

# DETERMINATION OF NUTATION OFFSETS BY COMBINING VLBI/GPS-PRODUCED NORMAL EQUATIONS

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**ABSTRACT.** Long standing routine operation of individual geodetic space- and ground-based techniques (like, for instance, VLBI, GNSS, LLR, etc.) revealed their strong and weak aspects. More effective use of these strengths as well as reduction of their weaknesses is possible by incorporating of the information collected by each individual technique into combined products. Such a consistent combination can be performed either by combination at the observational level or at the level of normal equations (NEQ's). We concentrate on the combination of normal equations gathered during VLBI/GPS-data processing. The main goal of this combination is to construct a time series of nutation offsets in the most consistent way. The objective of this presentation is to describe the developed strategy of combination and to present the current status of its implementation and first results. Combination presented here is based on the normal equations stemmed from the processing of VLBI and GPS observations during a continuous VLBI campaign CONT08. Earth orientation parameter determination will, in our procedure, benefit from angle and rate observation for a unique estimation.

## 1. GPS AND VLBI SOLUTIONS

In order to generate both GPS and VLBI normal equations we took observations gathered during campaign CONT08. CALC/SOLVE software (Paris Observatory) is used to produce VLBI solution. GPS observations are processed with Bernese v.5.0 software at the Royal Observatory of Belgium. During the processing of observations site coordinates are constrained to the ITRF2005 values. We used IAU2000A nutation model as a reference for both solutions. Diurnal and semidiurnal variations in the EOP are modeled according to the IERS 2003 conventions. Niell mapping function (MF) have been chosen for the troposphere modeling. There are two main reasons for such a choice: 1. we pre-eliminate troposphere parameters before NEQ solving and thus, this a priori model cannot be changed during the combination process; 2. more modern MF are not implemented into CALC/SOLVE package.

## 2. RIGOROUS COMBINATION OF NUTATION OFFSETS AND RATES (PRELIMINARILY RESULTS)

For a combination of Earth orientation parameters and site coordinates at the level of normal equations (with the primary goal of combining nutation offsets and rates) we used Bernese v.5.0 software [1]. For this purpose an implementation of some additional procedures like calculation of weighting factors and introduction of local ties have been performed. In order to find an appropriate weights for individual data sets we used the procedure described in the work of Thaller, 2008. The obtained re-weighting factors are summarized in Table 1. They are in a good agreement with re-weighting factors obtained in other studies for VLBI/GPS combination performed by means of Bernese software [2],[3]. In this study all available local ties have been taken into consideration (in spite of qualities of individual ties).

Fig. 1 represents the difference between our combined solution and IERS C04 time series. The comparison shows rather good agreement between our combined estimation for polar motion and the values from IERS C04. For the nutation offsets the correspondence is worse probably due to: 1. the systematic errors introduced by GPS orbits missmodeling which are shifting away the nutation rates; 2. nutation values given by IERS C04 are interpolated values and thus do not suit very well for comparison purpose.

	this work		Thaller(2008)		Thaller,Rothacher(2003)	
	GPS	VLBI	GPS	VLBI	GPS	VLBI
data used	daily solutions (CONT08)		daily solutions (CONT02)		1 yr of weekly solutions IERS comb campaign	
weighting factor	$2.5648 * 10^{-5}$	1.0	$3.7636 * 10^{-6}$	1.0	$5.1321 * 10^{-6}$	1.0

Table 1: The comparison of the weighting factors, which have been calculated for this work, with the values used in the work of Thaller [1] and IERS SINEX Combination campaign [2]. Since we use Bernese software to process GPS observations and also for further combination of GPS/VLBI normal equations, we are keeping GPS NEQ's in the Bernese's internal format. In it's internal manipulations, Bernese software multiply GPS-based normal equations with the weighting factor  $\sigma^2 = 10^{-6}$ . Thus, the difference of 5-6 orders in weighting factors for VLBI and GPS Neq matrices is not real.

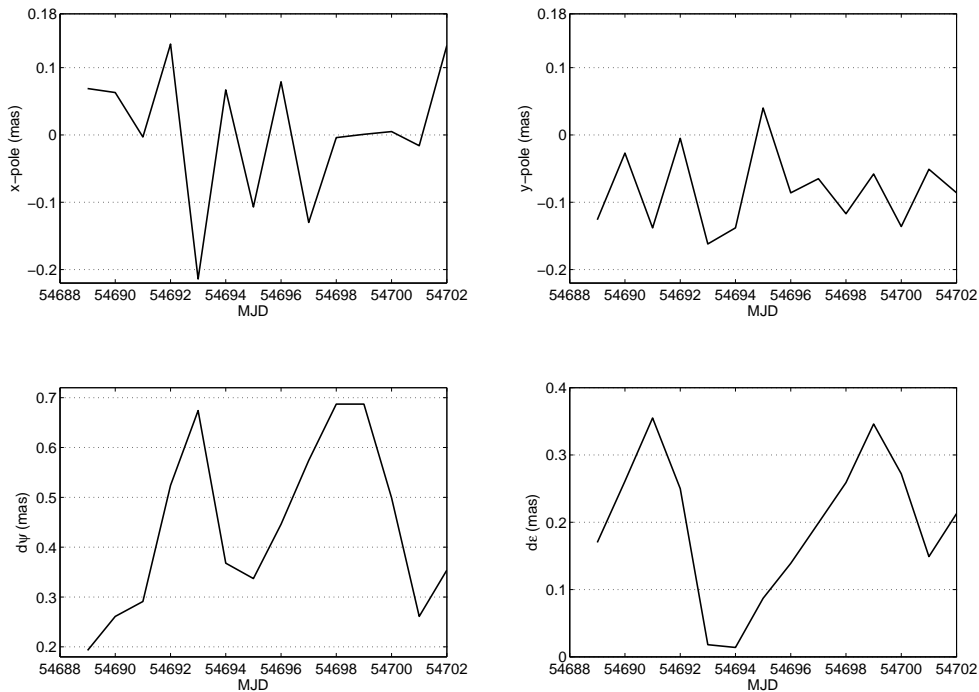


Figure 1: Difference between combined solution and IERS C04 time series. Upper panel: x- and y-pole coordinates (left and right, respectively) over two weeks. The total scales on the two graphs are 0.4 and 0.25 mas for the x- and y-pole coordinates, respectively. Bottom panel: nutation offsets in longitude and obliquity (left and right, respectively) over two weeks. The total scales on the two graphs are 0.4-0.5 mas.

### 3. REFERENCES

- Bernese GPS Software v. 5.0, U.Hugentobler, R. Dach, P.Fridez (eds.), 2007.
- Thaller, D., 2008, "Inter-technique combination based on homogeneous normal equation systems including station coordinates, Earth orientation and troposphere parameters"; Dissertation, Scientific Technical Report STR 08/15, Deutsches GeoForschungsZentrum, ISSN 1610-0956, doi: 10.2312/GFZ.b103-08153.
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