The Impact of Time Variable Gravity Field on GPS Precise Orbit Determination

Nikta Amiri, Shailen Desai, Christina Selle, and Aurore Sibois
Jet Propulsion Laboratory, California Institute of Technology

We study the impact of temporal variations of the Earth's gravity field on GPS Precise Orbit Determination (POD) solutions. We process globally distributed GPS data from 1998 to 2014 and compare the results between static and time variable gravity POD solutions that use the EGM2008 and EIGEN-6S2 models, respectively. The time variable gravity field solutions were computed by also accounting for atmospheric and ocean circulation effects using the Atmospheric and Ocean De-aliasing (AOD1B) products. Comparison of the post-fit data residuals, orbit position estimates, and recovery of reference frame and Earth orientation parameters indicate negligible impact from time-variable gravity. Differences in orbit position estimates appear to be geographically correlated, despite their small magnitudes.

Introduction

- We have quantified the impact of time-varying gravity (TVG) on GPS-based network solutions by comparing to similar solutions that use static gravity fields for the period 1998-2014 (every other year).
- JPL's operational POD strategy was used for our analysis, but with changes to the gravity field only. The models for the TVG and static gravity fields include EIGEN-6S2.extended.v2 and EGM2008 with the modifications described in the IERS2010 conventions (up to degree 12).

Results

Earth Orientation Parameters (EOP)

Reference Frame Parameters

differences are not significant

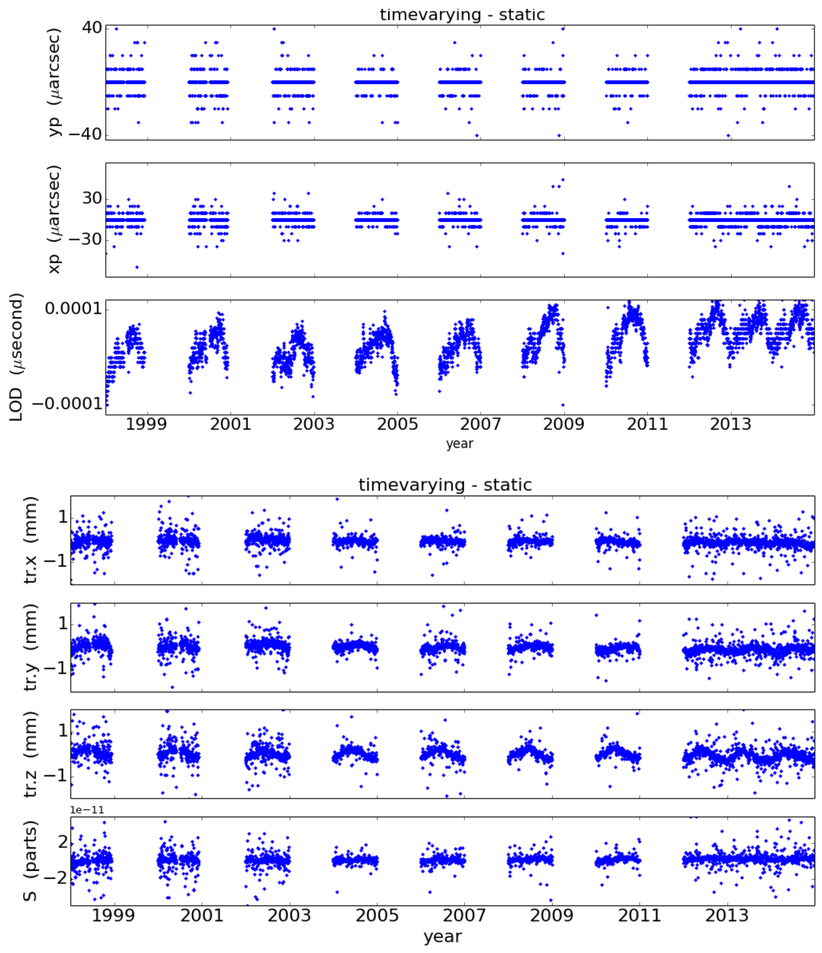


Fig. 1 : Difference in estimated EOP (top) and Reference Frame Parameters (bottom) between TVG and static gravity field POD solutions. Despite being small, the differences in estimated parameters indicate periodic signals.

	RMS	Maximum
LOD (μsec)	5.2E-5	0.00014
Xp (μarcsec)	6.07	30.00
Yp (μarcsec)	5.99	30.00
Tr.x (mm)	0.25	1.33
Tr.y (mm)	0.26	1.61
Tr.z (mm)	0.31	1.93
Scale	7.24E-12	6.70E-11

Table 1: Difference of the estimated EOP and reference **f**rame **p**arameters between static and TVG solutions. Numbers represent RMS, Maximum of the difference (TVG – static).

Differenced Residuals

Fig. 2: Differenced LC and PC residuals between static and TVG POD solutions. **We find no statistically significant impact on LC and PC residuals using TVG in our POD solutions.**

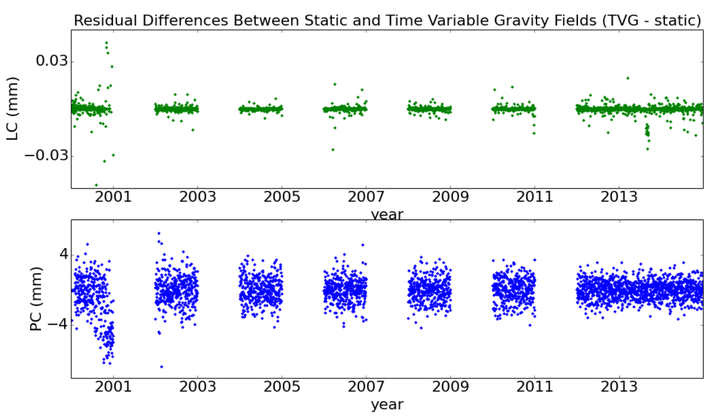


Table 2: RMS, Maximum of the difference for LC and PC residuals between static and TVG solutions (TVG – static).

	RMS	Max
LC (mm)	0.03	0.46
PC (cm)	1.50	6.48

Radial Orbit Differences

- We use grid size of 5 deg for latitude and 12 deg for longitude.
- For each grid we average the orbit differences monthly and then fit bias, drift, annual, and semi-annual signals (Fig. 3).
- The radial orbit differences indicate systematic biases which appear to be geographically correlated. This shows the differences between the static components of the two gravity fields used in our solutions (EIGEN-6S2 and EGM2008).
- The 3D rms for orbit differences is 0.1 cm; differences are negligible.

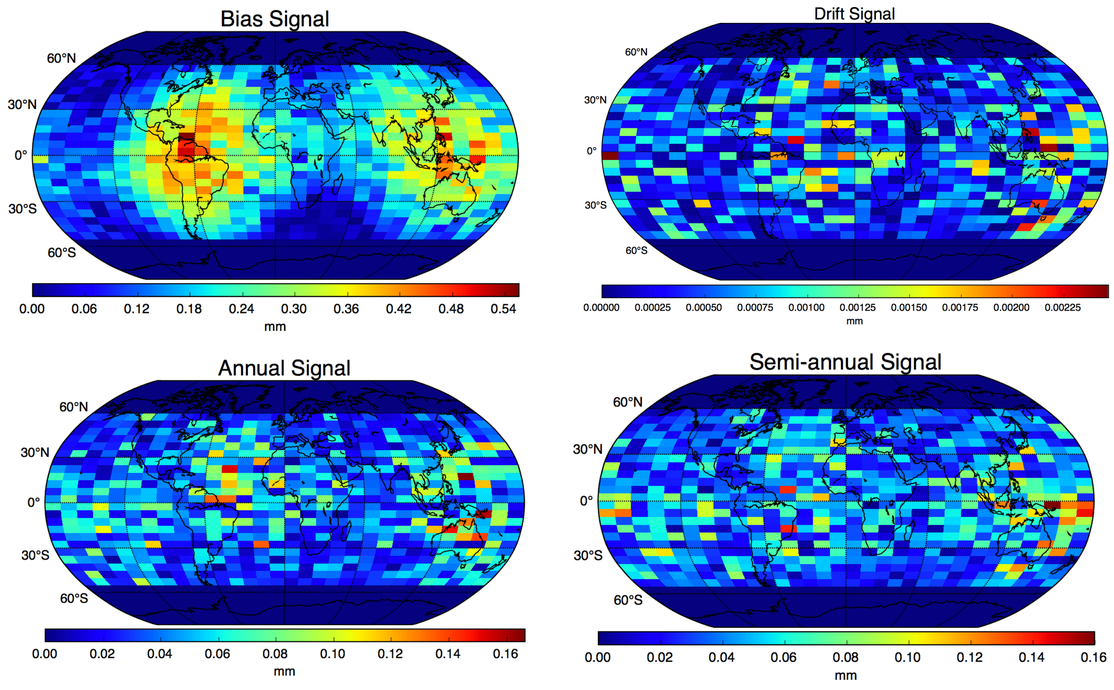
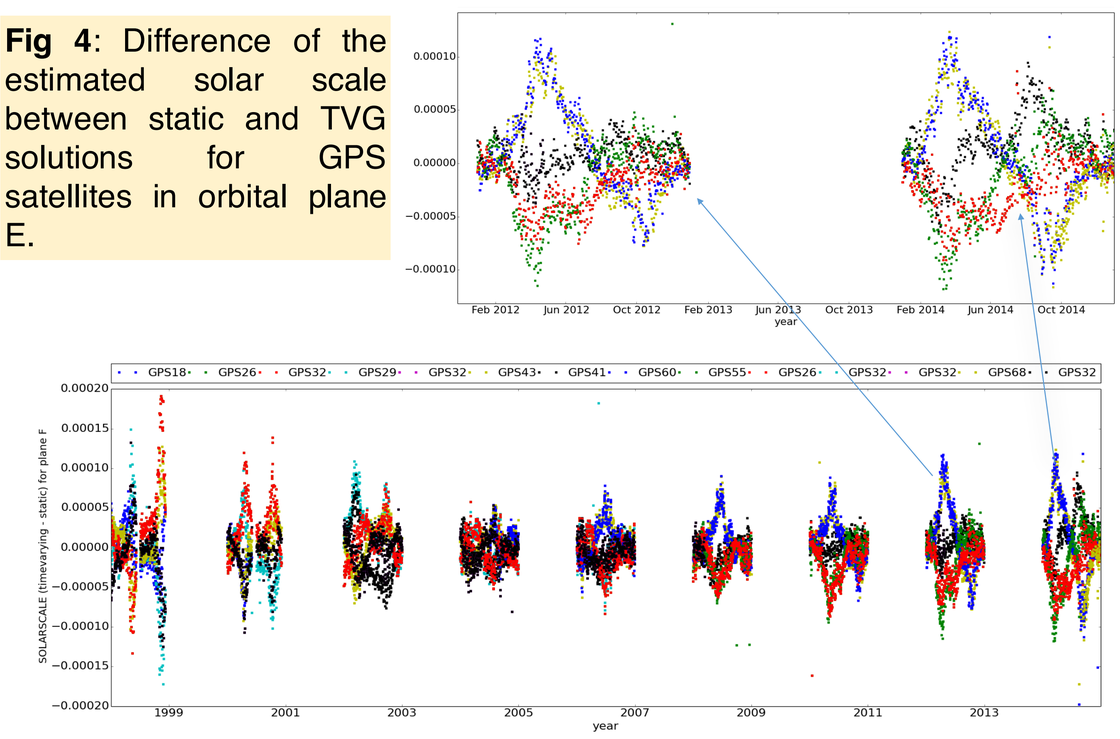


Fig. 3: Radial orbit differences between solutions obtained using static and TVG fields.

Solar Scale and Y-Bias

- We find that the difference of the estimated solar scale in our static and TVG solutions show periodic behaviors at draconitic frequencies. For illustration we show the solar scale differences for GPS satellites in plane E.
- RMS of the differences for solar scale and Y-BIAS is ~3.23E-5 and ~0.0019 nm s^{-2}. Differences are negligible.

Fig 4: Difference of the estimated solar scale between static and TVG solutions for GPS satellites in orbital plane E.



Conclusions

- The impact of TVG on the JPL POD strategy and orbit solutions is negligible. The 3D rms for orbit differences between static and TVG (0.1 cm) is smaller than the orbit accuracy (2-3 cm for 3D rms).
- Differences are small in part because the solar scale and Y-bias parameters absorb the differences between static and TVG in our POD solutions.
- We find the difference in estimated EOP and reference frame parameters show periodic variability.