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An Atlas of the 180th Order WGS84 Geopotential (U)

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Naval Center for Space Technology

November 14, 1988

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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

(U) To compare the detailed differences in geopotential models, a series of graphics of the undulation of the geoid, anomalous gravity components, and gravity gradient components for WGS84 are presented as complementary contour maps. This report is a companion to NRL Report 9155, dated November 14, 1988, that is unclassified.

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CONTENTS (U)

AN ATLAS OF THE 180TH ORDER WGS84 GEOPOTENTIAL (U)

(U) INTRODUCTION

(U) This atlas of fields derived from the WGS84 spherical harmonic, Earth gravitational model is a companion to Ref. 1. The series of complementary contour images in Ref. 1 and in this report were created in the same time frame (summer of 1986), at the same scale, with the same software as described in Ref. 2, and on the same equipment. At that time the only other high quality 180th order geopotential in the author's possession was RAPP81 of Ref. 3.

(U) When the images of this report and Ref. 1 were created, there were no sources for an independent comparison of large scale, global maps. It is thus pleasing that the map of the undulation found here and in Ref. 4 agree so well. The author has not yet seen similar maps of the other components presented here and in Ref. 1.

(U) AN ATLAS OF THE 180TH ORDER WGS84 GEOPOTENTIAL

(U) The development of the complementary contour image means that the separation of positive and negative contours used in Ref. 2 to gain partially quantitative information from unlabeled contours is not necessary. Complete quantitative information is not gained, however, because counting contours works only in regions of a monotone gradient from the zero level that separates the white and black backgrounds. Further information is needed to decide whether a closed contour represents a bump up or a bump down in the field. This report presents 14 maps of WGS84, but here all 10 fields available from the algorithm of Ref. 2 are plotted.

(U) Figure 1(a) is the undulation of the geoid with a 2-m contour interval; Fig. 1(b) is the radial gravity disturbance with a 10-mGal contour interval. Figures 2(a) and 2(b) are the longitude and latitude gravity disturbances with a contour interval of 10 mGal.

(U) The next six maps are of components of the anomalous gravity gradient tensor with a contour interval of two Eötvös units. Figure 3(a) is the radial-longitude component; Fig. 3(b) is the radial-latitude component. The second radial derivative of the geopotential is plotted in Fig. 4(a); the longitude-longitude component is plotted in Fig. 4(b). Figure 5(a) plots the latitude-longitude component. It is this component that most accentuates any satellite ephemeris error that may be carried over into the geopotential model from the radar altimetry data. Figure 5(b) plots the latitude-latitude gravity gradient component.

(U) Figures 6 and 7 are transverse Mercator projections showing polar behavior. The central longitude is 64°. Figure 6(a) shows the undulation of the geoid; Fig. 6(b) shows the radial gravity disturbance. Figure 7(a) shows the longitude anomaly; Fig. 7(b) shows the latitude anomaly.

Manuscript approved August 12, 1988.

(U) COMPARISON OF EXTREMA

(C) The author has no independent source of data to judge the correctness of any gravity model, but visually comparing the figures of this document with those of Ref. 1 shows that WGS84 appears more credible than RAPP81 in certain areas, in particular the polar regions. WGS84 has better control of the satellite ground trace problem in the gravity disturbance components than does RAPP81, but examination of the lineations in the gravity gradient components shows that WGS84 also has artifacts of satellite ground traces. WGS84 does not exhibit the Gibbs phenomenon near the very short wavelength features such as the trenches and Hawaii as does RAPP81.

(U) There appears to be a price to be paid for eliminating the Gibb's phenomena, however, that is not apparent from the maps. The first step in creating the maps is evaluating the spherical harmonics on a regular, 1/2°, equal angular grid. The field values are then obtained by linear interpolation from the grid to create the contours and mask for the complementary contour image. As part of the software for creating the grid, the extreme values of the fields are printed. The values obtained for WGS84 and RAPP81 are given in Table 1.

(C) Reference 2 notes that the extremes of RAPP81 are smaller than the measured values. For instance, the gravity anomaly in Hawaii is the largest known value at more than 700 mGal. The radial gravity disturbance of RAPP81 is roughly half that value but for WGS84 it is about one-third. Table 1 shows that the absolute values of the extrema of WGS84 are significantly less than those of RAPP81.

(U) REFERENCES

1. P.J. Melvin, "Images of the Geopotential," NRL Report 9155, Nov. 1988.

2. P.J. Melvin, "An Atlas of Rapp's 180-th Order Geopotential," (AAS 85-333), *Astrodynamics 1985*, Vol. 58, *Part 1, Advances in the Astronautical Sciences*, Kaufman, Liu, Calico, and Hoots, eds., Proc. AAS/AIAA Astrodynamics Specialist Conference, Vail, Colorado, Aug. 1985 (Univelt, San Diego, CA, 1986) pp. 677-696.

3. R.H. Rapp, "The Earth's Gravity Field to Degree and Order 180 Using SEASAT Altimeter Data, Terrestrial Gravity Data, and Other Data," Report No. 322, Department of Geodetic Science, The Ohio State University, 1981.

4. R.W. Smith, "Technical Report: Part III — Non-Releasable WGS 84 Geoid, Earth Gravitational Model, and Datum Shift Information and/or Graphics (U)," Defense Mapping Agency DMA TR 8350.2-C, 1987 (Confidential).

Table 1. (U) 180th Order Extrema

Field	RAPP81 Latitude	RAPP81 Longitude	RAPP81 Min/Max	WGS84 Latitude	WGS84 Longitude	WGS84 Min/Max
Undulation of	5.0	79.0	−107 m	4.5	79.5	−107 m
geoid	−5.5	143.0	83 m	−4.5	149.0	81 m
Radial	19.5	−155.5	−329 mGal	19.5	−155.5	−254 mGal
disturbance	19.5	−66.5	288 mGal	19.5	−66.5	251 mGal
Longitude	33.5	141.0	−206 mGal	33.5	141.0	−186 mGal
disturbance	−19.5	−70.5	218 mGal	−26.0	−70.5	183 mGal
Latitude	18.0	−66.0	−208 mGal	18.5	−66.5	−160 mGal
disturbance	27.0	87.0	227 mGal	29.5	80.0	189 mGal
Radial-longitude	19.5	−156.5	−35.4 E	19.5	−156.5	−25.8 E
gravity gradient	48.5	155.5	34.6 E	33.5	141.0	27.8 E
Radial-latitude	45.0	150.0	−38.7 E	45.0	150.5	−29.9 E
gravity gradient	20.5	−155.5	33.2 E	19.0	−66.0	27.4 E
Radial-radial	44.0	150.0	−51.5 E	44.0	150.0	−39.1 E
gravity gradient	19.5	−155.5	61.3 E	19.5	−155.5	46.5 E
Longitude-longitude	−31.5	−71.5	−27.6 E	−31.5	−71.5	−21.8 E
gravity gradient	33.5	141.0	30.8 E	33.5	141.0	26.0 E
Longitude-latitude	20.5	−155.5	−19.1 E	20.5	−155.5	−14.6 E
gravity gradient	44.5	149.5	20.2 E	44.5	149.5	15.6 E
Latitude-latitude	19.5	−155.5	−27.7 E	19.5	−155.5	−21.7 E
gravity gradient	19.5	−66.5	37.8 E	19.5	−66.5	31.3 E

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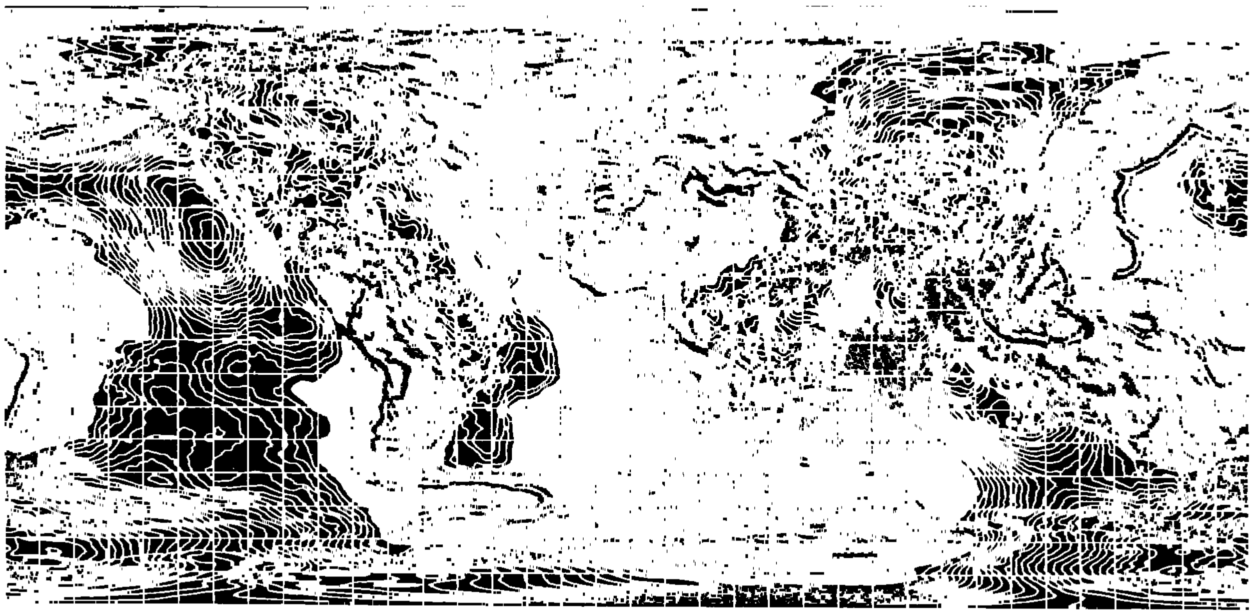
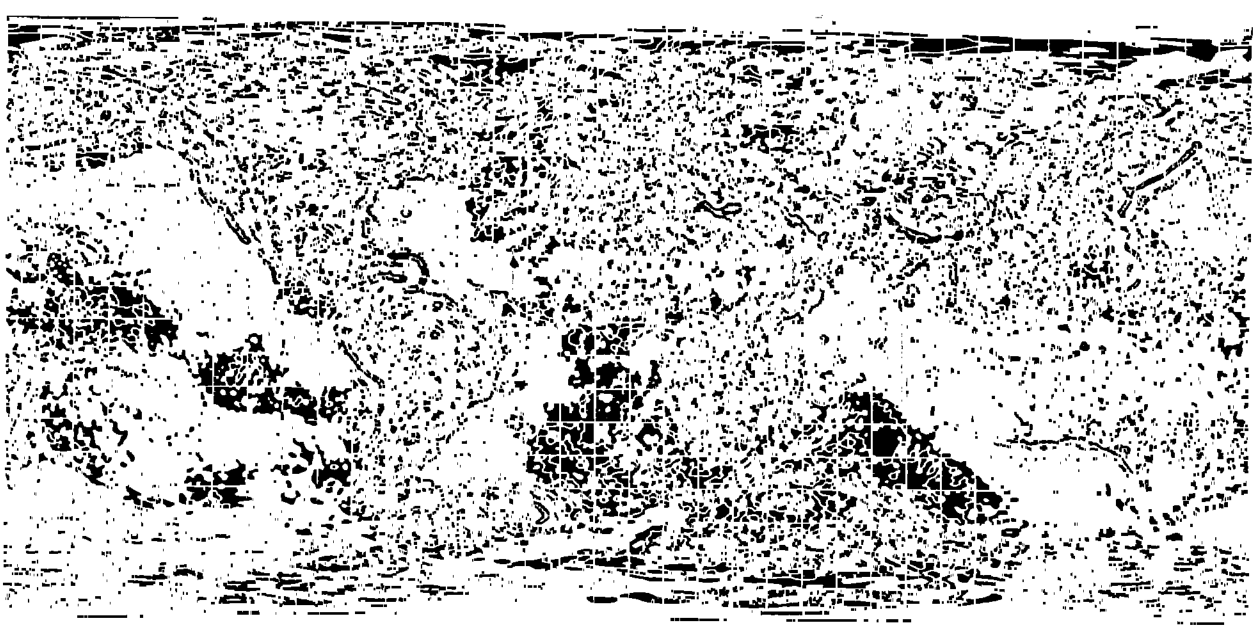


(a) Undulation of the geoid



(b) Gravity disturbance

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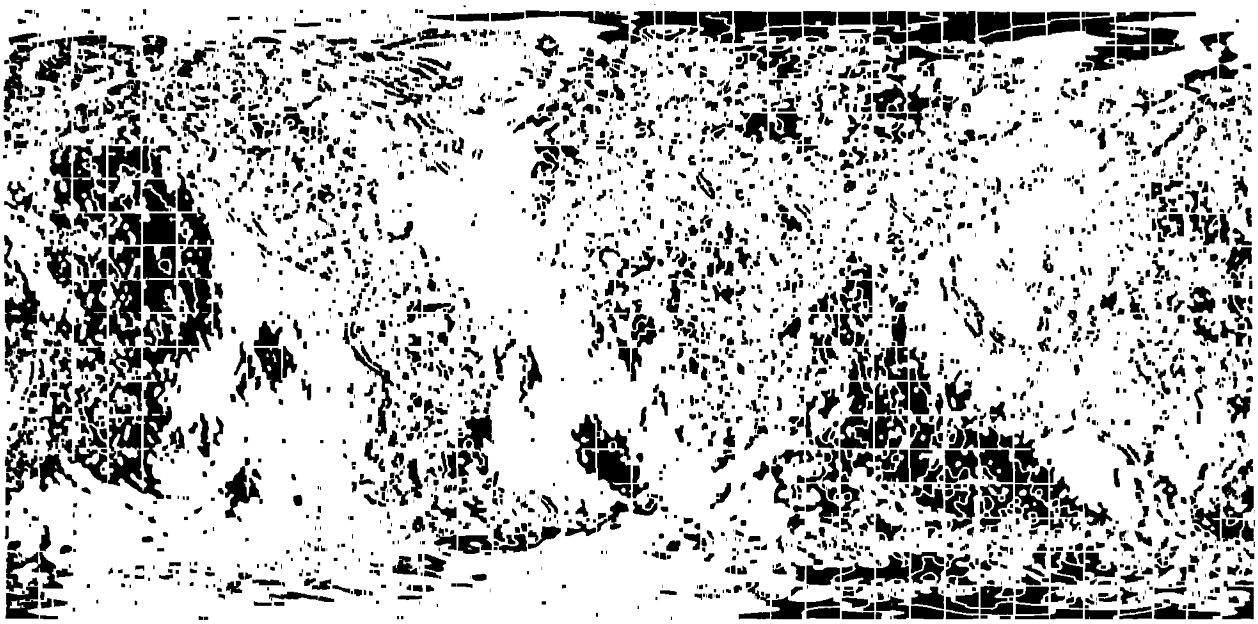
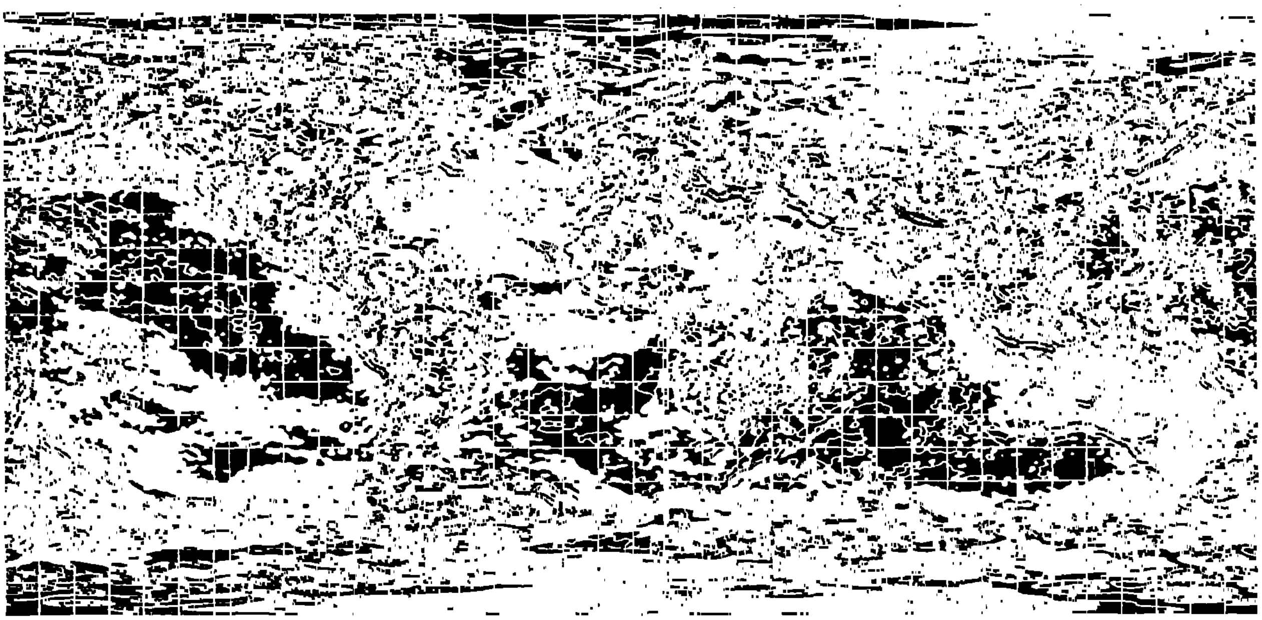
Fig. 1 — (U) WGS84, 180th order geopotential model



(a) Longitude disturbance



(b) Latitude disturbance

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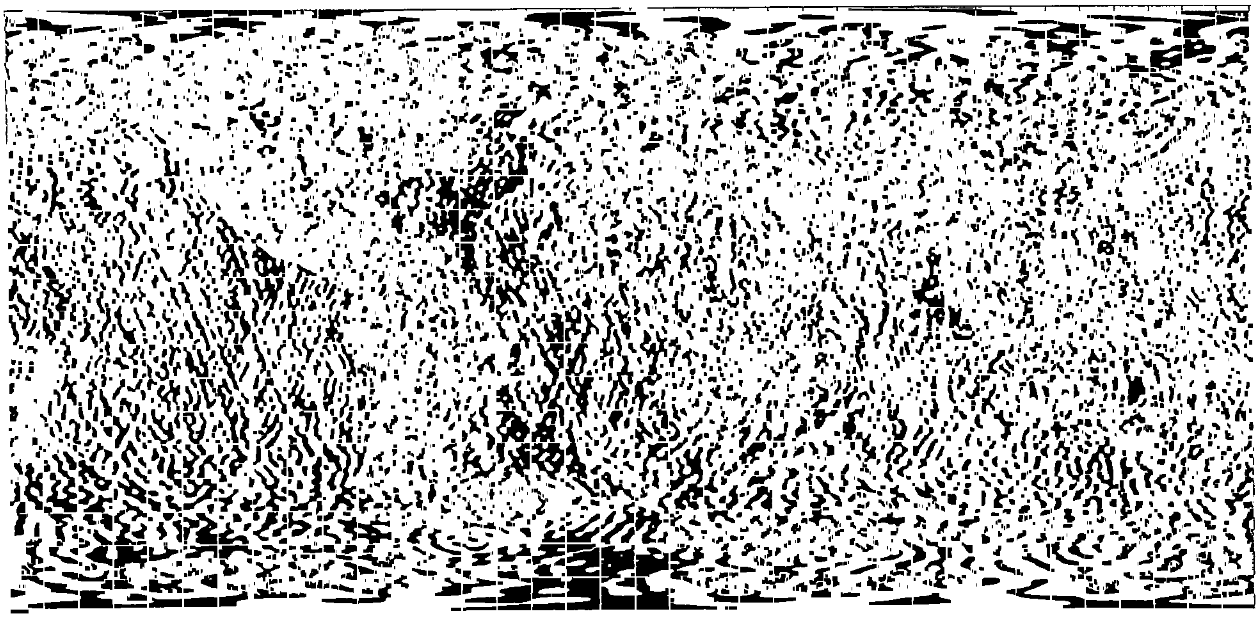
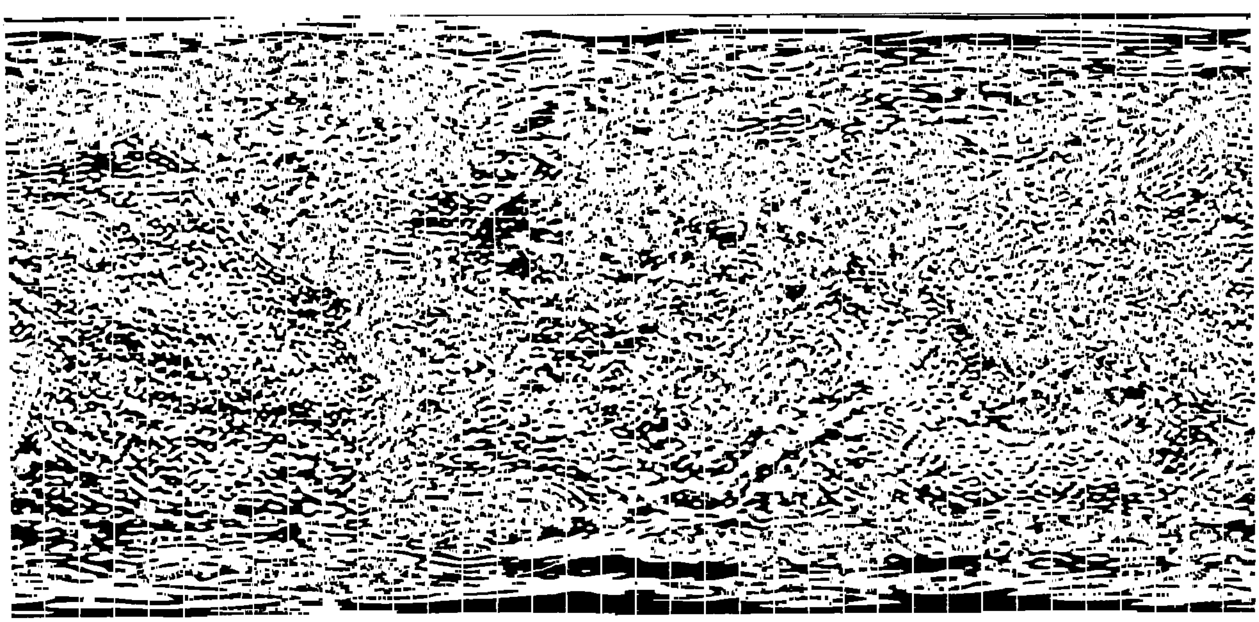
Fig. 2 — (U) WGS84, 180th order geopotential model



(a) Anomalous radial-longitude gravity gradient



(b) Anomalous radial-latitude gravity gradient

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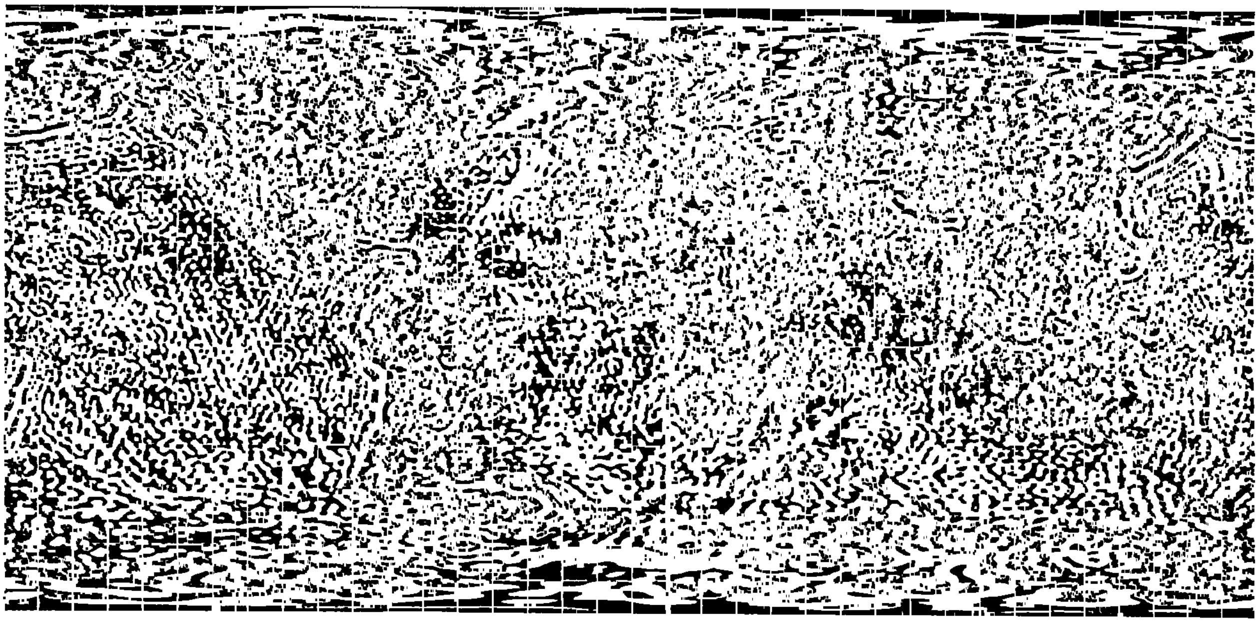
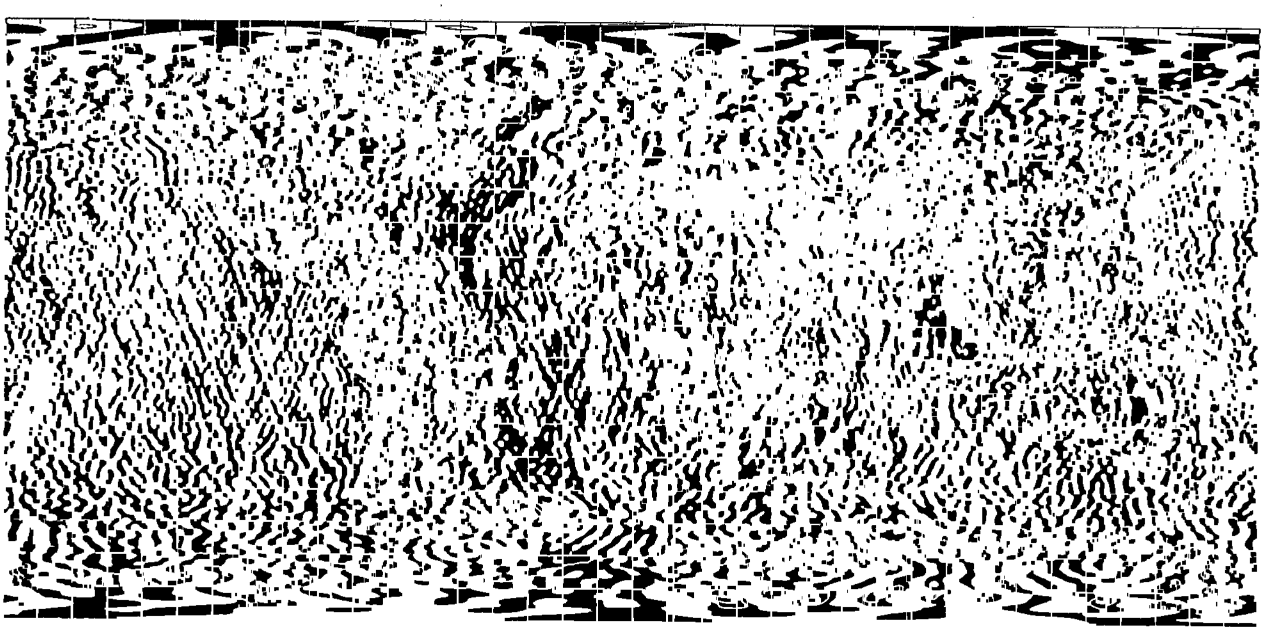
Fig. 3 — (U) WGS84, 180th order geopotential model



(a) Anomalous radial-radial gravity gradient



(b) Anomalous longitude-longitude gravity gradient

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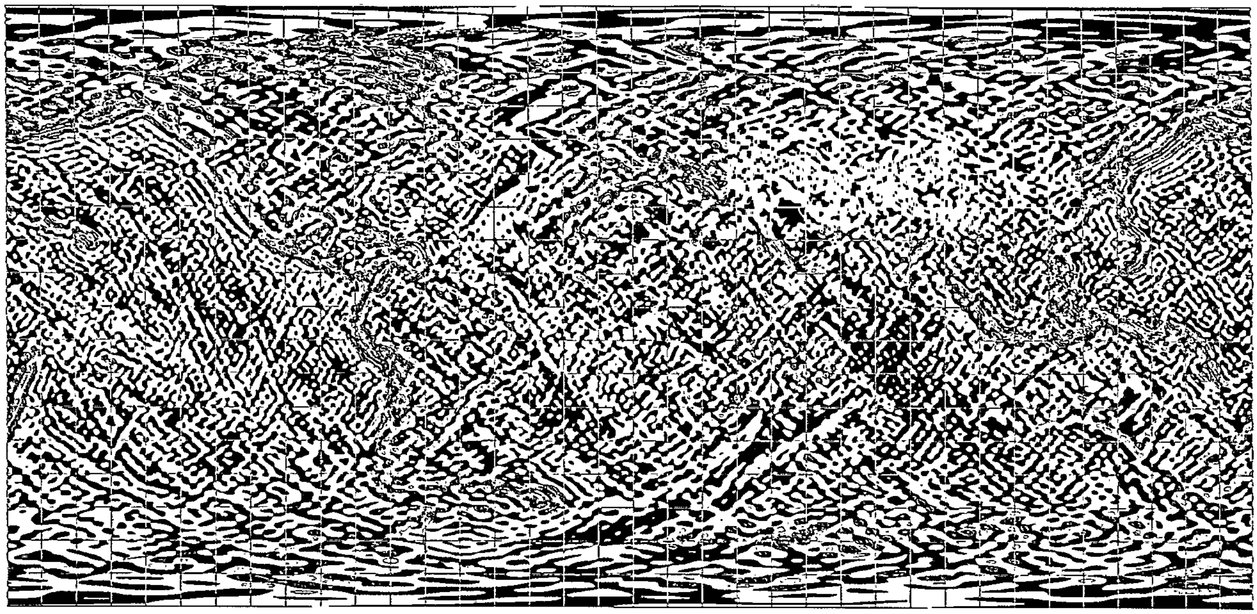
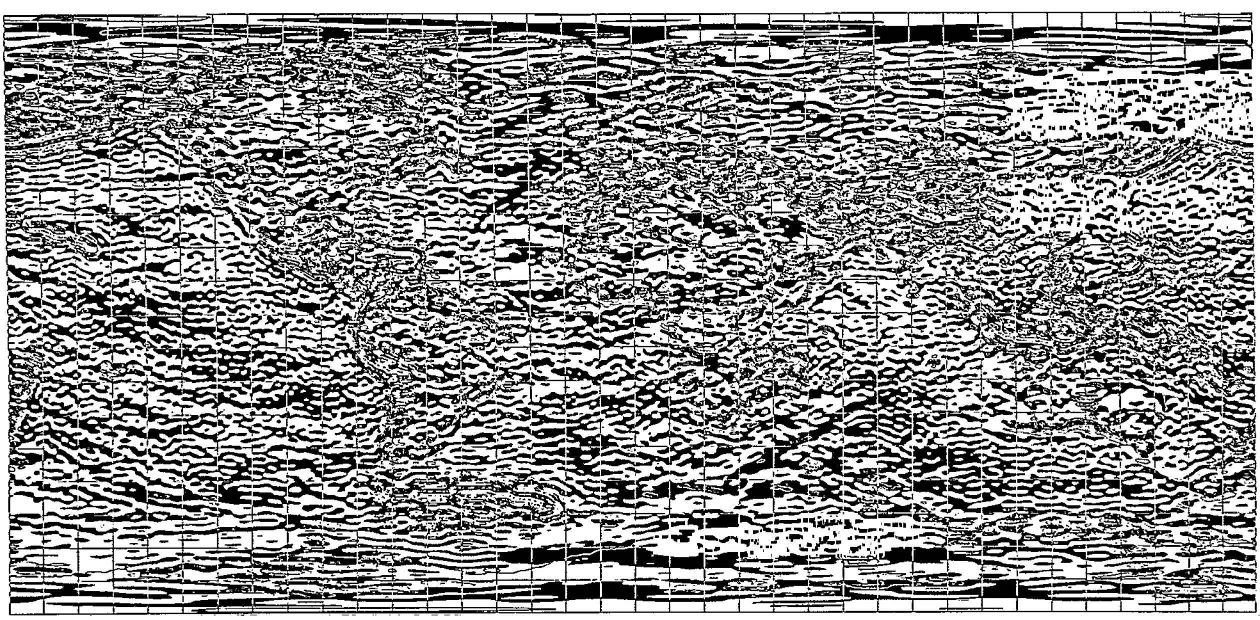
Fig. 4 — (U) WGS84, 180th order geopotential model



(a) Anomalous longitude-latitude gravity gradient



(b) Anomalous latitude-latitude gravity gradient

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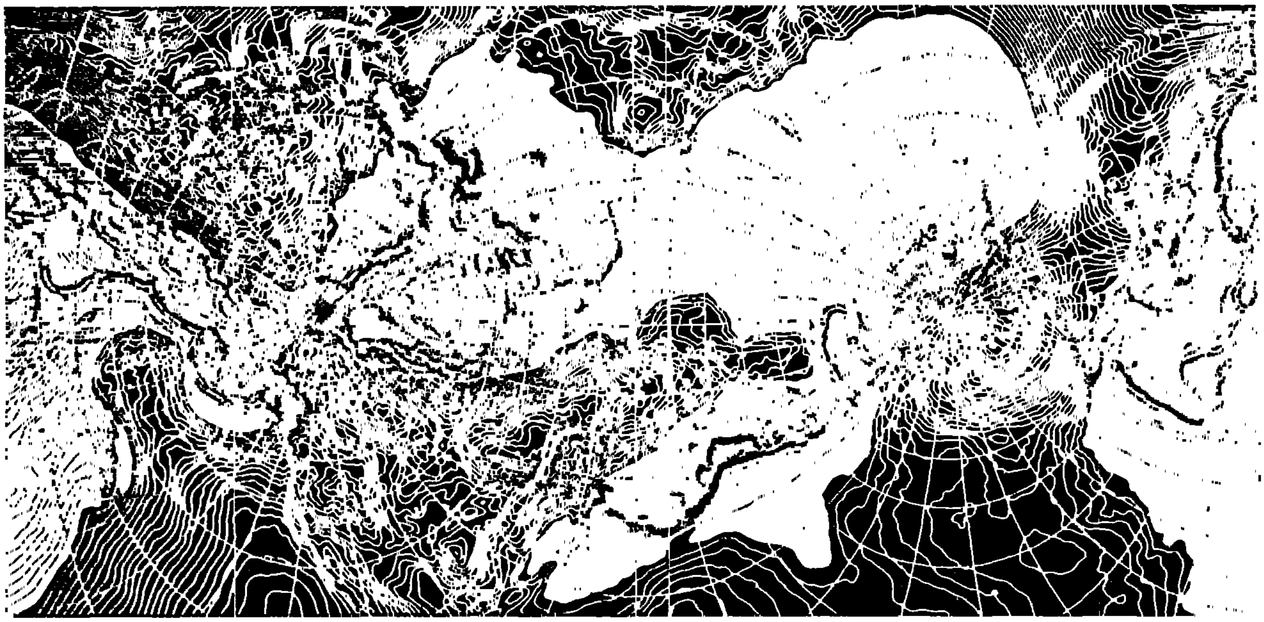
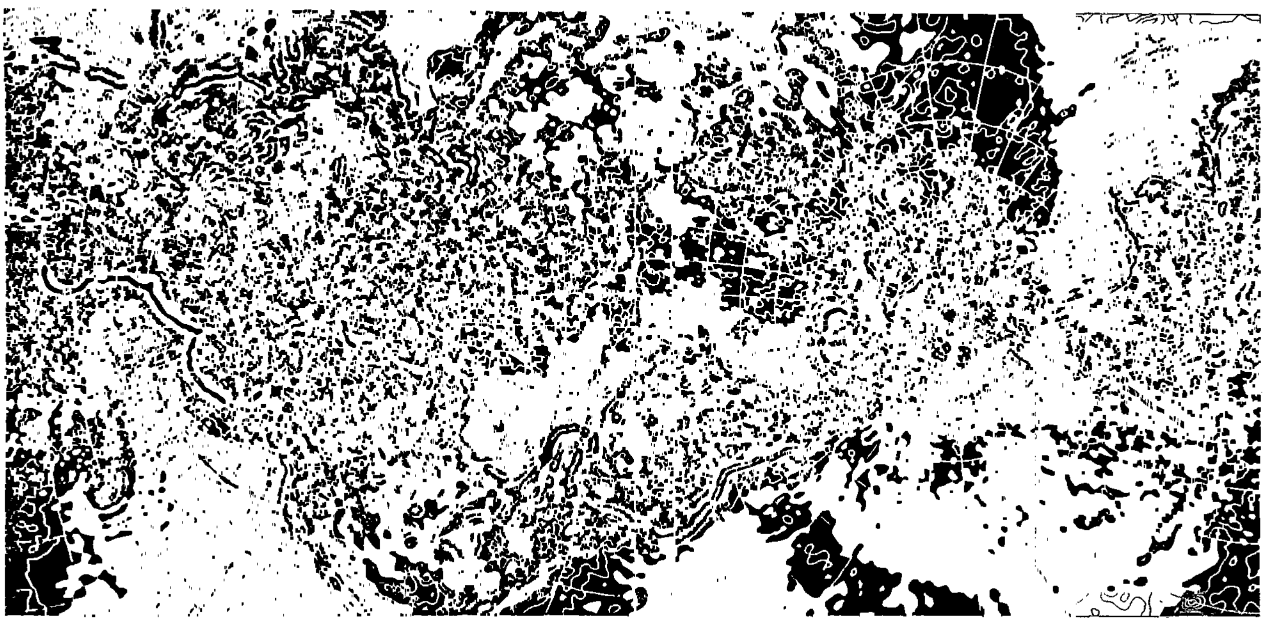
Fig. 5 — (U) WGS84, 180th order geopotential model



(a) Undulation of the geoid



(b) Gravity disturbance

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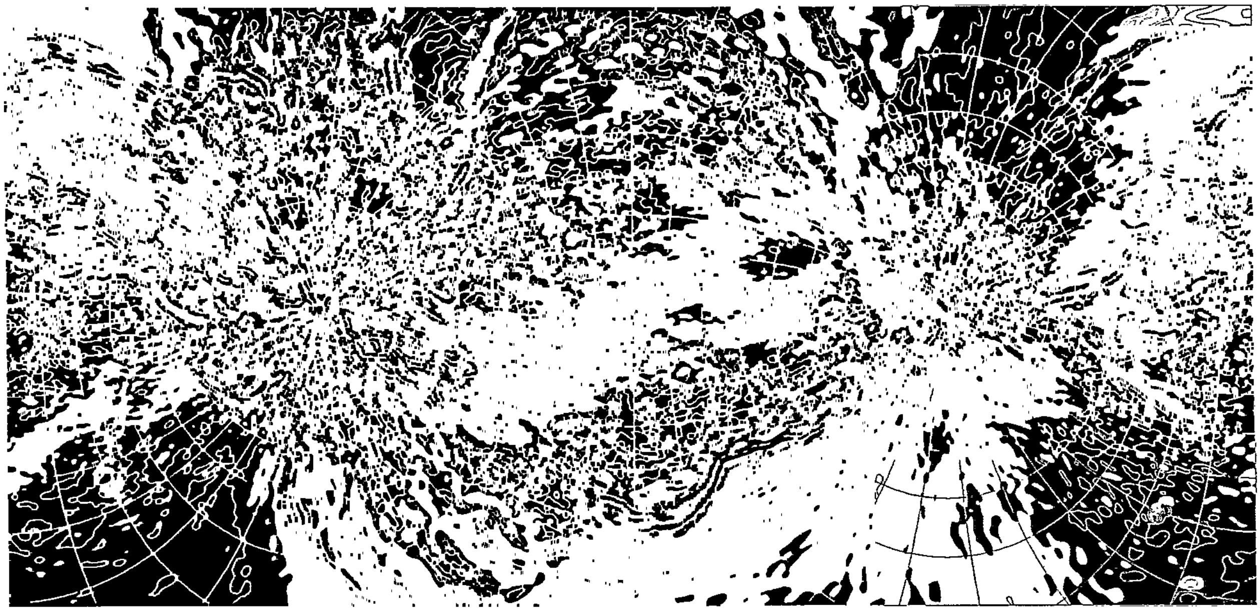
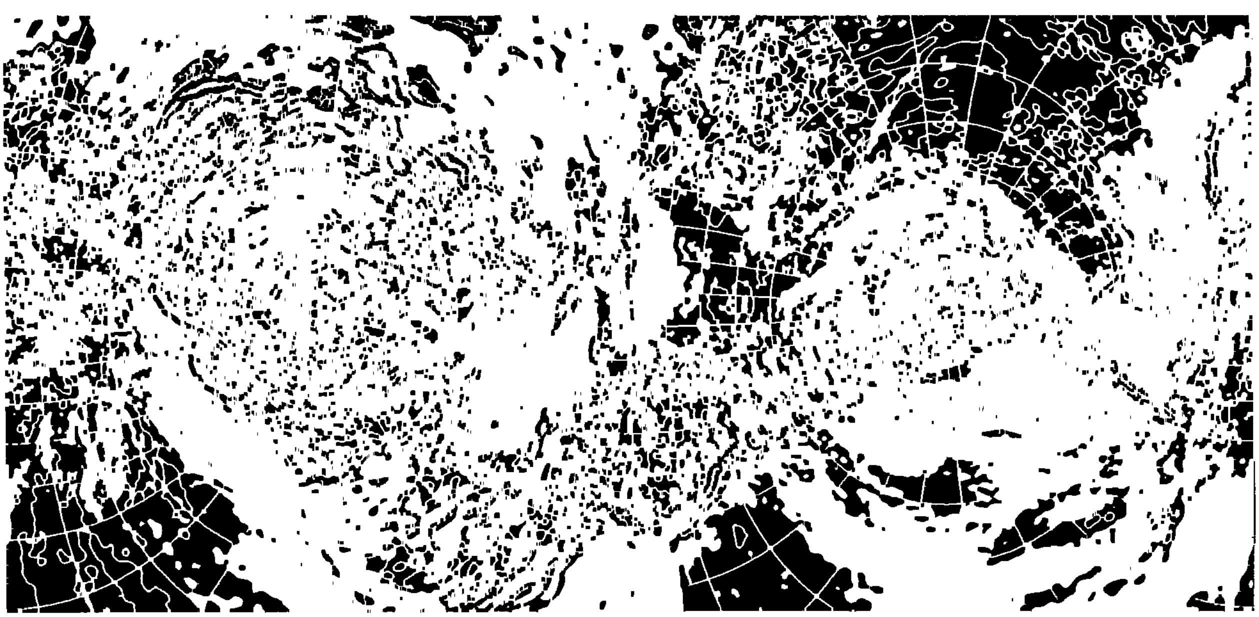
Fig. 6 — (U) WGS84, 180th order geopotential model, transverse Mercator projection



(a) Longitude disturbance



(b) Latitude disturbance

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Fig. 7 — (U) WGS84, 180th order geopotential model, transverse Mercator projection

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