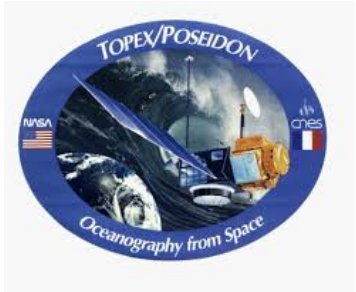

Improved orbit time series for the TOPEX & Jason missions from 1992-2019

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(4) KBR, Greenbelt, Maryland, USA

NEW J3 Orbits Delivered

Orbits were delivered to the POD Team, and are available upon request.

Jason-3: **std1808a cycles 1-131** (**GOCO05S, ITRF2014, IERS2014 mean pole**)
Jason-3: **tvg0012**, **cycles 1-108** (**as std1808a, ITRF2014, tvg0012 5x5 series augment GOCO05s**)

ITRF2014-based orbits are delivered to MEASURES for Sea Level ESDR Product.
(std1504_dpod2014: (**GOCO02S + TVG5x5, ITRF2014, IERS2010 mean pole**)

New series std1808a, tvg0012 under evaluation for entire altimeter time span (TOPEX, Jason-1, Jason-2).

Orbits will be delivered in sp3 format to NASA CDDIS.

Introduction:

(1) Refined several aspects 2018 std1808a standards and tested several SLR+DORIS based gravity solutions spanning 1992-2019. We plan to soon define a new GSFC 5X5 gravity model to augment GOCO05s. Preliminary gravity solutions already show improvement. New POD standards. based on the new gravity model, are expected to produce a more accurate and consistent orbit time series across the TOPEX and Jason Missions.

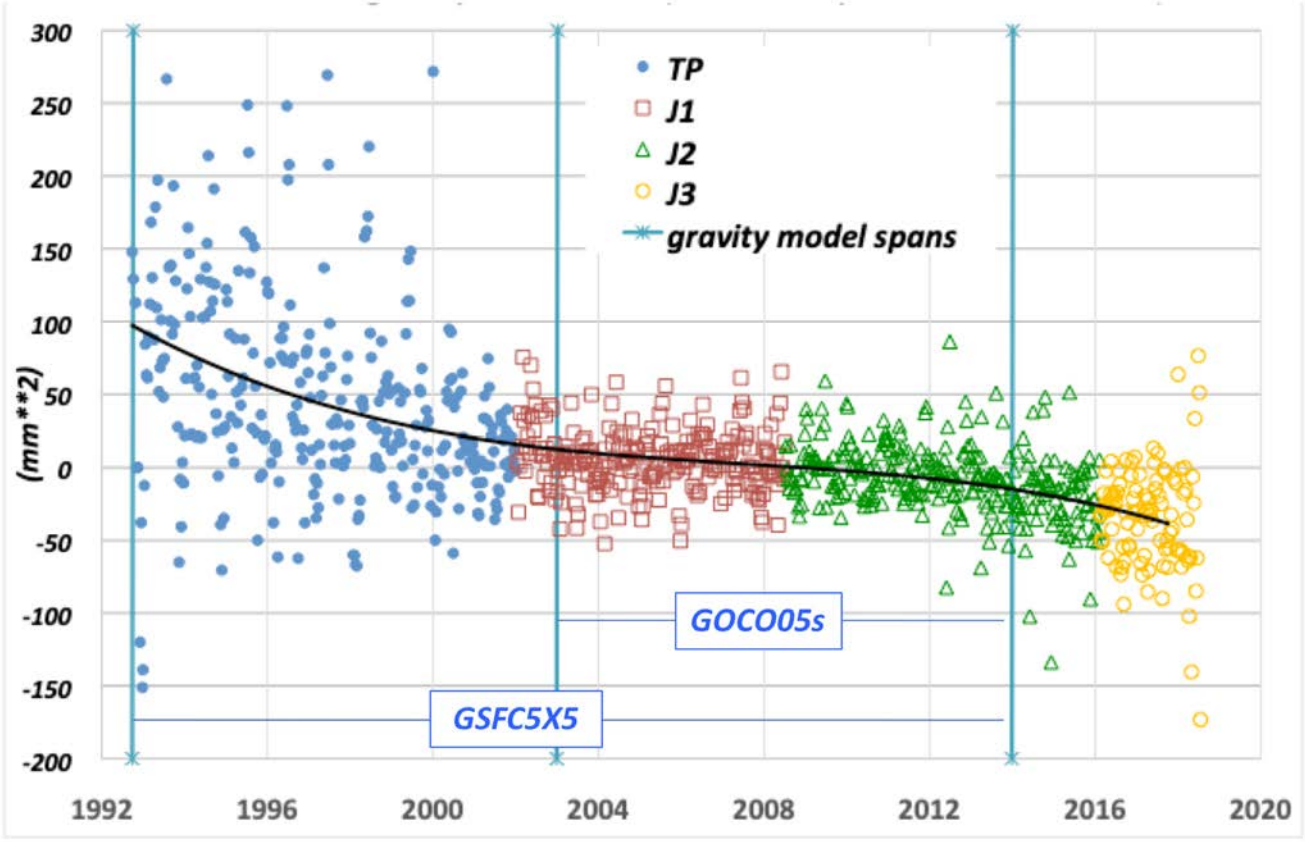
(2) With Alexandre Belli (*NPP@ NASA GSFC*), evaluated using improved USO frequency model on Jason-2, applied using DORIS RINEX data. This model is under evaluation for inclusion in DORIS processing for ITRF2020.

GSFC Jason-3 POD Strategy (changes)

model	dpod2014v04 (2017)	std1808a (2018)	tvg0012 (2019)
GEODYN	1612	1802	1906
gravity	GSFC5x5 model; GOCO02s (6x6 ->)	GOCO05S	5x5 GSFC 2-week SLR+DORIS solutions; GOCO05s(6x6 ->)
atmosphere gravity	ECMWF 50x50, 6-hour	GFZ 90X90 3-hour	GFZ 90X90 3-hour
mean pole	IERS2010	IERS2014 (linear)	IERS2014 (linear)
integration step size	30 seconds	15 seconds	15 seconds
SRP	old TSI, Cr=0.945	new TSI, re-tuned SA+, X- , tuned Cr/arc (2019)	new TSI, tuned SA+, X-, tuned Cr/arc
DPOD2014	Version 0.4	Version 2.0	Version 4.0
LRA phase center	constant correction	constant + elevation cor.	constant + elevation cor.
SLR bias template	gsfc2014(ILRS 2010)	gsfc2018(ILRS 2018; SLR with T2L2 TB correction)	gsfc2018
est. C31/S31 per arc	yes	no	no
OPR parameters	12-hr	24-hr (2019)	24-hr

Why is modelling TVG before 2003 necessary?

Compare Altimeter Crossover variance differences
for GOCO5s & a prior model (GOCO2S+old-GSFC5X5)I with TVG modelling
Negative differences => improvement for GOCO05s

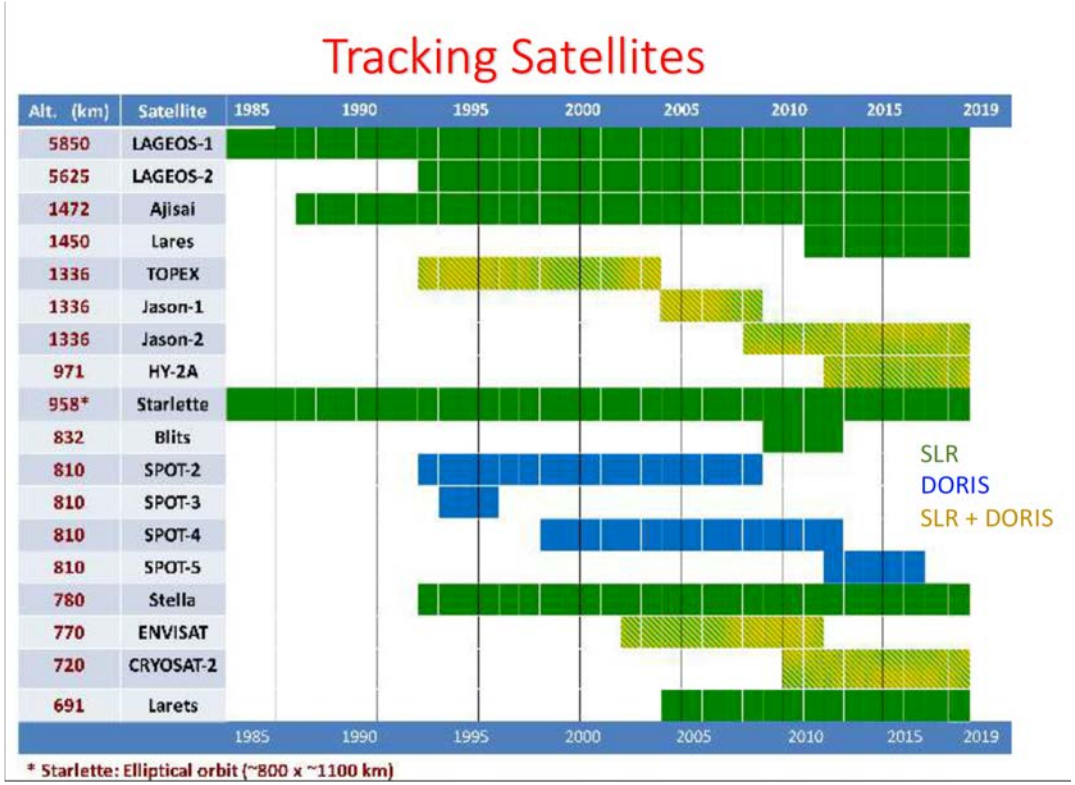


Need a separate solution because GRACE-era rates from 2003-2014, shouldn't be projected backward in time.

New biweekly SLR+DORIS 17-satellite Gravity solutions (1)

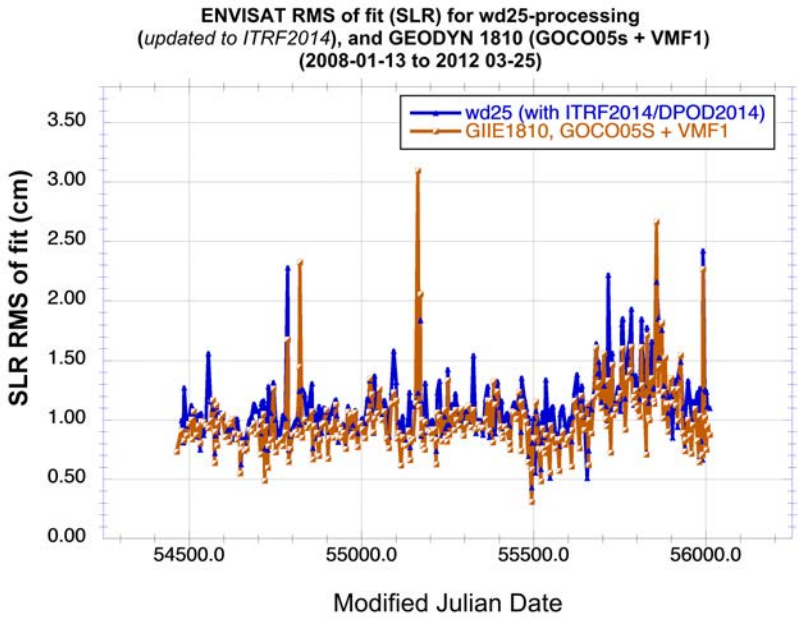
1. Update the previous series developed as part of ITRF2014 (1992-2019), as part of work for ITRF2020.
2. <u>Use New standards as a priori</u>
   (A) GOCO05s.
   (B) GFZ-provided AOD (RL06) to 90x90 & associated air tides.
   (C) IERS2014 linear mean pole.
   (D) VMF1 for DORIS Troposphere refraction correction.
   (E) New ILRS-supplied SLR/CoM corrections for SLR satellites (*José Rodriguez, NERC, UK*).
   (F) Bi-weekly instead of weekly solutions.

<u>Experimental solutions so far</u>:
tvg0012, tvg0035



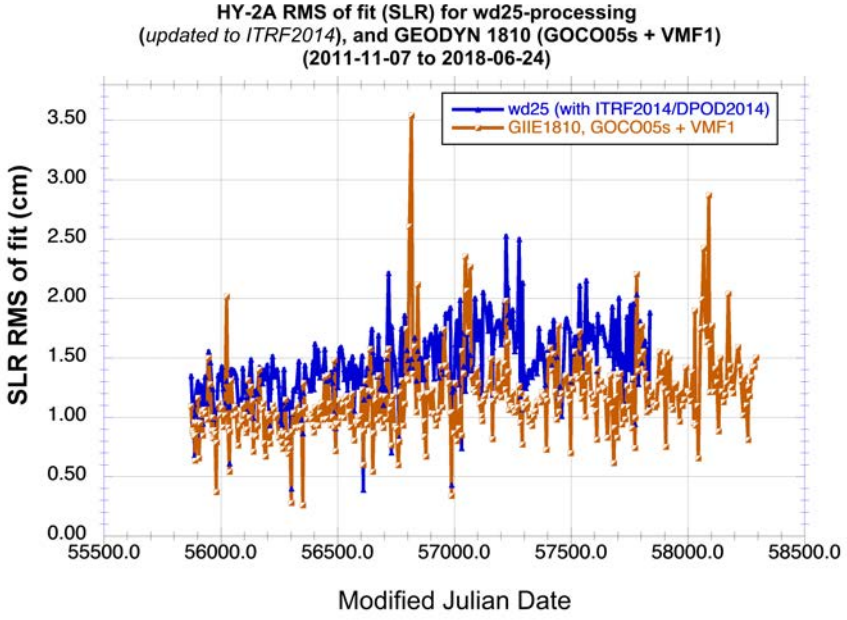
New biweekly SLR+DORIS 17-satellite Gravity solutions (2): Validation of new modelling

ENVISAT SLR RMS of fit



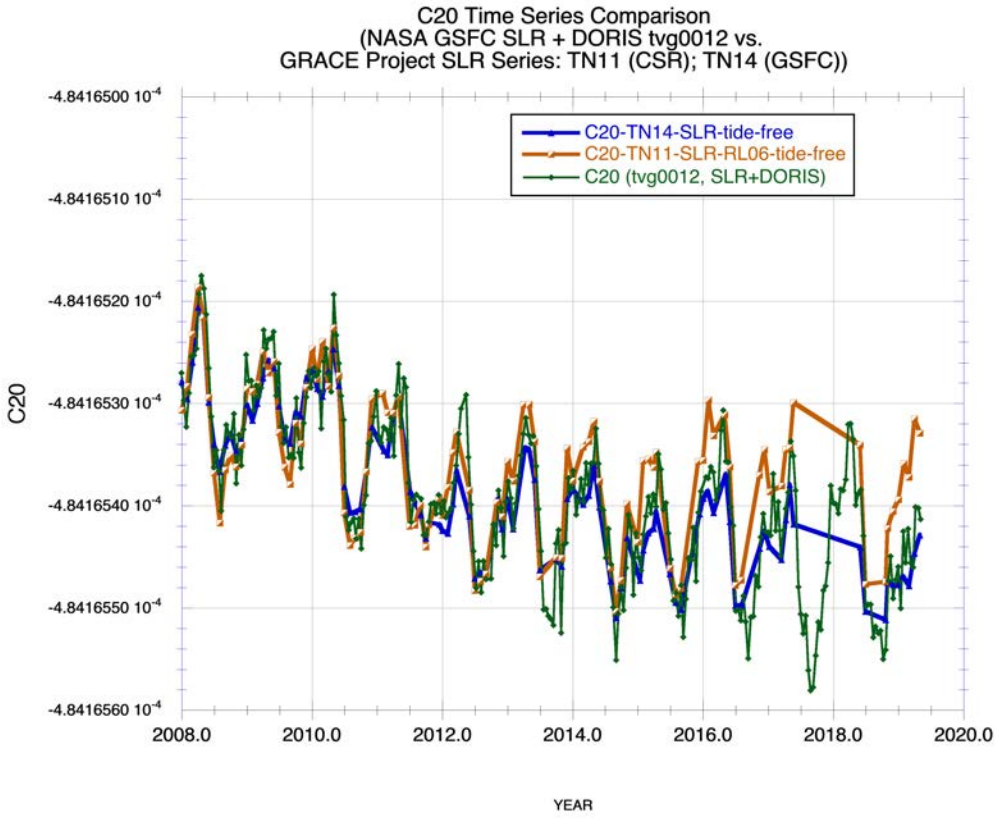
ENVISAT	Narcs	Dates	Avg. SLR fit (cm)
wd25	296	2008/01/03 – 2012/03/25	1.093
GOCO05s	296	2008/01/03 – 2012/03/25	0.997

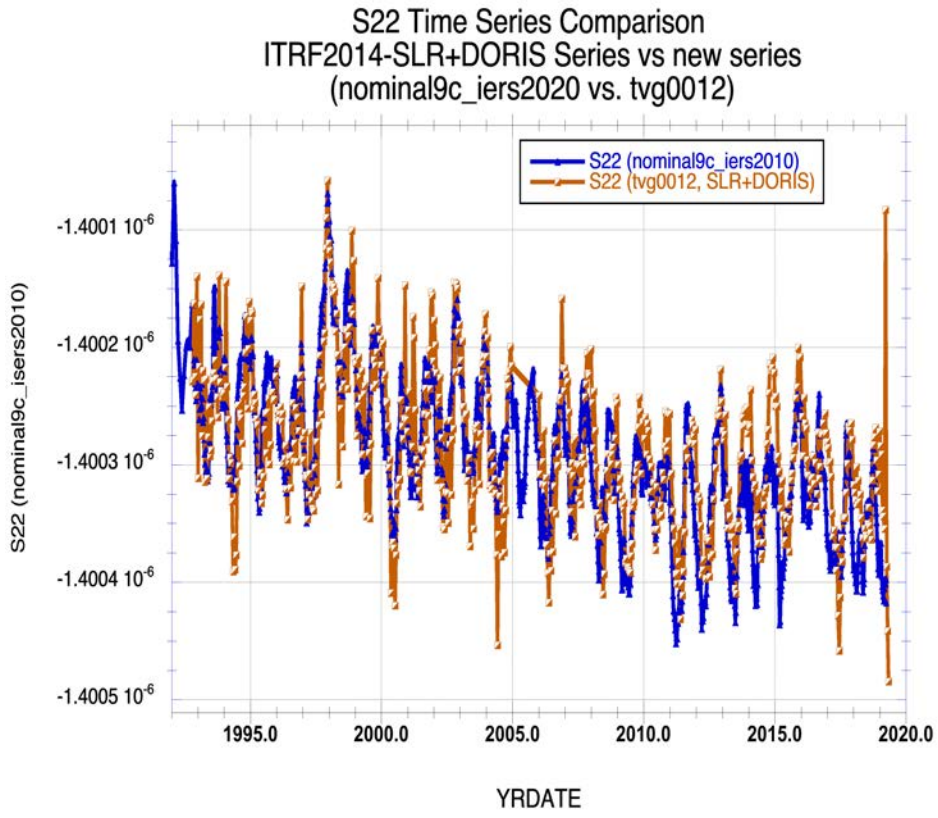
HY-2A SLR RMS of fit



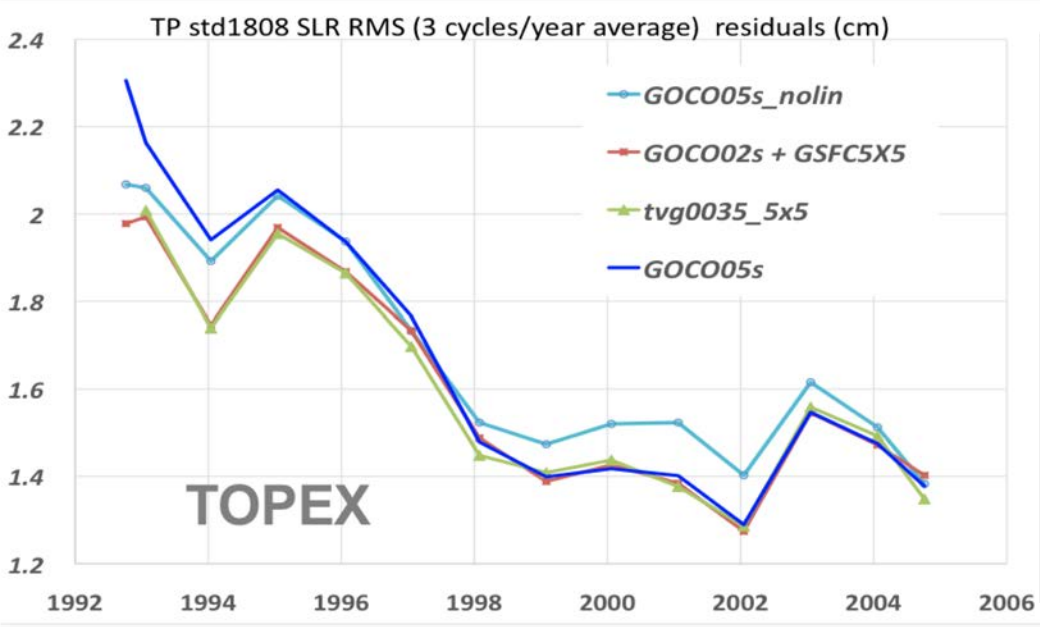
HY-2A	Narcs	Dates	Avg. SLR fit (cm)
wd25	329	2011/11/07 – 2017/0326	1.431
GOCO05s	401	2011/11/07 – 2018/06/24	1.161

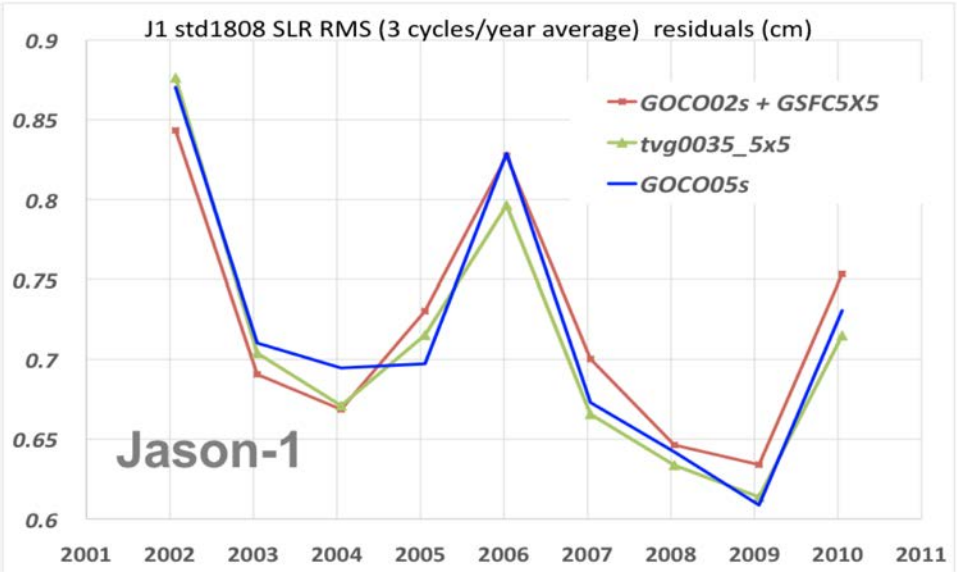
New bi-weekly SLR+DORIS 17-satellite Gravity solutions (3)



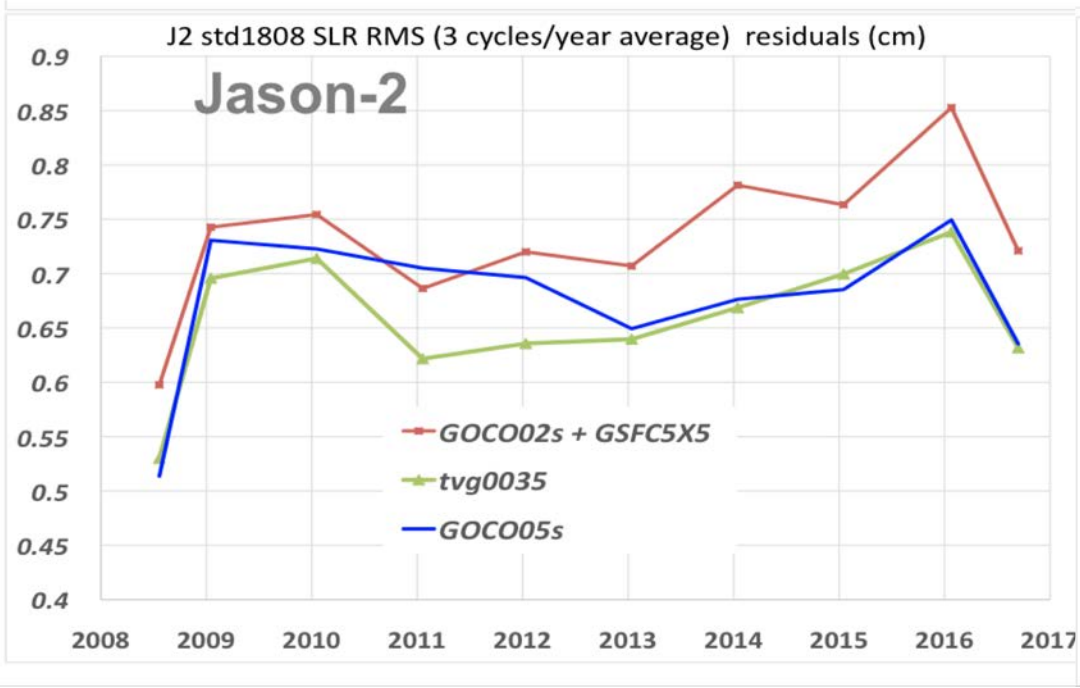


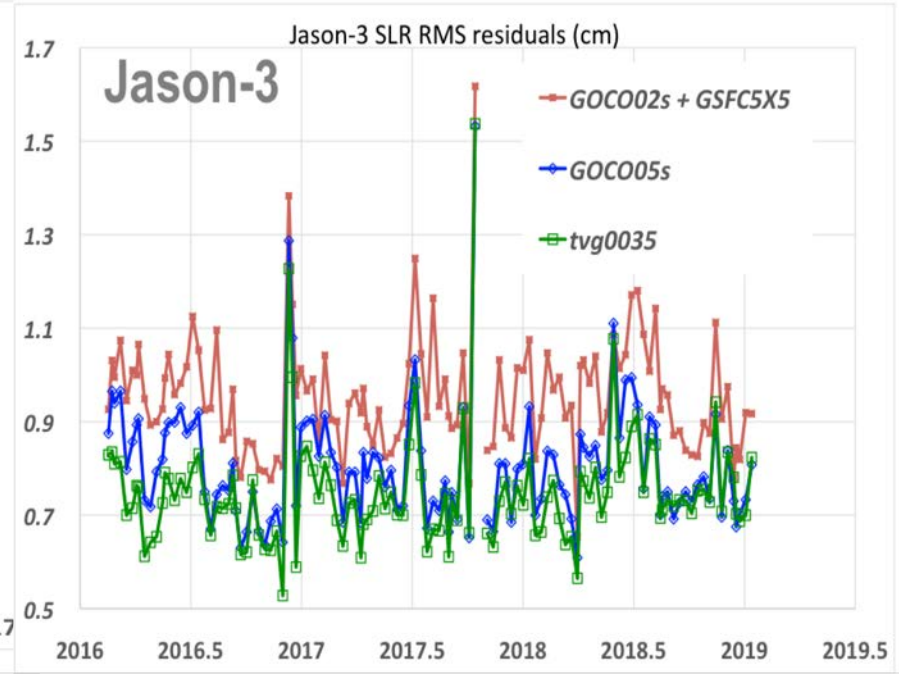
Gravity solution SLR+DORIS POD most recent tests: SLR residuals (cm) for different TVG models





Gravity solution SLR+DORIS POD most recent tests: SLR residuals (cm) for different TVG models

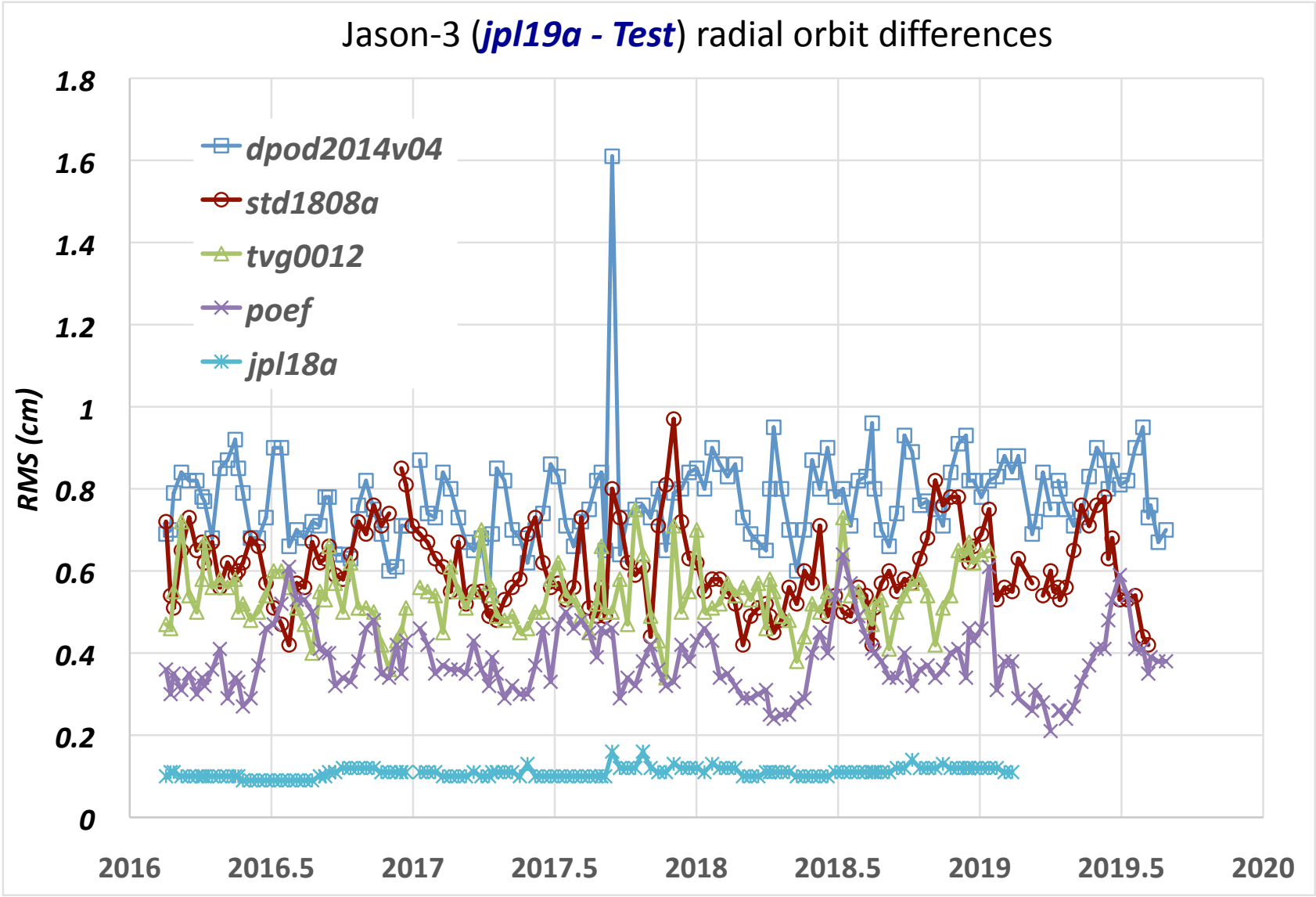




Jason-3 Residuals Summary using external ephemeris

Orbit (cycles 1-108)	DORIS (mm/s)	SLR (cm)	Xover (cm)
dpod2014v04 (SLR+DORIS dynamic)	0.4173	1.056	5.349
std1808a (SLR+DORIS dynamic)	0.4171	1.109	5.294
tvg0012 (SLR+DORIS dynamic)	0.4169	1.027	5.280
poef (GPS+DORIS red-dyn)	0.4169	1.141	5.306
jpl18a (GPS red-dyn)	0.4174	1.093	5.276
jpl19a (GPS red-dyn)	0.4174	1.092	5.272
Orbit (cycles 1-131, Xover cyc. 1-128)	**DORIS (mm/s)**	**SLR (cm)**	**Xover (cm)**
dpod2014v04 (SLR+DORIS dynamic)	0.4196	1.146	5.357
std1808a (SLR+DORIS dynamic)	0.4194	1.198	5.302
poef (GPS+DORIS red-dyn)	0.4192	1.233	5.317
jpl19a (GPS red-dyn)	0.4197	1.187	5.281

Jason-3 jpl19a-Test Radial RMS orbit differences (cm)



Jason-3 Mean Radial orbit differences over water (mm)

Jason-3 Mean radial orbit differences over water

CM Z peak-to-peak annual amplitude differences = 3 to 3.5 mm

Mean (mm)

3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2

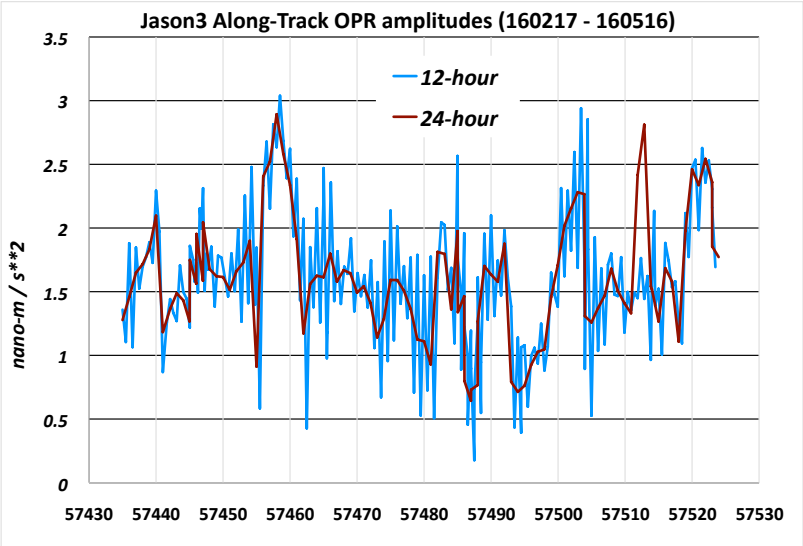
poef-std1808a
poef-jpl19a
std1808a-jpl19a

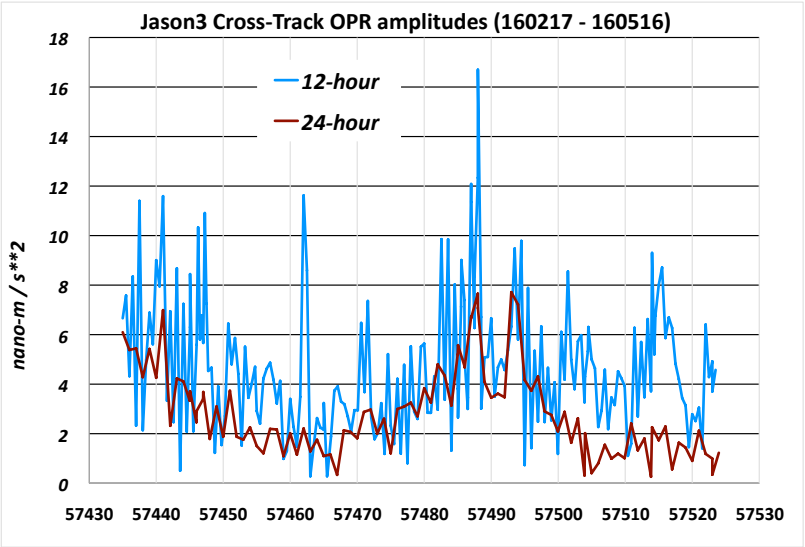
2016
2016.5
2017
2017.5
2018
2018.5
2019
2019.5
2020

24-hr OPR estimation per arc (vs 12-hr OPR) for J3 SLR+DORIS POD Improves the orbit

Jason3 external ephemeris residual summary (cycles 1-92)

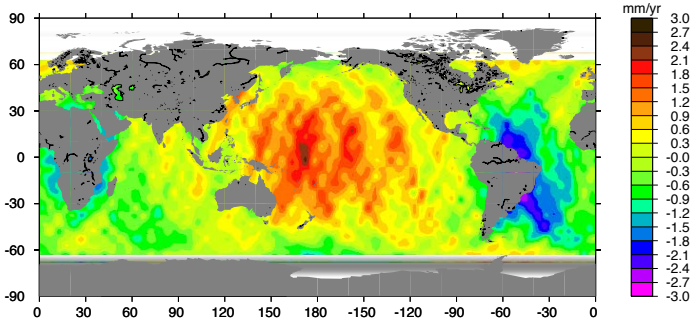
Test	DORIS RMS (mm/s)	SLR RMS (mm)	Xover RMS (mm)_	jpl18a radial diff. RMS (mm)
dpod2014v04 (12-hr OPR)	0.4160	1.044	5.308	7.6
std1808a_12hr	0.4160	1.259	5.290	6.5
std1808a_24hr	0.4161	1.275	5.264	6.4



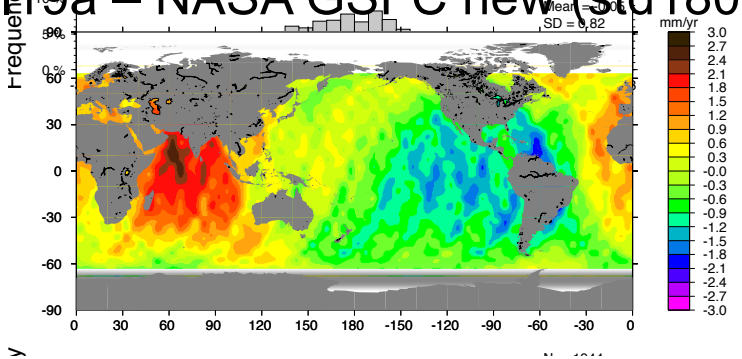


Jason-3 (jpl19a - "Test ")
radial orbit difference Rates (mm/yr)
(160217 – 190123; cycles 1-108)

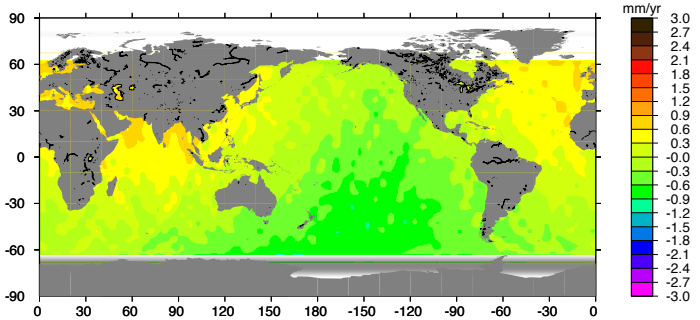
jpl19a – NASA GSFC old (dpod2014v04)



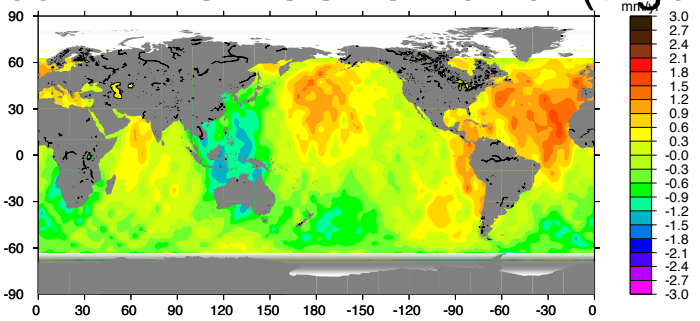
jpl19a – NASA GSFC new (std1808a)



jpl19a – CNES poef

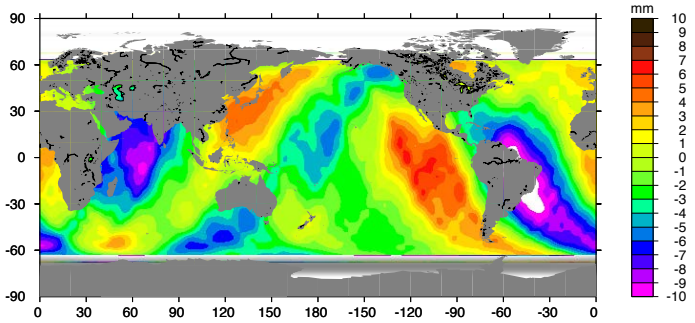


jpl19a – NASA GSFC newer (tvg0012)

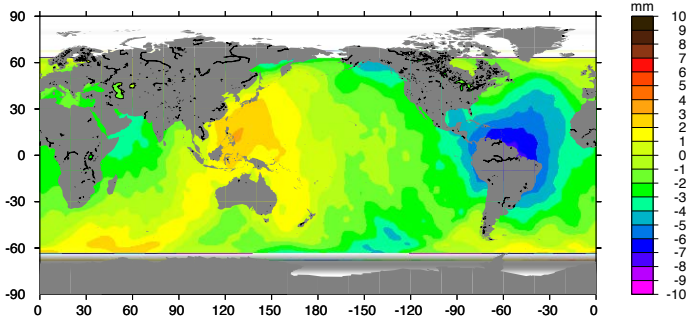


Jason-3 (jpl19a - "Test ")
mean radial orbit differences (mm)
(160217 – 190123; cycles 1-108)

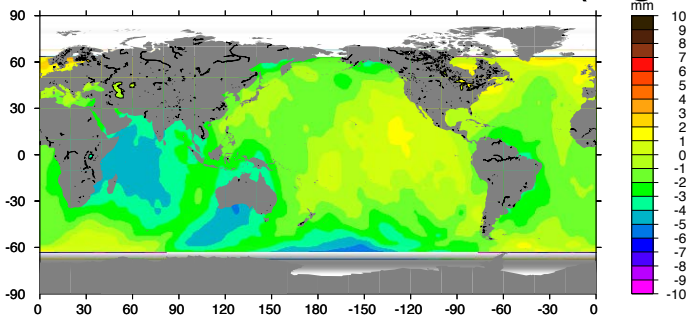
jpl19a – NASA GSFC old (dpod2014v04)



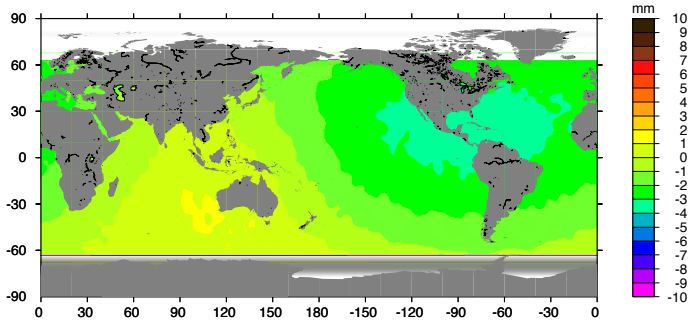
jpl19a – NASA GSFC new (std1808a)



jpl19a – NASA GSFC newer (tvg0012)



jpl19a – CNES poef



JPL orbit Differences	$\sigma\ (mm)$
jpl19a – dpod2014v04	3.45
Jpl19a – std1808a	2.08
Jpl19a – tvg0012	1.64
Jpl19a – poef	1.27

Summary

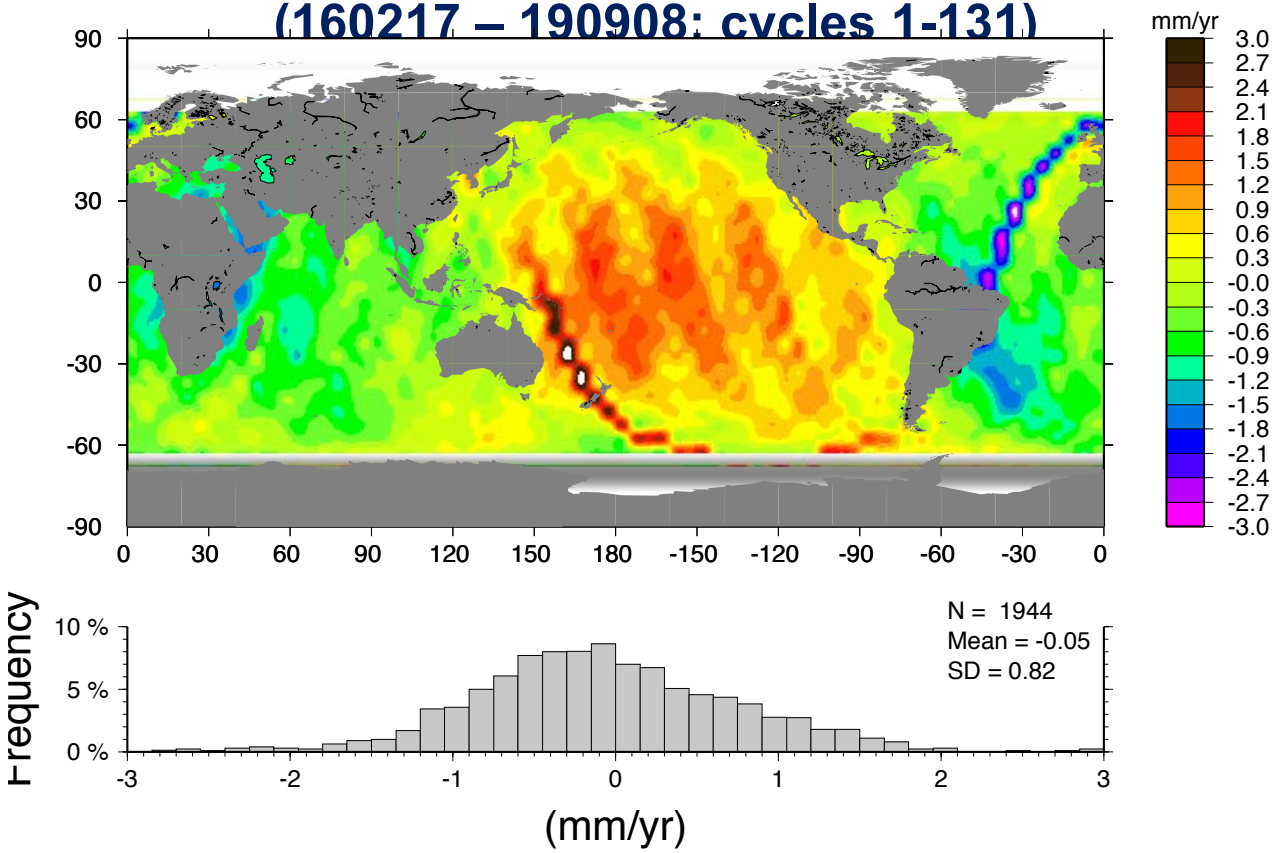
(1) We have produced a new series of SLR+DORIS "dynamic" orbits based on a newer GRACE+GOCE-based gravity model, more detailed modelling of Time-variable gravity (biweekly 5x5), application of the IERS2014 linear mean pole, improved SRP modeling and other changes (std1808a, tvg2012).
(2) The new orbit series is improvement over the previous series (dpod2014) and would be a candidate to update the MEASUREs product.
(3) The ensemble of orbit tests and comparisons (GSFC, JPL, CNES) allow us to assert that the radial orbit error on Jason-2, Jason-3 are now at the level of 8 mm RMS.

Future work & concerns.

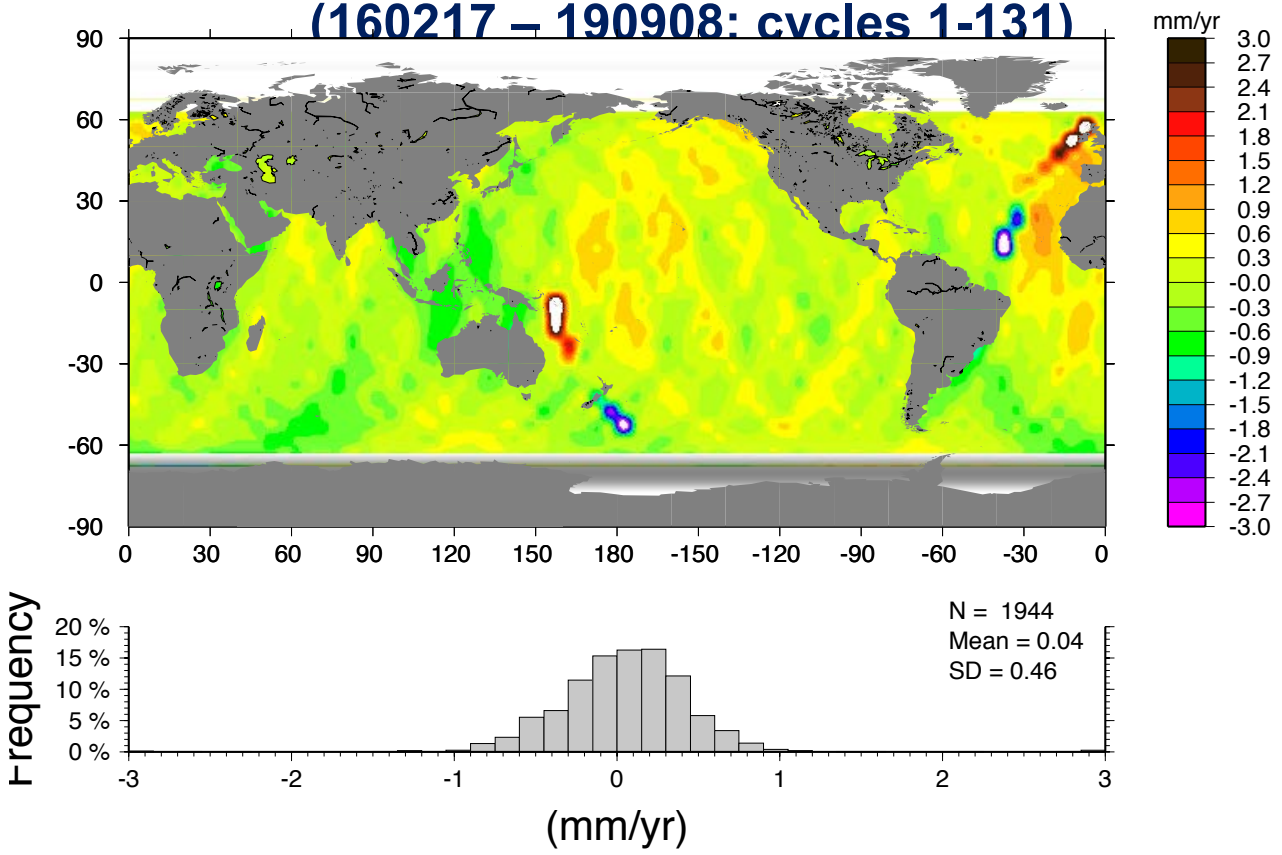
(1) We need to continue to investigate cause of large radial orbit rate differences between different sets of orbits; Strong candidates are differences in TVG parameterization and sensitivity, and how the different techniques respond to the geocenter.
(2) We need to remember that the ability to discern systematic errors in the orbits of altimeter satellites relies on having three independent tracking techniques of comparable quality in tracking precision.

Backups

Jason3 (jpl19a-dpod2014v04) radial orbit difference Rates (mm/yr)
(160217 – 190908: cycles 1-131)



Jason3 (jpl19a-std1808a) radial orbit difference Rates (mm/yr)
(160217 – 190908: cycles 1-131)



Jason3 (jpl19a-poef) radial orbit difference Rates (mm/yr) (160217 – 190908; cycles 1-131)