SHAO Analysis Center 2014 Annual Report

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Abstract This report presents the routine work and the research carried out at the SHAO VLBI Analysis Center (AC) during 2014. The SHAO AC continues the routine VLBI data analysis of 24-hour geodetic/astrometric sessions to generate products, and it processes the CVN data, which will be submitted to the IVS starting in 2015. We also carry out the navigation for the Chang'E mission, using the VLBI technique as usual, and some basic research in astrometry, which are the systematical variations in the Celestial Reference Frame and the effect of aberration.

1 General Information

The SHAO VLBI Analysis Center is located at the Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai, China. It is a part of the astrometry research group in the department of astro-geodynamics. Some members are from the VLBI application in the Chinese deep space mission. Therefore, we are processing the Chinese VLBI Network (CVN) data, IVS 24-hr routine sessions, and 1-hr Intensive UT1 sessions.

1. SHAO, Chinese Academy of Sciences
2. GFZ

SHAO Analysis Center

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2 Activities during the Past Year

The SHAO Analysis Center analyzed all the IVS sessions and five CVN sessions (including resolving ambiguities and determining the ionospheric effect from dual band data) by using the Calc/Solve and the nuSolve software package. During 2014, we continued generating the ITRF2013 solution, which extends the VLBI observations from the end of 2013 to 2014. We provided VLBI products, i.e., EOP, CRF, and TRF, for the Chinese EOP Services.

3 Current Status

- Resolving ambiguities. We investigated the principle and the methods that were used to resolve the ambiguities of the VLBI group delay by using the single band delay. Even though the ambiguity issue was solved from the very beginning of the VLBI technique, the deep understanding of this procedure will facilitate both the data analysis and resolving sub-ambiguities. Some ambiguity points can be effectively identified by comparing the ionosphere effects from the single band delay. This work was partly carried out by using nuSolve, which is quite helpful software with a GUI.
- Ionosphere effect. The ionosphere effect correction is obtained from dual band data by using the ionosphere effect free combination. It is calculated based on the effective frequency, which is a weighted "mean" frequency depending on the amplitude of the cross correlation and the number of the accumulated period. Thus, it varies with respect to time and also baseline due to the loss of

data in some channels or lower amplitude at some sidebands. As a result, if there is a constant offset in a baseline between two bands after closing all the triangles in the big network, this constant offset can not be completely absorbed by the clock model because this offset is not a constant after correcting the ionosphere effect. There are other problems left; for instance, its second order, the signal paths not being totally the same for two bands, and the scintillation.

- High frequency variation in source position. CONT14 is a campaign of continuous VLBI sessions, which was scheduled for observation starting in early May 2014 (6-MAY-2014 00:00 UT through 20-MAY-2014 24:00 UT). With a network size of 17 stations (ten in the northern hemisphere and seven in the southern hemisphere), it continually obtained more than 500 observables per day for about eight radio sources (for example, 1739+522, 0016+731, and 0059+581). These data provide a good opportunity to get high frequency variation, two- or four-hour interval, in the position of these radio sources, and to investigate these variations.
- Different level of NNT and NNR constraints. There are degeneracies of the normal equation when one determines TRF, CRF, and EOP by using VLBI. The common way of circumventing these degeneracies is to apply in the least-square adjustment no-net-rotation (NNR) and no-net-translation (NNT) constraints of the station positions and velocities of a subset of stations with respect to the ITRF, and NNR constraints to the defining sources with respect to the ICRF. We investigate the influence on the EOP, CRF, and TRF of three different degrees of these constraints, 0.1 *m*, 1 *mm*, and 0.01 *mm*. The results show that different degrees of the NNR and NNT constraints on the TRF have no impact on the CRF and precession but cause significant change in the TRF and ERPs. When the constraints were reduced to 1.0 mm and smaller, the difference was less than 1 mm for the station coordinates. But when looser constraints, such as 0.1 m, were used, big differences in the station positions led to significant drifts in the ERP.
- Solar velocity. The motion of the barycenter with respect to the CMB, probably steadily constant over a few hundred years, can be reasonably taken as the same as the motion of the object with respect to the CMB and modeled into the effect of proper motion. As we know, the motion of each individual object is random over the sky, but the motion of the barycenter is identical for all objects. Therefore, there are two systematic effects in those variations, which requires consideration for recently refined measurements in astrometry: the apparent proper motion caused by the acceleration of the barycenter with respect to the CMB (Xu et al., 2014), which has been determined and discussed in a series of papers, and the proper motion caused by the velocity of the barycenter with respect to the CMB, which is actually the variation in the parallax effect caused by this motion. Simulations and estimation from VLBI data are being made to get interesting results.
- Aberration. Special efforts are still being made to clarify this (Xu et al. 2014).
- CVN data. The CVN data analysis includes resolving ambiguities, determining the ionosphere effect, detecting clock breaks, identifying the outliers, and estimating the geodetic parameters. We are preparing to submit these data to the IVS so that they can be widely used.
- ITRF2013. Due to the ITRF2013 solution having been changed from 2013 to 2014 to include all the 2014 VLBI data available until February of 2015, we continued the data analysis to provide the complete solution to the IVS.

4 Staff

During 2014, the staff of SHAO AC contained one consultant, the group leader Dr. Wang, three employees, and two PhD students. Dr. Wang is also a member of the Observing Program Committee in the IVS. Postdoc, Zhibing Zhang joined us at the end of this year.

5 Future Plans

Plans for the future include contributing to the ICRF3, investigating the ionosphere effect, preparing the CVN data, and submitting to the IVS. We will also collect the resources and the staff to develop new VLBI data analysis software, with which we can contribute more to VLBI and VLBI2010.

Table 1 Staff members and the main tasks.

Dr. Guangli Wang	VLBI2010, observing, data analysis, and head leader
Dr. Jinling Li	Positioning, VLBI2010, and data analysis
MSc. Minghui Xu	Data analysis, ITRF solution, CRF and astrometry in VLBI
Dr. Li Guo	Positioning, data analysis
Dr. Fengchun Shu	Scheduling, correlation, and data analysis
Dr. Zhihan Qian	Consulting
MSc. Liang Li	Data analysis and CRF

References

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2. M. Xu and G. Wang. On the definition of aberration. In D. Behrend, K. D. Baver, and K. Armstrong, editors, Proceedings of the Eighth IVS General Meeting: VGOS: The New VLBI Network, pp. 490-494, 2014.