Ensuring a smooth operational transition from GIPSY-OASIS to GipsyX: product verification and validation overview

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2017 IGS Workshop
Paris, France

Abstract

Following extensive testing, the Jet Propulsion Laboratory (JPL) IGS Analysis Center recently transitioned from using JPL's legacy software, GIPSY-OASIS, to the more capable, modern software package GipsyX. We give an overview of the tests that were conducted before the operational switch of the software. We detail the approach and performance metrics adopted to guarantee a seamless transition from the user and IGS community standpoints. We present the main results from a comparison of the legacy and new solutions for multiple specific applications: GPS and low-Earth orbiter precise orbit determination, precise point positioning, tropospheric delay/gradients estimation and Earth rotation parameter determination. We ultimately demonstrate that the GipsyX products meet or exceed the quality of the products generated using GIPSY-OASIS.

Highlights

- **Transition** from legacy GIPSY-OASIS software to GipsyX occurred on **Jan. 29, 2017 (GPS week 1934)**
- legacy-formatted products located at: ftp://sideshow.jpl.nasa.gov/pub/JPL_GPS_Products
- GipsyX-formatted products located at: ftp://sideshow.jpl.nasa.gov/pub/JPL_GNSS_Products

GipsyX products meet/exceed the quality of the products generated using legacy software

- Results presented were obtained from a collaborative effort between JPL's groups 335A, 335S and 335N

Verification method and validation metrics

- Shadow processes run for ~10 months for ultra-rapid, rapid and final processes
- Specialized tests to demonstrate **long-term quality and stability** of modern products and backward compatibility with 3rd party operational processes (LEO POD, large-scale PPP, Kalman Earth Orientation Filter, Deep Space Network zenith trop delays…)
- **Performance metrics considered**: precision, latency/timing, spectral/fit analysis, comparison of *all* parameters (orbits, transmitter/receiver clocks, dynamical parameters, troposphere parameters, phase biases, …) between legacy and GipsyX when using same data

Application Type		Input Product Type (gipsyx products converted to legacy goa format)		
		Ultra	Rapid	Final
GPS POD		✔	✔	✔
LEO POD	Jason-2	-	✔	✔ (fiducial)
	GRACE	-	-	✔ (fiducial)
	Jason-3 (input to 3rd party s/w)	✔	✔	- (fiducial)
Precise Point Positioning		-	-	✔ (free, nnr)
DSN tropospheric delays comparison		✔	✔	N/A
DSN Earth Rotation Parameter files		✔	✔	N/A
IGS products (sp3, erp, snx…)		N/A	✔	✔

N/A: not applicable; "-" : not *extensively* tested before transition

Performance Analysis

- **GPS Precise Orbit Determination**

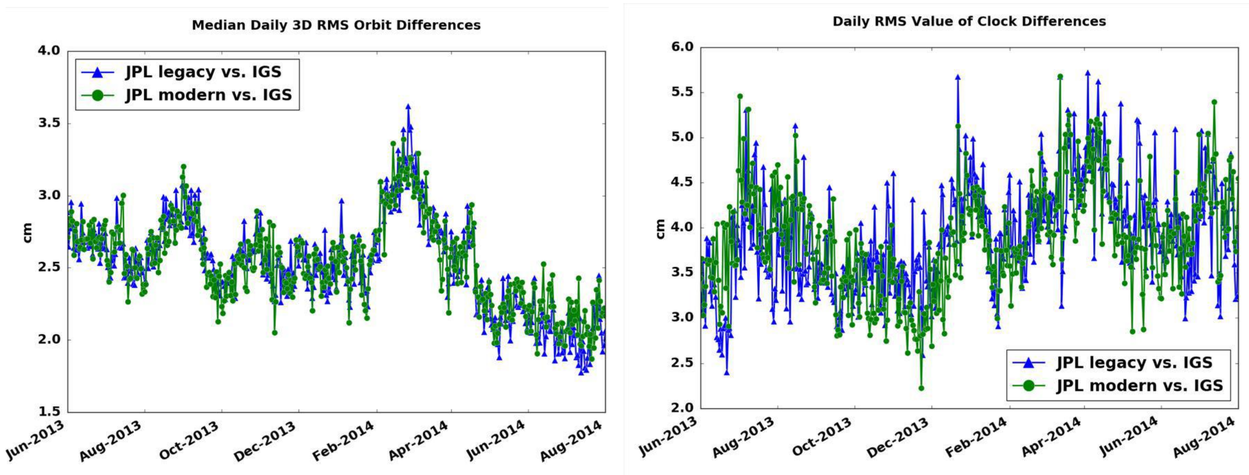

Figure 1: Comparison with IGS final combination orbit and clock products.
Median daily 3D RMS orbit differences (left) and daily RMS of clock differences (right) relative to IGS Final combination. Blue line is JPL GIPSY-based system versus IGS. Green line is JPL GipsyX-based system versus IGS. ***Note that legacy (GIPSY-OASIS) solution is part of IGS combination.*** **Median differences at the level of 0.1 mm for both cases.**

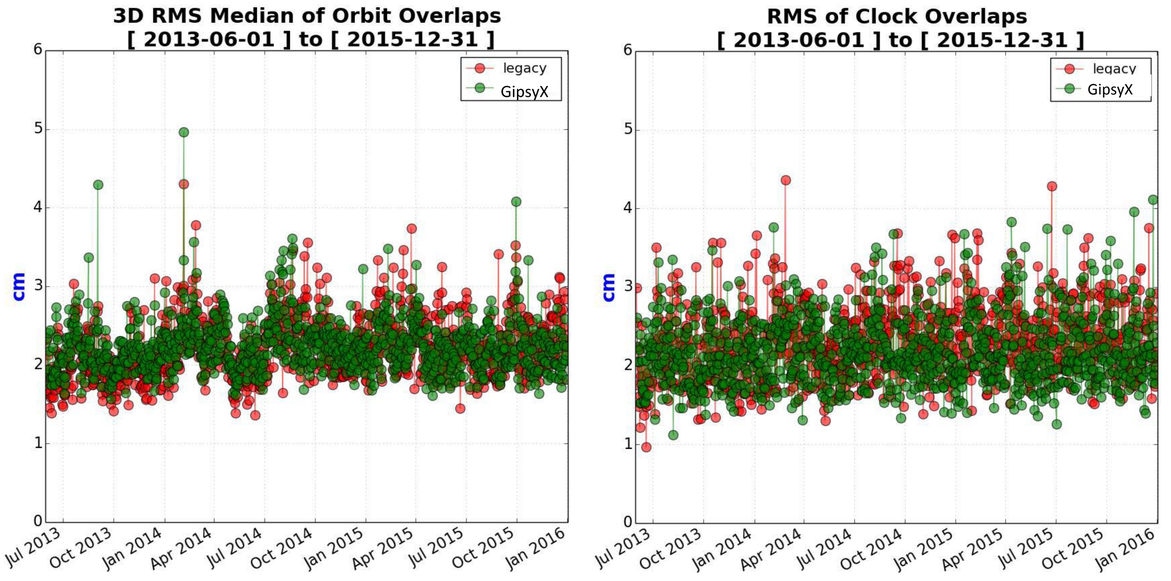

Figure 2: Internal orbit and clock overlaps as a measure of precision.
Median daily 3D RMS orbit overlaps (left) and daily RMS of clock overlaps (right). Red line is JPL GIPSY-based system. Green line is JPL GipsyX-based system. Daily solutions span 30 hours, adjacent days overlapping for 6 hours. Statistics are computed over central 5 hours of overlap period to remove edge effects.
Difference in median of daily 3D RMS median orbit overlaps < 0.5 mm. Median of daily RMS clock overlaps across constellation smaller by 1.6 mm for GipsyX solution versus legacy solution.

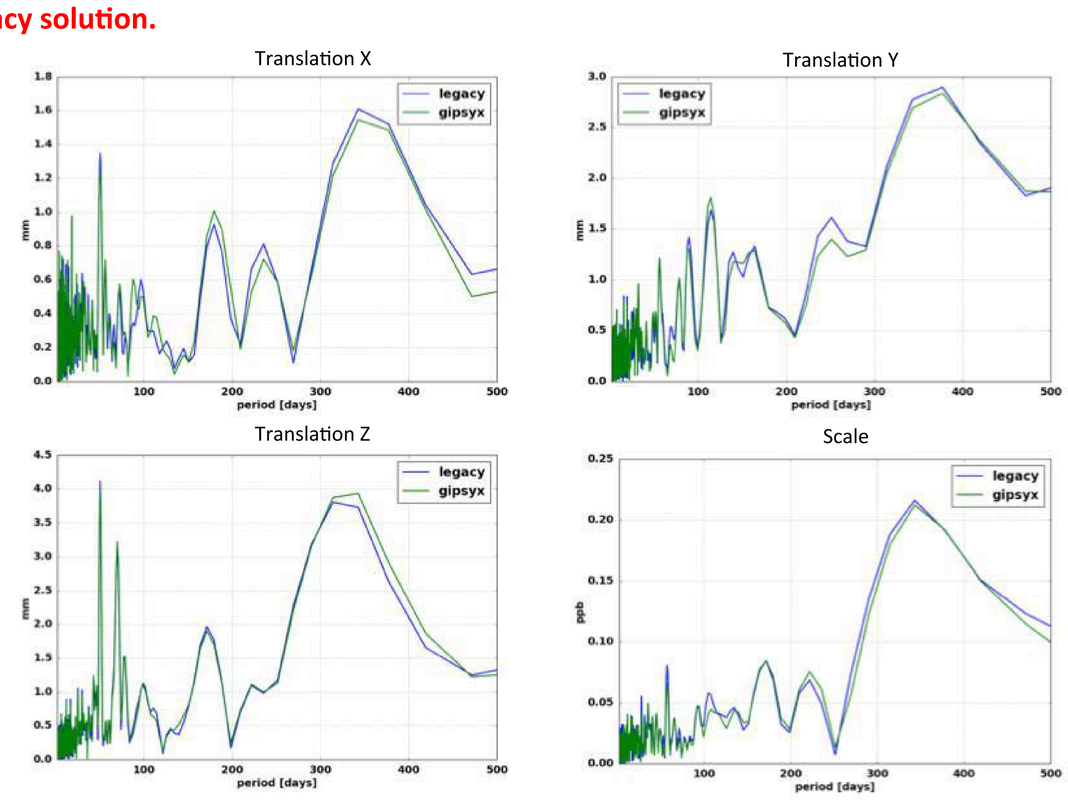

Figure 3: Impact on estimated frame parameters.
Periodograms of Helmert parameters to transform between fiducial-free network and IGb08 reference frame based on 2.5 year-long test using same data/network for legacy and GipsyX solutions. **No systematic signal introduced.**

- **Validation from user perspective: DSN Zenith tropospheric delay estimation**

DSN Site	Mean of the differences (mm)	Scatter (mm)
GOL2, GOLD	0.33	0.68
GMSD	0.17	0.72
TIDB, TID2, TIDV	-0.13	0.78
USUD	-0.91	1.19
MAD2, MADR	0.09	0.82
PERT	0.23	0.77
NNOR	0.16	0.89
CEBR	0.01	0.53
IISC	-0.21	1.12

Table 1: Statistics of the differences between zenith troposphere delay estimates at Deep Space Network (DSN) sites obtained using Rapid GIPSY products relative to using Rapid GipsyX products. Statistics computed over 5 months.

- **Validation from user perspective: Network Processor**

- Precise Point Positioning performed on **hundreds of stations over 2.5 years**.
- **Very similar** time series obtained when using GipsyX relative to legacy products
- GipsyX products lead to **less scatter** than using legacy products in a few cases

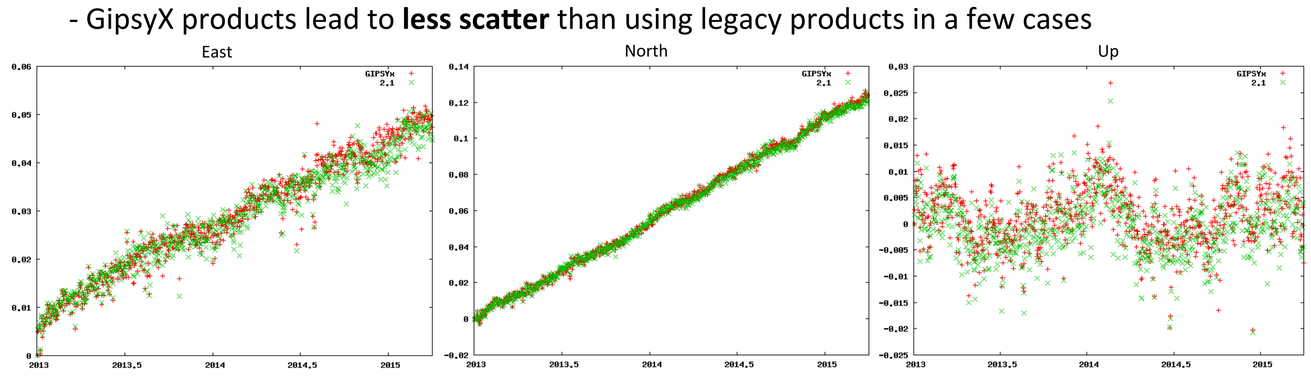

Figure 4: Precise Point Positioning results for TIDB station (typical example). Green points corresponds to time series obtained using JPL repro 2.1 products, generated using legacy software. Red points correspond to time series obtained using GipsyX-generated products. Units are meters. **Switch between software packages transparent to PPP users.**

- **Validation from user perspective: DSN Earth Orientation Parameter Estimation**

	Xp (mas)	Yp (mas)	LOD (ms)
Ultra (shadow)	0.0747 (2.3 mm)	0.09817 (3.0 mm)	0.02319
Rapid (Shadow)	0.04335 (1.3 mm)	0.04681 (1.4 mm)	0.01826
Rapid (1year -2 outliers)	0.04472 (1.4 mm)	0.04927 (1.5 mm)	0.01248

Table 2: RMS of differences between ERP estimated using legacy and GipsyX products.

- **Validation from user perspective: Low-Earth Orbiter Precise Orbit Determination**

Both Final-type and Rapid-type products tested.
- Final products: 14 months of Jason-2 data
- Rapid products: 3 months of Jason-2 data (not shown here), one month of GRACE data
- Processed with identical settings except for input GPS orbits/clocks/wlpb products

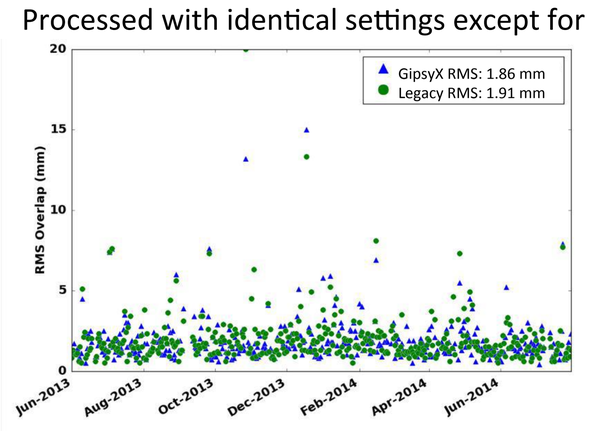

Figure 5: Daily RMS of Jason-2 radial overlaps over 14 months. Days > 30 mm excluded (maneuvers,…). Green dots represent statistics obtained using legacy Final products. Blue dots are associated with the use of GipsyX-generated products in LEO POD process.

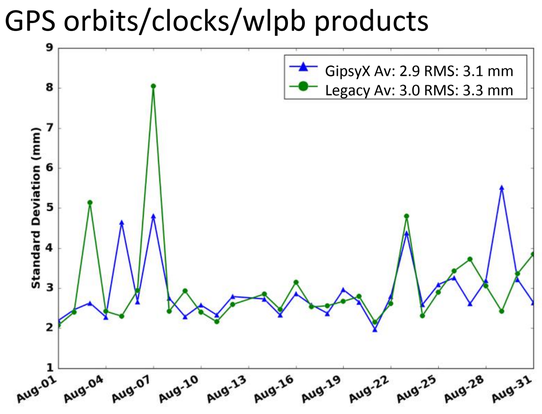

Figure 6: Comparisons of the standard deviation of the inter-satellite GRACE range determined with GPS versus the K-band measurement (micron level accuracy) over one month for solutions using legacy Final products (green line) versus solutions using products generated with GipsyX (blue line)