

Bordeaux Observatory Analysis Center Report

Patrick Charlot, Antoine Bellanger, Géraldine Bourda, Arnaud Collioud, Alain Baudry

Abstract

This report summarizes the activities of the Bordeaux Observatory Analysis Center in 2006. During this period, our group has been strengthened by the arrival of a new staff member, allowing us to further develop the VLBI imaging activity initiated in 2005. A total of 548 VLBI maps have been produced by full imaging of three RDV sessions. Another highlight was the analysis of a complete year of data with the newly-developed GINS software and the estimation of the Earth Orientation Parameters. Other activities focus on regular processing of the IVS-R1 and IVS-R4 sessions and calculation of additional structure indices to refine our source categorization based on this criterion. Plans for 2007 follow the same analysis and research lines and include participation in the recently-created IAU/IVS/IERS working group on the second realization of the International Celestial Reference Frame.

1. General Information

The Bordeaux Observatory is located in Floirac, near the city of Bordeaux, in the southwest of France. It is funded by the University of Bordeaux and the CNRS (National Center for Scientific Research). VLBI analysis and research activities are primarily developed within the M2A group (“Métrologie de l’espace, Astrodynamique, Astrophysique”) led by P. Charlot.

The contribution of Bordeaux Observatory to IVS is mostly concerned with the maintenance, extension, and improvement of the International Celestial Reference Frame (ICRF). This includes regular VLBI imaging of the ICRF sources and evaluation of their astrometric suitability, as well as the monitoring of the temporal evolution of their astrometric coordinates. The group also develops observing programs aimed at extending the ICRF and is in charge of the VLBI aspects in the multi-technique GINS software which combines VLBI and space geodetic data at the observation level.

2. Description of Analysis Center

The Bordeaux Observatory Analysis Center routinely analyzes the weekly IVS-R1 and IVS-R4 sessions. This analysis, conducted with the JPL VLBI estimation software MODEST [1], is primarily targeted at estimating monthly radio source coordinates. We expect in the near future to implement an operational solution in order to quickly report source position instabilities.

Another activity is focused on producing VLBI maps of the ICRF sources by analysis of data from the RDV sessions. This analysis is conducted with the AIPS and DIFMAP calibration and imaging software. The aim of such regular imaging is to compare source structural evolution and positional instabilities. The maps are also used to derive “structure indices” in order to characterize the astrometric suitability of the sources. Such a categorization will be important in the framework of the newly-created IAU/IVS/IERS working group on the next realization of the ICRF.

In addition, we develop experimental VLBI analysis with the GINS multi-technique software [2], as part of a project aimed at combining all VLBI and space geodetic data (SLR, GPS, DORIS) at the observation level. In this collaborative effort, the VLBI data are analyzed in Bordeaux, while the satellite geodetic data are processed either at the GRGS (“Groupe de Recherches de Géodésie Spatiale”) in Toulouse (for GPS and DORIS) or at the OCA (“Observatoire de la Côte d’Azur”) in Grasse (for SLR), with the final multi-technique combination produced at Paris Observatory.

3. Scientific Staff

The IVS group in Bordeaux comprises the following five individuals who are involved either part time or full time in VLBI analysis and research activities, as described below:

- Patrick Charlot (50%): overall responsibility for Analysis Center work and data processing. His major research interests include the densification and extension of the ICRF and studies of source structure effects in astrometric VLBI data.
- Antoine Bellanger (100%): engineer with background in statistics and computer science. His main role is to conduct initial VLBI data processing with MODEST and develop analysis tools as needed. He is also the web master for the M2A group.
- Géraldine Bourda (25%): postdoc fellow funded by the French space agency (CNES). She is in charge of implementing and validating routine VLBI analysis with the GINS software for multi-technique data combination at the observation level.
- Arnaud Collioud (75%): engineer with background in astronomy and interferometry. He was recruited as a new staff member on 1 April 2006. His task is to process the RDV sessions with AIPS and DIFMAP in order to image the sources observed in these sessions.
- Alain Baudry (10%): radioastronomy expert with specific interest in radio source imaging and astrometric VLBI.

4. Analysis and Research Activities during 2006

During 2006, our level of activity has significantly increased thanks to the arrival of Arnaud Collioud in our group. His arrival has allowed us to take our share in the processing of the RDV sessions, as part of a collaboration involving USNO, Whittier College (USA), and the Max Planck Institute for Radioastronomy in Bonn. Initial work consisted in establishing and testing appropriate procedures for calibration, edition, and automatic imaging of all the sources observed in these sessions. After validation of the procedures, three such sessions (RDV20, RDV42 and RDV51) have been fully processed and a total of 548 VLBI images at either X or S band for 162 different sources have been produced. See Fig. 1 for a sample of images derived from the RDV42 data. In addition, we have pursued our collaboration with Julio Camargo (Observatorio do Valongo, Brazil) to process the RDV36 session in a similar way. We expect to place all of our images along with the corresponding structure correction maps on our web site in the near future.

In parallel with this work, we have also continued our calculation of structure indices in order to improve the source categorization based on intrinsic VLBI structures. The aim is to densify our series of structure indices, taking advantage of newly-available maps, in order to identify the sources that remain astrometrically suitable (i.e. with a structure index value of either 1 or 2) at any epoch [3]. Our current calculation indicates that there are 221 such ICRF sources (out of the 560 sources for which a structure index value is available for at least one epoch). These sources are potential candidates to serve as defining sources in the next realization of the ICRF.

A specific study was also targeted at examining the astrometric suitability of the sources with bright optical counterparts (QSOs) that are potential candidates for the link with the future GAIA frame [4]. This study showed that there are only 67 sources that have excellent or good astrometric suitability in the ICRF, hence indicating the need to identify additional radio sources to establish

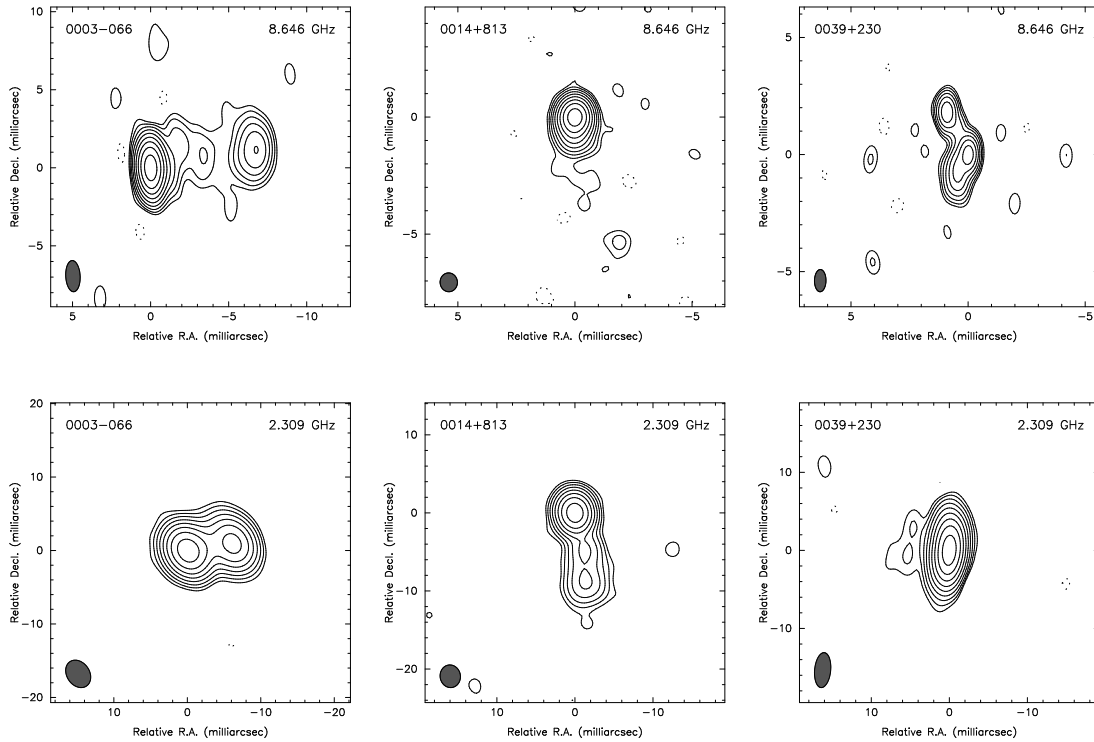


Figure 1. VLBI images at X band (upper panel) and S band (lower panel) for three ICRF sources (0003–066, 0014+813, and 0039+230) as derived from the data of the RDV42 session conducted on 2003 December 17. The three sources were selected randomly according to increasing right ascension starting at RA=00h.

the GAIA link. Interestingly, it was also found that the brightest QSOs tend to have less accurate ICRF positions, most probably because they possess more extended structures.

Another major achievement during the past year was the realization of the first large-scale VLBI analysis (i.e. including all IVS-R1 and IVS-R4 sessions from 2005) estimating Earth Orientation Parameters (EOP) with the GINS software. The results for polar motion and nutation offsets derived from this analysis are plotted in Fig. 2 and compared with the corresponding estimates in the IVS combined series. This comparison shows agreement between the two EOP series at the 0.2 mas level. Additional testing continues by carefully comparing the calculated VLBI delays in GINS with those from MODEST in order to guarantee millimeter accuracy in modeling. In the future, GINS may eventually replace the MODEST software for our routine IVS analysis.

5. Outlook

For the year 2007, our plans include the following:

- Keep on analyzing the new IVS-R1 and IVS-R4 sessions as they become available and implement an operational monthly “arc solution” to quickly report the temporal evolution of the source positions.

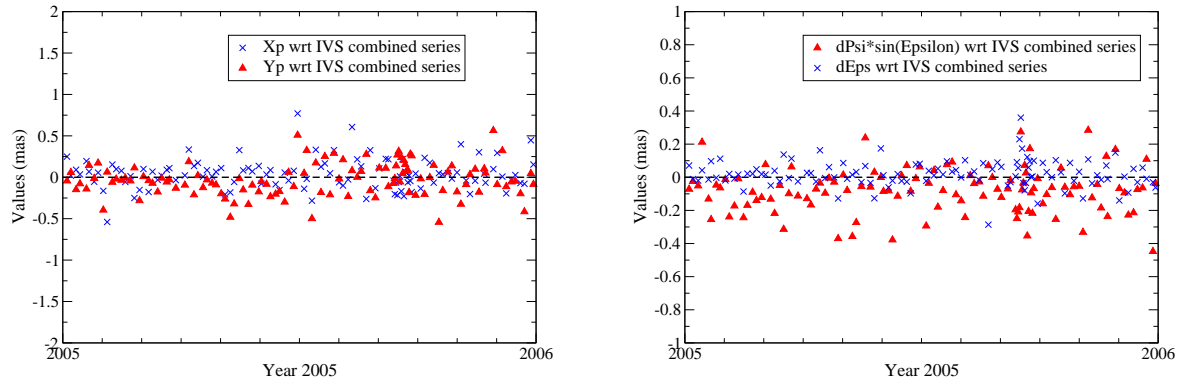


Figure 2. Polar motion (X_p , Y_p) and nutation offsets ($d\epsilon$, $d\psi \sin \epsilon$) derived from analysis of the 2005 IVS-R1 and IVS-R4 sessions with the GINS software. The results are reported with respect to the corresponding values in the IVS combined series.

- Pursue further the testing of the GINS software and develop operational procedures for VLBI analysis as part of the effort to integrate VLBI, GPS, DORIS and SLR data in a multi-technique combination at the observation level.
- Continue the processing of the RDV sessions to monitor the X- and S-band structural variability of the ICRF sources in cooperation with the other groups that contribute to the imaging of these sessions.
- Continue to evaluate the astrometric suitability of the ICRF sources as new maps become available and categorize the sources according to our structure index criterion.
- Participate in the work of the newly-created IAU/IVS/IERS working group on the realization of the next ICRF, in particular by contributing to the selection of defining sources and the identification of unstable sources.
- Implement an online database to make our source maps, structure correction maps and structure indices publicly available through the web.

References

- [1] Sovers, O. J., Jacobs, C. S.: 1996, Observation Model and Parameter Partial for the JPL VLBI Parameter Estimation Software “MODEST”–1996, JPL Publication 83-39, Rev. 6, August 1996.
- [2] Meyer, U., Charlot, P., Biancale, R.: 2000, GINS: A New Multi-technique Software for VLBI Analysis, IVS 2000 General Meeting Proceedings, Eds. N. R. Vandenberg and K. D. Baver, NASA/CP-2000-209893, p. 324–328.
- [3] Charlot, P., Fey, A. L., Ojha, R., Boboltz, D. A.: 2006, Astrometric Suitability of ICRF Sources Based on Intrinsic VLBI Structure, IVS 2006 General Meeting Proceedings, Eds. D. Behrend and K. D. Baver, NASA-CP-2006-214140, p. 321–325.
- [4] Charlot, P., Le Campion, J.-F., Bourda, G.: 2006, Searching candidate radio sources for the link with the future GAIA frame, XXVIIth IAU General Assembly, JD16, Nomenclature, Precession and New Models in Fundamental Astronomy, Highlights of Astronomy (in press).