DETECTION OF THE 531-DAY-PERIOD WOBBLE FROM THE POLAR MOTION TIME SERIES

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ABSTRACT. After Cater (1981, 1982) weakly detected a 530-day-period wobble (531dW) in the polar motion, only few studies were addressed to the observations of this wobble. In this report, based the EOP C04 polar motion time series by using the ensemble empirical mode decomposition method, the 531dW of the polar motion was clearly observed. Here, we present main results, and the details can be found in Ding & Shen (2014). Key words: Polar motion time series; EEMD; 531-day-period wobble.

1. INTRODUCTION

Due to the frequency modulation, the Chandler wobble (CW) has respectively periods 1 cpy (cycles per year) and 0.69 cpy when the beat frequency is 0.157 cpy (Carter 1981, 1982). Based on a 16-year time series of International Polar Motion Data, a 0.686 cpy component with its amplitude being around 10 to 17 mas (milliarcsecond) was weakly detected (Carter (1982). Morgan et al. (1982) found two spectral peaks at 532±10.8 days and 537±15.2 days, with their amplitudes around 8.6±2.0 mas and 7.4±2.2 mas, respectively. After confirming that a 500-day period component exists in the polar motion data with amplitude of 20 mas, Na et al. (2011) suggested that this phenomenon should be caused by resonance of an oscillating mode of the Earth. C. Bizouard (2013 personal communication) investigated this 530-day-period wobble without details released. This wobble (or referred to as an 18-month wobble) was also found in the analysis of the atmospheric angular momentum data by Wahr (1983) and Chen et al. (2010). In this report, using ensemble empirical mode decomposition (EEMD) as a filter, we demonstrated that the amplitude of the 531dW is about 40 mas (mean value). In another aspect, applying the frequency modulation of CW with a modulation index M=0.5 it was shown that there exists a 531dW signal with an amplitude of about 33 mas, but it has an opposite phase with the former. Hence, when the amplitude difference between them is below the background noise level, the 531dW could not be observed by conventional approach; otherwise it can be observed. In the sequel we present the main results. The details are referred to Ding & Shen (2014).

2. METHOD AND RESULTS

The EEMD (Huang & Wu 2008) is suitable for analyzing nonlinear and non-stationary time series (Wu & Huang 2009; Shen & Ding 2013). We chose the EOP C04 series (spanning from 1962 to 2013) to search for the target signals. In order to compare with the results of Carter (1981), we divided the series into three sub-series without overlap: 1962-1977 (16 yr), 1978-1994 (17 yr), and 1995-2013 (18.6 yr) series. For the 1962-1977 series, the data length is as same as that of Carter (1981), hence, we re-estimated the frequency and amplitude of the 531dW.

Based on the Fourier analysis, the target peak appeared only in the spectra of the 1962-1977 series, which is over their corresponding background noise level. This result is consistent with previous studies. The estimate values are listed in Table 1. For the x- and y-components of the 1962-1977 series, the corresponding amplitudes are 11.3 mas and 14.6 mas, while the estimates of both Carter (1981) and Morgan et al. (1982) are about 8 mas.

Carter (1981, 1982) considered that the modulation index M of the CW could be 0.23 or 0.38, where the modulation index M is defined as

$$e_t(x, y) = C_c \sin[\phi_0 + 2\pi f_c t + M. \sin(2\pi f_m t)] \quad (1)$$

		Target Wobble		Chandler Wobble		Annual Wobble	
		Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
1962-1977	x-Component	0.68751±3.2e-4	11.3±4.6	0.84381±2.4e-4	129.2±3.3	1.00023±2.6e-4	97.1±4.1
	y-Component	0.68753±3.4e-4	14.6±4.8	0.84383±2.7e-4	129.2±3.2	1.00028±3.1e-4	90.8±3.9
1978-1994	x-Component	–	–	0.84312±1.7e-4	180.1±2.1	1.00031±2.4e-4	90.6±3.4
	y-Component	–	–	0.84314±1.8e-4	180.1±2.2	1.00029±2.7e-4	84.1±3.5
1995-2013	x-Component	–	–	0.83892±2.5e-4	128.0±3.4	1.00030±3.6e-4	100.8±4.5
	y-Component	–	–	0.83893±2.4e-4	128.2±3.2	1.00027±3.8e-4	91.8±5.1

Table 1: The observed frequencies (cpy) and amplitudes (mas) of the CW, Annual wobble and the target wobble.

where $e_t(x, y)$ is the expected value of the x-component or x-component, f_m the frequency of the modulating signal, set as 0.157 cpy; f_c and C_c are the frequency and amplitude of the CW, and M is the modulation index, defined as $M = \dfrac{\Delta f}{f_m}$, where Δf is the maximum variation of f_m; Φ_0 is the starting phase, set as zero. However, our synthetic tests show that $M = 0.23$ and 0.38 cannot explain the results for the 1977-1994 and 1995-2013 series. Based on the results after using EEMD, when M=0.5, the results of synthetic tests are consistent with the observations of the three polar motion series. Here we only provide a simple explain, with the x-components of the 1962-1977 series being chosen; more details can be found in Ding & Shen (2014). Figure 1 shows the amplitudes of the IMF5 and IMF6 after using EEMD, where IMFs denote the intrinsic mode functions which compose the original data series; and Figure 2 shows the amplitude spectra of the synthetic series without using EEMD, and the modulation index M=0.5. The amplitude of the 531dW in the synthesis is 33.36 mas (Figure 2b), whereas the corresponding results of IMF 6 are 33.2. When M=0.5, the results from the frequency modulation of CW are consistent with the corresponding results from IMF6 very well.

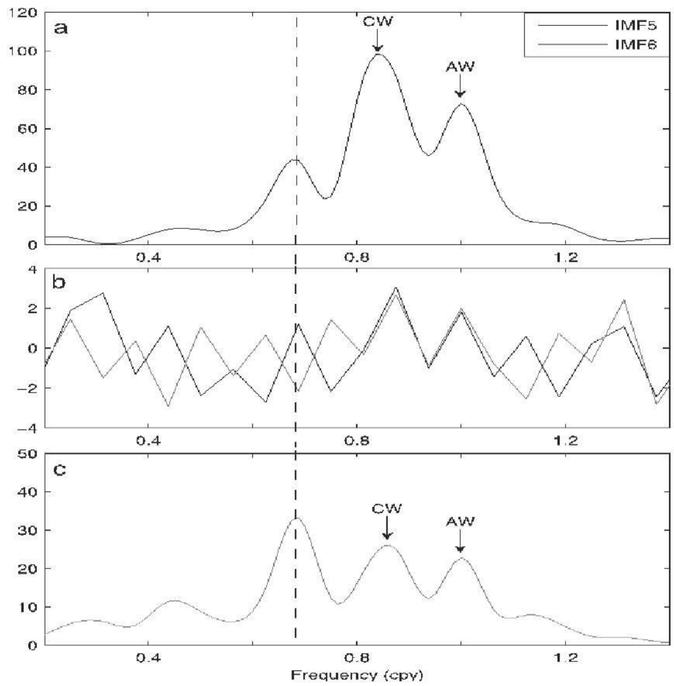

Figure 1: The amplitudes and phase spectra (middle slots) of the IMF 5 (top slots) and IMF 6 (bottom slots) of the x-components of the 1962-1977 series. CW and AW denote Chandler wobble and annual wobble respectively.

We considered that the 531dW in IMF5 might be caused by the atmospheric/oceanic excitation according to the results of Wahr (1983) and Chen et al. (2010) (some other excitations may also exist), whereas the 531dW in IMF6 might be caused by the frequency modulation of CW with a modulation index M=0.5; they have different phases. The relevant details are referred to Ding & Shen (2014).

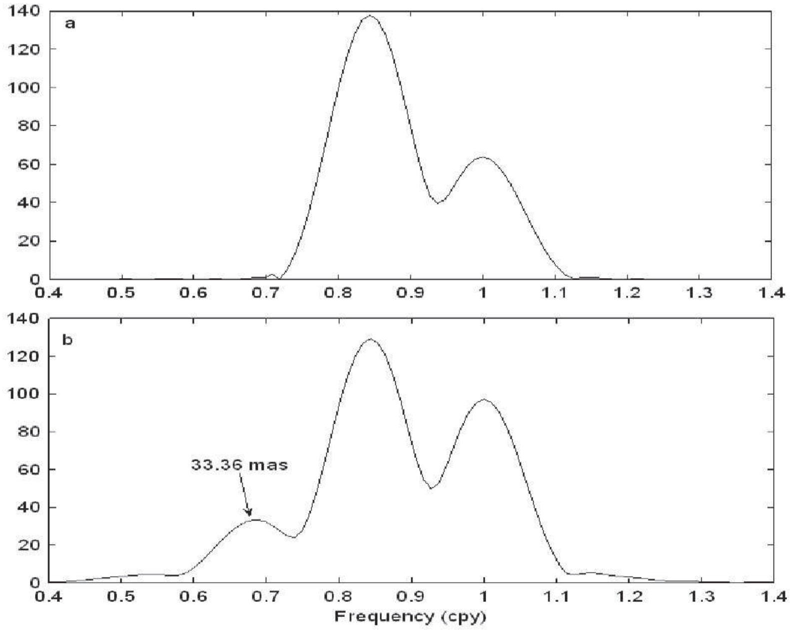

Figure 2: The amplitude spectra of the synthetic series for the x-component of the 1962-1977 series without using EEMD. (a) no frequency modulation; the input amplitudes of the Chandler wobble (CW) and annual wobble (AW) can make the corresponding amplitudes after considering frequency modulation of CW be equal to the observations. (b) The modulation index M=0.5.

3. DISCUSSION

As a suggestion, we consider that the 531dW is composed by two parts: one might be excited by the atmospheric/oceanic angular momentum and other by frequency modulation. Although our observed results can be appropriately explained by the suggested mechanism and the synthetic results, further confirmations are needed because until now the 531dW signal was poorly studied.

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