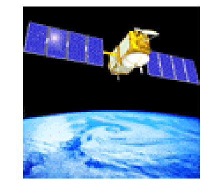
Jason-1 Precision Orbit Determination (POD) Evaluation and Orbit Comparison



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ABSTRACT

Precision orbit determination (POD) is a critical component to meeting the ocean topography goals of the Jason-1 mission. Jason-1 carries aboard four tracking data systems (an enhanced GPS receiver, improved SLR and DORIS systems, and the altimeter itself) which provide an opportunity to compare the contribution of the various tracking data types to POD. Through the comparison and evaluation of orbits computed by different groups, using different combinations of tracking data, we access orbit accuracy and orbit centering. Such a comparison provides an opportunity to evaluate long-term systematic orbit effects, relative error due to gravity and tides, possible effects due to degradation in the DORIS data, and possible improvements to SLR measurement modeling.

POD Evaluation / Comparison

Orbit Performance Tracking data residuals and direct orbit comparison are used to illustrate relative orbit accuracy (Tables 1 and 2, Figure A.1). Orbit improvement is achieved through the application of the reduced dynamic technique and using the Grace gravity fields (ggm01c and, ggm01s) (Figures A.1 and A.2). The analysis shows the GPS-based reduced dynamic orbits have the best performance and are likely achieving the 1 cm radial orbit accuracy goal (see Luthcke et al. poster). The crossover residuals difference between the GPS orbit and the dynamic orbit suggests the standard, dynamic SLR+DORIS orbits have an accuracy of about 2-cm. As expected, orbit comparison improves with improved orbit accuracy (Table 2).

Table 1. Tracking data residuals summary : cycles 8-24
independent data in italics

Jason-1 orbit solutions	RMS residuals doris (mm/s)	RMS residuals slr (cm)	RMS residuals xover (cm)	Crossover residuals mean (cm)	Crossover residuals std (cm)
dynamic JGM3					
cnes slr+doris (GDR)	0.419	2.666	*6.033*	-0.427	0.613
csr slr+doris	0.421	1.762	*5.988*	0.128	0.456
gsfc slr+doris	0.421	1.710	*5.926*	0.229	0.468
dynamic GGM01C					
csr slr+doris	0.421	1.718	*5.916*	0.258	0.513
gsfc slr+doris	0.421	1.667	*5.867*	0.332	0.511
dynamic GGM01S					
csr slr+doris	0.421	1.606	*5.906*	0.089	0.493
gsfc slr+doris	0.419	1.524	*5.859*	0.129	0.508
red_dyn JGM3					
gsfc slr+doris	0.418	1.665	*5.867*	0.219	0.584
gsfc slr+doris+xover	0.418	1.914	5.780	0.048	0.251
gsfc gps	*0.419*	*1.698*	*5.766*	-0.026	0.356
jpl gps	*0.420*	*1.586*	*5.754*	0.035	0.490
csr gps+slr (cyc 8-20)	*0.415*	1.504	*5.811*	0.170	0.316
gsfc gps+slr	*0.419*	1.341	*5.750*	-0.029	0.338
red_dyn GGM01C					
gsfc gps	*0.420*	*1.593*	*5.757*	0.025	0.391
jpl gps	*0.420*	*1.520*	*5.747*	0.072	0.519
gsfc gps+slr	*0.420*	1.273	*5.739*	0.074	0.375
red_dyn GGM01S					
gsfc gps	*0.419*	*1.596*	*5.754*	0.024	0.397
gsfc gps+slr	*0.419*	1.249	*5.735*	0.012	0.383

Table 2. Orbit difference summary (cm) : cycles 8-24

Orbit Solutions	RMS radial	RMS cross	RMS along	RMS total	ECF XY mean	ECF XY std	Z mean	Z std
red_dyn GGM01S gsfc gps+slr –minus-								
dynamic JGM3								
cnes slr+doris (GDR)	1.50	4.50	6.15	7.80	0.24	0.70	-0.04	0.69
csr slr+doris	1.43	3.19	4.64	5.85	0.54	0.60	0.24	0.37
gsfc slr+doris	1.36	3.05	4.66	5.76	0.46	0.55	0.03	0.28
dynamic GGM01C								
csr slr+doris	1.22	2.73	4.38	5.33	0.36	0.60	0.44	0.34
gsfc slr+doris	1.14	2.98	4.19	5.29	0.35	0.53	0.23	0.29
dynamic GGM01S								
csr slr+doris	1.15	2.43	4.34	5.16	0.10	0.60	0.63	0.34
gsfc slr+doris	1.03	2.63	3.63	4.64	0.06	0.53	0.29	0.27
red_dyn JGM3								
gsfc slr+doris	1.13	2.31	3.95	4.74	0.22	0.41	0.04	0.32
gsfc slr+doris+xover	1.07	2.35	4.63	5.33	0.26	0.39	0.08	0.45
gsfc gps	0.62	0.98	1.35	1.78	0.16	0.14	-0.03	0.16
jpl gps	0.90	1.61	2.11	2.81	0.12	0.19	-0.02	0.42
csr gps+slr (cyc 8-20)	1.19	1.48	3.33	3.86	0.19	0.71	0.19	0.30
gsfc gps+slr	0.57	0.95	1.20	1.64	0.09	0.05	0.04	0.07
red_dyn GGM01C								
gsfc gps	0.43	0.63	1.15	1.38	0.10	0.11	-0.06	0.14
jpl gps	0.78	1.42	2.00	2.59	0.03	0.19	-0.06	0.44
gsfc gps+slr	0.31	0.63	0.86	1.11	0.08	0.04	0.00	0.04
red_dyn GGM01S								
gsfc gps	0.37	0.37	0.99	1.12	0.09	0.11	-0.13	0.11
gsfc gps+slr	-----	-----	-----	-----	-----	-----	-----	-----
dynamic slr+doris ggm01s (gsfc-csr)	0.93	2.23	4.02	4.84	0.10	0.33	0.34	0.21

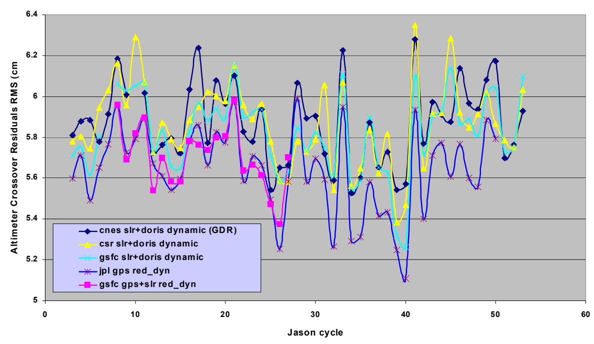

Figure A.1 Altimeter crossover residual RMS per cycle

Illustrates the improvement gained with GPS-based reduced dynamic solutions. The JGM3 gravity model was used for all solutions shown in this figure.

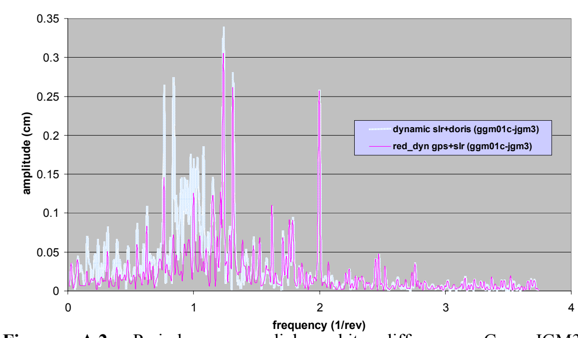

Figure A.2 Periodogram radial orbit difference Grace-JGM3 dynamic/reduced-dynamic

Illustrates how orbit improvement is gained: the currently tuned reduced-dynamic largely accommodates error at 1/rev and lower frequencies, whereas improvement at higher frequencies largely depends on the gravity field.

Orbit Centering evaluated using the mean crossover residuals (Table 1, Figure B.1) and mean orbit differences (Table 2, Figure A.3, Figure A.4). The GPS-based orbits appear to be as well-centered as the SLR+DORIS dynamic solutions traditionally used to monitor orbit centering.

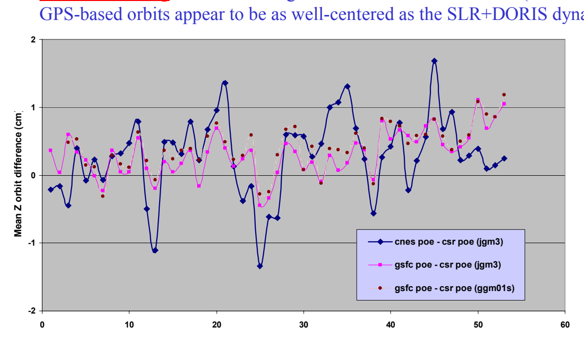

Figure A.3 Dynamic solution mean Z orbit difference

Illustrates centering in Z depends little on force modelling differences

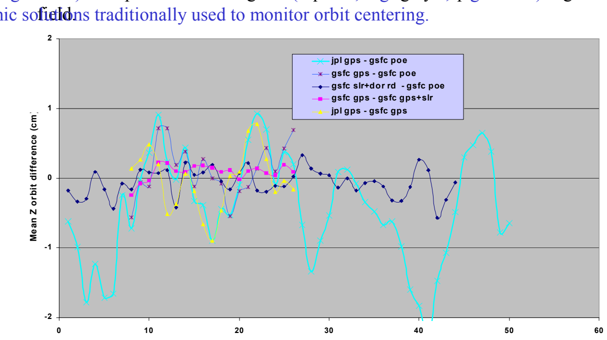

Figure A.4 Reduced-Dynamic solution mean Z orbit difference

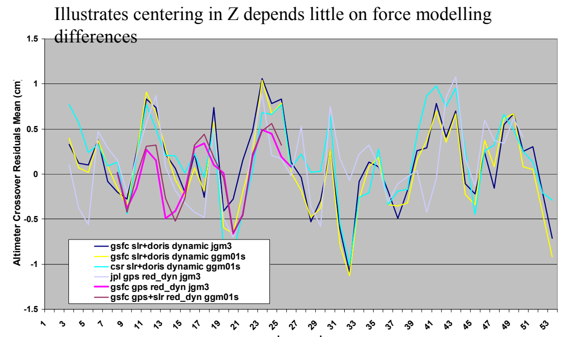

Figure B.1 Mean altimeter crossover residuals

The independent mean crossover residuals show least scatter with the GSFC GPS-based orbits (Table 1). Although all orbits display some common features for this time series, the GSFC GPS most clearly show a 60-day signature. It is believed this signal is not an orbit artifact.

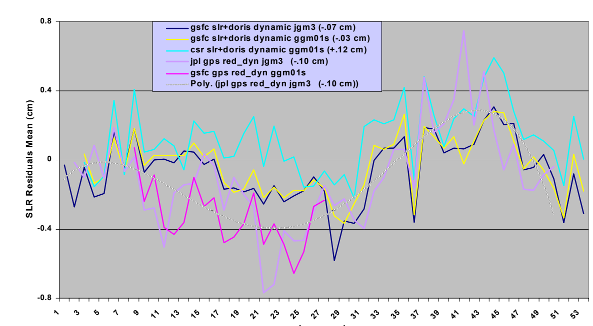

Figure B.2 Mean SLR residuals

The SLR residuals mean/cycle display an approximate annual signal and do not suggest improvements to the LRA correction model are required.

Mean Radial JGM3 Orbit Differences (mm) cycles 8-24

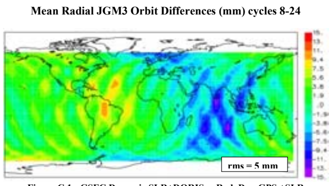

Figure C.1. GSFC Dynamic SLR+DORIS – Red_Dyn GPS +SLR

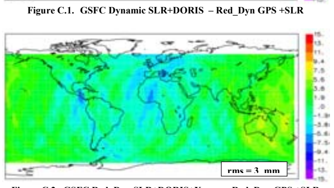

Figure C.2. GSFC Red_Dyn SLR+DORIS+Xover – Red_Dyn GPS +SLR

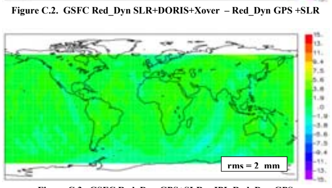

Figure C.3. GSFC Red_Dyn GPS+SLR – JPL Red_Dyn GPS

Mean Radial Orbit Differences (mm) cycles 8-24

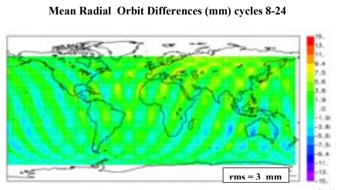

Figure C.4. GSFC Dynamic SLR+DORIS – CSR Dynamic SLR+DORIS *JGM3*

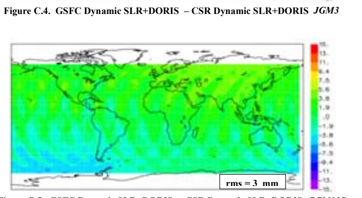

Figure C.5. GSFC Dynamic SLR+DORIS – CSR Dynamic SLR+DORIS *GGM01S*

Table 3. T/P Collinear Altimeter Analysis

Orbit solutions T/P cycles 10-50 (*Zelensky et al., Fall '01 AGU*)	Number cycles	altimeter collinear differences (cm) Mean	altimeter collinear differences (cm) Std Dev
slr+doris dynamic	38	0.014	8.454
gps red_dyn (JPL)	29	0.178	8.428
slr+doris red_dyn	38	0.020	8.407
slr+doris+xover red_dyn	38	0.019	8.263

Orbit Consistency and the Tandem Mission The requirement for orbit consistency becomes more stringent as we near the 1-cm Jason orbit accuracy goal. Orbit consistency depends not only on using consistent reference frame and satellite force models, but also consistent POD strategies. Figures C.1 – C.3 illustrate the progressive improvement in consistency between the reduced dynamic GPS-based orbit, dynamic SLR+DORIS, reduced-dynamic SLR+DORIS based, and finally the reduced-dynamic GPS orbit computed at another center, JPL. Figures C.4-C.5 further illustrates the reduced-dynamic GPS based orbits are more consistent than the dynamic SLR+DORIS orbits. In order to maximize benefit from the Tandem Mission, Jason-1 orbits should also be consistent with those of T/P. It has been shown reduced-dynamic SLR+DORIS T/P orbits are superior to their dynamic counterparts, and even to the T/P reduced-dynamic GPS orbits (Table3). Perhaps such T/P orbits should be re-computed for the Tandem Mission?

DORIS Tracking

Does the degradation in the Jason DORIS tracking, most evident in data collected from beacons under the SAA region, coupled with an apparent decrease of the available data, affect POD using SLR+DORIS data?

The GSFC SLR+DORIS dynamic orbits (POE) are computed with no special processing of the DORIS data, which is imported from CDDIS. Standard T/P PODPS editing is applied, and the standard measurement bias and troposphere scale bias are adjusted per DORIS pass. Figure D.1 shows the steady increase in DORIS residual RMS, and figures D.2 and D.3, the decline in available tracking data.

Altimeter crossover residuals from the POE are compared with the GPS reduced-dynamic orbit which does not include DORIS in the determination. (Figure D.4) Figure D.4 suggests the POE crossover residuals may be increasing relative to those of the GPS orbit. The relative degradation in POEs following cycle 30 and computed at three centers, is more clearly visible in Figure D.5.

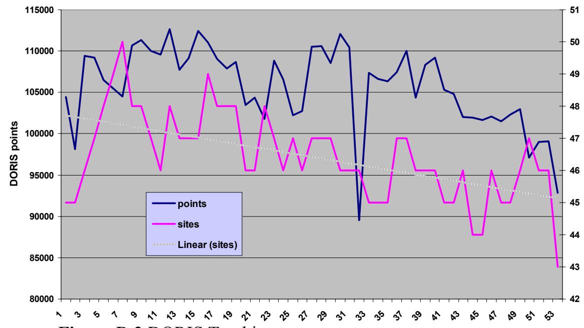

Figure D.2 DORIS Tracking

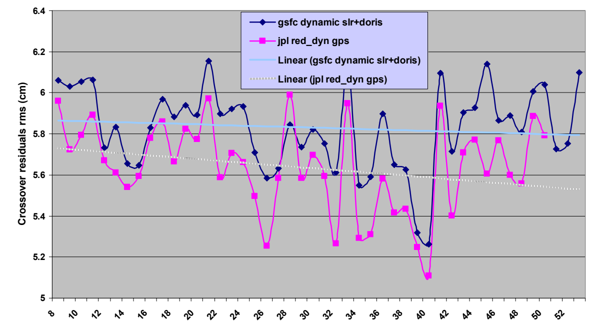

Figure D.4 Altimeter crossover residuals for SLR+DORIS and GPS orbits

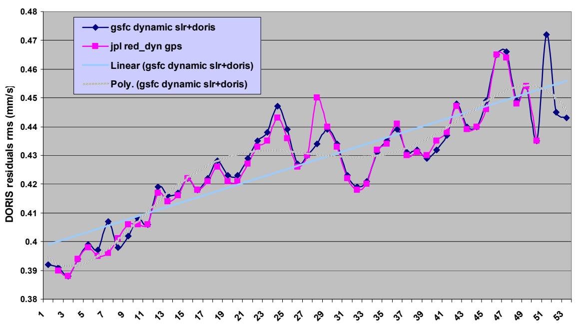

Figure D.1 DORIS Residuals

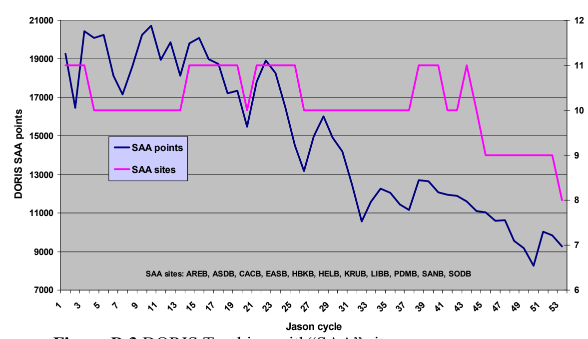

Figure D.3 DORIS Tracking with "SAA" sites

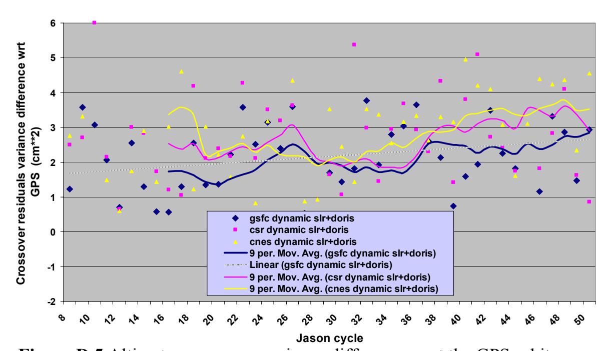

Figure D.5 Altimeter crossover variance differences wrt the GPS orbit

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