Bordeaux Observatory Analysis Center Report

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Abstract

This report summarizes the activities of the Bordeaux Observatory Analysis Center during the year 2002. On the analysis side, a milestone was recently reached with completion of pre-processing for four years (1999–2002) of NEOS-A/IVS-R4 data. On the research side, our achievements include the organisation and scheduling of a second experiment as part of our ICRF densification project in the northern sky, an evaluation of the source quality at higher radio frequencies as part of a large collaborative project directed to extend the ICRF in the 24–43 GHz range, and further progress in massive source structure modeling for improved astrometric data analysis. Plans for the year 2003 follow the same analysis and research lines.

1. General Information

The Bordeaux Observatory Analysis Center 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).

Our work 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]. Regular analysis of IVS data, initiated a year ago, is now conducted routinely, and we expect to start producing time series of source positions in the near future. The motivation for developing such analyses is to study 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 imaging software. Unfortunately, our old HP workstation died last fall. As a result, we have no more local access to the Goddard data base system and SKED software.

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. In the future, he will also maintain a web site dedicated to our analysis activities.
- 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 2002

During the past year, our level of activity has significantly increased, as compared to that in the previous years. On the analysis side, a milestone has just been reached with the completion of initial processing of all NEOS-A and IVS-R4 sessions conducted between 1999 and 2002. Next to be developed are specific astrometric analyses estimating source positions as "arc" parameters, while we keep on analyzing new sessions as they become available.

Research activities have also been pursued along the lines described in our previous reports [4, 5]. These have focused on the following projects: ICRF densification in the northern sky, ICRF extension to higher radio frequencies, and massive source structure modeling in astrometric data analysis. A brief summary of our achievements in these areas is given below.

- ICRF densification in the northern sky:
  As described in [1], the aim of this project is to add 150 new sources at carefully selected sky locations to fill the "empty" regions of the frame and improve the overall source distribution. Subsequent to the first experiment which observed an initial set of 50 new sources on May 31, 2000 [4], a second experiment observing another 50 sources, was carried out on June 5, 2002. The network used for the latter was composed of eight telescopes from the European VLBI Network (EVN) along with two external non-EVN geodetic stations that agreed to join this project. The participating telescopes are listed in Table 1. The data from this experiment have just been correlated with the Bonn Mark IV correlator. Final fringe-fitting, data export, and astrometric analysis is to be conducted in the near future.

Table 1. Network used in second ICRF densification experiment.

EVN telescopes	Non-EVN telescopes
Effelsberg	Algonquin Park
Medicina	Goldstone (DSS 13)
Noto	
Onsala	
Wettzell	
Hartebeestoek	
Urumqi	
Shanghai	

  The third experiment, dedicated to observe the last set of 50 sources, was scheduled for February 11, 2003, but had to be cancelled since a crack was discovered in the azimuth track of the Effelsberg telescope, making this key element of the network unavailable until repairs are made. Re-scheduling by the EVN is expected during either the May-June or October-November 2003 EVN sessions.

- ICRF extension to higher radio frequencies:
  At the end of 2001, a large collaboration was set up to pursue the extension of the ICRF in the 24–43 GHz range by using the Very Long Baseline Array (VLBA) telescope [6]. The major motivations for initiating this large effort include: improving state-of-the-art astrometry, extending the list of calibrators at 24 and 43 GHz to enhance VLBI phase-referencing at high frequencies, studying source structures and their variations with respect to frequency

and time, and preparing for deep space navigation at higher frequencies. This project was approved and three initial 24/43 GHz VLBA experiments, each 24 hours long, have been carried out in May, August and December 2002.

Our contribution to this project has been concerned with the evaluation of the astrometric impact of source structure at these higher frequencies. Based on VLBI images from the May experiment, we calculated source structure indices at 24/43 GHz with our standard scheme [7], and compared these indices to those from contemporaneous 8.4 GHz maps. The results of this comparison show that on average the emission structures at 24 and 43 GHz are more compact than their 8 GHz counterparts, hence providing better fiducial points to build highly-accurate reference frames. Further calculations based on source visibilities also indicate that the observed structures might be more extended at 43 GHz than at 24 GHz, as would be the case if the 43 GHz observations start to resolve the core of the sources.

- Massive source structure modeling in astrometric data analysis:
  As reported in [5], we conducted the first large-scale analysis with massive source structure modeling at the end of 2001. This test involved a total of 800 maps (as available from the USNO data base), which were used to derive structure corrections for $\sim$ 207000 delay and delay rate pairs for 155 sources observed during 10 RDV experiments from January 1997 to August 1998. Initial results were presented at the 2002 IVS General Meeting [8]. Later on, time was devoted to refining the analysis, checking the results, and obtaining relevant statistical information.

  Overall, the 30-ps weighted rms delay residuals were found to decrease by 8 ps in quadrature upon introducing source maps to model the structural delays, with improvements as large as 40 ps for some sources with extended or rapidly varying structures. Scatter of "arc positions" about a time-linear model was also reduced substantially for such extended sources. Our work further demonstrated that identification of a true fiducial feature within each extended source is crucial to properly and accurately model structural delays, as otherwise the results may be worse than with no structure corrections. Such statement was illustrated by a specific study on the source 2200+420 (see [2] for details).

4. Outlook

During the year 2003, our plans include the following:

- Finish up the analysis of the 1999–2002 NEOS-A and IVS-R4 sessions while we keep on analyzing the new IVS 2003 sessions as they become available, and develop specific astrometric analyses for monitoring the temporal evolution of the source coordinates.
- Terminate the analysis of our first and second ICRF densification experiments, assess the results, and prepare the third (and last) segment of the project.
- Reinforce our participation to the ICRF high-frequency extension project, especially by extending our initial work to subsequent experiments, as to provide a larger statistical basis for evaluating the overall source compactness and astrometric suitability at 24/43 GHz.
- Assess more precisely the impact of massive source structure modeling in astrometric data analysis by repeating our previous test on the RDV data after identification of the most appropriate structural reference feature for each source.

- Re-design our web page[1] to make multi-epoch and multi-frequency structure indices and false color structure correction images publicly available, along with results of source position stability, for possible use by IVS operation centers and analysis centers.

References

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