FORECASTING IRREGULAR VARIATIONS OF UT1-UTC AND LOD DATA CAUSED BY ENSO

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ABSTRACT. The research focuses on prediction of LOD and UT1-UTC time series up to one-year in the future with the particular emphasis on the prediction improvement during El Niño or La Niña events. The polynomial-harmonic least-squares model is applied to fit the deterministic function to LOD data. The stochastic residuals computed as the difference between LOD data and the polynomial-harmonic model reveal the extreme values driven by El Niño or La Niña. These peaks are modeled by the stochastic bivariate autoregressive prediction. This approach focuses on the auto- and cross-correlations between LOD and the axial component of the atmospheric angular momentum. This technique allows one to derive more accurate predictions than purely univariate forecasts, particularly during El Niño/La Niña events.

1. INTRODUCTION

Variations of Universal Time (UT1-UTC) and its first derivative Length-of-Day (LOD) are driven by various geophysical processes and contain oscillations ranging from decades to hours. There are irregular fluctuations, which are directly associated with El Niño/Southern Oscillation (ENSO). El Niño events are always preceded by weakening of zonal winds, which causes the increase of the axial component of atmospheric angular momentum (AAM χ_3) and LOD. There exist relationships between LOD fluctuations and indices which quantitatively describe ENSO (Southern Oscillation Index, Niño indices) (e.g. Gross et al., 1996). As a result, extreme irregular variations of zonal winds preceding ENSO decrease the accuracy of LOD predictions. The multivariate stochastic approach to predict LOD/UT1-UTC is proposed by Niedzielski and Kosek (2007).

2. DATA AND METHODS

For the analysis the two time series are selected. First, we process the nontidal LOD time series denoted as $\Delta - \delta\Delta$, where Δ is the LOD time series and $\delta\Delta$ is the tidal correction (McCarthy and Petit, 2004). The time span of data is January 1, 1962 – October 22, 2006. Second, the AAM χ_3 time series is analysed. The AAM χ_3 data being the sum of wind (motion) and pressure (mass) terms modified by inverted barometer (IB) correction were smoothed and interpolated at 1-day sampling interval.

The polynomial-harmonic least-squares (LS) model is fit to $\Delta - \delta\Delta$ data. This model consists of annual, semi-annual, 9.3-year, 18.6-year harmonic oscillations and the linear trend. The similar model, however with annual, semi-annual oscillations and the mean, is applied to AAM χ_3 time series. The polynomial harmonic LS models are used to compute the residual time series $\varepsilon(\Delta - \delta\Delta)$ and $\varepsilon(\mathrm{AAM}\chi_3)$, for LOD and AAM χ_3, respectively. Furthermore, the polynomial-harmonic LS model for $\Delta - \delta\Delta$ is extrapolated in order to compute the deterministic prediction of these data.

In order to capture both causal and temporal relations between $\varepsilon(\Delta - \delta\Delta)$ and $\varepsilon(\mathrm{AAM}\chi_3)$ time series the multivariate autoregressive (MAR) technique is adopted. This method allows one to fit vector time series model to the multivariate data by estimating the memory of the process (autoregressive order p) and the autoregressive coefficient matrices. The matrices say about the structure of the relations in question. The computationally efficient method for fitting the autoregressive models is proposed by Neumaier and Schneider (2001). The prediction of $\Delta - \delta\Delta$ time series is the sum of the polynomial-harmonic LS model extrapolation and the stochastic MAR prediction of $\varepsilon(\Delta - \delta\Delta)$ residuals. This prediction scheme is denoted as LS+MAR. The predictions of UT1-UTC are computed by integrating predictions of $\Delta - \delta\Delta$ and adding the tidal model together with leap seconds.

3. RESULTS AND DISCUSSION

The results indicate that the application of the LS+MAR technique allows one to derive the LOD/UT1-UTC predictions with the acceptable accuracy. For instance, root mean square errors (RMSEs) of UT1-UTC prediction are: 1.15 ms, 2.85 ms, 24.51 ms, and 53.96 ms, for 10-day, 20-day, 180-day, and 360-day in the future, respectively (Niedzielski and Kosek, 2007). For short-term predictions, these values are slightly greater than those computed by Schuh et al. (2002). However, 90-day predictions computed by the technique presented in this paper are more accurate than those obtained by Schuh et al. (2002). In contrast, the MAR solution presented herein provides one with the predictions exhibiting smaller RMSE values than those computed using the autocovariance technique by Kosek et al. (1998).

The predictions obtained by the LS+MAR method are more accurate than forecasts derived by the pure polynomial-harmonic LS model extrapolation. In particular, the improvement is well seen during the periods when El Niño or La Niña events occur. This significant improvement may be noticed in the case of El Niño 1994/1995, La Niña 1998/1999, and El Niño 2002/2003. This can be seen from maximum absolute differences between UT1-UTC data and their predictions (Tab. 1). However, the maximum reduction in the RMSE for one-year predictions may reach even 20 % in respect to the RMSE of predictions computed using the polynomial-harmonic LS model.

The results allow one to infer the multivariate approach combined with the polynomial-harmonic LS modelling to be a promising method for LOD/UT1-UTC prediction. In fact, the proposed method may lead to the improved UT1-UTC predictions during the ENSO periods, hence when there are extreme fluctuations of the Earth's rotation rate.

	10-day	90-day	180-day	360-day
LS	4.45	58.60	115.55	197.20
LS+MAR	3.70	36.56	56.27	121.59

Table 1: Maximum absolute values of differences between UT1-UTC data and their predictions for different prediction lengths.

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