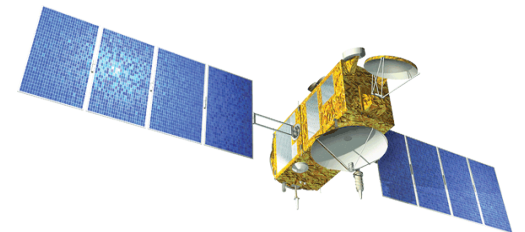
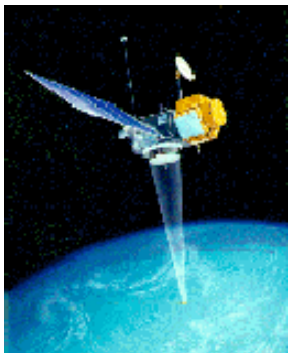




Calibration and validation of the precise orbits for OSTM, and extending the TOPEX, Jason-1, and Jason-2 Time Series

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Seattle, Washington
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Introduction

(Summary since Nice SWT)

I. **Evaluated and applied force and measurement model changes to TP/J1/J2.**

e.g. (1) New LPOD v11; DPOD2005 updates; (2) GPT model (Boehm, 2007) & Niell mapping function for DORIS; (3) UCL model for Jason-1; (4) Estimated offsets for J1 & J2; Downweight SAA stations for J1; (5) Preliminary tuning of macromodel for J2; (6) Tested more detailed modelling of T.V.G; (7) Tested DORIS SAA2 model.

II. **Developed std0905 orbit series for TP, J1 (SLR/DORIS + SLR/Crossover, *dynamic*), and J2 (SLR/DORIS *dynamic* + *red-dynamic*).**

III. **Applied std0905 (*dynamic*) orbits to Tandem phase SSH data (J1+J2).**



Model changes (since the Nice SWT: std0809 to std0905)

- I. **Station Coordinates/Reference frame**
 - (1) New LPOD v11 (vs. v10)
 - (2) DPOD2005 v1.4
- II. **Jason-1: UCL (Cr=1)** vs CNES macromodel (Cr=0.929)
- III. **DORIS measurement modelling: Apply GPT model (Boehm 2007, JoG)** as a priori met data; **Apply Niell mapping function** for troposphere correction.
- IV. **Downweight 14 SAA stations on J1 (over entire Jason time series) + Downwt DORIS (2 mm/s --> 3 mm/s)**



Measures GSFC Orbits - June 2009

GSFC TP, J1, and J2 orbit Release anonymous ftp [dirac.gsfc.nasa.gov](ftp://dirac.gsfc.nasa.gov)

Path <i>pub/earth/.....</i>	Orbit Name	Cyc.	Description	Release Date
TOPEX <i>repro_topex/swt09</i>	gsfc_poe_std0905.\$cycle	001-446	LPOD2005/DPOD2005 stations, 0905 standard	summer 2009
JASON-1 <i>repro_jason/swt09</i>	gsfc_ja1_poe_ld_std0905.\$cycle.Z	240-259	LPOD2005/DPOD2005 stations, 0905 standard	summer 2009
JASON-2 <i>repro_jason/ostm/swt09</i>	gsfc_ja2_poe_ld_std0905.\$cycle.Z	001-030	LPOD2005/DPOD2005 stations, 0905 standard	summer 2009



Evaluation of new Topex/Poseidon orbits

Evaluation of new TOPEX orbits				
TOPEX SLR/DORIS Orbits Cycles 1-364	DORIS RMS (mm/s)	SLR RMS (cm)	SLR mean (cm)	Altimeter Crossover RMS (cm)
<i>GDR</i>	<i>0.5348</i>	<i>2.210</i>	<i>0.323</i>	<i>---</i>
<i>ITRF2005 SLR-rescaled (2007 release)</i>	<i>0.5111</i>	<i>1.828</i>	<i>0.347</i>	<i>---</i>
<i>std0809 (2008 release)</i>	<i>0.5110</i>	<i>1.824</i>	<i>0.415</i>	<i>---</i>
<i>std0905 (2009 release)</i>	<i>0.5215</i>	<i>1.914</i>	<i>0.385</i>	<i>---</i>
<u>Subset Analysis:</u> 21 TOPEX Cycles (344-364)				
<i>ITRF2005 SLR-rescaled</i>	<i>0.4682</i>	<i>1.553</i>	<i>0.198</i>	<i>5.526</i>
<i>std0809</i>	<i>0.4677</i>	<i>1.544</i>	<i>0.255</i>	<i>5.521</i>
<i>std0905</i>				<i>5.508</i>

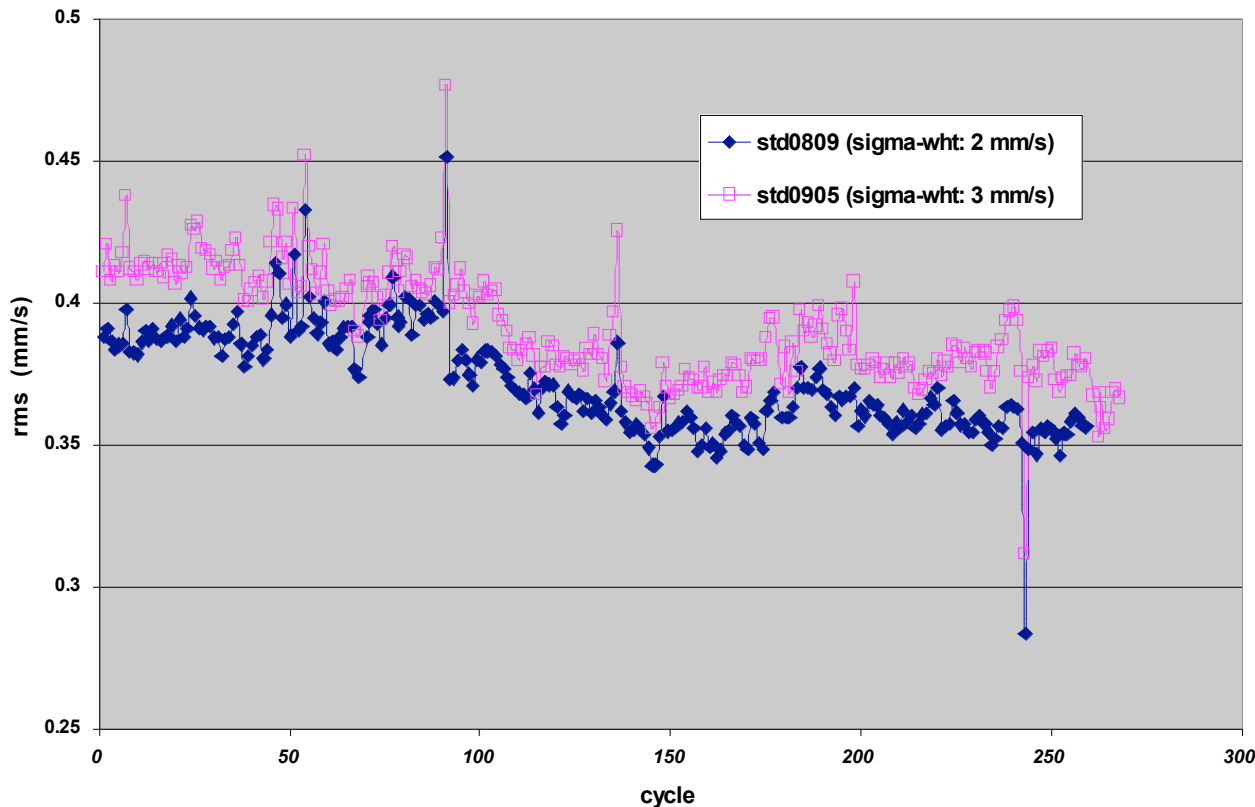
Crossover fits are independent



Evaluation of new Jason-1 orbits

Evaluation of new Jason-1 orbits						
Jason-1 SLR/DORIS orbits cycles 1-259	doris		slr			xover rms (cm) cyc 1-176
	points	rms (mm/s)	points	mean (cm)	rms (cm)	
std0809 (release 2008)	112067	0.3727	4105	0.010	1.120	5.525
std0905 (release 2009)	113496	0.3923	4125	0.179	1.114	5.474

Jason-1 SLR/DORIS solution DORIS residuals

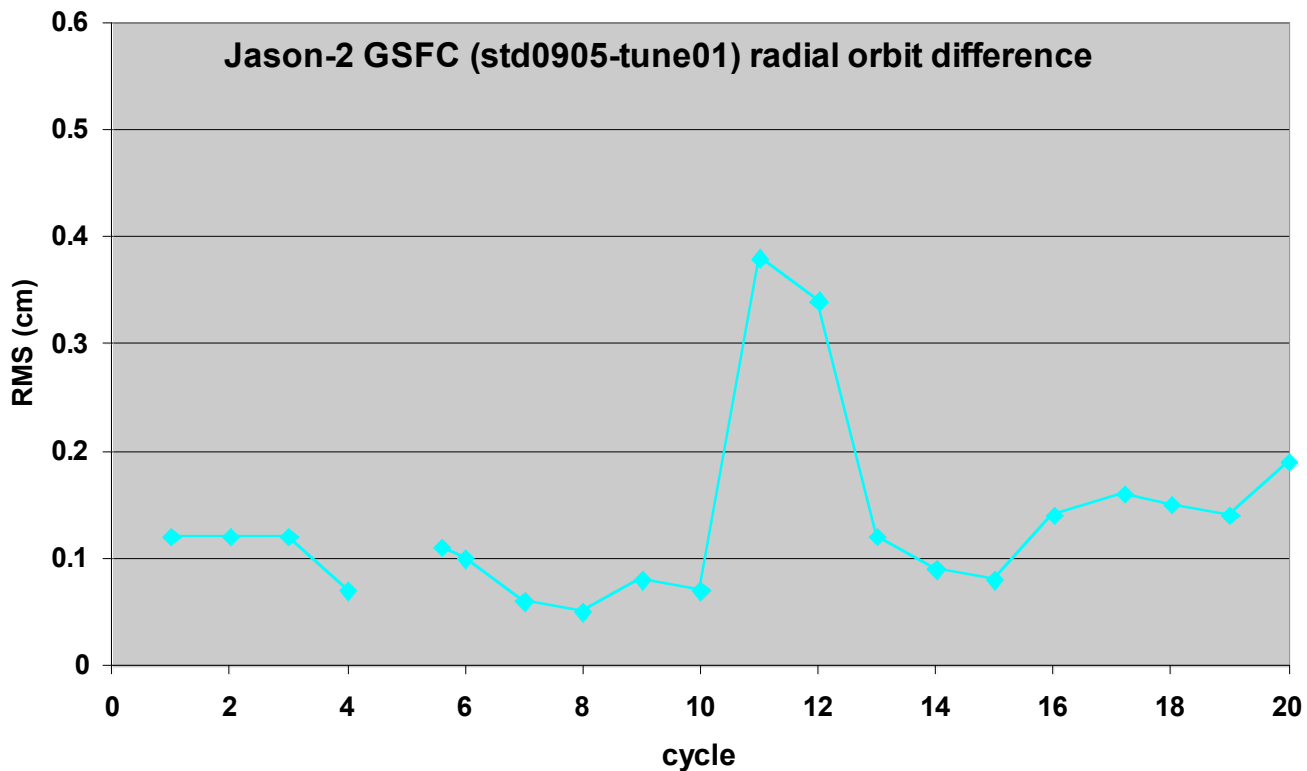


Crossover fits are independent



Evaluation of new Jason-2 orbits

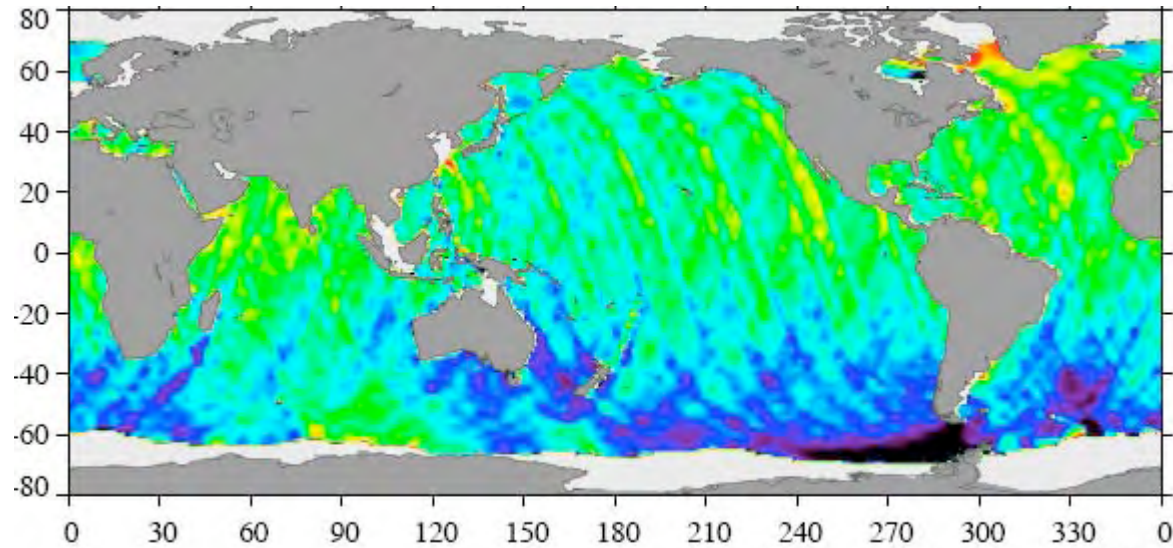
Evaluation of new Jason-2 orbits						
Jason-1 SLR/DORIS orbits cycles 1-20	doris		slr			xover rms (cm) cyc 1-10
	points	rms (mm/s)	points	mean (cm)	rms (cm)	
tune01 (release 2008)	166264	0.3626	2519	0.000	1.171	5.581
std0905 (release 2009)	167104	0.3699	2595	-0.020	1.216	5.563



Crossover fits are independent

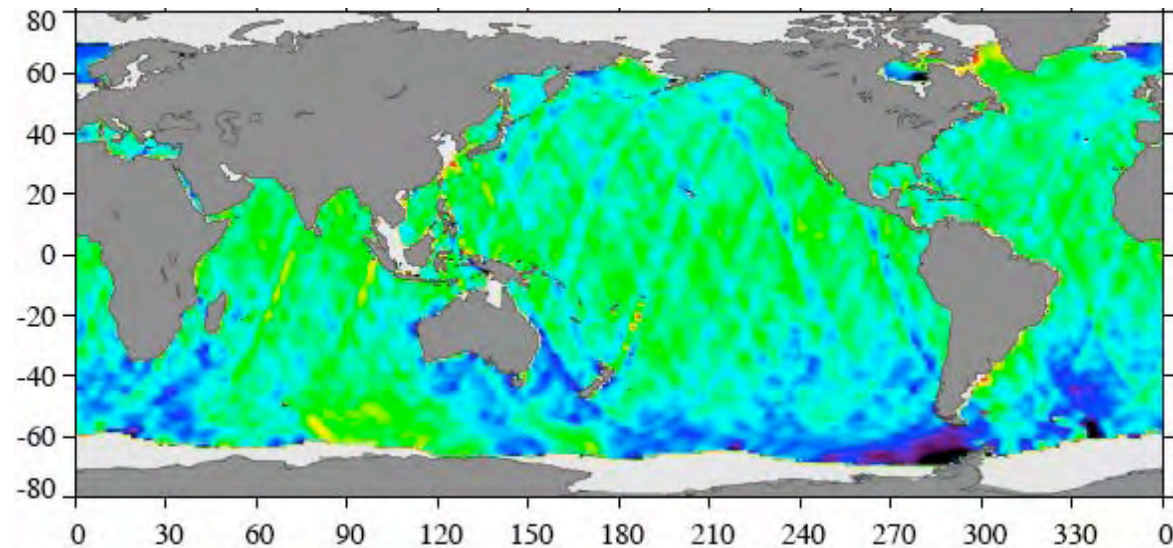


OSTM-Jason1 Sea Surface Height Differences (OSTM Cycles 1-20) with only cross-track gradient correction applied show high consistency for both GDRC and GSFC orbits



GDRC orbits

Mean = 83.4 mm (83.8)
Sdev = 3.3 mm (9.5)



**GSFC replacement
std0905 orbits**

Mean = 83.8 mm (84.1)
Sdev = 2.4 mm (9.3)



Evaluation of the ITRF2005 DORIS reference frame

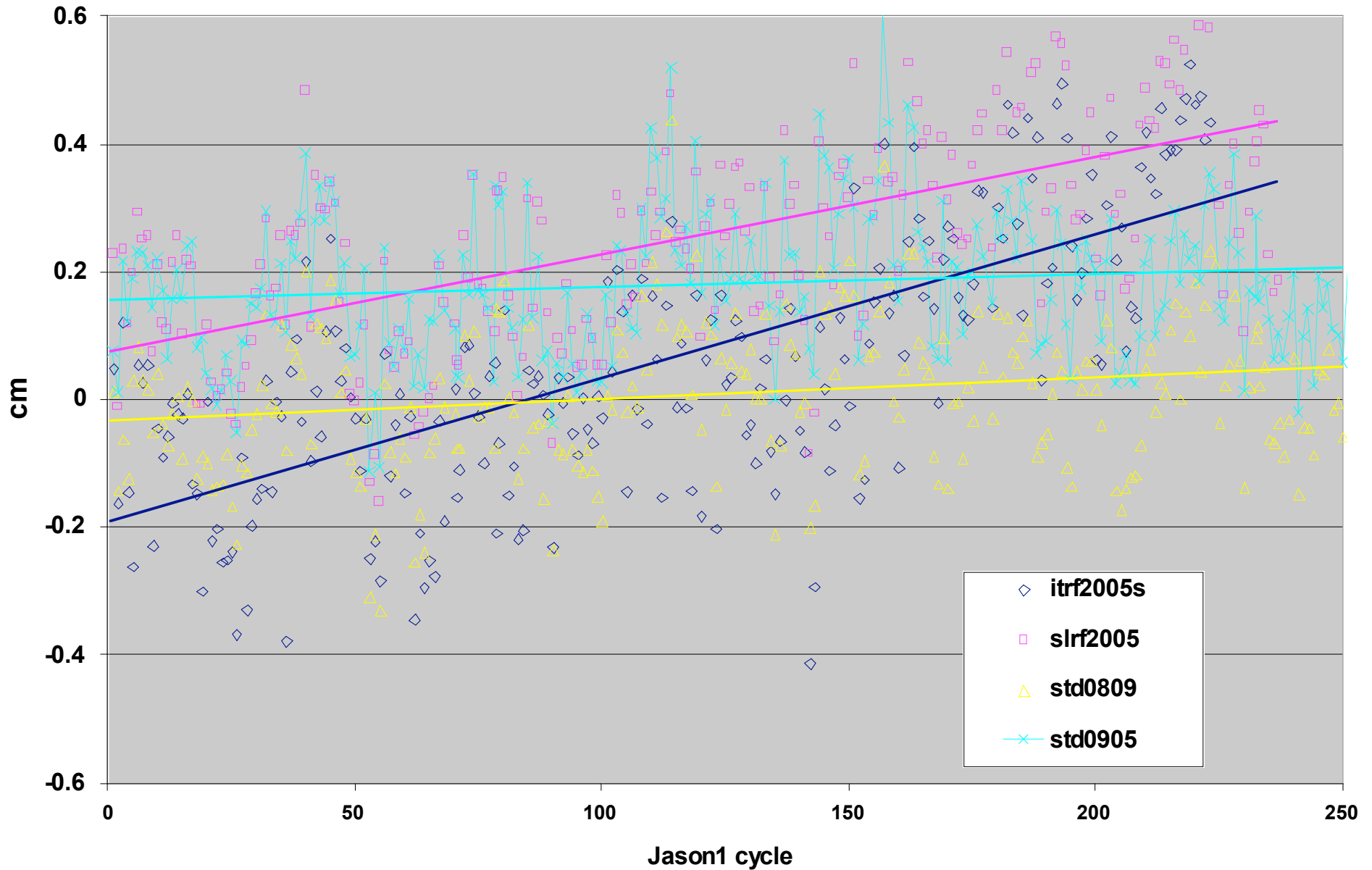
TOPEX/Poseidon, Jason-1 and -2 precise orbit determination results when using ITRF2005 or DPOD2005 as terrestrial reference frame for tracking station coordinates

Test DORIS -only orbit	DORIS		SLR RMS (cm)	Orbit difference RMS (cm)	
	number of stations	RMS (mm/s)		radial	3-D total
<i>T/P cycles 1 -21 from September 1992</i>					
ITRF 2005 original	42	0.5437	7.3		
DPOD 2005	48	0.5403	7.3	0.50	3.95
<i>Jason -1 cycles 1 -21 from January 2002</i>					
ITRF200 5 original	53	0.3970	3.0		
DPOD2005	54	0.3970	3.0	0.12	0.96
<i>Jason -1 cycles 240 -253 from July 2008</i>					
ITRF2005 original	35	0.3752	4.3		
DPOD2005	55	0.3514	3.4	0.47	4.67
<i>Jason -2 cycles 001 -014 from July 2008</i>					
ITRF2005 original	35	0.3876	3.9		
DPOD2005	56	0.3638	3.2	0.60	3.34



Evaluation of ITRF2005 SLR terrestrial reference frame – mean residuals

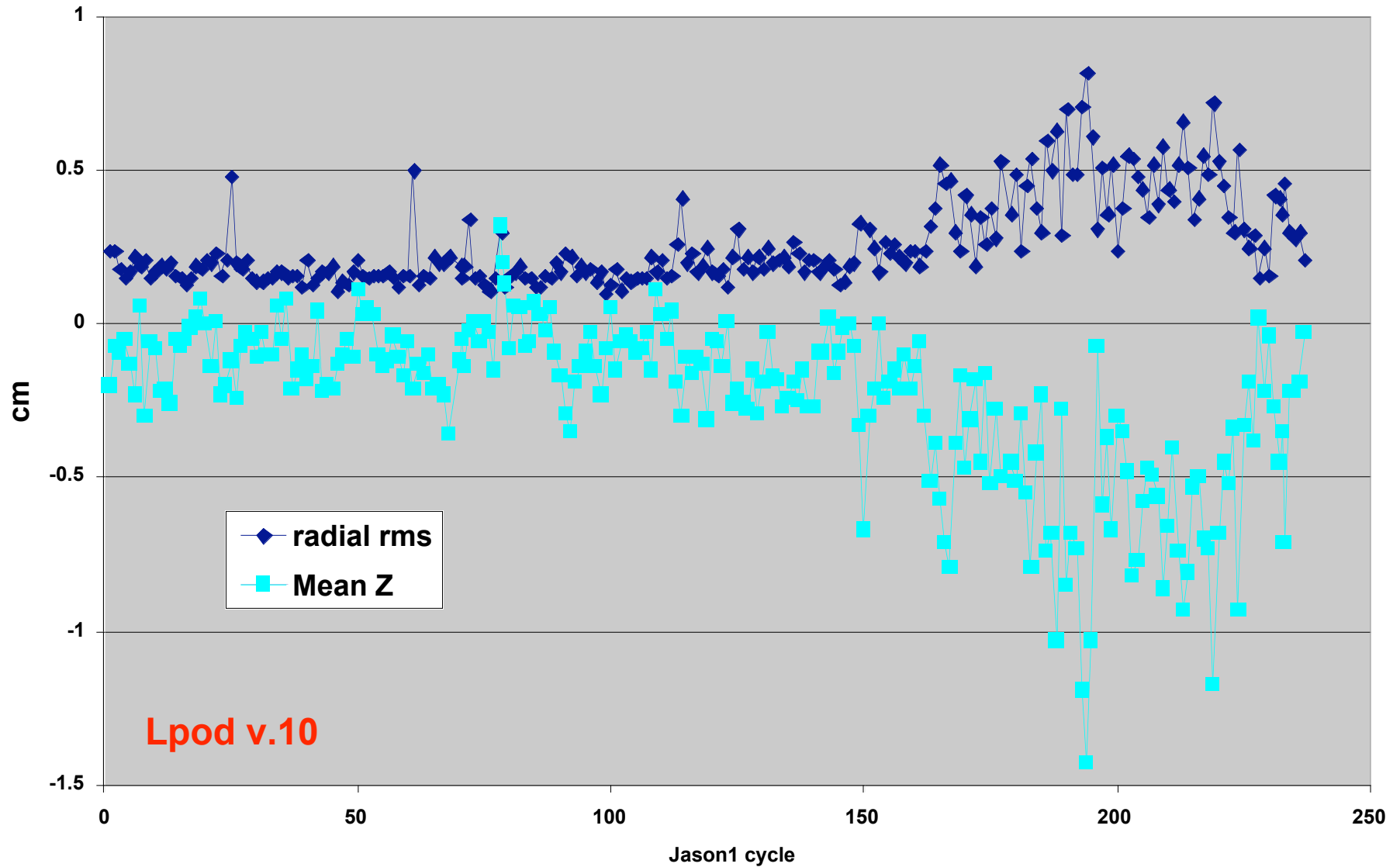
Jason1 Mean SLR residuals





Only a few SLR station position/bias errors will affect the SLR/DORIS orbit

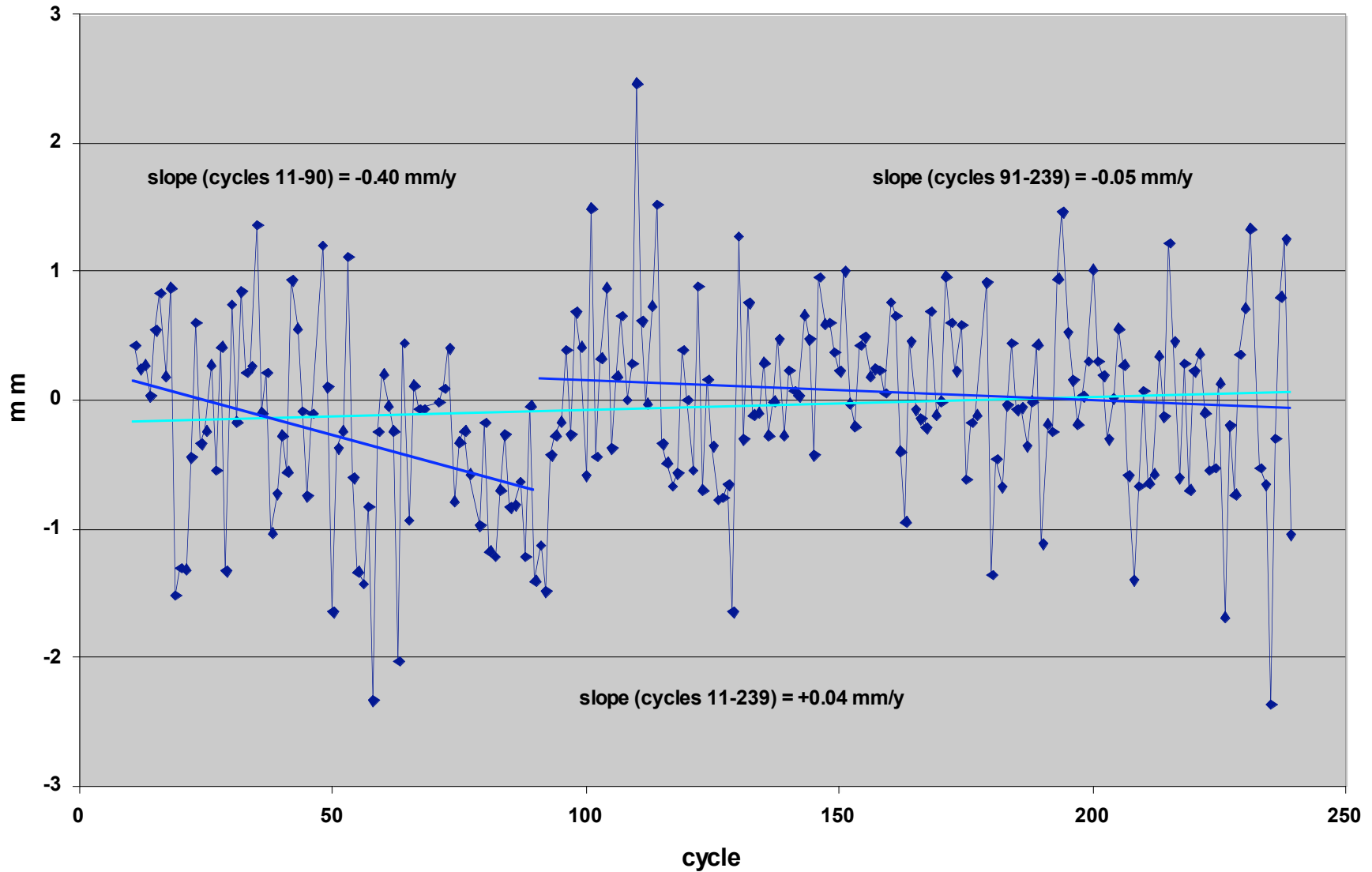
Jason1 orbit differences (lpod2005-slr2005)





Orbit centering affects mean radial error over water

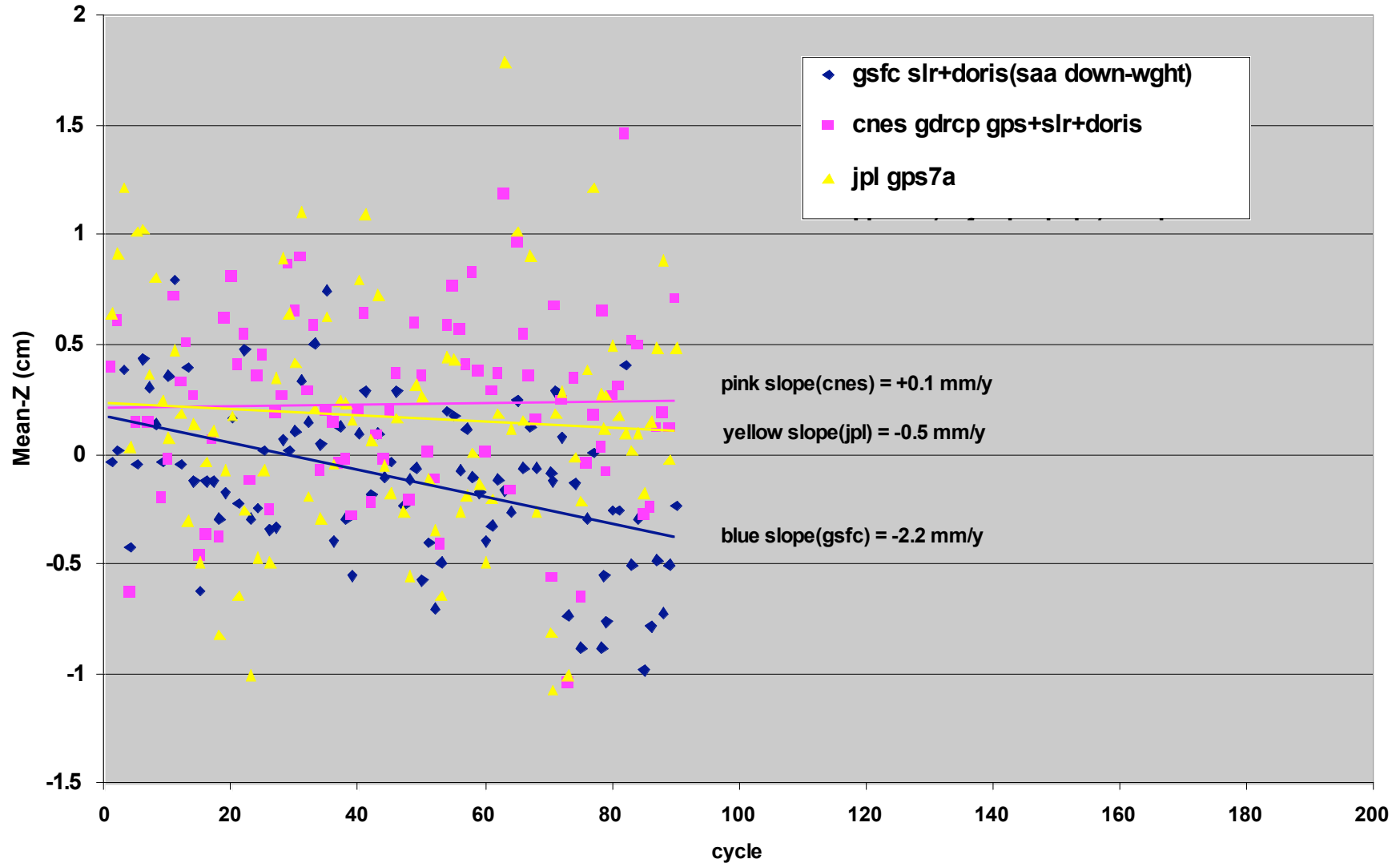
Jason-1 GSFC std0905 - GDRc Mean radial orbit differences over water (cycles 11 - 239)





J1 mean-Z orbit differences to cycle 90

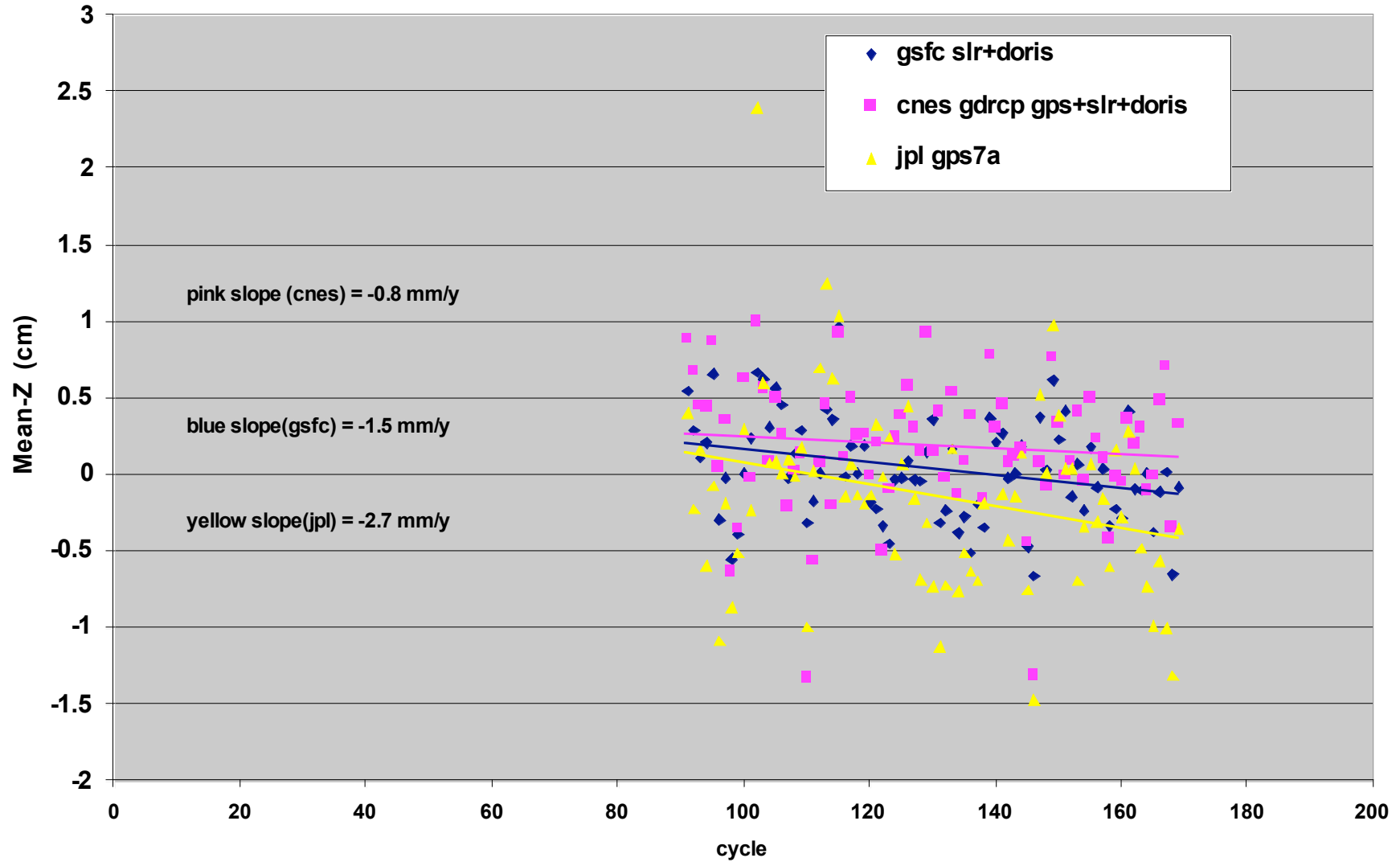
Jason-1 Mean-Z GSFC SLR/Crossover - test orbit differences





J1 mean-Z orbit differences from cycle 91

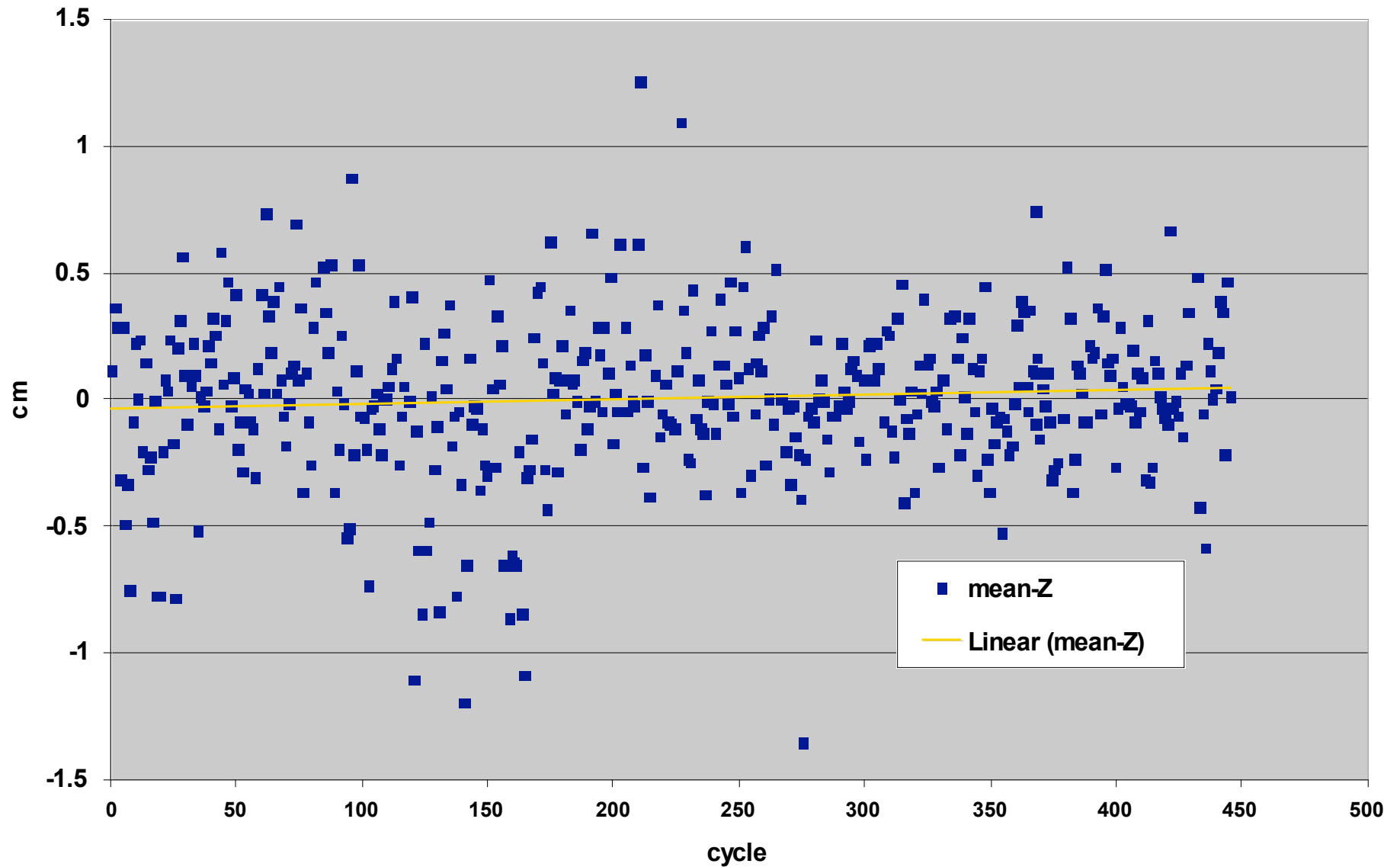
Jason-1 Mean-Z GSFC std0809 SLR/Crossover - test orbit differences





TP mean-Z differences indicate no trends due to DORIS

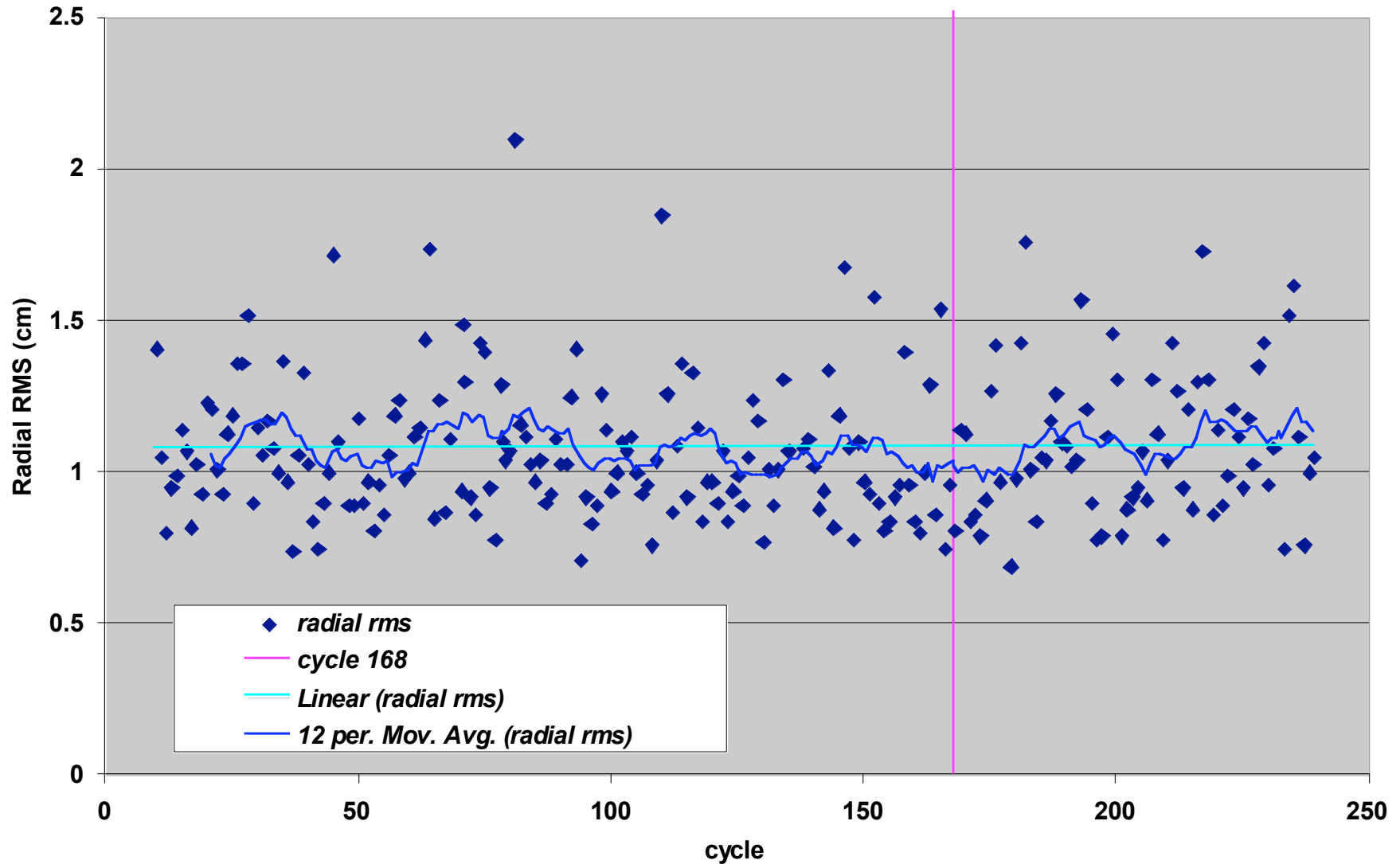
TP (slr/doris - slr/xover) orbit differences





Excellent agreement between GSFC and GDRc J1 orbits both prior and post GPS receiver degradation

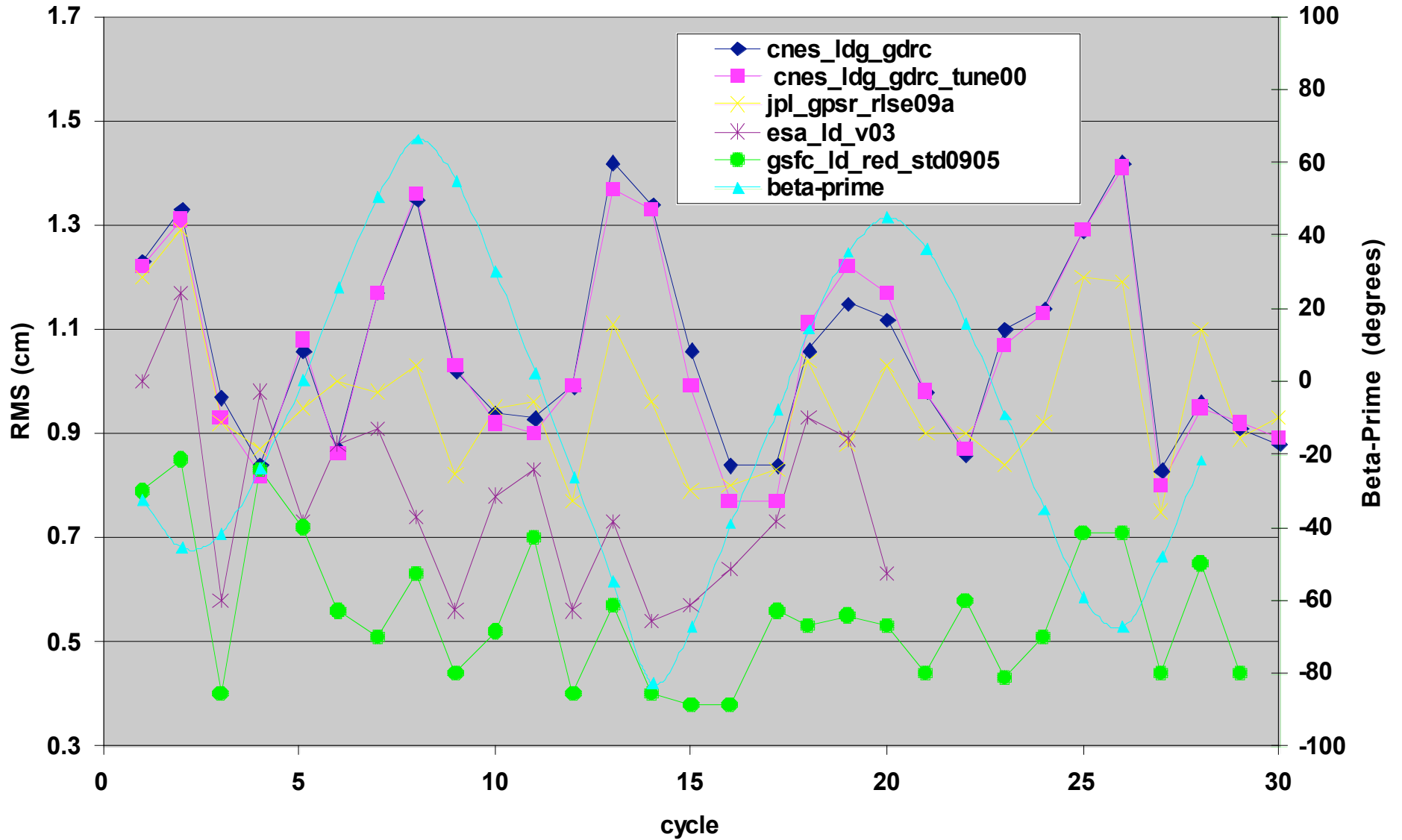
Jason-1 GSFC std0905 - GDRc Radial orbit differences (cycles 11 - 239)





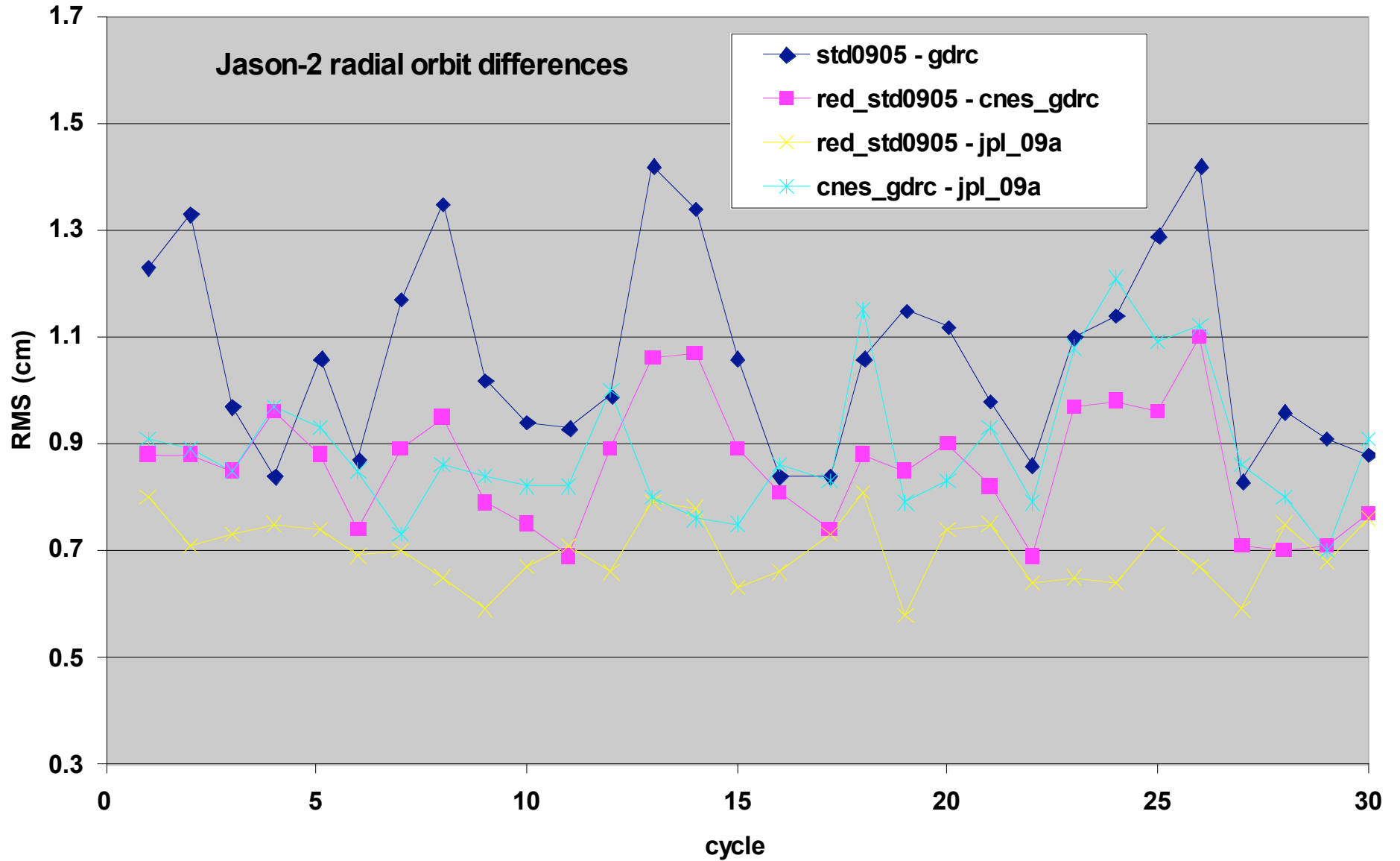
J2 orbit differences -wrt- GSFC dynamic orbit

Jason-2 radial difference -wrt- gsfc_ld_std0905 (dynamic) orbit





J2 orbit differences (continued)





J2 orbit evaluation

Jason2 orbit evaluation cycles 1 -20	doris (edit cyc 18)		slr (edit cycles 18)			xover rms (cm) (edit cyc 18,20)	
	point s	rms (mm/s)	points	mean (cm)	rms (cm)	points	rms (cm)
gsfc ld std0905	169900	0.3719	2764	-0.02 0	1.288	4814	5.512
gsfc ld srp0906	169900	0.3718	2764	-0.017	1.29 0	4814	5.505
gsfc ld red_std0905	169900	0.3711	2764	-0.075	1.242	4814	5.46 0
cnes ldg gdrc	167553	0.3719	2718	0.000	1.215	4812	5.523
cnes ldg gdrc tune00	167553	0.3718	2718	-0.019	1.209	4812	5.532
jpl gps rse09a	162291	0.372 0	2662	0.015	1.307	4414	5.362



J2 orbit evaluation

Jason2 orbit evaluation cycles 1-20	doris (edit cyc 18)		slr (edit cycles 18)			xover rms (cm) (edit cyc 18,20)	
	points	rms (mm/s)	points	mean (cm)	rms (cm)	points	rms (cm)
gsfc ld std0905	169900	0.3719	2764	-0.020	1.288	4814	5.512
gsfc ld srp0906	169900	0.3718	2764	-0.017	1.290	4814	5.505
gsfc ld red_std0905	169900	0.3711	2764	-0.075	1.242	4814	5.460
cnes ldg gdrc	167553	0.3719	2718	0.000	1.215	4812	5.523
cnes ldg gdrc tune00	167553	0.3718	2718	-0.019	1.209	4812	5.532
jpl gps rlse09a	162291	0.3720	2662	0.015	1.307	4414	5.362



Summary

- We have generated complete time series of orbits for TP, J1, J2 with consistent geophysical modelling. The new time series will be available this summer.
- Orbit quality is sensitive to reference frame error - even for a few key stations.
- J2 orbits exhibit nonconservative force model error (beta-prime related signal) & should be improved.
- J2 red-dyn orbits (SLR/DOR or GPS) have best independent Xover statistics.
- GPT model + Niell mapping function demonstrably improves DORIS POD.
- We need to evaluate how to include more complete TVG information in a homogeneous manner over all the altimetric time series (1993-2009).



Measures GSFC Orbits – std0905

GSFC POD Model Standards May 2009: std0905 (changes from std0809 in red)			
<i>Reference frame and displacement of reference points</i>			
SLR	SLRF2005 + LPOD2005 (version 11)		
DORIS	DPOD2005 (version 1.4)		
Earth tide	IERS2003		
Ocean loading	Got4.7 all stations		
Tida l CoM & EOP	Got4.7; VLBI high frequency terms		
EOP	IERS Bulletin A daily (consistent with ITRF2005)		
Precession / Nutation	IAU2000		
<i>Gravity</i>			
Static	Eigen -G104s		
Time varying	Linear C20 -dot, C21 -dot, S21 -dot (IERS2003) + 20x20 annual terms from GRACE		
Atmospheric	ECMWF, 50x50@6hrs		
Tides	Got4.7 20x020 (ocean); IERS2003 (Earth)		
<i>Satellite Surface Forces and attitude</i>			
Albedo /IR	Knocke -Ries -Tapely (1988)		
Atmospheric drag	MSIS86		
Radiation pressure	TOPEX	Jason-1	Jason-2
	tuned 8 -panel	UCL	Jason-1 8-panel
Radiation scale coeff.	$C_R = 1.0$	$C_R = 1.0$	$C_R = 0.916$ (tuned)
Attitude	Nominal Yaw; Quaternions off-nominal	Nominal Yaw	Quaternions
<i>Tracking data and parameterization</i>			
Tracking data	SLR/DORIS (Jason1 DORIS corrected for SAA)		
Troposphere model	SLR: Mende z-Pavlis; DORIS: GPT + GPS/Neill		
Parameterization	Drag/8 hrs + opr along & cross -track/24 hrs + DORIS time bias /arc; 10 -day arc dynamic solution		
Antenna reference	TOPEX	Jason-1	Jason-2
	SLR	LRA model	tuned offset
DORIS	pre -launch	pre -la unch	pre -launch
SLR/DORIS weight	10- cm / 2 -mm/s	10-cm / 3 -mm/s; down -weight 14 SAA stations	10- cm / 2 -mm/s