Testing new Empirical SRP Models at the JPL IGS Analysis Center

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INTRODUCTION

Solar radiation pressure modeling is important for propagating the orbits of GNSS satellites and in turn in obtaining station positions and other parameters of geodetic interest. JPL has devised a series of Fourier Solar-radiation Pressure (FSPM) models which have been used in the production of orbit and clock products at the JPL IGS analysis center, the most recent of which is FSPM13b (Sakumura et al 2017). To date, however, JPL has relied upon a manufacturer table for the most recent block of GPS satellites, GPSIII. Recently, a team at JPL successfully developed a Fourier model (FSPM26) for GPS III SVNs 74-79. Other analysis centers typically use the ECOM-2 radiation pressure model instead (Arnold et al 2015), but a team from PosiTim has recently developed a Fourier model for all existing major GNSS satellites (RnR25 - Dilssner and Springer 2025). This poster presents some comparisons between the RnR25 and the JPL FSPM models, as well as the manufacturer table model for GPSIII satellites.

ORBIT FITTING COMPARISON

We performed orbit fitting for IGS Final orbits from 2024-01-01 through 2026-04-11 for the JPL FSPM models (FSPM26 for GPS III, FSPM13b for other blocks), the RnR25 model, and the manufacturer table model for block III satellites (FSPM13b for others). Since the JPL Block III model is done on a per-satellite basis, there was insufficient data to create a model for SVNs 80 and higher. Therefore, Block III statistics only include SVNs 74-79. For the JPL FSPM model and Table model, fit parameters are an initial state, solar scale, solar scale X and Z, and a Y bias and constant Y acceleration. RnR25 fits include initial state and ECOM1 parameters (Const DYB + once per rev cos/sin for B).

Figure 1 shows the RMS of the resulting fits for a sample satellite from each block. Table 2. shows the mean RMS fit over all satellites. Overall, the RnR25 model shows substantially worse performance than the JPL FSPM model for Blocks IIR, IIR-M and III, but performance of the two models is comparable for block IIF satellites. The plots of per-block examples reveal that the RnR model outperforms the FSPM model in the eclipse range (Beta < ~14 degrees) but underperforms when not eclipsing. The table model somewhat outperforms the FSPM model.

The bottom left plot in Figure 1 shows that the Block III satellites may possibly be divided into 3 different subsets by observing qualitative changes in RMS fit residual patterns relative to the table model: 74-79, 80+81, 82+83.

Block	RnR25+ECOM1	JPL FSPM	Block III Table
IIR	9.3	4.7	N/A
IIR-M	9.5	5.6	N/A
IIF	8.4	8.1	N/A
III	11.3	5.8	4.8

Figure 1. *Table comparing mean 3-D RMS orbit fitting (in cm) between the RnR25 model, JPL FSPM model, and Block III manufacturer table.*

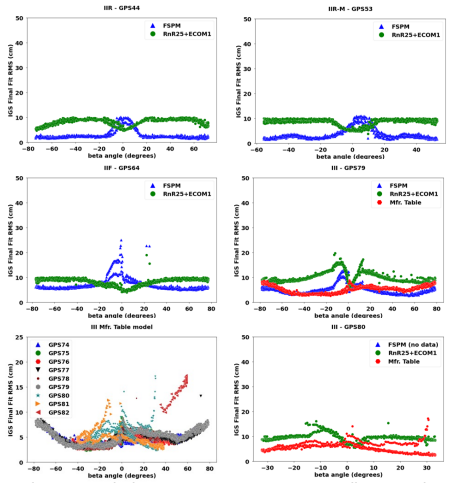

Figure 1. *Plots of 3-D RMS orbit fits for various GPS satellites. All plots show different model fits vs beta angle for a single satellite, except for the bottom left, which shows all block III satellites fit with manufacturer table.*

POD COMPARISON

We performed GPS-only POD from 2023-05-01 through 2025-04-30 to compare the same three solar radiation pressure models as above. This period was chosen because it includes GPS 74-79, has about two years of data, and has only a few months of GPS80. We use the following settings common to each set of POD runs:

- Range and phase data processed at 300s
- 120 stations (same stations/data for all 3 SRP models), VMF1 trop apriori
- 30-hour arcs for each day
- constraint based fiducialization to IGc20 reference frame
- GPS80 and higher SVNs excluded (since not part of FSPM26 model)

In our experiment, POD using the RnR25+ECOM1 model does not perform as well as the JPL models in terms of orbit overlaps observed (Fig. 2) so the implementation may need refinement.

Nevertheless, we observe some meaningful distinction in periodicities in Helmert parameters between the free network solution and frame. In Fig 3., the RnR25 model shows reduced power at the annual and semi-annual periods in scale. In Fig. 4, the Helmert translations from RnR25 are dominated by day-to-day noise which prevent useful comparison to the JPL models. However, the Z translation, which is most sensitive to draconitics, shows the FSPM26 has more spectral power than the table model at annual and 50-day periods.

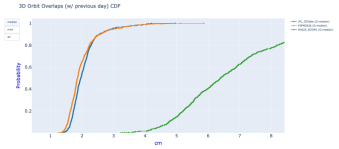

Figure 2. *Plots of cumulative distribution of median 3-D orbit overlaps for POD with the 3 different SRP methods. Blue=FSPM13b+III table, orange=FSPM13b+FSPM26, green=RnR25+ECOM1*

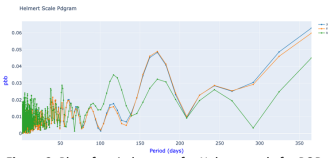

Figure 3. *Plot of periodograms for Helmert scale for POD with the 3 different SRP models.*

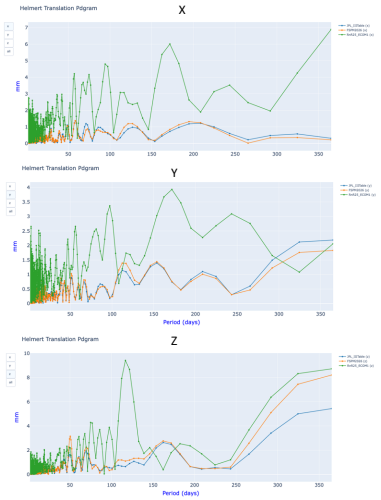

Figure 4. *Plot of periodograms for 3 Helmert translation axes for POD with the 3 different SRP models.*

CONCLUSIONS

The manufacturer table model performs best in terms of:

- Helmert Z spectra
- GPS III Orbit fitting

FSPM26 performs best in terms of:

- Orbit overlaps
- GPS IIR, IIR-M orbit fitting

RnR25 performs best in terms of:

- Helmert Scale at long periods

Of the three models tested, none clearly stands out as superior across all metrics.

Further study of the differences between these models is recommended.

ACKNOWLEDGEMENTS AND REFERENCES

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