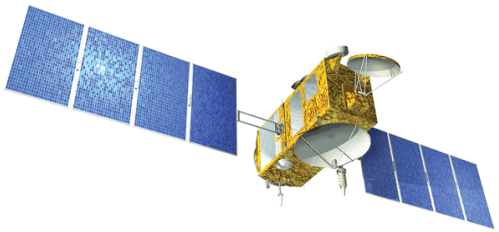
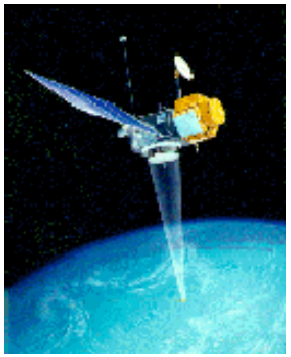
The puzzling 59-day altimeter data signal and possible causes

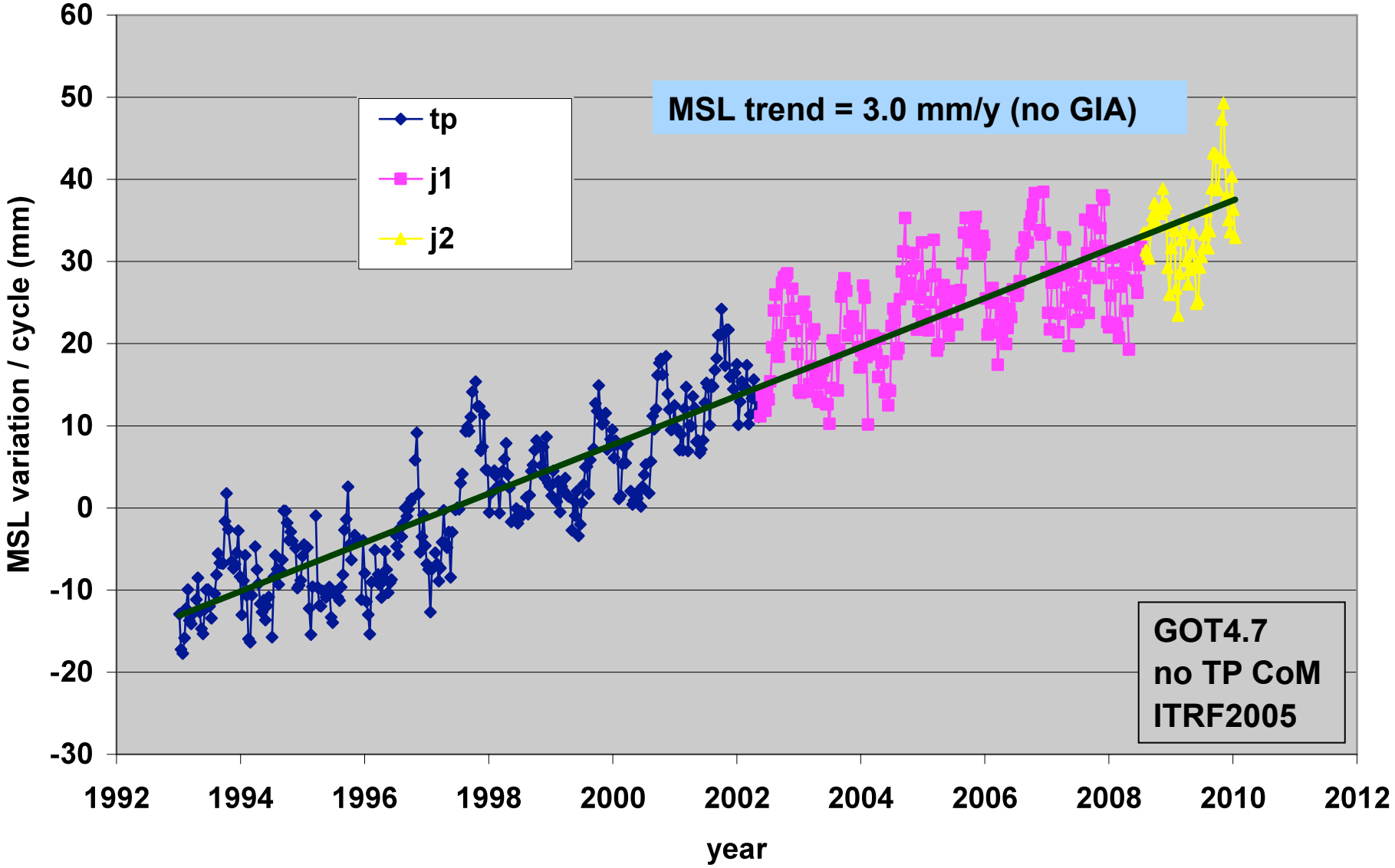
N.P. Zelensky, B.D. Beckley, F.G. Lemoine, S.M. Klosko, R.D. Ray, S. Holmes, D.D. Rowlands, S.B. Luthcke, D.S. Chinn, O. Bordyugov

OSTST 2010 60-day Splinter
Lisbon, Portugal
October 18-20, 2010

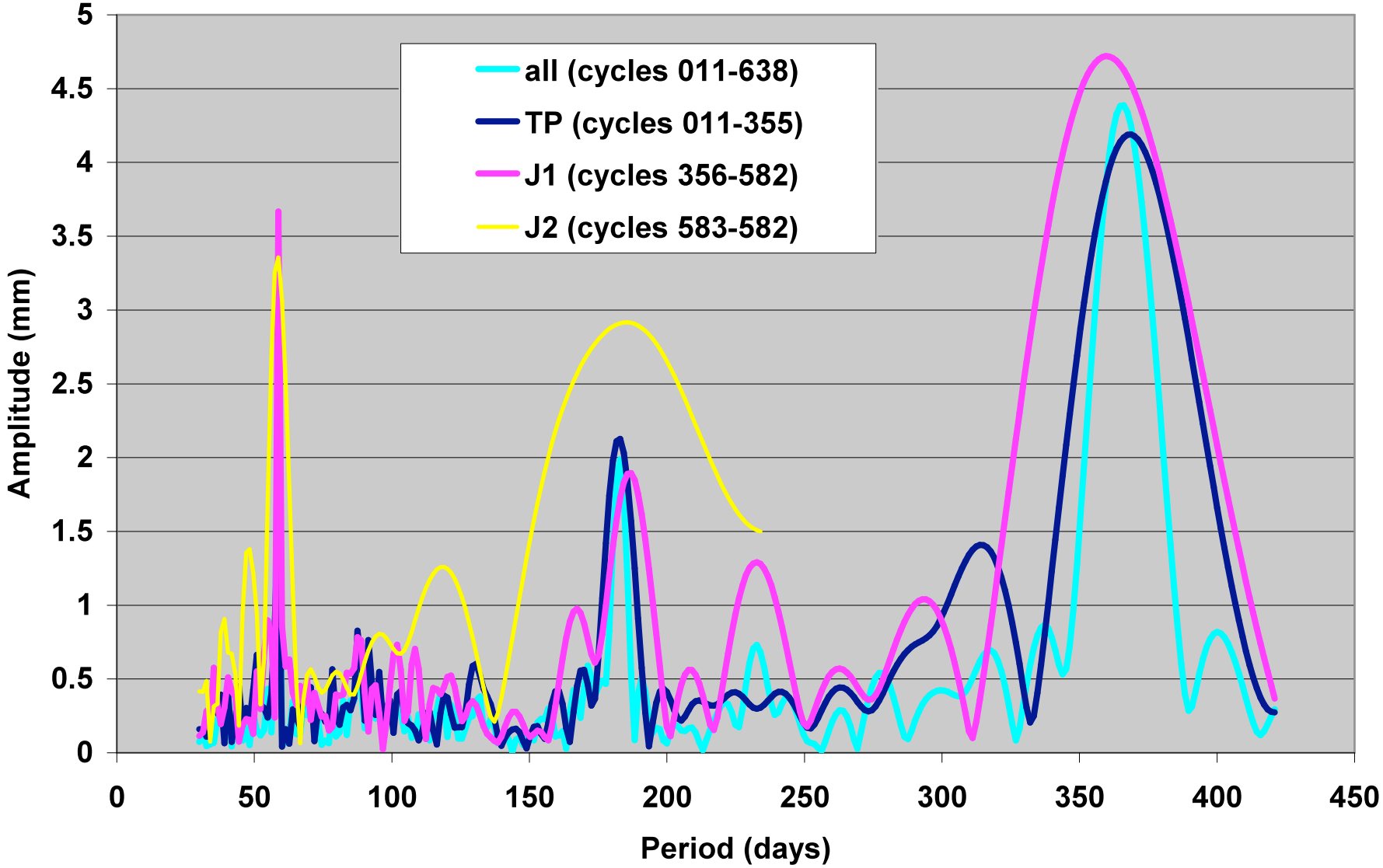




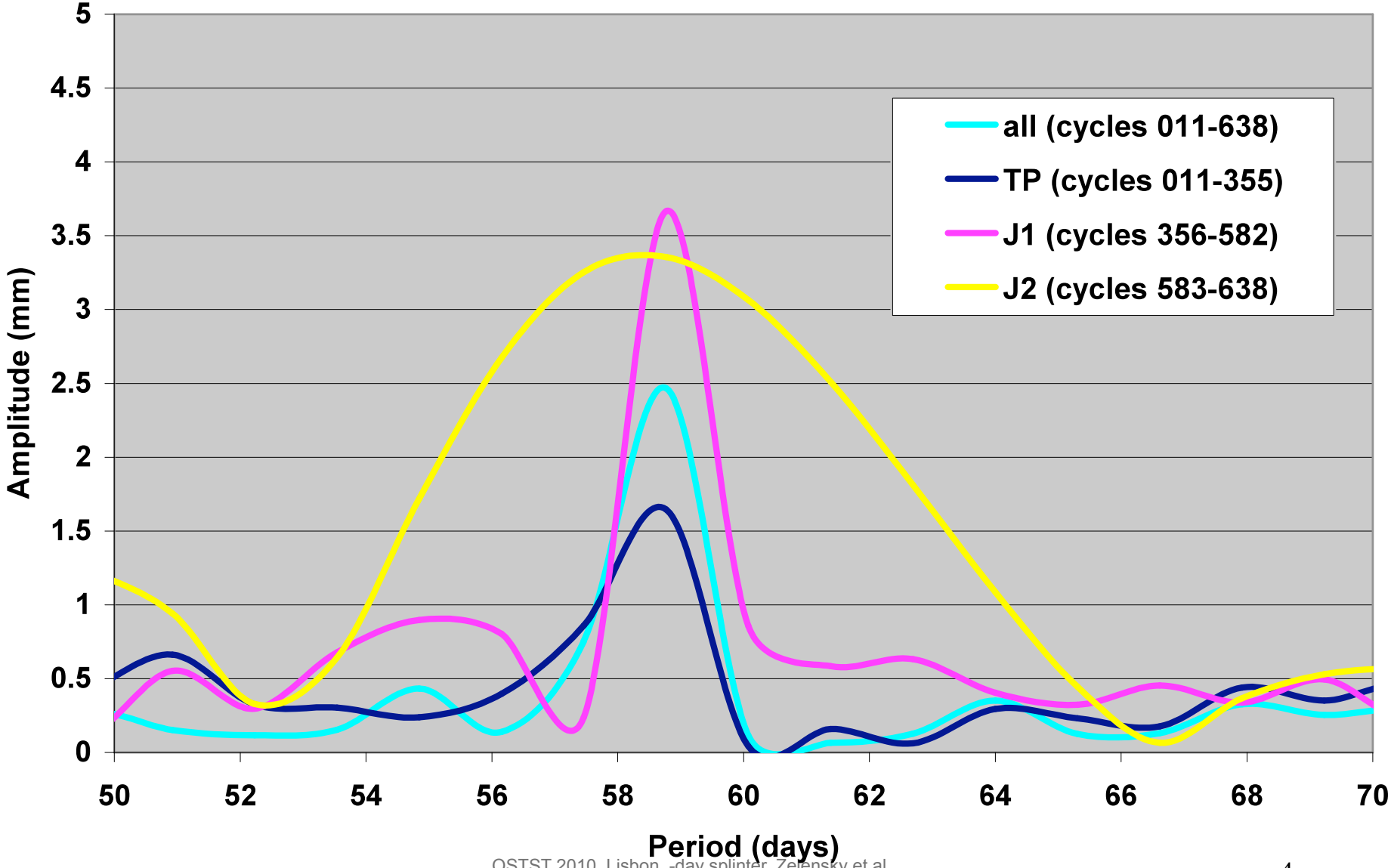
Estimated test altimeter MSL / cycle 1993-2009



Periodogram MSL variation/cycle 1993-2009
(power at annual, 58.76 day, and semi-annual periods)

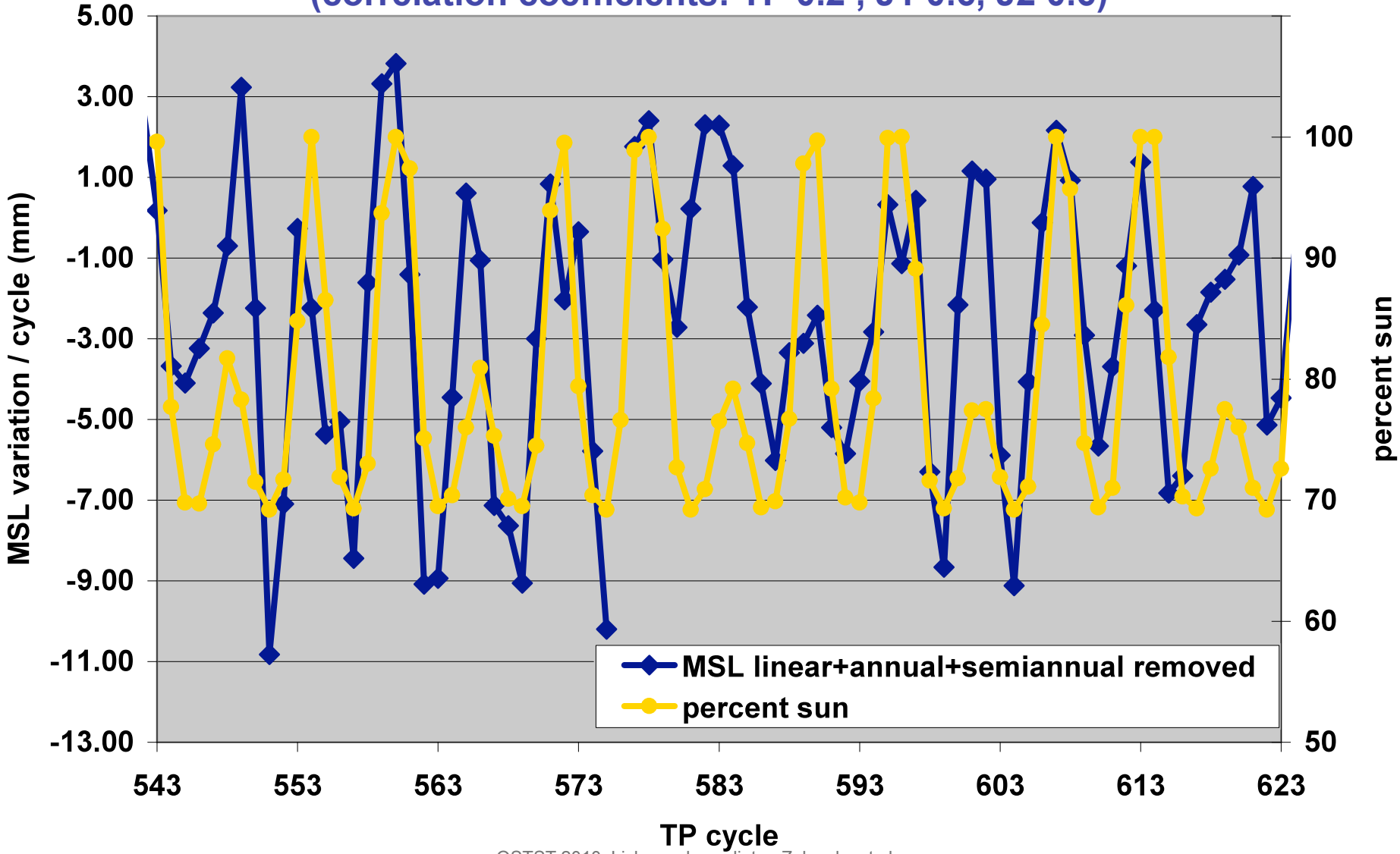


Periodogram MSL variation/cycle
(power in vicinity of 59 days (peak at 58.76 days))



59-day term correlated with percent satellite in sun (with cycle 583 Jason-2 begins)

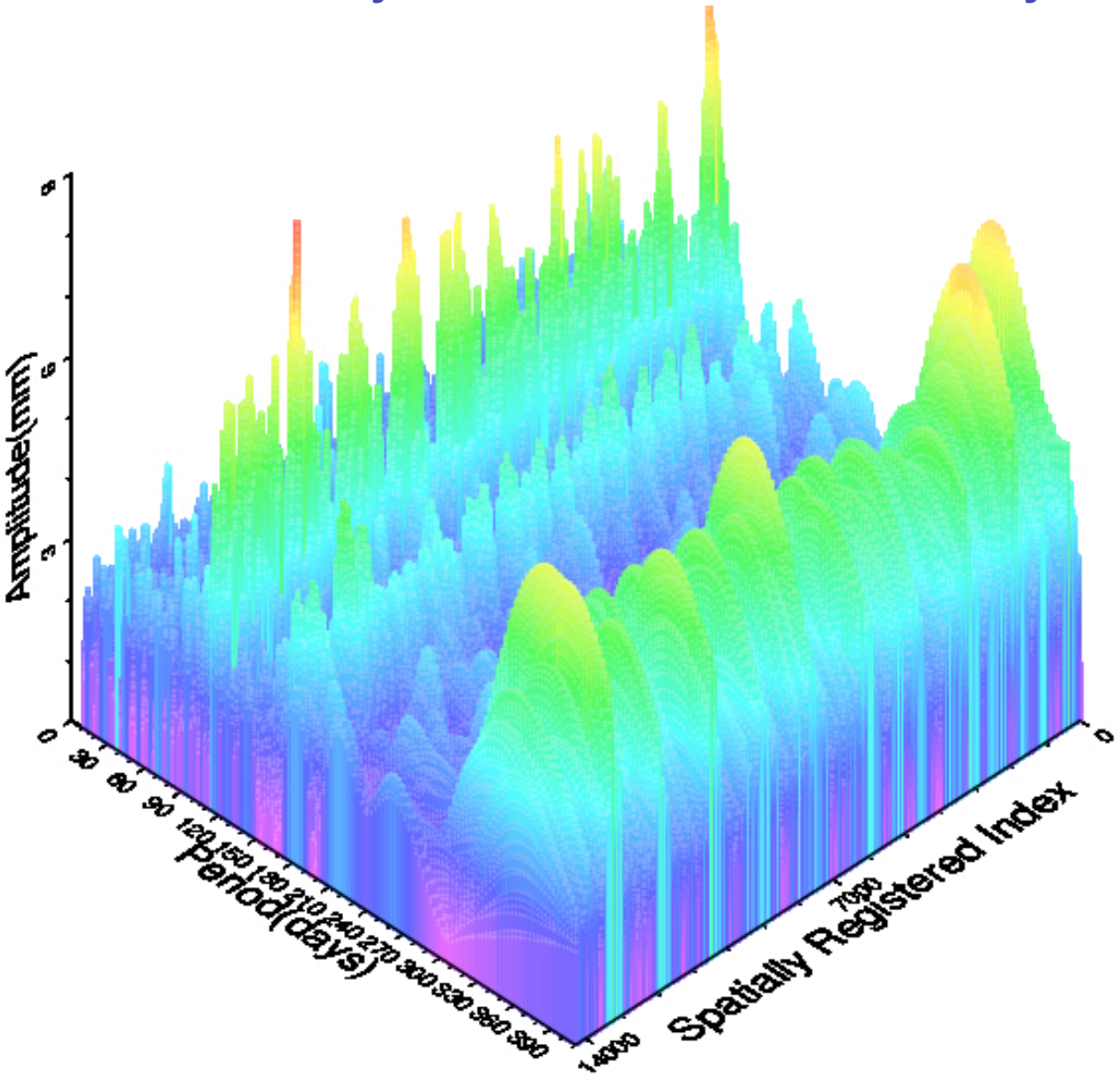
(correlation coefficients: TP 0.2 , J1 0.6, J2 0.6)

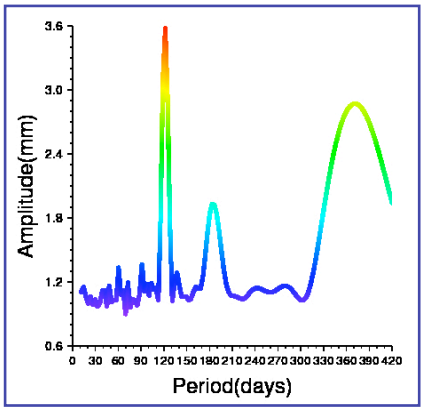


Remaining force model errors in J1 dynamic orbits

periodogram radial differences sampled over geographic points

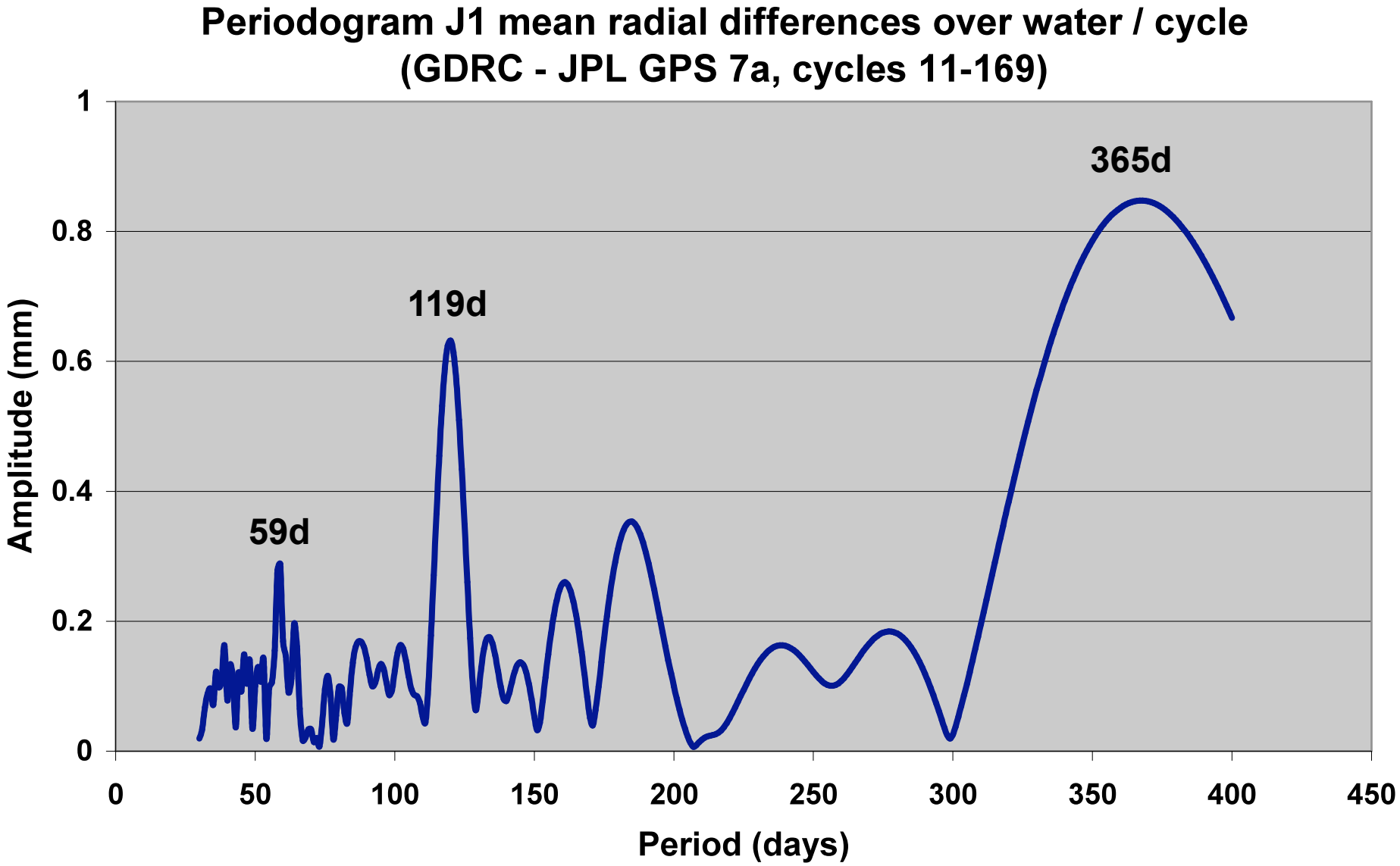
GDRC dynamic - JPL GPS 7a reduced dynamic cycles 11-169



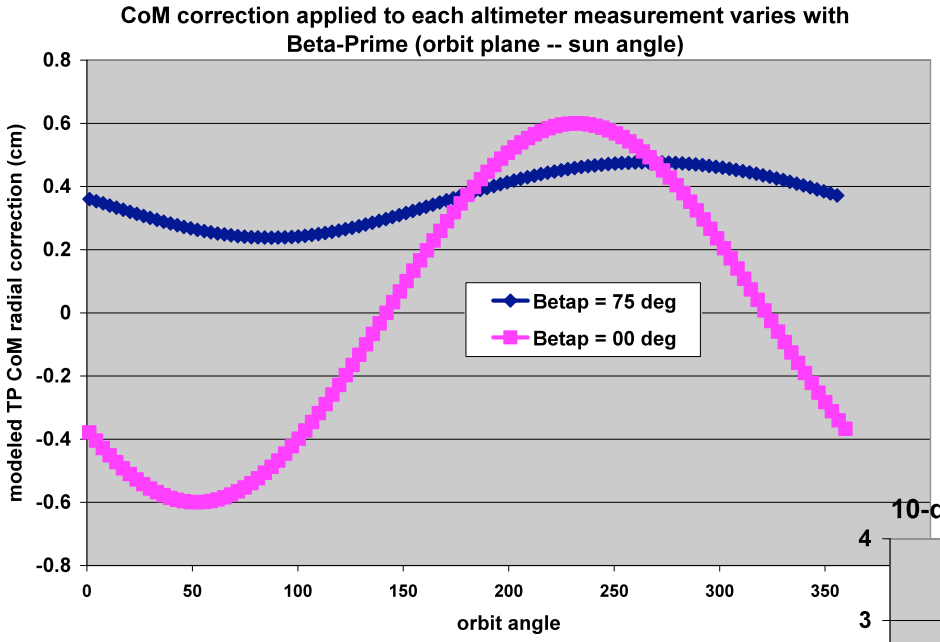


period (days)	peak (mm)
118	3.6
180	1.8
365	2.8

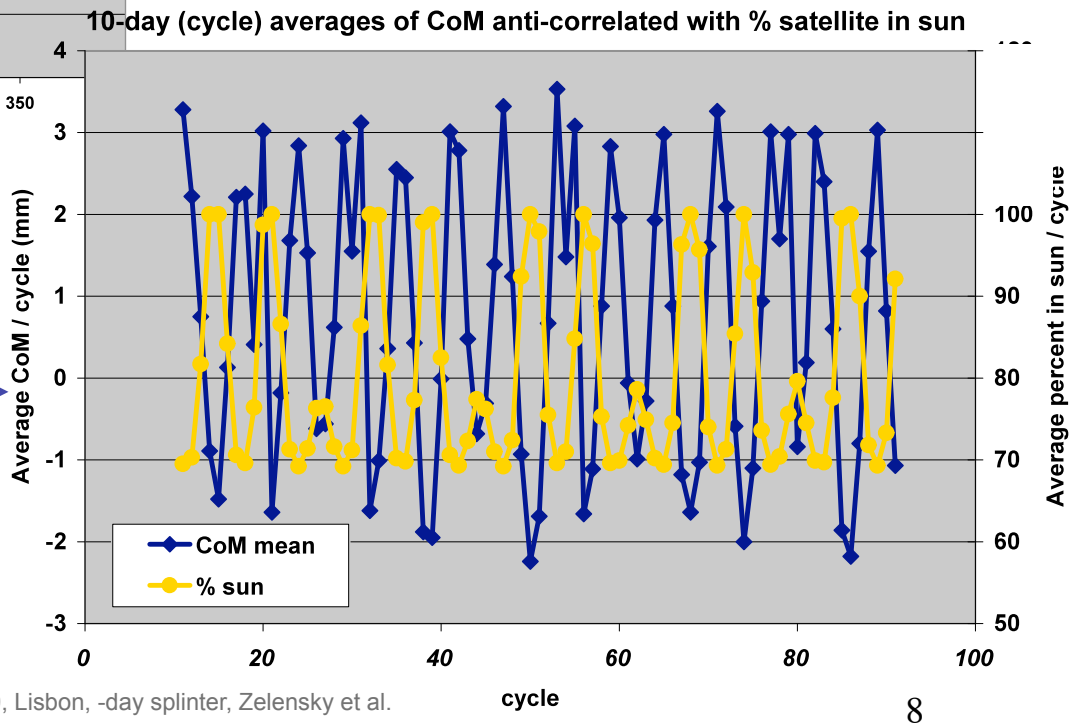
Orbit error is likely not a source for the 59 day term



Evaluate TP GDR CoM correction due to solar array warping (added to range)

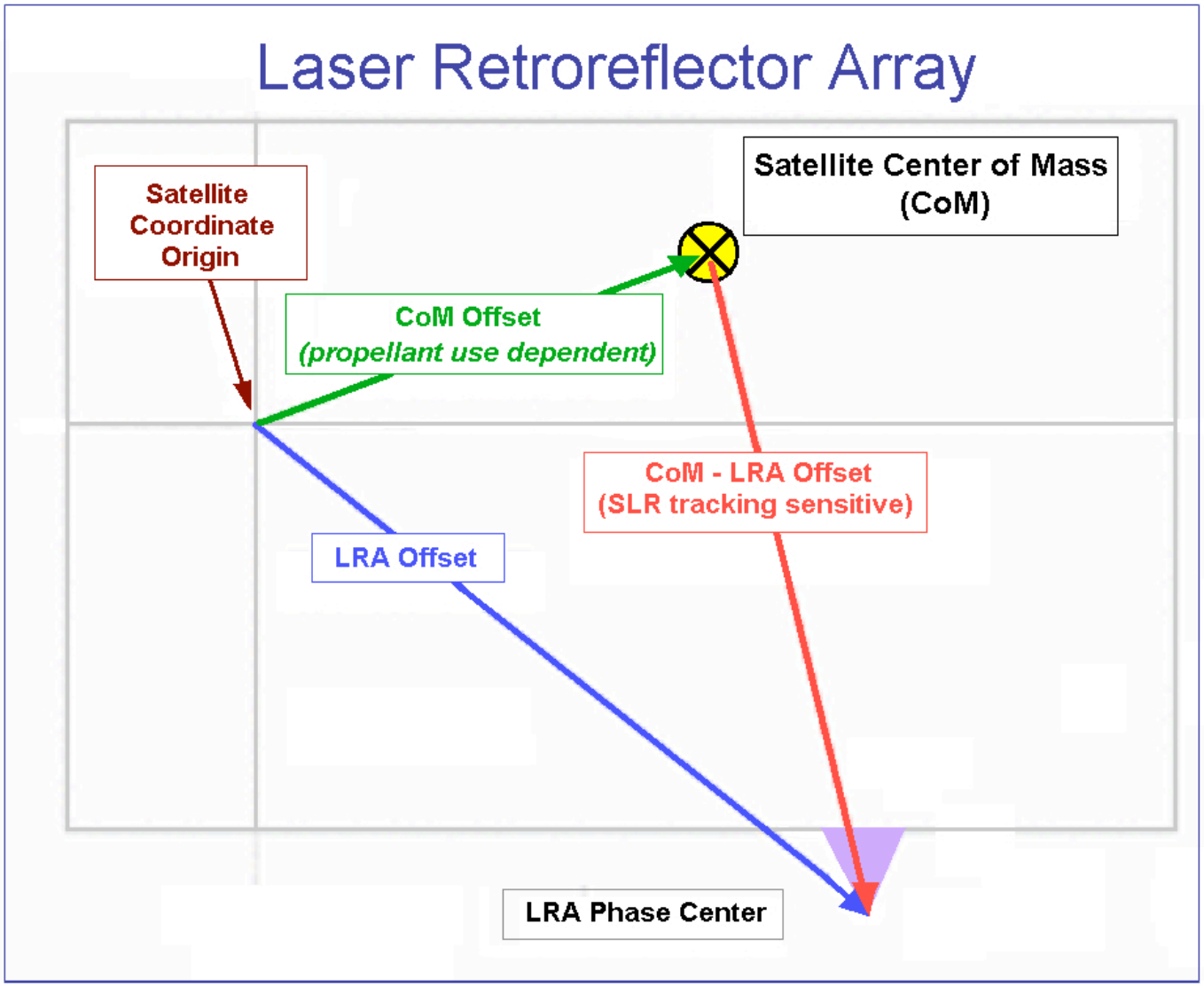


CoM correction applied to each altimeter measurement varies with Beta-Prime (orbit plane -- sun angle)

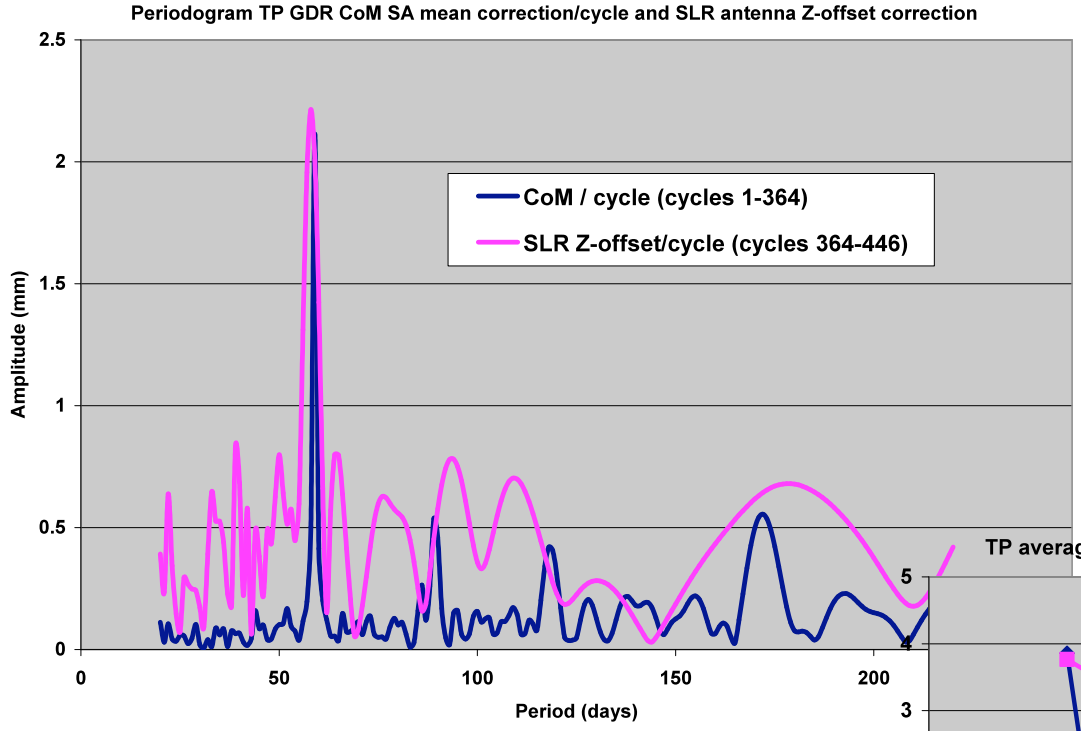


10-day (cycle) averages of CoM are anti-correlated with satellite percent in sun (-0.8 correlation coefficient cycles 1-364)

Evaluate TP GDR CoM correction using SLR data - estimate radial changes in LRA antenna Z-offset over each 10-day arc

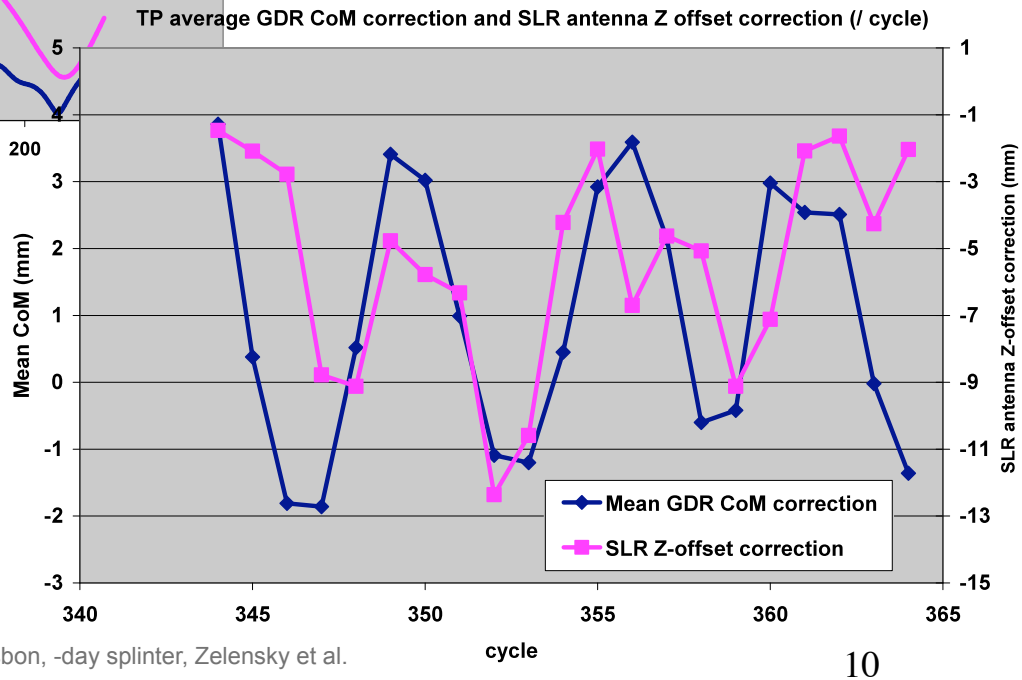


TP SLR estimates of LRA Z-offset support GDR CoM correction in amplitude and phase

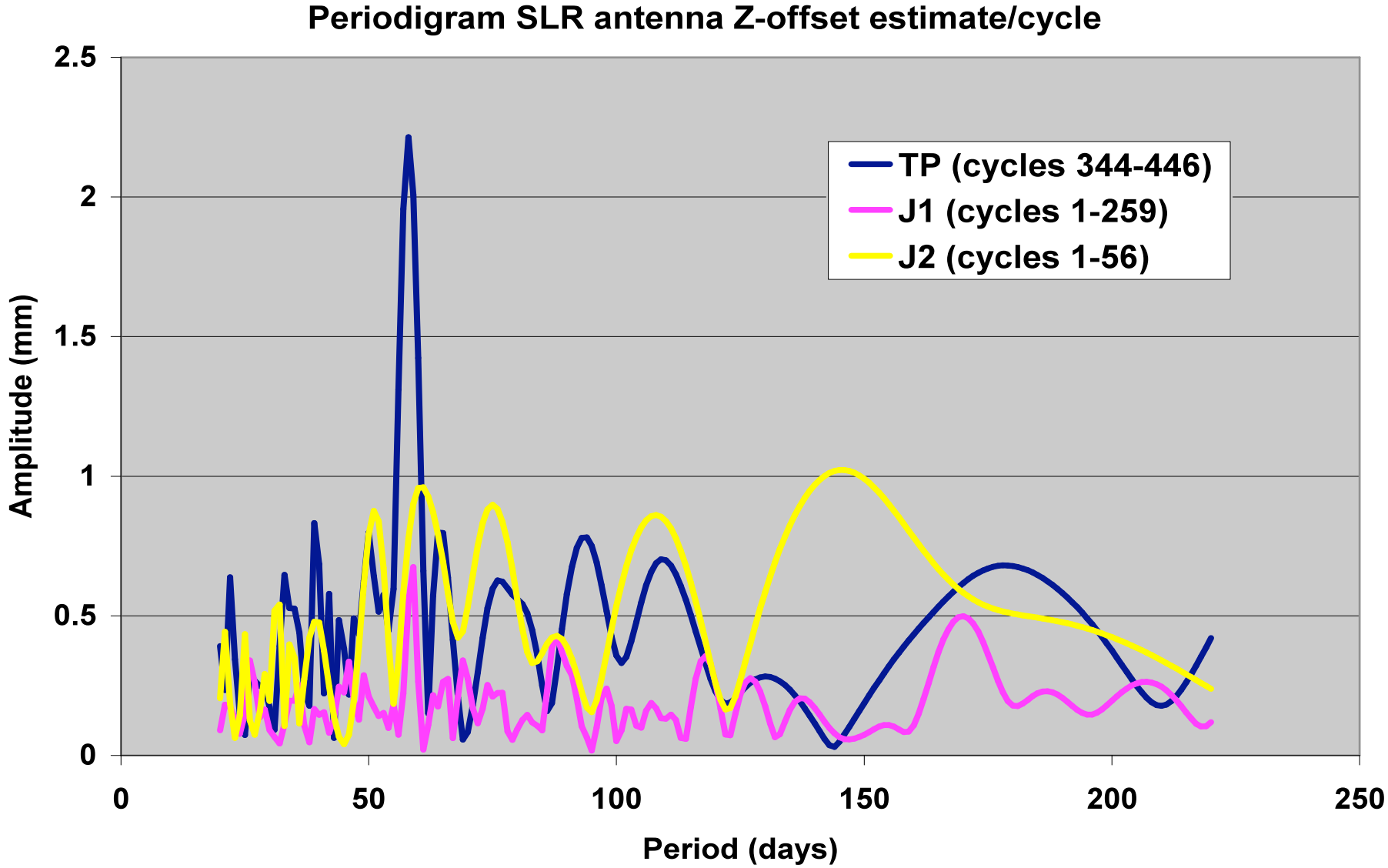


Amplitude

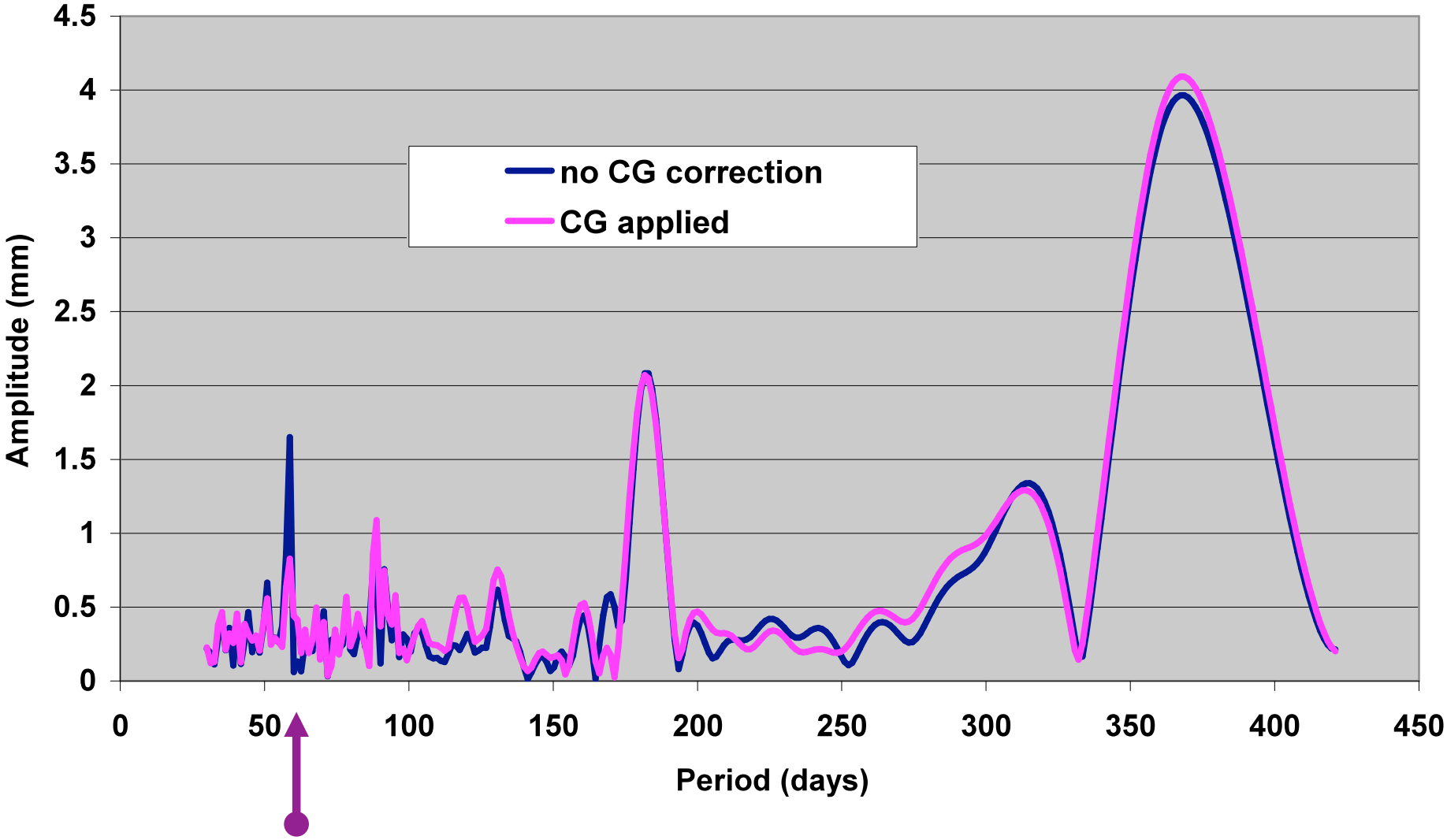
Phase



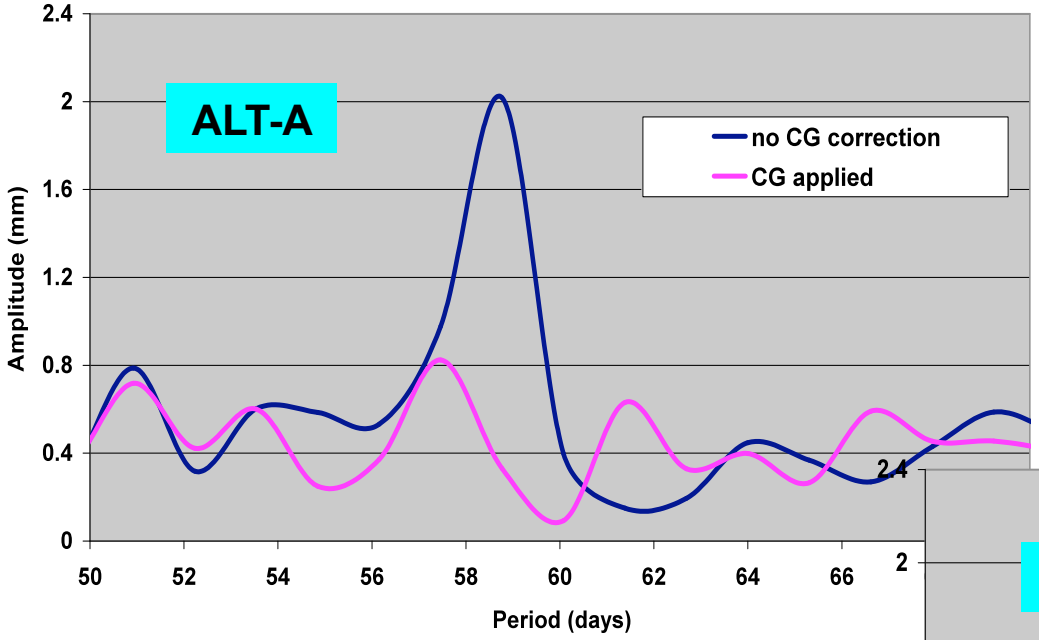
SLR analysis of LRA Z-offset only shows 59-day mm term for TP, but not for J1 or J2



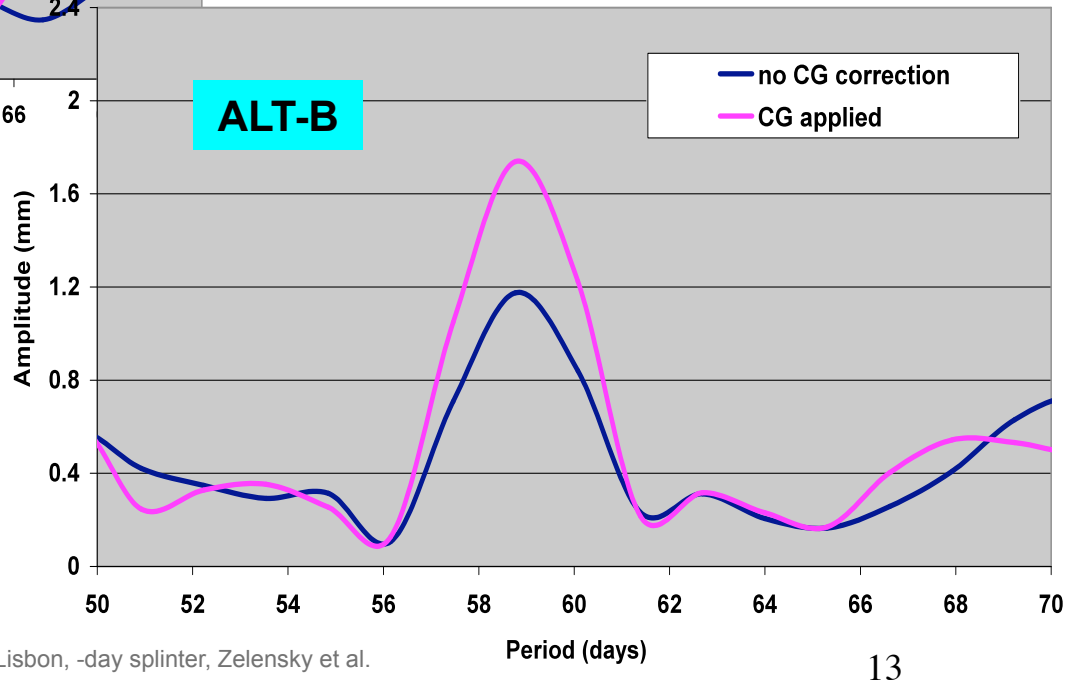
Application of GDR CoM correction reduces TP 59-day term overall (test MSL cycles 11-364 as shown in slides 2, 3)



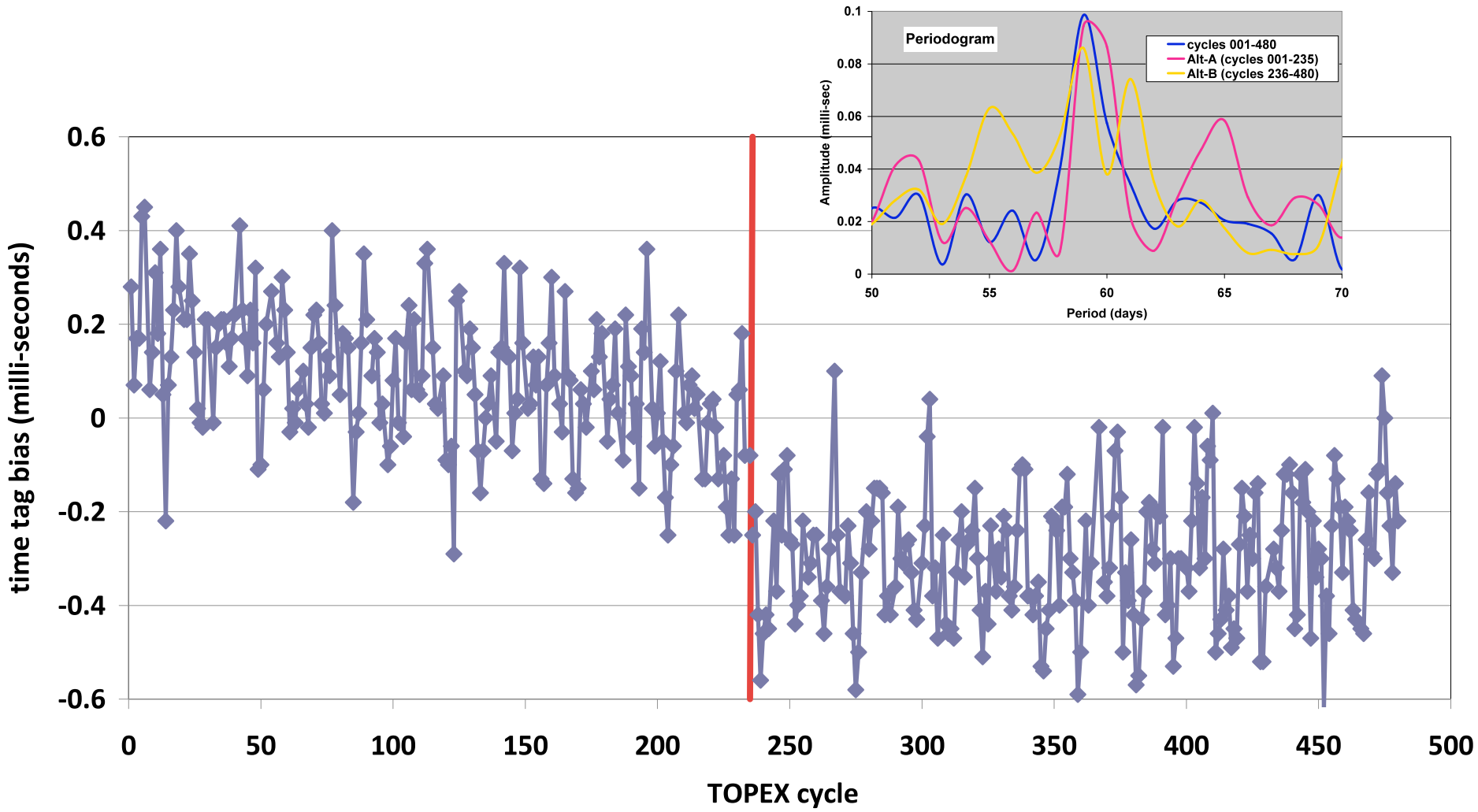
Application of GDR CoM correction reduces TP 59-day signal over Alt-A, but increases the signal and total MSL RMS over Alt-B



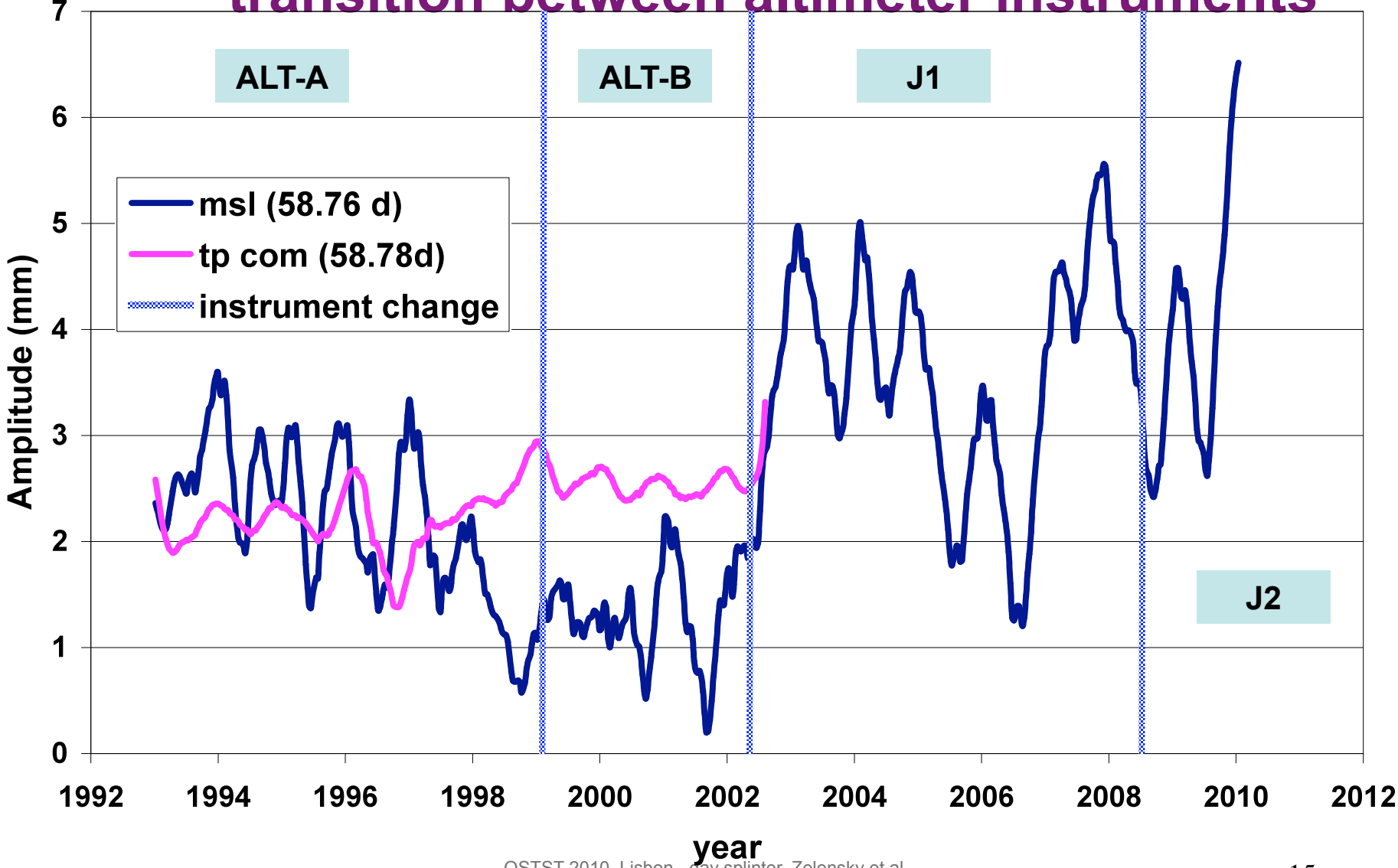
RMS (mm)	ALT-A	ALT-B
no CG	8.8	11.1
CG	8.5	12.1



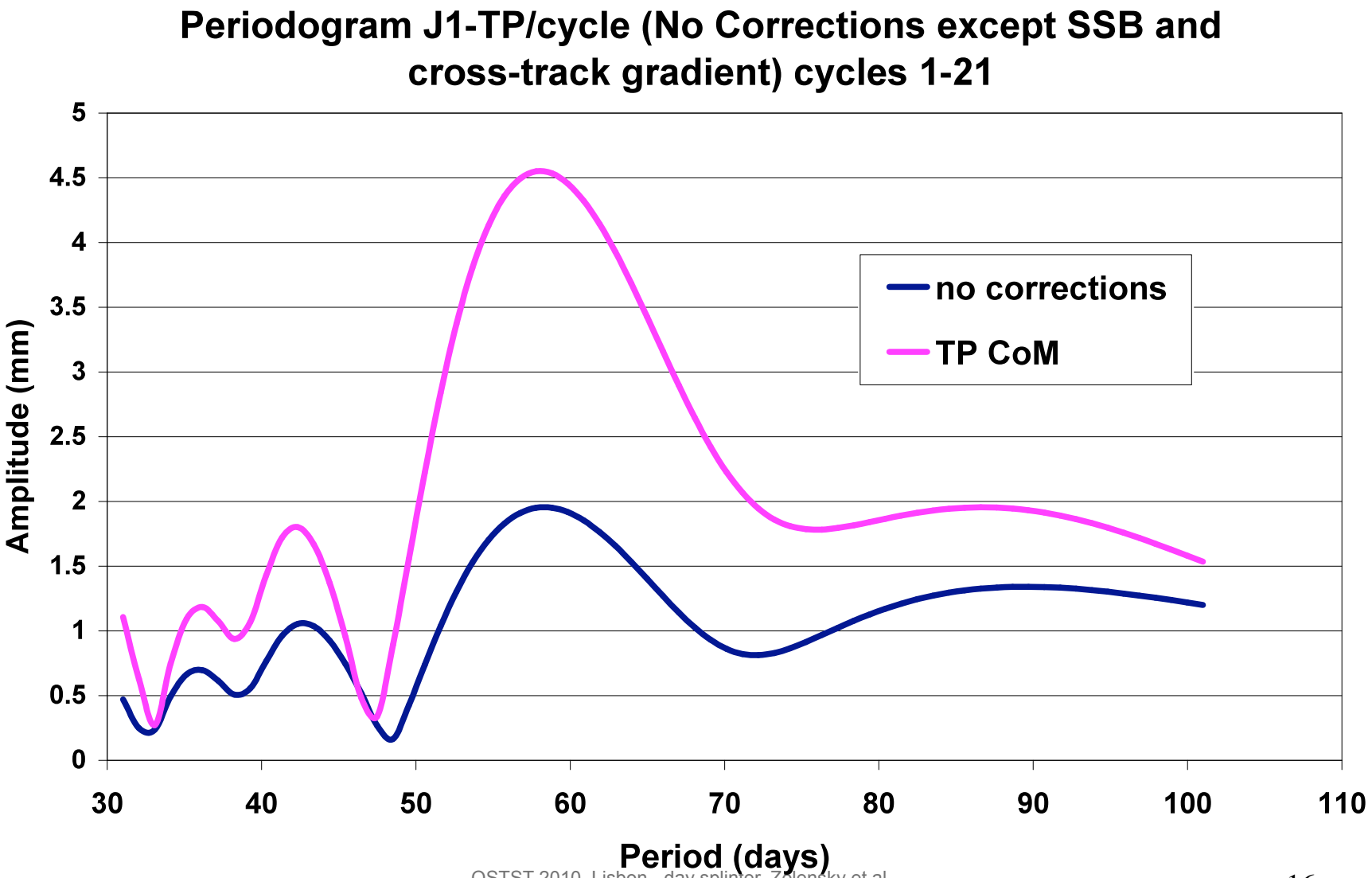
TP altimeter time biases estimated using crossovers show 59-day signal and transition from ALT-A to ALT-B instruments



Estimating 59-day term for MSL variations using a 1-year weighted window shows transition between altimeter instruments



Analysis of Jason1 - TOPEX observations with no corrections applied indicates 59-day signal is present in altimeter instrument(s)



Conclusions

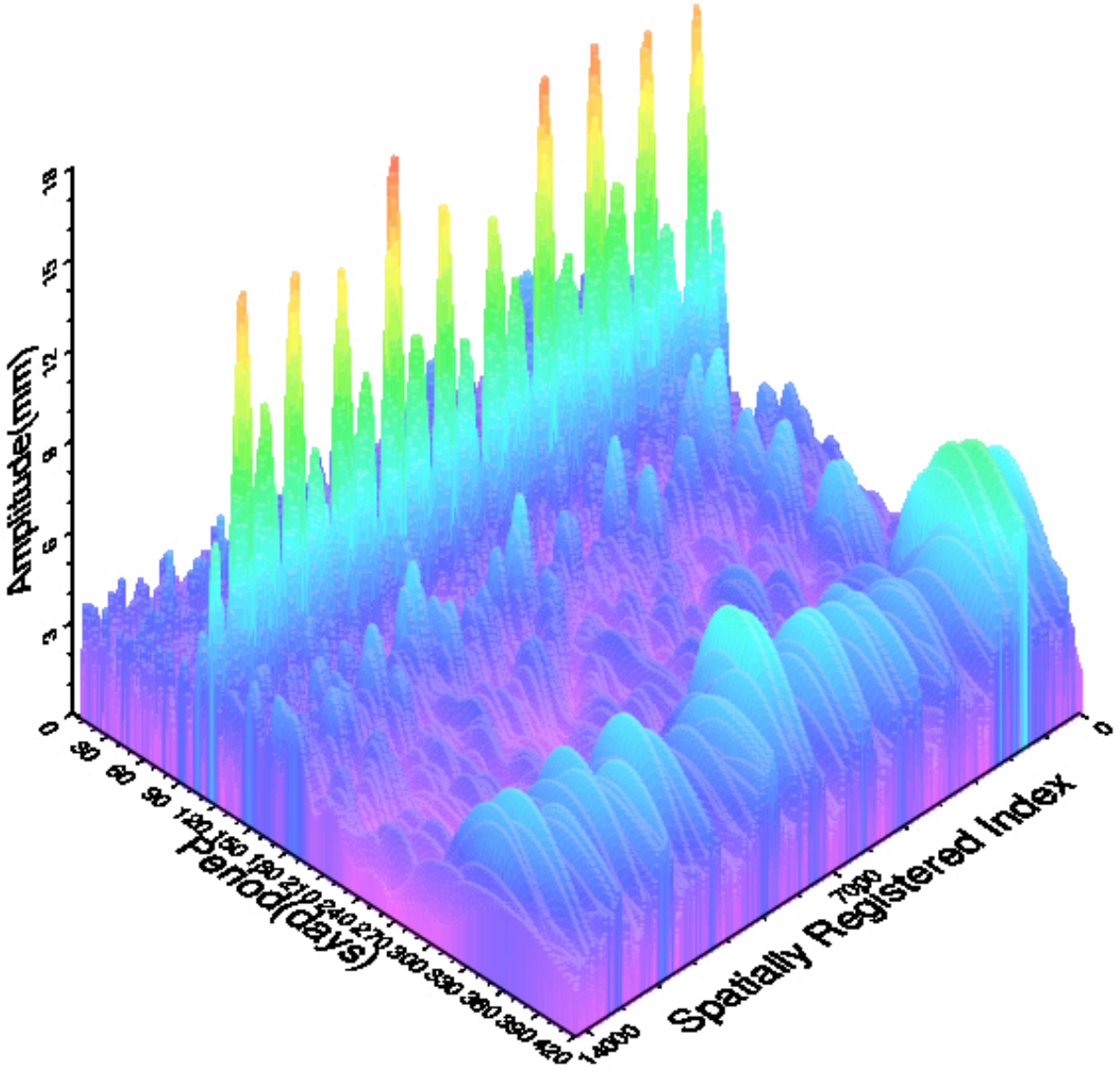
1) Amplitude of 59-day (58.76d) signal seen in our test altimeter MSL time series is about 1.5 mm for TP, 3.5 mm for J1 and J2, and 2.5 mm overall.
2) TP GDR CoM correction validity supported by SLR analysis of LRA antenna Z-offset estimates.
3) SLR analysis of LRA antenna Z-offset estimates indicate there is no appreciable CoM effect for J1 and J2.
4) Compelling evidence 59-day signal is present in altimeter instrument:
    1) Application of TP GDR CoM correction reduces 59-day signal over ALT-A, but increases the signal over ALT-B.
    2) Moving window estimate of 59-day term shows changes in amplitude which correspond to changes in the altimeter instruments.
    3) 59-day term seen in J1-TP observations without corrections applied indicates the signal is present in the instrument(s).
5) Altimeter-derived models, such as tides, will accommodate the 59-day instrument(s) signal. New GSFC tide models will reduce 59-d signal (see Beckely et al. poster)

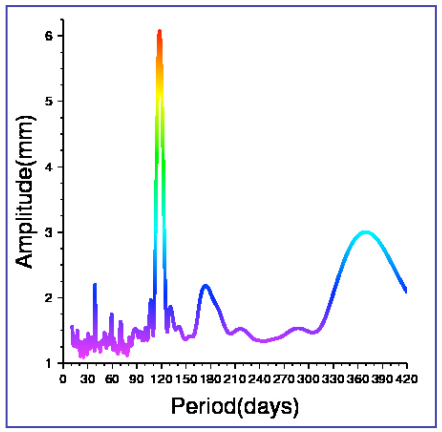
BACKUP

Remaining force model errors in J1 dynamic orbits

periodogram radial differences sampled over geographic points

GSFC std0905 dvnamic - JPL GPS 7a reduced dvnamic cycles 1-169



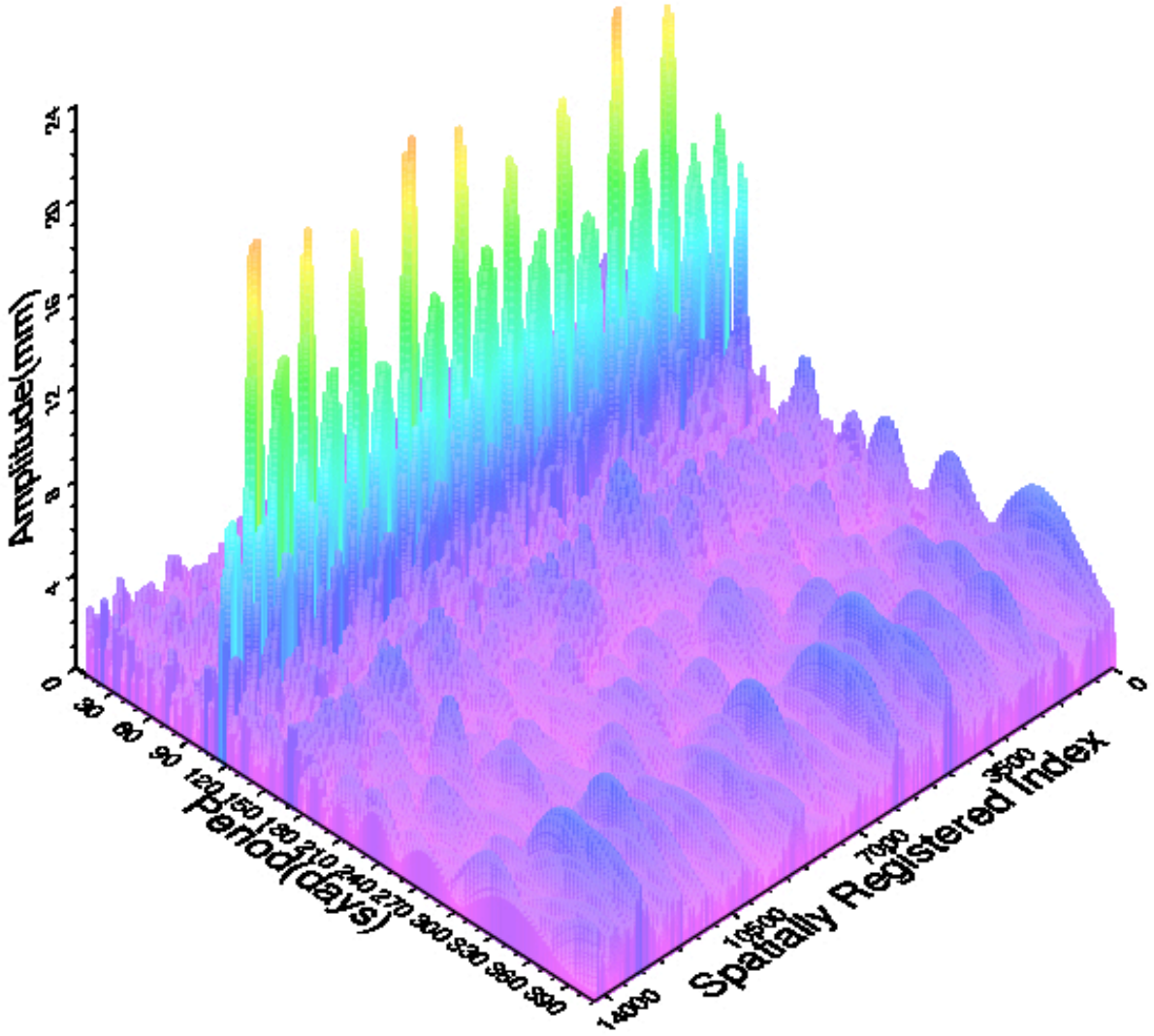


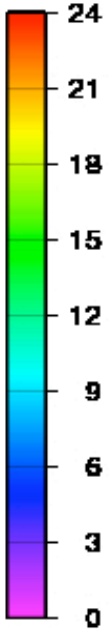
period (days)	peak (mm)
118	6.0
180	2.2
365	3.0

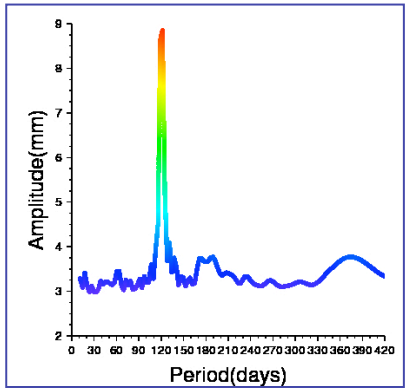
Force modeling differences in J1 dynamic orbits

periodogram radial differences sampled over geographic points

GSFC std0905 dynamic - GDRC dynamic cycles 11-169

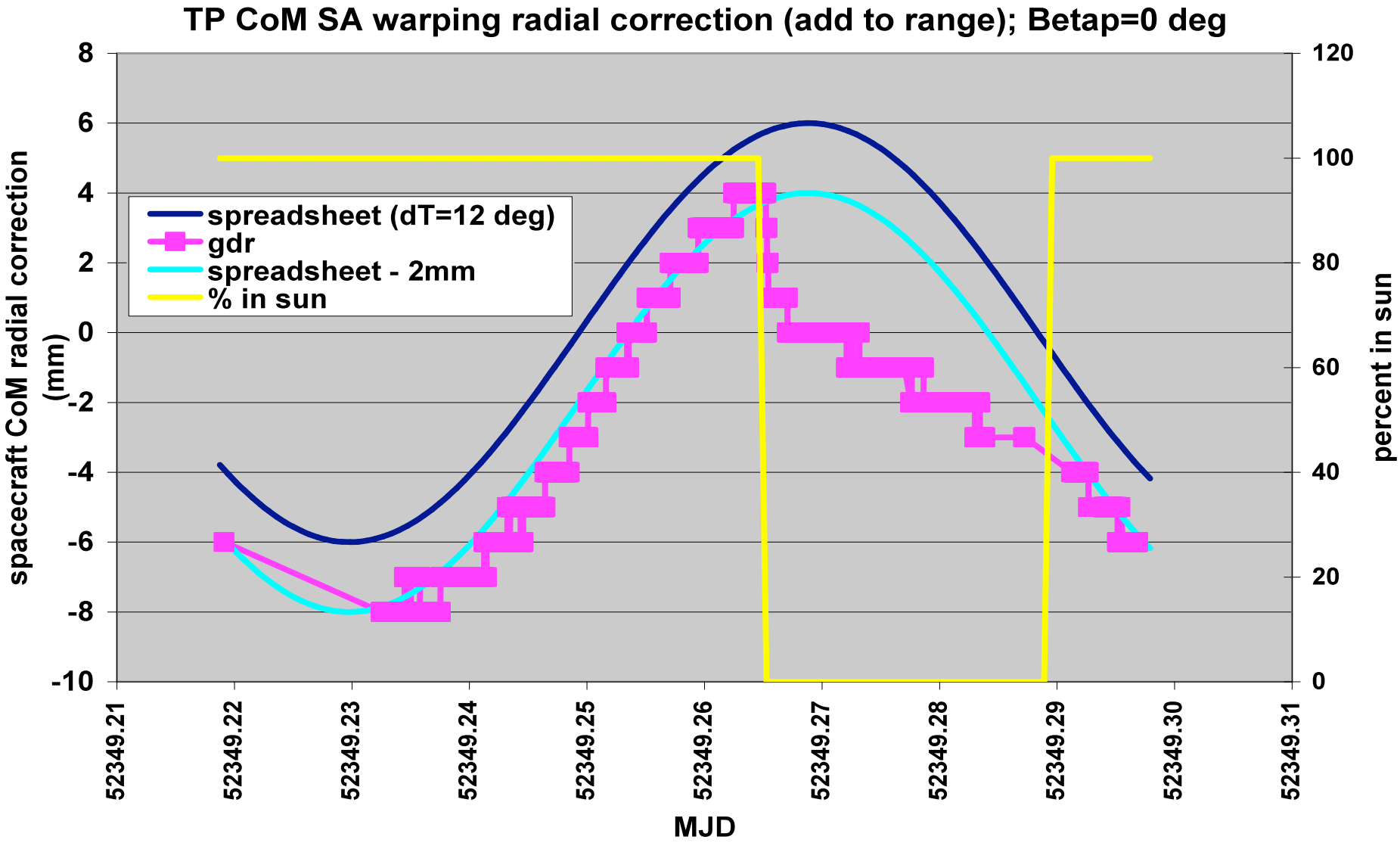




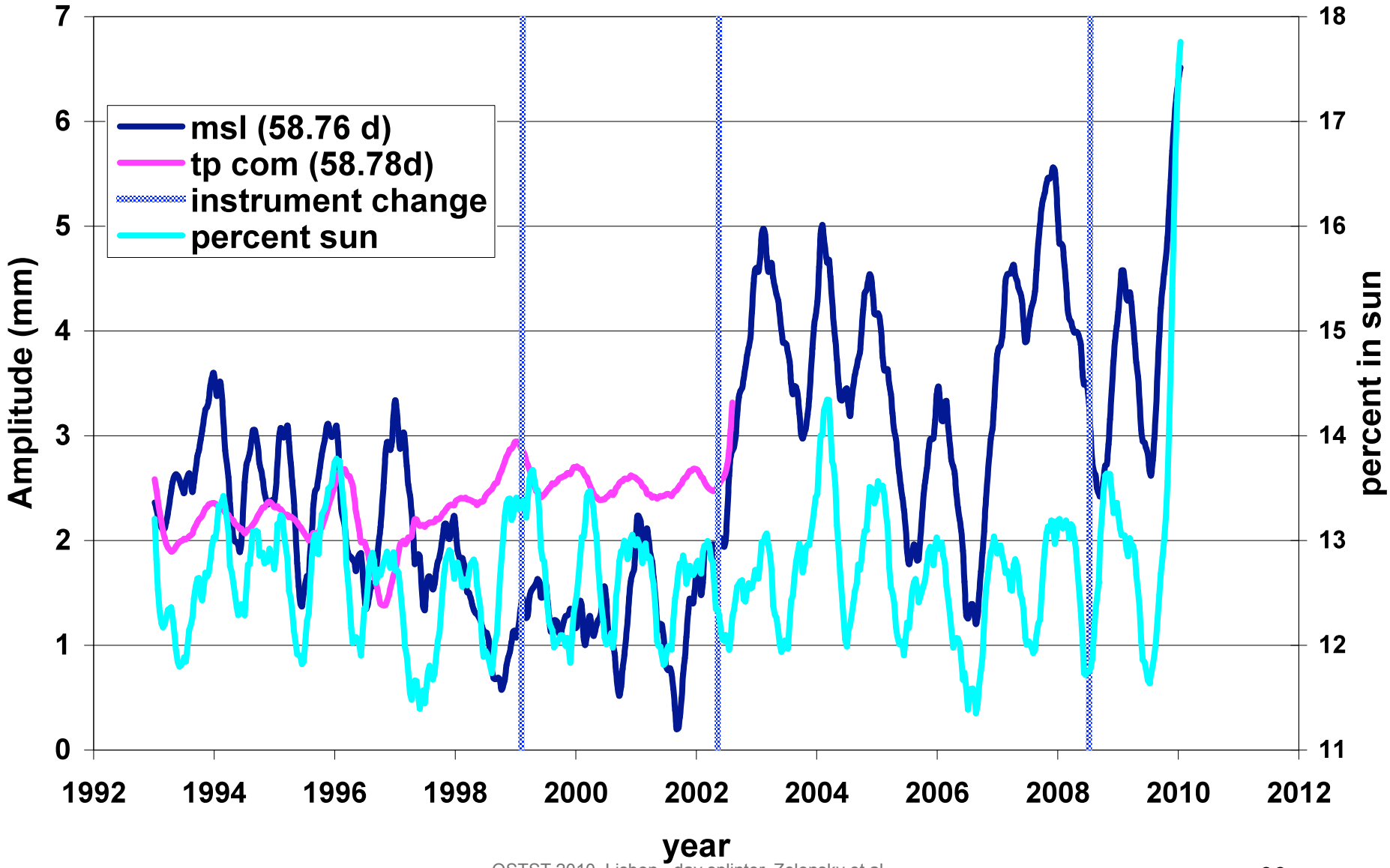


period (days)	peak (mm)
118	9.0
180	---
365	---

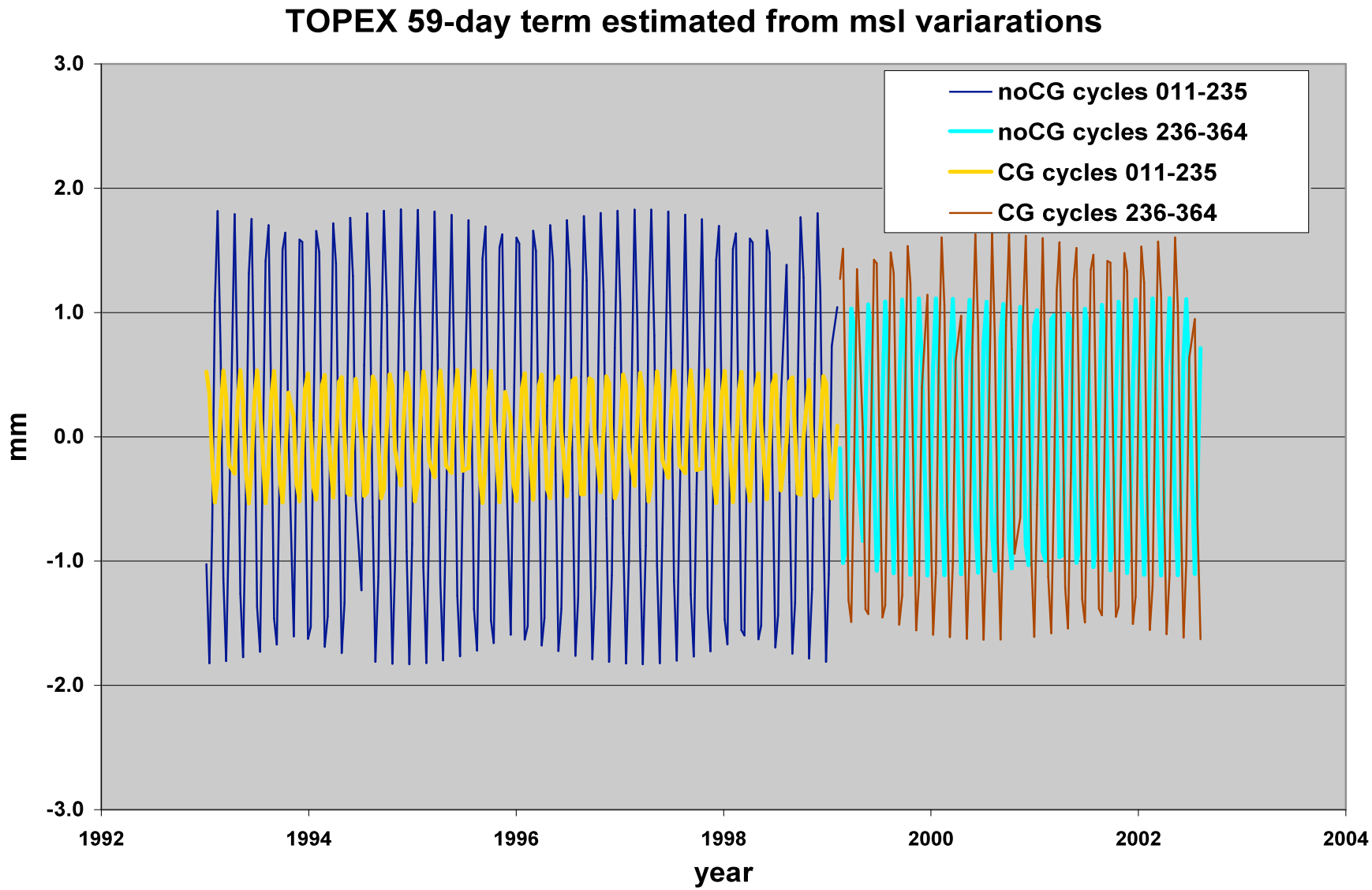
Spreadsheet model corresponds to TP GDR SA CoM correction



Estimating 59-day term using a 1-year weighted window

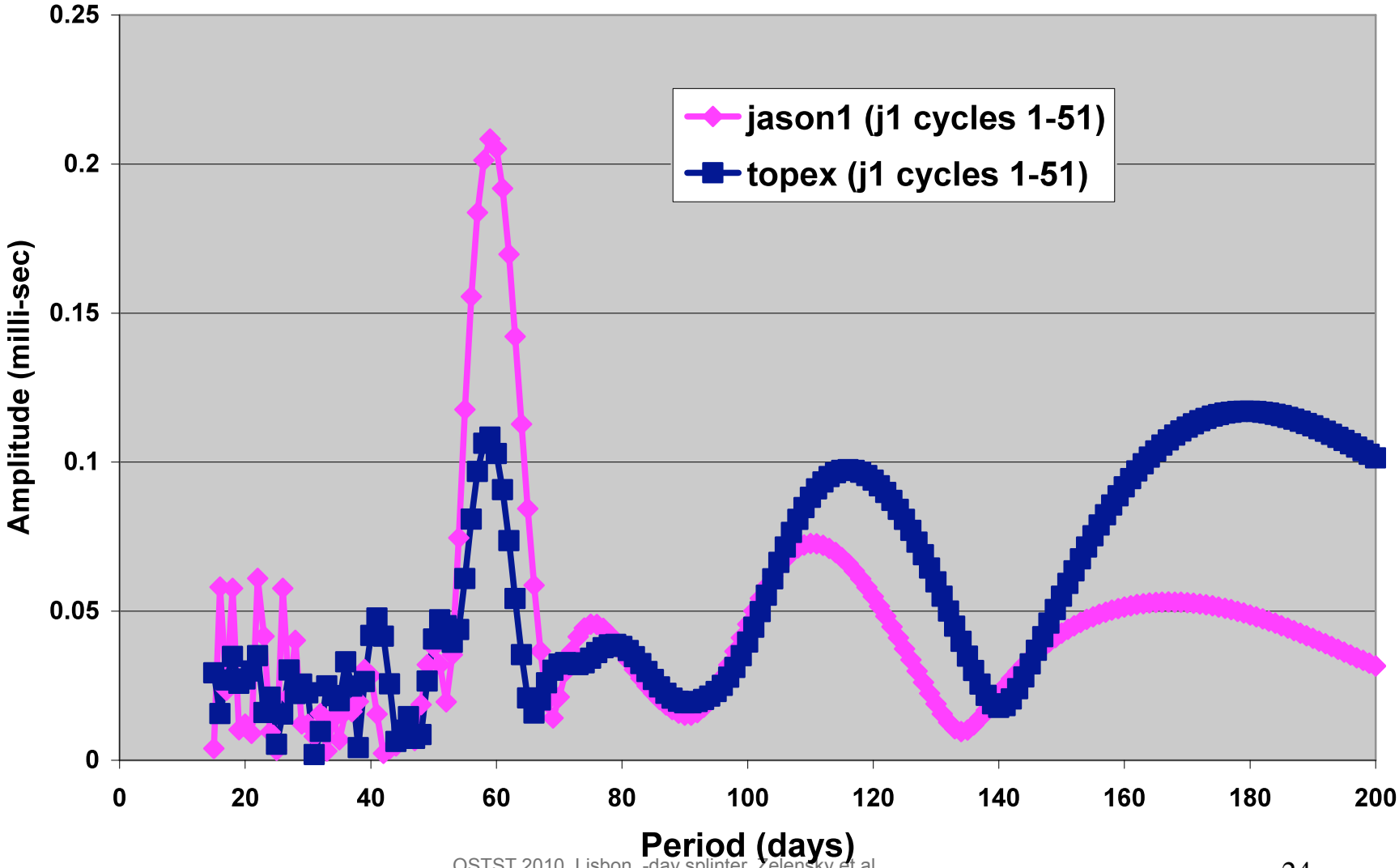


Backup

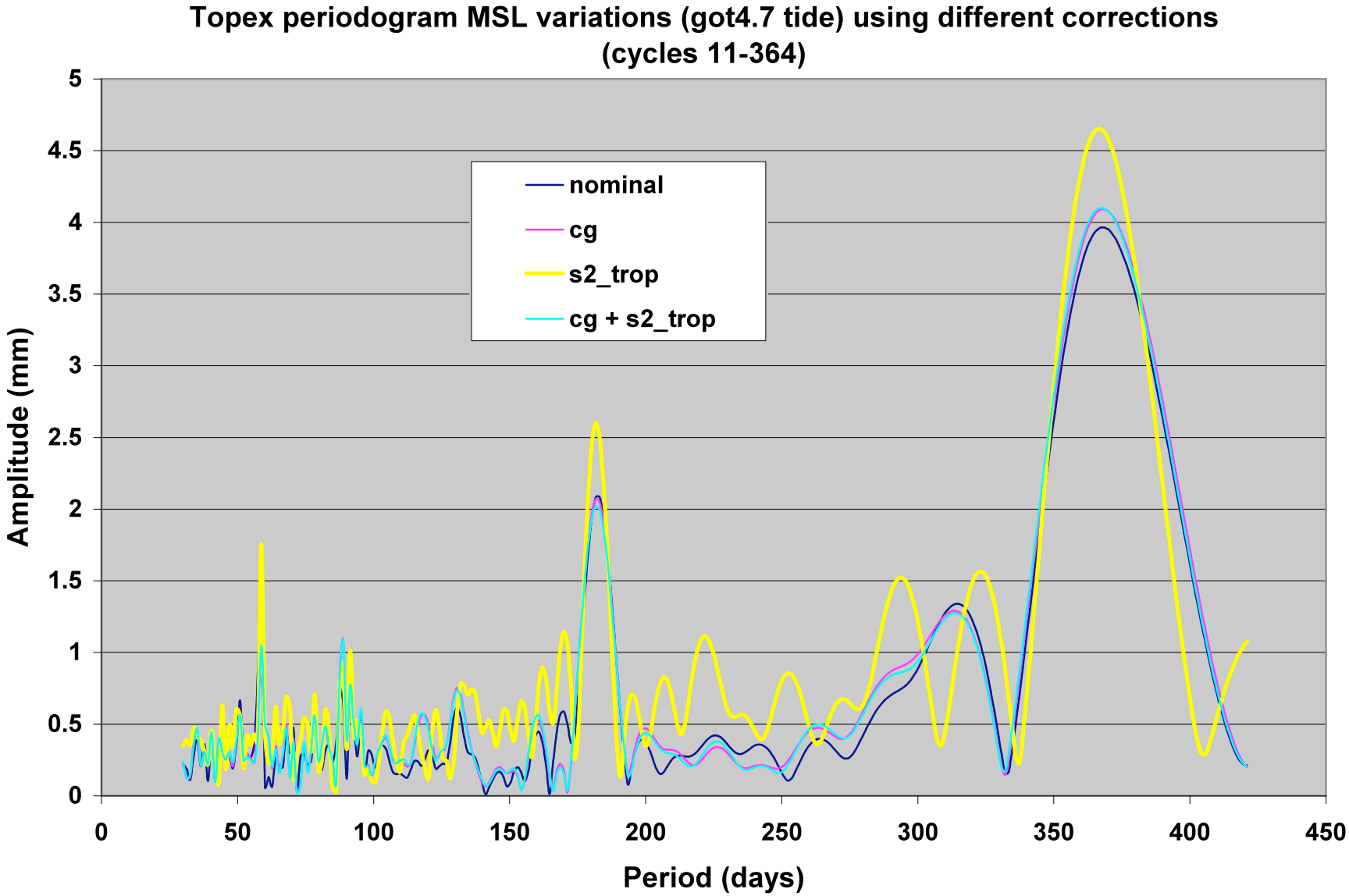

TOPEX 59-day term estimated from msl variarations
noCG cycles 011-235
noCG cycles 236-364
CG cycles 011-235
CG cycles 236-364
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
mm
1992
1994
1996
1998
2000
2002
2004
year

Backup

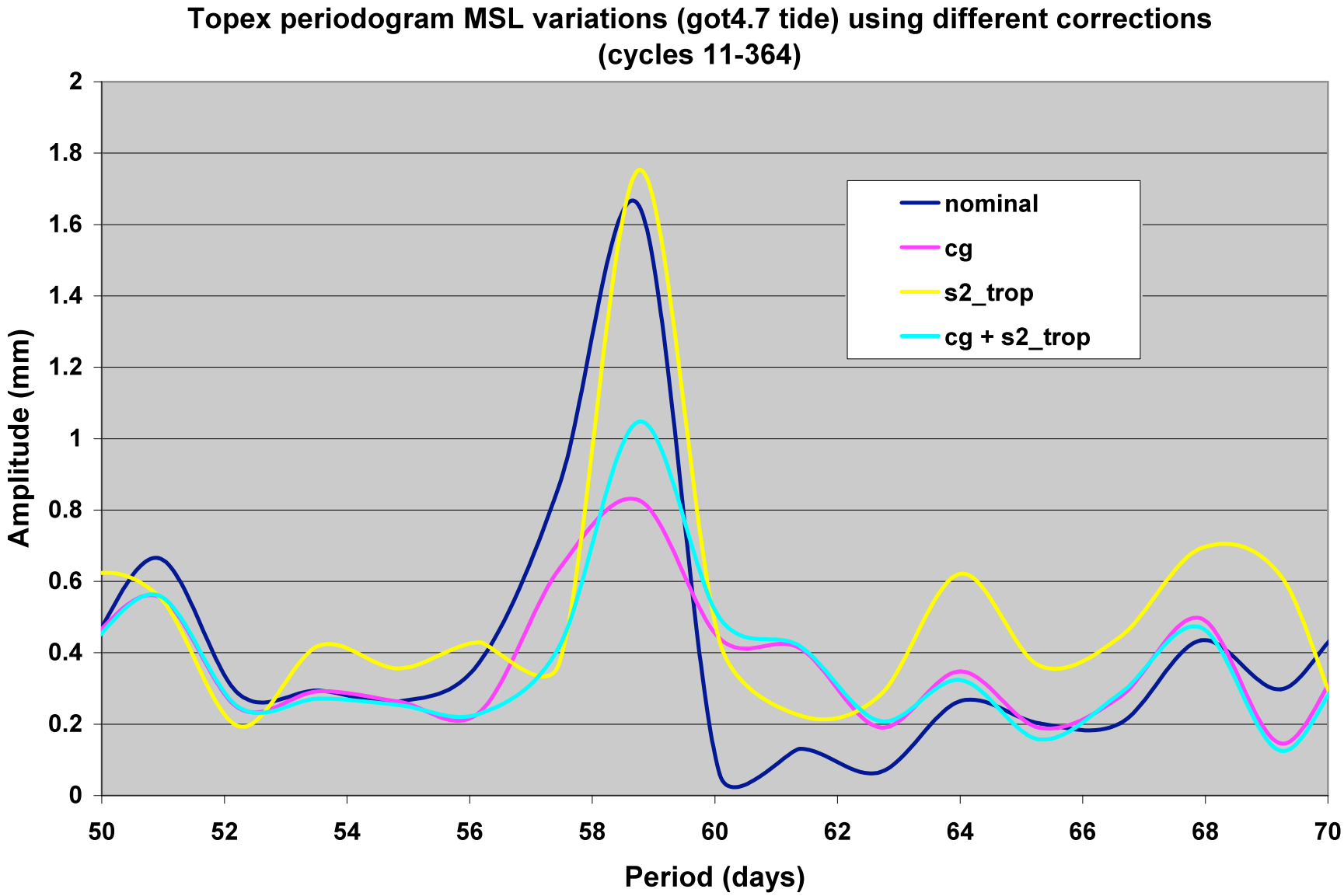
Periodogram time biases estimated from altimeter crossovers / cycle



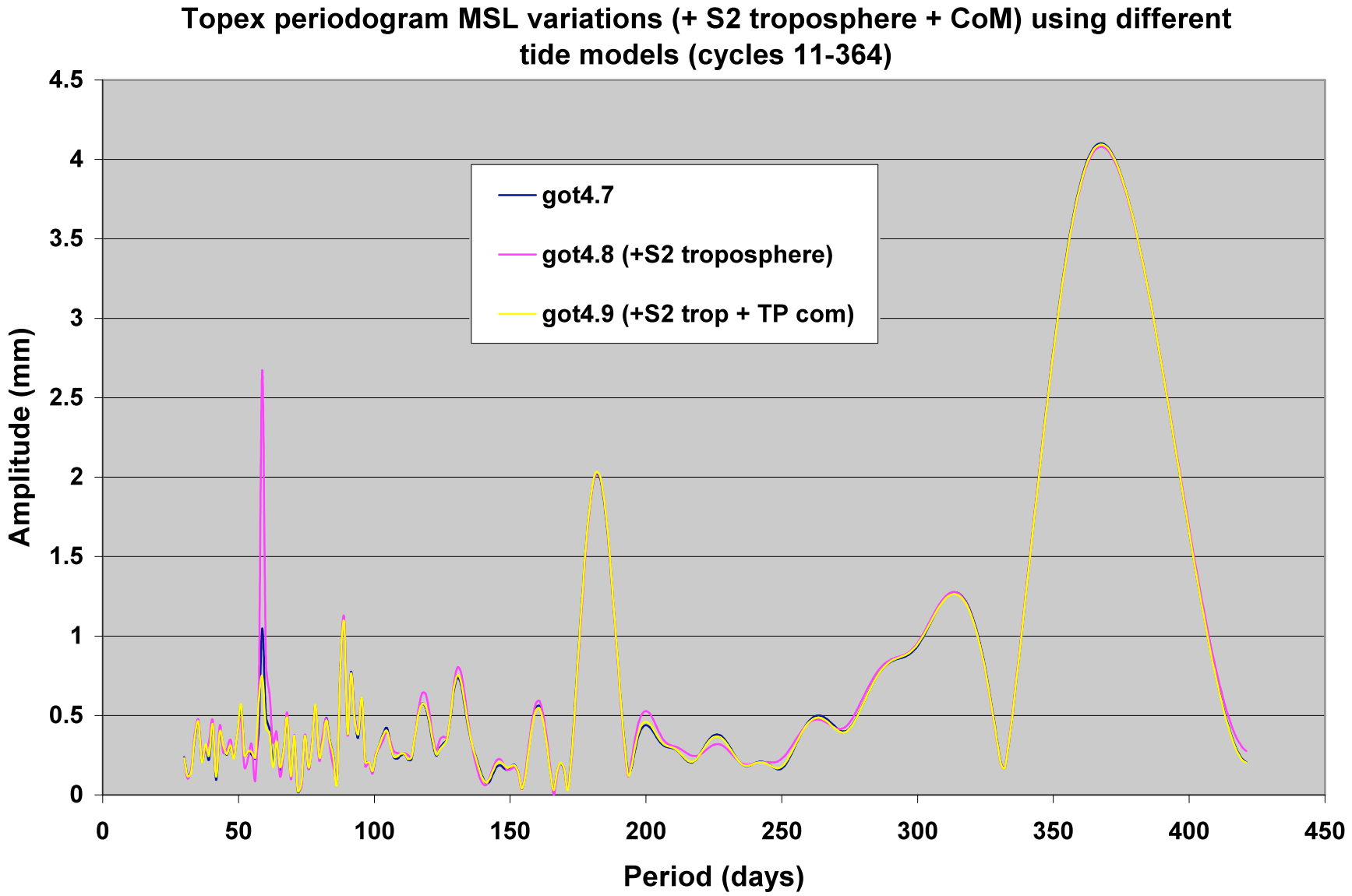
Backup


Topex periodogram MSL variations (got4.7 tide) using different corrections
(cycles 11-364)
Amplitude (mm)
Period (days)
nominal
cg
s2_trop
cg + s2_trop
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
50
100
150
200
250
300
350
400
450

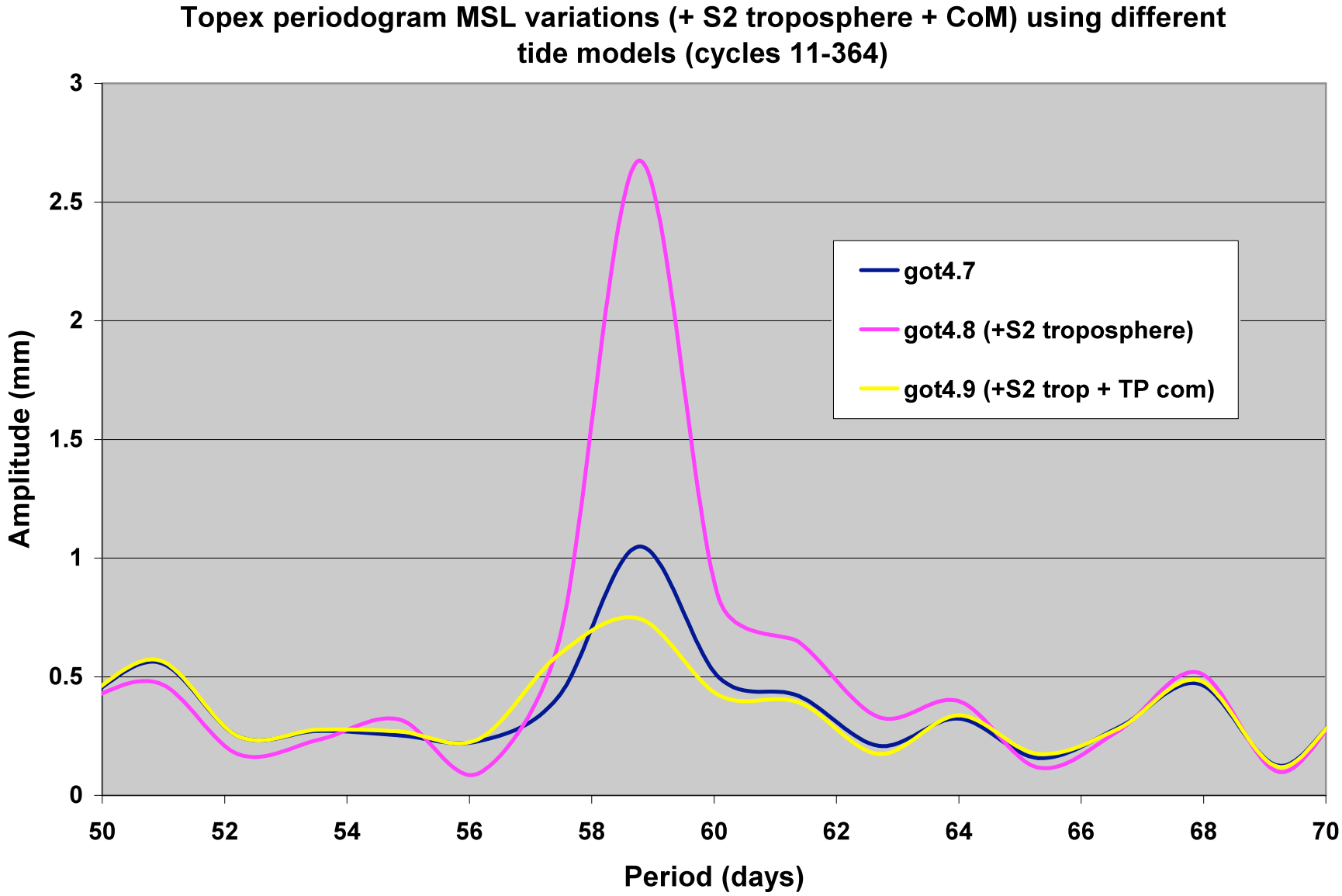
Backup


Topex periodogram MSL variations (got4.7 tide) using different corrections
(cycles 11-364)
Amplitude (mm)
Period (days)
nominal
cg
s2_trop
cg + s2_trop
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
50
52
54
56
58
60
62
64
66
68
70

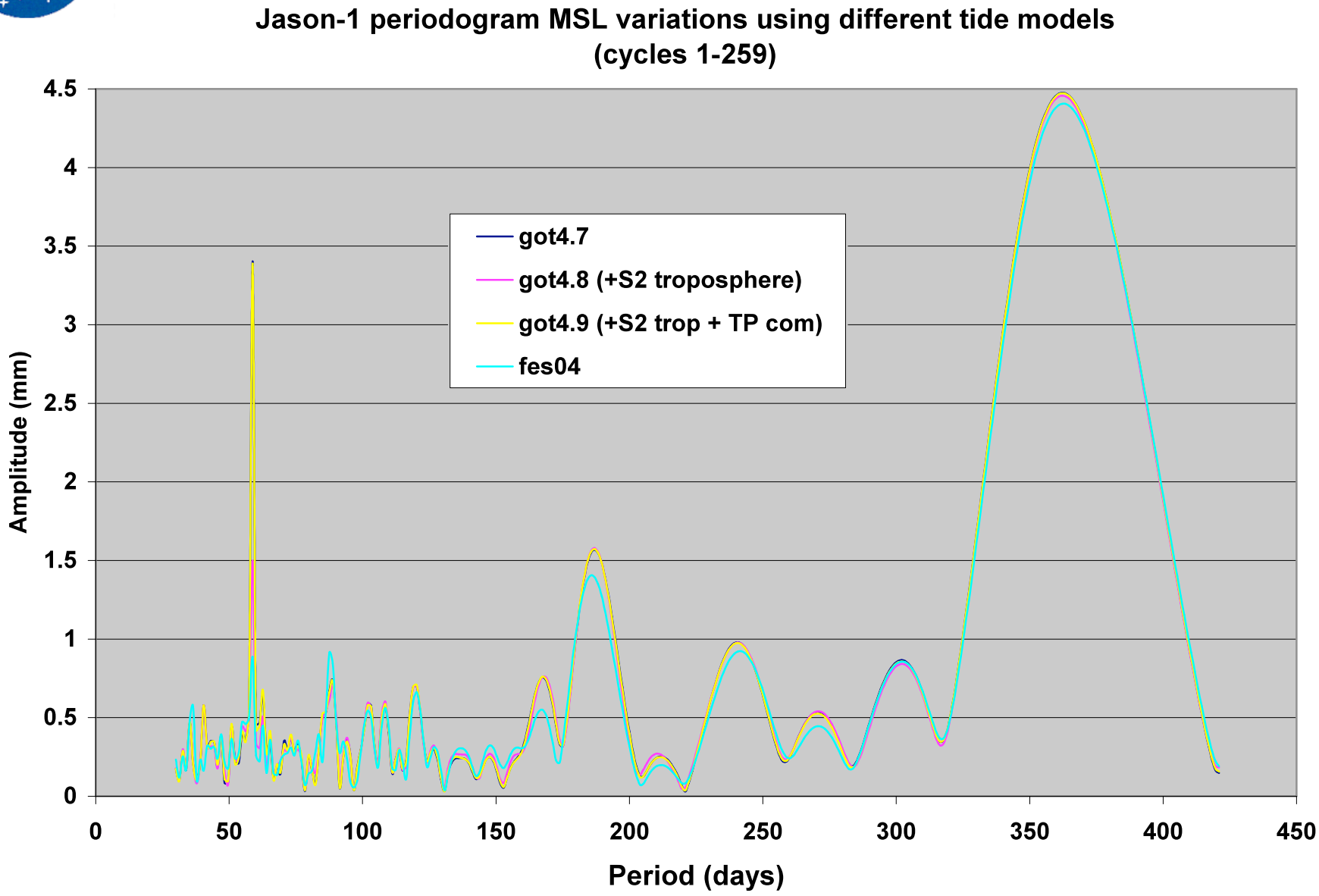
Backup


Topex periodogram MSL variations (+ S2 troposphere + CoM) using different tide models (cycles 11-364)
Amplitude (mm)
Period (days)
got4.7
got4.8 (+S2 troposphere)
got4.9 (+S2 trop + TP com)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
50
100
150
200
250
300
350
400
450

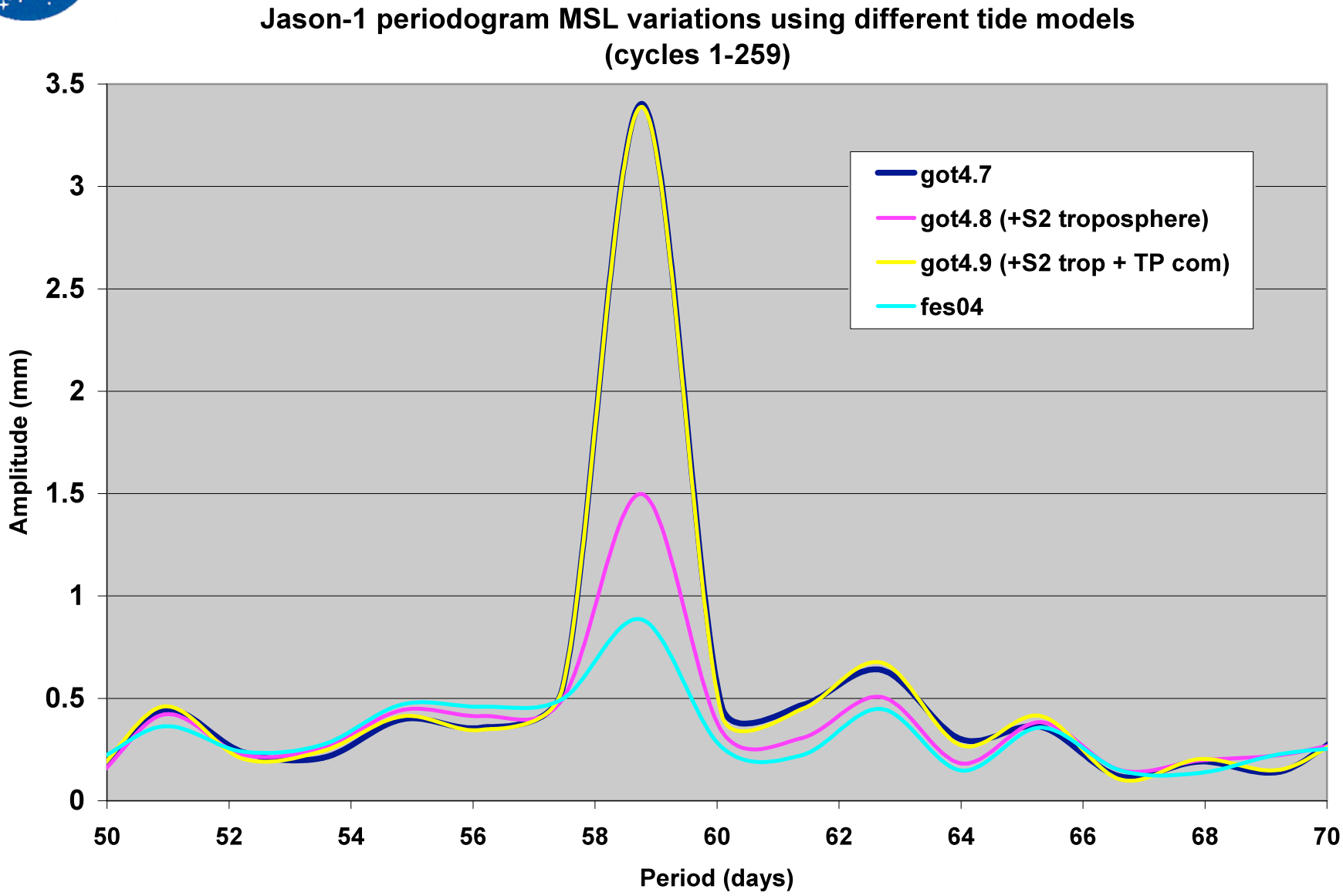
Backup


Topex periodogram MSL variations (+ S2 troposphere + CoM) using different tide models (cycles 11-364)
Amplitude (mm)
3
2.5
2
1.5
1
0.5
0
50
52
54
56
58
60
62
64
66
68
70
Period (days)
got4.7
got4.8 (+S2 troposphere)
got4.9 (+S2 trop + TP com)

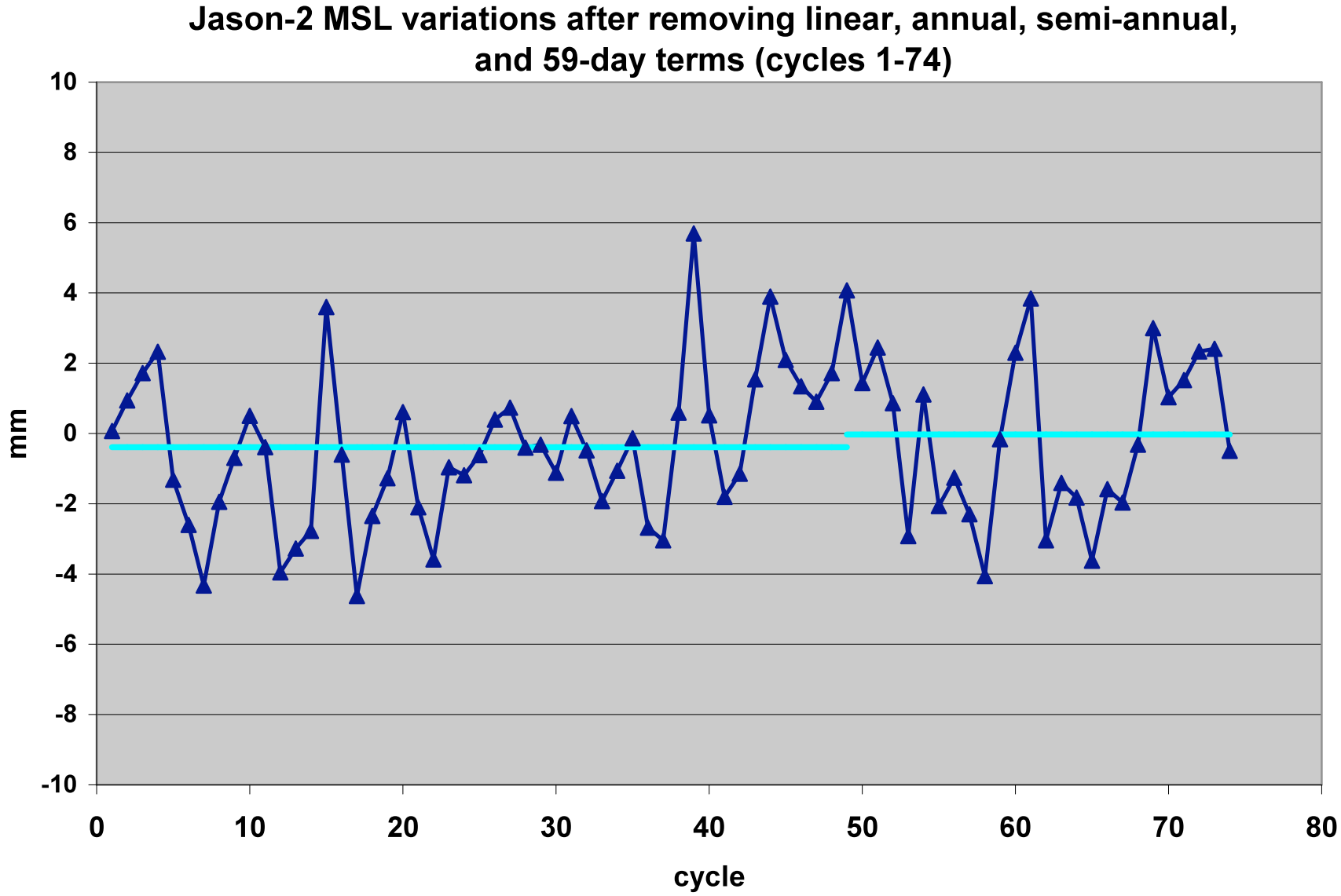
Backup


Jason-1 periodogram MSL variations using different tide models
(cycles 1-259)
Amplitude (mm)
Period (days)
got4.7
got4.8 (+S2 troposphere)
got4.9 (+S2 trop + TP com)
fes04
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
50
100
150
200
250
300
350
400
450

Backup


Jason-1 periodogram MSL variations using different tide models
(cycles 1-259)
Amplitude (mm)
Period (days)
got4.7
got4.8 (+S2 troposphere)
got4.9 (+S2 trop + TP com)
fes04
0
0.5
1
1.5
2
2.5
3
3.5
50
52
54
56
58
60
62
64
66
68
70

Backup


Jason-2 MSL variations after removing linear, annual, semi-annual, and 59-day terms (cycles 1-74)
mm
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
10
20
30
40
50
60
70
80
cycle