Three-year solution of EOP by combination of results of different space techniques

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Contents:

- Introduction;
- Basic idea of the method;
- The transfer function T;
- Example of three-year solution;
- Conclusions.

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Introduction:

- Each technique has analysis centers whose products are published (positions and velocities of stations, Earth orientations parameters etc.);

Products of techniques can only be combined for stations equipped with more than one technique;

There are two approaches to combination:

- rigorous combination – combined are original observation equations or results of individual techniques using covariance matrices;

- non-rigorous combination is much simpler because the covariance matrices are not needed;

Original method derived by Kostelecký and Pešek:

➢ The method is based on combining station position vectors in the celestial reference frame that are functions of both EOP and station coordinates:

$$X_C = PNR_Z(-GST)R_X(y_p)R_Y(x_p)X_T. \qquad (1)$$

Two types of constraints are necessary:

- constraint of "no net rotation" to conserve station coordinate system;
- constraint to tie EOP at the adjacent epochs with simple formula applied in the form of additional observation equations with a properly chosen weight ***w***:

$$EOP(n+1) - EOP(n) = 0 + v. \qquad (2)$$

The method is further modified by applying "Vondrak smoothing":

- The smoothing method consists in finding a weighted compromise between two different conditions: smoothness (*S*) of the searched curve and its fidelity (*F*) to observed function values.

$$S = \frac{1}{b-a}\int_a^b \varphi'''^2(t)\,\mathrm{d}t, \quad F = \frac{1}{n-3}\sum_1^n pvv$$

- The compromise is then done by minimizing a combination of these constraints, i.e. the expression $S + \varepsilon F = \min$, in which **ε** is the coefficient of smoothing.

$\varepsilon = 0$ leads to a quadratic parabola,

$\varepsilon = \infty$ leads to a curve running through all points.

Implementation of the smoothing method:

- We use the definition of the smoothness (*S*) for condition **(2)** so that adjacent EOP are more suitably constrained to each other;

- The fidelity (*F*) is implicitly included by using standard least-squares condition $\sum pvv = \min$ for the whole combination of EOP and station coordinates.

Relation between the coefficient of smoothing and the new weight:

➢ We suppose that the new weight **w** is reciprocal value of the coefficient of smoothing **ε**.

The transformation (1) yields observation equation of the form:

$$\sum_j \frac{\partial x_c}{\partial U_j} dU_j = x_{obs} - x_0 + v \qquad (3)$$

We can study the behavior of each periodic term separately:

- right hand side of equation **(3)** is changed in order to simulate signal with known period (**P**) and amplitude (**A**);
- transfer function for different values of **P** and **w** is derived as a ratio of amplitude of our solution to that of modeled one;

➢ Three independent solutions of transfer function were compared with analytical formula expressed by Huang & Zhou (1981,1982) for situation when we wish to pass 99% of amplitude of a periodic process with period P days:

$$\frac{1}{w} = \varepsilon\left(P_{0.99}\right) = 99\left(\frac{2\pi}{P_{0.99}}\right)^{6}. \qquad (4)$$

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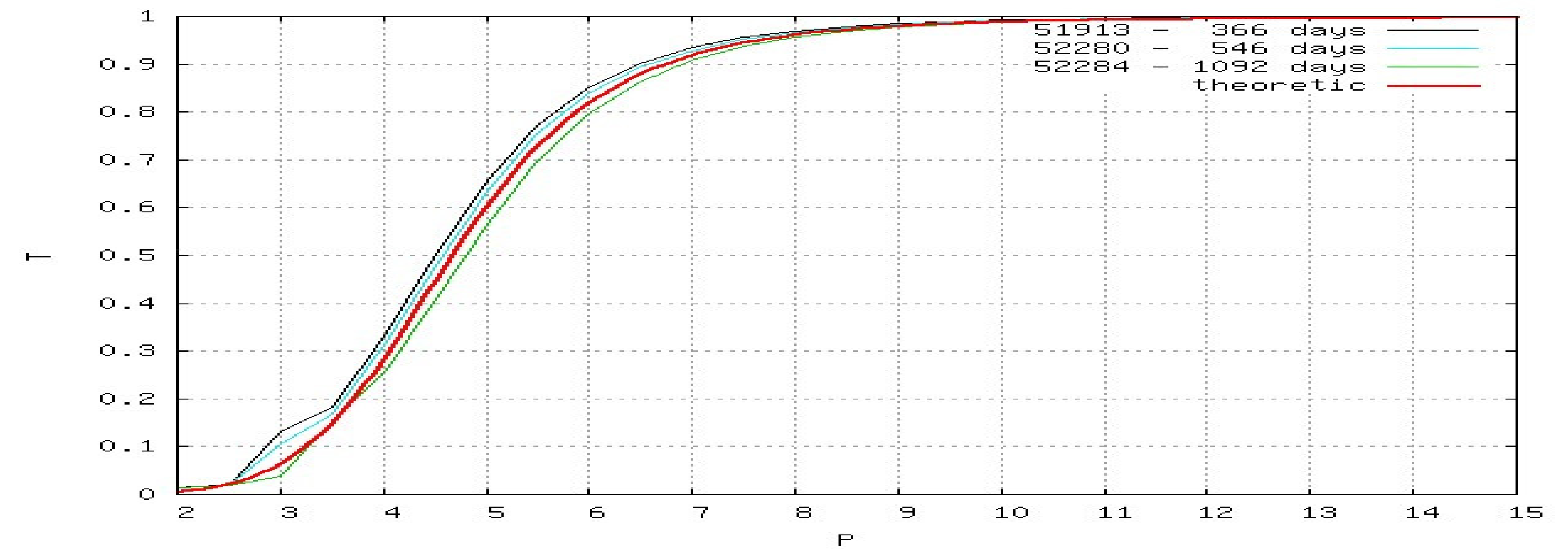
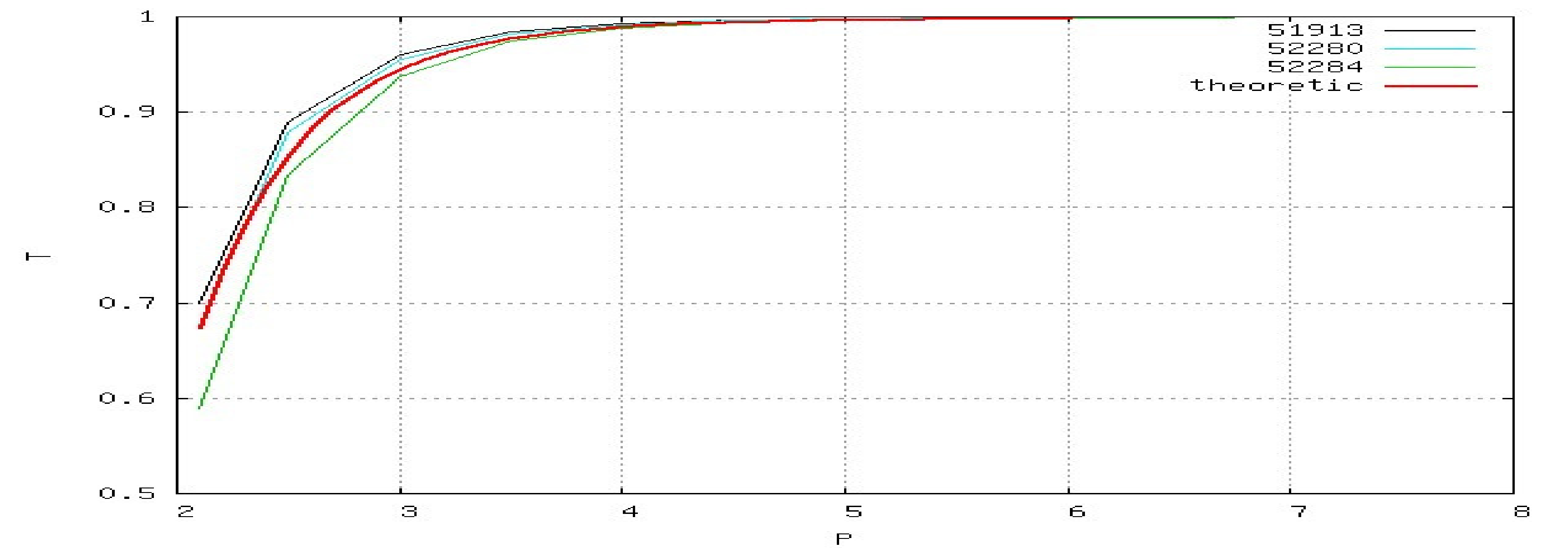


➢ This graph shows comparison of computed transfer functions with theoretic one.

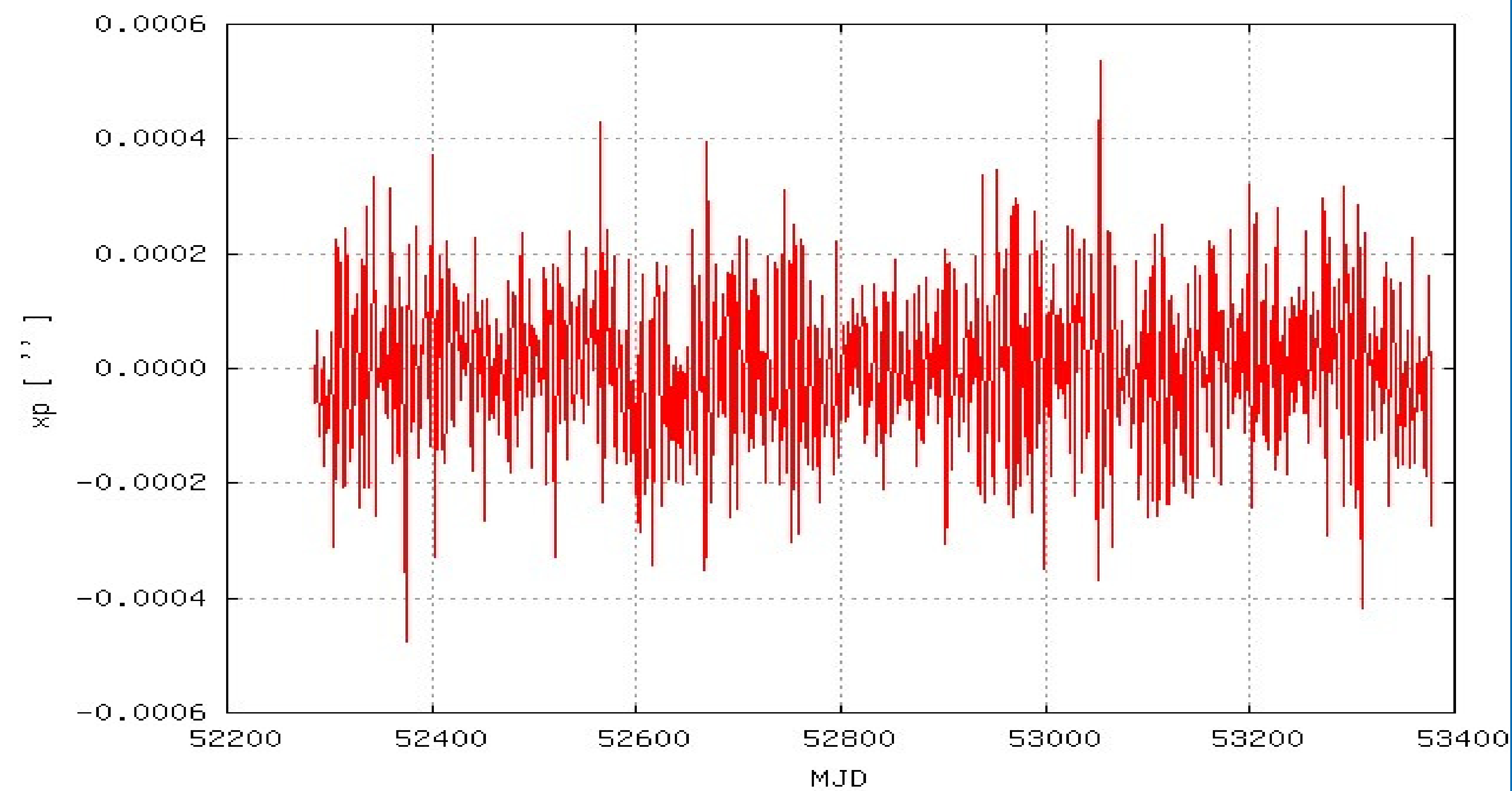
➢ The choice of the numerical values of **w** and **ε** were calculated by formula **(4)** where $P_{0.99}$ = 10 days.



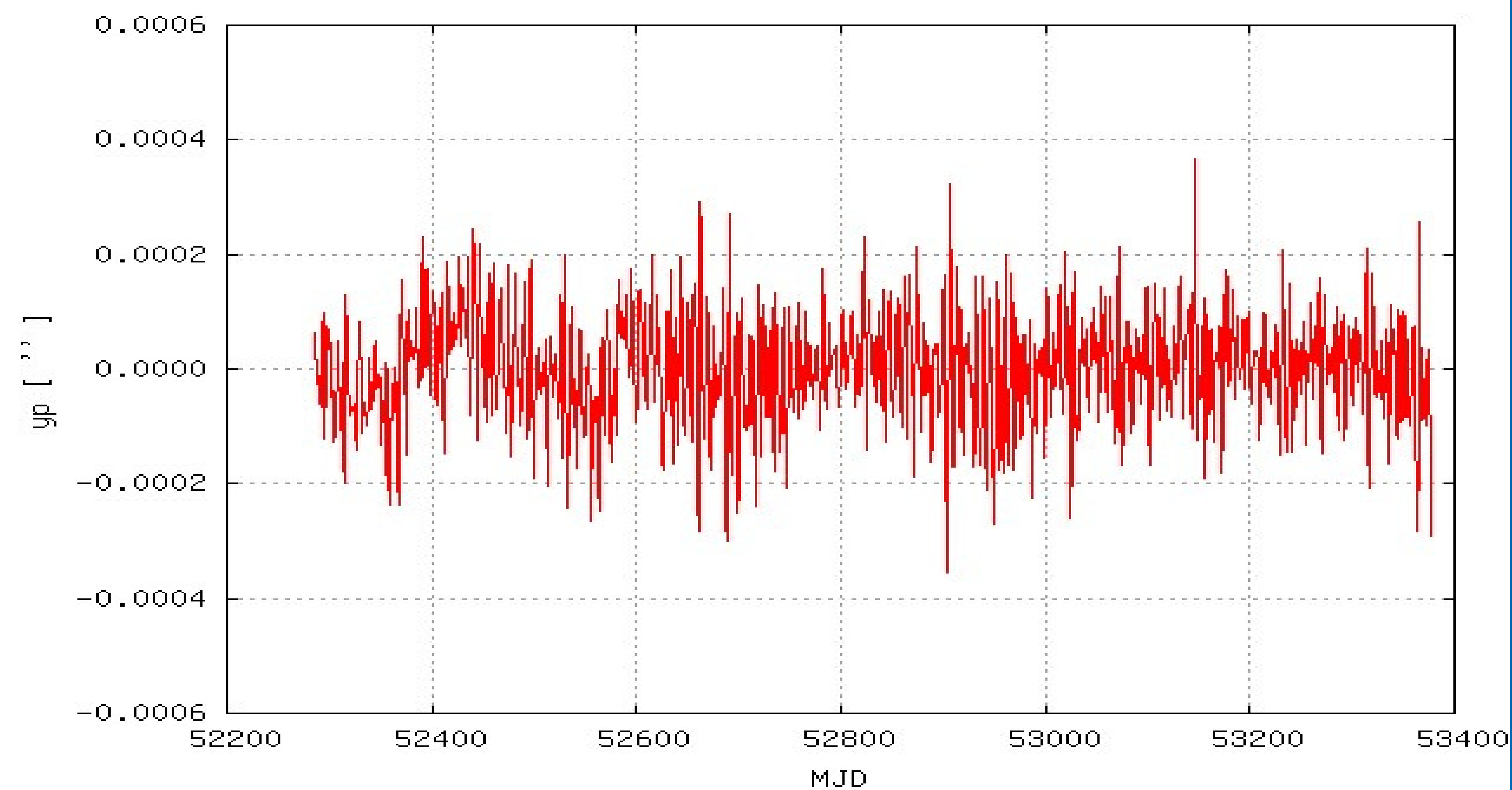
➢ This graph shows comparison of computed transfer function with theoretic one.

➢ The choice of the numerical values of **w** and **ε** were calculated by formula **(4)** where $P_{0.99}$ = 4 days.

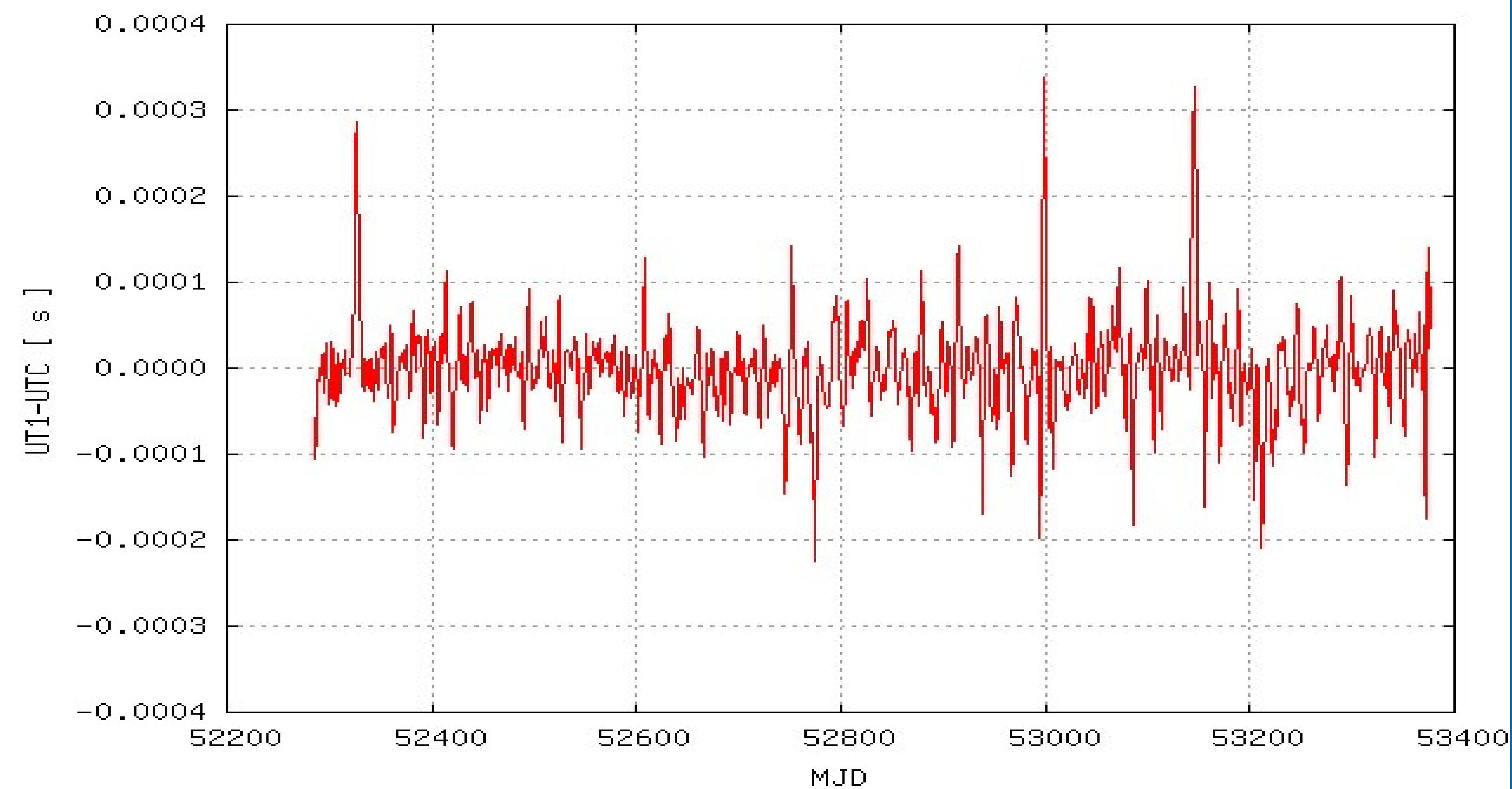
Differences of xp between IERS C04 and our solution :



Differences of yp between IERS C04 and our solution :



Differences of UT1-UTC between IERS C04 and our solution :



Conclusions:

- Comparison of transfer function derived by our method and the one expressed analytically shows a good agreement so that we can use a simple formula $w = \frac{1}{\varepsilon}$.

- Three-year solution was computed with weight assuring that all periodic variations with period of 4 days and longer are passed by our system completely.

- The combined EOP are very close to the IERS C04 series. The rms differences are 0.132 mas, 0.101 mas and 0.0545 mas for xp, yp and UT1 – UTC, respectively.

Thank you for your attention !!!