SHAO Analysis Center 2005 Annual Report

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Abstract

Our research activities in 2005 were 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 of the Asia-Pacific Space Geodynamics program. Our contribution to the next realization of the International Terrestrial Reference Frame (ITRF2005) proved to be of good quality covering the complete period of VLBI observations. 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 extension solutions of Earth Orientation Parameters, to analyze the position stability of astrometric/geodetic radio sources, to apply differential VLBI in satellite positioning, and to discuss regional cooperations of astrometric/geodetic VLBI.

1. General Information

As one of the research groups of Shanghai Astronomical Observatory (SHAO), we focus our activities on the studies of Radio Astrometry and Celestial Reference Frames. We use the CALC/SOLVE software package for the routine VLBI data processing. We are now developing softwares in FORTRAN code to deal with satellite VLBI observations. The related members involved in the IVS activities are Jinling Li, Guangli Wang, Bo Zhang, Li Guo, Jing Wang, Ming Zhao, and Zhihan Qian.

2. Activities in 2005

2.1. Observations and Data Reduction

In October and December of 2005 two new 24hour VLBI sessions of the Asia Pacific Space Geodynamics program (APSG) were carried out. As shown in Table 1, up to now there are in total 17 APSG sessions with a single solution $wrms$ of about $40ps$. Shanghai participated in several IERS/IVS campaigns aimed at comparisons of reference frames and/or Earth Rotation Parameters (EOP); for instance, the contribution to the next realization of the International Terrestrial Reference Frame (ITRF2005), which proved to be of good quality covering the complete period of high quality VLBI observations. We also give some effort in the preparation of the EOP extension solutions.

2.2. The Ionosphere Delay Correction of the Satellite VLBI Observations

In astrometric/geodetic VLBI dual-frequency observations at S/X bands are used to correct the ionosphere delay. However, in the Chinese lunar mission Chang'E, the S/X dual-band observations could not be always guaranteed during the satellite positioning and trajectory determination by range, Doppler and VLBI. It was therefore necessary to make the ionosphere delay corrections by using other means besides the dual-band technique, for instance using GPS data. In addition, it should be checked whether the dual-band technique is still valid to the ionosphere delay correction of the satellite VLBI tracking data or not.

Table 1. VLBI observations of APSG

Code	Session	Stations	Duration	Delays	*wrms*
APSG01	97OCT06XA	GC,HB,KK,SE,UR	24h01m57s	858	46ps
APSG02	97OCT20XA	GC,HB,KA,KK,SE,UR	24h02m48s	1533	50ps
APSG03	98NOV05XA	GC,KK,SE,TS,UR	24h58m04s	1404	40ps
APSG04	98NOV12XA	GC,HB,KK,SE,TS,UR	23h56m49s	1700	43ps
APSG05	99NOV01XA	GC,HB,KA,KK,SE,UR	23h58m04s	931	56ps
APSG06	99NOV04XA	GC,HB,KA,KK,SE,UR	23h55m02s	1443	47ps
APSG07	00OCT02XA	GC,HB,KK,SE,TS,UR	23h42m26s	950	41ps
APSG08	01OCT10XA	HB,KK,SE	23h51m29s	274	51ps
APSG09	01OCT15XA	HB,KK,SE,TS,UR	23h57m39s	1143	42ps
APSG10	02OCT08XA	GC,HB,KK,SE,TS,UR	23h49m19s	1516	37ps
APSG11	02NOV05XA	GC,HB,KK,SE,TS,UR	23h56m41s	1961	38ps
APSG12	03OCT08XA	GC,HB,KK,SE,TS,UR	23h26m21s	2120	35ps
APSG13	03OCT21XA	KK,SE,TS,UR,HB	23h24m15s	1296	43ps
APSG14	04SEP15XA	GC,HB,KK,SE,TS	23h48m42s	1050	35ps
APSG15	04SEP29XA	GC,HB,KK,SE,TS	24h00m00s	1508	37ps
APSG16	05OCT11XA	GC,HO,KK,SH,TS	23h53m37s	1359	34ps
APSG17	05DEC06XA	GC,HO,KK,PA,SH,TS,UR	23h50m30s	2690	36ps

The Total Electron Content (TEC) along the ray path measured by VLBI and predicted by GPS for Seshan25 — Urumqi baseline and baselines of CONT02, a two-week campaign of continuous VLBI sessions in 2002, were compared. The comparisons indicated that ionosphere information from GPS observations could be applied to correct the VLBI observations of satellite, but there may exist significant systematic difference between the two techniques. Further analysis showed that this systematic difference is mainly related to the phase-calibration during the VLBI observation. In the reduction of astrometric and geodetic VLBI observations this systematic behavior is parameterized as the quasi clock bias leaving no effects on the solutions of source positions, station coordinates and EOP. In the data reduction of satellite VLBI tracking, however, practice shows that the quasi clock bias could not be solved simultaneously with the positions or the orbit elements of satellite. In order to determine this systematic behavior we therefore need to observe extragalactic radio sources during the satellite tracking, even though the dual band technique is being applied.

When the observation elevation is low there may be quadratic trend in the systematic difference, whose determination also requires observations of extragalactic radio sources at low elevation. In consideration of the time-space variation of the ionospheric ion density it is helpful to observe radio sources close to the tracking pass. There is a large scatter in the difference of TEC obtained by the two techniques at low elevation. The increase in GPS sampling rate and those observations from GPS local network are therefore beneficial to the improvement both in the time-space coverage of ionosphere and in the prediction precision of TEC by GPS observations, especially at low elevation.

2.3. The Reduction of the Satellite VLBI Observations

For the satellite positioning and orbit determination by VLBI during the Chang'E mission, the software is still under development and is partly examined by geo-satellite VLBI tracking data. There is still a long way to go to apply the software to the mission. Issues that still need some effort include (1) synthesis reduction of range and Doppler as well as VLBI observations of satellite, (2) synthesis reduction of observations of satellite as well as quasars, (3) setting of constraint of geocentric or lunar centric distance of satellite and so on.

2.4. Other Astrometric Activities

The Large Sky Area Multi-object Fiber Spectroscopic Telescope (LAMOST) was primarily proposed by Chinese scientists Shouguan Wang and Dingqiang Su, members of the Chinese Academy of Sciences. This telescope is characterized by important creative ideas in several aspects and the tracking mode is special too. Usually the tracking motion of telescopes is accomplished by setting the velocity to be in accordance with the diurnal motion and then adjusted by, for instance, the optical-electronic tracking device, which maintains the image of a guiding star staying at the center of the field of view (FOV). However, for LAMOST no object image at the FOV center could be available. In addition, all the fibers are required to precisely capture and track their corresponding objects. Due to the diurnal motion, the atmospheric refraction, and the aberration, the coordinates of images on the focal plane are changing with time. The tracking of images can be done by machinery driving systems only if the image positions could be precisely predicted, or equivalently, the tracking parameters of LAMOST could be precisely calculated. The precise vectorial expressions of tracking parameters of LAMOST are deducted by taking into consideration the real observation conditions, including the effects of atmospheric refraction, the diurnal and annual aberration, as well as the variation of the refraction coefficient with the altitude of the observation station and the air temperature and pressure at the observation epoch. Comparisons and analysis show that on the level of arc second a comprehensive consideration of all the effects is necessary to the precise tracking of objects by LAMOST fibers.

We are also working on the CCD observations and data reduction of stars and satellite.

3. Plans for 2006

We will continue to focus our efforts on the application studies of VLBI to satellite positioning and orbit determination, mainly concerning the post-correlation stage. We will try our best to be closely involved in the IERS/IVS activities. We intend to provide to the IVS the extension EOP solutions, to analyze the position stability of astrometic/geodetic radio sources, to think about the application of differential VLBI in the satellite positioning and to discuss regional cooperations of astrometric/geodetic VLBI. The analysis of the high frequency variation of EOP will be continued.