Shanghai Astronomical Observatory Analysis Center Report

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Abstract

Our activities in the calender year 2003 are involved in the coordination of the VLBI observations for the Asia-Pacific Space Geodynamics (APSG) program, data archives and reduction and application studies. Our plans for the calender year 2004 will be mainly focused on the application of VLBI to the positioning of spacecraft.

1. General Information

As one of the research groups of the Center for Astrogeodynamics Research, Shanghai Astronomical Observatory (SHAO), we focus our activities on studies of Radio Astrometry and Celestial Reference Frames. Facilities for us to analyze the astrometric and geodetic VLBI observations are the HP C180 Workstation, several sets of personal computers with advanced technical specifications, as well as several sets of SUN Workstations in the computer division of SHAO. We use CALC/SOLVE system in the routine VLBI data reduction. The members involved in the IVS activities are Jinling Li, Guangli Wang, Bo Zhang, Li Guo, Nianchuan Jian, Ming Zhao and Zhihan Qian.

2. Current Activities

2.1. Observation Coordination and Data Reduction

Our group continue the coordination of the VLBI experiments as well as the observation archives and reduction for the Asia-Pacific Space Geodynamics (APSG) program. In October of 2003 two 24h VLBI sessions were carried out. We also participated in some IERS/IVS campaigns aimed at comparisons of reference frames and/or Earth Rotation Parameters. We contributed to IERS several sets of global solutions from VLBI data reduction.

2.2. Modelling the Residual Clock Behavior in VLBI Data Reduction

Based on the observations and simulated data, the feasibility of the periodic function modelling (P-model) of the residual clock behavior in the routine VLBI data reduction was discussed. Two global solutions of 1,567 VLBI sessions from 1990 to 2001 were performed corresponding to the continuous piecewise linear modelling (N-model) and the P-model of the residual clock behavior. It is shown that compared with the N-model the number of unknowns in the solution could be evidently decreased and so the degree of freedom increased when the P-model was used. Though the formal errors of the coordinates of stations and sources as well as the Earth Orientation Parameter are on the same level, it is slightly better to model the residual clock behavior by the P-model than the N-model. The formal errors of coordinates could be decreased for more than 80% of the stations and 70% of the radio sources (Figure 1 and Figure 2).

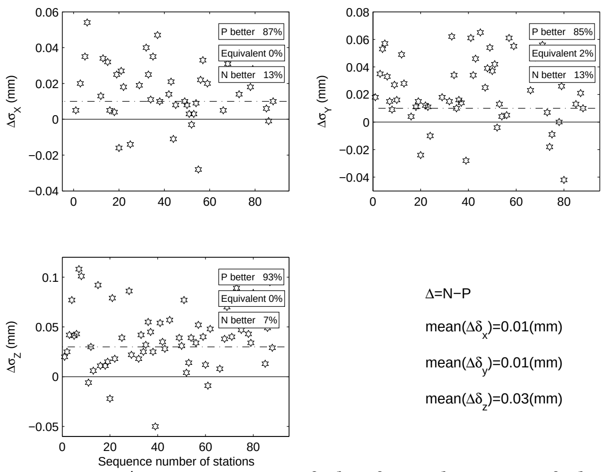

Figure 1. A comparison of the formal errors of the station coordinates between the P- and N-model of the residual clock behavior

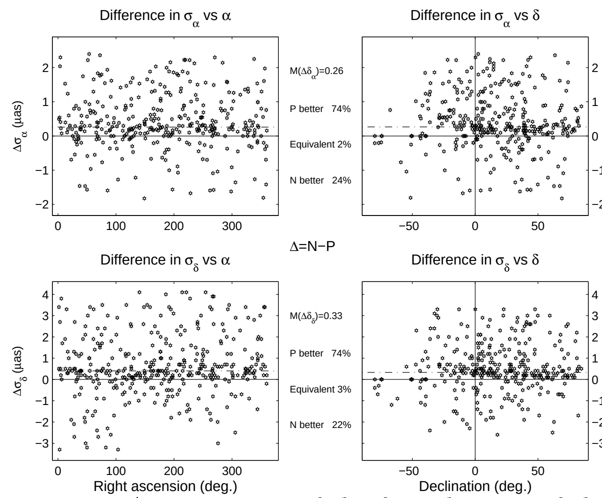

Figure 2. A comparison of the formal errors of the radio source coordinates between the P- and N-model of the residual clock behavior

2.3. Solutions and Analysis of EOP High Frequency Variation

To get the solutions of the EOP high frequency variation in a piecewise manner, we could use piecewise continuous linear modelling with constraints on the change of the rate between connected pieces. By doing so the solutions to the rates could be strongly correlated with each other and the real change in the rate may be concealed. We have tried to solve for the means of EOP within every piece without any constraints. Comparisons show that if the data points are sufficient the constraints are not necessary. Figure 3 shows our solutions to the high frequency variation of EOP and its wavelet analysis.

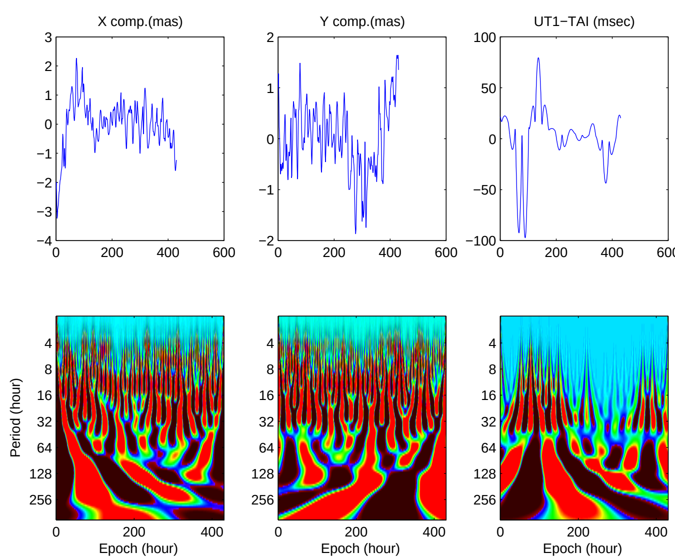

Figure 3. An example of the solutions and analysis of the high frequency variation of EOP

2.4. Some Other Activities Related with the Chinese CHANGE Project

The angular resolution in spacecraft positioning by the intended Chinese VLBI network was analyzed in order to provide some quantitative reference specifications to the feasibility demonstration and the program design of the Chinese CHANGE project.

Table 1 lists the angular resolution estimations by shifting the spacecraft geocentric distance, the constraint of range, the configuration of station network and the type of observations. The spherical coordinates of the spacecraft are $\alpha = 105°$ and $\delta = 35°$. In Table 1, the site code from 1 through 7 represent respectively the VLBI stations of SHANGHAI, URUMQI, KUNMING, BEIJING, KASHIMA, SVETLOE and HARTEBEESTHOEK, σ_α and σ_δ represent respectively the angular resolution in the right ascension and declination, "Corr" is the correlation coefficient between the two estimations. From Table 1 it could be concluded that (1) either τ or $\dot{\tau}$ could be used independently in the spacecraft positioning, if τ and $\dot{\tau}$ observations are used in combination in the positioning the precision of the resulting angular resolution is better than only using one of the two types observations; (2) if only $\dot{\tau}$ observations are used without the range constraint, the angular resolution in right ascension and declination are strongly correlated with each other and so result in a low precision of estimation; (3) in the combination use of τ and $\dot{\tau}$ observations the latter contributes to a very limited extent to the improvement of the precision; (4) the range constraint obviously improves the angular resolution; (5) the intended Chinese VLBI network is longer in east-west baseline than in north-south, the corresponding longitudinal angular resolution is better than the latitudinal; (6) if the Chinese network is supplemented with some international stations when tracking the spacecraft, the angular resolution could be improved significantly.

Taking into consideration the inclination angles among the lunar orbit, equatorial and ecliptic planes, Figure 4 and Figure 5 demonstrate the estimation of angular resolutions for the intended Chinese network only and for the Chinese network supplemented by some international stations. The target distance is $380,000km$, only delay observations are used with $1km$ range constraint and $\sigma_\tau = 1ns$. The comparison of the two figures shows that with the supplement of international stations the sky coverage with high resolution is extended and the resolution is improved significantly.

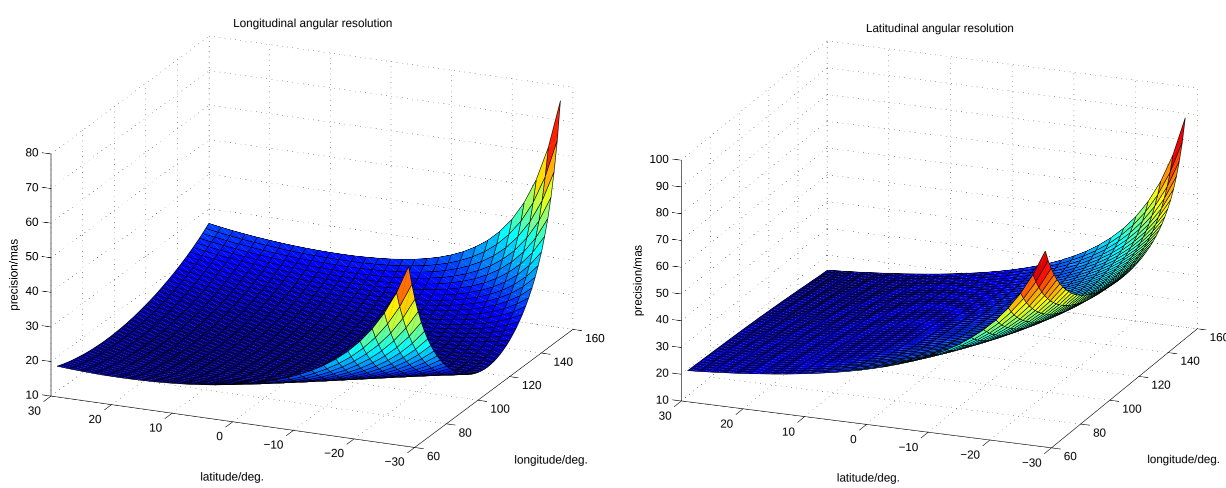

Figure 4. Angular resolution estimation with $1ns$ delay observation $380,000km$ target $1km$ range constraint and four (1 to 4) tracking stations

Table 1. Angular resolution estimation from VLBI observables

$r = 180,000km$		Without constraint			$1km$ range constraint		
Site code	Data type	Angular resolution(mas)			Angular resolution(mas)		
		σ_α	σ_δ	Corr	σ_α	σ_δ	Corr
1 to 4	τ	18.0	21.1	0.16	17.2	19.2	0.33
	$\dot{\tau}$	4290.8	21556.2	-0.99	533.7	413.4	-0.34
	$\tau, \dot{\tau}$	17.2	19.1	0.33	17.2	19.1	0.33
1 to 7	τ	6.5	4.4	-0.09	6.3	4.4	-0.10
	$\dot{\tau}$	134.1	485.3	-0.46	129.2	274.6	-0.44
	$\tau, \dot{\tau}$	5.3	4.4	-0.09	5.2	4.4	-0.09
$r = 380,000km$		Without constraint			$1km$ range constraint		
Site code	Data type	Angular resolution(mas)			Angular resolution(mas)		
		σ_α	σ_δ	Corr	σ_α	σ_δ	Corr
1 to 4	τ	18.4	21.5	0.16	17.5	19.5	0.34
	$\dot{\tau}$	5119.4	19386.1	-0.99	539.7	347.3	-0.36
	$\tau, \dot{\tau}$	17.6	19.6	0.32	17.5	19.5	0.34
1 to 7	τ	6.7	4.4	-0.08	5.0	4.4	-0.12
	$\dot{\tau}$	128.0	379.9	-0.42	125.4	124.7	-0.71
	$\tau, \dot{\tau}$	5.9	4.4	-0.08	4.9	4.4	-0.12

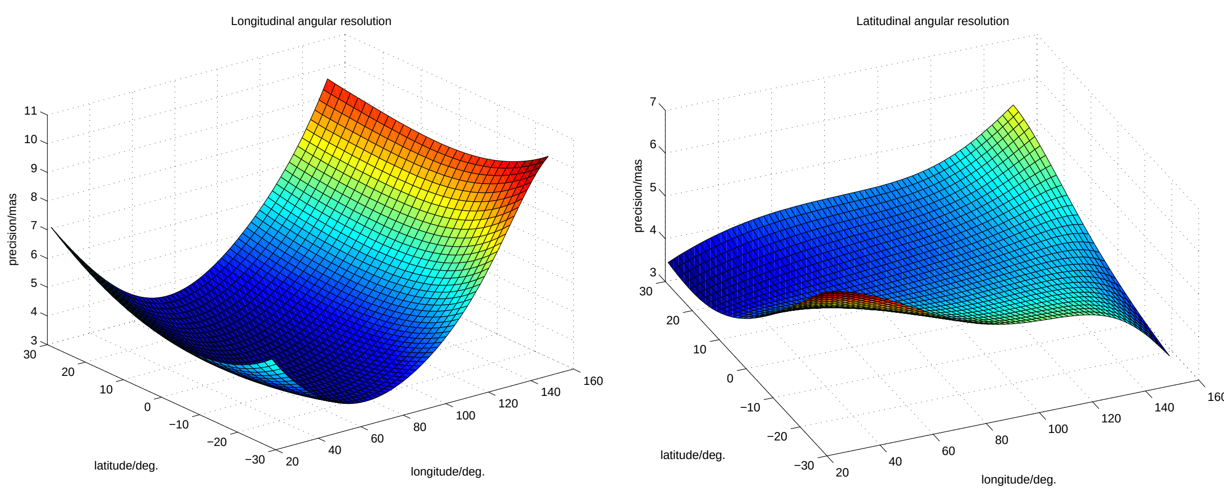

Figure 5. Angular resolution estimation with $1ns$ delay observation $380,000km$ target $1km$ range constraint and seven (1 to 7) tracking stations

3. Plans for the Calendar Year 2004

We will continue to deliver our efforts on the coordination of the APSG program as well as on the response to various IERS and IVS campaigns of regional and global VLBI data analysis. We will focus most of our efforts on the application of VLBI to the positioning of spacecraft.