A Comparison of VieSched++ Simulations with Observed VLBI Sessions

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Abstract The scheduling software VieSched++ uses simulations to predict the formal errors for Earth Orientation Parameters (EOPs) in a variety of generated schedules as a means of selecting the best one. To determine how closely the simulations match real Very Long Baseline Interferometry (VLBI) observations, VieSched++ is used to simulate existing VLBI schedules and predict EOP formal errors. These predicted formal errors are then compared to the observed formal errors produced by the USNO Analysis Center for both one-hour and 24-hour geodetic VLBI sessions. Comparisons use the Pearson correlation coefficient (ρ) to determine the correlation between simulated and observed EOPs.

Keywords VLBI, Scheduling, Simulation

1 Introduction

Simulation can be a powerful tool for improving VLBI scheduling techniques. It allows for the optimization of individual schedules and helps inform observing strategies for future sessions types. However, using these predictions is only effective if the simulation results reflect actual observations.

VieSched++ [1] is VLBI scheduling software that generates multiple schedules (typically between ten and 1,000) with different parameters. The schedules are then simulated to obtain formal error predictions for EOPs. These predictions are used to find schedules with favorable formal errors, and to ultimately select a single schedule to use. Numerous VLBI sessions are already scheduled for the International VLBI Service for Geodesy and Astrometry (IVS) using VieSched++ with simulations; the DACH Operation Center uses it for the AUAs, CRDs, CRFs, INT2/3s, and more.

VieSched++ simulations are also used to study improvements to the design of VLBI sessions. They have been used to suggest new VLBI station locations [2] and the optimal geometry for geodetic sessions [3, 4].

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2 Methodology

IVS VLBI S/X schedules are simulated with VieSched++ and are compared to the observed formal errors from the sessions.

The observed EOP formal errors are taken from usn2021c.eoxy and usn2021c.eopi, which are published by the USNO Analysis Center and are publicly available from the CDDIS, BKG, and OPAR Data Centers.

Table 1 Session summary.

Session Type	Date Range	# Sessions
1-hour Int. (I, Q)	2020-01-02 to 2022-03-10	720
24-hour sess. (R1, R4)	2020-01-02 to 2022-02-28	225

Predicted EOP formal errors are generated using existing IVS schedules. 113 IVS-R1 (R1928–R11040) and 112 R4 (R4927–R41039) schedules are used for 24-hour geodetic sessions. 486 IVS-INT1 (I20002–I22069) and 234 INT2/INT3 (Q20004–Q22066) schedules are used for the one-hour UT1-UTC Intensive sessions. These sessions are summarized in

Table 1. These schedules are input into VieSched++ with the *–sim* flag, along with the default simulation templates provided with VieSchedpp_AUTO. When simulated, all scheduled observations are considered to be successful when calculating the formal errors.

For fitting, all one-hour Intensive sessions are combined and all 24-hour sessions are combined. Any 1-sigma outliers for observed formal errors are rejected from fitting.

3 Results

IVS Intensive simulations and observations for UT1-UTC formal errors tend to agree fairly well, with a Pearson correlation coefficient of $\rho = 0.519$. The relationship between simulations and observations is linear aside from a large number of high formal errors in the observation data (Figure 1). A histogram of the ratios also demonstrates the large number of sessions with high formal errors from the observed data (Figure 2). Since one-hour sessions have a small number of scans and the simulations assume all scans are successful, any failed observations could cause formal errors to deviate from predictions.

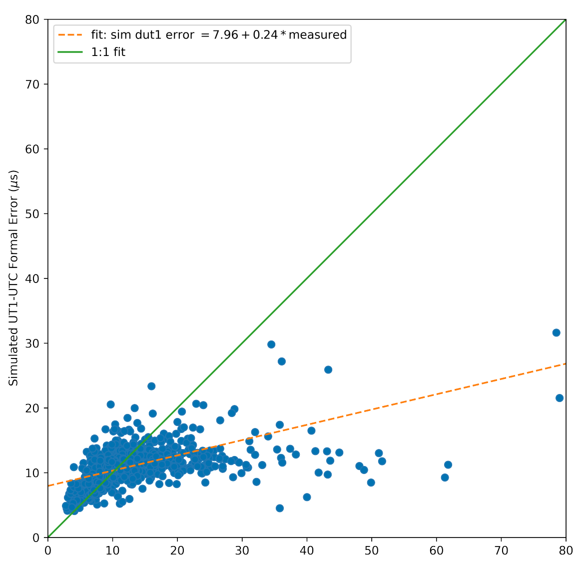

Fig. 1 Simulated UT1-UTC formal errors versus observed formal errors for IVS Intensive sessions (I, Q). The dashed orange line is the line of best fit, while the solid green line denotes a 1:1 fit.

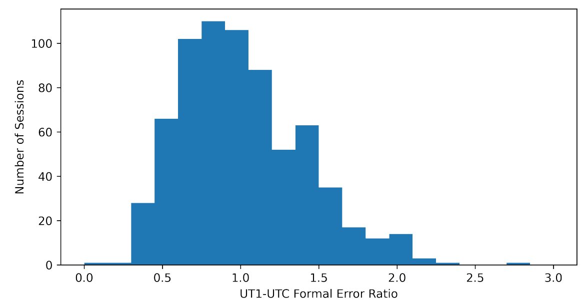

Fig. 2 Distribution of the ratio of simulated to observed UT1-UTC formal errors for IVS Intensive sessions.

IVS 24-hour simulations for most EOP formal errors also correlate well with observed formal errors. UT1-UTC, X Nutation, and Y Nutation all correlate strongly ($\rho = 0.630$, $\rho = 0.759$, and $\rho = 0.754$, respectively). There is more scatter in the relationship between simulated and observed errors for the X and Y pole coordinates ($\rho = 0.185$ and $\rho = 0.230$, respectively). These relationships are shown in Figures 3 and 4.

The results for both Intensive and 24-hour sessions are summarized in Table 2.

Table 2 Simulation statistics.

EOP	# Sessions Fit	Pearson Corr. Coeff. (ρ)
1-hour UT1-UTC	700	0.519
24-hour UT1-UTC	183	0.630
X-axis Polar Motion	195	0.185
Y-axis Polar Motion	194	0.230
X-axis Nutation	199	0.759
Y-axis Nutation	194	0.754

4 Conclusions

For IVS 24-hour sessions, VieSched++ is able to simulate the formal errors for UT1-UTC and nutation in a way that correlates well with the observed formal errors. The correlation for polar motion is much weaker.

For IVS one-hour Intensive sessions, VieSched++ is able to simulate UT1-UTC formal errors. Although most of the predictions correlate with observations, a subset of the observed formal errors tend to be much higher than predicted. This may be due to failed observations in sessions that have relatively few scans.

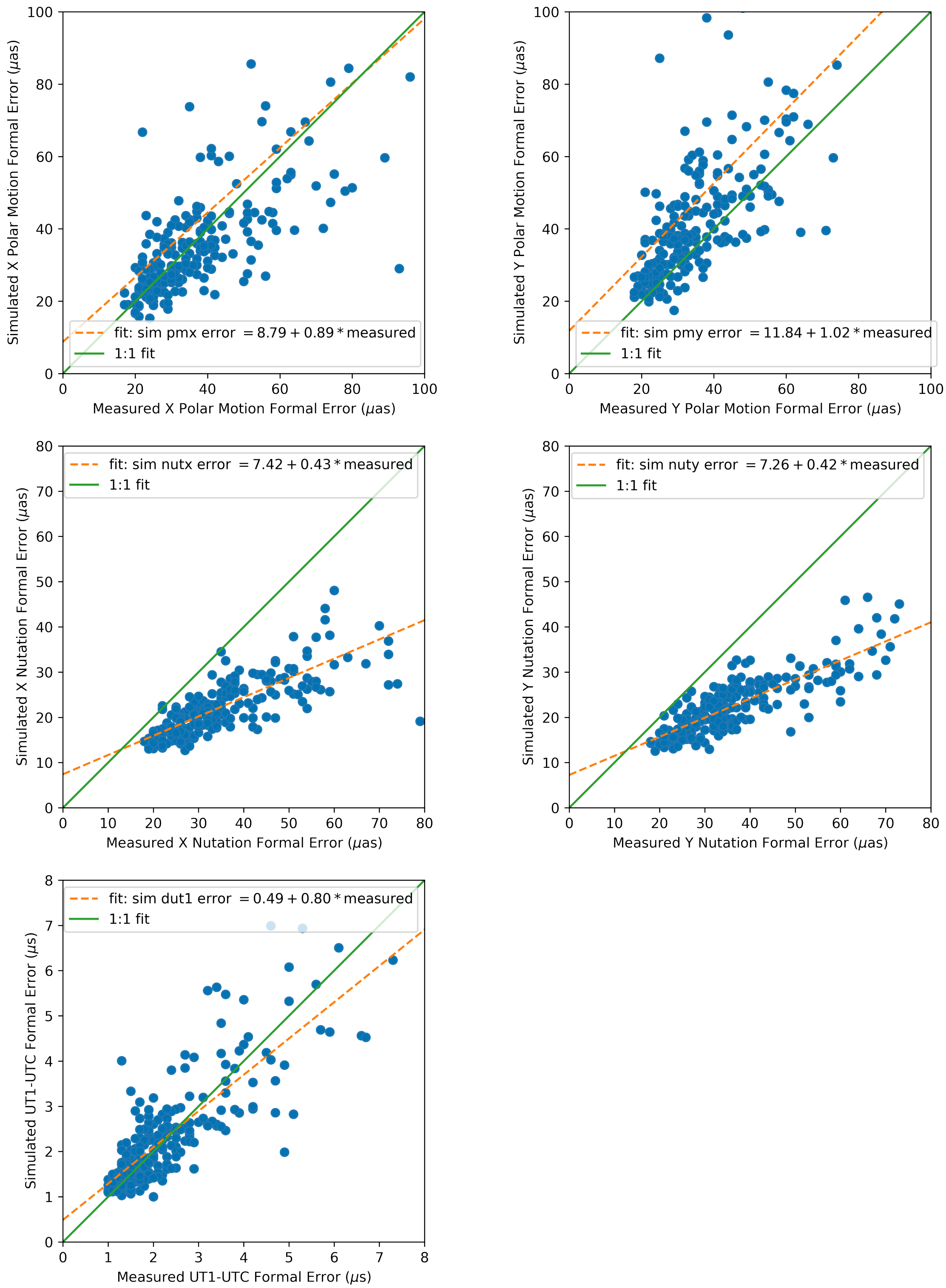

Fig. 3 Simulated EOP formal errors versus observed formal errors for IVS rapid sessions (R1, R4). The dashed orange line is the line of best fit, while the solid green line denotes a 1:1 fit.

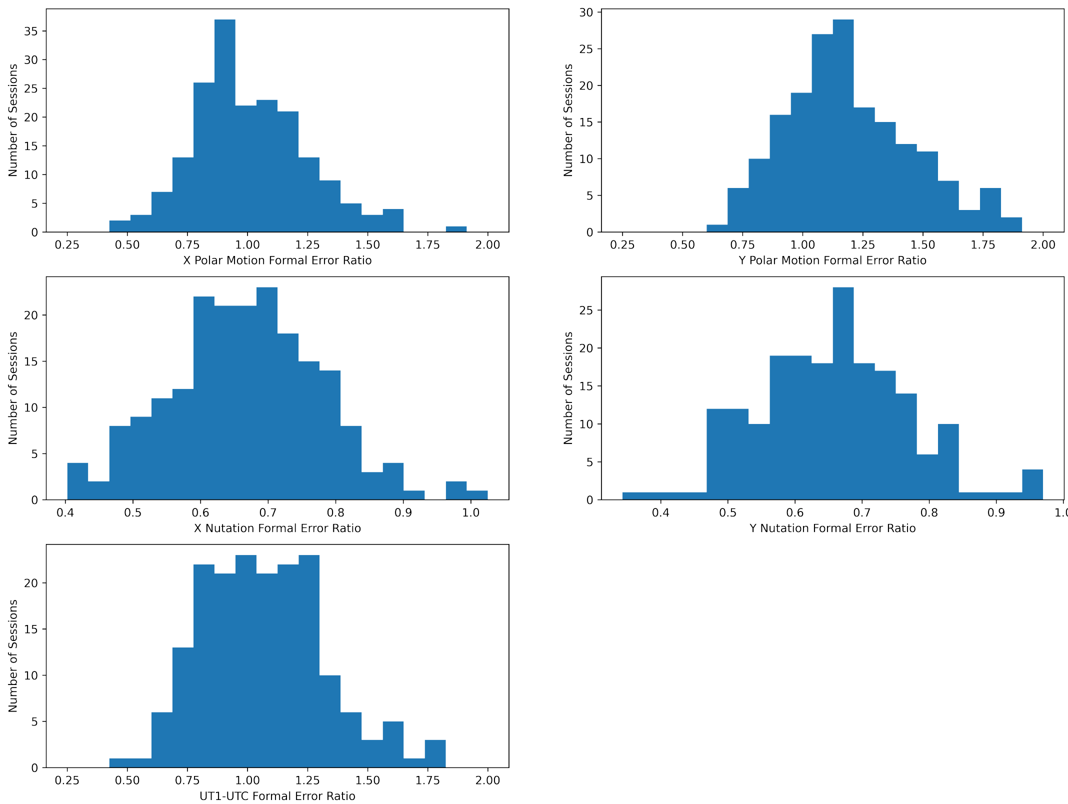

Fig. 4 Distribution of the ratio of simulated to observed EOP formal errors for IVS rapid sessions.

VGOS sessions were not compared because for VGOS sessions, no observed EOPs have been published yet. Possible avenues for future work include comparing VGOS sessions, investigating why polar motion is only weakly correlated, and examining other comparison methods (such as computing f statistics).

References

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