

New GSC POD Standards for TOPEX/ Poseidon, Jason-1, Jason-2 (OSTM)

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Introduction:



From the last OSTST (2013):

“The outstanding problem we face in POD is how to deliver a consistent and stable orbit using a combination of static and time-variable gravity model with minimal latency.”

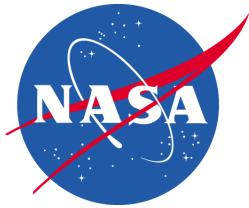
Therefore, we have focused our work on the past year to

- (1) Refine & Evaluate our 5x5 SLR-DORIS-based time-variable gravity time series.
- (2) Develop a derivative that could be used for routine TVG computations.
- (3) Evaluate other geopotential models and TVG time series for TP, J1, J2 POD.

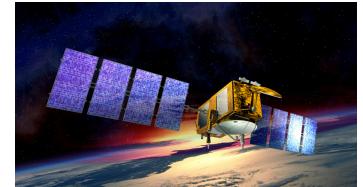
In addition we have implemented specific improvements:

- (1) IERS2010 standards (*Petit and Luzum, 2010, Table 7.7, pp.115*).
- (2) Vienna Mapping Function-1 (VMF-1) for routine DORIS troposphere refraction correction.
- (3) DORIS antenna phase map corrections.

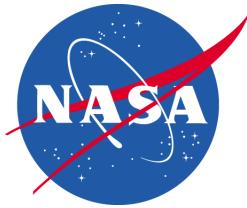
**We have also evaluated use of forward models for Earth center of mass variations and the application of atmospheric loading
(See presentation by N. Zelensky in the POD splinter).**



GSFC POE Description



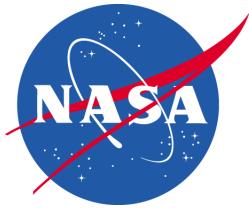
GSFC SLR + DORIS orbits	Description
std1007	GDR-C comparable. EIGEN-GL04S. 5 linear gravity terms.
std1204	GDR-D comparable. (stk4x4) Parameter fit to 4x4 from previous TVG SLR+DORIS solutions.
tvg5x5_gsfc	Smoothed 7-day TVG time series (5x5) derived from tracking of 20 SLR+DORIS satellites (1993-2014). Used at GSFC for ITRF2013.
std1404 (stk5x5)	Time-wise parameter fit (5x5) to tvg5x5_gsfc
std1404_reddyn	SLR+DORIS Reduced-dynamic orbit.
stk5x5 est. C_{31}/S_{31}	as std1404, but Estimate per arc C_{31} & S_{31}
eigen-6s2	GRACE, LAGEOS, GOCE solutions of static, periodic, linear terms in periods: 1) 2x2 1986-2002, 2) 50x50 2013-2013;
tvg5x5_csr	GRACE-derived CSR RL05 monthly solutions. Use with GGM05s
tvg60x60_csr	GRACE-derived CSR RL05 monthly solutions. Use with GGM05s.



General Model Summary (std1404)



Model Summary	std1204 (previous Measures)	std1404 (new, Prelim)
Station coordinates	SLRF2008, DPOD2008	Some updates
Dynamic tides	GOT4.8	Same
Ocean loading	GOT4.8	Same
J2 Cr	Tuned 2011	Same
DORIS Troposphere	GPT/GMF; Est. wet.	VMF1
J1/J2 OPR	12-hr	Same
Pole Model	IERS2003	IERS2010
Static gravity	GOCO2S (> L=4)	GOCO2S (> L=5)
TVG	Harmonic fit to 4x4 weekly solutions	Harmonic piecewise fit to 5X5 weekly solutions



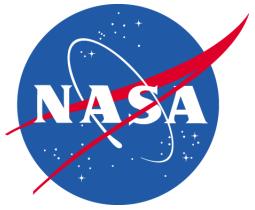
tvg5x5 time series description



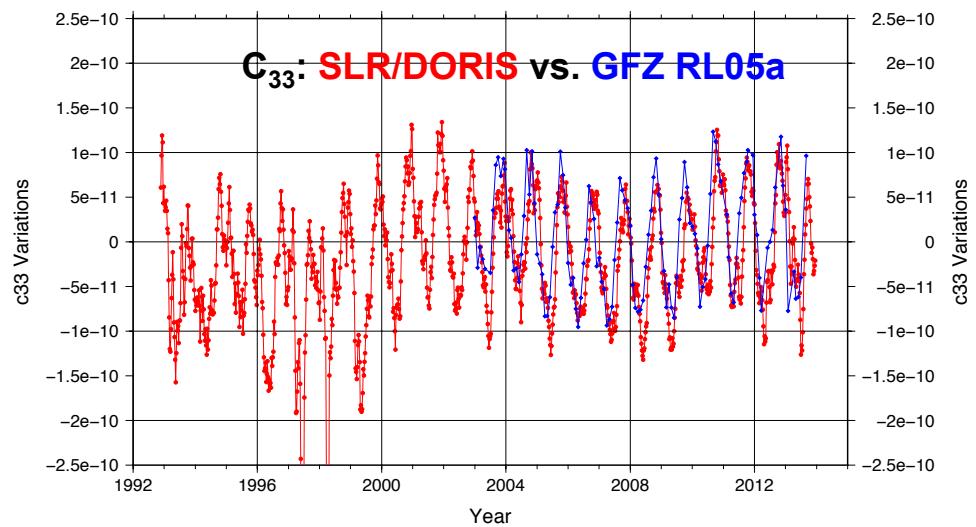
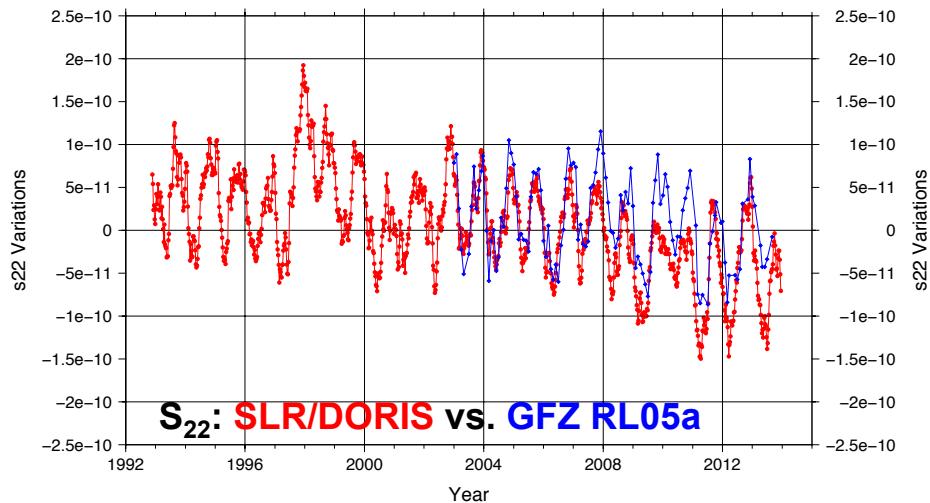
- **20 SLR+DORIS satellites, mostly 7-day arcs (1993-2014).**
(Lageos1, Lageos2, Starlette, Stella, Ajisai, TOPEX, Jason-1, Jason-2 SPOT-2, SPOT-3, SPOT4, Envisat, Larets, Cryosat-2, Blits, Westpac, Lares, Etalon-1, Etalon-2)
- **Subset solution analysis to converge on adopted weights.**
- **Smoothed with a moving window over several solution periods.**
- **Used for ITRF2013 @ NASA GSFC for IDS submission.**
- **Solution compares well with independent solutions to 4x4; Order 1 terms (C_{31}/S_{31} , C_{41}/S_{41}) not so well determined.**

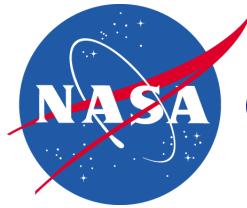
stk5x5 description

**Harmonic fit to tvg5x5 time series by time period.
1992.0 to 2003.0; 2003.0 to 2007.0; 2007.0 to 2014.0**

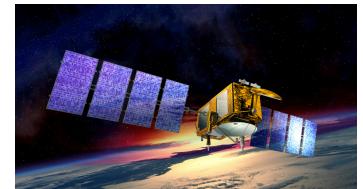


tvg5x5 time series: examples





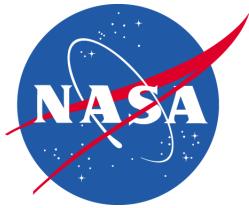
Gravity POD tests using Jason2 SLR+DORIS



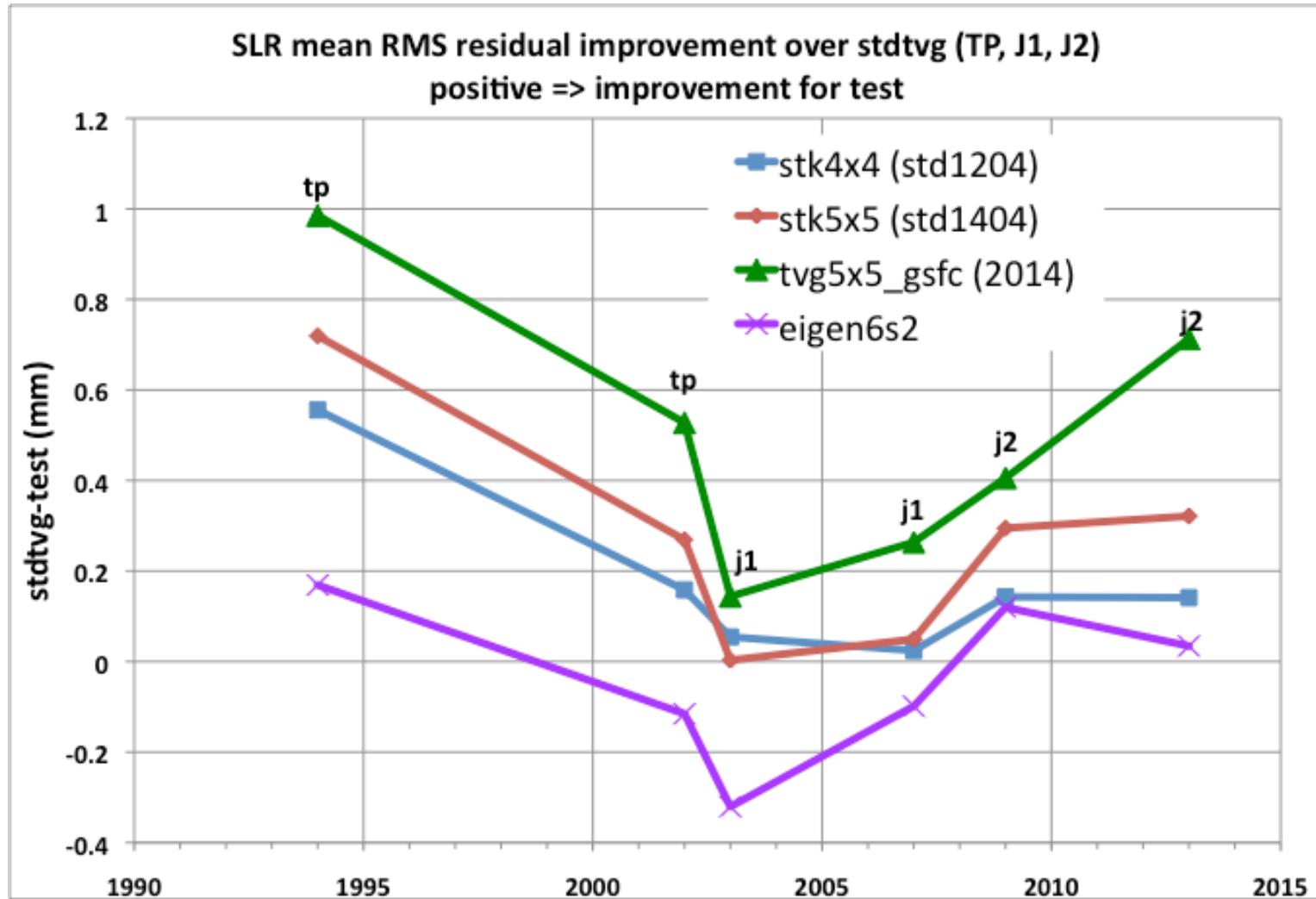
New orbits (swt2014)

Test gravity model std1204 SLR+DORIS POD (external ephemeris residuals)	Jason-2 55 arcs span 2008-2009			Jason-2 63 arcs span 2012-2013		
	DORIS (mm/s)	SLR (cm)	Xover (cm)	DORIS (mm/s)	SLR (cm)	Xover (cm)
stdtvg (std1007)	0.3765	0.940	5.475	0.3803	1.092	5.364
stk4x4 (std1204)	0.3764	0.925	5.462	0.3801	1.078	5.336
stk5x5 (std1404, prelim)	0.3764	0.910	5.453	0.3800	1.060	5.313
stk5x5 est. C_{31}/S_{31}	0.3763	0.900	5.454	0.3799	1.038	5.312
eigen-6s2	0.3763	0.928	5.457	0.3799	1.036	5.316
tvg5x5_gsfc	0.3764	0.899	5.451	0.3799	1.021	5.309
** tvg5x5_csr	0.3763	0.907	5.452	0.3799	1.051	5.307
** tvg60x60_csr	0.3763	0.905	5.452	0.3797	1.014	5.303

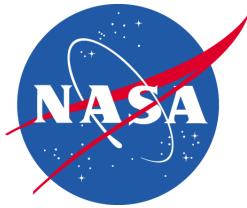
** cannot be extended prior to GRACE launch in 2002.



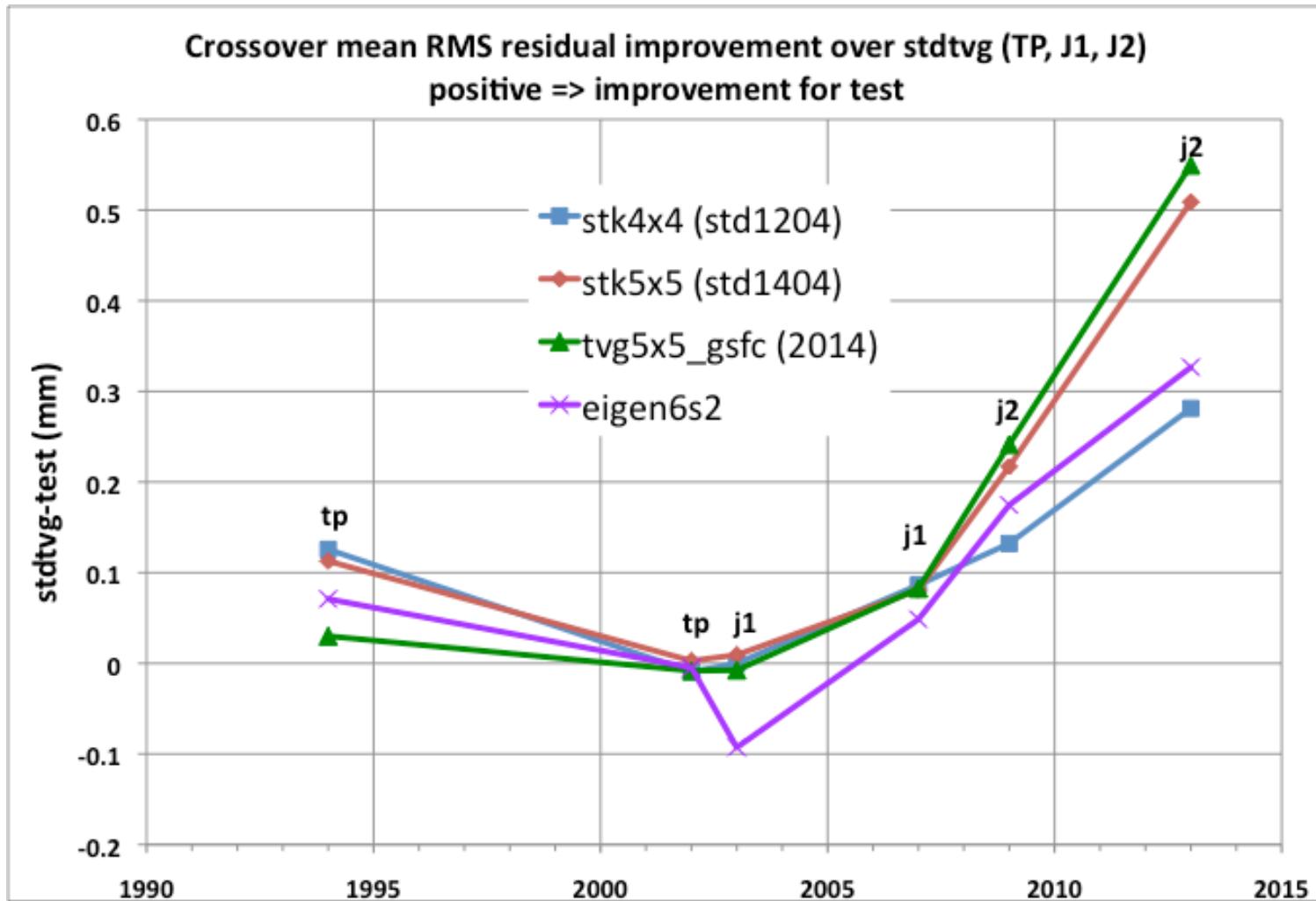
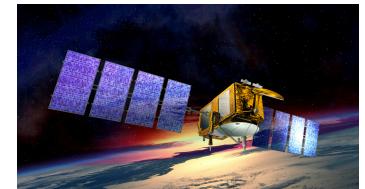
Orbit Improvement seen by SLR (comparisons wrt. EIGEN-GL04S1)



Lemoine et al., 2014; New POD Standards (std1404), OSTST, Konstanz, Germany



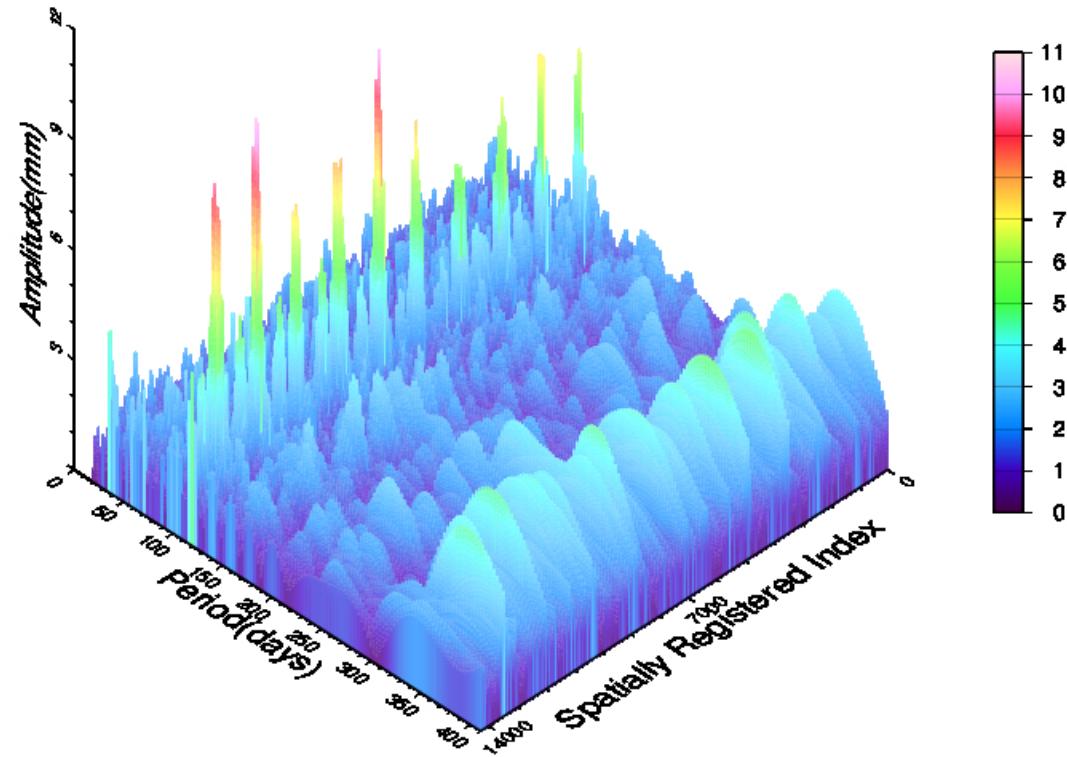
Orbit Improvement seen by Crossovers (comparisons wrt. EIGEN-GL04S1)

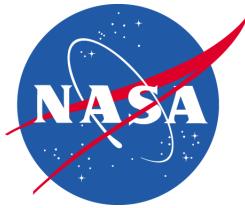


Lemoine et al., 2014; New POD Standards (std1404), OSTST, Konstanz, Germany

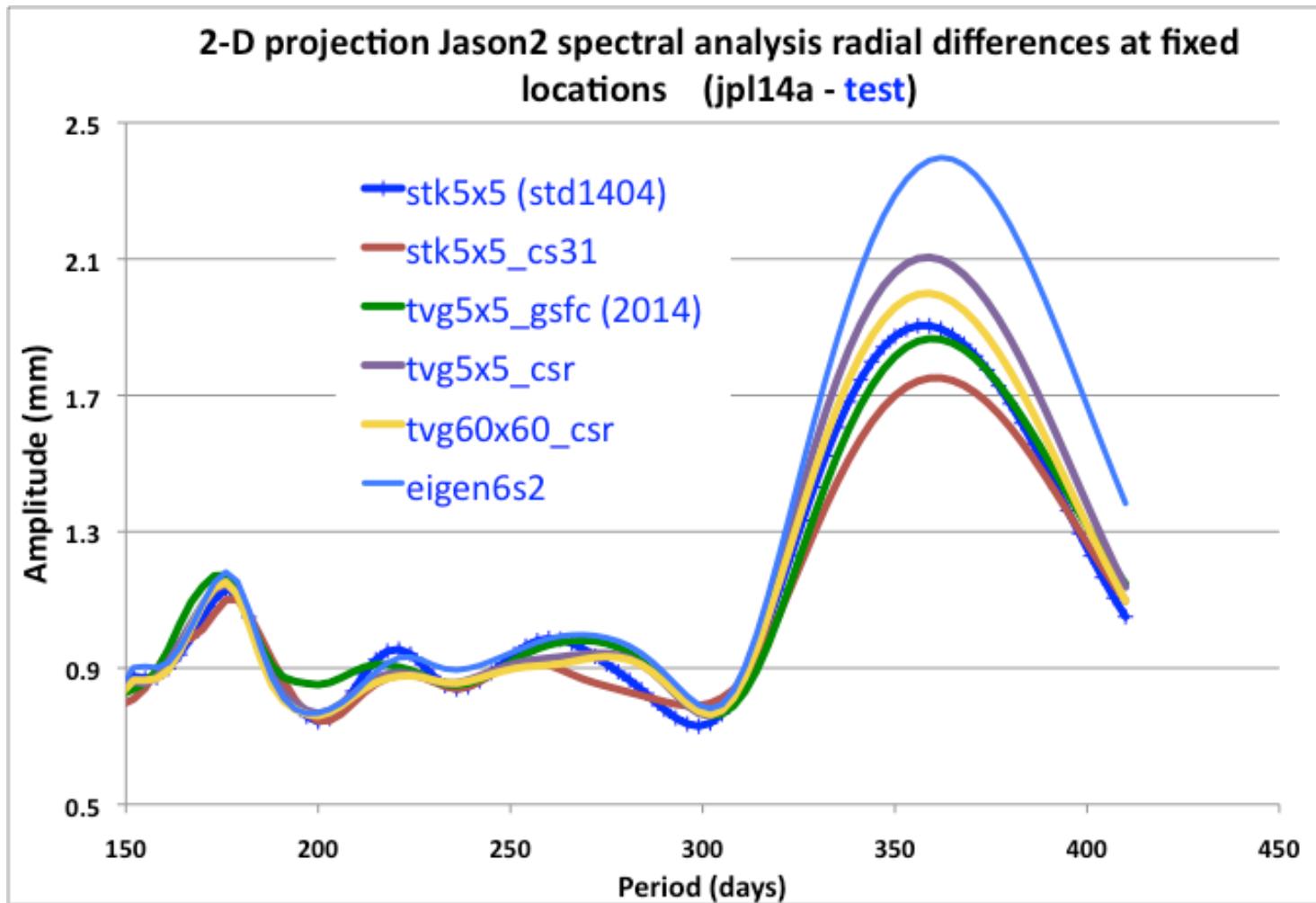


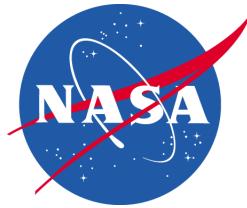
(jpl14a-stk5x5) radial differences at fixed geographic points (2008-2013)



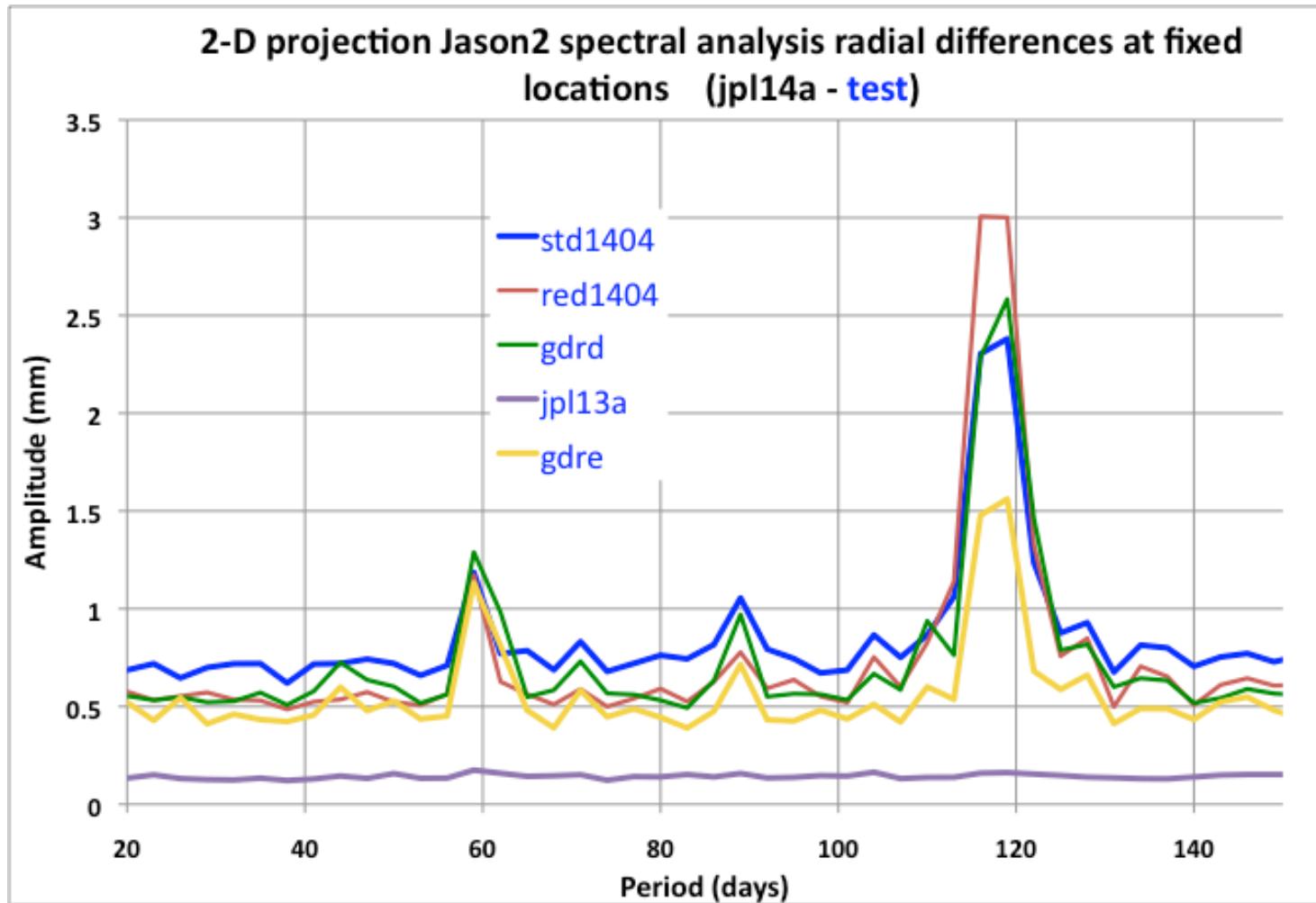


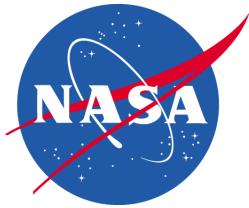
2-D projection of 3-D spectral plots wrt. jpl14a (2008-2013). (I)





2-D projection of 3-D spectral plots wrt. jpl14a (2008-2013). (II)

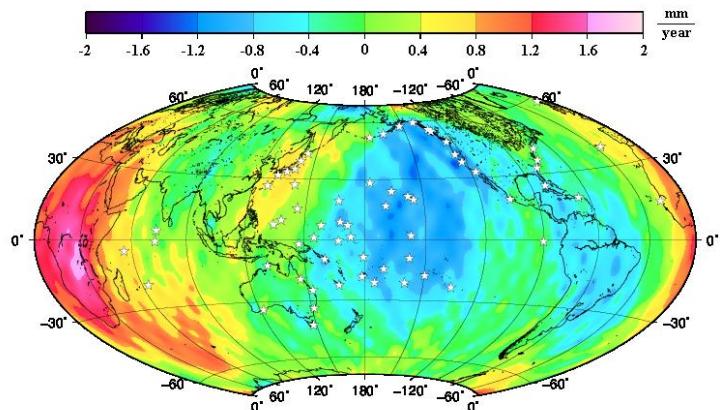




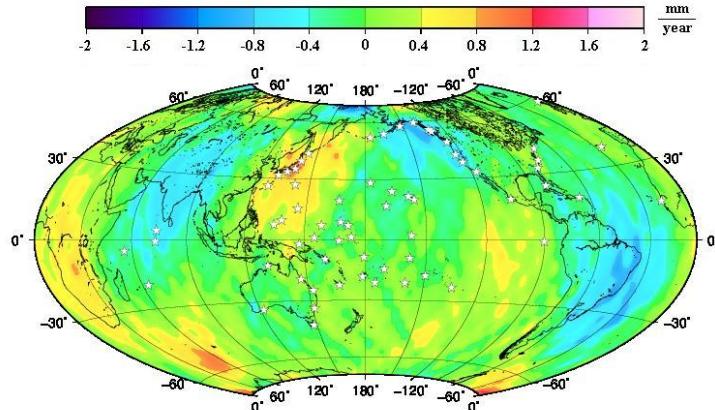
Radial Orbit Difference Rates for Jason-2 (Cycles 1-191); jpl14a (gps-reddyn) - Test



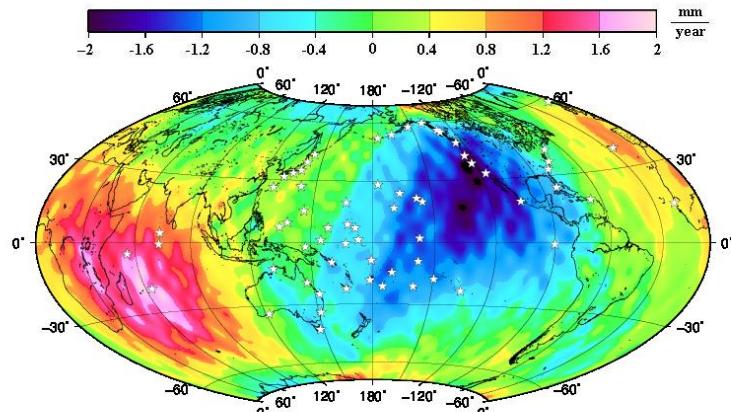
stk5x5_9k2 – jpl14a



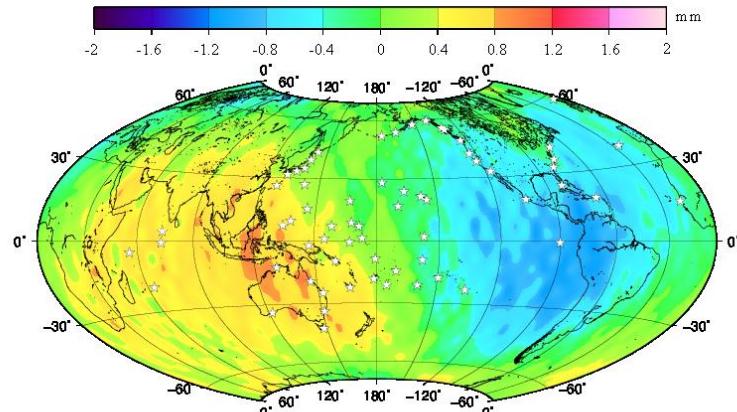
stk5x5_9k2_estC₃₁S₃₁ – jpl14a

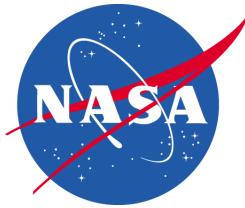


eigen6s2 – jpl14a



gdrd – jpl14a

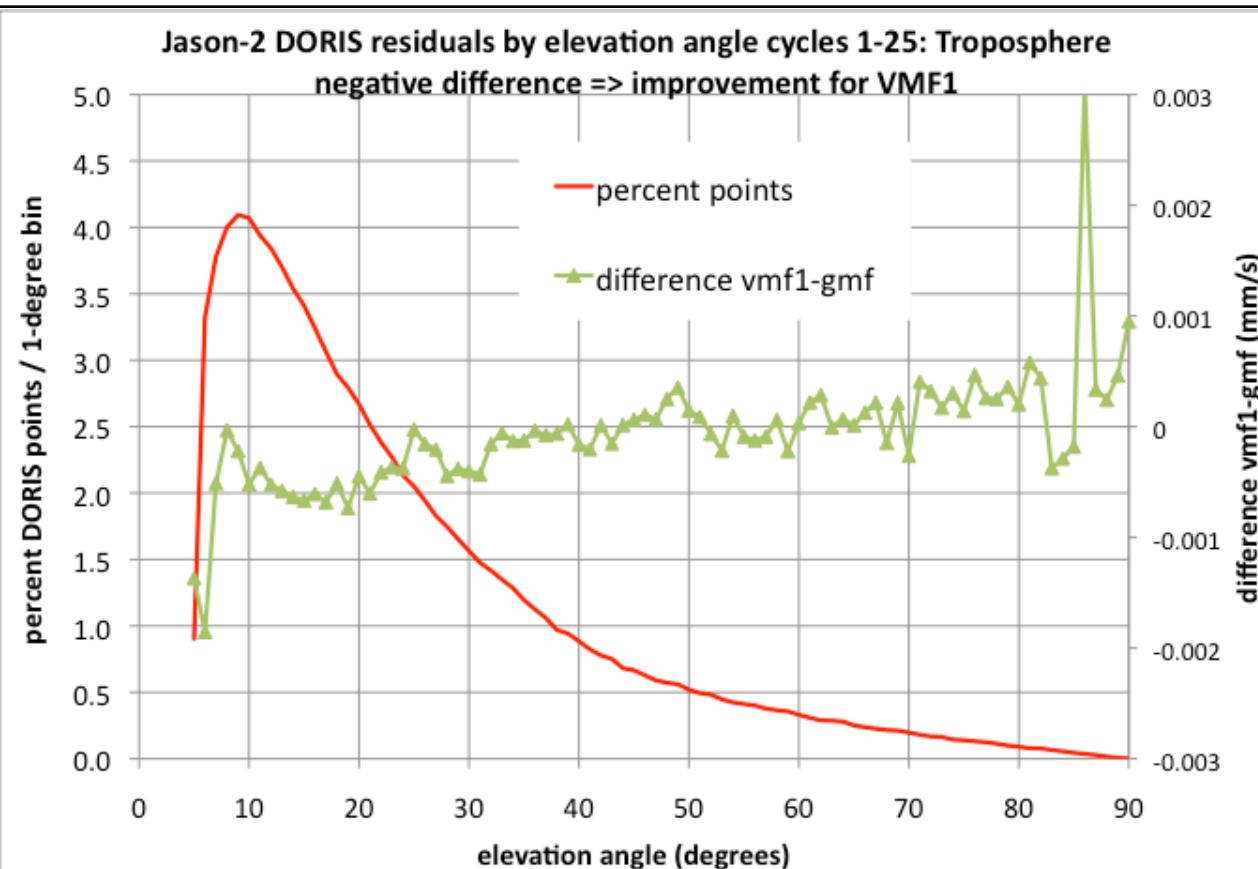




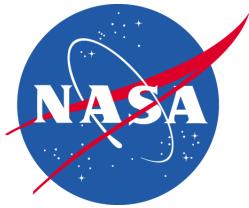
Testing of VMF1 on Jason-2 DORIS data



6-hrly grids from TU Wien (<http://ggoatm.hg.tuwien.ac.at>), derived from ECMWF, supply Zenith delays (hydrostatic and wet), which are then mapped to the station height & the elevation of observation.



Lemoine et al., 2014; New POD Standards (std1404), OSTST, Konstanz, Germany



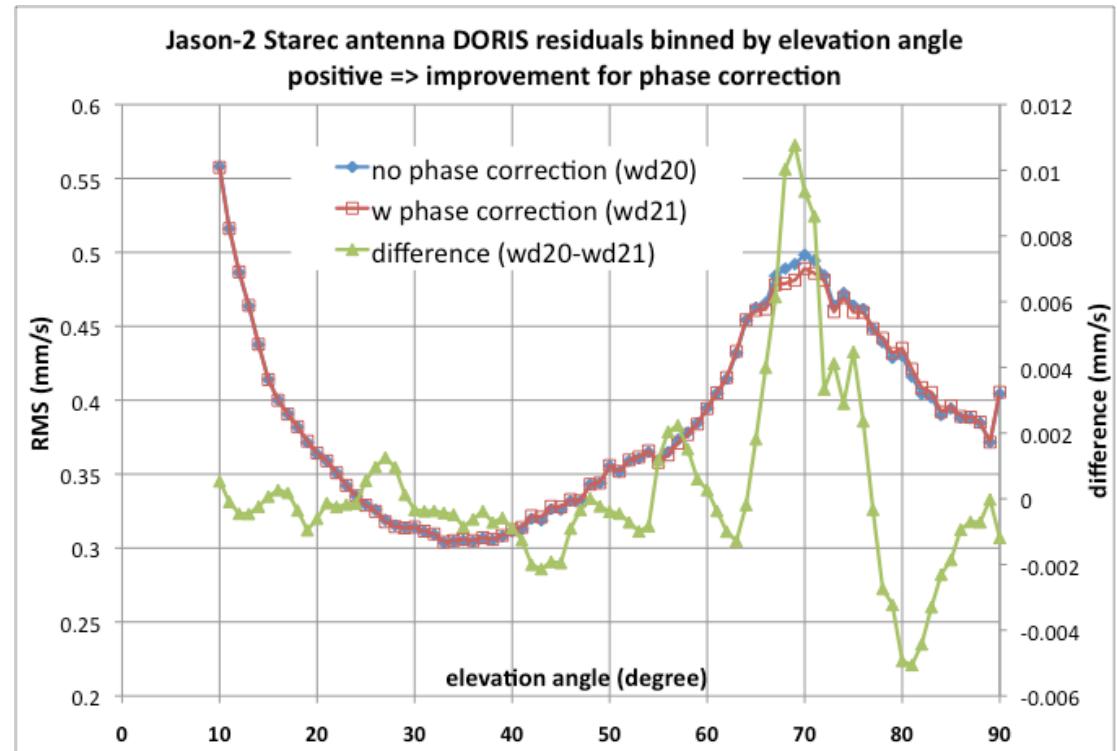
Testing of the DORIS Antenna Phase Correction

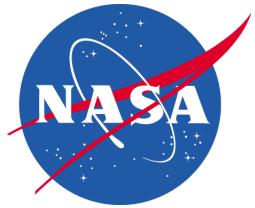


- Separate correction for Starec & Alcatel antennae.
- The Starec ground antennae (APC) were derived from tests in an anaechoic chamber by the CNES.
- For Jason-2, most ground stations have used the Starec antenna.



Starec antenna at Greenbelt

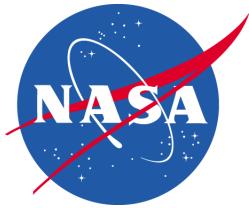




TOPEX, Jason-1, Jason-2 POD performance summary



satellite	test	mean RMS residuals		
		DORIS (mm/s)	SLR (cm)	Xover *
TOPEX cyc 1-446	std1204	0.4962	1.597	5.605
	std1404 (prelim)	0.4960	1.579	5.610
Jason-1 cyc 1-374	std1204	0.3697	0.853	5.458
	std1404 (prelim)	0.3673	0.795	5.445
Jason-2 cyc 1-226 (xover 1-216)	std1204	0.3778	0.934	5.345
	std1404 (prelim)	0.3779	0.907	5.332

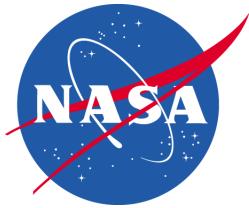


Jason-2 POD performance summary



ORBIT (external ephemeris residuals)	Jason2 mean RMS residuals cycles 1-216 (July 2008 – May 2014)		
	DORIS (mm/s)	SLR (cm)	Xover (cm) §
std1007	0.3789	1.126	5.435
std1204	0.3782	0.931	5.350
std1404 – LD – dynamic	0.3781	0.949	5.336
red1404 – LD – reddyn	0.3777	0.993	5.318
gdrd	0.3779	1.216	5.341
gdre – LDG – reddyn	0.3782	1.450	5.270
jpl14a – gps – reddyn	0.3785 §	1.070 §	5.270

§ independent data

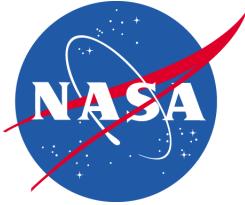


Jason-2 Orbit Difference Summary



Jason2 <i>jpl14a-test</i> orbit differences cycles 1-224	Mean RMS TOD (mm)			Mean ECF (mm)		
	radial	cross-trk	along-trk	X	Y	Z
std1007	10.7	24.1	35.6	2.4	-4.8	3.0
std1204	8.0	23.1	30.5	1.4	-2.2	3.1
std1404 (prelim)	7.6	22.2	29.3	3.1	0.3	2.9
red1404	6.5	18.9	24.8	2.0	0.8	2.5
gdrd	6.2	13.0	17.5	1.1	2.7	1.5
gdre	4.3	13.0	15.4	0.5	1.4	1.4

For current project orbits (JPL, CNES, GSFC) RMS radial orbit differences are 4-8 mm.



Summary & Future work



- (1) We have developed a new time series of orbits (*std1404-prelim*) for TOPEX, Jason-1, Jason-2.**
- (2) This series will be updated in the near future with further improvements:**
 - Forward modeling of Earth center of mass motion.
 - Using `stk5x5_estc31s31`
- (3) Significant errors remain in due to SRP error (6-10 mm amplitude differences at 120-days);**
- (4) The issue of how best to model TVG is still an issue – it seems the time series are optimum – but their latency and questions about their routine availability – mean some other strategy is also needed.**
- (5) Prepare for Jason-3 verification phase.**