NTSC VLBI System and Recent Activities in Geodesy

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Abstract The National Time Service Center of the Chinese Academy of Sciences operates a geodetic VLBI network that consists of three stations located in Jilin, Kashi, and Sanya, and one Data Center located in Xi'an. The baseline length of the network ranges from 3,000 to 4,000 km. Construction of the network was completed in 2017. In mid-2021, we started domestic UT1 observations with two or three sessions per week, ∼100 sessions per year. The 1 sigma accuracy of UT1 measurement in 2023 is around 85 µs compared with IERS C04 series. Apart from VLBI observations, other related activities are also reported, including development of geodetic VLBI software, studies in EOP combination, and EOP prediction.

Keywords VLBI, Universal Time, EOP combination, EOP prediction

1 Introduction

The National Time Service Center (NTSC) of the Chinese Academy of Sciences (CAS) operates a domestic VLBI network that is mainly used for UT1 measurement and service. The baseline length of the network ranges from 3,000 to 4,000 km. The location of stations are shown in Figure 1. Construction of the network was finished in July 2017. Commissioning observations was start in 2018 [1].

In June 2021, we started regular domestic UT1 sessions with two or three observations per week, around 100 sessions per year. In Section 2, we introduce this VLBI network. In Section 3, results of domestic UT1 sessions in 2023 are presented. In Sections 4 and 5 we report our activities on software development and investigations on EOP combination and prediction. Prospects are presented in Section 6.

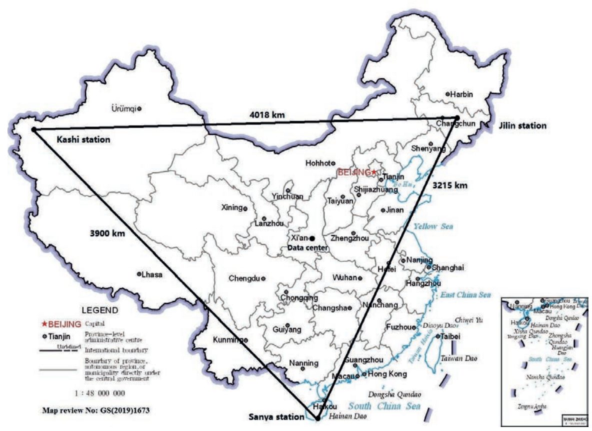

Fig. 1 The geographical locations of the NTSC VLBI network. The network consists of three 13-m telescopes located in Jilin, Kashi, and Sanya, and a data Analysis Center located in Xi'an.

2 The NTSC VLBI Network

Figure 2 shows the 13-m telescope located in Jilin station, which is a Cassegrain-type radio telescope with a 13-meter primary paraboloid and 1.48-meter secondary reflector. More specifications of the antenna system is presented in Table 1. Each station is equipped with a cryogenically cooled broadband receiver.

1. National Time Service Center of Chinese Academy of Sciences

Fig. 2 The 13-m radio telescope located in Jilin station.

Table 1 Specifications of the antennas system.

Parameter	Value
Antenna mount	Altazimuth
Main dish Diameter	13-m paraboloid
Main dish Sureface accuracy	0.3 mm rms
Secondary reflector Diameter	1.48 m
Secondary reflector Surface accuracy	0.1 mm rms
Pointing accuracy	30 as
Azimuth range	$-270^\circ \sim +270^\circ$
Elevation range	$50^\circ \sim 92^\circ$
Azimuth slewing rate	12° s^{-1}
Elevation slewing rate	6° s^{-1}

The receiver can receive right- and left-hand circular polarization (RCP and LCP) signals with frequencies ranging from 1.2 to 9 GHz for Jilin and Sanya stations. Due to severe radio frequency interference (RFI), the Kashi station can currently only observe at frequencies from 7.5 to 9 GHz. The cryogenic system cools the low noise amplifier (LNA) down to ∼20 K. The typical system temperature measured onsite at X-band is ∼70–100 K.

3 Domestic UT1 Sessions

Rregular UT1 observations began in June 2021. Usually, two or three sessions were scheduled every week. The observation time is during local midnight (UTC 16:30–18:30) to minimize the delay errors due to the unmodeled ionospheric delay. Around 60-80 good scans can be obtained within the two-hour observation. After observation, the raw data were transferred to Xi'an Analysis Center via Internet and then correlated and analyzed by following the procedure given in [1].

Figure 3 shows the domestic UT1 session results from March to October in 2023. The right panel of Figue 3 shows the RMS of differences between NTSC measurement and C04 UT1 series in 2023; the value of which is 85 µs.

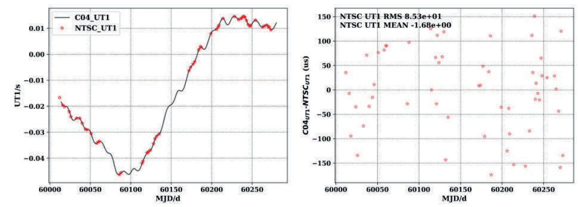

Fig. 3 Measurements of UT1–UTC with NTSC's domestic UT1 sessions from March to October 2023 (left panel). The right panel shows the differences of NTSC's measurements compared to the IERS's C04 series.

Simulation studies suggested an accuracy of 30 µs can be achieved by the 4,000-km Jilin–Kashi baseline. The disagreement between the simulation and the real observation is mostly due to the deterioration of the Kashi station's electromagnetic environment and the uncertainties of station coordinates.

4 Geodetic VLBI Software

We developed a Geodetic Analysis Tool for VLBI, named GATV, which is similar to the VieVS and nuSolve software. The software is written in Python and can be easily installed and used in both pipeline and

Fig. 4 The graphical user interface of the GATV used in interactive mode.

interactive modes. In Figure 4, the graphical user interface of the GATV is shown.

In Figure 5, we show the performance of the software, evaluated with IVS-INT-1 data. In summary, the result estimated with GATV is consistent well with BKG and USNO results. After a full evaluation, we will share the GATV with the community for open use.

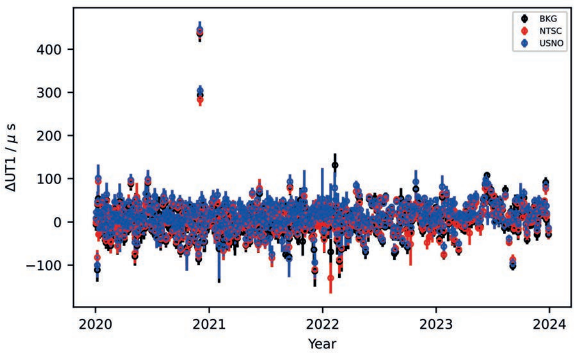

Fig. 5 Evaluations on the performance of the GATV software. The GATV estimated IVS-INT-1 UT1 result is consistent with BKG and USNO estimations.

5 EOP Combination and Prediction

To produce a continuous daily updated UT1 series, we developed an EAM-aided Kalman filter that uses VLBI measured UT1, GNSS measured LOD, and Earth Angular Momentum (EAM) data as inputs to yield a multi-technique combined UT1, LOD and EAM series. In Figure 6, we show the difference of the combined UT1 series with respect to the C04 UT1 series. The error bar, with a typical value of 35 µs, denotes the Kalman estimated uncertainties. The RMS of the difference between the NTSC combined UT1 and C04 UT1 is 49 µs.

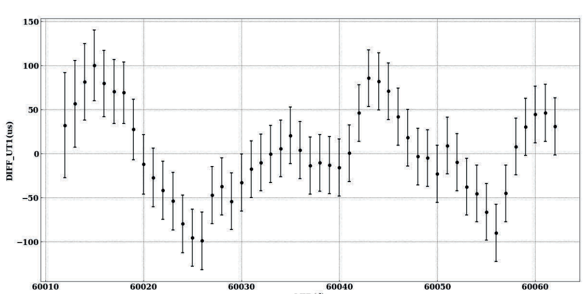

Fig. 6 A Kalman combined UT1 series, using NTSC's UT1, GNSS LOD, and EAM data as inputs. The typical formal error estimated by the filter denoted as error bar is ∼35 µs.

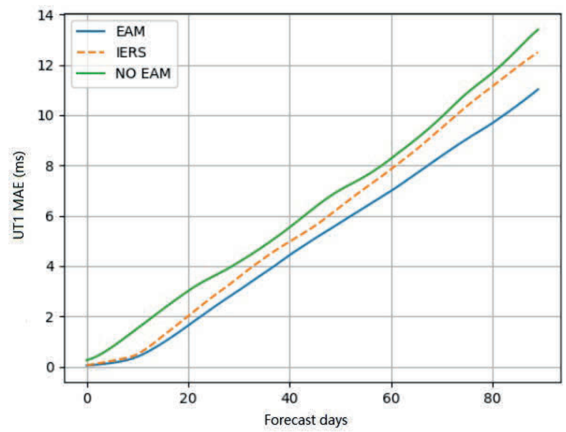

Fig. 7 The MAE of UT1 predictions in 90 days. Blue, orange, and green lines denote predictions of LS+AR+EAM, IERS Bulletin A, and LS+AR without EAM data.

For UT1 service, short-term predictions are also needed. Recently, we followed [2]'s LS+AR+EAM algorithm but with minor revisions to find the optimized prediction parameters at different prediction spans [3, 4]. In Figure 7, the mean average error of the predicted UT1 in 90 days evaluated with 1.5 year data is shown. In general, the performance is similar to that of the IERS Bulletin A prediction.

6 Future Prospects

In the aim to improve the capability of NTSC VLBI network, a tri-band (S/X/K) receiver is now under development. The new narrow-band tri-band receiver will be installed at the Kashi station in 2025. We hope to join the international and regional VLBI networks, such as IVS's legacy S/X network and EAVN VLBI network, to link our stations with the ITRF frame, and to promote our activities in geodetic VLBI.

References

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