Improving DORIS Troposphere Modeling for Jason-1 and Jason-2

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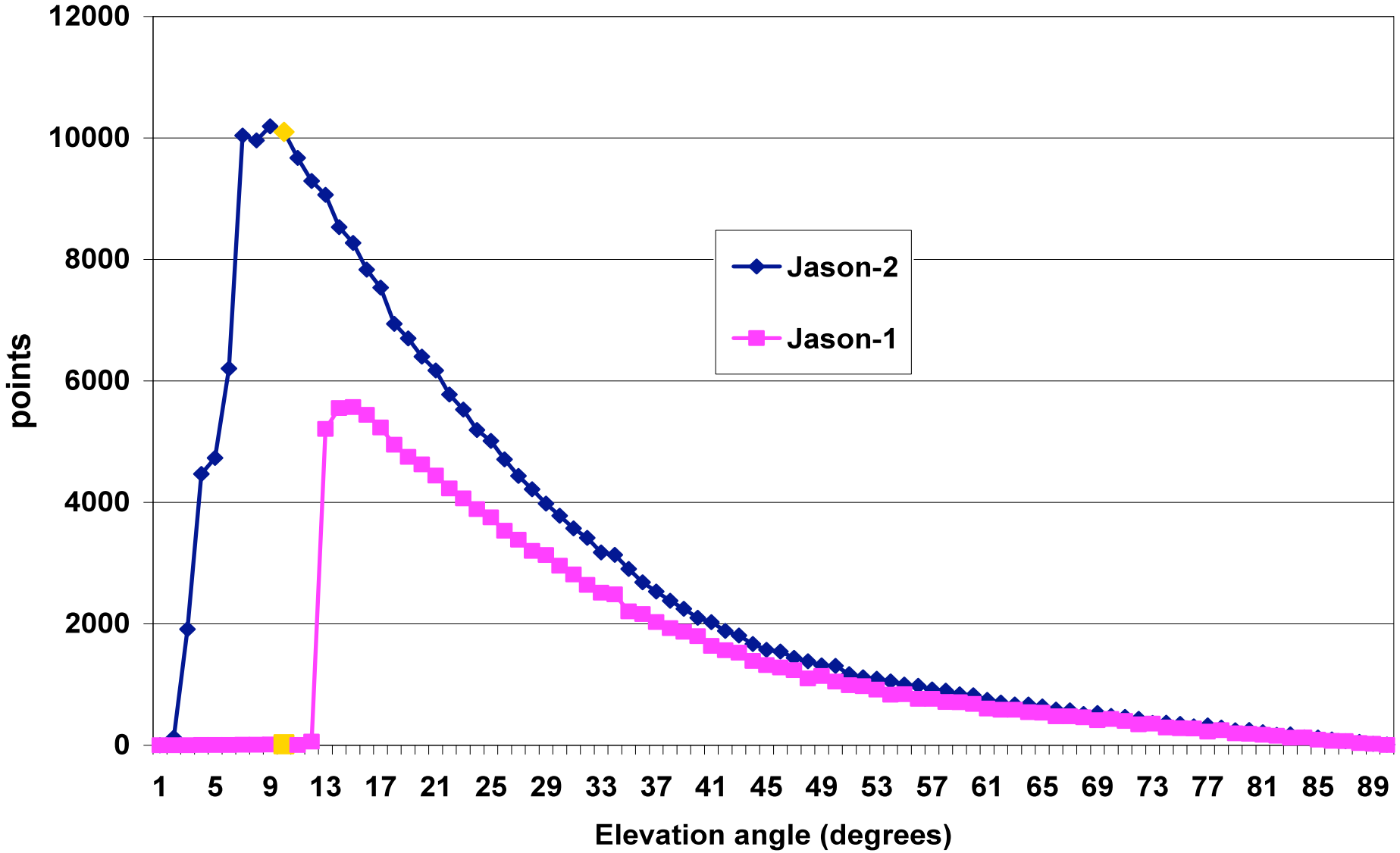
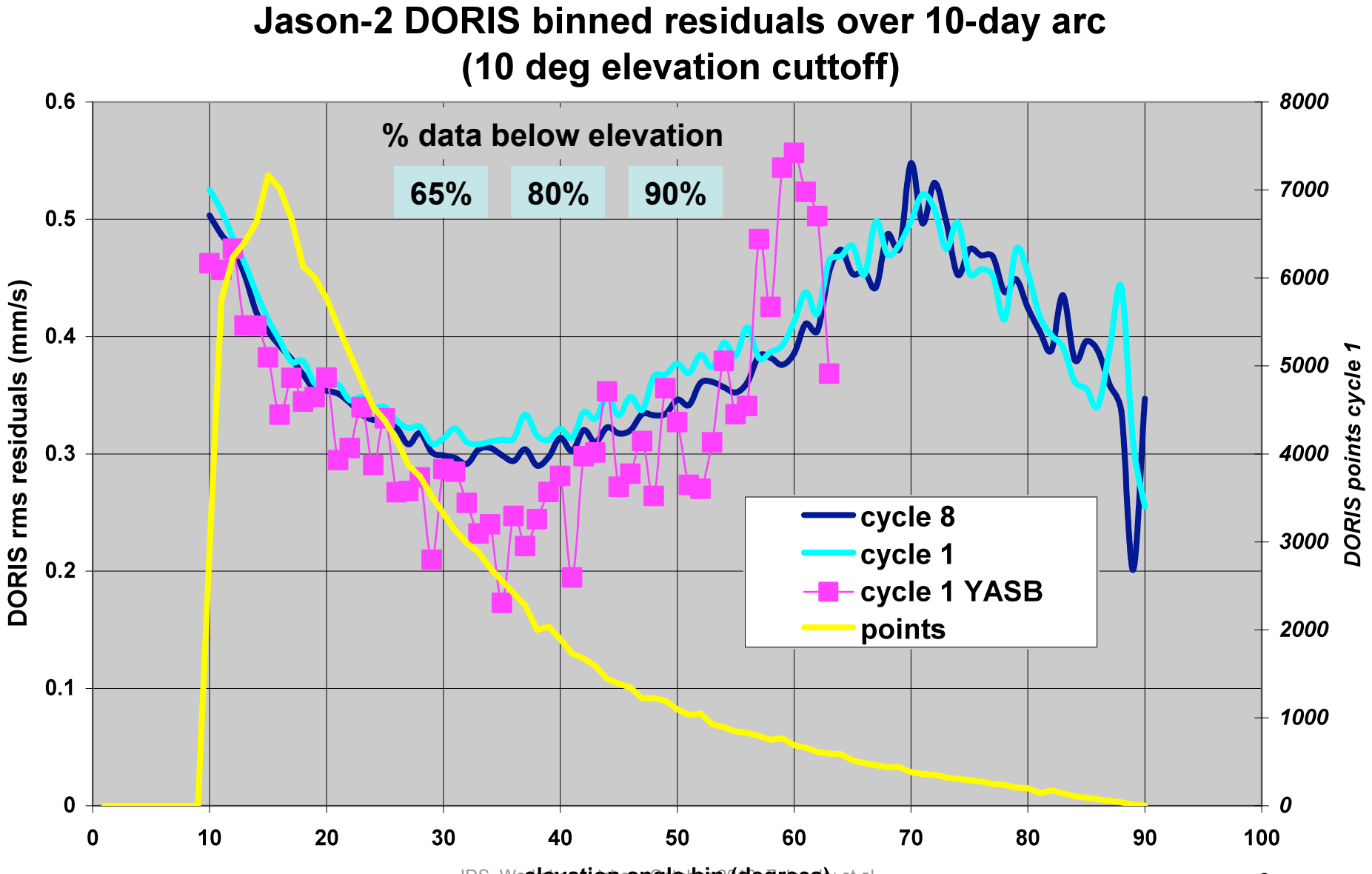
IDS Workshop – Session 4
Lisbon, Portugal
October 21-22, 2010

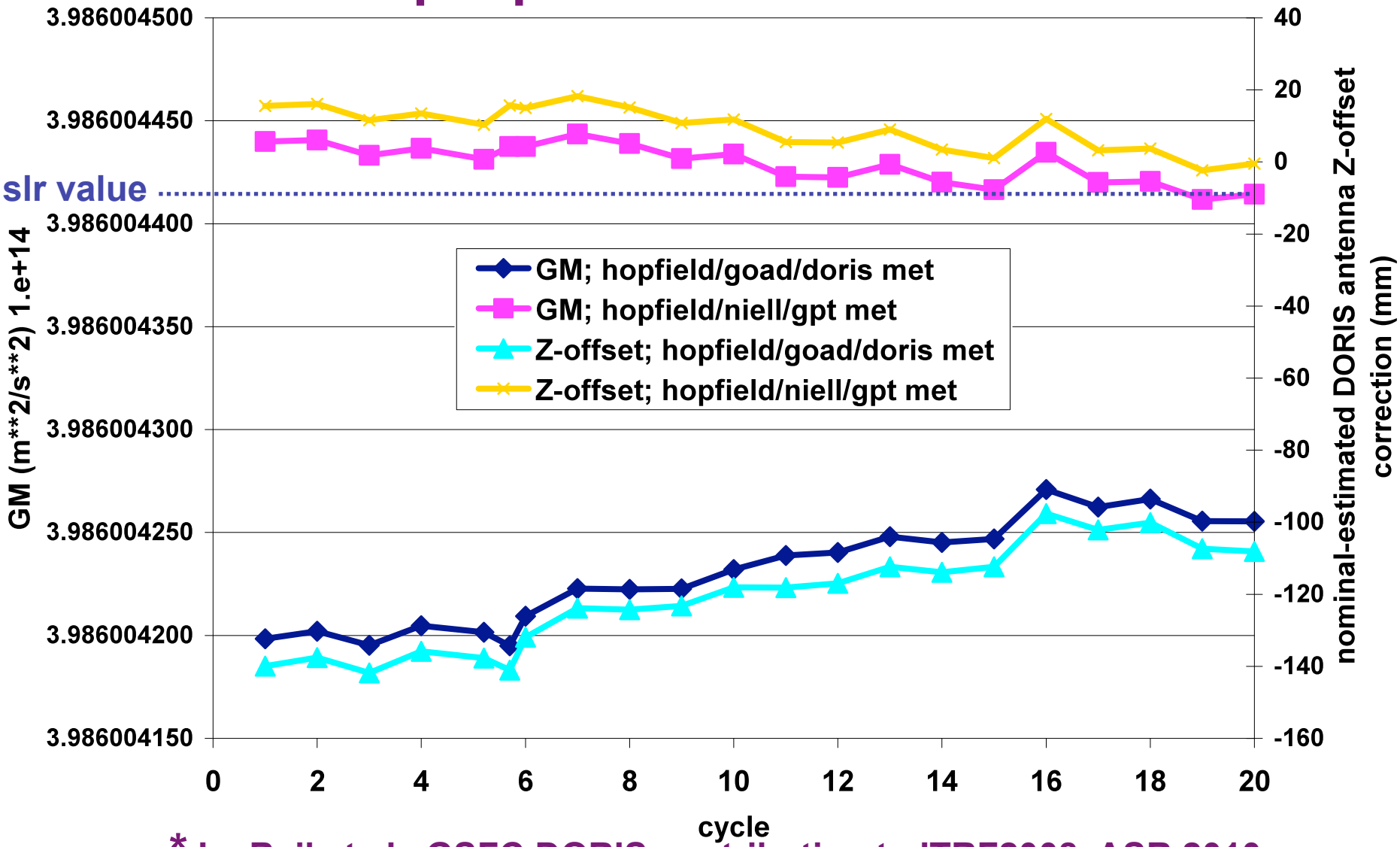
Jason-2 new DORIS receiver allows more tracking at low elevation angles



Tropospheric refraction error dominates DORIS residuals



DORIS estimates of scale sensitive to tropospheric refraction error *



* Le Bail et al., GSFC DORIS contribution to ITRF2008, ASR 2010

Tests for improving troposphere measurement modeling

with 10° elevation cut-off, and estimating a zenith delay scale bias per pass, test :

1) meteorological data (DORIS, GPT)
2) zenith delay model (Hopfield, VLBI)
3) mapping functions (Goad, Niell, GMF)
4) estimation strategy (wet+dry, wet, bias_nuisance, bias_complete, J1+J2 multi-satellite)

test metrics DORIS-only runs:

1) improvement in tracking data residuals (SLR is independent)
2) near-zero adjustment to a-priori value of estimated antenna Z-offset (DORIS - DORIS/SLR estimates similar)

GEODYN nuisance bias (ebias) definition

Nuisance biases are partitioned from other estimated parameters so they only contribute to correct the data in the pass and do not enter into the complete solution. So for example the estimation of these parameters will not influence the estimation of any other parameters, such as the orbit state.

Where $$\delta m = B_e \Delta b + B \Delta x + \varepsilon \quad (1)$$

$\boldsymbol{\delta m}$ = *the vector of residuals* $(O - C)$

$\boldsymbol{\Delta b}$ = *the set of corrections that should be made to the electronic biases*

$\boldsymbol{B_e}$ = the matrix of partial derivatives of the measurements with respect to the biases. The elements of this matrix are either 1's or 0's

$\boldsymbol{\Delta x}$ = *the set of corrections to be made to all other adjustable parameters*

$\boldsymbol{B}$ = the matrix of partial derivatives of the measurements with respect to the $\boldsymbol{x}$ parameters

$\boldsymbol{\varepsilon}$ = *the measurement noise vector*

The least squares solution of (1) is:

$$\begin{bmatrix} \Delta\hat{b} \\ \Delta\hat{x} \end{bmatrix} = \begin{bmatrix} B_e^T W B_e & B_e^T W B \\ B^T W B_e & B^T W B \end{bmatrix}^{-1} \begin{bmatrix} B_e^T W \delta m \\ B^T N \delta m \end{bmatrix}$$

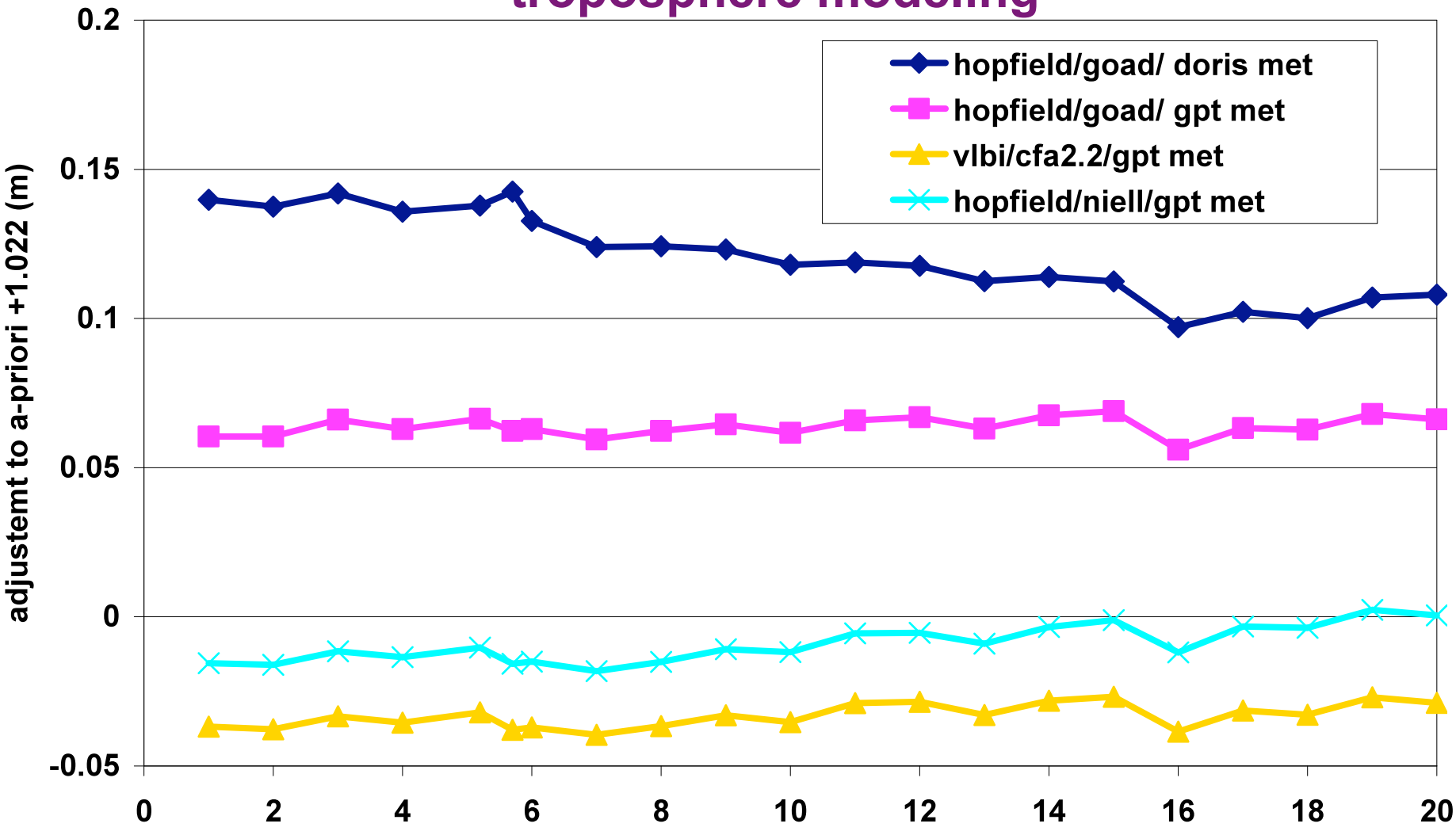
Initial Jason-2 Tests (using GPT values significantly improves solution)

Jason-2 DORIS-only tropospheric delay model tests, cycles 1-20					
troposphere delay modeling: zenith delay / mapping function /meteorological data	residuals		orbit differences RMS (cm)		
	DORIS (mm/s)	SLR* (cm)	radial	cross-track	along-track
a) Hopfield/Goad/DORIS	0.3726	3.235	----	----	----
b) Hopfield/Goad/GPT	0.3656	2.645	0.06	1.58	0.27
c) VLBI/CFA2.2/GPT	0.3666	2.247	0.15	4.25	0.74
d) Hopfield/Niell/GPT	0.3653	2.433	0.13	2.68	0.59

*** SLR data independent**

Initial Jason-2 Tests

estimate DORIS antenna Z-offset - new metric for troposphere modeling *



select hopfield / niell / gpt

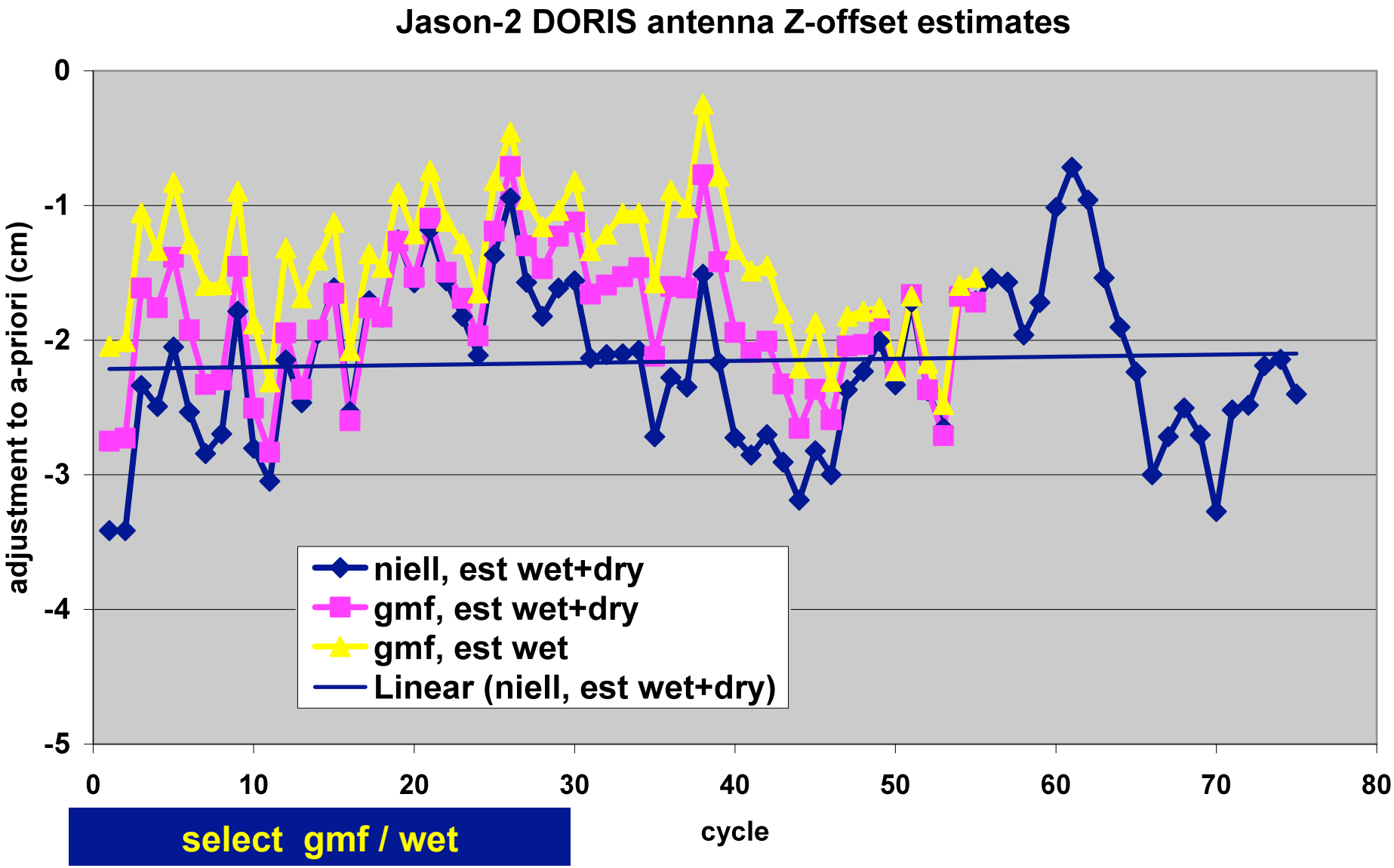
* Zelensky et al., ASR 2010

Further DORIS-only Jason-2 tests using Hopfield model and GPT

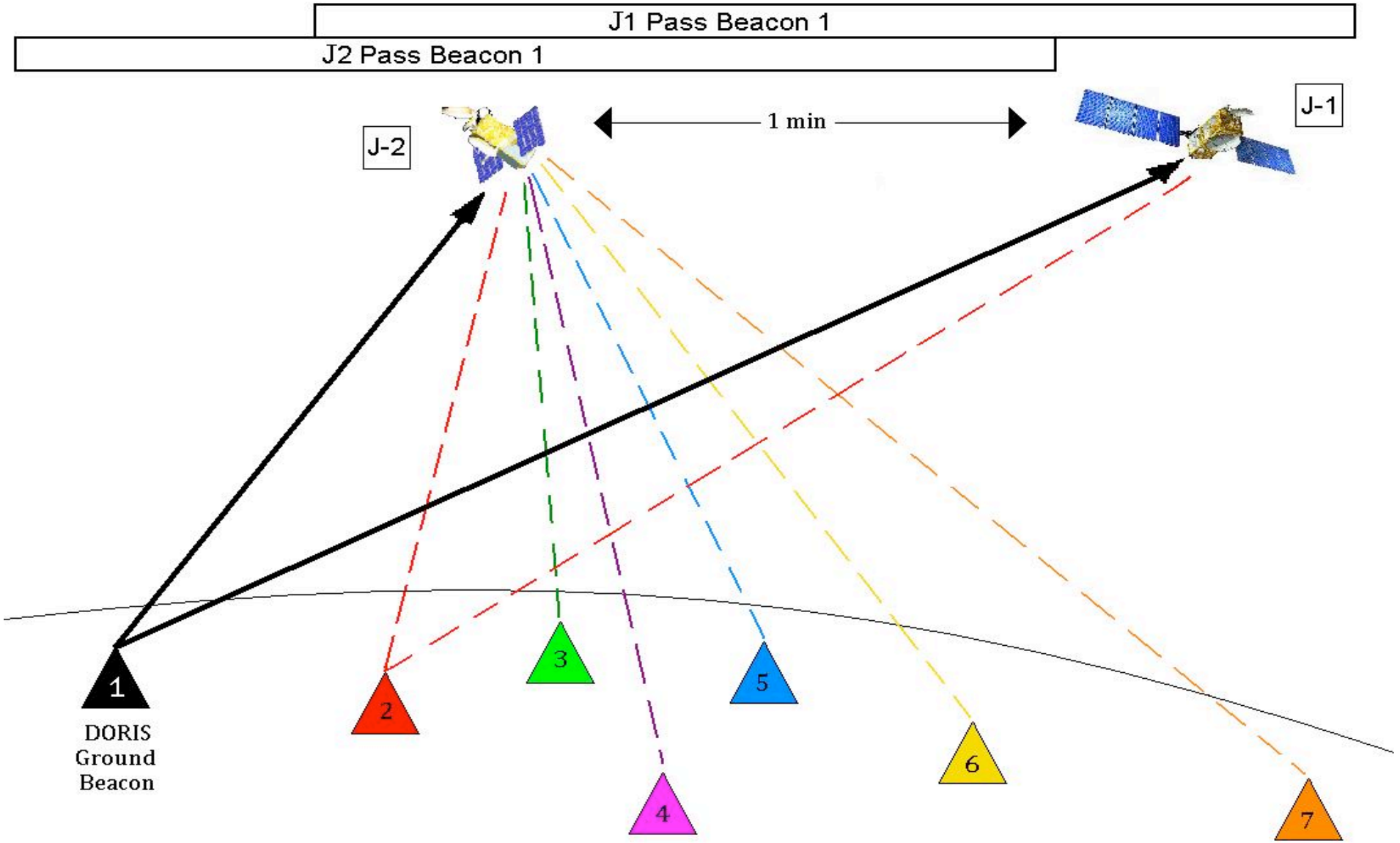
Jason-2 DORIS-only tropospheric delay model tests, cycles 1-55 using Hopfield model and GPT pressure/temperature			
test troposphere delay: mapping function /estimate	residuals		mean Z-offset estimates (cm)
	DORIS (mm/s)	SLR* (cm)	
a) Niell /dry+wet	0.3627	2.29	-2.20
b) GMF / dry+wet	0.3626	2.33	-1.85
c) Niell / wet	0.3628	2.21	-1.65
d) GMF / wet	0.3625	2.24	-1.42

* SLR data independent

Further DORIS-only Jason-2 tests using Hopfield model and GPT



Jason-1 / Jason-2 Validation Period



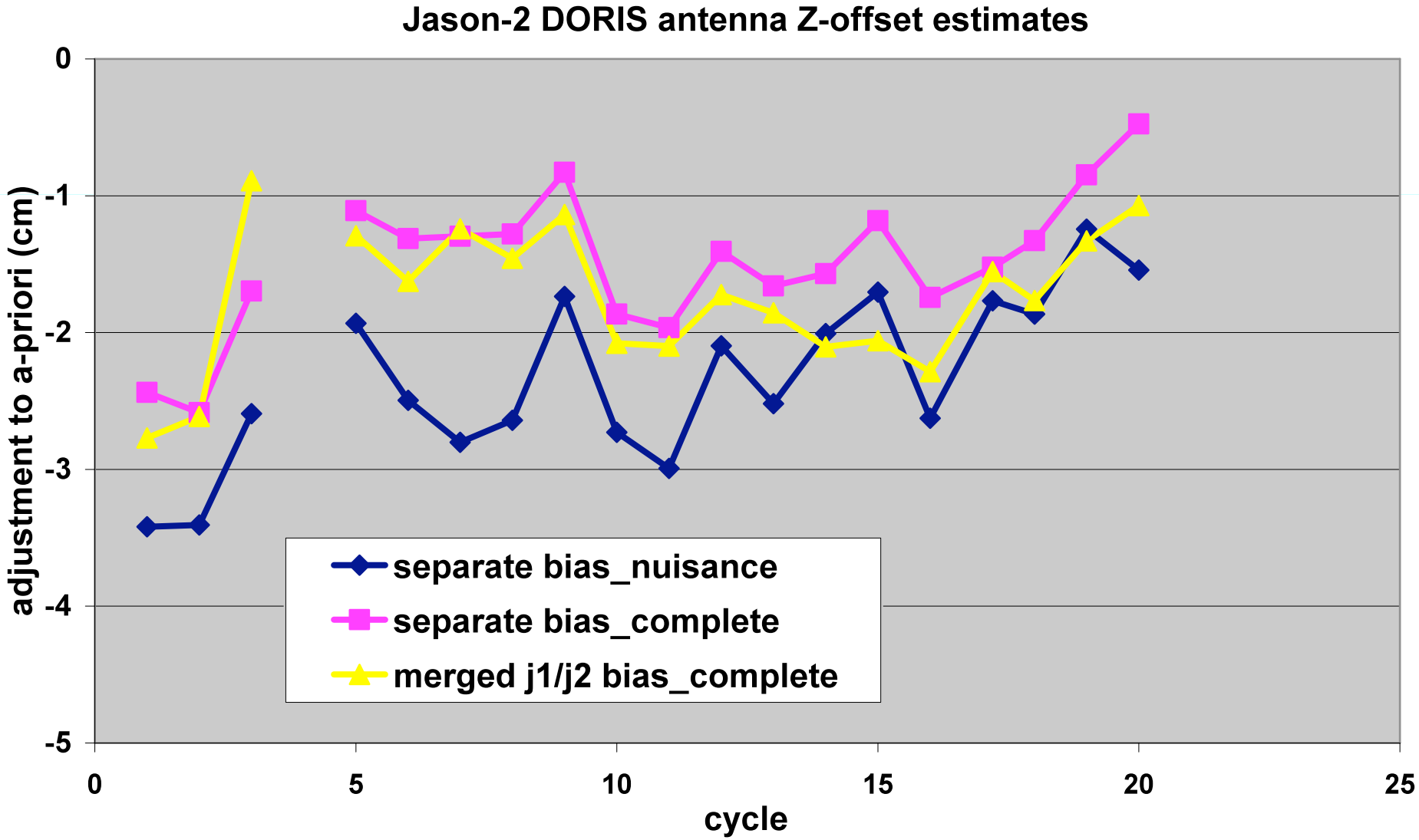
Combine Jason-1 / Jason-2 passes to estimate troposphere zenith delay bias

Jason-1/2 DORIS-only tropospheric delay model tests J2 cycles 1-20 test nuisance/complete bias estimation and combining J1/J2					
use Hopfield model , Niell mapping, GPT, estimate wet+dry delay component	Jason-1		Jason-2		number estimated parameters per J1/J2 arc (cycle 1)**
	DORIS (mm/s)	SLR* (cm)	DORIS (mm/s)	SLR* (cm)	
a) separate J/J2 bias_nuisance (nominal)	0.3507	3.15	0.3591	2.21	173
b) separate J1/J2 bias_complete	0.3741	3.21	0.3639	2.34	4668
c) merged J1/J2 (80% merged) bias_complete	0.3891	3.53	0.3932	3.05	2390

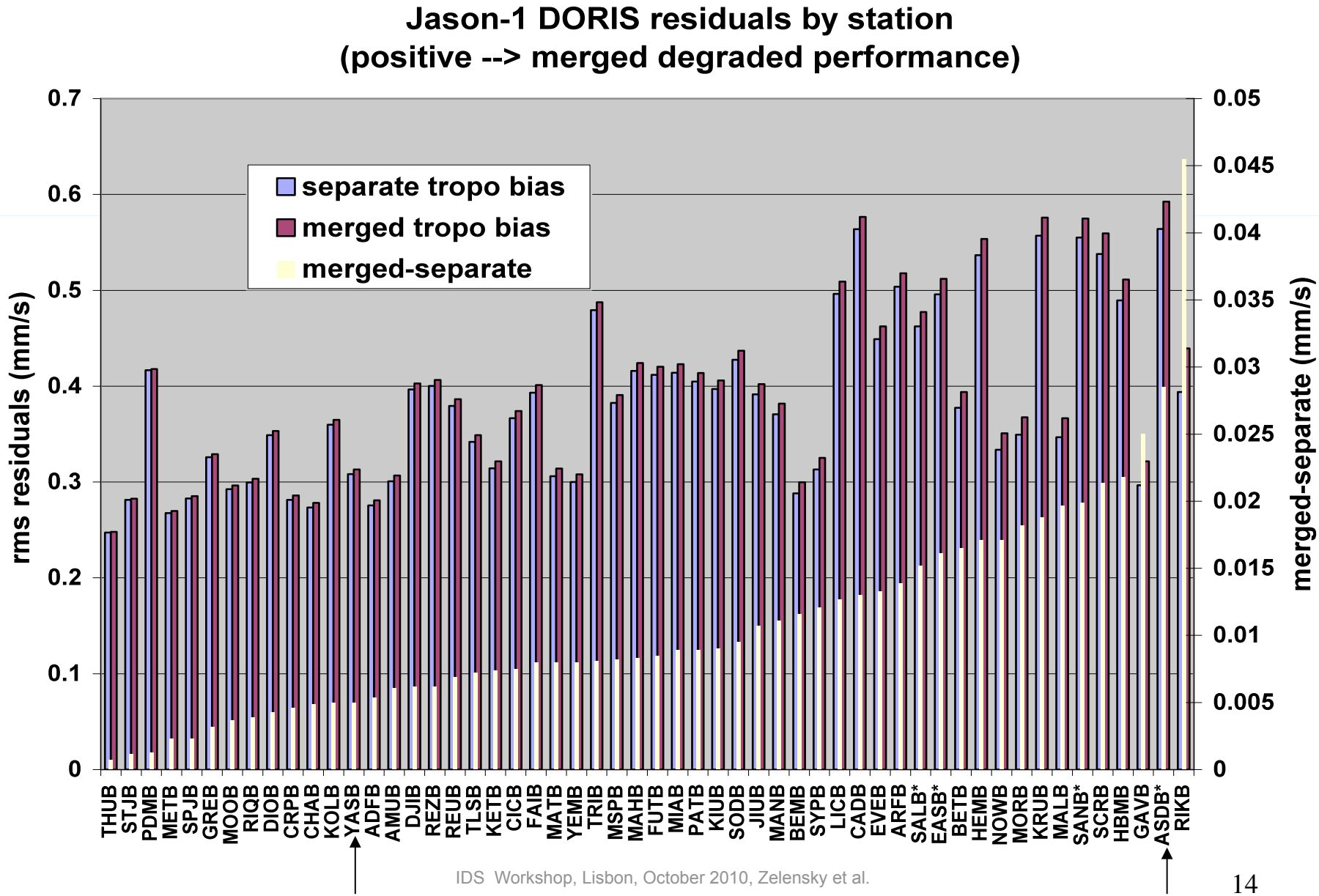
* SLR data independent

** about 300,000 obs

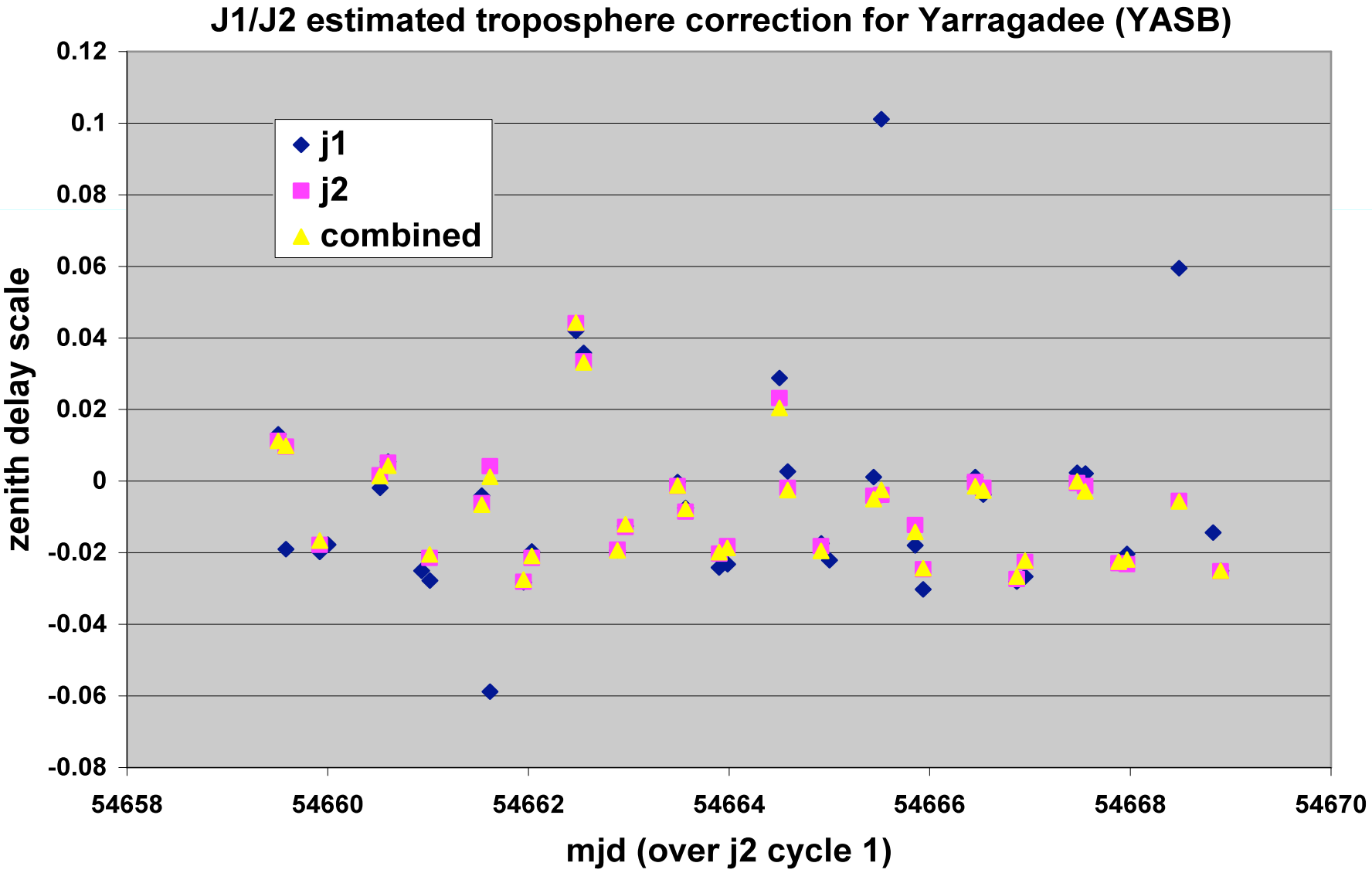
Combine Jason-1 / Jason-2 passes to estimate troposphere bias



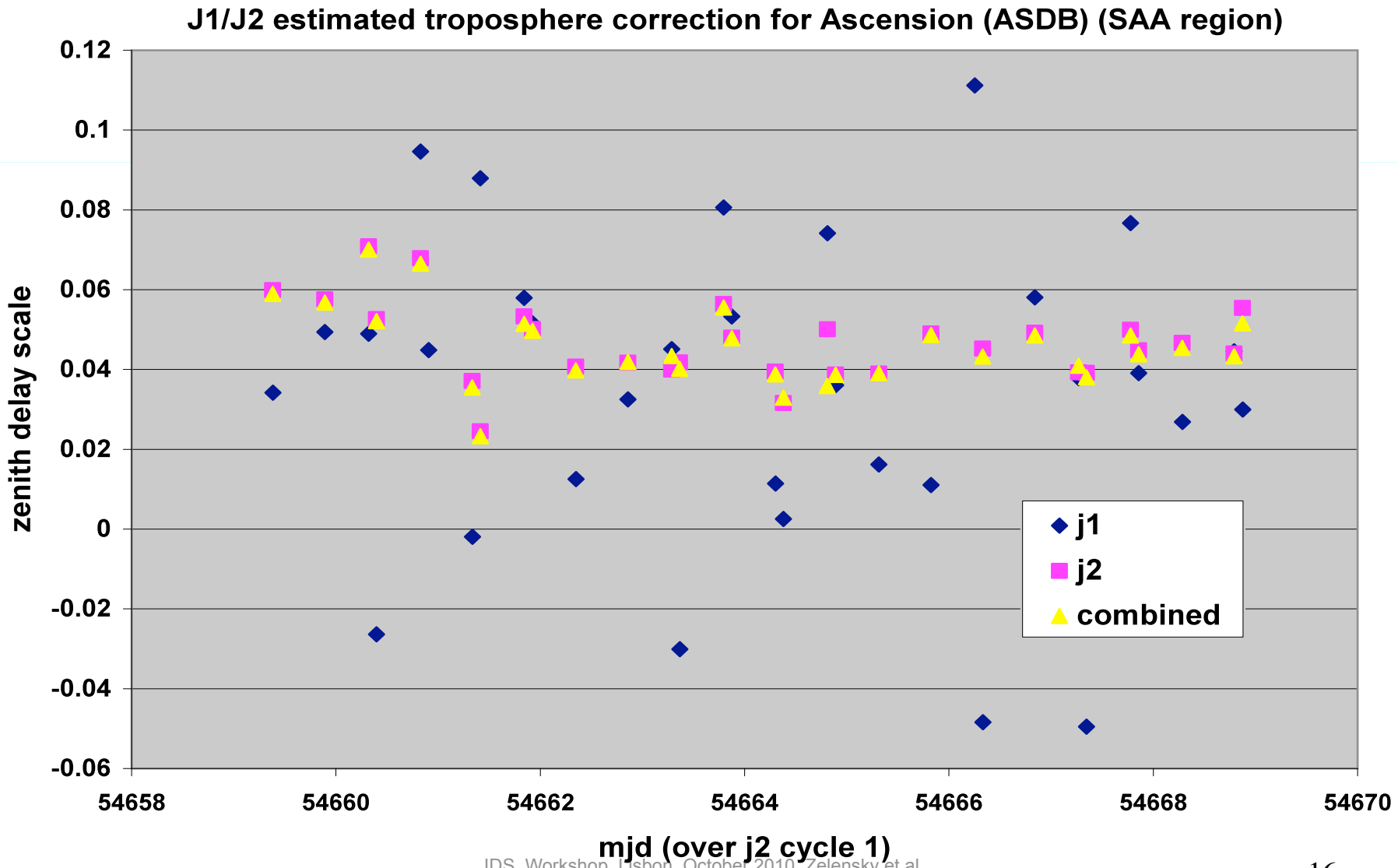
Combine Jason-1 / Jason-2 passes to estimate troposphere bias



Combine Jason-1 / Jason-2 passes to estimate troposphere (complete) bias



Combine Jason-1 / Jason-2 passes to estimate troposphere (complete) bias
(notice J1 scatter)



Summary

1) DORIS antenna Z-offset offers new metric for testing troposphere modeling.

2) Best combination using: Hopfield / GPT meteo data / GMF mapping /estimate wet-only.

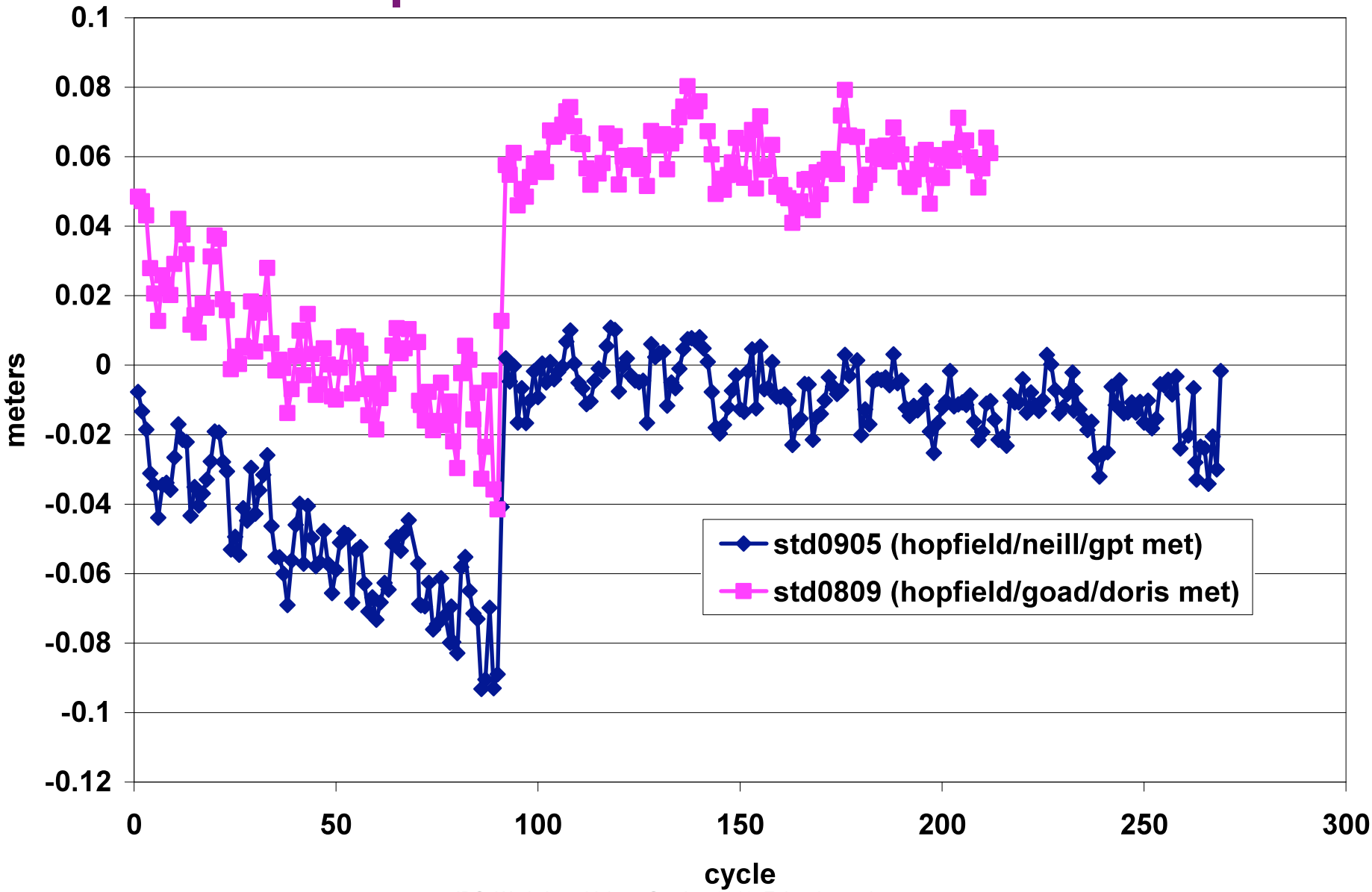
3) Estimating the troposphere scale bias in a complete solution (not as nuisance bias) shows promise.

4) Estimating one troposphere bias for intersecting J1/J2 passes did not improve modeling. Possibly due to J1 SAA effect and will be investigated in further testing.

5) future analysis will consider: VMF1 mapping, estimate horizontal gradients, pressure data from numerical models, reduced-dynamic bias constraints, multi-satellite solutions with GPS.

BACKUP

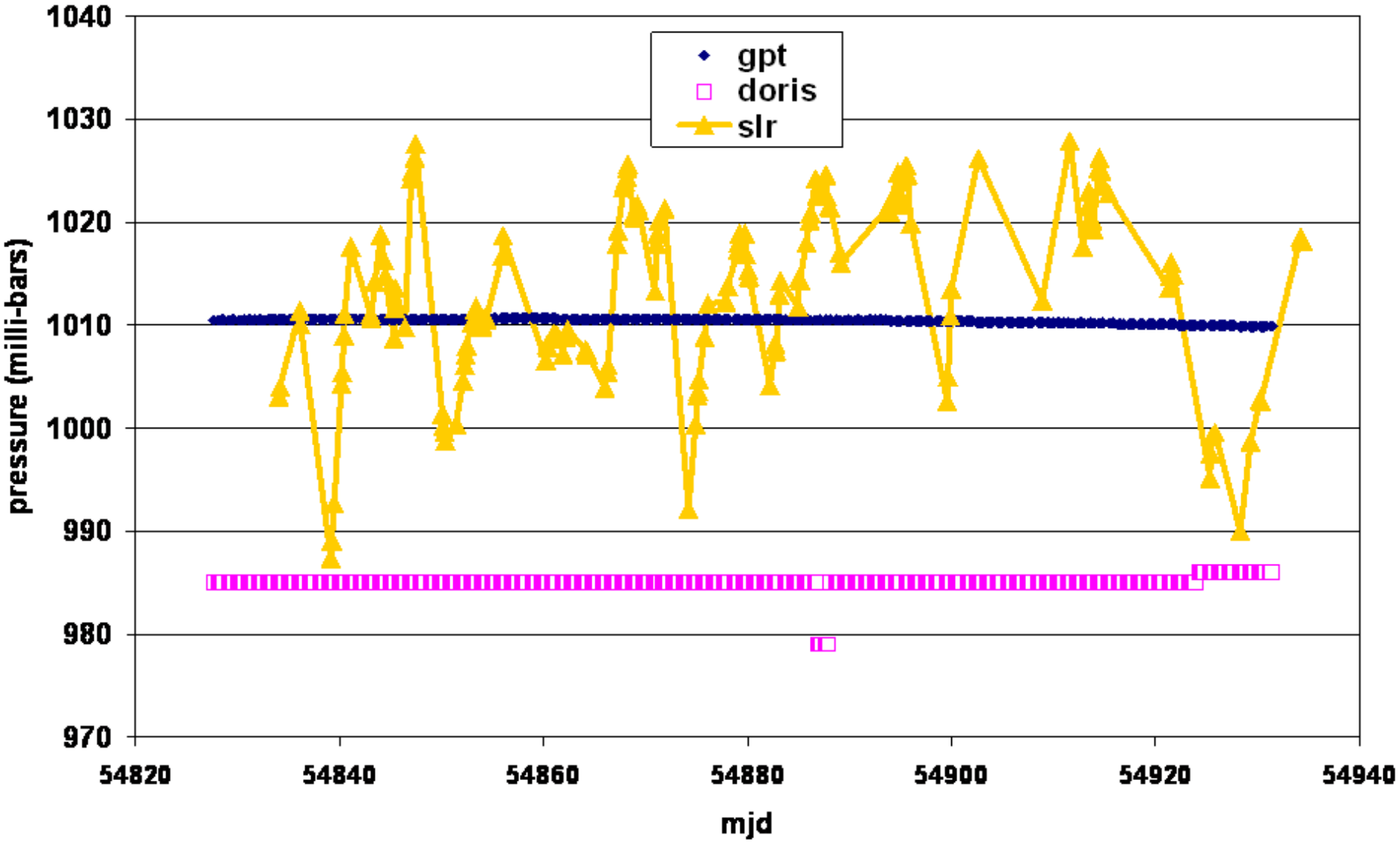
Jason-1 DORIS antenna Z-offset estimate - a predictor of oscillator health



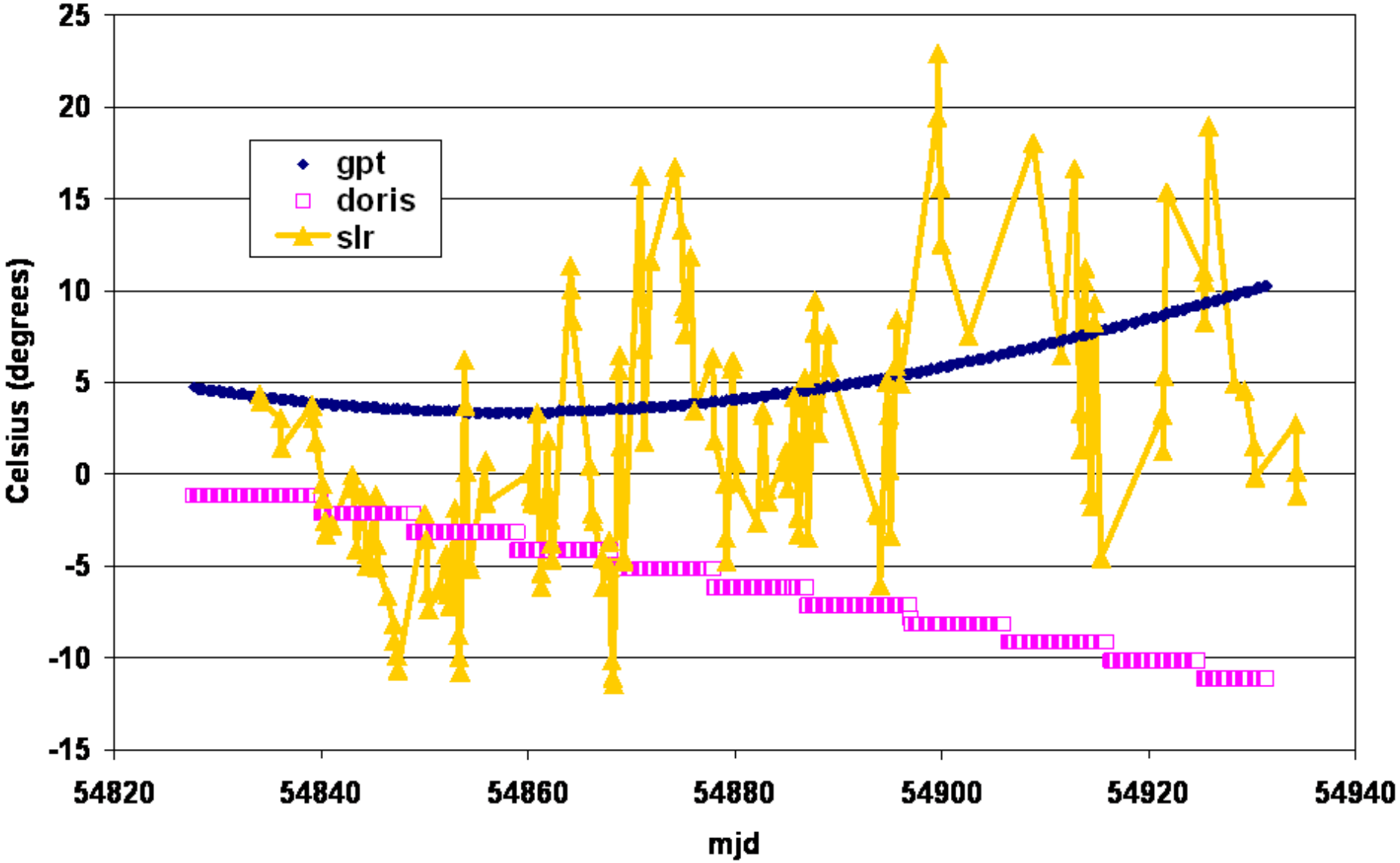
J1 / J2 YASB DORIS passes over 1-day

		start y md	time hm	points		rmsb mm/s	rmsa mm/s	bias .mm/s	tbias millis	max elv
431	YASB4292	80712	1208	40	40	0.2637	0.2608	-0.5662	0.0355	40 24.4
432	YASB4292	80712	1208	40	40	0.2902	0.2348	2.2600	-0.1546	40 24.4
436	YASB4292	80712	1215	34	34	0.3259	0.3253	0.1777	-0.0095	40 24.2
437	YASB4292	80712	1215	24	24	0.3730	0.3613	-1.4917	0.0937	40 22.5
518	YASB4292	80712	1401	40	40	0.2685	0.2532	0.1681	-0.0154	40 55.0
519	YASB4292	80712	1402	40	40	0.3269	0.3118	0.3790	-0.0266	40 51.6
524	YASB4292	80712	1408	40	40	0.2007	0.1902	0.7960	-0.0306	40 57.1
525	YASB4292	80712	1408	40	40	0.2682	0.2574	-0.0027	0.0043	40 57.1
528	YASB4292	80712	1415	10	10	0.3070	0.2949	-1.1294	0.2513	40 19.1
529	YASB4292	80712	1415	16	16	0.3747	0.3662	-0.2765	0.0776	40 22.1
884	YASB4292	80712	2205	40	40	0.2948	0.2518	1.0005	-0.0533	40 26.3
885	YASB4292	80712	2205	40	40	0.2816	0.2370	1.2397	-0.0663	40 26.3
889	YASB4292	80712	2211	32	32	0.3482	0.2921	-3.3430	0.2081	40 25.8
890	YASB4292	80712	2212	37	37	0.3223	0.2778	-1.6032	0.0927	40 26.1

DORIS Greenbelt station (GREB) pressure (January 2009 - May 2009)



DORIS Greenbelt station (GREB) dry temperature (January 2009 - May 2009)



DORIS Greenbelt station (GREB) relative humidity (January 2009 - May 2009)