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NOTES SCIENTIFIQUES ET TECHNIQUES  
DU BUREAU DES LONGITUDES.

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S 004

THE CALCULATION OF THE POSITIONS AND VELOCITIES  
OF THE EARTH DURING THE HIPPARCOS MISSION

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*Ce document a été publié par les soins du consortium "FAST"  
du projet HIPPARCOS.*

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Mai 1984



During the HIPPARCOS mission, corrections to the apparent positions of the stars, as observed by the satellite, will have to be taken into account to allow for parallax and aberration corrections.

Let the barycenter  $G$  of the Solar System be the origin of a reference system as close as possible to an inertial system. If  $T$  is the center of the Earth and  $S$  the satellite, we have :

$$\vec{GS} = \vec{GT} + \vec{TS}$$

and,

$$\dot{\vec{GS}} = \dot{\vec{GT}} + \dot{\vec{TS}}$$

The second vectors of the right hand members of the above equations are the position and the velocity of the satellite with respect to the center of the Earth; it is supposed that they will be measured whenever wanted with a sufficient accuracy.

We need the first vectors of the right hand members of the equations; these vectors are the position and the velocity of the Earth with respect to the barycenter of the Solar System.

#### NEEDED ACCURACY.

Let  $X_G$ ,  $Y_G$ ,  $Z_G$  be the components of the position vector of the Earth  $\vec{GT}$  with respect to the barycenter of the Solar System,  $\dot{X}_G$ ,  $\dot{Y}_G$ ,  $\dot{Z}_G$  the components of the velocity of the Earth  $\dot{\vec{GT}}$  with respect to the same point.

It will be assumed that the reductions of the observations of HIPPARCOS will have to be made to a precision of  $10^{-4}$  arcsecond.

The highest star parallax is roughly equal to one arcsecond; to ensure a precision of  $10^{-4}$  arcsecond, the Earth-barycenter distance  $\|\vec{GT}\|$  has to be measured with the same relative precision which corresponds to  $10^{-4}$  astronomical unit, or 15 000 km. In fact, a much higher precision can be attained easily and, as will be seen, the formulae which will be given ensure a precision 1000 times greater.

Again, as far as the aberration corrections are concerned, the precision to be attained is  $10^{-4}$  arcsecond. The main part of the aberration corrections is of the order of  $\|\dot{\vec{G}}S\|/c$ , where  $c$  is the velocity of light. As the velocity of the satellite with respect to the Earth  $\|\dot{\vec{T}}S\|$  is supposed to be known with a sufficient accuracy, we are concerned here with the precision needed on the velocity of the Earth with respect to the barycenter of the Solar System  $v = \|\dot{\vec{G}}T\|$ . To reach a precision of  $10^{-4}$  arcsecond upon  $v/c$ , one needs to know  $v$  within an accuracy of 15 cm/s. A precision of 5 cm/s has been retained.

#### SOURCES AVAILABLE.

There are two up to date theories of the motions of the Sun and planets which can be used for our purpose :

*DE 200*, which is the result of a numerical integration carried out at the Jet Propulsion Laboratory (*Standish and Williams, 1982*). This ephemeris covers the years 1800 to 2050; it is related to an equinox and equator J2000.0 close to those defined by FK5.

*Ephémérides BDL 82 of the Bureau des Longitudes*. These ephemerides use the planetary theories VSOP82 and TOP82 (*Bretagnon, 1982*), (*Simon, 1983*) and the lunar theory ELP2000-82 (*Chapront-Touzé and Chapront, 1983*) which are analytical or semi-analytical. The constants of integration have been determined by adjustment to DE200. These theories upon which the ephemerides BDL82 are built, are referred to a dynamical ecliptic and equinox; a rotation matrix allows to refer the ephemerides to the FK5 system.

In the case of the Earth, angular differences obtained in the positions using DE200 or BDL82 never exceed 0.007 arcsecond, which corresponds to 5 km (*Francou et al., 1983*). In BDL82, the IAU System of astronomical constants has been used all through.

As far as the velocity is concerned, Table 1 shows, for a certain number of dates, the corresponding values of  $v/c$  in arcsecond, where  $v$  is the velocity of the Earth with respect to the barycenter of the Solar System calculated from BDL82.  $D$ , in the last column, is the difference expressed in  $10^{-6}$  arcsecond between the value of  $v/c$  listed and the value obtained from DE200. This difference has been evaluated in the FK5 system.

It can be seen that this difference never exceeds  $3 \cdot 10^{-6}$  arcsecond (or, 0.5 cm/s on the velocity), which is well within the accuracy limit we have chosen.

In the forthcoming formulae, we have taken the ephemerides BDL82 as a source.

REPRESENTATION OF THE EPHEMERIS.

BDL82 represents the ephemerides using developments into Chebyshev polynomials for given intervals of time. Although this procedure saves room, we have adopted here a still more compact representation of the position vector and velocity of the Earth for the required precision. We describe below the adopted formulation of this new type of approximation.

We have kept the same notations as before and introduce the Earth-Moon barycenter denoted by  $\Gamma$  (capital gamma). We have :

$$\begin{aligned} \vec{G}_T &= \vec{G}_\Gamma + \vec{\Gamma}_T \\ \text{and,} \quad \dot{\vec{G}}_T &= \dot{\vec{G}}_\Gamma + \dot{\vec{\Gamma}}_T \end{aligned} \tag{1}$$

This writing splits in two parts the short periodic terms due to lunar action through the vectors  $\vec{\Gamma}_T$  and  $\dot{\vec{\Gamma}}_T$ , and the annual terms through the vectors  $\vec{G}_\Gamma$  and  $\dot{\vec{G}}_\Gamma$ .

The components  $X_T, Y_T, Z_T$  of  $\vec{\Gamma}_T$  and  $\dot{X}_T, \dot{Y}_T, \dot{Z}_T$  of  $\dot{\vec{\Gamma}}_T$  are represented by the following Fourier series :

$$\begin{aligned} X_T &= \sum_{i=1}^{22} A_i \cos(n_i t + \phi_i) \\ Y_T &= \sum_{i=1}^{22} A_i \sin(n_i t + \phi_i) \\ Z_T &= \sum_{j=1}^8 B_j \sin(m_j t + \psi_j) \\ \dot{X}_T &= \sum_{i=1}^{22} -A_i' \sin(n_i t + \phi_i) \\ \dot{Y}_T &= \sum_{i=1}^{22} A_i' \cos(n_i t + \phi_i) \\ \dot{Z}_T &= \sum_{j=1}^8 B_j' \cos(m_j t + \psi_j) \end{aligned} \tag{2}$$

These formulae are valid from 1900 to 2000. The quantities  $A_i$ ,  $A'_i$ ,  $B_j$ ,  $B'_j$ ,  $n_i$ ,  $m_j$ ,  $\phi_i$  and  $\psi_j$  are given in Table 2.

The components  $X$ ,  $Y$ ,  $Z$  of  $\vec{GT}$  and  $\dot{X}$ ,  $\dot{Y}$ ,  $\dot{Z}$  of  $\dot{\vec{GT}}$  are represented by a sequence of approximating functions defined upon time intervals of 400 days covering 1980 to 2000. The approximating functions are written as follows :

$$\begin{aligned}
 & a_0 + a'_0 t \\
 & + a_1 \sin(Nt + b_1) + a'_1 t \sin(Nt + b'_1) \\
 & + a_2 \sin(2Nt + b_2) + a'_2 t \sin(2Nt + b'_2) \\
 & + a_3 \sin(3Nt + b_3) \\
 & + a_4 \sin(4Nt + b_4) .
 \end{aligned} \tag{3}$$

The quantities  $a_0$ ,  $a'_0$ ,  $a_1$ ,  $b_1$ ,  $a'_1$ ,  $b'_1$ , ... are listed in table 3, for each interval.

Remark. The above formula (3) must be strictly used for dates which belong to its interval of definition.

In formulae (2) and (3), the time  $t$  is measured in julian years from J2000.0 (2 451 545.0). The coefficients  $A_i$ ,  $A'_i$ ,  $B_j$ ,  $B'_j$ ,  $a_n$  and  $a'_n$  are expressed in kilometers. Frequencies  $\phi_i$ ,  $\psi_j$  and  $N$  are in radians per year; in particular,

$$N = 2\pi \text{ rad/year.}$$

Phases  $\phi_i$ ,  $\psi_j$ ,  $b_n$  and  $b'_n$  are in radians.

#### SPECIFICATIONS OF THE COMPUTATIONS.

Positions and velocities of the Earth with respect to the barycenter of the Solar System are computed using formulae (1), (2) and (3).

The components  $X_G$ ,  $Y_G$ ,  $Z_G$  of  $\vec{GT}$  are measured in kilometers. The components  $\dot{X}_G$ ,  $\dot{Y}_G$ ,  $\dot{Z}_G$  of  $\dot{\vec{GT}}$  are measured in kilometers per second.

A comparison between the source BDL82 and the results obtained with formulae (2) and (3) allows us to guarantee an accuracy of 10 km for the positions and 5 cm/s for the velocities.

The computed components are ecliptic coordinates referred to the equinox of the fundamental catalogue FK5 for J2000.0 (2451 545.0).

The time scale is Terrestrial Dynamical Time (TDT). The time is expressed in julian years from J2000.0. For a given julian date  $JD$ , one has :

$$t = ( JD - 2451\ 545.0 ) / 365.25$$

EXAMPLE OF USE OF THE TABLES.

Compute the position and velocity of the Earth with respect to the barycenter of the Solar System for the date : Feb. 5 1988 0<sup>h</sup> (TDT) in the fixed ecliptic frame for J2000.0.

This date corresponds to the julian date :

$$JD = 2\ 447\ 196.5$$

All the computations have been performed with a pocket computer with 10 digits.

The time  $t$ , expressed in julian years and reckoned from J2000.0, is :

$$t = ( JD - 2451\ 545.0 ) / 365.25 = - 11.905\ 544\ 15$$

Introducing this value of  $t$ , the series of Table 2 give for the components of the vectors  $\vec{\Gamma}_T ( X_T , Y_T , Z_T )$  and  $\dot{\vec{\Gamma}}_T ( \dot{X}_T , \dot{Y}_T , \dot{Z}_T )$  :

$$\begin{array}{ll} X_T = - 105\ 877\ 923 & \dot{X}_T = - 21.336\ 566 \\ Y_T = + 103\ 632\ 152 & \dot{Y}_T = - 21.392\ 455 \\ Z_T = + \quad \quad 4\ 543 & \dot{Z}_T = - 0.000\ 629 \end{array}$$

In Table 3, to compute the vectors  $\vec{G}_T ( X , Y , Z )$  and  $\dot{\vec{G}}_T ( \dot{X} , \dot{Y} , \dot{Z} )$ , one searches for the interval covering the date  $JD$ , i.e., the interval from Sept. 1 1987 ( 2 447 040.0) to Oct. 5 1988 ( 2 447 440.0). One gets :

$$\begin{array}{ll} X = + 4\ 584 & \dot{X} = + 0.004\ 182 \\ Y = - 1\ 800 & \dot{Y} = + 0.010\ 985 \\ Z = - 116 & \dot{Z} = + 0.001\ 031 \end{array}$$

Finally, with  $\vec{G}_T = \vec{G}_T + \vec{\Gamma}_T$  and  $\dot{\vec{G}}_T = \dot{\vec{G}}_T + \dot{\vec{\Gamma}}_T$ , one obtains the following results for the components of the vectors  $\vec{G}_T ( X_G , Y_G , Z_G )$  and  $\dot{\vec{G}}_T ( \dot{X}_G , \dot{Y}_G , \dot{Z}_G )$  :

$$\begin{array}{ll} X_G = - 105\,873\,339 & \dot{X}_G = - 21.332\,384 \\ Y_G = + 103\,630\,352 & \dot{Y}_G = - 21.381\,470 \quad (C_1) \\ Z_G = \quad \quad 4\,427 & \dot{Z}_G = + 0.000\,402 \end{array}$$

These results have to be brought together with the direct computations from the source BDL82 of the components of the vector  $\vec{G}^T$  listed in Table 1. For the date  $JD$ , one reproduces below the  $\vec{G}^T$  components :

$$\begin{array}{ll} X_G = - 21.332\,381 \\ Y_G = - 21.381\,454 & (C_2) \\ Z_G = + 0.000\,406 \end{array}$$

Differences between  $(C_1)$  and  $(C_2)$  are always smaller than 5 cm/s.

#### REFERENCES.

- Bretagnon, P. : 1982, *Astron. Astrophys.* 114, 278.  
Chapront-Touzé, M., Chapront, J. : 1983, *Astron. Astrophys.* 124, 50.  
Francou, G., Bergeal, L., Chapront, J., Morando, B. : 1983, *Astron. Astrophys.* 128, 124.  
Simon, J.L. : 1983, *Astron. Astrophys.* 120, 197.  
Standish, E.M., Williams, J.G. : 1982, *Development Ephemeris DE200-LE200*, Magnetic tape.



NOTATIONS

The notations which belong to the right column are used in Tables 1, 2 and 3.

$G$	Barycenter of the Solar System	$G$
$T$	Center of the Earth	$T$
$\Gamma$	Barycenter of the Earth-Moon system	GAMMA
$X_G \ Y_G \ Z_G$	Components of vector $\vec{GT}$	$XG \ YG \ ZG$
$\dot{X}_G \ \dot{Y}_G \ \dot{Z}_G$	" " " $\dot{\vec{GT}}$	$XPG \ YPG \ ZPG$
$X_T \ Y_T \ Z_T$	" " " $\vec{\Gamma T}$	$XT \ YT \ ZT$
$\dot{X}_T \ \dot{Y}_T \ \dot{Z}_T$	" " " $\dot{\vec{\Gamma T}}$	$XPT \ YPT \ ZPT$
$X \ Y \ Z$	" " " $\vec{GT}$	$X \ Y \ Z$
$\dot{X} \ \dot{Y} \ \dot{Z}$	" " " $\dot{\vec{GT}}$	$XP \ YP \ ZP$
$A_i \ A'_i \ B_j \ B'_j$	Coefficients in formulae (2)	$A(I), AP(I), B(J), BP(J)$
$n_i \ , \ m_j$	Frequencies in formulae (2)	$N(I), M(J)$
$\phi_i \ , \ \psi_j$	Phases in formulae (2)	$PHI(I), PSI(J)$
$N = 2\pi$	Basic frequency in formula (3)	$N$
$t$	Time expressed in julian years reckoned from J2000.0	$T$
$v$	Velocity of the Earth with respect to the barycenter of the Solar System.	$V$
$c$	Velocity of light	$C$
$D$	Difference upon $v/c$ between DE200 and BDL82.	$D$



T A B L E 1

VELOCITY OF THE EARTH WITH RESPECT TO THE BARYCENTER  
OF THE SOLAR SYSTEM.

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CALCUL DE LA VITESSE DE LA TERRE PAR RAPPORT AU BARYCENTRE DU SYSTEME SOLAIRE.  
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SOURCE  
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EPHEMERIDES BDL82 ISSUES DES THEORIES DU BUREAU DES LONGITUDES : THEORIE PLANETAIRE VSOP82 (P.BRETAGNON), THEORIE DE LA LUNE ELP2000-82 (M. ET J. CHAPRONT). LES COMPOSANTES DU VECTEUR VITESSE DE LA TERRE PAR RAPPORT AU BARYCENTRE DU SYSTEME SOLAIRE SONT DES COORDONNEES RECTANGULAIRES ECLIPTIQUES RAPPORTEES A L'EQUINOXE DEFINI PAR LE CATALOGUE FONDAMENTAL FK5 EN J2000.0 (DJ 2451545,0).

CONSTANTES  
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LES CONSTANTES UTILISEES SONT CELLES RECOMMANDEES PAR L'U.A.I. A PARTIR DE 1984.  
VITESSE DE LA LUMIERE : 299 792 458 M/S.  
UNITE ASTRONOMIQUE : 149 597 870 000 M.  
RAPPORTS MASSE SOLEIL / MASSE PLANETE :  
MERCURE 6 023 600 JUPITER 1 047,355  
VENUS 408 523,5 SATURNE 3 498,5  
TERRE+LUNE 328 900,5 URANUS 22 869  
MARS 3 098 710 NEPTUNE 19 314  
RAPPORT MASSE LUNE / MASSE TERRE : 0, 012 300 02.  
OBLIQUITE DE L'ECLIPTIQUE SUR L'EQUATEUR FK5 EN J2000.0 : 23 D 26 M 21,448 S.

NOTATIONS  
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G : BARYCENTRE DU SYSTEME SOLAIRE.  
T : CENTRE DE LA TERRE.  
DATE : DATE DU CALCUL A OH.  
ECHELLE DE TEMPS : TEMPS DYNAMIQUE TERRESTRE (TDT).  
XPG YPG ZPG : COMPOSANTES DU VECTEUR VITESSE G-T (KM/S).  
V/C : RAPPORT DE LA VITESSE DE LA TERRE A CELLE DE LA LUMIERE (SECONDE DE DEGRE).  
D : DIFFERENCE ENTRE LA VALEUR DE V/C ISSUE DE BDL82 ET CELLE ISSUE DE L'INTEGRATION NUMERIQUE DE200/LE200 DU JET PROPULSION LABORATORY (SECONDE DE DEGRE / 1000000).

DATE	XPG	YPG	ZPG	V/C	D
1/ 1/1988	-29.81182996	-5.27350821	-0.00065781	20.829734	0.55
6/ 1/1988	-29.23986886	-7.84715991	0.00036565	20.829651	-0.38
11/ 1/1988	-28.45070409	-10.36682156	0.00067037	20.833807	0.94
16/ 1/1988	-27.44025101	-12.81774906	-0.00020707	20.837766	0.80
21/ 1/1988	-26.20247440	-15.17285655	-0.00150111	20.832349	1.31
26/ 1/1988	-24.75320926	-17.39288316	-0.00140572	20.814714	0.60
31/ 1/1988	-23.12422909	-19.46315464	-0.00033544	20.795494	0.98
5/ 2/1988	-21.33238138	-21.38145437	0.00040607	20.780610	0.20
10/ 2/1988	-19.38515907	-23.14196894	0.00005805	20.770334	0.06
15/ 2/1988	-17.28579038	-24.73138577	-0.00125040	20.760131	0.37
20/ 2/1988	-15.04366270	-26.12171594	-0.00192930	20.739780	0.98
25/ 2/1988	-12.69518366	-27.29115123	-0.00105158	20.709158	0.24
1/ 3/1988	-10.27152407	-28.24518984	0.00003263	20.678509	0.24
6/ 3/1988	-7.78793760	-28.98991721	0.00025045	20.652995	0.72
11/ 3/1988	-5.25299966	-29.52564520	-0.00069386	20.633394	0.44
16/ 3/1988	-2.67418468	-29.84171962	-0.00189594	20.614133	1.02
21/ 3/1988	-0.07630188	-29.91853528	-0.00164787	20.584777	-0.16
26/ 3/1988	2.50054404	-29.76003417	-0.00042043	20.547809	-0.62
31/ 3/1988	5.03540389	-29.38492084	0.00031782	20.512260	-1.18
5/ 4/1988	7.51852737	-28.80613421	-0.00009588	20.483308	0.56
10/ 4/1988	9.94528582	-28.02793080	-0.00133099	20.461943	-0.24
15/ 4/1988	12.30371860	-27.04171510	-0.00184737	20.440674	-0.11
20/ 4/1988	14.56068352	-25.84552725	-0.00085670	20.410185	-1.86
25/ 4/1988	16.68831474	-24.46304741	0.00025461	20.374619	-1.17
30/ 4/1988	18.67812563	-22.91806227	0.00041689	20.341710	-0.55
5/ 5/1988	20.52905440	-21.22655616	-0.00054528	20.317247	1.07
10/ 5/1988	22.24076571	-19.39121645	-0.00153372	20.301656	-0.79
15/ 5/1988	23.79490797	-17.40890196	-0.00112623	20.285287	-0.24
20/ 5/1988	25.16316393	-15.29746946	0.00011980	20.261118	-0.45
25/ 5/1988	26.33559741	-13.08785769	0.00077003	20.233744	0.70
30/ 5/1988	27.31503496	-10.80356838	0.00027324	20.210013	0.65
4/ 6/1988	28.10966589	-8.45792837	-0.00090189	20.196677	0.12
9/ 6/1988	28.71811695	-6.04942168	-0.00113196	20.192409	-2.10
14/ 6/1988	29.11930560	-3.58705012	-0.00006155	20.186256	-1.97
19/ 6/1988	29.30056257	-1.10068379	0.00095369	20.173748	-0.77
24/ 6/1988	29.26731185	1.38087681	0.00095009	20.159053	0.08
29/ 6/1988	29.03233554	3.83806440	-0.00009695	20.148775	0.13
4/ 7/1988	28.60939588	6.26575669	-0.00094395	20.150537	-1.22
9/ 7/1988	27.99103485	8.66487830	-0.00029312	20.160177	-1.98
14/ 7/1988	27.16383576	11.01294822	0.00092430	20.166996	-1.15
19/ 7/1988	26.13291287	13.27951866	0.00139911	20.168354	0.98
24/ 7/1988	24.91488347	15.44236252	0.00073198	20.167688	0.26
29/ 7/1988	23.53076542	17.48992712	-0.00048761	20.172106	-0.17
3/ 8/1988	21.99247934	19.42671173	-0.00052855	20.189368	-1.13
8/ 8/1988	20.28972716	21.24509187	0.00066420	20.212341	-0.55
13/ 8/1988	18.42520841	22.91722828	0.00156831	20.231778	-0.37
18/ 8/1988	16.41781605	24.42013367	0.00137396	20.245812	0.66
23/ 8/1988	14.29244527	25.74099531	0.00022480	20.257326	-1.50
28/ 8/1988	12.07392073	26.88069796	-0.00061616	20.274596	-1.37
2/ 9/1988	9.76637719	27.84797084	0.00018723	20.304228	-1.26
7/ 9/1988	7.36695078	28.62593521	0.00138575	20.337127	0.47
12/ 9/1988	4.89419928	29.19279269	0.00169885	20.365693	-0.14
17/ 9/1988	2.37568064	29.53724440	0.00088006	20.387999	0.46
22/ 9/1988	-0.15889534	29.65972886	-0.00034729	20.406938	-0.25
27/ 9/1988	-2.68909178	29.57491607	-0.00037322	20.432231	1.07

DATE	XPG	YPG	ZPG	V/C	D
2/10/1988	-5.21687938	29.28806637	0.00085622	20.468108	1.46
7/10/1988	-7.73124538	28.78246236	0.00162683	20.505028	1.07
12/10/1988	-10.20466019	28.04986925	0.00126201	20.536493	-0.80
17/10/1988	-12.60614674	27.09363486	0.00006257	20.560103	-0.73
22/10/1988	-14.90848027	25.93096589	-0.00069940	20.579639	-1.12
27/10/1988	-17.10376339	24.58490039	0.00008965	20.605825	-0.35
1/11/1988	-19.19295912	23.05579295	0.00119460	20.640064	0.53
6/11/1988	-21.15546975	21.33800396	0.00131402	20.673579	0.28
11/11/1988	-22.96352151	19.43886415	0.00036477	20.700220	0.35
16/11/1988	-24.58997361	17.37826172	-0.00076817	20.717113	0.55
21/11/1988	-26.02145063	15.18806741	-0.00067622	20.729934	1.31
26/11/1988	-27.26424956	12.88962871	0.00048912	20.749204	0.71
1/12/1988	-28.31518474	10.48403900	0.00107726	20.774090	2.12
6/12/1988	-29.15487784	7.97994936	0.00052213	20.797112	1.17
11/12/1988	-29.76308517	5.39779435	-0.00072082	20.811799	0.55
16/12/1988	-30.12639172	2.77176954	-0.00125453	20.815265	-0.96
21/12/1988	-30.25389774	0.13650225	-0.00037158	20.815660	-0.21
26/12/1988	-30.16032043	-2.49557307	0.00062583	20.821979	-0.49
31/12/1988	-29.84266731	-5.11847195	0.00054659	20.832329	1.43
5/1/1989	-29.29131942	-7.71474004	-0.00052909	20.840452	0.27
10/1/1989	-28.49878581	-10.25637979	-0.00159171	20.839038	0.43
15/1/1989	-27.47407302	-12.70475120	-0.00121722	20.826101	0.04
20/1/1989	-26.24534710	-15.03879698	-0.00001782	20.811870	1.22
25/1/1989	-24.82865838	-17.25571005	0.00045432	20.803204	0.19
30/1/1989	-23.22632226	-19.34733531	-0.00023754	20.798193	0.53
4/2/1989	-21.43985693	-21.29579004	-0.00150494	20.791326	0.15
9/2/1989	-19.47664338	-23.07228205	-0.00187738	20.774148	0.63
14/2/1989	-17.36815529	-24.64966157	-0.00077010	20.746658	0.83
19/2/1989	-15.14694816	-26.02856656	0.00020372	20.719918	0.56
24/2/1989	-12.82647917	-27.21333541	0.00004172	20.698979	-0.41
1/3/1989	-10.41395643	-28.19904282	-0.00105084	20.682418	-0.39
6/3/1989	-7.91814997	-28.97229041	-0.00203816	20.664721	0.59
11/3/1989	-5.36094302	-29.51071478	-0.00148157	20.636425	0.35
16/3/1989	-2.78380915	-29.81140866	-0.00018825	20.600238	0.44
21/3/1989	-0.20973997	-29.89161433	0.00022439	20.566694	-0.27
26/3/1989	2.35217936	-29.76049872	-0.00048795	20.539833	-0.01
31/3/1989	4.89429906	-29.41826957	-0.00163402	20.518719	-0.24
5/4/1989	7.40399410	-28.85619012	-0.00187583	20.496907	0.10
10/4/1989	9.84884274	-28.06634579	-0.00064678	20.464787	-1.11
15/4/1989	12.19552566	-27.06989952	0.00028636	20.427637	0.20
20/4/1989	14.43514313	-25.89001550	0.00005292	20.394657	-0.02
25/4/1989	16.56437049	-24.53844410	-0.00098245	20.369659	0.12
30/4/1989	18.57835360	-23.01788126	-0.00173713	20.351809	-1.47
5/5/1989	20.46044908	-21.32426492	-0.00105998	20.332915	0.07
10/5/1989	22.17783639	-19.46980617	0.00024147	20.304673	-0.38
15/5/1989	23.71661221	-17.48752124	0.00052123	20.273891	0.53
20/5/1989	25.07941083	-15.39903245	-0.00025299	20.248377	-0.12
25/5/1989	26.26939297	-13.21554978	-0.00125905	20.232294	-0.33
30/5/1989	27.28332282	-10.93868126	-0.00122852	20.224135	-1.24
4/6/1989	28.10077431	-8.57319157	0.00005009	20.213818	0.25
9/6/1989	28.70186706	-6.14834095	0.00087942	20.195615	-0.38
14/6/1989	29.09143338	-3.69549693	0.00048100	20.176490	-0.59
19/6/1989	29.28020363	-1.23176115	-0.00058738	20.163340	-1.10
24/6/1989	29.27659079	1.23595862	-0.00113271	20.160978	-0.53
29/6/1989	29.07485086	3.70674695	-0.00024703	20.166150	-0.20

DATE	XPG	YPG	ZPG	V/C	D
4/ 7/1989	28.65752563	6.16235057	0.00100642	20.167809	0.40
9/ 7/1989	28.02503322	8.56840277	0.00112175	20.163017	-0.01
14/ 7/1989	27.19432473	10.90206997	0.00020649	20.157926	-0.93
19/ 7/1989	26.18223616	13.15250315	-0.00078992	20.159234	-0.21
24/ 7/1989	24.99837257	15.31966309	-0.00053457	20.172296	-1.14
29/ 7/1989	23.63354432	17.39765268	0.00080502	20.191202	-0.81
3/ 8/1989	22.08410253	19.35805598	0.00151128	20.205489	-0.44
8/ 8/1989	20.36806694	21.17364219	0.00095521	20.214148	1.01
13/ 8/1989	18.50908010	22.83174896	-0.00019080	20.222267	0.22
18/ 8/1989	16.52790789	24.33041780	-0.00068929	20.237081	0.47
23/ 8/1989	14.42994686	25.67498447	0.00034383	20.263814	-1.46
28/ 8/1989	12.20948279	26.85007774	0.00150192	20.293810	-0.81
2/ 9/1989	9.88158939	27.82905352	0.00146794	20.318333	-0.28
7/ 9/1989	7.47429702	28.59813825	0.00045927	20.337156	1.28
12/ 9/1989	5.01466269	29.15597011	-0.00053792	20.354592	-0.16
17/ 9/1989	2.52257321	29.51198940	-0.00023220	20.379037	-0.16
22/ 9/1989	-0.00272225	29.67099589	0.00110275	20.414397	-1.35
27/ 9/1989	-2.55396901	29.61316257	0.00161542	20.450240	-0.90
2/10/1989	-5.10279247	29.32530073	0.00093397	20.479727	-0.76
7/10/1989	-7.61833661	28.80891075	-0.00020223	20.502605	0.04
12/10/1989	-10.07444718	28.07613538	-0.00064339	20.523046	-0.49
17/10/1989	-12.45951354	27.14653574	0.00039595	20.550821	0.36
22/10/1989	-14.77575487	26.01974174	0.00139559	20.587368	0.77
27/10/1989	-17.00197417	24.68396471	0.00114369	20.622006	0.21
1/11/1989	-19.10730696	23.14407620	0.00007346	20.649215	0.19
6/11/1989	-21.06477579	21.41695950	-0.00080011	20.668388	0.79
11/11/1989	-22.85704235	19.52863430	-0.00042453	20.684426	1.08
16/11/1989	-24.48613725	17.50136986	0.00084532	20.707949	0.43
21/11/1989	-25.94961173	15.33236300	0.00111336	20.737587	0.20
26/11/1989	-27.22247525	13.02637681	0.00025099	20.763661	-0.92
1/12/1989	-28.28149036	10.60389744	-0.00085644	20.781160	-0.33
6/12/1989	-29.11123869	8.09491818	-0.00108970	20.789206	0.34
11/12/1989	-29.71246588	5.53284772	-0.00001366	20.794341	1.29
16/12/1989	-30.09874781	2.93299778	0.00086678	20.806790	0.53
21/12/1989	-30.26360328	0.29694303	0.00038101	20.823128	1.39
26/12/1989	-30.19072544	-2.35655090	-0.00078722	20.835166	-0.15
31/12/1989	-29.87092869	-4.99820520	-0.00153268	20.837679	1.01
5/ 1/1990	-29.30762853	-7.59208717	-0.00093508	20.829981	0.62
10/ 1/1990	-28.52233850	-10.11152001	0.00032385	20.820772	0.60
15/ 1/1990	-27.53192287	-12.55249396	0.00047752	20.818558	-0.22
20/ 1/1990	-26.33249594	-14.90717705	-0.00051736	20.819154	1.54
25/ 1/1990	-24.92195635	-17.15262745	-0.00161062	20.815655	0.49
30/ 1/1990	-23.30691266	-19.25898480	-0.00163889	20.802053	0.24
4/ 2/1990	-21.51193457	-21.19679800	-0.00041749	20.778679	-0.79
9/ 2/1990	-19.56940263	-22.95909601	0.00041488	20.756045	-0.79
14/ 2/1990	-17.49246941	-24.55022320	-0.00013194	20.740283	-0.67
19/ 2/1990	-15.28411373	-25.96099637	-0.00130337	20.727469	1.16
24/ 2/1990	-12.95366382	-27.17300049	-0.00195423	20.711384	0.53
1/ 3/1990	-10.52167544	-28.16291500	-0.00116722	20.684923	-0.27
6/ 3/1990	-8.02667323	-28.92093476	0.00008263	20.650481	-0.15
11/ 3/1990	-5.49551895	-29.46050586	0.00016636	20.619215	-0.30
16/ 3/1990	-2.93603050	-29.78937253	-0.00081336	20.595151	0.67
21/ 3/1990	-0.35614794	-29.90236702	-0.00179139	20.575045	0.84
26/ 3/1990	2.22910430	-29.78855425	-0.00169037	20.552583	0.63
31/ 3/1990	4.78900057	-29.43712895	-0.00037551	20.519761	-0.43

DATE	XPG	YPG	ZPG	V/C	D
5/ 4/1990	7.28694205	-28.86326322	0.00032100	20.481758	0.52
10/ 4/1990	9.71124727	-28.08992855	-0.00027075	20.448970	-0.70
15/ 4/1990	12.05834301	-27.12566591	-0.00132733	20.424103	-0.68
20/ 4/1990	14.31977808	-25.97035202	-0.00176885	20.404507	-1.27
25/ 4/1990	16.47802353	-24.61971038	-0.00085789	20.382922	-0.31
30/ 4/1990	18.49911101	-23.08087992	0.00035932	20.351414	-0.89
5/ 5/1990	20.36371442	-21.38618120	0.00026390	20.317723	0.70
10/ 5/1990	22.07377515	-19.55692327	-0.00071109	20.290622	-0.35
15/ 5/1990	23.62936685	-17.60146789	-0.00149387	20.272345	-0.69
20/ 5/1990	25.02379862	-15.52238125	-0.00116800	20.260387	-1.43
25/ 5/1990	26.23741665	-13.32266519	0.00020557	20.245903	-0.21
30/ 5/1990	27.24466573	-11.02842385	0.00075814	20.222538	-0.46
4/ 6/1990	28.04787096	-8.67373890	0.00000811	20.199337	0.73
9/ 6/1990	28.65663777	-6.27387371	-0.00099693	20.183483	-0.18
14/ 6/1990	29.07452843	-3.83565745	-0.00120749	20.177338	-0.60
19/ 6/1990	29.29546554	-1.36248306	-0.00014547	20.177810	-0.41
24/ 6/1990	29.30043322	1.13161902	0.00104197	20.174470	0.13
29/ 6/1990	29.08344159	3.61002843	0.00076348	20.163708	-0.80
4/ 7/1990	28.66186361	6.04819377	-0.00031007	20.154364	-0.80
9/ 7/1990	28.04921614	8.43687390	-0.00100545	20.152676	-0.61
14/ 7/1990	27.25130851	10.77259802	-0.00047792	20.161404	-0.90
19/ 7/1990	26.26084174	13.04938663	0.00090892	20.175905	0.09
24/ 7/1990	25.06815803	15.24107290	0.00136643	20.185107	0.61
29/ 7/1990	23.68875086	17.31500224	0.00047053	20.188195	0.10
3/ 8/1990	22.14637778	19.25885362	-0.00056216	20.192875	-0.32
8/ 8/1990	20.45711121	21.06962268	-0.00066959	20.205260	0.29
13/ 8/1990	18.62612963	22.74782118	0.00048519	20.228367	-1.00
18/ 8/1990	16.64739022	24.28069836	0.00154847	20.255166	0.01
23/ 8/1990	14.52958789	25.63814096	0.00116304	20.275433	-0.38
28/ 8/1990	12.30182572	26.80213817	0.00002843	20.290210	0.18
2/ 9/1990	9.98935179	27.77140265	-0.00063324	20.305934	-0.63
7/ 9/1990	7.60883500	28.55087775	-0.00002308	20.329338	0.20
12/ 9/1990	5.16209871	29.14266763	0.00128595	20.363020	-0.81
17/ 9/1990	2.65234394	29.52749330	0.00154587	20.397460	0.60
22/ 9/1990	0.10618162	29.68542463	0.00058431	20.424455	0.39
27/ 9/1990	-2.44389796	29.61585647	-0.00040984	20.445719	0.78
2/10/1990	-4.97393067	29.32839971	-0.00044816	20.466817	-0.01
7/10/1990	-7.47130307	28.83694036	0.00072082	20.495644	0.98
12/10/1990	-9.93653628	28.14095410	0.00154516	20.533240	-0.07
17/10/1990	-12.35149007	27.22419063	0.00097027	20.568573	0.20
22/10/1990	-14.68246461	26.08635802	-0.00015815	20.595678	-0.20
27/10/1990	-16.90146124	24.74256624	-0.00069905	20.616137	0.14
1/11/1990	-18.99045172	23.21394202	-0.00002388	20.635305	0.19
6/11/1990	-20.94686275	21.52003160	0.00120152	20.662339	0.27
11/11/1990	-22.76847631	19.65694494	0.00115415	20.695717	-0.29
16/11/1990	-24.42783760	17.62371135	0.00007029	20.724466	-0.76
21/11/1990	-25.89745025	15.43917077	-0.00083924	20.744231	0.66
26/11/1990	-27.16022945	13.13072951	-0.00072017	20.756187	1.51
1/12/1990	-28.21143527	10.72821330	0.00047416	20.766283	2.02
6/12/1990	-29.06074566	8.24858128	0.00114061	20.784356	1.03
11/12/1990	-29.70033115	5.68997372	0.00030469	20.806203	0.57
16/12/1990	-30.10749432	3.06966589	-0.00085457	20.822107	-0.85
21/12/1990	-30.26986221	0.41788118	-0.00124945	20.828417	0.34
26/12/1990	-30.18690335	-2.23186064	-0.00044650	20.826043	-0.33
31/12/1990	-29.87262738	-4.85070110	0.00075808	20.822325	-0.00



DATE	XPG	YPG	ZPG	V/C	D
5/ 1/1991	-29.34355986	-7.43200802	0.00054953	20.826599	0.08
10/ 1/1991	-28.59068957	-9.97011003	-0.00067181	20.832864	1.43
15/ 1/1991	-27.60671191	-12.43823844	-0.00152196	20.832975	0.22
20/ 1/1991	-26.39686482	-14.80490545	-0.00123510	20.823194	1.09
25/ 1/1991	-24.97954126	-17.04030093	-0.00000556	20.804654	0.34
30/ 1/1991	-23.38384733	-19.12993042	0.00061820	20.786549	0.83
4/ 2/1991	-21.62395328	-21.07781552	-0.00030620	20.776425	0.36
9/ 2/1991	-19.69696779	-22.87223590	-0.00145454	20.767765	0.42
14/ 2/1991	-17.61138310	-24.48893433	-0.00172089	20.753617	-0.98
19/ 2/1991	-15.38716367	-25.90366849	-0.00078691	20.729609	-0.32
24/ 2/1991	-13.05752766	-27.10150320	0.00033426	20.697907	-0.50
1/ 3/1991	-10.65272607	-28.08928397	0.00009641	20.669276	-0.49
6/ 3/1991	-8.17984136	-28.87532623	-0.00109622	20.648720	-0.33
11/ 3/1991	-5.64449776	-29.44857657	-0.00180947	20.630196	0.27
16/ 3/1991	-3.06446442	-29.79412404	-0.00136530	20.607258	0.67
21/ 3/1991	-0.46910910	-29.90024056	-0.00010521	20.574655	1.47
26/ 3/1991	2.10503888	-29.77430805	0.00034868	20.536612	0.69
31/ 3/1991	4.64091241	-29.43806014	-0.00055831	20.504280	-0.34
5/ 4/1991	7.13649801	-28.89860453	-0.00156336	20.480273	0.76
10/ 4/1991	9.58119252	-28.15061505	-0.00162337	20.459430	0.77
15/ 4/1991	11.95436620	-27.18903656	-0.00055540	20.435054	0.31
20/ 4/1991	14.22329896	-26.01801975	0.00046184	20.401310	-1.44
25/ 4/1991	16.36330386	-24.66512383	0.00004694	20.365155	-0.73
30/ 4/1991	18.37383664	-23.15328278	-0.00106817	20.336618	-0.79
5/ 5/1991	20.25448045	-21.48776157	-0.00156973	20.316770	0.56
10/ 5/1991	21.99436512	-19.66932874	-0.00092582	20.301232	-0.42
15/ 5/1991	23.57284844	-17.70130235	0.00039631	20.282344	-0.60
20/ 5/1991	24.96227087	-15.60546465	0.00064722	20.254670	-1.43
25/ 5/1991	26.15942617	-13.41677834	-0.00036967	20.227541	0.27
30/ 5/1991	27.17356151	-11.15076643	-0.00125106	20.209004	-0.17
4/ 6/1991	28.00498256	-8.81224663	-0.00109755	20.199547	0.12
9/ 6/1991	28.64471802	-6.40597427	0.00009190	20.195113	-0.94
14/ 6/1991	29.07357267	-3.94430953	0.00108101	20.186600	-0.41
19/ 6/1991	29.27977226	-1.46263073	0.00045601	20.170344	-0.74
24/ 6/1991	29.27899406	1.01155200	-0.00067941	20.156709	0.10
29/ 6/1991	29.08319382	3.47031052	-0.00104316	20.151923	-0.62
4/ 7/1991	28.69407526	5.90906573	-0.00025377	20.156524	-0.80
9/ 7/1991	28.10433248	8.32019351	0.00107097	20.166058	-0.66
14/ 7/1991	27.30106964	10.68046832	0.00123171	20.170068	-1.01
19/ 7/1991	26.29498637	12.95332079	0.00008064	20.167651	-1.31
24/ 7/1991	25.11029435	15.12545375	-0.00075258	20.168723	-0.55
29/ 7/1991	23.75927927	17.19402816	-0.00048641	20.178482	0.47
3/ 8/1991	22.24502438	19.15562276	0.00071519	20.197722	0.31
8/ 8/1991	20.56224905	20.99842114	0.00159252	20.220686	0.15
13/ 8/1991	18.71306413	22.69167352	0.00086696	20.236494	-1.73
18/ 8/1991	16.72636349	24.21188346	-0.00030011	20.246968	-1.60
23/ 8/1991	14.62657418	25.55833232	-0.00058564	20.260740	-0.72
28/ 8/1991	12.42629732	26.73284509	0.00025148	20.282841	0.92
2/ 9/1991	10.12880991	27.73349527	0.00142258	20.314110	0.94
7/ 9/1991	7.73501319	28.54310111	0.00141895	20.346702	1.34
12/ 9/1991	5.26687570	29.13542145	0.00022135	20.370811	-0.93
17/ 9/1991	2.75951501	29.50675025	-0.00054072	20.389979	-1.24
22/ 9/1991	0.23441411	29.66585489	-0.00018156	20.411497	-1.36
27/ 9/1991	-2.29699905	29.62064925	0.00098929	20.440943	0.43
2/10/1991	-4.83204587	29.36935454	0.00159427	20.478524	0.60

DATE	XPG	YPG	ZPG	V/C	D
7/10/1991	-7.35736865	28.89412937	0.00074624	20.514253	1.61
12/10/1991	-9.83789910	28.18699632	-0.00037295	20.540651	0.35
17/10/1991	-12.24330731	27.26209866	-0.00051684	20.561722	0.12
22/10/1991	-14.55706185	26.13691620	0.00039961	20.583879	-0.40
27/10/1991	-16.77313749	24.82549446	0.00144002	20.613718	0.19
1/11/1991	-18.88772927	23.32471700	0.00113130	20.649803	-0.16
6/11/1991	-20.87495352	21.62749899	-0.00011074	20.680998	0.00
11/11/1991	-22.70182485	19.74864361	-0.00076292	20.702381	0.06
16/11/1991	-24.34955507	17.71466410	-0.00026752	20.717563	1.41
21/11/1991	-25.81110306	15.55078715	0.00092561	20.732751	1.66
26/11/1991	-27.09022422	13.27273547	0.00131146	20.755636	0.92
1/12/1991	-28.17895959	10.87807217	0.00023140	20.782309	-0.13
6/12/1991	-29.05011744	8.37900759	-0.00085526	20.802012	-0.74
11/12/1991	-29.68594979	5.80608509	-0.00087124	20.811672	0.58
16/12/1991	-30.08334836	3.19159907	0.00012104	20.814264	0.82
21/12/1991	-30.25026348	0.56296969	0.00113179	20.816552	1.77
26/12/1991	-30.19953716	-2.07028847	0.00060672	20.826814	0.91
31/12/1991	-29.91995352	-4.70458080	-0.00071670	20.838613	0.74
5/ 1/1992	-29.39762624	-7.31242795	-0.00127364	20.842649	-0.20
10/ 1/1992	-28.63478836	-9.85991912	-0.00067526	20.836710	1.07
15/ 1/1992	-27.64557097	-12.31733402	0.00050106	20.823361	0.30
20/ 1/1992	-26.45353810	-14.66579866	0.00083989	20.810638	0.77
25/ 1/1992	-25.07304183	-16.90668837	-0.00035856	20.806295	-0.25
30/ 1/1992	-23.49614600	-19.02796349	-0.00137420	20.802185	-0.08
4/ 2/1992	-21.72811678	-21.00019237	-0.00126217	20.790654	-0.63
9/ 2/1992	-19.78799537	-22.79698931	-0.00023478	20.769563	0.81
14/ 2/1992	-17.70411921	-24.40038961	0.00066925	20.741594	0.34
19/ 2/1992	-15.50689657	-25.80987414	0.00012119	20.716458	0.97
24/ 2/1992	-13.20403979	-27.03385907	-0.00117448	20.700031	0.37
29/ 2/1992	-10.79714061	-28.05656043	-0.00155388	20.683704	0.02
5/ 3/1992	-8.30547849	-28.85801890	-0.00083059	20.661004	-0.09
10/ 3/1992	-5.75778054	-29.42540888	0.00028139	20.629367	0.44
15/ 3/1992	-3.18826720	-29.75942289	0.00046591	20.592407	-0.43
20/ 3/1992	-0.61954607	-29.87787680	-0.00070099	20.561155	-0.75
25/ 3/1992	1.94799017	-29.78809745	-0.00155953	20.538742	-0.23
30/ 3/1992	4.50334651	-29.47838330	-0.00123134	20.517179	-0.25
4/ 4/1992	7.02219592	-28.94178624	-0.00012094	20.490432	0.11
9/ 4/1992	9.47329820	-28.18086105	0.00061379	20.455357	-0.38
14/ 4/1992	11.82867420	-27.21606844	-0.00006508	20.417457	-0.50
19/ 4/1992	14.08285893	-26.07200642	-0.00126285	20.387811	-0.67
24/ 4/1992	16.23718620	-24.75151237	-0.00142342	20.366986	0.35
29/ 4/1992	18.27665141	-23.25132449	-0.00051365	20.348110	0.22
4/ 5/1992	20.17803146	-21.57561041	0.00060755	20.324831	0.47
9/ 5/1992	21.91417632	-19.74237594	0.00056278	20.293745	-1.02
14/ 5/1992	23.47476318	-17.78424897	-0.00064601	20.262831	-0.88
19/ 5/1992	24.86825368	-15.71953839	-0.00136226	20.241676	-1.29
24/ 5/1992	26.09380112	-13.54948319	-0.00083693	20.229290	0.18
29/ 5/1992	27.13774467	-11.27859627	0.00037901	20.219798	-0.46
3/ 6/1992	27.98050246	-8.91998118	0.00104187	20.205871	-0.02
8/ 6/1992	28.60695705	-6.50502523	0.00016799	20.184761	-0.95
13/ 6/1992	29.02763312	-4.06422294	-0.00097090	20.166554	-0.39
18/ 6/1992	29.25506431	-1.60563250	-0.00099290	20.158518	-0.78
23/ 6/1992	29.28719400	0.86766725	0.00002367	20.159173	0.29
28/ 6/1992	29.11415130	3.34600176	0.00114841	20.163128	-0.04
3/ 7/1992	28.72242450	5.80754570	0.00098424	20.161669	-0.26

TABLE 2

POSITIONS AND VELOCITIES OF THE EARTH WITH RESPECT  
TO THE EARTH-MOON BARYCENTER.

-----  
CALCUL DES POSITIONS ET DES VITESSES DE LA TERRE PAR RAPPORT AU BARYCENTRE DU  
SYSTEME TERRE-LUNE.  
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SOURCE  
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SERIES DE FOURIER ETABLIES A PARTIR DES THEORIES DU BUREAU DES LONGITUDES :  
THEORIE PLANETAIRE VSOP82 (P.BRETAGNON), THEORIE DE LA LUNE ELP2000-82 (M. ET J.  
CHAPRONT).  
LES COMPOSANTES DES VECTEURS POSITIONS ET VITESSES DE LA TERRE PAR RAPPORT AU  
BARYCENTRE DU SYSTEME TERRE-LUNE SONT DES COORDONNEES RECTANGULAIRES ECLIPTIQUES  
RAPPORTEES A L'EQUINOXE DEFINI PAR LE CATALOGUE FONDAMENTAL FK5 EN J2000.0  
(DJ 2451545,0).

NOTATIONS  
-----

GAMMA : BARYCENTRE DU SYSTEME TERRE-LUNE.  
T : CENTRE DE LA TERRE.  
XT YT ZT : COMPOSANTES DU VECTEUR POSITION GAMMA-T (KM).  
XPT YPT ZPT : COMPOSANTES DU VECTEUR VITESSE GAMMA-T (KM/S).  
A(I) : COEFFICIENTS POUR XT ET YT (KM).  
AP(I) : COEFFICIENTS POUR XPT ET YPT (KM/S).  
B(J) : COEFFICIENTS POUR ZT (KM).  
BP(J) : COEFFICIENTS POUR ZPT (KM/S).  
N(I) : VITESSES ANGULAIRES POUR XT, YT, XPT ET YPT (RADIAN/AN).  
PHI(I) : PHASES POUR XT, YT, XPT ET YPT (RADIAN).  
M(J) : VITESSES ANGULAIRES POUR ZT ET ZPT (RADIAN/AN).  
PSI(J) : PHASES POUR ZT ET ZPT (RADIAN).

UTILISATION  
-----

XT = SOMME(I = 1 A 22) : A(I) \* COS (N(I)\*T + PHI(I))  
YT = SOMME(I = 1 A 22) : A(I) \* SIN (N(I)\*T + PHI(I))  
ZT = SOMME(J = 1 A 8 ) : B(J) \* SIN (M(J)\*T + PSI(J))  
XPT = SOMME(I = 1 A 22) : -AP(I) \* SIN (N(I)\*T + PHI(I))  
YPT = SOMME(I = 1 A 22) : AP(I) \* COS (N(I)\*T + PHI(I))  
ZPT = SOMME(J = 1 A 8 ) : BP(J) \* COS (M(J)\*T + PSI(J))  
T EST COMPTE EN ANNEES JULIENNES A PARTIR DE J2000.0 (DJ 2451545,0).  
ECHELLE DE TEMPS : TEMPS DYNAMIQUE TERRESTRE (TDT).

VECTEUR (GAMMA-T)

I	A(I)	AP(I)	N(I)	PHI(I)
1	4653.7	0.012387	83.99684730	0.66875
2	383.2	0.000009	0.70993300	1.45470
3	128.5	0.000681	167.28376200	3.02430
4	75.8	0.000028	11.85622000	2.05200
5	39.1	-0.000088	-71.43070000	5.97900
6	28.3	0.000140	156.13748000	2.42700
7	9.3	-0.000025	-84.67248000	3.69600
8	9.2	0.000070	239.42439000	4.78300
9	7.5	0.000018	77.71377000	0.73100
10	7.3	0.000021	90.27992000	3.76700
11	5.3	0.000042	250.57068000	5.38000
12	3.2	0.000002	18.13930000	2.00900
13	3.6	0.000011	95.14313000	4.40800
14	2.8	-0.000006	-65.14762000	5.93600
15	1.9	0.000000	6.99301000	1.41200
16	2.1	0.000000	6.28308000	1.75400
17	1.8	-0.000005	-82.57698000	2.24200
18	1.4	0.000007	149.85440000	2.47000
19	1.1	0.000006	161.00069000	3.06800
20	0.9	0.000000	-5.57314000	4.80600
21	0.8	0.000004	173.56684000	6.12300
22	0.9	0.000009	322.71131000	0.85500

  

J	B(J)	BP(J)	M(J)	PSI(J)
1	418.3	0.001118	84.33466200	4.76950
2	34.0	0.000001	1.04775000	5.55600
3	15.5	0.000035	71.09288000	5.62700
4	11.5	0.000061	167.62158000	0.84200
5	5.5	-0.000002	-12.19403000	3.27200
6	2.5	0.000013	156.47529000	0.24500
7	0.8	-0.000002	-64.80981000	3.75400
8	0.8	0.000006	239.76220000	2.60000



TABLE 3

POSITIONS AND VELOCITIES OF THE EARTH-MOON BARYCENTER  
WITH RESPECT TO THE BARYCENTER OF THE SOLAR SYSTEM.

-----  
CALCUL DES POSITIONS ET DES VITESSES DU BARYCENTRE DU SYSTEME TERRE-LUNE PAR  
RAPPORT AU BARYCENTRE DU SYSTEME SOLAIRE.  
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SOURCE  
-----

FONCTIONS D'APPROXIMATION ETABLIES A PARTIR DES EPHEMERIDES BDL82 ET VALABLES  
SUR DES PERIODES DE 400 JOURS (J.CHAPRONT).  
LES COMPOSANTES DES VECTEURS POSITIONS ET VITESSES DU BARYCENTRE DU SYSTEME  
TERRE-LUNE PAR RAPPORT AU BARYCENTRE DU SYSTEME SOLAIRE SONT DES COORDONNEES  
RECTANGULAIRES ECLIPTIQUES RAPPORTEES A L'EQUINOXE DEFINI PAR LE CATALOGUE FON-  
DAMENTAL FK5 EN J2000.0 (DJ 2451545,0).

NOTATIONS  
-----

GAMMA : BARYCENTRE DU SYSTEME TERRE-LUNE.  
G : BARYCENTRE DU SYSTEME SOLAIRE.  
X Y Z : COMPOSANTES DU VECTEUR POSITION G-GAMMA (KM).  
XP YP ZP : COMPOSANTES DU VECTEUR VITESSE G-GAMMA (KM/S).  
T : TEMPS COMPTE EN ANNEES JULIENNES A PARTIR DE J2000.0 (DJ 2451545,0).  
EHELLE DE TEMPS : TEMPS DYNAMIQUE TERRESTRE (TDT).  
N : FREQUENCE DE BASE EGALE A  $2 \cdot \pi$  RADIAN/AN.

PRECISION  
-----

LES POSITIONS SONT ASSUREES A UNE PRECISION INFERIEURE A 10 KM.  
LES VITESSES SONT ASSUREES A UNE PRECISION INFERIEURE A 5 CM/S.  
ATTENTION ! CHAQUE FONCTION DOIT ETRE STICTEMENT UTILISEE POUR DES DATES APPAR-  
TENANT A SON INTERVALLE DE DEFINITION DE 400 JOURS.



VECTEUR G-GAMMA

DU 1/ 1/1980 A 12H AU 4/ 2/1981 A 12H DELTAT = 400.  
 2444240.0 2444640.0

$$\begin{aligned}
 X = & \quad +3711638. & \quad +84028.47*T \\
 & +150399748.*\text{SIN}( N*T+3.32283525) & +50688.53*T*\text{SIN}( N*T+2.744497) \\
 & +1129390.*\text{SIN}(2*N*T+3.36547895) & +7812.80*T*\text{SIN}(2*N*T+5.797082) \\
 & +15535.*\text{SIN}(3*N*T+3.243478 ) \\
 & +227.*\text{SIN}(4*N*T+3.3021 / )
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad +5289175. & \quad +452422.67*T \\
 & +149555970.*\text{SIN}( N*T+1.75185655) & +28384.94*T*\text{SIN}( N*T+0.128169) \\
 & +1251201.*\text{SIN}(2*N*T+1.77692215) & +3846.84*T*\text{SIN}(2*N*T+3.288621) \\
 & +15553.*\text{SIN}(3*N*T+1.665297 ) \\
 & +212.*\text{SIN}(4*N*T+1.5199 )
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad -170126. & \quad -6797.86*T \\
 & +49688.*\text{SIN}( N*T+0.83506705) & +2386.71*T*\text{SIN}( N*T+0.703988) \\
 & +11209.*\text{SIN}(2*N*T+3.88264304) & +578.06*T*\text{SIN}(2*N*T+3.870445) \\
 & +16.*\text{SIN}(3*N*T+2.433936 ) \\
 & +6.*\text{SIN}(4*N*T+1.5759 )
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad -0.132692 & \quad -0.00695250*T \\
 & +29.778595*\text{SIN}( N*T+4.89574743) & +0.00215147*T*\text{SIN}( N*T+3.310705) \\
 & +0.485318*\text{SIN}(2*N*T+4.88814034) & +0.00098446*T*\text{SIN}(2*N*T+0.867219) \\
 & +0.009241*\text{SIN}(3*N*T+4.809051 ) \\
 & +0.000175*\text{SIN}(4*N*T+4.8419 )
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.084523 & \quad -0.00507923*T \\
 & +29.725520*\text{SIN}( N*T+3.31865165) & +0.01210259*T*\text{SIN}( N*T+1.505740) \\
 & +0.517113*\text{SIN}(2*N*T+3.39479468) & +0.00295432*T*\text{SIN}(2*N*T+4.556373) \\
 & +0.009322*\text{SIN}(3*N*T+3.232873 ) \\
 & +0.000173*\text{SIN}(4*N*T+3.0667 )
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.000235 & \quad +0.00002185*T \\
 & +0.006028*\text{SIN}( N*T+2.18395381) & +0.00029424*T*\text{SIN}( N*T+1.961090) \\
 & +0.002511*\text{SIN}(2*N*T+5.30103959) & +0.00012968*T*\text{SIN}(2*N*T+5.297872) \\
 & +0.000005*\text{SIN}(3*N*T+4.204922 ) \\
 & +0.000004*\text{SIN}(4*N*T+3.0688 )
 \end{aligned}$$

VECTEUR G-GAMMA

DU 4/ 2/1981 A 12H AU 11/ 3/1982 A 12H  
 2444640.0 2445040.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad -192388. & \quad -121859.88*T \\
 & +150207885.*\text{SIN}( N*T+3.32121803) & +53726.77*T*\text{SIN}( N*T+2.443520) \\
 & +1209574.*\text{SIN}(2*N*T+3.35580110) & +5000.79*T*\text{SIN}(2*N*T+5.323556) \\
 & +15583.*\text{SIN}(3*N*T+3.248975 ) & \\
 & +228.*\text{SIN}(4*N*T+3.2057 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad +5136039. & \quad +443870.79*T \\
 & +149800734.*\text{SIN}( N*T+1.75379641) & +17830.95*T*\text{SIN}( N*T+0.914067) \\
 & +1222943.*\text{SIN}(2*N*T+1.69630821) & +2026.49*T*\text{SIN}(2*N*T+5.599770) \\
 & +15413.*\text{SIN}(3*N*T+1.679406 ) & \\
 & +209.*\text{SIN}(4*N*T+1.6605 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad -69842. & \quad -1595.86*T \\
 & +51391.*\text{SIN}( N*T+0.47416657) & +2740.68*T*\text{SIN}( N*T+0.342181) \\
 & +13681.*\text{SIN}(2*N*T+3.22955135) & +740.96*T*\text{SIN}(2*N*T+3.216365) \\
 & +23.*\text{SIN}(3*N*T+1.377408 ) & \\
 & +2.*\text{SIN}(4*N*T+1.1675 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad +0.097383 & \quad +0.00551665*T \\
 & +29.965723*\text{SIN}( N*T+4.88804860) & +0.01778743*T*\text{SIN}( N*T+3.922326) \\
 & +0.496815*\text{SIN}(2*N*T+4.98179252) & +0.00331157*T*\text{SIN}(2*N*T+0.203706) \\
 & +0.009319*\text{SIN}(3*N*T+4.814933 ) & \\
 & +0.000178*\text{SIN}(4*N*T+4.7519 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.054261 & \quad -0.00372035*T \\
 & +29.749192*\text{SIN}( N*T+3.32300903) & +0.00545829*T*\text{SIN}( N*T+1.419545) \\
 & +0.507324*\text{SIN}(2*N*T+3.25815178) & +0.00097746*T*\text{SIN}(2*N*T+2.257213) \\
 & +0.009179*\text{SIN}(3*N*T+3.248507 ) & \\
 & +0.000162*\text{SIN}(4*N*T+3.2379 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.030907 & \quad +0.00168451*T \\
 & +0.038507*\text{SIN}( N*T+3.69961146) & +0.00203366*T*\text{SIN}( N*T+3.701945) \\
 & +0.011281*\text{SIN}(2*N*T+5.83856976) & +0.00061553*T*\text{SIN}(2*N*T+5.824152) \\
 & +0.000025*\text{SIN}(3*N*T+3.508511 ) & \\
 & +0.000004*\text{SIN}(4*N*T+3.0267 ) & 
 \end{aligned}$$

VECTEUR G-GAMMA

DU 11/ 3/1982 A 12H AU 15/ 4/1983 A 12H  
 2445040.0 2445440.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad -3750723. & \quad -320978.13*T \\
 & +149721521.*\text{SIN}( N*T+3.32064789) & +48443.09*T*\text{SIN}( N*T+1.921147) \\
 & +1321739.*\text{SIN}(2*N*T+3.30834176) & +4475.10*T*\text{SIN}(2*N*T+3.655008) \\
 & +15557.*\text{SIN}(3*N*T+3.252266 ) & \\
 & +233.*\text{SIN}(4*N*T+3.2292 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad +3096592. & \quad +328849.69*T \\
 & +150139808.*\text{SIN}( N*T+1.75351048) & +36087.28*T*\text{SIN}( N*T+1.291733) \\
 & +1244588.*\text{SIN}(2*N*T+1.77120451) & +4059.13*T*\text{SIN}(2*N*T+3.366342) \\
 & +15659.*\text{SIN}(3*N*T+1.680025 ) & \\
 & +233.*\text{SIN}(4*N*T+1.6112 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad +53748. & \quad +5271.37*T \\
 & +13384.*\text{SIN}( N*T+4.96328532) & +1114.07*T*\text{SIN}( N*T+4.953479) \\
 & +2314.*\text{SIN}(2*N*T+0.53136607) & +133.06*T*\text{SIN}(2*N*T+0.488931) \\
 & +3.*\text{SIN}(3*N*T+3.656083 ) & \\
 & +0.*\text{SIN}(4*N*T+2.4545 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad -0.183777 & \quad -0.01005511*T \\
 & +29.825931*\text{SIN}( N*T+4.89901301) & +0.00449274*T*\text{SIN}( N*T+5.812516) \\
 & +0.473614*\text{SIN}(2*N*T+4.87337224) & +0.00147517*T*\text{SIN}(2*N*T+1.379779) \\
 & +0.009375*\text{SIN}(3*N*T+4.824748 ) & \\
 & +0.000190*\text{SIN}(4*N*T+4.7484 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.011502 & \quad -0.00126670*T \\
 & +29.863359*\text{SIN}( N*T+3.32409842) & +0.00588410*T*\text{SIN}( N*T+2.689539) \\
 & +0.499493*\text{SIN}(2*N*T+3.32839961) & +0.00123067*T*\text{SIN}(2*N*T+4.775766) \\
 & +0.009342*\text{SIN}(3*N*T+3.251846 ) & \\
 & +0.000187*\text{SIN}(4*N*T+3.1942 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.003875 & \quad +0.00021480*T \\
 & +0.002244*\text{SIN}( N*T+3.04112284) & +0.00007164*T*\text{SIN}( N*T+2.679817) \\
 & +0.000416*\text{SIN}(2*N*T+3.99900268) & +0.00002333*T*\text{SIN}(2*N*T+4.007505) \\
 & +0.000001*\text{SIN}(3*N*T+0.402490 ) & \\
 & +0.000000*\text{SIN}(4*N*T+4.6256 ) & 
 \end{aligned}$$

VECTEUR G-GAMMA

DU 15/ 4/1983 A 12H AU 19/ 5/1984 A 12H  
 2445440.0 2445840.0 DELTAT = 400.

X = -5790563. -442311.37\*T  
 +149520289.\*SIN( N\*T+3.32330842) +25368.57\*T\*SIN( N\*T+1.615507)  
 +1288240.\*SIN(2\*N\*T+3.30024186) +2494.41\*T\*SIN(2\*N\*T+3.740595)  
 +15890.\*SIN(3\*N\*T+3.257975 )  
 +236.\*SIN(4\*N\*T+3.2217 )

Y = -489745. +113845.77\*T  
 +149971028.\*SIN( N\*T+1.74975896) +56062.46\*T\*SIN( N\*T+0.616363)  
 +1376468.\*SIN(2\*N\*T+1.72269767) +7705.36\*T\*SIN(2\*N\*T+1.775108)  
 +15771.\*SIN(3\*N\*T+1.696847 )  
 +255.\*SIN(4\*N\*T+1.5433 )

Z = +147398. +10916.20\*T  
 +36842.\*SIN( N\*T+3.00120700) +2167.47\*T\*SIN( N\*T+3.136205)  
 +9991.\*SIN(2\*N\*T+4.01419388) +620.03\*T\*SIN(2\*N\*T+3.993405)  
 +26.\*SIN(3\*N\*T+0.913425 )  
 +8.\*SIN(4\*N\*T+4.3337 )

XP = -0.104092 -0.00557441\*T  
 +29.849042\*SIN( N\*T+4.89700428) +0.00431156\*T\*SIN( N\*T+4.964389)  
 +0.505989\*SIN(2\*N\*T+4.92317010) +0.00211885\*T\*SIN(2\*N\*T+6.224738)  
 +0.009478\*SIN(3\*N\*T+4.823965 )  
 +0.000185\*SIN(4\*N\*T+4.8171 )

YP = -0.134501 -0.00855345\*T  
 +29.734402\*SIN( N\*T+3.32500279) +0.00339383\*T\*SIN( N\*T+0.741438)  
 +0.505103\*SIN(2\*N\*T+3.28155915) +0.00041517\*T\*SIN(2\*N\*T+2.947171)  
 +0.009487\*SIN(3\*N\*T+3.263471 )  
 +0.000194\*SIN(4\*N\*T+3.0887 )

ZP = -0.032788 -0.00204806\*T  
 +0.046008\*SIN( N\*T+5.68843323) +0.00289162\*T\*SIN( N\*T+5.698207)  
 +0.011546\*SIN(2\*N\*T+0.35079818) +0.00071518\*T\*SIN(2\*N\*T+0.329035)  
 +0.000030\*SIN(3\*N\*T+2.961448 )  
 +0.000006\*SIN(4\*N\*T+6.2785 )

VECTEUR G-GAMMA

DU 19/ 5/1984 A 12H AU 23/ 6/1985 A 12H  
 2445840.0 2446240.0 DELTAT = 400.

$$\begin{aligned}
 X = & \begin{aligned} & -5470948. & -420905.18*T \\ & +149889526.*\text{SIN}( N*T+3.32290700) & +36394.20*T*\text{SIN}( N*T+2.362209) \\ & +1300845.*\text{SIN}(2*N*T+3.27183939) & +3426.07*T*\text{SIN}(2*N*T+2.908738) \\ & +15919.*\text{SIN}(3*N*T+3.253864 ) & \\ & +254.*\text{SIN}(4*N*T+3.1603 ) & \end{aligned}
 \end{aligned}$$

$$\begin{aligned}
 Y = & \begin{aligned} & -3677380. & -90352.00*T \\ & +149870492.*\text{SIN}( N*T+1.74995595) & +54333.05*T*\text{SIN}( N*T+0.529433) \\ & +1286648.*\text{SIN}(2*N*T+1.68555910) & +3352.42*T*\text{SIN}(2*N*T+0.840251) \\ & +16005.*\text{SIN}(3*N*T+1.677363 ) & \\ & +232.*\text{SIN}(4*N*T+1.5412 ) & \end{aligned}
 \end{aligned}$$

$$\begin{aligned}
 Z = & \begin{aligned} & +159814. & +11793.33*T \\ & +26415.*\text{SIN}( N*T+2.31243980) & +1448.70*T*\text{SIN}( N*T+2.413187) \\ & +7916.*\text{SIN}(2*N*T+2.95505215) & +521.79*T*\text{SIN}(2*N*T+2.944458) \\ & +25.*\text{SIN}(3*N*T+5.696921 ) & \\ & +4.*\text{SIN}(4*N*T+3.9734 ) & \end{aligned}
 \end{aligned}$$

$$\begin{aligned}
 XP = & \begin{aligned} & -0.153689 & -0.00930055*T \\ & +30.012497*\text{SIN}( N*T+4.89606490) & +0.01551581*T*\text{SIN}( N*T+4.809727) \\ & +0.541573*\text{SIN}(2*N*T+4.91246943) & +0.00344265*T*\text{SIN}(2*N*T+5.459389) \\ & +0.009425*\text{SIN}(3*N*T+4.824181 ) & \\ & +0.000210*\text{SIN}(4*N*T+4.7698 ) & \end{aligned}
 \end{aligned}$$

$$\begin{aligned}
 YP = & \begin{aligned} & -0.146975 & -0.00955876*T \\ & +29.780933*\text{SIN}( N*T+3.32674871) & +0.00175727*T*\text{SIN}( N*T+4.887397) \\ & +0.479495*\text{SIN}(2*N*T+3.31518432) & +0.00159508*T*\text{SIN}(2*N*T+5.778495) \\ & +0.009542*\text{SIN}(3*N*T+3.239956 ) & \\ & +0.000181*\text{SIN}(4*N*T+3.1636 ) & \end{aligned}
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \begin{aligned} & -0.042019 & -0.00281071*T \\ & +0.056758*\text{SIN}( N*T+5.14969198) & +0.00377798*T*\text{SIN}( N*T+5.158966) \\ & +0.014305*\text{SIN}(2*N*T+5.56675337) & +0.00095067*T*\text{SIN}(2*N*T+5.546791) \\ & +0.000037*\text{SIN}(3*N*T+1.354766 ) & \\ & +0.000006*\text{SIN}(4*N*T+5.4167 ) & \end{aligned}
 \end{aligned}$$

VECTEUR G-GAMMA

DU 23/ 6/1985 A 12H AU 28/ 7/1986 A 12H  
 2446240.O 2446640.O DELTAT = 400.

$$\begin{aligned}
 X = & \quad -3744288. & \quad -300971.29*T \\
 & +150067039.*\text{SIN}( N*T+3.32349905) & +43193.34*T*\text{SIN}( N*T+2.706130) \\
 & +1315551.*\text{SIN}(2*N*T+3.26562286) & +5015.78*T*\text{SIN}(2*N*T+2.894545) \\
 & +15672.*\text{SIN}(3*N*T+3.236223 ) & \\
 & +241.*\text{SIN}(4*N*T+3.1828 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -6611048. & \quad -291821.77*T \\
 & +149547303.*\text{SIN}( N*T+1.75058141) & +46874.40*T*\text{SIN}( N*T+0.115580) \\
 & +1241154.*\text{SIN}(2*N*T+1.66676218) & +4210.08*T*\text{SIN}(2*N*T+6.228300) \\
 & +15722.*\text{SIN}(3*N*T+1.658481 ) & \\
 & +237.*\text{SIN}(4*N*T+1.6608 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad +114136. & \quad +8695.42*T \\
 & +9980.*\text{SIN}( N*T+0.25231765) & +793.63*T*\text{SIN}( N*T+6.078296) \\
 & +1352.*\text{SIN}(2*N*T+0.16113635) & +96.58*T*\text{SIN}(2*N*T+0.104050) \\
 & +3.*\text{SIN}(3*N*T+1.898454 ) & \\
 & +0.*\text{SIN}(4*N*T+4.9967 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad +0.092771 & \quad +0.00731538*T \\
 & +29.748794*\text{SIN}( N*T+4.89542971) & +0.00324658*T*\text{SIN}( N*T+2.581984) \\
 & +0.493775*\text{SIN}(2*N*T+4.85356218) & +0.00027955*T*\text{SIN}(2*N*T+1.894984) \\
 & +0.009340*\text{SIN}(3*N*T+4.800769 ) & \\
 & +0.000195*\text{SIN}(4*N*T+4.7916 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.141754 & \quad -0.00948250*T \\
 & +29.830931*\text{SIN}( N*T+3.32685725) & +0.00427510*T*\text{SIN}( N*T+3.899298) \\
 & +0.511221*\text{SIN}(2*N*T+3.31020179) & +0.00134985*T*\text{SIN}(2*N*T+4.035931) \\
 & +0.009325*\text{SIN}(3*N*T+3.234008 ) & \\
 & +0.000196*\text{SIN}(4*N*T+3.1971 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad -0.005144 & \quad -0.00038761*T \\
 & +0.005260*\text{SIN}( N*T+4.48118005) & +0.00034905*T*\text{SIN}( N*T+4.639695) \\
 & +0.001162*\text{SIN}(2*N*T+4.34985199) & +0.00008262*T*\text{SIN}(2*N*T+4.335973) \\
 & +0.000002*\text{SIN}(3*N*T+5.437739 ) & \\
 & +0.000000*\text{SIN}(4*N*T+1.9323 ) & 
 \end{aligned}$$

VECTEUR G-GAMMA

DU 28/ 7/1986 A 12H AU 1/ 9/1987 A 12H  
 2446640.0 2447040.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad -768697. & -79657.46*T \\
 & +150056242.*\text{SIN}( N*T+3.32210822) & +56033.88*T*\text{SIN}( N*T+2.474080) \\
 & +1313813.*\text{SIN}(2*N*T+3.20471619) & +9146.64*T*\text{SIN}(2*N*T+2.210092) \\
 & +15685.*\text{SIN}(3*N*T+3.228055) & \\
 & +232.*\text{SIN}(4*N*T+3.2647) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -7749320. & -375240.65*T \\
 & +149669057.*\text{SIN}( N*T+1.75247260) & +28414.20*T*\text{SIN}( N*T+0.412703) \\
 & +1272254.*\text{SIN}(2*N*T+1.66695448) & +4712.57*T*\text{SIN}(2*N*T+0.462435) \\
 & +15489.*\text{SIN}(3*N*T+1.651936) & \\
 & +254.*\text{SIN}(4*N*T+1.5567) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad +44104. & +3444.59*T \\
 & +26493.*\text{SIN}( N*T+4.75621129) & +2379.94*T*\text{SIN}( N*T+4.776395) \\
 & +5747.*\text{SIN}(2*N*T+4.00709453) & +444.62*T*\text{SIN}(2*N*T+3.985239) \\
 & +26.*\text{SIN}(3*N*T+5.002368) & \\
 & +6.*\text{SIN}(4*N*T+0.3905) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad -0.013889 & -0.00088857*T \\
 & +29.877336*\text{SIN}( N*T+4.89229330) & +0.01228555*T*\text{SIN}( N*T+3.982551) \\
 & +0.518876*\text{SIN}(2*N*T+4.76816201) & +0.00372296*T*\text{SIN}(2*N*T+3.667376) \\
 & +0.009364*\text{SIN}(3*N*T+4.797155) & \\
 & +0.000187*\text{SIN}(4*N*T+4.8403) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad +0.148840 & +0.01248379*T \\
 & +29.627346*\text{SIN}( N*T+3.31917316) & +0.01910794*T*\text{SIN}( N*T+1.065262) \\
 & +0.457586*\text{SIN}(2*N*T+3.24526556) & +0.00340786*T*\text{SIN}(2*N*T+0.512654) \\
 & +0.009171*\text{SIN}(3*N*T+3.215419) & \\
 & +0.000216*\text{SIN}(4*N*T+3.1251) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.033258 & +0.00257313*T \\
 & +0.047039*\text{SIN}( N*T+0.76311301) & +0.00371294*T*\text{SIN}( N*T+0.745069) \\
 & +0.011737*\text{SIN}(2*N*T+6.26280097) & +0.00091157*T*\text{SIN}(2*N*T+6.237857) \\
 & +0.000035*\text{SIN}(3*N*T+0.666288) & \\
 & +0.000006*\text{SIN}(4*N*T+2.4256) & 
 \end{aligned}$$

VECTEUR G-GAMMA

DU 1/ 9/1987 A 12H AU 5/10/1988 A 12H  
 2447040.0 2447440.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad +1767306. & \quad +124679.53*T \\
 & +149873097.*\text{SIN}( N*T+3.32150163) & +57333.93*T*\text{SIN}( N*T+2.198456) \\
 & +1214054.*\text{SIN}(2*N*T+3.23701927) & +5708.16*T*\text{SIN}(2*N*T+1.087967) \\
 & +15497.*\text{SIN}(3*N*T+3.234605 ) & \\
 & +247.*\text{SIN}(4*N*T+3.2907 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -7054773. & \quad -318062.22*T \\
 & +149880435.*\text{SIN}( N*T+1.75395672) & +27255.88*T*\text{SIN}( N*T+1.374492) \\
 & +1275547.*\text{SIN}(2*N*T+1.69998796) & +2489.36*T*\text{SIN}(2*N*T+1.118104) \\
 & +15615.*\text{SIN}(3*N*T+1.677850 ) & \\
 & +213.*\text{SIN}(4*N*T+1.6298 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad +6904. & \quad +438.07*T \\
 & +20490.*\text{SIN}( N*T+5.88658069) & +1960.55*T*\text{SIN}( N*T+5.746100) \\
 & +4698.*\text{SIN}(2*N*T+4.71744233) & +401.74*T*\text{SIN}(2*N*T+4.688597) \\
 & +20.*\text{SIN}(3*N*T+4.700716 ) & \\
 & +4.*\text{SIN}(4*N*T+0.9551 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad +0.004117 & \quad +0.00000228*T \\
 & +29.824788*\text{SIN}( N*T+4.89225134) & +0.01101472*T*\text{SIN}( N*T+3.672392) \\
 & +0.480865*\text{SIN}(2*N*T+4.82075070) & +0.00199431*T*\text{SIN}(2*N*T+2.430282) \\
 & +0.009243*\text{SIN}(3*N*T+4.807645 ) & \\
 & +0.000194*\text{SIN}(4*N*T+4.8437 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad +0.019229 & \quad +0.00247608*T \\
 & +29.803685*\text{SIN}( N*T+3.32424850) & +0.00368281*T*\text{SIN}( N*T+2.282847) \\
 & +0.499325*\text{SIN}(2*N*T+3.28330890) & +0.00011645*T*\text{SIN}(2*N*T+3.346957) \\
 & +0.009297*\text{SIN}(3*N*T+3.249232 ) & \\
 & +0.000171*\text{SIN}(4*N*T+3.1732 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.011116 & \quad +0.00094315*T \\
 & +0.017059*\text{SIN}( N*T+0.34820501) & +0.00151018*T*\text{SIN}( N*T+0.336428) \\
 & +0.004363*\text{SIN}(2*N*T+5.42413917) & +0.00037042*T*\text{SIN}(2*N*T+5.399171) \\
 & +0.000017*\text{SIN}(3*N*T+5.791498 ) & \\
 & +0.000003*\text{SIN}(4*N*T+2.2206 ) & 
 \end{aligned}$$



VECTEUR G-GAMMA

DU 5/10/1988 A 12H AU 9/11/1989 A 12H DELTAT = 400.  
 2447440.0 2447840.0

X = +3468606. +274530.85\*T  
 +149558278.\*SIN( N\*T+3.32272388) +37482.42\*T\*SIN( N\*T+1.703852)  
 +1217620.\*SIN(2\*N\*T+5.28720143) +2908.22\*T\*SIN(2\*N\*T+0.009521)  
 +15732.\*SIN(3\*N\*T+3.258030 )  
 +227.\*SIN(4\*N\*T+3.2954 )

Y = -4959263. -131259.53\*T  
 +149934542.\*SIN( N\*T+1.75149582) +54628.96\*T\*SIN( N\*T+0.819366)  
 +1190532.\*SIN(2\*N\*T+1.68412246) +6407.51\*T\*SIN(2\*N\*T+5.360163)  
 +15663.\*SIN(3\*N\*T+1.683766 )  
 +230.\*SIN(4\*N\*T+1.6841 )

Z = -46452. -4245.41\*T  
 +5215.\*SIN( N\*T+3.40926807) +575.77\*T\*SIN( N\*T+4.017750)  
 +911.\*SIN(2\*N\*T+1.66974121) +82.36\*T\*SIN(2\*N\*T+1.624835)  
 +3.\*SIN(3\*N\*T+1.336907 )  
 +0.\*SIN(4\*N\*T+2.5484 )

XP = +0.003195 -0.00051043\*T  
 +29.776074\*SIN( N\*T+4.89324372) +0.00823289\*T\*SIN( N\*T+3.277024)  
 +0.482264\*SIN(2\*N\*T+4.85804766) +0.00139938\*T\*SIN(2\*N\*T+1.603583)  
 +0.009387\*SIN(3\*N\*T+4.828933 )  
 +0.000180\*SIN(4\*N\*T+4.8568 )

YP = +0.066823 +0.00664128\*T  
 +29.772314\*SIN( N\*T+3.32390337) +0.00413311\*T\*SIN( N\*T+1.553978)  
 +0.490560\*SIN(2\*N\*T+3.28392412) +0.00062284\*T\*SIN(2\*N\*T+0.171226)  
 +0.009409\*SIN(3\*N\*T+3.256187 )  
 +0.000184\*SIN(4\*N\*T+3.2917 )

ZP = +0.001095 +0.00011493\*T  
 +0.002349\*SIN( N\*T+5.57468719) +0.00026059\*T\*SIN( N\*T+5.790680)  
 +0.000674\*SIN(2\*N\*T+3.65889425) +0.00006189\*T\*SIN(2\*N\*T+3.631155)  
 +0.000002\*SIN(3\*N\*T+3.214643 )  
 +0.000000\*SIN(4\*N\*T+4.3593 )

VECTEUR G-GAMMA

DU 9/11/1989 A 12H AU 14/12/1990 A 12H  
 2447840.0 2448240.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad +3434782. & +269070.21 * T \\
 & +149791038. * \text{SIN}( N * T + 3.32378708 ) & +32946.40 * T * \text{SIN}( N * T + 2.508579 ) \\
 & +1185517. * \text{SIN}( 2 * N * T + 3.25370020 ) & +7455.48 * T * \text{SIN}( 2 * N * T + 0.612894 ) \\
 & +15642. * \text{SIN}( 3 * N * T + 3.252063 ) & \\
 & +223. * \text{SIN}( 4 * N * T + 3.3131 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -2850095. & +76770.38 * T \\
 & +149731333. * \text{SIN}( N * T + 1.75166435 ) & +46662.85 * T * \text{SIN}( N * T + 0.504115 ) \\
 & +1201906. * \text{SIN}( 2 * N * T + 1.71143688 ) & +4749.42 * T * \text{SIN}( 2 * N * T + 4.827788 ) \\
 & +15772. * \text{SIN}( 3 * N * T + 1.675158 ) & \\
 & +240. * \text{SIN}( 4 * N * T + 1.6575 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad -80605. & -7765.04 * T \\
 & +37774. * \text{SIN}( N * T + 1.99266914 ) & +3596.47 * T * \text{SIN}( N * T + 1.990821 ) \\
 & +9950. * \text{SIN}( 2 * N * T + 5.74625001 ) & +1041.75 * T * \text{SIN}( 2 * N * T + 5.713825 ) \\
 & +38. * \text{SIN}( 3 * N * T + 4.345647 ) & \\
 & +5. * \text{SIN}( 4 * N * T + 4.3059 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad +0.129646 & +0.01261208 * T \\
 & +29.963203 * \text{SIN}( N * T + 4.89701209 ) & +0.01938423 * T * \text{SIN}( N * T + 5.032456 ) \\
 & +0.460855 * \text{SIN}( 2 * N * T + 4.74921897 ) & +0.00642273 * T * \text{SIN}( 2 * N * T + 2.576186 ) \\
 & +0.009241 * \text{SIN}( 3 * N * T + 4.819603 ) & \\
 & +0.000170 * \text{SIN}( 4 * N * T + 4.8203 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad +0.008197 & +0.00060873 * T \\
 & +29.812790 * \text{SIN}( N * T + 3.32276099 ) & +0.00845346 * T * \text{SIN}( N * T + 2.140822 ) \\
 & +0.478856 * \text{SIN}( 2 * N * T + 3.27535145 ) & +0.00190251 * T * \text{SIN}( 2 * N * T + 0.306032 ) \\
 & +0.009408 * \text{SIN}( 3 * N * T + 3.245216 ) & \\
 & +0.000190 * \text{SIN}( 4 * N * T + 3.2153 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad -0.016073 & -0.00165417 * T \\
 & +0.022537 * \text{SIN}( N * T + 2.35251161 ) & +0.00231196 * T * \text{SIN}( N * T + 2.313273 ) \\
 & +0.006040 * \text{SIN}( 2 * N * T + 0.02485995 ) & +0.00062765 * T * \text{SIN}( 2 * N * T + 6.278171 ) \\
 & +0.000028 * \text{SIN}( 3 * N * T + 5.316494 ) & \\
 & +0.000005 * \text{SIN}( 4 * N * T + 5.4737 ) & 
 \end{aligned}$$

VECTEUR G-GAMMA

DU 14/12/1990 A 12H AU 18/ 1/1992 A 12H  
 2448240.0 2448640.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad +2453135. & +159138.26 * T \\
 & +149831003. * \text{SIN}( N * T + 3.32403036 ) & +36890.79 * T * \text{SIN}( N * T + 2.713965 ) \\
 & +1221225. * \text{SIN}( 2 * N * T + 3.29783518 ) & +3910.10 * T * \text{SIN}( 2 * N * T + 5.793020 ) \\
 & +15727. * \text{SIN}( 3 * N * T + 3.239650 ) & \\
 & +225. * \text{SIN}( 4 * N * T + 3.2510 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -1483650. & +227342.80 * T \\
 & +149565140. * \text{SIN}( N * T + 1.75231844 ) & +35945.90 * T * \text{SIN}( N * T + 0.107701 ) \\
 & +1264764. * \text{SIN}( 2 * N * T + 1.73564478 ) & +3953.37 * T * \text{SIN}( 2 * N * T + 2.758656 ) \\
 & +15687. * \text{SIN}( 3 * N * T + 1.663479 ) & \\
 & +226. * \text{SIN}( 4 * N * T + 1.4912 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad -55340. & -5254.83 * T \\
 & +26988. * \text{SIN}( N * T + 1.34308134 ) & +2851.15 * T * \text{SIN}( N * T + 1.268804 ) \\
 & +6815. * \text{SIN}( 2 * N * T + 4.73987633 ) & +800.76 * T * \text{SIN}( 2 * N * T + 4.696222 ) \\
 & +32. * \text{SIN}( 3 * N * T + 2.798720 ) & \\
 & +8. * \text{SIN}( 4 * N * T + 3.7217 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad +0.039223 & +0.00402069 * T \\
 & +29.875045 * \text{SIN}( N * T + 4.89455784 ) & +0.01230399 * T * \text{SIN}( N * T + 4.465194 ) \\
 & +0.476036 * \text{SIN}( 2 * N * T + 4.87106881 ) & +0.00269216 * T * \text{SIN}( 2 * N * T + 1.301180 ) \\
 & +0.009397 * \text{SIN}( 3 * N * T + 4.813998 ) & \\
 & +0.000180 * \text{SIN}( 4 * N * T + 4.8448 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad +0.124112 & +0.01375967 * T \\
 & +29.806498 * \text{SIN}( N * T + 3.32814873 ) & +0.01090787 * T * \text{SIN}( N * T + 4.604063 ) \\
 & +0.498888 * \text{SIN}( 2 * N * T + 3.23590760 ) & +0.00275150 * T * \text{SIN}( 2 * N * T + 1.712047 ) \\
 & +0.009256 * \text{SIN}( 3 * N * T + 3.236412 ) & \\
 & +0.000166 * \text{SIN}( 4 * N * T + 3.0664 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.002982 & +0.00036588 * T \\
 & +0.003646 * \text{SIN}( N * T + 3.99570075 ) & +0.00037673 * T * \text{SIN}( N * T + 4.092182 ) \\
 & +0.001640 * \text{SIN}( 2 * N * T + 0.60794671 ) & +0.00019304 * T * \text{SIN}( 2 * N * T + 0.569187 ) \\
 & +0.000011 * \text{SIN}( 3 * N * T + 4.406153 ) & \\
 & +0.000005 * \text{SIN}( 4 * N * T + 5.4806 ) & 
 \end{aligned}$$

VECTEUR G-GAMMA

DU 18/ 1/1992 A 12H AU 21/ 2/1993 A 12H  
 2448640.0 2449040.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad +1032343. & & -20067.11*T \\
 & +149754551.*\text{SIN}( N*T+3.32272226) & & +53514.43*T*\text{SIN}( N*T+2.211798) \\
 & +1243372.*\text{SIN}(2*N*T+3.31720790) & & +5608.91*T*\text{SIN}(2*N*T+4.976948) \\
 & +15628.*\text{SIN}(3*N*T+3.232144 ) & & \\
 & +219.*\text{SIN}(4*N*T+3.1443 ) & & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -927242. & & +296301.36*T \\
 & +149600320.*\text{SIN}( N*T+1.75285079) & & +27928.78*T*\text{SIN}( N*T+0.258491) \\
 & +1245714.*\text{SIN}(2*N*T+1.72502437) & & +2030.17*T*\text{SIN}(2*N*T+3.537113) \\
 & +15576.*\text{SIN}(3*N*T+1.663514 ) & & \\
 & +217.*\text{SIN}(4*N*T+1.6018 ) & & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad -6394. & & +727.23*T \\
 & +5951.*\text{SIN}( N*T+6.05884037) & & +993.98*T*\text{SIN}( N*T+5.696901) \\
 & +853.*\text{SIN}(2*N*T+2.29746327) & & +111.56*T*\text{SIN}(2*N*T+2.260274) \\
 & +3.*\text{SIN}(3*N*T+0.563079 ) & & \\
 & +0.*\text{SIN}(4*N*T+0.2968 ) & & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad -0.031907 & & -0.00423128*T \\
 & +29.787908*\text{SIN}( N*T+4.89452802) & & +0.00543338*T*\text{SIN}( N*T+3.535918) \\
 & +0.495963*\text{SIN}(2*N*T+4.86851833) & & +0.00093172*T*\text{SIN}(2*N*T+0.371781) \\
 & +0.009305*\text{SIN}(3*N*T+4.805229 ) & & \\
 & +0.000173*\text{SIN}(4*N*T+4.7430 ) & & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.006312 & & -0.00211952*T \\
 & +29.771006*\text{SIN}( N*T+3.32313779) & & +0.00769075*T*\text{SIN}( N*T+1.558711) \\
 & +0.500667*\text{SIN}(2*N*T+3.29871124) & & +0.00104167*T*\text{SIN}(2*N*T+4.441790) \\
 & +0.009299*\text{SIN}(3*N*T+3.232478 ) & & \\
 & +0.000171*\text{SIN}(4*N*T+3.1637 ) & & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.000986 & & +0.00012945*T \\
 & +0.000177*\text{SIN}( N*T+3.52171756) & & +0.00004583*T*\text{SIN}( N*T+0.092686) \\
 & +0.000049*\text{SIN}(2*N*T+2.73655236) & & +0.00000544*T*\text{SIN}(2*N*T+2.560430) \\
 & +0.000000*\text{SIN}(3*N*T+2.779381 ) & & \\
 & +0.000000*\text{SIN}(4*N*T+2.3127 ) & & 
 \end{aligned}$$

VECTEUR G-GAMMA

DU 21/ 2/1993 A 12H AU 28/ 3/1994 A 12H  
 2449040.0 2449440.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad -136725. & \quad -189710.07*T \\
 & +149720380.*\text{SIN}( N*T+3.32322766) & +47031.54*T*\text{SIN}( N*T+2.245622) \\
 & +1244433.*\text{SIN}(2*N*T+3.31160466) & +5357.83*T*\text{SIN}(2*N*T+4.920378) \\
 & +15544.*\text{SIN}(3*N*T+3.235384 ) & \\
 & +212.*\text{SIN}(4*N*T+3.1740 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -1105325. & \quad +268760.81*T \\
 & +149689073.*\text{SIN}( N*T+1.75385561) & +18430.56*T*\text{SIN}( N*T+1.366907) \\
 & +1220169.*\text{SIN}(2*N*T+1.71589128) & +4415.59*T*\text{SIN}(2*N*T+4.702539) \\
 & +15601.*\text{SIN}(3*N*T+1.675621 ) & \\
 & +232.*\text{SIN}(4*N*T+1.5897 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad +36386. & \quad +7118.88*T \\
 & +19482.*\text{SIN}( N*T+3.74508384) & +3247.40*T*\text{SIN}( N*T+3.812594) \\
 & +5291.*\text{SIN}(2*N*T+5.41276619) & +848.31*T*\text{SIN}(2*N*T+5.358830) \\
 & +25.*\text{SIN}(3*N*T+2.164716 ) & \\
 & +3.*\text{SIN}(4*N*T+0.4951 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad -0.018083 & \quad -0.00188743*T \\
 & +29.796683*\text{SIN}( N*T+4.89445456) & +0.00664477*T*\text{SIN}( N*T+3.731985) \\
 & +0.495251*\text{SIN}(2*N*T+4.87138240) & +0.00129292*T*\text{SIN}(2*N*T+0.323654) \\
 & +0.009268*\text{SIN}(3*N*T+4.809203 ) & \\
 & +0.000171*\text{SIN}(4*N*T+4.7768 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.006954 & \quad -0.00245514*T \\
 & +29.783210*\text{SIN}( N*T+3.32452589) & +0.00183748*T*\text{SIN}( N*T+1.872257) \\
 & +0.488387*\text{SIN}(2*N*T+3.27865504) & +0.00143587*T*\text{SIN}(2*N*T+0.422239) \\
 & +0.009302*\text{SIN}(3*N*T+3.247938 ) & \\
 & +0.000186*\text{SIN}(4*N*T+3.1735 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.000615 & \quad +0.00006486*T \\
 & +0.002799*\text{SIN}( N*T+5.17433595) & +0.00046644*T*\text{SIN}( N*T+5.309752) \\
 & +0.001634*\text{SIN}(2*N*T+0.57605019) & +0.00026285*T*\text{SIN}(2*N*T+0.536513) \\
 & +0.000012*\text{SIN}(3*N*T+3.545791 ) & \\
 & +0.000002*\text{SIN}(4*N*T+1.7406 ) & 
 \end{aligned}$$

VECTEUR G-GAMMA

DU 28/ 3/1994 A 12H AU 2/ 5/1995 A 12H  
 2449440.0 2449840.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad -987849. & \quad -335100.98*T \\
 & +149571015.*\text{SIN}( N*T+3.32368128) & +33077.00*T*\text{SIN}( N*T+1.712158) \\
 & +1277823.*\text{SIN}(2*N*T+3.27949530) & +5426.22*T*\text{SIN}(2*N*T+3.052879) \\
 & +15643.*\text{SIN}(3*N*T+3.248737 ) \\
 & +251.*\text{SIN}(4*N*T+3.2762 )
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -1908027. & \quad +129802.76*T \\
 & +149761262.*\text{SIN}( N*T+1.75361210) & +36525.33*T*\text{SIN}( N*T+1.385878) \\
 & +1258612.*\text{SIN}(2*N*T+1.72937009) & +4428.38*T*\text{SIN}(2*N*T+2.808849) \\
 & +15692.*\text{SIN}(3*N*T+1.667866 ) \\
 & +240.*\text{SIN}(4*N*T+1.5155 )
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad +54571. & \quad +10651.00*T \\
 & +15484.*\text{SIN}( N*T+3.26787004) & +2938.37*T*\text{SIN}( N*T+3.345071) \\
 & +3699.*\text{SIN}(2*N*T+4.55397080) & +703.65*T*\text{SIN}(2*N*T+4.495093) \\
 & +18.*\text{SIN}(3*N*T+0.636602 ) \\
 & +8.*\text{SIN}(4*N*T+6.0143 )
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad -0.019069 & \quad -0.00161647*T \\
 & +29.782083*\text{SIN}( N*T+4.89483433) & +0.00459157*T*\text{SIN}( N*T+3.411181) \\
 & +0.506349*\text{SIN}(2*N*T+4.85170839) & +0.00167517*T*\text{SIN}(2*N*T+4.678614) \\
 & +0.009356*\text{SIN}(3*N*T+4.818808 ) \\
 & +0.000199*\text{SIN}(4*N*T+4.8405 )
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.069673 & \quad -0.01412064*T \\
 & +29.725474*\text{SIN}( N*T+3.32536295) & +0.01119581*T*\text{SIN}( N*T+6.149426) \\
 & +0.493017*\text{SIN}(2*N*T+3.25760899) & +0.00256388*T*\text{SIN}(2*N*T+1.287556) \\
 & +0.009435*\text{SIN}(3*N*T+3.249612 ) \\
 & +0.000205*\text{SIN}(4*N*T+3.0515 )
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad -0.005625 & \quad -0.00113672*T \\
 & +0.008788*\text{SIN}( N*T+5.92000561) & +0.00174075*T*\text{SIN}( N*T+5.918968) \\
 & +0.002226*\text{SIN}(2*N*T+0.86444555) & +0.00042848*T*\text{SIN}(2*N*T+0.806918) \\
 & +0.000008*\text{SIN}(3*N*T+3.458221 ) \\
 & +0.000006*\text{SIN}(4*N*T+1.5764 )
 \end{aligned}$$

VECTEUR G-GAMMA

DU 2/ 5/1995 A 12H AU 5/ 6/1996 A 12H DELTAT = 400.  
 2449840.0 2450240.0

$$\begin{aligned}
 X = & \quad -1277193. & \quad -394408.30*T \\
 & +149604763.*\text{SIN}( N*T+3.32384595) & +32461.41*T*\text{SIN}( N*T+1.970929) \\
 & +1264518.*\text{SIN}(2*N*T+3.28451035) & +3098.55*T*\text{SIN}(2*N*T+3.433125) \\
 & +15816.*\text{SIN}(3*N*T+3.249131 ) & \\
 & +245.*\text{SIN}(4*N*T+3.1591 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -2849061. & \quad -70914.37*T \\
 & +149700693.*\text{SIN}( N*T+1.75253322) & +57354.95*T*\text{SIN}( N*T+0.667405) \\
 & +1274448.*\text{SIN}(2*N*T+1.71486128) & +5481.13*T*\text{SIN}(2*N*T+1.808042) \\
 & +15798.*\text{SIN}(3*N*T+1.678936 ) & \\
 & +245.*\text{SIN}(4*N*T+1.5891 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad +51683. & \quad +10181.75*T \\
 & +1115.*\text{SIN}( N*T+4.71301451) & +587.50*T*\text{SIN}( N*T+4.916720) \\
 & +564.*\text{SIN}(2*N*T+6.02893129) & +135.96*T*\text{SIN}(2*N*T+5.939019) \\
 & +5.*\text{SIN}(3*N*T+2.258742 ) & \\
 & +1.*\text{SIN}(4*N*T+0.1920 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad -0.004559 & \quad +0.00194090*T \\
 & +29.775974*\text{SIN}( N*T+4.89449123) & +0.00734489*T*\text{SIN}( N*T+3.188164) \\
 & +0.502308*\text{SIN}(2*N*T+4.85056162) & +0.00093814*T*\text{SIN}(2*N*T+4.475538) \\
 & +0.009466*\text{SIN}(3*N*T+4.819964 ) & \\
 & +0.000193*\text{SIN}(4*N*T+4.7220 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.000155 & \quad +0.00049957*T \\
 & +29.806625*\text{SIN}( N*T+3.32324804) & +0.01204778*T*\text{SIN}( N*T+2.266146) \\
 & +0.508204*\text{SIN}(2*N*T+3.28626398) & +0.00236793*T*\text{SIN}(2*N*T+3.415097) \\
 & +0.009429*\text{SIN}(3*N*T+3.249748 ) & \\
 & +0.000196*\text{SIN}(4*N*T+3.1658 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.000082 & \quad -0.00005884*T \\
 & +0.000496*\text{SIN}( N*T+5.68712303) & +0.00016284*T*\text{SIN}( N*T+6.026848) \\
 & +0.000234*\text{SIN}(2*N*T+0.95723638) & +0.00005628*T*\text{SIN}(2*N*T+0.882533) \\
 & +0.000002*\text{SIN}(3*N*T+3.629097 ) & \\
 & +0.000000*\text{SIN}(4*N*T+1.6584 ) & 
 \end{aligned}$$

VECTEUR G-GAMMA

DU 5/ 6/1996 A 12H AU 10/ 7/1997 A 12H  
 2450240.0 2450640.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad -1107439. & \quad -342780.53*T \\
 & +149651481.*\text{SIN}( N*T+3.32424993) & +31579.96*T*\text{SIN}( N*T+2.704027) \\
 & +1259350.*\text{SIN}(2*N*T+3.28821871) & +3429.10*T*\text{SIN}(2*N*T+3.849802) \\
 & +15780.*\text{SIN}(3*N*T+3.238571 ) & \\
 & +242.*\text{SIN}(4*N*T+3.1948 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -3620255. & \quad -285748.48*T \\
 & +149605454.*\text{SIN}( N*T+1.75266766) & +54451.98*T*\text{SIN}( N*T+0.260863) \\
 & +1255830.*\text{SIN}(2*N*T+1.70558734) & +2945.18*T*\text{SIN}(2*N*T+0.495880) \\
 & +15856.*\text{SIN}(3*N*T+1.668046 ) & \\
 & +235.*\text{SIN}(4*N*T+1.6063 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad +49220. & \quad +9345.56*T \\
 & +1593.*\text{SIN}( N*T+6.13156474) & +826.88*T*\text{SIN}( N*T+5.649451) \\
 & +423.*\text{SIN}(2*N*T+5.47511991) & +147.36*T*\text{SIN}(2*N*T+5.345351) \\
 & +4.*\text{SIN}(3*N*T+0.191227 ) & \\
 & +1.*\text{SIN}(4*N*T+2.7569 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad -0.021358 & \quad -0.00349402*T \\
 & +29.809092*\text{SIN}( N*T+4.89496685) & +0.01060565*T*\text{SIN}( N*T+4.469492) \\
 & +0.504867*\text{SIN}(2*N*T+4.85889927) & +0.00233439*T*\text{SIN}(2*N*T+5.125025) \\
 & +0.009427*\text{SIN}(3*N*T+4.812752 ) & \\
 & +0.000192*\text{SIN}(4*N*T+4.7422 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.042215 & \quad -0.01094726*T \\
 & +29.783029*\text{SIN}( N*T+3.32491278) & +0.00358186*T*\text{SIN}( N*T+4.658052) \\
 & +0.496624*\text{SIN}(2*N*T+3.29554905) & +0.00217263*T*\text{SIN}(2*N*T+5.011338) \\
 & +0.009388*\text{SIN}(3*N*T+3.234498 ) & \\
 & +0.000196*\text{SIN}(4*N*T+3.2151 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.000968 & \quad +0.00022305*T \\
 & +0.001172*\text{SIN}( N*T+1.60589187) & +0.00043023*T*\text{SIN}( N*T+1.397192) \\
 & +0.000321*\text{SIN}(2*N*T+1.35299066) & +0.00010901*T*\text{SIN}(2*N*T+1.226629) \\
 & +0.000003*\text{SIN}(3*N*T+2.423611 ) & \\
 & +0.000000*\text{SIN}(4*N*T+4.9653 ) & 
 \end{aligned}$$



VECTEUR G-GAMMA

DU 10/ 7/1997 A 12H AU 14/ 8/1998 A 12H  
 2450640.0 2451040.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad -611695. & -138936.21*T \\
 & +149635341.*\text{SIN}( N*T+3.32390187) & +55082.84*T*\text{SIN}( N*T+2.303901) \\
 & +1253138.*\text{SIN}(2*N*T+3.26717582) & +8940.69*T*\text{SIN}(2*N*T+1.711694) \\
 & +15647.*\text{SIN}(3*N*T+3.224032 ) & \\
 & +230.*\text{SIN}(4*N*T+3.3641 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -4029958. & -448256.10*T \\
 & +149565765.*\text{SIN}( N*T+1.75325526) & +29704.30*T*\text{SIN}( N*T+6.068393) \\
 & +1245575.*\text{SIN}(2*N*T+1.70503180) & +3635.68*T*\text{SIN}(2*N*T+5.599585) \\
 & +15510.*\text{SIN}(3*N*T+1.651325 ) & \\
 & +242.*\text{SIN}(4*N*T+1.5853 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad +41737. & +6271.36*T \\
 & +3609.*\text{SIN}( N*T+0.10340788) & +1970.32*T*\text{SIN}( N*T+6.077018) \\
 & +696.*\text{SIN}(2*N*T+6.01321192) & +371.17*T*\text{SIN}(2*N*T+5.879708) \\
 & +7.*\text{SIN}(3*N*T+1.804681 ) & \\
 & +7.*\text{SIN}(4*N*T+3.1876 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad +0.006043 & +0.00548977*T \\
 & +29.780826*\text{SIN}( N*T+4.89497544) & +0.00421266*T*\text{SIN}( N*T+3.476263) \\
 & +0.497410*\text{SIN}(2*N*T+4.84431444) & +0.00186010*T*\text{SIN}(2*N*T+3.086982) \\
 & +0.009296*\text{SIN}(3*N*T+4.796640 ) & \\
 & +0.000187*\text{SIN}(4*N*T+4.8967 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.031047 & -0.00877551*T \\
 & +29.790796*\text{SIN}( N*T+3.32466811) & +0.00606299*T*\text{SIN}( N*T+3.919178) \\
 & +0.500272*\text{SIN}(2*N*T+3.28188203) & +0.00141122*T*\text{SIN}(2*N*T+3.347273) \\
 & +0.009269*\text{SIN}(3*N*T+3.230244 ) & \\
 & +0.000188*\text{SIN}(4*N*T+3.1123 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.005303 & +0.00264861*T \\
 & +0.007331*\text{SIN}( N*T+1.22327790) & +0.00383833*T*\text{SIN}( N*T+1.138762) \\
 & +0.001832*\text{SIN}(2*N*T+0.89518208) & +0.00093717*T*\text{SIN}(2*N*T+0.731915) \\
 & +0.000022*\text{SIN}(3*N*T+1.941496 ) & \\
 & +0.000008*\text{SIN}(4*N*T+4.6533 ) & 
 \end{aligned}$$

VECTEUR G-GAMMA

DU 14/ 8/1998 A 12H AU 18/ 9/1999 A 12H  
 2451040.0 2451440.0 DELTAT = 400.

X =	-294308. +149605867.*SIN( N*T+3.32404634) +1250251.*SIN(2*N*T+3.27431799) +15437.*SIN(3*N*T+3.223178 ) +243.*SIN(4*N*T+3.1963 )	+92873.19*T +64747.43*T*SIN( N*T+2.178999) +6345.21*T*SIN(2*N*T+1.513808)
Y =	-4080740. +149598347.*SIN( N*T+1.75336673) +1252346.*SIN(2*N*T+1.70667220) +15457.*SIN(3*N*T+1.660044 ) +233.*SIN(4*N*T+1.5785 )	-476101.55*T +30846.11*T*SIN( N*T+0.708286) +4224.63*T*SIN(2*N*T+0.815015)
Z =	+33461. +2283.*SIN( N*T+0.10560336) +573.*SIN(2*N*T+5.87294026) +19.*SIN(3*N*T+0.252945 ) +2.*SIN(4*N*T+2.8434 )	+931.21*T +2463.34*T*SIN( N*T+6.017972) +593.53*T*SIN(2*N*T+5.534393)
XP =	+0.004278 +29.783953*SIN( N*T+4.89486289) +0.497676*SIN(2*N*T+4.84609203) +0.009217*SIN(3*N*T+4.795429 ) +0.000193*SIN(4*N*T+4.7586 )	+0.00156780*T +0.01083449*T*SIN( N*T+3.744200) +0.00205467*T*SIN(2*N*T+3.139628)
YP =	-0.024769 +29.795212*SIN( N*T+3.32438445) +0.501784*SIN(2*N*T+3.27662809) +0.009329*SIN(3*N*T+3.232679 ) +0.000176*SIN(4*N*T+3.1931 )	-0.01144305*T +0.01675758*T*SIN( N*T+3.373150) +0.00510570*T*SIN(2*N*T+2.656462)
ZP =	+0.000777 +0.001325*SIN( N*T+0.93530968) +0.000388*SIN(2*N*T+0.44889597) +0.000012*SIN(3*N*T+1.168209 ) +0.000001*SIN(4*N*T+3.9165 )	+0.00089596*T +0.00155793*T*SIN( N*T+0.752720) +0.00040059*T*SIN(2*N*T+0.100605)

VECTEUR G-GAMMA

DU 18/ 9/1999 A 12H AU 22/10/2000 A 12H DELTAT = 400.  
 2451440.0 2451840.0

X =                   -217882.                   +326772.87\*T  
 +149583453.\*SIN( N\*T+3.32431032)       +57329.99\*T\*SIN( N\*T+1.757246)  
 +1250612.\*SIN(2\*N\*T+3.27928436)       +3720.93\*T\*SIN(2\*N\*T+0.149120)  
 +15515.\*SIN(3\*N\*T+3.248931 )  
 +219.\*SIN(4\*N\*T+3.2031 )

Y =                   -4064393.                   -366009.50\*T  
 +149574812.\*SIN( N\*T+1.75347707)       +44106.94\*T\*SIN( N\*T+1.169916)  
 +1251839.\*SIN(2\*N\*T+1.71091989)       +5305.00\*T\*SIN(2\*N\*T+0.230240)  
 +15608.\*SIN(3\*N\*T+1.672031 )  
 +229.\*SIN(4\*N\*T+1.6800 )

Z =                   +30533.                   -6141.74\*T  
 +509.\*SIN( N\*T+0.38489544)           +1386.29\*T\*SIN( N\*T+4.878096)  
 +83.\*SIN(2\*N\*T+5.51264658)           +174.30\*T\*SIN(2\*N\*T+3.385190)  
 +4.\*SIN(3\*N\*T+3.428166 )  
 +0.\*SIN(4\*N\*T+5.1998 )

XP =                   +0.007855                   +0.00964536\*T  
 +29.778083\*SIN( N\*T+4.89501407)       +0.00314739\*T\*SIN( N\*T+5.155517)  
 +0.497519\*SIN(2\*N\*T+4.85268326)       +0.00155009\*T\*SIN(2\*N\*T+4.344650)  
 +0.009345\*SIN(3\*N\*T+4.817349 )  
 +0.000177\*SIN(4\*N\*T+4.8263 )

YP =                   -0.012585                   +0.00406163\*T  
 +29.781073\*SIN( N\*T+3.32420385)       +0.00458985\*T\*SIN( N\*T+2.216017)  
 +0.497873\*SIN(2\*N\*T+3.28111303)       +0.00087577\*T\*SIN(2\*N\*T+1.995136)  
 +0.009321\*SIN(3\*N\*T+3.246682 )  
 +0.000177\*SIN(4\*N\*T+3.2458 )

ZP =                   -0.000145                   -0.00018504\*T  
 +0.000031\*SIN( N\*T+0.31178768)       +0.00008018\*T\*SIN( N\*T+1.159745)  
 +0.000013\*SIN(2\*N\*T+1.97230815)       +0.00003239\*T\*SIN(2\*N\*T+5.892052)  
 +0.000002\*SIN(3\*N\*T+5.685569 )  
 +0.000000\*SIN(4\*N\*T+1.0986 )

VECTEUR G-GAMMA

DU 22/10/2000 A 12H AU 26/11/2001 A 12H  
 2451840.0 2452240.0 DELTAT = 400.

$$\begin{aligned}
 X = & \quad -295004. & \quad +444857.72*T \\
 & +149575218.*\text{SIN}( N*T+3.32438046) & +34298.38*T*\text{SIN}( N*T+1.819332) \\
 & +1255239.*\text{SIN}(2*N*T+3.27923428) & +5628.82*T*\text{SIN}(2*N*T+0.071333) \\
 & +15766.*\text{SIN}(3*N*T+3.255121 ) & \\
 & +231.*\text{SIN}(4*N*T+3.3337 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Y = & \quad -4249788. & \quad -133023.59*T \\
 & +149536943.*\text{SIN}( N*T+1.75370575) & +58365.26*T*\text{SIN}( N*T+0.899664) \\
 & +1260628.*\text{SIN}(2*N*T+1.71141249) & +9171.23*T*\text{SIN}(2*N*T+5.222586) \\
 & +15740.*\text{SIN}(3*N*T+1.678667 ) & \\
 & +237.*\text{SIN}(4*N*T+1.5747 ) & 
 \end{aligned}$$

$$\begin{aligned}
 Z = & \quad +36188. & \quad -12325.52*T \\
 & +3406.*\text{SIN}( N*T+5.66305439) & +2098.18*T*\text{SIN}( N*T+2.774004) \\
 & +886.*\text{SIN}(2*N*T+2.95160938) & +607.21*T*\text{SIN}(2*N*T+0.082189) \\
 & +28.*\text{SIN}(3*N*T+5.939319 ) & \\
 & +7.*\text{SIN}(4*N*T+5.6366 ) & 
 \end{aligned}$$

$$\begin{aligned}
 XP = & \quad +0.025190 & \quad -0.00814222*T \\
 & +29.791853*\text{SIN}( N*T+4.89544207) & +0.01560803*T*\text{SIN}( N*T+2.800019) \\
 & +0.499055*\text{SIN}(2*N*T+4.84357086) & +0.00348005*T*\text{SIN}(2*N*T+0.850308) \\
 & +0.009461*\text{SIN}(3*N*T+4.831575 ) & \\
 & +0.000184*\text{SIN}(4*N*T+4.9505 ) & 
 \end{aligned}$$

$$\begin{aligned}
 YP = & \quad -0.009058 & \quad +0.00361769*T \\
 & +29.775989*\text{SIN}( N*T+3.32430141) & +0.00692597*T*\text{SIN}( N*T+2.391189) \\
 & +0.500332*\text{SIN}(2*N*T+3.28252372) & +0.00252728*T*\text{SIN}(2*N*T+0.530199) \\
 & +0.009433*\text{SIN}(3*N*T+3.248871 ) & \\
 & +0.000191*\text{SIN}(4*N*T+3.1645 ) & 
 \end{aligned}$$

$$\begin{aligned}
 ZP = & \quad +0.002310 & \quad -0.00196982*T \\
 & +0.003399*\text{SIN}( N*T+5.60747848) & +0.00245390*T*\text{SIN}( N*T+2.538532) \\
 & +0.000911*\text{SIN}(2*N*T+3.33048740) & +0.00064875*T*\text{SIN}(2*N*T+0.425004) \\
 & +0.000019*\text{SIN}(3*N*T+0.208794 ) & \\
 & +0.000007*\text{SIN}(4*N*T+0.6672 ) & 
 \end{aligned}$$