

Bordeaux Observatory Analysis Center Report

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Abstract

This report summarizes the activities of the Bordeaux Observatory Analysis Center during the year 2005. On the analysis side, we completed processing of seven years of NEOS-A/IVS-R4 data (1999–2005) and three years of IVS-R1 data (2003–2005) with the MODEST software. Additionally, we have been involved in testing the VLBI model of the GINS software for multi-technique combination at the raw data level. On the research side, our major achievements include the completion of observing for our ICRF densification project in the northern sky, the study of source structure index temporal variability—which led to the identification of 242 ICRF sources with potentially high astrometric quality—and a newly-developed activity aimed at monitoring the structure of the ICRF sources based on the RDV data. Plans for the year 2006 follow the same analysis and research lines.

1. General Information

The Observatory of Bordeaux 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). IVS analysis and research activities are attached to the M2A group (“Métrologie de l’espace, Astrodynamique, Astrophysique”) led by P. Charlot.

Our Analysis Center’s work is primarily focused on the maintenance, extension, and improvement of the celestial reference frame. In particular, we initiated an observing program on the European VLBI Network (EVN) to densify the International Celestial Reference Frame (ICRF) [1]. We also conduct routine analyses of IVS data with the aim of studying the ICRF source position stability and the physical phenomena that can affect this stability, with specific interest in studying the impact of source structures in geodetic and astrometric VLBI [2].

Our level of activity has significantly increased during the past year thanks to two new staff members (G. Bourda and J. Camargo) participating in the IVS Analysis Center work. Recent developments include VLBI analysis and testing with the GINS multi-technique software and astrophysical imaging to monitor the structural variability of the ICRF sources.

2. Scientific Staff

During 2005, the following five individuals contributed part or full time in IVS 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 geodetic VLBI data.
- Antoine Bellanger (100%): engineer with background in statistics and computer science. His main role is to conduct initial VLBI data processing 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) since 1 September 2005. She is in charge of implementing and validating routine VLBI analyses with the GINS software for multi-technique combination.

- Julio Camargo (25%): postdoc fellow funded by the University of Bordeaux to develop astrophysical imaging of ICRF sources. His contract ended on 1 October 2005 and he has since then taken up another postdoctoral position at the Observatory of Valongo in Brazil.
- Alain Baudry (10%): radioastronomy expert. He is involved in the ICRF densification project with the EVN and has interest in radio source imaging.

3. Data Analysis and Software Testing

VLBI analyses are primarily conducted with the MODEST software, developed and maintained by the Jet Propulsion Laboratory [3]. It is installed on a Compaq DS20 workstation along with the AIPS and DIFMAP software which are used for astrophysical imaging (see below). During the past year, we completed initial processing for all NEOS-A and IVS-R4 sessions conducted between 1999 and 2005 along with all IVS-R1 sessions conducted since 2003. Based on this data set, we expect soon to produce a so-called “arc solution” estimating monthly ICRF source positions. The data processed also comprise the two-week-long CONT05 session conducted in September 2005.

In parallel, we also began experimenting VLBI data analysis with the GINS multi-technique software. This software, originally developed by the GRGS (“Groupe de Recherches de Géodésie Spatiale”) in Toulouse (France) for analyzing satellite geodetic data (SLR, GPS, DORIS) has been extended with a VLBI module for processing both Earth-based and space VLBI data [4]. Preliminary results for the Earth Orientation Parameters (EOP) have been obtained for all IVS-R1 and IVS-R4 sessions in 2005 and these results are being compared to those reported by the IERS. Additional testing is being carried out by carefully comparing the calculated VLBI delays in GINS with those from MODEST in order to ensure millimeter accuracy in modeling.

The developments using GINS are part of a research project aimed at combining all VLBI and space geodetic data in a consistent way to unify the reference frames and the EOP estimation. In this framework, the VLBI data are analyzed in Bordeaux, while the other space geodetic data are analyzed at the GRGS in Toulouse (for GPS and DORIS) and at the OCA (“Observatoire de la Côte d’Azur”) in Grasse (for SLR), with the final combination produced at Paris Observatory.

4. Celestial Frame Activities

On the observational side, we obtained EVN observing time for an additional 24-hour experiment to complete our ICRF densification project in the northern sky (see [5, 6, 7] for a description of the previous experiments). All sources that had > 1 mas position errors were re-observed during this experiment, using the same EVN+ network as used previously, in order to improve their coordinates [1]. The network includes eight EVN telescopes along with three non-EVN geodetic telescopes, as listed in Table 1. A preliminary analysis comprising all data acquired so far indicates that more than 90% of the 150 sources observed for this project have now sub-milliarcsecond position errors with the addition of this new experiment. Our analysis will be finalized shortly and a paper presenting the source position results based on all such EVN+ data will be written.

Another major achievement was the study of the structure index variability by deriving time series of structure indices for all ICRF sources that have been imaged at multiple epochs. A total of 1768 X-band maps and 1544 S-band maps from the USNO data base (with up to 20 epochs for some intensively-observed sources) have been used for this investigation. Overall, our study shows that the structure index generally varies smoothly with time or is stable. By categorizing

Table 1. Network used in ICRF densification experiment conducted on 2005 February 22.

EVN telescopes	Non-EVN telescopes
Effelsberg	Algonquin Park
Medicina	Goldstone (DSS 13)
Noto	Ny-Ålesund
Onsala	
Wetzell	
Hartebeestock	
Urumqi	
Shanghai	

the sources using the maximum value of the structure index over all epochs, we also identified a subset of 242 sources (from a total of 557 sources that have been characterized in this way) with “permanently” good (i.e. either 1 or 2) structure indices. Such sources are potential candidates to serve as defining sources in the next realization of the ICRF. Further details about the results of this investigation will be given in the Proceedings of the 4th IVS General Meeting.

As mentioned above, we also initiated a new activity aimed at imaging the ICRF sources observed during the RDV experiments. This project is conducted in close cooperation with the USNO group in order to extend the time base of the current image data base. Our work so far has focused on establishing an appropriate way to calibrate and edit the RDV data, and to test semi-automatic procedures to map the sources. We have also began imaging the sources observed in the RDV36 experiment (conducted on 2002 December 11). Examples of the X-band images derived for 1308+326 and 0234+285 from these data are shown in Fig. 1. 1308+326 is an ICRF defining source while 0234+285 is categorized as a candidate source. The two sources show maximum structure indices of 4 and 3, respectively, in the structure index time series analysis described above.

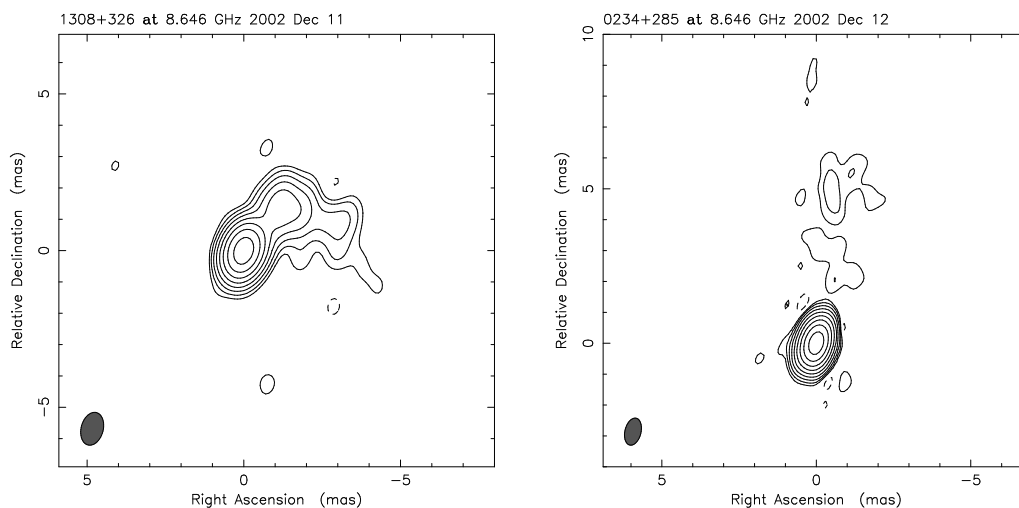


Figure 1. VLBI images at X band for two ICRF sources (1308+326 and 0234+285) as derived from the data of the RDV36 experiment.

5. Outlook

For the year 2006, our plans include the following:

- Keep on analyzing the new IVS-R1 and IVS-R4 sessions as they become available and set up an operational “arc position” solution to monitor the temporal evolution of the source coordinates.
- Pursue further the testing of the GINS software and implement 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.
- Obtain final results for the astrometric coordinates of the 150 sources observed in our four ICRF densification experiments, and compare these with the VLBA Calibrator Survey positions for the common sources.
- Continue to evaluate the astrometric suitability of the ICRF sources as new maps become available at S, X, K and Q bands, and make the corresponding structure indices and structure correction images publicly available.
- Continue the processing of the RDV experiments in cooperation with the USNO team to monitor the X- and S-band structural evolution of the ICRF sources and extend the time coverage of the current image data base.

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