SARAL GSFC Processing Update

NASA GSFC POD Team

March 26-27, 2014

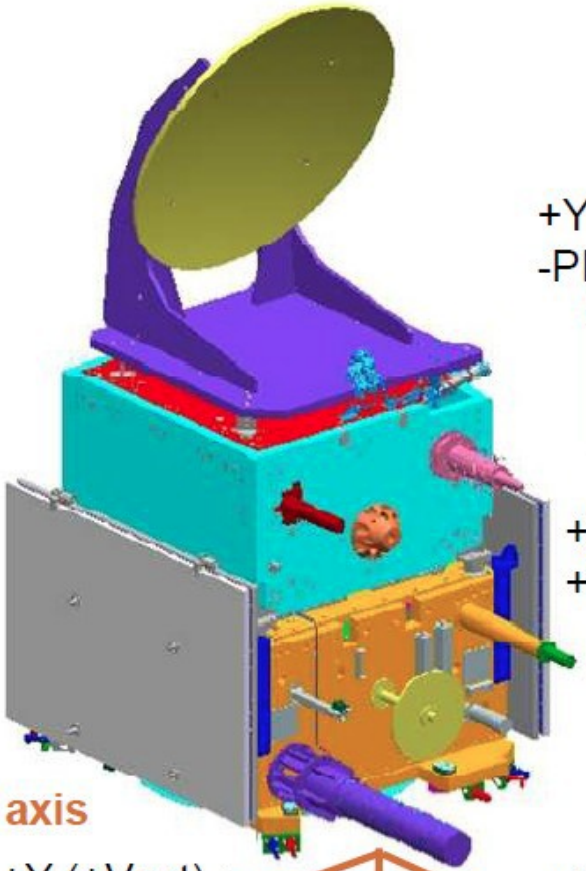
IDS AWG Meeting, Paris, France

Outline

- tune SLR / DORIS antenna offsets and satellite CM
- altimeter time tag and crossover data processing
- test recent gravity models

SARAL ISRO axis: X (nadir), Y (cross-track), Z (along-track)

SARAL SPACECRAFT



PIM axis

+Y (⊥ orbital plane) :
-PITCH

+X (-Vsat) :
-ROLL

+Z (toward earth center):
+YAW

ISRO S/C axis

+Y (+Vsat) :
+ROLL

+X (toward earth center) :
+YAW

+Z (⊥ orbital plane) :
+PITCH

SARAL DORIS/SLR antenna offset estimates

SARAL SLR / DORIS tuning 130317-131215		DORIS antenna offset (m)			SLR antenna offset (m)			LRA (m)
		X	Y	Z	X	Y	Z	
a-priori** (cnes)		0.8050	-0.3040	-1.1290	0.4735	0.0000	-0.9400	
test1	correct.	0.0031	---*	-0.0406	0.0080	---*	-0.0454	-0.0434 (CNES)
	sigma	±0.0012	---*	±0.0019	±0.0016	---*	±0.0014	
test2	correct.	0.0031	---*	-0.0406	0.0158	---*	-0.0456	-0.03748 (Arnold)
	sigma	±0.0012	---*	±0.0019	±0.0016	---*	±0.0014	
* note. DORIS/SLR antenna Y offset estimates show 0.997 correlation and are suppressed ** CoM: X(nadir)= -.0112, Y(cross track)= -.0067, Z(along track) -.6183 (m)								

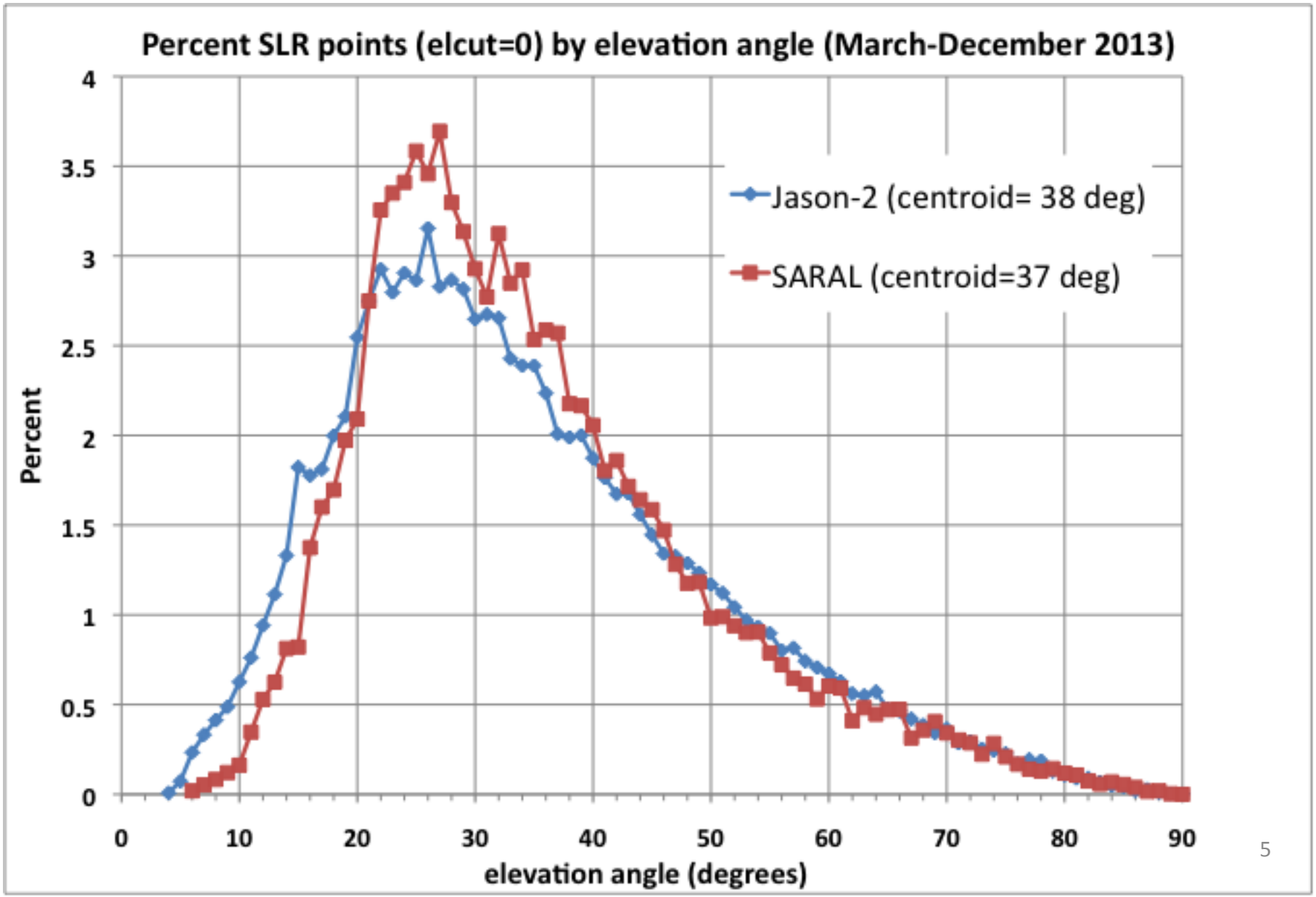
Note:

***1)* similarity of DORIS & SLR along-track (Z) adjustments suggests an error in satellite CM**

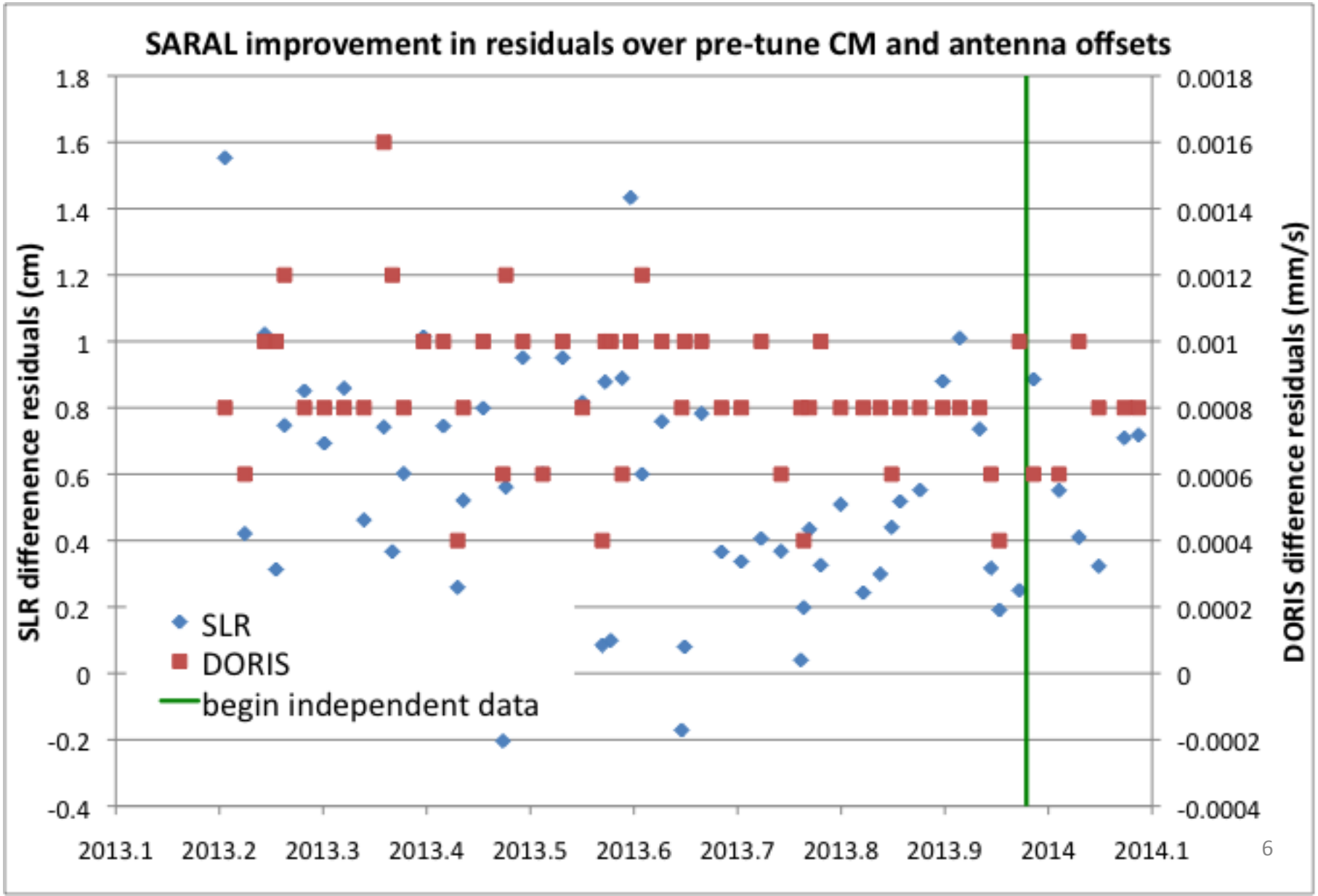
2) Arnold LRA constant correction model is adopted at this time as it also provides correction by incidence angle.

Correct SARAL CM and re-estimate DORIS/SLR antenna offsets

SARAL SLR / DORIS antenna offset re-tuning over 130317-131222 data. (CM corrected using mean of test2 SLR+DORIS Z estimates)		Offset (m)		
		X (nadir)	Y (cross-trk)	Z (along-trk)
CM (Center of Mass)	CNES a-priori	-0.0112	-0.0067	-0.6583
	Corrected	-0.0112	-0.0067	-0.6152
LRA antenna offset	a-priori	0.4735	0.0000	-0.9400
	correction to a-priori	0.0157	---*	-0.0025
	estimate sigma	±0.0016		±0.0014
DORIS antenna offset	a-priori	0.8050	-0.3040	-1.1290
	correction to a-priori	0.003	---*	0.002
	estimate sigma	±0.001		±0.002
Note. LRA OBSCOR = -0. 03748 m (Arnold) * note. DORIS/SLR antenna Y offset estimates show 0.997 correlation and are suppressed				


Percent SLR points (elcut=0) by elevation angle (March-December 2013)
Jason-2 (centroid= 38 deg)
SARAL (centroid=37 deg)
Percent
elevation angle (degrees)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
10
20
30
40
50
60
70
80
90

SARAL tuned CM and antenna offset performance
positive => improvement



SARAL tuned CM and antenna offset performance summary

SARAL residual summary (130317-140210)			
test SLR+DORIS	DORIS (mm/s)	SLR (cm)	
		Mean	RMS
std1204 (pre-tune)	0.4151	-0.221	2.137
std1204 (post-tune) CM corrected, re-tuned offsets	0.4142	-0.036	1.576

SARAL orbit difference summary						
orbit differences (130317-140210)	RMS inertial (cm)			Mean ECF (cm)		
	radial	cross-track	along-track	X	Y	Z
post - pre tune CM/offsets	0.08	1.67	0.54	0.00	0.00	-0.03
slr+doris minus doris-only	0.18	1.56	1.88	0.00	0.00	0.16
slr+doris minus slr-only	4.22	10.44	63.17	0.08	-0.13	-0.13

Transmit time externally applied to altimeter data time tag in pre-processing for GEODYN

altimeter signal path sequence: send, bounce, receive

Jason-2 time tag (t):

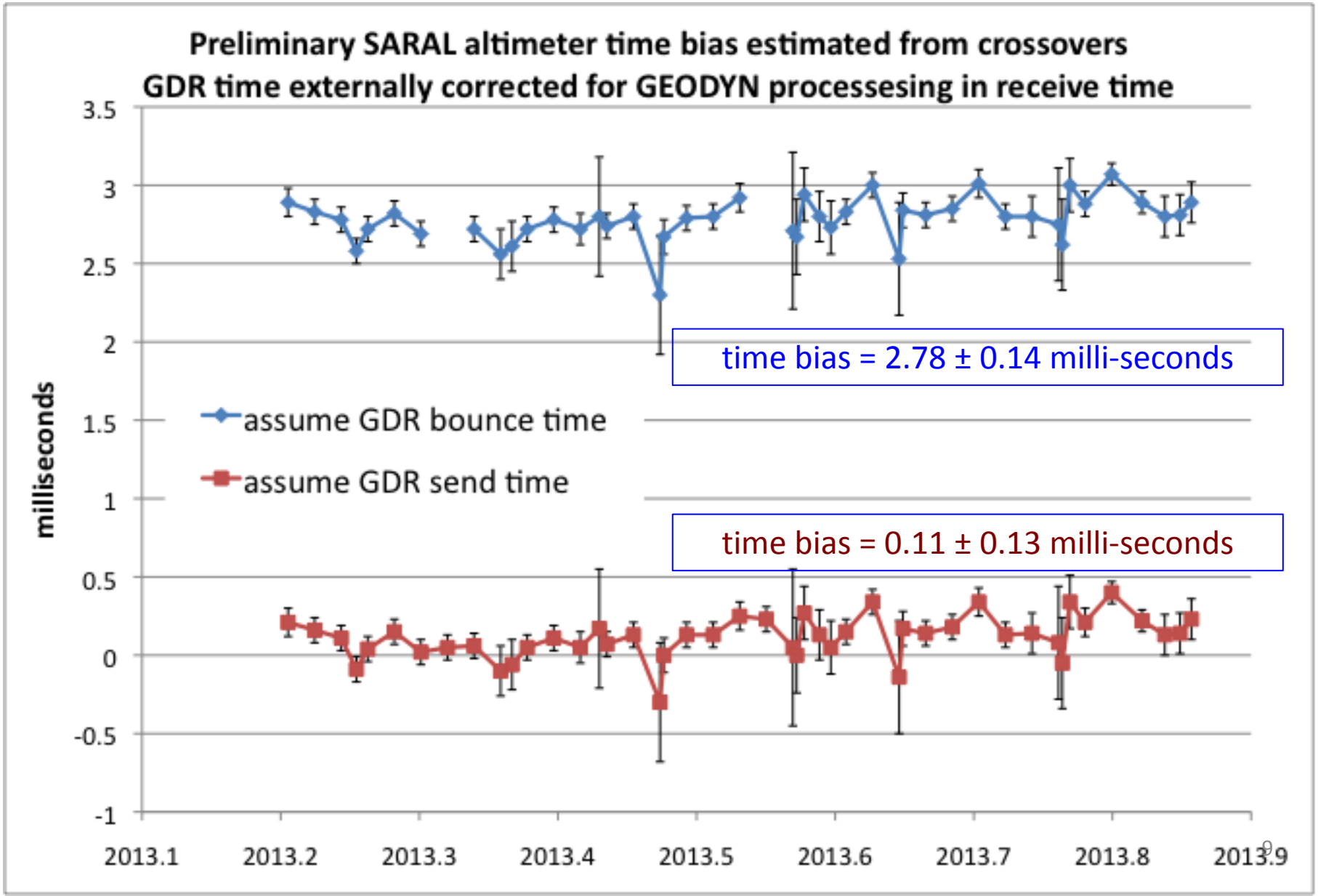
GEODYN $t_{receive}$ = GDR t_{bounce} + 1 * transmit time

SARAL time tag (t):

GEODYN $t_{receive}$ = GDR t_{send} + 2 * transmit time

SARAL altimeter data obtained from
ftp://avisoftp.cnes.fr/AVISO/pub/saral/gdr_t/

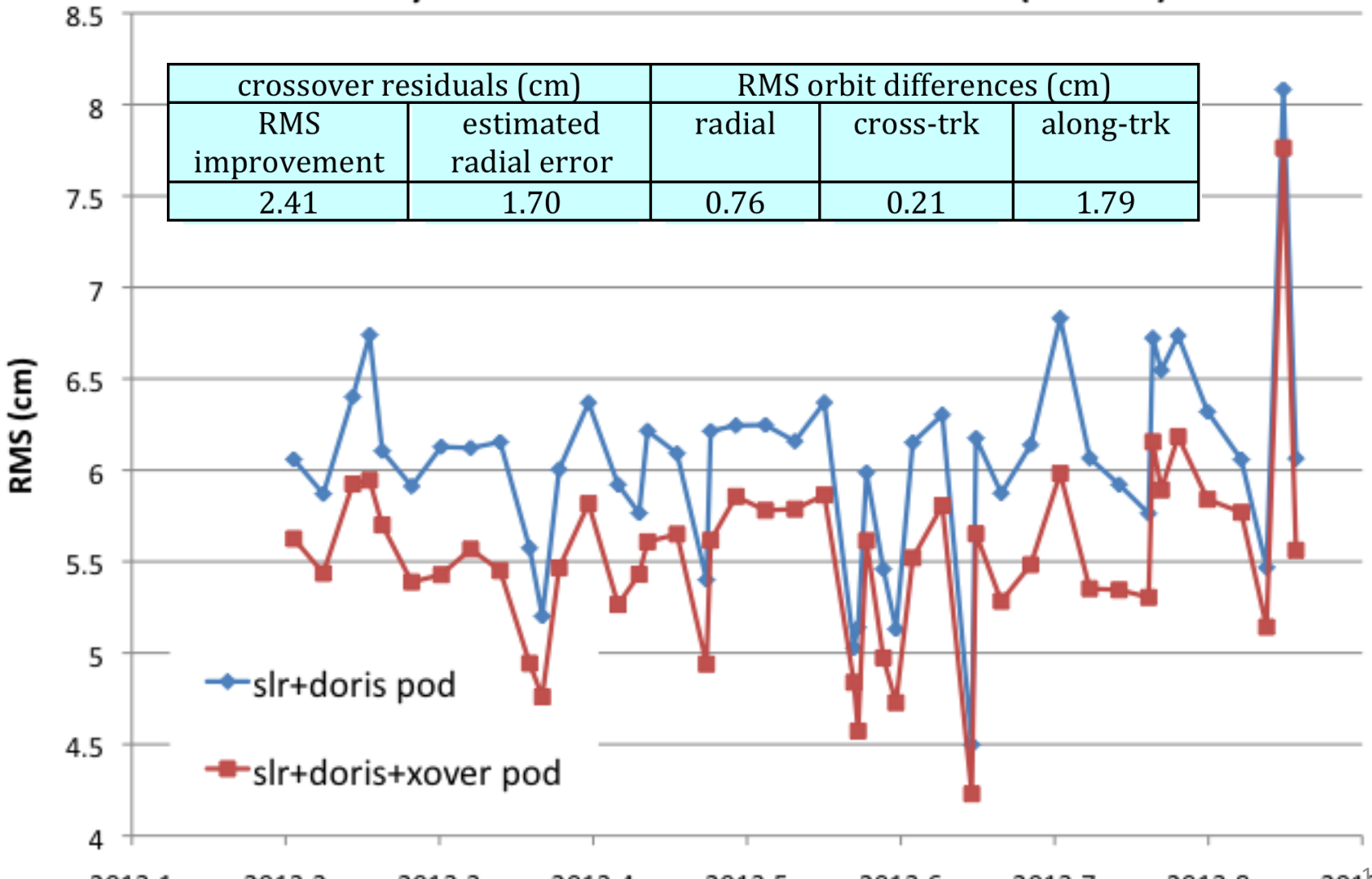
Assume GDR bounce time: apply 1*transmit time
Assume GDR send time: apply 2*transmit time



Preliminary Crossover residuals reduced by 2.4 cm RMS when used in POD processing (GDR altimeter corrections)

Preliminary SARAL altimeter crossover residuals (std1204)

crossover residuals (cm)		RMS orbit differences (cm)		
RMS improvement	estimated radial error	radial	cross-trk	along-trk
2.41	1.70	0.76	0.21	1.79



Time Varying Gravity models

TVG model	Description (all forward model atmosphere gravity using ECMWF 6-hour data and apply the IERS2010 C21/S21 model)
stdtvg (std1007)	5 coefficient terms linear (IERS); 20x20 annual (GRACE)
goco2s_fit2 (std1204)	4x4 linear+periodic fit to previous tvg4x4 series; 5x20 annual (GRACE)
tvg5x5_nom8	7-day SLR/DORIS 5X5 estimates with relative weights for 21 satellites in solution calibrated using subset analysis; 6x20 annual (GRACE)
tvg5x5_nom9c	as tvg5x5_nom8 but SPOT-2, SPOT-4 down-weighted due to influence of atmosphere drag orbit error
eigen-6s	50x50 linear+periodic GRACE+LAGEOS, GOCE 2003.0-2009.5 data
eigen-6s2	50x50 periodic GRACE+LAGEOS, GOCE piece-wise continuous rate + offset time series by year (1985-2012): • 2x2 1986 – 2002 • 50x50 2003 – 2011 • **zero rate 1985 and before, 2012 and after** • 1985 offset extended backwards, 2012 offset forwards

SARAL gravity model performance.

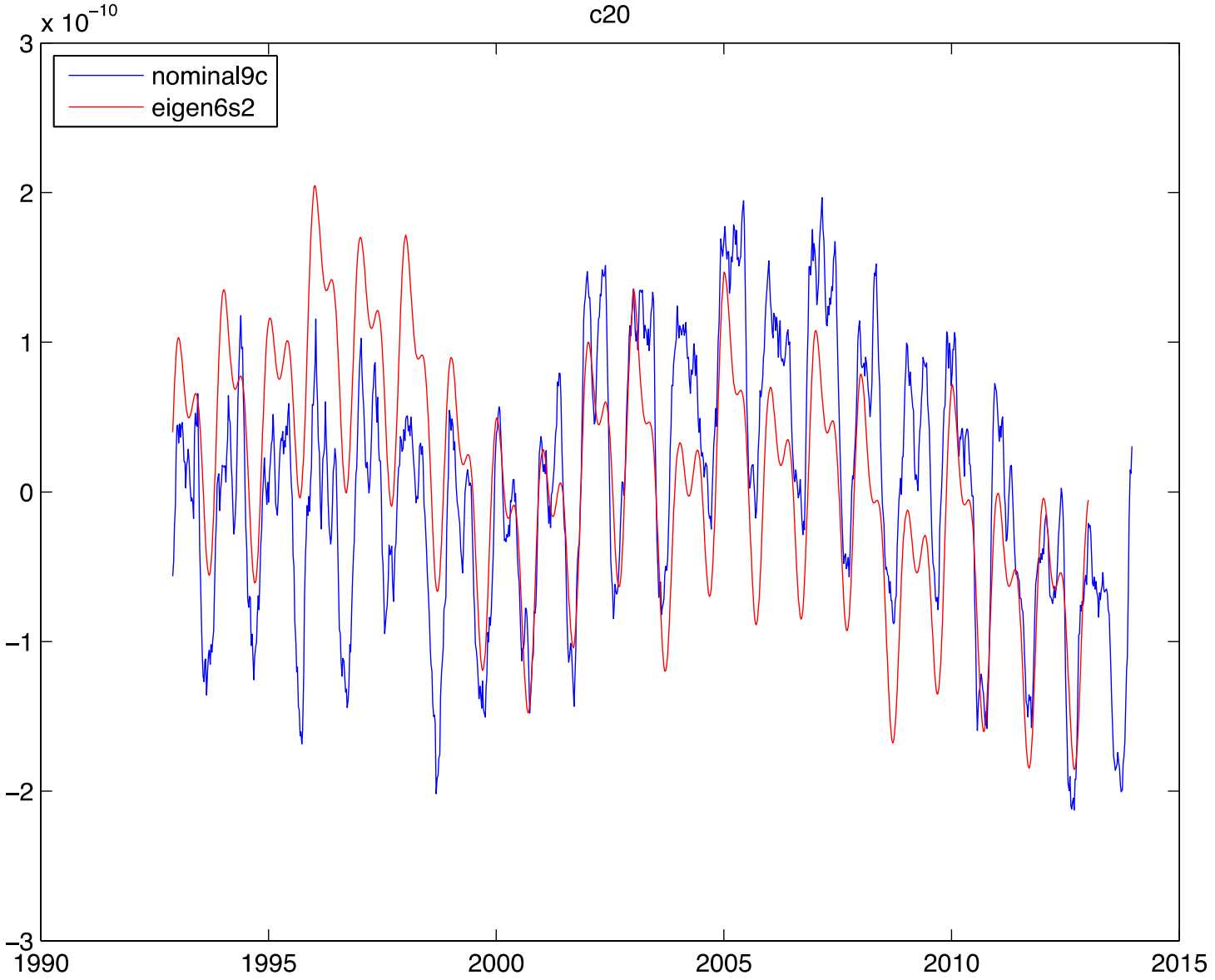
SARAL test external ephemeris	Average RMS residuals; 34 arcs spanning Mar-Sep 2013		
	DORIS (mm/s)	SLR (cm)	Xover (cm)
stdtvg	0.4155	1.815	5.951
goco2s_fit2	0.4142	1.683	5.916
tvg5x5_nom8	0.4106	1.429	5.905
tvg5x5_nom9c	0.4113	1.490	5.890
eigen-6s	0.4100	1.224	6.031
eigen-6s2	0.4321	2.906	7.169

SARAL not used in GSFC gravity solutions.

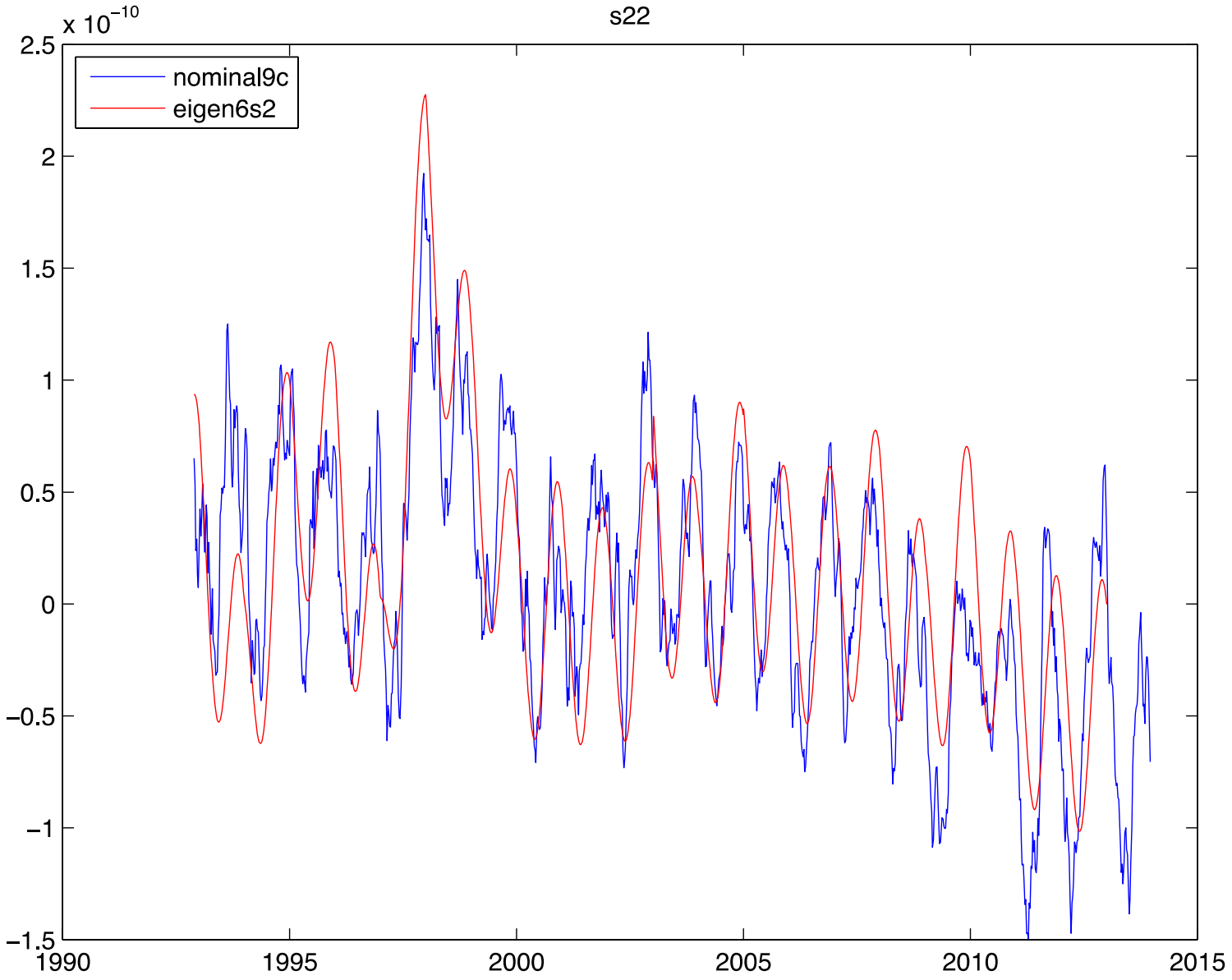
SARAL orbit comparison with CNES GDRD DORIS

cnes_gdrd_doris -minus- *test* orbit Mar-Sep 2013	RMS Inertial (mm)			Mean ECF (mm)		
	radial	cross-track	along-track	X	Y	Z
stdtvg	17.3	26.0	41.9	-0.9	-21.2	6.8
goco2s_fit2	16.4	23.8	39.8	0.2	-20.8	6.2
tvg5x5_nom8	9.7	31.0	31.1	-2.0	-5.6	4.1
tvg5x5_nom9c	11.0	30.1	33.5	-3.0	-8.6	4.2
eigen-6s	7.9	21.3	25.0	-0.5	-3.3	3.9
eigen-6s2	27.8	40.3	69.7	-1.9	-0.3	4.5

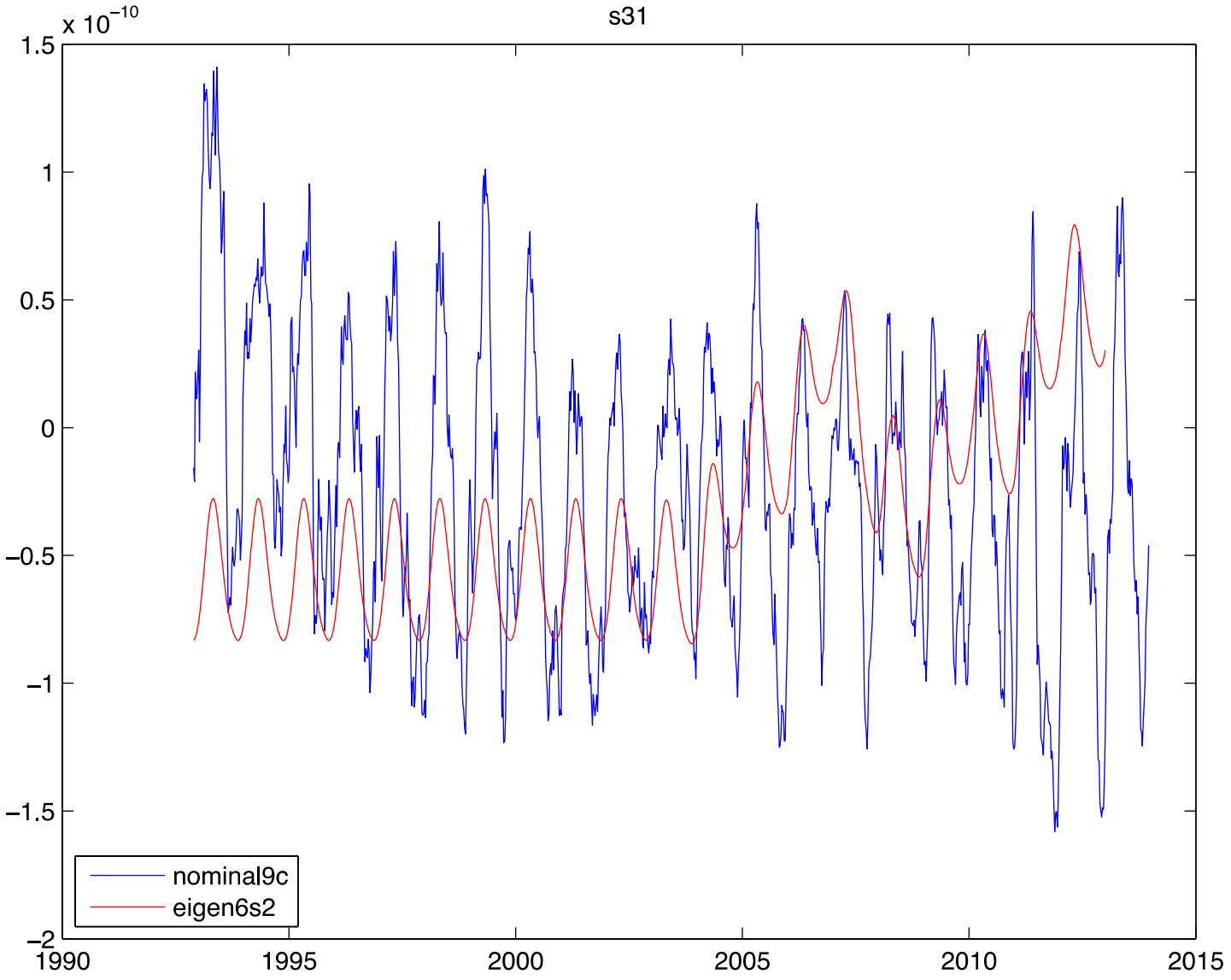
Gravity C_{20}


c20
x 10^-10
nominal9c
eigen6s2
3
2
1
0
−1
−2
−3
1990
1995
2000
2005
2010
2015

Gravity S_{22}


s22
x 10^-10
nominal9c
eigen6s2
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
1990
1995
2000
2005
2010
2015

Gravity S_{31}


s31
x 10^−10
1.5
1
0.5
0
−0.5
−1
−1.5
−2
1990
1995
2000
2005
2010
2015
nominal9c
eigen6s2

Summary

1) SLR and DORIS antenna offset estimates suggest SARAL CM position is in error by about 4-cm along-track.

2) Upon correcting CM and re-estimating the SLR/DORIS antenna offsets SLR residuals are reduced from 2.14 to 1.58 cm RMS and DORIS residuals are also improved.

3) DORIS stabilizes and dominates the SLR+DORIS orbits.

4) Altimeter crossover analysis indicates SARAL GDR altimetry is tagged as “send” time.

5) 2.4 RMS signal in crossover data is absorbed when used in POD processing.

6) As implemented EIGEN-6S2 performance significantly differs from the other models. Have any other centers tested EIGEN-6S2?

7) Radial differences with the CNES GDRD DORIS orbits are close to 1-cm RMS using the best gravity models.