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Investigating High-Frequency Earth Orientation Variations with Continuous Geodetic VLBI Campaigns

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Abstract

The analysis of geodetic VLBI data allows to investigate high-frequency variations in earth orientation and rotation. Results from the three continuous VLBI campaigns CONT94, CONT02 and CONT05 are presented and compared to corresponding model predictions. The remaining residuals do show significant signal strength in the diurnal and semi-diurnal frequency bands. However, these residual signals are not identical for the different CONT campaigns.

1. Introduction

Geodetic VLBI is one of the most important space geodetic techniques for the observation of earth rotation and orientation. The analysis of geodetic VLBI data provides the complete set of earth rotation and orientation parameters. It also allows to investigate high-frequency polar motion and UT1 variations which are caused by geophysical processes. Therefore it promises to contribute to a better understanding of these processes.

2. Theoretical Background

High-frequency variations of earth orientation and rotation are caused by exchange of angular momentum between ocean, atmosphere and solid earth. The theoretical basis for these geophysical variations of earth orientation and rotation is described for example in [1], [2], [3].

During the last decades, a number of models for ocean tidal influences on polar motion and UT1 in the diurnal and sub-diurnal frequency band have been developed, e.g. [4], [5], [6], [7], [8], [9], [10]. The use of an hydrodynamical ocean model [11] allowed to model even ter-diurnal ocean tidal influences on polar motion [12]. Exchange of non-tidal ocean angular momentum is predicted to cause diurnal polar motion and UT1 variations [3]. The influence of atmospheric tides, thermal and gravitational, on polar motion and UT1 is described by [13] [14]. Furthermore, sub-diurnal effects on polar motion due to external luni-solar torques acting on the tri-axial figure of the earth are predicted [15], [16], [17].

3. Observational Results

The data archive of the International VLBI Service for Geodesy and Astrometry (IVS) includes geodetic VLBI observations since the early 80ies of the last century. Most of the sessions are individual 24 hour long sessions that were observed in different global VLBI networks. However, there are also a number of continuous campaigns that were observed during several days with the same global VLBI networks. Examples are the campaigns CONT94, CONT02 and CONT05 that

were observed in 1994, 2002 and 2005, respectively. Due to their continuous and consistent data, these campaigns are of particular interest for the investigation of high-frequency earth orientation and rotation variations [18].

VLBI data analysis with the CALC/SOLVE analysis software [19] allows to estimate polar motion and UT1 as piece-wise linear functions with hourly updates. Figure 1 shows for example the time series of hourly polar motion and UT1 observations determined from the continuous VLBI campaign CONT05. The circles with error bars are hourly values for polar motion and UT1, while the continuous line shows the model predictions according to the Ray-model [6], [7].

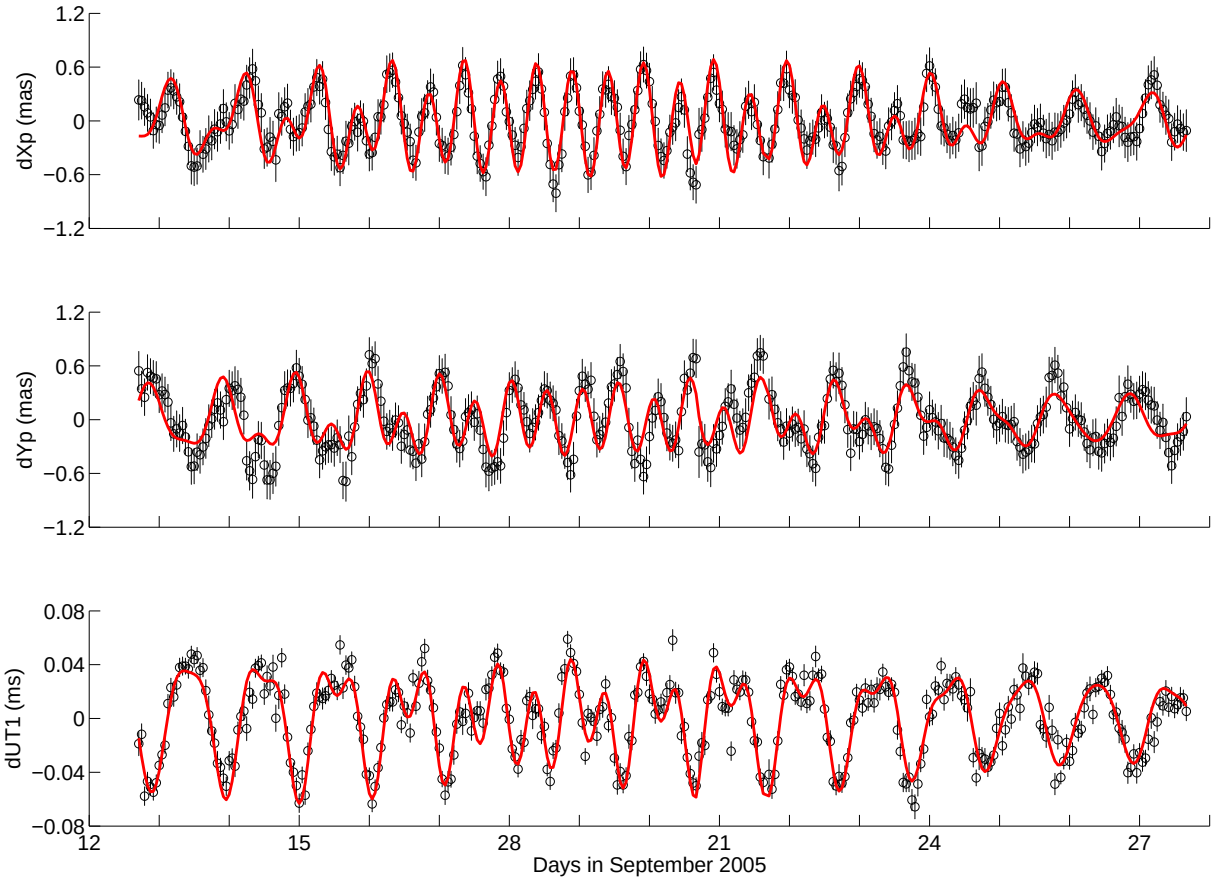

Figure 1. Hourly estimates of polar motion and UT1 from CONT05 VLBI shown as circles with errorbars that indicate the formal errors of the analysis. The continuous thin line shows the corresponding predictions based on the extended version of the Ray-model [6], [7].

Figure 2 shows the amplitude spectra of the residual hourly polar motion and UT1 estimates from CONT94, CONT02 and CONT05 after subtracting the extended Ray-model [6], [7]. Significant residual signals in the diurnal and sub-diurnal frequency bands are clearly visible. However, the amplitude spectra of the three different VLBI campaigns are not identical. In particular the strong signal with 8 hour period in the CONT02 residuals cannot be seen in the CONT94 and CONT05 results. Also the signals in the diurnal and semi-diurnal frequency band do not agree.

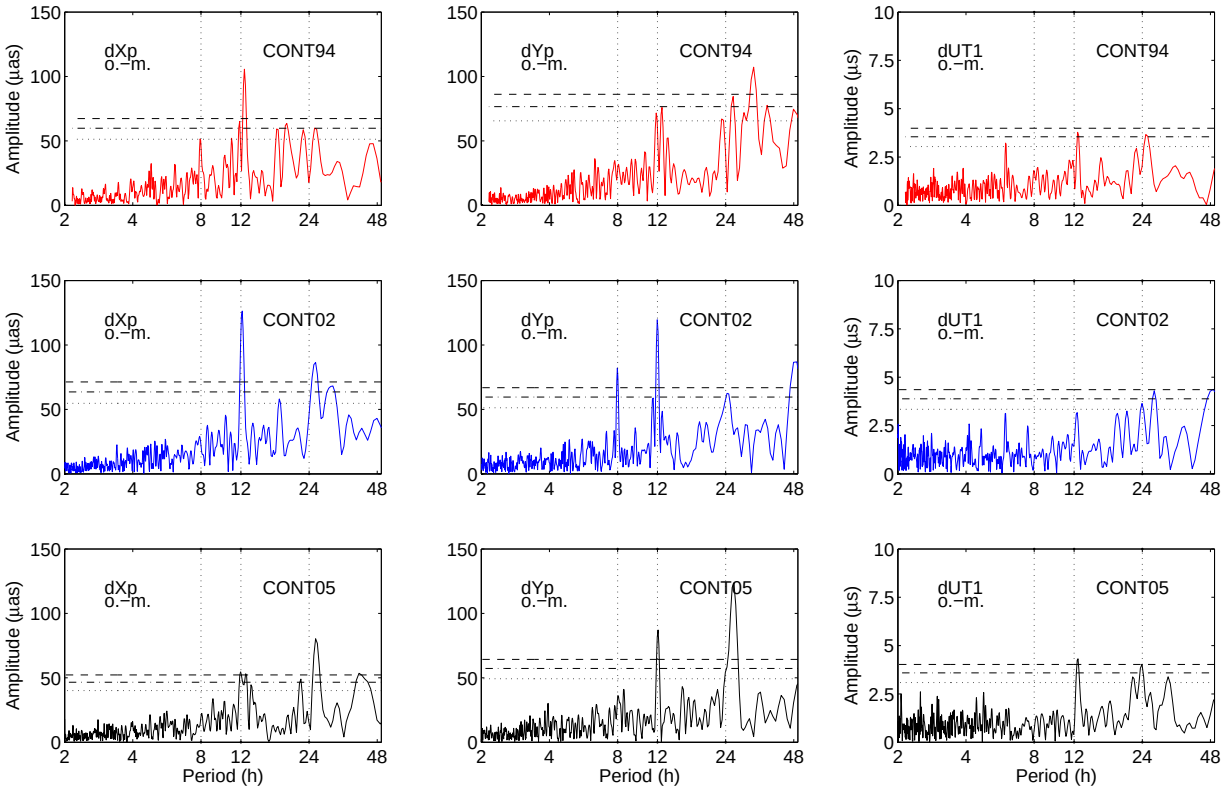

Figure 2. Amplitude spectra of residual hourly polar motion and UT1 estimates for CONT94, CONT02 and CONT05 after subtracting the extended Ray-model [6], [7]. The vertical dotted lines indicate periods of 8, 12 and 24 hours. The horizontal lines indicate the significance levels of 99.5% (dashed), 95% (dashed-dotted) and 50% (dotted).

4. Discussion and Outlook

The continuous VLBI campaigns can be used to investigate high-frequency earth orientation and rotation variations. To a large extent the empirical results can be explained by ocean tidal influences. However, the remaining residual signals after subtracting the model predictions do not show the same results for the three different continuous campaigns. In particular a polar motion signal with 8 hour period that was reported from the CONT02 data set [20] cannot be confirmed from the analysis of the CONT94 and CONT05 data. The remaining signals in the diurnal and semi-diurnal frequency range do not agree either among the three continuous campaigns. The reason for these discrepancies is so far not understood. More effort is needed to investigate this problem and future continous VLBI campaigns will support this work.

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