GSFC OSTM (Jason-2), Jason-1 & TOPEX POD Update

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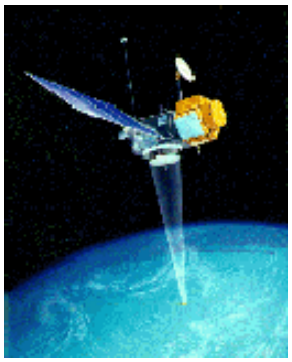
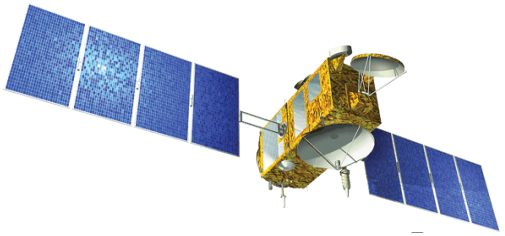


OSTST 2011 POD Splinter
San Diego, California
October 19-21, 2011



Outstanding Questions from 2010 SWT

- **Consistency of orbits, geophysical models, and Reference frames, especially in the Z coordinate.**

- **Sufficiency of Time-variable gravity modelling and impact on orbit quality and evolution *(cf. Cerri et al., 2010, Marine Geodesy)***

- **Radiation pressure modelling induced error on Jason-2.**

- *(Continued) refinement and improvement of SLR & DORIS coordinates and measurement modelling (beyond ITRF2008); e.g. DPOD2008, SLRF2008, analysis of SLR biases.*

- *59-day signal.*

Developing new GSFC POD Standards for TP, J1, J2

Standard	Description
std0905	2009: ITRF2005-based (SLR/DORIS: LPOD2005/DPOD2005; GPS, IGS05), Standard TVG model (tvgstd), EIGEN_GL04S
std1007	2010: as std0905 with ITRF2008 SLR/DORIS (e.g. Measures orbits @ PODAAC)
std1007_cr	2011: as std1007 with re-tuned Jason-2 solar radiation pressure coefficient.
std1110 (experimental)	2011: as std1007_cr (1). Replace tvgstd with using updated 4x4 gravity coefficients per arc obtained from GSFC weekly solution series determined from SLR/DORIS tracking of 9 satellites (tvg4x4); (2). SLRF2008/DPOD2008; (3). DORIS troposphere, GMF mapping function.

Time Varying Gravity (TVG) Modeling

TVG	Description: (*atmosphere gravity is forward modeled using ECMWF 6-hour pressure data*)
tvgstd	Linear rates for C_{20}, C_{30}, C_{40}, C_{21}, S_{21}, (IERS 2010, 2003) (Zonal rates from EIGEN-GL04S) + 20x20 annual field derived from 4 years of GRACE data.
Eigen6s	GFZ/GRGS 50x50 annual, semi-annual and linear terms estimated simultaneously with 240x240 static field determined over 6.5 years of GRACE+Lageos data (2003-2009.5), and includes GOCE data.
tvg4x4	GSFC time series of smoothed gravity coefficients to degree/order 4x4 determined weekly from SLR & DORIS data to 9 satellites (*including Lageos1, Lageos2, Starlette, Ajisai, Stella, TOPEX, Envisat*) with GGM03s (120x120) background model; from 1993.

Satellite Data Used for 4x4 *(weekly)* Solutions

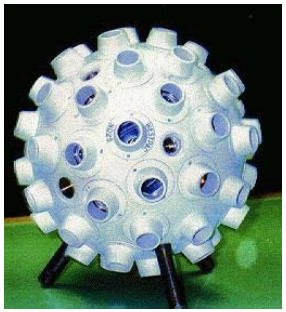
Satellite Laser Ranging (SLR)

Lageos1 & 2

Starlette & Stella

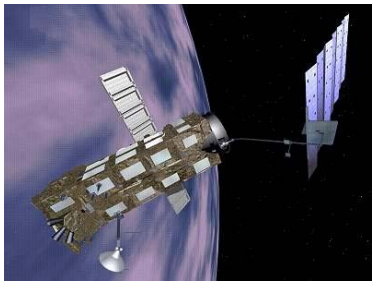
Ajisai

Larets



Westpac

TOPEX Poseidon



Envisat

SLR & DORIS

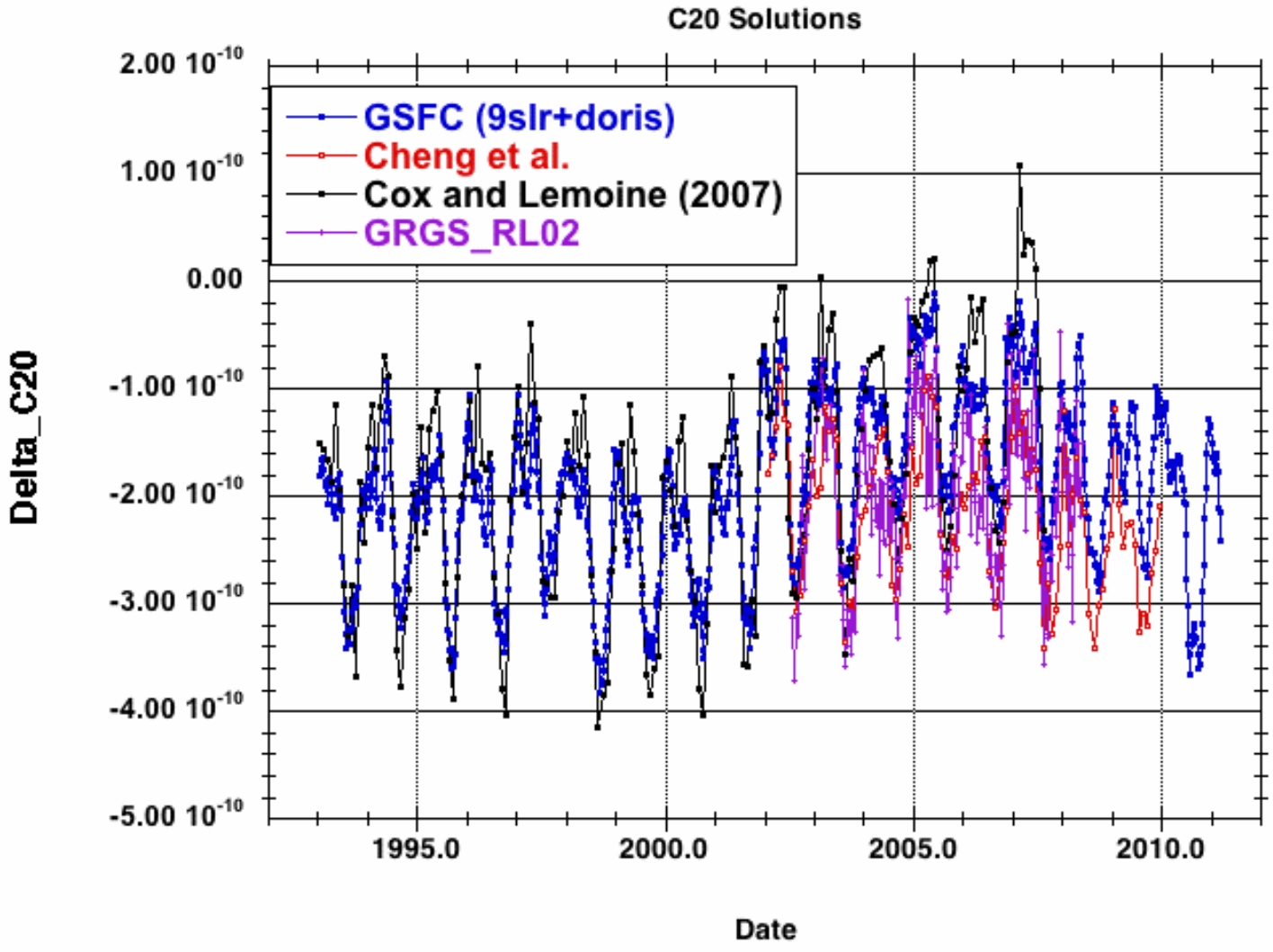
Satellite Data Summary for TVG Solutions (1993-2011)

- ~7 day arcs;
- ITRF2008+fixes.
- weekly solutions weighted by SLR RMS of fit.
- Update to processing of Cox & Lemoine (2007)
- GGM03s, otherwise same modelling as std1007.

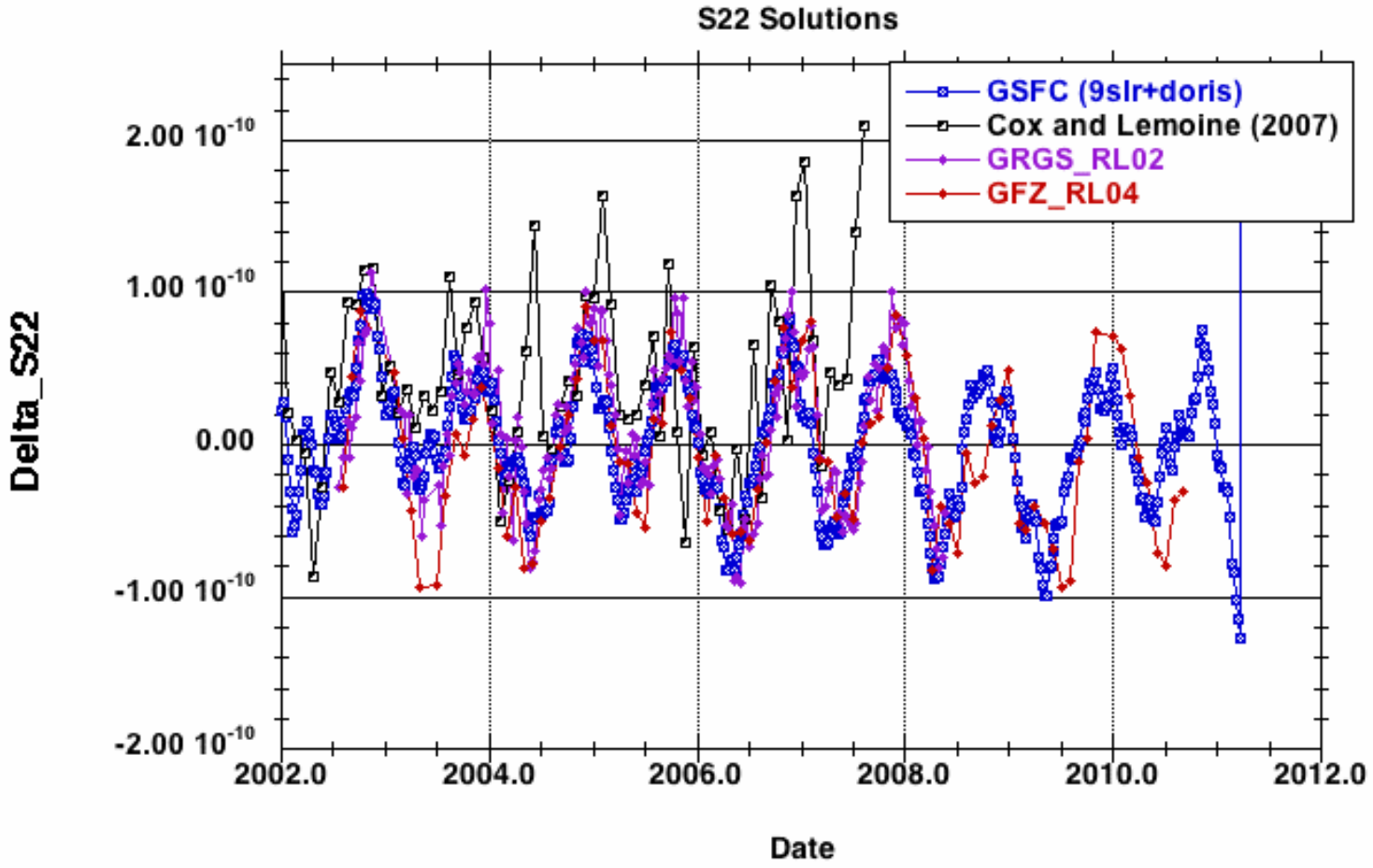
Small contributors

Satellite	Data Span	Avg. Arc RMS of fit	
		SLR (cm)	DORIS (mm/s)
TOPEX	***10/1992-10/2004***	**1.72**	**0.5130**
Envisat	***06/2002 - present***	**1.10**	**0.4810**
Lageos1	*01/1993 - present*	0.92	---
Lageos2		0.90	---
Starlette		1.61	---
Ajisai		2.16	---
Stella	*10/1993 - present*	1.53	---
Westpac	*01/1999 - 12/2001*	*1.32*	---
Larets	*01/2004 - present*	*1.52*	**---**

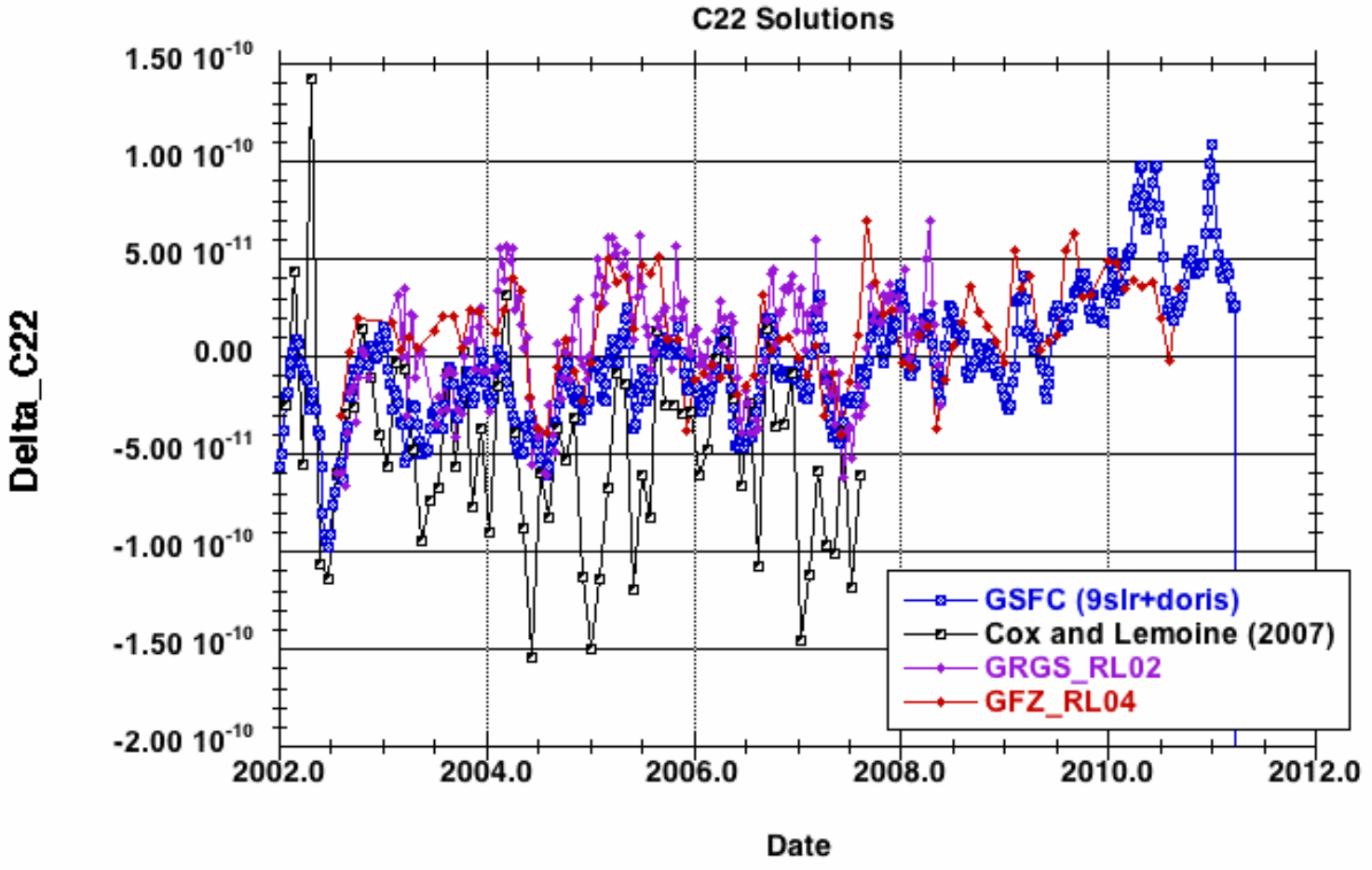
TVG Solutions (1993-2011): *(Some)* Comparisons for C_{20}



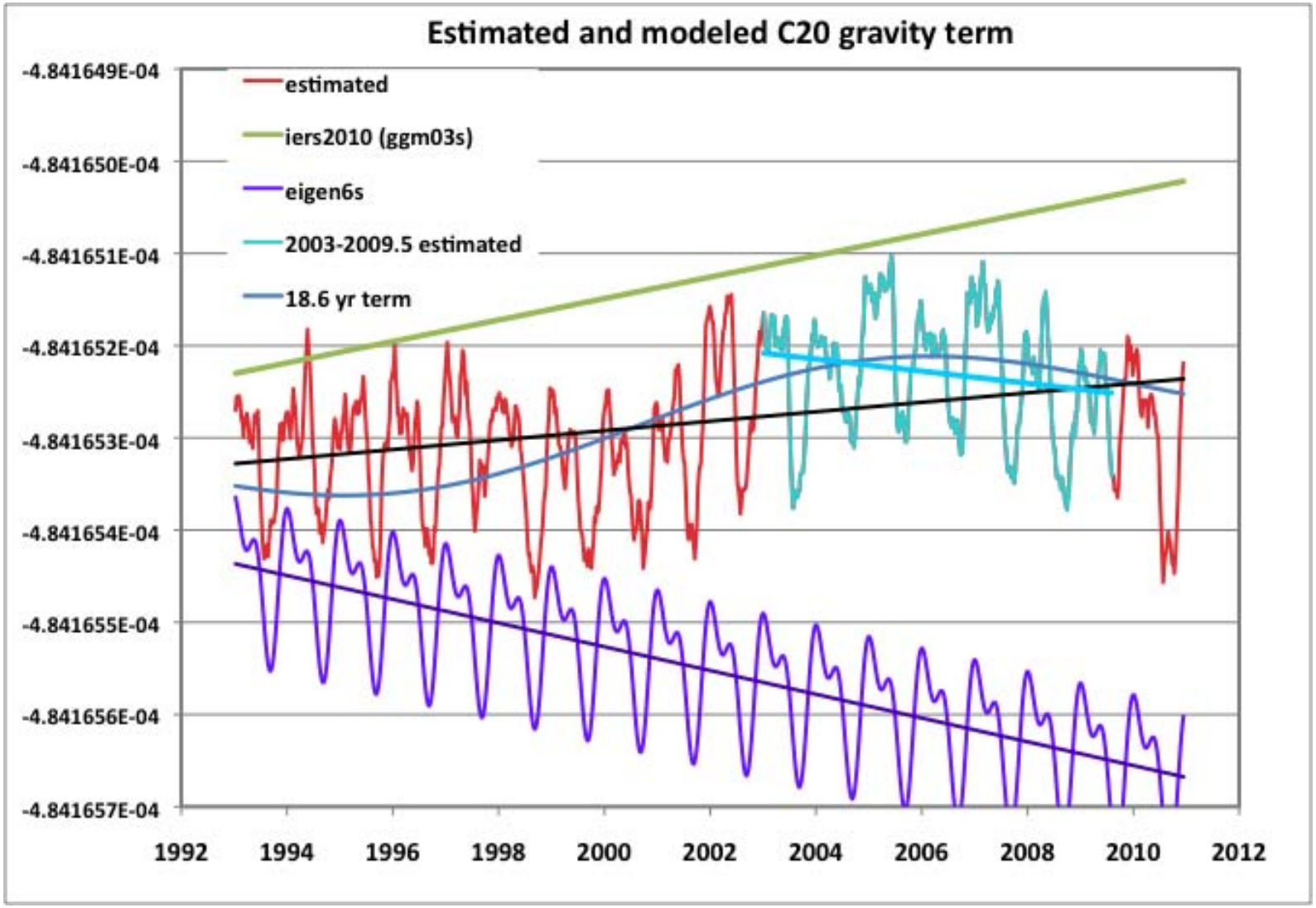
TVG Solutions (1993-2011): *(Some)* Comparisons for S_{22}



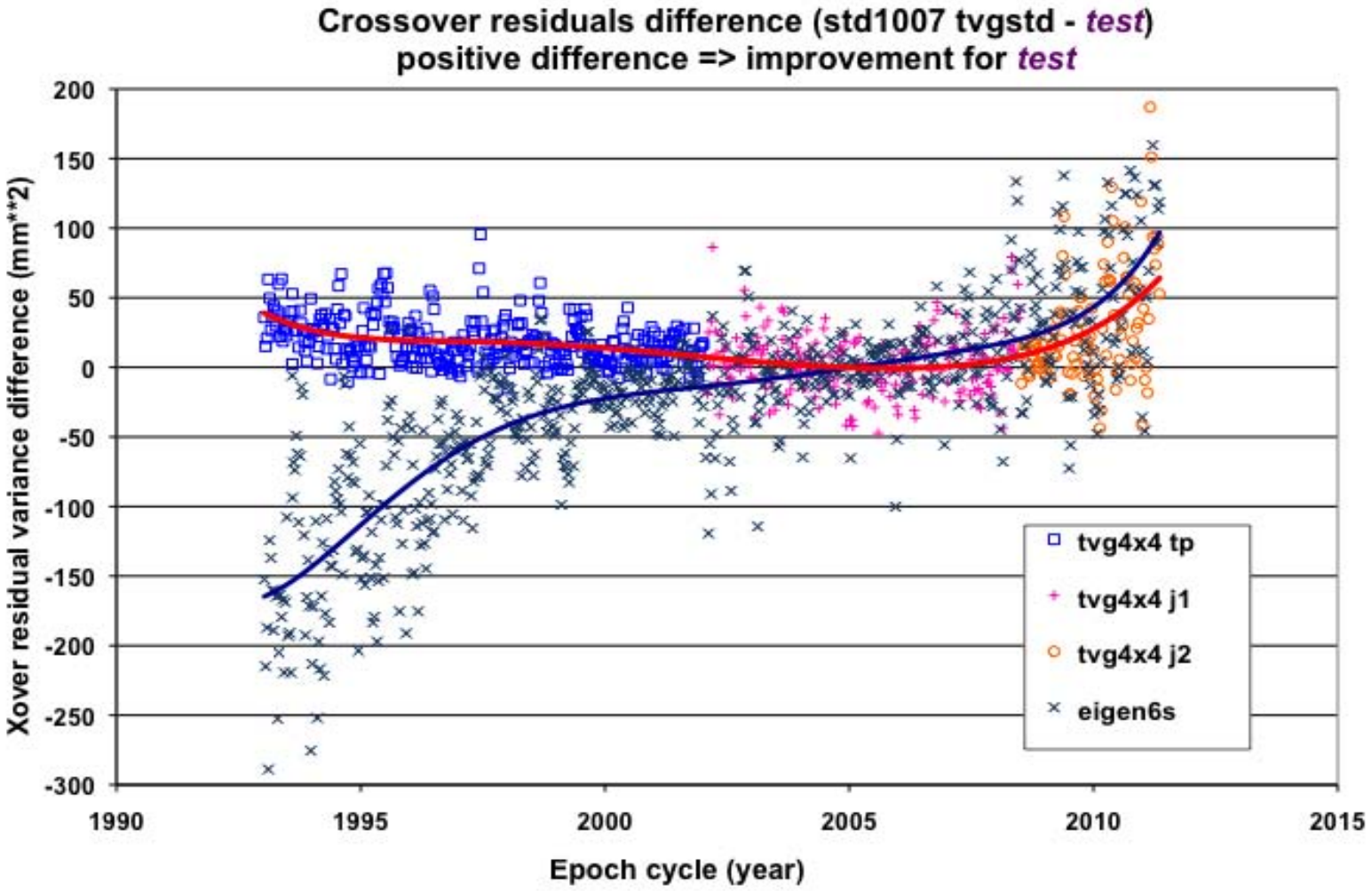
TVG Solutions (1993-2011): *(Some)* Comparisons for C_{22}



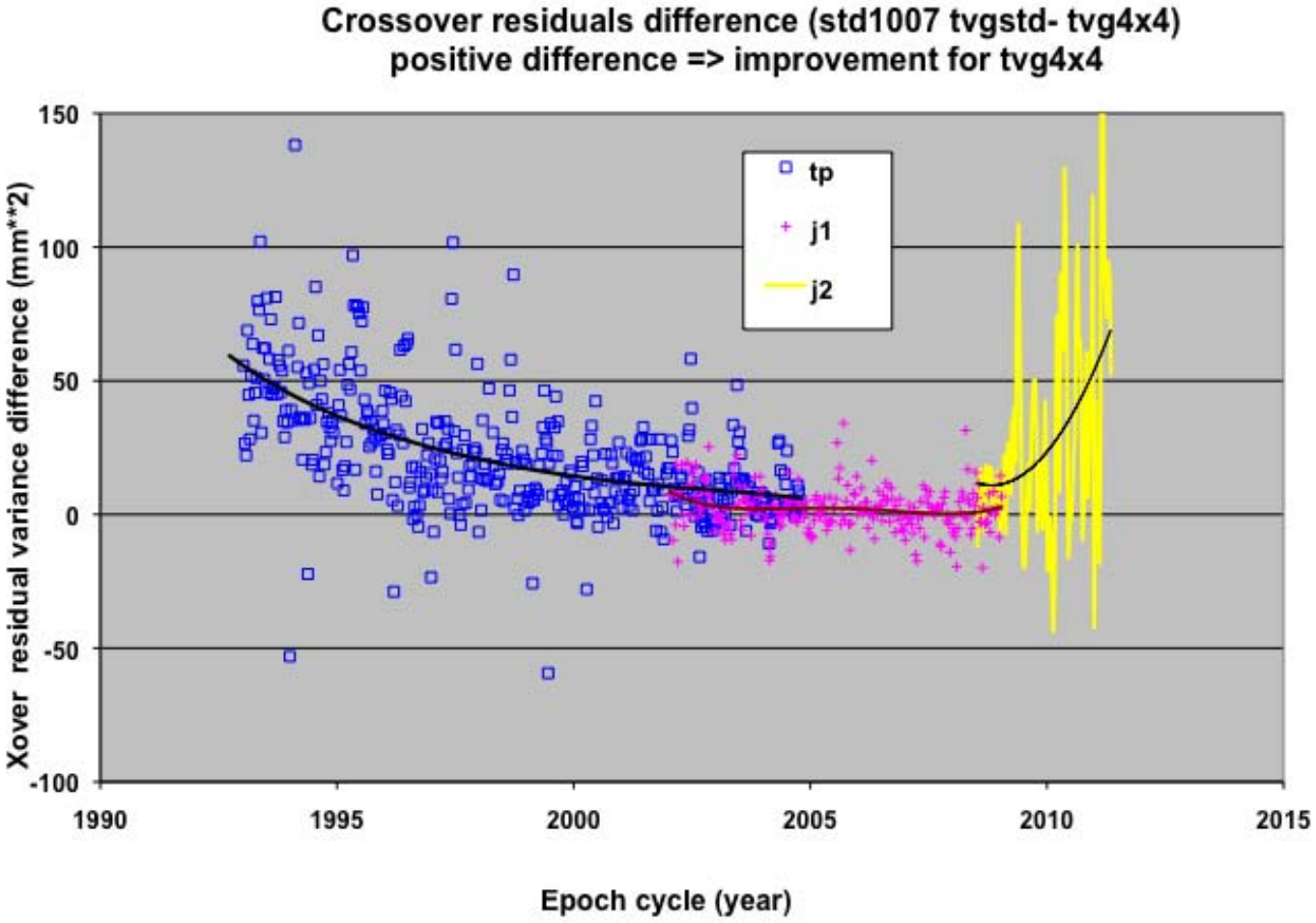
TVG Model Advantages/Disadvantages: Illustration



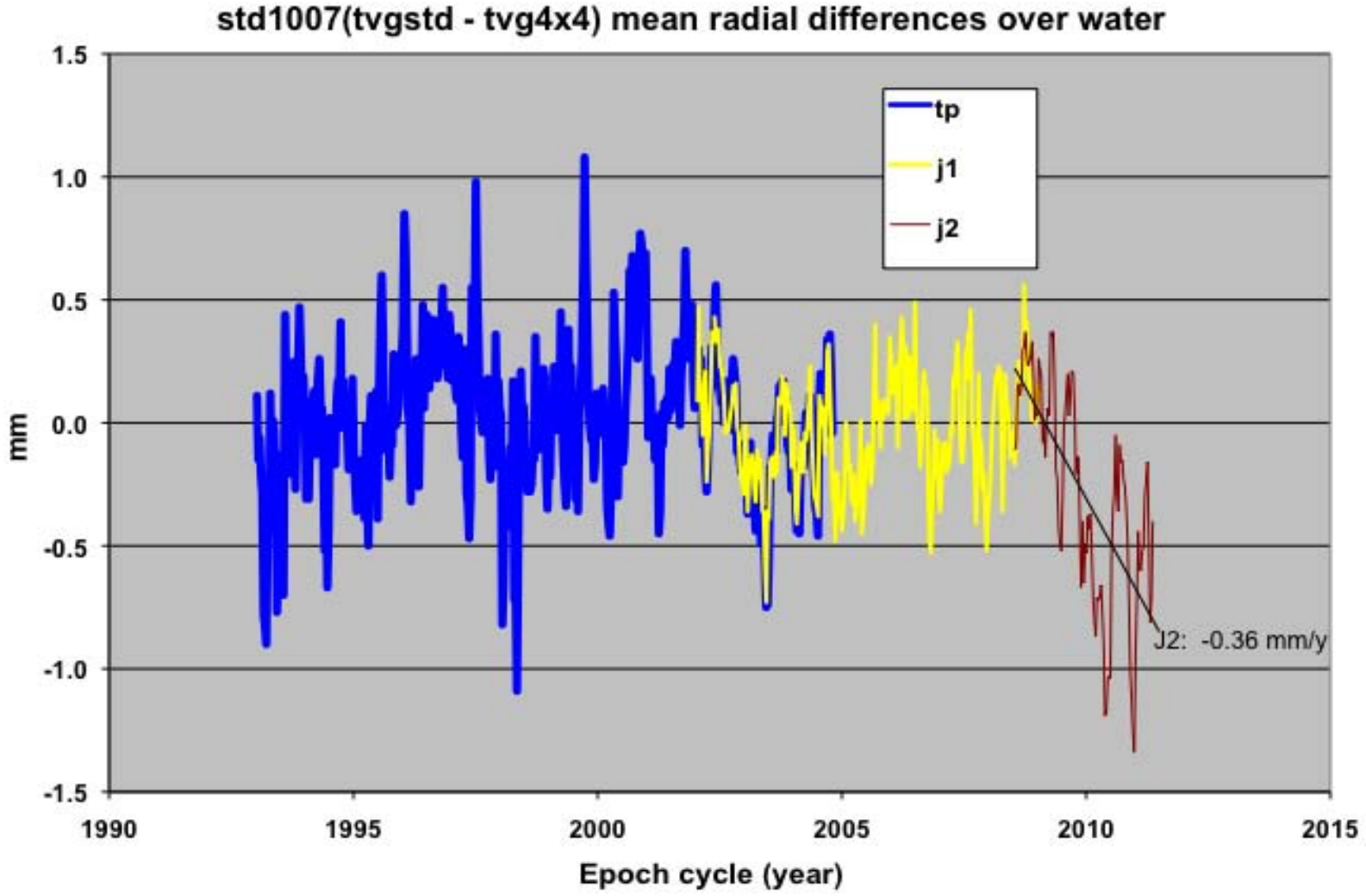
tvg4x4 Shows Orbit Improvement Across TP, J1, J2; Eigen6s only after about 2005



tvg4x4 Shows Orbit Improvement Across TP, J1, J2;

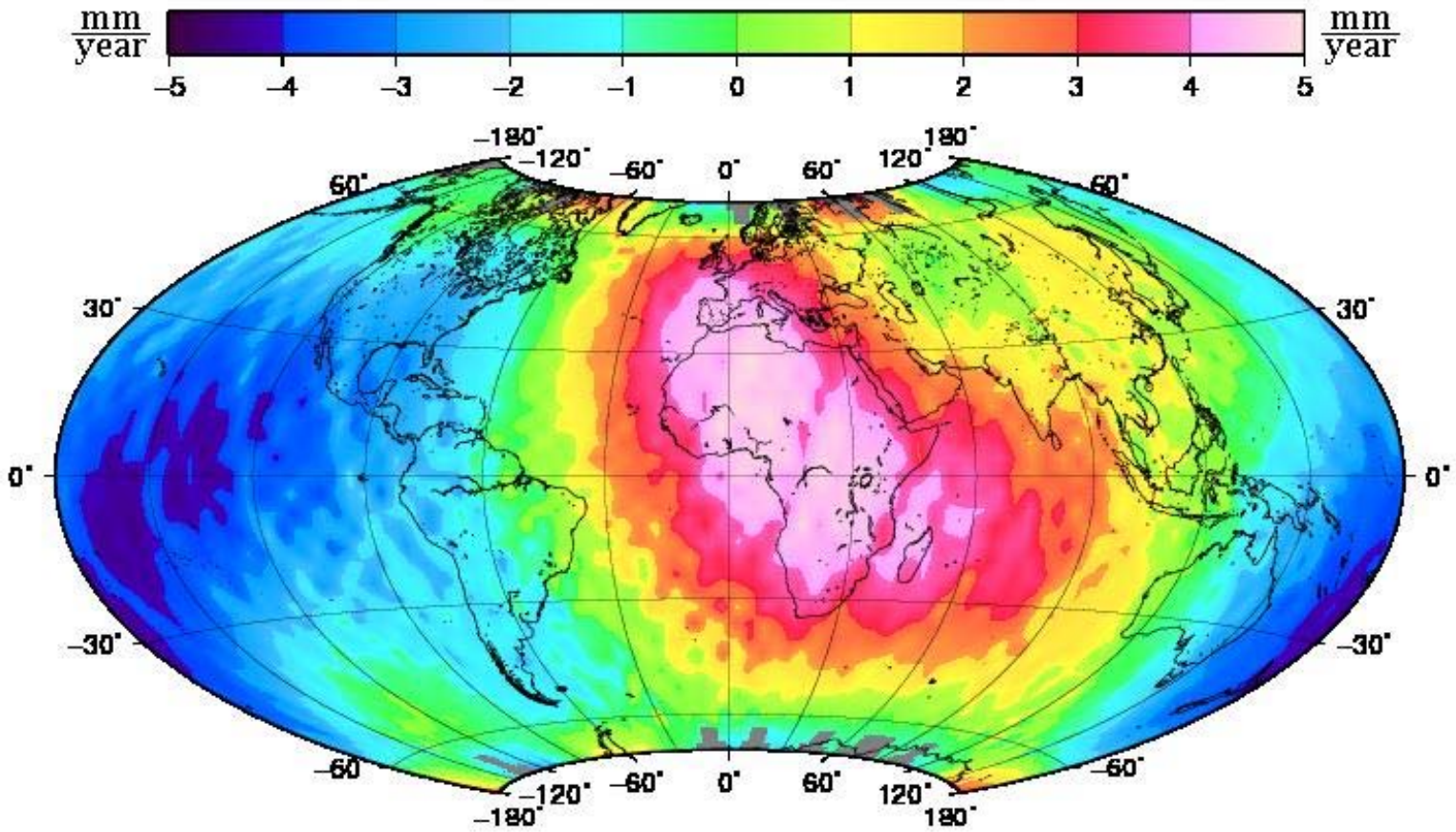


std1007 (tvgstd –tvg4x4) Mean Radial Orbit Differences / cycle, over oceans



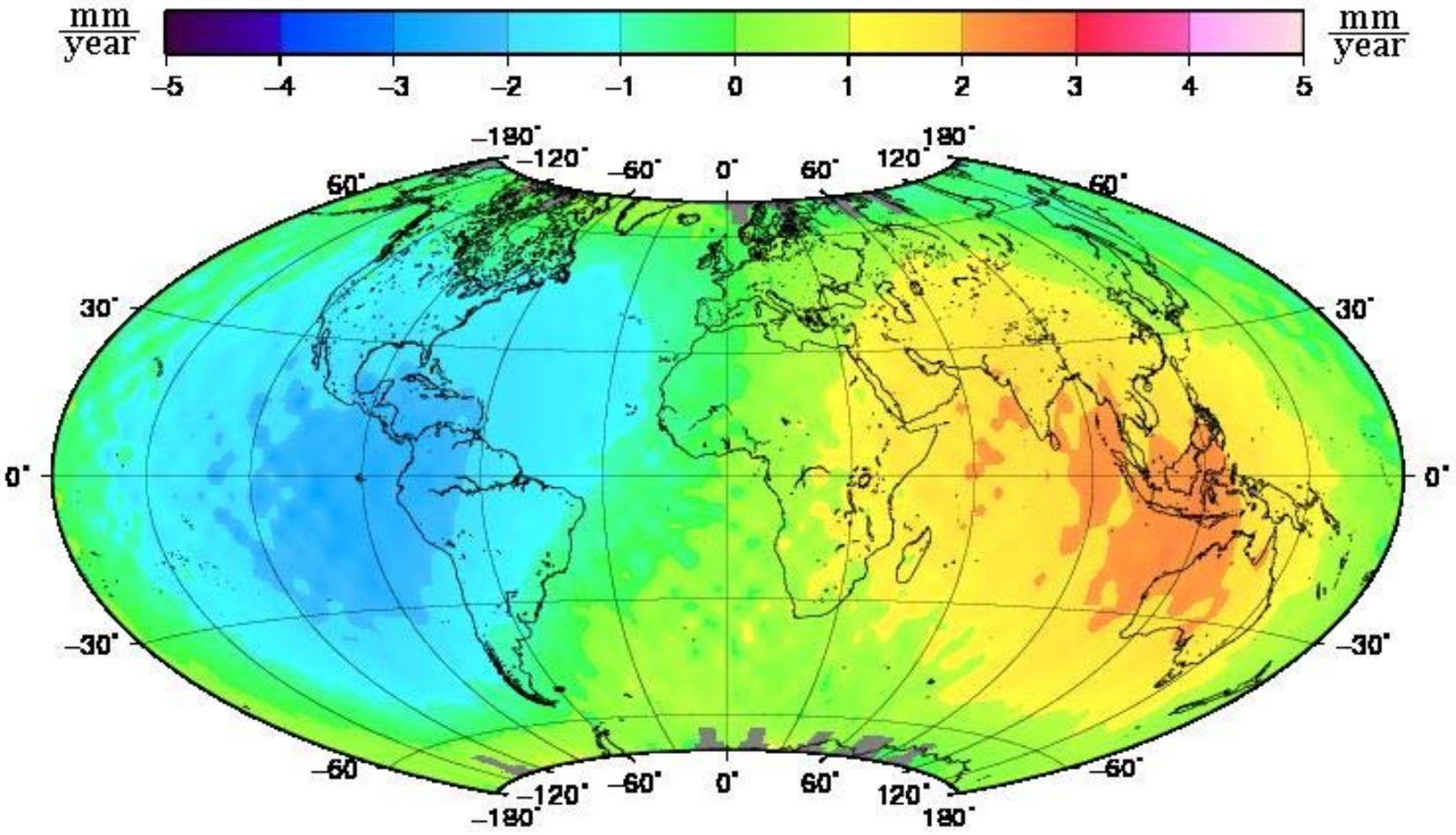
Jason2 std1007 (tvgstd–tvg4x4) Radial Orbit Rates, cycles 1-105

(annual and semi-annual terms removed)



Jason2 std1007 (tvgstd–Eigen6s) Radial Orbit Rates, cycles 1-105

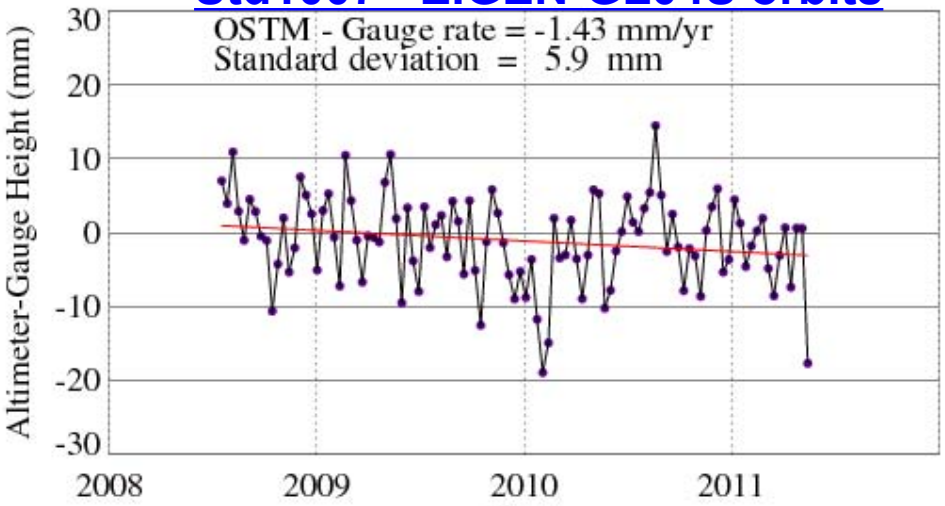
(annual and semi-annual terms removed)



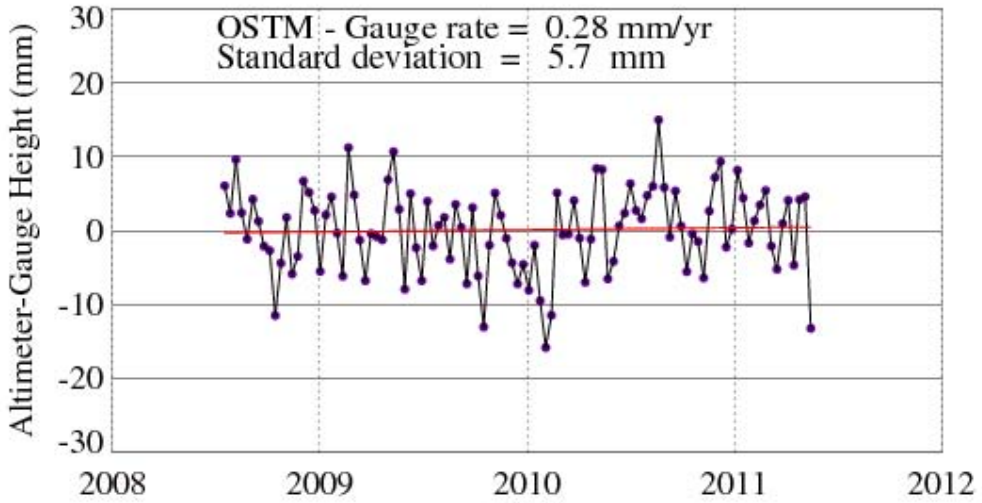
Jason2 Tide Gauge Comparisons

(std1007 vs std1110)

Std1007= EIGEN-GL04S orbits



Std1110=GGM03S + tvg4x4 orbits

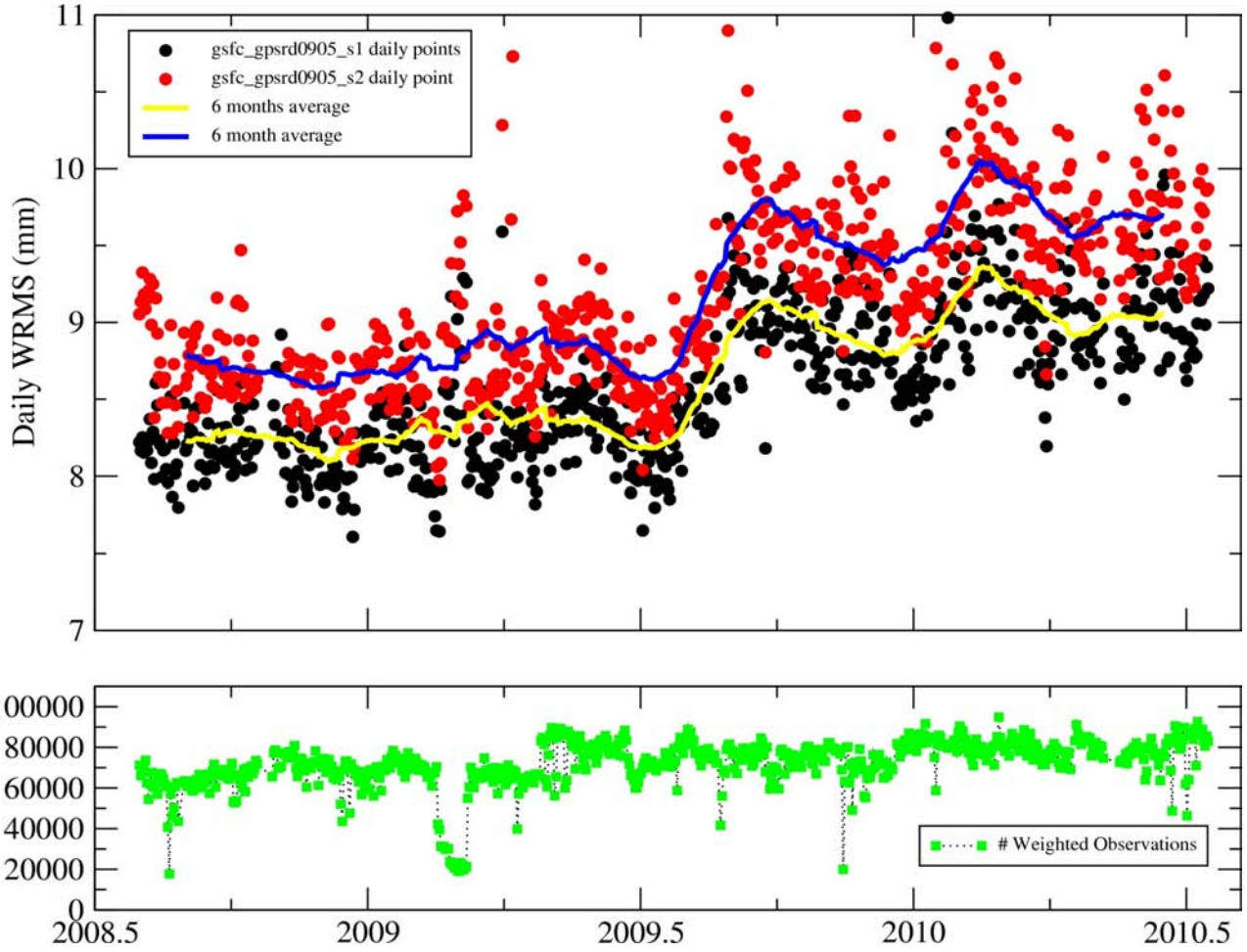


Tide Gauge comparisons from Gary Mitchum (Univ. of South Florida)

GPS Processing Summary

- 38 IGS05 and IGS08 stations
- Tracking data : DD LC iono-free tracking data
- GPS PCOs and PCVs : igs05.atx and igs08_1604_woGLO_final
- IGS05 and IGS08 (w. station corrections) TRF
- 1/hr scale(wet+dry) troposphere (GMF/GPT-hopfield) s1
- Float ambiguities
- J2 JPL GPS antenna PCV map
- J2 revised LC GPS antenna PCO values
- Solutions S1 : troposphere is adjusted /1 hr using 2 paths (1 station + 2 GPS s/c) during the POD
- Solutions S2 : troposphere is adjusted /1 hr using 4 paths (2 stations + 2 GPS s/c) in a ground network solution

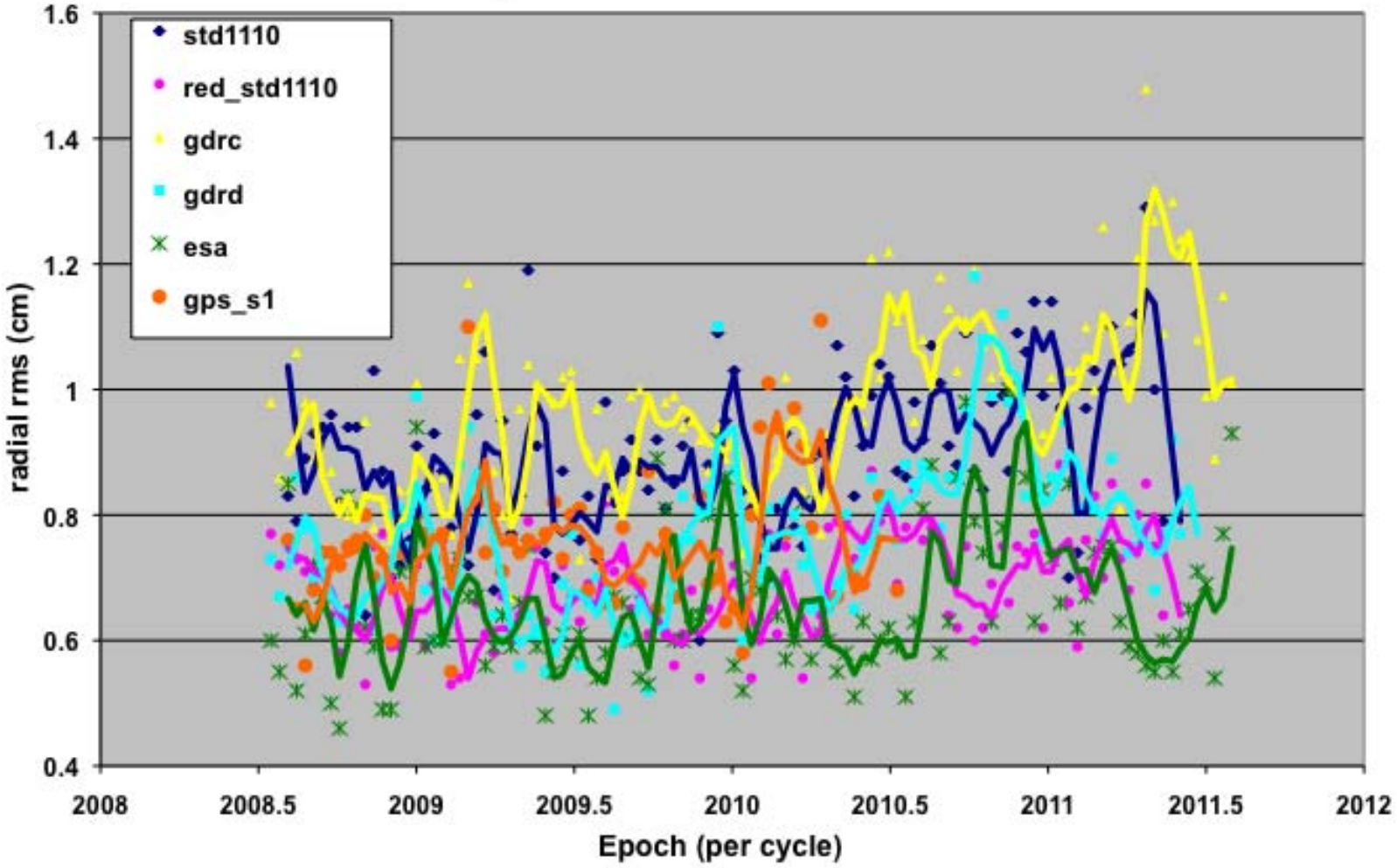
GPS Processing Results



See poster by S. Melachroinos et al. for more details.

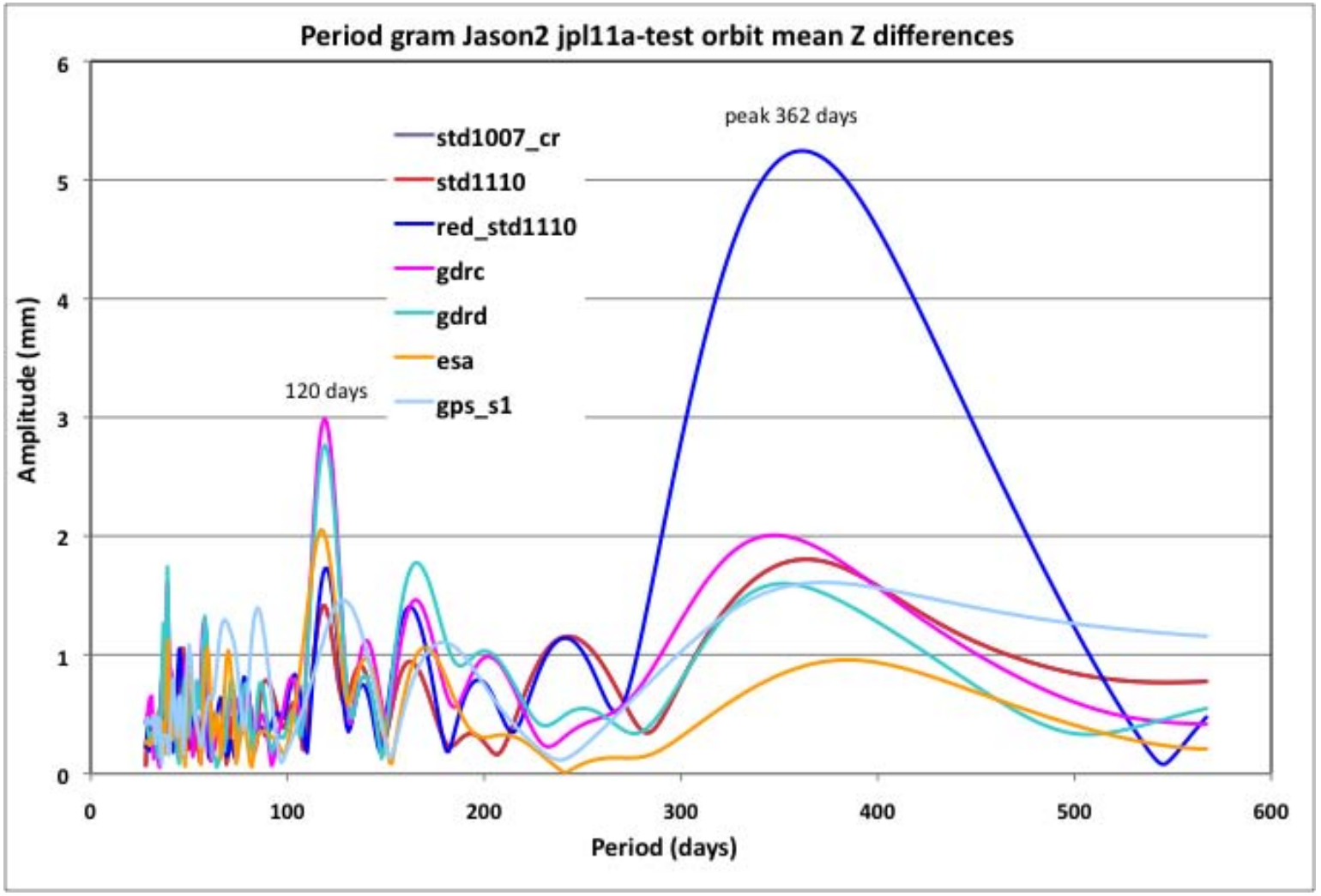
Jason2 Radial RMS Orbit Differences

(SLR+DORIS, GPS-only and SLR+DORIS+GPS orbits wrt. JPL_rlse11a)



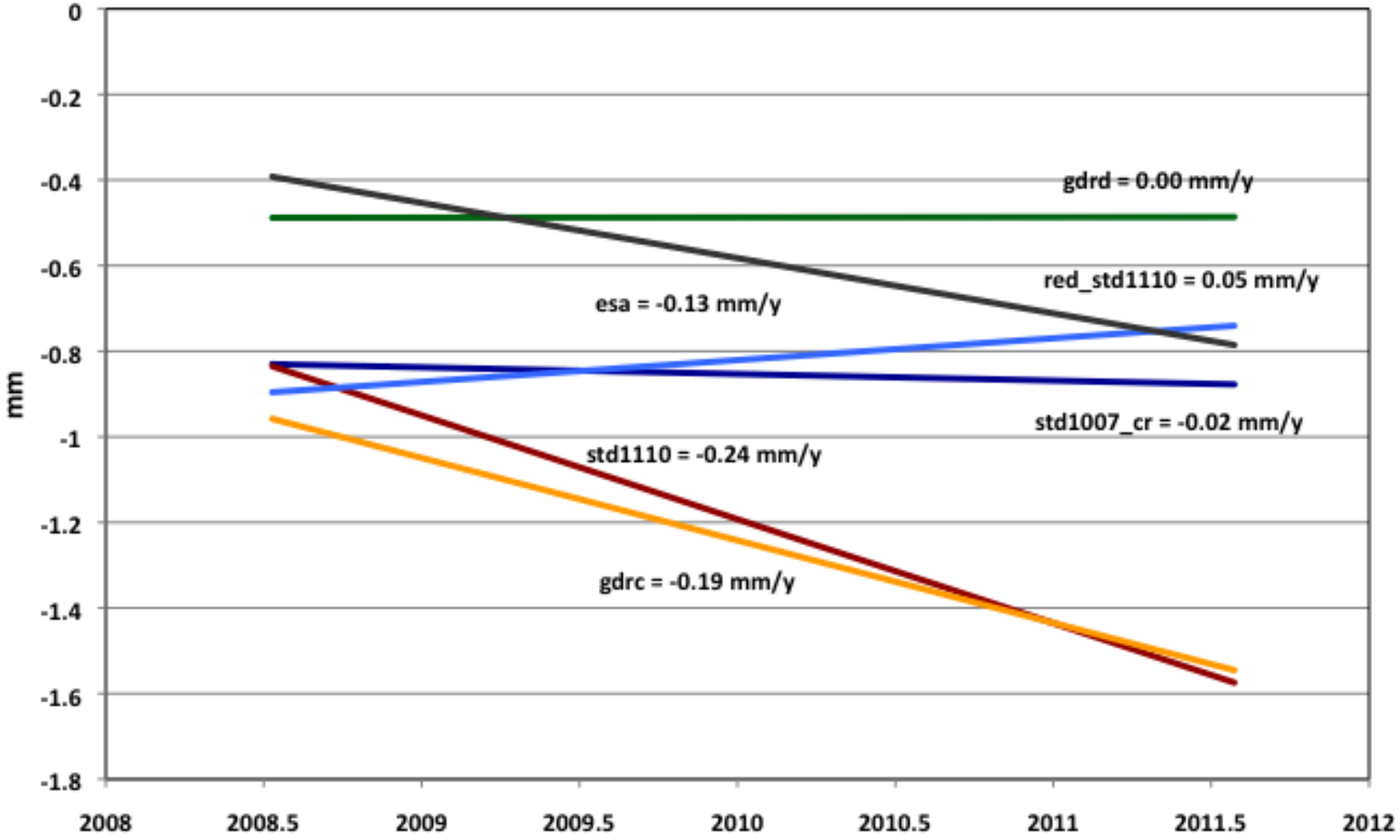
Periodogram, Jason2 orbit mean Z differences

(SLR+DORIS, GPS-only and SLR+DORIS+GPS orbits wrt. JPL_rlse11a)



Jason2 Radial Orbit Difference Rate over Oceans

(SLR+DORIS, GPS-only and SLR+DORIS+GPS orbits wrt. JPL_rlse11a)



Jason-2 Orbit Comparison Summary cycles 1-105

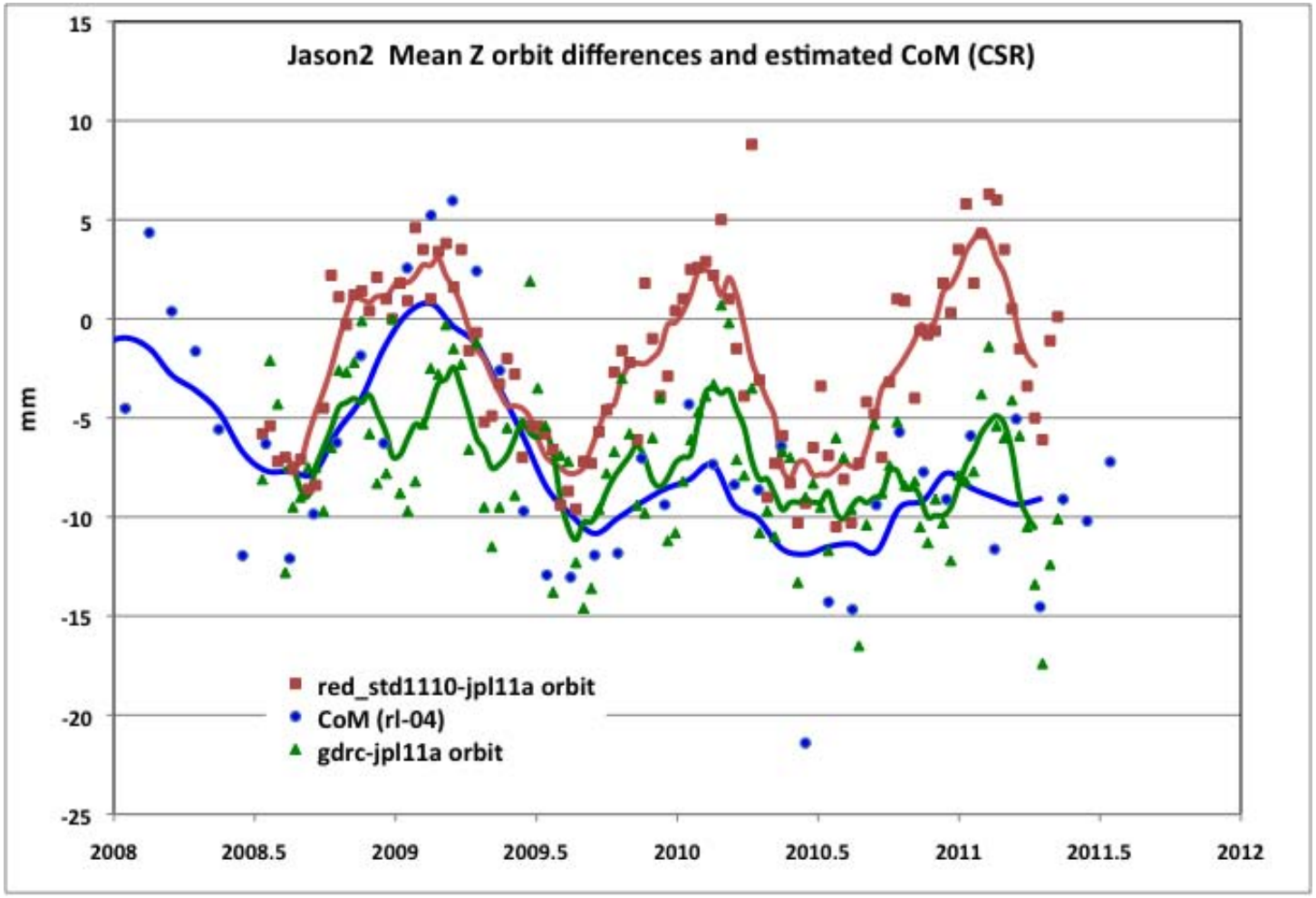
Jason2 Orbit Comparison Summary over Cycles 1 -105							
orbit	average RMS residuals			jpl11a -test orbit (mm)			
	DORIS (mm/s)	SLR (cm)	Xover (cm)	radial rms	ECF Mean X	Y	Z
std1007_cr	0.3704	1.148	5.449	9.2	1.3	-3.4	2.6
std1110	0.3705	1.143	5.421	9.1	3.3	0.5	3.5
red_std1110	0.3696	1.060	5.378	6.9	2.3	-1.3	2.3
gdrc	0.3705	1.160	5.483	9.6	2.3	-4.0	7.3
gdrd	0.3703	1.139	5.441	7.6	2.2	1.4	2.4
esa	0.3702	1.480	5.386	6.6	3.8	0.1	1.8
jpl11a	0.3700	1.139	5.323	---	---	---	---
tst1110	0.3705	1.126	5.422				
red_tst1110	0.3696	1.049	5.382				

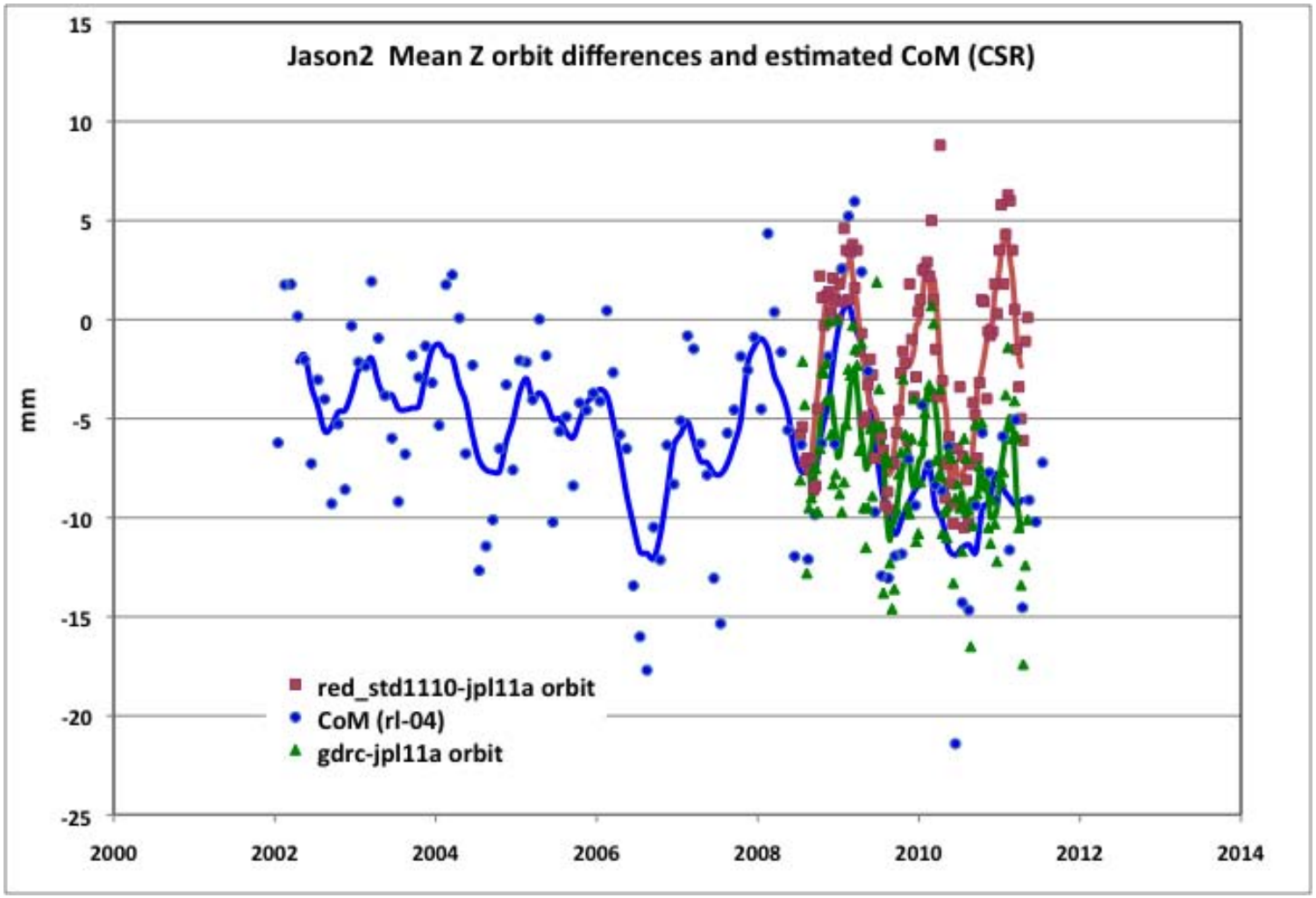
Summary & Conclusions

1) compared to the standard TVG model (**tvgstd**), **tvg4x4** improves the orbits across the TP, J1, J2 missions. Eigens6s improves the orbits only after about 2004.
2) J2 orbits are not sensitive to individual Eigen6s TVG coefficients such as C20, C21, S21. The set of 4x4 low degree & order Eigen6s TVG coefficients contribute 78% to the orbit difference variance using **tvgstd** compared to the full 50x50 set.
3) The **tvgstd** model shows significant and progressive degradation in accuracy since about 2008/2009. The TVG is much better modeled since 2008/2009 using **tvg4x4**, Eigen6s, and also the reduced-dynamic approach with GPS. However, the radial orbits show systematic differences between these different models that affect the MSL rate and tide gauge comparisons.

4) The Jason-2 orbits agree to with 0.9 cm radial RMS -- amongst different centers, but radial and Z-differences have prominent signals at 120-day and annual frequencies;
5) C.O.M modelling & radiation pressure mis-modelling remain open issues.

Backups


Jason2 Mean Z orbit differences and estimated CoM (CSR)
mm
15
10
5
0
-5
-10
-15
-20
-25
2008
2008.5
2009
2009.5
2010
2010.5
2011
2011.5
2012
red_std1110-jpl11a orbit
CoM (rl-04)
gdrc-jpl11a orbit

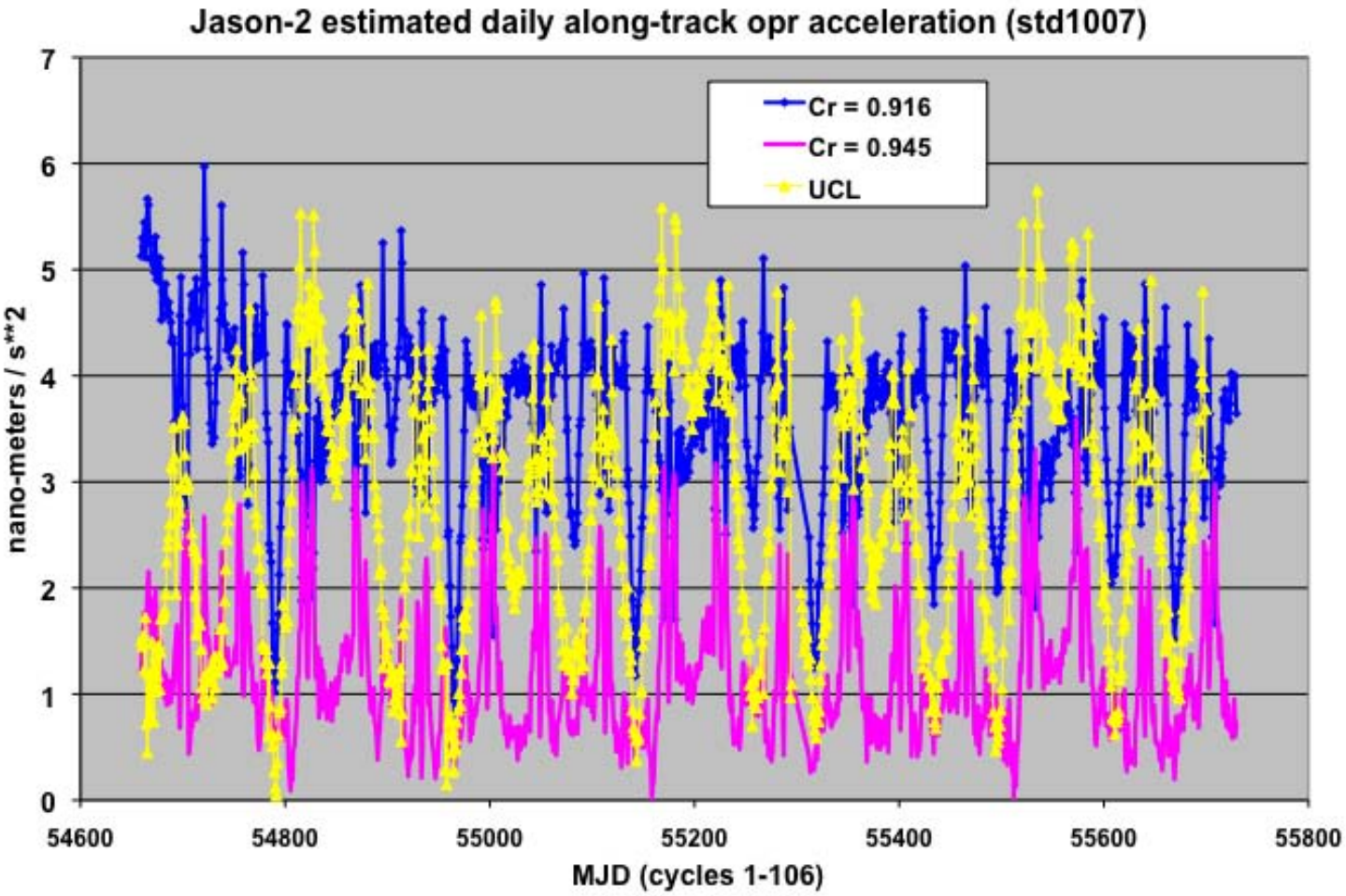

Jason2 Mean Z orbit differences and estimated CoM (CSR)
mm
15
10
5
0
-5
-10
-15
-20
-25
2000
2002
2004
2006
2008
2010
2012
2014
red_std1110-jpl11a orbit
CoM (rl-04)
gdrc-jpl11a orbit

Jason-2 testing SRP Model Improvements cycles 1-103

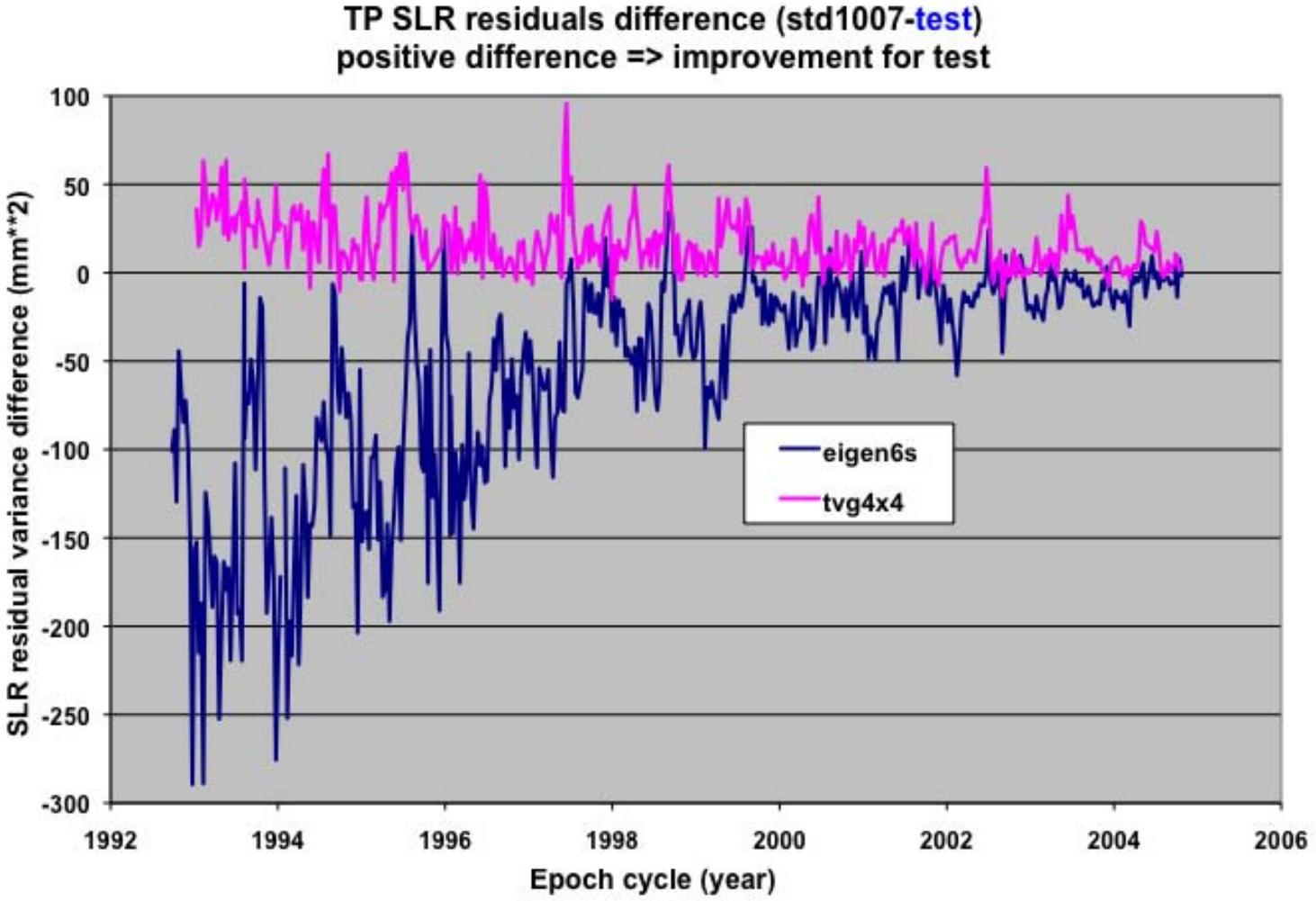
Test slr+doris ITRF2008	points		residuals		
	doris	slr	doris (mm/s)	slr (cm)	xover* (cm)
std1007 (Cr= 0.913)	158566	4386	0.3719	1.123	5.527
std1007_UCL	158566	4386	0.3719	1.132	5.523
std1007_cr (Cr= 0.945) dynamic	158566	4386	0.3719	1.127	5.519
red_std1007 (Cr=.913)	158566	4386	0.3711	1.070	5.469
red_std1007_cr (Cr= 0.945) red_dyn	158566	4386	0.3710	1.083	5.463

*independent data

Jason-2 testing SRP Model Improvements cycles 1-103



TOPEX SLR Residual Variance Difference for new TVG models



Jason2 Periodogram of Geographically Fixed Radial Differences std1007 (tvgstd –tvg4x4) cycles 1-105