SHAO Analysis Center 2007 Annual Report

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Abstract

Our research activities in 2007 focused on the atmosphere delay calibration of VLBA phase-referencing observations, the selection of stable sources for the next realization of the extragalactic celestial reference frame, and the processing of the satellite VLBI tracking data. These activities will be continued next year; in particular, we will prepare the software for the Chinese lunar exploration and Martian exploration. The local survey at Sheshan section of Shanghai Astronomical Observatory will be continued too.

1. General Information

We use CALC/SOLVE for our routine VLBI data analysis. We are developing softwares coded in FORTRAN to deal with the tracking data of satellite by VLBI, ranging, and Doppler. The members involved in the IVS analysis activities are Jinling Li, Guangli Wang, Bo Zhang, Shubo Qiao, Li Guo, Feng Tian, and Zhihan Qian.

2. Activities in 2007

We participated in some IERS/IVS campaigns aimed at comparisons of reference frames and/or Earth Rotation Parameters (EOP). We were able to do the VLBI solutions on a regular base. Our research activities in 2007 also included the atmosphere delay calibration of the VLBA phase-referencing observations, the selection of stable sources, the processing of the satellite tracking data, and a local survey at Sheshan section of the Shanghai Astronomical Observatory (SHAO).

2.1. The Atmosphere Delay Calibration of the VLBA Phase-referencing Data

Comparisons between atmospheric delay derived from GPS and VLBI observations at co-location sites show that the standard deviation of the difference is about several millimeters after a systematic bias is removed. This motivated us to calibrate the VLBA phase-referencing data using tropospheric estimates from GPS observations.

At present only six VLBA sites are co-located with GPS receivers. Table 1 illustrates the peak-to-noise ratio (PNR) of source images, where the second and the third column list the PNR only using geodetic VLBI data and combined GPS and VLBI data, respectively. (In the combined data column, column 3, if GPS data is available at a station, it is used by itself; if no GPS data is available, VLBI data is used.) Differences between the PNRs are very small. We therefore suggest to install GPS receivers at all VLBA sites and to correct for tropospheric effects in VLBA phase-referencing by using only GPS data or a combination of VLBI and GPS data. The precision of this correction will be at the millimeter level, while the geodetic VLBI observations could be omitted or compressed in order to save the observation time of targets.

Table 1. Comparison of PNR of source images.

Source	PNR (VLBI)	PNR (GPS/VLBI)
G350(Maser)	100.1	103.7
1855(QSO)	15.1	16.4
1907(QSO)	15.6	14.1
185X(QSO)	6.7	6.8

2.2. The Selection of Stable Sources

Based on the Calc/Solve system and aiming at the selection of stable sources, we have obtained a series of global solutions for astrometric/geodetic VLBI observations from 1984 to 2006 by changing the settings of the control parameters.

Firstly, a selected working list of sources is sorted by declination and then it is divided into six groups. Mathematically, the i^{th} source belongs to group j where $j = mod(i/6)$, and if $j = 0$ then set $j = 6$. By doing so we obtain similar sky coverage for the six groups. Secondly, take each of the six groups in turn as arc parameters and all the others as global parameters to obtain the global solutions of VLBI data. We allow only one sixth of the sources as arc parameters in order to maintain a uniform reference system. Thirdly, in each of the solutions the frame orientation is constrained to the ICRF, while different solutions may still have their own orientations that are slightly different from the others. We perform small angle rotations of the solutions in order to let the reference systems of all the arc parameters be further unified. Finally, after comparison and statistical analysis of the solutions we proposed a list of 173 candidate stable sources. We also compared the list with those recommended by other authors.

2.3. Data Analysis in the Chang'E-1 Project

As designed in the Chinese lunar exploration project Chang'E-1 (CE-1), the tracking data of satellite consist of range and Doppler measurements from the Chinese United S-Band network as well as delay and delay rate data from the Chinese VLBI network. We are tasked with processing the tracking observations of the CE-1 satellite in real-time and we have independently developed the data reduction software, which provides the instantaneous state vectors (ISVs) including the three-dimensional position and velocity. The software reads in tracking observations with clock, instrument, and propagation corrections in real time, automatically identifies the central gravitational body within the Earth-Moon system, and takes into consideration the perturbations of the non-spherical figure, N-body gravitation, light pressure, atmospheric drag, tidal effects and so on. The satellite ISVs are sequentially reduced with a $5s$ sampling interval.

From the ISVs it is easy to get the corresponding orbit elements and to predict the satellite ephemeris by orbit integration. The ISVs at a specified epoch could be reduced whenever the independent observations related to the wave-front of signal at this epoch are sufficient, that is, enough delay and range observations for the three-dimensional position and enough delay rate and Doppler for the velocity. This reduction is geometrically performed rather than applying dynamical constraints on the observations belonging to different wave-fronts at different epochs, and so the length of the tracking arc is not a crucial prerequisite. It could be used to monitor the quality of tracking data and to identify the evolution of satellite orbit, which satisfies the needs of efficiency and speediness in the view of the implementation of projects. Comparatively, precise orbit determination requires a sufficiently long tracking arc and is mainly applied in scientific studies with high precision requirements as in the post-analysis stage rather than in real time.

On November 5 of 2007, CE-1 satellite successfully entered a lunar orbit. During that period the real-time reduced ISVs from our software very well followed the evolution of the satellite orbit with a time lag of about five minutes, including the delays for the data transfer from the antenna to the correlation center, the correlation, the extraction of the delay and rate, among other things. The next step is to do the synthesis reduction of VLBI observations of satellite and quasars, especially the differential VLBI observations.

3. Plans for 2008

In the past year, the available time of the 25m antenna at Sheshan was almost completely used for the CE-1 project, which blocked the progress of the local survey to connect the reference markers of the SLR, VLBI, and GPS. Now we have local survey network of concrete pillars, a lease contract for survey instrumentation, auxiliary survey equipment such as the target on the antenna and the connections of the pillar to the instrument. The first session of the survey should be completed in 2008.

Other research activities will be continued in 2008, especially, we will get ready in knowledge and software for the Chinese lunar exploration and Martian exploration. We will make softwares to automatically do the analysis of the intensive EOP observations, we will also do some comparisons and combinations of individual EOP time series.