GSFC VLBI Analysis Center

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Abstract

This report presents the activities of the GSFC VLBI Analysis Center during 2002. The GSFC Analysis Center analyzes all IVS sessions and performs research and software development activities 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. The group processes all 1-hr Intensive and all 24-hour IVS sessions and submits updated EOP files to the IVS immediately after analysis. The group also periodically submits updated TRF and CRF solutions to the IVS using all available VLBI sessions. The GSFC group uses, maintains, develops, and distributes the Calc/Solve analysis system. The group also engages in research and analysis activities aimed at improving the VLBI technique.

2. Activities

2.1. Analysis Activities

The GSFC analysis group analyzes all Mark 4 IVS sessions using the Calc/Solve system, and submits updated session EOP and daily solutions in Sinex format to the IVS data centers, normally within 3 working hours of correlator release for NEOS Intensive sessions and within one working day for 24-hr sessions. The group also performs the AIPS post correlation analysis (phase calibration and fringe fitting) and the Calc/Solve analysis of the VLBA correlated RDV sessions. The group submits databases to IVS for all NEOS Intensive, R1, RDV, CONT02, RD02, APSG, and Survey sessions. During 2002, the group processed and analyzed 192 1-hr NEOS Intensive and 164 24-hr sessions (56 R1/CORE, 50 R4/NEOS-A, 14 RDV, 10 CONT02, 9 T2, 7 CRF, 6 CORE-OHIG, 5 RD02, 3 EUROPE, 2 APSG, 1 SURVEY, and 1 IRIS-S).

2.2. Research Activities

The GSFC analysis group seeks to improve the VLBI technique by performing research aimed at improving VLBI analysis techniques and modeling, improving troposphere and other geophysical modeling, improving the measurement and understanding of Earth rotation and orientation, maintaining and refining the celestial and terrestrial reference frames, and through other related scientific investigations. The primary research activities undertaken during 2002 include the following:

- Onsala phase cal: It was found that Onsala baseline lengths in the RDV sessions, in which manual phase cal offsets are used for non-VLBA sites, were significantly biased (by 1-2 cm) relative to lengths determined from all other sessions. A study was undertaken that showed a strong azimuthal dependence of Onsala's phase cal and cable cal. The magnitude of the dependence decreases approximately linearly with temperature. The variation of phase cal

group delay is approximatley twice that of cable cal delay. Models were developed to describe the azimuthal dependence of the cable cal and the phase cal. One of these models will be applied to Onsala data for those sessions when phase cal was not available.

- Site position time series: Different ways of generating site position time series were investigated. It was found that the best precision was obtained by applying both no-net-translation and no-net-rotation constraints for each session. Most of the best sites then have precisions better than 8 mm vertically and 3 mm horizontally. The effect of non-linear site motions on estimated Earth orientation parameters is at the 1-2 sigma level.
- Possible global deformation modes: The possible presence of global modes of deformation were investigated, specifically degree-1 (spherical harmonic) deformation and degree-0 (length scale) deformation. This work was done in response to work done by Blewitt et al. (2002) who found a large annual degree-1 variation from GPS site time series. VLBI estimates of these modes show clear annual signals. But our conclusion is that the distribution of VLBI global sites is too uneven and dominated by northern hemisphere sites to interpret the VLBI estimates as determinations of such modes. We also concluded that the interpretation of the GPS results as an estimate of the degree-1 mode was not justified. We also examined the effect of various loading models on the estimates of the modes.
- Annual site position variations: Annual site position variations derived from the 22-year set of VLBI observations were analyzed. It was found that applying a hydrology model reduces the annual signal by 30%. Annual site position variations were compared with the variations at the colocated GPS stations. It was noticed that even after applying the models of ocean tidal loading, ocean non-tidal loading, and atmosphere pressure loading, the residual signal derived from analysis of VLBI and GPS observations has a positive correlation which is significant at the 5% confidence level [1].
- Atmosphere pressure loading: Algorithms and programs were developed for computing the time series of the 3-dimensional site displacements caused by atmosphere pressure loading using the National Centers for Environmental Prediction (NCEP) numerical weather model. A service for computation of atmosphere pressure loading for VLBI was established by the GSFC analysis center. Beginning 2002.12.12, an automatic procedure computes daily displacements caused by atmosphere pressure loading at each VLBI site. The effects of the improved procedure for computing atmosphere pressure loading on site position and EOP were investigated. A paper on this subject is in preparation.
- IMF model: Algorithms and a program for implementing the new generation of mapping function, the Isobaric Mapping Function (IMF), were developed. The IMF is computed on the basis of a numerical weather model. Numerous tests solutions with the IMF were run and compared to solutions using the NMF mapping function. Initial results are encouraging but no conclusions have yet been made. This work is still in progress.
- An empirical nutation expansion was obtained directly from analysis of the 22-year set of VLBI observations. Amplitudes of all nutation terms exceeding 20 picorad were obtained. The errors of the IAU2000 nutation model were analyzed. It was demonstrated that there is no need to estimate daily nutation angle offsets. Instead, an empirical nutation expansion can be derived every three months. A paper is in preparation.

- 14 vs. 16 channel Mark4 fringing: SOLVE solutions were run to compare databases fringed with 14 versus 16 channels. Sessions R1004 and C1014, fringed with both 14 and 16 channels, were analyzed. No systematic differences in baseline lengths were found for either session. Solution WRMS baseline fits were somewhat better for the 16-channel databases.
- Troposphere parameter SINEX files: Software was written to extract troposphere parameters (zenith delays and gradients) and generate session troposphere SINEX files. These files were generated for all R1 and R4 sessions in 2002 and submitted to the IVS troposphere parameter pilot project.
- CONT02 campaign: The correlations between estimates of EOP parameters for different candidate CONT02 schedules were examined. A schedule was chosen to minimize these correlations on a subdaily time scale as well as for the daily offsets. The correlations between subdaily parameters indicates that the CONT02 data may not be sufficient to estimate EOP at intervals less than 2 hours.
- Geodetic source catalog: A new geodetic source catalog was generated by merging the NASA catalog and the USNO source catalog, by updating the fluxes using experiments from the first 3 months of 2002, and by adding 35 additional sources in the $+11^\circ$ - $+15^\circ$ declination range from ICRF-Ext.1 and the VCS1 catalog [2] to fill out the sky distribution for Intensive experiments. The 35 new sources were observed in weekly R1 and R4 sessions to determine their fluxes.
- RDV southern source problem: RDV22 correlator comparisons showed no significant differences between VLBA/AIPS and Mark4/Fourfit group delays [3]. However, an error in computing the AIPS delay sigmas was found and corrected. Also, a change was made in measuring the VLBA phase cal tones to take a phase cal measurement near the band center rather than at the high end. Subsequent RDV sessions processed at GSFC do not show any significant statistical anomalies for southern sources.
- VLBA Calibrator Survey-2 (VCS-2) sessions: Two VLBA astrometric sessions were made by Dr. Ed Fomalont, et. al, as a followup of the ten very successful VCS-1 [2] sessions. Their purpose was to obtain positions and X/S fluxes of $\sim$410 (319 new to geodesy/astrometry) candidate calibrator sources, most at low (-20° to -46°) declinations, or near the galactic plane. The GSFC group processed the VLBA correlator output using AIPS, created databases, and performed the Calc/Solve astrometric analysis. This analysis detected 276 new sources. Of the new and old sources solved for in these session, positions were obtained to better than 3 mas for $\sim$50%. A paper announcing this work and the new catalog is in preparation.
- GBT-ties experiments: Two ties sessions, between the new GBT antenna and the NRAO20 antenna, were run by Dr. F. Ghigo (NRAO), and correlated at the VLBA. They were processed through AIPS and analyzed with Calc/Solve at the GSFC analysis center to get a position for the GBT in the ITRF. Due to uncalibrated antenna mechanical deformations and lack of phase cal measurements, the GBT's position was determined at only the $\sim$3 cm level. Use of a mechanical deformation model is planned. Also, a future, more accurately calibrated session may be made.
- VLBA K/Q high frequency CRF sessions: The GSFC group undertook the AIPS post-correlation fringe fitting and Calc/Solve astrometric analysis of the first two K/Q VLBA

sessions. K-band (∼24 GHz) and Q-band (∼43 GHz) positions were obtained for 65 ICRF sources. This work is being done in cooperation with JPL, USNO, and NRAO, and is directed towards extending the ICRF to higher frequencies, which may also be needed for future spacecraft navigation. A VLBA observing proposal for four additional K/Q sessions in 2003 was approved by NRAO.

- Intensives: We began ongoing monitoring of the performance of and investigation of problems with the NEOS Intensives. Recommendations for eliminating some sources and for using more low declination sources have resulted so far. We began analyzing and comparing the performance of the IVS-INT2 (Tsukuba-Wettzell Intensive) sessions to other UT1 series.

2.3. Software Development

The GSFC group develops and maintains the Calc/Solve analysis system. Updates were released approximately bimonthly in 2002. Significant developments included the development of an Interger*4 version of Solve, implementation of the IMF model into Solve, and software for SINEX format extraction of troposphere parameters from Solve solutions. Future plans call for development of a Linux compatible version of Calc/Solve.

3. Staff

Members of the analysis group include Dr. Chopo Ma, Dr. Dan MacMillan, Dr. David Gordon, Dr. Leonid Petrov, Ms. Karen Baver, and Ms. Cindy Villiard. The analysis group is part of a larger VLBI group of civil service and contractor personnel, which also includes a Technology Development Center, a network station, the Core Operations Center, and the IVS Coordinating Center.

References

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[3] Gordon, D., RDV Analysis and Mark4/VLBA Comparison Results, In: International VLBI Service for Geodesy and Astrometry General Meeting Proceedings, NASA/CP–2002–210002, N. R. Vandenberg and K. D. Baver (eds.), 277–281, 2002.