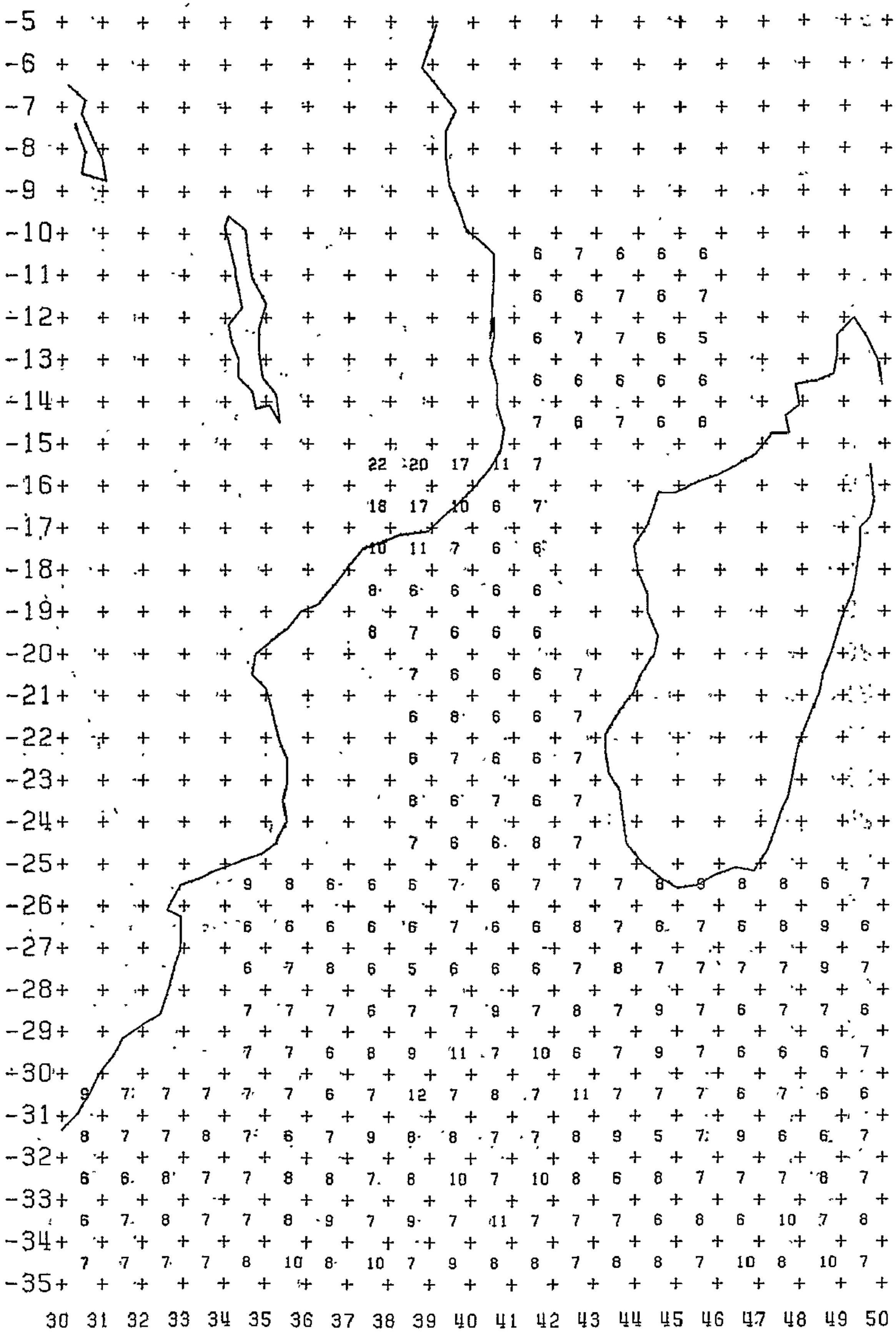
Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B 5A



1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 5B



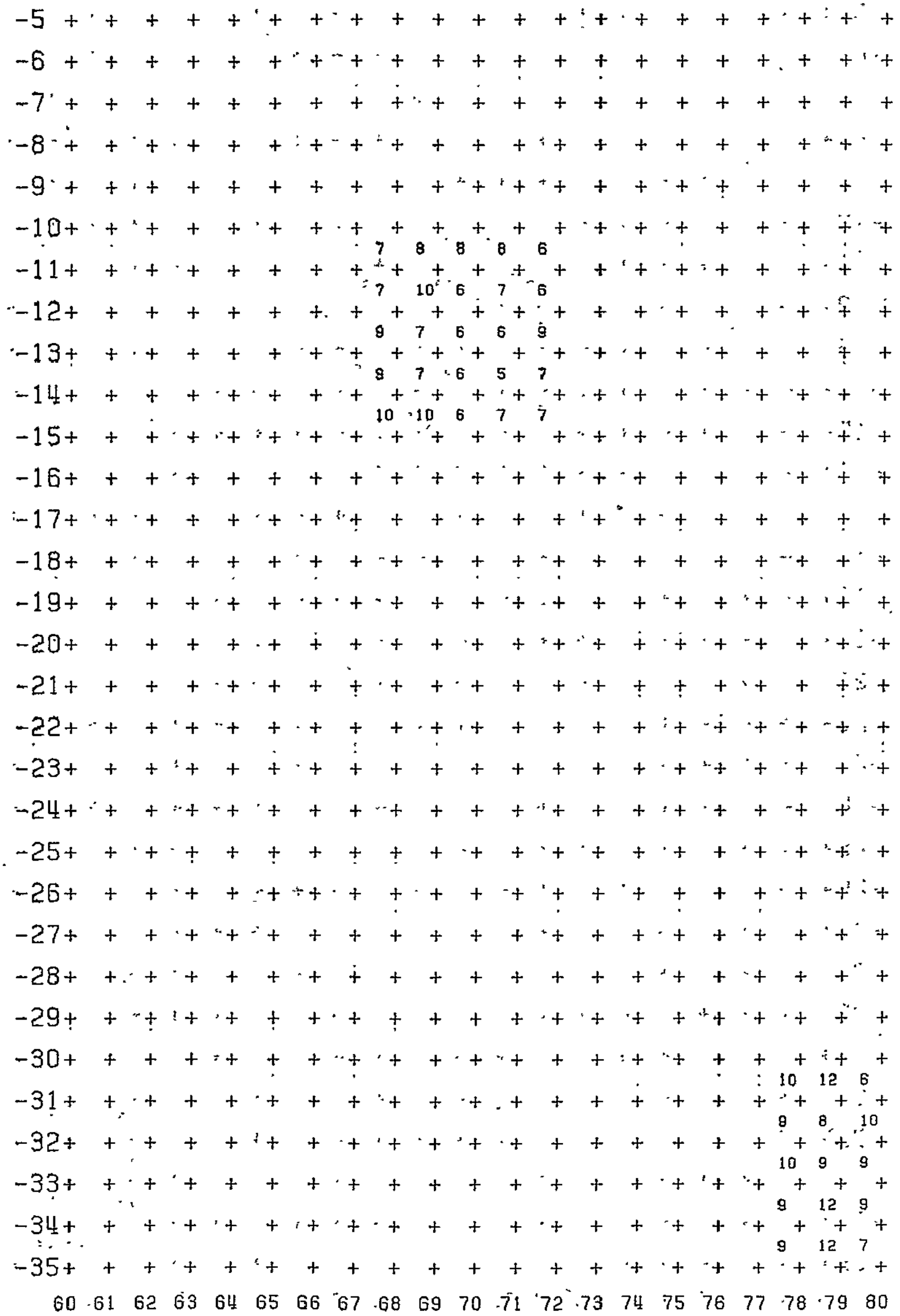
Accuracy of Predicted 1°x 1° Mean Anomalies (mgals)

Figure B 6A

-5	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-6	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-7	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-8	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-9	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
								-5	-8	-24	-14	-4									
-11	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
								-3	-9	-12	-6	-8									
-12	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
								1	-8	-6	-4	-13									
-13	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
								6	3	-6	-4	-10									
-14	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
								7	6	2	-2	-6									
-15	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-16	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-17	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-18	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-19	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-21	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-22	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-23	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-24	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-25	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-26	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-27	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-28	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-29	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-30	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
																		21	12	4	
-31	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
																		17	15	10	
-32	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
																		17	17	18	
-33	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
																		19	15	8	
-34	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
																		21	14	13	
-35	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 6B



Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

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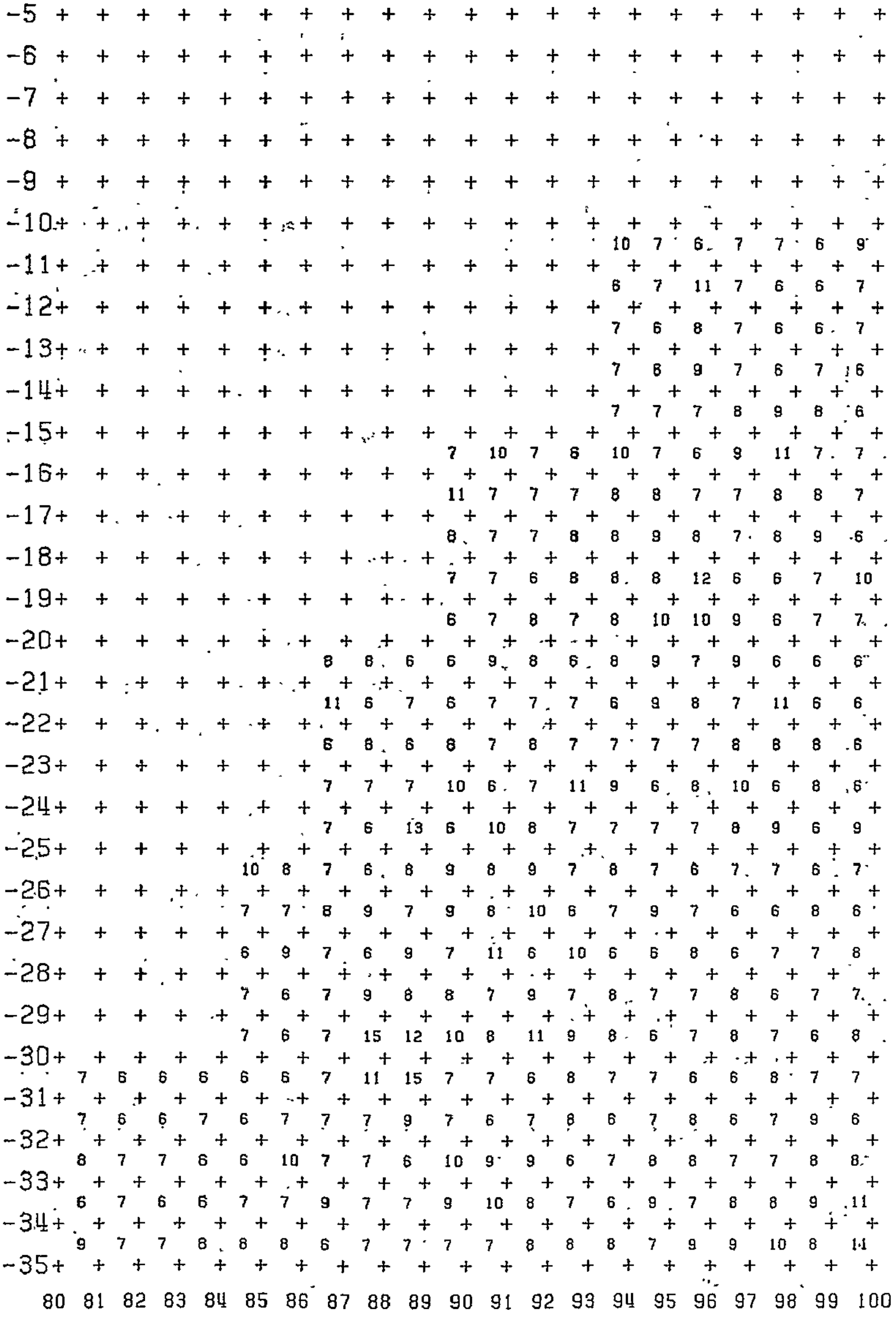
OF POOR QUALITY

Figure B 7A

	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
-5																					
-6																					
-7																					
-8																					
-9																					
-10														-25	-16	-14	-6	-16	-9	-3	
-11														-26	-21	-18	6	-4	-1	-6	
-12														-33	-18	7	6	-13	-12	-18	
-13														-28	-49	1	-2	-8	-24	-17	
-14														-21	-28	-8	-16	2	-32	-22	
-15										-43	-25	-32	-23	-30	-20	-24	-15	-13	-22	-23	
-16										-39	-27	-27	-12	-16	-7	-42	-12	-23	-17	-21	
-17										-41	-11	-32	-24	-7	-18	-36	-22	-19	-25	-25	
-18										-42	-16	-31	-19	-6	-32	-29	-22	-18	-32	-28	
-19										-15	-20	-3	-1	-21	-22	-20	-20	-19	-34	-31	
-20							-0	7	-17	-20	-10	-10	-7	-26	-24	-18	-18	-28	-38	-32	
-21							-3	12	-4	-25	-10	-24	-22	-22	-21	-11	-17	-33	-32	-28	
-22							-6	15	3	-40	-19	-14	-21	-20	-12	-11	-18	-30	-32	-28	
-23							-5	1	1	-16	-15	-16	-20	-20	-11	-15	-15	-27	-29	-23	
-24							-12	13	6	-13	-20	-9	-18	-14	-15	-16	-16	-18	-19	-18	
-25					-8	-18	4	31	1	-8	-16	-14	-17	-15	-24	-21	-22	-21	-16	-14	
-26					-6	-10	8	16	-7	-14	-21	-14	-12	-20	-21	-19	-26	-16	-24	-10	
-27					-3	-1	-3	14	-6	-11	-15	-10	-14	-13	-18	-20	-19	-15	-2	-16	
-28					3	1	1	-3	-6	-10	-12	-22	-17	-5	-6	-1	-16	-14	20	-17	
-29					10	-1	-3	2	2	-1	1	-15	-12	-3	-4	-6	-15	-17	-1	-15	
-30	6	14	-1	6	4	1	-3	13	13	8	9	1	9	4	13	-7	-17	-14	-9	-13	
-31	5	4	14	11	6	-1	1	24	11	1	-19	-11	-16	-3	-7	6	-3	-9	-8	-13	
-32	4	11	12	10	3	-3	10	19	4	-6	-5	-5	-7	-10	-16	-16	-12	-23	-14	-8	
-33	14	6	7	6	9	6	14	9	-1	-1	-2	-5	-3	-8	-10	-12	-15	-18	-19	-11	
-34	20	12	3	4	11	8	9	8	-4	-1	0	1	-7	-0	-6	-10	-12	-17	-16	-10	
-35																					

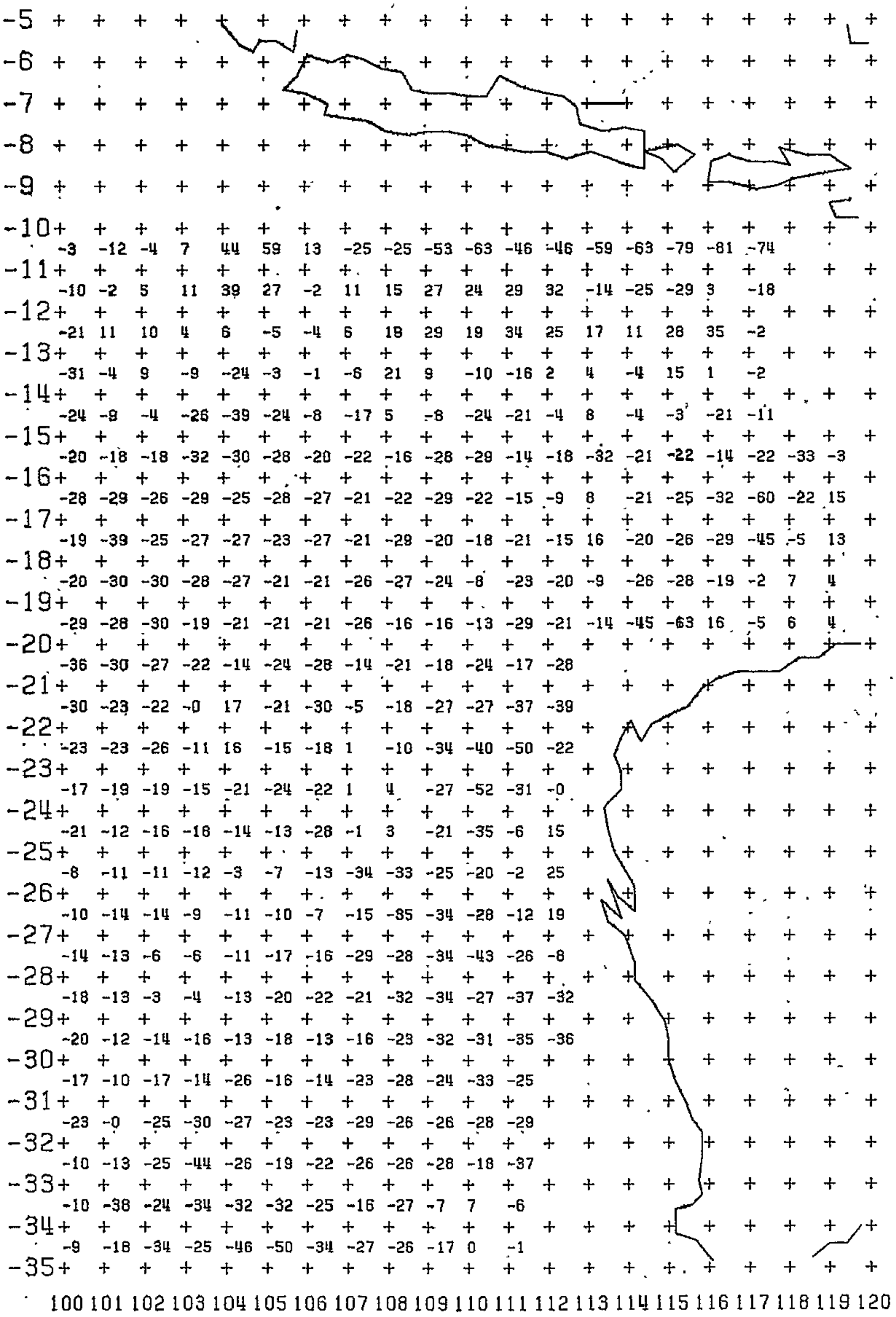
1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 7B



Accuracy of Predicted 1°x 1° Mean Anomalies (mgals)

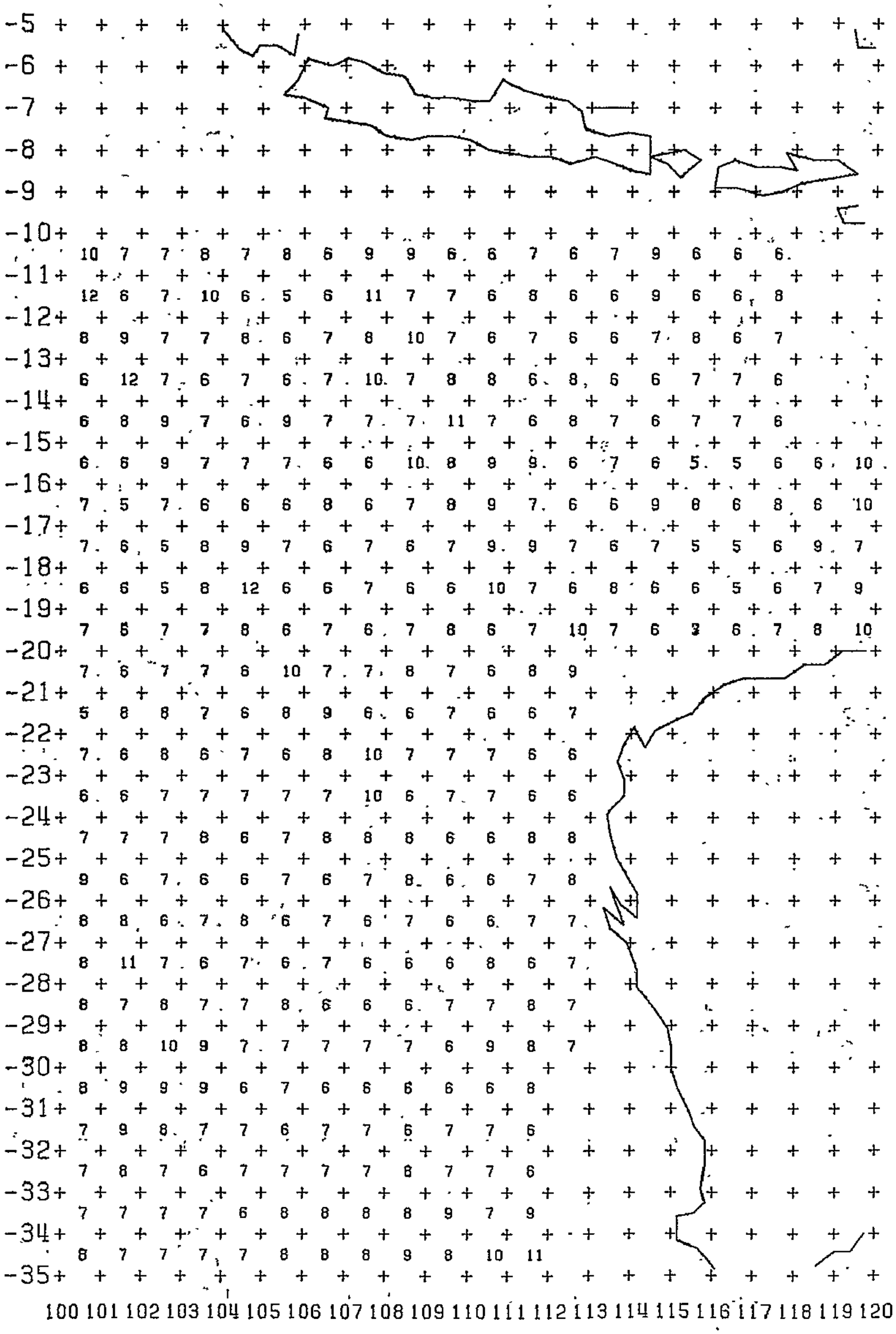
Figure B8A



	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
-10	-3	-12	-4	7	44	59	13	-25	-25	-53	-63	-46	-46	-59	-63	-79	-81	-74		
-11	-10	-2	5	11	39	27	-2	11	15	27	24	29	32	-14	-25	-29	3	-18		
-12	-21	11	10	4	6	-5	-4	6	18	29	19	34	25	17	11	28	35	-2		
-13	-31	-4	9	-9	-24	-3	-1	-6	21	9	-10	-16	2	4	-4	15	1	-2		
-14	-24	-9	-4	-26	-39	-24	-8	-17	5	-8	-24	-21	-4	8	-4	-3	-21	-11		
-15	-20	-18	-18	-32	-30	-28	-20	-22	-16	-28	-29	-14	-18	-32	-21	-22	-14	-22	-33	-3
-16	-28	-29	-26	-29	-25	-28	-27	-21	-22	-29	-22	-15	-9	8	-21	-25	-32	-60	-22	15
-17	-19	-39	-25	-27	-27	-23	-27	-21	-29	-20	-18	-21	-15	16	-20	-26	-29	-45	-5	13
-18	-20	-30	-30	-28	-27	-21	-21	-26	-27	-24	-8	-23	-20	-9	-26	-28	-19	-2	7	4
-19	-29	-28	-30	-19	-21	-21	-21	-26	-16	-16	-13	-29	-21	-14	-45	-63	16	-5	6	4
-20	-36	-30	-27	-22	-14	-24	-28	-14	-21	-18	-24	-17	-28							
-21	-30	-23	-22	-0	17	-21	-30	-5	-18	-27	-27	-37	-39							
-22	-23	-23	-26	-11	16	-15	-18	1	-10	-34	-40	-50	-22							
-23	-17	-19	-19	-15	-21	-24	-22	1	4	-27	-52	-31	-0							
-24	-21	-12	-16	-16	-14	-13	-28	-1	3	-21	-35	-6	15							
-25	-8	-11	-11	-12	-3	-7	-13	-34	-33	-25	-20	-2	25							
-26	-10	-14	-14	-9	-11	-10	-7	-15	-85	-34	-28	-12	19							
-27	-14	-13	-6	-6	-11	-17	-16	-29	-28	-34	-43	-26	-8							
-28	-18	-13	-3	-4	-13	-20	-22	-21	-32	-34	-27	-37	-32							
-29	-20	-12	-14	-16	-13	-18	-13	-16	-23	-32	-31	-35	-36							
-30	-17	-10	-17	-14	-26	-16	-14	-23	-28	-24	-33	-25								
-31	-23	-0	-25	-30	-27	-23	-23	-29	-26	-26	-28	-29								
-32	-10	-13	-25	-44	-26	-19	-22	-26	-26	-28	-18	-37								
-33	-10	-38	-24	-34	-32	-32	-25	-16	-27	-7	7	-6								
-34	-9	-18	-34	-25	-46	-50	-34	-27	-26	-17	0	-1								

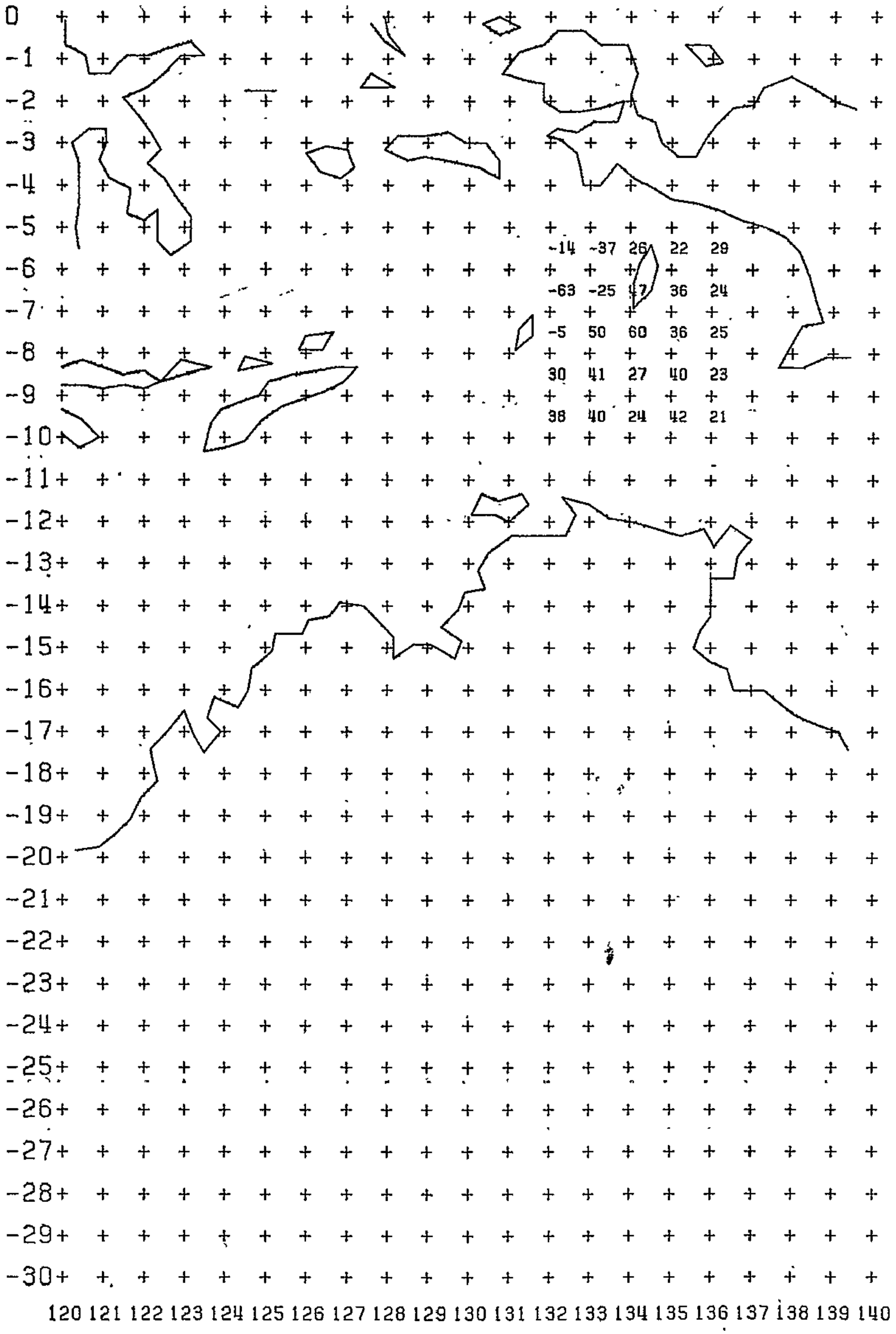
1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 8 B



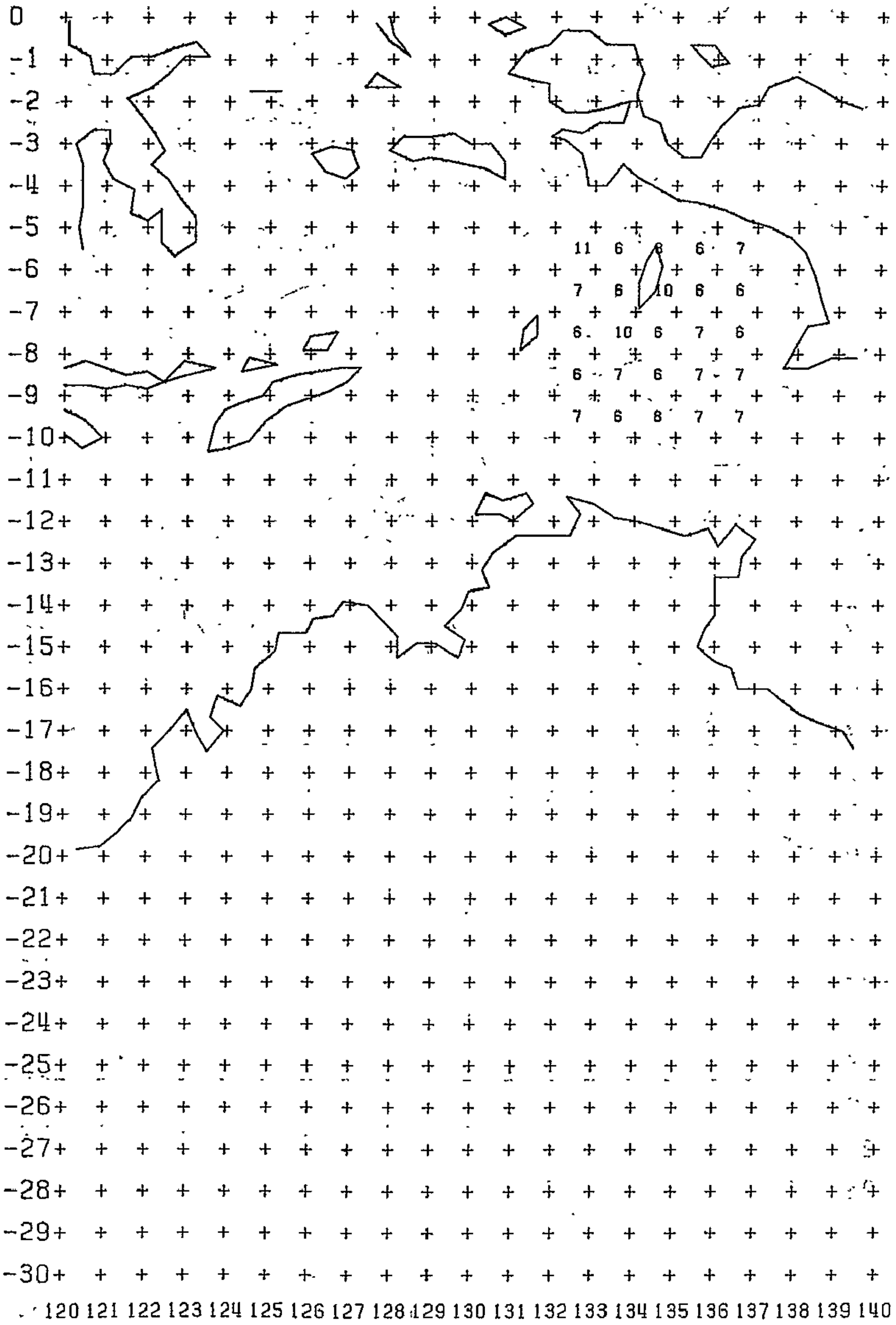
Accuracy of Predicted 1°x 1° Mean Anomalies (mgals)

Figure B 9 A



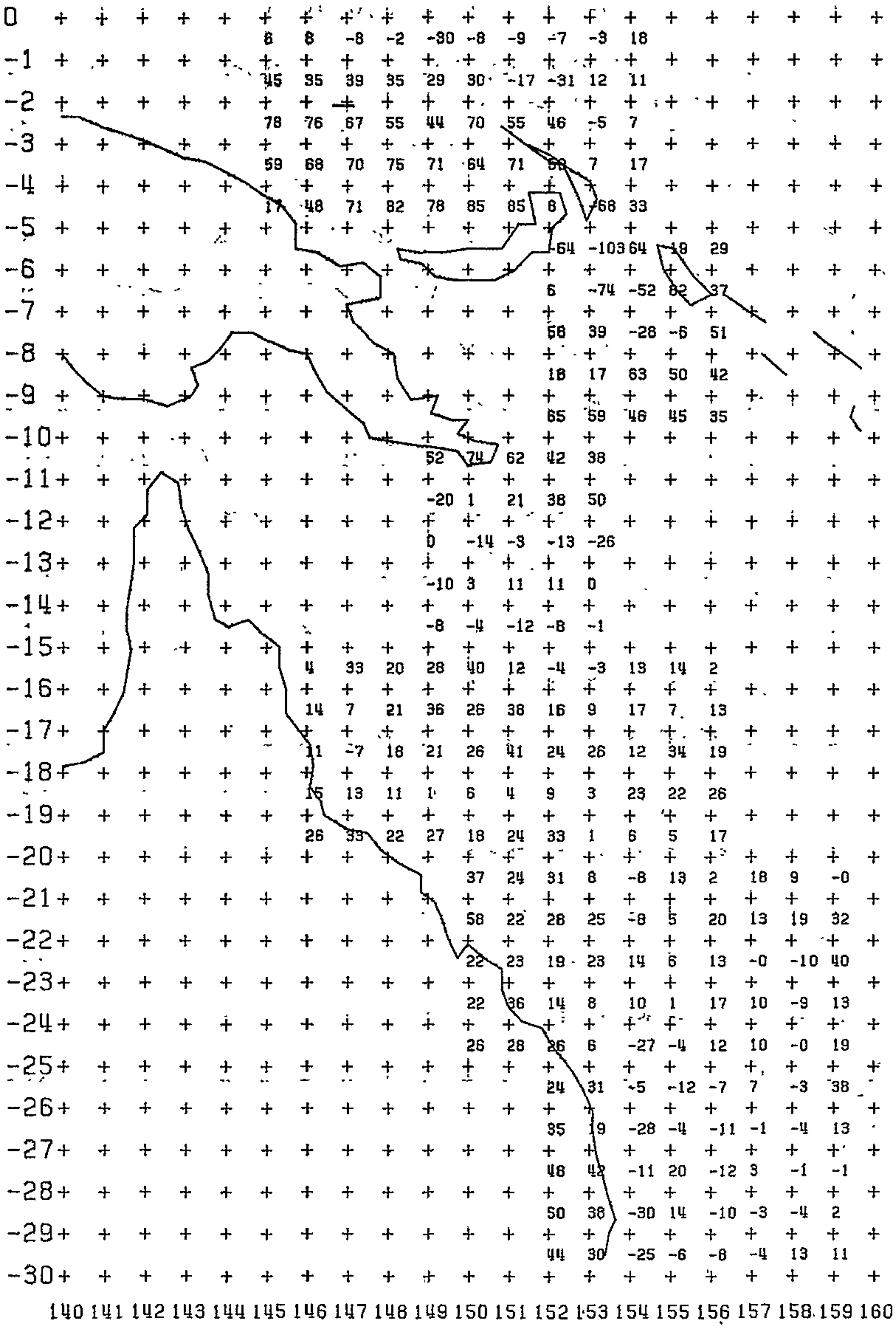
1° x 1° Mean Free-Air Anomalies (mgals)

Figure B.9 B



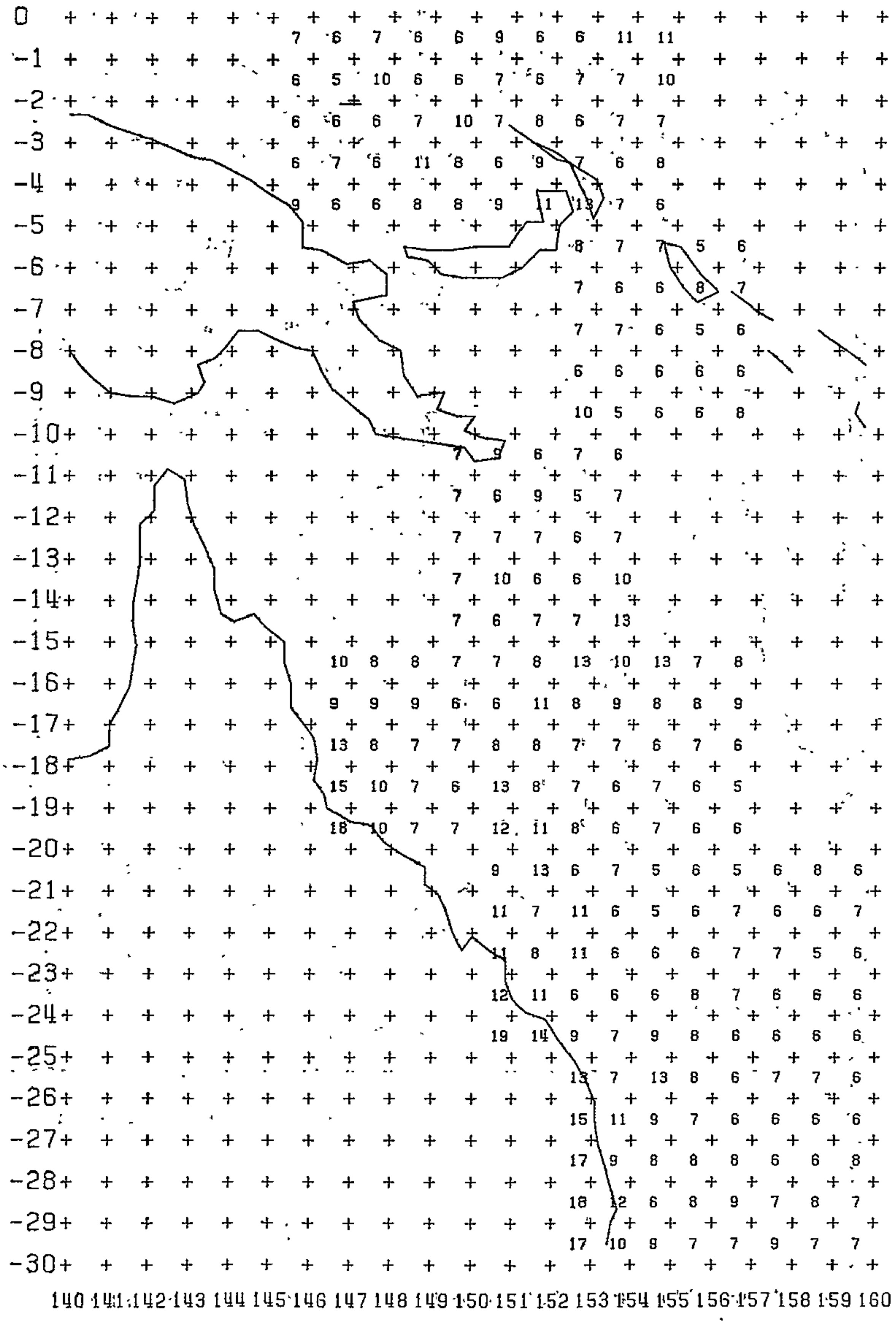
Accuracy of Predicted 1°x 1° Mean Anomalies (mgals)

Figure B10A



1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 10 B



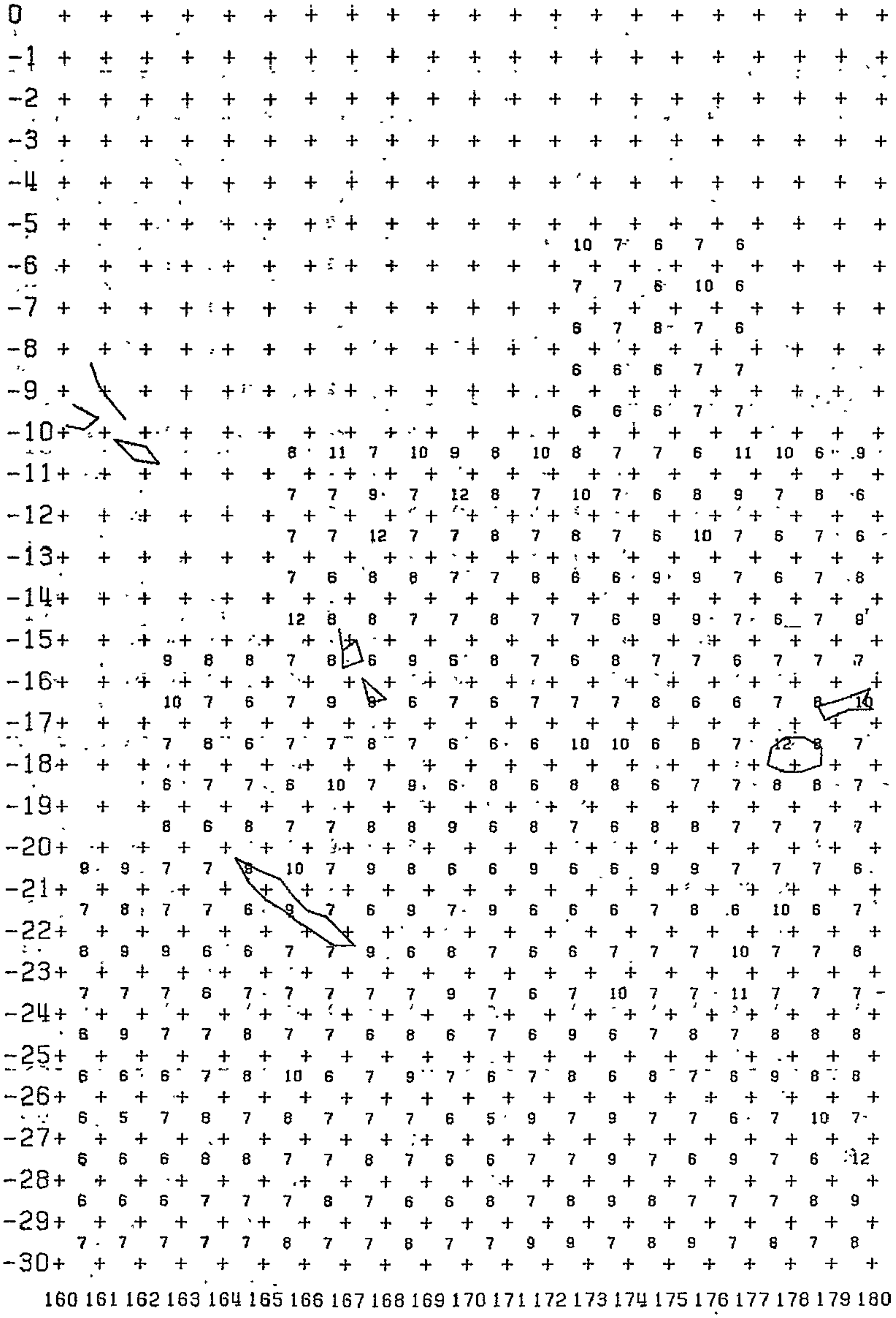
Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B11A

	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
0																					
-1																					
-2																					
-3																					
-4																					
-5													-9	-16	5	5	-13				
-6													-24	-4	4	-17	-10				
-7													-17	8	4	-13	-8				
-8													1	3	-4	-2	4				
-9													-2	-7	-14	1	-7				
-10						13	33	42	39	25	-6	14	21	-8	-19	-17	-28	-29	-21	8	
-11						-87	0	45	45	31	30	20	14	6	11	28	8	-0	23	11	
-12						-70	-58	56	47	31	40	40	39	22	21	29	28	28	16	-4	
-13						24	-102	63	38	45	44	33	25	33	20	27	31	19	27	-3	
-14						-22	-58	33	34	47	45	34	30	31	21	34	24	22	31	12	
-15			18	15	25	4	12	33	58	49	40	34	31	27	23	36	24	29	18	16	
-16			15	-1	8	19	5	23	74	49	41	38	34	31	32	29	29	29	28	26	
-17			12	15	15	20	6	-38	63	59	42	40	37	36	39	27	32	35	38	18	
-18			28	34	21	-30	14	-67	8	82	51	43	39	42	33	32	26	26	21	-4	
-19			4	48	24	32	23	-26	-66	56	58	40	44	42	33	32	27	31	-2	-10	
-20	35	33	0	-14	42	47	48	28	-96	16	76	54	49	43	47	46	35	14	15	35	
-21	8	21	26	-13	-11	44	41	55	-16	-46	45	78	58	58	58	45	14	13	5	-9	
-22	-0.	11	17	-1	-6	-8	39	54	44	-18	-74	38	11	-9	-19	5	18	11	4	8	
-23	6	22	18	17	1	14	10	32	46	34	-9	-44	-29	-2	17	22	20	14	5	15	
-24	4	24	16	7	-10	16	10	23	32	29	29	28	37	29	24	18	18	14	9	16	
-25	1	22	24	12	6	-4	3	23	23	24	24	17	25	23	16	21	21	8	12	21	
-26	3	14	23	20	8	-3	10	30	18	23	27	15	24	23	24	21	14	10	8	21	
-27	4	15	14	22	-2	-10	-6	18	20	15	23	27	13	23	29	13	16	17	10	14	
-28	-3	13	6	19	-3	-8	6	24	26	16	19	21	20	30	19	24	19	21	25	13	
-29	3	13	20	-3	-6	-4	8	24	34	24	25	20	29	30	13	22	24	16	32	23	
-30																					

1° x 1° Mean Free-Air Anomalies (mgals)

Figure B 11 B



```
  0 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -1 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -2 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -3 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -4 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -5 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                     10   7   6   7   6
 -6 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                      7   7   6  10   6
 -7 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                      6   7   8   7   6
 -8 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                      6   6   6   7   7
 -9 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                      6   6   6   7   7
-10 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                          8  11   7  10   9   8  10   8   7   7   6  11  10   6   9
-11 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                          7   7   9   7  12   8   7  10   7   6   8   9   7   8   6
-12 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                          7   7  12   7   7   8   7   8   7   6  10   7   6   7   6
-13 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                          7   6   8   8   7   7   8   6   6   9   9   7   6   7   8
-14 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                         12   8   8   7   7   8   7   7   6   9   9   7   6   7   8
-15 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
              9   8   8   7   8   6   9   6   8   7   6   8   7   7   6   7   7   7
-16 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
             10   7   6   7   9   8   6   7   6   7   7   7   8   6   6   7   8  10
-17 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
              7   8   6   7   7   8   7   6   6   6  10  10   6   6   7  12   8   7
-18 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
              6   7   7   6  10   7   9   6   8   6   8   8   6   7   7   8   8   7
-19 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
              8   6   8   7   7   8   8   9   6   8   7   6   8   8   7   7   7   7
-20 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      9   9   7   7   8  10   7   9   8   6   6   9   6   6   9   9   7   7   7   6
-21 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   8   7   7   6   9   7   6   9   7   9   6   6   6   7   8   6  10   6   7
-22 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      8   9   9   6   6   7   7   9   6   8   7   6   6   7   7   7  10   7   7   8
-23 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   7   7   6   7   7   7   7   7   9   7   6   7  10   7   7  11   7   7   7
-24 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      6   9   7   7   8   7   7   6   8   6   7   6   9   6   7   8   7   8   8   8
-25 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      6   6   6   7   8  10   6   7   9   7   6   7   8   6   8   7   6   9   8   8
-26 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      6   5   7   8   7   8   7   7   7   6   5   9   7   9   7   7   6   7  10   7
-27 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      6   6   6   8   8   7   7   8   7   6   6   7   7   9   7   6   9   7   6  12
-28 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      6   6   6   7   7   7   8   7   6   6   8   7   8   9   8   7   7   7   8   9
-29 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   7   7   7   7   8   7   7   8   7   7   9   9   7   8   9   7   8   7   8
-30 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

   160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
```

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

ORIGINAL PAGE IS
OF POOR QUALITY

Figure B 12 A

	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
0																					
-1																					
-2																					
-3																					
-4																					
-5																					
-6																					
-7																					
-8																					
-9																					
-10	13	-22	-11	2	3	-4	1	14	13	-8	-13	2	10	-14	-4						
-11	25	18	19	0	-9	-13	-11	-3	20	8	-16	-4	-3	-12	9						
-12	-5	21	6	11	-1	29	-10	-12	-2	-3	-7	1	-12	4	-19						
-13	13	47	0	10	-5	2	-5	49	7	-2	21	-10	-14	4	-19						
-14	33	25	30	33	3	15	-28	-25	12	45	63	-6	-5	-10	-5						
-15	35	24	15	36	32	54	62	-89	-23	22	-6	-13	-4	-17	-5	-7	-13	3			
-16	32	15	21	25	33	60	80	-91	-27	42	-1	9	-16	-7	-2	-12	-14	8			
-17	15	18	24	21	44	74	92	-93	12	14	15	12	-14	-1	-2	-13	6	12			
-18	7	36	28	34	48	99	38	-95	16	19	36	9	-5	-6	-13	-5	-1	7			
-19	7	21	26	49	67	128	-39	-96	12	28	20	1	3	-1	-4	0	-2	-3			
-20	12	35	41	56	100	138	-102	-49	23	19	-6	6	-3	-6	2	9	6	6	2	6	
-21	20	33	38	72	124	28	-105	5	25	9	11	1	-18	-12	-2	-4	-1	-3	8	28	
-22	19	38	43	91	88	-136	-48	18	21	1	10	7	2	-0	-6	-8	-3	0	4	17	
-23	29	41	50	100	-40	-118	9	25	11	6	-1	-2	-7	4	4	-6	-8	7	12	5	
-24	27	48	52	93	-82	-45	37	23	11	3	6	-2	-4	-6	-1	2	-11	8	13	3	
-25	30	49	79	75	-102	-5	46	30	21	2	-1	2	5	-10	-7	-7	-7	3	4	1	
-26	40	51	83	23	-120	47	30	28	19	14	-2	6	9	-4	-6	2	-3	-13	-6	-5	
-27	47	61	87	9	-126	41	38	19	27	14	8	2	-8	-3	-8	7	6	-6	-9	1	
-28	43	68	68	-59	-74	22	55	25	20	8	10	5	-0	-3	-3	5	2	1	-2	7	
-29	58	101	28	-109	-22	20	27	12	11	17	3	8	6	5	13	6	2	-3	5	-5	
-30																					

1° x 1° Mean Free-Air Anomalies (mgals)

Figure B 12 B

```
  0 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -1 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -2 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -3 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -4 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -5 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -6 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -7 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -8 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
 -9 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-10 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      6   9   7   8   7   7   7   7   9   7  10   7   7   7   8
-11 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   8   8   8   7   6   9   7   7   8   6   8   8   8   7
-12 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      9   7   8  10   7   8   6   7   7   8   7   7   6   8   6
-13 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   7   6   9   7   8   7   9   8   8   7   7   6   6   6
-14 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   6   7   7  12   8   7   8   8   9   9   6   6   7   7
-15 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      9   6   7   6  11  12   6   7   7   6   7   6   6   7   5   7   7   7
-16 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   7   6   8   7   8  11   6   7   8   5   6   6   6   6   6   7   7
-17 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   8   7   7   7  10  10   7   6   7   6   6   7   6   7   6   7   6
-18 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      6   6   9   8   7   7   7   8   7   6   7   7   6   6   6   7   6   7
-19 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   9   9   7  10   7   7   9   7   6   6   6   7   7   6   7   6   7
-20 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   6   9   9   7   7   5   9   7   6   6   6   6   7   7   6   6   7  10   7
-21 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   8   7   9   6   6   7   6   7   7   6   5   8   6   6   7   7   8   6   6
-22 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      9   7   6   9   7   6   7   6   6   7   6   6   7   6   6   7   7   8   6   7
-23 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      9   7  11   7   6   9   6   7   6   7   7   6   6   7   6   7   9   6   8   7
-24 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      6   9   8   8   9   7   6   7   7   7   8   7   6   7   7   8   7   6   8   8
-25 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      8   8   6   7   6   8   7   6   6   6   7   7   6   6   9   6   7   8   7   7
-26 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     10   6  10   7   6   6   6   9   6   6   5   7   7   7   7   7   6   8   8   6
-27 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      7   9   7   6   6   7   8   6   6   6   6   6   8  11   7   6   7   7   6   6
-28 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     10   7   7   6   7   7   7   7   7   6   8   7  10   9   7   6  10   6   6   8
-29 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      8   8   7   6   7   6   7   6   6   8   7  11   7   7   7   7   9   8   7   7
-30 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

   180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
```

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B13A

-35	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
						-10	-6	-6	-3	-7	-7	4	11	13	24	7	-12	-2	-0	-2	
-36	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
						1	2	3	4	0	-3	7	17	11	17	-2	-11	-7	-1	7	
-37	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
						18	15	11	7	4	0	11	7	14	14	3	-5	1	-1	7	
-38	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
						16	13	4	9	16	6	9	6	15	12	-0	-1	2	3	15	
-39	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
						25	23	14	15	20	-5	9	18	11	-1	2	-2	5	8	4	
-40	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-5	-4	-2	1	16	37	24	26	18	6	-3	11	9	-2	12	-1	6	6	15	22	
-41	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-0	-3	9	3	17	32	24	19	13	-5	-3	4	-7	-8	6	8	9	23	22	18	
-42	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-4	7	14	17	15	18	12	5	-2	3	-5	-9	-12	1	8	11	18	29	25	16	
-43	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	1	5	10	6	8	15	2	-8	6	-0	-10	-15	1	9	14	17	41	34	35	31	
-44	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	7	4	7	6	10	3	-21	5	-0	-11	-10	-6	10	15	27	34	50	42	39	31	
-45	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			10	3	6	2	3	-1	-17	-13	-4	5	11	19	41	46	39	34	26	24	
-46	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			4	3	21	3	-6	-9	-14	-1	5	28	27	44	45	40	24	41	26	24	
-47	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			-8	-0	-1	-13	-6	3	1	14	18	11	27	39	39	28	14	15	-2	7	
-48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			2	7	-1	-9	3	8	6	18	10	19	41	20	19	13	12	8	0	9	
-49	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			6	6	7	5	6	6	15	10	12	16	21	9	2	11	20	6	-3	13	
-50	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-51	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-52	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-53	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-54	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-55	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-56	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-57	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-58	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-59	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-60	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
														9	17	9	7	8	11	11	
-61	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
														-1	4	-0	1	8	13	20	
-62	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
														-6	4	9	6	5	10	-4	
-63	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
														-6	-3	0	4	6	7	9	
-64	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
														-20	-3	-1	4	2	8	1	
-65	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40

1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 13 B

```
-35+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                          8  10   7   7   8   7   8   6   7   9   7   9   8  10   6
-36+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                          9   7   8   6   8   8   7   7   7   7   7   8   9  10   7
-37+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                          7   7   7   8   7   7   8   7   8   6   9   8   8   8   7
-38+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                          8   7   8   8   8   8   9   8   8  10   7  11   9   6   8
-39+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                          8   9   8   8   8  10   9   8  10   7  10   8   7   8   7
-40+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     11   8   8   8   6   8   7   8   7   7   8   8   8   9   8   8   7   7  10   8
-41+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     11   7   7   7   8   8   8   7   8   8   8  10   8   9  11   7   7   9   7   9
-42+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      9   8   7   7   7   8   7  10   7   8   9   7   9   9   7   9   8   7   8   8
-43+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     10   7   8   7   8   8   8   9   9   8   8  10   8   7   9   8   9   8   7   9
-44+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
      8   8   8   8   8   8  10   9  10  10   9  10   7   8   9  10   7   9   8   9
-45+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
              7   7   8   9   7   9   9   8  11   7   7   8   7   8   7   8  10   7
-46+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
              6  10  11   9   8   8  12  10   7   9  10   7   9   9   8   8   6   7
-47+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
              9   8   8   9  10  10   9   9  11   8   8  12   9   8   8   6   7   7
-48+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
             11  10  10   9  13   8   8  12  10   9  10  11  13   8   8   8   8   8
-49+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
             13  11  16  15  10   9   9  10   9  10  14  11   8   8   8  10  10  10
-50+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

-51+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

-52+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

-53+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

-54+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

-55+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

-56+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

-57+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

-58+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

-59+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

-60+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                         11  11   8  10  10  10   9
-61+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                         14  13   8  10   8   9   8
-62+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                         12  10  11  11  12  11  11
-63+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                         14  12  10  10   9  10   9
-64+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                         11  14  12   9   8   8   9
-65+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40
```

Accuracy of Predicted 1°x 1° Mean Anomalies (mgals)

Figure B 14A

	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
-35	-4	-3	-0	27	27	24	20	15	16	22	24										
-36	1	1	7	28	30	31	16	20	30	32	37										
-37	14	8	11	23	21	23	24	37	35	47	50										
-38	24	24	19	30	22	22	31	55	47	44	36										
-39	-2	34	27	34	39	34	49	40	30	25	16										
-40	9	32	28	36	37	42	23	22	16	17	18	18	23	12							
-41	26	29	19	22	32	23	11	16	20	20	25	16	21	16							
-42	32	26	20	17	20	17	17	17	22	27	23	20	32	25							
-43	44	23	13	14	19	14	13	12	21	21	17	14	19	27							
-44	32	24	15	21	20	16	26	28	12	4	7	7	12	25							
-45	27	28	25	8	17	39	42	19	-9	41	69	22	10	14	21	27	27	24	15		
-46	19	5	28	2	19	44	37	14	5	61	80	93	56	11	15	24	27	20	17		
-47	11	4	-11	16	8	12	21	13	-4	2	6	13	8	12	20	24	22	16	20		
-48	12	16	13	4	6	7	15	12	15	15	14	12	17	21	17	18	23	19	18		
-49	20	15	8	4	1	7	17	22	19	12	14	16	24	23	17	14	14	10	9		
-50																					
-51																					
-52																					
-53																					
-54																					
-55																9	11	14	12	6	
-56																11	17	11	9	6	
-57																8	5	2	7	10	
-58																7	4	4	10	9	
-59																3	5	7	8	14	
-60	8	13	7	4	7	8	8	3	-1	-2	-4	-4	-4	2	6	2	2	4	9	12	
-61	15	19	20	13	11	5	1	0	4	4	-0	-1	1	3	6	9	10	6	10	13	
-62	-20	19	18	12	10	-12	12	14	7	2	1	-4	3	0	2	10	14	14	12	11	
-63	13	11	11	6	7	6	9	3	-10	-17	-13	-13	-11	-9	-3	-1	3	14	17	15	
-64	11	17	15	4	1	-1	1	12	11	13	13	16	9	6	4	-3	4	7	9	7	
-65																					

1° x 1° Mean Free-Air Anomalies (mgals)

Figure B14B

```
-35+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      8    7    8    8    8    8    8    6    8    6    7
-36+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      6    8    9    6    8    6    6    9    6    7    9
-37+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      7    8    7    7    7    7    9    6    7    6   10
-38+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
     10    7    7    6    9    8    8    7    7    8    7
-39+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      8    7    7    7    8    8    6    7    8    7    9
-40+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      7    8    9    7    6    6    8    8    8    7    7    7    7    8
-41+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      8    8   10    9    6    6    8    9    7    8    6    6    7    7
-42+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
     10    9    7    7    8    7    7    7    8    7    8    8    8   11
-43+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      8    9    7    7    9   10    8    7    7    9    8    9    8    9
-44+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      9    8    9    8    7   10    9    8    7    8    9    8   10    9
-45+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      6    7    7    7    9    6    7    7    7    7    7    9    6   10    9    7    9    7   12
-46+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      7    7    8    9    7    8    6    7   12    9    7    6   10    8    8    9    8   12    9
-47+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      8    9    8    8    8    9    9    8    8    9    8    9    7    6    8    8   13    9   11
-48+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
     10   11    8    8    8   10   12    9    8    9   12    9    9    7    9   11    8   13   11
-49+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      8    8   10   11   10    8   10   10   13   11    8    9    9   11    8    8   12   10   12
-50+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +

-51+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +

-52+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +

-53+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +

-54+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +

-55+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                                                                  9    8   10   15   14
-56+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                                                                 11   11   10   12   11
-57+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                                                                 10   11    9   10    9
-58+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                                                                 10   10    9    8    8
-59+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                                                                 10    9    8    8    7
-60+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      8    9    9   10   12   14   13   13   12   11   11   13   10   10   11   10    9    8   10   11
-61+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      8    9    9   11   10    9   11   12   12    9   10    9   11   10   11    9   10   11    8   10
-62+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      7    9    9    8    8    8    8    7   10    8   10   10   10   10    8    9    9    9    9   10
-63+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      9    9    9    9   10    9    8    9    7    9    7    9    8    8    8    9    9    9   11    8
-64+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
      8    8    8    8    8    9    9    9    8   10    8   10    9    9    9    9    8    8    8    9
-65+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +

  40   41   42   43   44   45   46   47   48   49   50   51   52   53   54   55   56   57   58   59   60
```

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

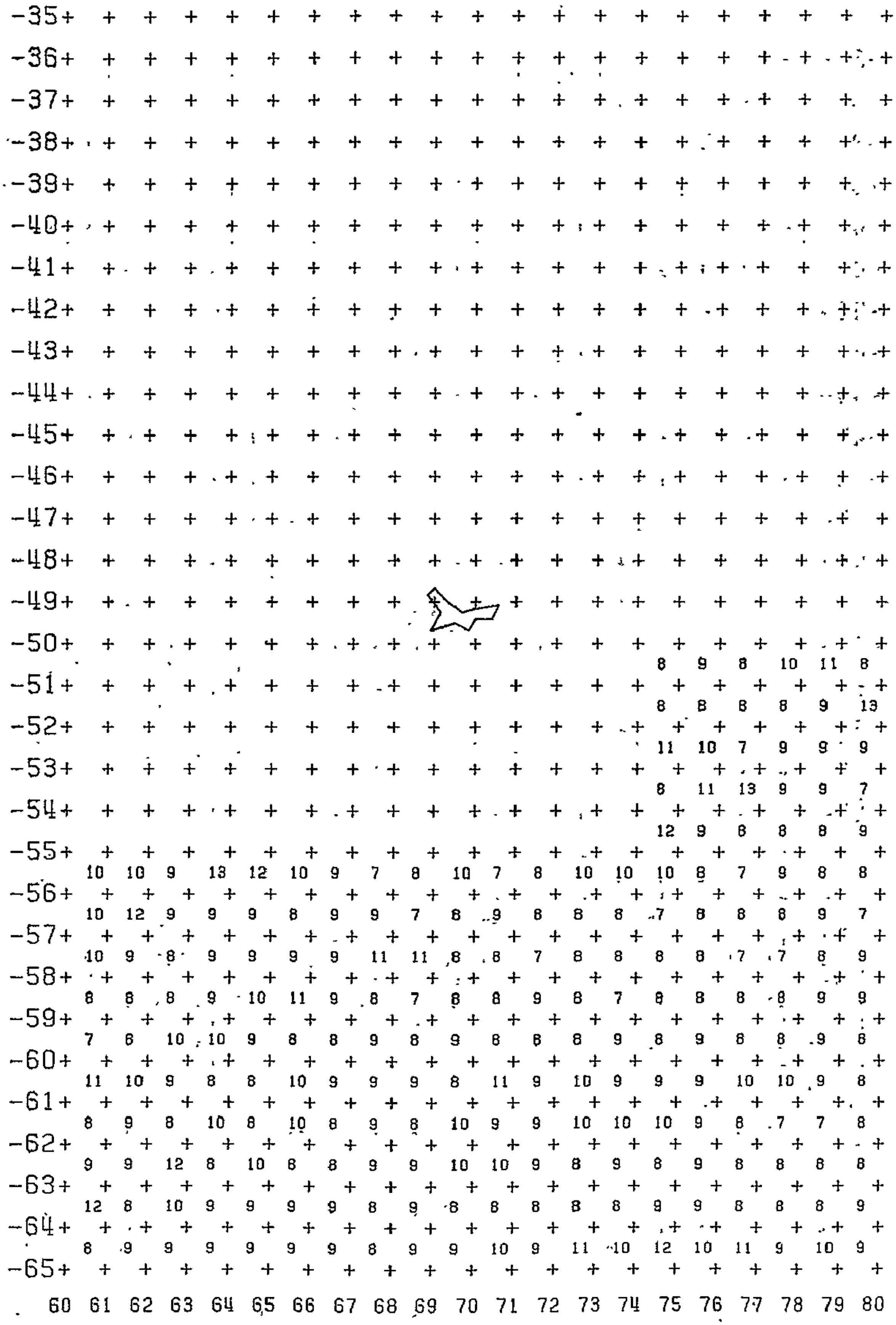
ORIGINAL PAGE IS
OF POOR QUALITY

Figure B 15 A

	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
-35	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-36	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-37	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-38	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-39	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-40	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-41	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-42	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-43	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-44	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-45	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-46	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-47	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-49	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-50	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
															38	27	13	17	17	23	
-51	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
															40	44	31	13	21	25	
-52	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
															58	50	56	39	38	23	
-53	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
															41	43	45	35	17	-7	
-54	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
															31	35	33	24	20	2	
-55	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	4	6	6	6	15	14	8	0	2	11	26	22	17	19	14	13	33	32	19	12	
-56	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	7	8	5	9	25	43	40	40	49	20	24	41	33	18	19	21	22	14	24	21	
-57	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	8	12	14	15	8	-6	-6	2	10	10	5	19	20	13	15	18	19	13	29	31	
-58	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	10	10	8	5	-4	-6	8	16	11	8	4	-4	-2	16	27	38	49	34	36	30	
-59	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	12	10	7	0	-5	11	17	23	22	11	7	10	8	-18	25	23	31	34	26	21	
-60	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	10	6	6	4	2	8	17	20	13	14	11	3	2	5	5	12	18	14	17	24	
-61	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	11	13	10	8	3	6	8	6	11	14	17	6	4	8	8	14	8	9	12	18	
-62	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	11	13	14	15	9	4	3	1	3	8	7	5	8	14	15	11	3	-1	-1	-1	
-63	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	10	7	11	8	6	6	5	9	9	12	8	8	4	8	11	19	19	16	13	8	
-64	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	1	-1	9	10	8	-3	1	14	24	17	14	6	2	-4	2	7	7	10	10	8	
-65	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

1° x 1° Mean Free-Air Anomalies (mgals)

Figure B 15 B



	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
-50															8	9	8	10	11	8
-51															8	8	8	8	9	13
-52															11	10	7	9	9	9
-53															8	11	13	9	9	7
-54															12	9	8	8	8	9
-55	10	10	9	13	12	10	9	7	8	10	7	8	10	10	10	8	7	9	8	8
-56	10	12	9	9	9	8	9	9	7	8	9	8	8	8	7	8	8	8	9	7
-57	10	9	8	9	9	9	9	11	11	8	8	7	8	8	8	8	7	7	8	9
-58	8	8	8	9	10	11	9	8	7	8	8	9	8	7	8	8	8	8	9	9
-59	7	6	10	10	9	8	8	9	8	9	8	8	8	9	8	9	8	8	9	8
-60	11	10	9	8	8	10	9	9	9	8	11	9	10	9	9	9	10	10	9	8
-61	8	9	8	10	8	10	8	9	8	10	9	9	10	10	10	9	8	7	7	8
-62	9	9	12	8	10	8	8	9	9	10	10	9	8	9	8	9	8	8	8	8
-63	12	8	10	9	9	9	9	8	9	8	8	8	8	8	9	9	8	8	8	9
-64	8	9	9	9	9	9	9	8	9	9	10	9	11	10	12	10	11	9	10	9

Accuracy of Predicted 1°x 1° Mean Anomalies (mgals)

ORIGINAL PAGE IS
OF POOR QUALITY

Figure B 16 A

	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
-35									-1	-2	3	2	-2	-3	-4	-9	-8	-15	-12	-9	
-36									-1	6	0	-5	-5	-5	-4	-6	-12	-12	-10	-15	
-37									4	2	0	-0	1	-0	1	-7	-7	-5	-12	-16	
-38									8	2	5	-1	0	4	1	-6	-2	-3	-14	-6	
-39									10	10	5	6	9	1	3	5	1	-12	-4	-3	
-40									14	12	9	8	5	5	11	3	-6	1	-4	-3	
-41									14	11	15	9	10	11	7	-5	6	1	-1	-2	
-42									17	17	13	10	16	10	2	8	4	5	-1	-2	
-43									20	16	11	18	14	7	12	7	11	7	1	0	
-44									13	10	18	14	8	14	9	12	5	3	7	2	
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-46		20	16	17	23	24	14	15	21	5	12	18	12	15	5	6	12	6	10	8	
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-58	29	38	36	13	-5	-8	4	7	7	5	10	13	12	9	11	13	7	3	-0	3	
-59	23	31	46	51	28	-17	-21	-9	1	5	4	1	6	9	4	10	7	4	-1	2	
-60	32	41	37	37	29	4	-1	3	-3	-4	1	3	-3	-11	-6	-3	2	1	-6	-10	
-61	26	31	31	27	16	4	-4	-3	-6	-3	1	-6	-17	-20	-15	-9	-9	-7	-14	-23	
-62	6	21	18	16	12	4	2	3	1	0	-2	-6	-13	-12	-13	-26	-22	-13	-20	-23	
-63	-3	-4	6	14	11	4	1	2	1	-0	-2	-3	-7	1	5	-4	2	2	-1	-3	
-64	1	2	6	13	14	9	12	12	6	-3	-11	-5	-2	11	24	34	43	37	29	22	
-65																					

1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 16 B

-35																				
									8	7	6	9	8	9	8	8	11	6	12	6
-36																				
									8	6	8	7	10	8	11	8	7	11	6	7
-37																				
									7	8	7	9	6	10	9	8	9	7	7	6
-38																				
									7	7	8	7	8	8	11	12	10	7	7	8
-39																				
									10	9	7	8	8	10	11	11	8	7	8	7
-40																				
									8	7	7	7	8	8	9	8	7	8	7	7
-41																				
									10	7	7	7	8	9	7	7	8	8	9	8
-42																				
									7	8	7	9	7	7	7	8	9	8	9	9
-43																				
									7	8	10	8	7	6	7	8	8	8	8	9
-44																				
									10	9	7	8	7	8	8	9	8	7	7	8
-45																				
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-46																				
		7	8	9	7	6	9	7	7	8	7	8	8	8	7	8	7	7	7	8
-47																				
		9	11	8	9	10	7	7	7	8	7	9	9	8	8	7	8	8	9	6
-48																				
		9	8	10	12	9	7	6	8	7	9	9	8	9	8	8	8	8	8	8
-49																				
		9	10	10	8	8	8	7	8	8	8	8	9	9	9	8	9	8	8	9
-50																				
	8	12	9	9	8	7	8	9	9	7	7	7	8	8	9	8	7	9	11	10
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-52																				
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-53																				
	7	9	9	9	9	8	9	9	8	9	9	8	9	9	8	9	8	7	10	8
-54																				
	8	8	9	9	8	9	9	10	10	9	10	10	9	11	10	8	7	8	8	9
-55																				
	9	8	9	8	9	11	10	8	8	9	9	10	11	9	8	8	8	8	7	9
-56																				
	8	10	9	10	10	8	8	11	9	10	8	8	9	8	8	8	9	9	9	8
-57																				
	10	10	9	8	10	10	11	9	8	8	8	8	9	8	10	10	8	8	8	8
-58																				
	8	9	9	11	10	9	8	9	8	8	8	9	10	10	8	9	8	8	9	8
-59																				
	9	9	9	9	8	8	8	9	9	10	10	9	9	8	8	9	9	10	10	10
-60																				
	8	8	8	7	6	8	9	8	8	7	7	8	9	11	10	9	8	9	10	10
-61																				
	9	8	8	9	8	7	8	7	7	7	7	9	9	9	9	10	10	13	11	7
-62																				
	7	7	8	8	9	10	10	8	11	11	9	10	9	9	9	8	8	8	7	7
-63																				
	8	8	10	12	15	15	15	13	11	10	8	8	8	9	9	11	12	10	8	9
-64																				
	9	10	10	11	9	10	11	9	10	10	11	11	13	17	18	18	16	15	12	16
-65																				

80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

ORIGINAL PAGE IS
OF POOR QUALITY

Figure B 17 A

	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
-35	-15	-9	-7	-25	-24	-32	-31														
-36	-15	-8	-16	-11	-16	-17	-25														
-37	-12	-15	-13	-16	-15	-18	-16														
-38	-8	-9	-16	-15	-16	-21	-17														
-39	-8	-9	-14	-11	-17	-15	-14														
-40	-7	-7	-11	-12	-8	-7	-21	-14	-15												
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-42	-5	-9	-4	-4	-4	-6	-8	-11	-12												
-43	-5	1	3	-3	-4	-9	-6	-12	-17												
-44	0	1	3	2	-2	-4	-8	-1	-8												
-45	8	2	3	0	2	-5	-4	1	-2	-5	-3	-15	-15	-11	-12	-12	-6	-7			
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-47	7	4	3	2	4	3	-1	-4	-1	2	-2	-2	-2	-3	-4	-8	-11	-8			
-48	9	5	8	2	0	2	3	1	-1	-6	-3	-1	-1	-4	-8	-10	-9	-8			
-49	5	5	8	3	12	14	-3	-2	-1	-1	3	-3	-7	-3	-4	-4	-2	-0			
-50	6	7	8	8	3	3	3	1	1	2	-0	-1	-4	-5	-8						
-51	3	6	5	0	2	6	3	2	4	3	5	3	-1	-4	-9						
-52	9	9	9	4	5	8	8	0	4	13	-2	-7	-4	-5	-8						
-53	8	8	5	8	12	6	6	9	1	2	-1	-3	-2	-6	-11						
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-55	7	10	10	2	4	11	5	-2	1	1	0	1	-3	-9	-4	-7	-8	-6	-3	-4	
-56	2	9	6	2	2	6	3	1	1	-3	0	-2	-7	-4	-4	-10	-4	-4	-9	-13	
-57	5	8	2	-1	-1	2	2	1	-0	2	3	-6	-7	1	3	-2	-6	-8	-7	-9	
-58	7	7	0	-1	11	6	3	0	-1	-1	-2	-1	0	-7	-5	-9	-5	-7	-6	-8	
-59	2	5	-3	-6	2	5	2	-1	1	4	3	9	-1	-2	-1	-6	-6	-7	-8	-10	
-60	-9	-7	-9	-4	2	6	7	7	12												
-61	-28	-17	-11	5	15	9	-8	-14	-6												
-62	-22	-22	-19	-14	-9	-3	-11	-11	-12												
-63	-7	-14	-22	-24	-20	-10	-2	-4	-17												
-64	16	6	-2	-7	-9	-6	-3	-1	-11												
-65																					

1° x 1° Mean Free-Air Anomalies (mgals)

Figure B 17 B

-35+	7	7	6	6	7	7	8													
-36+	6	7	6	6	7	9	8													
-37+	9	6	8	8	7	7	8													
-38+	7	8	8	9	7	7	7													
-39+	8	8	8	7	9	8	8													
-40+	9	8	7	7	7	9	8	6	11											
-41+	7	7	8	7	8	9	7	8	8											
-42+	8	8	7	6	7	7	8	10	10											
-43+	10	10	8	8	7	7	9	8	14											
-44+	11	15	9	7	7	8	7	10	12											
-45+	9	10	8	9	8	7	11	7	8	8	7	9	8	8	11	8	9	11		
-46+	8	9	10	10	9	9	6	8	6	6	7	9	12	8	7	12	11	8		
-47+	8	10	9	10	12	8	7	8	7	7	8	9	9	9	10	8	10	13		
-48+	7	8	8	10	8	9	7	8	9	8	9	9	9	12	12	11	8	9		
-49+	8	8	8	8	7	8	10	10	10	9	9	8	8	9	10	12	10	10		
-50+	8	7	7	7	7	9	9	11	10	9	7	8	9	11	9					
-51+	9	8	9	7	8	9	8	7	8	8	10	9	8	8	12					
-52+	8	7	9	9	9	8	7	8	8	8	9	9	12	9	9					
-53+	9	8	9	9	8	8	-8—	7	7	9	11	12	10	13	16					
-54+	10	11	9	8	9	9	8	9	10	9	9	10	10	10	15					
-55+	7	8	9	10	8	8	7	10	9	10	10	8	8	9	10	13	13	11	11	12
-56+	7	7	9	9	9	9	9	10	9	10	11	8	8	7	7	8	10	11	10	12
-57+	9	9	8	9	8	11	13	11	12	10	9	9	8	7	8	9	8	10	11	13
-58+	9	11	10	13	10	11	11	12	12	10	9	8	7	7	8	13	14	11	11	14
-59+	11	12	12	11	11	12	12	9	9	8	9	9	8	8	9	11	13	16	14	15
-60+	12	10	9	8	7	7	7	7	7											
-61+	7	6	7	7	6	7	8	7	7											
-62+	7	7	7	8	8	8	8	11	13											
-63+	10	12	14	15	15	15	14	11	11											
-64+	17	17	17	15	12	13	14	14	15											
-65+																				

100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

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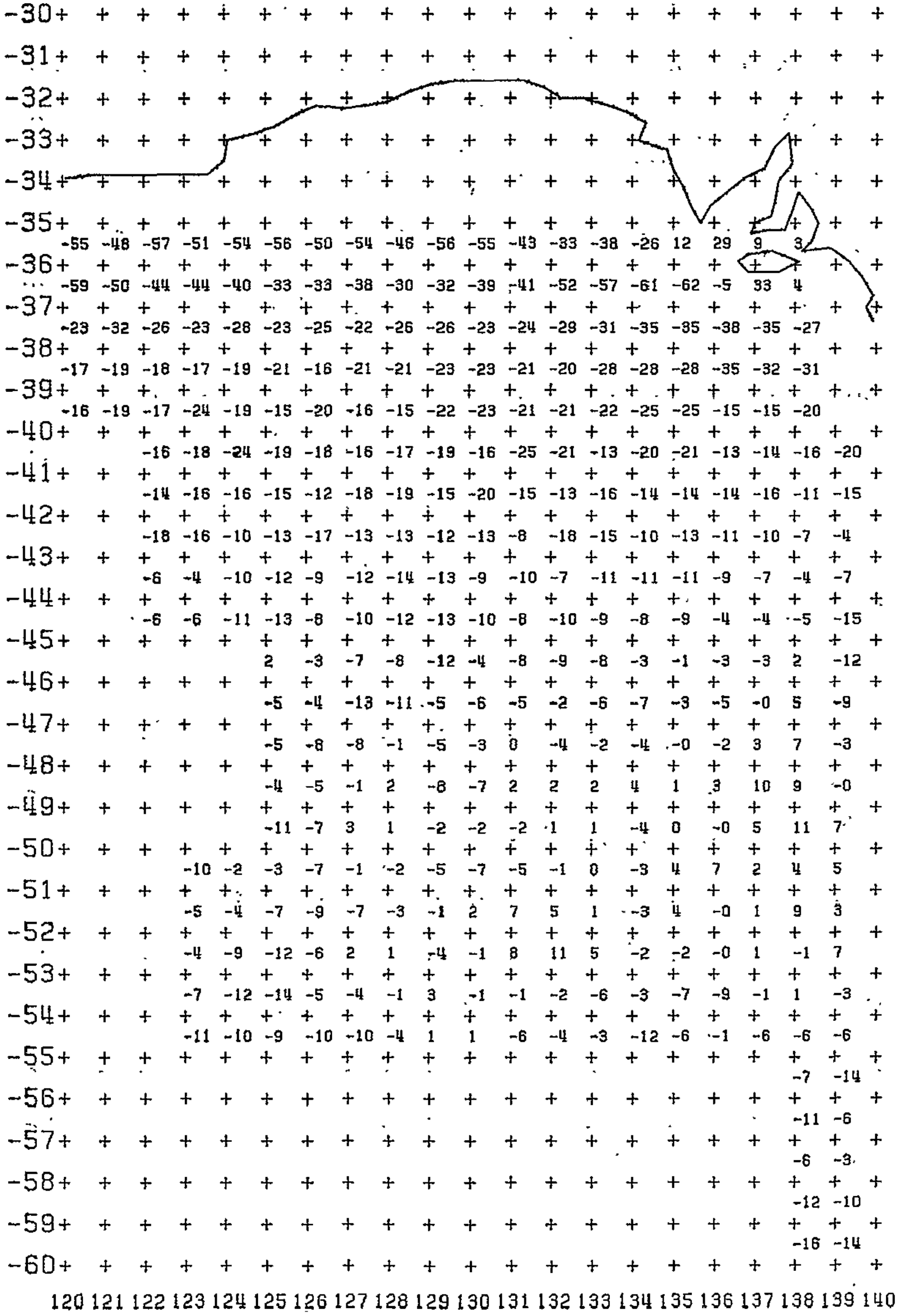
Figure B 18 A



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-30																					
-31																					
-32																					
-33																					
-34																					
-35	-55	-48	-57	-51	-54	-56	-50	-54	-46	-56	-55	-43	-33	-38	-26	12	29	9	3		
-36	-59	-50	-44	-44	-40	-33	-33	-38	-30	-32	-39	-41	-52	-57	-61	-62	-5	33	4		
-37	-23	-32	-26	-23	-28	-23	-25	-22	-26	-26	-23	-24	-29	-31	-35	-35	-38	-35	-27		
-38	-17	-19	-18	-17	-19	-21	-16	-21	-21	-23	-23	-21	-20	-28	-28	-28	-35	-32	-31		
-39	-16	-19	-17	-24	-19	-15	-20	-16	-15	-22	-23	-21	-21	-22	-25	-25	-15	-15	-20		
-40			-16	-18	-24	-19	-18	-16	-17	-19	-16	-25	-21	-13	-20	-21	-13	-14	-16	-20	
-41			-14	-16	-16	-15	-12	-18	-19	-15	-20	-15	-13	-16	-14	-14	-14	-16	-11	-15	
-42			-18	-16	-10	-13	-17	-13	-13	-12	-13	-8	-18	-15	-10	-13	-11	-10	-7	-4	
-43			-6	-4	-10	-12	-9	-12	-14	-13	-9	-10	-7	-11	-11	-11	-9	-7	-4	-7	
-44			-6	-6	-11	-13	-8	-10	-12	-13	-10	-8	-10	-9	-8	-9	-4	-4	-5	-15	
-45						2	-3	-7	-8	-12	-4	-8	-9	-8	-3	-1	-3	-3	2	-12	
-46						-5	-4	-13	-11	-5	-6	-5	-2	-6	-7	-3	-5	-0	5	-9	
-47						-5	-8	-8	-1	-5	-3	0	-4	-2	-4	-0	-2	3	7	-3	
-48						-4	-5	-1	2	-8	-7	2	2	2	4	1	3	10	9	-0	
-49						-11	-7	3	1	-2	-2	-2	1	1	-4	0	-0	5	11	7	
-50				-10	-2	-3	-7	-1	-2	-5	-7	-5	-1	0	-3	4	7	2	4	5	
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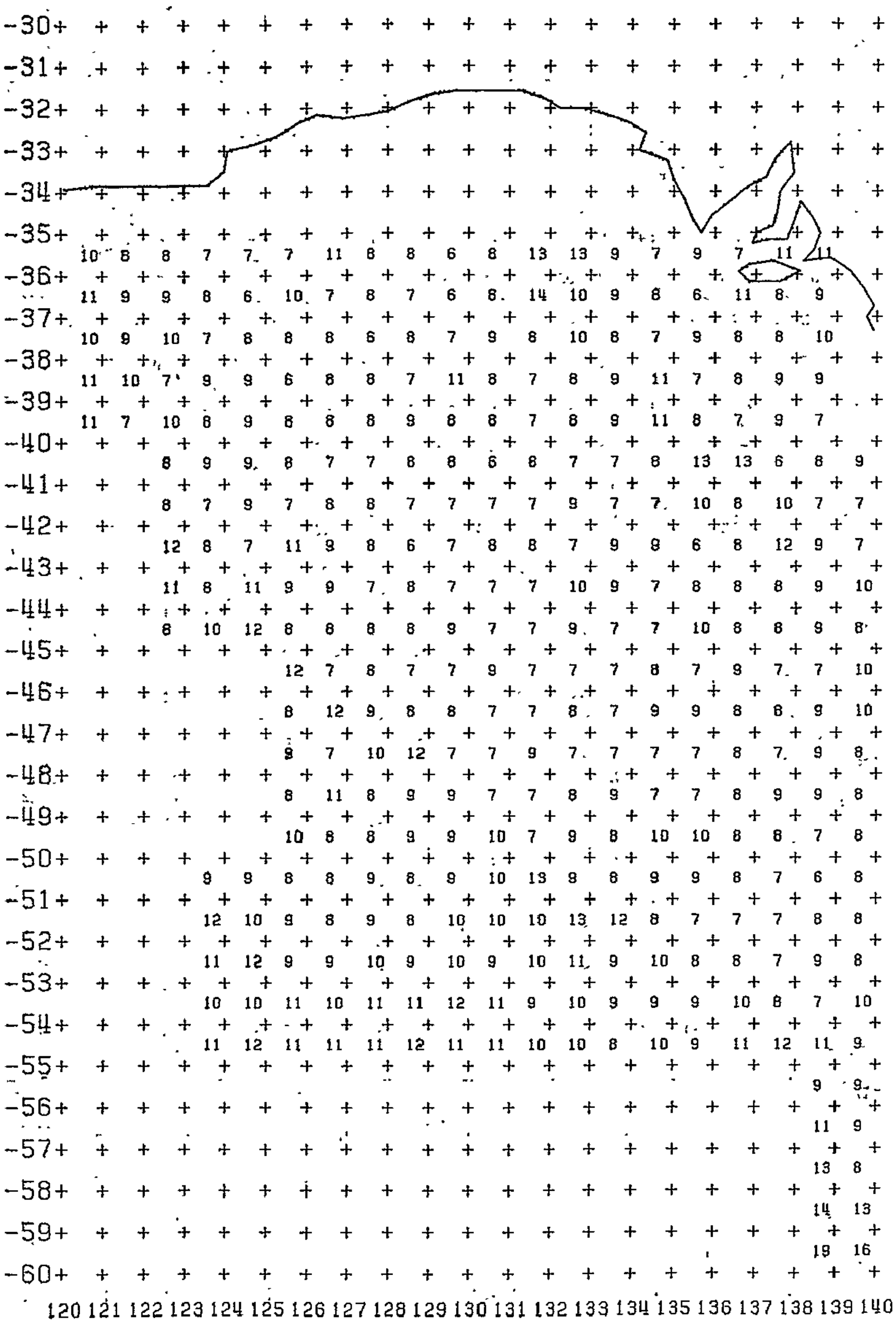
-53				-7	-12	-14	-5	-4	-1	3	-1	-1	-2	-6	-3	-7	-9	-1	1	-3	
-54				-11	-10	-9	-10	-10	-4	1	1	-6	-4	-3	-12	-6	-1	-6	-6	-6	
-55																			-7	-14	
-56																			-11	-6	
-57																			-6	-3	
-58																			-12	-10	
-59																			-16	-14	
-60																					

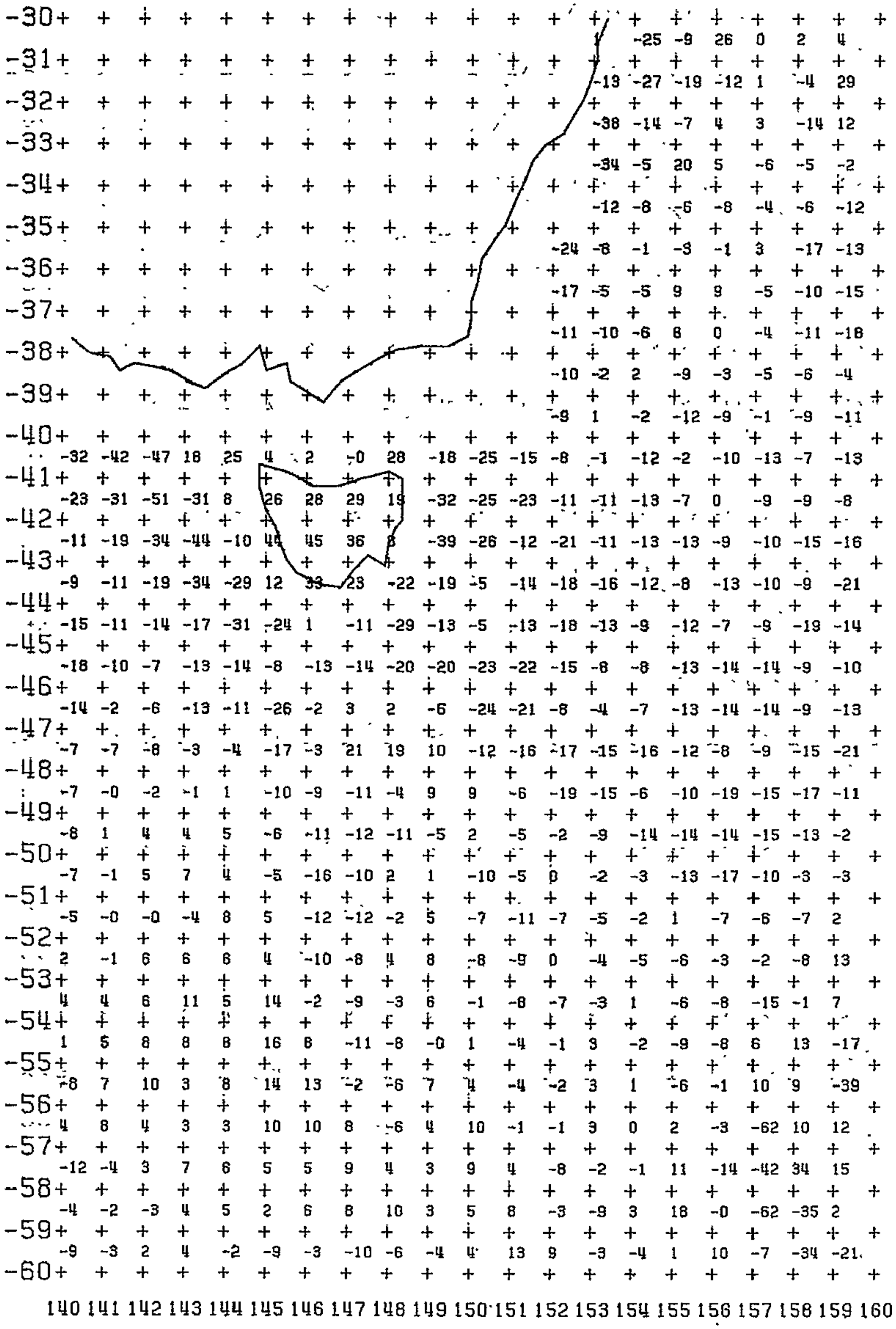
1° x 1° Mean Free-Air Anomalies (mgals)

Figure B 18 B



Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B 19 A



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-31														-13	-27	-19	-12	1	-4	29
-32														-38	-14	-7	4	3	-14	12
-33														-34	-5	20	5	-6	-5	-2
-34														-12	-8	-6	-8	-4	-6	-12
-35													-24	-8	-1	-3	-1	3	-17	-13
-36													-17	-5	-5	9	9	-5	-10	-15
-37													-11	-10	-6	6	0	-4	-11	-18
-38													-10	-2	2	-9	-3	-5	-6	-4
-39													-9	1	-2	-12	-9	-1	-9	-11
-40	-32	-42	-47	18	25	4	2	-0	28	-18	-25	-15	-8	-1	-12	-2	-10	-13	-7	-13
-41	-23	-31	-51	-31	8	26	28	29	19	-32	-25	-23	-11	-11	-13	-7	0	-9	-9	-8
-42	-11	-19	-34	-44	-10	44	45	36	8	-39	-26	-12	-21	-11	-13	-13	-9	-10	-15	-16
-43	-9	-11	-19	-34	-29	12	33	23	-22	-19	-5	-14	-18	-16	-12	-8	-13	-10	-9	-21
-44	-15	-11	-14	-17	-31	-24	1	-11	-29	-13	-5	-13	-18	-13	-9	-12	-7	-9	-19	-14
-45	-18	-10	-7	-13	-14	-8	-13	-14	-20	-20	-23	-22	-15	-8	-8	-13	-14	-14	-9	-10
-46	-14	-2	-6	-13	-11	-26	-2	3	2	-6	-24	-21	-8	-4	-7	-13	-14	-14	-9	-13
-47	-7	-7	-8	-3	-4	-17	-3	21	19	10	-12	-16	-17	-15	-16	-12	-8	-9	-15	-21
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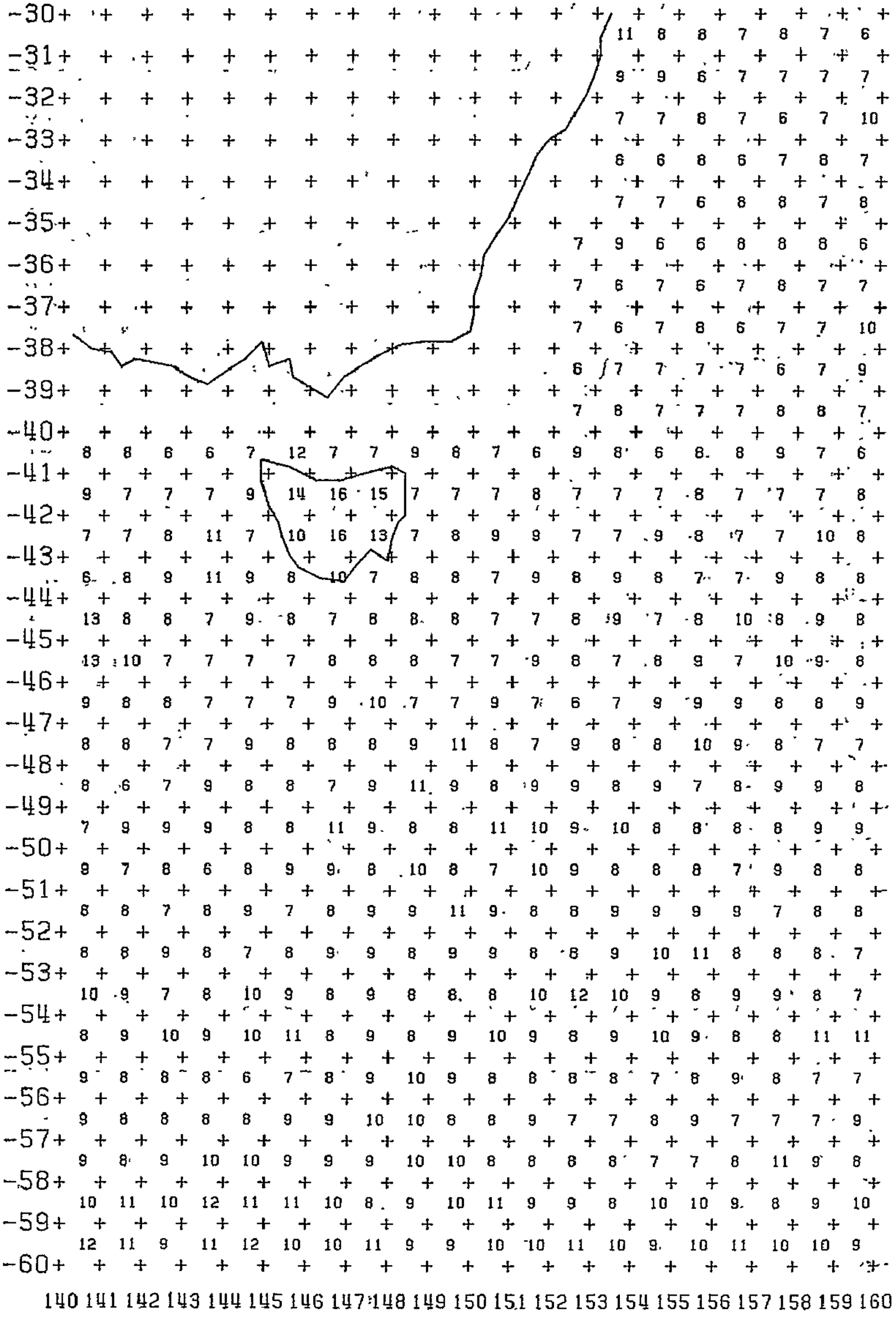
-58	-4	-2	-3	4	5	2	6	8	10	3	5	8	-3	-9	3	18	-0	-62	-35	2
-59	-9	-3	2	4	-2	-9	-3	-10	-6	-4	4	13	9	-3	-4	1	10	-7	-34	-21

1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 19 B



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-34														7	7	6	8	8	7	8
-35													7	9	6	6	8	8	8	6
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-37													7	6	7	8	6	7	7	10
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-39													7	8	7	7	7	8	8	7
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-54	8	9	10	9	10	11	8	9	8	9	10	9	8	9	10	9	8	8	11	11
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-56	9	8	8	8	8	9	9	10	10	8	8	9	7	7	8	9	7	7	7	9
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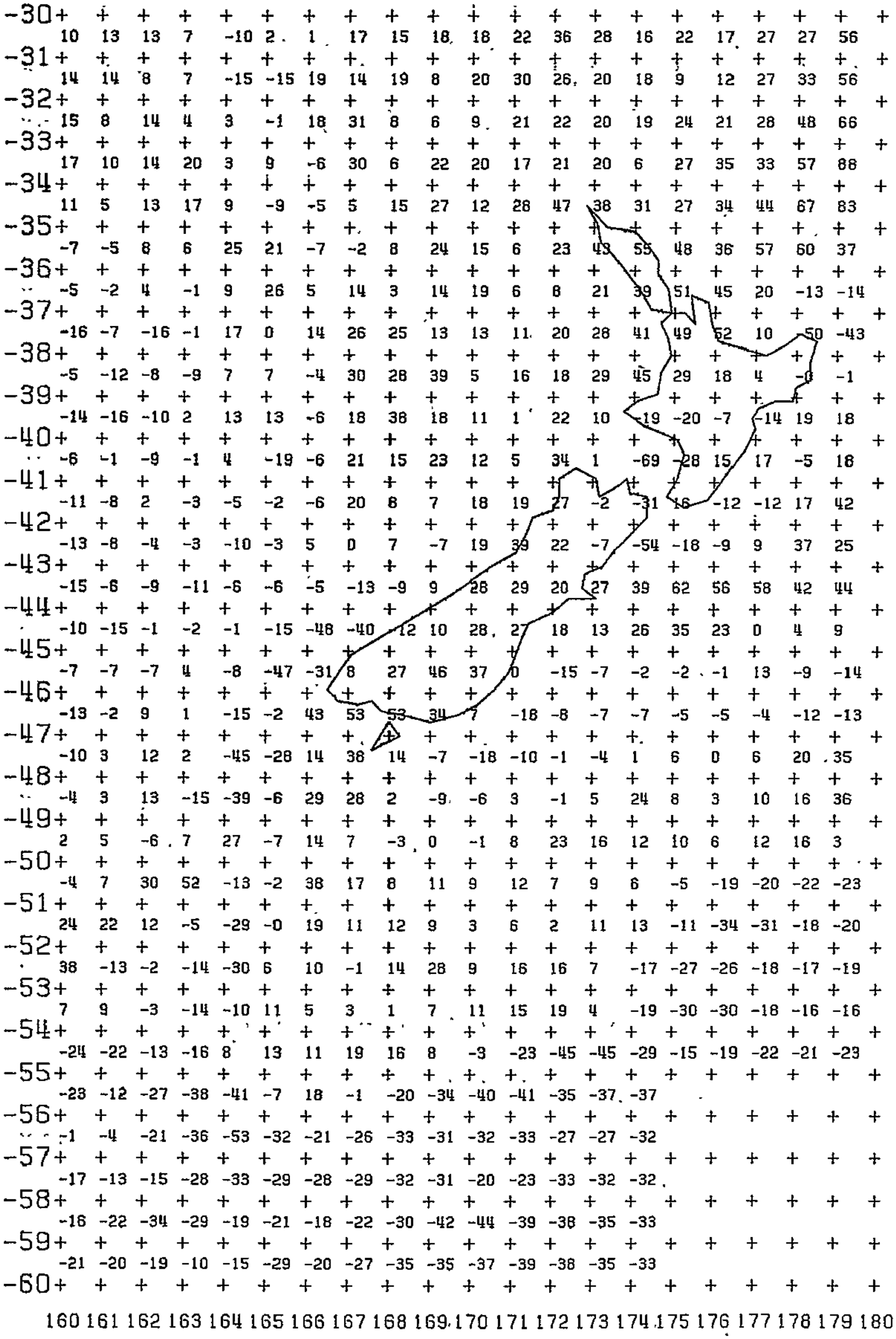
-58	10	11	10	12	11	11	10	8	9	10	11	9	9	8	10	10	9	8	9	10
-59	12	11	9	11	12	10	10	11	9	9	10	10	11	10	9	10	11	10	10	9
-60																				

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B 20 A



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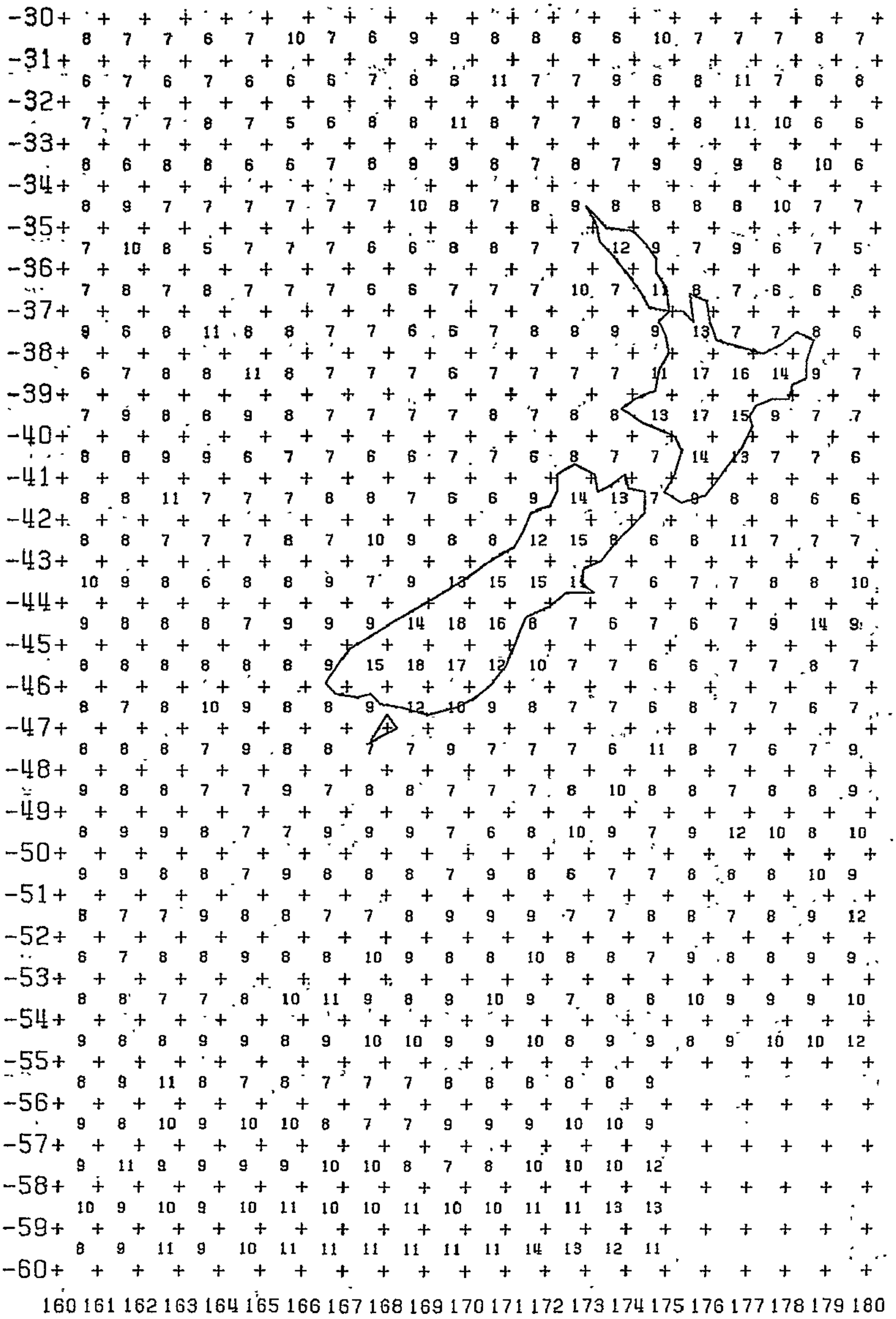
-31	14	14	8	7	-15	-15	19	14	19	8	20	30	26	20	18	9	12	27	33	56
-32	15	8	14	4	3	-1	18	31	8	6	9	21	22	20	19	24	21	28	48	66
-33	17	10	14	20	3	9	-6	30	6	22	20	17	21	20	6	27	35	33	57	88
-34	11	5	13	17	9	-9	-5	5	15	27	12	28	47	38	31	27	34	44	67	83
-35	-7	-5	8	6	25	21	-7	-2	8	24	15	6	23	43	55	48	36	57	60	37
-36	-5	-2	4	-1	9	26	5	14	3	14	19	6	8	21	39	51	45	20	-13	-14
-37	-16	-7	-16	-1	17	0	14	26	25	13	13	11	20	28	41	49	52	10	-50	-43
-38	-5	-12	-8	-9	7	7	-4	30	28	39	5	16	18	29	45	29	18	4	-8	-1
-39	-14	-16	-10	2	13	13	-6	18	38	18	11	1	22	10	-19	-20	-7	-14	19	18
-40	-6	-1	-9	-1	4	-19	-6	21	15	23	12	5	34	1	-69	-28	15	17	-5	18
-41	-11	-8	2	-3	-5	-2	-6	20	8	7	18	19	27	-2	-31	16	-12	-12	17	42
-42	-13	-8	-4	-3	-10	-3	5	0	7	-7	19	39	22	-7	-54	-18	-9	9	37	25
-43	-15	-6	-9	-11	-6	-6	-5	-13	-9	9	28	29	20	27	39	62	56	58	42	44
-44	-10	-15	-1	-2	-1	-15	-48	-40	-12	10	28	27	18	13	26	35	23	0	4	9
-45	-7	-7	-7	4	-8	-47	-31	8	27	46	37	0	-15	-7	-2	-2	-1	13	-9	-14
-46	-13	-2	9	1	-15	-2	43	53	53	34	7	-18	-8	-7	-7	-5	-5	-4	-12	-13
-47	-10	3	12	2	-45	-28	14	36	14	-7	-18	-10	-1	-4	1	6	0	6	20	35
-48	-4	3	13	-15	-39	-6	29	28	2	-9	-6	3	-1	5	24	8	3	10	16	36
-49	2	5	-6	7	27	-7	14	7	-3	0	-1	8	23	16	12	10	6	12	16	3
-50	-4	7	30	52	-13	-2	38	17	8	11	9	12	7	9	6	-5	-19	-20	-22	-23
-51	24	22	12	-5	-29	-0	19	11	12	9	3	6	2	11	13	-11	-34	-31	-18	-20
-52	38	-13	-2	-14	-30	6	10	-1	14	28	9	16	16	7	-17	-27	-26	-18	-17	-19
-53	7	9	-3	-14	-10	11	5	3	1	7	11	15	19	4	-19	-30	-30	-18	-16	-16
-54	-24	-22	-13	-16	8	13	11	19	16	8	-3	-23	-45	-45	-29	-15	-19	-22	-21	-23
-55	-23	-12	-27	-38	-41	-7	18	-1	-20	-34	-40	-41	-35	-37	-37					
-56	-1	-4	-21	-36	-53	-32	-21	-26	-33	-31	-32	-33	-27	-27	-32					
-57	-17	-13	-15	-28	-33	-29	-28	-29	-32	-31	-20	-23	-33	-32	-32					
-58	-16	-22	-34	-29	-19	-21	-18	-22	-30	-42	-44	-39	-38	-35	-33					
-59	-21	-20	-19	-10	-15	-29	-20	-27	-35	-35	-37	-39	-38	-35	-33					

1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 20 B



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8	6	8	8	6	6	7	8	9	9	8	7	8	7	9	9	9	8	10	6
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7	10	8	5	7	7	7	6	6	8	8	7	7	12	9	7	9	6	7	5
7	8	7	8	7	7	7	6	6	7	7	7	10	7	11	8	7	6	6	6
9	6	8	11	8	8	7	7	6	6	7	8	8	9	9	13	7	7	8	6
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7	9	8	6	9	8	7	7	7	7	8	7	8	8	13	17	15	9	7	7
8	8	9	9	6	7	7	6	6	7	7	6	8	7	7	14	13	7	7	6
8	8	11	7	7	7	8	8	7	6	6	9	14	13	7	8	8	8	6	6
8	8	7	7	7	8	7	10	9	8	8	12	15	8	6	8	11	7	7	7
10	9	8	6	8	8	9	7	9	13	15	15	[illegible]	7	6	7	7	8	8	10
9	8	8	8	7	9	9	9	14	18	16	8	7	6	7	6	7	9	14	9
8	8	8	8	8	8	9	15	18	17	12	10	7	7	6	6	7	7	8	7
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8	8	8	7	9	8	8	7	7	9	7	7	7	6	11	8	7	6	7	9
9	8	8	7	7	9	7	8	8	7	7	7	8	10	8	8	7	8	8	9
8	9	9	8	7	7	9	9	9	7	6	8	10	9	7	9	12	10	8	10
9	9	8	8	7	9	8	8	8	7	9	8	6	7	7	8	8	8	10	9
8	7	7	9	8	8	7	7	8	9	9	9	7	7	8	8	7	8	9	12
6	7	8	8	9	8	8	10	9	8	8	10	8	8	7	9	8	8	9	9
8	8	7	7	8	10	11	9	8	9	10	9	7	8	6	10	9	9	9	10
9	8	8	9	9	8	9	10	10	9	9	10	8	9	9	8	9	10	10	12
8	9	11	8	7	8	7	7	7	8	8	8	8	8	9					
9	8	10	9	10	10	8	7	7	9	9	9	10	10	9					
9	11	9	9	9	9	10	10	8	7	8	10	10	10	12					
10	9	10	9	10	11	10	10	11	10	10	11	11	13	13					
8	9	11	9	10	11	11	11	11	11	11	14	13	12	11					

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B 21 A

```
-30+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    78   95   -60  -113 29   31   35   15   -0   10   -3   4    0    2    5    4    2    5    4    1
-31+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    96   58   -141 -53  39   44   8    25   -0   -8   4    3    -0   6    -6   -0   7    -0   7    9
-32+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    122  -16  -154 -1   44   97   12   -1   28   -5   5    5    7    -0   -9   -2   13   5    6    9
-33+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    81   -112 -83  28   43   23   24   -0   20   1    -1   7    6    -4   -5   4    7    1    1    11
-34+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    -21  -124 -20  40   28   28   24   4    5    -0   -1   9    12   -1   10   8    3    3    -1   6
-35+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    -69  -87  17   21   28   23   5    6    4    32   13   6    8    1    6    8    -1   4    0    -2
-36+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    -74  -27  24   28   23   11   6    7    2    2    8    2    9    16   13   0    6    3    8    7
-37+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    -5   32   29   31   18   6    3    -3   7    4    21   5    7    10   9    7    6    -0   5    18
-38+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    34   27   40   19   13   1    -5   -2   14   2    -16  29   33   -4   6    15   5    3    11   15
-39+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    27   30   19   9    12   -9   -8   -5   3    -19  -6   -6   16   22   2    -1   13   10   7    11
-40+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    55   29   14   11   -1   -4   2    -11  -13  1    -2   5    -7   3    17   -3   -0
-41+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    29   19   17   19   16   14   5    -3   1    3    -3   1    6    -5   -7   38   21
-42+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    17   18   15   8    17   11   10   15   10   4    3    2    -7   0    0    5    13
-43+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    41   29   39   53   39   24   17   6    3    1    -3   -6   -12  -4   2    -0   3
-44+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    18   28   32   41   32   14   -3   -2   -6   -10  -11  -11  -8   -3   -11  -10  3
-45+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    -9   -13  -8   -7   -2   -2   -3   -7   -14  -15  -11  -7   -11  -12  -7   -8   -10  -5   -7   -1
-46+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    -19  -34  -22  -6   -12  -11  -4   -7   -12  -8   -4   -7   -8   -11  -3   1    -1   -6   -3   -2
-47+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    18   -22  -17  -16  -15  -23  -13  -7   -6   -3   -6   -5   -4   -10  -9   -6   4    4    1    -3
-48+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    37   -12  -19  -15  -15  -11  -17  -22  -6   -1   -8   -4   -3   -3   -1   -4   4    1    -1   -3
-49+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
    -1   -6   -0   5    -20  -24  -15  -9   -14  -5   2    -7   -12  -3   0    -1   -3   -4   1    -5
-50+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                            -0   -6   -14  -8   -7   -9   -9   -5   -4   -4   -5   -1
-51+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                            -8   -2   -2   -10  -9   -9   -13  -11  -6   -7   -8   -1
-52+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                            -11  -7   -9   -11  -8   -11  -9   -5   -5   -10  -12  -10
-53+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                            -20  -14  -11  -15  -14  -13  -14  -9   -6   -10  -13  -11
-54+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                            -16  -17  -12  -14  -15  -12  -8   -15  -19  -6   -6   0
-55+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                                                          -7   -9   -16  -13  -17  -10
-56+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                                                          -15  -14  -12  -2   -4   -10
-57+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                                                          -23  -15  -11  -11  -9   -6
-58+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                                                          -15  -13  -9   -6   -9   -9
-59+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +
                                                                          -15  -12  -7   -6   -6   -6
-60+    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +

  180  181  182  183  184  185  186  187  188  189  190  191  192  193  194  195  196  197  198  199  200
```

1°x 1° Mean Free-Air Anomalies (mgals)

C-2

Figure B 21 B

	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199
-30	7	6	6	7	6	6	6	7	9	7	7	7	6	6	9	12	6	6	8	6
-31	6	6	8	6	6	6	6	6	8	7	9	6	7	6	9	7	6	6	6	10
-32	6	6	6	7	6	6	7	6	8	8	8	7	7	10	7	7	9	7	7	11
-33	7	6	7	7	6	7	6	8	7	9	6	6	9	7	7	7	9	12	8	6
-34	6	7	6	6	8	7	8	7	9	8	7	8	8	7	7	9	7	14	9	7
-35	7	6	7	6	6	8	7	8	7	7	7	9	7	6	7	8	8	7	7	6
-36	6	11	6	6	6	9	12	7	6	7	8	7	6	8	8	8	9	6	6	7
-37	7	8	7	7	7	10	8	8	7	8	7	6	8	5	10	10	6	7	6	8
-38	7	7	7	8	9	7	7	8	9	8	6	8	6	9	8	6	7	6	8	7
-39	7	8	9	11	8	8	7	7	9	8	9	7	10	7	7	7	7	8	7	10
-40	7	8	11	10	8	6	7	7	6	8	8	8	7	7	7	8	7			
-41	8	14	9	10	8	10	7	6	7	6	7	8	7	6	9	8	8			
-42	7	9	8	7	9	11	9	6	7	7	7	10	7	9	7	10	10			
-43	8	6	7	11	9	9	10	8	7	10	7	8	11	8	8	8	11			
-44	7	6	7	8	10	9	7	9	12	7	9	7	8	8	10	10	8			
-45	7	9	7	8	7	8	9	8	10	10	9	9	7	7	10	9	9	10	10	9
-46	12	9	8	7	7	7	10	9	7	13	12	8	8	8	7	10	11	8	8	8
-47	8	9	9	7	10	8	8	9	13	8	10	14	9	7	10	8	8	11	9	9
-48	8	7	8	12	9	8	7	8	8	12	10	9	14	13	8	8	7	8	10	9
-49	9	9	9	9	9	10	10	8	9	8	9	12	11	12	9	9	9	9	10	11
-50									8	8	9	9	9	8	11	11	11	8	9	8
-51									11	10	7	8	9	10	11	11	15	14	9	8
-52									13	9	10	9	8	9	10	13	11	12	15	12
-53									9	10	11	13	10	10	9	9	12	13	10	13
-54									12	10	9	12	15	13	10	9	10	8	11	8
-55															14	11	9	8	8	7
-56															8	8	11	11	10	9
-57															12	12	9	9	12	13
-58															16	13	13	13	11	9
-59															21	19	17	13	12	13

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B 22 A

	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
-20																					
-21																					
-22																					
-23																					
-24																					
-25				-3	-1	2	19	5													
-26				-5	-8	-6	4	-3													
-27				-11	-10	-2	-4	-1													
-28				-10	1	-4	3	-9													
-29				-1	5	-3	-2	-22													
-30	-13	-3	-5	-5	1	0	1														
-31	9	-6	3	-2	-0	-1	14														
-32	10	2	-3	5	-3	10	13														
-33	5	6	-2	1	10	4	-1														
-34	10	5	5	-2	9	4	4														
-35	8	3	2	7	-7	-2	2	5													
-36	5	7	6	-2	-6	4	0	1													
-37	15	10	14	4	5	-1	-3	1													
-38	20	14	10	11	8	6	4	1													
-39	18	18	5	13	16	19	14	9													
-40																					
-41																					
-42																					
-43																					
-44																					
-45	10	13	33	13	5	19															
-46	-2	-4	-1	10	11	16															
-47	-3	-2	2	6	7	2															
-48	-9	-9	-4	4	4	8															
-49	-2	-0	-6	-7	-6	0															
-50																					

1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 22 B

```
-20+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-21+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-22+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-23+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-24+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-25+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                 9   10  6   7   7
-26+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                 10  6   6   8   8
-27+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                 8   7   7   7   12
-28+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                 7   6   7   10  8
-29+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                 7   7   9   7   9
-30+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     9   7   6   6   8   8   10
-31+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     6   6   6   7   7   7   8
-32+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     7   6   7   7   8   7   7
-33+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     7   7   7   8   10  8   8
-34+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     7   8   8   9   10  8   8
-35+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     6   9   10  8   7   10  10  10
-36+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     9   7   9   7   8   7   10  13
-37+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     9   10  7   9   8   8   10  11
-38+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     11  8   8   11  10  11  8   13
-39+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     7   9   13  9   10  9   15  11
-40+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-41+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-42+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-43+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-44+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-45+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     8   8   9   10  8   11
-46+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     11  9   8   10  10  8
-47+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     9   12  10  9   9   10
-48+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     10  9   12  9   10  8
-49+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     11  9   8   10  12  11
-50+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
  200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
```

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

ORIGINAL PAGE IS OF POOR QUALITY

Figure B. 23 A

	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
-35	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-36	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-37	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-38	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-39	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
-40	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
													-1	1	-2	-2	-9	-12	-1	-2	
-41	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
													-4	2	-4	-1	-2	6	1	12	
-42	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
													7	7	4	4	12	7	1	5	
-43	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
													8	8	4	6	10	5	8	5	
-44	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
													8	7	12	4	4	11	7	3	
-45	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
					11	17	9	-4	0	3	7	8	-1	3	0	4	7	-0	4	10	
-46	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
					5	6	-2	-5	2	6	2	6	6	3	4	2	5	5	3	8	
-47	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
					-6	-10	-6	3	8	9	9	7	5	3	-1	-0	5	5	-2	1	
-48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
					-14	-9	3	3	-1	6	9	2	-4	5	3	2	2	0	-1	5	
-49	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
					-1	2	-0	-9	2	5	-2	6	3	2	-1	3	4	1	2	4	
-50	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			2	8	8	-2	-7	-1	1	1	4	-1	4	8	1	-4	2	5	5	8	
-51	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			12	3	-14	-2	-4	-13	-6	-3	-2	-5	-1	2	2	4	-1	-3	-10	8	
-52	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			3	-4	5	3	-8	-7	-4	-5	-4	-0	0	-5	-7	-5	-3	-2	0	-2	
-53	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			10	2	-3	-4	-8	-5	-1	7	-0	-6	-8	-4	-7	-10	-0	1	6	5	
-54	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			-9	9	-3	-14	-11	3	7	5	8	8	1	-1	-6	-6	2	-2	-1	5	
-55	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	3	-1	6	15	-8	-15	-17	-9	1	-0	5	3	-3	-5	4	4	-4	-8	-3	4	
-56	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	4	2	2	-0	-4	-7	-6	-2	-6	-12	-8	-8	-14	-5	-14	-1	1	0	-3	-1	
-57	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	0	1	-0	-3	0	-1	-3	2	8	1	-2	2	-1	-6	-8	12	-1	1	-3	-0	
-58	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-6	-6	-13	-10	12	23	2	-3	1	-0	3	-1	-6	-5	-2	-11	-12	-3	-4	-1	
-59	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-9	-3	-1	4	-8	-11	-10	-9	-5	-7	-5	3	-4	-4	3	-4	-6	-7	-10	-7	
-60	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			-5	-6	-5	-4	-3	-5	-7	-12	-12	-8	-8	-6	-3	-3	-5	-6	2	-10	
-61	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			-12	-8	-9	-6	-6	-7	-11	-11	-5	-9	-18	-14	-12	-13	-14	-14	-13	-12	
-62	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			-16	-10	-3	-6	-15	-15	-14	-9	-3	-4	-9	-14	-15	-18	-16	-7	-2	-2	
-63	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			-17	-11	-6	-4	-3	-9	-11	-6	-6	-7	-8	-11	-17	-16	-12	-3	-8	-14	
-64	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			-16	-18	-16	-12	0	-18	-13	-0	-5	-10	-10	-6	-5	-8	-12	-8	-7	-6	
-65	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

1°x 1° Mean Free-Air Anomalies (mgals)

ORIGINAL PAGE IS
OF POOR QUALITY

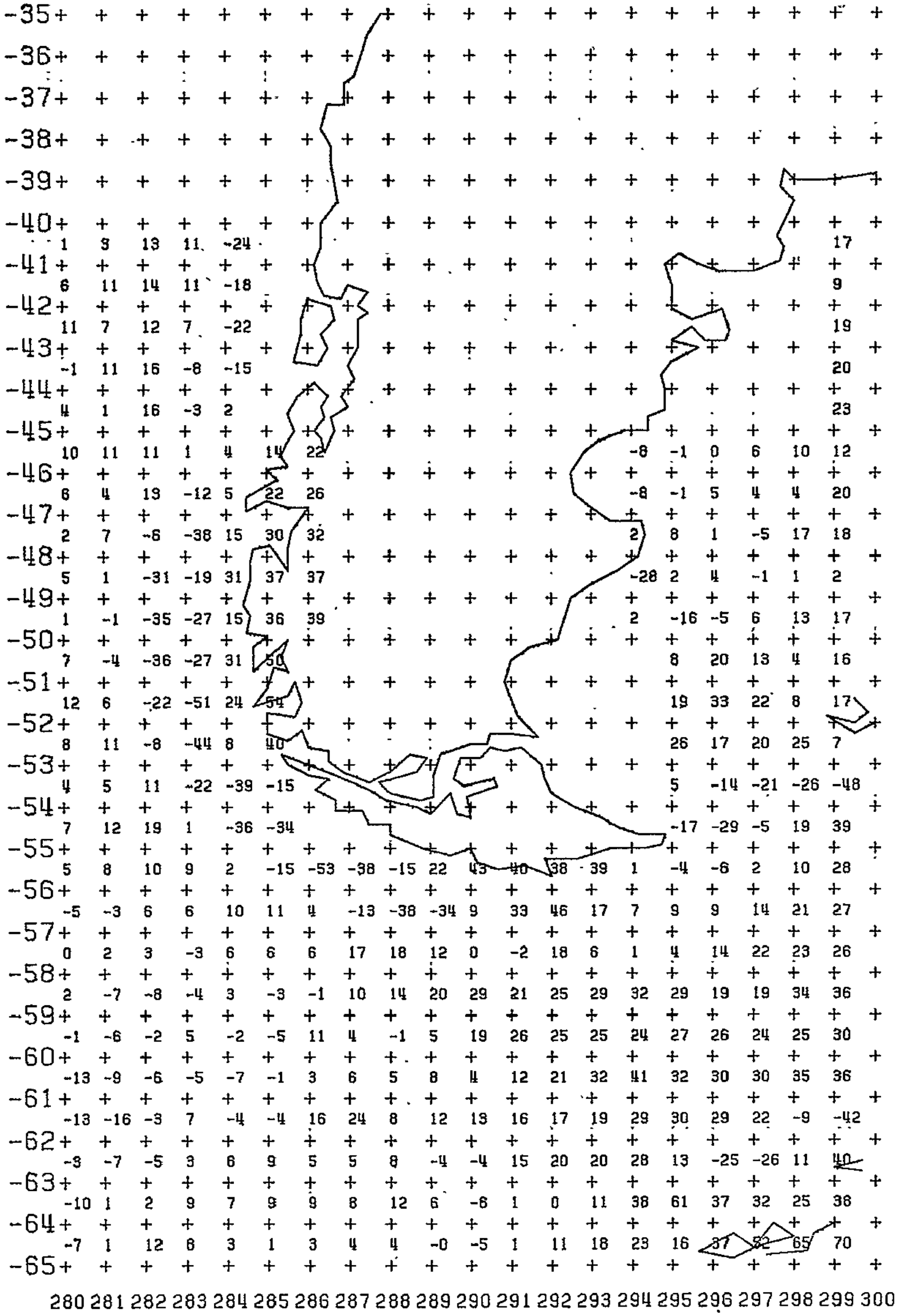
Figure B 23 B

```
-35+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-36+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-37+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-38+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-39+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
-40+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                    10   7   8   7   8   7   6   7
-41+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                     6  12   9   7   6   6   8   7
-42+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                    11   7   7   6   6   7   8   8
-43+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                     9   8   6   7   8   7   7   7
-44+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                                                     9   7   7   8   9   8   7   7
-45+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                     8   9   8   8   7   8   8   7   7   7   8   8   7   7   7   6
-46+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                    11   7   7   8  10   7   6   6   7   8   8   7   7   6   7   8
-47+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                    10   8   8   8   8   7   7   7   9   8   8   8   8   7   9   7
-48+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                     9  12   9   7   6   6   8   8   7   8   7   7   9   8   8   7
-49+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
                    12   9   8   8   7   8   7   8   8   7   7   9   9   9   8   8
-50+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
            12  10   7   7   7   8   9   7   7   8   7   8   8   7   7   7   8   8
-51+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
             9   8   7   6   9   8   7   7   8   8   9   8   8   8   7   7   6   7
-52+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
             9   7   8   8   7   7   7   6   9   9   9   8   8   9   9   8   7   8
-53+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
             7   9   8   7   8   7   7   9  10   8   9   9   9   9   7   8   9   8
-54+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
             9   8   8   8   8   8  10   8  12   9   9   8   7   8   8   9   9   8
-55+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
    10  10   9   8   8   8   8  10   9   8   8   6   7   6   7   7   7   7   8  10
-56+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     8   8   8   9  13  12  10   8   8   7   7   7   8   6   8   7   8   9   9   9
-57+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     8  10   9  10  10   9   8   9   8   8   8   8   8   7   8   8   8  10   9   7
-58+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
    10  11  10   8   8   8   8  10  10  10   9   9   9   9   8   9  10   7  10   9
-59+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
     9   7   7   8   8  10   9   9   8  10   9  10  11  10   8   8   9  10  10  10
-60+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
             9   9   8  10   8  12   9  11   8  11  10   9   9   9  11   8   9   8
-61+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
            10   9   8  10   9  11   7   9   9   9   8  10  10   9  10  10   9  12
-62+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
             9   9  10   9  10  10  10  10   8  10   7   8   9   8   9   8   7   8
-63+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
             9  10   9  10   8  10   8  10   8   8   8   8   9   8   8   8   8   8
-64+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
            10   9   9   9   8   9   8  10   9   9  10   8   9   8   9   9  10  10
-65+   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

  260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
```

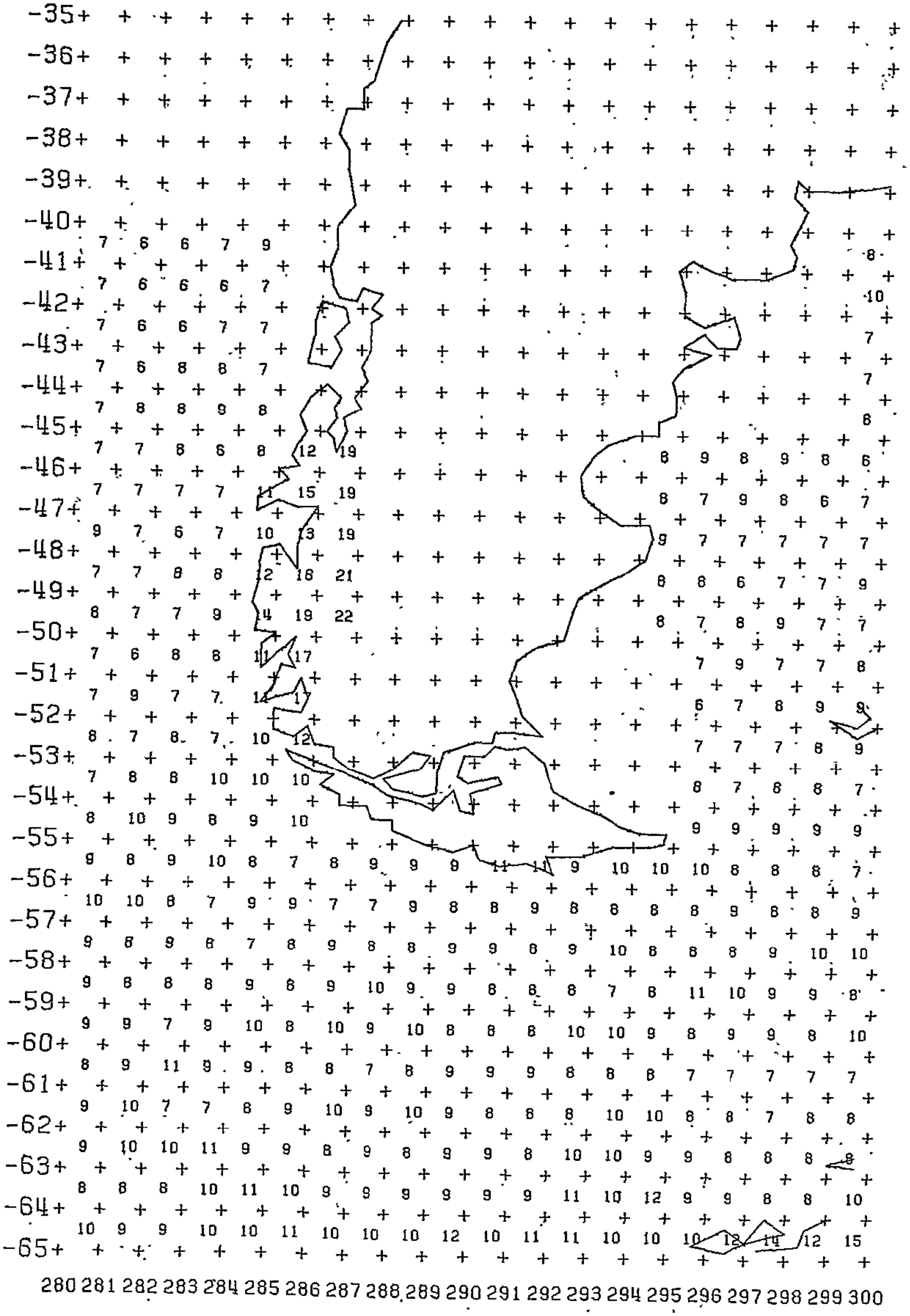
Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B 24 A



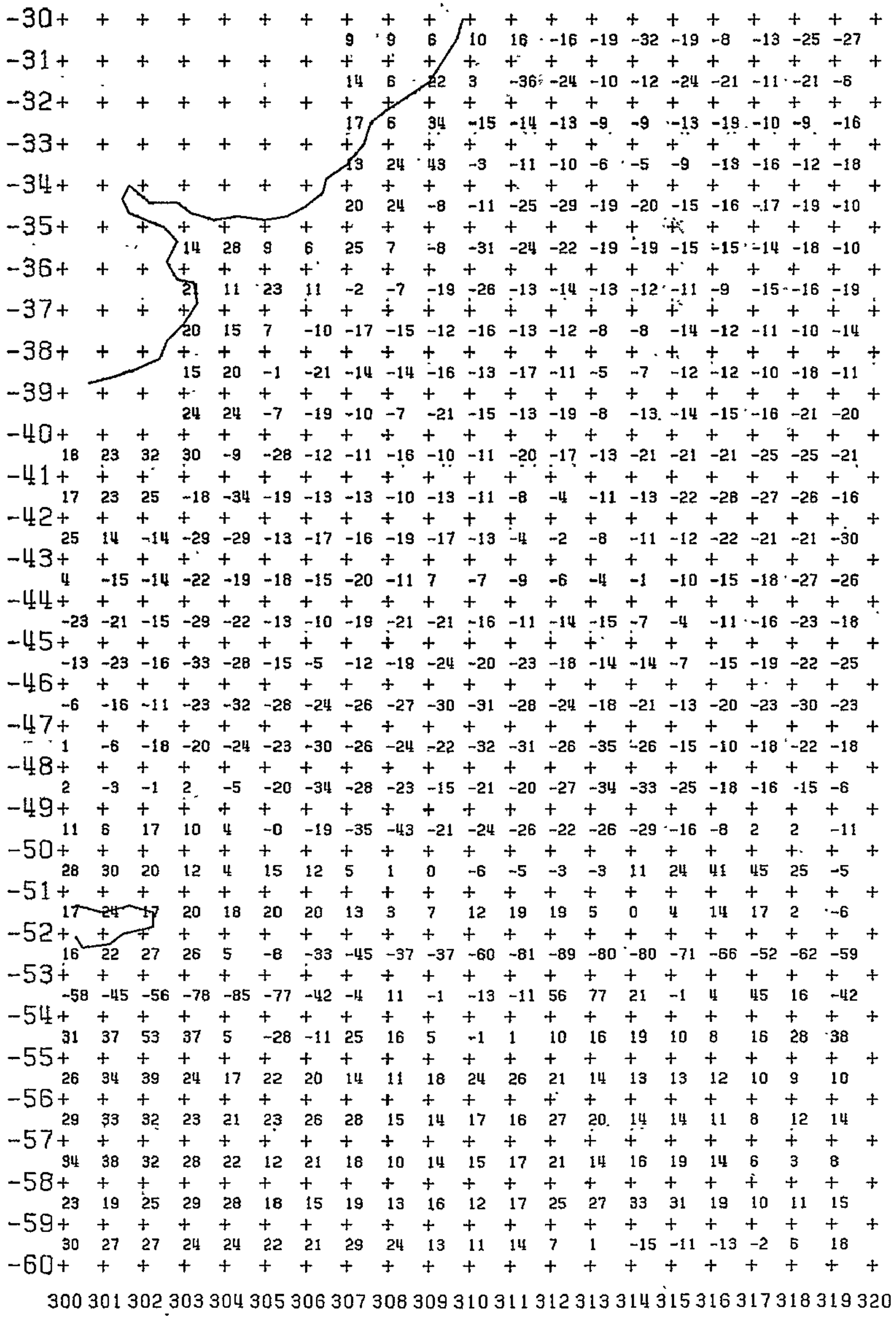
1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 24 B



Accuracy of Predicted 1°x 1° Mean Anomalies (mgals)

Figure B 25 A



	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319
-30								9	9	6	10	16	-16	-19	-32	-19	-8	-13	-25	-27
-31								14	6	22	3	-36	-24	-10	-12	-24	-21	-11	-21	-6
-32								17	6	34	-15	-14	-13	-9	-9	-13	-19	-10	-9	-16
-33								13	24	43	-3	-11	-10	-6	-5	-9	-18	-16	-12	-18
-34								20	24	-8	-11	-25	-29	-19	-20	-15	-16	-17	-19	-10
-35				14	28	9	6	25	7	-8	-31	-24	-22	-19	-19	-15	-15	-14	-18	-10
-36				21	11	23	11	-2	-7	-19	-26	-13	-14	-13	-12	-11	-9	-15	-16	-19
-37				20	15	7	-10	-17	-15	-12	-16	-13	-12	-8	-8	-14	-12	-11	-10	-14
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-42	25	14	-14	-29	-29	-13	-17	-16	-19	-17	-13	-4	-2	-8	-11	-12	-22	-21	-21	-30
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-46	-6	-16	-11	-23	-32	-28	-24	-26	-27	-30	-31	-28	-24	-18	-21	-13	-20	-23	-30	-23
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-52	16	22	27	26	5	-8	-33	-45	-37	-37	-60	-81	-89	-80	-80	-71	-66	-52	-62	-59
-53	-58	-45	-56	-78	-85	-77	-42	-4	11	-1	-13	-11	56	77	21	-1	4	45	16	-42
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-59	30	27	27	24	24	22	21	29	24	13	11	14	7	1	-15	-11	-13	-2	6	18
-60																				

1°x 1° Mean Free-Air Anomalies (mgals)

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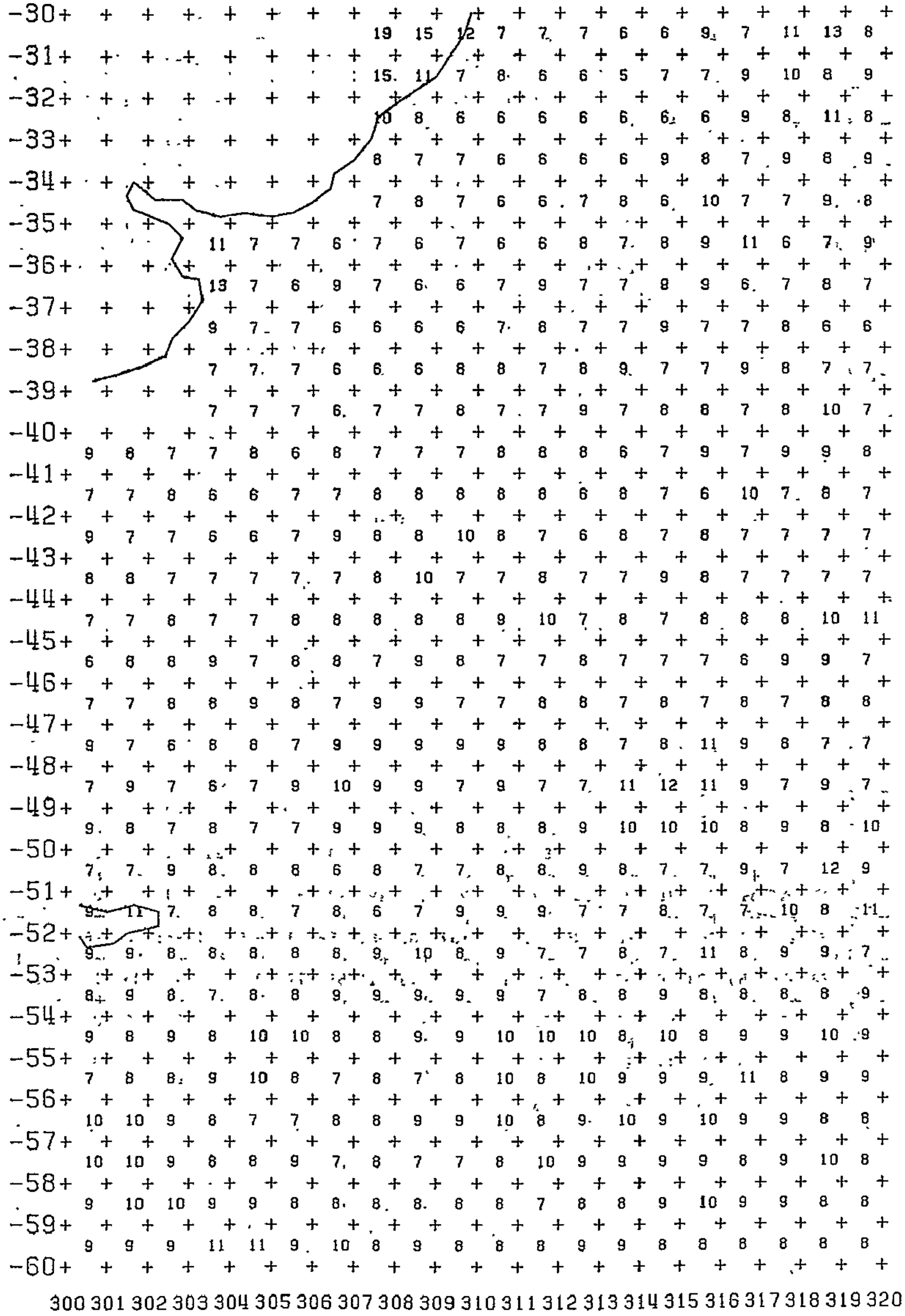
Figure B 25 B



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-33								8	7	7	6	6	6	6	9	8	7	9	8	9
-34								7	8	7	6	6	7	8	6	10	7	7	9	8
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-59	9	9	9	11	11	9	10	8	9	8	8	8	9	9	8	8	8	8	8	8
-60																				

300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B 26 A

	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
-30	-19	-4	-3	21	29																
-31	-18	-8	-14	-6	18																
-32	-16	-13	-18	-1	1																
-33	-17	-15	-15	-12	-11																
-34	-16	-19	-16	-12	-2																
-35	-13	-21																			
-36	-16	-16																			
-37	-15	-12																			
-38	-16	-16																			
-39	-15	-15																			
-40	-14	-15	-14	-11	-9	-12															
-41	-21	-17	-6	-13	-9	-5															
-42	-22	-19	-18	-14	-16	-17															
-43	-23	-32	-22	-15	-16	-17															
-44	-18	-19	-21	-26	-18	-15															
-45	-21	-16	-14	-16	-27	-24	-17	-18	-11	-4	-3										
-46	-21	-23	-22	-26	-28	-27	-18	-13	-14	-8	-4										
-47	-21	-23	-23	-16	-18	-16	-9	-12	-9	-5	0										
-48	-11	-6	-6	-4	-11	-8	-7	-11	-6	-14	-12										
-49	-29	-33	-29	-29	-18	-20	-16	-17	-18	-17	-15										
-50	-12	-16	-12	-7	4	-3	-19	-9	0	2	-2	-9	-2	15	6	-2	-0	3	7	4	
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-56	20	16	12	15	13	18	29	42	51	53	58	74	98	20	-137	-151	-9	32	25	19	
-57	5	12	14	12	15	18	24	28	33	46	39	36	53	53	-19	-115	-56	22	27	18	
-58	13	8	8	18	23	18	21	27	31	37	44	47	54	68	32	-56	-69	7	26	23	
-59	22	14	7	8	25	20	20	29	31	35	41	42	36	21	-43	-113	-50	29	34	30	
-60																					

1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 26 B

	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
−30	6	6	6	5	7																
−31	6	7	7	6	6																
−32	10	6	6	7	8																
−33	9	8	8	8	6																
−34	9	7	19	8	8																
−35	7	12																			
−36	9	9																			
−37	7	7																			
−38	7	8																			
−39	7	7																			
−40	7	6	7	11	8	10															
−41	6	7	7	7	8	7															
−42	10	9	8	7	6	8															
−43	8	8	7	7	6	7															
−44	7	8	8	8	7	8															
−45	7	6	9	7	9	8	6	8	7	7	9										
−46	7	8	6	8	10	8	8	6	6	7	10										
−47	8	8	9	8	7	9	8	7	7	7	7										
−48	7	8	8	8	8	7	7	10	9	7	8										
−49	8	8	11	10	9	8	8	8	8	10	9										
−50	8	8	6	8	8	9	8	10	8	6	11	10	8	8	7	9	9	9	12	10	
−51	10	7	8	7	7	9	9	9	9	9	8	9	8	8	7	7	7	9	8	12	
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−54	9	9	8	11	12	12	9	10	7	8	7	8	8	8	8	8	8	8	7	8	
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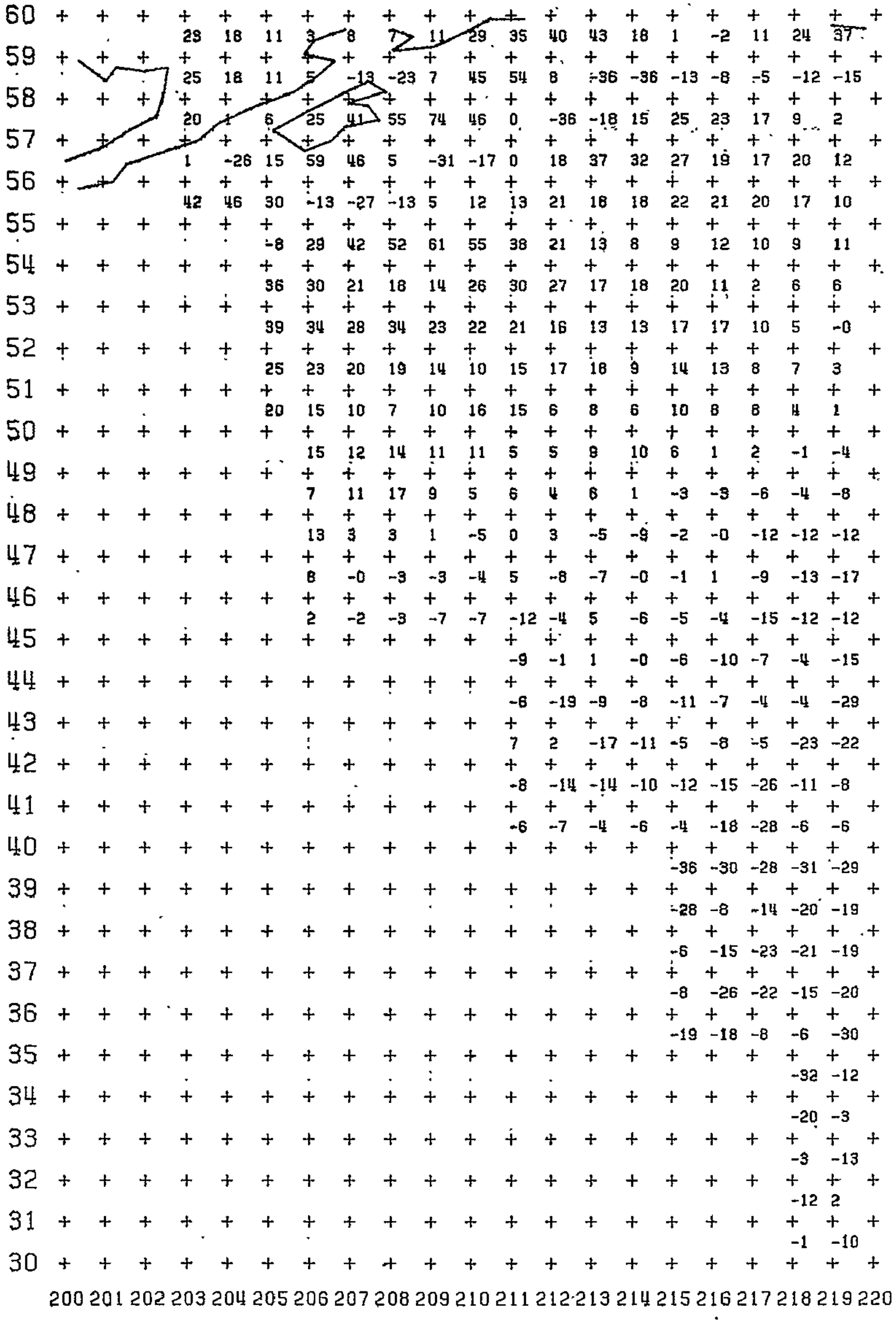
−56	10	10	8	9	9	8	7	8	7	8	9	9	8	8	7	6	9	9	7	10	
−57	8	8	8	9	8	9	7	8	8	8	8	9	8	9	8	7	8	7	10	9	
−58	8	8	7	8	8	9	8	8	9	8	9	9	10	10	9	10	10	9	8	9	
−59	8	8	8	9	9	10	9	9	10	12	12	11	12	10	8	9	10	9	9	8	
−60																					

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B 27 A



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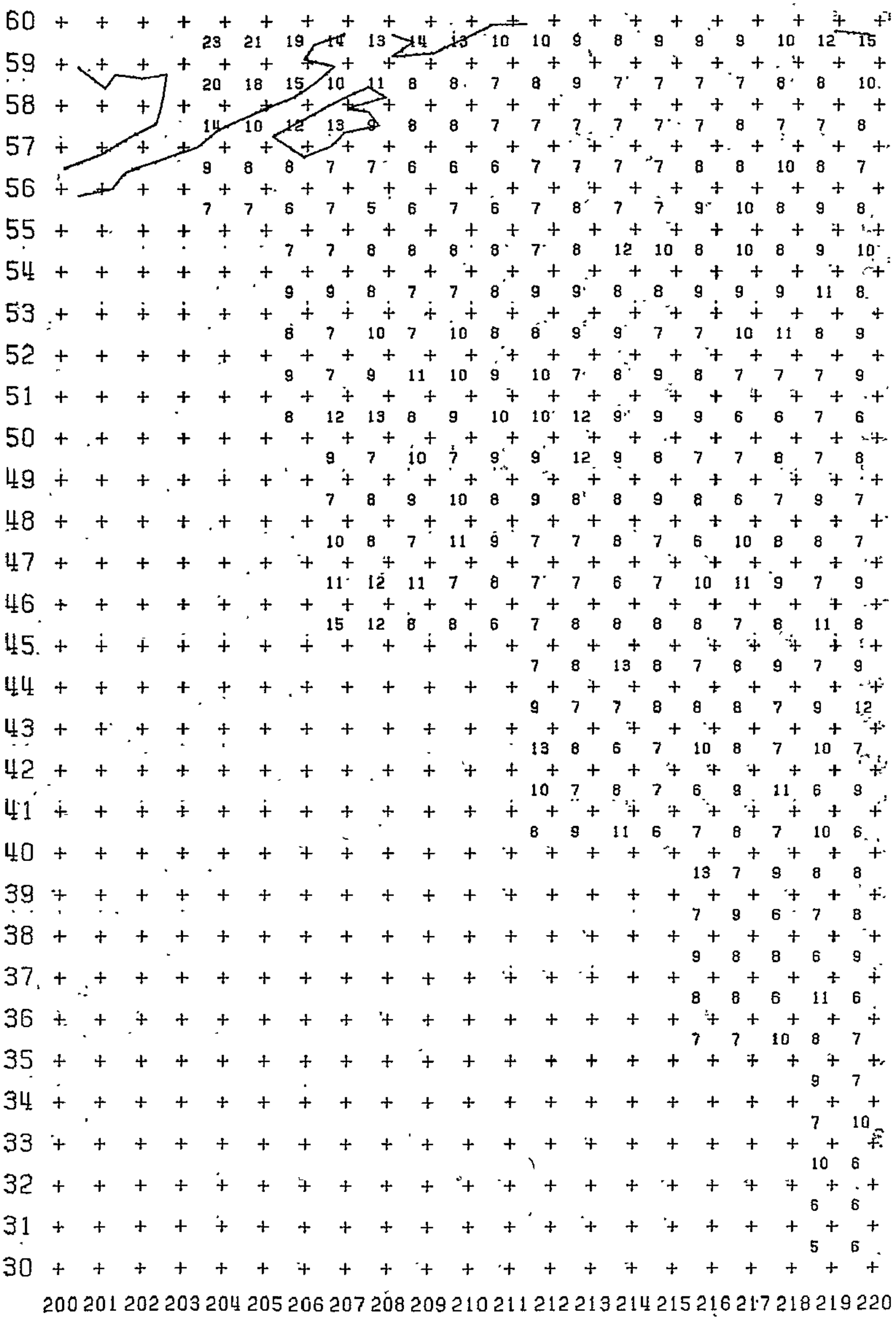
59	25	18	11	5	-13	-23	7	45	54	8	-36	-36	-13	-8	-5	-12	-15
58	20	1	6	25	41	55	74	46	0	-36	-18	15	25	23	17	9	2
57	1	-26	15	59	46	5	-31	-17	0	18	37	32	27	19	17	20	12
56	42	46	30	-13	-27	-13	5	12	13	21	18	18	22	21	20	17	10
55			-8	29	42	52	61	55	38	21	13	8	9	12	10	9	11
54			36	30	21	18	14	26	30	27	17	18	20	11	2	6	6
53			39	34	28	34	23	22	21	16	13	13	17	17	10	5	-0
52			25	23	20	19	14	10	15	17	18	9	14	13	8	7	3
51			20	15	10	7	10	16	15	6	8	6	10	8	8	4	1
50				15	12	14	11	11	5	5	8	10	6	1	2	-1	-4
49				7	11	17	9	5	6	4	6	1	-3	-3	-6	-4	-8
48				13	3	3	1	-5	0	3	-5	-9	-2	-0	-12	-12	-12
47				8	-0	-3	-3	-4	5	-8	-7	-0	-1	1	-9	-13	-17
46				2	-2	-3	-7	-7	-12	-4	5	-6	-5	-4	-15	-12	-12
45									-9	-1	1	-0	-6	-10	-7	-4	-15
44									-6	-19	-9	-8	-11	-7	-4	-4	-29
43									7	2	-17	-11	-5	-8	-5	-23	-22
42									-8	-14	-14	-10	-12	-15	-26	-11	-8
41									-6	-7	-4	-6	-4	-18	-28	-6	-6
40													-36	-30	-28	-31	-29
39													-28	-8	-14	-20	-19
38													-6	-15	-23	-21	-19
37													-8	-26	-22	-15	-20
36													-19	-18	-8	-6	-30
35																-32	-12
34																-20	-3
33																-3	-13
32																-12	2
31																-1	-10

1°x 1° Mean Free-Air Anomalies (mgals)

Figure B 27 B



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60																					
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59																					
				20	18	15	10	11	8	8	7	8	9	7	7	7	7	8	8	10	
58																					
				14	10	12	13	9	8	8	7	7	7	7	7	7	8	7	7	8	
57																					
				9	8	8	7	7	6	6	6	7	7	7	7	8	8	10	8	7	
56																					
				7	7	6	7	5	6	7	6	7	8	7	7	9	10	8	9	8	
55																					
						7	7	8	8	8	8	7	8	12	10	8	10	8	9	10	
54																					
						9	9	8	7	7	8	9	9	8	8	9	9	9	11	8	
53																					
						8	7	10	7	10	8	8	9	9	7	7	10	11	8	9	
52																					
						9	7	9	11	10	9	10	7	8	9	8	7	7	7	9	
51																					
						8	12	13	8	9	10	10	12	9	9	9	6	6	7	6	
50																					
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49																					
							7	8	9	10	8	9	8	8	9	8	6	7	9	7	
48																					
							10	8	7	11	9	7	7	8	7	6	10	8	8	7	
47																					
							11	12	11	7	8	7	7	6	7	10	11	9	7	9	
46																					
							15	12	8	8	6	7	8	8	8	8	7	8	11	8	
45																					
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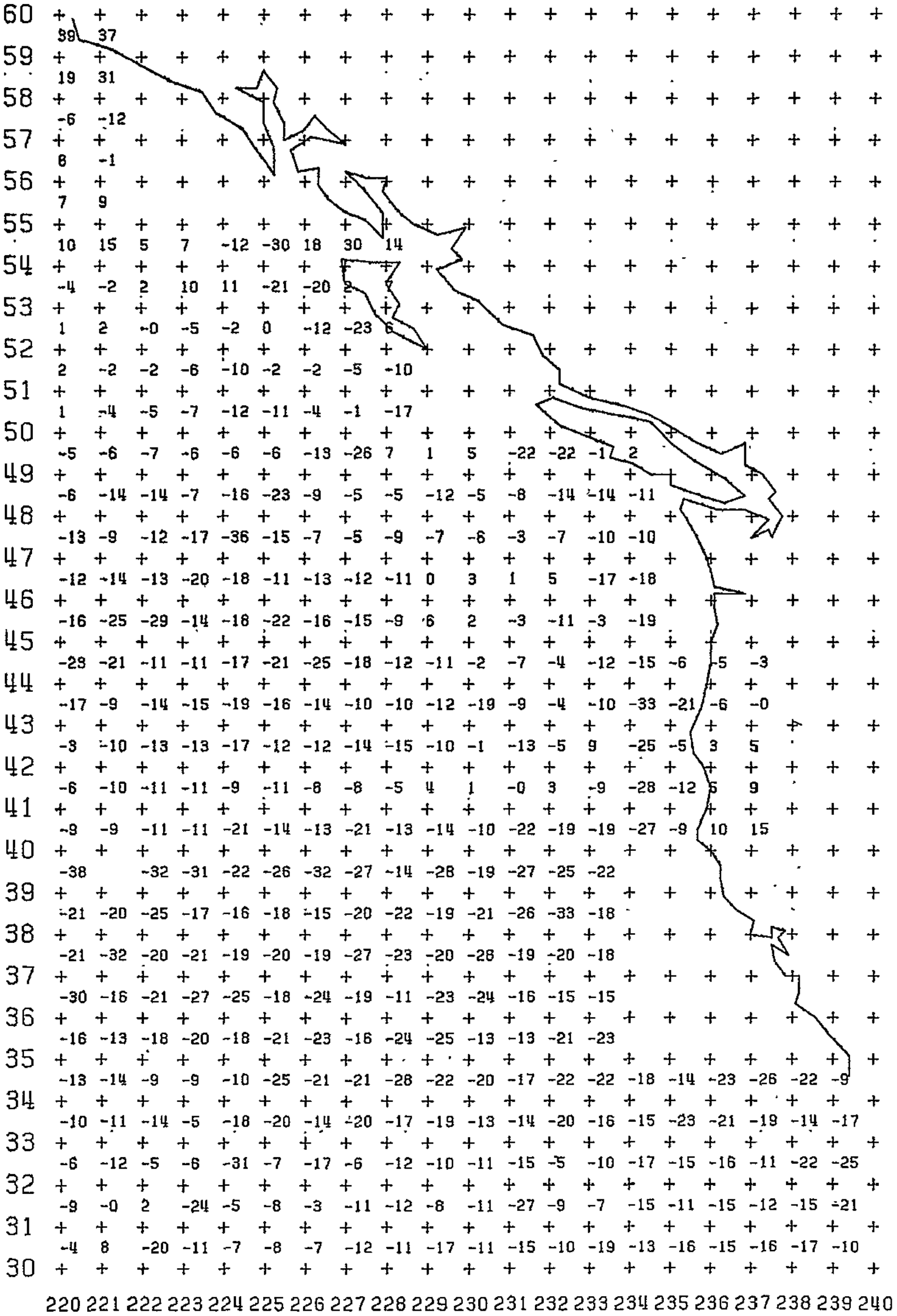
44																					
												9	7	7	8	8	8	7	9	12	
43																					
												13	8	6	7	10	8	7	10	7	
42																					
												10	7	8	7	6	9	11	6	9	
41																					
												8	9	11	6	7	8	7	10	6	
40																					
																13	7	9	8	8	
39																					
																7	9	6	7	8	
38																					
																9	8	8	6	9	
37																					
																8	8	6	11	6	
36																					
																7	7	10	8	7	
35																					
																			9	7	
34																					
																			7	10	
33																					
																			10	6	
32																					
																			6	6	
31																					
																			5	6	
30																					

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

Figure B 28 A



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60	39	37																			
59	19	31																			
58	-6	-12																			
57	8	-1																			
56	7	9																			
55	10	15	5	7	-12	-30	18	30	14												
54	-4	-2	2	10	11	-21	-20	2	7												
53	1	2	-0	-5	-2	0	-12	-23	6												
52	2	-2	-2	-6	-10	-2	-2	-5	-10												
51	1	-4	-5	-7	-12	-11	-4	-1	-17												
50	-5	-6	-7	-6	-6	-6	-13	-26	7	1	5	-22	-22	-1	2						
49	-6	-14	-14	-7	-16	-23	-9	-5	-5	-12	-5	-8	-14	-14	-11						
48	-13	-9	-12	-17	-36	-15	-7	-5	-9	-7	-6	-3	-7	-10	-10						
47	-12	-14	-13	-20	-18	-11	-13	-12	-11	0	3	1	5	-17	-18						
46	-16	-25	-29	-14	-18	-22	-16	-15	-9	6	2	-3	-11	-3	-19						
45	-23	-21	-11	-11	-17	-21	-25	-18	-12	-11	-2	-7	-4	-12	-15	-6	-5	-3			
44	-17	-9	-14	-15	-19	-16	-14	-10	-10	-12	-19	-9	-4	-10	-33	-21	-6	-0			
43	-3	-10	-13	-13	-17	-12	-12	-14	-15	-10	-1	-13	-5	9	-25	-5	3	5			
42	-6	-10	-11	-11	-9	-11	-8	-8	-5	4	1	-0	3	-9	-28	-12	5	9			
41	-9	-9	-11	-11	-21	-14	-13	-21	-13	-14	-10	-22	-19	-19	-27	-9	10	15			
40	-38		-32	-31	-22	-26	-32	-27	-14	-28	-19	-27	-25	-22							
39	-21	-20	-25	-17	-16	-18	-15	-20	-22	-19	-21	-26	-33	-18							
38	-21	-32	-20	-21	-19	-20	-19	-27	-23	-20	-28	-19	-20	-18							
37	-30	-16	-21	-27	-25	-18	-24	-19	-11	-23	-24	-16	-15	-15							
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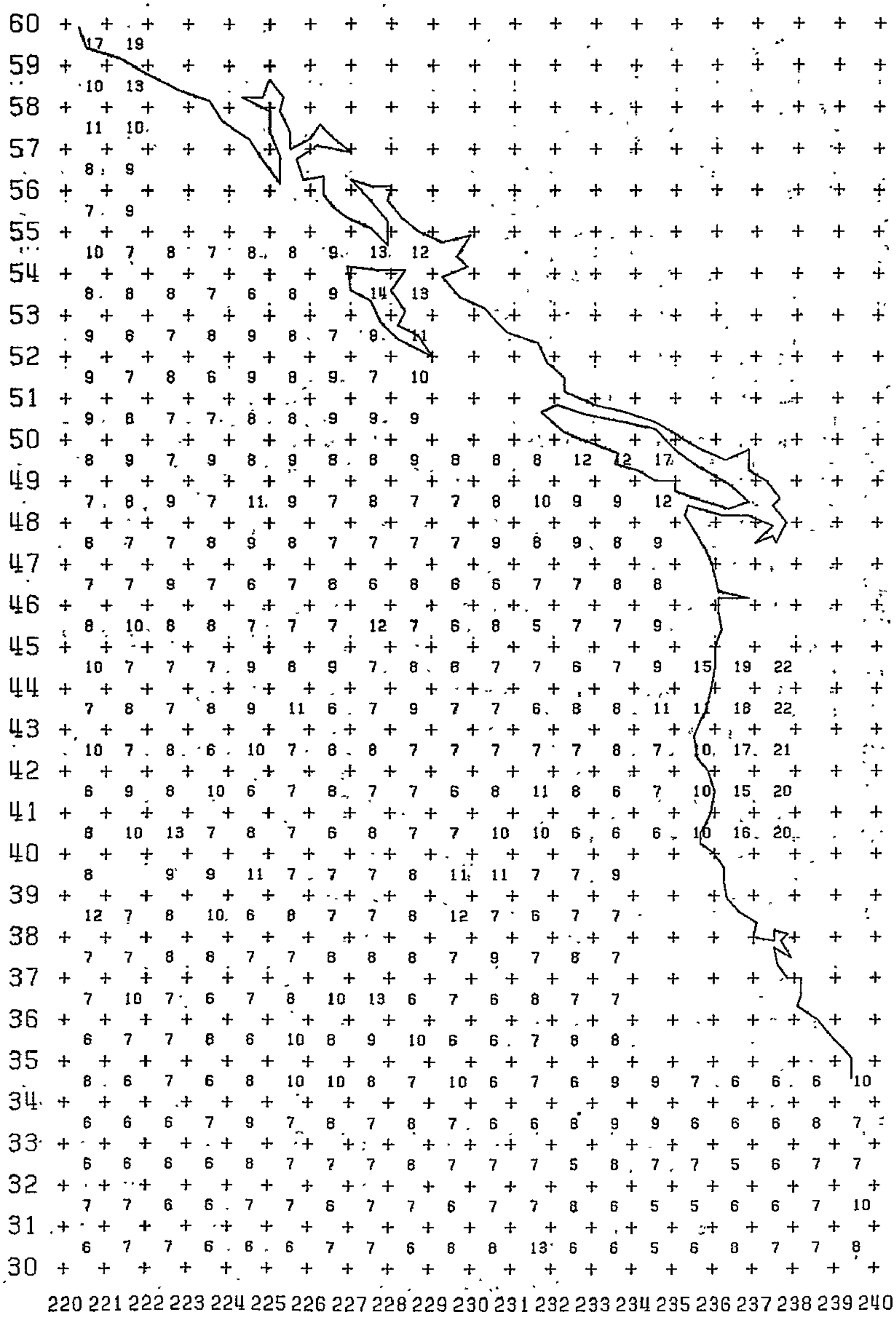
34	-10	-11	-14	-5	-18	-20	-14	-20	-17	-19	-13	-14	-20	-16	-15	-23	-21	-19	-14	-17	
33	-6	-12	-5	-6	-31	-7	-17	-6	-12	-10	-11	-15	-5	-10	-17	-15	-16	-11	-22	-25	
32	-9	-0	2	-24	-5	-8	-3	-11	-12	-8	-11	-27	-9	-7	-15	-11	-15	-12	-15	-21	
31	-4	8	-20	-11	-7	-8	-7	-12	-11	-17	-11	-15	-10	-19	-13	-16	-15	-16	-17	-10	
30																					

1°x 1°. Mean Free-Air Anomalies (mgals)

Figure B 28 B



Accuracy of Predicted 1°x 1° Mean Anomalies (mgals)

Figure B 29 A

30	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	2	-9	-21	6	-9	-7	-7	-7	-14	-18	-12	-14	-22	-16	-17	-21	-17	-16	-17	-12	
29	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	2	-30	7	-13	-3	-9	-4	-7	-8	-14	-16	-22	-23	-18	-17	-11	-17	-17	-18	-17	
28	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-16	-10	-6	-1	-7	-4	-12	-7	-19	-12	-14	-20	-19	-19	-18	-15	-20	-24	-17	-18	
27	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-10	8	-4	-4	-3	-13	-9	-9	-13	-14	-18	-19	-17	-25	-18	-18	-18	-20	-15	-22	
26	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-4	-11	5	-0	-13	-6	-7	-21	-6	-29	-25	-16	-22	-19	-21	-22	-21	-19	-27	-22	
25	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
												-13	-16	-17	-10	-17	-24	-21	-25	-18	
24	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
												-10	-13	-18	-7	-18	-19	-23	-15	-26	
23	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
												-11	-10	-20	-19	-11	-19	-22	-22	-23	
22	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
												-16	-16	-21	-21	-16	-17	-27	-27	-20	
21	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
												-19	-17	-23	-22	-20	-20	-24	-24	-19	
20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
																-24	-30	-15	-22	-22	
19	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
																-19	-24	-22	-12	-26	
18	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
																-27	-20	-14	-19	-22	
17	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
																-22	-18	-22	-21	-10	
16	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
																-17	-16	-17	-27	-25	
15	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
14	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
13	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
12	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
11	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
9	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
8	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
7	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
6	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
5	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
4	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240

1°x 1° Mean Free-Air Anomalies (mgals)

ORIGINAL PAGE IS
OF POOR QUALITY

Figure B 29 B

	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
30																					
	7	7	7	7	7	7	7	7	6	7	11	8	7	7	6	8	9	7	7	7	
29																					
	6	7	6	7	6	6	6	10	7	7	11	7	7	6	7	6	7	11	9	7	
28																					
	7	6	7	6	8	6	6	6	7	10	6	6	6	6	9	8	7	9	8	7	
27																					
	8	7	6	7	8	7	6	6	12	7	6	7	6	9	9	7	6	6	8	7	
26																					
	14	9	8	7	8	9	7	6	7	6	7	6	8	8	9	12	8	6	6	10	
25																					
												7	6	10	7	13	10	6	6	6	
24																					
												10	6	6	11	6	9	7	6	8	
23																					
												7	9	6	10	7	6	9	6	7	
22																					
												10	7	9	7	7	6	8	11	6	
21																					
												7	13	7	6	6	9	9	7	7	
20																					
																6	6	7	6	9	
19																					
																7	8	6	8	6	
18																					
																8	6	6	6	7	
17																					
																15	7	7	6	7	
16																					
																17	13	7	9	7	
15																					
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8																					
7																					
6																					
5																					
4																					
3																					
2																					
1																					
0																					

Accuracy of Predicted 1° x 1° Mean Anomalies (mgals)

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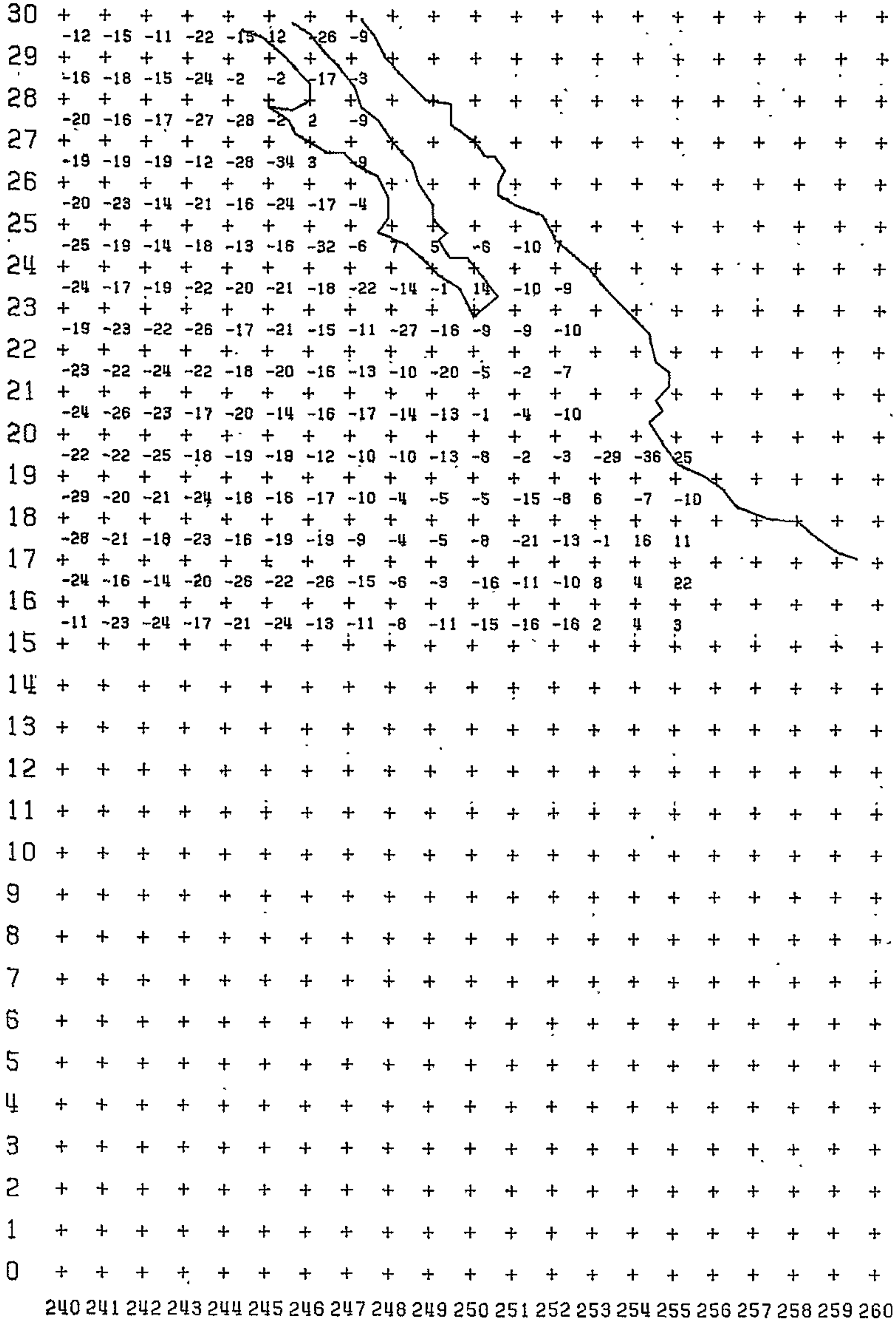
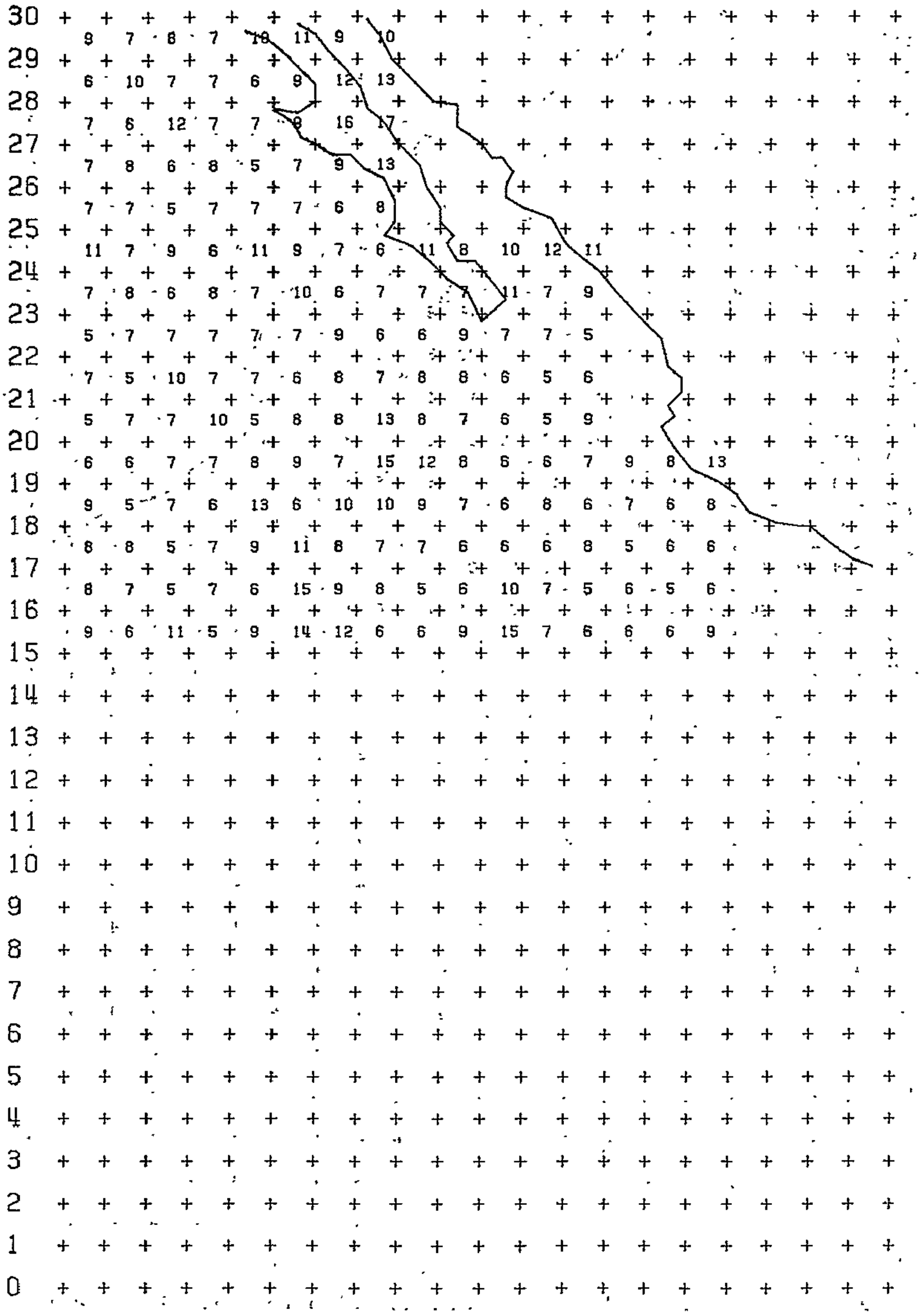
OF POOR QUALITY

Figure B 30 A



1°x 1° Mean Free-Air Anomalies.(mgals)

Figure B 30 B



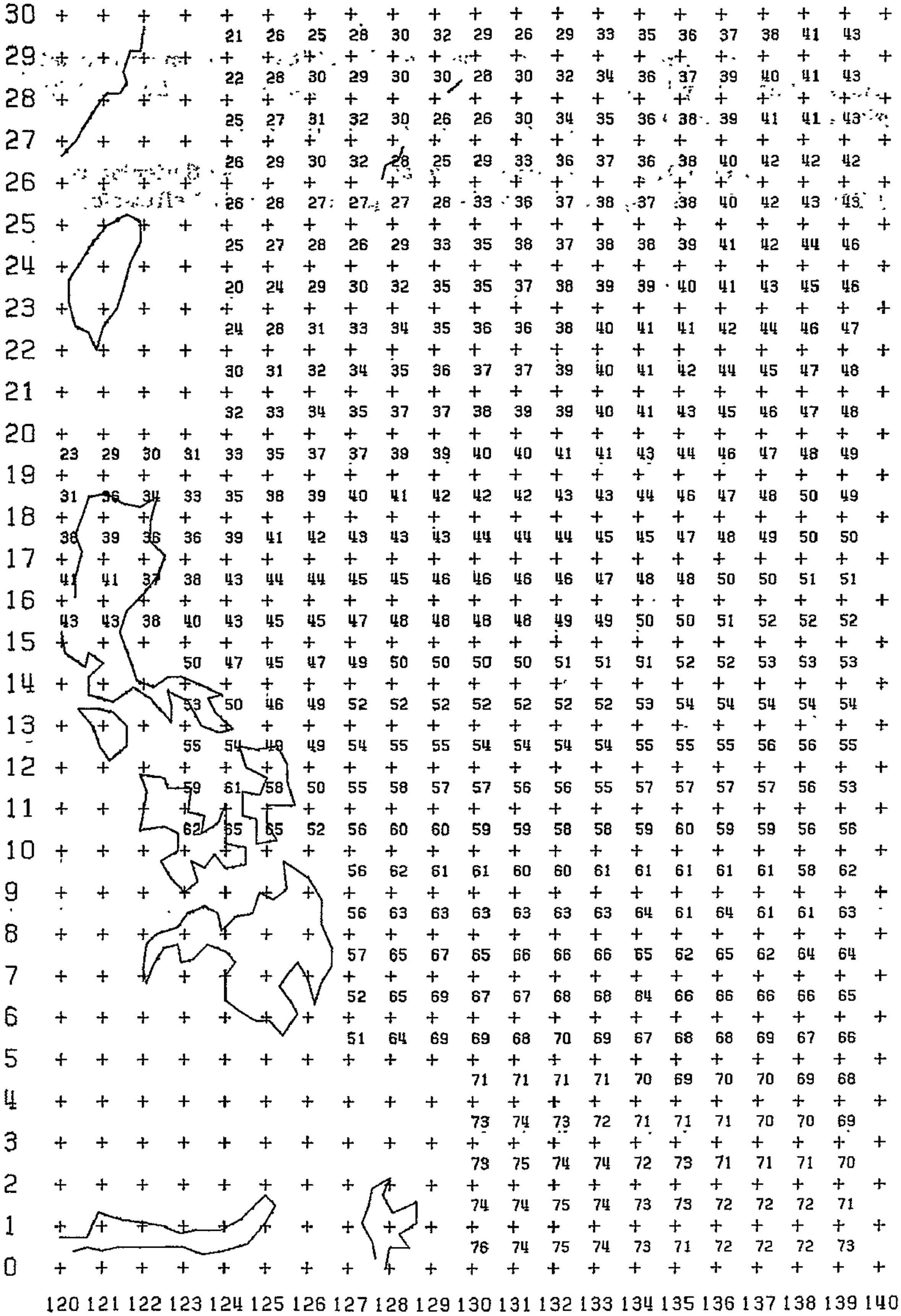
Accuracy of Predicted 1°x 1° Mean Anomalies (mgals)

Appendix C

This appendix contains a sample plot of the 1° x 1° mean undulations and their accuracy for one geographic region (Block 3 shown in the index map given in Appendix B).

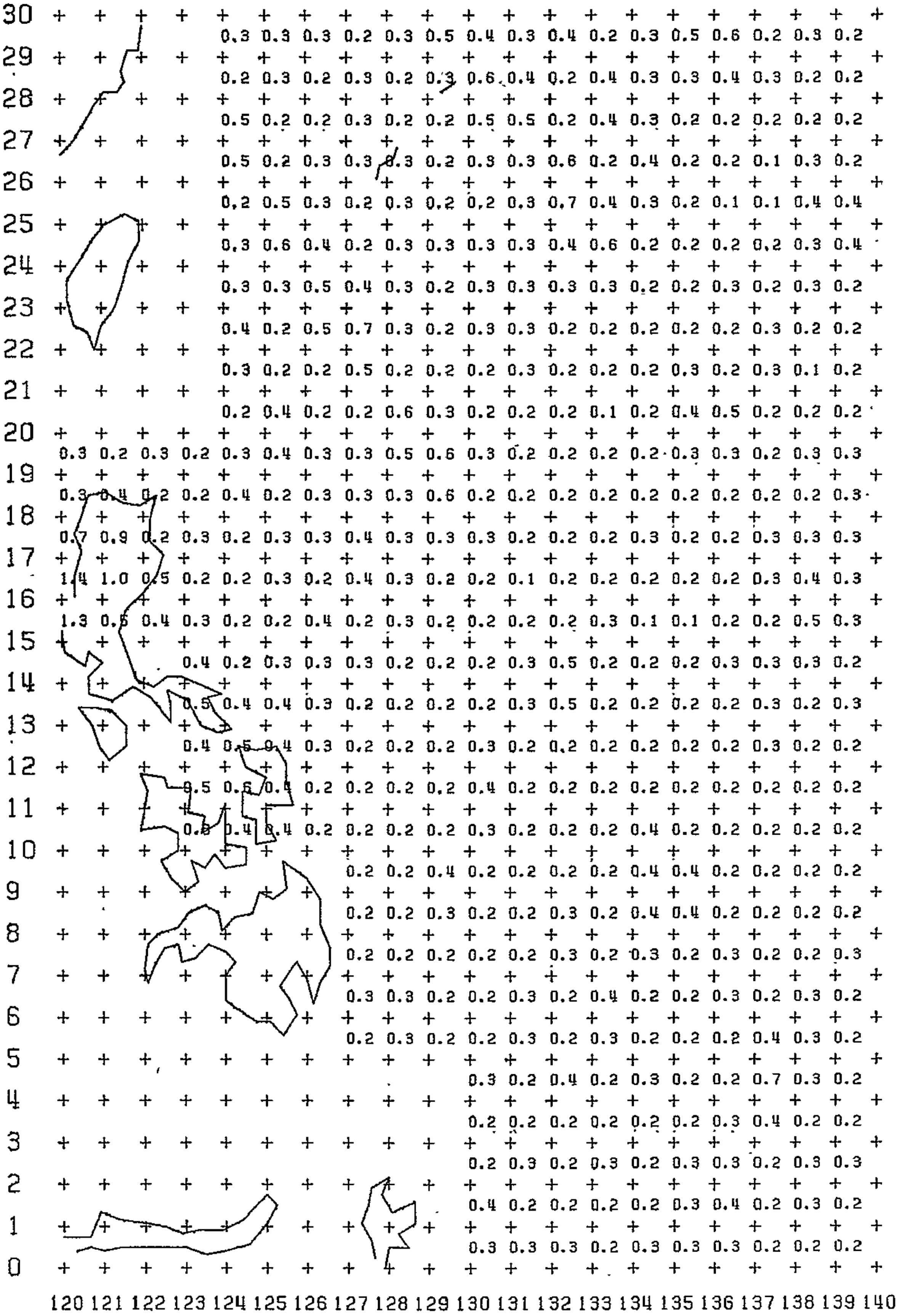
The undulations given refer to an ellipsoid whose flattening is 1/298.257 and whose equatorial radius of the given terrestrial ellipsoid.

Figure C 1



1° x 1° Mean Geoid Undulations (meters)

Figure C 2



	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139
30					0.3	0.3	0.3	0.2	0.3	0.5	0.4	0.3	0.4	0.2	0.3	0.5	0.6	0.2	0.3	0.2
29					0.2	0.3	0.2	0.3	0.2	0.3	0.6	0.4	0.2	0.4	0.3	0.3	0.4	0.3	0.2	0.2
28					0.5	0.2	0.2	0.3	0.2	0.2	0.5	0.5	0.2	0.4	0.3	0.2	0.2	0.2	0.2	0.2
27					0.5	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.6	0.2	0.4	0.2	0.2	0.1	0.3	0.2
26					0.2	0.5	0.3	0.2	0.3	0.2	0.2	0.3	0.7	0.4	0.3	0.2	0.1	0.1	0.4	0.4
25					0.3	0.6	0.4	0.2	0.3	0.3	0.3	0.3	0.4	0.6	0.2	0.2	0.2	0.2	0.3	0.4
24					0.3	0.3	0.5	0.4	0.3	0.2	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.3	0.2
23					0.4	0.2	0.5	0.7	0.3	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2
22					0.3	0.2	0.2	0.5	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.2	0.3	0.1	0.2
21					0.2	0.4	0.2	0.2	0.6	0.3	0.2	0.2	0.2	0.1	0.2	0.4	0.5	0.2	0.2	0.2
20	0.3	0.2	0.3	0.2	0.3	0.4	0.3	0.3	0.5	0.6	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.3
19	0.3	0.4	0.2	0.2	0.4	0.2	0.3	0.3	0.3	0.6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
18	0.7	0.9	0.2	0.3	0.2	0.3	0.3	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.3
17	1.4	1.0	0.5	0.2	0.2	0.3	0.2	0.4	0.3	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.3
16	1.3	0.6	0.4	0.3	0.2	0.2	0.4	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.1	0.1	0.2	0.2	0.5	0.3
15				0.4	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.3	0.5	0.2	0.2	0.2	0.3	0.3	0.3	0.2
14				0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.3	0.5	0.2	0.2	0.2	0.2	0.3	0.2	0.3
13				0.4	0.5	0.4	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2
12				0.5	0.6	0.4	0.2	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
11				0.8	0.4	0.4	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.2	0.2
10								0.2	0.2	0.4	0.2	0.2	0.2	0.2	0.4	0.4	0.2	0.2	0.2	0.2
9								0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.4	0.4	0.2	0.2	0.2	0.2
8								0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.3	0.2	0.2	0.3
7								0.3	0.3	0.2	0.2	0.3	0.2	0.4	0.2	0.2	0.3	0.2	0.3	0.2
6								0.2	0.3	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.2	0.4	0.3	0.2
5											0.3	0.2	0.4	0.2	0.3	0.2	0.2	0.7	0.3	0.2
4											0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.2	0.2
3											0.2	0.3	0.2	0.3	0.2	0.3	0.3	0.2	0.3	0.3
2											0.4	0.2	0.2	0.2	0.2	0.3	0.4	0.2	0.3	0.2
1											0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.2	0.2

1° x 1° Mean-Undulation Accuracies (meters)

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16 Abstract

Approximately 2000 GEOS-3 altimeter arcs, supplied by the NASA Wallops Flight Center and received by September 1977, have been analyzed to improve our knowledge of the geoid and gravity field. The first step in this process was a complex editing procedure used to eliminate bad and unacceptable data. After this, an adjustment procedure was used to fit the sea surface heights (geoid undulations) implied by the altimeter data to the geoid undulations implied by the GEM 9 potential coefficients, in an adjustment process that incorporated cross-over constraints. The error model used for the fit was a one or two parameter model which was designed to remove altimeter bias and orbit error. The adjustment process was carried out in two stages: first in a primary net of global data in 854 arcs; second in six regional areas. Typical a priori cross-over discrepancies were ±8 meters while a posteriori discrepancies were on the order of ±0.6 meters.

The undulations on the adjusted arcs were used to produce geoid maps in 20 regions where the data was suitably dense. In addition, the adjusted data was used to derive 301 5° equal area anomalies and 9995 1°x1° anomalies in areas where the altimeter data was most dense, using least squares collocation techniques. The average predicted accuracy of the 5° anomalies was ±3 mgals, and ±6 mgals for the 1°x1° values. Comparisons with terrestrial data indicate these anomaly accuracies were reasonable. We also emphasized the ability of the altimeter data to imply rapid anomaly changes of up to 240 mgals in adjacent 1°x1° blocks.

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