SHAO Analysis Center 2012 Annual Report

Guangli Wang, Jinling Li, Minghui Xu, Li Guo, Li Liu, Fengchun Shu, Zhihan Qian, Liang Li

Abstract

The Shanghai Astronomical Observatory (SHAO) Analysis Center in 2012 continued routine VLBI data analysis and produced earth orientation parameter (EOP), terrestrial reference frame (TRF), and celestial reference frame (CRF) information, which was submitted to the IVS quarterly. The activities of SHAO also consisted of data reduction of the Chinese VLBI Network (CVN), spacecraft navigation using the VLBI technique, and some research activities.

1. General Information

SHAO is responsible for the data processing and analysis of the CVN sessions which aim to monitor the crustal movement of the Chinese Mainland. This work includes the computation of the group delay and the analysis of these observations. Quarterly solutions of the IVS 24hr sessions were conducted to generate the time series of EOP and to realize the TRF and CRF. The software used for VLBI data analysis is Calc/Solve, released on 21 May 2010 [1]. We tried to model the movement of TIGOCONC after the big earthquake in Chile, and added the modeling into the Calc/Solve software. As in 2010 and 2011, SHAO continued to conduct the real-time navigation of the ChangE-2 (CE-2) satellite using the VLBI technique [2]. Research topics are outlined in Section 3. The members involved in these activities are Guangli Wang, Jinling Li, Minghui Xu, Li Guo, Li Liu, Liang Li, Fengchun Shu, and Zhihan Qian.

2. Activities and Data Analysis at SHAO

SHAO is in charge of the CVN and is an Analysis Center of the IVS. Routine VLBI activities at SHAO included:

-Data processing and analysis of the CVN geodetic experiments

The related work contains the calculation of the delay and delay rate of the CVN observations at every band, resolving group delay ambiguities, and computation of ionosphere calibrations. In addition, SHAO is responsible for the generation of the VLBI group delay in the NGS format and for the analysis of all CVN sessions by the software *shops*, which has been developed based on the software $OCCAM6.1E(Linux)$ with modifications mainly to VLBI data processing models.

-Regular data analysis of the IVS 24h sessions and product submission

We continued to routinely analyze all IVS 24h sessions using the Calc/Solve software, and during this year we regularly submitted our analysis products (EOP, TRF, and CRF) to the IVS Data Centers. For the movements of stations after earthquakes, especially for core stations such as TIGOCONC, modeling of the movements was built and added into the software.

-Analysis of EOP Determination via the Chinese VLBI Network

The EOPs are determined from the IVS observations in which Sheshan station in Shanghai and Nanshan station in Urumqi were involved. The precision is comparable to that of the IERS

EOP series. The current precision of UT1 determined from single baseline observations of the two stations is in the middle level of the international precision. The determination of precisions of UT1 either from the IVS Intensive sessions in 2011 with Sheshan included or from international EOP observations with the two stations included, meets the requirements of the 100-m positioning precision of the satellite of Mars to UT1 [3].

3. Research Topics at SHAO

3.1. Determination of the Solar Acceleration

Due to the acceleration of the known Solar system barycenter (SSB), the velocity vector of the origin of the International Celestial Reference System (ICRS) [4] is no longer constant but varies with time, which consequently causes a systematic variation in the direction of the observed object. This phenomenon is referred to as the secular aberration drift [5]. Based on the relationship between this effect and the acceleration of the SSB, the acceleration can be determined directly from VLBI measurements without any available kinematic or dynamic models of the Milky Way.

We developed two approaches to estimate the acceleration vector. One is to treat the Solar acceleration vector as a global parameter, which we call the global solution. The second method is to estimate the time series of the velocity variations through the solution and fit the acceleration from the time series. Although the latter method lacks the ability to effectively separate the velocity from other error sources, such as the influences of the position errors of the radio sources, the time series solution can clearly show the details and trends of the velocity variations of the SSB, and it can be taken as a validation for the first method. In total, 4,632 sessions, 3,492 radio sources, and approximately 7,100,000 group delay observables were analyzed.

We obtained the acceleration vector in the three components in the Galactic coordinate system (7.47±0.46, 0.17±0.57, 3.95±0.47) $mm{\cdot}s^{-1}{\cdot}yr^{-1}$ [6,7]. Figure 1 shows the velocity variation time series and the acceleration. The result from the two methods are consistent with each other. Traditionally it was generally believed that the acceleration component in the direction normal to the Galactic plane was too small to be detected and thus the acceleration vector should nearly point to the Galactic center [8], but our results show that the vertical acceleration is notable. And the vertical component is likely to be explained by three potential possibilities. Please refer to our paper [7] for details.

3.2. The Epoch ICRF

Due to the acceleration of the solar system, the radio source positions in the ICRF2 catalog measured by a fictitious observer located at the origin of the ICRS vary with time. It is technically incorrect, then, to state that the ICRF has no dependence on time. We propose the epoch ICRF as a new concept to consider the effect of apparent proper motion of the positions of radio sources. This apparent proper motion has a magnitude of approximately 5.8 microarcseconds (μas) per year, and for the 30-year Very Long Baseline Interferometry (VLBI) observational history these position variations will exceed 100 μas. We show that the dipole structure of the apparent proper motions leads to global rotation in the ICRF2, and the main term, the shift of the direction of the origin of right ascension, reaches 25 μas per century. The epoch ICRF is constructed using epoch positions at J2000.0 and apparent proper motions of radio sources [9]. Figure 2 shows the apparent proper motion field for 295 ICRF2 [10] defining sources.

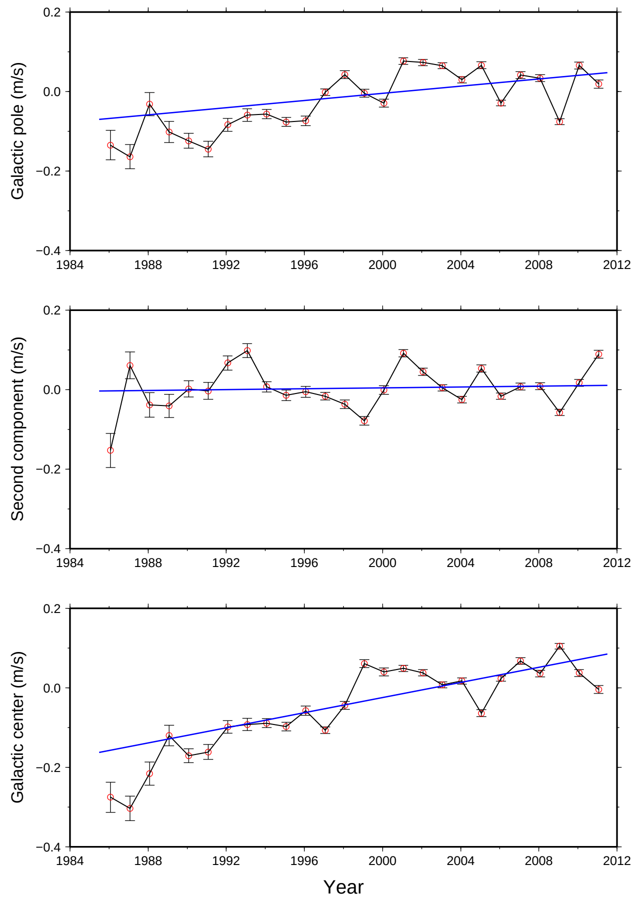

Figure 1. The velocity time series and its linear trend obtained from the time series solution [7].

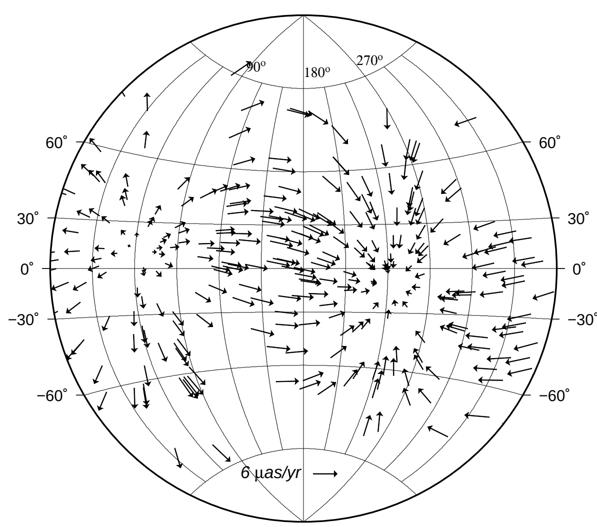

Figure 2. Apparent proper motion field for 295 ICRF2 defining sources based on the model of secular aberration drift [9]. It is plotted in right ascension and declination coordinates.

4. Plans for 2013

We will continue to submit our analysis products to the IVS Data Centers regularly and to develop software to transfer the data format of CVN observations, NGS, to netcdf. The research activities will focus on the effect of the Solar acceleration on the ICRF and the ICRS and on the study of the high frequency variations of EOP using VLBI observations. The processing strategy and treatment of irregularly moving stations, such as TSUKUB32 and KASHIM11 after a big earthquake, will also be considered in the near future.

5. References

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