Adjustable box-wing model for GNSS satellites: impact on geodetic parameters

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1. Solar radiation pressure modeling

The main non-gravitational orbit perturbation acting on GNSS satellites is the solar radiation pressure. Mismodeling of this force has the potential to explain orbit-related frequencies found in GPS-derived station coordinates, geocenter and Earth orientation parameters (e.g. Y-pole rate). In this work, we study the impact on geodetic parameters of two different models:

CODE empirical model (Beutler et al., 1994), commonly used by the IGS analysis centers and based on the following empirical parameters:

D0: direct acceleration
Y0: Y-bias acceleration
B0, BC, BS: constant and once-per-rev acceleration terms in B-direction

Adjustable box-wing model (Rodriguez-Solano et al., 2012), based on the physical interaction between the satellite's structure and solar radiation. The following parameters are estimated:

SP: solar panel scaling factor
SB: solar panel rotation lag angle
Y0: Y-bias acceleration
+XR: reflection coefficient of +X bus
+ZR: reflection coefficient of +Z bus
-ZR: reflection coefficient of -Z bus

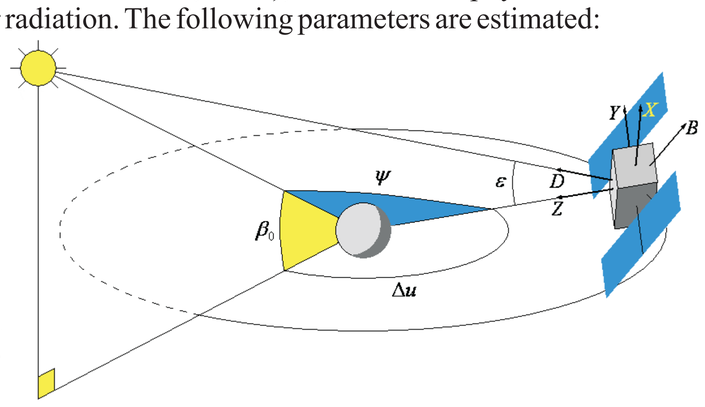


Fig. 1: Relative geometry of Sun, Earth and satellite. Illustration of DYB (Sun-fixed) and XYZ (body-fixed) frames.

In this study, four multi-year (2004-2011) GPS/GLONASS solutions have been computed, using a processing scheme derived from CODE (Center for Orbit Determination in Europe). Two 1-day solutions using the CODE and the adjustable box-wing models were computed. Furthermore, as the parameters of the box-wing model should be constant over time, we study the impact of stacking orbit and radiation pressure parameters of contiguous 1-day solutions, producing 3-day solutions.

2. Stacking of box-wing parameters

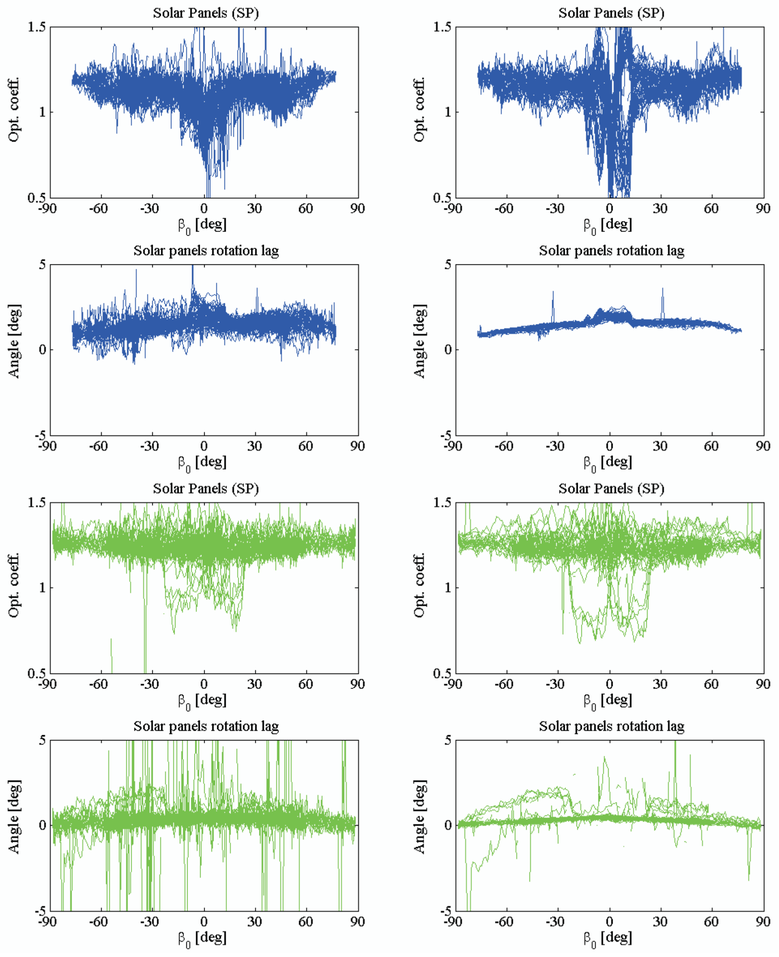
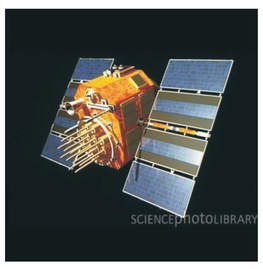


Fig. 2: Daily estimates of the adjustable box-wing model parameters from 1-day (left) and 3-day (right) solutions. The parameters are shown as a function of β_0 and for all GPS-IIA and GLONASS-M satellites available from 2007 to 2008.

GPS IIA



GLONASS-M

3. Impact on station coordinates

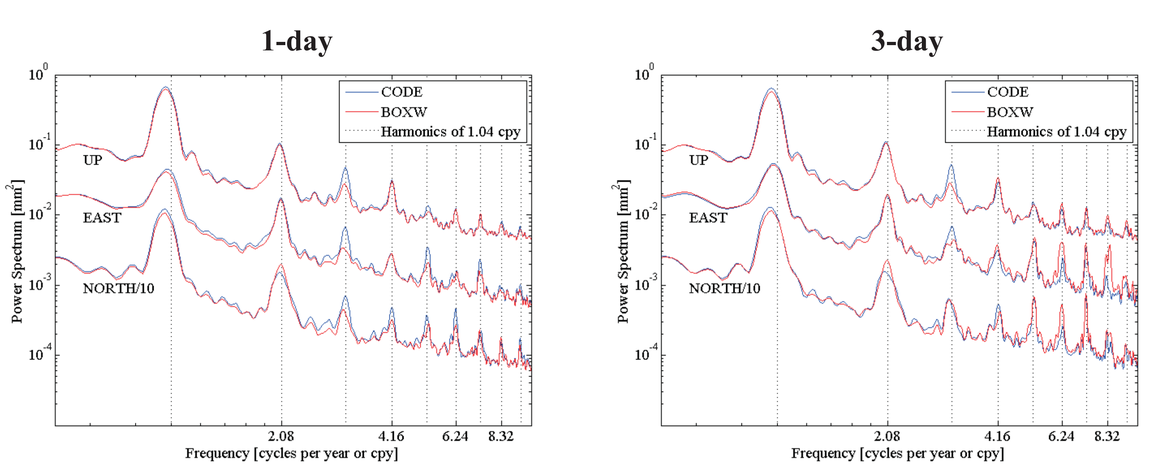


Fig. 3: Average power spectrum of GNSS daily position estimates (290 ground tracking stations) from 2004 to 2011. Comparison between CODE (blue) and box-wing (red) radiation pressure models and between 1-day (left) and 3-day (right) solutions.

4. Impact on geocenter

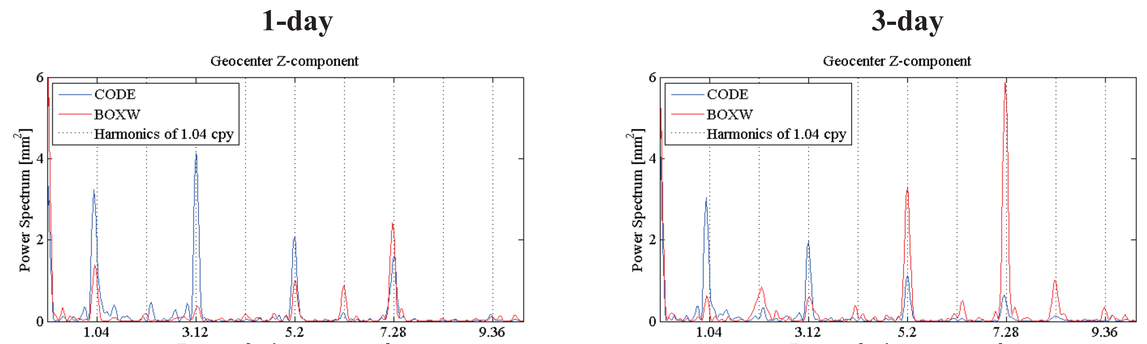


Fig. 4: Power spectrum of the geocenter Z-component from 2004 to 2011. Comparison between CODE (blue) and box-wing (red) radiation pressure models and between 1-day (left) and 3-day (right) solutions.

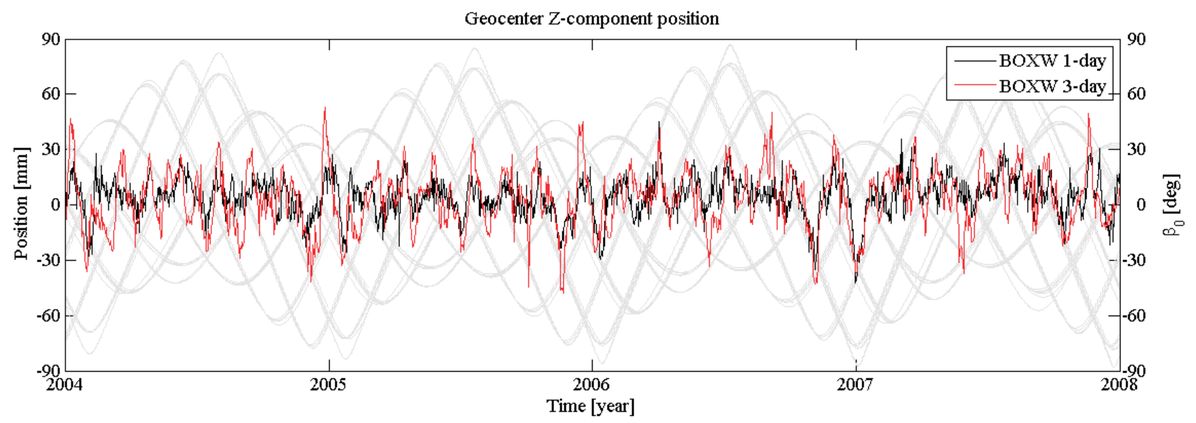


Fig. 5: Geocenter Z-component position for the adjustable box-wing model, comparison between 1-day and 3-day solutions. The β_0 angle to the GPS and GLONASS satellites is shown in gray.

5. Impact on Earth orientation parameters

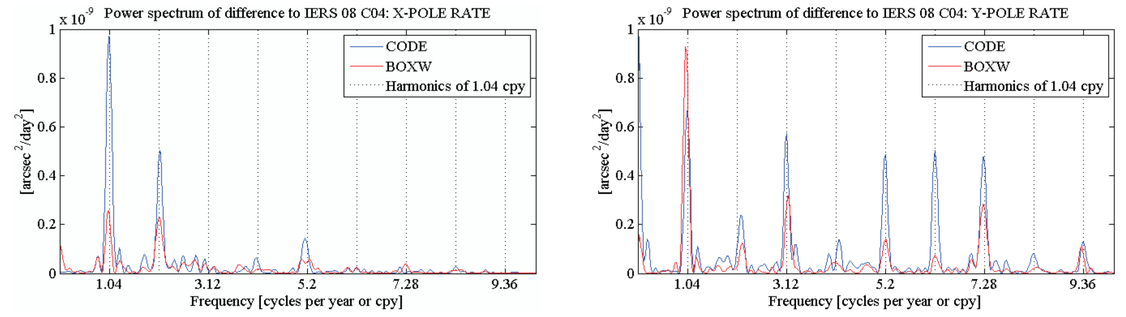


Fig. 6: Power spectrum of X- and Y-pole rates (1-day solution) after taking difference to IERS 08 C04 time series from 2004 to 2010.

CODE drift: -5.8475 ns/day

Length of Day (LOD)

BOXW drift: -0.0836 ns/day

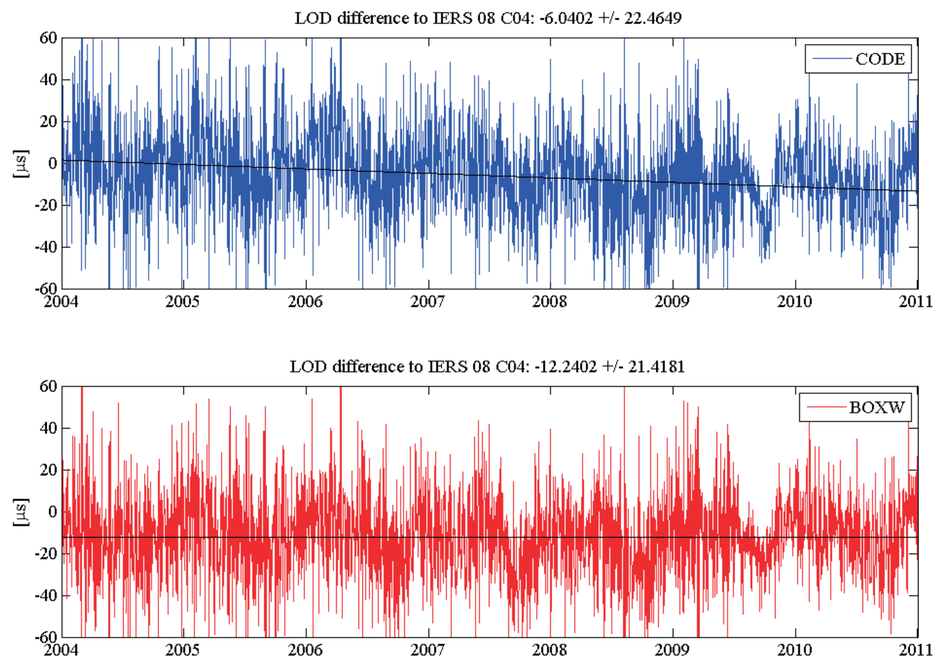


Fig. 7: Length of Day (LOD) difference to IERS 08 C04 time series at noon, after applying tidal corrections. Best fitting line is plotted in black.

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Rodriguez-Solano CJ, Hugentobler U, Steigenberger P (2012) *Adjustable box-wing model for solar radiation pressure impacting GPS satellites*. Adv Space Res 49(7): 1113–1128