上海天文台
Shanghai Astronomical Observatory

Research on prediction of Earth orientation parameters

Xueqing Xu Yonghong Zhou Leonid . Zotov

28 August 2012

Beijing China

Contents

- Introduction of EOP prediction
- Our work about EOP prediction
- Participation of EOPC PPP

（1） Introduction of EOP prediction

- Earth orientation parameters (EOP) mainly contains UT1-UTC, LOD (Length of day), PMX and PMY (Polar motion component).
- Earth orientation parameters (EOP) is essential for transformation between the celestial and terrestrial coordinate systems.

（1） Introduction of EOP prediction

- The Earth Orientation Parameters Prediction Comparison Campaign, abbreviated as EOP PCC.
- Attracted 11 participants, and collected almost 6500 submissions .
- Estimating the accuracy of the EOP predictions and provoke the improvement.

（1） Introduction of EOP prediction

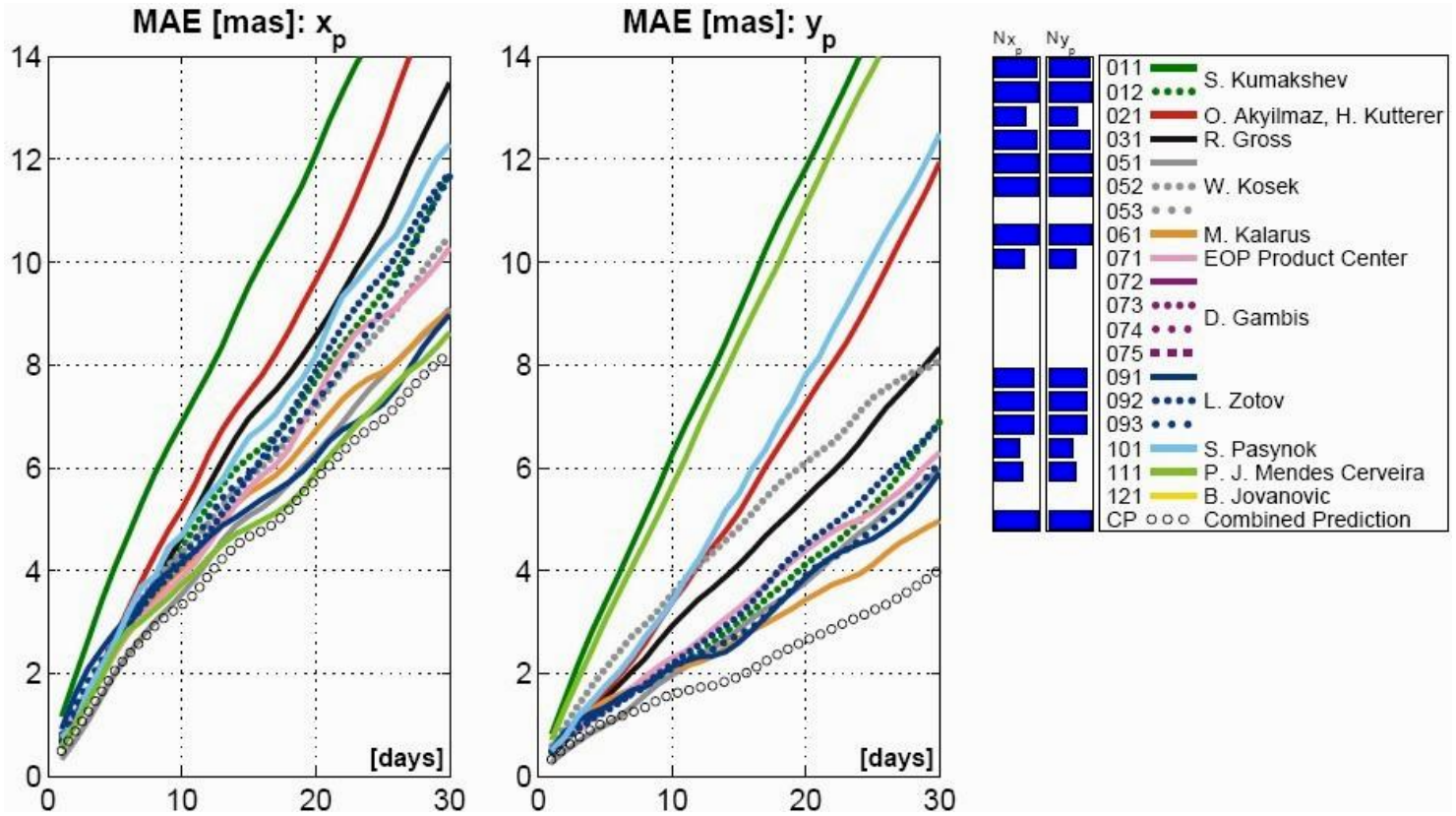


Fig 1. short term prediction accuracy（MAE）of PMX and PMY

（Kalarus et al., 2010）

（1） Introduction of EOP prediction

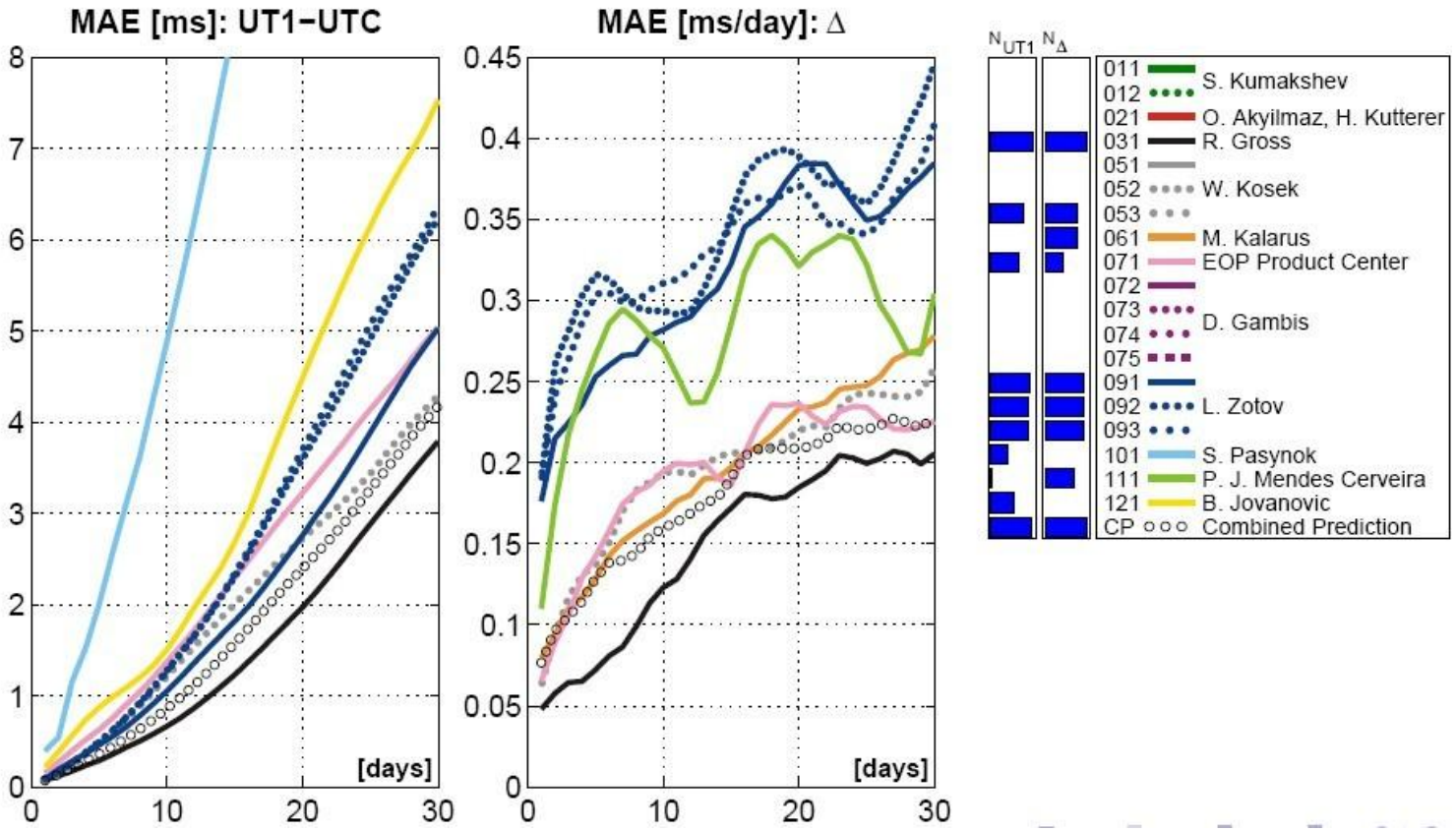


Fig 2. short term prediction accuracy（MAE）of UT1-UTC and △LOD（Kalarus et al., 2010）

（1） Introduction of EOP prediction

- Result shows that no single forecasting method works as good for all the parameters and all the time spans （Kalarus et al., 2010； XQ. Xu et al., 2010）.
- Get a joint solutions of variety forecasting methods to improve the accuracy and stability of EOP prediction .

（2） Our work about EOP prediction

- **AR+Kalman method**
- we employ for the first time a combination of AR model and Kalman filter (AR+Kalman) in short-term EOP prediction.
- The combination of AR model and Kalman filter shows a significant improvement in short-term EOP prediction.

（2） Our work about EOP prediction

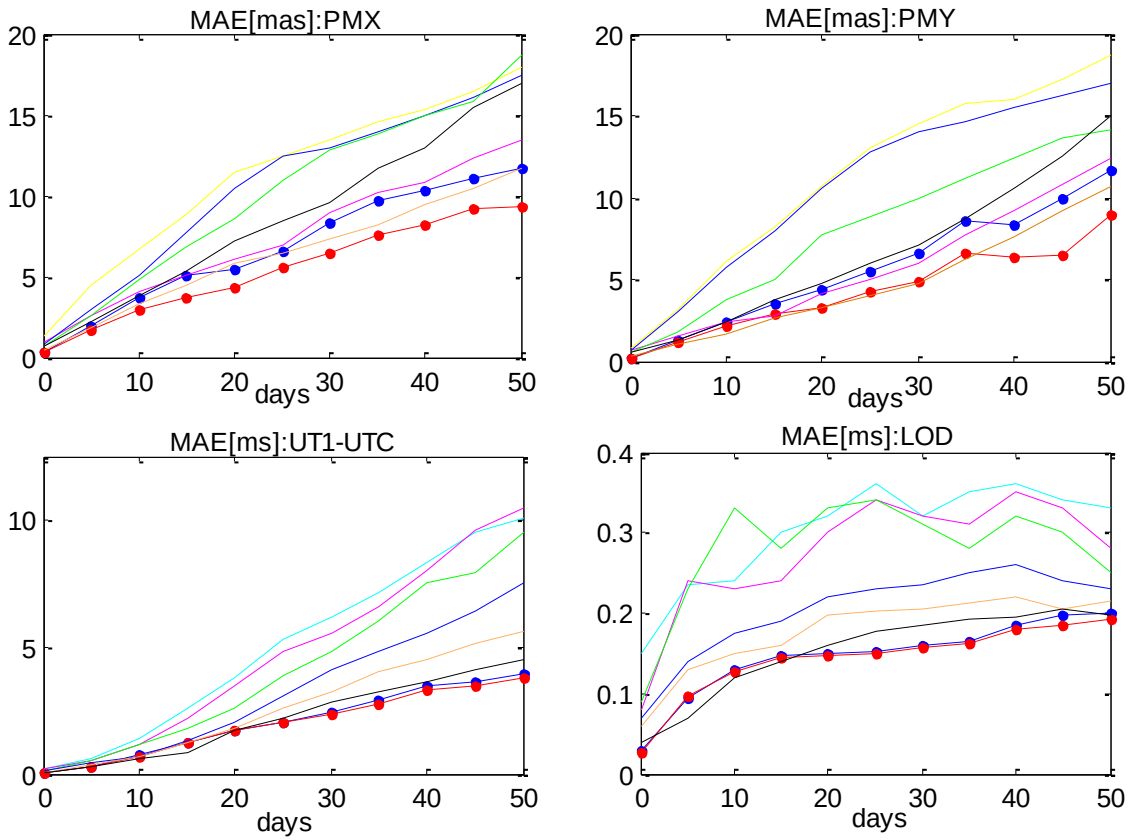


Fig 3. MAE for different prediction intervals for x and y components of polar motion (PMX, PMY),UT1-UTC, LOD from this study and the EOP prediction comparison campaign (EOP PCC) (Kalarus et al., 2010). Blue curve and dots: this study using AR model; Red curve and dots: this study using AR +Kalman model; others(EOP PCC)(XQ .Xu., et al., 2011; Kalarus et al., 2010).

（2） Our work about EOP prediction

- **Combined Prediction**

- Least Squares

$$X_t = A + Bt + C\cos(\frac{2\pi t}{p_1}) + D\sin(\frac{2\pi t}{p_1}) + E\cos(\frac{2\pi t}{p_2}) + F\sin(\frac{2\pi t}{p_2}), \quad (1)$$

- Auto Regression model

$$z_t = \sum_{i=1}^{p} \varphi_i z_{t-i} + a_t \quad , \quad (2)$$

- Least Squares Collocation

$$\hat{f} = Q_{fx} Q_{ll}^{-1} l \quad , \quad (3)$$

- Artificial Neural Network

$$y = f_3(W_3 f_2(W_2 f_1(W_1 x))) \quad (4)$$

（2） Our work about EOP prediction

- **Error statistics and weight**

- Mean error:

$$ME_i = \frac{1}{n-1}\sum_{j=1}^{n}(p_j^i - o_j^i) \qquad (5)$$

- Mean square error:

$$MSE_i = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(p_j^i - o_j^i)^2} \qquad (6)$$

- Weight:

$$w_l(t_i) = \frac{k}{ME(t_i)^2 + MSE(t_i)^2} \qquad (7)$$

$$\sum\nolimits_l w_l(t_i) = 1$$

（2） Our work about EOP prediction

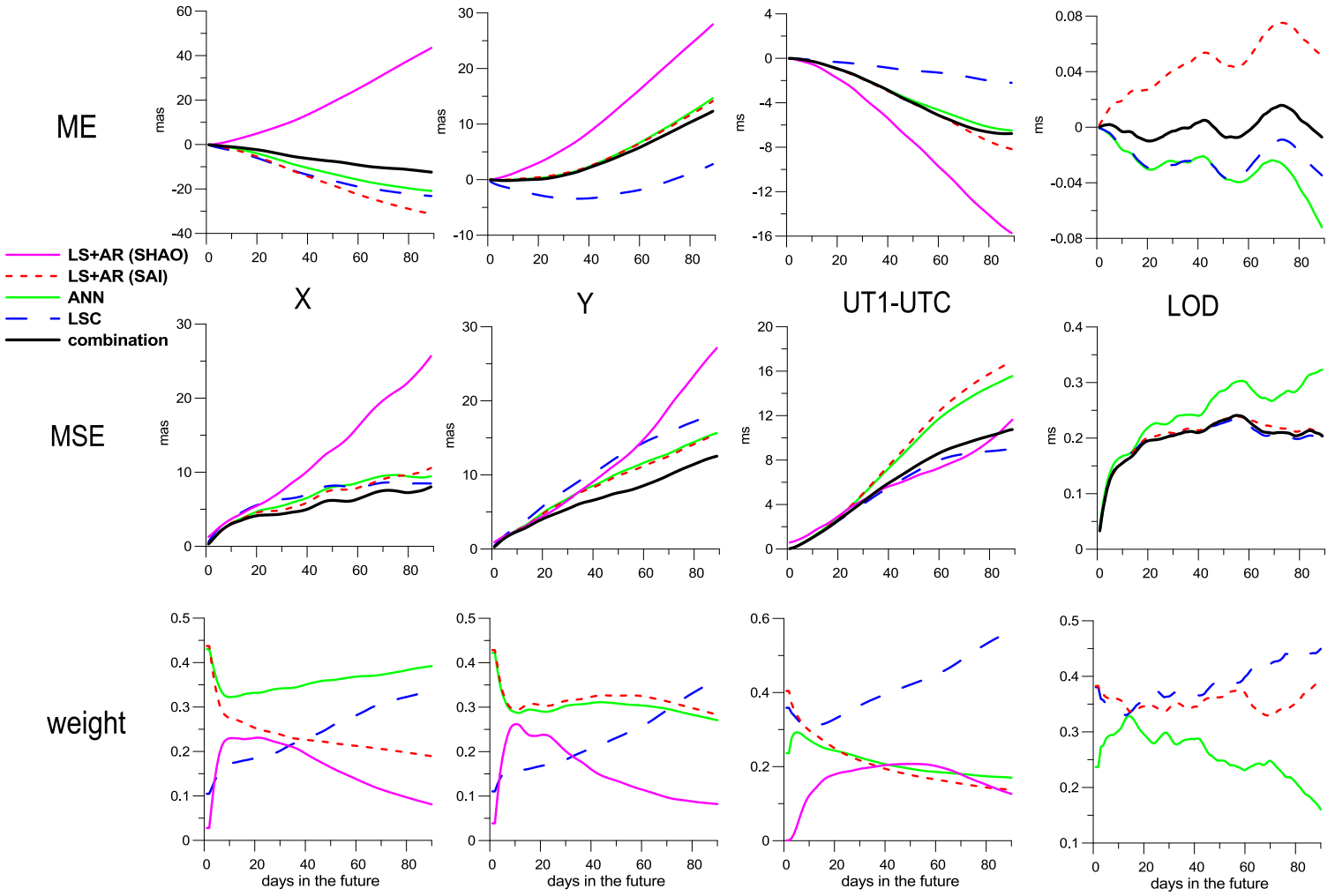


Fig 4. Statistics for MJD 55659-55900 (XQ .Xu., et al., 2012)

（2） Our work about EOP prediction

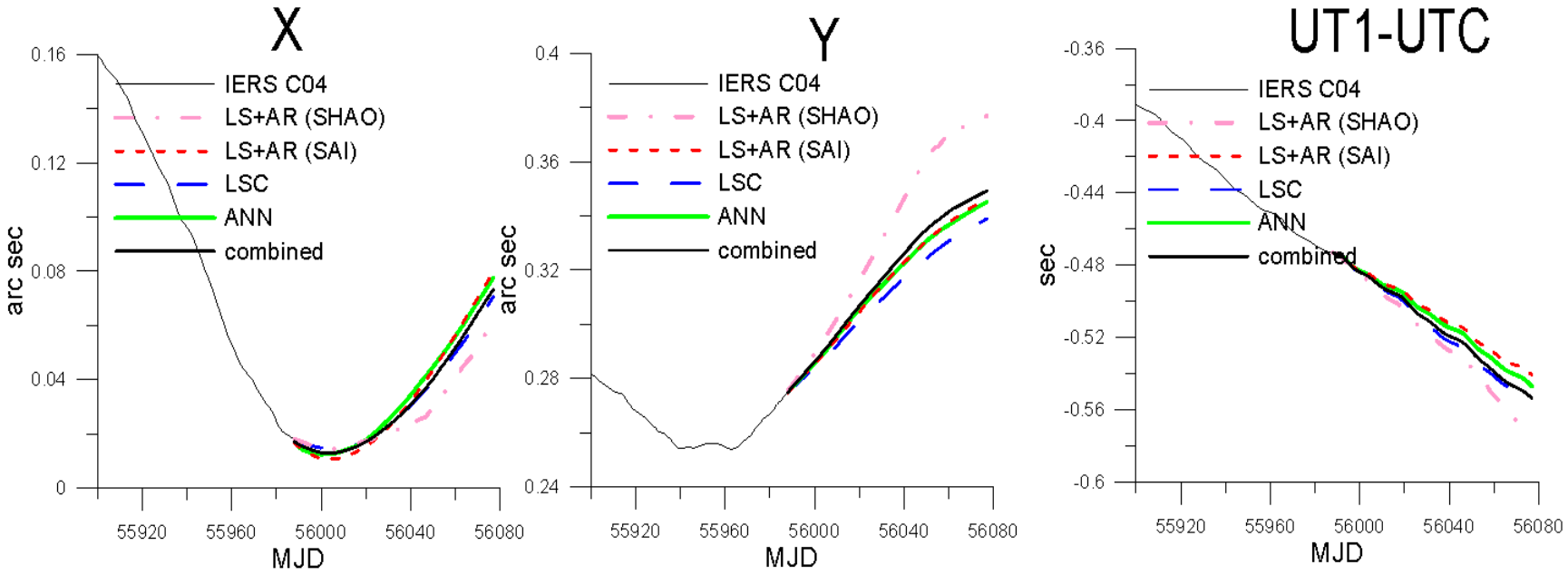


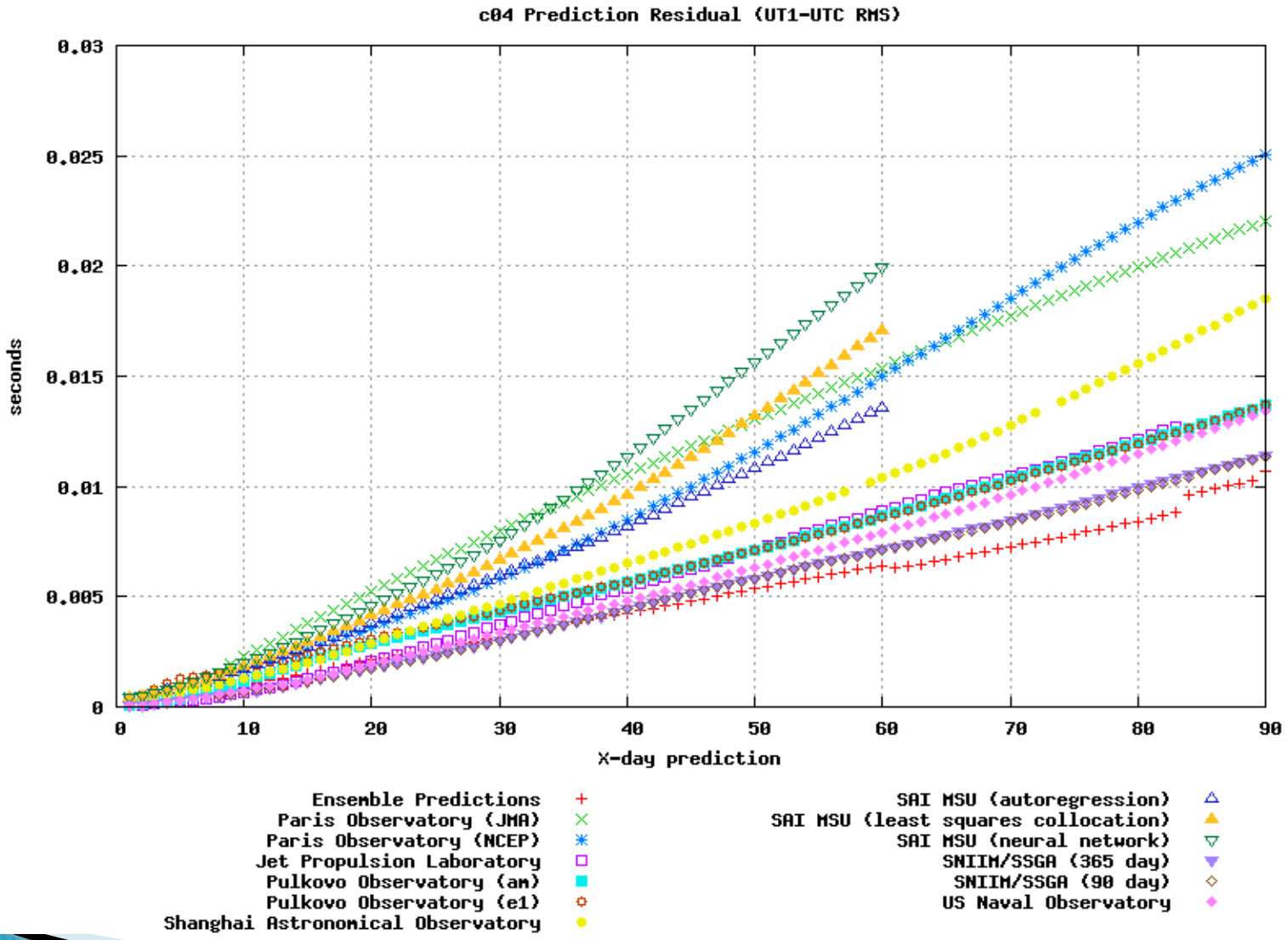
Fig 5. EOP 90 days prediction of different method and combined solution (XQ .Xu., et al., 2012)

（3） Participation of EOPC PPP

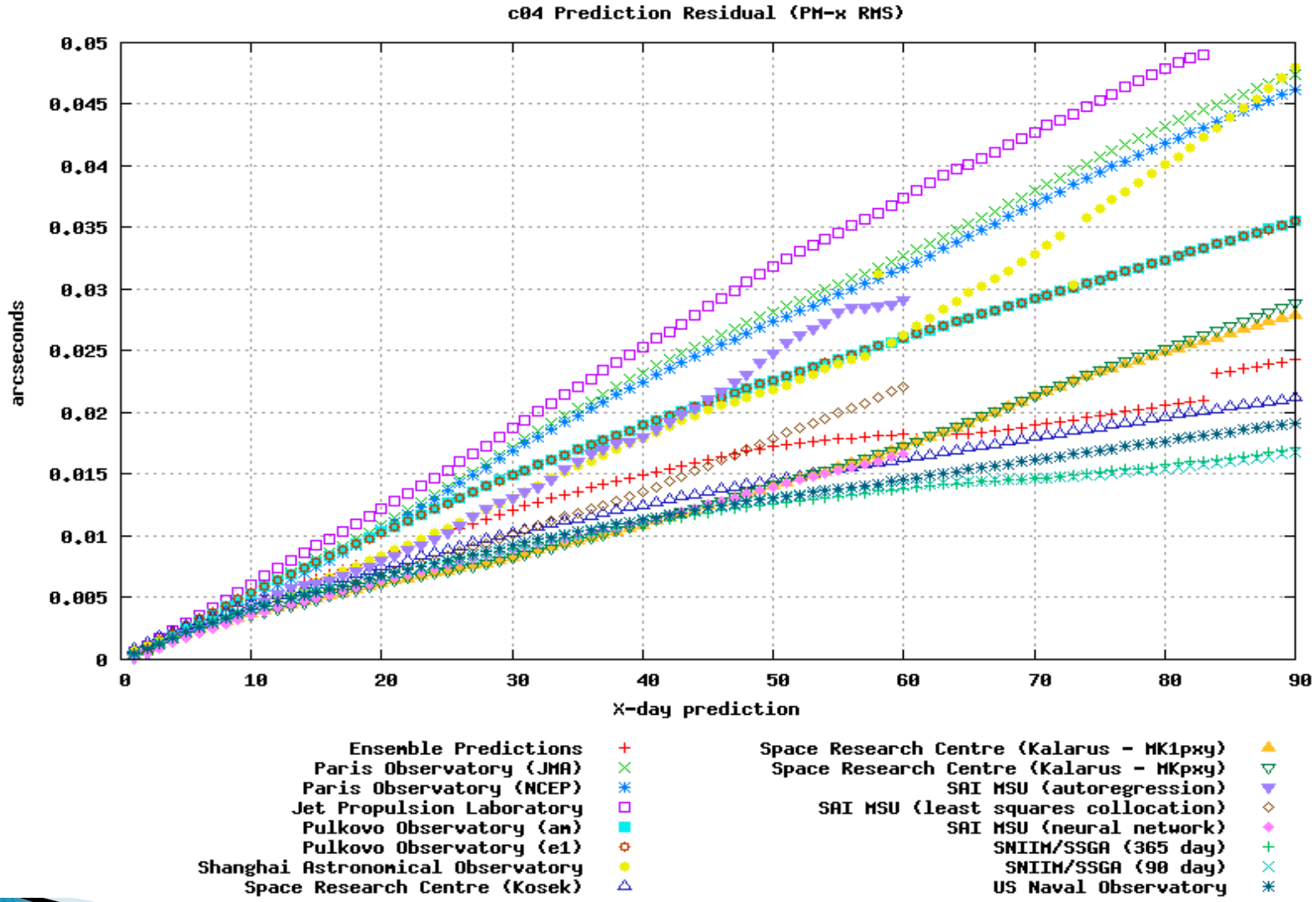
- **EOPC PPP**
- Earth Orientation Parameter Combination of Prediction Pilot Project，abbreviated as EOPC PPP, China participate in the activities for the first time .

Shanghai Astronomical Observatory	
Primary Contact	Xu Xueqing [xqxu@shao.ac.cn]
EOP Predictions	▪ http://202.127.29.4/xxg/ ▪ USNO mirror
Explanation/Methodology	▪ The EOP data are pre-processed to remove known effects such as leap seconds and solid Earth tides, differenced, and then least-squares extrapolation and autoregressive (LS+AR) methods are applied to the data.

（3） Participation of EOPC PPP



（3） Participation of EOPC PPP



summary

- AR+Kalman is an effective method for EOP Prediction.
- Combined prediction can improve EOP forecasting accuracy significantly.
- High precision EOP prediction needs more cooperation.

Thanks for your attention!