Oleg Titov: Spectral Analysis of the Baseline Length Time Series from VLBI Data, IVS 2002 General Meeting Proceedings, p.315–319
http://ivscc.gsfc.nasa.gov/publications/gm2002/titov

Spectral Analysis of the Baseline Length Time Series from VLBI Data

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Abstract

In addition to a linear trend VLBI baseline lengths demonstrate seasonal variations. Spectral and wavelet analysis of the baseline time series having the longest history show that annual and semiannual variations are present at these frequencies. It appears that the baseline length variations arise from instability in the vertical component of one or both VLBI sites.

1. Introduction

In accordance with the conventional model of tectonic plate motion NNR-NUVEL1 the variations of baseline lengths should be fitted by a linear approximation [1]. But at the beginning of the 90s scientists found a seasonal signature in a few baselines time series [2]. Later, the various deviations from linear dependence were described by Zarraoa [3]. The problem becomes complicated due to the fact that the detected seasonal variations can be affected by incorrect modeling of other natural effects. For example, Niell [4] showed that the seasonal variations into both horizontal and vertical components arise from incompleteness of mapping function simulation.

Important results on seasonal variations of the Earth's surface were published in papers about atmospheric pressure loading effect on VLBI station components displacement [5,6,7,8]. In spite of different approaches for modelling, the authors obtained similar estimates for vertical components annual shift (1-2 cm).

Scientists are used to paying more attention to high-frequency (2 weeks) variations of atmospheric pressure and VLBI site position components rather than to seasonal effects [9,10]. Additionally, Manabe et al., [7] and vanDam et al., [9] have studied the presence of an annual signal.

Titov et al., [11] have made a spectral analysis of baseline length time series from GSFC global solution published in 1995 [12]. They obtained evidence of annual and semiannual signals in the variations of the time series. It was demonstrated that variations of vertical components are responsible for changes in baselines.

In the last few years much new evidence for the presence of seasonal signals in geodetic time series have been collected. For example, Becker et al., [13] detected a seasonal signal for the Wettzell site vertical component from GPS time series. The signal has an amplitude about 4 mm. New results on seasonal variations of VLBI baseline lengths are presented this paper. The research has been made using NASA GSFC terrestrial reference frame solution 2001, July 2001 [14].

2. Results

Fig.1-3 demonstrate the results of WETTZELL - GILCREEK spectral and wavelet analysis. The spectrum in fig.1 has at least three significant signals - 0.5 year, 1 year and about 1.2 year

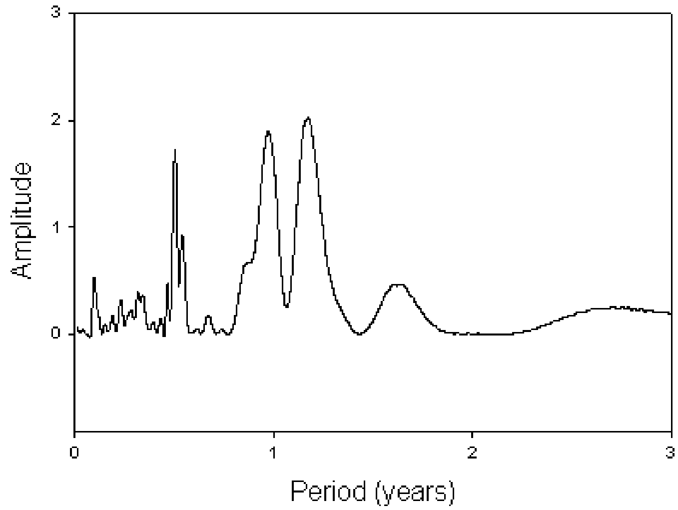

Figure 1. Spectrum of WETTZELL - GILCREEK baseline length time series. Significant semiannual, annual signals as well as signal with period about 1.2 year are visible.

which is close to the period of the Chandler wobble.

Detailed analysis showed that the periods and amplitudes of the signals are not constant, so it is impossible to use conventional procedures like least squares method for estimation of the parameters of the signals. Temporal behavior of the seasonal variations can be studied using wavelets. The method allows investigation of temporal variations of the periods and amplitudes if the signal is claimed as a process with variable parameters. To study unevenly spaced time series the special software by Foster [15] has been applied.

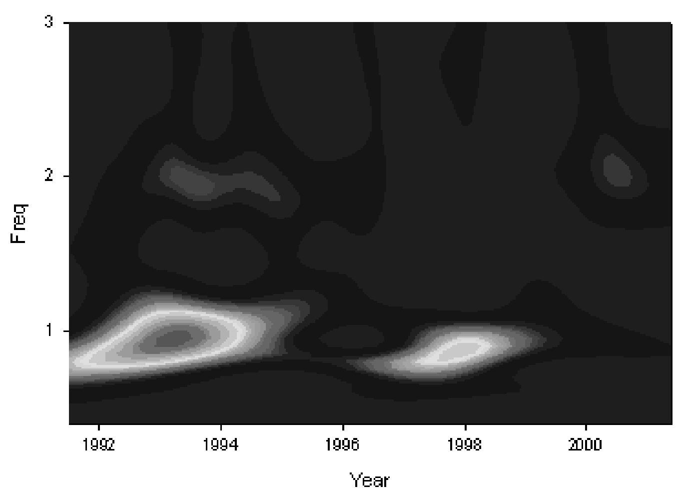

Figure 2. Wavelet of WETTZELL - GILCREEK baseline length variations (parameter 0.0125). Note increase in power near years 1993 and 1998.

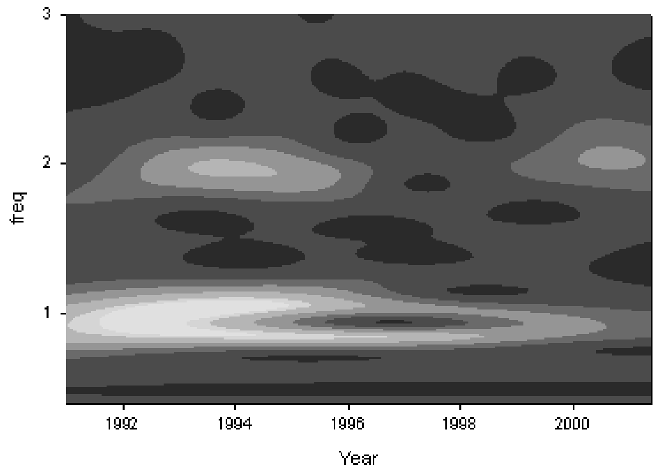

Figure 3. Wavelet of WETTZELL - GILCREEK baseline length variations (parameter 0.0030). The power is expanded across time interval, but now three signals are recognized (see fig.1).

In the wavelet technique a special parameter drives resolution in the time and frequency domains. The parameter 0.0125 provides an approximately equal resolution in both domains. Increasing the parameter results in increasing the resolution in time domain and decreasing in frequency domain. Decreasing the parameter has an opposite effect.

Results of the wavelet application to variations of baseline length WETTZELL - GILCREEK are shown on fig.2-3. In fig.2 the wide annual signal has maximum power near years 1993 and 1998. The semiannual signal has the only peak near year 1993. In fig.3 due to better resolution in the frequency domain the annual signal has been separated into two – properly annual signal and signal with period about 1.2 year. As to semiannual signal there are two wide maximums: in years 1993-1995 and in years 2000-2001.

Fig.4 demonstrates a spectrum of WETTZELL - WESTFORD baseline length variations between 1988 and 2001. Only an annual signal has been detected. Wavelets of the baseline length time series are shown in fig.5. The annual component in the baseline WETTZELL - WESTFORD has been fitted using least squares method to evaluate a range of seasonal signals (in spite of the variability of period). The estimate of the annual signal amplitude is 4.5 +/- 0.7 mm.

Similar estimation for baseline WETTZELL - GILCREEK (under assumption of constant periods and amplitudes) produced the following values: for period 0.5 year - 2.4 +/- 0.7 mm, for period 1 year - 1.7 +/- 0.7 mm, for period 1.2 year - 2.1 +/- 0.7 mm. It is obvious that for the period of maximum power the amplitudes are increasing and can reach a level of 4-5 mm.

3. Conclusion

Semiannual and annual signals have been found in spectra of baseline length time series. Additionally, a signal with period about 1.2 year has been found in the spectrum of baseline WETTZELL - GILCREEK. Meantime, detailed analysis of the time series using wavelets disclosed irregular behavior of the signals. Evaluation of the seasonal components under assumption of stability of the signals produced average estimates of the amplitude for all three components about 2.0 +/- 0.7

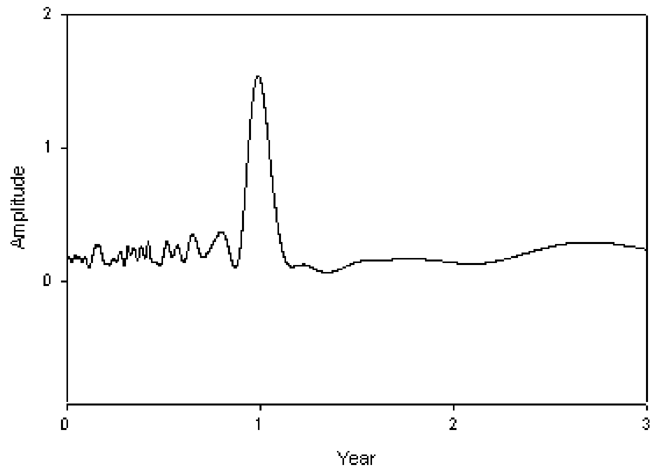

Figure 4. Spectrum of WETTZELL - WESTFORD baseline length variations has only one signal with period about 1 year.

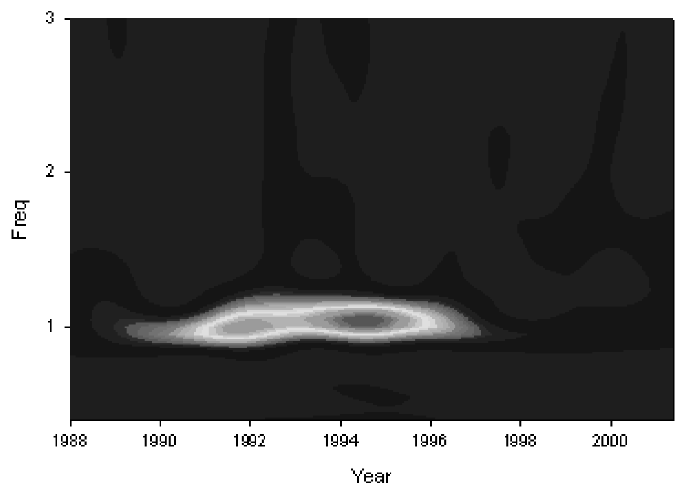

Figure 5. Wavelet of WETTZELL - WESTFORD baseline length variations (parameter 0.0125). The only annual signal has a maximum of power between years 1990 and 1997.

mm for baseline WETTZELL - GILCREEK and 4.5 +/- 0.7 mm for annual signal for baseline WETTZELL - WESTFORD.

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