Hypotheses on the absence of Chandler wobble since 2015

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Yamaguchi and Furuya (2022) pointed out that the Chandler wobble (CW) was missing after 2015; they demonstrated the anomaly from both the optimization of the Chandler period in the excitation domain (Wilson and Vicente, 1990) and the modeling of the absence of the 6-year beat in polar motion data, suggesting that the anomaly initiated around 2005. Incidentally, Chen et al. (2013) pointed out a change in the direction of polar drift around 2005 and attributed it to the rapid melting of the Greenland ice sheet due to global warming. Because the annual wobble does not change its phase by definition and its amplitude variation is insignificant, we can trace the CW amplitude back to the 1900s by removing the annual wobble derived by fitting the post-2015 polar motion data. Then the CW amplitude turned out to be almost zero in the post-2015 polar motion data, whereas we could confirm that the CW amplitude was variable over time and took the smallest but non-zero values in the 1920s. We thus regard the post-2015 anomaly as the first-time observation in history since the 1890s.

Meanwhile, based on a series of synthetic numerical experiments to generate CW on the assumption of Gaussian random noise, Chao and Chung (2012) demonstrated that the amplitude and phase of CW would be time-variable and concluded that the minimal amplitude of CW in the 1920s ".. was simply fortuitous by chance". Therefore, we may also consider the post-2015 anomaly caused by rare chances following the random excitation model. We will, however, propose another excitation model below.

It is now widely accepted that atmospheric and oceanic angular momentum (AAM and OAM) changes around the equatorial axes are responsible for the CW excitation (e.g., Gross 2000). However, it is still an open question if the CW excitations by AAM/OAM (and possibly others) are random or resonant. In contrast, numerous previous studies on CW excitations have explicitly or implicitly assumed a random noise excitation. Here, we would like to recall several earlier studies that conflict with the random excitation model, which we consider could reasonably explain the post-2015 CW anomaly. Moreover, we speculate on the possible source(s) of the post-2015 CW anomaly and discuss our future directions.

The absence of CW for several years indicates that the spectral power in the excitation around the Chandler frequency became much smaller than previously, regardless of either a random or resonant excitation model. The random excitation model will regard the smallest power level caused by coincidence (Chao and Chung, 2012). On the other hand, the resonant excitation model will indicate a sudden termination of continual excitation processes within a narrow band around the Chandler frequency. Furuya et al (1996 JGR-SE, 1997 JPE) have shown that the wind term of the AAM derived from JMA's analysis data has a narrow band spectral power to account for the CW. H-P Plag (1997, Lecture Notes in Earth Science) also asserted the resonant excitation model. Aoyama et al (2003, EPS) further confirmed the narrow-band power in the wind term, using ECMWF's analysis data. Unfortunately, the follow-up studies were lacking probably because the precision and accuracy of meridional wind velocities were imperfect in the early 2000s. Moreover, according to the analogy with the classical thermal-noise theory, the random excitation model seems contradictory to the recent trend of global warming that would raise the "noise" power level.

Sticking on the resonant excitation model, we need to demonstrate what has been happening in the atmosphere in the recent decade. One intriguing observation is already given by Osprey et al. (2016, Science) and Newman et al. (2016, GRL) that indicates disruption of the equatorial quasi-biennial oscillation (QBO) after February 2016. QBO is essentially zonally symmetric wind oscillation in the tropics with its mean period of 28 months and is responsible for axial angular momentum exchanges with solid Earth. Thus it should not directly affect the polar motion excitation for equatorial angular momentum exchanges. However, it remains uncertain if and how the QBO could be related to the equatorial angular momentum budgets. In the light of the recent advances in the modeling of the middle atmosphere since the early 2000s (e.g., development of gravity-wave resolving model), it deserves to re-examine the effect of atmospheric wind term, using the state-of-the-art analysis data and/or model.

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