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USNO Analysis of VLBA RDV Data

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Abstract

Previous analyses have indicated that there may be a problem with the VLBA RDV data for sources south of the celestial equator. We present an analysis of the effects of including VLBA RDV data in global VLBI SOLVE solutions on astrometric position estimation and on Earth Orientation Parameter estimation.

1. Introduction

Previous analyses by various individuals have indicated that there may be an "anomaly" (formerly know as the "southern source problem") with the VLBA RDV data. The primary manifestation of this anomaly was excess normalized residual delay (NRD) and/or excessive position variation for sources south of the celestial equator. We present an analysis of the effects of including VLBA RDV data in global SOLVE solutions on astrometric position and on Earth Orientation Parameter (EOP) estimation. *Note that this is a work in progress.* Additional details concerning this investigation and a complete description of the parameterization of the global SOLVE solutions can be found at

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

2. The Data

VLBA RDV data is defined as that data obtained under the auspices of the VLBA RDV proposals and correlated at the VLBA correlator in Socorro, NM. During each 24 hour VLBA RDV session, about 70 ICRF sources are observed at S/X band using the NRAO Very Long Baseline Array (VLBA) antennas together with up to 10 additional geodetic antennas. The VLBA RDV experiments are a joint collaboration between the USNO, Goddard Space Flight Center (GSFC) and the National Radio Astronomy Observatory (NRAO). The VLBA RDV data set used here is comprised of 527410 observations (delay/phase delay rate pairs) and covers the time range from 1997 to 2000 (RDV01 to RDV24 inclusive).

MkIII data is defined as VLBI data correlated with a Mark III/IV correlator. The full MkIII data set used in this analysis covers the time range from 1979 to 2001 and is comprised of 2489280 observations. The NEOS only data set used here is comprised of 210878 observations spanning the same time period as the VLBA RDV data (NA197 to NA397).

3. Excess Normalized Residual Delay

Previous analyses suggested that the primary manifestation of the VLBA RDV anomaly was excess normalized residual delay (NRD) for sources south of the celestial equator. Shown in

Figure 1 are plots of NRD as a function of declination for several VLBA RDV experiments. Note that there is larger than normal NRD, i.e. greater than 1.0, for some sources but these sources are not necessarily all southern hemisphere sources. Additionally, there appears to be a seasonal effect, i.e. winter experiments appear to have fewer sources with elevated NRD than do summer experiments.

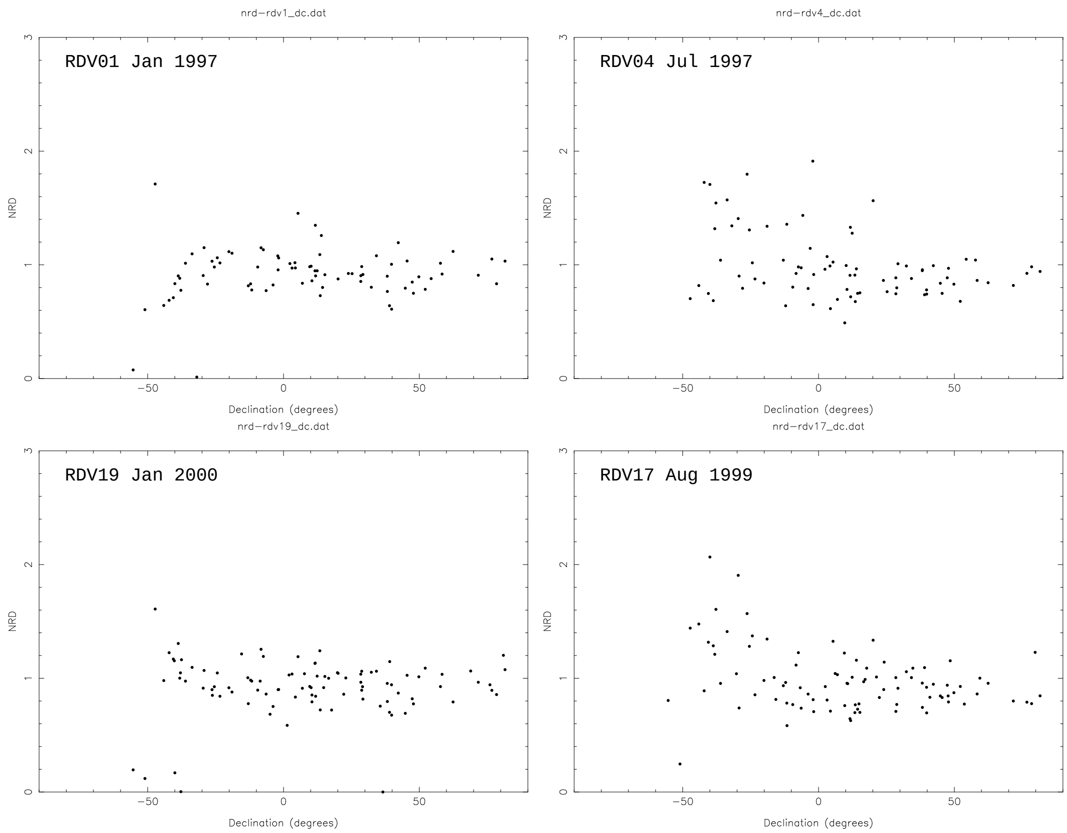

Figure 1. Normalized residual delay as a function of declination for four VLBA RDV experiments. The two panels on the left show values from winter experiments while the two panels on the right show values from experiments observed during the summer. Note the seasonal differences.

Shown in Figure 2 are results for combined solutions. With the exception of a few discrepant points, the NRD anomaly appears to almost completely disappear (or at least is extremely less well pronounced) when all the VLBA RDV data is combined into one global solution.

4. Excess Position Variation

Another claimed manifestation of the VLBA RDV anomaly was excess position variation for sources south of the celestial equator. We compare statistics of “arc” positions for selected sources. Arc position time series were calculated in SOLVE global solutions using VLBA RDV data and NEOS data. Two sets of solutions were made: 1) using only VLBA RDV data (RDV01 to RDV24, inclusive); and 2) using only NEOS data from the same time period as the VLBA RDV data (NA197 to NA397). A total of 64 sources were observed with sufficient frequency in the VLBA

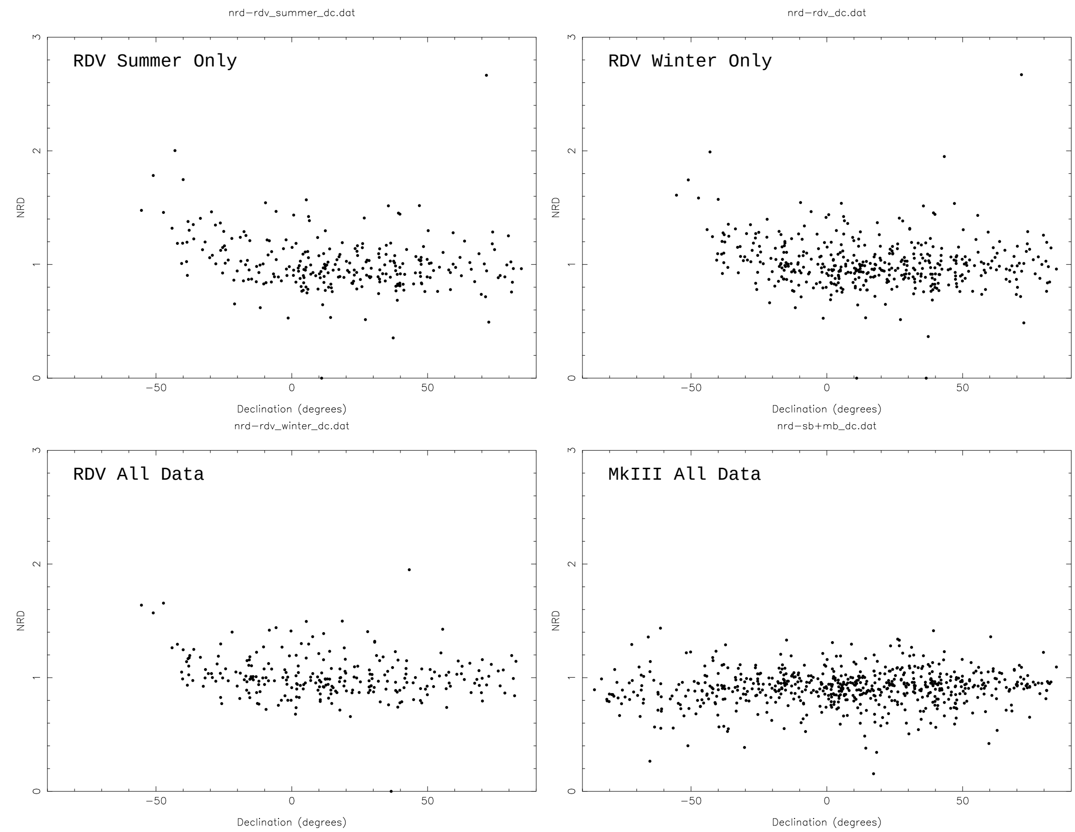

Figure 2. Normalized residual delay as a function of declination for combined VLBA RDV experiments. Note that the combined data show less seasonal differences than the individual experiments and when *all* VLBA RDV data are combined, the NRD "anomaly" almost completely disappears. The NRD for the MkIII data is shown for reference.

RDV data to estimate positions as arc parameters. Of these 64 sources, a total of 54 sources were observed with sufficient frequency in the NEOS data to estimate positions as arc parameters. Weighted root–mean–square (wrms) position residuals were calculated for each source using the GSFC program "ploser." Results are shown in Figure 3 as a plot of wrms position residuals from the NEOS data vs. wrms position residuals from the VLBA RDV data. Sources with zero wrms are those 10 sources which had insufficient data in the NEOS experiments to calculate wrms position residuals. Note that the NEOS data has much larger wrms residuals than the VLBA RDV data for *all* sources in both right ascension and declination.

5. Effect on Position Estimation

A number of SOLVE global solutions were made for the specific purpose of position estimation. Source positions were estimated as global parameters in these solutions. The only differences between different solutions were the included data (eg. MkIII only, VLBA only, MkIII+VLBA, etc.). Source position global differences are listed in Table 1.

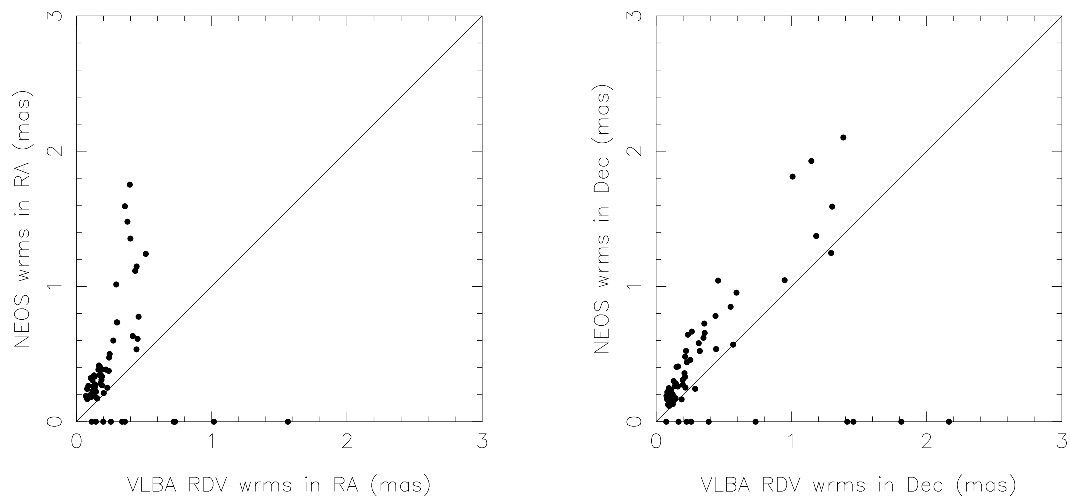

Figure 3. Weighted root–mean–square (wrms) position residuals derived using only NEOS data vs. wrms position residuals derived using only VLBA RDV data.

Solution Pair	RA mean (mas)	RA wrms (mas)	Dec mean (mas)	Dec wrms (mas)
MkIII/VLBA	−0.005	0.108	0.023	0.117
MkIII/VLBA Winter	0.003	0.102	0.030	0.114
MkIII/VLBA Summer	−0.015	0.123	0.014	0.137
VLBA Summer/Winter	0.016	0.085	0.019	0.104
MkIII+VLBA/MkIII	**0.000**	**0.031**	**−0.007**	**0.039**

Table 1. Weighted position differences for various solution pairs.

6. Effect on EOP

Two SOLVE global solutions were made for the specific purpose of EOP estimation. Wrms differences in X, Y, UT1, $\Delta\Psi$ and $\Delta\epsilon$ between different solutions are listed in Table 2. Comparison is made only for the time range 1997 to 2001. Solutions made at the USNO which include only the MkIII data are labeled USNO and solutions which include both the MkIII and the VLBA RDV data are labeled USNO+VLBA. Comparison is also made to the GSFC 2001c solution and to the IERS C04 series. These latter two comparisons are made for the time range 1996 to 2001. A slope and bias have been removed in all comparisons before calculation of the wrms.

Solution Pair	X (μas)	Y (μas)	UT1 (μsec)	$\Delta\Psi$ (μas)	$\Delta\epsilon$ (μas)
USNO+VLBA/USNO	76.7	72.9	3.33	143	51.6
USNO+VLBA/GSFC	77.0	94.6	3.85	160	54.5
USNO+VLBA/IERS	197	165	19.4	374	185

Table 2. Weighted EOP differences for various solution pairs.

7. Summary

Comparison of source positions between solutions with and without the VLBA RDV data show that differences are minimal (weighted mean and rms of 0.0 ± 31 microarcsecond in right ascension and -7.4 ± 39 microarcsecond in declination). Plots of NRD (normalized residual delay) versus declination from solutions with individual VLBA RDV databases show that there is larger than normal NRD, i.e. greater than 1.0, for some sources but these sources are not necessarily all southern hemisphere sources. Additionally, there appears to be a seasonal effect, i.e. winter experiments have fewer sources with elevated NRD than summer experiments. However, in the combined solutions (i.e. solutions with all the VLBA RDV data), with the exception of a few discrepant points, the NRD "anomaly" appears to almost completely disappear (or at least is extremely less well pronounced). The NEOS data from the same time period as the VLBA RDV data have much larger weighted rms position residuals than those estimated from the VLBA RDV data. This is true for *all* sources, in both right ascension and declination. Differences in X, Y, UT1 and nutation between solutions with and without the VLBA RDV data show that the VLBA RDV data appears to have no negative effect on the global solution estimation of EOP.