# FORECASTING POLE COORDINATES DATA BY COMBINATION OF THE WAVELET DECOMPOSITION AND AUTOCOVARIANCE PREDICTION

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## 1. INTRODUCTION

The basic problem in forecasting a time series is the necessity of separate treatment of the low and high frequency variations. This problem can be solved by combination of the discrete wavelet transform (DWT) decomposition with the autocovariance forecast (AC) technique (DWT+AC) (Kosek et al. 2005). In this approach each frequency component determined by the DWT is predicted separately by the AC technique, and the final prediction is the sum of the predicted components (Kosek et al. 2005). Combination of the DWT+AC technique enables adaptive forecasting of time series in different frequency bands. The applied DWT decompositions were based on the Meyer (Meyer 1990, Popiński and Kosek 1995) and Shannon (Benedetto and Frazier 1994) wavelet function concepts.

## 2. DATA USED, THEIR ANALYSIS AND RESULTS

The following $x, y$ pole coordinates data were used: EOPC01 in 1846 - 2002 and EOPC04 in 1962 - 2005.6 (IERS 2005). The combined pole coordinates series which consist of the EOPC01 data interpolated at 1 day sampling interval from 1880 to 1962 and the EOPC04 data from 1962 to 2005.6 was created.

Decomposition of the $x, y$ pole coordinates data into frequency components using the DWT based on the Meyer or Shannon wavelets does not enable separation of the Chandler and annual oscillations. It was found previously that the AC forecast applied directly to the pole coordinates data attains lower accuracy than the AC forecast applied in the polar coordinate system (Kosek 2002). Thus, to solve the problem of the separation of the Chandler and annual oscillations the DWT+AC forecast was computed in the polar coordinate system using the following algorithm:
Step 1. Computation of the mean pole coordinates data by the Ormsby (1961) low pass filter and its forecast by the least-squares method.
Step 2. Transformation of $x, y$ pole coordinates data into the radius and angular velocity data, which were then interpolated at 1 week sampling interval.
Step 3. Decomposition of the radius and angular velocity series into frequency components using the chosen DWT. In order to reduce the DWT filtration errors at the ends of these frequency components time span, the radius and angular velocity data were preliminary predicted by the AC method to extend their time span to $n = 2^{12}$ points (78.5 years) before decomposition.

Step 4. Computation of predictions of the frequency components of the radius and angular velocity data by the AC forecast. The final prediction of the radius and angular velocity series is the sum of the predicted components.
Step 5. Transformation of the predictions of the radius and angular velocity data from the polar to the Cartesian coordinate system using linear intersection formulae (Kosek 2003).
Step 6. The next prediction point of $x, y$ pole coordinates data can be computed by repeating the Step 5 after the previously determined predictions of the pole coordinates data and of the mean pole coordinates data are added at the end of the corresponding time series, etc.

The absolute values of the difference between the $x, y$ pole coordinates data, the radius and angular velocity data and their corresponding predictions computed by the DWT+AC method for different starting prediction epochs are shown in Figure 1.

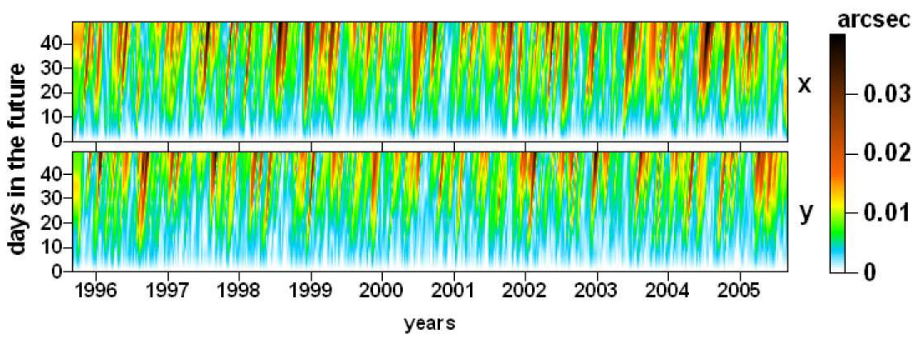


Figure 1: The absolute values of the difference between $x, y$ pole coordinates data and their predictions for 50 days in the future, at different starting prediction epochs, obtained by the DWT+AC technique with Shannon wavelet function. Contour line at 0.01 second of arc.

## 3. DISCUSSION

The DWT+AC combination enables adaptive prediction of $x, y$ pole coordinates data in different frequency bands. The transformation from the Cartesian to polar coordinate system is necessary to solve the problem of the resolution of the Chandler and annual oscillations. There are still many problems to be solved when using this forecast approach: 1) the applied prediction algorithm is very time consuming, 2) each frequency component computed by the DWT has got the errors at the end of time series due to filtration, so the preliminary extension of time series is necessary to diminish these errors, 3) for each frequency component the appropriate length of data used for the prediction computation should be found.

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## REFERENCES

Benedetto J.J. and Frazier M.W., 1994, Mathematics and Applications, LRC Press, Boca Raton, 221-245.
IERS 2005, Earth Orientation Parameters, http://hpiers.obspm.fr/eop-pc/.
Kosek W., 2002, *Advances in Space Research*, 30, 375-380.
Kosek W., 2003, *Proc. Journees 2002*, Bucarest, 25-28 Sep. 2002, 125-131.
Kosek W., Kalarus M., Johnson T.J., Wooden W.H., McCarthy D.D. and Popiński W., 2005, *Artificial Satellites*, Vol. 40, No. 2, 119-125.
Meyer Y., 1990, Ondelettes et Operateurs, Vol. 1, Hermann, Paris.
Ormsby J.F.A., 1961, *J. Assoc. Compt. Mach.*, 8, 440-466.
Popiński W., Kosek W., 1995, *Proc. Journees 1995*, 121-124.