Second Earth Orientation Parameters Prediction Comparison Campaign (2^{nd} EOP PCC) Workshop

February 15-16, 2022, Online

Program

Registration: http://eoppcc.cbk.waw.pl/registration/

Organizing committee: Jolanta Nastula, Henryk Dobslaw, Justyna Śliwińska, Małgorzata Wińska, Tomasz Kur, Aleksander Partyka

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2nd EOP PCC Workshop Programme

Tuesday 15 February 2022, 08:00 – 10:00 CET

Convener: Henryk Dobslaw (GFZ)

08:00 – 08:10: Jolanta Nastula, Henryk Dobslaw, Welcome

08:10 – 08:40: Jolanta Nastula, Henryk Dobslaw, Justyna Śliwińska, Tomasz Kur, Małgorzata Wińska, Aleksander Partyka, ***Second Earth Orientation Parameters Prediction Comparison Campaign – overview***

08:40 – 09:00: Zinovy Malkin, Victor Tissen, ***On the accuracy assessment of EOP predictions***

09:00 – 09:20: Radoslaw Zajdel, Krzysztof Sośnica, Grzegorz Bury, ***Determination of ERPs from GPS, GLONASS, and Galileo***

09:20 – 09:40: Xin Zhao, Xinyu Yang, Yuanwei Wu, ***EOP Prediction for the 2nd EOPPCC of NTSC***

09:40 – 10:00: Discussion

Tuesday 15 February 2022, 17:00 – 19:00 CET

Convener: Jolanta Nastula (CBK PAN)

17:00 – 17:20: Robert Dill, Henryk Dobslaw, Maik Thomas, Jan Saynisch, Christopher Irrgang, ***ESMGFZ EAM Prediction Products and EOP (polar motion, UT1-UTC, LOD) Prediction***

17:20 – 17:40: Sara Bruni, Volker Mayer, Michiel Otten, Erik Schoenemann, ***ESA's Earth Rotation Parameter Service***

17:40 – 18:00: Matthias Schartner, Mostafa Kiani Shahvandi, Junyang Gou, Benedikt Soja, ***Introducing the EOP prediction framework at ETH Zurich***

18:00 – 18:20: Mostafa Kiani Shahvandi, Junyang Gou, Matthias Schartner, Benedikt Soja, ***Recursive and recurrent machine learning methods for the ultra-short-term prediction of EOP time series***

18:20 – 19:00: Discussion

Wednesday 16 February 2022, 08:00 – 10:00 CET

Convener: Justyna Śliwińska (CBK PAN)

08:00 – 08:20: Weitao Lu, ***A Polar Motion Prediction Method by Using Wavelet Artificial Neural Networks***

08:20 – 08:40: Zhijin Zhou, ***An ERP prediction method based on LS+AR model and product precision introduction***

08:40 – 09:00: Wei Miao, Leyang Wang, ***The importance of differences between polar motion series***

09:00 – 09:20: Xue-Qing Xu, Yong-Hong Zhou, Ming Fang, Can-Can Xu, ***EOP predictions and climate change indications in Earth rotation***

09:20 – 10:00: Discussion

Wednesday 16 February 2022, 17:00 – 18:00 CET

Convener: Małgorzata Wińska (PW)

17:00 – 17:20: Mohammad Ali Sharifi, Shayan Shirafkan, Kourosh Shahryarinia, Seyyed Mohsen Khazraei, Sadegh Modiri, Alireza Amiri-Simkooei, ***Predicting polar motion components of EOP using LS-HE and AR(p)***

17:20 – 17:40: Sadegh Modiri, Daniela Thaller, Santiago Belda, Sonia Guessoum, Jose M. Ferrandiz, Shrishail Raut, Sujata Dhar, Robert Heinkelmann, and Harald Schuh, ***Towards the improvement of EOP prediction: The Preliminary result of our joint group contributions to EOP PCC***

17:40 – 18:00: Robert Dill, Jan Saynisch-Wagner, Christopher Irrgang, ***Improving atmospheric angular momentum forecasts by machine learning***

Wednesday 16 February 2022, 18:00 – 19:00 CET

Convenors: Jolanta Nastula (CBK PAN), Henryk Dobslaw (GFZ)

18:00 – 19:00: Discussion, Feedback, Next Steps, Wrap-Up

2nd EOP PCC Workshop Abstracts

Second Earth Orientation Parameters Prediction Comparison Campaign – overview

Jolanta Nastula[1], Henryk Dobslaw[2], Justyna Śliwińska[1], Tomasz Kur[1], Małgorzata Wińska[3], Aleksander Partyka[1]

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Precise positioning and navigation on the Earth's surface and in space require accurate Earth Orientation Parameters (EOP) data and predictions. In the last few decades, the problem of EOP prediction has become a subject of increased attention within the international geodetic community, and many research centres from around the world have developed their own methods of forecasting the EOP.

A re-assessment of the various EOP prediction capabilities is currently pursued in the frame of the 2nd EOP PCC, which started in September 2021. The new campaign was prepared by the EOP PCC office run by the Space Research Centre of the Polish Academy of Sciences (CBK PAN) in cooperation with GeoForschungsZentrum (GFZ) and under the auspices of the International Earth Rotation and Reference Systems Service (IERS). The campaign will be continued until the end of the year 2022 and all interested scientists are invited to contribute with new predictions at any time.

In this presentation, we provide an update of the results of 2nd EOP PCC five months after its beginning. We focus on the accuracy of EOP predictions for 10 and 30 days into the future. The quality assessment includes metrics such as mean absolute error (MAE) and root mean square error (RMSE) for the ensemble of all predictions, but also more detailed assessments of individual predictions. We will also present statistics about the number of participants and valid prediction files received so far.

On the accuracy assessment of EOP predictions

Zinovy Malkin[1], Victor Tissen[2, 3]

[1]Pulkovo Observatory, St. Petersburg, Russia

[2]West Siberian Branch of Russian Metrological Institute of Technical Physics and Radio Engineering, Novosibirsk, Russia

[3]Siberian State University of Geosystems and Technologies, Novosibirsk, Russia

Various statistical methods are used to assess the accuracy of EOP predictions made in different analysis centers and/or by different authors. In this presentation, we compare four estimates of EOP prediction errors, such as standard (root-mean-square) error, mean absolute deviation, median error, and maximum error. These methods were applied to three series of the Pole coordinates and UT1 predictions of different quality. It is shown that, although in some cases different estimates are practically equivalent, there is not always a direct relationship between them. An especially large difference between the estimates was found for short-term prediction. Therefore, it is recommended to use several estimates together to obtain the most informative and complete results of the accuracy assessment of EOP prediction series.

Determination of ERPs from GPS, GLONASS, and Galileo

Radosław Zajdel[1], Krzysztof Sośnica[1], Grzegorz Bury[1]

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The Earth Rotation Parameters (ERPs) are time-variable global geodetic parameters with a purely geophysical origin. On the one hand, monitoring phenomena in the Earth system shall be independent of the satellite constellation used in the processing. On the other hand, apparent differences in ERP time series are noticed when using different GNSS constellations. The GNSS-based products, including ERPs, are sensitive to the modeling issues (e.g., accuracy of the background models) or the orbit characteristics. Depending on the purpose, the ERPs can be estimated in different time resolutions.

The conducted research provide the daily and sub-daily series of Earth Rotation Parameters (ERPs), estimated using GPS, GLONASS, and Galileo orvations in search of differences between the system-specific solutions and occurrence of system-specific signals. The GNSS-based sub-daily estimates have been compared with the external models of variations in ERPs induced by the ocean tides from the IERS 2010 Conventions, a new model by Desai-Sibois, and the VLBI-based model by Gipson.

Any system-specific ERPs are affected by the orbital and draconitic signals. The orbital signals are visible in all system-specific ERPs at the periods that arise from the resonance between the Earth's rotation and the satellite revolution period, e.g., 8.87h, 34.22h, 3.4 days for Galileo; 7.66h, 21.29h, 3.9 days, 7.9 days for GLONASS; 7.98h (S3 tidal term), 11.97h (S2 tidal term), 23.93h (S1 tidal term) for GPS. In the Galileo and GLONASS solutions, the artificial non-tidal signals' amplitudes can reach up to 30 µas. The GPS-derived sub-daily ERPs suffer from the overlapping periods of the diurnal and semidiurnal tidal terms and the harmonics of the GPS revolution period. After recovery of 38 sub-daily tidal terms, the Galileo-based model is more consistent with the external models than the GPS-based model, especially in the prograde diurnal band. The results confirmed that the Desai–Sibois model is more consistent with GNSS observations than the currently recommended model in the IERS 2010 Conventions. Moreover, GPS-based length-of-day (LoD) is systematically biased with respect to the IERS-C04-14 values with a mean offset of − 22.4 µs/day. The Galileo-based and GLONASS-based solutions are almost entirely free of this issue. Against the individual system-specific solutions, the multi-GNSS solution is not affected by most of the system-specific artifacts. Thus, multi-GNSS solutions are clearly beneficial for the estimation of both daily and sub-daily ERPs.

EOP Prediction for the 2nd EOPPCC of NTSC

Xin Zhao, Xinyu Yang, Yuanwei Wu

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Here, we report the methods that the we used to produce the prediction of pmx/pmy/ut1. Generally, the LS+AR method is used for predictions for all 5 EOP parameters. For prediction of pmx/pmy/ut1, the numerical effective angular momentum data from GFZ are used for the prediction. For dX, dY dPsi and dEpsilon, dX and dY with LS+AR, then transformed to dPsi and dEpsilon.

ESMGFZ EAM Prediction Products and EOP (polar motion, UT1-UTC, LOD) Prediction

Robert Dill[1], Henryk Dobslaw[1], Maik Thomas[1], Jan Saynisch[1], Christopher Irrgang[1]

[1]ESMGFZ (Earth System Modelling Group GFZ Section 1.3)

ESMGFZ provides not only daily updated angular momentum function for Earth rotation excitation (AAM atmosphere, OAM ocean, HAM hydrology, SLAM barystatic sealevel) but also 6-day forecasts for each of the subsystems. In addition, a 90-day EAM prediction is available. We will give a short description of these products and our EAM prediction algorithm. For EOP PCC we take the latest available EOP coordinates from USNO, made available via CDDIS, as initial value and integrate our 90-day EAM prediction forward in time to obtain the 90-day EOP prediction for polar motion, UT1-UTC, and dLOD. In order to discuss the impact of the accuracy of the initial value, we prepare two submissions. The first submission is calculated around 11 UTC as soon as the EAM prediction is available using initial EOP values from the day before, the second submission is calculated in the evening after new initial EOP coordinates for the actual day are available.

ESA's Earth Rotation Parameter Service

Sara Bruni[1], Volker Mayer[2], Michiel Otten[1], Erik Schoenemann[3]

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[3]ESA

ESA's Navigation Support Office is responsible for providing the geodetic reference for ESA missions. This includes supplying accurate information on Earth Rotation Parameter (ERP) estimates and predictions that are key for any type of positioning and navigation applications. To resolve the existing dependencies on external ERP services and to ensure operational capability, the Navigation Support Office developed an independent ERP Service.

ESA's Earth Rotation Parameter Service is built-up on the algorithms developed in the frame of the ESA study "Independent Generation of Earth Orientation Parameters" executed by a consortium led by Deutsches Geodätisches Forschungsinstitut (DGFI-TUM).

In the past year ESA has prepared and tuned its ERP estimation and prediction routines and is now, on a daily basis, providing updated ERP estimates for three weeks in the past and predictions for 119 days. The computation of predicted values is designed to ensure the highest accuracy for the first week into the future, which is considered the most critical prediction period for operation.

ESA's ERP estimates are based on the rigorous combination on normal equation level of ESA's contributions to the Services of the International Association of Geodesy (IAG). The predictions are generated by taking into account three different components. First, the deterministic part of the signal is characterized by means of a least-square fitting of the whole ERP history. Auto-regressive modelling is used to describe the high-frequency (<100 days) variability induced by non-tidal atmosphere and ocean dynamics. Finally, forecasted Effective Angular Momentum (EAM) functions are assimilated in the prediction of the stochastically irregular ERP variations.

This presentation will provide an overview of the methodology used to generate ESA's ERP products, of the prediction accuracy achieved in test operations and on the current status of the Service.

Introducing the EOP prediction framework at ETH Zurich

Matthias Schartner[1], Mostafa Kiani Shahvandi[1], Junyang Gou[1], Benedikt Soja[1]

[1]ETH Zurich

Within this presentation, we will introduce the EOP prediction framework developed at the Chair of Space Geodesy at ETH Zurich. The framework generates daily EOP forecasts, some of which are also submitted to the second EOPPCC. Thereby, the full set of EOP is predicted using more than 60 approaches utilizing approximately 10 forecasting methods based on machine learning approaches. For the prediction of LOD, mostly recurrent neural networks are used, including LSTM. For the remaining EOPs, mostly first-order neural ordinary differential equation fitting is used.

The developed forecasting methods are trained based on different EOP products, either from IERS, SYRTE, or JPL. Additionally, EAM observations and forecasts from GFZ are also utilized by many approaches to enhance prediction accuracy. Currently, the focus is on providing ultra-short-term predictions (up to ten days), since machine learning methods yield good performance for this forecast horizon.

Besides producing EOP predictions, the framework is also evaluating past predictions for quality control. For instance, for LOD, our average accuracy is around 30 µs for day 0 and grows to 100 µs for day 10. This is also confirmed by the first evaluations from the second EOPPCC. The quality control results, as well as the predictions themselves, are uploaded and freely available at https://gpc.ethz.ch/.

Recursive and recurrent machine learning methods for the ultra-short-term prediction of EOP time series

Mostafa Kiani Shahvandi[1], Junyang Gou[1], Matthias Schartner[1], Benedikt Soja[1]

[1]Institute of Geodesy and Photogrammetry, ETH Zurich

For the ultra-short-term prediction of Earth Orientation Parameter (EOP) time series, we have developed a series of machine learning methods to accurately predict these parameters into the future. Based on the fact that EOPs are represented in the form of time series, two main categories of machine learning models are especially focused on: recursive and recurrent.

Recursive methods are based on fitting Ordinary Differential Equations (ODEs) to data. These methods, which are a subset of the larger learning category of neural ODEs, consider time series to follow a differential equation function, which is learnt during the training process. We mainly focus on first-order ODEs and show that a simple linear recursive formula can be derived. The models built upon this recursion formula are capable of arbitrary input and output sequence lengths, meaning they can handle different features and predict different horizons to the future. The recursive models are used to predict polar motion, LOD, dUT1, and celestial pole offsets.

Recurrent methods are another vital category of machine learning algorithms for time-series prediction. The fundamental assumption behind these methods is that different time steps in the input sequence contain information from previous ones. This information is represented using a linear combination of the current time step and the so-called hidden variables, containing the more deep information of the previous time steps. The linear combination then goes to an activation function, resulting in discarding or preservation of relevant or unnecessary information.

With a special focus on LOD prediction, we have used one of the most promising recurrent models called Long Short-Term Memory (LSTM) neural networks. LSTM can handle complex time series and extract meaningful information from different features and different time steps in the input sequence. In addition, stacking several layers of LSTM is possible and can help in introducing encoder-decoder architectures.

The idea of LSTM is further investigated and a new, general recurrent method for the prediction of time series is developed. The architecture consists of stacking several layers of LSTM and augmenting them with the concepts of attention and greedy layer-wise pretraining. This method is suitable for the prediction of EOPs since it only requires a small number of samples to train the model.

A Polar Motion Prediction Method by Using Wavelet Artificial Neural Networks

Weitao Lu[1]

[1]AFDL EOP Prediction Team, Beijing Aerospace Control Center (BACC), China

The Earth's rotation reflects the coupling process between the solid Earth and atmosphere, oceans, mantle, core of the earth on multiple spatial and temporal scales, which can be described by the Earth's orientation parameters (EOP). EOP mainly includes precession, nutation, polar motion and length of day (LOD), all of which are the transformation parameters between the terrestrial and celestial reference systems, playing a key role in many areas, especially in deep space exploration. However, due to complex data process, EOP is usually released with delay and makes it impossible to use in many real-time situations, so it is to very meaningful to make prediction of EOP.

Artificial neural network (ANN) is a technique for data processing developed during recent decades. Some theoretical analyses show that a BP network with two or three layers is capable of approximating any function with a finite number of discontinuities [Cybenco, 1989; Hornik et al., 1989; Hecht-Nielsen, 1992; Xu and Wu, 2002; Demuth et al., 2008]. So far, many research groups have used ANN to predict EOP (Egger, 1992; Egger and Fröhlich, 1993; Schuh et al., 2002; Zotov, 2005; Milkov et al., 2008; Wang et al., 2008a,b; Xu and Zhou, 2010). The ability of ANN to forecast quasi-periodic and irregular processes in EOP was first tested and shown in Egger (1992) and Egger and Fröhlich (1993). About ten years later, a four-layer neural network was used to forecast EOP by Schuh et al. (2002), and the EOP predictions were shown to have an accuracy that was comparable to and even higher than some traditional linear and non-linear forecast techniques. After that, in 2012, Liao D C et al also using a three-layer network with fixed node numbers of the input- and output-layer.

Considering the time-frequency domain analysis capability of wavelet transform, we adopt the wavelet function in ANN to predict the polar motion, as showed in Fig.1. A three-layer network is constructed and the wavelet function is utilized in mid-layer to approximate the non-linear relationship between the input and output, and finally to make a high-resolution prediction of polar motion.

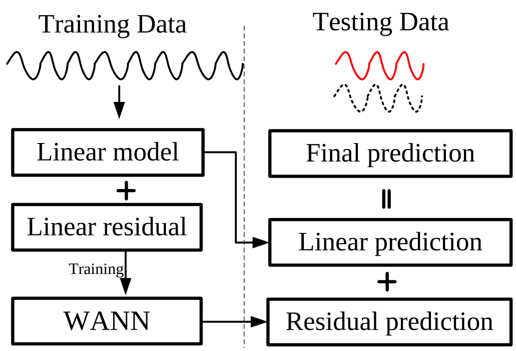

Fig.1 the polar motion prediction scheme based on WANN

Predictions are divided into two parts: the first part is called the linear prediction which is obtained by using linear model parameters to extrapolate 360 days into future, and the second part is called the nonlinear prediction which is obtained by the WANN model. Finally, the linear and nonlinear predictions are added together and compared with the observations.

In order to make a clear comparison, we use the same test strategy as that in Liao (2012), including the time-span of polar motion data and the same prediction error evaluation. The leading time of prediction is from 1 day to 360 days. The first prediction is made between 2001.04.06 (MJD52005) and 2002.03.31 (MJD5264), and then make a 91-day forward to predict again, repeat this progress until the total prediction times is up to 37. The RMSEs of the proposed method and that of Liao (2012) are shown in Fig.2, from which one can see the errors of predictions for each lead time from 1 day to 360days. Moreover, the prediction accuracy of the proposed method is remarkably better than that of in Liao (2012) for the same prediction leading time.

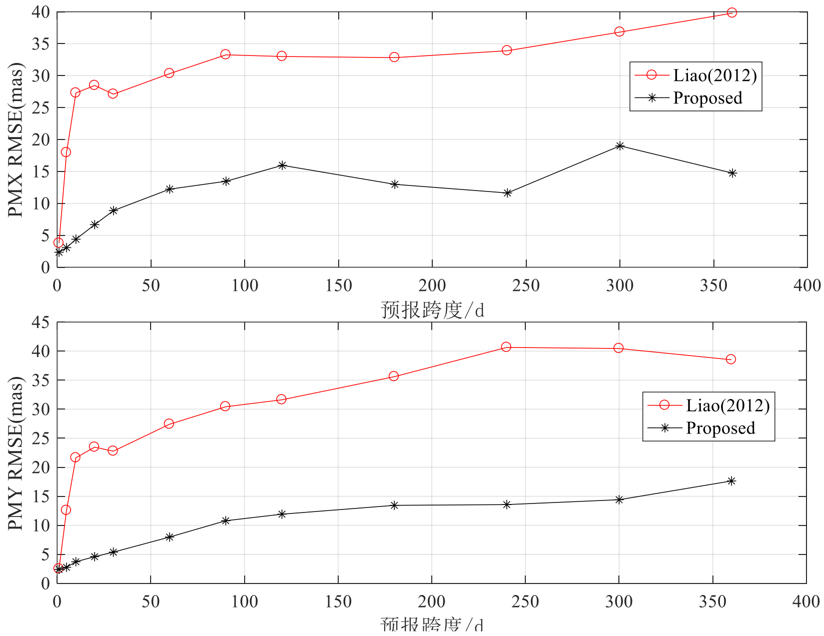

Fig.2 the comparison of polar motion prediction results

An ERP prediction method based on LS+AR model and product precision introduction

Zhijin Zhou[1]

[1]Beijing Aerospace Control Center (BACC), China

Earth orientation parameters（EOP）represent the pointing characteristics of the Earth in inertial space through polar motion coefficients, UT1-UTC, precession and nutation. Among them, precession and nutation describe the kinematic characteristics of the earth system under the inertial celestial system, while polar motion coefficients and UT1-UTC reflect the dynamic characteristics of the earth system itself. Precession and nutation can be accurately modeled, so this report focuses on polar motion coefficients and UT1-UTC prediction methods.

Firstly, the least square modeling is carried out on the EOP data after difference processing to obtain its linear term and periodic term. Then, an autoregression model is established for the nonlinear trend term of EOP. Finally, the inverse differential calculation should be performed to obtain the final prediction products.

Beijing Aerospace Control Center (BACC) developed the EOP prediction software（EOPS）based on the above approach and has been providing daily EOP prediction products automatically since 2015. During these years, the prediction error of pmx in BACC is lower than 0.26 mas in 1 day, 3 mas in 7days, 8 mas in 30 days, 20 mas in 90 days. The prediction error of pmy in BACC is lower than 0.22 mas in 1 day, 1.7 mas in 7days, 5 mas in 30 days, 16 mas in 90 days.The prediction error of UT1-UTC in BACC is about 0.06 ms in 1 day, 0.5 ms in 7days, 4 ms in 30 days, 10 ms in 90 days.

The importance of differences between polar motion series

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In order to further improve users' satisfaction with the medium-short term prediction accuracy of polar motion, this study is the first attempt to introduce the differencing between polar motion series for modeling prediction, and the input data consisted of truth value series and rapid data. This study believes that the stability and forecasting ability of a forecasting method need be tested in the longer forecast interval. Therefore, this study uses the series of the past ten years for testing. The test results show that the overall prediction accuracy of my method is better than IERS Bulletin A within six months in the X direction and three months in the Y direction. The new forecasting strategy proposed in this study has certain reference value.

EOP predictions and climate change indications in Earth rotation

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As one of participations for the 2nd Earth Orientation Parameters Prediction Comparison Campaign (2nd EOP PCC), we submit 2 data files with different methods. One of the file is 365 days' predictions in the future for all the 8 parameters (Px, Py, UT1-UTC, ΔLOD, dX_2000, dY_2000, dPsi_1980, dEps_1980), and proposed by the traditional Least-square and Auto-regressive (LS+AR) model. The another file is 90 days' predictions for the 4 parameters (Px, Py, UT1-UTC, ΔLOD) by the combined Least-square and convolution method (LS+Convolution), with the total effective angular momentum (EAM) from Earth System Modeling GeoForschungsZentrum in Potsdam (ESMGFZ). Compared to LS+AR model, the LS+Convolution method shows generally superiority at short and medium (1-90 days) EOP predictions. Furthermore, based on our latest research about climate change indications in Earth rotation (mainly in Chandler and inter-annual ΔLOD terms), the short-term forecast of climate change preformed both in polar motion and length of day are investigated with EOP predictions.

Key words： EOP prediction. Effective angular momentum. Climate change indication

Predicting polar motion components of EOP using LS-HE and AR(p)

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Earth orientation parameters (EOP) describe the rotation of Earth in space. These parameters explain the coupling process between solid Earth and atmosphere, oceans, mantles, and the Earth's core at different temporal and spatial aspects. Also, the EOP are needed for satellite navigation positioning and spacecraft tracking. However, the EOP are not provided in real-time due to the complexity of the measurement model and data processing. Therefore, it is essential to predict the EOP to fill these temporal gaps precisely. EOP consist of two kinds of parameter sets. One set includes Earth rotation parameters (ERP), whereas the second set consists of precession and nutation. ERP include changes in the length of day (LOD), UT1-UTC and polar motions (PM), polar coordinates x and y components, expressing the position of the Earth's instantaneous rotation axis. In this study, time series of x and y components were analyzed by the Least Squares Harmonic Estimation (LS-HE) method to extract their dominant frequencies. These frequencies compensate for the deterministic periodic behavior of the series, used in the functional model. To compensate for the stochastic process of the series, in the next step, the autoregressive (AR) model is fitted to the detrended time series. AR(50) was found to be an appropriate stochastic process. The above functional and stochastic models were then used to forecast future values. To be consistent with the results of the Bulletin A, we predicted values on the 360 days basis from 2016 to 2019 with a window shift of 28 days. The predicted values were then compared with their true (observed) values. The results provide a mean absolute error (MAE) of 14.80 mas and 16.80 mas for x and y, respectively. These values are substantially smaller than the results provided by the Bulletin A. The improvement in the PM prediction accuracy, up to 360 days in a year ahead, is found to be 30% on average compared with the Bulletin A prediction, and hence can be used to replace this model.

Towards the improvement of EOP prediction: The Preliminary result of our joint group contributions to EOP PCC

Sadegh Modiri[1], Daniela Thaller[1], Santiago Belda[2], Sonia Guessoum[2], José M. Ferrándiz[2], Shrishail Raut[3,4], Sujata Dhar[3], Robert Heinkelmann[3], and Harald Schuh[3,4]

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The real-time Earth orientation parameters (EOP) estimation is needed for many applications, including precise tracking and navigation of interplanetary spacecraft, climate forecasting, and disaster prevention. However, the complexity and time-consuming data processing always lead to time delays. Accordingly, several methods were developed and applied for the EOP prediction. However, the accuracy of EOP prediction is still not satisfactory even for prediction of just a few days in the future. Therefore, new methods or a combination of the existing approaches can be investigated to improve the predicted EOP. To assess the various EOP prediction capabilities, the international Earth rotation and reference systems service (IERS) established the working group on the 2nd Earth Orientation Parameters Prediction Comparison Campaign (2nd EOP PCC). Our EOP prediction team provides the full set of EOP predictions weekly for one year ahead. In this campaign, we used the SSA+Copula method and the empirical free core nutation (FCN) model (named B16) for Earth rotation parameters and celestial pole offsets (CPO) prediction, respectively. Additionally, we investigated new prediction techniques and different input data set; as an example, the Convolutional Neural Networks (CNN) is introduced to model and predict the short-term EOP. Our preliminary results illustrate an improvement in EOP prediction compared to the current EOP prediction methods, especially on CPO.

Keywords: EOP, Prediction, Copula-based analysis, IERS, FCN

Improving atmospheric angular momentum forecasts by machine learning

Robert Dill[1], Jan Saynisch-Wagner[1], Christopher Irrgang[1]

[1]ESMGFZ (Earth System Modelling Group GFZ Section 1.3)

Earth angular momentum forecasts are naturally accompanied by forecast errors that typically grow with increasing forecast length. In contrast to this behavior, we have detected large quasi-periodic deviations between atmospheric angular momentum wind term forecasts and their subsequently available analysis. The respective errors are not random and have some hard to define yet clearly visible characteristics which may help to separate them from the true forecast information. We tested an analytical approach and a neural network to predict and remove those forecast errors. With a cascading forward neural network model a total error reduction with respect to the unaltered forecasts amounts to about 30% integrated over a 6 day forecast period. Integrated over the initial 3 day forecast period, in which the largest artificial errors are present, the improvements amount to about 50%. After the application of the neural network, the remaining error distribution shows the expected growth with forecast length.