Status DORIS Rinex Processing at GSFC

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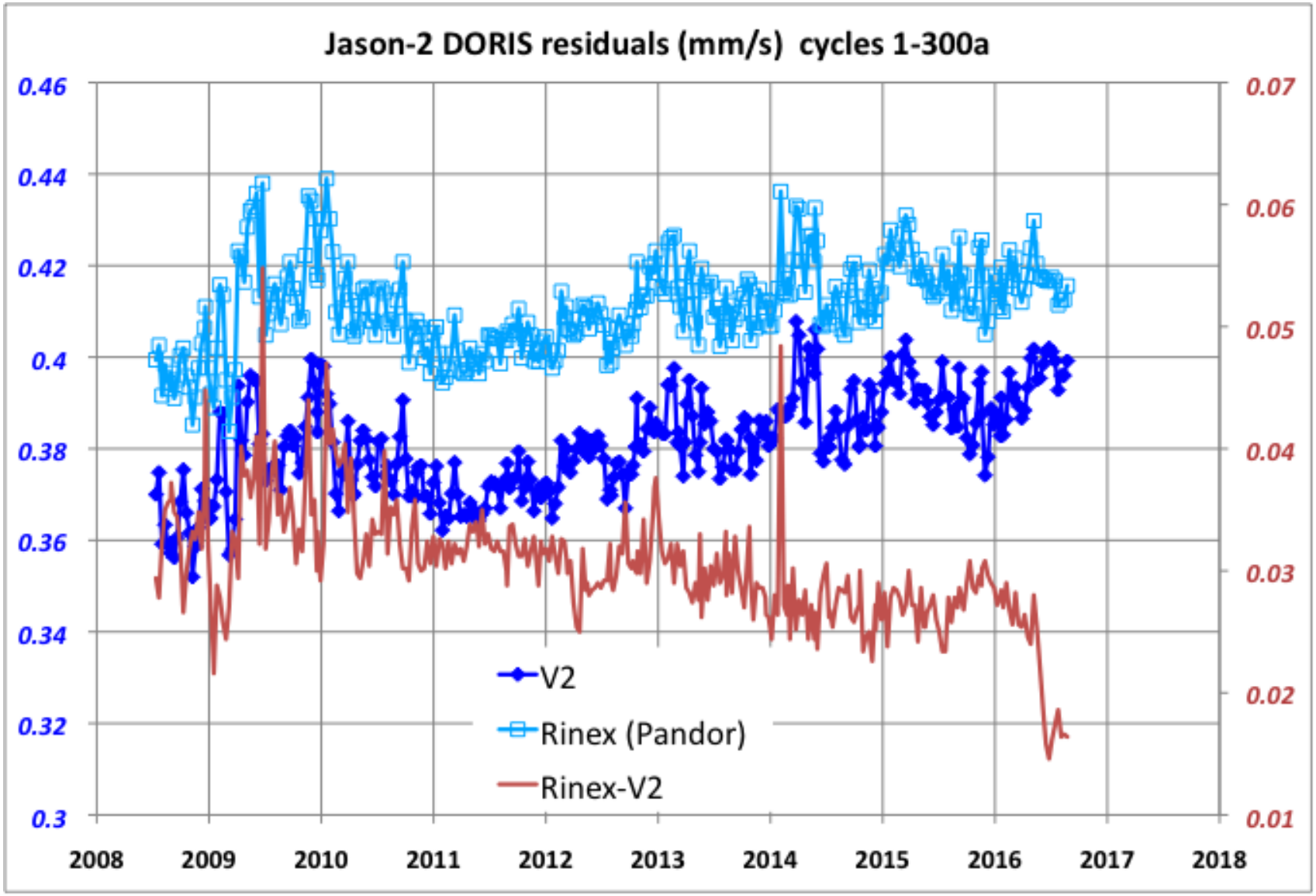
Outline

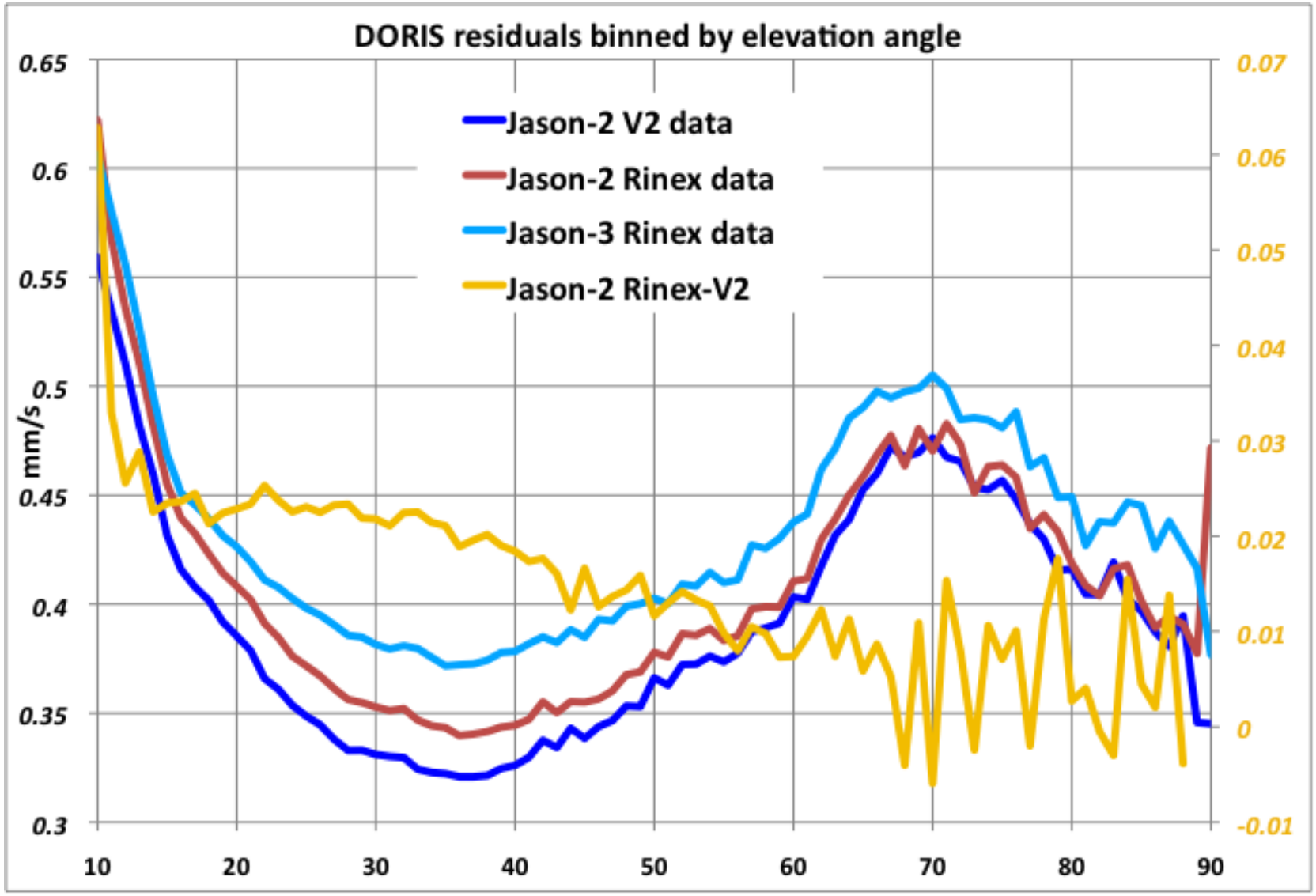
- Status Preliminary DORIS Rinex (Pandor) Processing (CDDIS import)
  - Jason-2 (to Sep 2016)
  - Jason-3 (to Sep 2016, operational)
  - SARAL (to Jan 2016)
  - Crysosat-2 (to Jan 2016)
  - HY2A (to Jan 2016)

- Improvements to DORIS Rinex Processing
  - Jason-2 Belli USO frequency correction tests
  - Relativity (included in operational processing)

Jason-2 DORIS Residuals (mm/s)
080712-160831 (cycles 1-300a)



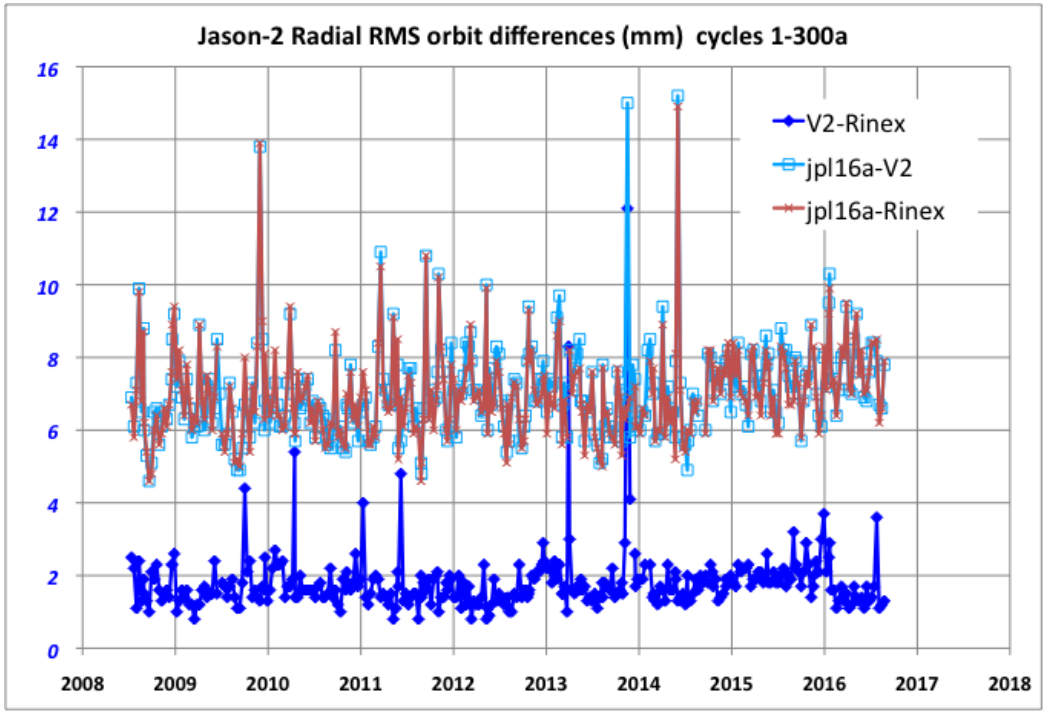
DORIS residuals binned by elevation angle
(Jason2 - Jason3 Inter-comparison Period)



Jason-2 GSFC std1504-based orbit performance 080712-160831 (cycles 1-300a)

Test SLR+DORIS orbits	DORIS points	SLR points	DORIS RMS (mm/s)	SLR RMS (cm)	Xover * RMS (cm)
std1504	162513	4109	0.3810	0.877	5.325
std1504_rx (DORIS Rinex)	171739	4210	0.4113	0.901	5.322

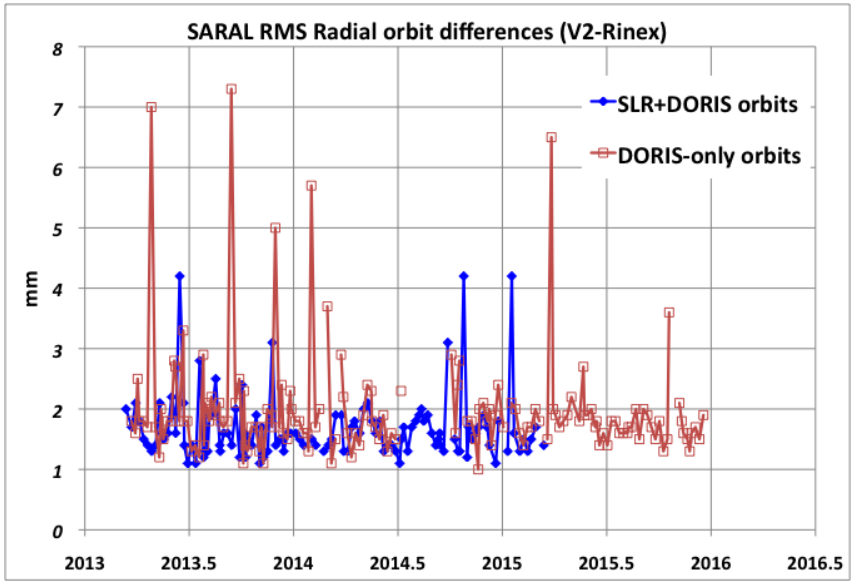
* independent altimeter GDR data cycles 1-297



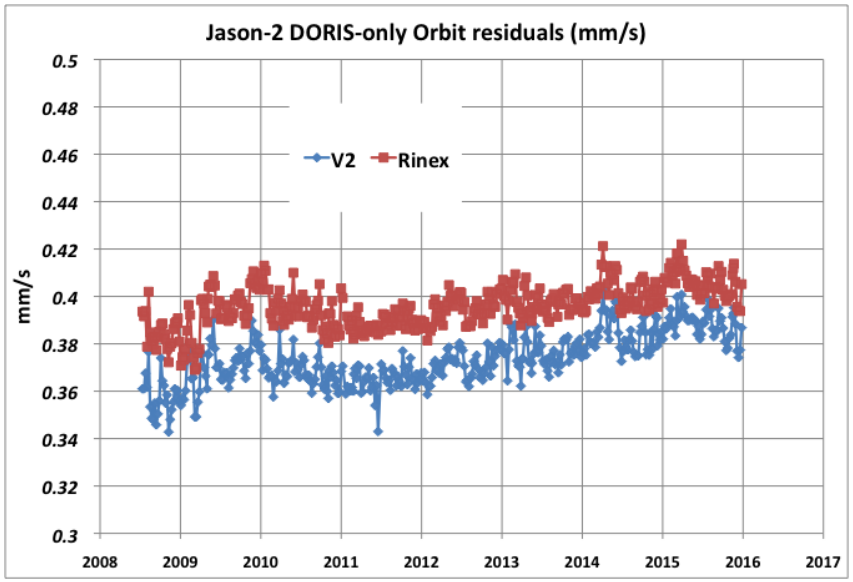
SARAL std1504-based orbit performance

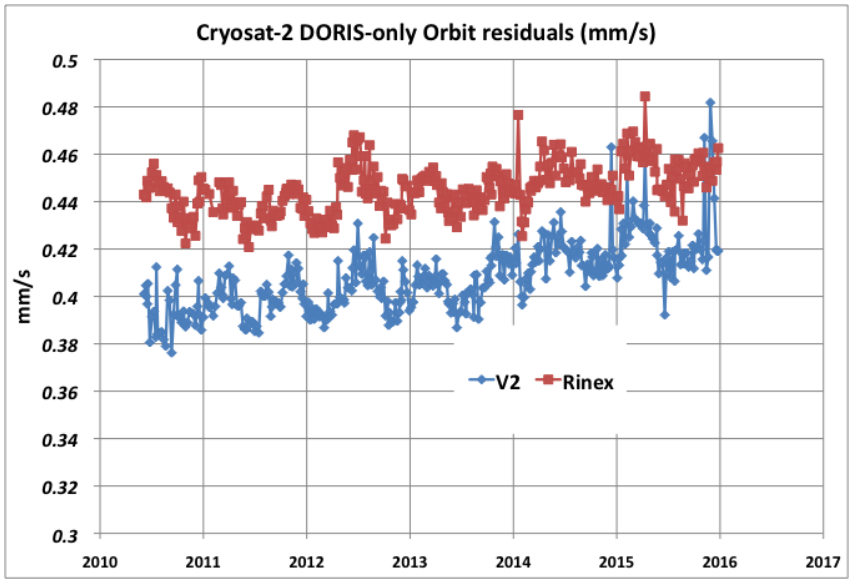
Test SLR+DORIS orbits (130314-150327)	DORIS points	SLR points	DORIS RMS (mm/s)	SLR RMS (cm)	Xover * RMS (cm)
std1504	75120	1063	0.4191	1.517	5.562
std1504_rx (DORIS Rinex)	72086	1063	0.4492	1.571	5.658

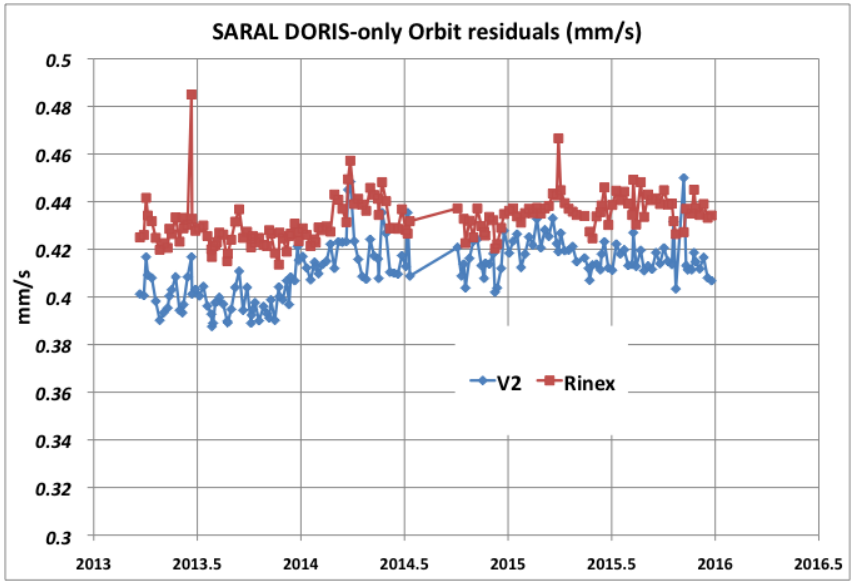
* independent altimeter GDR data 131117- 140809

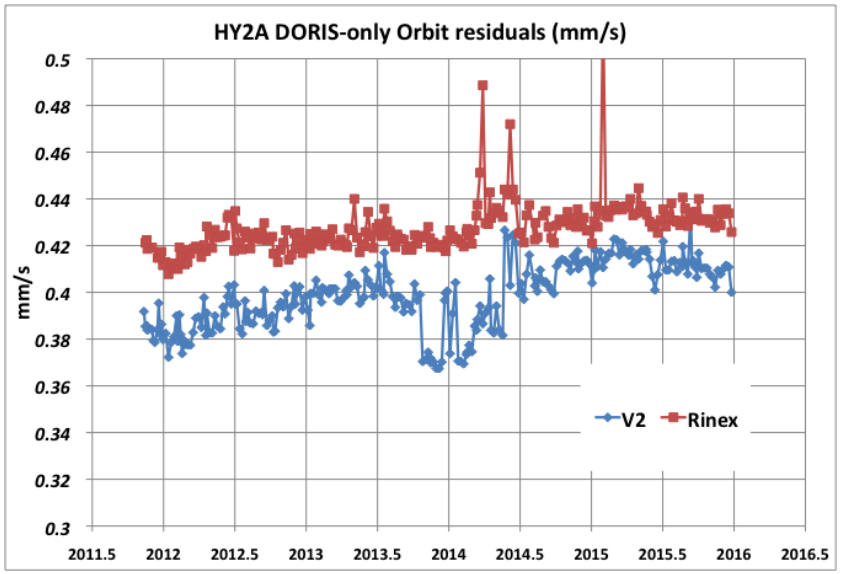


WD25 DORIS-only V2 / Rinex Residuals (mm/s)

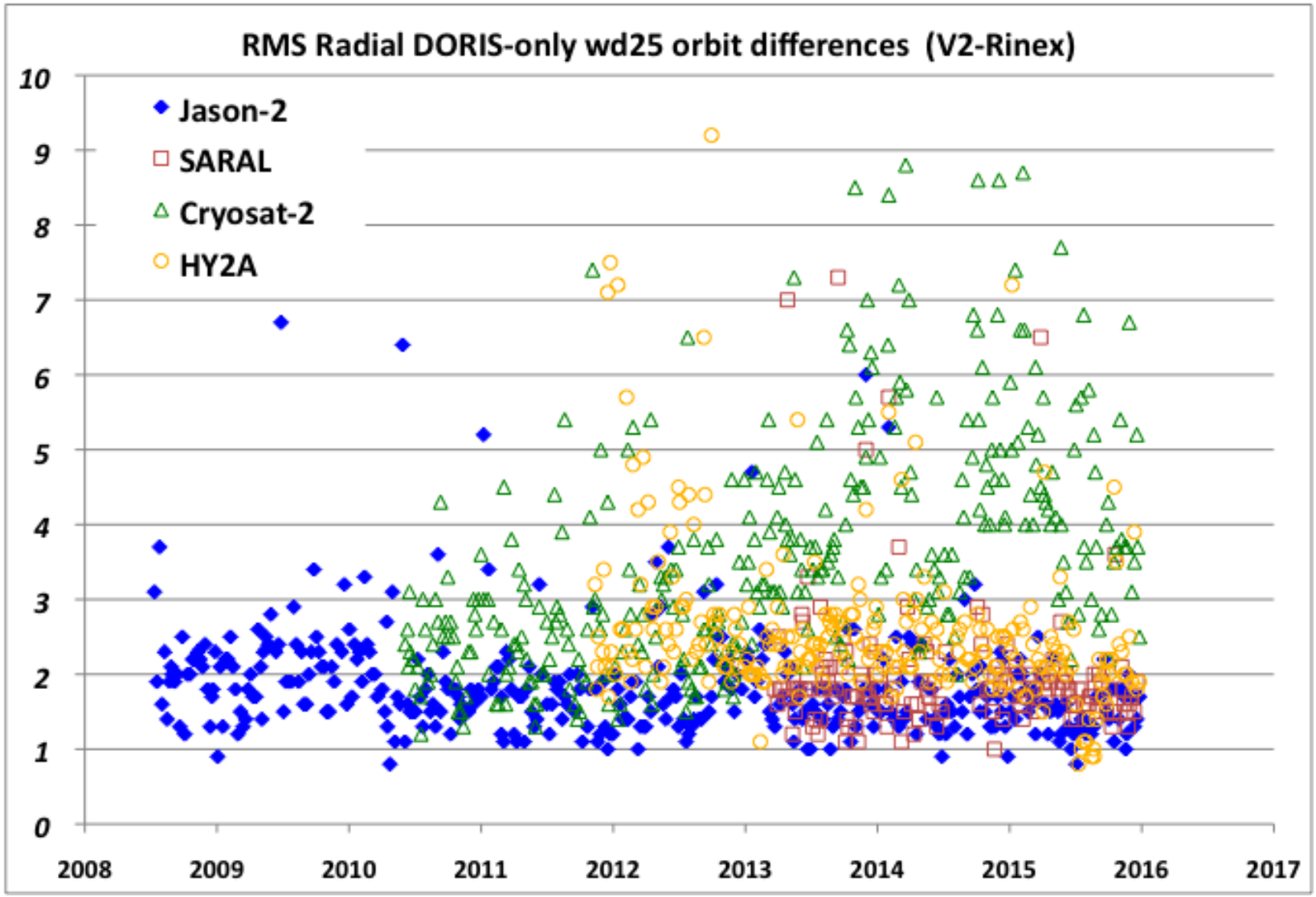








WD25 DORIS-only (V2 – Rinex) Radial orbit differences (mm)



WD25 DORIS-only V2 / Rinex orbit POD Summary

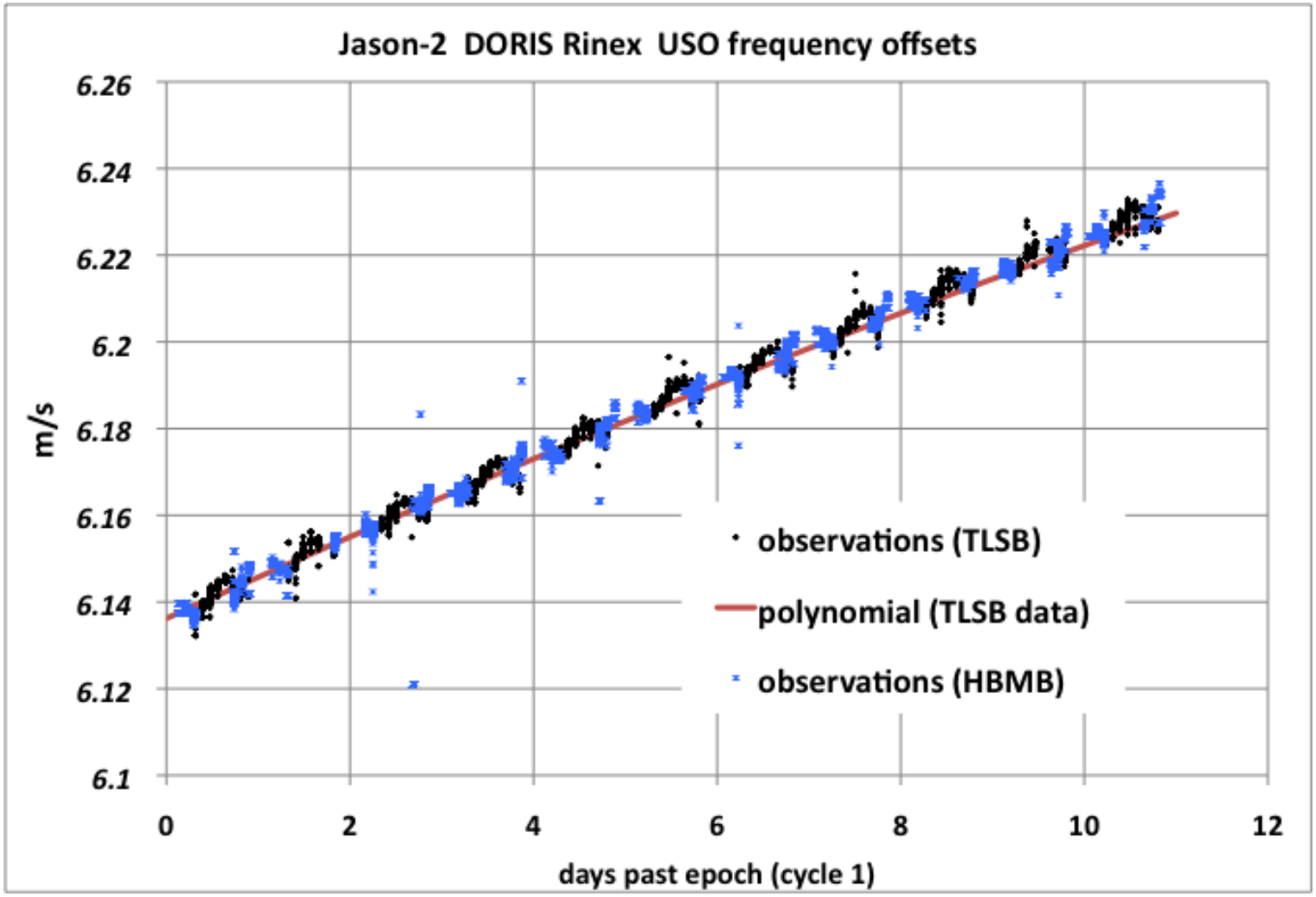
Satellite	DORIS data	points	Residual RMS (mm/s)	Radial RMS* difference (mm)
Jason-2 080713-160103	V2	113350	0.3736	1.8
	Rinex	121945	0.3960	
SARAL 130324-160103	V2	57246	0.4114	2.0
	Rinex	57141	0.4326	
Cryosat-2 100606-160103	V2	50240	0.4080	3.6
	Rinex	50387	0.4452	
HY2A 111107-160103	V2	66930	0.3986	2.6
	Rinex	68751	0.4271	

* orbit difference outliers removed

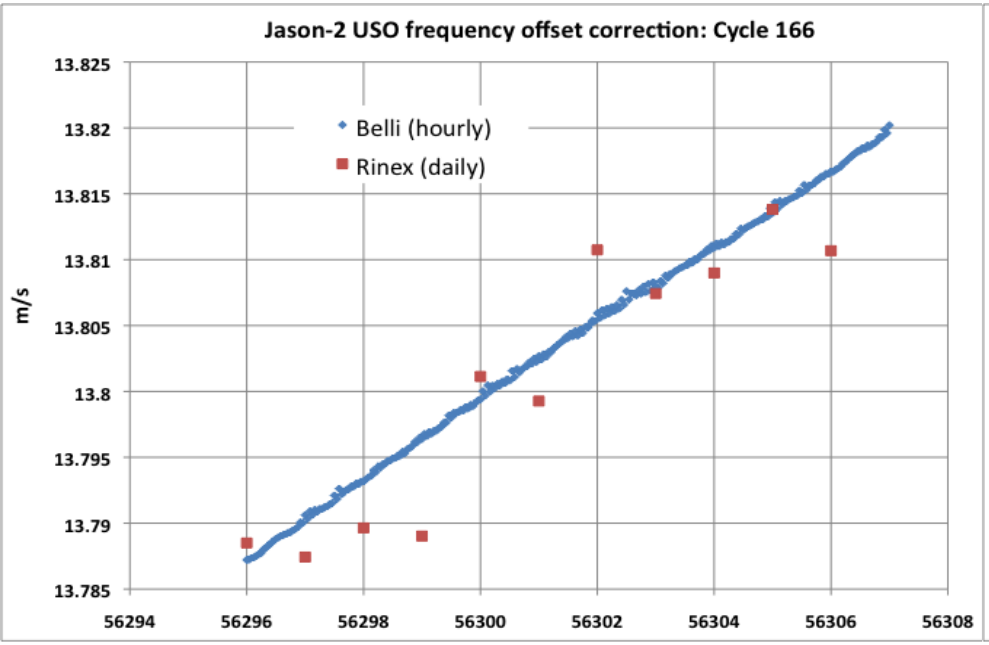
Improvements to DORIS Rinex Processing

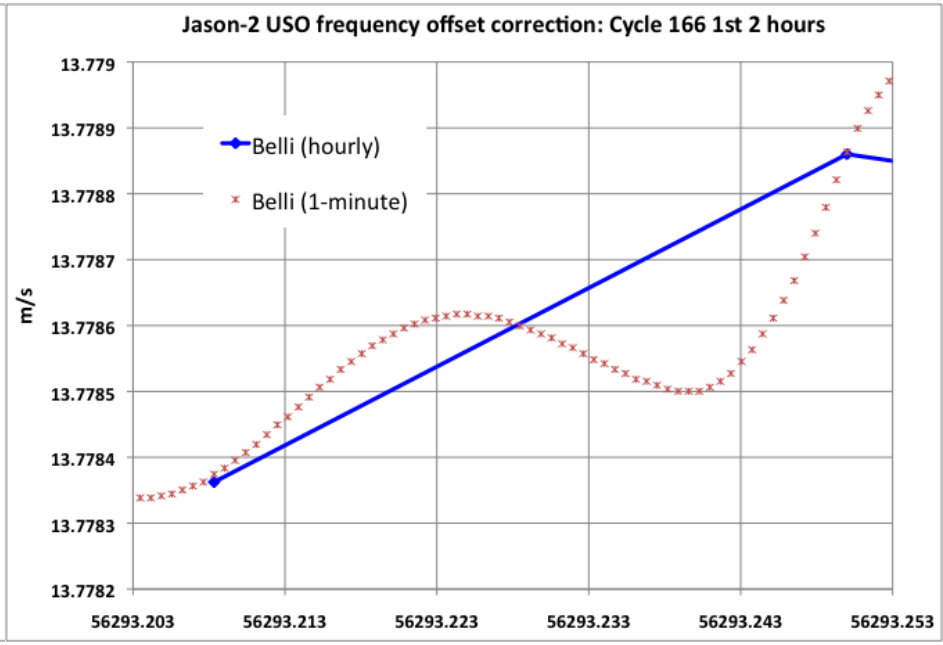
$\Delta_{\text{satellite USO frequency}}$: 2nd order polynomial fit

Rinex frequency offset estimates include satellite clock error and Relativistic bias/drift

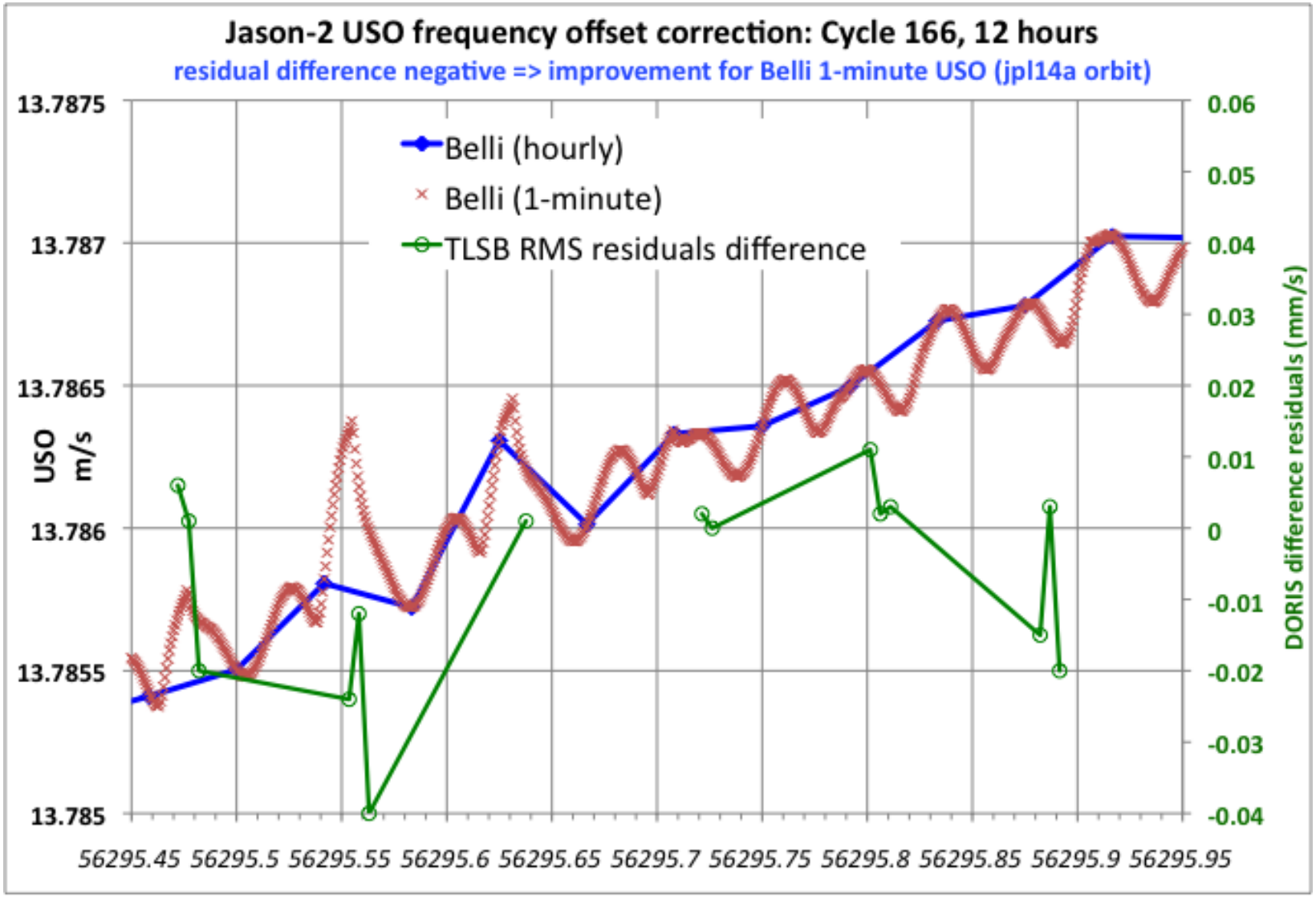


Using T2L2 A. Belli (ASR 2015) has computed USO frequency offset corrections for Jason-2 available on the Internet in hourly and minute series

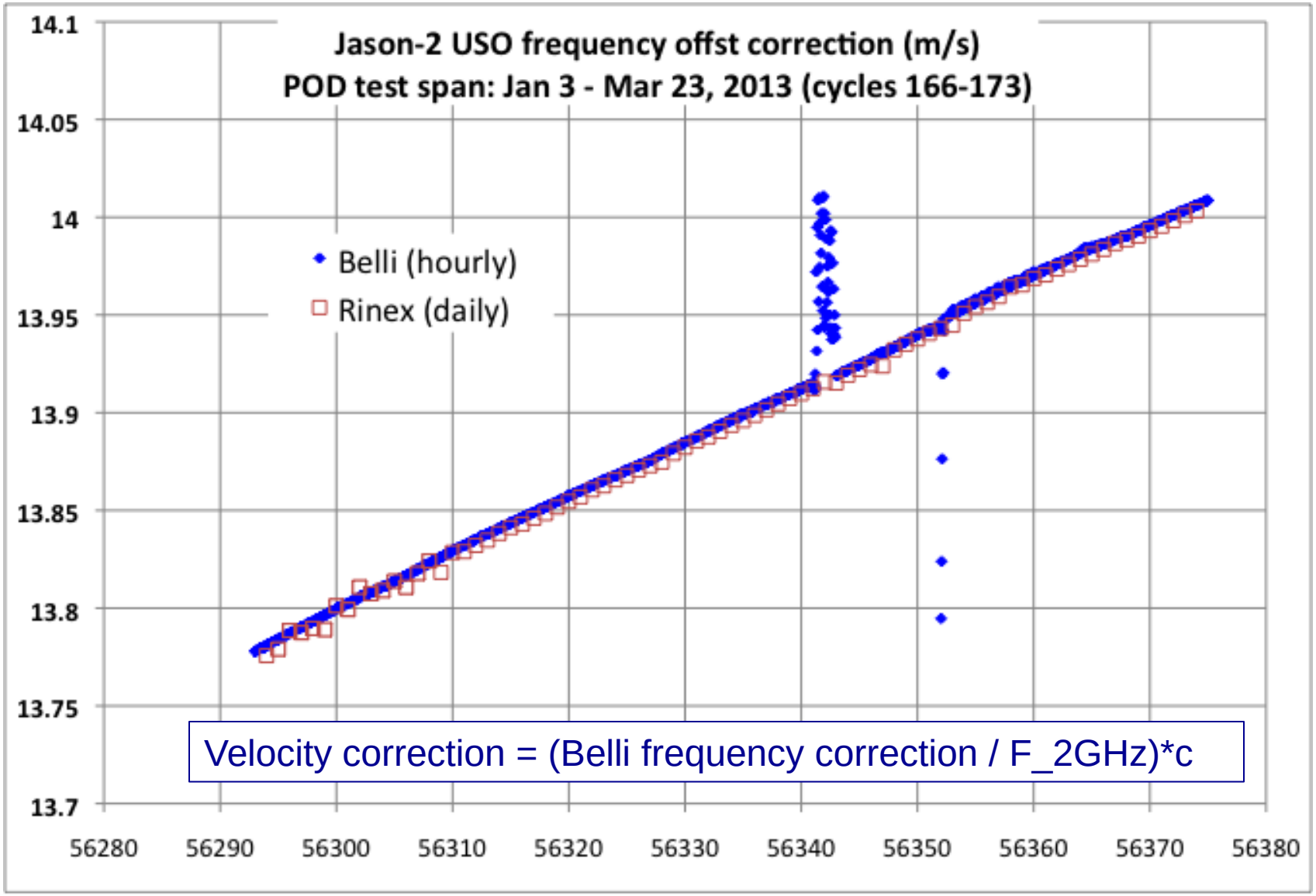




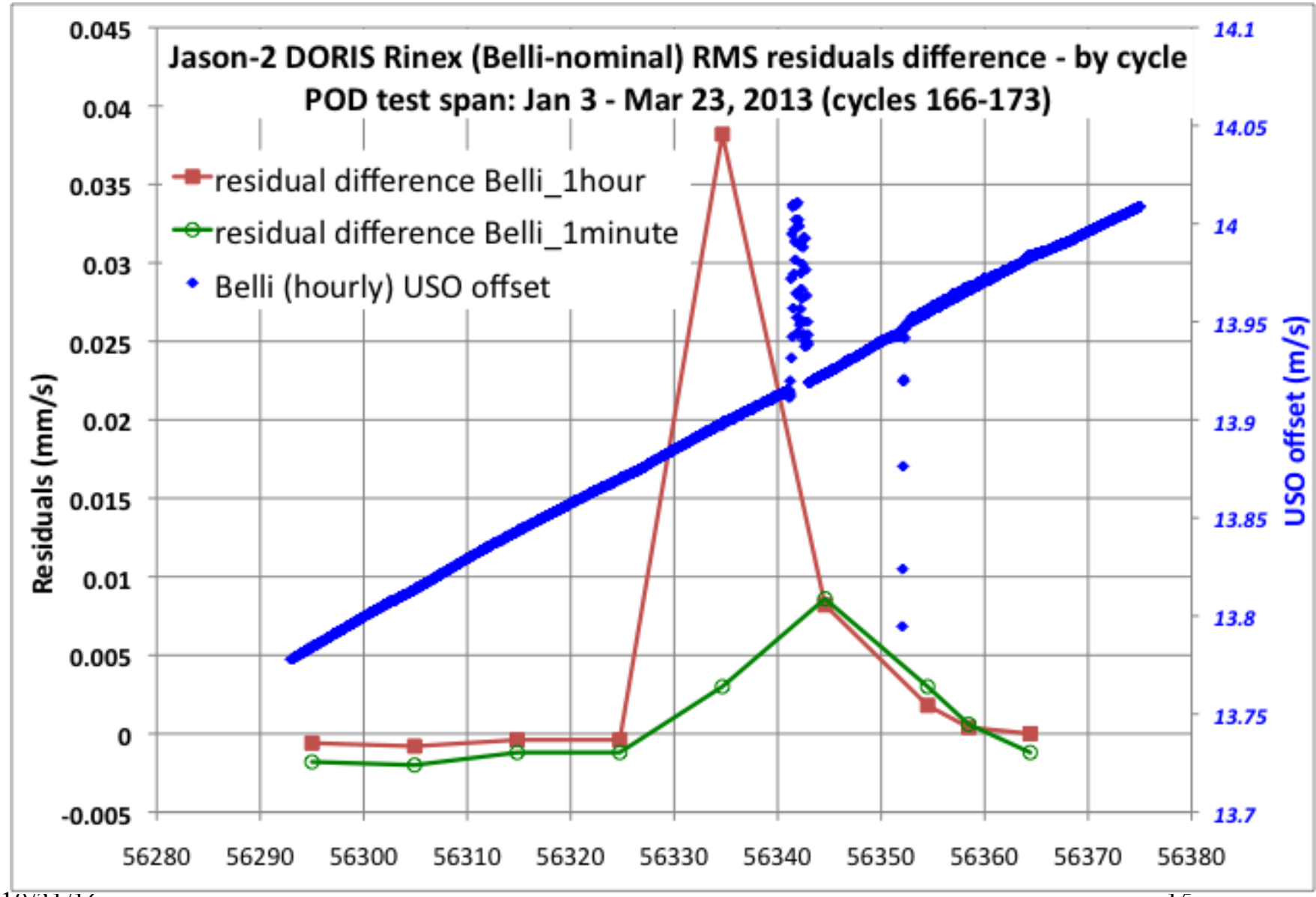
External JPL GPS orbit (jpl14a) indicates the Belli minute series offers an improvement over the hourly



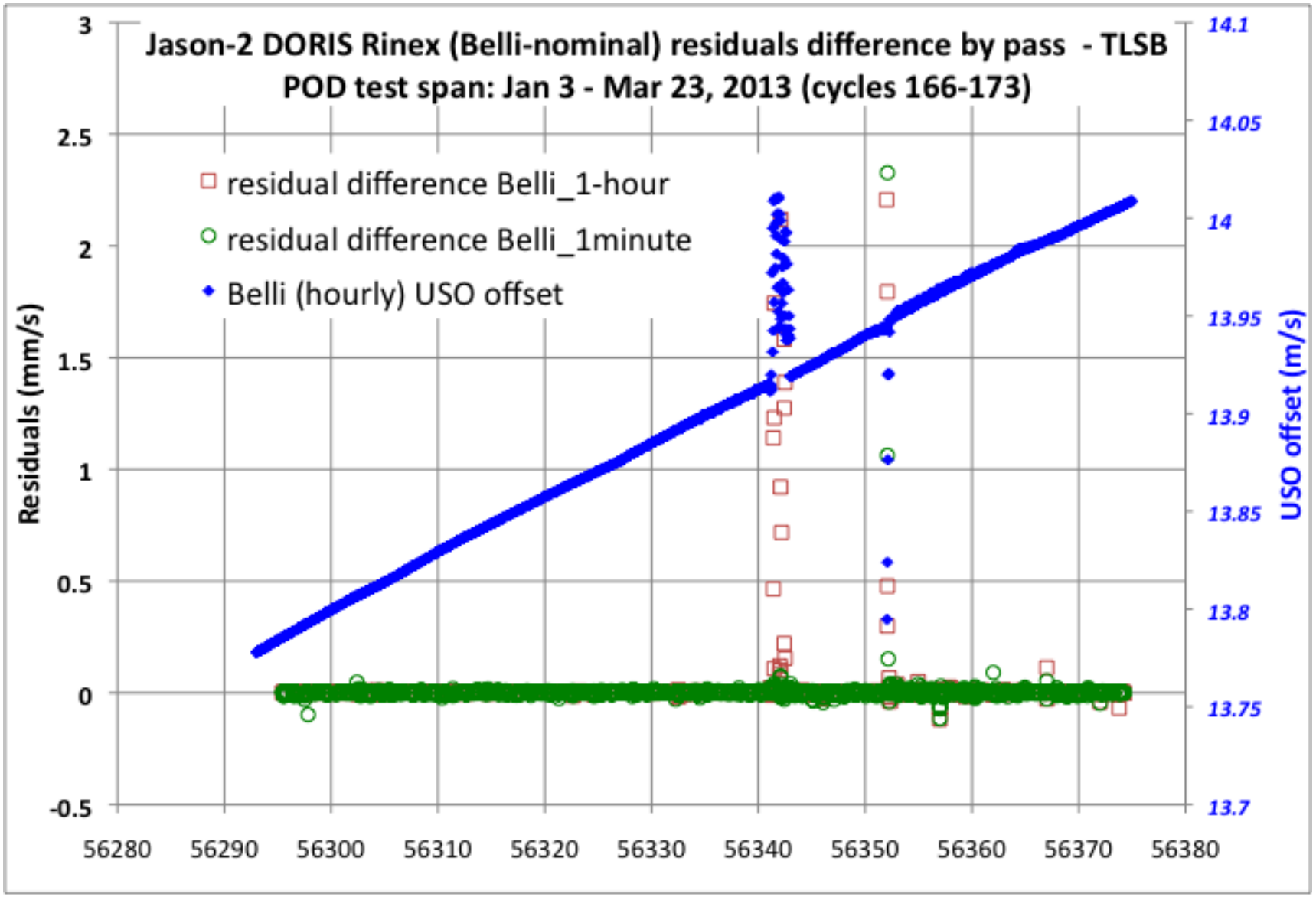
POD Test Span: Jan 3 -Mar 23, 2013



POD Performance: Belli -vs- Rinex USO corr. negative residuals => improvement for Belli



POD Degradation over periods with excursions in the Belli corrections: Toulouse residuals by pass



DORIS range-rate Relativity correction for satellite clock – only periodic terms required

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

(JM Lemoine et al., 2015)

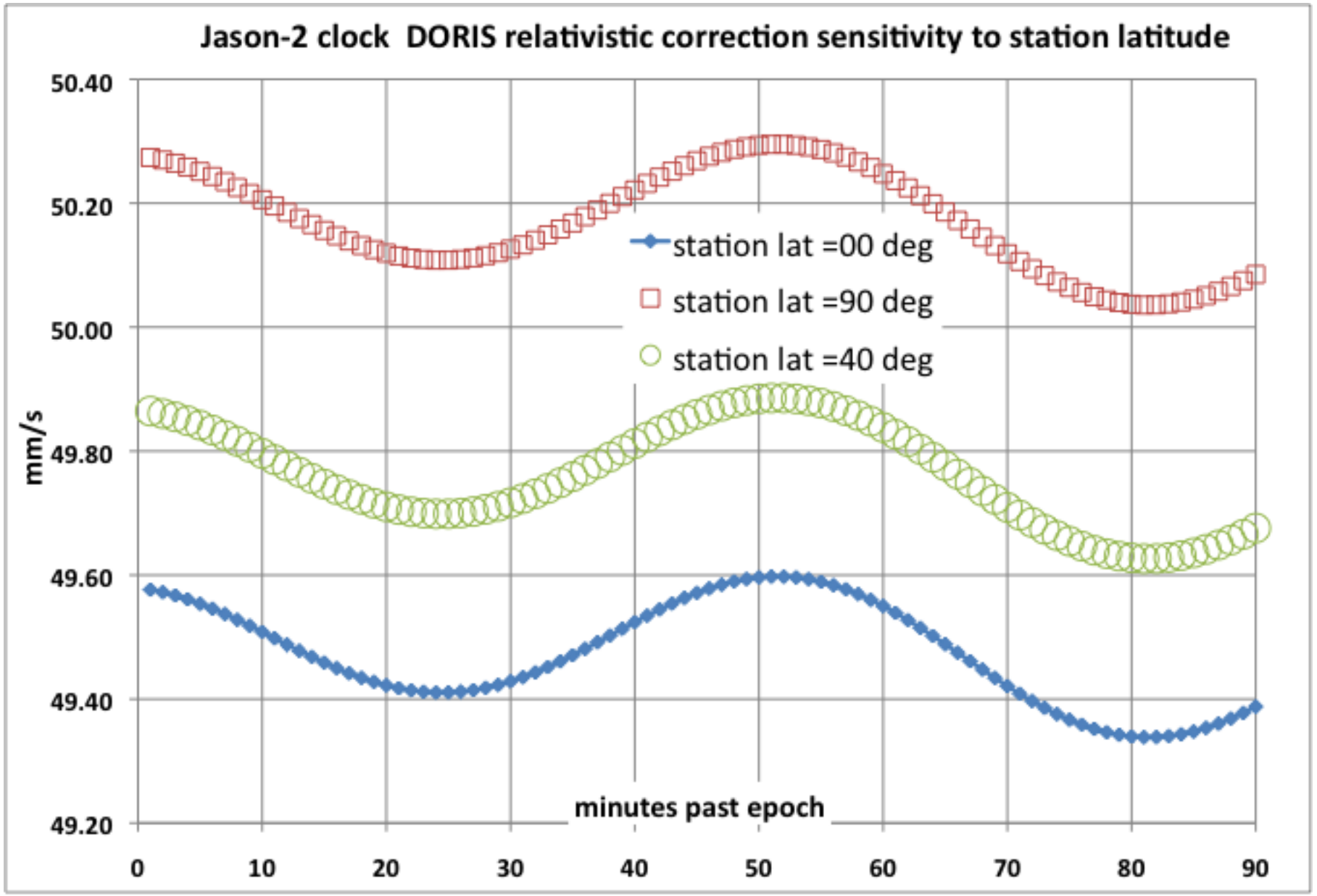
$$U = \frac{GM}{r}\left(1 - \left(\frac{a_e}{r}\right)^2 J_2 \frac{3\sin^2(\varphi) - 1}{2}\right)$$

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

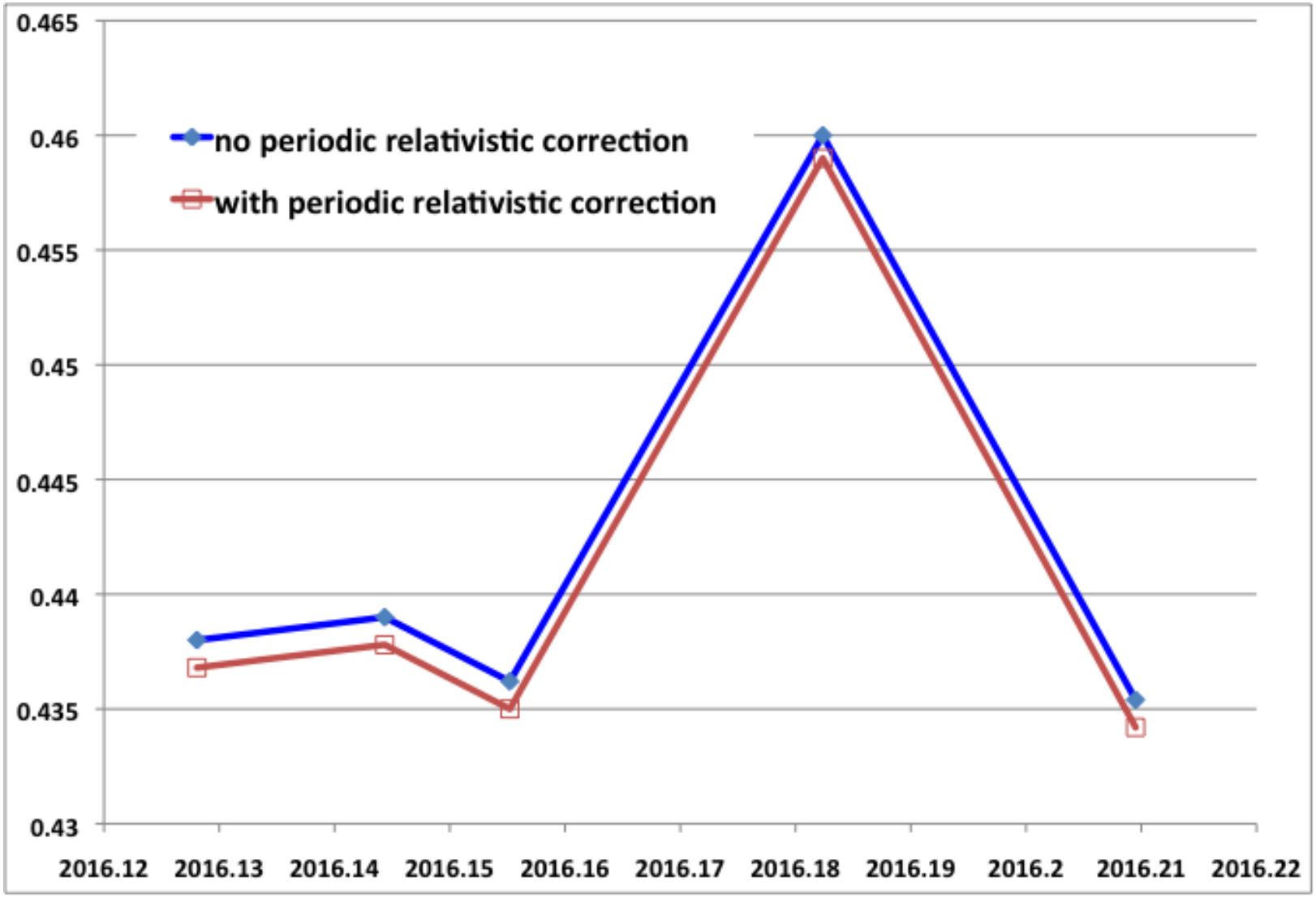
For correction to RINEX data:

1) use 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) periodic terms obtained upon removing an estimated offset+rate from the total relativity correction.

Relativity periodic terms are due only to the satellite and will be identical for any ground station



Jason-3 Rinex DORIS Residuals (mm/s) with / without Periodic Relativistic Corrections



Conclusions

a) Preliminary orbit solutions computed for Jason-2, SARAL, Cryosat-2, HY2A using DORIS Rinex and V2 data. Jason-3 Rinex POD operational.

b) Jason-2 SLR+DORIS orbits using either V2 or Rinex are comparable in accuracy; the SARAL Rinex orbits may be slightly less accurate.

c) Rinex POD appears less stable than V2 – data editing? Including SLR improves stability.

d) The Belli Jason-2 USO corrections improve Rinex POD, but correction estimates must be edited.

e) Periodic relativity terms improve Rinex residuals

BACKUP

Range Rate from DORIS Rinex phase and corrections to observed measurement

$$\text{rrate}(T^c) = \lambda_1 (\Phi_1(T_i) - \Phi_1(T_{i-1})) / (T_i - T_{i-1}) \quad \textit{(Mercier 2015)}$$

$$= (D(T^c_i) - D(T^c_{i-1})) / \Delta T + c(\Delta t_r - \Delta t_e) / \Delta T$$

$$+ \Delta_{\text{satellite USO frequency}} + \Delta_{\text{ionosphere}} + \Delta_{\text{relativity}}$$

where

$D(T^c)$: distance between emitter (e) and receiver (r) 2GHz phase centers at coordinate TAI time (T^c), and includes refraction effects.
$(\Delta t_r - \Delta t_e)/ \Delta T$: satellite-beacon clock frequency offset difference; Δt clock offset between i and i-1 times; ΔT = 10 TAI seconds.

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 GEODYN processing:

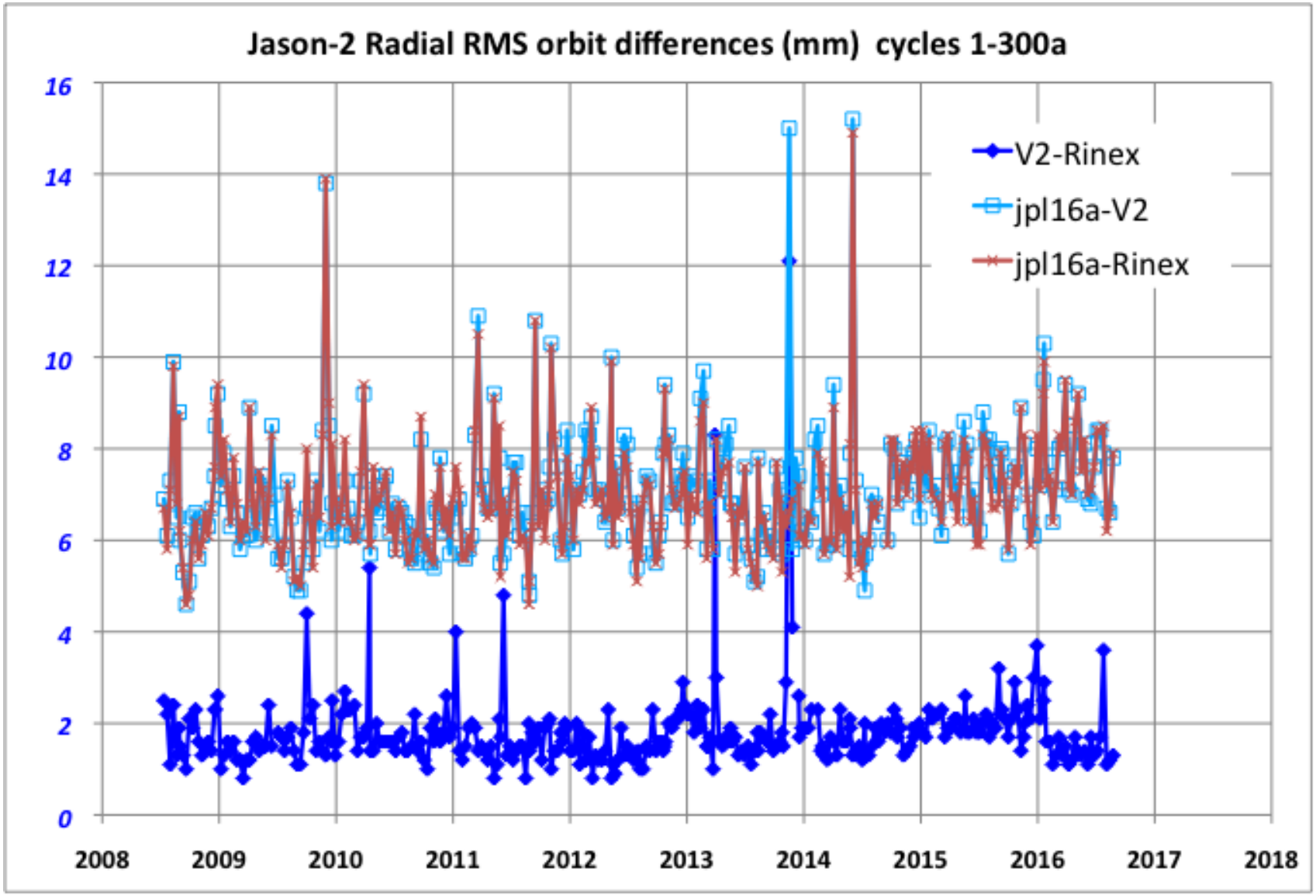
range rate + USO frequency bias (per pass) +
$\Delta_{troposphere} + \Delta_{phase\ center}$

where

$\Delta_{troposphere}$: VMF1 (plus bias/pass)
$\Delta_{phase\ center}$: update satellite antenna Z offset and Starec station Up eccentricity to ionosphere-free positions

Jason-2 RMS radial orbit differences (mm)

(remove 3 Rinex problem arcs)



Example of Belli hourly and minute series