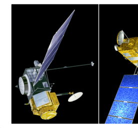
Improvement of the Complete TOPEX/POSEIDON and Jason-1 Orbit Time Series: Current Status



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ABSTRACT

Orbit error is a major component in the overall error budget of all altimeter satellite missions. Jason-1 is no exception and a 1 cm radial orbit accuracy goal has been set, which represents a significant improvement over what is currently being achieved for TOPEX/Poseidon (TP). Studies have demonstrated this goal is being met and that the orbit accuracies can be improved *(Luthcke et al. 2003 and Haines et al. 2004)*. However, the challenge is to continually achieve this high accuracy, verify the perfo rmance, and characterize and quantify the remaining errors over the lifetime of the mission. The computation, verification and error characterization of such high accuracy orbits requires the reduction and analysis of all available tracking data (GPS, SL R, DORIS and altimeter). Current analysis also indicates the history of TP orbits can be further improved employing new solution strategies developed and tested on Jason-1. Our research focuses on the calibration, validation and improvement of the compl ete TP and Jason-1 orbit time series using all available tracking data including altimetry. Our effort will result in a complete and consistent time series of improved orbits for both TP and Jason, significantly benefiting the long time series of altimet er climate data records. The resultant high accuracy orbits and the characterization of their error will allow further improvements to the accuracy and overall quality of the altimeter measurement time series making possible further strides in radar altim eter remote sensing. In this presentation we summarize the current status of our research effort.

Improvement of the Complete TP Orbit Time Series : Results from a recent reprocessing

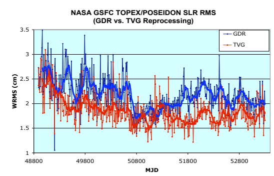
Overview: ***Table 1 presents the current modeling upgrades used to compute our latest complete TP orbit time series (cycles 1 through 446) based on a dynamic solution reduction of SLR+DORIS data. While several additional improvements are planned, the following Tables and Figures demonstrate the new TP orbits represent a considerable improvement over the TP GDR orbits.***

Table 1. TP Modeling Improvements

Models	GDR orbits	TVG New 2006
Gravity (static)	JGM3 (70x70)	GGM02C (120x120) *(Tapley et al. 2004)*
Gravity (time-variable)	C20dot, C21dot, S21dot	C20dot, C21dot, S21dot + 20x20 annual terms from GRACE inter-sat. tracking only *(Luthcke et al., 2006)*
Atmospheric gravity	Not applied	NCEP, 50x50 @6 hrs *(Petrov and Boy, 2004)*
Ocean Tides	Ray 94 + GEMT3X	(T/P-derived) GOT00.2 (20x20) *(Ray and Ponte, 2003)*
Solid Earth tides	k_2= 0.300; k_3=0.093 + special handling for FCN.	IERS2003
Station Coordinates	CSR95L02 (c001-360) ITRF2000 (c360 -)	ITRF2000

Table 2. TP Tracking Data Summary Statistics Cycles 001-446

	DORIS		SLR	
GSFC SLR/DORIS dynamic Orbits	Points	Residual (mm/s)	Points	Residual (cm)
gdr T/P Standards (JGM3, Ray-94 tides, CSR95 stations to cycle 360, ITRF2000 stations from cycle 360)	24952608	0.5246	2065219	2.218
ggm02c+ GGM02C, ITRF2000 stations, Earth & Ocean (GOT00.2) tides conform to IERS2003	25695843	0.5010	2391924	1.963
tvg As **ggm02c+**, plus IAU2000 reference, forward gravity modeling of the atmosphere,GSFC GRACE-derived annual time varying gravity	25698634	0.5012	2392355	1.880



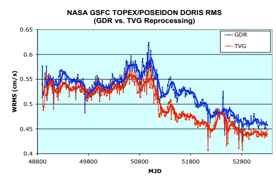
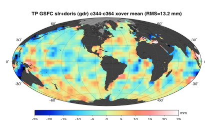
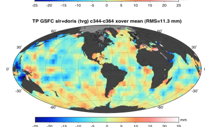


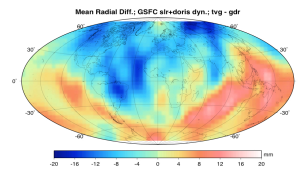
Table 2b. TP Tracking Data Summary Statistics Cycles 344-364

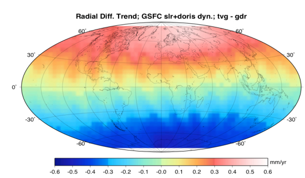
SLR/DORIS orbits	doris (mm/s)	slr (cm)	crossover (cm)
GDR (dynamic)	.4819	2.420	5.618
tvg (dynamic)	.4799	1.816	5.442

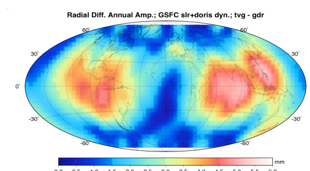




Impact on long-term sea level studies: ***The impact of the new orbits on sea level studies can, in large part, be characterized through the analysis of orbit differences between the new 'TVG' and the old 'GDR' orbits. The figures below present mean, trend and annual amplitude observed from the cycle by cycle gridded mean radial orbit differences computed from cycle 1 through 446.***







Improvement of the Jason-1 Orbit Time Series

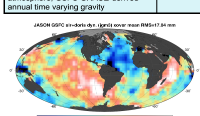
Overview: ***For Jason-1 the modeling upgrades described in Table 1 were implemented to update the POD solution models and strategy outlined in Luthcke et al. 2003. We have computed a new Jason-1 orbit time series (cycles 1 through 135) based on a dynamic solution reduction of SLR+DORIS data. We have also computed SLR+DORIS reduced dynamic, GPS-only reduced dynamic and GPS+SLR reduced dynamic orbits within the TP and Jason inter-comparison period (cycles 1-21). Again, while several additional improvements are planned, the following Tables and Figures demonstrate the new Jason-1 orbits represent an improvement over previous orbit generations. The results indicate the GPS-based orbits are exceeding the 1-cm radial orbit accuracy goal and improvement in SLR+DORIS based solutions have been made.***

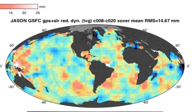
Table 3. Jason-1 Tracking Data Summary Statistics Cycles 001-135

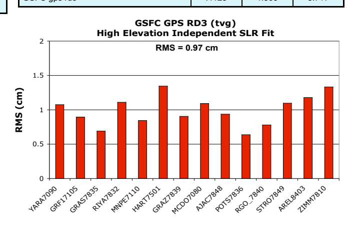
	DORIS		SLR	
GSFC SLR/DORIS dynamic Orbits	Points	Residual (mm/s)	Points	Residual (cm)
ggm01s GGM01S, GOT99.2 tides, ITRF2000 stations	13357375	.3990	506557	1.634
ggm02c+ GGM02C, ITRF2000 stations, Earth & Ocean (GOT00.2) tides conform to IERS2003	13423135	.4151	506878	1.546
tvg As **ggm02c+**, plus IAU2000 reference, forward gravity modeling of the atmosphere, GSFC GRACE-derived annual time varying gravity	13393169	.4071	506768	1.481

Table 4. Jason-1 Tracking Data Summary Statistics Cycles 008-020

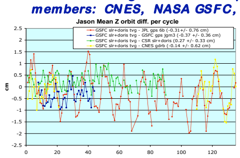
Jason cycles 008-020 Solution	doris (mm/s)	slr (cm)	crossover (cm)
GSFC slr/doris ggm01s (dynamic)	.4124	1.422	5.864
GSFC slr/doris tvg (dynamic)	.4120	1.331	5.807
GSFC slr/doris tvg (reduced-dynamic)	.4109	1.413	5.784
CNES GDR-B gps/slr/doris (dynamic)	.4126	1.579	5.765
GSFC gps/slr tvg (reduced-dynamic)	.4123	1.108	5.712
JPL gps release_6b	.4131	1.403	5.719
GSFC gps rd3	.4123	1.300	5.717

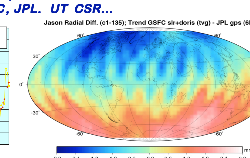


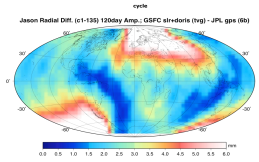


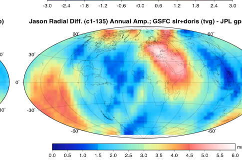


Orbit uncertainty and impact on sea level studies: ***Tables 3 and 4, and the Figures presented, demonstrate significant improvement in orbit accuracy and good agreement between various solution strategies and orbits computed from different centers. However, uncertainties in the orbits still remain that are troublesome for sea level studies. This is demonstrated below through the analysis of long-term (cycles 1 through 135) orbit differences between the most recent generations of the JPL GPS-only reduced dynamic orbits and the NASA GSFC SLR+DORIS dynamic orbits. It is important to note that the comparison does not target a problem solution, but characterizes the remaining orbit uncertainty. Problems and errors could equally exist in the NASA GSFC and JPL orbits. Future analysis, as well as model and solution strategy improvements will be made in order to further reduce the orbit uncertainties. The success in large part will depend on the continued diligence and cooperation of the OSTM POD Team members: CNES, NASA GSFC, JPL. UT CSR…***









Future: ***Future analysis, as well as model and solution strategy improvements will be made in order to further reduce the orbit uncertainties. The success, in large part, will depend on the continued diligence and cooperation of the OSTM POD Team members: CNES, NASA GSFC, JPL, UT CSR…***

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References:

Haines, B., Y. Bar-Sever, W. Bertiger, S. Desai and P. Willis, "One-Centimeter Orbit Determination for Jason-1: New GPS-based Strategies," *Marine Geodesy*, Special Issue on Jason-1 Calibration/Validation, Part 2, Vol. 27, No. 1-2, 2004.

Luthcke, S.B., N.P. Zelensky, D.D. Rowlands, F.G. Lemoine and T.A. Williams, "The 1-centimeter Orbit: Jason-1 Precision Orbit Determination Using GPS, SLR, DORIS and Altimeter data," *Marine Geodesy*, Special Issue on Jason-1 Calibration/Validation, Part 1, Vol. 26, No. 3-4, 2003.

Luthcke, S.B., D.D. Rowlands, F.G. Lemoine, S.M. Klosko, D. Chinn and J.J. McCarthy, "Monthly spherical harmonic gravity field solutions determined from GRACE inter-satellite range-rate data alone," *Geophys. Res. Lett.*, Vol. 33, L02402, doi:10.1029/2005GL024846, 2006.

Tapley, B.D., S. Bettadpur, M. Watkins, and C. Reigber, "The gravity recovery and climate experiment: Mission overview and early results," *Geophys. Res. Lett., 31*, L09607, doi:10.1029/2004GL019920, 2004.

Petrov, L. and J.-P. Boy, "Study of the atmospheric pressure loading signal in very long baseline interferometry observations," *J. Geophys. Res.*, 109, B03405, 2004.

Ray, R. D., and R. M. Ponte, "Barometric tides from ECMWF operational analyses," *Ann. Geophys.*, 21, 1897-1910., 2003.

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