Report on DORIS Rinex processing with Jason-2

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IDS AWG
Washington DC
October 15-16, 2015

Range Rate from DORIS Rinex and corrections to observed measurement

$$rrate\ (T^c) = \lambda_1 \left(L_1 (T_i) - L_1 (T_{i-1})\right) / (T_i - T_{i-1})$$

$$= \left(D (T^c_i) - D (T^c_{i-1})\right) / \Delta T + c(\Delta t_r - \Delta t_e) / \Delta T + \Delta_{\text{satellite USO frequency}} + \Delta_{\text{ionosphere}} + \Delta_{\text{relativity}}$$

where

$D(T^c)$: distance between emitter (e) and receiver (r) 2GHz phase centers at TAI time (T^c), and includes Troposphere refraction. $c(\Delta t_r - \Delta t_e)$: satellite-beacon clock drift; Δt difference clock offsets between i and i-1 times

and

$\Delta_{\text{satellite USO frequency}}$: polynomial fit to offset estimates

$\Delta_{\text{ionosphere}}$: 1st order correction (Lemoine 2015)

$\Delta_{\text{relativity}}$: Periodic terms

DORIS Rinex range rate GEODYN processing (computed or theoretical measurement)

Rinex range rate :

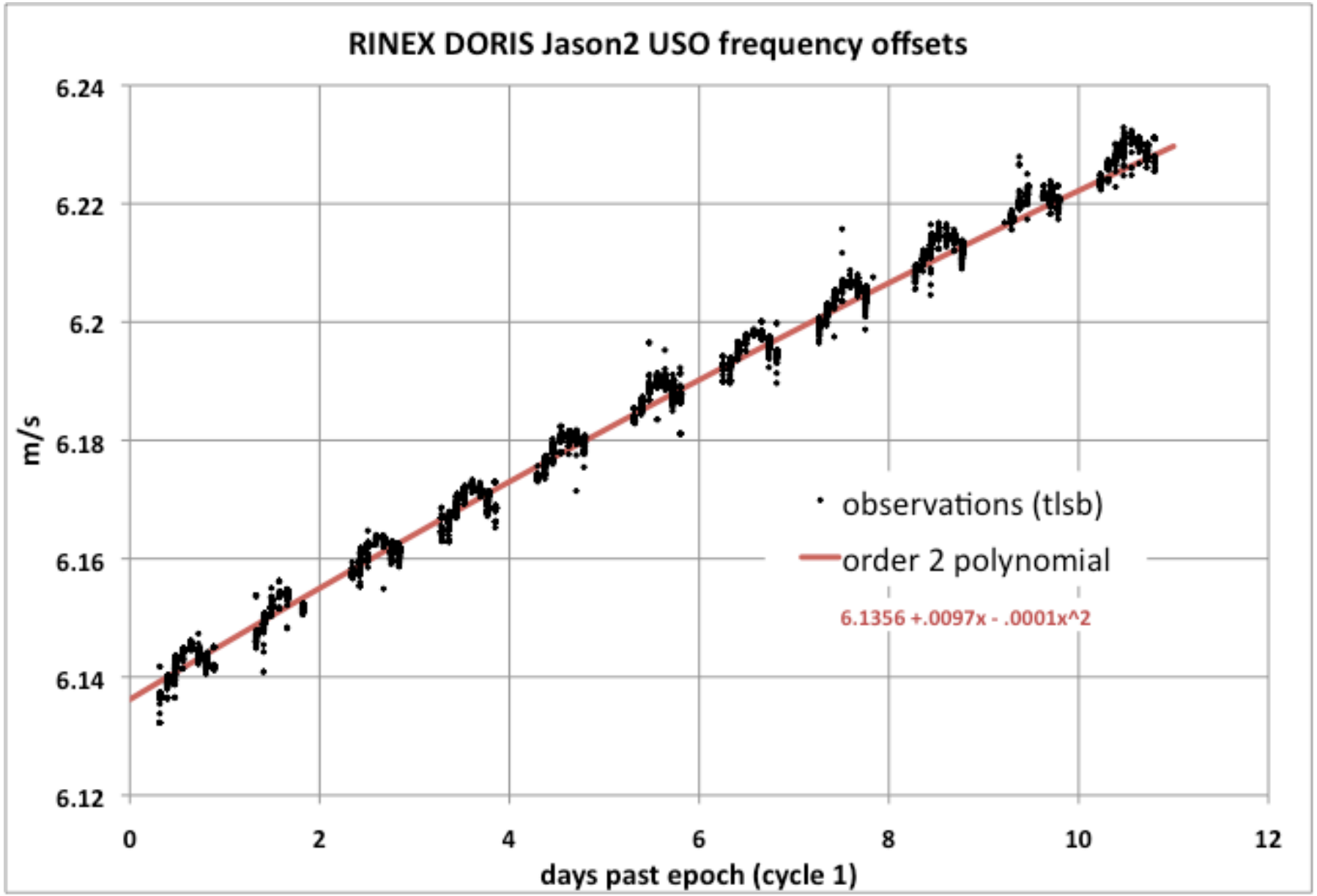
range rate + USO frequency bias (per pass) + $\Delta_{\text{troposphere}}$ + $\Delta_{\text{phase center}}$

where

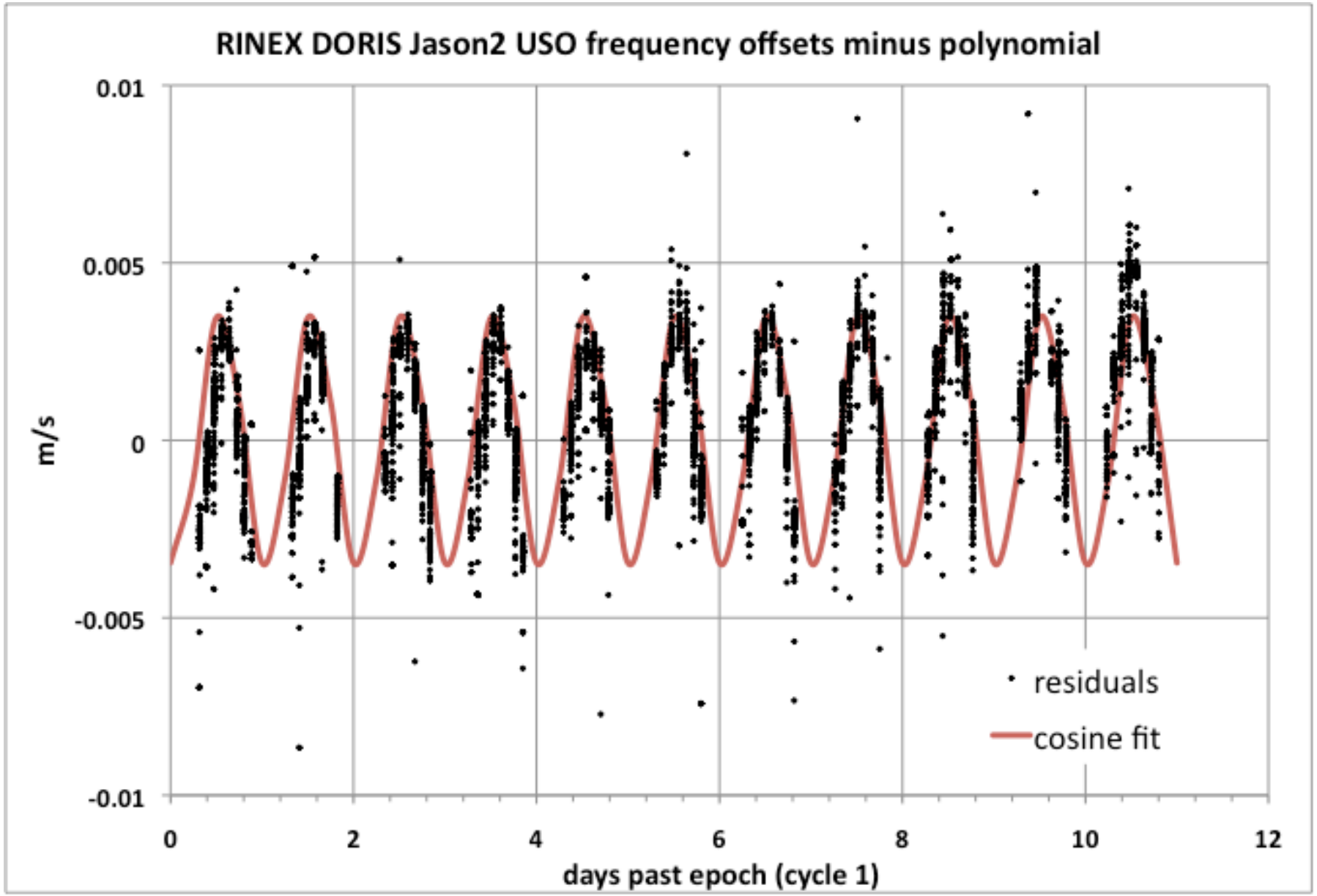
$\Delta_{\text{troposphere}}$: VMF1 (plus bias/pass)

$\Delta_{\text{phase center}}$: update satellite antenna Z offset and Starec station Up eccentricity to ionosphere-free positions

Δ satellite USO frequency : 2nd order polynomial fit



USO frequency correction residuals



USO frequency correction performance using external ephemeris

test (SLR/DORIS) 10-day (cycle 001)	DORIS points	DORIS (mm/s)	time bias (10^{-6} sec)
v2.2	187402	0.3686	-2.8
rinex; no correction	190605	0.3810	-1.0
rinex; linear correction	190565	0.3786	-0.9
rinex; 2nd order polynomial	190573	0.3784	-1.0

Relativity correction to DORIS satellite clock

$$\Delta V_{REL} = \frac{1}{c}\left[U_r - U_e + \frac{V_r^2 - V_e^2}{2}\right]$$

(Lemoine et al., 2015)

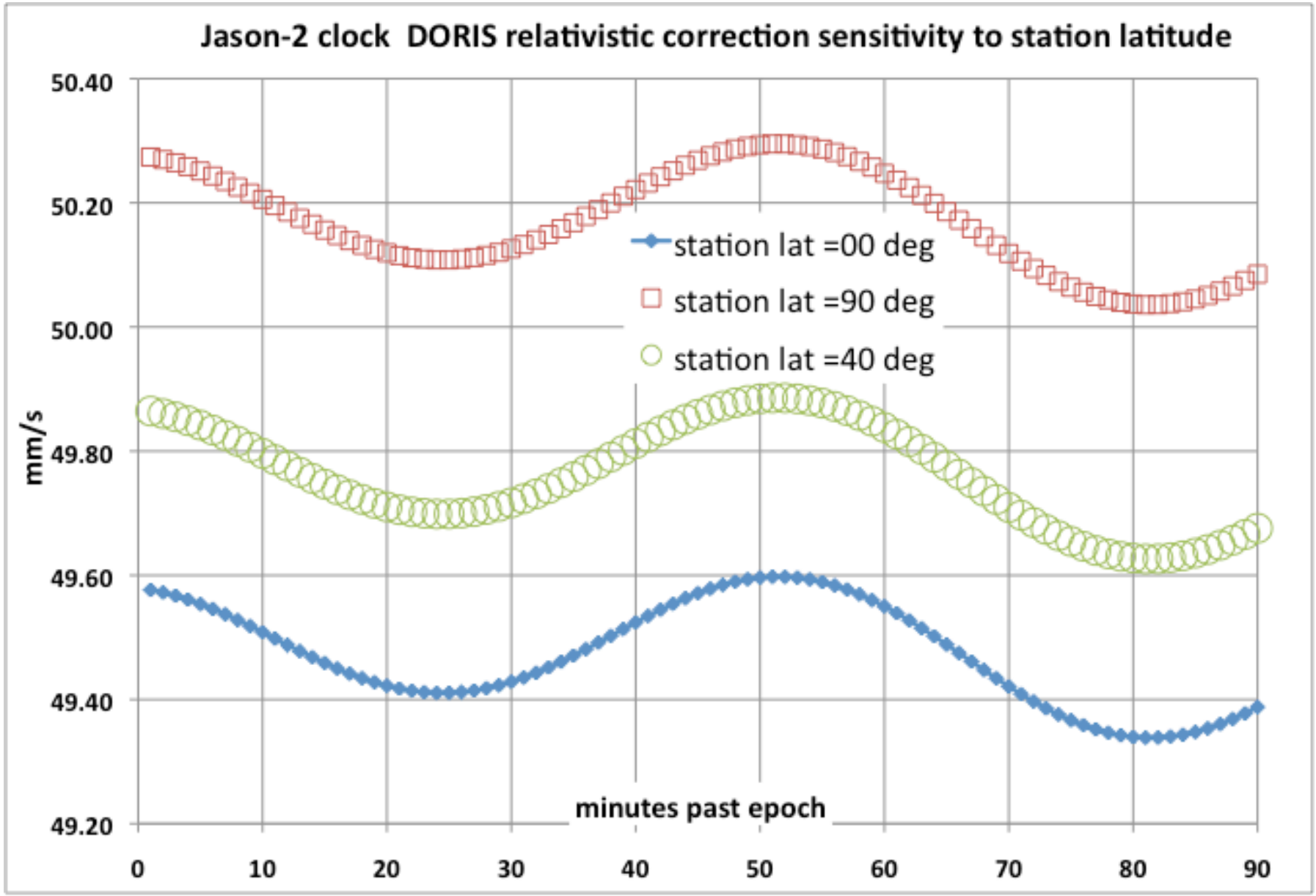
$$U = \frac{GM}{r}\left(1 - \left(\frac{a_e}{r}\right)^2 J_2 \frac{3\sin^2(\varphi) - 1}{2}\right)$$

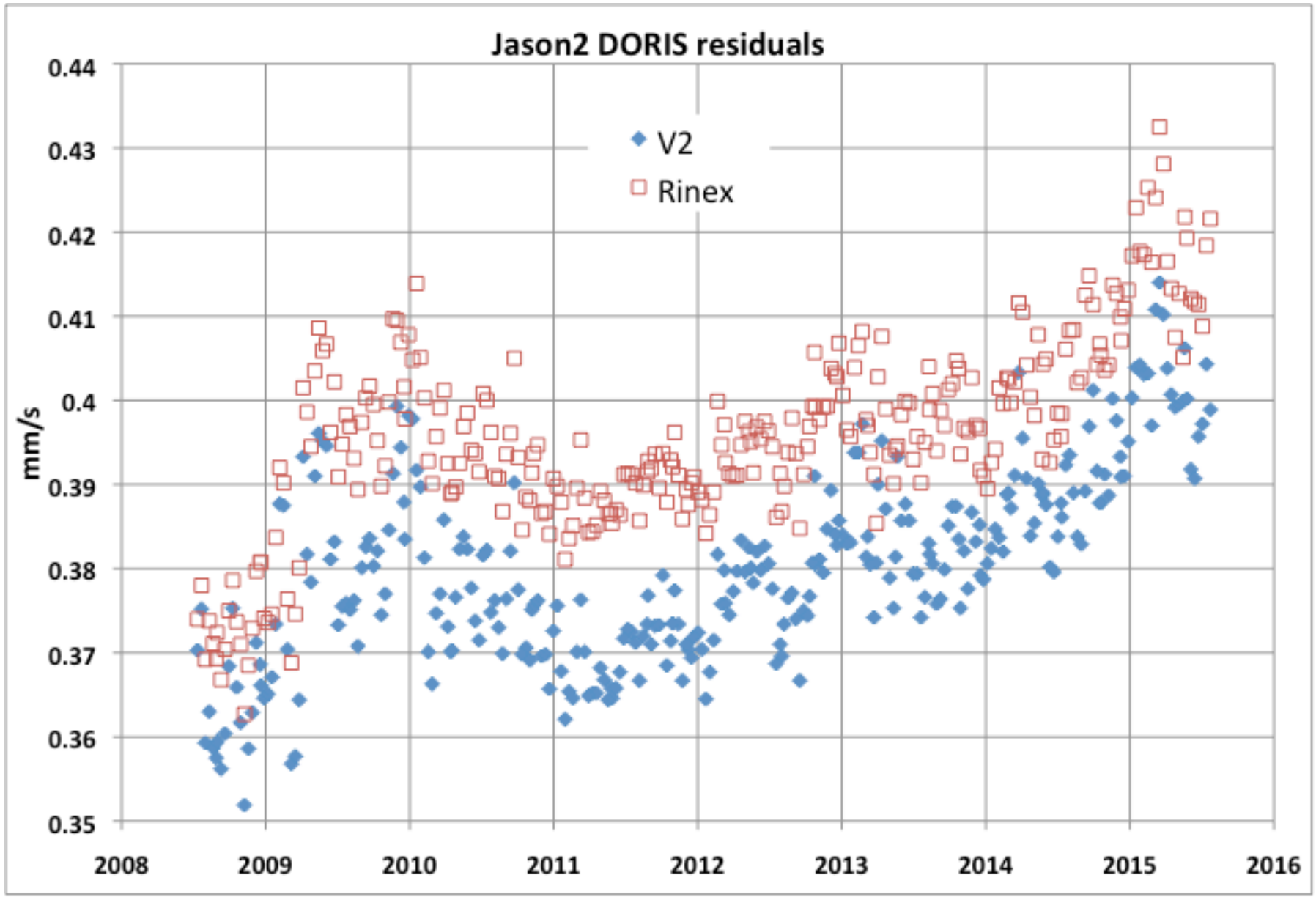
With $J_2 = 1.0826264\ 10^{-3}$

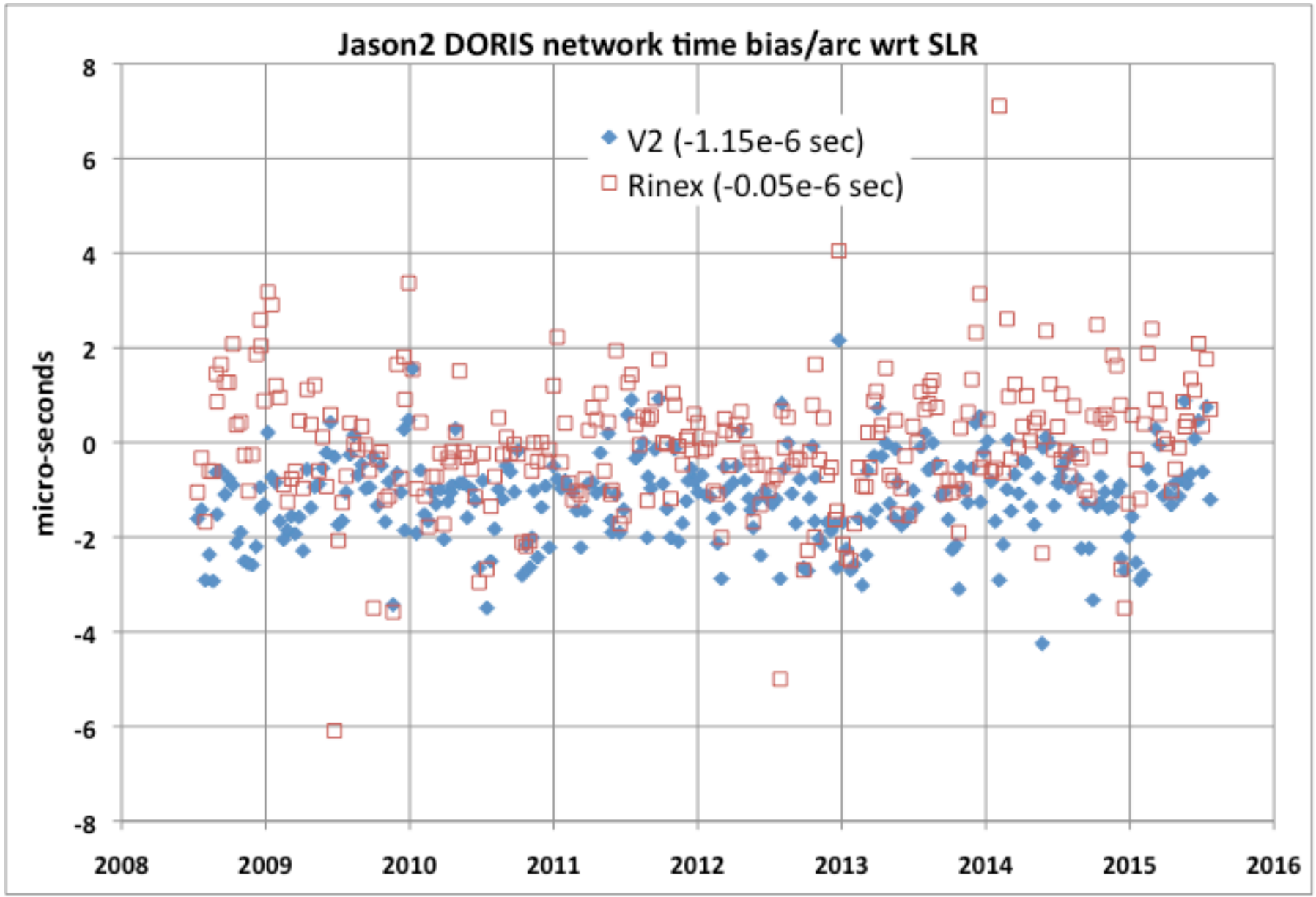
For correction to RINEX data:

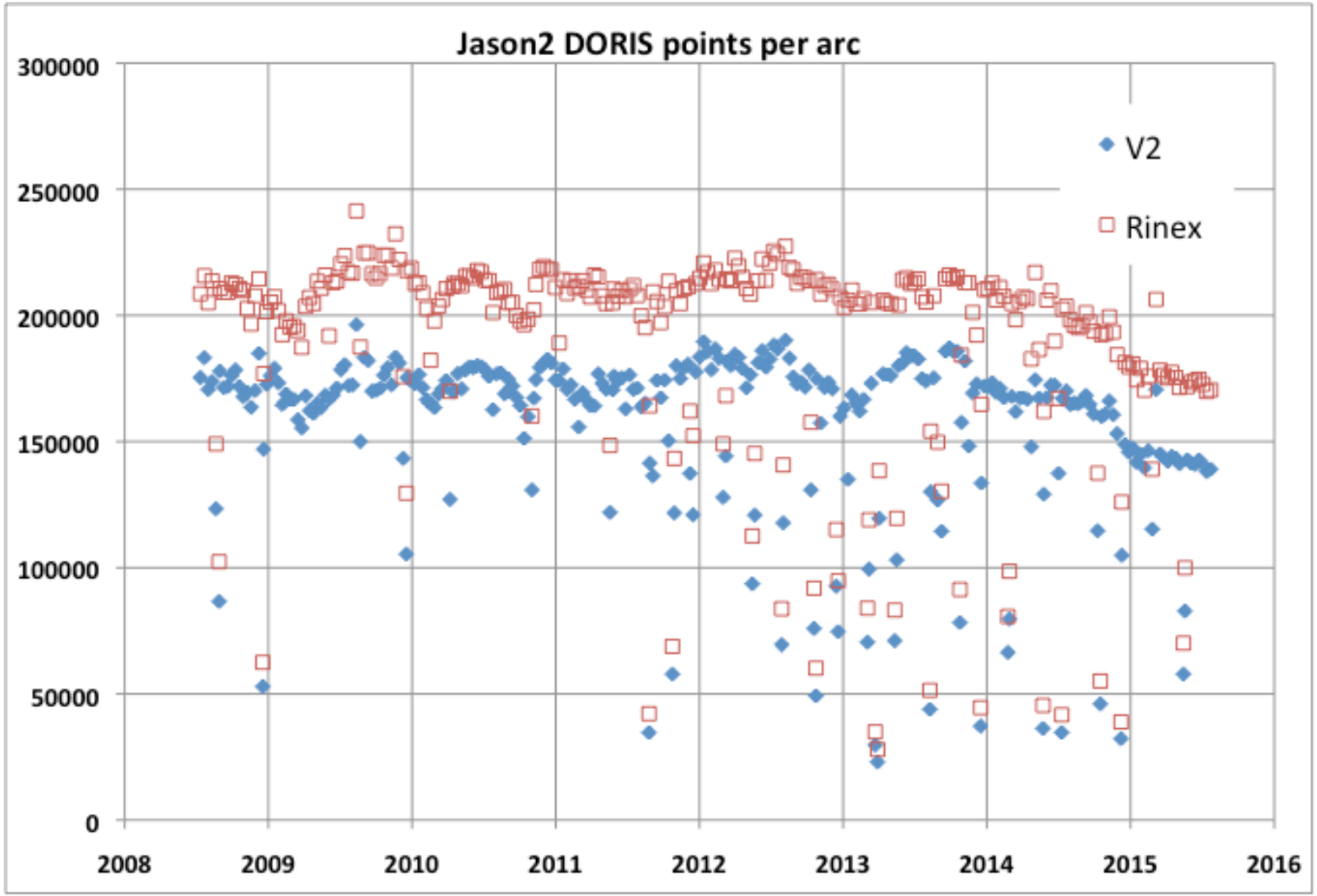
1) use sp3 orbit data to compute U_r and V_r which vary in time.
2) assume a single station position to compute U_e and V_e which do not vary in time.
3) apply interpolated periodic terms after removing an estimated offset+rate from the total relativity correction.

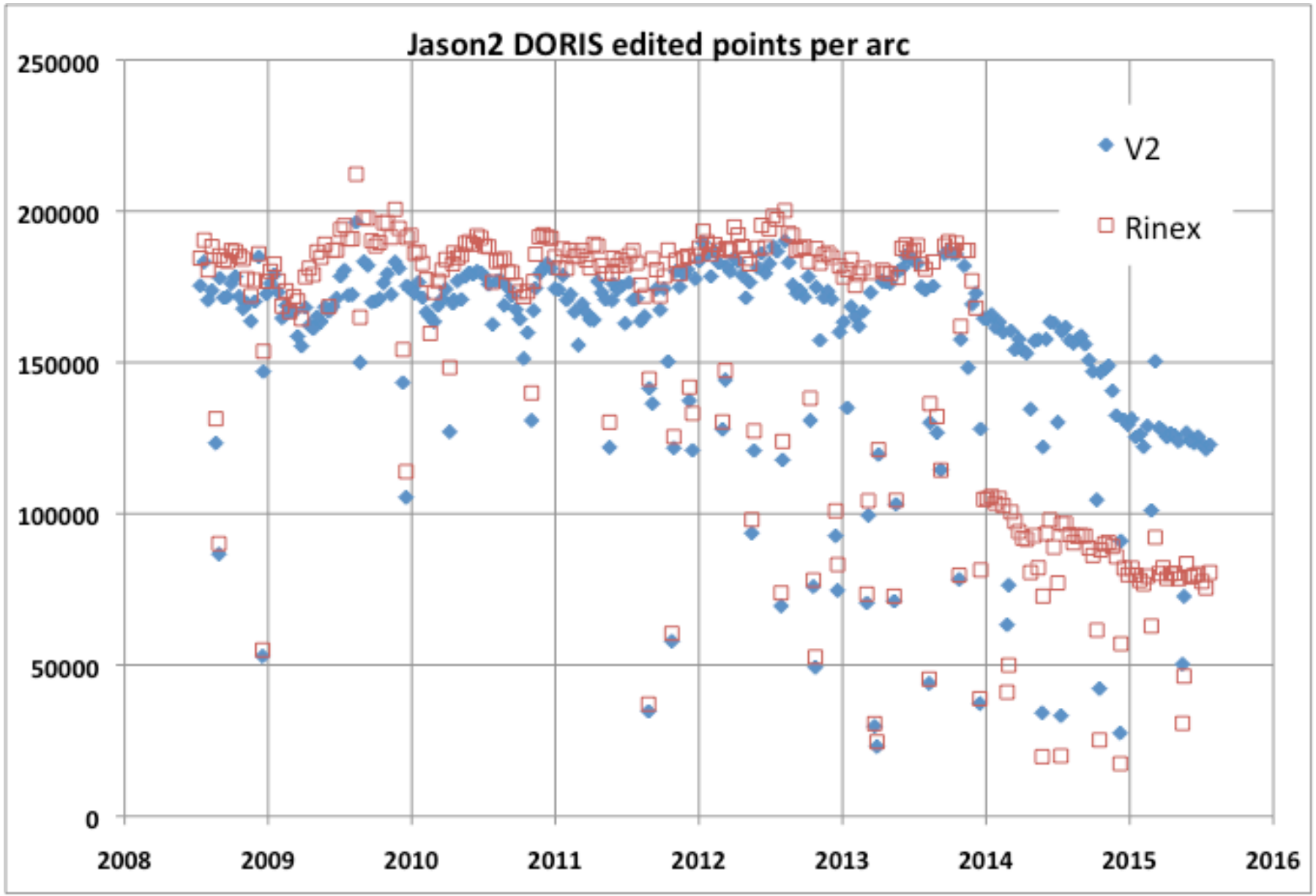
Station bias/pass will compensate for differences in Relativity offset/rate corrections

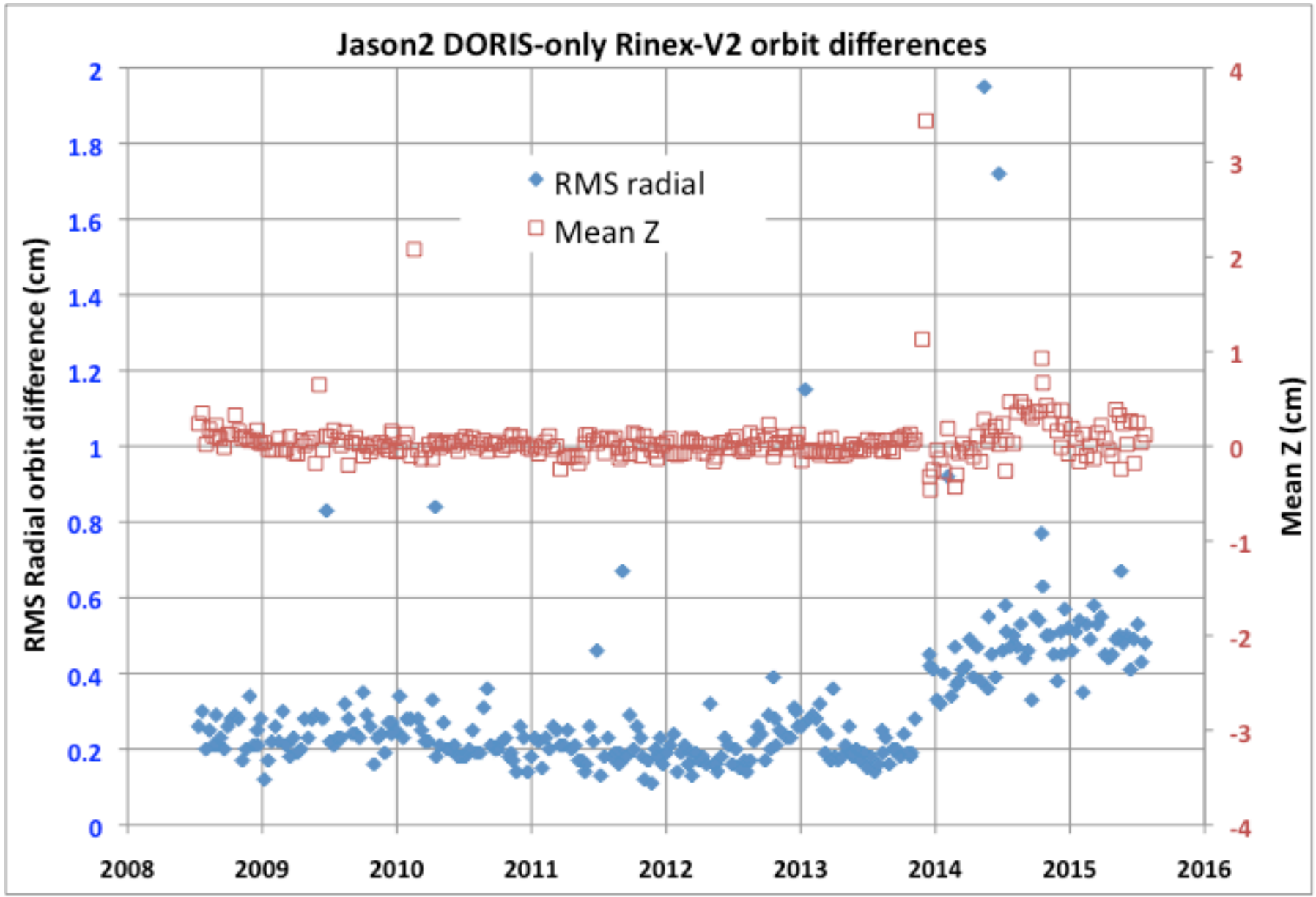


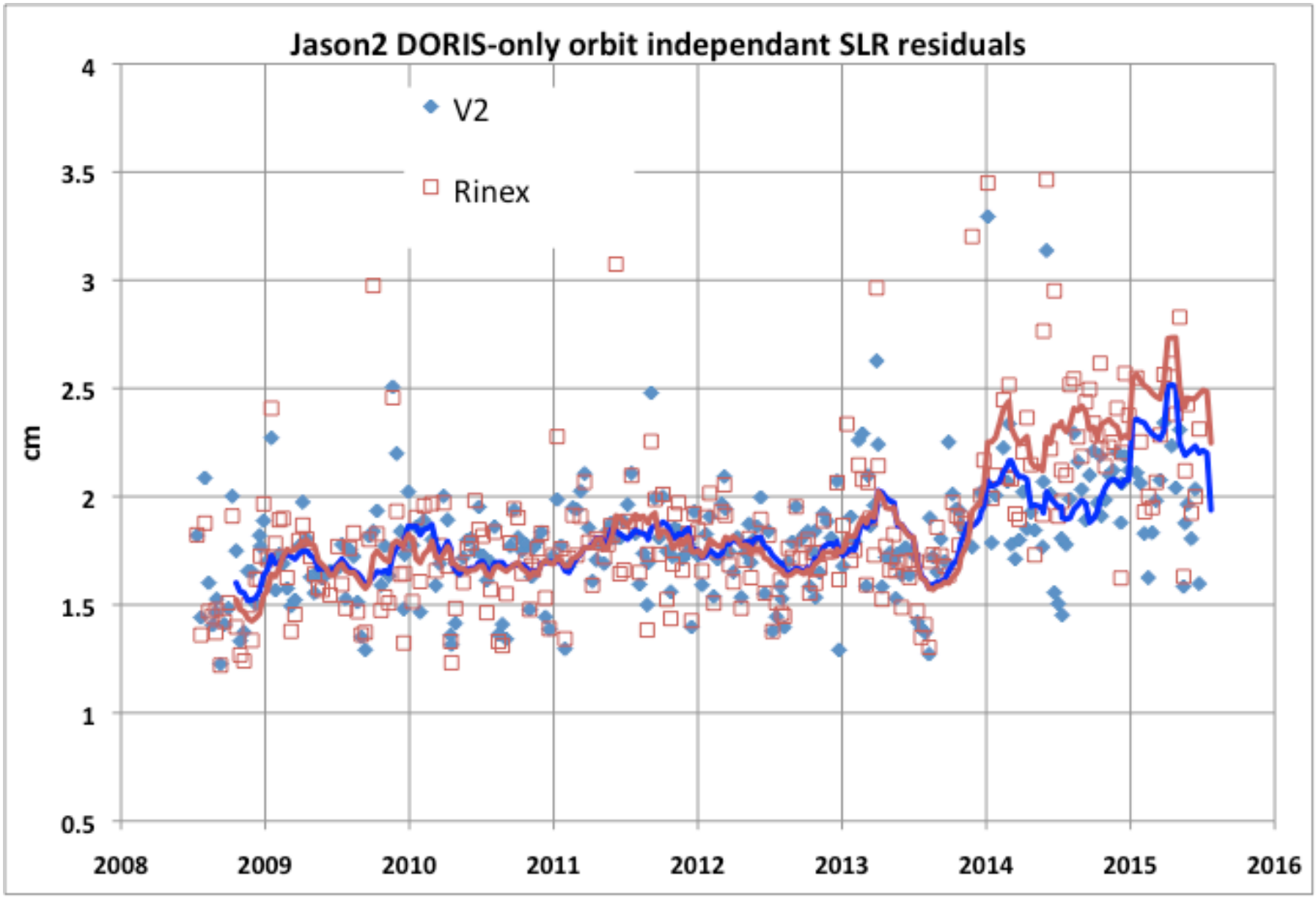

Jason2 DORIS residuals
V2
Rinex
mm/s
0.44
0.43
0.42
0.41
0.4
0.39
0.38
0.37
0.36
0.35
2008
2009
2010
2011
2012
2013
2014
2015
2016


Jason2 DORIS network time bias/arc wrt SLR
V2 (-1.15e-6 sec)
Rinex (-0.05e-6 sec)
micro-seconds
8
6
4
2
0
-2
-4
-6
-8
2008
2009
2010
2011
2012
2013
2014
2015
2016

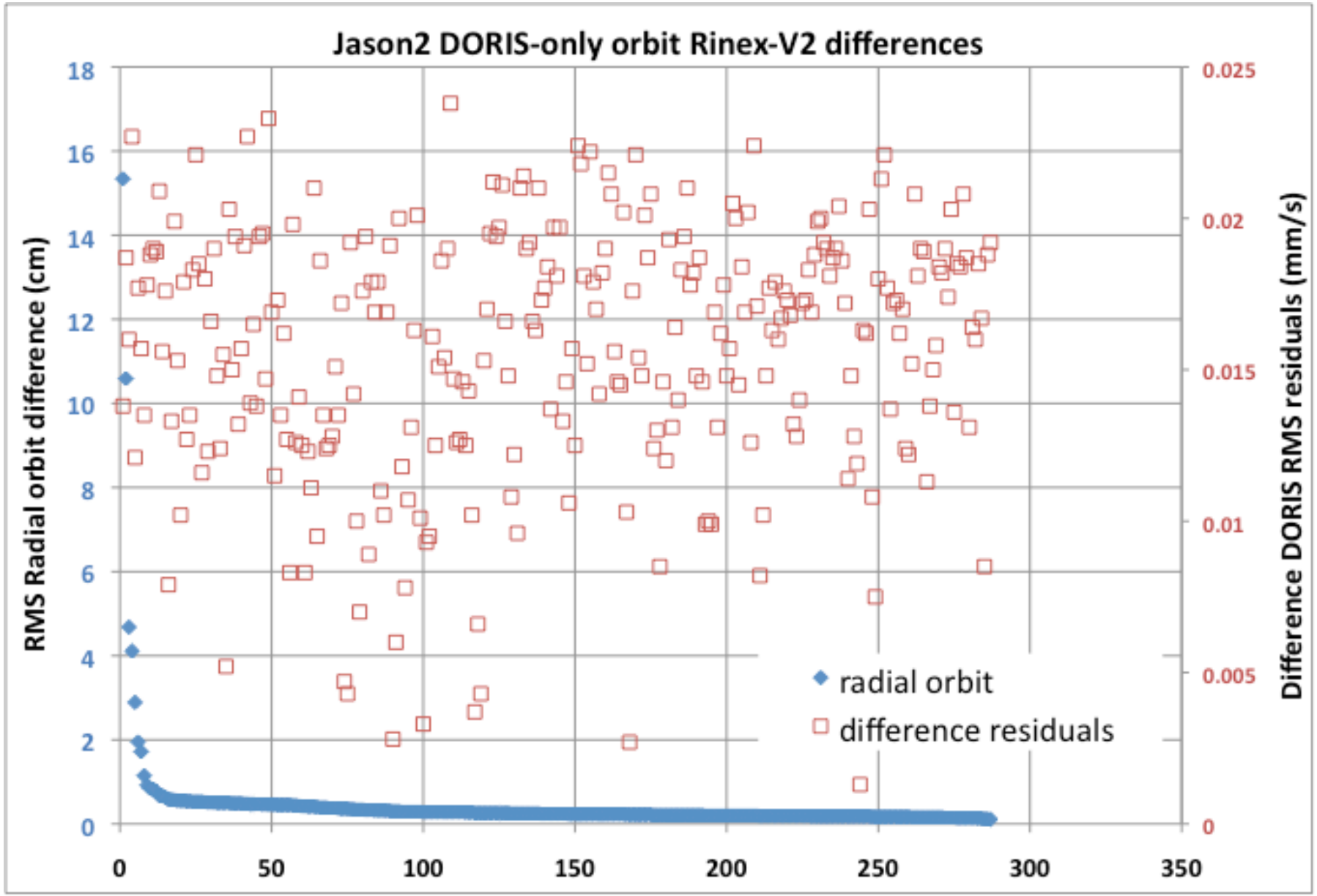

Jason2 DORIS points per arc
300000
250000
200000
150000
100000
50000
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
V2
Rinex

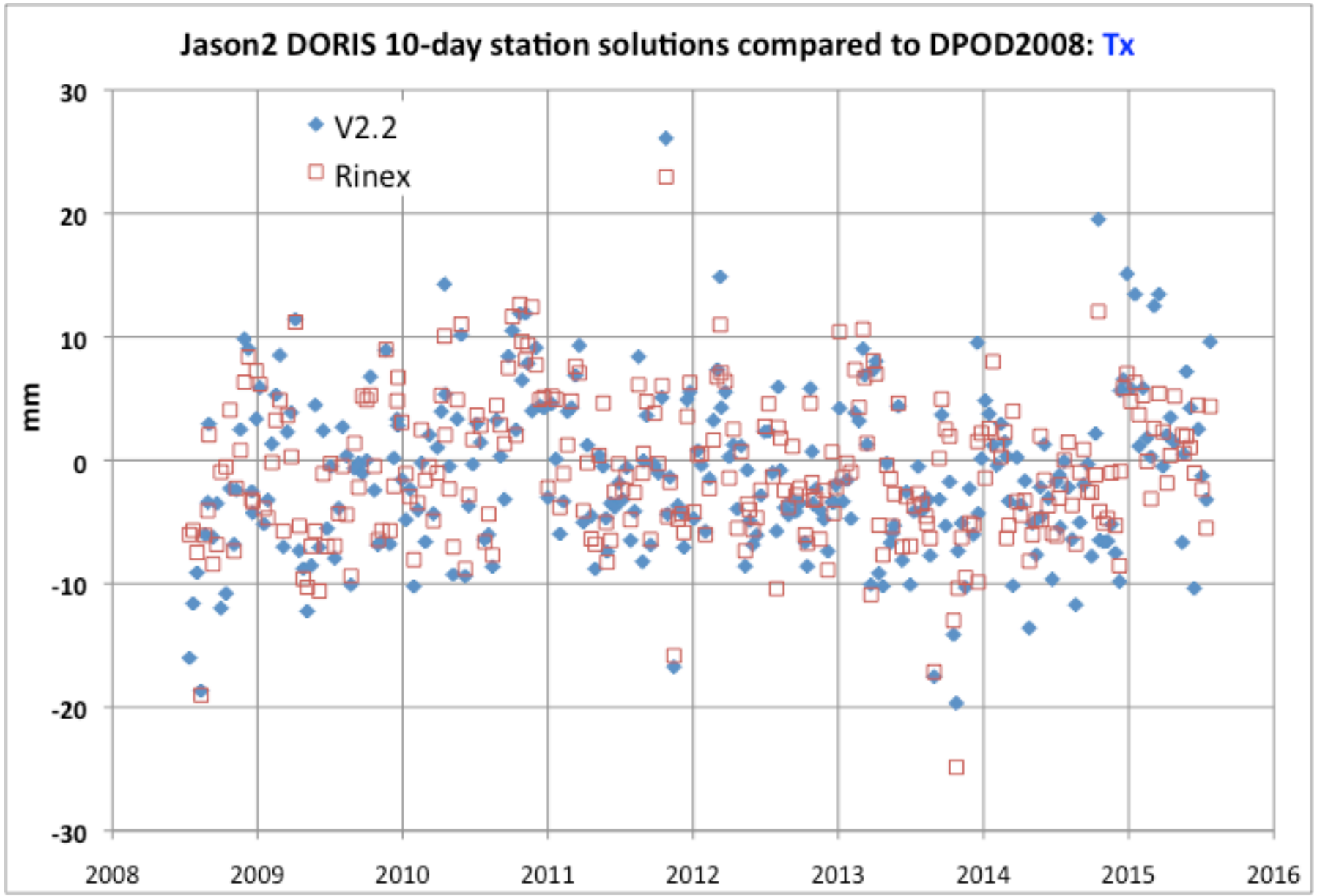

Jason2 DORIS edited points per arc
250000
200000
150000
100000
50000
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
V2
Rinex

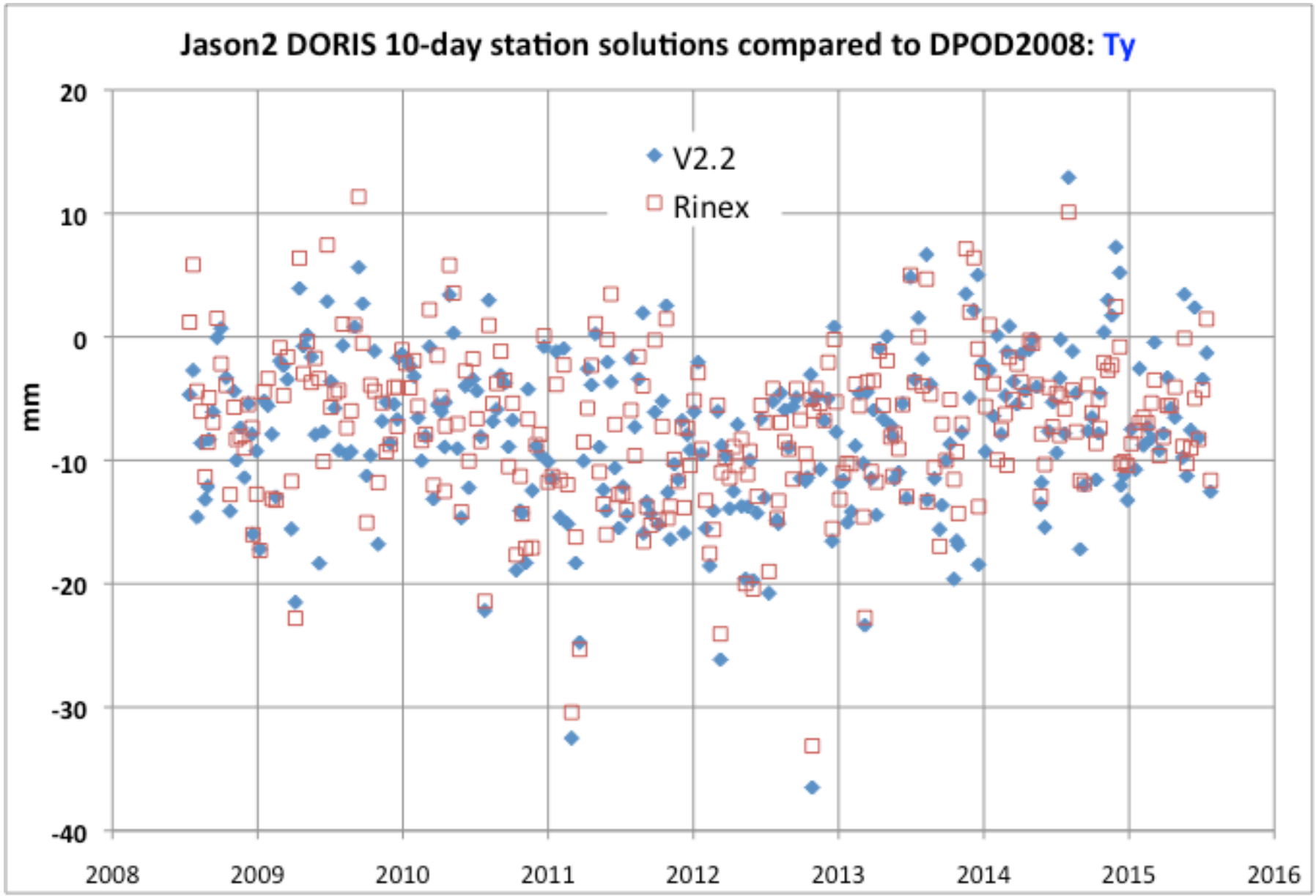

Jason2 DORIS-only Rinex-V2 orbit differences
RMS radial
Mean Z
RMS Radial orbit difference (cm)
Mean Z (cm)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
4
3
2
1
0
-1
-2
-3
-4
2008
2009
2010
2011
2012
2013
2014
2015
2016

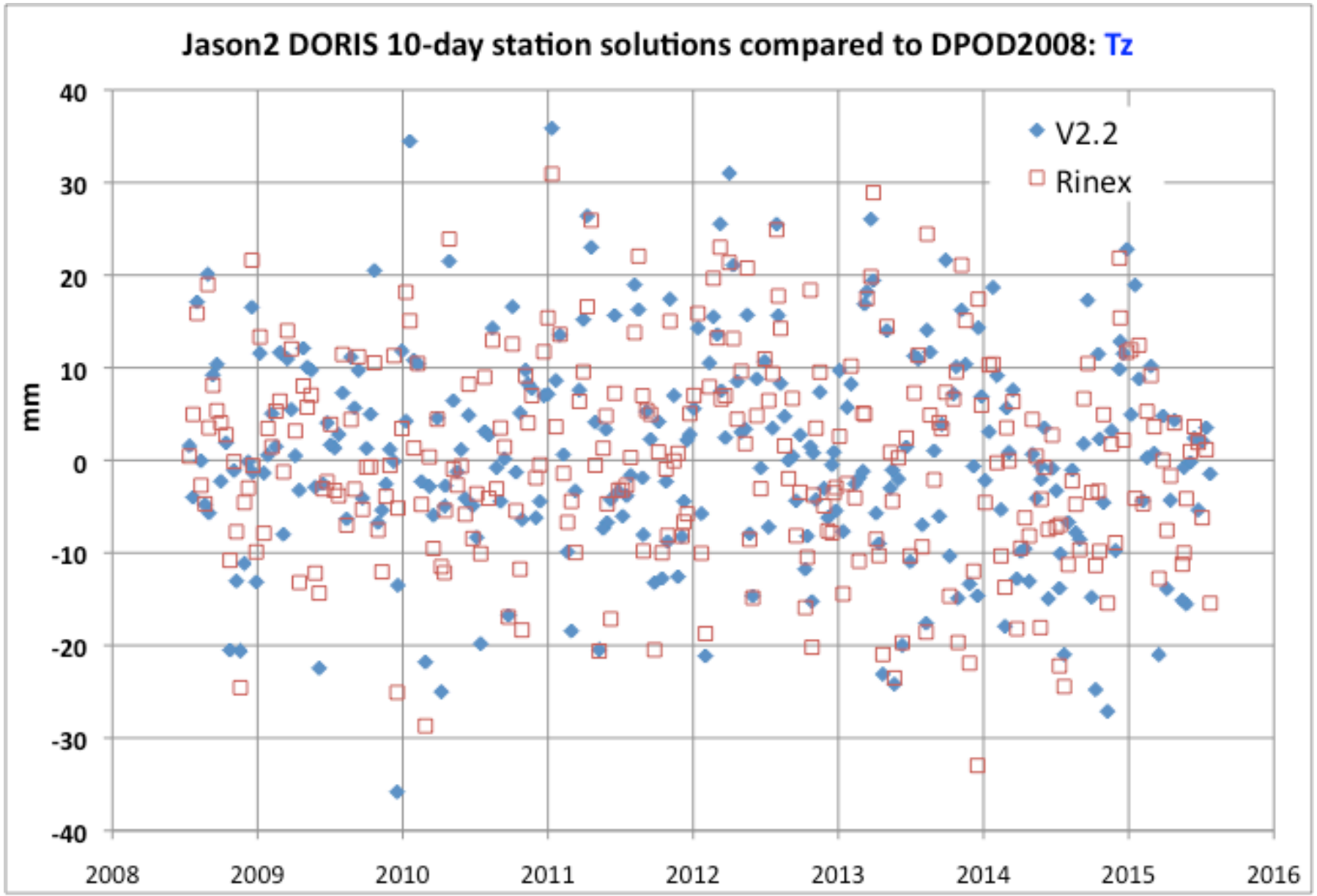

Jason2 DORIS-only orbit independant SLR residuals
V2
Rinex
cm
4
3.5
3
2.5
2
1.5
1
0.5
2008
2009
2010
2011
2012
2013
2014
2015
2016

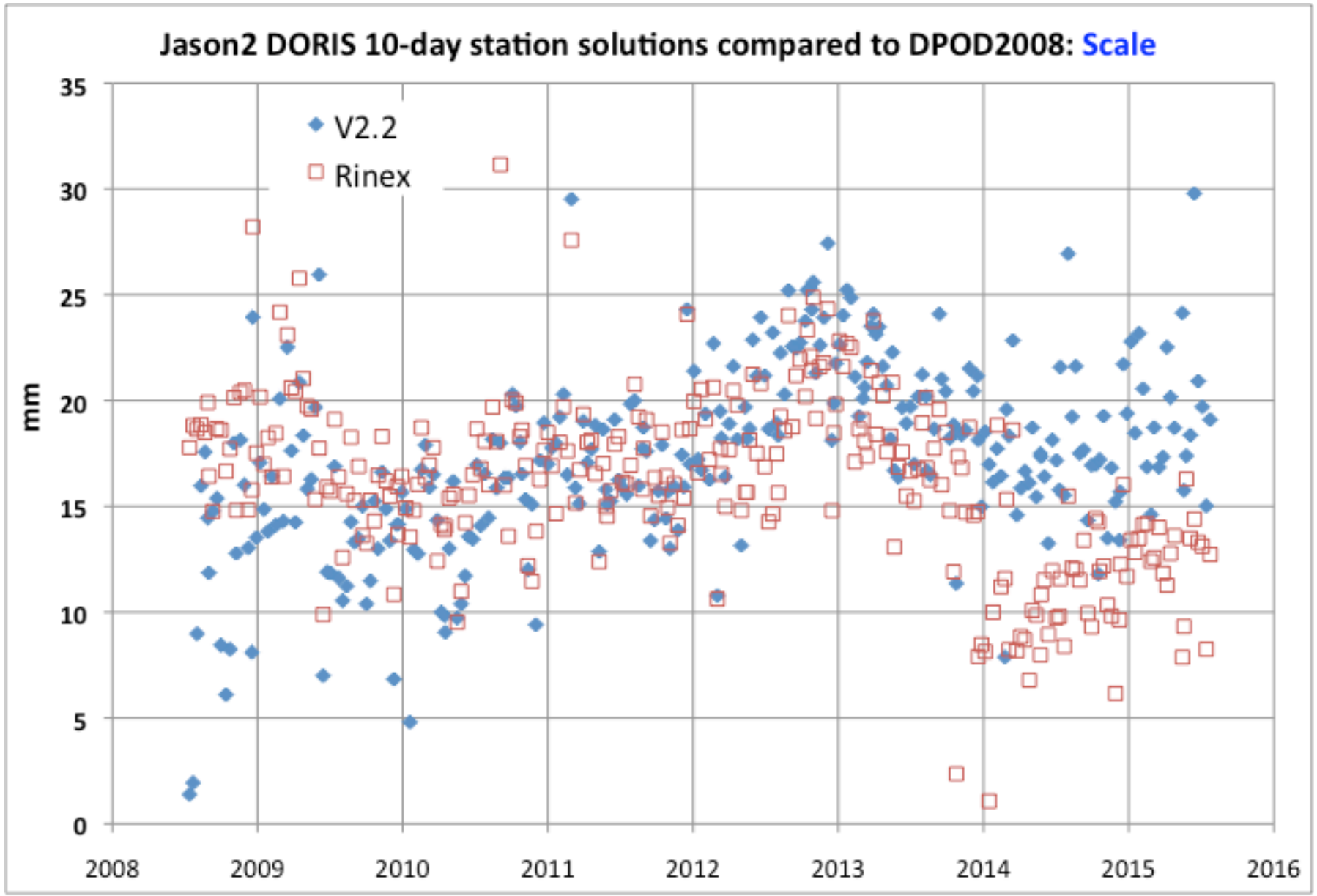
A few cases where Rinex DORIS converges to degraded orbits

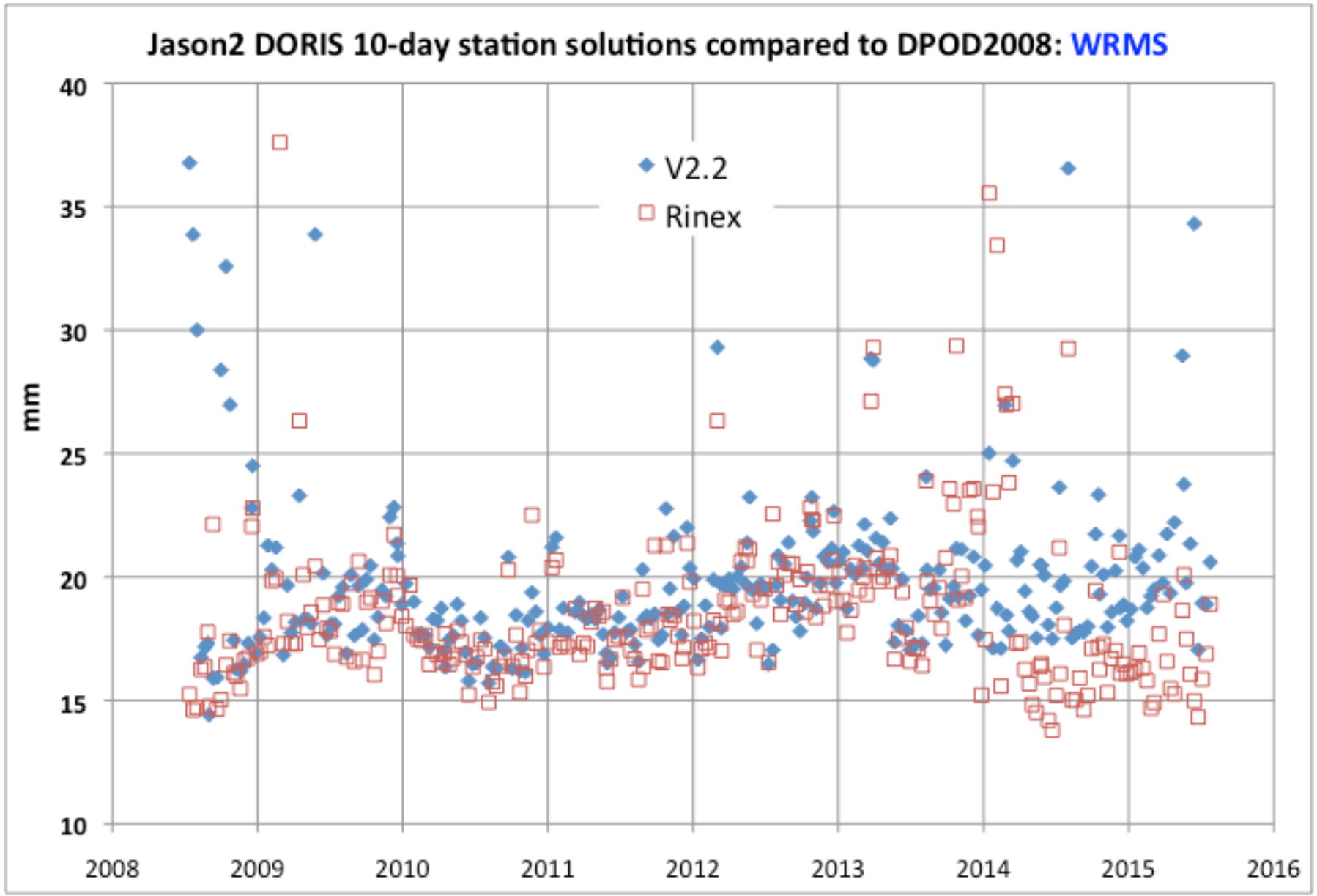



Jason2 DORIS 10-day station solutions compared to DPOD2008: Tx
V2.2
Rinex
mm
30
20
10
0
-10
-20
-30
2008
2009
2010
2011
2012
2013
2014
2015
2016


Jason2 DORIS 10-day station solutions compared to DPOD2008: Ty
V2.2
Rinex
mm
20
10
0
-10
-20
-30
-40
2008
2009
2010
2011
2012
2013
2014
2015
2016


Jason2 DORIS 10-day station solutions compared to DPOD2008: Tz
V2.2
Rinex
mm
40
30
20
10
0
-10
-20
-30
-40
2008
2009
2010
2011
2012
2013
2014
2015
2016


Jason2 DORIS 10-day station solutions compared to DPOD2008: Scale
V2.2
Rinex
mm
35
30
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016


Jason2 DORIS 10-day station solutions compared to DPOD2008: WRMS
V2.2
Rinex
mm
40
35
30
25
20
15
10
2008
2009
2010
2011
2012
2013
2014
2015
2016

Summary

1) Jason2 Rinex DORIS converted to range-rate and compared to V2.2 data processing over cycles 1-260.

2) Overall V2.2 /Rinex data POD processing compares as follows:

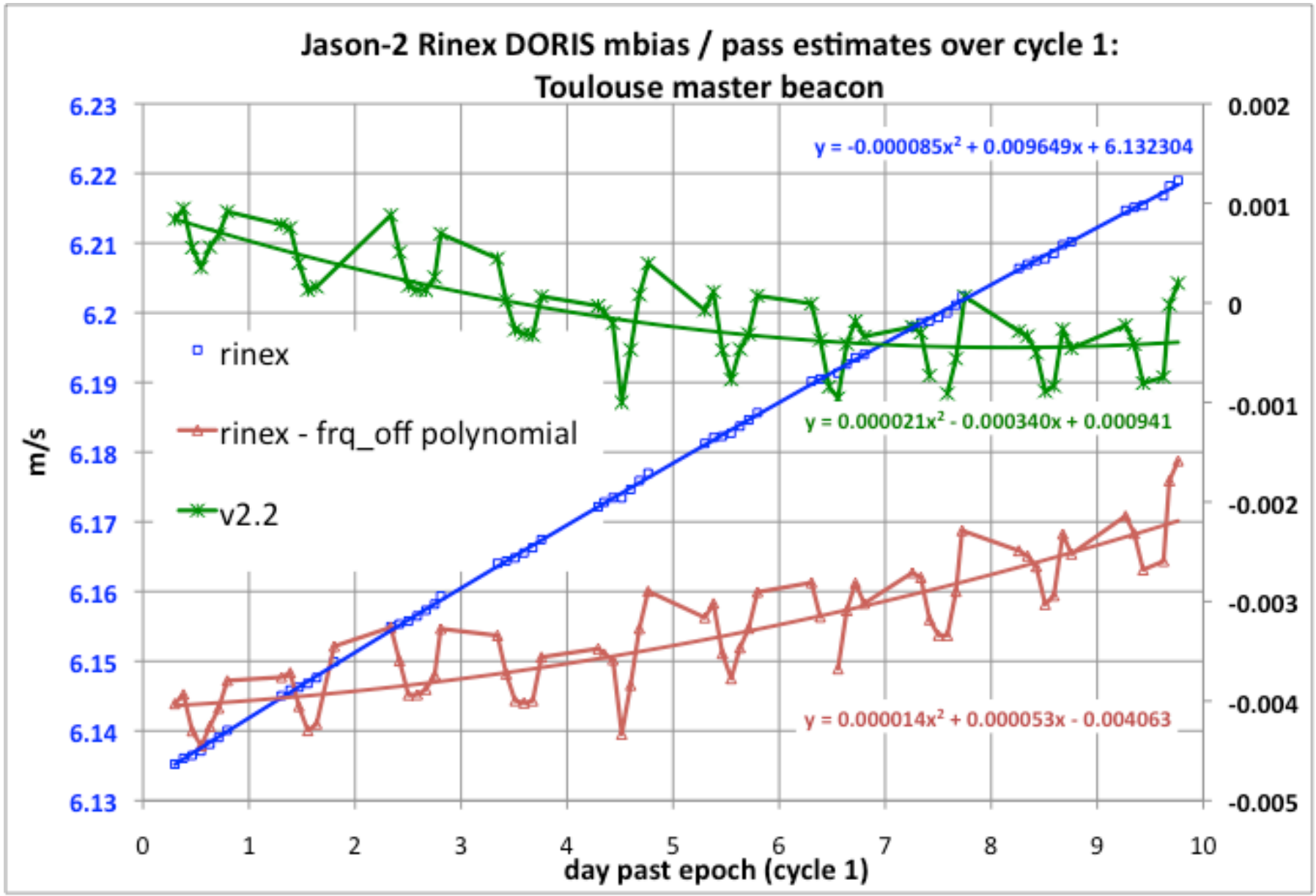
DORIS data	average points used	rms residuals mm/s	radial cm	cross-trk cm	along-trk cm
V2.2	152883	0.3803	---	---	---
Rinex	149142	0.3959	0.43	1.88	2.39

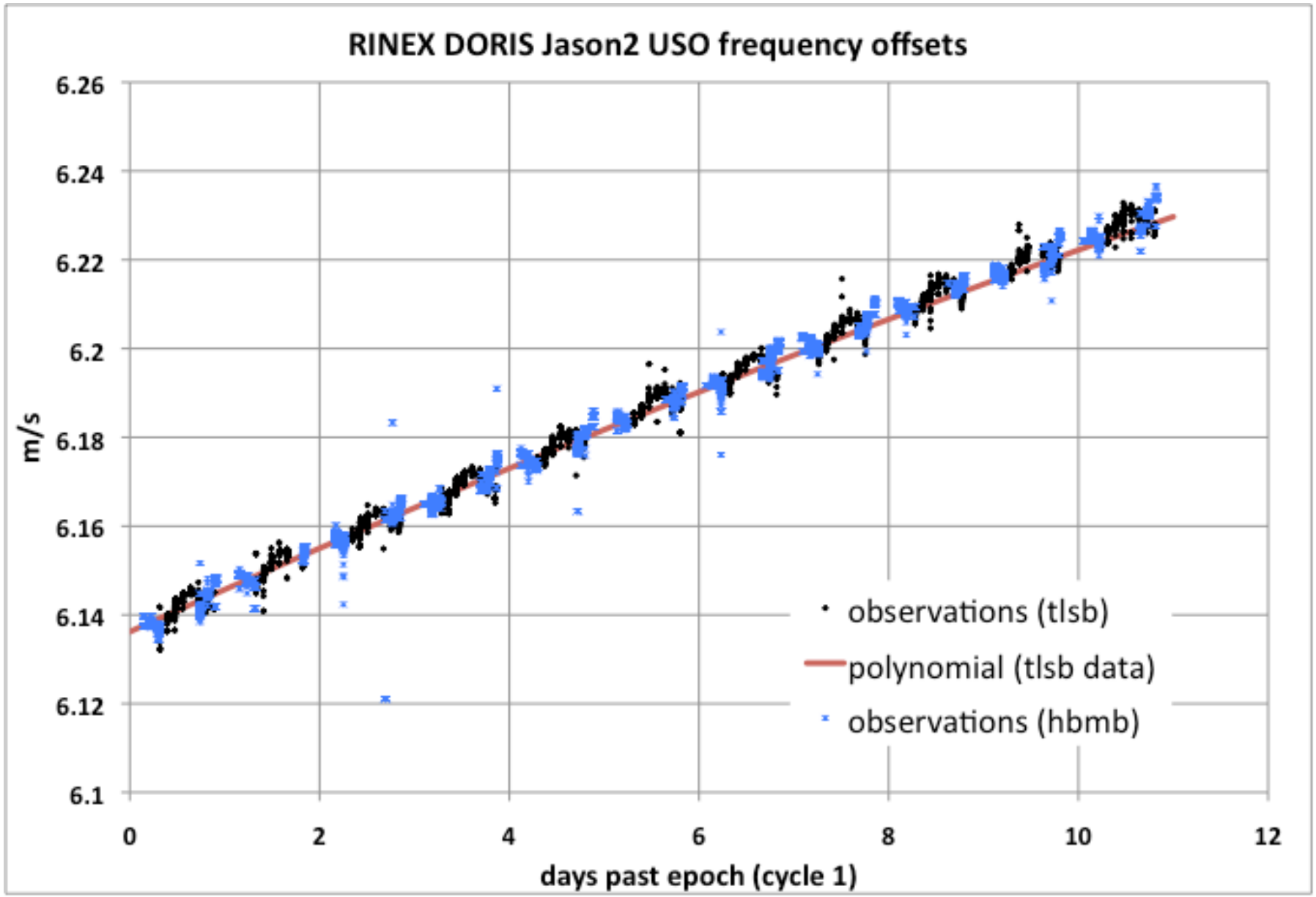
3) However there are two major problems:

   1) Isolated Rinex arcs can converge to degraded orbit solutions yet show normal DORIS residuals

   2) Rinex v10 data (from 2015) shows degraded POD

BACKUP


Jason-2 Rinex DORIS mbias / pass estimates over cycle 1:
Toulouse master beacon
y = -0.000085x² + 0.009649x + 6.132304
y = 0.000021x² - 0.000340x + 0.000941
y = 0.000014x² + 0.000053x - 0.004063
rinex
rinex - frq_off polynomial
v2.2
m/s
day past epoch (cycle 1)
6.23
6.22
6.21
6.2
6.19
6.18
6.17
6.16
6.15
6.14
6.13
0.002
0.001
0
-0.001
-0.002
-0.003
-0.004
-0.005
0
1
2
3
4
5
6
7
8
9
10


RINEX DORIS Jason2 USO frequency offsets
6.26
6.24
6.22
6.2
6.18
6.16
6.14
6.12
6.1
m/s
0
2
4
6
8
10
12
days past epoch (cycle 1)
observations (tlsb)
polynomial (tlsb data)
observations (hbmb)