Automated analysis of Kokee-Wettzell intensive sessions

Niko Kareinen, Thomas Hobiger, and Rüdiger Haas

Department of Earth and Space Sciences, Chalmers University of Technology, Onsala Space Observatory, SE-439 92 Onsala, Sweden

Contact: niko.kareinen@chalmers.se

Introduction

A total of 1669 IVS intensive (INT1) between 2001 and mid January of 2015 on the Kokee Wettzell baseline were processed with the c5++ VLBI analysis software [1]. We only included sessions where Kokee-Wettzell was the only available baseline and discarded sessions which had an additional observing station (e.g. Svetloe). We started the processing from version 1 databases for X- and S-band. These were converted to NGS cards to start the processing with c5++, which was first used to do ambiguity resolution and ionosphere calibration in automatic mode with GMF2 mapping function and pressure data from GPT2. The ambiguity resolved and ionosphere corrected data were then processed to derive UT1-UTC. The analysis process is shown schematically in Figure 1. Using different analysis setups, we address the following questions:

1) Do we need the local weather information from the log files?

2) What is the impact of using different mapping functions?

3) What is the effect of the cable delay data?

4) How accurately do we need to know the a priori polar motion?

5) Can we simultaneously estimate UT1-UTC and the position of one of the stations?

Questions **1)** and **2)** are addressed in Figure 2 and 3 where the sessions were analyzed with VMF1 or GMF(GPT2) and with/without logs. In all tested analysis options crude outliers were eliminated by setting an absolute value limit of 1000 μs for the UT1-UTC residuals w.r.t. C04 and 50 μs or exactly 0 for the formal errors. Null formal error indicates that no solution was obtained for the session. If no log file was available for either of the stations and log files were in the analysis option, the session was skipped. In Figure 2 and 3 only sessions which appear in all configurations were selected to make the difference comparison more robust.

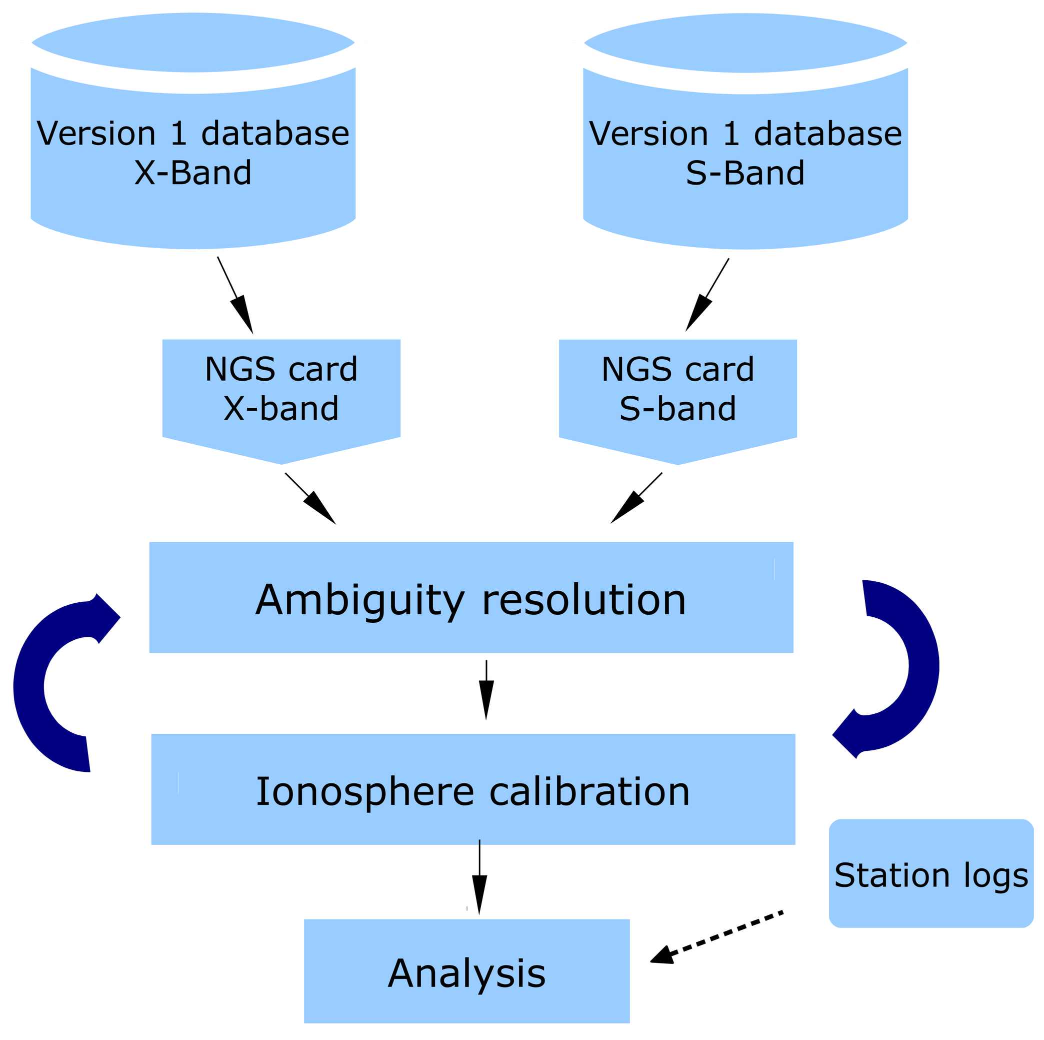

***Figure 1**: Flowchart of the automated data analysis with c5++.*

Impact of log files and mapping functions

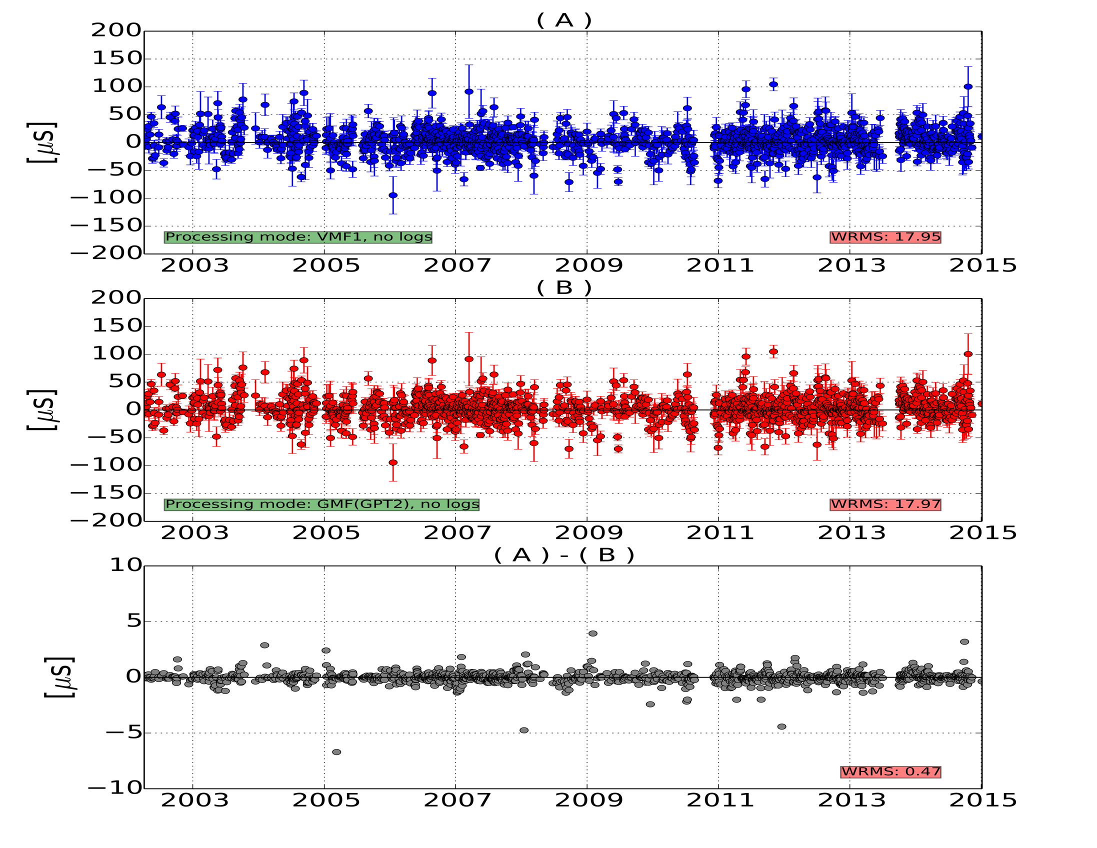

***Figure 2**: Processing without log files: UT1-UTC residuals w.r.t. C04 processed with (A) VMF1 and (B) GMF(GPT2). The bottom row presents the difference of time series (A) and (B).*

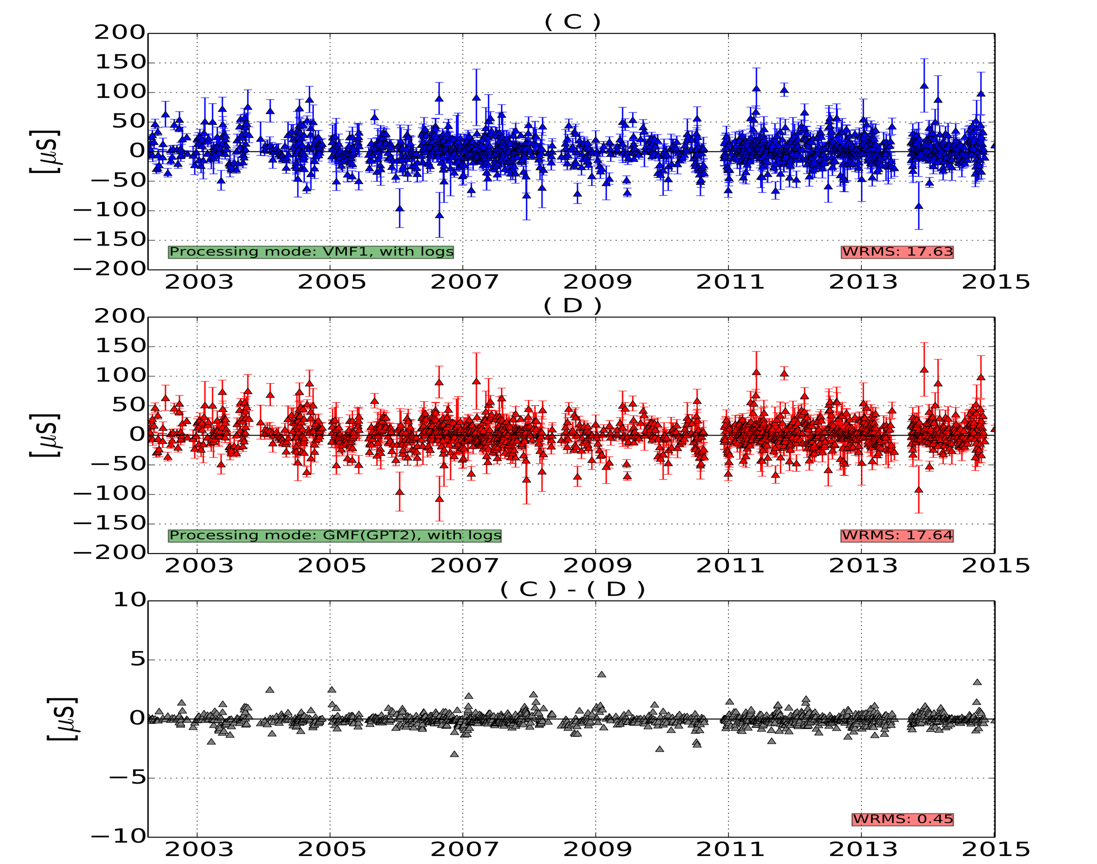

***Figure 3**: Processing with log files: UT1-UTC residuals w.r.t. C04 processed with (C) VMF1 and (D) GMF(GPT2). The bottom row presents the difference of time series (C) and (D).*

The results show that the choice of mapping function and the use of log files give differences smaller than 1 μs. Table 1 summarizes statistical information for each solution type. Based on the small differences between the processing strategies we choose GMF(GPT2) for all further investigations.

***Table 1**: Used sessions (out of 1669), WRMS and weighted BIAS for each solution type individually and differences for the common sessions.*

	Used	WRMS [μs]	Weighted. bias [μs]	WRMS of difference	Weighted bias of difference
VMF1, no logs	1406	18.03	2.65	3.27	0.16
VMF1, logs	1358	17.63	2.65		
GMF(GPT2), no logs	1406	18.04	2.67	3.26	0.17
GMF(GPT2), logs	1358	17.64	2.65		

Impact of cable delay data

The impact of cable delay data is presented in Figure 4, which is a difference of the data in Fig. 2B and Fig. 3D. The jump in late 2013 to early 2014 is related to large RMS for the cable delay data at Wettzell, see Figure 5.

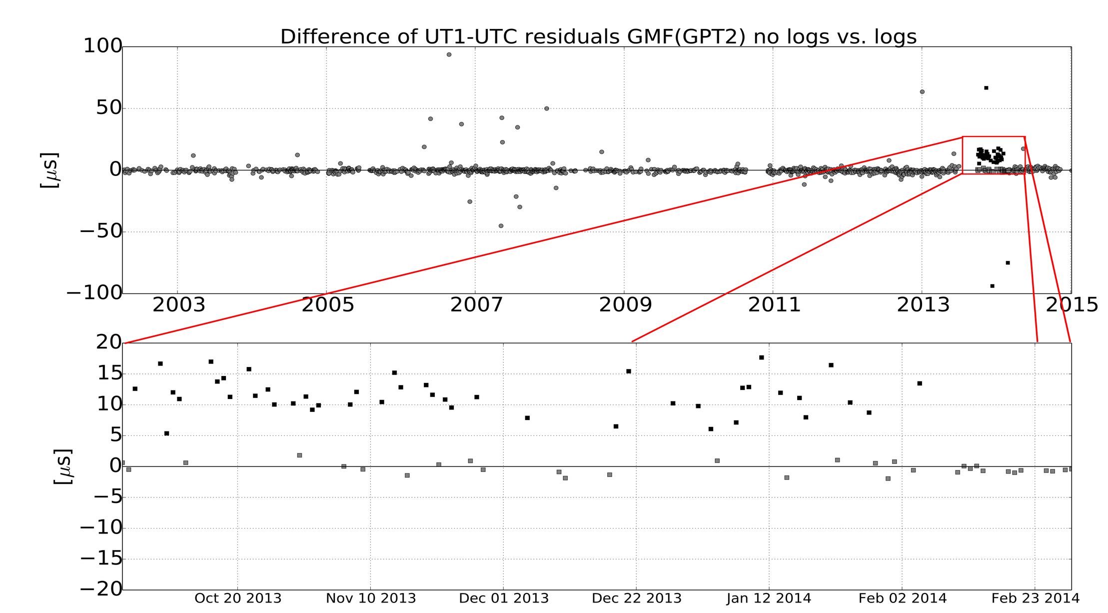

***Figure 4**: Top: the difference between the no logs – logs with GMF(GPT2) processing. Bottom: zoom into the period with the systematic jump.*

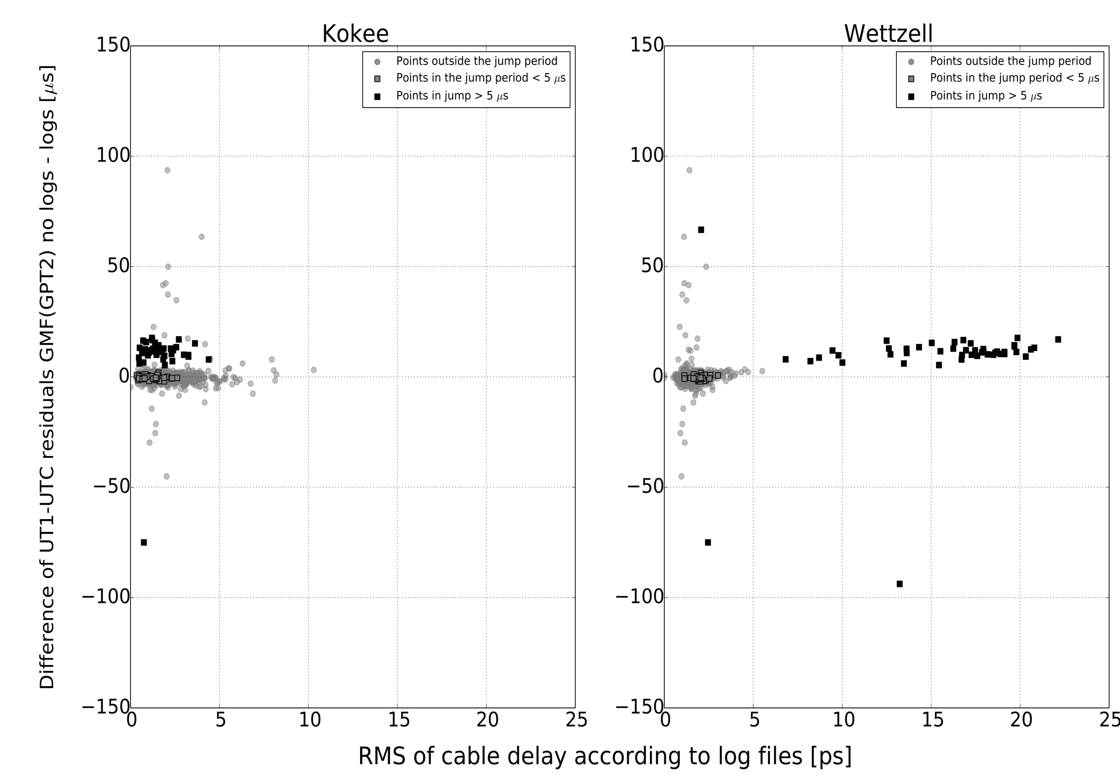

***Figure 5**: Correlation of difference of UT1-UTC residuals GMF(GPT2) no logs – logs vs. RMS of cable delays in Kokee and Wettzell.*

The impact of polar motion accuracy

According to the IERS bulletin A (update frequency of one week) the accuracy of the polar motion is

$$\sigma_{X_p}, \sigma_{Y_p} = 0.00068 \cdot D^{0.80} \qquad (1)$$

where D is the days elapsed since the Bulletin A epoch.

The impact of the polar motion accuracy on the UT1-UTC estimation was studied by a Monte Carlo simulation. The simulation was carried out by adding a noise term to the a priori polar motion information. This noise term was drawn from a normal distribution with a standard deviation based on the estimated accuracy according to Equation (1). This was done in a Monte Carlo fashion for 20 times for each of the 1669 sessions with a prediction interval of 0.25 to 6 days in 24 steps of 0.25 days.

For each set of Monte Carlo calculations (1-20) within a noise level a weighted RMS was computed and then these 20 values were averaged over the respective noise level, and a standard deviation for the 20 values was computed as a measure of formal error. Figure 6 presents the result of the Monte Carlo simulation and a power function fit to the data.

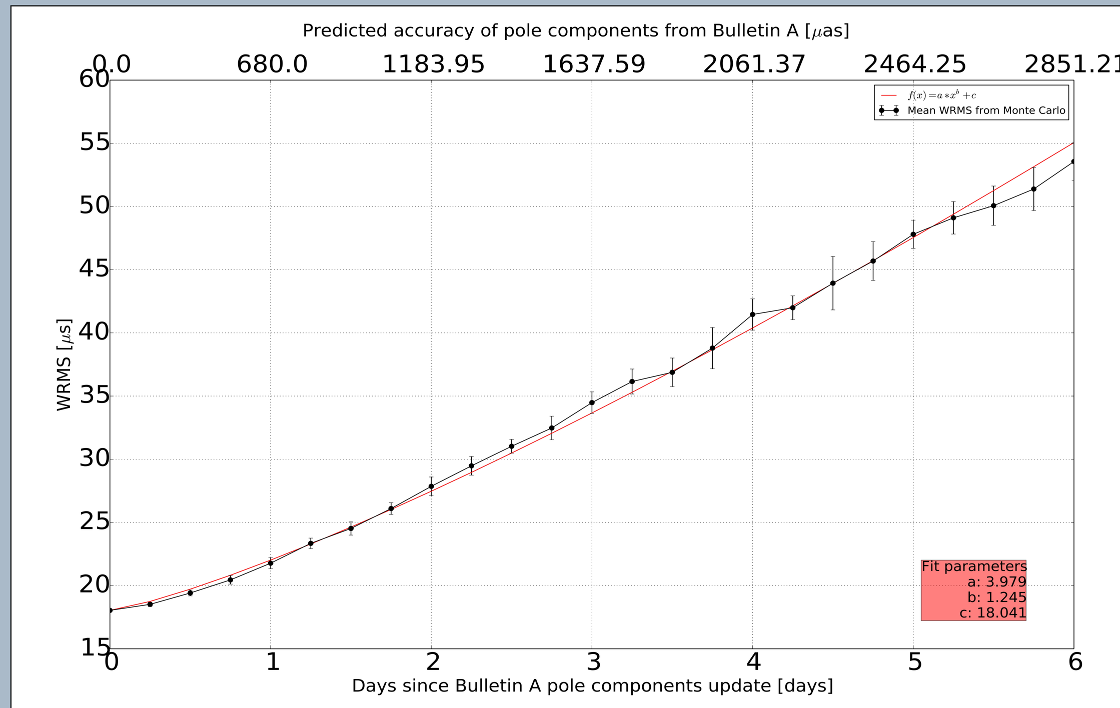

***Figure 6**: Mean WRMS of UT1-UTC residuals w.r.t. C04 as a function of polar motion accuracy. The X-axis shows days elapsed since Bulletin A epoch (bottom) and polar motion accuracy (top).*

Impact of estimating the station position

Wettzell was kept as the reference station, while the position of Kokee was estimated with constraints between 0.1 mm to 10 mm, with steps of 0.025 in a logarithmic scale. Figure 7 shows the effect of the constraint level on the WRMS of UT1-UTC residuals w.r.t. C04. Also shown is the number of sessions used relative to the available sessions. Sessions are lost because estimating the station position of Kokee with too loose constraints sometimes causes solutions to not converge.

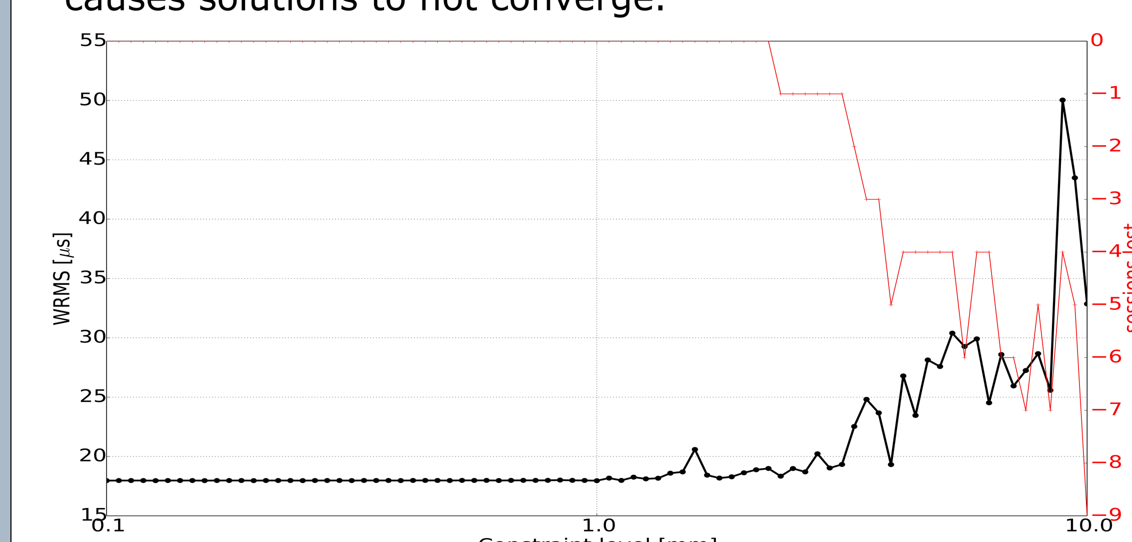

***Figure 7**: Effect of constraint level for station position estimation on the WRMS of the UT1-UTC residuals w.r.t. C04 (left scale) and the number of sessions that failed when station position was estimated (right scale).*

Conclusions

For the automated analysis of INT1 sessions we can conclude:

1) There is no clear advantage in using local weather data from the station log files compared to using GPT2.

2) There is no significant difference in using VMF1 or GMF.

3) There is a benefit in using cable delay data, provided that it is reliable.

4) Old (outdated) polar motion values have a significant impact on our UT1-UTC estimates. Daily updated polar motion values enable us to provide UT1-UTC with a mean accuracy of better than 25 us.

5) Station position estimation does not degrade UT1-UTC if tight constraints on the millimeter level are applied

References

[1] Hobiger, T. et al., 2010, Fully automated VLBI analysis with c5++ for ultra-rapid determination of UT1, *Earth, Planets and Space*, 62 (12), 933-937.