SHORT - TERM POLAR MOTION AND UT1 VARIATIONS OBSERVED BY IGS

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The GPS polar motion and UT1 series available from the IGS'92 Campaign and its continuation are compared with the geodetic IERS combined series and the modelled atmospheric series based on effective atmospheric angular momentum functions. The short-term oscillations are obtained by removing the long periodical variations of the individual series. Polar motion variations in range from days to months are observed by GPS and significant correlation with both IERS combined and atmospheric series is found. The correlation of GPS UT1R with geodetic combined and atmospheric series reaches maximum for weekly variations. The monthly GPS UT1 oscillations exhibit discrepancies with other series.

ANALYZED DATA

The daily GPS series from 3 processing centers CODE, JPL and SIO are available for almost whole period 1992.5-1993.0. They give polar motion and the CODE series also UT1. The daily IERS series based on combination of VLBI, SLR and LLR observations [1] gives x, y, UT1 and covers the whole IGS Campaign. For the UT comparisons we use also the daily VLBI series from Westford - Wettzell baseline. The complete Yoder et. al [2] model for periodic variations due to zonal tides is removed from all UT1 series. In Table 1 we summarize the data used in further comparison studies.

The EOP variations caused by meteorological excitations have been obtained from time series of atmospheric angular momentum χ-functions at 12-hour intervals computed from pressure and wind fields generated at the Japan Meteorological Agency [3]. The motions of Celestial Ephemeris Pole $\mathbf{p}(t)=p_1+ip_2$ induced by atmospheric fluctuations $\chi=\chi_1+i\chi_2$ are computed from linearized Liouville equation [4]

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$$\mathbf{p}(t)+\frac{i}{\sigma_0}\frac{d\mathbf{p}(t)}{dt}=\boldsymbol{\chi}(t) \ , \tag{1}$$

where σ_0 is frequency of Chandler wobble. Let $\mathbf{P}(\omega)$ denote the Fourier transform of $\mathbf{p}(t)$ and $\mathbf{X}(\omega)$ the Fourier transform of $\boldsymbol{\chi}(t)$. Then eq.(1) transformed into frequency domain becomes

$$\mathbf{P}(\omega)=\frac{\sigma}{\sigma-\omega}\mathbf{X}(\omega) \ . \tag{2}$$

The procedure used to compute the AAM induced polar motion consist in Fast Fourier Transform (FFT) of $\boldsymbol{\chi}(t)$, multiplication with transfer function (2) and recovering $\mathbf{p}(t)$ by inverse FFT. Two alternatives of $\mathbf{p}(t)$ from χ-functions have been obtained according to the pressure term used - with and without the inverted barometer (IB) approximation.

The atmosphere induced UT is inferred from χ_3 component (wind term and pressure term with IB) by numerical integration.

Table 1
Analyzed series

Technique	Series	Period	EOP
GPS	EOP(CODE) 92 P 04	1992 Jun. 19 - 1993 Jan. 26	x,y,UT1
GPS	EOP(JPL) 92 P 02 EOP(JPL) 92 P 03	1992 Jul. 17 - 1992 Nov. 14 1992 Nov. 15 - 1993 Jan. 16	x,y
GPS	EOP(SIO) 92 P 03	1992 Jun. 7 - 1993 Nov. 12	x,y
Combined	EOP(IERS) 90 C 04	1992 Jan. 1 - 1993 Jan. 31	x,y,UT1
VLBI	EOP(NOAA) 92 R 02	1992 Jan. 1 - 1992 Dec. 31	UT1
AAM	AAM(JMA) 92 * 01	1992 Jan. 1 - 1992 Dec. 31	χ_1,χ_2,χ_3 -> x,y,UT

HIGH FREQUENCY VARIATIONS OF EARTH ROTATION PARAMETERS

The short-term oscillations of x, y and UT1R as well as of the AAM induced series are obtained by removing the long periodical variations of the individual series. Three types of residuals according to degree of Vondrak [5] smoothing are analysed. Fig.1 shows transfer functions of the used filters. The cut-off periods 9 days (filter I), 30 days (filter II) and 90 days (filter III) correspond roughly to daily, weekly and monthly variations of residuals.

Fig.2 and Fig.3 show the high pass filtered monthly and daily oscillations of the three GPS polar motion solutions and the AAM induced polar motion based on JMA pressure term without IB approximation for the period 1992.5-1993.0. Mean formal uncertainties of GPS series are 0.11 mas for CODE, 0.18 mas for JPL and 0.20 mas for SIO. The upper graphs show that the individual GPS series follow the same pattern which is sporadically identical with AAM variations. The daily variations in lower graphs have significantly larger scatter for CODE and SIO series when compared with JPL polar motion and significantly exceed the formal uncertainties.

Fig.4 shows the UT1R residuals of GPS CODE series, combined IERS series as well as the UT AAM series. The monthly GPS variations differ from IERS and AAM in the beginning of IGS campaign, the daily variations of the three series have similar behaviour.

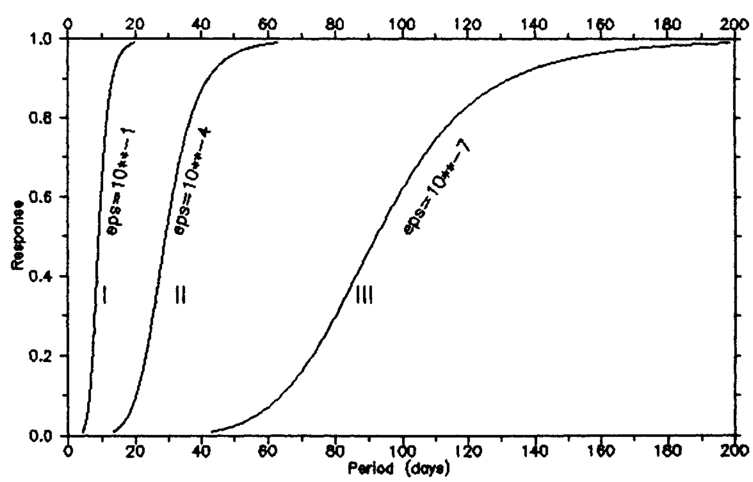

Fig.1 Transfer functions of Vondrak smoothing

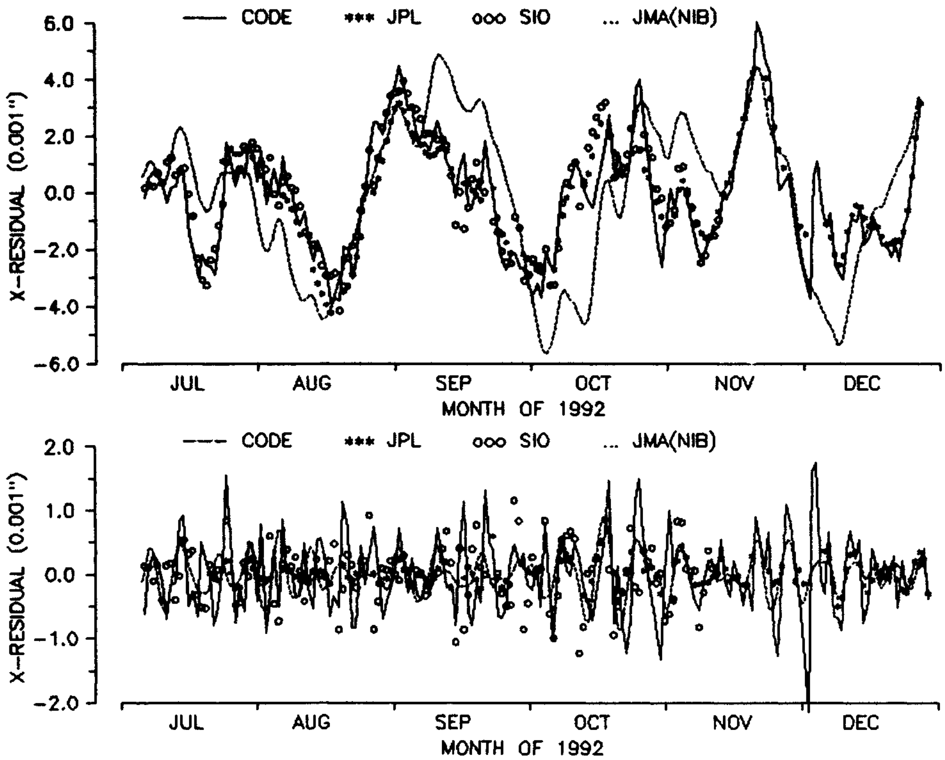

Fig.2 x-coordinate residuals from smoothing III (upper graph) and from smoothing I (lower graph)

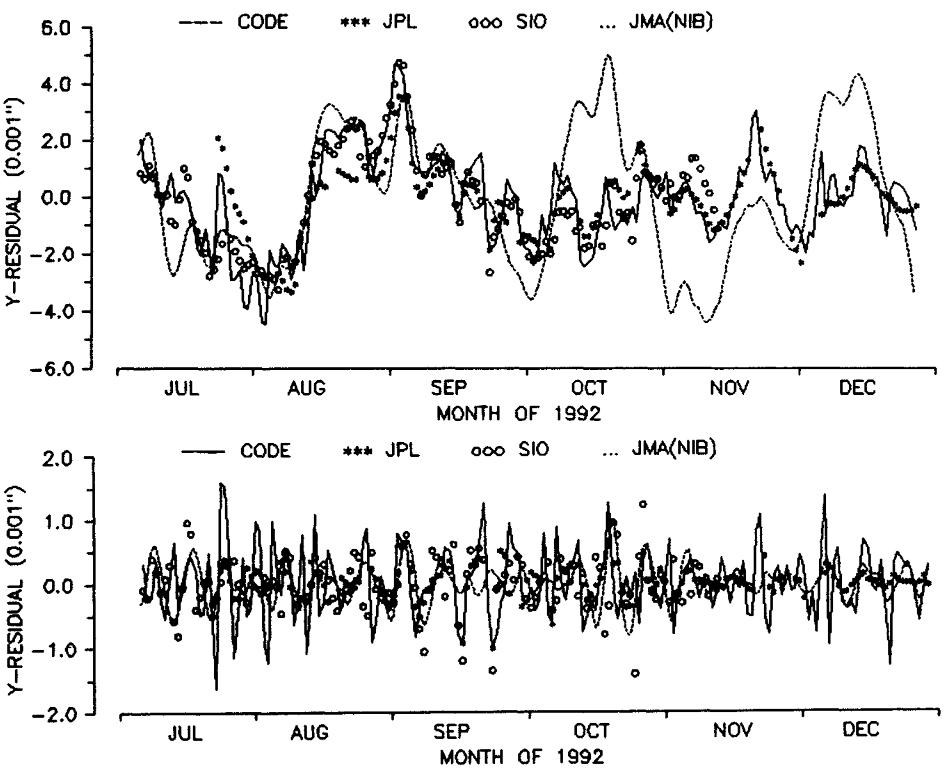

Fig.3 y-coordinate residuals from smoothing III (upper graph) and from smoothing I (lower graph)

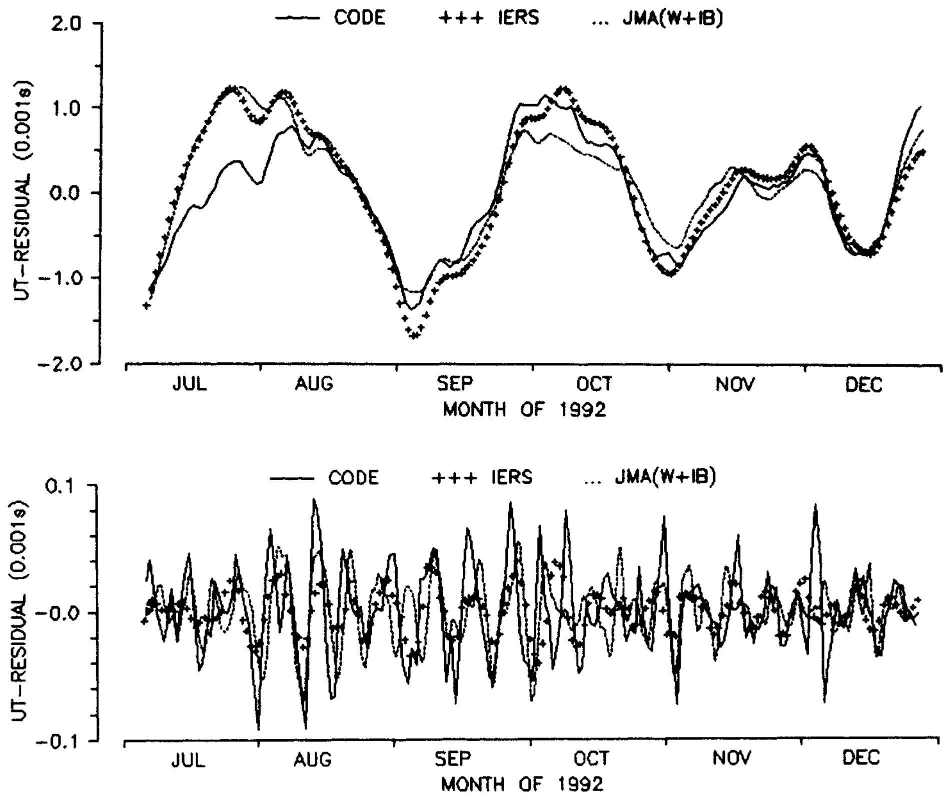

Fig.4 UT1R residuals from smoothing III (upper graph) and from smoothing I (lower graph)

DIFFERENCES OF EOP SERIES - UNCERTAINTIES AND CORRELATIONS

The residuals of GPS solutions, combined series and AAM series (with IB and without IB) representing the monthly, weekly and daily variations are compared pair by pair. Table 2 gives the estimates of rms differences after removing bias. As we are analyzing the residuals, bias of their differences is close to zero. For pairs of GPS series also the corresponding formal uncertainties based on information from processing centers are shown. Fig.5 is a plot of rms differences between GPS solutions. Displayed are also rms differences between JPL GPS series and IRES combined solution - two series with the best mutual agreement.

Table 3 summarizes correlation coefficients for pairs considered in Table 2. Correlation exceeding critical values at 0.01 significance level is found for each pair of geodetic series except the difference between SIO and CODE daily variations (0.05 level). Correlation coefficients between GPS series and between JPL and combined series are shown in Fig.6.

Table 2
Rms differences of various pole coordinates series (units 0.001"). Unc. means the formal uncertainty of GPS series differences.

Series	Filter	JPL	IERS	SIO	AAM (NIB)	AAM (IB)
CODE	III x	0.89	0.95	1.09	2.23	1.75
	y	1.00	0.85	0.98	2.14	1.53
	II x	0.70	0.80	0.95	1.03	1.11
	y	0.71	0.79	0.91	1.07	0.95
	I x	0.48	0.59	0.70	0.57	0.58
	y	0.51	0.56	0.66	0.61	0.58
	Unc.	0.20	-	0.23	-	-
AAM(IB)	III x	1.40	1.42	1.48		
	y	1.07	1.23	1.48		
	II x	0.67	0.80	0.75		
	y	0.63	0.53	0.74		
	I x	0.17	0.14	0.39		
	y	0.23	0.13	0.42		
	Unc.	-	-	-		
AAM(NIB)	III x	2.04	1.98	2.26		
	y	2.18	1.98	2.07		
	II x	0.71	0.75	0.82		
	y	0.74	0.72	0.89		
	I x	0.25	0.21	0.46		
	y	0.31	0.23	0.42		
	Unc.	-	-	-		
SIO	III x	0.89	0.77			
	y	0.87	0.71			
	II x	0.58	0.64			
	y	0.43	0.53			
	I x	0.35	0.42			
	y	0.31	0.38			
	Unc.	0.26	-			
IERS	III x	0.82				
	y	0.69				
	II x	0.48				
	y	0.39				
	I x	0.18				
	y	0.23				
	Unc.	-				

Table 3
Correlation coefficients for x and y pole coordinates
Crit. means the critical value for α=0.01.

Series	Filter	JPL	IERS	SIO	AAM (NIB)	AAM (IB)
CODE	III x	0.97	0.89	0.82	0.57	0.54
	y	0.81	0.86	0.84	0.48	0.37
	II x	0.78	0.74	0.55	0.54	0.38
	y	0.68	0.73	0.53	0.40	0.40
	I x	0.44	0.36	0.15	0.42	0.48
	y	0.37	0.30	0.20	0.16	0.18
	Crit.	0.22	0.18	0.21	0.22	0.22
AAM(IB)	III x	0.65	0.65	0.60		
	y	0.51	0.45	0.44		
	II x	0.43	0.51	0.60		
	y	0.45	0.60	0.22		
	I x	0.34	0.61	0.35		
	y	0.33	0.49	0.34		
	Crit.	0.22	0.18	0.21		
AAM(NIB)	III x	0.65	0.66	0.50		
	y	0.51	0.55	0.49		
	II x	0.57	0.65	0.55		
	y	0.61	0.63	0.47		
	I x	0.49	0.68	0.28		
	y	0.34	0.61	0.34		
	Crit.	0.22	0.18	0.21		
SIO	III x	0.91	0.91			
	y	0.89	0.91			
	II x	0.71	0.73			
	y	0.84	0.72			
	I x	0.49	0.31			
	y	0.64	0.39			
	Crit.	0.26	0.21			
IERS	III x	0.91				
	y	0.88				
	II x	0.85				
	y	0.83				
	I x	0.50				
	y	0.43				
	Crit.	0.18				

Standard deviations and correlations for pairs of UT1R series - GPS, combined, daily VLBI and AAM are given in Table 4 and Table 5. The statistics obtained for weekly variations and daily variations have similar value for all compared series. This proves that GPS observed variations are reliable for periods shorter than one month.

Table 4
Rms differences between GPS, daily VLBI, IERS combined and atmospheric UT series (units 0.001 ms)

Series	Filter	IERS	VLBI	AAM
CODE	III	0.507	0.527	0.522
	II	0.103	0.096	0.093
	I	0.034	0.048	0.037
AAM	III	0.229	0.298	
	II	0.108	0.093	
	I	0.021	0.041	
VLBI	III	0.261		
	II	0.093		
	I	0.036		

Table 5
Correlation coefficients between GPS, daily VLBI, IERS combined and atmospheric UT series.
Crit. means the critical value at significance level α=0.01.

Series	Filter	IERS	VLBI	AAM
CODE	III	0.77	0.71	0.71
	II	0.80	0.80	0.79
	I	0.39	0.17	0.37
	Crit.	0.18	0.24	0.18
AAM	III	0.96	0.91	
	II	0.78	0.80	
	I	0.50	0.14	
	Crit.	0.18	0.24	
VLBI	III	0.94		
	II	0.84		
	I	0.23		
	Crit.	0.24		

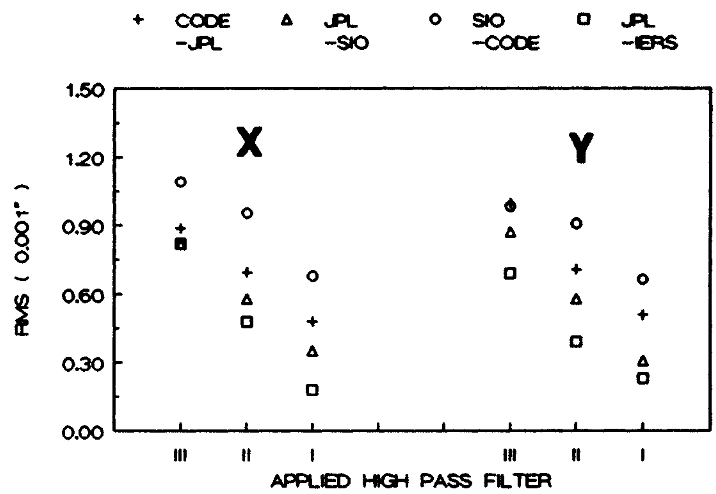

Fig.5 Rms differences of polar motion series

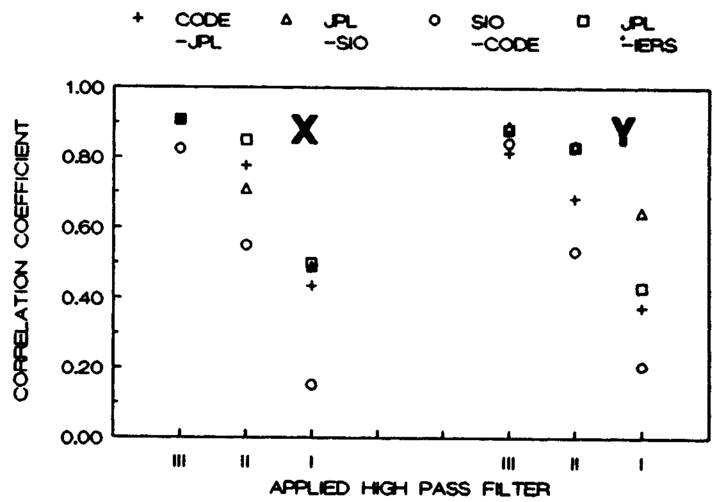

Fig.6 Correlation coefficients between polar motion series

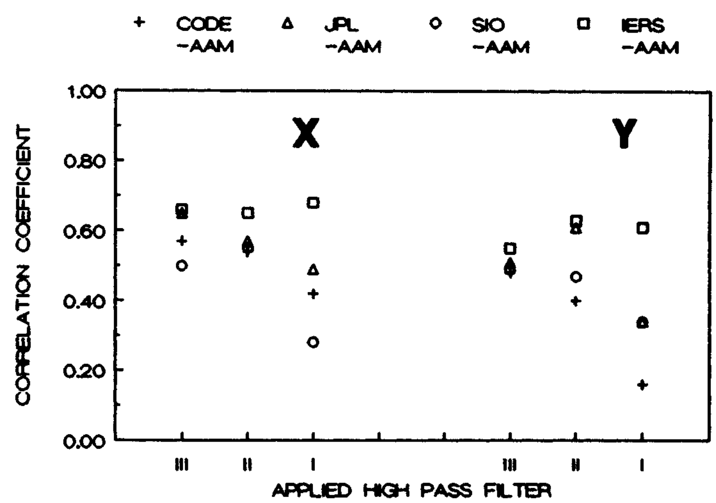

Fig.7 Correlation coefficients between geodetic and AAM polar motion

CONCLUSIONS

The short-term polar motion variations in range from days to months observed by GPS are at 0.5 - 5 mas level according to used high pass filtering and significantly exceed the formal uncertainties. Rms differences for pairs of geodetic series (GPS and combined) are bellow 1 mas and gradually decrease towards high frequencies. Correlations between geodetic series is also decreasing but remains significant for daily variations except the SIO-CODE pair. Significant correlation 0.4 - 0.6 results from comparison of GPS polar motion series with both IB and without IB approximation atmospheric models.

Monthly, weekly and daily non-tidal UT variations are well observed by GPS CODE series. The monthly GPS oscillations exhibit the most significant discrepancies with other geodetic series, especially in the beginning of IGS campaign. The atmospheric driving of short-term Earth's rotation is recognized by GPS at the time scales from days to months.

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