X-592-73-58
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NASA TM X- 66240

THE GEOID AND FREE AIR GRAVITY ANOMALIES CORRESPONDING TO THE GEM-4 EARTH GRAVITATIONAL MODEL

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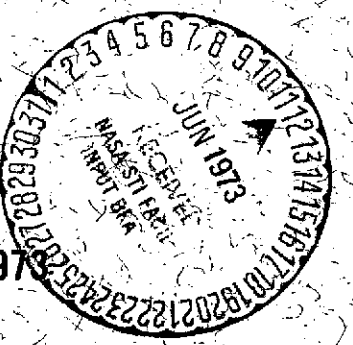

FEBRUARY 1973

GSFC

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

X-592-73-58

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ABSTRACT

This paper presents contour maps of the global geoid and free air gravity anomalies of the GEM-4 Earth gravitational model derived at the Goddard Space Flight Center in 1972.

CONTENTS

ILLUSTRATIONS

THE GEOID AND FREE AIR GRAVITY ANOMALIES CORRESPONDING TO THE GEM-4 EARTH GRAVITATIONAL MODEL

1.0 INTRODUCTION

This paper presents the geoid and free air gravity anomalies corresponding to the GSFC GEM-4 model of the Earth's gravitational field. The GEM-4 solution (Lerch, et al. 1972) is based upon a combination of electronic, laser and optical observations of 27 satellites with 5° x 5° mean free air gravity anomalies covering about 70% of the world.

2.0 COMPUTATION OF THE GEOID

The procedure for computation of the geoid consisted of first fixing a value of the potential of the geoid, W_0, and then calculating the geoid height as

$$N = r - r_E \tag{1}$$

where:

- r is the radial distance to the equipotential surface (the geoid) defined by W_0 and the potential coefficients of the GEM-4 gravity model.
- r_E is the radial distance to a selected reference ellipsoid defined by a semimajor axis (a_e) and flattening (f).

The radial distance, r, to the equipotential surface W_0 at a particular latitude and longitude ϕ, λ is determined by using equation 2.

$$W_0 = \psi(r, \phi, \lambda) =$$

$$\frac{GM}{r}\left[1 + \sum_{n=2}^{\infty}\sum_{m=0}^{n}\left(\frac{a_e}{r}\right)^n \left(\bar{C}_{nm}\cos m\lambda + \bar{S}_{nm}\sin m\lambda\right)\bar{P}_{nm}(\sin\phi)\right]$$

$$+ \frac{\omega^2 r^2}{2}\cos^2\phi \tag{2}$$

where

GM	= the product of the gravitational constant and the mass of the earth
a_e	= semimajor axis of the reference ellipsoid
r	= geocentric radius
ω	= earth's angular velocity
$\bar{C}_{nm}$ and $\bar{S}_{nm}$	= fully normalized spherical harmonic coefficients of the gravitational potential
$\bar{P}_{nm}$ $(\sin\phi)$	= the Associated Legendre Polynomial (fully normalized)

The only unknown in this equation is r. The value of r at each specified point of latitude and longitude is obtained by iteration. Geoid undulations were then computed as the separation between the geoid and the reference ellipsoid by means of equation (1).

The parameter values adopted for these calculations were:

$$GM = 3.986009 \times 10^5 \text{ km}^3/\text{sec}^2$$

$$a_e = 6378.142 \text{ km}$$

$$\omega = 0.72921151467 \times 10^{-4} \text{ rad/sec}$$

$$1/f = 298.255$$

$$W_o = 6263687.5 \text{ kgal m}$$

A map of the GEM-4 geoid heights plotted with a 2 meter contour interval is presented at the end of this report.

3.0 COMPUTATION OF FREE AIR GRAVITY ANOMALIES

A plot of the free air gravity anomalies (Δg) is also presented at the end of the report. These were obtained by evaluating the following equation.

$$\Delta g = \bar{\gamma} \sum_{n=2}^{\infty} \sum_{m=0}^{n} (n-1) \left[\bar{C}_{nm} \cos m\lambda + \bar{S}_{nm} \sin m\lambda\right] \bar{P}_{nm} (\sin\phi) \quad (3)$$

where

$\bar{\gamma}$ = Mean value of gravity over the earth (0.98×10^6 mgal)

In equation (3), the $\bar{C}_{20}$ and $\bar{C}_{40}$ terms do not represent the complete coefficients but rather the difference between the complete coefficients and the coefficients compatible with the ellipsoid used in computing N. The difference values used were $\overline{\Delta C}_{20} = 0.01954 \times 10^{-6}$ and $\overline{\Delta C}_{40} = -0.2417 \times 10^{-6}$ (fully normalized).

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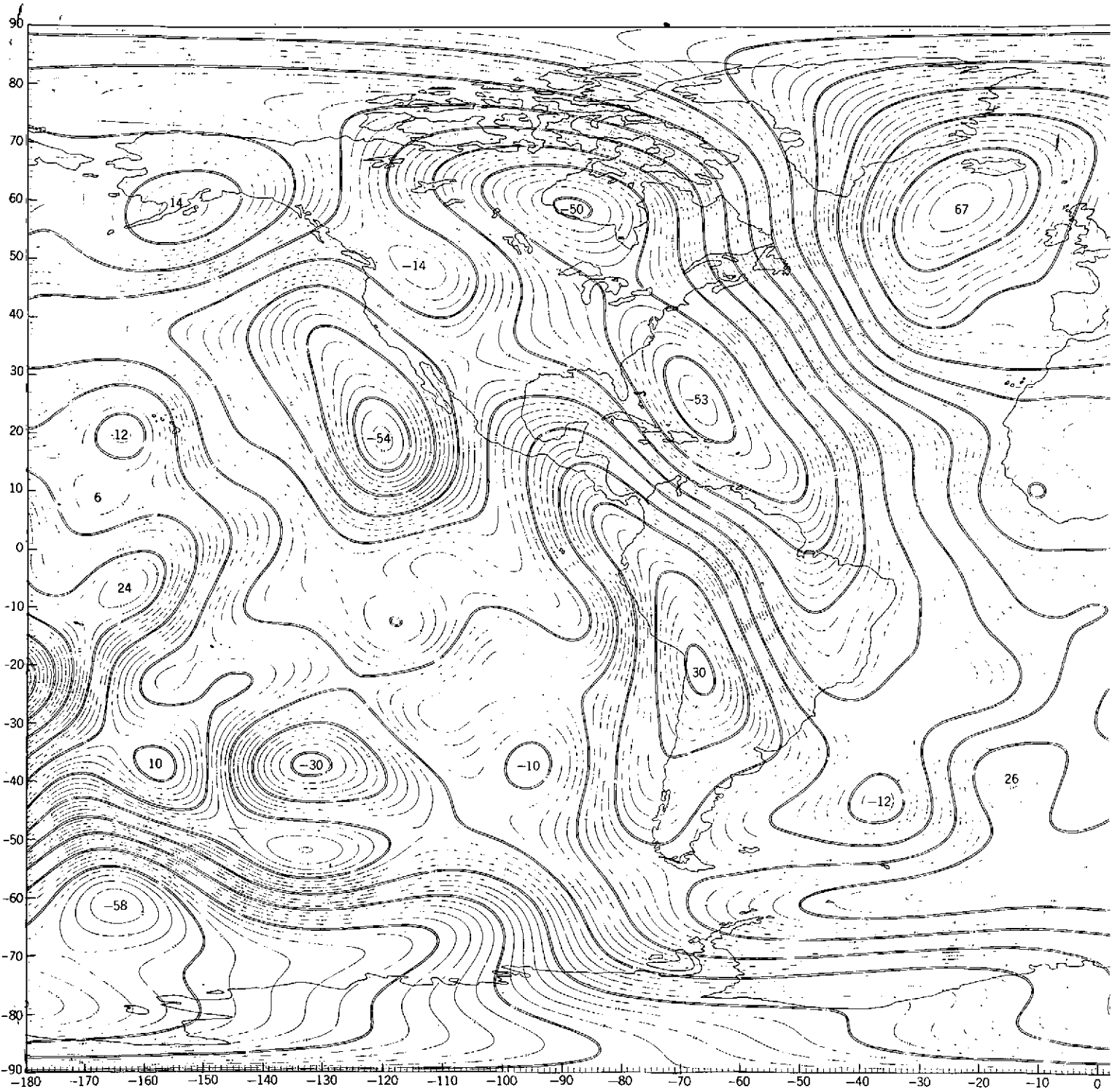
2. Vincent, S. F., Strange, W. E., Marsh, J. G., "A Detailed Gravimetric Geoid of North America, the North Atlantic, Eurasia, and Australia," GSFC Document X-553-72-331, September 1972.

* U.S. GOVERNMENT PRINTING OFFICE: 1972—735-969/760



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GEOID HE

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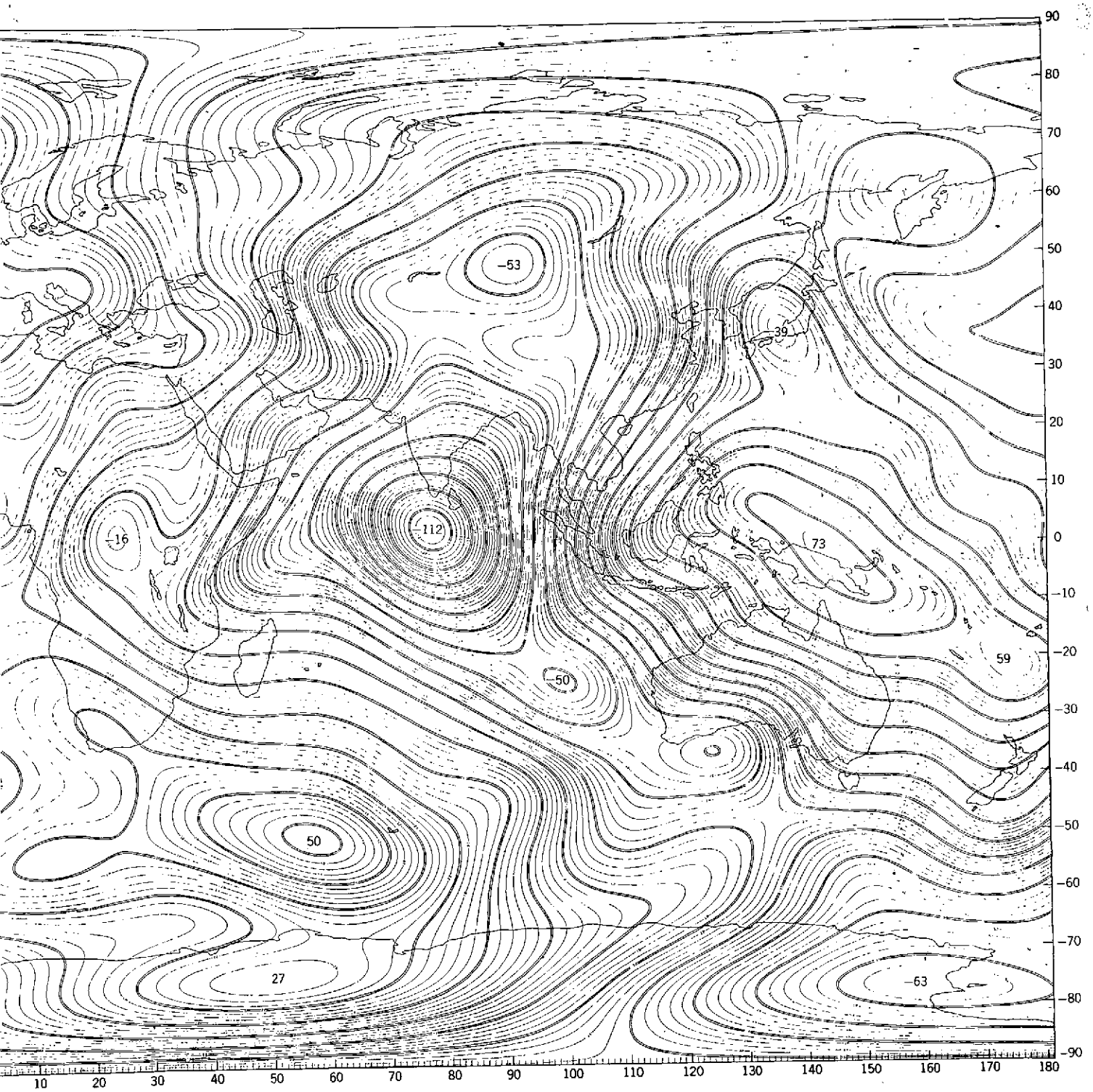

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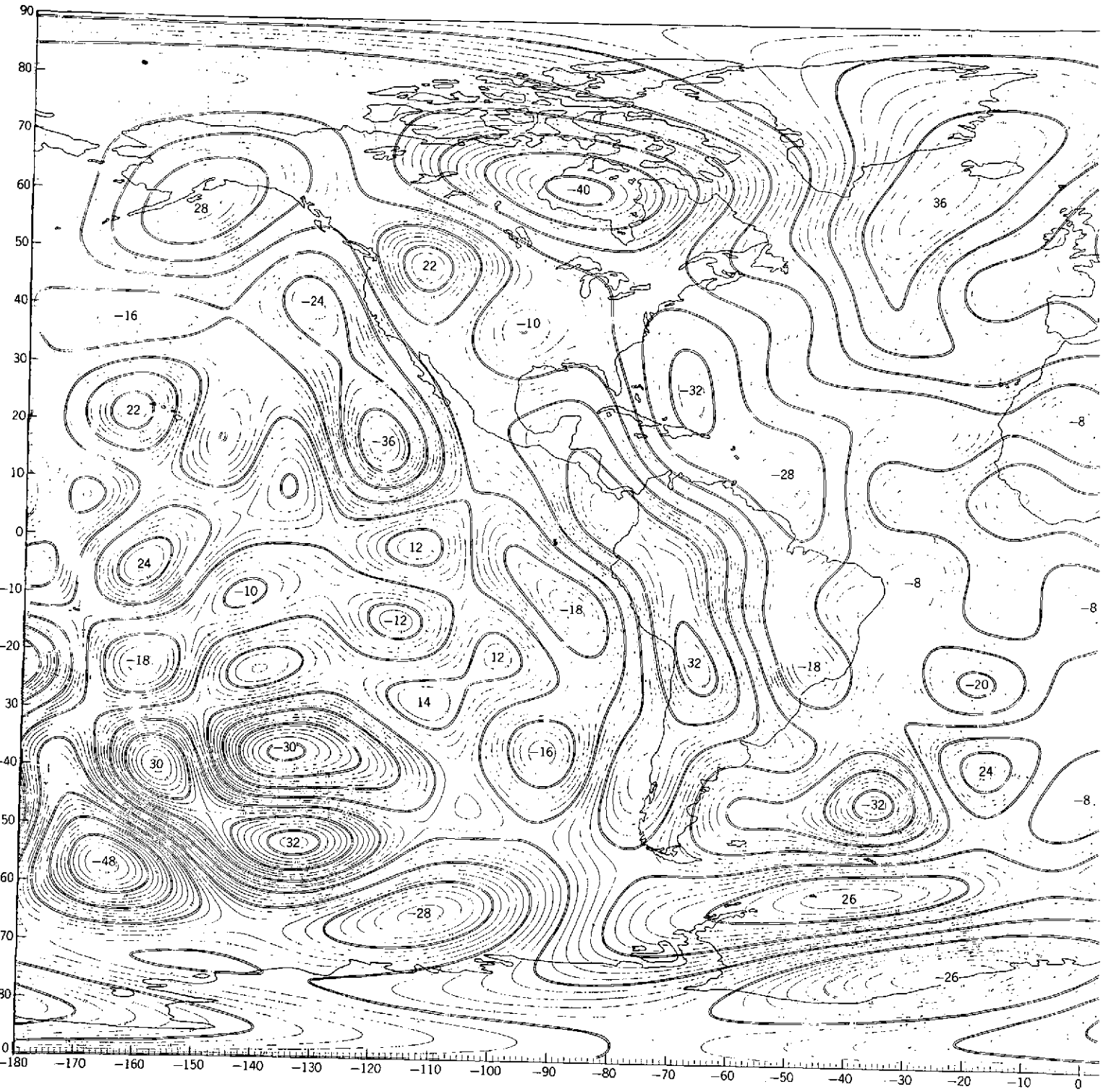

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EARTH MODEL

FREE AIR GRAVITY

CONTOUR INTERVAL 2mgal, EARTH RADIUS: 6378.142 km, 1/f = 298
THIS FIELD IS DERIVED FROM A COMBINATION OF SATI
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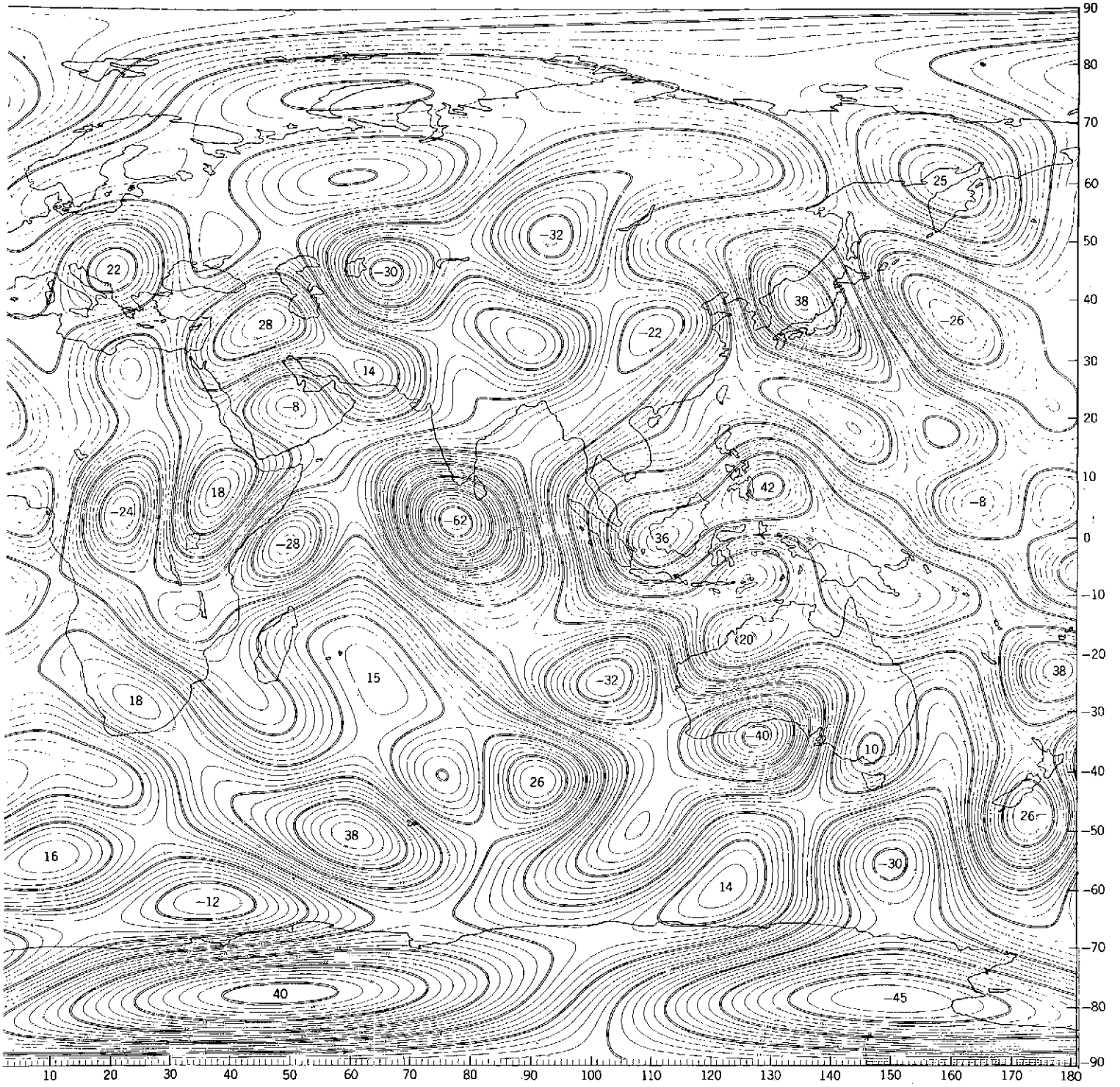

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4 (GEM - 4)

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