Bordeaux Observatory Analysis Center Report

Patrick Charlot, Antoine Bellanger, Alain Baudry

Abstract

This report summarizes the activities of the Bordeaux Observatory Analysis Center during the year 2004. On the analysis side, we have completed processing of six years of NEOS-A/IVS-R4 data (1999–2004) and two years of IVS-R1 data (2003–2004). On the research side, our major achievements include initial analysis of the three experiments conducted as part of our ICRF densification project in the northern sky, evaluation of astrometric suitability for an additional 96 ICRF sources at X band – all of which are in the southern sky – and another 122 sources at K band. Plans for the year 2005 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 south-west of France. It is funded by the University of Bordeaux and the CNRS (National Center for Scientific Research). During the past year, the observatory was reorganized in three scientific groups: radioastronomy, planetology, and a new group named M2A ("Métrologie de l'espace, Astrodynamique, Astrophysique"). IVS analysis and research activities (previously attached to the radioastronomy group) are now part of this new group. P. Charlot is the head of the M2A group.

The work of the Bordeaux Observatory Analysis Center is focused on the maintenance, extension, and improvement of the celestial reference frame. In particular, we lead an observing program on the European VLBI Network (EVN) to densify the International Celestial Reference Frame (ICRF) [1] and conduct research related to the effect of source structure in geodetic VLBI data [2]. Additionally, we develop routine analyses of IVS data with the aim of studying the ICRF source position stability and the physical phenomena that can affect this stability.

VLBI analyses are 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.

2. Scientific Staff

Our group is composed of the following three individuals, who are involved 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. He is the PI of the ICRF densification project on the EVN. He is also involved in radio source imaging and has a major interest in studying 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 data processing and develop analysis tools as needed. He is also currently developing a web site for the M2A group, including a section dedicated to IVS analysis activities. We expect to bring this site on-line in spring 2005.
- Alain Baudry (10%): radioastronomy expert. He is involved in the ICRF densification project and has interest in radio source imaging.

3. Analysis and Research Activities during 2004

During the past year, our level of activity has been stable. On the analysis side, we have completed initial processing of all NEOS-A and IVS-R4 sessions conducted between 1999 and 2004 along with all IVS-R1 sessions conducted in 2003 and 2004. We are now working on a so-called "arc solution" estimating monthly source positions based on this data set. In parallel, we also keep on analyzing new IVS-R1 and IVS-R4 sessions as they become available.

On the research side, a milestone was reached with the completion of initial analysis for our three EVN+ experiments dedicated to densify the ICRF in the northern sky (see [4, 5, 6] for a description of these experiments). The results show that all 150 new potential ICRF sources observed for this project have been successfully detected, hence indicating that the source selection strategy and observing scheme were appropriate [1]. About two thirds of the targets have coordinate uncertainties smaller than 1 mas (Fig. 1) and thus constitute valuable candidates for extending the ICRF. A comparison of our estimated astrometric positions with those available from the VLBA Calibrator Survey [7] for 129 common sources shows agreement within 1 mas for half of the sources and within 2 mas for 80% of the sources. EVN observing time has been approved for an additional 24-hour experiment in order to re-observe all sources with > 1 mas position errors.

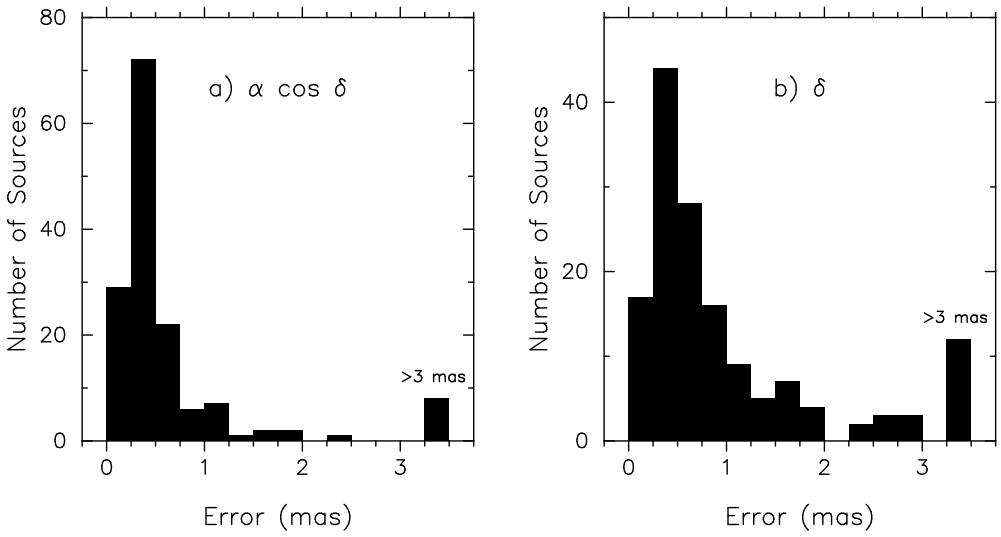

Figure 1. Error distribution in *a)* right ascension and *b)* declination for the 150 new potential ICRF sources observed in the northern sky. All errors larger than 3 mas are placed in a single bin marked with the label "> 3 mas" on each plot.

Another major achievement was the evaluation of X-band astrometric suitability for an additional 96 ICRF sources, all of which are located in the southern sky. This was made possible thanks to the southern-hemisphere imaging program initiated by the US Naval Observatory and Australia Telescope National Facility [8]. Structure indices were derived according to the average structural delay effects for these sources following our standard scheme [9]. Overall, structure indices are now available for 546 ICRF sources at X band, corresponding to 90% of the total number of ICRF sources. Analysis of the structure index distribution (Fig. 2) shows that 52% of such sources have a structure index value of either 1 or 2, indicating compact or very compact structure.

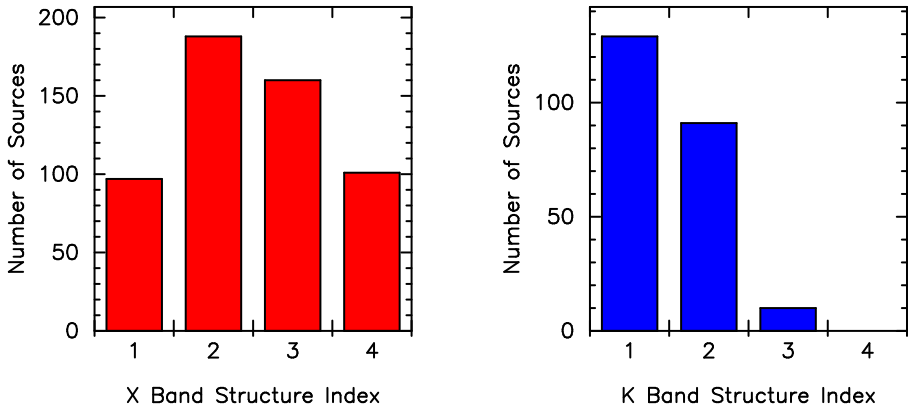

Figure 2. Current distribution of source structure indices at X band and K band. These indices are available for 546 ICRF sources at X band and 230 sources at K band. There are 167 common sources between the two samples. 54 sources observed at K band are not part of the ICRF.

Additionally, we also evaluated the astrometric suitability of another 122 sources at K band (24 GHz) based on further data acquired by the VLBA K-Q Survey collaboration [10]. Structure indices are now available for 230 sources at K band, 56% of which have a structure index value of 1 (Fig. 2). This result confirms our previous finding that the astrometric suitability of the sources is significantly better at 24 GHz than at the standard 8 GHz geodetic observing frequency [11].

4. Outlook

For the year 2005, 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.
- Obtain final results for the astrometric coordinates of the 150 sources observed in our ICRF densification experiments, and refine the comparison with the VLBA Calibrator Survey positions for the 129 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 available through our web page.
- Assess more precisely the impact of massive source structure modeling in astrometric data analysis by repeating our previous test on the RDV data [12] after identification of the most appropriate structural reference feature for each source.
- Start processing 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 basis of the current image data base.
- Finish up the design of a new web page including multi-epoch and multi-frequency structure indices and false color structure correction images, along with results of source position stability, for possible use by IVS operation and analysis centers.

References

[1] Charlot, P., Fey, A. L., Jacobs, C. S., Ma, C., Sovers, O. J., Baudry, A.: 2004, Densification of the International Celestial Reference Frame: Results of EVN+ Observations, Proceedings of the 7th European VLBI Network Symposium, Eds. R. Bachiller, F. Colomer, J.-F. Desmurs and P. de Vicente, OAN Madrid, p. 313–316.

[2] Charlot, P.: 2002, Modeling Radio Source Structure for Improved VLBI Data Analysis, IVS 2002 General Meeting Proceedings, Eds. N. R. Vandenberg and K. D. Baver, NASA/CP-2002-210002, p. 233–242.

[3] Sovers, O. J., Jacobs, C. S.: 1996, Observation Model and Parameter Partials for the JPL VLBI Parameter Estimation Software "MODEST"–1996, JPL Publication 83-39, Rev. 6, August 1996.

[4] Charlot, P., Viateau, B., Baudry, A.: 2001, Bordeaux Observatory Analysis Center Report, International VLBI Service for Geodesy and Astrometry 2000 Annual Report, Eds. N. R. Vandenberg and K. D. Baver, NASA/TP-2001-209979, p. 203–206.

[5] Charlot, P., Bellanger, A., Baudry, A.: 2003, Bordeaux Observatory Analysis Center Report, International VLBI Service for Geodesy and Astrometry 2002 Annual Report, Eds. N. R. Vandenberg and K. D. Baver, NASA/TP-2003-211619, p. 228–231.

[6] Charlot, P., Bellanger, A., Baudry, A.: 2004, Bordeaux Observatory Analysis Center Report, International VLBI Service for Geodesy and Astrometry 2003 Annual Report, Eds. N. R. Vandenberg and K. D. Baver, NASA/TP-2004-212254, p. 166–169.

[7] Beasley, A. J., Gordon, D., Peck, A. B., Petrov, L., MacMillan, D. S., Fomalont, E. B., Ma, C.: 2002, The VLBA Calibrator Survey – VCS1, ApJS, 141, 13–21.

[8] Ojha, R., Fey, A. L., Johnston, K. J., Jauncey, D. L., Reynolds, J. E., Tzioumis, A. K., Quick, J. F. H., Nicolson, G. D., Ellingsen, S. P., Dodson, R. G., McCulloch, P. M., Koyama, Y.: 2004, VLBI Observations of Southern Hemisphere ICRF Sources – I, AJ, 127, 3609–3621.

[9] Fey, A. L., Charlot, P.: 2000, VLBA Observations of Radio Reference Frame Sources. III. Astrometric Suitability of an Additional 225 Sources, ApJS, 128, 17–83.

[10] Boboltz, D. A., Fey, A. L., Charlot, P., Fomalont, E. B., Lanyi, G. E., Zhang, L. D., KQ VLBI Survey Collaboration: 2004, Extending the ICRF to Higher Radio Frequencies – Imaging and Source Structure, IVS 2004 General Meeting Proceedings, Eds. N. R. Vandenberg and K. D. Baver, NASA/CP-2004-212255, p. 361–365.

[11] Charlot, P.: 2004, The ICRF: 2010 and Beyond, IVS 2004 General Meeting Proceedings, Eds. N. R. Vandenberg and K. D. Baver, NASA/CP-2004-212255, p. 12–21.

[12] Sovers, O. J., Charlot, P., Fey, A. L., Gordon, D.: 2002, Structure Corrections in Modeling VLBI Delays for RDV Data, IVS 2002 General Meeting Proceedings, Eds. N. R. Vandenberg and K. D. Baver, NASA/CP-2002-210002, p. 243–247.