The 5^{th} IVS General Meeting Proceedings, 2008, p. 251–255

Interpretation of VLBI Results in Geodesy, Astrometry and Geophysics

Some Challenges in Developing the Second ICRF

Chopo Ma, David Gordon, Daniel MacMillan, Leonid Petrov

NASA Goddard Space Flight Center, USA

Abstract. The generation of the second realization of the ICRF catalog is scheduled for the beginning of 2009. VLBI data and analysis have both improved significantly since the first ICRF, which was completed in mid 1995. The observed data distribution is still inhomogeneos spatially and temporally, although the IVS monitoring source monitoring program has led to a larger, better observed set of candidate defining sources. The vast majority of observations have been made by northern hemisphere networks observing ∼100 geodetic sources. Analysis of radio source position time series will provide measures of source stability, which will be supplemented with source structure information from an extensive set of radio source images. Since there will be many catalogs generated by different analysis groups using different strategies, methods for selecting the best solution will be required to generate the final ICRF-2.

1. Introduction

The ICRS is the idealized barycentric coordinate system to which celestial positions are referred. It is kinematically nonrotating with respect to the ensemble of distant extragalactic objects. It has no intrinsic orientation but was aligned close to the mean equator and dynamical equinox of J2000.0 for continuity with previous fundamental reference systems. Its orientation is independent of epoch, ecliptic or equator and is realized by a list of adopted coordinates of extragalactic sources.

The ICRF is a set of extragalactic objects whose adopted positions and uncertainties realize the ICRS axes and give the uncertainties of the axes. It is also the name of the radio catalog whose 212 defining sources are currently the most accurate realization of the ICRS. The IAU adopted the ICRF effective Jan. 1, 1998. The orientation of the ICRF catalog was carried over from earlier IERS radio catalogs and was within the errors of the standard stellar and dynamical frames at the time of adoption. The original ICRF was based on the analysis of S-Band and X-band data collected through from 1979 to 1995 [3].

Analysis of the statistics of these astrometric solutions yielded a source position uncertainty floor of 250 μas and an accuracy of the reference frame axes of about 30 μas. Successive revisions of the ICRF, ICRF-Ext.1 and ICRF-Ext.2 [1] were intended to minimize rotation from its original orientation. Fig. 1 shows the the latest revision, ICRF-Ext.2, which keeps unchanged the positions of the original 212 defining sources, improves positions of the remaining sources and adds $\sim$15% more sources.

VLBI data and analysis have both improved significantly since the first ICRF, which was completed in mid 1995. However, difficulties remain because of the inhomogeneity of the data distribution spatially and temporally, in particular the relative dearth of observations in the southern hemisphere and the two-order range in the number of observation epochs by source. The data set is still dominated by the $\sim$100 sources observed regularly in EOP and TRF sessions, some of which are not ideal in terms of astrometric stability.

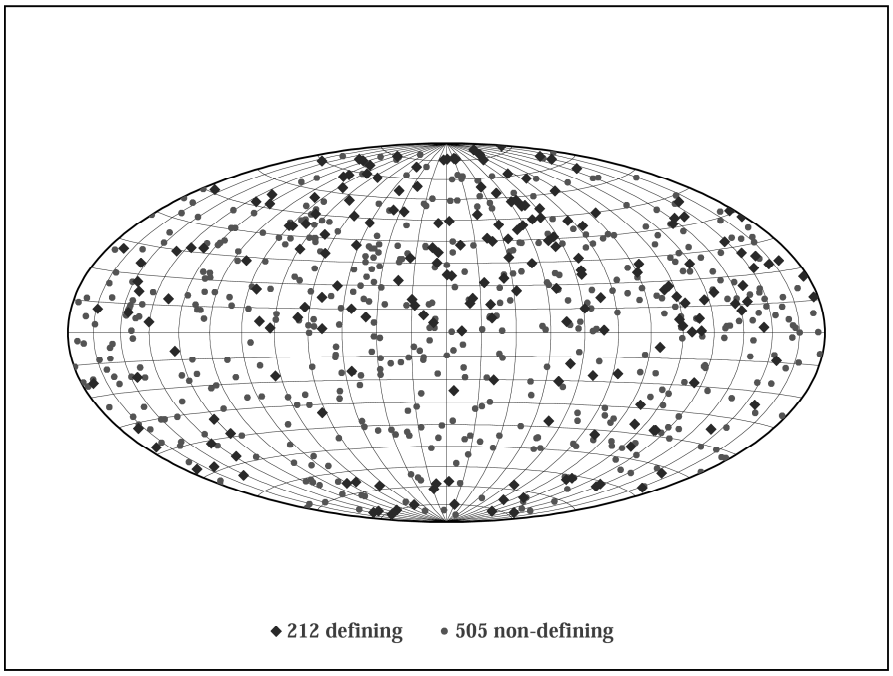

Figure 1. ICRF-Ext.2 sources: 212 defining, 505 non-defining

2. Current Data Set

The original set of ICRF defining sources is dominated by sources in the northern hemisphere, because most observing has been done with northern hemisphere geodetic networks. Since the time histories of many non-geodetic

sources were sparse, the IVS started the CRF monitoring program in 2004 to monitor stable, potentially stable, and ICRF defining sources. This should remedy gaps in the astrometric observing profile and allow a somewhat larger, better observed set of defining sources for the second ICRF.

To assess the statistics of current available source position data, we generated time-series files for 626 sources observed during the period 1979–2007. More details about the analysis of these time series and the determination of a new set of "defining" sources is given in [2]. Fig. 2 shows the statistics of these 626 sources. Clearly, sources at declinations less than $-30°$ were observed much less frequently, almost by an order of magnitude than the bulk of northern hemisphere sources.

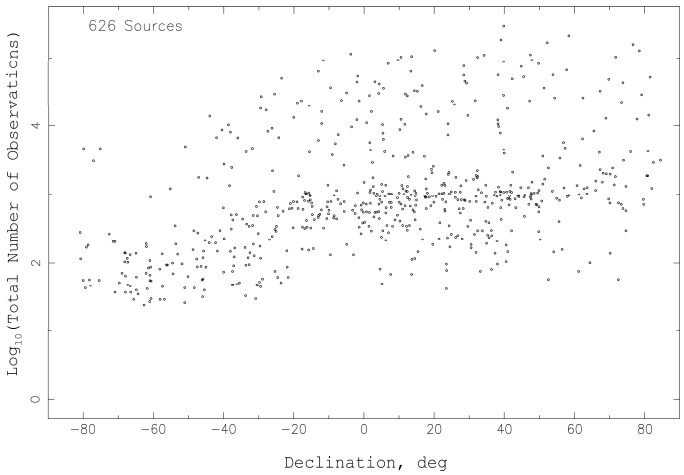

Figure 2. Total number of observations of each source

3. Criteria for the ICRF-2 Defining Sources

To construct ICRF-2, we need to determine the criteria that must be met by the new set of "defining" sources. Two possible criteria are: 1) stability of the source position time series and 2) source structure information from radio images. We now have available extensive source structure information to supplement the identification of stable and unstable sources from position time series. It still may be necessary for the criteria for defining sources to have some flexibility in order to have more uniform spatial distribution since the frequency of source observation as such a strong declination dependence.

When a source has been observed frequently, it is possible to identify clear systematic variations in the estimated source position. For instance, of the 107 geodetic sources, there are a number of sources that have unstable source positions. Fig. 3 shows time-series for 2145+067, which has clear non-linear

variation. However, one of the difficulties in determining the stability from position time-series is that many sources have a very sparse observing history. The number of observing sessions per source varies from 5 to more than a thousand sessions.

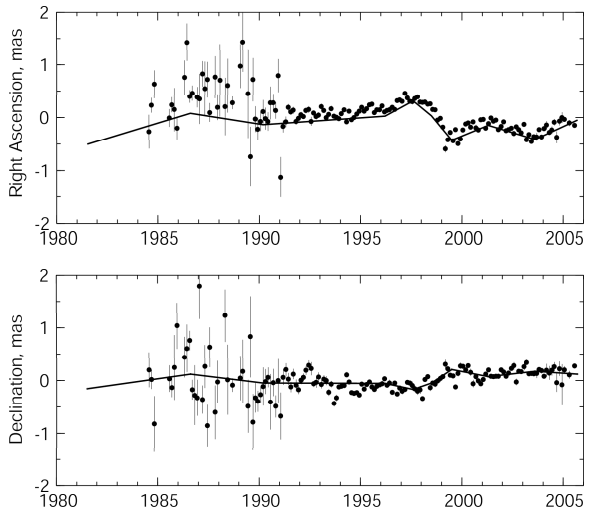

Figure 3. Radio source position time-series in right ascension and declination for 2145+067. Positions shown are 45-day averages

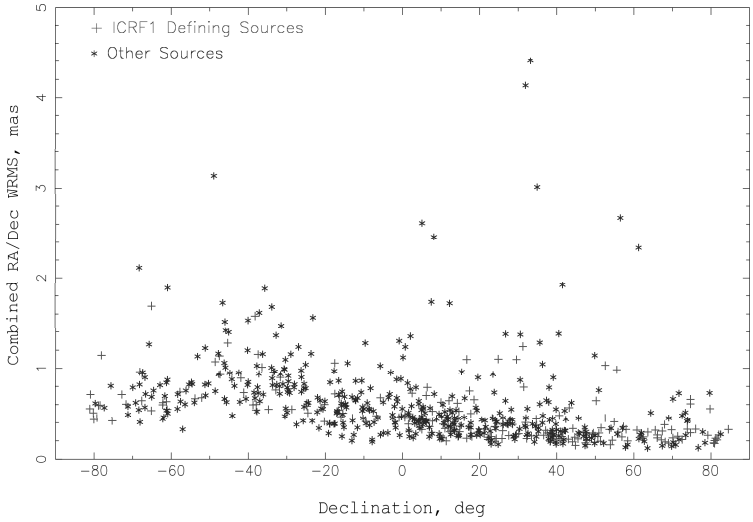

Figure 4. Combined RA/Dec Position WRMS's of GSFC Time Series

One possible criteria for source stability is the WRMS of the RA and DEC position time series for each source. The combined (added in quadrature) WRMS of the RA and DEC series is plotted as a function of declination in Fig. 3. The WRMS is clearly worse for sources south of $-20°$, because the vast majority of observations are made with northern hemisphere stations.

4. ICRF-2 Analysis Plan

The development of ICRF-2 will involve the following issues:

- selection of defining sources;
- treatment of source position variations;
- improvement of geophysical and astronomic modeling;
- data weighting;
- selection of data;
- integration of ICRF, ITRF, and EOP;
- generation of the final catalog.

In the analysis for the second ICRF it will be necessary to improve the estimation of gradients, correlated noise, source position variations and observation weighting. As there will be many catalogues generated by the various analysis groups, methods for selecting the best solution among several or for combining solutions will be needed. The provisional milestone timeline for the analysis leading to the final ICRF-2 is:

spring 2007	Working Group Meeting, Vienna;
fall 2007	Generation, comparison of time series (Working Group Meeting, Paris);
spring 2008	Analysis of time series (Working Group Meeting, St. Petersburg);
mid 2008	Defining source criteria;
fall 2008	Selection of defining sources, analysis configuration;
spring 2009	Generation of ICRF-2 catalogue.

References

[1] Fey, A., C. Ma, F. Arias, et al. The second extension of the ICRF. Astron. J., 127, 3587, 2004.

[2] Gordon, D., C. Ma, J. Gipson, et al. On Selection of "Defining" Sources for ICRF-2. This volume.

[3] Ma, C., F. Arias, T. Eubanks, et al. The International Celestial Reference Frame as realized by very long baseline interferometry. Astron. J., 116, 516, 1998.