Analysis Center Report from Shanghai Astronomical Observatory for 1999.03—2000.12

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Abstract

Here we summarize the activities of the astrometric and geodetic VLBI group of Shanghai Astronomical Observatory during the period from March 1999 to the end of 2000. Our activities are involved in the coordination of the VLBI observations for Asia-Pacific Space Geodynamics (APSG) program and several Chinese national geodetic projects, the data archives and reduction, the astrometric and geodetic application studies of VLBI. We also describe our plans for the year 2001 and finally show our thanks to all IVS colleagues and others giving us help.

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, the Mechanism and Prediction of Continental Intensive Earthquakes. In January and October of 2000, our group organized in total four 24-hour Chinese national VLBI experiments. The antennas are one fixed at Sheshan and one 3-m mobile at Kumning. In November of 1999 two international VLBI sessions were coordinated and in October of 2000 one session. All are for the APSG program. The stations are Sheshan and Urumqi of China, Gilcreek and Kokee of USA, Kashima of Japan and Hobart of Australia. These observations are important to the studies of contemporary crustal motions within the China mainland as well as in the Asia-Pacific region.

2. Data Archives and Reduction

The original HP C180 workstation was updated by extending the memory capacity to 260 Mb and the hard disk to 54 Gb. The originally installed CALC8.2 was replaced by CALC9.1. The observations were archived in personal computer disk, which is cheaper, faster and more convenient than originally used 4-mm tape and its tape driver.

As a milestone in our group's history of data reduction, Mark III VLBI observations between August 1979 and December 1998 were successfully analyzed in 1999. It was the first time for our group to perform a full time span global VLBI data reduction. We compared our solution with ITRF96, RSC (WGRF) 95 R01 and EOP (IERS) 97 C04. The three orientation angles for the Celestial Reference Frame are not significant at the level of precision of $0.1mas$. Though no significant values are found for the three deformation parameters, coordinate drifts up to $0.5mas$ are identifiable for some sources in the southern hemisphere. The relative rotation angles and their rates of change for the Terrestrial Reference Frame are not significant respectively at the precision level of $0.2mas$ and $0.1mas/yr$. Detailed comparisons however show that the differences in the velocity field are obvious for the eastern part of Eurasian plate and Australian plate. About Earth

Orientation Parameter series, the systematic differences and the relative drifts are not significant respectively at the level of $0.4mas$ and $0.1mas/yr$.

In the year 2000, our global VLBI solution was adopted as one of the three input solutions of the latest version International Terrestrial Reference Frame (ITRF2000), which is really encouragement to the whole group and also to the supervisors of our work unit.

3. Application Studies

3.1. Temporary crustal movement

Based on our global VLBI solution, we analyzed the motion of Sheshan VLBI station using two different methods. One is based on the prediction of plate motion model. The other is based on the absolute angular velocity of plate. In the first method, the VLBI measurement of Eurasia plate motion was compared with the prediction of the plate motion model NNR-Nuvel1a by the following equation,

$$\begin{pmatrix} v_x \\ v_y \\ v_z \end{pmatrix}_{NNR-NUVEL1A} - \begin{pmatrix} v_x \\ v_y \\ v_z \end{pmatrix}_{VLBI} = \begin{pmatrix} T_1 \\ T_2 \\ T_3 \end{pmatrix} + \begin{pmatrix} D & R_3 & -R_2 \\ -R_3 & D & R_1 \\ R_2 & -R_1 & D \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix}_{VLBI} \quad (1)$$

where D, $T_{1,2,3}$ and $R_{1,2,3}$ are respectively the scaling factor, the translation and rotation parameters between the measurement and prediction. These parameters are solved for by a least-squares adjustment in a re-processing procedure. Only stations with post-fit residuals in horizontal velocity less than the analysis formal error (1σ) were finally used to contribute to the solution. Then after the removal of the effects of systematic transformation parameters and the prediction of plate motion model from the VLBI measurement, the motion of Sheshan station relative to the stable part of Eurasia plate is found to be 8.4 ± 0.4mm/yr in the direction N$122.4 \pm 2.8°$E.

In the second method, the absolute angular velocity of Eurasia plate, $\vec{\Omega}(\Omega_x, \Omega_y, \Omega_z)$, was solved for from the following equation,

$$\vec{v}(v_x, v_y, v_z) = \vec{\Omega} \times \vec{r} \quad (2)$$

where $\vec{v}$ and $\vec{r}$ are the geocentric velocity and position of a station from VLBI measurement. Again, only stations with post-fit residuals in horizontal velocities less than the analysis formal error were used to solve for the absolute angular velocity. The motion of Sheshan station relative to the Eurasia plate was found in this way to be 7.4 ± 0.3mm/yr in the direction N$117.4 \pm 2.0°$E. By comparing this with that from the first method, the difference between them is obvious. However, if we neglect the effect of the scaling factor and the translation parameters in $Eq.(1)$, the motion will be 7.3 ± 0.4mm/yr in the direction N$113.5 \pm 3.0°$E, which becomes consistent with that from the second method within the error budgets. Since D, T and R are independent parameters from each other and modeling possible real systematic effects, the motion determined from the first method should be more reliable than from the second one.

In Table 1 some results about the motion of Sheshan station relative to the Eurasia plate determined by various authors are shown for comparison. From this one can only say that the motion is eastward about 1 cm/yr. An efficient way to improve the precision of this determination would be to improve the temporal coverage of data rather than solely the accumulation of observations.

Table 1. The motion of Sheshan station relative to Eurasia plate

Author	Technique	Rate mm/yr	Azimuth N°E
Heki, 1996	VLBI	11.1±1.2	112.1±6.2
Molnar & Gipson, 1996	VLBI	8.0±0.5	116.5±4.1
Zhu Wenyao et al., 1997	GPS	11.2	75.7
Zhu Wenyao et al., 1999	GPS	10.8	87.3
Yu & Kuo, 1999	GPS	11.2±1.0	112.3±6.4
This paper (based on absolutely angular motion)	VLBI	7.4±0.3	117.4±2.0
This paper (based on plate motion model)	VLBI	8.4±0.4	122.4±2.8

The relative motion between Eurasia and North America was also analyzed based on our global VLBI solution. In Table 2 several determinations are listed for comparison. Various authors provided generally consistent results. The rotational velocity is about $0.2°/Myr$ with a slightly faster rotation for the modern space technique determination compared with the past millions of years' geophysical records. The positions of the rotational pole and the azimuths of major semiaxis given by various authors are obviously different from each other, so again the coverage and amount of observations must be improved.

Table 2. Angular motion between Eurasia and North America plates

Author	Technique	Angular velocity			Pole error ellipse		
		Latitude °N	Longitude °E	ω °/Myr	σ_{max} °	σ_{min} °	A N°E
DeMets et al., 1994	NUVEL1A	62.4	135.8	0.21 ±0.01	4.1	1.3	−11
Cook et al., 1986	Earthquake	71.2	132.0				
Argus & Heflin, 1995	GPS	78.5	122.0	0.23 ±0.03	4.1	2.4	−8
Larson et al., 1997	GPS	68.1	126.6	0.24 ±0.02	3.2	2.0	−30
Kogan et al, 2000	GPS	74.3	123.0	0.231±0.008	1.8	1.4	16
This paper	VLBI	74.34	137.98	0.242±0.007	3.5	2.1	−9

ω: rotational velocity.
σ_{max}, σ_{min}: major and minor semiaxes of the 1σ error ellipse.
A: azimuth of major semiaxis reckoned clockwise from north.

3.2. Polar motion

In a spectrum and wavelet analysis of the VLBI determined polar motion series for the time span from August 1979 to December 1998, it is shown that (1) during the VLBI data span the Markowitz wobble does not appear, (2) the amplitudes of both annual and Chandler wobble show temporal variations, with the former being more obvious than the latter within the observation period, (3) all the signals in polar motion series are characterized by temporal variation in amplitudes, which means that it is almost impossible to separate signals by a least-squares fit and (4) by applying a low-pass filter the secular polar motion is found to be 2.74±0.01 mas/yr towards 83.9±0.3 °W longitude, which is smaller in rate and more westward in direction compared with those determined from optical observations (Li & Wang, 2000).

3.3. Optical astrometry

Image restoration has been shown to be a very useful tool for many kinds of research, such as in the reduction of Hubble Space Telescope images, gamma ray data and in monitoring the gravitational lenses of AGNs. Members of our group used image restoration to remove the influence of tracking error in astrometric CCD images. As shown in Fig.1, (a) is the two-dimensional Gaussian distribution of an ideal image, (b) is the image of the standard star degraded by tracking error in a CCD frame, (c) shows the blended images of two nearby stars and (d) shows that after the image restoration the two nearby stars are well separated. By applying image restoration, the precision of the center of star image can be improved, the images of nearby stars too (Tang et al., 2001). The optical counterparts of 23 extragalactic radio sources, of which 13 are in the southern hemisphere, are observed with CCD. The positions have been determined with mean standard errors in right ascension and declination better than 0.2 arcsec (Tang et al., 2000).

4. Plans for the Year 2001

Most important, try our best to provide analysis products to IVS data center quarterly. Continuously coordinate VLBI experiments for 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. Improve our ability in VLBI data reduction and application studies.

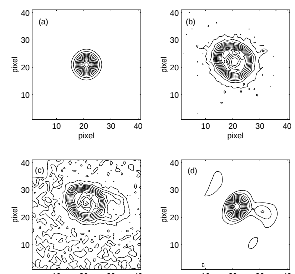

Figure 1. Separating nearby images degraded by tracking error with image restoration.

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