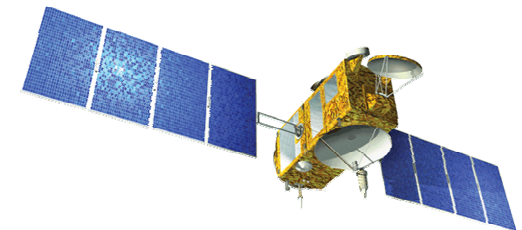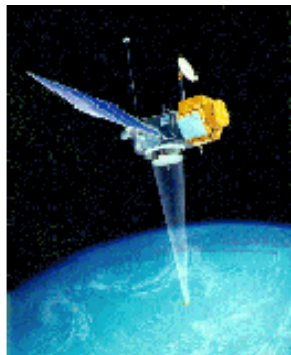# DPOD2005 Performance and Impact of Modelling Improvements for TOPEX, Jason-1, and Jason-2

N.P. Zelensky, F.G. Lemoine, D.S. Chinn,
P. Willis, JP Boy, D.D. Rowlands

IDS / OSTST 2008
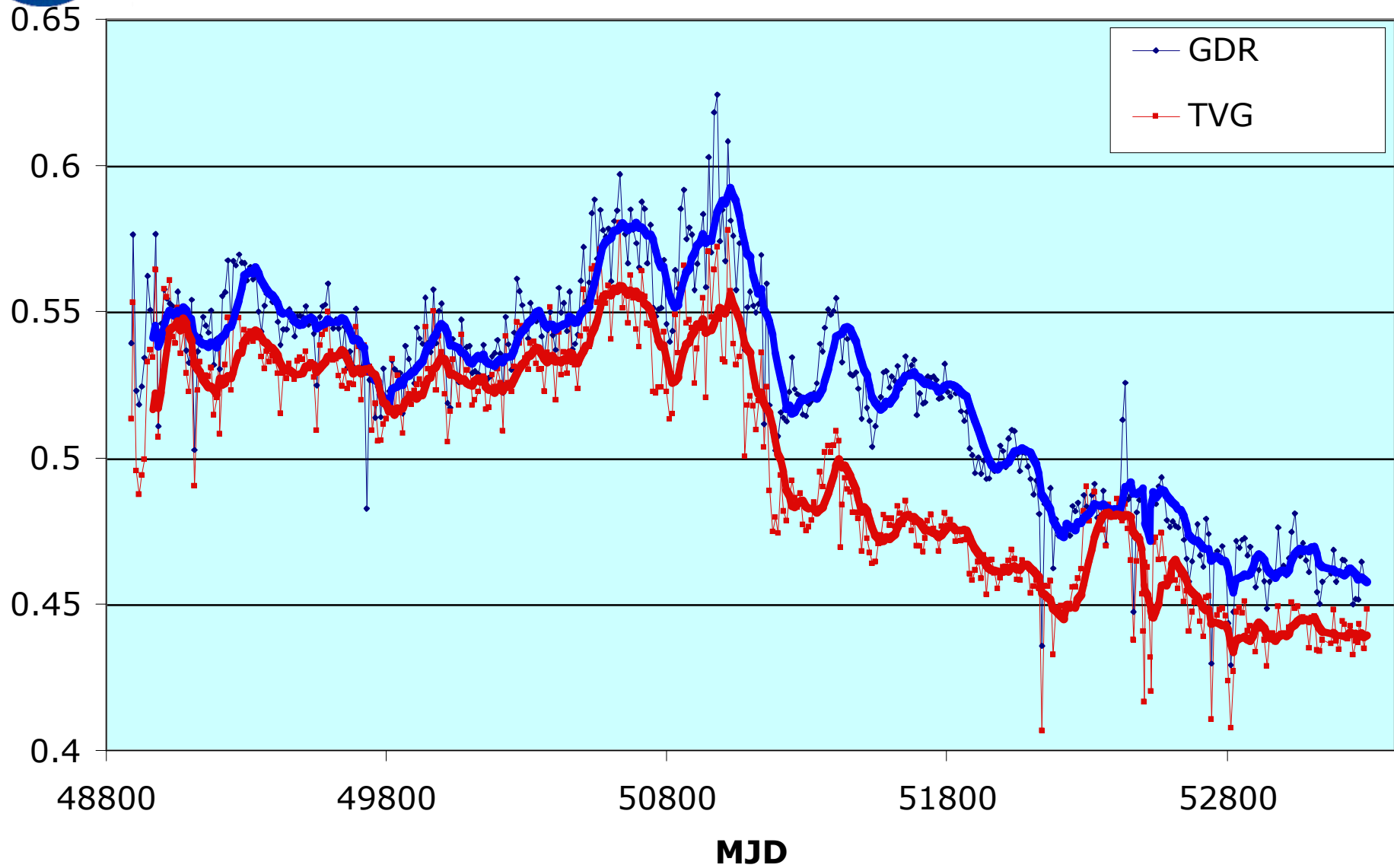Nice, France
November 14, 2008

Outline

- **POD modeling improvements**
- **Need for accurate and stable TRF**
- **DPOD2005 POD over the march of time**
  - **1992: TOPEX/Poseidon**
  - **2002: Jason-1**
  - **2008: Jason-2**
- **Jason-2 and DORIS**
  - **Strength in POD**
  - **Model tuning**

POD Modeling Improvements

**NASA GSFC TOPEX/POSEIDON DORIS RMS
(GDR vs. TVG Reprocessing)**

New POD Standards Testing

Significant improvements to GSFC 2008 POD Standards					
test name	Jason-1 SLR/DORIS residual summary cycles 1-21	doris rms (mm/s)	slr (cm)		xover rms (cm)
			mean	rms	
nominal 2007	itrf2005(s)_merged (itrf2000), ggm02c	0.3976	-0.073	1.519	5.730
trf2005	+ slrf2005/dpod2005 (version 1.1)	0.3979	0.086	1.508	5.732
eigen_gl04s	+ switch to eigen gl04s	0.3979	0.081	1.479	5.728
tidal_com/eop	+ tidal CoM (got4.7) & tidal EOP	0.3978	0.073	1.428	5.724
cr_panel	…. + tune Cr=0.929	0.3978	0.074	1.409	5.727
lpod2005	….+ lpod2005 + lra phase map	0.3978	-0.041	1.324	5.725
dpod2005 v1.4	most recent DPOD2005 release	?	?	?	?

Orbit difference with 2007 release

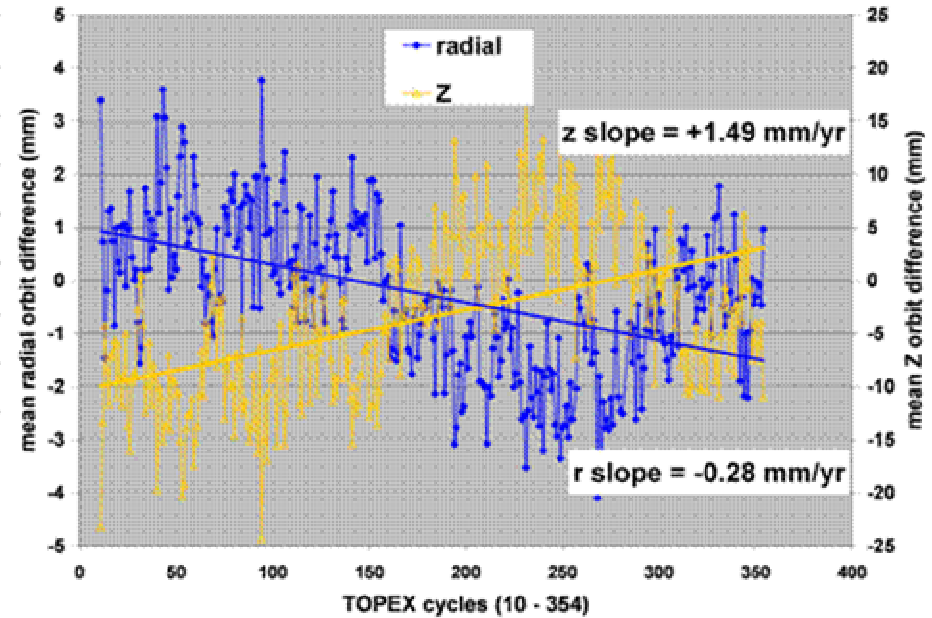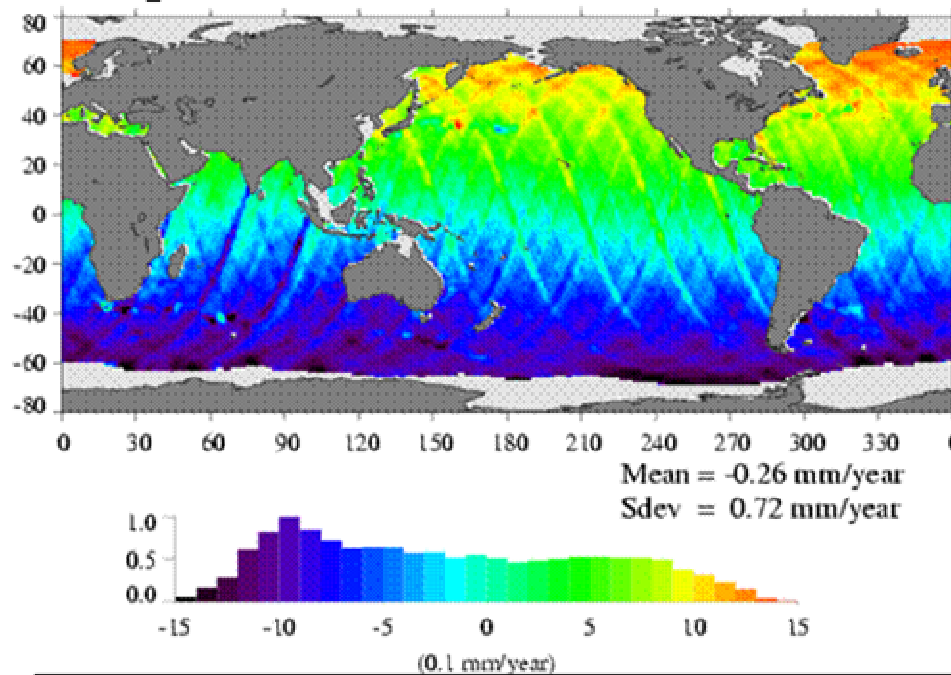Jason1 radial orbit differences 5x5 degree latitude/lontitude bins
Std0809-Nominal2007_Cycles_1-21
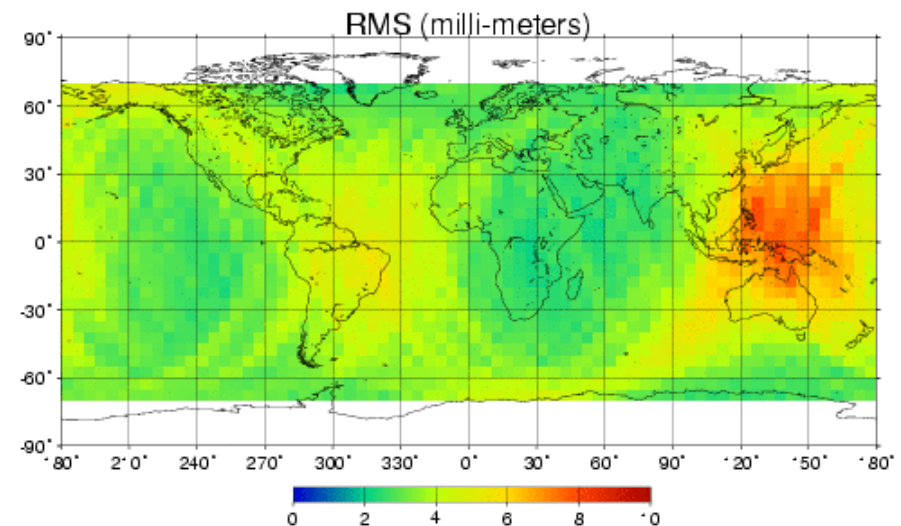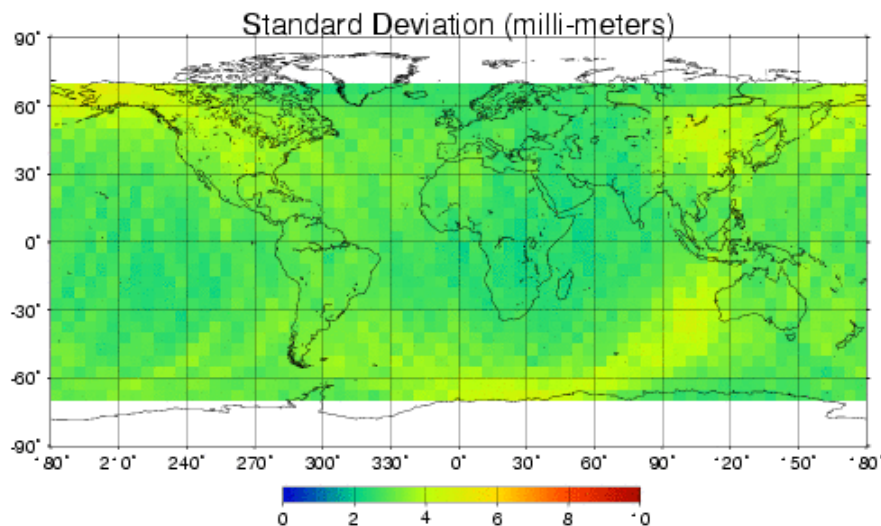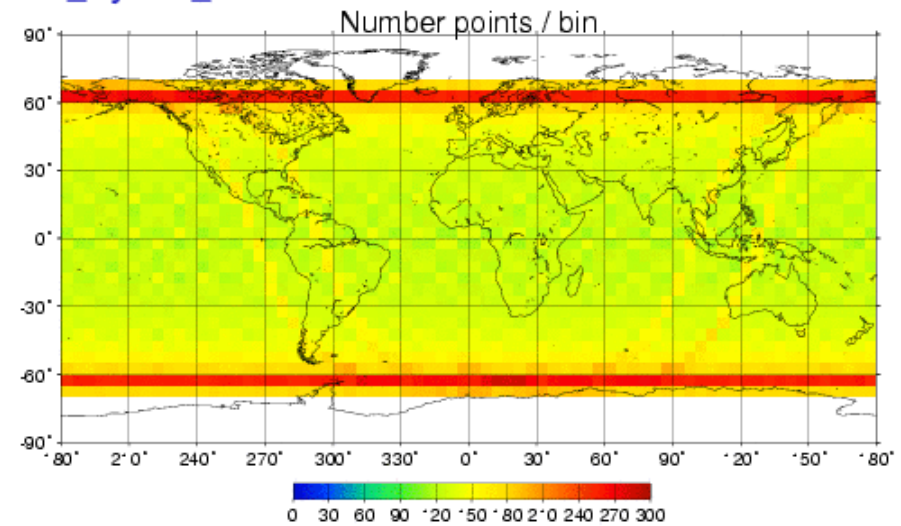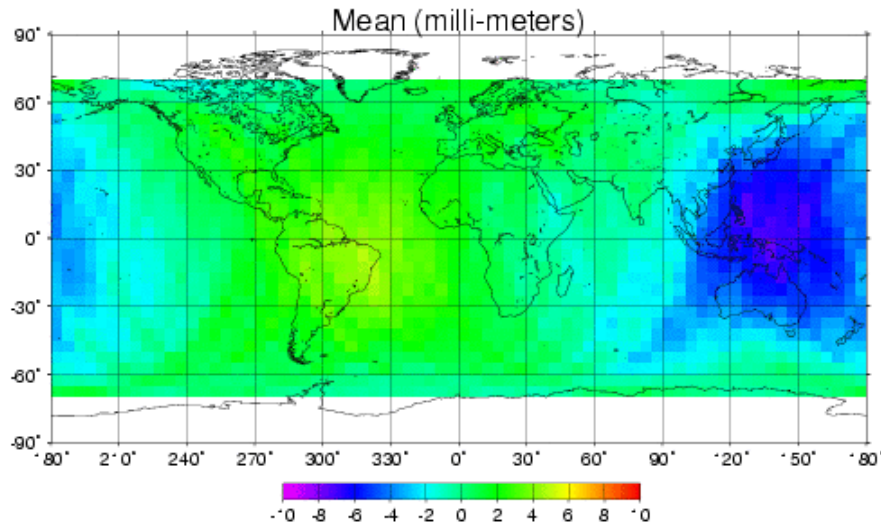
Need for Accurate and Stable Terrestrial Reference Frame (TRF)

Impact of Terrestrial Reference Frame on Mean Sea Level

Mean = -0.26 mm/year
Sdev = 0.72 mm/year

(0.1 mm/year)

Regional **TOPEX** (**1993-2002**) Sea Surface Height Trend differences from direct impact of the **ITRF2005** (**GGM02C**) minus **CSR95** (**JGM3**) orbit differences.

z slope = +1.49 mm/yr

r slope = -0.28 mm/yr

TOPEX cycles (10 - 354)

R slope / Z slope = -0.28 mm/yr / 1.49 mm/yr
MSL rate error = - 0.19 x TZ (mm/yr)
*Where TZ is the mean orbit rate error in Z.*
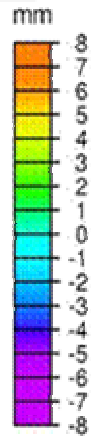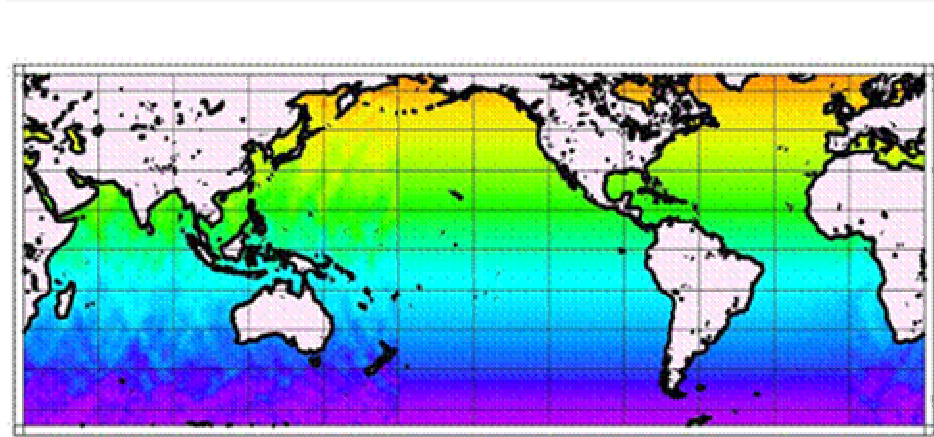
Regional mean sea level errors resulting from a 10 mm Z-translation of the Terrestrial Reference Frame (DORIS station coordinates). *From Morel L., and Willis, P., 2005.*
Mean sea level= -0.12 x TZ (mm)
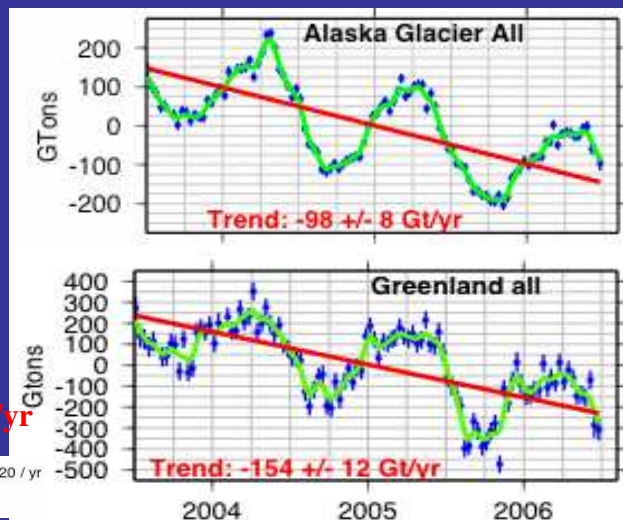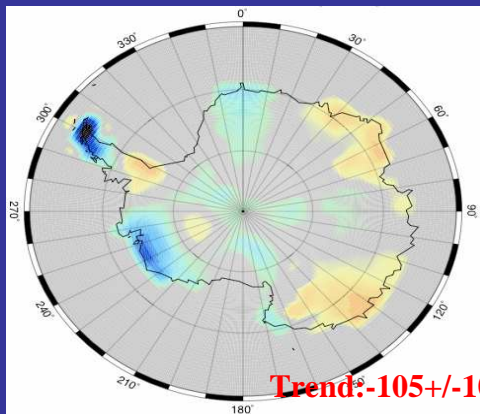*where TZ is the TRF error in Z.*
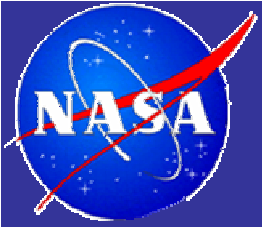
Important recent contributions to sea level rise are sub-mm/year

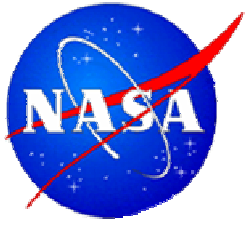## Assessing the total global MSL budget…..How does it add up ?
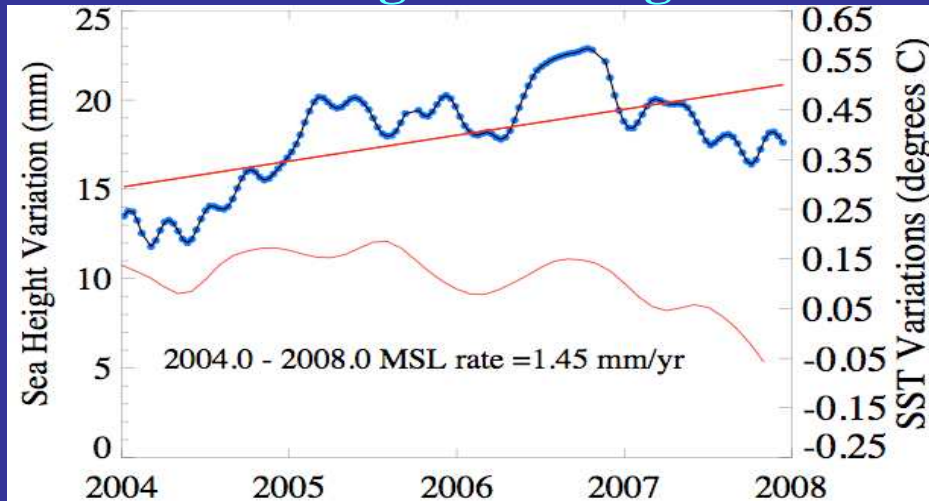
Total (thermosteric+mass influx) MSL rate derived from altimetry from 2004 – 2008 (with JMR correction and GIA applied) = **1.75** mm/yr.

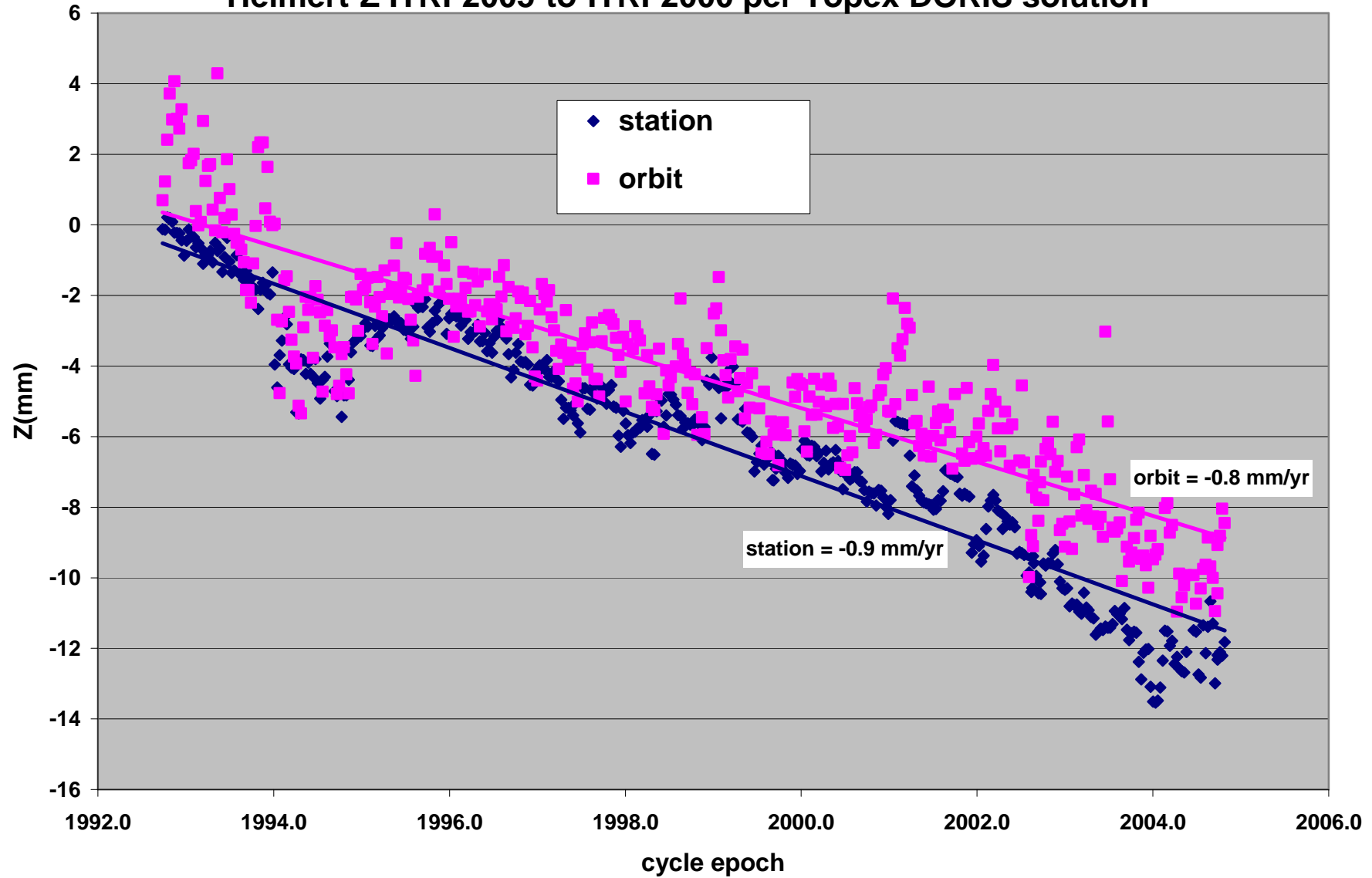Negligible thermosteric rate during this time period.

Mass influx contribution to MSL rate increase from 2003 - mid 2007 from sum of GRACE mascon estimates = **1.1** mm/yr.

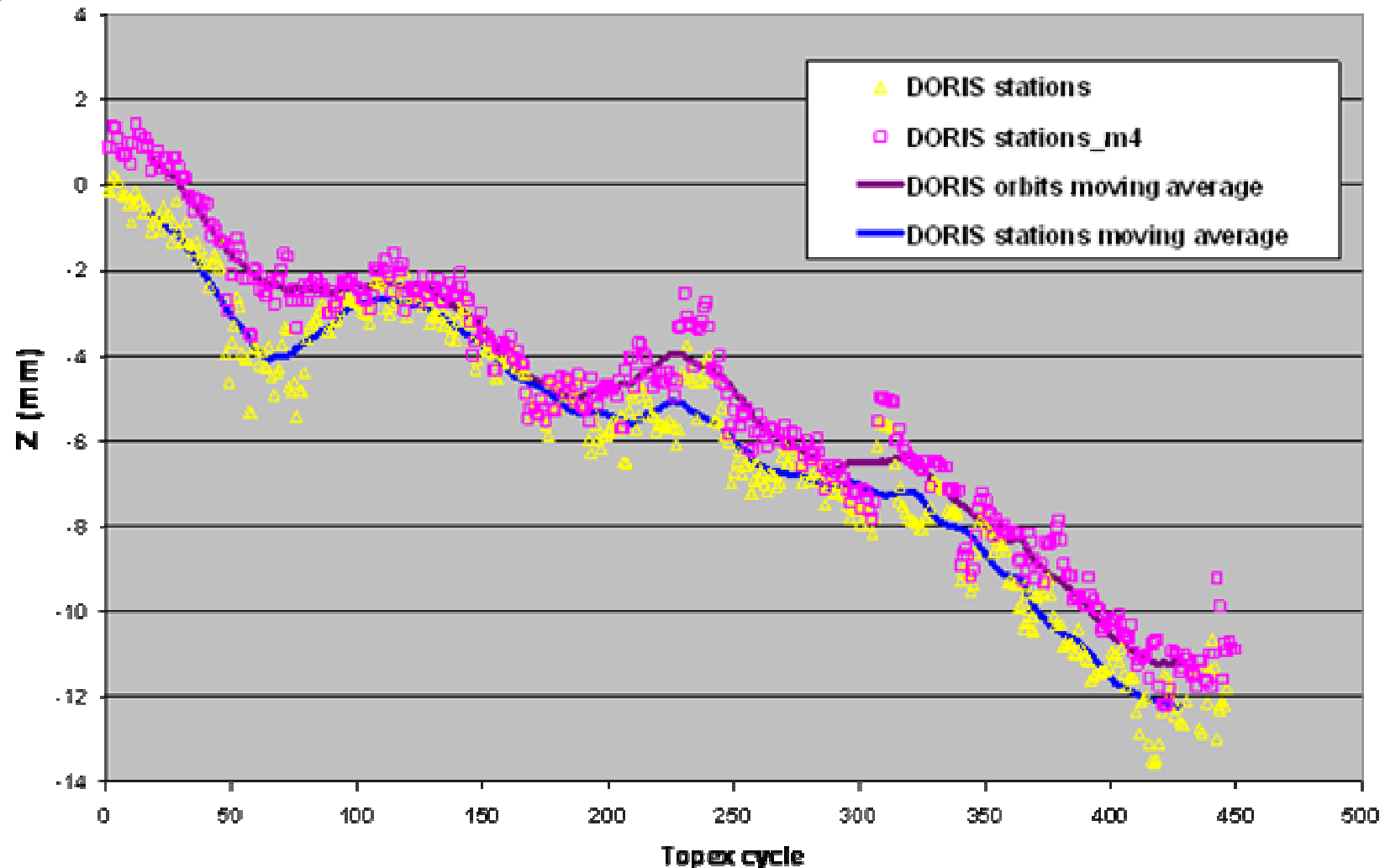# Stochastic component orbit origin stability in Z

Helmert-Z ITRF2005-to-ITRF2000 per Topex DORIS solution

DORIS Z-dip explained

Helmert - Z ITRF 2005 to ITRF 2000 from Topex DORIS stations (m4: cola,gala,rota,samb)

Removing 4 stations from the DORIS STC comparison removes much of the problematic dip. These stations are COLA, GALA, ROTA, SAMB, and were selected based on a high frequency of tracking/not tracking over the 1994 dip period. The dip is can be explained by the stochastic nature of stations tracking/not tracking over a given period. Both datasets "stations" and "stationsm4" (minus 4) both have the same linear trend.

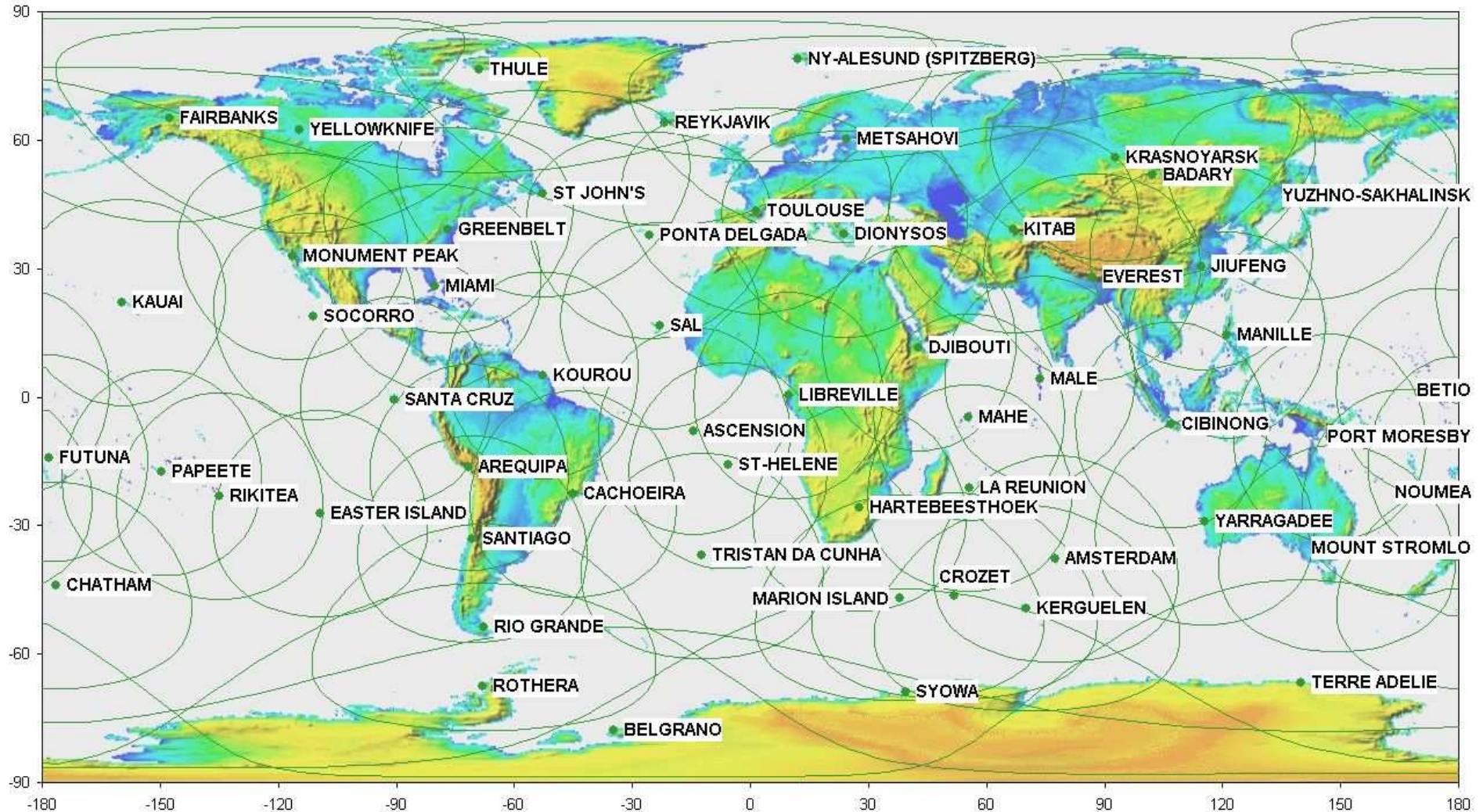# Variations in Z due to just a few stations stopping/starting to track

DORIS station CSR95-to-ITRF2000 Helmert Z estimate
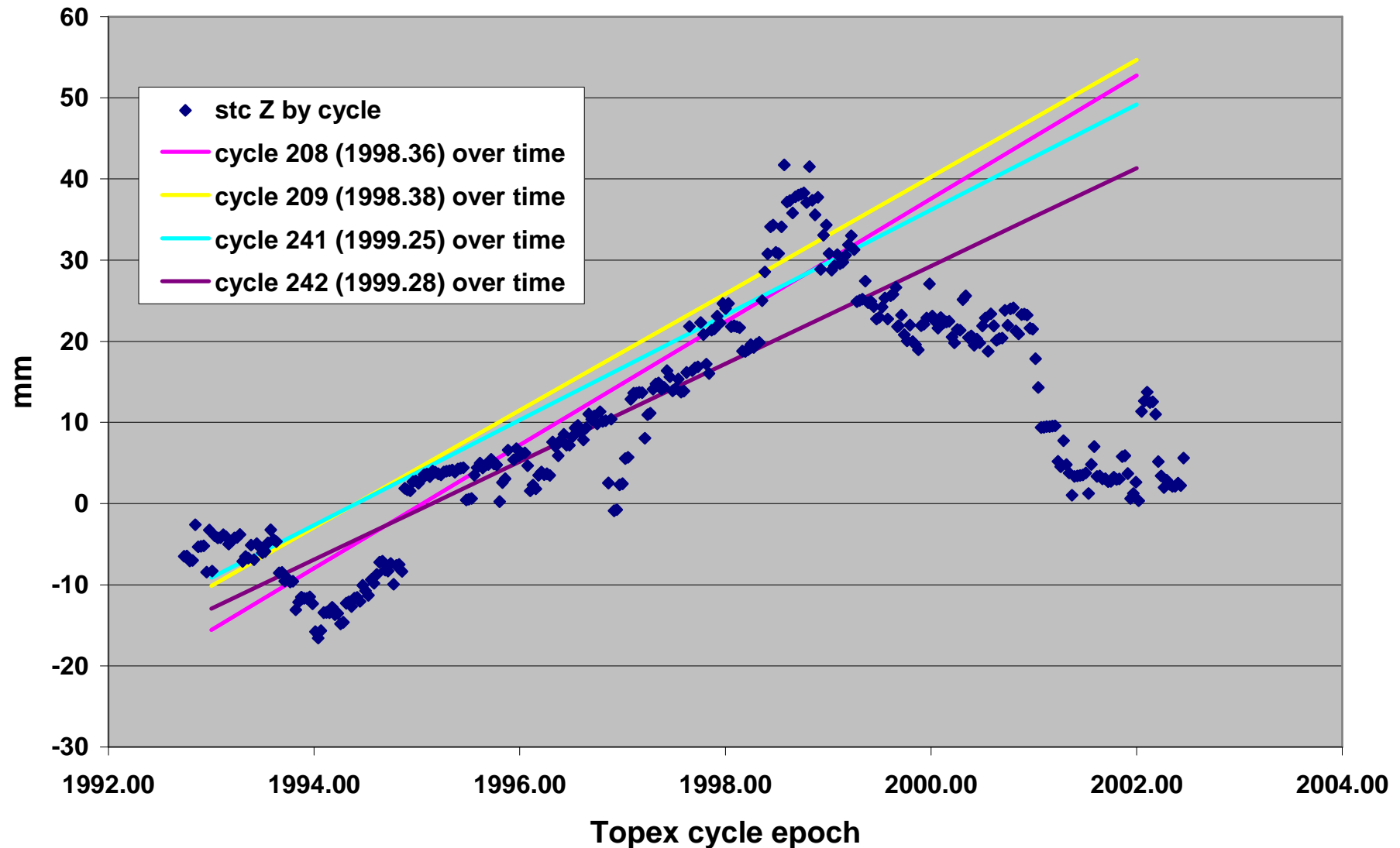
The Geodetic Networks are Key to Altimeter Satellite Mission Success

Jason-1 DORIS stations visibilities
Elevation 12°

DPOD2005 POD over the march of time

DPOD2005 Evaluation – What is compared?

- **DPOD2005** is an enhanced and extended ITRF2005-based DORIS TRF realization designed for POD. It includes station editing information. It includes new stations.

- **ITRF2005-merge** is the DORIS ITRF2005 solution merged with transformed ITRF2000 stations. It does <u>not</u> include new stations.

Consistent POD models across all tests

Models include:

| Reference frame and displacement of reference points	
SLR	SLRF2005 + LPOD2005 (version 10)
DORIS	DPOD2005 (version 1.4)
Earth tide	IERS2003
Ocean loading	Got4.7 all stations
Tidal CoM &EOP	Got4.7; VLBI high frequency terms
Gravity	
Static	Eigen-Gl04s
Time varying	Linear C20-dot, C21-dot, S21-dot (IERS2003) + 20x20 annual terms from GRACE
Atmospheric	ECMWF, 50x50@6hrs
Tides	Got4.7 (ocean); IERS2003 (Earth)

DPOD2005 evaluation -summary

DPOD2005 over time				
test name **DORIS-only**	**doris**		**slr (cm) rms**	**xover rms (cm)**
	average points	**rms (mm/s)**		
TP cycles 1-21 from September 1992				
itrf2005_merge	53758	0.5370	7.3	5.845
dpod2005 v1.4	51932	0.5392	7.2	5.849
Jason-1 cycles 1-21 from January 2002				
itrf2005_merge	118614	0.3970	3.0	5.770
dpod2005 v1.4	114362	0.3973	3.0	5.772
Jason-12 cycles 1-21 from July 2008				
itrf2005_merge	110151	0.3818	3.8	5.582
dpod2005 v1.1	154254	0.3701	3.5	5.592
dpod2005 v1.4	152714	0.3639	3.2	5.632

SLR data independent in these tests

DPOD2005 v1.4 evaluation – Jason-2
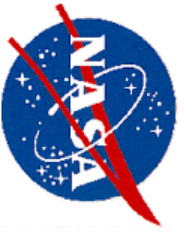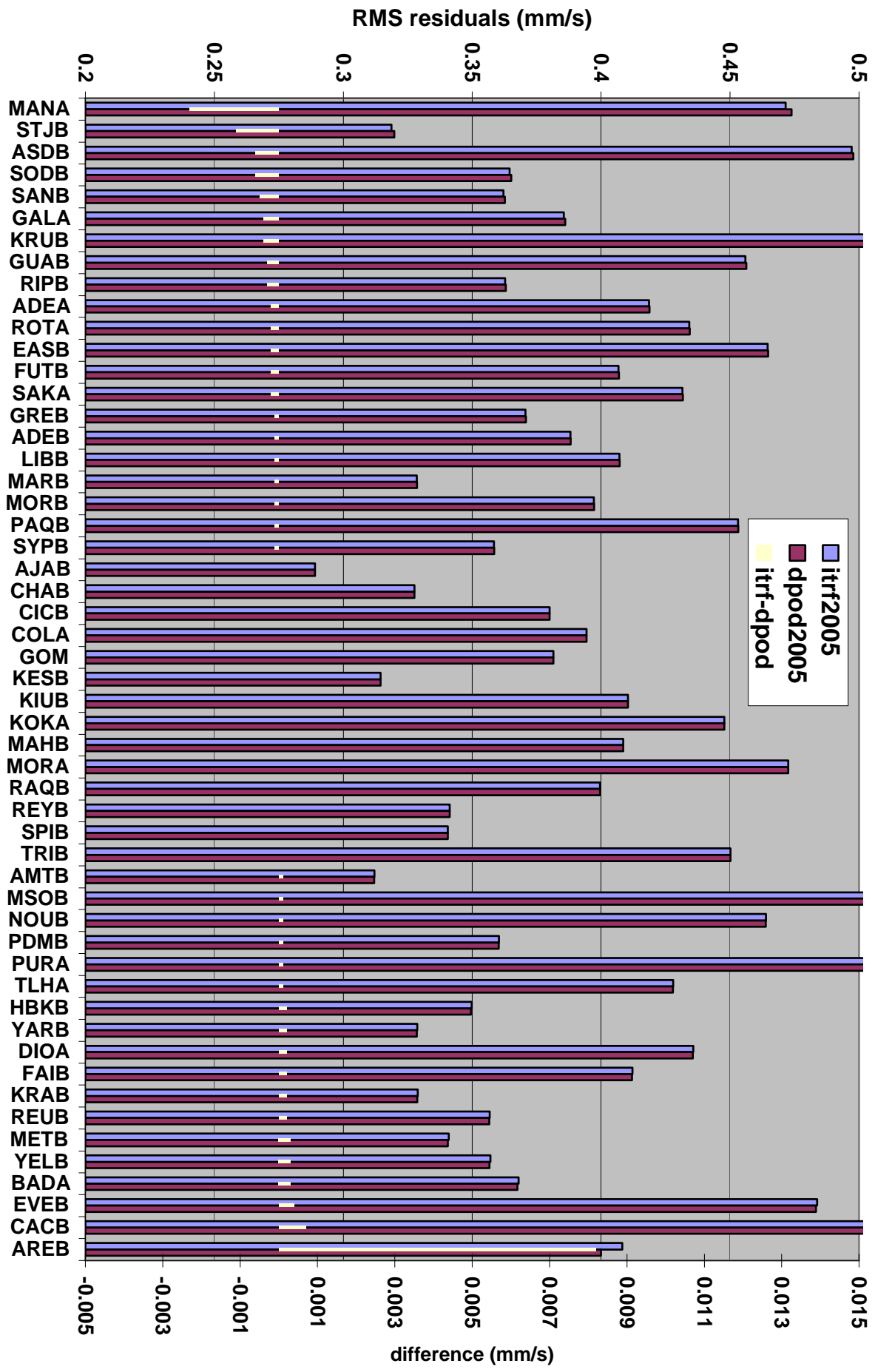
Jason-2 DPOD2005 v1.4 (55 stations) -vs- iTRF2005 (40 stations) Cycles 1 - 8
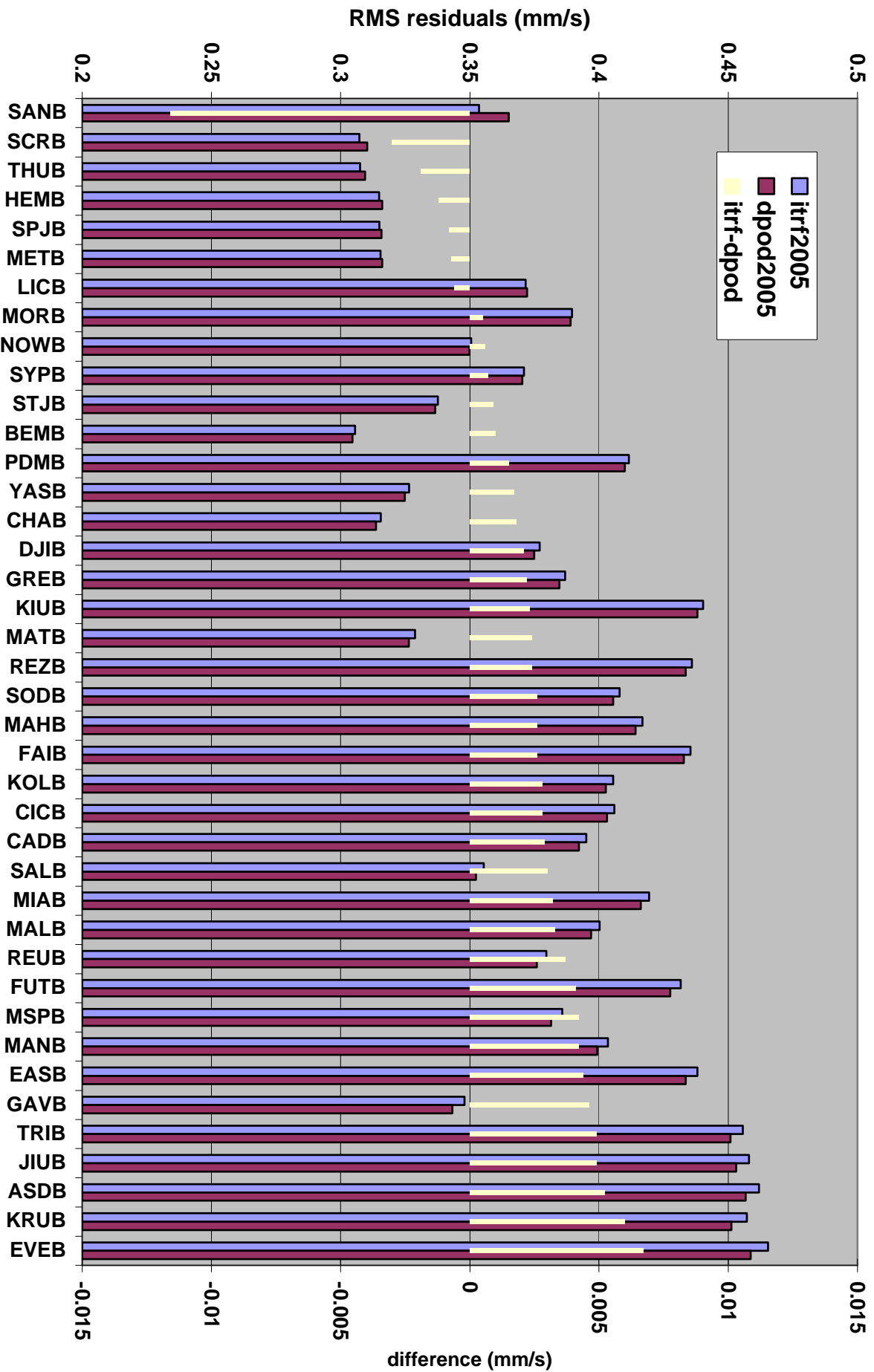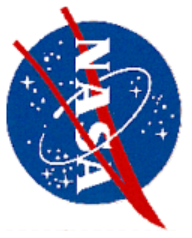
DPOD2005 v1.4 evaluation – Jason-1

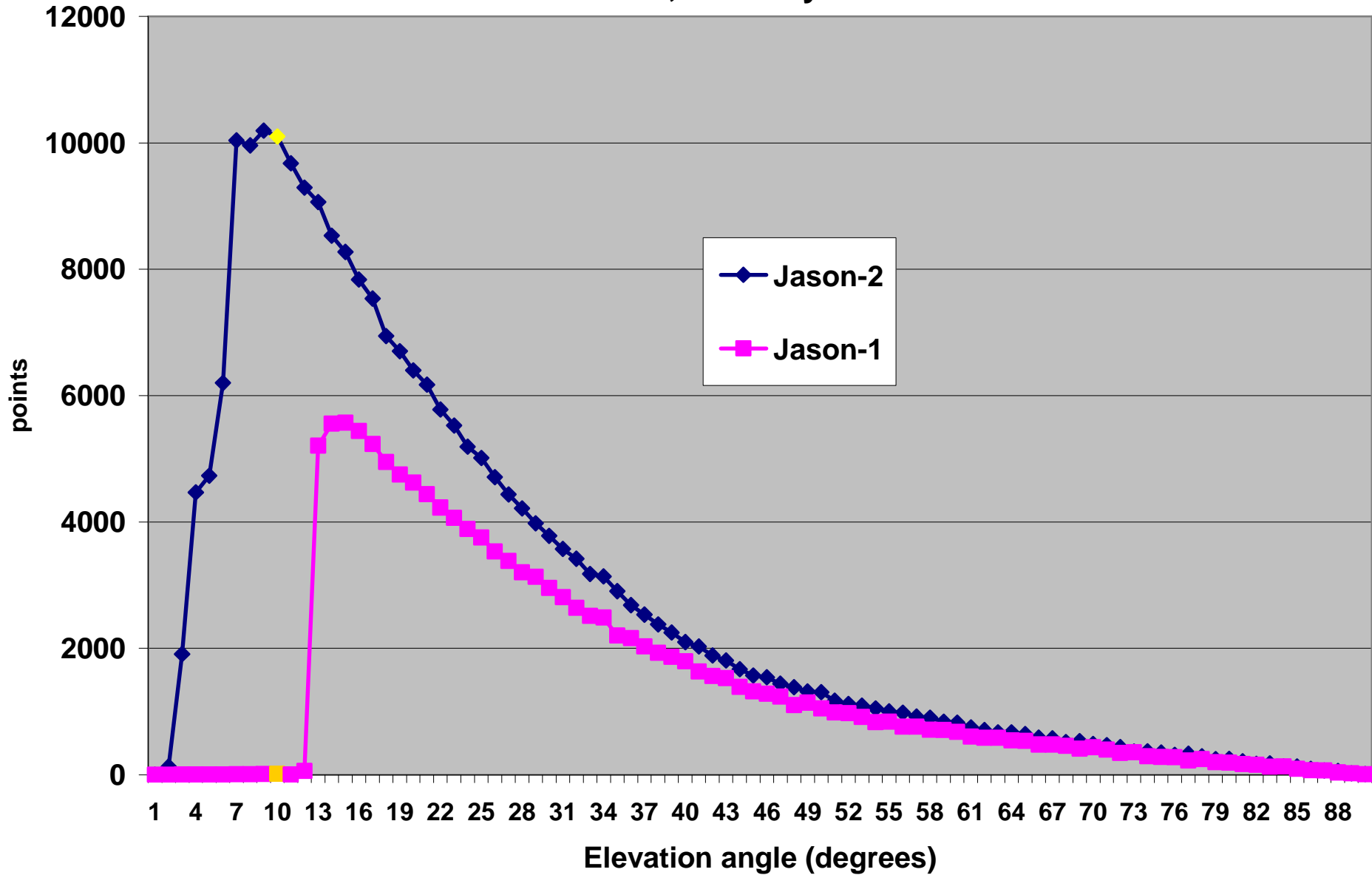Jason-1 DPOD2005 v1.4 (54 stations) -vs- iTRF2005 (55 stations) Cycles 1 - 21

Jason-2 DORIS
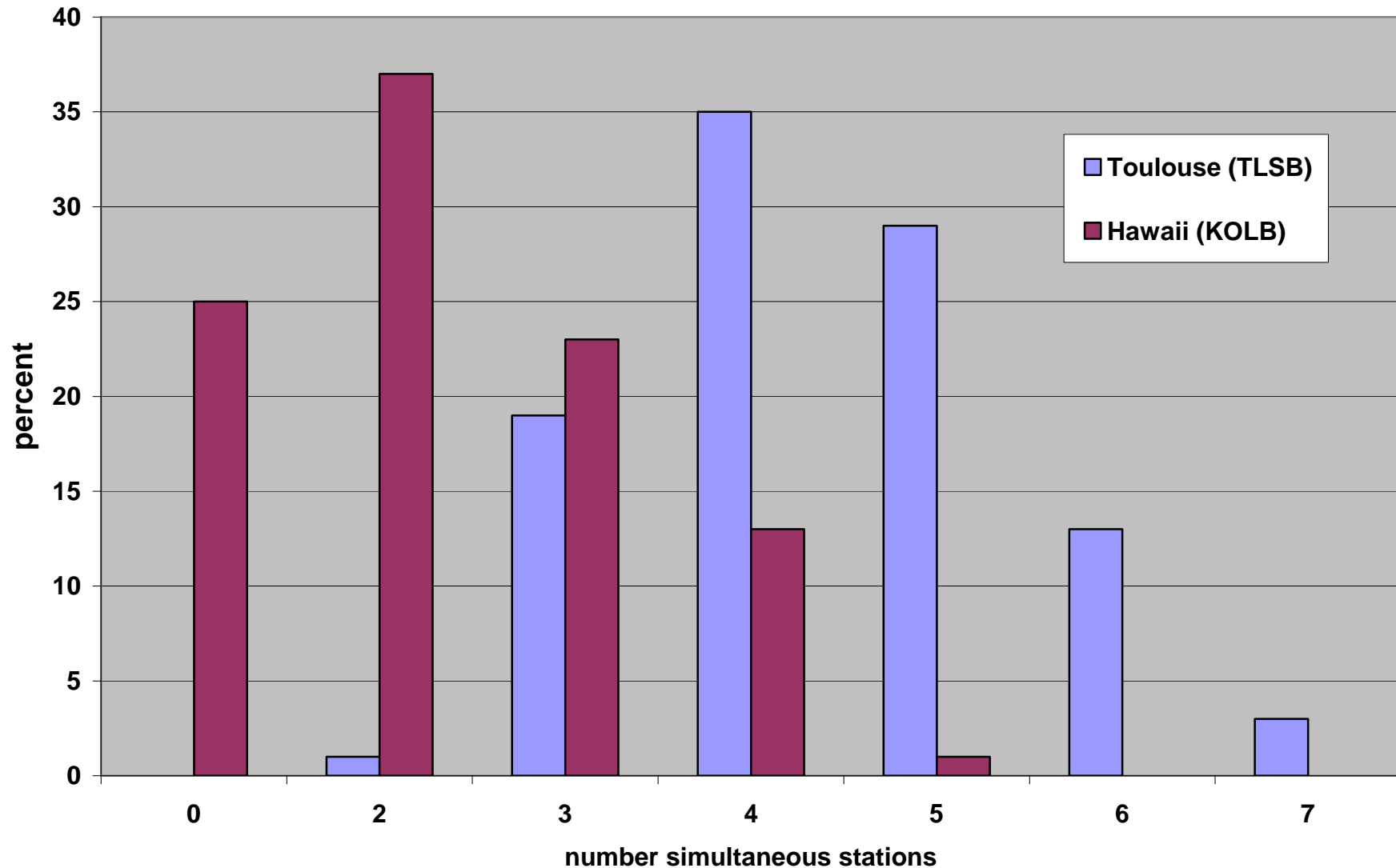
Jason-2 DORIS new receiver: tracking

DORIS from CDDIS, J1/J2 Cycles 241/002

Jason-2 DORIS new receiver: simultaneous tracking
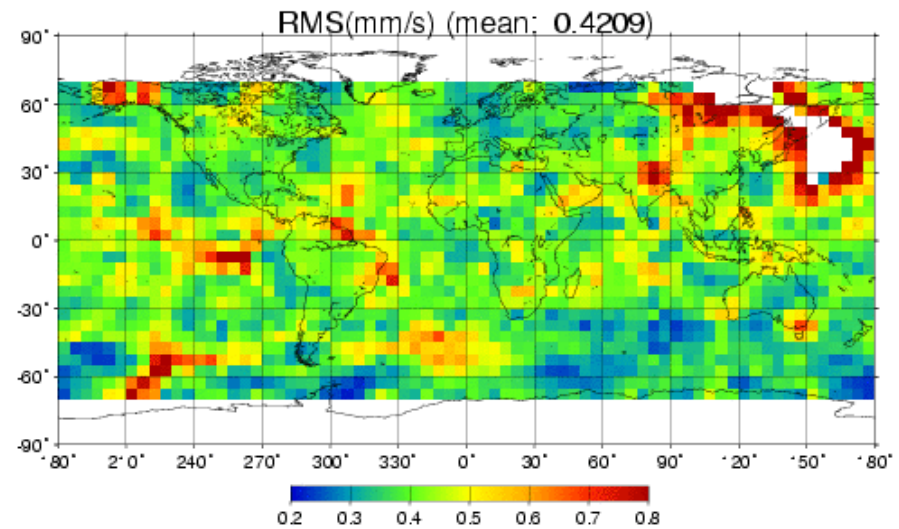

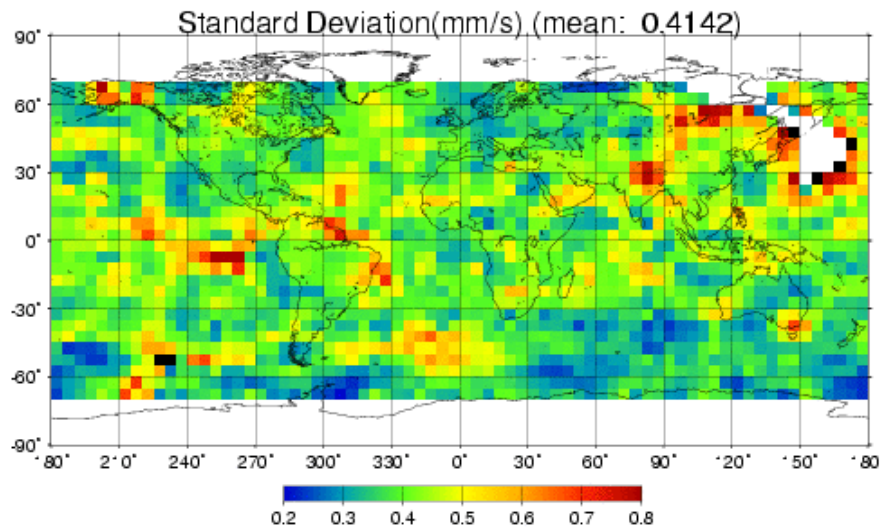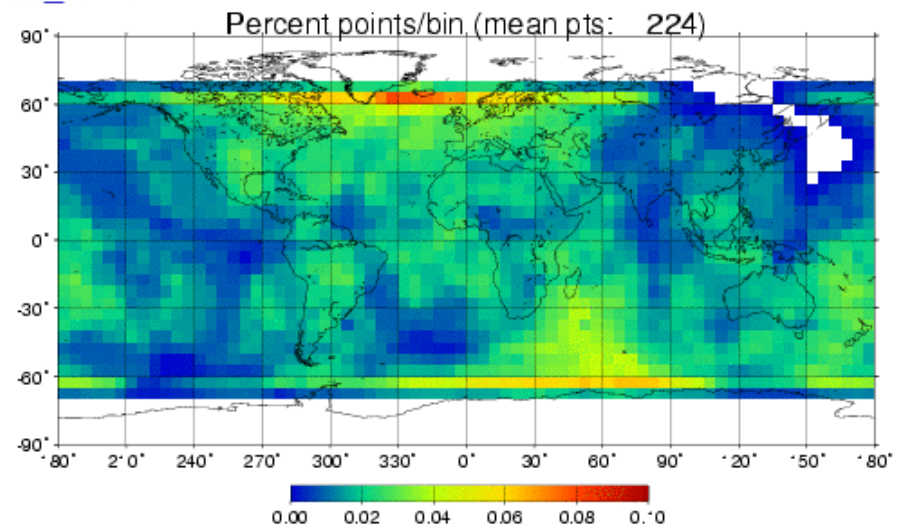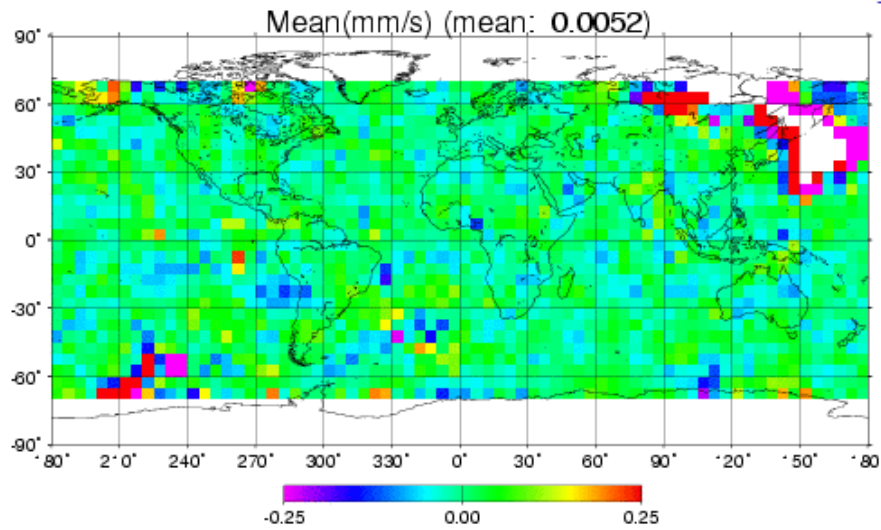Jason-2 DORIS simultaneous station observations; cycle 001

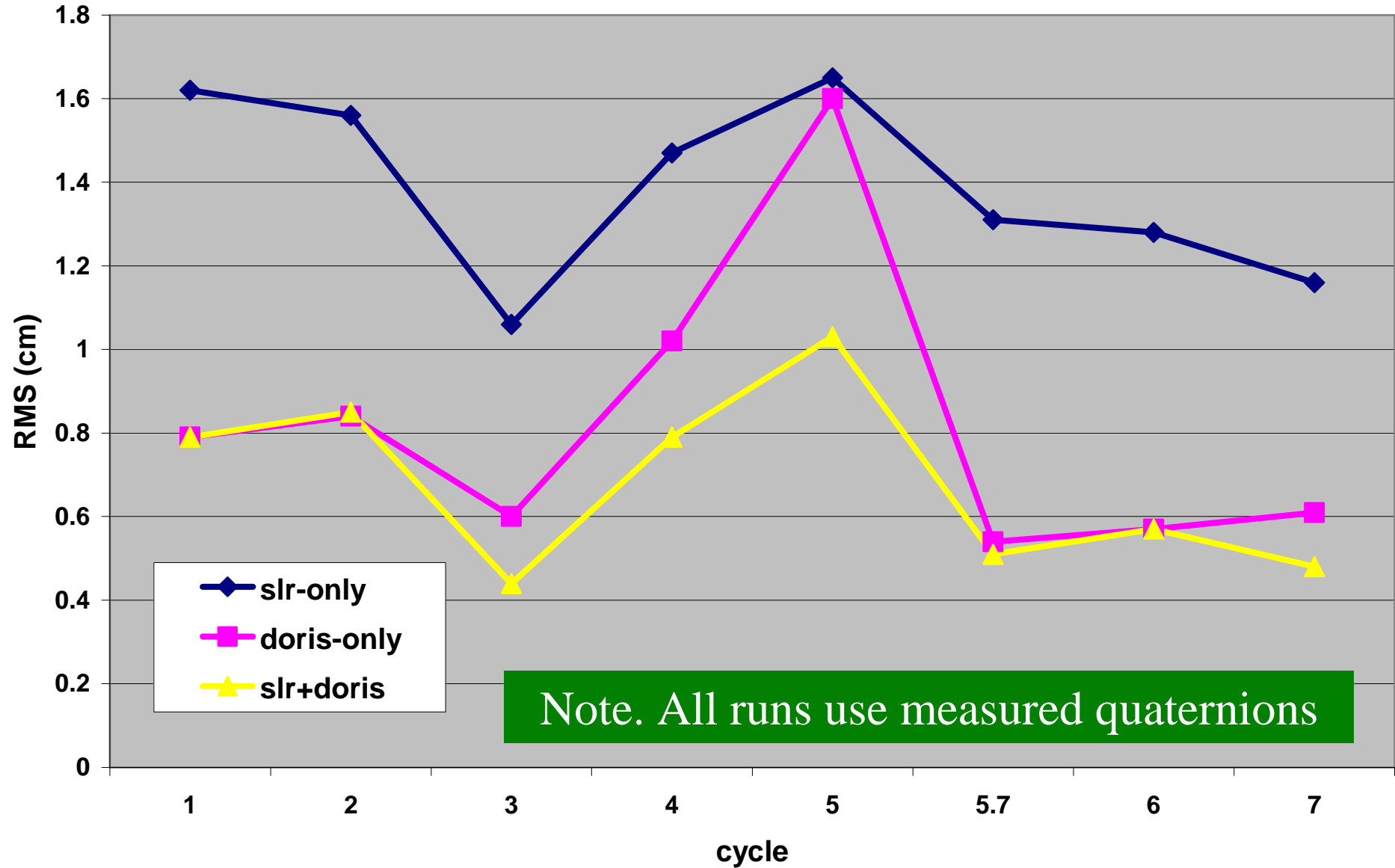# Jason-2 DORIS residuals and coverage

DORIS residuals 3x3 degree latitude/lontitude bins
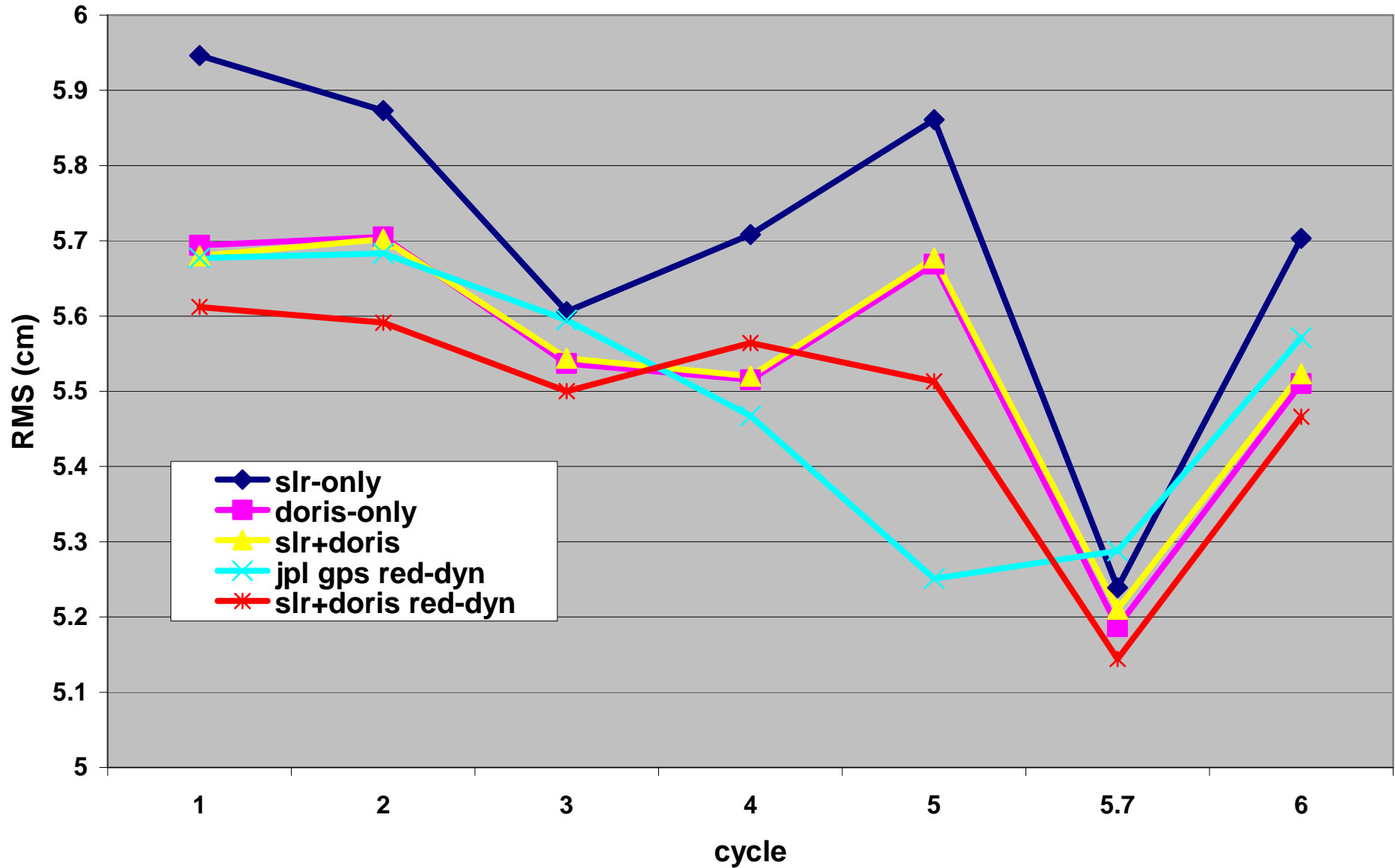
Jason2_cycles_001-007

Jason-2 DORIS POD strength

Jason-2 radial orbit differences (slr+doris reduced-dynamic - test)

Note. All runs use measured quaternions

Legend:
- slr-only
- doris-only
- slr+doris

Jason-2 DORIS POD accuracy

Jason-2 independent altimeter crossover residuals

Jason-2 SLR/DORIS model tuning: C_R

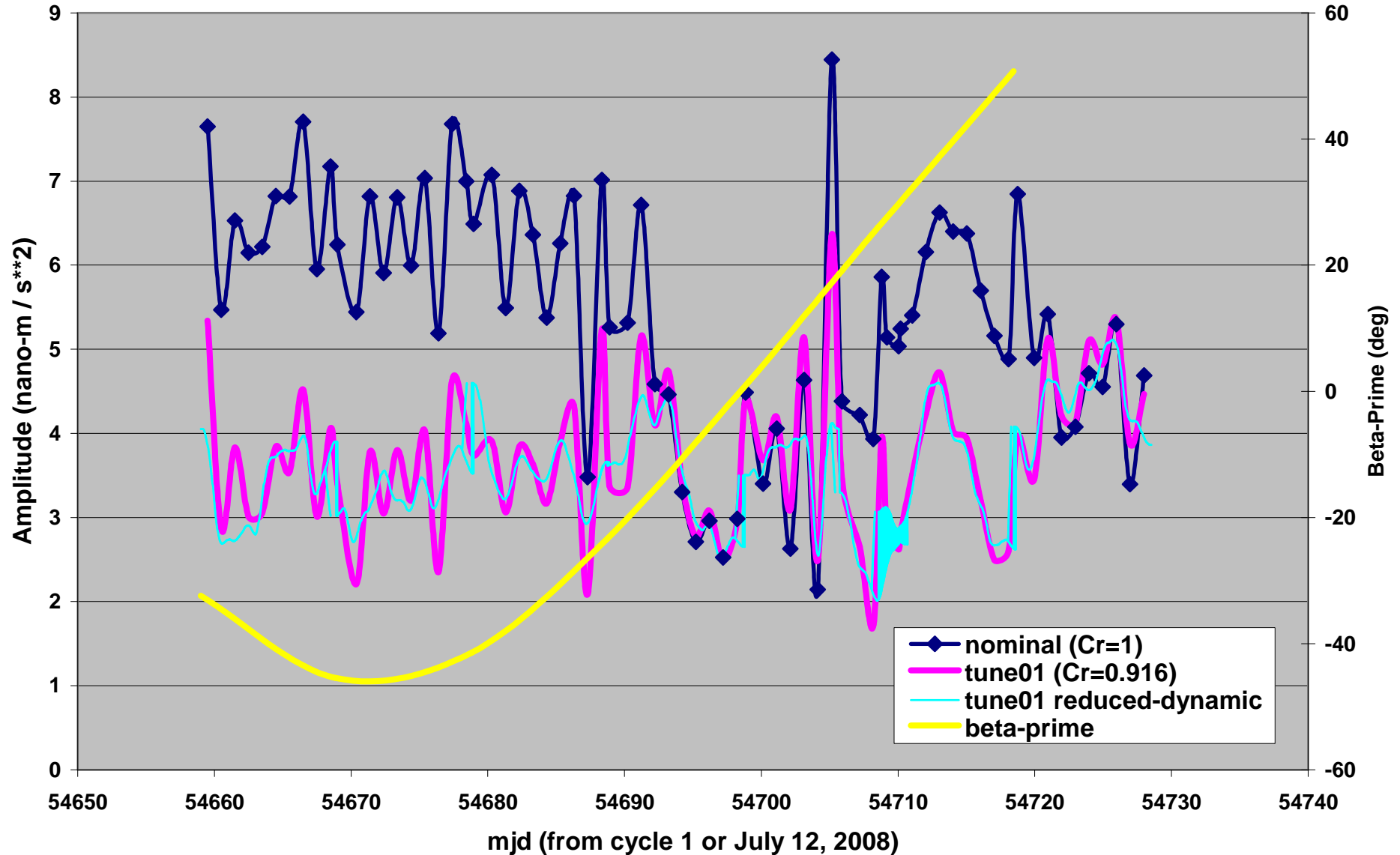|	a-priori	estimated increment	standard deviation	new value
Jason-2 Estimated Solar Radiation Pressure Coefficient (C_R) **SLR/DORIS cycles 1-7; Jason-1 panel cards (external attitude, std0809 models)**				
C_R	1.00000	-0.08394	0.01660	0.916

Jason-2 estimated along-track opr acceleration; slr/doris cycles 1-7
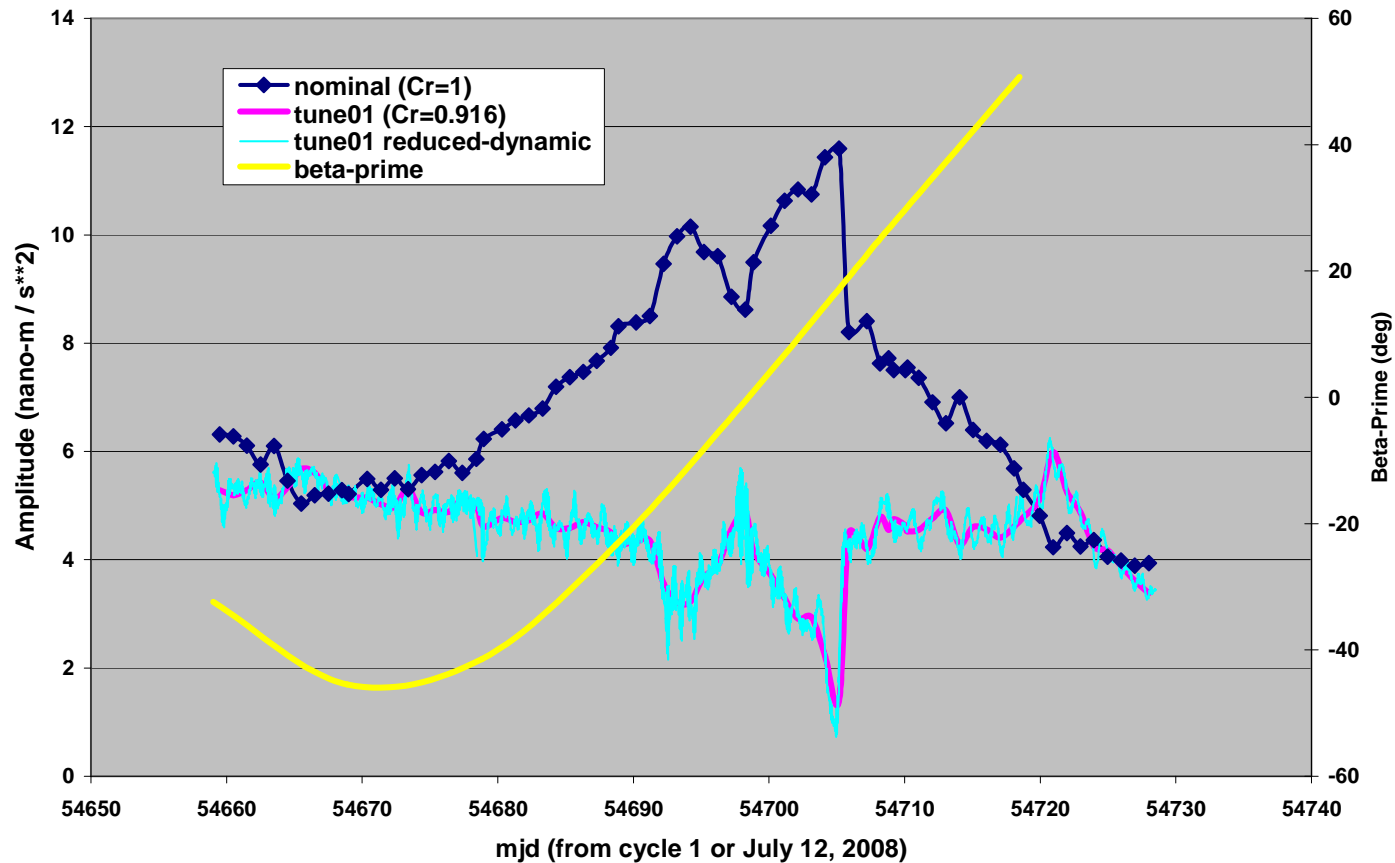
Jason-2 SLR/DORIS model tuning: C_R

Jason-2 estimated cross-track opr acceleration; slr/doris cycles 1-7

Jason-2 SLR/DORIS model tuning: DORIS antenna offset

| Jason-2 Estimated DORIS Antenna Phase Offset SLR/DORIS cycles 1-7; (external attitude; std0809 models)				
DORIS antenna offset (m)	a-priori	estimated increment	standard deviation	new value
X	1.194	-0.00191	0.00254	1.192
Y	-0.598	0.00626	0.00237	-0.592
Z	1.022	0.13498	0.00254	1.157

Jason2 Model Tuning Evaluation residual summary cycles 1-7 external attitude; std0809 models	doris		slr (cm)		xover (cm)
	rms (mm/s)	time bias (µs)	mean	rms	
slr/doris					
nominal (std0809)	0.3689	-2.35	-0.089	1.191	5.534
ld_cr: as nom+ Cr=0.916	0.3681	-2.34	-0.059	1.150	5.542
dor01: as ld_cr + est. doris ant. offs.	0.3610	-2.19	-0.044	1.121	5.545
doris-only					
nominal	0.3689	----	-0.4	3.6	5.571
dor_cr: as nom+ Cr=0.916	0.3677		-0.5	3.5	5.576
dor01: as dor_cr + est. doris ant. offs.	0.3608	----	-0.1	2.7	5.581

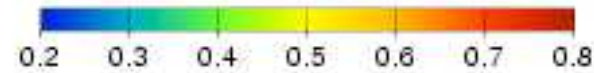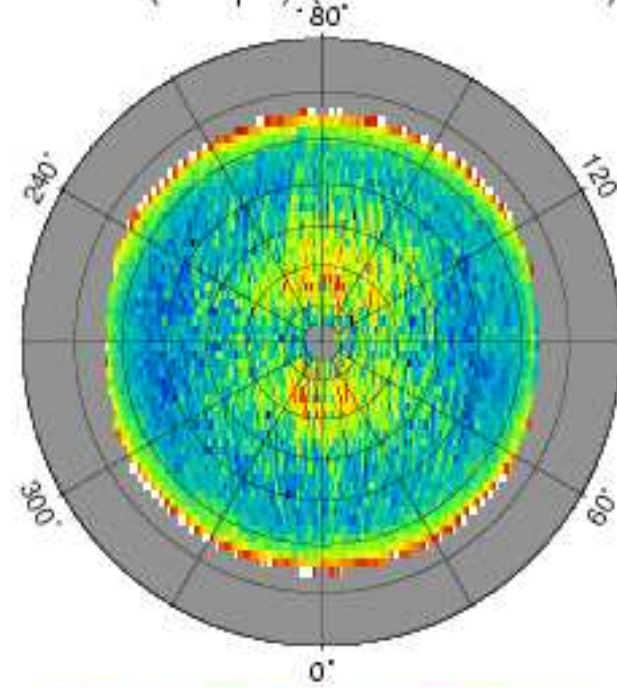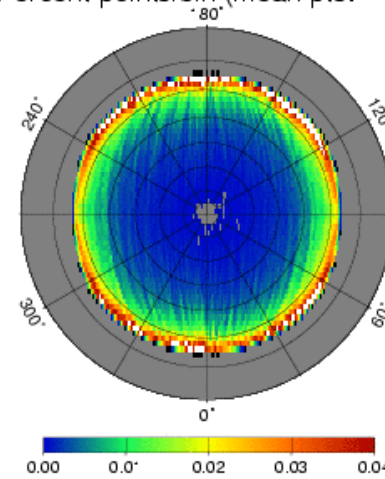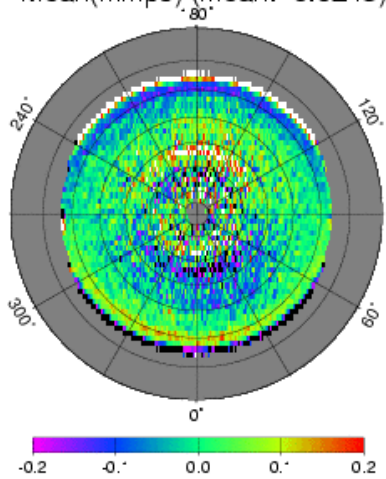Jason-2 DORIS Residuals Mapped by Satellite Azimuth & Elevation (1°x1° bins, cycles 1-7)
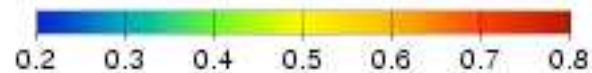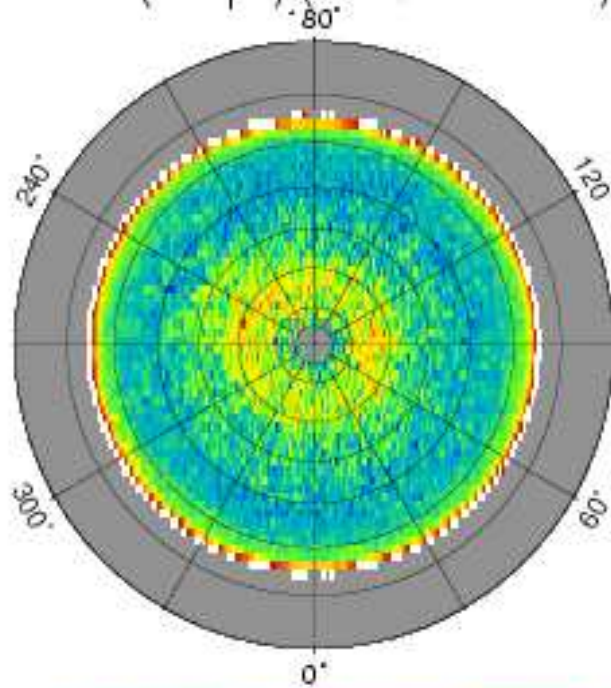
Jason-2 SLR/DORIS model tuning: DORIS phase map?

DORIS residuals 1x1 degree satellite azimuth/elevation 20-90 deg bins
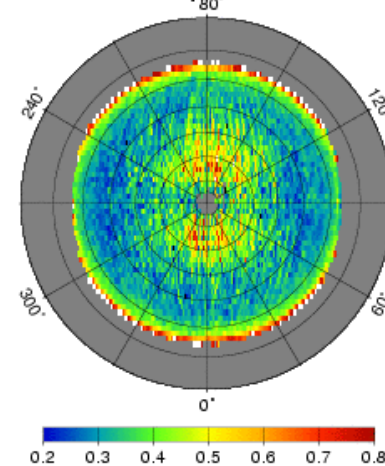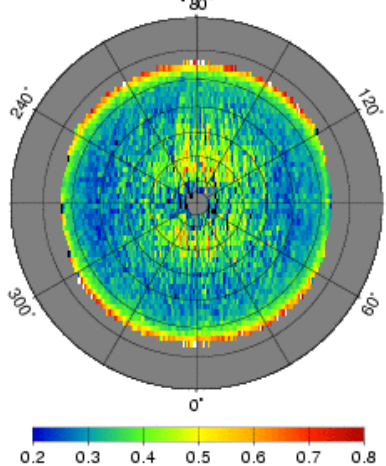
Jason2_antenna_off01_cycle_001-007

Conclusions

- Testing over 15 new POD models has culminated in new GSFC POD standards and a superior SLR/DORIS TP/J1 orbit series.

- Accurate and stable TRF is key to altimeter missions and DPOD2005 uniquely provides just that from 1992 to the present, and hopefully into the future.

- Strength of Jason-2 DORIS dominates the dynamic orbit solution and significantly improves accuracy in the reduced-dynamic.

- Surprisingly Jason-2 DORIS antenna offset adjusts 13.5 cm in Z, and improves SLR residuals.

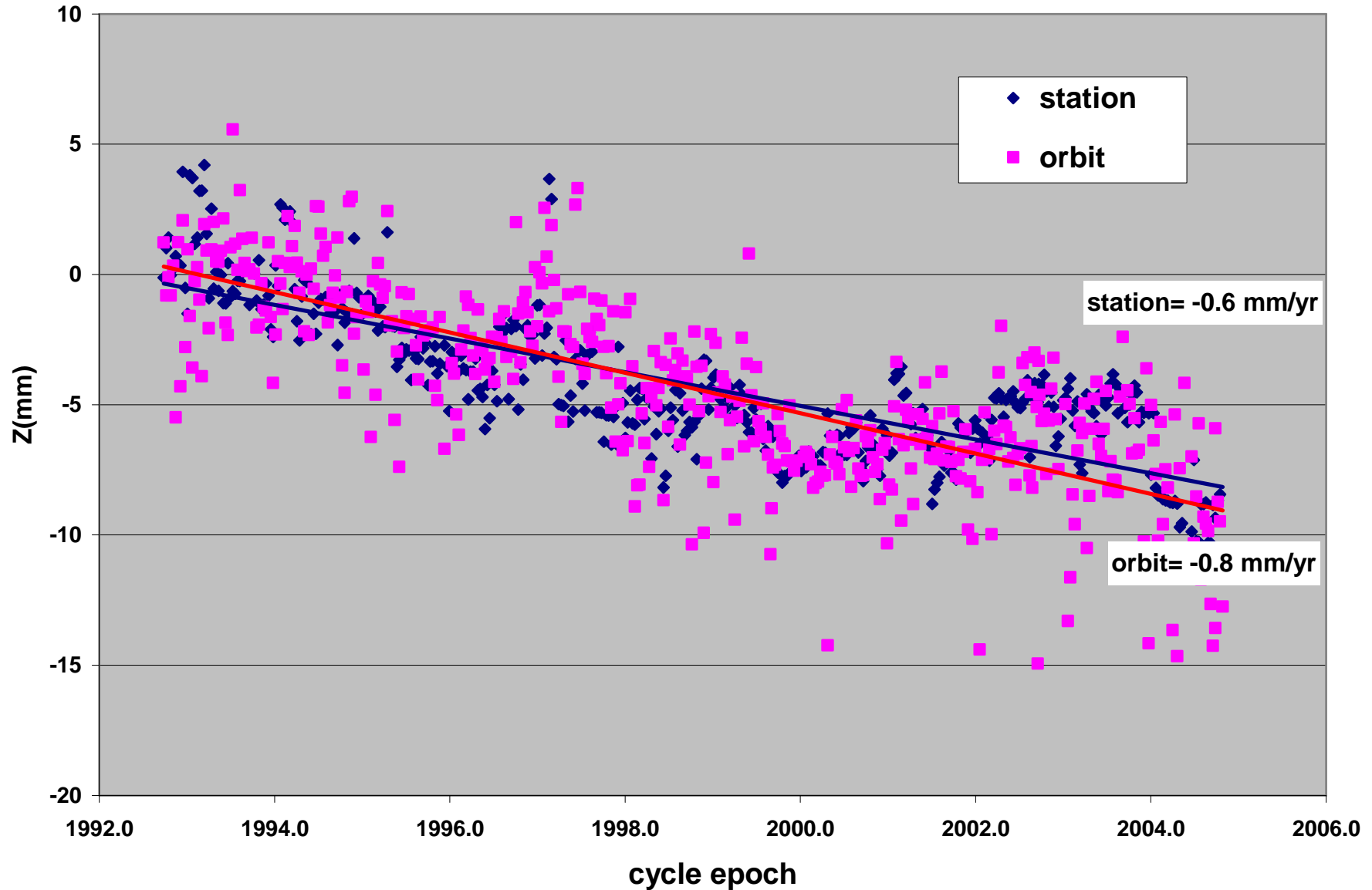- Jason-2 DORIS processing may benefit having a tuned phase map.

BACKUP
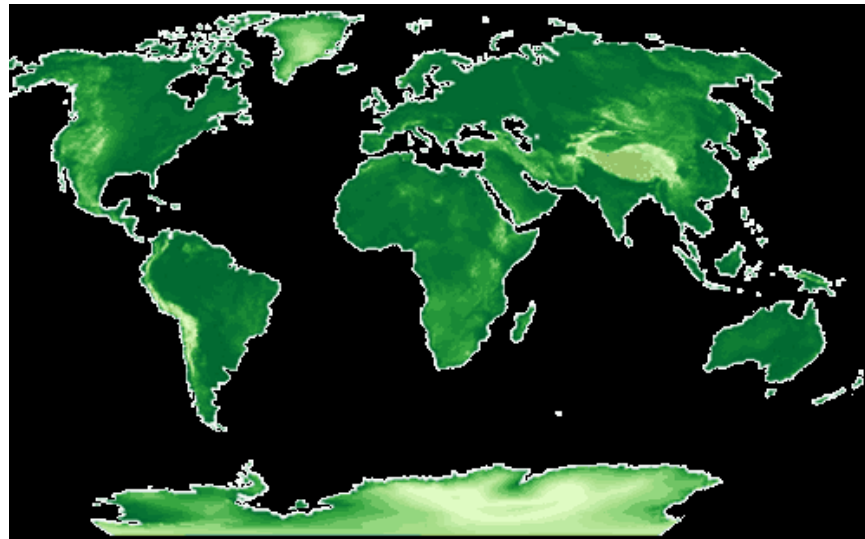
SLR Helmert comparison

6. Helmert-Z SLRF2005-to-ITRF2000 per Topex SLR solution

SLR/DORIS Helmert comparison

7. Helmert-Z CSR95-to-ITRF2000 per Topex SLR/DORIS orbit