IVS SHAO Analysis Center 2015–2016 Biennial Report

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Abstract This report presents the routine work and the research work carried out at SHAO VLBI Analysis Center (AC) during 2015 and 2016. The SHAO AC continues the routine VLBI data analysis of IVS 24-hour geodetic/astrometric sessions and takes the responsibility of analyzing the CVN data. We investigated structure effects in geodetic VLBI, in terms of demonstrating source structure effect at the level of each individual observable, deriving structure index from geodetic sessions without making images, deriving source structure from delays, and studying the impact of structure effects. We used the archived dual-band observations from VERA to study the atmosphere fluctuation and made a proposal for new observations by VERA to better investigate it. The VGOS antenna in Shanghai was under construction and was expected to make trial observations in late 2017.

1 General Information

The SHAO VLBI Analysis Center is located at the Shanghai Astronomical Observatory (SHAO), Chinese Academy of Sciences, China. It is a part of an astrometry research group in the Department of Astro-Geodynamics at SHAO. Some staff members are from the VLBI application in the Chinese deep space mission. We are processing the Chinese VLBI Network (CVN) data and IVS 24-hour routine sessions and one-hour Intensive UT1 sessions to provide our results and investigate some interesting topics in VLBI.

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2 Activities during the Past Two Years

The SHAO Analysis Center analyzed all the IVS sessions by using the Calc/Solve and the nuSolve software packages, and ten CVN sessions (including solving ambiguity and determining the ionospheric effect from dual-band data). We provided VLBI products, i.e., EOP, CRF, and TRF, for the Chinese EOP Services. We investigated source structure effects in geodetic VLBI and attempted to correct source structure effects in data analysis.

3 Current Status

- Closure delay is the sum of delay observables over closed triangles. Closure delay is independent of atmospheric effects and clocks, and captures information of source structure. Figure 1 shows closure delays of six triangles with one common baseline, BADARY–WESTFORD. The six stations in these six triangles are those stations in Europe, which are located in between baseline BADARY–WESTFORD. Note that BADARY–WESTFORD is the longest baseline in these triangles. The two peaks far away from zero with this systematical pattern are unlikely due to measurement noise, but can be well explained by source structure effect. We further explored the observable of closure delay to detect source structure of 0642+449 with two equally-bright components separated by half a milliarcsecond. The result of this study was published in Xu et al. (2016). Closure delay can serve as an indicator of the magnitude of structure effect of each individual source and as a criterion to evaluate the performances of structure models, no matter how they are derived.

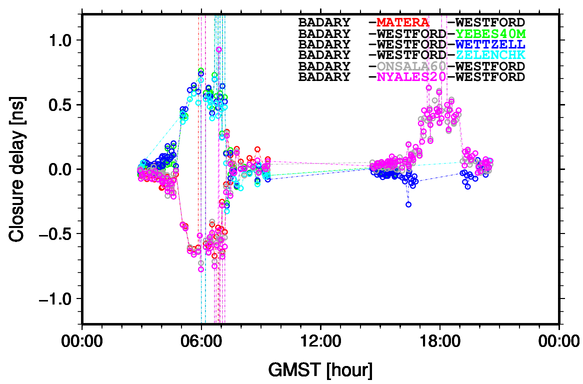

Fig. 1 Closure delays of triangles with BADARY and WESTFORD and one of the six European stations.

- Structure index (Fey & Charlot 1997) is used to classify radio sources in the sense of compactness of radio source. For example, a radio source with a structure index of 1 is considered to be compact and one with a structure index of 4 is considered to be much extended. The traditional way of calculating structure index is based on images of sources. One has to obtain an image of the source by standard imaging process and then to calculate the structure delays on each grid over the *uv* plane with the size of the Earth. The structure index is related to the median value of the structure delays of all these possible grids. We demonstrated the correlation of closure delays and structure index and proposed a method to derive structure index from closure quantities. By applying this method, one does not need to make images anymore. The historical VLBI data will provide us a great amount of information about structure index even if we do not make use of them to make images.
- We attempted to develop a method of correcting structure effects independent of calibration in imaging and the impact of structure effects on geodetic VLBI since we may expect to correct source structure effect independent of images. We referred to the method as forward modeling. It works in an iterative way: (1) closure phases of small triangles with longest baseline lengths shorter than a certain value, such as 2,000 km depending on the structure scale of the interested source, are used to determine the relative position and the flux density ratio of two components based on the model of structure phase in Charlot (1990); (2) closure phases of triangles with larger baseline lengths are gradually added and used to test the obtained multicomponent model by the previous step until a significant mismatch between modeled closure phases and observed closure phases occurs; (3) another component is proposed and added to the previous model, and then repeat the second step. The whole procedure will stop when all the closure phases were exploited.
- A three-component model was determined for 3C371, and a detailed comparison was done with imaging results of the visibility from the same observations. The impact of source structure was preliminarily studied by using the derived three-component model of 3C371. The rms residual of source 3C371 was reduced by 1 ps (Xu et al., 2017)
- We have been investigating the systematic variation of Celestial Reference Frame, which was identified first by the GSFC VLBI group. The pattern is that the southern sources appear with lower declinations, determined from all historical data till recent years, compared to the catalog of ICRF2. We have some clues for this phenomenon at the moment. We are also processing Q-band VLBI observations made by VLBA from November 2014 to May 2016, and K-band observations.
- We have been working on building a VGOS antenna in the area of the Tianma 65-meter antenna. The construction permission by related administrations has just been worked out and the constructing contract for the company also went through. Now the pillar is under construction. Within the great effort of several members in our group, this new antenna should be able to do trial observations in late 2017.
- After submitting the SINEX products for the ITRF2014, we continued the evaluation of the ITRF2014P and submitted our report to Dr. Zuheir Altamimi.

Fig. 2 Group photo of the SHAO AC members taken in front of our main building.

- The comparison of theoretical delays for different software packages organized by Onsala observatory was participated at the SHAO AC.

4 Staff

During 2015 and 2016, the staff of the SHAO AC contains one consultant, a group leader Dr. Wang, five employees, and one PhD student, shown in Table 1 and in Figure 2.

Table 1 Staff members and the main tasks.

Dr. Guangli Wang	Group lead, VGOS project, data analysis
Dr. Minghui Xu	Data analysis and imaging
Dr. Li Guo	Positioning and data analysis
Dr. Bo Zhang	Phase referencing and imaging
MSc. Shuangjing Xu	Imaging and data analysis
Prof. Zhihan Qian	Consulting
Dr. Liang Li	Data analysis and CRF

5 Future Plans

We will mainly focus on data analysis of observations made by VGOS antennas in China. There should be about four 13-meter antennas in China to conduct such observations. We will continue the current study of the systematical variation in CRF, source structure effects, and data analysis of VLBI observations at high frequencies. A proposal was made to VERA to get dual-beam observations to study the atmosphere effect. We will continue our study of determining Solar acceleration from VLBI as long as we work out the systematic variation in CRF, since we suspect this variation will affect the estimation of the Solar acceleration.

References

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