

Second Earth Orientation Parameters Prediction Comparison Campaign (2nd EOP PCC) Workshop No. 3

9 April 2026, Online

Programme

Registration: <http://eoppcc.cbk.waw.pl/workshop-no-3-workshop-registration/>

Contact: eoppcc@cbk.waw.pl, <http://eoppcc.cbk.waw.pl/>

Workshop No. 3 Organizing Committee

Jolanta Nastula (Centrum Badań Kosmicznych Polskiej Akademii Nauk)

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Sadegh Modiri (Federal Agency for Cartography and Geodesy, BKG)

2nd EOP PCC Workshop No. 3 Programme

Thursday 9 April 2026

15:00-15:10 (CEST)

Jolanta Nastula
Welcome, Introduction

15:10-15:30 (CEST)

Wei Chen, Jiesi Luo, Jim Ray, Jian Cheng Li
Short-term LOD and UT1-UTC Forecast Based on LS+AR and Holt-Winters Algorithms with Geophysical Excitations

15:30-15:50 (CEST)

Qiaoli Kong, Guoli Bo, Puxuan Wu, Lulu Zhang, Xiyuan Jing, Yingjie Huang
Improved polar motion prediction with denoised geophysical fluid excitation information and Long Short Term Memory neural network

15:50-16:10 (CEST)

Wei Miao, Xueqing Xu, Yonghong Zhou
Optimizing the Liouville Convolution Input Enhances 10-Day Polar Motion Predictions

16:10-16:30 (CEST)

Jessica Page, Maria Davis, Sharyl Byram
IERS Rapid Service Prediction Center (RS/PC) Overview and Updates

16:30-16:50 (CEST)

Sujata Dhar, Robert Heinkelmann, Kyriakos Balidakis, Santiago Belda, Sadegh Modiri, Shrishail Raut, Nagarajan Balasubramanian, Onkar Dikshit, Harald Schuh
Insights into relationship between extreme climate and LOD for improving long-term LOD predictions

16:50-17:20 (CEST)

Justyna Śliwińska Bronowicz, Aleksander Partyka, Maciej Michalczak
Current status of the post-operational phase of Second Earth Orientation Parameters Prediction Comparison Campaign (2nd EOP PCC) and EOP PML

17:20-18:00 (CEST)

Discussion
moderated by Robert Dill and Sadegh Modiri

Abstracts

Short-term LOD and UT1-UTC Forecast Based on LS+AR and Holt-Winters Algorithms with Geophysical Excitations

Wei Chen (School of Earth and Space Science and Technology, Wuhan University, China)

Jiesi Luo (School of Earth and Space Science and Technology, Wuhan University, China)

Jim Ray (National Oceanic and Atmospheric Administration, Silver Spring, Maryland, USA, retired)

Jian Cheng Li (Central South University, Changsha, China)

We propose a hybrid method for forecasting ΔLOD (length of day variations) and UT1-UTC (difference between universal time and coordinated universal time) over horizons ranging from 1 to 30 days. This method combines the Least Squares plus Autoregressive (LS+AR) model with the Holt-Winters (HW) additive algorithm, and incorporates effective angular momentum (EAM) functions derived from global atmospheric, oceanic, and land water models, as well as zonal tidal signals. In this approach, the dominant signals in ΔLOD are modeled using LS with multiple periodic components (annual, semi-annual, and ter-annual terms), while the residuals are captured by an AR model. The secondary residuals are further modeled and predicted using the HW additive algorithm. Then UT1-UTC predictions are obtained through iterative summation of the predicted ΔLOD . Especially, the day-1 forecasts are calculated from the last-day $d\text{LOD}/dt$ using the formula of central finite difference. The method is validated using 365 consecutive daily forecasts from January 1 to December 31, 2023. Results show that the LS+AR model achieves mean absolute errors (MAE) of 0.0050 ms, 0.0311 ms, and 0.1118 ms for ΔLOD at 1-day, 2-day, and 7-day forecast horizons, respectively, with corresponding UT1-UTC MAEs of 0.0091 ms, 0.0652 ms, and 0.3349 ms. The HW-enhanced model shows marginal improvements for longer horizons, reducing ΔLOD MAE from 0.1118 ms to 0.1091 ms at day 7. Compared with IERS Bulletin A and recent studies, our method demonstrates competitive accuracy, particularly for ultra-short-term forecasts within 7 days.

Improved polar motion prediction with denoised geophysical fluid excitation information and Long Short Term Memory neural network

Qiaoli Kong (Shandong University of Science and Technology)

Guoli Bo (Shandong University of Science and Technology)

Puxuan Wu (Shandong University of Science and Technology)

Lulu Zhang (Shandong University of Science and Technology)

Xiyuan Jing (Shandong University of Science and Technology)

Yingjie Huang (Shandong University of Science and Technology)

Polar Motion (PM) is a crucial parameter linking the celestial and terrestrial reference frames. Integrating Earth's fluid effective angular momentum (EAM) and neural network is an effective way to improve PM prediction accuracy. However, EAM data is polluted by high-frequency noise and the neural network models are highly sensitive to the input EAM dataset. To improve PM prediction accuracy, this study proposes a method combining Complex Segmented Least Squares (CSLS) with Long Short-Term Memory (LSTM) using the noise-reduced EAM data and the filtered 6-day forecast EAM data. Geodetic angular momentum function is employed to reduce the high frequency noise signal of EAM, Kalman Filter is adapted to denoise the 6-day forecast product, and CSLS + Autoregression (AR) and CSLS + LSTM are used for fitting and prediction. The 6-day predicted outcomes with denoised EAM achieved the reductions of the Mean Absolute Error (MAE) in x direction by 48.68% and 53.47% compared to those of Bulletin A and those gained with the original EAM, and in y direction, the reductions reached 37.16% and 41.24%, respectively. The 365-day predicted results with CSLS+LSTM achieved MAE reduction of 43.02% and 32.65% in x and y directions, respectively, compared to Bulletin A. The results confirm that, for short-term PM prediction, CSLS+AR with the denoised EAM data outperforms other methods, while for long-term, CSLS+LSTM with the original EAM data performs better. It is also found that the denoised-EAM can improve PM prediction accuracy within future 1~30 days, while for longer time, there is no significant improvement.

Optimizing the Liouville Convolution Input Enhances 10-Day Polar Motion Predictions

Wei Miao (Shanghai Astronomical Observatory, Chinese Academy of Sciences)

Xueqing Xu (Shanghai Astronomical Observatory, Chinese Academy of Sciences)

Yonghong Zhou (Shanghai Astronomical Observatory, Chinese Academy of Sciences)

Improving the accuracy of 1–10-day Polar Motion (PM) predictions can directly benefit related application fields such as satellite autonomous navigation and deep-space exploration, thereby enhancing the satisfaction with their services. The final results of the 2nd Earth Orientation Parameters Prediction Comparison Campaign (2nd EOP PCC) show that the top two IDs in the PM prediction competition were both based on the LS+AR+EAM method proposed by Dill et al. (2019). In-depth analysis reveals that the convolutional input to the Liouville equation in this method is a key factor affecting the 1–10-day prediction accuracy. We first propose that the first iteration of the convolution should be computed starting from the current day using the same day's rapid data, rather than re-using the convolutional result from the previous step. Subsequently, the PM for the first prediction day is obtained using the 6-hour resolution ultra-rapid data released by the International GNSS Service (IGS). On this basis, multiple methods are employed to predict the Geodetic Angular Momentum (GAM) and Effective Angular Momentum (EAM) required in the LS+AR+EAM framework. Since the convolutional inputs include the PM at the previous epoch, the GAM at the previous epoch, and the GAM at the current epoch, and because forecast results from several methods are already available for these three inputs, combining them effectively introduces additional constraints, which is expected to reduce the error of the convolutional prediction. Following the above approach, we conducted comprehensive validation over the hindcast period from 1/9/2021 to 7/1/2026, and performed a detailed analysis of the Absolute Error (AE) and Mean Absolute Error (MAE) of the predictions.

IERS Rapid Service Prediction Center (RS/PC) Overview and Updates

Jessica Page (US Naval Observatory (USNO))

Maria Davis (US Naval Observatory (USNO))

Sharyl Byram (US Naval Observatory (USNO))

The IERS Rapid Service/Prediction Center (RS/PC) is responsible for providing a daily, multi-technique Earth Orientation Parameter (EOP) combined solution, which includes predictions up to 1 year. This community has utilized our daily (e.g., `finals2000A.daily.extended`) and weekly (e.g., `Bulletin A/finals2000A.data`) products as a reference series to evaluate new EOP prediction methods or as input into prediction algorithms. In support of these efforts, we will give a general overview of IERS RS/PC products and provide updates to our ongoing efforts. The discussed topics include VLBI additions such as VGOS and Southern intensives, forthcoming improvements to our short-term UT1-UTC predictions, and a brief insight into the impact of reference series selection on prediction evaluation.

Insights into relationship between extreme climate and LOD for improving long-term LOD predictions

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Harald Schuh (Institute of Geodesy and Geoinformation Science, Technische Universität Berlin, Germany)

Accurate long-term LOD predictions are essential for understanding the dynamics of diverse geophysical processes, and they also play a critical role in estimating satellite lifetimes for specific missions. In recent years, prediction techniques have been improved. However, till today, the predictions of highly variable LOD are slightly less accurate than observations even for a few days in future. LOD is linked with changes in the climate. The variability in the internal dynamics of the ocean and atmosphere is an important factor that determines the Earth's climate and are represented by the climate indices. But their relationship with LOD is complex and not yet fully understood. LOD predictions can be facilitated by effective angular momentum (EAM) functions based on ECMWF data. In this work, we utilize combination of Ensemble techniques with least-squares (LS) method to improve the predicted LOD for 90 days and 365 days. In order to investigate the relationship between LOD and climate indices, we employ multivariate empirical mode decomposition to identify the various frequency components of the auxiliary data. This helps to clarify the significance of climate indices on LOD prediction. This valuable information is used to build a benchmark dataset that helps improve the accuracy of the predicted LOD in long-term. In this study, the Ensemble combined with LS techniques, EnsGA+LS, are curated to prepare robust model for long-term LOD predictions. We compare LOD prediction performance using only EAM versus EAM combined with selected climate indices as input parameters. The LOD prediction model is developed in such a way to minimize overfitting, and its robustness is evaluated by assessing prediction performance across multiple and varied testing epochs. In addition, the study incorporates forecasted climate information to examine the capability of our prediction model in generating operational long-term LOD prediction products.

Current status of the post-operational phase of Second Earth Orientation Parameters Prediction Comparison Campaign (2nd EOP PCC) and EOP PML

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Following the successful completion of the Second Earth Orientation Parameters Prediction Comparison Campaign (2nd EOP PCC) in 2022, scientific interest in the routine comparison and evaluation of EOP predictions remains high. To support this, the EOP PCC Office continues to systematically collect and analyze EOP forecasts produced by various institutes worldwide, using diverse methodologies and input datasets.

In response to the growing application of machine learning (ML) in EOP prediction, a dedicated sub-campaign, EOP PML, was launched in November 2025 as part of the 2nd EOP PCC. The goal of EOP PML is to further investigate the potential of ML techniques for EOP forecasting by systematically collecting, comparing, and evaluating forecasts generated using a variety of ML approaches. By adhering to strict guidelines regarding input data, prediction horizons, and evaluation procedures, EOP PML ensures an objective assessment of ML-based models.

This presentation summarizes the activities of the 2nd EOP PCC and its EOP PML sub-campaign, while outlining plans for future developments. We also report new findings from the analysis of collected EOP forecasts, focusing on the accuracy of individual ML methods compared with the IERS 20 C04 reference solution for short-term predictions up to 10 days — a forecasting horizon critical for many operational applications.