Impact of atmosphere loading and geocenter motion station corrections on the Jason-2 and Envisat SLR+DORIS orbits

N.P. Zelensky[1], F.G. Lemoine[2], S. Melachroinos[1], D.S. Chinn[1], B.D. Beckley[1], D.E. Pavlis[1], J. Wimert[1]

[1] *SGT Inc., Greenbelt, Maryland, U.S.A.*
[2] *NASA Goddard Space Flight Center, Greenbelt, Maryland, U.S.A.*

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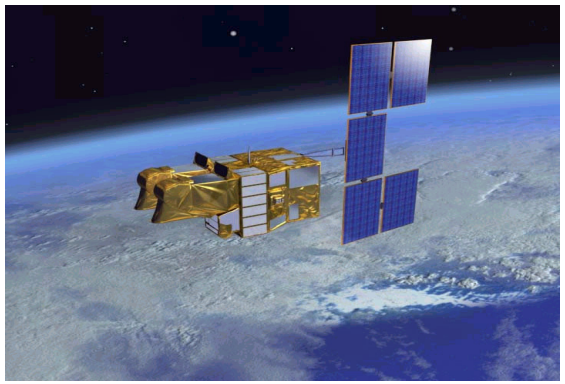
POD



Questions Addressed:

1) Is station position modeling improved?

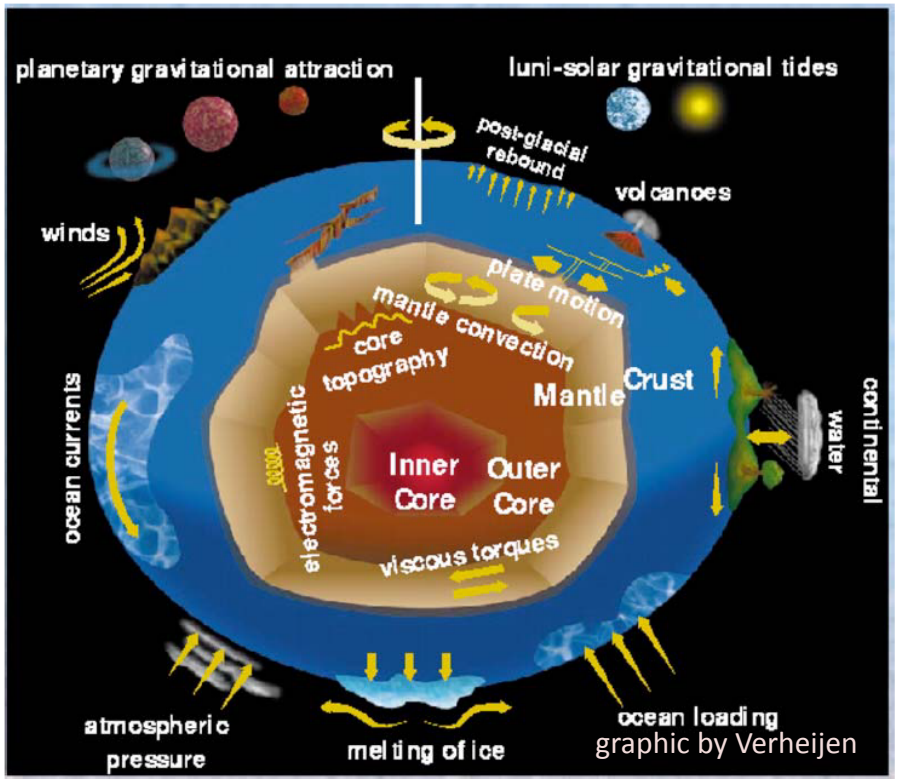
2) Is the computed orbit origin better aligned with the instantaneous center of mass (CM) using CSR-SLR CM model.

3) In principle, there is an inconsistency in applying both atmosphere pressure loading (APL) deformation corrections and those from the CSR CM model - whose derivation did not consider APL. Is this significant?

Earth's total center of mass (CM) is computed wrt center of figure (CF) – both are changing

In the **solid** Earth center of mass frame, geocenter motion of the Total Earth's mass referenced to CF:

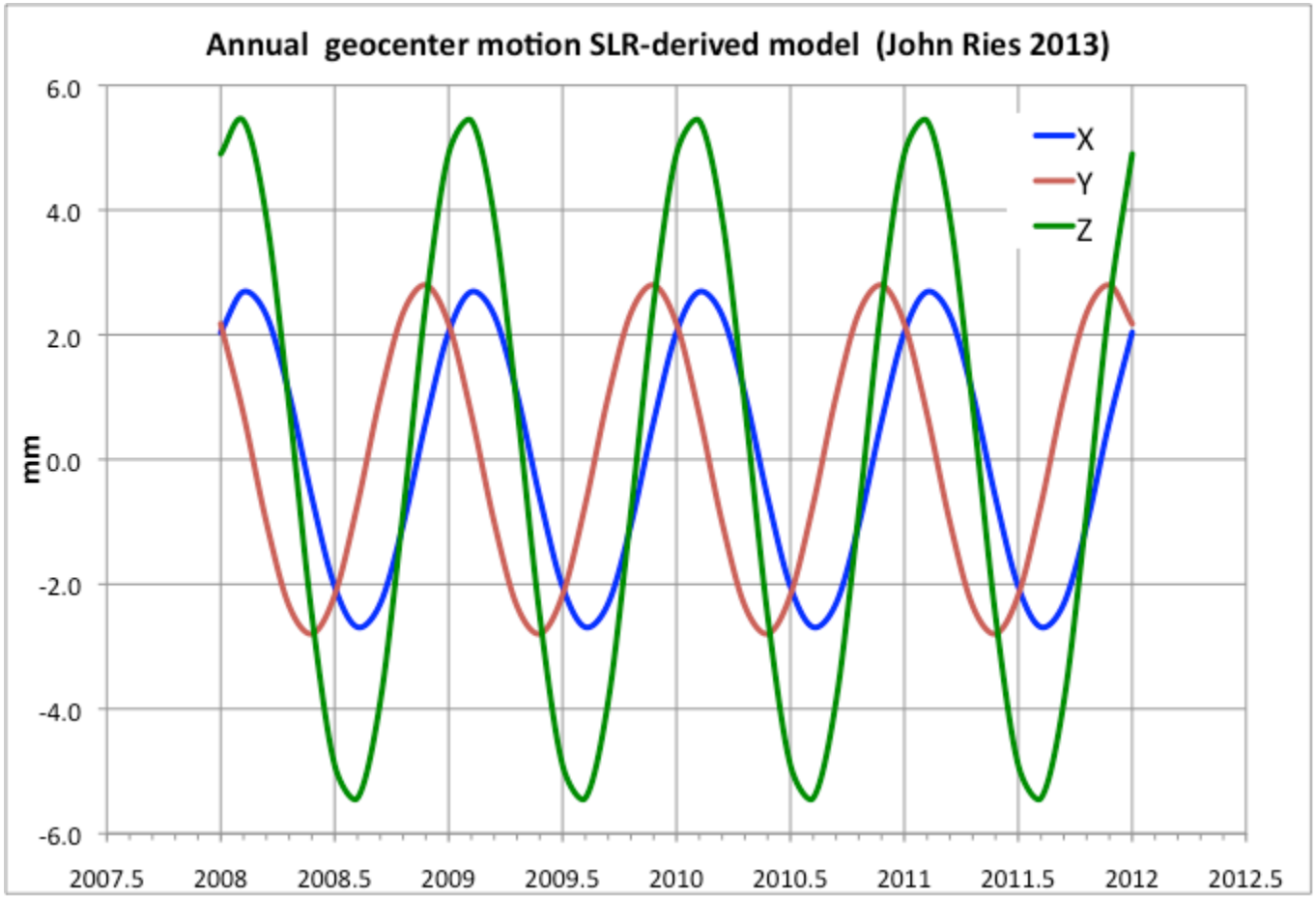
$$r_c(t) = r_{cm}(t) - r_{cf}(t)$$



$r_{cm}(t)$: displacement of the center of mass (CM) largely due to redistribution of continental water, atmospheric and oceanic mass at the Earth's surface.

$r_{cf}(t)$: displacement of the center of figure (CF) due in large part to elastic deformation of the Earth's surface caused by loading.

CSR SLR-derived Annual CM model



Note. The SLR center of network (CN) becomes the center of figure (CF) origin in the SLR geocenter estimate.

Jason2 POD Summary – station positioning improved

Jason-2 SLR+DORIS Residuals cycles 1-128 (July 2008 – December 2011) doris elcut= 10 deg	average rms Residuals		
	doris (mm/s)	slr (cm)	xover (cm)
1) nominal (std1403)	0.3743	0.873	5.404
2) annual geocenter (cm)	0.3743	0.867	5.402
3) atmosphere loading (apl)	0.3742	0.864	5.404
4) combined (apl + cm)	0.3741	0.861	5.403

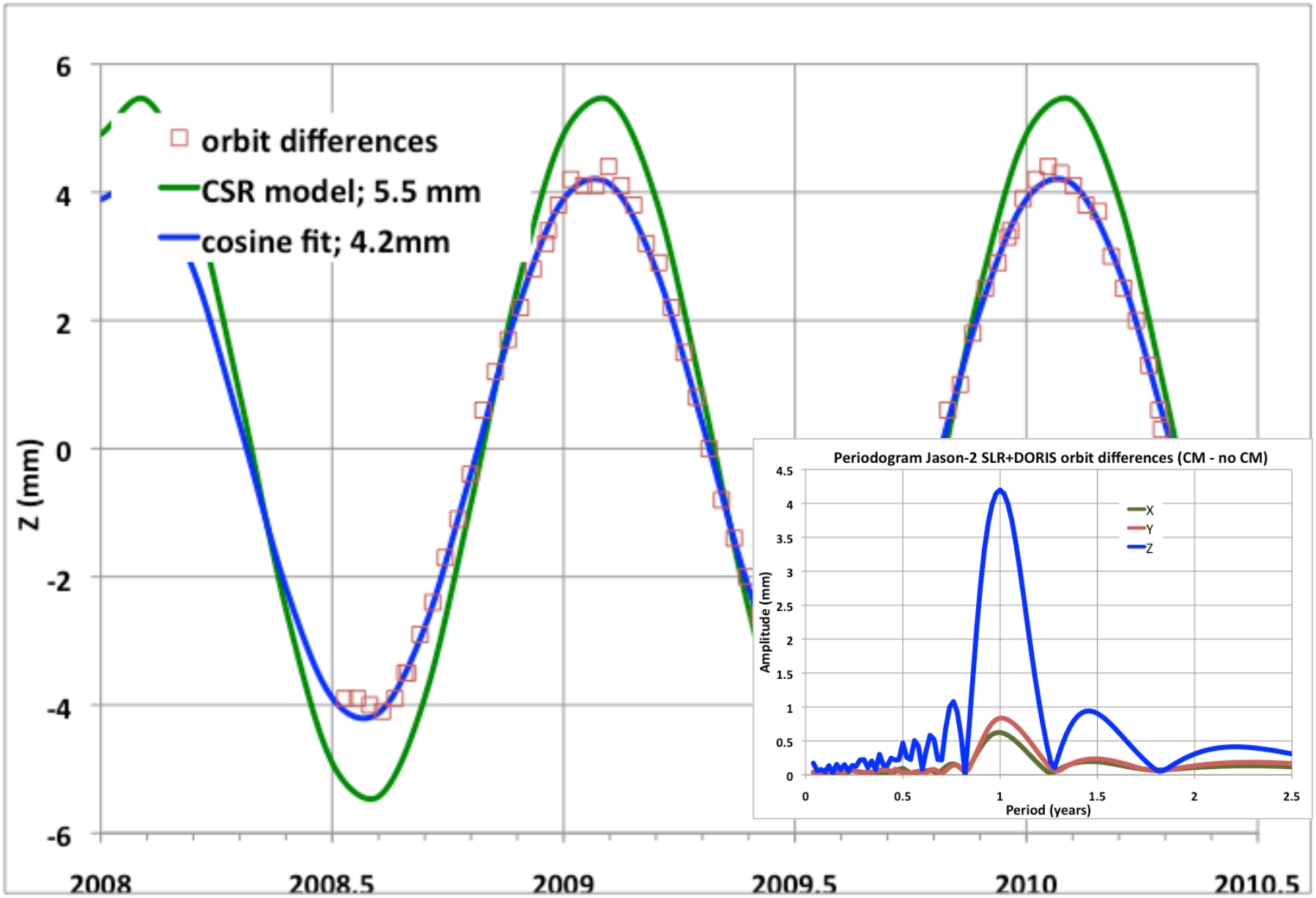
Jason-2 SLR+DORIS Orbit (nominal – *Test*) differences cycles 1-128	average rms Orbit differences (mm)		
	radial	cross-trk	along-trk
annual geocenter (cm)	1.6	1.9	3.2
atmosphere loading (apl)	0.9	1.7	1.9
combined (apl + cm)	2.1	2.8	4.3

Envisat POD Summary - station positioning improved

Envisat SLR+DORIS Residuals (Jan 2008 – Dec 2011) doris elcut= 10 deg	average rms Residuals	
	doris (mm/s)	slr (cm)
1) nominal (wd25)	0.4747	1.058
2) annual geocenter (cm)	0.4747	1.055
3) atmosphere loading (apl)	0.4747	1.052
4) combined (apl + cm)	0.4747	1.051

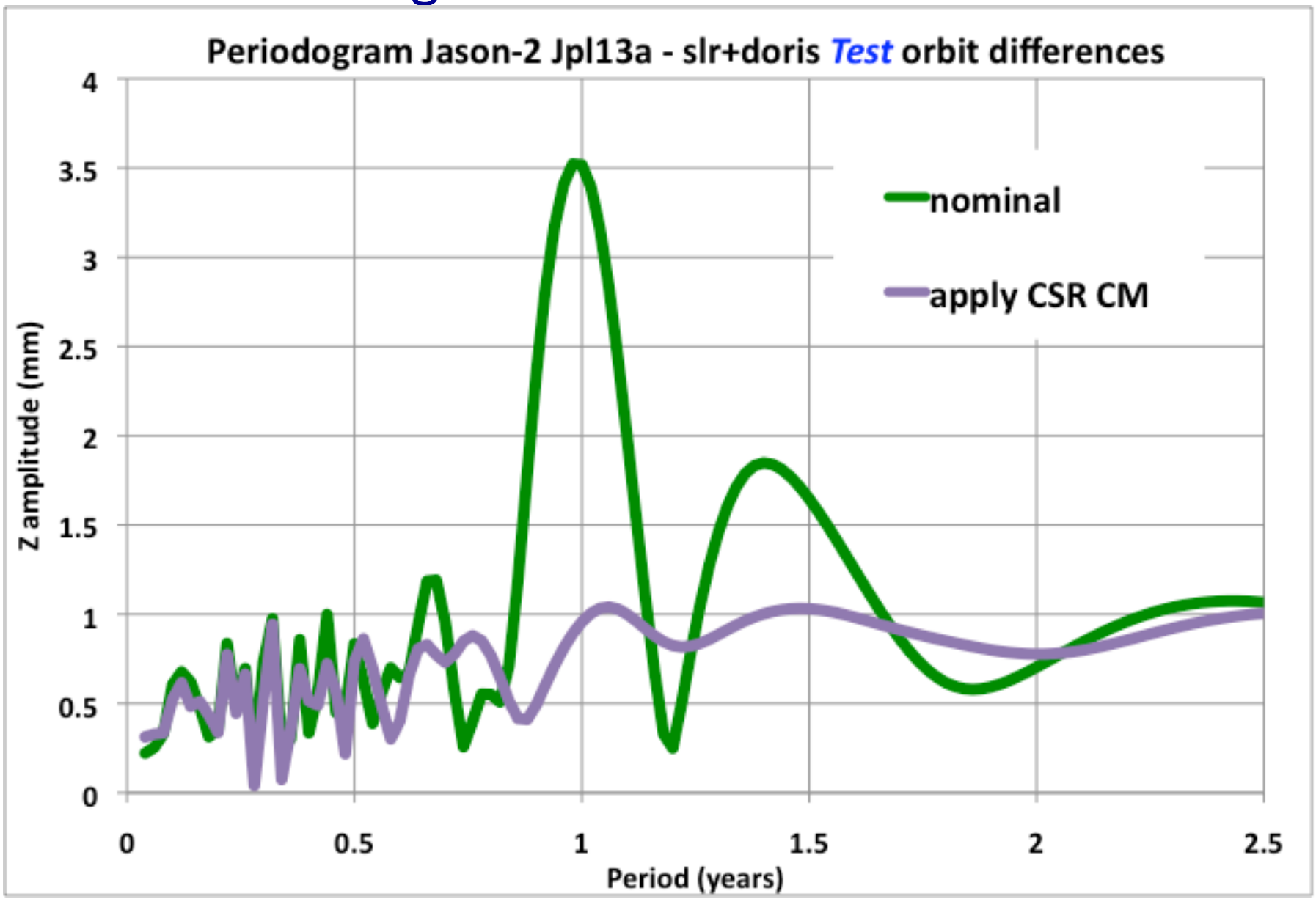
Envisat SLR+DORIS Orbit (nominal – *Test*) differences (Jan 2008 – Dec 2011)	average rms Orbit differences (mm)		
	radial	cross-trk	along-trk
annual geocenter (cm)	1.4	1.3	2.9
atmosphere loading (apl)	0.7	1.0	1.5
combined (apl + cm)	1.8	1.8	3.8

CSR CM largely affects J2 SLR+DORIS orbit in Z

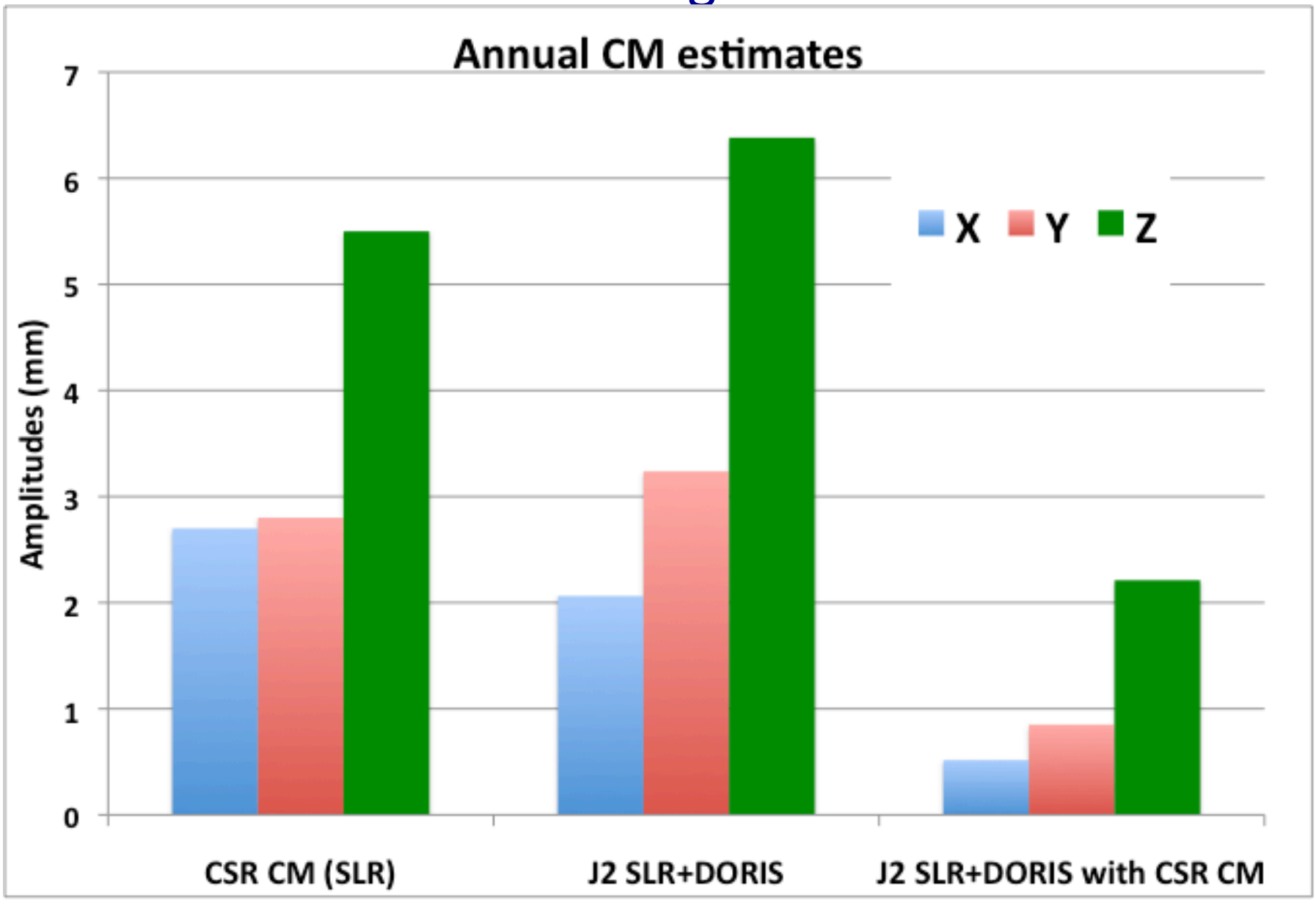


Is the computed orbit origin better aligned with the instantaneous center of mass ?

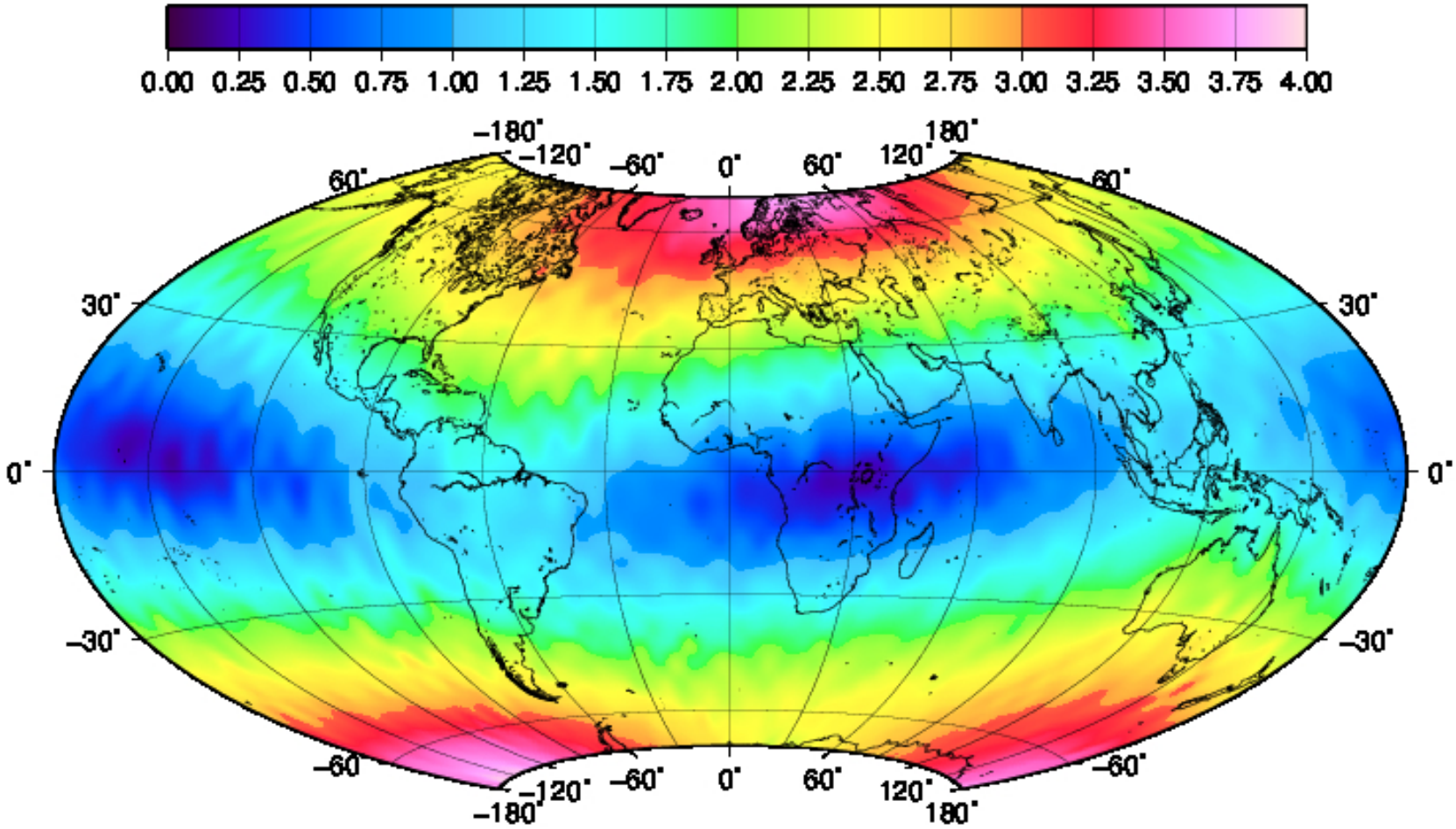
CSR CM largely removes annual Z difference signature with JPL13a orbits



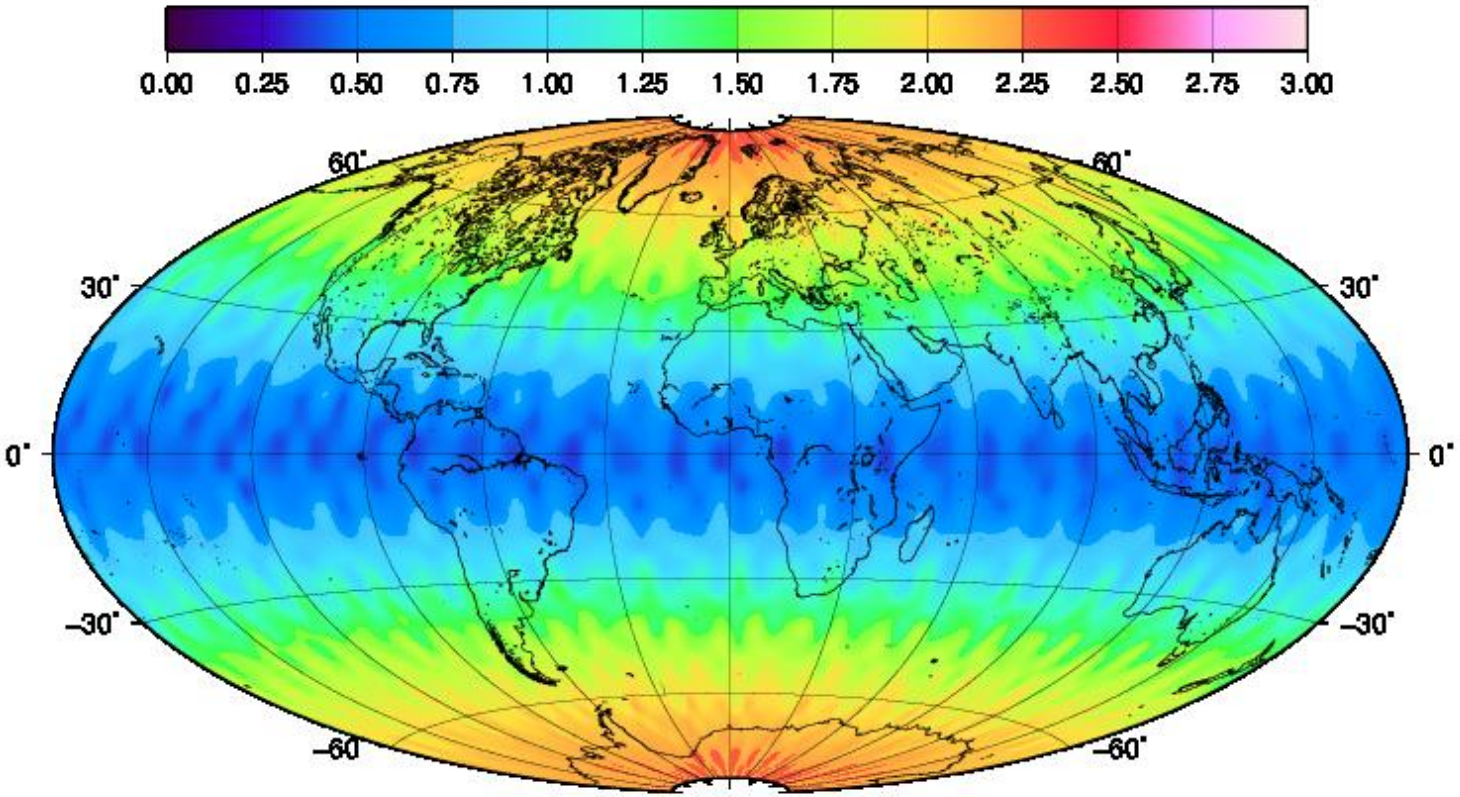
CSR CM also reduces annual amplitudes in CM estimate using J2 SLR+DORIS data



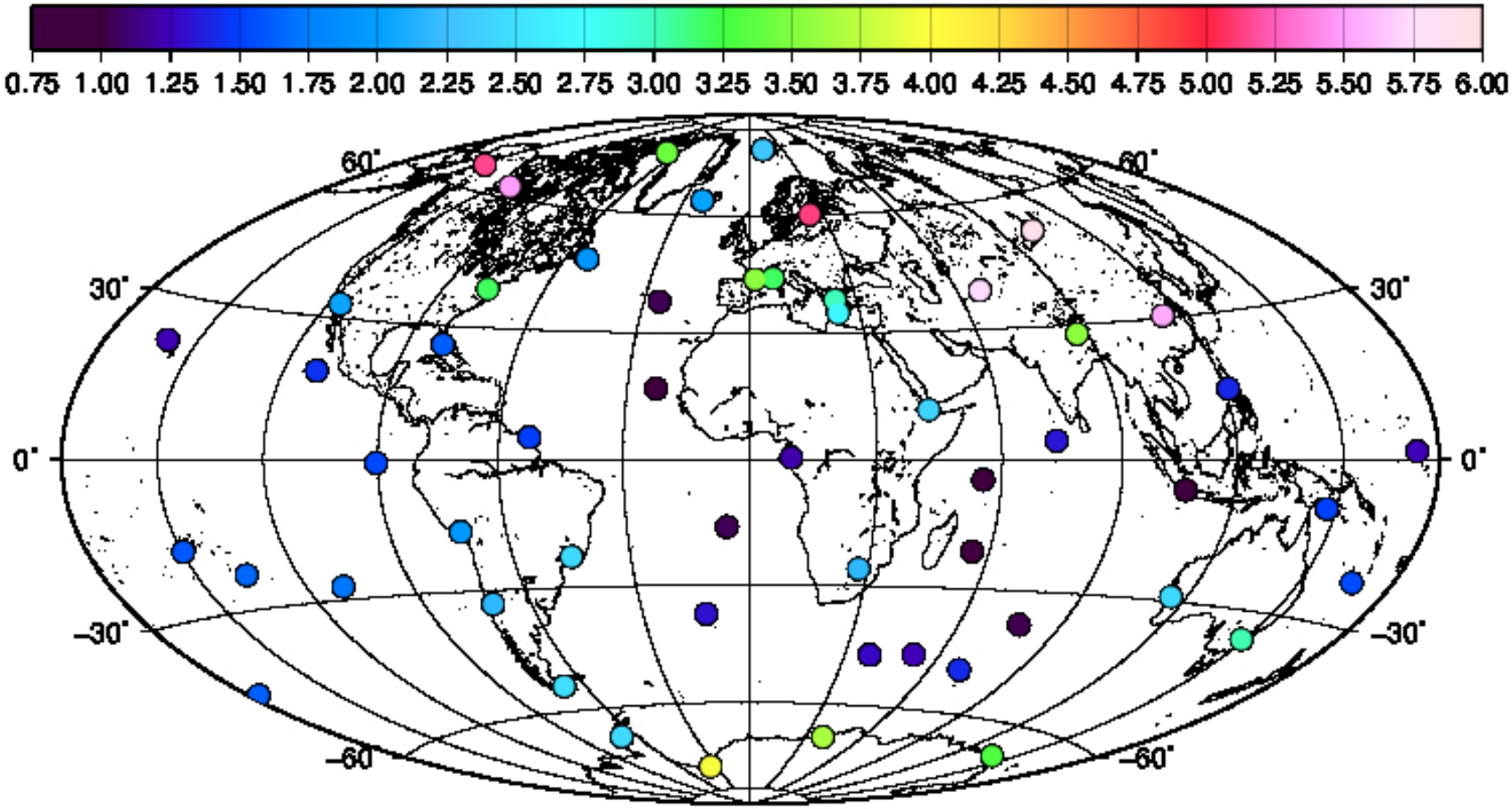
Annual amplitude of Jason-2 radial orbit differences sampled at fixed geographic points (CM – no CM) (mm)



Annual amplitude of ENVISAT radial orbit differences sampled at fixed geographic points (CM – no CM) (mm)

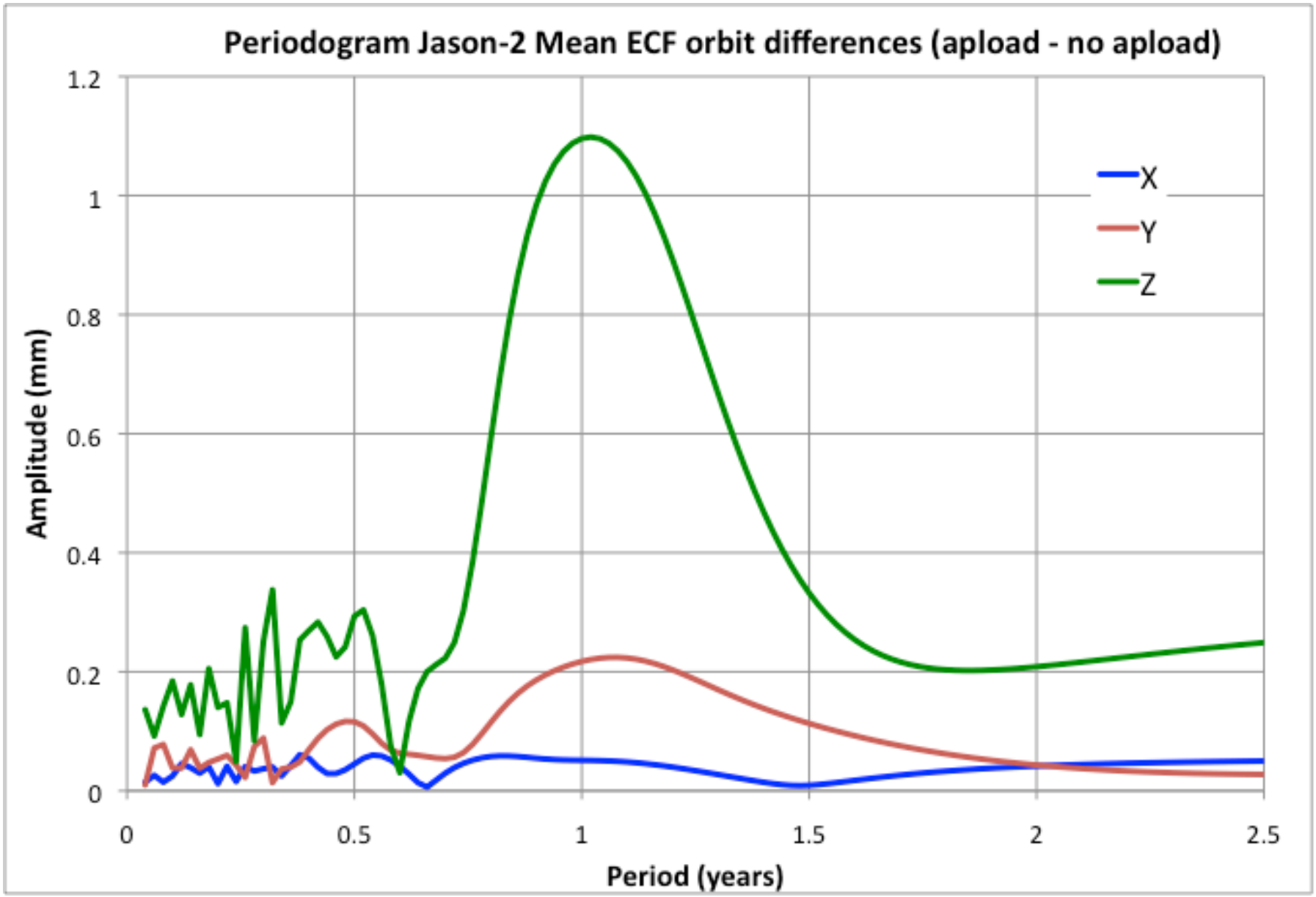


Atmosphere Station Loading RMS vertical deformation corrections at 55 DORIS stations over 2008-2011 (mm)



Atmosphere loading corrections provided by Tonie van Dam in N, E, Up

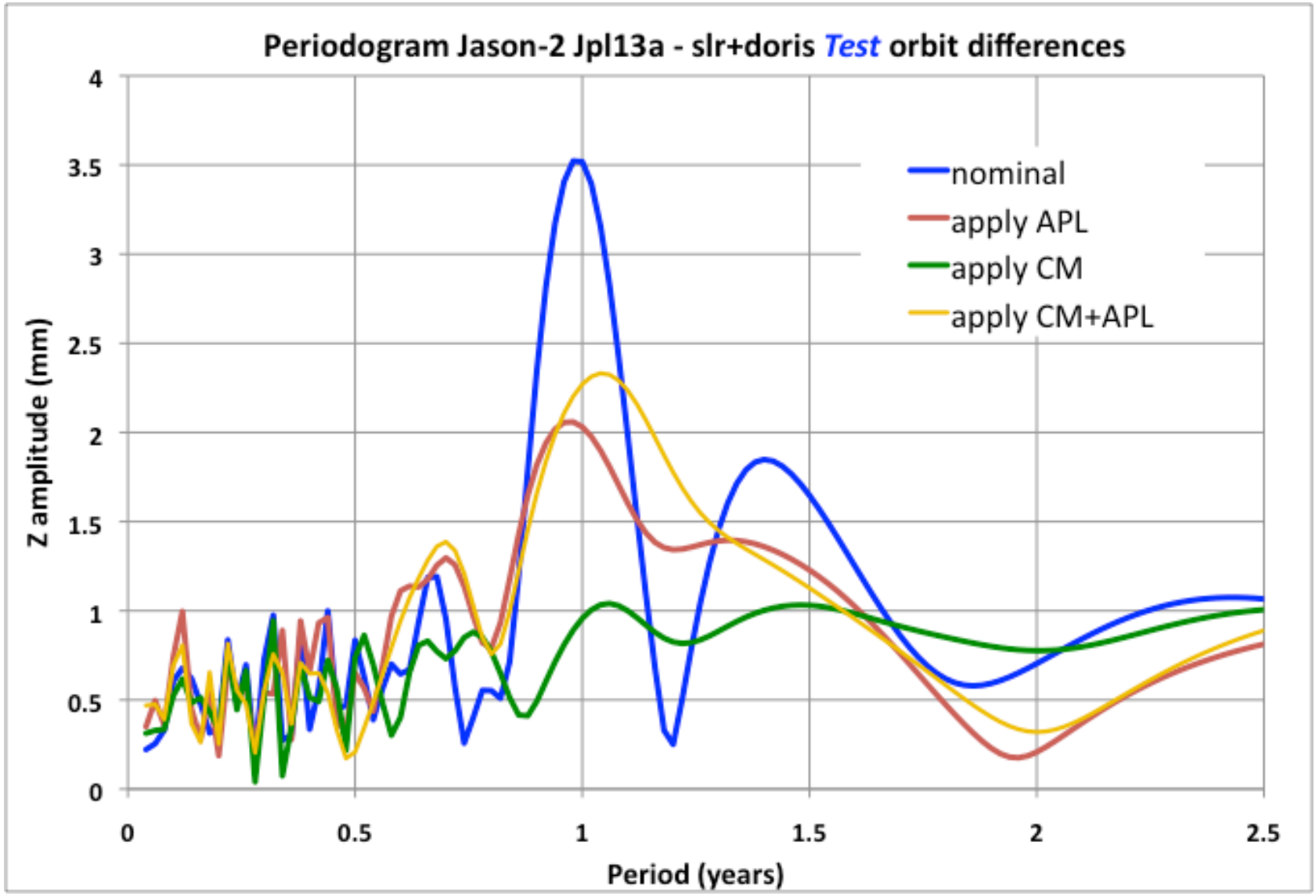
APL station deformation corrections largely affects J2 SLR+DORIS orbit in Z



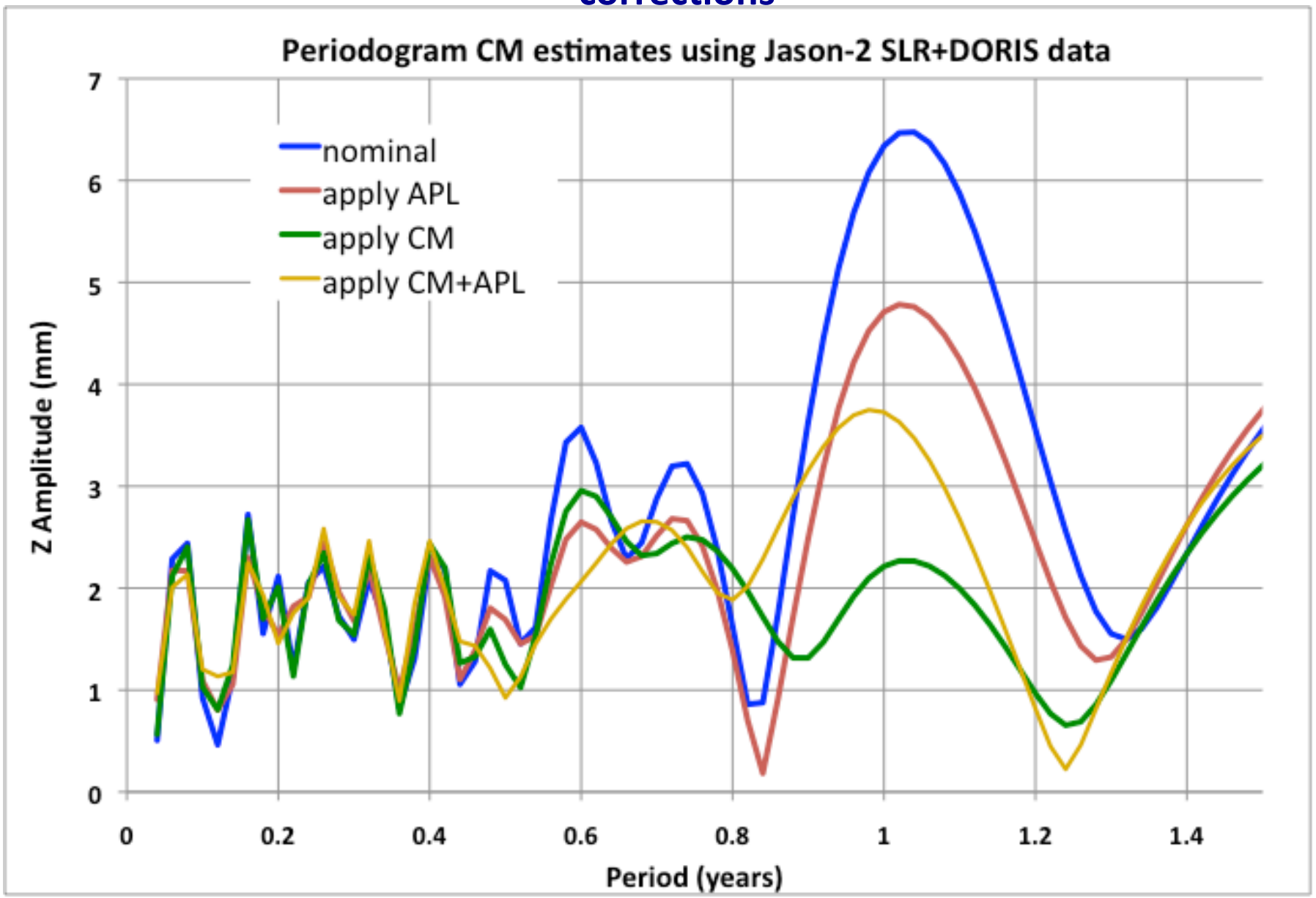
Atmosphere loading deformation (APL) will change the center of figure (CF), and consequently the CM computed wrt CF.

Should APL station corrections be applied in combination with a CM model derived without APL corrections (the CSR model)?

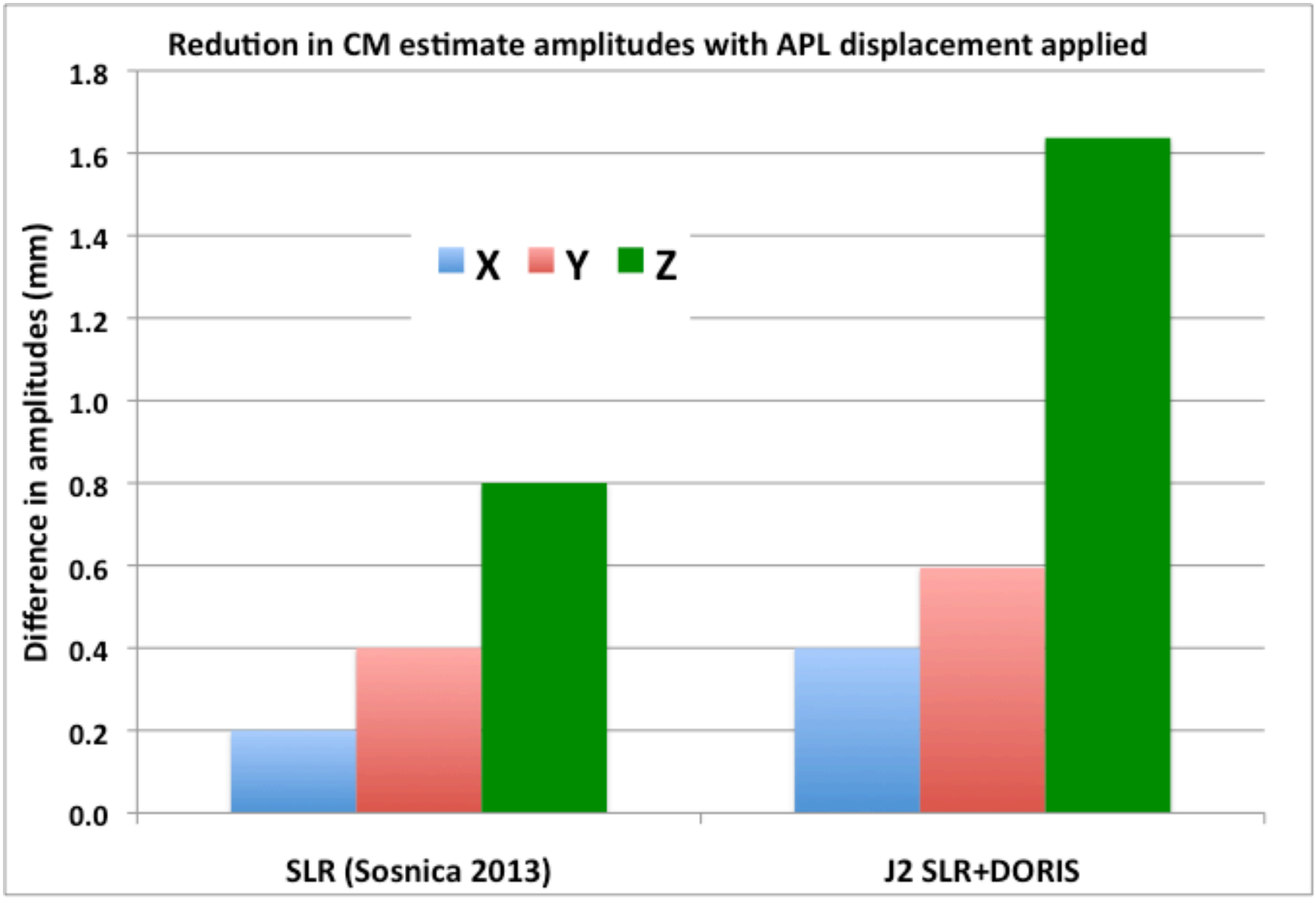
Orbit differences with JPL13a suggest the CSR CM model should NOT be used in combination with APL station corrections



CM estimates using J2 SLR+DORIS also suggest the CSR CM model should NOT be used in combination with APL station corrections



CM estimates which apply APL show a reduction in annual amplitudes.



Conclusion

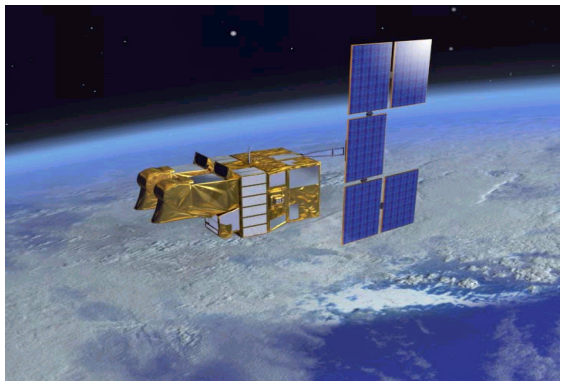
• Station position modeling is improved with the center of mass (CM) and atmosphere loading (APL) station corrections individually and even more so in combination as shown by the small improvements in SLR residuals.

• Comparison with the JPL13a GPS-based orbit and with separate estimates of CM using Jason-2 SLR+DORIS data show the computed orbit origin is much better aligned with the instantaneous CM using the CSR CM model.

• Preliminary analysis suggest APL station displacement corrections should not be used in combination with a CM model where such corrections were not considered in the model development.

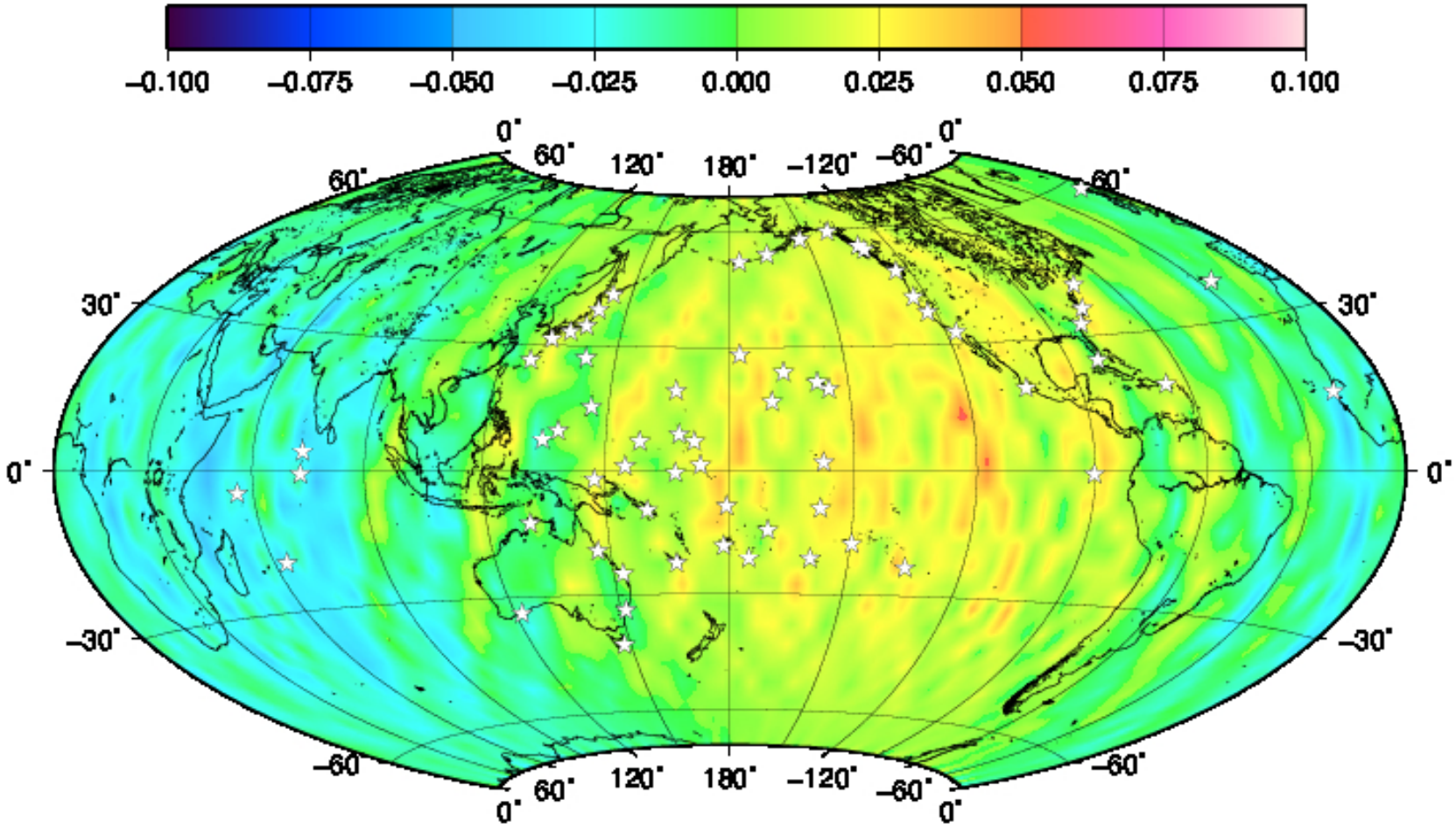
• The radial orbit, consistent with the signal in Z, shows the CM annual variations, with the CSR-model, reaching amplitudes of 4mm / 3mm for Jason-2 / Envisat at latitudes above/below 60°.

Thank you

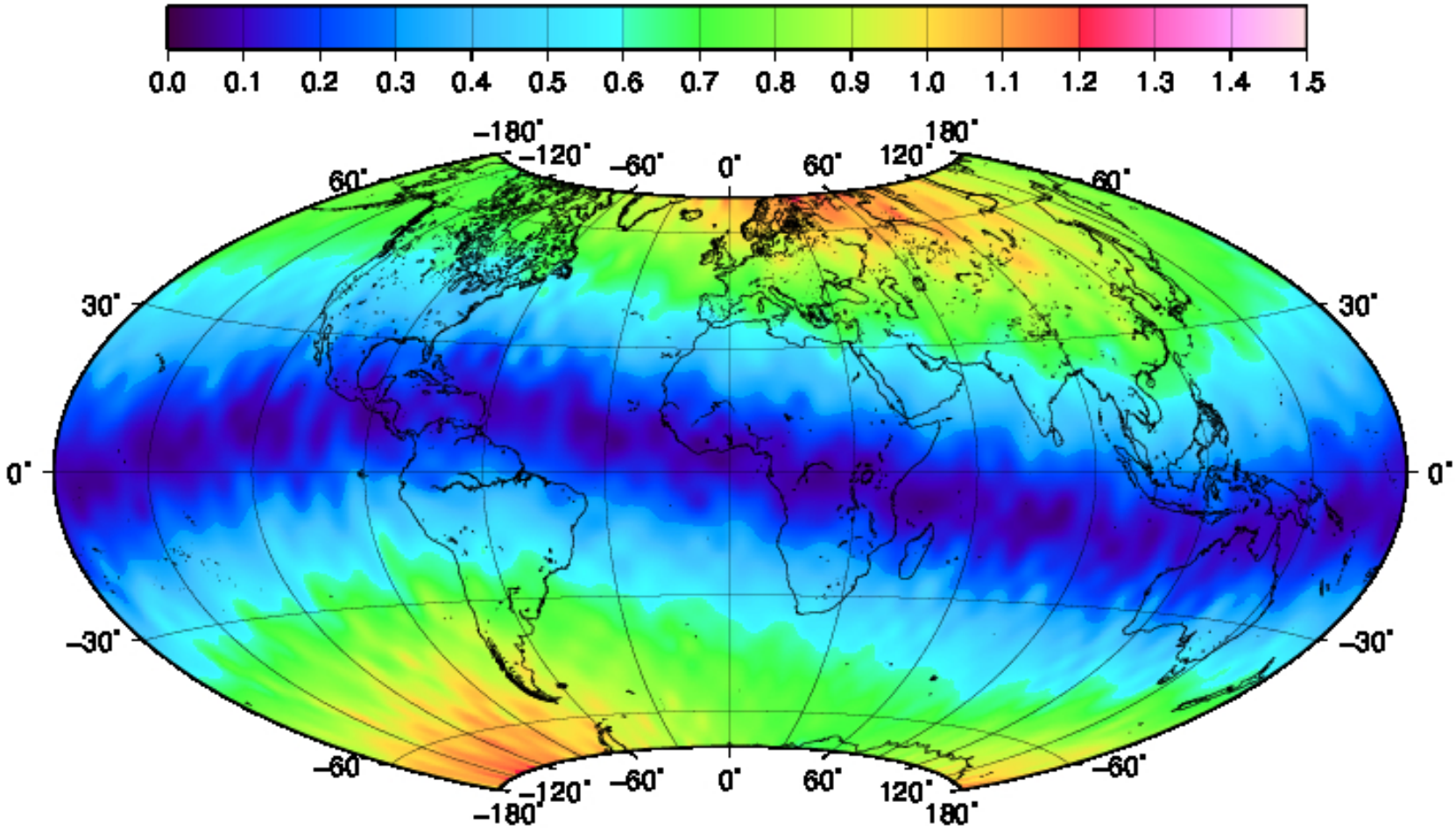


BACKUP

Apparent Jason2 orbit rates due to an annual Annual CM model are nearly zero when averaged over 3.5 years (mm/year)



Annual amplitude of Jason-2 radial orbit differences sampled at fixed geographic points (APL – nominal) (mm)



Annual amplitude of Jason-2 radial orbit differences sampled at fixed geographic points (CM+APL – nominal) (mm)