ESTIMATION OF SUBDIURNAL TIDAL TERMS IN UT1-UTC FROM VLBI DATA ANALYSIS

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INTRODUCTION

Subdiurnal UT1–UTC variations arisen from oceanic forced effect have been estimated since 1989. Brosche et al. [1991] presented their results for four terms only (O1, K1, M2, S2) using one-year observational data set. Currently, it is possible to detect UT1–UTC oceanic tidal terms with accuracy 1-3 μsec due to progress in VLBI observations performance. Gipson [1996] published estimates for 41 tidal terms in UT1–UTC and for 57 tidal terms in polar motion using 1.6 billion delays from 1979 till 1996.

There are two ways for estimation of subdiurnal tidal terms in EOP. The first way foresees preliminary estimation of long-term EOP time series with high time resolution and subsequent adjustment using conventional least squares technique [Brosche et al.,1991; Titov, 2000]. The second one makes a direct adjustment of all tidal terms under analysis without intermediate calculation of time series [Herring, Dong, 1994; Haas et al., 1995]. The former approach is very useful if we want to receive the EOP subdiurnal variations and seek for non-tidal effects. Obvious oceanic effects can be demonstrated visually. It is appeared that the EOP time series a sensitive to chosen a priori information. As a result, the estimates of oceanic tidal terms can be unstable on level of a few μsec. Therefore, from general point of view, the latter approach looks more preferable because we do not need any a priori information about EOP behavior on subdiurnal time scale.

Another problem is a strong correlation between main band and sidebands because it can bias an estimates. Historical limit on observational data set prevents an appropriate reducing of correlation between close effects. It can be shown that the correlation coefficients are depend on choice of a priori information.

GLOBAL ADJUSTMENT

Let consider parametrical model of observations

$$Ax + By + Cz + w = l, \qquad (1)$$

where l – vector of observations (O–C); w – vector of observations. Three types parameters to be considered: 'global' (tidal terms) – vector x; 'arc' or 'daily' (site positions, EOP) – vector y; 'stochastic' (clock offset, troposphere) – vector z. Here A,B,C are matrixes of partial derivatives. For each single VLBI session the following matrix of normal equations can be constructed

$$A^TQAx = A^TQl \qquad (2)$$

where covariance matrix Q is a combination of matrixes

$$Q = Q_0^{-1} - Q_0^{-1}B(B^TQ_0^{-1}B)^{-1}B^TQ_0^{-1} \qquad (3)$$

where Q_0 as follows

$$Q_0 = CQ_ZC^T + Q_w. \tag{4}$$

Matrix Q_Z can be calculated using information about covariance functions of stochastic parameters (see below). Q_w – diagonal covariance matrix of observational dispersions. Full matrix Q_0 (size N×N, N – the amounts of VLBI sessions under analysis) to be inverted. Making a sum on all VLBI sessions we are able to get an solution of global parameters vector

$$\hat{x} = \left(\sum_{i=1}^{n} (A^TQA)_i \right)^{-1} \cdot \sum_{i=1}^{n} (A^TQl)_i, \tag{5}$$

where n – the amounts of VLBI sessions under analysis. Estimates of vectors y and z for each VLBI session are given by

$$\hat{y} = (B^TQ_0^{-1}B)^{-1}BQ_0^{-1}(l - A\hat{x}) \tag{6}$$

$$\hat{z} = Q_ZC^T(CQ_ZC^T + Q_w)^{-1}(l - A\hat{x} - B\hat{y}). \tag{7}$$

It means that the y and z parameters can be estimated after adjustment of global parameter vector only. Procedure for a priori covariance function calculation is discussed at the paper "Full covariance matrix for lest squares collocation method" (see this volume).

Three solutions have been obtained using different dispersion for wet delay as well as clock offset variations. Table 1 contains list of a priori dispersion for wet delay and clock offset.

Parameter	Solution 1	Solution 2	Solution 3
Wet delay	2.5	12.5	12.5
Clock offset	2	10	2

Table 1. A priori dispersion for wet delay and clock offset (cm**2).

SOLUTION

Regular observational VLBI data (IRIS-A, NEOS-A) from 1984 till 1999 have been used for global adjustment procedure. Celestial reference frame has been fixed by radiosources coordinates (ICRF 1997). Terrestrial reference frame has been fixed by coordinates of Wettzell, direction from Wettzell to another VLBI station and vertical component of third station. We process 898 VLBI sessions (more than 546.000 time delays) using OCCAM 3.4 software [Titov, Zarraoa, 1997] and estimate 34 tidal terms by LSCM. No special constraints for reducing of correlation has been applied for solution. Table 2 contains coefficients of correlation between main tidal terms and their sidebands. Upper triangle shows the coefficients for cosines components, low triangle – for sinus ones.

	O1'	O1	K1"	K1	K1'
O1'	-	0.42			
O1	0.42	-			
K1"			-	0.38	-0.13
K1			0.38	-	0.37
K1'			-0.09	0.37	-

	M2'	M2	K2	K2'
M2'	-	0.33		
M2	0.34	-		
K2			-	0.32
K2'			0.36	-

Table 2. Coefficient of correlation.

Other sidebands demonstrate the analogous level of correlation. Suddenly, it has been discovered significant correlation between 2Q1 and S1 terms (up to 0.45) as well as 2N2 and R2 terms (up to 0.35). Probably, it can be explained by closeness of fundamental arguments (l, l', F, Ω, θ) combination $l' - \theta \approx l + 2F + 2\Omega - \theta$ for time interval 1984 – 1999.

DISCUSSION

A few LSCM estimates of tidal amplitudes are compared with the same terms from IERS Conventions [McCarthy, 1996] and paper by Gipson [1996]. Table 3 demonstrates that the values estimates do not essentially depend on a priori dispersions from Table 1. Generally, all estimates for diurnal tidal terms are in a good accordance with ones from IERS Conventions 1996. Disagreement with results by Gipson is on level 1-2 μsec in diurnal time band. In semidiurnal band all LSCM estimates exceed the alternatives on 1-6 μsec. The essential disagreement indicates that more detailed research must be done in future.

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	Tide	IERS Conv. 1996	Gipson (1996) constrained	Gipson (1996) uncostraine d	Solution 1	Solution 2	Solution 3
1	Q1	5.6	5.9	6.7	5.6	5.6	5.7
2	O1'		4.2	3.3	4.3	4.3	4.3
3	O1	20.1	22.5	22.8	20.6	20.8	20.6
4	K1"		0.3	2.2	3.0	3.0	3.4
5	K1	19.7	18.5	15.3	19.2	19.3	18.9
6	K1'		2.6	4.1	4.3	4.3	3.9
7	N2	4.1	3.9	3.8	4.9	5.0	4.8
8	M2'		0.6	1.4	2.2	2.0	2.2
9	M2	17.7	18.3	17.4	22.8	23.4	21.3
10	S2	7.6	7.8	7.8	10.8	11.0	10.4

Table 3. Estimates of amplitudes of main UT1–UTC tides and sidebands (in μsec).

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