Implementation of the Vondrak's smoothing in the combination of EOP and station coordinates from different techniques

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ICRS, ITRS and their frames:

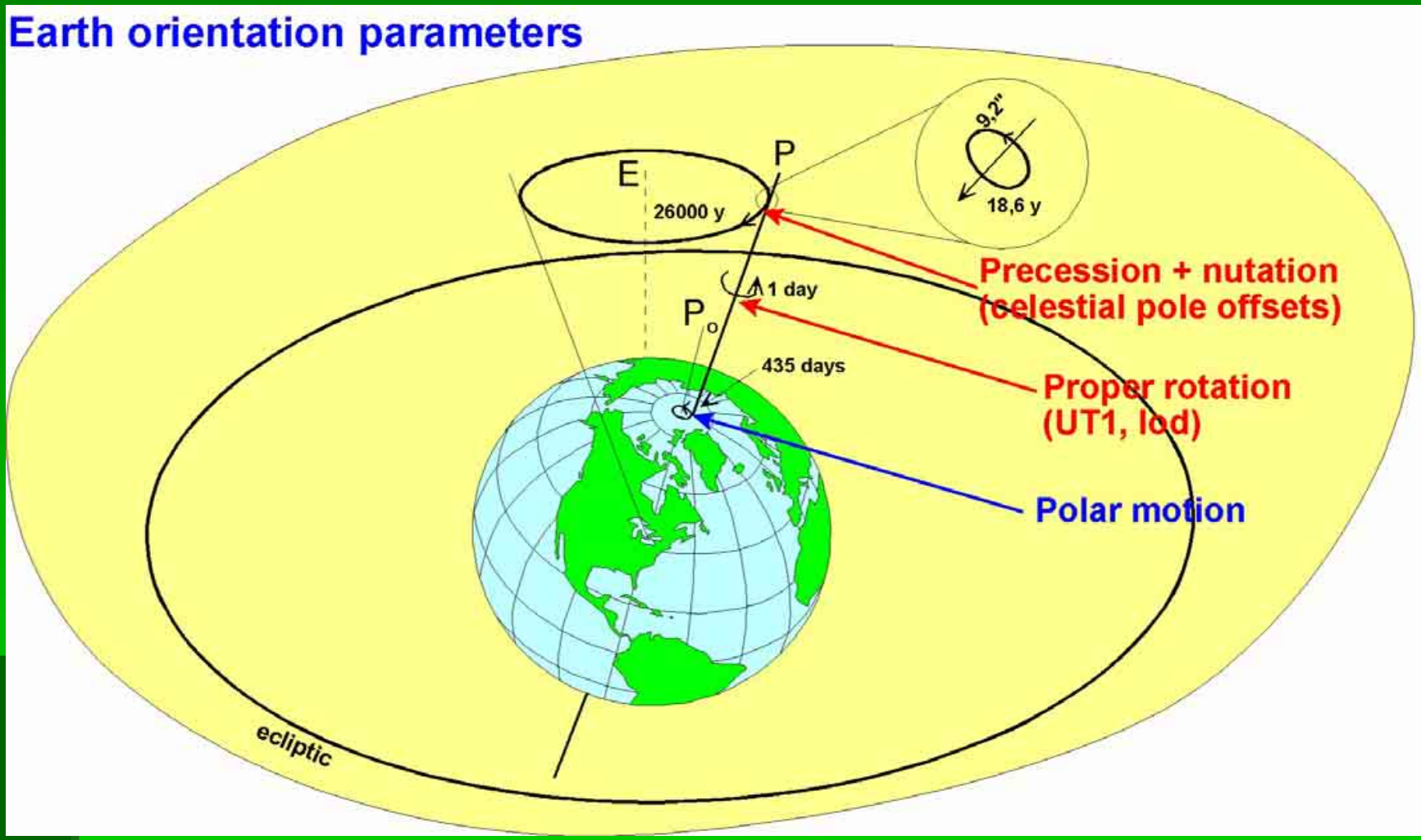
- International Celestial Reference System (ICRS)

▪ ICRS is realized by International Celestial Reference Frame (ICRF) which contains a set of adopted coordinates and uncertainties of extragalactic sources;

- International Terrestrial Reference System (ITRS)

▪ ITRS is realized by International Terrestrial Reference Frame (ITRF) based upon estimated coordinates and velocities of a set of stations observed by VLBI, LLR, GPS, SLR and DORIS;

▪ The systems are related to each other by five Earth Orientation Parameters (EOP), i.e. precession-nutation, polar motion and UT1.


Earth orientation parameters
E
P
26000 y
9,2"
18,6 y
1 day
P_o
435 days
Precession + nutation
(celestial pole offsets)
Proper rotation
(UT1, lod)
Polar motion
ecliptic

Observation techniques:

SLR and LLR:

DORIS:

VLBI:

GPS:

Regular and non-rigorous solution:

- 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 then one techniques;

➢ There are two approaches to combination:
- rigorous combination – combined are original observation equations or results of individual techniques using covariance matrices (not full solved yet);
- non-rigorous combination is much simpler because the covariance matrices are not used;

Method of Kostelecky and Pesek:

- The method is based on combining station position vectors in the celestial reference frame, where they are functions both the EOP and the station coordinates:

$$(*)\ X_C = PNR_z(-GST)R_X(yp)R_Y(xp)X_T.$$

Two types of constraints are necessary:

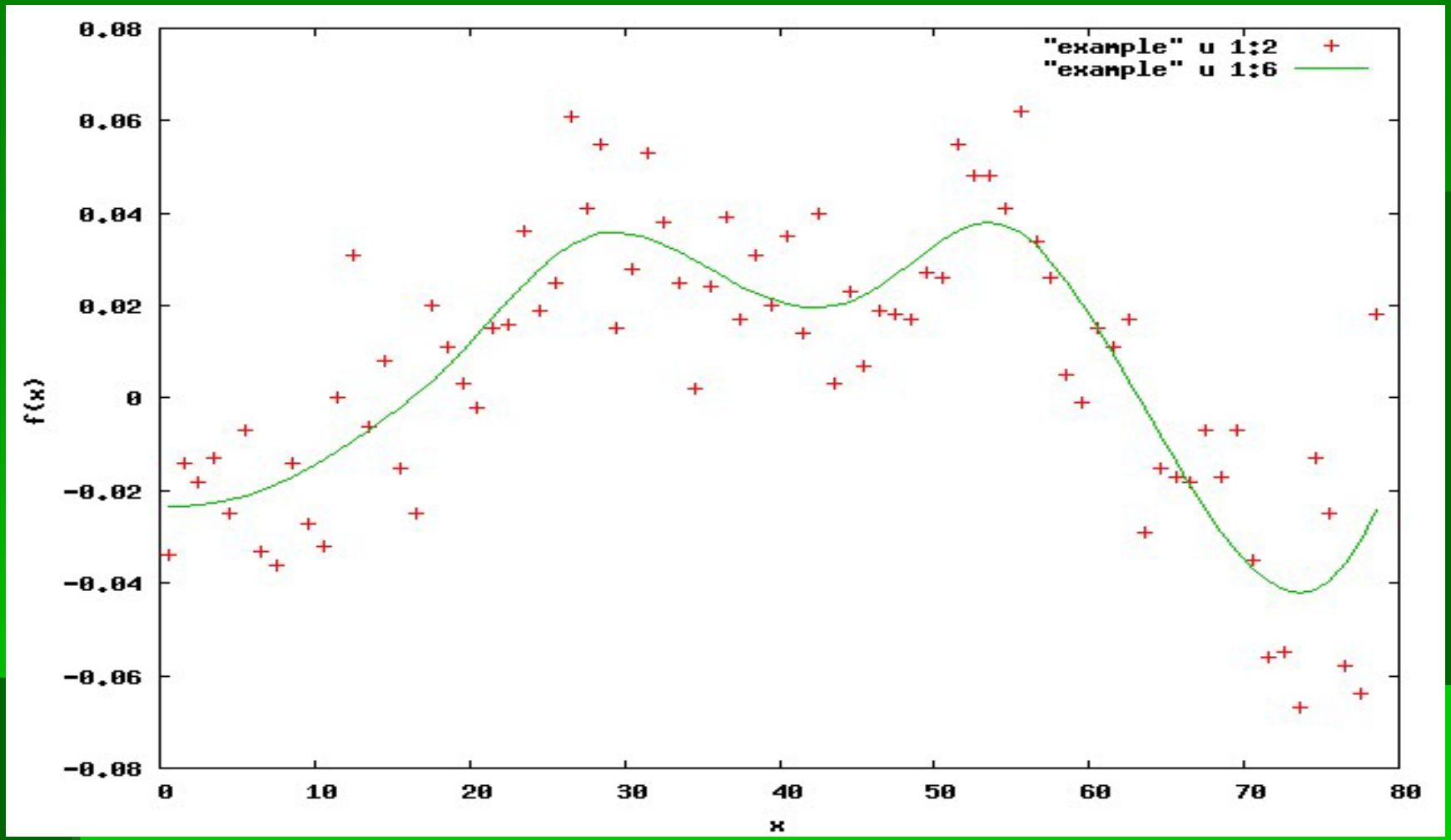
- constraint of "no net rotation" to conserve station coordinate system;
- constraint to tie EOP at the adjacent epochs with simple formula applied in the form of additional observation equations:

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

Vondrak's smoothing:

- The method consists in finding a weighted compromise among two different conditions: smoothness (S) of searched curve and its fidelity (F) to observed function value.
- The compromise is then done by minimizing a combination of the constraints, i.e. the expression $S + \varepsilon F = \min$, in witch ε is coefficient of smoothing.

Example of Vondrak's smoothing (ε = 0.05):



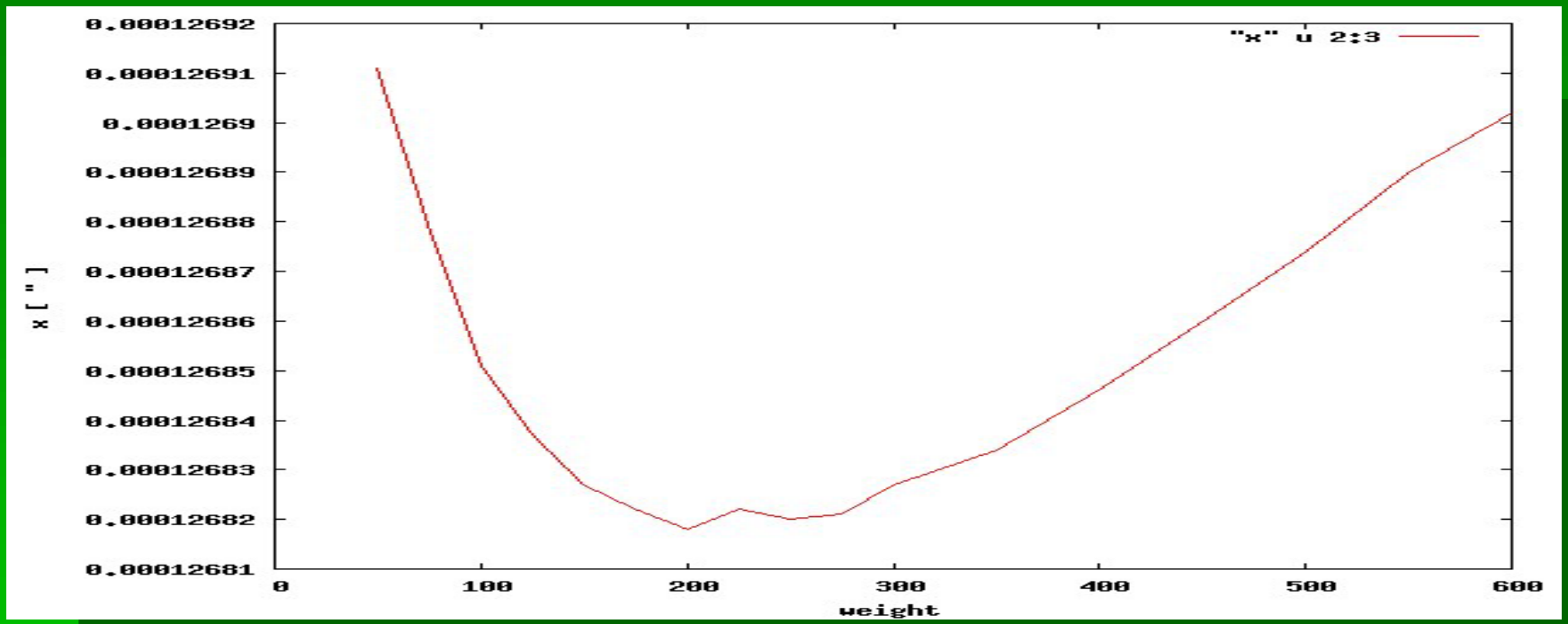
Implementation of the Vondrak's smoothing :

- We used Vondrak's smoothness (S) for condition (**) so that adjacent EOP are more suitably constrained to each other;

- Of course, the fidelity (F) is included by $\sum pvv = \min$ for the whole combination of the EOP and station coordinates.

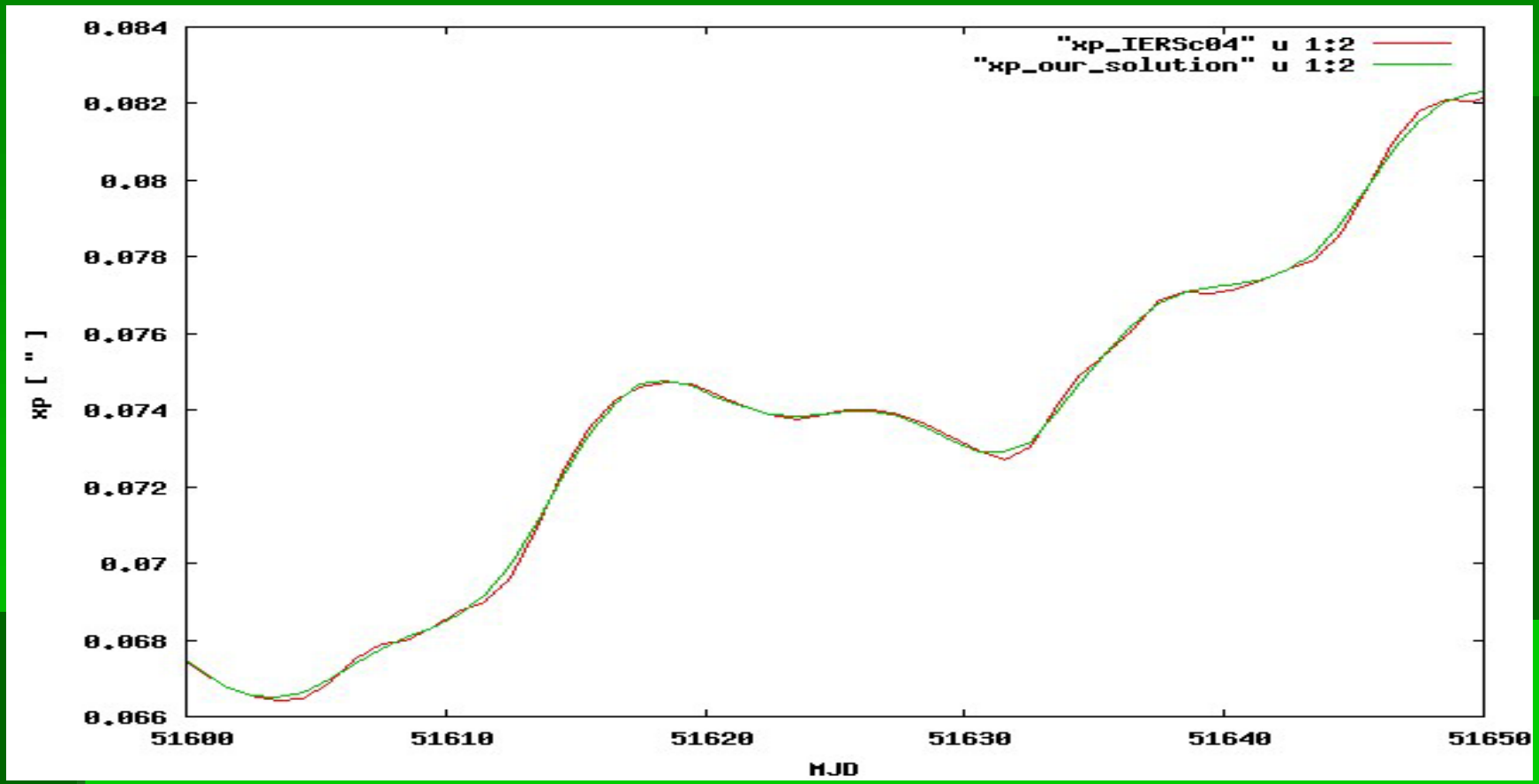
- There is close relation between Vondrak's coefficient of smoothing and our weight used for the constraint.

- Evolution of mean error of differences between our solution of EOP and IERS c04 and weight used for the smoothness:

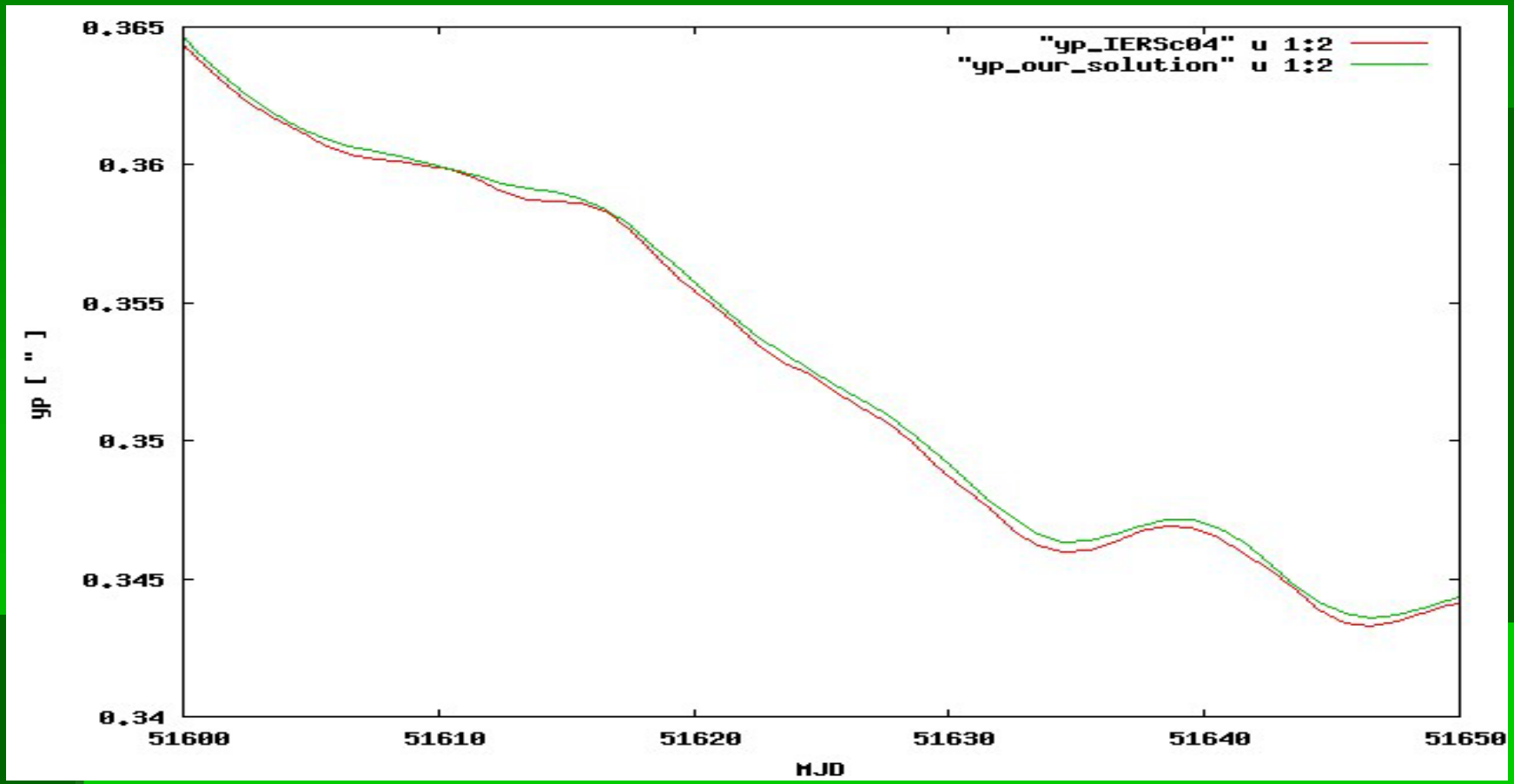


- Greater weight yields smoother solution;
- When compared with the IERS c04 series, best fit is achived for the weight of 200.

Example of one year solution for xp (shown is the period of 50 days) :



Example of one year solution for yp (shown is the period of 50 days) :



Example of one year solution for UT1-UTC (shown is the period of 50 days) :

Conclusions:

- Vondrak's smoothing was implemented to the combination of the EOP and the station coordinates as derived from different techniques;

- With appropriate weights for smoothing, the combined EOP are very close to the IERS c04 series. The rms errors are 0.113 mas, 0.245 mas and 0.0564 ms for xp, yp and UT1-UTC, respectively;

- The presented method could be used as an independent check of the first stages of rigorous combinations.

Thank you for your attention !!!