VARIATIONS OF ANNUAL OSCILLATION PARAMETERS, EL NIÑO AND THEIR INFLUENCE ON POLAR MOTION PREDICTION ERRORS

W. KOSEK[1], D. D. McCARTHY[2], B. J. LUZUM[2]
[1]Space Research Centre, PAS, Warsaw, Poland,
[2]U.S. Naval Observatory, Washington D.C., USA.

1. INTRODUCTION

The error of short-term prediction of the pole coordinate data determined from space techniques is several times greater than their determination error, which is now of the order of 0.1 mas. The causes of such prediction errors are mainly due to irregular amplitudes and phases of the semiannual (Kosek and Kołaczek 1997) and shorter period oscillations (Kosek et al. 1995, 1998; Kosek 1997, 2000; Schuh and Schmitz-Hübsch 2000). Poor accuracy of short-term polar motion prediction can be also caused by the variable phase/period of the annual oscillation (Schuh et al. 2001a) which increase/decrease before the last 1997/98 El Niño event (Kosek et al. 2000, 2001). The Chandler phase/period variations at subseasonal time scale are more stable than the annual ones (Kosek et al. 2000, 2001).

In some of the prediction methods of polar motion, the parameters of harmonic functions including bias and drift were estimated and extrapolated into the future (Zhu 1981; McCarthy and Luzum 1991, 1996; Malkin and Skurikhina 1996). The polar motion was recently predicted using artificial neural networks (Schuh et al. 2001b), a nonlinear extended Kalman filter (Fernandez 2001) or by the autocovariance prediction applied to the pole coordinate data transformed into polar motion radius and angular distance (Kosek 2001). The current prediction method of polar motion data carried out in the IERS Rapid Service/Prediction Center is the least-squares extrapolation of a Chandler circle, annual and semiannual ellipses and a bias fit to the last 1 year of combined pole coordinate data (McCarthy and Luzum 1991). In this paper the same least-squares model is fitted to the last 1, 2,..., 6 years of combined pole coordinate data in order to determine the Chandler and annual amplitude and phase variations as well as to find the optimum model length for the prediction computation.

2. DATA

The analysis used USNO pole coordinate data (formerly referred to as NEOS data) in the years 1973.0 to 2001.6 with the sampling interval of 1 day (USNO 2001) and the monthly sea surface temperature anomalies Niño 1+2 in the years 1976.0 to 2001.6 from the Climate Prediction Center (NOAA 2001). The USNO series is based on a weighted cubic spline of multi-technique observational results corrected for possible bias and rate with respect to the IERS C04 series. The weights used in the combination are proportional to the inverse square of the estimated accuracy of input data.

3. ANALYSIS

Implementing the least-squares model of the Chandler circle, annual and semiannual ellipses and the bias which is sliding along the whole data interval of pole coordinate data, it is possible to find the Chandler and annual amplitude and phase variations. Such variations were detected using the least-squares model fit to the 2, 3 and 4-year pole coordinate data sliding with a step of _-7 days along the whole data interval from 1973.0 to 2001.6 (Fig. 1).
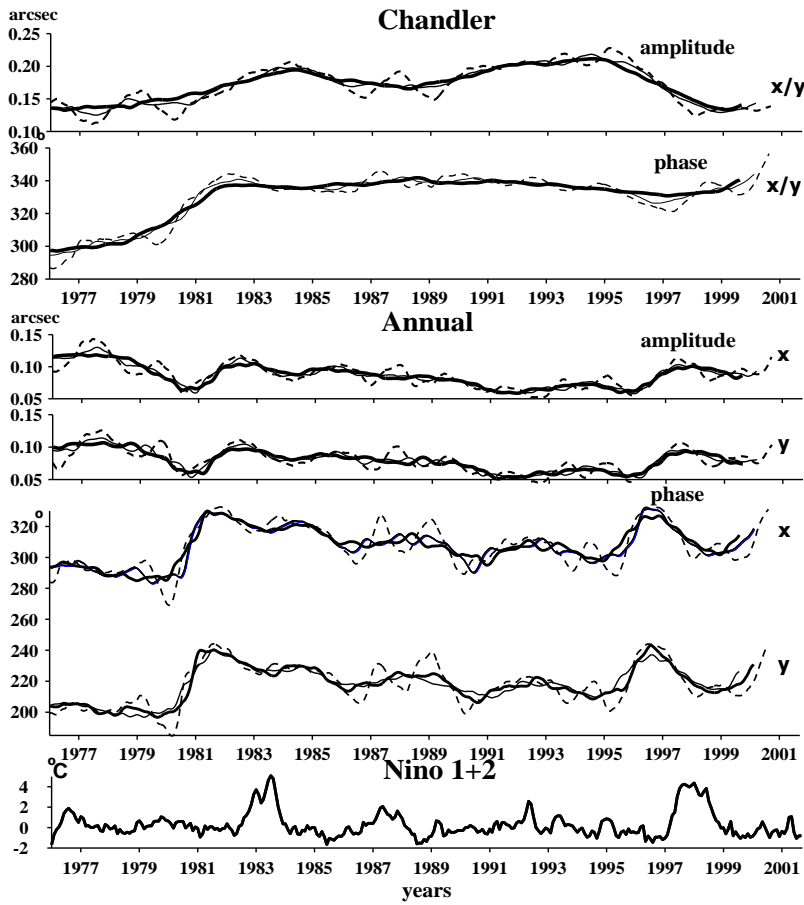
Fig. 1. The least-squares amplitudes and phases referred to the epoch 1976.060 (MJD=42800) of the Chandler and annual oscillations computed by the running 2 (dashed line), 3 (thin line) and 4-year (heavy line) boxcar windows and the Niño 1+2 data.

There are some increases of the annual oscillation amplitude just before or at the time of El Niño events in 1982/83 and 1997/98, respectively. After the 1980s, the amplitude of the annual oscillation was maximum during the time of the El Niño events in 1982/83 and in 1997/98, so it seems to be mostly correlated with the Niño 1+2 data. Before 1982 an increase of the phase of the Chandler oscillation of the order of 40° during 5 years can be seen and after that the variations of the phase of the Chandler oscillation are less than that of the annual oscillation. There are significant increases of the annual oscillation phase in the x and y pole

coordinate data of the order of 30°-_40° before El Niño events in 1982/83 and 1997/98. Notice that the decrease of the phase values of the annual oscillation correspond to the maxima of El Niño events in 1982/83 and in 1997/98, so the first differences of the phase of the annual oscillation seem to be mostly correlated with the Niño 1+2 data.

The 1, 2 and 4-year least-squares extrapolation residuals of pole coordinate data were computed from the 1, 2, and 4-year series after subtracting the least-squares model data consisting of a Chandler circle, annual and semiannual ellipses and a bias (Fig. 2). These residuals were shifted by 7 days with respect to each other, then weighted by the trapezoid function and connected. The increase of the least-squares model length increases the amplitudes of the extrapolation residuals, and energetic oscillations of y extrapolation residuals usually have longer period oscillations than x extrapolation residuals.
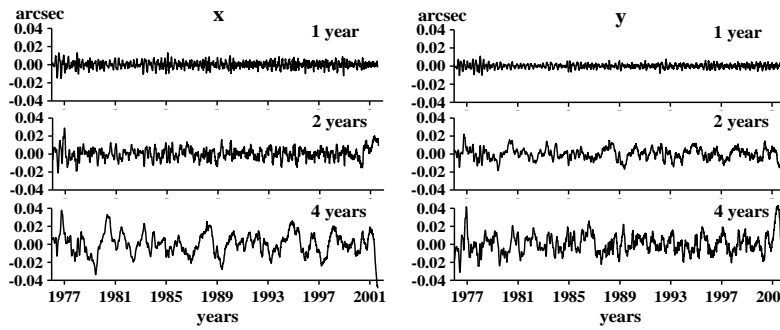

Fig. 2. Least-squares extrapolation residuals of x, y polar coordinates computed for the models with lengths of 1, 2 and 4 years.

Figure 3 shows the distance between the real and predicted pole positions from 1 to 90 days in the future as a function of starting prediction epochs and different lengths of pole coordinate data equal to 1, 2, 3, 4 and 6 years going into the least-squares model. Notice that when the length of the least-squares model increases, then the polar motion prediction errors increase too, and these errors became greater during the biggest El Niño events in 1982/83 and 1997/98. This suggests that there must be some relationship between the increase of polar motion prediction errors and the biggest El Niño events in 1982/83 and 1997/98. Big polar motion prediction errors before the 1980s were caused by less accurate polar motion data.

To check the relations between El Niño and the annual oscillation parameters, the correlation coefficients between the Niño 1+2 data and amplitude/phase variations of the annual oscillations were computed in the two time intervals 1980-2000 and 1990-2000 (Table 1). The least-squares amplitudes and phases were computed assuming the length of polar motion data going into the least-squares model_was equal to 3 years. Notice that the absolute values of the correlation coefficients are significant at the 90% confidence level except the least-squares phase change data during the time interval of 1980-2000.

To estimate the relationship between El Niño and the polar motion prediction errors, the correlation coefficients between the Niño 1+2 data and mean polar motion prediction errors for 50 and 80 days in the future were computed (Table 1). The length of pole coordinate data going into the least-squares model was 3 years. Notice that these correlation coefficients are significant at the 90% confidence level except the polar motion prediction error at 80 days in the future computed during the time interval of 1980-2000.
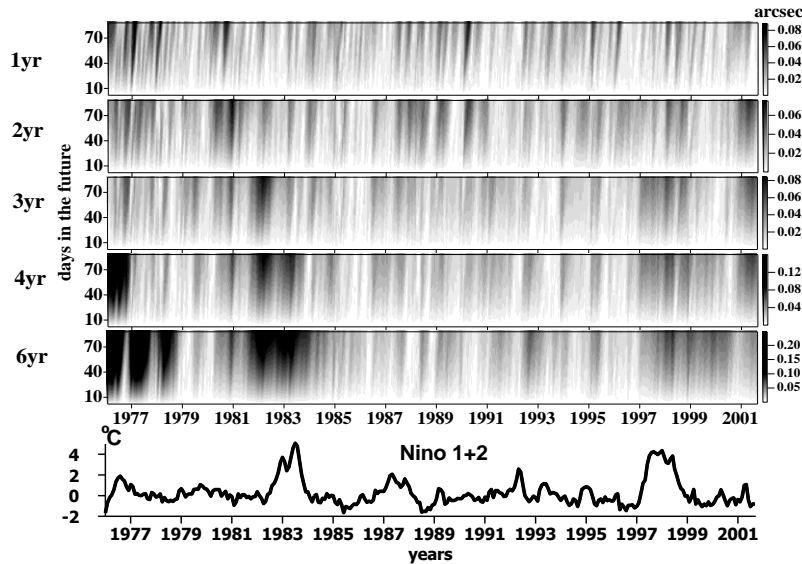
Fig. 3. The distance between the real polar motion position and that predicted by least-squares at different starting prediction epochs as a function of different lengths of the extrapolation models from 1 to 6 years. Niño 1+2 data are also shown.

Table 1. The correlation coefficient values between the Niño 1+2 data and the amplitudes/phase changes of the annual oscillation or the mean polar motion prediction error at 50 and 80 days in the future. * denotes correlation coefficients values significant at the 90% confidence level.

Time series	LS amplitude		LS phase-difference		Mean PM prediction error	
					days in the future	
Time period	x	y	X x	y	50	80
Degrees of freedom	26		36		26	24
→ 1980-2000	0.27*	0.28*	-0.20	-0.18	0.34*	0.25
Degrees of freedom	13		18		13	12
→ 1990-2000	0.42*	0.44*	-0.35*	-0.32*	0.42*	0.46*

Figure 4 shows the mean prediction errors for polar motion as the mean error of the two errors estimated separately for x and y pole coordinate. These errors were estimated from the pole coordinate data in the time intervals of 1973.0 - 2001.6, 1984.0 - 2001.6 and 1984.0 - 1997.0 using different lengths of pole coordinate data equal to 1, 2,…, 6 years going into the least-squares model. Notice that during the first time interval of data the two biggest El Niño events in 1982/83 and 1997/98 occurred. During the second time interval of data there was only one El Niño in 1997/98, and during the third time interval of data no large energy El Niño events occurred. Notice that increasing the length of the pole coordinates data going into

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the least-squares model increases the mean polar motion prediction errors. The polar motion prediction errors became larger when the time interval of polar motion data contain El Niño events.
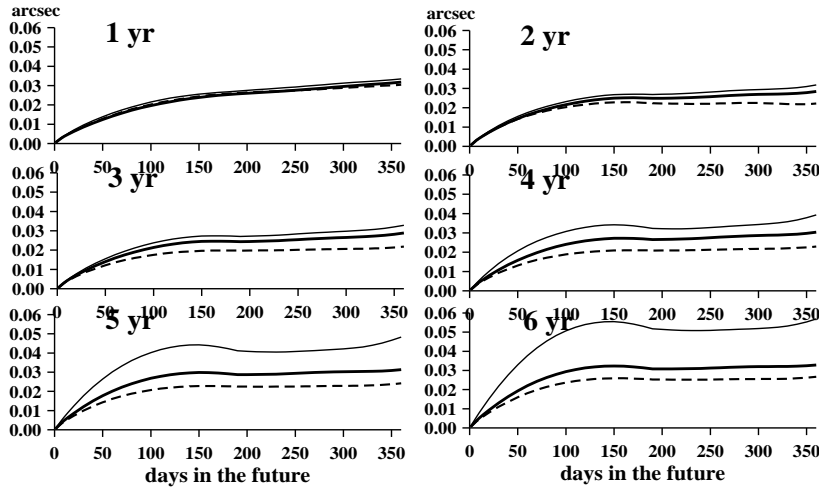

Fig. 4. Mean prediction errors for polar motion computed in 1973.0-2001.6 (thin line) (in the time period of the two biggest El Niño events in 1982/83 and 1997/98), in 1984.0-2001.6 (heavy line) (in the time period of the biggest El Niño event in 1997/98) and in 1984.0-1997.0 (in the time period between the two biggest El Niño events) as a function of least-squares model length of 1,2, …, 6 years.

4. CONCLUSIONS

-Poor accuracy of polar motion predictions can be caused by variable phase or period of the annual oscillation. There were two significant increases of the annual oscillation phase of the order of 30°-40° before the two biggest 1992/93 and 1997/98 El Niño events. The Chandler oscillation phase/period is more stable than the annual one and shows no significant correlation with El Niño events.

-The correlation coefficients between the 50- and 80-day predictions or amplitude/phase variations of the annual oscillation and the Niño 1+2 data are significant at the 90% confidence level.

-The increase of polar motion data length going into the least-squares extrapolation model increases the polar motion prediction errors, especially during the time of the biggest El Niño events in 1982/83 and 1997/98. Thus, it is advisable to choose a shorter least-squares extrapolation model lengths for polar motion prediction during the time of El Niño events.

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