Federal Agency for Cartography and Geodesy

BKG
Wir geben Orientierung.

EOP Prediction with special focus on SLR

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Introduction

Accurate real-time transformation between the CRF and TRF is needed

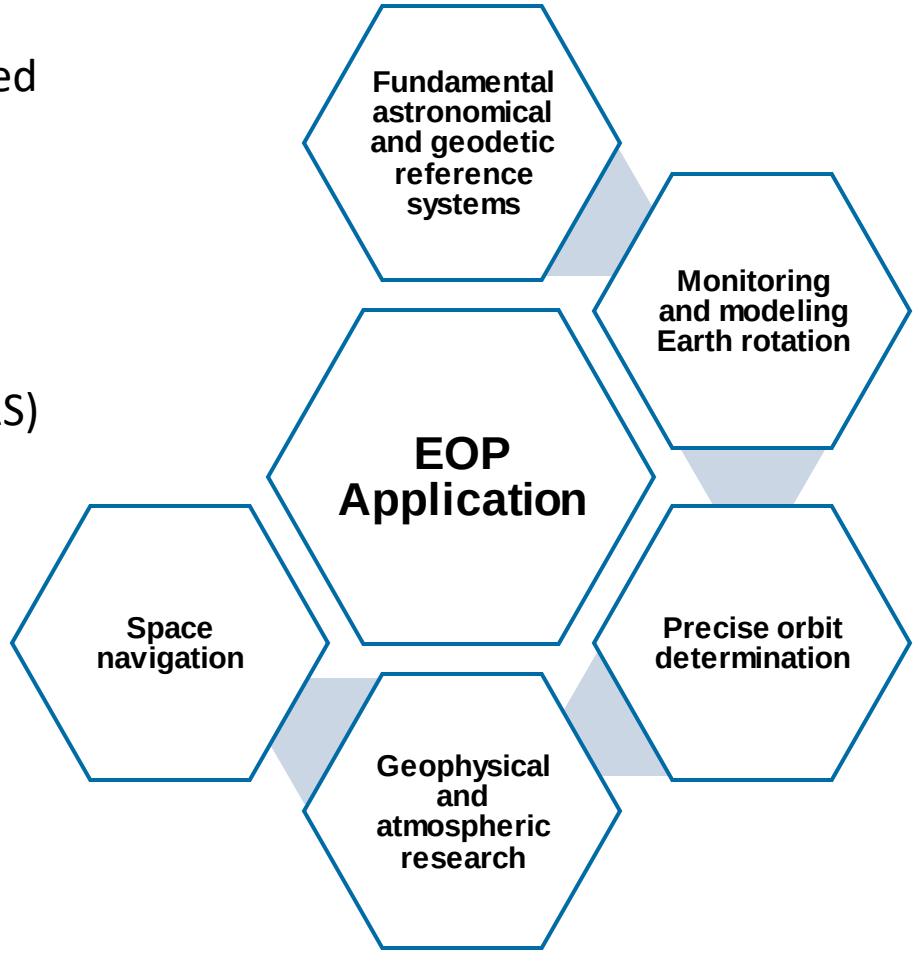
- High-precision satellite navigation and positioning
  - Used for monitoring water vapor, Tsunamis, and Earthquakes.
- Interplanetary spacecraft missions
- Radio and radar astronomy observation

The International Earth Rotation and Reference Systems Service (IERS) provides EOP data with a **delay** of **hours** to **days**.
Therefore, **EOP prediction** is needed!

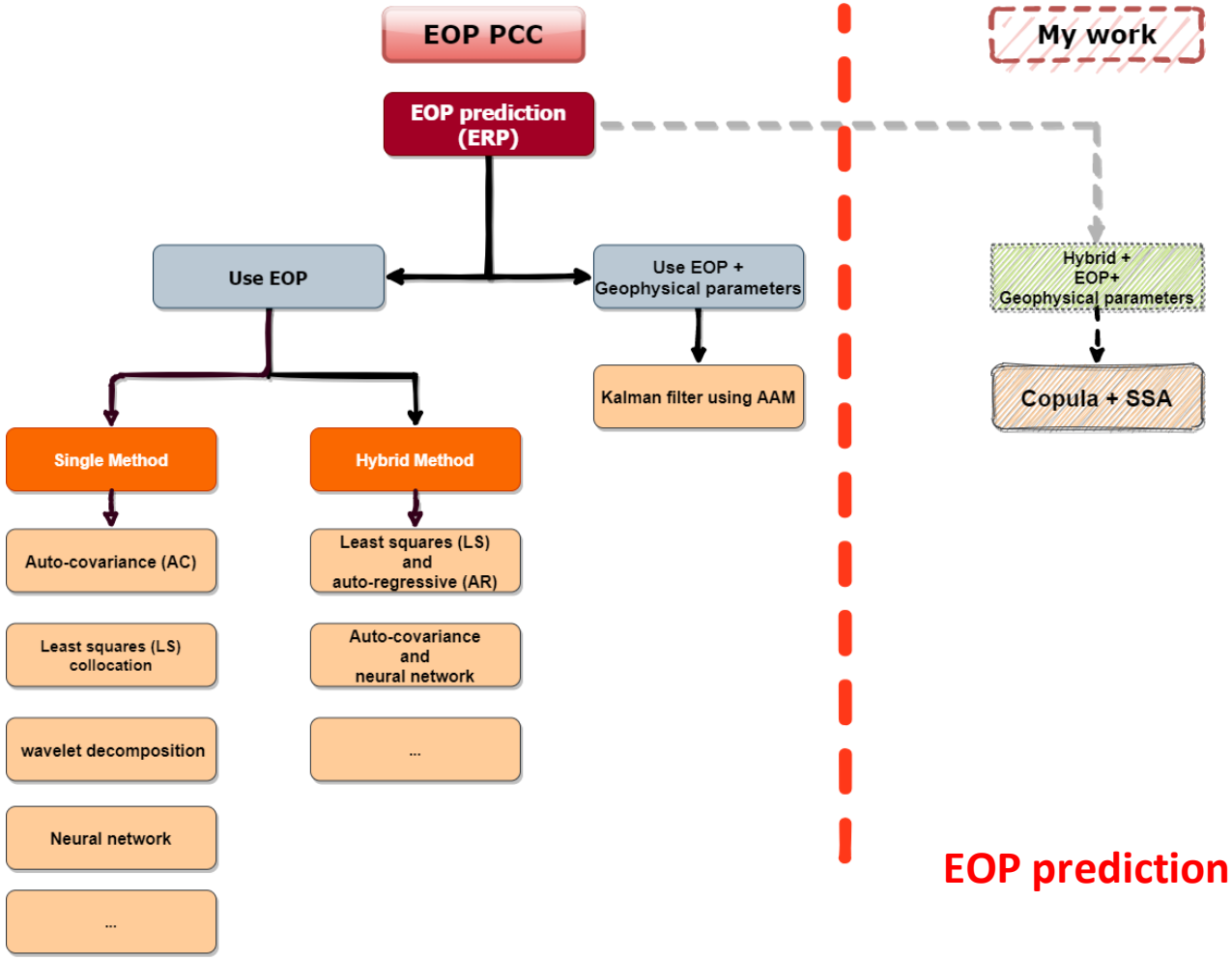
However, the accuracy of EOP prediction is still not satisfactory!

There is **no** single prediction technique performing best for all EOP components and all prediction intervals.

Therefore, new approaches / combination of existing approaches are investigated to improve the accuracy of the predicted EOP.



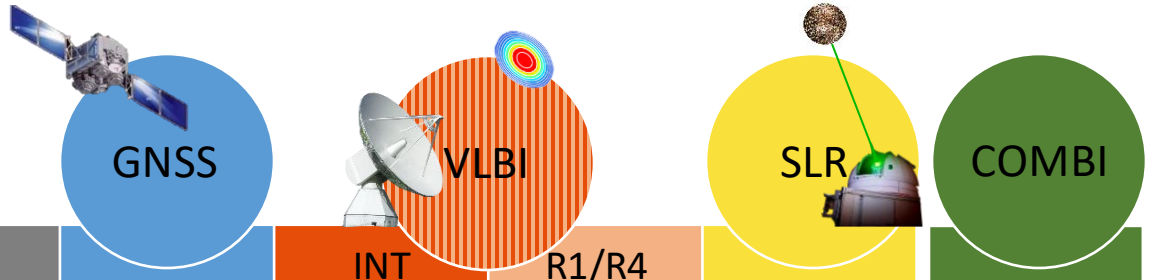
2nd Earth Orientation Parameters Prediction Comparison Campaign (EOP PCC)



Starting in 2021, the 2nd EOP PCC is being performed under the auspices of the IERS. The dedicated IERS Working Group on 2nd EOP PCC has been established.

EOP prediction comparison campaign (EOP PCC) within 2005–2009 (Kalarus et al. 2010)

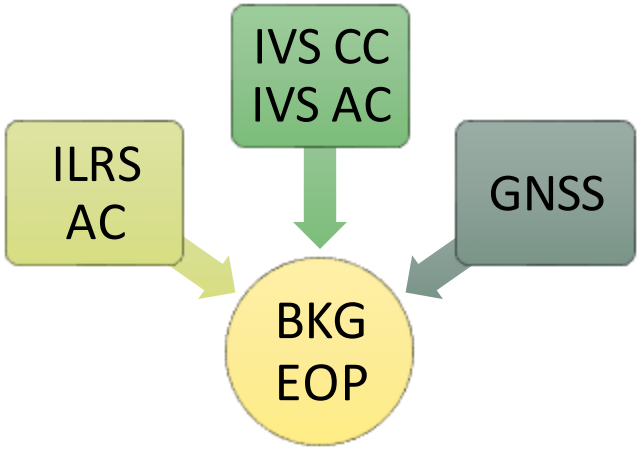
EOP Data



ERP		INT	R1/R4		
dUT1	●	●	●	●	●
LOD	●	●	●	●	●
Polar Motion	●	●	●	●	●

In **BKG**, we provide EOP data from different space geodetic techniques and plan to have an operational EOP prediction service.

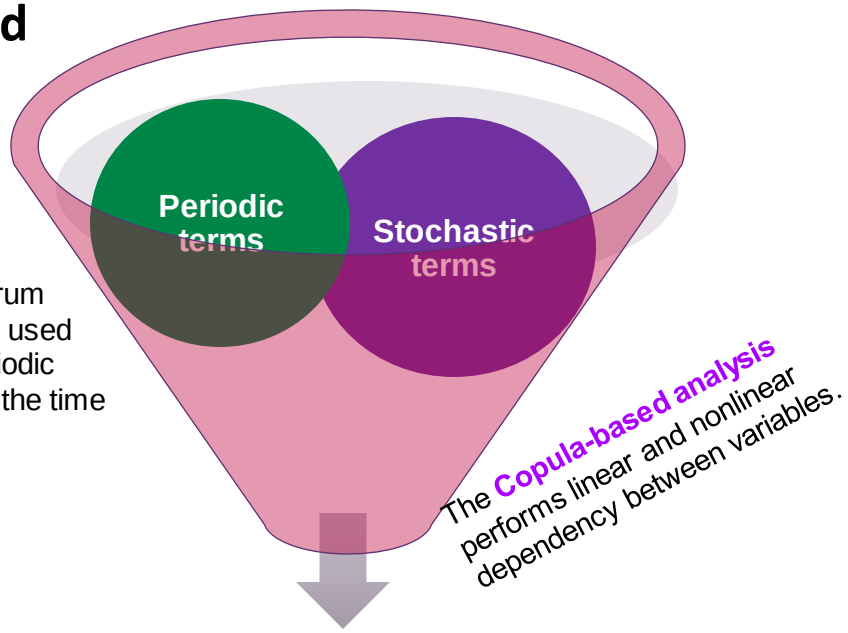
We used IERS EOP data for 2nd EOP PCC!



Prediction Technique

- **ERP Prediction**

  - **Combination of SSA + Copula analysis method**



Singular Spectrum Analysis (**SSA**) used for deriving periodic components of the time series.

The **Copula-based analysis** performs linear and nonlinear dependency between variables.

Hybrid model: SSA + Copula

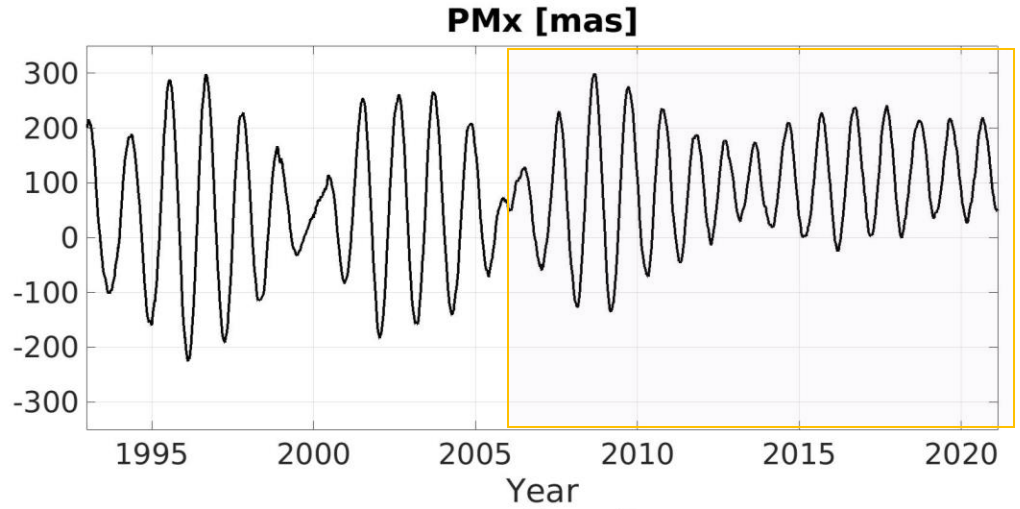
Singular Spectrum Analysis (SSA)

- SSA is a general time series analysis method which has been used for a wide range of tasks such as trend detection and extraction, de-noising, forecasting and change-point detection.
- It is a nonparametric method.

Copula-based Analysis

- Copula contains all the information about dependence between random variables,
- Any multivariate distribution can serve as a Copula,
- Extension of the common concept of Correlation and Covariance.

Example 1: PM Prediction using SLR



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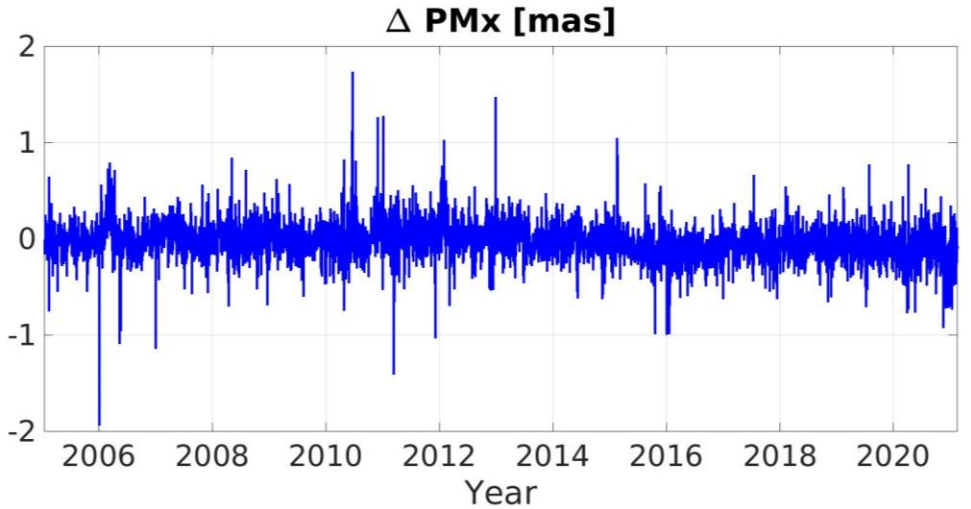

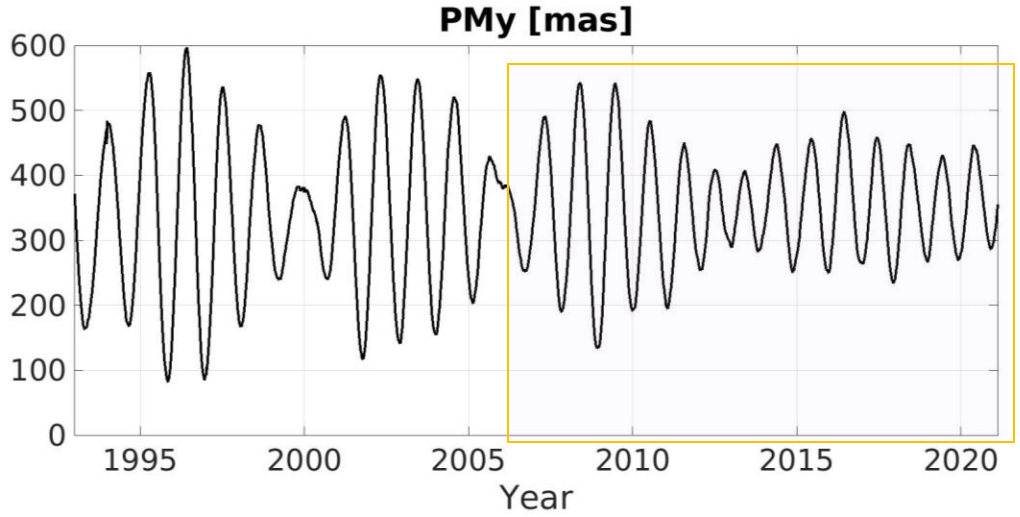

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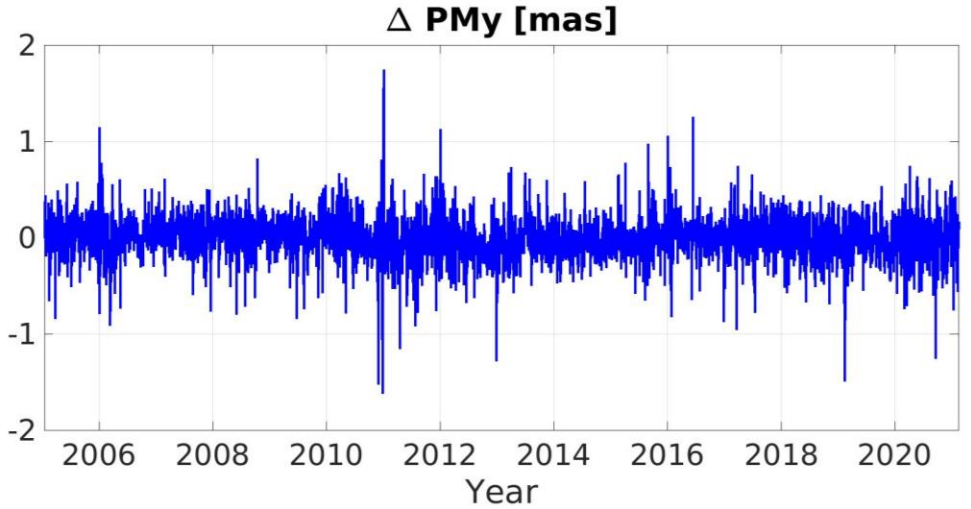

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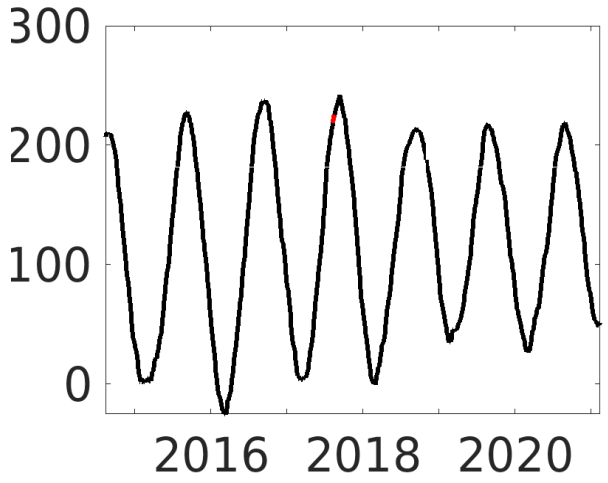
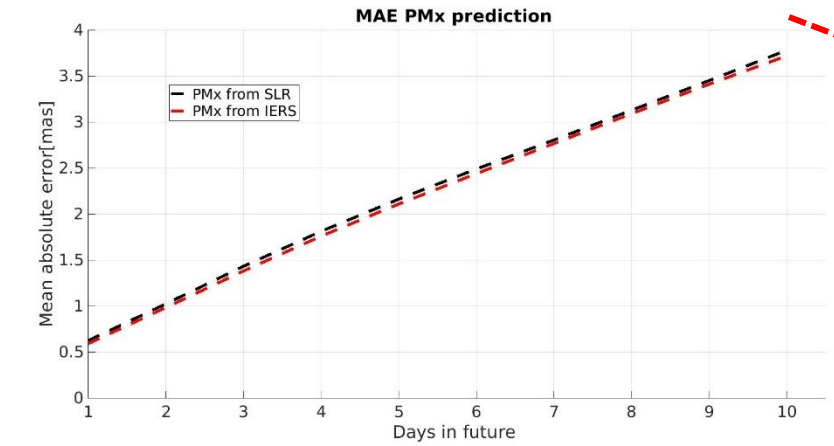
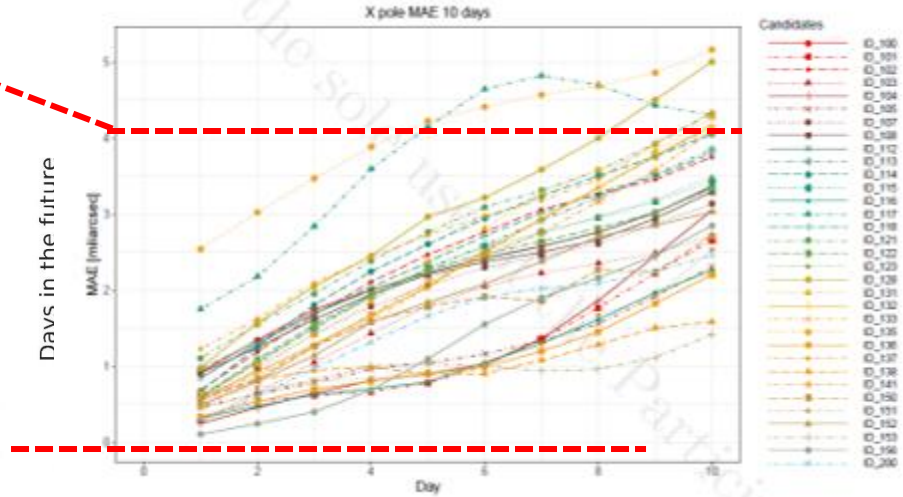
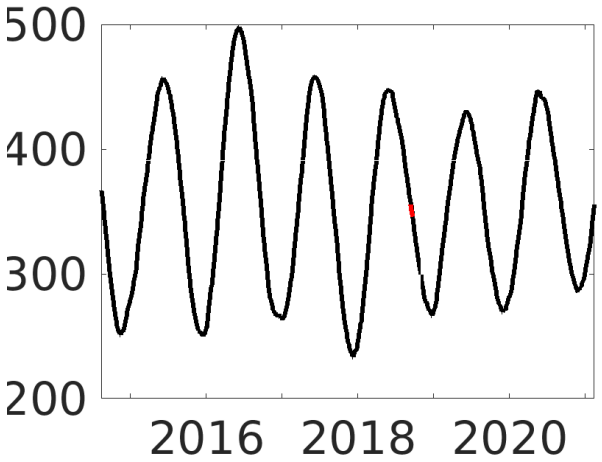
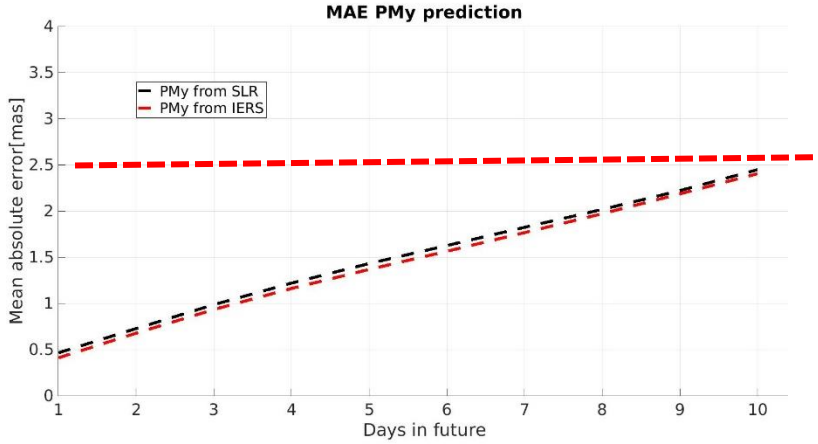
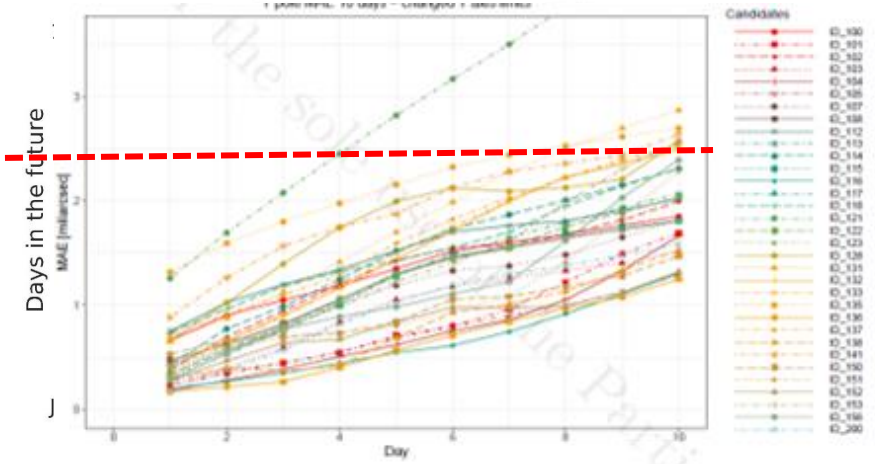




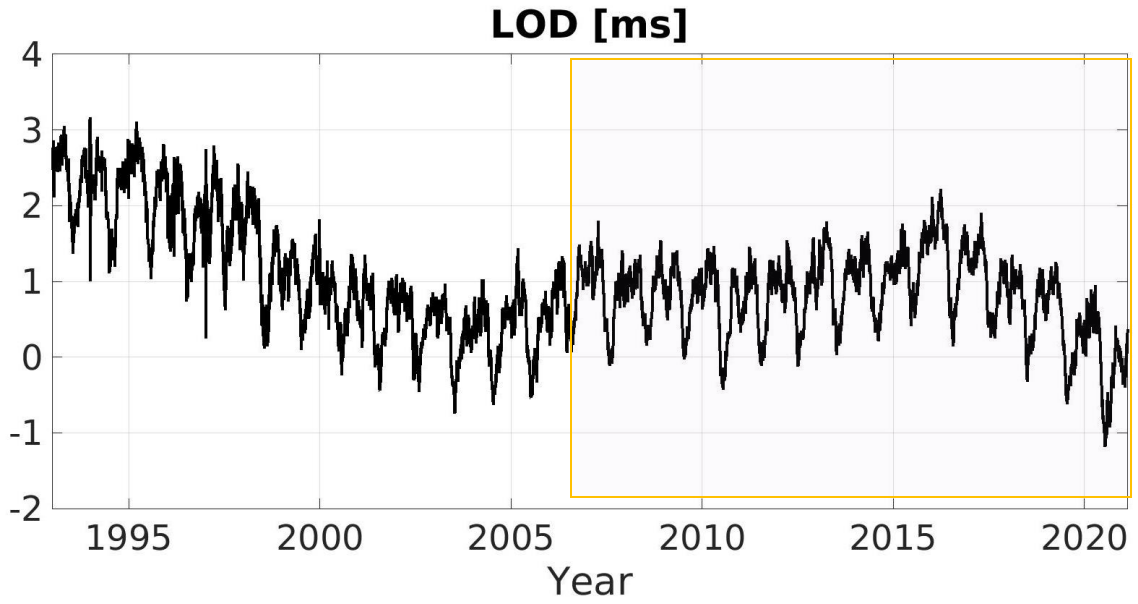


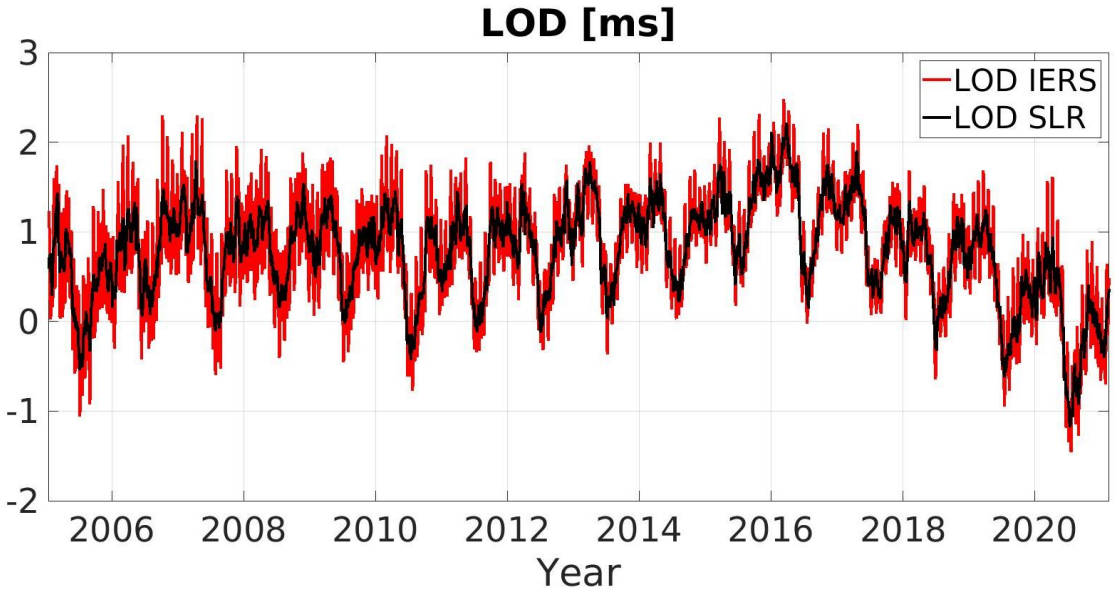




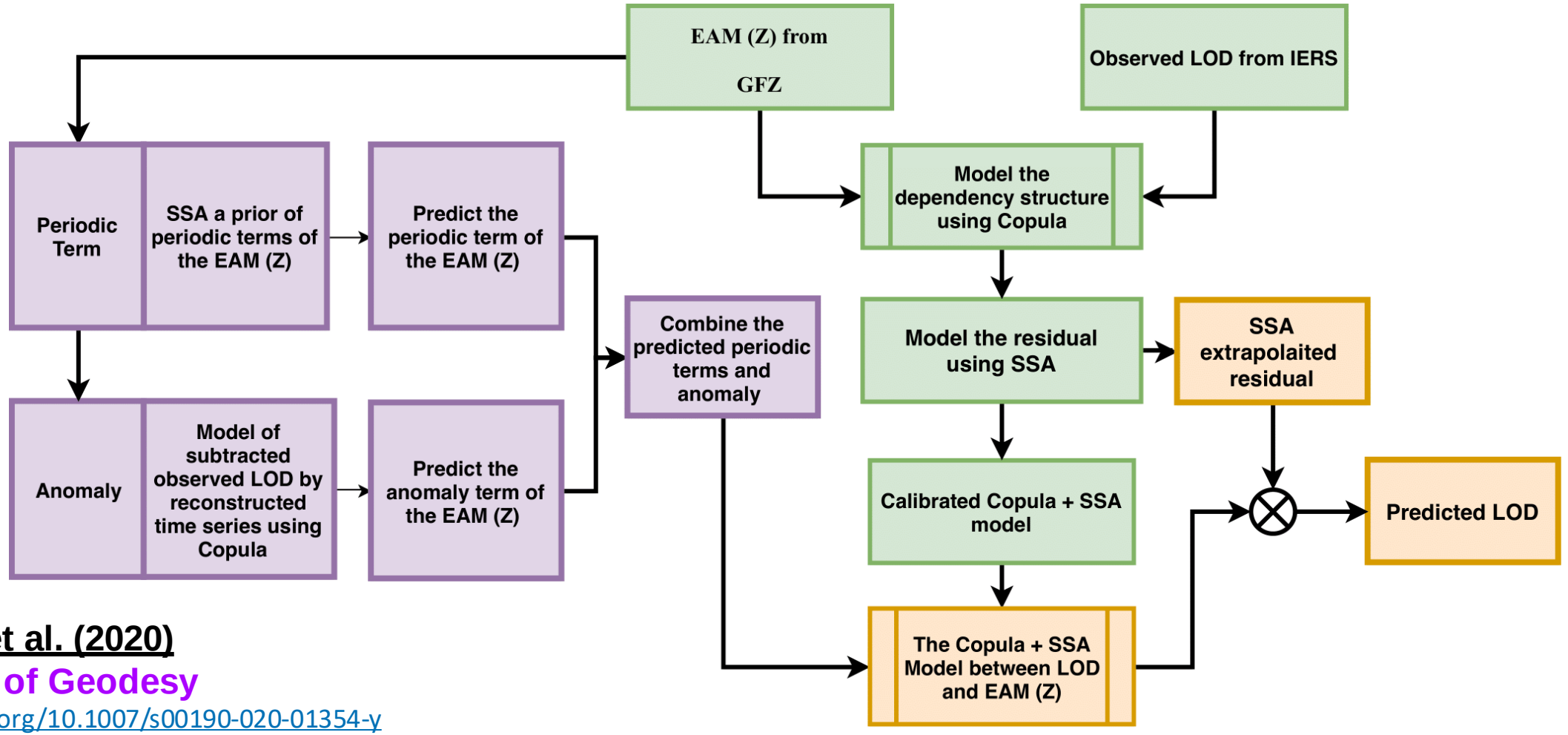


Example 2: LOD Prediction using SLR





Example 2: LOD Prediction Model

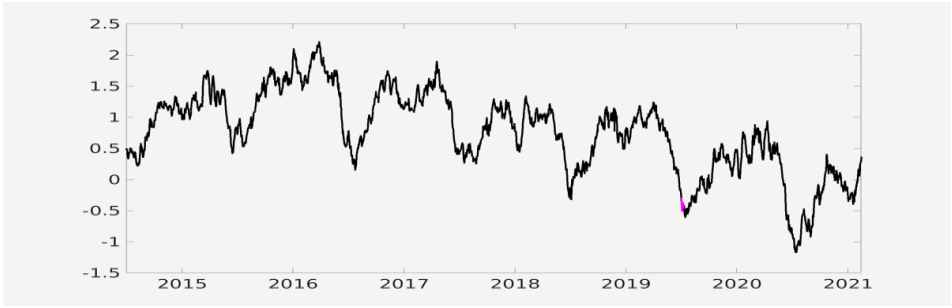


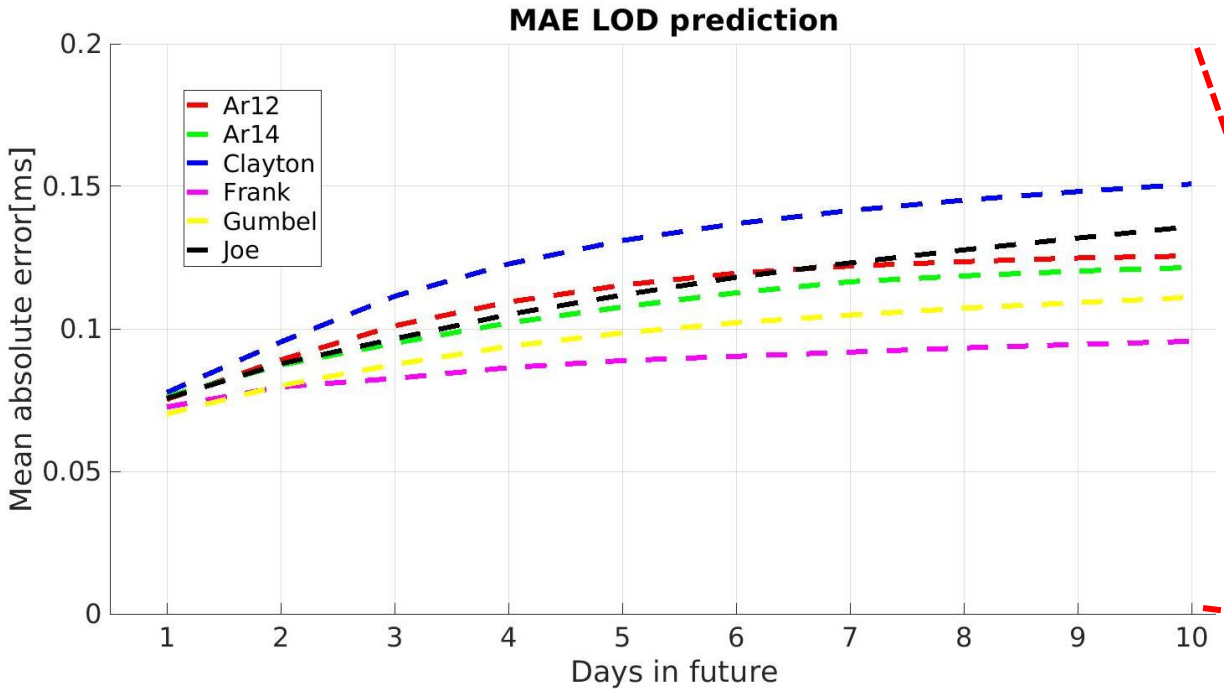
Modiri et al. (2020)

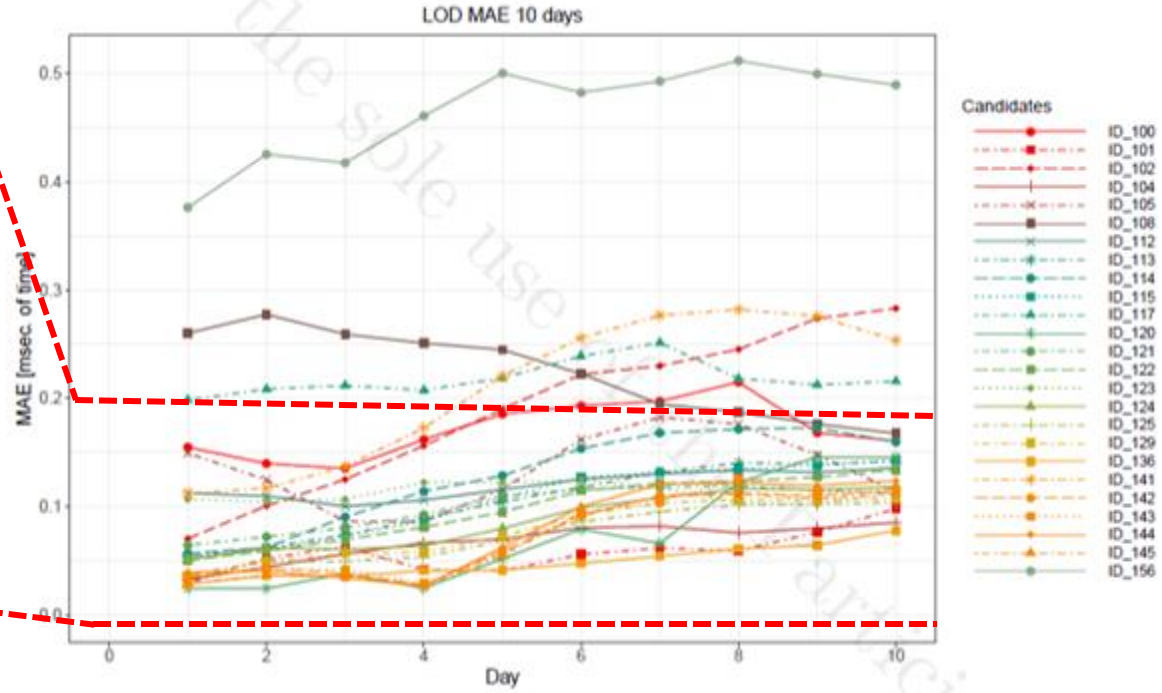
Journal of Geodesy

https://doi.org/10.1007/s00190-020-01354-y

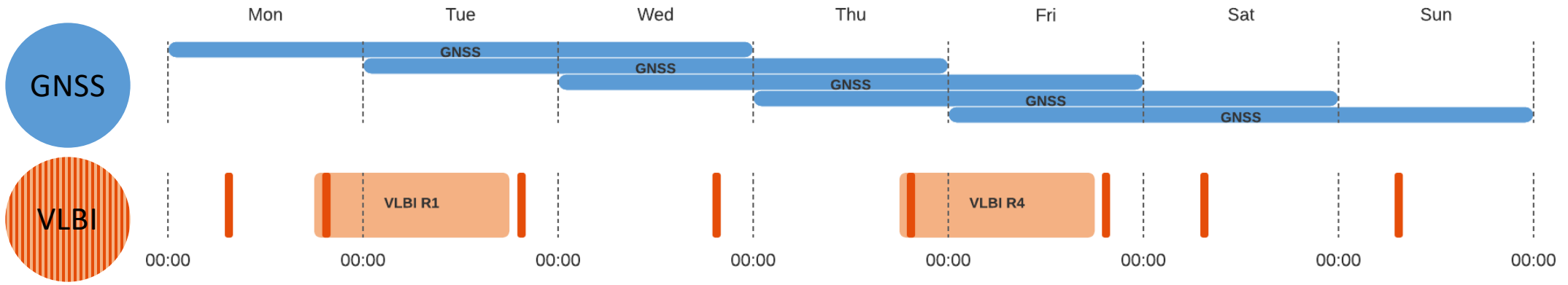
Example 2: LOD Prediction using SLR







Example 3: dUT1 Prediction using Combination of GNSS and VLBI as Input



72h-Rapid SINEX
IGS CODE AC

24h-R1/R4 SINEX
1h-Intensives SINEX
IVS BKG AC

VLBI Rapid Sessions (R1/R4)

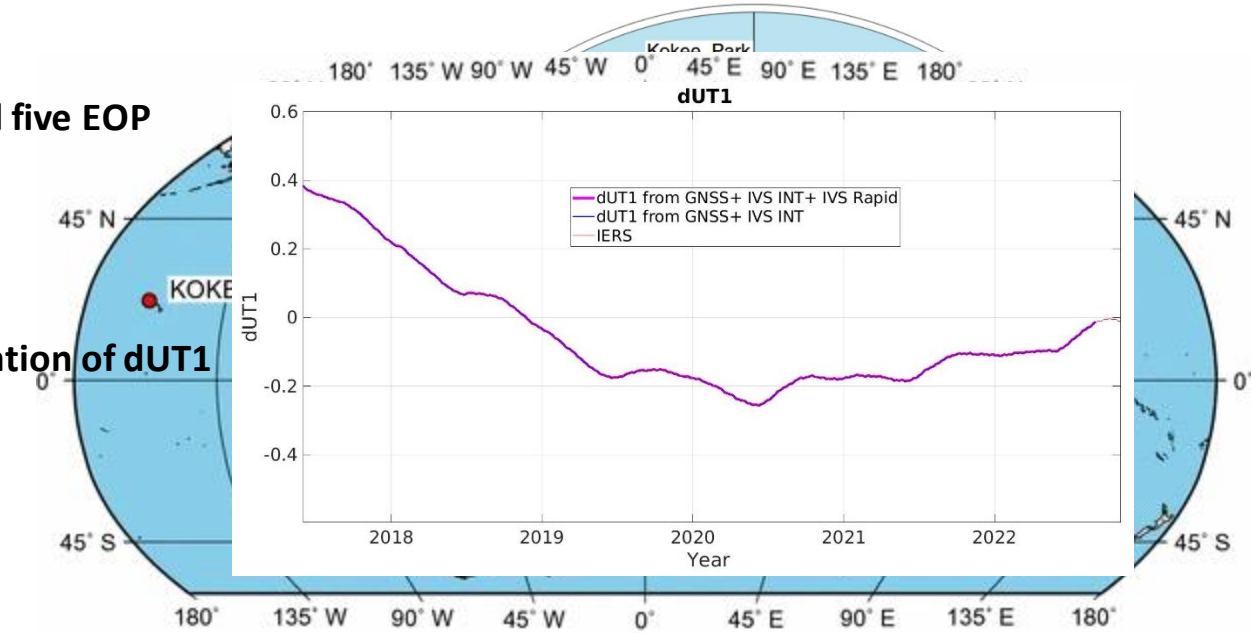
- Global network of 8-15 antennas for the **estimation of all five EOP**
- **24-hour** observation **twice per week**
- **14 days** latency

VLBI Intensive Sessions (INT)

- Baselines optimized in **East-West direction** for the **estimation of dUT1**
- **1-hour** observation **per day**, not equidistant in time

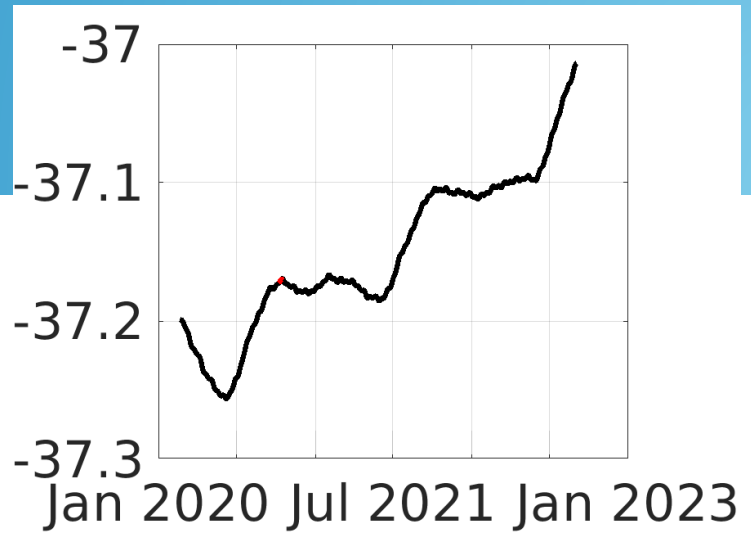
INT1	Mon-Fri	18:30-19:30 UTC
INT2	Sat-Sun	07:30-08:30 UTC
INT3	Mon	07:30-08:30 UTC

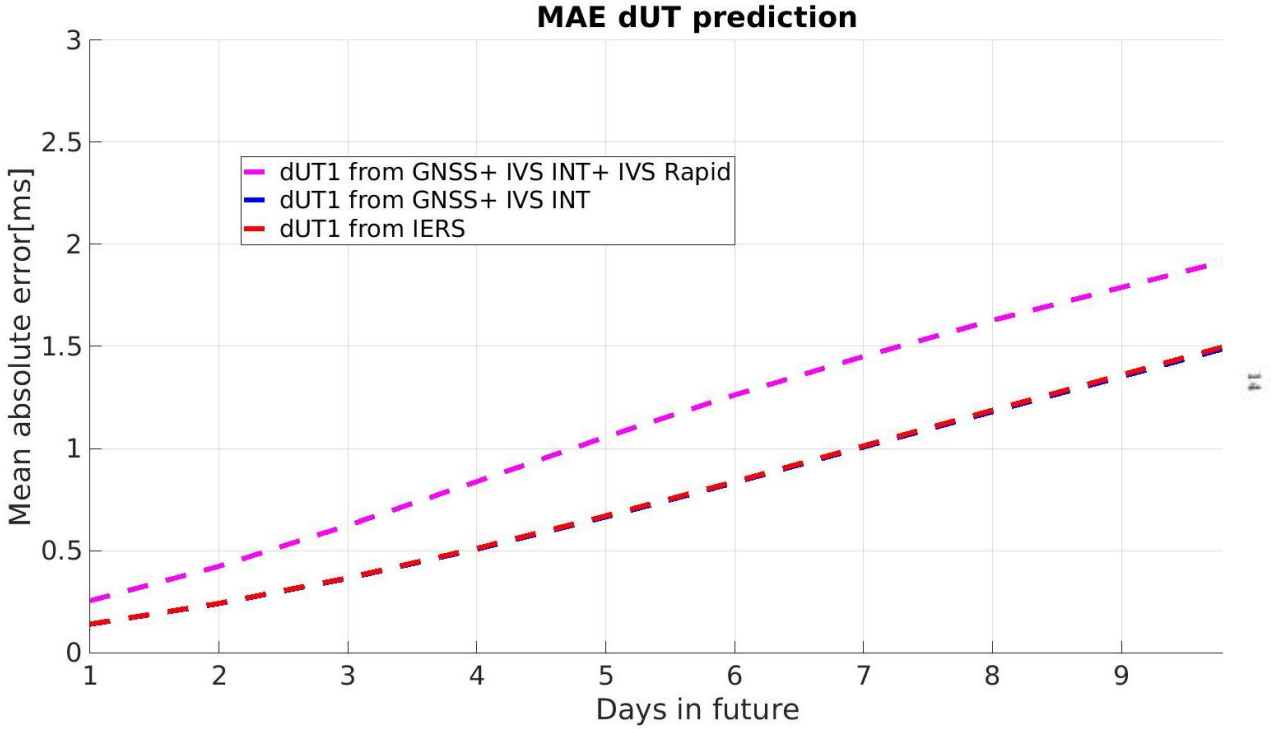
- **1-2 days** latency

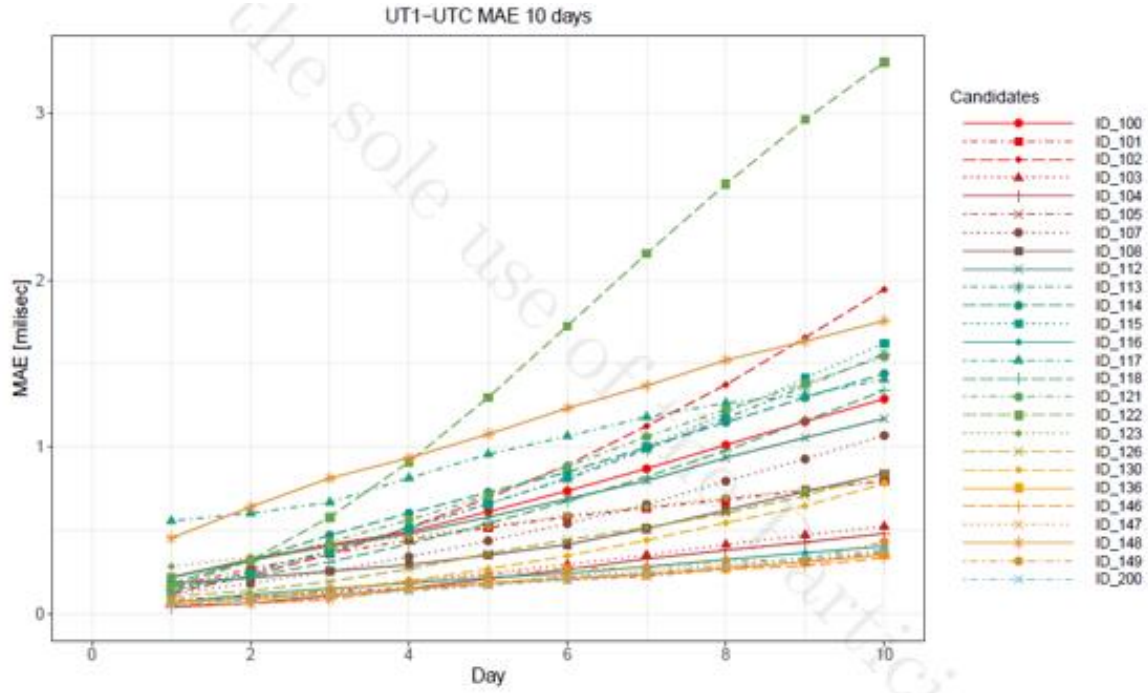


[Kuzmet et al. in Geodesy (2018) 92:95-70269 DOI 10.1007/s00190-010-0372-4]

Example 3: dUT1 Prediction using Combined EOP







the sole use of the author

Summary, Conclusion, Outlook

- Real-time EOP is highly demanding for various geophysics and meteorology approaches, including precise tracking and navigation of satellites and spacecraft, weather modelling, and disaster prevention.

- EOP data from IERS are compared with EOP data derived from only the SLR technique (PM and LOD) and combined VLBI GNSS techniques (dUT1) using the combination of a deterministic and a stochastic method.

- The results show the potential of using only the SLR technique and combined EOP to obtain real-time estimation.
    - Our predictions provide a comparable error with the existing methods used for the 2nd EOP PCC.

- Different prediction techniques focusing on ML approaches will be tested and implemented in our prediction software to establish an operational EOP prediction service at **BKG**.

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Thank you for your kind attention!

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