SHORT PERIODIC OSCILLATIONS IN GPS POLE COORDINATES DATA

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ABSTRACT. The 3.5 day oscillation has been found in GPS x, y pole coordinates data determined by different processing centers in July 1992 - March 1993 using the Band Pass Filter Spectral Analysis and the Ormsby band pass filter.

1. Introduction

Earth rotation parameters have recently been obtained from networks observing Global Positioning System (GPS) satellites (Herring et al., 1991; Lichten et al., 1992). Analyses of GPS data of pole positions indicate about 0.5 mas agreement with the VLBI estimates (Lindqwister et al., 1992). The GPS results are obtained usually from one day observations of 16-18 satellites in a network of different number of stations ranging from 10 to about 30. The analysis of 17-60 days common time intervals between the pairs of series of x, y pole coordinates during the SEARCH 92' Campaign found no significant correlation between them (IGS'92 Campaign third report, 1992).

2. Analysis of GPS pole coordinates data

The pole coordinates series from the following centers and data intervals have been used in order to analyze the short periodic oscillations from 2 to about 15 days in pole coordinates data:

BERNE (University of Berne (AIUB)) 48792.5-49042.5
EMR (Energy Mines and Resources, Canada) 48838.5-49038.5
ESOC (European Space Operations Center) 48794.5-49038.5
GFZ (GeoForschungsZentrum, Potsdam) 48795.0-48925.5
JPL (Jet Propulsion Laboratory, Pasadena) 48794.5-49024.5
SCRIPPS (Scripps Institute (UCSD)) 48780.5-49038.5
UTX (University of Texas at Austin) 48794.5-48870.5
COMBIN (U.S. Naval Observatory, Washington D.C.) 48781.0-49042.0

The sampling interval of all these data is equal to 1 day except the GFZ solution in which there is a 1.5 day gap in the middle of data and some gaps noticed in the UTX, EMR and ESOC solutions. All the data were interpolated at 1 day time intervals using the first order linear interpolation.

Next, long periodic and the Chandler and annual oscillations were removed by computation of the second difference by the following formula:

$$\Delta^2 x_{j,k} = x_{j+2,k} - 2x_{j+1,k} + x_{j,k}, \tag{1}$$

where $x_{j,k}$ are data points of kth solution interpolated at the moments of $t_m = 48792.5 + \Delta t(m-1)$, Δt is the sampling interval.

This second difference is the high pass filter enlarges amplitudes of high frequency oscillations ranging from $\frac{1}{2\pi\Delta t}$ to $\frac{1}{2\Delta t}$. The band pass filter spectral analysis (BPFSA) (Kosek, 1991) has been applied in order to compute spectrum estimations by the following formula:

$$\hat{S}(\lambda_o) = \frac{1}{N(k)-2L+1} \sum_{j=1}^{N(k)-2L+1} [\sum_{l=-L}^{L} \Delta^2 x_{j+l,k} h_l(\lambda_o)]^2 \tag{2}$$

where $\frac{\Delta t}{15days} < \lambda_o < \frac{\Delta t}{2days}$, $N(k)$ is the number of interpolated data of kth solution, L is the length of the Ormsby band pass filter with the impulse response given by the following formula:

$$h_l(\lambda_o) = \frac{2sin(\pi l\lambda)cos(2\pi\lambda_o)sin(2\pi\beta)}{\lambda(\pi l)^2} \tag{3}$$

where λ is the transition band, β is the half of the sum of the pass band and the transition band, $\lambda_o = \frac{\Delta t}{T_o}$ is the normalized frequency, for which the oscillation with period T_o is computed.

The spectra $\hat{S}(\lambda_o)$ have been computed assuming $\lambda = 0.03$, $\beta = 0.03$ and $L = 50$. In these spectra (Fig. 1) two main peaks correspond to about 2.4 and 3.5 days oscillations except the spectrum of the COMBIN solution where the power corresponds to the lower frequency oscillations. The COMBIN solution does not represent the solutions determined by different processing centers in the case of short periodic oscillations. The weighted mean which enables to transfer all frequency information to the output has been computed by the following formula:

$$\hat{x}_m = \frac{\sum_{k=1}^{M} x_{j,k} p_{j,k}}{\sum_{k=1}^{M} p_{j,k}} \quad for \quad j = 1, 2, ..., N(k) \tag{4}$$

where $M = 7$ is the number of solutions and the weight of such interpolated point is assumed:

$$p_{j,k} = \frac{t_{i+1,k} - t_{i,k}}{\hat{\sigma}^2_{x_{i,k}}(t_{i+1,k} - t_m) + \hat{\sigma}^2_{x_{i+1,k}}(t_m - t_{i,k})} \tag{5}$$

where $t_{i,k}$ is the MJD of data $x_{i,k}$.

Usually all these data are equidistant, so $t_m = t_{i,k}$ and the weight of the point is expressed by $p_{j,k} = 1/\hat{\sigma}^2_{x_{i,k}}$ where $\hat{\sigma}^2_{x_{i,k}}$ is the RMS of the ith point in the kth solution.

The spectrum of the second difference of such weighted data has the peaks corresponding to around 2.5 and 3.5-4.0 day oscillations and looks very similar to the spectra of solutions from different processing centers (Fig. 1).

3. Model data analysis

The spectra of x, y pole coordinate second differences computed by the BPFSA do not have the confidence intervals for their values and its difficult to say whether detected peaks are real or not. In order to check the reality of detected peaks in x, y pole coordinates the BPFSA spectra have been also computed for the model data of 260 data points sampled at 1 day intervals. This model consists of the Chandler oscillation with the amplitude of 200 mas, the annual oscillation with the amplitude of 100 mas and the white noise with standard deviation of 1 mas. The spectra computed for the second difference of such 4 different model data increase their power almost monotonically toward higher frequencies and show no significant power around 3.5 day oscillation (Fig. 2).

4. The 3.5 days oscillation determined by the Ormsby filter

Next, the Ormsby band pass filter has been applied in order to compute the 3.5 day oscillation in the second difference of pole coordinates. The parameters of the Ormsby band pass filter are the same as for the spectrum computation except the filter length, which was reduced to $L = 30$. The amplitude of the output was multiplied by the factor of $-(\frac{3.5days}{2\pi\Delta t})^2$ in order to convert it to the amplitude of data. In the case of x, y pole coordinates of BERNE. SCRIPPS, and JPL there is some agreement in phase and in some sense in the amplitude of 3.5 day oscillations (Fig. 3). This amplitude is variable and of the order of 0.3 mas.

5. Conclusions

The COMBIN solution computed from 7 GPS pole coordinates does not contain information about short periodic oscillations from 2 to about 15 days.

The Ormsby band pass filter spectra of second differences of GPS x, y pole coordinates have the common peaks corresponding to 3.5 and about 2.5 days oscillations. There is some phase and amplitude agreement of the 3.5 days oscillations in the case of BERNE, SCRIPPS and JPL solutions.

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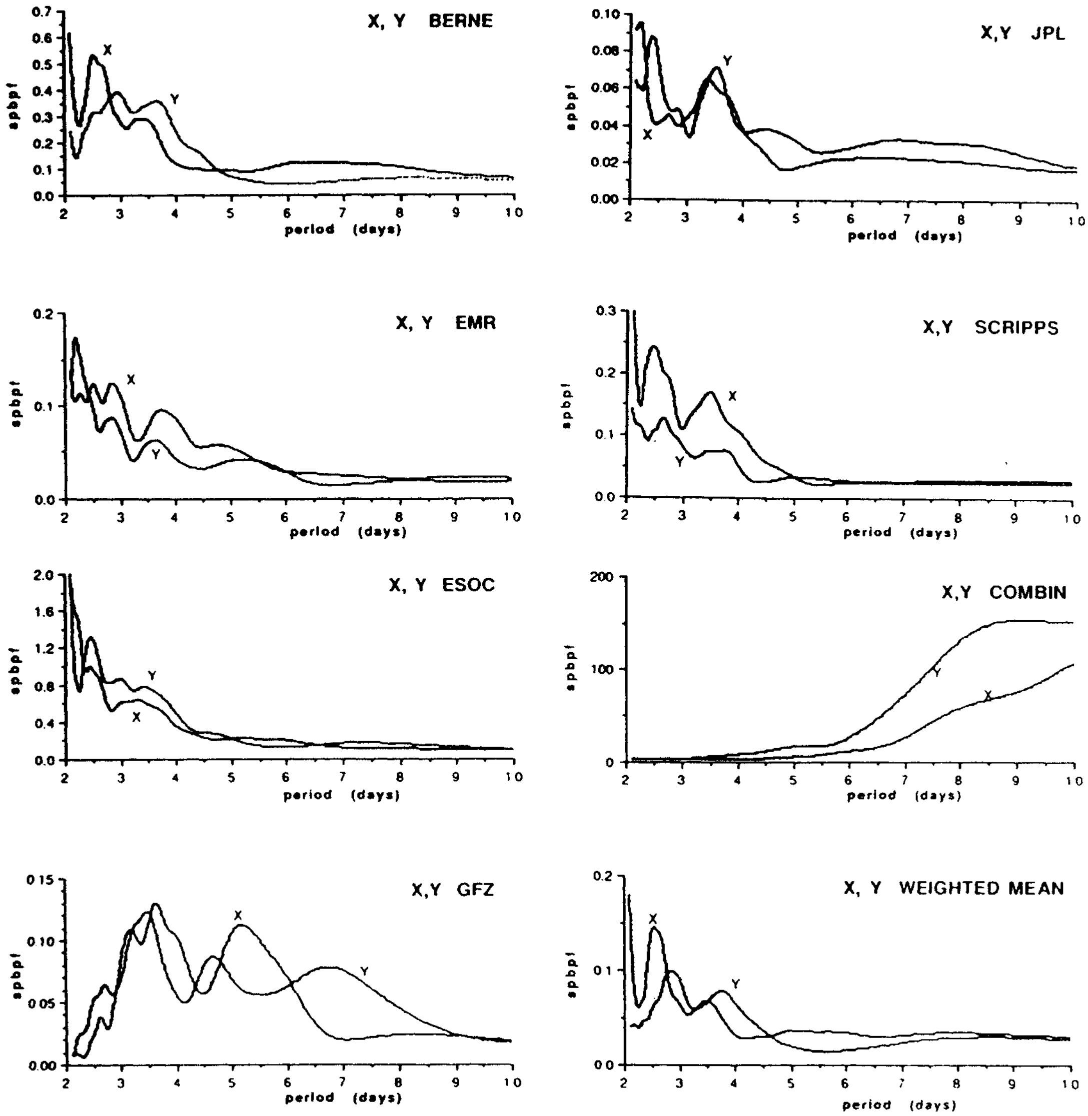


Fig. 1. The BPFSA spectra of the second difference of pole coordinates determined by different processing centers.

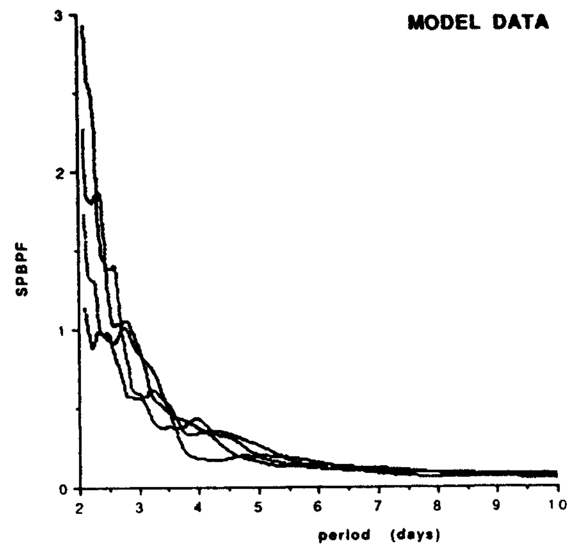
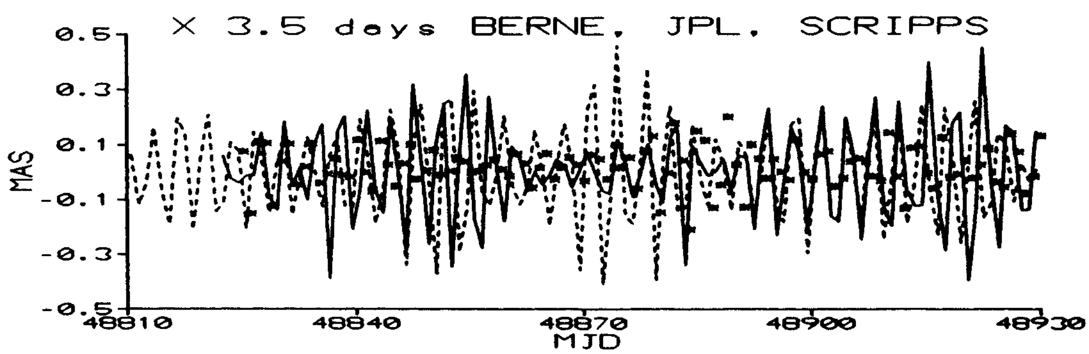


Fig. 2. The BPFSA spectra of the second difference of 4 model data.



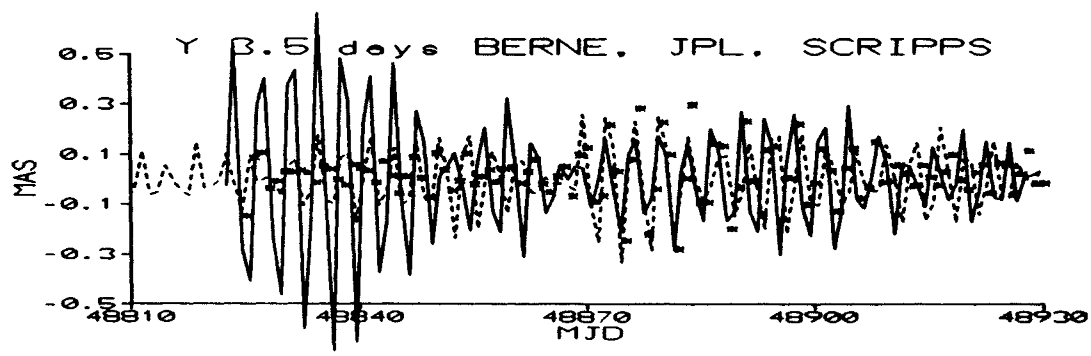


Fig. 3. 3.5 day oscillation computed by the Ormsby band pass filter in x,y pole coordinates determined by BERNE (thin line), JPL (stars), SCRIPPS (dotted line).