USNO Analysis Center for Source Structure Report

Alan L. Fey, David A. Boboltz, Ralph A. Gaume, Kerry A. Kingham

Abstract

This report summarizes the activities of the United States Naval Observatory Analysis Center for Source Structure for calendar year 2002. VLBA RDV experiments RDV12 and RDV31 were calibrated and imaged. VLBA high frequency (K/Q-band) experiments BR079A and BR079B were calibrated and imaged. Based on these latter experiments, it was found that ICRF sources observed at higher frequencies than are currently used may be better astrometrically. A Southern Hemisphere imaging and astrometry program for maintenance of the ICRF continued. Activities planned for the year 2003 include imaging of additional VLBA RDV and higher frequency observations and continued research into the effects of intrinsic source structure on astrometry.

1. Analysis Center Operation

The Analysis Center for Source Structure is supported and operated by the United States Naval Observatory (USNO). The charter of the Analysis Center is to provide products directly related to the IVS determination of the "definition and maintenance of the celestial reference frame." These include, primarily, radio frequency images of ICRF sources, intrinsic structure models derived from the radio images, and an assessment of the astrometric quality of the ICRF sources based on their intrinsic structure.

The web server for the Analysis Center is hosted by the USNO and can be accessed by pointing your browser to

`http://rorf.usno.navy.mil/ivs_saac/`

The primary service of the analysis center is the Radio Reference Frame Image Database (RRFID), a web accessible database of radio frequency images of most ICRF sources with declination greater than about -30 degrees. Source structure information is provided in the form of synthesis images and source models suitable for evaluating sources for astrometric and/or geodetic use and for long-term monitoring of sources. The RRFID currently contains over 3300 images of over 450 sources and can be accessed from the Analysis Center web page or directly at

`http://www.usno.navy.mil/RRFID/`

The Analysis Center currently has a program of active research investigating the effects of intrinsic source structure on astrometric position determination. Results of this program are published in the scientific literature.

2. Current Activities

2.1. VLBA RDV Imaging

Very Long Baseline Array (VLBA) observations for maintenance of the celestial and terrestrial reference frames have been carried out since about 1994. Since 1997, these VLBA RDV observations have been part of a joint program between the USNO, Goddard Space Flight Center (GSFC) and the National Radio Astronomy Observatory (NRAO). During each 24 hour VLBA RDV session, about 70 ICRF sources are observed at S/X-band (2.3/8.4 GHz) using the VLBA together

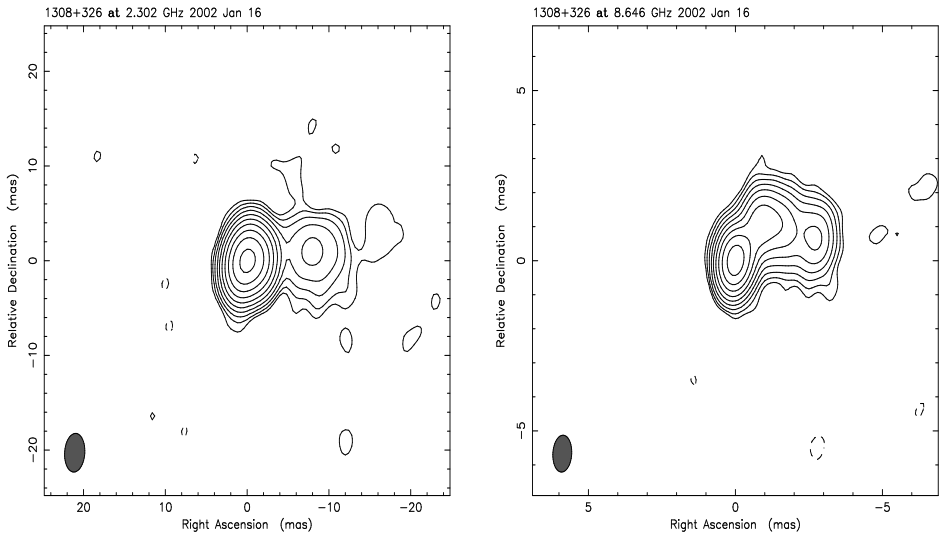

Figure 1. VLBI radio frequency images at S-band (left panel) and X-band (right panel) of the ICRF source 1308+326 at epoch 2002 January 16 (RDV31) taken from the USNO Radio Reference Frame Image Database.

with up to 10 additional geodetic antennas. Images are produced from these observations and made available through the RRFID. An example of the images available from the RRFID at these frequencies is shown in Figure 1. During the calender year 2002, two VLBA RDV experiments (RDV12 and RDV31) were calibrated and imaged.

2.2. VLBA High Frequency Imaging

Very Long Baseline Array observations to extend the ICRF to K-band (24 GHz) and Q-band (43 GHz) (Jacobs et al. 2002, in International VLBI Service for Geodesy and Astrometry 2002 General Meeting Proceedings, edited by Nancy R. Vandenberg and Karen D. Baver, NASA/CP-2002-210002) began in May 2002. The long term goals of this program are to 1) develop higher frequency reference frames for improved deep space navigation, 2) extend the VLBA calibrator catalog at K/Q-band, 3) provide the benefit of the ICRF catalog to new applications at these higher frequencies, and 4) study source structure variation at K/Q-band in order to improve the astrometric accuracy. These observations are part of a joint program between NASA, the USNO, NRAO and Bordeaux Observatory. Images are produced from these observations and made available through the RRFID. An example of the images available from the RRFID at these frequencies is shown in Figure 2. During the calender year 2002, two VLBA high frequency experiments (BR079A and BR079B) were calibrated and imaged.

2.3. Astrometric Suitability of Sources

The resulting intrinsic source structure information from the RRFID provides a valuable resource for evaluating the astrometric suitability of the extragalactic sources used to define the ICRF. Fey & Charlot (2000, Astrophysical Journal Supplement Series, Vol. 128, pp. 17–83) used

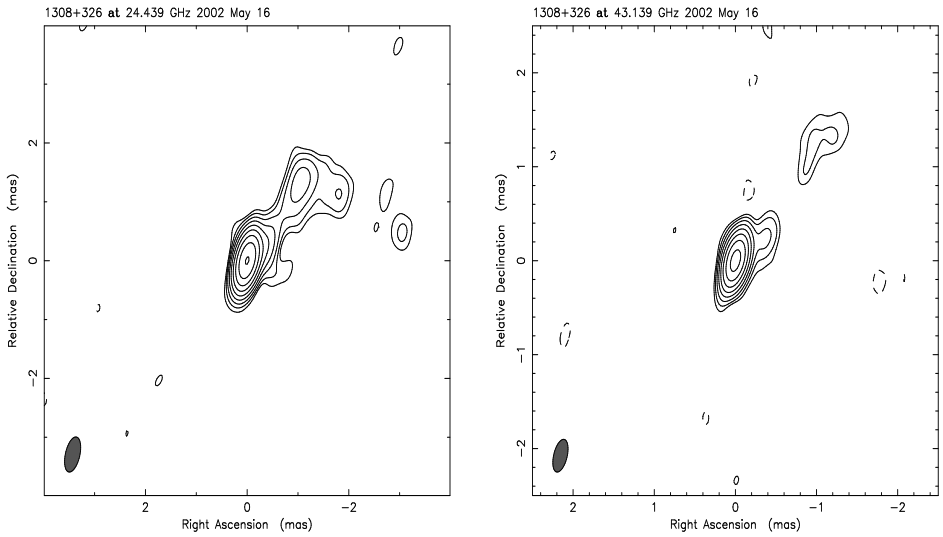

Figure 2. VLBI radio frequency images at K-band (left panel) and Q-band (right panel) of the ICRF source 1308+326 at epoch 2002 May 16 (BR079A) taken from the USNO Radio Reference Frame Image Database.

RRFID data to quantify the magnitude of the expected effect of intrinsic source structure on astrometric bandwidth synthesis VLBI and presented their results in the form of a "Structure Index" for the observed sources. The "Structure Index" ranges from a value of 1 for the least contribution (best astrometric sources) to a value of 4 for the most contribution (worst astrometric sources). The "Structure Index" can be used as an estimate of the astrometric quality of the sources based on intrinsic structure.

The distribution of "Structure Index" calculated from the first epoch of K/Q-band images (Charlot 2002, private communication) is shown in Figure 3. Also shown are values for the 28 sources observed in RDV31 at X-band which overlap with these sources. Note the shift toward lower values as the frequency of observation increases.

2.4. ICRF Maintenance in the Southern Hemisphere

The USNO and the Australia Telescope National Facility (ATNF) are collaborating in a continuing VLBI research program in Southern Hemisphere source imaging and astrometry using USNO, ATNF and ATNF-accessible facilities. These observations are aimed specifically toward improvement of the ICRF in the Southern Hemisphere. Plans include strengthening the ICRF in the Southern Hemisphere by a) increasing the reference source density with additional S/X-band bandwidth-synthesis astrometric VLBI observations, and b) VLBI imaging at 8.4 GHz of ICRF sources south of $\delta = -20°$. These observations will provide a strong tie between the Northern and Southern Hemisphere through the overlap with common sources measured from the north.

2.5. Using VLBA RDV Data

Although preliminary analysis of the RDV experiments suggested that these data had systematic errors of unknown origin, an analysis performed by Center personnel helped to show that initial

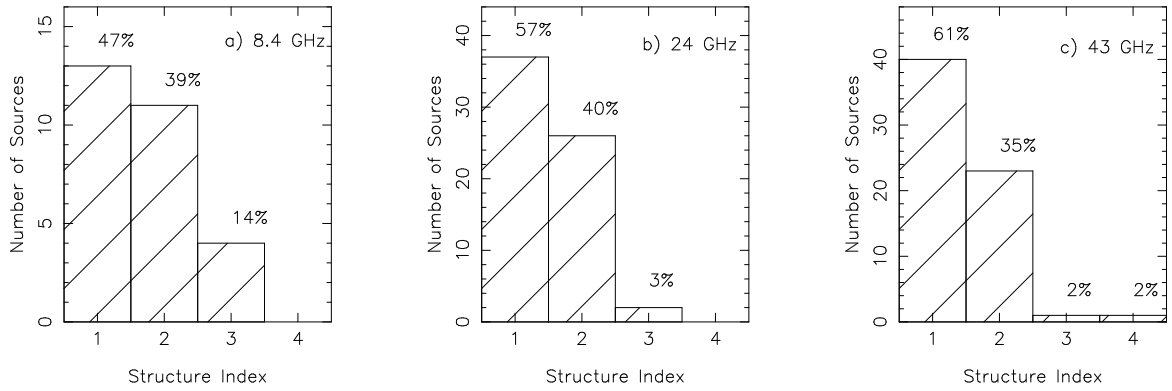

Figure 3. Distribution of "Structure Index" for sources at a) 8.4 GHz, b) 24 GHz, and c) 43 GHz. A total of 65 sources were observed at 24 and 43 GHz on 2002 May 15 (BR079A). Also shown are the values for the 28 overlap sources observed at 8.4 GHz on 2002 Jan 16 (RDV31).

concerns were unfounded and that these data should be incorporated into the general astrometric and geodetic database. Results can be found at

`http://rorf.usno.navy.mil/vlba_rdv/`

3. Staff

The staff of the Analysis Center is drawn from individuals who work at the USNO. The staff and their responsibilities are:

Name	**Responsibilities**
Alan L. Fey	Primary scientific contact, Web and data base design and content, Webmaster, Web server administration, VLBA data analysis (imaging), structure analysis
David A. Boboltz	VLBA data analysis (imaging), structure analysis
Ralph A. Gaume	Liaison to the ICRF Product Center of the IERS
Kerry A. Kingham	Web and data base design and content, Webmaster, Web server administration, geodetic data analysis (imaging), Mark 4 interface to imaging software, structure analysis

4. Future Activities

The following activities are planned:

- Continue imaging of VLBA RDV experiments
- Continue imaging of VLBA high frequency experiments
- Make additional astrometric and imaging observations in the Southern Hemisphere in collaboration with ATNF partners
- Continue research into the effects of intrinsic source structure on astrometry