IDS, PARIS, 3-4 May, 2004.

Comparison of Geocenter Variations Derived from GPS and DORIS Data

S.K. TATEVIAN, S.P.KUZIN, V.I. KAFTAN*
Institute of Astronomy, RAS (INASAN)
48, Pyatnizkaya str., Moscow, Russia
*Central Research Institute of Geodesy and Mapping,
26 Onezhskaya str, Moscow, Russia.

Abstract

The two 10 years sets of the geocenter coordinates, derived from GPS and DORIS data, have been analysed separately and compared. The harmonic and regression analyses have been applied in order to estimate linear trend, amplitudes, periods and phases of variations. Additionally to the annual and semiannual signals with amplitudes 4.1-11.5 mm, several other shorter periods were found in both time series. It must be noted that the amplitudes of some short-periodic signals are comparable with the amplitudes of semiannual signals.The secular trend of the geocenter motion with a velocity of a few mm per year was estimated. An investigation of the observed time series of geocenter motion is important for improvement of geophysical models and for establishing a more accurate ITRF system.

Time series of geocenter variations (1999.2- 2002.6) with respect to the ITRF00 have been derived from the DORIS data analysis with the use of GIPSY/OASIS2 software. More detailed description of the methods used at the INASAN Analysis Center for DORIS data processing has been described in our previous works [Kuzin S.P. and S.K.Tatevian, 2000; 2002]. The station coordinates were estimated on daily basis using three satellites (SPOT2, SPOT4, TOPEX). In addition to station coordinates, we estimated simultaneously the orbital parameters, velocities and several other parameters (EOP, tropospheric corrections, clock drifts offsets) with a free-network approach and weakly constraining the apriori station coordinates to a 100 meters sigma. Then daily solutions are combined into weekly solutions, projected (removing of the indetermination due to loosely definition of the terrestrial reference frame) and transformed to a well defined reference frame ITRF00 with the use of 7 parameters of Helmert transformation. The results of the transformation operation provide simultaneously the coordinates (and full-covariance matrix) and also the estimated 7 parameters of the transformation. Three translations parameters and scale factor are more significant as compared with 3 rotational ones, as they can provide information on the position of the reference terrestrial network origin.

In a whole a repeatability of station coordinates has been estimated at the level of 3-7 cm and with standard deviations 1.5-5.0 cm. Besides systematic drift, several periodic variations with amplitudes 1.0-3.5 cm have been found [Kuzin S., S.Tatevian, 2002]. The annual period is inherent in all components of stations coordinates, but it shows itself more obvious for the radial components.

Time series of the derived weekly geocenter positions are shown at Fig.1-3. In order to determine the annual and semiannual signals a regression analysis has been used.

$$J(t) = A_0 \sin\left(\frac{2\pi}{P}(t) + \varphi_0\right) + a_0 + b_0 t$$

where: A_0 –amplitude of the signal;
P – period;
φ_0 – initial phase;
a_0 – constant term;
b_0 –trend.

A constant term and trend have been estimated in order to express the time series in a common reference frame. The amplitudes and phases of the annual and semiannual variations of the geocenter components X, Y, Z (date from 1999.0) are presented in Table 1.

Table1. Annual and semiannual amplitudes and phases of the Geocenter variations (1999.2-2002.6).

Component	Annual		Semiannual		Trend
	A, mm	***Phase, deg***	***A, mm***	***Phase, deg***	***mm/year***
X	**5.7 ± 0.8**	**99.0 ± 11.1**	**3.4 ± 0.8**	**157.7 ± 20.9**	**-3.1 ± 0.9**
Y	**5.5 ± 0.2**	**303.9 ± 12.6**	**2.3 ± 1.1**	**252.8 ±14.1**	**-0.6 ± 0.8**
Z	**36.4 ± 4.5**	**254.4 ± 4.0**	**15.9 ± 1.1**	**147.9 ± 17.6**	**6.1 ± 3.4**

The obtained values are comparable in amplitudes with the results of previous DORIS geocenter analysis [C.Boucher, P.Sillard, 1999], but phases are sometimes different. The greater amplitude for Z may be caused by the dominance of seasonal mass redistributions between the northern and southern hemisphere [H. Montag, 1999]. Additionally to the annual and semiannual signals several other shorter periods (a fortnight and 1-4 months) were found and it must be noted that the amplitudes of some short-periodic signals are comparable with the amplitudes of the semiannual signals.

In order to compare variations of the geocenter obtained from the individual DORIS and GPS solutions, we have examined the sets of Helmert transformation parameters, derived from the IGS/GPS daily coordinates for the 10 years period: 1993.0-2003.8 [ftp://sideshow.jpl.nasa.gov/pub/mbn] and from the DORIS weekly solutions, submitted to the web site [ftp://ccdisa.gsfc.nasa.gov/pub/doris/products/geoc] for the same time period. Two approaches have been applied for the analysis. Results of the regression analysis (as described above) are shown in Table 2.

Table2. Annual and semiannual amplitudes and phases of the Geocenter variations (1993.0-2003.0).

Component		Annual		Semiannual		Trend
		A, mm	*Phase, deg*	*A, mm*	*Phase, deg*	*mm*
X	*DORIS*	5.5 ± 0.3	106.6 ± 5.2	1.3 ± 0.2	160.4 ± 22.0	-1.7 ± 0.1
	GPS	2.4±0.1	304.4±11.0	18.5±0.3	356.4±1.1	-0.3±0.1
Y	*DORIS*	4.2 ± 0.3	339.2 ± 8.4	7.0 ± 0.5	187.5 ± 3.4	-0.8 ± 0.1
	GPS	5.9±0.2	279.4±3.0	1.5±0.2	169.5±11.9	-2.2±0.1
Z	*DORIS*	11.6 ± 0.1	316.6 ± 19.2	6.6 ± 2.7	178.7 ± 24.4	1.7 ± 0.7
	GPS	17.3±0.4	107.6±2.8	8.2±0.2	120.7±6.4	4.8±0.2

The periodicity analysis technique based on the least squares iterations was used for mathematical modeling. The method allows to determine the trend component and the set of harmonics. (Fig. 4-6).

Two steps of computations were used: 1) estimation and removal of the trend (linear component), 2) finding one after another and removal of the periodical components (harmonics) with amplitudes, twice exceeded their standard errors. After elimination of the trend component, the data set was approximated by a periodical function using an iterative approach. This procedure allows to estimate, in sequence, parameters of the dominant harmonics and their standard errors. The final model is a polyharmonical function that has the best fitting to the initial time series. An analysis of the obtained series of the Geocenter variations shows that the precision of the X and Y components is generally significantly better than for Z component. And amplitudes of Z components are 2-3 times higher than for X and Y for both GPS and DORIS solutions.

Summary

Center of mass variations must be properly accounted for in the realization of the tracking station locations within the terrestrial reference frame, that is especially important for the altimeter measurements of sea-level, plate tectonics studies and for improvement of geophysical models. Geocenter motions as determined using DORIS and GPS data, are of the order of 5-18 mm in each coordinate, and secular trend is about 1.7 mm/yr. Amplitudes of Z components are 2-3 times higher than for X and Y for both GPS and DORIS solutions. Our investigations will be continued for the analysis of more longer time series of GPS and DORIS data.

References:

S.P.Kuzin, S.K.Tatevian (2000) "DORIS data analysis at the Institute of Astronomy, RAS", Proceedings of "DORIS DAYS", 1-3 may, 2000, Toulouse, France.

S.P.Kuzin, S.K.Tatevian (2002) "On Computation of Weekly Doris Solutions for 1999-2001 Time Period", Proceedings of the IDS workshop, Biarritz - France, 13-14 June 2002. *http://ids.cls.fr/html/report/ids_workshop_2002/programme.html*

C.Boucher, P.Sillard "Synthesis of submitted geocenter time series", IERS Technical Note 25, IERS Analysis Campaign to Investigate Motions of the Geocenter J.Ray (Ed.), April 1999.

H.Montag "Geocenter motions derived by different satellite methods", IERS Technical Note 25, IERS Analysis Campaign to Investigate Motions of the Geocenter J.Ray (Ed.), April 1999.

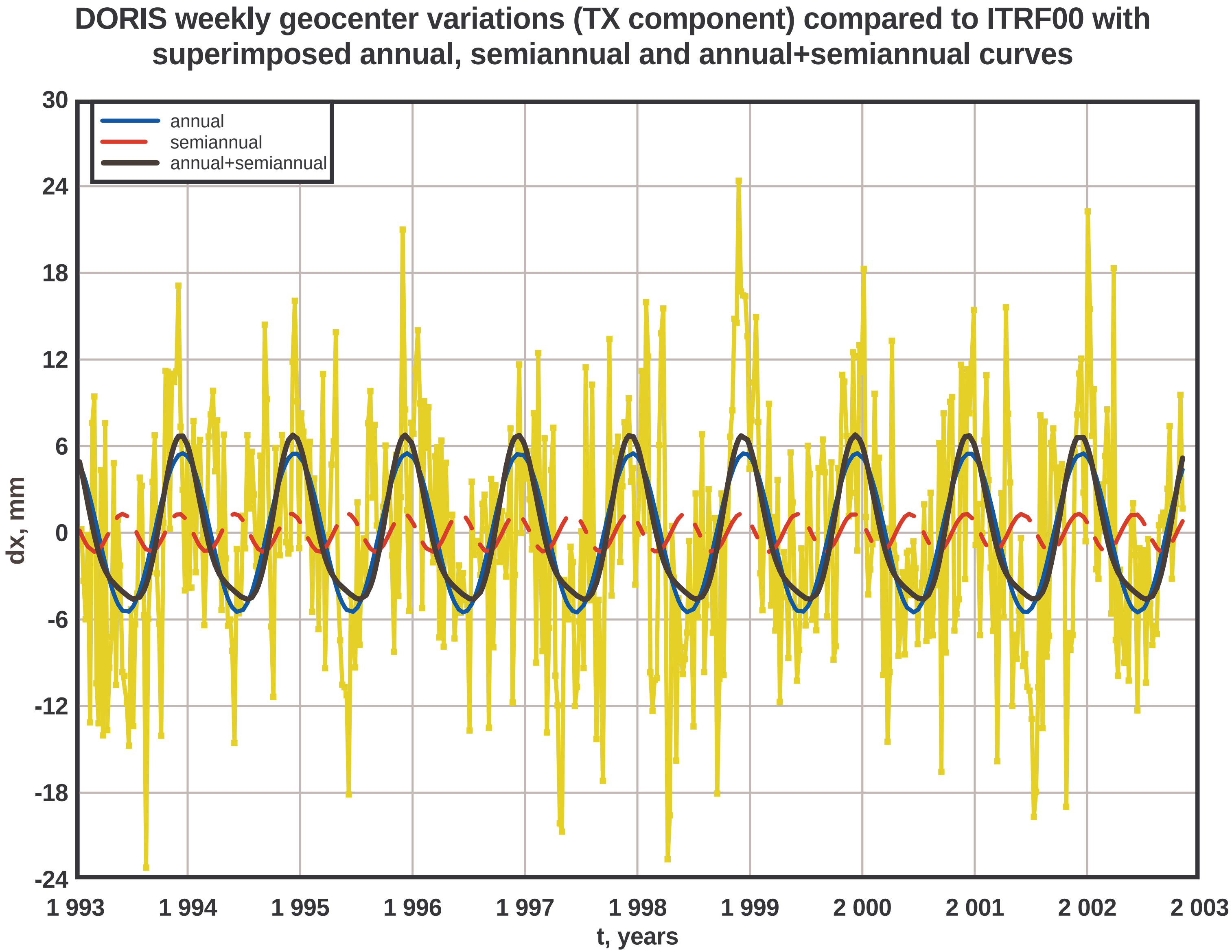

DORIS weekly geocenter variations (TX component) compared to ITRF00 with superimposed annual, semiannual and annual+semiannual curves
annual
semiannual
annual+semiannual
30
24
18
12
6
0
-6
-12
-18
-24
dx, mm
1 993
1 994
1 995
1 996
1 997
1 998
1 999
2 000
2 001
2 002
2 003
t, years

Fig. 1.

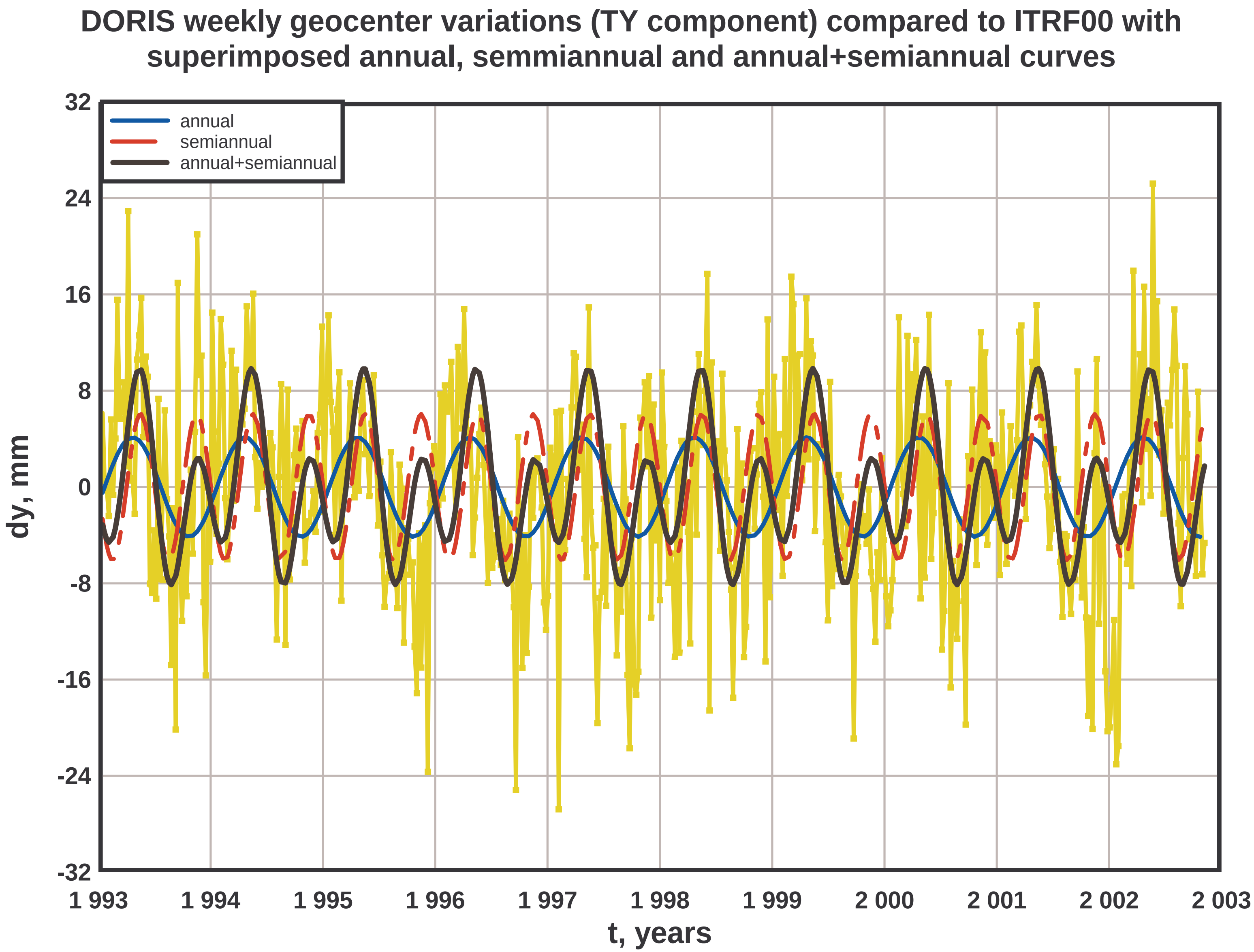

DORIS weekly geocenter variations (TY component) compared to ITRF00 with superimposed annual, semmiannual and annual+semiannual curves
annual
semiannual
annual+semiannual
32
24
16
8
0
-8
-16
-24
-32
dy, mm
1 993
1 994
1 995
1 996
1 997
1 998
1 999
2 000
2 001
2 002
2 003
t, years

Fig. 2

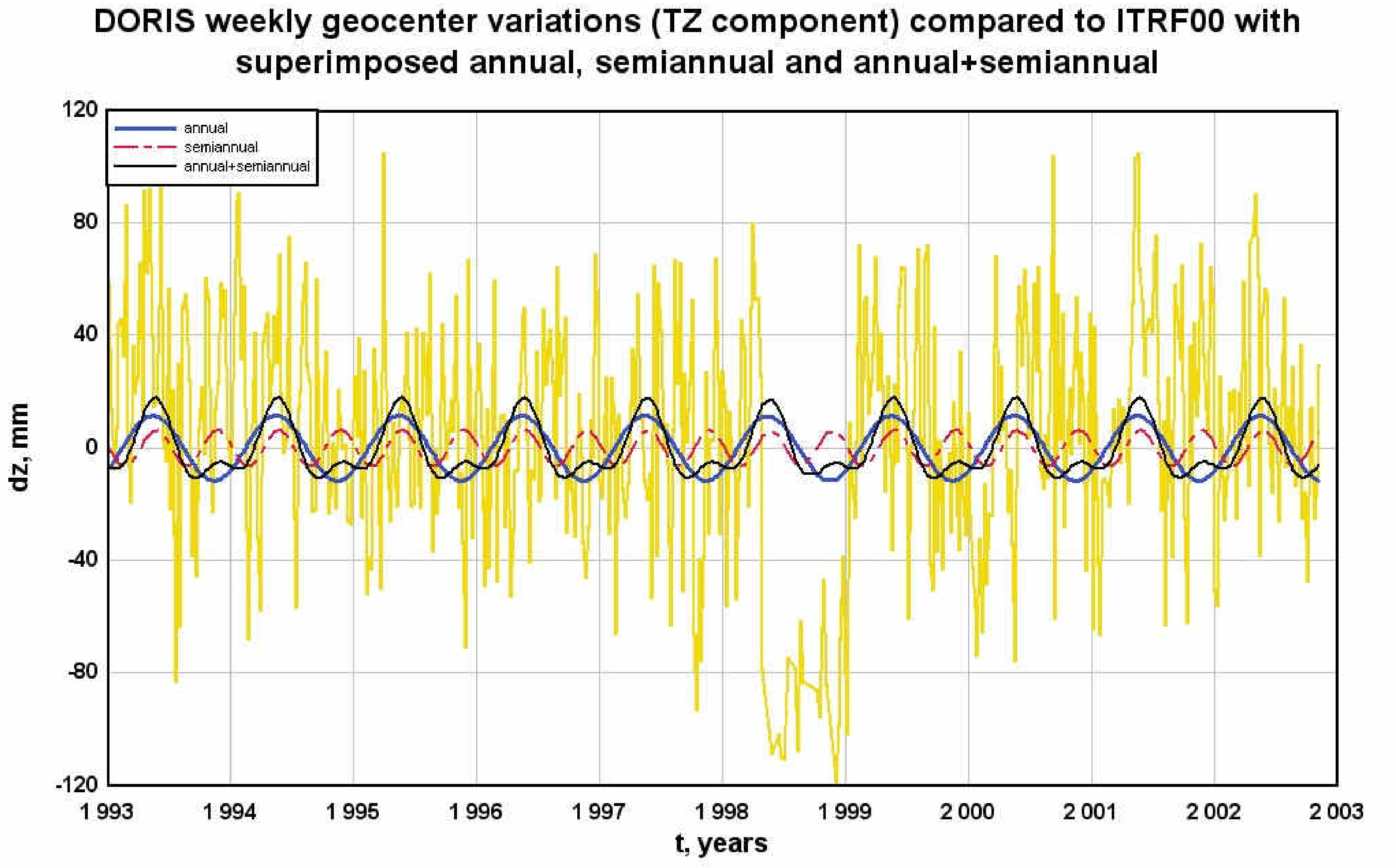
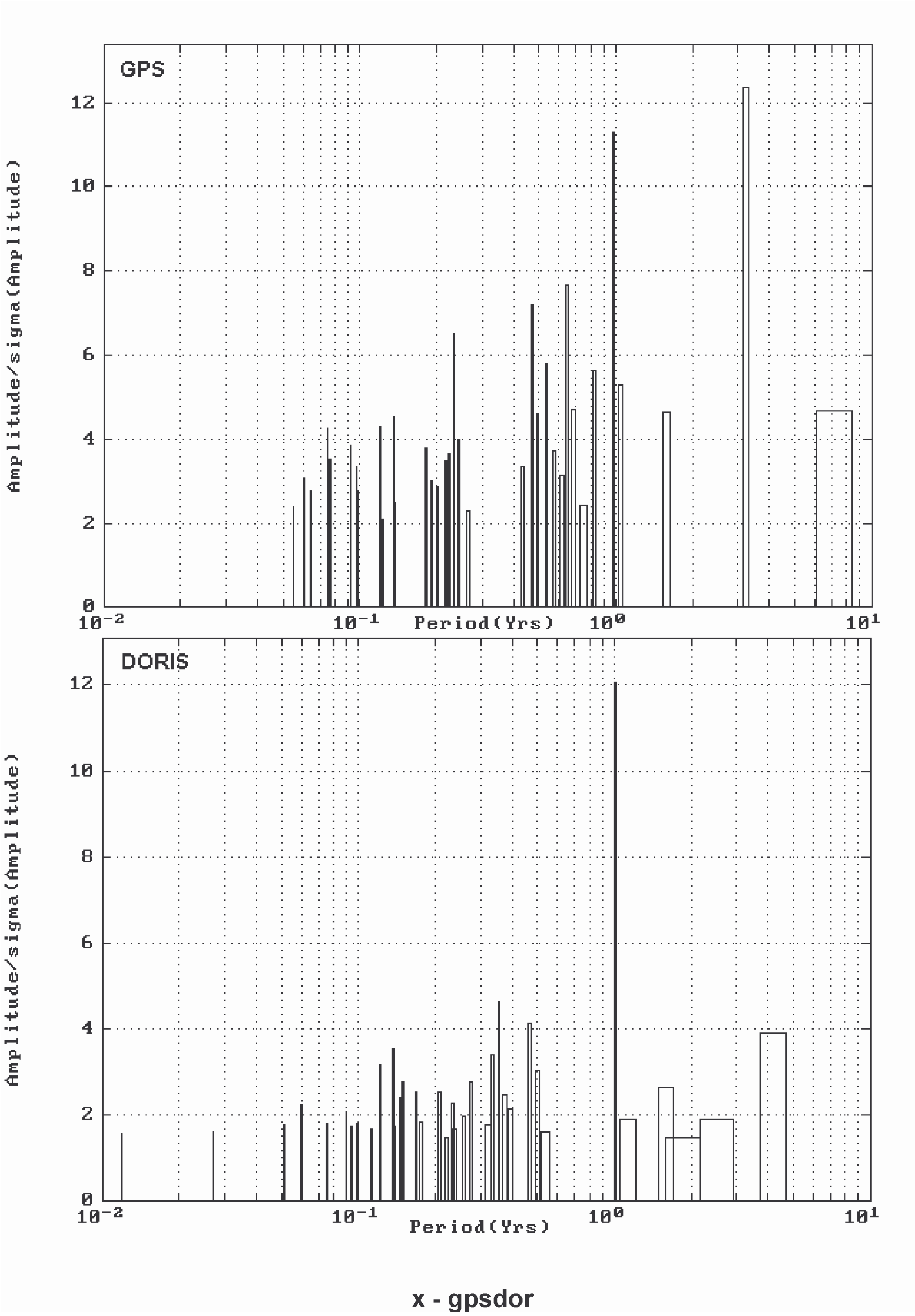
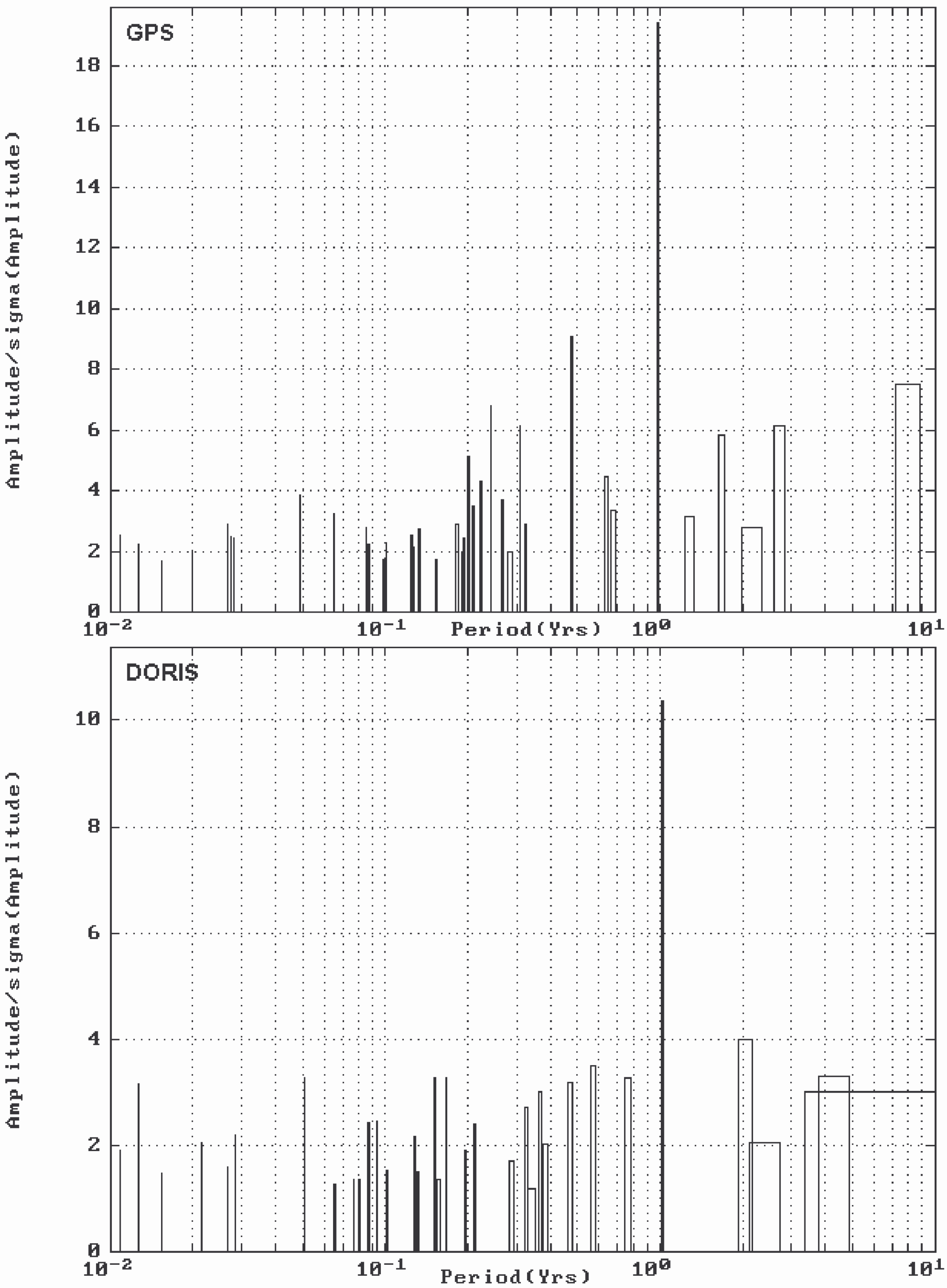

DORIS weekly geocenter variations (TZ component) compared to ITRF00 with superimposed annual, semiannual and annual+semiannual
annual
semiannual
annual+semiannual
120
80
40
0
-40
-80
-120
dz, mm
1 993
1 994
1 995
1 996
1 997
1 998
1 999
2 000
2 001
2 002
2 003
t, years

Fig. 3.



x - gpsdor

Fig. 4.



y - gpsdor

Fig. 5.

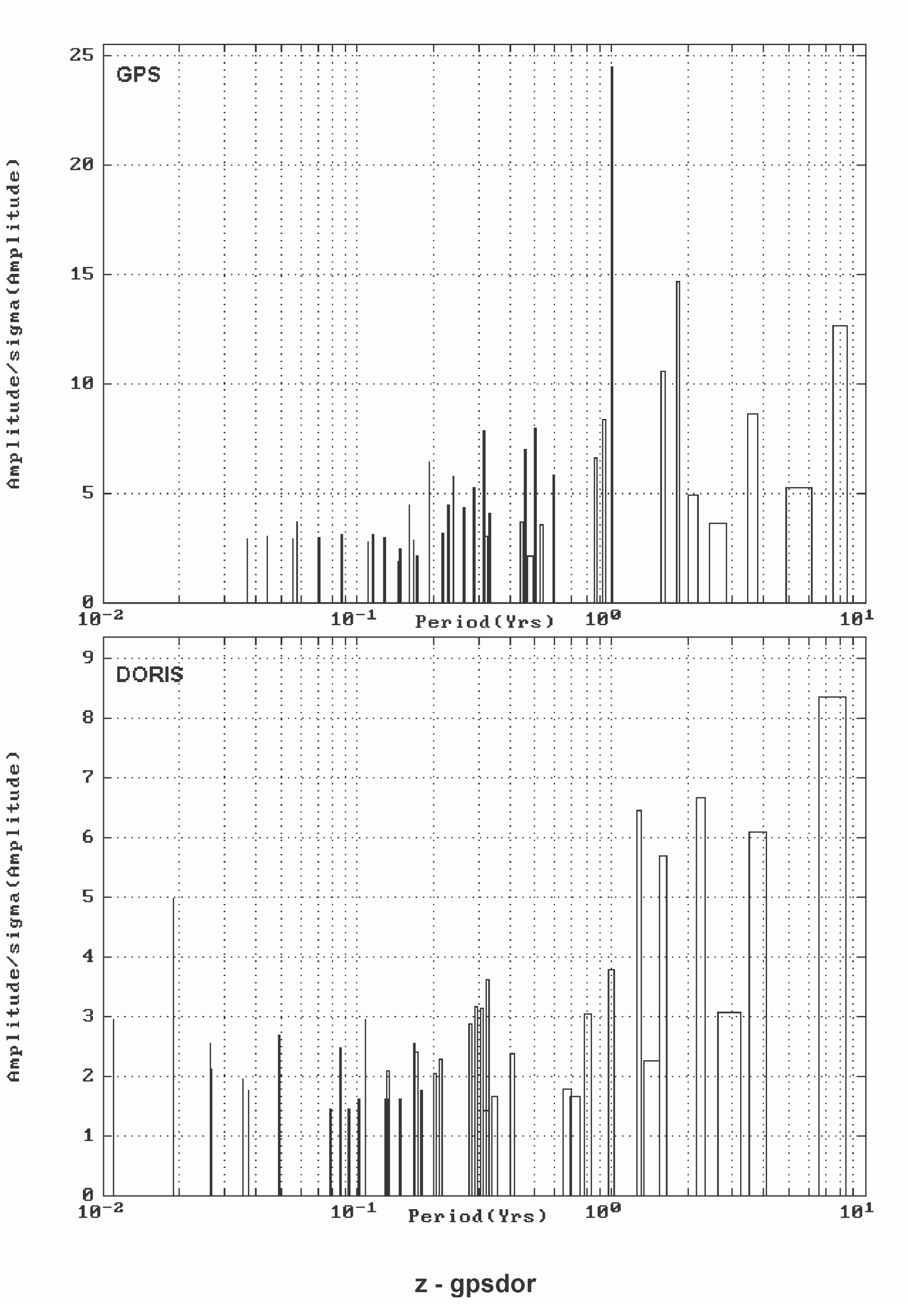

GPS
Amplitude/sigma(Amplitude)
Period(Yrs)
DORIS
Amplitude/sigma(Amplitude)
Period(Yrs)
z - gpsdor

Fig. 6.