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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

DoD has developed a new World Geodetic System 1984 (WGS 84) which includes an ellipsoidal model, a gravity formula, an earth gravitational model and transformation equations from conventional geodetic datums to WGS 84. Implementation of this System will be in 1985.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

WORLD GEODETIC SYSTEM 1984

Mark M. Macomber
Defense Mapping Agency
United States of America

The Defense Department of the United States has developed a World Geodetic System 1984 (WGS 84) for cartographic application in those cases where mapping with respect to the center of mass of the earth is desired. Use of this system will be initiated in 1985, but complete implementation will not be effected for a period of several years.

WGS 84 consists of the following components:

An ellipsoidal model.

An ellipsoidal gravity formula.

An earth gravitational model.

Transformation equations from conventional geodetic datums to WGS 84.

The ellipsoidal model is based on the Geodetic Reference System model of 1980 (GRS 80) adopted by the International Union of Geodesy and Geophysics, but the flattening term is indicated by a normalized second harmonic coefficient in lieu of the regular coefficient. The defining parameters are given in Table 1.

The ellipsoidal gravity formula is given in Table 2. Only the closed form of the formula is given, since the ready availability of effective calculators has eliminated the need to use a truncated infinite series as an approximation.

The earth gravitational model, given in Table 3, is complete through degree and order 12. This model is based on three independent data types:

a. Dynamics of near-earth satellites which have been tracked by means of doppler shift, and the higher altitude Lageos satellite tracked by laser ranging.

b. Satellite altimetry data from the world's oceans.

c. Surface mean anomaly data (3 degree grid).

The transformation equations from conventional geodetic datums to WGS 84 have been based primarily on doppler positioning operations; however, the determination of the longitudinal zero point was made using Very Long Baseline Interferometry. Table 4 provides the equations to transform to WGS 84 from:

North American Datum 1927

South American Datum 1969

European Datum 1950

Tokyo Datum

Australian Geodetic Datum

In the past we have used a mean datum shift for each datum, and employed the Molodensky Transformation Equations for conversions. The primary reason for using such a technique is the ease of transformation. An undesireable consequence of that technique is that distortions in the geodetic network are transformed into the world geodetic system positions. In WGS 84, regression equations are used which fit the existing geodetic net to the observed doppler positions, thus removing many of the distortions inherent in the older geodetic nets.

In addition to being used by the Defense Mapping Agency for charting purposes, WGS 84 will be the reference frame used by the Global Positioning System when it becomes operational.

A Technical Report describing the development of WGS 84 is in preparation and should be printed by June 1985.

TABLE 1

WGS 84 ELLIPSOID

DEFINING PARAMETERS

PARAMETERS	NOTATION	VALUE
Semimajor Axis	a	6,378,137 m
Second Degree Normalized Zonal Harmonic Coefficient of the Geopotential	$\bar{C}_{2,0}$	$-484.166\ 85 \times 10^{-6}$
Angular Velocity of the Earth	ω	$72.921\ 15 \times 10^{-6}$ rad s^{-1}
The Earth's Gravitational Constant (Mass of Earth's atmosphere included)	GM	$398{,}600.5 \times 10^{9}\ m^{3}s^{-2}$

PARAMETER VALUES FOR SPECIAL APPLICATIONS

PARAMETERS	NOTATION	VALUE
Angular velocity of the Earth	ω'	$72.921\ 151\ 467 \times 10^{-6}$ rad s^{-1}
The Earth's Gravitational Constant (Mass of Earth's atmosphere not included)	GM'	$398{,}600.15 \times 10^{9}\ m^{3}s^{-2}$

TABLE 2

WGS 84

ELLIPSOIDAL GRAVITY FORMULA

$$\gamma = 978{,}032.677\ 15 \frac{(1 + 0.001\ 931\ 851\ 353 \sin^2\phi)}{(1 - 0.006\ 694\ 380\ 022\ 90 \sin^2\phi)^{1/2}} \text{ mgals}$$

MEAN VALUE OF THEORETICAL (NORMAL) GRAVITY

$$\bar{\gamma} = 979{,}764.465\ 6 \text{ mgals}$$

TABLE 3
WGS 84
EARTH GRAVITATIONAL MODEL
(TRUNCATED TO n=m=12)

DEGREE AND ORDER n	m	NORMALIZED GEOPOTENTIAL COEFFICIENTS $\bar{C}_{n,m}$	$\bar{S}_{n,m}$
2	0	-0.4841 6685 E-03	
2	1	-------------	-------------
2	2	0.2439 5796 E-05	-0.1397 9548 E-05
3	0	0.9570 6390 E-06	
3	1	0.2031 8729 E-05	0.2508 5759 E-06
3	2	0.9066 6113 E-06	-0.6210 2428 E-06
3	3	0.7177 0352 E-06	0.1415 2388 E-05
4	0	0.5369 9587 E-06	
4	1	-0.5354 8044 E-06	-0.4742 0394 E-06
4	2	0.3479 7519 E-06	0.6557 9158 E-06
4	3	0.9917 2321 E-06	-0.1991 2491 E-06
4	4	-0.1868 6124 E-06	0.3095 3114 E-06
5	0	0.7109 2048 E-07	
5	1	-0.6418 5265 E-07	-0.9249 2959 E-07
5	2	0.6518 4984 E-06	-0.3200 7416 E-06
5	3	-0.4490 3639 E-06	-0.2132 8272 E-06
5	4	-0.2971 9055 E-06	0.5321 3480 E-07
5	5	0.1752 3221 E-06	-0.6705 9456 E-06

DEGREE AND ORDER n	m	NORMALIZED GEOPOTENTIAL COEFFICIENTS $\bar{C}_{n,m}$	$\bar{S}_{n,m}$
6	0	-0.1506 4821 E-06	
6	1	-0.7418 0259 E-07	0.3278 0040 E-07
6	2	0.5182 4409 E-07	-0.3586 6634 E-06
6	3	0.5337 0577 E-07	0.6133 4720 E-08
6	4	-0.8869 4856 E-07	-0.4726 0945 E-06
6	5	-0.2681 8820 E-06	-0.5349 1073 E-06
6	6	0.1023 7832 E-07	-0.2374 1002 E-06
7	0	0.8581 9217 E-07	
7	1	0.2790 5196 E-06	0.9423 1346 E-07
7	2	0.3287 3832 E-06	0.8883 5092 E-07
7	3	0.2494 0240 E-06	-0.2122 3369 E-06
7	4	-0.2712 3034 E-06	-0.1269 6607 E-06
7	5	0.1024 6290 E-08	0.1732 1672 E-07
7	6	-0.3584 3745 E-06	0.1520 2633 E-06
7	7	-0.2099 1457 E-08	0.2280 5664 E-07
8	0	0.4297 9835 E-07	
8	1	0.1888 9342 E-07	0.4785 6967 E-07
8	2	0.7355 3952 E-07	0.4786 7693 E-07
8	3	-0.1213 2459 E-07	-0.8346 1853 E-07

E-03 = X 10^{-3}; E-05 = X 10^{-5}; etc.

TABLE 3 (Continued)
WGS 84
EARTH GRAVITATIONAL MODEL
(TRUNCATED TO n=m=12)

DEGREE AND ORDER n	m	NORMALIZED GEOPOTENTIAL COEFFICIENTS $\bar{C}_{n,m}$	$\bar{S}_{n,m}$
8	4	-0.2420 8264 E-06	0.7160 3924 E-07
8	5	-0.2496 6587 E-07	0.8775 1047 E-07
8	6	-0.6509 3424 E-07	0.3090 4202 E-06
8	7	0.6632 3292 E-07	0.7466 1766 E-07
8	8	-0.1237 2281 E-06	0.1221 0258 E-06
9	0	0.3317 3231 E-07	
9	1	0.1474 7969 E-06	0.2389 4354 E-07
9	2	0.2205 2093 E-07	-0.2687 6665 E-07
9	3	-0.1625 6047 E-06	-0.8592 8431 E-07
9	4	-0.1719 3827 E-07	0.2607 7030 E-07
9	5	-0.1690 2791 E-07	-0.5033 7365 E-07
9	6	0.6571 7910 E-07	0.2227 5858 E-06
9	7	-0.1164 8016 E-06	-0.9729 8769 E-07
9	8	0.1889 6045 E-06	-0.3102 6222 E-08
9	9	-0.4827 5744 E-07	0.9638 1072 E-07
10	0		
10	1		
10	2		
10	3		
10	4		
10	5	-0.	-0.
10	6		
10	7		
10	8		
10	9		
10	10		
11	0		
11	1		
11	2		
11	3		
11	4		
11	5		
11	6		
11	7		
11	8		
11	9		
11	10		
11	11		

TABLE 3 (Continued)
WGS 84
EARTH GRAVITATIONAL MODEL
(TRUNCATED TO n=m=12)

DEGREE AND ORDER		NORMALIZED GEOPOTENTIAL COEFFICIENTS		DEGREE AND ORDER		NORMALIZED GEOPOTENTIAL COEFFICIENTS	
n	m	$\bar{C}_{n,m}$	$\bar{S}_{n,m}$	n	m	$\bar{C}_{n,m}$	$\bar{S}_{n,m}$
12	0	-0.					
12	1	-0.	-0.				
12	2						
12	3						
12	4						
12	5						
12	6						
12	7						
12	8						
12	9						
12	10						
12	11						
12	12						

TABLE 4

Transformation Equations
Conterminous States of the U.S.
North American Datum 1927 (NAD 27) to WGS 84

$$\Delta\phi\ ('') = 0.18248 - 0.86722\ U + 0.11882\ V + 1.21366\ U^2 - 0.90132\ U^3 + 0.28702\ V^3 - 0.39213\ U^3V - 2.39061\ U^4V - 0.10417\ V^5 + 1.01204\ U^4V^3 - 0.06532\ UV^6$$

$$\Delta\lambda\ ('') = -1.16464 + 1.99762\ V - 0.76293\ UV - 2.64159\ U^3 - 0.06681\ UV^2 + 0.06283\ V^3 + 2.23121\ UV^3 + 4.96664\ U^5 - 1.20212\ UV^5 + 0.13948\ UV^7 - 0.03079\ UV^8$$

$$\Delta H\ (m) = -37.486 + 4.476\ U - 7.333\ V - 12.375\ U^2 + 6.543\ UV + 7.968\ V^2 - 5.168\ U^2V - 4.237\ UV^2 + 0.883\ V^3 - 47.903\ U^3V + 160.491\ U^5V + 121.064\ U^4V^2 - 41.751\ U^2V^4 + 17.008\ U^2V^6 + 17.751\ U^6V^9$$

where:

$U = K(\phi - 37)$
$V = K(\lambda - 265)$ $\qquad K = 0.0523599$

ϕ = Geodetic latitude in degrees and decimal part of a degree - positive north.

λ = Geodetic longitude in degrees and decimal part of a degree - positive east from 0° to 360°.

H = Geodetic height.

$\phi(\text{WGS } 84) = \phi(\text{NAD } 27) + \Delta\phi$
$\lambda(\text{WGS } 84) = \lambda(\text{NAD } 27) + \Delta\lambda$
$H(\text{WGS } 84) = H(\text{NAD } 27) + \Delta H$

These equations reproduced Doppler derived WGS 84 positions to an RMS accuracy of $\pm$ 1.3 meters at over 390 stations.

Test Case:

$\phi = 34°\ 47'\ 08''.833$ $\qquad \Delta\phi = 0''.376$
$\lambda = 273°\ 25'\ 07''.825$ $\qquad \Delta\lambda = -0''.254$
$\Delta H = -40.03m$

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Transformation Equations
South America
South American Datum 1969 (SAD) to WGS 84

$$
\begin{aligned}
\Delta\phi\ ('') = {} & - 1.70423 + 0.32457\ V + 1.47643\ U^2 + 0.16325\ U^3 - 1.25510\ U^2V \\
& - 0.91714\ V^3 - 2.04195\ U^4 - 0.23666\ U^4V + 0.60041\ V^5 + 0.97497\ U^6 \\
& - 0.19572\ U^5V^2 + 3.98279\ U^4V^3 - 0.15899\ U^8 + 1.07084\ U^4V^4 \\
& - 1.74285\ U^2V^6 + 0.03167\ U^9V + 0.64519\ U^7V^4 - 1.77266\ U^6V^5 \\
& + 2.28485\ U^4V^8 - 1.36268\ U^7V^8 - 0.72115\ U^9V^7 - 1.77821\ U^9V^8 \\
& - 0.93127\ U^9V^9
\end{aligned}
$$

$$
\begin{aligned}
\Delta\lambda\ ('') = {} & - 2.01792 + 0.43588\ U + 0.45994\ V - 0.08554\ U^2 - 0.48166\ UV \\
& - 0.94304\ V^2 - 0.39748\ U^2V + 0.19540\ UV^2 + 2.26011\ V^4 + 4.14470\ U^3V^3 \\
& - 0.22411\ U^2V^4 - 2.29019\ V^6 - 2.30331\ U^4V^3 - 2.61500\ U^5V^3 \\
& + 0.86795\ V^8 - 3.64267\ U^4V^5 - 0.09489\ V^9 + 1.69296\ U^7V^3 - 3.79714\ U^5V^5 \\
& + 11.04801\ U^6V^5 - 2.72999\ U^7V^5 + 2.42904\ U^5V^7 - 1.57488\ U^9V^5 \\
& - 6.46086\ U^8V^7 + 4.36655\ U^9V^7
\end{aligned}
$$

$$
\begin{aligned}
\Delta H\ (m) = {} & 5.527 - 8.550\ U - 26.828\ V + 43.525\ U^2 + 12.372\ V^2 - 33.781\ UV^2 \\
& + 9.410\ V^3 - 104.522\ U^4 - 10.616\ U^5 + 19.940\ U^2V^3 + 81.922\ U^6 \\
& - 175.734\ U^4V^2 + 172.237\ U^5V^2 + 28.891\ U^3V^4 - 9.569\ V^7 - 21.417\ U^8 \\
& + 228.440\ U^6V^2 + 17.699\ U^2V^6 + 18.454\ UV^7 + 3.190\ U^9 - 193.669\ U^7V^2 - 68.982\ U^8V \\
& - 31.362\ U^4V^6 - 54.635\ U^3V^7 + 53.829\ U^9V^2 + 31.681\ U^5V^9 - 4.609\ U^9V^9
\end{aligned}
$$

where:

$U = K(\phi + 20)$ $\quad$ $K = 0.0523599$
$V = K(\lambda - 300)$

ϕ = Geodetic latitude in degrees and decimal part of a degree - negative south.

λ = Geodetic longitude in degrees and decimal part of a degree - positive east from 0° to 360°.

H = Geodetic height.

$\phi(\text{WGS 84}) = \phi(\text{SAD}) + \Delta\phi$
$\lambda(\text{WGS 84}) = \lambda(\text{SAD}) + \Delta\lambda$
$H(\text{WGS 84}) = H(\text{SAD}) + \Delta H$

These equations reproduced Doppler derived WGS 84 positions to an RMS accuracy of ± 1.6 meters at over 75 stations in Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Trinidad, and Venezuela.

Test Case:

$\phi = -45°\ 54'\ 34''.179$ $\quad$ $\Delta\phi = -\ 1''.418$
$\lambda = 291°\ 30'\ 18''.344$ $\quad$ $\Delta\lambda = -\ 2''.909$
$\Delta H = 32.10m$

TRANSFORMATION EQUATIONS
WESTERN EUROPE
EUROPEAN DATUM 1950 (ED) TO WGS 84

$$\Delta\phi\ ('') = -2.66438 + 2.07710\ U + 0.68334\ V + 0.58519\ U^2 + 0.44408\ U^3 + 0.25393\ V^3 - 1.45689\ U^2V^2 + 1.25066\ UV^3 - 0.68969\ UV^5 - 10.16433\ U^3V^4 + 42.98620\ U^5V^6 + 1.61758\ U^4V^8 - 48.16074\ U^7V^8 + 4.58189\ U^9V^7$$

$$\Delta\lambda\ ('') = -4.47322 - 1.65710\ U + 1.68392\ V - 0.94677\ U^2 + 1.10939\ UV - 0.82969\ U^3 + 2.49213\ U^2V - 0.77921\ U^2V^2 - 0.21330\ V^4 - 5.76767\ U^4V^3 + 4.00247\ U^2V^5 + 0.45095\ U^2V^8 - 19.06023\ U^4V^9 + 25.31250\ U^6V^9$$

$$\Delta H\ ('') = 35.190 - 28.978\ U - 24.827\ V + 14.230\ U^2 + 4.072\ UV + 7.569\ U^2V + 9.150\ UV^2 + 20.899\ V^3 - 16.693\ V^5 + 41.182\ U^3V^3 - 5.615\ UV^8 - 81.266\ U^7V^5$$

where:

$U = K(\phi - 52)$
$V = K(\lambda - 10)$ $\qquad K = 0.0523599$

ϕ = Geodetic latitude in degrees and decimal part of a degree - positive north.

λ = Geodetic longitude in degrees and decimal part of a degree - positive east from 0° to 180° and negative west from 0° to 180°.

H = Geodetic height.

$\phi(\text{WGS 84}) = \phi(\text{ED}) + \Delta\phi$
$\lambda(\text{WGS 84}) = \lambda(\text{ED}) + \Delta\lambda$
$H(\text{WGS 84}) = H(\text{ED}) + \Delta H$

These equations reproduced Doppler derived WGS 84 positions to an RMS accuracy of ± 1.0 meter at over 80 stations in Austria, Denmark, Federal Republic of Germany, Finland, France, Gibraltar, Greece, Netherlands, Norway, Portugal, Spain, and Switzerland.

Test Case:

$\phi = 46°\ 41'\ 42''.893$ $\qquad \Delta\phi = -3''.071$
$\lambda\quad 13°\ 54'\ 54''.088$ $\qquad \Delta\lambda = -3''.750$
$\Delta H = 39.19\text{m}$

Transformation Equations
Japan - Korea
Tokyo Datum (TD) to WGS 84

$$\Delta\phi\ ('') = 11.95340 - 9.62801\ U + 0.88665\ U^3 - 0.47946\ U^2V + 7.58688\ UV^2$$
$$+ 0.77749\ V^3 - 1.17313\ UV^6 - 0.08409\ V^9 - 0.13521\ U^2V^8 - 0.27780\ U^3V^8$$

$$\Delta\lambda\ ('') = -10.36350 - 2.05554\ V + 1.65977\ U^2V - 2.78777\ U^5 - 6.06792\ U^4V$$
$$+ 4.94331\ U^7 + 1.85890\ U^4V^4$$

$$\Delta H\ (m) = 11.514 + 43.175\ U - 24.604\ V - 14.246\ U^2 + 9.263\ U^3V$$

where:

$U = K(\phi - 35)$
$V = K(\lambda - 135)$ $\quad K = 0.1570796$

ϕ = Geodetic latitude in degrees and decimal part of a degree - positive north.

λ = Geodetic longitude in degrees and decimal part of a degree - positive east from 0° to 360°.

H = Geodetic height.

$\phi(\text{WGS 84}) = \phi(\text{TD}) + \Delta\phi$
$\lambda(\text{WGS 84}) = \lambda(\text{TD}) + \Delta\lambda$
$H(\text{WGS 84}) = H(\text{TD}) + \Delta H$

These equations reproduced Doppler derived WGS 84 positions to an RMS accuracy of ± 1.0 meter at 13 stations in Japan, South Korea and Okinawa.

Test Case:

ϕ = 40° 42' 38".260 $\qquad \Delta\phi$ = 9".715
λ = 141° 22' 23".979 $\qquad \Delta\lambda$ = -13".117
$\qquad \Delta H$ = 20.84m

Tranformation Equations
Australia
Australian Geodetic Datum (AGD) to WGS 84

$$\Delta\phi\ ('') = 5.19094 + 0.10880\ U + 0.53546\ V - 0.26415\ U^2 + 0.66905\ U^2V$$

$$+ 0.70726\ UV^2 - 1.08711\ U^2V^2 - 0.97089\ UV^3 + 2.86844\ U^4V^2$$

$$- 5.96789\ U^4V^3 - 6.11875\ U^3V^6$$

$$\Delta\lambda\ ('') = 4.38095 - 0.91915\ U - 0.62471\ V + 0.20891\ UV - 0.27391\ V^2$$

$$+ 0.93129\ U^4 + 0.57341\ U^3V^2 - 0.67696\ U^8$$

$$\Delta H\ (m) = 7.838 + 54.741\ U + 35.354\ V + 11.794\ UV - 2.373\ V^2$$

$$- 29.286\ U^3V - 3.921\ U^3V^2 - 11.470\ UV^4 + 30.504\ U^5V$$

$$+ 19.619\ UV^8 + 14.894\ UV^9$$

where:

$U = K(\phi + 27)$
$V = K(\lambda - 134)$

$K = 0.0523599$

ϕ = Geodetic latitude in degrees and decimal part of a degree - negative south.

λ = Geodetic longitude in degrees and decimal part of a degree - positive east from 0° to 360°.

H = Geodetic height.

$\phi(\text{WGS 84}) = \phi(\text{AGD}) + \Delta\phi$
$\lambda(\text{WGS 84}) = \lambda(\text{AGD}) + \Delta\lambda$
$H(\text{WGS 84}) = H(\text{AGD}) + \Delta H$

These equations reproduced Doppler derived WGS 84 positions to an RMS accuracy of ± 1.2 meters at over 100 stations.

Test Case:

$\phi = -17° 00' 32''.776$
$\lambda = 144° 11' 37''.245$

$\Delta\phi = 5''.476$
$\Delta\lambda = 3''.636$
$\Delta H = 55.81m$

29 June 1984

ST 10/29/84

TABLE 5

WGS 84
EARTH GRAVITATIONAL MODEL
(TRUNCATED TO n=m=12)

GREE ND DER	NORMALIZED GEOPOTENTIAL COEFFICIENTS		DEGREE AND ORDER		NORMALIZED GEOPOTENTIAL COEFFICIENTS	
m	$\bar{C}_{n,m}$	$\bar{S}_{n,m}$	n	m	$\bar{C}_{n,m}$	$\bar{S}_{n,m}$
0	-0.48416685E-03		6	3	0.53370577E-07	0.61334720E-08
1	---------------	---------------	6	4	-0.88694856E-07	-0.47260945E-06
2	0.24395796E-05	-0.13979548E-05	6	5	-0.26818820E-06	-0.53491073E-06
0	0.95706390E-06		6	6	0.10237832E-07	-0.23741002E-06
1	0.20318729E-05	0.25085759E-06	7	0	0.85819217E-07	
2	0.90666113E-06	-0.62102428E-06	7	1	0.27905196E-06	0.94231346E-07
3	0.71770352E-06	0.14152388E-05	7	2	0.32873832E-06	0.88835092E-07
0	0.53699587E-06		7	3	0.24940240E-06	-0.21223369E-06
1	-0.53548044E-06	-0.47420394E-06	7	4	-0.27123034E-06	-0.12696607E-06
2	0.34797519E-06	0.65579158E-06	7	5	0.10246290E-08	0.17321672E-07
3	0.99172321E-06	-0.19912491E-06	7	6	-0.35843745E-06	0.15202633E-06
4	-0.18686124E-06	0.30953114E-06	7	7	-0.20991457E-08	0.22805664E-07
0	0.71092048E-07		8	0	0.42979835E-07	
1	-0.64185265E-07	-0.92492959E-07	8	1	0.18889342E-07	0.47856967E-07
2	0.65184984E-06	-0.32007416E-06	8	2	0.73553952E-07	0.47867693E-07
3	-0.44903639E-06	-0.21328272E-06	8	3	-0.12132459E-07	-0.83461853E-07
4	-0.29719055E-06	0.53213480E-07	8	4	-0.24208264E-06	0.71603924E-07
5	0.17523221E-06	-0.67059456E-06	8	5	-0.24966587E-07	0.87751047E-07
0	-0.15064821E-06		8	6	-0.65093424E-07	0.30904202E-06
1	-0.74180259E-07	0.32780040E-07	8	7	0.66323292E-07	0.74661766E-07
2	0.51824409E-07	-0.35866634E-06	8	8	-0.12372281E-06	0.12210258E-06

-03 = X 10^{-3}; E-05 = X 10^{-5}; etc.

TABLE 5 (Cont'd)

WGS 84
EARTH GRAVITATIONAL MODEL
(TRUNCATED TO n=m=12)

EGREE ND RDER		NORMALIZED GEOPOTENTIAL COEFFICIENTS		DEGREE AND ORDER		NORMALIZED GEOPOTENTIAL COEFFICIENTS	
	m	$\bar{C}_{n,m}$	$\bar{S}_{n,m}$	n	m	$\bar{C}_{n,m}$	$\bar{S}_{n,m}$
	0	0.33173231E-07		11	1	0.95375839E-08	-0.22094828E-07
	1	0.14747969E-06	0.23894354E-07	11	2	0.21716225E-07	-0.10224810E-06
	2	0.22052093E-07	-0.26876665E-07	11	3	-0.30023695E-07	-0.13422019E-06
	3	-0.16256047E-06	-0.85928431E-07	11	4	-0.30407161E-07	-0.69823333E-07
	4	-0.17193827E-07	0.26077030E-07	11	5	0.35104609E-07	0.49175170E-07
	5	-0.16902791E-07	-0.50337365E-07	11	6	-0.37911105E-08	0.36848522E-07
	6	0.65717910E-07	0.22275858E-06	11	7	0.25774039E-08	-0.88658395E-07
	7	-0.11648016E-06	-0.97298769E-07	11	8	-0.71396627E-08	0.23243077E-07
	8	0.18896045E-06	-0.31026222E-08	11	9	-0.30246313E-07	0.41776400E-07
	9	-0.48275744E-07	0.96381072E-07	11	10	-0.53424279E-07	-0.18716766E-07
	0	0.50931575E-07		11	11	0.47514858E-07	-0.70415796E-07
	1	0.88706517E-07	-0.12536457E-06	12	0	0.34073235E-07	
	2	-0.82375203E-07	-0.38280049E-07	12	1	-0.60609926E-07	-0.38189082E-07
	3	-0.13137371E-07	-0.15553732E-06	12	2	0.74200188E-08	0.24640620E-07
	4	-0.87424319E-07	-0.79215732E-07	12	3	0.42149817E-07	0.32189594E-07
	5	-0.53980821E-07	-0.46294947E-07	12	4	-0.64346831E-07	-0.25364931E-08
	6	-0.42371448E-07	-0.79680607E-07	12	5	0.33126200E-07	-0.40658586E-09
	7	0.83736045E-08	-0.25636582E-08	12	6	0.86981502E-08	0.36711094E-07
	8	0.41239589E-07	-0.92269095E-07	12	7	-0.16598048E-07	0.34475954E-07
	9	0.12539514E-06	-0.37687117E-07	12	8	-0.26843700E-07	0.17838309E-07
	10	0.10124370E-06	-0.24874984E-07	12	9	0.42293015E-07	0.27107811E-07
	0	-0.58114696E-07		12	10	-0.44237357E-08	0.30823394E-07
				12	11	0.96462514E-08	-0.60711291E-08
				12	12	-0.30878714E-08	-0.10932316E-07

-03 $= X\ 10^{-3}$; E-05 $= X\ 10^{-5}$; etc.