Improved orbit time series for the TOPEX & Jason missions from 1992-2020

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New TOPEX & Jason 1-3 Orbits

Summary:

Orbits based on updated standards and a complete reprocessing were delivered to the NASA MeaSUREs (**Integrated Multi-Mission Ocean Altimeter Data for Climate Research (MEaSUREs-SSH, https://podaac.jpl.nasa.gov/MEaSUREs-SSH).** These orbits (**std2006**) are available for other users of the OSTST and will be distributed through the NASA GSFC NCCS dataportal. The standards used (based on ITRF2014 and implementing other improvements) represent refinements of the preliminary orbits we delivered in 2019 (std1808a) and tvg0012. This delivery to MEaSUREs updates the previous delivery (std1504_dpod2014, Beckley et al. (2017).

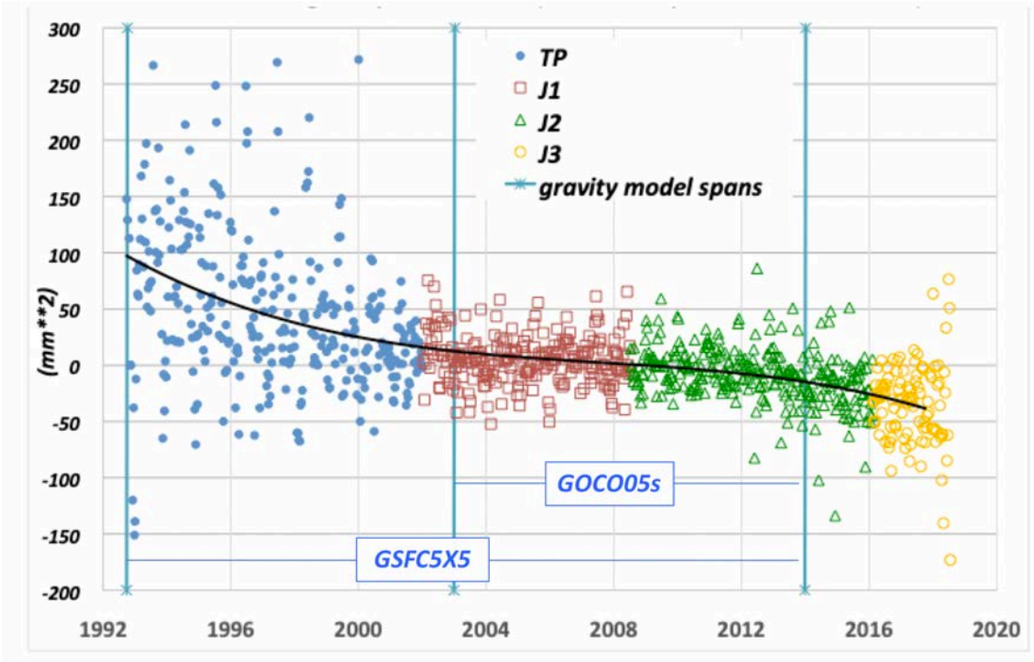
Comparisons to independent orbits (CNES/POEF, JPL/Reduced-dynamic orbits) for Jason-3) show RMS radial orbit agreement of 5-7 mm for Jason-3 for these new orbits (std2006), compared to 7-9 mm radial RMS agreement for the std1504_dpod2014 set of orbits.

GSFC POD Strategy for new orbits

model	dpod2014v04 (2017)	std2006 (2020)
GEODYN	1612	2002
gravity	GSFC5x5 model + GOCO02s	new GSFC 5x5 model (tvg0075) + GOCO05s
atmosphere gravity	ECMWF 50x50, 6-hour	GFZ 90X90 3-hr from ECMWF (cf. GRACE FO, RL06)
mean pole	IERS2010	IERS2014 (linear)
integration step size	30 seconds	15 seconds
Solar Rad. Pressure	old TSI, Cr=0.945	new TSI, tuned SA+, X-, tuned Cr/arc
DORIS/DPOD2014	Version 0.4, w. updates	Version 4.0
DORIS SAA Stations	J1: downweighted.	J1 & J3 downweighted.
elev. cutoff (DORIS)	10 deg.	7 deg.
DORIS data weighting	constant w. elevation	elevation-dependent (J2 & J3)
SLR/SLRF2014	SLRF2014 w. updates	SLRF2014 (v200428).
SLR Data Handling	gsfc2014 (ILRS 2014)	ILRS2014 with T2L2-derived corrections.
LRA phase center	constant correction	constant + elevation correction.
SLR Data Handling	gsfc2014(ILRS 2010)	gsfc2020 (from ILRS, 06-16-2020)
est. C31/S31 per arc	yes	no
OPR parameters	12-hr	24-hr

Why is modelling TVG before 2003 necessary?

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



Need a separate solution because the GRACE-era rates from 2003-2014, should not be projected backward in time.

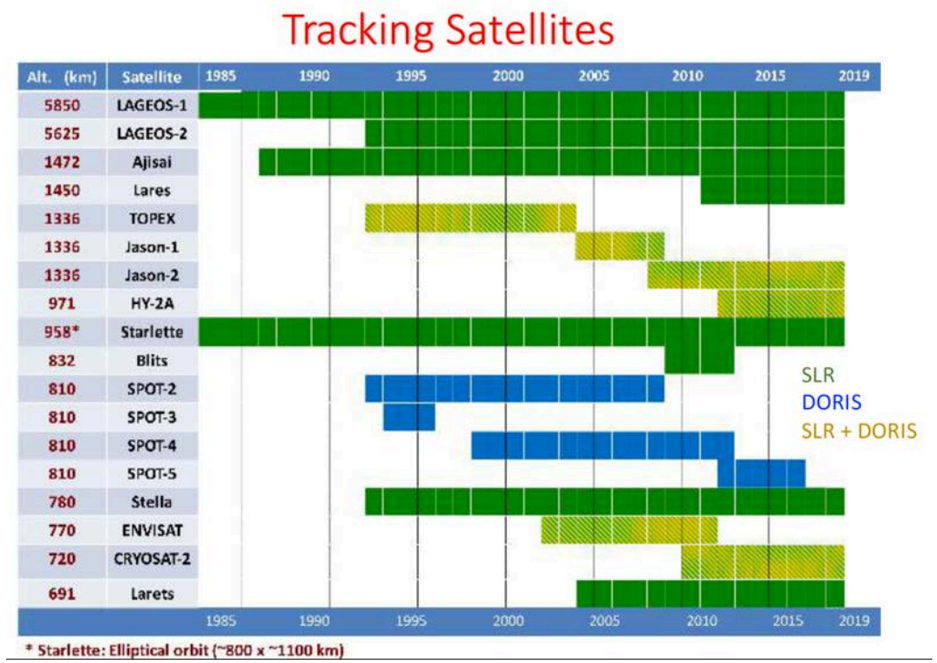
New biweekly SLR+DORIS 18-satellite Time-Variable Gravity solutions (1)

Update the previous series (1992-2014, extended) developed as part of ITRF2014 as part of the GSFC IDS/DORIS contribution for ITRF2020.

Use New standards as a priori

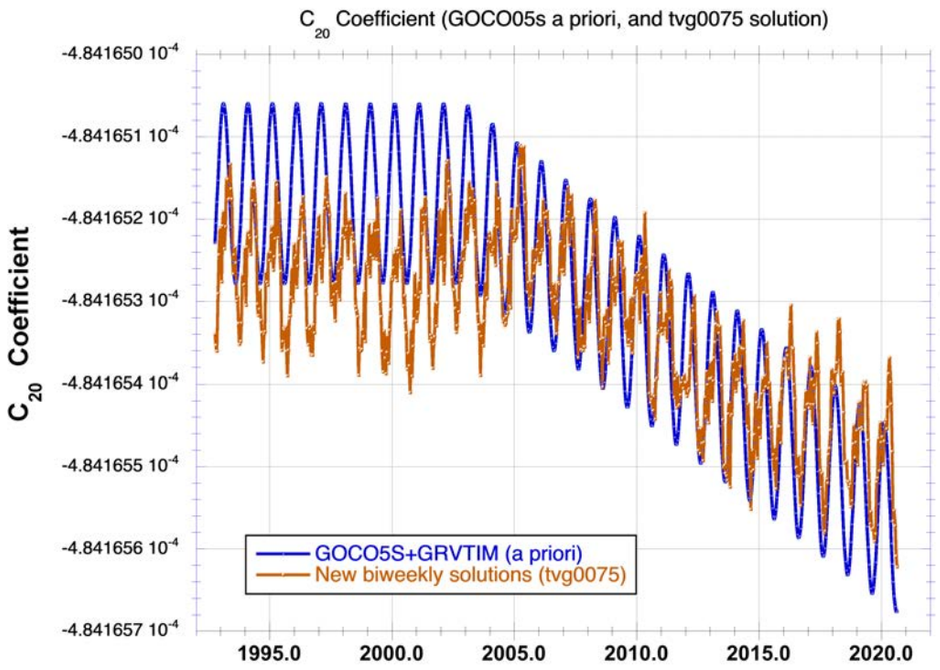
- GOCO05s (from GRACE & GOCE) is the general background model. We ignore the GRACE-derived linear rates prior to 2003.
- GFZ-provided AOD (RL06) to 90x90 & associated air tides.
- IERS2014 linear mean pole.
- VMF1 for DORIS Troposphere correction.
- New ILRS-supplied SLR/CoM corrections (Rodriguez et al., 2019, J Geodesy).
- Bi-weekly instead of weekly solutions.

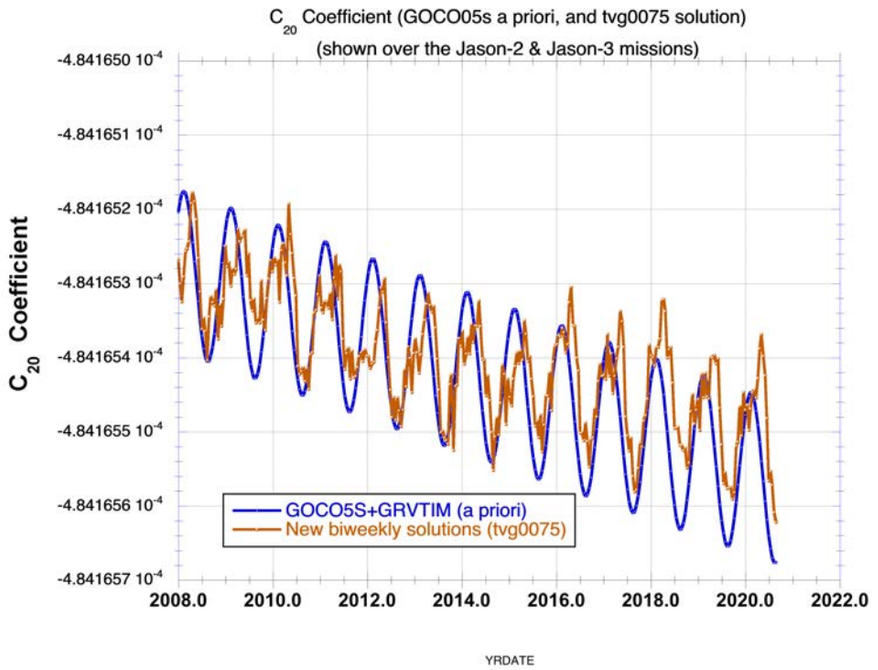
New TVG solution: **tvg0075**



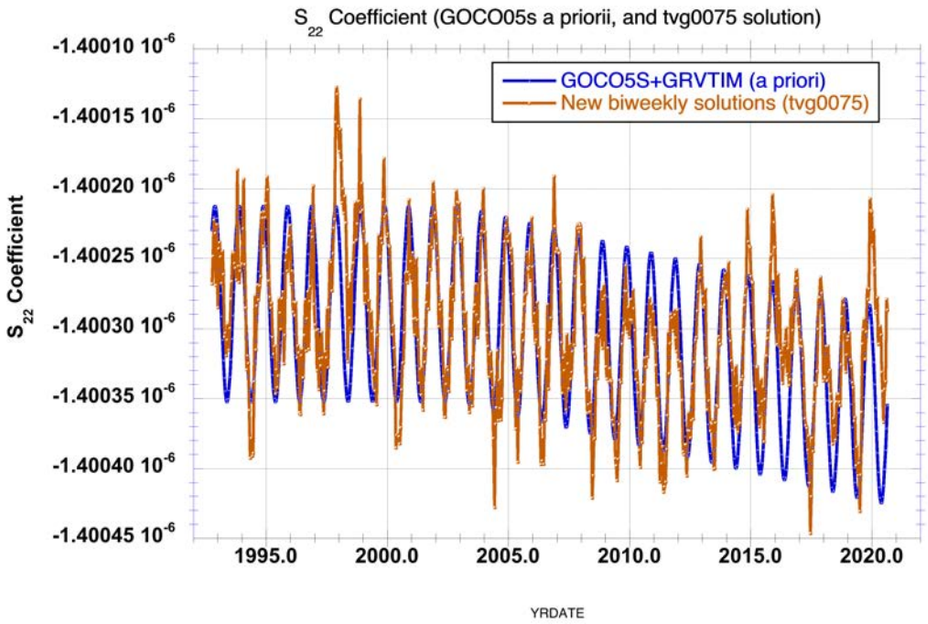
The idea is to provide a consistent background geophysical model from 1992 to 2020.

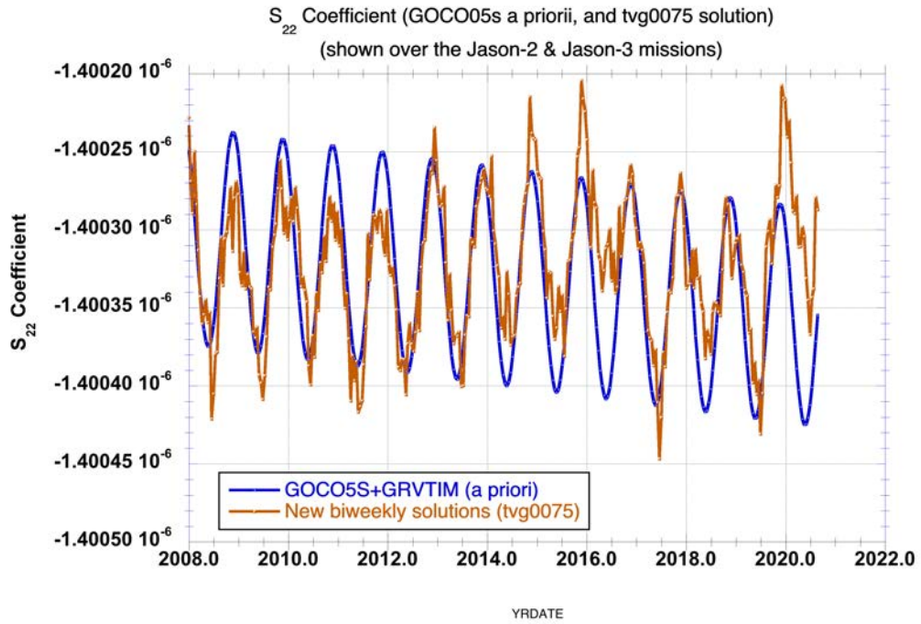
New bi-weekly SLR+DORIS 17-satellite Gravity solutions (2)



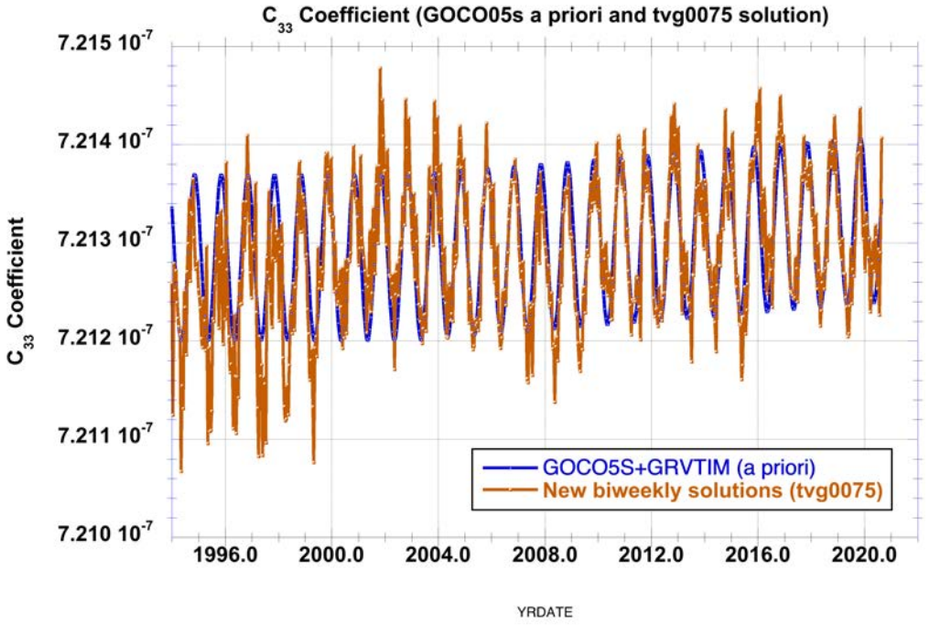


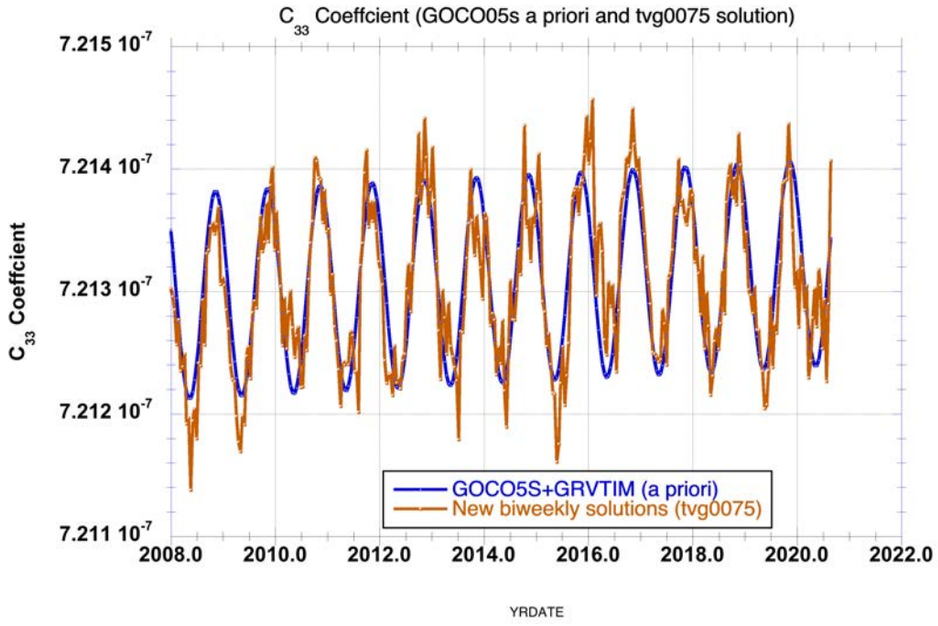
New bi-weekly SLR+DORIS 17-satellite Gravity solutions (2)





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





TOPEX/Poseidon (TP) test summary
1992-11-01 to 2004-10-02 (cycles 5-446)

Residuals computed with External Ephemeris (cycles 5-446)			
SLR+DORIS Orbits	DORIS (mm/s)	SLR (cm)	Xover (cm)
std1504_dpod2014	0.5078	1.659	5.609
std2006	0.5070	1.769	5.610

RMS orbit differences (std2006-Test) (cycles 5-446)			
Test Orbits	Radial (mm)	Cross-trk (mm)	Along-trk (mm)
std1504_dpod2014	4.8	26.4	26.0

Jason-1 (J1) Residual summary
2002-01-15 to 2009-01-26 (cycles 1-259)

Residuals computed with External Ephemeris				
SLR+DORIS Orbits		DORIS (mm/s)	SLR (cm)	Xover (cm)
std1504_dpod2014		**0.3826**	**0.933**	**5.507**
std1808a (GOCO05s)		0.3825	1.046	5.482
std2006	**OPR 12hr**	**0.3825**	**1.148**	**5.480**
	OPR 24hr	**0.3822**	**1.204**	**5.482**

Jason-1 (J1) Orbit Difference summary
2002-01-15 to 2009-01-26 (cycles 1-259)

RMS orbit differences (jpl11a-Test) cycles 9-162				
Test Orbit		**Radial (mm)**	**Cross-trk (mm)**	**Along-trk (mm)**
std1504_dpod2014		**8.4**	**26.5**	**30.5**
std1808a (GOCO05s)		7.9	26.4	27.0
std2006	**12hr OPR**	**7.8**	**26.0**	**26.0**
	24hr OPR	**8.2**	**22.6**	**26.8**

RMS orbit differences (std2006(24hr OPR)-Test) cycles 1-259			
Test Orbit	**Radial (mm)**	**Cross-trk (mm)**	**Along-trk (mm)**
std1504_dpod2014	**7.3**	**21.5**	**24.8**
std1808a (GOCO05s)	6.3	20.2	18.9
std2006 (12-hr OPR)	**5.0**	**15.3**	**12.9**
GDRE (CNES)	8.0	25.0	31.4

Jason-2 (J2) Residual summary
2008-01-15 to 2016-10-02 (cycles 1-303)

Residuals computed with External Ephemeris				
SLR+DORIS Orbits		DORIS (mm/s)	SLR (cm)	Xover (cm)
std1504_dpod2014		**0.3829**	**1.021**	**5.312**
std1808a (GOCO05s)		0.3895	1.150	5.285
std2006	**12hr OPR**	**0.3894**	**1.164**	**5.280**
	24hr OPR	**0.3896**	**1.205**	**5.285**
GDRE		0.3826	1.202	5.237
jpl18a		0.3907	1.220	5.236

Jason-2 (J2) Orbit Difference summary
2008-01-15 to 2016-10-02 (cycles 1-303)

RMS orbit differences (jpl18a-Test) cycles 1-303				
Test Orbit		**Radial (mm)**	**Cross-trk (mm)**	**Along-trk (mm)**
std1504_dpod2014		**7.1**	**24.3**	**29.3**
std1808a (GOCO05s)		5.9	21.7	24.1
std2006	**12hr OPR**	**5.4**	**22.7**	**23.0**
	24hr OPR	**6.0**	**21.5**	**24.1**

RMS orbit differences (std2006(24hr OPR)-Test) cycles 1-303			
Test Orbit	**Radial (mm)**	**Cross-trk (mm)**	**Along-trk (mm)**
std1504_dpod2014	**6.2**	**18.8**	**22.0**
std1808a (GOCO05s)	5.0	15.2	14.8
std2006 (12hr OPR)	**3.8**	**11.8**	**9.6**
gdre (CNES)	6.2	17.6	23.2

Jason-3 (J3) Residual summary
2016-02-17 to 2019-08-09 (cycles 1-128)

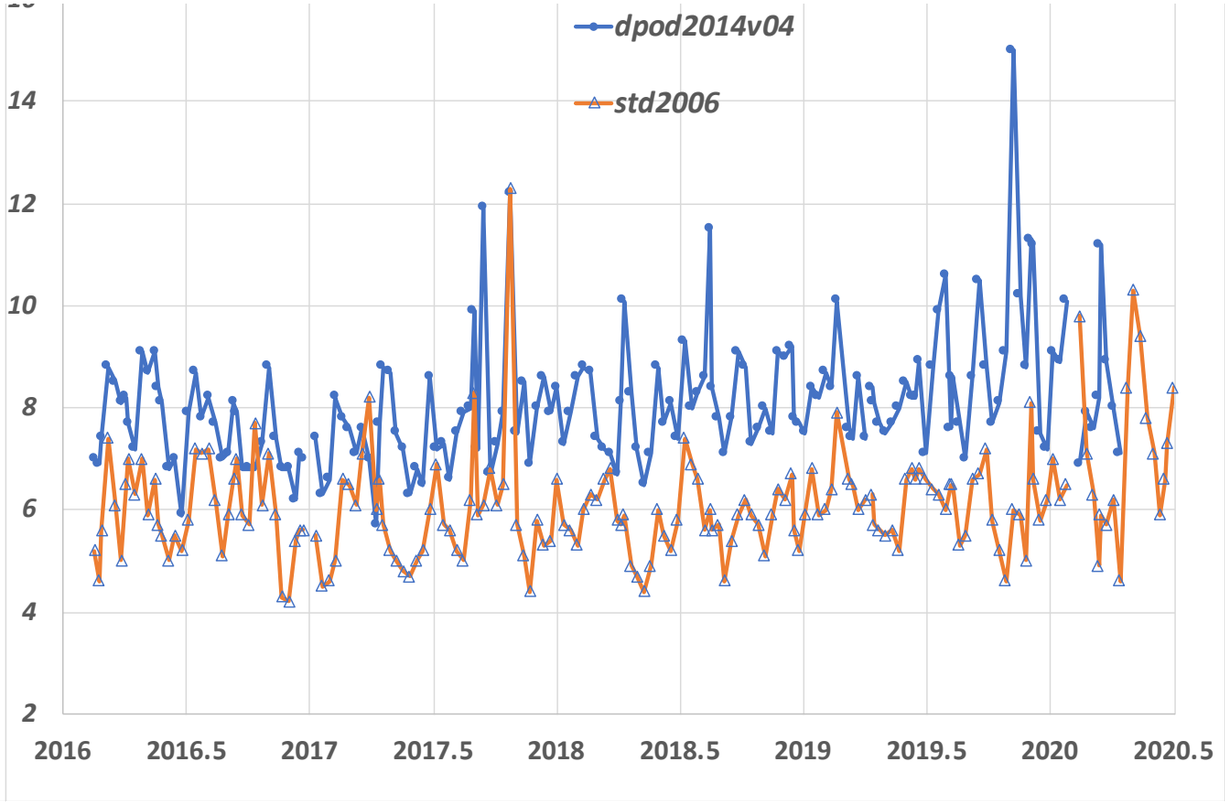
Residuals computed with External Ephemeris			
SLR+DORIS Orbits	**DORIS (mm/s)**	**SLR (cm)**	**Xover (cm)**
std1504_dpod2014	**0.4197**	**1.144**	**5.357**
std1808a (GOCO05s)	0.4195	1.196	5.302
std2006	**0.4192**	**1.092**	**5.280**
jpl19a	0.4197	1.181	5.261

Jason-3 (J3) Orbit Difference summary
2016-02-17 to 2020-04-23 (cycles 1-154)

RMS orbit differences (jpl19a-Test) cycles 1-154			
Test Orbit	**Radial (mm)**	**Cross-trk (mm)**	**Along-trk (mm)**
std1504_dpod2014	**7.9**	**29.8**	**31.8**
std1808a (GOCO05s)	6.2	21.4	24.8
std2006	**5.6**	**19.5**	**22.6**
POEF (CNES)	3.8	6.3	8.7

RMS orbit differences (std2006-Test) cycles 1-154			
Test Orbit	**Radial (mm)**	**Cross-trk (mm)**	**Along-trk (mm)**
std1504_dpod2014	**7.7**	**33.0**	**26.7**
std1808a (GOCO05s)	4.3	18.6	15.7
POEF (CNES)	6.3	25.4	26.9
std2006 (DORIS equal wt)	1.3	4.9	4.8

Jason-3 (J3) Orbit Differences with CNES/POEF old (std1504_dpod2014) vs. new (std2006) orbits (cycles 1 - 166)

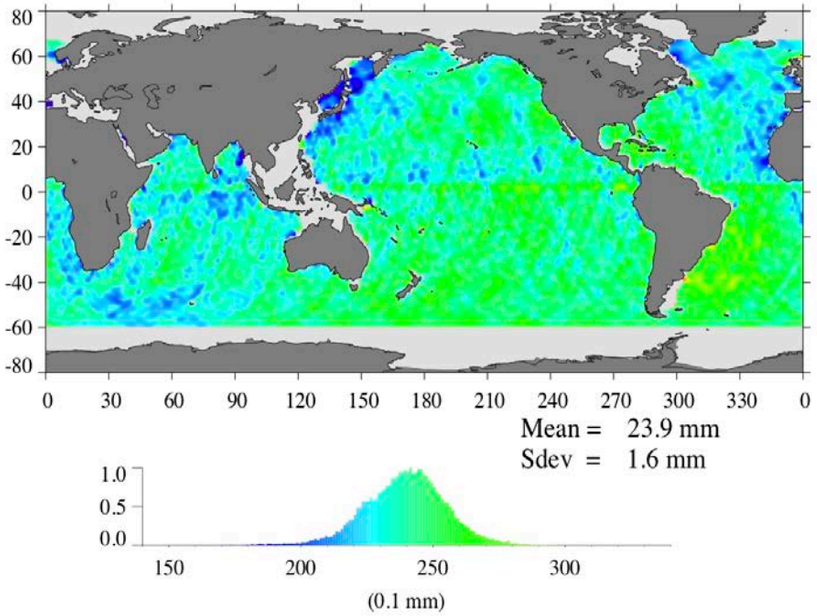


The previous (std1504_dpod2014) orbits showed an RMS radial agreement with the CNES/POEF of 7-9 mm, whereas the new orbits (std2006) show agreement at 5-7 mm radial RMS.

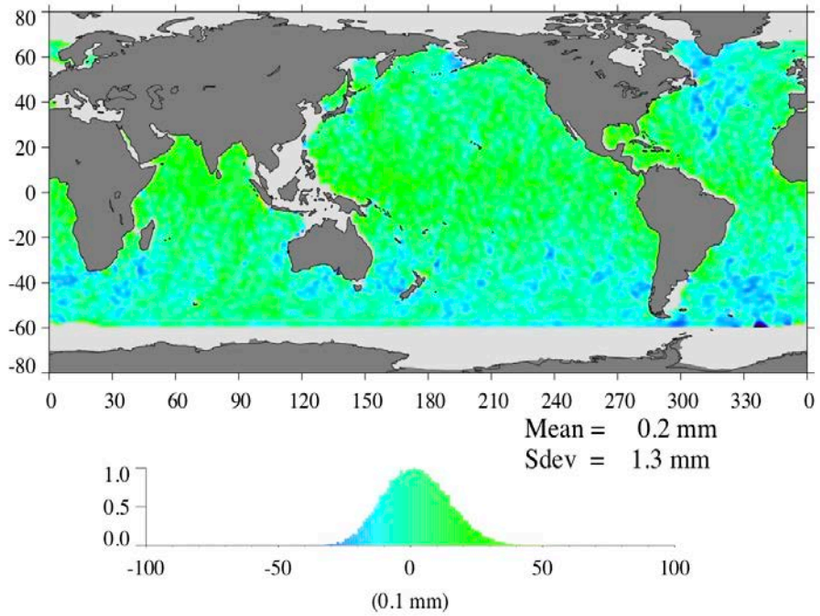
Lemoine et al., 2020. "**Improved orbits for TP, J1, J2, J3, 1992-2020",** OSTST, October 19-23, 2020

SSH differences for MEAsURES altimetry using the std2006 orbits over the tandem orbit periods: (TOPEX/Jason1 & Jason1/Jason2)

TOPEX/Jason-1

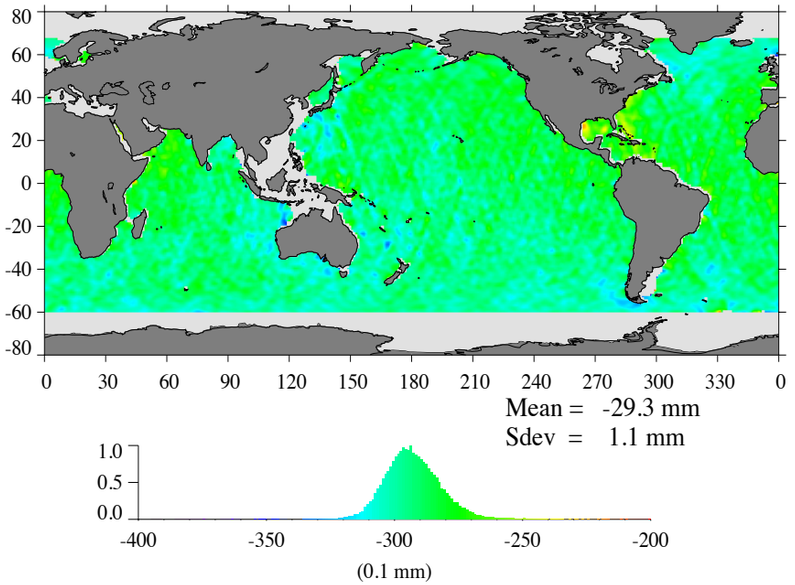


Jason-1/Jason-2

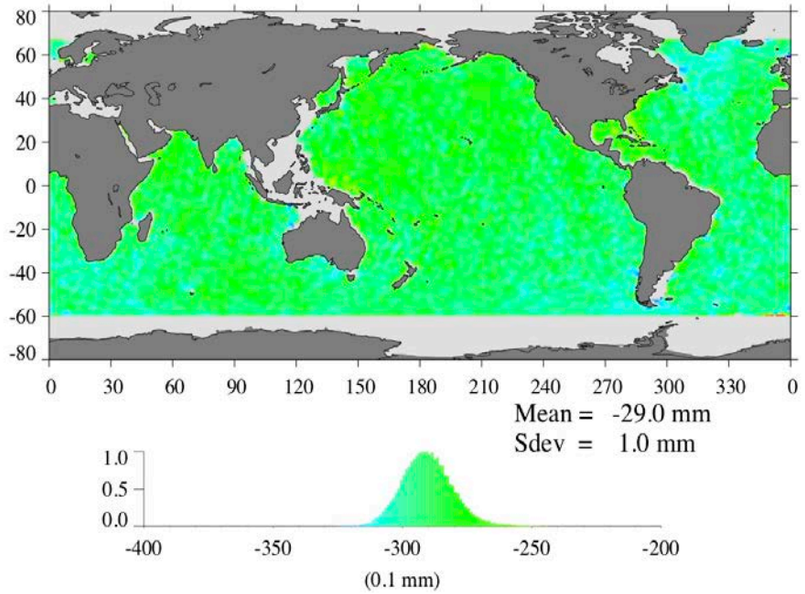


SSH differences for MEAsURES altimetry using the std2006 orbits over the tandem orbit periods: (Jason2/Jason3)

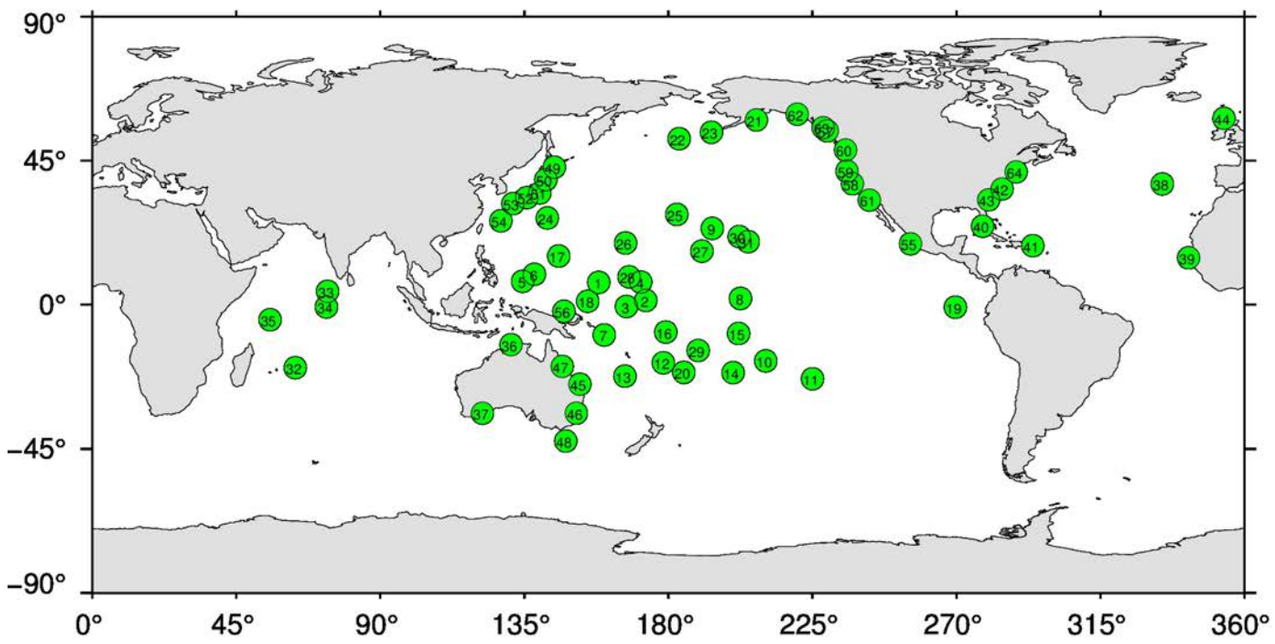
std1504_dpod2014 (previous)



std2006 (new)



Tide gauge comparison with MEaSUREs altimetry using the new std2006 orbits: Tide gauge distribution



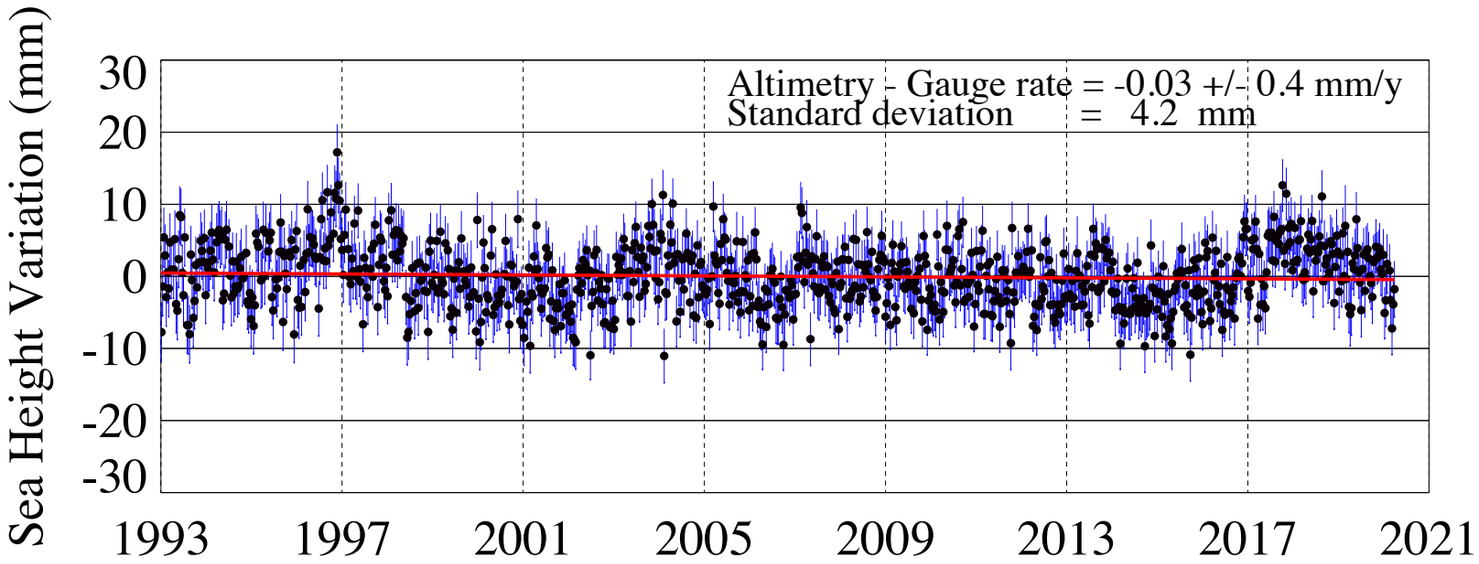
STATIONS NAME

1 : Pohnpei	33 : Male
2 : Tarawa	34 : Gan
3 : Nauru	35 : Pointe La Rue
4 : Majuro	36 : Darwin
5 : Malakal	37 : Esperance
6 : Yap	38 : Ponta Delgado
7 : Honiara	39 : Dakar
8 : Christmas Is.	40 : Key West
9 : French Frigate Shoals	41 : San Juan
10 : Papeete	42 : Duck
11 : Rikitea	43 : Charleston
12 : Suva	44 : Stornoway
13 : Noumea	45 : Bundaberg
14 : Rarotonga	46 : Sydney
15 : Penrhyn	47 : Townsville
16 : Funafuti	48 : Spring Bay
17 : Saipan	49 : Kushiro
18 : Kapingamarangi	50 : Ofunato
19 : Santa Cruz	51 : Mera
20 : Nuku Alofa	52 : Kushimoto
21 : Kodiak Island	53 : Aburatsu
22 : Adak	54 : Naha
23 : Unalaska	55 : Manzanillo
24 : Chichijima	56 : Lombrum
25 : Midway Is	57 : Prince Rupert
26 : Wake Is.	58 : San Francisco
27 : Johnston Island	59 : Crescent City
28 : Kwajalein	60 : Neah Bay
29 : Pago Pago	61 : San Diego
30 : Honolulu	62 : Yakutat Bay
31 : Hilo	63 : Ketchikan
32 : Rodrigues	64 : Newport

Tide gauge comparisons by Gary Mitchum, Univ. S. Florida.

Lemoine et al., 2020. “**Improved orbits for TP, J1, J2, J3, 1992-2020”,** OSTST, October 19-23, 2020

Tide gauge comparison with MEaSUREs altimetry using the new std2006 orbits (TOPEX & Jasons 1-3): Altimeter – Tide Gauge residuals



Tide gauge comparisons by Gary Mitchum, Univ. S. Florida.

Lemoine et al., 2020. "**Improved orbits for TP, J1, J2, J3, 1992-2020",** OSTST, October 19-23, 2020

Summary

(1) We have produced a new series of SLR+DORIS "dynamic" orbits (std2006) 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 change.
(2) The new orbit series (std2006) is improvement over the previous series (std1504_dpod2014). 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 6-7 mm radial RMS.

Future work:

(1) The std2006 orbits will be made available through the NASA GSFC NCCS dataportal, and possible other sources (such as the data centers of the International DORIS Service).
(2) A manuscript is in preparation to summarize the work that has been accomplished.