Analysis Center Report from Shanghai Astronomical Observatory for the Year 2001

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Abstract

After a brief description of the general status, we summarize the activities of the astrometric and geodetic VLBI group of Shanghai Astronomical Observatory for the year 2001. Our activities are involved in the coordination of the VLBI observations for the Asia-Pacific Space Geodynamics (APSG) program and several Chinese national geodetic projects, the data archives and reduction, and the astrometric and geodetic application studies of VLBI. We also describe our plans for the year 2002 and finally show our thanks to IVS colleagues and others giving us help.

1. General Description

As a research group of the Center for Astrogeodynamics Research, Shanghai Astronomical Observatory, Chinese Academy of Sciences, we focus our activities on Radio Astrometry and Celestial Reference Frames. Facilities for us to analyze the astrometric and geodetic VLBI observations are several sets of personal computers with advanced technical specifications and the HP C180 Workstation. The software is the CALC/SOLVE system. The staff involved in the IVS data analysis activities are:

Dr. Jinling Li, head of the group;
Dr. Guangli Wang, software support and data analysis;
Mr. Bo Zhang, data analysis and software update;
Prof. Ming Zhao, advisor;
Prof. Zhihan Qian, advisor.

There are other members in our group as follows:

Dr. Zhenghong Tang, ground optical astrometry and celestial reference frames;
Dr. Xiaoya Wang, space geodetic data analysis and application studies;
Mr. Yong Yu, celestial reference frames;
Prof. Wenjing Jin, advisor.

2. Research Activities

2.1. Observation Coordination

Outstanding characteristics such as high precision repeatability for long baseline length measurements and providing high precision observations in the quasi-inertial deep space background make VLBI one of the key supporting techniques of the Asia-Pacific Space Geodynamics (APSG) program and several Chinese national geodetic projects, for instance, the Chinese Observation Network of Crustal Movement, and the Mechanism and Prediction of Continental Intensive Earthquakes. Our group undertakes the coordination of the VLBI experiments for these projects as well as the observation archiving and reduction.

2.2. The Development of the Assessment System for VLBI Solutions

In the global analysis of the astrometric and geodetic VLBI observations, the management of huge amounts of data, the selection of various models, and the settings of numerous parameters complicate the observation processing. Therefore a subject and timely evaluation of the solution is desired to find out and overcome problems in the analysis. Accordingly, the assessment system of the global analysis solution has been developed. All the solutions including the celestial reference frame, the Earth Orientation Parameters, and the terrestrial reference frame can be evaluated by this system concerning the individual behavior of a single data point as well as the systematic behavior of the whole set of solutions.

2.3. The Selection of On-plate Sites

In the compilation of the conventional terrestrial reference frame with modern space geodetic techniques, one of the important issues is to select those sites on a given plate. Considering that whether the motion of a site can be modeled or not by plate rigid motion is not necessarily dependant on the distance from the site to the plate boundary or deforming zones, we accordingly propose a statistical selection of on-plate sites. By applying this selection method to a VLBI global solution, the following are shown:

- The statistically selected on-plate sites are more than and consistent globally with the VLBI primary sites of the International Terrestrial Reference Frame 2000 (ITRF2000).
- The statistical selection emphasizes the consistency between the site motion and the plate rigid motion but ignores the distance from the site to the plate boundaries or deforming zones.
- Some of the statistically selected on-plate sites are not primaries in ITRF2000. However, by including these sites the estimations of plate rigid motion are not changed significantly. Instead, the precision of estimated parameters is increased due to the improvement in the site geometric distribution.
- Details of our analysis show that RICHMOND can be taken as an on-plate site, but it is not in the list of those most firmly on-plate. This site is usually used as one of the velocity constraint sites in VLBI global analysis. We recommend using ALGOPARK, FD-VLBA or NRAO_140 as substitutes.

2.4. Plate Motion and Crustal Deformation

By applying the statistical selection method as mentioned above to a global VLBI solution we selected out those on-plate sites for the Eurasia, North America, Pacific and Australia plates. We accordingly determined the relative motions between each pair of the four plates and the motion of other sites relative to their located plate.

2.5. Modeling of the Residual Clock Behavior and Atmosphere Effects

In the analysis of the astrometric and geodetic VLBI observations the residual clock behavior and atmosphere effects are those of the most outstanding error sources. Therefore, a suitable modeling of these residual effects is desirable to improve the analysis precision of parameters. In the present CALC/SOLVE system the continuous piecewise linear modeling is adopted and the time interval is usually set to be 60 minutes and 20 minutes for the residual clock behavior and the atmosphere effects respectively. We checked the dependence of the estimation of parameters on the choice of the piecewise interval in the modeling by single analysis of 27 VLBI experiments involving Shanghai station (Seshan25). The following are tentatively shown:

- Different choices of the piecewise interval lead to differences in the estimation of station coordinates and in the weighted root mean squares (*wrms*) of the delay residuals, which can be centimeters or dozens of picoseconds large respectively (Please refer to Figure 1 and Figure 2). So the choice of piecewise interval should not be arbitrary.
- The piecewise interval should not be too long; otherwise the short-term variations in the residual clock and atmospheric effects can not be properly modeled. But in order to maintain enough degrees of freedom in parameter estimation, the interval cannot be too short; otherwise the normal equation may become near or solely singular and accordingly the noises cannot be well constrained. Therefore the choice of the interval should be within some reasonable range.
- Since the conditions of clock and atmosphere are different from experiment to experiment and from station to station, the reasonable range of the piecewise interval should be tested and chosen separately for each experiment as well as for each station by real data analysis. This is really arduous work in the routine data analysis.
- Generally speaking, with the default interval for atmosphere as 20 minutes, the reasonable range of piecewise interval for residual clock behavior modeling is between 20 minutes to 100 minutes (as shown by Figure 3), while with the default interval for clock as 60 minutes, that for residual atmospheric effect is between 10 minutes to 40 minutes (as shown by Figure 4).

For most of our analyzed experiments the residual short-term variations are dominated by noise and the continuous piecewise linear function leads to variation in the estimation of parameters dependent on choices of interval. We accordingly propose to use periodic modeling of these residual variations by all the data set rather than piecewise function. If there is signal rather than solely random noises, the periodic modeling can extract the signal quite well, while the performance of the continuous piecewise linear function varies dependent on different situation. We also tested simulated data composed of quasi-periodic signals with random variations in amplitudes, periods and phases. The *wrms* of residuals for the piecewise function varies significantly for different intervals, while the *wrms* for the periodic modeling is on the same level of those piecewise functions with extremely short interval.

We only have shown the periodic modeling works mostly by simulated data tests. We are now starting to realize the modeling in SOLVE and trying to check the modeling by real data analysis. Preliminary results show that the periodic modeling is at least as good as the continuous piecewise linear function. Further analysis is still in progress.

3. Plans for the Year 2002

- Continuously coordinate VLBI experiments for the Chinese national geodetic projects and for the APSG program.
- Make some analysis of the effects of various constraints on the global solution.

- Precisely determine the positions of the optical counterparts of two dozen extragalactic radio sources. We are now testing a new method to process the CCD observations, and hope to get positive results in the near future.
- Improve our ability in VLBI data reduction and application studies.

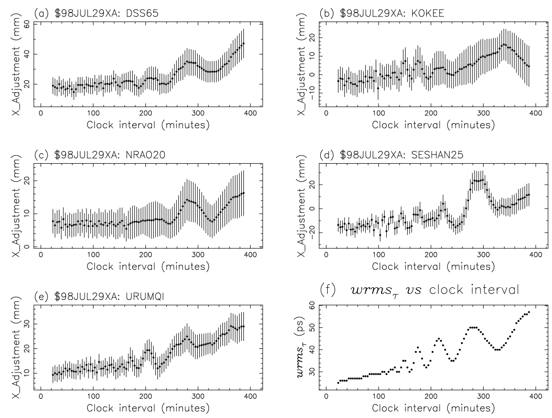

Figure 1. The distributions of the adjustment and formal error of the x-component and the delay residual *wrms* versus the length of interval in the continuous piecewise linear modeling of the residual clock behavior.

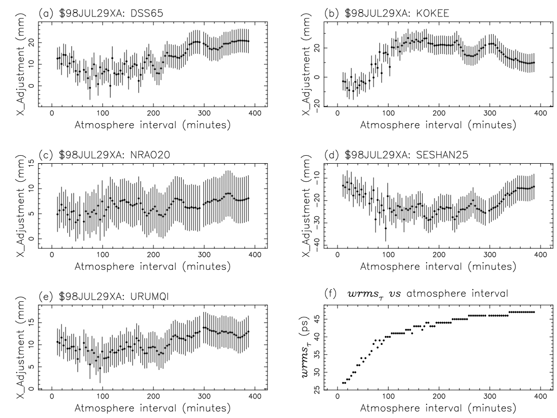

Figure 2. The distributions of the adjustment and formal error of the x-component and the delay residual *wrms* versus the length of interval in the continuous piecewise linear modeling of the residual atmospheric effect.

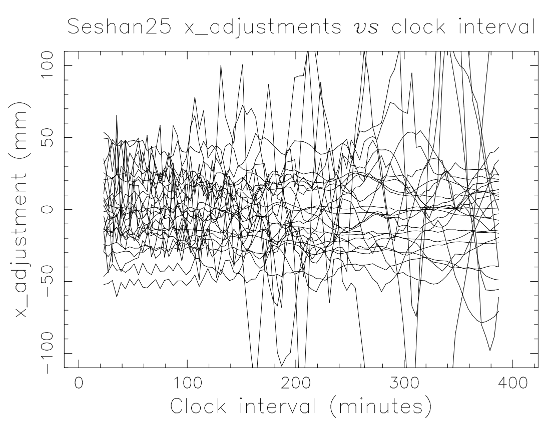

Figure 3. The adjustments of the x-component of SESHAN25 versus the length of interval in the continuous piecewise linear modeling of the residual clock behavior for all the analyzed 27 sessions. The default interval is 20 minutes for the modeling of the atmosphere.

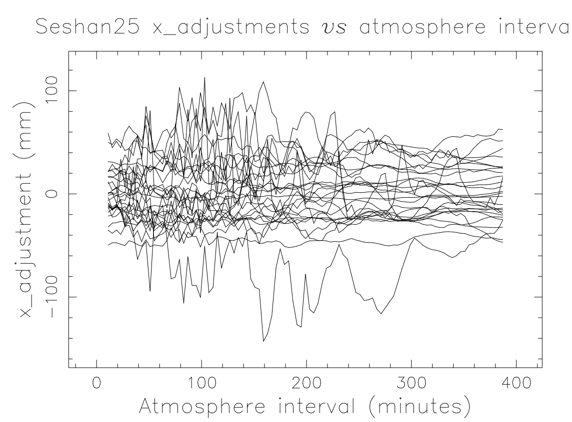

Figure 4. The adjustments of the x-component of SESHAN25 versus the length of interval in the continuous piecewise linear modeling of the residual atmospheric effect for all the analyzed 27 sessions. The default interval is 60 minutes for the modeling of clock behavior.

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