GSFC VLBI Analysis Center

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Abstract

This report presents the activities of the GSFC VLBI Analysis Center during 2007. The GSFC Analysis Center analyzes all IVS sessions, makes regular IVS submissions of data and analysis products, and performs research and software development aimed at improving the VLBI technique.

1. Introduction

The GSFC VLBI Analysis Center is located at NASA's Goddard Space Flight Center in Greenbelt, Maryland. It is part of a larger VLBI group which also includes the IVS Coordinating Center, the CORE Operation Center, a Technology Development Center, and a Network Station. The Analysis Center participates in all phases of geodetic and astrometric VLBI analysis, software development, and research aimed at improving the VLBI technique.

2. Activities

2.1. Analysis Activities

The GSFC analysis group routinely analyzes all IVS sessions using the Calc/Solve system, and performs the AIPS fringe fitting and Calc/Solve analysis of the VLBA-correlated RDV sessions. The group submits the analyzed databases to IVS for all R1, RDV, R&D, APSG, NEOS INT01, and INT03 sessions. During 2007, the group processed and analyzed 164 24-hr (54 R1, 53 R4, 6 RDV, 1 R&D, 2 T2, 6 CRF, 10 CRDS, 2 CRMS, 6 EURO, 2 OHIG, 2 APSG, 6 E3, and 14 JADE) sessions and 344 1-hr UT1 (230 NEOS INT01, 97 INT02, and 17 INT03) sessions. We also submitted updated EOP files and daily Sinex solution files for all IVS sessions to the IVS Data Centers immediately following analysis. The group also generated a new list of axis offsets and a file of cable cal signs for the IVS. The GSFC Analysis Center maintains a Web site at http://lupus.gsfc.nasa.gov/, where the latest solutions and velocity plots can be found.

2.2. Support Activities

The GSFC VLBI Analysis Center has provided a source position service as part of the RDV program since 1997. Observations of 63 requested sources were made in 2007 for members of the astronomy/astrometry community, and precise positions were obtained where possible.

2.3. Research Activities

The GSFC Analysis Center performs ongoing research aimed at improving the VLBI technique. Several of these research activities are described below:

- Station Dependent Correlations: The group continued studying the effect of applying station dependent noise. Best results were achieved when $\sim$10 psec of correlated atmosphere noise due to atmosphere mismodeling was applied.

- Source Imaging and Source Selection: A major effort was undertaken to collect and make available all existing maps of geodetic and non-geodetic VLBI radio sources. Using images and visibility plots, all sources were evaluated concerning their suitability as geodetic sources, and a new list of geodetic sources was proposed. The new list rejects many of the old geodetic sources based on structure and resolution effects.

- ICRF2 Preparation: A source position time series file was generated and studied. For each source, the right ascension and declination position WRMS's were computed. Possible methods for selecting the best set of defining sources were studied.

- MK-VLBA Earthquake: A 6.7 magnitude earthquake occurred near the MK-VLBA site on 15 Oct, 2006. Careful evaluation of the data indicates an episodic displacement of (-8, -10, +1) mm at MK-VLBA in its Up, East, and North components.

- Higher Frequency CRF: Members of the analysis group continued working with associates at JPL, USNO, NRAO, and Bordeaux Observatory to extend the celestial reference frame to higher frequencies by using the VLBA at K and Q bands ($\sim$24 and $\sim$43 GHz). The primary goals are to build up a reference frame for use in planetary spacecraft navigation at Ka band ($\sim$33 GHz), and to build a reference frame less affected by source structure and potentially more precise than the current X/S frame. One K band session was observed in 2007, concentrating on weaker sources and ecliptic sources. To date, the group has conducted 10 VLBA sessions and developed a catalog of 267 sources at K-band and 132 sources at Q-band, with sub-mas positions. Software was developed to insert ionosphere delay corrections into the databases using GPS ionosphere maps. When these ionosphere corrections are applied, an approximately linear bias in declination positions compared to X/S positions is cut in half. Future work will concentrate on observing weaker sources and on densifying the catalog along the ecliptic and in the regions needed for several upcoming Mars missions.

- Source Monitoring: We continued the source monitoring program which began on February 1, 2004. The goals of this program are to observe all geodetic catalog sources at least 12 times per 12 month period and sources in the ICRF at least 2 times per 12 month period. This is done by including the sources which have not met their targets in the weekly R1s. The maximum number of monitored sources in the R1s is restricted to 10. In 2006 we modified the use of the RDVs in the monitoring program. Our goal is to periodically observe all the monitored sources in the RDV sessions with a sufficient number of observations to image each source. For the geodetic sources our target is 6 times in any two year period, and for the other sources in the monitoring program at least once per year. We developed a MySQL database to track which sources and stations appear in each session. This database is updated whenever 1) a schedule is posted to IVS; 2) the GSFC group analyzes and posts a database; 3) the master file is updated. For each source and station, the database contains information about how many observations were scheduled, how many were correlated, and how many were used in the solution. It also contains information about the fit of the solution. In late 2007 we converted one of our machines from an HP machine to a Linux machine. In the process one of the scripts involved in updating the database stopped working. Because of this the source monitoring program did not work as planned during the last few months of 2007 and the first few months of 2008. This error has subsequently been fixed.

- Simulations: We continued work on simulations of the performance of networks of VLBI2010 antennas. Our investigation uses a Monte Carlo procedure to simulate the performance of

different antenna networks and different antenna specifications, where a critical specification is the antenna slew rate. Baseline length and vertical precision (scatter of simulation estimates) are improved as azimuthal antenna slew rates increase up to about 6 deg/sec but not significantly for higher rates. Precision of scale and EOP improves by a factor of 1.5 to 2 as network size increases from 8 to 32 sites.

- Reference Frame Scale: We investigated the systematic effects that contribute to bias and annual variation of the VLBI reference frame scale. The largest effects are antenna thermal deformation, loading, and atmosphere modeling, which explain about 0.35 ppb of the observed annual variation of about 0.5 ppb. Most of the scale bias between SLR and VLBI in the recent ITRF2005 combination was explained.

2.4. Software Development

The GSFC group develops and maintains the Calc/Solve analysis system. Calc/Solve is a package of approximately 120 programs and 1.2 million lines of code. Several updates were released during 2007.

3. Staff

Members of the analysis group and their areas of activity include: Dr. Chopo Ma (CRF, TRF, EOP, K/Q reference frame development, IVS representative to the IERS, current chairman of the IERS directing board, and ICRF2 development); Dr. Dan MacMillan (CRF, TRF, EOP, mass loading, antenna deformation, apparent proper motion, post-seismic studies, and ICRF2 development); Dr. David Gordon (database analysis, RDV processing and analysis, K/Q reference frame development, VLBA calibrator surveys, Calc development, and ICRF2 development): Dr. Leonid Petrov (CRF, TRF, EOP, mass loading analysis, VLBA calibrator surveys, Calc/Solve development, source mapping and monitoring, Linux migration, GEODYN development, and ICRF2 development); Dr. John Gipson (source monitoring, station dependent noise, improved parameter estimation, and chairman of IVS Working Group 4 on VLBI data structures); and Ms. Karen Baver (UT1 Intensive session analysis, software development, Linux migration, and Web site development and maintenance).

4. Future Plans

Plans for the next year include: participation in the development of the ICRF2, continued source monitoring, revision of the geodetic source catalog, participation in VLBI2010 development efforts, participation in the development of a new VLBI data structure, publication of a refereed RDV geodesy paper, participation in additional K/Q observations and high frequency reference frame development, and performing further research aimed at improving the VLBI technique.