Shanghai Astronomical Observatory Analysis Center 2004 Annual Report

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Abstract

Our research activities in 2004 mainly focused on satellite positioning and orbit determination by VLBI. We were also involved in the coordination of VLBI experiments, data archives, reduction and application studies. The plan for the next year is to continue our efforts in the application studies of VLBI. We are also planning to contribute to IVS the quarterly solutions of Earth Orientation Parameters.

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

In September of 2004 two new 24hour VLBI sessions of the Asia-Pacific Space Geodynamics (APSG) program were carried out. Up to now there are in total 15 APSG sessions with single solution $wrms$ about $40ps$. We also participated in some IERS/IVS campaigns aimed at comparisons of reference frames and/or Earth Rotation Parameters.

2.2. Solutions and Analysis of High Frequency Variation of ERP

The time series of Earth Rotation Parameters (ERP, UT1-UTC, x and y) with two hour resolution from 1980 to 2003 are solved by performing global solutions of thousands of astrometric and geodetic VLBI sessions. The solution mode is newly developed based on the *User-partial* entry of SOLVE, which takes into consideration the deficiency in the precession/nutation models and directly solves the ERP mean within every data piece, rather than by applying constraints on the time rate and the continuation at epoch nodes. Power spectrum analysis of the x component of polar motion is shown by Figure 1, from which the main ocean tidal terms ($Q_1, O_1, P_1, K_1, N_2, M_2, S_2, K_2$) are clearly indicated. As shown in Table 1, least squares estimation of the diurnal and semi-diurnal zonal tide terms within various time spans demonstrates the possible time variation of the amplitude and phase, which may relate to the resonance with the nearby frequency terms and requires further checks in the future.

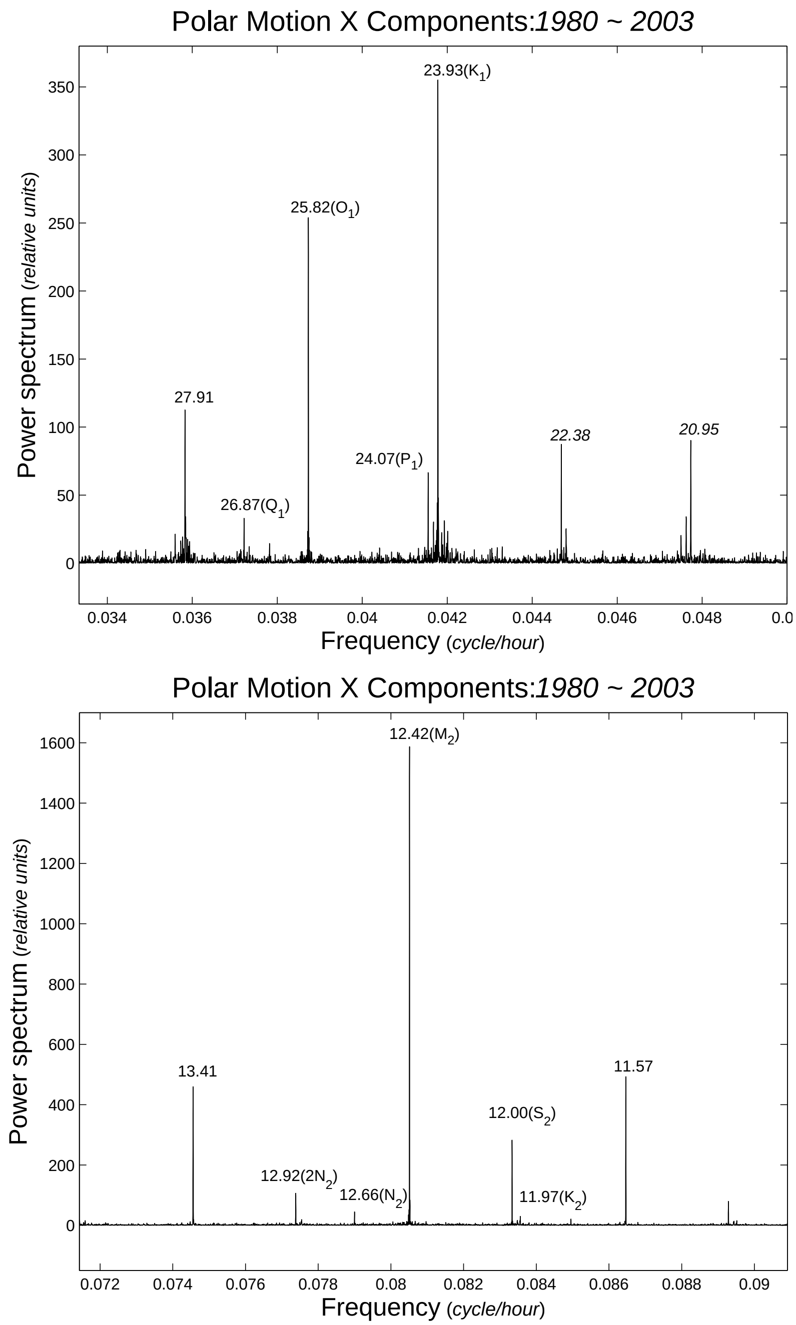

Figure 1. Power spectrum analysis of the x component of polar motion from 1980 to 2003

2.3. Activities Related to Chang'E Project

Our group is closely involved in Chang'E project, the Chinese lunar mission. Our duty is (1) to extract from correlation outputs the VLBI observations delay and delay rate, (2) to study the means of various corrections to satellite VLBI observations and (3) to perform satellite positioning and orbit determination by VLBI observations.

Table 1. Least squares estimation of zonal tide terms within various time spans

Unit: μs

	1990—2003	2000—2003	1996—1999	1990—1995	IERS(2003)
$Q_1 cos$	– 2.20	– 1.17	– 3.45	– 1.95	– 2.50
$Q_1 sin$	3.87	5.75	3.71	3.18	5.12
$O_1 cos$	– 12.13	– 8.97	– 9.93	– 14.56	– 12.07
$O_1 sin$	15.23	19.19	14.52	13.90	16.02
$P_1 cos$	– 3.19	– 3.14	– 3.70	– 2.83	– 3.10
$P_1 sin$	5.45	5.29	4.90	5.89	5.51
$K_1 cos$	8.97	11.88	8.27	8.14	8.55
$K_1 sin$	– 14.80	– 16.78	– 14.37	– 14.05	– 17.62
$N_2 cos$	– 1.54	– 1.76	– 1.76	– 1.36	– 1.56
$N_2 sin$	– 3.19	– 3.48	– 2.86	– 3.27	– 3.79
$M_2 cos$	– 8.74	– 8.85	– 8.64	– 8.73	– 7.15
$M_2 sin$	– 14.80	– 15.38	– 15.18	– 14.37	– 16.19
$S_2 cos$	– 0.18	– 0.72	– 0.32	0.12	– 0.16
$S_2 sin$	– 7.54	– 7.73	– 7.24	– 7.59	– 7.55
$K_2 cos$	0.10	0.56	0.13	– 0.09	0.04
$K_2 sin$	– 2.48	– 2.35	– 2.43	– 2.56	– 2.10

For the observation extraction, a FX type correlator for Chang'E mission is under development at SHAO. It will be capable of processing observations of five stations simultaneously. We are making software to extract the delays and rates from the correlation fringe. The software (i) for single baseline, single channel extraction is completed, (ii) for single baseline, multi-channels it is almost finished except for the check with real observations, (iii) for multi baselines, multi-channels it is still under development.

For the corrections of satellite VLBI observations, we now focus on the ionospheric corrections. In the observation of extragalactic radio sources the technique of dual frequency bands is applied. If the dual bands observation is not always available as in the case of Chang'E mission, it is intended to make the ionospheric correction by using GPS observations. We therefore checked the effectiveness of (i) the application of GPS observations and (ii) the dual bands technique in the satellite observation by VLBI concerning the ionospheric correction.

We compared the ionospheric information from VLBI and GPS for the Seshan25 — Urumqi baseline and for the baselines in CONT02 (October 16-31,2002). As an example, Figure 2 is for Kokee — Westford baseline. In this figure, TEC is the Total Electron Content and TECU is the unit of TEC. "TEC by VLBI" is converted from the ionospheric correction at reference frequency as given in the VLBI database. "TEC by GPS" means the prediction of TEC at the VLBI observation direction based on the reduction of GPS tracking data (The time series of the zenith TEC is deduced from the GPS pseudo-range and carrier phase measurements and then mapped to the direction of the VLBI observation.). "Interval" means the time interval between sessions or the broken time span (not less than three hours) of VLBI tracking, whose epochs are indicated by the black points at the lower part of the figure.

Figure 2 shows that (i) during the VLBI continuous tracking period the correlation between the

VLBI observed TEC and the GPS predicted TEC is very good (more than 80%), which demonstrates the applicability of GPS observations for the ionospheric correction, but (ii) there may exist systematic jumps between the VLBI continuous trackings. In the reduction of astrometric and geodetic VLBI observations the systematic jumps are absorbed into the clock bias leaving no effects on the solutions of source and station coordinates as well Earth Orientation Parameters. In the data reduction of satellite VLBI tracking, practice shows that the clock bias could not be solved simultaneously with the positions or the orbit elements of satellite. In order to determine this systematic jump we therefore need to observe extragalactic radio sources during the satellite tracking, even the dual band technique has already been applied.

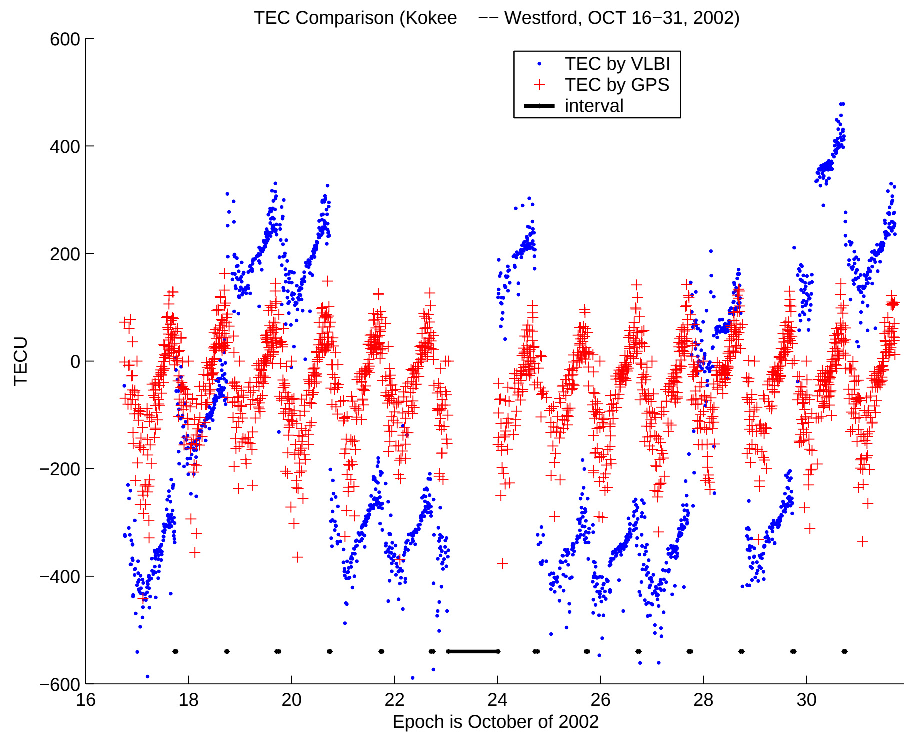

Figure 2. Comparison of TEC observed by VLBI and predicted by GPS

For the satellite positioning and orbit determination by VLBI during the Chang'E mission, the software is still under development and is partly tested against geo-satellite VLBI tracking data. There is still a long way to go to let the software be applicable to the mission.

3. Plans for 2005

We will continue to deliver our efforts on the application studies of VLBI to satellite positioning and orbit determination, mainly concerning the post-correlation stage. We will update our computers in order to be involved in IERS/IVS activities more easily. We will still pay attention to the coordination of VLBI experiments for the APSG program as well as data archives and analysis. We intend to provide to IVS the quarterly solutions of EOP.