Current CRF Status at X/S and K Bands

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Abstract We present the status of the X/S- and K-band celestial reference frames four years after ICRF3 was generated. The reference frames now have ∼20% more sources at X/S-band and ∼25% more sources at K-band. Median scaled uncertainties for the original ICRF3 sources have improved by ∼25% at X/S-band and by ∼37–40% at K-band.

Keywords ICRF3, X/S band, K band, astrometry

1 Introduction

ICRF3 [1] was approved by the International Astronomical Union in August 2018 and became the official IAU celestial reference frame in January 2019. ICRF3 contains catalogs of precise positions of compact extragalactic radio sources at three radio frequencies—a primary catalog of 4,536 sources at X/S-band (8.6/2.3 GHz) and secondary catalogs of 824 sources at K-band (24 GHz) and 678 sources at X/Ka-band (8.4/32 GHz). However, observations to maintain and expand the ICRF have continued at all three bands during the four years since ICRF3 was finalized. In the next sections we present the curent CRF status at X/S- and K-bands.

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2 The CRF at X/S band

The X/S CRF catalog currently contains 5,442 sources, some 20% more than ICRF3. Most of the additional sources (∼750) were added in monthly 2 Gb/s astrometry sessions on the Very Long Baseline Array (VLBA) and in bi-monthly RDV sessions (VLBA plus several IVS stations) at 512 Mb/s. Approximately half of these additional sources are within 7° of the ecliptic, observed in an effort to provide more sources for future spacecraft navigation. IVS sessions have added another ∼150 more sources, mainly in AOV and AUA sessions. The distribution of these 5,442 sources is shown in Figure 1. The source distribution clearly favors northern hemisphere observations, showing a sudden drop in source density south of $\sim -45^\circ$ declination, the practical limit of the VLBA. Due to a scarcity of large southern hemisphere antennas available for X/S VLBI astrometry/geodesy, this assymetry cannot currently be remedied.

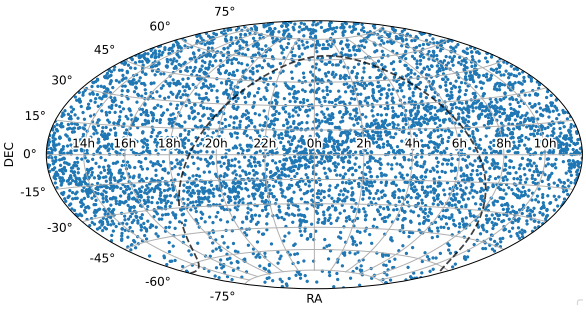

Fig. 1 Distribution of the 5,442 sources in the current X/S-band CRF catalog. The dotted line shows the galactic plane.

3 The CRF at K band

The K-band CRF catalog now contains 1,035 sources, some 211, or 25% more than the ICRF3-K catalog. Most of these (183) were added in monthly K-band VLBA astrometry sessions, at 2 Gb/s before November 2019 and at 4 Gb/s after. Southern hemisphere observations on the HARTRAO–HOBART26 baseline have also added an additional 28 sources south of $-46°$ declination. And 206 of the sources were observed on both the VLBA and HARTRAO–HOBART26 networks, helping to tie the two networks together. The distribution of K-band sources is shown in Figure 2. Unlike at X/S-band, the K-band sources are much more evenly distributed over the sky, although source positions are much less precise in the far south.

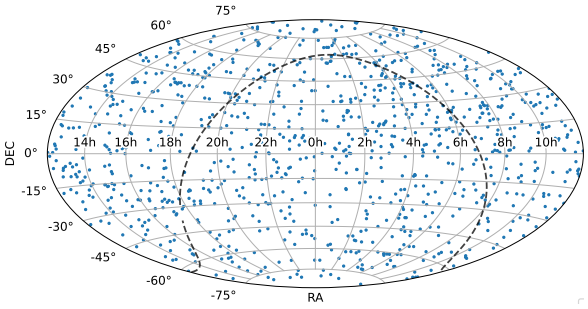

Fig. 2 Distribution of the 1,035 sources in the current K-band CRF catalog. The dotted line shows the galactic plane.

4 Precision Improvements

With four additional years of observations, the median scaled Right Ascension/Declination errors for the 4,536 ICRF3-SX sources has improved from 127|218 µas to 95|161 µas, or by ∼25%. And for the 824 ICRF3-K sources, it has gone from 73|134 µas to 46|80 µas, improving by ∼37|40%. In Table 1 we intercompare K and X/S precision for common sources. For the original ICRF3 sources, K-band was ∼15|53% less precise than X/S. The current K-band, with an additional ∼200 sources in common, is slightly more precise in RA than the original ICRF3-SX, but slightly less precise than the current X/S. The K-band ICRF3 noise floor was 30 µas in RA and 50 µas in Dec, a result of the shorter north-south extent of the VLBA compared to its east-west extent; so Declination uncertainties are always greater for K-band. Even so, K-band has the potential to surpass X/S-band in precision over the next few years.

Table 1 K vs. X/S median scaled RA/Dec errors for common sources.

# Sources	ICRF3-K	ICRF3-XS
793	72.0/132.6 µas	62.6/86.8 µas
# Sources	Current K	ICRF3-XS
999	48.2/82.7 µas	51.8/67.9 µas
# Sources	Current K	Current XS
1014	48.4/83.2 µas	46.9/60.3 µas

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