GSFC VLBI Analysis Center

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Abstract

This report presents the activities of the GSFC VLBI Analysis Center during the period from March 1, 1999 through December 31, 2000. The center's primary software development, analysis and research activities are reported, and the responsible staff members are described. Plans for 2001 are also presented.

1. Introduction

The GSFC VLBI Analysis Center is located at NASA's Goddard Space Flight Center in Greenbelt, MD. GSFC analyzes all geodetic and astrometric VLBI sessions and submits databases to IVS for all NASA/GSFC and USNO sessions within 24 hours or less of their correlation. The group's main thrust is the operation and analysis of the CORE experiments and the gradual expansion of CORE into a full time EOP monitoring program. The group processes all 24-hour sessions from the Mark 4 correlators and submits EOP values derived from each session within 24 hours of correlation. The group also analyzes NEOS Intensive experiments and submits the UT1 values within 2 hours of correlator release. Additionally, GSFC periodically submits station positions and velocities as well as source coordinates from global solutions using all available VLBI observations. The analysis group also processes all VLBA RDV sessions using the NRAO AIPS program.

GSFC uses, maintains, develops, and distributes the Calc/Solve analysis system. The group also engages in research and analysis activities aimed at improving the measurement and understanding of Earth rotation, improving VLBI analysis techniques and modeling, improving troposphere modeling, and maintaining and refining the celestial and terrestrial reference frames.

2. Activities

The primary software development activities from March 1, 1999 - Dec. 31, 2000 included:

- Program Calc was upgraded to versions 9.1 and 9.11 to add the permanent tide option and to fix a minor error.
- F-Solve development was moved from GIUB/BKG to GSFC in April 2000, and the two groups' Solve versions were consolidated.
- Extensive changes in programs Dbedit and Solve were made to support the processing of data from the new Mark 4 correlators.
- Developed an automated system for data transmission between correlators, the IVS Data Centers and the IVS Analysis Centers (programs dserver, dclient, geo_export and geo_import).
- Developed an automated system for generating EOP and submitting EOP series and databases to IVS (program opa).
- Began bimonthly Calc/Solve system updates, in the form of an easy-installation distribution kit. Considerably increased the Calc/Solve system documentation. Currently 44

Calc/Solve documents are available from http://gemini.gsfc.nasa.gov/solve. (An activity begun at GIUB/BKG and moved to GSFC in April 2000.)

- Developed software for analysis of phase calibration errors and for correction of spurious phase cal signals. (Begun at GIUB/BKG and moved to GSFC in April 2000.)

The primary analysis activities during the period included:

- ICRF-Ext.1, the first extension of the ICRF, was produced in mid 1999 to include additional data from July 1995 to April 1999. This solution added 59 new sources to the catalog and introduced small modeling improvements consistent with the stated uncertainties of the ICRF.
- Two solutions were generated as input to ITRF2000. The first submission, gsf1122, in the Spring of 2000 (CALC 8.2/S-Solve) included data through the end of 1999. Based on the discussions at the ITRF2000 workshop, a second solution, gsf2000b, was made at the end of 2000 (CALC 9.1/F-Solve) which incorporated additional Asian stations as well as data through October 2000.
- Began manual database submissions within 24 hours to IVS in June 1999. Upgraded to automated submissions in October 2000.
- Began manual EOP-S weekly IVS submissions (polar motion, UT1, and nutation) in September 1999. Upgraded in October 2000 to automated submissions within 24 hours of correlator release.
- Began NEOS-Intensive session analysis and automated EOP-I (UT1) series IVS submissions in November 2000.
- Analysis activities were shifted from Calc8.2/S-Solve analysis to Calc9.1/F-Solve analysis in June 2000.
- Assumed the initial analysis and data submission responsibilities for NEOS-A and NEOS-Intensive experiments from the USNO in December 2000.
- Submitting all old (1979-1998) databases to IVS, approximately two-thirds completed.

The primary research activities during the period included the following:

- Investigated the precision and accuracy of daily VLBI EOP estimates. Two EOP series derived from simultaneous CORE and NEOS sessions were compared with an IGS GPS series for the period 1997-2000. The level of bias between the VLBI networks is greater than expected and is most likely due to an error in the underlying TRF. Based on 3-corner hat comparisons between the two simultaneous VLBI series and the GPS series, the observed precision of polar motion (80-120 μas) from the three series is similar, although GPS is somewhat better. Several sources of unmodeled or mismodeled station position error that contribute to the EOP error are being examined, for example, tidal ocean loading, atmospheric pressure loading, and hydrology loading.
- Continued investigations using meteorological data assimulation models to improve VLBI tropospheric delay modeling. Use of a priori mean site gradients reduces systematic error in both the CRF and the TRF. Use of a priori 6-hour gradients yields some improvement in repeatabilities. Mapping functions based on raytracing of model profiles yield improvement in repeatabilities.

- Examined signatures in corresponding VLBI and GPS baseline length and site time series. An error budget summarizing the remaining unmodeled error was developed. Spectral analysis indicates that there are annual and semi-annual signatures in many of the VLBI and GPS series, but the VLBI and GPS signatures are only similar for some sites.
- Investigated the determination of high frequency tidal amplitudes from hourly EOP VLBI estimates. Collaborated with Markus Rothacher (Technical University of Munich) to compare VLBI and GPS tidal amplitudes and to determine tidal amplitudes from a combination of VLBI and GPS hourly series.
- Developing methods for the direct estimation of nutation expansion coefficients, precession parameters, and high frequency EOP amplitudes and phases in a single combined solution. Examined the differences between a combined solution versus a two-step approach, in which a nutation time series and the nutation expansion coefficients are estimated separately, neglecting their mutual correlations.
- Estimated Love numbers for long period tides from VLBI observations.
- Investigated the feasibility of an arc-length approach for the selection of primary and secondary sources.
- Made a correlator comparison study of Mark 3 versus VLBA/AIPS processing in the RDV11 experiment. Results indicated an error source on the VLBA/AIPS side. Preparing for a larger comparison of Mark 4 versus VLBA/AIPS in RDV22.
- Began collaboration with NRAO on astrometric analysis of the VLBA calibrator survey experiments.

3. Staff

The GSFC analysis group is part of a larger VLBI group of civil servant and contractor personnel, led by Dr. Thomas A. Clark, which also includes a Technology Development Center, three Network Stations, the CORE Operation Center, and the Coordinating Center. The analysis group is composed of the following six individuals who are involved full time, or nearly so, in analysis activities.

Dr. Chopo Ma leads the analysis group. His interests include astrometry, the celestial and terrestrial reference frames, extension and improvement of EOP measurement, and the improvement of analysis and modeling. He is a member of the IAU working group on the Celestial Reference System and heads the subgroup for the maintenance and extension of the ICRS. As such he has particular interest in improving the modeling and optimization of ICRF analysis as well as providing better information about source position variations. He is also one of the VLBI representatives on the IERS directing board, and is responsible for generating ITRF and ICRF products for IVS and IERS use and for improvement of consistency between them.

Dr. Dan MacMillan (NVI, Inc.) is involved in VLBI technique improvement and analysis system software development (Solve), particularly in the area of tropospheric delay modeling. His interests include improving the modeling of atmospheric delay gradients, deriving better mapping functions from meteorological assimilation data, and various TRF and CRF studies. He is also working on improving or adding modeling for atmospheric pressure loading, ocean loading, and hydrology loading. He is also studying differences in EOP derived from different simultaneous

VLBI networks and GPS EOP in order to assess the observed accuracy and precision of the VLBI and GPS estimates.

Dr. David Gordon (Raytheon ITSS) manages all initial data processing and analysis activities, performs the AIPS geodetic processing of VLBA experiments, and maintains and develops program Calc. His research interests include astrometry, global and regional tectonic motions, improving VLBI modeling, improving VLBA/AIPS processing, correlator support, correlator comparisons, and phase delay development.

Dr. Leonid Petrov (NVI, Inc.) moved from the GIUB/BKG analysis group to the GSFC analysis group in April 2000. He maintains and develops the Mark 4 VLBI analysis software Calc/Solve and the suite of programs for automated data transmission and processing. He conducts research in the fields of optimal estimation of EOP, estimation of Love numbers, improvements in the modeling of ocean loading, and investigation of instrumental errors in VLBI.

Ms. Karen Baver (Raytheon ITSS) maintains and develops a wide range of software, including the database and solution archive catalog systems, the SNOOP reporting programs, and various analysis graphics programs. She also supports the group's web page activities, assists in generating all types of TRF and CRF reports, generates site and velocity plots, assists in generating IVS publications, and provides assistance to new and current users of the analysis package.

Ms. Cindy Lonigro (Raytheon ITSS) works on initial experiment preparation and data archiving and provides analysis support, web page support, and miscellaneous support.

4. Outlook

Plans for 2001 include:

- Calc/Solve: Develop source structure correction capabilities. Add the Niell isobaric mapping function (IMF). Incorporate mapping functions derived by raytracing atmospheric profiles and compare with the Niell IMF mapping function. Test effects of hydrology loading series and three dimensional atmospheric pressure loading (from loading convolution method) series. Implement new schemes for estimating EOP. Update as necessary for compliance with IERS 2000 Conventions. Modify as necessary for HPUX11.0 on an HP9000/785 workstation.
- Collaborate on the development of a new database format.
- Make a comparison study of Mark 4/Fourfit versus VLBA/AIPS correlating/fringing in the RDV22 experiment. Also compare and study Mark 3 versus Mark 4, and K4 versus Mark 4 processing.
- Complete the astrometric analysis of the VLBA Calibrator survey experiments.